Radionuclide Monitoring for The CTBTO Verification

Ninth Annual Radiation Measurements Cross Calibration (RMCC-9) Workshop

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Ektimal Al-Nemri
Radionuclide Evaluation Officer
OES Division/ Evaluation Section
email: ektimal.al-nemri@ctbto.org

Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization
Provisional Technical Secretariat
Vienna International Centre
P.O. Box 1200, A-1400 Vienna
AUSTRIA

Overview of the presentation

- Introduction of the CTBTO
- Introduction of the International Monitoring System (IMS)
- The CTBTO Radionuclide Monitoring Network
- Radionuclide Monitoring Stations Overview
- Radionuclide Laboratories supporting the IMS Network
- Operation of Radionuclide Monitoring Network, Data Processing and IDC Products
- Operational experience of CTBTO (Fukushima)

Introduction of the CTBTO

The primary objective of the

Comprehensive Nuclear Test Ban Treaty (CTBT)

is *<u>outlawing nuclear test explosions in all environments</u>*: in the atmosphere, underground and under water tests,

The Treaty was adopted by the United Nations General Assembly and open for signature in New York on

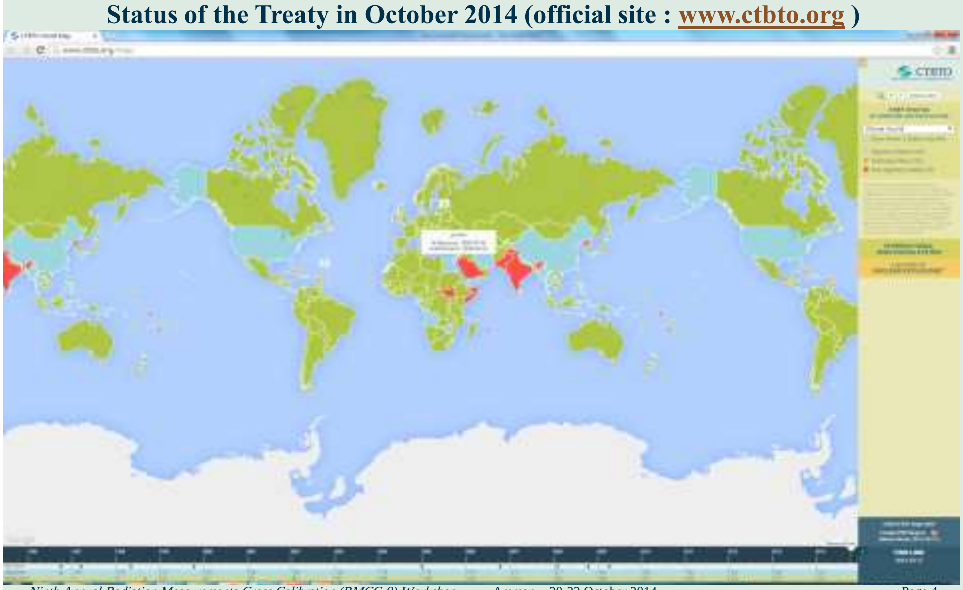
24 September 1996

Since then it has been:

signed by 183 States and ratified by 161.

Introduction of the CTBTO

Status of the Treaty in October 2014 (official site : www.ctbto.org)



Comprehensive Nuclear Test Ban Treaty Organization (CTBTO)

A **Preparatory Commission** for the Organization was established by the United Nations on **19 November 1996** and located at the **Vienna International Centre:**

- to establish a **global Verification Regime**, to monitor compliance with the Treaty
- to promote the signature and ratification of the Treaty, for Entry into Force

Comprehensive Nuclear Test Ban Treaty Organization (CTBTO)

Three main components of verification regime:

- **The International Monitoring System:** is the global network of sensors and devices for detecting and providing evidence of possible nuclear explosions.
- **The International Data Center:** is designed to collect, process, analyse and report on data received from facilities of the IMS, including the results of analyses conducted at certified Radionuclide Laboratories
- **The On-Site Inspections:** after the entry into force of the Treaty, might be requested by States and will have the purpose to clarify whether a nuclear explosion has been carried out in violation of the Treaty

The International Monitoring System (IMS)

- **321 stations:** seismic, hydroacoustic, infrasound and radionuclide
- **16 radionuclide laboratories** to support the IMS network
- The **Global Communications Infrastructure** to send raw data in near real time to IDC in Vienna for processing and analysis.

