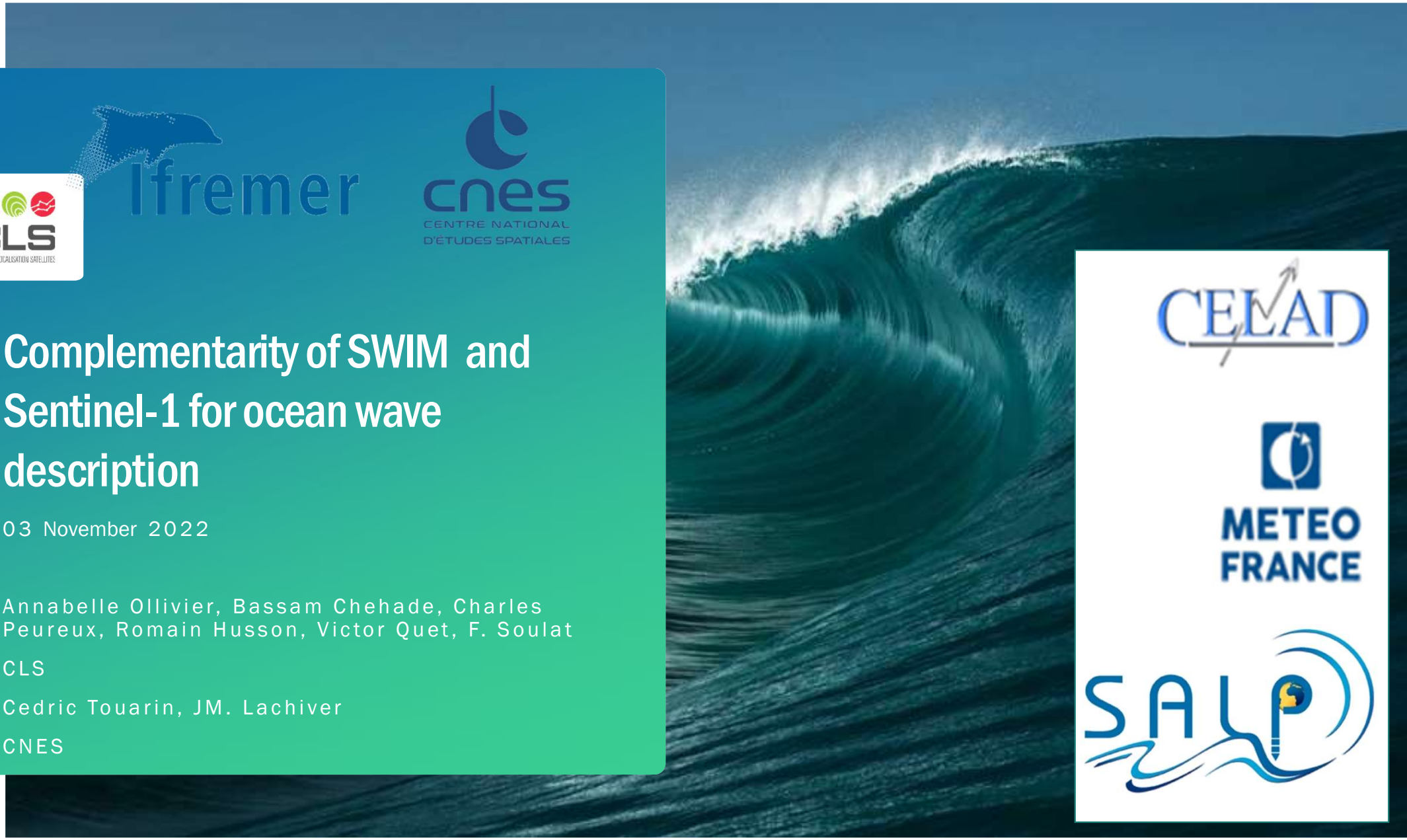


Complementarity of SWIM and Sentinel-1 for ocean wave description

03 November 2022

Annabelle Ollivier, Bassam Chehade, Charles Peureux, Romain Husson, Victor Quet, F. Soulat

CLS

Cedric Touarin, JM. Lachiver

CNES

SWIM and S1 complementarity

Altimetry retrieves a 1 dimension estimate of ocean waves.

Hs = SWH= global energy of the wave.

But today, more than ever, it is important to go further in our understanding of Sea States Effects.

- 1km-50km Bump effect (see AOllivier's talk on 5Hz wave products)
- Wave group characterisation (Marine De Carlo et al. juste before)
- Doppler SAR biases…
- SWOT coming…

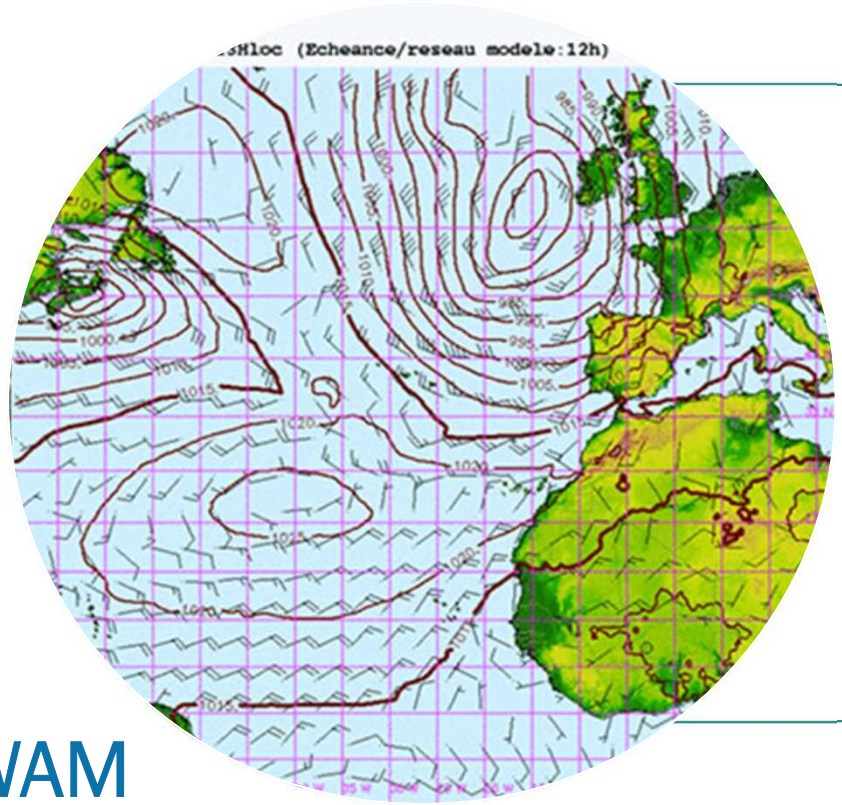
➔ A 2D spectral approach is needed!

Since 3 years: unique opportunity to observe Sea States with both CFOSAT and Sentinel-1. **How can they complement eachother? What are their best skills?**

Overview

- Where do SWIM/ S1 observe Sea States?
- What do they observe?
- How?
- S1 best observation domain
- SWIM best observation domain
- What about mixing skills?

SWIM and S1 Datasets used

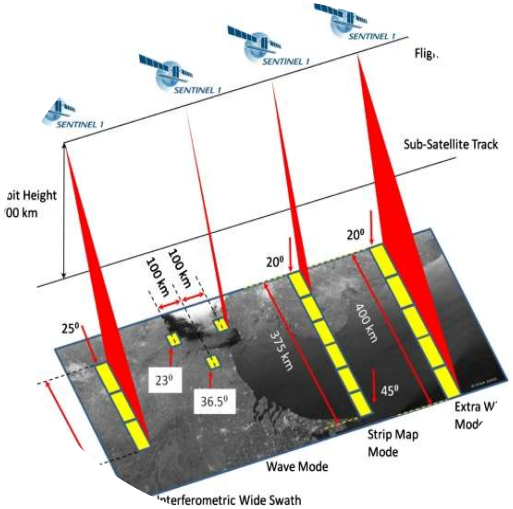


WAM

All data, collocated with SWIM (MF production for Calval group)

Swim: L2P

- VALID DATA : flag_valid_swh_box = 0
- Non-VALID DATA : flag_valid_swh_box = 1

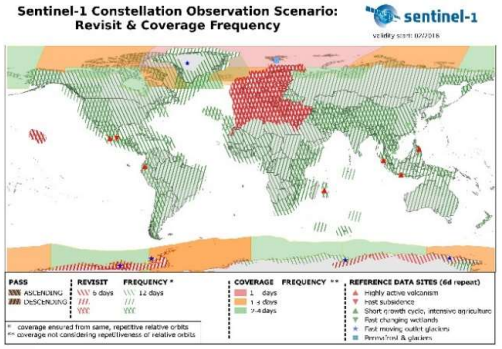


Sentinel-1: L2 wave mode

- VALID DATA : Quality flag of partition #1 = 0, 1 ou 2 (3/5 niveaux)
- Non-VALID DATA : Quality flag of partition #1 = 3 ou 4

