Automatic Seismic Processing at the IDC

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ABSTRACT

The Provisional Technical Secretariat (PTS) of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) has been ramping-up the installation of the International Monitoring System (IMS) consisting of a network of seismic, hydroacoustic, infrasound, and radionuclide stations, since its inception in March 1997. Data from these networks are automatically processed at the International Data Centre (IDC) to produce, within a few hours, a series of automatic bulletins called the Standard Event Lists (SEL1, SEL2, SEL3). After analyst review and correction as necessary the Reviewed Event Bulletin (REB) is produced. Additional information about characterization of an event as an earthquake or otherwise is also available in the Standard Event Bulletin (SEB) shortly after production of the REB.

Primary Seismic station data, delivered by CD Protocol, is formed into 10-minute data intervals as soon as sufficient data has arrived at the IDC. Station Processing - working on seismic stations individually - is initiated on the completed time intervals by a fully automatic transaction management system. Station Processing performs quality control checks, bandpass filtering and beamforming to improve the signal-to-noise ratio and detects signals in the data interval. Feature extraction is then performed for each detection and the resulting arrival time, amplitude, period, azimuth and slowness are written to a central database. Rule-based signal grouping, initial phase identification and location of single station events complete the station processing.

Network Processing - considering the entire network of stations - is scheduled every 20 minutes, with fixed delays relative to real-time, to produce a global SEL1 bulletin by associating arrivals detected at the IMS stations into events with their hypocentre details. Final phase identification is made at this stage. A computationally-efficient, grid-based search algorithm is used to handle the large number of stations in the network. The SEL1 bulletin, produced 2 hours after real-time, considers only primary seismic and hydroacoustic data. Segmented auxiliary seismic data are requested via email from all auxiliary seismic stations within 30 degrees of a SEL1 hypocentre. The four-hour delay between the SEL1 and SEL2 bulletins allows incoming auxiliary data to undergo station processing and provide arrivals to refine event solutions in subsequent SEL bulletins. The SEL2 and SEL3 bulletins, produced 6 and 12 hours respectively after real-time, use primary data from all three technologies and auxiliary seismic data. Interactive analysis starts from the most comprehensive automatic bulletin (SEL3).

Postanalysis Processing of REB events commences on completion of interactive analysis. Event characterization parameters are computed and are used to screen out events that are considered to have natural or non-explosive characteristics. Postanalysis processing results in the SEB, comprising all the REB events, supplemented by Event Screening parameters, and an SSEB (Standard Screened Event Bulletin) containing only the subset of SEB events that remain after the Event Screening criteria have been applied.

An Executive Summary, illustrating the number of events for each technology, a breakdown by Event Screening category and other high-level information, is presented to States Parties via a Secure Web Site. Other raw data, bulletins and products are available to authorized users by email via requests or standard subscriptions.

Key words: CTBTO, IDC, SEL, REB, SEB, automatic processing

PRESENTER'S BIOGRAPHY

Dmitry Bobrov has worked in the Scientific Methods Unit of Software Applications Section in the International Data Centre of the CTBTO since 2003, maintaining and improving the IDC application software. This includes automatic and interactive

IDC processing, event characterization and event screening subsystems. Prior to joining CTBTO, he spent 21 months at the Center for Monitoring Research (USA) as a visiting scientist, working on joint US-RF calibration program. Mr. Bobrov worked in nuclear monitoring in the Russian Federation from 1988 to 1999 and from 2001 to 2002.

Utilizing the concept of "hot stations" to identify potential seismic events at the IDC

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ABSTRACT

The International Monitoring System (IMS) is being developed by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) as part of its global verification regime. The seismic component of the IMS includes 50 Primary Seismic and 120 Auxiliary Seismic stations. About 70% of the stations are currently operating and sending data in real-time to the International Data Centre (IDC) in Vienna, Austria. Upon receipt of the data, automatic processing is invoked, which results in a series of bulletins, known as Standard Events Lists (SELs). The final automatic bulletin, produced 12 hours behind real time, is reviewed by analysts. The result of this review is published in the Reviewed Event Bulletin (REB).

