Infrasound Technology Workshop 2017 (ITW2017)

Report of Contributions

https://conferences.ctbto.org/e/20

ID: Type: **Oral**

# of Balloon-Borne Infrasound Sensors as a Function of Source and Detector Altitude

Primary author: YOUNG, Eliot (Southwest Research Institute)

Presenter: YOUNG, Eliot (Southwest Research Institute)

Track Classification: Split session: atmospheric sciences

ID: Type: **Oral**

in remote sensing using satellite radar interferometry (InSAR)

Primary author: LAUKNES, Tom Rune (Northern Research Institute (NORUT))

Presenter: LAUKNES, Tom Rune (Northern Research Institute (NORUT))

Track Classification: Split session: atmospheric sciences

ID: Type: **Oral**

weather and its effect on the upper atmosphere

The Earth's upper atmosphere is a dynamic region affected by both forcing from below and above. A number of processes on the Sun is resulting in eruptions of electromagnetic radiation on a number of wavelengths, and the acceleration of charged particles embedded in electromagnetic fields. The resulting space weather around the Earth shows great variability, and in this presentation we will look into the different sources of space weather and the effects it has on our upper atmosphere and technological systems at and around our planet.

Primary author: STRØMME, Anja (Norwegian Space Center)

Presenter: STRØMME, Anja (Norwegian Space Center)

Track Classification: Split session: atmospheric sciences

ID: Type: **Oral**

Space Center A versatile Research Infrastructure at Polar Latitude (69°N,16°O)

Andøya Space Center (ASC) is a well developed research infrastructure for atmosphere science and related research fields. Since 1962 ASC is a service provider for sounding rockets and in parallel we build-up a comprehensive ground based infrastructure of atmospheric radars, lidars and passive ground based instrumentation. Through a project within H2020 new research on the dynamics of the middle
atmosphere using gravity waves and infrasound has started at Andøya.
The present talk will summarise past and present activities and will give an outlook for future activities.

Primary author: GAUSA, Michael (Andøya Space Center)

Presenter: GAUSA, Michael (Andøya Space Center)

Track Classification: Split session: atmospheric sciences

ID: Type: **Oral**

in Planetary Seismology Using Infrasound Signatures on Venus

The planetary evolution and structure of Venus remain uncertain more than half a century after the first visit by a robotic spacecraft. To understand how Venus evolved it is necessary to detect potential signs of current seismic activity. Due to the adverse surface conditions on Venus, with extremely high temperature and pressure, it is infeasible in the near future to place seismometers on the surface for an extended period of time. JPL in collaboration with ISAE and Caltech Campus is in a process of developing an instrument to measure seismic activity on Venus by in-situ measurements of infrasonic waves in the atmosphere. The overall objective of this research is to demonstrate the feasibility of sensitive barometers to detect infrasonic signals from seismic and volcanic activity on Venus from a balloon platform. The seismic signals are known to couple about 60 times more efficiently into the atmosphere on Venus than on Earth, which might allow the detection of small regional quakes (magnitude ~3). We will report results on the first flight experiment that will focus on using the barometer instruments on a tethered helium-filled balloon. The experiments are intended to validate the two-barometer signal processing approach using a well-characterized point-source signal.

Primary author: KOMJATHY, Attila (NASA JPL)

Presenter: KOMJATHY, Attila (NASA JPL)

Track Classification: Split session: atmospheric sciences

ID: Type: **Oral**

between atmosphere and near Earth Space as investigated in the framework of the ARISE 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: Split session: atmospheric sciences

ID: Type: **Oral**

IMS Infrasound Network – Station and Engineering Projects

The infrasound component of the International Monitoring System (IMS) is composed of sixty stations. Forty-nine of them are already certified and transmit data in near real-time to the International Data Centre, Vienna, Austria. Each infrasound station is composed of an array of infrasound measurement systems capable of measuring micropressure changes produced at ground by infrasonic wave propagation. The Provisional Technical Secretariat (PTS) of the Comprehensive Nuclear-Test-Ban Treaty (CTBTO) is working towards the completion and sustainability of the IMS infrasound network. In this presentation, the recent progress made with the installation and major upgrade of IMS infrasound stations will be summarized. The main infrasound engineering and development projects carried out by the PTS will also be reviewed. This includes projects to improve station reliability and resilience as well as data availability and quality with the objective to reach compliance with IMS Operational Manual requirements.

Primary author: MARTY, Julien (CTBTO)

Presenter: MARTY, Julien (CTBTO)

Track Classification: IMS and IDC Infrasound Projects

ID: Type: **Oral**

Infrasound technology developments

The IDC advances its methods and continuously improves its automatic system for the infrasound technology. The IDC focuses 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. An objective of this study is to reduce the number of associated infrasound arrivals that are rejected from the automatic bulletins when generating the reviewed event bulletins. A number of ongoing projects at the IDC will be presented, such as: - improving the detection accuracy at the station processing stage by introducing the infrasound signal detection and interactive review software DTK-(G)PMCC (Progressive Multi-Channel Correlation) and by evaluating the performances of detection software; - development of the new generation of automatic waveform network processing software NET-VISA to pursue a lower ratio of false alarms over GA (Global Association) and a path for revisiting the historical IRED. The IDC identified a number of areas for improvement of its infrasound system, those will be shortly introduced.

Primary author: MIALLE, Pierrick (CTBTO Preparatory Commission)

Presenter: MIALLE, Pierrick (CTBTO Preparatory Commission)

Track Classification: IMS and IDC Infrasound Projects

ID: Type: **Oral**

# of IMS Infrasound Stations

Calibration is an essential process to ensure data quality and trustworthiness. As defined in the IMS Operational Manual, it encompasses two distinct processes: “initial calibration” and “on-site calibration”. When an infrasound measurement system is to be deployed at an IMS station, specification data provided by the manufacturer for each individual piece of equipment are first reviewed to ensure that the delivered equipment substantially meets theoretical specifications. The initial calibration is then performed with two objectives: (a) verifying that the system response remains within tolerances of the manufacturer supplied data once the equipment is installed in operational conditions at the station (b) establishing a baseline for future calibrations. The on-site calibration consists of measuring the system response and comparing it against the baseline response established at the time of the initial calibration. It shall be performed at least once a year or whenever it is suspected that the baseline calibration is affected (after equipment replacement for example). The objective of this presentation is to review the recent efforts made by the PTS together with infrasound expert laboratories and national metrological institutes to define and implement calibration procedures in agreement with the IMS Operational Manual requirements.

Primary author: MARTY, Julien (CTBTO)

Presenter: MARTY, Julien (CTBTO)

Track Classification: IMS and IDC Infrasound Projects

ID: Type: **Oral**

Infrasound Generators and Compact Infrasonic Tracking Systems

Primary author: AHUJA, Krishan K (Georgia Institute of Technology)

Presenter: AHUJA, Krishan K (Georgia Institute of Technology)

Track Classification: Station engineering and performance

ID: Type: **Oral**

comparison of recent wind noise reduction systems for infrasonic research

Large, passive wind noise reduction systems are of great interest to the infrasound community. Recently, several different designs were built and tested in order to quantify their effectiveness in reducing wind noise while maintaining acoustic waveform fidelity in the frequency range of interest to the monitoring community. The designs include large perforated aluminum domes, domes constructed from tents covered with various porous fabrics, and wind fences with various sizes and porosities. This talk will briefly review the basic principles of wind noise reduction, will analyze the performance of each system, and will discuss the advantages and disadvantages of each. Finally, there will be a summary of best-practices in the design and placement of wind noise reduction systems, and suggestions for future work.

Primary author: WEBSTER, Jeremy (U.S. Department of Energy, National Nuclear Security Administration)

Presenter: WEBSTER, Jeremy (U.S. Department of Energy, National Nuclear Security Administration)

Track Classification: Station engineering and performance

ID: Type: **Oral**

calibration for infrasound sensors

Complex frequency response is a critical function in understanding the impact of a transducer on a measurement. For an acoustic transducer, a single volts-per-pascal value is often cited as the response; however, the magnitude and phase of this ratio over the entire frequency range of interest is required to understand the effects of that transducer on broadband waveforms. While this ratio can be determined by comparison to a reference transducer, any reference must itself be calibrated. Reciprocity calibration is a well-established calibration technique that does not require a pre-calibrated acoustic reference. In its most general form, reciprocity requires two transducers in addition to the sensor being calibrated; however, the responses of these transducers do not need to be known. For the cases discussed in this paper, two moving-coil loudspeakers attached to a closed volume are used and the dominant sources of uncertainty are described. Furthermore, having two drivers makes possible two-tone tests of microbarometer linearity. This paper describes development, evaluation, and uncertainty analysis of a reciprocity-based calibration procedure designed expressly for measuring the complex frequency response of infrasound sensors in the International Monitoring System infrasound band.

Primary author: GABRIELSON, Thomas (Penn State University)

Presenter: GABRIELSON, Thomas (Penn State University)

Track Classification: Station engineering and performance

ID: Type: **Oral**

-of-health assessment of infrasound elements using operational data

A desirable adjunct for infrasound arrays in the International Monitoring System is remote diagnosis of data quality. In-situ comparison measurement provides an unparalleled degree of diagnosis for infrasound-array elements; however, this method requires either a visit to the station or installation of a permanent reference sensor at each element. A technique that uses only the normal array data to assess the health and data quality would have value. The method described in this paper is based on long-term monitoring of element-pair correlations. Detection events – signal periods in which correlation across the array exceeds some threshold – are frequently of little interest to the IMS mission; however, these more frequent, unimportant "events" are valuable for monitoring the correlations between pairs of elements. By using a detection metric that is resistant to single-element degradation and by examining all of the element-pair correlations, elements with performance significantly below the average can, at least in some cases, be identified.

