

Seismological Investigation of the NPE2019

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The NDC Preparedness Exercises (NPE) are regularly performed dealing with fictitious treaty violations to practice the combined analysis of CTBT verification technologies. These exercises should help to evaluate the effectiveness of analysis procedures applied at NDCs and the quality, completeness and usefulness of IDC products.

The NPE2019 is a combined radionuclide-waveform scenario. The source region and time domain of a possible treaty violation activity was determined from ATM in backtracking mode with input data from fictitious particulate radionuclide and radioxenon measurements at stations of the IMS of the CTBTO.

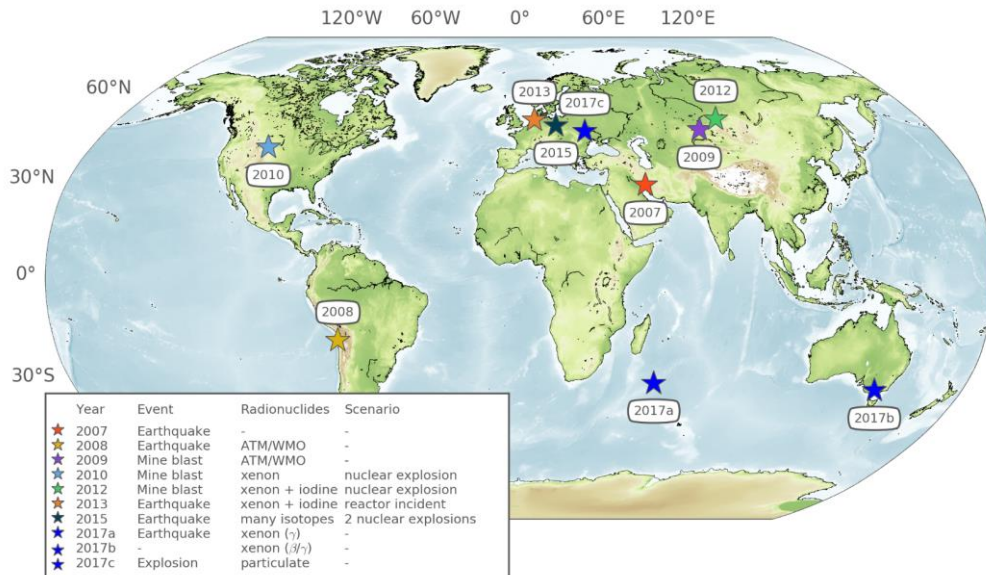
The seismicity of the determined source region was investigated to identify events which cannot be classified as natural. An earthquake sequence could be identified within the specified source region and time frame from ATM analysis. The unusual shallow source depth of about 3 km and no mining activities in this region could classify these events as a possible treaty violation. The trigger event of NPE2019 scenario could be identified clearly as a tectonic event with a cluster analysis and moment tensor solution.

National Data Centre Preparedness Exercises (NPE)

NPE are regularly performed dealing with fictitious treaty violations (often real waveform events combined with simulated RN evidence) to practice the combined analysis of CTBT verification technologies and national technical means (NTM)

NPE shall improve

- Analysis procedures
- Data products and services
- Inclusion of NTM
- Communication routines between experts
- Merging of different kinds of information
- ... and scientists from various disciplines
- Decision about an OSI



NPE scenarios since 2007 with location of the main trigger events

NPE2019 - Scenario Information

Scenario Design NPE2019 – An Italian-German collaboration

- Storyline and radionuclide scenario invented by colleagues from ENEA, Bologna
- Several meetings to develop details
- Forward ATM for RN concentrations by German NDC
- Organizational issues and website managed by German NDC
- First request of Expert Technical Analysis during NPE2019

For detailed scenario information see presentation **O4.1-636**

ANNOUNCEMENT on 30 July 2019:

The national nuclear safety authority of the state of RAETIA released the following public announcement. *"An accident at TRIGA reactor facility located in Pavia, RAETIA, has occurred this morning 30th July 2019. We are expecting some small release of radioactive isotopes, but well below the hazardous limit for human health. A dedicated monitoring system has been activated around the facility and in the neighbouring in order to monitor the radioactivity in the air. There is no need to activate any emergency procedures for the population neither any closure of schools and public areas is required"*



