Complementarity of SWIM with respect to Sentinel-1 for ocean wave description

13 September 2022

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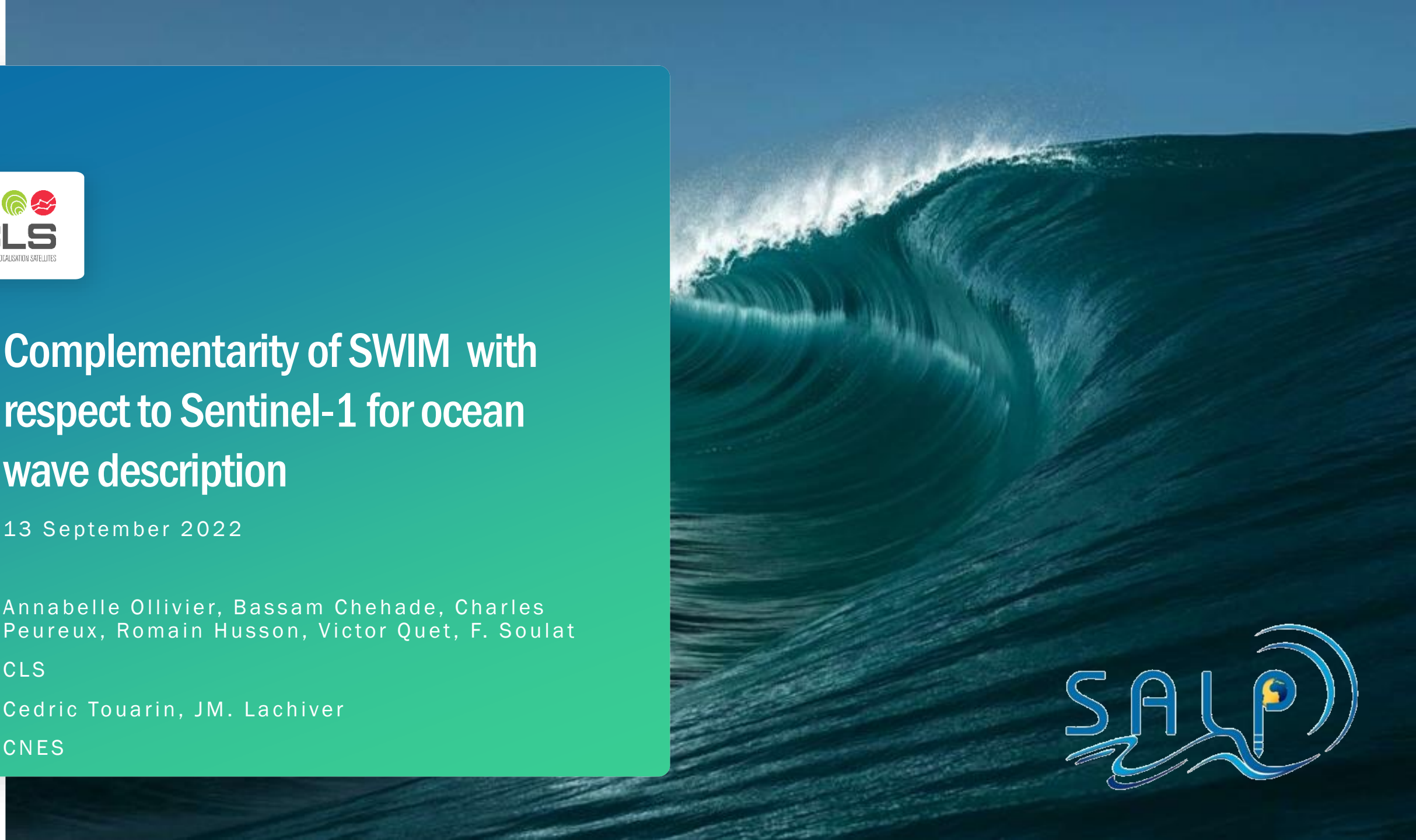
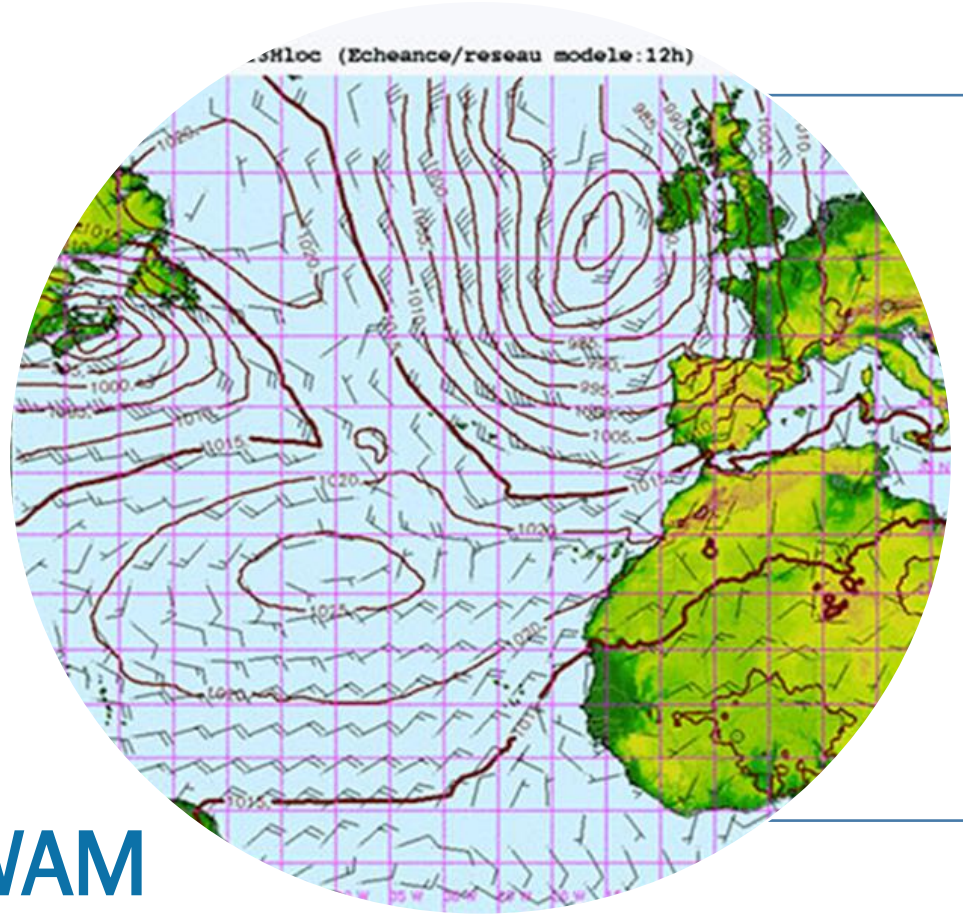
CNES



SWIM and S1 complementarity: Datasets used

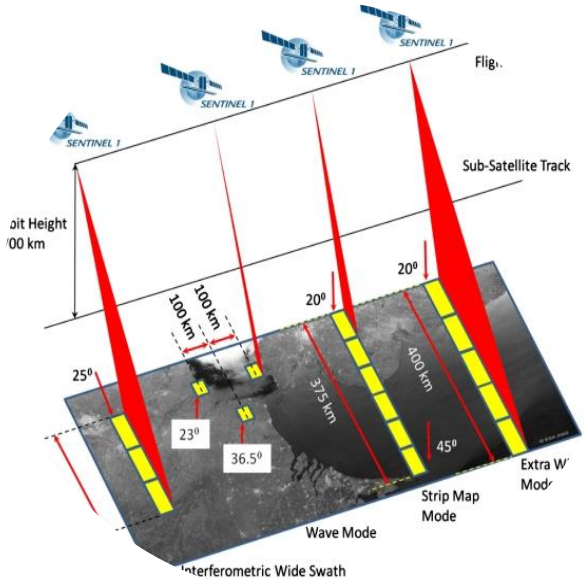


WAM

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

SWIM and S1 complementarity: Maturity of the systems

Nadir
30 years

SAR wave mode
20 years

Sentinel-1
8 years

CFOSAT
3years

Since 2019: Unique opportunity to have simultaneously 3 types of observations!

Still room for improvement (thanks to reprocessings) and mutual benefits.

SWIM and S1 complementarity: Maturity of the systems

How can they complement one another? What are there best skills?

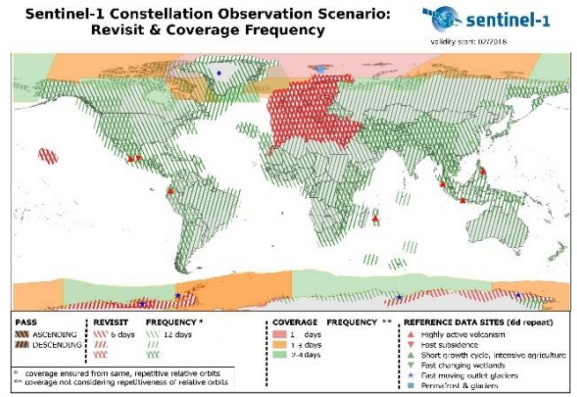
<u>3 Remarks:</u>
We will not talk about **Nadir** but see **Marine De Carlo et al.** ‘s talk to see a great exemple of benefits from SWIM to Nadir understanding for short scales dynamics (below 100km)!

Different approach than [Wang, et al. 2021] based on triple collocation analysis and comparison of swell partitions only.
We look at SWIM and S1 datasets compared to WAM common reference.

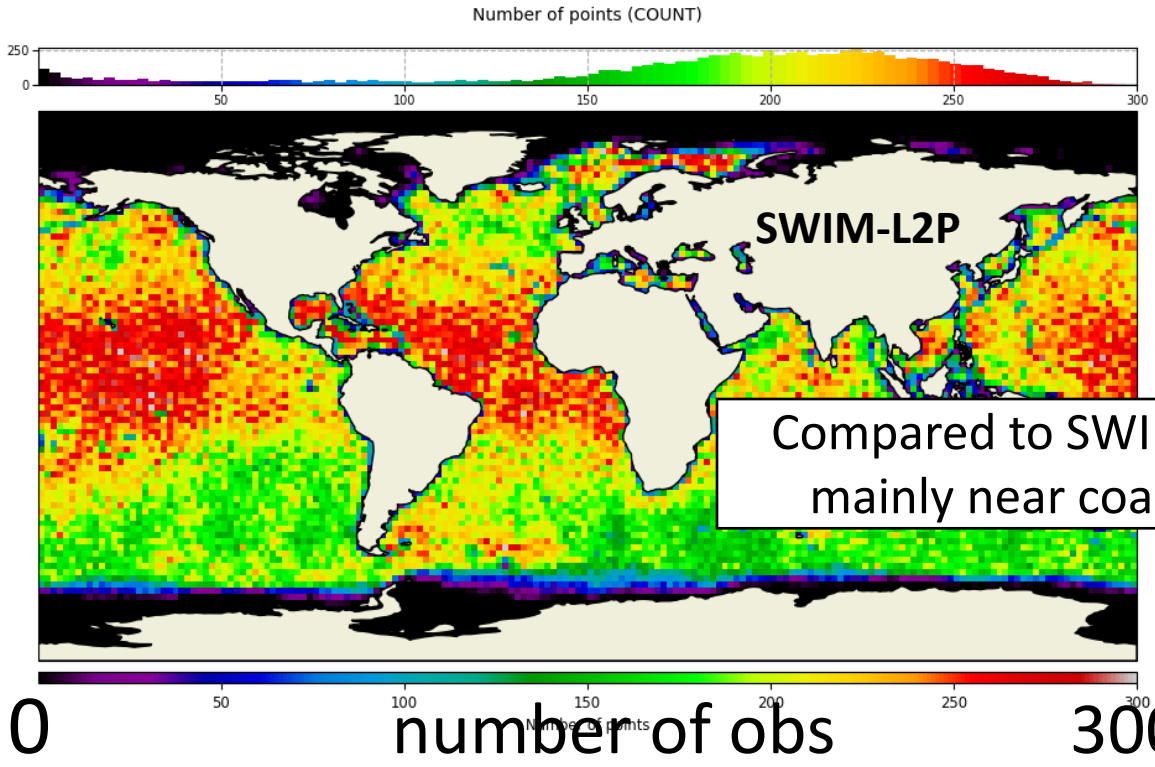
We **symetrised all spectra** to take into account the ambiguity in the direction (at 180°).

Global coverage of ocean data number of observations

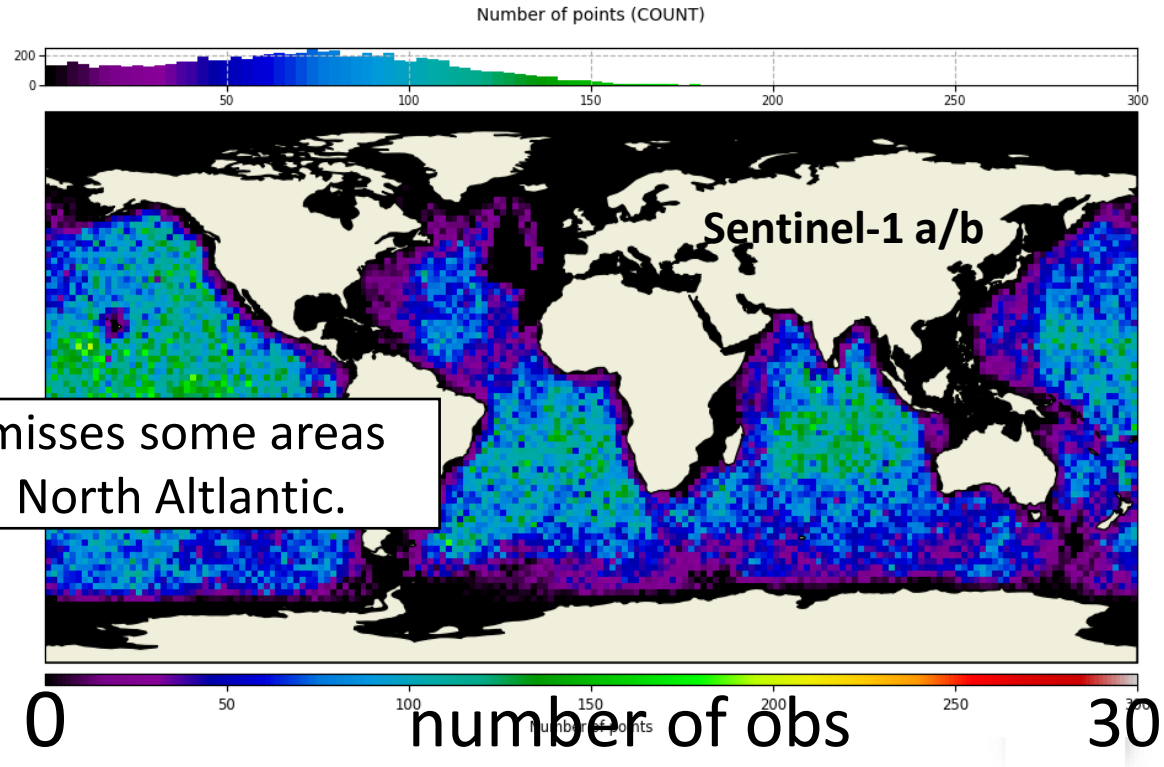
	CFOSAT off nadir	S1
Coverage	+/-83° North/South	Irregular in wave mode
Blind areas	Above 83° North	North Altlantic and coastal zones
Perturbated areas	Blooms or small wind areas	Mixed seas area
Good coverage	Elsewhere	Pacific / Indian ocean



