Science and Technology 2013 Conference

Report of Contributions

https://conferences.ctbto.org/e/SnT2013
Comprehensive Standard New Seismic Noise Models Extracted from Very Broadband Stations in North Africa and Middle East

It has been two decades since the last comprehensive standard model of ambient earth noise was published (PETERSON, 1993). PETERSON model was updated by analyzing the absolute quietest conditions for stations within the GSN (BERGER et al., 2005; MCNAMARA and BULAND, 2004; RINGLER et al., 2010). Unfortunately, both the original model and the updating models did not include any deployed station in North Africa and Middle East, which reflects the noise levels within the desert environment of those regions. In this study, a survey was conducted to create new seismic noise model from very broadband stations which recently deployed in North Africa and Middle East. Seasonal and diurnal variations in noise spectra were recorded in each station. Moreover, new noise model for each individual station had been constructed. Finally, a cumulative new noise model from all the stations is obtained. We compared the new high-noise model (EHNLM) and new low-noise model (ELNM) with both the high-noise model (NHNM) and low-noise model (NLNM) of PETERSON (1993). The results of this study could be considered as the first step to create permanent seismic noise models for North Africa and Middle East regions.

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Track Classification: Theme 1: The Earth as a Complex System
Update on Earthquake Recurrence in Northeast India Himalaya and Vicinity

An update on earthquake recurrence for the region has been presented with the aid of spatial distribution of seismicity and tectonic features utilizing earthquake data of 1808-2008. Nineteen seismogenic sources were delineated on the basis of certain seismological and geomorphological criteria for the estimation of repeat times of earthquakes to derive the predictive relations. These relations and using the magnitude and time of occurrence of the last mainshocks in each seismogenic source, time dependent conditional probabilities of the next mainshocks and their occurrence during the next 10, 20 and 30 years as well as the magnitude of the expected main shocks are forecast. Occurrence of Sikkim earthquake of September 18, 2011 (predicted magnitude 5.8/occurred 6.8) and Myanmar-India border earthquake of 4th February, 2011 (predicted magnitude 6.2/occurred 6.4), as well as M 6.8 Shwebo, Myanmar Earthquake of November 11, 2012 signify the validity of the model and forecasts. Study report that eight such earthquakes would occur till 2019 with high degree of probabilities, of which six will be located in Arakan-yoma region (three intermediate and three shallow) and remaining two shallow focus one each in the Himalayan Frontal Arc and the Eastern Syntaxis.

**Primary author:** SHANKER, Daya (Indian Institute of Technology Roorkee)

**Presenter:** SHANKER, Daya (Indian Institute of Technology Roorkee)

**Track Classification:** Theme 1: The Earth as a Complex System
Analysis on Propagation and Potentiality of Tsunami in West Coast of Sumatra

Earthquake was frequently occurred in Aceh and in some cases with tsunami potentially. In this research we identify earthquake with tsunami potential. The purpose of this study to analyze the shape and location of ocean bottom earthquake source to observe the pattern of tsunami wave propagation by means of the cross section area bathymetry maps of the study. The research method used well and Coppersmith equations in the input parameters in the software settings tsunami L-2008. these equations can be obtained through extensive section of data information USGS CMT parameter, then performed on the input data software L-2008, until the resulting output from the vertical display position of fault deformation, bathymetry structure and tsunami run-up. The conclusion is the shape of bathymetry of the Sunda trench before reaching the west coast of Sumatra will inhibit propagation run-up the achievement of maximum tsunami wave as it passes through the ridge oceanic plate boundaries around the Sunda trench. Maximum tsunami run-up to external sources of subduction zone earthquakes ranging from 0.8 - 158 m. These results contrast with the historical data for the case of the tsunami in Aceh earthquake different sources.

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Track Classification: Theme 1: The Earth as a Complex System
of Quality Factor Beneath the Local Seismic Networks in SE Central Iran

Quality factor of seismic waves (Q), is one of the important parameters to explain attenuation of seismic waves. By calculating the quality factor in each area we can understand the rate of seismic activity in the region. This quantity has many applications in determination other earthquake parameters, such as moment and magnitude. According to these applications and the existence of high seismic risk in SE central Iran, calculation of quality factor for this region is important. In this investigation, we used single back scattering method given by Aki. For this purpose, the recordings of earthquakes on stations of Kerman and Minab sub networks installed by Iranian Seismological Center (IRSC), which occurred during 2010 to 2012, have been used. We applied a bandpass filter from 2 to 20 Hz, and obtained a relation for Q in Kerman region as $Q=132.49f^{0.87}$, in Minab region as $Qc=62.5 f^{0.91}$ and the relation for Q in southeast central Iran as $Qc=97.5 f^{0.89}$, that confirms the increasing of Q with frequency. The results have been compared with other regions in Iran. And results show that the attenuation is higher in SE central Iran compared to west and east central Iran.

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**Presenter:** MOBASHERI, Marjan (Islamic Azad University)

**Track Classification:** Theme 1: The Earth as a Complex System
Imaging of Central Java, Indonesia: Joint Inversion of the MERAMEX and MCGA Earthquake Data

We used the local MERapi AMphibious EXperiments (MERAMEX) data catalog that consists of 292 events from May to October 2004. The new data of regional events in the Java region were taken from the Meteorological Climatological and Geophysical Agency (MCGA) of Indonesia that consist of 882 events, which have at least 10 recording phases at each seismographic station from April 2009 to February 2011. We have conducted joint inversions of the combined data sets using double-difference tomography. Our tomographic inversions reveal a low velocity anomaly at the Lawu - Merapi zone, which is consistent with the results from previous studies. A strong velocity anomaly zone is identified between Cilacap and Banyumas. We interpret this anomaly as a fluid content material with large aspect ratio or sediment. This anomaly zone is in a good agreement with the existence of a large dome containing sediment in this area as proposed by previous geological studies. A low velocity anomaly zone is also detected in Kebumen, where it coincides with the extensional oceanic basin toward the land. Vertical cross sections of tomograms confirm that the Merapi’s magma source is not vertically inclined but comes from the south of Merapi.

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Track Classification: Theme 1: The Earth as a Complex System
Signals and Wind Noise

Understanding of the seismic background noise is an important step in reducing the noise level of the seismic data. Wind noise refers to vibrations generated by the coupling of wind energy into ground motion. The data demonstrated a consistent correlation between recorded noise levels and wind speed. Signals from desirable events may be obscured by earth noise arising from the wind. Only the passive protection methods are available now. The absence of objects that couple wind energy to the ground (such as trees, topographic irregularities and buildings) is an important consideration in selecting of a quiet site. The seismic stations are extended only a few decimeters above ground. Placing a seismometer at depth greatly reduces the wind effects. The greatest effects in high-frequency wind noise reduction appear within the first 50 m. In the last 10-20 years considerable progress has been achieved in the structural analysis of wind excitation. Numerical techniques have been developed to reproduce the complex structure of wind-induced loading with high accuracy. Finally, can we identify the noise associated with the wind, if we know speed and direction of the wind? If so, can we reduce it on the seismic record? What are costs needed for this?

Primary author: KISLOV, Konstantin (Institute of Earthquake Prediction Theory and Mathematical Geophysics (IEPT RAS))

Presenter: KISLOV, Konstantin (Institute of Earthquake Prediction Theory and Mathematical Geophysics (IEPT RAS))

Track Classification: Theme 1: The Earth as a Complex System
Periodicity in seismic activity is important in earthquake study, because these patterns may lead to the prediction of large earthquakes. The observations of temporal variation of seismic activity in Northeast India as well as Gujarat and adjoining region indicate that a periodic seismicity probably exists. Study use the data from 1819 to 2006 of shallow earthquakes distributed over Gujarat and adjoining regions have been analyzed on the basis of stationary model of seismicity rates and seismic energy released in 11-years time window, for future earthquake occurrences. In a harmonic variation of seismic energy release shows a system of periodicities with predominant period in low seismicity rate intervals followed by in high seismicity rate intervals with a period of 105 years. However, the time interval of low seismicity rates is slightly larger than high seismicity rates. The frequency distribution of earthquakes show that the earthquakes of small magnitude (M 4.0-5.9) follow the Poisson distribution and large earthquakes (M 6.0-7.8) follows the nonrandom distribution (exponential distribution). The non-randomness characteristics indicate that the prediction of magnitude and time of occurrences of forthcoming large earthquakes may be possible. The occurrence of large earthquakes lies on the maxima of the harmonic curve.

**Primary author:** SHANKER, Daya (Indian Institute of Technology Roorkee)

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**Track Classification:** Theme 1: The Earth as a Complex System
of Snowpack as an Indicator for Detection of Underground Nuclear Explosions

The concentrations of tritium have been determined outside “Degelen” site, as well as in settlements Kurchatov, Kaynar and Sarzhal adjacent to the STS. Accumulation of tritium has been estimated in the snow cover over the epicenters of underground nuclear explosions of some adits on “Degelen” site and warfare borehole 1355 on “Balapan” site. The major mechanisms for tritium inflow in the snow have been examined and identified.

No tritium in the snow cover was detected in the residential areas adjacent to the STS, the detection limit was 11 Bq/kg. In the southern and south-easterly direction from “Degelen” site the average tritium concentration in the layers of snow cover is 11 Bq/kg.

At the mouth area of the warfare borehole 1355 over the UNE epicentre tritium content in the snow cover is changing over time, upon that maximum tritium accumulates in spring, reaching 75-100 Bq/kg in the near the ground layer. There no surface water flows near the mouth area of the warfare borehole, so the presence of tritium in the surface layer of snow confirms the assumption on the flow of tritium from the UNE cavity, or close located ground-water table.

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Track Classification: Theme 1: The Earth as a Complex System
Determination in the Western Part of Egypt from Gravity Data and GPS/Leveling

Precise geoid determination is one of the main current geodetic interests in Egypt. The method of Least-squares collocation (LSC) is used in this research for the computation of geoid in Egypt, combining a geopotential model complete to degree and order 360 in addition to gravity and GPS/leveling data. No topographic information was taken into account on the area under study.

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**Track Classification:** Theme 1: The Earth as a Complex System
Motion Scaling in Northern Egypt

We present the empirical scaling relationships for the high-frequency ground motion in northern Egypt. Regression is carried out on more than 650 short period vertical seismograms recorded by the Egyptian National Seismographic Network, with Mw from 2.6 to 4.08 and hypocentral distance up to 550 km. The peak ground velocities are measured in selected narrow-frequency bands between 1.0 and 12.0 Hz. Results are presented to estimate the propagation term, peak filtered velocity, duration and source excitation. The best fit model to parameterize the regression results, quantified the attenuation, following the general power law:

\[ Q(f) = 320 f^{0.49} \]

for, \[ g(r) = r^{-0.9} \] for \( r < 45 \) km.

\[ g(r) = r^{-0.6} \] for \( r > 45 \) km.

and \( k = 0.05 \) sec, which indicates that, almost all the seismicity within the study area are intra-plate and reflects a high attenuation at the upper most part of the crust, due to faulting or lithologic heterogeneity.

Key words:
Ground-motion scaling, regression.

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Track Classification: Theme 1: The Earth as a Complex System
of Site Amplification, Structural Dynamic Characteristics, and Structural Vulnerability Rating of the City of Aqaba

In this study, recordings of free oscillation were made directly on 18 structures in Aqaba, which represent the structural culture of the city. Ground ambient vibration records were conducted at 18 nearby location of each structure. Records were conducted during the cultural activities using three-component seismometer of 2 Hz. Analytical results of structural records, has given the following equation: \( f = \frac{18}{N} \), where \( f \) is the fundamental mode of structure and \( N \) is the number of stories. All structural records were conducted at the top level of each structure except a few. Analysis of obtained records on structures in Aqaba show that most of them are of short periodic structures except a few tall buildings. Most of the results on structures refer to damping factors that range between 0.05 - 0.208.

Ground records indicate to the westward and north-westward decrease of dominant frequency relative to the eastern and southeastern part of the city, where the granite bedrock is much shallower. Striking that the H/V amplification was relatively higher in the scope of areas where the thicknesses of surface deposits in the eastern and southeastern part are much shallower relative to the western and northwestern part of the study area.

Primary author: NASER, Mohammad
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Track Classification: Theme 1: The Earth as a Complex System
and Vs Tomography Beneath the Kalabsha Area, Lake Nasser, Aswan, Egypt

Tomographic inversion is applied to determine detailed three-dimensional velocity (Vp, Vs) structures beneath the Kalabsha area, Aswan by inverting the arrival time data from 731 events. The results obtained from three-dimensional inversion shows a low P-wave velocity zone in the north-western side of the Kalabsha area elongated to the east direction around Seiyal fault and to the south between Khour Ramla and Kurkur faults extended down to 6 km. A high velocity block appears in the northeast of the studied area around Khour Ramla fault at depth 1 Km extended horizontally to south and down to 6 km. High S-wave velocity zone appears in the northeastern side of the Kalabsha region around Khour Ramla fault extended horizontally to south and extended down to 6 Km, tending to southeast direction. Low S-wave velocity zone appears in the south western Kalabsha fault extended down to 14 Km.

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Track Classification: Theme 1: The Earth as a Complex System
Simulation Through Analytical 3D Method: The Ray-Tracing and Modal Summation Technique in the WKBJ-Approximation

Analytical simulation methods help us to understand real behavior of earthquake physics and nature which can give us some measurable parameters to discriminate earthquakes, to make realistic hazard plans and to create reliable data bank of earth motion synthetic record, where true data is not available. In order to enable reliable estimation of the ground motion response to an earthquake, 3D velocity models have to be considered. At present study, we use an innovative methodology for computing synthetic seismograms, complete of the main direct, refracted, converted phases and surface waves in three-dimensional anelastic models based on the combination of the Modal Summation technique with the Asymptotic Ray Theory in the framework of the WKBJ –approximation. The 3D models are constructed using a set of vertically heterogeneous sections (1D structures) on a regular grid. 3D models are constructed in such a way to fulfill the requirement of weak lateral inhomogeneity in order to satisfy the condition of applicability of the WKBJ –approximation, i.e. the lateral variation of all the elastic parameters has to be small with respect to the prevailing wavelength. The method has been used to study the 26 December 2003, Bam earthquake, Mw= 6.6.

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Track Classification: Theme 1: The Earth as a Complex System
’s Crust of Bulgaria by P Receiver Functions

Receiver function technique is applied to evaluate the Moho depth and Vp/Vs ratio on the territory of Bulgaria. Bulgarian National Seismological Network (BNSN) is equipped with broad-band seismometers and digital acquisition systems. It enables application of modern techniques of analysis of the velocity structure in Bulgaria. The method was applied to eleven stations of BNSN. The obtained results show that the Moho depth varies between 30 and 50 km. The crust is shallower in Northeast of Bulgaria and goes deeper in Southwest direction. The crust is thicker in the Rhodopes massif, where it reaches more than 50 km beneath the station Musomishte (MMB). A thick sedimentary layer was also delineated in the Northern Bulgaria. The crustal structure in Southwestern Bulgaria especially beneath the station Vitosha (VTS) is very complex. Further more detailed analysis of data should be performed in order to better estimate the depth of the Mohorovicic discontinuity. The Vp/Vs ratio in the study area varies between 1.60 and 1.90. It varies between 1.80 and 1.90 in Northern Bulgaria and decreases in South and Southwest direction. The western part of Rhodopes massif is characterized by low Vp/VS (1.6-1.65) and could be explained with presence of felsic rock formation.

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Presenter:  GEORGIEVA, Gergana (Sofia University St. Kliment Ohridski)

Track Classification:  Theme 1: The Earth as a Complex System
and Temporal Variations in the Fine Structure of the Middle Atmosphere According to Acoustic Sounding Data

Spatial and temporal variations in the fine layered structure (scales 10m-1km) of the middle atmosphere (20-120 km) have been studied on the basis of data obtained from acoustic sounding within the range of infrasonic waves. Surface explosions equivalent to 10kg -70 t of TNT were the sources of infrasounds. These explosions were set off in different regions of Russia during different seasons. Data obtained from the 1981-2011 experiments have been analyzed. It has been found that the middle atmosphere has a fine layered structure during all seasons. It has been found that, on the whole, the vertical distribution of temperature and wind-velocity inhomogeneities, which are characteristic of the fine structure of the middle atmosphere, can be stable over a period of no less than a few hours. It has also been found that the numerical values of both layered temperature and wind-velocity inhomogeneities (absolute values, vertical gradients, etc.), which characterize the fine structure of the middle atmosphere, can be constant over a time period of no less than 10 minutes.

The data obtained suggest the presence of stable layered inhomogeneities in the middle atmosphere within the range of vertical scales from a few tens of meters to several kilometers.

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**Presenter:** KULICHKOV, Sergey (A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences)

**Track Classification:** Theme 1: The Earth as a Complex System
of Elevated Xe-135 in Northern Japan

The Pacific Northwest National Laboratory (PNNL), the Comprehensive Test-Ban-Treaty Organization (CTBTO) and willing local partners have made a series of measurements in a number of regions to better understand radioactive xenon measurements in hopes of improving discrimination of background sources and potential nuclear explosions. A measurement campaign was conducted in Northern Japan with cooperation from the Japan Atomic Energy Agency (JAEA) from April through September 2012, in an area where backgrounds were poorly understood. A most unusual signature was measured during this time period, a time when all local reactors were shut down. Measurements showed a single sample with a nearly pure xenon-135 isotopic signal, which has never occurred in an environmental sample to our knowledge. We present possible sources of pure xenon-135 in environmental samples and discuss how such events affect a xenon categorization scheme.

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Presenter: BOWYER, Theodore (Pacific Northwest National Laboratory)
Track Classification: Theme 1: The Earth as a Complex System
of Intrusion and Channeling of Regional Air Mass over Kathmandu Valley

Numerical experimentations were performed to understand the mechanism of intrusion and channeling of regional aerosols over the Kathmandu valley with the applications of regional scale atmospheric transport model by releasing tracers inside and outside the valley. The study reveals that the regional aerosol intruding into the valley with the westerly/southwesterly wind contributes 20 to 80 percent of the total concentration over the valley during the night and daytime, respectively. The valley’s air mass, particularly, over the central area of the valley appears to be significantly decoupled from the regional air mass transport processes during the nighttime whereas in the afternoon regional air mass regularly sweeps the valley floor with little day-to-day variation.

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Presenter:  MAHARJAN, Sangeeta (National Atmospheric Resource and Environmental Research Laboratory, Central Department of Physics, Tribhuvan University)

Track Classification:  Theme 1: The Earth as a Complex System
Flow Characteristics of Different Regions of Nepal

Regional scale spatial and temporal distribution of meteorological flows over different regions of Nepal have been studied with the application of Weather Research and Forecast Model (WRF) incorporating field observations to identify major roots of air mass transport towards Himalayas from the Ganges Plain. The calculation domain consists of triply nested two-way interacting mesh with 9km, 3km and 1km grid resolution for coarse, fine and finest domains. The study includes selected areas located in the Eastern, Central, Western, Mid-Western and Far-Western Development Regions of Nepal. The study has identified three major routes of air mass transport from Ganges Plain to the Tibetan Plateau from Western, Central and Eastern regions of Nepal. The air mass transport route from Western Region of Nepal appears to be highly important for aerosols/suspected particulates transport from Ganges Plain to Nepal and then to the Tibetan Plateau.

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Track Classification: Theme 1: The Earth as a Complex System
Assessment of Radionuclide Release According to the Plutonium Isotopic Composition in the Environment

Plutonium isotopic composition analysis is an important and reliable tool for determination of the artificial radionuclide source. As each anthropogenic emission could be characterized by its own unique radionuclide composition, these “fingerprint” make it possible to determine the evidence of radionuclide contamination source reliably. In order to find out the Chernobyl accident influence, samples of undisturbed grassland soils, mature forests and shallow lakes were taken from southern and south-western regions where Chernobyl plume travelled over the Lithuania. 238Pu/239+240Pu activity ratio was measured with the alpha spectrometric technique, 240Pu/239Pu isotopic ratio measured by the inductively coupled plasma high resolution mass spectrometry. 238Pu/239+240Pu activity and 240Pu/239Pu isotopic ratios varied within 0.02 – 0.18 and 0.187 – 0.267, respectively. Based on linear interpolation method described it has been shown that fall-out evidence of the Chernobyl fourth reactor is still clearly seen even after twenty five years after the meltdown, although its signs are vanishing. The explanation of that reason is given. The significant fall-out inhomogeneity in nearby sampling locations is discussed as well.

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Presenter: PUZAS, Andrius (Center for Physical Sciences and Technology (FTMC))

Track Classification: Theme 1: The Earth as a Complex System
Pressure Fluctuations Produced by Total Solar Eclipse of 1 August 2008

The purpose of this presentation is to estimate the surface atmospheric pressure fluctuations produced by the passage of the 1 August 2008 total solar eclipse and to compare these pressure fluctuations with those recorded by a temporary network of microbarographs and by the infrasound stations of the International Monitoring System. The surface pressure fluctuations expected at all the measurement sites are estimated using a linear spectral numerical model. It is shown that the cooling of both the ozonosphere and the troposphere can produce detectable pressure fluctuations at the ground surface but that the tropospheric cooling is likely to be the predominant source. Since the expected eclipse signals are in a frequency range that is highly perturbed by atmospheric tides and meteorological phenomena, the pressure fluctuations produced by these latter synoptic disturbances are characterized and removed from the recorded signals. Low-frequency gravity waves starting just after the passage of the eclipse are then brought to light at most measurement sites. The time-frequency characteristics of these waves are similar to those obtained from the model, which strongly suggests that these waves were produced by the passage of the 1 August 2008 solar eclipse.

Primary author: MARTY, Julien (CTBTO)

Presenter: MARTY, Julien (CTBTO)

Track Classification: Theme 1: The Earth as a Complex System
Monitoring of the Wind Velocity Fine-Scale Structure in the Middle and Upper Atmosphere

The scattering of infrasound from anisotropic wind velocity and temperature fluctuations in the middle and upper atmosphere leads to the penetration of the infrasound field into acoustic shadow zones. Based on this effect a method of acoustic sounding of an atmospheric fine-scale wind velocity vertical structure is developed to retrieve vertical profiles and vertical wavenumber spectra of the wind velocity fluctuations in the middle and upper atmosphere (up to a height of 130 km above ground). Some recently obtained results of the reconstruction of these fluctuations from the wave forms and travel times of the stratospheric and thermospheric arrivals detected in the shadow zones near surface explosions and volcano eruptions are presented. The temporal variability of the retrieved wind vertical profiles over the time scales of 10-30 min is analyzed.

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Presenter: CHUNCHUZOV, Igor (Obukhov Institute of Atmospheric Physics, Russian Academy of Science)

Track Classification: Theme 1: The Earth as a Complex System
Site Effect Evaluation in Austria

Strong site effect can cause anomalous site amplification and result in massive deviations from general earthquake ground motion prediction. Site amplification was firstly observed at the Austrian Seismic Network (network code OE) during our work on peak ground acceleration attenuation (Jia and Lenhardt, 2011) and this initiated investigations in this paper.

We firstly applied a spectral ratio technique to noise and shear-wave spectra from the ten most stable stations in our network. Then we extended our study to all strong motion stations with discontinuous data by using the spectral ratio technique only for shear-waves. To better understand the correlation between site responses and station magnitude residuals, we expanded our study to remaining stations, which have accelerometers within the site and also contributed to the calculation of our network magnitude, including three stations in the Czech Republic and six stations in Northern Italy.

Further investigations were made for data from three co-located stations with different conditions at the Conrad-Observatory: CONA (in the tunnel), CSNA (free field) and a station located in the borehole, for understanding how seismic signals depend on site effects. In addition, dependence of station detection performance on the site effects was evaluated.

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Presenter: JIA, Yan (Central Institute for Meteorology and Geodynamics)
Track Classification: Theme 1: The Earth as a Complex System
Engagement Between the Medical Isotope Production and Nuclear Explosion Monitoring Communities

Thanks in large part to ongoing dialogue between the medical isotope production and nuclear explosion monitoring communities at events like the annual Workshop on the Signatures of Medical and Industrial Isotope Production (WOSMIP), the challenges that effluents from isotope production can create when monitoring for nuclear explosions are receiving due attention. The two communities have shown a willingness to explore potential technical solutions to these challenges, including the increased use of facility stack monitoring data and the examination of existing and future effluent containment systems. In addition, the two communities have discussed the means by which to recognize those isotope producers who show willingness to go beyond what is required by current industry regulations. This model of cooperation between two communities with diverse and disparate goals holds promise in resolving some of the technical challenges presented, while minimizing interference in doing so.

Primary author: CAMERON, Ian (Pacific Northwest National Laboratory)

Presenter: CAMERON, Ian (Pacific Northwest National Laboratory)

Track Classification: Theme 1: The Earth as a Complex System
Local and Regional Wave Propagation

Seismograms reflect the combined effects of the source, recording instrument, ambient noise, and the propagation path. Especially for recording at distances smaller than 10° the signal is affected mainly by the crustal structure, as waves propagate in the crust and/or along Moho. Therefore, appearance of regional seismograms varies strongly, which complicates record interpretation and phase identification severely. However, for earthquakes with small magnitudes, close distance records are the only ones available with a sufficient signal at all. Due to sparse seismic station coverage and the use of only the most distinct phases, typically P\textsubscript{g} and S\textsubscript{g}, localization can not always be ensured. Yet, retrieving accurate earthquake location, including depth information and the relation with faults is important for understanding tectonic processes and for estimating seismic hazard. Prior works by e.g. Ma (2010) show the benefit of using additional regional phases for localization, in particular depth. At local and regional distances the challenge lies in robustly detecting and identifying these phases correctly, which are usually superimposed by the coda of the P- and S-phase and sometimes even arrive simultaneously. In this work we want to shed light on the different influences on seismograms at local distances < 300 km.

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Track Classification: Theme 1: The Earth as a Complex System
85Kr monitoring in USSR-Russia was ceased in 1993, 85Kr concentration activity was 0.9 - 0.92 Bq/m3. The monitoring of Xe and 85Kr radionuclides was renewed since August 2006, and was arranged at the sampling station in Cherepovets city, located in 220 km northward from the Kalinin NPP. Kr-Xe gas mixture was filled in balloon with charcoal and transported to Radium Institute. For the period of monitoring in Cherepovets city concentration activity of 85Kr, varied from 1.3 to 1.8 Bq/m3 and amounted to 1.55 ± 0.12 Bq/m3 in average. For the period since 85Kr monitoring cessation in Russia its atmospheric activity has grown approximately 1.5 times, and at present the results obtained for the North-West region of Russia correspond to the data for Europe and Japan. Mean 85Kr concentration activity in atmospheric air in St.-Petersburg made up 2.11 ± 0.66 Bq/m3, which is 37% higher than that in Cherepovets. Air masses with increased 85Kr content are mainly transferred from the west and the south-west, i.e. from NPPs location regions. Air masses with lowered 85Kr concentration moved from the North (Greenland Sea, Northern and Norwegian Seas), where there are no NPPs located, which could discharge accumulated 85Kr. Data of 85Kr monitoring in 2012-2013 are presented.

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**Presenter:** DUBASOV, Yuri (Khlopin Radium Institute)

**Track Classification:** Theme 1: The Earth as a Complex System
High-Resolution Mapping of Surface-Wave Velocities Across Asia Using Automated Inter-Station Measurements

The rapid recent expansion of broadband seismic networks around the world has paved the way for a new generation of tomographic models of the Earth. These models will yield high resolution — previously achievable only in small-scale regional studies — at large, continental scales, advancing our understanding of the structure and dynamics of the Earth’s tectonic plates. Importantly, they will also facilitate the continued improvement in the accuracy of regional seismic travel time prediction and event location, through their accurate representation of seismic-wave velocities within the crust and upper mantle. Here, we apply new, automated techniques for inter-station measurements of surface-wave phase velocities to a very large data set, including seismic data from the CTBT IMS network and the broadband data available from international data centres. The many thousands of new surface-wave dispersion curves are then inverted for tomographic phase-velocity maps. The resulting whole-Asia model of surface-wave velocities provides a significant advance in resolution compared to previously available models. The detailed seismic images of the lithosphere offer new insights into fascinating geological processes that formed Asia. The high-resolution tomographic models will also be used for accurate modelling of seismic wave propagation in regions of particular interest in the CTBTO framework.

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Track Classification: Theme 1: The Earth as a Complex System
Model Validated with the Events and Stations in Egypt

The International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) will ultimately have 170 seismic stations for the purpose of monitoring underground nuclear explosions, in which about 80 percent are currently running. The seismic event location will play an important role in the monitoring process and the accuracy of location is important to the success of the On-site Inspection operation. The Regional Seismic Travel Time (RSTT) modelling approach (described by Myers, et al., 2009) provides a path toward reducing location uncertainty. IDC has performed validation tests on events from Europe, Asia, and North America. In areas where there is little ground-truth, validating the RSTT model can be done by examining location results from well covered regional networks. Regional seismic travel times from 16 events, well recorded by the Egyptian National Seismological Network (ENSN) and IMS in Egypt in the period from 1999 to 2011, were gathered. The events were located using different travel-time models (IASPEI91, AK135 and JB). Travel time residuals compared with travel time corrections from RSTT model indicate the best model for the events in Egypt.

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Presenter: ALI, Sherif (CTBTO)

Track Classification: Theme 1: The Earth as a Complex System
of Ground Motion in Bangladesh

Bangladesh is located in a seismically active region close to the plate boundary between the northward moving Indian plate and the Eurasian plate. Historically Bangladesh has been affected by six earthquakes of large magnitude, 7.0 (Richter) or greater, within the last 250 years. Three of them had their epicentres within the country. In the absence of seismic instrumentation, strong motion data for those earthquakes are not available. Several publications have been critically examined for identifying isoseismals and related intensities for some historical earthquakes. Attenuation of earthquake intensity appear to have directional dependence, and directions affecting Bangladesh show greater attenuation. Attenuation law describing attenuation of ground motion within Bangladesh has been developed from isoseismals of major earthquakes (mostly historical) and compared with published attenuation laws developed for other countries of the world including India, Iran, Western USA, Eastern USA and Europe. Such attenuation relationships are needed for seismic hazard studies. Only in recent years, digital seismic stations have been installed at different locations of the country. These stations have yielded some ground motion data for recent moderately strong earthquakes in neighbouring countries. The decay of ground motion with distance for these earthquakes is studied and compared with developed attenuation relationship.

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Track Classification: Theme 1: The Earth as a Complex System
Aerosol Survey in Kathmandu, Nepal

Monitoring radioactive gases and particulates is a vital component in arms control and nonproliferation treaty verification. The International Monitoring System (IMS) established in the CTBT specifies 80 radionuclide monitoring stations located around the world. While the official stations cover vast tracts of the world, there are large sections of the globe that have not been surveyed for natural or man-made radioactivity that could make CTBT verification difficult. Nepal and Kathmandu lie in such a region, and thus should be very interesting for xenon background study. Kathmandu is the most logical place for such a study for logistical reasons. However, the local geography of the Kathmandu Basin poses a problem: past studies show parts of the basin may have air that is decoupled from regional flows for part of the diurnal cycle. This is being validated with preliminary set of aerosol measurements made at Tribhuvan University. Samples are taken with a commercial aerosol sampler and subsequently measured in low background laboratories in the U.S. Initial results of this study will be discussed.

Primary author: REGMI, Ram Prasad (National Atmospheric Resource and Environmental Research Laboratory (NARERL), Central Department of Physics, Tribhuvan University)

Presenter: REGMI, Ram Prasad (National Atmospheric Resource and Environmental Research Laboratory (NARERL), Central Department of Physics, Tribhuvan University)

Track Classification: Theme 1: The Earth as a Complex System
Simple Filter Design for Noise in CTBTO Lembang Seismological Station (West Java, Indonesia)

Lembang Seismological Station (LEM) is one of CTBTO’s stations network located in West Java, Indonesia. This station integrated in Indonesia Tsunami Early Warning System (InaTEWS) since June 2007 and have important role to analyze earthquake in West Java and surroundings area. Therefore, the quality of waveform is very important to localized the earthquake accurately. This research have purpose to determine a simple filter design for noise in LEM seismological station based on analyze Z/H spectra ratio of pre-seismic, co-seismic, and post-seismic signal. The filter design can influence performance of waveform data in a seismological station. We have analyzed seismic waveform of 20 earthquakes that recorded in LEM station. The results show that the dominant peak of noise stable on 0.08 – 0.1 Hz. Based on the result we suggest to using Bandpass filter or Notch filter to get best performance of seismic waveform.

Primary author: YATIMANTORO, Tatok (Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG))

Presenter: YATIMANTORO, Tatok (Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG))

Track Classification: Theme 1: The Earth as a Complex System
Adsorption Studies at the Laboratory Scale

The reduction of noble gas emissions from large radiopharmaceutical production facilities is a key issue in increasing the sensitivity of the International Noble Gas Monitoring Network. To study the possibility of increasing the efficiency of the current xenon traps in place at the Institute for Radioelements (IRE) a laboratory set-up for stable xenon was realized at SCK•CEN to investigate different adsorption materials under different conditions. The set-up consists of a gas management system and adsorption bed that simulates in the best possible way the industrial conditions at IRE. Detection of the breakthrough of xenon is performed by the principle of measuring the difference in thermal conductivity between a pure helium flow (reference) and the helium-xenon flow. The set-up is calibrated for a wide range of xenon concentrations (<\ 1000 ppm). Two adsorption materials were studied: a commonly used activated carbon (Norit RKJ 1) and a new silver zeolite material (Ag-ETS-10). The results obtained for the silver zeolite are very promising. The adsorption capacity is very high at room temperature and the efficiency for the xenon retention remains constant even at low xenon concentrations. Several regeneration tests have been performed, showing no decrease of the xenon adsorption capacity.

**Primary author:** CAMPS, Johan (Belgian Nuclear Research Centre)

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**Track Classification:** Theme 1: The Earth as a Complex System
ISC Contribution to the RSTT Development and Validation Effort

Recently the CTBTO has launched a global initiative to facilitate the development of the Regional Seismic Travel Time (RSTT) velocity model on a global scale by forming regional expert groups. Essential to this effort is to collect and develop new ground truth information covering the Southern hemisphere. Ground truth events collected in this project are added to the IASPEI Reference Event List (Ground Truth database) hosted by International Seismological Centre (ISC) on behalf of the IASPEI. To further support the RSTT development and validation studies, the ISC has developed a version of its location software to accommodate local and regional travel-time predictions provided by the RSTT software package. The RSTT-enabled ISC locator is made available through the ISC website.

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Track Classification:  Theme 1: The Earth as a Complex System
Faults and Peculiarities of Seismicity and Fault Behavior on the Territory of Armenia

Earthquakes are the expression of the continuing evolution of the Earth planet and of the deformation of its crust and occur worldwide. Armenia lies in the central part of the Armenian Highland and is situated on the north of the collision boundary between the Arabian plate and the Eurasian plate. This region is one of typical collision boundaries in the world. The Arabian plate is moving northward at the rate of 20-30 mm/year and collides with the Eurasian plate. The Anatolian and the Iranian blocks are squeezed westward and eastward respectively. Seismic events in the territory of Armenia are determined by its position in the collision zone of the Arabian and Eurasian plates. In the present work the relationship between well known active faults and local seismicity is considered. The national catalogue of Earthquake and catalogue of focal mechanisms are used. More than 400 earthquake focal mechanisms have been analyzed and some peculiarities of faults behavior are revealed.

Track Classification: Theme 1: The Earth as a Complex System
Depth and Crustal Velocity Structure Beneath Stations RTC and TAM from Teleseismic P-Wave Receiver-Function Analysis

We apply the P-wave receiver-function technique to invert teleseismic data to investigate the S-wave velocity structure beneath stations RTC and TAM in West Africa. Our results show that the crust beneath RTC is relatively complex with large velocity fluctuations. In the upper crust, a low velocity layer extends from 8 to 12 km deep. This shallow low velocity layer is mainly due to the station’s location on a zone of transition between a thick continental crust and the thinner oceanic crust. At Tamanrasset (Algeria), the crustal structure of the East and the West of the station differs. We found a high-velocity zone between 2 and 8 km to the east that we attribute to a high conductivity unit corresponding to intrusions described in the literature. We find no similar feature west of the station. Our velocity models for RTC and TAM are consistent with the respective tectonic environments. TAM, located on a stable craton, displays a fairly homogeneous velocity structure while RTC, located on thick sediments in an ocean-continent transition zone, has more heterogeneous structure. This structural difference is reflected as well by the depth of the Moho, ~22 km at RTC and nearly 38 km at TAM.

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Track Classification: Theme 1: The Earth as a Complex System
Cesium and Iodine Aerosol Characterization in North America

The Fukushima Reactor accident generated a large data set of global radionuclide observations. The frequent observations of xenon, cesium and iodine isotopes provided an opportunity to examine the performance of atmospheric transport and dispersion models driven by numerical weather prediction models, in particular, the important mechanisms of in-cloud scavenging, precipitation, deposition and iodine phase conversions in long range models. Previous studies have investigated these phenomena over short range, but this is the first time a global, coordinated surveillance system including non-scavenged noble gas have been available. Since particle size distributions are very different at long range, the parameterization of the deposition and phase change parameters is important for accurate atmospheric modelling, particularly in a Comprehensive Nuclear-Test-Ban Treaty (CTBT) context. The atmospheric removal time and results of modelling the deposition and airborne activity of cesium and iodine concentrations are presented for North America and compared with the actual measurements.

**Primary author:** HOFFMAN, Ian (Radiation Protection Bureau)

**Presenter:** HOFFMAN, Ian (Radiation Protection Bureau)

**Track Classification:** Theme 1: The Earth as a Complex System
Variation of Pn Amplitude Across Western Tien Shan

Previous researches suggested that the velocity gradient of upper mantle, heterogeneities in the mantle lid and Moho topography may influence the amplitude of Pn. In order to show which should mainly account for abnormal variation of Pn amplitude, Pn waves of an earthquake occurred on southwest margin of Tarim Basin recorded by CHENGIS and KN network stations are employed, and the amplitude variations of Pn across western Tien Shan are investigated. The results show that the Pn amplitude near 1Hz don’t decrease systemically as distance increase, and Pn amplitudes at some stations are three times larger than those at other stations with approximately equal distance. The 2D Spectral Element Method is applied to simulate the propagation of Pn across western Tien Shan using the structure model derived from Moho depth model and Pn velocity structure in western Tien Shan. The Moho depth model is derived by Liu(2011) using receiver functions and the Pn velocity structure is inversed by Li(2007) using Pn travel time. The result obtained indicates that the variation of Moho depth along the wave propagation path may account for the abnormal variation of Pn amplitude.

**Primary author:** WANG, Hongchun (Northwest Institute of Nuclear Technology)

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**Track Classification:** Theme 1: The Earth as a Complex System
the Localizability of Atmospheric Tracer Sources Using ATM

With the Additional Protocol to the Non-Proliferation Treaty, atmospheric sampling analysis of the noble gas Krypton-85, which is a suitable tracer for plutonium separation, was introduced. Our project focused on the investigation of the effects of temporal sampling resolutions to the localizability of tracer sources using atmospheric transport models (ATM). Predefined weekly quantities of Kr-85 were hypothetically released in 2009 over La Hague reprocessing plant and tracer dispersion was simulated using the Lagrangian particle dispersion model Flexpart. In so-called “catch-the-plume”-scenarios, pseudo concentration samples were generated at fictitious stations. Then, source-receptor-sensitivity fields were simulated and averaged to yield backward sensitivities of different temporal sampling resolutions. Afterwards correlation fields, called “possible source regions” (PSR), of the multiple measurement scenario were calculated to compute localizability parameters values for reliability, e.g. the distance between the spatio-temporal correlation maximum and the source, and sharpness, i.e. the size of a user-defined PSR. A cost-benefit analysis yield optimum results for a sampling interval of 12h applied to two sampling stations. The tracer origin stayed locatable up to 2000km away from the source. Further research is needed to improve the localizability in diffusive weather situations, assessing the minimum detectable source strength and qualify nesting methods for complex topography.

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Track Classification: Theme 1: The Earth as a Complex System
the Sensitivity of the International Noble Gas Monitoring Network by Mitigating Radioxenon Releases from Radiopharmaceutical Facilities

Noble gases are a key indicator if an explosion was nuclear in nature or not and since World War II the short-lived radioxenon noble gases have been used to detect nuclear activities. In the last 10-15 years with the construction of the International Monitoring System (IMS), the measuring technologies and sensitivities have improved significantly. The sensitivity of the noble gas network is partly determined by the radioxenon background originating from civil nuclear applications. This background comes mainly from a few large medical isotope production facilities. It will be therefore possible to enhance the sensitivity of the radioxenon network by decreasing the global background. Atmospheric releases from medical isotope production facilities are, however, well below any health standards and these facilities have no direct need themselves to reduce these discharges. In the framework of the Joint Action V program the EU is likely to support a study for the mitigation of xenon released by radiopharmaceutical facilities. The goal of this project is to construct a transportable xenon mitigation system for reducing the xenon at specific processes in such facilities. Tests will be performed in real conditions in a production plant, at the Institute for Radioelements (IRE), Fleurus, Belgium.

Primary author: CAMPS, Johan (Belgian Nuclear Research Centre)
Presenter: CAMPS, Johan (Belgian Nuclear Research Centre)
Track Classification: Theme 1: The Earth as a Complex System
Medical Isotope Experiments for Detection Validation

Fission gases such as Xe-133 are used extensively for monitoring the world for signs of nuclear testing in the International Monitoring System (IMS). Medical isotope production for Mo-99 is an additional source of radioxenon that has been shown to also be detected in the IMS. Understanding and interpreting interferences from medical isotope production is still a relatively new concept. This work will present many different ideas for experiments that will allow various parts of the problem at hand to be validated. Proposed experiments will address methods to better understand releases from facilities and subsequent detections in the IMS. Many of these ideas will rely on collaboration between facilities and the monitoring community. Experiments will address data correlation between what is released (as determined by stack monitoring) and what is detected at a remote location, calibrated releases, effluent characterization and many others.

Primary author: KEPHART, Rosara (USAF)

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Track Classification: Theme 1: The Earth as a Complex System
the Noise Field Recorded at the USArray TA Infrasound Stations

With the addition of acoustic sensors to the seismograph stations of the US National Science Foundation EarthScope USArray Transportable Array (TA), there is an opportunity for significant advances in our understanding of infrasound source physics and propagation, as well as coupling between seismic and infrasound waves. Central to these efforts is an improved understanding of infrasound noise. We present a comprehensive analysis of the ambient acoustic noise recorded at over 400 of the USArray TA stations. Owing to the spatial extent and the density of these stations (spacing of ~70 km) the noise field exhibits a large variability, diurnal and seasonal, influenced by local and long-range sources. The method of ambient noise characterization is based on power spectral density (PSD) estimates, often used in processing seismic noise records. Continuous time series are demeaned, detrended, and deconvolved with the instrument response. The waveform data are divided into overlapping sub-windows and FFT-based power estimates are averaged to reduce the PSD variance. To visualize the general spectral noise characteristics the processing also involves merging the PSD estimates into 2D histograms, resulting in probability density functions, for each single-channel station and for all the combined stations.

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Track Classification: Theme 1: The Earth as a Complex System
Isotopic Ratios from Medical Isotope Production and CANDU

The nuclear and radiopharmaceutical industrial emissions of the four CTBT-relevant radioxenon isotopes are detected by the IMS along with possible treaty violations. To better understand the source terms of these background emissions, a joint project between Health Canada (HC), Australian Nuclear Science and Technology Organisation (ANSTO), Pacific Northwest National Lab (PNNL) and Chalk River Laboratory (CRL) to install real-time detection systems to monitor 135Xe, 133Xe, 131mXe and 133mXe at ANSTO and CRL 99Mo production facility stacks as well as the CANDU (CANada Deuterium Uranium) primary coolant monitoring system at CRL. At each site, high-resolution gamma spectra were collected from a bypass stack feed or CANDU primary coolant system as it passed through a sampling cell. HC also conducted radioxenon atmospheric monitoring approximately 200 km from CRL. The isotopic signatures of the various radioxenon species can be determined from different source terms. Comparison of 133mXe and 133Xe activity ratios showed distinct differences between the closed CANDU primary coolant system and radiopharmaceutical production releases. The multiple isotopic activity ratios were distributed in different domains (civilian/nuclear test). Most measurements were found to be civilian in nature. There were some situations where isotopic ratios from 99Mo production emissions fell within the nuclear test domain.

Primary author:  HOFFMAN, Ian (Radiation Protection Bureau)

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Track Classification: Theme 1: The Earth as a Complex System
for the Radioactive Source Location Problem

In radionuclide monitoring, one of the most significant challenges from a verification or surveillance perspective is the source location problem. Modern monitoring/surveillance systems employ meteorological source reconstruction - for example, the Fukushima accident, CRL emissions analysis and even radon risk mapping. These studies usually take weeks to months to conduct, involving multidisciplinary teams representing meteorology; dispersion modeling; radionuclide sampling and metrology; and, when relevant, proper representation of source characteristics (e.g. reactor engineering expertise). Several different approaches have been tried in an attempt to determine useful techniques to apply to the source location problem and to develop rigorous methods that combine all potentially relevant observations and models to identify a most probable source location and size with uncertainties. The ultimate goal is to understand the utility and limitations of these techniques so they can transition from R&D to operational tools.

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Track Classification:  Theme 1: The Earth as a Complex System
-22 Atmospheric Tracer and Radiochronometer

The aerosol monitoring component of the International Monitoring System (IMS) was principally designed to detect atmospheric nuclear testing for the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Beyond the CTBT applications, IMS radionuclide data also has important Earth science research applications such as climate change, meteorology, solar cycle impacts on terrestrial processes, etc. Na-22 and Be-7 are two natural radionuclides produced in the stratosphere through cosmic ray spallation with atmospheric gases. While Be-7 is extremely easy to measure, Na-22 is produced in such minute quantities that it is rarely observed when there is strong vertical atmospheric transport. Using a spectral summation technique, it is possible to the Na-22 signal. By comparing the Na-22 signal with Be-7 concentrations it is possible to investigate solar cycle impacts on these natural radionuclides and possibly provide information on the airborne transport pathway of air masses. The relative concentrations of Be-7 and Na-22 function as a radiochronometer providing information on transit time from the site of production (stratosphere) to the observing site. This type of information is important for understanding the 3D motion of the atmosphere which is also important to CTBT.

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Presenter:  HOFFMAN, Ian (Radiation Protection Bureau)
Track Classification:  Theme 1: The Earth as a Complex System
Particles in the Environment

Radionuclides in the environment are often observed in particulate form. This aerosol material collected in an air filter will contain a multitude of particles, both ambient particles and particles that contain radioactive material. The amount of radioactivity in each hot particle is a function of its method of formation. Different types of nuclear explosions will create a different particle distribution. These differences can include particle size, elemental distribution in the particles, location of the radioactivity on the particle, and shape of the particles. Many of these properties of hot particles will affect how they transport in the environment which will make them available for collection at aerosol collection stations. Examples of these hot particles from nuclear explosions will be shown and discussed along with the implications they create for sample processing and filter splitting for verification of IMS detections in radionuclide laboratories. E.C. Freiling, Radionuclides in the Environment: A Symposium, Vol. 93, DOI 10.1021/ba-1970-0093, 1970, American Chemical Society

Primary author: FRIESE, Judah (Pacific Northwest National Laboratory)
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Track Classification: Theme 1: The Earth as a Complex System
1D Seismic Velocity Model with GT5 Events in Brazil and Tests of Crustal Thickness Corrections to Improve the RSTT Model for South America

Good 3D lithospheric velocity models are necessary for reliable epicentre determination. To test different models, we compiled a set of 17 Brazilian reference events, magnitudes 4.0 to 5.1. Only four were truly GT5 events. Most of the events had the epicenter assigned to the middle of the aftershock zone determined by aftershock studies, with origin times calculated with IASP91 table using teleseismic stations. The travel times were normalized to zero depths and compared to some 1D models. The average residuals, up to 1640km, were -2.6s ± 1.9s (for IASP91 model), -1.9s ± 1.7s (Herrin1968), and 0.4 ± 1.5s (Brazilian NewBR). Corrections for crustal thicknesses, using the model of Assumpcao et al.(2012), to a 40 km crust changed the average residuals very little: -2.2s ± 1.9s (IASP91), -1.4s ± 1.6s (Herrin1968), and 0.8 ± 1.3s (NewBR). The raw travel times (uncorrected for event depth and crustal thickness) were compared with the current RSTT model (basically CRUST2.0 in South America) giving average residual of +0.2s ± 1.3s, the smallest of all models. Crustal thickness corrections, while necessary, have limited impact in reducing travel time scatter, and accounting for upper mantle heterogeneities is more important to improve regional travel times in Brazil.

