MODARIA Marine Transport Modelling

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IAEA

International Atomic Energy Agency

MODARIA (2012-2015)

- http://www-ns.iaea.org/projects/modaria/default.asp?l=116
- The general aim of the MODARIA Programme is to improve capabilities in the field of environmental radiation dose assessment by means of acquisition of improved data for model testing, model testing and comparison, reaching consensus on modelling philosophies, approaches and parameter values, development of improved methods and exchange of information.
- Objectives:
  - To test the performance of models developed for assessing the transfer of radionuclides in the environment and radiological impact to man and environment;
  - To develop and improve models for particular environments and, where appropriate, to agree on data sets that are generally applicable in environmental transfer models;
  - To provide an international forum for the exchange of experience, ideas and research information.

MODARIA working groups

- Remediation of Contaminated Areas
  - Working Group 1 – Remediation strategies and decision aiding techniques
  - Working Group 2 – Exposures in contaminated urban environments and effect of remedial measures
  - Working Group 3 – Application of models for assessing radiological impacts arising from NORM and radioactively contaminated legacy sites to support the management of remediation
- Uncertainties and Variability
  - Working Group 4 – Analysis of radioecological data in IAEA Technical Reports Series publications to identify key radionuclides and associated parameter values for human and wildlife exposure assessment
  - Working Group 5 – Uncertainty and variability analysis for assessments of radiological impacts arising from routine discharges of radionuclides
  - Working Group 6 – Common framework for addressing environmental change in long term safety assessments of radioactive waste disposal facilities
  - Working Group 7 – Harmonization and intercomparison of models for accidental tritium releases
- Exposures and Effects on Biota
  - Working Group 8 – Biota modelling: Further development of transfer and exposure models and application to scenarios
  - Working Group 9 – Models for assessing radiation effects on populations of wildlife species
- Marine Modelling
  - Working Group 10 – Modelling of marine dispersion and transfer of radionuclides accidentally released from land-based facilities.

WG10 scenarios on accidental releases in the marine environment

1) Fukushima releases in the Pacific Ocean

- Intercomparison of hydrodynamic submodels
- Intercomparison of dispersion models

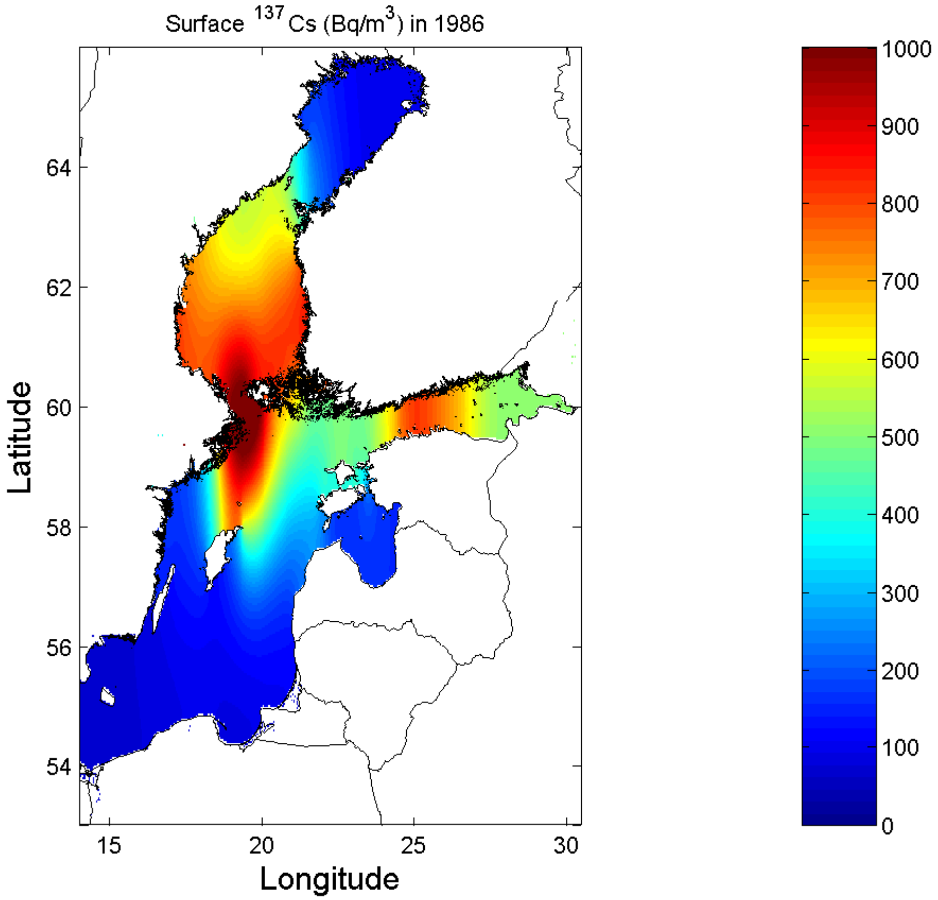
2) The Baltic Sea: modelling Chernobyl fallout

- Results provided by 4 models:
    - NRPA box model
    - POSEIDON box model
    - USEV hydrodynamic model
    - THREETOX hydrodynamic model
- Results compared with HELCOM database measurements

