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Comparison of modelled atmospheric radionuclides from the Fukushima Dai-ichi nuclear accident with CTBTO station measurements

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ABSTRACT

The global atmospheric dispersion and deposition of radionuclides released from the Fukushima Dai-ichi nuclear power plant accident was modelled using the EMAC atmospheric chemistry – general circulation model at different resolutions (equivalent to ~50 km and ~110 km Gaussian grid).

The model accounts for emissions and transport of the radioactive isotopes ^{131}I and ^{137}Cs, and removal processes through precipitation, particle sedimentation and dry deposition.

In addition, we simulated the release of ^{133}Xe, a noble gas that can be regarded as a passive transport tracer of contaminated air.

Modelled surface concentrations were compared to station observations by the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) global monitoring network for a number of stations through the CTBTO Virtual Data Exploitation Centre.

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INTRODUCTION

Scientific application of the data used for test ban verification from CTBTO International Monitoring System (IMS).

More than 35 radionuclide stations that are part of the IMS have provided information on the spread of radioactive particles and noble gases from the Fukushima accident.

By comparing modelled surface concentrations to station observations by the CTBTO global monitoring network after the Fukushima NPP accident, we can:

- **Obtain observational constraint** on aerosol lifetimes provided by radionuclide measurements **to evaluate model performance**

- **Evaluate impacts** by estimating global deposited radioactivity:
  In particular the isotopes of iodine and caesium adversely affect human health through the large-scale contamination of air, water, soils and agricultural products

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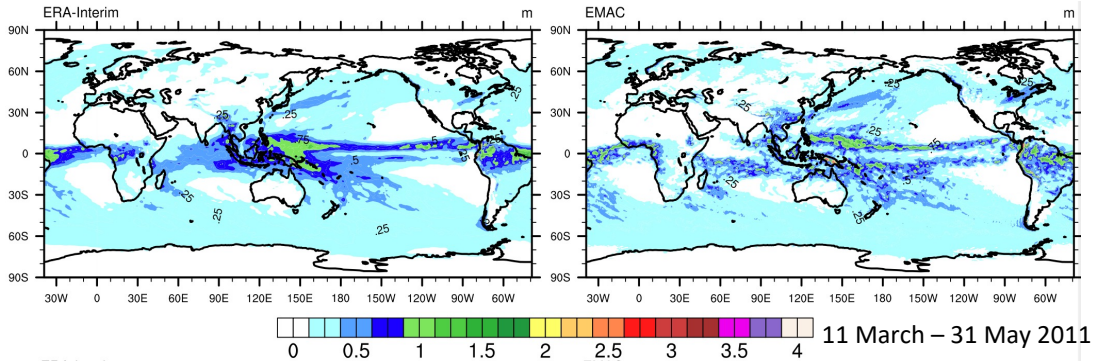
METHODS

EMAC (ECHAM5/MESSy) Global Model

www.messy-interface.org

- **Resolution**: 50km (0.5°) and 110km (1.1°)
- 31 vertical levels up to 10 hPa
- ECMWF ERA-Interim re-analysis **nudging**
- **Period**: 1st March – 31st May 2011
- **Scavenging** by impaction (below-cloud) and nucleation (in-cloud) by rain and snow/ice
- **Dry deposition**: removal by turbulent transfer onto the earth's surface.
- **Sedimentation**: based on mass of aerosol

ERA-Interim – EMAC Model Precipitation Comparison



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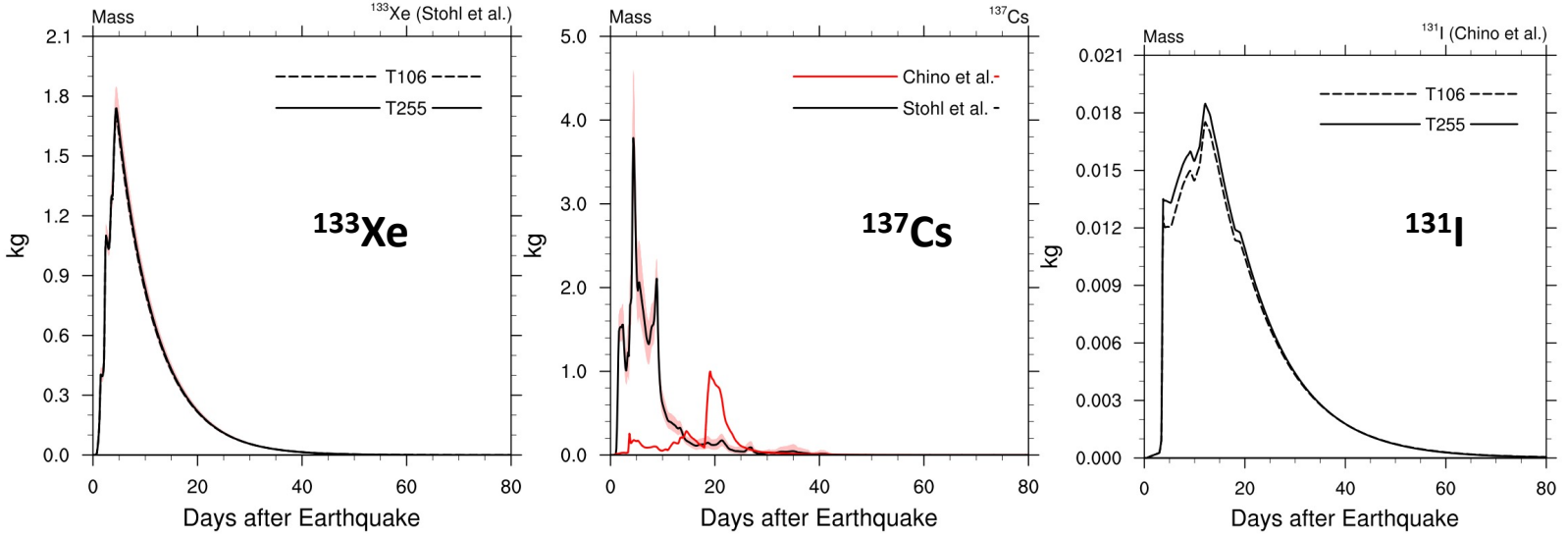
RESULTS



