Radioactive pollutants and dose

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HYSPLIT Nuclear Applications

"The scientific foundation and inspiration for HYSPLIT's trajectory capabilities can be traced back to 1949, when the Special Project Section (SPS) (ARL's predecessor) of the U.S. Weather Bureau [now NOAA's National Weather Service (NWS)] ***was charged with trying to find the source of radioactive debris*** *originating from the first Soviet atomic test and detected by a reconnaissance aircraft near the Kamchatka Peninsula",* Stein et al. (2015) 10.1175/BAMS-D-14-00110.2)

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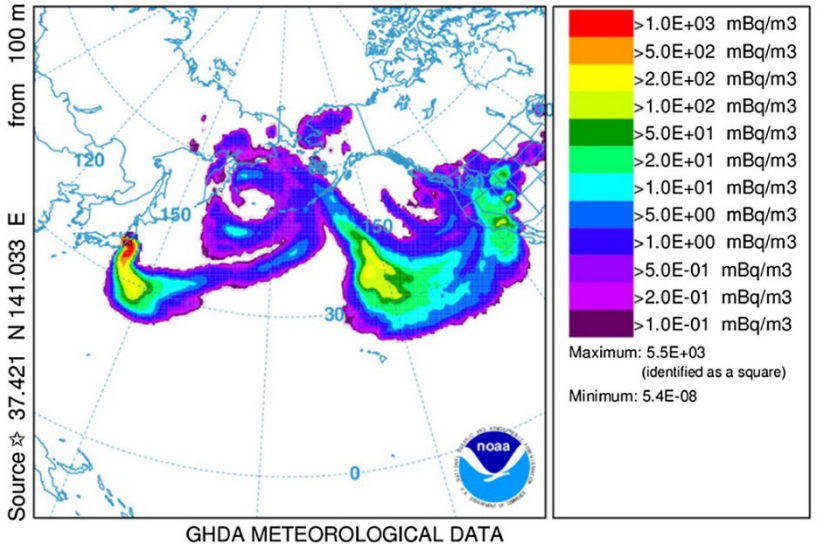
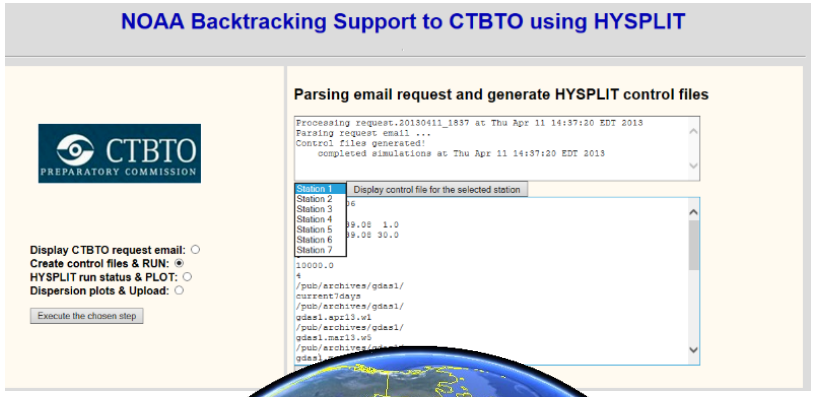
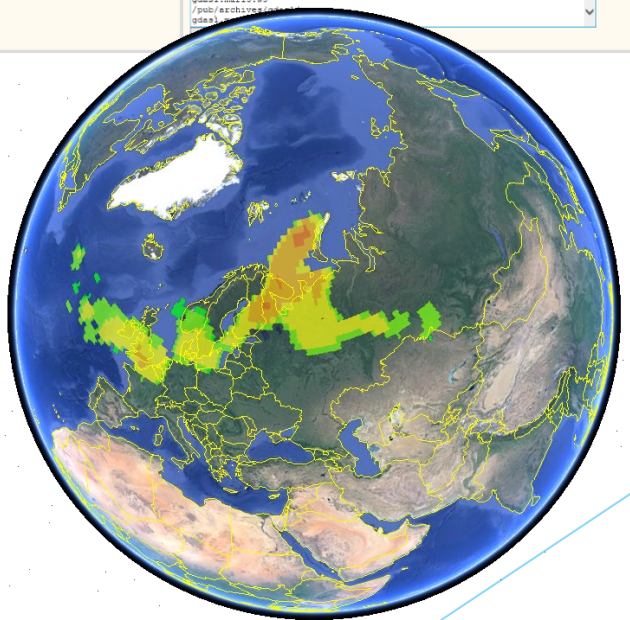