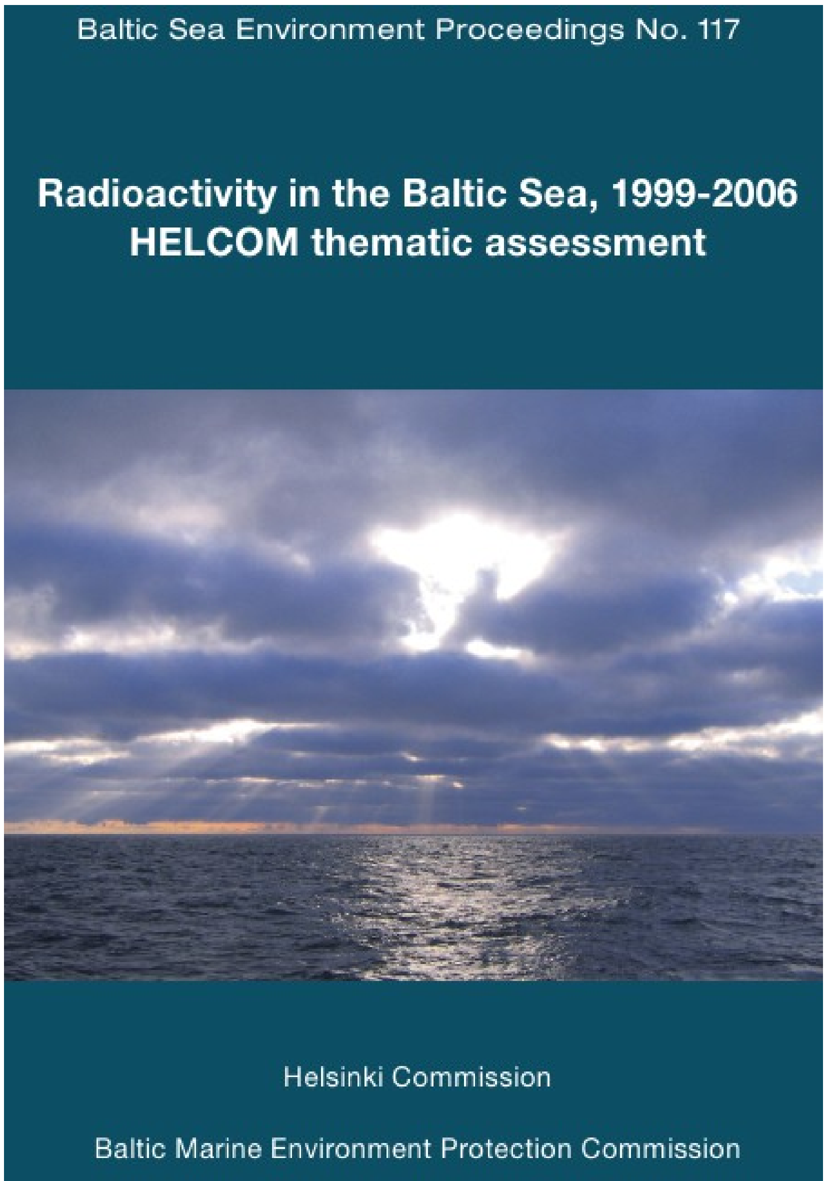
Baltic Sea scenario

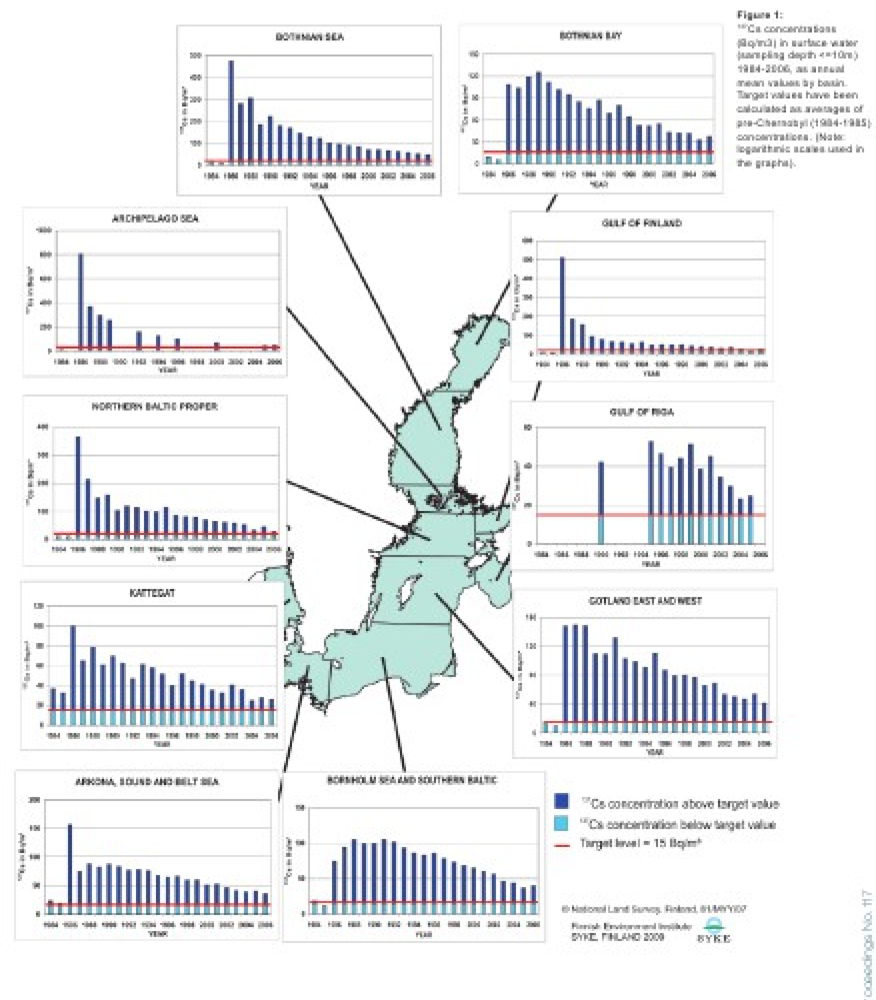
5 year of calculation from October 31, 1986

- Maps of 137-Cs concentration in surface water and sediments in October 31, 1991
- Time series of 137-Cs inventories in the water column and bed sediments
- Time series of concentrations in water and sediments at selected locations
- Mean concentrations in water and sediments in several sub-basins