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**Presenter:** ASSUMPCAO, Marcelo Souza de (University of Sào Paulo Seismology Center)

**Track Classification:** Theme 1: The Earth as a Complex System
Attenuation Models of the Lithosphere to Predict Expected Signal to Noise Ratios for Regional Phases

We have developed a methodology to construct high-resolution regional lithospheric attenuation models of the earth based on regional P and S-waves. The method uses Pn, Pg, Sn, and Lg amplitudes to simultaneously invert for the crust and upper mantle attenuation structure. The method was initially developed for the Middle East, then expanded to include most of Eurasia, and now we have transported the methodology to North America. Lithospheric structure can cause strong variation in regional amplitudes, which are captured in the models. A key use of the models is in predicting the expected signal amplitude of regional phases for earthquakes of arbitrary magnitude and explosions of arbitrary yield, depth, and emplacement point material properties. We utilize an MDAC source model for earthquakes and have included, tested, and compared a number of existing and emerging explosion source models. Combining the expected signal with the observed noise characteristics of the station provides information on the detection thresholds of regional phases. Merging this information for a constellation of stations can be used to produce network detection maps. The attenuation models are available to the broader community, and the regional models will eventually be incorporated into the NetMOD (Network Monitoring for Optimal Detection) tool.

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Track Classification: Theme 1: The Earth as a Complex System
Global 3D P-Velocity Model of the Earth’s Crust and Mantle for Improved Seismic Event Location

To test the hypothesis that high quality 3D Earth models will produce seismic event locations that are more accurate and more precise than currently used 1D and 2.5D models, we are developing a global 3D P wave velocity model of the Earth’s crust and mantle using seismic tomography. In this paper, we present the most recent version of SALSA3D and demonstrate its ability to reduce mislocations for a large set of realizations derived from a carefully chosen set of globally-distributed ground truth events. We obtain path-dependent travel time prediction uncertainties for our model by computing the full 3D model covariance matrix of our tomographic system and integrating the model slowness variance and covariance along paths of interest. This approach yields very low travel time prediction uncertainties for well-sampled paths through the Earth and higher uncertainties for paths that are poorly represented in the data set used to develop the model. While the calculation of path-dependent prediction uncertainties with this approach is computationally expensive, uncertainties can be pre-computed for a network of stations and stored in 3D lookup tables that can be quickly and efficiently interrogated using GeoTess software.
of Medical Isotope Production

Medical isotope production has recently been identified as a source of radioxenon in the atmosphere which can pose a potential problem for the International Monitoring System. The quantity of xenon released and the xenon isotopic ratios observed are variable between facilities and also within a facility. The reasons for the differences can be understood with knowledge of the fundamental processes associated with medical isotope production. This work will be a brief tutorial on the steps used for the production of Mo-99, highlighting the areas of variability. The process steps discussed will begin with irradiation and move through chemical processing, abatement, and stack monitoring and emissions. The discussions will focus on generic examples and will not give individual facility specific details.

**Primary author:** KEPHART, Rosara (USAF)

**Presenter:** KEPHART, Rosara (USAF)

**Track Classification:** Theme 1: The Earth as a Complex System
of Environmental Radionuclide Measurements from Nuclear Accidents and Nuclear Explosions

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) has remote radionuclide monitoring followed by an On-Site Inspection (OSI) to clarify the nature of a suspect event as part of its verification regime. An important aspect of radionuclide measurements on site is the discrimination of other potential sources of similar radionuclides such as reactor accidents or medical isotope production. The Chernobyl and Fukushima nuclear reactor accidents offer two different reactor source term environmental inputs that can be compared against historical measurements of nuclear explosions. The comparison of whole-sample gamma spectrometry measurements from these events and the analysis of similarities and differences are presented. This analysis is a step toward confirming what is needed for measurements during an OSI under the auspices of the Comprehensive Nuclear-Test-Ban Treaty. DE Robertson, RW Perkins, EL Lepel, CW Thomas, J. Environ. Radioactivity, 17 (1992) 159-182, Radionuclide Concentrations in Environmental Samples Collected Around Chernobyl During the International Chernobyl Project

Primary author:  FRIESE, Judah (Pacific Northwest National Laboratory)
Presenter:  FRIESE, Judah (Pacific Northwest National Laboratory)

Track Classification:  Theme 1: The Earth as a Complex System
of Atmospheric Radionuclides from the Fukushima Nuclear Accident in Xi’an, China

Aerosol radionuclides (131I, 134Cs, 137Cs) and gaseous radioactive xenon (133Xe) were monitored at Xi’an, China following the accident at the Fukushima nuclear power plant in March 2011. The monitoring results showed that the maximum concentrations of 131I and 133Xe were 3.92 mBq/m3 and 5.5 Bq/m3, respectively, on March 25–27. And the concentrations of all observed radionuclides decreased gradually after April 5. Possible transport pathways of the released radionuclides from Fukushima to Xi’an were investigated. The occurrence of an anticyclone in the Pacific Ocean region and the extended period over which the radionuclides were released made the determination transport pathways complex, but divergence in the plume and easterly flow evidently brought the initial suite of radionuclides to Xi’an.

Primary author: LIU, Longbo (Northwest Institute of Nuclear Technology)

Presenter: LIU, Longbo (Northwest Institute of Nuclear Technology)

Track Classification: Theme 1: The Earth as a Complex System
Infrasonic microbarom signals are attributed to the nonlinear resonant interaction of ocean surface waves. IMS stations around the globe routinely detect these microbaroms with a dominant frequency of ~0.2 Hz from regions of marine storminess and in the wake of tropical storms. We have produced the predicted global microbarom source field for 2000-2010 from the WAVEWATCH III spectral wave model. The Climate Forecast System Reanalysis (CFSR) provides a continuous global wind dataset created by state-of-the-art numerical model and assimilation technique to construct a homogenous dataset in time and space at 0.5° resolution. The CFSR incorporates the numerous observed data into their product creating the most accurate and extensive dataset for forcing the wave model. The predicted microbarom field over Earth was used in conjunction with infrasonic observations to test long-range propagation algorithms and atmospheric specifications. Comparisons between predicted and observed global microbarom fields will be presented.

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Track Classification: Theme 1: The Earth as a Complex System
Comparison of Depositing and Non-Depositing Processes for Atmospheric Transport Modeling of Radionuclides

CTBTO runs FLEXPART operationally on a daily basis in backwards mode to estimate sources of aerosols and noble gases detected at over 80 stations distributed throughout the world. For simplicity, these runs are performed under the assumption of no convective or depositing processes. With the acquisition of enhanced computing resources, it is now possible to consider runs of higher complexity. In this poster we present initial experiments for assessing the performance of these runs - using FLEXPART and HYSPLIT in similar configurations - first comparing the effects of convection versus no-convection on passive tracers, then investigating the effects of wet, dry, wet+dry deposition, and convection, on depositing species. The experiments performed here represent a first step to understand the various issues and tradeoffs from increasing the sophistication of the model runs.

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Track Classification: Theme 1: The Earth as a Complex System
Locations for Xenon Background/Medical Isotope Investigations

Medical isotope production facilities constitute a serious challenge to the interpretation of xenon isotopic information collected by the International Monitoring System (IMS) and analyzed by the International Data Centre (IDC). The monitoring community has grown to understand much about the size, temporal character, and isotopic composition of medical isotope xenon from several well-known production facilities. However, much of the world background of xenon, particularly near new or expanded medical isotope facilities, remains unknown. To facilitate a science-based method of choosing an experiment location, a series of atmospheric transport calculations have been done to determine what regions have less coverage from the partially-complete xenon network and which locations of these may have interesting, medical xenon background.

**Primary author:** MILEY, Harry (Pacific Northwest National Laboratory)

**Presenter:** MILEY, Harry (Pacific Northwest National Laboratory)

**Track Classification:** Theme 1: The Earth as a Complex System
of Teleseismic Tomography Across the Trans-European Suture Zone

The presented study is a part of the passive seismic experiment PASSEQ 2006-2008. The PASSEQ project aims to study lithosphere – asthenosphere system around the Trans-European Suture Zone (TESZ). Nearly 200 temporary seismic stations were installed along 1200 km long and 400 km wide area from Germany throughout Czech Republic and Poland to Lithuania, and provided continuous recordings from May 2006 to June 2008. The target area of the presented study embraces all PASSEQ profile. From the PASSEQ data we picked 8308 P-wave arrivals, and used non-linear teleseismic tomography algorithm to obtain model of P-wave velocity variations in the upper mantle down to 350 km beneath the target area. We compiled crustal corrections and applied them directly to our data set. Using IASP91 velocity model as a starting model for teleseismic tomography inversion we obtained results of complex structure of the upper mantle beneath the target area. We distinguished separate zones of upper mantel with significant lateral perturbations in P-wave velocities along the PASSEQ profile. The results show higher velocities beneath the East European Craton and lower velocities to the west from the TESZ.

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**Presenter:** JANUTYTE, Ilma (Lithuanian Geological Survey; Vilnius University)

**Track Classification:** Theme 1: The Earth as a Complex System
Atmospheric Transport Modeling (ATM): Forecasting the Potential Contribution of Isotope Production Facilities on Xenon Activity Concentrations at DEX33, Schauinsland

For both operational daily information on expected radioactive xenon background levels and the fast evaluation of possible sources for real detections at DEX33, an automatically running ATM forecasting and backtracking system is set up at the German NDC (BGR, Hannover) in close cooperation with Federal Office for Radiation Protection (BfS, Freiburg). The station operator and radionuclide experts at BfS are notified by automatic messages on predicted sensitivities and SRS analysis results. The automatic system runs on a UNIX server retrieving Meteorological NCEP forecast and analysis data in 0.5 degree horizontal resolution as soon as available. Right after that, the basic HYSPLIT runs start automatically including forward runs with emissions at Fleury, Belgium, and Chalk River, Canada, as well as backward runs from DEX33 following the classical Source-Receptor-Sensitivity approach. The predicted possible concentrations are compared with actual radio-xenon occurrences and evaluated. Additionally, differences between forward and backward calculated sensitivity are systematically studied. Furthermore, a comparison with SRS-fields provided by the IDC is planned as a second step after a longer period of data will have been collected. The results shall facilitate a more comprehensive understanding of the radioxenon background situation in Central Europe.

Primary author: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Presenter: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Theme 1: The Earth as a Complex System
Localization of Possible Source Region for Multiple Radionuclide Detections Using a Logical Approach Evaluating ATM-SRS Fields

The calculation of Source Receptor Sensitivity (SRS) fields calculated in backward mode is state of the art of Atmospheric Transport Modeling for CTBT verification purposes. The Lagrangian Particle Dispersion Models FLEXPART and HYSPLIT are available for that purpose using mostly ECMWF or NCEP analysis data for simulations on global domain. Various localization approaches for atmospheric backtracking in case of detections at multiple stations exist. The IDC software tool Webgrape calculates a correlation based Possible Source Region (PSR) comparing simulated detection scenarios quantitatively with the real one. Our new method is based on an additive coincidence score value combining binary sensitivities of detecting and non-detecting samples pointing to areas of high source location probability. The presented test cases comprise detections related to the Fukushima release 2011, scenarios of the NDC Preparedness Exercises NPE2012 and NP2010, and recent detections at Schauinsland, Germany (DEX33). Although the standard backward simulations have their operational and political advantages in the CTBT context, additional forward simulations for specific cases are essential to provide a most consistent picture of a potential release scenario.

Primary author: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Presenter: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Theme 1: The Earth as a Complex System
Transport Modelling for Noble Gas Detections at Darwin, Australia, with Focus on Interhemispheric Exchange

The location of the noble gas station AUX09 in Darwin is particular in its position relative to the seasonally oscillating position of the Inter Tropical Convergence Zone (ITCZ). Darwin is located in the Southern Hemisphere but is influenced by the Australian-Indonesian Monsoon with advection of northern air masses during the Australian Summer (wet season). It is affected by south-easterly trade winds during the Australian Winter (dry season). This climatic setup is also influencing possible source regions for detections of radioactive xenon isotopes at Darwin. For comparison with the INGE time series and tagging of air masses, krypton-85 measurements taken in weekly samples from 2007 to 2010 by the Environmental Research Institute of the Supervising Scientist (eriss) in cooperation with the German Federal Radiation Protection Office (BfS, Freiburg) are used. Due to the global distribution of nuclear reprocessing facilities as main krypton-85 emitters nearly exclusively in the Northern Hemisphere, elevated krypton-85 levels at Darwin indicate recent advection of northern air masses. A sensitivity study is performed to quantify the seasonally dependent potential influence of xenon emissions of the ANSTO medical isotope production facility in Sydney, Australia and the Batan Serpong Medical Isotope Production Facility in Jakarta, Indonesia to AUX09 concentrations.

Primary author: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Presenter: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Theme 1: The Earth as a Complex System
Development in Australia

The first RSTT model for Australia has been developed using in-depth seismic velocity information from the region. The model is primarily based on the Australian Seismological Reference Model (AuSREM) that was released in late 2012. The densely-grided P and S wave velocity distributions of the crust and upper mantle of AusREM have been simplified and translated into the 7 layer crustal and upper mantle RSTT model. The locations derived from the new model are evaluated against a groundtruth dataset, consisting of earthquakes, mine explosions, and single shot explosions. A comparison is also made to the location of these events computed from full 3D travel times through the AuSREM model, to illustrate some of the inherent issues with a simplified method like RSTT. Australia has a potential wealth of groundtruth data to validate and improve the models for Australia. The current status of groundtruth data collected and plans for its augmentation are described.

Primary author: DE KOOL, Marthijn (Geoscience Australia)
Presenter: DE KOOL, Marthijn (Geoscience Australia)
Track Classification: Theme 1: The Earth as a Complex System
Order Reduction for Infrasound Propagation in Range-Dependent Atmospheres

The usual approach to study infrasound propagation is to compute the acoustic component superimposed to a mean atmospheric state. The justification of such an approach is questionable given that meteorological uncertainties may affect the waveforms in such a way that some arrivals may literally disappear. In the present work, we perform a sensitivity analysis to estimate the role of atmospheric uncertainties in the signal predictions at large distances from the source. The atmospheric structures are obtained through a wavelet decomposition of ECMWF data with the sensitivity of signals being analysed through a perturbative approach. Our approach provides statistical insight into the waveform analysis by mode-based reduced-order models. Very accurate low CPU time models are obtained by retaining only few eigenvalues/modes, thereby leading to better converged statistics. We consider the case of the Fukushima power plant explosion (March 2011) for which an infrasound signal was recorded 250 km away from the power plant. It is shown that several commonly made simplifications can lead to 2 or 3 arrivals, depending on the profile datasets. The signals obtained with the range-dependent normal mode code are in very good agreement with those obtained with the finite element method.

Primary author: MILLET, Christophe (Commissariat à l’énergie atomique et aux énergies alternatives (CEA))

Presenter: MILLET, Christophe (Commissariat à l’énergie atomique et aux énergies alternatives (CEA))

Track Classification: Theme 1: The Earth as a Complex System
a Coherence Model for Infrasound Signals Recorded at International Monitoring System Arrays

The majority of detection algorithms employed to identify signals within infrasound array data (e.g., Fisher-statistic detector, Progressive Multi-Channel Correlation) rely on the signal being coherent, or correlated, across the microbarographs within the array. The signal coherence allows the detector to distinguish signal from incoherent noise. Therefore, in order to optimize signal detection algorithms and to advise on the design of new arrays, it is important to understand both the correlation structure of signals as they propagate across the array and any correlation structure of the ambient noise field. Here, we take preliminary steps towards developing a model of the signal coherence loss in the 0.02 to 4Hz frequency bandwidth that is of interest to the Nuclear-Test-Ban verification community. For over ten years operational International Monitoring System infrasound arrays have recorded signals from a wide range of sources which have associated ground truth parameters. We use a subset of these signals to assess infrasound signal coherence structure, and how this is dependent upon the signal-to-noise ratio, the array configuration, the source-to-receiver distance, and the source characteristics.

**Primary author:** GREEN, David (AWE Blacknest)

**Presenter:** GREEN, David (AWE Blacknest)

**Track Classification:** Theme 1: The Earth as a Complex System
Noise Tomography and Bouguer Anomaly in East Java - Indonesia

Ambient noise seismic tomography study is a new method that uses noise to depict the structure of the surface layer. The purpose of this research is to represent the thickness of sediments in the area of east java and discover faults in east java. This study combined with data on regional gravity anomaly study, to compare the result from ambient noise tomography study. Ambient noise tomography study used data from 24 seismograph installed in east java and surrounding areas, with a range of observation time for 2 years. Gravity anomaly data is derived from measurements performed geological survey center-Indonesia. The study of ambient noise tomography showed a low velocity at a certain depth which indicates a fairly wide hollow in the east java with east-west direction. This study demonstrates the existence of faults buried far away from the subduction zone. The thickness of sediment northern regions thicker than the southern study area. the results of this study are expected to be used for earthquake disaster mitigation and urban development plan study area, so as to minimize losses due to earthquake disaster will happen.

Primary author: ADI MARTHA, Agustya (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Presenter: ADI MARTHA, Agustya (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Track Classification: Theme 1: The Earth as a Complex System
vs Range Models for Regional Event Location Using Dense Seismic Network Recordings

Celerity vs. range models can be used for the association of infrasound automatic detections, for event location and for the validation of acoustic propagation simulations. Signals recorded from ground truth events are used to establish celerity vs. range models, but data coverage is uneven in both space and time. To achieve a high density of regional recordings we use data from USArray seismic stations recording air-to-ground coupled waves from explosions during the summers of 2004-2008 at the Utah Training and Test Range, together with data from 6 microbarograph arrays at regional distances (<2000 km). Our regional celerity vs. range model has 2315 picks; considerably more than global models used at the IDC for event association and location. We have developed a consistent methodology for analysing the infrasound and seismic data, including choosing filter characteristics from a limited group of two-octave wide filter bands and picking the maximum peak-to-peak arrival. We clearly observe tropospheric, thermospheric and stratospheric arrivals, in agreement with regional ray-tracing models (Marcillo et al. in prep). The new model suggests event locations could be improved, particularly for events where stations detect at ranges 120-300km.

Primary author: NIPPRESS, Alexandra (AWE Blacknest)

Presenter: NIPPRESS, Alexandra (AWE Blacknest)

Track Classification: Theme 1: The Earth as a Complex System
and Applying Regional Seismic Travel Time Models to IDC Event Detection and Location

The real time data processing in the IDC will be able to give rapid location parameters of underground nuclear explosion. However for those events with small magnitude there are usually only a few stations near the source or with low enough background-noise level will detect the signals from the event. As a result, the location uncertainty of events will be large and identifying the area for a subsequent inspection will be difficult. For the regional phases, the IDC uses an approach based on station-specific-source-corrections (SSSC) which are the corrections relative to the IASP91 travel times as a function of source location. However, these corrections have been difficult to extend to new stations and regions. The Regional Seismic Travel Time (RSTT) modeling approach (described by Myers, et al., 2009) provides an easier framework to extend the model with additional data. By re-calculating these corrections using the RSTT model, the same approach can be followed to investigate the use of RSTT in the IDC system. The IDC has performed validation tests on events from Eurasia and North America. In general, RSTT compares favorably to the current IDC approach both in terms of the accuracy of the location and its associated uncertainty.

**Primary author:** FAN, Guangchao (Northwest Institute of Nuclear Technology)

**Presenter:** FAN, Guangchao (Northwest Institute of Nuclear Technology)

**Track Classification:** Theme 1: The Earth as a Complex System
of Wet Deposition into Atmospheric Transport Modelling for CTBT Verification Purposes Using Available Precipitation Observation Data

Air concentrations of particulate radioisotopes are strongly influenced by wet deposition. Therefore the impact of precipitation should generally being included for atmospheric transport modelling applied in the CTBT verification context. Switching on the existing parameterizations for wet deposition in Lagrangian particle dispersion models leads to a more complete representation of involved physical processes, but not necessarily to better simulation results. Those are strongly dependent on the quality of the driving meteorological data determining presence and strength of precipitation and the correct choice of particle properties. While atmospheric reanalysis data show numerically consistent fields with global coverage, computing spatial and temporal precipitation patterns and their variability is limited in many cases. Therefore the use is discussed of additional observation data as provided by the Global Precipitation Climatology Center of the German Weather Service. Methods of introducing a correction for wet deposition in post-processing of backward simulations are compared with online calculations during the ATM runs. This comparison leads to the conclusion that in a first step wet deposition should be neglected to ensure robust and reliable back-tracking results. However, the following in-depth special event analysis should be based on the best available models and data, including wet deposition schemes.

**Primary author:** ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

**Presenter:** ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

**Track Classification:** Theme 1: The Earth as a Complex System
of Atmospheric Transport Modelling to Assess Possible Influence of Emissions from a Radiopharmaceutical Facility on Detections at Selected IMS Radionuclide Stations

Radionuclide network of the International Monitoring System (IMS) monitors the presence of the Treaty-relevant radioisotopes in the atmosphere. These radioisotopes may have, however, a non-Treaty-relevant origin. Dispersed in the atmosphere they constitute a background which contributes to the detections at the IMS radionuclide stations. Consequently, the background needs to be understood and assessed to better assist the States Signatories in their Treaty verification function. An aspect of assessing the contribution of the background concentrations to the IMS radionuclide detections is presented in this poster. Recently, joint efforts of the national and CTBTO experts resulted in stack emission monitoring data from a radiopharmaceutical facility become available for scientific investigation. We will present studies performed with an atmospheric transport model which assess the influence of the emissions from a radiopharmaceutical facility on detections at the neighbouring IMS radionuclide stations. We will also make an attempt of reconstructing source information on the basis of the measurements and benchmark the results against stack monitoring data.

Primary author: KRYSTA, Monika (Comprehensive Nuclear-Test-Ban Treaty Organization)
Presenter: KRYSTA, Monika (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 1: The Earth as a Complex System
the Role of Stratospheric Anomalies in Long-Range Propagation of Infrasound

The importance of atmospheric structures on the infrasonic waveguides has been illustrated in several works using asymptotic techniques. However, these techniques fail to describe the interactions between infrasounds and stratospheric changes, such as the sudden stratospheric warmings. In the present work, we study how breaking gravity waves in the stratosphere impact the long-range propagation of infrasounds. We consider the case in which the gravity waves break near their critical levels, producing a force on the large-scale flow. When the horizontal extension of the corresponding wave packet is around a few hundred kilometers or less, the large-scale atmosphere response contains inertial oscillations, inertio gravity waves, and balanced disturbances associated with potential vorticity anomalies. When the critical level is close enough to the ground, these perturbations can also trigger non-geostrophic baroclinic instabilities. The relative importance of these different processes on the tropospheric and stratospheric infrasound arrivals is analyzed with a numerical model based on the Finite Element Method. Our results can be used to study the resultant effect of localized stratospheric disturbances on the recorded signals. Determining how the waveforms are affected by stratospheric changes will provide insight into how reasonable comparisons between measured signals and purely numerical results may be made.

Primary author: MILLET, Christophe (Commissariat à l’énergie atomique et aux énergies alternatives (CEA))
Presenter: MILLET, Christophe (Commissariat à l’énergie atomique et aux énergies alternatives (CEA))
Track Classification: Theme 1: The Earth as a Complex System
the Regional Seismic Travel-Time (RSTT) Model in the Middle East Using Calibrated Earthquake Locations

One-dimensional velocity models used in earthquake location do not account for lateral heterogeneities found in the crust and upper mantle. The regional seismic travel-time (RSTT) model (Myers et al., 2010) was developed to account for the effects of crust and upper-mantle structure on regional seismic phase travel-times. The IDC propose to implement RSTTs in their production of earthquake locations. We use travel-time station corrections for a set of calibrated earthquake locations in the Middle East to test the RSTT predictions in this region. Multiple event relocation (Douglas, 1967) is used to calibrate clusters of earthquakes, using several kinds of ground truth information, including near-source seismic observations, InSAR modelling and mapped faulting. Our data set is derived from ten evenly spaced clusters, containing 453 events with arrival times from the IDC, ISC and local in-country networks. We find a weak correlation between RSTT and station corrections, with the RSTT corrections generally larger. In specific areas, regional station corrections vary significantly depending on cluster location, while in other places they show no dependence. RSTT corrections show a smaller dependence on cluster location. Teleseismic station corrections for each cluster are comparable and also compare well to patch/station corrections described by other studies.

**Primary author:** NIPPRESS, Stuart (AWE Blacknest)

**Presenter:** NIPPRESS, Stuart (AWE Blacknest)

**Track Classification:** Theme 1: The Earth as a Complex System
of CTBTO Measurements to Estimate Source Strengths and Atmospheric Removal Times of Radionuclides Set Free During Reactor Accidents

CTBTO radionuclide measurement data were widely used to describe the hemispheric-wide dispersion of radioactive aerosols after the nuclear accident in Fukushima in March 2011. Due to their high precision, these data are uniquely qualified for model validation. Especially the differences between the tracer-like noble gases and the aerosol-bound substances allow improved estimates of atmospheric lifetimes of aerosols. Comparison of model results with measurements provides a unique opportunity to validate and improve deposition parameterizations in models. For many ATM modellers worldwide, improvement of deposition codes will be a priority research activity for the years to come.

**Primary author:** WOTAWA, Gerhard (Central Institute for Meteorology and Geodynamics)

**Presenter:** WOTAWA, Gerhard (Central Institute for Meteorology and Geodynamics)

**Track Classification:** Theme 1: The Earth as a Complex System
of Noble Gas Events

CTBTO noble gas system has been introduced to the provisional operations since 2011 and the data analysis system was upgraded in 2012 to accommodate also categorization of the results. Basic categorization scheme has three levels: Level A: no radioxenon detected, Level B: radioxenon detected and concentration is typical for the station, Level C: radioxenon detected and the detection is not typical for the station. The categorization was enabled in the International Data Centre processing in August 2012 and since that thousands of spectra were categorized. The quality of the data is also checked during the review process and if the sample does not fulfill minimum reliability criteria, it is not either categorized. Due to variation in the global radioxenon background, the detections are very much different on a day-to-day and station-by-station basis. Therefore understanding atmospheric transport influencing the detections is essential. The presentation will show the categorization statistics of typical stations.

Primary author: NIKKINEN, Mika (Comprehensive Nuclear-Test-Ban Treaty Organization)

Presenter: NIKKINEN, Mika (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 1: The Earth as a Complex System
of Regional Seismic Travel Time (RSTT) Predictions and Use in Event Location

The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is sponsoring international cooperation activities that enhance the Regional Seismic Travel Time (RSTT) model. In order to assess current and future versions of the RSTT model, we are developing approaches to measure both RSTT prediction accuracy and the impact on seismic event locations. Validation of RSTT performance emphasizes non-circular empirical tests, whereby data used for validation are not used for model development. Data that provide the most information about RSTT model performance are identified based on prior knowledge of the event location and the geographic distribution of the recording network. A model for testing is then produced without the benefit of the validation data, with the goal that test results are representative of performance for future events. Travel time tests include direct comparisons of observed and predicted travel times. Location tests include the difference between estimated and 'ground-truth' event locations, as well as assessments of whether computed location uncertainty estimates (e.g. epicenter confidence ellipses) are representative of observed error. We find average epicenter error is less than 10 km when RSTT is used, and uncertainty estimates are representative of true error when uncertainty estimates account for data and model prediction covariance.

**Primary author:** MYERS, Stephen (Lawrence Livermore National Laboratory)

**Presenter:** MYERS, Stephen (Lawrence Livermore National Laboratory)

**Track Classification:** Theme 1: The Earth as a Complex System
P-Wave Tomography Model for Improved Regional and Teleseismic Travel Time Prediction

We develop a global-scale P-wave velocity model designed to accurately predict seismic travel times at regional and teleseismic distances simultaneously. The model provides a new image of Earth’s interior, but the underlying practical purpose of the model is to provide enhanced seismic event location capabilities. The LLNL-G3Dv3 model is based on ~2.8 million P and Pn arrivals that are re-processed using our global multiple-event locator called Bayesloc. We construct LLNL-G3Dv3 within a spherical tessellation based framework, allowing for explicit representation of undulating and discontinuous layers including the crust and transition zone layers. We demonstrate the impact of Bayesloc multiple-event location on the resulting tomographic images through comparison with images produced without the benefit of multiple-event constraints (single-event locations). We find that the multiple-event locations allow for better reconciliation of the large set of direct P phases recorded at 0-97° distance and yield a smoother and more continuous image relative to the single-event locations. Travel times predicted from a 3-D model are also found to be strongly influenced by the initial locations of the input data, even when an iterative inversion/relocation technique is employed.

Primary author: MYERS, Stephen (Lawrence Livermore National Laboratory)

Presenter: MYERS, Stephen (Lawrence Livermore National Laboratory)

Track Classification: Theme 1: The Earth as a Complex System
Dynamics Research Infrastructure in Europe: The ARISE Project

ARISE proposes to design a new infrastructure that integrates different station networks in order to provide a new "3D" image of the atmospheric dynamics from the ground up to the mesosphere with unprecedented spatio-temporal resolution. These networks are: - the International infrasound network developed for the verification of the Comprehensive nuclear Test Ban Treaty (CTBT). This system is unique by its quality for infrasound and atmospheric wave observations, - the Network for the Detection of Atmospheric Composition Changes (NDACC) which uses Lidar to measure stratospheric dynamics, - the Network for the Detection of Mesopause Changes (NDMC), dedicated to airglow layer measurements in the mesosphere, and additional complementary stations and satellite data. The infrastructure extends across Europe and outlying regions, including polar and equatorial regions. The measurements will be used to improve the parameterization of gravity waves in the stratosphere to better resolve climate models. The project also concerns civil applications related to monitoring of natural hazards as volcanoes. The presentation will highlight the first results obtained in the frame of the project.

Primary author: BLANC, Elisabeth (Commissariat à l’énergie atomique et aux énergies alternatives (CEA))

Presenter: BLANC, Elisabeth (Commissariat à l’énergie atomique et aux énergies alternatives (CEA))

Track Classification: Theme 1: The Earth as a Complex System
Role of Deposition in Atmospheric Transport of Radionuclides

For the project flexRISK, which was devoted to the investigation of risks and hazards from hypothetical severe nuclear power plant accidents in Europe, atmospheric transport has been simulated for noble gases (no dry and wet deposition) and aerosols (with dry and wet deposition). Simulations were done for 2,800 cases distributed over 10 years so that climatological representativity is given. Source locations were 88 nuclear power plant sites in Europe, Armenia, Turkey, and Iran. The simulation domain covers Europe, the Mediterranean with the North African coast, the Near East and parts of the Middle East. By comparing these simulations for selected source locations, detectable thresholds of xenon-133 and barium-140 or caesium-137 can be derived and compared. It shall also be shown which errors are incurred if deposition is neglected for an aerosol-bound species.

Primary author: SEIBERT, Petra (University of Natural Resources and Applied Life Sciences (BOKU))

Presenter: SEIBERT, Petra (University of Natural Resources and Applied Life Sciences (BOKU))

Track Classification: Theme 1: The Earth as a Complex System
Modelling of the Xenon and Caesium Release from Fukushima

Methodology and results of two different estimates of the releases from the Fukushima disaster are presented. The first method aims at reconstructing the detailed time series of the emission of xenon-133 and caesium-137 using CTBTO/IMS and Ro5 measurements over the Northern hemisphere plus additional measurements, including deposition data, from Japan. It was published in 2012 in Atmospheric Chemistry and Physics (http://www.atmos-chem-phys.net/12/2313/) and yielded a total of 15.3 (12.2-18.3 EBq) of Xe-133 and 36.6 (20.1-53.1) PBq Cs-137. The second approach, for xenon-133 only, is based on an estimate of the atmospheric inventory of this nuclide from the CTBTO/IMS data over several weeks. It gave values between 14 and 19 EBq. The difference to the estimated inventory is explained by decay of iodine-133. This study has been published in Journal of Environmental Radioactivity (http://dx.doi.org/10.1016/j.jenvrad.2012.06.001).

**Primary author:** SEIBERT, Petra (University of Natural Resources and Applied Life Sciences (BOKU))

**Presenter:** SEIBERT, Petra (University of Natural Resources and Applied Life Sciences (BOKU))

**Track Classification:** Theme 1: The Earth as a Complex System
Transport of the Noble Gas Emissions as Seen Through CTBT Monitoring

The International Monitoring System (IMS) developed by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is a global system of monitoring stations, using four complementary technologies: seismic, hydroacoustic, infrasound and radionuclide. Data from all IMS stations are collected and transmitted to the International Data Centre (IDC) in Vienna, Austria. The radionuclide network comprises 79 stations, of which more than 60 are certified and send data. The aim of radionuclide stations is a global monitoring of radioactive aerosols, radioactive noble gases, in particular xenon isotopes, supported by atmospheric transport modeling (ATM). The aim of this study is to investigate the transport of xenon emissions using the atmospheric transport modelling system based on the Lagrangian Particle Dispersion Model FLEXPART. The influence of convection on the long and short-range transport is discussed. The modelling results are compared with the measurements.

Primary author: KUSMIERCZYK-MICHULEC, Jolanta (CTBTO Preparatory Commission)
Presenter: KUSMIERCZYK-MICHULEC, Jolanta (CTBTO Preparatory Commission)

Track Classification: Theme 1: The Earth as a Complex System
Monitoring of Volcanoes: A Remote Sensing Method of the Upper Atmosphere

Volcanic eruptions represent a significant source of low-frequency acoustic energy radiated directly into the atmosphere. During explosive volcanic eruptions, release of overpressure and rapid and sustained injection of mass into the atmosphere are the primary sources of infrasound waves (0.01-20 Hz). The International Monitoring System (IMS) infrasound network of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) permits detection of volcanic activity throughout the globe. Over the past 10 years, the International Data Centre (IDC) has collected a significant number of infrasound recordings related to volcanic activity worldwide. These recordings are outstanding natural calibration sources to improve atmospheric models in ranges of altitude where routine measurements still remain illusive. We present case studies on the use of infrasound as a remote sensing technique for horizontal winds in the upper atmosphere. Of specific interest are planetary waves and solar tides which are not well resolved by the current atmospheric specifications. Within the Atmospheric dynamics Research and InfraStructure in Europe (ARISE) framework, we focus on infrasound measurements from the Etna volcano in Italy. Through the ARISE network, we will have access to independent temperature and wind measurements that can be used for valuable cross-comparison studies, in addition to various infrasound arrays in the region.

Primary author: LE PICHON, Alexis (CEA/CENTRE Ile-de-France)
Presenter: LE PICHON, Alexis (CEA/CENTRE Ile-de-France)

Track Classification: Theme 1: The Earth as a Complex System
Monitoring at the BATAN Teknologie (BaTeK) Facility and Implications for the Tracking of Medical Isotope Plumes

With increased interest into the radioxenon emission from radiopharmaceutical production, it has become important to study the best methods to incorporate the data into the IDC analysis of radioxenon stations. A first step is to actually obtain stack monitoring data and then to apply atmospheric modeling and isotopic ratios to best screen out mundane medical isotope signatures from daily radioxenon data sets. As part of this effort, a small stack monitoring system was developed, assembled, and deployed during 2012 by a joint CTBTO/IDC-BATAN-PNNL team at the BaTek medical isotope production facility in Jakarta, Indonesia. This poster will cover the modeling, design and implementation of the air handling component of the BaTeK stack monitor. It will also discuss some screening methods developed so that greater confidence can be assigned to interesting radioxenon signatures vs. the mundane and confounding signatures that medical isotopes produce.

**Primary author:** MCINTYRE, Justin John (Pacific Northwest National Laboratory)

**Presenter:** MCINTYRE, Justin John (Pacific Northwest National Laboratory)

**Track Classification:** Theme 1: The Earth as a Complex System
Gas Background and Radiopharmaceutical Facilities

Since the introduction of radioxenon measurements in the CTBTO, it was found that radiopharmaceutical facilities are responsible for a large portion of nuclear signatures. Radioxenon usually does not cause radiation threats and since it is difficult to filter out, the emissions are substantially depending on production facility type. This is causing a challenge for the CTBT regime, as the contribution of these facilities need to be understood when monitoring similar emissions caused by a nuclear testing. The problem has been discussed within Workshops of Signatures of Medical and Industrial Isotope Production (WOSMIP). If possible, the reduction of emissions from the radiopharmaceutical facilities would be the optimal solution. Otherwise, the availability of close to real time emission data would help to calculate their contribution to the detections. One possibility is to measure the emission directly at the facility stack and report the measured radioxenon release, for example on hourly basis. If high quality data would be available, the contribution of the emission to the actual measurements could be calculated using atmospheric transport modeling tools. Recently, many organizations have performed background measurements to better understand the radioxenon background in the areas where data were previously not available.

Primary author: NIKKINEN, Mika (Comprehensive Nuclear-Test-Ban Treaty Organization)

Presenter: NIKKINEN, Mika (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 1: The Earth as a Complex System
Patterns of Beryllium-7 Depositions and Activity Concentrations in the Phillipines

The study seeks to evaluate appropriate machine learning algorithms in getting the correlation between Beryllium-7 concentrations in surface air with selected meteorological parameters: precipitation, wind speed, wind direction and relative humidity. It will use the CTBTO IMS radionuclide data from its PHP52 monitoring station (14.58N 121.37E) located at the PAGASA (Philippines Weather Agency) Synoptic and Upper Station in Tanay, Rizal for the period 2007-2012. Beryllium-7, a cosmogenic radionuclide produced in the atmosphere through the spallation of nitrogen and oxygen by cosmic-ray-produced neutrons and protons, scavenges itself to aerosols and is carried to the earth’s atmosphere. Investigations on the behavior of this radionuclide are important for radioecological assessment, e.g., tracer for vertical air mass transport and impact of accidental releases from nuclear installations to the environment. Overall, this study aims to provide relevant and advanced information on the the distribution and behavior of Beryllium-7 in surface air in the Philippines which can be used as reference for the development of nuclear techniques to aid in the evaluation of environmental problems.

Primary author: CONJARES, Ana Elena (Philippine Nuclear Research Institute (PNRI))

Presenter: CONJARES, Ana Elena (Philippine Nuclear Research Institute (PNRI))

Track Classification: Theme 1: The Earth as a Complex System
Radioxenon’s Local Sources by Studying the Seasonal Variability of Worldwide Atmospheric Background: Application to JPX38-Takasaki Detections

Radioxenon background can be locally complex, and may be due to the contribution of local and distant sources. This study also shows that seasonal variability of the global circulation can affect drastically the local nature of the background. By comparing IMS noble gas stations detections and calculated radioxenon background, it can be highlighted inconsistencies indicating that a local sources exist and must be taken into account. In this study, we focus on JPX38-Takasaki, Japan, IMS station carried out during 2012. Despite the shutdown of Japanese nuclear power plants after the Fukushima accident and the restart of two reactors in August 2012, the measured background is roughly equivalent to that observed before the Fukushima accident. However, the simulations show that during the summer period background levels should be very low, which was not observed. The detailed analysis shows that during summer period air masses came from the east of the station. On the contrary, during winter, air masses came mainly from west and the Asian continent. It is shown that summer radioxenon peaks are mainly due to releases from a medical radioxenon facility located near Tokyo, while peaks observed in winter can be mainly attributed to the releases of distant plants.

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Track Classification: Theme 1: The Earth as a Complex System
Seismic Travel Time (RSTT) Tomography

The Regional Seismic Travel Time (RSTT) tomography model has been developed to improve travel time predictions for regional phases (Pn, Sn, Pg, Lg/Sg) in order to increase seismic location accuracy. The RSTT model is specifically designed to permit the use of regional phases for location, especially when combined with teleseismic arrivals. Previously, the RSTT model was calibrated for specific geographic regions (North America, Eurasia) only. In a cooperative project with the Comprehensive Test-Ban Treaty Organization, we are currently expanding the RSTT model to full global calibration using a base set of ~3 million arrivals for summary rays (806,796 Pn, 193,786 Sn, 78,152 Pg, and 39,204 Lg/Sg). We fully describe the tomography methodology required to create the RSTT model, including smoothing and damping constraints. The RSTT model is defined on a tessellated grid, with a velocity profile at each node: crust, upper mantle, and upper mantle gradient allowing for the presumption of diving rays. Crustal phases are similarly determined by solving for a mid-crustal slowness, allowing for downgoing/upgoing components of the rays in the crust. We also solve for an overall crustal modifier that accounts for small variations in the crust beyond the starting velocity model.

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Track Classification: Theme 1: The Earth as a Complex System
-Time Source-Specific Station Correction Improves Location Accuracy

Accurate earthquake locations are crucial for investigating seismogenic processes, as well as for applications like verifying compliance to the Comprehensive Test Ban Treaty (CTBT). It is known that modeling errors of calculated travel times may have the effect of shifting the computed epicenters far from the real locations by a distance even larger than the size of the statistical error ellipses. The consequences of large mislocations of seismic events in the context of the CTBT verification is particularly critical in order to trigger a possible On Site Inspection (OSI). In this study, we develop a method of source-specific travel times corrections based on a set of well located events recorded by national seismic networks in two seismically active regions (Italy and Iran). We show that mislocations of the order of 10-20 km affecting the epicenters, and even larger mislocations in hypocentral depths, calculated from a global seismic network and using the standard IASPEI91 travel times can be effectively removed by applying source-specific station corrections. In addition to that, we also show that the application of source-specific station corrections reduces significantly the sensitivity of the location algorithm to the inclusion or exclusion of critical stations in the data set used.

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Presenter: GIUNTINI, Alessandra (Istituto Nazionale di Geofisica e Vulcanologia (INGV))

Track Classification: Theme 1: The Earth as a Complex System
Seismic Tomography Imaging Using Ambient Seismic Noise in Jakarta Area

In this study, we extracted Green’s function from ambient seismic noise data in order to get information about the shallow subsurface structure. The waveform cross-correlation technique has been applied for 31 days of recordings of ambient seismic noise at 36 seismographic stations around the DKI Jakarta area. We used the dispersive behaviour of the retrieved Rayleigh waves to infer velocity structures in the shallow subsurface. Our preliminary results obtained from tomographic inversions at periods of 0.5 s, 1.0 s and 1.5 s depict low velocity anomalies in East Jakarta and West Jakarta areas. Meanwhile a high velocity anomaly is observed in South of Jakarta area. The low velocity structures observed in this study may be associated with the local geological condition, where soft sediment layers exist.

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Presenter:  PRANATA, Bayu (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Track Classification: Theme 1: The Earth as a Complex System
Dispersion of Radioxenon to Kuwait City

In the framework of the International Noble Gas Experiment (INGE), a field measurement campaigns is being carried out in Kuwait Institute for Scientific Research (KISR) to establish the radioxenon baseline data for the Gulf region and to provide assessment in establishing ambient air global noble gas monitoring system of Comprehensive Nuclear Test Ban Treaty Organization (CTBTO). The CTBTO provides KISR with a transportable radioxenon measurement system “the SPALAX detection system” for the campaigns in the state of Kuwait. The SPALAX system is being used to sample and measure the atmospheric concentration of radioxenon isotopes for 133Xe, 135Xe, 133mXe and 131mXe in Kuwait City. The installation and operation was done at the IMS station RN40, on the premises of KISR, and performed in collaboration with the CTBTO. The system started to produce data on 15 May 2012. Both the atmospheric transport Model (ATM) of CTBTO and Hybrid Single Particle Lagrangian (HYSPLIT) trajectory model were used to assess the dispersion of radioxenon to Kuwait-city and attribution of the air mass that influences the gulf region. The atmospheric modeling results for the key isotopes will be presented to add knowledge to the transport of global radioxenon in the gulf region.

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Track Classification: Theme 1: The Earth as a Complex System
and Anelastic Regional Structures for Crust and Upper Mantle in Iran

In this study, we purposed first elastic and anelastic structure of the lithosphere and asthenosphere of the Iranian Plateau is derived by means of tomographic techniques applied to local phase, group velocities and local attenuation coefficients of Rayleigh wave fundamental mode. We used commonly known as Hedgehog nonlinear inversion method to evaluate of the velocity structure. We improved Hedgehog to derive attenuation structure by using attenuation coefficients of Rayleigh wave fundamental mode. For this goal, we conducted a tomographic inversion of Rayleigh wave dispersion and attenuation coefficient to obtain, two-dimensional (2-D) phase, group velocity and attenuation coefficient tomographic images in the period range from 10 s to 100 s for the Iranian Plateau. For this purpose, the fundamental modes, identified by FTAN, are used to determine the inter-station path average phase, group velocities and attenuation coefficient at selected periods. With this procedure, more than 240 group and phase velocity dispersion curves and 150 attenuation coefficient curves have been processed to obtain tomographic maps. Finally, we used fully non-linear inversion procedure to derive tomographic images of the elastic and anelastic structure of the lithosphere and asthenosphere of the Iranian Plateau.

**Primary author:** RAHIMI, Habib (University of Tehran)

**Presenter:** RAHIMI, Habib (University of Tehran)

**Track Classification:** Theme 1: The Earth as a Complex System
Response of CTBT Radionuclide Monitoring System to the Fukushima Accident

The CTBT radionuclide monitoring system comprises a total of 80 stations; 63 were operational in March 2011 and able to detect particulate airborne radioactivity worldwide. When completed, 40 of the 80 stations will operate systems that can also detect the noble gas xenon. Certification of the stations results in a high level of technical standardization of the equipment and QA procedures are in place to demonstrate compliance with agreed data reproducibility standards during operation. However, the CTBTO monitoring system and procedures are tailored for detecting traces of radioactive material from clandestine nuclear tests and are not per se appropriate for monitoring comparatively high levels of radionuclides following a reactor accident.

The "stress test" of the CTBT radionuclide monitoring system in March and April 2011, when the releases of radioactive material from the Fukushima Daiichi nuclear power plant to the atmosphere were detected by 41 particulate stations and 19 stations designed to detect noble gases demonstrated a high standard of operational capabilities and resilience. Initial detections of radioactive materials were made on 12 March at the IMS station at Takasaki in Japan, just 300 km away from the accident site. Key radionuclides such as Iodine-131 and Cesium-137, which provide major contributions to public exposures were detected continuously and reported to the International Data Centre in Vienna. The detection of Niobium-95 and Ruthenium-103 was an early indicator of a meltdown inside one or more of the reactors.

Nine days after the accident the radioactive cloud had crossed North America. Three days later trace amounts of radionuclides had reached Europe, the first detection was reported in Iceland. By day 15, traces from the Fukushima accident were detectable all across the northern hemisphere. By 13 April, radioactivity had spread to the southern hemisphere of the Asia-Pacific region where it was detected at stations located in Australia, Fiji, Malaysia and Papua New Guinea.

The CTBT data contributed to the better understanding of the radiological situation world-wide by predicting the global dispersion of radioactive material based on its ATM tools. Forward ATM predictions proved to be highly reliable; the radionuclides were detected at the stations within hours of the time predicted. This "precision" was very reassuring to the public; it contributed to trust and public confidence in recommendations issued by authorities dealing with radiological protection and public health issues.

The sharing of CTBT data with the IAEA and other international organizations such as UNSCEAR has been highly beneficial for both the CTBT and science. The CTBT used the lessons learned to improve the operational capabilities and the robustness of the radionuclide network. The data on radionuclide concentrations in air received from the CTBT for the period 15 March to 24 May 2011 were reviewed by UNSCEAR internally under arrangements made by the Committee taking into account detailed description of sampling, measurement and analysis methods applied by the CTBT monitoring system. UNSCEAR has made particular use of the radionuclide ratios obtained from the CTBT data with the emphasis on the characterization of the nuclide spectrum of the released radioactive material as an input to public exposure assessments and the assessment of the source term. The results will be documented in a report to the General Assembly of the United Nations, which is prepared for publication in 2013.
**Presenter:** WEISS, Wolfgang

**Track Classification:** Theme 1: The Earth as a Complex System
Assets Put at Stake Through Enhanced Xenon Background Concentrations Released from Medical and Industrial Isotope Production Facilities as Shown by Atmospheric Transport Modelling

Interpretation and understanding of radio-xenon daily sampled within the International Monitoring System demands for an atmospheric transport modelling (ATM) system that delivers the source attribution to the isotopic concentrations measured. Typical Xe-133 releases from medical and industrial isotope production (MIPs) facilities notably contribute to a great part of the regularly measured civil background and challenge any Xe-133 event categorization scheme for distinguishing CTBT relevant from any other xenon releases.

In-line with the deliberations of the 2009 and 2011 WOSMIP workshops, this presentation shall serve as an impulse to discussions on feasible ways to provide data specifying the temporal variability of the xenon emissions from MIPs, including their potential benefits for the provider (e.g. knowledge transfer on remote safeguarding). It will also provide an overview on the countermeasures at hand to the PTS in the field of ATM aided bogus event screening. Obviously these measures are limited, and the prospect of increasing backgrounds of key nuclides Xe-131m and Xe-133 limiting their use similar to Kr-85 should motivate for the most suitable solution: A best possible mitigation of anthropogenic radio-xenon releases with special emphasis on MIPs, for example by applying best practices in Mo-99 production.

