



# Disaster warning and promoting human welfare – the civil and scientific uses of CTBTO data

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) bans all nuclear explosions. Its verification will be assured by the global alarm system currently being established by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO).

The 337 facilities of the International Monitoring System (IMS), which span the entire globe, ensure that no nuclear explosion escapes detection. The IMS uses four technologies – radionuclide, seismic, infrasound and hydroacoustics. Almost 90% of this system has already been established.

“Even before entering into force,  
the CTBT is saving lives.”

*United Nations Secretary-General Ban Ki-moon*

Apart from detecting nuclear explosions, this one-billion-dollar investment by the CTBTO's more than 185 Member States can be put to a wide range of civil and scientific uses, thereby contributing to sustainable development, knowledge expansion

and saving lives. However, to a large extent, these benefits are still untapped.

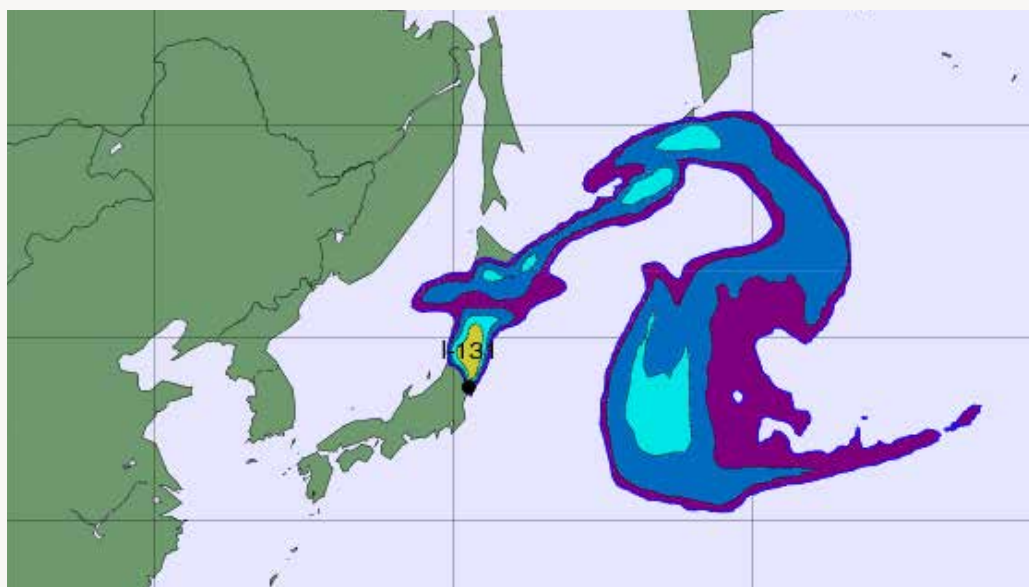
## EXAMPLES OF CIVIL AND SCIENTIFIC USES

Detection and real time warning of

- Earthquakes and tsunamis
- Radiation dispersal from nuclear accidents
- Volcanic eruptions
- Meteors

Research on

- The Earth's core
- Climate change
- Meteorology
- Break-up of ice shelves and the creation of icebergs
- Oceans and marine life
- Worldwide background radiation



SIMULATION OF EMISSIONS OF IODINE-131 FROM THE DAMAGED FUKUSHIMA POWER PLANT IN MARCH 2011.

SOURCE: ZENTRALANSTALT FÜR METEOROLOGIE UND GEODYNAMIK (ZAMG)



THE TAKASAKI RADIONUCLIDE STATION, LOCATED AROUND 250 KILOMETRES FROM FUKUSHIMA, JAPAN, WAS THE FIRST TO DETECT RADIOACTIVITY FROM THE STRICKEN POWER PLANT.



RADIONUCLIDE STATIONS CAPTURE AIRBORNE PARTICLES FOR ANALYSIS TO IDENTIFY THE RADIOACTIVE ELEMENTS, OR RADIONUCLIDES, THEY CONTAIN.

