SWIM directional spread as compared to Sentinel-1 and directional wave buoys

Collard Fabrice, Guitton Gilles, Alexey Mironov
Oceandatalab

OceanDataLab

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Theoretical SWIM directional resolution

By design SWIM radar is able to provide wave spectrum information in very narrow directional band. According to Jackson, 1981 directional resolution can be determined by the combination of finite radar footprint and wave front curvature factors and expressed as

$$\Phi = \frac{\left(L_{\phi}^{-2} + \left(k L_{\phi} / 2 r_0 \sin(\theta) \right)^2 \right)^{1/2}}{k}$$

where Lphi is the azimuthal window length and r0 is the distance from satellite antenna to observed sea surface. This equation predicts Gaussian-like directional window with resolution about 4°-5° (on the half-power level) that slightly depends on wavenumber only

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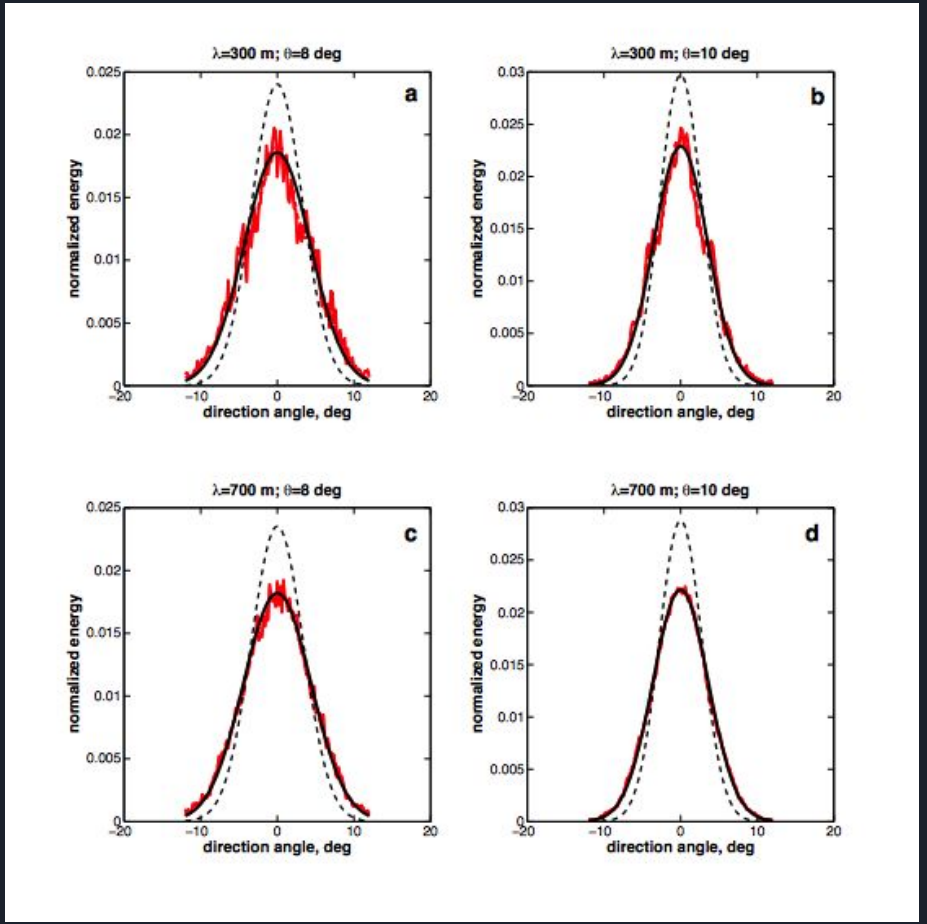
Theoretical vs. simulated directional resolution

Theoretical parameterization is tested with use of simulated radar signal corresponding to anisotropic wave set traveling in near-range direction.

Directional width is independent of wave amplitude. Simulation confirmed this for different wavelength and incidence angles.

about 9° directional width for 10° beam
about 11° directional width for 8+° beam



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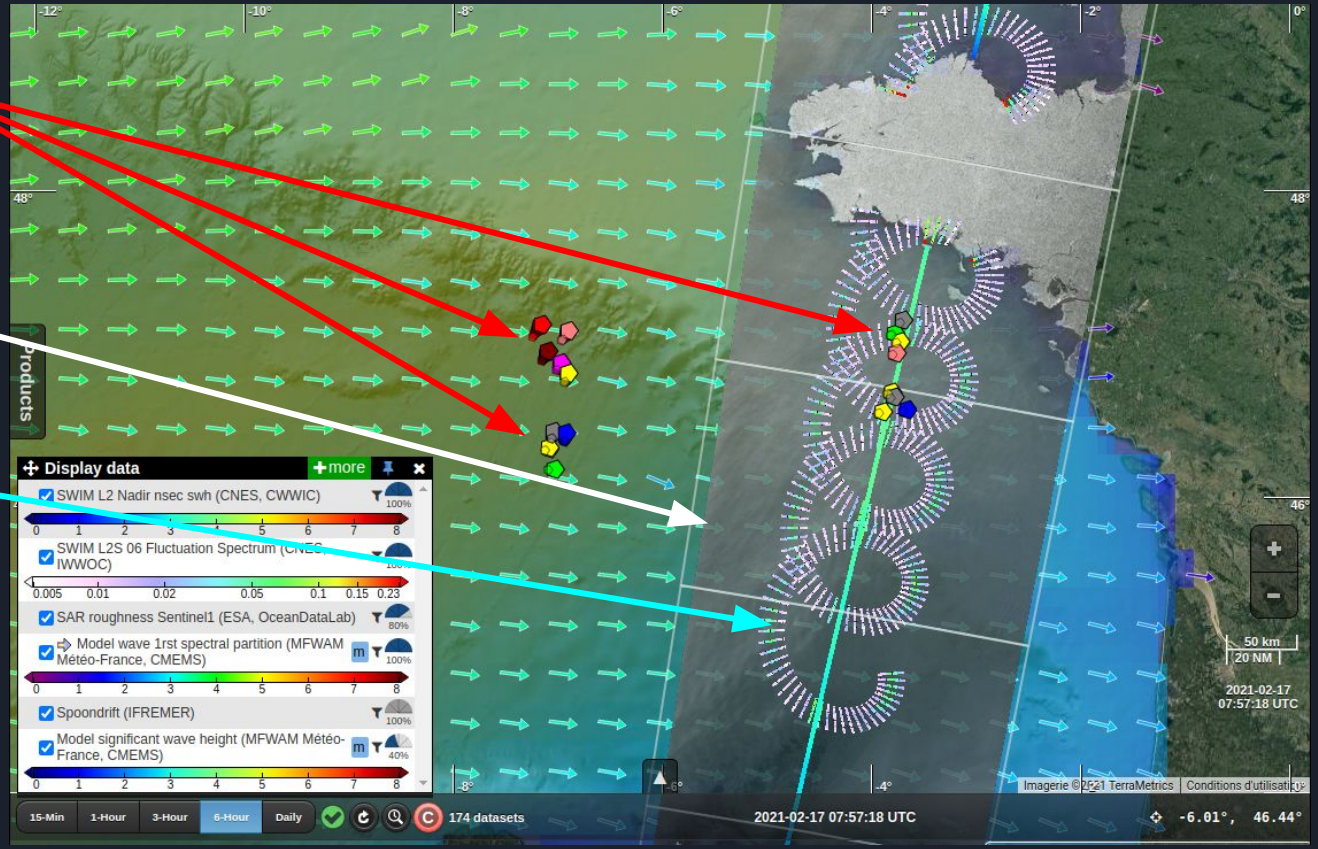
Dir. wave spectra comparisons : SUMOS validation campaign

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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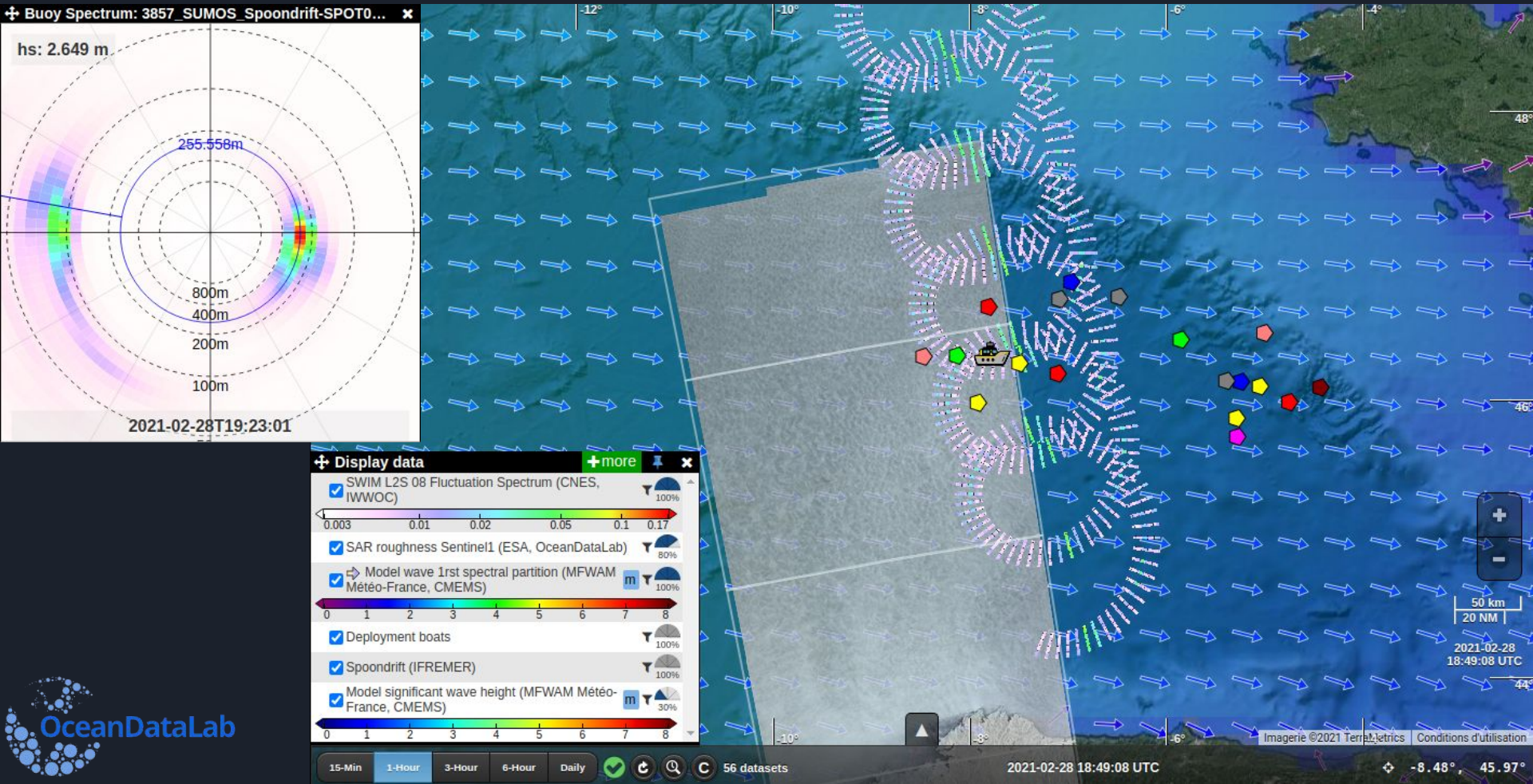
28 Feb 2021 7pm : Opposing Wind Sea and Swell



