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Monitoring the Earth's Atmosphere with the Global IMS Infrasound Network

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The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is tasked with monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) which bans nuclear weapon explosions underground, in the oceans, and in the atmosphere. The verification regime includes a globally distributed network of seismic, hydroacoustic, infrasound and radionuclide stations which collect and transmit data to the International Data Centre (IDC) in Vienna, Austria shortly after the data are recorded at each station. The infrasound network defined in the Protocol of the CTBT comprises 60 infrasound array stations. Each array is built according to the same technical specifications, it is typically composed of 4 to 9 sensors, with 1 to 3 km aperture geometry. At the end of 2000 only one infrasound station was transmitting data to the IDC. Since then, 41 additional stations have been installed and 70% of the infrasound network is currently certified and contributing data to the IDC. This constitutes the first global infrasound network ever built with such a large and uniform distribution of stations.

Infrasound data at the IDC are processed at the station level using the Progressive Multi-Channel Correlation (PMCC) method for the detection and measurement of infrasound signals. The algorithm calculates the signal correlation between sensors at an infrasound array. If the signal is sufficiently correlated and consistent over an extended period of time and frequency range a detection is created. Groups of detections are then categorized according to their propagation and waveform features, and a phase name is assigned for infrasound, seismic or noise detections. The categorization complements the PMCC algorithm to avoid overwhelming the IDC automatic association algorithm with false alarm infrasound events. Currently, 80 to 90% of the detections are identified as noise by the system. Although the noise detections are not used to build events in the context of CTBT monitoring, they represent valuable data for other civil applications like monitoring of natural hazards (volcanic activity, storm tracking) and climate change.

Non-noise detections are used in network processing at the IDC along with seismic and hydroacoustic technologies. The arrival phases detected on the three waveform technologies may be combined and used for locating events in an automatically generated bulletin of events. This automatic event bulletin is routinely reviewed by analysts during the interactive review process. However, the fusion of infrasound data with the other waveform technologies has only recently (in early 2010) become part of the IDC operational system, after a software development and testing period that began in 2004.

The build-up of the IMS infrasound network, the recent developments of the IDC infrasound software, and the progress accomplished during the last decade in the domain of real-time atmospheric modelling have allowed better understanding of infrasound signals and identification of a growing data set of ground-truth sources. These infragenic sources originate from natural or man-made sources. Some of the detected signals are emitted by local or regional phenomena recorded by a single IMS infrasound station: man-made cultural activity, wind farms, aircraft, artillery exercises, ocean surf, thunderstorms, rumbling volcanoes, iceberg calving, aurora, avalanches. Other signals may be recorded by several IMS infrasound stations at larger distances: ocean swell, sonic booms, and mountain associated waves. Only a small fraction of events meet the event definition criteria considering the Treaty verification mission of the Organization. Candidate event types for the IDC Reviewed Event Bulletin include atmospheric or surface explosions, meteor explosions, rocket launches, signals from large earthquakes and explosive volcanic eruptions.