Map with the two fictitious states RAETIA and EASTRIA of NPE2019 scenario

NPE2019 - Scenario Information

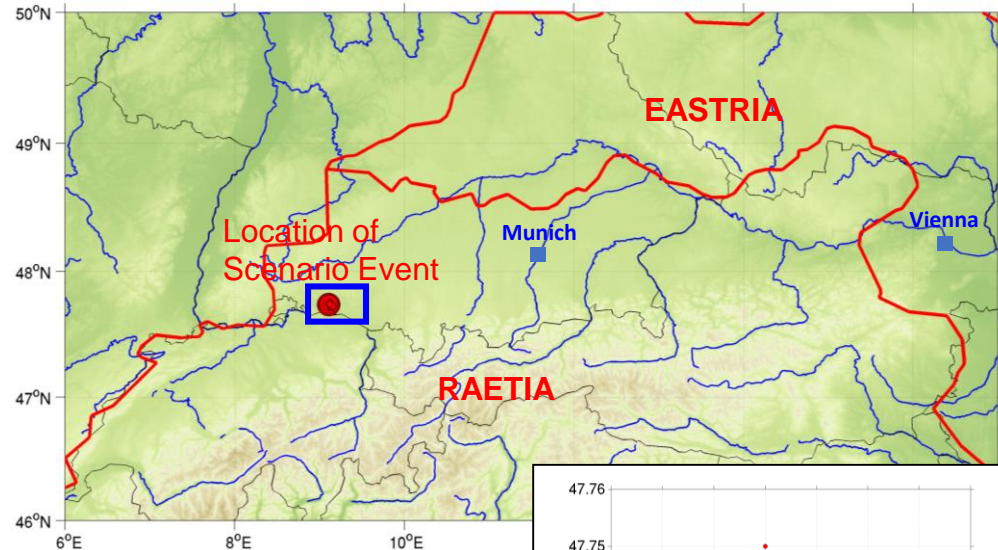
A real tectonic seismic event in south Germany near city of Constance was selected as source point for simulated RN releases of a fictitious clandestine underground nuclear test.

This event is unexpected shallow and therefore could also be a blast or an induced event

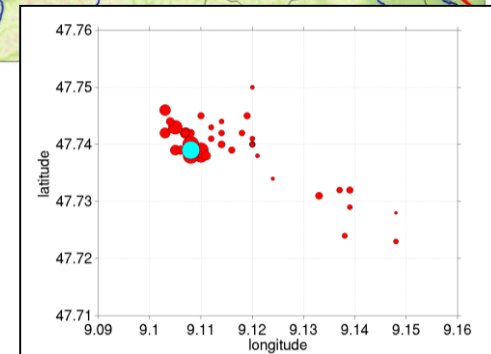
For detailed scenario information: **O4.1-636**

Parameter of scenario event

Origin time	29 June 2019 23:17:47.9 UTC
Epicentre	47.739N 9.108E
Source depth	3 km
Magnitude	3.7 ML
Region	Lake Constance



The scenario event (blue, small map) is the strongest event of a small-scale series (blue rectangle, upper map) of tectonic events (43) in this region



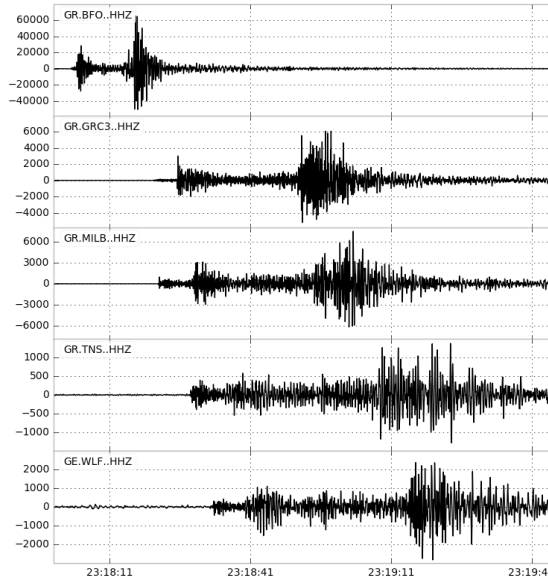
INTRODUCTION

Waveform data from a “suspicious event” and possible source of the RN observations were provided by state **EASTRIA** in a later stage of the exercise to demonstrate the non compliance of state **RAETIA**

