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An assessment of Infrasound events in the REBs produced in the year 2016.

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Introduction

The critical aspect of monitoring in the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) is the analysis by the IDC of data obtained from the IMS (International Monitoring System) network comprised of 321 stations when completed. This network provides data from four technologies (Seismic, Hydroacoustic, Infrasound and Radionuclide). The first three provide waveform data and are categorized as SHI (Seismic, Hydroacoustic and Infrasound) IMS data. This category of the network is planned to comprise 170 Seismic (50 Primary and 120 Auxiliary), 11 Hydroacoustic and 60 Infrasound stations. Of these, 149 Seismic (42 Primary and 107 Auxiliary), 10 Hydroacoustic, and 49 Infrasound SHI technology stations are currently operational. Effective monitoring of violations of the CTBT depends upon the States Parties' ability to determine the nature of the source of the signals recorded by the IMS stations based on the products they receive from the IDC; one of these products being the Reviewed Event Bulletin (REB). In this regard, the products must be of high quality enabling States Parties to make timely and informed decisions on the nature of the source of the signals. The REB is a product of human interactive analysis of the SHI waveform data and is the most comprehensive and highest-quality seismo-acoustic product provided to States Signatories. Furthermore, it is also the basis for subsequent and automatically generated products such as the Standard Event Bulletin (SEB) and Standard Screened Event Bulletin (SSEB), which provide additional data and information on event characterization to the States Parties. With this general overview, it is of great interest to closely look into the contributions of these technologies (in this case Infrasound technology) towards the production of the REB.

Objective of the study

This study investigates the contribution of the Infrasound technology to the REB in 2016, with the following main objectives;

a) Investigate the overall contribution of the Infrasound technology towards the REB production.
b) Investigate the seasonal, daily and hourly distribution of Infrasound only events.
c) Contribute towards having a better understanding for future allocation distribution of SHI analysis man power.

Data and Investigation approach

In this study the REB bulletins for the year 2016 are considered. A total number of 37,090 events were found for the REBs produced in 2016. Figure 1 shows the geographic distribution of these REB events. As can be seen from that figure, the REB events are located in known seismically active regions of the world. To accomplish the task of the investigation, SQL query of the IDC database is used to extract Infrasound only events.

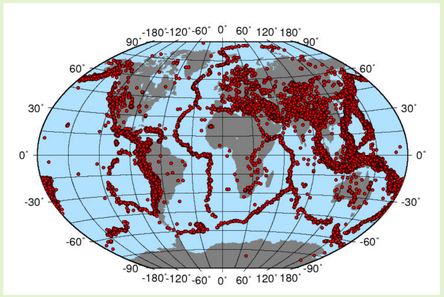

Fig. 1. Geographic distribution of all REB events as obtained during the year 2016.

Since the main focus of this study is to assess the contribution of Infrasound only events to the REB, we will briefly consider how such events are currently produced at the IDC. Infrasound Analysis uses the Progressive Multi-channel Correlation detection Processing (PMCC) method. PMCC assumes plane wave propagation across sensor arrays and performs a grid search for coherent signals in advancing time windows using infrasound frequency passbands of interest. It records the wavefront properties of the dominant coherent arrival in a given time-window and frequency-band pair as a pixel. PMCC then groups pixels with similar wavefront properties into families. Figure 2. shows an example of PMCC pixels and corresponding waveform data.

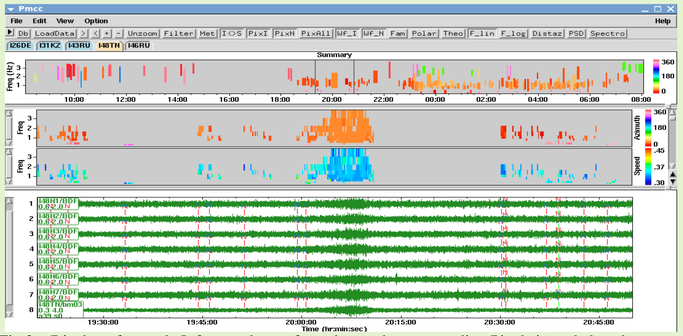

Fig.2 . Display of sample Infrasound waveform data and corresponding Pixels intended to show how the current Infrasound data analysis is performed at the IDC.

Investigation results

a) Geographic distribution of current Infrasound stations and Infrasound only events

To help asses the contribution of Infrasound technology, we also present geographic distribution of Infrasound stations currently available in operations (OPS) at the IDC (see Fig. 3a). Figure 3b shows geographic distribution of Infrasound only events as recorded at these stations.

a) b)

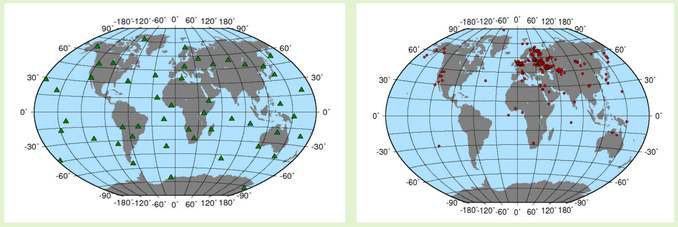

Fig. 3. Geographic distribution of: a) currently available Infrasound stations in OPS; b) Infrasound only events for the year 2016.

