Collaborative Research: The Japan March 11 Earthquake: Tsunami inundation, and initial spread of Fukushima Dai-ichi Radionuclides into the Pacific Ocean: Model Assessment

J-Rapid

PI: Jun Sasaki[1]

T. Suzuki[1] and R. U. A. Wiyono[1]

Rapid

PI: Changsheng Chen[2]

C. Beardsley[3], Z. Lai[2], R., H. Lin[2], J. Lin[3] and R. Ji[3]

[1]Yokohama National University (YNU), Japan

[2]University of Massachusetts-Dartmouth (UMASS-D), USA

[3]Woods Hole Oceanographic Institution (WHOI), USA

Outline

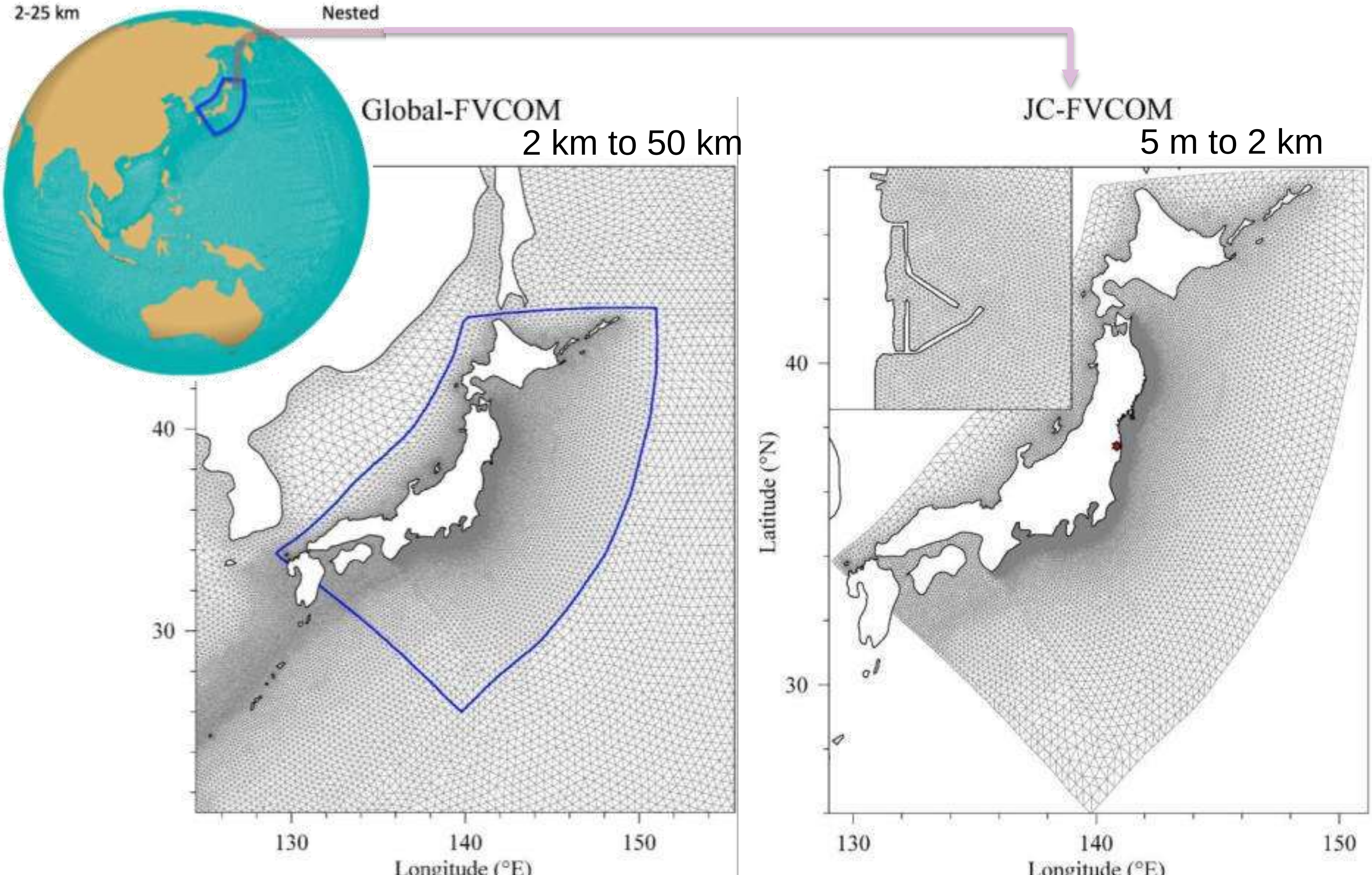
- Global-Japan coastal nesting FVCOM (Finite Volume Community Ocean Model) tsunami model system
  - Concept of the system
  - Application to 2011 Tohoku tsunami inundation
  - Application to the initial spread of Fukushima Dai-ichi radionuclides into the Pacific Ocean
  - Discussion on the necessity of the system
- FVCOM simple application to tsunami problems
  - 2011 Tohoku tsunami propagation in Tokyo Bay
  - Tsunami damage to seaweed farming

GLOBAL-JAPAN COASTAL NESTING FVCOM TSUNAMI MODEL SYSTEM

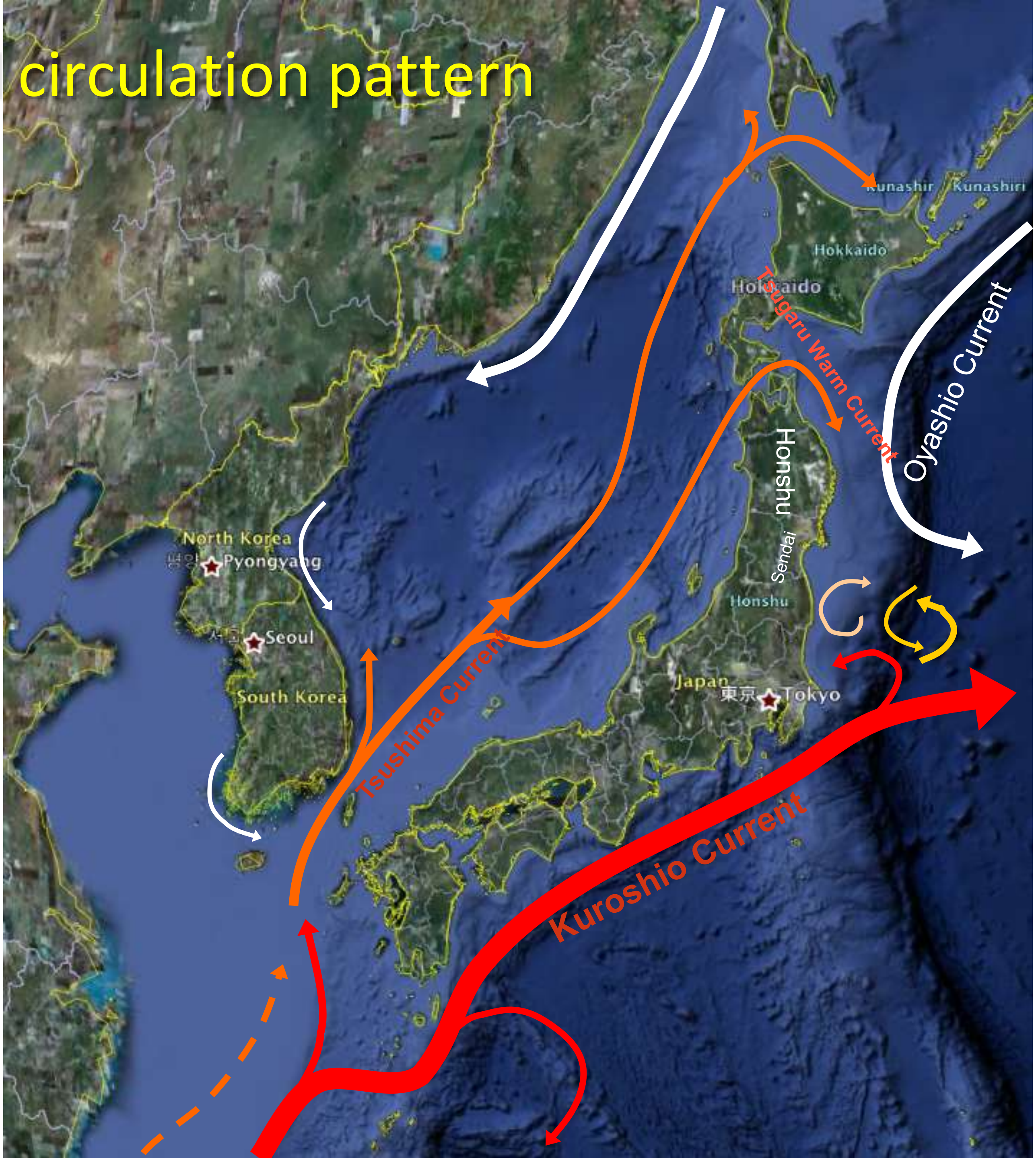
Global-Japan coastal nested FVCOM tsunami model system

- Run **Global-FVCOM** (Finite-Volume Community Ocean Model) to hindcast ocean conditions from January 1 to May 31, 2011.
- Re-run **Global-FVCOM** with starting at 00:00 GMT, March 11, and add seafloor change at 14:46 JST.
- Run nested high-resolution **JC-FVCOM** coastal inundation model with boundary conditions from **Global-FVCOM** and initial earthquake-induced sea level setup from the earthquake model for period: March 11 to May 31, 2011.

