Besoins pour la validation des missions existantes (Sentinel–1 / SWIM / SWOT) et futures (Harmony, Sentinel-3 Next Gen)

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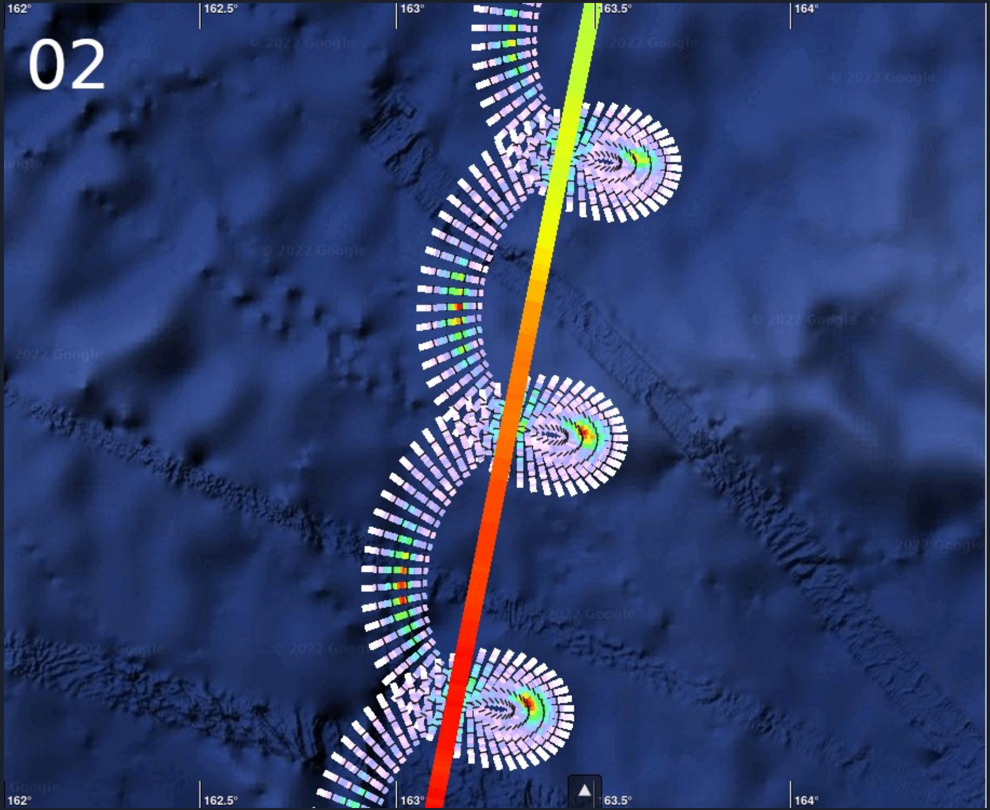
Journée sur les états de mer, Dec 11, 2023

SWIM instrument franco-chinois lancé en Oct 2018

- SWIM (Surface Wave Investigation and Monitoring) measures the ocean surface wave related modulations in Ku band using a rotating instrument
- In nominal macrocycle mode, it provides a directional 1D wave spectra
  - every ~7 degrees
  - for each of its 5 beams at 2, 4, 6, 8, and 10° incidence angle
  - resulting in a very special cycloid ground footprint geometry.



Example of 1D raw fluctuation spectra projected over range footprint
With nadir Hs

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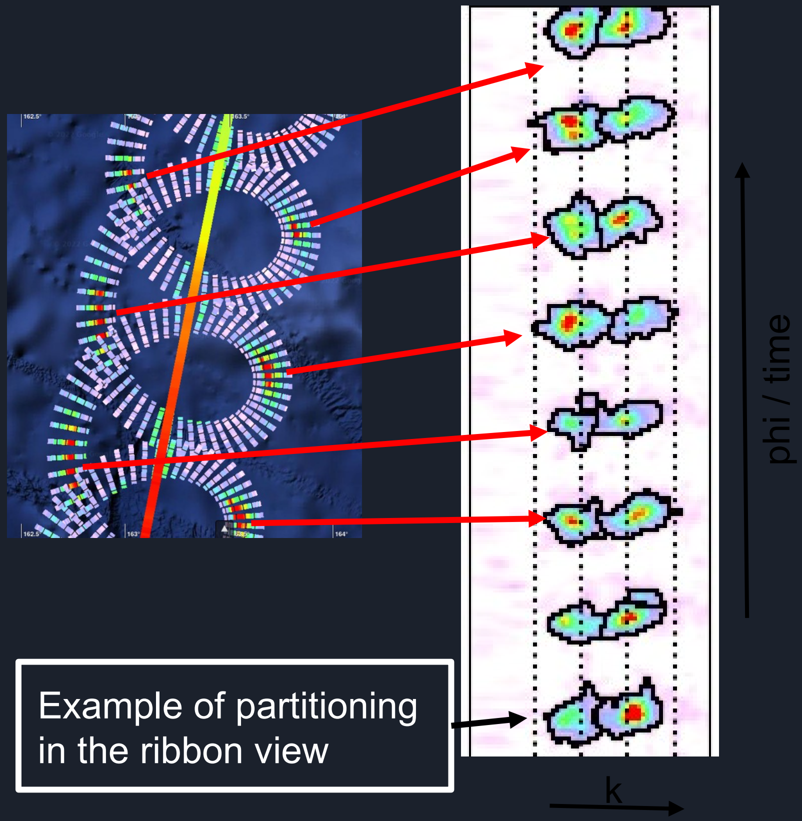
SWIM L2S product overview (IWWOC Ifremer processing center)

- L2S product is a L2 like product with the following features:
  - wave spectra partitioning along the continuous cycloid (“ribbon view”)
  - speckle correction based on a learned look-up table
  - empirical MTF (work in progress shown by Gilles and Manuel)
  - all beams including 2 et 4 degrees beams (no onboard range migration)
  - includes variables of interest : sigma0, raw spectra, nadir variables, ancillary data
- First public release in early 2022 (version v1.0):
  - HTTP access: https://data-cersat.ifremer.fr/projects/iwwoc/swi_l2s/
  - FTP access: ftp://ftp.ifremer.fr/ifremer/cersat/projects/iwwoc/swi_l2s/



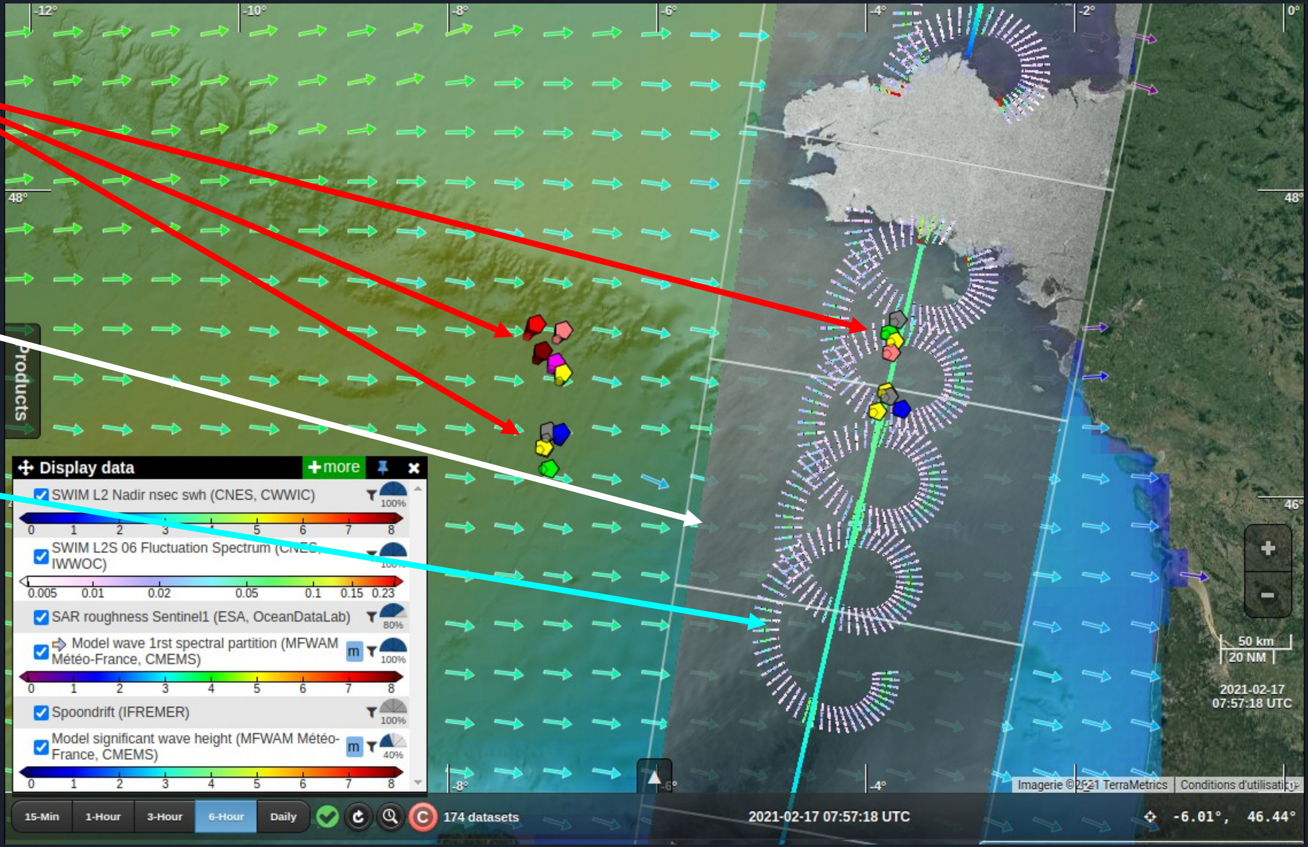
Example of partitioning in the ribbon view

Dir. wave spectra comparisons : SUMOS validation campaign

Spotter directional wave drifters

Sentinel-1 A/B SAR

CFOSAT SWIM



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Directional wave spectra observations

SWIM L2S spectra are derived after a wind dependant speckle correction (see Nouguier & al. presentation) and an empirical MTF based on massive comparison between observed and modeled spectra.

SAR 2D spectra are retrieved after a quasi non-linear inversion of RAR and SAR MTF (following Sentinel-1 L2 OSW retrieval scheme)

In situ SPOTTER 2D wave spectra are reconstructed from spectral moments a1,b1,a2,b2 using the MEM method (e.g. Lygre and Krogstad, 1986, specifically their equation 13). These are considered as the reference spectra.