Primary author: GABRIELSON, Thomas (Penn State University)

Presenter: GABRIELSON, Thomas (Penn State University)

Track Classification: Station engineering and performance

ID: Type: **Oral**

WNRS testing results from the US NACT R&D Testbed Infrasound Array

Here we report on updated testing at the US NACT R&D Testbed Infrasound Array at the Sandia National Laboratories (SNL) FACT site. Rosette and polyethylene hose (HDPE) wind noise reduction systems (WNRS) were co-located at multiple elements in 2016. The long- and short-term frequency response of the two WNRS and associated sensors are compared using the in situ response technique. The installation of new metal inserts in the HDPE WNRS have helped identify the source of the high-frequency roll-off in the HDPE system being related to clogged inlets from dirt and other debris. We detail the changes made to the system and a potential long-term solution to improve and stabilize the response. Wind noise reduction is also compared between the different WNRS, with noise reduction generally matching theory. Small WNRS domes were also installed over the reference sensor ports to increase the coherence, and we also detail the efficacy of these domes for coherence and noise reduction.

Primary author: FEE, David (Defense Threat Reduction Agency, Nuclear Arms Control Technology Program)

Presenter: FEE, David (Defense Threat Reduction Agency, Nuclear Arms Control Technology Program)

Track Classification: Station engineering and performance

ID: Type: **Oral**

and analysis of pilot Studies PTSAVH.A-PS1 and PTSAVH-A-PS2 on infrasound sensor calibration

The PTS Midterm Strategy (CTBT/PTS/INF.1249) defined for the 2014-2017 time period underlines for the infrasound technology the importance of ensuring data quality at both the station and network levels in order to maintain and improve the capability to detect events relevant to the CTBT. This includes the use of accurate and regularly calibrated measurement systems as specified in the draft Operational Manual for Infrasound Monitoring and the International Exchange of Infrasound Data (CTBT/WGB/TL-11,17/17/Rev.5). In order to review the state-of-the-art knowledge on infrasound sensors, the PTS organized two pilot studies, PTSAVH.A-PS1 and PTSAVH-A-PS2. These pilot studies are concerned with measurements of Self-Noise, Dynamic Range, Sensitivity, Frequency Response and Passband measurements on infrasound sensors. The participating Laboratories were CEA (Commissariat à l'Énergie Atomique), Los Alamos National Laboratory (LANL), SNL (Sandia National Laboratories), and Umiss (University of Mississippi) and the role of coordinator was undertaken by the CTBTO. Several MB2005 and Chaparral 50A infrasound sensors were circulated between participants. This presentation includes the measurement results from the participants, information about their calibration/measurement methods, and the comparison analysis leading to the assignation of equivalence degrees.

Primary author: RODRIGUES, Dominique (LNE)

Presenter: RODRIGUES, Dominique (LNE)

Track Classification: Station engineering and performance

ID: Type: **Oral**

Infrasound Signal Quality Issues Using Power Density Spectra: Categorization of Distortion Sources

Number of distortions can affect the data quality of infrasound records. Remote diagnostics of infrasound stations in the area of signal quality includes analysis of power spectral density plots (PSD) of the remote elements. In the presentation we try to summarize the most typical signal distortions which are visible in the PSD, with source explanation and recommendation for remedial actions. In general, the distortions of the signal can be divided into three main parts: (a) distortions of electrical origin, (b) distortions of acoustical origin and (c) distortion of seismic/mechanical origin. Typical examples of each type are presented and discussed.

Primary author: MARTYSEVICH, Pavel (CTBTO)

Presenter: MARTYSEVICH, Pavel (CTBTO)

Track Classification: Station engineering and performance

ID: Type: **Oral**

ocean ambient noise using a regional infrasound network

The ability of the International Monitoring System (IMS) global infrasound network to detect atmospheric explosions and events of interest strongly depends on station specific ambient noise signatures which include both incoherent wind noise and real coherent infrasonic waves. To characterize the coherent ambient noise, broadband array processing was performed on 10 years of continuous IMS recordings. Ocean wave interactions contribute to the atmospheric coherent ambient noise field, and we apply wave action models to model these microbarom sources. To further evaluate oceanic wave action models at regional scales, infrasound analyses are supplemented using data from several experimental arrays on the Scandinavia peninsula. We use two-dimensional energy spectrum ocean wave products to build a multi-year reference database of oceanic noise sources in the North Atlantic. Then we compare observed and modeled directional microbarom amplitudes at several stations. The expected benefits of such studies concern the use of multi-year complementary data to finely characterize the coupling mechanisms at the ocean-atmosphere interface. In return, better knowledge of ambient ocean noise sources opens new perspectives not only by enhancing the characterization of explosive atmospheric events, but also by providing additional integrated constraints on middle atmosphere dynamics and disturbances where data coverage is otherwise sparse.

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

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

Track Classification: Data Processing

ID: Type: **Oral**

influence of periodic wind turbine noise on infrasound array measurements

Aerodynamic noise from the continuously growing number of wind turbines in Germany creates increasing problems for infrasound array measurements recording acoustic signals at frequencies below 20 Hz. Ten years of continuous data (2006-2015) from the 4-element infrasound array IGADE in Northern Germany are analysed to quantify the influence of wind turbine noise in terms of enhanced amplitude modulations. Furthermore, a theoretical model is derived and validated by a field experiment with mobile micro-barometers. Fieldwork was carried out to measure the infrasonic pressure level of a single horizontal-axis 200 kW wind turbine and to extrapolate the noise effect for turbines with higher electric powers and for a larger number of collocated wind turbines. The model estimates the generated sound pressure level of wind turbines and thus enables for specifying the minimum allowable distance between wind turbines and infrasound stations for undisturbed recording. This aspect is particularly important to guarantee the monitoring performance of the German infrasound stations I26DE in the Bavarian Forest and I27DE in Antarctica. These stations are part of the International Monitoring System (IMS) verifying compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT), and thus have to meet stringent specifications with respect to infrasonic background noise.

Primary author: PILGER, Christoph (Federal Institute for Geosciences and Natural Resources (BGR))

Presenter: PILGER, Christoph (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Data Processing

ID: Type: **Oral**

Infrasound Arrival Parameters Using Limited Sensor Pair Correlation

Estimating the direction of infrasound signals over arrays usually utilizes similarity between waveforms on neighbouring sensors to measure time-delays accurately. Estimate quality can suffer due to diminished coherence over the full array aperture and methods such as PMCC exploit the increased similarity between signals on the most closely-spaced instruments. It is often helpful to examine the coherence over the full slowness space. This allows measurement of the F-statistic and makes the arrival of signals from multiple directions easier to visualize. The correlation traces between channel pairs can form a virtual co-array in which the correlation between channels i and j, C(ij), is ascribed the coordinates x(j) − x(i). For the original data, with conventional processing, removal of a channel results in data loss. For the correlation co-array, we are at liberty to remove a given C(ij) for any sensor pair for which the correlation is poorer and which may diminish the quality of our direction estimate while still utilizing data from all sensors. We demonstrate examples of high frequency signals on IMS infrasound arrays for which classical direction estimates are poor but for which robust estimates are made using the virtual array of correlations between only the most closely-spaced sensors.

Primary author: GIBBONS, Steven John (NORSAR)

Presenter: GIBBONS, Steven John (NORSAR)

Track Classification: Data Processing

ID: Type: **Oral**

# of a Generalized Least Squares Beamformer for Infrasonic Data Analysis

As infrasound research interests move to lower signal-to-noise ratio (SNR) signals, it is necessary to enhance detection capabilities, particularly in noisy environments. The application of an adaptive F-detector has successfully reduced false detection rates attributed to coherent noise across array elements; however, the detector is applied post-processing after analysis using a standard (Bartlett) beamformer, which raises the detection threshold and can lead to missed detections. Application of a generalized least squares (GLS) beamformer can enhance processing of transient infrasonic signals, particularly in the presence of correlated noise. The GLS beamformer enhancement will lead to improved capabilities for accurately detecting low amplitude infrasonic events of interest that would not normally produce a sufficiently high F statistic to be declared a detection. Application of this beamformer to data sets with various background noise environments (strong microbaroms, wind farms, etc.) will be presented.

Primary author: DANNEMANN, Fransiska (Los Alamos National Laboratory)

Presenter: DANNEMANN, Fransiska (Los Alamos National Laboratory)

Track Classification: Data Processing

ID: Type: **Oral**

the global coherent infrasound noise - avenues using the IMS

In this study we are going to present results of global coherent infrasound noise field measured at IMS infrasound stations and its correlation with atmospheric dynamics. A new implementation of the Progressive Multi-Channel Correlation (PMCC) algorithm has been used, which enables a better characterization of all received signals in their wave parameter space (e.g., frequency-azimuth space, frequency-trace-velocity space). This, in-turn, allows an accurate signal discrimination, as well as source and propagation studies. For instance, we are using the processing for microbarom source and propagation studies and for analysing the occurrence of mountain associated waves. Such analyses are enabled after performing a re-processing of the entire previous IMS infrasound database covering the time period from January 2003 to December 2015; whereas the number of stations has increased from 6 to 48. Results indicate a continuous spectrum of coherent signals at IMS stations within the 0.02 to 5.0 Hz band. Moreover, these results could be used for estimating network detection capability based on empirical station coherent infrasound noise models.

