SWOT – CTOH studies for fine-scale ocean dynamics

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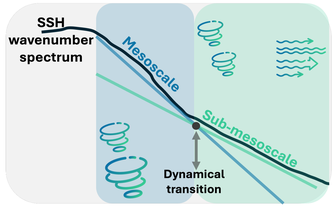
The **Centre for Topography of the Oceans and Hydrosphere** (CTOH) is a French National Observation Service at the **LEGOS** CNRS Laboratory in Toulouse, created in 1989 & dedicated to satellite altimetry studies.

Transition from balanced to unbalanced motions

SSH spectrum results from the relative dominance of several processes taking place at different scales in space and time.

- At the mesoscale wavelength range, SSH variability is dominated by geostrophic turbulence, including mesoscale eddies.
- At sub-mesoscales, SSH variability can be influenced by smaller eddies and by phase-locked and non phase-locked internal gravity wave continuum.

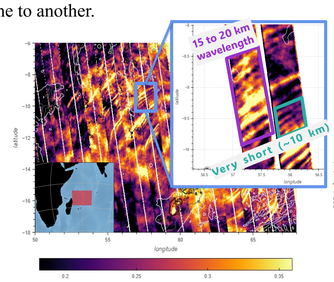
SSH wavenumber spectra often displays two slopes, & we can statistically compute a spatial scale that characterizes the transition from one dynamical regime to another.



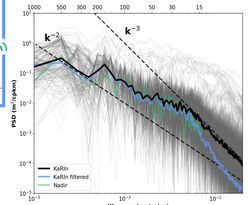
2D KaRIn images reveal the complexity of the SSH variability in the **Mascarene Basin**

KaRIn observations show tidal peaks at 200 and 300 km wavelength. A power-law energy decrease occurs at wavelengths shorter than 100 km.

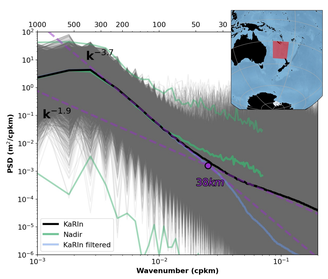
Nadir observations capture the tidal peaks but the sub-mesoscale signal variations are masked by the noise levels.

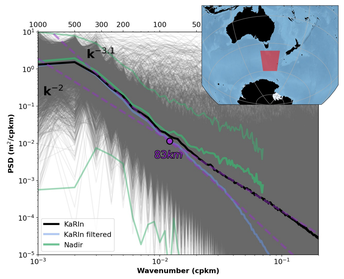


SSHa (m) from KaRIn during the SWOT science phase over the Mascarene Basin (21 days). The SSHa variability is dominated by internal tides from a few km to several tens of km wavelength. Zoom insert corresponds to track 94, cycle 3.



KaRIn SSHa spectra from SWOT over the Mascarene Basin. Data corresponds to passes 94 and 122 which are separated by less than a day. POS5 Nadir observations and KaRIn filtered product are also shown.





SWOT KaRIn transition scales : two different dynamical regimes

Transition occurs at 38 km in ACC, well below the nadir noise level, but at 83 km in the subtropics

*SSH spectra over the two regions delimited in the map inserts, representing two distinct variability regimes. Average spectra for three available products are plotted: KaRIn calibrated data (**KaRIn**), KaRIn calibrated and filtered (**KaRIn filtered**), and POS5 Nadir data (**Nadir**). The fitted spectral slopes over the meso and sub-mesoscale wavelength range for KaRIn are illustrated. The intercept wavelength of the observed spectral slopes is also plotted. Distribution of the individual spectra of KaRIn (gray lines) and Nadir (green limits) are also included. Time period spans 5 months, from August to December 2023.*

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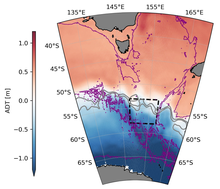
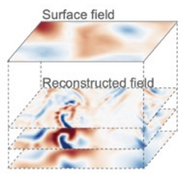
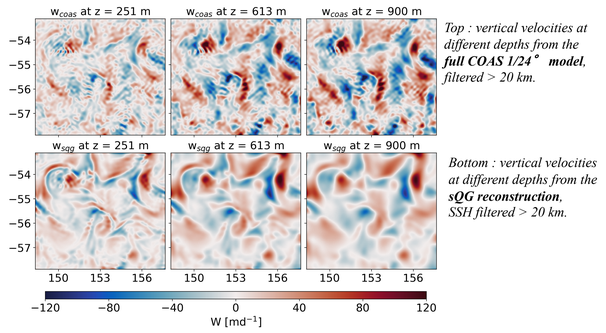
Vertical reconstruction from SWOT SSH

We use an effective Surface Quasi-Geostrophic (eSQG) methodology to reconstruct vertical velocity and heat fluxes in the Southern Ocean from altimetric SSH data only. Downstream of a major ridge South of Tasmania, we can reconstruct structures with a minimum diameter of 30km at 500m, gradually degrading to 70 km at 1000 m. w amplitude is retrieved with an accuracy of 90% for the first 500 m, and 70% on average at the bottom.
The amplitude underestimation is partly due to the *w* developing from the interaction with bottom topography, not captured by the SQG.