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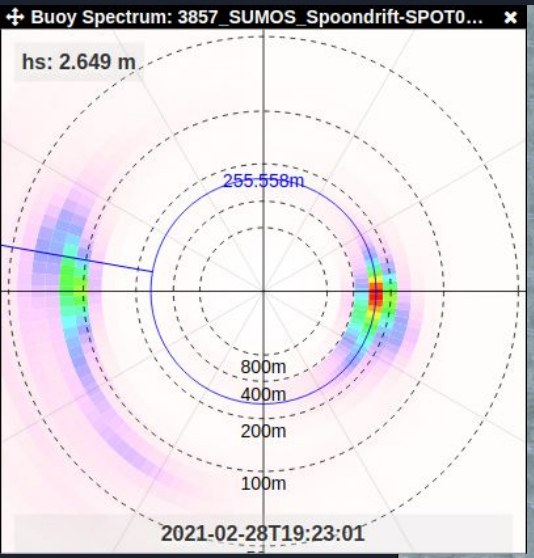

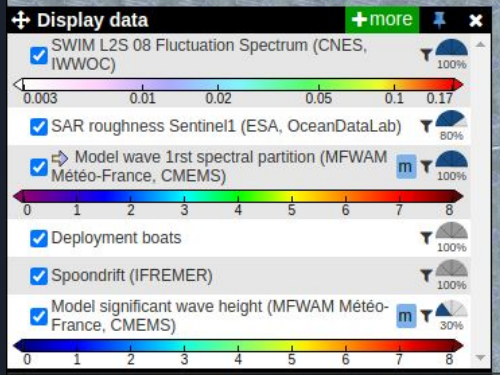

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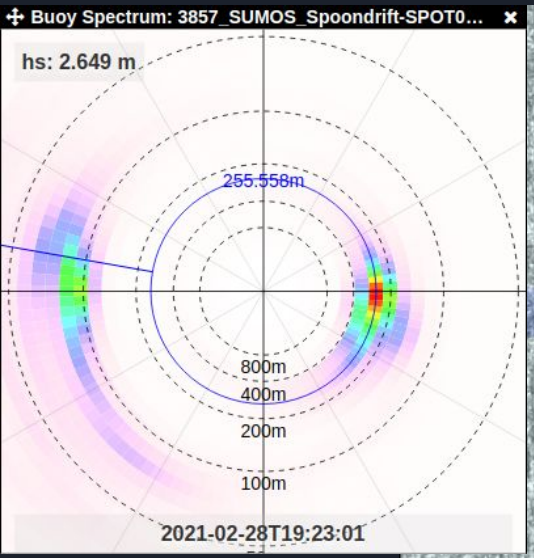

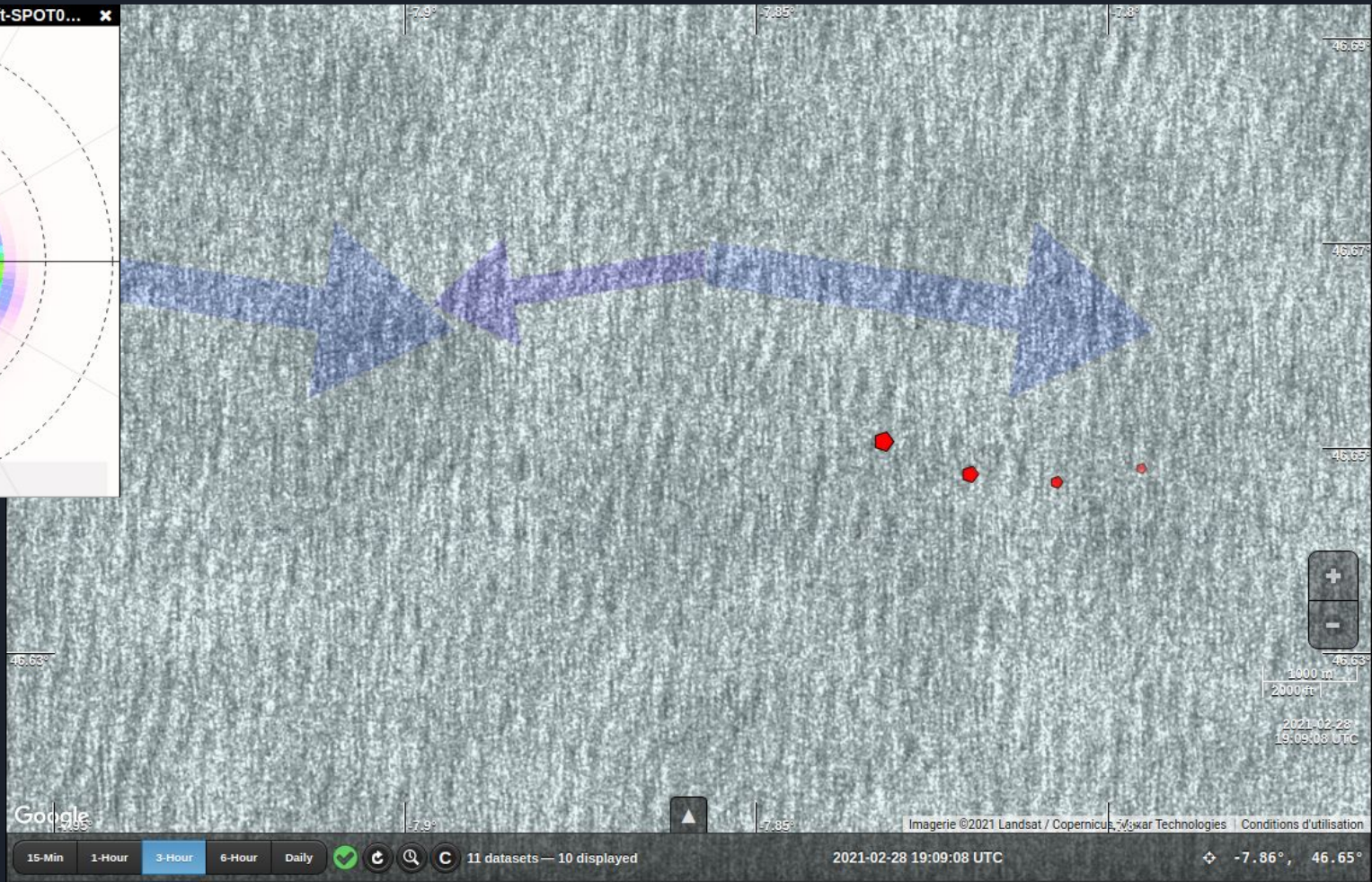

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28 Feb 2021 7pm : Opposing Wind Sea and Swell

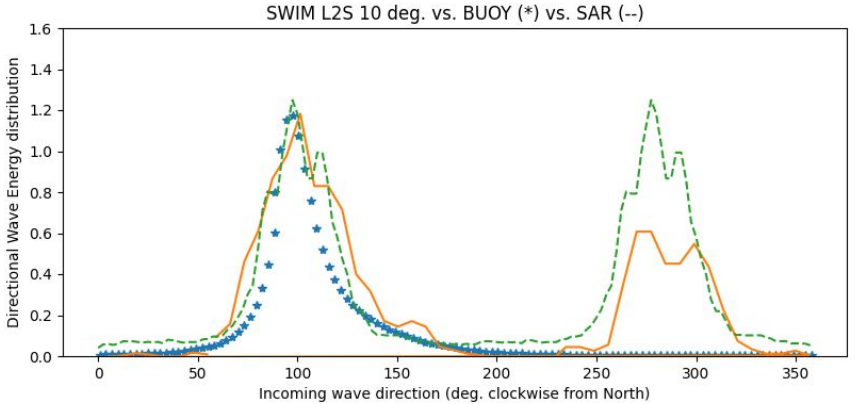
SWIM 10° beam

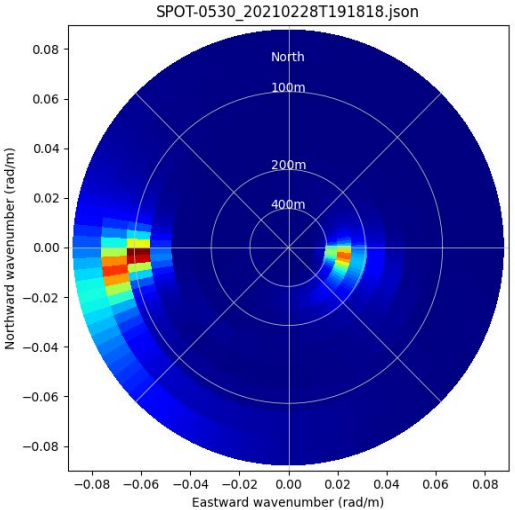
Directional spread : swell 285m

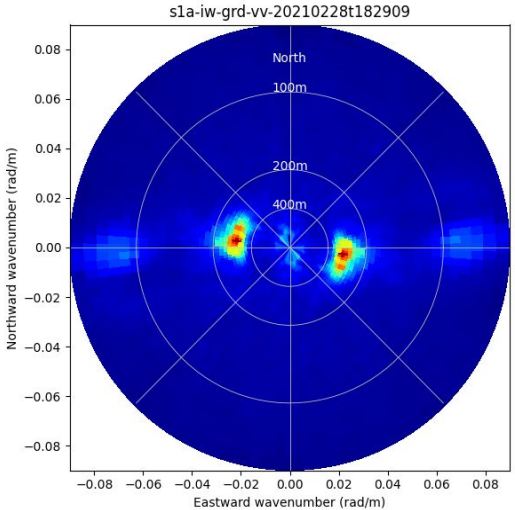
BUOY : 22°

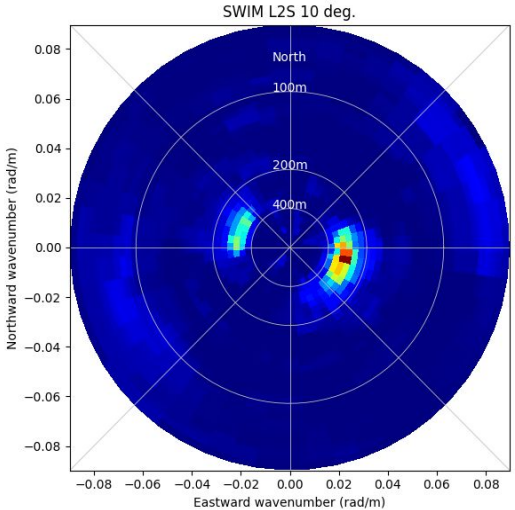
SAR : 40°

SWIM : 46°









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28 Feb 2021 7pm : Opposing Wind Sea and Swell

