Uncertainties of Atmospheric Dispersion Calculations for Emergency Preparedness

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Times are changing…

Previously, there was only one long-range atmospheric dispersion prediction available in real time for emergency preparedness.

And when asked: “How accurate is it?” the meteorologist at hand could at best only give a rough estimate based on hand-waving arguments.

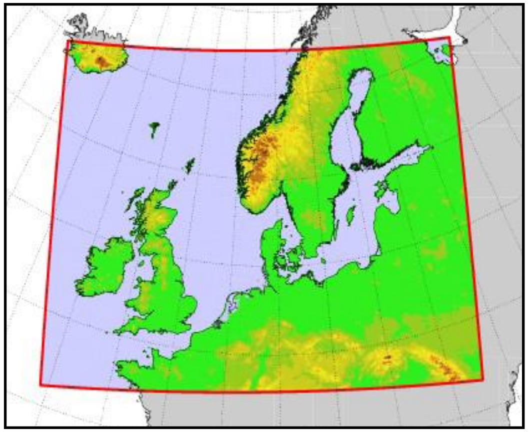
This has now changed.

Trough the development of e new computer-intensive methodology, we can today provide quantitative estimates of the inherent meteorological uncertainty.

Short-range limited-area ensemble weather prediction

Quantify effect of inherent uncertainties from

- Initial conditions (meteorological observations)
- Lateral boundary conditions (outer model)
- Model physics (parameterization of subgrid scale processes)



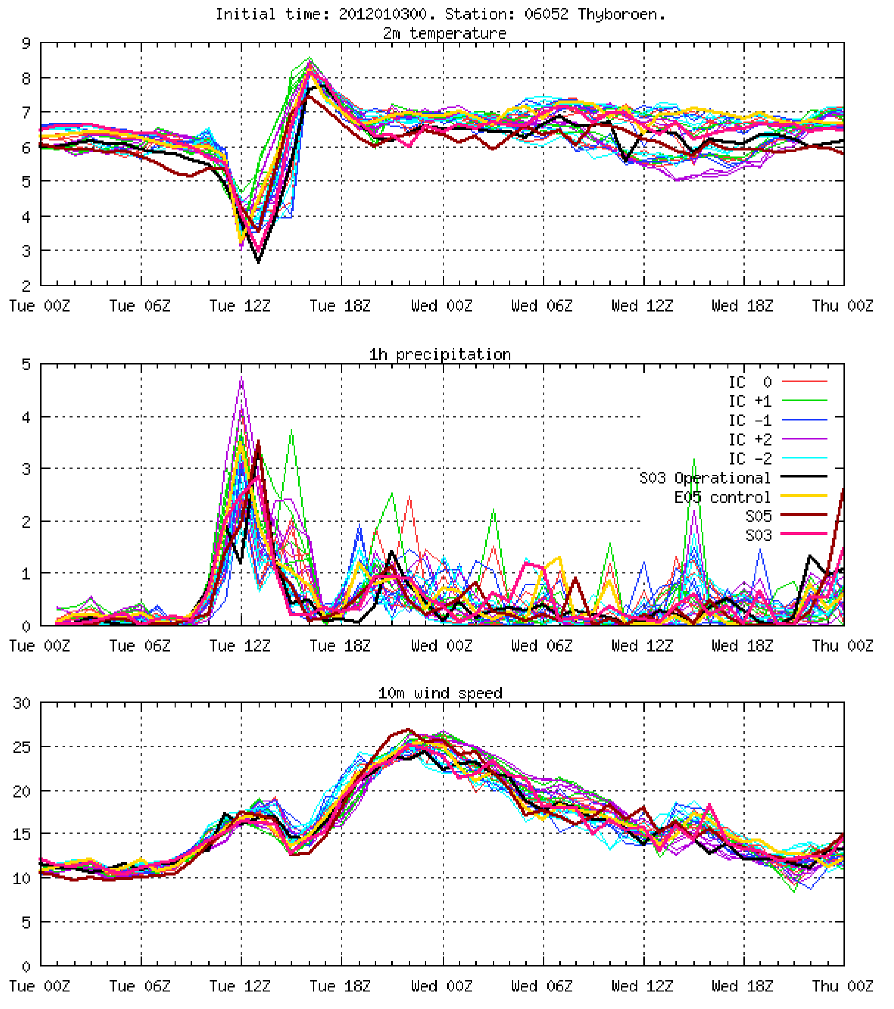
At DMI, ensemble of 25 members

- HIRLAM model
- Four times per day
- 54 h forecast
- Horizontal resolution 0.05°
- 40 vertical levels

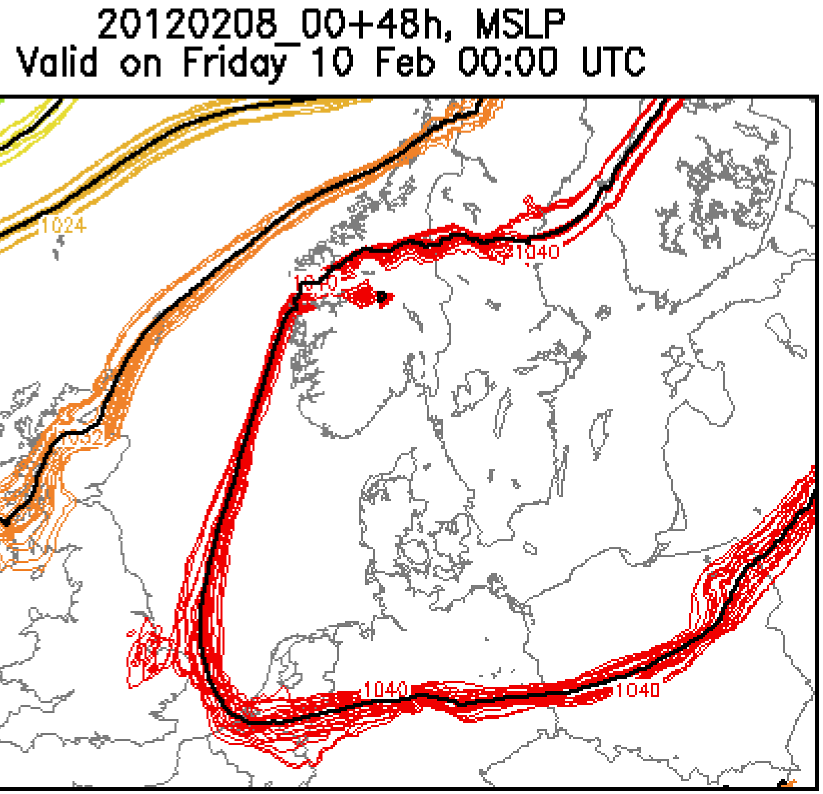
Used operationally mainly for prediction of high-impact weather

The ensemble of meteorological forecasts enables calculation of e.g. probabilities for rain.