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Track Classification: Theme 1: The Earth as a Complex System
of Atmosphere and Infrasound Monitoring

The atmosphere is a complex system submitted to disturbances in a wide range of scales, including high frequency sources as earthquakes, volcanoes, thunderstorms, tornadoes, explosions and at larger scales, gravity waves from deep convection or wind over mountains, atmospheric tides and planetary waves. All these waves propagate in the different atmospheric layers submitted to different temperature and wind systems which strongly control the wave propagation. The infrasound stations of the IMS (Infrasound Monitoring System) developed for the verification of the CTBT (Comprehensive nuclear-Test-Ban Treaty) showed a high capacity to detect, localize and identify most of the disturbances of the atmosphere. As infrasonic waves propagate up to thermospheric altitudes, they are sensitive to the large scale waves opening a new field for atmospheric remote sensing. The precision of atmospheric models is not sufficient today to explain all observations mainly because lack of long term, high resolution measurements in the stratosphere and mesosphere. The integration of gravity and planetary waves constitutes a challenge for the development of future models of atmosphere and climate. Associations of the infrasound network with Lidar and airglow observation networks, as proposed by the European ARISE project, or dense arrays, as proposed in USA, will provide important observations of these waves and strongly contribute to these new challenging studies.

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Track Classification: Theme 1: The Earth as a Complex System
of Radionuclides from Fukushima Nuclear Accident at Some Environmental Radiation Monitoring Stations in Vietnam

After 15 days, radionuclides from the nuclear accident at the Fukushima Nuclear Power Plant in Japan were observed in air at four environmental radiation monitoring stations from north to south of Vietnam: Lang Son, Hanoi, Da lat and Ho Chi Minh City. During the period from March 26 to April 23, 2011, the maximum concentration of isotopes 131I, 137Cs and 134Cs in air measured at four above stations were: 137, 27 and 23 µBq m⁻³; 127, 23.5 and 12.8 µBq m⁻³; 193, 35.7 and 30 µBq m⁻³; 75, 37 and 33 µBq m⁻³, respectively. The moment of the peaks of isotope concentration in the air at these stations is not the same, it means that radionuclide clouds came to Vietnam from North-East. The Lang Son station was the first one observed the isotopes, then Hanoi and Ho Chi Minh City station. And the activity concentration of these isotopes decrease with distance from Fukushima. The concentration of 131I in precipitation collected at Hanoi station in April 15 was 17 mBq/l, and after that day, the concentration of 131I, 137Cs and 134Cs in air at Hanoi station decreased quickly.

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Track Classification: Theme 1: The Earth as a Complex System
of the April 11, 2012 Sumatra Outer-Rise Earthquake Based on Seismic Wave Calculation

The April 11, 2012 Sumatra Earthquake, has very large magnitude Mw = 8.6 and allegedly caused huge tsunamis but the reality is very low only H = 0.3 m. We categorize this incident as an outer-rise earthquake and depth = 40 km. The calculation of source parameters using the teleseismic wave characterized as the tsunamigenic earthquake with seismic moment Mo = 6.3E+21 Nm, seismic energy E = 3.3E+16 Nm, ratio energy and moment R = -5.3 and long rupture duration 134 sec.

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Track Classification: Theme 2: Events and Their Characterization
Two Decades of Great Earthquake Mw > 7 In Java Region Based on Seismic Wave Calculation

The great earthquake in Java region caused high tsunami damage for two decades. We determine the source parameters of the earthquakes based on seismic wave calculation. We calculate the formula using the teleseismic wave signal processing with the initial phase of P wave with bandpass filter 0.001 Hz to 5 Hz. The amount of teleseismic stations is 84 broadband seismometers. The results are the 2 June 1994 Java earthquake with Mw=7.8 and the 17 July 2006 Java earthquake with Mw=7.7 categorized as a tsunami earthquake which distributed about ratio Q=-6.1, long rupture duration To>100 s and high tsunami H>7 m. The 2 September 2009 Java earthquake with Mw=7.2, Q=-5.1 and To=27 s which characterized as a small tsunamigenic earthquake.

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Track Classification: Theme 2: Events and Their Characterization
of Site Effect of Zarqa City and Hashemite University Campus Based on Microtremor Field Measurements - A Microzonation Study

Zarqa governorate is one of the important governorates in Jordan. It is the second populated after the capital Amman, the location of Zarqa gives it a great importance because it lies on the main high ways leading to Syria, Iraq and Saudi Arabia, most of Jordan’s industries, power plants and strategic projects are located in Zarqa, which gives it a special importance. The Nakamura’s technique is applied in this study for both areas; in order to determine the resonance frequencies (F) and amplification factors (A) for each site then draw there maps which will be of a great use in the field of civil and structural engineering by enriching the building codes. The results of our study show that; values of F are not affected by the time of recording. While values of A can vary accordingly. Results also show that the A varies from 0.8 to 8.55 in Zarqa and varies from 0.4 to 9.36 in Hashemite University Campus, F also varies between 0.37 Hz and 2.98 Hz in Zarqa city and varies from 0.59 Hz to 1.77 Hz in Hashemite University Campus, that means some constructions in the study area, in case of a major earthquake, may experience minor damages respectively.

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Track Classification: Theme 2: Events and Their Characterization
Relocation of Tasikmalaya Earthquake of 2 September 2009 and Its Aftershocks Using Grid Search and Simulated Annealing Methods

A large earthquake occurred on September 2, 2009 at 02:55 local time with a magnitude 7.0 (Mw). BMKG published that the epicenter is located at 8.24S 107.32E and depth 30 km. The source mechanism is thrusting faulting, where the strike direction perpendicular to the trench, raises doubts whether the earthquake is an intraplate or interplate. In this study, we relocate the hypocenter of Tasikmalaya earthquake occurred on September 2, 2009 and its aftershock. Hypocenter and origin time data obtained from the BMKG earthquake catalog is set as initial data. The data of P wave arrival time is obtained by picking P phase in the waveform that is high-pass-filtered with frequency cut off 2 Hz. Grid search and simulated annealing methods are used to relocate the hypocenter. The hypocenters of mainshock and aftershocks are clustered at a depth of about 10-30 km. Hypocenter of mainshock has a depth of about 22-25 km or above the contact plane. mainshock and aftershocks shows the southwest-northeast linearization or perpendicular to the Java trench. This result appropriate with the calculation of the source mechanism published by the USGS, Global-CMT and BMKG. This linearization is caused by crust deformation trending northwest-southeast.

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Track Classification: Theme 2: Events and Their Characterization
and Thorium in Cox’s Bazar Paleo-Beach Groundwater: Insights into the Source(s) and Mobility in the Cox’s Bazar Coastal Area, Bangladesh

Ninety eight groundwater samples collected from paleo-beach and its adjoining areas were analyzed using ICP-MS. Physico-chemical parameters were also measured in situ. Concentrations of U (<0.01 - 3.40 ug/l), and 4% of shallow tubewells (<30m deep) contained excess the WHO (1998) guideline, 2.0 ug/l and limited in paleo-beach area. Concentrations of Th (<0.01- 1.60 ug/l) and Ce (0.01 - 9.89 ug/l), both of which do not have the WHO guideline values, are strongly correlated. U and Th rich groundwater occurred in the high Eh (0.35 - 0.5V), and found in pH (6.6 to 7.5) and (8.0 to 8.5) respectively. U correlated between its concentration to EC (220 - 3655 uS/cm) and alkalinity (1.24 - 13.12 meq/l), and an inversely with Pb concentrations, indicating solubility of U-bearing minerals by carbonate complexation and predicted that successive recoils of U and Th and release of Ra, Rn and Pb and enrichment by adsorption processes. SEM-EDX studies on monazite and zircon grains, taken from the out crop of Paleo-beach area, contained U(5.21 wt%) and Th (16.48 wt%).

Release of U and Th from heavy minerals and measurement of radioactivity should be the focus of further research to better understand the mobilization processes in Paleo-beach aquifers.

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**Track Classification:** Theme 2: Events and Their Characterization
Relocations and Constraints on Lateral Velocity Variations Using the Joint Hypocenter Determination Method along the Gulf of Suez

A total number of 250 earthquakes recorded by more than 5 stations from Egyptian seismic network around the Gulf of Suez were relocated and the seismic stations correction for P-wave is estimated using joint hypocenter determination method. Five stations TR1, SHR, GRB, ZAF and ZET have minus signs in station P-wave travel time corrections and their values -0.235, -0.366, -0.288, -0.366 and -0.058, respectively. It is possible to assume that the underground structure in this area has a particular characteristic of high velocity structure and other stations TR2, RDS, SUZ, HRG and ZNM have positive sign and their values 0.024, 0.187, 0.314, 0.645 and 0.145 respectively. It is possible to assume that underground structure in this area has particular characteristic of low velocity structure. The hypocenter location determined by the joint hypocenter determination method is more precise than those determined by other routine work program. The station corrections reflect not only different crustal condition in the vicinity of the stations, but also the difference between actual and model seismic velocities along each of the earthquake - station ray paths. The stations correction obtained correlate with the major surface geological features in the study area.

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**Track Classification:** Theme 2: Events and Their Characterization
of Tsunamigenic Earthquake in Indonesia Using Ratio of Seismic Energy and Moment

Since July 1991 s.d. April 2012 has occurred 27 earthquakes generated tsunami with magnitude Mw > 6.5. The aim of this study is to characterize these events based on the ratio (Q) between seismic waves radiated energy (E) and seismic moment (Mo), source duration (To), tsunami height (H), focal mechanism of focus and the depth. The authors obtain the vertical component broadband seismometers from global network of IRIS with a total number of 783 teleseismic station. The frequency is 0001 Hz - 5.0 Hz. Almost earthquakes as 24 events were characterized as tsunamigenic earthquakes which vary tsunami height depend on its magnitude. The others were tsunami earthquakes with moderate magnitude but caused high tsunami, low ratio of energy and moment, long rupture duration and thrusting focal mechanism.

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Track Classification: Theme 2: Events and Their Characterization

Thirty-five VLF-EM profiles, 140 VES and relevant hydrogeological data were acquired along regular grids/profiles for detailed terrain/subsurface mapping of Ijebu-Ode which is situated within a problematic transition zone, between the Precambrian Basement rocks and Cretaceous sediments of Dahomey Basin, in southwestern Nigeria, where unique geological structures, complex coexistence of different rock types and poorly defined basal/lateral contacts make groundwater development very challenging. Obtained data were filtered, inverted and enhanced and the resultant current density and geoelectric parameters were employed to generate terrain conductivity distribution and subsurface geophysical models. Conductivity distribution identified three layers in the Basement Complex terrain which comprised lateritic topsoil, weathered and fresh basement rocks. The five layers encountered in the sedimentary terrain were topsoil, lateritic unit, dry sandy unit, saturated sandy unit and fresh basement rocks. Hydraulic conductivity of thick lateritic unit was determined to be $1.32 \times 10^{-5}$ mm/sec, while that of the underlying sandy units, averaged $1.36 \times 10^{-3}$ mm/sec. The low groundwater resource potential around Ijebu-Ode is due to less permeable lateritic overburden which overlaid more permeable rock units that prevents adequate recharge during/immediately after rainfall as well as rugged/undulating basement topography that controls the distribution and storage of the limited recharged water.

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Presenter: OSINOWO, Olawale Olakunl (Federal Ministry of Science and Technology)

Track Classification: Theme 2: Events and Their Characterization
Review on the Use of IMS Data in the Scientific Community

Comprehensive Nuclear Test Ban Treaty Organization (CTBTO), through its International Monitoring System (IMS) and International Data Centre (IDC), collects, processes, analyses and stores IMS data to support the implementation of the verification regime.

However, these data may contribute not only to the monitoring of nuclear explosions, but also have a wide range of application in civil and scientific areas.

Interest in these data has greatly increased over the past years, as it has been noted that these data can be applied to the enhancement of the understanding and furthering of technical capabilities in fields such as: natural hazard risks, earth processes, undersea earthquakes and tsunami warning, climate monitoring using ice-breaking noise or ocean swell noise, ocean acoustic thermometry, marine mammals migration studies, volcanic activities, avalanches and storm tracking as well as aurorae and meteorites detections.

A selection of highly relevant scientific articles published in established scientific journals since 2001 have been analysed, in order to understand the actual use of IMS Data in the scientific community.

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**Track Classification:** Theme 2: Events and Their Characterization
Melcepstral coefficients have been extracted from a number of infrasonic hand-digitized atmospheric explosion waveforms from the 1962 Operation Dominic series of atmospheric nuclear tests. These explosions have a distinctive pattern of melcepstral coefficients which can be modeled with synthetically-generated waveforms consisting of a reflective phase from the surface and a direct arriving phase. From atmospheric explosions generated at the surface, and for bolides in the upper atmosphere, the distinctive pattern of the melcepstra coefficients due to surface reflections is missing. A discriminant using the melcepstra coefficients is proposed for the detection and identification of atmospheric nuclear explosions.

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**Track Classification:** Theme 2: Events and Their Characterization
How to Define Estimation of Average Strain Release Energy and Dislocation Site of Rupture Based on Seismic Moment and Length of Fragment (Case Study: Earthquake of Simeuleu – Nias, 11 January, 2012 in Mw: 7.2)

It was noted on 11 January 2012 at 01:36:57 a.m - WIB had already happened a shallow tectonic earthquake with epicenter located 2.41 NL, 93.09 EL, precisely 358 South West of Simeuleu-Nias, North Sumatra Province with its Magnitude moment (Mw) : 7.2, with 10 km depth. In the Simeuleu earthquake with Magnitude moment (Mw) : 7.2, we had already estimated its seismic moment in the earthquake using a Kanamori equation (1977), found 5.6 x 10^26 dyne.cm. It means, by using a Scaling Law method, it was noted the length (L) and Wide of fragment with rapture in the earthquake of Simeuleu of (Mw : 7.2) in 50.1 Km and 25.05 Km, whereas the wide area deformation in surface of fragment site has got already rapture in 2.208 x 10^13 cm^2. Even so, its average dislocation of rapture usus = 152 Cm. It was that Estimation Strain Release Energy on the Earthquake Simeuleu (Mw : 7.2) based on its length of rapture was noted 5.7 x 10^16 erg. Keywords : Strain Release Energy, Dislocation, rapture, seismic moment.

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**Track Classification:** Theme 2: Events and Their Characterization
and Stress-Tensor Inversion along the Gulf of Aqaba

The goal of this work was to study the seismicity and to estimate the stress field acting in the Gulf of Aqaba Region. The Gulf of Aqaba earthquakes is mainly concentrated in four zones; the first zone is located in the Hume Basin in the southern entrance of the Gulf. The second zone is located along the Arnona fault between 28.3 – 28.6 and longitude 34.5 - 34.7 degrees; the third zone is located in the Aragonese Basin, the fourth zone is located in the Aqaba Basin. The b-value ranges between 0.4 – 1.1. The technique Stress-Tensor Inversion has been applied to 20 events from the Gulf of Aqaba earthquake sequence for which we have found best fit stresses (plunge and azimuth): σ1=55.60 σ2=34.256 σ3=3.161 and R=0.50. The average misfit between the stress model and all the data is about 5.5°. It was concluded that the maximum regional stress in the Gulf of Aqaba from NE-SW direction, while the minimum regional stress to NW-SE direction (extension).

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Track Classification: Theme 2: Events and Their Characterization
the Application of MWP in the Near Field and the March 11, 2011 Tohoku Earthquake

Tsunami Warning Centers have used Mwp to issue Tsunami Warnings 5–10 min after Earthquake origin time since 2002. However, because Mwp is based on the far-field approximation to the P-wave displacement, we should only very carefully apply Mwp to data obtained in the near field, at distances of less than a few wavelengths from the fault. On the other hand, the surface waves from Great Earthquakes, such as the 2011 Tohoku earthquake, clip seismographs located near the fault. Because the first arriving P-waves from such large events are often on scale, Mwp should provide useful information, even for these Great Earthquakes. We therefore calculate Mwp from 18 unclipped STS-1 broadband P-wave seismograms, recorded at 2–15 distance from the Tohoku epicenter to determine if Mwp can usefully estimate Mw for this earthquake. Our analysis indicates that Mwp does indeed give reliable results (Mw 9.1) beginning at about 11 distance from the epicenter. The values of Mwp from seismic waveforms obtained at 11–15 epicentral distance from the Mw 9.1 off the east coast of Tohoku earthquake of March 11, 2011 fell within the range 9.1–9.3, and were available within 4–5 min after origin time.

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Track Classification: Theme 2: Events and Their Characterization
Among one of the most fascinating sea creatures, the blue whale holds a special place. The largest ever living animal, it has been recognized that they can be tracked remotely at large distances at sea using fixed and moored hydrophones. The frequency range (30-100Hz) of their acoustic calls falls within the range of the IMS hydroacoustic stations and it is thus theoretically possible to track them in oceans where the IMS hydrophone stations provide a complete coverage and if the signal they emit is strong enough to be seen at a minimum of two groups of hydrophones. This may be the case in the Indian ocean where two stations are complete enough at the moment to provide detections and an azimuth provided signal from the same individual can be detected at these two sets of hydrophones. We propose to establish a data set that will be rich enough to contain several blue whale individuals and setup a contest on the Kaggle site. The goal is to determine the best method to be used to distinguish among different individuals using distinctive features of their calls, taking into account transmission loss of acoustic power.

**Primary author:** LE BRAS, Ronan (CTBTO Preparatory Commission)

**Presenter:** LE BRAS, Ronan (CTBTO Preparatory Commission)

**Track Classification:** Theme 2: Events and Their Characterization
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Track Classification:  Theme 2: Events and Their Characterization
Blast Discrimination for the Events Near BURAR Array (Romania) Using Different Specific Techniques

Since 2002, when the Bucovina (BURAR) array was installed in the north-east of Romania, numerous small-magnitude events were detected, characterized by impulsive first arrival phases. Since most of these events occurred during day time, the purpose of our work is to apply different discrimination techniques to identify the quarry blasts events generated in the array neighborhood. It is important to demonstrate that these small events belong to quarries located near array in order to use them to calibrate travel times, slowness or/and backazimuth. First, we compared the spectra of the waveforms recorded for the studied events with those of events classified as earthquakes. The analysis revealed that in most cases for the events characterized by small magnitudes, the P-wave spectral amplitudes were greater than the S-wave spectral amplitudes, this behavior being typical for quarry blasts. We investigated in parallel the Rayleigh waves’ behavior for the two types of events together with their spectrograms. Since the approach proposed in this paper led to reliable results, it can be further extended to be applied to other three-components broadband stations located in different regions where low magnitudes events with similar characteristics are recorded.

**Primary author:** BORLEANU, Felix Victor (Romania National Data Centre)

**Presenter:** BORLEANU, Felix Victor (Romania National Data Centre)

**Track Classification:** Theme 2: Events and Their Characterization
-Induced Electromagnetic Fields in the Ocean

Electric and magnetic (EM) fields are generated within ocean currents moving through the earth’s magnetic field, and tsunami flows are also considered to generate EM fields in the ocean although its signal levels are very low. Recent advances in high precision measurements of EM fields enabled the seafloor measurements of the tsunami signals. In order to extract useful information from the offshore measurements of tsunami EM signals and utilize them for the tsunami warning at coast, we need an appropriate theory which relate the EM signals observed at seafloor to tsunami parameters. Results of the theoretical examination demonstrate that the observations of the three components of the magnetic field and the two horizontal components of the electric field at a single seafloor station can reveals, (1) variations of the sea level change associated with tsunami flows, (2) propagation direction of tsunami waves, (3) frequency dependence of phase velocity of tsunami propagation, and (4) frequency dependence of apparent electrical conductivities observed at seafloor. We will show that these theoretical relations are verified by the results of the first simultaneous observation of the 2010 Chilean earthquake tsunami and applicable to the 2011 Tohoku earthquake tsunami.

Primary author: SUGIOKA, Hiroko (Kobe University)
Presenter: SUGIOKA, Hiroko (Kobe University)

Track Classification: Theme 2: Events and Their Characterization
of Coulomb Stress Change, Aftershock Distributions and Earthquake Trigger in South of Bali, Indonesia

Mw 6.4 earthquake hit Bali on 13 October 2011. Strong ground shaking felt in Denpasar, Tabanan, Karangasem and Gianyar. Also felt at many places in Java Island, Lombok Island and Sumbawa Island.

In case of one earthquake might trigger another at nearby stress field, by using rapid calculation of coulomb stress change we analyze aftershock distributions cause by mainshock activity. It has significant correlation between numerous subsequent smaller events after bigger event. Mw 6.4 produce eight coulomb stress change lobus. Mostly aftershock event located on positive value of Coulomb Stress Change between 0.04 to 0.08 bar. Laying North West-South East along fault line. Moreover, positive value of Coulomb Stress Change at North East lobus trigger M 4.3 in early 2013, which is known as silent seismic area before.

Keywords : Coulomb Stress, Aftershock Distribution, Earthquake trigger

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Track Classification: Theme 2: Events and Their Characterization
Earthquake Triggering and Its Mechanism After Great 2011 Tohoku Earthquake in Korean Peninsula

The Korean Peninsula is located in the far-eastern Eurasia plate, and belongs to intraplate seismicity regime with low seismicity. The instrumental seismicity is scattered over the peninsula, with relatively high seismicity at paleo-tectonic regions that are associated with paleo-rifting and paleo-collision. The paleo-rifting is responsible for the separation of Japanese islands from the Eurasian plate. The paleo-continental collisions formed a current shape of Korean Peninsula. It is known that dozens of devastating earthquakes with magnitudes of 7 occurred historically. The paleo-structures appear to be reactivated by the current ambient stress field. The Korean Peninsula is located at about 1200 km away from the 11 March 2011 M9.0 Tohoku-Oki earthquake. Nine triggered earthquakes within one hour after the Tohoku-Oki earthquake were identified in the Korean Peninsula. The sizes of triggered earthquakes are small, allowing observation only at stations in nearby distances. The short PS differential times suggests that the earthquakes appear to occur by brittle failure in shallow crust. The focal mechanism solution of the largest triggered earthquake presents normal-faulting sense of motion with a tensional axis in the southeast, suggesting that the event occurred due to the response to the displacement caused by the Tohoku-Oki earthquake. We present the spatio-temporal evolution of the Korean seismicity before and after the Tohoku-Oki earthquake. The response of intraplate regime to the rapidly sweeping dynamic stress field is discussed.
Primary author: TAHIR, Mohammad (ISTerre Grenoble France, Yonsei University South Korea)

Presenter: TAHIR, Mohammad (ISTerre Grenoble France, Yonsei University South Korea)

Track Classification: Theme 2: Events and Their Characterization
Time Functions of North Korean Events of 9 October 2006 and 25 May 2009

The announced nuclear tests of 9 October 2006 and 25 May 2009 of the Democratic People's Republic of Korea are located close to each other, on a global scale, and the Green's functions at a teleseismic receiver are essentially the same. The differences in the seismograms, apart from the noise, are caused by the difference in the source time functions – the first event (mb(IDC)=4.1) had a lower magnitude than the second (mb(IDC)=4.5). If the amplitude and period of the source time functions of the events scale in proportion to the cube-root of their energies, it follows that the source time functions of the events are scaled versions of each other. The two seismograms and the scaling law provide three equations which can be solved for the three unknowns: the two source time functions and the Green’s function. IDC data are used to obtain the two source time functions and the Green’s functions for a number of sites. The method of solution requires spectral ratios of seismograms of the two events. Averaging spectral ratios at different sites increases the signal-to-noise ratio, yielding better estimates of the source time functions. The Green’s functions are then obtained by deconvolution.

Primary author: ZIOLKOWSKI, Antoni (University of Edinburgh)

Presenter: ZIOLKOWSKI, Antoni (University of Edinburgh)

Track Classification: Theme 2: Events and Their Characterization
Frequency Processing of Blasts and Earthquakes

In this work, we exploit the difference in time-frequency signatures between blasts and earthquakes, as a possible discriminant. Time-varying instantaneous frequency signals will be computed in two ways:

1) We will use the classical method of Taner and Koehler [1]. The instantaneous frequency is obtained by differentiating the instantaneous phase of the analytic signal. If the data is very noisy, then the resulting instantaneous frequency, as a function of time, is not a useful result. When the signal envelope is very small, the instantaneous frequency is amplified incorrectly;

2) A two-dimensional frequency map is computed using a novel implementation of the Short-Time Fourier Transform, the Stockwell Transform (ST) [2], which is a form of the continuous wavelet transform [3]. The ST frequency-centroid yields the instantaneous frequency signal, without differentiation.

References

Primary author: YEDLIN, Matthew (University of British Columbia)
Presenter: YEDLIN, Matthew (University of British Columbia)
Track Classification: Theme 2: Events and Their Characterization
Observing of Earthquakes and Tsunamis for Advanced Early Warning System and Prediction Researches

Based on lessons from 2004 Sumatra Earthquake/Tsunamis and 2011 East Japan Earthquake/Tsunami, we recognized the importance of real time monitoring on Earthquakes and Tsunamis. Especially, the real time monitoring system using multi kinds of sensors such as the accelerometer, broadband seismometer, pressure gauge, difference pressure gauge, hydrophone and thermometer is indispensable for not only Earthquakes/ Tsunamis, but also broadband crustal activities around mega thrust earthquake seismogenic zones. Therefore, we deployed DONET and are developing DONET2 which are dense ocean floor networks around the Nankai trough Southwestern Japan. At 2011 East Japan Earthquake, DONET observatories detected offshore tsunamis 15 minutes earlier than onshore stations. Furthermore, DONET/DONET2 will be expected to monitor slow events such as low frequency tremors and slow earthquakes for the estimation of seismic stage which is the inter seismic or pre seismic stage based on slow event simulation researches. I will introduce the details of DONET/DONET2 and simulation researches.

Primary author: KANEDA, Yoshiyuki (Kagawa University)
Presenter: KANEDA, Yoshiyuki (Kagawa University)

Track Classification: Theme 2: Events and Their Characterization
Validation of Explosive Atmospheric Sources

Despite recent advancements in infrasonic technology and modelling, identifying sources of infrasound remains an elusive task. During their passage through the atmosphere, meteoroids produce a range of phenomena, most notably a hypersonic shock, which can be recorded at the ground in the form of infrasound.

Utilizing the recently established Elginfield Infrasound Array (ELFO) near London, Ontario, Canada, in conjunction with optical instruments in the Southern Ontario Meteor Network (SOMN), experimental studies to detect meteor infrasonic shocks and combine this information with metric, mass and energy data about each meteor detected simultaneously are discussed.

A research project presented here will aid in understanding explosive sources in the atmosphere, using meteors as a natural source of high altitude, cylindrical line explosions with the intent of further improving and refining analytical detection techniques to ensure increased resolution, and accuracy for such atmospheric explosions. Furthermore, this database of tested and well characterized meteor events will be the first of its kind and it will be used to produce a validated theory of hypersonic shock production at high altitudes for the first time.

**Primary author:** SILBER, Elizabeth (Western University)

**Presenter:** SILBER, Elizabeth (Western University)

**Track Classification:** Theme 2: Events and Their Characterization
Seismic Capacity-Building to Enhance Event Location and Regional Tectonic Understanding

Lawrence Livermore National Laboratory works through the National Nuclear Security Administration’s Seismic Cooperation Program to train and pursue joint studies with seismologists in the Middle East and Southeast Asia. These activities offer a model for capacity-building that strengthens regional scientific communities and monitoring of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Collaborative projects include operating high-quality seismic instrumentation, sharing data using seismological tools (e.g., Seisan and SeisComp3), developing regional lithospheric models, and producing seismic hazard maps. While these projects are only beginning in Southeast Asia, in the Middle East they already show important findings. For example, studies reveal fundamental differences in the velocity structure of the uppermost mantle of the Arabian Shield and Arabian Platform. The earth’s crust is relatively thicker in the Mesopotamian Foredeep, characterized by thick sediments. Further, coda magnitude calibration of small- and moderate-size events is conducted on a local/regional scale. The knowledge and analytical techniques gained by National Data Center staff and affiliated scientists are used in earthquake hazard mitigation, tsunami warning, and CTBT monitoring. Data from national seismic networks and derived measurements are integrated into lithospheric velocity, attenuation, and source models to increase resolution, improve event location accuracy and source parameter determination, and advance regional tectonic understanding.

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Track Classification: Theme 2: Events and Their Characterization
Modelling of the Release and Migration of Radioactive Xenon Through the Soil by Means of AMBER Compartment Model Software

As a first step of a more general study on the dispersion of radioactive products from an underground nuclear test, we have tried to define the dynamics of the inert gaseous products migration in the underground environment in which a hypothetical nuclear test has been carried out. The identification of the transport mechanism through the geosphere could be combined with the modeling of the migration paths, in order to identify the possible accumulation points to be surveyed and sampled in the framework of an On Site Inspection. We applied a deterministic approach by using the software AMBER, a compartment model that estimates the concentrations of radioactive compounds in soils, rocks and groundwater, for the design of a sampling strategy and to understand the dispersion of gaseous radioisotopes in the atmosphere. After appropriate validation, we have evaluated the potentiality of this software, originally designed for the performance assessment of a radioactive waste disposal, in order to verify and extend its possible application also in verification activities related to CTBT treaty. A preliminary AMBER modelization of a realistic case study of xenon migration from a hypothetical underground release source through the soil, up to its interface with the atmosphere, is discussed.

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**Track Classification:** Theme 2: Events and Their Characterization
Use of Machine Learning in Seismic Monitoring at the IDC: Classification of Events Built with Waveform Cross Correlation

Seismic monitoring with waveform cross correlation has demonstrated a significant reduction in detection threshold, which may reach 0.5 magnitude units in the areas where master events with high quality templates are available. With the increasing completeness of the Reviewed Event Bulletin, a larger number of event hypotheses are also built in automatic processing. We have applied supervised machine learning (naïve Bayes classifier, Support Vector Machine, and bootstrap aggregating applied to decision tree methods) to the automatic cross correlation bulletin (XSEL) built for the 2012 Sumatera 2012 (Ms(IDC)=8.6) aftershock sequence. The XSEL includes 4924 events with 19027 arrivals at 7 IMS stations. Training dataset includes 461 arrivals from 119 newly built REB (valid) events and 451 arrivals from 144 rejected XSEL (bogus) events as obtained in interactive processing by experienced IDC analysts. The success rate of phase classification is near 75%, with false positive rate exceeding the false negative rate by a factor of 3.

Primary author: KITOV, Ivan (CTBTO)
Presenter: KITOV, Ivan (CTBTO)

Track Classification: Theme 2: Events and Their Characterization
Truth and Detection Threshold from WWII Naval Clean-Up in Denmark

The sea bed below the Danish territorial waters is still littered with unexploded mines from World War II. As the mines still pose a potential threat to fishery and other marine activities, the Danish Navy searches for the mines and destroy them by detonation, where they are found. The largest mines destroyed in 2012 are equivalent to 800 kg TNT each. The Geological Survey receives notifications from the navy regarding the large detonations. This includes information about position, detonation time and the estimated amount of explosives. Some of the blasts are clearly registered not only on the Danish seismographs, but also on the large seismograph arrays in Norway, Sweden, and Finland. The ground truth information enables us to assess the quality of our earthquake catalogue in all parts of the country. A systematic study of the explosions also results in a more detailed understanding of the detection threshold. Furthermore the study will shed light on the sensitivity of the network to various seismograph outages.

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Track Classification: Theme 2: Events and Their Characterization
Man-Made Earthquakes and New Vision on Seismic Hazard Assessment

There is a growing concern about the potential for destructive earthquakes caused by human activity. Studies of seismicity related to impoundment of reservoirs, injection of fluids in a well, withdrawal of fluids and mining activity, all bear evidence to the presence of critically stressed rocks in the earth’s crust, where in small stress changes, induced by human activity, trigger earthquakes. The most known type of man-made earthquakes are dam Reservoir Induced/Triggered Seismicity (RIS/RTS) because of its wide usage all over the world. Seismicity induced by human activity is confined in both space and time, and its study can lead to a better understanding of the physics of earthquakes. Reservoir impoundment can trigger seismicity in two ways; an immediate, undrained response to loading, and a delayed response due to the diffusion of pore pressure. We have studied RIS/RTS associated with 4 great dams of Iran territory from years ago, before and after impoundment. It gives a new vision to seismic hazard assessment based on collected data from local seismography networks operating for dam monitoring. The effect of dam filling and the rate of seismicity because of water level change is studied and clear evidences of filling effects are presented.

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Track Classification: Theme 2: Events and Their Characterization
of Nuclear-Energy Excursion Possibility at Fukushima-1 NPP Accident

Radionuclide station of CTBTO IMS network RN38 located in Takasaka, at closest distance from Fukushima. The highest values of radioactivity were measured on March, 15-16. Thus, the specific activity of short-lived Iodine-135 (half-life period = 6.6 hour) reached value of 370 Bq/m³, and the ration of Iodine-135/Iodine-131 activities reached value of 23 that pointed to arrival of “fresh” fission products from the damaged reactors, and also testified to uncontrollable nuclear-energy excursion possibility. The radioactive xenon isotopic rations could confirm or disprove essentially a hypothesis of this possibility.

The necessary data was obtained by the North Western Pacific National Laboratory (PNNL). About 30 measurement results of Xenon-131m, Xenon-133 and Xenon-133m concentration in atmospheric air near Richland during the period from March, 1 to March, 30, 2011 were obtained.

For the check of a hypothesis of emerged uncontrollable nuclear reaction at NPP Fukushima-1 accident, obtained data was compared with the calculated data characterizing decreasing of activity of fission products after the reactors shutdown taking into account possibility of “fresher” products additional emission which could be formed at emerged uncontrollable criticality. Results of comparison rather confirm a hypothesis of emerged uncontrollable nuclear reaction than reject it.

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**Track Classification:** Theme 2: Events and Their Characterization
Etna Volcano Monitoring

The International Monitoring System (IMS) technologies can have civil and scientific applications other than its primary mission which is the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). One of those applications is volcano Monitoring.

The Italian volcano Etna is one of the active volcanoes in the world and its activity is detected by more than one IMS station such as IS48, which is located in Tunisia and is about 550KM away from Etna.

In this Poster, we will present some of the NDC-TN results pertaining to the Etna activity monitoring over many years. We will try to show the general trend in signal backazimuth between winter and summer and the effect of the seasonal reversal of the stratospheric winds.

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Track Classification: Theme 2: Events and Their Characterization
Tensor Determination of the September 2, 2009 Tasikmalaya, West Java Earthquake Using the Waveform Inversion Method of Near Field Data

The source mechanism of the September 2, 2009 Tasikmalaya, West Java earthquake is not consistent with the characteristic of the tectonic stress in this region in which the strike direction in general parallels to the present-day trench. In fact, the strike of the September 2, 2009 Tasikmalaya earthquake is nearly perpendicular to the trench. We determined the moment tensor using the near field data from the regional network of the Meteorological, Climatological and Geophysical Agency (MCGA) of Indonesia, and from the IRIS-DMC seismic network. The frequency of band pass filter and the velocity structure model are determined by referring to previous study results, as well as by trial and error. The band pass filter and the velocity structure model that produce the smallest variance of 0.2402 is 0.01 to 0.03 Hz and the Jeffreys-Bullen model, respectively. The Green’s functions were calculated using the extended reflectivity method for the near field data. Our inversion results show that the earthquake is an interplate earthquake type, which is located at the border around the plate interface at a depth of 44 km. The strike is almost perpendicular to the trench, which may be related to a strong slab pull beneath the region.

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Track Classification: Theme 2: Events and Their Characterization
Acoustic Thermometry Using Active Biological Sources Recorded at IMS Hydrophones: A Feasibility Study

The ATOC project (The ATOC Consortium, 1998) had the goal of measuring acoustic velocity in the oceans to assess variations of the ocean temperature with various applications, including long term trend monitoring of Earth climate. The method for measuring the velocity variations relied on a few active sources and receivers. Several issues hampered the project, mainly the concern over the consequences of the active sources on cetaceans. In conjunction with the work of Roda et al. (2013), we are proposing to use the calls of automatically located whales as the active source for monitoring the variation of acoustic propagation. The speed of propagation is related to an integrated measurement of temperature along the paths between the location of the whale and the IMS hydrophones. The general lines of the project are to implement automatic detection and location of the marine mammals, and jointly assess their location and speed of propagation between their location and the IMS hydrophones. The ATOC Consortium, 1998, Ocean climate change: Comparison of acoustic tomography, satellite altimetry, and modeling, Science, 281, 1327–1332. Roda, G., Sucic, V., and Le Bras R., Individual blue whale recognition. Wigner-Ville time-frequency analysis and preparation for a Kaggle contest, CTBTO S&T conference, 2013.

**Primary author:** LE BRAS, Ronan (CTBTO Preparatory Commission)

**Presenter:** LE BRAS, Ronan (CTBTO Preparatory Commission)

**Track Classification:** Theme 2: Events and Their Characterization
Data and Seismicity Interpretation in Sumatra - Indonesia

Geographically, Research Areas Located between Coordinates 7ºS to 7ºN and 92ºE to 107ºE. Free Air Anomaly (FAA) and topography data are Used Retrieved from Global Marine Gravity from Geosat and ERS-1 altimetry and Global seafloor Topography from Satellite altimetry and Ship Depth Soundings. It is use amount of 1 ` (1 minute) Latitude and Longitude or the sum of 1.85 Km for acquisition as a space. It is use the data released by the BMKG too. The study results showed that the High gravity residual anomaly Associated With high-density rocks. In earthquake occurs on the region flanked by subduction zone boundary and high gravity residual anomaly. High Residual anomalies associated with high-density rocks. Based on Data and Modeling earn Bouguer Anomaly ($\rho = 2.67 \text{ gr/cm}^3$), which is Subduction Zone Sumatera Quite Shallow depth. It means that the earthquake in Sumatra Happens Shallow depth. Western part of Sumatra Regional Is Prone Regions Against by Tsunami.

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**Track Classification:** Theme 2: Events and Their Characterization
Identification of ULF and VLF Pre-Seismic Signal as Candidate Precursor in CTBTO Lembang Seismological Station (West Java, Indonesia)

The main purpose of this research is to investigate characteristic of Ultra Low Frequency (ULF) and Very Low Frequency (VLF) pre-seismic signal based on Z/H and resultant spectra ratio. In this method, we analyzed seismic signal and noise before the 2 September 2009 Tasikmalaya earthquake and their aftershock. Then we compared all results to find the similarities and differences. We have assumed before the large earthquake occurred, there was energy in the area that could be analyzed in ULF and VLF pre-seismic signal. The energy release occurred when the large earthquake occurred. We used seismic signal and noise from 20 earthquakes that were recorded at LEM station. The results show that in Z/H and resultant spectra ratio of seismic signal and noise before the large earthquake occurred, there are dominant peaks frequency which came from noise (< 0.1 Hz), ULF (0.1 – 0.2 Hz), and VLF (0.2 – 0.4 Hz) signal. Meanwhile, the results of Z/H and resultant spectra ratio after the large earthquake only dominated by noise frequency with peak signal < 0.1 Hz. Therefore, we supposed that the ULF and VLF pre-seismic signal might be used as a candidate precursor of the future large earthquake.

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Track Classification:  Theme 2: Events and Their Characterization
Seismic Hazard Assessment Using Empirical Attenuation Relationship for the Estimation of PGA in the Area of West Java

Peak Ground Acceleration (PGA) is very important for seismic hazard assessment and quick response. One of hazard assessment of potential damage from earthquake is to determine the effect or impact type of ground motion at the specific site. Seismic hazard assessment for quick determination has been developed by using relationship of attenuation of ground motion with site-distant and processed by linear least square fit method. We used observe data and prediction of displacement energy in the period of three second of P-wave. Empirical Attenuation relationship for the estimation of PGA in the area of west java provide the new formula for Earthquake Early Warning solution especially for Jakarta and Bandung. Number of seismic event about 69 data of velocity broadband seismogram, included Tasikmalaya earthquake, September 2, 2009 magnitude M = 7.2 Richter Scale, recorded at CISI Station, Cisompet, Garut, west of Java and their aftershocks. Simulation technique applied for acceleration broadband seismogram data by differential of velocity seismogram. Least square fit analysis calculated for attenuation of PGA such as : \[ \log \text{(PGA)} = -3.88 + 0.995 \text{Mw} - 1.324 \log \text{R} \]. Quick Estimation of attenuation of PGA very urgent for EEW.

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Track Classification: Theme 2: Events and Their Characterization
Icebergs with Hydro-Acoustic Arrays of the International Monitoring System

Due to low acoustic attenuation in the ocean, small acoustic events are recorded at ranges of thousands of kilometres on hydrophone arrays deployed in the SOund Fixing And Ranging (SOFAR) channel. On two arrays in the Indian Ocean, signals were identified generated by drifting icebergs that crack, disintegrate and collide. Acoustic source locations estimated from the signal bearings at the arrays are used to track two very large icebergs, C20 and B17B. Spatial and temporal correlation of the location estimates with satellite observations confirm that the icebergs can be hydro-acoustically tracked. Hydro-acoustic generation rates at both C20 and B17B are highest at times of observed break-up. For C20, which underwent continuous break-up, clusters of events to the south-east of the main iceberg suggests that hydro-acoustic observations can identify trails of icebergs that calved from the main berg whose dimensions are less than that easily resolved by moderate resolution satellite monitoring.

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Track Classification:  Theme 2: Events and Their Characterization
Simulation and Uncertainty Quantification of Gas Transport in Unsaturated Fractured Rocks as Viewed from the Roselend Natural Laboratory

The Roselend Natural Laboratory is a unique facility for studying gas transport in the subsurface. By combining experimental and numerical approaches, computer models are developed, calibrated, and validated for future predictive simulations. In addition to long-term monitoring of naturally produced 222Rn and CO2 gas-tracer experiments have been conducted recently with SF6, freon and 3He. The NUFT code, developed at the Lawrence Livermore National Laboratory, is used to model multi-phase multi-component transport and to interpret experimental data. Gas migration towards the ground surface is controlled by barometric pressure fluctuation through major conductive fractures. Infiltration that contributes to liquid-phase movement and saturation distribution can greatly affect gas transport. Using NUFT coupled to the LLNL PSUADE code, global-sensitivity analysis is conducted for identifying main parameters influencing gas transport and breakthrough at the surface. Surrogate-based optimization is then used to estimate rock parameters from experimental data, with the associated parametric uncertainties. By employing the calibrated model, simulations can be done to design future gas tracer experiments and to predict radionuclide migration from an underground nuclear cavity in a variety of geological and hydrological contexts.

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**Presenter:** GUILLON, Sophie Lauriane Chloe (MINES ParisTech)

**Track Classification:** Theme 2: Events and Their Characterization
Observations of Micro-Earthquakes at a Platform Territory

We used the small-aperture arrays measurements for a few areas in East-European Craton territory and compared the seismic data processing results and regularities revealed during the analyses with the data obtained from geomorphology studies of fault structures. The results confirm most small and micro-earthquakes (up to M~ -2) locate in the fault zones and zones of “dynamic influence of faults”. Location of variety scales earthquakes on fault zones is more distinct in cases with more accurately hypocenters determined. At the same time branched structures of major fault zones, it is assumed that some of the earthquakes occur at feathering fractures of smaller scale. It is thus possible to develop a “seismological” criterion for definition of a zone of “dynamic influence of faults”, i.e. the zone containing the majority of earthquakes associated with the fault zone under consideration. The first example of the need for registration of micro-earthquakes in the platform territory is to monitor Nuclear Power Plants (NPP) as safety standards provide for seismic monitoring in local area around the NPP both during the periods of their erection and exploitation.

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**Presenter:** KISHKINA, Svetlana (Institute of Geospheres Dynamic, Russian Academy of Sciences)

**Track Classification:** Theme 2: Events and Their Characterization
and Detection of Gas in Geological Media: Lessons Learned from the Roselend Natural Laboratory

The Roselend Natural Laboratory (French Alps) is a unique facility for studying gas transport in the subsurface and across the geosphere-atmosphere interface. At 55 m depth, a sealed cavity allows for gas release experiments across fractured porous rocks in the unsaturated zone. While many parameters describing the state of the geological system are controlled, analogous gas-tracer experiments were conducted at the field-scale with SF6, freon and 3He. Water infiltration, permeability and the concentrations of many gases, naturally occurring or injected, are recorded via long-term and high-resolution monitoring. The fracture network was characterized through extensive drilling and modeling. These experiments are used to determine the physical and chemical processes that would control the noble gas source term after an underground nuclear explosion, and to develop and validate the corresponding numerical models. The Roselend Natural Laboratory also provides a test bed for sampling protocols and instrument developments. Detection of gases relevant to CTBT issues requires that their baseline concentration is understood. Experiments and subsequent modeling demonstrated that baselines are a highly dynamical process resulting from gas sources, sinks and modulation by barometric pressure. Transient gas concentration anomalies, up to 2 orders of magnitude, commonly result from water movements amplified in fracture networks.

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**Track Classification:** Theme 2: Events and Their Characterization
Regional Earthquake Depths Using IMS Seismic Arrays

Teleseismic observations from the International Monitoring System’s (IMS) global seismic network provide complementary information to national and regional earthquake monitoring. Standard Event Lists (SEL1-3) from the International Data Centre (IDC) provide automatic short term feedback on significant events observed globally, while Reviewed Event Bulletins (REB) provide comprehensive global epicentral solutions and precise arrival times to which regional locations can be compared. This is of interest where regional epicentre bias may exist due to sparse station density and/or poor azimuthal coverage. IMS primary and auxiliary arrays’ beamforming capabilities in particular may be used to constrain earthquake depths and their uncertainties by statistically identifying candidate depth phases (pP/sP). Candidate depth phases may be evaluated statistically to determine an event’s most-probable depth using the methodology of Heyburn & Bowers (BSSA, 98(1), 2008). These probabilistic results serve as an automatable means of determining event depth, and provide a tool to robustly identify and pick depth phases for manual review. This methodology is applied to a series of significant aftershocks after the 7.7 Mw earthquake on October 28th, 2012 off the southwestern coast of Haida Gwaii, Canada, where regional stations provide limited azimuthal coverage of the offshore events and poorly constrained free depths.

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Presenter: EDWARDS, Wayne (Natural Resources Canada)

Track Classification: Theme 2: Events and Their Characterization
an Experiment to Simulate a Small Scale Vent

Researchers at Pacific Northwest National Laboratory are preparing an experiment intended to simulate the near-field deposition pattern of radionuclides released in a small-scale vent from an underground nuclear explosion. The experiment is designed to release short-lived radionuclides with sufficient activity to enable ground and airborne survey to measure the plume above background over an area of roughly 1 km². Background survey and sampling have already been completed at the experiment site. The deposition field will be used to compare and contrast several techniques of gamma radiation survey and environmental sampling followed by gamma assay that could be utilized by an On-Site Inspection (OSI) team under the verification regime of the Comprehensive Nuclear-Test-Ban Treaty. This work will present details of the experiment, and will focus on lessons learned that are relevant to the conduct of an OSI.

**Primary author:** BOWYER, Theodore (Pacific Northwest National Laboratory)

**Presenter:** BOWYER, Theodore (Pacific Northwest National Laboratory)

**Track Classification:** Theme 2: Events and Their Characterization
of Radioxenon and Argon-37 Released into a Nuclear Explosion Cavity for Development/Evaluation of OSI Field Sampling Methods

Detection of radioactive noble gases during an On-Site Inspection (OSI) can be strong evidence that a nuclear weapons explosion occurred at that location. The expected subsurface concentrations of radioactive noble gas signatures during an OSI, however, have not been fully established. To begin understanding how to best estimate the radioxenons and 37Ar concentrations at the subsurface after a nuclear explosion, a field experiment was conducted to release radiotracers (127Xe and 37Ar) into an existing nuclear explosion cavity then monitor for the gases at surface locations. The first phase of the project was to inject chemical tracers to determine optimal sampling locations. Based on the concentrations of the chemical tracer injected into the explosion cavity and the levels measured at various locations at the surface, dilution factors and favorable sampling locations were determined. The final phase of the field experiment will be conducted in the spring of 2013 when 127Xe and 37 Ar will be produced in a nuclear reactor then injected into the shot cavity produced by an historical nuclear test. Soil gas sampling will be conducted at various locations to determine transit time and concentrations after transport from a nuclear explosion cavity to the subsurface.