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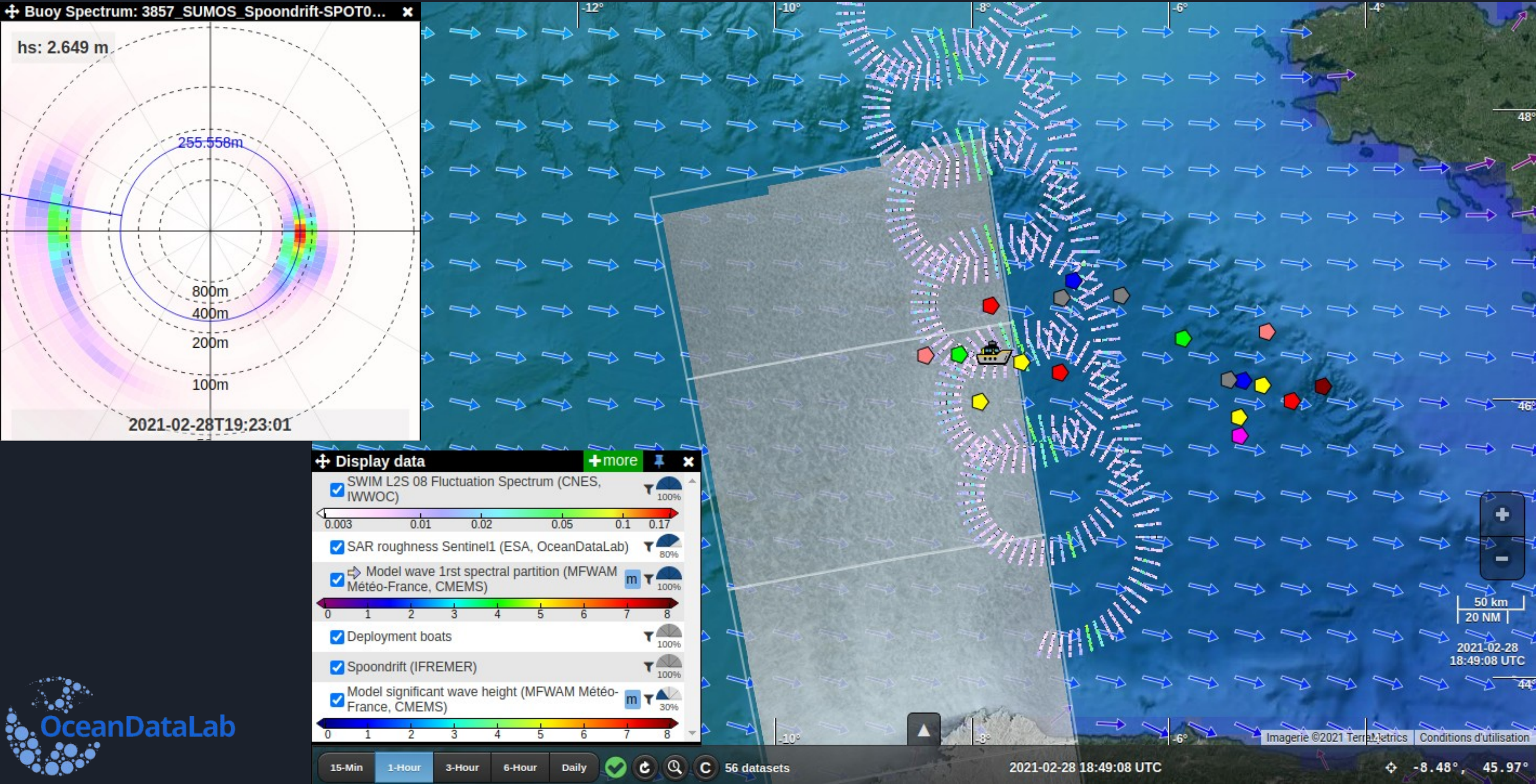
28 Feb 2021 7pm : Opposing Wind Sea and Swell



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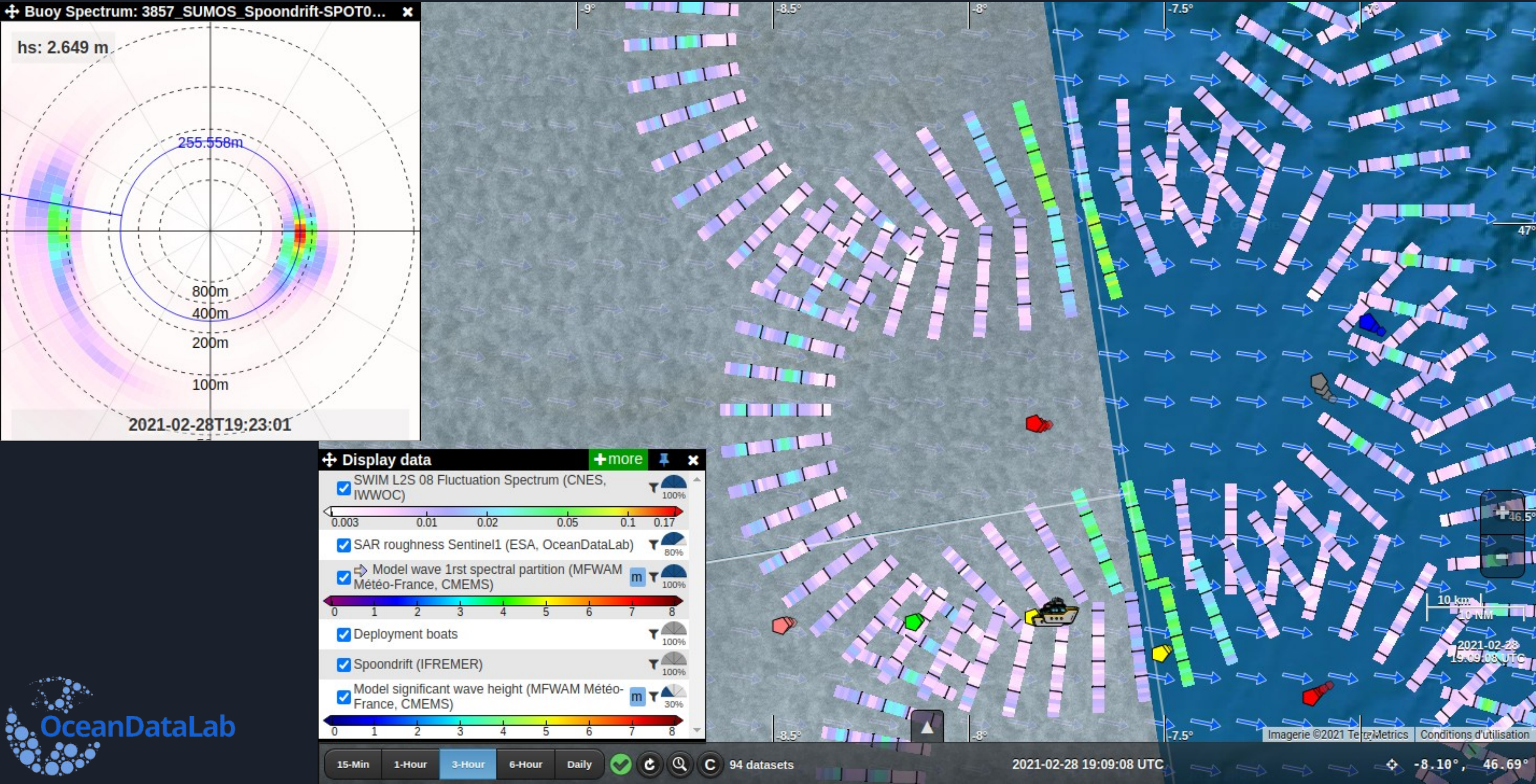
28 Feb 2021 7pm : Opposing Wind Sea and Swell



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28 Feb 2021 7pm : Opposing Wind Sea and Swell