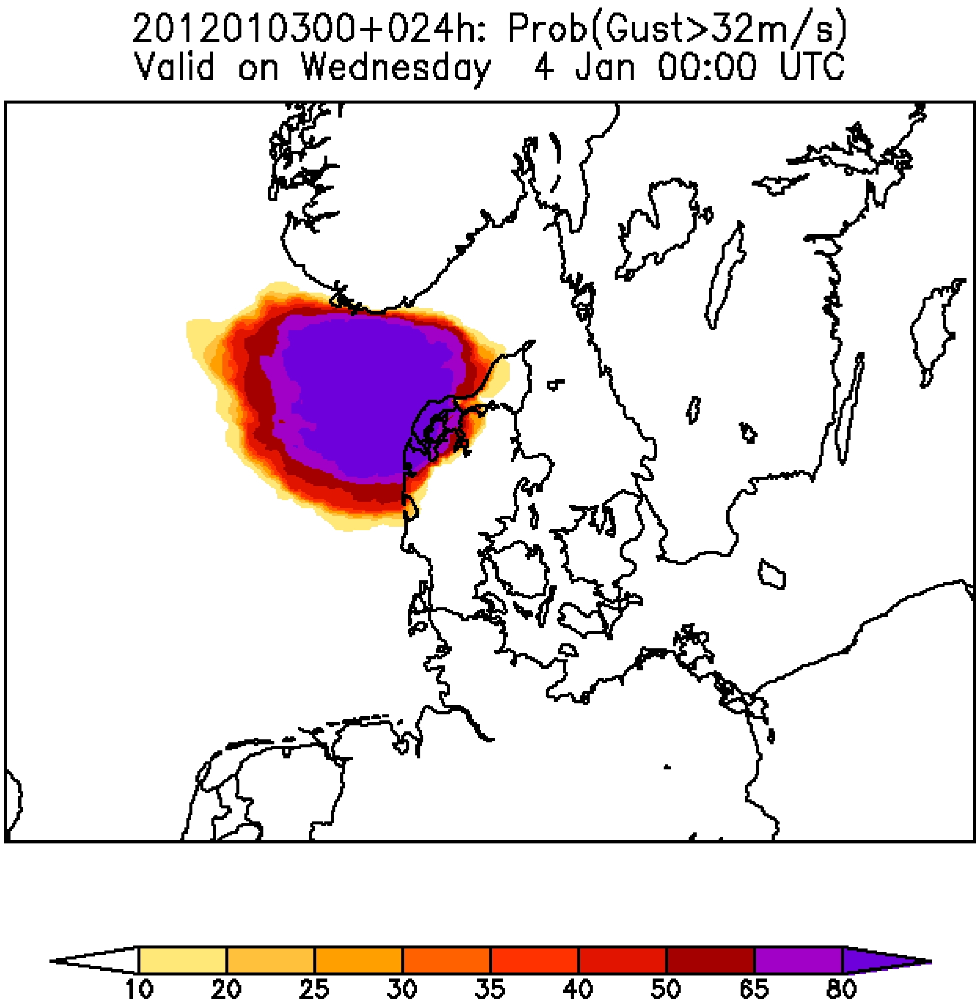
Point location forecasts



Spaghetti plots



Probabilities



Uncertainties of atmospheric dispersion model predictions

Previously, only 'most likely' dispersion scenarios. However, the recent developments in probabilistic forecasting techniques, EPS, can be utilised also for atmospheric dispersion models.

Corresponding ensembles of atmospheric dispersion can be computed from which e.g. uncertainties of predicted radionuclide concentration and deposition patterns can be derived.

How should the uncertainties best be presented to authorities?

Obviously, there are other sources of uncertainty, e.g. on the source term.

DMI

NKS projects

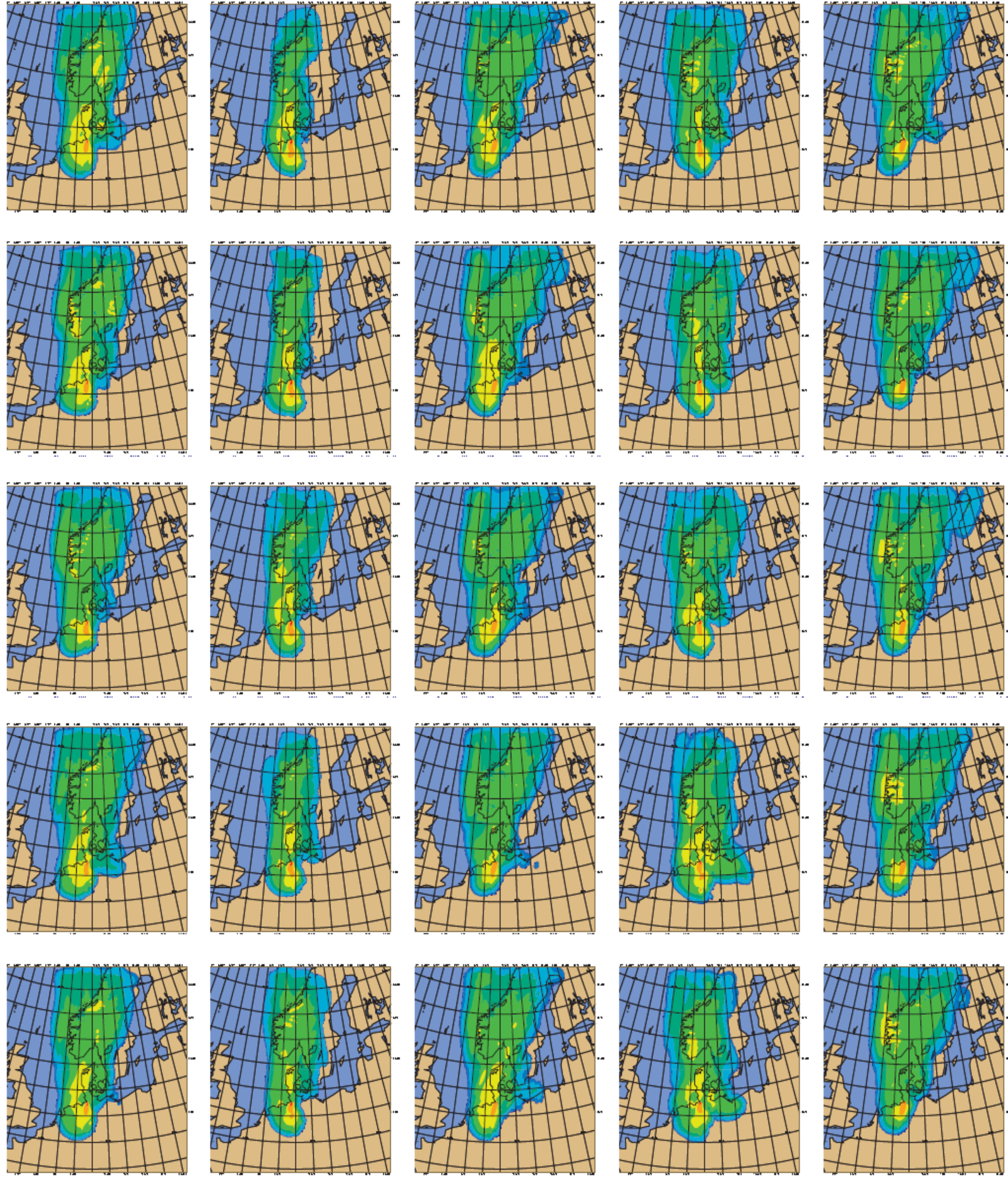
MUD: Meteorological Uncertainty of atmospheric Dispersion model results

