Design of Physical Oceanographic Observing Systems with Numerical Modeling for Coastal Seas

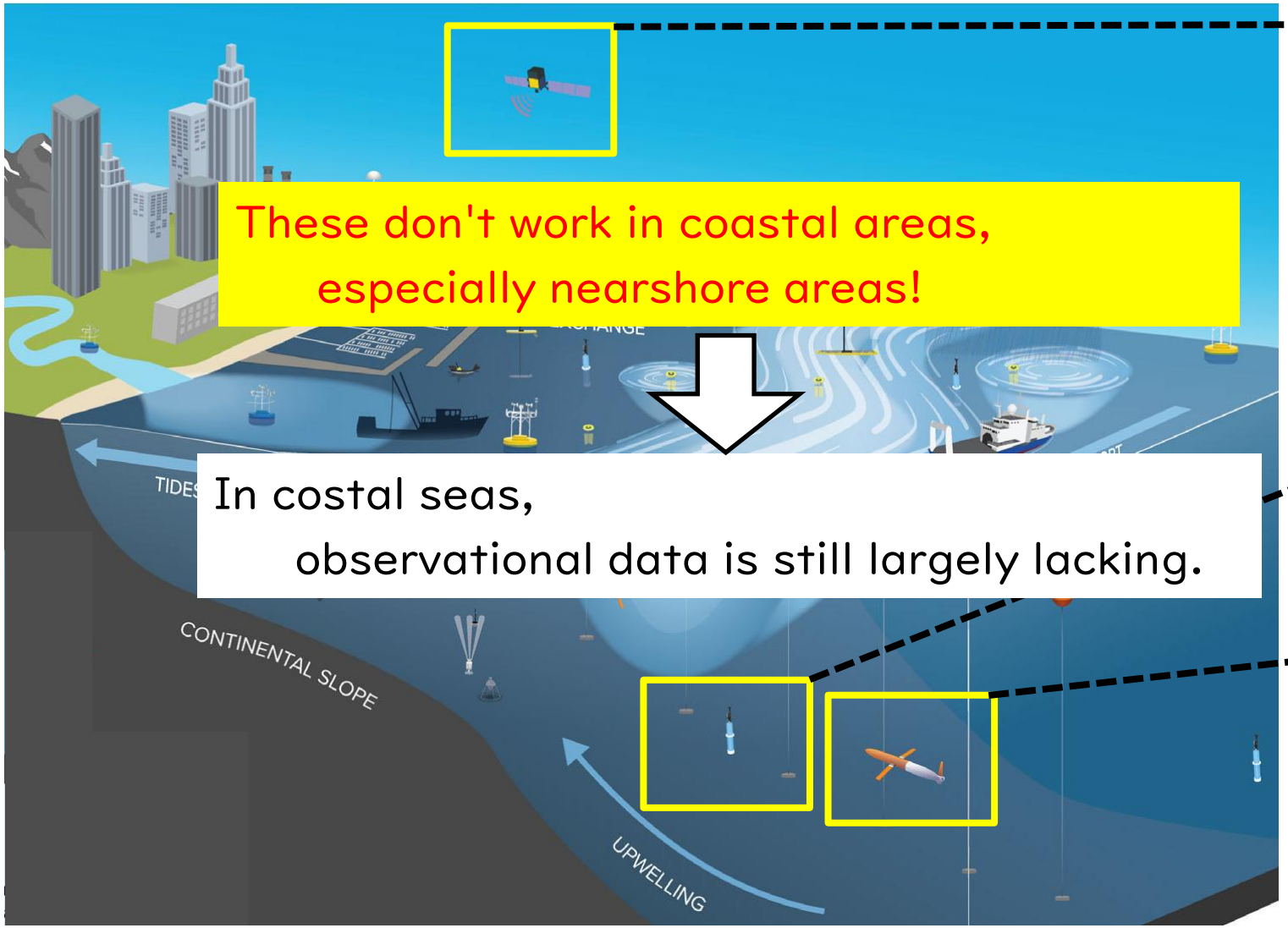
Kiyoshi Tanaka

Atmosphere Ocean Research Institute, University of Tokyo

Today, I'd like to introduce my research activities in coastal physical oceanography, rather than discuss specific results.

Problem with Coastal Sea Observation

Observation is the first step in oceanography. However, ---



Satellites



(JMA)

Argo floats



(JAMSTEC)