Primary author: CERANNA, Lars (Federal Institute for Geosciences and Natural Resources (BGR))

Presenter: CERANNA, Lars (Federal Institute for Geosciences and Natural Resources (BGR))

Track Classification: Data Processing

ID: Type: **Oral**

mapping of the seismo-acoustic background noise at IMS array stations for improving event detection

Seismic and acoustic sensors record background noise that is a superposition of different wavefields that originate from sources distributed in space and that arrive at such sensors simultaneously (e.g.: ocean noise and anthropogenic noise). Event detection can be improved through mapping these sources and their spatio-temporal evolution with historical data that includes effects of persistent sources (microseisms and microbaroms), and then including this information in detection algorithms. We are currently processing available IMS array data with algorithms that can resolve and extract multiple simultaneous signals present in the data and creating enhanced noise maps. We propose to include such maps within our detection framework as prior information, thereby reducing detection thresholds and improving overall detection capability. This effort is particularly important for detecting small events masked by background noise out to great distances.

Primary author: MARCILLO, Omar (Los Alamos National Laboratory)

Presenter: MARCILLO, Omar (Los Alamos National Laboratory)

Track Classification: Data Processing

ID: Type: **Poster**

-field detections of UniFI arrays, synergies with IMS infrasound arrays and early warnings

The last two decades witnessed a dramatic increase of scientific interest for infrasound technology: since the establishment of the CTBTO Preparatory Commission and the progressive development of the International Monitoring System (IMS) Network. The infrasound component of the IMS Network (completed by 82%) largely demonstrated its potential for the detection of a variety of man-made and natural events: these results prompted several scientific groups to establish additional infrasound arrays for monitoring specific sources and generating potential synergies with the Provisional Technical Secretariat. The Department of Earth Sciences, Florence University, Italy (UniFI) has established since 2000 in Italy six small-aperture infrasound arrays for volcano and avalanches monitoring, one large-aperture array (Mount Amiata) in the framework of the ARISE Project, two small aperture arrays in Japan, four small aperture arrays in Iceland and 2 small aperture arrays in South America. All the arrays have demonstrated their key contribution and potential for early warning purposes, setting the ground for complementing with near-field observations the IMS infrasound detections: a specific vDEC Project is currently under development. This work will present various UniFI detections in different geographical areas and will discuss their potential for synergies with IMS data, with special focus on early warnings' issuance.

Primary author: CAMPUS, Paola (Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Via G. La Pira, 4, 50121- Firenze, Italy)

Presenter: CAMPUS, Paola (Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Via G. La Pira, 4, 50121- Firenze, Italy)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

RESEARCH STATUS IN MADAGASCAR

Infrasound research in Madagascar started since the installation of I33MG in 2001. At that time, only data from this station were processed. Starting from 2010 Madagascar got access to IMS data and IDC products, and then after Madagascar NDC received the Capacity Building System, infrasound data from other IMS station was accessible and easily processed. Infrasound data from IMS stations I19DJ, I32KE, I33MG, I35NA, I47ZA and I52GB are continuously processed using PMCC method . Permanent signals from natural sources MAWs, microbaroms and thunderstorms are common to these stations. Besides, bolides, volcanoes and explosions are also detected. Source identification and location are performed with raytracing technics available Tau-P (Garces 1998) or Hamiltonian method (Virieux 2004) or with fullwave technic like FDTD (Hedlin 2010). Recent studies show that gravity waves signatures from deep convection and orographic source can be extracted using IMS infrasound stations. This approach is not only used in monitoring nuclear explosion but was also applied in civil application and in scientific research coupled with other fields such as seismology, oceanography and climatology. In this perspective inverse problem could mainly enhance atmospheric model in Madagascar and East african region where direct observation is very sparse.

Primary author: RAMBOLAMANANA, Gérard (Institute and Observatory of Geophysics)

Presenter: RAMBOLAMANANA, Gérard (Institute and Observatory of Geophysics)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

# of Tropical Cyclones using Seismic and Infrasonic stations surrounding the South-Western Indian Ocean.

In the South-West Indian Ocean, tropical cyclones occur every year from December to April. As they move, cyclones generate swells that may represent infrasound sources (microbaroms at 0.2 Hz) and sources of microseismic noise(secondary peak, 0.1-0.35 Hz). A dominant source of noise in the oceans is issued from interaction of two swells of similar periods propagating in opposite directions. These stationary waves generate microbaroms travelling the atmosphere and then recorded by infrasound stations(Benioff & Butenberg, 1939). In the meantime, such standing waves generate pressure variations through the water column down to the ocean floor, and create seismic waves(Rayleigh waves) and that may be recorded by seismic stations. We combined these two independent observables of stationary waves for tracking cyclone. We used IMS infrasound data from CTBTO, seismic stations from the OVPF on La Réunion Island and from MACOMO project. The microbarom sources are analyzed with WinPMCC4.3 software (CEA/DASE2010) based on PMCC method (Cansi, 1995). The azimuths of the microseismic source regions are determined by polarization analyses (Schimmel et al., 2012). As result, during the passage of Haruna cyclone (Feb2013), we observed a clear signature in both seismic and infrasound sources that show good agreement with the cyclone track.

Primary author: ANDRIANAIVOARISOA, Jean Bernardo (Institute and Observatory of Geophysics of Antananarivo (IOGA))

Presenter: ANDRIANAIVOARISOA, Jean Bernardo (Institute and Observatory of Geophysics of Antananarivo (IOGA))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Infrasound from the Maritime Environment

Wide infrasound coverage is obtained using fixed, land-based monitoring stations. However, two-thirds of the earth's surface is composed of oceans, and while some sensing stations are located on islands, no capability yet exists to monitor infrasound from sensors fielded directly in the maritime environment. We investigate the potential of fielding of microbarometer sensors in the maritime environment, on boats, buoys, or unmanned surface vehicles (USVs). This has the potential to provide an expansive, new, remote environment from which infrasound signal detection can be made to supplement the coverage obtained with land-based networks. Placement of sensors in ocean locations may offer coverage where it doesn't exist, or when current land-based monitoring coverage is less reliable due fluctuating environmental conditions. Gaps in detection coverage may be filled with appropriate placement and operations from the technology deployed directly in the oceans. The technical challenges to overcome include sensor survivability, sensor motion-induced interference, wind noise mitigation, and the formation of multi-element directional arrays. This concept will be described, as well as efforts made to develop this technology through at-sea experimentation.

Primary author: GRIMMETT, Doug (U.S. Department of Defense, OUSD (A&S)/NCB/TRAC)

Presenter: GRIMMETT, Doug (U.S. Department of Defense, OUSD (A&S)/NCB/TRAC)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

detection of the lunch and the Re-entry of PLSV-C32 and PSLV-C14

International Monitoring System (IMS) Infrasound network is a state of art network of sensors that records several acoustics sources, Waves generated by anthropogenic atmospheric source ranging from regular air traffic, subsonic signals, rocket lunch are usually recorded by the IMS Infrasound stations. Interestingly Rocket lunch and re-entry acoustic signatures are recorded by IMS. These recording can be used to track the rocket and confirm the success of the mission. Many cases are recorded in IMS infrasound network, in this work two events is investigated: The Polar Satellite Launch Vehicle C14 (PSLV-C14) which was launched in September 23, 2009 and the PLSV-C32 by the Indian Space Research Organization (ISRO) in February 15, 2017 to deliver 114 satellite. The nearby infrasound stations are analyzed to detect the different phases of the lunching and track the azimuth of the rocket.

Primary author: HAMAMA, Islam (National Research Institute of Astronomy and Geophysics (NRIAG))

Presenter: HAMAMA, Islam (National Research Institute of Astronomy and Geophysics (NRIAG))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

signals from natural phenomena observed by infrasound stations in Japan

At the time of the 2011 off the Pacific coast of Tohoku Earthquake, several microbarographs around focal region recorded pressure changes excited in tsunami source region. After that, Japan Weather Association(JWA) have started experimental infrasound observation at two stations in Ofunato city and Shima district to study infrasound monitoring technique for detection of large tsunami generation and other disaster like severe storm, tornado and so on. Since a variety of phenomena can excite infrasound, infrasonic signals are frequently observed at Japanese IMS station I30JP and two JWA's infrasound stations mentioned above. It is our goal in the future to detect and identify such natural phenomena by observed signals, and it will help to distinguish between signals from explosion and natural phenomena as well. In this presentation, we will introduce some cases of detected signals traveling from known sources such as volcanic eruption and fireball(bolide). Through the analysis on observed signals from a variety of phenomena, it is expected to accumulate useful information for application to source identification and propagation characteristics of signals.