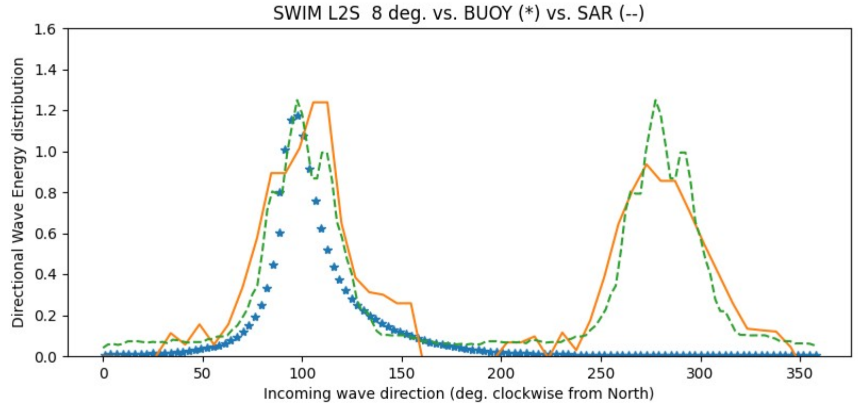
SWIM 8° beam

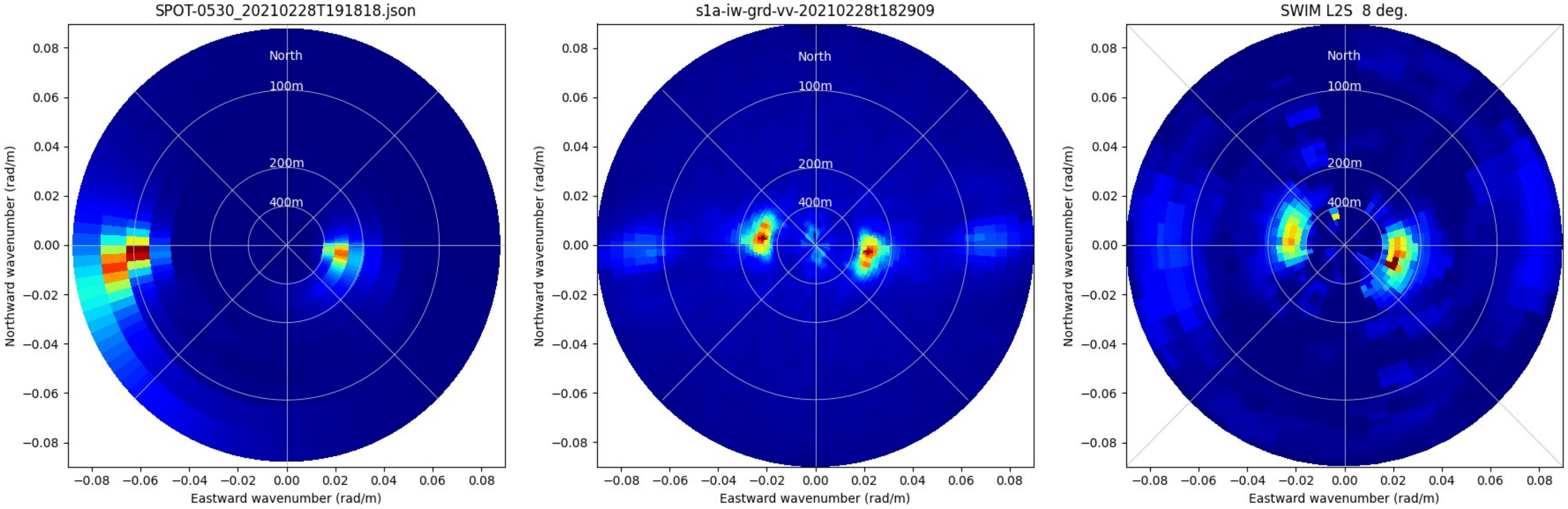
Directional spread : swell 285m

BUOY : 22°

SAR : 40°

SWIM : 44°





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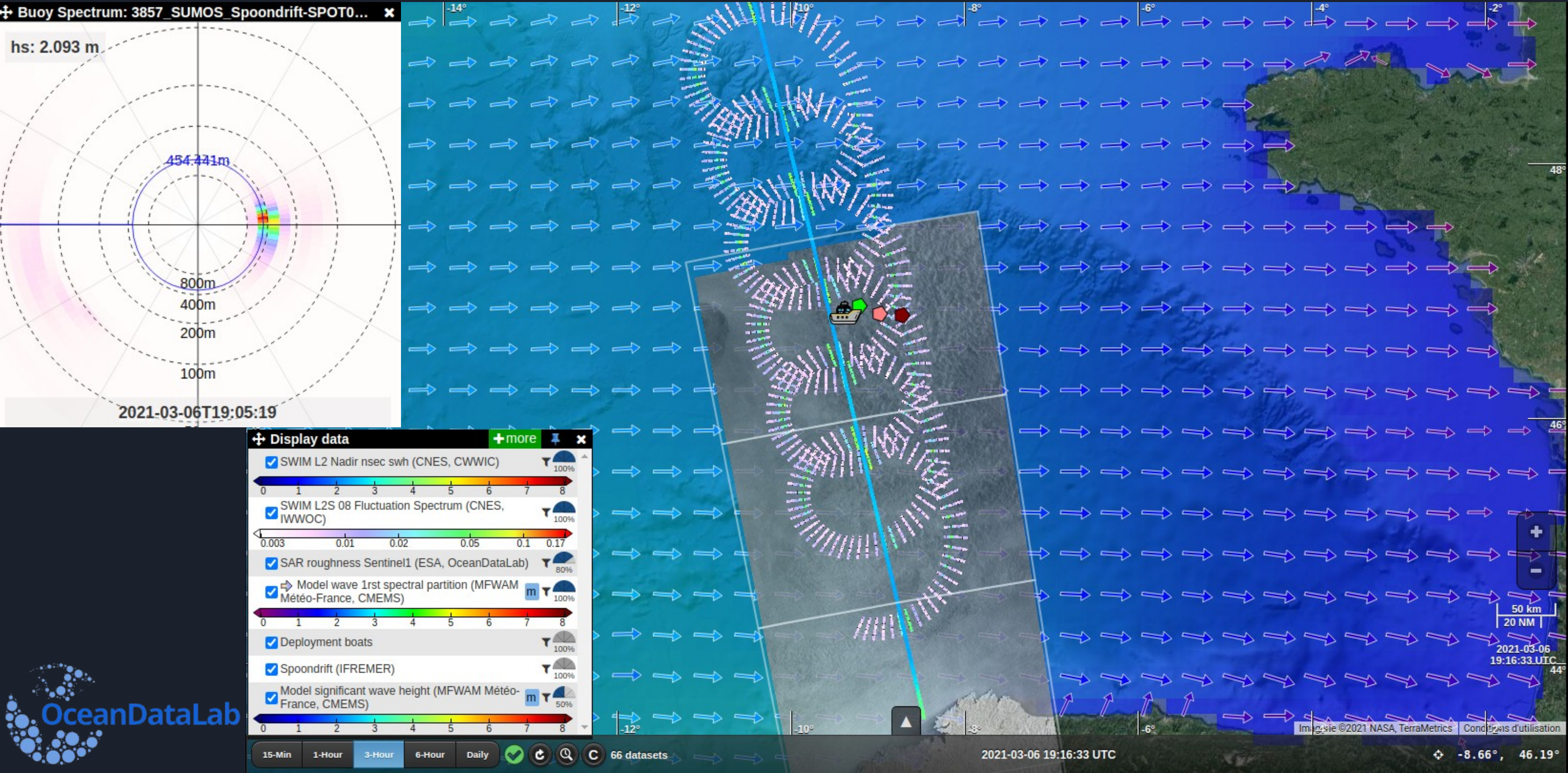
March 6 2021 7pm : Long western Swell



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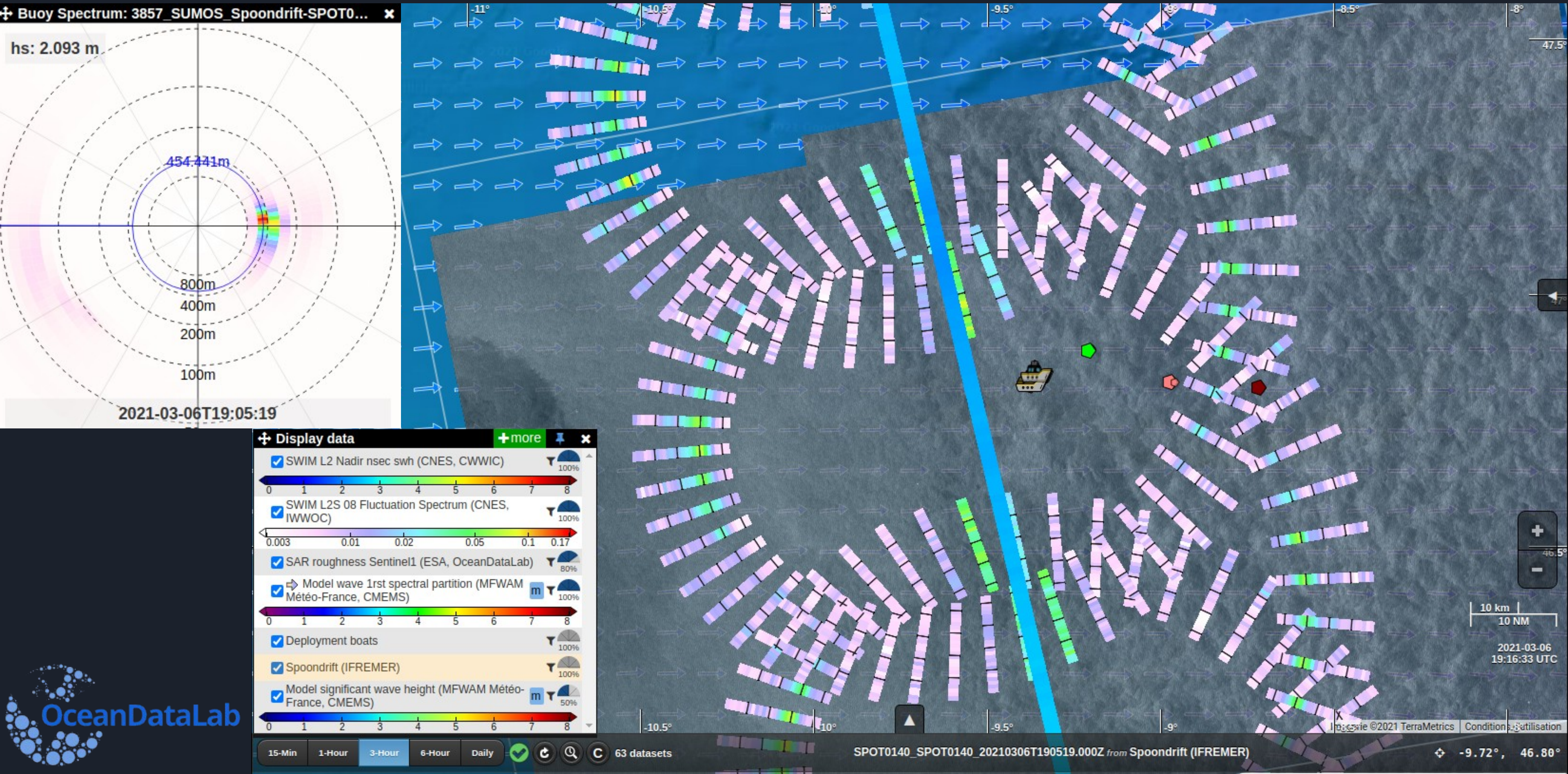
March 6 2021 7pm : Long western Swell



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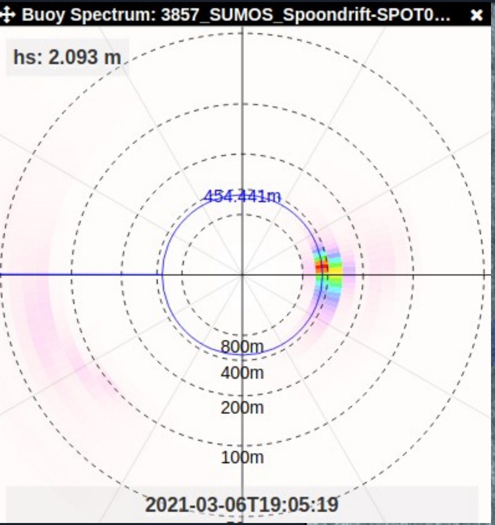
March 6 2021 7pm : Long western Swell



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March 6 2021 7pm : Long western Swell