All blank areas correspond to wave mode acquisitions



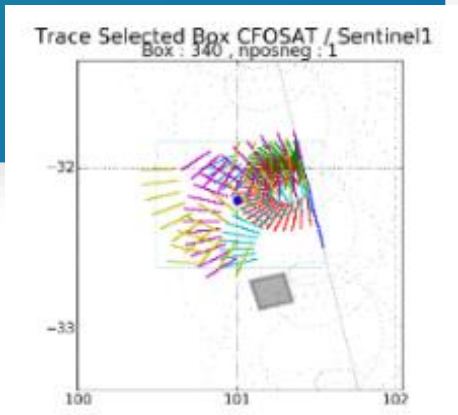
April-May-June 2021

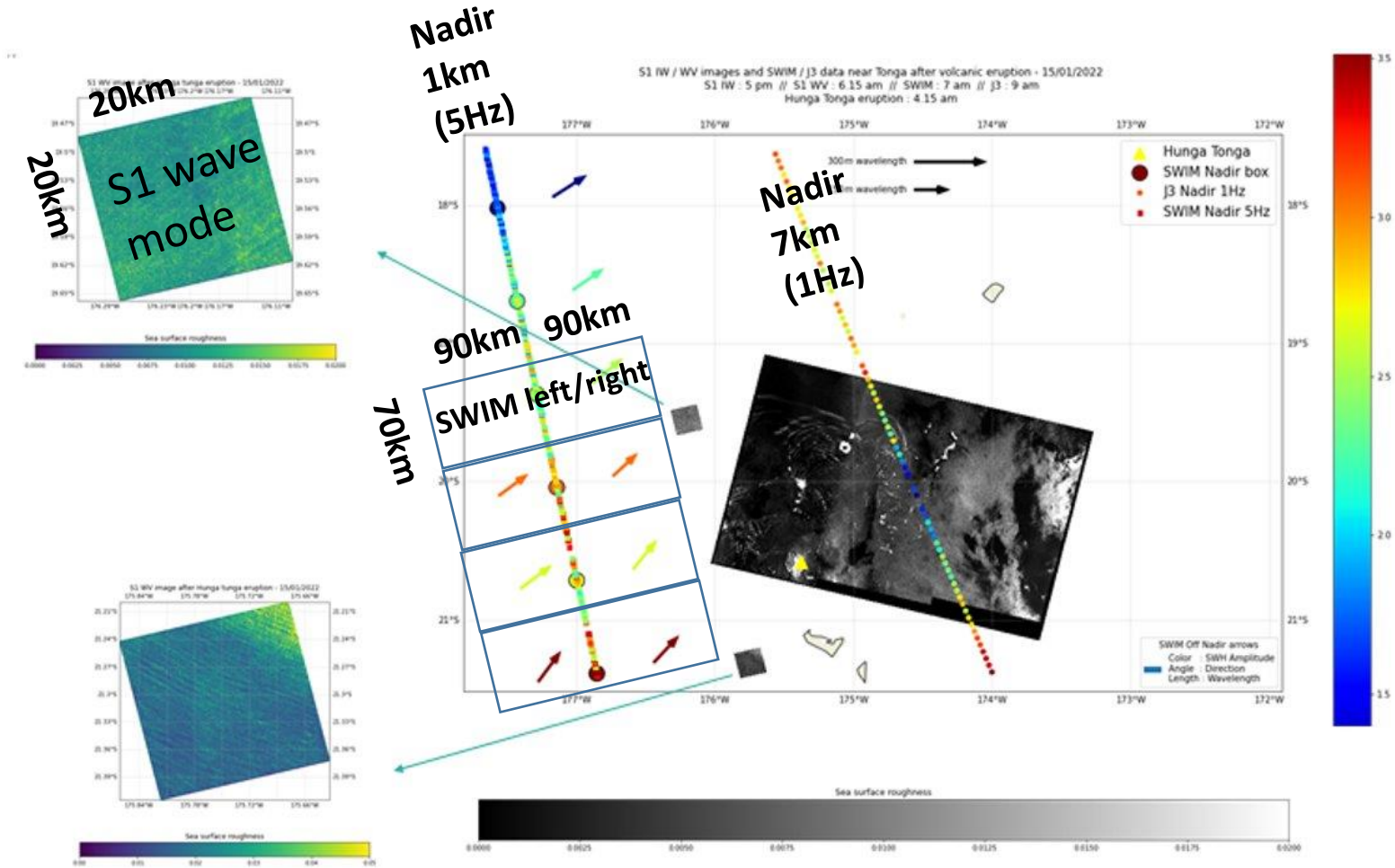


Compared to SWIM, S1 misses some areas mainly near coasts and North Altlantic.

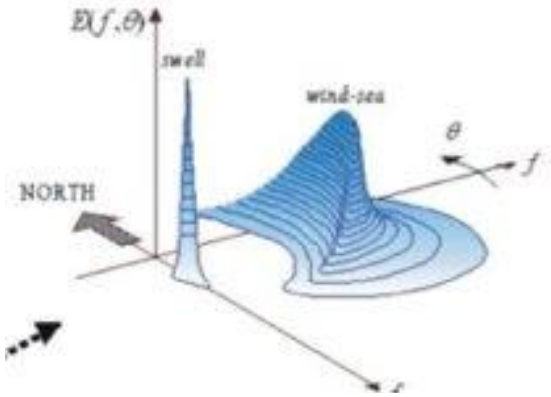
Ground track resolution

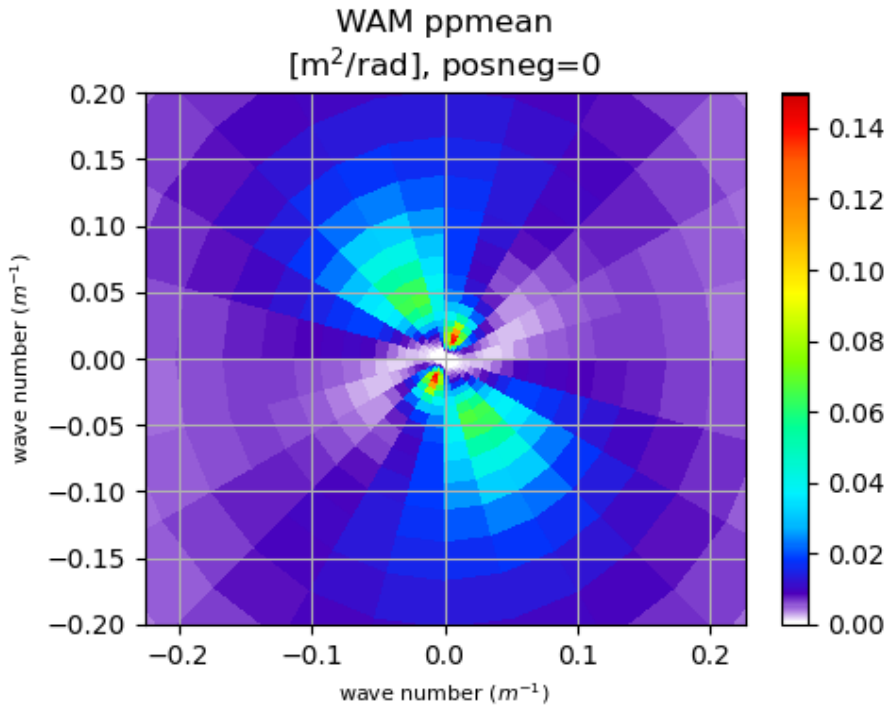
	CFOSAT off nadir	S1
Ground track resolution	70km/90km	20kmx20km
Sampling	Every 90km along track	Every 100km along track

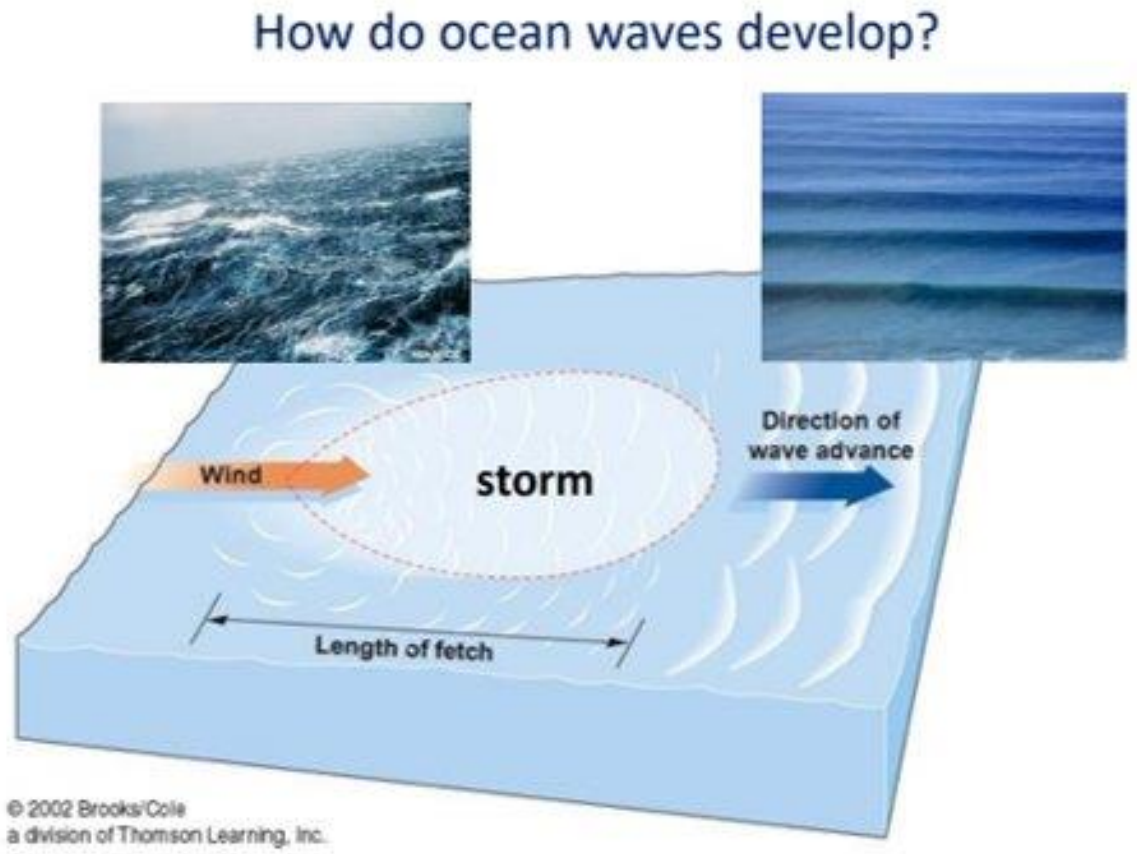




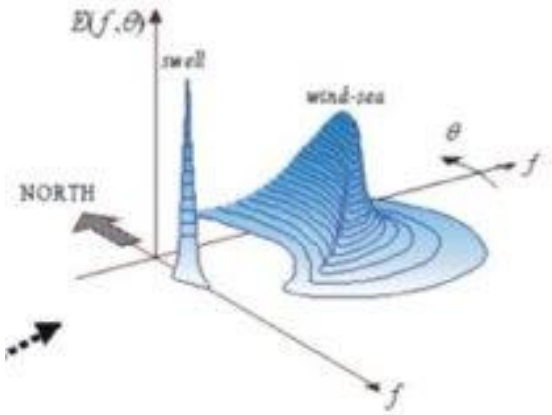
Large Swells, wind waves, or both?



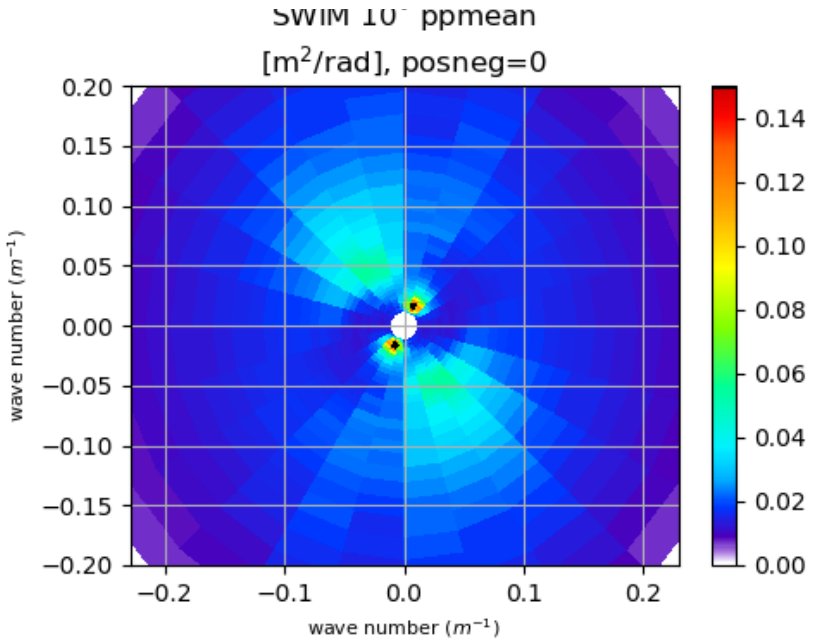


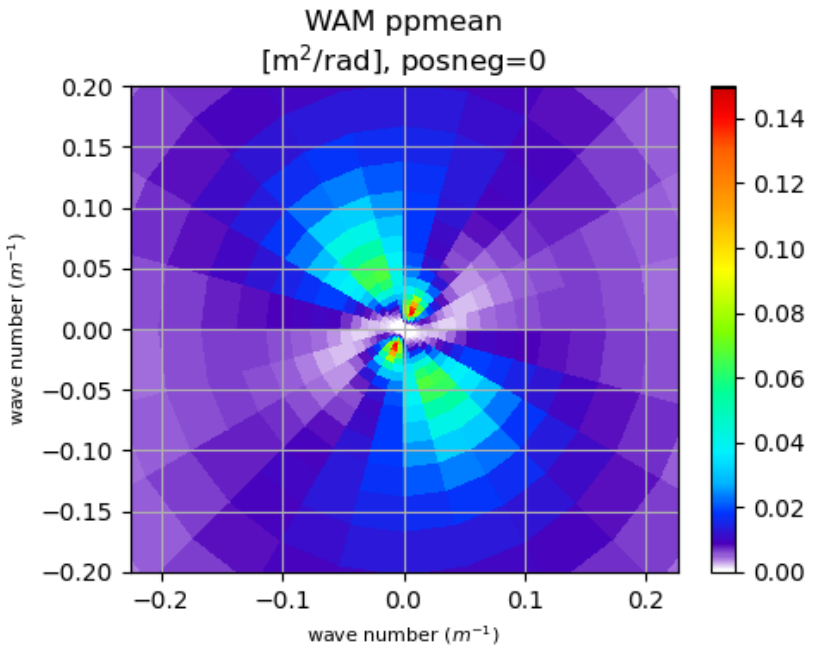


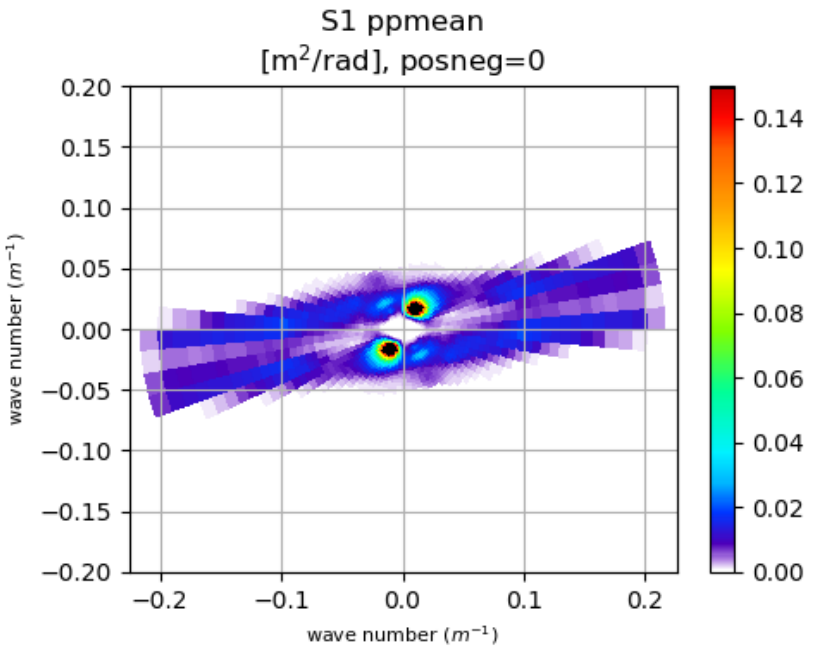
Large Swells, wind waves, or both?