Primary author: OTSU, Takayuki (Japan Weather Association (JWA))

Presenter: OTSU, Takayuki (Japan Weather Association (JWA))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

POTENTIAL OF THE CTBT VIRTUAL DATA EXPLOITATION CENTRE (vDEC) TO SUPPORT GLOBAL RESEARCH AND DEVELOPMENT INITIATIVE (GRDI) IN INFRASOUND VERIFICATION PROCESSES

Over the years, the ability of Researchers and other experts from across the globe to participate in the effective utilization of Infrasound Data and products is limited by the access to these data and products . The ability to constitute a major step towards the overall success of the CTBT implementation and its universalization is hinged on the greater involvement of the relevant stakeholders in the GRDI. To ensure this greater involvement, the CTBT through funding from the EU and support from Educational Institutions from across the globe, developed the Virtual Data Exploitation Centre (vDEC). The vDEC is a very important avenue for access to the CTBT data by non-NDC Users with Research in the relevant CTBT areas. The value and benefits of this platform is still not well appreciated. On this premise, the Nigerian NDC has continued to encourage members of the academia to utilize the vDEC platform to support the GRDI. This project is to bring to the fore the potentials of the vDEC in respect of GRDI in the area of infrasound technology and how the verification process can benefit from it.

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

Presenter: BISALLAH, Awwal (Nigeria Atomic Energy Commission)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

# of Infrasound and Seismic data in the detections of mining activities in Côte d'Ivoire

The IS17, DBIC and TORD stations are all within 1000km from the Tongon open pit mines which are located in the north of Côte d'Ivoire, 55km south of the border with Mali. The ability of these stations to be deployed for civil and scientific purposes was assessed from July 2016 to March 2017 with the study of mining activities that occurred at Tongon. Using IMS data and IDC products in the study of infrasound and seismic signals, the azimuth from the infrasound station and the seismic stations crossed at the mining site. This study presents the analysis of these stations within the period of study.

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

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

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

idea to development of Volcanic Infrasound Network OVSICORI-UNA in Costa Rica

In Costa Rica we currently have a volcanic seismic network of around 60 volcanic seismic stations, permanent GPS stations and gases stations in active volcanoes of Costa Rica, such as Rincon Vieja Volcano, Turrialba Volcano, Irazu Volcano and Poas Volcano. We want to include the Infrasound technique to correlate it with data from seismic stations and volcanic video surveillance systems. The idea is to try to implement Infrasound sensors of low cost equitment in these 60 sides of stations in Active Volcanoes in Costa Rica. For the initial developments, is to develop infrasound sensors through Raspberry Pi 3 development cards as data acquisition card and network connectivity to all sites that have data communication through cellular or wireless systems and be sent directly to the Platform of data acquisition of OVSICORI-UNA. In addition to the inclusion of low cost infrasound sensors to Raspberry Pi 3 development cards.

Primary author: VILLALOBOS VILLALOBOS, Hairo (Observatorio Vulcanológico y Sismológico de Costa Rica (OVSICORI))

Presenter: VILLALOBOS VILLALOBOS, Hairo (Observatorio Vulcanológico y Sismológico de Costa Rica (OVSICORI))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Sub-Regional Capacity in Infrasound Monitoring with the Possible Deployment of IMS Portable Infrasound Array in Cote d'Ivoire

Infrasound monitoring is one of the four Comprehensive Nuclear-Test-Ban Treaty (CTBT) monitoring technologies globally deployed by the Provisional Technical Secretariat (PTS) to continuously monitor the planet for signs of nuclear explosions in the atmosphere or shallow underground. There is continuous interest by the PTS to enhance its capability in acoustic source detection, localization and characterization. Hence, the commencement of the deployment of IMS portable infrasound array on a temporary basis in some regions of interest. These portable infrasound array deployment are expected to assist in monitoring/detecting, understanding and categorizing infrasound signals of unknown origins. With the possible deployment of this portable infrasound array in Cote dâ□□Ivoire under discussion for further consideration, it can additionally be tailored to build Sub-regional capacity in infrasound monitoring coupled with the planned project objectives. Thus upon approval, the deployment process may be used to offer technical training in installation and operation of the system to selected participants from NDCs within the West African sub-region. Since neighboring countries like Ghana, Liberia, Burkina Faso, Nigeria among others do not have such CTBTO monitoring facility within their territories. Thus an opportunity to receive practical technical skills in infrasound monitoring for better source characterization.

Primary author: AMARTEY, Edmund Okoe (Ghana Atomic Energy Commission)

Presenter: AMARTEY, Edmund Okoe (Ghana Atomic Energy Commission)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

Discrimination Using Seismoacoustic Catalog Probabilities

Presented here are three seismoacoustic catalogs from various years and locations throughout Utah and New Mexico. To create these catalogs, we combine seismic and acoustic events detected and located using different algorithms. Seismoacoustic events are formed based on similarity of origin time and location. Following seismoacoustic fusion, the data is compared against ground truth events. Each catalog contains events originating from both natural and anthropogenic sources. By creating these seismoacoustic catalogs, we show that the fusion of seismic and acoustic data leads to a better understanding of the nature of individual events. The probability of an event being a surface blast given its presence in each seismoacoustic catalog is quantified. We use these probabilities to discriminate between events from natural and anthropogenic sources. Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.

Primary author: ALBERT, Sarah (U.S. Department of Energy, National Nuclear Security Administration)

Presenter: ALBERT, Sarah (U.S. Department of Energy, National Nuclear Security Administration)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Isolation Chamber for Improved Sensor Calibration

Infrasound isolation chambers are used to isolate sensors from ambient conditions in order to perform calibrations of the sensors being evaluated. Calibrations are typically performed on sensors to be deployed within a monitoring station. Calibrations identifying that a sensor meets performance requirements are necessary before a station can be certified for inclusion within the International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Infrasound isolation chambers are able to attenuate variations in ambient pressure and temperature that may otherwise affect the outcome of a sensor calibration. Recent advances in infrasound chamber design have improved the isolation through the use of sturdier materials and provided a large volume for evaluating more sensors simultaneously. Infrasound sensor designs have been observed to have performance that is variable at different elevations. In response to this, researchers at Sandia National Laboratories have been developing improvements that will allow a chamber to be pressurized or evacuated in order to replicate the static pressure observed at different elevations. In addition, developments are underway to control the temperature within the chamber to improve traceability and to generate higher dynamic pressures so as to evaluate sensors over a greater amplitude range.

Primary author: MERCHANT, Bion John (Sandia National Laboratories)

Presenter: MERCHANT, Bion John (Sandia National Laboratories)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

# of ground-truth events with reduced models

While long-range infrasound propagation modeling is a useful tool in nuclear treaty verification, the inherent unpredictability of subgrid-scale atmosphere dynamics results in a poorly constrained propagation medium. When faced with such a situation it is natural to treat incomplete knowledge within a probabilistic framework and to seek a numerical approach that describes long-range propagation at the lowest numerical cost and complexity. Such a task is rendered complex by the fact that each plausible atmospheric state produces large deviations from the operational numerical weather predictions. The approach used in this work for propagation modeling is based on reduced-order models provided by the numerical platform FLOWS (Fast Low-Order Wave Simulation). Such models are obtained by retaining a few propagating modes that are confined within waveguides causing the sound to propagate through multiple paths to the receiver. The overall performance of this approach is demonstrated using several ground truth events from the IDC Infrasound Reference Event Database (IRED). A particular focus will be made on the computational cost in relation to a operational-like environment such as in the French NDC or at the IDC.

Primary author: MIALLE, Pierrick (CTBTO Preparatory Commission)

Presenter: MIALLE, Pierrick (CTBTO Preparatory Commission)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

signatures of polar lows - comparing a decade of polar low tracks to infrasonic detection backazimuths

Polar lows are short-lived, but intense, small-scale extreme events which can develop quickly over polar waters. The development and tracking of these mesoscale cyclones is challenging to predict and monitor, while their high intensity may represent a significant hazard to Northern sea activities. Infrasonic tracking of polar low systems was reported in Ørbaek and Naustvik's pioneering work [Tellus A (1992): 47(5), 921-940], as well as in a recent paper by Claud et al., [Tellus A (2017): 69, 1338885]. We build upon these works by analyzing polar low tracks from 2002 to 2015 in the North Atlantic and Barents Seas. These tracks are estimated from observations, mainly in satellite data. We exploit recordings from infrasound arrays in Fennoscandia at regional distances, which for the last three of the analyzed winter seasons also includes the I37NO IMS array. At each station, we compare the backazimuth angle towards the event track to infrasonic data-derived backazimuth estimates. Based on these comparisons, we compile statistics on the number of polar low events where the infrasonic backazimuth agrees with the direction to the event track.

Primary author: NÄSHOLM, Sven Peter (Norwegian Seismic Array (NORSAR))

Presenter: NÄSHOLM, Sven Peter (Norwegian Seismic Array (NORSAR))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

WNRS of IS48TN infrasound station : Problems and solutions

The Infrasound Station IS48, in Kesra, Tunisia is part of the verification regime for the Comprehensive Nuclear-Test-Ban Treaty. IS48 is managed and maintained by the Tunisian NDC. Its good location in the middle of the Mediterranean Sea allows to have various and interesting detections. Several signals with different signatures were recorded and identified. But since 2010, the performance of the station has began to be noisy , due to a leakage in the pipe array, despite efforts to solve the issue through the pressure test and maintenance . To this issues, PTS decided to upgrade the WNRS at IS48TN in April 2017. In this poster we will present the new design of the Tunisian infrasound station IS48TN with highlight on its performance after the upgrade.

Primary author: SOUAYEH, Saoussen (National Data Centre)

Presenter: SOUAYEH, Saoussen (National Data Centre)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

IMS Infrasound data : Investigation of the Ascension Islands Event

On 25/04/2017, Burkina Faso NDC found an extremely rare event that occurred in the Atlantic Ocean northwest of the Ascension Islands near the West African coast (943 km Monrovia Liberia), a non-seismic zone . What led us to conduct a study on this event in order to know exactly what is happening in the area. This is how, we used seismic and infrasound data and also referred to the IDC REB and SSEB bulletins in order to complete our study. Infrasound technology is an essential part of the international monitoring system of the CTBTO (IMS), which monitors the world to prevent disasters caused by explosions. Understanding this technology and knowing how it works is very important for the overall performance of the IMS and even the entry into force of the Treaty.