Model results compared with HELCOM data



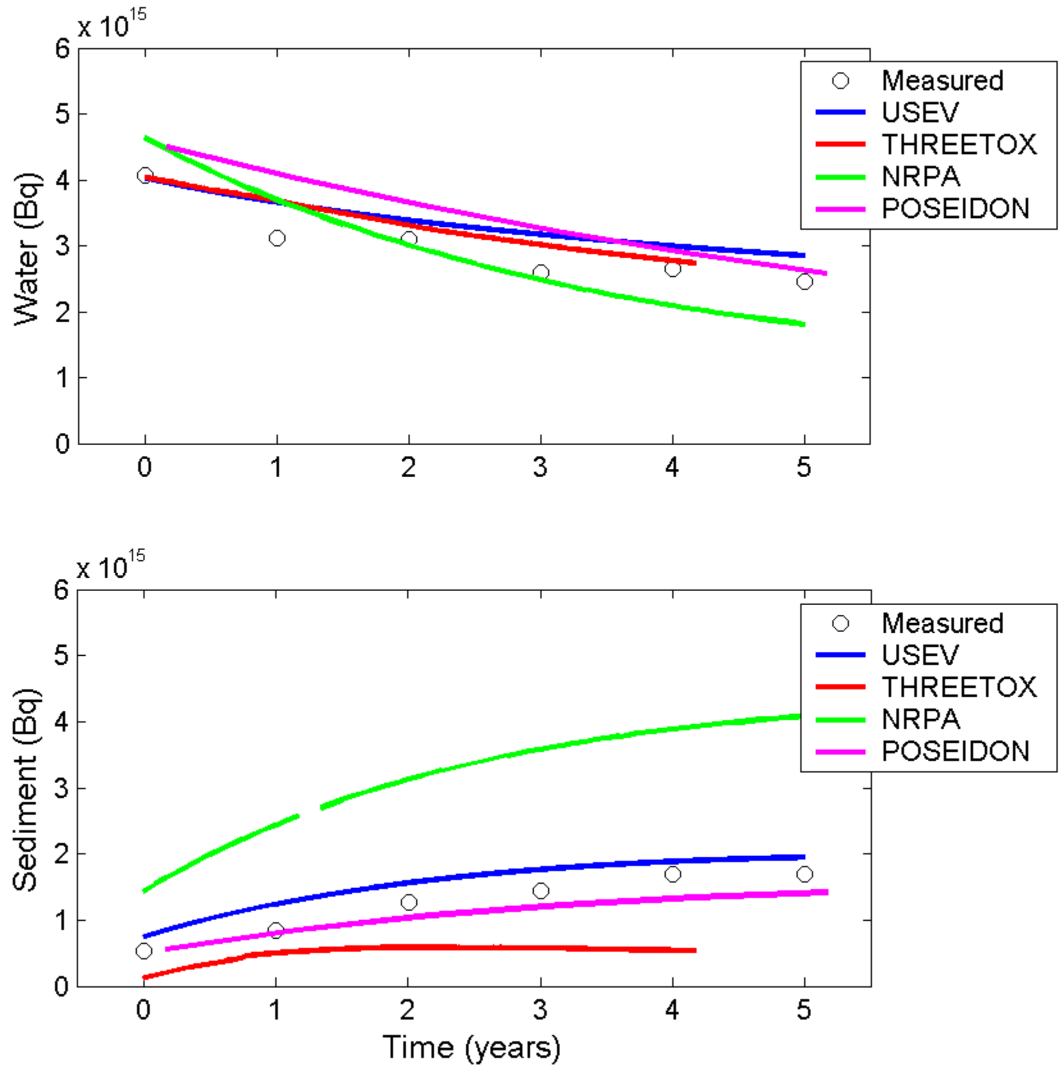


Applied models

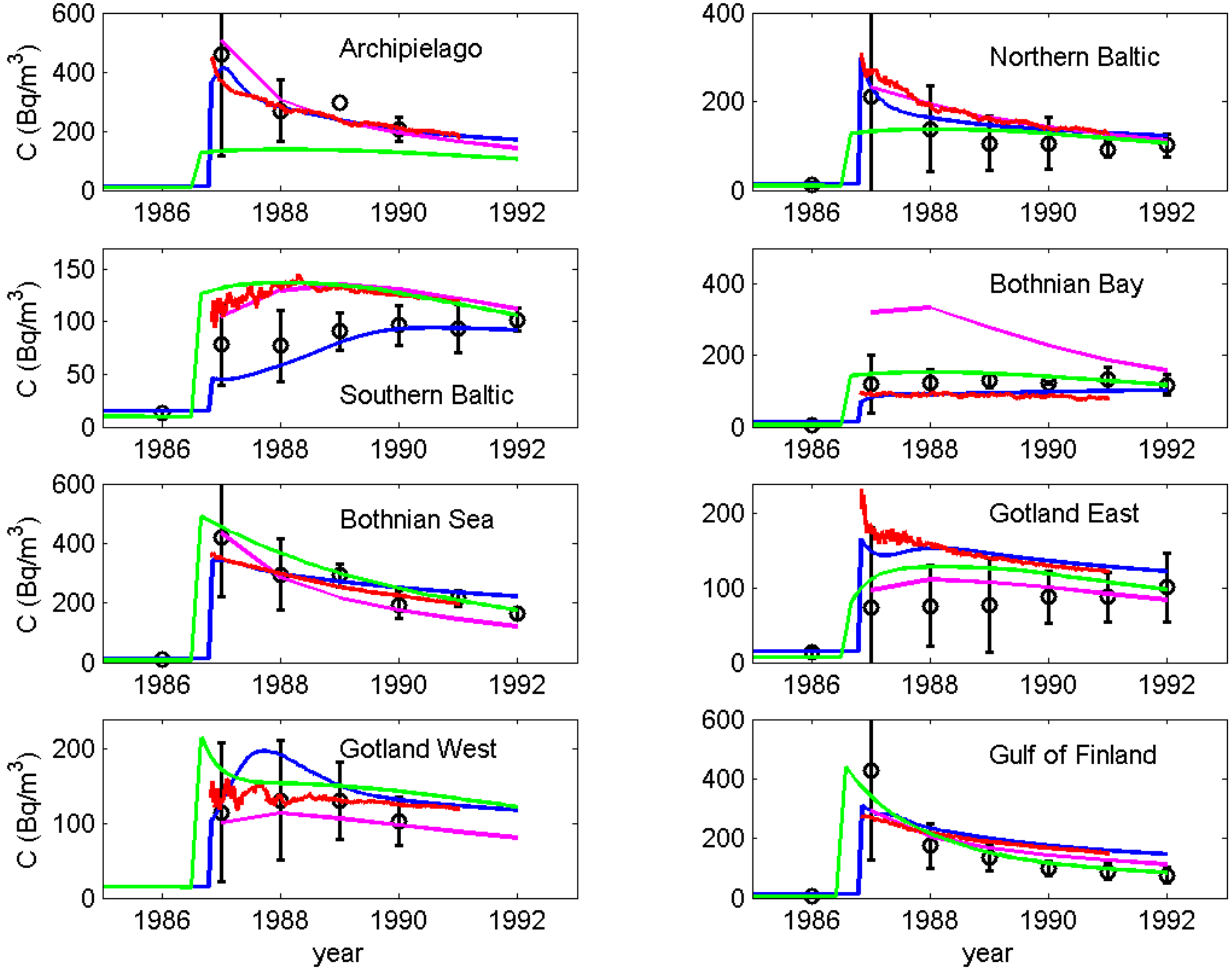
- POSEIDON box model
- NRPA box model
- THREETOX: 3D hydrodynamic model
- USEV: 2D depth-averaged model, forced with annual mean wind