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







Large Swells, wind waves, or both?

Wavelength < 200m,

Wind wave dominating,

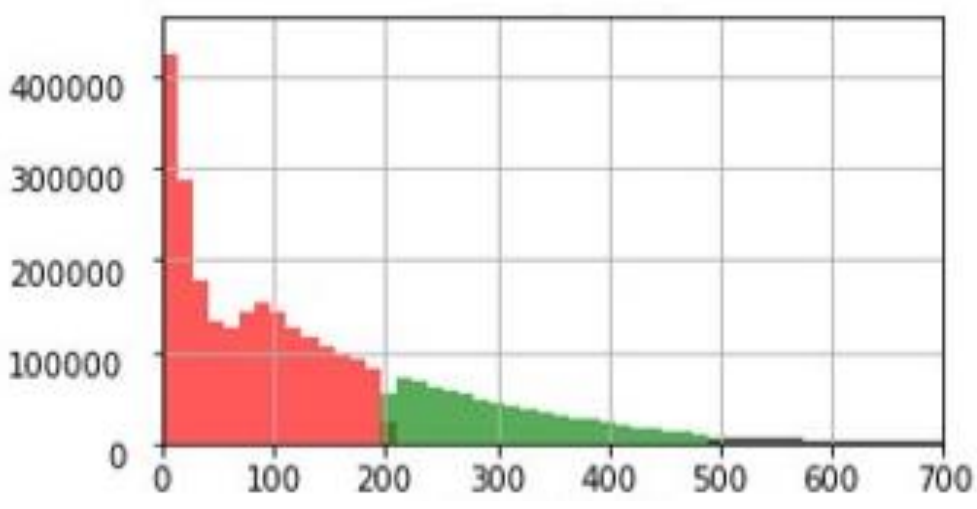
Wavelength between 200 and 500m,

Mixed seas with swell

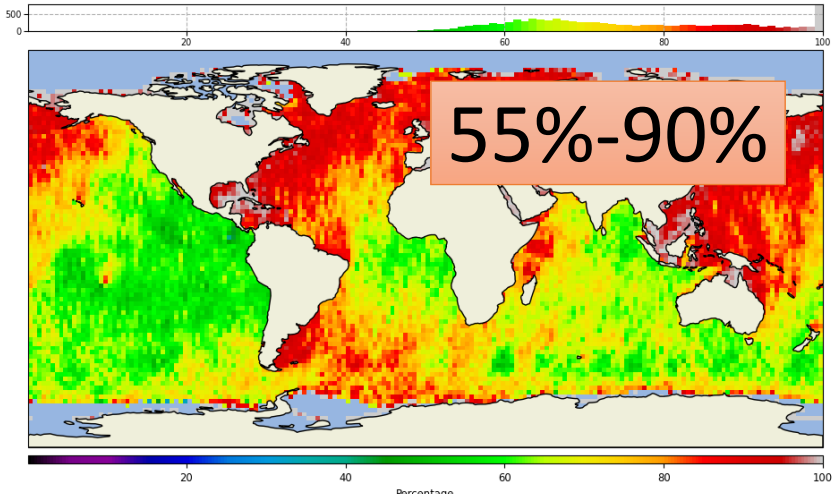
Class3: Wavelegth>500m,

Very large swells,

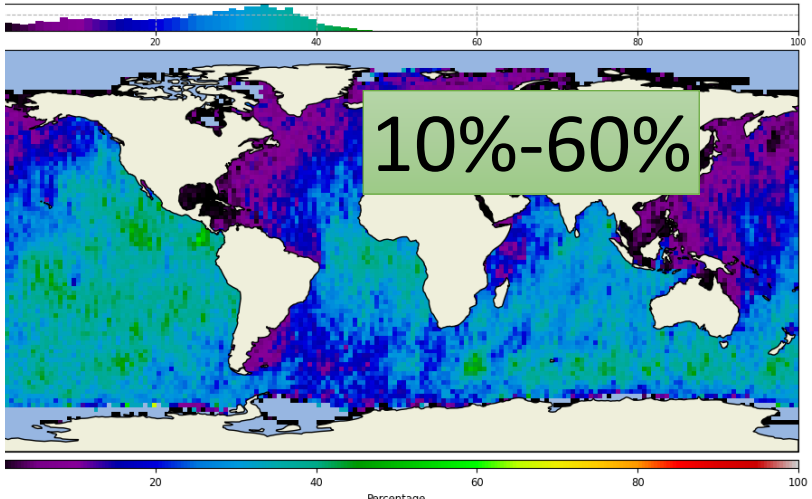
% of occurrence probability w.r.t WAM



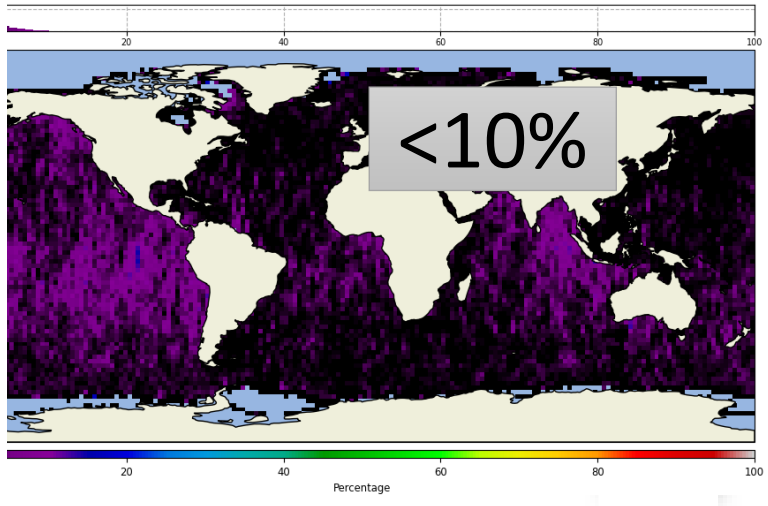
Percentage of points number for: 0 < wl < 200



Percentage of points number for: 200 < wl < 500



Percentage of points number for: 500 < wl < 800



Wave parameters: Large wavelength > 500m

<10%

Direction

Wavelength

Hs

SWIM

Sentinel-1

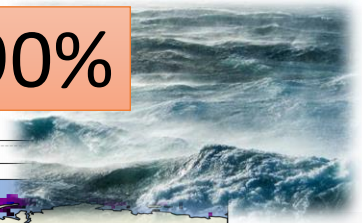
WAM

SWIM L2 Wave parameters are masked for those wavelengthes (could possibly be relaxed?, cf L2S relevant observations)