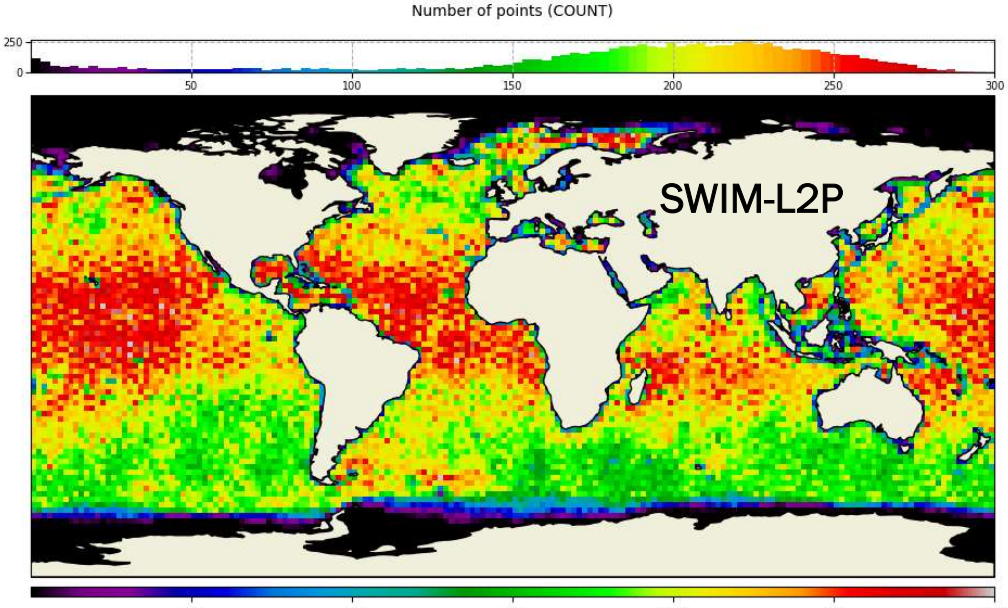
Global coverage of ocean data number of observations

Compared to SWIM, S1 misses some areas mainly near coasts and North Altlantic.

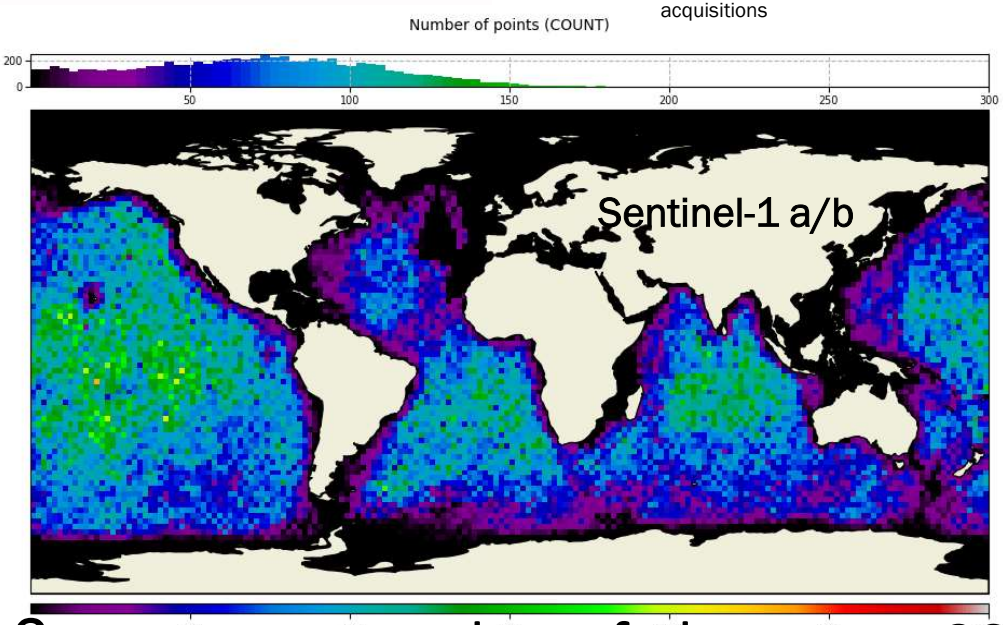


All blank areas correspond to wave mode acquisitions

April-May-June 2021



April-May-June 2021



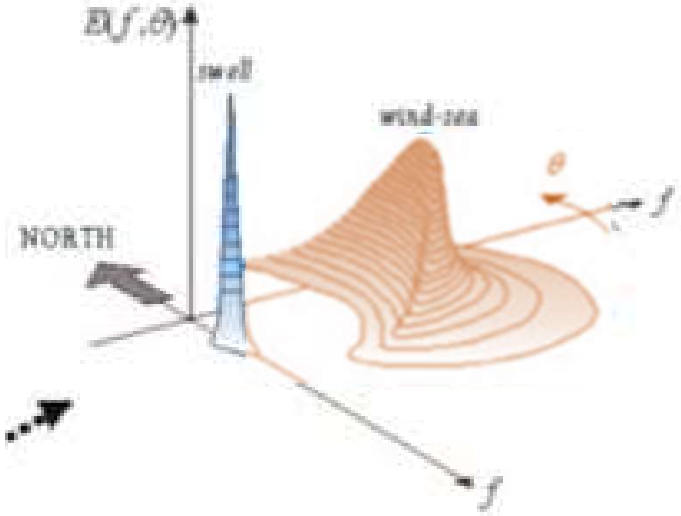
0 number of obs 300

0 number of obs 300

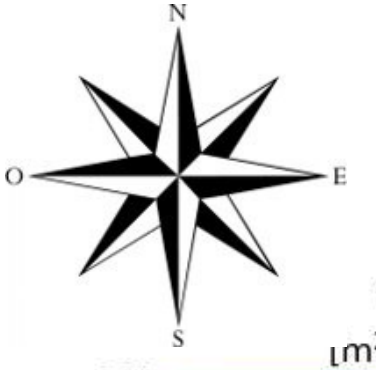
Sea State: what we look

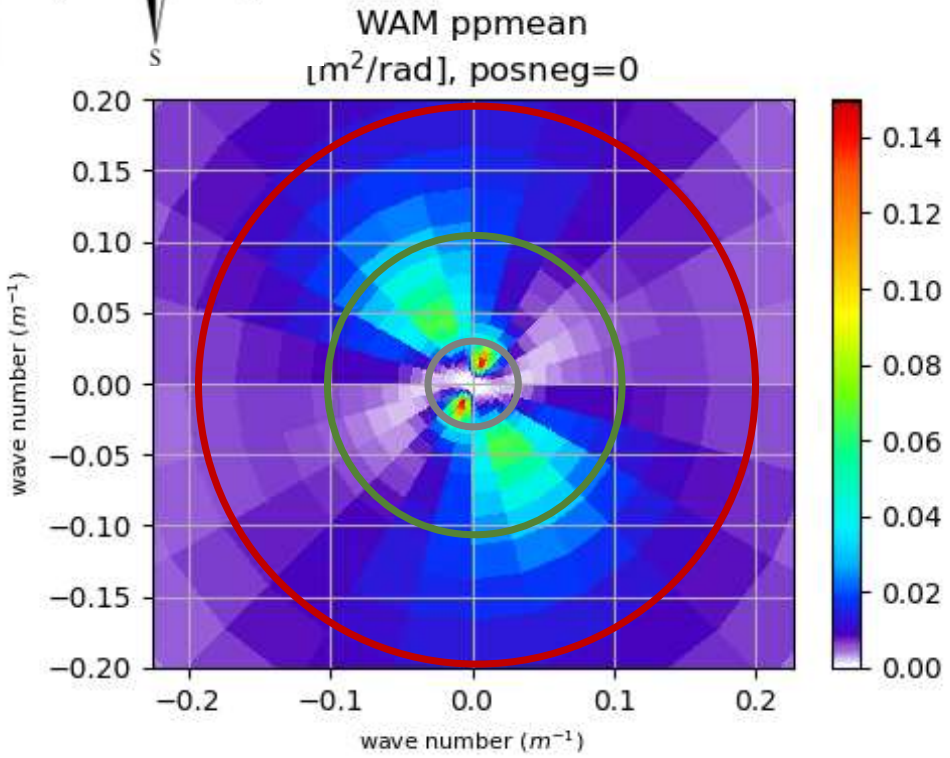
Large swell

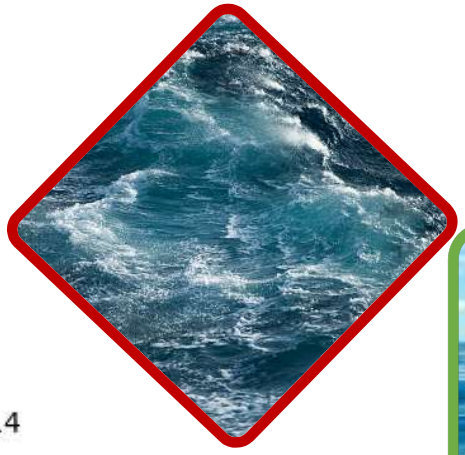
Wind sea



Large Swells, wind waves, or both?