Global-FVCOM and JC-FVCOM grids



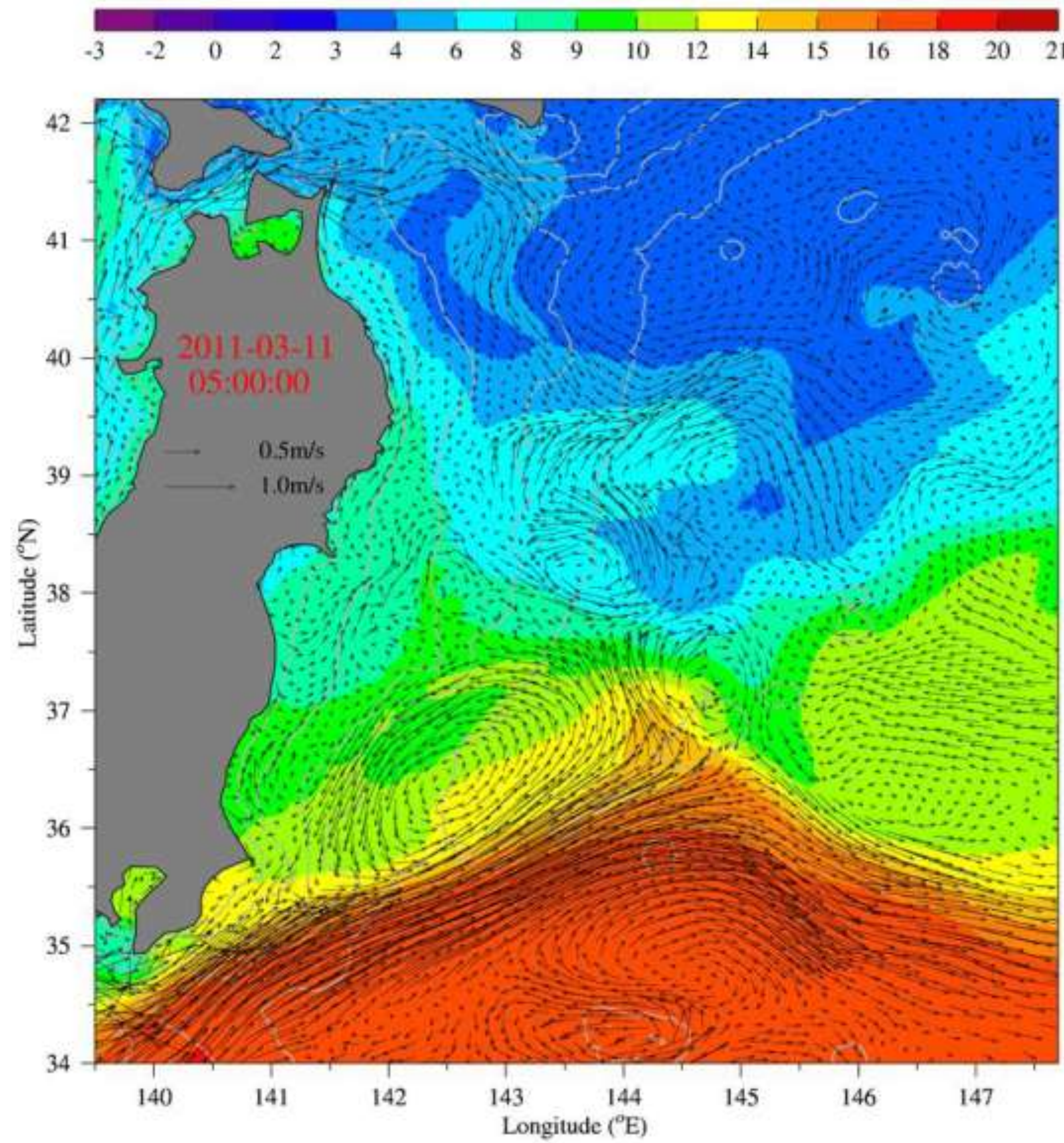
Regional circulation pattern



Reproducing regional circulation pattern

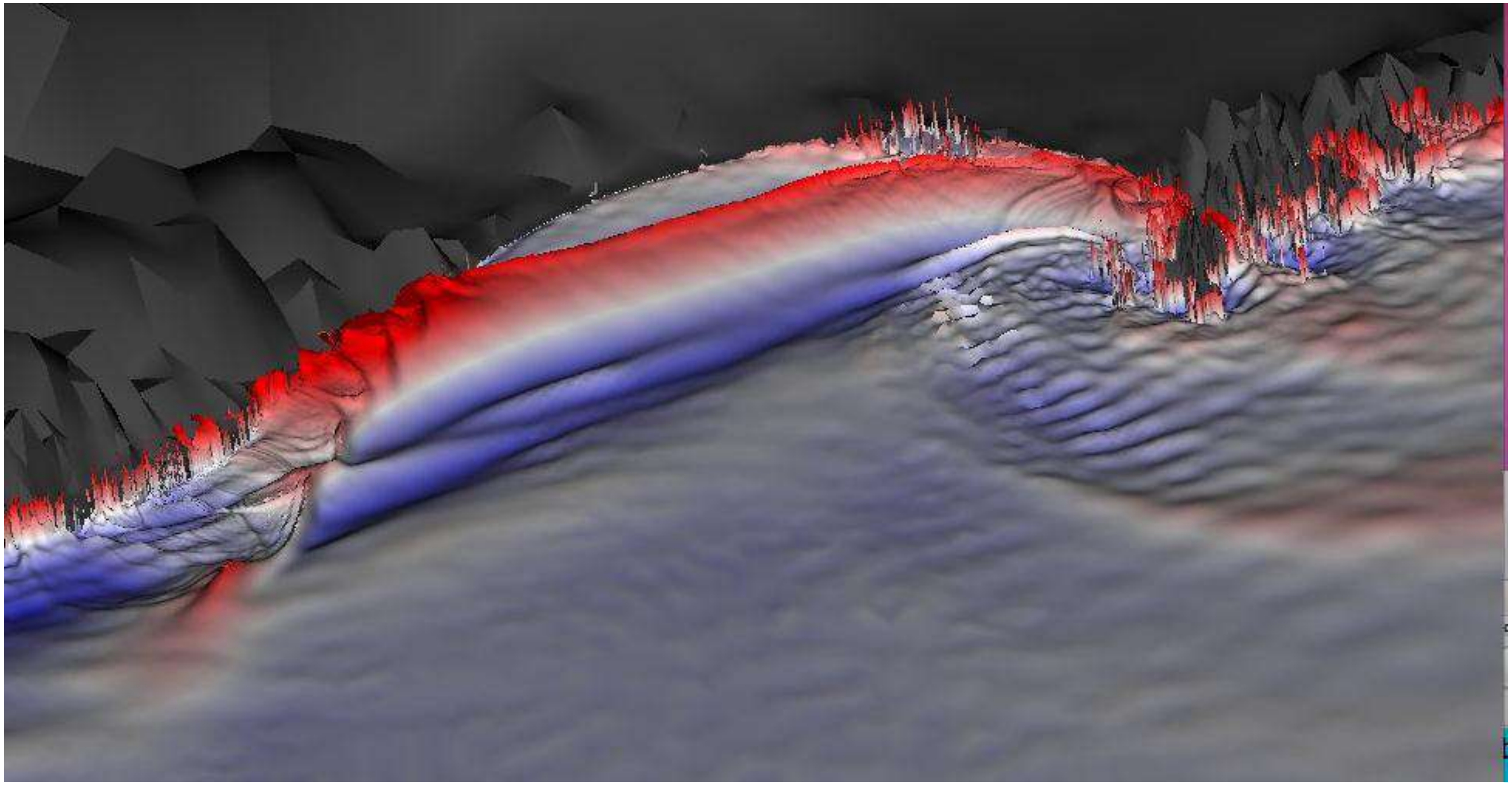
❑ Global-FVCOM

- Vertically 45 levels
- Driven by astronomical tidal forcing with 8 constituents and NCEP reanalysis data for meteorological conditions
- Products of GHRSST SST and AVISO SSH were assimilated into the model.

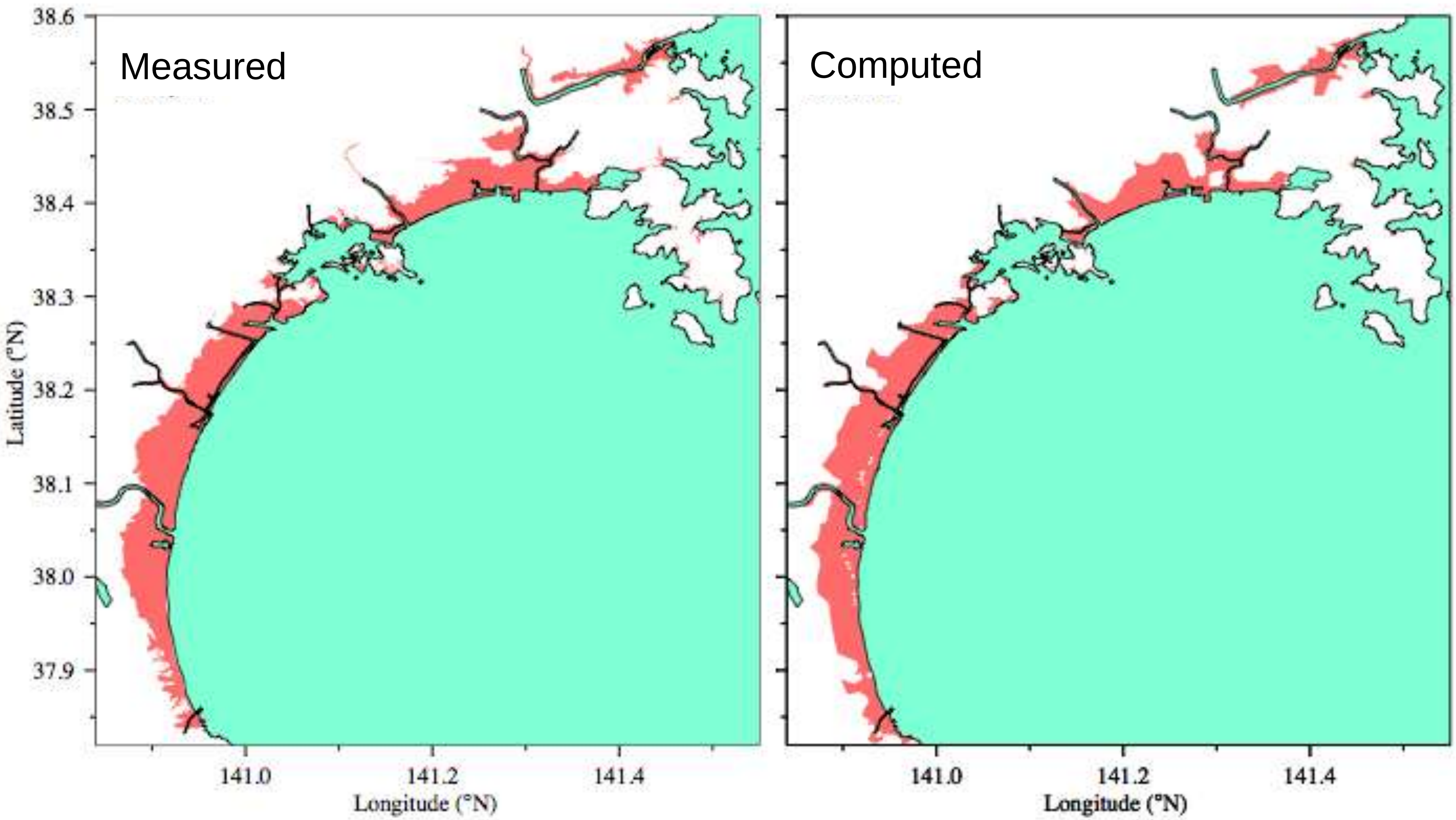


JC-FVCOM

- JC-FVCOM was driven by the same meteorological forcing and output of Global-FVCOM at the nested boundary