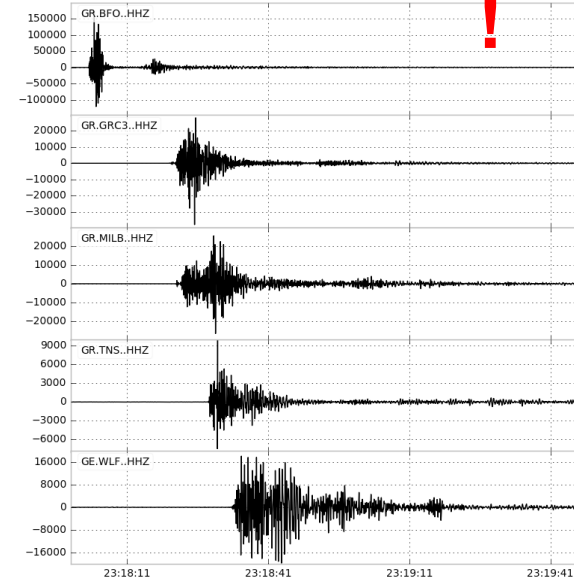
The waveform data were **modified!** from a real and obviously “**tectonic**” signature to an “**explosion like**” signature with high amplitude P waves

The original waveform data could be collected from open sources like the FDSN Web Server

Original Waveform Data



Modified! Waveform Data provided by EASTRIA



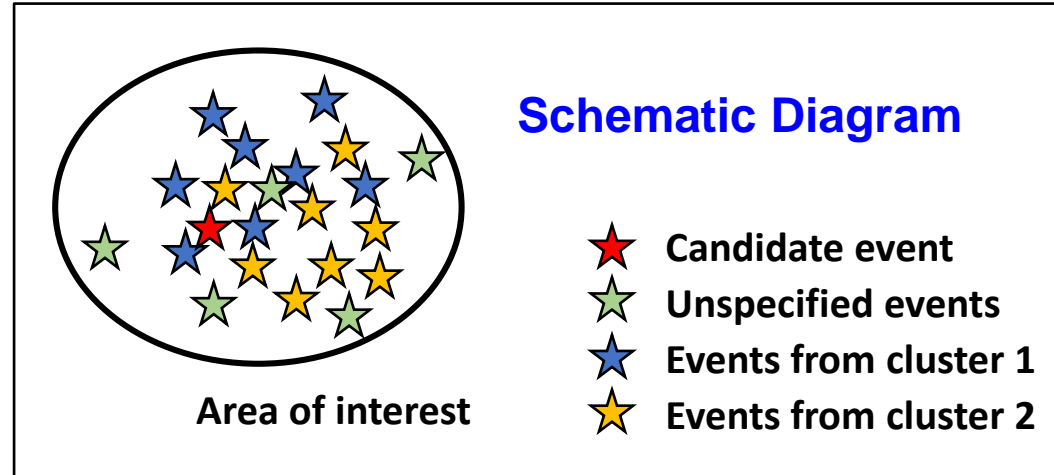
29 June 2019 23:17:47.9 UTC, Magnitude 3.7 ML
Region Lake Constance

Cluster Analysis

A cluster analysis was applied to the waveform data of a series of events in the source region

The objective is the identification of events with an unusual waveform that don't belong to one of the clusters. In case of an treaty violation we search for a single event within a group of "regular" tectonic events

We concentrate the analysis on the scenario event of the exercise
(29 June 2019 23:17:47.9 UTC, 3.7 ML)



