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Perspective

Measurements of Radionuclides inside the Global Monitoring System

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INTRODUCTION

The mission of the International Monitoring System (IMS) is to detect nuclear explosions anywhere in the world through a unique worldwide network of sensors that are calibrated to measure different phenomenology. A part of this network measures the amount of radioactive gases and particles or radionuclides that are present in the atmosphere. This allows for the verification of conformity with the Comprehensive Nuclear Test Ban Treaty (CTBT). There are 120 sensors spread across 80 locations in the radionuclide sub-network, which is backed by 16 measurement labs. To measure radionuclides from samples, all radionuclide stations employ a type of γ-ray spectroscopy; this method has mainly not changed since the network was first set up 25 years ago. Enhancements in spectroscopic and sampling technologies can enhance the network's ability to identify nuclear explosions. This paper evaluates new technology that could improve future iterations and potentially increase the verification power of the IMS. It also highlights the current state of the IMS radionuclide network and the suite of technologies now in operation.

DESCRIPTION

The Comprehensive Nuclear Test Ban Treaty (CTBT, sometimes known as "The Treaty"), when it comes into effect, will outlaw all nuclear explosions worldwide, whether they occur in the atmosphere, below ground or underwater. A demand for verification has supported the Treaty, which was formally opened for signature on September 24, 1996, after being adopted by the UN general assembly in 1996. A network of sensors is needed for this kind of verification in order to find any potential Treaty violations. Numerous signals, including seismic, infrasound, hydro acoustic and Radionuclide (RN) signals, can be produced by a nuclear explosion. As a result, these signals need to be continuously monitored in the order to spot any deviations from background noise that might be the result of a nuclear explosion. The International Monitoring System (IMS) is a network of 337 facilities that makes use of all of these monitoring capabilities. The synthesis and release of radionuclides or radioactive isotopes, during an explosion is one such phenomenon that results from a nuclear explosion. Particulate (or aerosol) and noble gas radionuclide monitoring systems are the two types of systems included in the IMS. Here, we examine the advancements made in creating and implementing a global network of radionuclide sensors and talk about what lies ahead for this unique verification instrument.

A variety of radioactive "activation products" are created when heavy fuel actinides, such 235U or 239Pu, fission or when other materials, like stable isotopes found in steel, are activated by neutrons. Such materials may escape from the explosion site and scatter into the atmosphere, where they can be transported worldwide; depending on the level of containment (this is especially important for underground nuclear testing). Either High Volume Air Sampling (HVAS) into filter sheets or the isolation of particular elements can be used to gather these radionuclides. Xenon is one such element.

Of it, four radioactive fission product isotopes can be detected with existing methods since they are created in high numbers during a nuclear explosion and have a long enough half-life. These serve as the cornerstone of the IMS RN network's Noble Gas (NG) monitoring network. When finished, the IMS's present configuration will include 40 noble gas monitoring stations and 80 particulate monitoring stations. There may be up to 80 noble petrol stations after the Treaty comes into effect. There were 26 noble petrol stations and 72 particulate stations in operation as of December 2022. Data from the IMS is sent to the IDC in Vienna, the headquarters of the CTBT Organization (CTBTO), which is operated by the Provisional Technical Secretariat (PTS).

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From here, the IMS data is made available to states parties through their National Data Centres (NDCs) designated technical organizations tasked with providing evaluations of the IMS data to their respective governments. Every station system uses gamma (γ) spectrometry based measurement technology to generate spectral data that, when processed, can provide information on the activity concentrations (Bq/m^3) of radionuclides in the atmosphere. For certain radionuclides, some existing systems have a sensitivity of $\mu Bq/m^3$ or one decay per million seconds per cubic meter of air. The "detection limit," also known as the minimum quantifiable activity per cubic meter of air sampled at a given confidence level, is the ultimate measure of a system and is also sometimes referred to as the Minimum Detectable Activity (MDA) or in the case of these air sampling systems, the Minimum Detectable Concentration (MDC).

CONCLUSION

When the CTBT is put into effect, verification will be a major obstacle. The international monitoring system offers the practical tools for confirming the treaty and discouraging governments from breaking its provisions. A key component of the verification regime is the monitoring of radionuclides in the atmosphere and technological and scientific advancements to the IMS RN network will allow this to continue for many years to come.