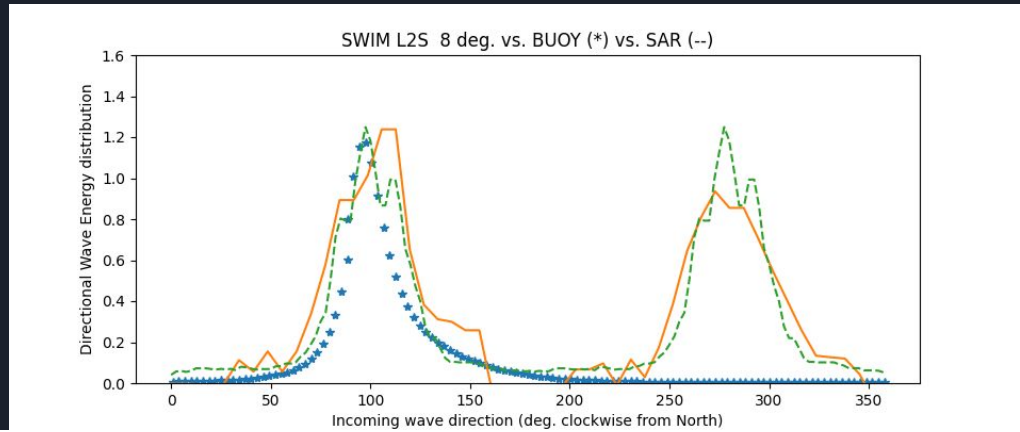
SWIM 8° beam

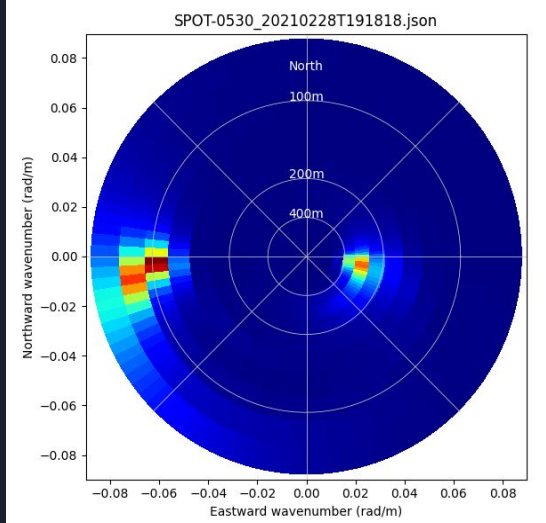
Directional spread : swell 285m

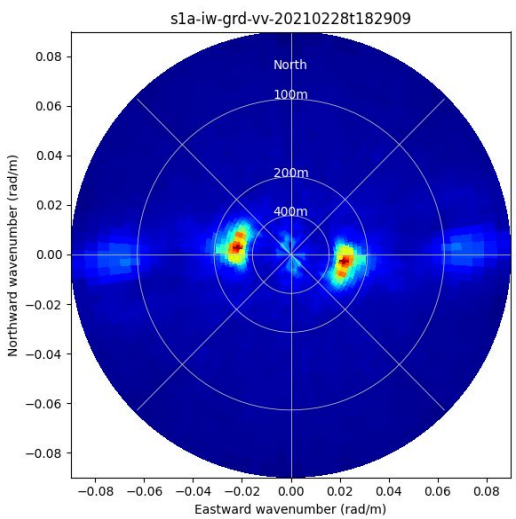
BUOY : 22°

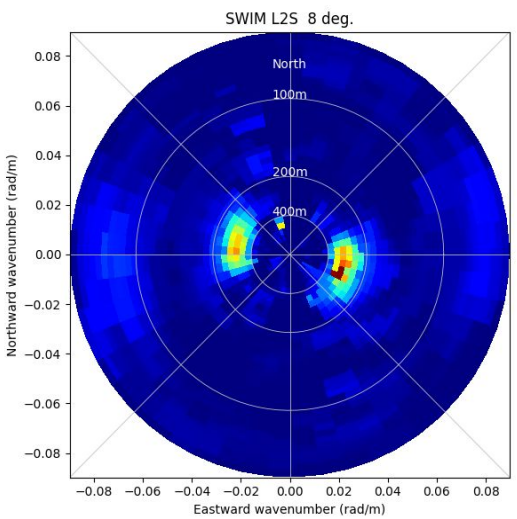
SAR : 40°

SWIM : 44°









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28 Feb 2021 7pm : Opposing Wind Sea and Swell

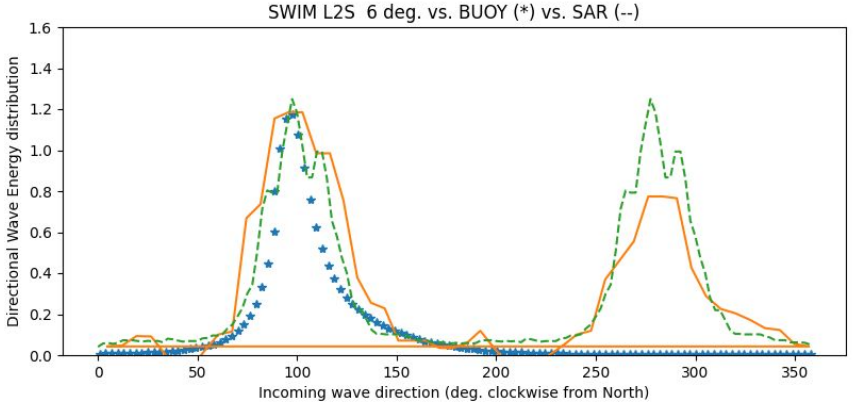
SWIM 6° beam

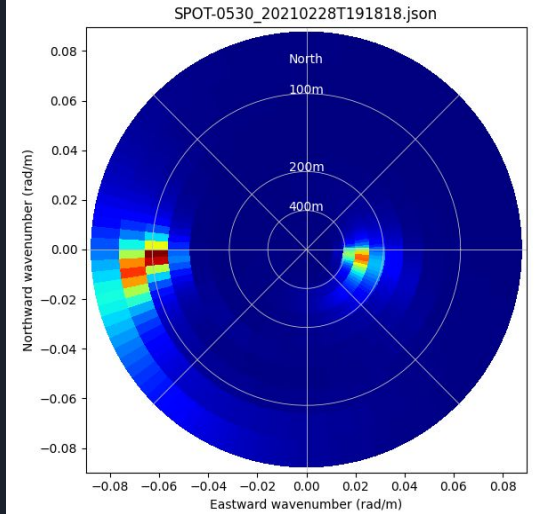
Directional spread : swell 285m

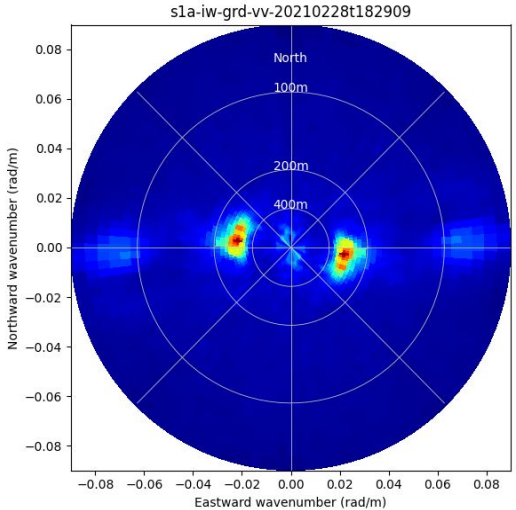
BUOY : 22°

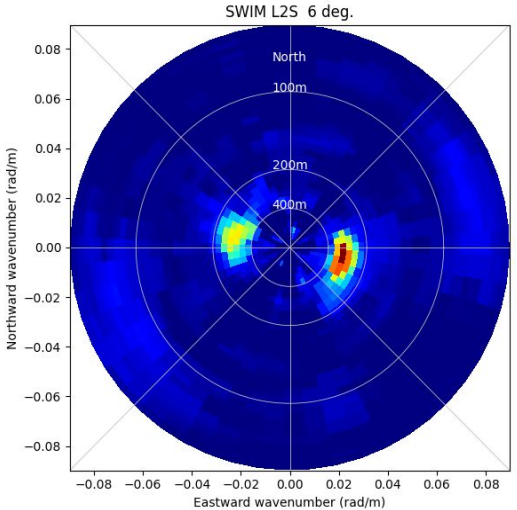
SAR : 40°

SWIM : 50°









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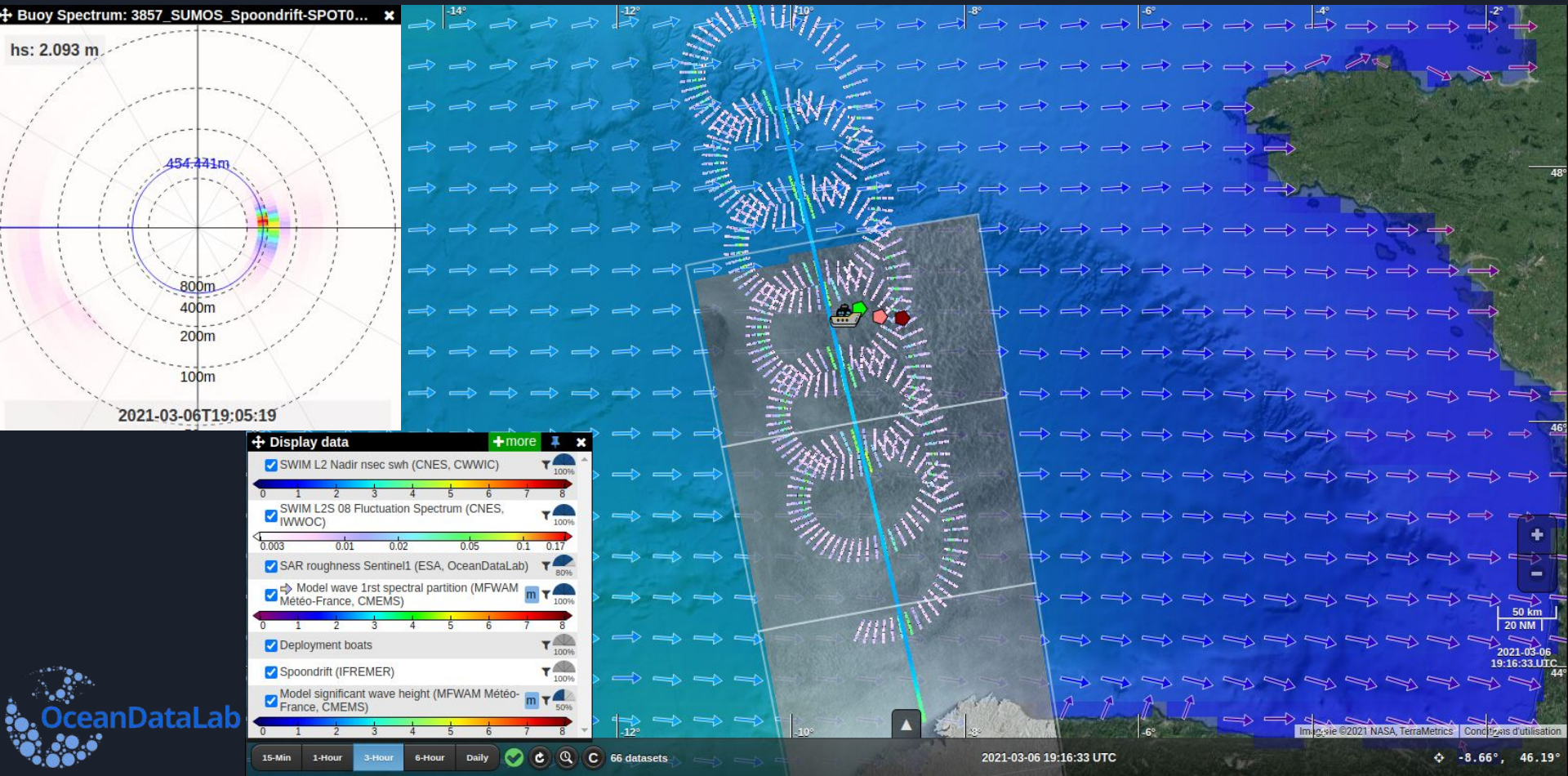
March 6 2021 7pm : Long western Swell



