Standards and Measurement Science for Nuclear Test Monitoring Technologies

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CTBT – The Treaty

Comprehensive Nuclear-Test-Ban Treaty

Article I

1. Each State Party undertakes not to carry out any nuclear weapon test explosion or any other nuclear explosion, and to prohibit and prevent any such nuclear explosion at any place under its jurisdiction or control.

Opened for signature on 24 September 1996

Near-universal – 184 signatures, 167 ratification

Entry-into-Force when 44 States listed in Annex 2 ratify the Treaty

8 Annex 2 States have not ratified the Treaty yet

CTBTO – The Organization

Comprehensive Nuclear-Test-Ban Treaty Organization

- The Preparatory Commission for the CTBTO is tasked with building up the verification regime and promoting the Treaty's universality
- Seat of the Organization in Vienna, Austria
- The Commission consists of two main organs: a plenary body composed of all States Signatories (PrepCom) and the Provisional Technical Secretariat (PTS)
- The PTS assists the plenary body in carrying out its activities. It includes more than 260 staff members from more than 70 countries

CTBTO
PREPARATORY COMMISSION

The 4 Components of the Verification Regime

1. International Monitoring System

Collect, analyze and distribute data from the 337 monitoring facilities

2. Consultation and clarification

Highlight potential non-conformity through consultations

3. On-site Inspection

Clarify potential non-conformity through on-site inspection

4. Confidence-Building Measures

Prevent the wrong interpretation of data and support the calibration of monitoring tools