Water/sediment interactions included in all models

Inventories in the Baltic

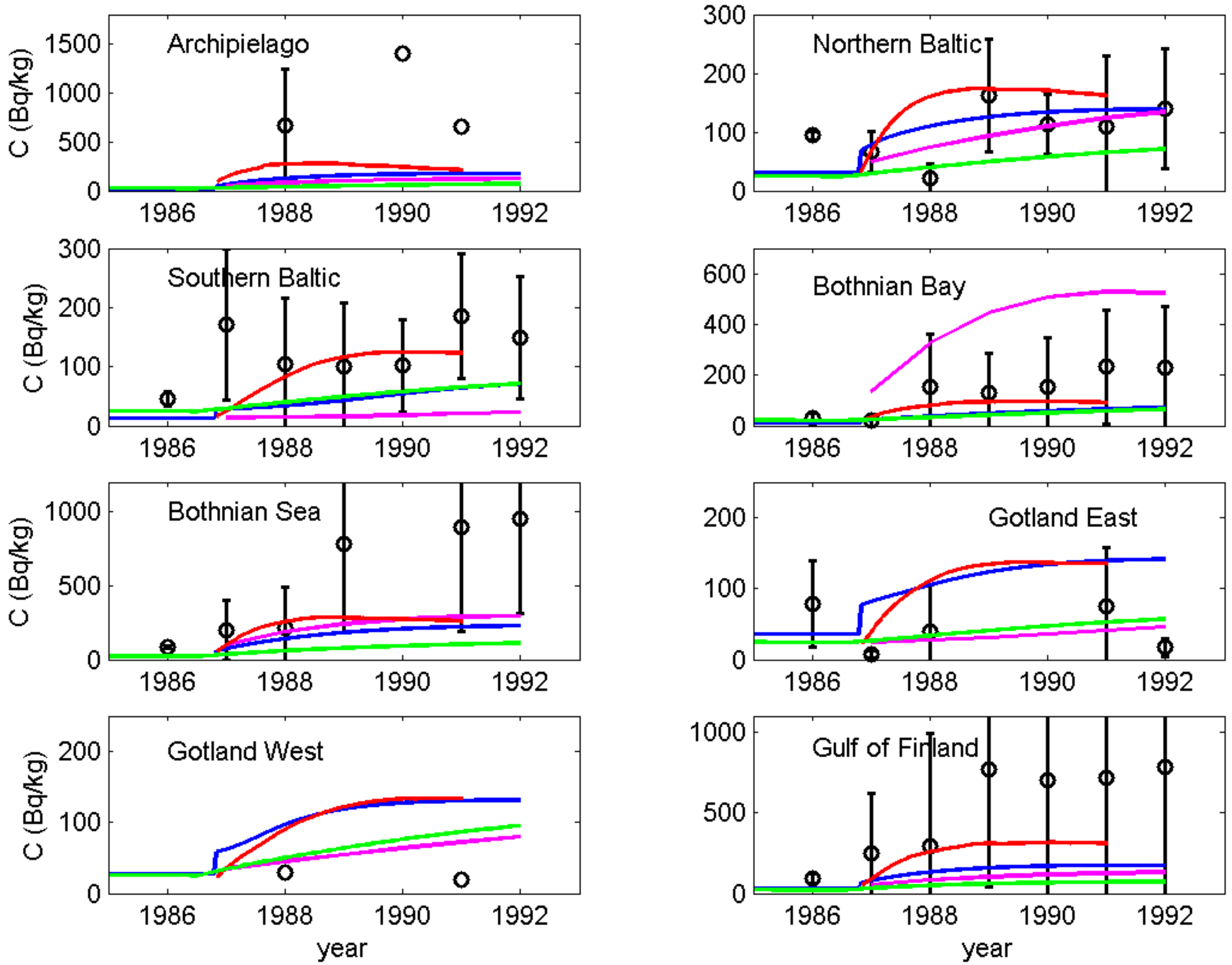


Calculated and measured concentrations in water



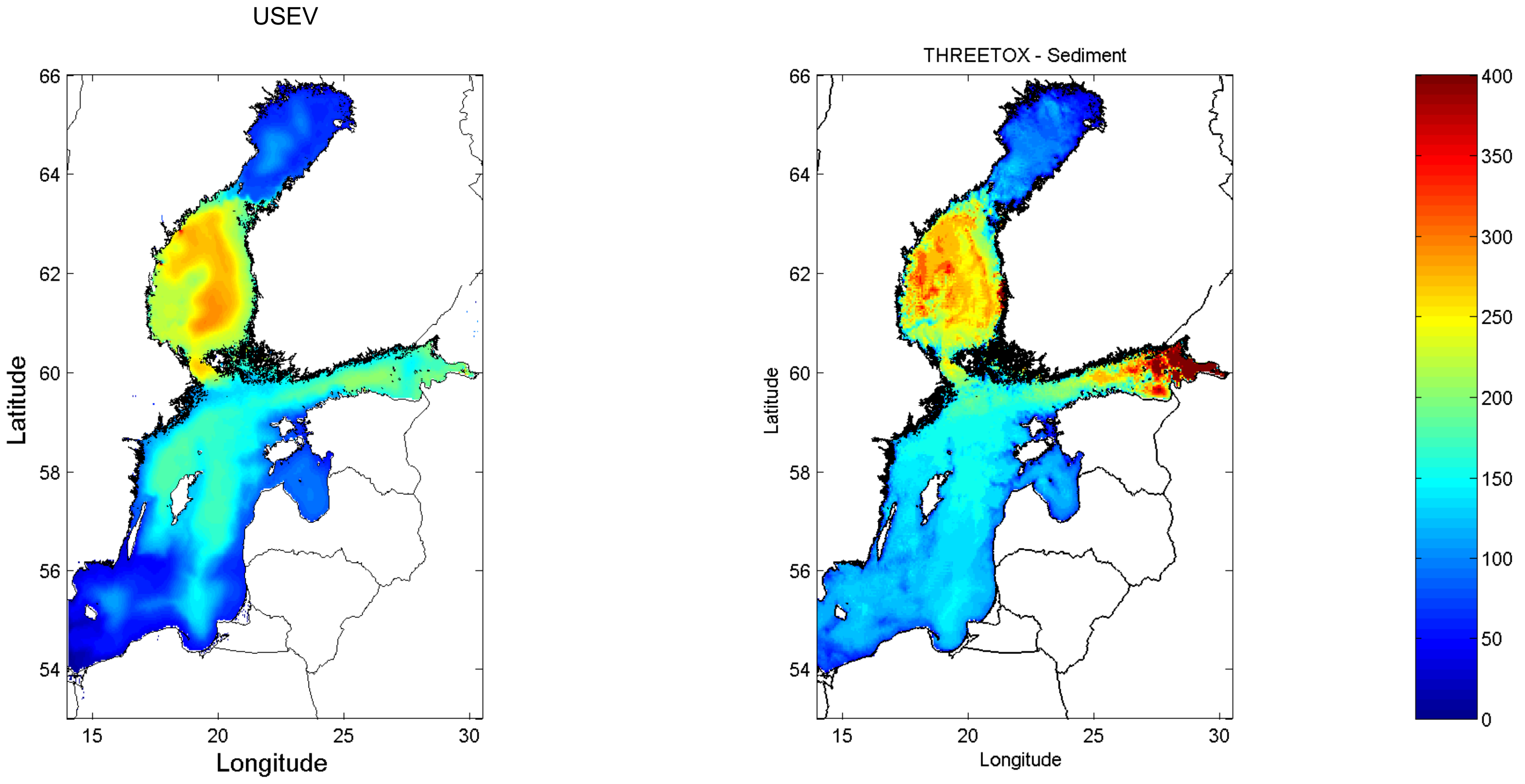
Magenta: POSEIDON
Red: THREETOX
Green: NRPA
Blue: USEV

Calculated and measured concentrations in sediments



Magenta: POSEIDON
Red: THREETOX
Green: NRPA
Blue: USEV

Concentrations in sediments (Bq/kg) after 5 years



Fukushima: participating models

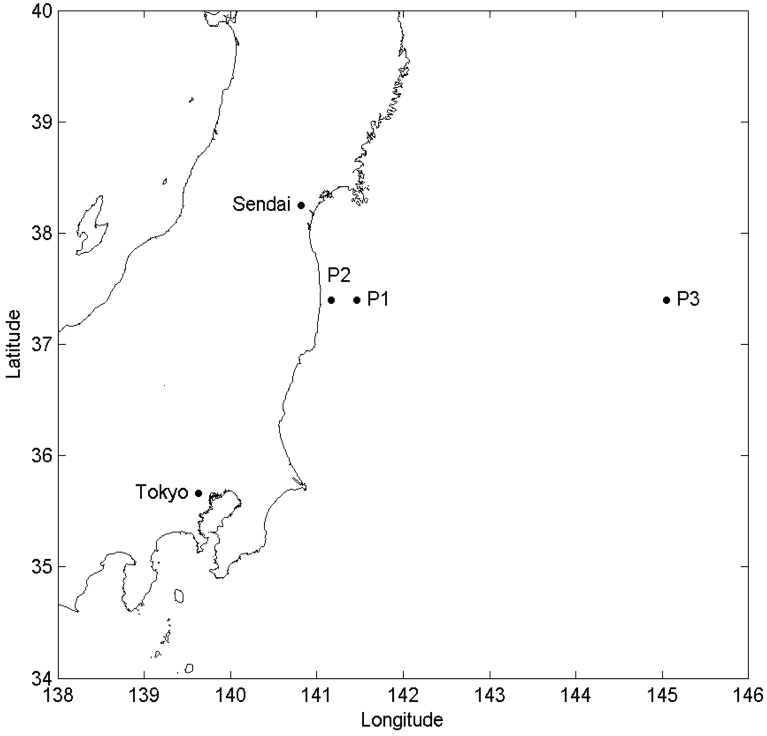
Institute	Scale	Circulation	Model type
KAERI	Regional, global	NCOM, JCOPE2	Lagrangian
JAEA	Local, regional, global	Kyoto University	Lagrangian
Univ. Tolouse	Regional	Own, NCOM bound. cond.	Eulerian
Univ. Seville	Local	JCOPE2, HYCOM	Eulerian
IEN, Brasil	Local	Own	Eulerian
NTUA, Greece	Local	Own	Eulerian
IMMSP/KIOST Ukraine	regional	Own, HYCOM bound. cond.	Eulerian

All models are three-dimensional dynamic models

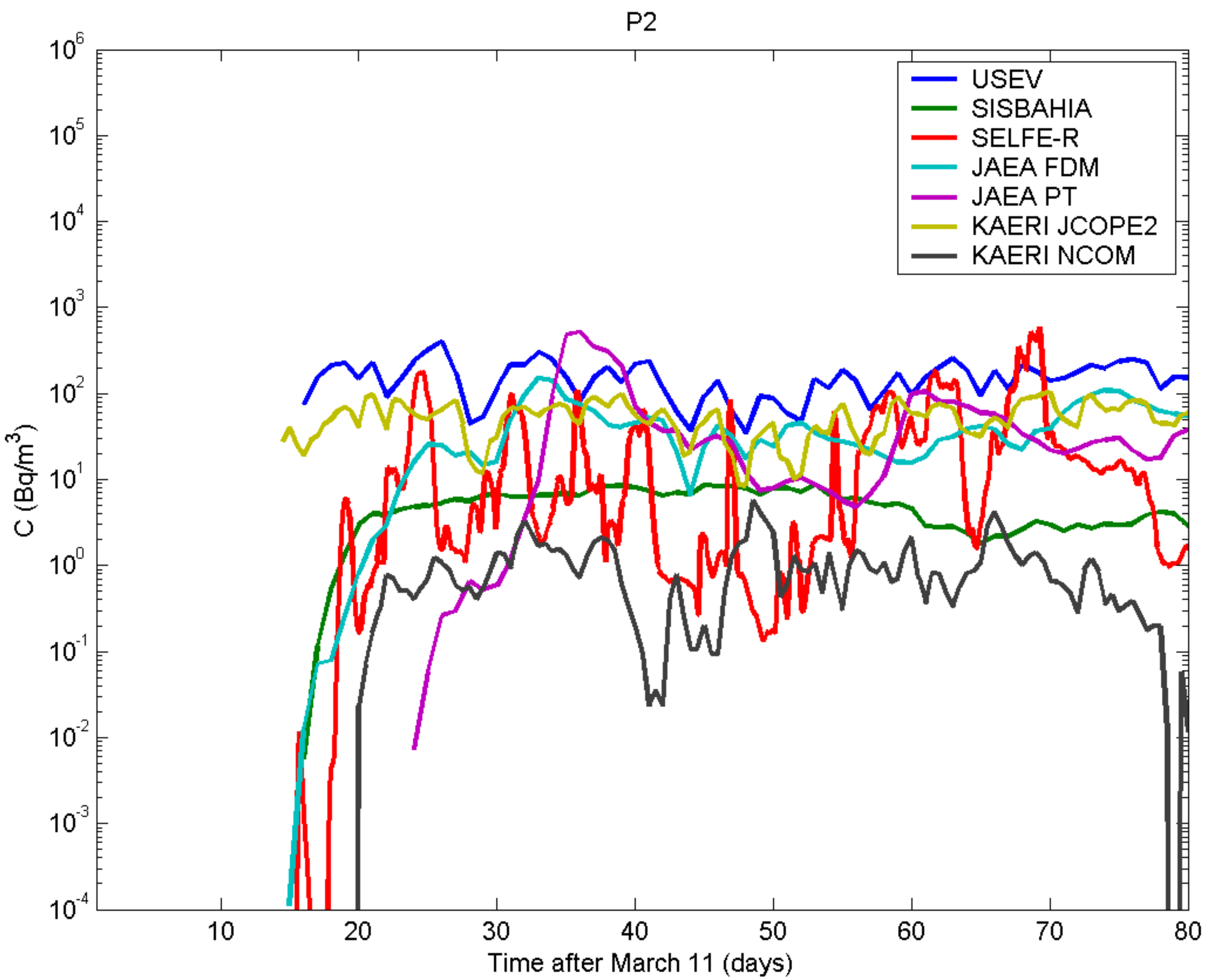
Fukushima first modelling exercise

Constant release (hypothetical magnitude) of a perfectly conservative radionuclide (no water/sediment interactions)