Sea gliders

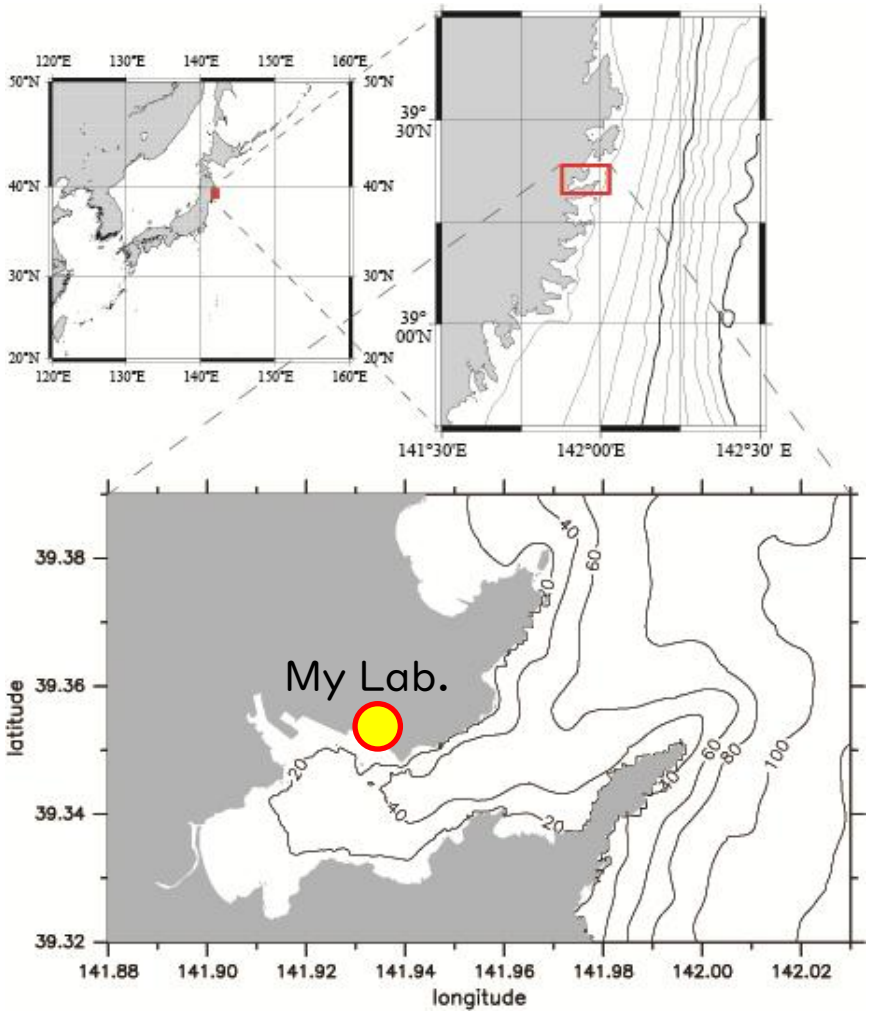


(JMA)

(Nadia et al., 2024)

Problem with Observation in Nearshore areas

Otsuchi Bay



Many fishing implements are placed in coastal seas.



Map: MDA Situational Indication Linkages, JCG
Photos: Shin-Otsuchi Fish. Coop.

Research Vessels Unavailable

Nearshore areas are very crowded.



Research vessels (equipped with advanced instruments such as ADCPs and CTDs) **cannot navigate** there.

Large vessel



Small vessel

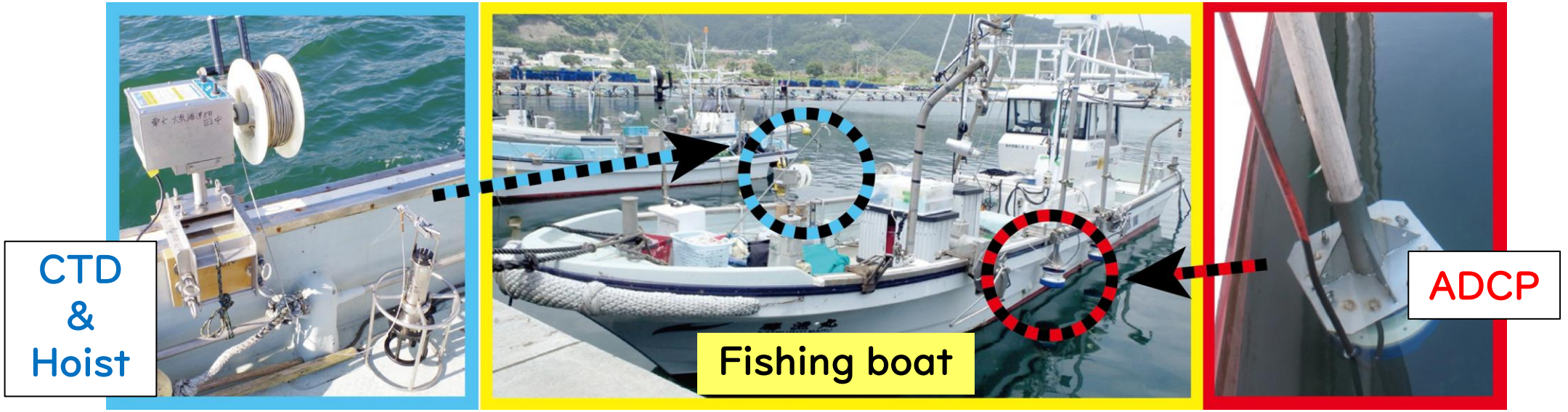




(JAMSTEC)

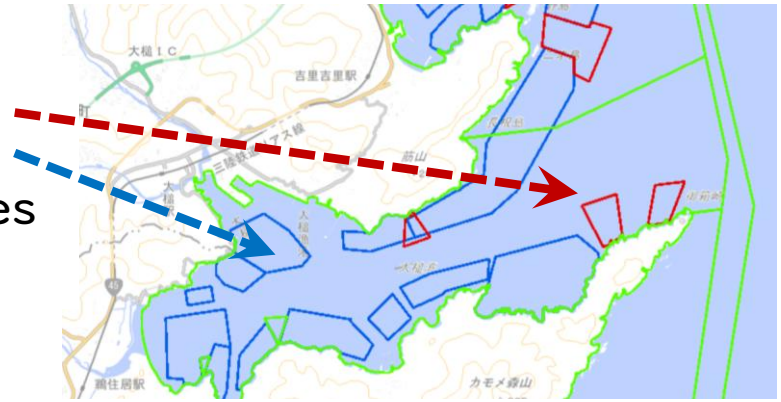
Sustainable Observation System (Uniquely Developed)

An ordinary small fishing boat was equipped with ADCP & CTD.