Primary author: BOWYER, Theodore (Pacific Northwest National Laboratory)
Presenter: BOWYER, Theodore (Pacific Northwest National Laboratory)
Track Classification: Theme 2: Events and Their Characterization
on Tsunami Inundation Simulation in the Northwestern Coast of Sabah, Malaysia

Tsunami simulations and inundation analyses are conducted on the northwestern coast of Sabah by assuming earthquake along the Manila Trench (MT) proposed by Salcedo (2010). TUNAMI (Tohoku University’s Numerical Analysis Model for Investigation) code is used. To calculate tsunami propagation and inundation we perform numerical simulations of linear and nonlinear shallow water wave equations in a spherical coordinate system with four different spatial grid sizes of 60, 20, 6.6667 and 2.2222 arc-sec. As output points, 24 tide gauge stations are assumed along Kudat coastal areas. Seven scenarios with different moment magnitudes are considered to perform tsunami simulations. Earthquake source regions are divided into four segments, MT1, MT2, MT3, and MT4. Single and multi segmentation are used to assess the scenario earthquakes for all three target areas, Kudat Peninsula, Balambangan Island and Banggi Island. Computation results show that the tsunami heights are larger with large slip on the fault. We found that the slip on the segment MT1 is not sensitive for the tsunami height to the coastal area of northwest Sabah. We also found that the most significant tsunami is expected from MT4, as well as MT3 and MT2 cause large tsunamis.

**Primary author:** BASRI, Siti Nurhaida (Malaysian Meteorological Department)

**Presenter:** BASRI, Siti Nurhaida (Malaysian Meteorological Department)

**Track Classification:** Theme 2: Events and Their Characterization
Time-Clustering Behavior in Absheron-Prebalkhan Seismicity (Azerbaijan)

We performed the Allan factor analysis on the 1842-2012 seismicity of the Absheron-Prebalkhan seismogenetic zone of Azerbaijan. The historical and instrumental catalog of the Absheron-Prebalkhan region in the Caspian Sea area was analyzed in order to reveal the existence of temporal clustering in the time dynamics of the seismicity. The timespan of the catalog is from 1842 to 2012 and the magnitude of the events ranges from 2.5 to 6.8. The Gutenberg-Richter analysis indicates 4.0 as the completeness magnitude of the catalog. The methods have revealed the presence of time-clustering behavior in the time dynamics of large events in the Absheron-Prebalkhan region. Our findings suggest a non-Poissonian behavior of the seismicity of the investigated area, could contribute to a deeper knowledge of the time dynamics of the seismicity and to a better assessment of the relative seismic hazard.

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Presenter: BABAYEV, Gulam (Institute of Geology and Geophysics, Azerbaijan National Academy of Sciences)

Track Classification: Theme 2: Events and Their Characterization
Advanced Discriminants for Explosive Hydroacoustic Phases

The enforcement of the Comprehensive Nuclear-Test Ban Treaty (CTBT) requires the monitoring of acoustic sources in the oceans in order to detect underwater explosions. We present new advanced criteria used to discriminate hydroacoustic phases between explosive events and earthquakes. These criteria can be applied on records from both hydrophones and “T-phase” seismic stations. In the time domain, and in addition to the classical amplitude/Duration discriminant, we use a catalogue of reference envelopes to which a signal can be directly compared by cross-correlation algorithms. In the frequency domain, we use several methods including: the study of the decay of spectral amplitude with frequency (both in terms of a power law, and of smoothness), and the evolution of the duration of the signal when corrected using an empirical compensation of any frequency dispersion present in its Fourier spectrum. We show that a combination of these various methods allows the correct identification of the nature of all sources in a large dataset of more than 300 signals. We further discuss methods to improve the calculation of the period of a pulsating bubble on signals from “T-phase” seismic stations.

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Presenter: HYVERNAUD, Olivier (Laboratoire de Geophysique de PAMATAI)

Track Classification: Theme 2: Events and Their Characterization
of Rocket Launches from Baykonuyr Space Port by Data of Seismic and Infrasound Stations of Kazakhstan

Tens of rockets are launched each year from Baykonuyr space port located in Central Kazakhstan. The rockets flight routes are above several Kazakhstan regions. Since 1994 the IGR RK monitoring network has been operating successfully on the territory of Kazakhstan. The network includes 8 seismic arrays, 7 three-component stations, and 2 infrasound arrays. 5 objects of the system are included into the IMS. In addition to the permanent stations, a network of field stations is frequently installed on the territory of Kazakhstan to solve different investigation tasks; data of field stations can be used for more detailed monitoring of different nature events. Using data of seismic and infrasound monitoring stations of the IGR RK the tracking possibilities for different flight phases of the rockets were investigated: launching, flight, stage separation and falling, and explosion in air and on surface during accidents of rockets. The events catalogue related to the stages fall was compiled, waveform features as well as kinematic and dynamic parameters of these events were investigated. Large accidents of July 26, 2006 related to Dnepr carrier rocket and of September 5, 2007 for Proton rocket were investigated in details.

Primary author: SOKOLOVA, Inna (Institute of Geophysical Researches)
Presenter: SOKOLOVA, Inna (Institute of Geophysical Researches)

Track Classification: Theme 2: Events and Their Characterization
Characteristics and Seismic Hazard of Nepal Himalaya

Monitoring of seismicity in Nepal Himalaya in collaboration with DASE France lead us to understand the seismotectonics and earthquake nucleation process. Belt of seismicity, at a depth of 10-20 km, follows the front of higher Himalaya. This midcrustal seismic cluster lies within a zone of interseismic stress accumulation characterized by high uplift rate inferred from geodetic measurements. Low magnitude seismic events within that cluster describe a seasonal oscillation, partially simulated by seasonal detection level changes due to variations of seismic noise level, partially genuine due to hydrological forcing. GPS data shows that the MHT between the higher Himalaya to the MFT around 100 Km width is currently locked and accumulate slip deficit at a rate of approximately 1.8cm/yr. Himalayan region has been shocked by 5 great earthquakes, but region between 78°E and 85°E has not produced any major earthquake since more than four centuries and stands for being a large seismic gap in the Himalayan region. High seismogenic potential of this locked fault zone exposes the North-Western Himalaya and the densely populated region of nearby Ganges basin in India to a high level of seismic risk. Understanding the future seismic behavior within this seismic gap is the major challenges.

**Primary author:** SAPKOTA, Soma Nath (National Seismological Center)

**Presenter:** SAPKOTA, Soma Nath (National Seismological Center)

**Track Classification:** Theme 2: Events and Their Characterization
Source Mechanism and Uncertainty Analysis Using a Multi-Objective Optimisation Approach

Reliable source mechanism estimates for small-to-medium sized seismic sources are important for monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). For sources located in regions where there are no dense local networks of seismic stations, often there are only a small number of stations recording surface and body wave signals with high signal-to-noise ratios. To obtain reliable estimates of the source mechanism by inversion of the observed data, it is an advantage if multiple data types can be used in the inversion. We demonstrate how a multi-objective optimisation approach can be used to jointly invert different seismic data types recorded at a range of distances to estimate source mechanisms for sources located in Asia. The data used include teleseismic body-wave observations, three-component broadband waveform data recorded at near-regional distance stations, and surface wave amplitude spectra. Uncertainties from each individual inversion can also be combined to estimate upper and lower bounds on the best-fit source mechanism. The good fit of the synthetic seismograms to the observed seismograms for many of the sources analysed here, indicates that the method is useful for source identification.

Primary author: HEYBURN, Ross (AWE Blacknest)
Presenter: HEYBURN, Ross (AWE Blacknest)

Track Classification: Theme 2: Events and Their Characterization
Observation of the Great 2011 Tohoku Earthquake

The great 2011 Tohoku Earthquake (Mw 9.0) occurred offshore of the east coast of Honshu, Japan on 11 March 2011, and strong T-waves generated by the event are recorded in the Hawaii hydroacoustic array operated by International Monitoring System. We examine the back-azimuths of the signals and spectral contents of the T-waves, and we compare them with the rupture models estimated from previous seismic studies. The results show that the complex rupture process probably causes the scattered back-azimuths and several local peaks. We also analyze T-waves of the Mw 7.7 normal-faulting aftershock. It shows unique envelope shape and frequency contents comparing with those of other thrust-faulting events. These differences would reflect the different source and excitation mechanism.

Primary author: YUN, Sukyoung (Korea Polar Research Institute)
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Track Classification: Theme 2: Events and Their Characterization
-Acoustic Analysis of Quarry Blast in Mongolia

Seismic and acoustic recordings are particularly important to help identifying and locating industrial blasting sources. We have analyzed seismo-acoustic signals from mine blast for 2000 and 2009 in order to determine detection seismo-acoustic signals of explosion by seismic and infrasound stations. Several large mines in the region routinely generate explosions that are detected seismically and with infrasound. The mine range in distance from 40-500 km from the seismic, infrasound array. In last few years mining activity in Mongolia significantly increased. All events identified as quarry blasts have occurred during daytimes between 03:00 p.m. and 08:00 a.m. GMT and on weekdays from Monday to Friday. The corresponding number of infrasound detection is found to be dependent upon the regional weather condition, which is included air temperature, epicentral distance, wind force and velocity. We present the seismic and infrasound IMS stations and some results of analysis.

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**Track Classification:** Theme 2: Events and Their Characterization
Between Kazakhstan, the Kyrgyz Republic and Norway on CTBT-Related Capacity Building

Kazakhstan, the Kyrgyz Republic and Norway have for a number of years cooperated on a program in the area of capacity building for verification of compliance with the Comprehensive Nuclear-Test-Ban Treaty, on the basis of financial support from the Norwegian Ministry of Foreign Affairs. The cooperating institutions are the Institute of Geophysical Research (IGR) of the National Nuclear Center of Kazakhstan, the Institute of Seismology (IS) of the National Academy of Sciences of the Kyrgyz Republic, and NORSAR in Norway. Within this cooperative framework, an international training center in support of technical CTBT verification activities has been established by IGR at the Kazakhstan National Data Center in Almaty. In the Kyrgyz Republic, this cooperation has enabled modernization of ten seismic stations of the national network as well as establishment of data analysis capabilities at the Kyrgyz National Data Center operated by IS in Bishkek. Support has also been provided for participation in CTBT-related workshops and international conferences. Recently, the Norwegian Ministry of Foreign Affairs decided to support financially a continuation of these activities for the period 2013 - 2015. The presentation will highlight results achieved in this program so far, and will present plans for the work ahead.

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Presenter: MYKKELTVEIT, Svein (NORSAR)

Track Classification: Theme 2: Events and Their Characterization
Capability of the Plostina Infrasound Array Using Well Characterized Events

Plostina infrasound station (IPLOR) is a 6-element array, with 2.5 km aperture. Since January 2013, all IPLOR instruments are Chaparral Physics microphones. Additionally, six 3C BB seismic sensors, three electrometers and three 3C fluxgate sensors are collocated with the infrasonic instruments. A weather station is installed at the central element (IPH4). Seismo-acoustic data and information on electric, magnetic and electromagnetic fields are continuously collected and real-time transmitted to the Romanian NDC, in Magurele. Considering the sensors’ characteristics (frequency response, dynamic range), the IPLOR array proved its efficiency in observing acoustic signals produced by specific sources as explosions (chemical, mines, volcanos), blasts, or local thunderstorms. The paper presents several types of detected events using a ground-truth data set compiled from IDC LEBs, Romanian earthquake catalogue, reports of Osservatorio Etneo (INGV), atmospheric and electric records. Using the automatic detector DFX-PMCC, we were able to characterize infrasonic signals from different events: explosion at an ammunitions depot in Bulgaria, eruptive episode of Etna volcano, regional gas pipeline explosion in NW Russia, regional mining blast (Turkey), local quarry blast (Dobrogea), and thunderstorms observed at Plostina site. Multiple correlations between meteorological data, atmospheric parameters, infrasound observations and seismic signals were performed.

**Primary author:** GHICA, Daniela Veronica (Romania National Data Centre)

**Presenter:** GHICA, Daniela Veronica (Romania National Data Centre)

**Track Classification:** Theme 2: Events and Their Characterization
Parameters of Weak Nuclear Explosions Conducted at the Semipalatinsk Test Site on the Basis of Historical Seismogram Study

During several years the IGR RK has been digitizing historical analogue seismograms of nuclear explosions collected from archives of different Organizations of Kazakhstan, currently a database contains more than 6000 seismograms at regional distances. The digitized historical seismograms allowed to recover and add parameters for more than 40 air and contact explosions conducted at Opytnoye Polye site of the Semipalatinsk Test Site in 1961-1962. The records from high-sensitive stations installed along Pamir – Baykal profile were used to determine the explosions parameters. The profile was installed by the IPE AS USSR to study earth crust structure and upper mantle, the profile length was 3500 km. The epicentral distance from some stations of the profile to Opytnoye polye site was 300-400 km. In addition, data from the permanent seismic station Semipalatinsk (SEM) located 175 km away from the site were used. The seismograms from this station became available recently. Origin time, coordinates, regional magnitudes mpv, MLV and energy class K were determined for explosions. A regional travel-time curve for Central Kazakhstan constructed using records of calibration chemical explosions conducted at the STS in 1997-2000 and ground-truth underground nuclear explosions was used to determine the explosions epicenters and origin time.

Primary author: SOKOLOVA, Inna (Institute of Geophysical Researches)
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Track Classification: Theme 2: Events and Their Characterization
Focal Mechanisms as Criterion for Explosions Discrimination

Recommends using first motion of P-wave for filtration of phenomena. Positive shifts should be observed in first arrivals of longitudinal waves in all directions from an explosion. Our practical observations showed that it is not always possible to discriminate an explosion using these criteria. In some cases on the seismograms of the same explosion obtained in different azimuths from an epicenter both positive and negative shifts were observed in first motions. Nuclear explosions. In Caspian depression focal mechanisms were constructed for 19 nuclear explosions which were mistakenly entered in a catalogue of earthquakes focal mechanisms. Calibration explosions. Calibration experiments Omega-2 and Omega-3 were conducted. Distribution of signs for two explosions was almost the same, and this resulted in identical solutions of the explosions focal mechanisms. One of nodal planes has extension which coincides with fault orientation at which an explosion chamber was installed. Industrial blasts. Focal mechanisms are constructed quite often for this type of explosions conducted in quarries. Thus, it is not always possible to identify definitely an explosion using such criteria as “first motion of P-wave” and “focal mechanism”. Abnormal cases by these criteria were revealed among explosions of different types: nuclear, calibration, quarry.

Primary author: POLESHKO, Natalya (Institute of Geophysical Researches)
Presenter: POLESHKO, Natalya (Institute of Geophysical Researches)
Track Classification: Theme 2: Events and Their Characterization
Nuclear Explosion Test Bed for OSI/IMS Gas Release Scenarios: Phase I, Chemical Tracer Experiment

The Non-Proliferation Experiment (NPE) involved detonating 1 kiloton of chemical explosive in a subsurface cavity which also contained bottles of tracer gases. As an alternative to performing large chemical detonations to simulate gas transport from underground nuclear explosions (UNE), we have developed a new test bed for gas transport, release and detection studies using a former UNE cavity. The test bed allows for the opportunity to evaluate pathways to the surface created by the UNE as well as possible transport mechanisms including barometric pumping and cavity pressurization. We have monitored long-term chemical tracers as well as newly injected tracers. In order to perform high temporal resolution tracer gas monitoring, we have also developed a Subsurface Gas Smart Sampler (SGSS) which has potential application during an actual On Site Inspection (OSI) and will be available during IFE14. Deployment of five SGSS at the remote test bed has provided unparalleled detail concerning the relationship between tracer gas transport to the surface, barometric fluctuations and temporal variations in the natural radon concentration. We anticipate that the results of our tracer experiments will support the development of improved noble gas technology for OSI and IMS applications.

Primary author: CARRIGAN, Charles (Lawrence Livermore National Laboratory)

Presenter: CARRIGAN, Charles (Lawrence Livermore National Laboratory)

Track Classification: Theme 2: Events and Their Characterization
Transport from an Underground Source in Fractured Rock with Application to the OSI and IMS Regimes: A French-US Collaborative Study

The CEA Roselend Underground Laboratory near Mont Blanc is a well instrumented facility for evaluating the transport of gases from depth across a highly fractured regime to the surface. At its deepest, the laboratory is 55 m beneath the surface and contains a sealed cavity for gas release experiments. The laboratory allows field scale studies of some aspects of the effect of transport on the noble gas source term of an underground nuclear explosion. A collaboration between the CEA and LLNL is exploring the dependence of gas releases driven both by cavity pressure and barometric fluctuations and preliminary modeling using the LLNL NUFT transport program has been performed as part of an experiment design effort. Experiments at the well characterized site will also allow computer simulations to be used in a predictive mode regarding the transport of tracer gases and their detectability. Future work involves deployment of the LLNL Subsurface Gas Smart Sampler (SGSS) to evaluate the temporal correlation between measurement of naturally produced radon and inert tracer gases released from the pressurized chamber in the facility. This study will support the development of improved sampling methods for capturing noble gases during a CTBT on-site inspection.

Primary author: CARRIGAN, Charles (Lawrence Livermore National Laboratory)
Presenter: CARRIGAN, Charles (Lawrence Livermore National Laboratory)

Track Classification: Theme 2: Events and Their Characterization
Series Analysis of Seismic Events Worldwide (2000-2012)

One of the main missions of the Capacity Building and Training Section of CTBTO is to publish Monthly Performance Reports timely and correctly. The report is based on all Reviewed Event Bulletins which were reviewed by the analysts for each month. These bulletins have the information such as origin times, locations, and magnitudes of the events, which could be used as a basic element for the study of the global seismicity. In this context, a time series analysis with the seismic events occurred worldwide from A.D. 2000 to 2012 was carried out. Totally 382,662 events have occurred in this period and the average number of events is about 81 events each day. The numbers of events per year has slightly increased recently, but this can be regarded as due to the newly installed IMS stations. The released energy is relatively high both in 2004 and 2011. Although no additional trend was found yet, data over a longer period might yield different results. The analysis according to the seismological region was also performed. Each b-value of the Gutenberg-Richter relation was compared in 50 regions. The value is the highest in the Fiji Island Area and the lowest in the Pacific Basin.

Primary author: LEE, Jun-Hee (Comprehensive Nuclear-Test-Ban Treaty Organization)

Presenter: LEE, Jun-Hee (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 2: Events and Their Characterization
Truth Events in Mongolia (2011-2012)

The International Data Centre (IDC) of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) will ultimately process 170 seismic stations for the purpose of monitoring underground nuclear explosions. However, for most of events with lower magnitude, only sparse network or several stations are able to contribute on monitoring, meanwhile the location uncertainty will be quite large. The Regional Seismic Travel Time (RSTT) modeling approach (Myers, et al., 2009) provides a path toward reducing location uncertainty. IDC has performed validation tests on events from Europe, Asia, and North America. Before integrating in IDC processing platform, the validating test must be performed with ground truth events or events with good location in local or regional scale. Locating east of Eurasia, Mongolia has seismic stations with quite good background noise level, which give excellent monitoring performance for regional scale. The local and regional phases travel times information of 15 events happened in Mongolia during 2011 and early 2012 were gathered, which had been compared with travel time correction from RSTT model. With station-specific source corrections of some of these stations, relocating tests were performed. Some events relocation got better results, which gave positive support the RSTT model applying in some regional scale in Eurasia.

Primary author: KHUKHUDEI, Urtnasan (Comprehensive Nuclear-Test-Ban Treaty Organization)

Presenter: KHUKHUDEI, Urtnasan (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 2: Events and Their Characterization
Capacity to Enhance Use of Data and Products by States Parties

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) obliges each State Party to undertake not to carry out any nuclear weapon nuclear explosion or participate in the carrying out of such. States Parties undertake to cooperate for facilitating the verification of compliance with this Treaty. The verification regime of the CTBT uses cutting-edge technologies and scientific methods to monitor nuclear explosions. In order to increase the capability of State Parties to participate in nuclear explosion monitoring, the Provisional Technical Secretariat (PTS) of the CTBTO PrepCom has launched a range of capacity building activities. Many of these activities are funded through voluntary contribution, in particular by the European Union. The activities consist of various phases encompassing country capabilities evaluation, regional NDC development workshops, training courses for NDC technical staff and provision of computer equipment. Even though use of data and products from regions with previous low usage is still lagging compared to the more active regions, there is a marked increase in the last four years with regard to the number of countries involved and the total volume of data transferred. This can be attributed to the enhanced and focused capacity building efforts by the CTBTO in the regions of interest.

**Primary author:** PHIRI, Remmy Lemekani (Rientec GmbH)

**Presenter:** PHIRI, Remmy Lemekani (Rientec GmbH)

**Track Classification:** Theme 2: Events and Their Characterization
Modeling Tool for Source Characterization

Information regarding the source of radionuclides detected in the atmosphere can be obtained by comparing the observed activity concentrations and their ratios to those expected from various types of sources. Nuclear explosions with various fuels as well as reactors and irradiation facilities all yield different inventories of radionuclides, and the signatures finally observed are also dependent on factors such as radioactive decay, chemical fractionation and selective release of the originally produced inventories. This poster will present an initial version of a tool used by the Swedish NDC to model the activity of selected radionuclides produced as a function of time for fission source scenarios defined by e.g. type of source, release timing and fraction of gaseous radioactivity released. The tool, which is under continuous development, is used to compare measured data to source hypotheses both stand-alone and as a generator of model data for the Seicon data fusion tool also developed by the Swedish NDC.

Primary author: AXELSSON, Anders (Swedish Defence Research Agency (FOI))
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Track Classification: Theme 2: Events and Their Characterization
of a Bomb in the River Danube

In the afternoon of 25th of August 2012 five strong-motion stations located in Vienna and four broadband stations of the Austrian Seismic Network registered a shock, which occurred due to the detonation of an aircraft bomb from the Second World War. As well 13 stations of the Czech Seismic Network including the auxiliary seismic IMS station VRAC recorded the event. Independent locations were conducted by Zentralanstalt für Meteorologie und Geophysik (ZAMG) and by the Institute of Physics of the Earth (IPE) and the hypocenter of the event was determined close to the Danube in Vienna by both institutes. The event could be localized with an accuracy of approximately one kilometer. Due to the registrations the exact time of detonation (14:47:08 MESZ) could be calculated. Analyzing the signal showed a clear arrival of the shear wave about one second after the arrival of the longitudinal wave. The long-period signals arriving about ten seconds later are probably caused by acoustic waves which have been generated by the underwater detonation.

Primary author: MITTERBAUER, Ulrike Helene (Central Institute for Meteorology and Geodynamics)

Presenter: MITTERBAUER, Ulrike Helene (Central Institute for Meteorology and Geodynamics)

Track Classification: Theme 2: Events and Their Characterization
Deconvolution of the Seismic Source Time Function Based on Higher Order Statistics of Regional Coda Waves

At regional distance, the assessment of the source time function of moderate magnitude events is often a difficult task due to bad knowledge of the Source-station seismic Green’s function. Several studies have already demonstrated the capability of the regional coda wavefield to provide valuable information on the seismic source. Nevertheless, all the current methods are based on the use of second order statistics providing source power spectral density without any information on the phase and thus the source time function (STF). By using Higher Order Statistics, a modified version of our two step spectral factorization algorithm [Sèbe et al. 2005] of coda waves has been proposed allowing to recover the complete STF. Belonging to the class of blind deconvolution methods, this new approach performs the estimation of STF without any prior knowledge of seismic Green’s function taking advantage of the stochastic nature of regional coda wavefield. This algorithm has been applied on 2 events: the Rambervillers earthquake, France, 22/02/2003, and an artificial explosion in Kambara, Kyrgyzstan, 22/12/2009. The recovered STF are in good agreement with the source obtained by empirical Green function methods or with the known source phenomenology of the artificial explosion.

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Presenter: SÈBE, Olivier (CEA/CENTRE Ile-de-France)

Track Classification: Theme 2: Events and Their Characterization
on Importance of Education in the Field of Nuclear Law in Serbia

We still remember the accident in the Institute for nuclear sciences “Vinča”, many years ago in the former Yugoslavia. This paper gives insight in the legal framework of the nuclear armament area in the Republic of Serbia. We are speaking about legal framework of peaceful utilization of nuclear energy too. Knowledge is the treasure that follows everywhere its owners. The Government of the Republic of Serbia by Conclusion adopted the National action plan for application of the Resolution 1540 of the UN Security Council on prevention of the proliferation of nuclear, chemical or biological weapons and their means of delivery (2012 - 2016). Republic of Serbia is the first country in the wider region which prepared the National Action Plan for fulfillment of its obligations according to this Resolution. Decision on forming of the Working Group for monitoring of the National Action Plan for application of the Resolution 1540 of the United Nations Security Council on prevention of the proliferation of nuclear, chemical or biological weapons and their means of delivery (2012 - 2016) carrying out was made in Serbia in 2012.

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Presenter: TOMIĆ-PETROVIĆ, Nataša (University of Belgrade)

Track Classification: Theme 2: Events and Their Characterization
Tools Foreseen in the CTBT to Enhance Effective Verification and Foster Technological Development

The CTBT prohibits nuclear explosions in all environments in an effectively verifiable manner. Its verification regime for monitoring compliance is the most comprehensive ever envisaged in any multilateral instrument. As the CTBT is intended to be of unlimited duration, and bearing in mind the importance of keeping abreast with technological developments and challenges in order to ensure efficient and cost-effective multilateral verification in a fast changing world, the Treaty foresees several mechanisms to enable States Parties to adapt to new situations and to benefit from the civil and scientific applications of monitoring technologies. Under the Treaty, States Parties are required to cooperate in improving the CTBT verification regime and facilitate national capacity-building. The CTBT’s emphasis on fostering scientific and technological development is coupled with an emphasis on peaceful purposes. The research and capacity-building referred to in Article IV can only be carried out within the context of the fundamental obligation in Article I: the prohibition of nuclear explosions. Article III requires each State Party to take the necessary national measures to bind persons under its jurisdiction. With this poster/presentation, the authors wish to support stakeholders by illustrating the process and the legal framework for carrying this out.

Primary author: TONOS PANIAGUA, Fanny (Comprehensive Nuclear-Test-Ban Treaty Organization, Legal Services Section)

Presenter: TONOS PANIAGUA, Fanny (Comprehensive Nuclear-Test-Ban Treaty Organization, Legal Services Section)

Track Classification: Theme 2: Events and Their Characterization
of CTBTO Infrasound Data to Volcano Monitoring

ARISE (Atmospheric dynamics Research Infrastructure in Europe) project seeks to improve the understanding of the dynamics of the atmosphere using complementary sounding methods (infrasound, LIDAR and airglow measurements). The project involves more than 40 institutes, including the CTBTO which is the main provider of infrasound data and Toulouse Volcanic Ash Advisory Centre (VAAC) which is part of the ARISE Advisory Committee. One of the components of ARISE project comprises the monitoring of extreme natural events. Powerful volcanic eruptions in Europe and African regions may cause disturbances in the different layers of the atmosphere. These fluctuations are measured by ground stations and analyzed in order to find out parametric data that best characterize the atmospheric models and the volcanic source. ARISE provides continuity with the collaborative work that was originally undertaken by CTBTO and Toulouse VAAC in 2008 to assess the usefulness of infrasonic data to International Airways Volcano Watch. As a new asset, ARISE introduces the parameterization of the atmosphere dynamics that drives the infrasound wave propagation. It is expected that the proposed modeling approach helps implement near real-time “significant” eruption notification system for the VAACs to prevent eruption disasters and mitigate the impact of ash clouds on aviation.

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Presenter: BRACHET, Nicolas (CEA/CENTRE Ile-de-France)

Track Classification: Theme 2: Events and Their Characterization
Truth Events on the Territory of Kyrgyzstan

Five large chemical explosions with well-known parameters which can be used for calibration of regional seismic networks in the Central Asia have been conducted in the territory of Kyrgyzstan. These are three powerful industrial explosions in the Toktogul area: “Burlykiya” (February, 8th, 1975, Yield 702 tons), “Uchterek” (June, 11th, 1989, Yield 1623 tons) and recent double explosion “Kambarata” (December, 22, 2009, Yield 700 and 2160 tons), and also two explosions around Tuya-Muyun mountain mass, conducted on December, 31, 1959 with Yield 190 tons, and on March, 3, 1960 with Yield 600 tons. Seismograms of historical explosions have been collected and digitized from archives of analogue seismograms of the various seismological organizations of the Central Asia. “Kambarata-2” explosion has been recorded by a large number of modern digital seismic stations. For explosions we studied the kinematic and dynamic parameters of seismic records, and the distinct and composite regional travel-time curve have been created. Comparison of seismic effect of investigated explosions and seismic effect of the large chemical explosions conducted in the Central Asia territory is made.

Primary author: BEREZINA, Anna (Institute of Seismology (IS))

Presenter: BEREZINA, Anna (Institute of Seismology (IS))

Track Classification: Theme 2: Events and Their Characterization
Inverse modeling, also known as data assimilation, provides effective tools for reconstruction of a nuclear accident by the means of combining measured data with a numerical simulation of the accident. Application of advanced methods based on repetitive evaluation of the model, e.g. Monte Carlo methods, requires high computational power. This need becomes even more urgent when real-time analyses are performed. Our goal is to develop a system for modeling and reconstruction of nuclear accidents localized for Czech conditions. To ensure sufficient computational resources without extensive investments we attempt to develop a framework for construction of distributed computational environments using a large number of common personal computers connected to the internet. The framework is based on client-server architecture. The core components of the server side is a no-SQL database for storage of various data in different formats and a task scheduling service for communication with remote clients running computational codes. The framework can be used for construction of system dedicated to a single extensive task or as a computational base for multiple concurrent users. For the latter, a web-based user interface for configuration of desired task is provided. A decision support system based on the presented framework will be demonstrated.

**Primary author:** HOFMAN, Radek (CTBTO)

**Presenter:** HOFMAN, Radek (CTBTO)

**Track Classification:** Theme 2: Events and Their Characterization
Importance of CTBT Radionuclide Data for Emergency Preparedness

Nuclear emergencies require fast and reliable information for governments as well as for the public and the scientific community. The Fukushima accident illustrated this necessity very well. People, even in large distances to the source of releases like in Europe, wanted to know whether and to which extent they might be affected. For evaluation of the radiological situation the global dispersion of the radionuclides had to be observed. The Fukushima accident demonstrated in an impressive way that the International Monitoring System of the CTBT is the only system which is suited to measure the global dispersion of the released radionuclides. It indicated the transport of the radionuclides over the pacific to the USA and further to Iceland, Scandinavia and middle Europe. These measurements did not only show the radiological situation at the different measuring stations, they also allowed to predict the time of arrival of contaminated air in other areas by atmospheric transport modelling and the order of magnitude of the radionuclide concentration in air expected. The poster will indicate which data from the CTBTO were used in Germany as supplement to other available information for briefing the government by means of emergency response and for information of the public.

Primary author: BIERINGER, Jacqueline (Federal Office for Radiation Protection, Institution for Atmospheric Radiation/Support)

Presenter: BIERINGER, Jacqueline (Federal Office for Radiation Protection, Institution for Atmospheric Radiation/Support)

Track Classification: Theme 2: Events and Their Characterization
Test In-Depth View

Remote yield estimation of the underground nuclear explosions is possible by the inspection of different seismic phases. The most important seismic parameters are the amplitude, body wave and surface wave magnitudes. Therefore, to estimate the yield of the DPRK explosion (Feb 12, 2013), we need to find the necessary relationships. In Iran, near to 85 stations from the Iranian Seismological Center has received this seismic event. However the CTBTO evaluated the yielded estimation of the explosion about 4.9, we have study this event with available stations. Stations consist of short period, mid band and broad band sensors. The methodology we used here is first to derive several relationships for previous explosion tests like Semipalatinsk, and then to employ these relationships for estimating the yield of DPRK explosion. In this paper, different methods have been used to derive relationships between the recorded seismic parameters by the seismograms and the known explosions. These methods include: the amplitude of P-wave with a period of one second, the body wave magnitude, mb, and the surface wave magnitude in the time domain and in the frequency domain. Also, we have compared standard methods of distinguishing an earthquake from explosion like P/S spectra from earthquakes.

Primary author:  REZAEI, Reza (Institute of Geophysics, University of Tehran)
Presenter:  REZAEI, Reza (Institute of Geophysics, University of Tehran)
Track Classification: Theme 2: Events and Their Characterization
of Global Seismological Data for Disaster Prediction, Detection, Analysis and Management

This study suggests shared use of seismic data collectively acquired by different national & global apparatus for disaster prediction research. Techniques like, but not limited to, Pattern informatics have likelihood of success provided global dataset is studied in unison. Three main objectives suggested. Firstly, Event Prediction or Forecasting Secondly, Precise Event Detection and Thirdly, Post Occurrence Analysis of global dataset for concept validation and finding new techniques. Multi stage data processing, at source initial processing and report triggering, intermediate processing and final processing for refined results. It suggests increasing the deployment density of sensor arrays along known fault lines and vulnerable cores, introduction of autonomous sensor arrays, power-self-sufficient, network-self-configuring and processing-capable. Global collaboration, sharing of technology, knowledge, data and expertise are the bottom lines of proposed initiative. A unified open-source-multi-access-collaborative architecture, distributed storage, availability, update, data warehousing, data resolution enhancement, accuracy, cross validation and new customizable data presentation formats for early interpretation with ease, incorporation of GIS, open availability of knowledge ware and replications to prevent loss. Public availability of data will encourage new collaborative initiatives towards development of improved algorithms, techniques, interpretations and development of new business models for furtherance of the concept towards attainment of maturity and intended aim.

Primary author: SHAH, Syed Muhammad Ayub (National Defense University (NDU))

Presenter: SHAH, Syed Muhammad Ayub (National Defense University (NDU))

Track Classification: Theme 2: Events and Their Characterization
of CTBTO Teleseismic Data Analysis to Improve Moderate Earthquake’s Depth Estimations: Examples of Application

The depth of moderate events (M<5.5) is difficult to estimate using regional datasets in poorly instrumented areas. Focal depths should be better constrained by teleseismic data but, in practice, for such small magnitude, the weak signal to noise ratio reduces the range of use; depth estimation remains challenging. However, nowadays, with access to the data of the CTBTO monitoring system, smaller events can be detected and analyzed. Hence, we have investigated here the possibility to estimate the depths for moderate magnitudes (M<5.5 and M>3.5) from teleseismic data. Facing new problems (high frequency contents, weak signal to noise ratios, few recordings), two methods have been developed. First, a depth-phase recognition method based on a new improved cepstral analysis is developed. In addition to this approach, we have developed a focal mechanism inversion which focuses on depth resolution through an envelope-fitting procedure, and adapted genetic algorithm. A selection of events has been treated which allows to validate the methodology. This study shows that these two methods developed here provide a complementary approach to constrain the depth for moderate magnitude events. This new vision of depth estimation based on CTBTO arrays will help to renew our vision of the seismo-tectonic.

Primary author: LETORT, Jean (CEA - Grenoble University)
Presenter: LETORT, Jean (CEA - Grenoble University)

Track Classification: Theme 2: Events and Their Characterization
Classifier Based on Dynamic Time Warping of Cepstrum for Events Detected in the English Channel: Earthquake or Marine Explosion?

The French NDC operates a network of 40 seismic stations in France. A major part of the events located in the English Channel concern submarine explosions, most of them being conducted by French Navy. The clear identification of earthquakes is important to understand the tectonic of this region. We developed a method to identify marine explosion. Underwater explosions generate a gas bubble which can cyclically shrink and expand. This phenomenon is called bubble pulse. This phenomenon induces an echo in the signal, which is bringing out by cepstral analysis. We use this property to identify underwater explosions. The originality of our approach was to compare cepstra each other, instead of using a detector of bubble peak (like F-statistic approaches). The drawback of such a method lies on the random position of the bubble peak (function of depth and yield) which is different from one explosion to another. Our approach is based on Dynamic Time Warping method associated to Euclidean distance. A k-nearest neighbour method is then used to classify events. This method leads to a correct identification of more than 90% reference events (313 explosions and 41 earthquakes).

**Primary author:** LETORT, Jean (CEA - Grenoble University)

**Presenter:** LETORT, Jean (CEA - Grenoble University)

**Track Classification:** Theme 2: Events and Their Characterization
Verification of the U.S. Underground Nuclear Explosions of 1992 Using GPS: Case Study

We collected the Global Positioning System (GPS) data available in the International GNSS Service database for the days corresponding to two of the U.S. underground nuclear tests that is the Hunters Trophy and Divider, carried out in 1992 at the Nevada Test Site (NTS) and Yucca Flat, respectively. Each total electron content (TEC) of all possible ray paths between the GPS stations and the available satellites was extracted, then, we applied the numerical derivative method to compute slant TEC (STEC) derivatives. From the continuous STEC derivative data spans, the traveling ionospheric disturbances (TIDs) were isolated. These TIDs of two UNEs consisted their own array signatures in terms of the constant propagation velocity of the TID induced by specific event. The approximate propagation velocity from the Hunters Trophy was about 573.00 m/s, which was supported by another independent verification from an astronomical radio telescope, the Very Large Array (VLA) in New Mexico that was about 570-710 m/s. In addition, the TID propagation velocity of the Divider was 739.76 m/s. This study suggests that the global availability of GNSS tracking networks with algorithmic improvement of this method may offer a future UNE detection method, which could complement the International Monitoring System (IMS).

Primary author: PARK, Jihye (Oregon State University)

Presenter: PARK, Jihye (Oregon State University)

Track Classification: Theme 2: Events and Their Characterization
Role of Faulting Styles on Controlling Aftershock Patterns

Using global earthquake catalogs, we resolve that on average most of the parameters of the Omori law are dependent on faulting styles. Strike slip events, have lower aftershocks rate and K-value than thrust and normal events, respectively. Within the ETAS model strong K- and rate values are driven by high branching ratio. Within the same framework, a relatively higher branching ratio for the thrust events also predicts the lower p-value we observe for thrust events as compared to strike slip and normal events, respectively. From the one hand the Anderson faulting theory predicts thrust faulting requires a somewhat larger stress context, in absolute magnitude, that does normal and strike-slip faulting. From the other hand within the framework of rate and state friction law a change in the stress heterogeneity patterns reproduce the p-value changes we observe. Second, we resolved on average, reverse faults have a smaller magnitude and distance from the mainshock to largest aftershock than strike-slip faults i.e. the Bath’s law is impacted by the faulting style.

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**Presenter:** TAHIR, Mohammad (ISTerre Grenoble France, Yonsei University South Korea)

**Track Classification:** Theme 2: Events and Their Characterization
Changes in Radioxenon Isotope Activity Ratios During Subsurface Transport

Atmospheric concentrations of radioxenons $^{135}\text{Xe}$, $^{133m}\text{Xe}$, $^{133}\text{Xe}$ and $^{131m}\text{Xe}$ can be used to discriminate between civilian releases and nuclear explosion sources. It is based on the isotopic activity ratio method. It is not clear whether subsurface migration of radioxenons, with eventual release into the atmosphere, can affect the activity ratios due to fractionation. Fractionation can be caused by different diffusivities due to mass differences between radioxenons. Barometric pumping causes an oscillatory flow in upward trending fractures which, combined with diffusion into the porous matrix, leads to a net transport of gaseous components. Species transport has been widely studied with different numerical codes. However, transport in the post-detonation regime is still neglected in the literature. We use a general purpose reservoir simulator (Complex System Modelling Platform, CSMP++), specifically designed to account for structurally complex geologic situation of fractured, porous media. Parabolic differential equations are solved by a continuous Galerkin finite-element method, hyperbolic differential equations by a complementary finite volume method. The parabolic and hyperbolic problem can be solved separately using the operator-splitting method. This study examines fractionation of $^{135}\text{Xe}$, $^{133m}\text{Xe}$, $^{133}\text{Xe}$, $^{131m}\text{Xe}$ during barometric pumping-driven subsurface migration, which can affect surface arrival times and isotopic activity ratios.

**Primary author:** ANNEWANDTER, Robert (Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK)

**Presenter:** ANNEWANDTER, Robert (Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK)

**Track Classification:** Theme 2: Events and Their Characterization
GT5 Earthquake Identified in Central Brazil

Ground-truth (GT) events, accurately located with a precision of 5 km (GT5 event) and associated travel times to regional stations are important in developing precise velocity models. The low Brazilian seismicity, with only three continental earthquakes of magnitude five in the last three decades, and the low number of seismic stations explain the difficulty to detect events at regional distances. In the world maps of GT events, Brazil appears completely empty. In Stable Continental Interiors, like Brazil, it is difficult to find an event fulfilling all the GT5 prerequisites, particularly in respect with the number of picked phases and azimuthal gaps. Recently PTS-CTBTO has organized meeting and workshops to encourage seismologists from South and Central America to cooperate with the work of identifying GT5 events in these countries, with a goal of developing a 3-dimensional velocity model for this part of the globe not covered yet like Europe and North America. As a result we studied a recent magnitude 5 event in Central Brazil detected by few regional stations. Aftershock studies with local stations, showed a fault 5 km long. Joint relative locations of events recorded locally and regionally allowed the main shock to be a GT5 event.

Primary author:  VIEIRA BARROS, Lucas (Seismological Observatory)

Presenter:  VIEIRA BARROS, Lucas (Seismological Observatory)

Track Classification:  Theme 2: Events and Their Characterization
Sensitivity Analysis of Meteor-Generated Infrasound

In recent years, numerous bolide sources have been detected by the IMS infrasound arrays. Even though waveform data can be extracted from recorded signals, only a few parameters are used throughout infrasound research. A majority of results are obtained by employing energy estimates that are based on semi-empirical relations which possess errors. The justification of such estimates is questionable given that no analysis of the significant error has been performed. In our goal of understanding how the dynamical and structural properties of a meteor (during atmospheric entry) affect the emitted ballistic shockwave, we have developed a propagation model and have performed a sensitivity analysis of all unknown parameters. This model is applied to the Carancas meteor event in 2007. The core results of this study demonstrate that the variation in the trajectory, entry angle, initial velocity, diameter of the meteor as well as the atmospheric environment completely govern the variation within the emitted waveform, whereas the variation of the density and drag coefficient of the meteor have little effect on the waveform. Moreover, we show how the dominant input factors change over the parameter space, thereby leading to new advanced waveform data which consequently improves the characterization of the meteor.

Primary author: HAYNES, Christophe (Humboldt University of Berlin)
Presenter: HAYNES, Christophe (Humboldt University of Berlin)
Track Classification: Theme 2: Events and Their Characterization
Spectral Variation and Yield Estimation Derived from
High Frequency P and S Codas from Local High
Frequency Explosion Data

We report on two near-source explosion data sets to better understand the generation and properties of the scattered P and S wavefields. In the first case, we look at tamped single-fired explosions (~130-270 lbs) shot in Barre granite from the New England Damage Experiment (NEDE) using high-frequency 3-component stations ranging from ground zero to 15 km distance for a variety of explosives that have various velocities of detonations. In the second case, we look at 10 explosions of 1450 lbs that were shot at a range of depths of burial (DOB) and heights of burst (HOB) from the Humble-Redwood series of explosions in alluvium at Albuquerque, NM. These well-instrumented experiments provide us with excellent data from which to document the spectral shape, relative partitioning between P and S-waves, and amplitude/yield dependence. We also consider two methods of obtaining the coda-derived source spectra and compare these results. The first method uses a modified Mueller-Murphy source model derived from spectral ratios and the second uses a more traditional coda calibration procedure outlined in Mayeda et al. (2003).

Primary author: MAYEDA, Kevin (Weston Geophysical Corporation)
Presenter: MAYEDA, Kevin (Weston Geophysical Corporation)
Track Classification: Theme 2: Events and Their Characterization
Tensor Inversion Method for Determining Focal Mechanism of Bac Yen Earthquake (M4.0, date 2009/11/26) and Song Ma Earthquake (M4.7, date 2010/12/30)

Moment tensor inversion method used for determining the focal mechanism earthquakes have large magnitude occurred on the northwestern region of VietNam in recent years. In this study, the inverse results was calculated for the five earthquakes (including 2 aftershocks) have strong levels occurred in 2009 and 2010 on the northwestern region. Seismograms at the seismic stations recorded five earthquakes used in the inversion process. Synthesis seismograms results obtained after the inverse process well fitting with the real data and the correlation function up to 70-80%. The focal mechanism of the 5 earthquakes obtained by inverting the process have good results: All of focal mechanisms have stress state strike-slip type. The surface of maximum tangential stresses have large dip (δ) angle, with δ varies in the range from 70 - 85 degree. The stress field compression in the direction north - south, separated in the direction east-west, fitting with tectonic characteristics on the northwestern region of VietNam.

Primary author: HA, Thi Giang (Institute of Geophysics)
Presenter: HA, Thi Giang (Institute of Geophysics)

Track Classification: Theme 2: Events and Their Characterization
Technical Analysis of the DPRK-2013 Seismic Event and Waveform Cross-Correlation Perspectives at the International Data Centre

We have performed a comparative analysis of three announced DPRK underground tests using data from International Monitoring System (IMS), including the fusion of seismic and infrasound technologies. Unique similarity between the 2009 and 2013 year waveforms and spectra allows making strong conclusions about the similarity of the source mechanism and the conditions of conduction: depth of burial, geological structure, tectonic stress, and the containment technology, presuming all three events were explosions. For sources close in space and mechanism, waveform cross-correlation (CC) is a natural technique for continuous monitoring as the joint processing of the 2006, 2009, and 2013 data demonstrates. The CC-based relative location has a few hundred meters resolution, i.e. by two orders of magnitude more accurate than the IDC absolute location. The detection capability is enhanced by 0.5 units of magnitude and allows detection of M2.5 aftershocks. The results of the IDC expedite CC-based location of the 2013 event (14 min after the event) are supported by later reports of different national agencies. This proves the perspective of the IDC CC monitoring prototype, its state-of-the-art status, and its importance in the CTBT practice.

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Track Classification: Theme 2: Events and Their Characterization
2013 Russian Fireball Largest Ever Detected by CTBTO Infrasound Sensors

On 15 February 2013 at 03h20 UT, a large Earth-impacting fireball disintegrated over the Ural Mountains. The burning mass produced shock waves that blew out windows, injured hundreds of people and damaged buildings in many surrounding cities. Infrasonic waves generated by the explosion propagated over very long distances. The event was globally detected by 20 IMS infrasonic stations. For the first time since the establishment of the IMS infrasound network, propagation path round the globe was observed (~45000 km). In order to better characterize the wave parameters of the recorded signals, the filter settings of the PMCC cross-correlation based method (Cansi, 1995) were extended down to 0.01 Hz. Continuous recordings of all operating IMS stations were reprocessed using a log-scale configuration (Matoza et al., 2013). This fireball event provides a prominent milestone for studying in detail infrasound propagation traveling all around the globe for almost two days. Moreover, in the context of the future verification of the CTBT, its analysis offers a unique opportunity to calibrate detection and location methods and evaluate the global performance of the IMS network.

Primary author:  LE PICHON, Alexis (CEA/CENTRE Ile-de-France)
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Track Classification:  Theme 2: Events and Their Characterization
Robust P-Wave-Based Source Measure of the North Korean-Declared Nuclear Test

We explore the utility of additional phases in the initial P-wave packet for a more-transportable source estimator as well as to gain diagnostic insights into the 2013 North Korea-declared nuclear test (NK3). The amplitudes and periods of the "Pa" phase (first zero-to-peak), the "Pb" phase (first peak-to-first trough) and the "max" cycle are measured, with the associated station mb(Pa), mb(Pb), mb(Pmax) computed and then averaged across the IMS network for deriving the NK3 event mb(Pa), mb(Pb), mb(Pmax) of 4.62, 4.79, and 5.02, respectively. The magnitude differentials are then compared against the patterns of historic nuclear test sites reported in Jih et al. (1994). NK3 appears to be similar to the tests at Novaya Zemlya and Orenburg; and different from those in Nevada, Semipalatinsk or Argir. Since Pa phase is the initial down-going P wave which does not interact with the free surface above the explosion, the corresponding mb(Pa) is therefore a more direct measure of the isotropic source than mb(Pmax). The mb(Pa)-yield formula (Jih et al., 1993) results in 8.9±3KT for NK3. Other successful stories of using mb(Pa) as a more-transportable size estimator will be described. (Disclaimer: The views presented do not necessarily reflect those of the US Government.)

Primary author: JIH, Rong Song (U.S. Department of State)

Presenter: JIH, Rong Song (U.S. Department of State)

Track Classification: Theme 2: Events and Their Characterization
and Relative Location of the February 12, 2013, DPRK Announced Nuclear Test

Signals from the announced nuclear test in North Korea on February 12, 2013, were routinely detected and rapidly identified by the Norwegian National Data Center using both a site-specific alert algorithm and using multi-channel correlation detectors on several IMS seismic arrays with signals from both the 2006 and 2009 DPRK events as waveform templates. Using data from IMS seismic stations only, and measuring accurate waveform-correlation-based relative delay times, we estimate the location of the 2013 event to be approximately 450 m SW of the 2009 event with a horizontal uncertainty of approximately 100 m. Using the same techniques, the site of the 2006 event is estimated to be approximately 2 km ESE of the 2009 event. Due to the greater waveform similarity between the signals from the 2009 and 2013 events, together with the greater number of stations recording both events with a higher signal-to-noise ratio, the horizontal uncertainty in the location estimates of the two larger events relative to each other is smaller than for the location of the 2006 explosion relative to the more recent events. All relative location estimates made are consistent with independent estimates made using non-IMS seismic data recorded at regional distances.