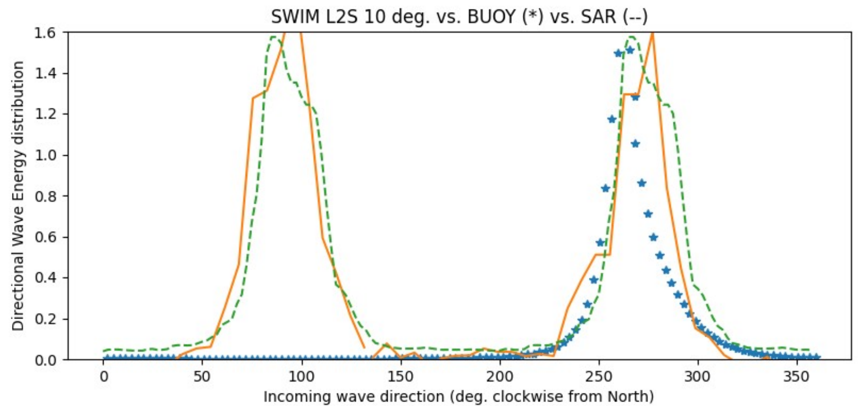
SWIM 10° beam

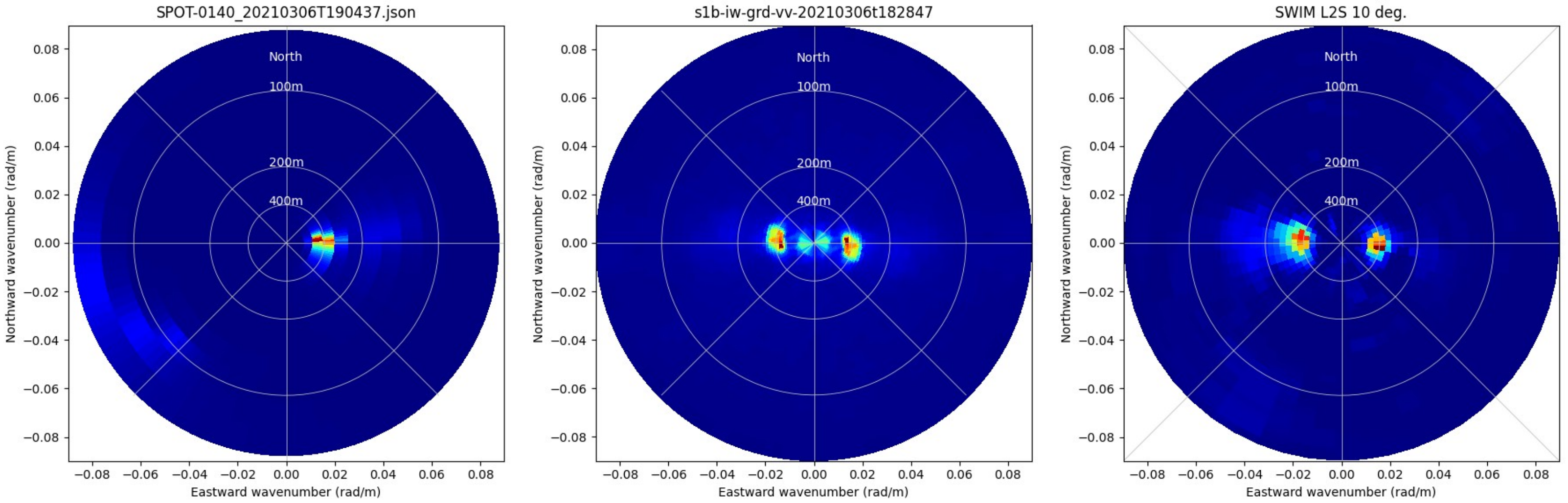
Directional spread : swell 440m

BUOY : 20°

SAR : 34°

SWIM : 30°





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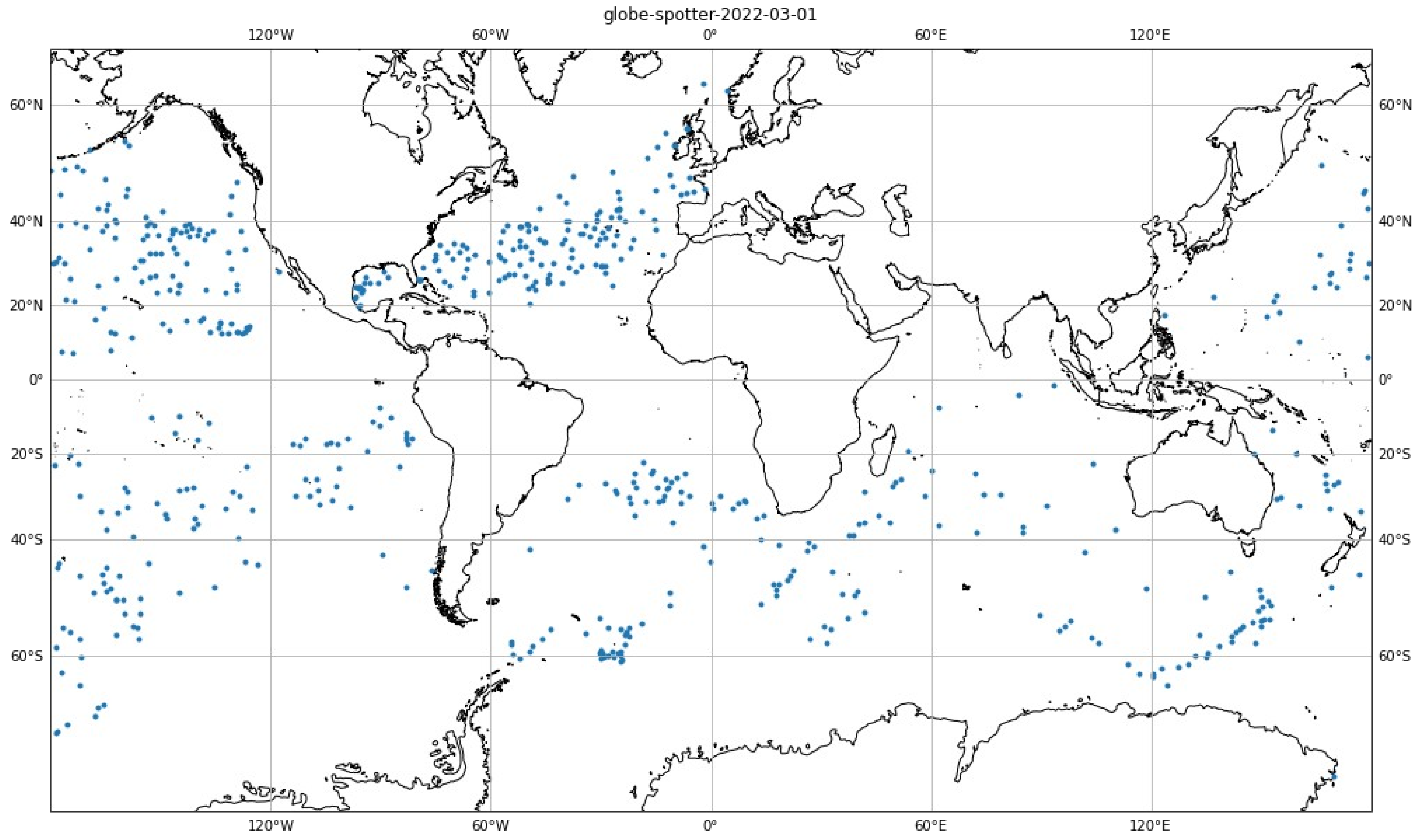
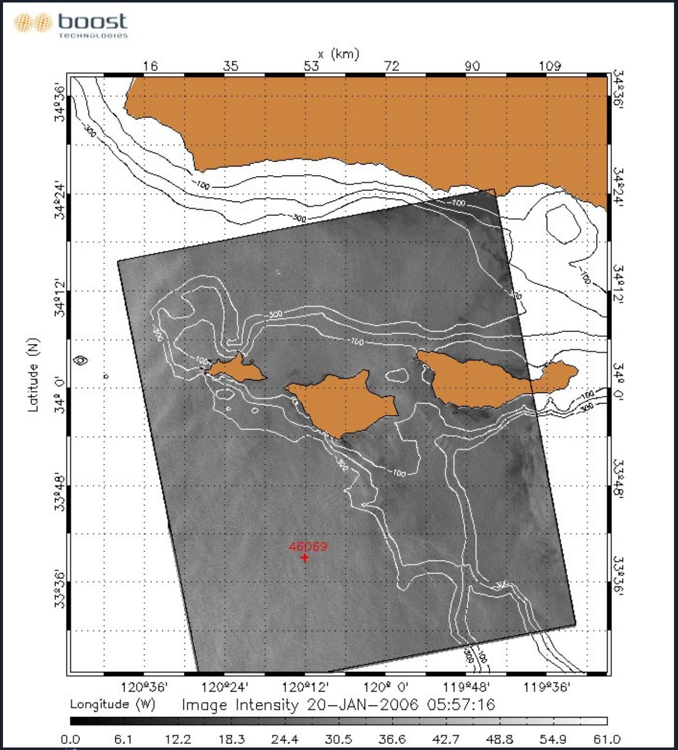
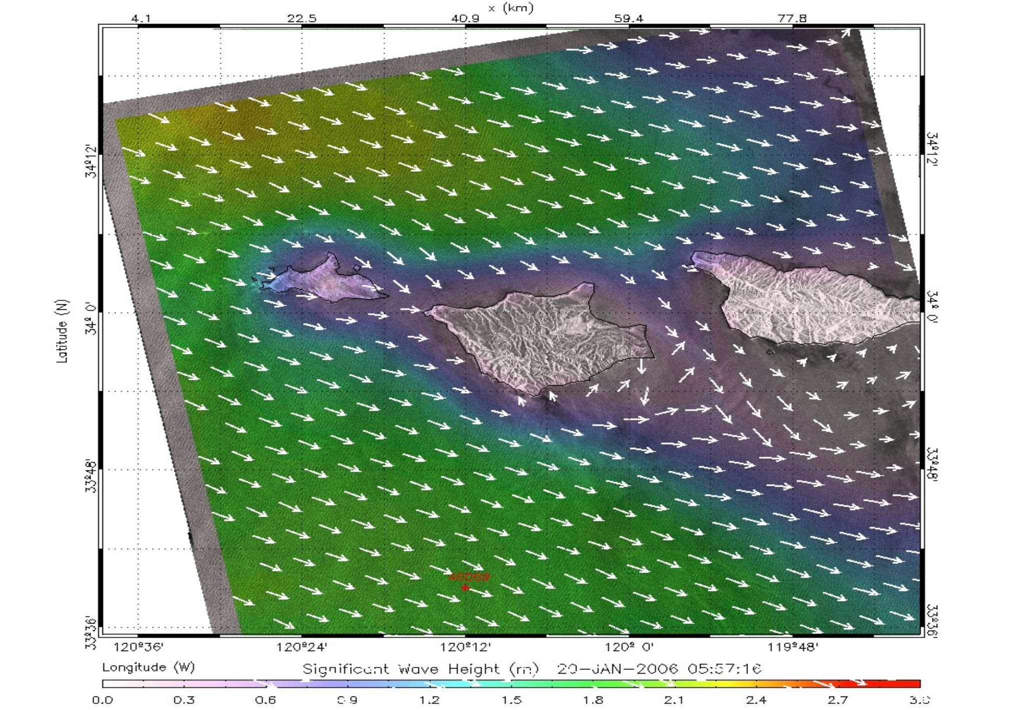

globe-spotter-2022-03-01
120°W
60°W
0°
60°E
120°E
60°N
40°N
20°N
0°
20°S
40°S
60°S

