CTBTO.ORG

WOSMIP VIII

The Workshop on Signatures of Man-Made Isotope Production

20 - 23 June 2022

CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

A demonstration of CTBTO's high-resolution ATM in identifying the possible source region: the DPRK 2013 case

Anne Tipka, Robin Schoemaker, Jolanta Kuśmierczyk-Michulec, Yuichi Kijima, Martin Kalinowski

CTBTO/IDC/SA

The views expressed herein are those of the author(s) and do not necessarily reflect the views of the CTBT Preparatory Commission.

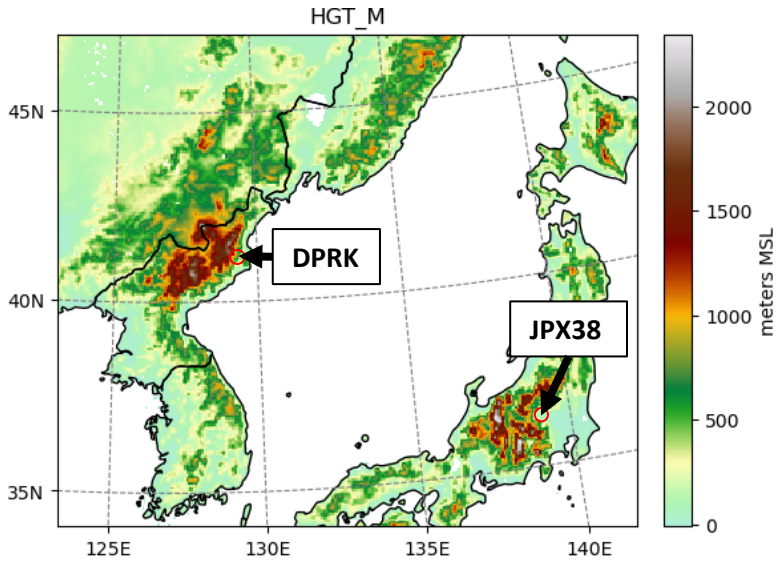
General Aim

To further improve the accuracy in localizing possible source regions for measured elevated values of radioactive substances from nuclear tests and as such increase the capabilities to identify CTBTO's IMS (International Monitoring System) stations that might detect these (hypothetical) released substances.

Background

- Numerical weather models with 0.5° grid size can reproduce observations quite well for **flat terrains**; the source location procedure for such terrains will work adequately.

- Local atmospheric dynamics in the lower planetary boundary layer across **complex terrains**, however, requires higher resolution modelling to improve the localization of transported quantities. *Reason: turbulent phenomena and special effects due to elevations, coastlines, textures as forests and cities, etc.*

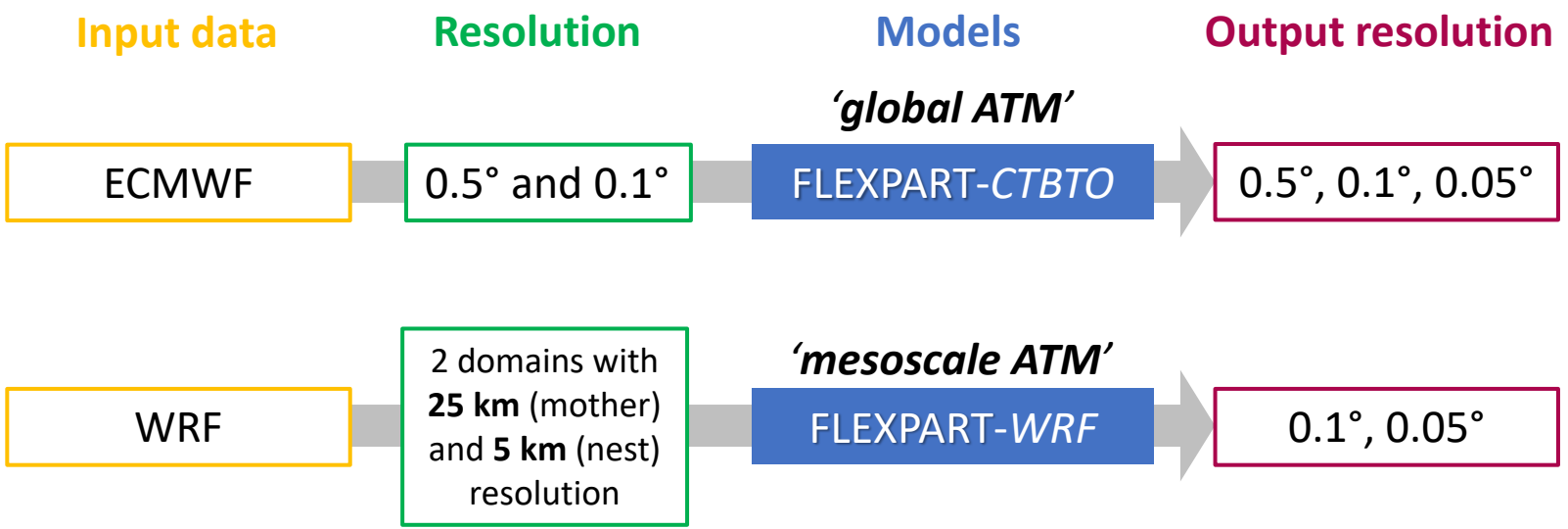


Elevations from green to brown.

Methodology

- Use data from different weather models (ECMWF, WRF) as meteorological input for two adapted versions of the atmospheric transport model FLEXPART.
- Conduct a sensitivity study on combinations of input and output spatial resolutions for meteorological data for FLEXPART.
- Compare model results against each other in the DPRK 2013 case study and investigate sample association in this regard.

