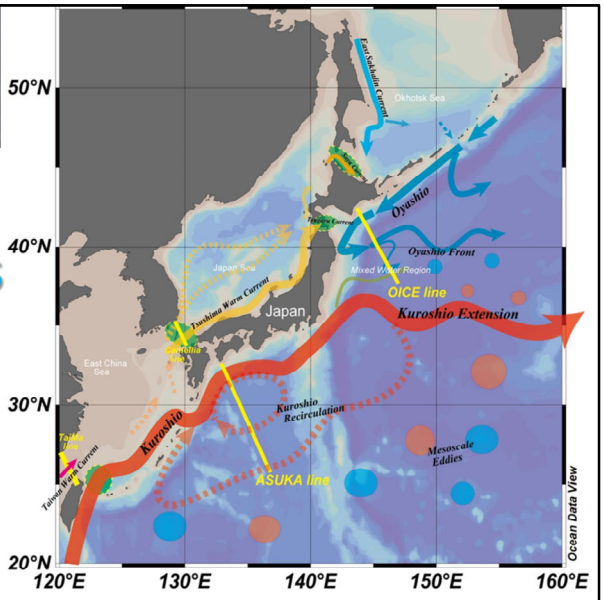
Variations of Sea Surface flow fields in the East Asian marginal seas and the western North Pacific



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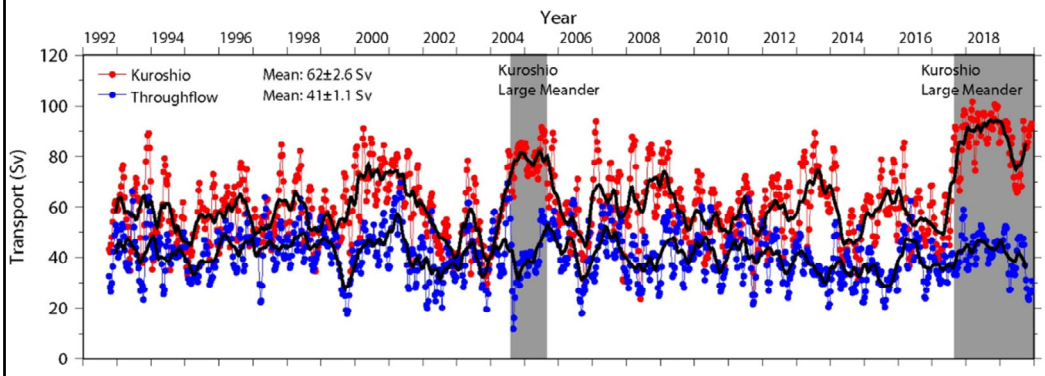
I would like to first acknowledge my co-authors of this OSTST research project.
Since this project covers comprehensive researches on variations in the western North Pacific and the East Asian marginal seas, various kinds of results are obtained.

