Integration of 3D model THREETOX in JRODOS-HDM, implementation studies and model validation on marine Fukushima scenarios

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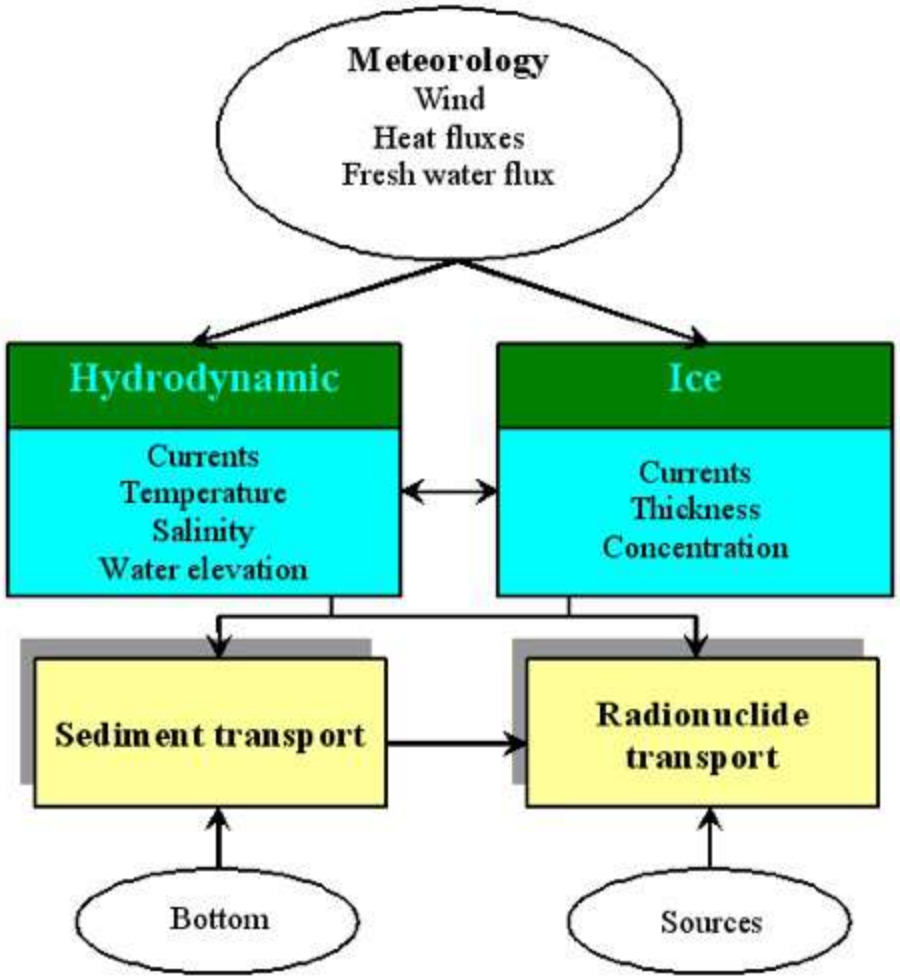
THREETOX in RODOS-HDM

- RETRACE (source: deposition from ADM)
  - Model for calculation of radionuclide washout from watersheds
- RIVTOX (sources: direct release and washout from watersheds)
  - 1-dimensional model of radionuclide transport in river network
- COASTOX (sources: direct release, deposition from ADM and release with rivers water)
  - 2-dimensional model for simulation of short- or mid-term radionuclide transport in reservoirs, lakes, estuaries and coastal areas of seas
- **THREETOX (sources: direct release, deposition from ADM and release with rivers water)**
  - **3-dimensional model for simulation of short- or mid-term radionuclide transport in rivers, reservoirs, lakes, estuaries and coastal areas of seas**
- POSEIDON (sources: direct release, deposition from ADM and release with rivers water)
  - Compartment model for simulation of long-term radionuclide transport in marine environment including marine biota