Primary author: TIENDREBEOGO, Sombewindin Emile (National Center of Scientific and Technological Research (CNRST))

Presenter: TIENDREBEOGO, Sombewindin Emile (National Center of Scientific and Technological Research (CNRST))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

2011 May-August Mount Etna paroxysmal activity episodes: Infrasonic Long-range observations at IS42 Station, Azores Islands

IS42 is located in the Azores islands, in the middle of the North Atlantic and is one of the International Monitoring System (IMS) infrasound stations. Within the ARISE2 project, University of Azores and University of Florence (UniFi) are carrying out a collaborative research focused on the long-range detection and analysis of infrasound from volcanic eruptions at Etna Volcano recorded at IS42 at a source-to-receiver distance of 3700 km. Mt. Etna is the largest and most active volcano of Europe, located in NE region of Sicily Island, Southern Italy. Typically, effusive with explosive episodes and lava fountaining, its recent volcanic activity is able to produce high (up to 15 km) eruptive plume affecting local air traffic and nearby airports and cities. In this work we present the detections at IS42 of the May-August 2011 related to Etna Volcano, when eruptive activity was characterized by 9 (nine) paroxysmal eruptive episodes from "Pit Crater". Infrasound recording and detections at IS42 are compared with the pressure time history at the source obtained from local infrasound array observations, performed at 5 km from the source since 2007 by UniFi to investigate the long-range signal detectability and potentials of long-range infrasound monitoring of eruptive volcanoes.

Primary author: MATOS, Sandro Branquinho de (Instituto de Investigação em Vulcanologia e Avaliação de Riscos (IVAR))

Presenter: MATOS, Sandro Branquinho de (Instituto de Investigação em Vulcanologia e Avaliação de Riscos (IVAR))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

and Advances in Installation of IMS Infrasound stations in Argentina

Argentina has adopted the CTBT and fully ratified in December 1998. Since the beginning, ARN was designated responsible for the RN and IS technology of the International Monitoring System (IMS).In this sense, ARN and Provisional Technical Secretariat (PTS) started working together towards the installation of the stations under Argentina responsibility. IS02 Ushuaia station became operational in April 2005 but due to flooding of the vaults all of them were reinforced in January 2006. In August 2006, IS02 Ushuaia station (Tierra del Fuego) was certified. After two years new problems with water filtration appeared at the station, making it extremely necessary to update its infrastructure. Today presents high performance being operated and maintenance by ARN. Low frequency acoustic waves can propagate thousands of kilometers until they arrive at infrasound arrays of the IS stations. IS02 Ushuaia station is a five element infrasound array and IS01 Bariloche station is planned to be an eight element infrasound array. After more than 10 years of ARN's experience, we move forward with the installation of IS01 station in Pilcaniyeu location.

Primary author: QUINTANA, Eduardo Edmundo (Autoridad Regulatoria Nuclear (ARN))

Presenter: QUINTANA, Eduardo Edmundo (Autoridad Regulatoria Nuclear (ARN))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

first observations of the Hungarian infrasound array

The Research Centre for Astronomy and Earth Sciences of Hungarian Academy of Sciences joined to the ARISE2 project in 2016. This year we received national funding for the deployment of an infrasound array in Hungary. After a long preparation process the array started its operation in Piszkés-tető on 1st June 2017. The Piszkés-tető Infrasound array (PSZI) consists of 4 elements, all equipped with a SeismoWave MB3d microbarometer, and star array wind-noise reduction system made of porous hoses. It has an aperture of approximately 250 m, and the central element is co-located with a broadband seismological station, thus it is able to detect regional seismo-acoustic events. The array improves the coverage of the ARISE infrasound network in the Eastern European region. The waveform data is available on GEOFON under the network code HN. In the first months the PSZI array detected different signals. It regularly detects the signals of aircrafts passing above the station, on the way between Western Europe and the Middle East. We identified signals from several known mine explosions, detected also seismically. In the future we plan to develop a method for the discrimination of earthquakes and mine explosions with the joint analysis of infrasound and seismic data.

Primary author: CZANIK, Csenge (Research Center for Astronomy and Earth Sciences, Geodetic and Geophysical Institute,)

Presenter: CZANIK, Csenge (Research Center for Astronomy and Earth Sciences, Geodetic and Geophysical Institute,)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

analysis of infrasound events from Arctic region recorded by IMS infrasound network.

The aim of this study is to assess the current status of IMS infrasound network in order to monitor the Eurasian Arctic region and analyse the geographical distribution of infrasound events based on the Late Event Bulletin (LEB) at the CTBTO. The study area covers several provinces of the Eurasian Arctic such as Fennoscandia, North-Western Russia and adjacent territories. In total over 500 LEB events with infrasound associations were recorded by the IMS Network and reviewed by analysts at the International Data Centre (IDC) during the period January 2011 to December 2016 at high latitude regions (above 60°N) and its surroundings. The geographical distribution shows multiple clusters with mostly mixed technology events (infrasound and seismic) – e.g. Sweden and Finland-Russia border region. There are also multiple clusters where events recorded by both technologies are observed, such as Finland and North-Western Russia and multiple clusters with infrasound only events, such as Barents Sea. In this work we study similarities and differences between those clusters focusing on the variability of the wave parameters.

Primary author: GORE, Jane (CTBTO)

Presenter: GORE, Jane (CTBTO)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

portable array I67RO in the framework of the Romanian infrasound monitoring network

PTS portable infrasound array (I67RO) has been deployed in western Romania for one year, starting with late September 2016, within a collaboration project between National Institute for Earth Physics (NIEP) and PTS of the Preparatory Commission for CTBTO. The four-element array of 0.9 km aperture is equipped with CEA/DAM MB2005 microbarometers and Reftek RT 130 data loggers. Currently, I67RO array is operated and maintained in the framework of Romanian infrasound monitoring network, which comprises two other stations: IPLOR 6-element array of 2.5 km aperture, installed by NIEP in 2009, in the central part of the country, and BURARI, a four-element research array of 1.2 km aperture, deployed in July 2016, in the northern Romania, under a joint effort of Air Force Technical Application Center AFTAC (USA) and NIEP. We present results of processing of the data recorded by the three infrasound arrays deployed in Romania. CEA/DASE PMCC algorithm embedded in DTK-GPMCC (NDC-in-a-box) was applied to obtain detection arrival bulletins for each station. DTK-DIVA software (NDC-in-a-box) was used to plot and to analyze the results, in order to assess station detectability and capacity of fusing detections into support of NIEP efforts for infrasound monitoring of both natural and anthropogenic acoustic sources.

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

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

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

importance of IS08 infrasound station inside the re localization of strong motion felt in Bolivia.

Bolivia has four seismogenic sources, shallow (from 0 to 75km), intermediate (from 100km to 300km), deep (from 350km to 600km) and far away sources (south of Peru and north of Chile) due to the seismic waves amplification under the main capital cities (La Paz, Cochabamba, Oruro, Santa Cruz), the earthquake of 1st April 2014 at 23:46:47 UT 8.2mww located at northern cost of Chile was felt with IV MM this earthquake also generated ground coupled air waves which were analyzed with the DTK – GPMCC software to help us to start the research in infrasound, the second event was on 1st October 2014 at 06:08:22 UT 4.9Mw located at Lloja - La Paz, it was felt with IV – V MM around the city, this event did not generate ground coupled air waves but using the IS08 technology and data in combination with DTK – GPMCC helped us to reduce the ellipse epicenter uncertainty moreover this procedure confirmed the re localization of the event based on back azimuth and the intensity map. Both analyses were developed by NDC staff in order to do infrasound analysis during the daily routine with further events recorded in IS08.

Primary author: NIETO CANAVIRI, Mayra (Observatorio San Calixto)

Presenter: NIETO CANAVIRI, Mayra (Observatorio San Calixto)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

, regional, and remote seismo-acoustic observations of the April 2015 VEI 4 eruption of Calbuco volcano, Chile

We are developing methodologies for automated remote detection, location, and source characterization of volcanic infrasound. The two major sub-plinian explosive phases of the 22–23 April 2015 VEI 4 eruption of Calbuco volcano, Chile produced powerful infrasound. The eruption was recorded on regional seismo-acoustic stations out to 1,540 km and on 5 stations (IS02, IS08, IS09, IS27, and IS49) of the International Monitoring System (IMS) infrasound network at distances from 1,525 km to 5,122 km. The remote IMS infrasound arrays provide an accurate explosion chronology consistent with the regional and local seismo-acoustic data. This case study highlights the significant capability of the IMS infrasound network to provide automated detection, location, characterization, and timing estimates of global explosive volcanic activity. Augmenting the IMS with regional seismo-acoustic networks will dramatically enhance signal detection, latency, and discrimination capability.

