Development of a high resolution coastal ocean model

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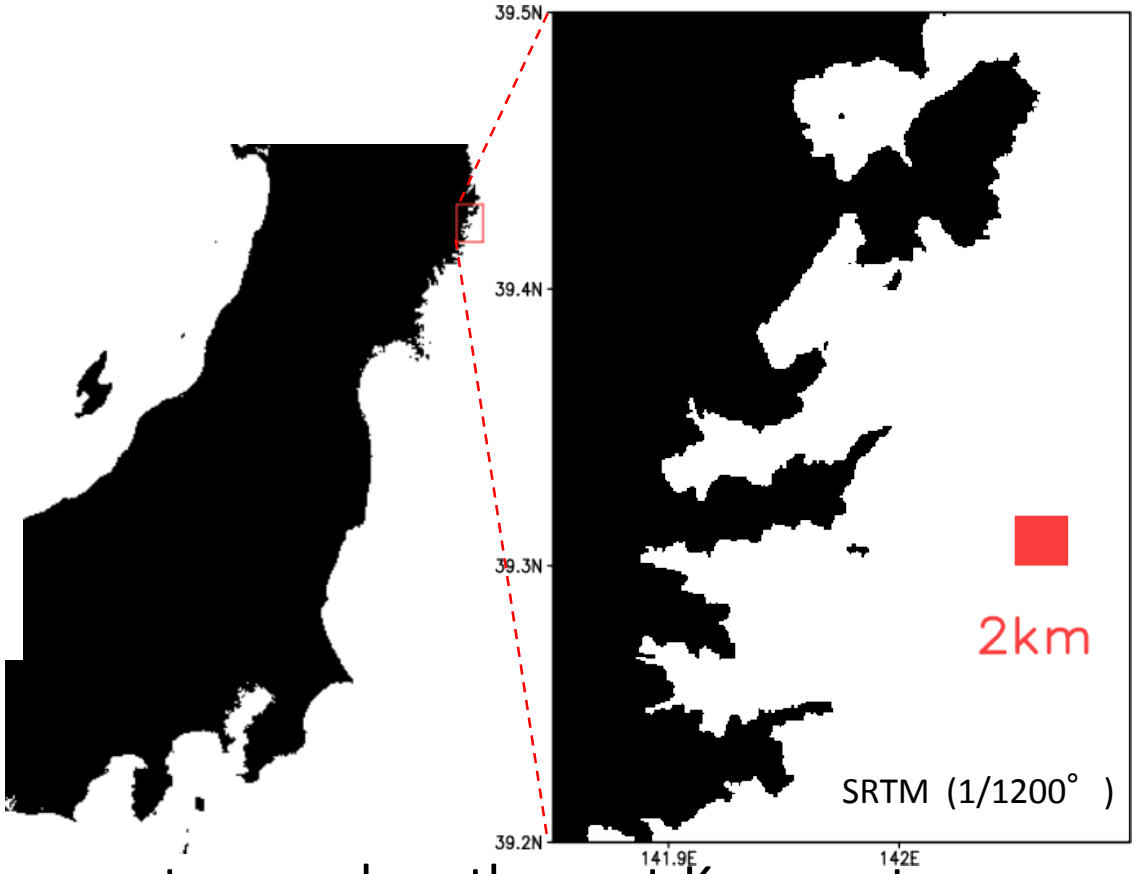
The highest resolution used in OGCMs covering the entire Japanese coastal system is about 2km.

With this resolution, small scale bays are not resolved and simulations for such bays have been executed individually.



By using next-generation supercomputers, such as the post-K computer, OGCMs covering the entire Japanese coastal system with 100 m horizontal mesh（～mesh size of above figures）will be able to run. We are planning to develop a coastal prediction system based on an OGCM with this resolution.

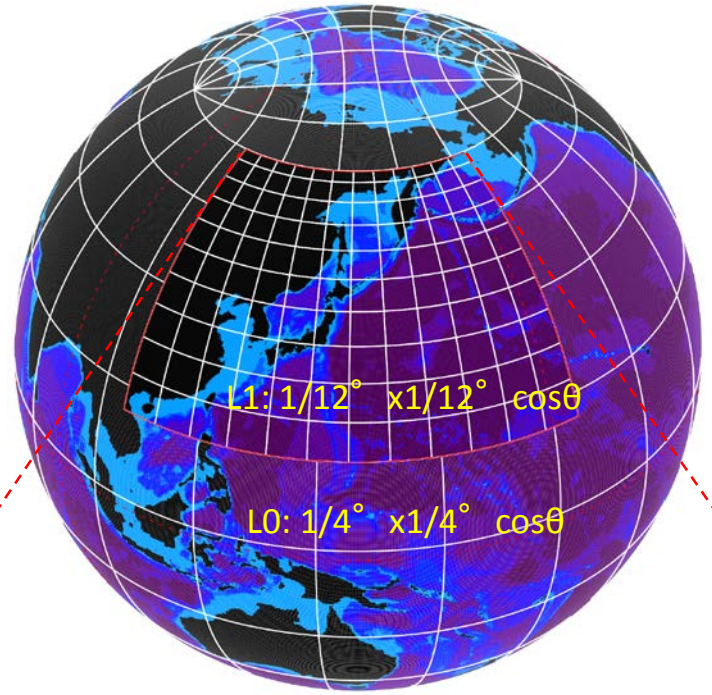
We are now developing an OGCM with 500 m horizontal mesh by using the K computer. Fine scale features which have not been captured by conventional models are appeared and are compared with observations.

Model

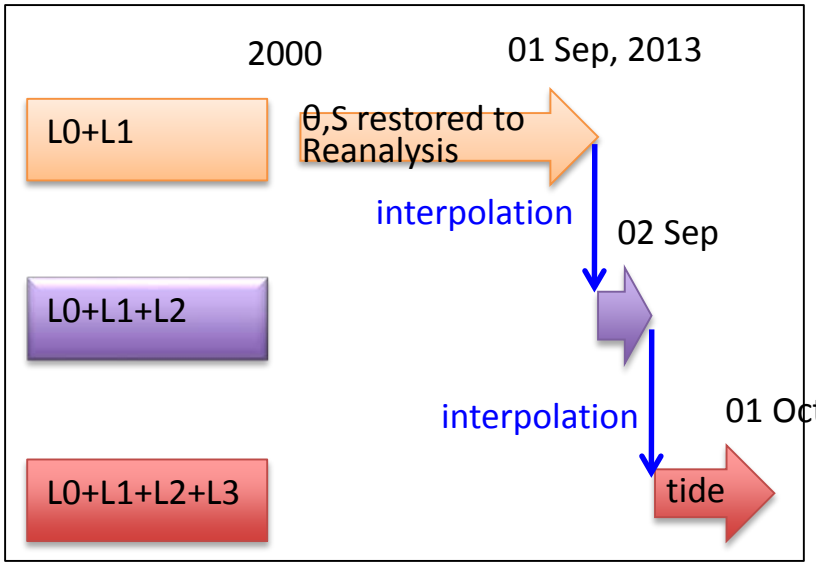
- Two-way nested-grid OGCM based on COCO
  - composed of four models (L0-L3)
  - Interactively coupled including sea ice
  - heat/water flux is conserved at boundaries

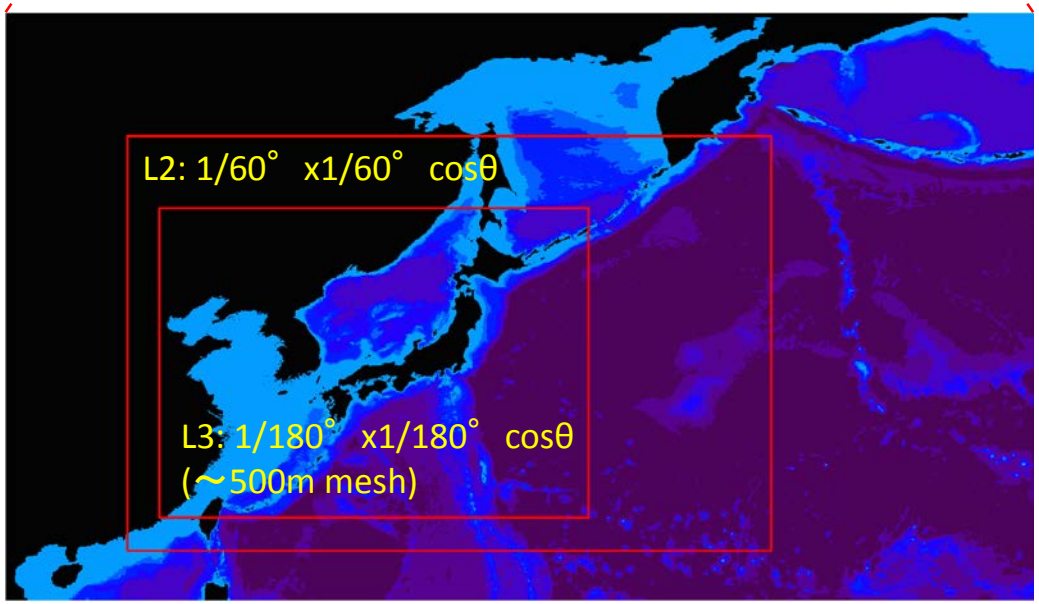
Forcing

- JRA-55 base dataset
- tidal potential



Model is integrated as follows:

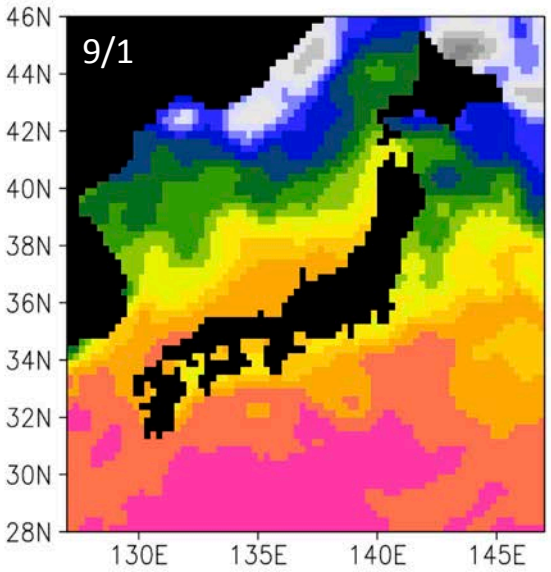




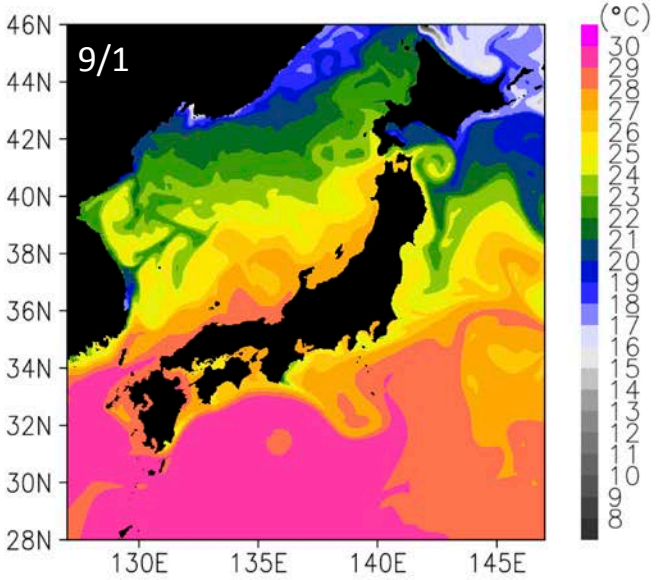
SST development during integration

Initial state (9/1)
Close to observations because θ and S are restored to reanalysis data (FORA-WNP30).

Observations (NOAA OISST)

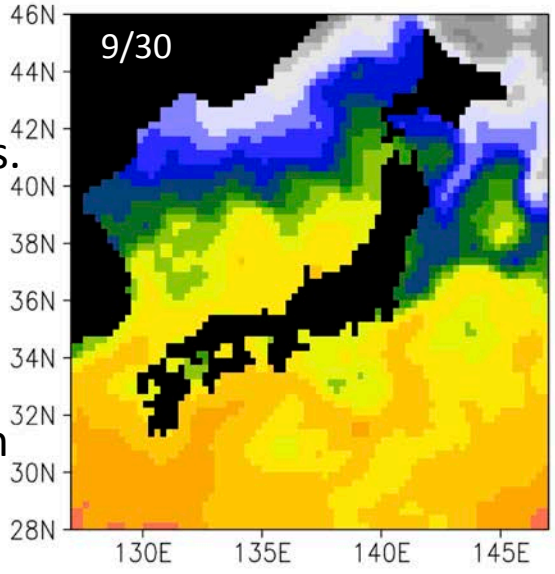


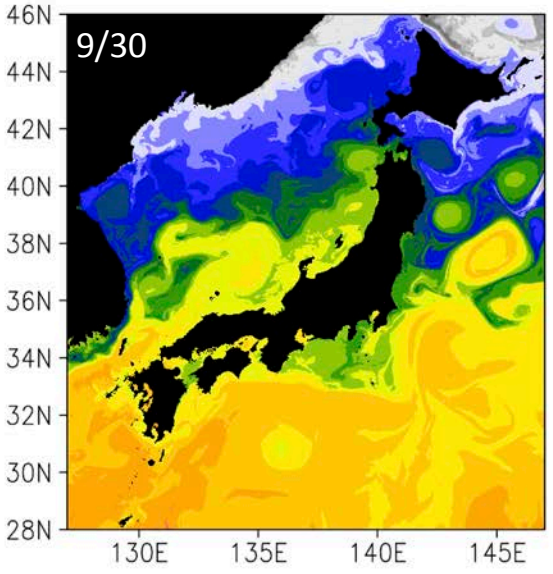
Model



After one month integration (9/30)

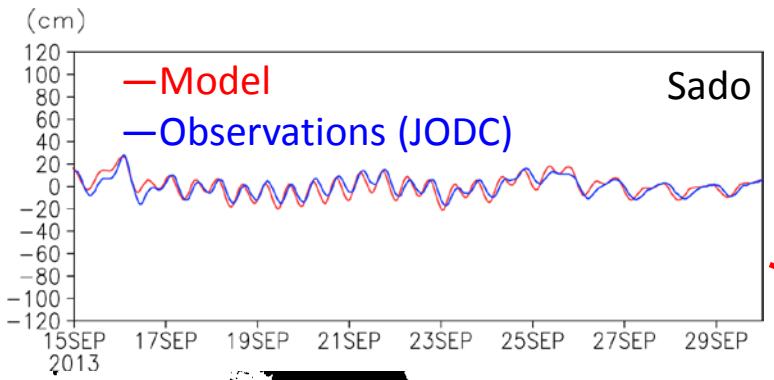
- Basically similar to observations.
- Kuroshio meander shifts eastward than observed.
- SST in Kuroshio meander region is colder.

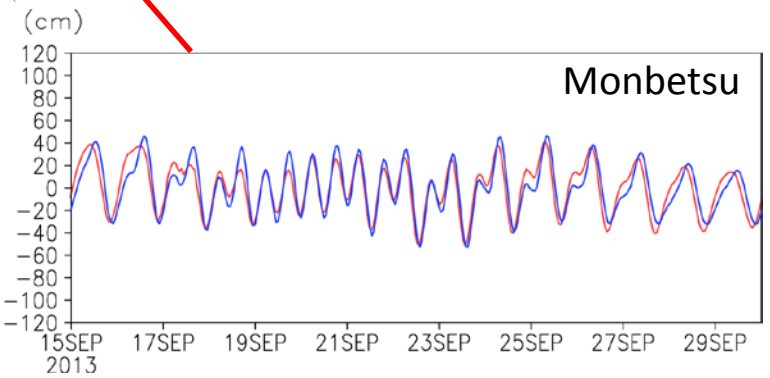


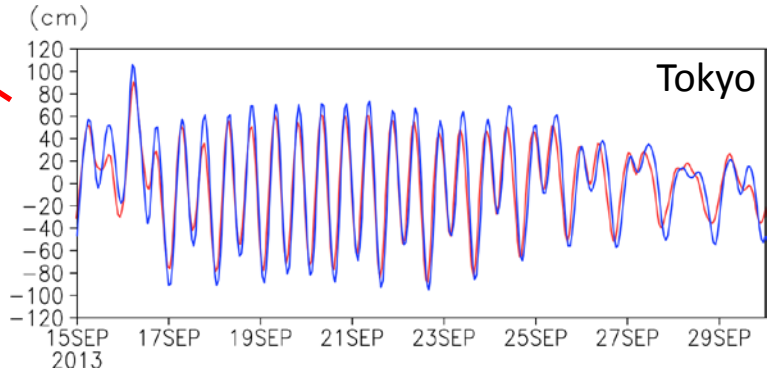


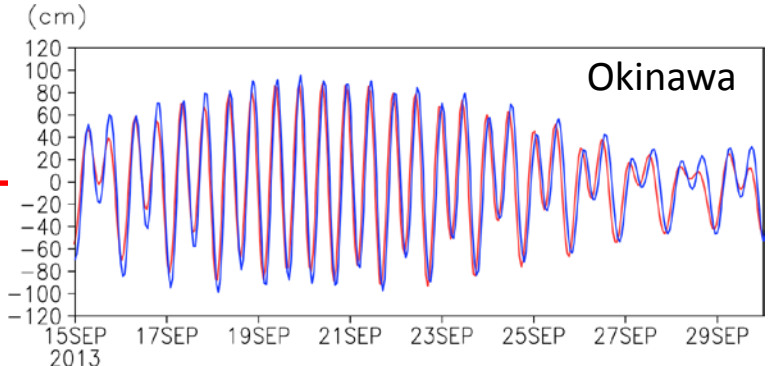
SSH Anomaly

Model basically represent SSHA fluctuation which is mainly caused by the tide.





