Making sense of it all

Three data analysts talk about the challenges and rewards of working at the International Data Centre

BY DENISE BRETTSCHNEIDER

Every day the global network of monitoring stations of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) transmits around 10 gigabytes of data to the International Data Centre (IDC) in Vienna. This vast amount of data needs to be reviewed by a team of highly trained analysts in order to help determine whether an ambiguous event has taken place and whether such an event may have been a nuclear explosion.

IDC analysts review an average of 30,000 waveform events a year, the majority of which are earthquakes, and analyze approximately 20,000 radionuclide spectra. Analyzing the data requires great technical expertise combined with considerable experience and careful judgment.

Of the 25 current analysts at the IDC, nine are women (temporary and regular staff) from a diverse range of countries, reflecting the commitment of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) to ensuring a wide and well-balanced geographical distribution of staff.

GEOPHYSICIST MARCELA VILLARROEL IS PROUD OF HER WORK, HELPING TO MAKE THE WORLD A SAFER PLACE

I first came to the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in 2001 to participate in a training course for analysts at the International Data Centre (IDC). After completing the course, I was offered a position as an associate analyst at the IDC where I remained for seven years. In 2008, I had a complete change of scenery when I moved to London to work for a company in the oil and gas industry. Although I had an interesting job there, I missed the international environment that I had become used to in Vienna and the work being carried out by the CTBTO.

»The magnitude 9.0 earthquake that struck Japan on 11 March was the fourth largest ever recorded and our workload increased by 600 percent in the period directly afterwards.«

By banning nuclear explosions in all environments, the CTBT is helping to make the world a more secure place. I am deeply committed to the goals of the CTBT, so when I was offered the opportunity to return to the IDC as a lead analyst in August 2010, I was very happy.

As a geophysicist, working as a waveform data analyst at the CTBTO is a unique and challenging experience: monitoring data are collected by more than 240 waveform stations worldwide and transmitted daily to the IDC in Vienna for analysis. No organization anywhere else in the world carries out similar work on this scale!

In order to perform interactive waveform analysis with a high degree of confidence, it's essential to have a strong geophysical background and many years of experience. It's really important that you're familiar with each one of the monitoring stations that are part of the IMS network as well as the global seismicity. This is because data collected at the stations will look different depending on a number of factors such as the source location, distance to the station, local structure around the station etc…and you need to understand all of this to be able to build valid events with minimum error. Considering that we cover the whole world and that we have a huge number of stations to look at, it means that it may take several years before you become a good analyst.

An average of 160 events are recorded every day, which the team of analysts here at the IDC will check and decide to validate so that they can either be included in the Reviewed Event Bulletin or discarded as bogus events.

You never know what's going to happen next in terms of seismicity. The magnitude 9.0 earthquake that struck Japan on 11 March was the fourth largest ever recorded and our workload increased by 600 percent in the period directly afterwards. Working as an analyst at the IDC can be stressful but I like the atmosphere within my team. We all support each other and we all work towards the same objective.

When I look around, I consider myself very lucky to be able to carry out technical work in an organization that provides women with equal opportunities. Vienna is also a nice and secure city to live in and I love the cultural diversity and the possibility of communicating in the many different languages spoken here. All in all I'm very proud to be part of the CTBTO family.

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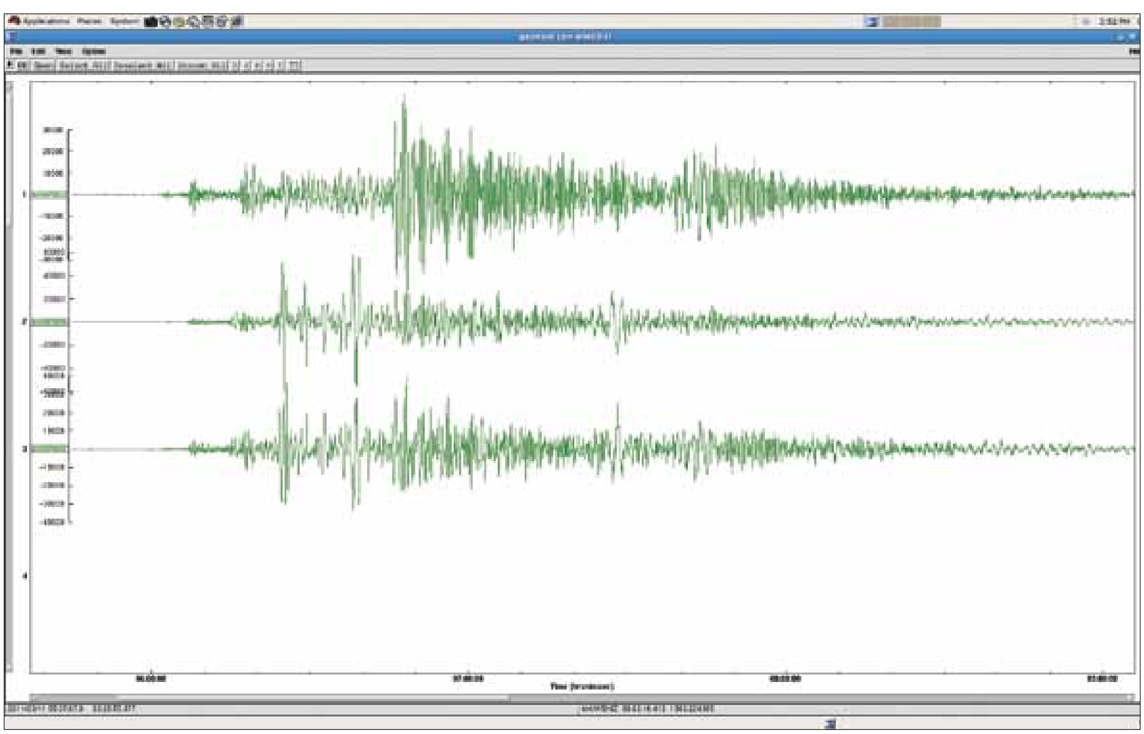


