Fewer Errors, Sharper Dynamics: Sea Level Mesoscale Mapping with SWOT KaRIn

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Ref paper

Data access

Introduction & Objectives

In 2024, new gridded sea surface height (SSH) products became available by combining traditional satellite altimetry with SWOT data to capture finer-scale ocean features. Adding KaRIn measurements reduced mapping errors in regions with strong ocean variability, though challenges remained in areas influenced by rainfall, storms, and internal tides. In this study, we introduce an updated product with improved handling of SWOT kaRin data, resulting in more accurate maps of ocean surface height.

Better Extraction of Sea-Level Signals from KaRIn

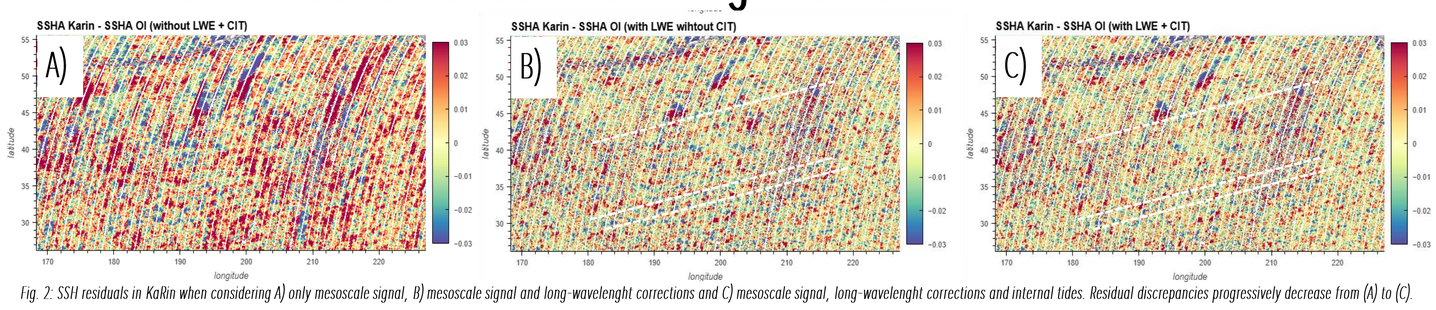

Fig. 2: SSH residuals in KaRin when considering A) only mesoscale signal, B) mesoscale signal and long-wavelenght corrections and C) mesoscale signal, long-wavelenght corrections and internal tides. Residual discrepancies progressively decrease from (A) to (C).

Karin Level-3 data may contain atmospheric or oceanic variability that biases mesoscale mapping, particularly long-wavelength signals or internal waves that can be misinterpreted. Specific strategies are needed to isolate or correct these effects. In MIOST, applying long-wavelength corrections and coherent internal tide modes improves consistency (Fig.2 B & C) and partly filters these variabilities from the SSH mesoscale maps, though some submesoscale and waves residuals still remain (see Fig.2 C).

Methodology Overview & Data

We use the DUACS processing system (Fig. 1) together with the MIOST mapping algorithm (Ubelmann et al., 2022) to generate the Level-4 product. The input data combine Level-3 nadir altimeter products distributed by the Copernicus Marine with the Level-3 KaRIn dataset (v2.0.1) available on AVISO+.

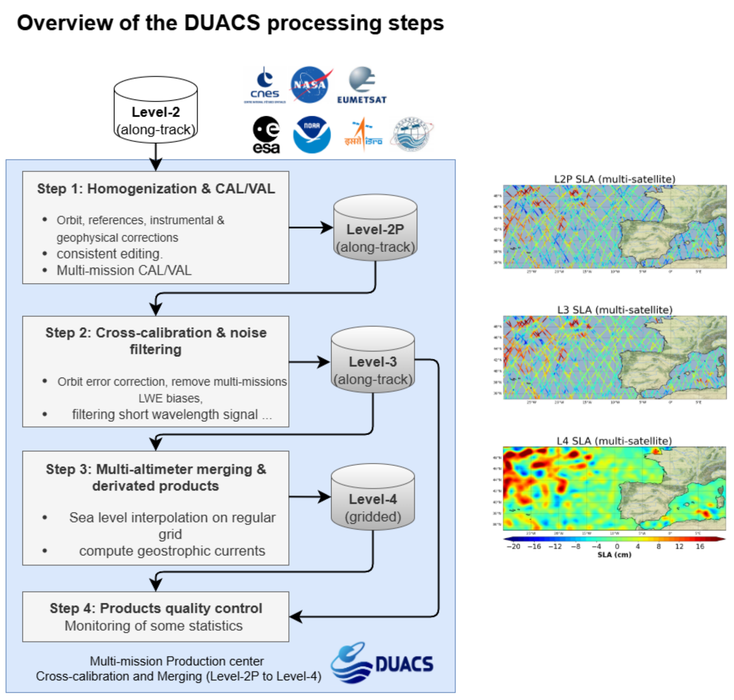

Fig. 1: Overview of the DUACS processing system

In this release, KaRIn noise levels were updated. Earlier estimates from OSSEs based on the GLORYS12 model likely underestimated noise, as the simulation omitted ocean processes such as internal tides. To better address residual coherent internal tides (CIT), we also tested adding a CIT mode in MIOST with the aim to absorb remaining internal tide signals.