FAUNA: Fukushima Accident – UNcertainty of Atmospheric dispersion modelling

Brokdorf

2011-05-23 00

DERMA results



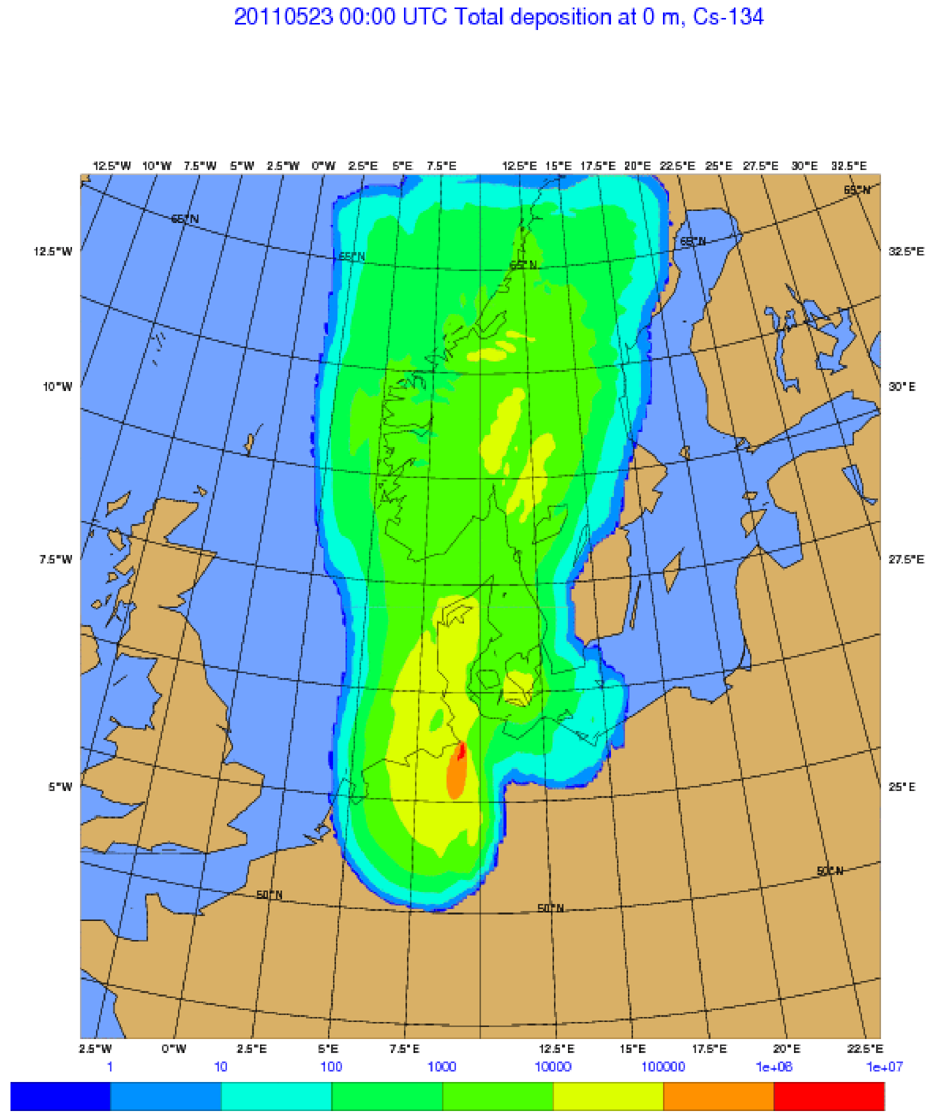
Brokdorf

2011-05-23 00

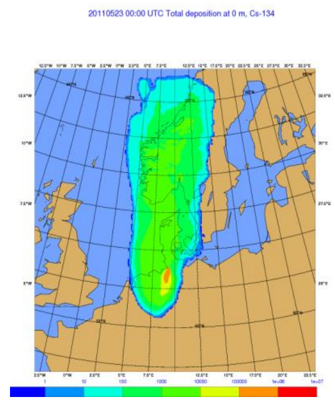
25 ensemble members.

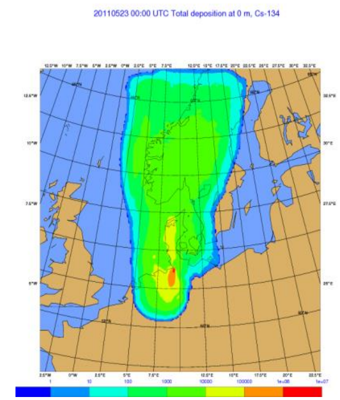
Equally likely representations of reality.

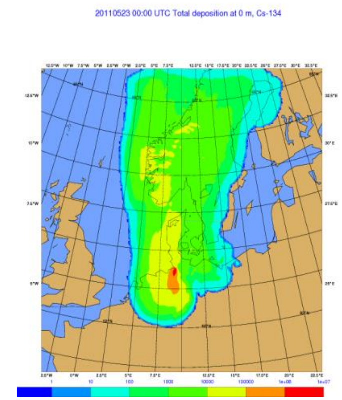
Together, they span the space of possible representations of reality.



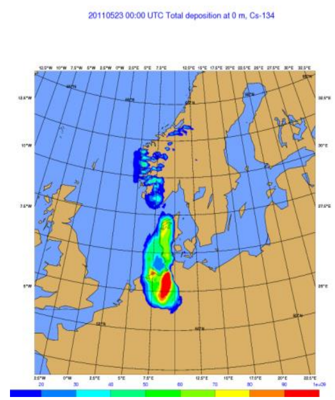
Brokdorf 2011-05-23 Deposition Cs-134



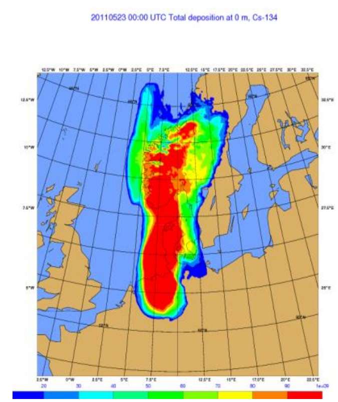




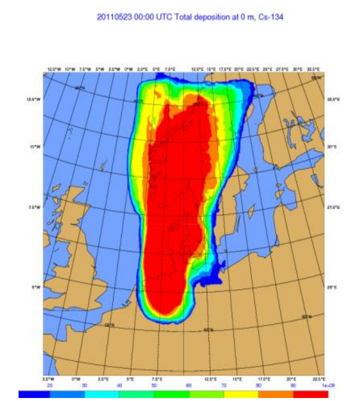
10th percentile | 50th percentile | 90th percentile