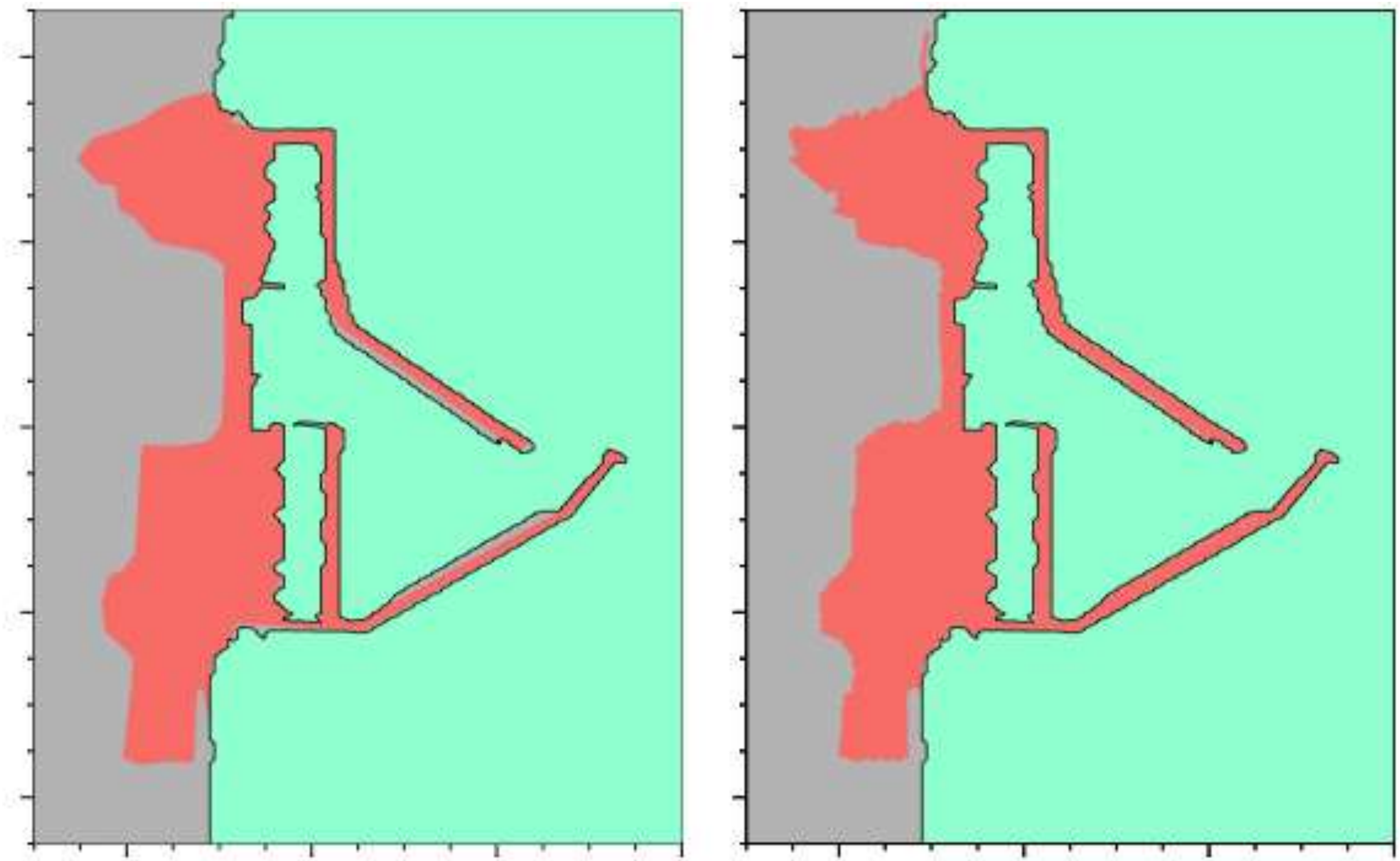


2011 Tohoku tsunami inundation along Sendai Coast

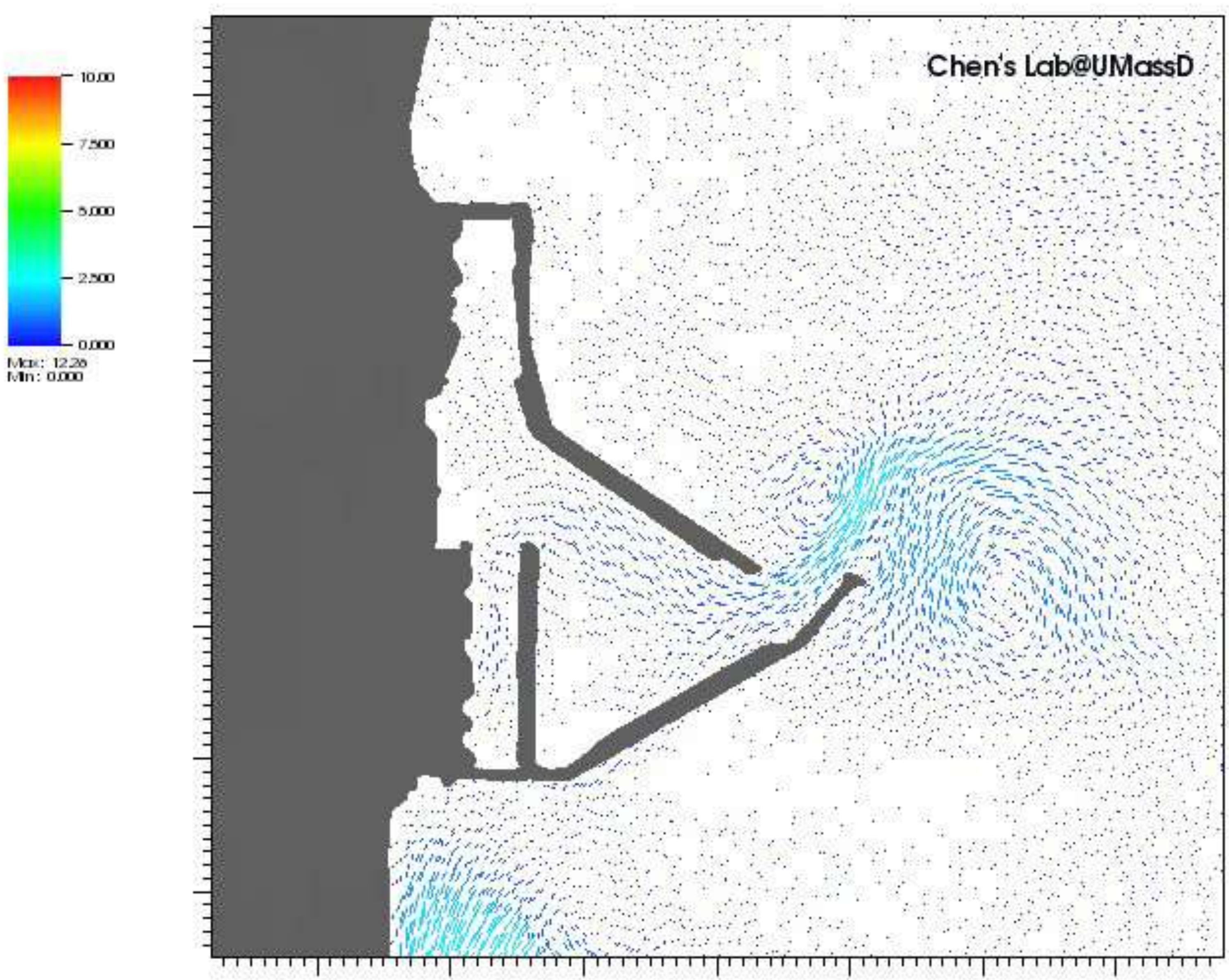


Tsunami inundation around FNPP1

Measured   Computed



Simulated currents around FNPP1

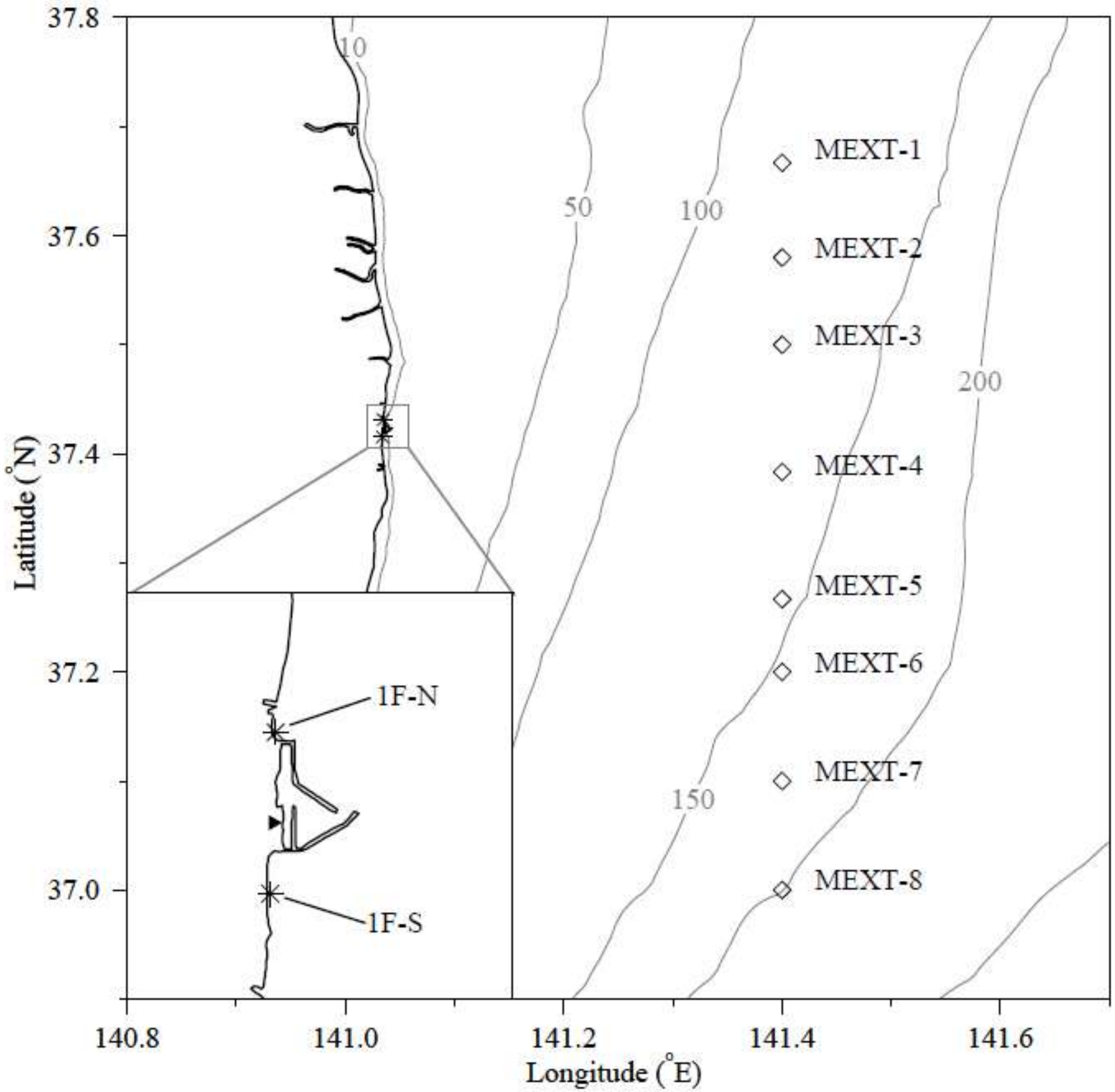


DISPERSION OF ^{137}Cs FROM FNPP1

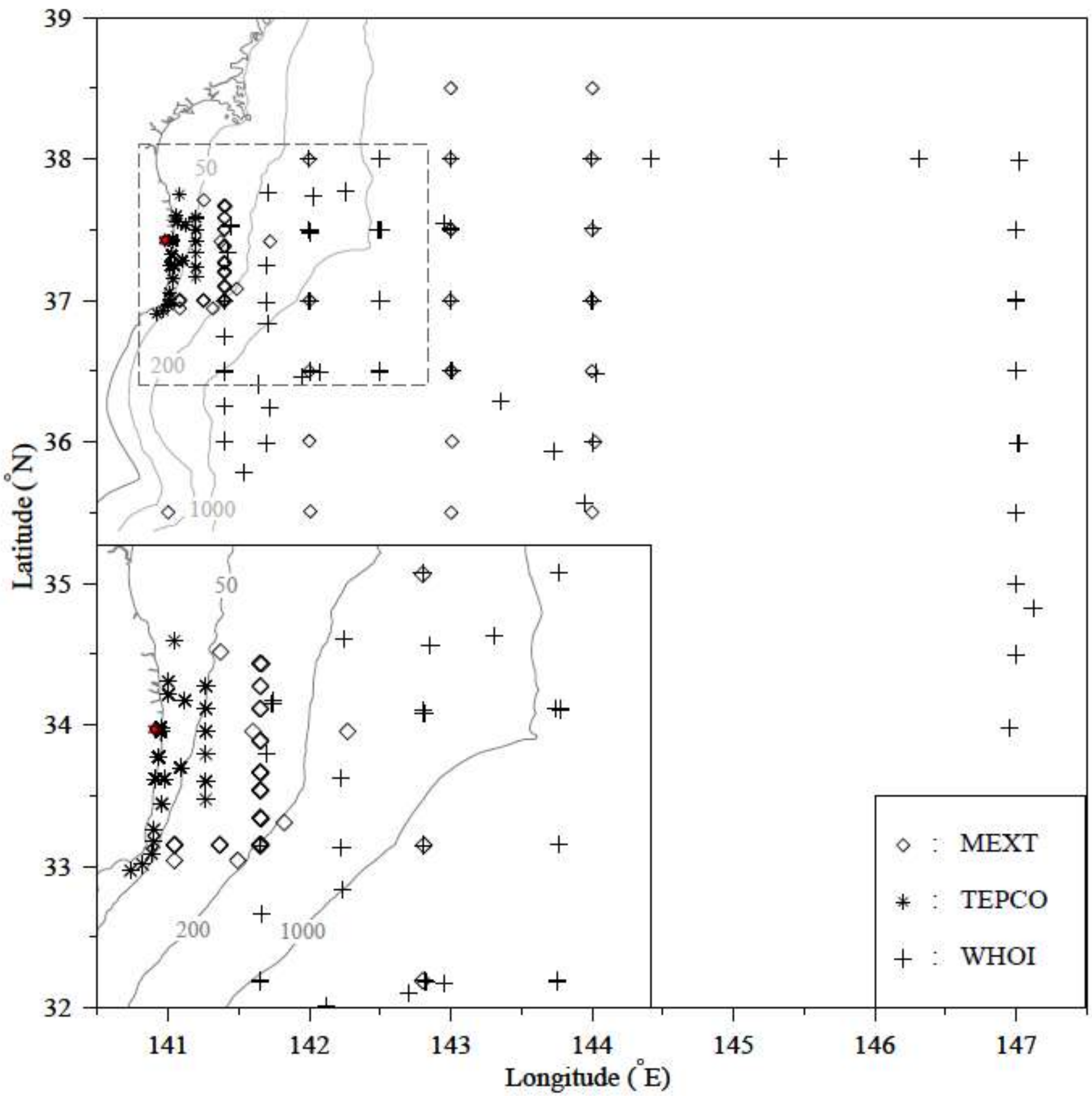
Global-Japan nesting FVCOM tracer experiment

- Release tracers (^{137}Cs) from FNPP1 and track them in both the Global-FVCOM and **JC-FVCOM** 3-D fields, using concentration-based approaches.
- Compare model results with land and ocean observations and use combined information to describe the key processes and assess model skill in their simulation.

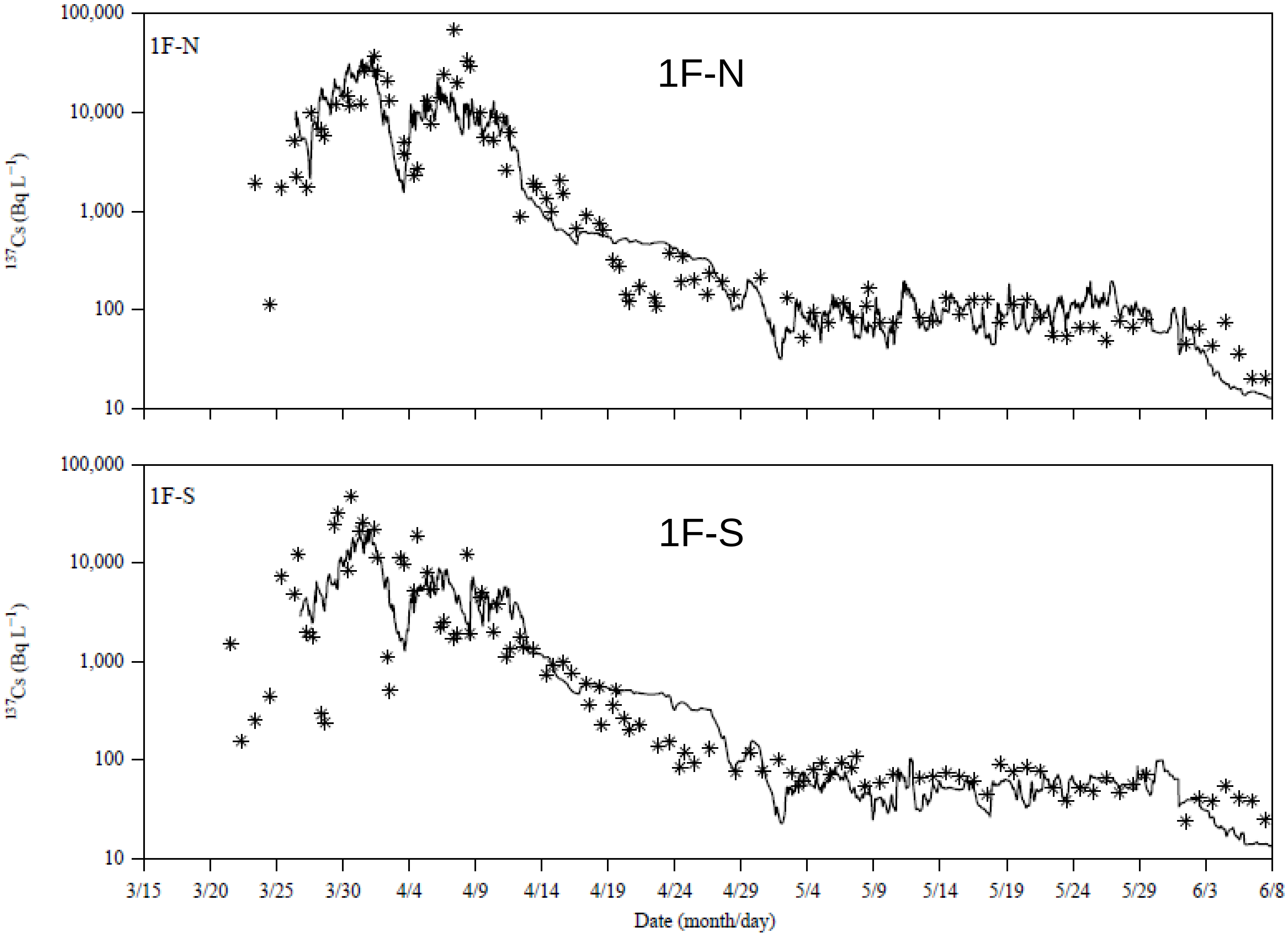
Locations of the north and south discharging canals of FNPP1 and 8 sampling sites 30 km off the coast



Locations for all the collected observation data



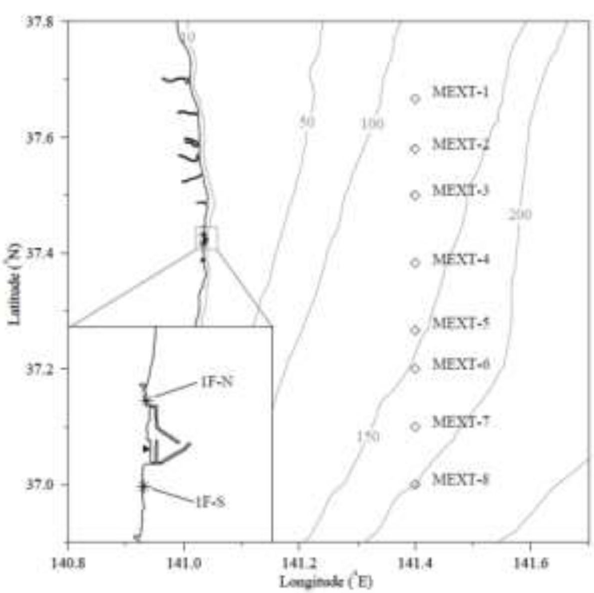
Time series of model data comparisons at 1F-N and 1F-S