The International Monitoring System: 337 facilities

4 monitoring technologies

Seismic – 170

Listening underground

Hydroacoustic – 11

Listening under water

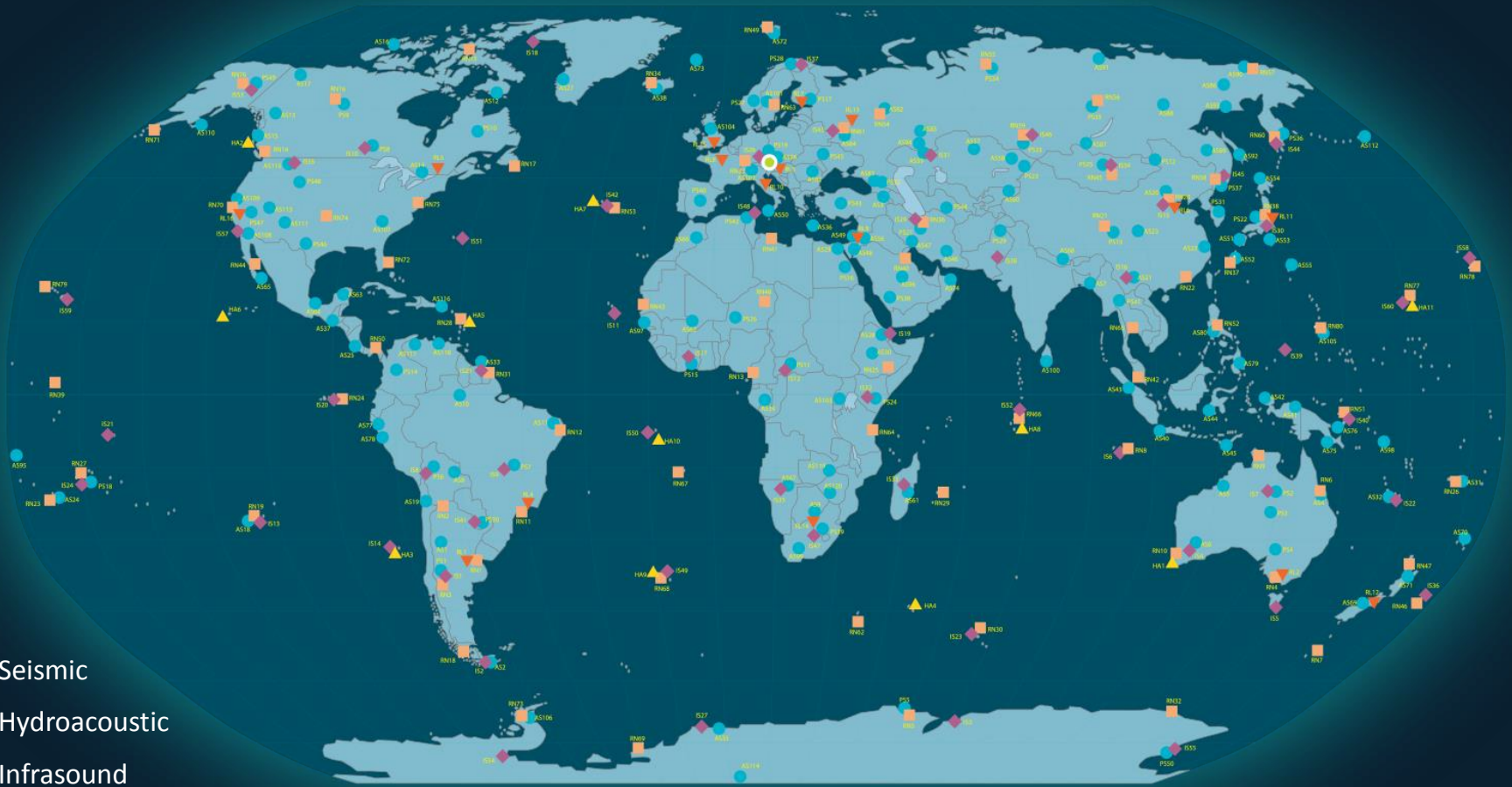
Infrasound – 60

Listening above ground

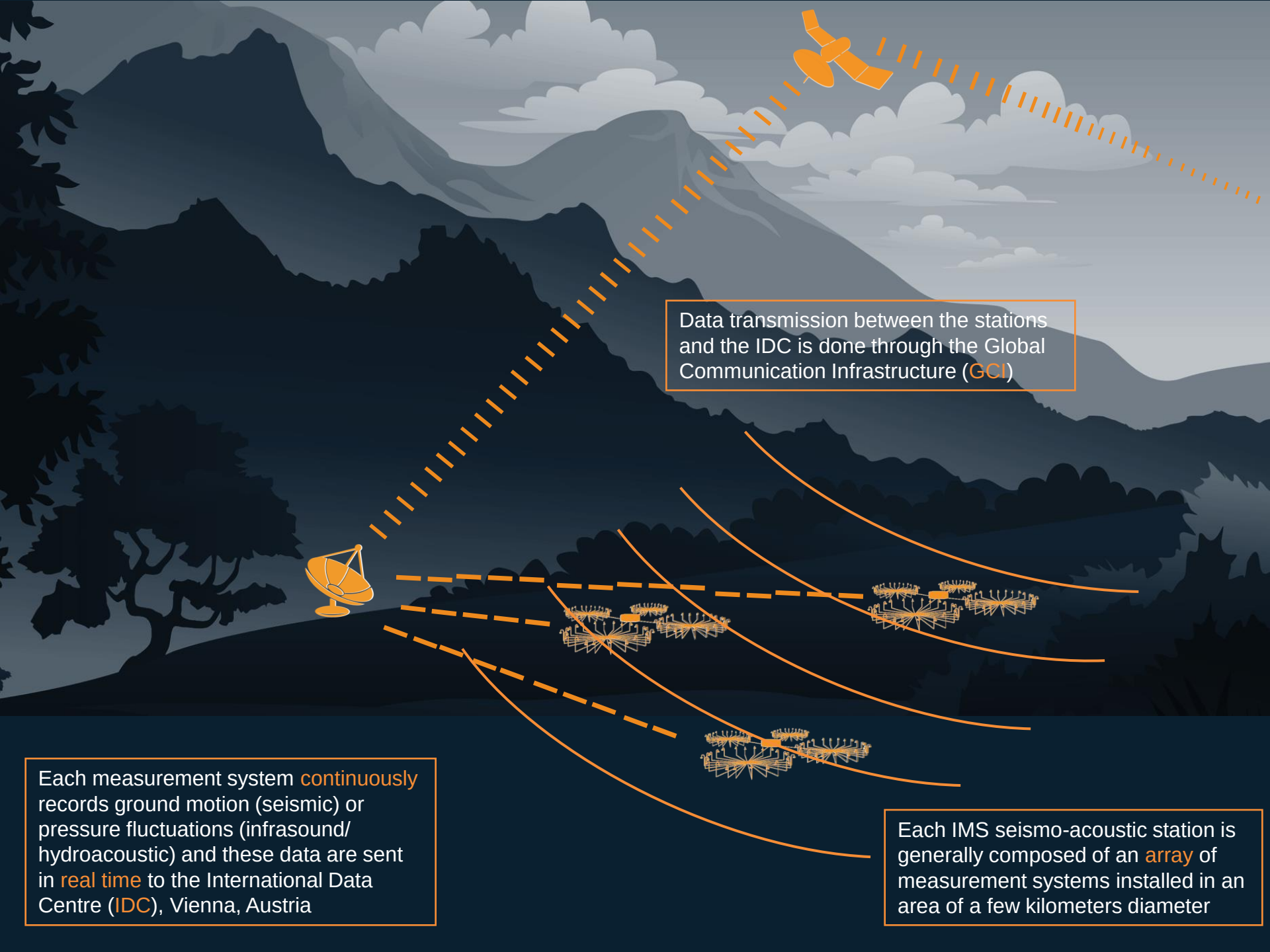
Radionuclide – 80

Sniffing for radiation

88% of IMS facilities already certified



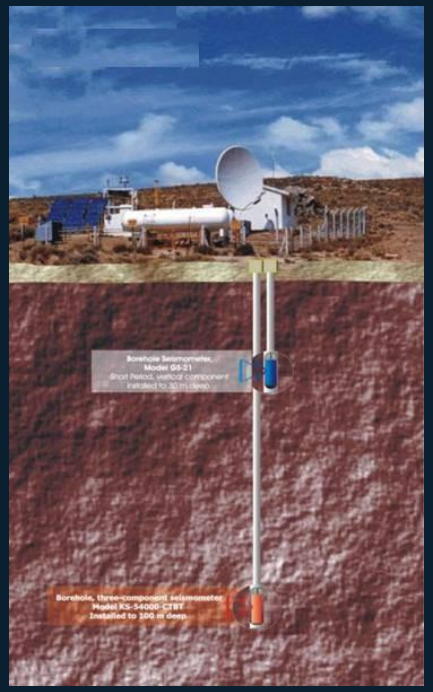
- Seismic
- Hydroacoustic
- Infrasound
- Radionuclide
- Radionuclide Laboratories
- International Data Centre

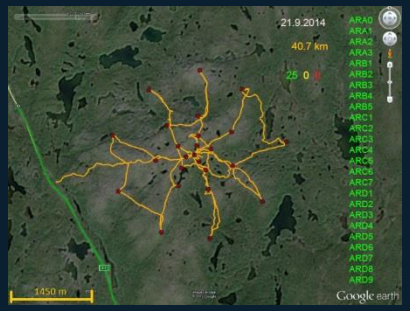

Data transmission between the stations and the IDC is done through the Global Communication Infrastructure (GCI)
Each measurement system continuously records ground motion (seismic) or pressure fluctuations (infrasound/ hydroacoustic) and these data are sent in real time to the International Data Centre (IDC), Vienna, Austria
Each IMS seismo-acoustic station is generally composed of an array of measurement systems installed in an area of a few kilometers diameter