(High-resolution) atmospheric transport modelling *(HR)ATM*

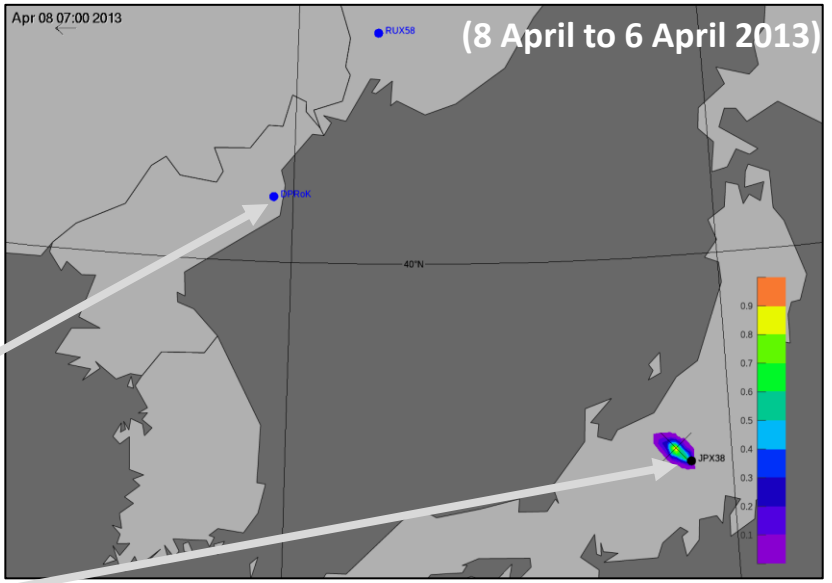


0.05° ≈ 5.5 km

Case study: DPRK 2013

For the DPRK 2013 case study, a first example of a possible source region (PSR) computed based on high-resolution ATM backward-runs.

- The event in question was the announced 2013 underground test of the Democratic People's Republic of Korea (DPRK). The source region is the Punggye-ri Nuclear Test Site.
- We investigate 3 (Level C) + 2 (Level B) radioxenon observations at JPX38 considered to have originated from this event.



collection stop times of samples

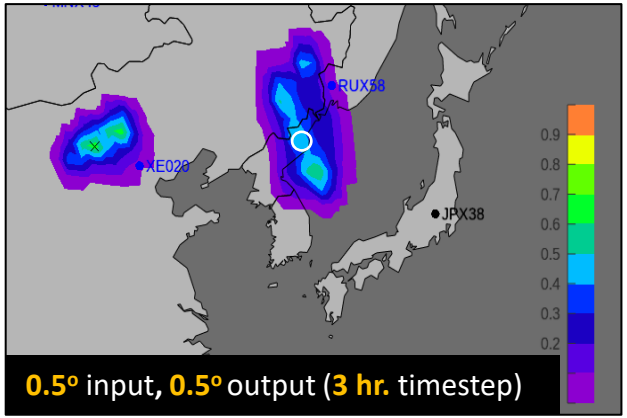
08/04/2013 07 UTC
08/04/2013 19 UTC
09/04/2013 07 UTC

See A. Ringbom, et al., "Radioxenon detections in the CTBT international monitoring system likely related to the announced nuclear test in North Korea on February 12, 2013", Journal of Environmental Radioactivity, 128, pp. 47-63 (2014).

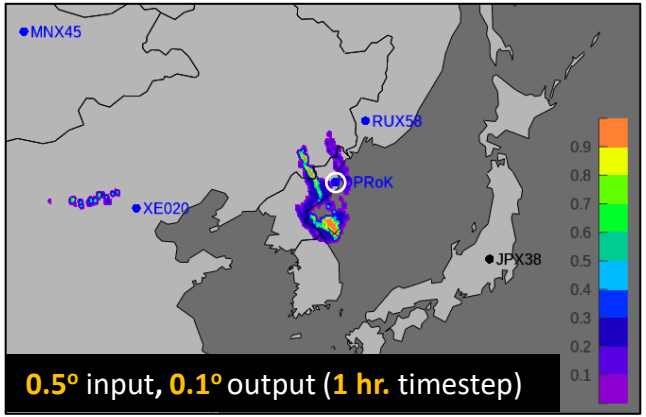
Lo-res and hi-res global ATM PSR

Spearman's Rank algorithm with Correlation / SRS > 0

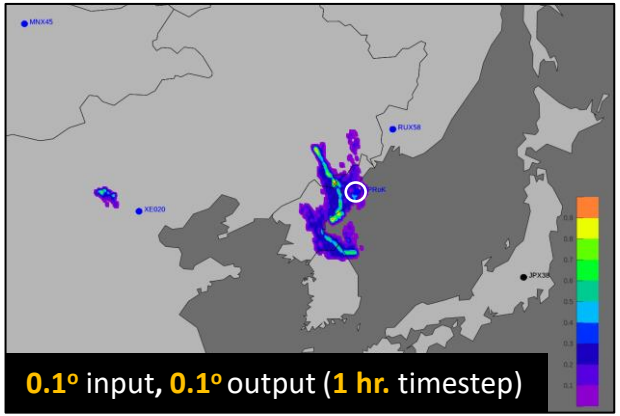
Comparing three options for input data from ECMWF with 0.5° & 0.1° spatial resolution.