THREETOX model components

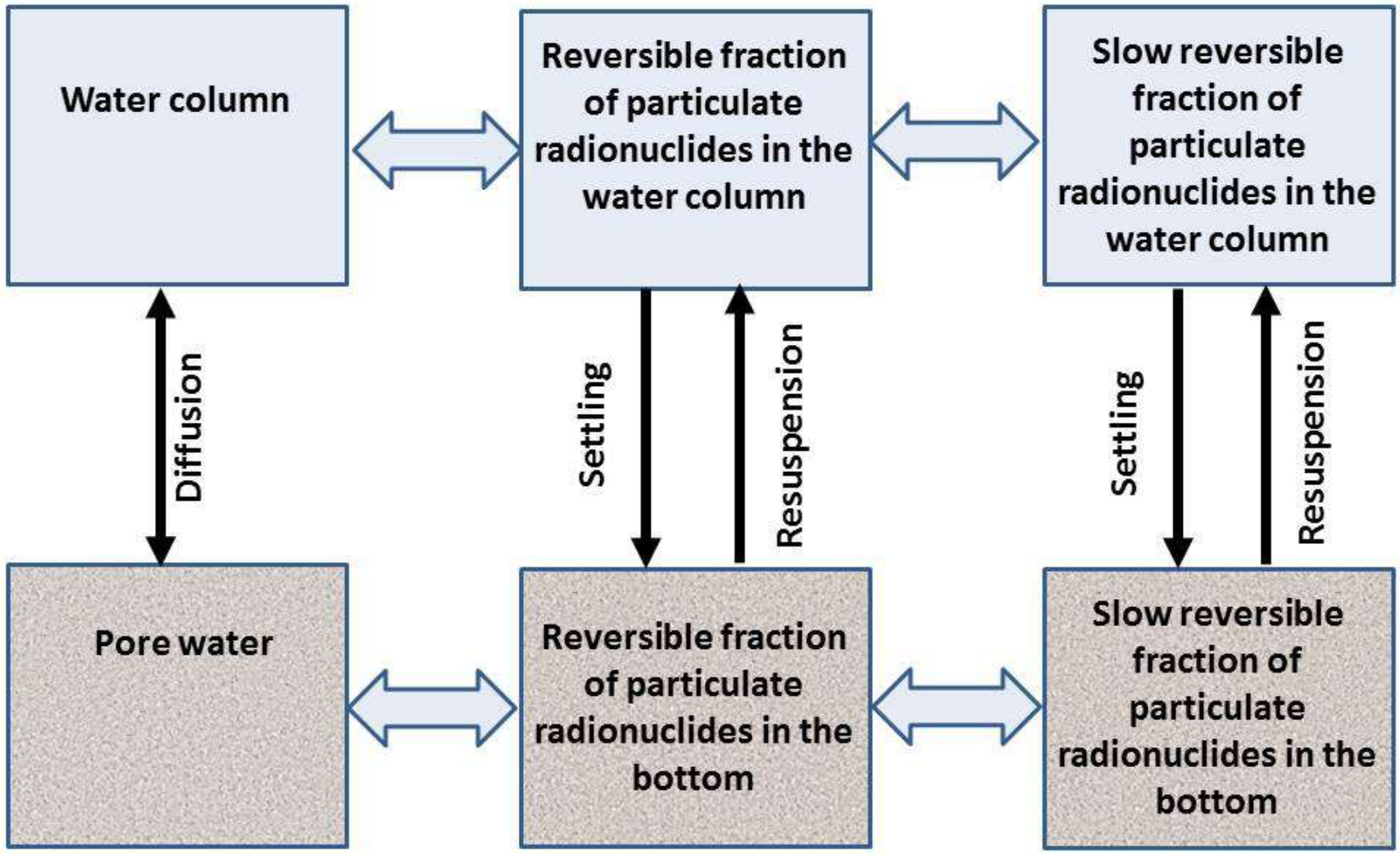


Improvements of THREETOX model

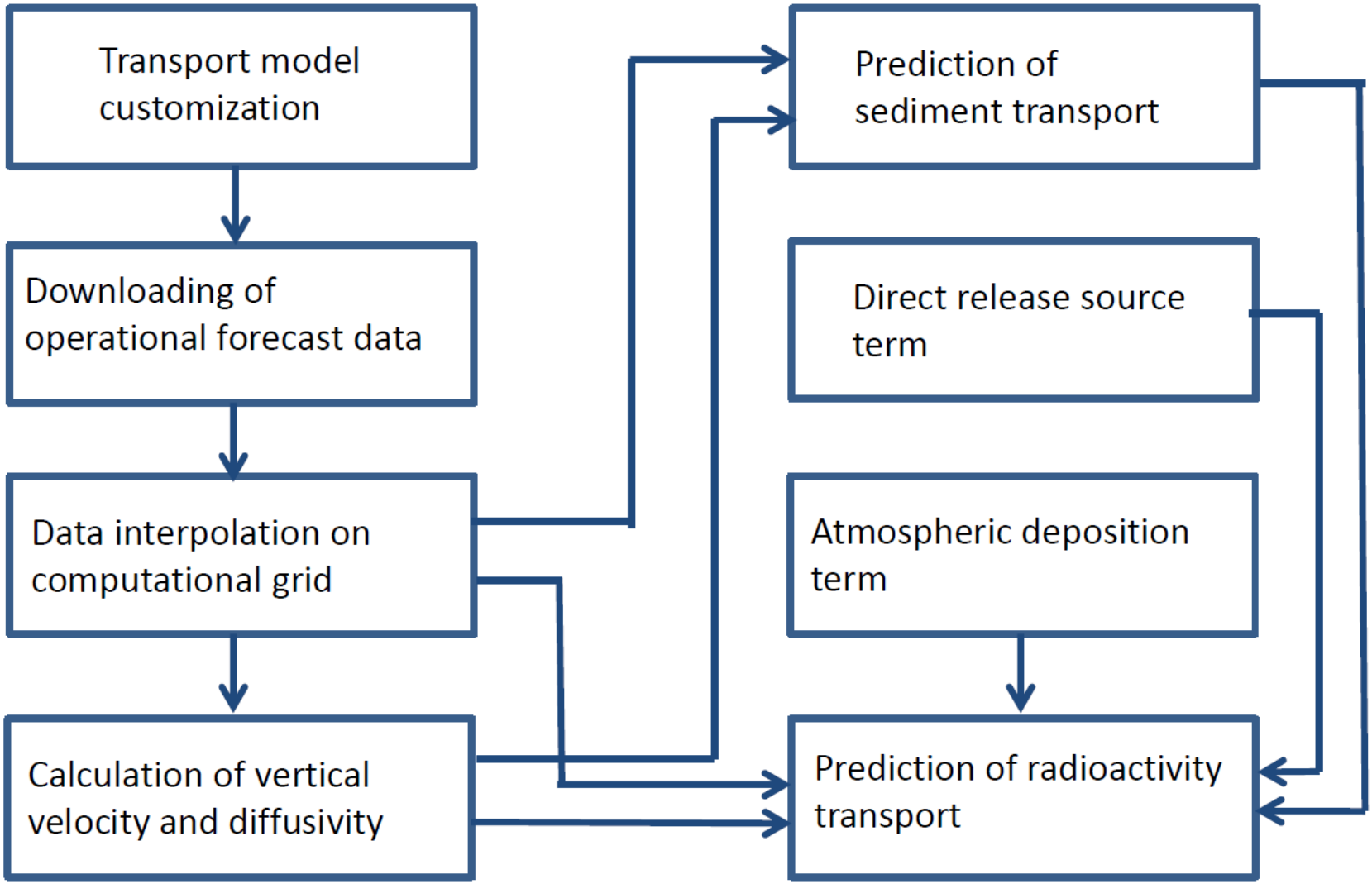
PREPARE

- Extension of the of radioactivity transport model for multi-fractional sediment and for two-step kinetics
  - The radioactivity transport model was extended for multi-fractional sediment and for two-step kinetics.
- Development of operational version based on ocean forecasting for European seas
  - The operational version of the radioactivity transport model is based on operational ocean forecasting for European seas.
- Integration in JRODOS
  - THREETOX integrated in JRODOS predicts concentration of radioactivity using deposition from ADM and release activity with river water and direct release under JRODOS interface.

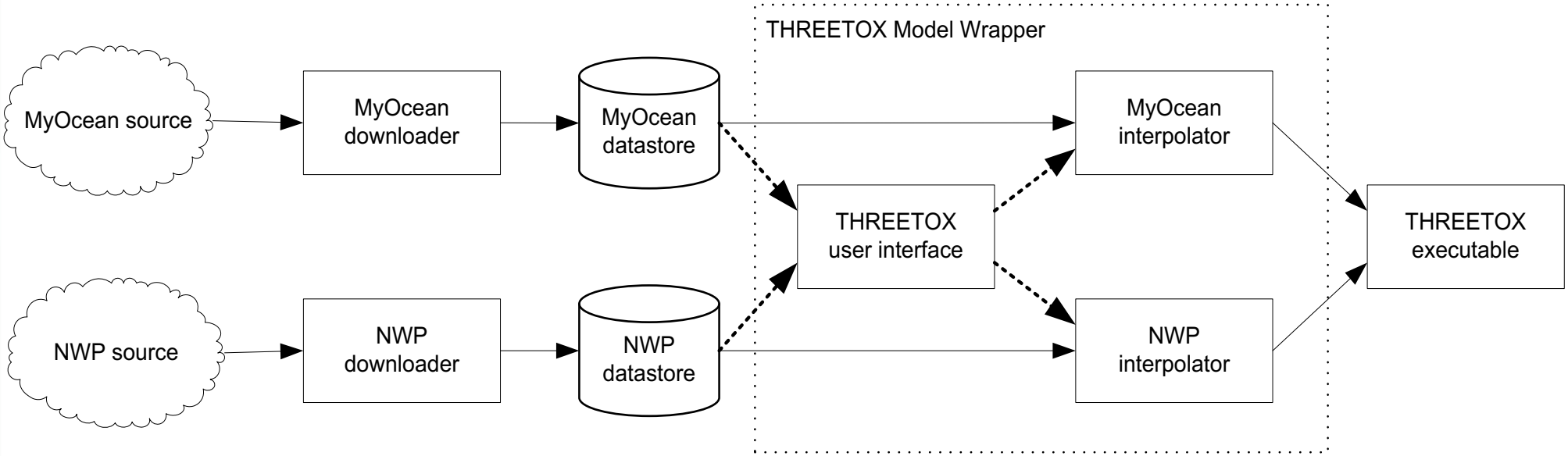
Extension of the of radioactivity transport model