An observed event will appear in the automatic or reviewed bulletins only if certain criteria are satisfied, including observations from a sufficient number of stations. Events in the automatic bulletin must be observed by two or more primary stations, while events in the REB must be observed by three or more primary stations.

Due to a variety of factors, different stations are more sensitive than others to different regions of the world. Contributing factors include: near-surface geologic conditions under the station, station noise levels, station design, and heterogeneities within the earth. The sensitivity of stations will be illustrated by a series of global maps which show the probability of a particular station to contribute defining phases for events for each region of the globe. The maps are based on historical contribution of each station to the REB, and takes into account the period of operation of each station. These observations show that many of the IMS arrays located in continental regions make a significant contribution of defining phases in many parts of the world. The observations also illustrate that other stations make a relatively limited contribution of defining phases in the REB. Stations which have a high probability of detection of events from a certain region are considered to be "hot stations" for that region.

After the events in the automatic bulletins are reviewed by analysts, the remaining unassociated automatic detections are reviewed by analysts, who look for any additional events which were missed by during automatic processing. This review procedure is facilitated with the use of the "scanner" software. This software attempts to form new trial events by combining unused automatic detections from "hot" stations for a region. The software ensures that the time, azimuth, and slowness observations from the candidate arrivals are consistent with an event originating from a particular area. A description will be provided of how the globe is divided into different regions, as well as the hot stations for particular regions.

The scanner software is routinely used at the IDC in producing the REB. The software accelerates the process of scanning for missed events, and brings homogeneity to the reviewed bulletin. The contribution of new IMS stations is assessed after they have begun to contribute to the REB, and the information used by scanner is updated accordingly.

Key words: CTBTO, IMS, IDC, REB, scanning

PRESENTER'S BIOGRAPHY

John Coyne has been the Software Applications Section Chief in the International Data Centre (IDC) of the CTBTO for the last three years. His section is responsible for the improvement and maintenance of the application software and underlying science used at the IDC. This includes software for all technologies used by the IDC, including seismic, hydroacoustic, infrasound, radionuclide, and atmospheric transport modeling. Mr. Coyne joined CTBTO in 1998 as a software engineer, concentrating on software used by the waveform technologies. He was appointed as the Head of Software Integration Unit when it was formed in 2001. This unit is within the Software Applications Section. Prior to CTBTO, Mr. Coyne worked as a software engineer and team leader at the Center for Monitoring Research and the Center for Seismic Studies in the USA. Mr. Coyne earned his B.S. and M.S. degrees in geosciences from the Pennsylvania State University and Cornell University, respectively.

CTBTO Seismic Observations of the DPRK Event on 9 October 2006.

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ABSTRACT

The verification regime of the CTBTO is designed to detect nuclear test explosions within the solid earth, underwater or in the atmosphere. The International Monitoring System (IMS) of the CTBTO, is composed of 337 facilities that monitor the earth. These include 170 seismic (50 primary and 120 auxilliary), 11 hydroacoustic, 60 infrasound, 80 radionuclide stations and 16 radionuclide laboratories. These facilities send data either in real-time or in data messages to the International Data Centre (IDC) in Vienna, Austria via an independent global communications infrastructure.

About 70% of the seismic stations are currently operating. Upon receipt at the IDC, the seismic data go through automatic processing to produce a series of Standard Event Lists (SELs) which are produced with a prescribed delay after real time; SEL1 is produced after 2 hours, SEL2 after 6 hours and SEL3 after 12 hours. Interactive analysis is performed by analysts to review and correct results of SEL3 data and to add missed events and discard invalid events. This task involves retiming, renaming and measuring the characteristics of phases identified by the automatic processing and associating additional phases to the automated results. After analyst review, the Reviewed Event Bulletin (REB) is produced. The Standard Event Bulletin (SEB) is produced automatically shortly after the REB, and it includes additional information about characterization of an event as an earthquake or otherwise. The Standard Screened Event Bulletin (SSEB) pertains only for events which failed standard criteria.