Validation of SAR 2D wave spectra against anchored BUOYS

- Collection of 50 image mode and 35 wide swath single look complex image.
- Collection of collocated buoy directional spectra over deep and shallow water.
  - NDBC buoys : courtesy of NOAA
  - Datawell buoys in iroise sea and golfe Normand Breton : courtesy SHOM

SAR image mode





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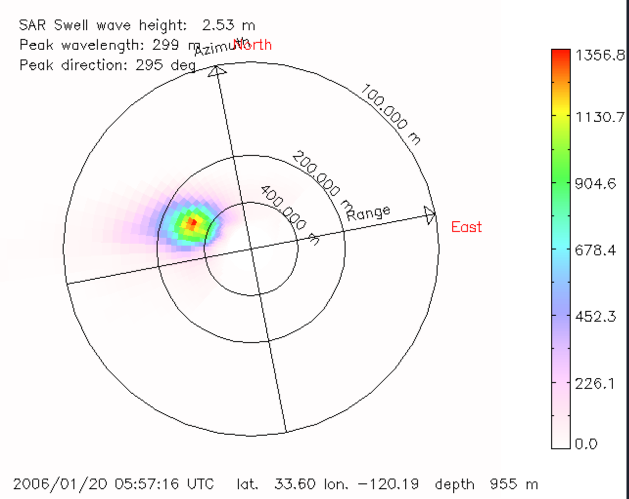
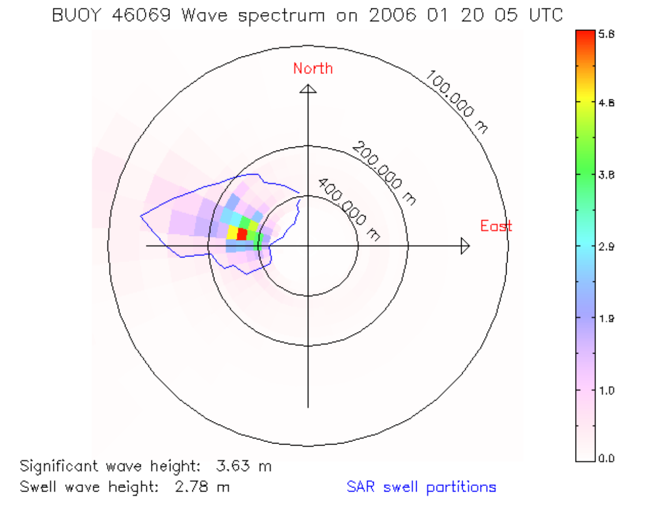
Buoy data preparation

- Maximum Entropy Method estimation
- SAR spectrum
  BUOY spectrum



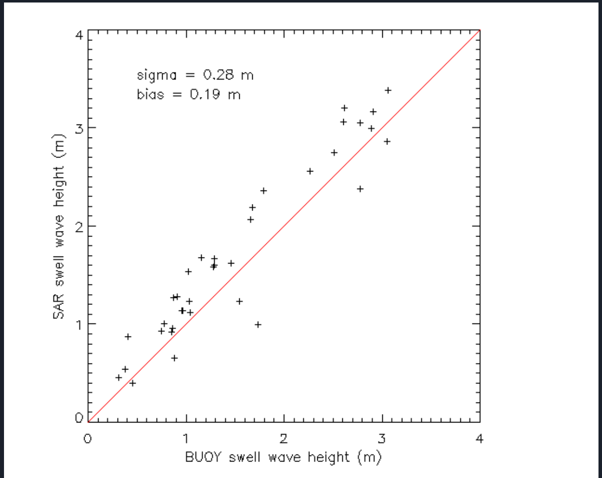


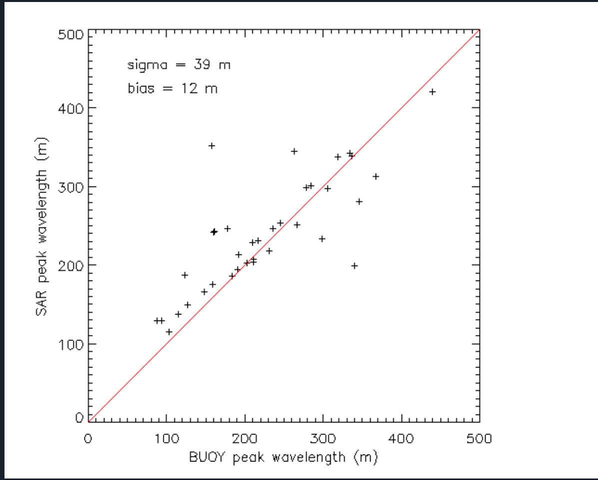
Integrated parameters comparison

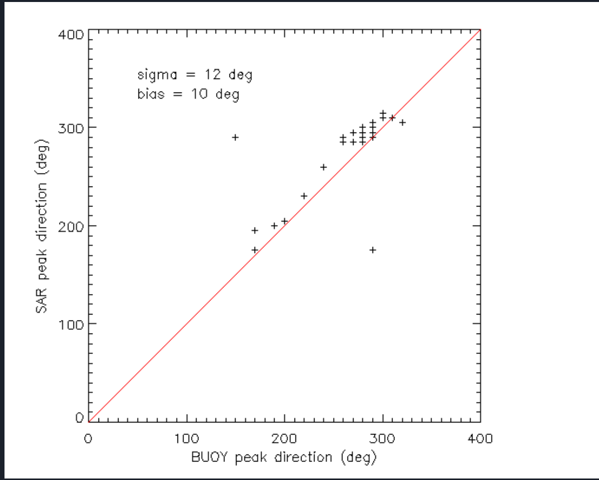
Swell Hs

Swell wavelength

Swell direction

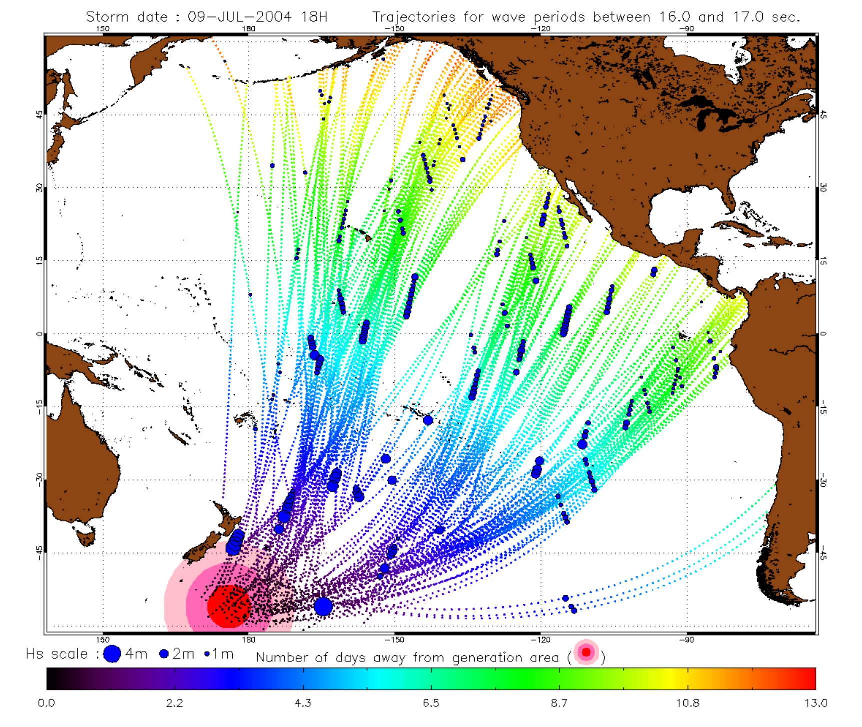






SAR wave mode “Dynamic” validation

- Extraction of swell systems parameters from ENVISAT WAVE MODE level2 products.
- Backward propagation to identify the swell origin (Storm source)
- Identification of all swell observations relative to a given Storm source.
- Determination of the propagation path by forward and backward propagation between observations.



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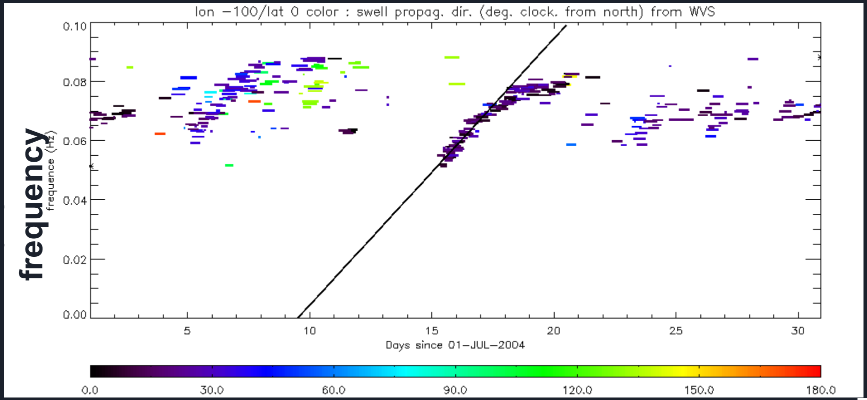
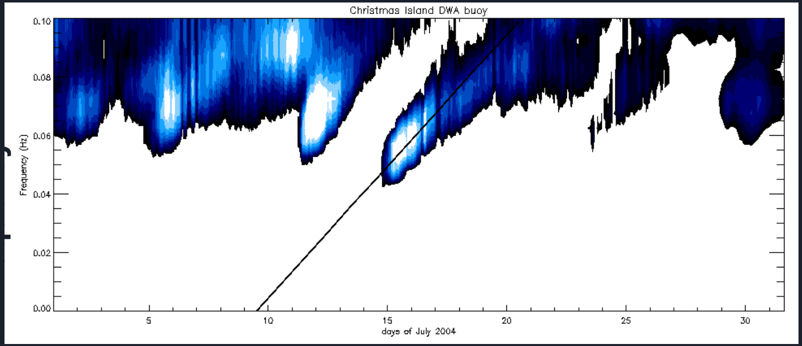
Observed swell at a given location versus time (virtual buoy)





- Time-frequency diagram for one month at position longitude 100 °W and 0°N
- color indicates propagation direction.

- diagram at the same position recorded at Christmas island buoy Time-frequency
- color indicates energy.