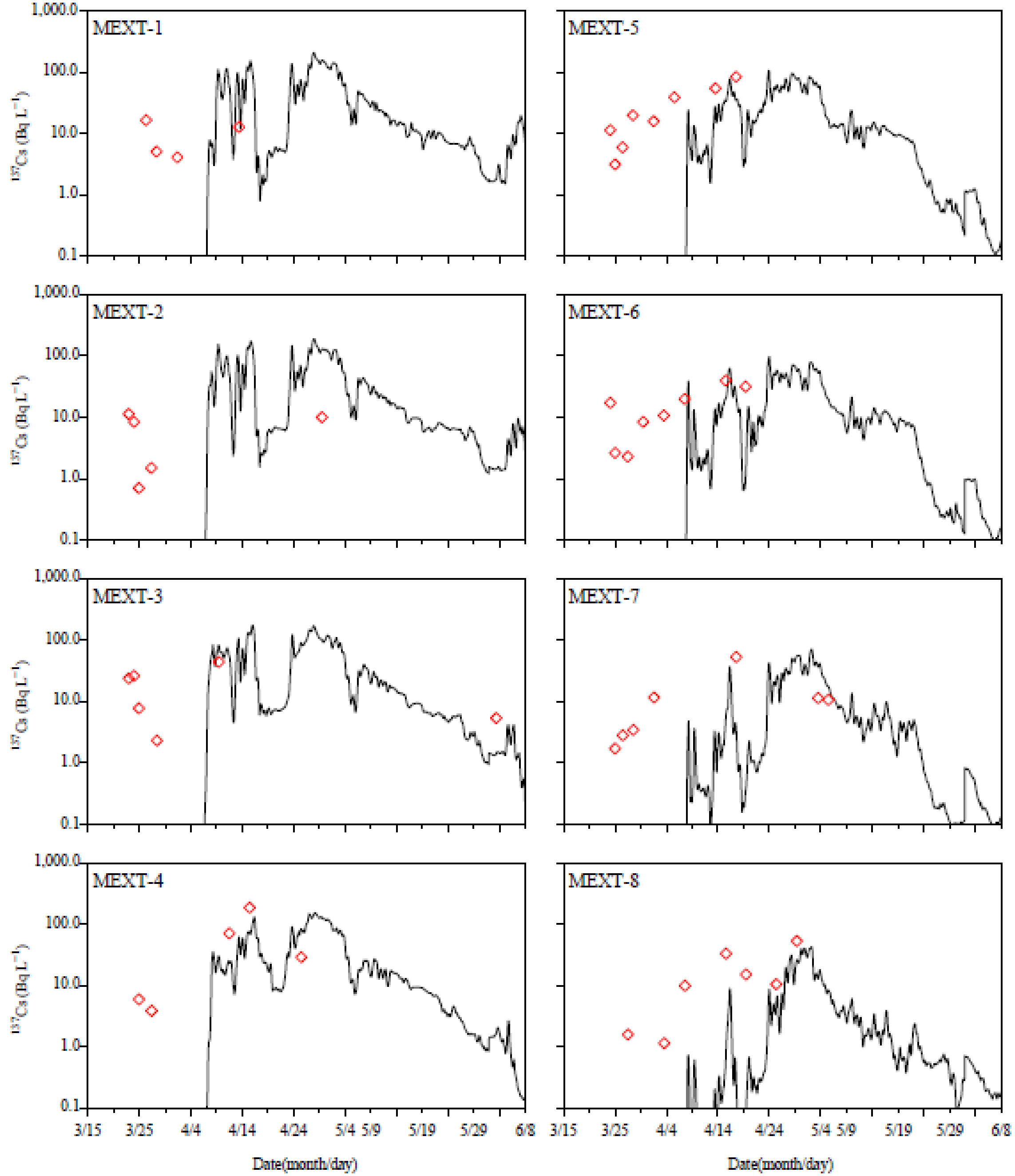


Time series of model data comparisons at 8 MEXT sampling sites 30 km off the coast

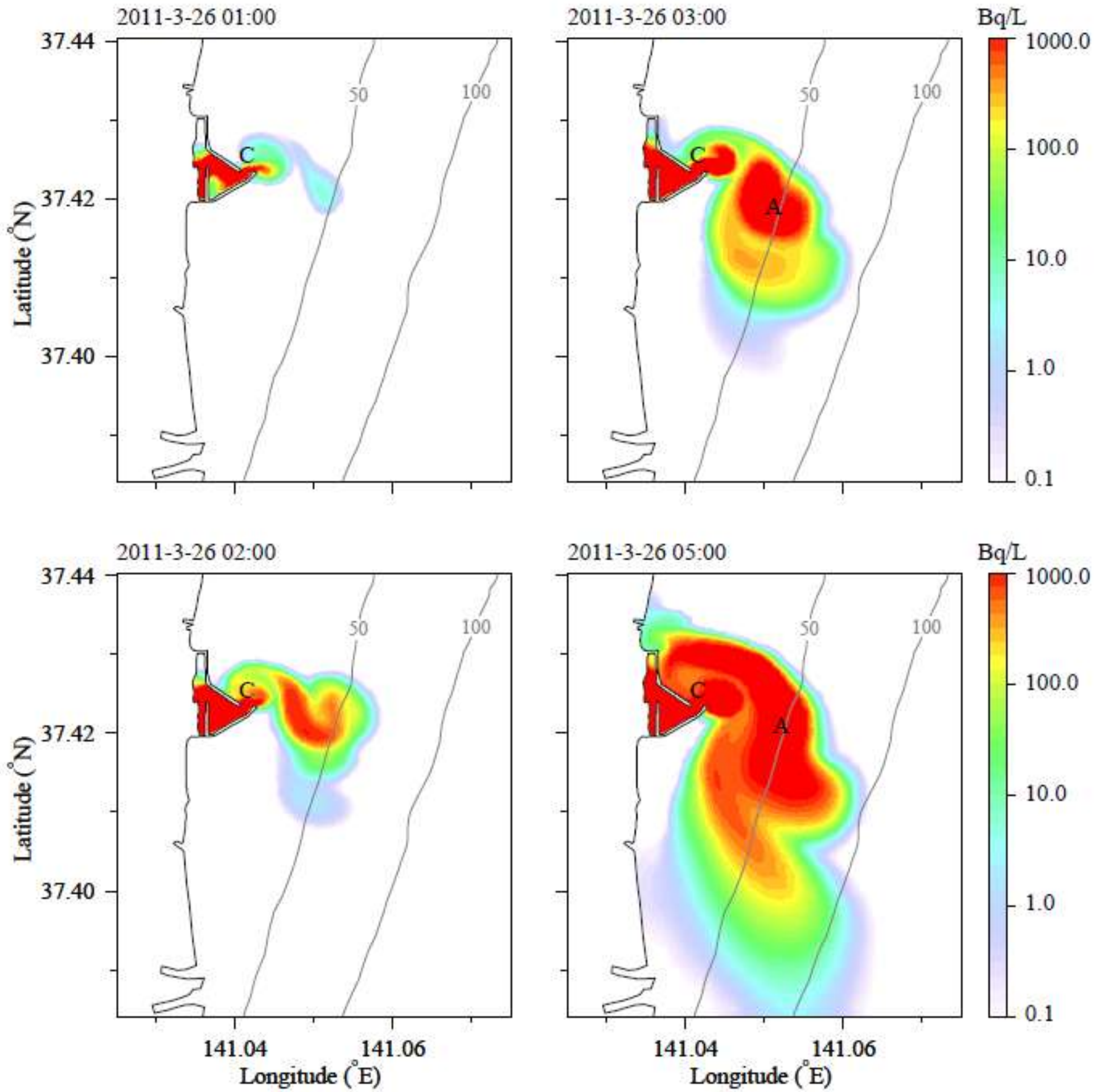
Detected after 2 weeks

Observed 137Cs before April 8 may be due to the atmospheric deposition.

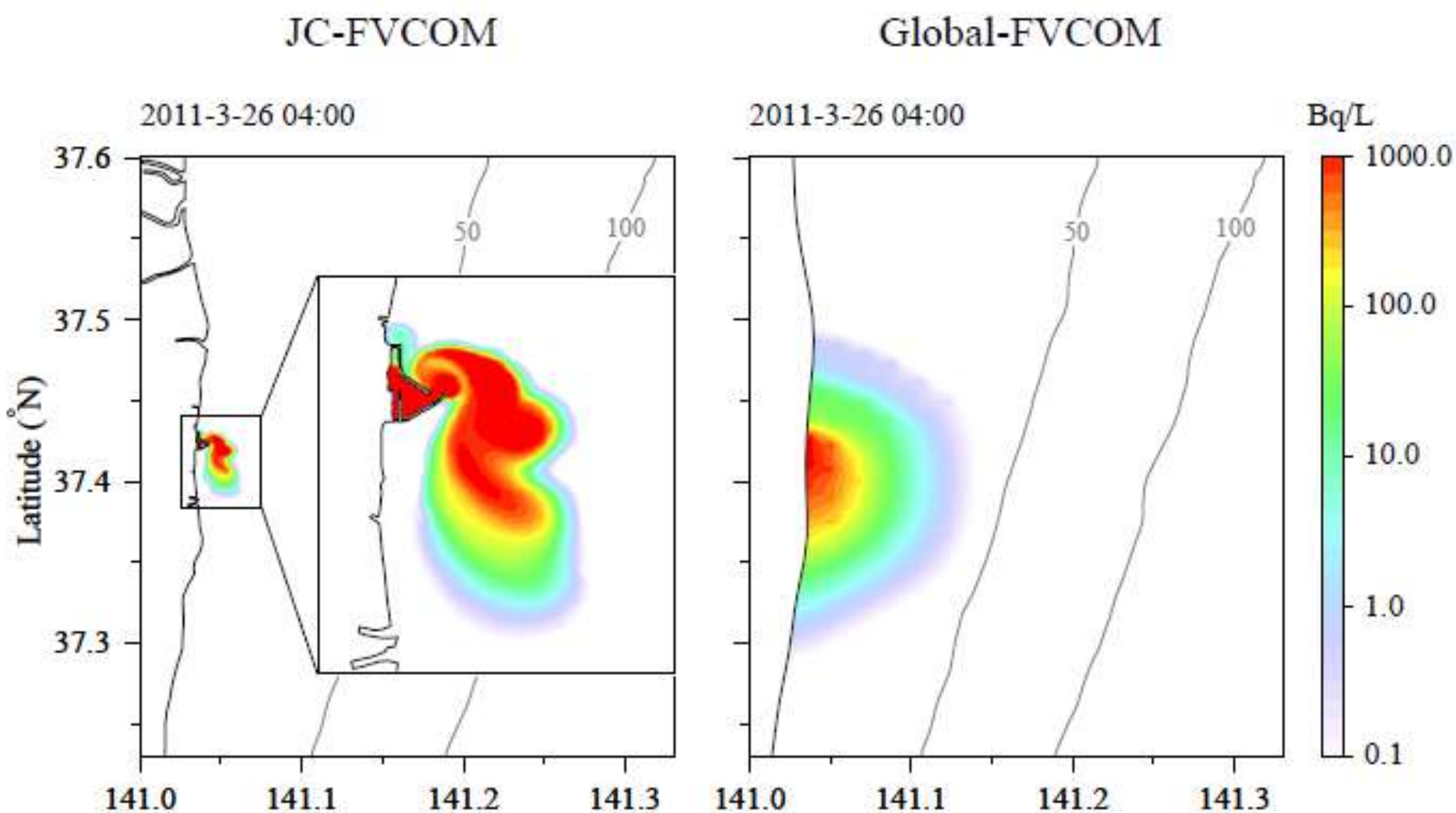




The initial surface dispersion of ^{137}Cs from FNPP1 into the coast

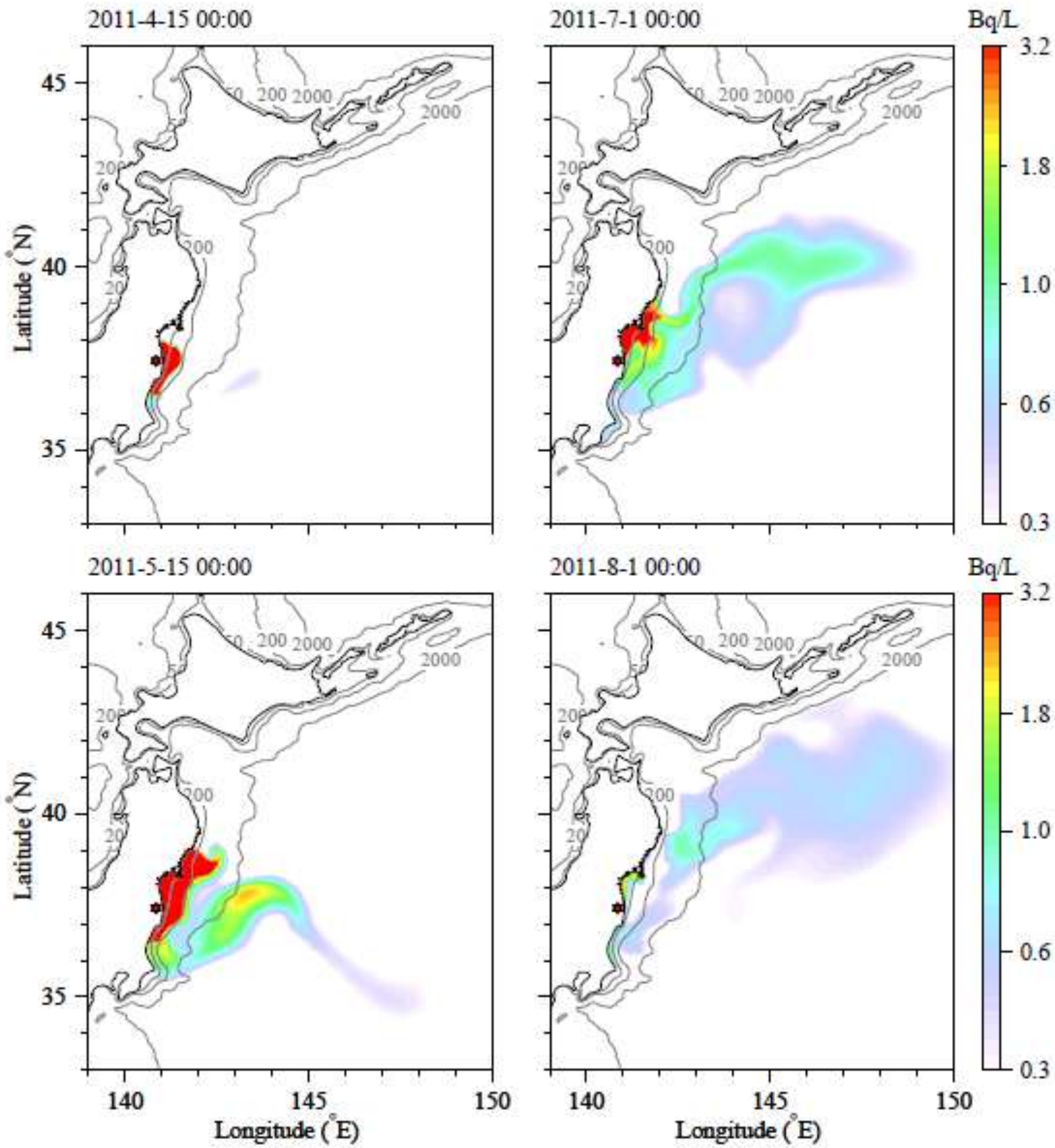


Comparison of the initial surface dispersion of ^{137}Cs between JC-FVCOM and Global-FVCOM