0.5° input, **0.5°** output (**3 hr.** timestep)



0.5° input, **0.1°** output (**1 hr.** timestep)

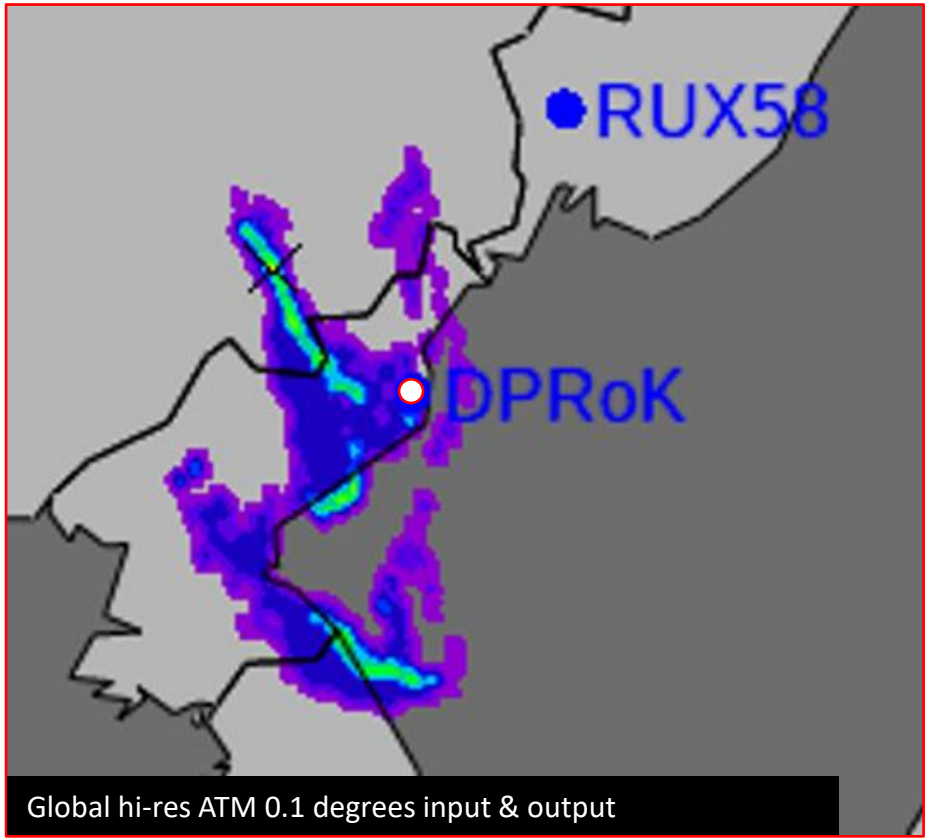


0.1° input, **0.1°** output (**1 hr.** timestep)

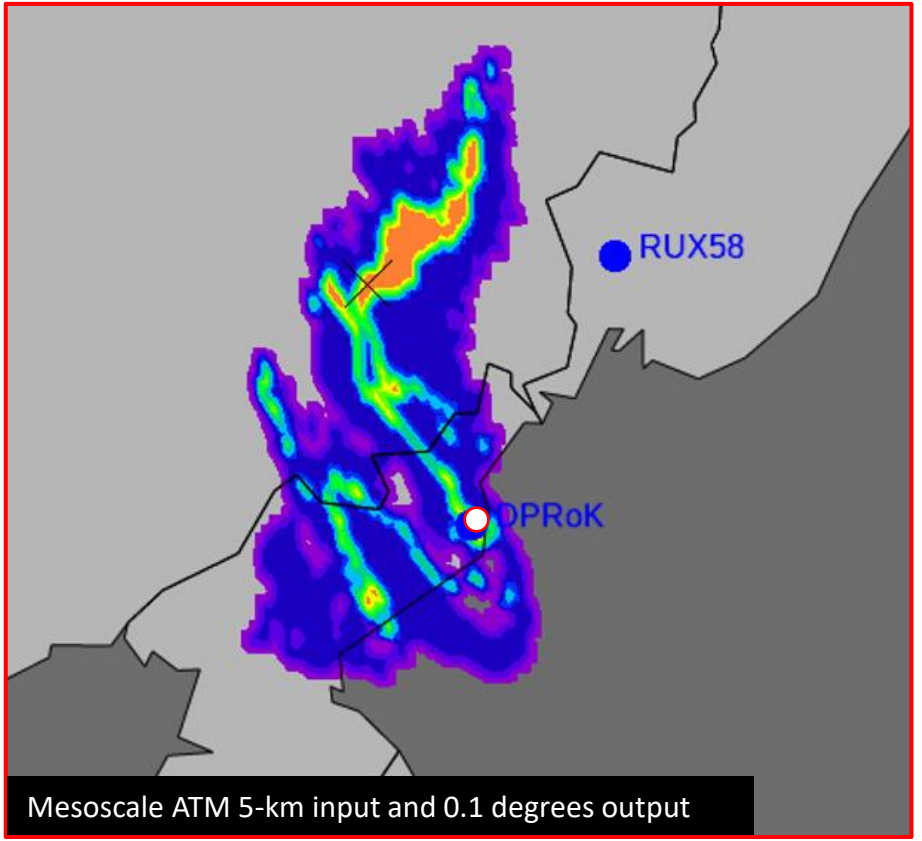
Relevant timestamp: 7 April 2013 at 06:00 hrs. UTC

CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

Global ATM vs Mesoscale ATM PSR for 7 April 2013 at 07:00 hrs. UTC based on three Level C detections at JPX38