Radionuclide	Model	Half-life	Emissions
^{133}Xe	Passive transport tracer	5.25 days	15.3 EBq (Stohl et al., 2012)
^{137}Cs	Water-soluble aerosol (dry & wet deposition)		13 PBq (Chino et al., 2011) 36.7 PBq (Stohl et al., 2012)
^{131}I	Gas	8 days	150 PBq (Chino et al., 2011)

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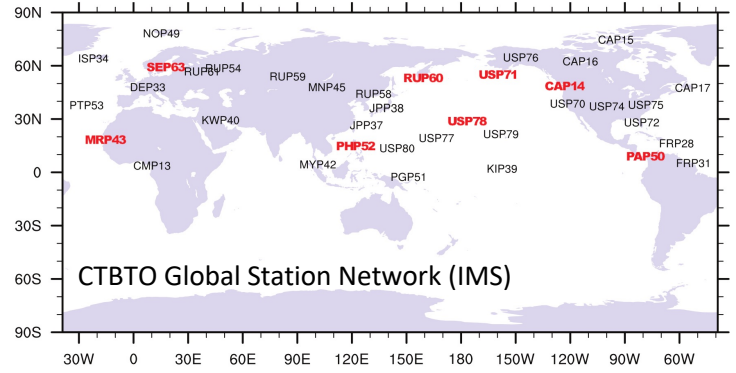
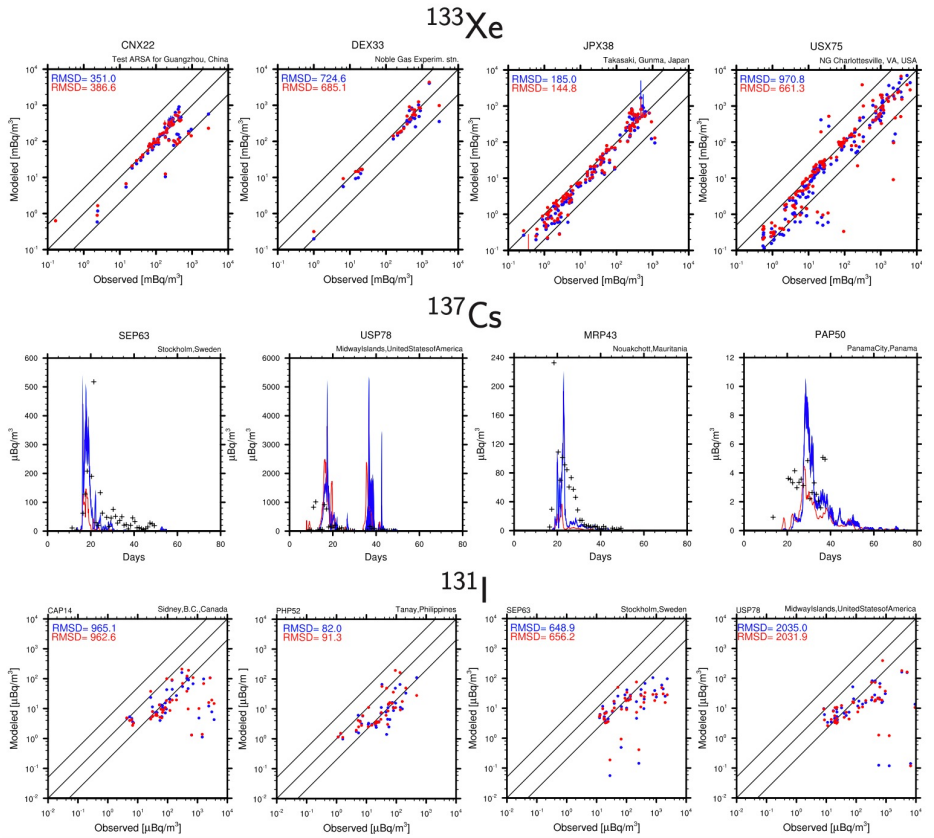