Wavelength < 200m,

Wind wave dominating,

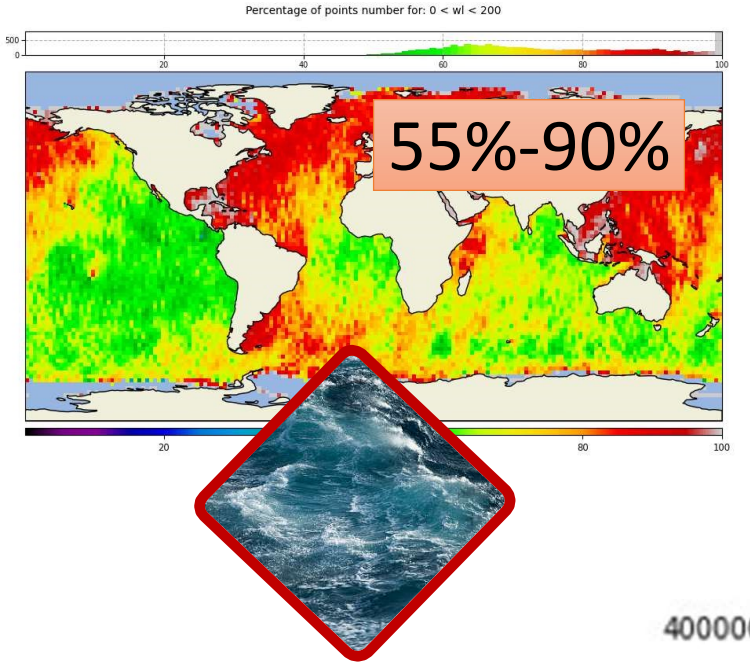
Wavelength between 200 and 500m,

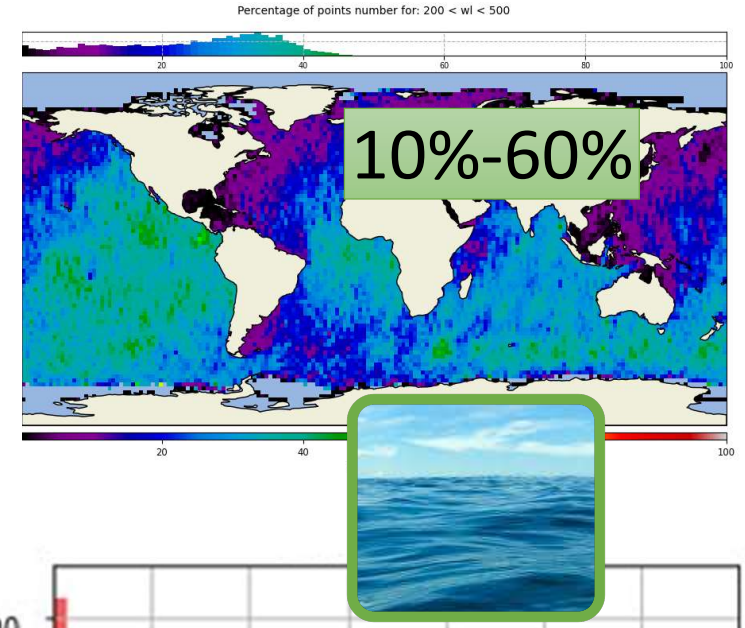
Mixed seas with swell

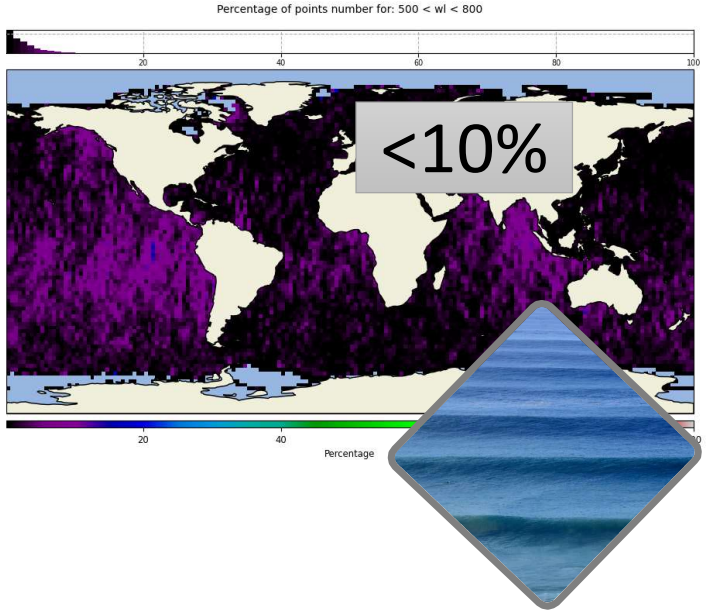
Class3: Wavelegth>500m,

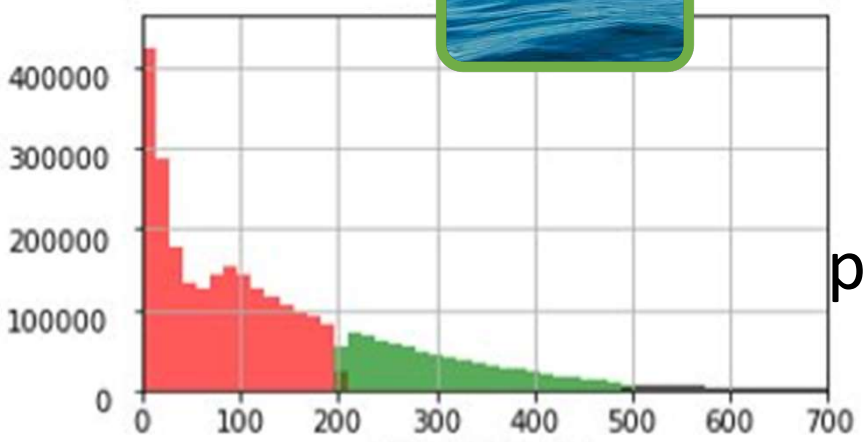
Very large swells,

The different types of waves



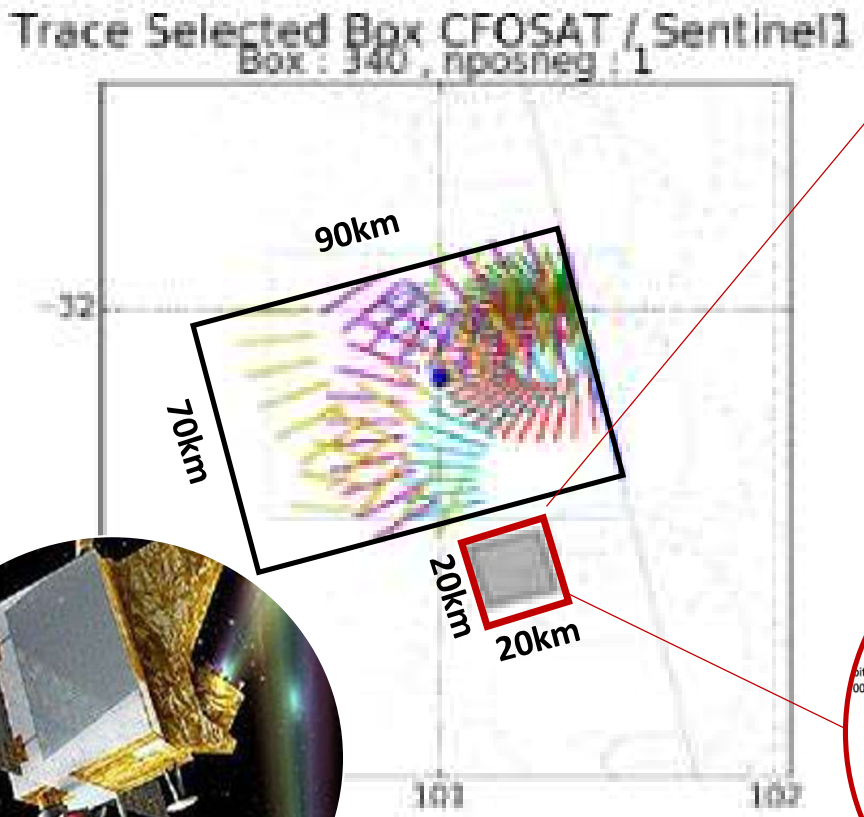






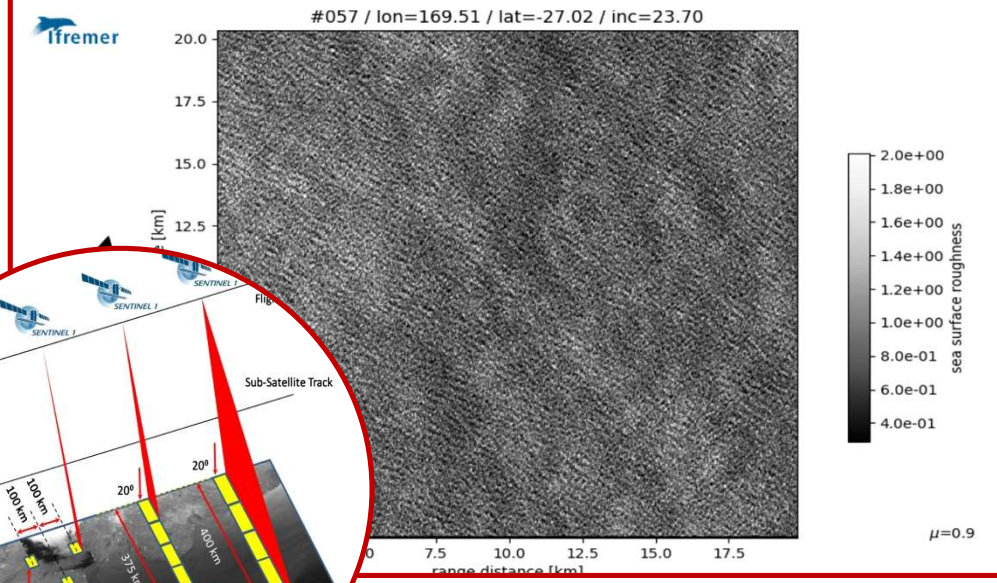
% of occurrence probability w.r.t WAM

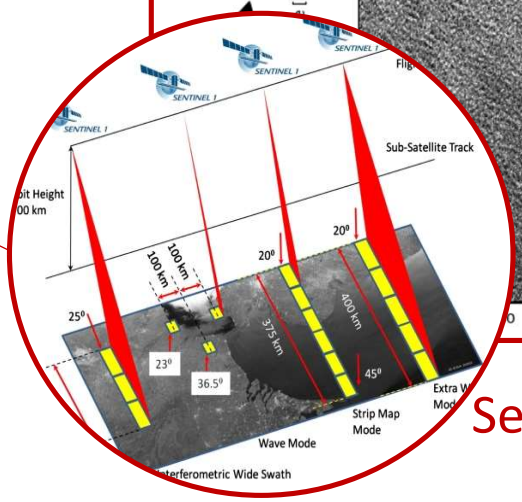
Sea State: how they look ?