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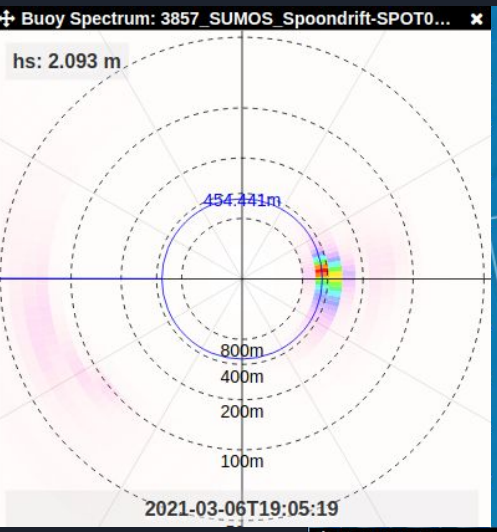

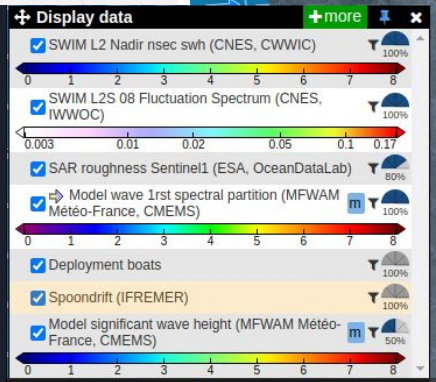

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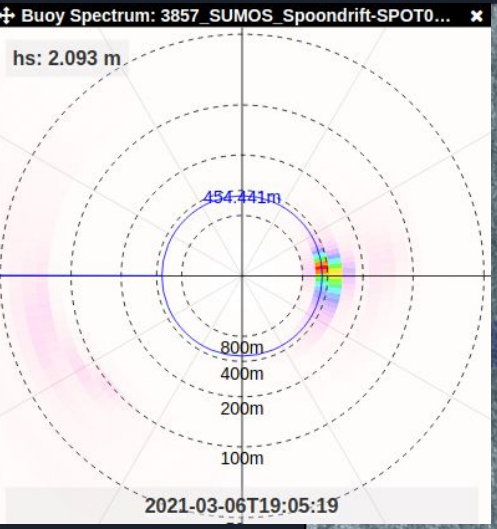

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March 6 2021 7pm : Long western Swell

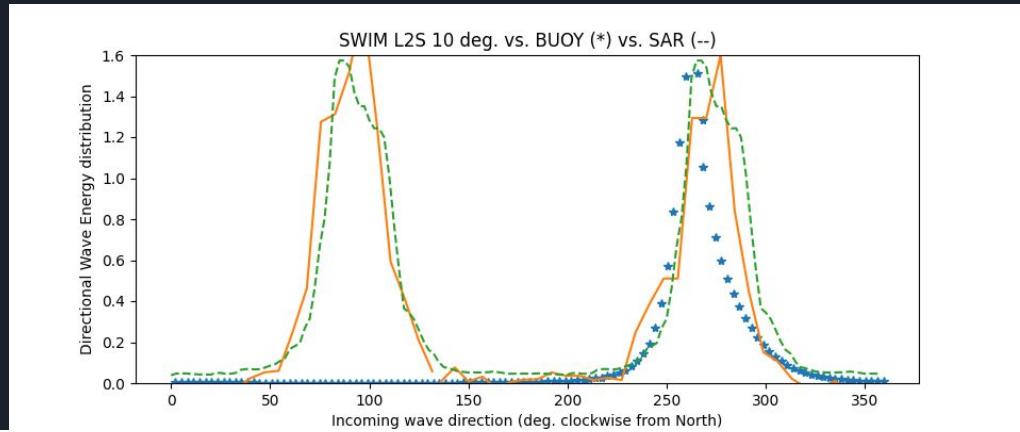
SWIM 10° beam

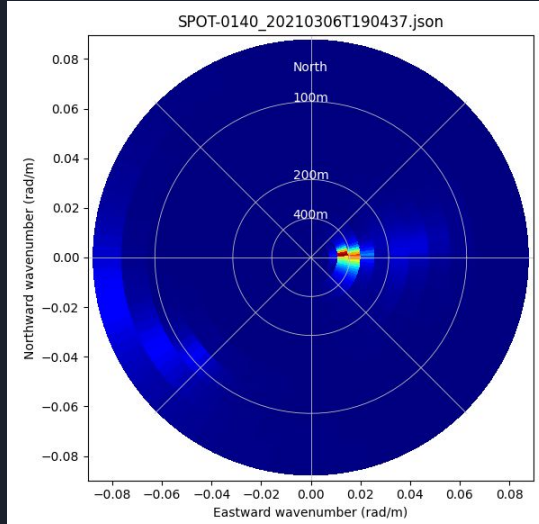
Directional spread : swell 440m

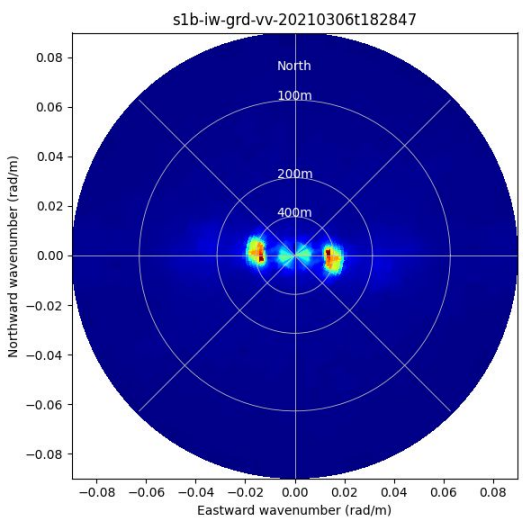
BUOY : 20°

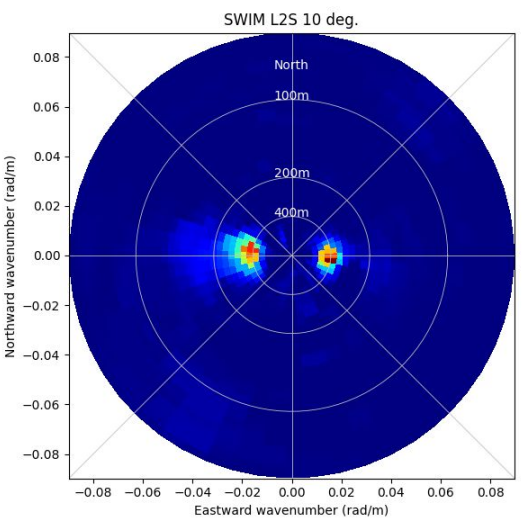
SAR : 34°

SWIM : 30°









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March 6 2021 7pm : Long western Swell

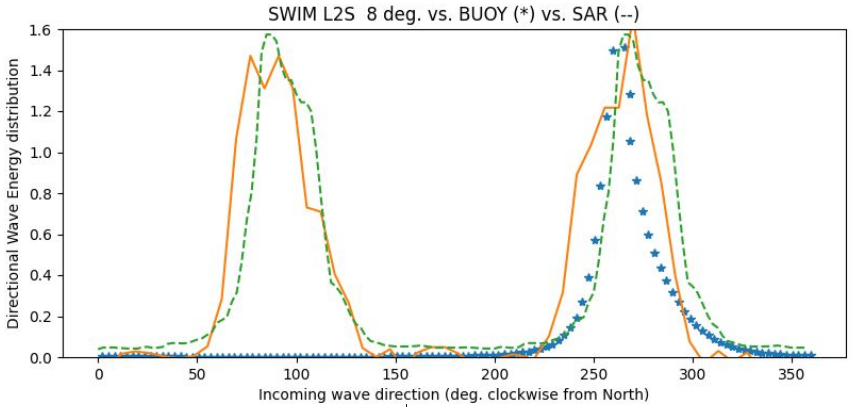
SWIM 8° beam

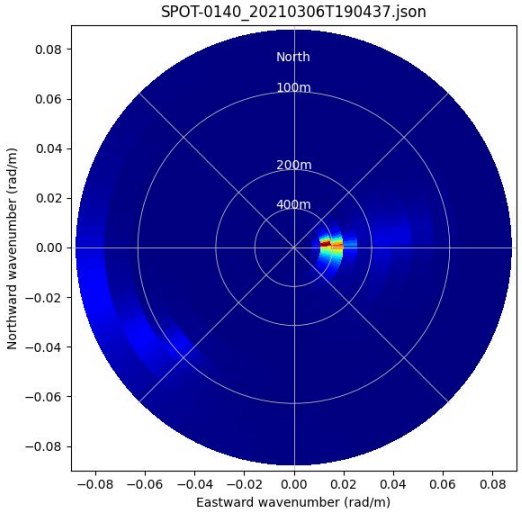
Directional spread : swell 440m

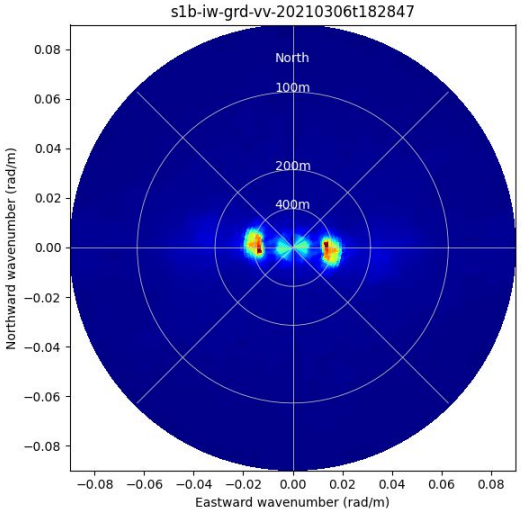
BUOY : 20°

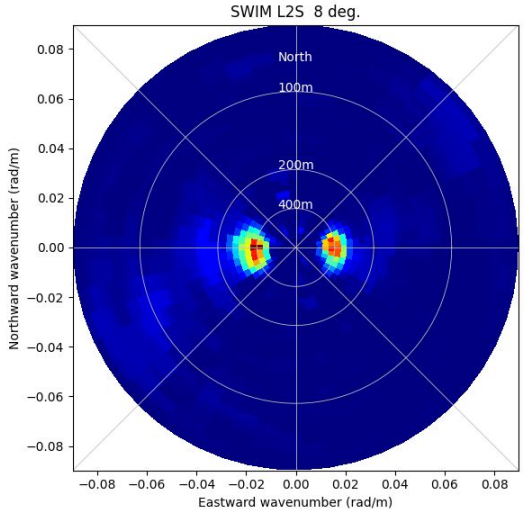
SAR : 34°

SWIM :45°









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March 6 2021 7pm : Long western Swell