Atmospheric nuclear explosions release radioactive gases into the atmosphere. It is also sometimes the case for underground and underwater explosions…


The gases are picked up by IMS radionuclide stations and the data are sent to the IDC

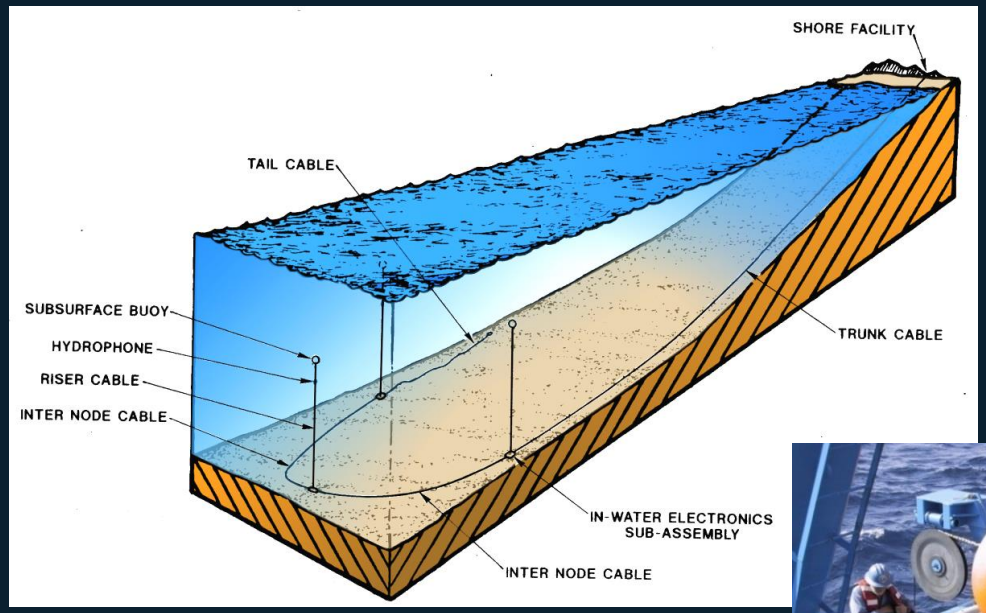
Seismic Stations – Listening underground

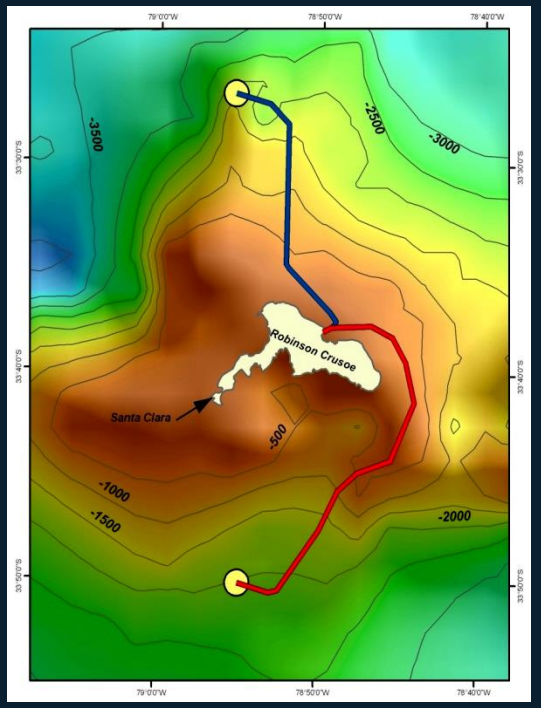


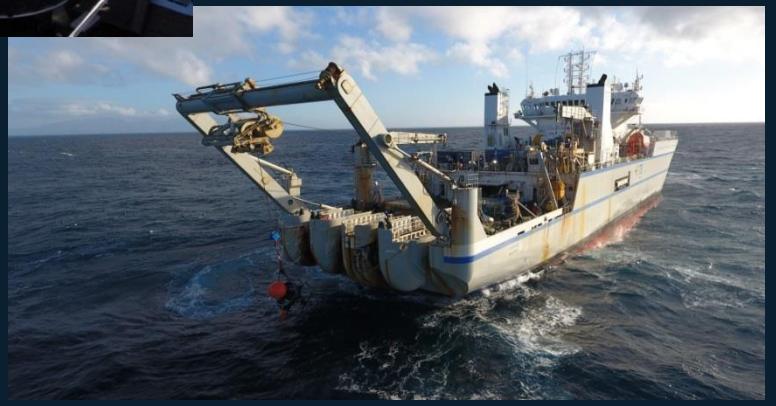


Infrasound Stations – Listening above ground

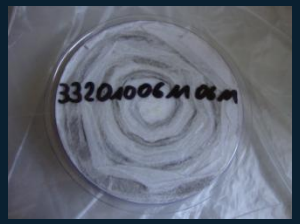
Hydroacoustic Stations – Listening underwater