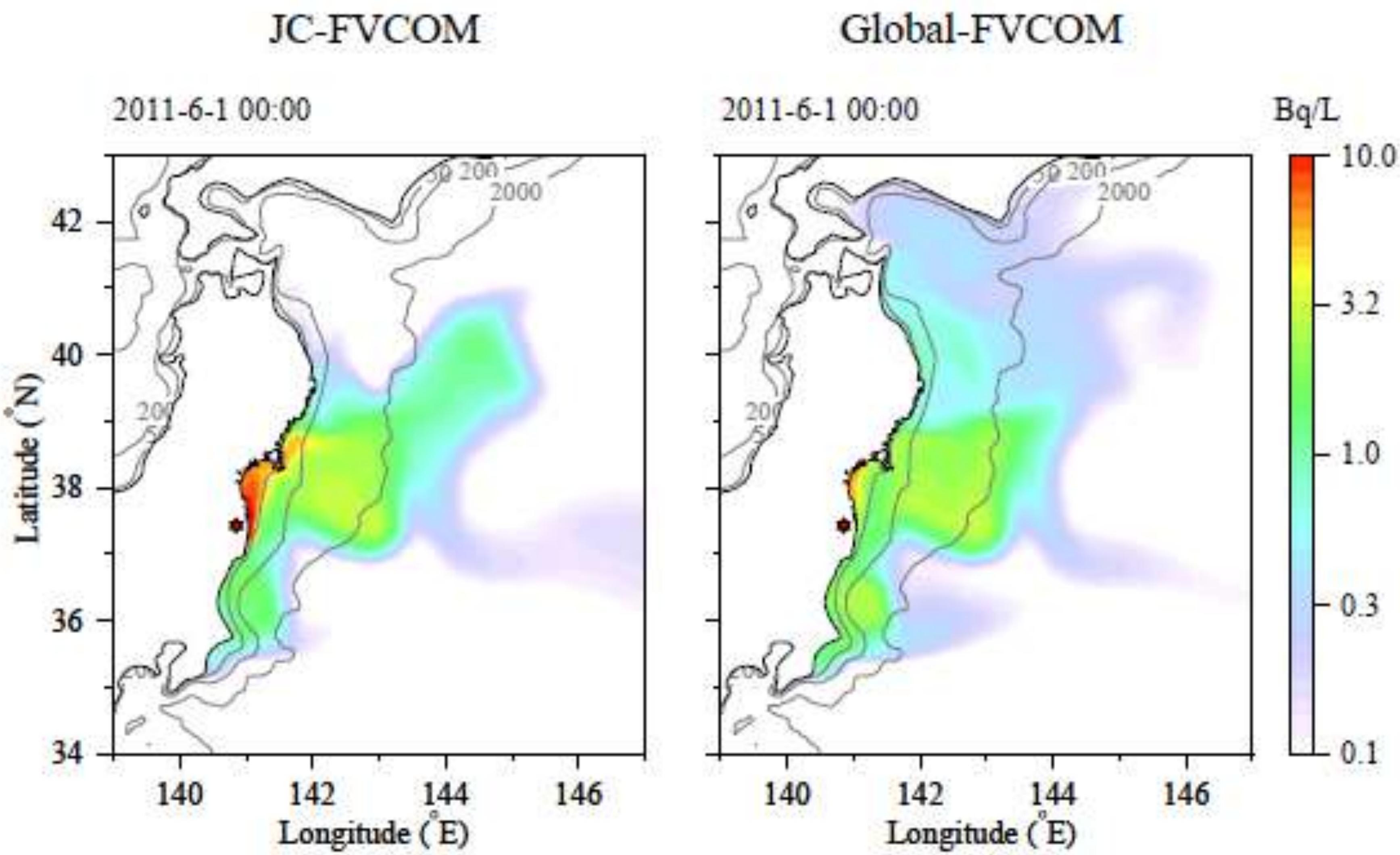


Initial surface spread of ^{137}Cs off the shelf of Japan in JC-FVCOM

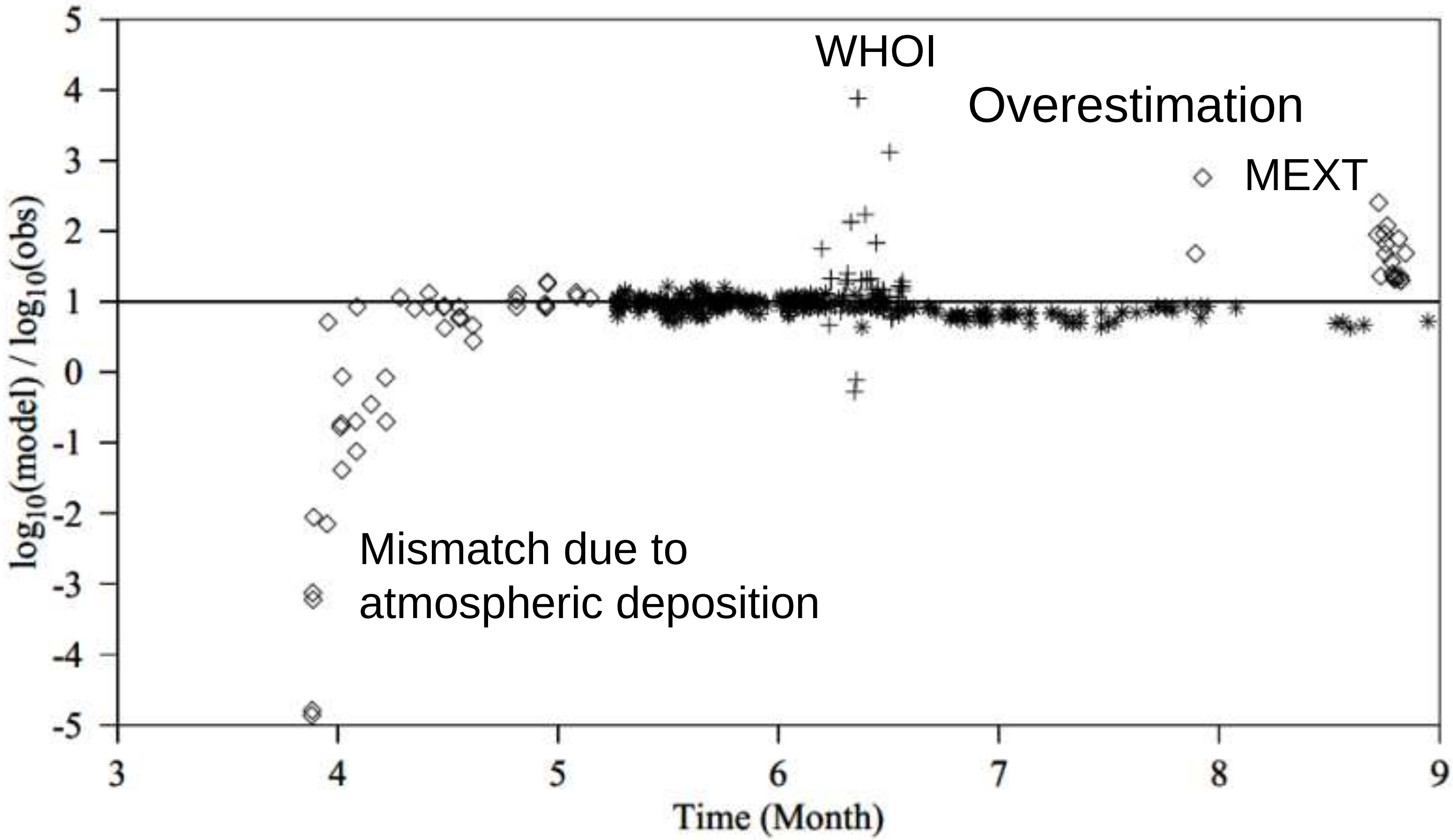
- Before June, the plume was mainly constrained within the coast and trasport southward
- Reaching its maximu extend about 180 km south of FNPP1 around June, some of which being carried away by Kuroshio
- In July and August, the plume was predominantly transported toward the north and gradually dispersed into the interior of Pacific Ocean.



Comparison of the surface spread of 137Cs on June 1

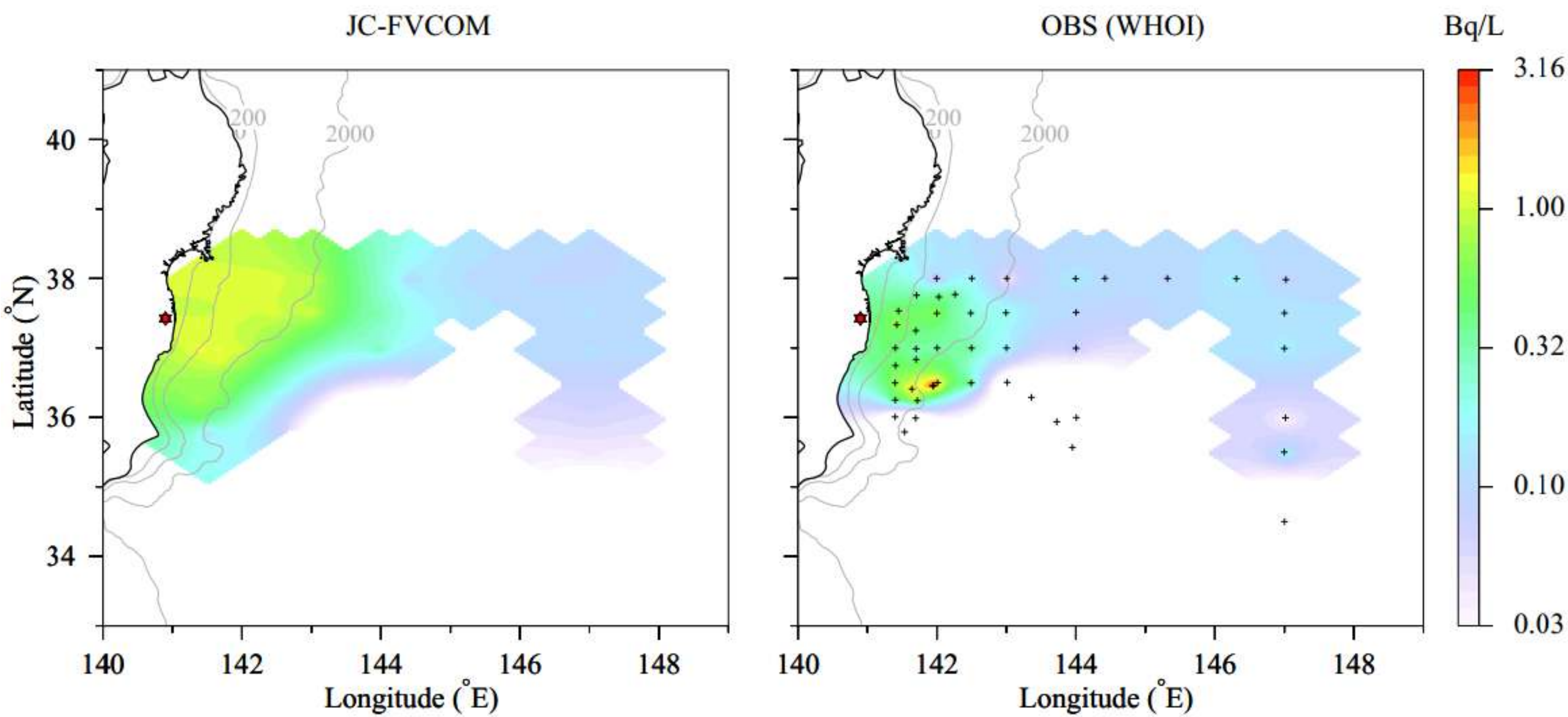


Time series of model-data comparison for surface ^{137}Cs



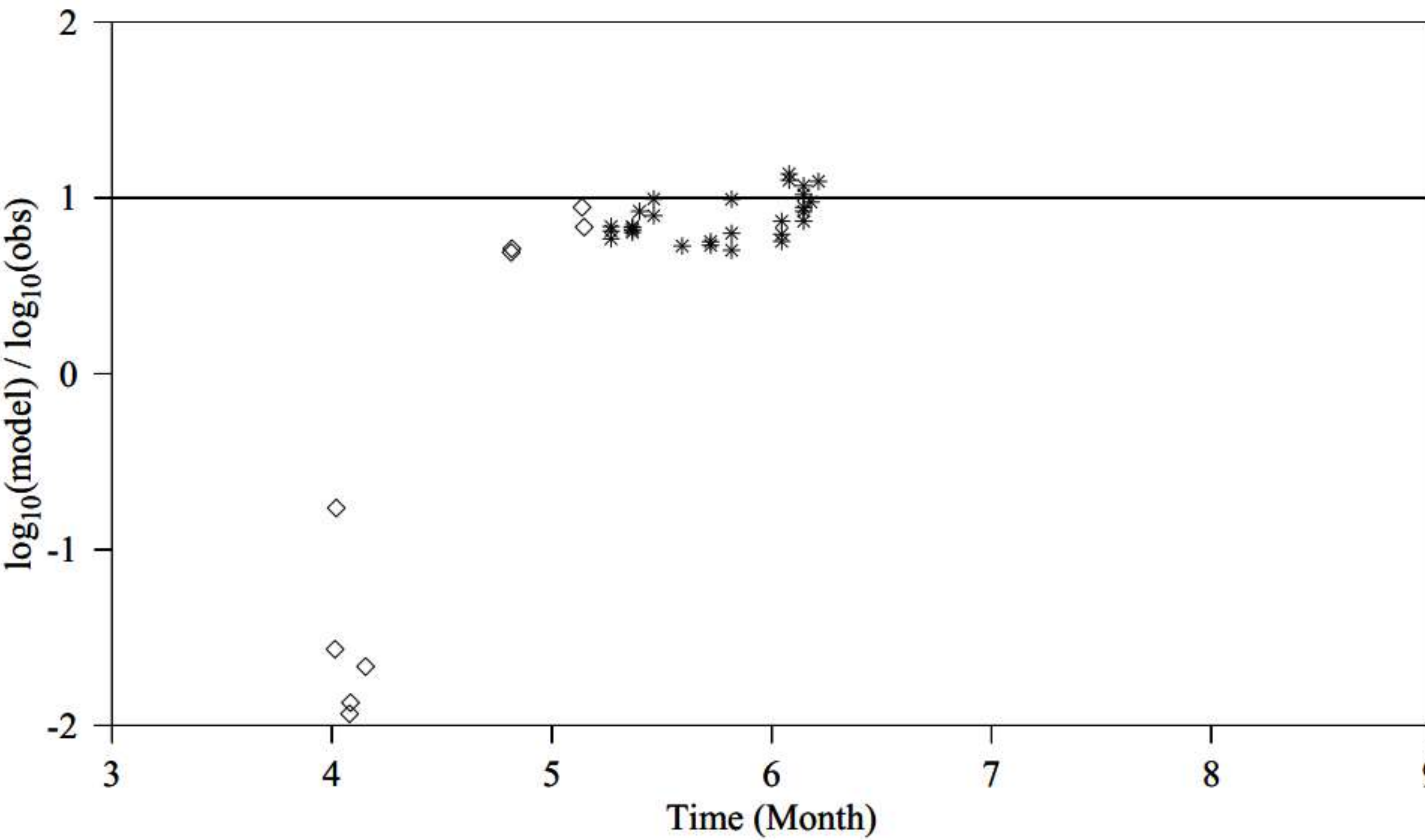
Comparison of the plan view of the surface ^{137}Cs

- Though the model makes a good prediction for the basin stations, it tends to overestimate the magnitude and size of the plume for the coastal area.