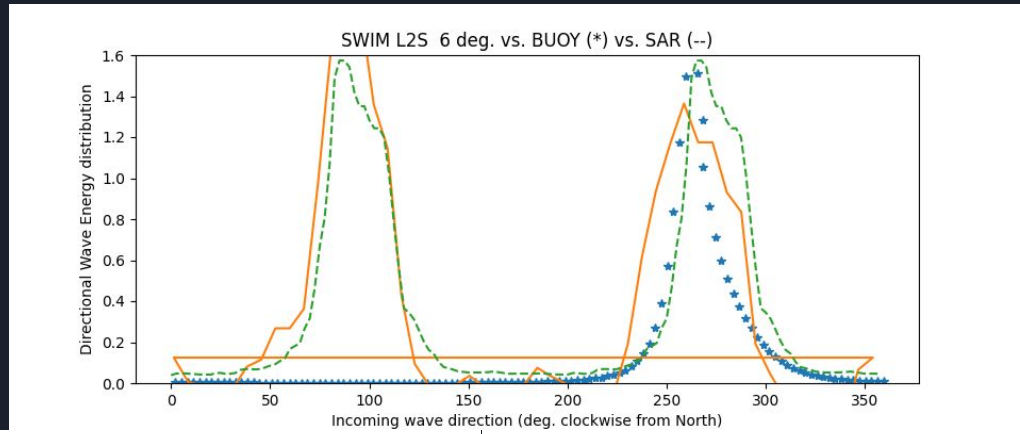
SWIM 6° beam

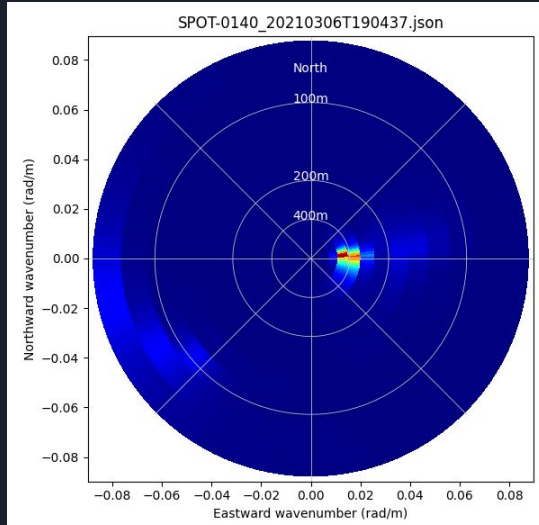
Directional spread : swell 440m

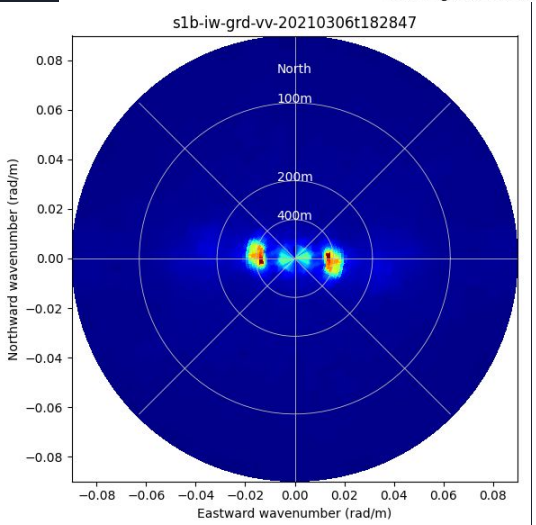
BUOY : 20°

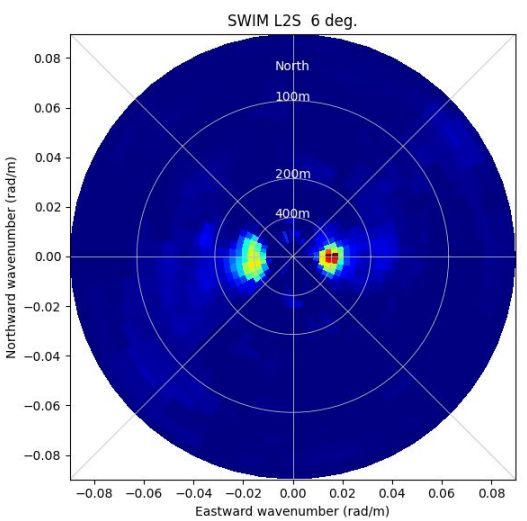
SAR : 34°

SWIM : 50°









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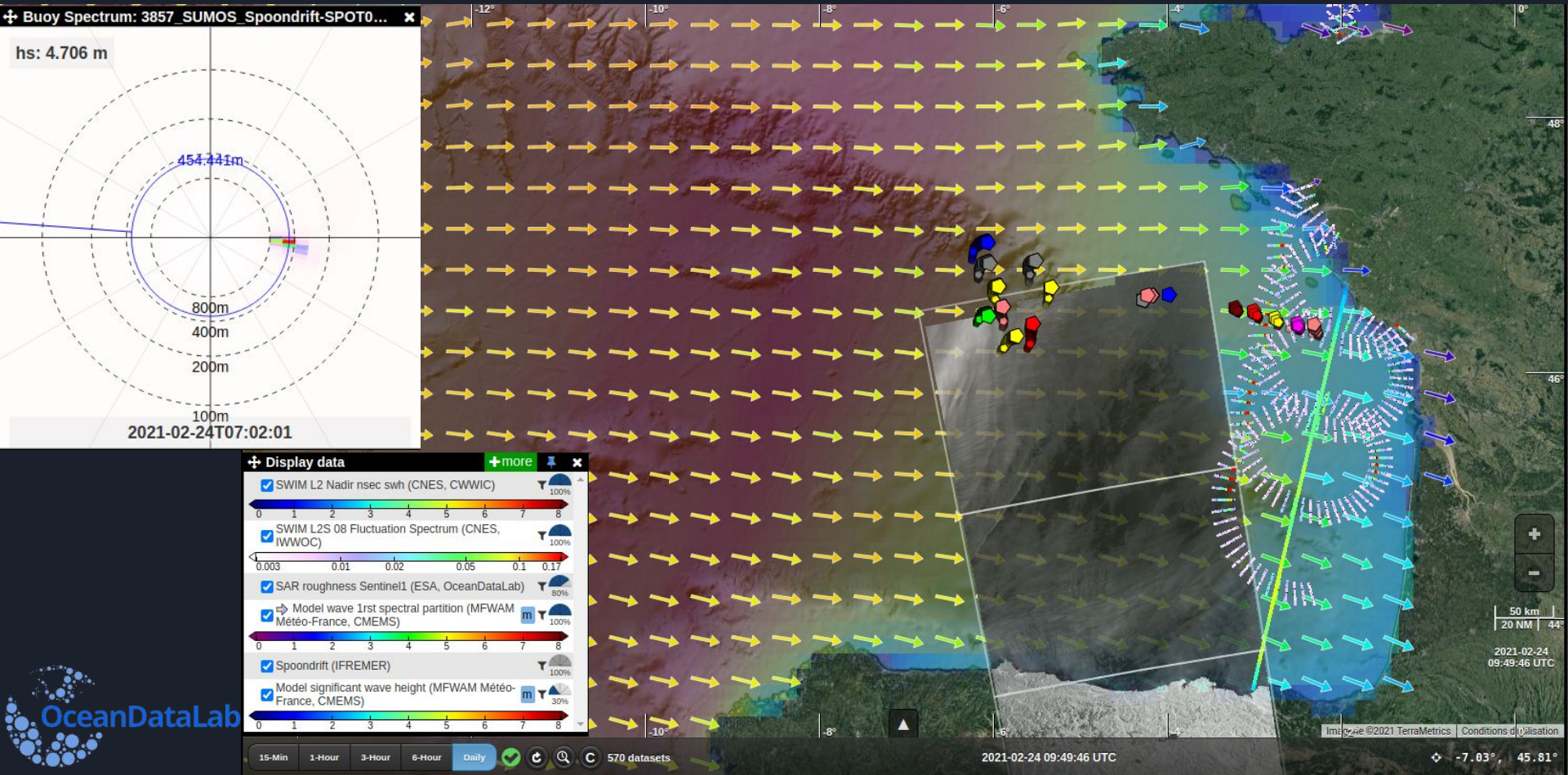
Feb. 24 2021 8am : narrow western Swell



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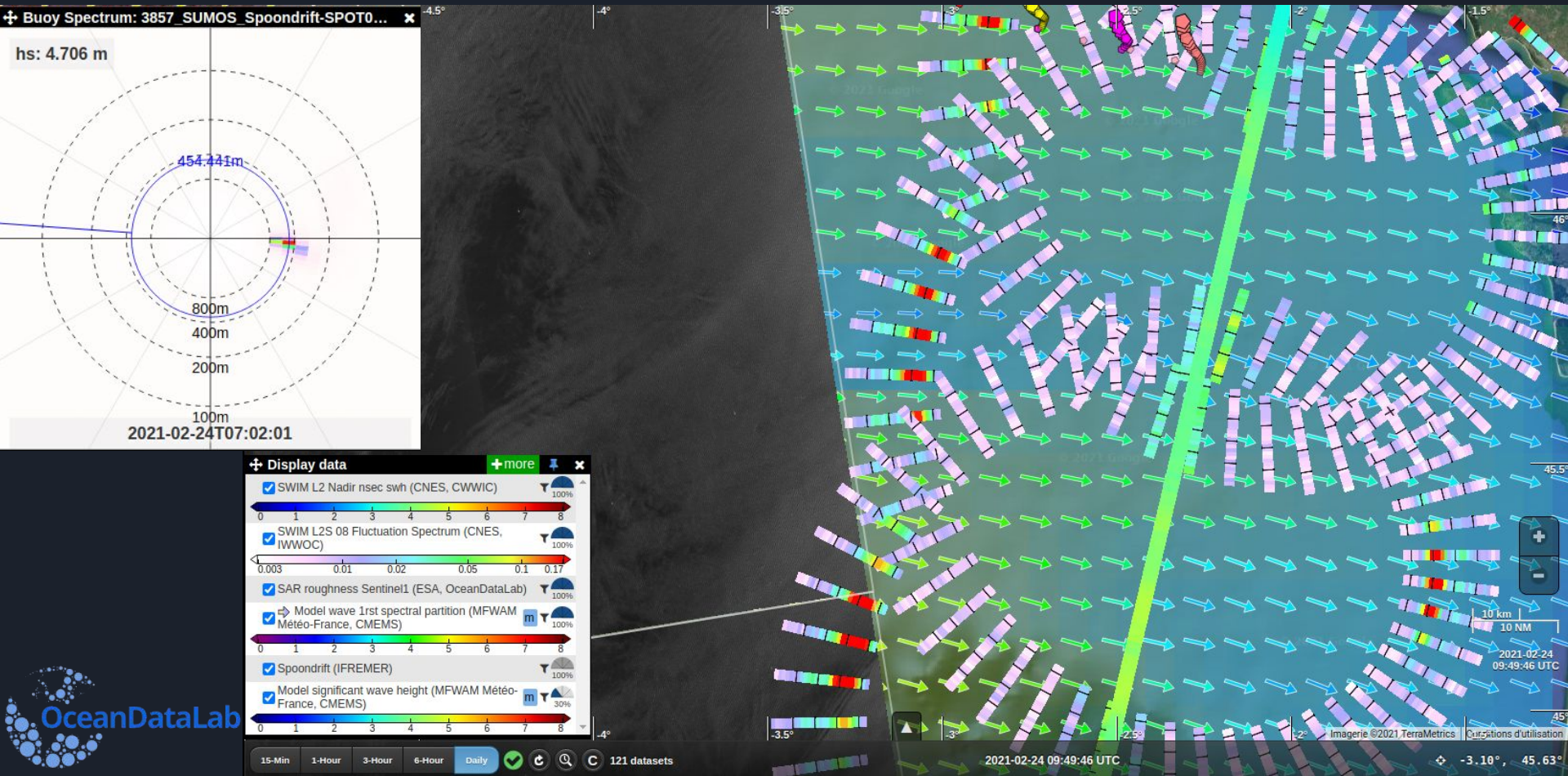
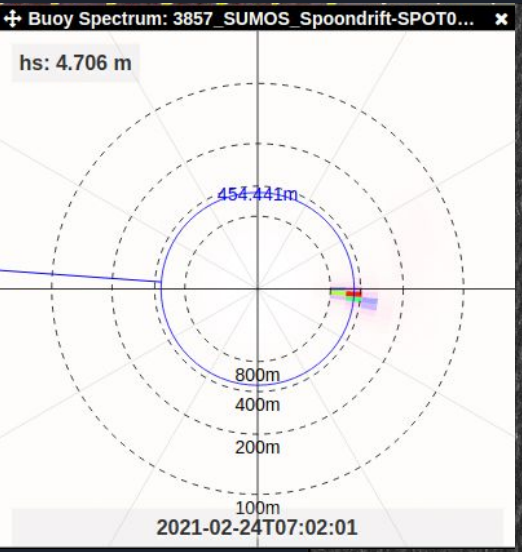