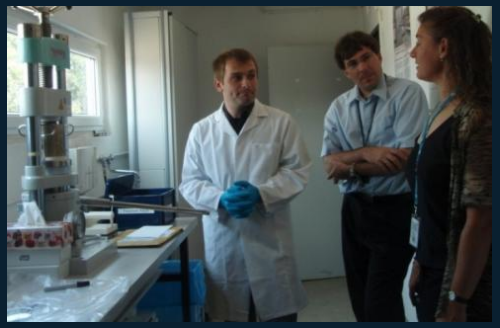


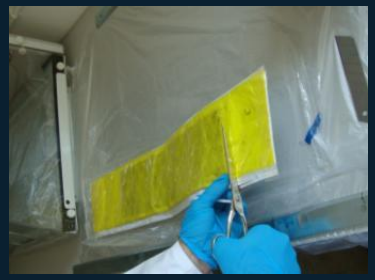




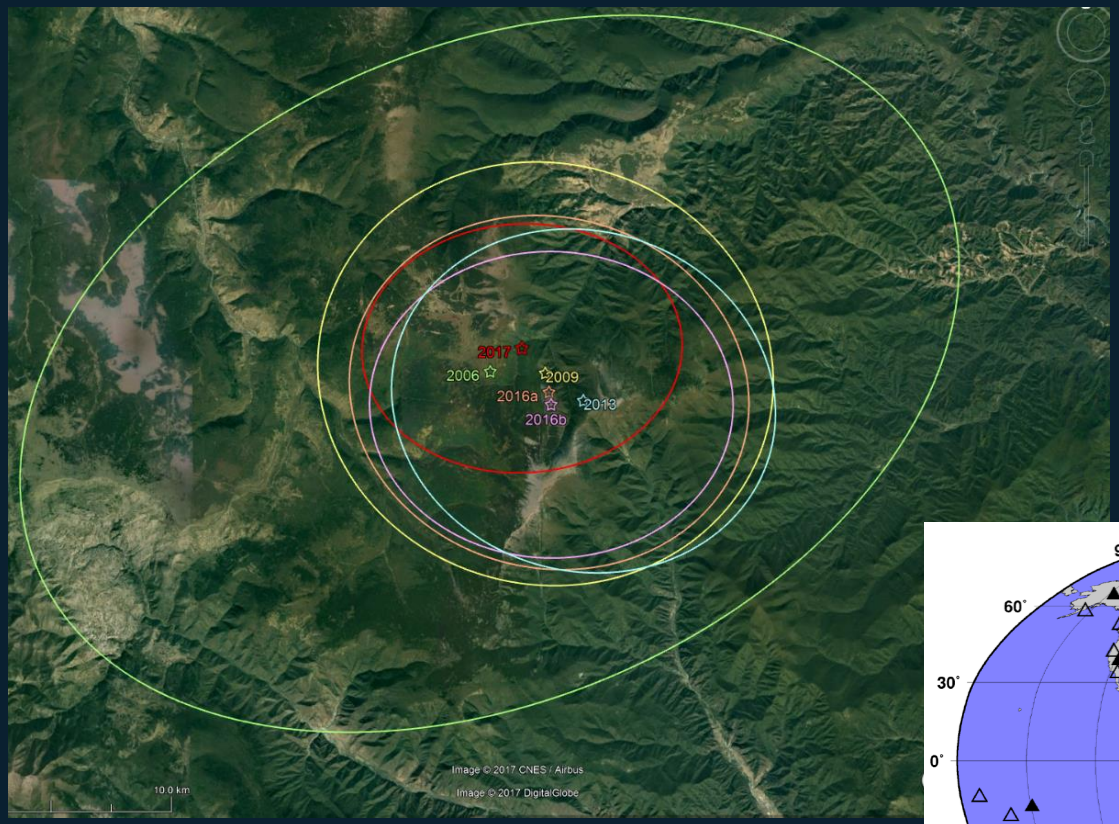
Radionuclide Stations and Laboratories







6th announced nuclear test by Democratic People's Republic of Korea (DPRK) on 3 September 2017



2017 event information (REB)

Date: 3 September 2017

Origin Time: 03:30:01.08 UTC ± 0.18 seconds

Latitude: 41.3205 degrees North

Longitude: 129.0349 degrees East

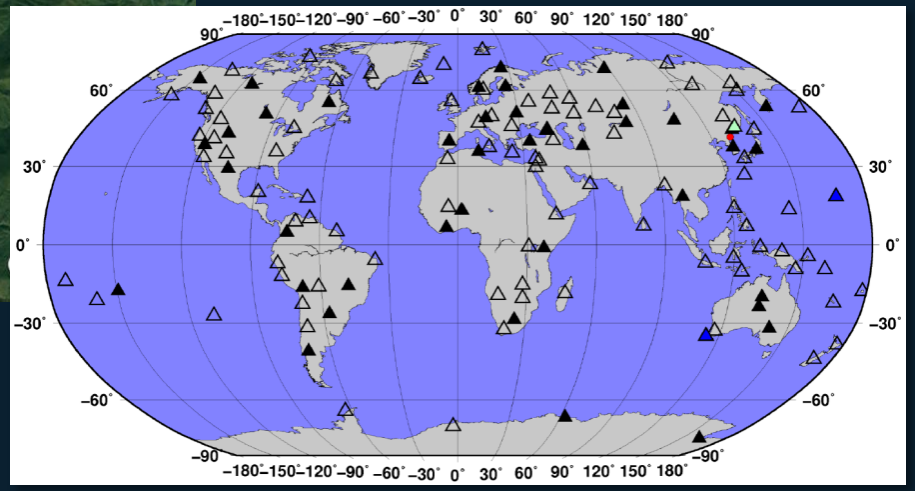
Approximate Location Accuracy: ± 6.7 km (109 km2)

Depth: 0.0 km (fixed)