The DPRK event of 9 October 2006 was automatically located in SEL1 by 13 primary stations with epicentral distances ranging from 17 to 151 degrees. The SEL1 was sent less than two hour after its occurrence. The automatic location has 41.28°N and 129.01°E with an origin time of 1:35.28 UT. An additional 9 stations were added during interactive review. The location of the event was refined to 41.31°N and 129.02°E at zero depth, with an origin time of 1:35.27.58 UT. The surface area of the error ellipse was reduced from 2 391 km^2 in SEL1 to 880 km^2. The REB for this event was issued two days after the end of 9 October.

This DPRK event demonstrated that the CTBTO can receive and review data to timelines envisaged after entry into force of the CTBT.

Key words: CTBTO, IMS, IDC, REB.

PRESENTER'S BIOGRAPHY

Ms Jane Gore is an analyst in the Waveform Analysis Unit 1, Monitoring and Data Analysis (MDA) section of the International Data Centre (IDC) for the last 18 months. In this section, analysts are responsible for reviewing automatically built events in the SEL3 bulletin to produce the REB. The events are built using seismic, hydroacoustic and infrasound data. Prior to joining the CTBTO, Ms Gore worked as a lecturer for 6 years at the University of Zimbabwe, Physics Department. Ms Gore earned her BSc Honours in Physics (1994), Masters in Exploration Geophysics (1997) and a PhD in Seismology (2005) from the University of Zimbabwe.

Matched Field Processing for Enhanced Array Resolution

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ABSTRACT

Wide-band f-k analysis using fixed frequency bands has been shown to provide very stable back-azimuth and slowness estimates for phases from repeating mining events. For example, such analyses of Pn phases at distant single arrays have provided useful indications of the probable source mine, even for regions of high mine density. We have attempted to improve the resolution capability of seismic arrays further using so-called empirical matched field processing. Matched field processing requires calibration events to calculate a template of spatial wavefield characteristics for a given source region, and utilizes this information in the processing of new events. Mine blasts often have very complex source functions, e.g., due to ripple-firing techniques, which also often vary strongly within a given mine. Classical waveform correlation methods tend to be very sensitive to such temporal variations within the signals. Matched field processing on the other hand is a narrow-band technique which reduce its sensitivity to variations in the event source-time functions. We present applications of matched field processing to large datasets where Pn phases observed at distances of several hundred kilometers have been used successfully to attribute the events to mines separated by only 2-3 kilometers. This is far in excess of the resolution limits for classical array processing.

In the context of monitoring the Comprehensive Nuclear-Test-Ban Treaty (CTBT), a reliable automatic assignment of an event to a given mine or source area will be an important step forward.

Key words: Matched field processing, seismic arrays, mining events, source location.

PRESENTER'S BIOGRAPHY

Dr. Kværna is the program manager for the section on "Array Seismology and Monitoring Research" at NORSAR, and holds a Ph.D. in geophysics from the University of Oslo, Norway.

‘Repeating earthquakes’ recorded by Liaoning Regional Seismograph Network: Network dependence of ‘repeating events’?