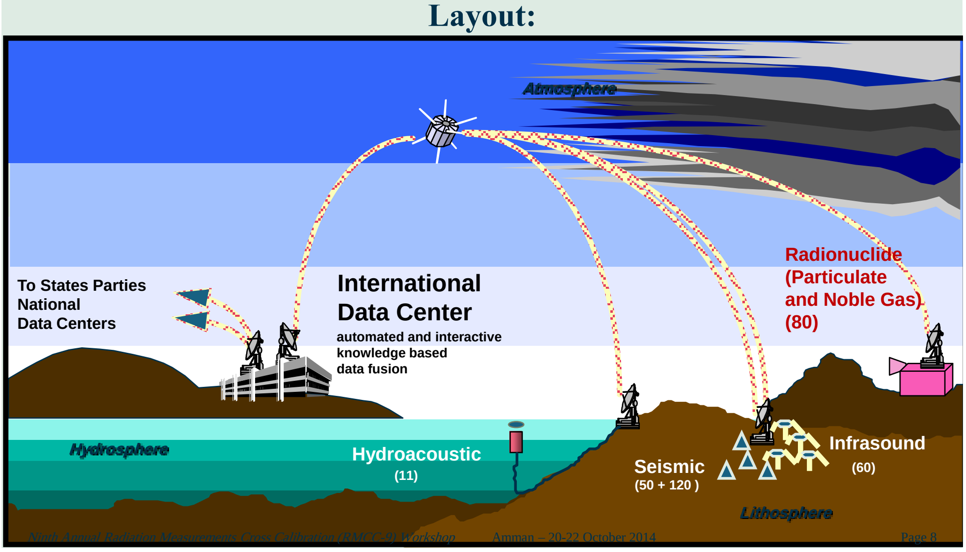
Requirements?

At EIF, data availability is set to 98% for waveform and 95% for RN technologies - which means:

Down time per station in one year NO MORE THAN
7 DAYS total (waveform)
15 DAYS total and 7 DAYS consecutive (RN)

The International Monitoring System (IMS)

Layout:



The International Monitoring System of CTBTO
Introduction of the IMS

CTBTO PREPARATORY COMMISSION

The International Monitoring System (IMS)

The CTBTO Radionuclide Monitoring Network

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The Radionuclide Monitoring Network

❖ The **primary role** of radionuclide monitoring is to provide an **definite evidence of a nuclear explosion** through the **detection and identification of fission products.**

❖ **Key parameters** in station design used by experts, in order to achieve an acceptable degree of detection, identification and precise localization of a suspicious event :

o ***number*** *of ground-based stations,*

o *sampling and reporting* ***time****,*

o ***sensitivity*** *of analysis system,*

❖ Goal:

capability of 90% detection within approximately 14 days for a 1 kt nuclear explosion in the atmosphere or from venting by an underground or underwater detonation*.*