Illustration of particulate cesium-137 concentrations originated from the Fukushima Daiichi reactor. Draxler and Rolph (2012)

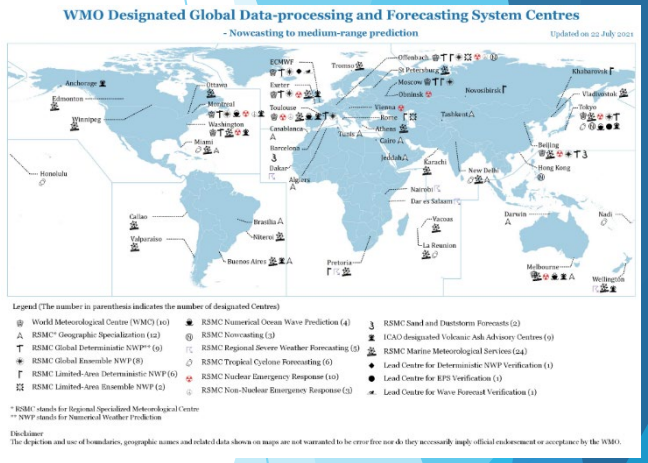
CTBTO On-demand Operation and RSMC Emergency Response activities

NOAA Backtracking support to Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) using HYSPLIT (On-demand Operation)

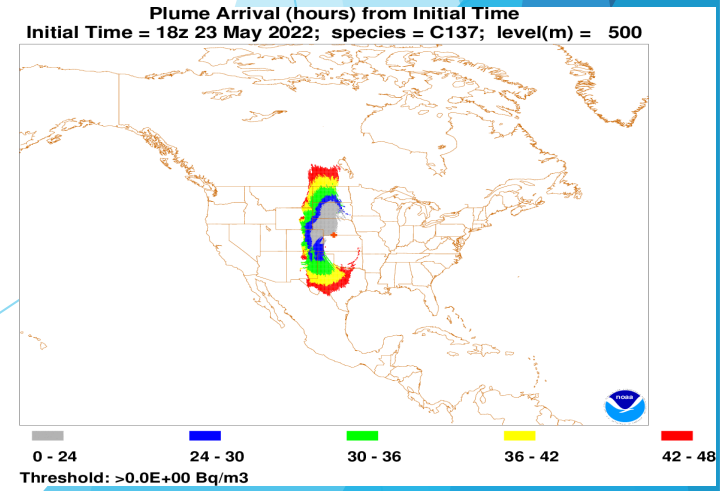




Regional Specialized Meteorological Centres (RSMCs) designated by WMO for Nuclear Emergency Response.



Time of arrival products for RSMCs



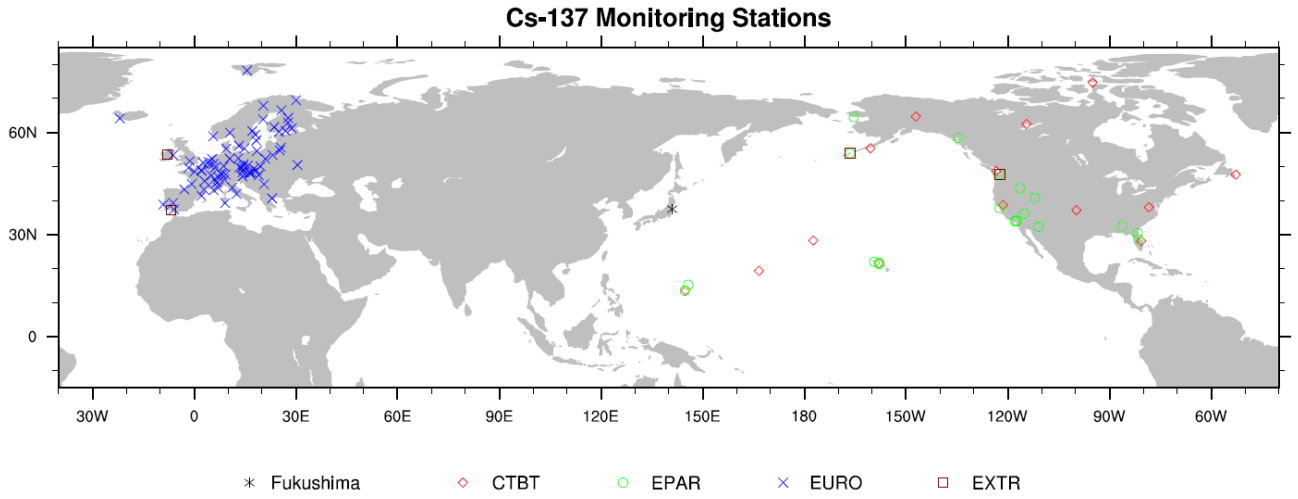
Radioactive pollutants and dose- Notes

- Radioactive decay
  - Calculated during transport or post-processed
- Dose calculation
  - Cloudshine – air concentration
  - Groundshine - deposition
- Using surrogates for multiple radionuclides
- Activity.txt file
  - can be used to calculate total dose from a large amount of radionuclides
- Emissions need to be decay-corrected with a reference time (e.g. reactor shutdown time)
- TCM approach may be needed for forecasts