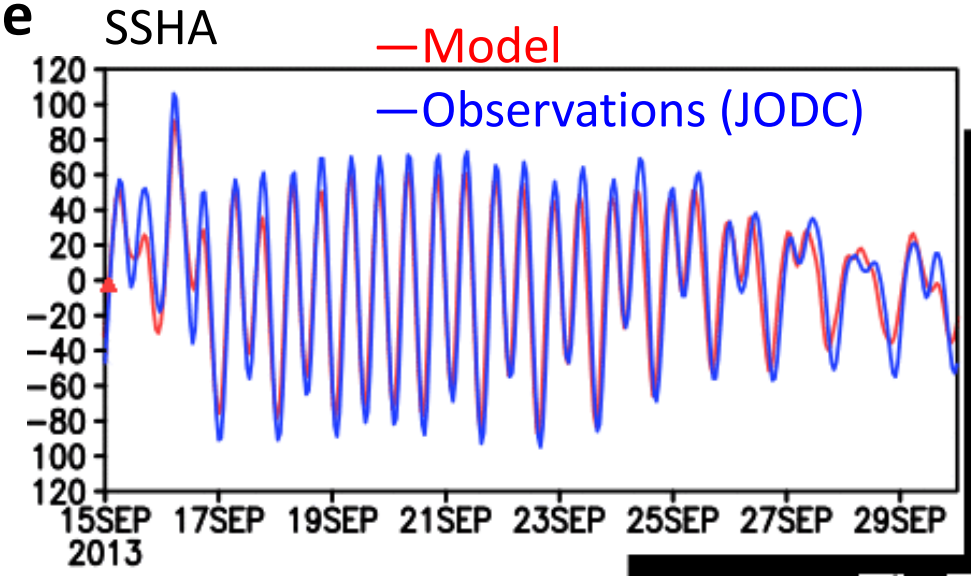


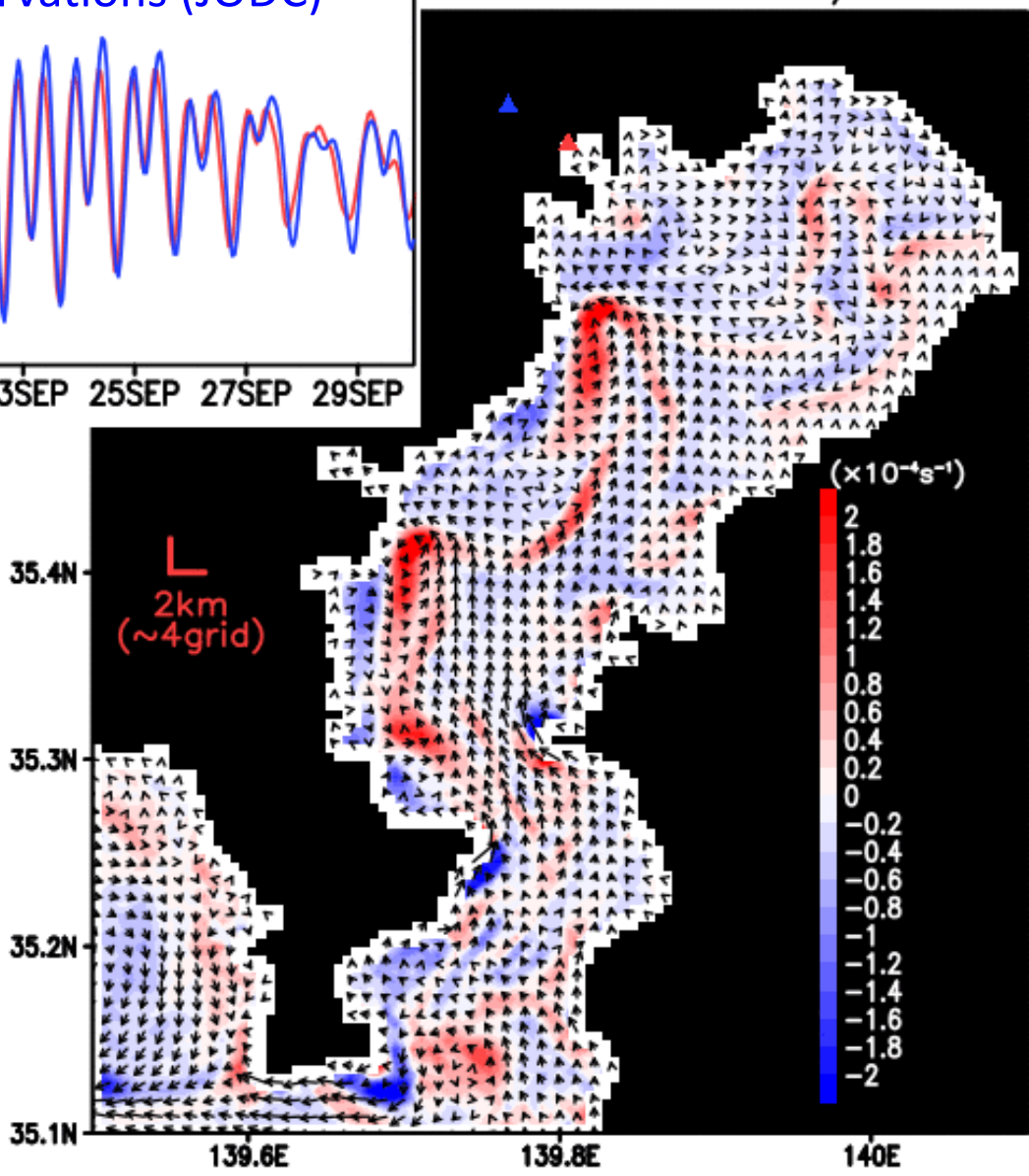


Hereafter, results are compared with observations focusing on small scale features.

First example
Eddies generated behind the headlands and islands are compared with SST data of the geostationary weather satellite Himawari-8.

Eddies in the Tokyo Bay





Eddies whose diameter > 2km can be represented.

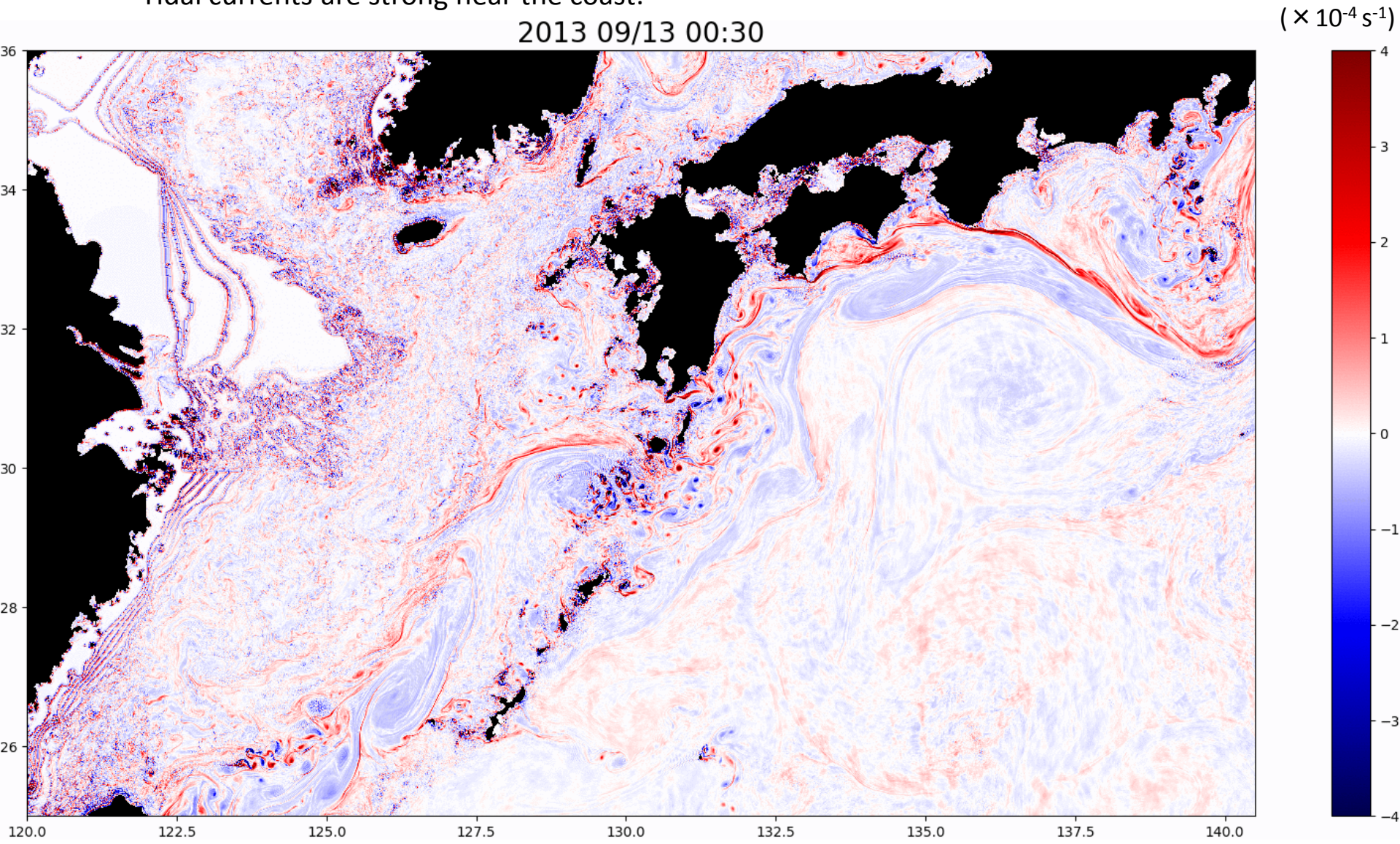
Eddies oscillate with tidal currents.