$P(c > 10^4 \text{ Bq/m}^2)$

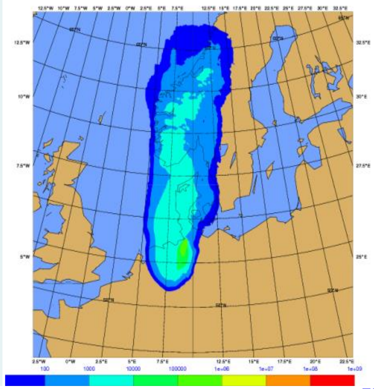
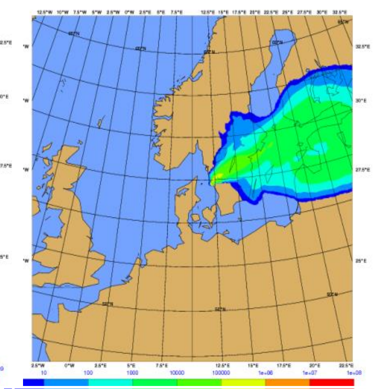
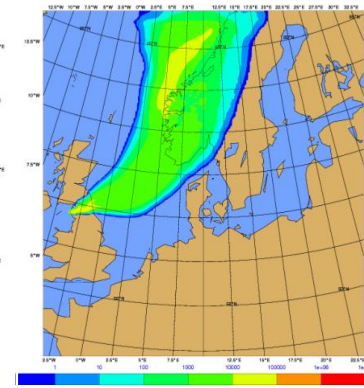
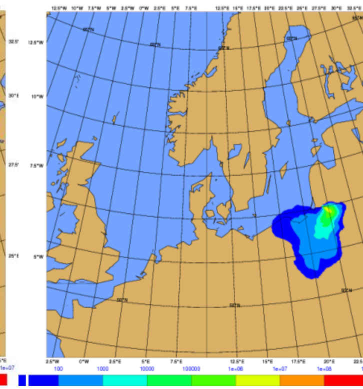
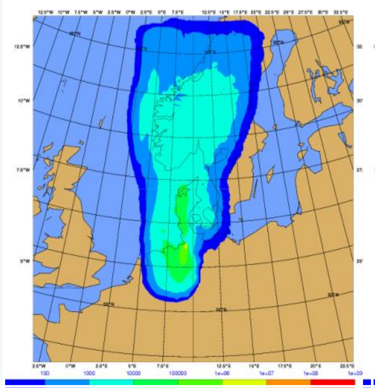
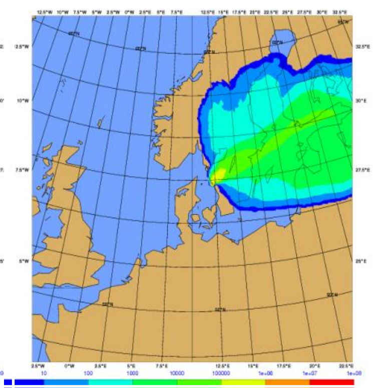
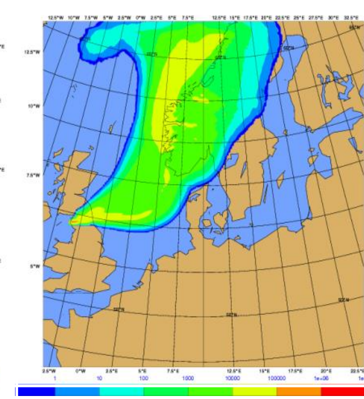
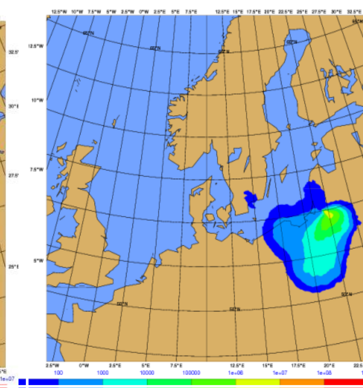
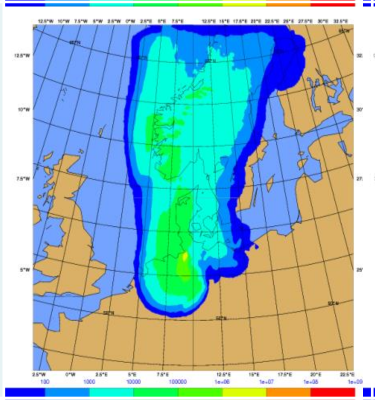
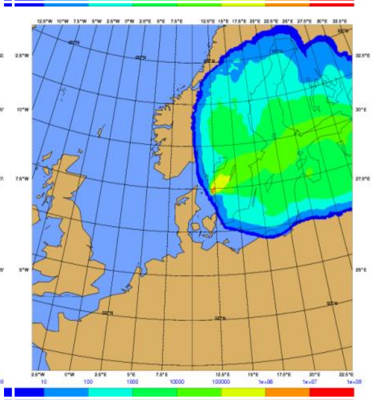
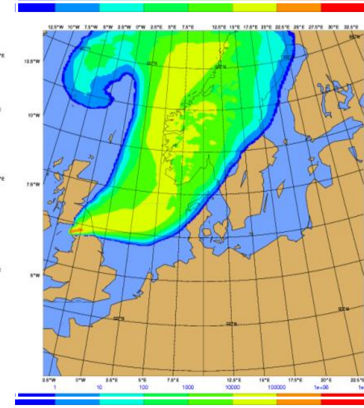
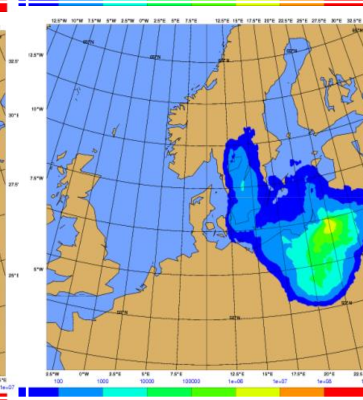