Compare time series of concentrations at the sea surface for the period March 11-May 30



Results



Each team uses its own hydrodynamics

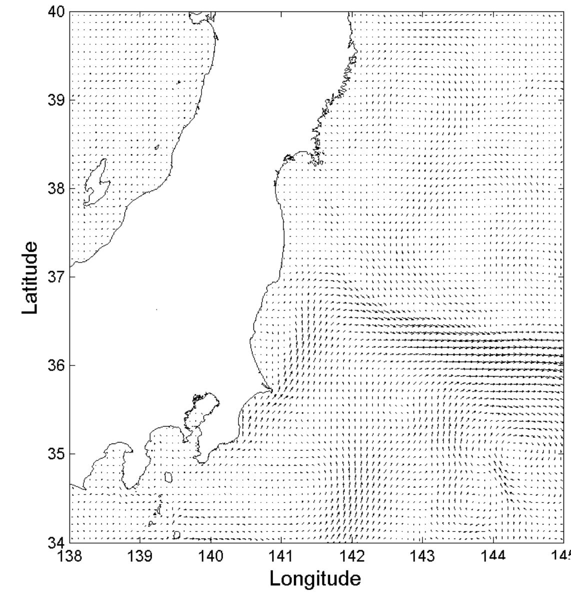
Constant hypothetical release

Conservative radionuclide

What is happening?

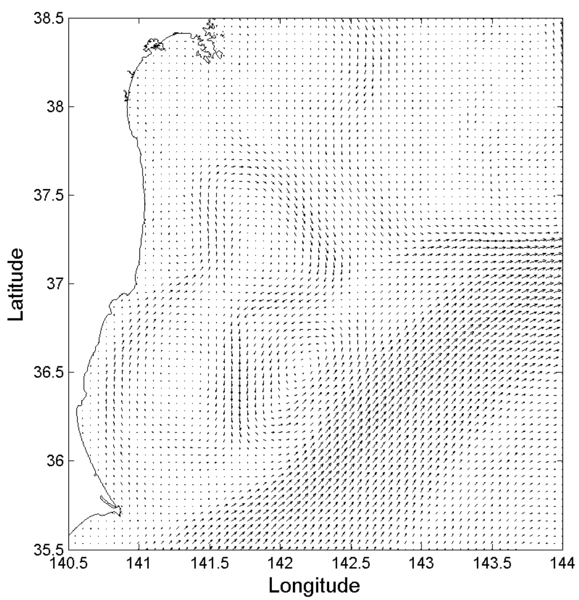
- Baltic Sea: very different models and similar results
- Fukushima: similar models and different results
- A marine dispersion model consists of two sub-models:
  - Hydrodynamic sub-model
  - Dispersion sub-model (transport by currents, turbulent mixing, water/sediment interactions)
- Let´s try to know the origin of discrepancies: model harmonization

Current field examples, April 30th (sea surface)

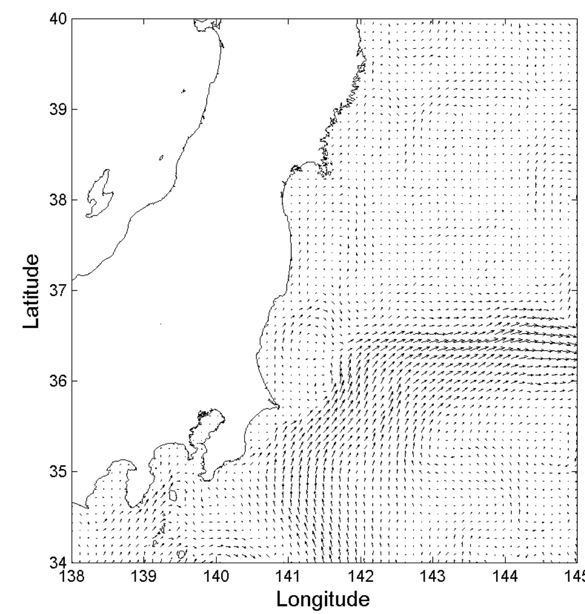


JCOPE2

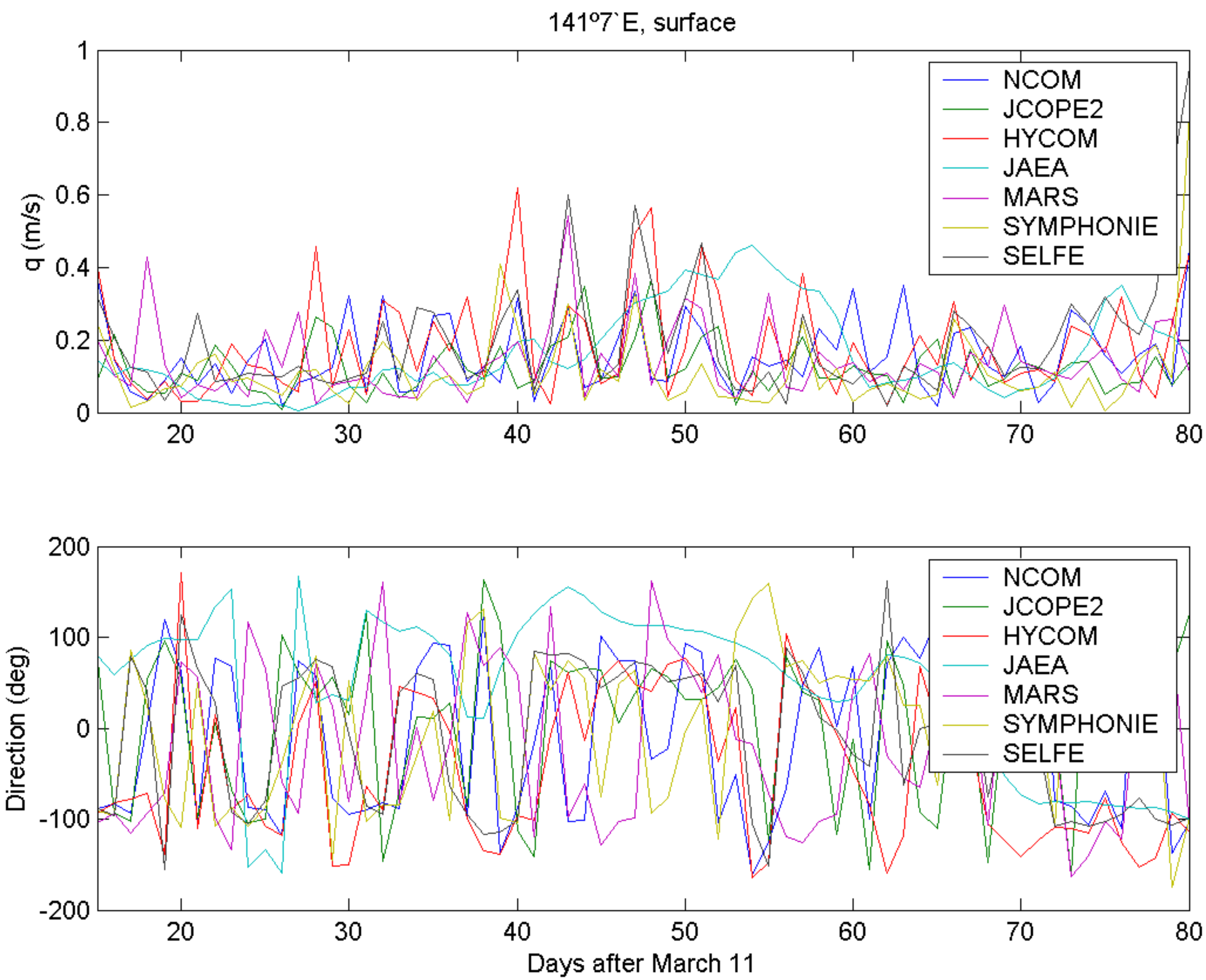
Kyoto Univ.