Similarity analysis with cross correlation

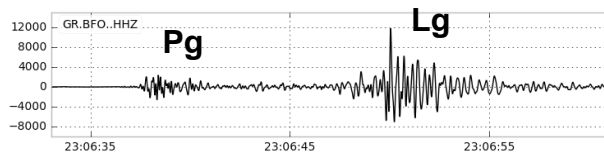
The similarity of the waveforms is estimated by the cross correlation

An example for two events recorded at station BFO with a high similarity and a coefficient of 0.97 is on the right. The analysis window include Pg and Lg wavetrain

A significant similarity is given for correlation values above 0.7

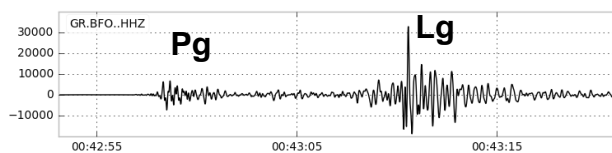
Seismic station BFO

Trace 1 (event #0)



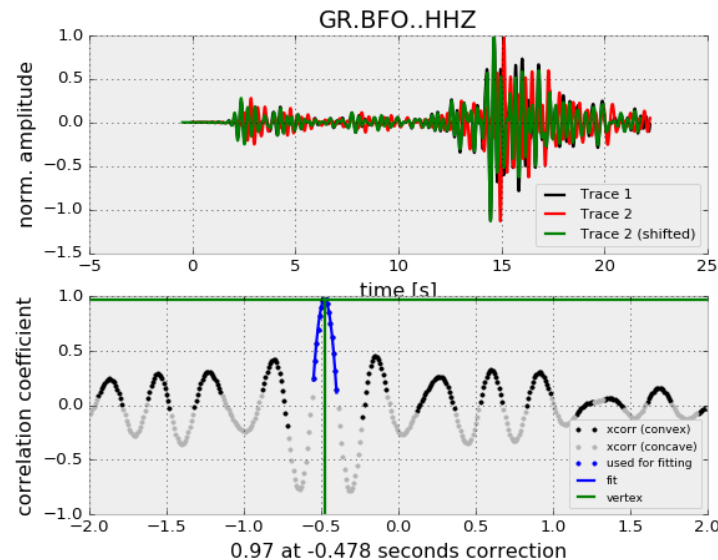
2019-07-29 ML 2.8

Trace 2 (event #9)