shades : relative vorticity at the sea surface

100

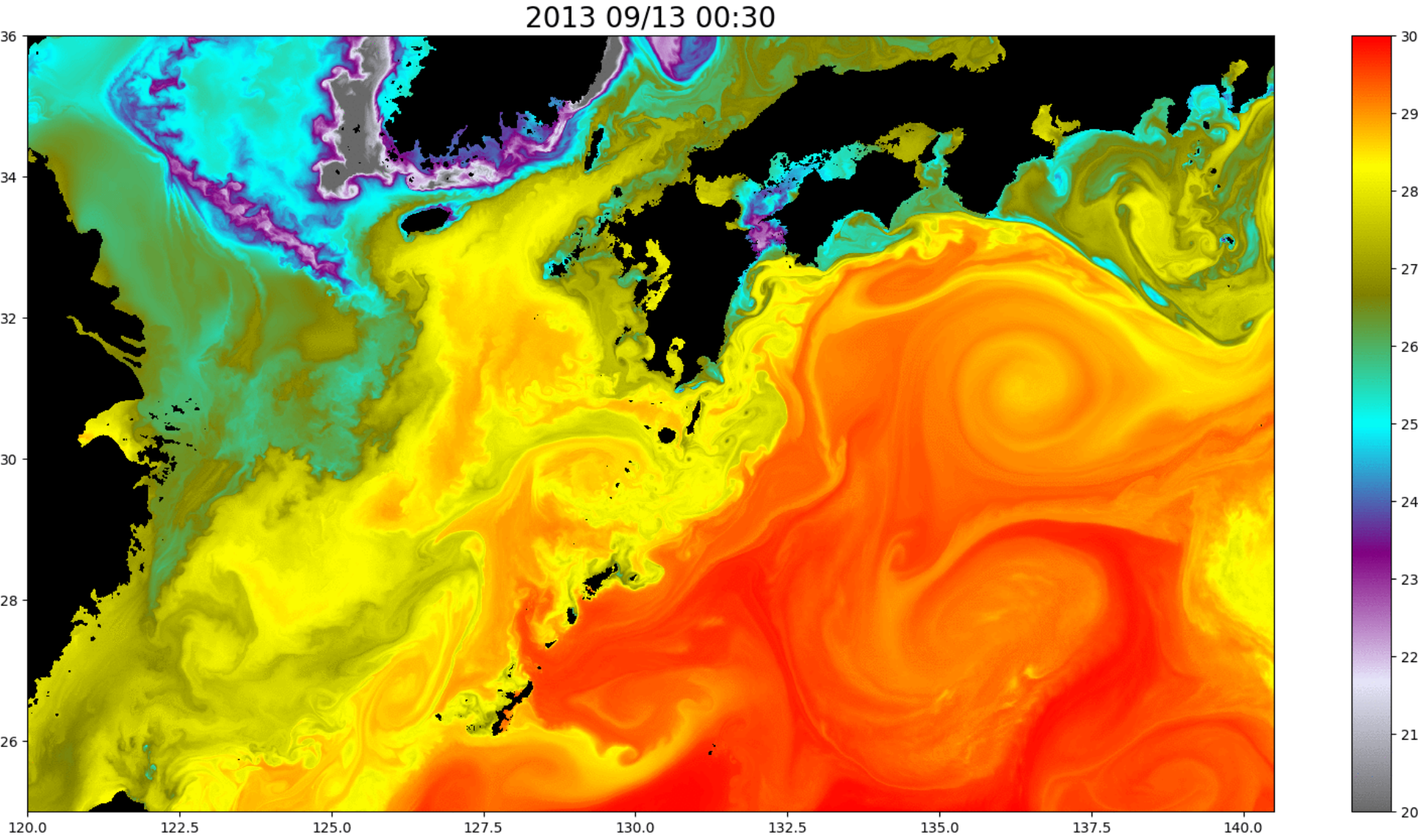
Relative vorticity at the sea surface

- Many eddies are generated behind the islands and headlands.
- Tidal currents are strong near the coast.



Signals of Eddies also appear in SST

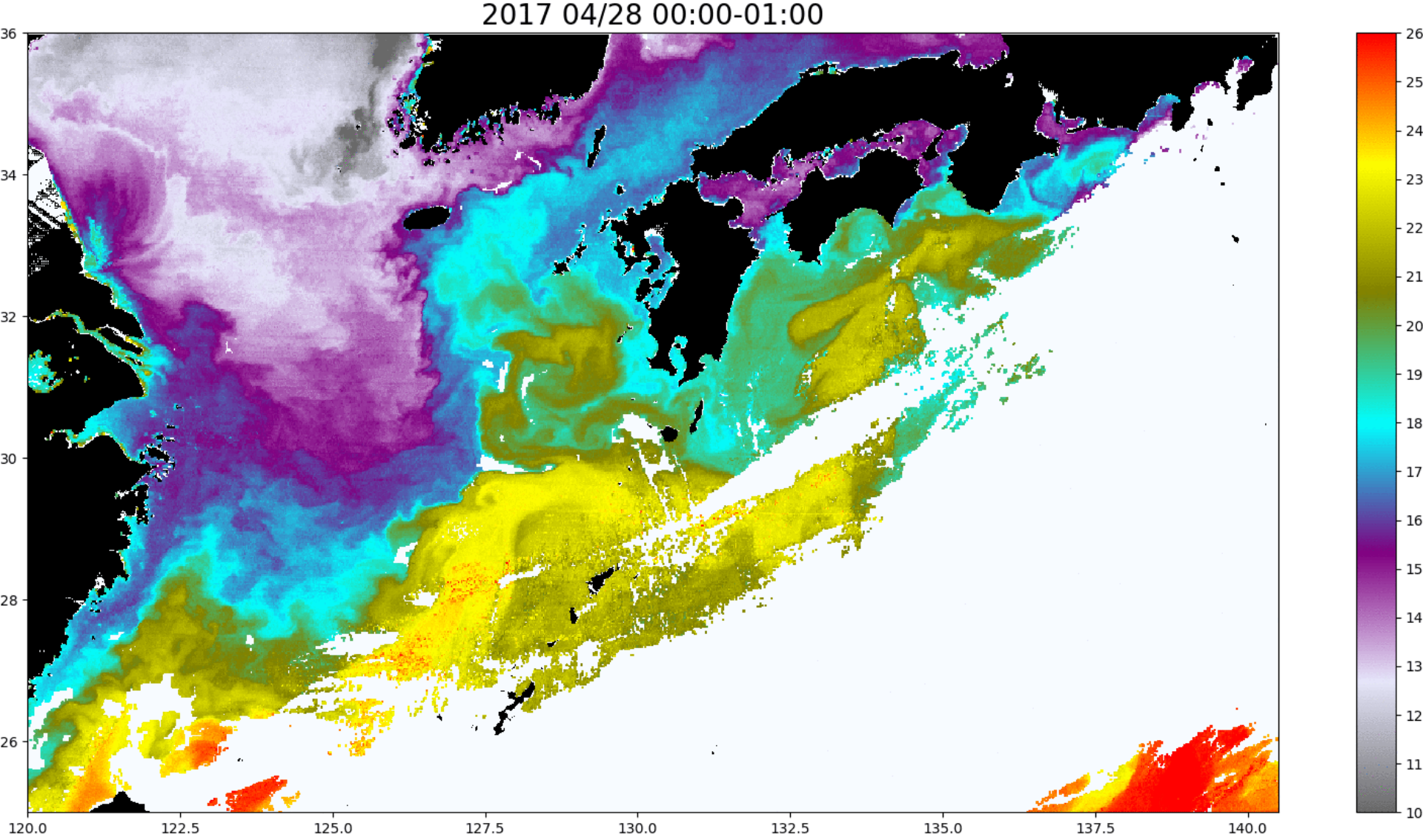
- Signals of eddies generated behind the islands and headlands are seen.
- Tidal signals are also seen.