S1 shows pretty could agreement with WAM

Wave parameters for Wavelengths < 200m

55%-90%



Direction

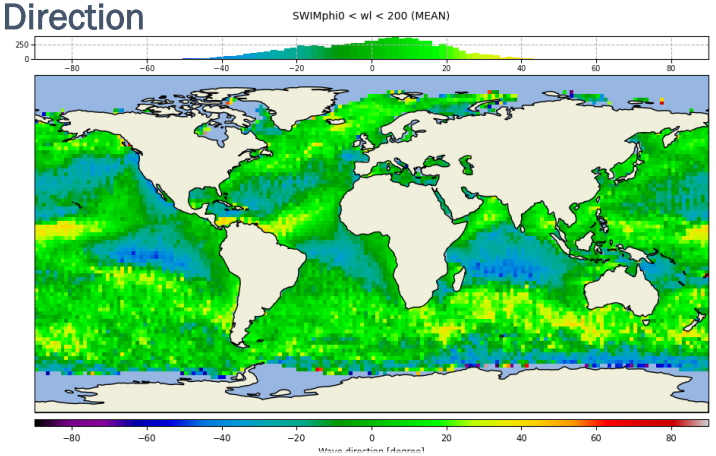
Wavelength

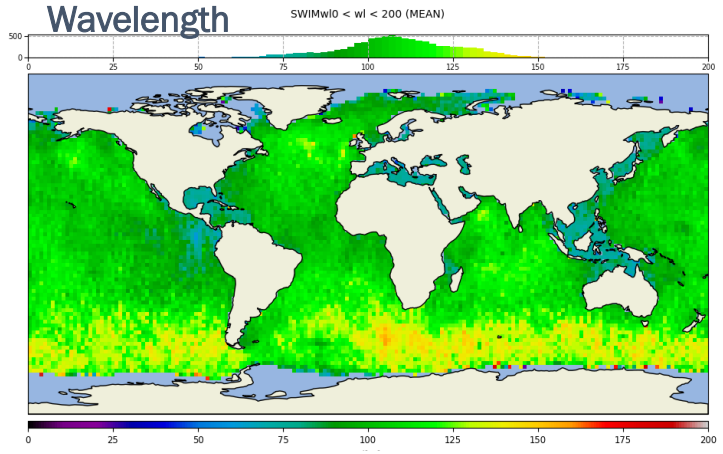
Hs

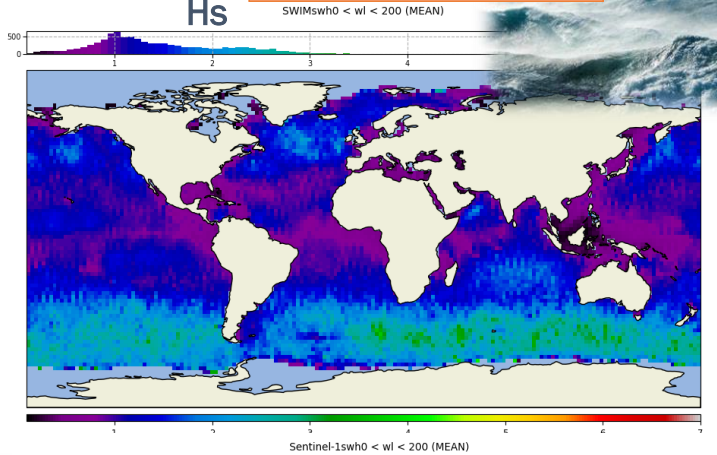
SWIM

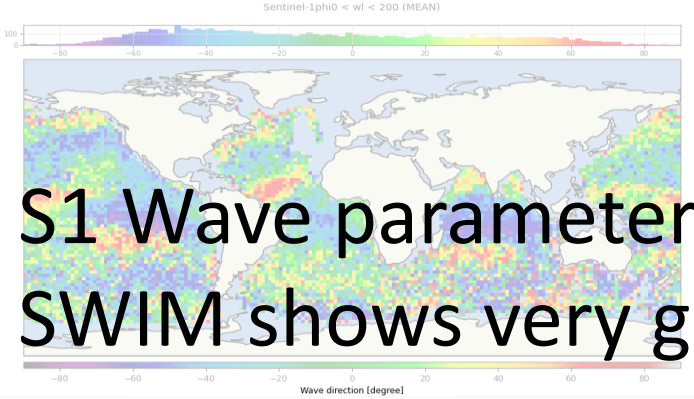
Sentinel-1

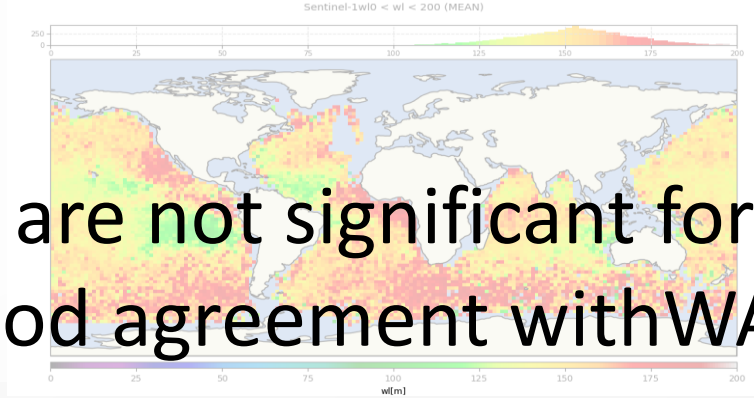
WAM

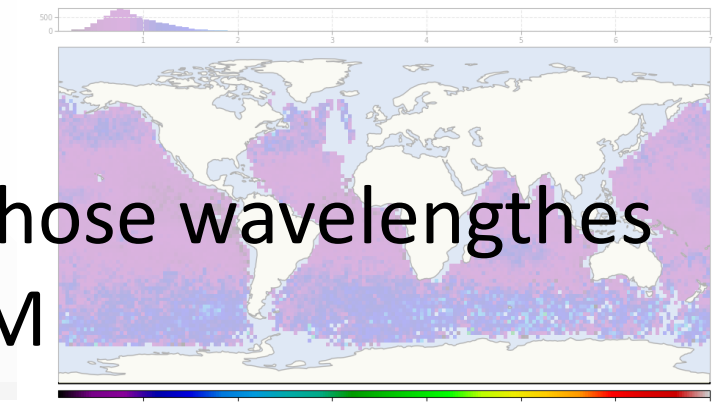






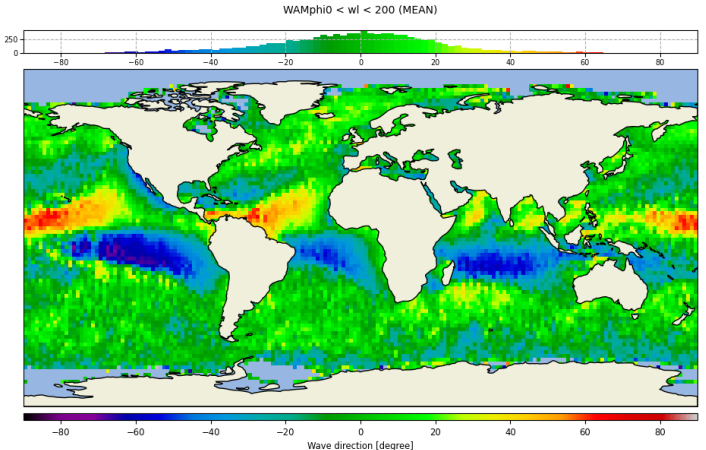


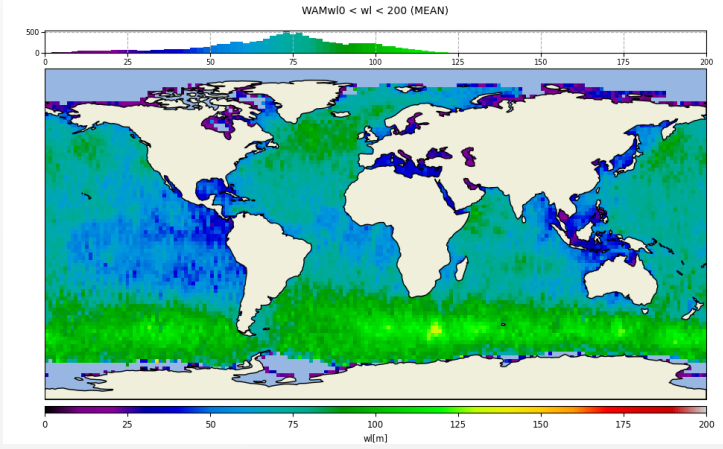


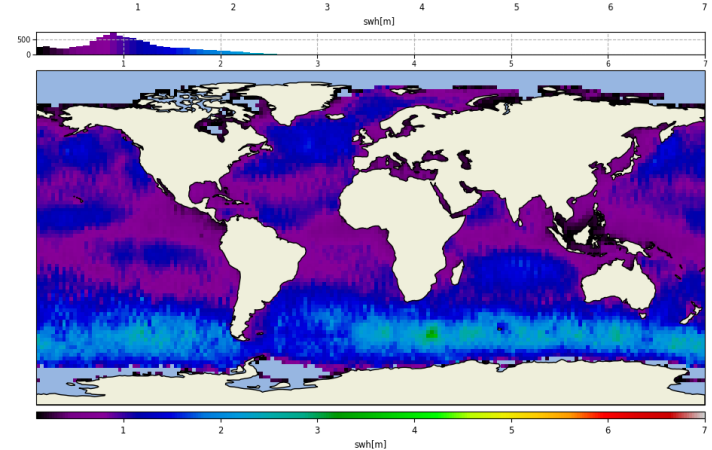


S1 Wave parameters are not significant for those wavelengthes

SWIM shows very good agreement withWAM

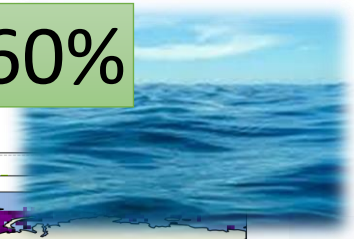


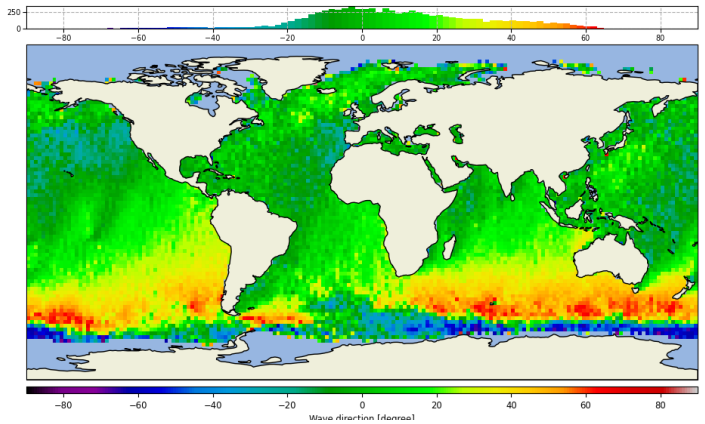
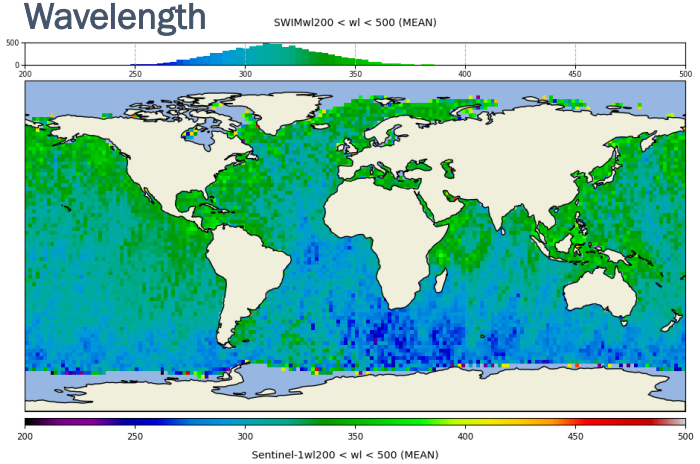
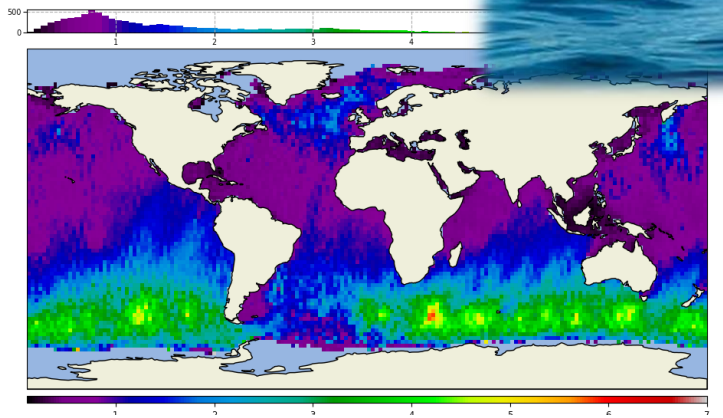
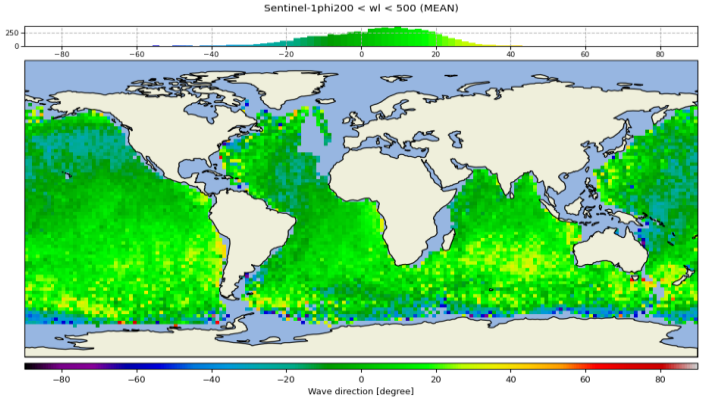
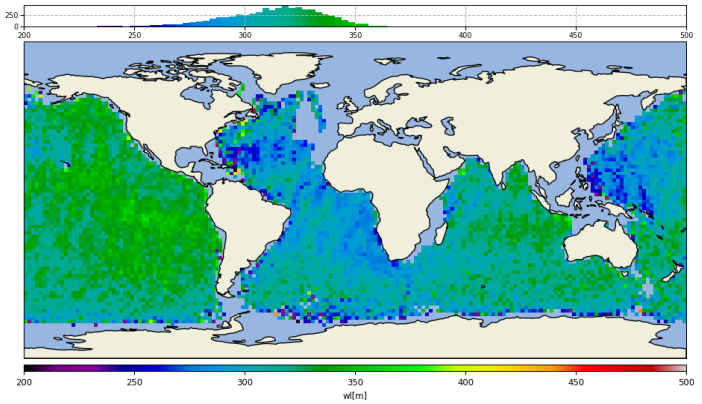
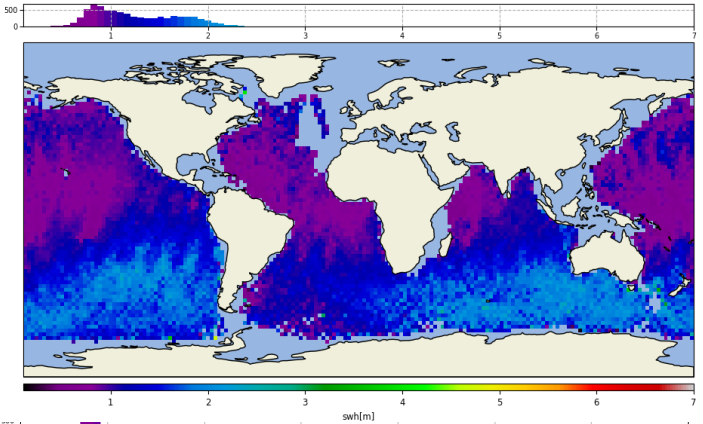
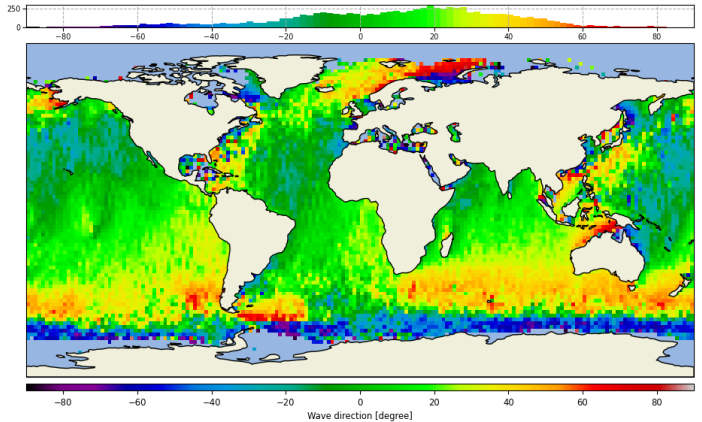
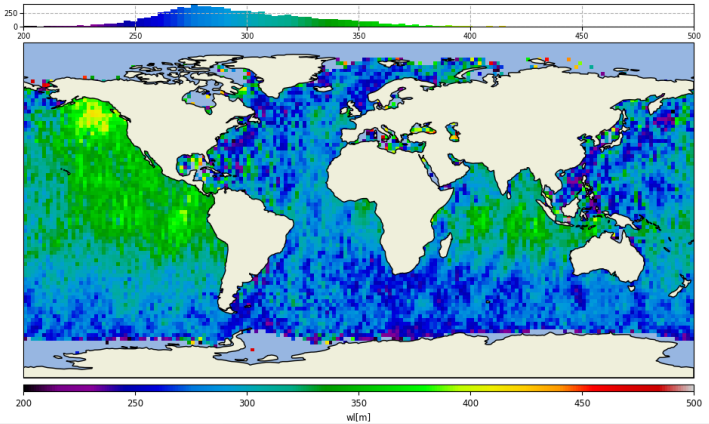
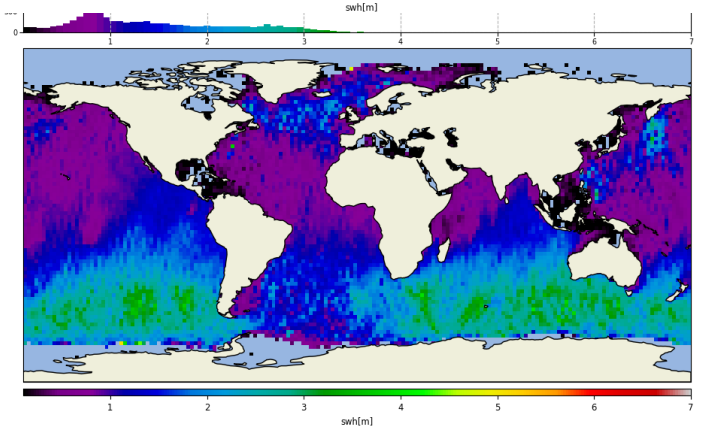




Wavelengths between 200m and 500m

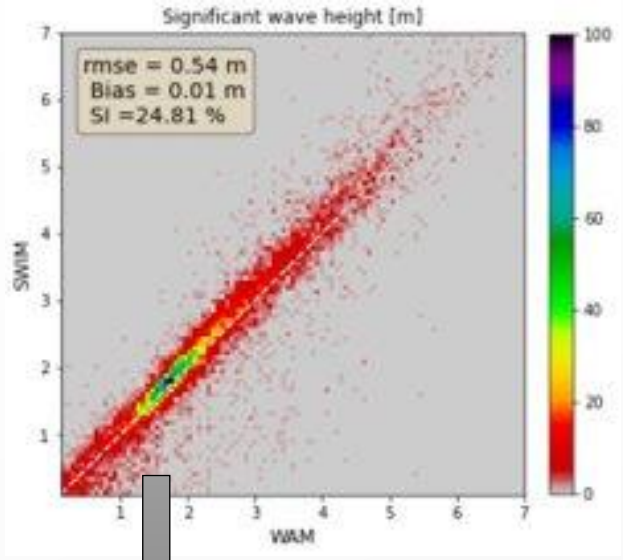
10%-60%



	Direction	Wavelength	Hs
SWIM			
Sentinel-1			
WAM			

Cartography of differences of swh between SWIM/S1 and WAM

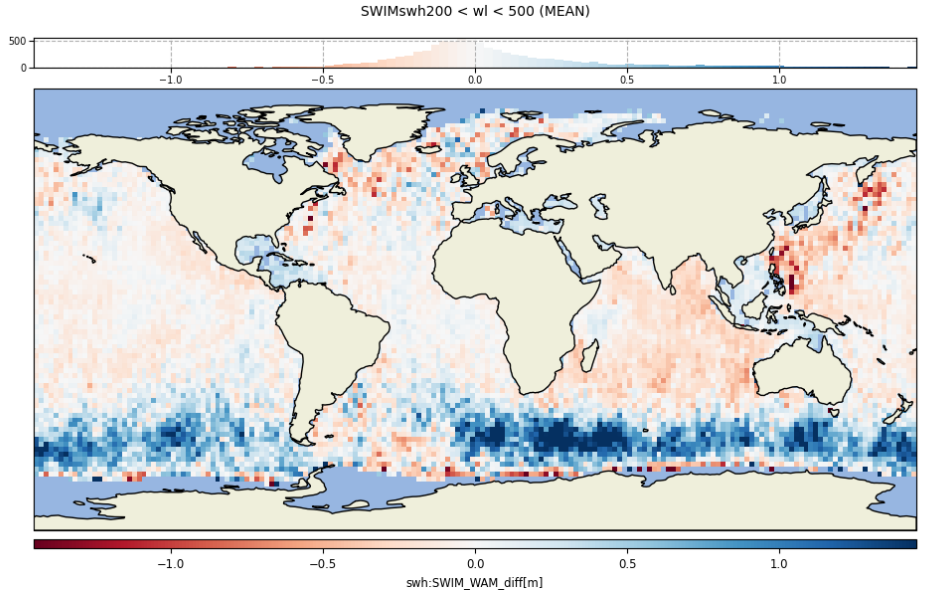
Classe 1 (0<wl<200m)



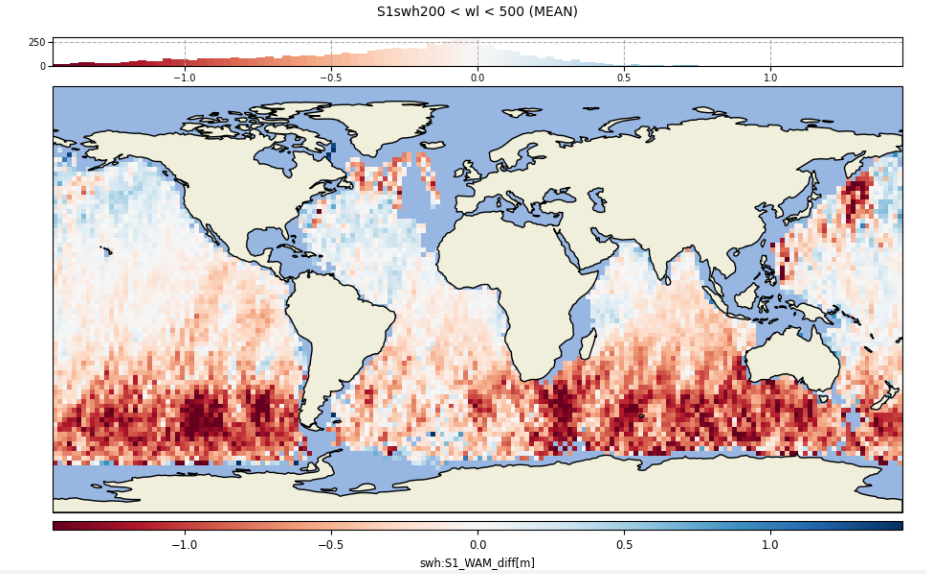
Very good agreement due to current MTF processsing based on nadir