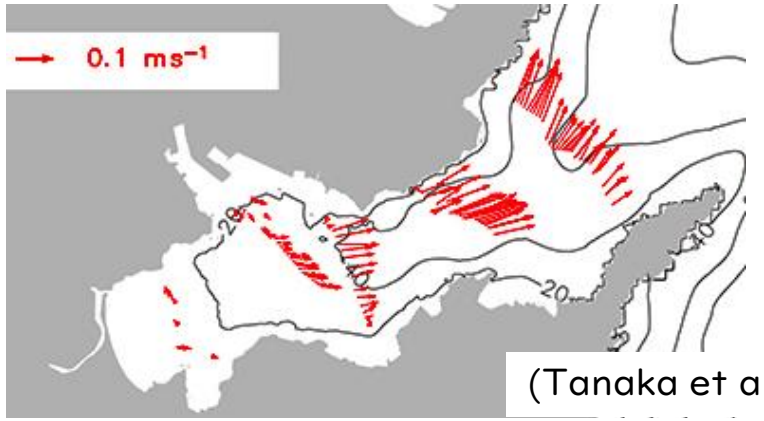


Usage of local fishing boats enables observation in the crowded areas.

Fishing areas, where many fishing facilities are set.



(MDA Situational Indicaion Linkages, JCG)



(Tanaka et al., 2017)