The CTBTO Radionuclide Monitoring Network

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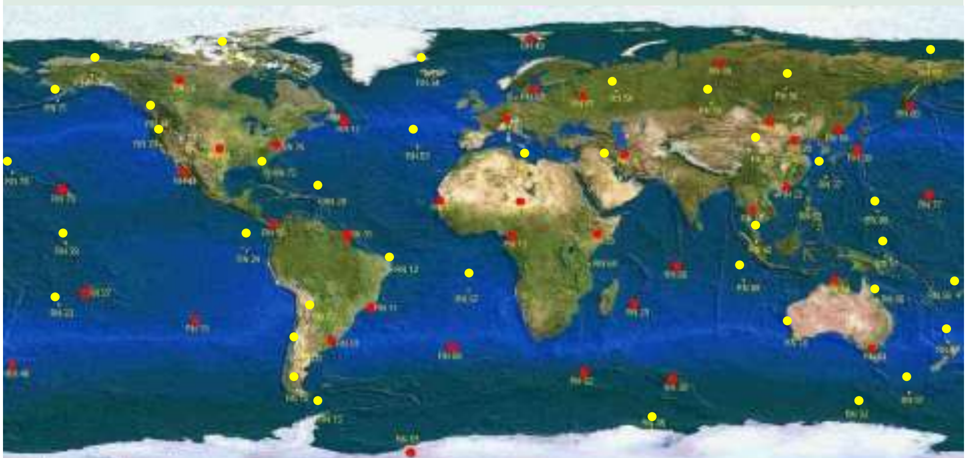
The Radionuclide Monitoring Network

80 Radionuclide stations:

40 particulate monitoring only and **40** particulate and noble gas monitoring:



Radionuclide Monitoring Stations Overview

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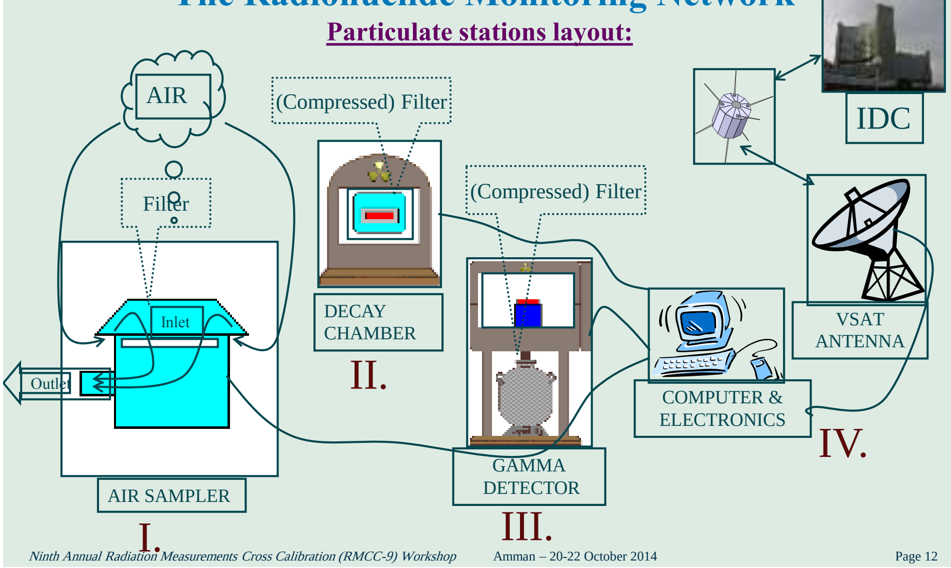
The Radionuclide Monitoring Network

Particulate stations layout:



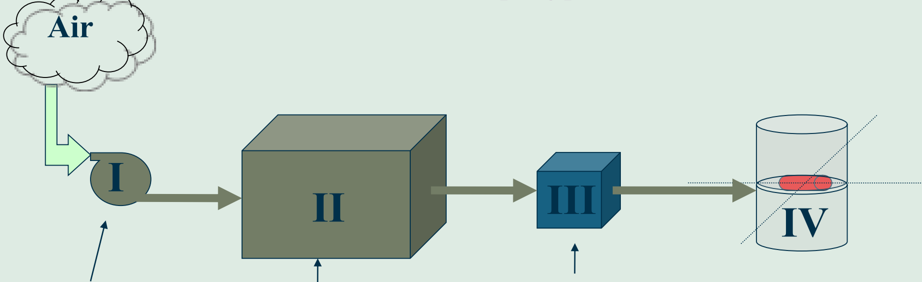
The Radionuclide Monitoring Network

Particulate stations minimum requirements:

System	Manual or automated
Air flow	500 m^3h^{-1}
Collection time	24 h
Decay time	≤ 24 h
Measurement time	≥ 20 h
Time before reporting	≤ 72 h
Reporting frequency	Daily
Filter	Adequate composition for compaction, dissolution and analysis
Particulate collection efficiency	For filter: ≥ 80% at Ø = 0.2µm Global: ≥ 60% at Ø = 10µm
Measurement mode	HPGe spectroscopy
HPGe relative efficiency	≥ 40%
HPGe resolution	< 2.5 keV at 1332 keV
Base line sensitivity	10 to 30 $\mu Bq m^{-3}$ for ^{140}Ba
Calibration range	88 to 1836 keV
Data format	Radionuclide Monitoring System Format (RMS)
State of health	Status and ancillary data recorded every 10 minutes
Communication	Two-way
Auxiliary data	Meteorological and flow rate data recorded every 10 minutes
Data availability	≥ 95%
Down time	≤ 7 consecutive days; ≤ 15 days annually

The Radionuclide Monitoring Network

Noble Gas stations sampling process:



Collection of Air

Gas Processing & Sample Preparation:

- Removal of water, O_2, CO_2, Rn (freeze traps, molecular sieves and/or activated charcoal)
- Producing of final concentrated Xe-sample

Measurement of sampled Xenon volumE

Activity Measurement (HPGe or beta-gamma coincidence)

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The Radionuclide Monitoring Network

Noble Gas stations minimum requirements:

Air flow	0.4 m^3 h^{-1}
Total volume of sample	10 m^3
Collection time	≤ 24 h
Measurement time	≤ 24 h
Time before reporting	≤ 48 h
Reporting frequency	Daily
Isotopes measured	^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe
Measurement mode	Beta-gamma coincidence or High resolution gamma spectrometry
Minimum Detectable Concentration	1 mBq m^{-3} for ^{133}Xe
State of health	Status data transmitted to IDC
Communication	Two-way
Data availability	95 %
Down time	≤ 7 consecutive days ≤ 15 days annually

Radionuclide Monitoring Stations Overview

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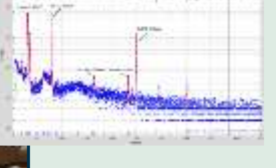
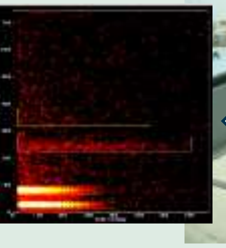
The Radionuclide Monitoring Network

Noble Gas stations:

SPALAX, *10 systems*

SAUNA-II, *14 systems*

ARIX, *3 systems*

Radionuclide Laboratories supporting the Network

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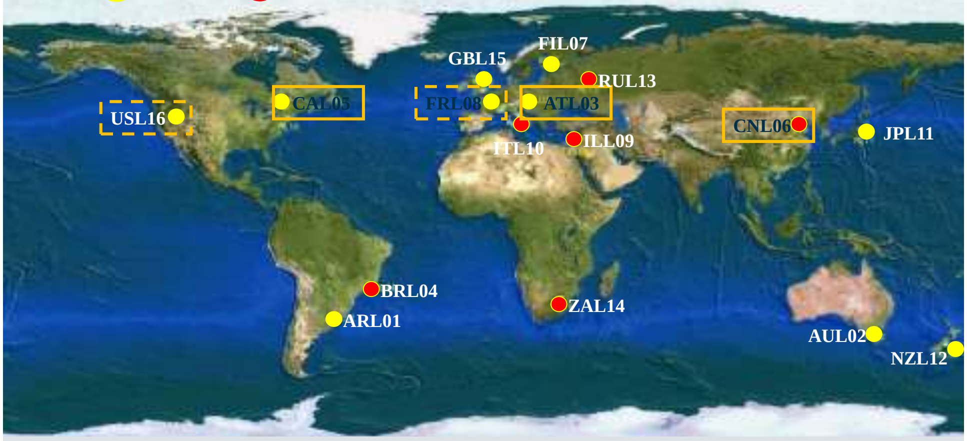
The IMS Radionuclide Laboratories Network