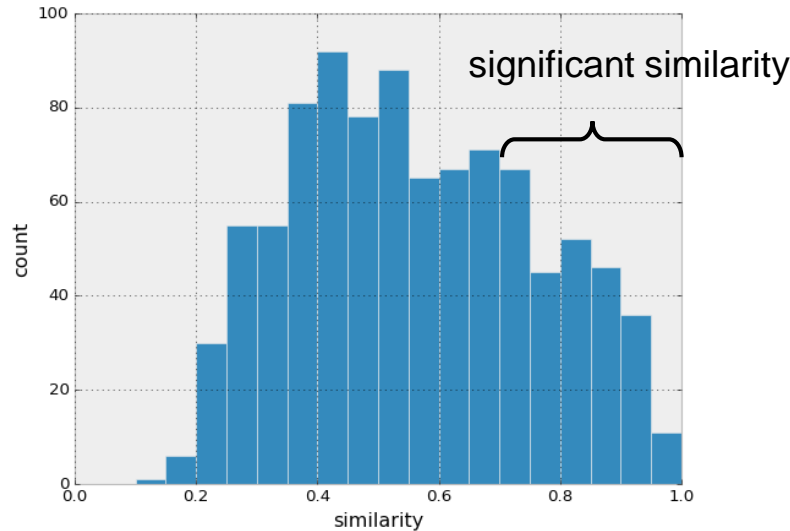


2019-07-30 ML 3.2

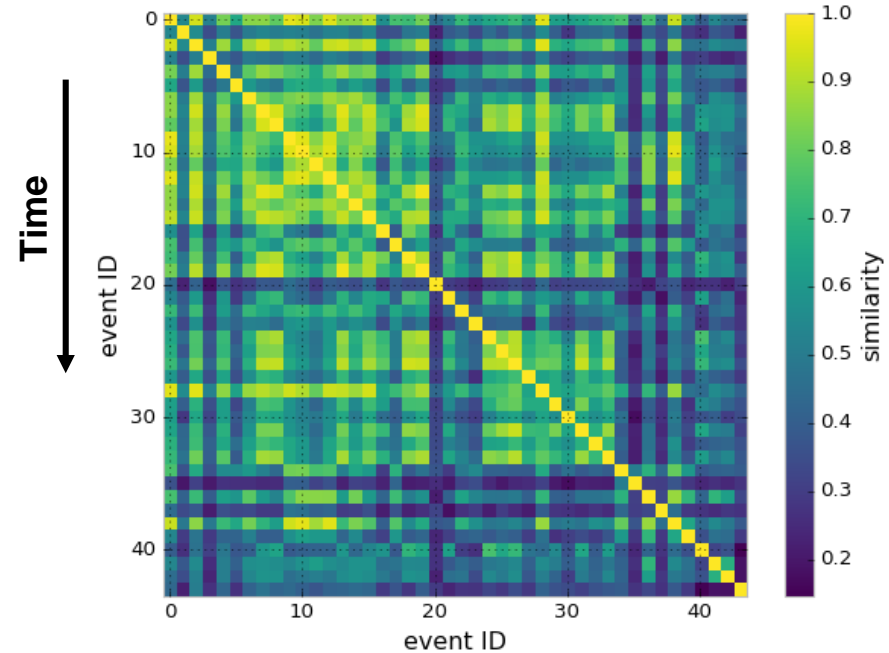
Epicentre to station distance: 88 km



Result of the cross correlation (cc) for the two traces on the left. The procedure calculate the cc value and the time shift with the best correlation



Distribution of cross correlation (cc) values of all events of the analysis. Significant similarity is above a cc value of 0.7



Matrix of cc values. The modified waveforms are included as last event (# 43)

Dendrogram of similarity analysis

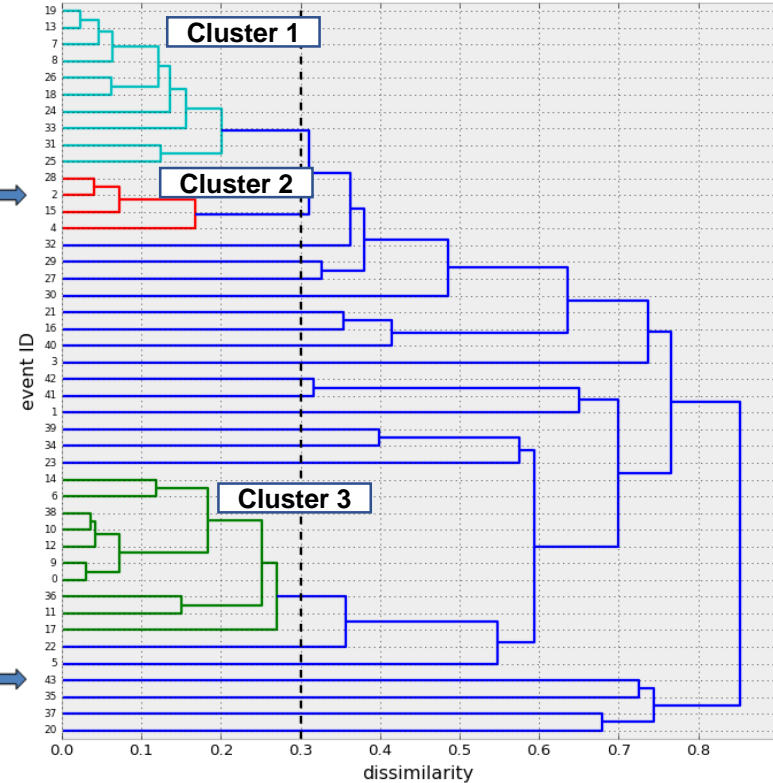
The similarity analysis of the 43 events (number 0 – 42) reveals 3 clusters. 24 events belong to one of the 3 clusters