$P(c > 10^3 \text{ Bq/m}^2)$

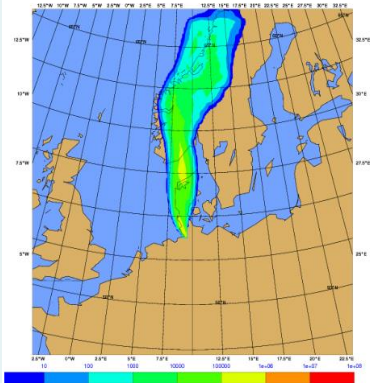
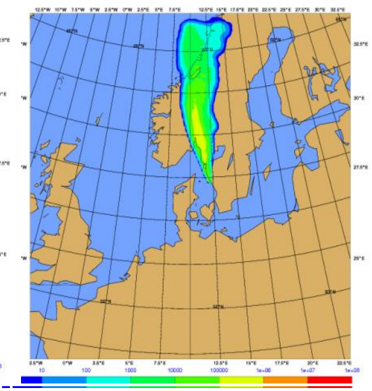
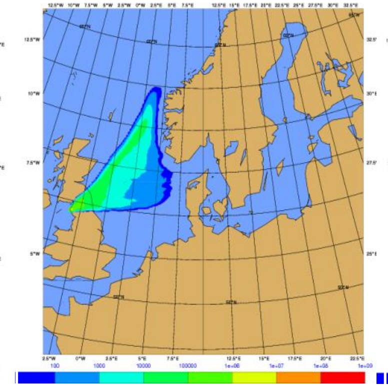
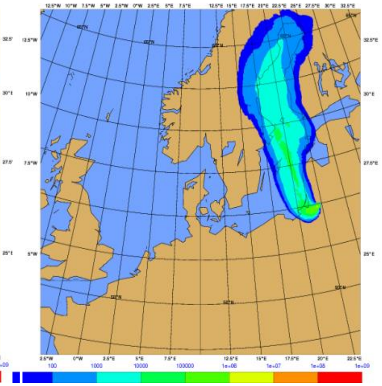
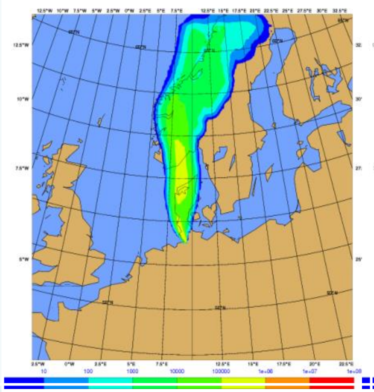
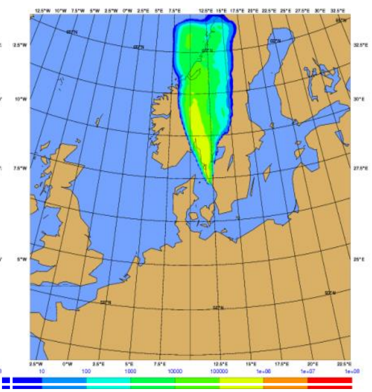
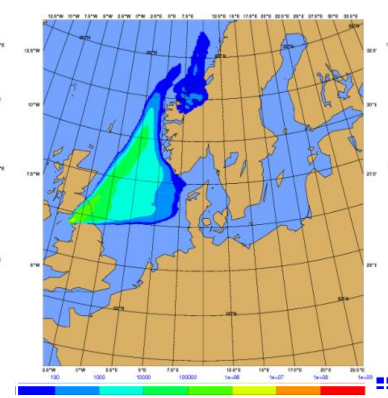
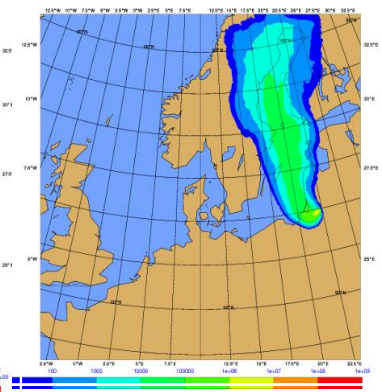
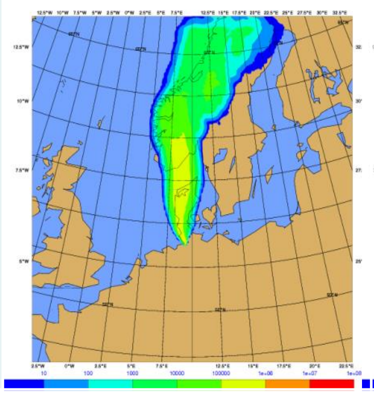
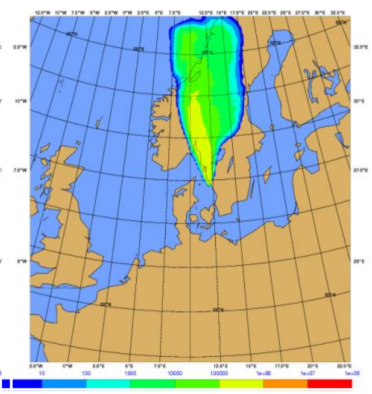
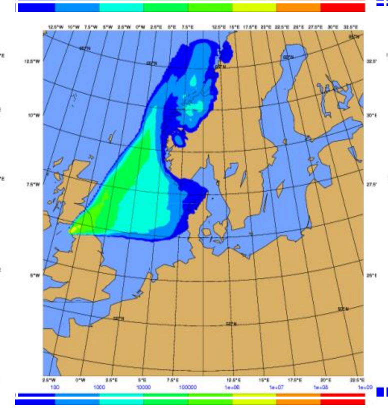
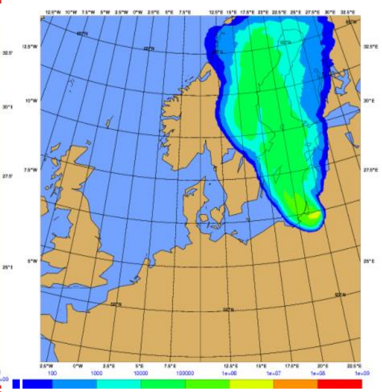


$P(c > 10^2 \text{ Bq/m}^2)$

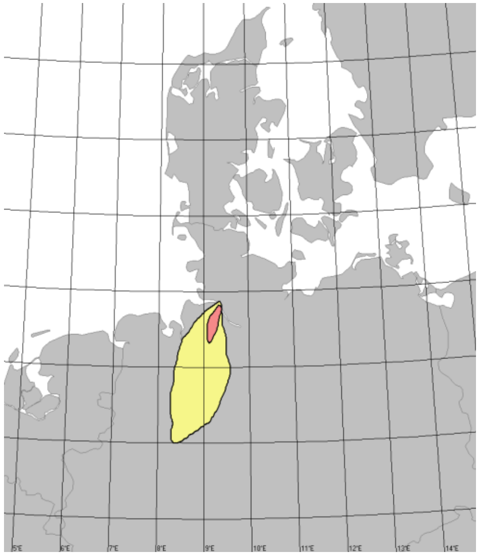
Scenario: 2011-05-23 Field: Deposition Nuclide: Cs-134

	Brokdorf	**Ringhals**	**Sellafield**	**Kaliningrad**
10th percentile				
50th percentile				
90th percentile				

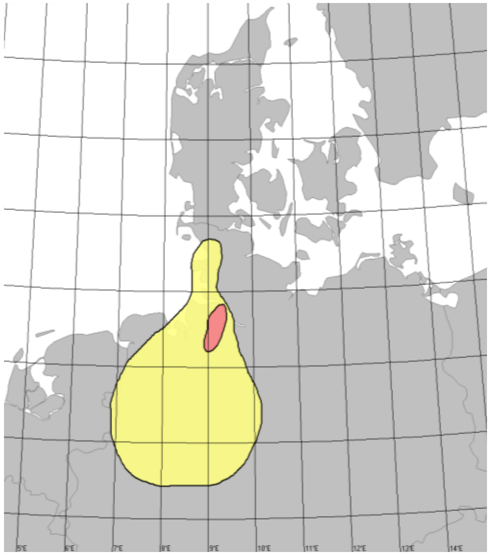
Scenario: 2012-03-09 Field: Deposition Nuclide: Cs-134

	Brokdorf	Ringhals	Sellafield	Kaliningrad
10th percentile				
50th percentile				
90th percentile				

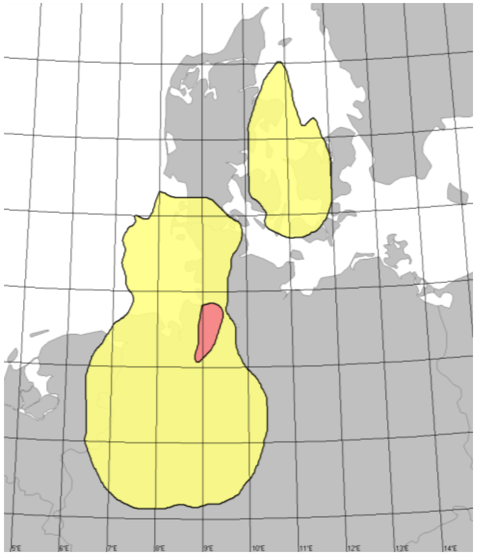
Dose modelling



10th percentile



50th percentile



90th percentile

Scenario: 2011-05-23
Field: Thyroid dose 54 hours after start of release.
Isocurves at 1 and 100 mGy.

The large percentile indicates the maximum area which *can possibly be* influenced by the plume. The real dose pattern will most likely be confined inside this domain.

The low percentile indicates the domain which *will be* influenced with large certainty.

The median indicates the domain which will most likely become influenced.