16 radionuclide laboratories:

10 certified, 6 not certified, 5 with Noble Gas measurements capability



Buenos Aires (AR), Melbourne (AU), Seibersdorf (AT), Rio de Janeiro (BR), Ottawa (CA), Beijing (CN), Helsinki (FI), Bruyères-le-Châtelle (FR) Yavne (IL), Rome (IT), Tokai (JP), Christchurch (NZ), Moscow (RU), Pelindaba (ZA), Aldermaston (GB), Richland(US)

Radionuclide Laboratories supporting the Network

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The IMS Radionuclide Laboratories Network

Minimum requirements for CTBT certified laboratory systems:

❖ **compliance with these technical specifications (CTBT/PTS/INF.96/Rev.7) is verified as part of certification process of the CTBT detection systems of each laboratory.**

Property	Requirement
Detector type	High resolution HPGe
Detector relative efficiency	≥ 40 %
Efficiency calibration measurement range	46.5–1836 keV
Efficiency calibration range (extrapolated)	30–2700 keV
Channels in spectrum	≥ 8192
MDA for 140Ba With decay correction to start of spectral acquisition, with acquisition time no longer than 7 days - For a cylindrical sample geometry with a diameter of 70 mm and height of up to 6 mm	≤ 24 mBq
FWHM at 1332.5 keV	≤ 2.3 keV
FWHM at 122.1 keV	≤ 1.3 keV
FWTM/FWHM at 1332.5 keV	≤ 2.0

Radionuclide Laboratories supporting the Network

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The IMS Radionuclide Laboratories Network

Minimum requirements for CTBT certified laboratory systems:

- different techniques are in place or under testing at IMS laboratories in order to optimise the sensitivity of CTBT certified detection systems:
  - ULB gamma detectors in underground laboratories
  - shields and enclosures including clean lead, copper, aluminium
  - radon control methods (LN2 boil-off in measurement chambers)
  - Compton suppression techniques
  - boron absorbers

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The International Monitoring System of CTBTO
Radionuclide Laboratories supporting the Network

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The IMS Radionuclide Laboratories Network

Support role of radionuclide laboratories:

(high -resolution gamma spectrometry only)

- Station samples for radionuclide network quality assurance (4 per year),
- station back-up samples when a station is down,
- samples from station visits,
- proficiency test exercise samples,
- special measurements agreed between the laboratory and the Commission,
- additional sample analysis of a suspect or irregular sample to verify the presence or absence of fission and/or activation products

Trigger: ❖ event screening process at the IDC ❖ a request of a State Party

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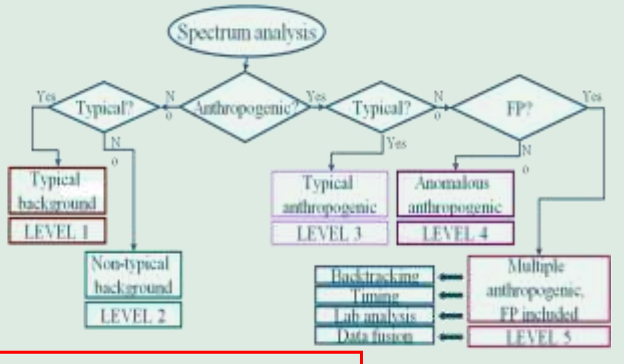
The IMS Radionuclide Laboratories Network

Categorization of CTBT samples:

❖ refers to a Standars list of 83 CTBT relevant fission/activation products

83 CTBT relevant nuclides:

AG-106M	EU-152	RB-84	U-237
AG-108M	EU-152M	RB-86	W-187
AG-110M	EU-155	RH-102	Y-88
AG-111	EU-156	RH-105	Y-91
AS-74	EU-157	RU-103	Y-93
AS-76	FE-59	RU-106	ZN-65
AU-196	GA-72	SB-120	ZN-69M
AU-196M	I-130	SB-122	ZR-89
AU-198	I-131	SB-124	ZR-95
BA-133	I-133	SB-125	ZR-97
BA-140	I-135	SB-126	
CD-115	IR-190	SB-127	
CD-115M	IR-192	SB-128	
CE-141	K-42	SC-46	
CE-143	LA-140	SC-47	
CE-144	MN-54	SM-153	
CO-57	MO-99	SM-156	
CO-58	NA-24	SN-125	
CO-60	NB-95	SR-91	
CR-51	ND-147	TC-99M	
CS-132	NP-239	TE-129M	
CS-134	PB-203	TE-131M	
CS-136	PD-112	TE-132	
CS-137	PM-149	TM-168	
	PM-151		



RASA split samples

Action:
❖ a Level 5 sample is split into 2 parts and sent from the station to 2 different laboratories for re-measurement

Manual split samples

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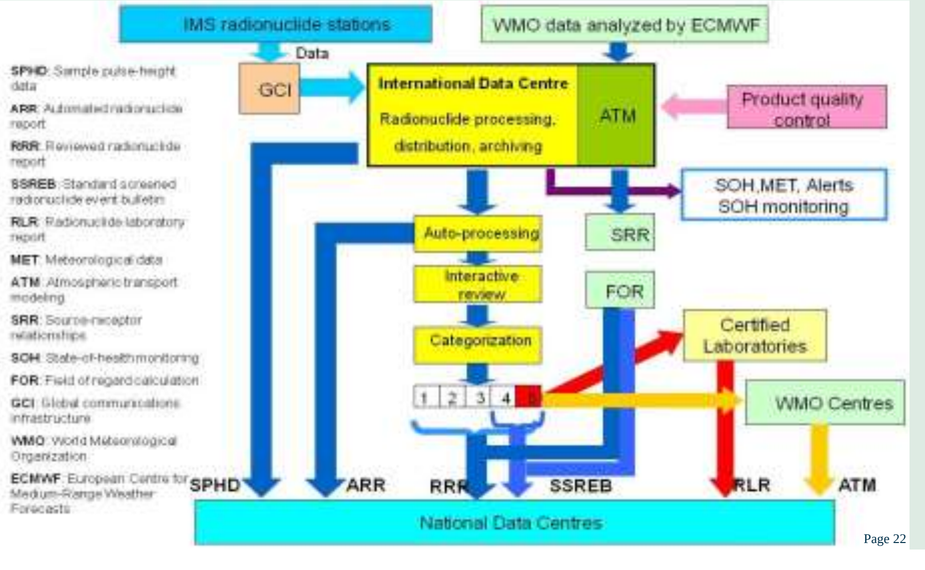
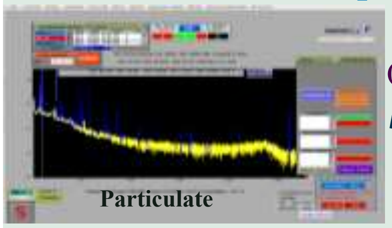
The Radionuclide pipeline

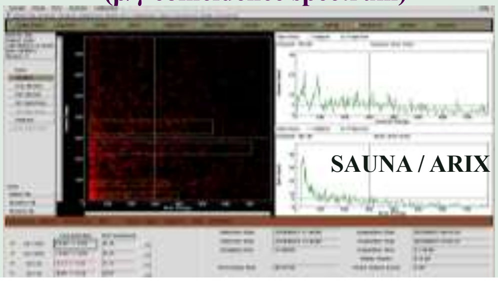


The IDC spectrum analysis software

SAINT 2
(gamma spectrum)