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ABSTRACT

In the list of ‘repeating pairs’ or ‘doublets’ of earthquakes in China identified by Schaff and Richards (2004) using teleseismic waveform cross-correlation, there were 23 repeating pairs located in Liaoning Province, belonging to the 1999 Xiuyan mainshock-aftershock sequence. In our study the waveforms of these events were cross-correlated using the records from Liaoning Regional Seismograph Network (LRSN), and the ‘repeating events’ in the sense of regional waveform cross-correlation were obtained. The result was compared with that of Schaff and Richards (2004) and was used for the assessment of the seismic phase picking and event location practice of LRSN. The result shows that ‘repeating events’ in the sense of teleseismic waveform cross-correlation and those in the sense of regional waveform cross-correlation have significant difference, although with some overlap. This indicates that using different stations and/or different waveforms, the identification of ‘repeating events’ may lead to different results. It seems that senso lato criterion, as represented by having at least one station with correlation coefficient larger than 0.8, is not as satisfactory as expected. This problem is more critical when the identification of ‘repeating events’ deals with the evaluation of CTBT-related monitoring system. The observation also raises the question of the completeness of ‘repeating event’ catalogue in the study of slip rate. On the other hand, however, the overall assessment of the location accuracy and the phase pick errors of LRSN by using the two sets of ‘repeating events’, defined by teleseismic waveform cross-correlation and regional waveform cross-correlation, respectively, provides similar results.

Key words: waveform cross-correlation; ‘repeating earthquakes’; regional seismograph network; Xiuyan of Liaoning Province

PRESENTER’S BIOGRAPHY

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On the New Fundamental Constant. Application in Geoscience.

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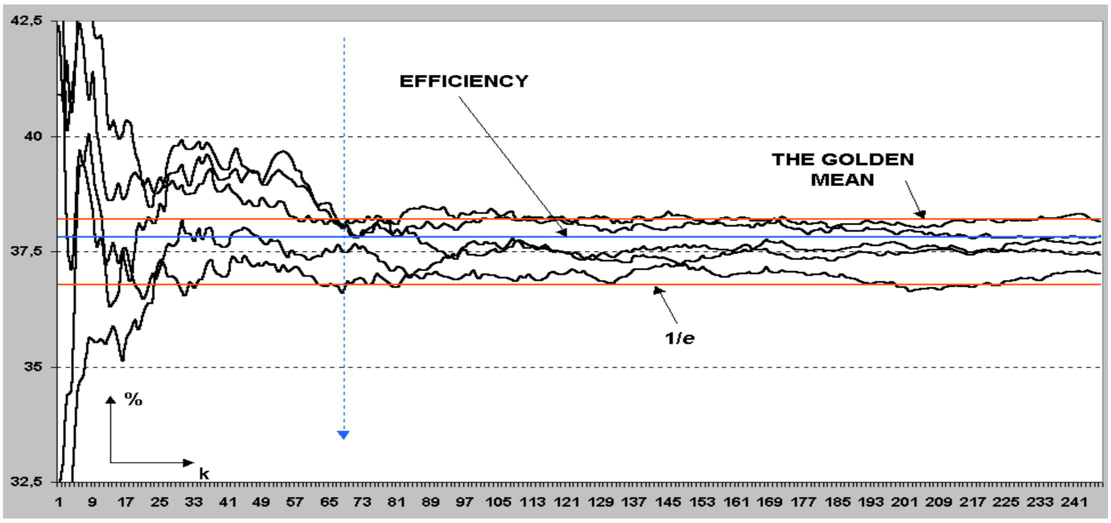
ABSTRACT

We present here the general result of analytical processing of the huge data arrays (about 1/3 bln of records) we deal with in econometrics and geophysics. It was noticed, verified and proved, the existence of the asymptotically stable limit value for the new parameter E we named as "the field efficiency". Investigating this new found phenomenon we got rather unexpected links with both the entropy and the Maxwell-Boltzmann distribution and proved the multidisciplinary nature of the result. We present and discuss two different ways, thermodynamical and number-theoretical, to get an explicit formula and numerical value for E (Fig.1). It is very interesting to note that our constant found itself between the inverse exponent $1/e \approx 0.367880$ and well-known Golden Mean in the form of $\varphi = 1-(\sqrt{5}-1)/2 \approx 0.381966$ (Fig.2). Possible application in geoscience presented in the work.