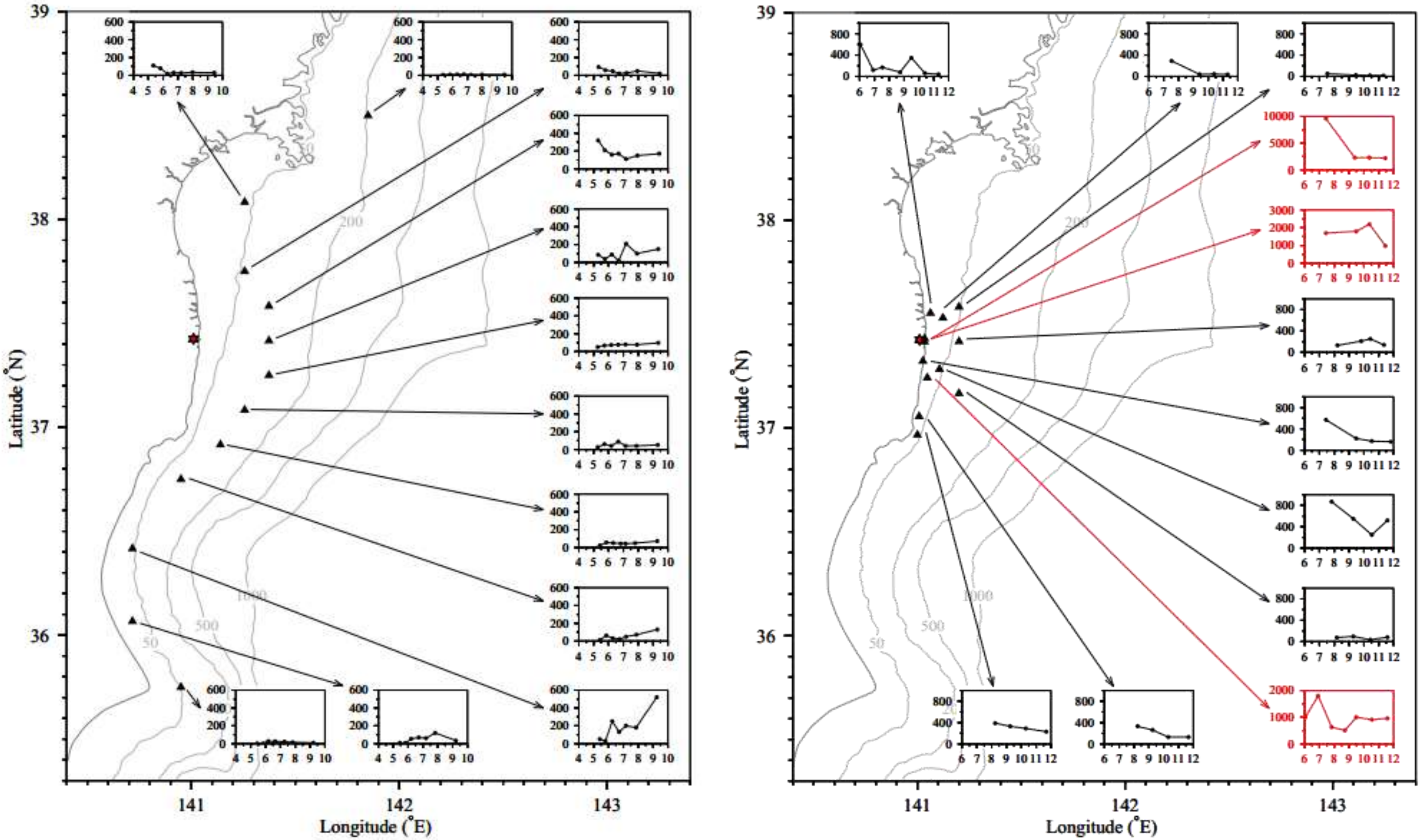


Time series of model-data comparison for near-bottom ^{137}Cs

- On the contrary, model tends to underestimate ^{137}Cs concentrations near bottom.

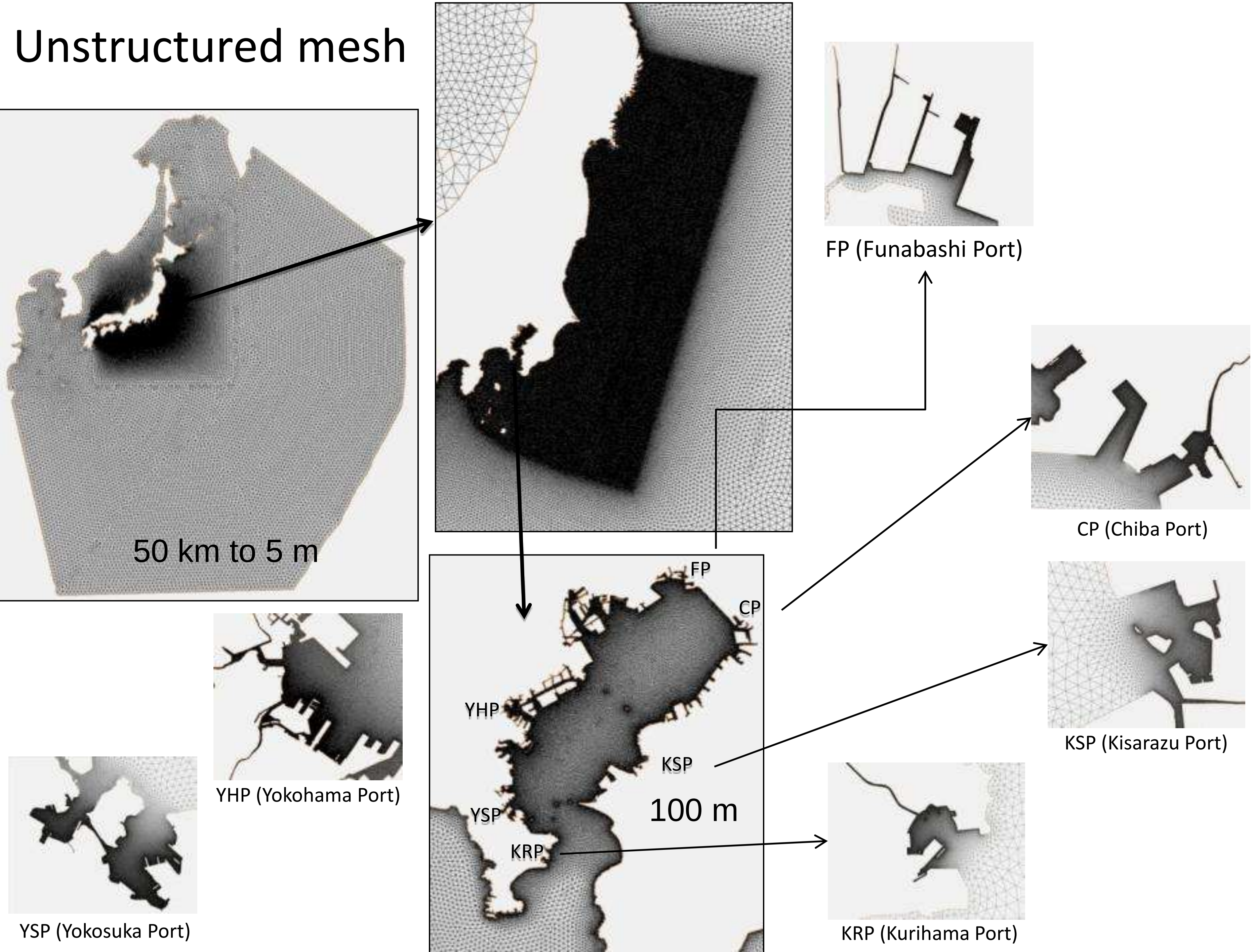


Spatial and temporal distribution of ^{137}Cs in sediments (Bq/kg)

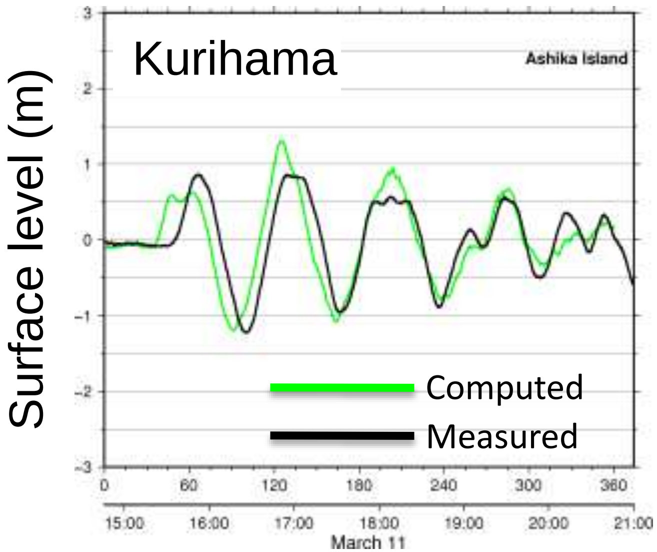


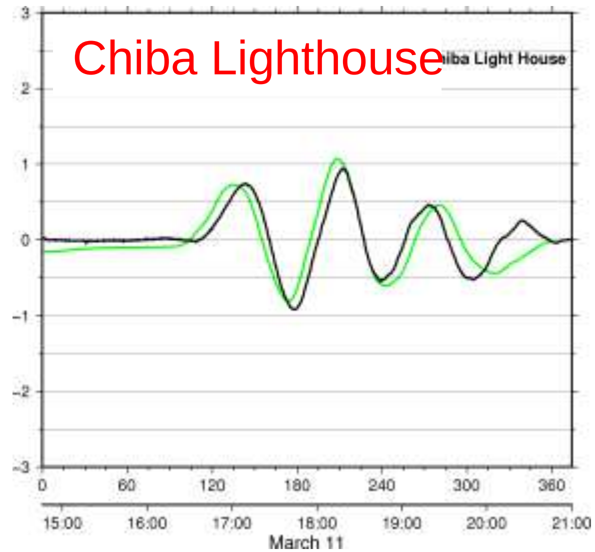
TSUNAMI DAMAGE IN TOKYO BAY

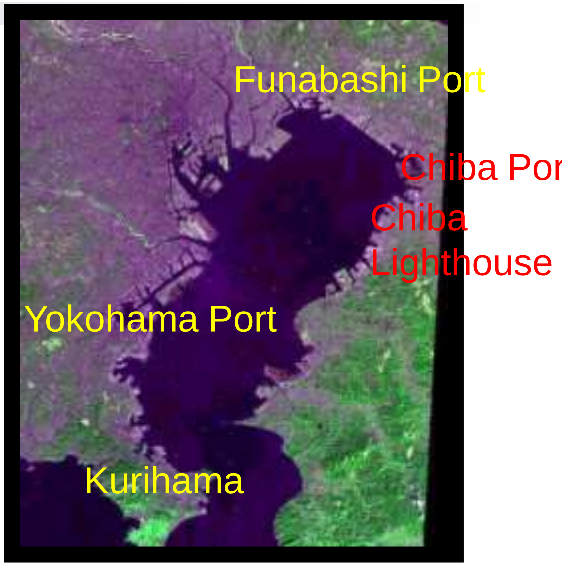
Unstructured mesh



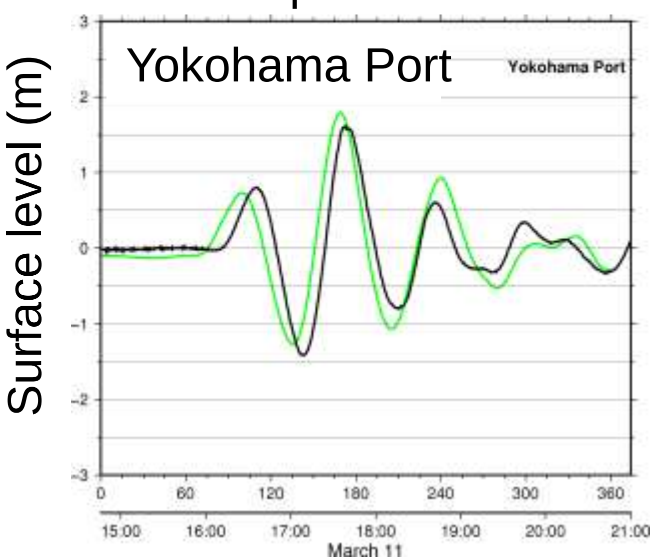
Comparison of Computed and Observed Tsunami Profiles