SST produced from Himawari-8

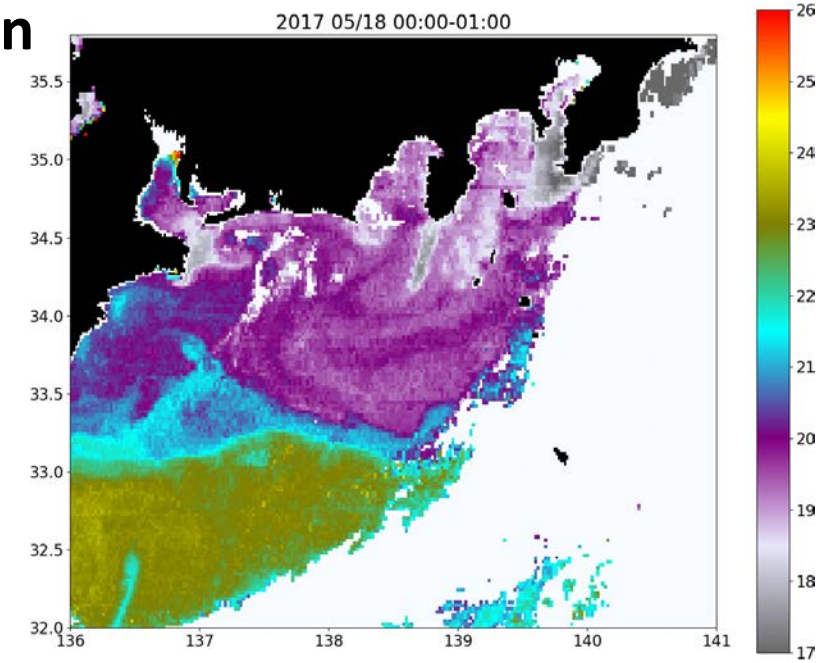
- Note that period is different from the simulation.
- Tidal signals are also seen.
- Though signals are less clear compared with the simulation, eddies are detected along the Kuroshio as in following sides.

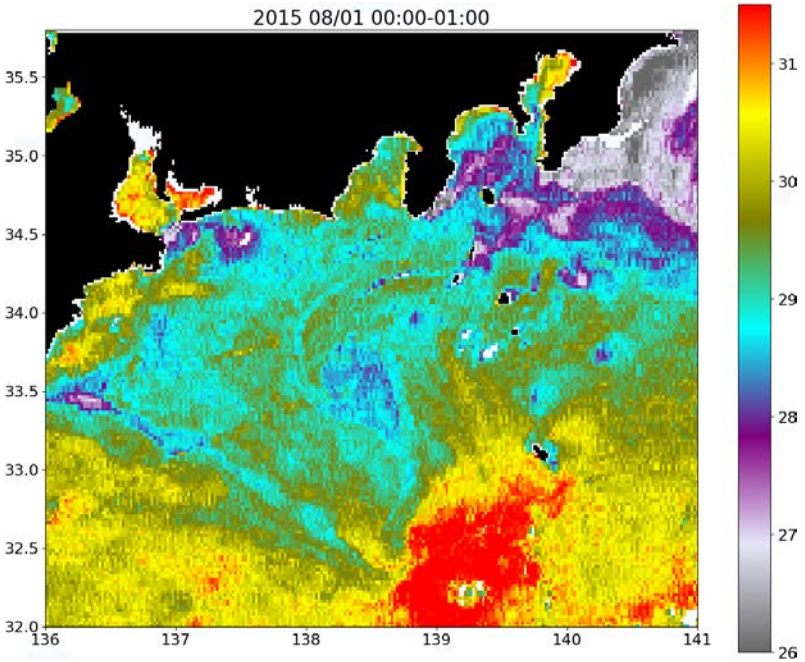
(supplied by the P-Tree System, Japan Aerospace Exploration Agency (JAXA))



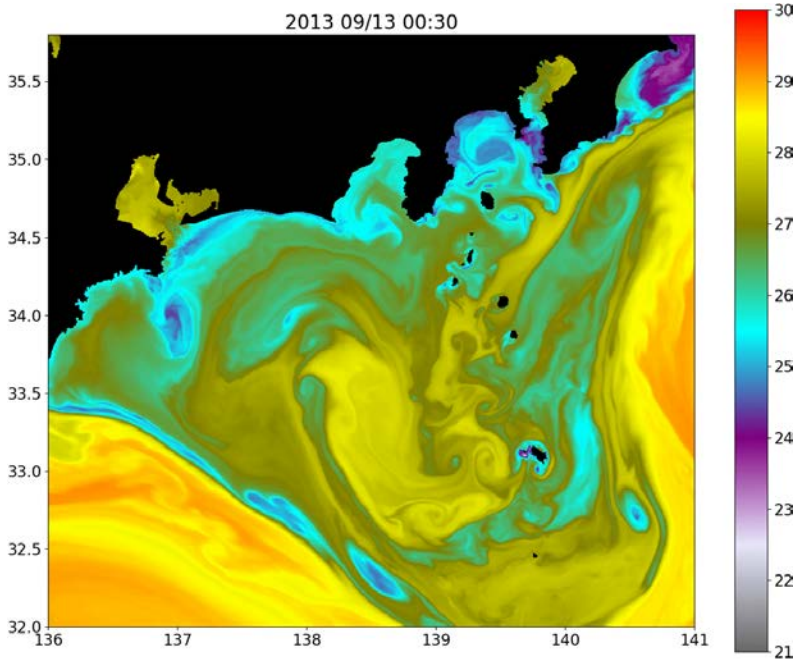
South of Japan

Himawari-8





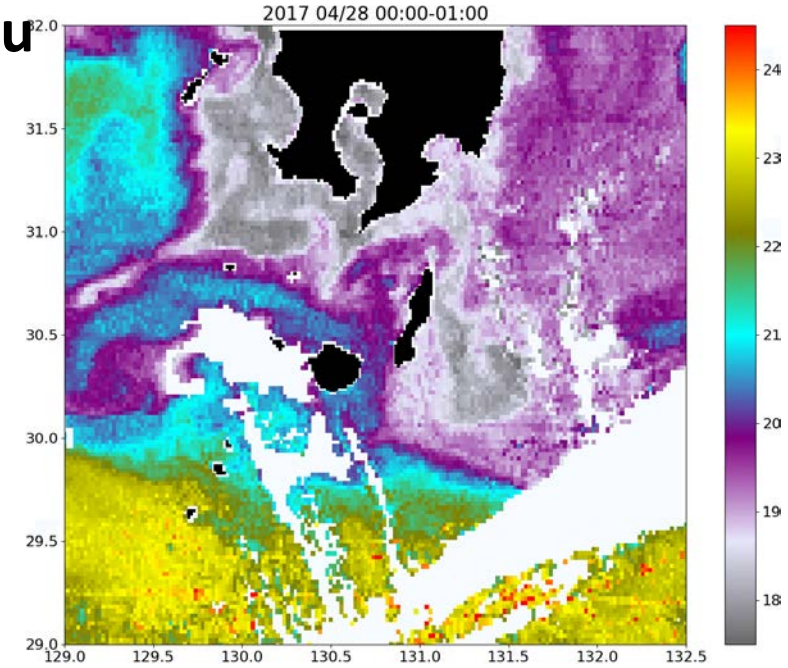
Model

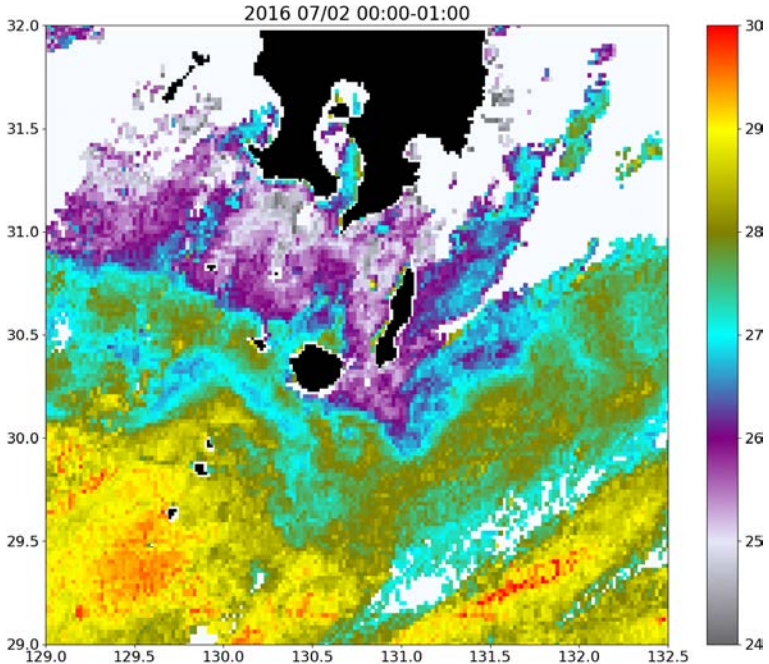


Eddies behind the Izu Islands are already pointed out by Isoguchi et al. (2009).