The modified waveforms are included as trace 43. This data have a very low similarity with other traces as expected

A high number of events has no similarity to each other. This applies not only to small magnitude events, which have a poor signal-to-noise ratio as seen on the next slides

Scenario event →

Scenario event modified data →



Clusters of similarity analysis

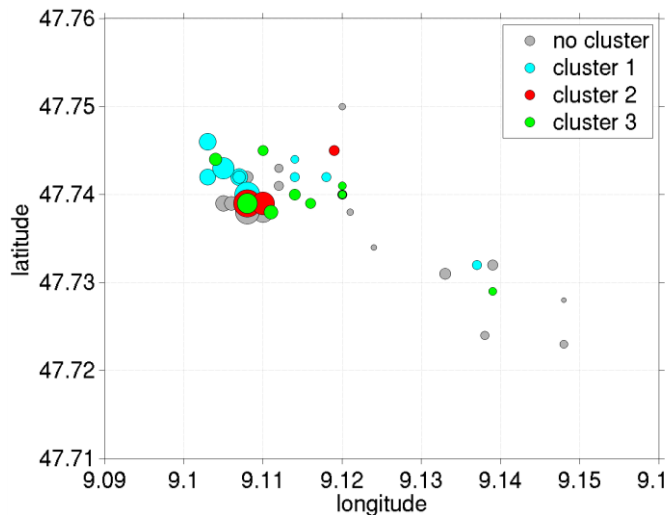
The figures on the right show the clusters in space and time

The scenario event is part of cluster 2 (red)

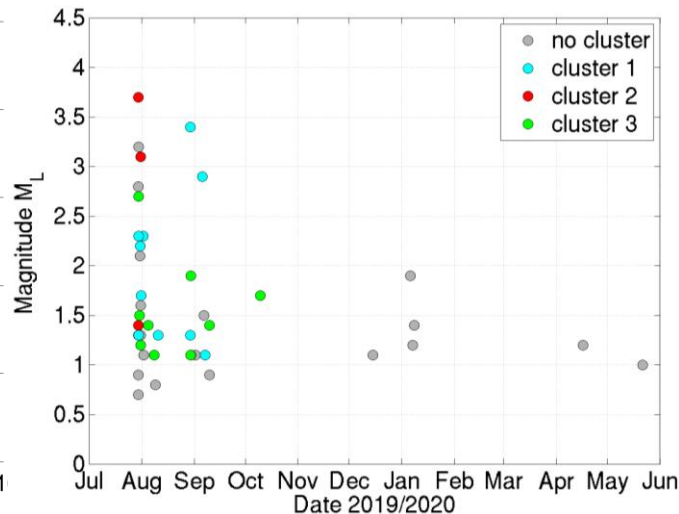
Events after Nov 2020 are not similar ($cc < 0.7$) to the early events in the region