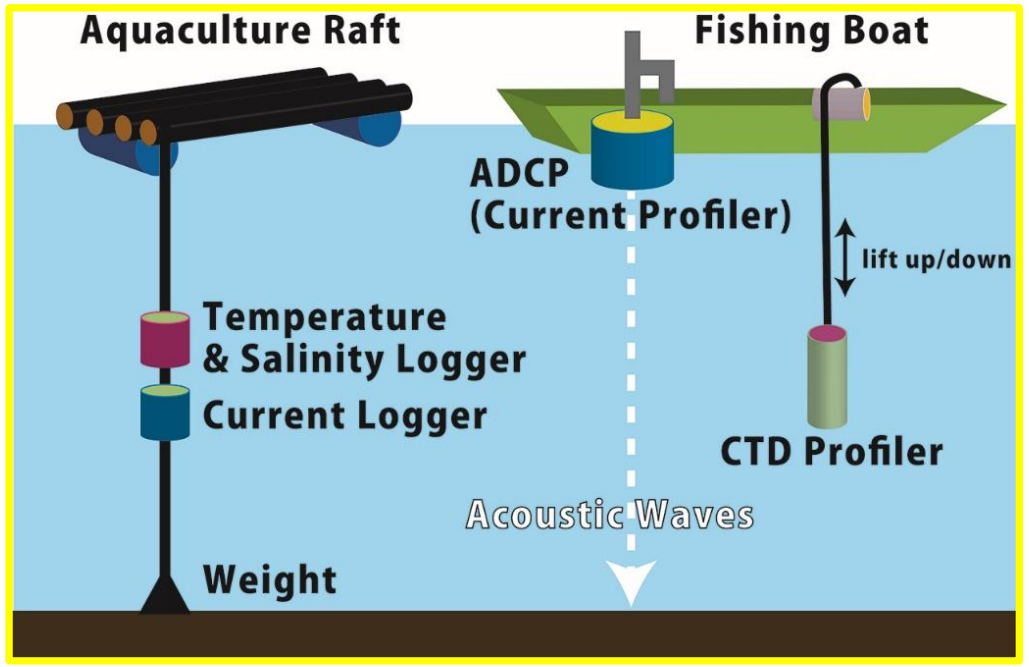
Result of the ADCP observation

Collaboration with Stakeholders

Collaboration with fisherpersons







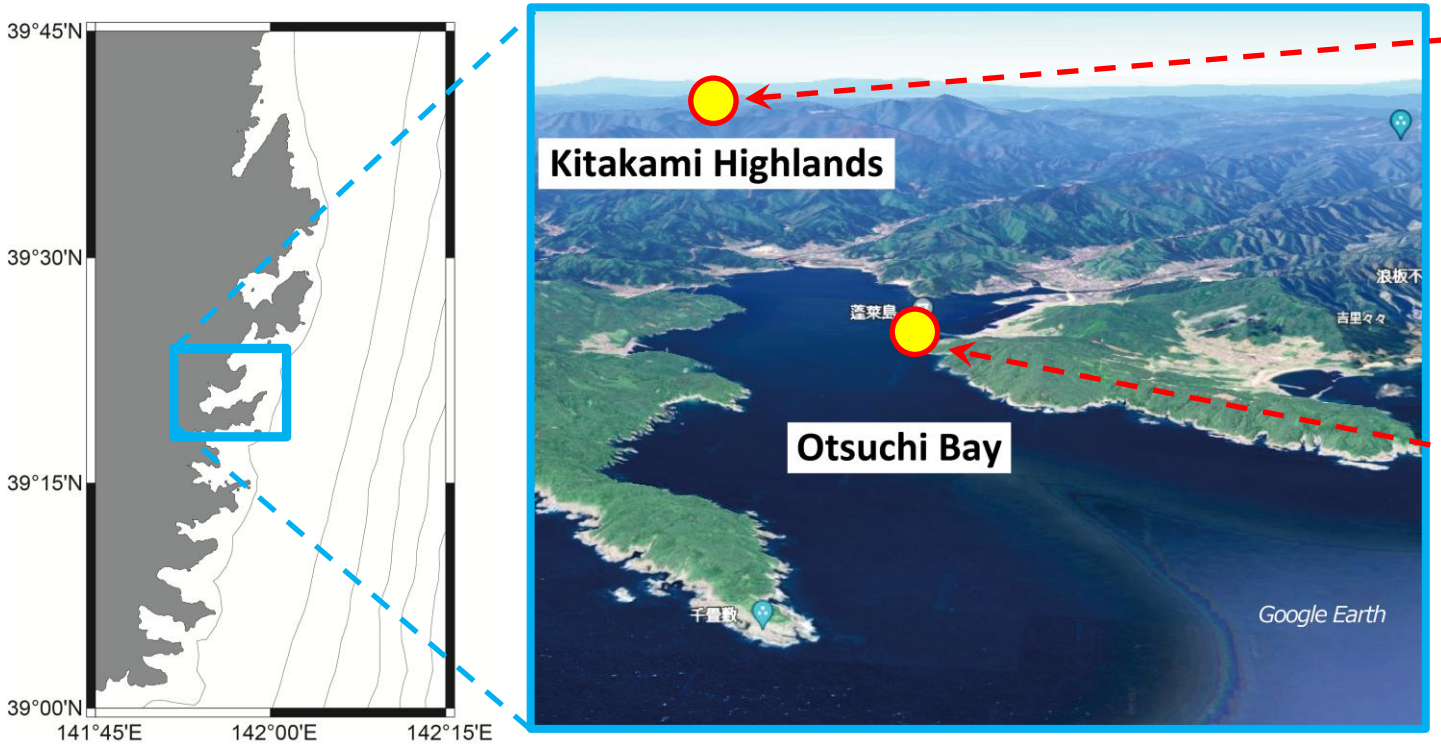
The collaboration with regional stakeholders enables

- not only navigation among marine facilities,
- but also continuous/frequent observation.

Importance of Atmospheric Observation

Ocean circulation is strongly influenced by atmospheric fields. However,
the atmospheric fields are particularly complex in coastal areas, affected by topography.

We have been conducting atmospheric observations in various environments, such as in mountainous areas and over the sea.