## Radionuclide Technology

Number of facilities: *80 (half of them capable of detecting noble-gases) + 16 laboratories*

Verification function: *Detects radioactive particles and radioactive noble gases from nuclear explosions*

### The Fukushima power plant accident

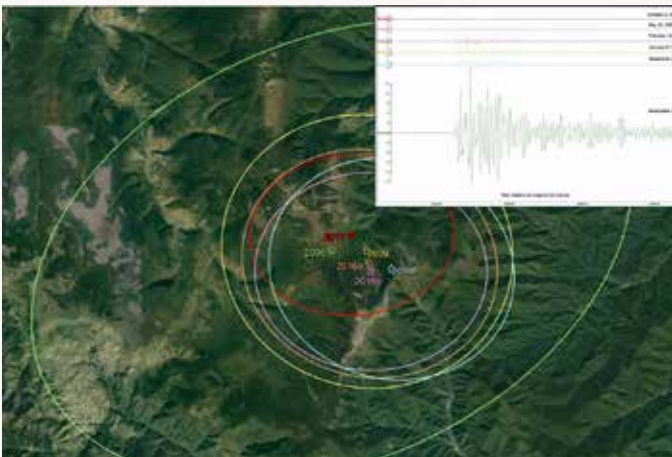
Just one day after the 11 March 2011 Japan disaster, the IMS started detecting radioactive particles, such as iodine-131 and caesium-137, emitted by the damaged Fukushima power plant. The Takasaki station (Tokyo, Japan) – located around 250 km from Fukushima – was the first to pick up the radionuclides. The radioactive cloud was then detected by an increasing number of IMS stations as it travelled first to Russia and the United States before dispersing across the northern hemisphere and later around the entire globe.

While the levels detected were far below those that would impact human health, the IMS demonstrated its ability to track radiation from nuclear accidents quickly and accurately. Furthermore, dispersion was predicted correctly using atmospheric transport modelling, the method by which the travel

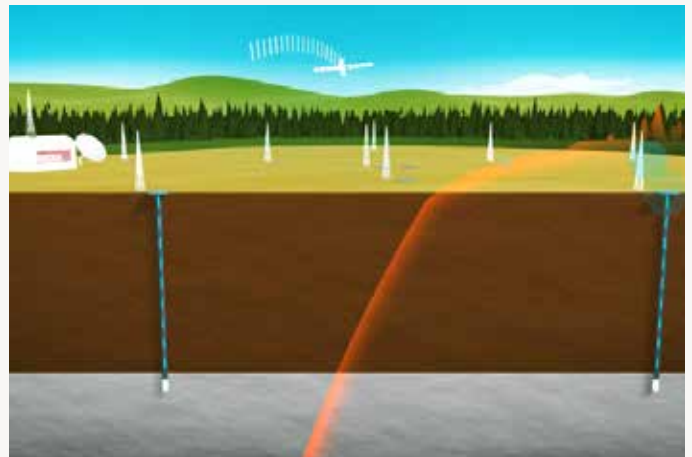
path of a given radionuclide is calculated either forwards or backwards, using meteorological data.

On the basis of these data, CTBTO Member States were able to provide reliable information to concerned populations. The Fukushima accident also led to intensified cooperation between the CTBTO and other relevant international organizations such as the International Atomic Energy Agency (IAEA), the World Health Organization (WHO) and the World Meteorological Organization (WMO).

- Providing critical information on nuclear accidents, including measurements of radioactivity and the prediction of the dispersion of radioactive material;
- Using meteorological studies to identify the dispersion of airborne pollutants and global air mass movements;
- Contributing to climate change research by providing sample archives for historical studies of pollutants and microorganisms;
- Researching worldwide background radiation levels.



COMPARISON OF THE REVIEWED EVENT BULLETIN EVENT LOCATIONS FOR THE 6 ANNOUNCED DPRK TESTS FROM 2006 TO 2017 AND THE CORRESPONDING SEISMIC SIGNALS IN AKTYUBINSK, KAZAKHSTAN, PLOTTED TO THE SAME SCALE.