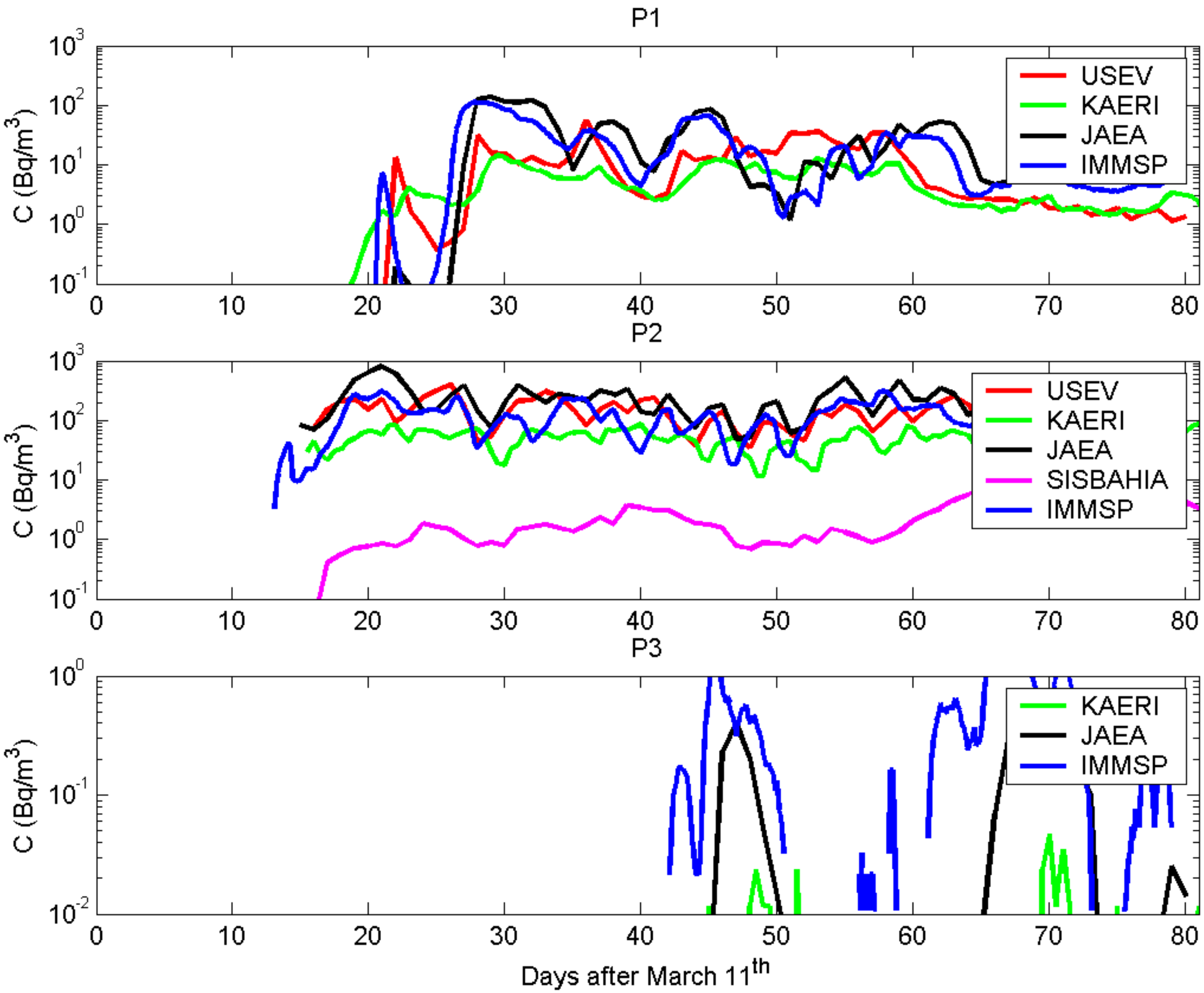
NCOM



Time series of currents



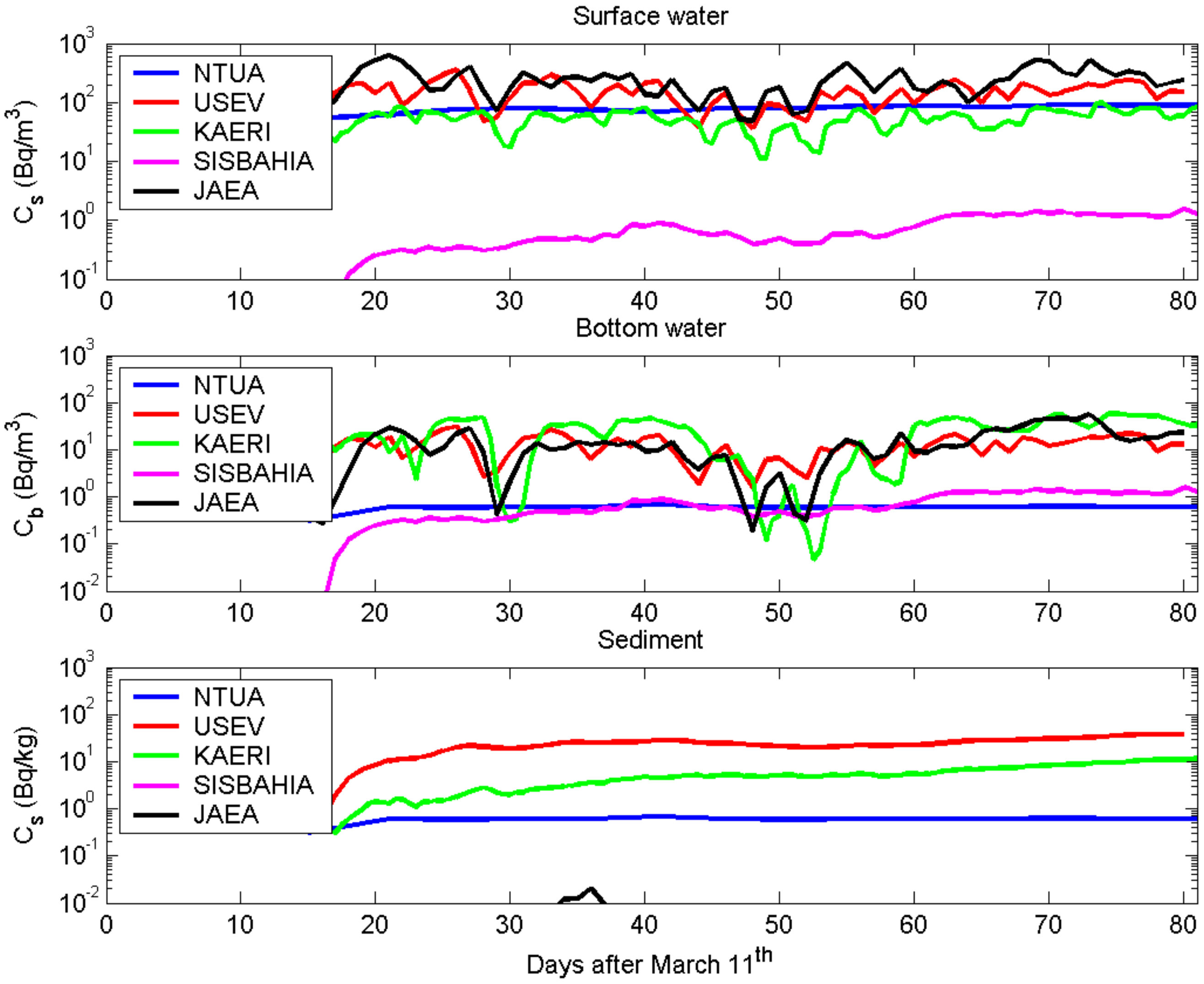
Exercise 2: tracer



All models use JCOPE2 model circulation

Same constant hypothetical release

Exercise 2: 137-Cs (water/sediment interactions included)