Primary author: MATOZA, Robin Samuel (University of California, Santa Barbara, CA, United States)

Presenter: MATOZA, Robin Samuel (University of California, Santa Barbara, CA, United States)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

AND INSTRUMENTATION FOR CALIBRATION OF INSTRUMENTS FOR INFRASOUND MEASUREMENTS

There is presented a set of instruments for calibrating of measuring instruments adapted for measurements in infrasound frequencies range and the technique of their practical application. There has been a lack of such devices so far, combined with a slight feeling of need for calibration of the measuring equipment by acoustic methods. The instrumentation has been developed in response to the growing demand for testing and metrological testing of sound level meters equipped with G weighting network and multi-channel measuring systems for infrasound monitoring in the environment. Besides of infrasound calibrators intended mainly for field use, the acoustical pressure measuring system for comparative testing is presented. It enables determination of frequency amplitude and phase response of microphones and microphones in lab conditions, as well as testing and selection of measurement microphones for multi-channel infrasound monitoring systems.

Primary author: WASALA, Michal (ECO-TECH)

Presenter: WASALA, Michal (ECO-TECH)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

2011 Izhevsk explosions: analysis of an REB seismo-acoustic event cluster

At ~19:50 UTC on 02-June-2011, the first explosion in a cannonade over a period of four hours occurred at a munitions depot near Izhevsk, Russia. Nine events are reported in the REB: six are seismo-acoustic events and three are infrasound-only. Analysis of these results has implications for IDC processing in three key areas: 1) detections - the importance of whether auxiliary data are available at the IDC, 2) association - e.g., an azimuth defining arrival with a time residual >1200 s, and 3) location - inadequate celerity-range model and using single three-component seismic stations as azimuth defining. Arrivals from the event cluster are observed both with the prevailing stratospheric wind (at IS43 (972 km), IS26, IS48 and at IS42, almost 6000 km away) and against it (at IS31 (762 km)). The celerities at IS43 are fast (~0.34 km/s) and are associated with a weak stratospheric duct. Over the four hour period IS43 waveforms are shown to be stable through cross-correlation using the first event as a template. Comparing these cross-correlation results with cross-correlation results for ARU (the closest seismic station, 337 km) leads to many more event detections.

Primary author: NIPPRESS, Alexandra (AWE Blacknest)

Presenter: NIPPRESS, Alexandra (AWE Blacknest)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

the use of infrasound for constraining global climate models

Numerical prediction of infrasound is a complex issue due to constantly changing atmospheric conditions and to the random nature of smallscale flows. Although part of the upward propagating wave is refracted at stratospheric levels, where gravity waves significantly affect the temperature and the wind, yet the process by which the gravity wave field changes the infrasound arrivals remains poorly understood. In the present work, we use a stochastic parameterization to represent the subgrid scale gravity wave field from the atmospheric specifications provided by the European Centre for MediumRange Weather Forecasts. It is shown that regardless of whether the gravity wave field possesses relatively small or large features, the sensitivity of acoustic waveforms to atmospheric disturbances can be extremely different. Using infrasound signals recorded during campaigns of ammunition destruction explosions, a new set of tunable parameters is proposed which more accurately predicts the smallscale content of gravity wave fields in the middle atmosphere. Climate simulations are performed using the updated parameterization. Numerical results demonstrate that a network of groundbased infrasound stations is a promising technology for dynamically tuning the gravity wave parameterization.

Primary author: RIBSTEIN, Bruno (CMLA - ENS Paris Saclay)

Presenter: RIBSTEIN, Bruno (CMLA - ENS Paris Saclay)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

signal proxies for explosive yield and scaled depth of burial during the Source Physics Experiment

Phase I of the Source Physics Experiment (SPE) was a series of six underground chemical explosions in granite. The experiment focused on improving the nuclear explosion monitoring community's understanding of the seismo-acoustic signatures of buried explosions. We discuss the amplitude, impulse, and peak frequency of each shot with respect to explosive yield and depth of burial. We describe a set of empirical models that relate explosion parameters to acoustic signal properties and assess the strengths of each. We assess the descriptive power of each model for the six events during the SPE Phase 1 and estimate their applicability for acoustic signals from explosions of unknown yield and scaled depth of burial.

Primary author: BOWMAN, Daniel (Sandia National Laboratories)

Presenter: BOWMAN, Daniel (Sandia National Laboratories)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

09 Infrasound station routine data analysis and sources from South America

The Infrasound Station I09BR, located in Brasilia, Brazil, was installed in 2001 and has been in operation to this date with four elements of 18m WNRS. The station has some data quality issues and is undergoing major maintenance works planned to be finished in 2018. Until now, the team at the Seismological Observatory of the University of Brasilia actively worked to maintain the station within the minimum required standards of an IMS infrasound station. Recently, the infrasound data was integrated to the routine data analysis at the observatory in synergy with the seismic data. The sources which are commonly detected by the IS09 station are: earthquakes; mine blasting; bolides; supersonic aircrafts; rocket launches from Kourou (French Guiana), South America volcano activity from Ecuador and Chile, big storms, etc. This analysis is important for some sources, like bolide, which are not always detected by the seismic sensors, e.g., the bolide from 26/march/2017 10:55 was felt and reported by many people, initially as a small earthquake, but it was not detected by any seismic station. After the infrasound data analysis, the detection of a signal from the atmosphere clearly indicated the possibility of a bolide, which was later confirmed by AMS.

Primary author: DE CARVALHO, Juraci Mario (Seismological Observatory)

Presenter: DE CARVALHO, Juraci Mario (Seismological Observatory)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

mining activity in Tsumeb, Namibia using complementary infrasound and seismic data sets.

The IS35 Infrasound station in Tsumeb Namibia has been operating since 2005. The Namibian NDC is located 400km away from the infrasound station and is managed by the sub-Division, Crustal Geophysics, in the Geological Survey of Namibia. High staff turnover was primarily due to lucrative salary improvements in the private sector, however with a significant slump in the mining sector in recent years, the Geophysics Division has been able to maintain its staff compliment since 2013. This allowed the Division to develop long-term projects with staff. The Crustal Geophysics sub-Division manages the Seismology Observatory of Namibia, the IS35 infrasound station and the NDC. Seismic data from the IMS network has assisted in regional seismic analyses, however it has always been the hope to make better use of the IS35 infrasound station data. The sub-Division is investigating a practical application to use the data from the IS35 station in conjunction with the AS067 auxiliary seismic station to identify mining activity. Tschudi, an open-pit copper mine located less than 15km from the infrasound station serves as source whereby the two data sets in a complimentary fashion is used to locate mining blasts. This poster illustrates the challenges faced.

Primary author: TITUS, Nortin Peter-David (Geological Survey of Namibia)

Presenter: TITUS, Nortin Peter-David (Geological Survey of Namibia)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

CAPABILITY OF INFRASOUND STATION IS34MN

First infrasound station I34MN was installed in 2002 in Mongolia. Since that the acoustic signals have been continuously being registered with seismic signals from mining blast and determining the source parameters. In the winter time we continuously detect mining signal from Baganuur blast (150 km from mine) but we did not register any signal in Summer time. That was not in agreed with ground truth data. With noise level analysis shows in this region acoustic signal noise level increased from 25-30 dB to 30-40 in summer. Another hand this could be connected infrasound propagation model difference winter and summer time. To check these phenomena we installed another new IBH infrasound station with distance 350 km from mining area. 25 blasts seismic and acoustic signals of from the Baganuur mine were analyzed at two infrasound stations. Obtained result compared infrasound wave propagation model generated by InfraTaup. Based on InfraTaup model 150 km form away, I34MN station detected reflective wave of stratosphere and 350 km from away IBHM station detected reflective wave of stratosphere and thermosphere.

Primary author: LKHAGVA, Tungalag (Institute of Astronomy and Geophysics, Mongolian Academy of Science (MAS))

Presenter: LKHAGVA, Tungalag (Institute of Astronomy and Geophysics, Mongolian Academy of Science (MAS))

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

to Glacier Infrasound in Northwestern Greenland

Inaudible sound, i.e., infrasound, is generated by glaciers while moving and cracking and during calving events. Such sounds can be continuously monitored with microbarometer arrays. Changes in the rate of events can be retrieved with a resolution of a few seconds. Applying array processing techniques enables the identification of individual sources over ranges of tens, in this case, to hundreds of kilometers. Here we show, that passively monitoring infrasound enables new insights in regional changes in the cryosphere under global warming. We concentrated on the region around Quanaq in northwestern Greenland and found coherent infrasound of at least five sources over a period of 12 years. It appeared that some glaciers show a reduction in activity, while others show a strong increase in infrasonic events over time. Diurnal variations in the activity of the glaciers is also retrieved through a spectral analysis, indicative for surface- meltwater induced basal sliding. Our results demonstrate the capacity of infrasonic monitoring as an independent proxy for changes in the cryosphere. We anticipate that monitoring glacial infrasound can contribute to a better understanding of the behavior of glaciers in the future, as phenomena can be passively resolved on a fine temporal scale.

Primary author: EVERS, Läslo (KNMI - Royal Netherlands Meteorological Institute)

Presenter: EVERS, Läslo (KNMI - Royal Netherlands Meteorological Institute)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

-Acoustic Coupled Signals - Epicentral and Secondary Sources of Infrasound

A sequence of moderate and strong earthquakes is recorded by infrasound arrays up to an epicentral distance of 750 km. Two distinct signals originating at the earthquake source are detected; (1) Seismic, consisting of body and surface phases, and (2) Infrasound. However, using array processing, a third type of signal can sometimes be detected. This signal arrives after the seismic detections and before the epicentral infrasound detections with a celerity of ~1 km/s to 460 m/s. This intermediate signal, as the epicentral infrasound signal, traverses the array with a trace velocity of roughly 350 m/s. Relative to the epicentral infrasound detections, which exhibit a stable back-azimuth pointing toward the epicenter, the intermediate signal detections are scattered with ±30°. The trace velocity of the intermediate signal indicates that it is infrasound but the celerity is too fast for it to originate at the epicenter. Therefore, this intermediate infrasound signal must have a propagation path which is part seismic and part atmospheric. We show that the manifestation of an intermediate, apparently fast-arriving infrasound signal occurs when ground motions are efficiently coupled to an existing atmospheric duct to the infrasound array.