SWIM

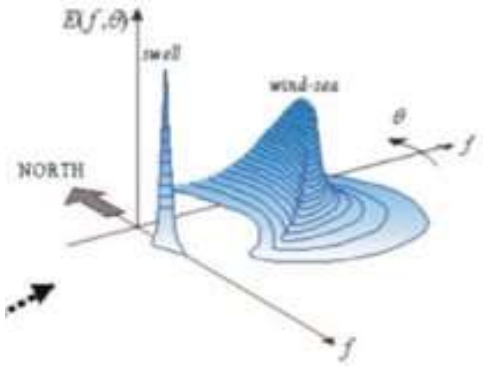
Advantage of S1: the existence of imagettes
(https://xwaves.ifremer.fr)





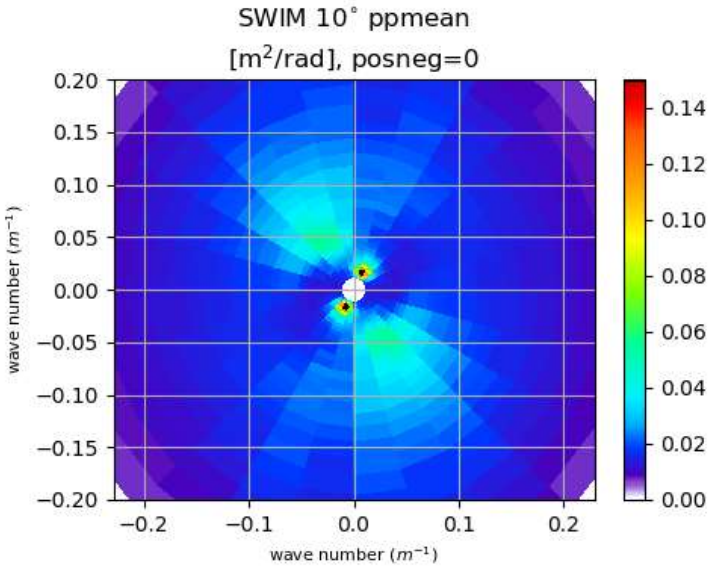
Sentinel-1 wave-mode

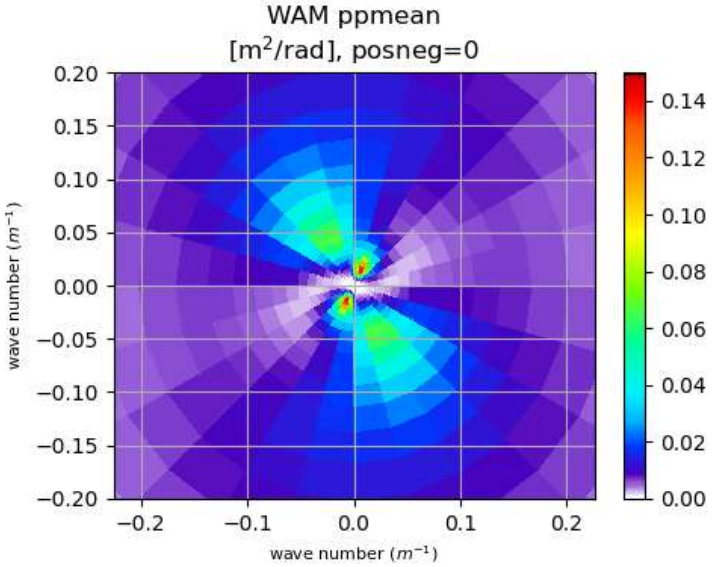
Large Swells, wind waves, or both?

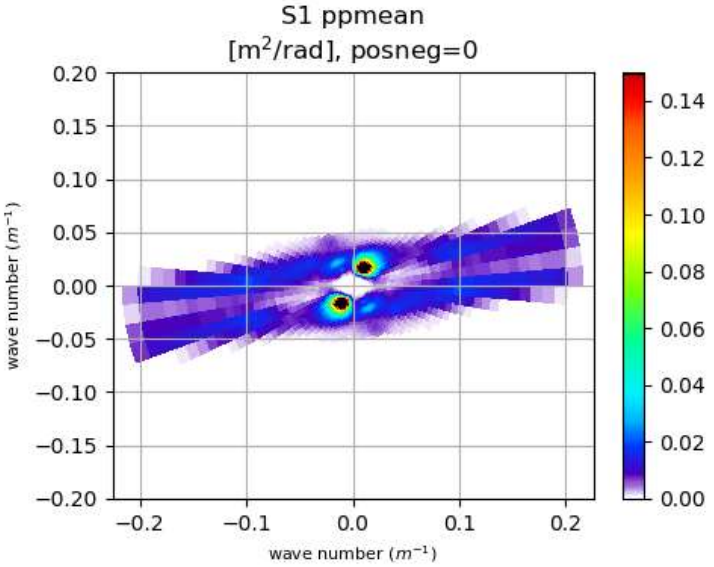


Mixed sea example for SWIM, WAM and S1:
(averaged over 10°/10° boxe)

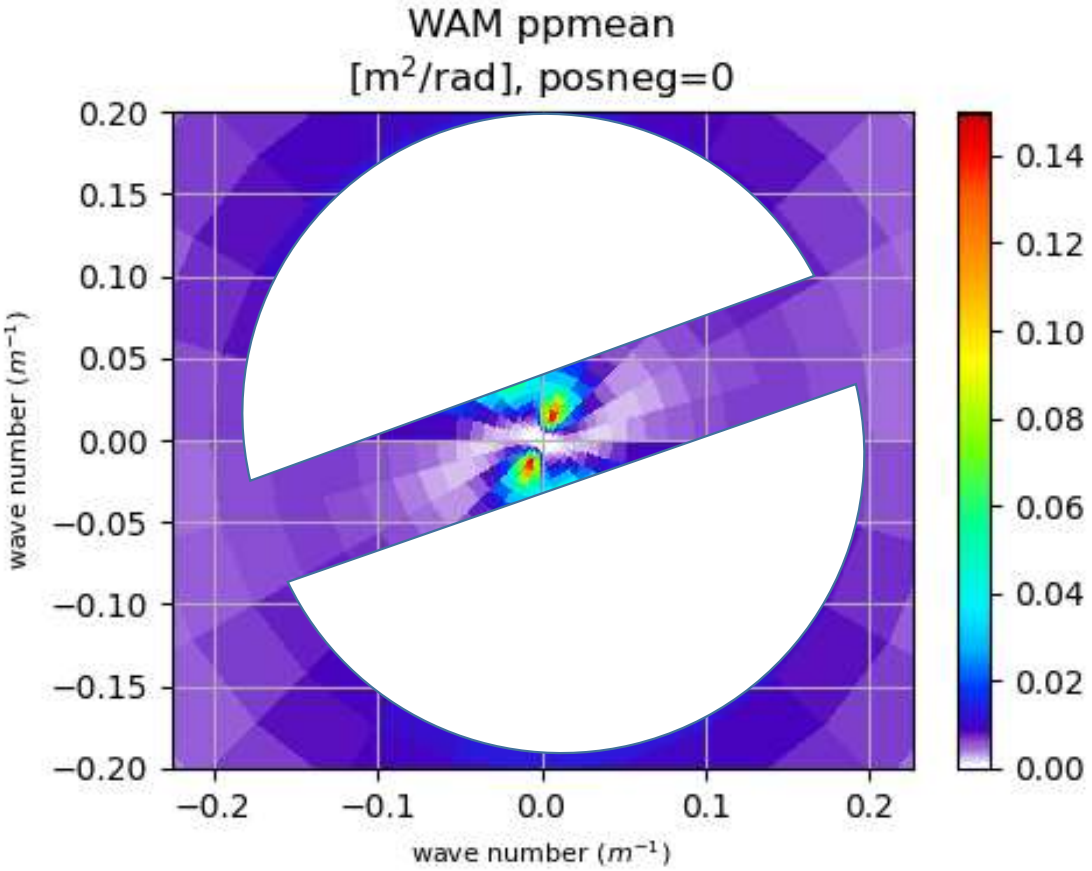
We **symetrised all spectra** to take into account the SWIM ambiguity in the direction (at 180°).