Fig.1.

$$\mathrm{E} \sim \frac{d}{dq}\left\{ q^{s_1} \prod_{j=1}^{s_2} \frac{1-q^{s_3+j}}{1-q^{j}} \right\} \cdot \int \left\{ q^{b_1} \prod_{j=1}^{b_2} \frac{1-q^{b_3+j}}{1-q^{j}} \right\} dq$$

Fig.2.



Key words: Efficiency, Maxwell-Boltzmann distribution

PRESENTER'S BIOGRAPHY

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Current status of the International Monitoring System seismic network and future sustainability challenges

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ABSTRACT

The International Monitoring System (IMS) network of seismic stations consists of 50 Primary and 120 Auxiliary seismic stations located around the globe with the primary objective to detect nuclear explosions. In November 2008, 76% of all primary seismic stations and 69% of all auxiliary seismic stations have been installed and certified. The fact that the number of remaining stations to be installed and certified have decreased and that some of these installed seismic stations have been operational for almost ten years, has prompted the PTS to change the primary emphasis from installation and certification of seismic stations, to maintenance and sustainment of these stations. The objective of this change in direction is to protect the substantial investment which has already been made.

Therefore the PTS has recently undergone restructuring to reflect this change in direction. In the IMS division two new sections were created, the Engineering and Development (ED) section and the Monitoring Facility Support (MFS) section. The responsibility of the ED section will be to install the remaining stations, cover any obsolescence problems and be involved with any new technology solutions.

The MFS section which consists of a Maintenance unit and a Logistics unit has the responsibility to maintain the currently installed and certified stations, with the aim of long term sustainability of the network.

A few sustainability challenges which we are currently facing are obsolescence of older equipment, shipment and customs clearance delays and reliable power sources which not only affect the acquisition equipment but also the Global Communications Infrastructure.

The future sustainment of the Auxiliary seismic network will also pose some unique problems. The main difference between the Auxiliary and Primary networks are that data from the Primary network will be sent in continuous mode to the International Data Centre (IDC) in Vienna, and that data from the Auxiliary network can be retrieved by the IDC from the station upon request. The treaty states that maintenance and operation of a certified Auxiliary seismic station is the responsibility of the host nation. This implies that the CTBTO cannot finance any of the maintenance and operation actions of these stations. A possible solution for some Auxiliary seismic stations would be to create partnerships between host countries and larger network operators, who could assist with the maintenance and operation of these stations.

In our view long term sustainment can be achieved by making use of a detailed inventory database and an accurate problem resolution log. By making use of information from these two sources an in-depth life cycle cost analysis can be performed. Problems such as obsolescence can be addressed by carefully planned, preventative maintenance and recapitalization actions.

PRESENTER'S BIOGRAPHY

In 1989 Jacques von Ludwig Pretorius joined the Geological Survey of South Africa as a technical officer, and was mainly involved with the upgrade and maintenance of the National Seismic Network of South Africa. In 1999 he was promoted to supervisor of the Electronics laboratory of the seismic section at the Council for Geoscience. Main responsibilities included operation and maintenance of the South African National Seismic Network, Africa Array project and various seismic projects which included a seismic monitoring component.

In 2006 he joined the Seismic Section of the International Monitoring System Division (IMS) of the CTBTO as an Associate Seismic Officer. Since restructuring of the PTS in 2007 he is a Maintenance Officer in the Maintenance Unit, of the Monitoring Facility Support (MFS/M) Section of the International Monitoring System Division (IMS) of the CTBTO.

The SPITS Array – A Case Study for Advanced Array Processing of CTBT Arrays

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ABSTRACT

The standard seismic arrays installed within the International Monitoring System (IMS) to monitor the Comprehensive Test-Ban Treaty (CTBT) consist of vertical sensors at all array sites and a very small number, often only one set, of horizontal sensors. With such a configuration, the arrays are tuned to detect and analyze short-period P- but not S-type phases. However, S phases have often a much better Signal-to-Noise Ratio (SNR) on horizontal than on vertical components due to the polarization of the S-type particle movements and the fact that they are then much less disturbed by all types of P-coda energy. Moreover, it is generally assumed that in all automatic algorithms that analyze seismic onsets, the higher the SNR, the better one can determine the onset time of the phase.