Seismogram of the 11 March 2011 earthquake recorded at the IMS seismic station Mawson in the Antarctic.

SEISMOLOGIST JANE GORE

FINDS HERSELF AT THE CUTTING EDGE OF DATA ANALYSIS AFTER A CHANGE OF CAREER AND LOCATION

> »By the end of February we had already analyzed the equivalent of about one-third of the events normally analyzed in a whole working year! «

I come from Zimbabwe where there are not that many women with PhDs in geophysics – people used to joke that I must be the only woman in the country to hold a PhD in Seismology. After completing my studies, I became a lecturer in the department of Physics at the University of Zimbabwe as well as a visiting lecturer in Geophysics at the University of the Witwatersrand in Johannesburg, South Africa. My previous jobs were very different to my current position at the CTBTO. As a lecturer I used to teach and conduct research. Now I analyze waveform data, lots of it!

It all started in 1999 in Washington DC when a colleague mentioned that she was applying to become an analyst at the CTBTO in Vienna. A couple of years later, looking for a career change, I contacted my friend who had been hired by the CTBTO upon completion of the International Data Centre (IDC) analysts' training course. She advised me to apply and I joined the organization in May 2007.

As a data analyst, I have to make sure that Member States receive a reviewed bulletin of all the events that have been detected by CTBT monitoring stations – an REB – within 10 days. So my job is challenging in that we are constantly chasing deadlines: we have to produce a high quality data bulletin for Member States in a timely manner which can mean working very long hours and at weekends, if necessary.

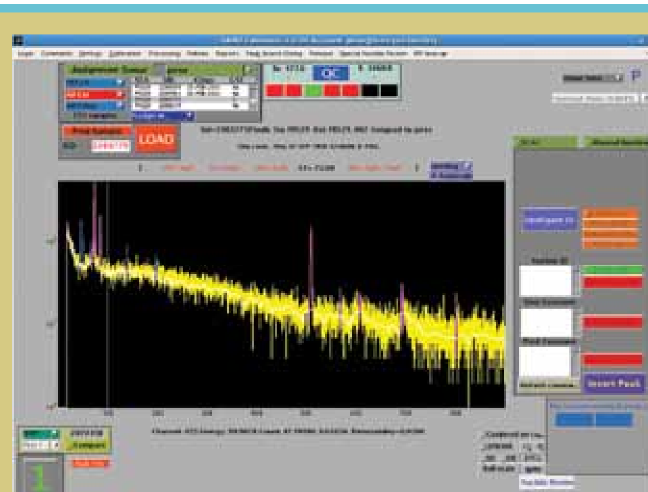
When Japan's massive earthquake struck the north-east coast of the country on 11 March and triggered a huge tsunami, the number of events we included that day in the REB increased to 816. And the following day there were 840 events. Considering that the average daily figure is 160 events, it meant that we had to work round the clock to make sure that Member States received the REB.

Even prior to 11 March, this year had been exceptionally busy. By the end of February we had already analyzed the equivalent of about one-third of the events normally analyzed in a whole working year! This was due to a particularly high number of events – mainly earthquakes – occurring after the Christmas break.

One of the most memorable days since I've been here was 25 May 2009. At 5 in the morning, my phone suddenly rang. It was the office. Some of my colleagues at the IDC had been following monitoring data which had been arriving in Vienna and indicated that there was a suspicious event located in the Democratic People's Republic of Korea, which could be a nuclear explosion. I was among the group of analysts who performed the initial analysis of the event. This event was well recorded by IMS stations around the world: 61 IMS seismic stations detected signals, with 59 of these stations contributing to the location of the event.