Classe 2 (200m<wl<500m)

SWIM - WAM



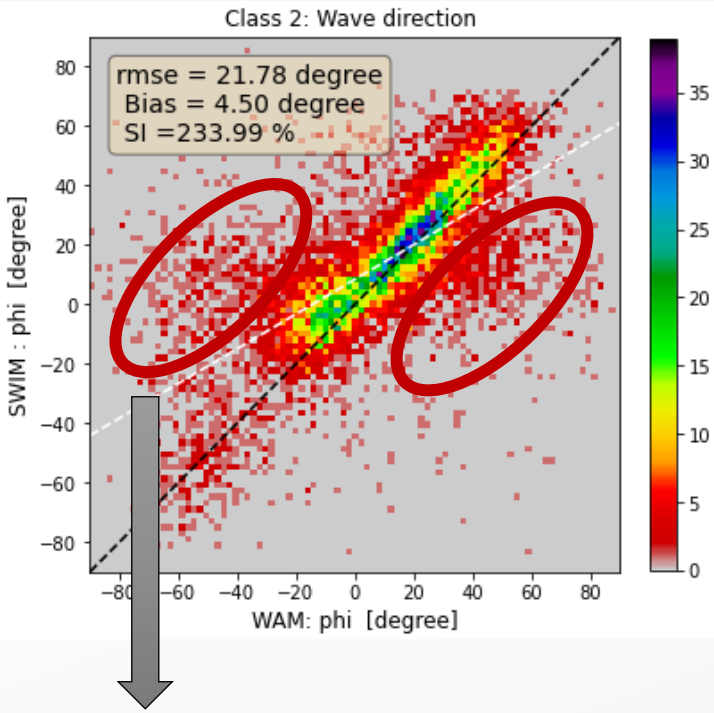
S1 - WAM



SWIM swh are closer to the model than S1.

Large under-estimation for S1

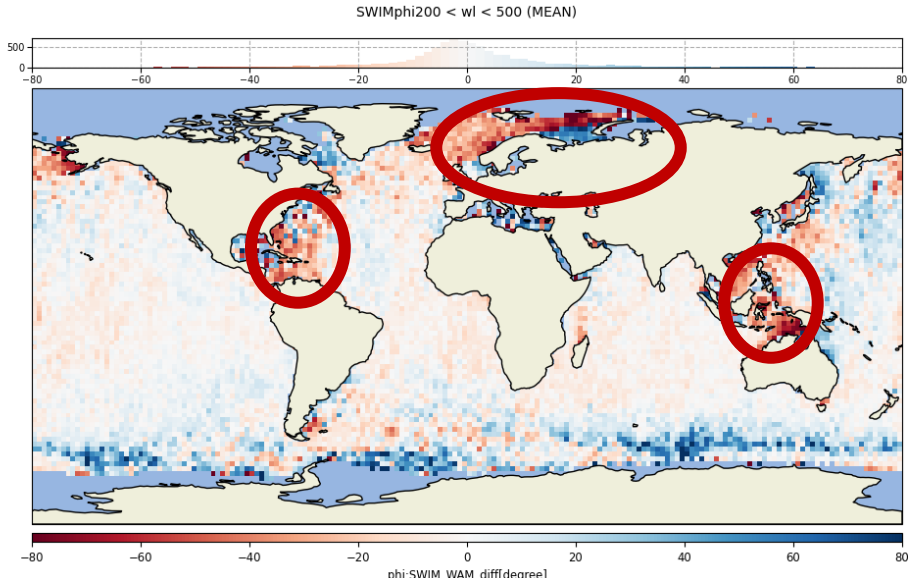
Cartography of differences of directions between SWIM/S1 and WAM



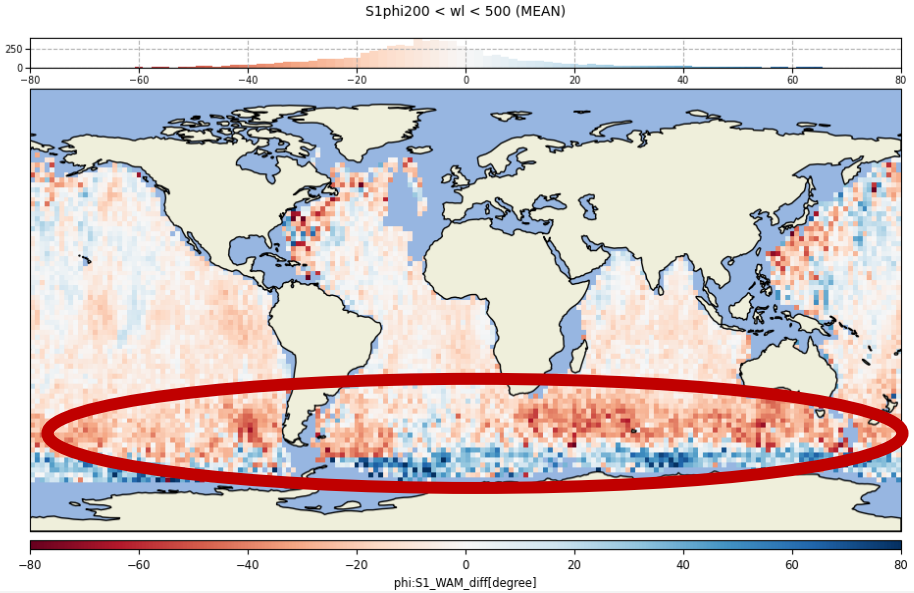
Should be flagged in upper level products ? TBD?

Classe of wavelength: (200m<wl<500m)

SWIM - WAM



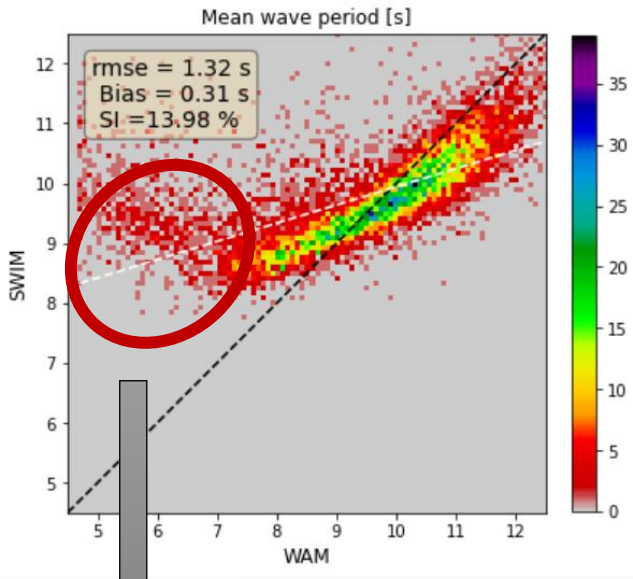
S1 - WAM



Despite the along track noise for SWIM and avoiding cut off zone for S1 (large wavelengthes):

Larger Biases for S1 than SWIM

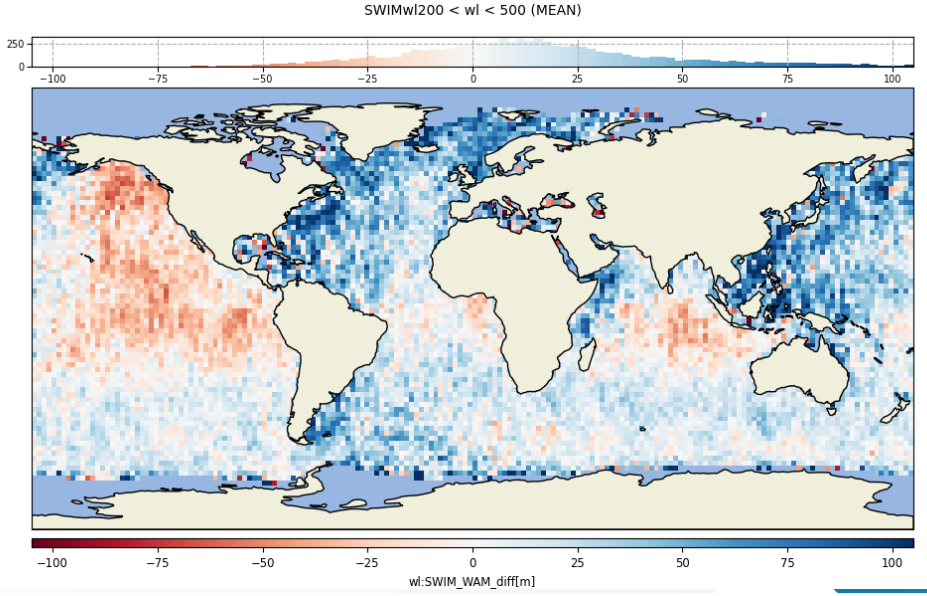
Cartography of differences of wl between SWIM/S1 and WAM



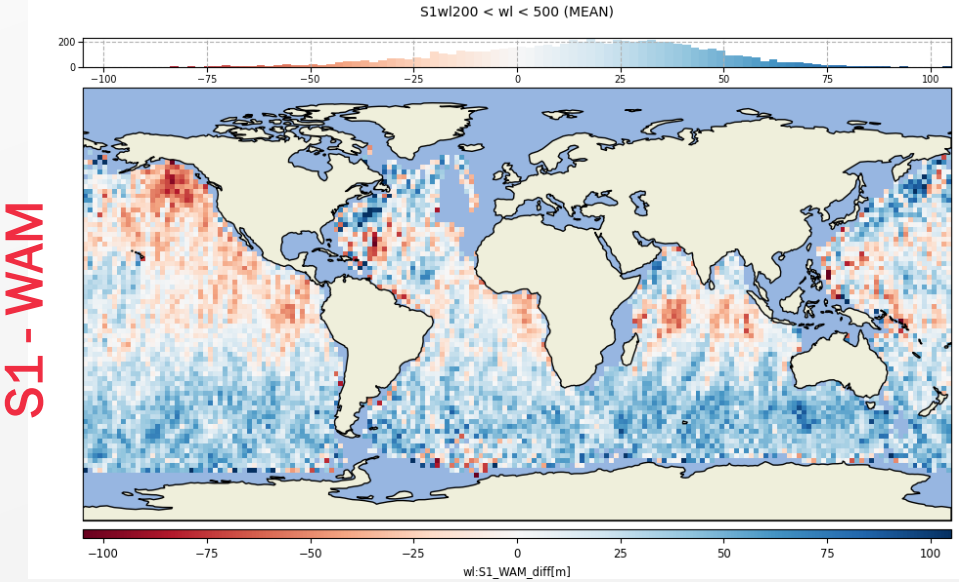
Should be flagged in upper level products ? TBD?

Classe of wavelength: (200m<wl<500m)

SWIM - WAM

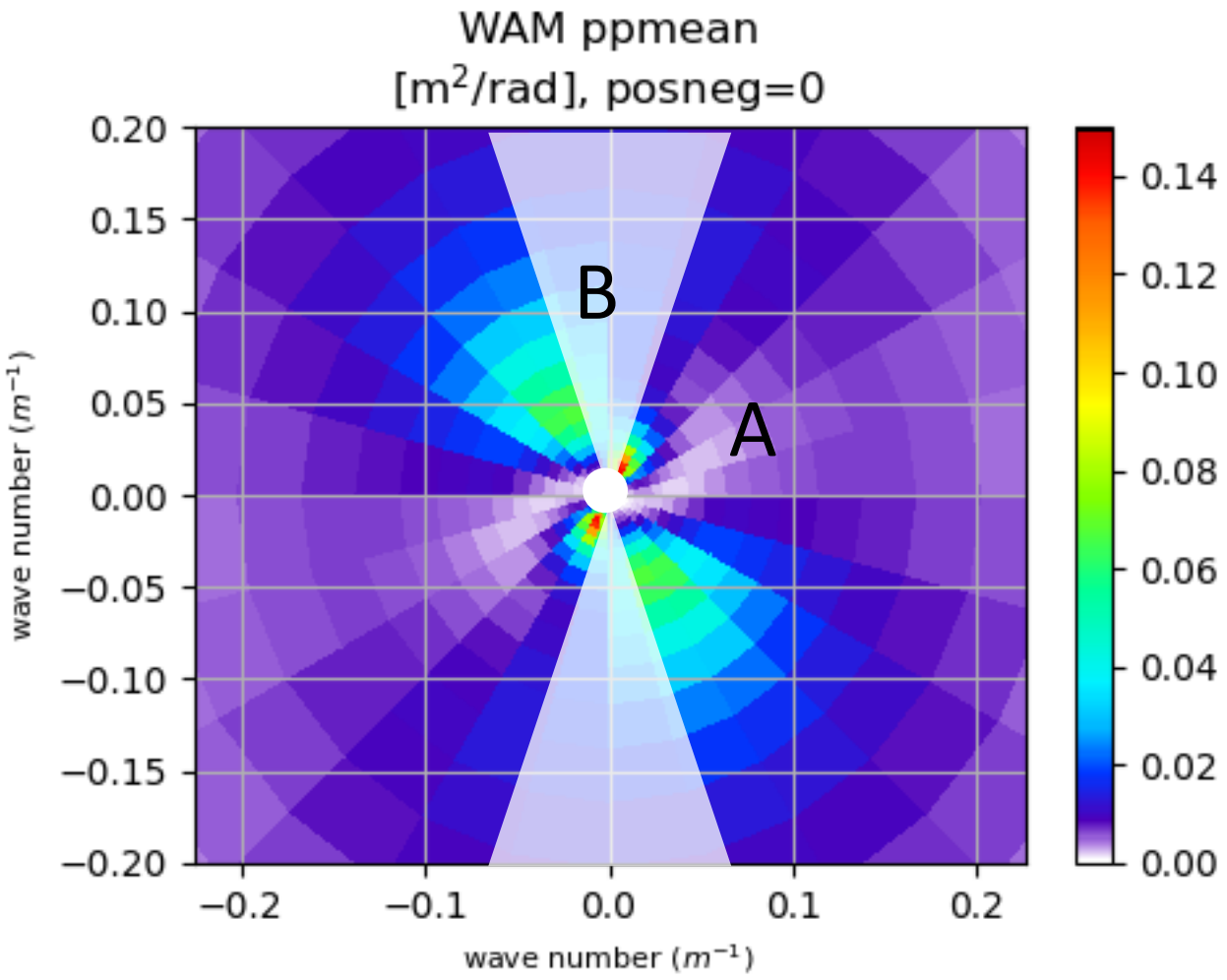


S1 - WAM



Similar patterns for SWIM and S1 over common zones

SWIM instrumental limitation



A - 500m mask (less than 10% of data) and
Parasitic peaks (weaker impact on slope spectra than on elevation spectra)