In the case of the CTBT arrays, the focus is to detect and monitor nuclear explosions which radiate quite low S energy. However, almost all seismic signals recorded by the IMS stations are coming from natural seismicity or non-nuclear man-made events. A major task of the International Data Centre (IDC), which analyses the IMS data, is to screen out all non-nuclear events and usually most of this work is done by locating and classifying the events. To do so, in particular for smaller events observed only at local or regional distances, well observed S-phases are essential.

When the small aperture auxiliary IMS array SPITS (Spitsbergen, AS72) was refurbished in August/September 2004, the mentioned ideas were taken into account after a special design study and six sites of the nine element array were additionally equipped with horizontal components. During the last years, the automatic array-data analysis procedures at NORSAR were adjusted and tuned to optimize the analysis of data from the SPITS array: the set of vertical detection beams was increased by including beams of the rotated horizontal components, the algorithms for the automatic fk-analysis were extended to include the horizontal components, and the necessity of introducing elevation corrections to the beams accounting for the topography of the array became even more evident for S- than for P-phase beams.

Within this contribution, a large improvement of the detection capabilities of the SPITS array due to the implementation of the horizontal beams will be demonstrated, and recommendations for upgrades of other IMS arrays will be made.

Key words: seismic arrays, three-component processing, S-waves, monitoring capabilities.

PRESENTER'S BIOGRAPHY

Johannes Schweitzer

Johannes Schweitzer was educated in Geophysics and in particular in Seismology at the Johann Wolfgang Goethe-University of Frankfurt. In his thesis' (Diploma 1985, PhD 1990), he worked on the S-velocity structure below the Pacific in the lower mantle and outer core. In the early 1990s, he mostly worked at Ruhr-University Bochum on array seismology (GERES array) and the topography of the core-mantle boundary. In 1997, he moved to Norway (NORSAR) to work mainly on questions of automatic analysis of array data, magnitude determination, locating seismic events (HYPOSAT) and the velocity structure of Fennoscandia and the European Arctic. Another research topic of his over the last decades was the history of seismology.

Open data exchange in support of CTBT research

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ABSTRACT

Seismological data from a variety of open sources can contribute to both research and monitoring related to the CTBT and complement the more formally structured and restricted data procedures of the International Monitoring System. In addition to providing an increasingly rich source of data for fundamental research programs and monitoring, the open exchange of data can encourage international and multi-disciplinary collaboration and lead to improvements in data quality and network practices.

As stated in its mission statement, the IRIS Consortium and its members commit to "promote exchange of geophysical data and knowledge, through use of standards for network operations, data formats, and exchange protocols, and through pursuing policies of free and unrestricted data access". All data collected through IRIS programs as supported by the US National Science Foundation are archived at the IRIS Data Management Center (DMC) from which they are freely and openly available to researchers and the public. Most of the continuous waveform data from the IRIS/USGS Global Seismographic Network and the EarthScope Transportable Array are available in real-time. Investigators using portable PASSCAL and the EarthScope Flexible Array equipment can request that access to their data be limited for a two-year proprietary period, following which all data must be archived at the DMC and made openly available.

In addition to data from IRIS programs, the DMC also provides archiving and distribution for data contributed by many other global networks (including members of the Federation of Digital Seismographic Networks), national networks in other countries and regional networks in the US. Expanding use of networked data services provides access to the archives of additional data centers worldwide. Data exchange with the USGS National Earthquake Information Center (NEIC), regional networks in the US and international mission agencies contributes to global and national earthquake monitoring. All of the data in the DMC can be accessed through a common set of data access tools, providing easy access to waveform data from thousands of sensors in hundreds of networks throughout the world, for studies of structure and source characteristics in varied tectonic and geographic environments. The archiving of continuous data, with well-maintained metadata and quality control, is becoming increasingly important in the investigation of long-term (decadal) changes in background noise (possibly related to climate change), studies of exotic sources and observing temporal changes in earthquake source characteristics.