Transfer Coefficient Matrix approach

- The simulation is divided into smaller time segments and each segment is an independent calculation using a unit source emission.
- The set of calculations for all emission times is defined as the Transfer Coefficient Matrix (TCM).
- When quantitative results are required, the actual air concentrations and depositions are computed in a simple post-processing step by multiplying the TCM by the appropriate time-varying emission rates and radioactive decay constant for each relevant radionuclide.
- Allows updated forecasts to be quickly produced when new emissions estimates are made available

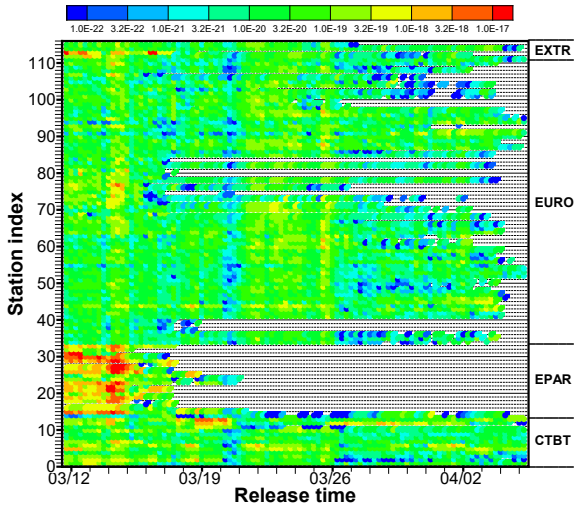
Fukushima source term estimation using TCM

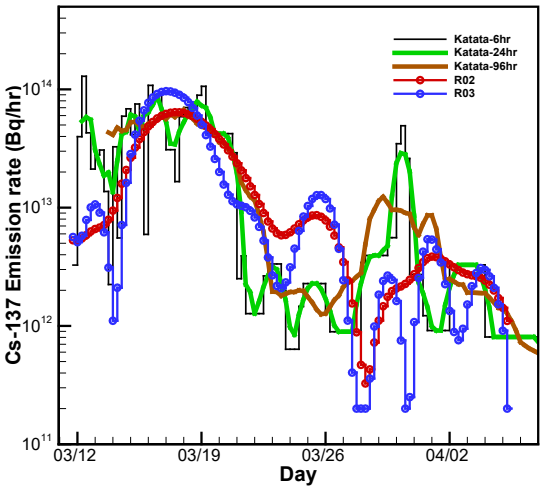


Data source	Number of monitoring stations	Count of total samples
CTBT	14	417 (421)
EPAR	19 (20)	35 (39)
EURO	78 (80)	785 (797)
EXTR	4	59 (61)
Total	115 (118)	1296 (1318)

Transfer coefficient matrix (TCM)

$$\begin{pmatrix} c_1^h \\ c_2^h \\ \vdots \\ c_M^h \end{pmatrix} = \begin{pmatrix} H_{1,1} & H_{1,2} & \cdots & H_{1,N} \\ H_{2,1} & H_{2,2} & \cdots & H_{2,N} \\ \vdots & \vdots & \ddots & \vdots \\ H_{M,1} & H_{M,2} & \cdots & H_{M,N} \end{pmatrix} \begin{pmatrix} q_1 \\ q_2 \\ \vdots \\ q_N \end{pmatrix}$$





$$\mathcal{F} = \frac{1}{2}\sum_{t=1}^{T}\sum_{k=1}^{K}\sum_{i=1}^{I}\frac{(q_{ikt} - q_{ikt}^b)^2}{\sigma_{ikt}^2} + \frac{1}{2}\sum_{n=1}^{N}\sum_{m=1}^{M}\frac{(c_{nm}^h - c_{nm}^o)^2}{\epsilon_{nm}^2} + \mathcal{F}_{other}$$

Source term estimation using air concentration measurements and a Lagrangian dispersion model–Experiments with pseudo and real cesium-137, T Chai, R Draxler, A Stein – *Atmos. Environ.*, 2015