There is no clear pattern in space and time of the earthquake series

Spatial clustering

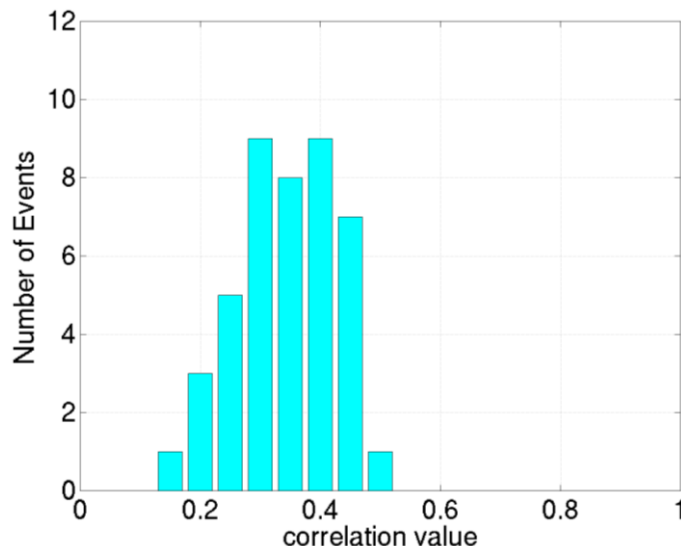


Clustering in time

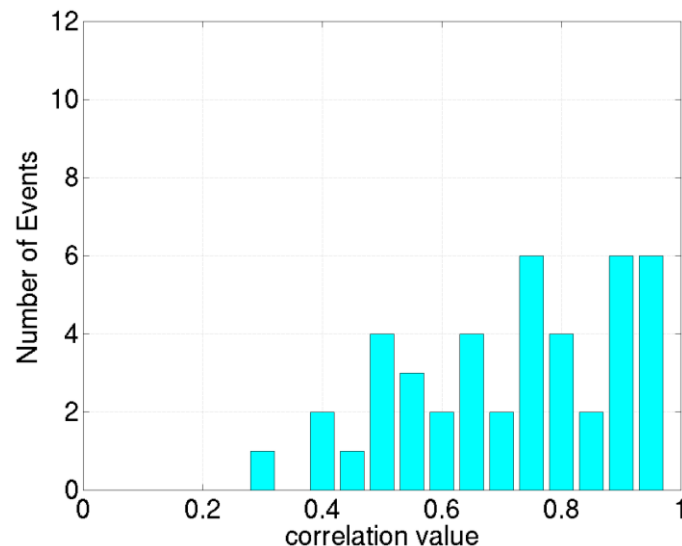


Similarities

The distribution of cross correlation values differ significant between the scenario event (right), which is a real tectonic event in the area and the modified waveform data (left)



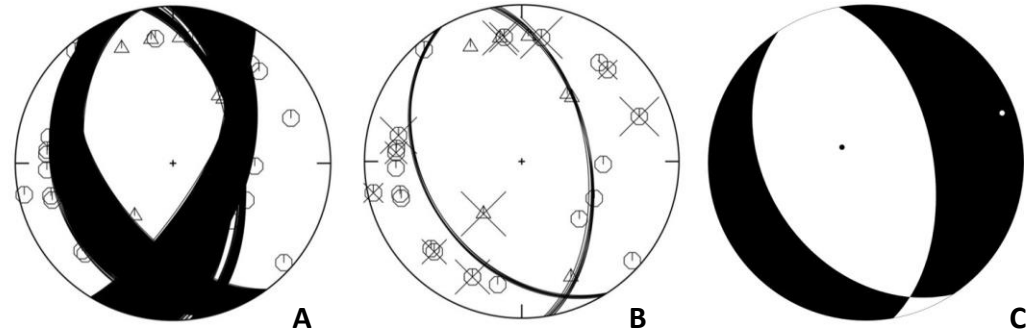
Distribution of cross correlation values for the **modified waveforms**. There is no similarity ($cc > 0.7$) with other events from the region



Distribution of cc values for the **scenario event**. There is clear similarity (above 0.7) with other events from the region

Focal Mechanism Solution

The scenario event (29 July 2019 23:17 UTC) can be classified as tectonic in origin from the results of the moment tensor. The results show a clear double-couple proportion



Focal mechanism determined from observations of P polarities and P/S amplitude ratios of the scenario event (29.7.2019, 23:17 UTC, ML 3.7. **A)** Input parameters as well as fitting nodal planes calculated with the program FOCMEC. **B)** Reduction of nodal planes by incorporating amplitude ratios. **C)** The corresponding 'beach ball' with the preferred fault planes

- The scenario event of NPE2019 has a significant similarity with other tectonic events in the source area
- The cluster analysis reveals that it belongs to a cluster with 4 events in total
- The calculated focal mechanism reveals also a clear tectonic origin
- Results demonstrate that it is not a singular suspicious event
- Manipulation of waveform data, which was part of the scenario, should draw attention to the fact that this may be possible in case of suspicion of a possible treaty violation and also in case of an OSI request
- The manipulation of the waveform data could be easily detected with the help of independent sources and other seismic stations from local networks in the region
- The scenario event was not detected with the IMS network which demonstrates the important role of local seismic networks as part of national technical means and