Operationalization

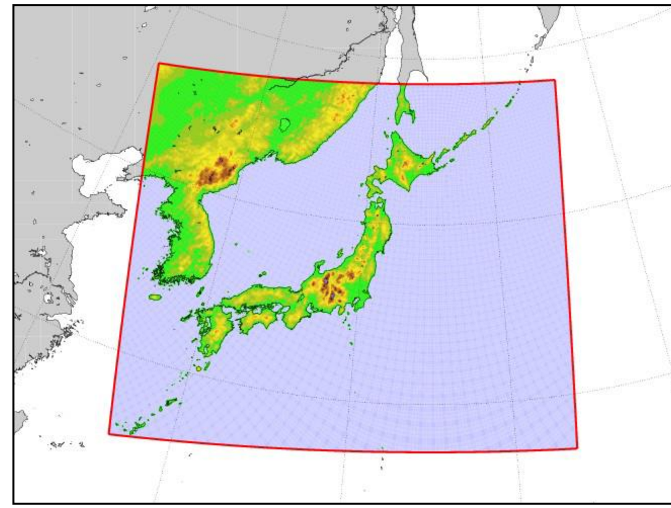
Operational service to DEMA: Since October 2014

To be used through the ARGOS decision-support system

FAUNA Project

Apply the MUD methodology to the Fukushima accident.

Investigate implications for the emergency management.



- A meteorological ensemble forecasting system has been set up for the period and geographical domain of concern. Two-day meteorological forecasts are generated four times a day.

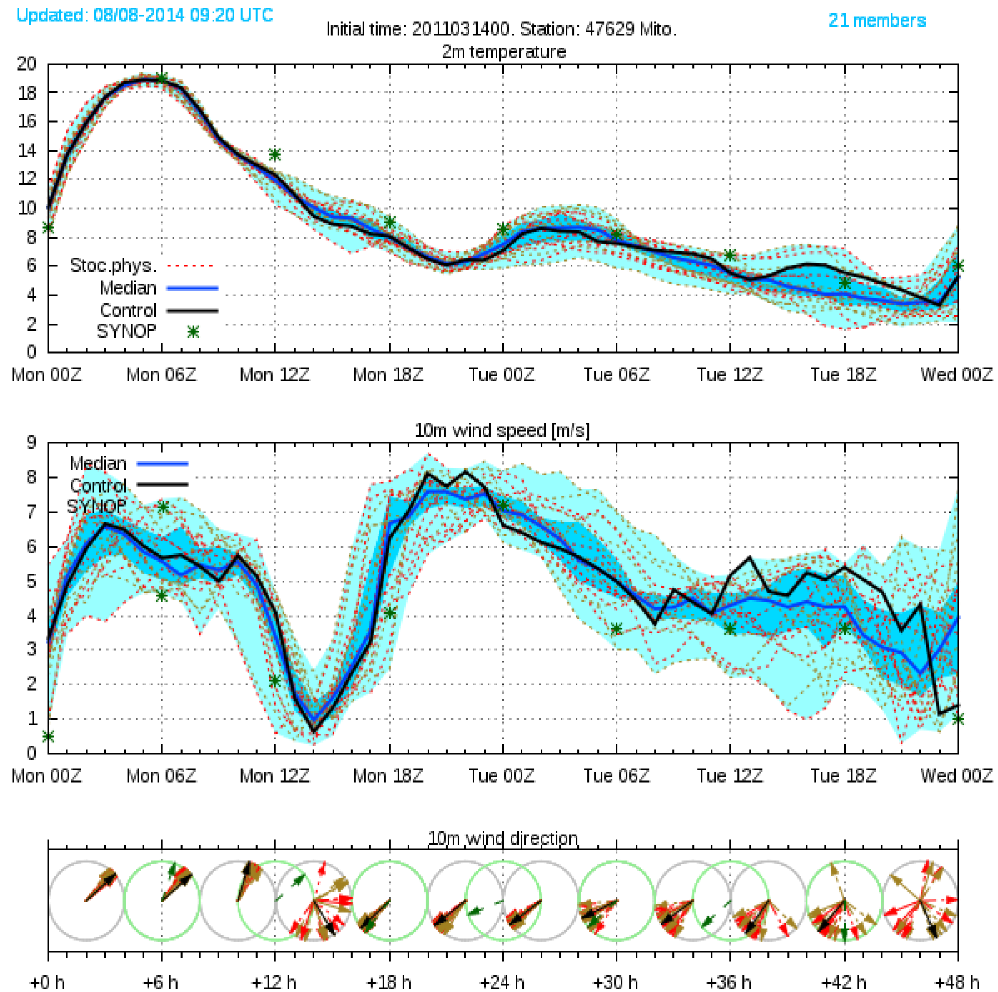
- For selected dates and times in the release period, the long-range atmospheric dispersion models will be run assuming that a *realistic* source term is available in near real time.

- Ensemble-statistical parameters have been calculated.

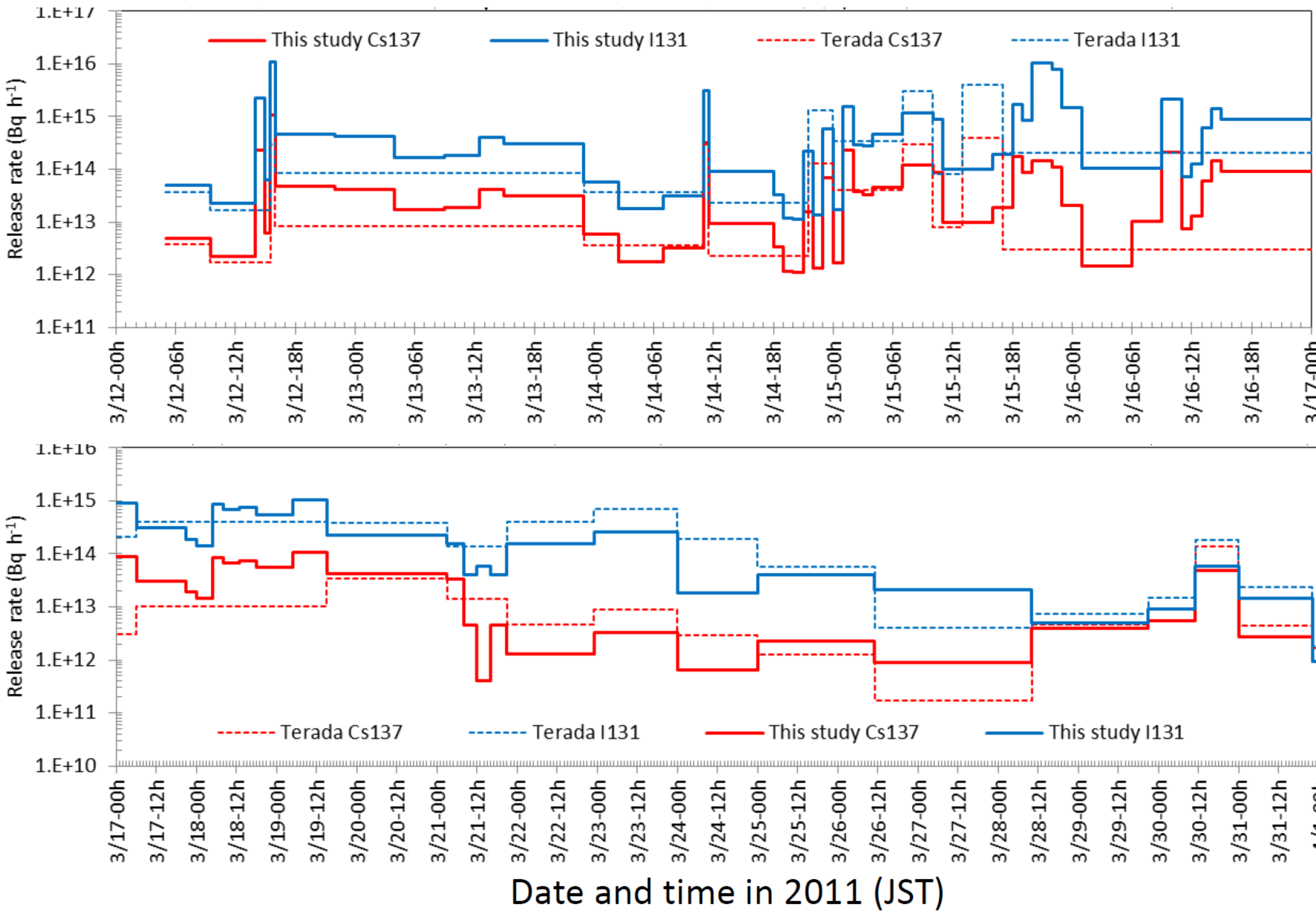
- The predictions will be made available to the ARGOS decision-support system for display and dose modelling.