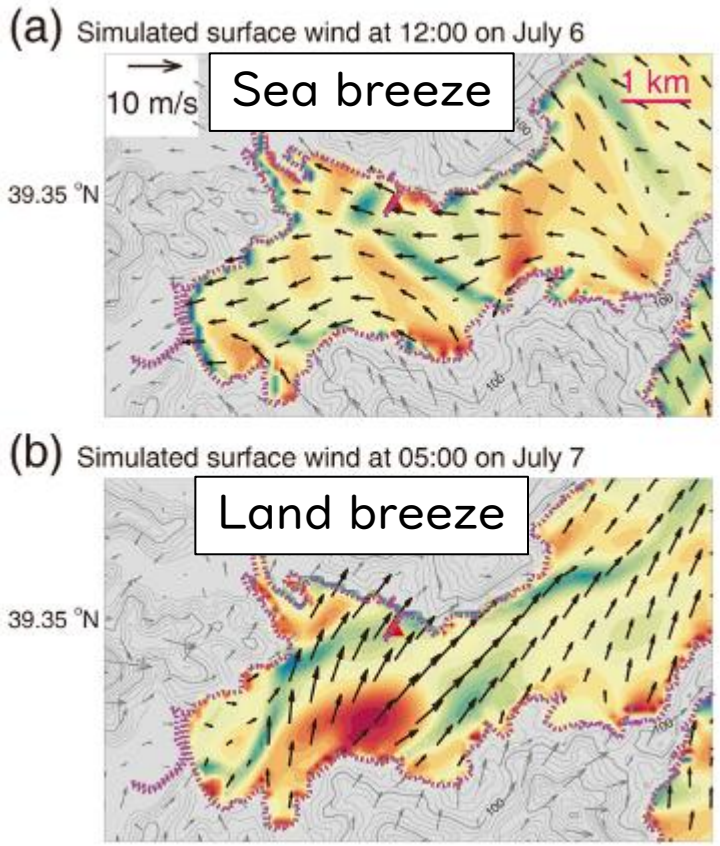




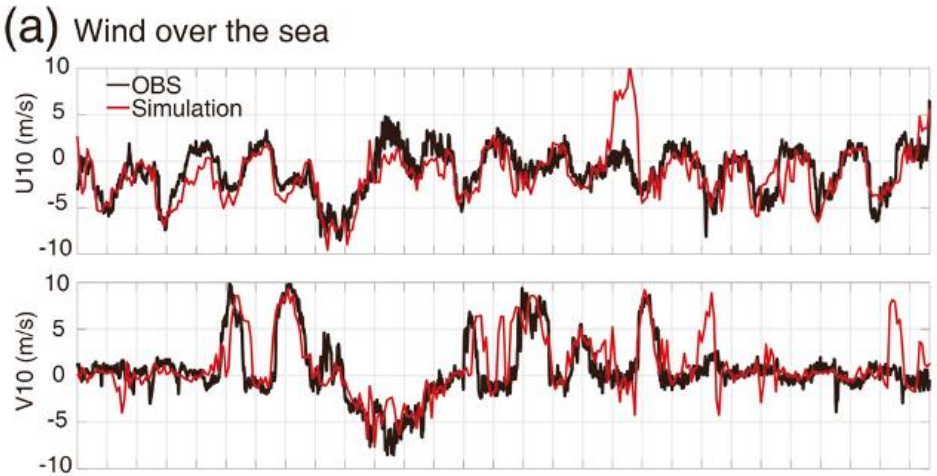
Simulation of Atmospheric Circulation

Realistically, it is very difficult to obtain high-resolution observational wind data.

WRF
(Weather Research & Forecasting Model)



When observational data are insufficient,
simulated wind data can be useful, for example,
for driving ocean circulation models.

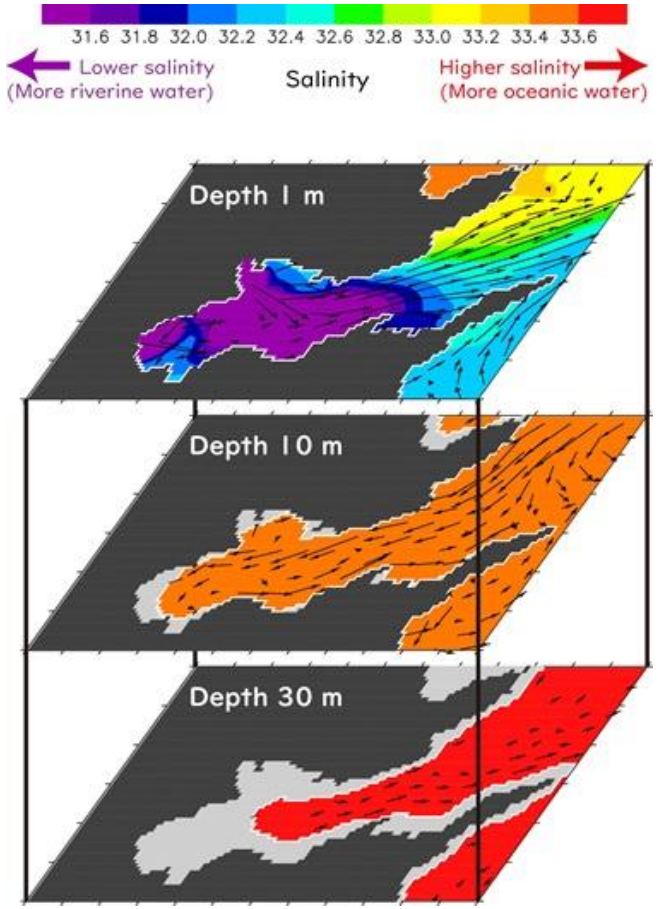


(Kim, Y.-J. (2026) : J. Geophys. Res.. 131, e2026JC024033)