It's very rewarding to work for an organization which is committed to making the world a safer place by banning all nuclear explosions. I also enjoy the cultural diversity and the opportunity to meet people from every corner of the globe. It has been interesting to learn how other people relate to issues and solve problems.

Spectrum acquired from the IMS radionuclide noble gas station in Reunion in the Indian Ocean.



PHYSICIST CARLA PIRES

IS PART OF THE TEAM THAT HELPS DEVELOP RADIONUCLIDE MEASUREMENT CAPABILITIES

Before I joined the IDC, I worked mainly in the field of radiological protection and nuclear safety. After graduating in Physics in 1998, I spent three and a half years working in an environmental laboratory at the Instituto Tecnológico e Nuclear in Portugal. I also gained valuable knowledge in 2001 at the Radiation and Nuclear Safety Authority in Finland, such as learning about sample analysis and the type of software used in the laboratory. Then in June 2002, I was fortunate enough to be offered a position as an associate analyst in the Radionuclide Monitoring Unit of the IDC at the CTBTO.

Being an analyst has been a great opportunity to increase my knowledge in the field of gamma spectroscopy and related issues. The work is very different to my previous jobs as I'm far away from measuring systems. In 2003 I became responsible for testing new International Monitoring System (IMS) radionuclide particulate stations. This work has been fascinating and has allowed me to familiarize myself with radionuclide systems being used in a number of countries around the world. I've gained a wealth of knowledge and experience about the different types of spectra acquired by various detection systems and have learned more about the telltale signs of malfunctioning devices.

In July 2008, I was promoted to radionuclide lead analyst and in 2010 I started reviewing the radionuclide noble gas spectra from gamma and beta-gamma systems. My job mainly involves identifying the radiation emitters responsible for the peaks observed in the radionuclide spectra. I also helped test the first radionuclide noble gas station that was certified in August last year and I'm part of the team that tests radionuclide software and contributes to its improvement.

Over the last eight years, I've sometimes had to work very late or over the weekend as there are constant deadlines to be met. For example, the other evening I left work at 20:00 because I needed to finish checking the data sent by one of the IMS radionuclide laboratories, the eleventh laboratory due for certification this year. These laboratories provide independent analysis of radionuclide particulate samples – only samples with specific radionuclides are sent there for repeat measurements to confirm the presence of fission and/or activation radionuclides[1]. When the devastating tsunami disabled the emergency generators required to cool the reactors at the Fukushima nuclear power plant in Japan on 11 March, I had to cancel my trip to the laboratory and the testing of the radionuclide software was postponed.

The development of the global monitoring system informs people all over the world about radionuclide measurement capabilities in other countries. I'm honoured to be part of a team that has helped create a database of worldwide information. We have gained knowledge and experience which is possible thanks to the Treaty, CTBTO staff and the National Data Centres. I hope in the future more studies are conducted with our data to increase our expertise.

[1] Fission products are usually radioactive. Activation products are materials made radioactive by neutron activation.

RADIONUCLIDE LEVELS

The IDC categorizes samples measured by IMS facilities based on the radionuclides detected into the following levels:

LEVEL 1:
Only radionuclides from natural sources detected.

LEVEL 2:
Radionuclides from natural sources detected at anomalous concentrations.

LEVEL 3:
Radionuclides from manmade sources detected that are frequently observed by that particular station (e.g. from hospitals).

LEVEL 4:
One type of radionuclide that is relevant to CTBT verification detected.

LEVEL 5:
More than one type of radionuclide detected that are relevant to CTBT verification of which one is a fission product (such as Cs-137, I-131, Ba-140, La-140 or Te-132).

BIOGRAPHICAL NOTE

DENISE BRETTSCHNEIDER
has been working for CTBTO Public Information since May 2008. She has a number of years of editorial experience working for international organizations in Nairobi, Kenya, including the United Nations Educational, Scientific and Cultural Organization.

ANALYZING DATA AT THE INTERNATIONAL DATA CENTRE

TWO MAIN TYPES OF DATA: WAVEFORM AND RADIONUCLIDE

Three of the technologies employed by the IMS - seismology, hydroacoustics and infrasound – are called waveform. Waveform stations monitor and record the movement of energy that is generated by certain events and propagates as seismic waves or acoustic waves through the Earth, the oceans or the atmosphere. As of 16 May 2011, almost 80 percent of these stations were operational and sending data to the IDC. Waveform data can help identify the location of an event and determine whether it was natural or manmade. Natural phenomena include earthquakes, submarine volcanic eruptions, meteorites, explosive volcanoes and storms, while manmade events can include mining and chemical explosions, aircraft, re-entering space debris, oil exploration, and military exercises.