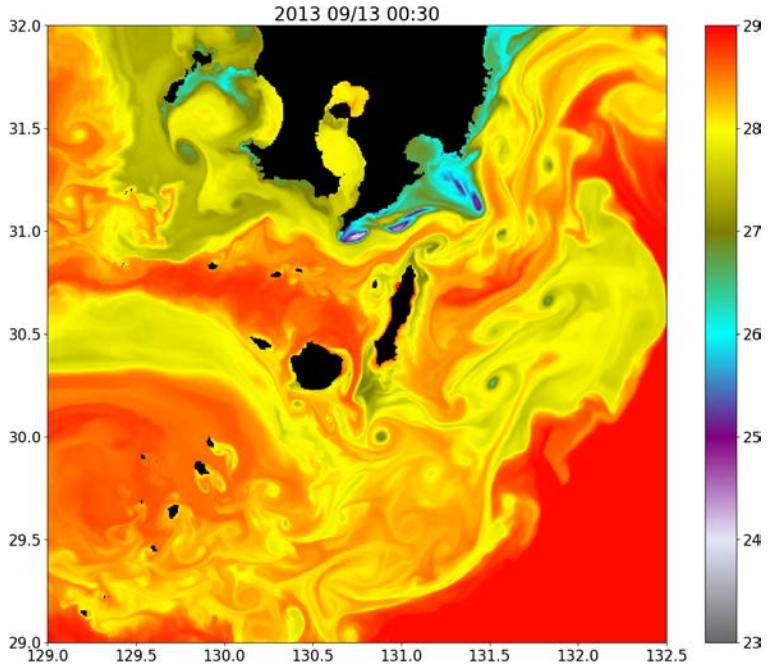
South of Kyushu

Himawari-8





Model

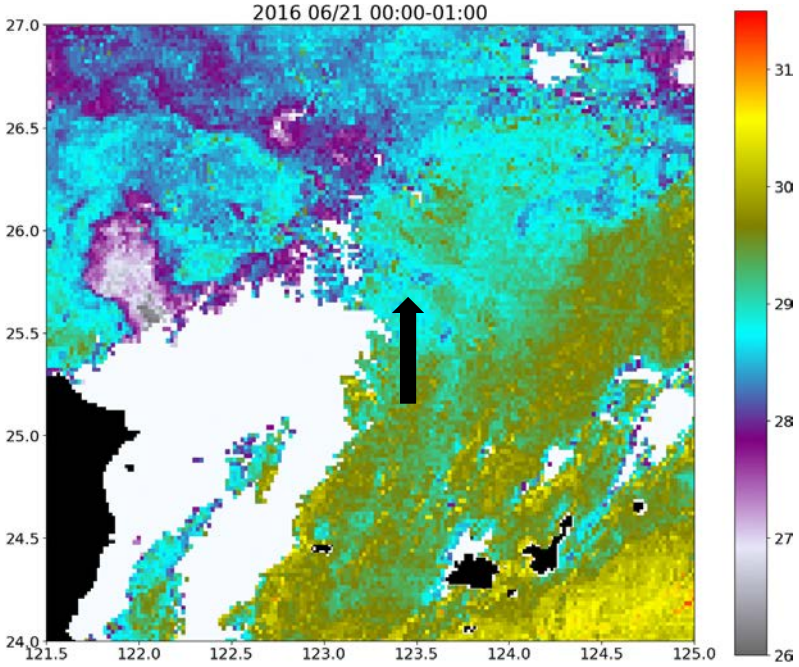


Eddies are generated

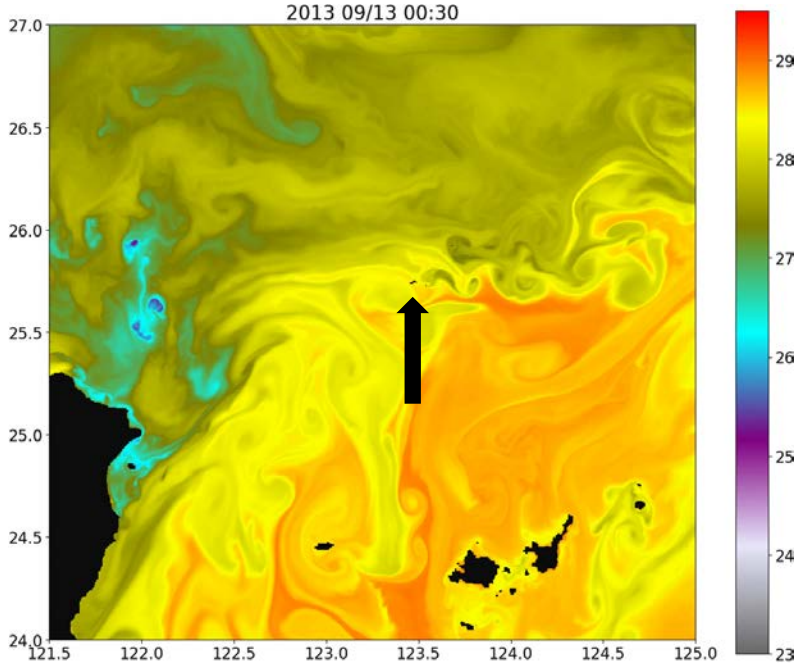
- behind the Yakushima Island
- behind the Tokara Islands

Around the Senkaku Ialands

Himawari-8



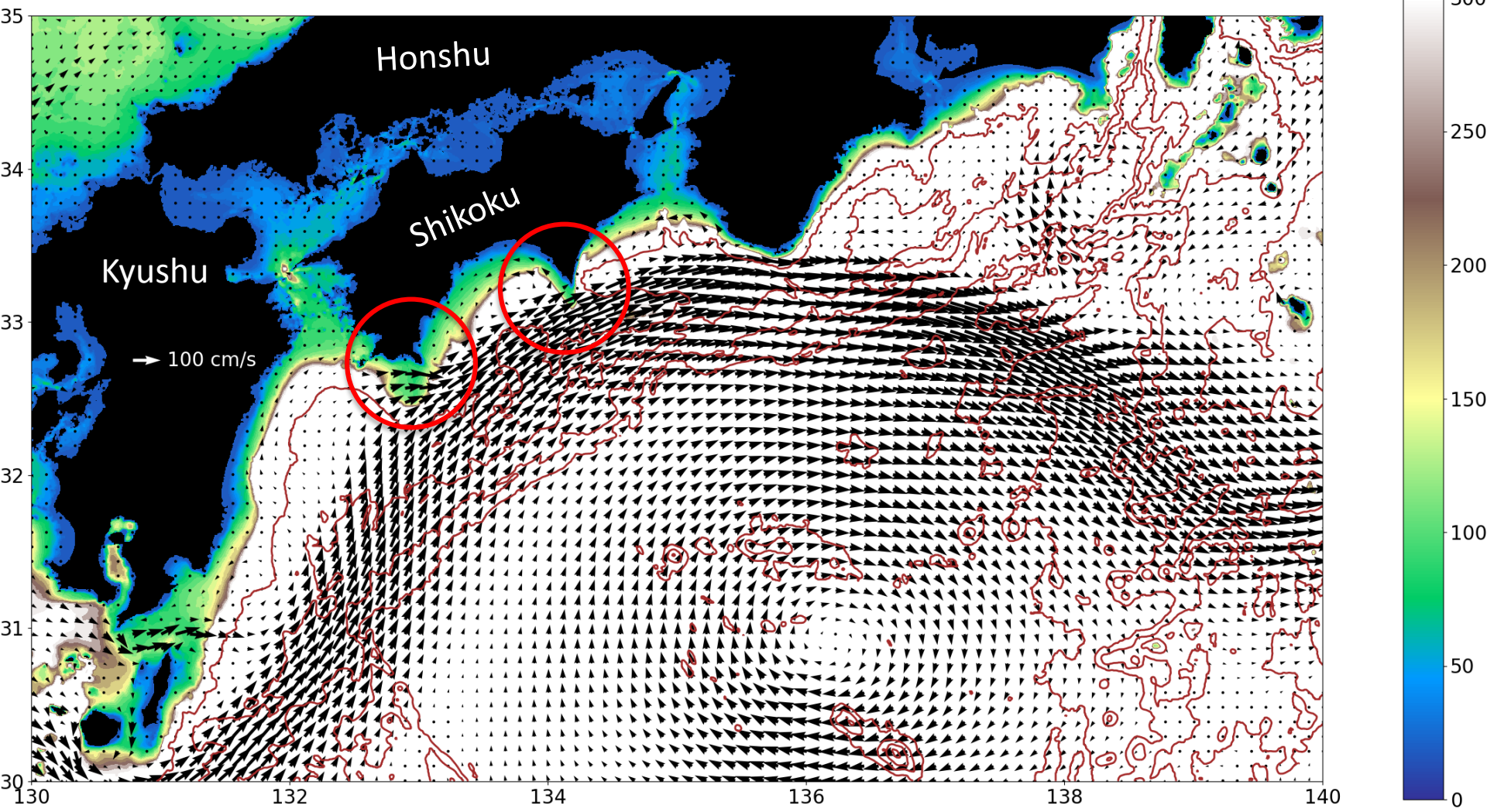
Model



Eddies in SST of Himawari-8 is barely recognizable.