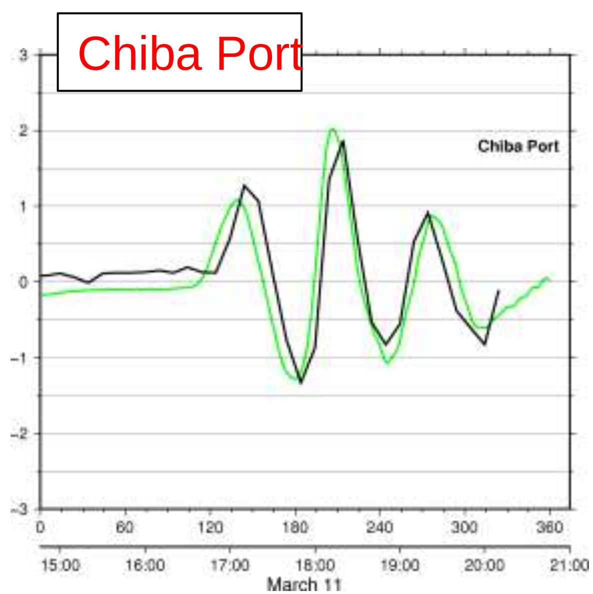


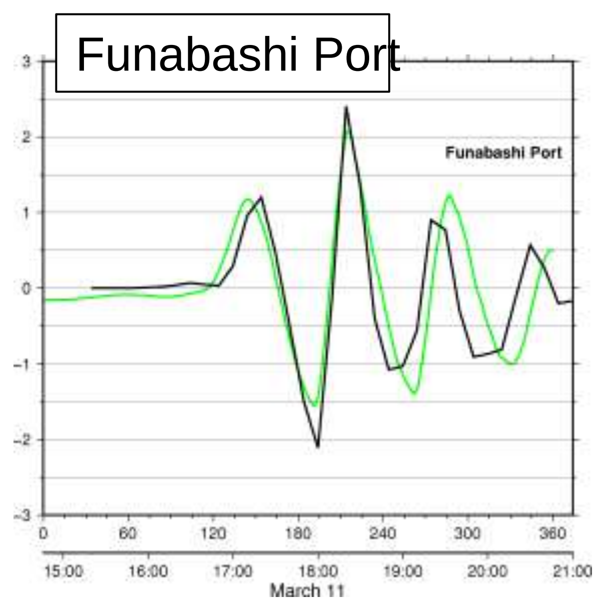




Stations in ports



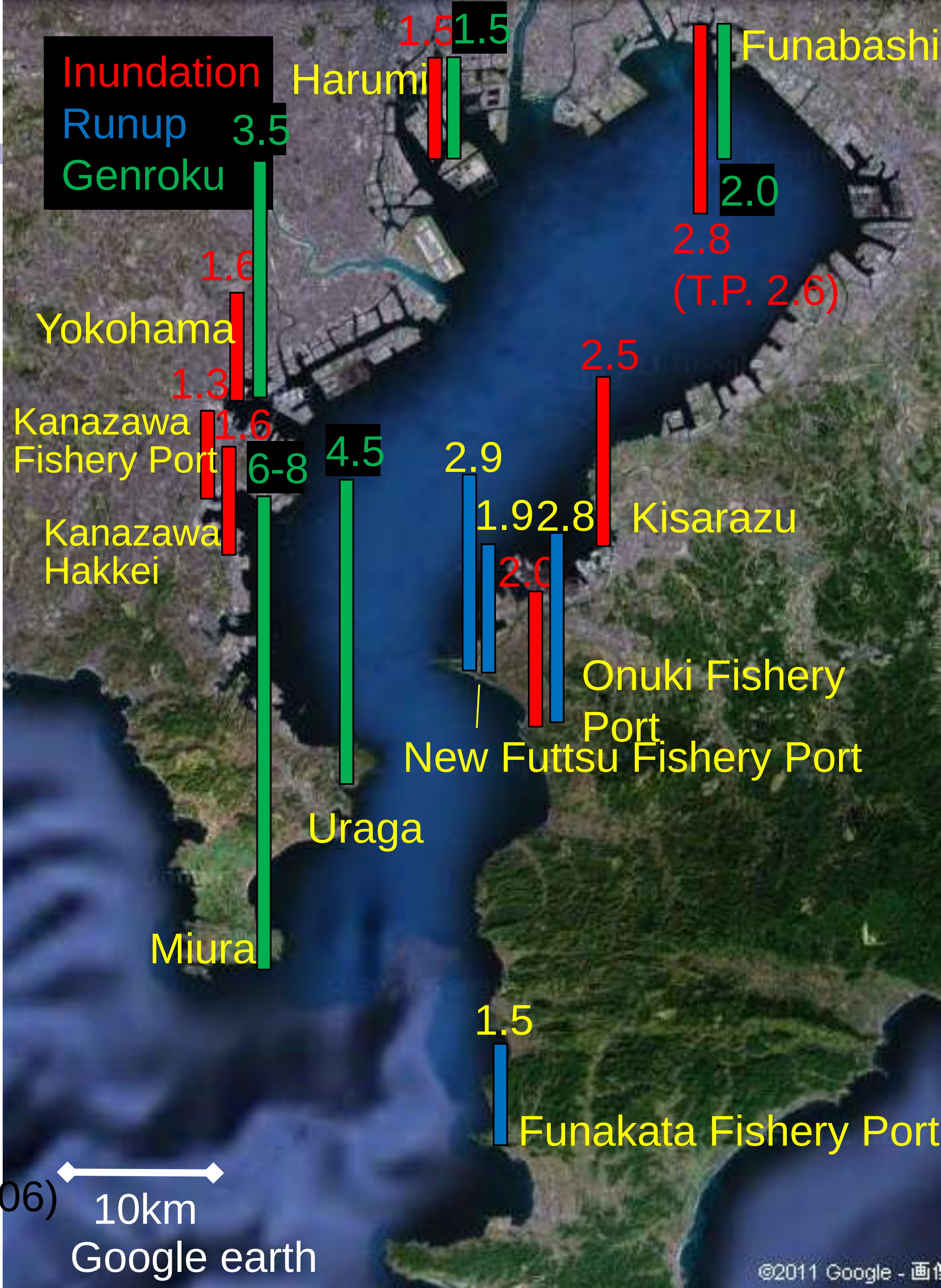




Past Tsunamis in Tokyo Bay

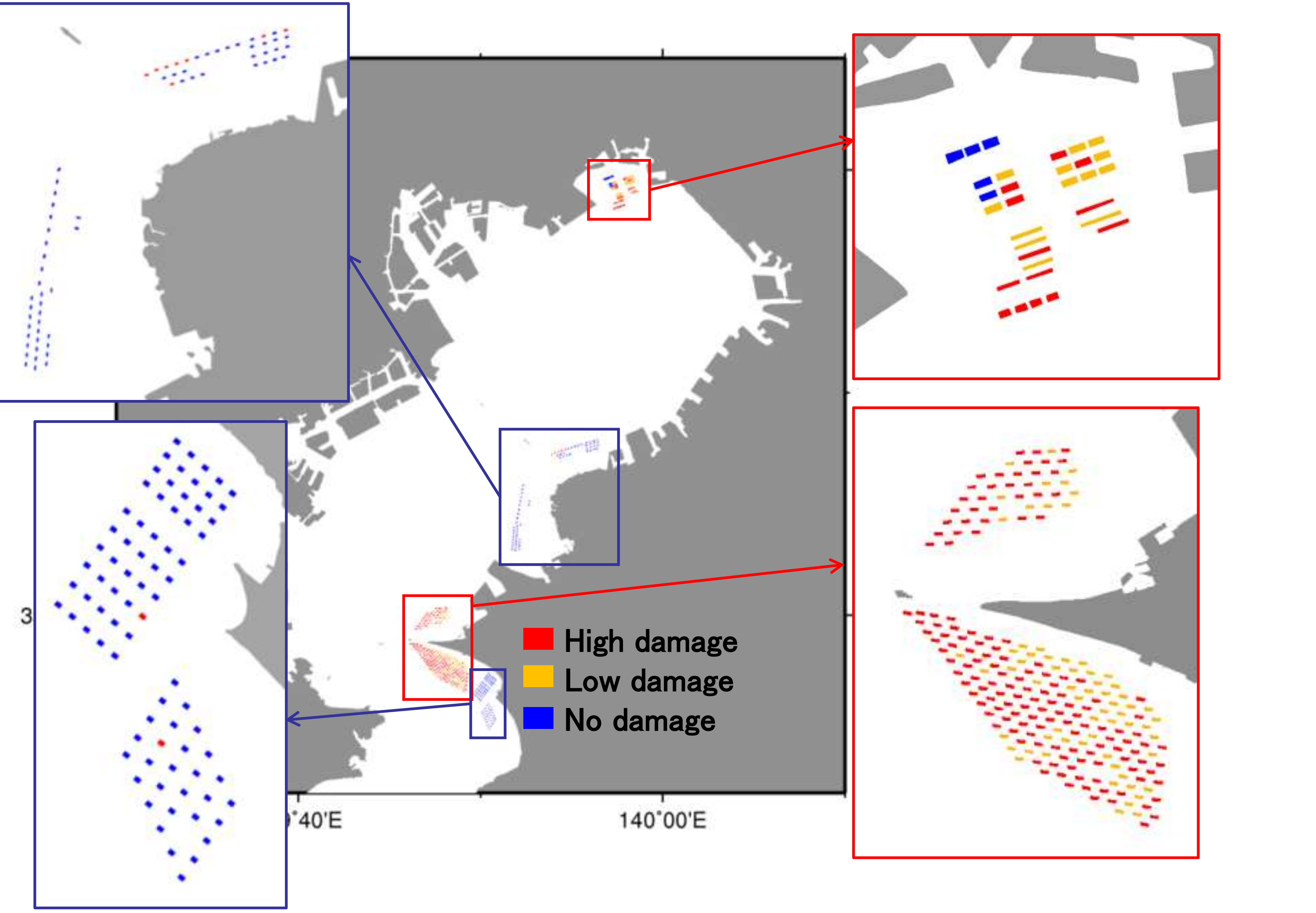
- 1703 Genroku-Kanto M8.2
  - Yokohama 3.5m, Miura 6-8m
- 1854 Ansei-Tokai in M8.3
  - Urayasu 1m, Yokohama 1-2m, Uraga 3m
- 1923 Taisho-Kanto M7.9
  - Funabshi 0.6m, Yokohama 1m, Uraga1.5m, Miura 5m
- 1960 Chilean M9.5
- 2011 Great East Japan M9.0
  - Funabashi 2.8m, Harumi 1.5m, Yokohama 1.6m
  - Designed storm surge: T.P. 3-4 m

Source: Sasaki et al. (2012), Hatori (2006)