The geographic distribution of Infrasound only events as extracted form the REB bulletins produced during the year 2016 is restricted to a few regions of the globe (see Fig. 3b). These regions include Europe, Asia and N. America. This observation is not consistent with the geographic distribution of stations which has an even distribution at a global level (see Fig. 3a). Furthermore, comparing Figures 1 and, 3b it can be seen that occurrence of seismic events has a global nature while this is not the case for Infrasound only events. Despite the global location of the infrasound stations, it was observed that no infrasound events are located below the -30 deg. latitude during the year 2016. At this time it has not yet been confirmed if a similar observation exists for the other years.

b) Geographic distribution of mixed technology (seismic and Infrasound) only events

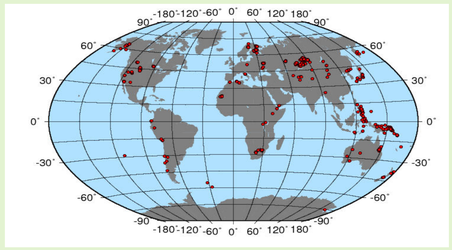

Fig. 4. Geographic distribution of mixed technology (Seismic and Infrasound) only events for the year 2016.

The spatial distribution of mixed technology (seismic and Infrasound) events (1886 events in number) is different to that of Infrasound only events distribution shown in Figure 3b.

c) Bi-monthly and Quarterly occurrence distribution of Infrasound only events.

An assessment of a Bi-monthly and Quarterly distributions of Infrasound only events are performed and the results are displayed in Figure 5.

a) b)

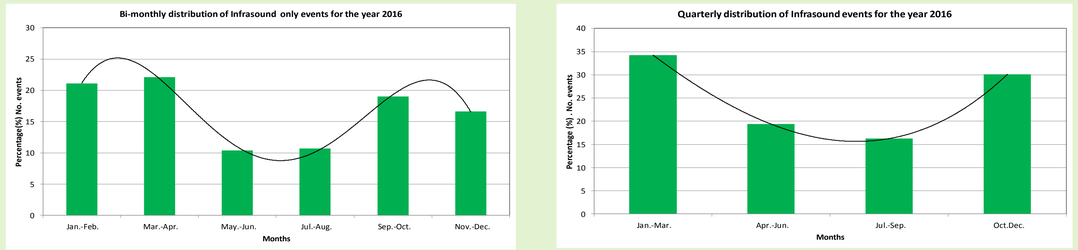

Fig. 5. a) Bi-monthly; b) Quarterly occurrence distributions of Infrasound only events for the year 2016. The black line in the figure is intended to show the trend of the occurrence during the time interval under study.

It can be seen from Figure 5 that fewer number of Infrasound only events occur during the summer time as compared to the other seasons of the year. This relatively low number of events during the summer time might be related to variations in wind directions.

d) Daily and Hourly occurrence distribution of Infrasound only events

Figure 6 shows daily and hourly occurrence distribution of Infrasound only events

a) b)

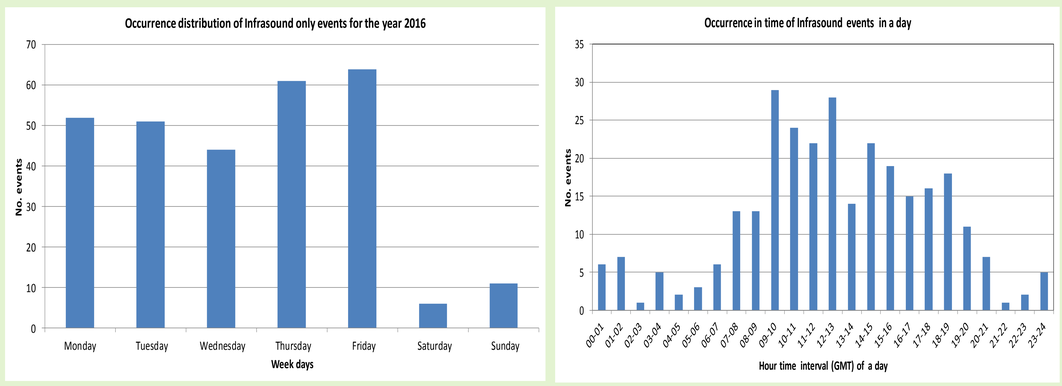

Fig. 6. a) Daily; b) Hourly occurrence distribution of Infrasound only events.

These figures show that the total number of Infrasound only events is only a few hundreds for the whole year and the events occur mainly during the working days of the week and during the daily working hours interval of 07:00-20:00 UTC. This is more or less a day time in Central Europe, where most of these events are observed. It can therefore be deduced that most of the infrasound only events during 2016 are the result of man-made-activities. Should a similar pattern be observed for all the other past years, then it would help in determining analyst resources needed to analyse infra events.

Conclusion

This study shows that only a few number of Infrasound only events (a couple of hundred) exist in REB when compared to the total number of all events in the same bulletin. The contribution of the number of such events does not exceed 10% of the total number of events in REB. As can be seen from the figures, the occurrence of Infrasound only evens is not evenly distributed on the Globe. Most of the mixed technology events are related to man-made activities, such as mining activities. Furthermore, the occurrence in time of these Infrasound only events, i.e. seasonal, daily and hourly occurrence distributions, also indicate that they are indeed mainly related to man made activities and more or less predictable both in time and region. Thus, knowledge of the pattern of occurrence of these events and their contribution to REB can be used to plan for allocating man power which in turn may help expedite the analysis work at the IDC (especially during high seismicity).