Meteorological verification

Meteogram for WMO meteorological station Mito halfway between Fukushima and Tokyo. Observations are marked by green asterisks.



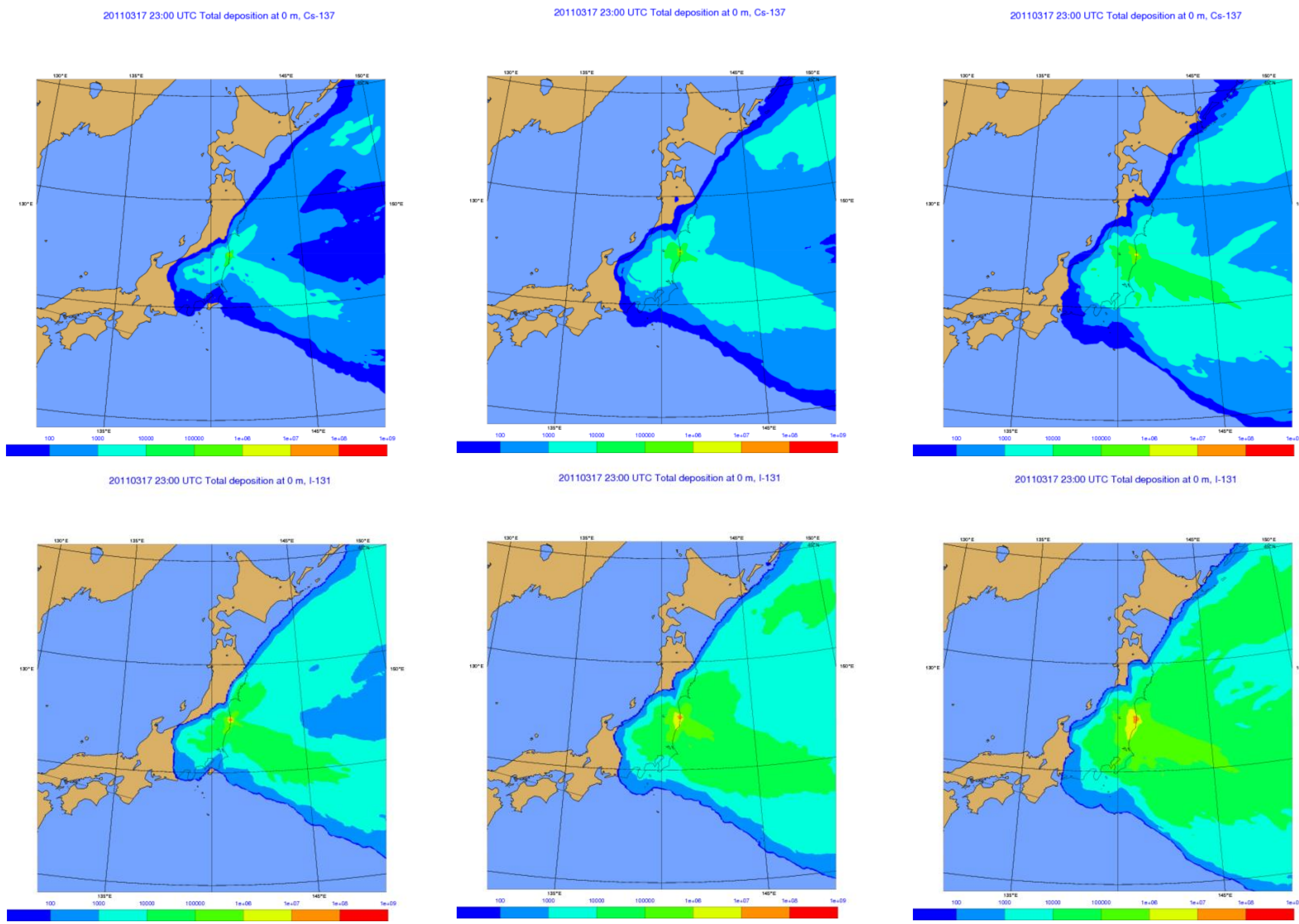
Source term by Katata *et al.*



Scenario 1: 2011-03-16 0 UTC

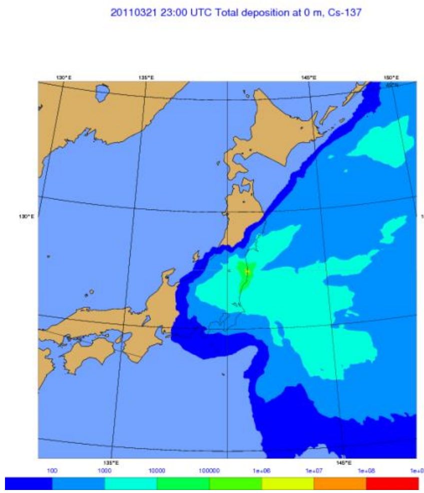
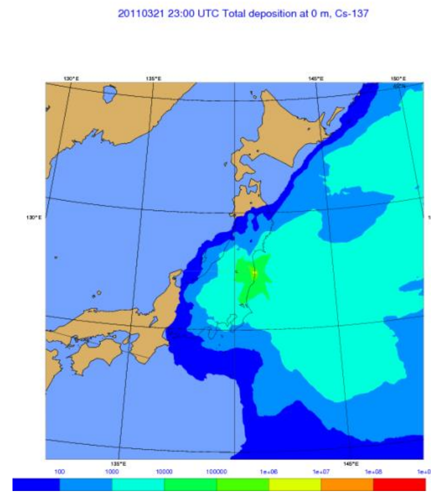
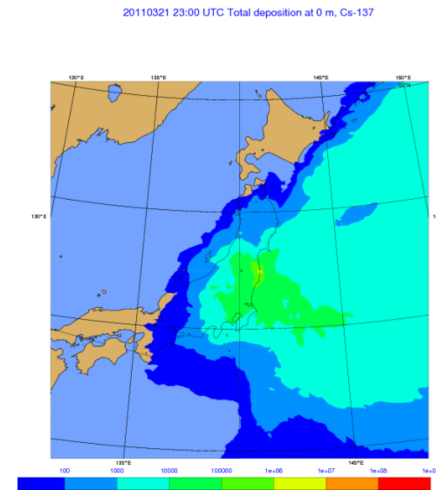
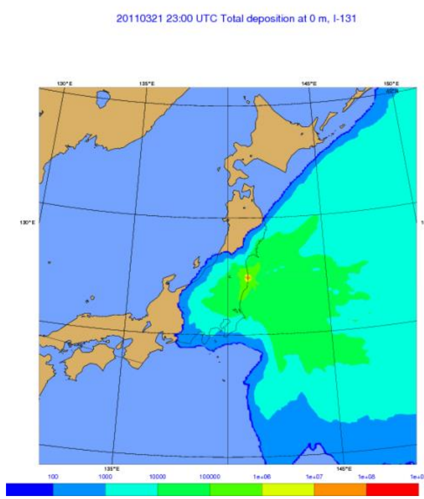
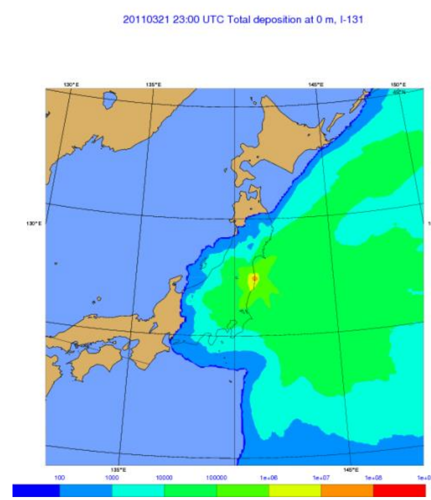
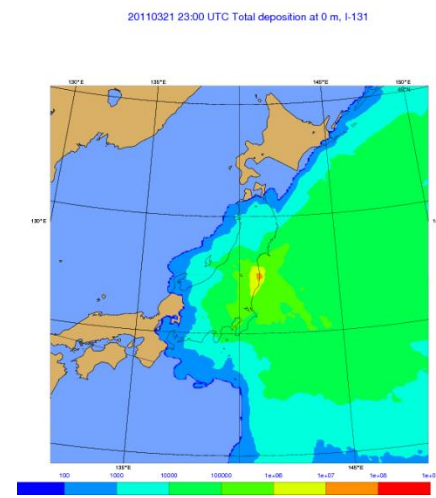
Final deposition

	10th percentile	50th percentile	90th percentile
Cs-137			
I-131			



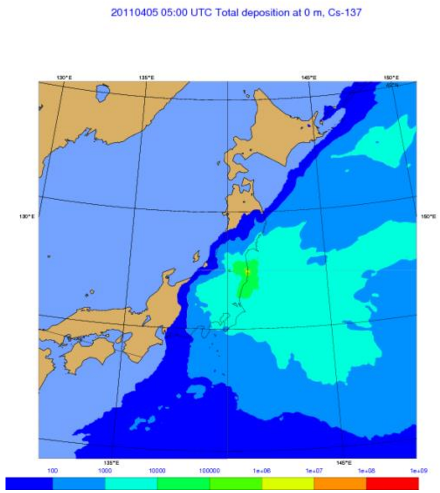