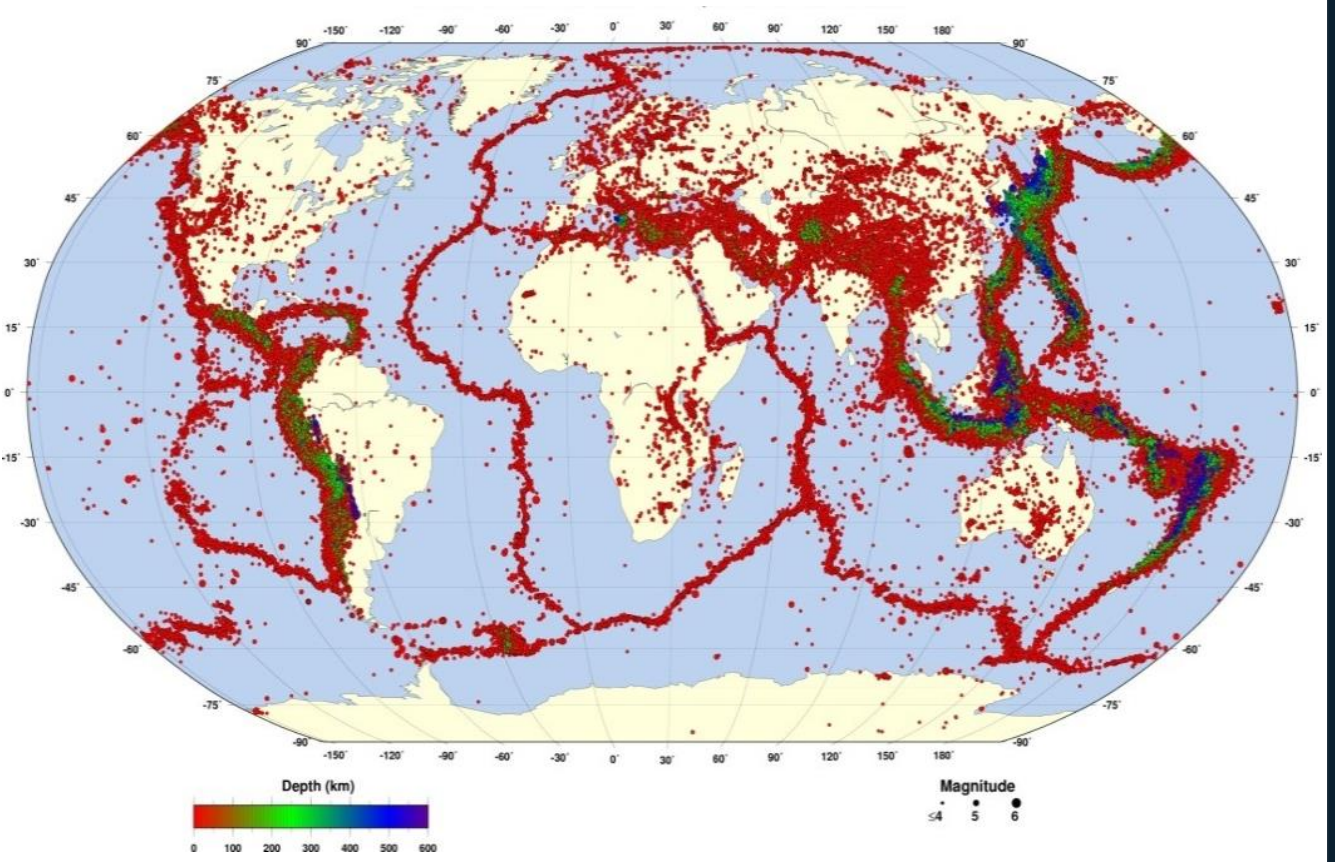
Body Wave Magnitude mb (IDC): 6.07

Number of Stations Used: 134

Issued: 5 September 2017 17:40:22 UTC



41 PS, 90 AS, 2 HA and 1 IS stations detected signals associated with DPRK event on 3 Sep 2017

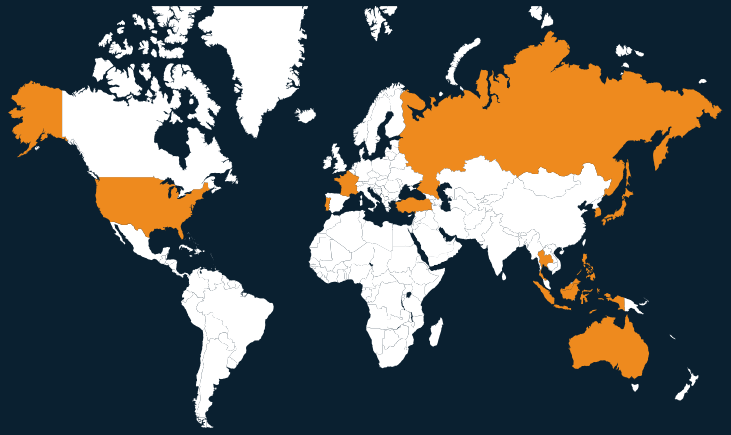


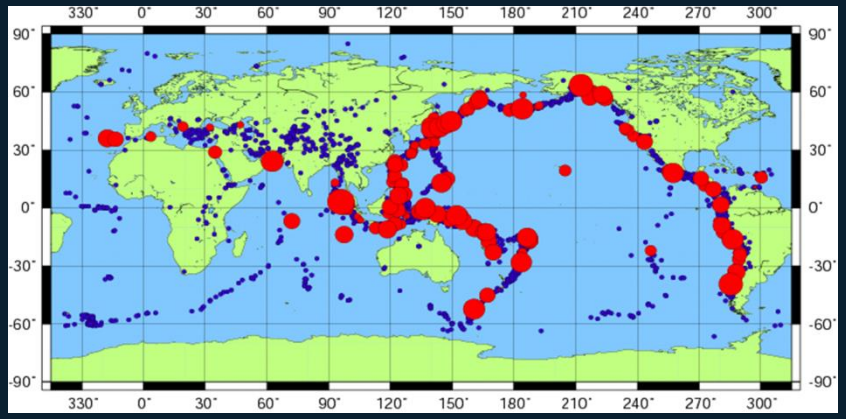
556,337

Seismo-acoustic events located by the International Data Centre from Feb 2000 – Nov 2017