High-resolution Simulation of Ocean Circulation

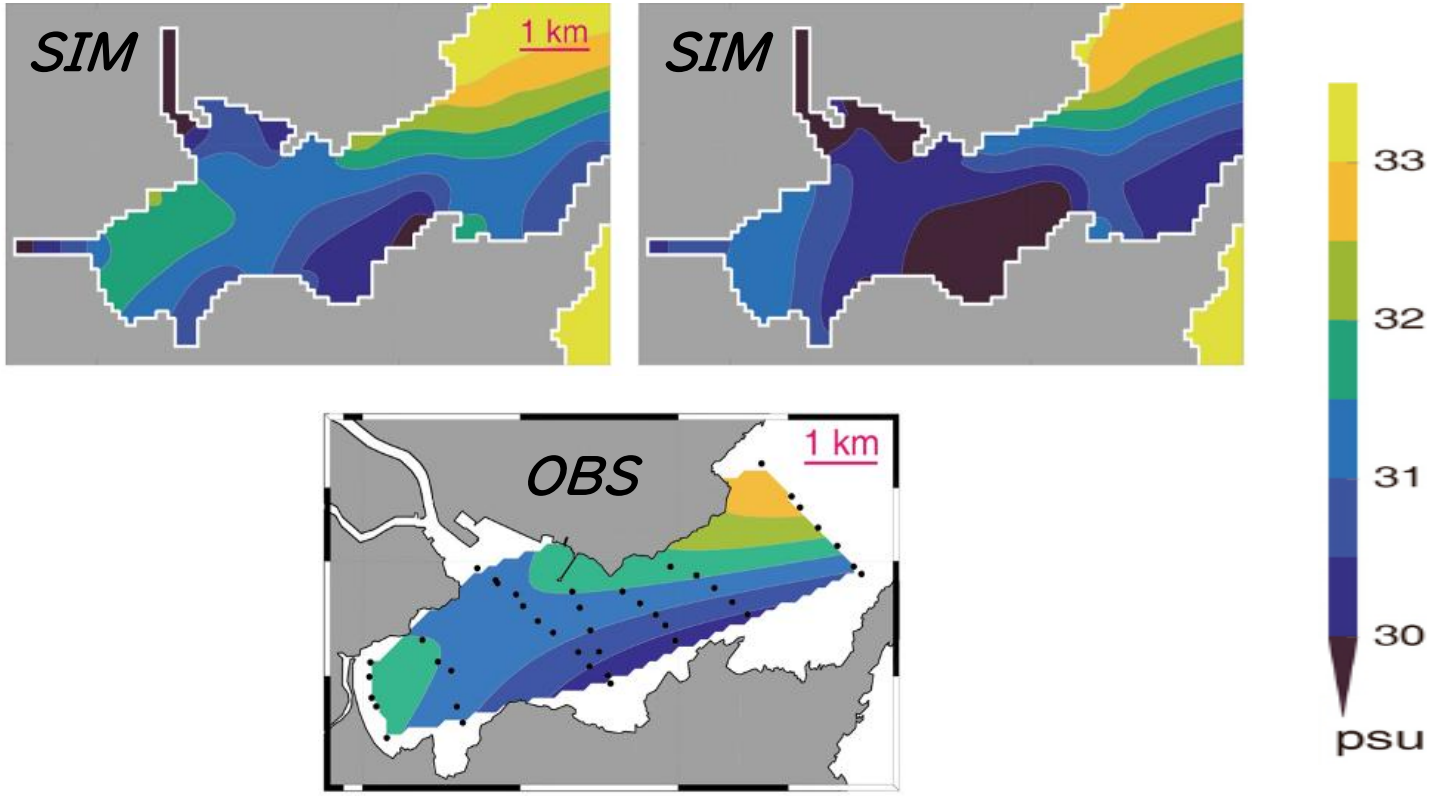
Driven by the high-resolution simulated wind field.

3D structure



Effect of the high-resolution wind field

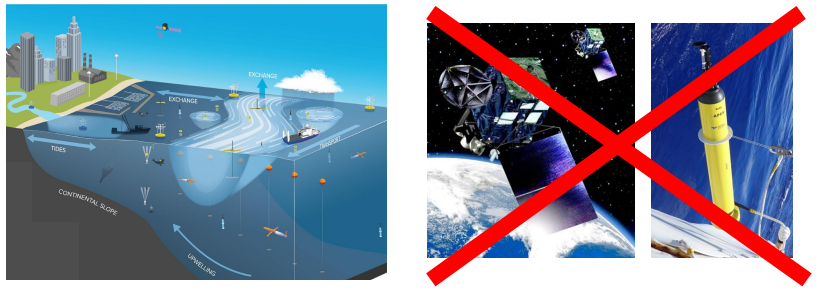
"High-resolution" & "Spatially uniform" wind fields

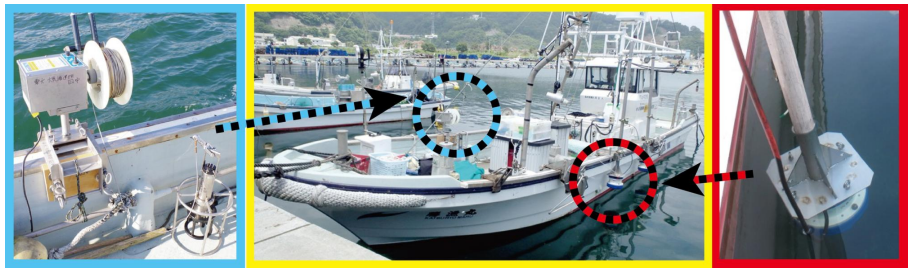


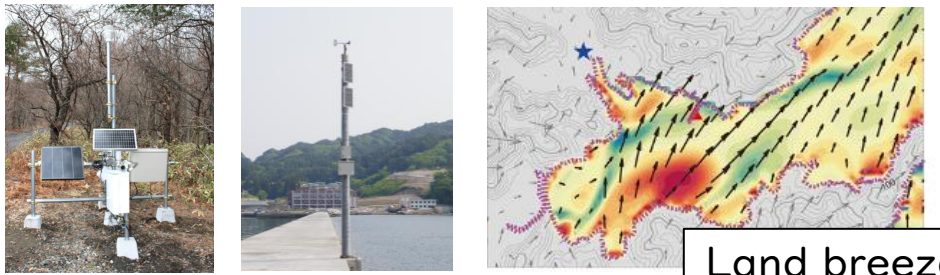
(Kim, Y.-J. (2026) : J. Geophys. Res.. 131, e2026JC024033)

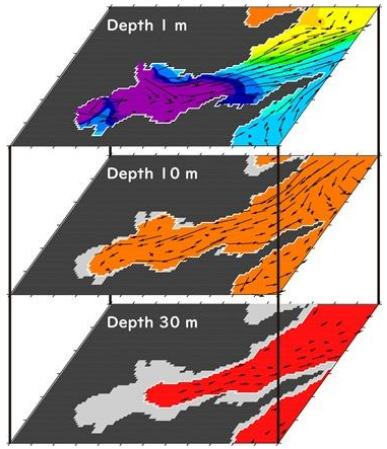
Summary

- Coastal seas, such as bays, estuaries, and nearshore areas within several tens of kilometers of the coast, neither satellite observations nor autonomous observing platforms (e.g., Argo floats and gliders) are effective.
- To address the above problem, we have been conducting sustainable ocean observation in collaboration with local stakeholders such as fishers.
- Moreover, we have been conducting atmospheric observation & simulation, because ocean circulation is strongly influenced by atmospheric fields in coastal seas.
- Finally, we have been conducting high-resolution ocean simulation driven by the simulated high-resolution wind field.