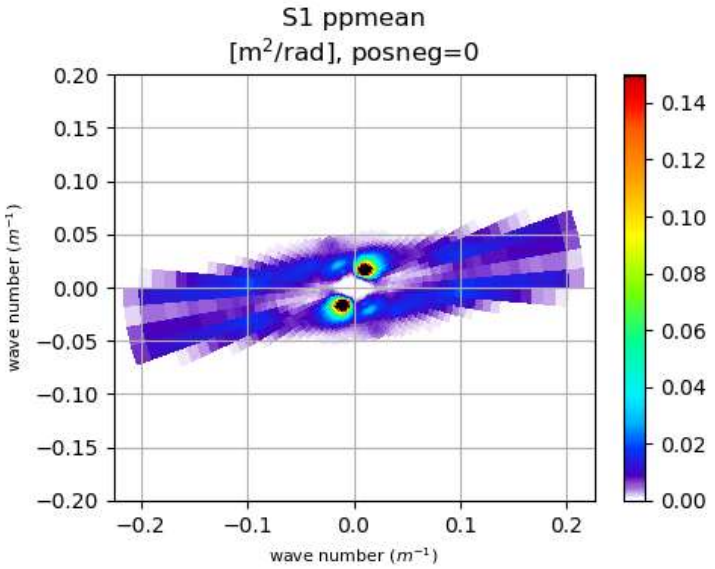






S1 azimut cut off limitation

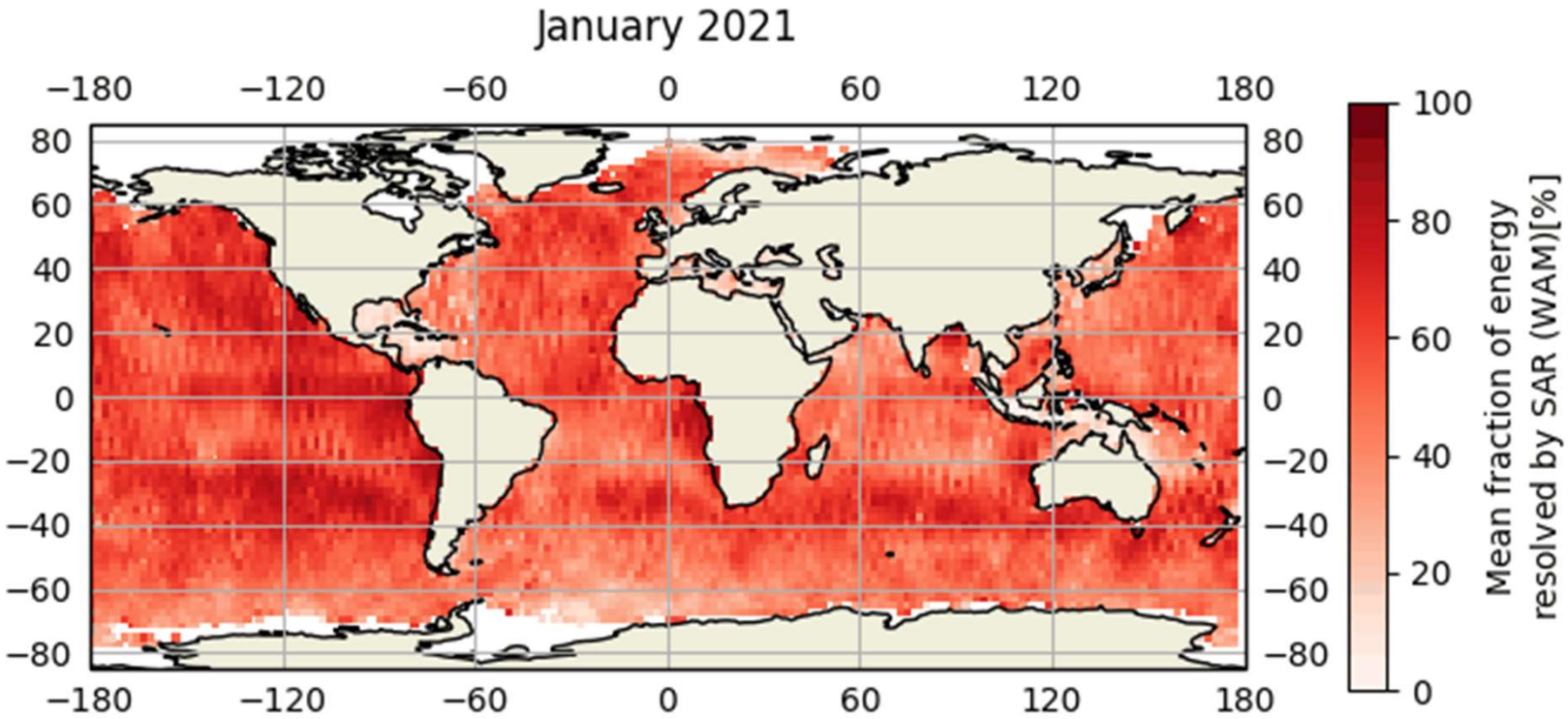




Sentinel-1 sees well very large scale swells

Sentinel-1 azimut cut off limitation

Mean fraction of energy resolved by SAR WAM % (red zones favorable for S1)

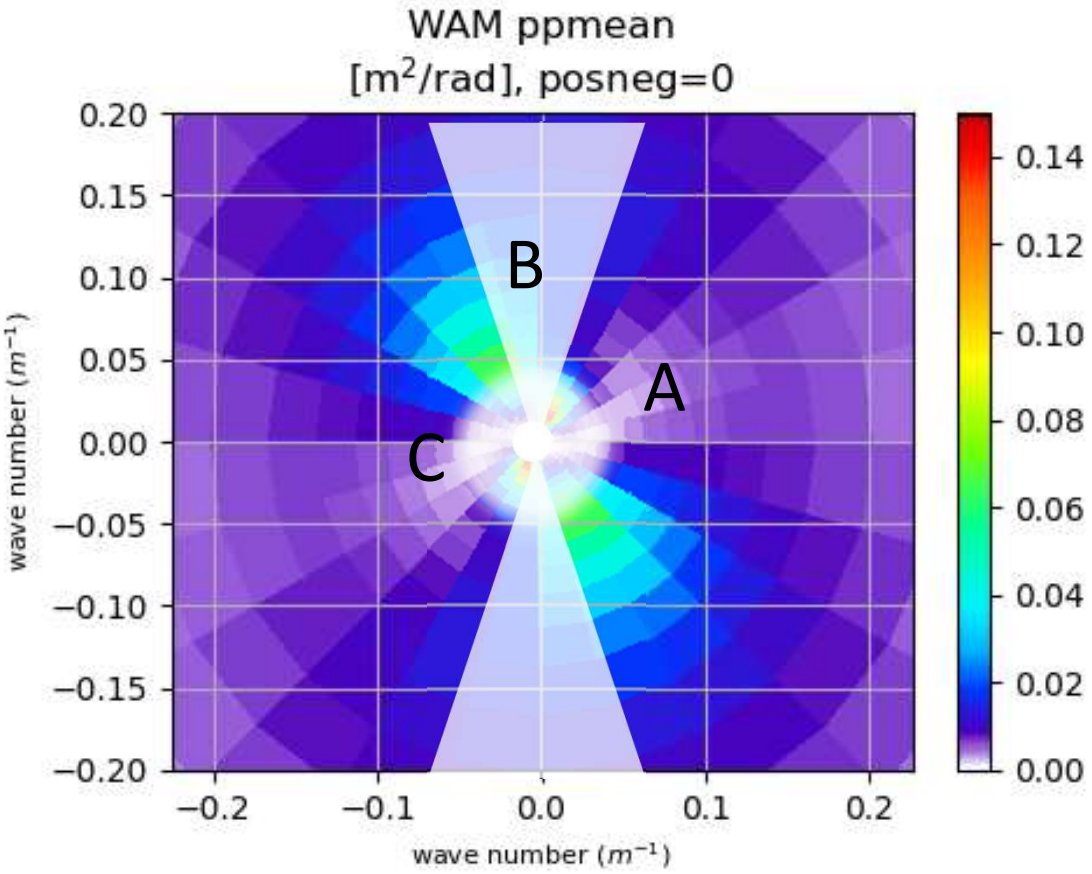


Red zones: Most favorable for Sentinel-1 (swell)

S1 misses information, mainly in wind-seas conditions.

Approximately 50% averaged over the year.