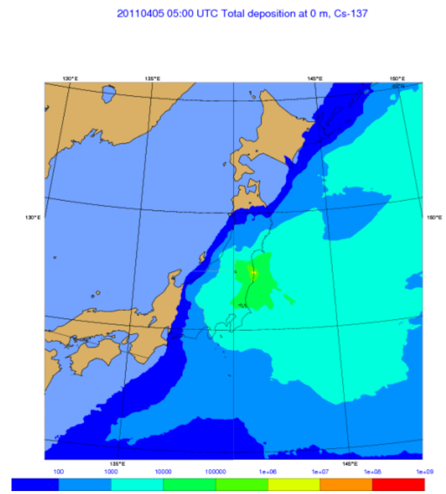
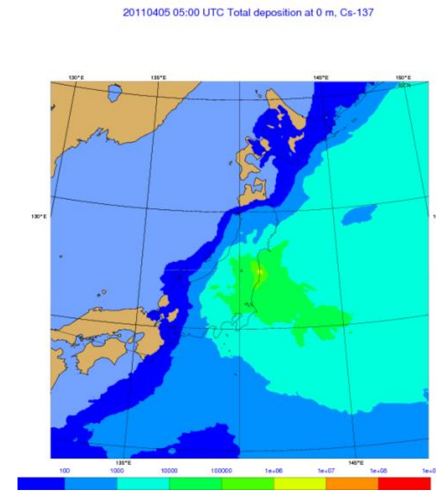
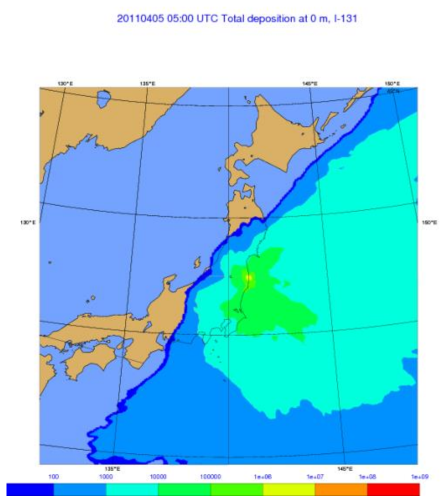
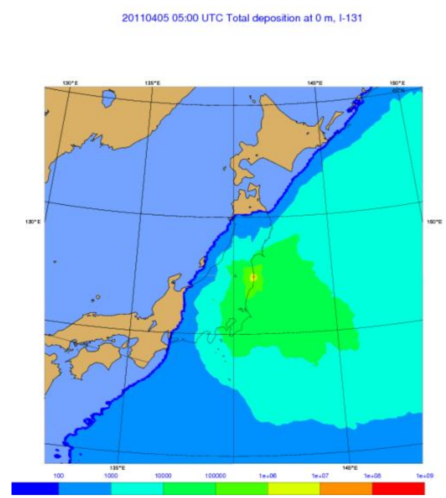
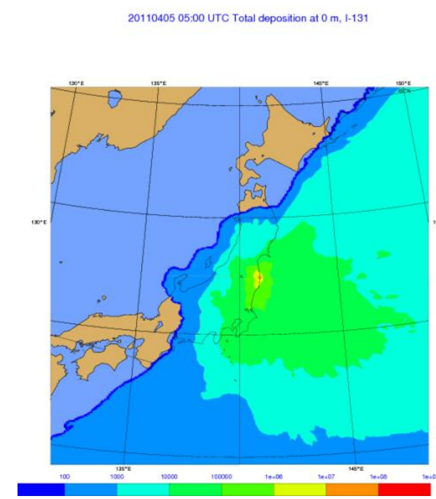
Scenario 2: 2011-03-20 0 UTC

Final deposition

	10th percentile	50th percentile	90th percentile
Cs-137			
I-131			

Scenario: Final (analyzed met. data – our best shot!)

Final deposition

	10th percentile	50th percentile	90th percentile
Cs-137			
I-131			

Conclusion

We are probably not making life easier for the decision makers…

However, by assessing the uncertainties we provide a more comprehensive basis for the decision making.