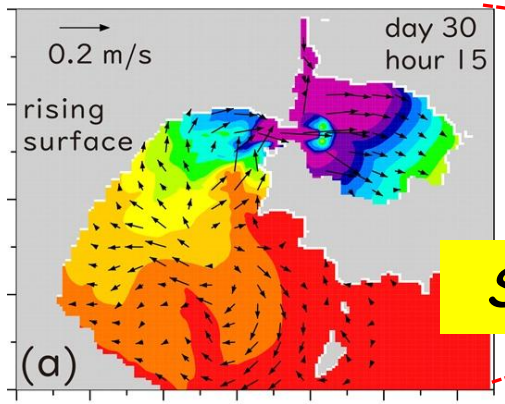




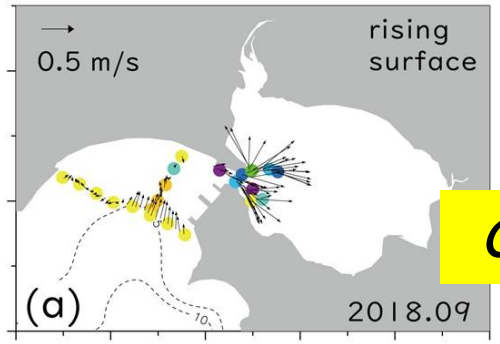


Feedback Processes between Observation and Simulation in Other Areas

Akkeshi Bay



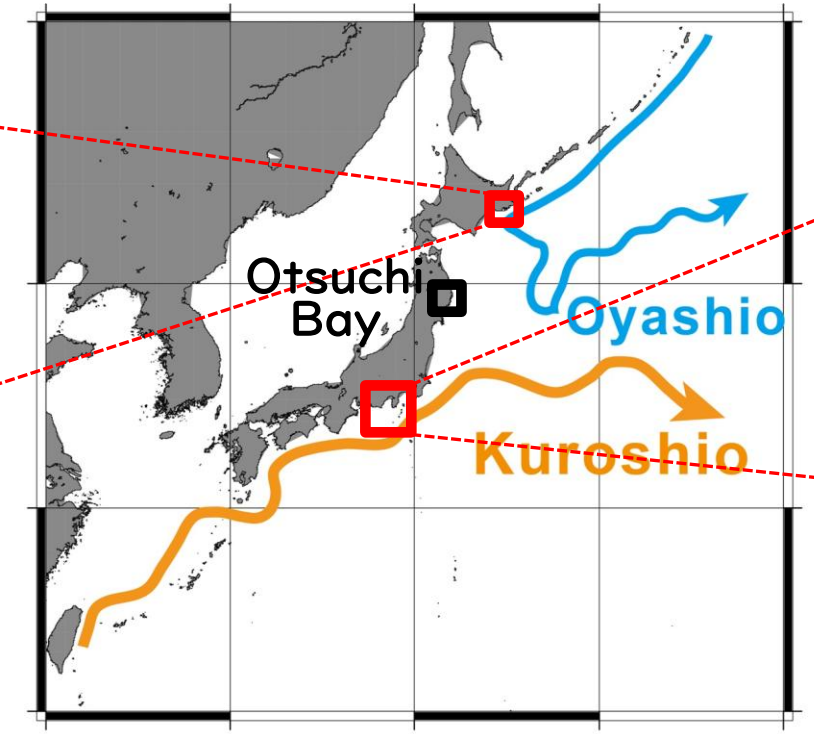
SIM



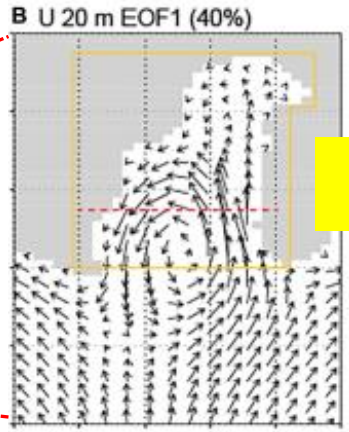
OBS



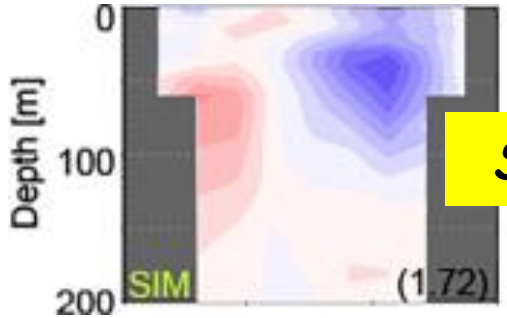
(Tanaka et al., 2025)