Feb. 24 2021 8am : narrow western Swell



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Feb. 24 2021 8am : very narrow western Swell

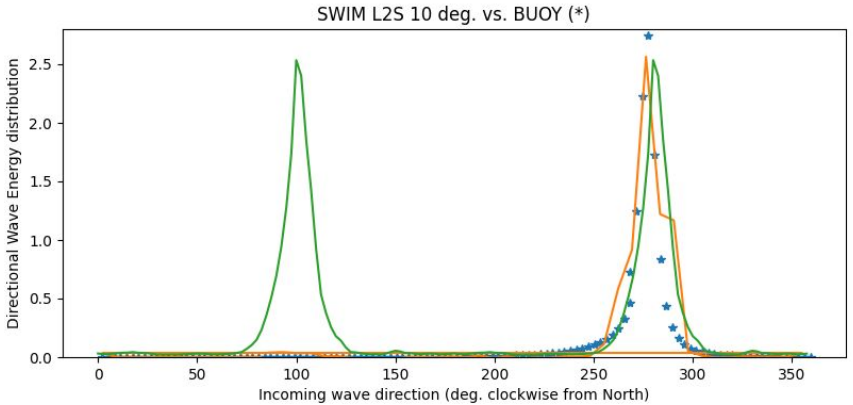
SWIM 10° beam

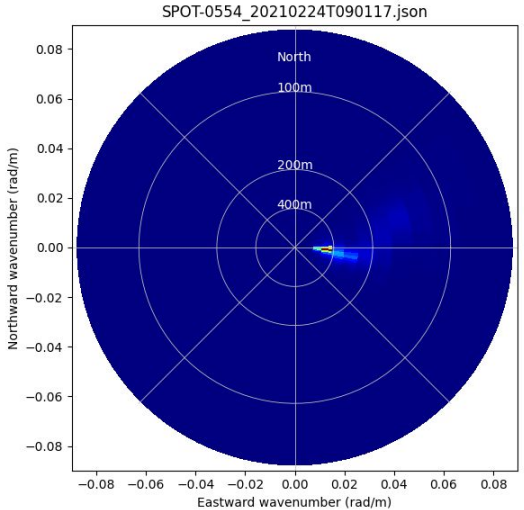
Directional spread : swell 450m

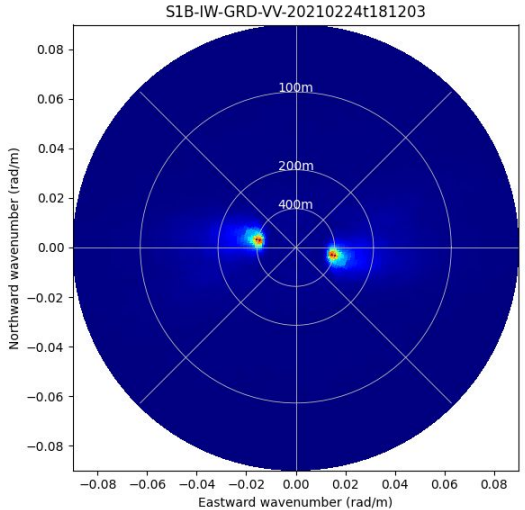
BUOY : 12°

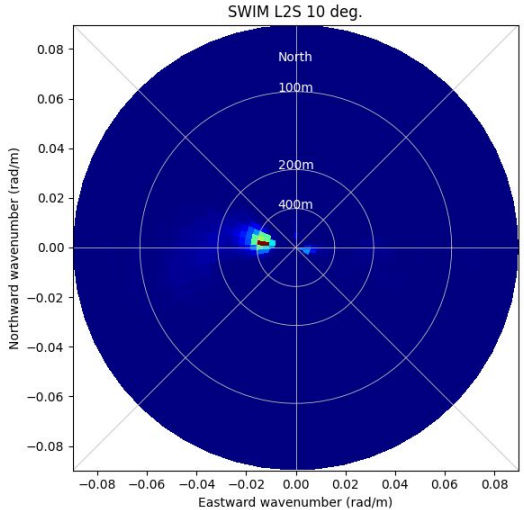
SAR : 14°

SWIM : 16°









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Feb. 24 2021 8am : very narrow western Swell

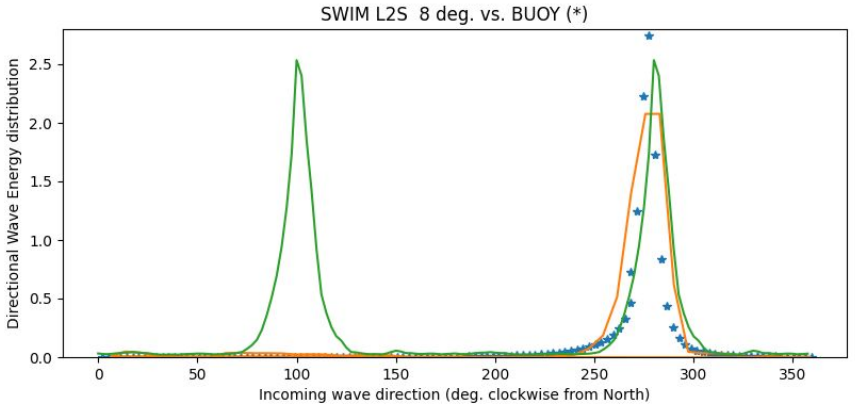
SWIM 8° beam

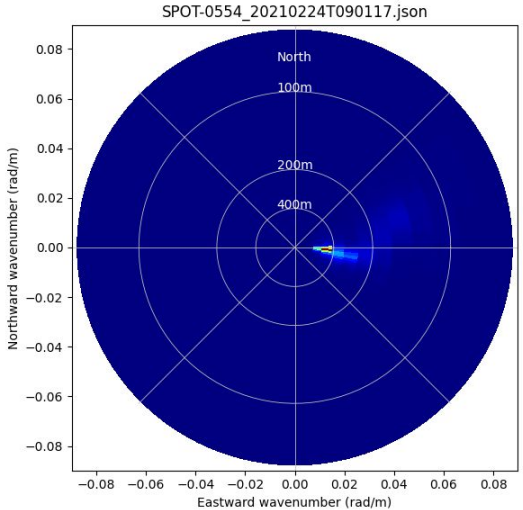
Directional spread : swell 450m

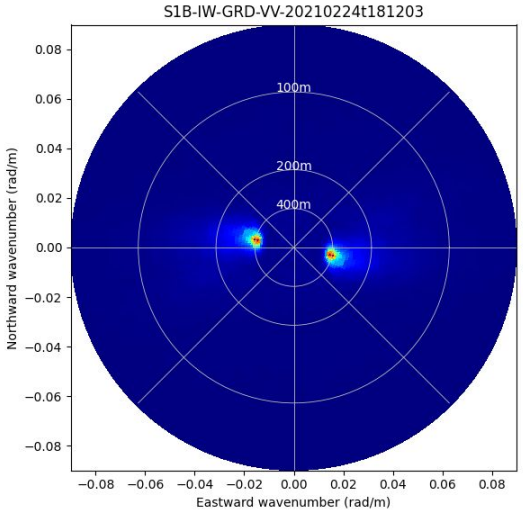
BUOY : 12°

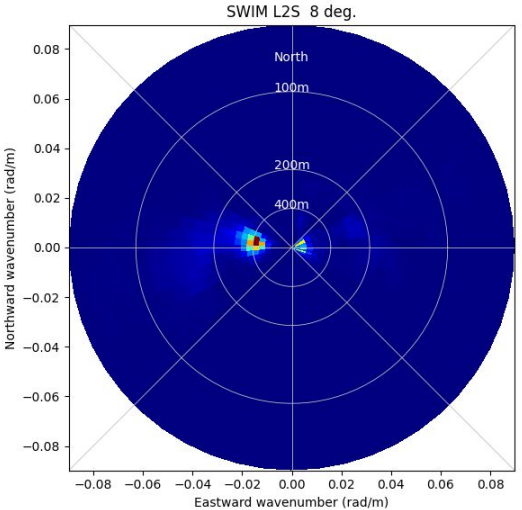
SAR : 14°

SWIM : 22°









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Feb. 24 2021 8am : very narrow western Swell

