Short-term Submesoscale Eddy Variations Observed in SWOT KaRIn SLA Fields

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EGU General Assembly 2024

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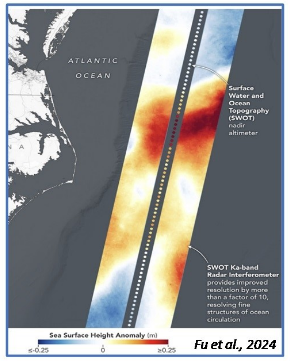
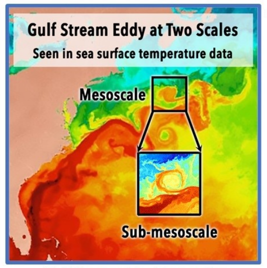
Introduction

- ***The Surface Water and Ocean Topography (SWOT) satellite mission***

The SWOT satellite mission has been successfully launched in December 2022. The SWOT swath measurements of Ka-band Radar Interferometer (KaRIn) provide global two-dimensional sea surface height fields with a ~5 km spatial resolution, which will revolutionize oceanography by detecting ocean features with 10 times better resolution than present interpolated products.



SWOT's KaRIn instrument captured its first data over the Gulf Stream on January 21, 2023



Gulf Stream eddy at two scales (Courtesy of NASA)

- ***Short-term submesoscale eddy***

Traditional altimeters have revealed the fundamental role of mesoscale eddies. However, an important part of the circulation is happening within structures less than 100 km across, and without capturing it a large part of the kinetic energy in the ocean is missed. SWOT is expected to unveil unprecedented details about sub-mesoscale eddies.

Data sources

- ***Altimeter data***

(1) SWOT L3 Sea Surface Height Data Products: https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/swot-l3-ocean-products.html

(2) Gridded L4 Sea Surface Heights (NRT): https://data.marine.copernicus.eu/product/SEALEVEL_GLO_PHY_L4_NRT_008_046/

- ***Mesoscale eddy identification and tracking data***

https://data.casearth.cn/en/sdo/detail/5fa668ad1f4600005e005ba3

- ***SST and Chlorophyll data***

https://oceandata.sci.gsfc.nasa.gov/

- ***BGC-Argo data***

https://biogeochemical-argo.org/data-access.php

Reference:

Fu,L.-L., Pavelsky,T., Cretaux,J.-F., Morrow,R., Farrar,J.T., Vaze,P., et al. (2024). The Surface Water and Ocean Topography Mission: A breakthrough in radar remote sensing of the ocean and land surface water. Geophysical Research Letters, 51, e2023GL107652

1. Consistency of SWOT-SLA fields and SST/Chlorophyll observations

(1) Verifying signals in KaRIn SLA fields using SST

- The SST contours are overlaid on the SWOT SLA field, revealing a strong concordance between the two.
- Numerous SST contours intersect at the convergence point of positive and negative SLA signals, which serves as the main site for generating oceanic fronts.

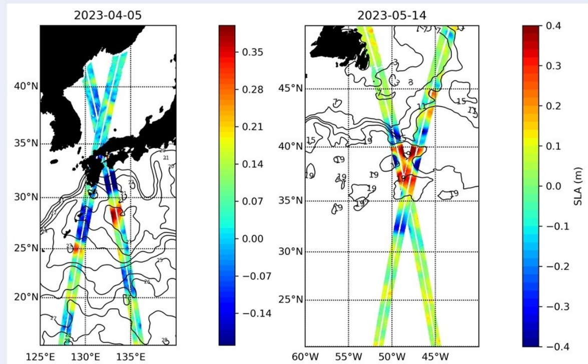


Fig. 1. SWOT SLA fields overlaid with SST contours in the Northwest Pacific Ocean and North Atlantic Ocean

(2) Fast-moving submesoscale eddy and corresponding chlorophyll maps

- The generation and decay processes of a submesoscale cyclonic eddy are evident in the KaRIn-derived SLA images.
- A chlorophyll ring is observed at the same location where the eddy appeared. Then, the eddy moved westward at a fast speed and disappeared after 18th April.

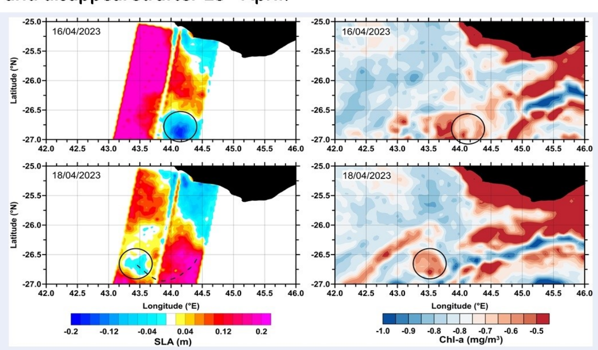


Fig. 2. An example of a short-term cyclonic eddy observed south of Madagascar in KaRIn SLA fields (left) and the corresponding chlorophyll maps (right)

2. Comparison between SWOT-SLA and merged SLA fields for eddy observation

(1) KaRIn SLA-based eddy early detection

- KaRIn's one-day repeat SLA fields can resolve eddy signals several days earlier compared to traditional merged SLA fields, and can tackle the problem of "ghost eddy" during eddy tracking process.