SWIM instrumental limitation



A - 500m mask (less than 10% of data) And

B- Speckle higher in the along track direction

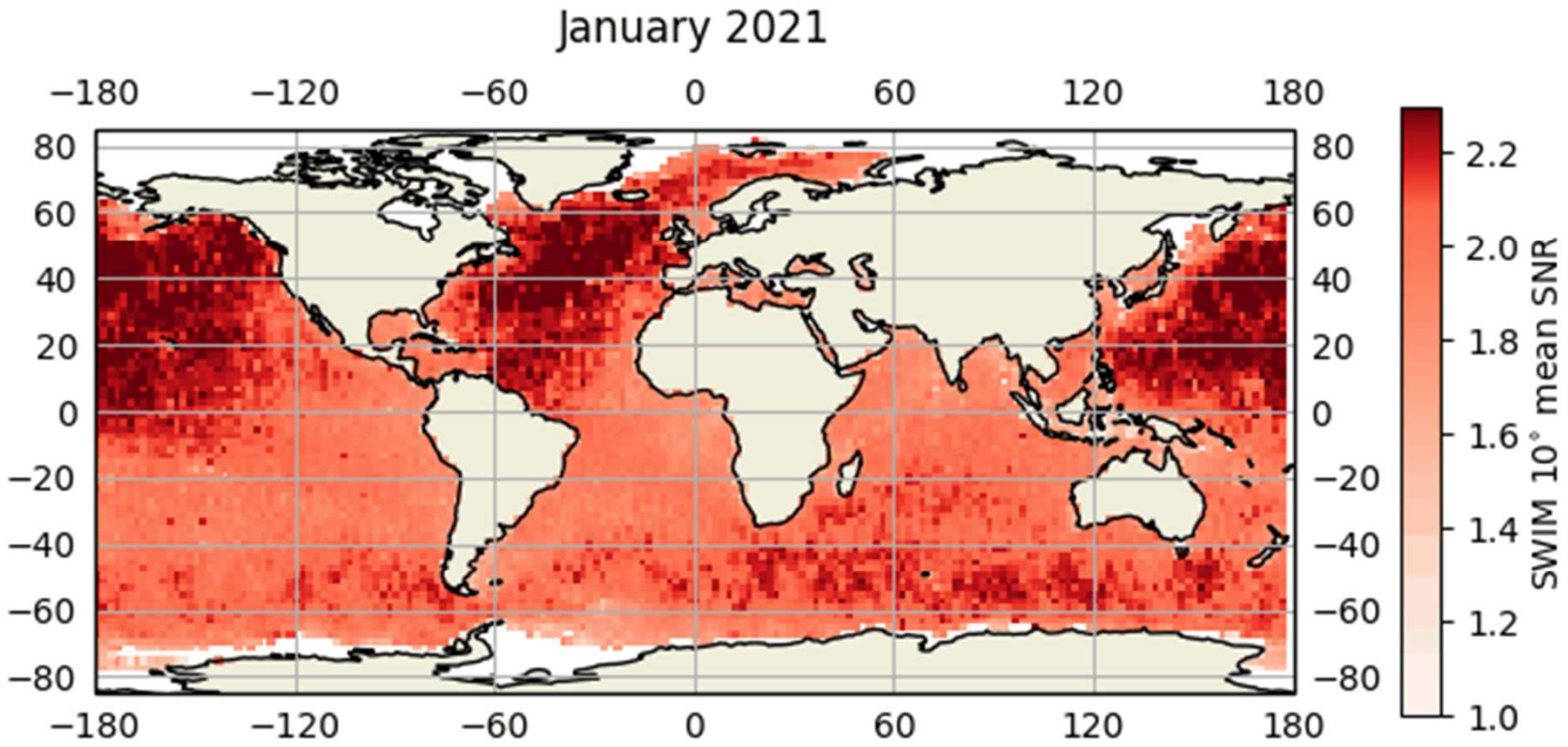
C- Parasitic peaks (weaker impact on slope spectra than on elevation spectra) appearing when Signal to Noise Ratio is too low

SWIM instrumental limitation

Still room for improvement to increase the signal to noise ratio in some areas. But valid observations everywhere.

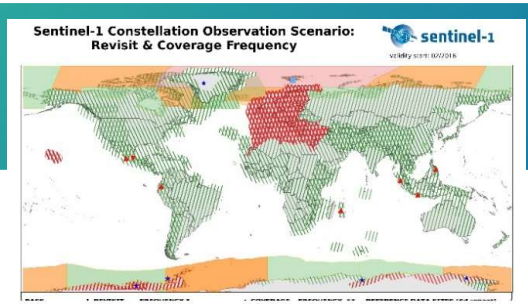
On SWIM side more work ongoing to:

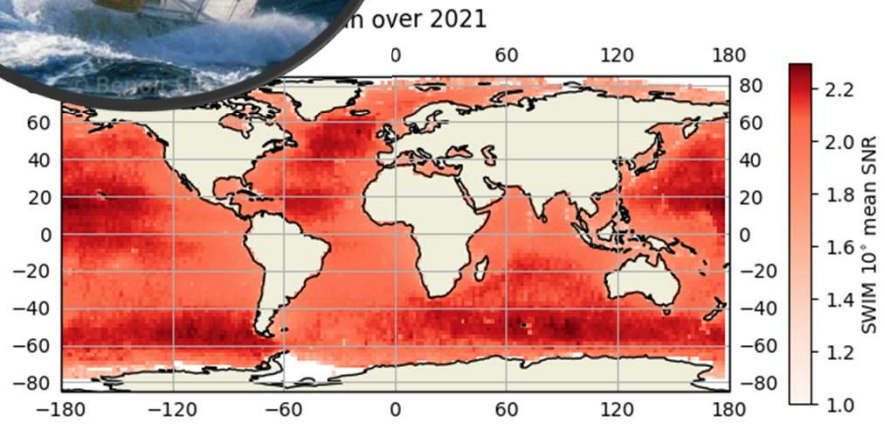
- Improve **spectral noise** (notably in the along track direction)
- Remove polluted data at the L1 level (on sigma0 profiles) thanks to
  - **Parasitic peaks studies**
  - **Atmospheric pollution**
  - **Coastal pollution**
- Raise the **ambiguity** at 180°

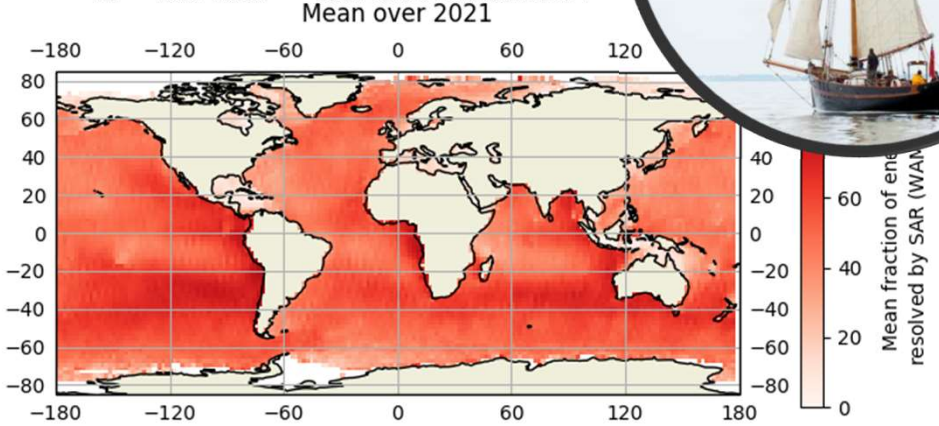


Red zones: Most favorable for SWIM observation: Signal >> Noise

In a nutshell…







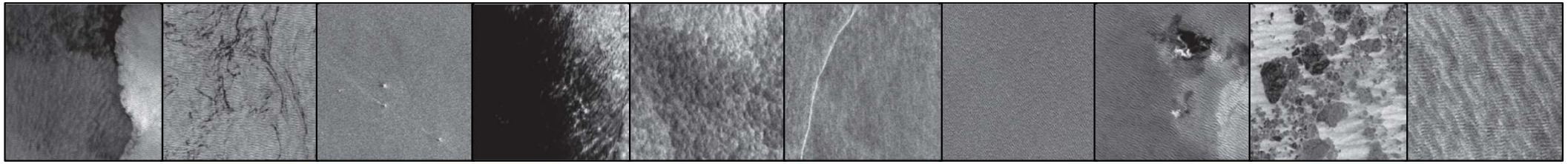
CFOSAT off nadir :