Step 1 : Theoretical development of SQG vertical projection : (u,v,w) currents at depth from 2D SSH

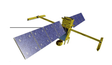




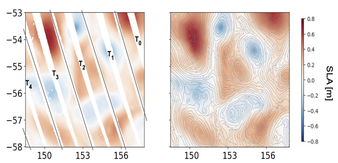
*Top : vertical velocities at different depths from the **full COAS 1/24° model**, filtered > 20 km.*

*Bottom : vertical velocities at different depths from the **sQG reconstruction**, SSH filtered > 20 km.*

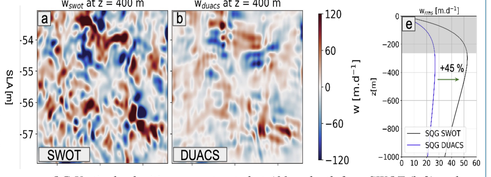
Step 2 : Constructing local 2D SSH fields from SWOT



Step 3 : Vertical *w* reconstruction from SWOT data



At 55° S, 5 days of closely spaced ascending tracks are followed by 5 days of descending tracks, giving four 500 x 500 km snapshots every 21 days



sQG Vertical velocities reconstructed at 400 m depth from SWOT (left) and DUACS multi-mission maps (right), filtered > 20 km. SWOT has 45% more rms variability compared to DUACS

Work is underway on reconstructions using these 5-day composites of SWOT KaRin data, and multi-mission gridded nadir & SWOT reconstructed SSH fields (MIOST, 4DVAR-QG). These are being validated against in-situ data from ADAC ACC_SMST

E Carli, L Siegelman, R Morrow, et al. Surface Quasi Geostrophic Reconstruction of Vertical Velocities and Vertical Heat Fluxes in the Southern Ocean: Perspectives for SWOT. *ESS Open Archive* . April 22, 2024. **DOI:** 10.22541/essoar.171379572.28719963/v1

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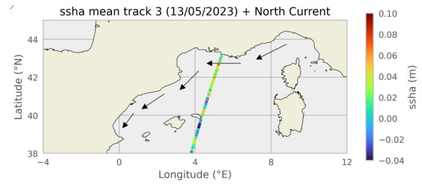
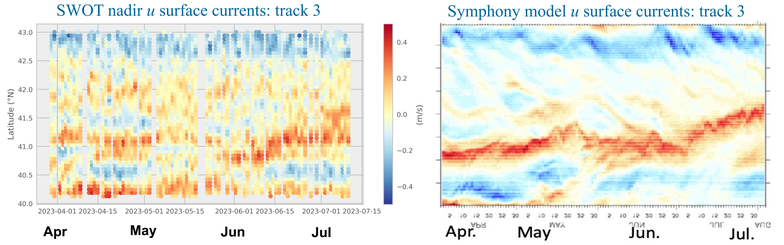
SWOT nadir coastal currents in the Mediterranean Sea

We analysed SWOT daily nadir data to observe coastal currents in the Northern Current (NC). This coastal current is formed in the Ligurian Sea and flows cyclonically along the continental slope of Italy, France and then Spain (Carret et al., 2019). We used ADT data along the track 3, which crosses the Northern Current.



SWOT daily nadir cross-track geostrophic currents, *u*, are compared to the **Symphony 2 km regional model,** projected onto the same track 3. We clearly observe the westward NC near the French coast (43° N) , and the eastward Balearic Front (BF) near 41° S. There is an excellent fit in current variability from SWOT and the model. Both the SWOT nadir and model highlight the meandering series of branching return currents

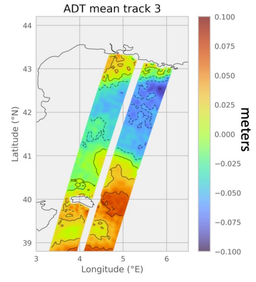
SWOT nadir *u* surface currents: track 3 — Symphony model *u* surface currents: track 3

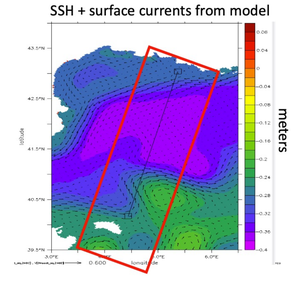


SWOT KaRIn's 2D observations help to explain the branch bifurcations and meanders. SWOT KaRIn and Symphony still show excellent 2D agreement. We discovered an eddy on the track 3 north of Minorca, deviating the trajectory of the BF.

SWOT KaRIn mean ADT track 3 — Symphony SSH and surface current speed

Due to the high temporal resolution of the SWOT Fast Sampling Phase, we were able to:
- Observe the NC daily variations, in intensity and position.
- Recognise the Balearic Front north of Minorca, which was impossible to detect previously with one cycle every ten days.





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CTOH and SWOT training and Data Access

For **SWOT Ocean Data Access**, the CTOH works in close relation with the CNES and CLS User support group, to aide with early access to the SWOT data, calculations with SWOT data on the CNES HPC, providing Juypter notebooks in Python with example scripts, accessing multiple satellite data sets collocated with SWOT, and training for LEGOS users as beta-testers for the new data access in place for national and international users.

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