Examples of Civil Applications – Seismic

14 Tsunami Warning Centres receive IMS data



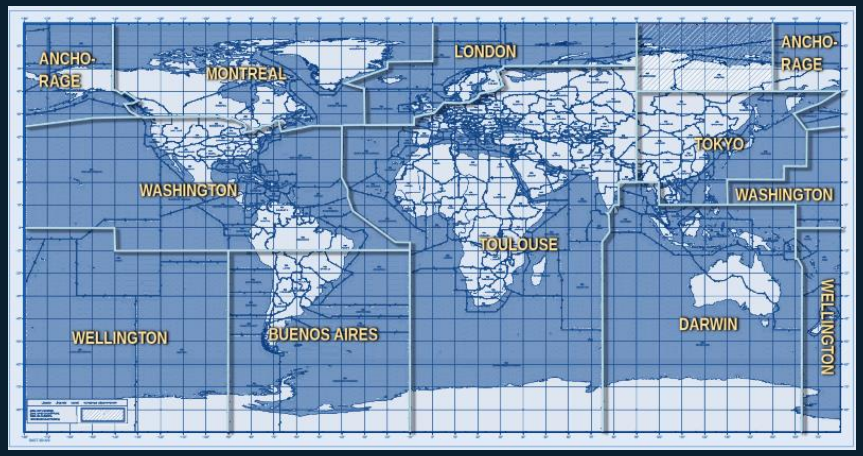


- with tsunami
- greater than M6.0

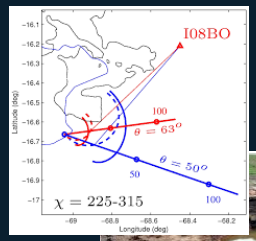
Examples of Civil Applications – Infrasound

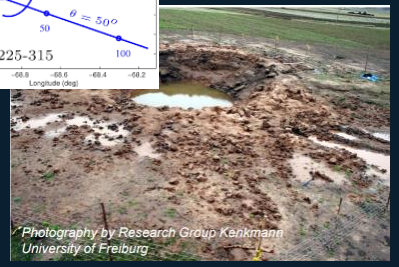
- Volcano ash plume warning for air flight with the International Civil Aviation Organization (ICAO) for the Volcanic Ash Advisory Centers (VAACs) – ARISE project
- Monitoring of airburst bolides – better statistics on Near-Earth Objects impacting the atmosphere
- Better explain dynamics of middle atmosphere to improve weather forecast – ARISE project