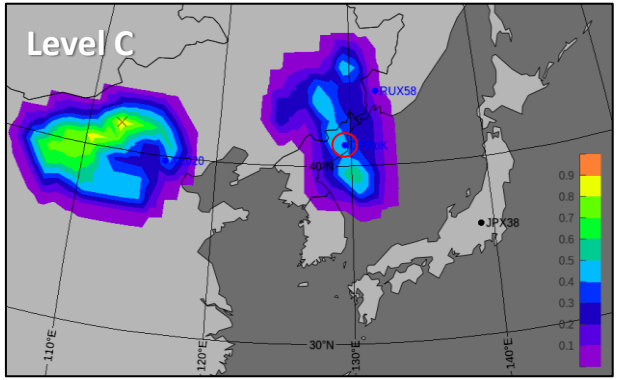
Global hi-res ATM 0.1 degrees input & output



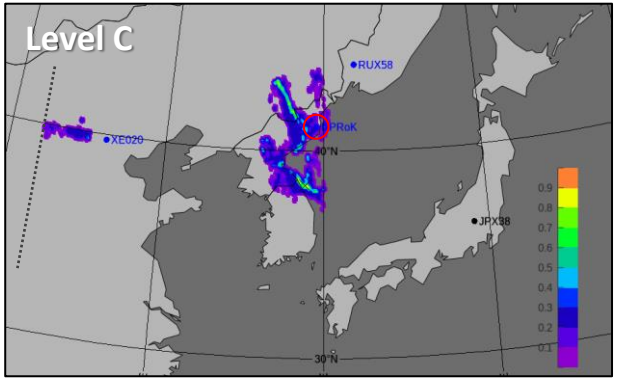
Mesoscale ATM 5-km input and 0.1 degrees output

CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

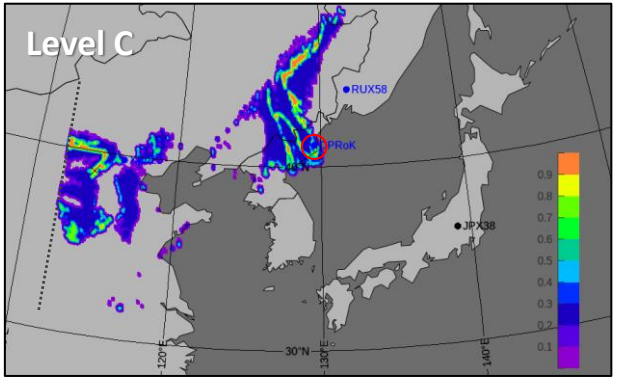
PSRs for sample association with lo-res global ATM (0.5°), hi-res global ATM (0.1°), and mesoscale ATM (0.1°) output data



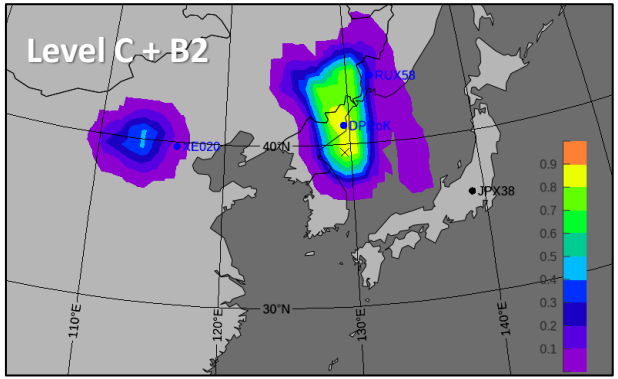
Global ATM: **0.5°** in, **0.5°** out, **3 hr.** step

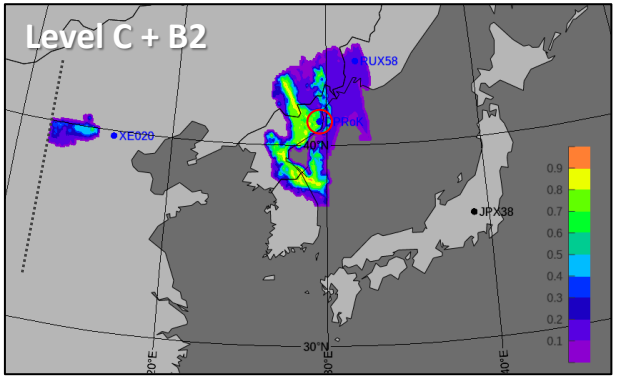


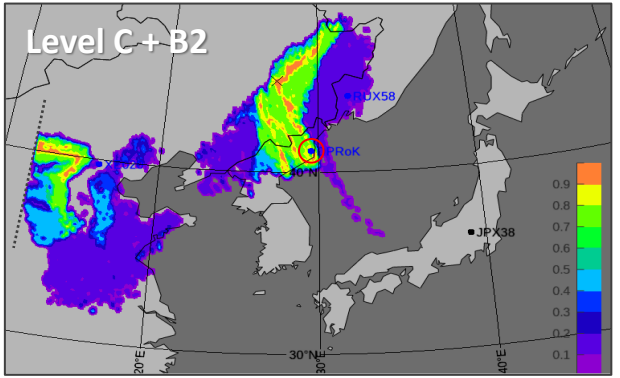
Global HRATM: **0.1°** in, **0.1°** out, **1 hr.** step