Flowchart of operational prediction

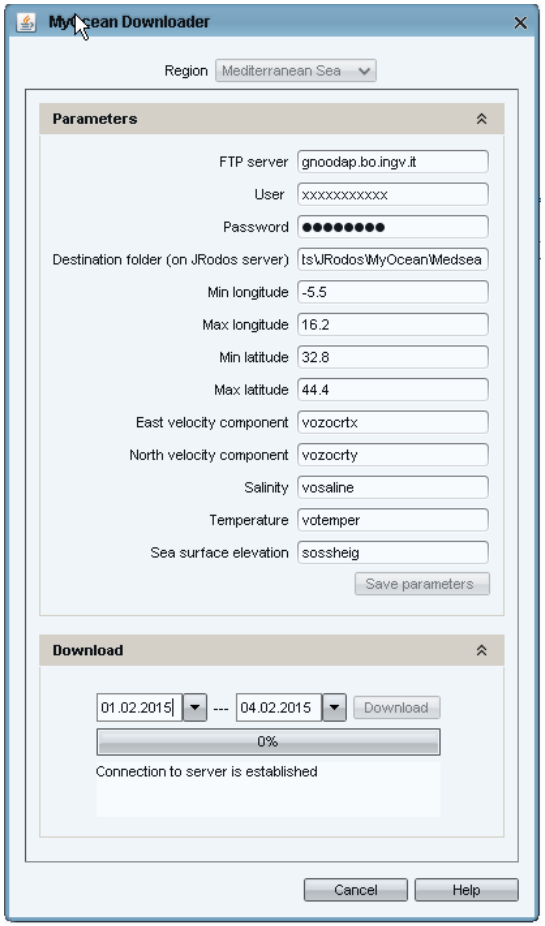


Data retrieval flow

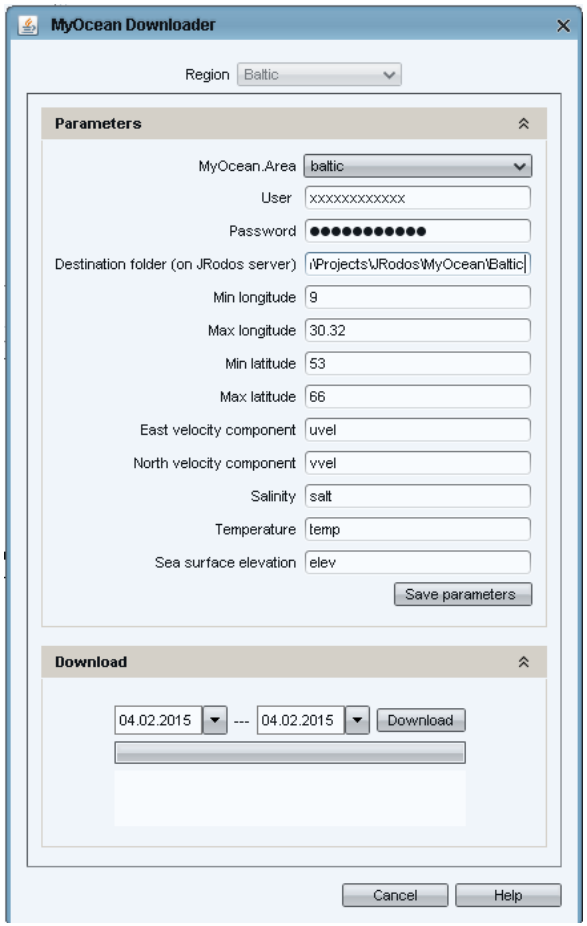


MyOcean Downloader user interface

PREPARE



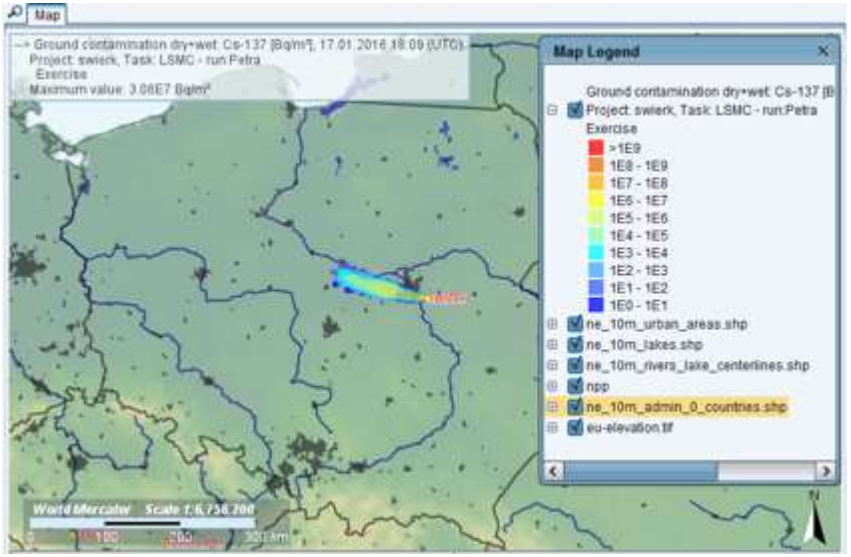
FTP access



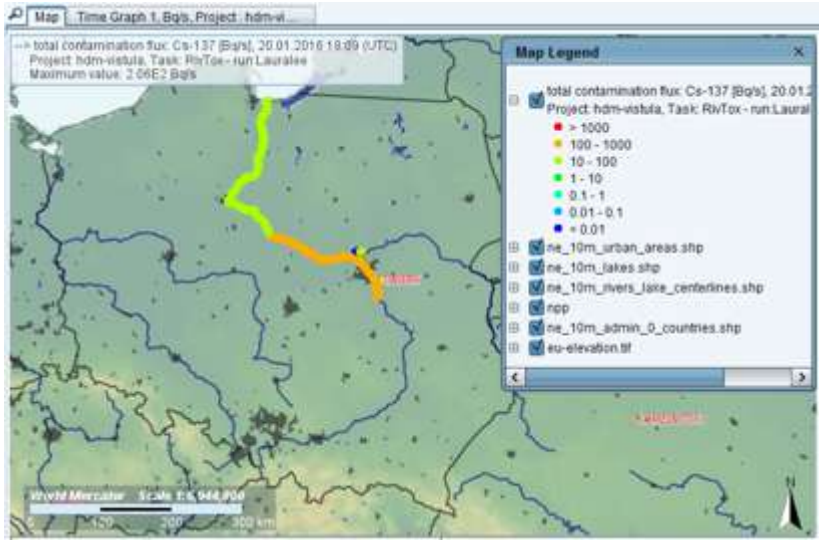
Motu client access

RIVTOX-THREETOX linkage

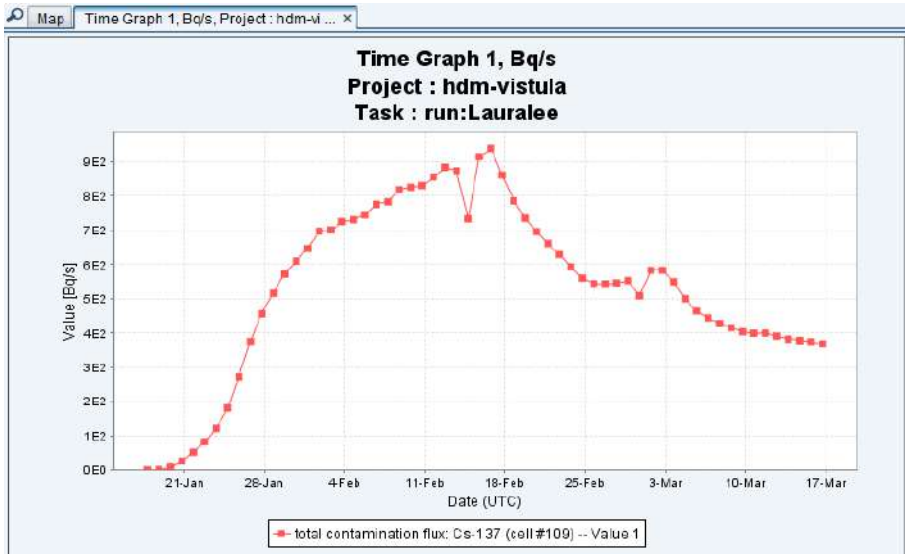
PREPARE



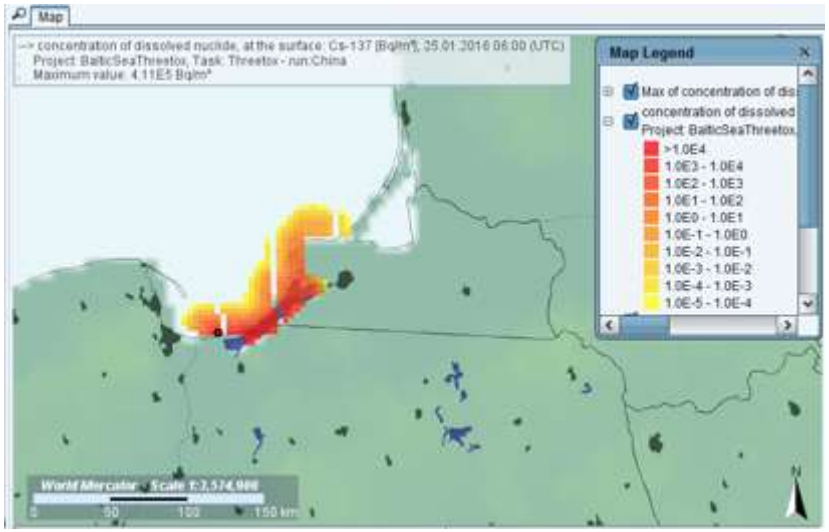
Deposition of Cs-137



Total flux of Cs-137 in Rivtox model after 8 days



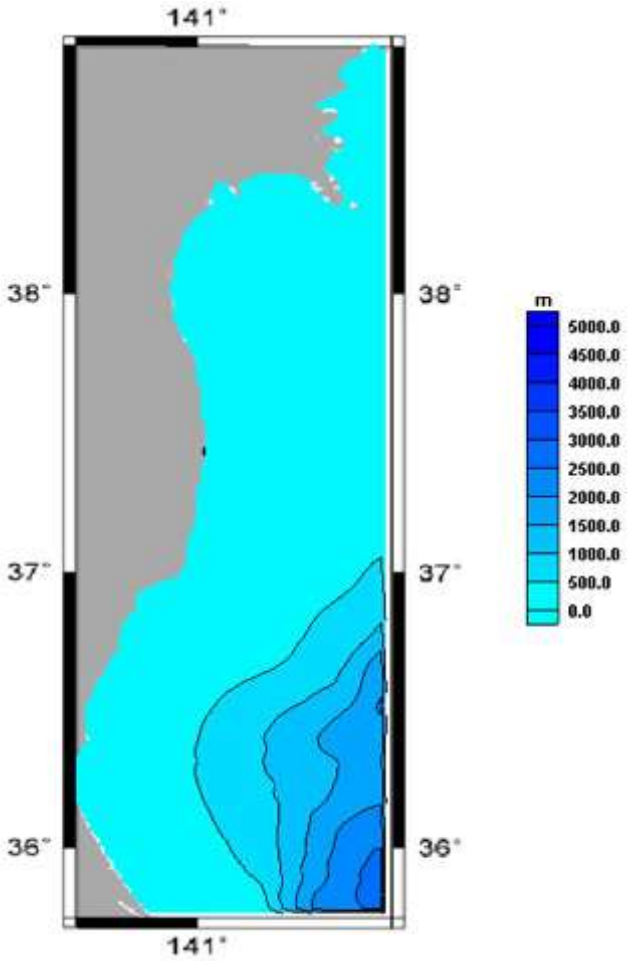
Total flux of Cs-137 in Rivtox model



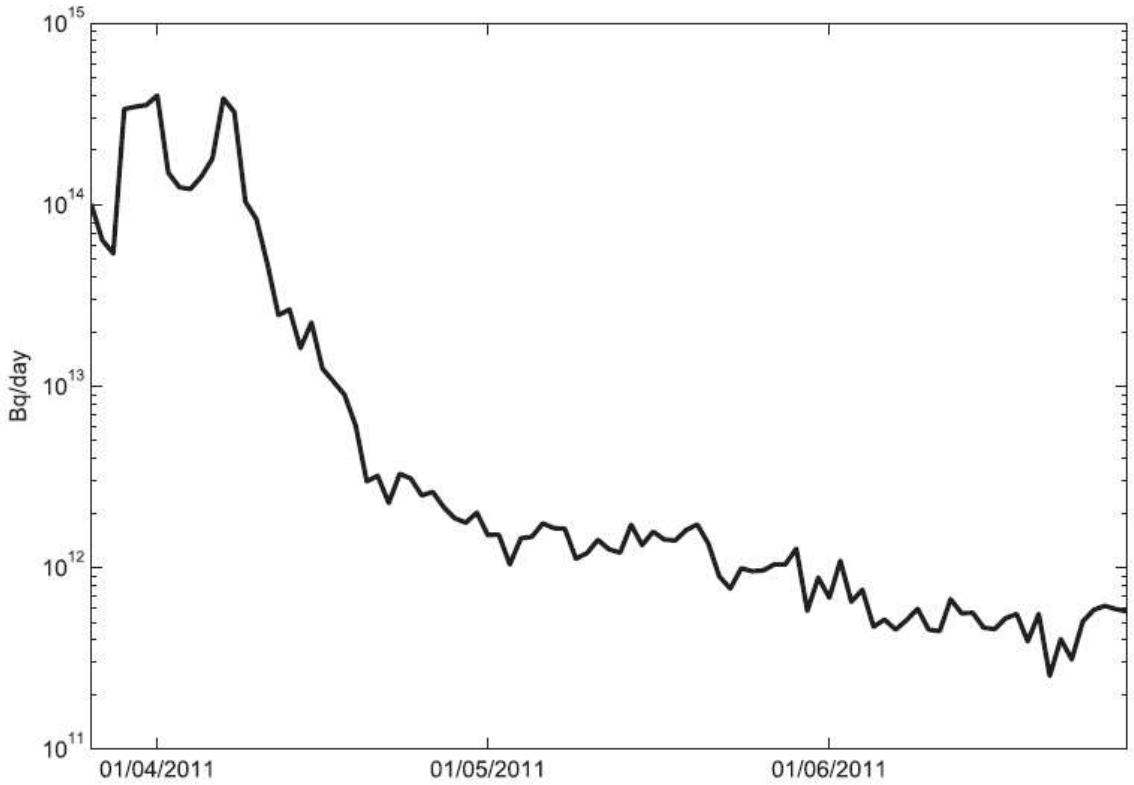
Concentration of Cs-137 one month after release

Application to the Fukushima accident:

Fukushima accident data

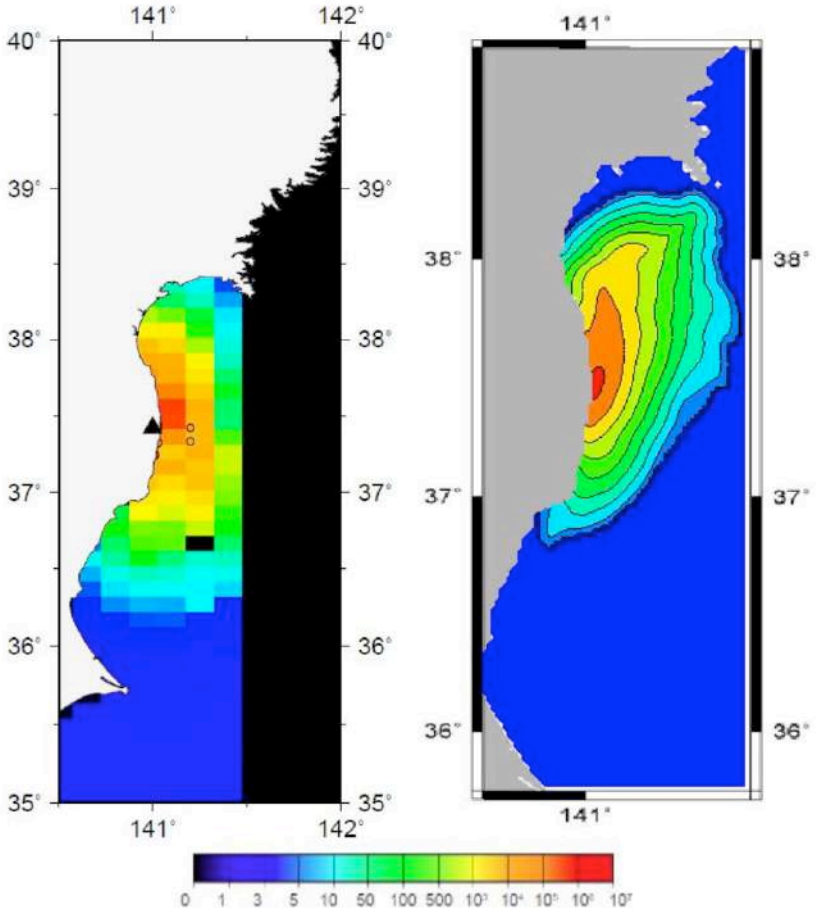


Bathymetry map



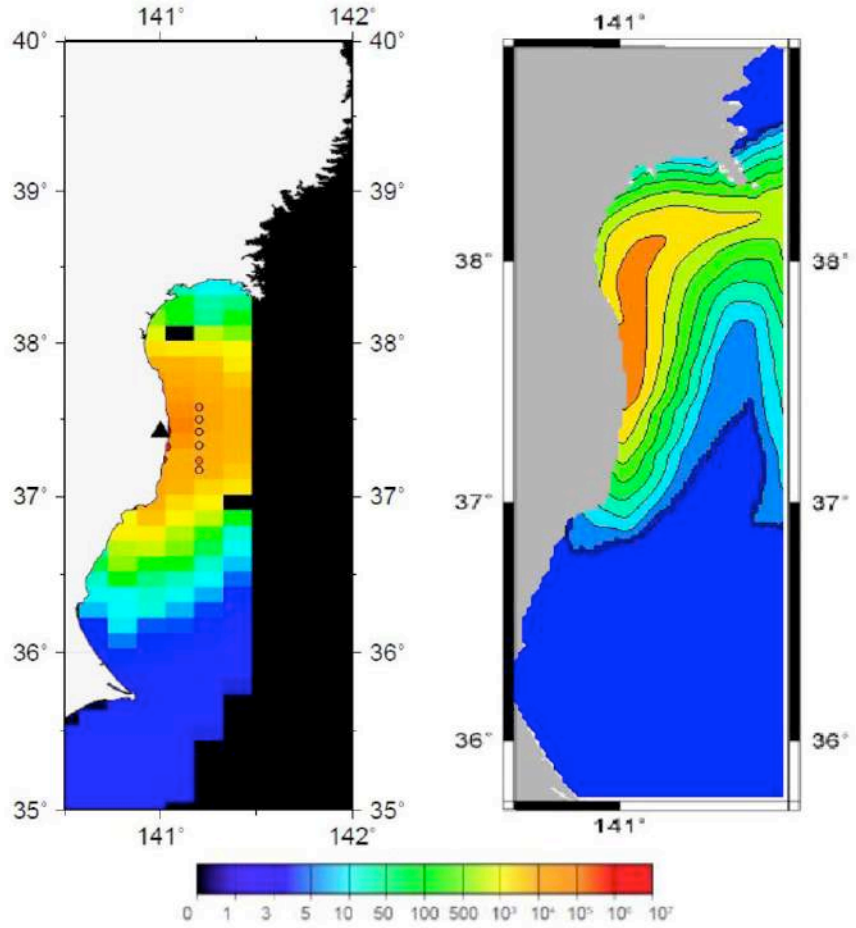
^{137}Cs release from FDNPP.

Distribution of ^{137}Cs in coastal areas



(a) 1 April 2011

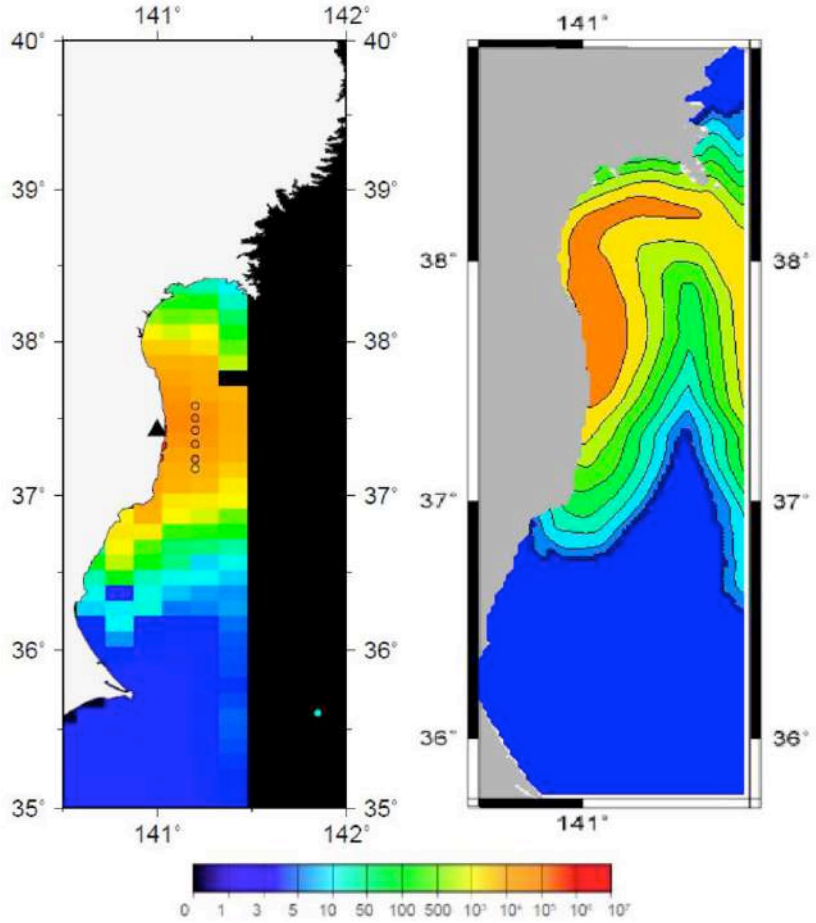
Inomata et al. (2016) Calculations



(b) 6 April 2011

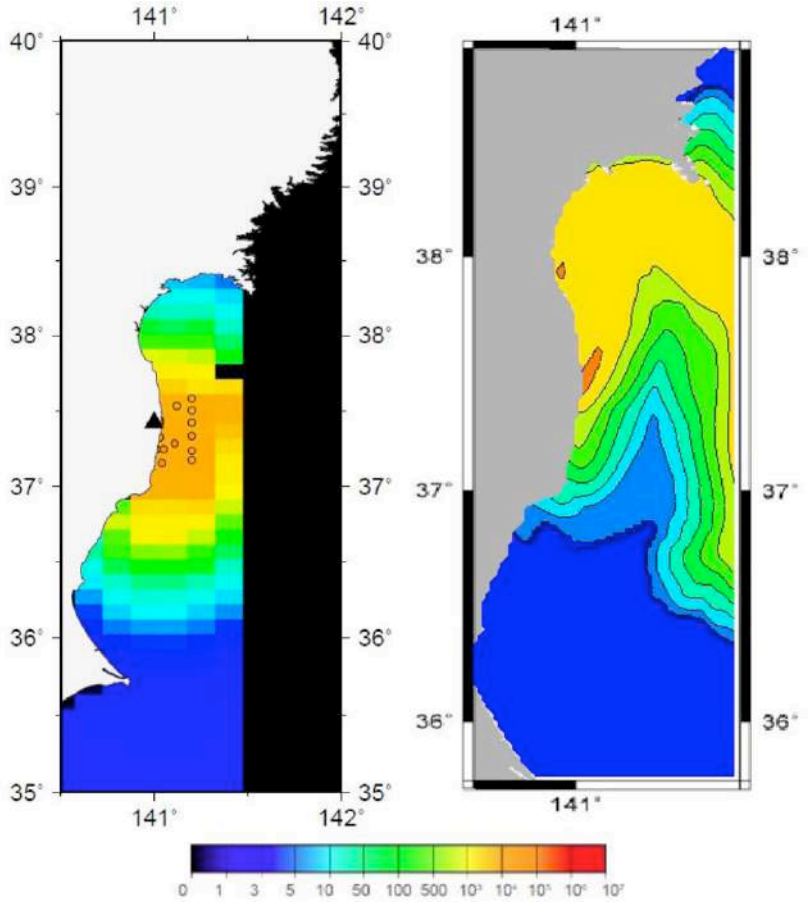
Inomata et al. (2016) Calculations

Distribution of ^{137}Cs in coastal areas



(c) 11 April 2011

Inomata et al. (2016)



