Wave Spectra from SWOT: Overview of the New Level 3 Wind Wave Product

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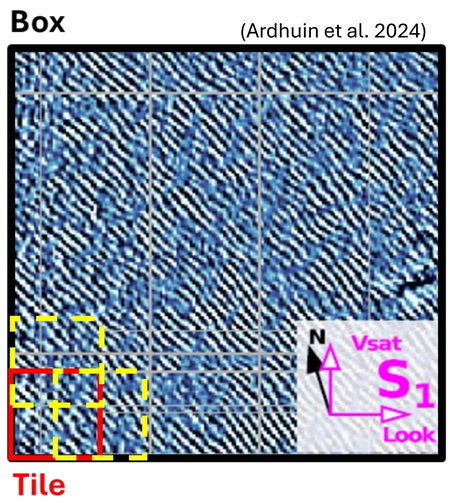
1: CLS, 2: LOPS, 3: CNES, 4: CELAD

KEY POINTS

- The SWOT KaRIn Level-3 Wind Wave product (**L3_LR_WIND_WAVE**) is an innovative product derived from the Unsmoothed L3_LR_SSH product, based on the algorithm in **Ardhuin et al. (2024)**
- It takes advantage of the capability of the KaRIn Low Rate (LR) heights of **resolving waves greater than ~500 m in wavelength** with a very high precision (few centimeters)
- The main geophysical quantity contained in this product is the **wave spectrum** and derived parameters, **estimated from LR heights**, for wavelengths greater than ~500 m
- **~1 year of data is available at AVISO** website

WAVE SPECTRUM ESTIMATION

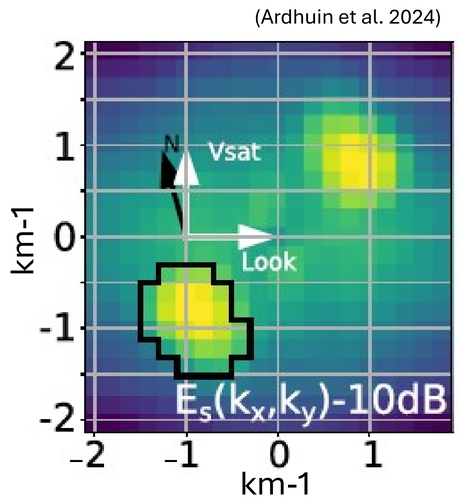


1) A **"box" of SSHA** is divided in overlapping tiles: **the spectrum is estimated for each SSHA tile, then averaged together** (Welch approach)
2) the "box" spectrum is **corrected by an approximation of the KaRIn transfer function G**, which accounts mainly for the azimuth point target response (PTR) and the on-board filters that reduce the sampling to 250 m

SWELL DETECTION AND WAVE PARAMETERS

3) For each SSHA box, the **closest WW3 wave spectrum** in time and space is selected
4) The **swell mask** is computed on WW3 spectrum, by applying a simple peak detection and binary dilation algorithm
5) The wave parameters **significant wave height (H18), wavelength (L18) and direction (ϕ18)** are obtained for the swell section of the SWOT wave spectrum

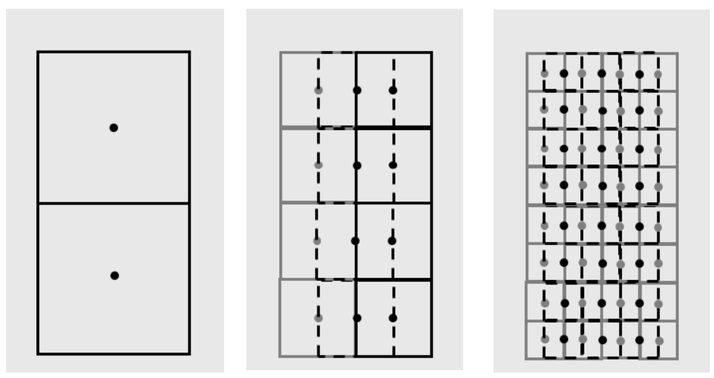
(Ardhuin et al. 2024)



SWATH SAMPLING

3 possible sampling schemes
(Only one swath presented here for simplicity)

40 km boxes **20 km boxes** **10 km boxes**



PRODUCTS

L3_LR_WIND_WAVE products are organized in **groups**

Each group contains the estimated wave quantities for the **respective box/tile configuration**

Light product

- One spectral configuration: 40km box / 5 km tile
- SWOT wave spectrum, in polar and cartesian coords
- Swell mask
- Integrated parameters
- Model integrated parameters >18 s (~500 m)

Extended product

- Contents of light product
- Additional box/tile confs
- WW3 spectrum
- Original model parameters
- Approximate KaRIn transfert functions
- Additional KaRIn information
- SSHA pixels indices

WHAT'S NEXT

- Provide multiple swell partitions with separate integrated parameters
- Include SWH 2D from L2 products after beta calibration
- Reprocess the full SWOT period
- And derived applications, studies and validation activities to come!