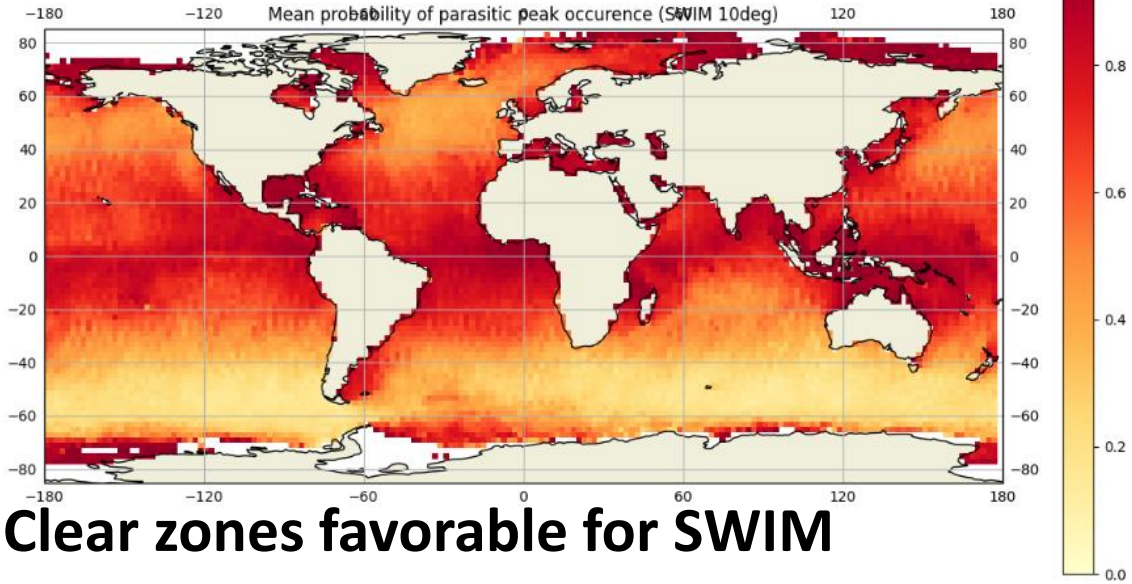
B- Speckle higher in the along track direction (see Gilles Guitton's talk from ODL)

SWIM instrumental limitation

More work needed to identify and remove and/or correct perturbated areas.
Tentative metrics are envisaged. Thresholds will be tuned.

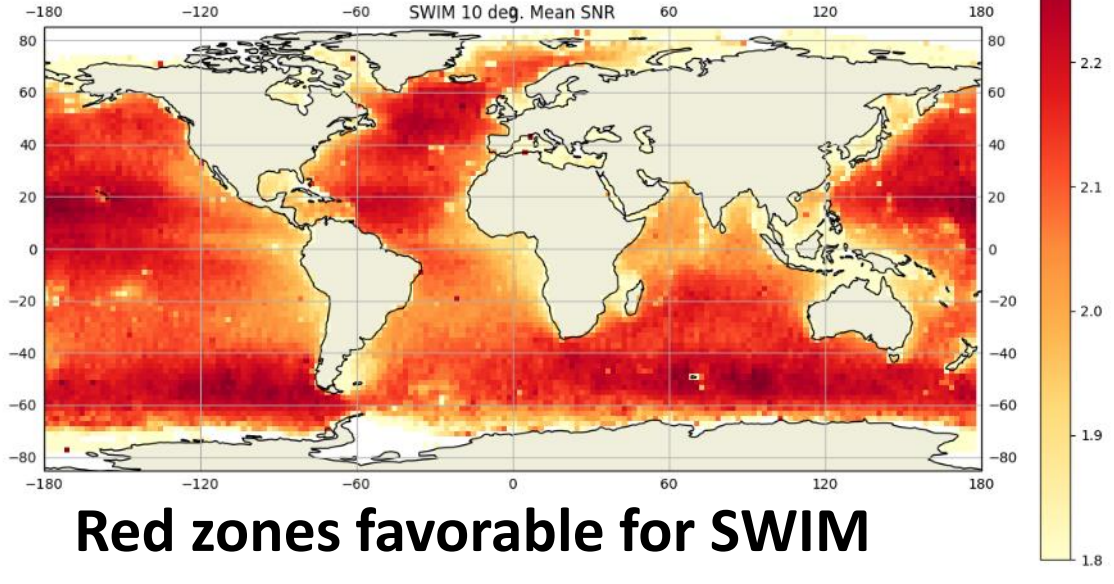
- Correlation between left/right boxes? Between beams 6°/8°/10°?
- 2D Signal to Noise ratio?
- Mean probability of parasitic peak? (based on Hs and delta wl between slope/elevation spectrum)
- …

Mean Probability of parasitic peak occurrence



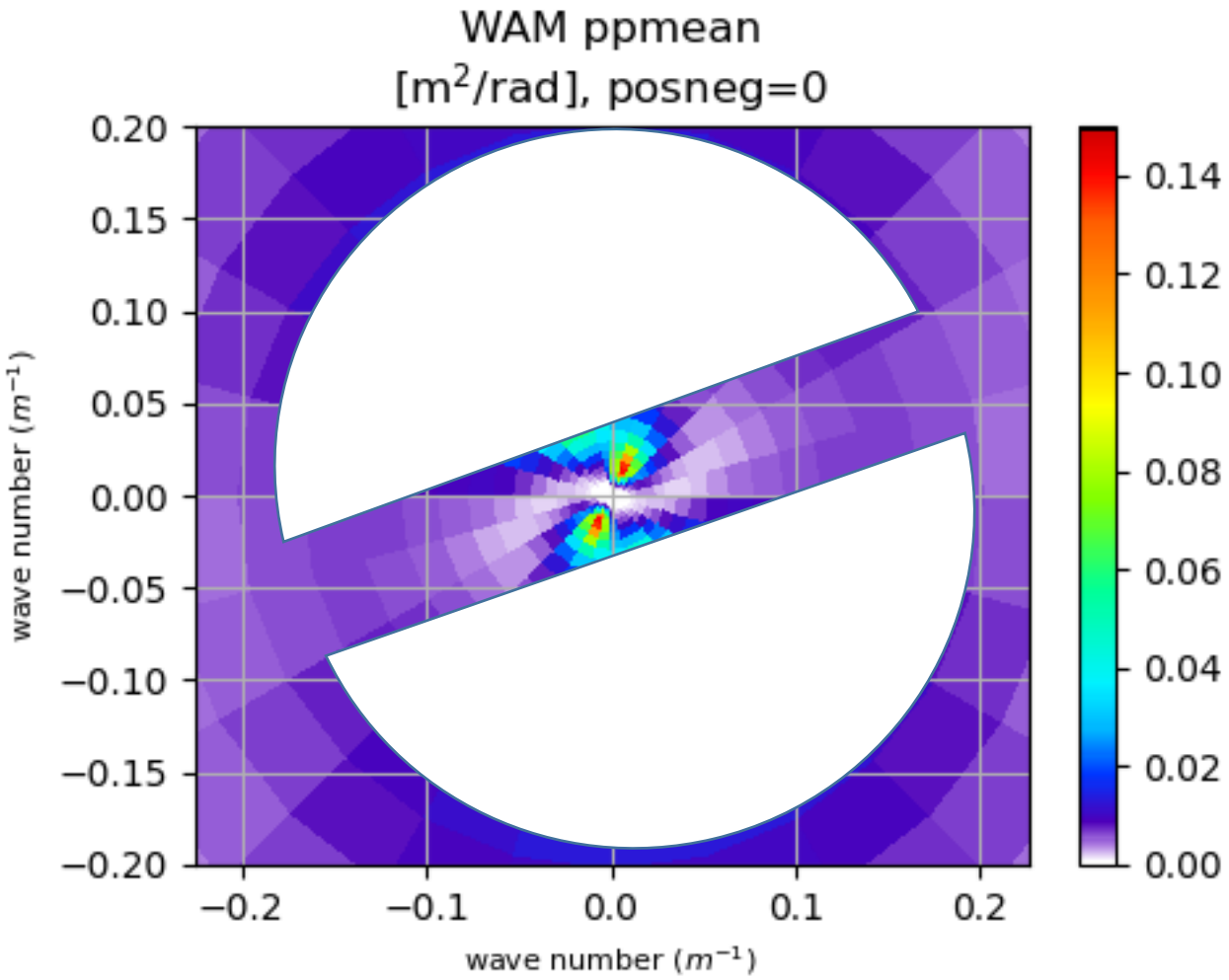
Clear zones favorable for SWIM

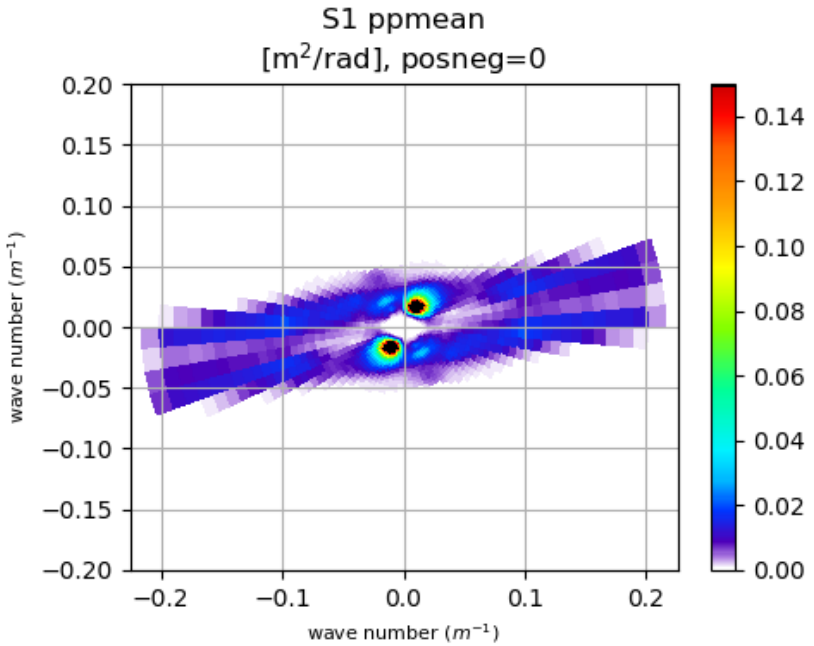
Signal to noise ratio estimated from 2D spectra



Red zones favorable for SWIM

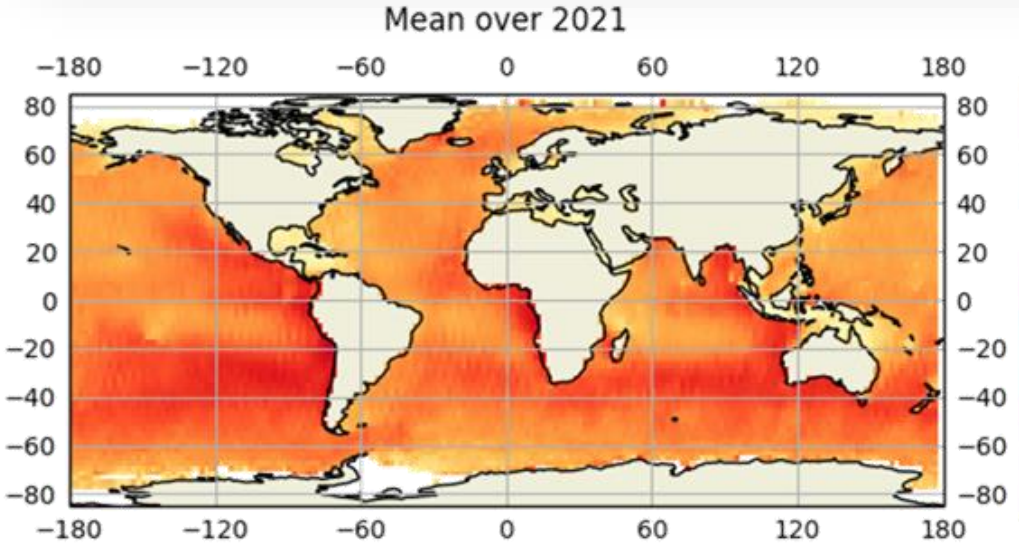
S1 azimut cut off limitation



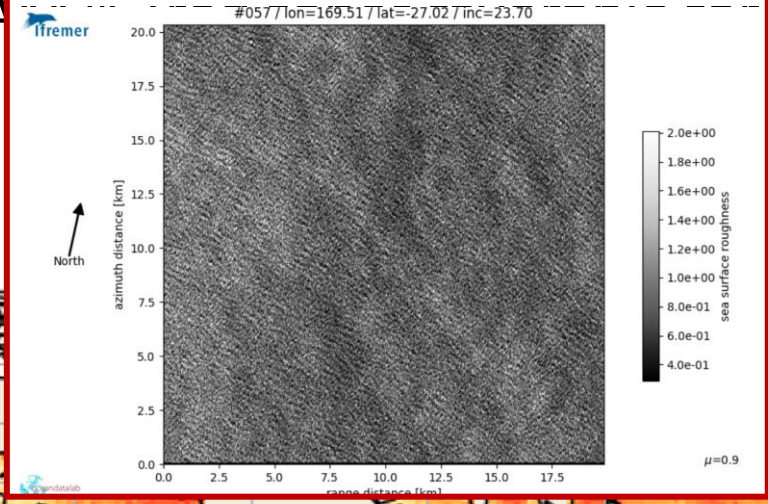


Sentinel-1 sees well very large scale swells

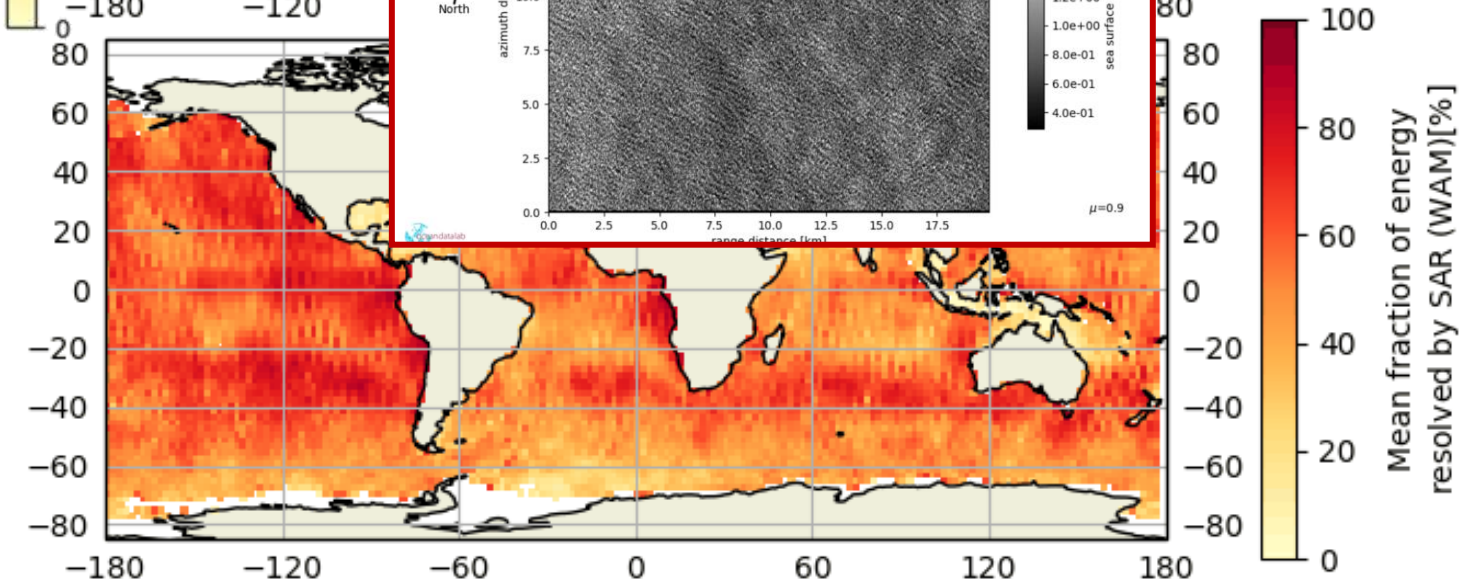
Sentinel-1 azimut cut off limitation



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



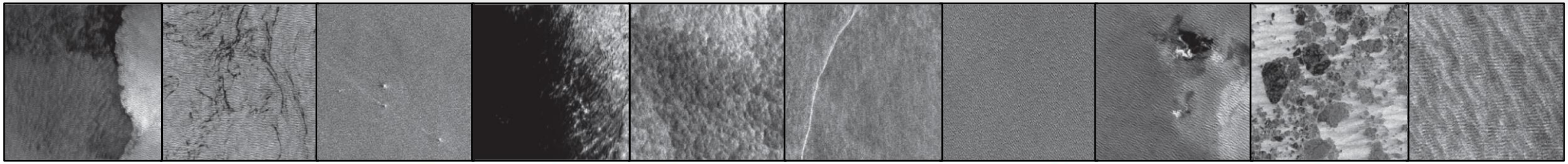
Mean … y SAR WA… S1)