Guagua Pichincha Volcano

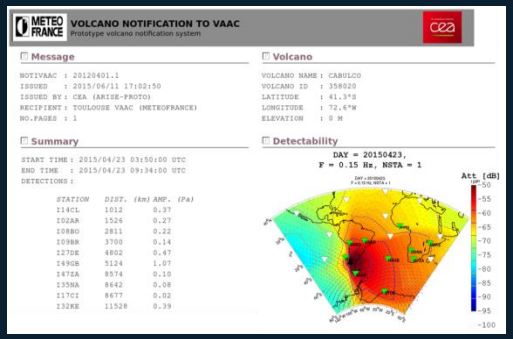


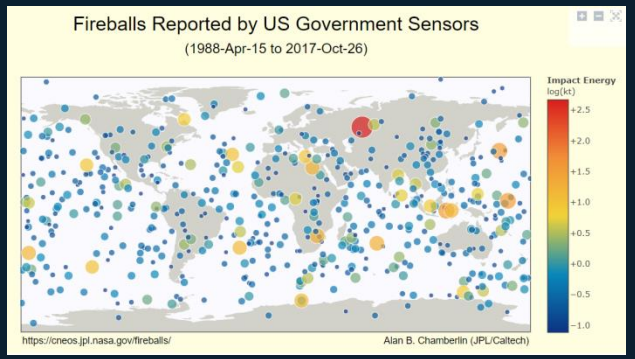
VAAC regions





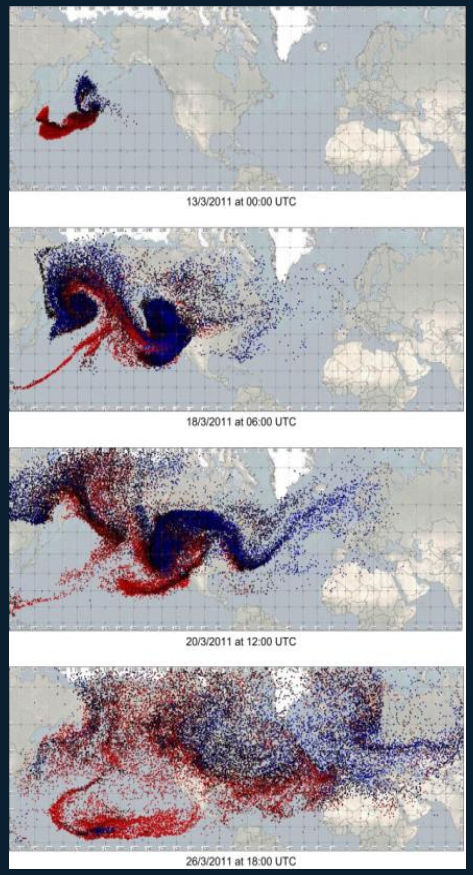
Carancas meteorite, 2007



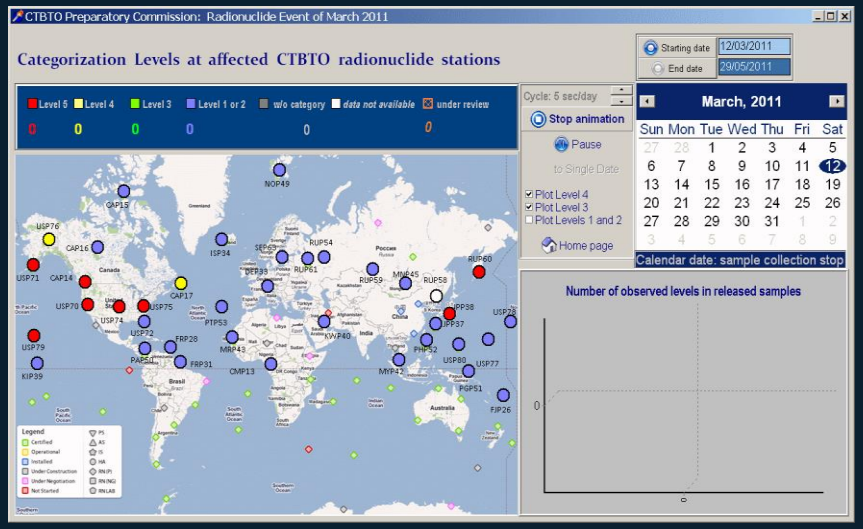


Examples of Civil Applications – Radionuclide

Fukushima Accident



IMS observations from 13 March to 29 May 2011



Daily detections of radionuclides after the accident:

Level 5 = multiples fission product detected

Level 4 = one fission product detected

Level 3 = detections of regular fission products for the station

Level 1 and 2 = natural radioactivity only

13 March 2011
First traces of radionuclides detected by the IMS radionuclide network and information shared with States Signatories

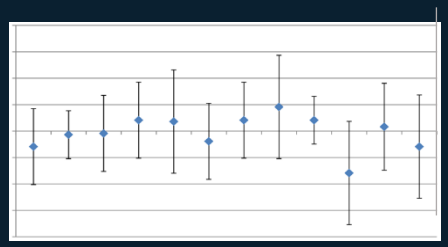
15 Mars 2011
Presentations to States Signatories

17 Mars 2011
Sharing of radionuclide observations put in place with the International Atomic Energy Agency (IAEA) and the World Meteorological Organization (WMO)

Calibration and Measurement Standards

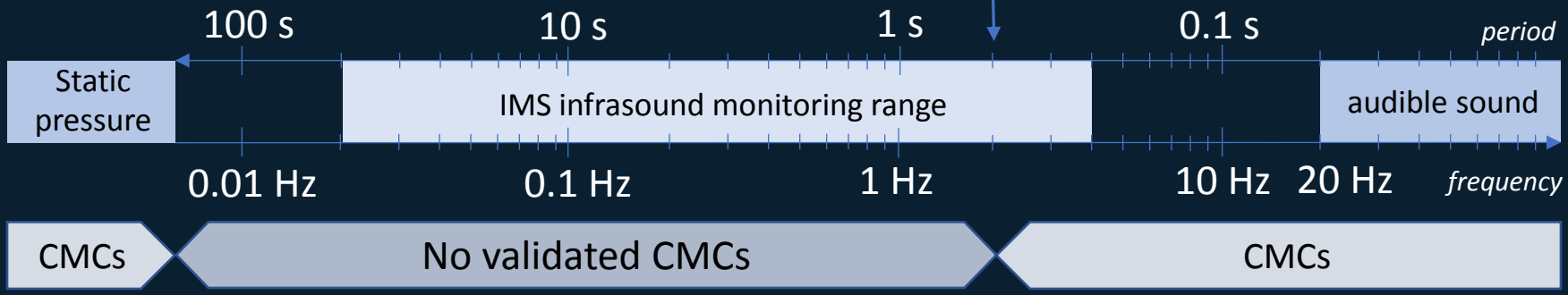
Infrasound Technology

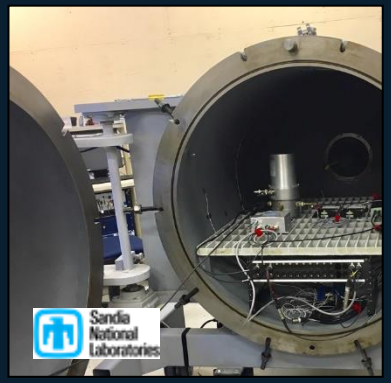
Measurement standards for static pressure based on the pressure balance



verified by CCAUV Key Comparison (CCAUV.A-K5, 2014)

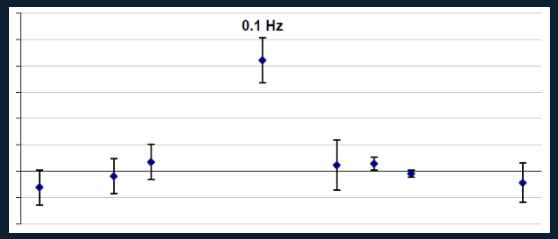
Measurement standards for sound pressure based on reciprocity calibration of measurement microphones





Calibration concepts and methods under development at NMIs and IMS service providers in IMS passband

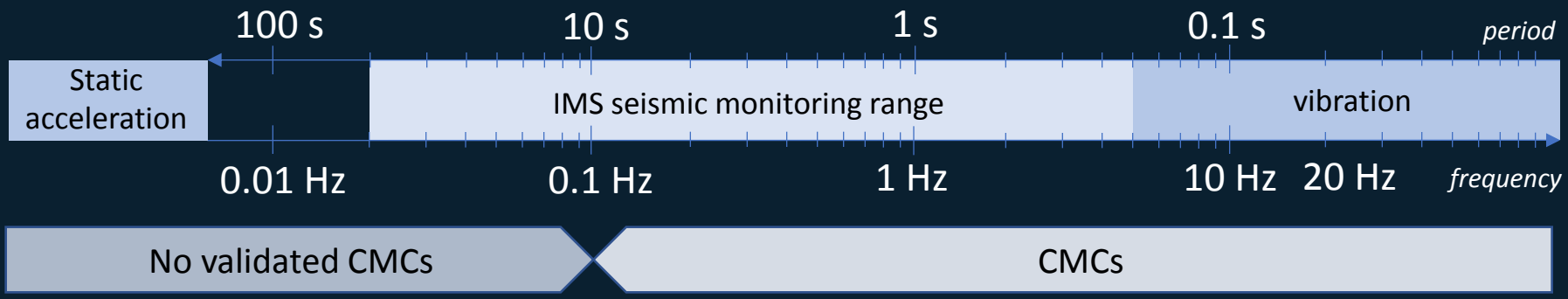
Seismic Technology



verified by CCAUV Key Comparison
(CCAUV.V-K3, 2016)