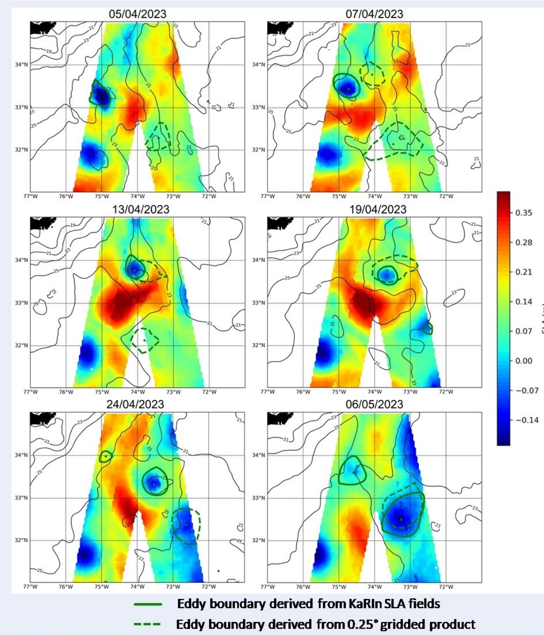


Fig. 3. Monitoring of a cyclonic eddy in the North Atlantic using KaRIn SLA fields, contrasted with eddy boundaries inferred from gridded product (shown by dashed lines)

(2) Observation of eddy merging and splitting

- A more detailed observation of the eddy splitting and merging process is available in the KaRIn SLA field, confirming its superiority in resolving complex and transient eddy-eddy interactions.

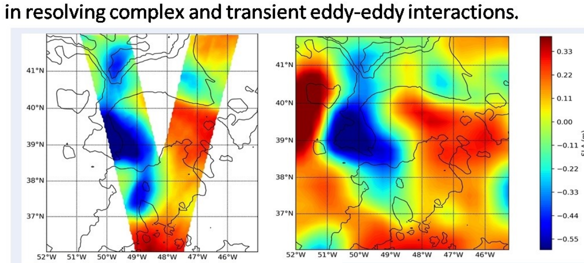


Fig. 4. An example of cyclonic eddy merging process observed in KaRIn (left) and multi-satellite interpolated (right) SLA fields on 12th April, 2023.

3. Vertical structure examination of SWOT-observed eddies combined with BGC-Argo

- A BGC-Argo float was trapped by an anticyclonic eddy for nearly two months in the Northwest Pacific, revealing that the vertical temperature anomaly of the eddy had a double-core structure during its generation phase.

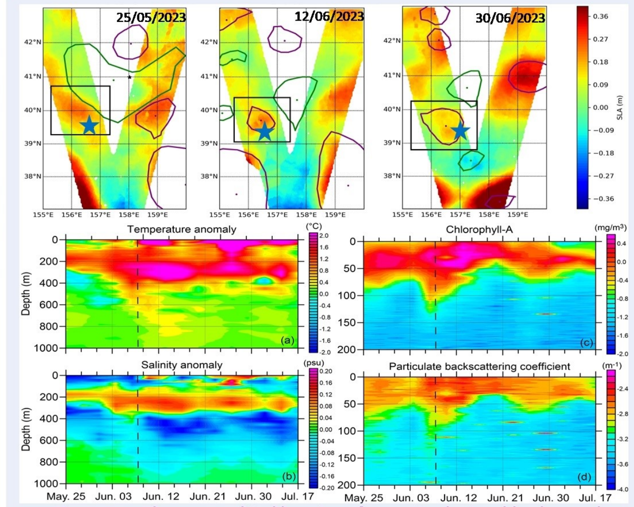


Fig. 5. Top: The geographical location of an anticyclonic eddy observed by SWOT (black boxes) and the trapped BGC-Argo (blue stars); Bottom: The vertical structure of an anticyclonic eddy in the Northwest Pacific Ocean during 25th May to 17th July.

Conclusions and future work

Conclusions:

- The recovery of submesoscale features by one-day repeat KaRIn SLA fields is much better than multi-satellite ten-day composites.
- Several representative cases highlight SWOT's capacity to continuously track submesoscale signals over multiple days.
- These features show consistent signals in temperature and/or ocean colour fields, further demonstrating their authenticity.

Future work:

- Submesoscale eddy detection and tracking in the global ocean.
- Spatial-temporal variability of submesoscale eddies and their dynamical characteristics.
- Interactions and energy cascading on meso- and submeso-scale eddies.

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This work was supported by the National Natural Science Foundation of China (No. 42030406).