**Primary author:** GIBBONS, Steven John (NORSAR)

**Presenter:** GIBBONS, Steven John (NORSAR)

**Track Classification:** Theme 2: Events and Their Characterization
Infrasound Analysis of 2013 DPRK Event and Russian Fireball

The first atmospheric event built only from infrasound arrivals was reported in the Reviewed Event Bulletin (REB) of the International Data Centre (IDC) of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) in 2003. In the last decade, 45 infrasound stations from the International Monitoring System (IMS) have been installed and are transmitting data to the IDC. In early 2010 the IDC began routine automatic processing of infrasound data reviewed by interactive analysis; the detected and located events are now systematically included in the REB. This study focuses on 2 important infragenic events that occurred in February 2013 and were thoroughly analyzed at the IDC. On February 12, an underground seismo-acoustic event was recorded in the Democratic People's Republic of Korea. Alongside the seismic recordings, infrasound waves were generated that were detected by 2 IMS infrasound stations located up to 1200 kilometers away. On February 15 a fireball in the Chelyabinsk region (Russia) was observed generating infrasound waves that were recorded by 20 infrasound IMS stations located from Greenland to Antarctica. This event is the largest ever recorded by the infrasound component of the IMS network. Related seismic observations were also found.

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**Presenter:** MIALLE, Pierrick (CTBTO Preparatory Commission)

**Track Classification:** Theme 2: Events and Their Characterization

Since 1994 the IGR RK monitoring network consisted of 4 small aperture, one medium and one large aperture seismic arrays, 7 three-component stations and 2 infrasound arrays has been operating successfully on the territory of Kazakhstan. Owing to good stations location from geological view and characteristics of seismic noise, well considered arrays configuration, most stations positioning in boreholes, integration of broadband and short-period instruments all system stations are high-sensitive to regional and teleseismic events. Despite the fact that all IGR RK stations were located at teleseismic distances from North Korean Test Site Punggyeri (distance range is 3725-5350 km) all 3 North-Korean nuclear tests (10.6.2006, 05.25.2009, 02.12.2013) were recorded by the stations. The stations data were used by different seismological agencies to determine the explosions parameters. Despite large distances from the explosions, and stations location within narrow azimuth to source range, the Kazakhstan Data Center managed to determine quite accurately the explosions parameters in operative mode, in particular the explosions magnitude. Comparative analysis of waveforms from 3 North Korean tests was conducted by data of Kazakhstan seismic stations.

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Presenter:  SOKOLOVA, Inna (Institute of Geophysical Researches)

Track Classification:  Theme 2: Events and Their Characterization
DPRK 2013 Underground Test and Chebarkul Meteorite: Joint Interpretation of Seismic, Infrasound, Acoustoseismic and Seismoacoustic Waves

Two events crucial for monitoring of nuclear explosions under the CTBT occurred on February 12 and 15 and attracted attention of the mass media and scientists. Seismic waves from the underground event and infrasound waves from the meteorite are of extreme interest as well as various processes of energy conversion at the free surface. Infrasound station I45(RU) collocated with seismic array USRK recorded the epicentral I-phase generated by the DPRK 2013 event and the seismoacoustic wave emitted beneath the station. The shock wave from the Chebarkul meteorite generated a regular I-phase recorded by many IMS infrasound stations and a series of seismic phases likely associated with impact and acoustoseismic conversion. Due to the altitude of the peak energy release, the air-coupled ground rolls with a group velocity of 3.5 km/s were generated. A similar pattern was observed after the 1984 r.Chulym (Siberia) bolide. We estimate the energy of both sources and discuss possible mechanisms of acoustic/seismic wave generation and conversion.

**Primary author:** KITOV, Ivan (CTBTO)

**Presenter:** KITOV, Ivan (CTBTO)

**Track Classification:** Theme 2: Events and Their Characterization
Limit Estimation of Radioxenon Release in DPRK Event

Following the claimed nuclear test in the Democratic People’s Republic of Korea (DPRK) on 12 February 2013, spectral analysis of radionuclide and ATM simulation were performed by the NDC-2 in Japan which is in charge of analysing radionuclides. There was no detection of artificial radioactive particulates. However, there were several detections of radioxenon, although each activity concentration was not far beyond the normal background range. We tried to estimate upper limit of radioxenon release in the DPRK event by using IMS data and the ATM simulation. The upper limit of Xe-133 release was estimated about 10^{12}-10^{13} Bq.

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Presenter:  KIJIMA, Yuichi (Japan Atomic Energy Agency (JAEA))

Track Classification:  Theme 2: Events and Their Characterization
Evaluation of the 3rd NK Nuclear Test: Comparison with the 1st and 2nd Tests

About noon of Feb. 12th 2013(KST), the seismic signals from the North Korea’s third underground nuclear test were detected by seismic stations in South Korea, Northeast China and Russia which are distributed uniformly along the boundaries between North Korea and adjacent countries. The relative location to the first event was calculated. The epicenter of the third event was about 400 meter south from the second event. A body wave magnitude (mb) was estimated as 4.9 and showed directional variations which were observed in the previous two events. The regional seismic discriminant and moment tensor inversion categorized the event into an explosion group. The infrasound signals from the test site detected at infrasound stations being operated by KIGAM in southern Korean Peninsula and the two IMS stations provide another evidence that the third event is an explosion. By analyzing empirical relationship between the calculated seismic magnitude and spectral ratios of P-waves, relative yield of 2013 is estimated as about 2 times larger than the second event and 10 times larger than the first events.

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Track Classification: Theme 2: Events and Their Characterization
of Infrasound Observations from the Underground Nuclear Tests of North Korea

This study shows that the observations of infrasound signals from the third underground nuclear test carried out by North Korea on 12 February 2013. The infrasound signals generated from their test site were detected by South Korea’s infrasound network operated by KIGAM as well as the two nearby IMS infrasound stations, IS45 and IS30. Compared with detection results of the second test in 2009, favorable condition in atmosphere for eastward propagation has limited the detectable range and stations located on the east side of the epicenter recorded the infrasound signals. Infrasound source locations are calculated based on wave parameters determined at the multiple infrasound stations, in which azimuths deflected by the favorable condition are corrected from atmospheric specification. Detectability for the last three times underground nuclear tests can be explained by the atmospheric model and ray tracing simulations. Besides the epicentral infrasonic signals that originated at the test site, diffracted infrasound signals generated by ground motions will be addressed by localization of its source regions.

Primary author: CHE, Il-Young (Korea Institute of Geoscience and Mineral Resources)
Presenter: CHE, Il-Young (Korea Institute of Geoscience and Mineral Resources)

Track Classification: Theme 2: Events and Their Characterization
Source Scaling of Underground Nuclear Explosions in Northern Korean Peninsula

The three underground nuclear explosions in northern Korean Peninsula bequeathed waves recorded by seismic stations in Northeast China and South Korea. Studies on the three events illustrated that the difference in the locations of the two explosions is tiny on a regional distance scale. The tiny difference could be incorporated to establish empirical source scaling relationships of the two explosions by excluding path effects through spectral ratios of the collocated seismograms. The spectral ratios have been compared to theoretical source model. This model analysis provided the scaling relationship of the yields and depth of burials of the two explosions: the relative depth of burial of the 2nd explosion is about 1.2 times deeper than that of the 1st explosion, and the relative yield of the 2nd explosion is about 5 times larger than that of the 1st explosion. Empirical scaling relationships of the 3 underground explosions in northern Korean Peninsula are analyzed by excluding path effects through estimation of spectral ratios between collocated seismograms. To obtain the empirical scaling relationship of the source parameters, the measured spectral ratios were compared with the Mueller-Murphy source model.

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Track Classification: Theme 2: Events and Their Characterization
Analysis of DPRK Nuclear Test of February 12, 2013 by Belbasi Nuclear Tests Monitoring Center - KOERI

On 12 February 2013, The Democratic People’s Republic of Korea (DPRK) announced the conduct of a nuclear test. Corresponding seismic event was recorded by IMS, upon which IDC released first automatic estimation (SEL1) of time (02:57:51 GMT), location (41.3386°N and 129.0711°E) and the magnitude (4.9 mb) of the event in less than two hours time. During the preliminary analysis of the 2013 DPRK event by the Turkish NDC, a very clear P arrival at 03:08:55 (GMT) at BRTR (Keskin SP array) has been observed, which was not associated to SEL3. The result of our analysis confirmed that the arrival belongs to the DPRK event. In this study, we would like to present the technical and scientific aspects of the 12 February 2013 DPRK from a multidisciplinary perspective such as seismic discrimination analysis (event depth, magnitude, mb:Ms ratio, moment tensor inversion, focal mechanism solution, spectral analysis) employed in a NDC. The analysis has also employed Infrasound and Radionuclide technologies.

**Primary author:** ŞEMIN, Korhan Umut (Belbasi Nuclear Test Monitoring Center)

**Presenter:** ŞEMIN, Korhan Umut (Belbasi Nuclear Test Monitoring Center)

**Track Classification:** Theme 2: Events and Their Characterization
Location of North Korea’s Third Underground Nuclear Test

On February 12, 2013 North Korea executed the third underground nuclear test at their test site in the vicinity of P’unggyeri. The event excited strong regional Pn and Pg phases compared to the weak regional Lg phase. The seismic waveforms were very similar to those of the North Korea’s first and second underground nuclear tests, which suggested nearly collocated epicenters of the three explosion sources. A grid search was utilized to decide the relative location of the third event compared to the first event with a net of 100 m x 100 m grid meshes and the observed Pn arrival times. The epicenter of the third event was determined at the global minimum of residuals. The coordinate of the epicenter is 41.275°N, 129.064°N which is located 400 meters south of the second event.

Primary author: KIM, Tae Sung (Korea Institute of Geoscience and Mineral Resources (KIGAM))

Presenter: KIM, Tae Sung (Korea Institute of Geoscience and Mineral Resources (KIGAM))

Track Classification: Theme 2: Events and Their Characterization
Applications in Comoros

The Civil and Scientific uses of CTBT Data and Products in Comoros is a reality considering Natural Hazards and Catastrophes related to the “Karthala” volcano activities in Comoros, which for some year’s eruptions, brought important releases of ashes and gases. The oceanic aspect is also affected by the fact that the 2004 Indonesian Tsunami is recorded with up to 6.7 run ups in several coastal areas in Comoros. Through the CTBT International Monitoring System, recent Events (2006, 2010, etc.) where clearly recorded.

Primary author: MADI, Mariama (CNDRS (Centre National de Documentation et de Recherche Scientifique))

Presenter: MADI, Mariama (CNDRS (Centre National de Documentation et de Recherche Scientifique))

Track Classification: Theme 2: Events and Their Characterization
T-Phase Observed from the Underground Nuclear Explosions of North Korea

North Korea conducted the third underground nuclear explosion on February 12, 2013 in the northeastern part of Korean Peninsula, where North Korea executed their first and second underground nuclear explosions. Analysis on the data recorded at seismic stations of Korea Institute of Geoscience and Mineral Resources revealed that a seismic array located in an island of East Sea recorded the T-phase generated from the second and the third underground nuclear explosions. The T-phase was converted from the P and S waves originated from the nuclear explosions. A detailed study was performed with spectrogram analysis, duration-amplitude discriminant and dispersion of the waveform.

Primary author: KIM, Seo Young (Korea Institute of Geoscience and Mineral Resources (KIGAM))

Presenter: KIM, Seo Young (Korea Institute of Geoscience and Mineral Resources (KIGAM))

Track Classification: Theme 2: Events and Their Characterization
Events and Confidence in an International Monitoring Regime

There is a long history of unusual events (unexpected natural seismicity, man-made seismic events, bolides, etc.) that have caused concern in terms of international treaties or cooperative engagement. These concerns include suspicions of undeclared activities or viability of geophysical data to screen the source of signals with high fidelity. Although most “unusual events” are resolved with detailed analysis, the short term consequences can be significant. For example, a small earthquake (magnitude 3.8) off the east coast of Novaya Zemlya on August 16, 1997 led some to question whether a low yield nuclear test can be conducted and undetected at the Russian test site. The ensuing political discussion of the seismic event led to scientific efforts to quantify assessments on event identification.

Today the International Monitoring System is producing high quality geophysical data with good global coverage of the planet in support of a Comprehensive Test Ban. This rich data stream is also capturing a large number of unusual events. Timely analysis of these unusual events can significantly change the confidence of the countries in the monitoring regime. The February 15, 2013 Chelyabinsk bolide is a recent example where the data from the IMS provided invaluable information that remove uncertainty from the nature of the event.

**Primary author:** WALLACE, Terry (Los Alamos National Laboratory)

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**Track Classification:** Theme 2: Events and Their Characterization
2012 Meteor over Russia via CELESTIA-Based 3D Live Visualization of the Global Challenges

CELESTIA-based Stereoscopic Live Visualization of the Global Challenges integrating monitoring of earthquakes, tsunamis, explosions or radioactive emissions tracked by CTBTO network with the live data stream coming from the Ground and Space-based Telescope Array to track high impact events like 2012 Ural meteor and/or more objects coming from asteroid belt like identified 2012 DA14, 2013 EC, 2013 ET or more to come. All-in-one visual interface to global challenges fed with live data streams in multimedia format can give better understanding to Next-2-come challenges. 2012 Ural meteor is the No.2 largest impact event on or near Earth in recorded history. All-in-one Live 3D mashup interface to seismic, hydroacoustic, infrasound live data streams integrated with radionuclide tracer observations and ground and space-based telescope monitoring including peer-viewed LBS video material recorded via GPS-enabled smartphones if required in case of official data missing (YouTube published video material by peers, 3D converted, geolocated and supported by physics plugin (known as Location Based Interactive Voice Video Service) to generate add-on value in case of emergency.

Primary author:  SLAVIETZ, darius (United Nations Framework Convention on Climate Change (Consultant))

Presenter:  SLAVIETZ, darius (United Nations Framework Convention on Climate Change (Consultant))

Track Classification:  Theme 2: Events and Their Characterization
of the Russian Fireball 2013 from Signals Recorded by I33MG

In the framework of the International Monitoring System (IMS), sixty infrasound stations were installed around the world to detect nuclear test of more than 1 kiloton. Besides, these stations can detect and measure waveforms from natural event such as ocean swell, volcanoes, severe weather or from man-made source such as chemical explosion, quarry blast, missile’s path etc. On 15 February 2013 at 03:22 AM, a meteor broke up over Russia’s Ural Mountain which was the largest fireball ever detected by IMS station. I33MG station in Antananarivo was among the 17 infrasound stations that detect the blast. Signals from exploding meteor are unique because the sources travels so the azimuth changes as the fireball moves and it’s not a single explosion. WinPMCC based on the PMCC method (Progressive Multi-Channel Correlation) is used to process data, and TauP method (Garcès, 1998) to simulate the propagation through the atmosphere. The azimuth detected is around 13°.

Primary author:  RANDRIANARINOSY, Fanomezana (Institute and Observatory of Geophysics of Antananarivo (IOGA))

Presenter:  RANDRIANARINOSY, Fanomezana (Institute and Observatory of Geophysics of Antananarivo (IOGA))

Track Classification:  Theme 2: Events and Their Characterization
of the Connection Between Radioxenon Samples Collected in the IMS in April 2013 and the Announced Nuclear Test in North Korea on February 12, 2013

More than seven weeks after North Korea’s third nuclear test conducted on February 12, 2013, unique combinations of the xenon isotopes 131mXe and 133Xe were detected at the IMS stations JPX38 in Japan and RUX58 in Russia within five days of each other. The consistent and coherent picture obtained from isotopic ratios in combination with station history and atmospheric transport modeling results in the conclusion that the detections very likely are caused by releases of noble gases created in the test. Analysis and data interpretation will be presented.

Primary author: RINGBOM, Anders (Swedish Defence Research Agency (FOI))
Presenter: RINGBOM, Anders (Swedish Defence Research Agency (FOI))

Track Classification: Theme 2: Events and Their Characterization
PTS Response to the DPRK Announced Nuclear Test

The Democratic People’s Republic of Korea (DPRK) has announced that it conducted its third nuclear test. The seismic component of the CTBT verification system detected a clear signal from the expected test area in proximity to the locations of the previous tests in 2006 and 2009. The International Data Centre (IDC) estimated the magnitude at 4.9, which is larger than either of the previous tests (IDC magnitudes of 4.1 and 4.5, respectively). As this event was larger and more stations in the International Monitoring System (IMS) were sending data to the IDC than during the previous tests, more IMS stations detected the event. Detections were found on 96 IMS stations, two of which were infrasound stations, and 88 were used in the event location estimate reported in the Reviewed Event Bulletin (REB). The REB location uncertainty for this event is approximately 8 km. In preparation for the possibility that radionuclides might have been released, atmospheric transport modeling was used to estimate where a possible radionuclide release would be detectable. Although some close-by stations had some clear radionuclide detections, the radionuclide composition and activity levels were typical for the stations and demonstrated the importance of understanding the global radiological background.

Primary author: NIKKINEN, Mika (Comprehensive Nuclear-Test-Ban Treaty Organization)
Presenter: NIKKINEN, Mika (Comprehensive Nuclear-Test-Ban Treaty Organization)
Track Classification: Theme 2: Events and Their Characterization
of High Activity Radioxenon and Radioargon Sources

Detection of noble gas fission and activation products resulting from underground nuclear tests is a key component of On-Site Inspections, the most confirmatory of the three verification regimes of the Comprehensive Nuclear-Test-Ban Treaty. Radioxenon and radioargon gases may reach the surface through several mechanisms, each with a characteristic timeline. In order to provide empirical data on these various mechanisms, a series of tests will be carried out. These tests will release tracer gases underground and require the production of operationally significant levels of radioxenon and radioargon - up to 100 Ci. The method of producing these gases through the irradiation of specially prepared targets will be described, along with proposed potential future uses such as testing the operational readiness of On-Site Inspection noble gas measurement techniques.

Primary author: BOWYER, Theodore (Pacific Northwest National Laboratory)
Presenter: BOWYER, Theodore (Pacific Northwest National Laboratory)
Track Classification: Theme 2: Events and Their Characterization
and Challenges in the Establishment of a New National Data Centre (NDC) - A Case of the Nigerian NDC

Usually, in the establishment of an NDC for the implementation of the National requirements relevant to the Comprehensive Nuclear Test Ban Treaty (CTBT) numerous challenges are encountered especially in developing countries. Some of these challenges could be frustrating and sometimes have the tendency of dragging the NDC establishment process to a halt.

I can say that we also have encountered some of these challenges during the establishment of the NDC-NG and have been able to surmount them to get to where we are today.

It is for the reason of sharing this story that this presentation is made so that other emerging NDCs, particularly those from the African countries, intending to establish NDCs can be encouraged to move on despite all odds. Highlights will be on the beginning, current status and the future plans of the NDC-NG.

Primary author: BISALLAH, Awwal (Nigeria Atomic Energy Commission)

Presenter: BISALLAH, Awwal (Nigeria Atomic Energy Commission)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
JISView had been made which is development of AMZTAK software that has function to modeling earthquake focal mechanism. Through the making of GUI some of the functionality built into automatically and added to the system and combined with GIS to support earthquake and tsunami vulnerability analysis in order to become more effective and systematic. Modeling is done using the P-wave phase data. JISView software system is designed in such a way that can perform earthquake focal mechanism modeling, data management, mapping and simultaneously in a single parametric analysis process flow. The method used in the form of merging multiple module functions include data conversion, processing and plotting. GIS designed to display information in relation to the territorial distribution of earthquake focal mechanism. GIS also provides facilities for analyst of earthquake to earthquake clustering based on spatial correlation of the fault. The output in the form of spherical focal software that is integrated directly on the map in a short time of about 7-10 minutes. Output speed of the faster data processing 5 minutes from the results of processing using AMZTAK. The accuracy has been compared with the output of BMKG, GFZ and USGS generally have the same result.

**Primary author:** NUGRAHA, Jimmi (NDC Meteorology Climatology and Geophysics Agency (BMKG))

**Presenter:** NUGRAHA, Jimmi (NDC Meteorology Climatology and Geophysics Agency (BMKG))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
-Gravity Studies in Archeo-Prospecting of the Valley of the Queen and Kings, Luxor, Egypt

Due to our success in studying the applicability of the micro-gravity investigations in archaeo-prospecting and cave detection, we started to study the resulted unknown features in the Valley of the Queen and Kings from our previous micro-gravity investigations. Some profiles selected to cross the main area of the resulted anomaly.

Our investigations concentrated in the testing site by micro-gravity measurements for the selected parallel profiles using models G and D if LaCoste & Romberg gravity meters with 1-meter interval between measuring stations. The resulted data were corrected and adjusted. The gravity效应 of the entrances and main bodies of the surrounding tombs were calculated using 2.5 and 3D-gravity modeling. The final gravity study and interoperation for this local testing site show a presence of a considerable anomaly, which was interpreted as subsurface hidden room or big hole. This conclusion was conceded with the information deduced from the archaeological information.

**Primary author:** RADWAN, Anwar Hassan Ahmed (National Research Institute of Astronomy and Geophysics (NRIAG))

**Presenter:** RADWAN, Anwar Hassan Ahmed (National Research Institute of Astronomy and Geophysics (NRIAG))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
for On-Site Inspections and Lessons Learned from Different Verification Regimes

On-site inspections, though intrusive in nature, is one of the most important and effective mechanism as a verification tool in order for a treaty to achieve its objectives. The IAEA safeguards inspection regime, which verifies the non-proliferation of nuclear weapons, has accumulated broad experience in the methodology and technology of conducting inspections on international, regional or national levels. The OPCW inspection regime, which verifies the prohibition of Chemical Weapons, though relatively new, has developed quite an effective methodology for their objectives. Other inspection regimes used for verifying other purposes, e.g. biological weapons, trafficking, illegal transport activities or networks and others provide different methodologies to achieve their goals. Experience of these different methodologies of inspection regimes provide important lessons that could contribute important lessons learned for the effective implementation and conduct of a CTBTO On-Site inspection for the detection of possible nuclear test explosion. Discussion of the methodology and objectives of the main inspection regimes and Examples of possible common methodology and technology for different inspection regimes with that of the CTBTO are here discussed.

**Primary author:** ABUSHADY, yousry (IAEA; ECFA)

**Presenter:** ABUSHADY, yousry (IAEA; ECFA)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
ERMES-WORLD: Environmental Radioactivity Monitoring for Earth Sciences—World Reference Laboratory and New Developments

The Environmental Sciences are approaching an important crossroad for understanding complex processes such as Climate Change, Earth’s interior and its heat budget, global geodynamic processes. The phenomenological study needs a comprehensive characterization for connecting past-present processes, which can be performed only through time-space markers such as radionuclides. The numerical modeling of complex systems such as those mentioned need, a growing number of experimental data with the highest possible accuracy for the scientific validation. This fundamental synergy requires an ultra-low level background environment as only found underground and ERMES-WORLD has been designed to achieve it. ERMES-WORLD will also promote and support other synergies providing to the scientific community the best reference facility. ERMES-WORLD delivers a high quality and innovative research program and will, as well, open new research opportunities for Environmental and Nuclear Sciences increasing the synergy between these fields and contributing to the development and monitoring of peaceful nuclear applications in other fields of interest for Science and the International Community: Astroparticle Physics, Non-proliferation, Nuclear Safety, Safeguards. The synergy proposed by ERMES-WORLD also combines the study of environmental radioactivity, using the most powerful technology in the best ultra-low level background environment around the world (INFN-Gran Sasso National Laboratory, Italy).

Primary author: PLASTINO, Wolfango (Roma Tre University)
Presenter: PLASTINO, Wolfango (Roma Tre University)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
to Support Future Sensors, Networks, Data Communications and Data Processing for Global Monitoring and On-Site Inspections

Over the past decade ocean observing technology for the scientific community has advanced from expeditionary ship based science and data collection to long time series real time ocean observation. This paradigm shift has been achieved through the installation of significant cabled infrastructure systems. Several research organizations have launched a new era of human discovery within the world’s oceans through electrical power and high speed internet connectivity in large portions of the global ocean through systems such as the Monterey Accelerated Research System (MARS), the NorthEast Pacific Time-Series Undersea Networked Experiments (NEPTUNE) system and most recently the Regional Scale Nodes (RSN) system. These underwater network systems allow land-based scientists, engineers, educators, and the public to remotely interact with ocean events as if they were actually in the ocean environment-events. High-bandwidth communications and power is provided to a network of instruments widely distributed across, above, and below the seafloor. This technology can be leveraged beyond ocean science allowing rapid fielding of new sensors, networks and processing technologies improving maintainability, reliability and efficiency of systems and operations. This paper will discuss background of some of the existing systems and how the Preparatory Commission could use this technology in future systems.

Primary author:  YINGER, Peter (L-3 MariPro)
Presenter:  YINGER, Peter (L-3 MariPro)
Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
into Future Technologies for Nuclear Test Verification: Technology Foresight at the CTBTO

As part of its mandate, the CTBTO’s nuclear explosion monitoring programme aims to maintain its sustainability, effectiveness and long-term relevance to the verification regime. As such, the Technology Foresight programme of activities identifies technologies that may serve said purpose within the next 20 years.

We have involved the wider seismology, infrasound, hydroacoustics, radionuclide technology, remote sensing and geophysical communities and have assembled an extensive database, which incorporates technologies with future relevance to the spectrum of CTBTO activities. To maximise strategic and planning usefulness, we have devised a “taxonomy” based on ten categories, against which each technology is assessed through a peer-review mechanism.

The resulting database is coupled to Pivot, a novel information management software tool offering powerful visualisation of the taxonomy’s parameters for each technology. Pivot offers advantages over conventional spreadsheet-interfaced database tools: based on shared categories in the taxonomy, users can quickly and intuitively discover linkages, commonalities and outlooks about prospective technologies.

We will illustrate the range of future technologies and will demonstrate how Pivot assists in strategic planning and development, and to identify possible gaps on the technology development horizon. We show how the Pivot taxonomy offers real and emerging insights when assessing large amounts of disparate technologies.

**Primary author:** JAIN, Amit (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Presenter:** JAIN, Amit (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Optimization of a Signal Processing Chain for Hydroacoustic Signal Classification

One sub-task in hydroacoustic signal processing for CTBT verification is automatic discrimination of incoming signals by source type. In particular, signals from any explosive-like source should be reliably identified among a wide range of noise (for example, seaquakes, marine mammals, or ship noise). Previous studies have applied rule-based systems, neural network classifiers, support vector machines (SVMs) with task-tailored kernel functions, as well as maximum-margin Bayesian network classifiers to features independently extracted by the current IMS data processing system. In the present contribution, we instead set up and parameterize a full processing chain from signal detection and feature extraction to classification. Its free parameters are optimized according to a single common objective function. Signals are detected by a flexible, generic trigger algorithm operating on the long- to short-term average ratio of the spectral energy. The signals are represented by general sound-processing features, with special focus on spectral and cepstral attributes. Several classifiers are explored, in particular SVMs with different kernel functions. Experiments show that SVMs with radial basis function kernels applied to the output of the optimized processing chain outperform earlier and baseline approaches. In particular, they exhibit 100% sensitivity at high specificity, which is desired for the application at hand.

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Presenter: TUMA, Matthias (Institut für Neuroinformatik, Ruhr-Universität Bochum)
Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Accurate or Fuzzy Arrival Onset Time Determination – Which Is More Adequate?

Event location is one of the main products of the CTBT verification regime. The first analysis step is to scan the time series at each station for the existence of relevant information and to determine when it arrived. The location and time of the generating event are estimated by solving an inverse problem based on the set of arrival times at the different stations. The location accuracy depends on the accuracy of the onset times, which in turn depends on the signal to noise ratio and the nature of the arrival: emergent or implosive. In this work we suggest that the analyst should declare the earliest and latest possible arrival time and then sample the onset time using a distribution on that time segment. With each new sample, the solution is computed to the inverse problem. This generates a collection of solutions that can be used to compute the error region associated with the location. The advantages of this method are that it simplifies the analysis, it finds the error region as a neutral outcome of the method and it more faithfully represents what analysts believe about their ability to pick the true arrival time.

Primary author: BEN HORIN, Yochai (Soreq Nuclear Research Center)
Presenter: BEN HORIN, Yochai (Soreq Nuclear Research Center)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Near-Surface Geophysical Methods to Detect Anthropogenic Events

In 2012, experts of the Hungarian Institute of Geology and Geophysics (formerly ELGI, Eötvös Loránd Geophysical Institute of Hungary) performed a series of mappings in a test site of Bakony Mountains, Hungary. To detect and delineate an underground storage facility, various methods and devices were applied. Above and inside the military construction, resistivity and seismic profilings, transient (time-domain) and frequency-domain (slingram) mapping, as well as GPR (ground penetration radar) measurements were made. While the detection capacity of these methods (and instruments) was more or less known, based on earlier experience, the 2012 test measurements gave information concerning to the important factors in applying these methods during the continuation period of an on-site inspection (CPT of OSI). The required factors are:

a., high productivity (high speed of mapping using the limited time window);
b., good portability (even if working on heavy terrain and dense vegetation);
c., easy positioning (mapping with integrated GPS receiver without prior surveying);
d., quick presentation (on-the-spot interpretation and visualisation).

Primary author: KAKAS, Kristof L. (Geological and Geophysical Institute of Hungary)
Presenter: KAKAS, Kristof L. (Geological and Geophysical Institute of Hungary)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Total Electron Content (TEC) Variation Related with Large Earthquakes in Sumatra - Indonesia

ABSTRACT ANALYSIS OF (TEC) TOTAL ELECTRON CONTENT VARIATION RELATED WITH LARGE EARTHQUAKES IN SUMATRA-INDONESIA By : (Hendri Subakti, Indonesia) Satellite enables to measure the number of Total Electron Content (TEC). It exists along ionosphere between the signal beam and GPS receiver. The calculation of TEC differential (dTEC) and slant TEC use the Sumatra GPS Array network data. It is done by utilizing the GAMIT algorithm software. The distribution of variation and vertical TEC are processed by using Matlab Software. The result of the analysis shows the existence of TEC value both the decrease and the increase of electrons number. From December 2004 until April 2005, ten earthquakes occurred in Sumatra with the magnitude M>6.0. Nine of them appeared the TEC anomaly (the decrease of TEC value is below the lower bound) in 1 up to 6 days before the earthquakes stroke. The TEC anomaly is considered as the precursory signal that occurs before the earthquake strikes. Keywords: TEC, GAMIT, SUGAR, Sumatra, Earthquake, Electron, Anomaly, Precursory, Signal.

Primary author: SUBAKTI, Hendri (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Presenter: SUBAKTI, Hendri (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Calibration and Characterization of the Radioxenon Gamma Spectroscopy Counting System of a Very Low Background HPGe Detector Using Monte Carlo Simulation

Measurement of noble gases started in 2011 at the ENEA Italian Laboratory for Environmental and Anthropic Monitoring Measurements and within the framework of the CTBT and the NDC related activities carried out at the laboratory. The present status of the noble gases gamma spectroscopy analysis system will be presented. A completely dedicated HPGe detector has been used: it is a p-type extended range detector (CANBERRA, model GX6020), 60% efficiency. The germanium crystal is contained in a very low background endcap made of carbon fiber that allows an energy range 3 keV - 10 MeV. The crystal is isolated from the background using a U-type ultralow background cryostat (model 7915-30ULB), and all the materials of the detector and shielding are selected with the requirement of Ultra Low Background. Based on the Monte Carlo simulation software VGSL, we have developed both the calibration efficiency procedure for the detection of xenon radioisotopes and the characterization of calibrated containers made of different materials such as aluminium and carbon fiber. Moreover, using VGSL, the efficiency distortion due to the self absorption of the source emissions, at different concentration of xenon and helium in the counting cell, is also modelled and discussed.

**Primary author:** DE SANCTIS, Jacopo (Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA))

**Presenter:** DE SANCTIS, Jacopo (Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Infrasound PMCC Detection Using Maximum Likelihood and Receiver Operating Characteristic Curve Analysis

We develop methods to determine the optimal detection thresholds for the Progressive Multi-Channel Correlation Algorithm (PMCC) used by the International Data Centre (IDC) to perform infrasound station level event detection. Statistical detection theory is used with synthetic data and real ground truth data to determine optimal individual delta time consistency detection thresholds and the “family” size threshold of grouped detection “pixels” with similar signal attributes (i.e. trace velocity, azimuth, time, and frequency). We vary the consistency threshold and present a trade-off between the probability of detection and the false alarm rate by way of Receiver Operating Characteristic (ROC) curve analysis. Further, a maximum likelihood approach is used to determine the optimal family size threshold before the detection should be considered for further processing. Optimal family sizes are determined based upon the consistency threshold, filter configuration, and Bayes cost criteria. Finally, we generate synthetic signals for particular array configurations, adjust the signal to noise ratio (SNR) to determine the SNR failure levels for the PMCC detection algorithm, and compare similar configurations to fielded infrasound station performance. For the fielded stations studied PMCC was able to detect signals with post-filtered SNRs greater than 2 dB.

Primary author:  LOUTHAIN, James (Air Force Institute of Technology)

Presenter:  LOUTHAIN, James (Air Force Institute of Technology)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Oceania Regional Seismic NETwork (ORSNET) concept

The shape of Vanuatu islands is a challenge to accurately locate earthquakes along the Vanuatu trench by the National Warning Center. Therefore regional cooperation between Vanuatu and New Caledonia is the best solution to this challenge. This cooperation is developed by a joint governmental project since January 2011 and through which the Vanuatu earthquake detection system has been operational.

The use of a common system helps both institutes on earthquake automatic detection. Then procedures and alert systems give support for regional decision makers within these countries. The first outcome of this regional network is to decrease the earthquake time detection and to help on the dissemination of early warning. Moreover this cooperation complies with the ICG/IOC/PTWS recommendations and it shows how better service observatories could bring to their country.

Positive results of this cooperation force to consider the potential to extend to a larger network between several countries amongst south west pacific area. Others PICS network could all be integrated within a virtual regional seismic network, sharing data regionally and helping locally decision makers regarding tsunami and earthquake threats. The Oceania Regional seismic NETwork (ORSNET) concept, coming from this collaboration, is aimed to bring a solution to this regional need.

**Primary author:** TODMAN, Sylvain (Vanuatu Meteorology and Geohazards department)

**Presenter:** TODMAN, Sylvain (Vanuatu Meteorology and Geohazards department)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
-Fiji Monitoring Seismic Network

TONGA - FIJI SEISMIC NETWORK INTRODUCTION. By Rennie Vaiomounga, Geologist, Ministry of Lands, Environment, Climate Change & Natural Resources. Tonga is located at the easternmost edge of the Australian plate and formed oceanic island arc in response to subduction of Pacific Plate beneath the Australian Plate. That cause high Seismic activities. WORK HAVE BEEN DONE Due to active seismic activities the Japanese Government funded 5 seismic stations to record earthquakes in the regions. After completion the installation, accuracy of data analysis wasn’t accurate due to station distributions. Japan extended the project to install 6 more seismic stations in Fiji to share the real time data and data analysis be more accurate. These stations transmitted data from stations to central hub through satellites. CHALLENGES Funding is the main problem we faced. For Tonga Fiji seismic network, each country funded the maintenance of their stations. Also lack of training staff in this field. WAY FORWARD Pacific Islands are high risk in earthquakes and tsunamis. Its better create Regional Seismic Network around the Pacific. Vanuatu and New Caledonia already have network and we better work to extend the network to other Islands to assist reducing the risk of the disaster.

Primary author: VAIOMOUNGA, Rennie (Senior Geological Assistant)
Presenter: VAIOMOUNGA, Rennie (Senior Geological Assistant)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Recognition Methods for Identifying Aftershock Sequences

The detection and identification of aftershocks is an important and challenging task for the efficient seismic processing in the CTBT context. In this work we apply a template-based sonogram pattern recognition and a waveform correlation detector in order to identify events which are part of the aftershock sequence. The concept is demonstrated using the February 2004 Dead Sea earthquake with magnitude ML=5.2 and its aftershock sequence. The events were recorded by stations of the Israeli seismic network and IMS stations EIL and MMAI. The master patterns include the main earthquake and several strong aftershocks with ML≥2.5. The obtained results are validated by the analyst and they are compared with the data set recorded by a portable sparse array deployed at an epicentral distance of 15 km from the earthquake.

Primary author:  BREGMAN, Yuri (Soreq Nuclear Research Center)

Presenter:  BREGMAN, Yuri (Soreq Nuclear Research Center)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Analytical Estimates of Broadband Seismic Instrument Self-Noise to Environmental Variations

Environmental sensitivity is sensitivity of instrument to environment (changes of pressure, temperature, magnetic field, etc.). To provide the best quality of the seismic data you have to understand the non-seismic noise sources and how to avoid them. For many years we investigated the effects that changes in external conditions have on the operation of broadband devices. We investigated effects such as changes of temperature, air pressure, magnetic field, humidity, examined the effects of thunderstorms, vibration, air currents, gravitational excitation, and so on. We examined the design elements of instruments, determined the effects of inelastic spring strain, Brownian motion, verified the sensitivity of the broadband instrument’s response function to variations the parameters of the elements around nominal values, and so on. There is no single solution to the design of seismic instruments. The best solution will depend on the some conditions: sensitivity, noise level, cost, dimensions, conveniences of manufacture, installation and operation and so on. The effect of the environment can be minimized at the stage of designing the device. Analysis was done in a general way and can be applied to the sensors of any design. Our hope is that this will lead to robust estimates of sensor self-noise.

Primary author: KISLOV, Konstantin (Institute of Earthquake Prediction Theory and Mathematical Geophysics (IEPT RAS))

Presenter: KISLOV, Konstantin (Institute of Earthquake Prediction Theory and Mathematical Geophysics (IEPT RAS))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
New Approach to Seismic Monitoring Networks: Objects, Equipment, Temporal Processes

The experience of monitoring using 3D seismic array is discussed: devices, programming, data processing and geophysical results. The array was created for seismic monitoring purposes on Chirkey hydropower plant dam in Caucasus region, Russia. Chirkey dam is a reinforced concrete construction 235 m height built in seismic hazard region.

The aims are: 1) to control the stresses within the dam and 2) to investigate the relation between tectonic deformation and seismicity. Discussed seismic 3D array was built with up-to-date technologies to satisfy both these needs.

The idea is to apply large constructions bounded with rocks as the peculiar strain sensor. The seismic network placed on construction is able to record not only earthquakes but weak seismic technical vibrations. Vibrations caused by turbine rotation act may be regarded as a seismic sounding signal needed for an examination of the construction. The map of amplitudes of this sounding signals recorded in different points shows the spatial distribution of its stress-strain state. As technical vibrations are persistent ones it is possible to obtain stress-strain maps with the short time intervals. Deformation processes as tides, weather influence, tectonic processes can be studied by temporal behavior investigation of the set of such maps.

Primary author: KAPUSTYAN, Nataliya (Institute of the Physics of the Earth Russian Academy of Science)

Presenter: KAPUSTYAN, Nataliya (Institute of the Physics of the Earth Russian Academy of Science)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of the CTBT Hydroacoustic Network

This presentation addresses the history of the CTBT hydroacoustic network, from its broad definition during negotiations of the Treaty through its early implementation by Provisional Technical Secretariat. It is based on the experience of the presenter during the negotiations of the CTBT (as chairman of the working group on hydroacoustic monitoring) and in the early days of the PTS (as chief of the section responsible for implementing the hydroacoustic-monitoring network of stations).

The period covered is approximately 1993 to 2004, a period encompassing definition of the concept of the hydroacoustic network and of the overall manner of implementing that concept. The overall rationale for the hydroacoustic network is addressed. The various technical choices that were made along the way are addressed, including rationale for the decisions concluded. Such issues include the number and location of stations and their technical characteristics.

Reflections are provided on some issues that could possibly provide further improvements to hydroacoustic monitoring. Also addressed is the issue of flexibility of developments in hydroacoustic monitoring.

**Primary author:** LAWRENCE, Martin (Former CTBTO)

**Presenter:** LAWRENCE, Martin (Former CTBTO)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Seismic analysts at the United States Nation Data Center (USNDC) routinely review events from repeating sources (e.g., mines, earthquake sequences). Typically these events are highly correlated and share similar station/phase associations. The USNDC has integrated a suite of efficient empirical signal detectors into the Detection and Feature Extraction (DFX) application that will simultaneously detect and identify events from repeating sources. The detector suite consists of array-based subspace and correlation detectors and a signal trace correlation detector. Detectors are trained manually using an interactive software application known as the Cluster Construction and Analysis Tool (CCAT). Cluster specific data are packaged by CCAT and imported into the USNDC framework for use in near-real time station processing. Multi-station detections from repeating events are associated to a common source, located using pre-computed empirical travel time corrections, and presented to analysts within the Analyst Review Station (ARS). Successful integration of this functionality into DFX has reduced analyst burden for repeating events allowing more time for interactive analysis of anomalous events. This work was performed in part under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract number DE-AC52-07NA27344.

Primary author:  KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

Presenter:  KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Automatic Time-Frequency Based Method for Signal Component Instantaneous Frequency Estimation

The field of time-frequency analysis provides a set of powerful tools for analyzing and processing nonstationary signals, i.e. signals with time-varying spectra. Majority of real-life signals are generally classified as nonstationary; some examples being acoustic signals, seismic signals, communication signals, etc. Time-frequency representations provide valuable information on the nature of analyzed signals, which is unavailable when the classical methods (instantaneous power or magnitude spectrum) are employed. Those time-frequency distributions of signal energy allow for detection and extraction of signal components by identifying dominant “ridges” in the joint time-frequency plane. From the local peaks of the ridges, the estimates of the components instantaneous frequency (IF) laws can be obtained. In this paper, we present an automatic method for detection of multicomponent signals individual components, and estimation of their respective instantaneous frequencies. The method is based on the cross Wigner-Ville distribution, and unlike many existing time-frequency techniques, it does not require prior information on the analyzed signal nor often cumbersome kernel filter parameters optimization techniques. The method is tested on both synthetic and real-life (sonar) signals, resulting in highly accurate IF estimates that outperform those obtained by using another recently proposed time-frequency IF estimation technique.

**Primary author:** SUCIC, Victor (University of Rijeka)

**Presenter:** SUCIC, Victor (University of Rijeka)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Integrated Field Exercise 2014: A True Testing Ground for the Application of On-Site Inspection Related Sciences and Technologies Under Field Conditions

Application of various techniques including data analyses and integration is at the heart of a CTBT On-Site Inspection (OSI). In order to realistically test and develop these aspects, field exercises are conducted on a regular basis. In 2011, the Preparatory Commission approved the conduct of another Integrated Field Exercise, which will be held in Jordan in late 2014.

IFE14 represents a crucial milestone in the development of the OSI verification regime. It will see the roll out of a series of techniques that have not been yet tested in an integrated manner, with 15 of the 17 inspection activities permitted under the Treaty being exercised.

Preparation and conduct of such a major activity requires both close coordination with the host country and support from other States Signatories. In this respect, ten Member States have offered various items of equipment as in kind contributions and experts from States Signatories will participate in the exercise in different functions such as Inspection Team, Inspected State Party or the Control Team members.

Our poster provides an overview of the objectives and scope of IFE14, information on preparations for this PTS-wide exercise and elaborates on inspection activities and techniques to be tested during the event.

Primary author: SUMMERS, Simon (Comprehensive Nuclear-Test-Ban Treaty Organization)
Presenter: SUMMERS, Simon (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Classification of Extensive Aftershock Sequences Using Empirical Matched Field Processing

Aftershock sequences following large earthquakes create problems for data centers attempting to produce near real-time event bulletins. The greatly increased number of events requiring processing can overwhelm analyst resources, reducing the capacity for examining events of monitoring interest. Waveform-correlation methods have shown promise for automatically identifying groups of events belonging to the same source region, allowing the more efficient analysis of event-ensembles rather than individual events. However, signals from very large earthquakes often correlate too poorly with signals from smaller aftershocks for correlation detectors to produce statistically meaningful triggers at the correct times. Empirical Matched Field Processing (EMFP) is a quasi-frequency-domain technique that recognizes signal patterns by calibrating the spatial structure of wavefronts crossing a seismic array in a collection of narrow frequency bands. It is a highly promising method for detecting pertinent arrivals with high sensitivity and a low false alarm rate and is here demonstrated to perform exceptionally in detecting aftershocks from the 2005 Kashmir and 2011 Van earthquakes. EMFP has the potential to produce reliable triggers of aftershocks in an evolving sequence such that correlation and subspace detectors can be created automatically, with well-chosen parameter specifications, to identify and classify clusters of very closely-spaced aftershocks.

Primary author: GIBBONS, Steven John (NORSAR)

Presenter: GIBBONS, Steven John (NORSAR)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of ANGLE Software for Quantitative Gamma-Spectrometry in CTBTO Radionuclide Stations

ANGLE software for semiconductor detector efficiency calculations (angle.dlabac.com) has been in use for 19 years now in numerous gamma spectrometry analytical laboratories all around the world. It allows for the accurate determination of the activities of gamma spectroscopic samples for which no "replicate" standard exists, in terms of geometry and matrix.

ANGLE is characterized by (1) wide range of applicability, (2) high accuracy, (3) ease of use, (4) short computation times, (5) flexibility in respect with input parameters and output data, including easy communication with another software and (6) suitability for teaching/training purposes. (7) It can readily be extended to users’ needs and/or fields of interest ("open ended" computer code). A key aspect and difference from other approaches, greatly enhancing practicality is that (8) no “factory characterization” of the detector response is required, i.e. (9) practically any detector may be used if some basic knowledge concerning its construction is available.

The above makes ANGLE perfectly suitable for gamma-spectromerical analyses at CTBTO Radionuclide Stations, both in automatic and man-assisted systems.

While developed at the University of Montenegro, ANGLE is commercially distributed by AME-TEK/ORTEC, U.S.A. (ortec-online.com).

Primary author: JOVANOVIC, Slobodan (Univertsity of Montenegro, Centre for Nuclear Competence and Knowledge Managemenet (UCNC))

Presenter: JOVANOVIC, Slobodan (Univertsity of Montenegro, Centre for Nuclear Competence and Knowledge Managemenet (UCNC))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Use of Wavelet Transformation Techniques in Structure of an Artificial Neural Network for Recognition of Early Arrival of Earthquakes on Strongly Noisy Seismic Records

The problem of automatic (in real time) recognition of seismic signals of the occurred earthquake is very important now. It is especially key for autonomous systems operating with an increased level of seismic noise, often having anthropogenous sources of an origin. This situation is typical when sensor systems are installed inside houses and buildings located in large cities or near big industrial facilities, airports, railways, and so on. In these cases, the first place is a problem to develop specialized processing system (algorithms) for noisy seismic signals received from local seismic sensors. The use of wavelet transform algorithm is embedded in the functioning of neural networks to allows significantly improve the accuracy of identification of early arrival of an earthquake in comparison with a systems based only on using of artificial neural networks or wavelet transform. Preliminary testing of the proposed system was made with using numerous data of real earthquakes (additional anthropogenous noise was added to data before test processing) recorded during the aftershock activity of the earthquake in Japan on 11 March 2011.

Primary author: GRAVIROV, Valentin (The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences (IPE RAS) / Institute of Earthquake Prediction Theory and Mathematical Geophysics of the Russian Academy of Sciences (IEPT RAS))

Presenter: GRAVIROV, Valentin (The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences (IPE RAS) / Institute of Earthquake Prediction Theory and Mathematical Geophysics of the Russian Academy of Sciences (IEPT RAS))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Air-Blast Data for Sayarim Calibration Explosions
Facilitate New Method of Source Identification and TNT Yield Estimation

Large on-surface explosions were conducted by the Geophysical Institute of Israel at Sayarim: 82 tons of strong HE explosives in August 2009, and 10&100 tons of ANFO explosives in January 2011 (initiated and supported by the CTBTO). The main goal was to provide strong controlled sources in different wind conditions, for calibration of IMS infrasound stations. High-pressure gauges were deployed at 100-600 m to record air-blast properties and provide reliable yield estimation. The rarely reported Secondary Shock (SS) phenomenon was clearly observed at the gauges, and numerous seismic and acoustic sensors. Empirical relationships for peak pressure, impulse, and SS time delay were developed and analyzed. The parameters, scaled by the cubic root of estimated TNT equivalent charges, were found uniform for all explosions, except of SS delays, clearly separated for 2009 and 2011 shots, thus demonstrating clearly dependence on the type of explosives with different detonation velocity. Additionally air-blast records from non-Sayarim shots, were used to extend the charge and distance range for the SS delay relationship, and showed consistency with Sayarim data. Obtained results evidence that measured SS delays can provide important information about an explosion source character, and can be used as a new simple cost-effective yield estimator.