The fourth technology employed by the IMS is radionuclide monitoring, which can confirm whether an event detected and located by the other technologies is indicative of a nuclear test. Radionuclide stations measure the abundance of radionuclides in the air. These include radioactive particles and noble gases such as xenon. As of 16 May 2011, 75 percent of the radionuclide stations were operational. Each radionuclide monitoring station sends a preliminary gamma ray spectrum to the IDC every two hours. The final spectrum which undergoes analysis at the IDC is a two-dimensional plot showing the type and number of radionuclides observed in a sample obtained from a filter that has been exposed to air for about 24 hours.

DATA PRODUCTS FOR MEMBER STATES

A number of products containing information about events recorded by IMS facilities are made available to CTBTO Member States in the form of automatically generated lists of all the events that have been detected followed by more refined lists that have undergone meticulous analysis.

1. STANDARD EVENT LISTS AND AUTOMATIC RADIONUCLIDE REPORTS

The first data processing occurs as soon as waveform data arrive at the IDC, resulting in the production of Standard Event Lists (SELs). These lists are generated automatically every 20 minutes throughout the year by specially designed computer programmes. SELs include location estimates for events formed from signals recorded at IMS waveform stations.

Improvements to the initial bulletin are made as more data arrive in Vienna and are processed. The IDC issues three SELs at different time intervals in order to provide progressively improved location estimates. The first list – SEL1 – is issued within two hours of 'real time', followed by SEL2 after about four hours and SEL3 after six hours.

The initial processing of radionuclide data is also automatic and the results are listed in the Automatic Radionuclide Report. After automatic analysis, the results are refined by IDC analysts during interactive review.

2. REVIEWED EVENT BULLETIN AND REVIEWED RADIONUCLIDE REPORT

In order to provide reliable and comprehensive information to Member States, every single event listed in SEL3 is reviewed by IDC analysts. During this process, analysts discard just over one-third of the automatically produced events. The confirmed and corrected events and signal measurements at each station that detected an event are listed in the Reviewed Event Bulletin (REB). The REB is produced daily and contains an average of 160 events.

Radionuclide data take much longer to be collected and analyzed so data analysis takes place on a different timescale. After reviewing the Automatic Radionuclide Report, analysts produce the Reviewed Radionuclide Report.

3. STANDARD SCREENED EVENT BULLETIN

The next bulletin is the result of an automatic screening process in which natural events such as earthquakes are discarded and manmade events remain. The Standard Screened Event Bulletin thus contains all events that are considered potentially suspicious in the CTBT verification context.

The findings of the screening process for radionuclide data are presented in the Standard Screened Radionuclide Event Bulletin.

SOME OF THE KEY RADIONUCLIDES

BARIUM-140 (Ba-140)
has a half-life of 12.8 days. The half-life is the time for half of the radionuclide's material to decay. Ba-140 decays into lanthanum-140 (La-140), which has a half life of 1.7 days. By analyzing the activity ratio of these two radionuclides, the time of a nuclear explosion can be established.

CAESIUM-134 (Cs-134)
has a half-life of 2.1 years. Only a small amount of Cs-134 is produced by nuclear weapon testing but it accumulates in nuclear reactors. It can therefore be used to distinguish between releases from nuclear weapon testing and nuclear power plants.

CAESIUM-137 (Cs-137):
has a half-life of 30.1 years. This is the most common radioactive form of caesium and is produced by nuclear fission. Cs-137 is one of the major radionuclides in spent nuclear fuel and radioactive wastes associated with the operation of nuclear reactors and fuel reprocessing plants. Large amounts of Cs-137 and other radioactive isotopes were released into the environment by atmospheric nuclear weapon tests between 1945 and 1980. Cs-137 did not occur in nature before nuclear weapon testing began.

IODINE-131 (I-131):
has a half-life of 8.0 days. I-131 is a radioactive isotope released into the environment mostly in gaseous form as a result of the atmospheric testing of nuclear weapons and accidents that have occurred at nuclear power plants (e.g. the Chernobyl nuclear power plant in 1986 and the Fukushima power plant in March 2011). It was a significant contributor to the effects on human health from atmospheric nuclear weapon testing and from the Chernobyl disaster.

TELLURIUM-132 (Te-132):
has a half life of 76 hours. It is produced by nuclear fission and is released in gaseous form in hot conditions after a nuclear power plant accident or nuclear test. It decays to iodine-132 (I-132), which has a half-life of 2.3 hours. I-132 contributes significantly to the effects on human health during the first few days after the nuclear reaction has stopped.

XENON-133 (Xe-133):
has a half-life of 5.2 days. It does not occur in nature but is released from nuclear power plants and nuclear weapon testing. As a noble gas, xenon-133 does not react with other materials and only poses a very small risk to human health when released into the atmosphere.