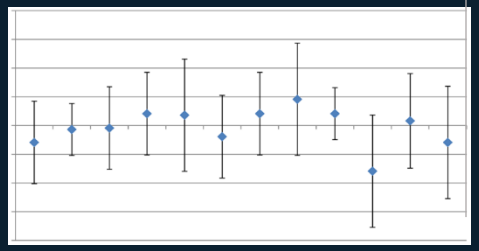
Measurement calibration bench for accelerometer calibration by primary means

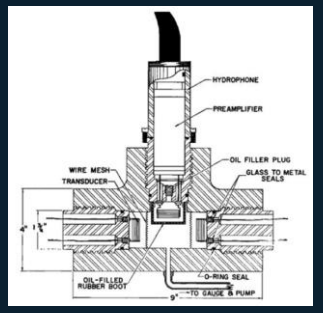
Measurement method by comparison to the standard gravity and an angular sensor - No primary method



Calibration concepts and methods under development at NMIs and IMS service providers in IMS passband

Hydroacoustic Technology





Measurement standards for static pressure based on the pressure balance

Only frequencies > 250 Hz will be verified by CCAUV Key Comparison (CCAUV.W-K2, 2018)

Standards for sound pressure in water based on reciprocity calibration of hydrophones

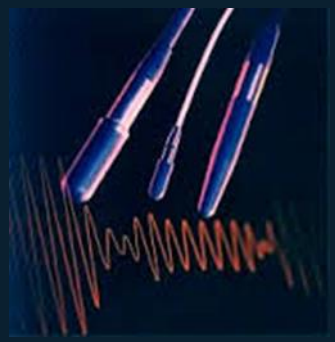
10 s | 1 s | 0.1 s | 0.01 s — *period*

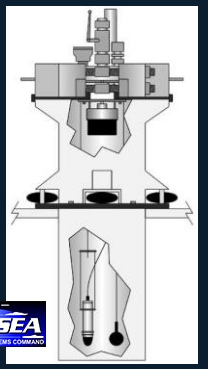
Static pressure

IMS hydroacoustic monitoring range

0.1 Hz | 1 Hz | 10 Hz | 100 Hz | 250 Hz — *frequency*

CMCs — No validated CMCs — CMCs

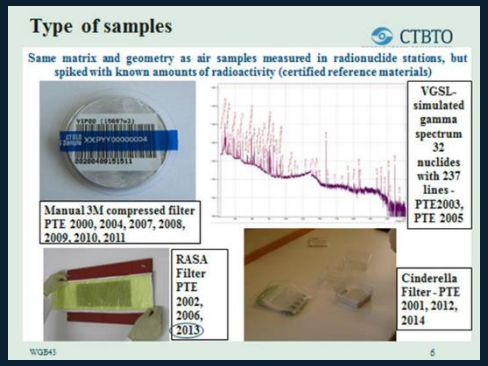


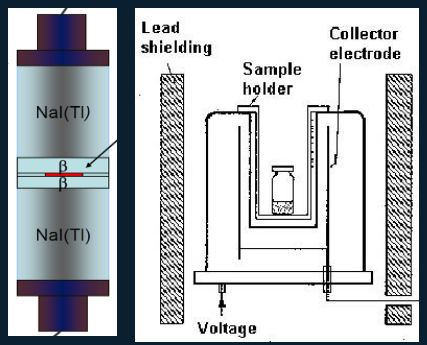


Calibration concepts and methods under development at NMIs and IMS service providers in IMS passband

Radionuclide Technology

Particulate





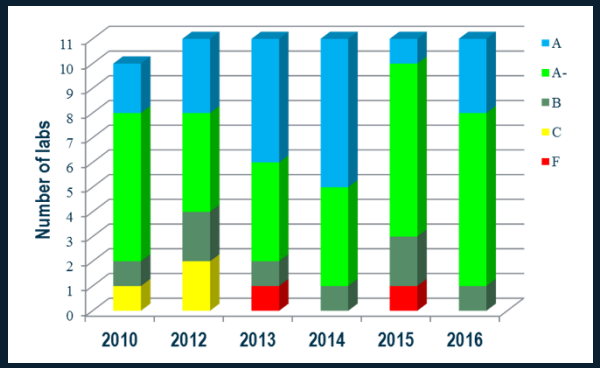
Measurement standards for Particulate (aerosol) samples based on Master Solutions prepared gravimetrically from traceable radionuclide solutions calibrated with 4πβ/γ coincidence counters, ionization Chambers or by high resolution gamma-ray spectroscopy (secondary)

13 out of the 16 IMS Radionuclide Laboratories are already certified (including 4 with noble gas capability)

CMCs

Standards are used for Proficiency Testing of IMS Radionuclide Laboratories and Station Calibration

Trends in Lab Performance
based on PTS grading scheme for PTEs



Noble gas

Measurement standards for Xenon gas samples based on internal gas counting using proportional detectors, checked by gamma spectrometry

Need for validated CMCs across the IMS infrasound, seismic and hydroacoustic monitoring ranges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PREPARATORY COMMISSION
Thank you !