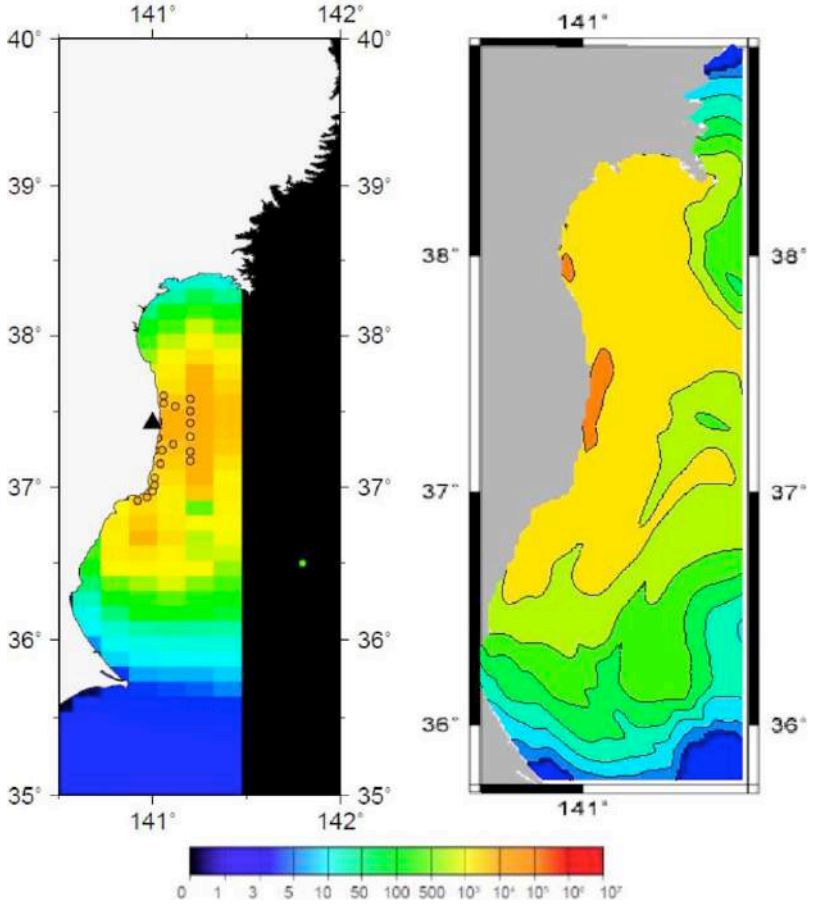
(d) 21 April 2011

Calculations

Inomata et al. (2016)