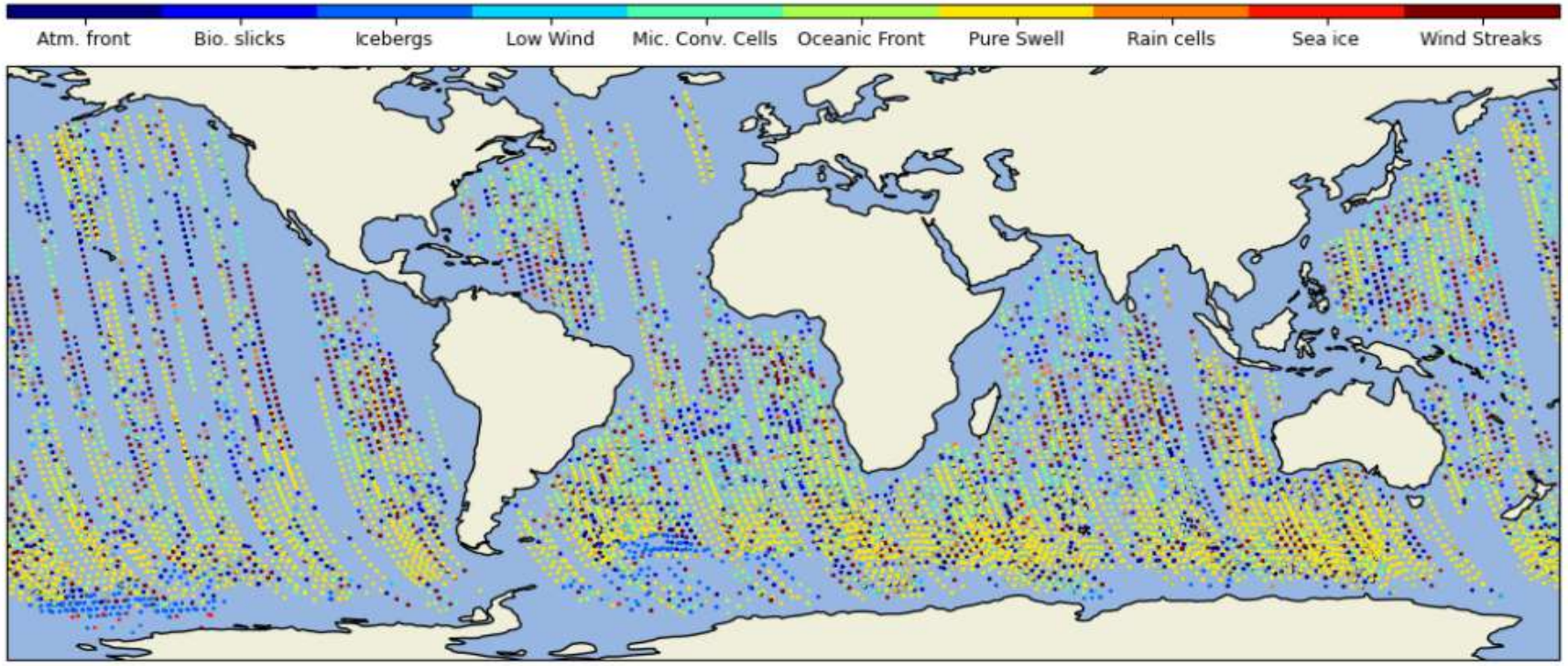
- ❑ Is young (4 year old) and sometimes noisy
- ❑ Loves raugh seas and strong swells
- ❑ Goes everywhere until 82°
- ❑ Can estimate almost all wave parameters
  (see C. Peureux's talk on Stokes drift)
- ❑ Has still some imperfections but works hard to get better

Sentinel-1 SAR wave mode:

- ❑ Is experienced (7/20 year old) and wise
- ❑ Loves long smooth swells
- ❑ Prefers seas without wind
- ❑ Never goes in North Atlantic and near costs
- ❑ Can see very accurate signatures and classifications

Merging CFOSAT and Sentinel-1 does great!





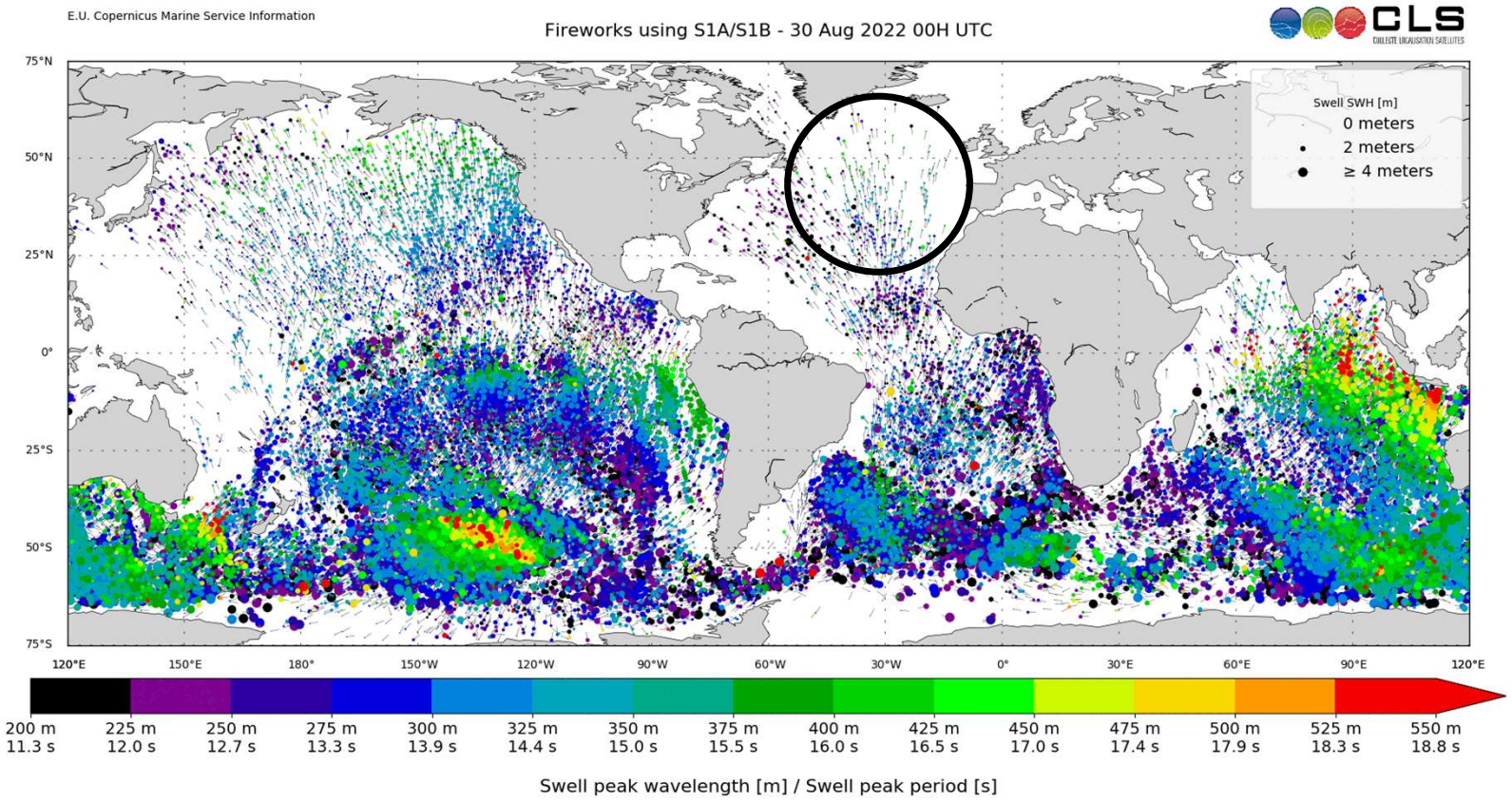
Colocation of Sentinel1 classification enables to better understand SWIM profiles behaviors.