Primary author: SHANI-KADMIEL, Shahar (Delft University of Technology)

Presenter: SHANI-KADMIEL, Shahar (Delft University of Technology)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

High Altitude Balloon Project - Measuring Tropospheric and Stratospheric Infrasound

Previous airborne measurements have been done in 2014 and 2015 over the southern United States, leaving the question of stratospheric infrasound in the rest of the world open. This provides an opportunity to listen for infrasound above the Arctic Circle in an area with a developed network of ground stations, which will be used to compare with the stratospheric results. Infrasound, temperature, pressure, wind velocity and direction will be measured with two independent sensor boxes. All data obtained will be analyzed with software used in the IMS and software developed at the Swedish Institute of Space Physics, with help from Dr. Kero. This will be compared with data from previous measurements in collaboration with Dr. Bowman, a student of the High Altitude Student Payload flights in the United States, and Professor Yamamoto, Kochi University of Technology, who provides the group with microphones developed by SAYAInc in collaboration with JAXA. In the future, a deeper understanding of low frequency sounds at stratospheric altitudes may help in examining the weather conditions and geological activity on other planets, especially on Mars as the pressure in the Earth's stratosphere is at the same order of magnitude as the atmospheric pressure on the Martian surface.

Primary author: PERSSON, Robert (Luleå tekniska universitet)

Presenter: PERSSON, Robert (Luleå tekniska universitet)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

# of improvement of characterization and localization of phenomena detected by IS17 station using a infrasound portable array

A better localization of infrasound events in West Africa and on the African equatorial band requires fairly close infrasound station data. This improvement of localizations is possible due to the zonal organization of altitude wind jet over this region. In Africa, Côte d'Ivoire has an infrasound station (I17CI) certified by the CTBTO since 2002. The few existing infrasound stations in this continent (Tunisia, South Africa, Djibouti, Central African Republic) are quite far thereof. In West Africa, we note the lack of other infrasound station that could allow improvement of events localization with I17CI. Thus, an infrasound portable array facility with CTBTO in Côte d'Ivoire will improve the detection of events and their locations. Note that Côte d'Ivoire has expertise in infrasound equipment. This project will also establish a collaboration with neighboring countries such as Burkina Faso, Mali, Ghana, etc.

Primary author: KOUASSI, Komenan Benjamin (Station Geophysique de Lamto)

Presenter: KOUASSI, Komenan Benjamin (Station Geophysique de Lamto)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Seismic and Infrasound Networks as National Technical Mean in Makran region South-East of Iran

Some local networks of Iran are presented and their activity compare with regional network. Seismic networks are and will be probably forever the only tool that enables study of the detailed structure and physical properties of the Earth. Local seismic networks could effectively use checking seismic activity of any area with highest resolution and precision. Lots of small events couldn't record on global networks and the magnitude of completeness of local network catalogs are always less than regional or global ones which is a great advantage of these kind of networks as national technical mean. The detecting ability simply changes with instrumental coverage which plays an effective role for professional and applied usages in seismology. 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. Infrasound networks are one of the other local networks that we could have. We could use infrasound networks in south-east of Iran, Makran subduction zone. We could detect interfering oceanic waves if we have Infrasound network in this region.

Primary author: NAJAFIPOUR, Nooshin (Parsian Seismograph Company)

Presenter: NAJAFIPOUR, Nooshin (Parsian Seismograph Company)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

physics perspective of the infrasonic monitoring

Infrasound monitoring plays a vital role in the detection of signals and determining the location and size of their source.There are several factors affect infrasonic detections namely the variations in atmospheric temperature and wind speed as well as the geographical location.The infrasound signals occur through a change in atmospheric pressure above the epicentre area and are spread across the atmosphere, the mechanism of generating the infrasound signal is related to the atmospheric pressure disturbances that occur around the epicentre, where air pressure is generated by the pumping resulting from an earthquake.The diversity of sources an earthquake may result in a difference in the propagation of waves that can be distinguished in terms of duration and amplitude of the infrasound signal.The longer the duration of the earthquake compared with the relatively short duration of the explosion below ground, the amplitude of the explosion under the ground allows identifying the signal significantly and conducting successful detection depends on our understanding of acoustic propagation through an atmosphere at various times and locations. In this poster, We refer to North Korea's attempt to conduct nuclear test and means of delivery the matter which consists a threat to the treaty.

Primary author: AL-BEHADILI, Saif Kadhim Gatea (Iraqi National Monitoring Authority)

Presenter: AL-BEHADILI, Saif Kadhim Gatea (Iraqi National Monitoring Authority)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

for installing the four-element infrasonic array at the Ukrainian Antarctic Station Academic Vernadsky.

Since 1996, Ukraine operates a scientific station in Antarctica. The station is called Academic Vernadsky and it is located on Galindez Island, 7 kilometers from the shoreline of the Antarctic Peninsula. In 2001, on the station was installed a seismoacoustic complex of equipment for studying geophysical processes and climate. This complex consists of a three-component seismograph and one microbarograph. To date, the issue of modernizing the infrasonic component of the complex has become acute. The infrastructure of the station and the size of the island allow it to accommodate a four-element infrasonic array in the form of a triangle with one element in the center with a maximum aperture of 600 to 750 meters. Elements of the array are planned to be placed on rocky bases, rather than on ice, which will somewhat simplify the operation of the system. This array is planned to be used for studying natural phenomena in Antarctica and in combination with other means for studying global climate changes. 45 km to the north from Vernadsky is the station Palmer (USA), which also has an infrasound complex. The joint use of data from two stations will make it possible to locate local sources of infrasonic signals.

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

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

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Infrasound Segment of the International Monitoring System

The infrasound network of the International Monitoring System (IMS) designed for the verification of the Comprehensive nuclear-Test-Ban Treaty includes 60 stations located around the world. Four of them are part of the Russian IMS segment: IS43 (Dubna), IS44 (Petropavlovsk-Kamchatskiy), IS45 (Ussuriysk), IS46 (Zalesovo). All Russian Infrasound IMS stations are certified and transmit data to the International Data Center (IDC), Vienna, Austria. Russian IMS stations play an important role in location and identification of events at the IDC. More than 50% of all infrasound detections included in REB in 2016-2017 are detections of Russian IMS stations. Within the last few years an upgrade of Russian infrasound IMS stations has been provided. It includes replacement of vaults, wind noise reducing systems, upgrade of communication and power supply systems. The objective of these activities is to make stations more reliable which allows to achieve the fulfilment of IMS data availability requirements and to improve station contribution to the network. We present the history of establishment and the current status of Russian infrasound IMS stations as well as description of their upgrades and examples of signals, recorded at these arrays and analysis of their detectability.

Primary author: DEMIAN, Evgenii (Special Monitoring Service (SMS) of the Ministry of Defense)

Presenter: DEMIAN, Evgenii (Special Monitoring Service (SMS) of the Ministry of Defense)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Monitoring of volcanic eruptions and contribution of ARISE to the Volcanic Ash Advisory Centers

With the advent of Civil Aviation and the exponential growth in the air traffic the problem of a volcanic ash encounter has become an issue of paramount importance, which needs to be addressed in real time. We discuss the contribution of the ARISE project to volcano monitoring and to Volcanic Ash Advisory Centers (VAACs) and highlight the need for an integration of the CTBT-IMS Infrasound network with local and regional infrasound arrays capable of providing a timely early warning to VAACs. In this work we focus on the eruptive activity from Etna volcano for the time period between 2014 and 2016 and compare the Volcanic Ash Advisories issued by Toulouse VAAC with information on the status of eruptive activity derived from infrasound array observations provided by local and regional arrays.

Primary author: MARCHETTI, Emanuele (University of Firenze)

Presenter: MARCHETTI, Emanuele (University of Firenze)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

from the shallow submarine eruption of Bogoslof volcano, Alaska

Bogoslof is a submarine stratovolcano in the Aleutian Arc with a shallowly submerged vent that results in abundant seawater interaction during eruptions. Most of the 63 significant explosive events have been recorded on the Alaska Volcano Observatoryâ☒s infrasound arrays that range from 60 to 800 km from Bogoslof. The events have been dominated by low frequency energy (0.067-1 Hz), with notable exceptions that shed light on how seawater interaction affects infrasound production. For example, the 31 January eruption began with discrete, low frequency infrasound that after two hours transitioned into continuous, broadband infrasound. A satellite image captured shortly after the end of the event showed that a tephra ring was formed during the eruption that temporarily isolated the below-sea-level vent from the ocean, and likely resulted in the change in observed signal character. A subset of the eruptions that only produced low frequencies, and presumably maintained a flooded vent, have simple, pulse-like waveforms similar to signals from gas bubbles bursting at the top of magma columns. We model the nonlinear bubble motion with a variation of the Rayleigh-Plesset equation and find that decimeter radii bubbles are required for volumetric oscillation to reproduce the infrasound frequencies and pressures recorded.