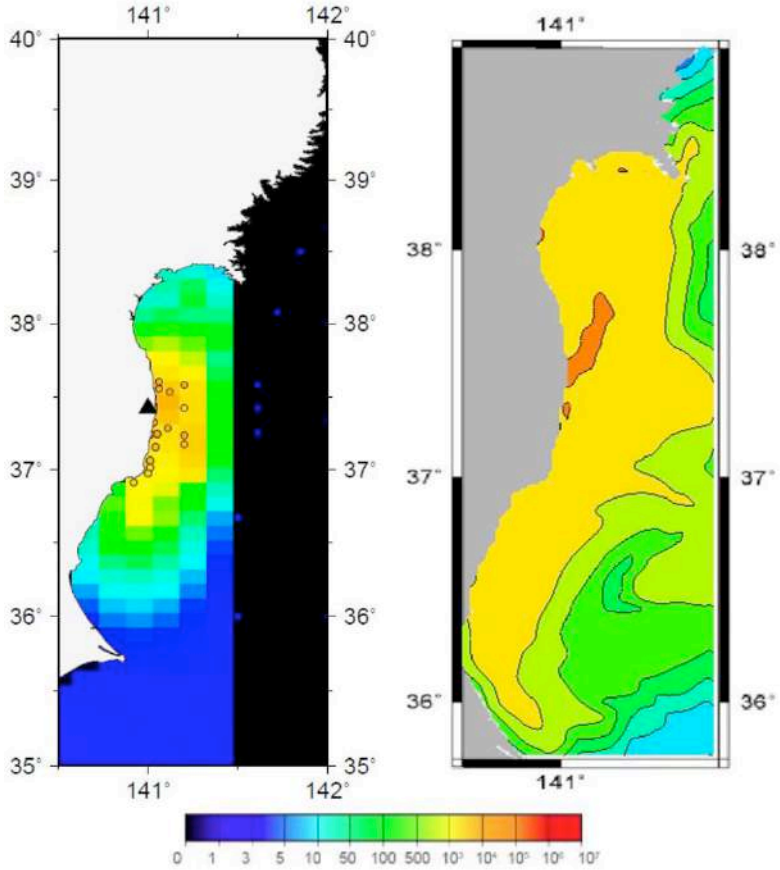
Calculations

Distribution of ^{137}Cs in coastal areas



1 May 2011

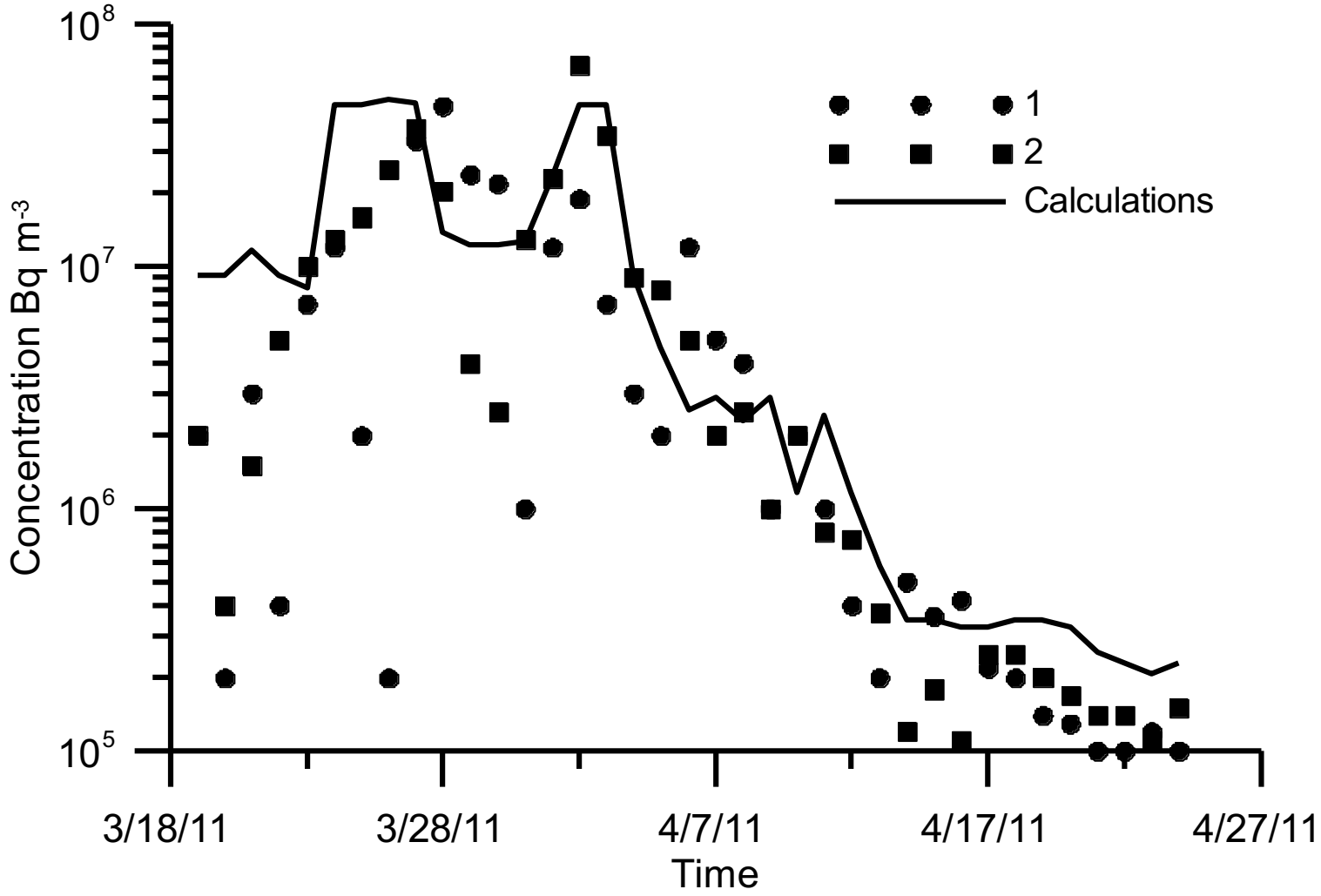
Inomata et al. (2016) Calculations



(f) 11 May 2011

Inomata et al. (2016) Calculations

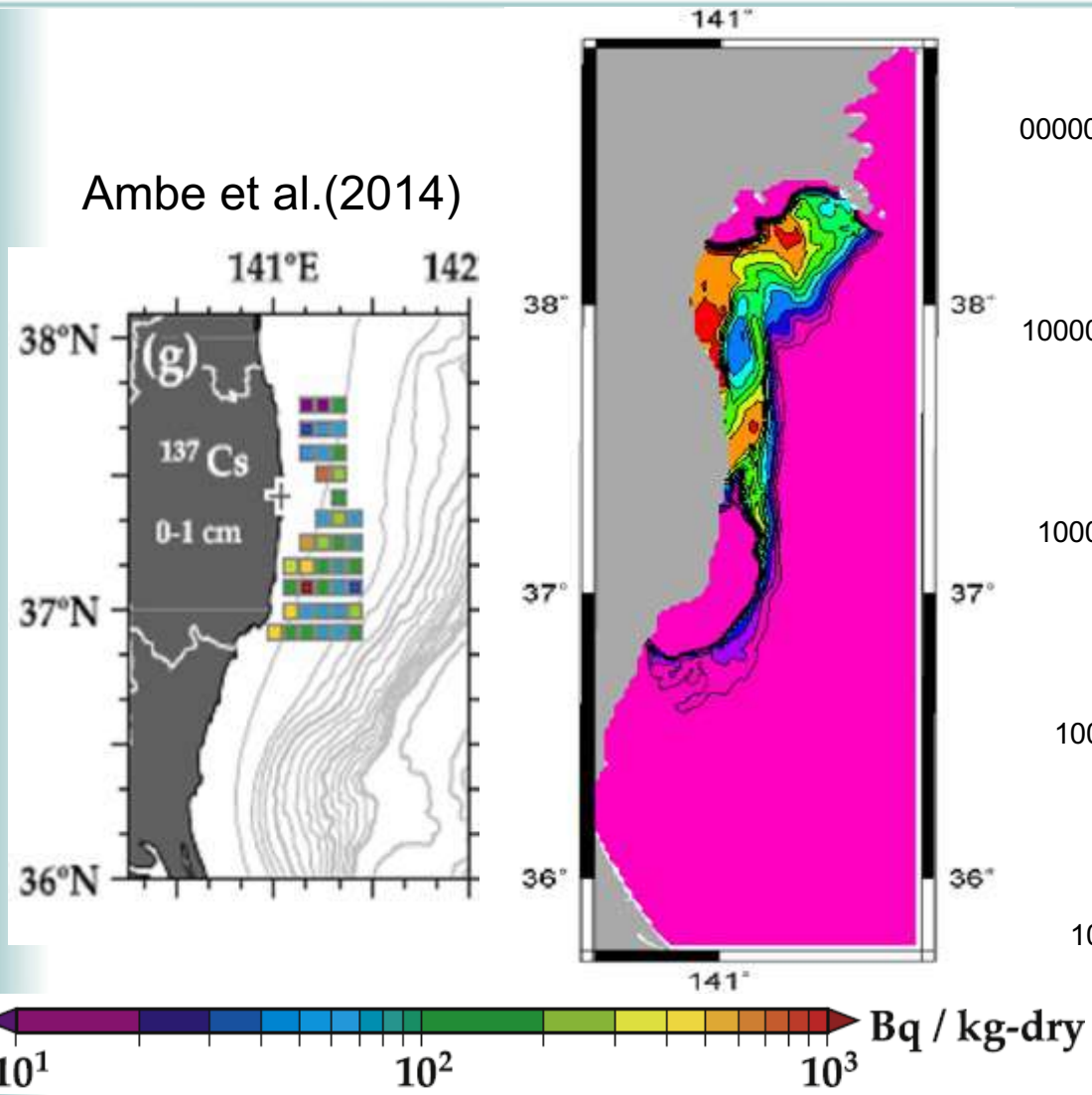
Time series of observed and simulated ^{137}Cs

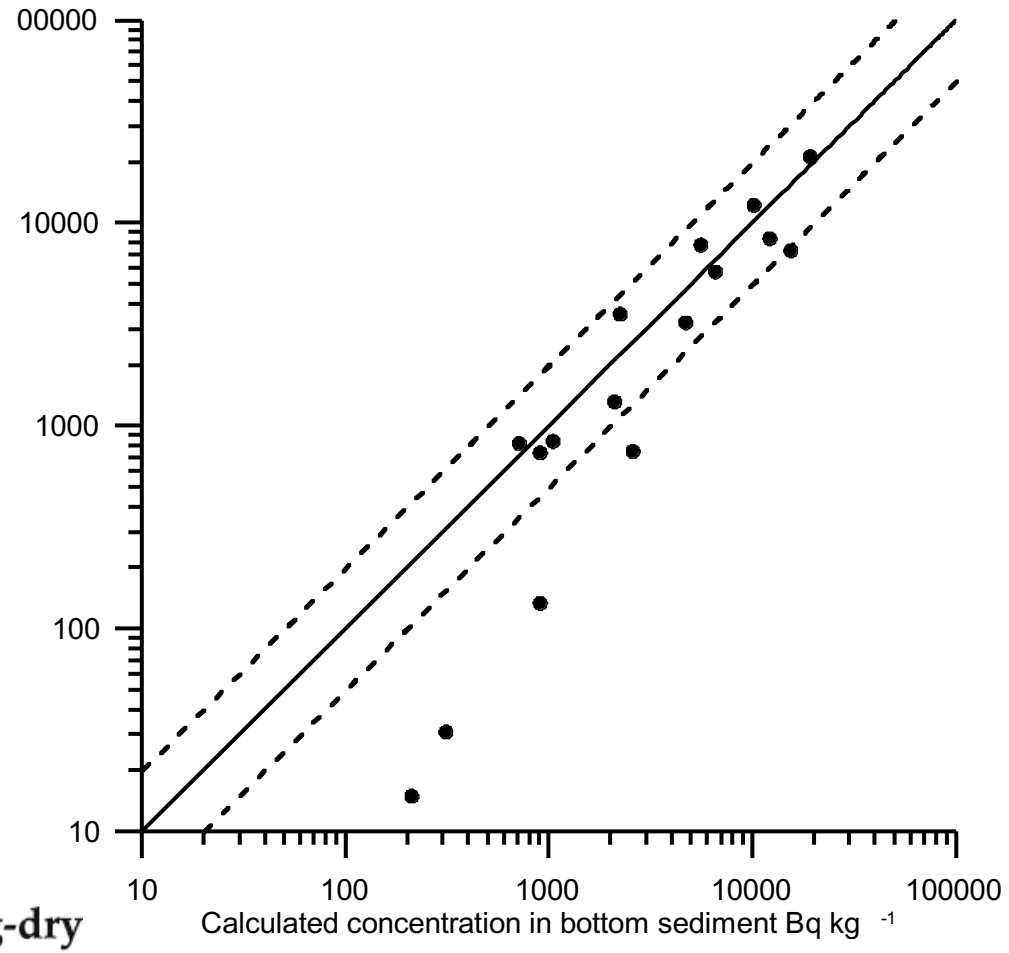


Time series of observed and simulated seawater-surface ^{137}Cs at TEPCO (2011) stations T-1 and T-2.

Predicted spatial distribution of ^{137}Cs in sediments

Ambe et al.(2014)



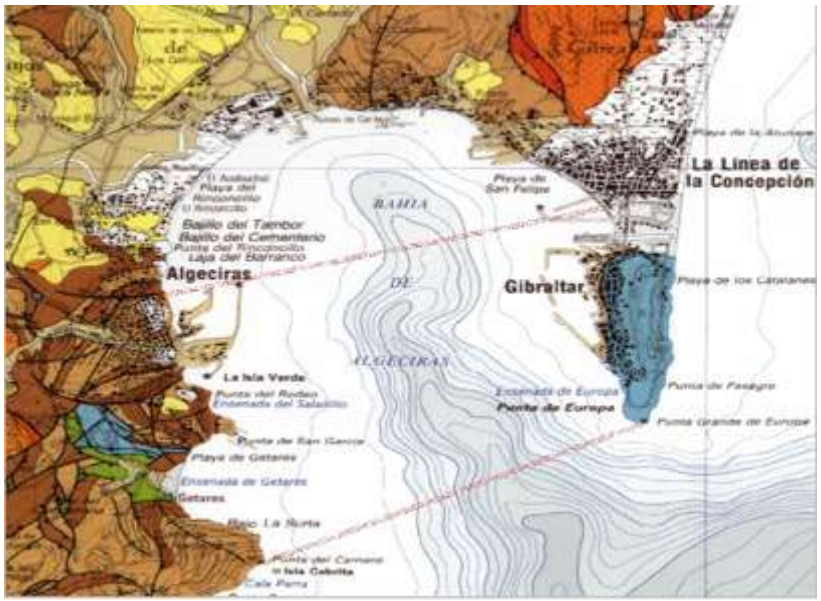


^{137}Cs concentration in the bottom sediments in October 2011

Correlation between the predicted and the measured (Otosaka and Kato, 2014) ^{137}Cs concentration in the bottom sediments.