Key words: CTBT, networks, instrumentation, data management, instrumentation, IRIS, GSN, PASSCAL, DMS

PRESENTER'S BIOGRAPHY

David Simpson has been President of the IRIS Consortium since 1991. IRIS manages facility programs, funded by the US National Science Foundation, that provide instrumentation, field services and data management to support seismological research. Prior to joining IRIS he was a research scientist and Associate Director at Lamont Doherty Earth Observatory of Columbia University, where he led research projects related to induced seismicity, nuclear monitoring and the tectonics and seismicity of Central Asia.

The International Monitoring System and its applicability to the scientific community

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ABSTRACT

The International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is composed of a global network of 337 facilities that monitor the earth. The IMS consists of 170 seismic, 11 hydroacoustic (of which 6 are hydrophones), 60 infrasound and 80 radionuclide monitoring stations and 16 radionuclide laboratories. The IMS facilities send monitoring data to the International Data Centre (IDC) in Vienna via an independent global communications infrastructure where the data are analyzed and distributed.

All data and products are typically received by National Data Centres (NDCs), as designated by the National Authority in each State Signatory. The National Authority is the typically the political entity which represents the State's political interests in CTBT, e.g., an office in the foreign ministry or defence ministry. NDCs are typically established within organizations which have a background in geosciences and/or radiation protection. In addition to NDCs, station operators are tasked with operating and maintaining one or more of the IMS stations.

In addition to its use for monitoring of nuclear tests, the IMS has applications for civil and scientific issues of global importance. Data from the IMS are already being sent to tsunami warning centres for alert purposes. It has been observed that hydroacoustic data are useful for modelling of tsunami generation and propagation and provide good information on directivity. Infrasound data processing at the IDC yields very good estimates of frequency content and azimuth bearing for observed signals. These observations can then be used for monitoring volcanic activity over large distances. The radionuclide network provides long term daily observations of natural radionuclides, which can be used to study fluctuations of these nuclides throughout the world.

In order to promote more effective use of IMS data and products for verification purposes and to improve the interaction with the scientific community, a new project will commence to provide additional technical assistance for countries within Africa. It is expected that through this project more users in Africa will be able to effectively utilize data from the IMS for a number of activities, ranging from monitoring local and regional geophysical phenomena to developing regional velocity models.

Another ongoing project is the International Scientific Studies of the Implementation of the CTBT Verification System. The purpose of this project is to carry out scientific studies and evaluations to address the readiness and the capability of the verification system of the CTBT in a coordinated international effort. The resulting new scientific material will assist States Signatories in their assessment of the verifiability of the Treaty. The work is focusing on a number of key issues identified during the planning phase: assessment of the seismic, radionuclide, infrasound and hydroacoustic networks; atmospheric transportation modeling; system performance monitoring; data fusion and the use of new approaches for data analysis. Institutions are also welcome to carry out studies on other issues relevant to CTBT verification regime and to present the results at the scientific conference in June 2009 that will be organized as part of this project.

Key words: CTBTO, IDC, NDC, station operator

PRESENTER'S BIOGRAPHY

Lassina Zerbo has held the position of the Director of the International Data Centre (IDC) of the Nuclear-Test-Ban Treaty Organization (CTBTO) since 2004. Prior to that Dr. Zerbo worked as a geophysicist developing new technologies for exploration for Anglo American for ten years, achieving the position of Divisional Principal Geophysicist for Africa in 2001. Dr. Zerbo held various geophysicist positions in France, Canada, and the USA for Institut de Recherche et Development, Geoterrex, and BHP Minerals Exploration from 1989 to 1995. Dr. Zerbo received his BsC (geology), MsC (geophysics), and Ph D. (geophysics) from Universite de Caen, Universite Paris VI, and Universite de Paris XI, respectively.