Suruga Bay

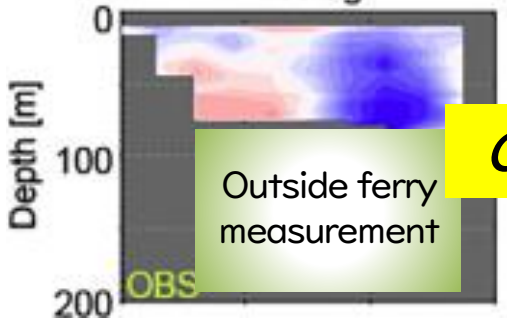


SIM



SIM

14 Aug



OBS

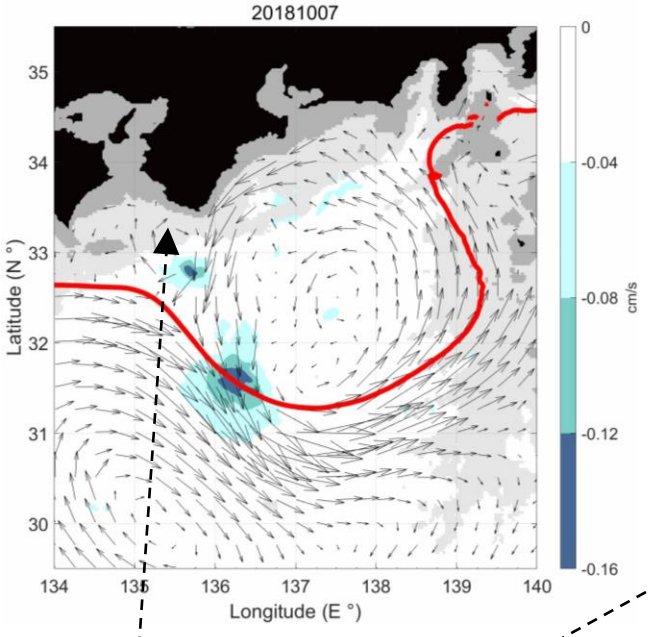
(Toyoda et al., 2021)



Ship-mounted
ADCP

Interaction between the Kuroshio Current and coastal circulation off the south coast of Japan

Downwelling occurs where the coastal current meets the Kuroshio.

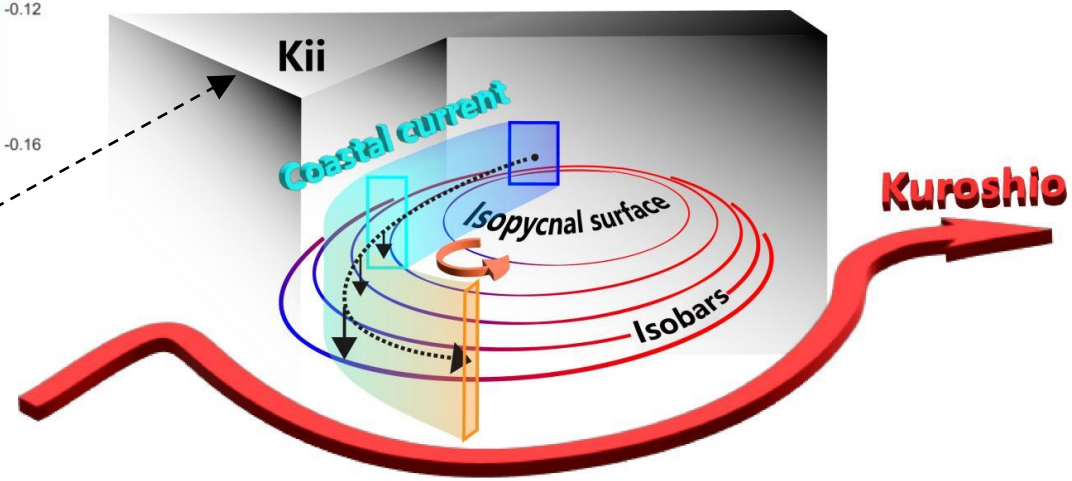


Kii Peninsula.

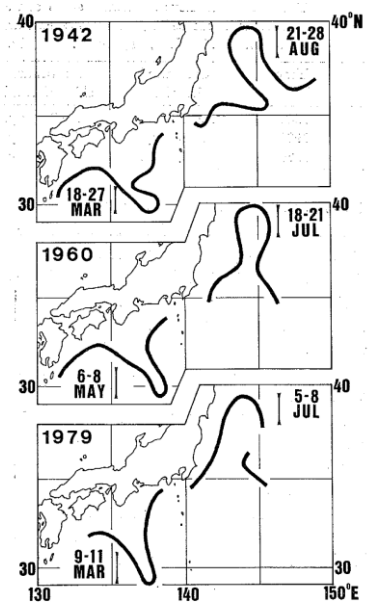
What happens?

As the southwestward coastal current encounters the Kuroshio, its flow direction changes abruptly, breaking down of geostrophic balance and generating downward motion.

Through the downwelling, the water-column is stretched, and it strengthens the meander of the Kuroshio.



Why important?



Examples of historical Kuroshio paths from 1942, 1960, and 1979.

(Kawai, 1989)

The large meander is possibly related to the anomalous northward displacement of the Kuroshio Extension.

Small-scale coastal circulation may have potential to modulate the large-scale behavior of the Kuroshio Current.