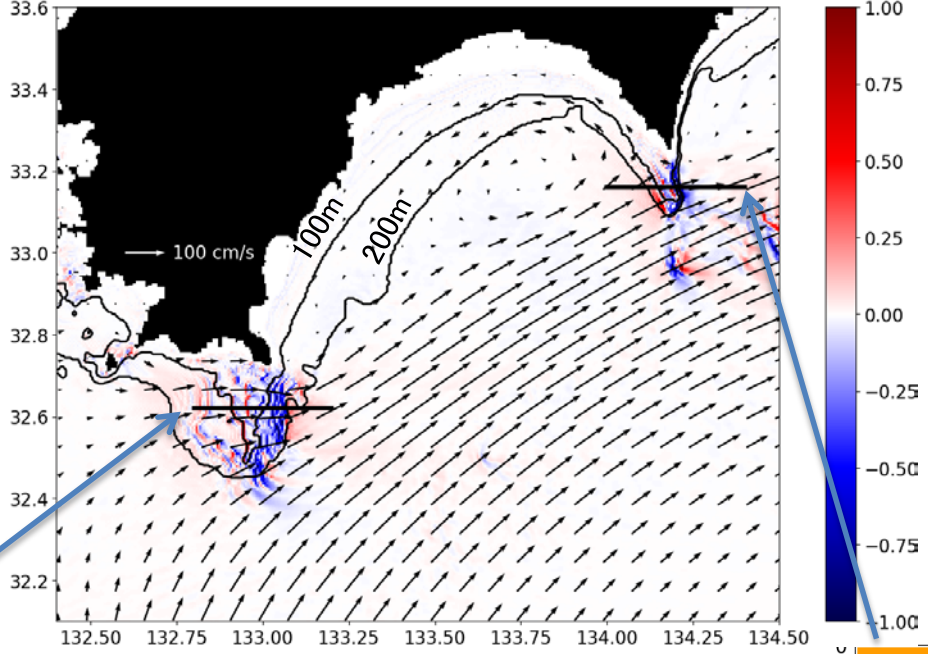
Another example of small scale features
Interaction between Kuroshio and shallow bottom topography

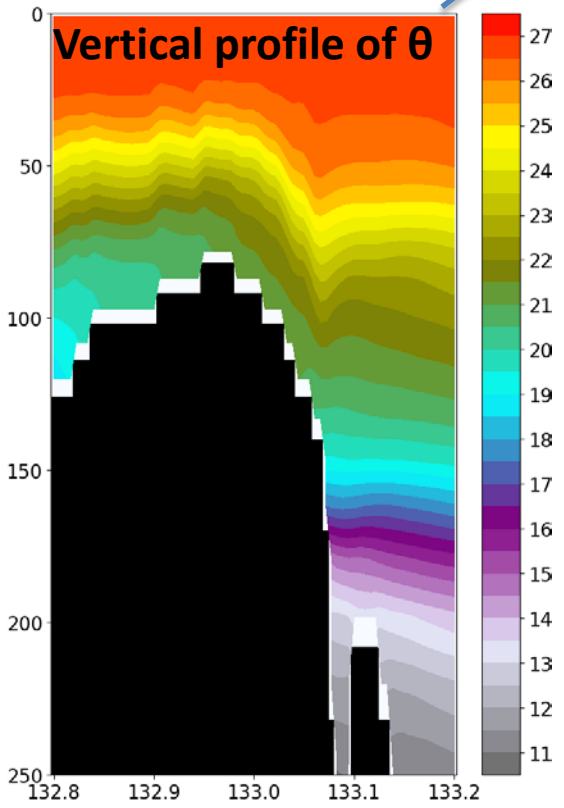
Surface current (arrow, 15 days average) and bottom topography (shades)

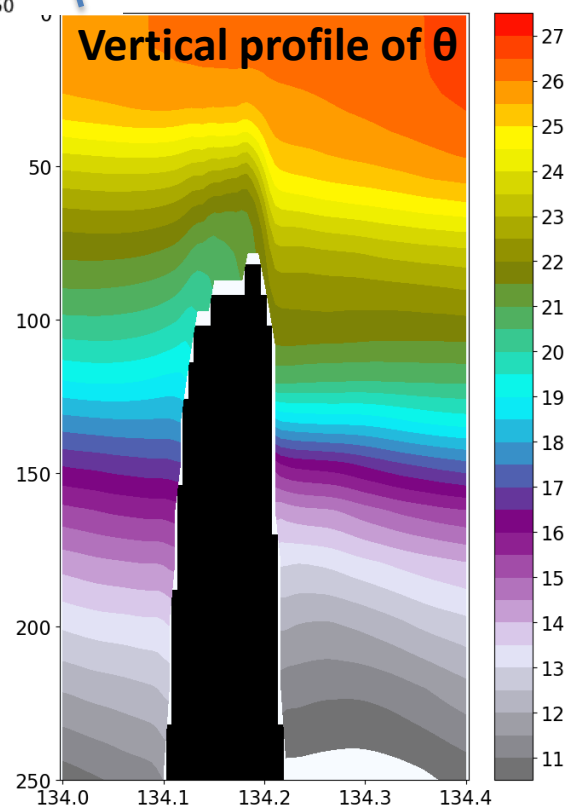


Arrows: surface current

Shades: vertical velocity at 50m depth
（15 days average）







Strong downwelling occurs in regions where the Kuroshio flows over shallow and steep bottom topographies.

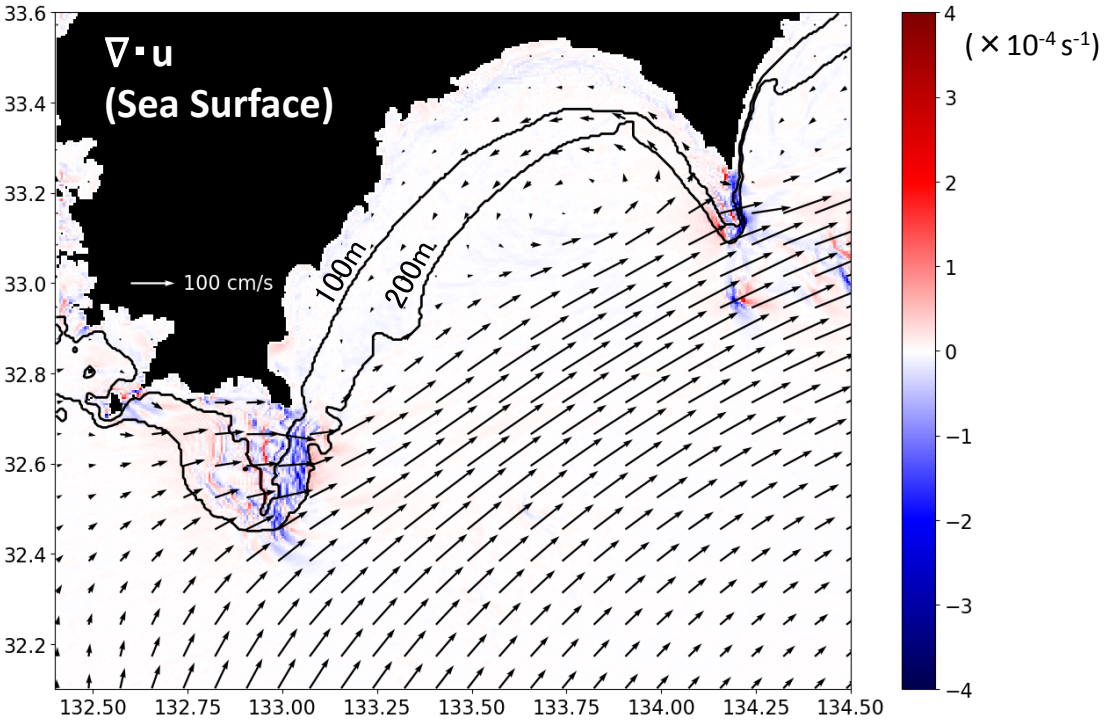
Surfaces of θ undulate over the topographies.