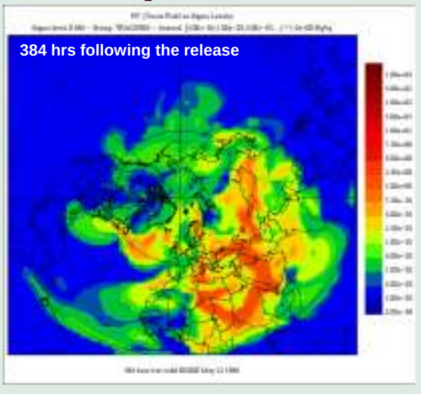


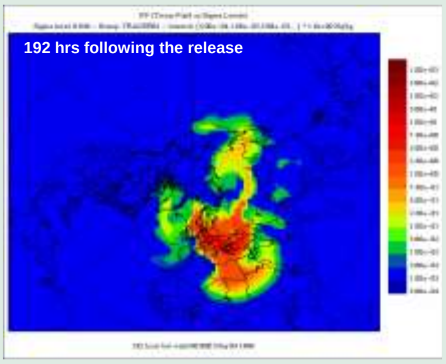
NORFY
(β/γ coincidence spectrum)



The Atmospheric Transport and Backtracking

Atmospheric transport models are developed to determine the distribution of the radioactive cloud in the atmosphere.

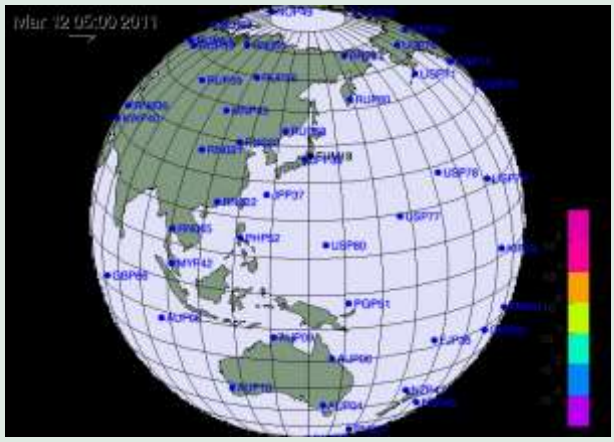




In order to locate the event, it is necessary to have meteorological data for the transport time in order to backtrack the path of the radionuclides to their source point.

Operational experience of CTBTO (Fukushima)

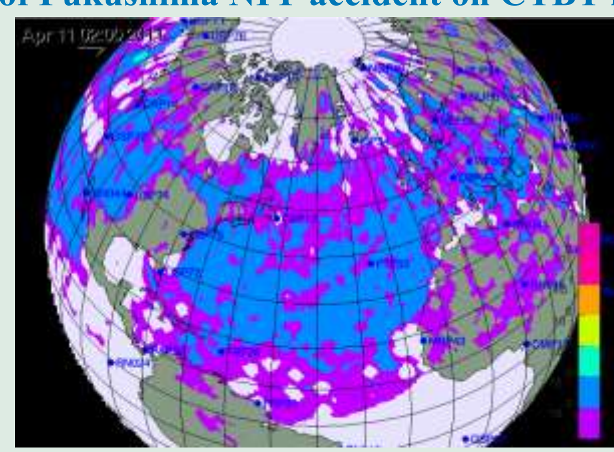
Effects of Fukushima NPP accident on CTBT network



- Atmospheric transport modeling played important role during the first day as there was a need to see which stations are going to be affected by the release.

Operational experience of CTBTO (Fukushima)

Effects of Fukushima NPP accident on CTBT network



- Atmospheric transport modeling played important role during the first day as there was a need to see which stations are going to be affected by the release.

Operational experience of CTBTO (Fukushima)

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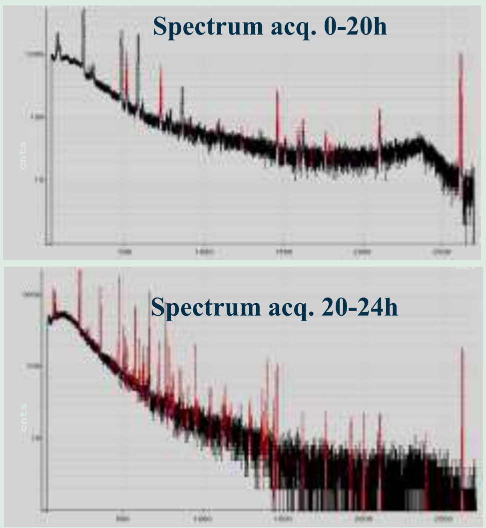
JPP38 (Takasaki, Japan) - Collection 12 – 13 March 2011