Mesoscale ATM: **0.1°** out, **1 hr.** step



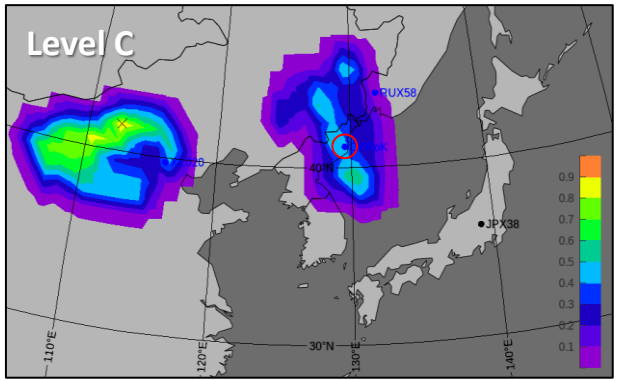




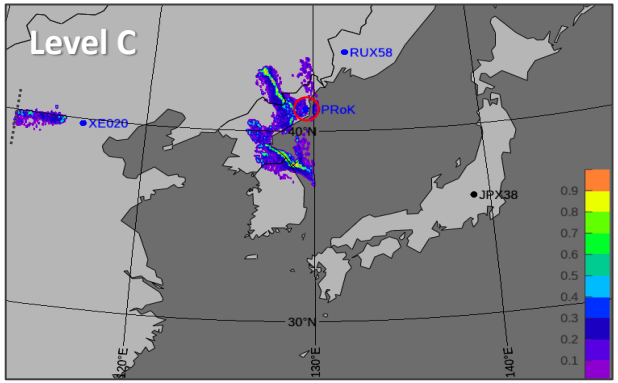
Relevant timestamp for the release event: **7 April 2013** at **06:00 hrs.** UTC

CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

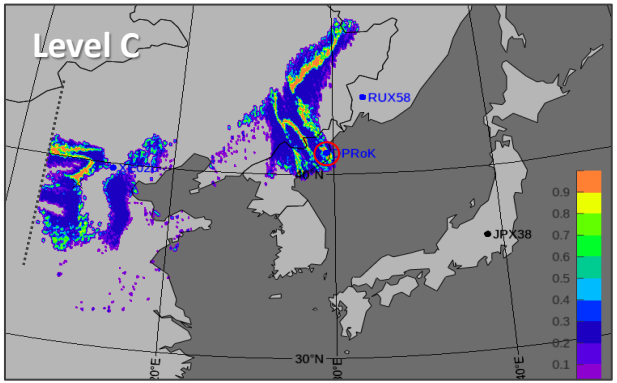
PSRs for sample association with lo-res global ATM (0.5°), hi-res global ATM (0.05°), and mesoscale ATM (0.05°) output data



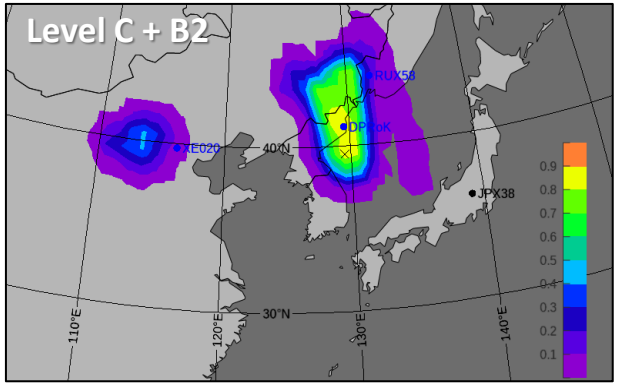
Global ATM: **0.5°** in, **0.5°** out, **3 hr.** step

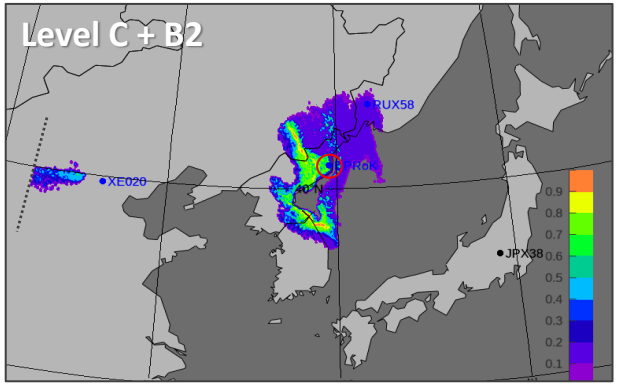


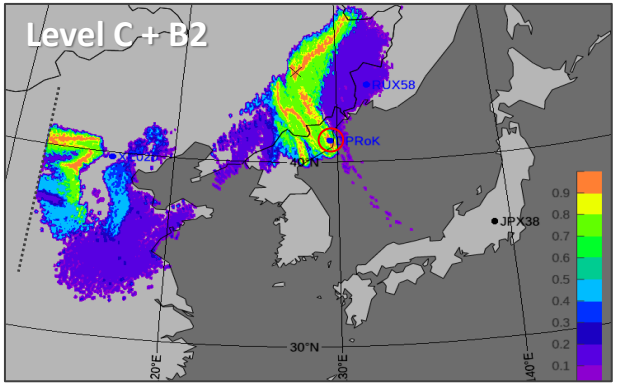
Global HRATM: **0.1°** in, **0.05°** out, **1 hr.** step