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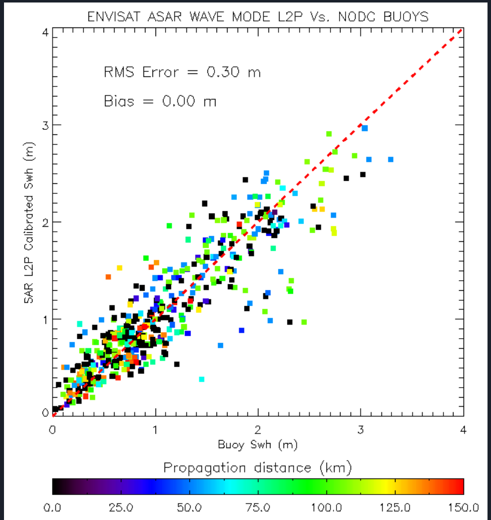
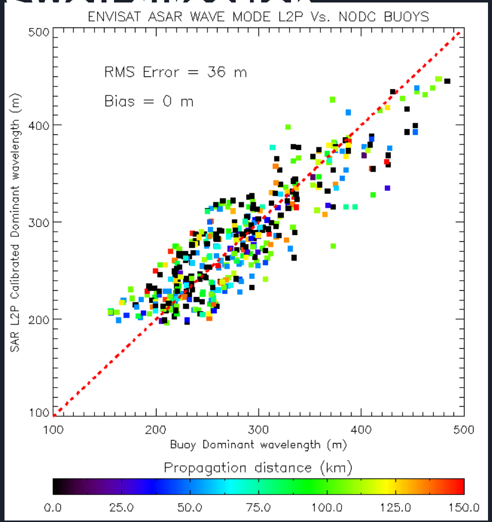
GLOBWAVE Satellite vs In situ Matchup Database

- A satellite vs. in situ matchup database has been constructed using a set of in situ data sources from POSEIDON/Puertos del Estado/NODC/UKMO/CDIP/MEDS

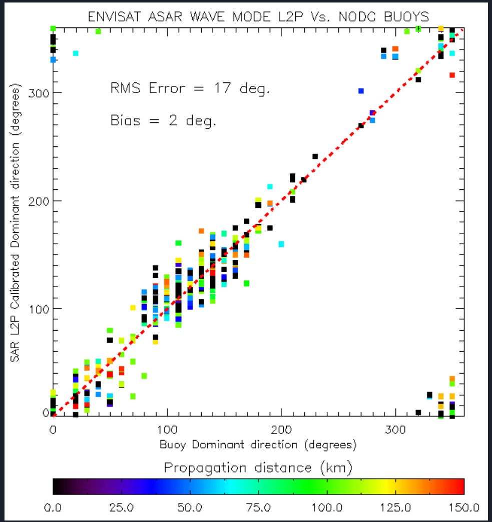
Swell Hs



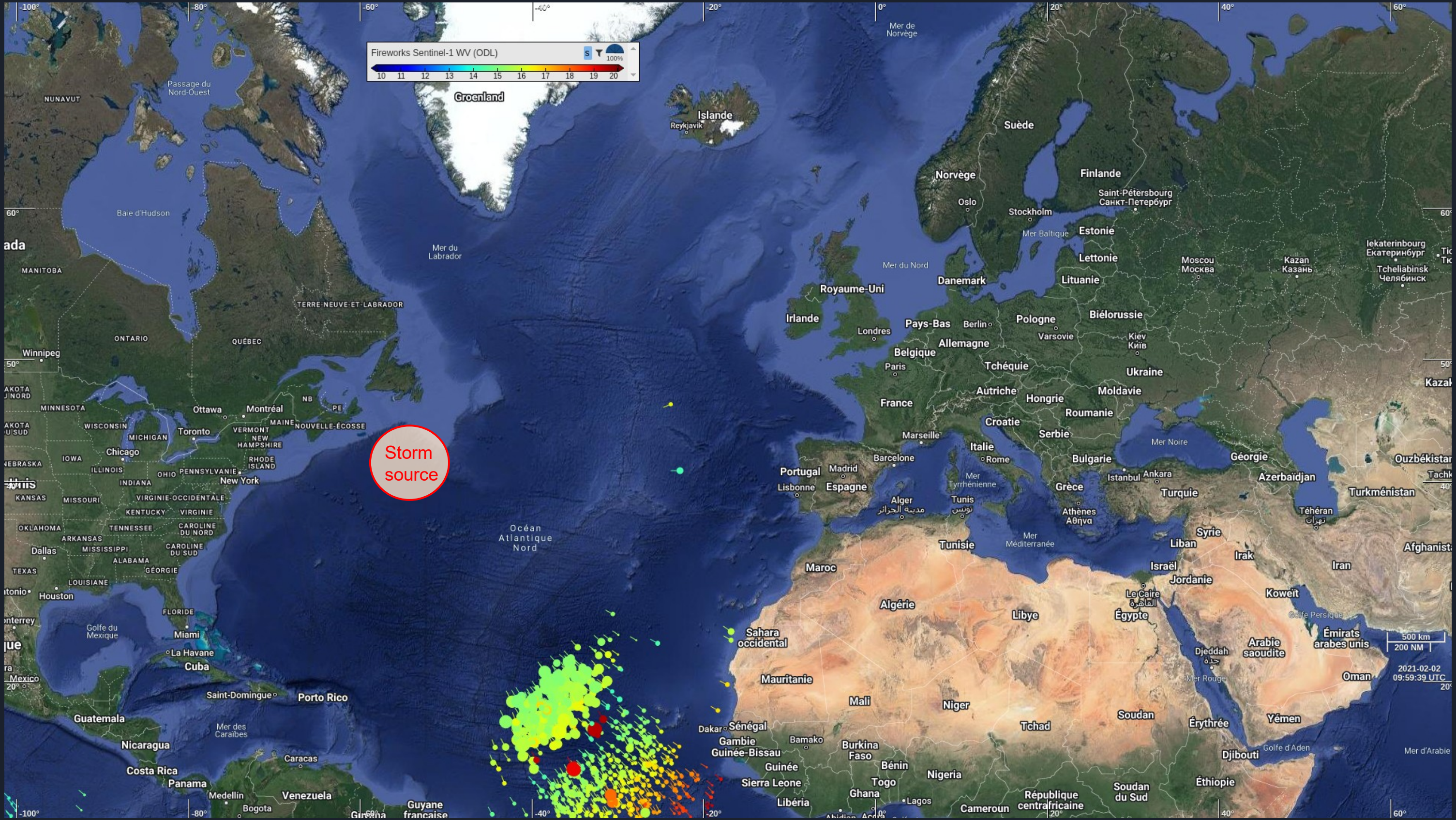
Swell wavelength



Swell direction



Sentinel-1 Wave Mode Swell tracking



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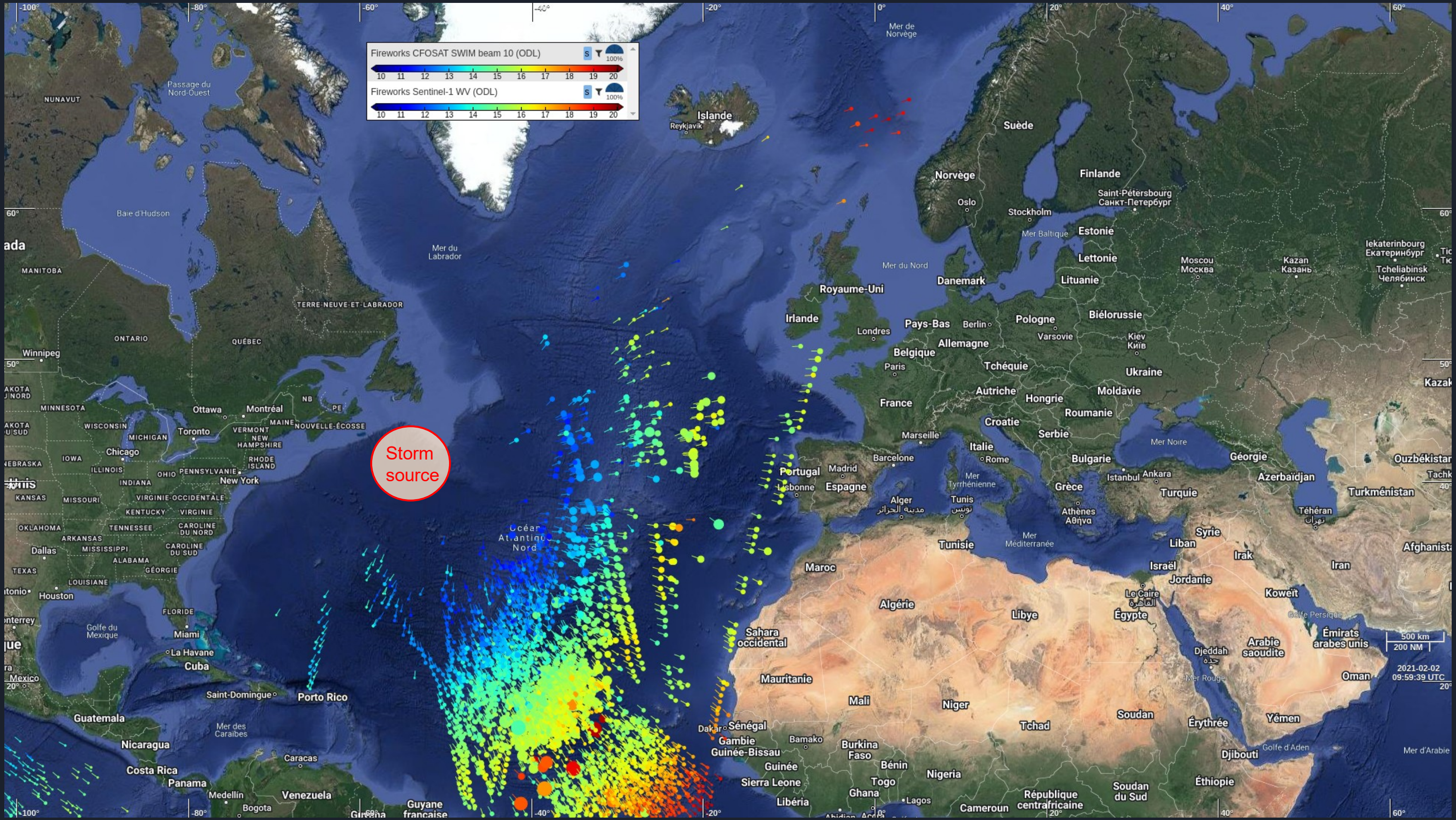
Sentinel-1 WV+SWIM Swell tracking