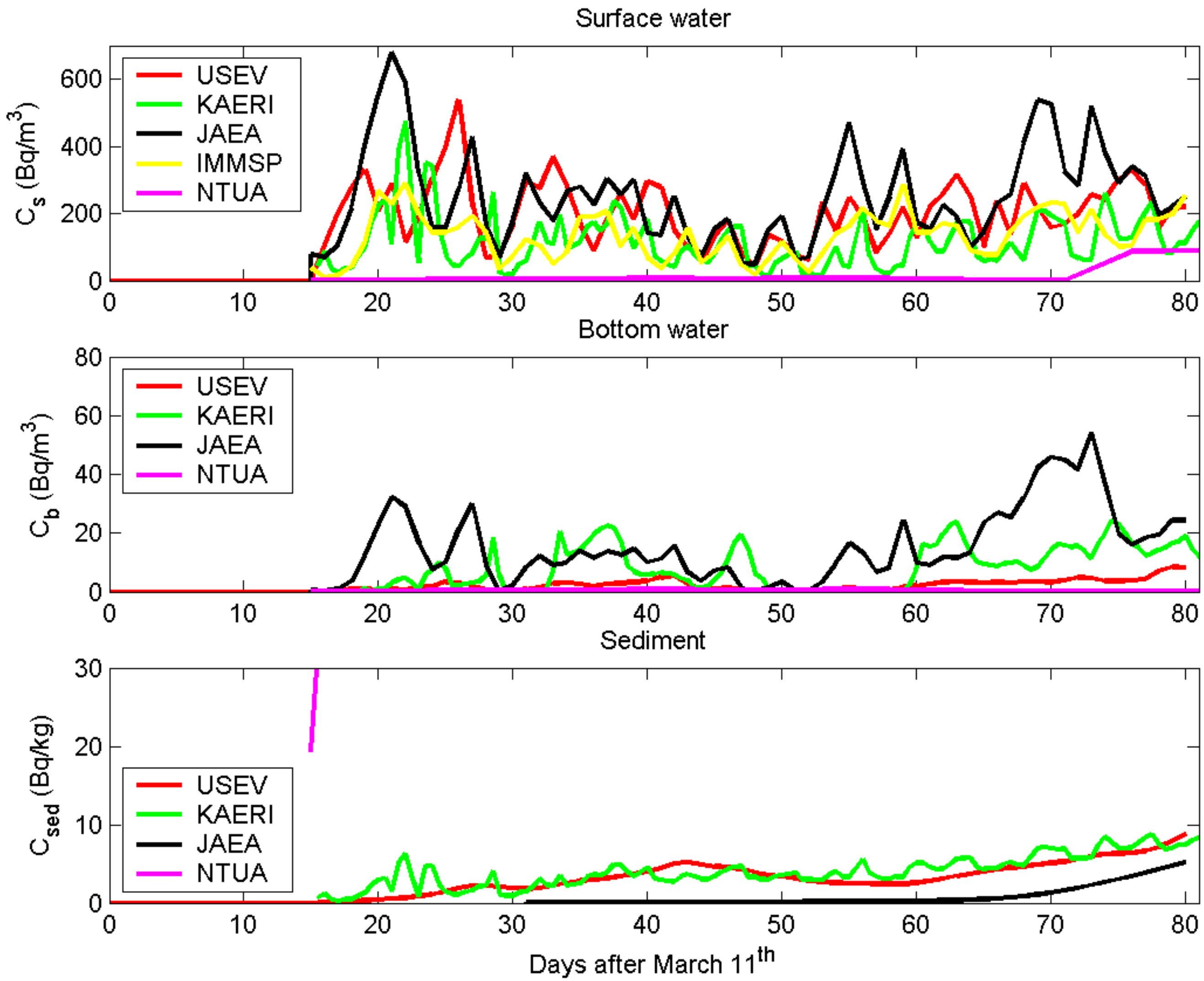
P2

Exercise 3

- Same circulation
- Exactly the same bathymetry
- Same diffusion coefficients
- Same adsoption/desorption parameters

- *In the case of a tracer, results do not significantly improve with respect to exercise 2. The main reason of discrepancy between models is water circulation*

Exercise 3: 137-Cs



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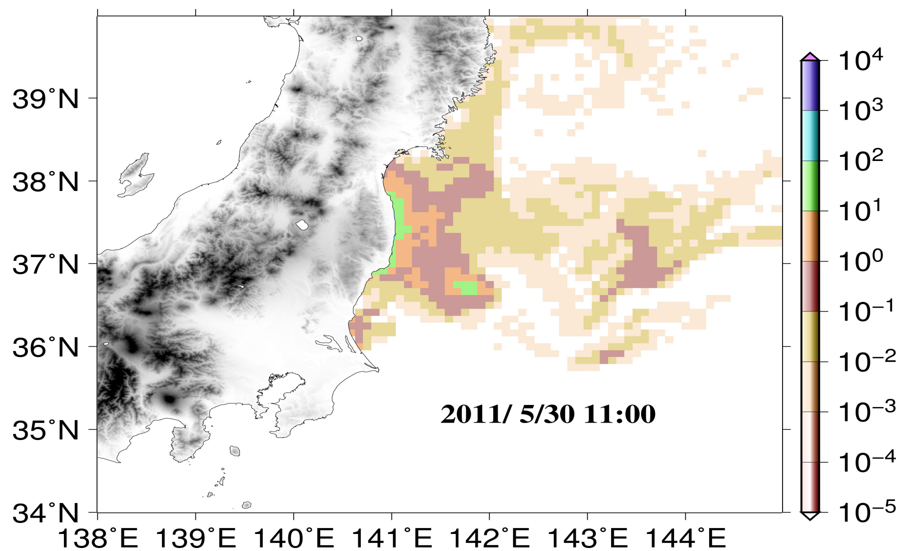
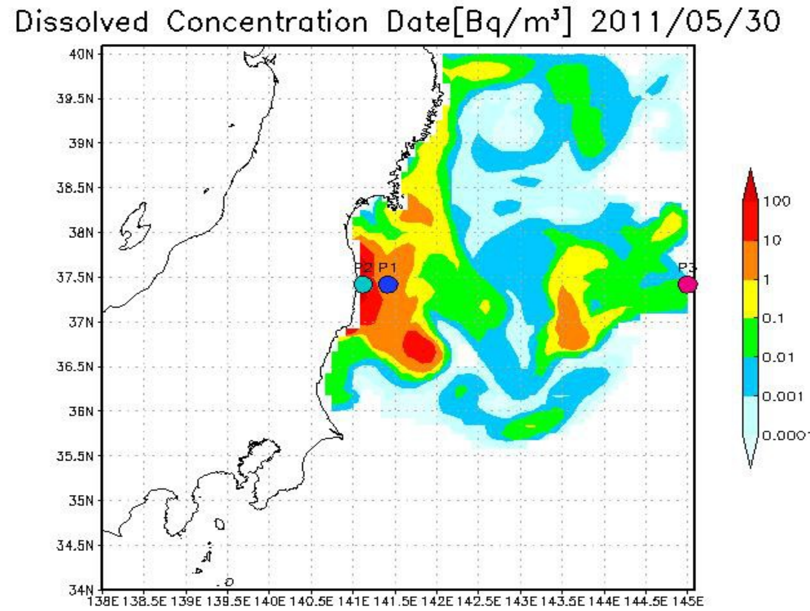
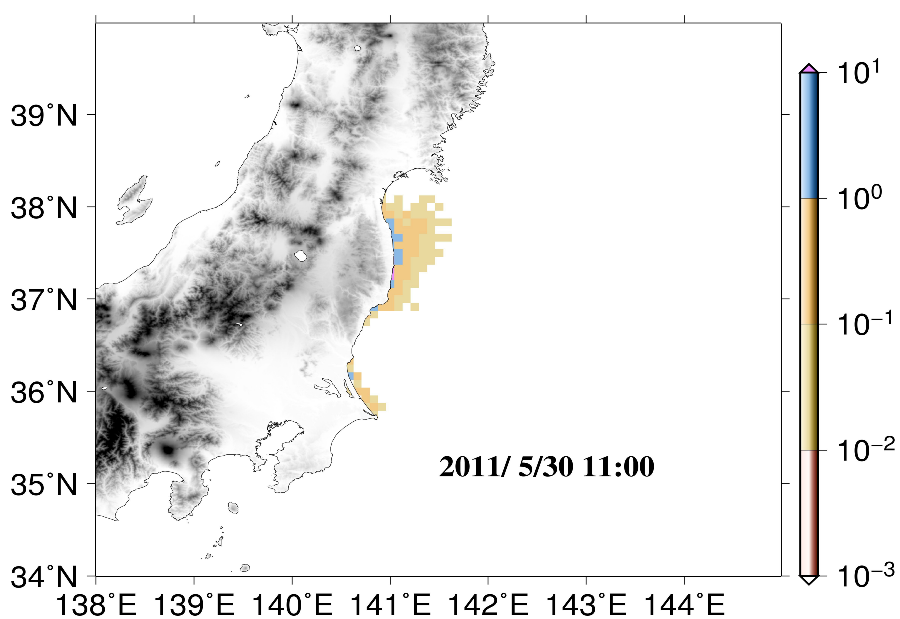
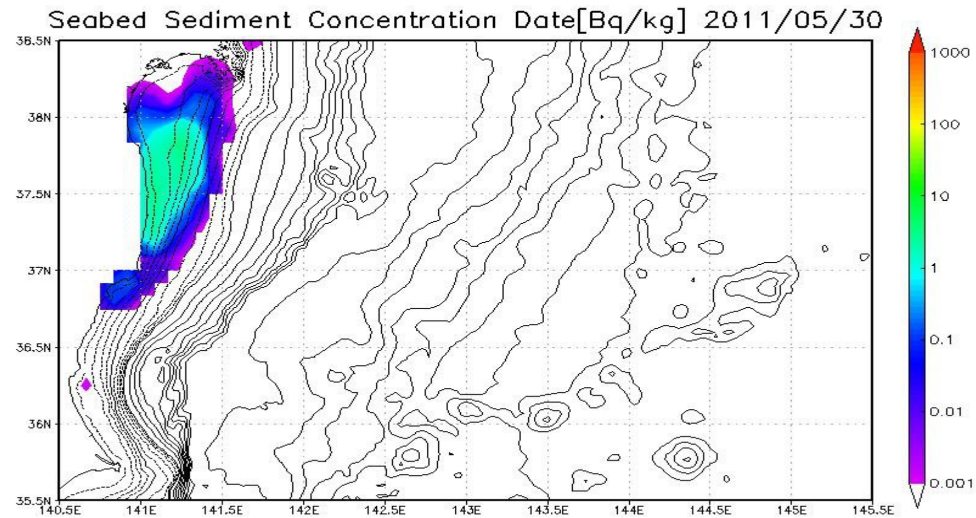
KAERI