Primary author: LYONS, John (USGS-AVO)

Presenter: LYONS, John (USGS-AVO)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Poster**

Infrasound Events Identified by the National Data Centre (IS41) in Paraguay

We present an analysis of infrasound events that could be performed by the paraguayan National Data Center (NDC); equipped with a Capacity Building Center (CBS), supported by AutoDRM and using GeoPMCC software to analyze the waveforms. This mentioned software comes included in the NDC in A Box. As an example, we take is41 as main station in a registration period from October 2016 to June 2017, and using as auxiliary stations IS02, IS08 and IS09. In that period of time we were able to identify the signal spectrum of a hydroelectric dam and falls; we were also able to pick regional electrical storms; register a local microearthquake and earthquake boom.

Primary author: FIGUERES, Vincent Hubert Rene (Universidad Nacional de Asuncion, Facultad de Ciencias Exactas y Naturales)

Presenter: FIGUERES, Vincent Hubert Rene (Universidad Nacional de Asuncion, Facultad de Ciencias Exactas y Naturales)

Track Classification: Analysis of Sources and Scientific Applications

ID: Type: **Oral**

infrasound to constrain ensemble predictions and detect model biases

For users of ensemble weather forecasts, a key metric of forecast success is its ability to effectively predict the uncertainty of a given weather condition happening at some point in the future. Knowledge on the quality of the forecasting system is essential. Evaluation methods of forecast performance focus predominantly on the surface and troposphere. However, knowledge on the stratospheric performance is valuable.
The potential of infrasound as an independent measure to evaluate the stratospheric forecast performance has been demonstrated for the 2013 sudden stratospheric warming, addressing a model bias due to a data assimilation issue. In this study, the performance of the stratospheric ensemble forecasts is evaluated to constrain ensemble predictions and detect model biases. A year of near continuous infrasound from the volcano Etna is compared with simulations using the ensemble forecast of the European Centre for Medium-range Weather Forecasts (ECMWF).

Primary author: SMETS, Pieter (KNMI - Royal Netherlands Meteorological Institute)

Presenter: SMETS, Pieter (KNMI - Royal Netherlands Meteorological Institute)

Track Classification: Modelling & Network Processing

ID: Type: **Oral**

in seismoacoustic GT database creation at Kazakh NDC

Kazakh infrasound network consists of tree arrays: IS31 at the west of Kazakhsatn, Kurchatov at the north-east and Makanchy at the east. Kazakh NDC also processes the data of the neighbor IS46 array, Altay, Russia. North Kazakhstan and neighboring part of Russia have got very high mining activity. Signal detection and its source location is automatically performed at Kazakh NDC since June 2014. The method of the seismoacoustic GT database creation was described at [Smirnov 2016] on ITW 2016. The technique was later improved, it was suggested to use Lg waves [e.g. Slinkard et al. 2014] for the seismic event correlation and historical Google Earth images for the mining activity estimation. The results of the improved technique approbation with the data of the Ekibastuz, Mykain and Akbastau quarries show that the technique applicability strongly depend on the quarry geometrical dimensions. The improved technique finally was applied to the several mining regions at the Central Asia.

Primary author: SMIRNOV, Alexandr (Kazakhstan National Data Centre)

Presenter: SMIRNOV, Alexandr (Kazakhstan National Data Centre)

Track Classification: Modelling & Network Processing

ID: Type: **Oral**

quantification in infrasound propagation modeling

The main aspect of uncertainty quantification that is studied in infrasound research community is propagation of atmospheric uncertainty, which is due to the random nature of small-scale flows (e.g. gravity waves). A simple approach to this problem is to use Monte Carlo sampling, which involves a large random sample of plausible atmospheric specifications from a given distribution. However, the classical full-wave propagation models take computing time to evaluate, so that the large number of runs required is impractical. The approach which is developed in this work, is to use chaos polynomial expansions and low-order reduced models to describe both the input uncertainty (gravity waves, source specifications) and the acoustic field. This approach is motivated by two observations. First, acoustic propagation in the atmosphere often involves a few modes that are confined within waveguides. Second, recent observations in the lower stratosphere show that the gravity wave field is dominated by large-amplitude wave packets, that can be described with normal modes of a suited wave equation. Numerical results are obtained using the FLOWS simulation platform, that integrate advanced spectral numerical methods and realistic representations of atmospheric disturbances. The method is used to revisit infrasound signals recorded during campaigns of ammunition destruction explosions.

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: Modelling & Network Processing

ID: Type: **Oral**

Wide Angle Time Domain Parabolic Equation Code to Modelling of Acoustic Signals Propagation in Different Media

Super wide angle time domain parabolic equation code to modelling of acoustic signals propagation in different media: sea water, bottom sediments and atmosphere and their combinations are proposed. The new super wide angle version of the TDPECode based on the pseudodifferential parabolic equation technique. The numerical calculations are made for sound rays with grazing angles till to 87 degrees. The presented results include practically interesting cases of calculation fields and signals forms for infrasound propagation from atmosphere to the ocean water and bottom sediments and vice versa.

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

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

Track Classification: Modelling & Network Processing

ID: Type: **Oral**

of the effect of a fine layered structure of the lower troposphere on propagation of acoustic pulses

The results of acoustic sounding of the lower troposphere by using detonation generators of acoustic pulses are presented. Such sounding method is based on a partial reflection of the acoustic pulses with shock fronts from vertical wind-velocity and temperature gradients continuously varying with height in the troposphere, and on the penetration of reflected signals into the acoustic shadow zone. The anti-hail acoustic system developed in Armenia (Talin) was first used as a generator of acoustic pulses for sounding of the troposphere. The experimental results have been compared with those obtained earlier in similar experiments carried out near Zvenigorod with the use of a special detonation generator of acoustic pulses. Due to high vertical resolution of the sounding method (about 1 m) the vertical profiles of layered effective sound speed fluctuations with vertical scales from a few to a few tens of meters have been retrieved in stably stratified atmospheric boundary layer (altitudes are in the range 250-650m). The influence of these fluctuations on the form and amplitude of low-frequency acoustic signals at a long distance from their pulsed source has been studied.

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

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

Track Classification: Modelling & Network Processing

ID: Type: **Oral**

events revisited with bayesian localization and machine learning

Long-range infrasound propagation is characterized by large variances due to factors such as stratospheric jet variability, turbulence, and the fact that the atmospheric specifications fail in representing small-scale fluctuations. In numerous situations, the atmospheric ducts are poorly formed, in the sense that they just barely return sound to the ground. In such cases, the proper numerical methods to use (e.g. finite element method or range-dependent normal mode method) are costly in computational memory and time. This is why acoustic source localization problem in the atmosphere is often solved using the ray tracing technique. This approach, however, is limited in most realistic situations, due to its sensitivity to the mismatch between model-generated signals and measurements. An alternative approach, which is addressed in this study, is to use surrogate data obtained from low-cost full-wave propagation models and recorded signals to infer finer, updated probability distributions of unknown parameters. This approach can be applied using a parallel MCMC (Markov chain Monte Carlo) algorithm to obtain a fast prediction of source location, given a few recorded signals. In turns, the posterior distributions of small-scale fluctuations can be estimated and updated, thereby providing a classification of infrasound events, in a complete machine-learning framework.

Primary author: BERTIN, Michaël (Commissariat à l'énergie atomique et aux énergies alternatives (CEA))

Presenter: BERTIN, Michaël (Commissariat à l'énergie atomique et aux énergies alternatives (CEA))

Track Classification: Modelling & Network Processing

ID: Type: **Oral**

the influence of flow-topography interactions on infrasound propagation

The accuray of propagation modeling depends in large part on the reliability of both the medium and the boundary conditions. In order to incorporate topography effects in infrasound propagation, high-resolution terrain models are used through approximating the lower boundary by a sequence of up and down stair steps. This simplified approach may also be viewed as applying a "mask" onto the atmospheric specifications, and ignoring the direct influence of the topography on the local wind and temperature fields. This is an extremely serious limitation, given that even small mountains can produce intense phenomena, like downslope winds, Foehn, or trapped lee waves. In this study, we use a combined approach, based on a mesoscale atmospheric model and the range-dependent normal mode technique, to examine the conditions that causes a low-level acoustic duct to be affected by topography-induced disturbances. It is shown that during statically stable situations, situations that are common during night over land and winter, topography can induce a strong Foehn effect, which shrinks the waveguide significantly. This yields a new form of infrasound absorption, that can largely outweigh the direct effect of the obstacle on the low level waveguide.

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: Modelling & Network Processing

ID: Type: **Oral**

the sensitivity of the IMS Infrasound Network using Balloon-Borne Microphones

Recent experiments with balloon-borne infrasound sensors suggest that they have lower noise levels and an increased signal detection range compared to ground based microphones. They can also travel over regions that lack station coverage, such as polar regions and the open ocean. However, current designs cannot determine the arrival azimuth of incident signals and cannot maintain a constant location. We discuss the noise levels recorded on recent balloon infrasound experiments in comparison with IMS baselines. We evaluate the effect on IMS network sensitivity from a single sensor traveling over regions that lack ground coverage. Finally, we present a conceptual model of a continuous IMS balloon network providing coverage over the Southern Hemisphere.

Primary author: BOWMAN, Daniel (Sandia National Laboratories)

Presenter: BOWMAN, Daniel (Sandia National Laboratories)

Track Classification: Modelling & Network Processing