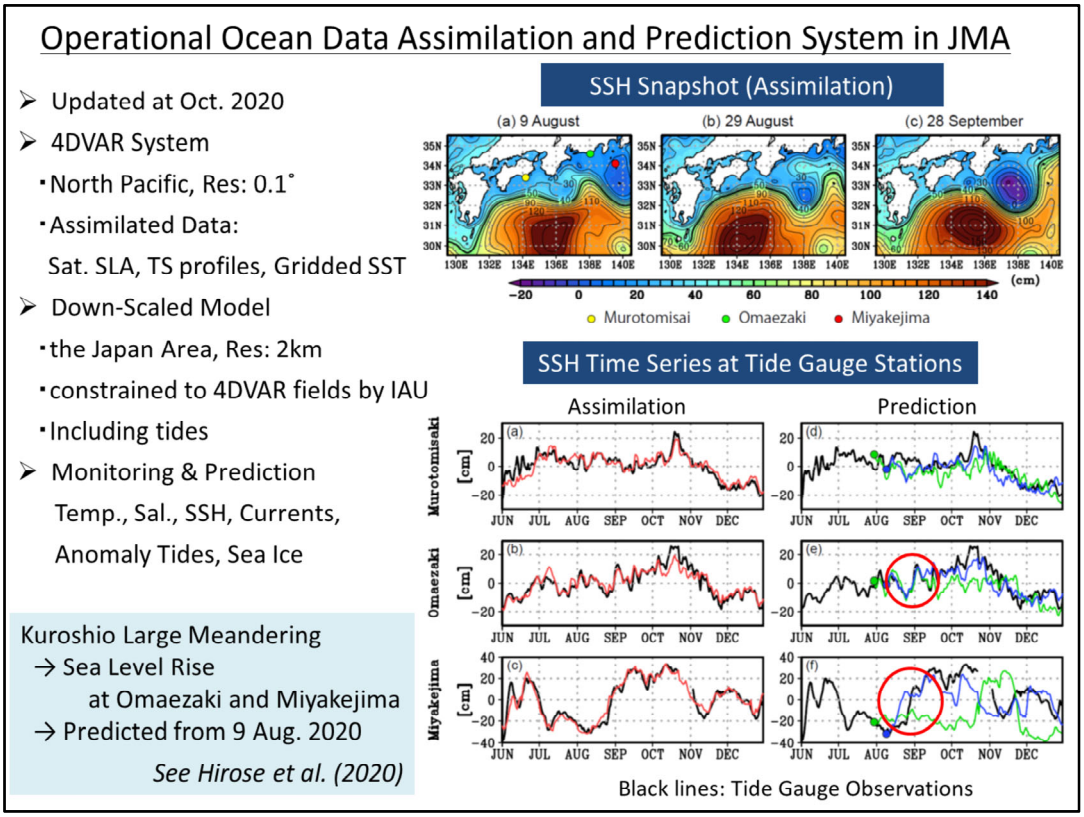
In this presentation, therefore, a few examples of our results are briefly introduced on
- the Kuroshio (western boundary current of the subtropical gyre),
- the Oyashio (western boundary current of the subarctic gyre) and
- coastal regions.

Volume transports of the Kuroshio south of Japan



Time series of eastward volume transport south of Japan (red line) and that of the net transport north of 25N (blue line) along the ASUKA line south of Japan, based on Imawaki *et al.* (2001). Stable large-meander periods are indicated by shadows.

The Kuroshio has taken a stable large meander path south of Japan for more than three years since 2017.
From long-term monitoring using altimeters, the eastward volume transport of the Kuroshio across the ASUKA line (along a T/P-Jason track) is found significantly increased during this meandering period, while the net volume transport of the subtropical gyre remains unchanged.
This would suggest that a strengthened local gyre south of Japan is associated with the large meander of the Kuroshio.

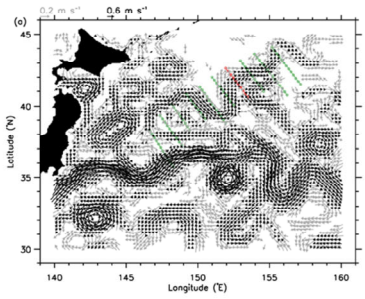


The stable Kuroshio meander is well represented in an operational ocean data assimilation and prediction system in Japan Met. Agency.

JMA/MRI has been developed high-resolution ocean data assimilation and prediction system for the Japan Area.
The system is named MOVE/MRI.COM-JPN. JMA starts to use the system in operation on this October 2020.
This system is composed of the 4DVAR analysis model with the 0.1-degree resolution, and the high-resolution model with the 2-km resolution. The state of the analysis model is reflected in the high-resolution model through incremental analysis updates (IAU).
The configuration and the quality of the system are introduced in Hirose et al. (2019).

