Global Radioxenon Analysis and Atmospheric Transport Modelling for Nuclear Explosion Monitoring

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The International Monitoring System (IMS) is a verification component of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). It includes, beside three-waveform technologies (seismic, hydro-acoustic and infrasound), two radionuclide technologies: global monitoring of radioactive aerosols and of radioactive noble gases. Atmospheric transport modelling is part of the system to establish a source geolocation capability.

The knowledge of the activity concentration and isotopic composition of radioactive noble gases in the atmosphere indicates the nuclear processes governing their formation. Furthermore, by use of atmospheric transport modelling (ATM), knowledge of possible source characteristics, points of origination and potential contamination from other sources in the area of the sampling point can be established.

The noble gas-monitoring technology is a fundamental and highly sensitive technique for the detection of nuclear explosions. It is the only technique, together with radionuclide particulate monitoring, that has the potential to provide unambiguous proof as to whether an explosion was nuclear or not.

In this framework, the International Noble Gas Experiment (INGE) of the Provisional Technical Secretariat (PTS) for the CTBT Organization (CTBTO) was established to develop and test suitable radioxenon monitoring systems. In order to ensure the quality and accuracy of the IMS noble gas measurement capabilities, it is of eminent importance to characterise the noble gas background. It is important for the assessment of measurements also to calculate and analyse the source–receptor relationships.

Therefore, understanding radioxenon time series and being able to distinguish anthropogenic from nuclear explosion signals are fundamental issues for the technical verification of the Comprehensive Nuclear-Test-Ban Treaty. Every radioxenon event categorisation methodology must take into account the background at each monitoring site to uncover anomalies that may be related to nuclear explosions. Feedback induced by local meteorological patterns on the equipment and on the sampling procedures has been included in the analysis to improve a possible event categorisation scheme.

Finally, the network coverage of the IMS noble gas component is considered in order to quantify its capability to detect nuclear explosions worldwide. Different emission and background scenarios are used to determine the ratio of detected and undetected events, and recommendations to improve this value are discussed.