Mesoscale ATM: **0.05°** out, **1 hr.** step



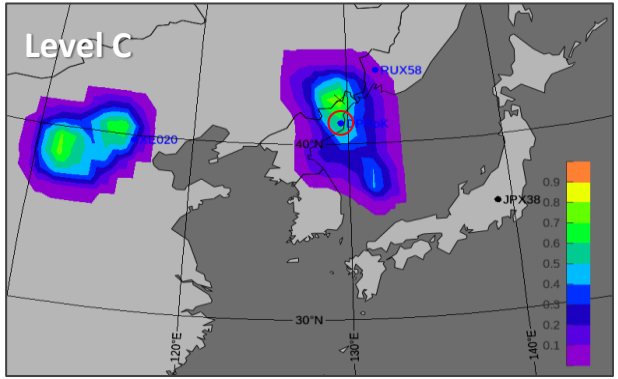




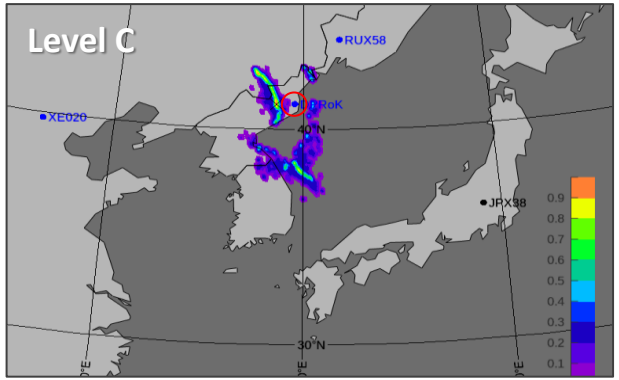
Relevant timestamp for the release event: **7 April 2013** at **06:00 hrs.** UTC

CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

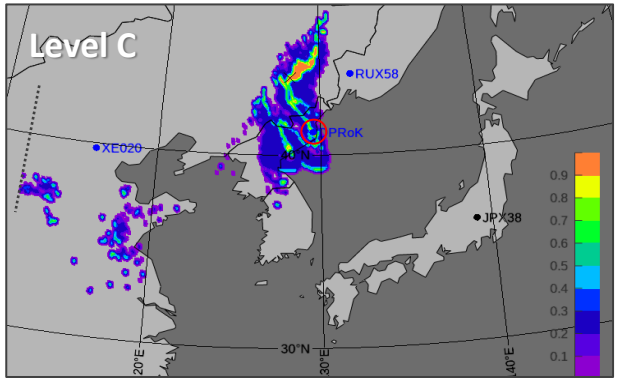
PSRs for sample association with lo-res global ATM (0.5°), hi-res global ATM (0.1°), and mesoscale ATM (0.1°) output data



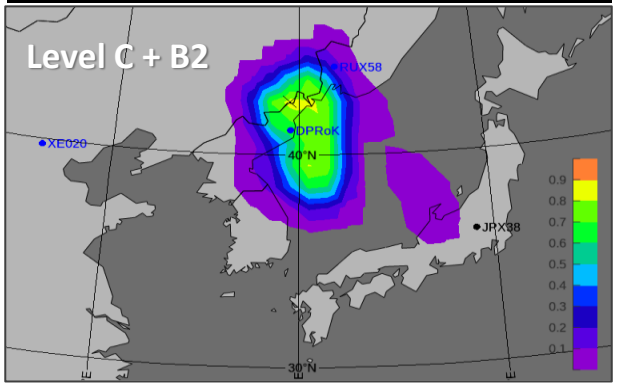
Global ATM: **0.5°** in, **0.5°** out, **3 hr.** step

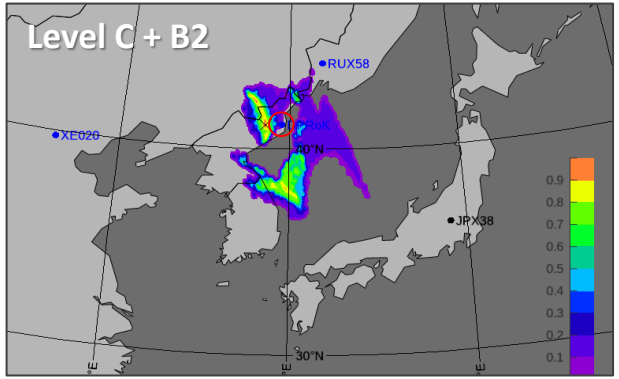


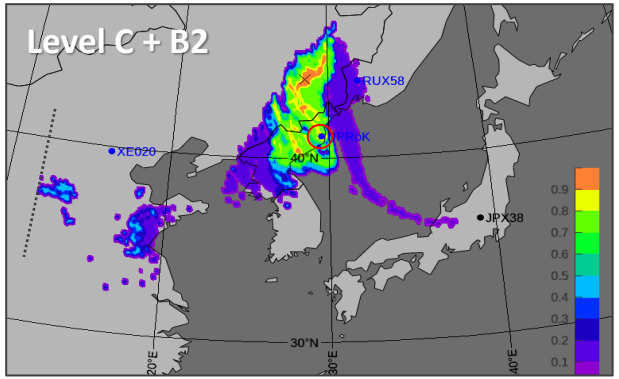
Global HRATM: **0.1°** in, **0.1°** out, **1 hr.** step