SEISMIC STATIONS MEASURE SHOCKWAVES GENERATED BY A SEISMIC EVENT - EARTHQUAKE OR EXPLOSION - THAT TRAVELS THROUGH THE EARTH. THIS ENABLES THE QUICK IDENTIFICATION OF THE LOCATION, STRENGTH AND NATURE OF A SEISMIC EVENT.

## Seismic Technology

*Number of facilities: 170 stations*

*Verification function: Detects shock waves from nuclear explosions travelling through the Earth*

### Tsunami warning

Following the catastrophic earthquake and tsunami off the coast of Sumatra, Indonesia, in December 2004, the CTBTO was mandated to provide monitoring data from its seismic and hydroacoustic stations directly to tsunami warning centres. During a test period, these centres received real-time continuous data which they confirmed improved their ability to identify potentially tsunami-generating earthquakes and to issue timely warnings. The CTBTO has concluded formal tsunami arrangements with 17 countries.

During the signing ceremony of the tsunami warning arrangement with Japan in August 2008, former Ambassador Yukiya Amano, who signed on behalf of his government, expressed his confidence that the CTBTO's verification data "... will help save many lives in the case of a tsunami." This was confirmed by Japanese authorities who stated that during the March 2011 earthquake and tsunami,

IMS data helped them issue timely warnings, thus allowing many people to escape to higher ground.

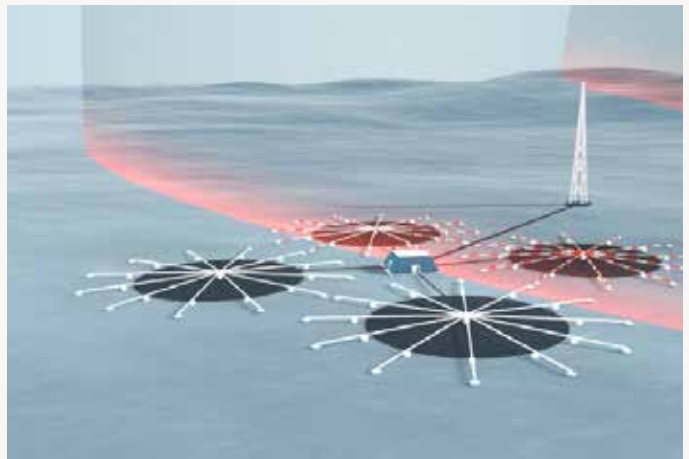
### Determining the time of plane crashes

If a large, heavy aircraft crashes, it causes seismic signals equivalent to small magnitude earthquakes that can be picked up by IMS seismic stations. The exact time of the impact of the Pan Am Boeing 747 near the Scottish town of Lockerbie in 1988 or the crash of a Swiss Air MD11 near Halifax, Canada, in 1998 could only be verified accurately by using seismic data.

- Rapidly acquiring and disseminating data on earthquakes, in particular on potentially tsunami-generating earthquakes, to assist disaster management and response efforts;
- Accurately reporting on the location and magnitude of earthquakes to improve earthquake hazard estimations;
- Enhancing research on the Earth's structure;
- Assisting in plane crash investigation by providing precise data on the time of the crash.



LARGE PARTS OF EUROPEAN AIRSPACE WERE CLOSED FOR SEVERAL DAYS DUE TO THE SPRING 2010 ERUPTION OF THE ICELANDIC VOLCANO EYJAFJALLAJOKULL.



INFRASONIC SENSORS MEASURE MICROPRESSURE CHANGES IN THE ATMOSPHERE WHICH ARE GENERATED BY THE PROPAGATION OF INFRASONIC WAVES – VERY LOW FREQUENCY WAVES THAT CAN BE CAUSED BY NUCLEAR EXPLOSIONS.