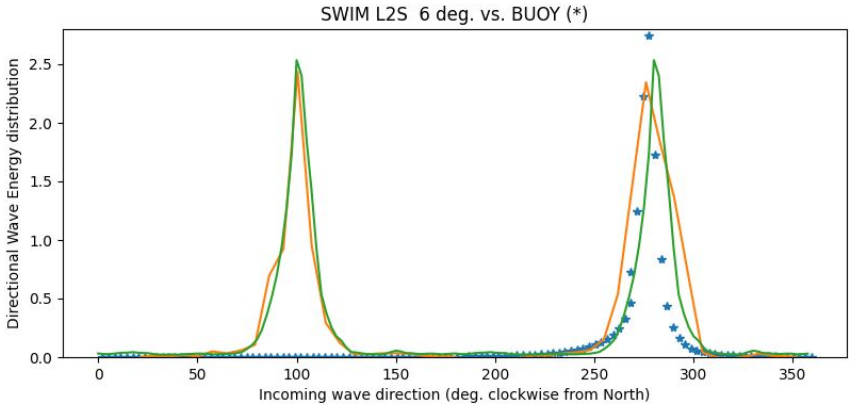
SWIM 6° beam

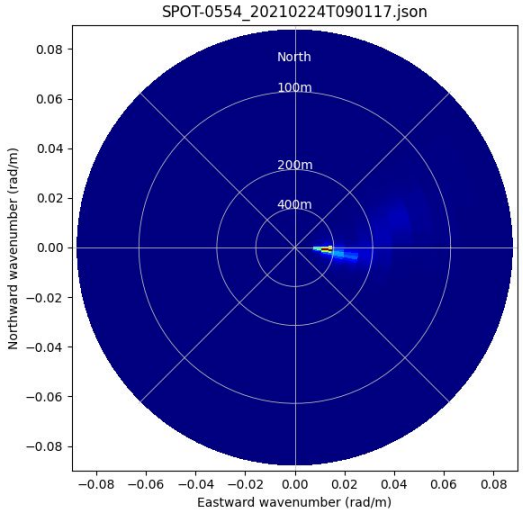
Directional spread : swell 450m

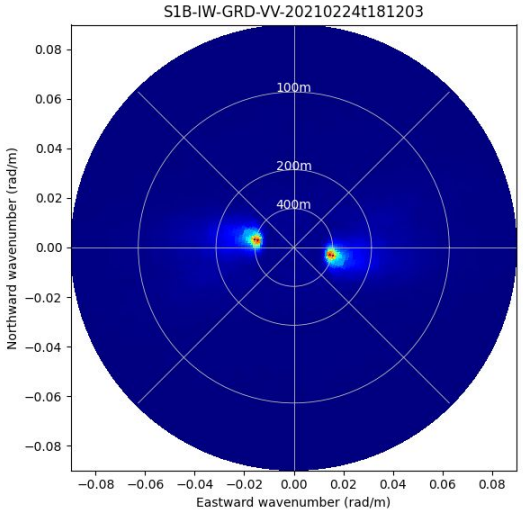
BUOY : 12°

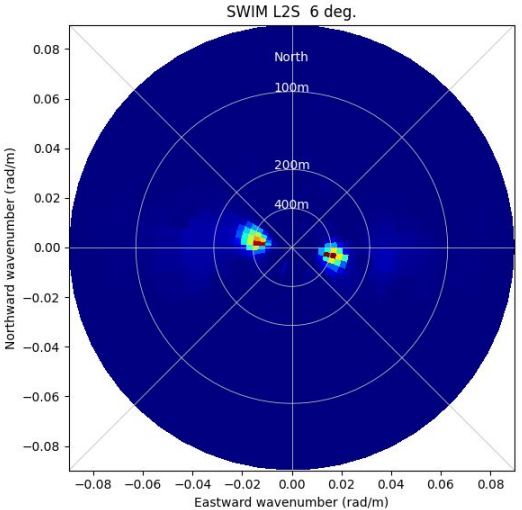
SAR : 14°

SWIM : 26°









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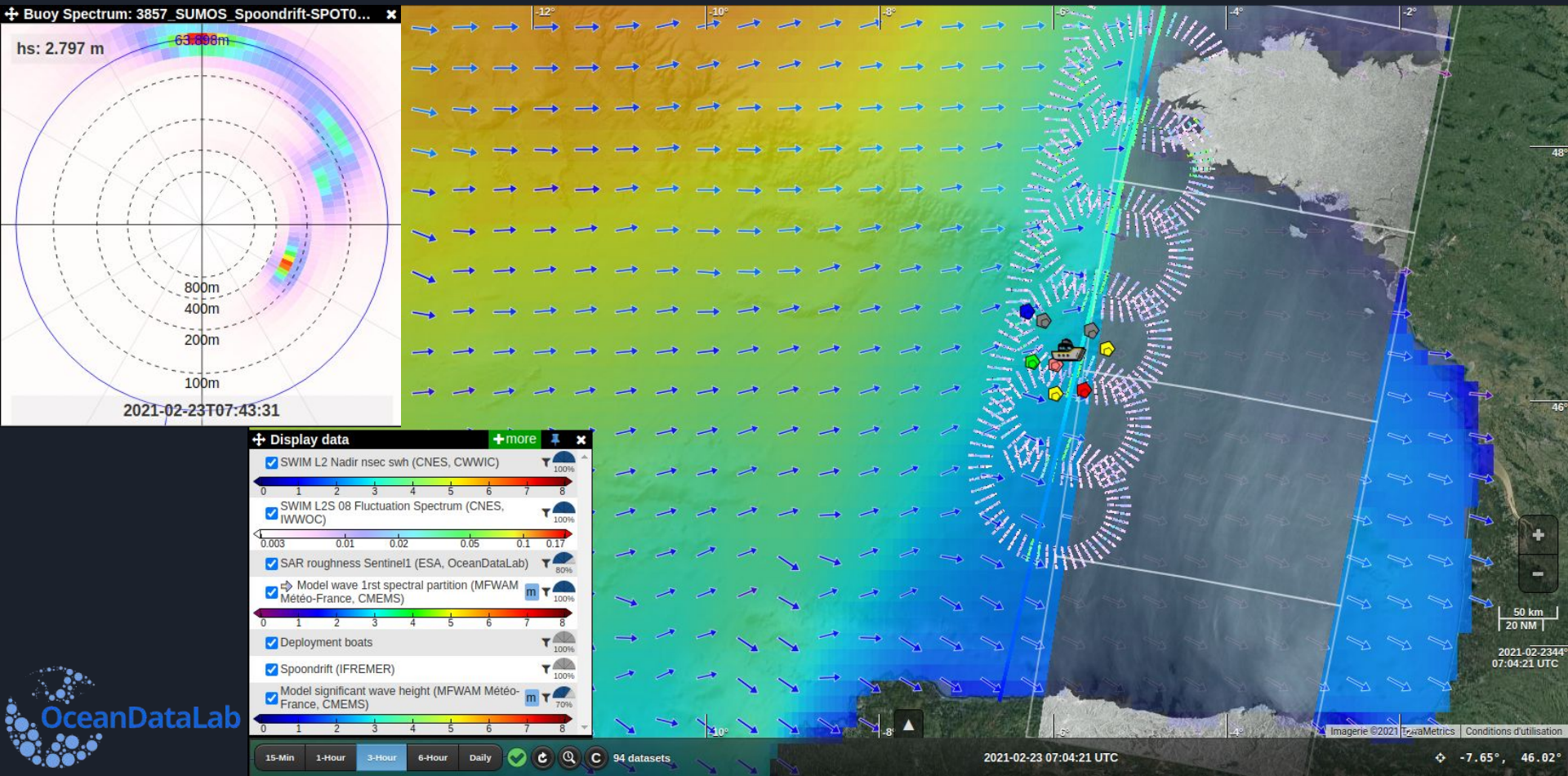
Feb. 23 2021 7am : Cross swell and Wind Sea



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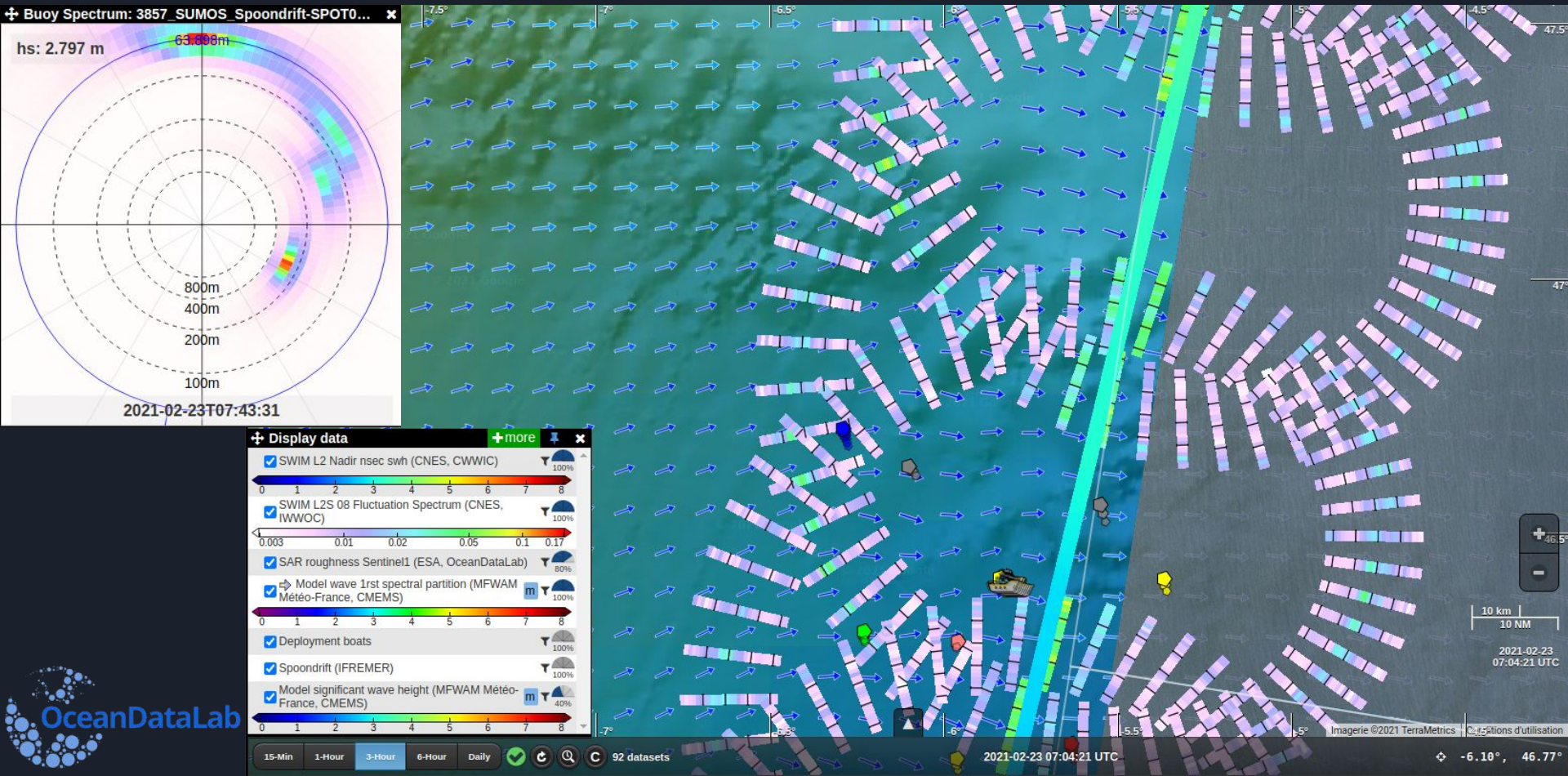
Feb. 23 2021 7am : Cross swell and Wind Sea



OceanDataLab

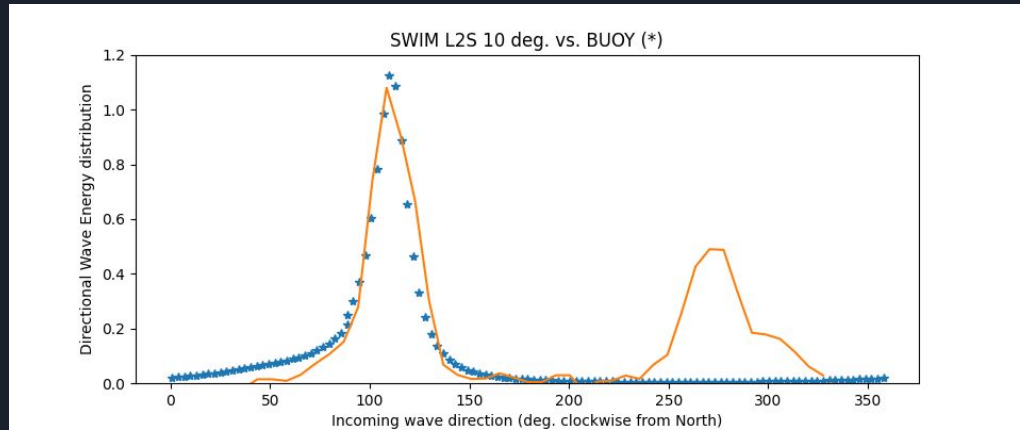
Feb. 23 2021 7am : Cross swell and Wind Sea