SOME APPLICATIONS

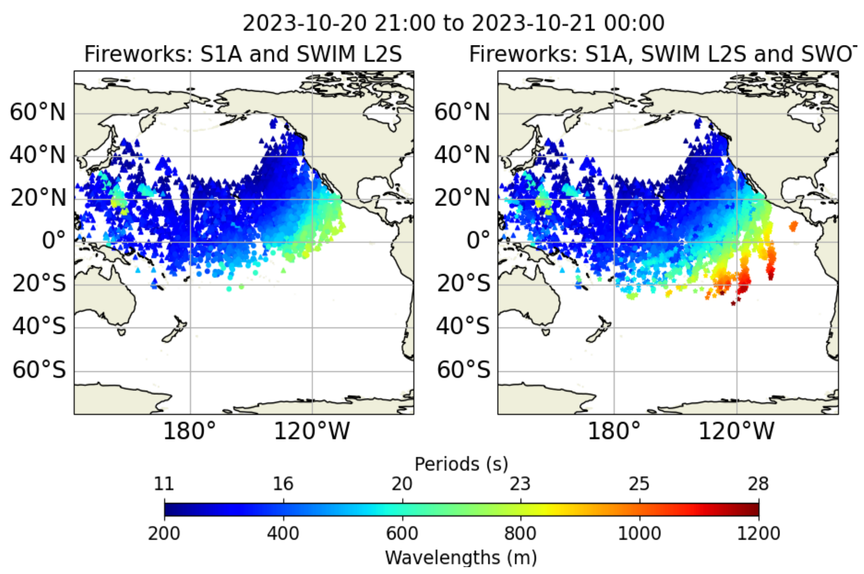
THIS CONFERENCE

Fabrice Ardhuin's presentation on *Sizing the largest ocean waves using the SWOT mission*

Taina Postec's poster on *Wave Observations across Tuamotu Archipelago from Wide Swath Radar Altimetry (SWOT)*

PREDICTING LONG WAVELENGTHS

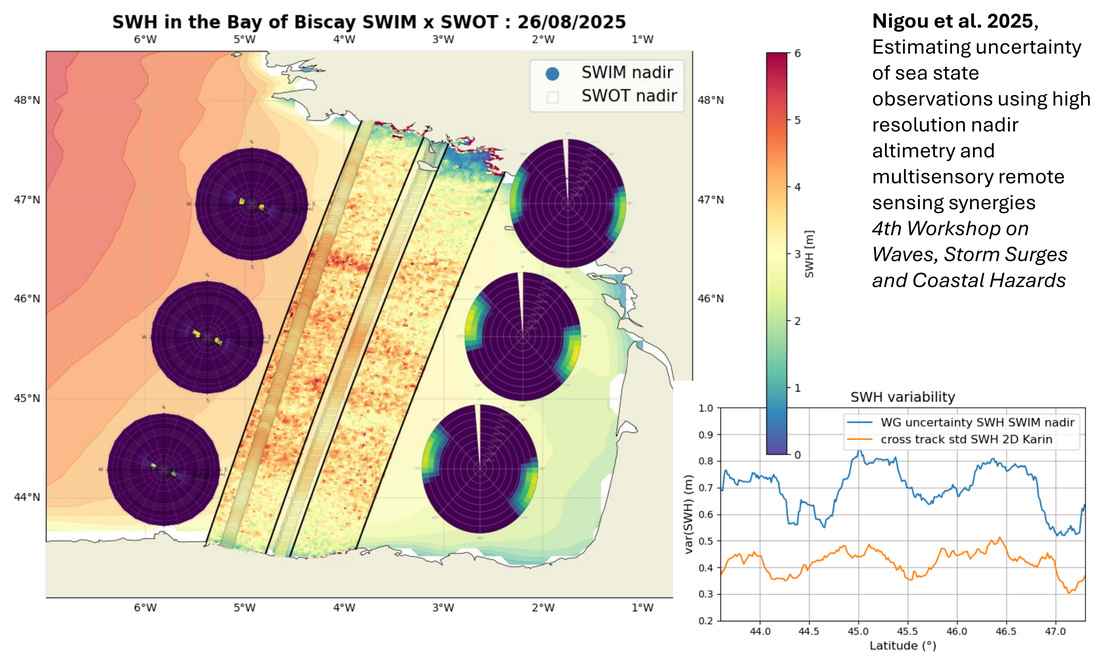
- The Copernicus L4 Fireworks product provides predictions of wave parameters as response to storm events, based on satellite observations
- When L3 LR WIND WAVE is included, longuer wavelengths can be predicted



De Carlo et al. 2025, Combining directional swell measurements from satellites using Fireworks to enhance short-term swell forecasting: a use case , *4th Workshop on Waves, Storm Surges and Coastal Hazards*

ASSESSING WAVE GROUPS

- Wave groups affect SWH estimation from nadir altimeters and KaRIn
- L3 LR WIND WAVE, in combination with other sensors, can help predicting them



SWH in the Bay of Biscay SWIM x SWOT : 26/08/2025

Nigou et al. 2025, Estimating uncertainty of sea state observations using high resolution nadir altimetry and multisensory remote sensing synergies *4th Workshop on Waves, Storm Surges and Coastal Hazards*

REFERENCES

AVISO/DUACS., 2025. SWOT L3 KaRIn Wind Wave (v2.0) [Data set].CNES. https://doi.org/10.24400/527896/a01-2024.016, https://doi.org/10.24400/527896/a01-2024.017

Ardhuin, F., B. Molero, A. Bohé, F. Nouguier, F. Collard, I. Houghton, A. Hay, and B. Legresy (2024). Phase-Resolved swells across ocean basins in SWOT altimetry data: Revealing centimeter-scale wave heights including coastal reflection. In Geophys. Res. Lett. 51, e2024GL109658. DOI: 10.129/2024GL109658.

Ardhuin, F., Postec, T., Accensi, M., Piolle, J. F., Dodet, G., Passaro, M., De Carlo, M., Husson, R., Guitton, G. & Collard, F. (2025). Sizing the largest ocean waves using the SWOT mission. *Proceedings of the National Academy of Sciences*, *122*(38), e2513381122. https://doi.org/10.1073/pnas.2513381122