Mesoscale ATM: **0.1°** out, **1 hr.** step



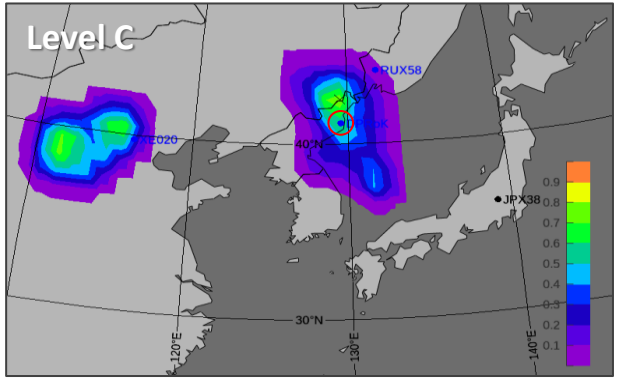




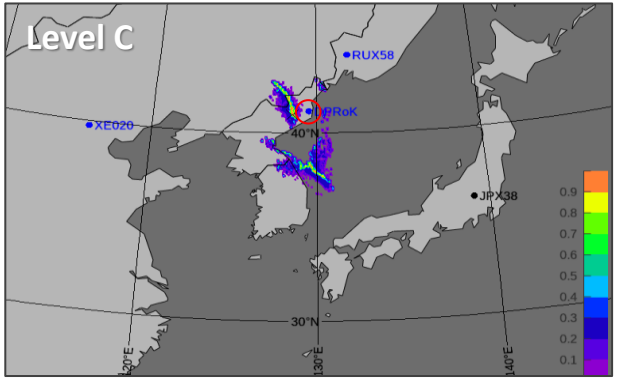
Relevant timestamp for the release event: **7 April 2013** at **09:00 hrs.** UTC

CTBTO PREPARATORY COMMISSION | COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

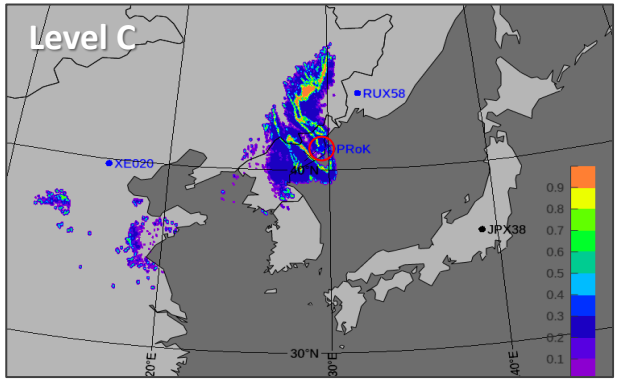
PSRs for sample association with lo-res global ATM (0.5°), hi-res global ATM (0.05°), and mesoscale ATM (0.05°) output data



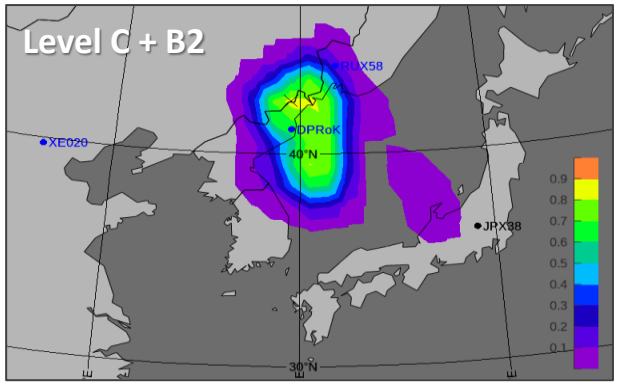
Global ATM: **0.5°** in, **0.5°** out, **3 hr.** step

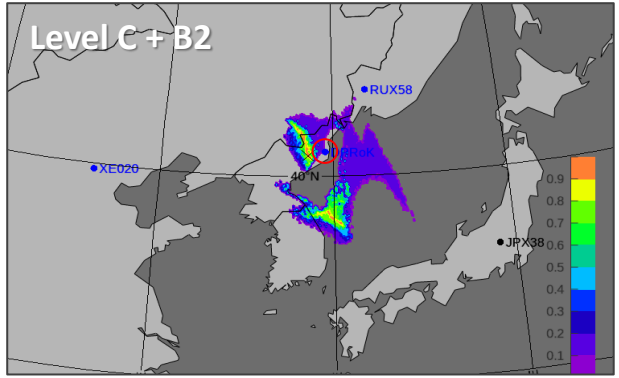


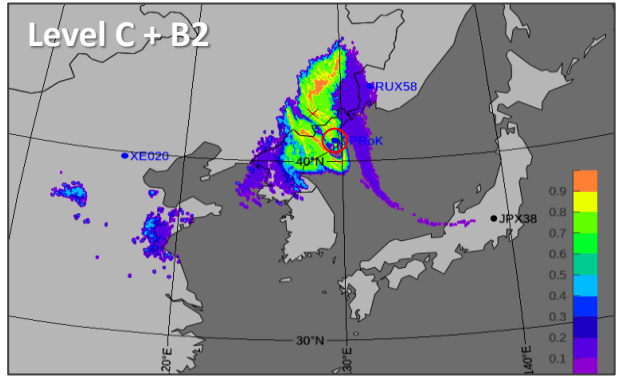
Global HRATM: **0.1°** in, **0.05°** out, **1 hr.** step