Primary author: GITTERMAN, Yefim (The Geophysical Institute of Israel)
Presenter: GITTERMAN, Yefim (The Geophysical Institute of Israel)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
CTBT-Related Activities

At the 29th session of WGB the RF delegation officially stated that the E-training and simulation system software for OSI developed by VNIIA would be a gratuitous contribution of the Russian Federation to CTBT monitoring regime. At present the training system is being updated under the contracts between CTBTO PrepCom and VNIIA.

An expert system computer model that is intended for providing assistance to an inspection team during OSI is under development, it contains a knowledge base related to OSI-triggering events, nuclear test scenarios, appropriate search objects and methods of their detection. Based on IDS products, geophysical and radionuclide information is regularly collected and analyzed in order to reveal events indicating possible non-observance of the Treaty by other states – parties to the Treaty. For the last 10 years a few tens of events have been revealed in areas of nuclear test site that, judging by some screening criteria, can be referred to the category of test explosions.

**Primary author:** ZASIMOV, Gleb (All-Russia Research Institute of Automatics named after N.L. Dukhov (VNIIA))

**Presenter:** ZASIMOV, Gleb (All-Russia Research Institute of Automatics named after N.L. Dukhov (VNIIA))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Simulation and Manufacturing a Seismic Geophone in Iran

For the years, seismic geophone production technology has monopolized to industrial countries and developing countries were less engaged in this field. Recent scientific researches and extending of exploration seismology in developing countries has persuade them to work on this important field of instrumental seismology as a base of safe and low cost instrument production.

As our case, we have taken great steps towards advance sensor technology and this paper presents manufacturing and analysis of a novel, absolute velocity geophone. Main geophone parameters; resonant frequency, magnetic flux of permanent magnet, and physical dimensions, were considered as inputs and spring dimensions, spring stiffness, spurious frequency and the generator constant are obtained as outputs.

Applying professional ANSYS analysis; effects of variation in proof mass, spring design, and damping constant of coils on frequency response to step and random vibration are studied.

Static stress analysis of springs in horizontal and vertical directions are calculated and results were used optimizing output parameters. A geophone with frequency of 10Hz and proof mass of 10gr is designed which its distinctive characteristic is having high spurious frequency of 460 Hz in comparison with existing types. Finally the theoretical and simulations are compared to the real experimental data.

Primary author: AHMADIAN, Hossein (GeoPersian Company)

Presenter: AHMADIAN, Hossein (GeoPersian Company)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
System of E-M Seismometer Calibration Using a Statistical Method by Removing a Step of Current Applied to Signal Coil

The calibration of seismic sensors is a fundamental step in the implementation, the monitoring and the maintenance of seismic stations. The technique of removing a step of current from their signal coil is one of the most used with geophones. However, in some particular circumstances, where the probe is directly placed on the ground surface, a high level of background seismic noise can alter the results provided by this technique. A statistic experimental method of calibrating an electromagnetic seismometer is introduced to overcome this challenge. It is to calculate the mean and the standard deviation of the three important characteristics for the seismometer over a great number of calibrations assumed to be identical. This process is automated in all its stages to simplify the task for the manipulator. An electronic bench and a software program are designed and realized for this purpose. The electronic bench was realized around an electromechanical relay, while the program we have made is realized under LabVIEW platform.

The statistic experimental calibration method based on signal coil excitation with a step of current is very accurate confronted to other methods. We have also studied the effect of different parameters on the results provided.

Primary author: ATMANI, Abderrahman (ENSA, Ibn Zohr University)

Presenter: ATMANI, Abderrahman (ENSA, Ibn Zohr University)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Acoustic Noise Cancelling Structures with Electrical Analogies

The use of electrical circuit elements to model physical devices has a long history of success. The analogy between flow of air and electrical current is mathematically accurate; momentum of a section of a gas also called Inertance is directly analogous with the electrical parameter Inductance. The compliance of a transmission vessel (hose or pipe) is directly analogous with electrical capacitance. Using these elements combined into a transmission line structure allows the analysis of leaks in the structures, and resonances with a circuit simulator such as SPICE (S.W. Director et al.). This paper will present preliminary results on the prediction of noise averaging characteristics of distributed input transmission lines such as soaker hoses and collections of end driven tubular transmission lines such as rosettes. Results to be presented include basic models of leaky hoses and end driven pipes with spatially distributed excitation. Resonant effects, attenuation, dispersion and summing of acoustic signals will be presented. The model will be used to compare the effectiveness of two of the current noise cancelling regimes used for Infrasound recording.


Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Processing of Seismic and Infrasound Monitoring in Northeast Italy: The Fadalto Case

In 2012 in the Fadalto area in the Belluno province several strong rumbles were heard, which eventually scared population and concerned authorities. The Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) in cooperation with the Earth Science Department of Florence University installed an integrated real time seismic and infrasound monitoring system in the area to understand the origin of the rumbles. A description of the technical system capabilities, together with the preliminary results of the analysis of several months of recordings will be illustrated.

Primary author:  PESARESI, Damiano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS))

Presenter:  PESARESI, Damiano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS))

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Broadband Seismometer

The seismometer is intended for mass observations. The pendulum of the seismometer has a period regulated up to 2 seconds. The feedback circuit is of the force-balance type. As the converter of fluctuations of the pendulum to an electric signal the differential capacitor converter is used with a resolution better 10E-10 m. The sensor electronic self-noise is below the NLNM from 100 sec to 10Hz. As a result the seismometer represents a force-balance velocimeter with a response as flat as possible in a range of frequencies 0.0083 – 40 Hz. Set includes one vertical and two horizontal seismometers, control and conditioning unit ("Host-box"). Vertical and horizontal seismometers are designed on the basis of physical pendula with identical mechanical parameters. The “host-box” contains a DC/DC converter, electronic feedback circuits, and other control, output and calibration signal distribution. The seismometer can automatically re-center the boom position. The “host-box” provides separate input to the calibration coil to allow individual excitation of the sensor. Standard velocity response is flat from 120 seconds to 40 Hz. The velocity response can be made flat up to 240 sec period if desired.

Primary author: GRAVIROV, Valentin (The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences (IPE RAS) / Institute of Earthquake Prediction Theory and Mathematical Geophysics of the Russian Academy of Sciences (IEPT RAS))

Presenter: GRAVIROV, Valentin (The Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences (IPE RAS) / Institute of Earthquake Prediction Theory and Mathematical Geophysics of the Russian Academy of Sciences (IEPT RAS))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Estimation Procedures That Enhance Homomorphic Wavelet Deconvolution

The Cepstral processing has made its mark in a number of applications since the first papers were published in the 1960’s. The principal author demonstrated the technique on biomedical data in his dissertation. Subsequent research was done on hydroacoustic, seismic, infrasound, gear-fault, and ground penetrating radar data. In most of these applications, the Complex Cepstrum was used, requiring the phase information to be utilized in the process. This current research employs a novel approach to the use of predictive filtering, that being, the use of a predictive filter on the Complex Cepstrum to remove the effect of the echo. This removal process has traditionally been accomplished by the use of a “comb” lifter. However, in many cases, this comb lifter causes severe distortion in the recovered wavelet partly due to the phase unwrapping problem, as well as the distortion caused by the necessary Nyquist filtering of the data. Additional signal processing techniques explored are time series weighting, zero padding of the data, and employing higher sample rates. Examples are shown on modeled data as well as on data from real events which demonstrate these improvements in the deconvolution process.

Primary author: KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

Presenter: KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Analysis of Nigerian National Network of Seismological Stations (NNNSS) as Auxiliary Stations at EIF

Nigeria is not located where there are major seismic activities. But in the south western part of Nigeria a fault line the Ifewarw-Zungeru fault is believed to exist. This fault has made it possible for the country to experience pockets of tremors of magnitudes with ranges of 4.3 to 4.5 mostly in the south western part. The dynamism of the earth has made it imperative for early warnings and proactive measures using seismological equipment for hazard monitoring to be put in place. National Agency for Science and Engineering Infrastructure (NASENI), Abuja established the Nigerian National Network of Seismological Stations (NNNSS) and transferred it to the Centre for Geodesy and Geodynamics, Toro for effective management in 2006. For any network to be considered as being efficient it must have the following parameters in place - human resources, structural capital, social capital, human capital and infrastructural capital other parameters include political, economical, social, technological and legal environments. An analysis of the strength, weakness, opportunities and threats of the NNNSS is conducted to assess its potentials of serving as auxiliary stations at EIF.

Primary author: MADU, Uchenna Onwuhaka (Nigeria Atomic Energy Commission)

Presenter: MADU, Uchenna Onwuhaka (Nigeria Atomic Energy Commission)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Technique on Earthquake Data Recording Based on an ARM IP Linux Base System

A sophisticated earthquake data recorder, based on ARM technology, has been developed and improved based on the last standards in the world of seismic data recording assigned for earthquake studies. Abilities of exact timing, low power consuming, long time field operating without maintenance, remote access and remote setting of parameters, customizable data sampling and various modes for recording with different formats of output data are just some the most important features of the developed instrument. It relies on a combination of commodity hardware and free, open-source software to deliver provable data recording quality. For accurate timing, routine GPS data is combined with the very low-jitter synchronization pulses modulated on the same signal and fed directly into a 24-bit analog-to-digital conversion unit. Samples thus acquired and time stamped are then collected and stored as self-describing, self-contained miniSEED streams, one per data channel. These seismography-specific functions are then presented, thanks to the versatility of the Linux kernel and accompanying userland tools, via a user-friendly web-based interface that can be accessed over any IP network on any web-capable device like general smart phones. Remote configuration, with proper access controls, is also provided through the interface.

Primary author: SEIF POUR ABOLHASSANI, Ali (GeoPersian Company)

Presenter: SEIF POUR ABOLHASSANI, Ali (GeoPersian Company)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Effective Radionuclide Methods for Identification of Nuclear Testing Venues

The authors of research propose development of a new effective method for locating a nuclear test by using tritium. The objects of the study were in the test area (wells, tunnels), as well as epicenter of surface and excavation explosions of the Semepalatinsk Test Site. At each object was carried out tritium distribution through ecosystem elements - surface and groundwater, air, snow, vegetation and soil. During research work was design the individual scheme for study of each object - boreholes, tunnels, epicenter of explosions. Methodology of research of level and distribution of tritium in the different object of ecosystems has also been developed. According of results the tritium content in water is about 1•10^5 Bq/l, in the air is up to 1 400 Bq/m3, in vegetation – up to 1•10^6 Bq/l, in the snow cover is about 500 Bq/kg, in soil – up to 50 000 Bq/kg. Based on all of the data will be held on the selection of the most effective elements of the ecosystem, which could be used as an indicator of nuclear test.

Primary author: LYAKHOVA, Oxana (Institute of Radiation Safety and Ecology, National Nuclear Centre of the Republic of Kazakhstan)

Presenter: LYAKHOVA, Oxana (Institute of Radiation Safety and Ecology, National Nuclear Centre of the Republic of Kazakhstan)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
False Event Solutions Using Archived Data and Logistic Regression

The archive of automated and reviewed event solutions residing at the International Data Center (IDC) is a valuable resource for improving the performance of event formation algorithms. Here, logistic regression is used to identify a set of event-centric (explanatory) variables for determining the validity of automated event solutions. The resulting logistic model computes the conditional probability that an event is valid given the values of the explanatory variables. A collection of logistic models are assembled from different combinations of explanatory variables and an optimum model identified based on their receiver operating characteristics, Akaike information criterion, and goodness-of-fit metrics. If successful, logistic models for Global Association (GA) grid cells with a sufficient number of historic events can be developed and used to validate preliminary event solutions. Rejection of preliminary event solutions with low probability of occurrence may reduce the number of events formed by GA having mixed, merged, or false associations. This work was performed in part under the auspices of the U. S. Department of Energy by Los Alamos National Laboratory under contract number DE-AC52-06NA24569.

**Primary author:** KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

**Presenter:** KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Maintainability and Reliability of Operations of the Northeast Italy Seismic Network

The Centro di Ricerche Sismologiche (CRS, Seismological Research Center) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS, Italian National Institute for Oceanography and Experimental Geophysics) in Udine (Italy) after the strong earthquake of magnitude M=6.4 occurred in 1976 in the Italian Friuli-Venezia Giulia region, started to operate the Northeastern Italy Seismic Network: it currently consists of 17 very sensitive broad band and 18 simpler short period seismic stations, all telemetered to and acquired in real time at the OGS-CRS data center in Udine.

Real time data exchange agreements in place with other Italian, Slovenian, Austrian and Swiss seismological institutes lead to a total number of about 100 seismic stations acquired in real time, which makes the OGS the reference institute for seismic monitoring of Northeastern Italy.

At OGS-CRS we spent a considerable amount of efforts in strengthening the reliability of data links, exploring the use of redundant satellite/radio/GPRS technologies: this in turn helped in improving maintainability and reliability of operations of the overall seismic network, which results will be shown.

Primary author: PESARESI, Damiano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS))

Presenter: PESARESI, Damiano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Xe and Kr Radionuclides Generator for Calibration and Functional Testing of Equipment

Radionuclide 252Cf is disintegrate main by alpha decay, half-life period T1/2 = 2.645 years (97%) and also by spontaneous fission with T1/2 = 86 years (3%). Number of spontaneous fissions ~ 610 fissions sec⁻¹ ng⁻¹. Thus, in 252Cf specimen the whole spectrum of fission products (fragments) is formed, including 133Xe, 135Xe, etc. Xe radionuclides generator is designed as a stainless steel hermetic cylindrical ampoule 8 cm³ by volume.

The generator contains about 1.5 ng of 252Cf; gamma-radiation dose rate is not more than 0.4 microSv/h at the distance of 15 cm from the protective case; neutron flux is ~ 2400 neutron/sec. During one month are accumulated: 133Xe - 19 Bq, 135Xe - 25 Bq, 133mXe - 0.6 Bq, 131mXe - 0.1 Bq per ng 252Cf. Radionuclide 131I (T1/2=8.02 days), which decays to 131mXe, can be added to the Xe(Cf)-generator. Then the removed xenon radionuclides gases mixture will be enriched in 131mXe.

Thus the generator may be used as the system for radionuclides monitoring stations, laboratories and on site inspection teams in field use.

The construction of Xe-Kr radionuclides generator as a sealed source provides its classification in accordance with International radiation safety regulations.

Primary author: DUBASOV, Yuri (Khlopin Radium Institute)

Presenter: DUBASOV, Yuri (Khlopin Radium Institute)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
and Integration of CTBTO IDC and the Integrated Northeast-Italy/Austrian Seismic Networks Operational Systems

The Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) in Udine (Italy) after the strong earthquake of magnitude \( M=6.4 \) occurred in 1976 in the Italian Friuli-Venezia Giulia region, started to operate the Northeastern Italy Seismic Network: it currently consists of 17 very sensitive broad band and 18 simpler short period seismic stations.

The Zentralanstalt für Metereologie und Geodynamik (ZAMG) in Vienna (Austria) run the Austrian Seismic Network to monitor in real time the seismicity in the Austrian territory. ZAMG maintains also the Conrad observatory, which is a permanent laboratory for various kind of geophysical experiments: it is currently used as a test site also by CTBTO.

Since 2002 OGS in Italy and ZAMG in Austria are using the Antelope software suite as the main common tool for collecting, analyzing, archiving and exchanging seismic data in real time, initially in the framework of the EU Interreg IIIA project “Trans-national seismological networks in the South-Eastern Alps”.

In this presentation we will illustrate the monitoring capabilities of the integrated Northeast-Italy/Austria seismic system and the comparison with the CTBTO IDC monitoring capabilities in the same area in terms of earthquake location and magnitude determination accuracy.

**Primary author:** PESARESI, Damiano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS))

**Presenter:** PESARESI, Damiano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Application of Small-Aperture Infrasonic Arrays in Geophysical Measuring Network of MCSM

Presently, the Main center of the special monitoring (MCSM) disposes two three-element small-aperture infrasonic arrays on Ukrainian territory that are located near Malin and Kamenets-Podol’skiy cities. The identification of seismic source in mine by infrasonic array can specify was it mining explosion or anthropogenic accident. The monitoring of large-scale atmospheric sources can also be as an example of intercommunication from the natural phenomena. Cyclonic activity generates microseismic noise in ground and microbaroms in atmosphere, which are registered by seismic and infrasonic sensors. The pictures from spacecraft and weather-charts serve as additional information. Microbaroms from North Atlantic which were registered by Ukrainian infrasonic arrays can be the example of registration. The sets of back azimuths on a source are extracted from both infrasonic arrays. The estimated distances to the source are varied within the limits of a 3000 – 3400 km. The trajectory of microbaroms motion was defined by theta-theta method. The mutual location of arrays is successful to get the acceptable estimations of location of source of microbaroms. For possibility to estimate signals from any direction, additional infrasonic arrays will be installing during 2013.

**Primary author:** KARYAGIN, Yevgeniy (Main Centre of Special Monitoring)

**Presenter:** KARYAGIN, Yevgeniy (Main Centre of Special Monitoring)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Motion Force Balance Triaxial Accelerometer

The accelerometer is a triaxial surface package useful for many types of earthquake recording applications. It is suitable for seismology and civil engineering applications. The unit consists of three force balance accelerometer modules mounted orthogonally in a compact aluminum case featuring a bolt anchoring slot and an integrated bubble level. The advanced features of the accelerometer include large linear range, high resolution and high dynamic range. The accelerometer has DC response. The standard frequency pass band is flat to acceleration from DC to 100 Hz. With full-scale recording range +/- 2.5g the accelerometer provides on-scale recording of earthquake motions even at near-fault locations. The accelerometer is ideal for applications where the instruments are difficult to access.
Ground-Truth Historical Data as a Substance for the New Master Event Representation Conception

The efficiency of cross-correlation (CC) and master event technique in CTBT global monitoring was presented at (Bobrov, 2012), (Kitov, 2013). The main CTBT monitoring goal is successful detection and location of clandestine nuclear explosions, so the CC global monitoring should be focused on extraction of such events first of all. As shown in (Bobrov, 2012), using adequate master may increase the number of events in REB up to 70%, while inadequate master may increase the number of bogus events and suppress valid events. In order to enhance the CC technique in given direction, a research conducted on defining the best master as a choice between real master event (explosion, recorded at IMS primary stations), transposed master event (synthesized at primary IMS station based on information from auxiliary station), and fully synthetic event built for primary station (Rozhkov, 2013). We used data from DTRA Verification Database to check the validity of approach. Multichannel seismograms of explosions conducted at different sites recorded at IMS stations analyzed, as well as multichannel seismograms created from the 3C stations. The detection and location results based on real, transposed and synthetic events were compared to make a decision on the most adequate master event representation.

Primary author: ROZHKOV, Mikhail (CTBTO)
Presenter: ROZHKOV, Mikhail (CTBTO)
Track Classification: Theme 3: Advances in Sensors, Networks and Processing
NET-VISA Progress and Enhancements

NET-VISA (NETwork processing Vertically Integrated Seismic Analysis) is a generative probabilistic model of global-scale seismology, as well as an inference algorithm for deducing the most probable seismic bulletin. The overall model has the following main parts: a prior for seismic event locations and magnitudes, a forward model for the transmission and attenuation of seismic waves, a probabilistic model for the detection of various seismic phases at a global network of seismic stations, as well as a model for false and coda detections. In this work we describe various enhancements to the NET-VISA model. Some of these enhancements are designed to ensure that the model corresponds better with seismological knowledge, for example the order of seismic phases and the correlation between their attributes. Other enhancements are designed to more efficiently detect weak seismic events in seismically actively regions using, for example, typical seismic energy radiation patterns. We also present results of the ongoing evaluation at the IDC (International Data Center), where NET-VISA has been running continuously since June 2012. These results indicate that NET-VISA can reduce the number of missed events by a factor of 2 to 3 while keeping the same rate of false events as the existing network processing.

**Primary author:** ARORA, Nimar (Bayesian Logic, Inc.)

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Generation Radioxenon Systems - More Reliability, Better Sensitivity, and More Frequent Measurements

Measurement of radioxenon gas concentrations in the air is an important part of verification of underground nuclear explosions, and automated measurements have been ongoing for over ten years in the International Noble Gas Experiment (INGE). Lessons learned from system development and field measurements illustrate opportunities for improvement in the next generation systems in the area of increased sensitivity and reliability. The increased sensitivity is needed to allow better discrimination of radioxenon signals from medical isotope production facilities and nuclear power reactors from nuclear explosions. Increased reliability will help reduce operational and maintenance costs for these systems which are often located in remote sites with limited accessibility. These increased capabilities are being implemented into the next generation system called Xenon International. Increased sensitivity will be achieved by increasing the collected xenon volume and also by increasing the sampling frequency. Improvements in gas processing technology and control system software will reduce power and other system consumables, and increase the system uptime and data availability. This paper will discuss the technical and operational requirements of this system along with the expected performance improvements.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of the IMS Radionuclide Detector Network and Lessons Learnt for Exotic Physics Searches

The diverse range of locations, continuous operation, and system uniformity of the IMS radionuclide network permits an unprecedented opportunity to evaluate long-term systematic effects on HPGe detector stability. An understanding of these effects is often crucial to physics experiments designed to evaluate exotic or anomalous nuclear decays over many years. In a unique effort to investigate reports of anomalous nuclear decay, we evaluate the $^{152}$Eu branching ratio for evidence of periodicities over many years using the daily “check source” measurements of multiple IMS Radionuclide Automated Sampler / Analyzer (RASA) detectors. After studying systematic effects across many RASA detectors, we document a number of statistically significant and unexplained periodicities occurring among the measured check source photo-peaks. The implications of these unexplained periodicities are examined in the context of searches for new physical phenomena and related to results of other recent experiments reporting anomalous decays. In addition, we also seek to highlight the applicability of techniques in High Energy Physics and Bayesian analytic methods in the review of IMS detector diagnostics and time-series interpretation of radionuclide data.

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Analysis of Aerial Radiological Overflights and Implications for Nuclear Testing Scenarios

Optimal use of on-site inspection radionuclide team resources requires an accurate understanding of the detection sensitivities of the equipment used for the various radionuclide measurement techniques. Parametric analysis of these sensitivities in terms of equipment design and measurement procedures can also provide input to help refine requirements for equipment, data processing, and operational strategies.

In this effort, we present an analysis of the expected minimum detectable concentrations (MDCs) of particulate radionuclides on the ground after a vented underground nuclear explosion. The MDCs are determined as a function of detector size, flight parameters, and data processing method. We find that the minimum fraction of particulate radionuclides that must be vented in order to detect their presence on the ground via aerial overflight is no greater than $10^{-5}$ for a notional underground nuclear explosion, and even less venting can be detected under favorable conditions with simple data processing methods. The calculated values for minimum detectable venting imply that the presence of OSI-observable radioactive particulates on the ground is plausible based on historical radioactivity release data from U.S. underground nuclear tests.

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Optimization of Beta-Gamma Detector Calibration for Xenon Detection

Three of four radio-xenon monitoring systems have been developed based on beta-gamma coincidence. Most important step in operation of Xe detection system is calibration by standards. An efficient method to accomplish this step is established using 137Cs gamma source. In that case the source position and detector geometrical design might effect the results. This paper will focus on some experimental study to explore radiation and light transport effects to calibration results.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Artifacts Recorded on the Ukrainian Experimental Infrasound Network

Ukrainian experimental infrasound network consist of two small aperture infrasound arrays. All array has 3-4 elements and equipped by micro barometers K-304-A type and have aperture around 130-150 m. Traditional CTBTO data processing using the 20 Hz simple rate and frequency band about 0.02 .. 4.0(8.0) Hz. In the Ukrainian infrasound arrays uses data with 40 Hz simple rate (and possible up to 80 Hz in case modification of micro barometers). Full current frequency band for research is around from 0.003 to 10-16 Hz.

In the data of "western" array (location Kamenets-Podolsky) using the data processing in "non-CTBTO" frequency sub bands the specific infrasound signals (artifacts) were detected. Some of high frequency signals were identified like signals from area of river Power station on the distance about 50-70 km to east. And some high and low frequency signals were not identified to man-made or natural sources. It mean that necessary to proceed research for studying of the atmospheric processes in area of Ukraine for good understanding they.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Developments of Seismometers in Russia

Various companies in Russia are engaged in development of such seismometers. Borehole seismometers on the basis of modules SEP-1 and SM-6 as well as seismometers SSKV and SSB3 can be considered the most promising developments for installation at IMS seismic stations.

Modules SEP-1 have been developed with the use of magnet suspension of inertia mass and employment of feedback. There are two modifications of modules SEP-1: short period and broadband with operating frequency ranges 0.5-50 Hz and 0.02-50 Hz respectively and lowered self-noise level. Pilot models of short period vertical and broadband 3-component borehole seismometers have been produced on this basis.

Modules SM-6 are a smaller analog of a well-known seismometer SM-3KV manufactured on the basis of magnet suspension of inertia mass and a magnetoelectric transducer. A small size of module SM-6 makes it possible to produce seismometers for installation in Ø150 mm boreholes. The operating frequency range of 0.5-40 Hz, a very low level of self-noise and a wide operating temperature range (from -20° to +45°C) make this seismometer perspective for use as part of technological equipment of seismic arrays in various regions of the Earth, including permafrost regions.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Grid of Master Events for Waveform Cross Correlation: Design and Testing

Seismic monitoring of the Comprehensive Nuclear-Test-Ban Treaty requires a uniform coverage of the earth. The global use of waveform cross correlation for monitoring purposes is hindered by the absence of master events outside the zones of seismic activity. To populate the aseismic areas we have studied two principal approaches. Around the seismically active areas, we replicate real events best representing seismicity in a given region and distribute them over a regular grid to distances ~1000 km. These replicated events are called "grand masters". For remote aseismic areas, we calculate synthetic seismograms for a regular grid of master events and a predefined set of array stations of the International Monitoring System. Both approaches were tested and showed a resolution similar to the use of real events. Considering three types of master events, we have created a regular and uniform grid with approximately 100 km spacing between nodes as obtained from the equilibrium distribution of charged particles over the earth’s surface. We have created three versions of the grid: v0.1 with only synthetic templates, v0.2 with real masters added where possible, and v0.3 with grand masters added. The performance of v0.1 has been assessed.

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**Presenter:** KITOV, Ivan (CTBTO)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Local Seismic Networks to Reach a Reliable Activity Detection of Earthquake Sources

Local, regional and global research of the Earth’s interior is the oldest goal of seismology. Seismic networks are and will be probably forever the only tool that enables study of the detailed structure and physical properties of the Earth. The inherent error in regional and global networks are as high that can’t give accuracy to determine the exact trend and depth of seismic sources and enough evaluation for early warning networks and rapid response systems which can effectively reduce the natural hazard of earthquakes. Recently, many local networks are operating for various goals of seismology in Iran and this definitely will increase the quality of studies and can prepare lots of informative data that directly relates to seismic hazard assessment. These networks have reduced the magnitude of completeness of seismic catalogs and increase the knowledge of crustal properties which will prepare a huge data bank to define realistic 2D, 3D earth models. These data banks are introduced and some recent advantages of them are discussed. They play a great role on seismic hazard mitigation especially in country such as Iran with high rate of seismicity.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
for Measurement of Low Activity Argon-37

The Khlopin Radium Institute conducts research targeted to creation of highly sensitive low-background installation, capable to satisfy the OSI required range of measuring argon-37 concentration. On the basis of this installation the liquid-scintillation principle of registration of low-energy electrons of argon-37 is used, and condensed argon itself is used as scintillator. Condensed argon represents sample isolated from the subsurface air by means of some processing procedure. Even minor impurities of nitrogen and oxygen, are inevitably presented in argon samples isolated from the air, causing quenching of scintillations, particularly their slow component. Inclusion of this adverse effect and the determination of amendments to the detection efficiency change are similar to that used in the measurement of tritium by the classic liquid scintillation measurement method - using the detection efficiency depends on the ratio of triple and double coincidence. Currently assembled prototype of installation, is being evaluated. The preliminary value of the minimum measured argon-37 activity in the sample of the liquid argon of 20 cm³ volume is about 0.1 Bq for a 5-hour exposure. This equivalent to the 2 m³ of processed air, that corresponds to 50 mBq/m³ subsurface argon-37 of measurement sensitivity, that is 20 times more sensitive than MARDS.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Seismometer for Seismomonitoring Networks

The seismometer is intended for the modernization of existing teleseismic networks for mass observations. The sensors are designed as observatory instruments. A feature of the device offered is the use of a pendulum with a period regulated up to 58 seconds. The vertical pendulum of the seismometer is configured using the Lacoste design. The spring is manufactured from highly stable alloys with unique Russian manufacturing techniques of a twisted cylindrical spring with zero initial length. The astatic mechanical elements used in the device has allowed the development of a compact superbroadband pendulum with inertial weight only 2 kg. The feedback circuit is of the force-balance type that is now standard in electronic seismometers. As the converter of fluctuations of the pendulum to an electric signal the differential capacitor converter is used with a resolution better 10E-10 m. The sensor electronic self-noise is below the NLNM from 300 sec to 5Hz. As a result the seismometer represents a force-balance velocimeter with a response as flat as possible in a range of frequencies 0.0015 – 15 Hz. Devices of this type do not exist in the world now.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
The IMS primary seismic network consists of 50 monitoring facilities where several certified stations are facing equipment obsolescence issues. The search for engineering solutions to replace obsolete hardware components is guided by two primary goals: 1) be compliant with IMS minimum technical requirements and 2) be able to be integrated with the existing system.

In context of technical specifications for seismic stations it was earlier stressed that verification seismology is concerned with searching for reliable methods of signal detections at high frequencies. Special attention was taken in redesign of short period vertical components of PS09, Yellowknife teleseismic array in Canada.

Array elements at PS09 comprise S13 seismometers designed by Geotech USA, connected to 24-bit CMGDM24EAM digitizer through the low-noise preamplifier both designed by Guralp Systems Ltd., UK.

The Sandia National Laboratories (SNL), USA have played a key role in the system integration testing of this system, assuring the PTS and Station Operator received a high-quality solution for the array.

The equipment was evaluated at SNL for performance characteristics of bit-weight accuracy, self-noise level, clip point, dynamic range, cross-talk, and harmonic distortion. The capability of full frequency calibration of the seismometer using white noise and sinusoidal signals as stimulus was confirmed.

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**Presenter:** STAROVOYT, Yuri (Comprehensive Nuclear-Test-Ban Treaty Organization/IMS Division)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Digital Seismic Network – The Way Forward and the Challenges

The threat of earthquakes has compelled the Government of Ghana to fund the purchase and installation of Digital Seismic Network to replace the defunct analogue seismic network. The six remote Libra VSat seismic network is now transmitting the various levels of earthquakes and their frequencies of occurrence successfully. The software programmes installed gives automatic location and magnitude determination of seismic events. It also allows post processing of events manually and moment tensor determination to study the stress regime and constraint the depth of faulting. Also ten stand alone strong motion accelerometers has been installed on some major dams in Ghana. The data from the seismic sensors will be used for studies into the internal properties of the earth and to obtain ground motion estimates to generate a new national seismic hazard map to form the basis for land use planning and building codes formulation etc. The way forward is to have open data sharing with the Global Seismological Community, especially within the West African sub-region to study the level of activeness of the West African craton through partnership and co-operation. Funding for the maintenance and upgrading of the network and activities within the sub-region is the key challenge.

Primary author: OPOKU, Nicholas (Geological Survey Department)
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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of P Wave from an Earthquake Using Locally Trained Neural Network

The algorithm put forward in this paper is designed for devices that provide ultrashort warning of earthquakes. It is based on the time difference between the arrivals of P and S waves. The difference is small, but rapid identification of a P wave arrival from a large earthquake is useful for mitigating the impact of such an earthquake, in particular, human losses. The method we propose is based on neural network recognition and can deal with the problem as stated above rather accurately and rapidly. Indeed, the training of a local network by local data (in contrast to the training using a “universal” sample) can significantly reduce the warning error. This study demonstrates the point by a Japanese example.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of the Tunisian NDC in the Field of Infrasound Detection and Calibration

The Infrasound Station IS48, in Kesra, Tunisia is part of the verification regime for the Comprehensive Nuclear-Test-Ban Treaty. IS48 was installed in 2006 and is managed and maintained by the Tunisian NDC. Since 2006, the NDC-TN staff has gained and acquired a good experience in the operations and activities related to the station. In addition to that, the good location of IS48 in the middle of the Mediterranean Sea allows to have various and interesting detections.

In this poster we will show two independent aspects: the aspect related to the station and the one related to the data analysis and the results obtained.

For the first aspect we will present some activities related to the maintenance of the station IS48 done by the technical staff of the NDC-TN such as the WNRS pressure test and the in-situ calibration.

The second aspect related to the results obtained from the data analysis will present the detections of IS48 (Explosions, Italian Volcanoes activities, Oceans swell ...) and show how the performance of the station is influenced by the seasonal wind direction.

Primary author: KHEMIRI, Lotfi (CTBTO)

Presenter: KHEMIRI, Lotfi (CTBTO)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Monitoring System in Belarus

Chernobyl accident has shown an importance of maintenance of high level national system of reaction in the case of radiological accident. In Belarus the general assessment of the radiological situation and the control of radioactive contamination of settlements and surface water are carried out by several governmental bodies: Ministry of Emergency Situations and Ministry of Environment protection. Observation over a natural radiation background and radioactive contamination are conducted on points of observation (stations and posts, observant alignments on water objects, observant chinks and hydro-geological posts arranged on sites with natural and broken ground water dynamics) and on 4 automated systems of radiating control in nuclear power plant’s influence zones. Radiation monitoring system can effectively detect the excess of background radiation in Belarus. But at the same time it can not predict distribution of radionuclides from the territories of neighboring states in the case of an emergency. In this situation, the most effective is the use of radionuclide monitoring data provided by the CTBTO International Monitoring System. National Data Center provides daily observations of radionuclide station RN33 (Germany), RN61 and RN54 (Russia), RN63 (Sweden) and RN40 (Kuwait). These stations are located in the immediate vicinity of the territory of Belarus.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Results of Detection and Location of Infrasound Events in Central Eurasia Using Data of IS46 Zalesovo Station Along with Data from the New Kurchatov Infrasound Array in Northeast Kazakhstan

KNDC (Kazakh National Data Center) acquires and processes data from seismic and infrasound stations located on the territory of Kazakhstan and adjacent Central Asia countries. At the present time, KNDC receives data from three infrasound arrays - IS31, IS46 and Kurchatov. The new infrasound array Kurchatov, North-East Kazakhstan, was installed on December 2010; IS46 Zalesovo infrasound array of the IMS located 560 km north-east of it has been operating since 2006. In 2010 – 2011, 38% of infrasound arrivals in REB are from IS46. Most IS46 arrivals associated with mining activity (Green 2011). Automated bulletins of infrasound detections are compiled in KNDC using infrasound stations data. The PMCC detector is used. Epicenters of infrasound events were located by known backazimuths from the stations IS46 and Zalesovo. First results of this technique application showed that data of these two stations allow to locate large number of infrasound sources quite accurately. In future, a database of ground truth events can be compiled for Central Eurasia using origin times for these events taken from seismic bulletins compiled in KNDC.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Two Closely Spaced Infrasound Sources Using Ray-Tracing Modeling – A Case Study

During an infrasound field campaign clear infrasound signals were observed on 16 February 2012. Media reports suggested a gas explosion source in Luxemburg, but an inquiry with the Federal Armed Forces (Bundeswehr) Airforce Information Center confirmed a supersonic flight at approximately the same time and in the same region. This case thus provides the opportunity of identifying the true source from infrasound propagation modeling using ray-tracing, as a reasonable evasion scenario within the task of verifying the CTBT. In local seismic station data we identified seismo-acoustic arrivals hinting at a source near Bitburg, Germany. According to the ground-truth information, the supersonic flight path was at almost 11 km altitude. Ray-tracing modeling was carried out using the HARPA/DLR code towards the station profile east of Heilbronn and IMS station IS26 located between 250 and 560 km east-southeast from the sources. The modeling from a ground-based explosion in Luxemburg predicts a less complex arrival pattern compared to an infrasound source at altitude, consistent with the observations. Our case study therefore highlights the potential of resolving the ambiguity of source inversions, when only a few infrasound stations record an event, a case highly likely with only 60 IMS infrasound stations world-wide.

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Presenter: KOCH, Karl (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
3: A New Microbarometer with Internal Calibration Capability

The development of high-sensitivity, high-resolution, low-noise and low consumption microbarometers is still a need for infrasound community. Internal calibration of such sensors remains a critical issue for CTBT application. To address this issue, a new sensor called MB3 has been developed by the CEA/DASE, following 20 years of experience with MB2000 series. It is composed of a metallic bellows used as the pressure sensitive element, and a magnet / coil electromagnetic transducer. Thanks to a secondary coil, self-calibration is possible the same way as for seismological stations. On site full frequency band transfer function measurements can thus be carried out using pseudo-random signals like maximum length sequences for example. The performances of the sensor in terms of noise floor (resolves the Low Noise Model on IMS bandwidth), sensitivity, resolution, pass-band and full range scale are presented. Analog (adaptable to any digitizer) and digital (all packed low consumption 24 bits digitizer encapsulated) versions are proposed.

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**Track Classification:**  Theme 3: Advances in Sensors, Networks and Processing
New Acoustic-Seismic Association Method Based on Knowledge

The infrasonic-seismic associated events are very important in the International Data Centre (IDC) bulletins, but about 85% automatically associated infrasonic-seismic events are false events at present. A new infrasound signal association method based on the seismic seed events from Standard Event Lists (SELs) or Late Event Bulletin (LEB) together with the background knowledge is proposed. The knowledge including the ground-truth events around the seismic-seed, the relationship between the infrasound transmission distance with the magnitude, the station distribution while some infrasound stations have the same location with the seismic station. The reliable infrasound stations for the association can be found by the mentioned experience, together with the transmission time and frequency attenuation rulers, the PMCC results and the signal characters, the detected infrasound signal can be right associated with the seed. The experimental results show that the method has a good performance in infrasonic-seismic association, can remarkably reduce the amount of false association.

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**Presenter:** TANG, Wei (CTBT Beijing National Data Center and Beijing Radionuclide Laboratory)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
of Xenon Laboratory Intercomparison Exercises Performed in 2012

The QA/QC program for Noble Gas systems of IMS Radionuclide network will be based on sample re-analyses at IMS laboratories. In order to ensure the credibility of IMS laboratories as providers of reference results, the laboratories have to be certified and have to undergo a QA/QC program, as well. Part of the laboratory QA/QC program will be regular intercomparison exercises. As a pilot program three such exercises have been performed in 2012. A bias of around 30% in activity concentration results between two groups of labs have been observed, but within the two groups results agreed very well in spite of different measurement technologies. Investigations on the reason for bias are needed ongoing.

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Presenter: GOHLA, Herbert (CTBTO Preparatory Commission)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Open Source Seismic Waveform Data in the IDC Processing: Case Study for 2011

The effects of adding data from open source seismic stations in the waveform processing system at CTBTO/IDC were explored. About 50 stations, located in the whole world and providing open source waveform data, were selected by following criteria: located in areas less covered by IMS stations; provided continuous data and real-time access; broad-band instrumentation; recording data at least 70 % during 2011; included in various networks. One-year waveform data from BH or HH continuous streams from 14 national or international networks were obtained from IRIS data centre in SEED format. The data were converted to CSS format and OSD database with sensor information and waveforms is created. Most of the instruments are STS-2 and the sampling rate of the data varies from 20 to 100 sps. Additional database tables and parameter files, necessary for processing OSD in the IDC pipeline, were created. The waveforms were processed by the IDC station processing applications DFX and StaPro, on the CTBTO VDEC platform. Further, the detections from OSD and IDC stations and arrays were analysed together by the IDC Global Association network processing software. The origin parameters and their uncertainties are compared to parameters in SEL1 evaluating the potential improvements.

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Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Observations in Belarus

Belarus and the Baltic States comprise the single seismotectonic region described by the similar geological evolution and common recent geodynamic conditions. The region shows a rather low seismic activity, however some seismic events with a magnitude $M \leq 4.5$ were recorded within its limits. Instrumental seismic observations started in the territory of Belarus in 1965 at the Pleshchenitsi geophysical observatory. At a later time the seismic network development was associated with investigations of the seismic regime and the territory division into the seismic regions, the study of deep structure. Seismological monitoring within the studied period was carried out by continuous observations at the sites as follow: geophysical observatories “Minsk” (Pleshchenitsi), “Naroch” and seismic stations “Soligorsk” (local network), “Brest”, “Gomel”, “Glushkevichi”, “Mogilev”, “Poltusk”, “Ostrovs” (local network). The seismicity of the territory of Belarus has recently received a thorough study. Full advantages were taken of the results of continuous instrumental observations presented in bulletins of seismic stations within 1965-2012. When the data available in seismological bulletins of the seismic stations of Belarus were analyzed and summarized, a Catalogue of Earthquakes of the territory of Belarus since 1887 till 2012 was compiled with a due regard for historical earthquakes revealed.

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Presenter: ARONAU, Uladzislau (The Centre of Geophysical Monitoring of National Academy of Sciences of Belarus)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Mobile Radioxenon Detector for On-Site Gas Sample Counting

Many Radioxenon detector systems used in the International Monitoring System (IMS) and in other applications employ beta/gamma coincidence detection to achieve high sensitivity. While very sensitive to small amounts of radioxenon, the existing systems require careful calibration and gain matching of several detectors and photomultiplier tubes and their organic scintillators show a memory effect from previous measurements. We present in this paper a novel detector designed for field measurements such as those performed during On-Site Inspections (OSI). The design is based on a simple phoswich geometry, where beta/gamma coincidences are detected by digital pulse shape analysis. Size, weight, and complexity have been reduced and the memory effect has been mitigated while still achieving the minimum detectable concentration required by IMS stations. Since a single photodetector is used to read the combined beta and gamma detector signal, this configuration also simplifies the calibration processes. Built-in gain stabilization addresses varying environmental field conditions such as temperature changes. This in turn reduces the instrument setup time and maximizes the identification of short lived radioxenon isotope. The detector design is studied by both GEANT4 and MCNPX modeling, and preliminary measurement results are reported. Sponsored by the National Nuclear Security Administration, Award No. DE-NA0001522.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Upper Cross-Section of UNE Area at Semipalatinsk Test Site According to Seismic Data (for OSI Purposes)

The presentation deals with the results of data processing from seismic observations conducted along eight parallel profiles of 6 km long and with a 500 m spacing between them on the site of an underground nuclear explosion boreholes. First arrivals curves indicated a low-velocity near-surface layer up to 1000-1500 m/s. With going deeper, velocity changes in the range of 4000-5500 m/s. A relative velocity reducing throughout this rock mass in the vicinity of explosion boreholes has been traced. Methods of a seismic-tomography and the direct beam modeling, giving considerable distinctions in two-dimensional high-velocity models, have been used. Tomography results depend on the starting model and that requires a priori data at selecting most optimal results. In beam modeling the distinguished seismic borders correlate with geological data. Results of processing by various techniques are compared with the purpose to estimate reliability of way of seismic model building. The obtained results can be used in OSI for deeper understanding of UNE phenomenology and further development of active seismic techniques in the context of OSI.

Primary author: BELYASHOV, Andrey (Trofimuk Institute of Petroleum Geology and Geophysics of Siberian Branch Russian Academy of Sciences)

Presenter: BELYASHOV, Andrey (Trofimuk Institute of Petroleum Geology and Geophysics of Siberian Branch Russian Academy of Sciences)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
NDC Contribution to the Regional Operational System in Support of CTBT Monitoring During 2012

Romania participates to the verification regime of the CTBT through the NDC and the IMS auxiliary seismic station Muntele Rosu, both operated by the National Institute for Earth Physics. The paper assesses the performance of the IMS at regional scale, i.e. for the Romania’s territory, during 2012. A comparative analysis of the IDC products (SEL3 and REB) and the ROM NDC bulletins for the Romanian events, are presented. The common solutions in IDC and NDC bulletins are investigated in terms of epicentral location, depth, magnitude, error ellipse and number of associated phases. As a consequence of the superior coverage with seismic stations of the Romanian territory, the NDC locations are better constrained. Events located only in REB or only in NDC bulletins are analyzed as well. Yearly, over 30 Romanian events (MD ≥ 3.5) located only at ROM NDC may have been missed by IDC in REB bulletins. Operational output and performance of the MLR auxiliary seismic station is presented. In IDC processing, at least 5 MLR seismic phases are associated daily to REB events. RO NDC reviewed bulletins are sent on a monthly basis to the IDC, providing ground truth solutions for events located by the IDC in Romania.

Primary author:  GHICA, Daniela Veronica (Romania National Data Centre)
Presenter:  GHICA, Daniela Veronica (Romania National Data Centre)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
IMS Data with National and Regional Data in Seismic Monitoring

At EIF of the Treaty, the IMS will consist of 337 facilities supplemented by 40 noble gas systems. Besides for Treaty monitoring purposes, the data from the IMS network and the products derived from them at the IDC can serve civil and scientific applications. The Member States apply various approaches to merge IMS data with their national or regional data. This is encouraged and supported by the PTS to increase usage and users of IMS data and IDC products. The Waveform component of NDC-in-a-Box software is being extended to include local seismic station information. Various open source conversion tools available from the scientific community which contribute to common data formats are being standardized. Developing user-friendly, open, integrated platform that uses an already widely used software and data formats in seismology and tsunami warning centres is another alternative. This present work is intended to describe the current state-of-the-art. A survey has been conducted to assess the current spread and usage of common software and data formats. The findings will be presented in two approaches: firstly with statistics per region and secondly by providing examples from certain countries that successfully used merged data that may serve as a role model.

Primary author: FISSEHA, Misrak (CTBTO)

Presenter: FISSEHA, Misrak (CTBTO)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
(Modular Data Acquisition System): The New Digitizer from France for Waveform Technologies

CEA/DASE has developed a new digitizer for waveform technologies. It is compatible with all CTBT specifications and requirements, including authentication and command & control / PKI. It allows digitizing 1 to 4 channels at 8, 20, 50 or 100 sps. The full scale input range can either be 40, 20,10 or 5 Vpp. Data are time tagged by GPS, authenticated by using DSS (1024 bits) or ECDSA and sent in CD1.1. Command & Control, including key management, is implemented through authenticated e-mails and ssh. The SMAD has an average power consumption of 5.5 Watts. For very remote sites that does not require authentication, a low power version (1W including UHF telemetry) is available. Thanks to PTS support, the digitizer was successfully tested at SNL for seismic application in 2012. The purpose of this evaluation was to perform system noise analysis with estimates of system band-width dynamic range for an STS2 application and to determine the following device specifications: bitweight, input terminated noise, bandwidth limited dynamic range, power consumption, common-mode rejection, cross-talk, analog bandwidth, relative transfer function, total harmonic distortion, time-tag accuracy, statistics, and drift. The test results were in response to static and to tonal-dynamic input signals.

Primary author: MILLIER, Philippe (CEA - Commissariat à l’énergie atomique et aux énergies alternatives - Département analyse, surveillance, environnement)

Presenter: MILLIER, Philippe (CEA - Commissariat à l’énergie atomique et aux énergies alternatives - Département analyse, surveillance, environnement)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Application of Airborne Remote Sensing for OSI

The use of airborne remote sensing and the acquisition of multispectral imagery including infrared are permitted in an On-Site Inspection (OSI) under Paragraph 80 of Part 2 of the Protocol to the Treaty. This paper reports on the findings of field tests conducted by the Provisional Technical Secretariat (PTS) to ascertain the extent to which, and under which conditions, airborne imagery can detect features relevant to an OSI; such features differ in their origin, extent and longevity and may be related to anthropogenic activities conducted in preparation for an underground nuclear explosion (UNE) as well as features that are the direct and indirect consequences of an UNE. Field tests based on features engineered by the PTS to mimic potential OSI-relevant signatures revealed that airborne imagery acquired within an OSI-realistic timeframe can successfully differentiate types of vehicle tracks and their relative chronology as well as the relative chronology of ground disturbance. Additionally, subsurface heated water has been detected as well as a stress signature in vegetation related to the detonation of charges. Workflows and algorithms to rapidly and efficiently process imagery now need to be refined to maximize the value of airborne remote sensing for an OSI.

**Primary author:** ROWLANDS, Aled (CTBTO Preparatory Commission)

**Presenter:** ROWLANDS, Aled (CTBTO Preparatory Commission)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
of Detector Tuning Methodology at the United States National Data Center

Upon the acquisition of a new station, the United States National Data Center (US NDC) employs a standardized detector tuning process with the goal of identifying station specific parameters for the automated detection of regional and teleseismic signals. These parameters include: filter passbands, beam deployment, detector configuration, array configuration, and detection threshold. Detector tuning is performed using a station specific ground truth dataset, which includes a series of data days that have a sufficient number of events. This dataset is scrubbed by an experienced analyst to ensure all possible regional and teleseismic arrivals are picked and archived. The Detection and Feature Extraction (DFX) application systematically runs over the dataset using a subset of possible detection parameter configurations. The automated detections from each run are then compared to the archived arrivals from the ground truth dataset where valid and false detections are determined. The set of automated processing parameters that provide the best trade-off between the probability of detection and false alarm rate are selected.