Set of gaseous fission products were detected. Sample is <u>level 5</u> (multiple fission products detected)

Nuclides
CS-134
CS-136
CS-137
I-131
I-132
I-133
Te-132
Ba-136M
Xe-133

Operational experience of CTBTO (Fukushima)

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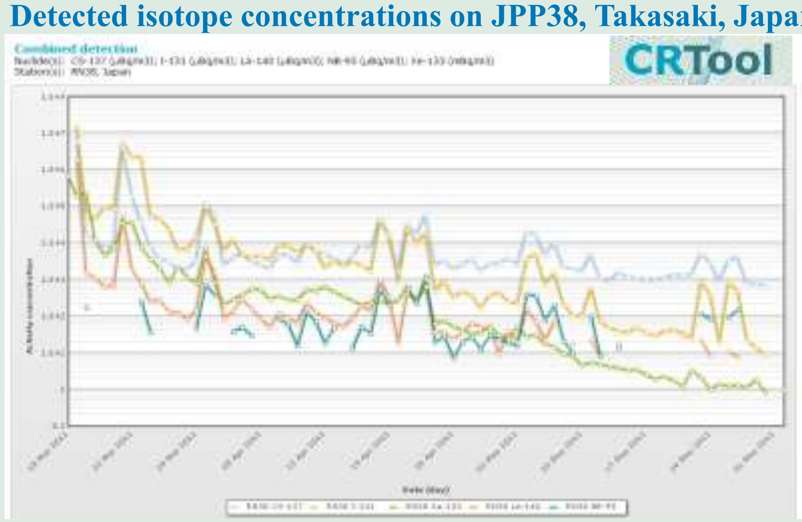
Detected isotope concentrations on JPP38, Takasaki, Japan



The station is 200 km SW from Fukushima. The radiation levels detected are low in the global scale.

Operational experience of CTBTO (Fukushima)

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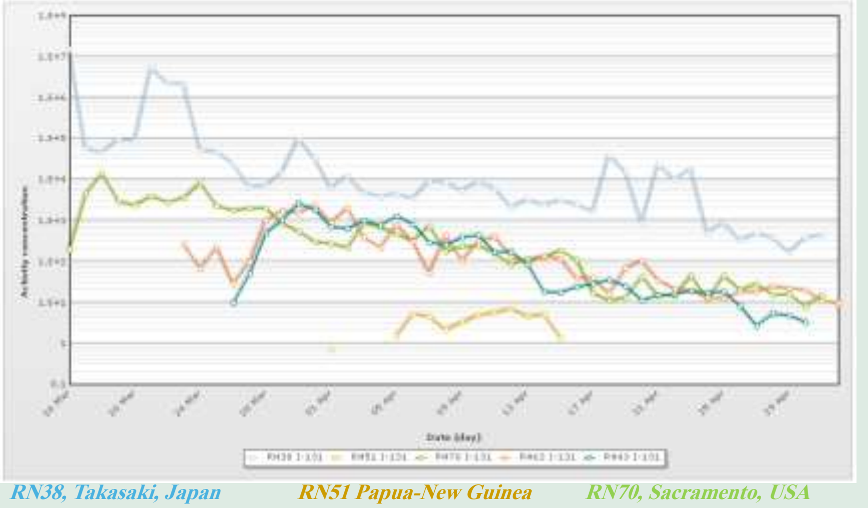
Detected activity concentrations of I-131 (µBq/m3)



RN38, Takasaki, Japan *RN51 Papua-New Guinea* *RN70, Sacramento, USA*
RN63, Stockholm, Sweden *RN43, Mauritania*

Public website: www.ctbto.org
Public information: info@ctbto.org

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