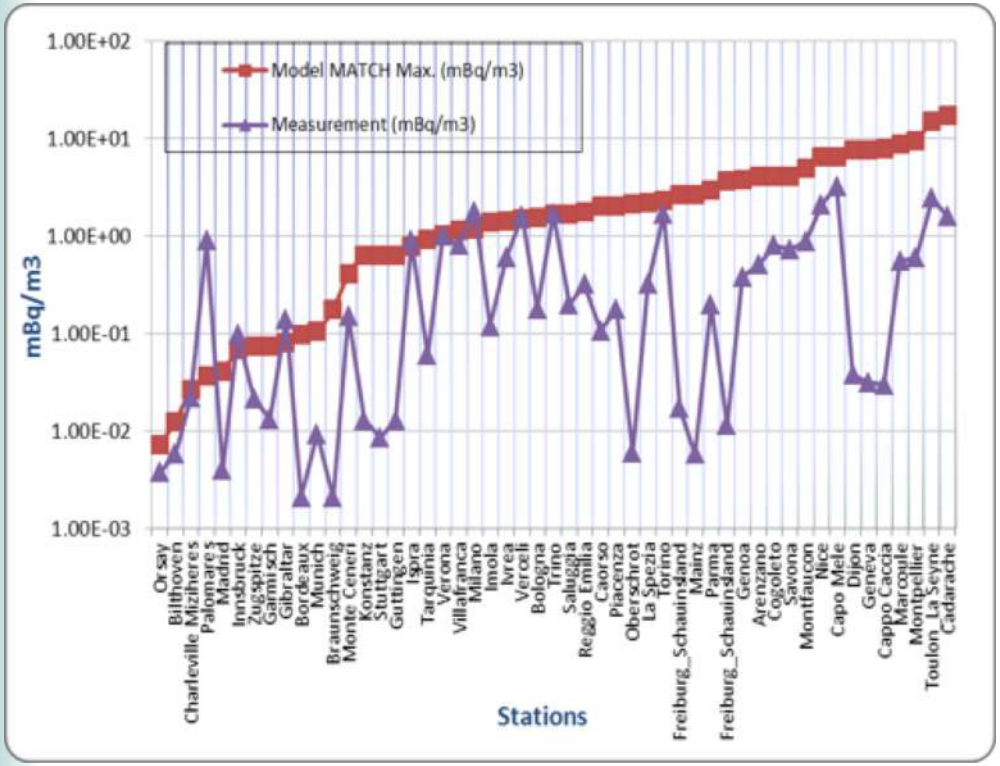
Acerinox incident (Spain)

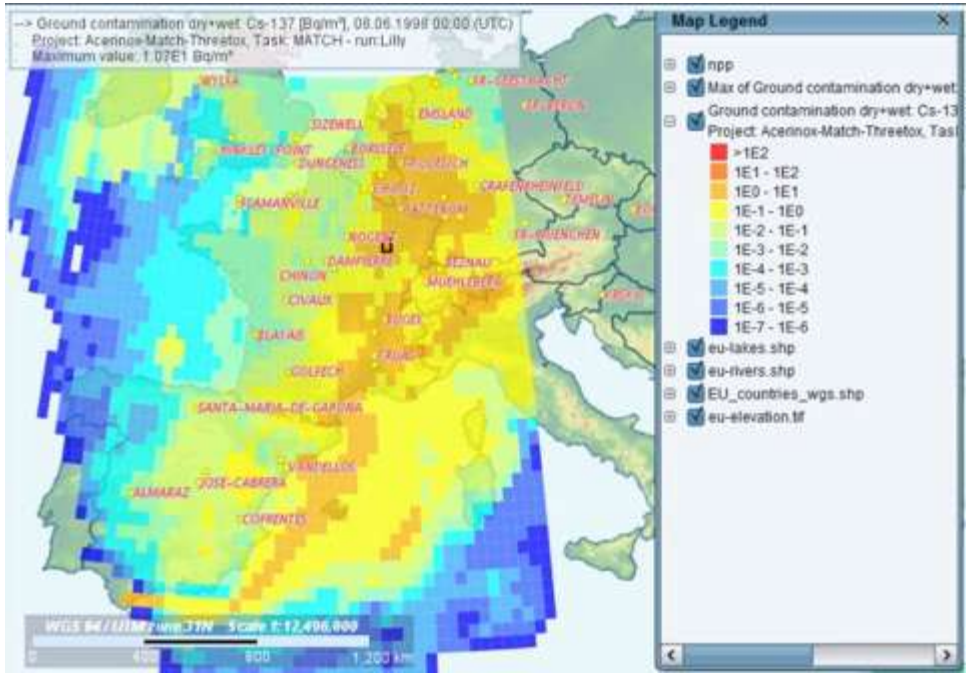
Algeciras Bay with ACERINOX plant location.



- On May 30, 1998, an orphan source of ^{137}Cs was accidentally melted in one of the furnaces of a stainless steel plant belonging to the enterprise Acerinox in the south of Spain
- 37 GBq of ^{137}Cs were released to the atmosphere
- The air contamination was dispersed on the large distance, practically in all European countries

JRODOS application to the Acerinox incident



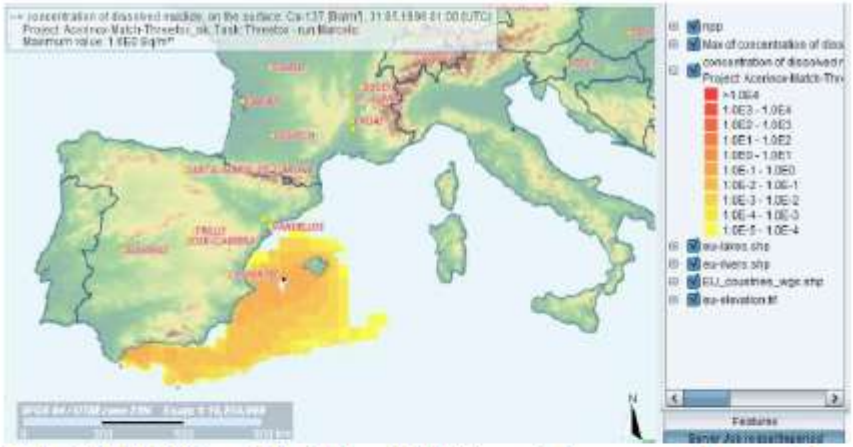


. Comparison of the maximum ^{137}Cs measured and modeled by MATCH

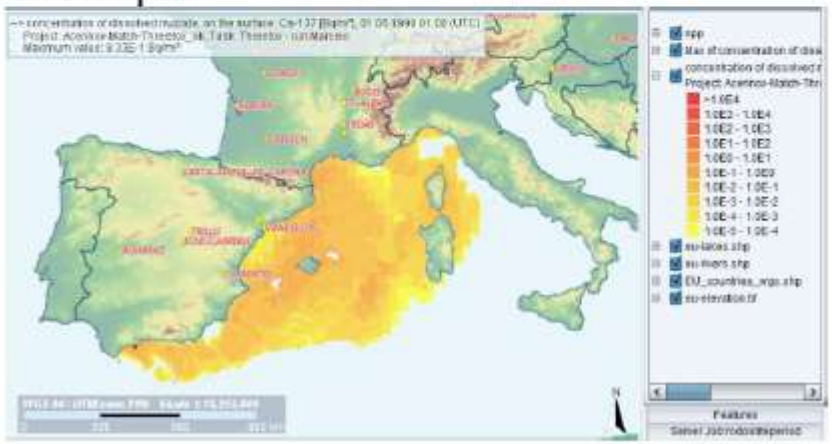
Atmospheric deposition simulated by MATCH model in JRODOS

JRODOS application to the Acerinox incident

30.05.1998 01:00 UTC. Max value is 2.16 Bq/m^3



31.05.1998 01:00 UTC. Max value is 1.6 Bq/m^3



01.06.1998 01:00 UTC. Max value is 0.933 Bq/m^3

02.06.1998 01:00 UTC. Max value is 0.729 Bq/m^3

Surface concentration of Cs-137 after Acerinox incident

JRODOS application to the Acerinox incident

PREPARE

03.06.1998 01:00 UTC. Max value is 0.673 Bq/ m^3

04.06.1998 01:00 UTC. Max value is 0.583 Bq/m^3

05.06.1998 01:00 UTC. Max value is 0.475 Bq/m^3

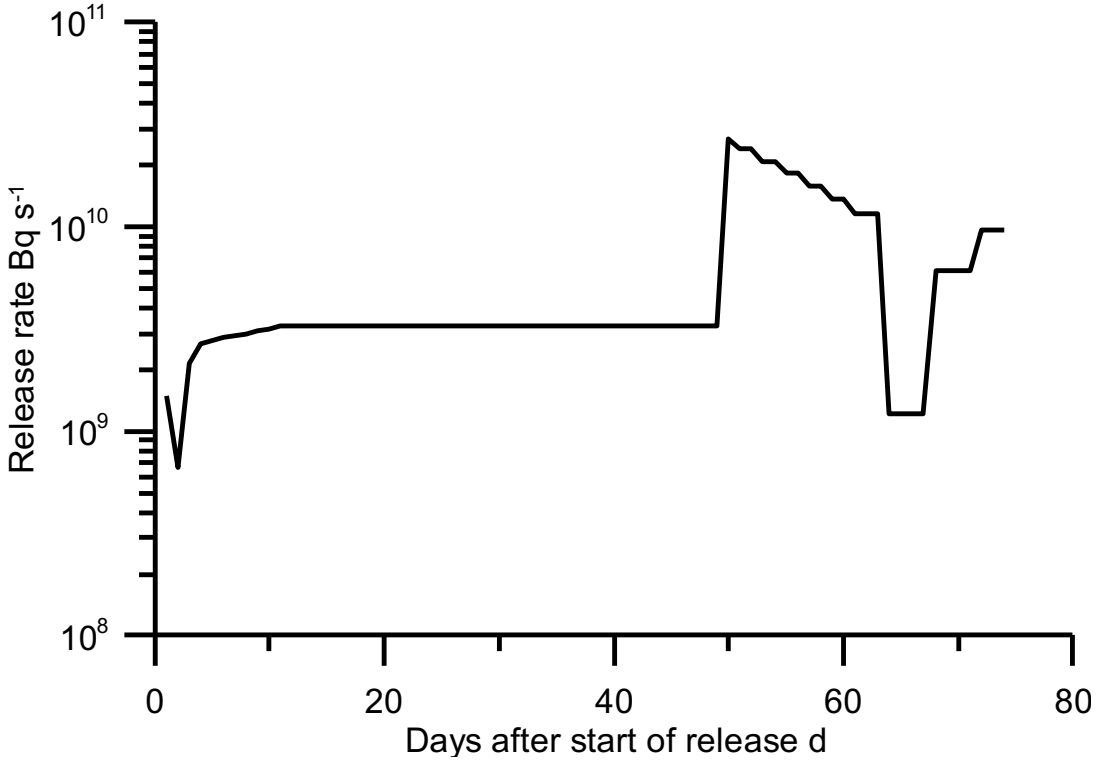
07.06.1998 01:00 UTC. Max value is 0.359 Bq/m^3