Primary author: KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

Presenter: KEMERAIT, Robert (U.S. Air Force Technical Applications Center)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Solution for the CTBT OSI Application

During the Launch phase of the OSI, immediately initiated after Inspection Request has been received, core Inspection Team will need to develop an Initial Inspection Plan and, a need of appropriate tool with access to necessary map libraries represents an essential part of the GIS solution. Data collected during the Inspection Phase of the OSI, using all 17 different techniques as listed in the CTBT Protocol, should be geo-referenced to allows a spatial analysis. A different techniques and huge amount of data arriving every day put in front of the IT a big challenge related to systematical analysis and visualization of data and results. The GIS techniques should synergistically provide a direction for further steps during the Inspection. A specific confidentiality and security measures should be implemented in order to protect the IT activities as well as national interests of the ISP.

At the end of the OSI, GIS solution should have capabilities to provide integrated pictographic results and images/maps in order to ease the preparation of the Preliminary Finding Document. All mentioned requirements resulted in highly sophisticated and technologically advanced OSI specific GIS developed for the purpose of the efficient operations during the OSI missions.

Primary author:  PRAH, Matjaz (Croatian Electric Utility (HEP), Division of Strategy and Development)

Presenter:  PRAH, Matjaz (Croatian Electric Utility (HEP), Division of Strategy and Development)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Development and Nuclear Science Education at the National Superconducting Cyclotron Laboratory

National Superconducting Cyclotron Laboratory (NSCL) is a world-leading center in rare isotope research and education. The NSCL mission is to understand the atomic nucleus and the experimental program encompasses a wide variety of techniques related to charged particle, photon, and mass spectroscopy of radioactive isotopes. A sustained research and development effort toward future detector technologies with increasing sensitivities is necessary to successfully carry out the NSCL mission. As examples, my group has deployed a mechanically-cooled HPGe system for efficient coincident beta- and gamma-ray counting coupled to a dead-time free data acquisition system. The faculty at NSCL also play an important role in STEM workforce development, training approximately 10% of the Ph.D. nuclear scientists in the U.S.A. each year. The students are drawn to NSCL based on the compelling science program and unique opportunities to apply novel detectors to study rare isotopes. These highly-skilled young scientists are recruited by national laboratories, industry, and academia, and many continue to work on problems related to radiation monitoring and detector development. In this talk, I will present an overview of the nuclear science program highlighting recent detector technologies at NSCL for nuclear science research.

*Work supported in part by NSF PHY and DOE.

**Primary author:** LIDDICK, Sean (National Superconducting Cyclotron Laboratory / Michigan State University)

**Presenter:** LIDDICK, Sean (National Superconducting Cyclotron Laboratory / Michigan State University)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Data Quality Objectives for Radionuclide Techniques in an OSI

Under CTBT, many different radionuclide OSI technologies are considered including survey (aerial, vehicle, backpack, and handheld), environmental sampling with laboratory analysis (atmospheric noble gas and particulate, subsurface noble gas, soil, water, and biota), and in situ measurement. Due to the many limitations, such as manpower, time, and field environment, that an OSI will face it is important that the CTBT OSI regime possess well-chosen equipment. By establishing Data Quality Objectives (DQOs) for the various technologies, appropriate equipment and software can be procured or developed, appropriate concepts of operations during an OSI can be developed, as well as appropriate training. This requires a good understanding of the minimum detectable limits (MDLs) for the various techniques and what equipment options are available in terms of performance, power needs, and field operation. Based on measurements and a search of published literature, we have determined the achievable MDLs of the various equipment considered for use in a CTBT OSI and will present this and proposed Data Quality Objectives for radionuclide techniques in an OSI.

Primary author: MILBRATH, Brian (Pacific Northwest National Laboratory)
Presenter: MILBRATH, Brian (Pacific Northwest National Laboratory)
Track Classification: Theme 3: Advances in Sensors, Networks and Processing
: A Rule-Based Interval State Machine Algorithm for Performance Analysis, Alert Generation and Monitoring Real-Time Data Processing

This paper presents a Rule-based Interval State Machine Algorithm (RISMA) for monitoring, and analysing the behaviour of interval-based data. The proposed algorithm uses the Interval State Machine (ISM) approach to model any number of interval-based data into well-defined states as well as inferring them. An interval-based state transition model and methodology are presented to identify the relationships between the different states of the proposed algorithm. By using such model, the unlimited number of relationships between large numbers of similar intervals can be reduced to well-defined number of relations, in our case 18 direct states relationships. Significant important information can be derived from the proposed algorithm, such as number and type of related alerts and system performance indicators. This algorithm has been tested using several different data sets received in near real-time, from International Monitoring System (IMS), by the International Data Centre (IDC) of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). For IMS interval-based data and at any period of time it is possible to analyse station behaviour, determine the missing data, generate necessary alerts, and to measure some of station performance indicators. The proposed algorithm, methodology, implementation, experimental results, advantages, and limitations of this research are presented.

Primary author: LABAN, Shaban (CTBTO)

Presenter: LABAN, Shaban (CTBTO)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
– The Processing Engineer Workbench

The Processing Engineers (PE) at the IDC are tasked with maintaining all processing parameters for all data streams delivered to the IDC. This includes coordinating the configurations for the operation of the stations/detectors and the usage of the various data streams by the processing software. This information is complex and the maintenance of this information is laborious. As all modifications require multiple stages and require expert operators, training new PEs is a complex process that can take a year or more to complete. To assist the Processing Engineers in becoming experts and in performing their daily tasks while lowering the likelihood of errors, ISTI created the Processing Engineer Workbench (PEW). PEW provides a central secure tool for the PEs to interact with the core systems. PEW’s power is in its ability to run scripts to automate tasks that address various issues. A PE uses PEW to gather input and then interact with the base systems, which include the database, ticketing system, revision control system, file system and tuxedo. PEW also has the ability to run shell scripts and specialized python code. PEW also provides a status overview and the ability to review and duplicate past operations.

Primary author:  HELLMAN, Sidney (Instrumental Software Technologies, Inc.)

Presenter:  HELLMAN, Sidney (Instrumental Software Technologies, Inc.)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Comparison of ARSA, SAUNA and ARIX Detector Responses
Using FLUKA for Xenon Isotope Beta–Gamma Coincidence Spectrum

It has been recognized that ambient radio-xenon activity concentration monitoring could be used for the purpose of identifying the nuclear nature of an explosion. Therefore four detection systems have developed to monitor ambient radio-xenon which three of them have worked based on beta-gamma coincidence method. A Monte Carlo code FLUKA was used to model geometry of ARSA, SAUNA and ARIX beta-gamma coincidence systems and to simulate radio-xenon sources and their detector responses. Two-and three-dimensional beta–gamma coincidence spectra from these systems was acquired and compared with each other. Since FLUKA has the option of determining source as a radioisotope, 4 concerning isotopes of radio-xenon (131mXe, 133Xe, 133mXe and 135Xe) were defined as source of the beta-gamma counting coincidence systems. Moreover, the electrons, beta and gamma lines produced by simulated radioisotope sources were compared with literatures. The results indicate that using this option would ensure users applying source as a radioisotope. Since Compton coincidence spectrum of 137Cs is usually used for energy calibration of detection system, the 3-dimensional spectrum of 137Cs reconstructed using FLUKA.

Primary author: AGHEL MALEKI, Atiyeh (AMIRKABIR University of Technology, Department of Physics)
Presenter: AGHEL MALEKI, Atiyeh (AMIRKABIR University of Technology, Department of Physics)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
GPS-Enabled Vehicle-Based Mobile Radiation Detection Search Tool for CTBT OSI

Searching for radioactivity during On Site Inspection (OSI) is critical to verifying the Comprehensive Nuclear-Test-Ban Treaty. Myriad tools are under development or commercially available for supporting search, but suffer from inadequate user-ability and have closed and proprietary software/hardware architectures. For search during a CTBT OSI, the Lawrence Livermore National Laboratory has developed and demonstrated a NaI-based radiation instrument that is GPS-enabled, and has an open software architecture interface (Glau). The interface has two display modes, histogram detector count rate or spectrum view, with a long-dwell data capture function. Stored data includes GPS location, date and time, count rate, and spectrum. If desired, additional hardware can be installed that enables these data and streaming video to be transmitted to the OSI base-camp via private self-forming mesh network. The instrument is comprised of a Na-I scintillation detector (4x4x16 inch), 1024-channel multichannel analyzer, a small computer, GPS antenna, and easy to use software. The Glau interface was developed to be an open source code in MatLab and operates under WindowsXP, Vista, or v7. Recent operations in vehicle-based search, both on water and on land, will be described. Work performed under the auspices of the U.S. DOE under contract DE-AC52-07NA27344, LLNL-ABS-611132.

Primary author:  KREEK, Steven (Lawrence Livermore National Laboratory (LLNL))
Presenter:  KREEK, Steven (Lawrence Livermore National Laboratory (LLNL))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Maintainability, Reliability and Efficiency of Systems and Operations at Zimbabwe’s NDC

The availability of power and internet affects the ability of National Data Centres (NDCs) to carry out their verification activities, including the accessing of IMS data and IDC products. Frequent, unscheduled power cuts and poor internet connection are some of the major constraints we face as we thrive to meet the 98% data availability and fulfilling our verification for our seismic station. Zimbabwe have been experiencing a lot of challenges in the maintenance and upkeep of its Seismic Auxiliary station AS120 ranging from instrumentation, power supply and communication systems. The CTBTO with its support services section have been helpful in averting most of these problems. The upgrading of the power system from AC to DC is some of the effort that was done to ensure continuous uptime of the station. The NDC have come up with a proposal to use solar energy to power the seismic station. The proposal to go green at the NDC is made so as to improve on power reliability. The use of solar energy at the NDC would contribute to a safer, cleaner and reliable power supply. Solar energy does not involve moving parts and this help to reduce maintenance requirements.

Primary author: MARIMIRA, Kwangwari (Goetz Observatory)
Presenter: MARIMIRA, Kwangwari (Goetz Observatory)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Periodic Noise: Application to Real Data and Advancing to Frequencies Shifting in Time

We are developing a method for removing periodic noise from recordings to detect weak impulse events. This could be used e.g. for seismic aftershock monitoring during CTBTO on-site inspections (OSI) where weak pulses may sometimes be masked by engine signals. We have continued our work (shown at ISS09, S&T11). By gradually fitting the frequency, amplitude and phase of a sine function to each single peak in the complex spectrum, subtraction of periodic noise is possible. The general procedure as well as a quantitative analysis of a helicopter flyby is shown. Of three planned improvements: 1. changing frequency, 2. neighbouring peaks, 3. simultaneous fitting of all peaks, we work on the first. To better work with real signals we analyse frequencies shifting linearly in time. The expression for the spectrum gets more complicated, an approximation has to be used. Problems appearing during implementation of the fitting algorithm are discussed, e.g. the initialisation of the four start parameters (the fourth is the frequency rate of change) is crucial.

Primary author: GORSCHLÜTER, Felix (Experimentelle Physik III, Technische Universität Dortmund)

Presenter: GORSCHLÜTER, Felix (Experimentelle Physik III, Technische Universität Dortmund)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Vertical Total Electron Content in Ionosphere of Java Region Associated with Yogyakarta Earthquake, May 26, 2006 UTC

Earthquake that struck Jogjakarta on May 27th 2006 (lokal time) gives negative impact to life and it became of no awareness disaster. Previously, there are many researches that developed a system which can give signal to earthquake pre-detection. One of them is Seismo-Ionospheric Coupling. This research, explain phases in Ionosphere before and after shock. Electron densities in vertical direction in Ionosphere (Vertical Total Electron Content) is selected as parameter. Total Electron Content (TEC) is defined as the amount of electron in vertical column(cylinder) with cross-section of 1 m$^2$ along GPS signal trajectory in Ionosphere at around 350 km of height. There are three times of significant decrease of VTEC value in Java and its surrounding, i.e. at 18, 20, 22 of May 2006. However, after corrected by Dst Index, the decrease VTEC value on May 18 2006 has relationship with magnetic disturbance. The decrease of VTEC value on May 20 and May 22 2006 is indicated as effect of Seismo-Ionospheric Coupling physical process before shock. This is supported by correction of Dst Index that shows there is no significant magnetic disturbance. Keywords: Seismo-Ionospheric Coupling, VTEC, Dst.Index

Primary author: GINTING, Mira (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Presenter: GINTING, Mira (NDC Meteorology Climatology and Geophysics Agency (BMKG))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Seismic Coupling in Porous Ground - Measurements and Analysis for On-Site-Inspection Support

During an on-site inspection (OSI) for the Comprehensive Nuclear Test-Ban Treaty the hypocentre of a suspected nuclear explosion has to be located with a precision of approximately 0.1 km. One possibility is the setup of a local seismic network, the seismic aftershock monitoring system (SAMS), to detect aftershock events caused as a consequence of the explosion. These events show a very weak magnitude so man-made noise can disturb the SAMS measurements. In a project for the Research Award for Young Scientists and Engineers we analyse airborne acoustic signals which excite soil vibrations when coupling into the ground that can disturb SAMS measurements. Such signals can be caused by vehicles or helicopters, used by inspectors during an OSI. The analysed signals are broadband (measurements of jet aircraft) and periodic CW signals, produced by a speaker. The research is focused on surface waves, excited by acoustic-seismic coupling in the surrounding of a sensor. The measured seismic signal is increased for constructive interference of the surface waves at the position of the sensor, which can occur for specific acoustic frequencies and elevation angles of the signal. The analysis shall give recommendations for an OSI to prevent or reduce such disturbing signals.

Primary author: LIEBSCH, Mattes (TU Dortmund, Experimentelle Physik III)

Presenter: LIEBSCH, Mattes (TU Dortmund, Experimentelle Physik III)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
-Phase Stations: Fifty Years of On-Land Hydroacoustic Recording in French Polynesia

Hydroacoustics constitute one of four technologies on which the International Monitoring System relies. Of the eleven stations involved, five are actually “T-phase” seismic stations located on land in the vicinity of shorelines. We present a review of this concept on the occasion of the 50th anniversary of the deployment of coastal seismometers in French Polynesia, specifically tuned for the recording of the high-frequency acoustic energy propagating in the SOFAR channel, and which can be considered as forerunners and prototypes of the now standard instrumentation of the IMS T-phase stations. In particular, we show that their performance is optimized when deployed on large atolls, and justify this result by considering (i) the processes of conversion of acoustic energy into seismic waves, critically dependent on the steepness of the receiving shore; (ii) the morphological and geological nature of the relevant island formations; and (iii) the origin of background microseismic noise. Our experience over decades of operations in French Polynesia illustrates the robustness of these stations, a combined result of their simple design, proven reliability, and ease of construction, deployment and especially maintenance, as compared to the more delicate technology of SOFAR-deployed hydrophones.

**Primary author:** HYVERNAUD, Olivier (Laboratoire de Geophysique de PAMATAI)

**Presenter:** HYVERNAUD, Olivier (Laboratoire de Geophysique de PAMATAI)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Model Visualization for NET-VISA

NET-VISA is a probabilistic system developed for seismic network processing. A rich amount of information is hidden inside its Generative Model (GM), an explicit mathematical description of the relationship between various factors in seismic network analysis. An Interactive Model Visualization tool (IMV) is being developed which will make “peeking into” the GM simple and intuitive through a web-based interface. Some of the relationships inside the GM are deterministic and some are statistical. Statistical relationships are described by probability distributions, the exact parameters of which (such as mean and standard deviation) are found by training NET-VISA using recent data. The IMV will make it possible to examine these distributions for attributes of events and arrivals such as the detection rate for each station for each of 14 phases. It will also clarify the assumptions and prior knowledge that are incorporated into NET-VISA’s event determination. When NET-VISA is retrained, the IMV will be a visual tool for quality control both as a means of testing that the training has been accomplished correctly and that the IMS network has not changed unexpectedly.

Primary author:  KUZMA, Heidi (Chatelet Resources LLC)
Presenter:  KUZMA, Heidi (Chatelet Resources LLC)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
to Evaluate New Data Mining and Machine Learning Algorithms Developed for Use at the IDC

A number of projects aim to introduce novel ideas from the computer science community into the IDC data processing pipeline. There is need to develop standard criteria for evaluating their success with respect to each other and to current IDC processing. It is proposed that such criteria be developed in a way that is appropriate to the mission of the IDC, namely to ensure that no nuclear explosions go undetected. Any technique or algorithm which is proposed for inclusion in the IDC pipeline should demonstrate that it either improves the quality of the IDC bulletins or is useful to analysts (or both). It should do one or more of the following: reduce spurious events, find more, lower magnitude events, improve event locations and/or depths, return better quality error ellipses, make better quality detections, and/or reduce the time that analysts must spend evaluating events on a per-event basis. It must not miss events which are currently being found by IDC, introduce a geographical bias or violate physics. Implementation of this system of metrics will ensure that all algorithms will be evaluated fairly regardless of where they are developed and by whom.

Primary author: KUZMA, Heidi (Chatelet Resources LLC)

Presenter: KUZMA, Heidi (Chatelet Resources LLC)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
New Network Modeling Tool for the Ground-Based Nuclear Explosion Monitoring Community

Network simulations have long been used to assess the performance of monitoring networks to detect events for such purposes as planning station deployments and assessing network resilience to station outages. Unfortunately, the tools used for these simulations are not widely available and are not based on modern software standards. For these reasons, we are developing and planning to openly release NetMOD (Network Monitoring for Optimal Detection), a Java-based tool designed to assess the performance of ground-based networks. NetMOD is implemented in a modern programming language that is multi-platform and compatible with multi-core technology. The package features an extensive Graphical User Interface to guide users through the simulation process, and will include a User’s Manual and a well-validated default parameter set with information for the full seismic, hydroacoustic, and infrasound IMS network. Development of the seismic detection simulation capability is being pursued first, but NetMOD is designed to be extendable through a plugin infrastructure, so new phenomenological models can be added. Infrasound detection and hydroacoustic detection are the next priorities.

Primary author:  YOUNG, Christopher (Sandia National Laboratories)
Presenter:  YOUNG, Christopher (Sandia National Laboratories)
Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
and Testing of the Probabilistic Event Detection, Association, and Location Algorithm

We present results of testing the latest version of our Probabilistic Event Detection, Association, and Location (PEDAL) algorithm. PEDAL uses an Earth model discretized into a dense 3D grid of 427,265 nodes, extended to 4D by the addition of a time dimension. Given a set of seismic observations (arrival time, horizontal slowness, azimuth and associated uncertainties), a ‘fitness’ value is calculated at each grid node, assuming that each observation was generated by a refracted P wave. The node with peak fitness value is accepted as a hypothetical seismic event location. We then solve for the corresponding origin time and associate individual arrivals with the event, considering many different phases. Improvements include: 1) incorporating prior probability of signal detection for each station; 2) association in two stages, P first, then later phases; 3) calculation of mb and association based on magnitude, depth, and distance from event to station; and 4) integration with waveform correlation. We tested the new version on a 2-week period of time processed by the IDC and carefully examined by an analyst to identify all legitimate events. A sophisticated bulletin review algorithm shows PEDAL performance superior to the Global Associator (GA).

Primary author: BALLARD, Sanford (U.S. Department of Energy, National Nuclear Security Administration)

Presenter: BALLARD, Sanford (U.S. Department of Energy, National Nuclear Security Administration)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Online Filter Monitoring System for IMS Stations

As a consequence of the Fukushima accident it became obvious that the IMS filter could potentially cause radiological concern for the station operators due to the high air flow rate which can lead to accumulation of sizeable activities on the filters. Also, the data from the filter analysis is not available until more than 52 hours from the collection start (the time of the first preliminary spectrum is sent to IDC). Therefore, PTS started investigation into an early warning online filter monitoring system with low resolution detectors. LaBr was selected as one of the best solution. Its resolution allows to distinguish radioactive iodine isotopes from the radon progenies and has orders of magnitude better sensitivity than conventional in-situ dose monitoring devices. This system gives possibility to warn station operators well in advance of any radiological hazards a filter can represent, and provides early notification to the PTS to timely implement necessary actions in response to such an event. The poster presents the system design and results of the measurements at the test station at VIC.

Primary author: KHRUSTALEV, Kirill (Instrumental Software Technologies Inc.)
Presenter: KHRUSTALEV, Kirill (Instrumental Software Technologies Inc.)
Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Event Detection Capability of the Auxiliary IMS Station VRAC (AS26)

Detection capability of the station VRAC were evaluated using comparison of seismic event bulletins containing the results of data processing carried out in the Czech NDC and REB-bulletins of IDC. The detection threshold is linked with roll-off effect in the earthquake frequency magnitude distribution. For the estimation of value of magnitude mb connected with the roll-off effect, various parameters were calculated in respect of epicentral distance (in the case of 2D analyses) and in respect of coordinates of epicentral areas on map. Parameter Mmf (most frequent magnitude for selected data subset) undervalues searched threshold, on the contrary, parameter M100con (magnitude, for which VRAC station has detected all events listed in REB-bulletin) is usually higher than detection threshold. There were also calculated percentage of events listed in REB-bulletins and detected by VRAC station for several various ranges of magnitude and results were plotted in the graphs and contoured maps. Results of statistical evaluation of detectability of station VRAC show that the detection threshold (mb of reliably detected events) varies between 4.4 and 4.8 for epicentral distances from 10° to 70°. Important fact is relatively good capability for epicentral distances from 143° to 150° because of caustic zone of PKP waves.

Primary author:  HAVÍŘ, Josef (Institute of Physics of the Earth, Masaryk University)

Presenter:  HAVÍŘ, Josef (Institute of Physics of the Earth, Masaryk University)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Foresight - Using of List Mode Electronics for a Modern Radionuclide Lab

Recent advances in high-speed electronics and multi-detector configurations have allowed the creation of laboratory detector systems requiring novel spectrum processing algorithms. Adoption of these new system designs led to revolutions in spectroscopy using techniques such as cosmic veto and coincidence counting spectroscopy and other applications. Now, with the advent of large high-density digital storage devices, it is possible to perform advanced processing on individual scintillator pulses. Processing of individual pulses allows multiple high-sensitivity analyses from a single measurement thereby improving laboratory throughput. The Centre for Security Science (CSS) of Defence Research and Development Canada (DRDC) in partnership with Health Canada (HC) hosted a workshop focused on directions for new designs appropriate for CTBT laboratory and other applications.

Primary author: HOFFMAN, Ian (Radiation Protection Bureau)
Presenter: HOFFMAN, Ian (Radiation Protection Bureau)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
- A Gamma-Ray Spectrometer for CTBT On-Site Inspections

We are designing and testing a new high-resolution gamma-ray spectrometer for on-site inspections under the Comprehensive Nuclear-Test-Ban Treaty: the On-Site Inspection RadioIsotopic Spectrometer—OSIRIS. The instrument provides robust protection for the potentially sensitive aspects of measured gamma-ray spectra, revealing only gamma-ray peak data for selected radioisotopes. We will evaluate the approach across gamma spectrum compositions for CTBT treaty-compliant and non-compliant scenarios. The OSIRIS hardware includes an ORTEC Trans-SPEC-DX-100T mechanically-cooled HPGe detector, requiring no liquid nitrogen, and a digital signal-processing multichannel analyzer1. Detector relative efficiency and energy resolution at 1332 keV are 40% and 2.1 keV, respectively. A ruggedized Panasonic notebook computer serves as the OSIRIS control panel and readout. A single external battery will operate the OSIRIS detector for 12 hours, swappable for longer operation. OSIRIS uses GAUSS nonlinear least-squares spectrum analysis software2 to process the spectra, and it can be energy-calibrated using natural background radiation. The energy spectra are not visible to the user; instead, the displayed information is limited to radioisotopes relevant to CTBT on-site inspections. By design, OSIRIS spectral data cannot be saved, and the collected spectra are erased from memory at shutdown. References 1. http://www.ortec-online.com/Solutions/gamma-spectroscopy.aspx 2. R.G.Helmer, M.H.Putnam, and C.M.McCullagh, Nuclear Instruments and Methods A242(1986)427.

Primary author: KREBS, Kenneth (Idaho National Laboratory)

Presenter: KREBS, Kenneth (Idaho National Laboratory)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Comparison for Atmospheric Filter Papers

Researchers at Pacific Northwest National Laboratory have recently completed construction of a 14 crystal low-background germanium array. A low-background shield system was also built to house a commercial low background germanium spectrometer. This system will be certified to measure atmospheric filter paper samples collected by the International Monitoring System (IMS). Both of these systems are currently operating in a new shallow underground laboratory at PNNL. This work briefly reviews the design and performance of these two gamma spectrometers. The sensitivity of these two systems is compared to that of a typical laboratory gamma spectrometer for the measurement of high fission yield gamma emitters collected on atmospheric filter papers.

Primary author: BOWYER, Theodore (Pacific Northwest National Laboratory)

Presenter: BOWYER, Theodore (Pacific Northwest National Laboratory)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Application of Lg-Wave Cross Correlation and Double-Difference Location

Previous work for a test case in the 1999 Xiuyan, China, earthquake sequence has demonstrated that Lg-waves correlate extremely well for this region and can be used to obtain high precision solutions for epicenters using the double-difference technique. Lg-waves are well suited for correlation when available because they are the largest amplitude arrivals on the regional seismogram, they have long durations, complex waveforms, with high frequencies that make correlations very robust. Measurement error is estimated to be about 7 ms based on internal consistency. Lg-waves for locations also propagate more slowly resulting in a smaller uncertainty in distance, for a given uncertainty in travel time. The inverted epicenter estimates have a location precision on the order of 150 m. The locations are computed using four to five regional stations 500 to 1000 km away. The epicenter estimates are not substantially affected by the sparseness of stations or large azimuthal gaps which is important for regional nuclear monitoring. We are currently extending the previous work to apply the technique on a massive scale to all the events in and near China from 1985 to 2005. We first are analyzing 2379 events that we have previously identified as repeating.

**Primary author:** STEVENS, Kerry (Columbia University)

**Presenter:** STEVENS, Kerry (Columbia University)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Waveform Correlation Techniques to Broad Regional Monitoring Using IMS Data

Waveform correlation techniques are of great interest for nuclear explosion monitoring because they provide a robust means to significantly lower detection thresholds while maintaining acceptably low false alarm rates. In previous work, using our research group’s distributed computing system, we have demonstrated the ability to monitor 3 years of seismicity in central Asia using our waveform correlation detector processing continuous data from the array MKAR. In the work presented here, we extend our processing to include multiple IMS stations processed together and show results for processing 3+ years of data from multiple IMS stations with a combined set of master events numbering in the thousands. Optimal detection thresholds for each template are determined using Schaff’s (2010) time reversal methodology to establish a null distribution and allow selection of a threshold for a desired false alarm rate. To establish the completeness of our catalog, we compare our output event lists against the IDC LEB as well as regional catalogs from central Asia. We present our results along with discussion of the practical aspects of engineering a robust correlation system, including automatic template library creation, multi-station integration, and computational requirements.

Primary author: SLINKARD, Megan (Sandia National Laboratories, Albuquerque, NM, USA)
Presenter: SLINKARD, Megan (Sandia National Laboratories, Albuquerque, NM, USA)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Seismic Spectral Decomposition Analysis with Continuous Wavelet Transformation

Seismic data, is naturally a non-stationary signals that have different frequencies and in the form of time. Non-stationary signal is the seismic waves generated by elastic disturbances that propagate from one city to another, in a medium, namely the earth. Characteristics of seismic data needs to be researched and analyzed for parameters of tectonic earthquake which arrival time determination of earthquake and seismic amplitude. In this case the data used is real seismic data is Tarutung regional tectonic earthquake on May 19, 2008. Tarutung earthquake seismic signal analysis used in this study wavelet Gauss4, Mexh, Morlet, and Haar. From the analysis of seismic signals with the wavelet used, the type of wavelet Mexh show better image resolution of this type of Gaussian 4 wavelet, Morlet and Haar. The resulting scale was smaller, this means that wavelet shortened and high frequency result with the wavelet analysis of seismic signals show arrival time Mexh Primary (P) wave on the GSI range sensor 1800 ms and the maximum amplitude is localized at 2000 ms, the sensor SISI Primary (P) wave arrival time ranges from 3000 ms and the maximum amplitude is localized around 4500 ms. Key words: non-stationary, Gauss 4, Mexh, Morlet, Haar.

Primary author: SINAMBELA, Marzuki (Meteorology Climatology and Geophysical Agency Regional I, Medan, North Sumatera, Indonesia)

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Learned from Fukushima: Improving Aerosol Systems for the IMS

The U.S.-designed Radionuclide Aerosol Sampler/Analyzer (RASA) was a key aerosol system of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) International Monitoring System (IMS) in the path of debris from the Fukushima-Daiichi reactor disaster. The releases from the reactor in some ways mimic the possible releases from a nuclear explosion that was partially contained, and operational issues observed in RASA systems likely represent real-world behavior in the scenario in which they are intended to function. Key findings include uncertainty about the arrival time of the plume, the leakage of contaminated room air into the detector, and behavior of the RASA during power interruptions caused by the great East Tohoku earthquake. The authors will present short, medium, and long timeline research activities to improve RASA or any aerosol system for the purpose of verification following a nuclear explosion on the surface or partially contained underground. Forrester et al, “Engineering upgrades to the Radionuclide Aerosol Sampler/Analyzer for the CTBT International Monitoring System” Journal of Radioanalytical and Nuclear Chemistry DOI 10.1007/s10967-012-2199-7

Primary author: MILEY, Harry (Pacific Northwest National Laboratory)

Presenter: MILEY, Harry (Pacific Northwest National Laboratory)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Future Technologies for Nuclear Test Verification: Novel Use of an Interactive Information Management Tool

As part of its mandate, the CTBTO’s nuclear explosion monitoring programme aims to maintain its sustainability and long-term effectiveness for the verification regime. The Technology Foresight Programme aims to identify and review potential future technologies, which is also consistent with the aims of the Science and Technology conference series. As part of the Foresight activities, a database within the Pivot environment was developed. This database is populated through a peer-review mechanism; it can be used to explore hypotheses about the future of verification technologies to assist programme managers and decisionmakers to prioritise projects and investments. Through the underlying categories in Pivot we were able to identify technologies that represent potential quick wins: technologies at early development stage, with short maturity and development time, with low financial and institutional cost, with substantial positive verification capability impacts. These technologies might be identified as high-priority. By contrast, a set of future CTBTO-relevant technologies could be seen as lower priority, due to limited verification capability impact, high financial and organisational development and implementation cost, and a long potential impact time. In this paper we review the gains from exploring future technologies in a Pivot environment.

**Primary author:** JAIN, Amit (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Presenter:** JAIN, Amit (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Detection of Low-SNR Seismic Events by Pattern Matching with Automatically Generated Prototypes in an OSI Scenario

The reliable, automatic detection of low-SNR seismic events is not yet feasible without a large amount of false-positive detections, i.e., false alarms. This applies especially to temporal local networks with exposed seismic stations and a-priori unknown noise conditions and event signatures, as in an OSI seismic aftershock monitoring. To overcome this problem, we use a multi-path approach. As a first step, high-SNR events from noise bursts and seismic signals are detected by conventional STA/LTA triggering and coincidence analysis. These events are grouped for similarity to define a set of master events. Thus in step two the events are transformed into noise-adapted sonograms, and further reduced in dimension by principal component analysis (PCA). A self-organizing map (SOM) is used then to create event prototypes by event alignment on a two-dimensional grid based on similarity. Prototypes which are based on noise signals will positively identify repetitive noise sources, while the remaining signal prototypes are used to detect any low-SNR events in the full data set through adapted pattern matching. This method allows to lower the automatic detection threshold significantly with only a small increase in false-positives.

Primary author: SICK, Benjamin (University of Stuttgart, Stuttgart, Germany)
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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Assessment of the Detection Performance of Global Association Algorithms

The seismic network of the International Monitoring System (IMS) operated by CTBTO detects signals that may originate from natural or anthropogenic sources. These signals are processed in the International Data Centre (IDC) of CTBTO to produce bulletins that provide lists of events hypothesised as being the sources of the signals. To do this, observations of signal properties such as arrival time, seismic phase, azimuth and slowness must be converted into the latitudes, longitudes, depths and times of generating events. This process is referred to as “global association”. As part of its remit, the Provisional Technical Secretariat (PTS) of CTBTO carries out studies to assess the performance of global association algorithms. This involves consideration both of the level of detection and the number of false associations produced by algorithms. A method is demonstrated by which algorithm performance is quantified and displayed in a format that allows algorithm strengths and weaknesses to be illustrated. This method has application both to the assessment of current methods and to the quantification of benefits that might be obtained by the adoption of new association algorithms. The views expressed are those of the authors and do not necessarily reflect the view of CTBTO Preparatory Commission.

**Primary author:** PRIOR, Mark Kevan (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Presenter:** PRIOR, Mark Kevan (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Seismic Network Detection Threshold in Flinn-Engdahl Seismic Regions

The detection capability of the seismic network of the International Monitoring System (IMS) operated by CTBTO can be quantified in terms of a threshold that measures the magnitude of the smallest seismic event that could occur at a location and have a specified probability of being detected and located. This threshold can be inferred from the results of bulletins produced by the International Data Centre (IDC). It may also be predicted by computer codes that take descriptions of the properties of seismic stations and calculate signal detection thresholds at individual and multiple stations. Network detection threshold is inevitably non-uniform across the globe and the accuracy with which this variation can be modelled is of interest to IDC. A method is described in which network detection threshold is studied in Flinn-Engdahl seismic regions. Thresholds are predicted by the NetSim network simulation code and inferred from the contents of IDC bulletins. The reasons for differences between predicted and inferred values are discussed. The views expressed are those of the authors and do not necessarily reflect the view of CTBTO Preparatory Commission.

Primary author: PRIOR, Mark Kevan (Comprehensive Nuclear-Test-Ban Treaty Organization)

Presenter: PRIOR, Mark Kevan (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Capability of the Mongolian Seismic Network

In 1957, international geophysical year, very first seismic station was installed in Mongolia and seismic monitoring started from this year. The Mongolia is seismically active region and generally, seismic activity of Mongolia is associated with the deformation induced by the collision between India and Eurasia. Several strong earthquakes took place in Mongolia last century. The Mongolian Seismic Network has been expanding year by year and now seismic stations including 5 mini-arrays (one of them belongs to CTBTO) are working at 12 separate points in Mongolian territory. A seismicity of Mongolia is recorded by The Mongolian Seismic Network, sparse network at present and determining and improving of detection capability of the Mongolian Seismic Network is important for seismic event detection and characterization in Mongolia. We will present Detection Capability of the Mongolian Seismic Network in this poster.

**Primary author:** JARGALSAIKHAN, Bayaraa (Mongolian National Data Center (MNDC))  
**Presenter:** JARGALSAIKHAN, Bayaraa (Mongolian National Data Center (MNDC))  
**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
of Electrical and Active Seismic Methods to Detect Evidence of an Underground Nuclear Explosion

There is little experience with application of electrical and active seismic methods that can be applied during the continuation period of an on-site inspection (OSI), one of the verification methods of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Controlled source audiomagnetotelluric (CSAMT), dipole-dipole resistivity, and induced polarization electrical measurements were carried out along three survey lines over and near to ground zero of an historic underground nuclear explosion. An active seismic survey was carried out over a series of lines over surface ground zero using a compressional and shear wave vibrator source and three-component receiver geophones. Seismic data were processed for reflection, refraction, and ReMi (refraction microtremor) methods. The presentation will provide details and results of the surveys, an assessment of application of the method toward the purposes of an OSI, and an assessment of the manpower and time requirements for data collection and processing that will impact OSI inspection team operations.

Primary author:  SWEENEY, Jerry (Lawrence Livermore National Laboratory)

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Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Roadmap for Infrasound Technology Evolution

The Infrasound Technology Roadmap (ITR) projects existing technological accomplishments into near-future technical targets that can sustain the CTBTO’s effectiveness and relevance to the verification regime. The ITR has a time horizon of seven years, and its activities are closely aligned to the Provisional Technical Secretariat’s Technology Foresight Program, which extends its perspective to 20+ years. Phase I of the Roadmap effort requested input from the international infrasound community through a Request for Contributions. This was an inclusive, participatory effort where individual or coordinated groups of scientists identified and assessed technological advances that would yield a more reliable, sustainable and trustworthy monitoring system. Phase II refined the technical target definitions and developed a draft ITR document that provided a summary of selected, prioritized focus areas and a draft timeline for technology evolution within the Roadmap’s horizon. Phase III was concerned with assessing and incorporating recommendations from the review of the ITR document by contributing partners. Here we summarize the Infrasound Technology Roadmap and present a proposed, prioritized timeline for infrasound technology evolution to stimulate discussions and feedback in a multi-disciplinary science forum.

**Primary author:** GARCES, Milton (Defense Threat Reduction Agency, Nuclear Arms Control Technology Program)

**Presenter:** GARCES, Milton (Defense Threat Reduction Agency, Nuclear Arms Control Technology Program)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
and Improved Monitoring System for Samoa

Ocean island flank collapses, landslides, earthquakes, tsunamis, cyclones, flooding, volcanic eruptions are some of the most dangerous hazards in the Pacific as they have the potential to cause damage and loss of life. In the past, Samoa’s heavy dependence on external sources for monitoring geohazards was risky and problematic this dependency highlighted the urgent need to set-up a monitoring system. In setting up Samoa’s monitoring network, there were many challenges faced in trying to design a system that could withstand the forces of nature (cyclones, earthquakes, tsunamis, and flooding) as well as the limited and unstable communication and power source options. How then do you design such a network that can allay all these concerns? The Samoa-China Digital Seismic Network is the answer to all of this; the Samoan government has been successful in building a network that is robust and can be duplicated in other countries with similar economic and physical conditions. This new system includes the installation of vaults, equipments and communication with careful consideration of climatic changes, availability, longevity and sustainability. The system also looks at combining the new and existing technologies to ensure an improved and reliable service to the country and the region.

**Primary author:** TAFUA, Tessa Jean Lasi (Ministry of Natural Resources and Environment)

**Presenter:** TAFUA, Tessa Jean Lasi (Ministry of Natural Resources and Environment)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
CTBTO Link to the ISC Database

The CTBTO Link to the database of the International Seismological Centre (ISC) provides the CTBTO and the National Data Centres with a dedicated access to seismological data sets maintained by the ISC using specially designed graphical interfaces and database queries. The Link service gives access to a multitude of products: the ISC/ISS bulletins covering the natural seismicity of the Earth, mining induced events as well as nuclear and chemical explosions; the EHB bulletin; the IASPEI Reference Event list (ground truth database) and the IDC REB. The database searches are tailored to the needs of the monitoring community and are divided into three main categories: the Area based (spatio-temporal search based on the ISC Bulletin), the REB based (spatio-temporal search based on specific events in the REB) and the IMS Station based (search for historical reporting patterns of seismic stations close to a selected IMS seismic station). The most recent development of the Link provided a convenient interactive web tool to preview waveform images of non-IMS stations that recorded specific REB events and to request the selected station waveforms from a variety of international waveform archives.

Primary author: STORCHAK, Dmitry (International Seismological Centre (ISC))

Presenter: STORCHAK, Dmitry (International Seismological Centre (ISC))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Large-Scale Cross-Correlation for Teleseismic and Regional Seismic Event Processing

The decreasing cost of storage and computation power invites new methods of seismic data processing. We use a research database containing tens of millions of waveforms to explore the power of seismic correlation to quantify signal similarities, to discover new events not in catalogs, and to more accurately locate events and identify source types. Building on the very efficient methodologies of Harris and Dodge (2011) we computed the correlation for event pairs in two ways. First we performed entire waveform cross-correlation over seven distinct frequency bands. The correlation coefficient exceeds 0.6 for more than 40 million waveform pairs for several hundred thousand events at more than a thousand stations. These correlations reveal clusters of mining events and aftershock sequences, which can be used to readily locate events. Second we determine relative pick times by correlating signals in time windows for distinct seismic phases. These correlated picks are then used to perform very high accuracy event relocations. We examine the percentage of events that correlate as a function of magnitude and observing station distance in selected high seismicity regions and seek to quantify relationships between correlation and event pair separation (in epicenter and depth) and mechanism differences.

**Primary author:** DODGE, Doug (Lawrence Livermore National Laboratory)

**Presenter:** DODGE, Doug (Lawrence Livermore National Laboratory)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
of Interactive Analysis of Infrasound Data in the IDC

Infrasound is one of three waveform technologies which are part of the Comprehensive Nuclear Test Ban Treaty verification regime. Routine analysis of seismo-acoustic events with associations at infrasound stations started in the beginning of 2010 after six years of offline improvements of the automatic processing. During the past three years over 9000 infrasound events were validated by analysts and included in Late Event Bulletin (LEB). Except large seismic events with infrasound associations, infrasound events are characterized by a small number of associated phases. It poses a challenge to both automatic processing and analysts to create valid solutions. The International Data Centre (IDC) is working on improving the infrasound data processing by enhancing the detection capability and examining events formed by the Global Association algorithm (GA) in a separate Infrasound pipeline. In addition to improvements in automatic processing analysts gained experience in interactive analysis of infrasound data. A subset of validated events will be added to the existing reference database which may further improve the quality of automatic and reviewed products. This study will summarize three year results of routine interactive analysis of infrasound data in IDC Operations.

**Primary author:** BITTNER, Paulina (CTBTO Preparatory Commission)

**Presenter:** BITTNER, Paulina (CTBTO Preparatory Commission)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
**Source Location Using the Neighbourhood Algorithm in an Inhomogeneous Atmosphere with Winds**

The Neighbourhood Algorithm is a grid-based search method that optimizes a user-supplied objective function over a computational domain using Voronoi cell tessellation. The algorithm is a method for solving geophysical inverse problems that has the additional benefit of not requiring the estimation of travel-time derivative information. In this application a misfit function for infrasound detections, which is defined in terms of observed and predicted values of travel time and backazimuth and their uncertainties, is minimised using the neighbourhood algorithm. Realistic atmospheric specifications are used to refine the forward modelling stage. Tests are performed using the events from the Infrasound Reference Event Data Base (IRED).

**Primary author:** BROWN, David John (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Presenter:** BROWN, David John (Comprehensive Nuclear-Test-Ban Treaty Organization)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Analysis and Atmospheric Transport Modeling for the National Data Center Preparedness Exercise 2012

For the NPE 2012 the trigger scenario was based on a selected seismic event from the Reviewed Event Bulletin serving as starting point for fictitious Radionuclide Dispersion. Hypothetical xenon and iodine radioisotope source terms with isotopic ratios fitting to a nuclear explosion were assumed. The simulated concentration at radionuclide stations of the International Monitoring System were calculated using the NOAA HYSPLIT model driven by NCEP GDAS analysis data with 0.5 degree horizontal resolution. Noble gas and particulate emissions were treated separately considering wet and dry deposition for the Iodine. Only stations which were operational and sending data in reality were taken for the creation of virtual samples according to the actual collection times. The actual meteorological conditions during the days following the NPE 2012 event and the location of the IMS stations lead to a detection pattern which allowed for sufficient backtracking results. The poster shows as well the exercise scenario as possible analysis solution considering as well radionuclide isotopic ratios for event dating and characterization as backward atmospheric transport modeling for localization. Those results build the connection to the waveform analysis and allow for an overall judgment on the chosen REB event.

Primary author: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Presenter: ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Method of Signal Analysis Based on the Mathematical Morphology (the Case of Model Experiment)

The morphological analysis method was applied for the extraction of quasi periodic signals from subwoofer. Signals were registered in August 2009 on science station of A.M. Obukhov Institute of Atmospheric Physics. The signals frequencies were 45, 75, 105, 130 Hz. Distance from sources were from 0 to 1255 m. The registration was carrying out during daytime and night. The effectivity of the method for the extraction of quasi periodic signals from different noises has been shown. The morphological analysis method allows to detect signals with nonconstant phase. It is important for detecting signals at large distances from sources.

Primary author: TSYBULSKAYA, Nadezda (A.M. Obukhov Institute of Atmospheric Physics)

Presenter: TSYBULSKAYA, Nadezda (A.M. Obukhov Institute of Atmospheric Physics)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Prototype of a Waveform and Radionuclide Data-Fusion Tool

A tool that shows connectivity between waveform events and radionuclide detections has been developed. CTBTO’s mission is to monitor compliance with the CTBT and to provide a set of independent data to the States Signatories to assist them in fulfilling their CTBT verification task. For this purpose, CTBTO operates networks of sensors to detect waveform signals and subsequently localize the epicenters of waveform events. Because the evidence of the nuclear character of a waveform event can only be provided by the radionuclide technology, a skillful fusion between detections made by the radionuclide network and waveform events has a potential of providing valuable information to the States Signatories. In achieving a fusion of information from radionuclide and waveform monitoring technologies, atmospheric transport modeling (ATM) plays a key role. ATM allows limiting the number of waveform events which are potentially sources of detected radionuclides by restricting attention to those which fall within a region indicated by the ATM. For 2012 this helps to reduce the number of waveform events which are potentially sources of radionuclides from 16439 to 341. To assist national-experts in their analysis, we have developed tools producing a daily updated waveform-radionuclide interactive connectivity table and a geographical visualizer.

Primary author: KUSHIDA, Noriyuki (CTBTO)
Presenter: KUSHIDA, Noriyuki (CTBTO)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Analysis of VSAT Jamming Attacks on the Recognition of Events

This study analyzes the potential impact of cyber attacks on the verification regime prior to the execution of an illegal nuclear test activity. In this matter, attacks on the availability of measurement stations by jamming their satellite up-links, namely the Very Small Aperture Terminals (VSATs), are relevant. The rationale is that any entity that wants to perform an illegal test activity will strive to cover its actions to evade liability. If the service of verification regime can be degraded to a point where the recognition of events is unreliable or disputable, the attacking entity can repudiate liability towards the States Parties. Devices to jam the VSATs’ signals are cheap and available. Disrupting a station’s communication capabilities might hamper the analysis procedures and in consequence the Quality-of-Service of the International Measurement System (IMS)-based data products. For instance, the temporal correlation of data items might be disturbed by disrupting their GPS-based timestamping. Therefore, we simulate a scenario in which an attacker maliciously launches a jamming attack to degrade the verification regime. We model the impact of single measurement signals on recognizing an Event and evaluate, if a jamming attack could force a configuration of signals such that the Event remains undetected.

Primary author: WASICEK, Armin (Vienna University of Technology)

Presenter: WASICEK, Armin (Vienna University of Technology)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
to Array and Network Processing for Enhanced Nuclear Explosion Monitoring

Single and multiple seismic array stations can provide an exquisitely sensitive monitoring capability for nuclear test sites which exceeds significantly that for general seismicity using standard algorithms. We here outline some methods for enhanced seismic monitoring employed at NOR-SAR. A detection on a single array with parameters consistent with a signal anticipated from a given site can initiate an Alert, followed by an automatic search in specific time-windows for corresponding detections at other global stations. For sites with available waveform templates from previous events, pattern detectors can identify similar signals even at low SNR; correlation detectors recognize wavetrain repetition on single or multi-channel datastreams and matched field detectors recognize the wavefront-specific phase and amplitude relationships between sensors of an array. Both are effective on arrays where scattering and incoherence preclude classical array processing. Spectrogram beamforming may be applied to larger arrays to detect and classify incoherent signals. Site Specific Threshold Monitoring uses data from a network of arrays to produce a continuous “threshold trace” indicating the upper bound of the magnitude of a seismic event which could have occurred at that site at any given time. The above methods are demonstrated for monitoring of the North Korea nuclear test site.

Primary author: GIBBONS, Steven John (NORSAR)
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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of Xe-127 in Quality Assurance of IMS Noble Gas Systems at Remote Locations

A quality assurance program for Noble Gas (NG) systems of IMS Radionuclide network is under development at PTS. Spiking NG systems with known amount of Xe-133/Xe-131m and reanalyzing spike samples at IMS Radionuclide laboratories with NG capability is part of the program. Remoteness and very difficult location of some IMS stations is preventing use of these two isotopes - due to their half-life, very short when compared to shipping times. Because of longer half-life and identical physical behaviour, Xe-127 has been suggested as possible candidate for spiking at remote locations. With technical and scientific support of the NLHB (Laboratoire National Henri Becquerel - CEA, LIST), PTS started in 2012 a feasibility study on use of Xe-127. The study is constituted by a test intercomparison for IMS labs and a set of test spikes at some designated IMS NG systems. Methods and results of this feasibility study are presented.