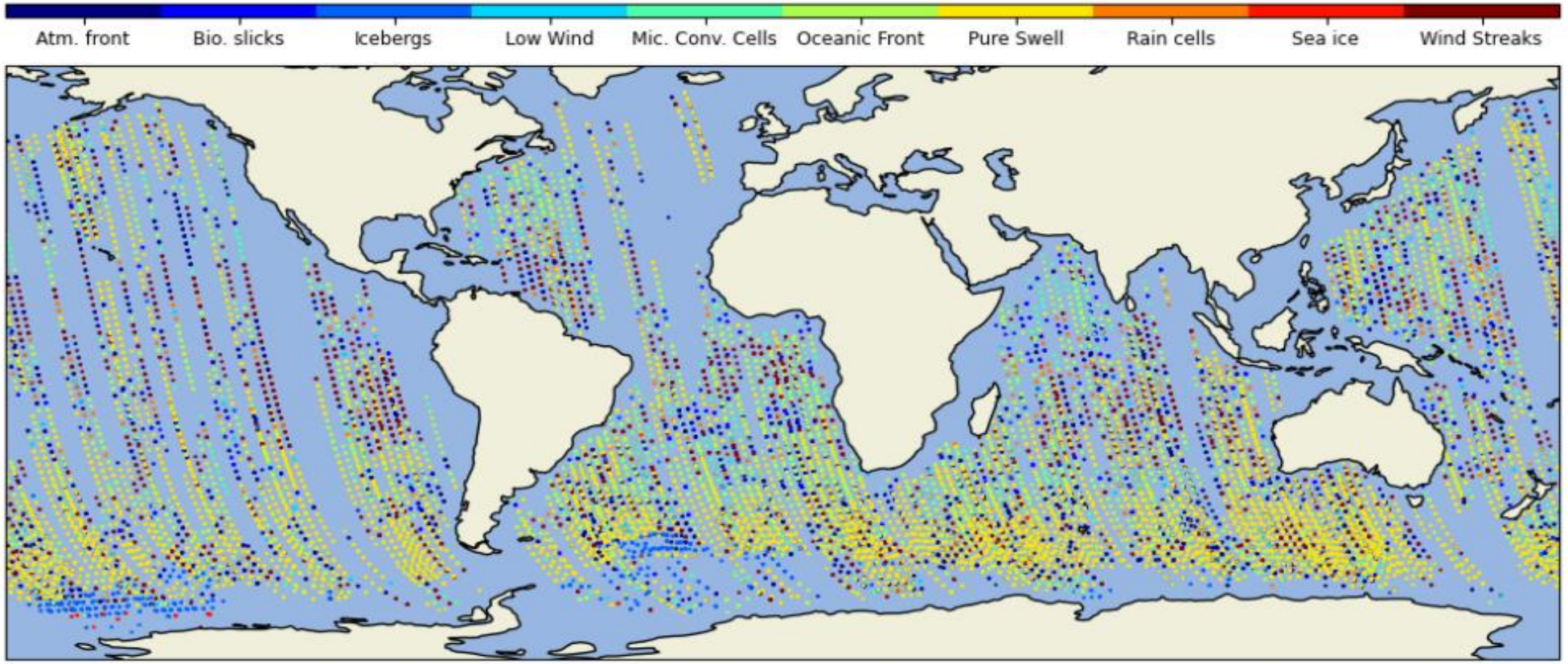


S1 misses information, mainly in wind-seas conditions.

Approximately 50% averaged over the year.

Merging CFOSAT and Sentinel-1 does great!





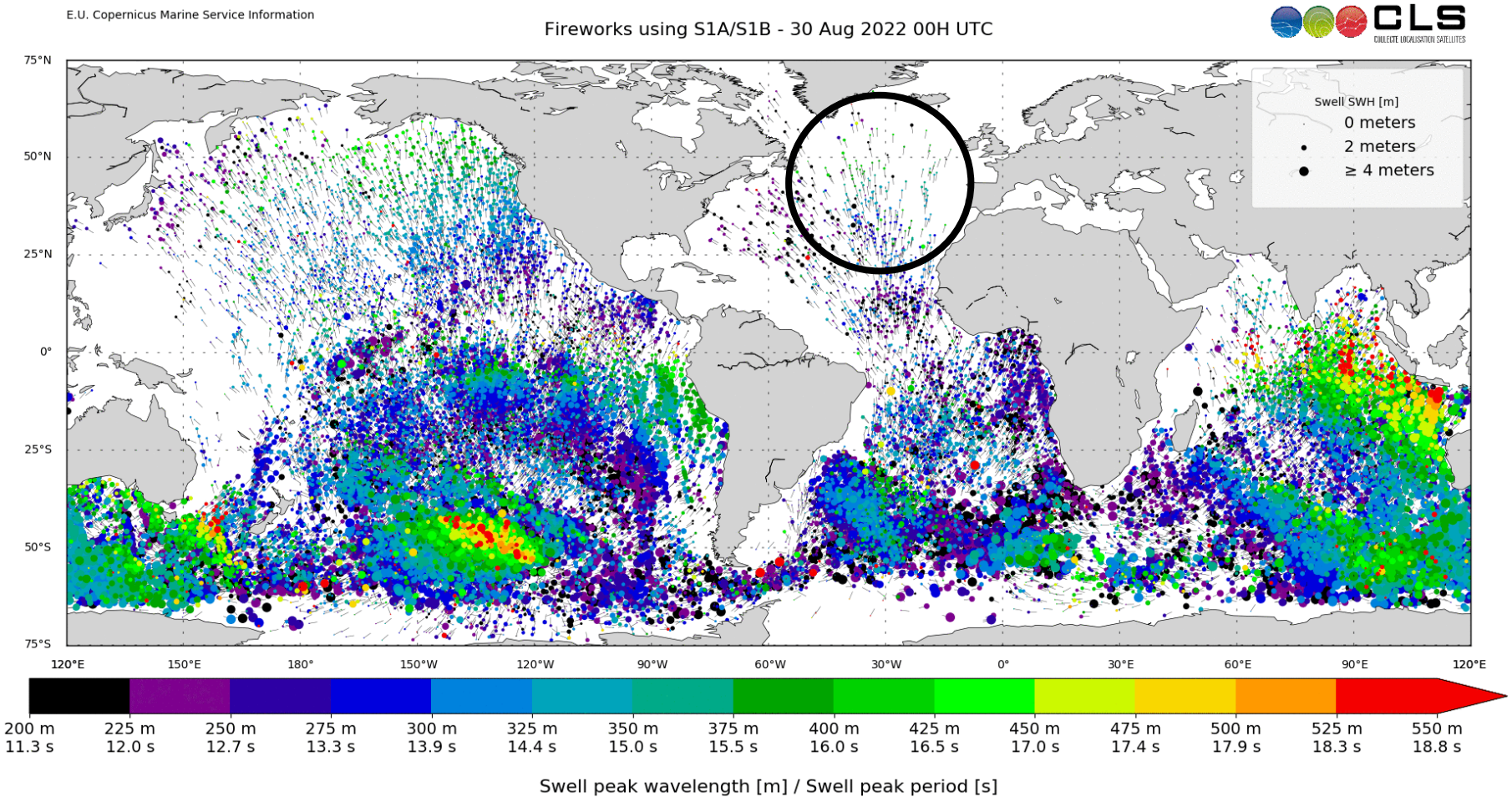
Colocation of Sentinel1 classification enables to better understand SWIM profiles behaviors.

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

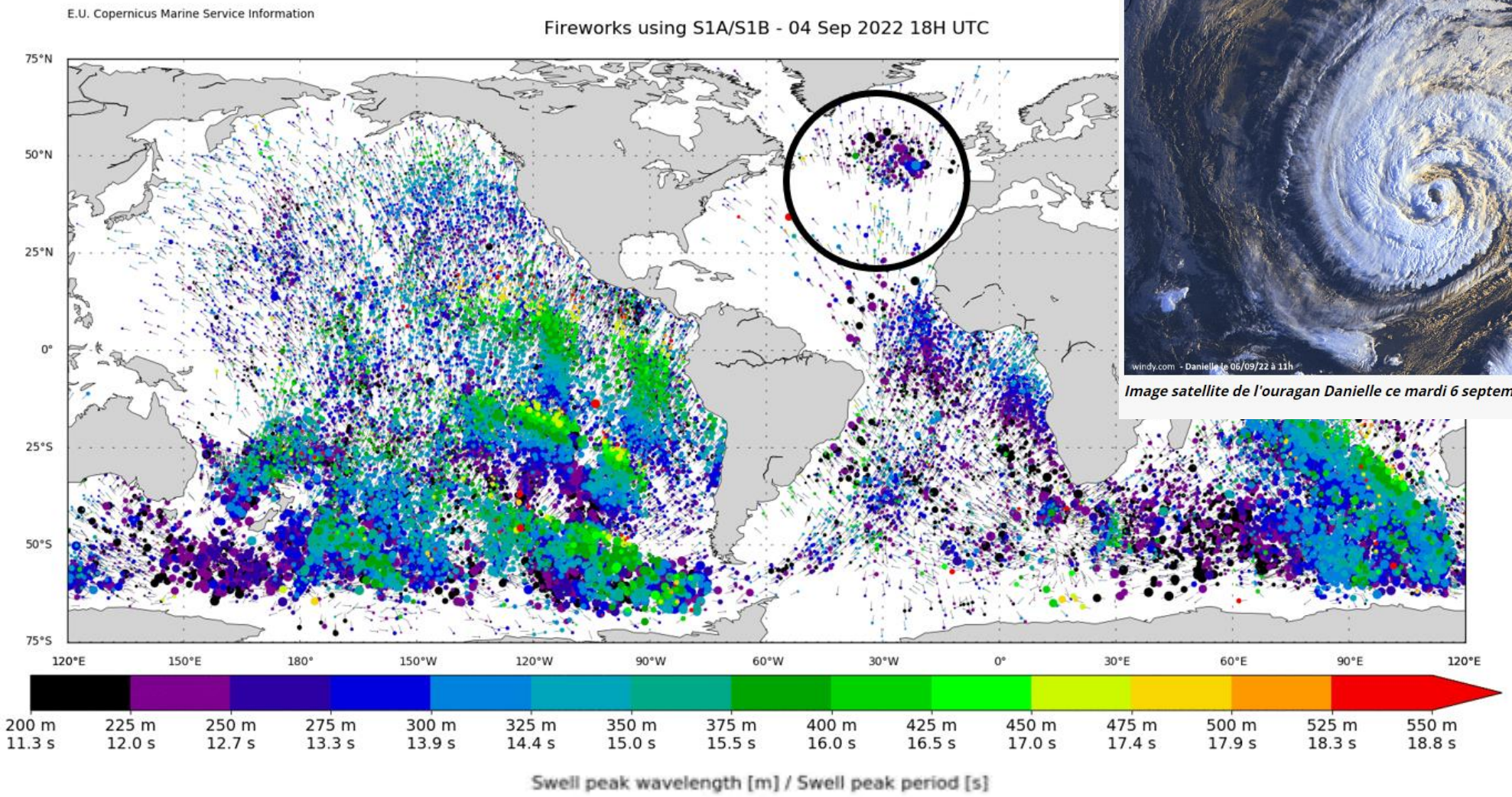
Merging CFOSAT and Sentinel-1 does great!

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/



CFOSAT captured Danièle!!!😉



Ouragan Danielle : un emballement médiatique ?

mardi 6 septembre 2022

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

Perspectives, exploring mutual benefits

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°

Keep on **valorising the complementarity** between SWIM and:

- Nadir constellation
- S1 historical dataset
- Model complience (label of partitions as swell/wind waves instead of Partition 1/2/3)
- Compare with L2S ODL/Ifremer products

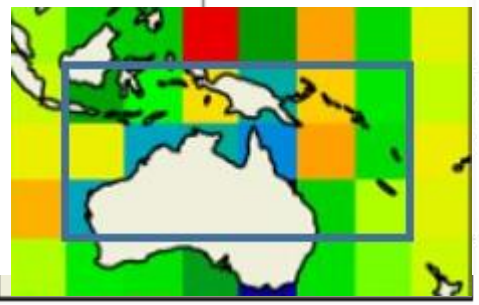
Complementarity and Skills in a nutshell

	CFOSAT off nadir	S1
Coverage	+/-83° North/South	Irregular in wave mode
Blind areas	Above 83° North	North Altlantic and coastal zones
Perturbated areas	Blooms or small wind areas	Mixed seas area
Good coverage	Elsewhere	Pacific / Indian ocean
Instrumental limitation	Speckle along track + parasitic peak	Cut off along track increasing with wind speed
Perturbating metocean conditions	Blooms, rain Non homogeneous areas (coast…)	Blooms, rain Non homogeneous areas (coast…)
Good observing conditions	Strong waves and winds	Swell if small winds
Directionality	Ambiguïty at 180°	No ambiguity but cut off effect in the along track direction.
Additionnal information	Hs from nadir, everywhere Sigma0 profiles	Imagette and Classification