JAEA

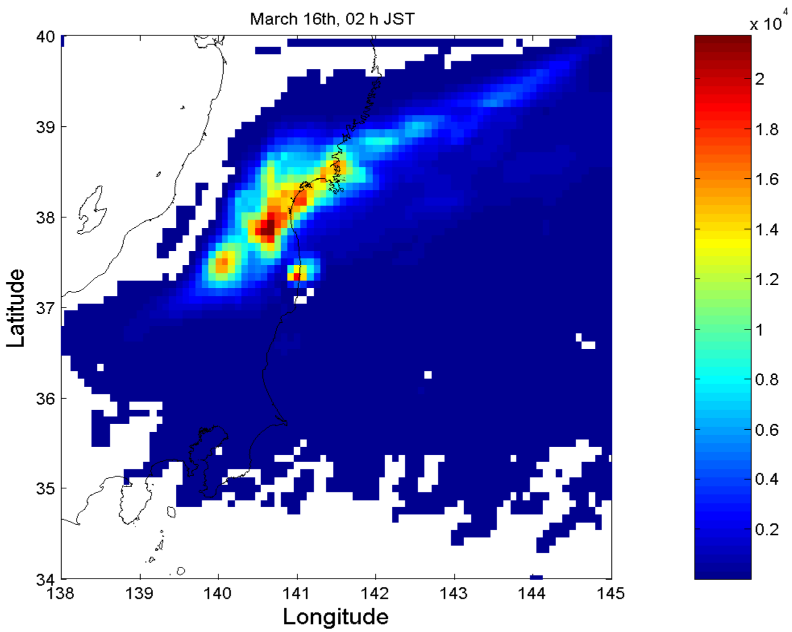

2011/ 5/30 11:00
39°N
38°N
37°N
36°N
35°N
34°N
138°E 139°E 140°E 141°E 142°E 143°E 144°E
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}

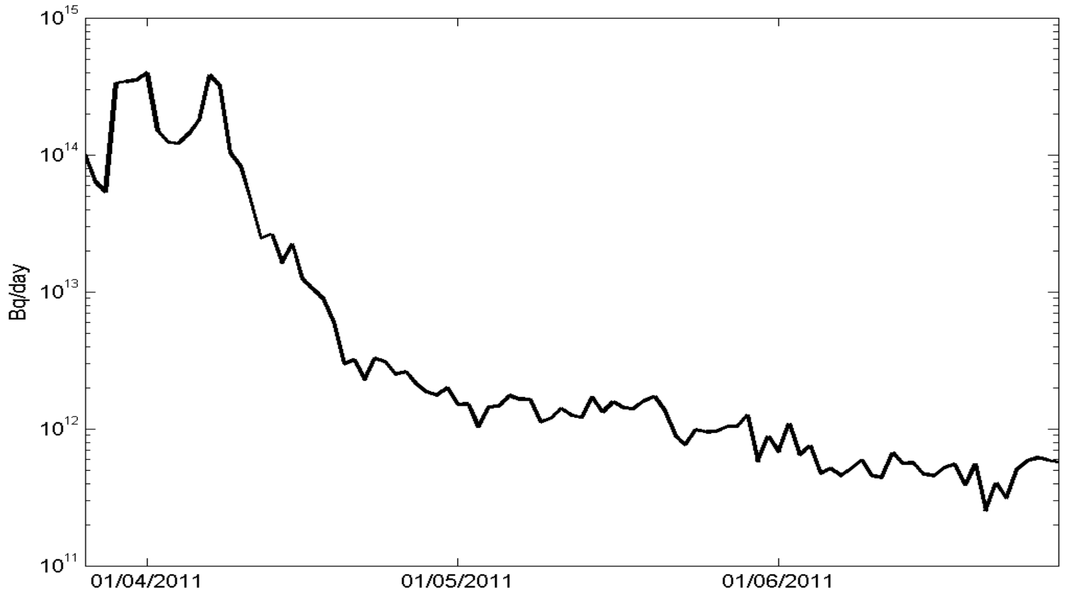

Dissolved Concentration Date[Bq/m³] 2011/05/30
P2 P1
P3
100
10
1
0.1
0.01
0.001
0.0001


2011/ 5/30 11:00
39°N
38°N
37°N
36°N
35°N
34°N
138°E 139°E 140°E 141°E 142°E 143°E 144°E
10^1
10^0
10^{-1}
10^{-2}
10^{-3}


Seabed Sediment Concentration Date[Bq/kg] 2011/05/30
1000
100
10
1
0.1
0.01
0.001

Next step: comparisons with measurements





Atmospheric deposition: from atmospheric dispersion models

Direct releases: reconstructed from TEPCO measurements in the release area

Conclusions

- Dispersion models are robust tools (consistent results in the Baltic), but:
- Large differences in model output occur in highly dynamic systems, with strong and variable currents (model harmonization required in Fukushima)
- This highlights the difficulties in developing operative models for decision-making support in these dynamic environments
- Further research in this field is required (MODARIA-II?)