SWIM--S1 Crossovers (100 km, 1h) over 6 cycles – S1 classifications

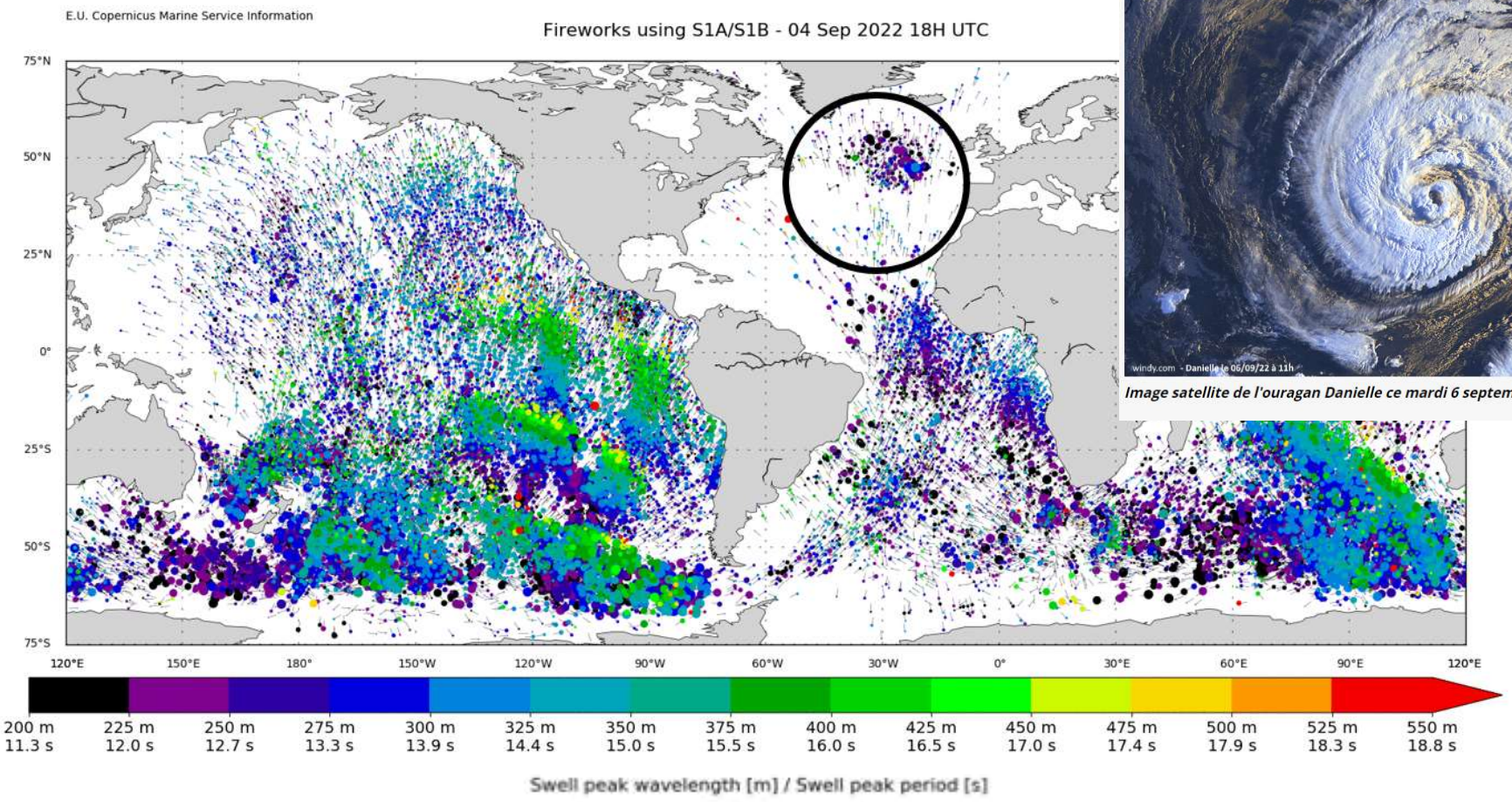
Merging CFOSAT and Sentinel-1 does great!

Fireworks products (L3 CMEMS since 2018) were built from S1 only. Since end 2021, they include CFOSAT and enable to catch storms in the North Atlantic where S1 never does.

Available here: http://satwave-report.cls.fr/



Merging CFOSAT and Sentinel-1 does great!



Ouragan Danielle : un emballement médiatique ?

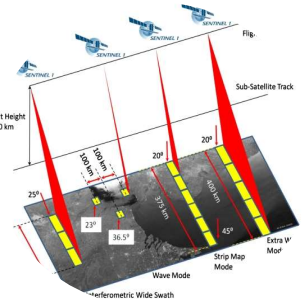
mardi 6 septembre 2022

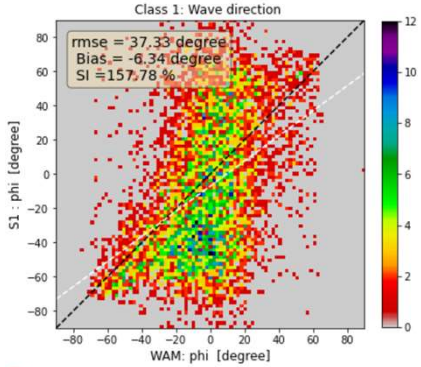
Image satellite de l'ouragan Danielle ce mardi 6 septembre 2022 - via windy.com

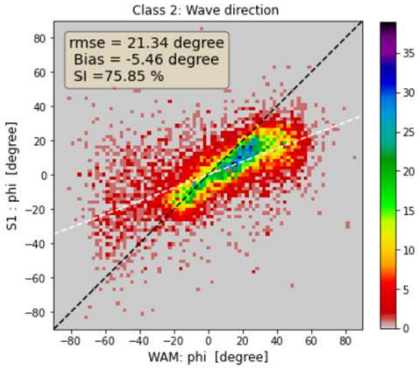
Thank you for your attention!

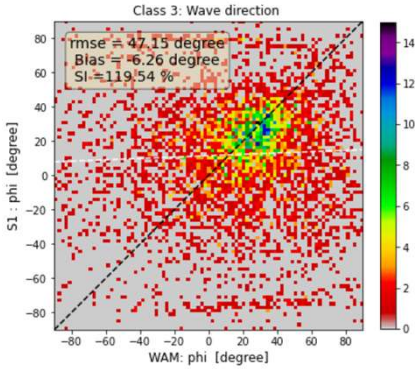
aollivier@groupcls.com

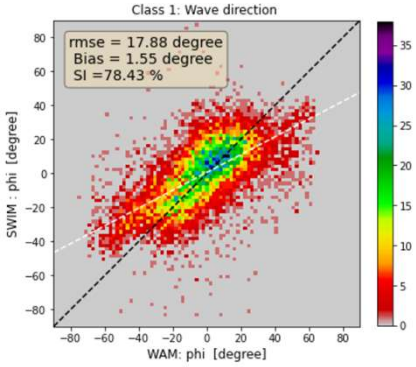
Direction observability

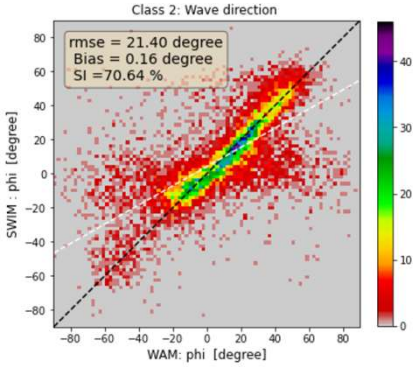


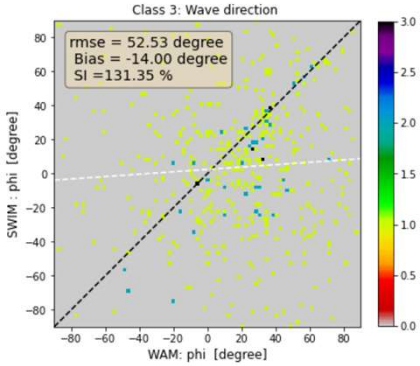




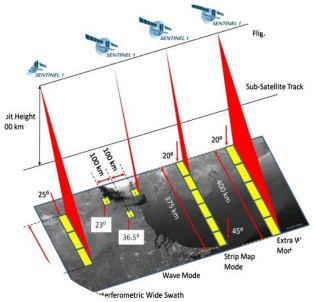


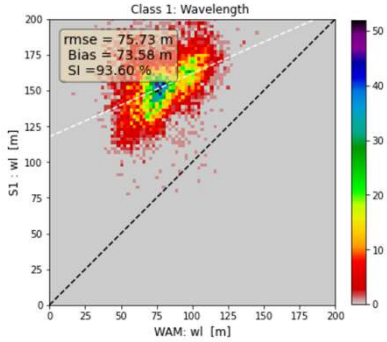


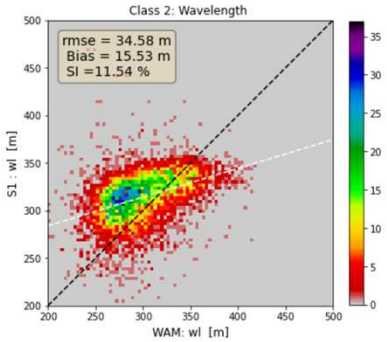


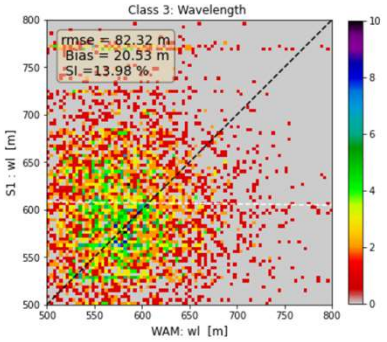


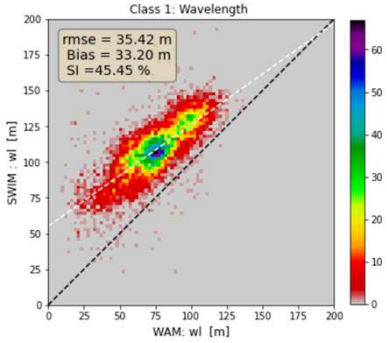
Wavelength observability

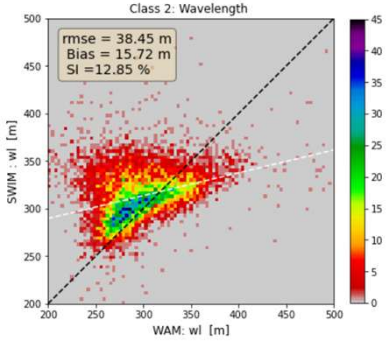


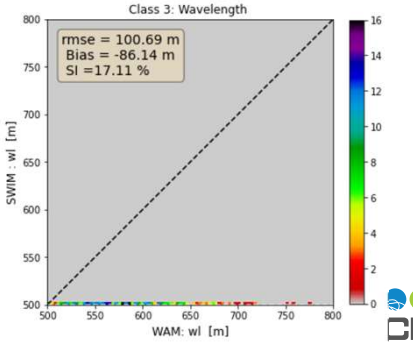












Hs observability