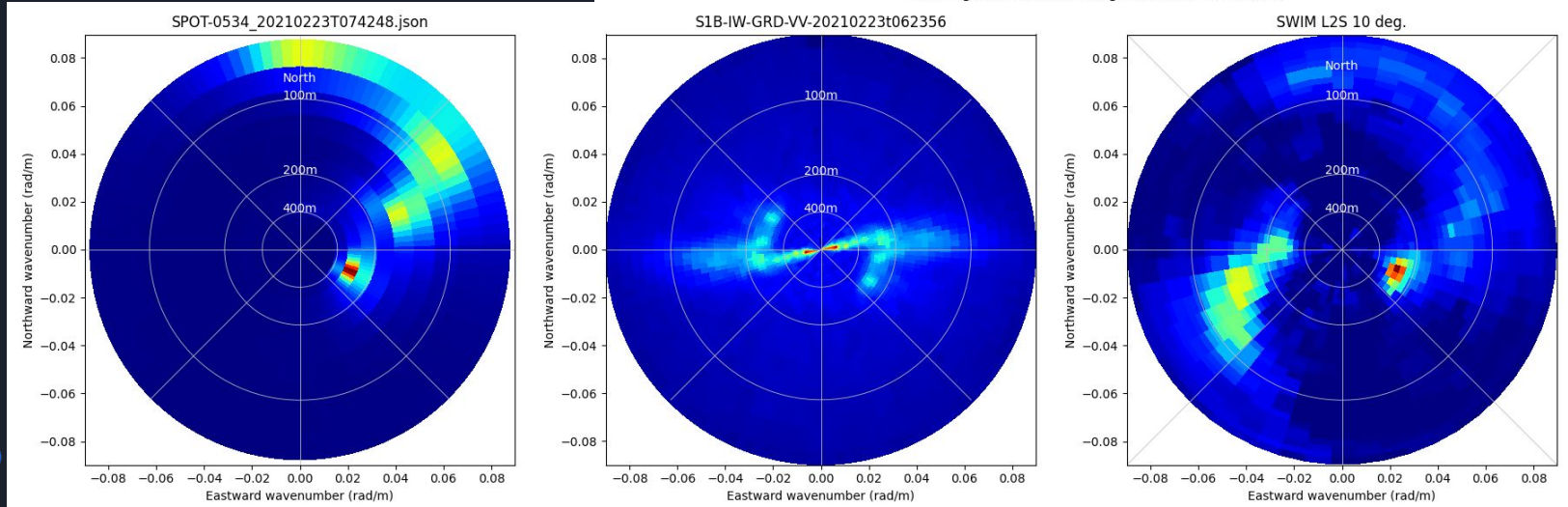
SWIM 10° beam

Directional spread : swell 450m

BUOY : 22°

SWIM : 28°





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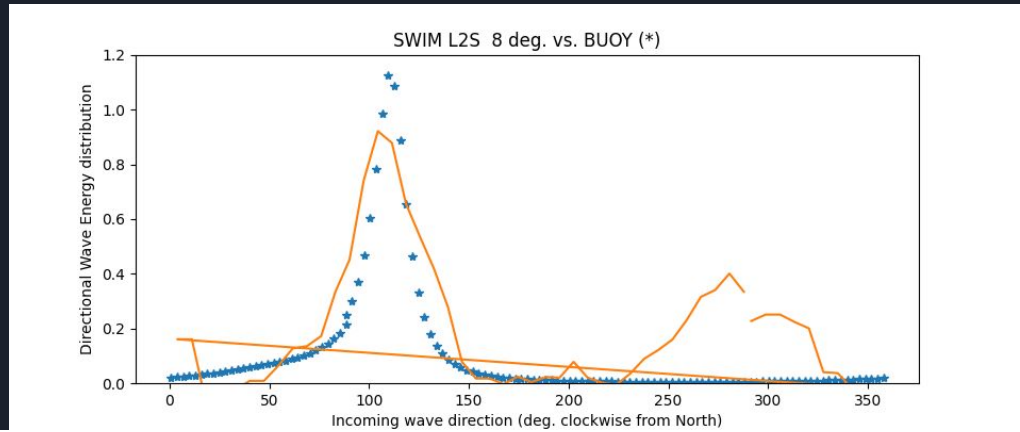
Feb. 23 2021 7am : Cross swell and Wind Sea

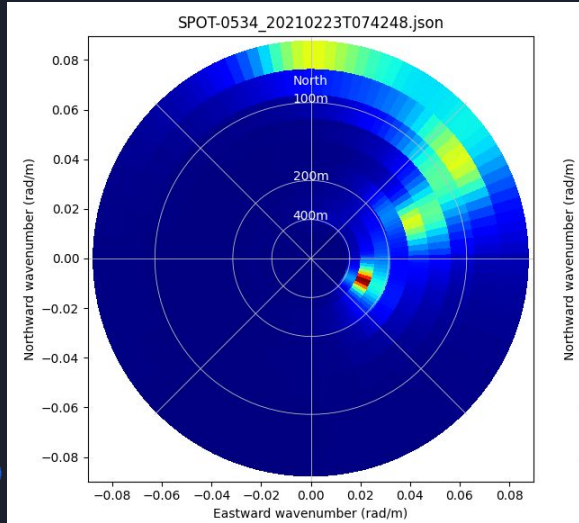
SWIM 8° beam

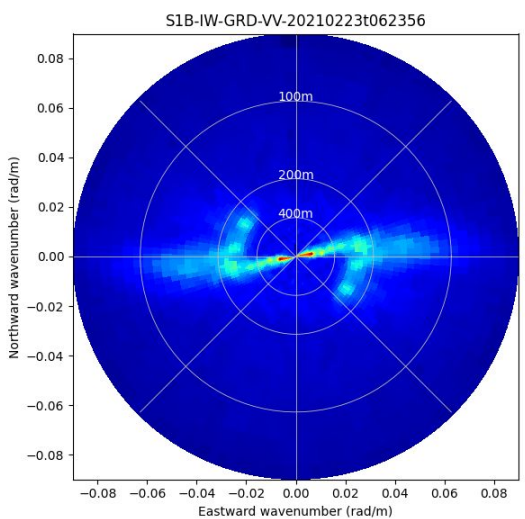
Directional spread : swell 450m

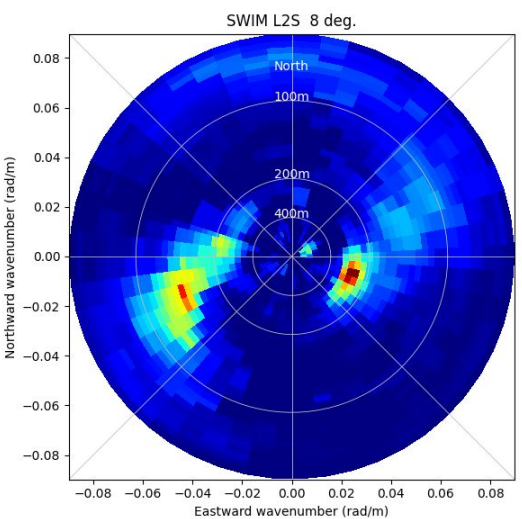
BUOY : 22°

SWIM : 38°









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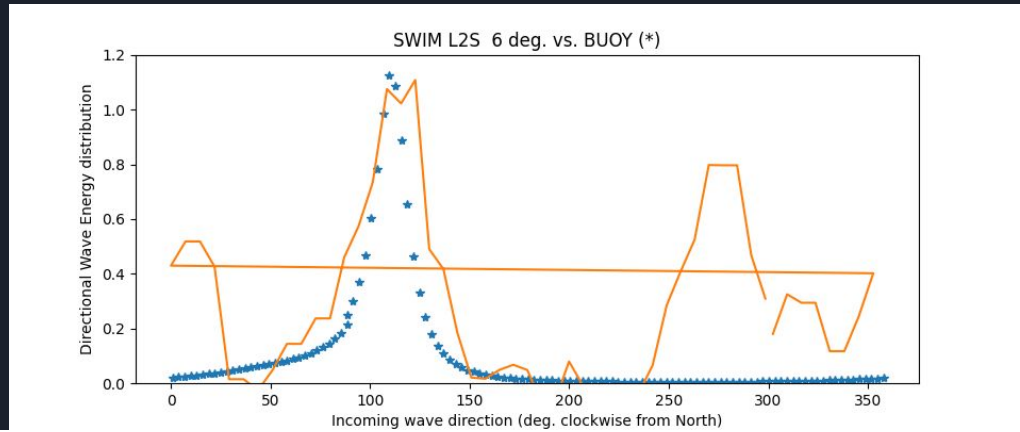
Feb. 23 2021 7am : Cross swell and Wind Sea

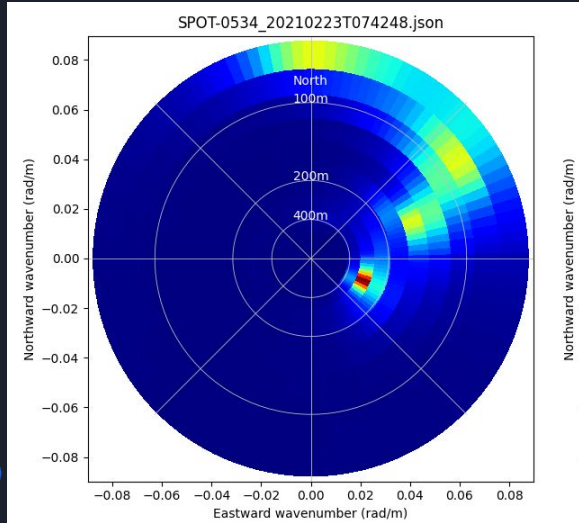
SWIM 6° beam

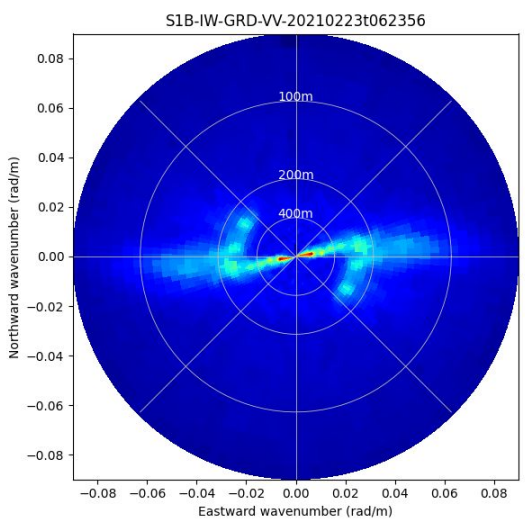
Directional spread : swell 450m

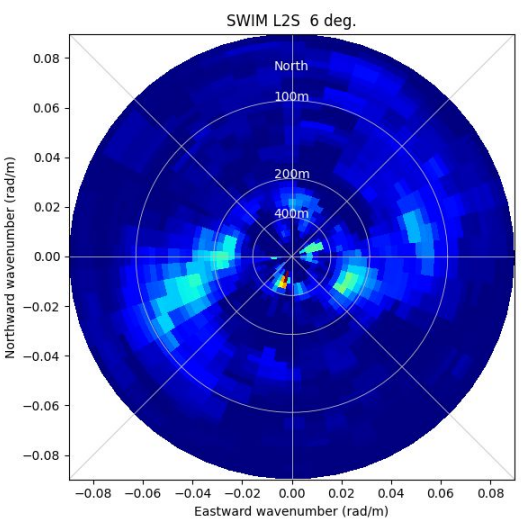
BUOY : 22°

SWIM : 38°









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Conclusion

SWIM has a good directional resolution when compared to SAR and directional buoys and slightly higher than theoretical estimates

The directional resolution is higher for narrow directional wave spectra. This could be en effect of the crest length vs. azimuthal aperture.

10° beam has a mean directional resolution of about 13°

8° beam has a mean directional resolution of about 15°

6° beam has a mean direction resolution of about 18°

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