References:
Anadon et al.: Level 4 global topography mapping including SWOT data with neural netwok, SWOT Science Team Meeting, 2025
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Bellemin-Laponnaz et al.: Variational method for dynamical reconstruction and separation of Balanced Motions and Internal Tide from SWOT, SWOT Science Team Meeting, 2025
Le Guillou et al.: Mapping SSH with VarDyn: Combining Physics and Variational Techniques for SWOT Data, SWOT Science Team Meeting, 2025
Ubelmann et al.: Simultaneous estimation of ocean mesoscale and coherent internal tide sea surface height signatures from the global altimetry record, Ocean Sci., 18, 469–481, https://doi.org/10.5194/os-18-469-2022, 2022.

Improved Accuracy in the Latest Release

The updated mapping parameters in the new MIOST product version (v2.0.1) reduce mapping errors compared with the previous version (v1.0), as demonstrated by independent along-track versus map comparisons (Fig. 3). For the new Level-4 products, the integration of KaRin data leads to notable performance gains: mapping errors are reduced by up to 11% in high-variability regions and 7% in low-variability regions. Integrating Karin also sharpens the effective resolution by 10–20 km (Fig. 4), while geostrophic current estimates improve by an average of 3–5%, with local improvements reaching 10% (not shown).

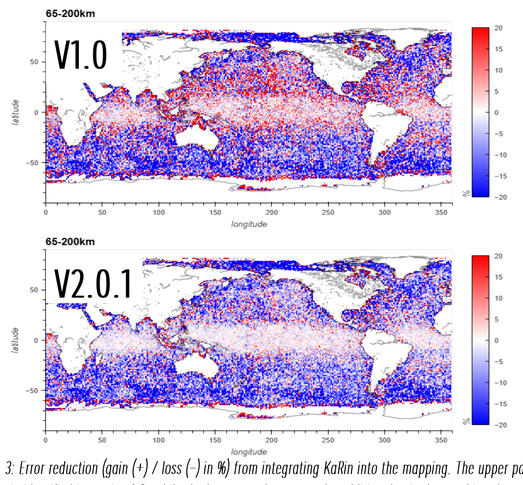

Fig. 3: Error reduction (gain (+) / loss (–) in %) from integrating KaRin into the mapping. The upper panel shows the gain identified in version 1.0, while the lower panel presents the additional gain detected in release v2.0.1. The figure highlights improved handling of KaRin data in the intertropical region and the North Pacific basin..

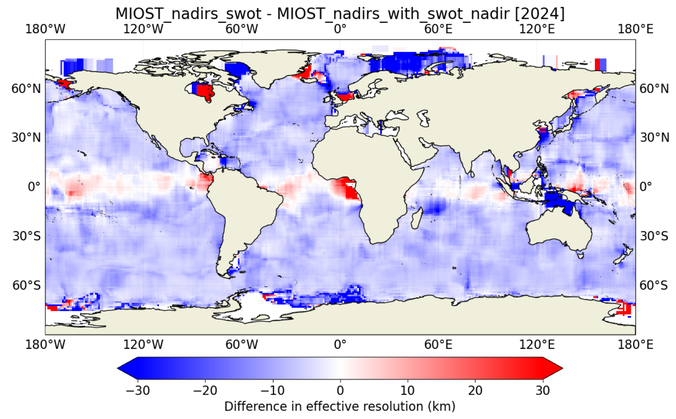

Fig. 4: Gain in effective resolution (in km) from integrating KaRin into the mapping. Blue means finer resolution with Karin.

Conclusions & Perspectives

A new version of Level-4 gridded sea level product is now available on AVISO+, combining nadir altimeter data with SWOT KaRin Level-3 data. This release extends the time coverage (March 2023 – June 2025) and benefits from improved mapping parameters compared to the previous version, yielding more accurate representations of sea surface height and currents. By incorporating KaRin data, mapping resolution improves by 5–20%, enabling the detection of ocean features at scales 10–20 km finer than before.

In November 2025, an experimental Near-Real-Time Level-4 product integrating KaRin will also be introduced into the Copernicus Marine catalogue, offering a comparable level of improvement over the current operational product.

At the same time, data-driven and dynamic mapping techniques—initially developed for the North Atlantic—are being scaled to global applications. These approaches hold strong potential for generating enriched global SSH datasets. For further details, see the works of Anadon et al. (2025), Bellemin-Laponnaz et al. (2025), and Le Guillou et al. (2025).

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DUACS

Advances in Sea Level Mapping with SWOT KaRIn Data

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