## Infrasound Technology

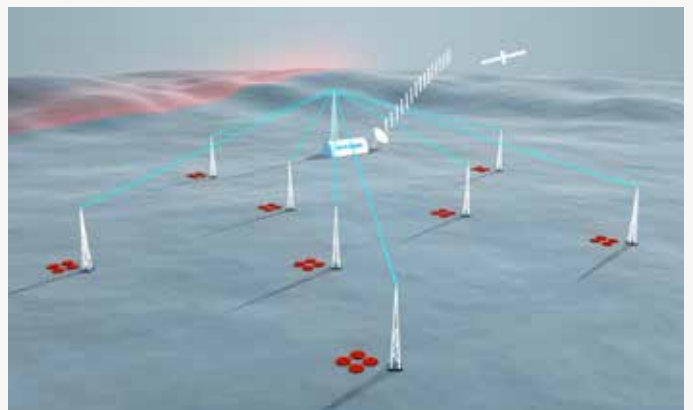
*Number of facilities: 60 stations*

*Verification function: Detects low-frequency sound waves in the atmosphere generated by nuclear explosions*

Infrasound technology has the potential to make civil aviation safer. Large ash plumes caused by volcanic eruptions can make jet engines malfunction or even stall completely.

In spring 2010, the airspace over many parts of Europe was closed due to the eruption of the Icelandic volcano Eyjafjallajokull. Many of the world's 600 active volcanoes are in the direct vicinity of much-frequented air routes and can render the airspace hazardous in a matter of minutes. IMS infrasound stations can detect the ultra-low frequency sound waves emitted by volcano eruptions and help provide warnings in real-time.

When a meteor exploded over Russia's Ural mountains on 15 February 2013, the blast was detected by 20 IMS infrasound stations, one of them 15,000 km away in Antarctica. The infrasound data can help scientists learn more about the altitude, energy released and how the meteor broke up.

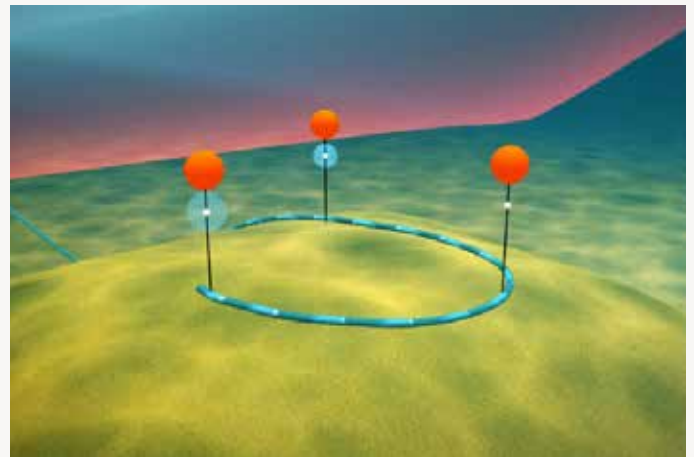


A VISUAL REPRESENTATION OF THE INFRASOUND SIGNALS RECORDED BY THE IMS STATION IN KAZAKHSTAN AND THE CORRESPONDING WAVE PARAMETERS COMPUTED BY THE IDC FOR THE 15 FEBRUARY 2013 FIREBALL.

- Detecting volcanic explosions and the presence of volcanic ash clouds to assist in aviation safety;
- Detecting a range of man-made and natural events on the Earth's surface, including chemical explosions, meteoroids entering the atmosphere, severe storm systems and aurorae;
- Contributing to climate change research by studying meteorological phenomena;



HYDROPHONES – UNDERWATER MICROPHONES – ALONG WITH BUOYS TO KEEP THEM AT A CERTAIN DEPTH, ARE BEING DEPLOYED INTO THE SEA.



UNDERWATER HYDROPHONE SENSORS MONITOR THE OCEANS FOR UNDERWATER EXPLOSIONS. A SMALL NUMBER OF STATIONS SUFFICE AS WATER IS AN EFFICIENT CONDUCTOR OF ACOUSTIC ENERGY OVER LARGE DISTANCES.