Funabashi Fishery Port

Survey results of seaweed damage in Tokyo Bay



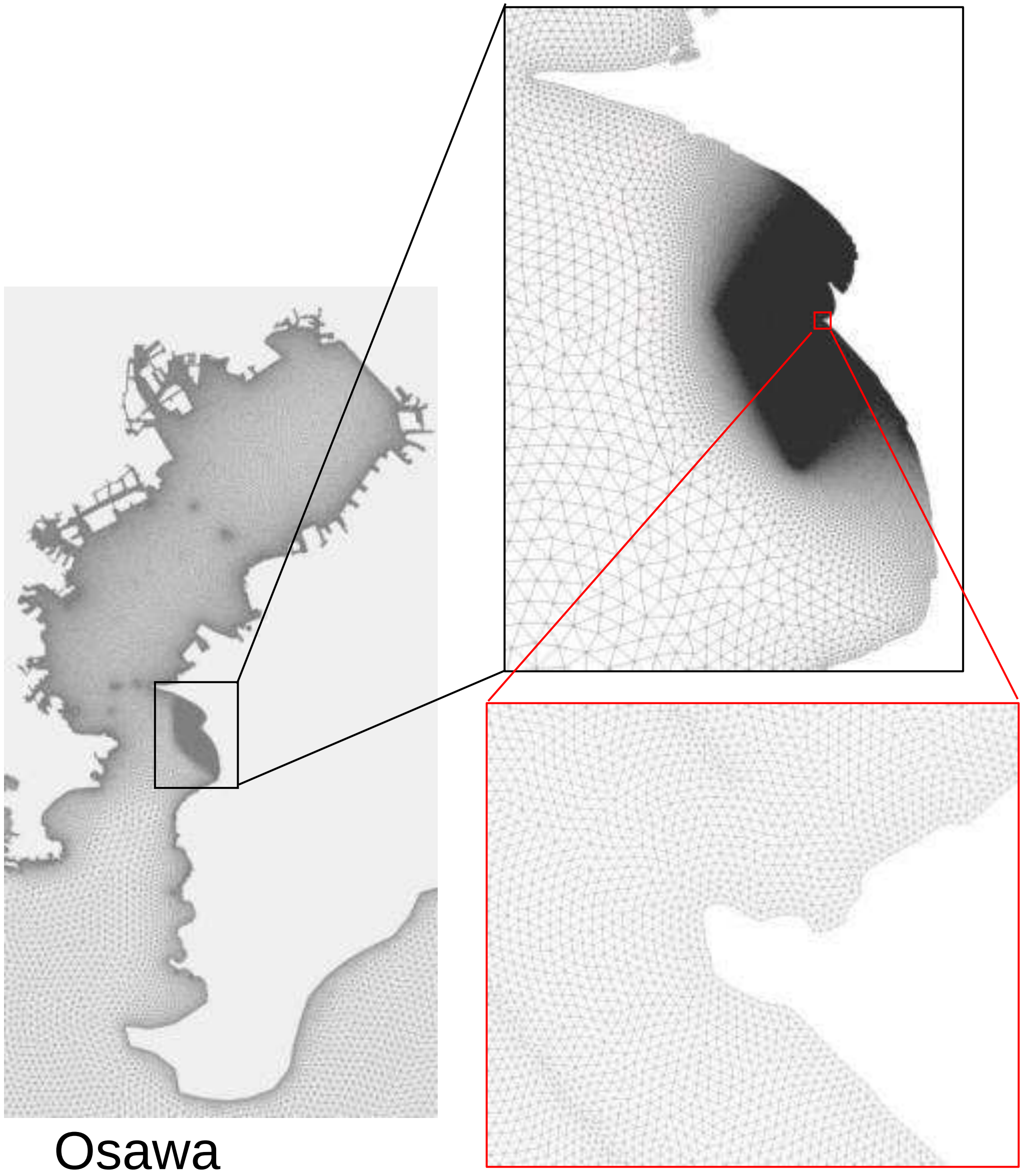
Grid

Grid size

Whole Tokyo Bay	5m～100m
Focusing areas, including seaweeds	5m
Fault area	1km

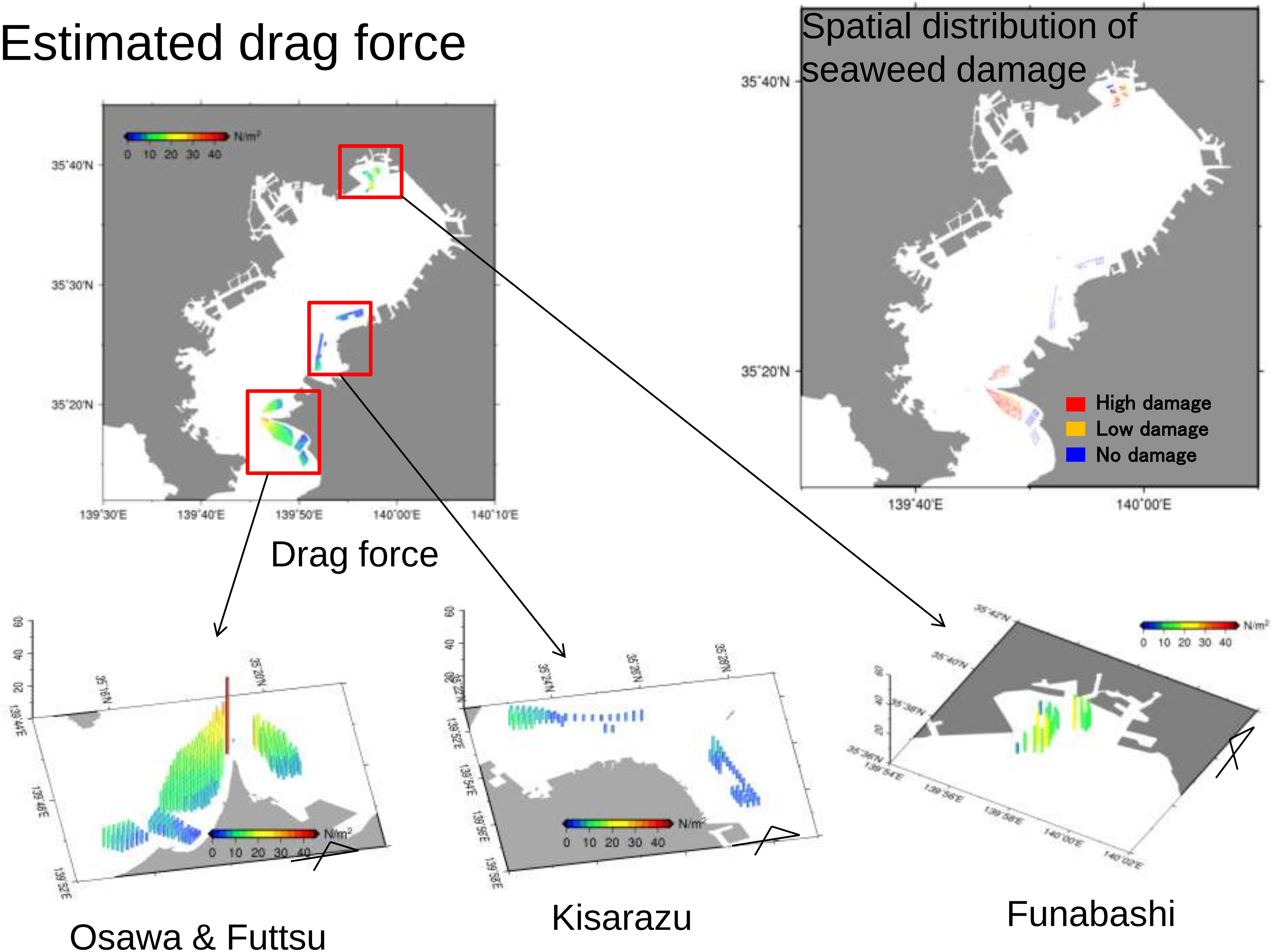
The number of grids

	Node	Cell
Osawa	651279	12361513
Futtsu	1111241	2179780
Kisaradu	1330454	2611429

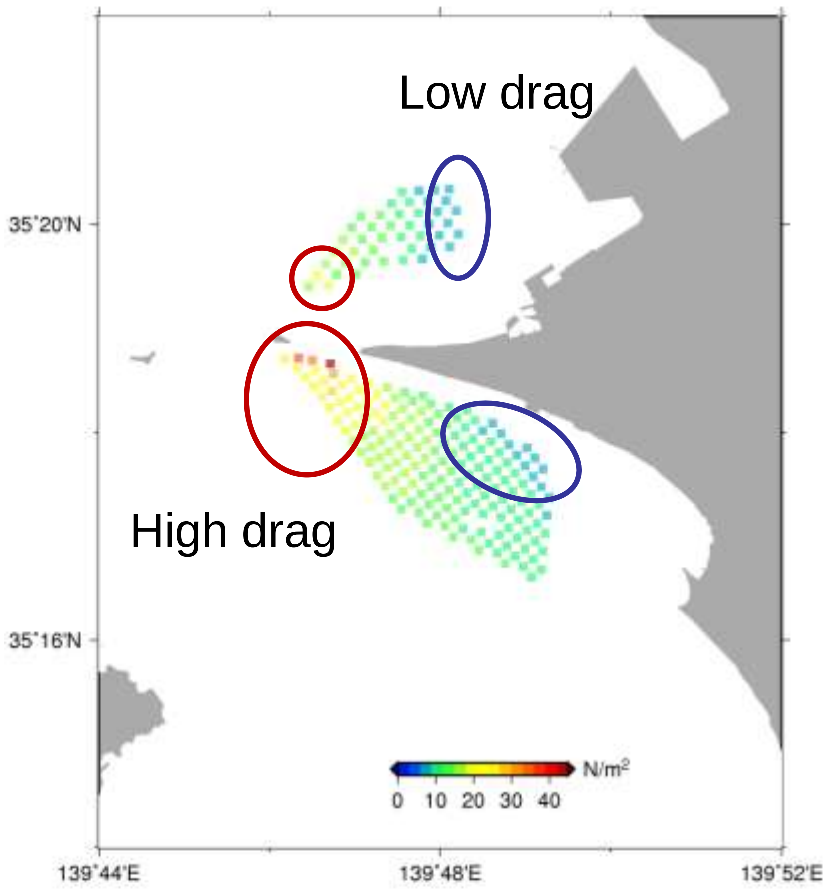


Osawa

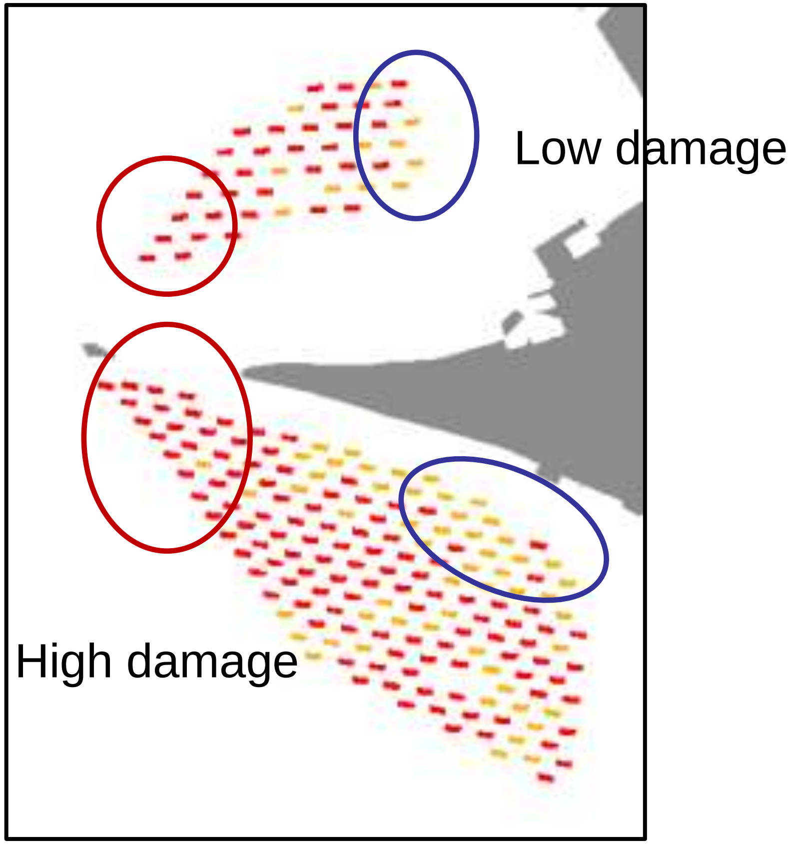
Estimated drag force



Correlation between damage and drag force in Futtsu



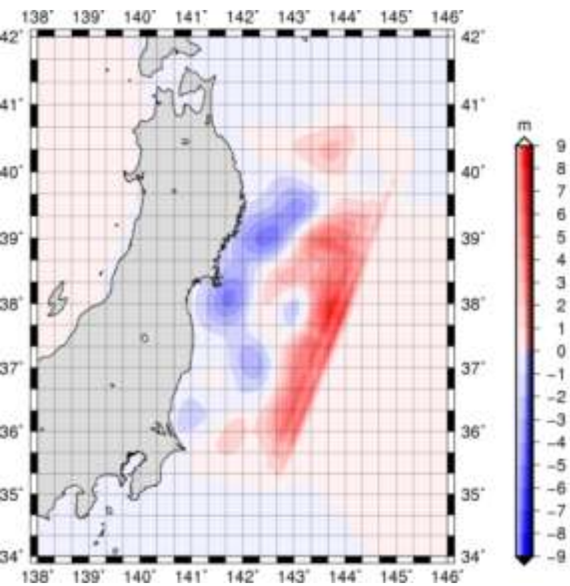
Drag force



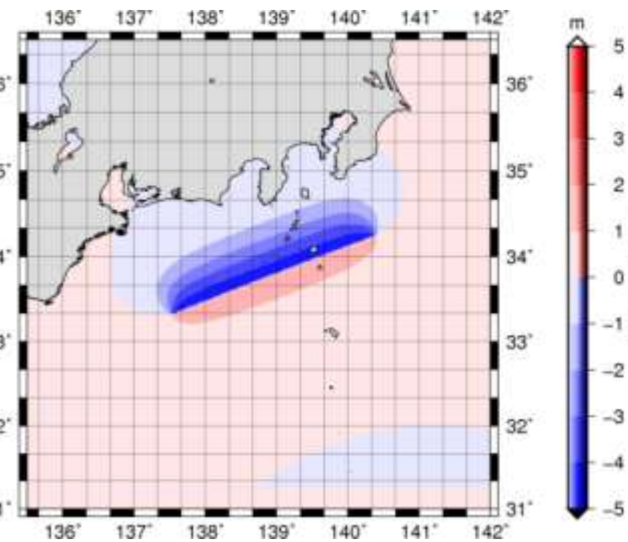
Damage

Three types of expected tsunamis

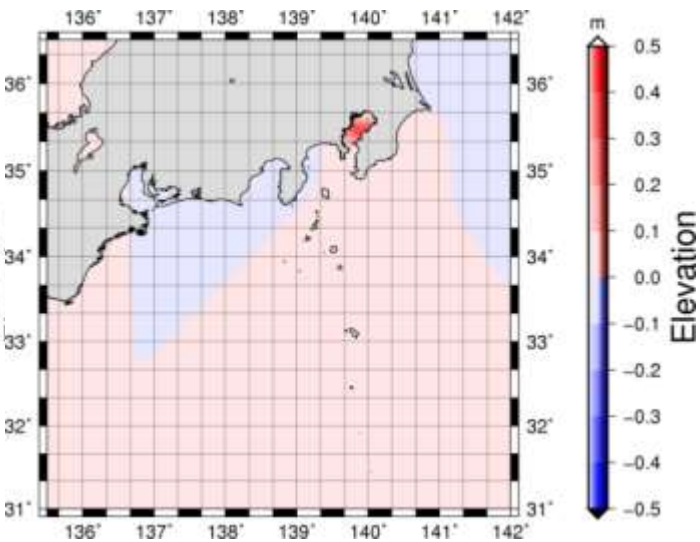
- Initial surface level



2011 Tohoku tsunami
Far-field

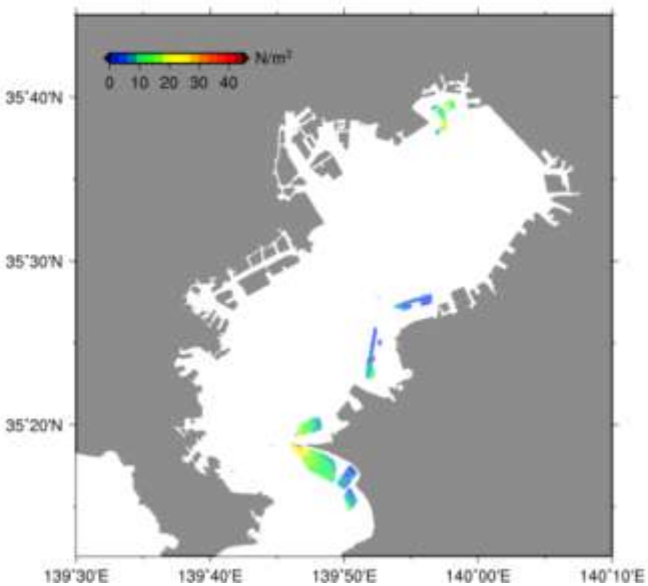


Keicho-type tsunami
Near-field

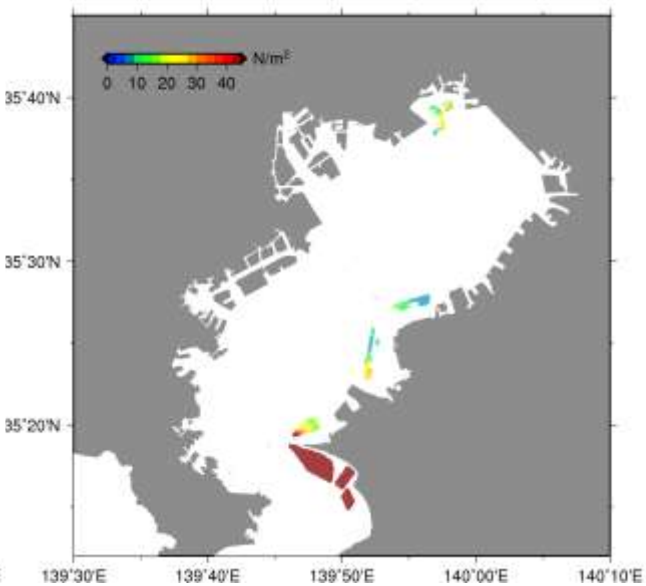


Northern Tokyo Bay tsunami
Inside the bay

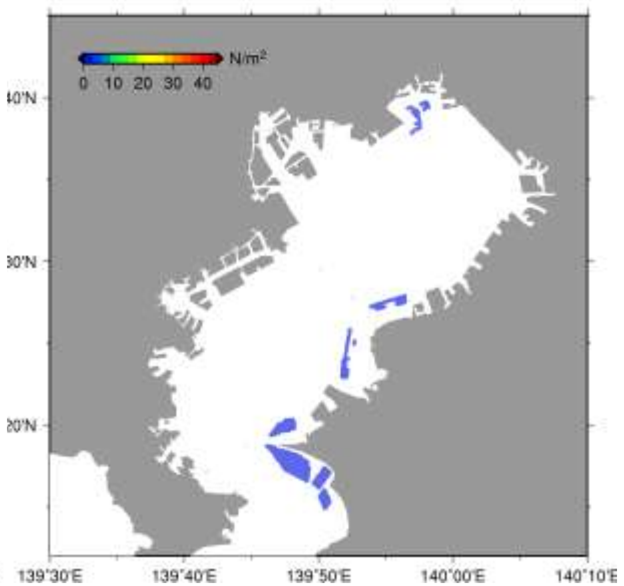
Three types of expected tsunamis



2011 Tohoku tsunami
Far-field



Keicho-type tsunami
Near-field



Northern Tokyo Bay tsunami
Inside the bay

Conclusions

- The global-Japan coastal nesting FVCOM tsunami model system is suitable for realistic tsunami inundation simulation.
- Initial spread of 137Cs over the shelf of Japan is well reproduced using the system.
  - Resolving the detailed shape of breakwaters of FNPP1 is the key factor for better reproduction
- Simple application of FVCOM is often acceptable for reproducing behaviors of tsunami propagation and inundation.

References

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- Sasaki, J., Ito, K., Suzuki, T., Wiyono, R.U.A., Oda, Y., Takayama, Y., Yokota, K., Furuta, A. and Takagi, H. Behavior of the 2011 Tohoku earthquake tsunami and resultant damage in Tokyo Bay. Coastal Engineering Journal, 54(1), 1250012, 26pp., 2012.