**Primary author:** NADALUT, Barbara (CTBTO)

**Presenter:** NADALUT, Barbara (CTBTO)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Noble Gas Equipment Development – System Technical Specifications and Capabilities

A high throughput system for processing and detection of radio-xenon for On-Site Inspection (OSI) purposes is currently being developed at FOI. To locate an underground event during an OSI it is important to cover and narrow down a large area of interest in a short time period. This will require a large number of sub-soil gas samples to be analyzed per day. Even if samples are combined, a noble gas system has to have a much higher throughput than currently available. The new system is intended to achieve this and have the capacity of separating high levels of Rn, CO2 and other gases in combination with the high sensitivity and performances of the current SAUNA II system. The new optimized beta-gamma detector design, and its sensitivity will be presented. Four detectors are collocated in one single lead-shield which is re-designed for simplified field deployment. The improved gas process and its capabilities, e.g. radon separation and re-quantification, will also be covered.

Primary author:  FRITIOFF, Tomas (Swedish Defence Research Agency, FOI)
Presenter:  FRITIOFF, Tomas (Swedish Defence Research Agency, FOI)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
of Kernel-Based Machine Learning Techniques for Infrasound Signal Classification

In IMS infrasound processing, incoming data is first treated on the level of individual array stations. Automatic station processing serves the detection of coherent wavefronts as well as estimation of their slowness and azimuth. Additionally, station processing categorizes detections into signal and noise, and also labels incoming signals based on their travel path through the atmosphere. The current contribution gives preliminary results from applying kernel-based machine learning algorithms to infrasound signal classification. This concerns both separating signal- and noise-type detections as well as discriminating signals by their travel path through the atmosphere. In addition, first investigations into the effects of seasonal variability on these classifiers are carried out.

Primary author: TUMA, Matthias (Institut für Neuroinformatik, Ruhr-Universität Bochum)
Presenter: TUMA, Matthias (Institut für Neuroinformatik, Ruhr-Universität Bochum)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Prototype Software for Automatic Data Fusion
Analysis of Candidates for Underground Nuclear Explosions Detected by IMS

A complete analysis of candidates for underground nuclear explosions detected in the IMS requires the combined use of seismic and radionuclide data, as well as atmospheric transport modelling (ATM). A new method performing such analysis automatically has been developed and tested at the Swedish NDC. The algorithm is implemented in a new pilot software called SEICON. The software calculates a time of fission window using observed radioxenon ratios, with uncertainties, in combination with a selected release scenario calculated using SCALE. Based on this, seismic events are selected, and further screened using possible source regions or field of regards obtained from ATM. The software was successfully tested in the NPE12. The methodology will be presented, together with results obtained so far.

Primary author:  RINGBOM, Anders (Swedish Defence Research Agency (FOI))
Presenter:  RINGBOM, Anders (Swedish Defence Research Agency (FOI))
Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
of NDC Austria at the NDC Preparedness Exercise 2012

The NDC Preparedness Exercise 2012 (NPE 2012) was a fictitious radionuclide triggered test conducted by the National Data Centers (NDCs) of CTBT States Signatories. During the NDC Preparedness Exercise 2012, a fictitious radionuclide scenario originating from a seismic event was calculated and distributed by the German NDC. It was assumed that a selected seismic event was the epicentre of an underground nuclear fission explosion. The scenario included detections of the Iodine isotopes 131I and 133I and the Radioxenon Isotopes 133Xe, 133MXe, 131MXe and 135Xe. By means of atmospheric transport modelling (ATM), concentrations of Radioxenon isotopes which would result from this hypothetical explosion were calculated by the German NDC and interpolated to the IMS station locations. Participating NDCs received information about the concentration of the isotopes at the station locations without knowing the underlying seismic event. The main goal of the analysis was to identify the event selected by NDC Germany to calculate the radionuclide scenario, and to exclude other events. In the presentation, the analysis methodology as well as the final results and conclusions will be shown and discussed in detail.

Primary author: MITTERBAUER, Ulrike Helene (Central Institute for Meteorology and Geodynamics)

Presenter: MITTERBAUER, Ulrike Helene (Central Institute for Meteorology and Geodynamics)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
National Data Centre Preparedness Exercise NPE 2012 – Waveform Data Analysis Results

The National Data Centre Preparedness Exercises (NPE) simulate a fictitious violation of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and are conducted by NDCs for NDCs with the aim to increase the awareness and preparedness of their duties. These exercises are regularly performed with different scenarios. For the NPE 2012 a seismic event from REB was selected as an internal source of a fictitious release of iodine and radio-xenon. The exercise started with the notification of hypothetical radionuclide concentrations detected at IMS stations. The internal release scenario was kept undisclosed for participants. Therefore one main task of the exercise was the identification of the seismic source event. Atmospheric transport modeling in backward mode was required to confine the possible source region and find candidate waveform events from REB. The analysis of xenon isotopic ratios gives additional information about the event timing. Seismological characteristics of the remaining candidate events were investigated in detail and combined with associated infrasound detections to discriminate between natural seismic events and explosions. Spectral behaviors and source characteristics were compared for events from various clusters associated with mining activities, leading to conclusion that this event was an explosion.

**Primary author:** GESTERMANN, Nicolai Johannes (Federal Institute for Geosciences and Natural Resources (BGR))

**Presenter:** GESTERMANN, Nicolai Johannes (Federal Institute for Geosciences and Natural Resources (BGR))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
56 Newport, WA Component Upgrade: Evaluation of the Replaced Digitizers (Geotech Dr24) and Infrasound Sensors (Martec MB2000) and Implications for Planning Future Maintenance and Upgrades

Since the Comprehensive Nuclear-Test-Ban Treaty was opened for signature in 1996, nearly 80% of the infrasound network has been certified as operational and sending data to the International Data Centre (IDC) in Vienna. Several of the stations have been in operation for close to 15 years. With new advancements in digital recording technology and sensor design, some station operators have started the process of upgrading the digitizers and sensors for stations under their control. This past year station IS56 Newport, WA upgraded its digitizers from Geotech DR24s to the new Smart24, and infrasound sensors from Martec model MB2000 to the Chaparral Physics model 50A. This upgrade offered the opportunity to evaluate the replaced components to determine the quality of the data residing at the IDC for this station. By reviewing the test results of the “aged” hardware against the minimum station requirements set for International Monitoring System (IMS) stations, we will provide information the Provisional Technical Secretariat (PTS) IMS Division staff can use to help make station maintenance and hardware upgrade decisions.

Primary author: HART, Darren (Sandia National Laboratories)

Presenter: HART, Darren (Sandia National Laboratories)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
CTBTO Model E3 Liquid Nitrogen Generator

With a mandate to reduce downtime related to use of electric coolers, the Engineering and Development Section of CTBTO started in 2009 a pilot project to evaluate implementation of liquid nitrogen (LN2) generators at IMS Radionuclide stations. A commercially available unit, produced by MMR Technologies, has been tested at IMS stations NZP47 (Kaitaia) during the last 4 years and FJP26 (Fiji) for 2 years. Close collaboration between PTS and MMR Technologies allowed the finalization, in 2012, of a new “CTBTO model E3 Liquid Nitrogen Generator” fitting specific CTBTO needs for robustness, easy maintenance, long term reliability and full remote control. Features added to the E3 include full logging of key state of health information (which can be accessed on the station PC), the ability for automatic control based on the detector LN2 level, and a complete redesign of the internal layout to allow for easy maintenance. The newly developed CTBTO E3 prototype has passed several stress tests at the factory, and since September 2012 has been in testing and evaluation phase at the IMS test station in Vienna.

Primary author: NADALUT, Barbara (CTBTO)

Presenter: NADALUT, Barbara (CTBTO)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Noble Gas Equipment Development – System Design and Envisaged Usage

A high throughput system for processing and detection of radioxenon for On-Site Inspection (OSI) purposes is currently being developed at FOI. To locate an underground event during an OSI it is important to cover and narrow down a large area of interest in a short time period. This will require a large number of sub-soil gas samples to be analyzed per day. Even if samples are combined, a noble gas system has to have a much higher throughput than currently available. The new system is intended to achieve this and have the capacity of separating high levels of Rn, CO2 and other gases in combination with the high sensitivity and performances of the current SAUNA II system. The system design covering current status and performance will be presented. Envisaged use in the field, user interface, sample identification and future possibilities will also be presented.

Primary author: ALDENER, Mattias (Swedish Defence Research Agency (FOI))
Presenter: ALDENER, Mattias (Swedish Defence Research Agency (FOI))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
- An Instrument for Detecting Nuclear Explosions from Low Levels of Radioactive Xenon - Latest Developments

Today, 16 stations within the IMS network of CTBTO have SAUNA Systems installed for noble gas capability. The activity measurement of the four xenon isotopes, $^{133}$Xe, $^{131m}$Xe, $^{133m}$Xe, and $^{135}$Xe is performed using the very sensitive beta gamma coincidence technique allowing high sensitivity also for the meta-stable states resulting in MDC:s of 0.3, 0.3, 0.3 and 0.7 mBq/m³ respectively. In the SAUNA Systems product portfolio there are systems for; continuous monitoring, in-field sampling, and reanalysis of archived samples. We are now upgrading SAUNA systems in the network with the latest developments; new digital detector electronics, an in house developed high voltage supply, new data acquisition software, new safety solutions, and a new sample archive. We are also in final testing of new memory free beta cells awaiting an upcoming release in the near future. The new detector electronics with new HV-supply have several advantages, better stability, better temperature dependence and an easier set up procedure. A new data acquisition software has made the system more user friendly and flexible. After release of the memory free beta cells the SAUNA detector system has been greatly improved and offers new possibilities.

**Primary author:** BERGLUND, Helena (Scienta SAUNA Systems)

**Presenter:** BERGLUND, Helena (Scienta SAUNA Systems)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Detection with Artificial Neural Networks: Reduction of Response Time and Development of Active Learning Techniques in Real Environment

To pursue the goal of substantially reducing the time of classification, it was necessary to collect much less information about the seismic event itself, and focus on the transition between noise and P input phase. In this experiment, the data used in training and validation were the same as in previous work, and the training procedure was identical. The difference was in the feature extraction method. A perfect classifier for the universe of data considered was achieved. The results in real environment evaluation were: R = 95.3% and S = 98.4% and an average response time of 1.5 s. Although these can be considered good results, the occurrence of false positives, as well as some non-detections, commits to pursue the line of research initiated earlier, which involves the application of active learning techniques after initial training of the classifier. Currently ongoing are experiments based on clustering methods, intended to elect representatives of the segments incorrectly classified in the evaluation of continuous recording, in order to increase the knowledge acquired by the classifier in real environment.

Primary author: MACHADO MATOS MADUREIRA, Guilherme Henrique (Instituto do Mar e da Atmosfera)

Presenter: MACHADO MATOS MADUREIRA, Guilherme Henrique (Instituto do Mar e da Atmosfera)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Design and Multi-Technology Analysis of the National Data Center Preparedness Exercise 2012

NDC Preparedness Exercises (NPE) are regularly performed dealing with fictitious treaty violations to practice the combined analysis of all CTBT verification technologies and also for the mutual exchange of information between NDC and also with the IDC. The exercises are organized and coordinated at the German NDC (BGR). The NPE 2012 scenario was based on a selected seismic event from the Reviewed Event Bulletin serving as starting point for fictitious radionuclide dispersion. The internal trigger event was not provided to the participants. Hypothetical xenon and iodine concentrations at operational IMS stations where simulated by forward atmospheric transport modeling (ATM) and the detections in virtual samples announced. The first task was for all participants to confine the potential source region by means of atmospheric backtracking and to identify candidate waveform events. For participants without ATM capacity two additional entrance levels were offered upon request: either a space-time-box containing the trigger event or even the REB Event ID with waveform parameters. The presentation will provide an overview on the event selection process and radionuclide scenario as well as on the event analysis combining signals from waveform and RN/ATM-technologies. Finally, an outlook on the upcoming NPE will be given as well.

**Primary author:** ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

**Presenter:** ROSS, Jens Ole (Federal Institute for Geosciences and Natural Resources (BGR))

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Aftershock Monitoring Network Optimization Based on Detection Threshold Estimation from Background Noise Measurements

The Seismic Aftershock Monitoring System (SAMS) is an important method during the initial period of an On-site Inspection (OSI) to identify the possible source area of an underground nuclear explosion (UNE). A network of tripartite mini-arrays and single three-component seismic stations will be deployed during an OSI to detect and localize aftershocks in the vicinity of a possible explosion. The threshold of a seismic network depends on many aspects such as configuration, data quality and site conditions of each individual station. During an OSI a tradeoff between fast station deployment and precise site analysis has to be made. A first rough site characterization is possible with information about geology, local facilities and infrastructure e.g. roads. An individual characterization needs additional information to be acquired by field measurements. A method with a visualization tool will be presented which can be integrated into the SAMS and allows an inspector to estimate the detection threshold of the inspection area and to adapt the network configuration to the needs by densifying the network or relocating stations. A threshold reduction at locations of interest can be implemented and information about station data quality assists an inspector to focus the work on sites with optimum conditions.

**Primary author:** SICK, Benjamin (University of Stuttgart, Stuttgart, Germany)

**Presenter:** SICK, Benjamin (University of Stuttgart, Stuttgart, Germany)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
of P-Wave Backazimuth and Slowness Residuals at Small-Aperture Keskin Seismic Array (BRTR), Turkey

Azimuth and slowness errors are essential for estimating station corrections in order to improve the location quality. Keskin (BRTR) array is a primary seismic array of the IMS (International Monitoring System) network located at near Ankara in the Central Anatolia, Turkey. It consists of 7 array elements in a circular array geometry with an approximate aperture of 3 km. Array processing techniques, especially the determination of slowness, are powerful in the characterization of seismic phases. We applied one of these techniques, standard f-k analysis, to estimate azimuth and slowness systematic errors for BRTR using Geotool software. In this study, observed backazimuth and slowness values from P phases of REB (Reviewed Event Bulletin) events in the last 3 years (2010-2012) were statistically analyzed. The back azimuth and slowness measurements are compared with theoretical predictions made using the iasp91 velocity model and residuals are obtained. Other IMS seismic arrays were also used for comparison purposes. Large and systematic azimuth deviations at BRTR array are identified in the study and will be presented.

Primary author: ŞEMİN, Korhan Umut (Belbasi Nuclear Test Monitoring Center)
Presenter: ŞEMİN, Korhan Umut (Belbasi Nuclear Test Monitoring Center)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Waveform QCtool: A Web-Based GUI for Examining Processing-End Station State of Health

A web-based graphical user interface has been developed that provides the user with the capability of determining processing-end station state of health information for seismic, hydroacoustic and infrasound stations. The main visual feature is a station x time matrix with coloured cells that provide information on the health of a selected parameter for that time interval, which is usually set to be one hour. Presently three parameters are being displayed, viz: station noise determined each hour for all Seismic, Hydroacoustic and Infrasound stations; the health of the QC mask used in DFX processing; and Event Quality information that plots information like event station magnitude residual as a function of time. Processed data in various formats is available to the user who can display waveforms for selected intervals.

Primary author:  BROWN, David John (Comprehensive Nuclear-Test-Ban Treaty Organization)

Presenter:  BROWN, David John (Comprehensive Nuclear-Test-Ban Treaty Organization)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Accumulation Detection Between Tectonic Plates

The law of conservation of energy states that, energy can neither be created nor be destroyed i.e., energy accumulation at any specified point of time and space is at the cost of energy loss at other points or point keeping the net energy of an ecosystem constant. Means of detecting the energy quantum between tectonic plates can be explored to possibly estimate the total energy quantum and in process its accumulation over a period of time, enabling calculation of net energy at any specified time, finding thresholds that trigger tremors and related specific or generic conditions. Alternatively estimation of the size and mass of respective tectonic plates and acceleration causing gradual shifts can help us find net force and thereby the energy quantum that can possibly accumulate over time. Different similar scenarios can be used to model the estimation of energy quantum verifiable through simulations. Possible time period between two successive events can also be estimated fairly accurately beside identification of specific conditions affecting the phenomenon. This study on success may help possibly in early prediction of events. The hypothesis needs ab-initio development but may yield certain in process additional challenging concepts for exploration.

Primary author: SHAH, Syed Muhammad Ayub (National Defense University (NDU))

Presenter: SHAH, Syed Muhammad Ayub (National Defense University (NDU))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Modernized Large-Aperture Broadband Array NOA, Norway

The large-aperture seismic array NOA had a major instrumental upgrade in 1994 and has been operational with the very same configuration until recently. Over time the instruments became obsolete and spare parts were not longer available. NOA consists of 42 sites grouped into seven subarrays covering a total aperture of about 60 km. It had been equipped with 7 broadband 3C-sensors (one in each subarray) and 42 short-period instruments. In 2008 NORSAR initiated the modernization of NOA. In order to utilize an instrument with the same response for all sites and to optimize the broadband monitoring capabilities of the array, NORSAR specified a hybrid instrument response for the seismometers, which were engineered by Guralp. The upgrade of the NOA array was completed in July 2012 and in the present configuration NOA has seven 3C sensors (360s - 50Hz) and 32 vertical borehole sensors (120s - 50Hz), with identical amplitude responses in the overlapping frequency band. We will report on the characteristics and the capabilities of the new all-broadband array NOA.

Primary author: ROTH, Michael (Swedish National Seismic Network, University Uppsala)
Presenter: ROTH, Michael (Swedish National Seismic Network, University Uppsala)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
NDC-in-a-Box: Integrated Data Acquisition, Processing and Analysis Platform for NDCs

The Commission operates a collection of software that processes Seismic, Hydroacoustic and Infrasonic (S/H/I) waveform data, measured at detector stations around the globe. Establishing a National Data Centre (NDC) aids a Member State in assuming its role under the Treaty as it helps to obtain, examine and analyse monitoring data and analysis reports provided by the CTBTO International Data Centre (IDC). Currently, 123 States have established an NDC as of 2013. CTBTO provides technical assistance that enables Member States to work with monitoring data and IDC products. This assistance includes the distribution and the installation of NDC software package. This ’NDC in a box’ consists of software to receive, work with and analyze the data. CTBTO is extending the current ’NDC in a box’ offering with additional software enabling users to easily combine data from the IMS stations with data from local and national stations and from other global networks and to significantly improve the NDCs processing capabilities. The poster explains how the new functionality in the extended ’NDC in a Box’ provides to NDCs an integrated acquisition, processing and analysis platform for S/H/I data.

**Primary author:** MILJANOVIC TAMARIT, Vera (CTBTO)

**Presenter:** MILJANOVIC TAMARIT, Vera (CTBTO)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Broad-Band Seismological Network Design and Actual State of the Art

Though Albania is an earthquake prone country the first seismological station dates in 1968. The local instrumental network was finalized in 1976 counting thirteen seismographic stations. It enabled systematic monitoring of the microearthquake activity in the country and led to the discovery of some characteristic features of the recent seismicity of Albania. Stations have been equipped with passive short period sensors recording on site. Modernization of Albanian Seismological Network (ASN) started in 2002 and continued to 2006. Six broad-band stations are installed and started their normal operation. The actual design of ASN is based widely on the broad-band instrumentation covering the most seismic active units of the country. Data transmission is done in near real time through satellite telemetry (VSAT) to the central processing center in Tirana. A very broad-band station operates in Tirana as part of Mediterranean Seismological Network (MEDNET) integrated virtually to ASN. The actual state of the art of ASN permits contribution to the regional and global seismological database, through its membership in several organizations such as ISC, EMSC, FDSN and IRIS. This paper aims an introduction of ASN giving details on its actual state of the art as part of the global seismological monitoring framework and contribution.

Primary author: DUSHI, Edmond (Institute of Geosciences, Energy, Water and Environment (IGEWE))

Presenter: DUSHI, Edmond (Institute of Geosciences, Energy, Water and Environment (IGEWE))

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Analysis of Transient Seismic Signals Using Wigner-Ville Distributions

Today's increased computing power of even a simple desktop computer makes it feasible to routinely use new methods for analysing or detecting transient seismic signals. Here we compare time-frequency representations of surface waves using the Wigner-Ville distribution (WVD) with other typically employed methods, such as the multiple filtering technique (MFT) used to measure group velocities. Initial results suggest WVD to be at least as good as MFT at measuring dispersion curves, albeit at a greater computational expense. Both MFT and WVD generally work well for teleseismic events and at longer periods. However, these conditions may be considered ideal, as the waveforms are nicely dispersed and signal to noise ratio is good. We are therefore particularly interested in how the methods compare in less optimal conditions, and will present our latest findings on this matter at the conference.

**Primary author:**  LLOYD, Simon (University of Vienna)

**Presenter:**  LLOYD, Simon (University of Vienna)

**Track Classification:**  Theme 3: Advances in Sensors, Networks and Processing
the Noble Gas Concept of Operations for Radionuclide Sampling Concepts

Soil gas sampling methods are a critical, yet underdeveloped, component of subsurface noble gas detection during an On-Site Inspection (OSI). The verification system for the Comprehensive Nuclear-Test-Ban Treaty (CTBT) is intended to detect any nuclear explosion, above or below ground. When a suspected nuclear explosion is detected, an OSI can be called at the site where the nuclear explosion is thought to have occurred. Subsurface environmental measurements of noble gases are allowed during an OSI for the intent of measuring noble gas fissions gases (e.g., $^{37}$Ar and $^{133}$Xe, $^{131}$mXe) that were released from a nuclear test. Noble gases can either quickly vent to the atmosphere or they can migrate to the surface through fissures and fractures in the surrounding geology. When noble gases migrate through the geology, they can be collected at the subsurface then measured by a radioxenon processing and measurement system. The challenge in an OSI is to obtain quality soil gas samples. This paper will discuss recent advances in subsurface soil gas sampling methods specific to the challenging requirements for an OSI.

**Primary author:** HAYES, James C. (Pacific Northwest National Laboratory)

**Presenter:** HAYES, James C. (Pacific Northwest National Laboratory)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Impact of High Resolution Beta Detectors on the Detection of Radioxenon Isotopes

There are currently three ongoing efforts to use Silicon PIN diodes as the beta detectors in beta-gamma systems used for radioxenon measurements [1,2,3]. The high resolution that these detectors have demonstrated for conversion electron have shown that they can significantly reduce the minimum-detectable-concentrations for the two meta-stable isotopes $^{131m}$Xe and $^{133m}$Xe. Additional physics signatures can be elucidated as triple and greater coincidence between, beta-particles, CE, gamma-rays and X-rays, that were summed in the past using standard beta-gamma detectors [4]. This poster will discuss the impacts to fielded systems and lab operations and the potential reduction in the MDC’s for the four radioxenon isotopes that these new detectors can achieve. 1. Hennig, W., et al., 2011, in Proceedings of 2011 Monitoring Research Review: Ground-Based Nuclear Explosion Monitoring Technologies, LA-UR-11-04823, Vol. 2, pp. 695–707. 2. V. Popov, N. Kazarinov , I.Popov, New beta – gamma detector System, International Noble Gas Experiment Workshop, 06-10 December 2011, Yogyakarta, Indonesia 3. Private communications with Gilbert Le Petit, CEA, DAM, DIF, F-91297 Arpajon, France, 2012. 4. Cooper MW, et al., Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors and Associated Equipment 579(1):426-430.

Primary author: MCINTYRE, Justin John (Pacific Northwest National Laboratory)

Presenter: MCINTYRE, Justin John (Pacific Northwest National Laboratory)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Infrasound Pipeline Initiative for Technology Development

The International Data Centre (IDC) of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) automatically processes infrasound data later reviewed by interactive analysis; the detected and located events are being systematically included in IDC products. The IDC works on enhancing the automatic system for the identification of valid signals and the optimization of the network detection threshold by identifying ways to refine signal characterization methodology and association criteria. The objective of this study is to reduce the number of associated infrasound arrivals that are rejected from the automatic bulletins when generating the reviewed bulletins. The study is twofold, the first part consist of improving the detection accuracy at the station processing stage by enhancing the infrasound signal detector DFX-PMCC (Detection and Feature eXtraction – Progressive Multi-Channel Correlation). The second part separates infrasound data from other waveform technologies at the automatic network processing stage. Infrasound rules in Global Association (GA) are tuned to pursue a lower ratio of false alarms. Once modifications are tested and validated, the updated algorithms will be implemented in the development area of the IDC for further assessment of their performances in fusion with other waveform technologies.

**Primary author:** MIALLE, Pierrick (CTBTO Preparatory Commission)

**Presenter:** MIALLE, Pierrick (CTBTO Preparatory Commission)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
**Geotool Analysis Software: Ghana’s Experience with the CTBTO/NDC Capacity Building Project**

The Comprehensive Nuclear Test-Ban-Treaty Organization (CTBTO) Capacity Building Project designed to equip and enhance the analytical skills of trainees of the beneficiary states, thereby resourcing Individual States with the requisite technical knowledge to fulfill their obligation under the treaty and make their own judgment of the nature of a suspicious event. The training programs include the access and analysis of IMS data and IDC products with emphasis on the application of the Geotool analysis software to process IMS data and other external data format applicable. With the introduction of the Geotool software to NDC–Ghana, it has engaged beneficiary staff to access and analyze IMS data and compare location parameters with that of the IDC analyst (REB) and participate in NPE2012 trigger event (i.e. level 3 entry) exercise. The software is user-friendly and allows interactive display of seismoacoustic data. The experience with Geotool analysis software though intriguing, came through challenging circumstances.

**Primary author:** AMARTEY, Edmund Okoe (Ghana Atomic Energy Commission)

**Presenter:** AMARTEY, Edmund Okoe (Ghana Atomic Energy Commission)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
European Seismological Research Infrastructure: Status and Developments

Europe is currently investing heavily in coordination of its seismological research infrastructures and the products and services they provide through a wide variety of EC and national projects. The current status and on-going developments can described within roughly three categories:

• Seismological data, including primary waveforms, metadata and primary measures (arrival times and amplitude of seismic waves) and building on existing network coordination initiatives within the ORFEUS (www.orfeus-eu.org) framework.
• Seismological products, including earthquake parameters (location, magnitude), seismic bulletins and (historical) catalogues, earthquake alerts and building on existing coordination efforts within the EMSC (www.emsc-csem.org) framework.
• Products and services in seismic hazard and risk, including base date for modeling (catalog of active faults, GMPEs, building vulnerability functions, etc) and modeling tools, hazard & risk maps and scenarios, and building on on-going initiatives in SHARE and NERA and within the EFEHR (www.efehr.org) framework. During 2013 the coordinating organizations are structuring those developments into a comprehensive European seismological RI, well embedded in the international framework to ensure compatibility and, specifically, the general European earth science RI of EPOS. This includes a long-term planning of integrated services based on a scientific research vision in earth sciences.

Primary author:  VANK ECK, Torild (Observatories and Research Facilities for EUropean Seismology)

Presenter:  VANK ECK, Torild (Observatories and Research Facilities for EUropean Seismology)

Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
of a 24-Channel Coincidence Radioxenon Detector with Silicon PIN Diodes

Existing radioxenon detectors for nuclear explosion monitoring typically use either scintillator based beta/gamma coincidence detectors or germanium based gamma only detectors. Silicon detectors have a number of potential advantages (high resolution, low background, sensitivity to both photons and electrons, and no memory effect) and have been shown previously to be a possible alternative to existing detectors. A radioxenon detector with 24 silicon PIN diodes has been designed, assembled, and tested. The PIN diodes are arranged as 2x2 arrays with 100 mm^2 active area on each of the six sides of a cubic Xe cell to achieve a high geometric efficiency. The probability for detecting higher energy gamma rays is low, but backgrounds are practically zero so that overall the minimum detectable concentration is estimated to be below 1 mBq/m^3.

Primary author: HENNIG, Wolfgang (XIA LLC, Hayward, CA, USA)
Presenter: HENNIG, Wolfgang (XIA LLC, Hayward, CA, USA)
Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Carlo Simulation of a Phoswich Detector for Beta-Gamma Coincidence Measurements

The well-known radioxenon systems are based on multichannel beta-gamma spectroscopy. Therefore, there always are some technical problems in and periodical calibrations and maintenance. On the other hand, phoswich detectors are simply based one channel. Appropriate design of a phoswich detector is based on accurate evaluations for different phenomena appearing in response generation. Geant4 is a toolkit that have required capabilities for a front end simulation of scintillation spectroscopy systems. The current study resulted in a proposed design which consists of a plastic beta counting cell made of BC404 coupled to a CsI(Tl) scintillation crystal. It is well-known that there is a correspondency between linearity of spatial dependence of response function and the intrinsic resolution. The main objective is to achieve a linear response function, mainly based on optimization of both of scintillation cells from radiation and optical transport points of view. The study was performed to render a complete evaluation of geometrical and optical effects dealing with the response functions. A detailed pulse shape analysis methodology has been implemented via Geant4 toolkit to evaluate particle discrimination efficiency. Based on the current study, it is expected that the proposed system to have a reasonable energy resolution in comparison to current systems.

Primary author:  SAFARI, Mohammad Javad (Amir Kabir University of Technology)
Presenter:  SAFARI, Mohammad Javad (Amir Kabir University of Technology)
Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Image Use in On-Site Inspection: From Site Selection through Field Efforts

In preparation for a field site visit, particularly for CTBTO investigative purposes, a variety of types, scales, and generations of open-source digital imagery can be compared within the framework of commercially-available geographic information systems (GIS) to focus on areas of interest. Simple image comparison from various open sources within GIS afford the opportunity to view anthropogenic and natural changes to a suite of sites over time, thus remotely elucidating information about a site’s use and level of activity. This method permits a first-pass down-selection of sites, critical to promoting focus and efficiency for initial site visits. Such image comparison and open-source availability could also strongly benefit on-site inspection teams during the pre-inspection and inspection phases, especially in geographically extensive areas, and for interpreting the context of site observables. This presentation will depict general examples of the methodology of GIS image generation and comparison from Hungary, Jordan, and Korea.

Primary author: HAWKINS, Ward (Los Alamos National Laboratory)

Presenter: HAWKINS, Ward (Los Alamos National Laboratory)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Verification Regimes: Lessons Learnt from the CTBTO

The purpose of this work is to examine the political and technical aspects of a verification regime pertaining to the Comprehensive Nuclear Test-Ban Treaty. Mainly two technical issues are studied. One is a detection issue critical to the verification of the treaty. The second is on the sharing of data generated by the IMS. The study will examine other other arms control and disarmament regimes. Sensitivities surrounding the derivation and use of information are studied and compared with the Comprehensive Nuclear Test Ban Treaty’s verification regime. This analysis will potentially help to clarify the distinction between the scientific and technical merits of implementation issues critical for treaty verification into the current international political context. Recommendations would be operationally-relevant and focused and would reflect the current state of inspection technologies, equipment and procedures.

Primary author: GOPALASWAMY, Bharath (ACDIS, University of Illinois at Urbana-Champaign)

Presenter: GOPALASWAMY, Bharath (ACDIS, University of Illinois at Urbana-Champaign)

Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of the Reverse Time Migration Method on Dense Seismo-Acoustic Arrays

We first present location results using the RTM method (Reverse Time Migration, e.g. Walker et al., 2011) applied to explosion events listed in the TAIRED catalogue (TA Infrasound Reference Event Database), recorded by the USArray. We compare our results to the TAIRED solutions (http://www.iris.edu/spud/infrasoundevent). Good agreements between both solutions are found.

In a second stage, we analyze data from the Lapnet / Polenet dense seismic network (Kozlovskaya et al., 2008). Detection and location in two-dimensional space and time of infrasound events presumably due to acoustic-to-seismic coupling, during the 2007-2009 period in Europe, are presented.

The aim of this work is to integrate near-real time infrasound network performance predictions to improve the RTM detection algorithm at regional scales (automatic selection of the sensors with the highest SNR with daily updated travel time curves). We show that the use of dense seismic networks provides a valuable tool to monitor infrasonic phenomena, since seismic location has recently proved to be more accurate than infrasound locations due to the large number of seismic sensors.

**Primary author:** LE PICHON, Alexis (CEA/CENTRE Ile-de-France)

**Presenter:** LE PICHON, Alexis (CEA/CENTRE Ile-de-France)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Development of a Cosmic Veto Gamma-Spectrometer

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) is supported by a network of certified laboratories that perform high-resolution gamma-spectrometry on global air filter samples for the identification of 85 radionuclides. At the UK CTBT Radionuclide Laboratory (GBL15), a novel cosmic veto gamma-spectrometer has been developed to improve the sensitivity of measurements for treaty compliance. The system consists of plastic scintillation plates operated in time-stamp mode to detect coincident cosmic-ray interactions within an HPGe gamma-spectrometer. This provides a mean background reduction of 75.2% with MDA improvements of 45.6%. The CTBT requirement for a 140Ba MDA is achievable after 1.5 days counting compared to 5 – 7 days using conventional systems. The system does not require dedicated coincidence electronics, and remains easily configurable with dual acquisition of unsuppressed and suppressed spectra. Performance has been significantly improved by complete processing of the cosmic-ray spectrum (0 – 25 MeV) combined with the Canberra LynxTM multi-channel analyser. The improved sensitivity has been demonstrated for a CTBT air filter sample collected after the Fukushima incident.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Technology in Indonesia

The Infrasound experiments have started in Indonesia in 2004, with the support of DASE (French CEA) BMKG installed an infrasound experimental station in the airport of Palangkaraya in Kalimantan. However, this preliminary study which was performed with only one single infrasound station was very encouraging and has demonstrated the potential of using infrasound data and processing for remote monitoring of volcanoes in the Indonesian region. Then a station has been setup in Pelabuhan Ratu (Java) to assess station in a non-favorable environment (proximity of the ocean, cultural noise, etc...). The station is surrounded by the ocean (2km away from the seashore) and topography is strongly influenced by mountains. Therefore the experimental station has started to produce a very large number of automatic detections. The small aperture of the Pelabuhan Ratu array has also an impact on the accuracy of the detection characteristics; however this experiment has shown that we could have results even with a non-optimum environment. These experiences, fruit of the collaboration between BMKG and CEA have been really satisfying, therefore it is planned in the near future to continue the experiment on other locations like near Tondano Lake (North Sulawesi).

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Suppressed Gamma-Spectrometry for Comprehensive Nuclear-Test-Ban Treaty Samples

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) is supported by a network of certified laboratories that perform high-resolution gamma-spectrometry on global air filter samples for the identification of 85 radionuclides. At the UK CTBT Radionuclide Laboratory (GBL15), the use of advanced Compton suppressed systems has been investigated to reduce the Compton continuum and improve detection sensitivity. Samples collected from the Philippines and during the Fukushima incident have been measured, demonstrating Compton continuum reductions of 28 - 59% with suppression factors of 0.1 - 147.0. Detection sensitivity has been improved with typically 40% lower MDAs, including 140Ba to meet CTBT requirements. True coincidence summing effects have been considered, including the application to remove interferences by the elimination of gamma-rays in cascade. This has been demonstrated for the removal of 134Cs allowing improved 131I measurement.

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Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
EarthScope USArray Transportable Array: Results from a Continental-Scale Array

The Transportable Array (TA) component of the EarthScope USArray program is yielding unprecedented observations of seismic and infrasound wavefields, and providing the ability to image earthquake rupture at teleseismic distances and to observe intra-array seismicity at magnitudes of two and lower. The rolling deployment of the 400-station TA has occupied over 1,400 station sites across the United States. Each station includes a three-component broadband seismometer, infrasound microphone, and precision barometer. Stations are deployed in a grid pattern, with 70 km separation between stations. Each station is operated for two years and all data are distributed openly and without restriction. TA stations are highly uniform in design, which facilitates efficient deployment, operation, and utilization of the data. Stations utilize simple vaults that provide low-noise performance in a wide range of terrains. Automated analysis of station state-of-health channels contributes to the overall performance of the network, and the full 400 station array routinely delivers greater than 98% data availability in real-time. Over time the station design has also been carefully evolved to enhance performance. The TA is developing plans to deploy to Alaska and is developing new sensor emplacement strategies that will yield high quality data in extreme Arctic conditions.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Capability of IDC Seismological Network in Egypt

The Egyptian National data center is an organization working with the treaty verification as integrated part of the Egyptian National authority with technical Expertise in the monitoring technologies. One of the main NDCS rule is the comparison between the seismological bulletins of both International Data Center (IDC) and local networks, to measure the capability of IDC to detect the local events in the signatory countries. In this work, we extract the earthquakes data from the archives of both IDC and the Egyptian National Seismological Network (ENSN). Consequently, the detection of the IDC capabilities to locate earthquakes has been evaluated for the period 1999-2011 in Egypt. The obtained results show that about 5.4% of the earthquakes with magnitude ML≥3.0 could be detected and located within Egypt. The errors in the location of earthquakes are relatively large compared to that located by the Egyptian national Seismological Network.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Effectively Are IMS Auxiliary Seismic Data Used in IDC Automatic Processing?

Paragraph 81 of the draft IDC Operational Manual states that “… Events … located in an earlier Standard Event List [SEL] give rise to requests for auxiliary seismic station data, whose aim is to confirm the validity of events and to improve the location estimates. …” We investigate the extent to which the second aim is achieved in current IDC automatic processing. This is assessed from the proportion of auxiliary data requests that contribute to the location of the same event in a later SEL, and from the consequential reduction in the area of the confidence ellipse. Comparison with the same event in the Reviewed Event Bulletin shows the extent to which requested auxiliary data have been used effectively in automatic processing, while comparison with the same event analysed with all auxiliary data reveals the validity of the choice of data requested. Examples, including events located in the Democratic People’s Republic of Korea, are used to illustrate specific issues.

**Primary author:** PEARCE, Robert Graham (CTBTO)

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Sustainment - Logistics Support Analysis (LSA) - How Theory Improves Reality

The International Monitoring System (IMS) is to consist of 321 monitoring facilities, composed of four different technologies with a variety of designs and equipment types, deployed in a range of environments around the globe. Despite this, the network is expected to reach extremely high levels of data availability which could induce unbearable Logistics Support costs. The IMS is now already performing Logistics Support Analysis (LSA) enabling us to: identify the most efficient improvements to our Integrated Logistics Support (ILS) strategy, optimize sparing as early as the design phase of new stations or major upgrades, and explore alternative designs or maintenance policies. Initial results have already been obtained and have proven the benefit of such analysis. The results of such simulations will be instrumental in validating the Integrated Logistics Support (ILS) strategy, the Engineering Design and ultimately the overall Network effectiveness and capability.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Importance of Being Informed - The Only Way of Ensuring Throughout Life Cycle Sustainment

If a couple of visionary, scientists and daring engineering teams from all around the world managed to design a global system which is composed of several modular components individually, transport these all around the world, attach them to one another and connect them to the International Data Centre to form the International Monitoring System, it will sound very surprising that one of the many challenges faced by the International Monitoring System is to do with those very factors that have made it exciting from the beginning: changing components, produced in different parts of the world, deployed at remote locations, operated by people speaking different languages and the requirement to communicate without personal contact on every modification made in a systematic manner. The solution to this challenge is simple however - with powerful databases, special software and cloud storage, it should be easy to produce and provide in an efficient manner real time up-to-date information on the IMS network to keep it credible and sustainable for ever. Reality teaches a different lesson. Document and information management is a challenging task but one that when executed as a joint effort ensures throughout life cycle sustainment and is beneficial to all stakeholders.

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Evaluation of CANBERRA® Cryo-Cycle™ Hybrid Cryostat as Cooling System for the High-Purity Germanium (HPGe) Detector in RN52 Radionuclide Monitoring Station in Tanay, Rizal, Philippines

The RN52 Radionuclide Monitoring Station in Tanay, Rizal and its surrounding vicinities are annually frequented by severe weather conditions such as heavy rains, thunderstorms, and landslides, which greatly affect the operation and maintenance of the facility, especially the delivery of liquid nitrogen (LN2) necessary for the normal operation of the high-purity germanium detector (HPGe). The newly-installed CANBERRA® Cryo-Cycle™ hybrid cryostat, which regularly regenerates liquid nitrogen from its initial supply, will greatly reduce the need for additional LN2 supply at the station thereby reducing operational costs and further ensuring safety for its staff members. The CANBERRA® Cryo-Cycle™ hybrid cryostat is hereby evaluated for its ease of operation and its general performance as cooling system for the HPGe detector in RN52 Radionuclide Station in Tanay, Rizal, Philippines.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
the Best Position for External Calibration Source in Beta-Gamma Coincidence Measurements

Beta-gamma coincidence method is the basis for low-activity radioxenon activity analysis. An important task in an accurate measurement is to precisely calibrate system. Usually it is expensive or even impossible to find a reasonable amount of purified radioxenon gas for calibration purposes. A good alternative is to calibrate using an external gamma-rays source like Cs-137. The main question is where to place the source to have a more accurate calibration measurement. There are several important factors in the simulation of response function, in which radiation and optical simulations have a dominant role. We have developed an improved radio-optical simulation procedure for this purpose to have enough data resulted in external calibration process. The method is to match between radiation transport using MCNP code; and optical scintillation light transport using our home-made code ray-tracing code Optix. Results of the current study shows that there are several factors regarding the calibration source positioning which should be taken into account for every individual configuration/system. The concentration was on our proposed cylindrical well-type coincidence system.

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Track Classification:  Theme 3: Advances in Sensors, Networks and Processing
Role of 'Event Definition Criteria’ in Compromising the Improvement of CTBTO Seismic Data Processing

Events in the CTBTO Reviewed Event Bulletin must satisfy ‘event definition criteria’ (REB-EDC). For seismic events these specify location-defining signals at a minimum of three IMS primary seismic stations, and a minimum score representing the number and type of location-defining parameters. Additional signal quality checks serve as ‘implied’ REB-EDC. EDC were introduced at the prototype International Data Centre (pIDC) in the mid 1990s, where their main purpose was to limit the burden of interactive analysis; they were inherited by IDC and became enshrined in its draft Operational Manual. They have not been reviewed in more than 15 years of operational experience. REB-EDC are not based upon location uncertainty or any other indicator of event quality or size. Following work presented at SandT2011, it is argued that any REB-EDC should be based solely upon event quality indicators, and should be applied as a final filter with no prior account taken of them during processing or analyst review. These two steps are necessary to avoid systemic impediments to the improvement of data processing: first to prevent the existing REB-EDC being used in performance indicators for current or proposed event-building algorithms, and secondly to exclude spurious constraints from the event-building process.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
the 'False Events' Myth Thwarts Improvement of CTBTO Automatic Seismic Data Processing

The traditional approach to building an automatic global seismic event list requires that signals detected at different stations, and which belong to the same event, be ‘associated’; this is an essential prelude to event location. Invalid signal detections and erroneous associations degrade the validity of many events, perhaps creating massive location errors or fictitious events built from signals rightly belonging to different events. CTBTO analysts ‘discard’ such events during review, and their associated signals are returned to the reservoir of unused signals unless used by analysts to contribute to a ‘manually added’ event. Analysts also discard many real events because they do not meet minimum criteria. An attempt is then made to find ‘missed’ events by applying a different association algorithm to the signals in the unused reservoir. Because this would result in the rebuilding of real events already discarded, the second association algorithm is applied only to signals not associated during automatic processing. Logical flaws in this procedure are explored, and proposals are made to correct them.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
the Design of the IMS Hydroacoustic Station HA04 Based on High-Fidelity 3-D Modelling of Hydroacoustic Signal Propagation

Continents, islands, plateaus and sea-mounts/guyots with shallow bathymetry, can block the propagation paths of hydroacoustic signals. However, diffraction around smaller structures, such as islands and sea-mounts/guyots, can illuminate parts of the shadow region, exposing portions of the oceans which are not covered by purely 2-dimensional (range/depth) acoustic models. In recent years, parabolic equation (PE) based models have advanced to a level where 3-D underwater acoustic propagation computations in the 1 – 100 Hz band relevant to Treaty Monitoring are possible at global scales. Examples are shown where diffraction into the shadow region of islands is consistent with measured seismic events that could not be associated based on the ray approximation or 2-D PE modelling. The model is furthermore applied in a study aimed at guiding the choice of hydrophone locations for the establishment of hydroacoustic station HA04 in the Crozet Islands (France), in the South-Western Indian Ocean. Three-dimensional horizontal effects related to bathymetric features and lateral stratification of the ocean and optimization of the hydrophone depth exploiting upslope enhancement, are addressed in the study. Quantitative estimates of the improvement in global coverage prediction based on fully 3-D modelling in comparison with the traditional 2-D slice modelling approach are also discussed.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
Observations in Turkmenistan on the Basis of a Digital Station PS44

System of seismological observations in Turkmenistan was established in 1947 when the first seismic station “Ashgabat” was built. The devastating earthquake with magnitude 7.3 which demolished Ashgabat in 1948 gave rise to further development of seismological research and deployment of seismic stations on the territory of Turkmenistan. By 1993 the seismic network of Turkmenistan included more than 25 seismic stations. All stations were equipped with analog equipment with galvanometric registration and recorded on photographic paper. Since certification time in 2010 IMS seismic station PS44, Alibeck, GEYT, has been acquiring seismic information and transmitting it in real-time via satellite intrasite communication to the National Data Centre of the Institute of Seismology of Academy of Science in Turkmenistan and over the basic GCI topology satellite link to the International Data Centre in Vienna. Seismic array “Alibeck” is 10 element array equipped with Guralp 1C and 3C sensors deployed in the boreholes helps to locate the epicenters of the seismic events as well as to improve the regional velocity models of the Earth crust and upper mantle. Seismic array “Alibeck” significantly improved the seismological monitoring in Turkmenistan, which is very important for seismic activities areas.

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Track Classification: Theme 3: Advances in Sensors, Networks and Processing
of the International Monitoring System Network

The IMS is a globally distributed network of monitoring facilities using sensors from four technologies. It is designed to detect the seismic and acoustic waves produced by nuclear test explosions and the subsequently released radioactive isotopes. Monitoring stations transmit their data to the IDC in Vienna, Austria, over a global private network known as the GCI. In order to satisfy the strict data and network availability requirements of the IMS Network, the operation of the facilities and the GCI are managed by IDC Operations. IDC Operations has three functions: the first is to ensure proper operation and functioning of the stations, the second to ensure proper operation and functioning of the GCI, and the third to provide network oversight and incident management.

At the core of the IMS Network operations are a series of tools for: monitoring the stations’ state of health and data quality, troubleshooting incidents, communicating with internal and external stakeholders, and reporting. An overview of the IDC’s strategy for operations and management of the stations will be presented. Special attention has been given to implementation of Data Quality in operations of IMS stations in 2011-2013 and results of this activity will be presented in the poster.

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**Presenter:** NIKOLOVA, Svetlana (Geoscience Australia)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Geophysical methods see a broad range of uses and span a wide range of scales and technologies. While the fundamentals of the field are well understood, there is constant advancement and refinement of the techniques and methodologies.

Applied geophysics appears in support of many human endeavours. Historically, the most common use has been in oil and gas exploration closely followed by mineral exploration. Both resource-based communities constantly advance geophysical technology and mapping techniques on depths scales of hundreds to thousands of meters.

Recently, engineering and infrastructure needs are driving rapid advancement in high-resolution geophysics. These applications are extremely diverse and range from assessing engineered structures, ground water search and evaluation, environmental site assessment, archeology, forensics, unexploded ordnance, and many others. Many of applications fall into the classification of "near-surface geophysics". While dependent on the same fundamental physics, these applications demand much higher spatial resolution, typically on the sub meter to 10's of meters scale.

Achieving this level of detail requires much higher spatial data density, more rapid data acquisition and more scale sensitive geospatial imaging. Ancillary control information require the same level of detail to aid with data evaluation and interpretation. Accomplishing all this at an affordable cost is extremely challenging!

Over the last five to ten years, the challenges are steadily being overcome by the advancement of sensor technology, computers and communications. Applications of geophysics, felt to be unattainable because of cost, are now becoming common place. This presentation will use some current examples to illustrate how the commercial drivers are creating a new world of applied geophysics for the near-surface.

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Human Factor in OSI

The human factor has special significance in the OSI regime; trained inspectors must implement OSI techniques, and Treaty provisions define both. These Treaty provisions result in a unique inspection regime because of the multiple technologies, the external inspectorate and the last minute definition of the inspection site. In addition to being a multi-national team, the inspection team will be composed by experts operating multiple technologies, which will add a multi-professional environment that may create opportunities for negotiations over resources or leading technology designation. In addition to training on specific implementation of techniques, treaty provisions and nuclear explosion signatures, training in soft skills is important thus creating an "organizational culture" across the inspectorate for understanding of how to approach negotiation prone situations. Because of the important teamwork aspect of the CTBT inspection regime, remote training (open university type) by itself cannot provide a full solution for OSI inspectors training, and team training at selected training centers is necessary. The training programme to be developed becomes therefore an intricate process as a result of the non in-house characteristic of the inspectorate that creates the need to balance between inspectors’ accessible time and training requirements.

**Primary author:** MELAMUD, Mordechai (Retiree)

**Presenter:** MELAMUD, Mordechai (Retiree)

**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing
Advances and Expectations

Today, we are in a time of unprecedented change and opportunity in technology and its application to solve real problems. Using information and opinion collected from a variety of sources, an overview of general trends in the Information and Communications Technology world will be presented, with particular reference to large scale data processing and storage and the development of international communications networks.

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**Track Classification:** Theme 3: Advances in Sensors, Networks and Processing