Mesoscale ATM: **0.05°** out, **1 hr.** step





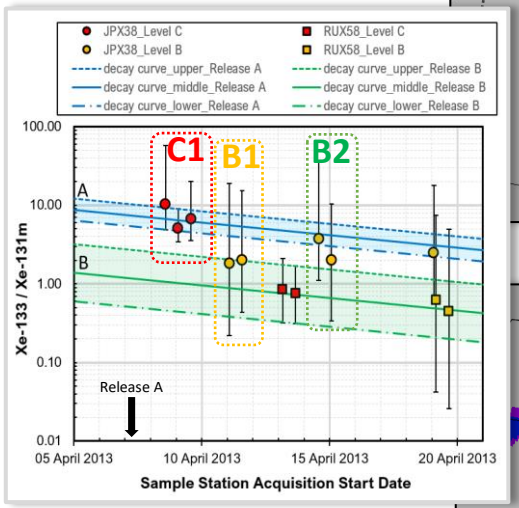


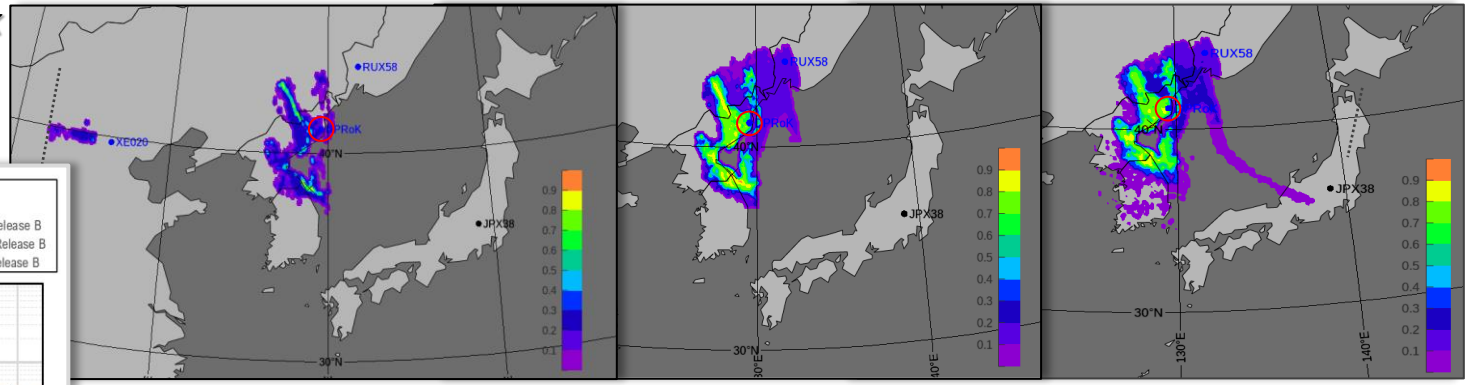
Relevant timestamp for the release event: **7 April 2013** at **09:00 hrs.** UTC

PSRs for sample association with hi-res global ATM (0.1°)

Two different algorithms

Spearman's Rank

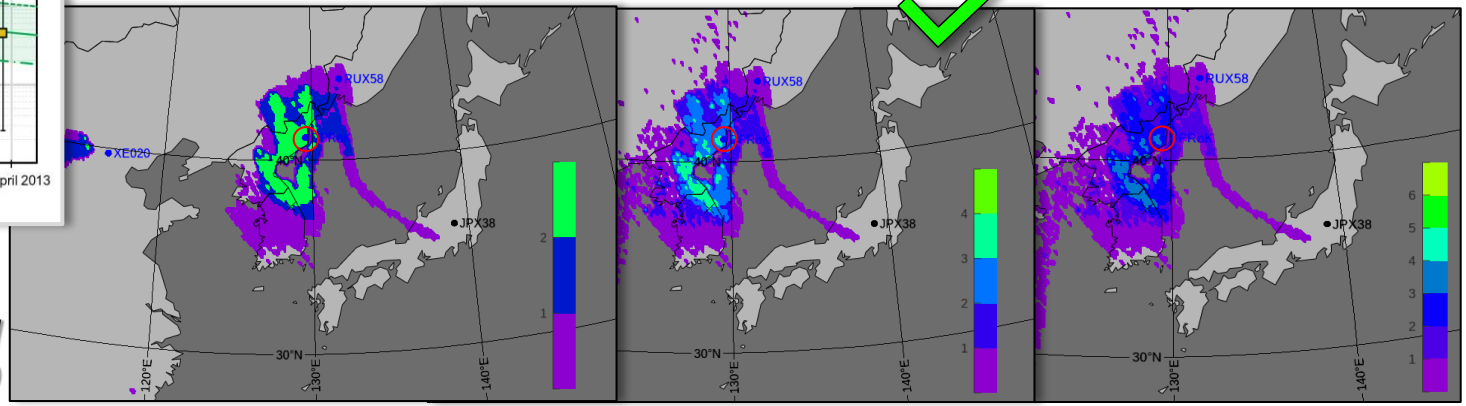




Level C1 | *Level C1 + B2* | *Level C1 + B1 + B2*

# of SRS > Threshold

(# of JPX38 samples that contribute)



Relevant timestamp for the release event: **7 April 2013** at **06:00 hrs.** UTC

Summary & Outline

- Increasing the spatial resolution of the meteorological input data improves the localization process.
- Using a meteorological domain of interest for the FLEXPART-CTBTO simulations only, the computational time can be reduced significantly.
- Currently, the resolution of ECMWF data is limited to 0.1 degrees. Considering mesoscale modelling, using WRF and FLEXPART-WRF for higher spatial resolution, seems to have a favorable impact on a more accurate estimation of the source location.
- The DPRK case study provides first promising results when comparing different higher resolution models (global and mesoscale for complex terrains); sample association benefits as well.
- Further investigations will cover:
  - Exploring the sensitivities due to physical parameterizations in WRF setups.
  - Increasing the spatial resolution in mesoscale ATM to 1 km.
  - Using forward modelling simulations to investigate the capability to locate possible measurements at IMS stations in case of a nuclear test event.

Thank you!

CTBTO
PREPARATORY COMMISSION

Vienna International Centre, PO Box 1200
1400 Vienna, Austria
CTBTO.ORG