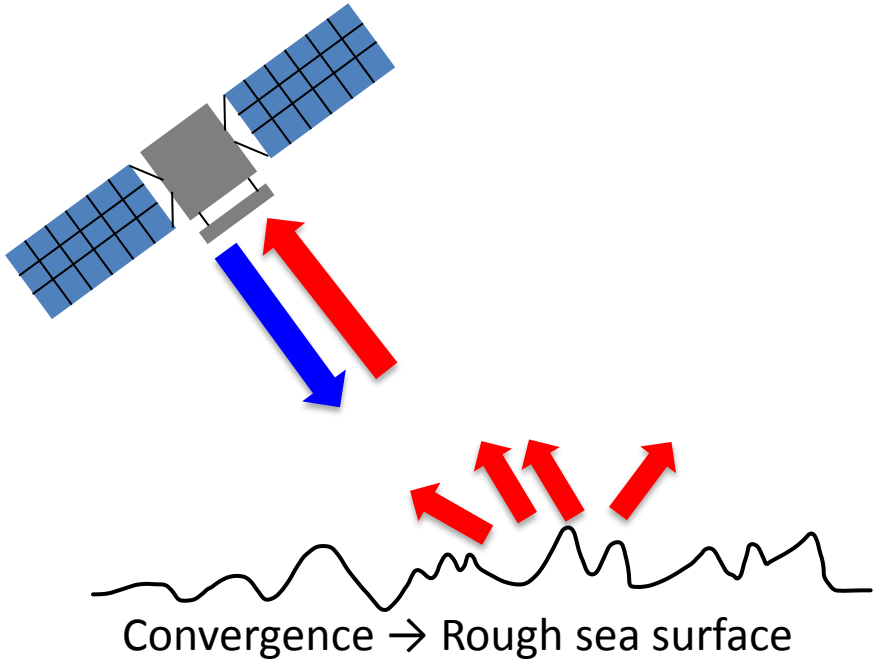
(Detailed mechanism is under investigation)

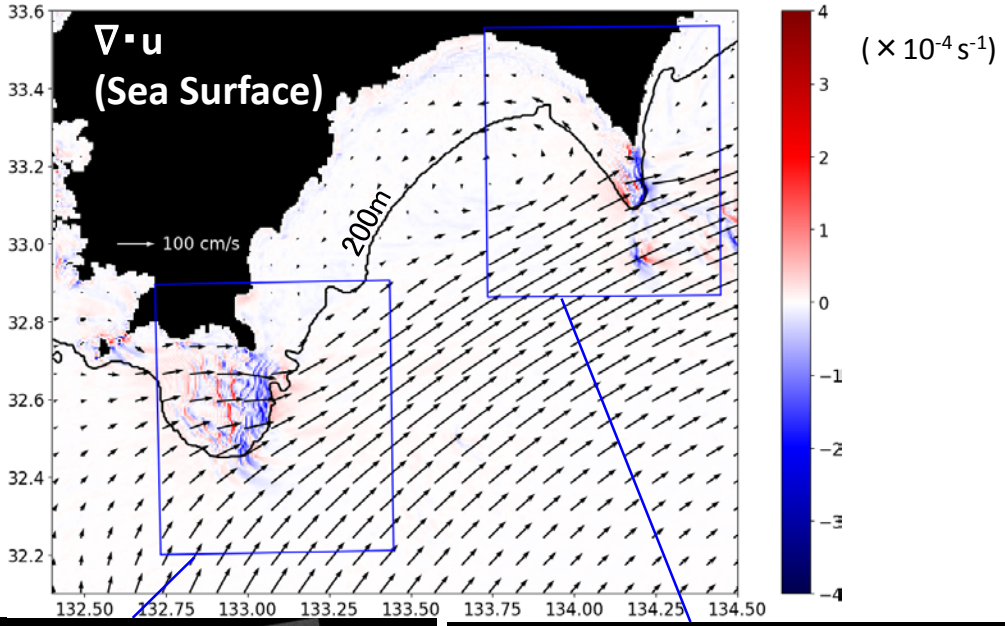
Strong downwelling is accompanied by strong convergence at the sea surface.

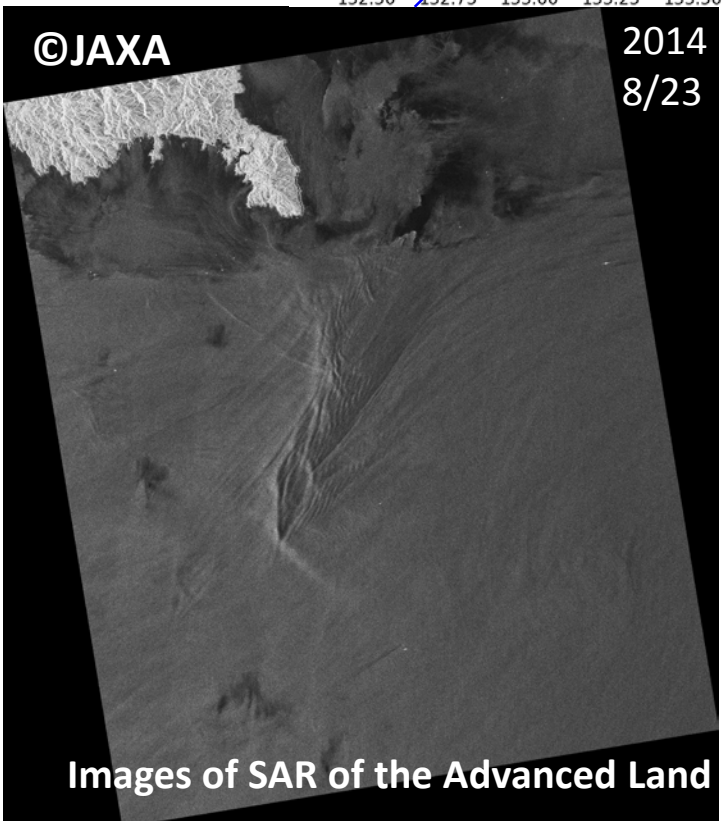
The convergence zone of surface current sometimes appears as bright area in the image of Synthetic Aperture Radar (SAR).

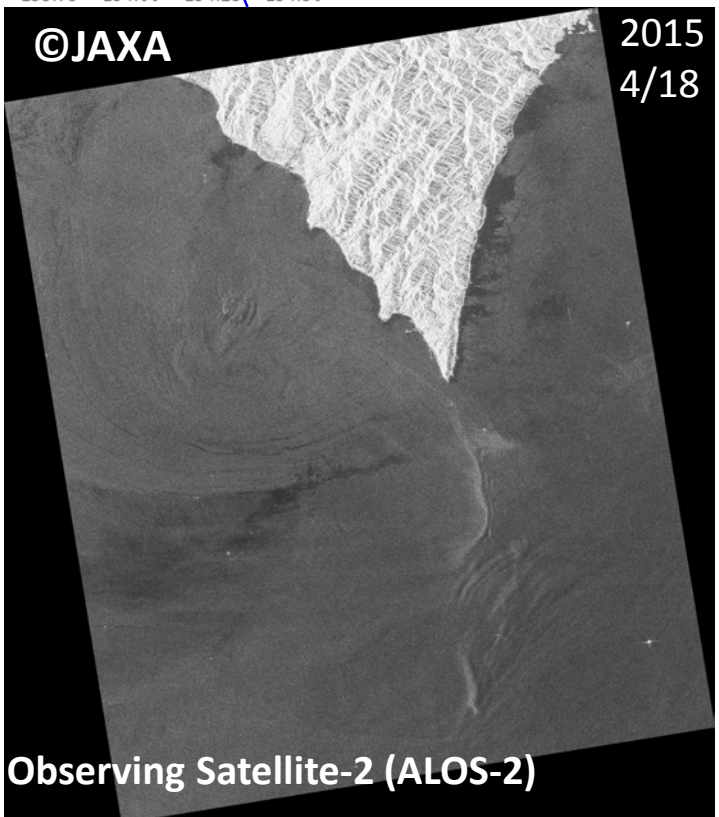
In the convergence zone, roughness of sea surface tends to be large and backscatter signal is enhanced.











Bright signals appear where surface current converges in the model.

There is a possibility that the simulated phenomenon is occurring in reality.

Summary

A nested-grid OGCM covering the entire Japanese coastal system with horizontal mesh of about 500 m is developed.
Simulated fine scale features are compared with observations.

Simulated	Obserbations (satellite)
Many eddies are generated behind the headland and islands along the strong current.	Similar eddies are detected in SST data of Himawari-8.
Surface current converges and density surface undulates over shallow and steep topographies offshore of Capes Ashizuri and Muroto.	Signals of such surface current convergence appear in images of SAR of ALOS-2.