Surface concentration of Cs-137 after Acerinox incident

Stress test for Asco NPP (Spain)

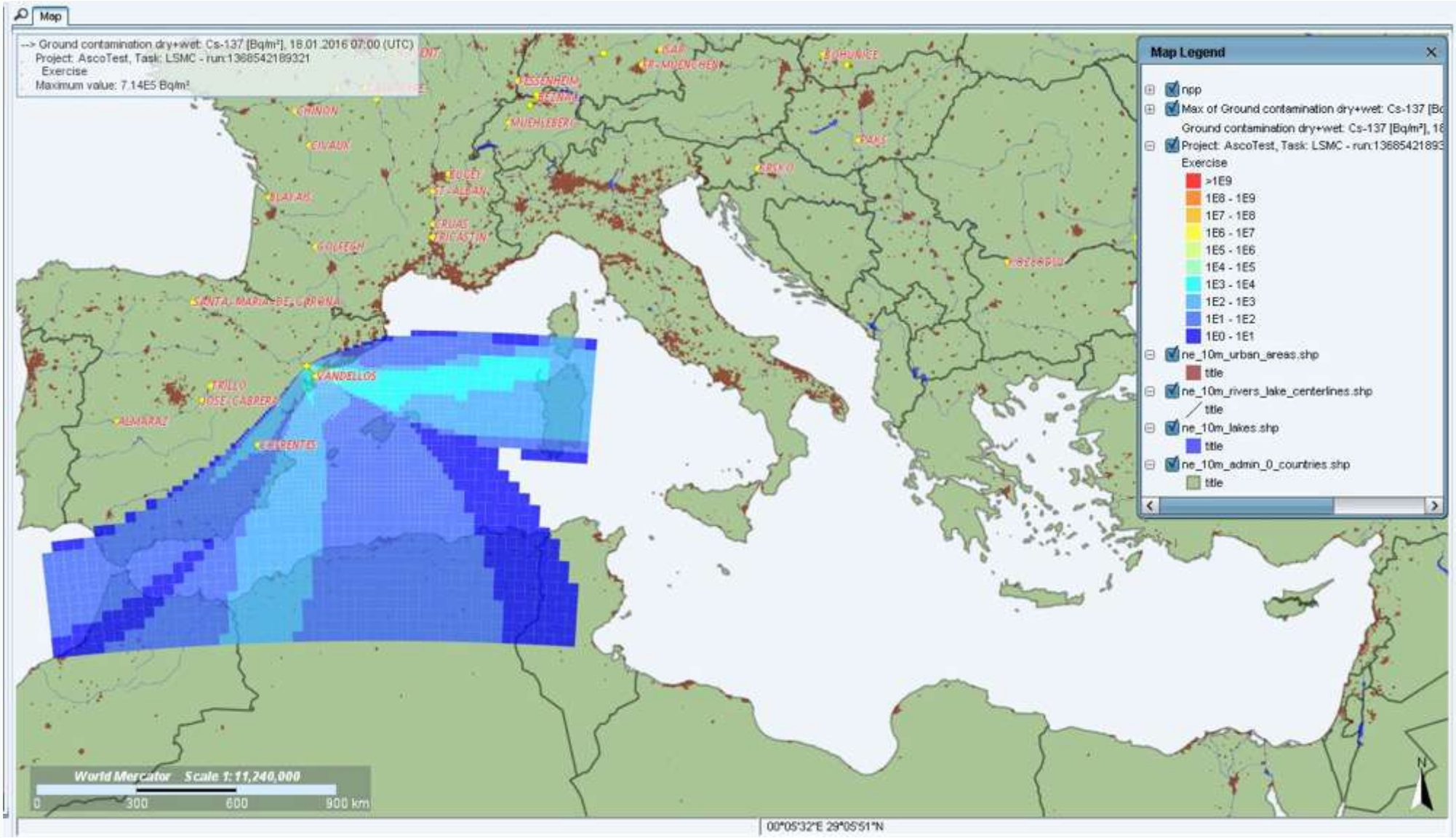
PREPARE

Asco NPP.

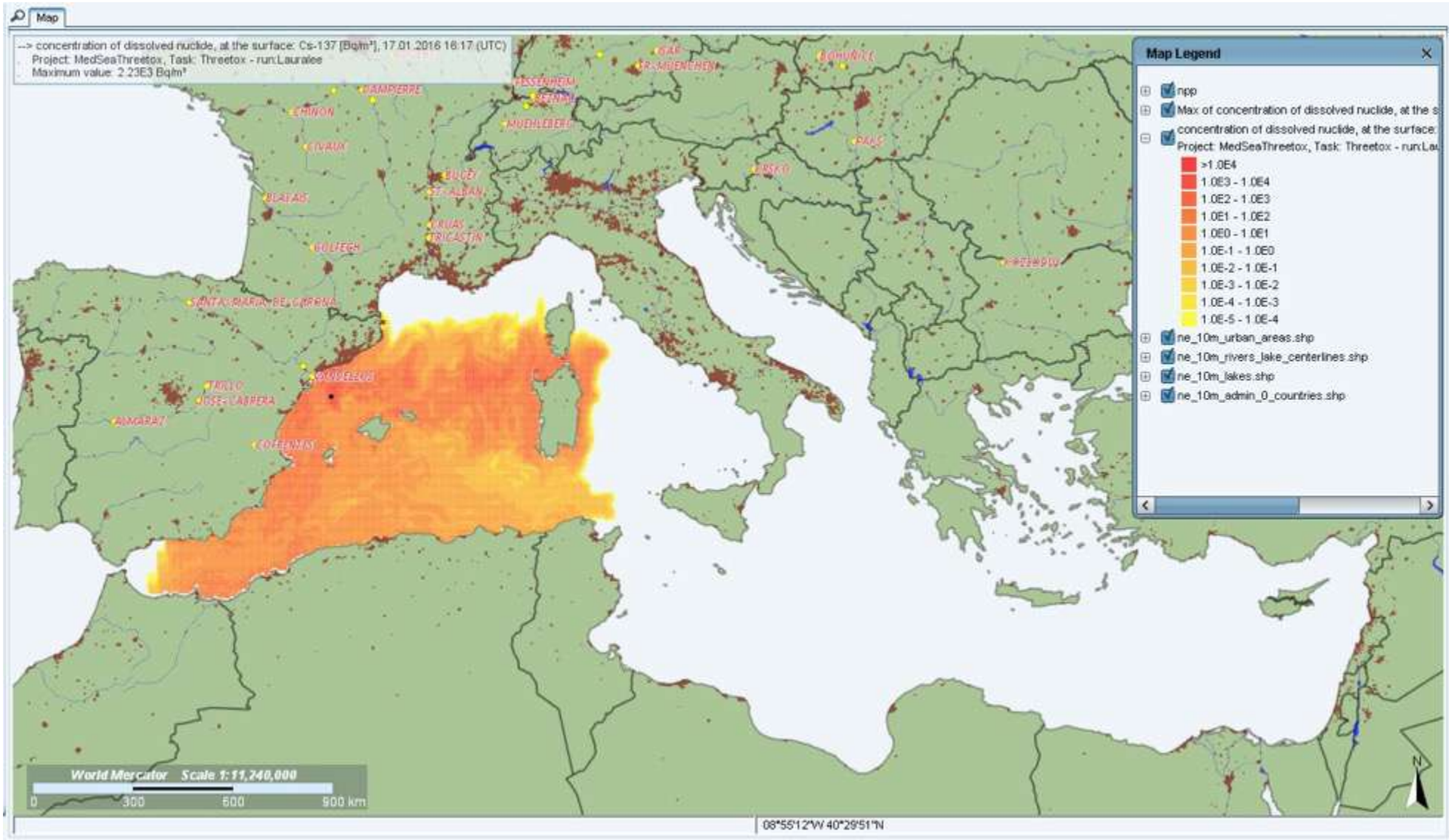


The intensity of source of ^{137}Cs in stress test

Results of deposition (wet + dry) for 18.01. 2016 07.00 (UTC)



Concentration of ^{137}Cs in solute in the surface water for 17.01.2016



Conclusions

- The THREETOX radioactivity transport model improvement includes extension of model for the multi-fractional sediments and two-step kinetics.
- The refinements of the THREETOX model within the PREPARE project results in operational model development which uses forecasts of marine currents from the operational ocean models.
- The algorithms of the operational use of the THREETOX model in JRODOS were developed.
- The results of comparison of the updated THREETOX model simulation with measurements for Fukushima-Daiichi case study are presented.
- The THREETOX model implemented into the JRODOS was applied to the Acerinox incident and in the stress test for Asco NPP.

Publications

- Brovchenko I., Ievdin I., Koshebutsky V., Maderich V., Periañez R.,Zheleznyak M. (2016) Integration of 3D model THREETOX in JRODOS-HDM, implementation studies and model validation on marine Fukushima scenarios. *Radioprotection*
- Periañez R., Bezhenar R., Iosjpe M., Maderich V., Nies H., Osvath I., Outola I., de With G. (2015) A comparison of marine radionuclide dispersion models for the Baltic Sea in the frame of IAEA MODARIA program. *Journal of Environmental Radioactivity* **139**, 66-77.
- Bezhenar R.V., Koshebutsky V.I., Kovalets I.V., Maderich V.S., Zheleznyak M.J.(2012) Model based analysis of effectiveness of the engineering solutions designed to increase cooling capacity of Tashlyk water reservoir of South-Ukrainian Nuclear Power Plant. *International Journal of Energy for a Clean Environment* **13**, (1-4) pp. 39-51.

- Any questions?

The research leading to these results has received funding from the European Atomic Energy Community Seventh Framework Programme [FP7/2007-2011] [FP7/2012-2013] under grant agreement n° [323287].