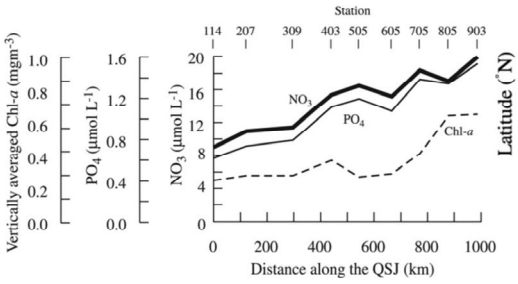
The top figure shows the sea surface height (SSH) snapshots south Japan reproduced in the high-resolution model, and the analyzed and forecasted time series of SSH are evaluated against tide-gauge observations in the bottom figure. The analyzed time-series (red lines) corresponds well with observation data (black lines). In addition, the figures indicates that SSH rose at Omaezaki and Miyakejima stations due to the large meandering of the Kuroshio Path. This SSH rise are well predicted by the forecast from 9 August (blue lines), although it is hardly predicted by the forecast from 30 July (green lines).

Elucidation of the quasi-stationary jet (Isoguchi Jet) in the western North Pacific

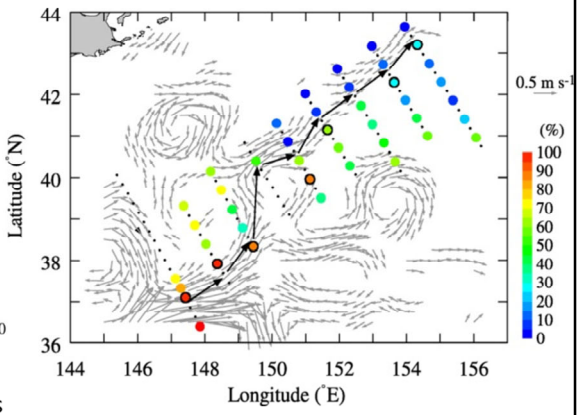


Locations of intensive hydrographic surveys along the Jason tracks in the Oyashio region, over geostrophic velocity field.

Wagawa et al. (2020, DSR-I)



Increasing nutrient-rich concentration is identified along the Isoguchi Jet.



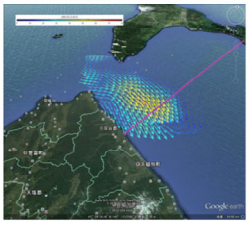
Kakehi et al. (2017, JGR)

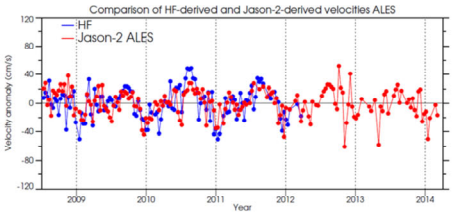
Intensive in situ survey in the Oyashio region have revealed presence of a quasi-stationary jet from the Kuroshio Extension to the subarctic region, and its enhancement of the biological production in a deeper mixed layer caused by transport of warmer water and entrainment of surrounding nutrient-rich subarctic water.

Isoguchi et al. (2016, JGR) found the quasi-stationary jet (Isoguchi Jet) in the western North Pacific that splits from the Kuroshio Extension Front and flows to the Subarctic Front across the Mixed Water Region.
Hydrographic intensive survey along the altimetry satellite tracks and mooring observations were conducted. The volume and heat transports by the Isoguchi Jet were estimated as 13.6-26.5 Sv and 0.0745–0.173 PW, respectively (Wagawa et al., 2020, DSR-I).

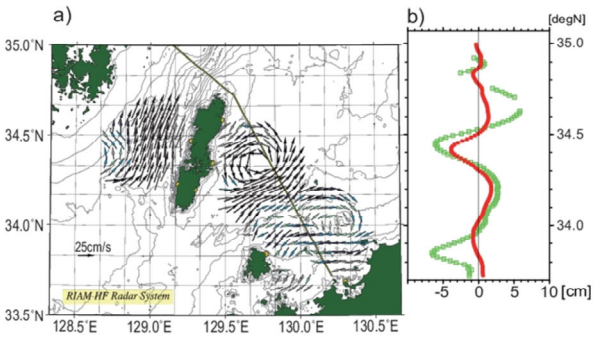
Along the Isoguchi Jet, nutrient concentration increased to the downstream by horizontal mixing with the Oyashio water (Kakehi et al., 2017, JGR). An ecological hot spot, where biological production is enhanced, is formed in the downstream of the Isoguchi Jet by providing warm and nutrient rich conditions.
Eddy-driven barotropic flows over bottom rises, their height is low (~500 m) compared with the full depth (~6000 m), deform the baloclinic Rossby wave propagation and maintain the Isoguchi Jet (Mitsudera et al, 2018, Nature Comm.).