Model represents the Xe and Cs measurements well in the vicinity of the source, but also in North and South America (stations USX75, PAX50, FRX31), and even as far downwind as Germany (DEX33)

Model shows arrival of **high aerosol concentrations in the Asia-Pacific region** (e.g. USP80 at Upi, Guam; PHP52 in Tanay, the Philippines) which are not reflected in the station observations

Even though only 20–50 % of the ^{131}I is captured on the filters, our model underestimates concentrations → **large uncertainty in ^{131}I inventory**



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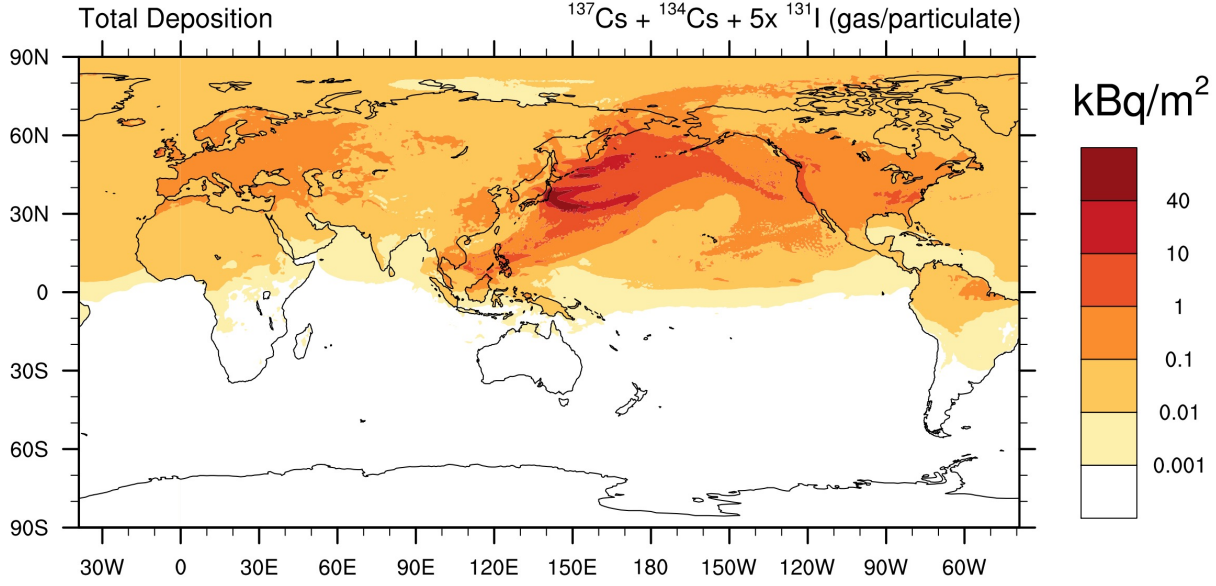

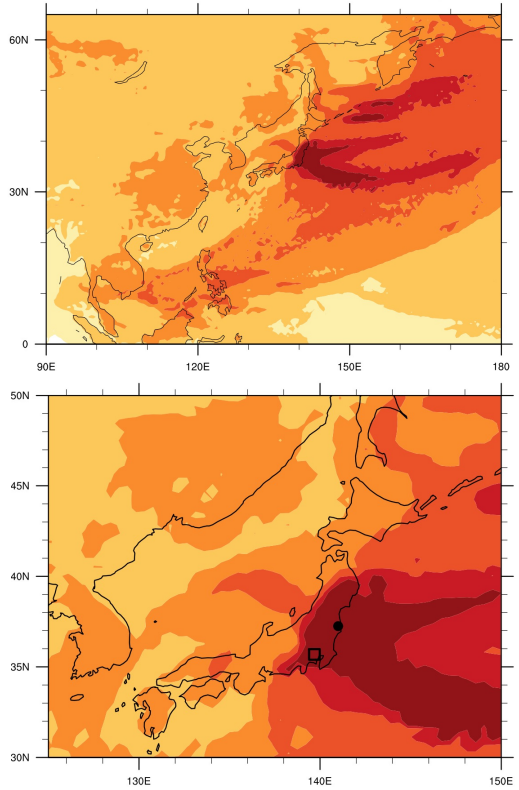

80% of deposition over Pacific Ocean

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CONCLUSIONS

Modelled the global atmospheric dispersion and deposition of radionuclides released from the Fukushima Dai-ichi nuclear power plant accident.

The EMAC global atmospheric chemistry – general circulation model was used, with circulation dynamics nudged towards ERA-Interim reanalysis at 50km resolution.

The calculated model concentrations have been compared to IMS station observations by CTBTO:

^{133}Xe - Excellent model/observations agreement

^{137}Cs - Good agreement within source and model transport, removal uncertainties
→ estimate 80% of radioactivity deposition over Pacific Ocean

^{131}I - Model systematically underestimates observations (factor of 5 uncertainty in source)