SWIM Wave scatterometer L2S wave spectra available publicly in NRT



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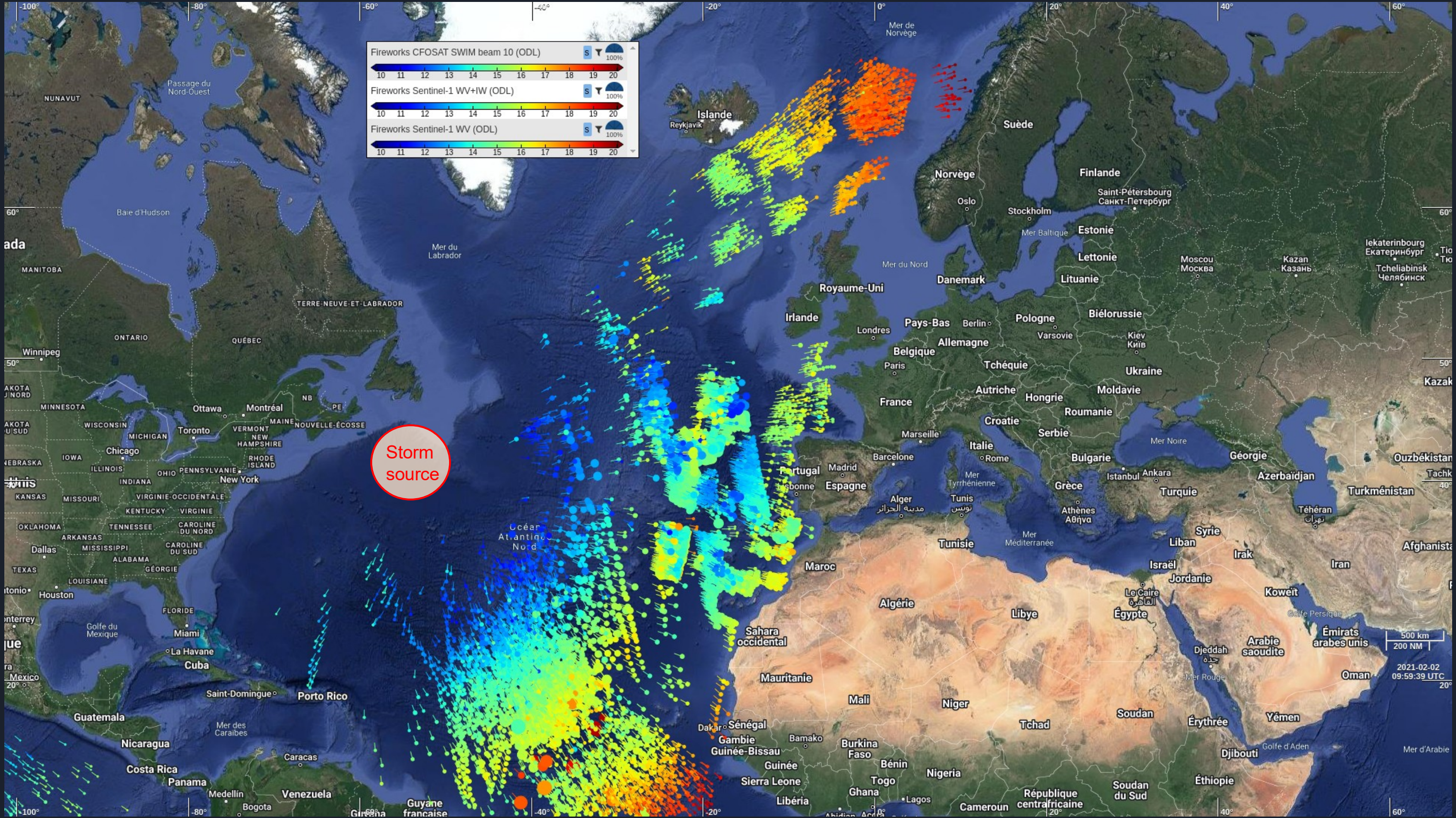
Sentinel-1 WV+SWIM+IW Swell tracking



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Ongoing validation of new U-net based direct inversion for SWIM 2D directional spectra

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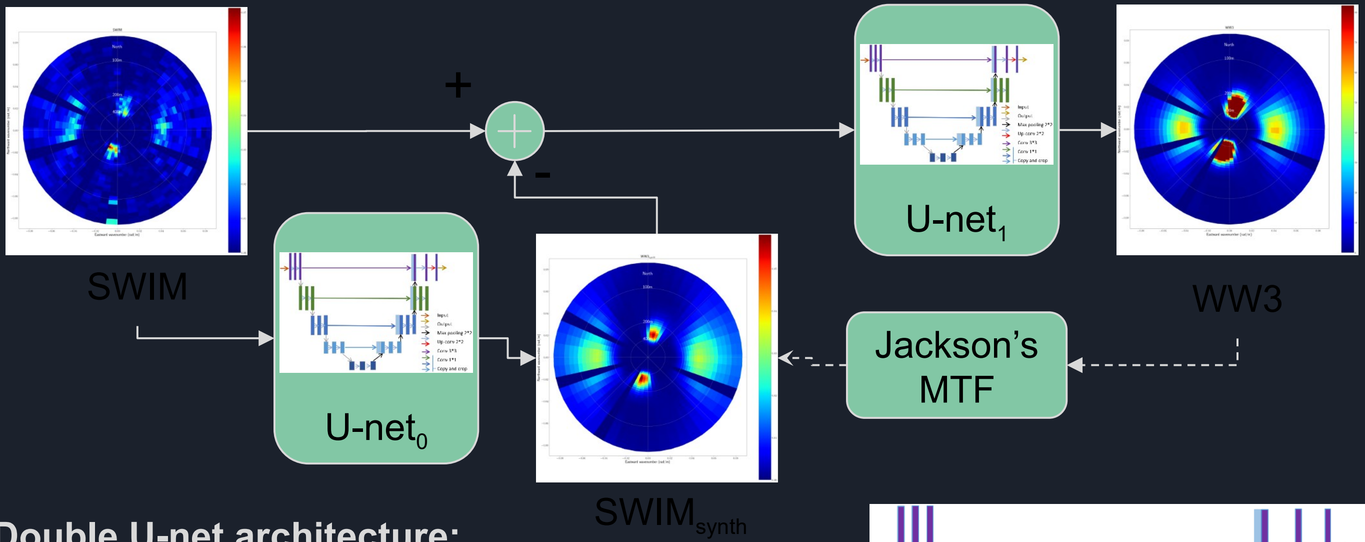
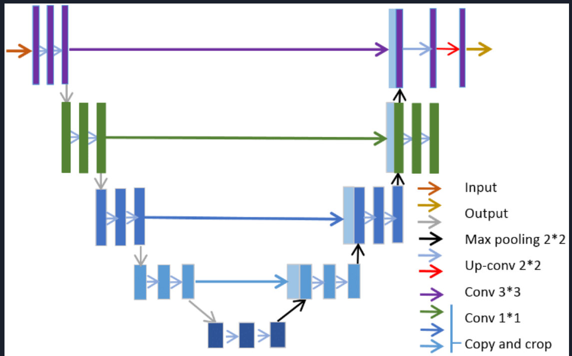
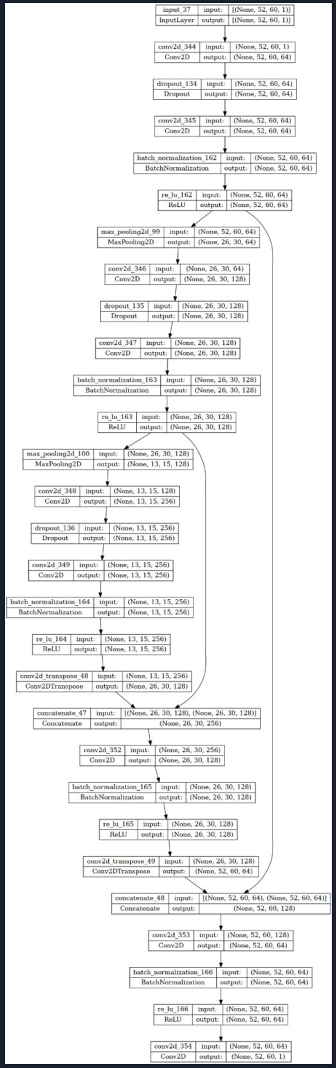
Network Architecture







Double U-net architecture:

U-net$_0$: Reconstruct synthetic SWIM spectra (WW3+Jackson) from real SWIM spectra

U-net$_1$: Reconstruct WW3 from anomaly between SWIM and synthetic SWIM spectra

Global Spotter Buoys Dataset : directional wave drifters

Colocalized SWIM/Spotter buoys dataset validation:

- 10 months-worth of data from 2021 (663 Buoys)
- Buoy data: Omnidirectional 1D spectra + 4 directional Fourier Coefficients
- Colocalization:
  - For each buoy observation, identify SWIM observations within:
    - 50 km
    - 60 minutes
  - SWIM 2D spectra centered around the identified spatio-temporal colocalization
  - 71856 total colocalized data points

Network results compared to Spotter data:

- Directional moments
- MEM reconstruction

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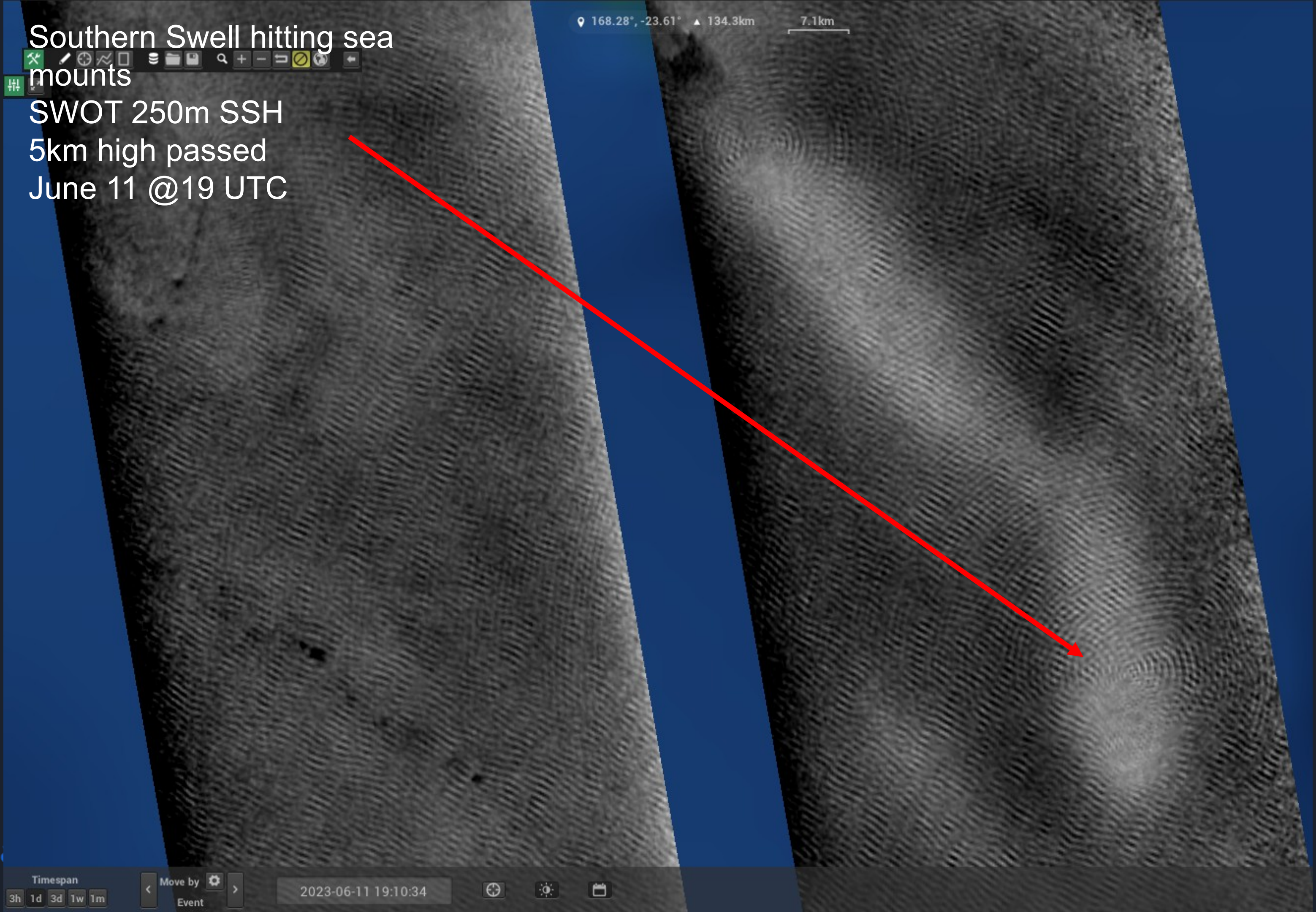
Southern Swell hitting sea mounts
SWOT 250m SSH
5km high passed
June 11 @19 UTC



EE10 Harmony (2029) Observation concept: stereo phase

Line-of-sight diversity for high resolution

3-D surface deformation (DInSAR)

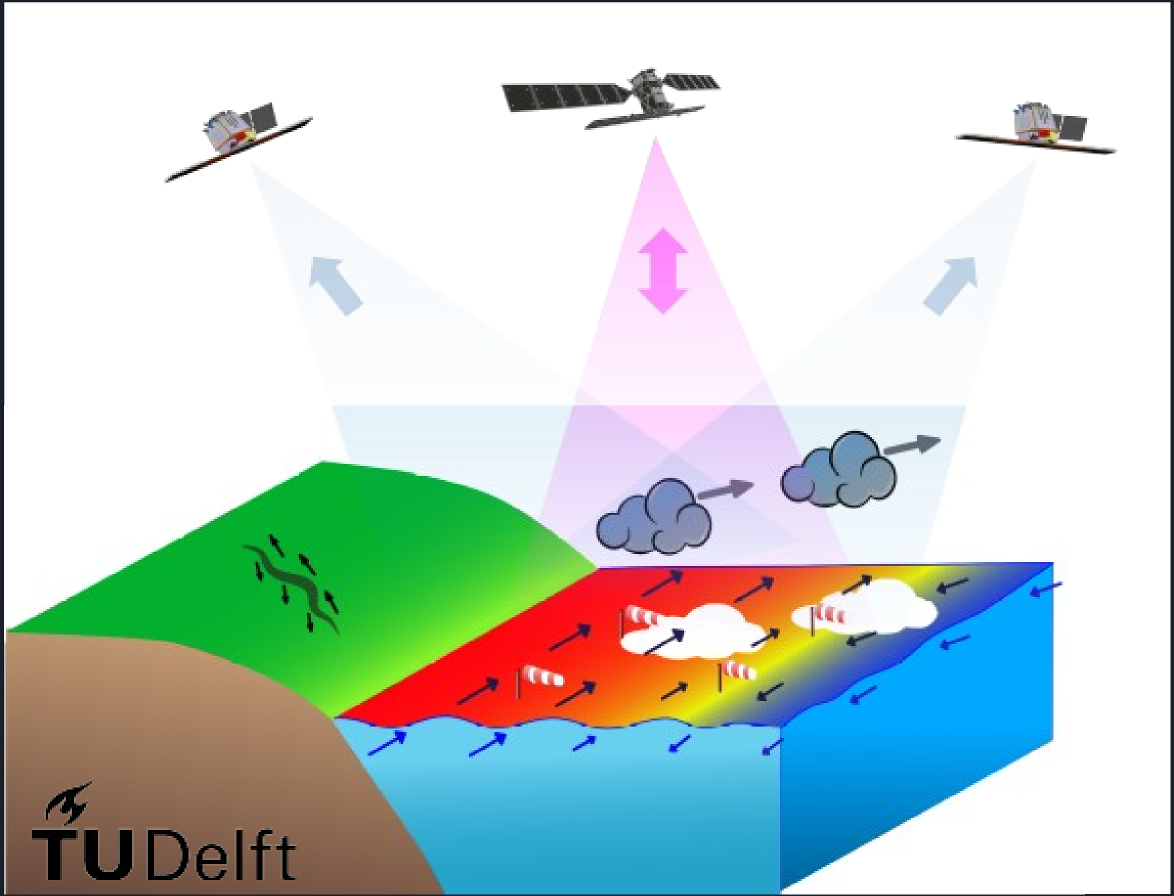
Ocean surface motion (Doppler)

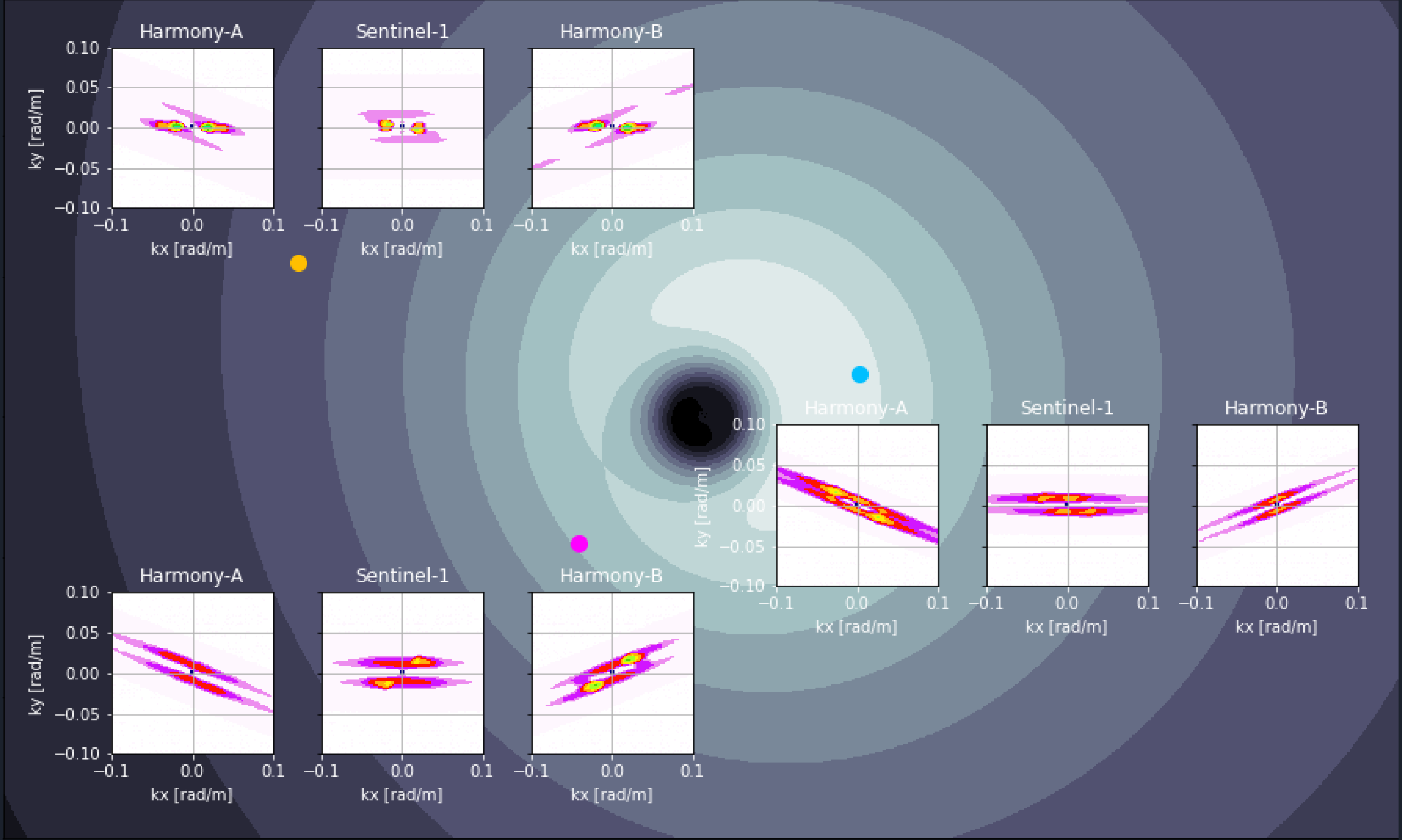
Surface winds (scatterometry)

Improved directional surface wave spectra

Sea Surface (skin) temperature

Cloud-top motion (TIR time-lapse) and height (TIR parallax)





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Conclusion

La mesure in-situ de spectres directionnels de vagues au large est critique pour la calibration/validation et le contrôle qualité des missions existantes (Sentinel-1 / SWIM / SWOT) et futures (Harmony / Sentinel3 Next Gen).

C’est la mesure de référence pour la validation des produits de niveau 2 (mesure géophysique). l’ESA définit ses mesures comme “Fiducial reference measurements”

Les mesures in-situ sont nécessaires ensuite au suivi de la qualité des observations satellite durant la mission

Ces mesures sont utilisés lors des campagnes aéroportées destinées à valider le concept de futures missions (Drift4SKIM, OSCAR,...)

Ces mesures sont enfin utilisées extensivement lors de la phase de calibration/validation des futures missions (durée 6 mois minimum)

Besoin d’investissement conséquent pour développer des solutions techniques de mesures au large de qualité au niveau français/européen.