## Hydroacoustic Technology

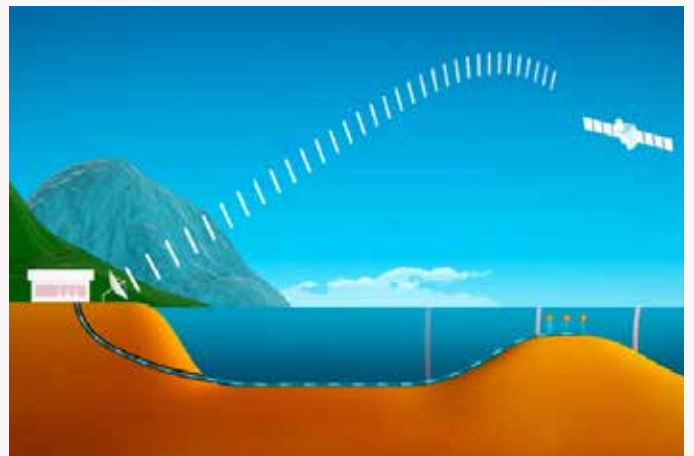
*Number of facilities: 11 stations*

*Verification function: Detects acoustic energy generated by an underwater nuclear explosion*

Hydroacoustic stations also play a role in tsunami warnings. Depending on a tsunami's amplitude and origin, they may detect its pressure wave and help tsunami warning centres – together with the seismic data – to issue timely warnings. In the case of the 11 March 2011 tsunami in Japan, the hydroacoustic station on Wake Island (USA) helped track the wave as it progressed across the Pacific Ocean.

By warning of underwater volcanic eruptions, hydroacoustic stations could further bring the same security benefits to maritime traffic as infrasound stations to air traffic.

In addition, the hydroacoustic network has a number of climate-related applications, such as improving weather prediction and estimates based on ocean temperatures or helping to analyze the migration patterns of whale populations. In fact in 2021, CTBTO's technology in the Indian Ocean led to the discovery of a new colony of pygmy blue whales, which have eluded discovery for decades despite their massive size.



IT TAKES ONLY SECONDS FROM THE TIME AN EVENT IS RECORDED UNTIL THE SIGNAL REACHES CTBTO HEADQUARTERS IN VIENNA.

- Rapidly acquiring and disseminating data on tsunamis;
- Improving shipping safety through the monitoring of underwater volcanic explosions;
- Supporting research on ocean processes, leading to better weather prediction and climate change estimates;
- Researching marine life;
- Monitoring ice shelf break-up and the creation of large icebergs.



## Synergies with Science

A series of scientific conferences have been held in Vienna since 2006 designed to foster closer cooperation between the CTBTO and the scientific community. Over 1200 participants have attended recent conferences, including scientists from around 100 countries. Apart from seeking innovations in nuclear test-ban verification, all of the meetings have

“The CTBTO is helping to save lives by providing data from the International Monitoring System for tsunami early warning and other natural disaster mitigation and prevention efforts ”

*CTBTO Executive Secretary Robert Floyd*

explored the civil and scientific applications of the CTBT’s verification regime.

The wealth of IMS data – around 35 gigabytes of raw data per day – have helped Earth scientists to better understand the complexities of our planet. This, in turn, enables experts at the CTBTO to hone their skills in detecting nuclear explosions. It’s a veritable cross-fertilization: a deepened understanding of the Earth’s crust, for example, helps scientists analyze the propagation of seismic waves from a nuclear explosion. Similarly, insights into atmospheric and meteorological phenomena can enhance knowledge on the propagation of infrasound waves or the travel paths of radionuclide particles and noble gases. The same applies to the hydroacoustic technology deployed in the oceans.



THE OPENING CEREMONY OF THE CTBT: SCIENCE AND TECHNOLOGY 2021 CONFERENCE, VIENNA, JUNE 2021.

### PRODUCED BY:

Public Information  
Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO)  
Vienna International Centre, P.O. Box 1200  
1400 Vienna, Austria

E [info@ctbto.org](mailto:info@ctbto.org)  
I [www.ctbto.org](http://www.ctbto.org)



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