Complementary observations in coastal areas





Comparison of the HF surface velocity and ALES geostrophic velocity in the Soya Strait



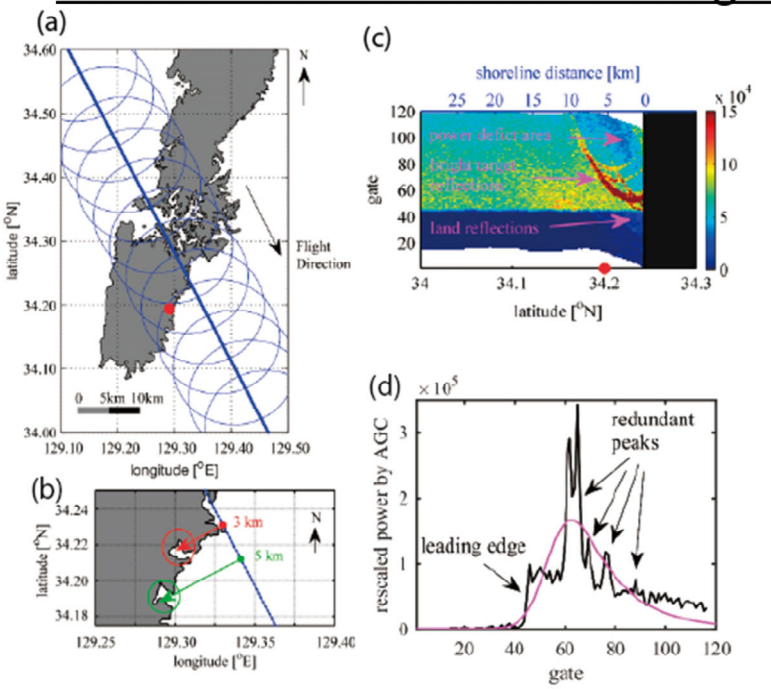
The HF radar current field in the Tsushima Strait (a) and SSHAs determined from ADCP and RTK GNSS along a ferry track (b) on 2011/11/7. (Ichikawa *et al.*, 2018)

In coastal areas, we have developed several complementary observation systems to overcome insufficient spatio-temporal resolutions of altimeters.

HF radars in strats are useful to measure surface currents. In Soya Straits, geostrophic current component normal to altimeter track determined from ALES retracker is well coincide with the HF radar observations.

In the Tsushima Strait between Japan and Korea, velocity field of the HF radar currents and SSHAs along a ferry track obtained from ADPC and RTK GNSS indicate presence of sub-mesoscale eddies (Ichikawa et al., 2018).

Jason-2 Coastal Retracker using radargrams



Jason-2 Pass 36 (with 1 Hz 10-km footprints) over the Tsushima Island (a); enlarged map of small bays (b).

The radargram along this track (c), and the waveform at 34.2N (d).

(Wang and Ichikawa, 2017)

In the Tsushima Strait, a new coastal retracker has been proposed that uses radargrams, or sequentially assembled adjacent waveforms.
Microwave echoes from calm water surface in small bays are stronger than ones from open ocean, so that they result in parabolic signature in the radargrams. In Wang and Ichikawa (2017), these parabolic signatures are successfully removed from the waveforms so that the ideal Brown model that assumes homogeneous reflection within a footprint can be applied in the retracking process.

The retracker successfully removes sigma0 blooms from calm water surface in isolated small bays.
The data-absent distance (distance of the closest valid data points to the land) is shrinked from 5 km to 3 km by this retracker.