Backups

Yet, SWIM already behaves well: Use case

Use case near New Caledonia

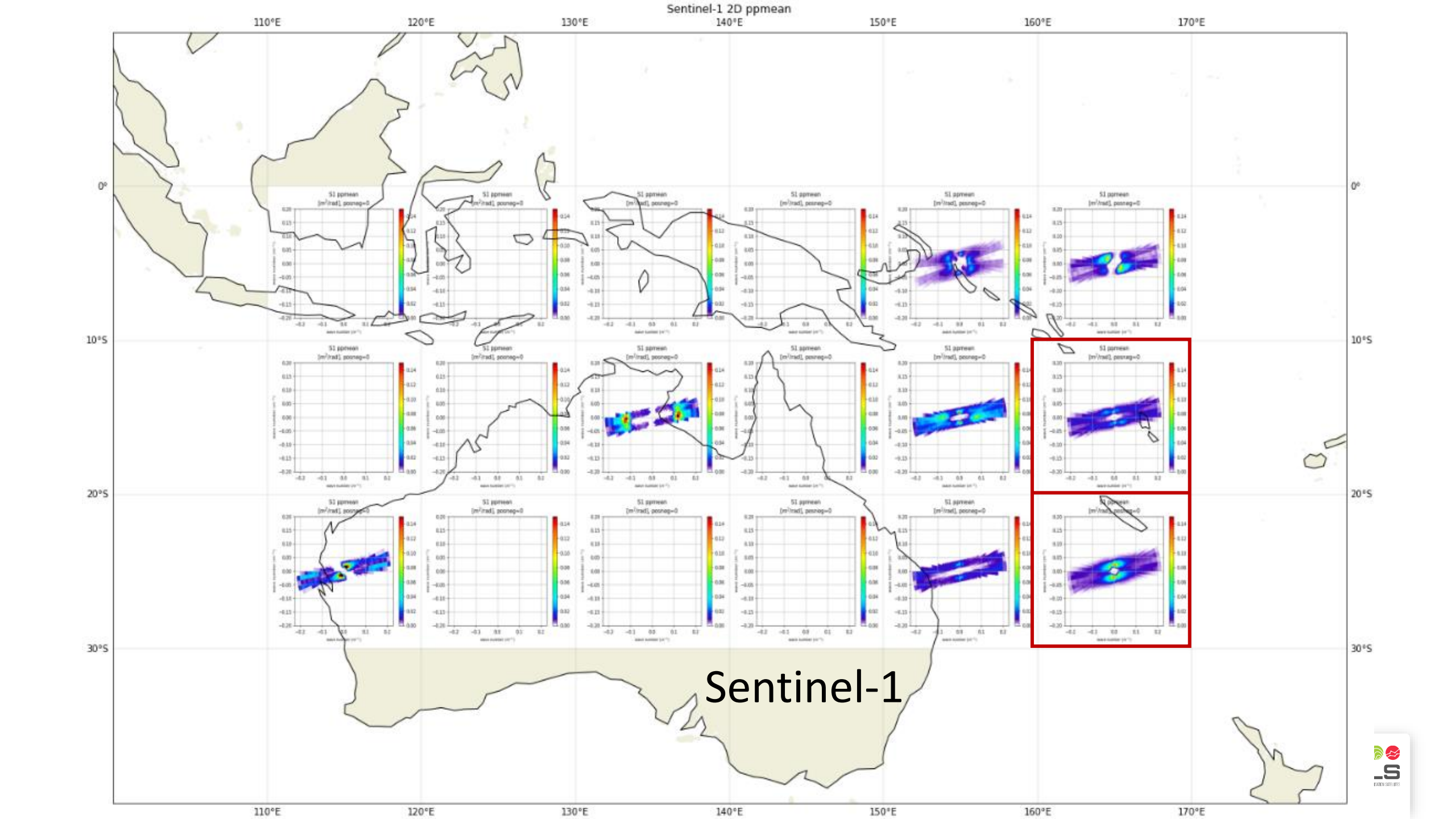


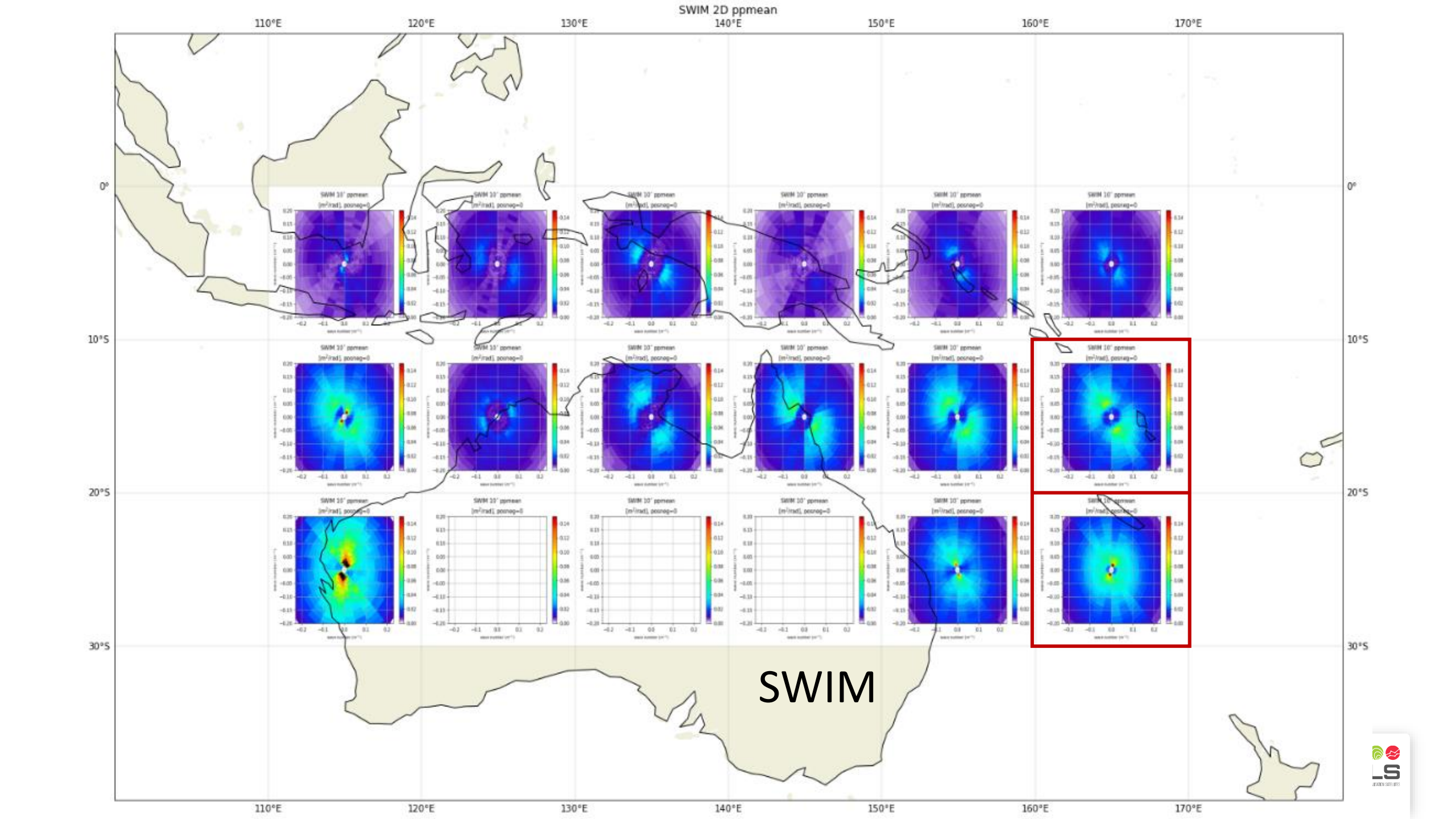
0 1000

Numer of spectrum averaged over june 2021

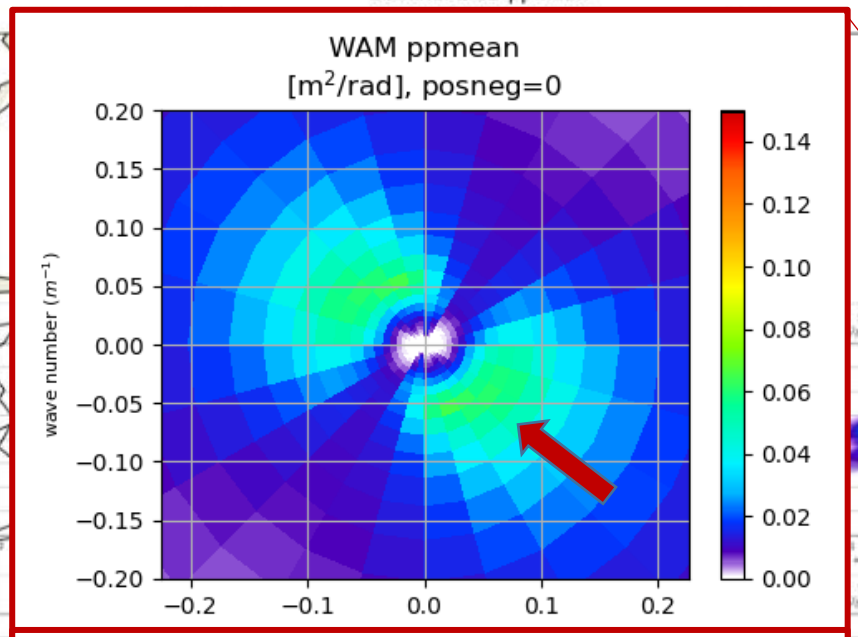
WAM

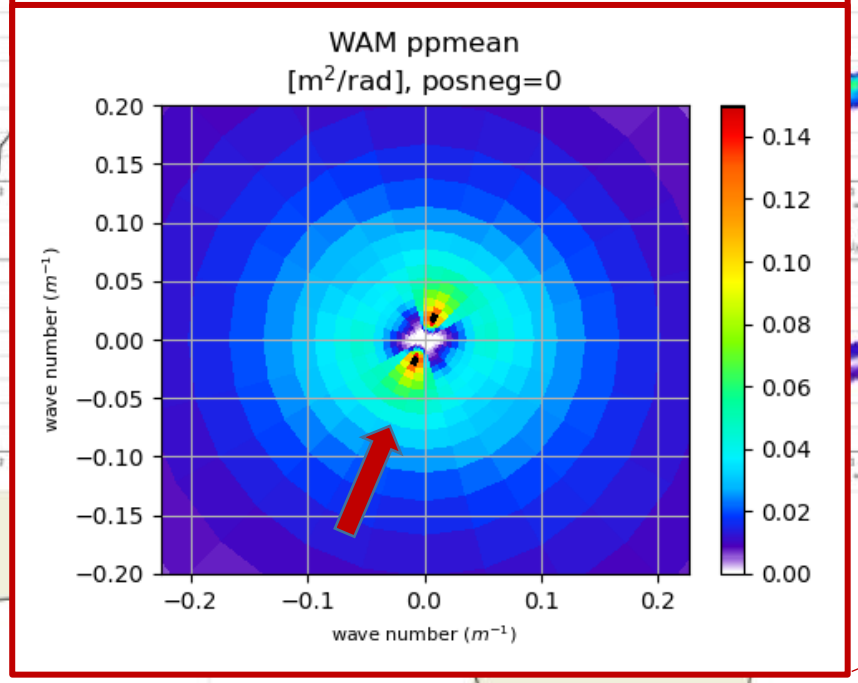
0°
10°S
20°S
30°S
120°E
130°E
140°E
150°E
160°E
170°E


Sentinel-1 2D ppmean
110°E
120°E
130°E
140°E
150°E
160°E
170°E
0°
10°S
20°S
30°S
Sentinel-1

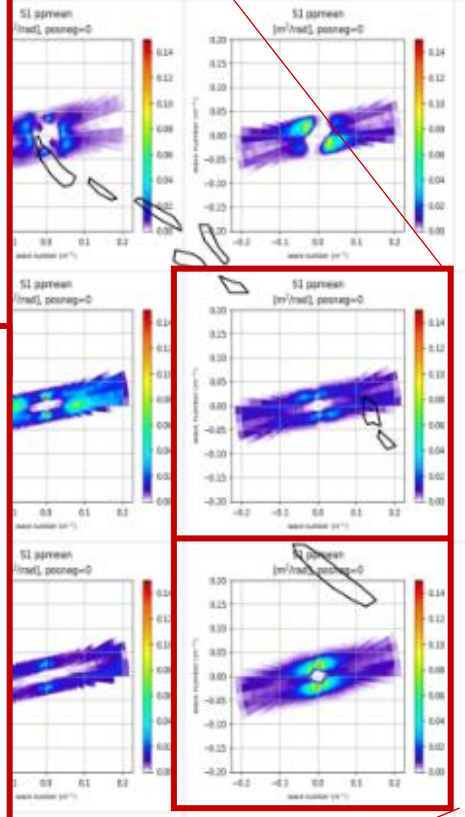

SWIM 2D ppmean
110°E
120°E
130°E
140°E
150°E
160°E
170°E
0°
10°S
20°S
30°S
SWIM

Sentinel-1 2D ppmean





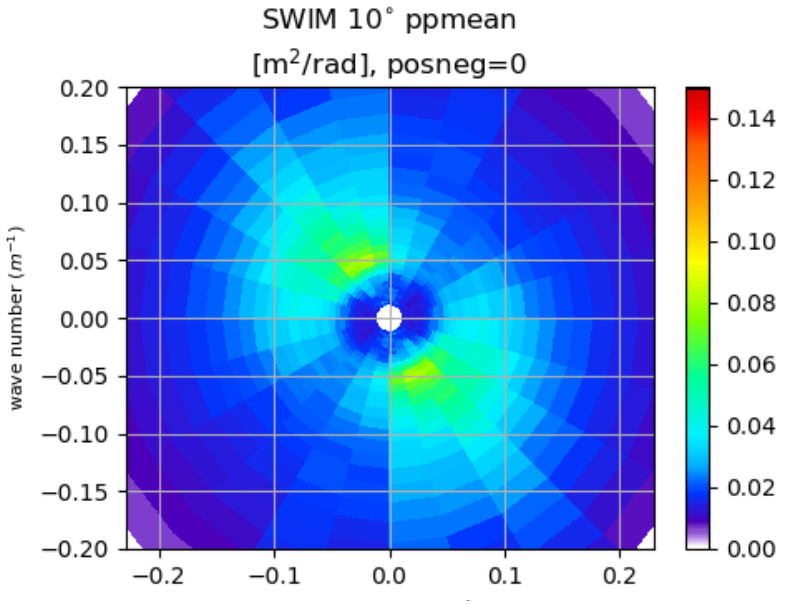
Alizés driven waves in the intertropical zone

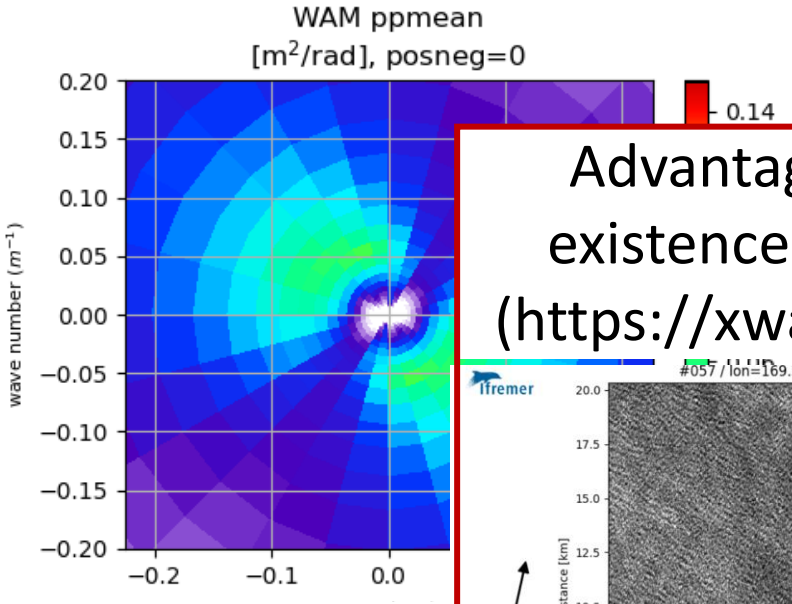


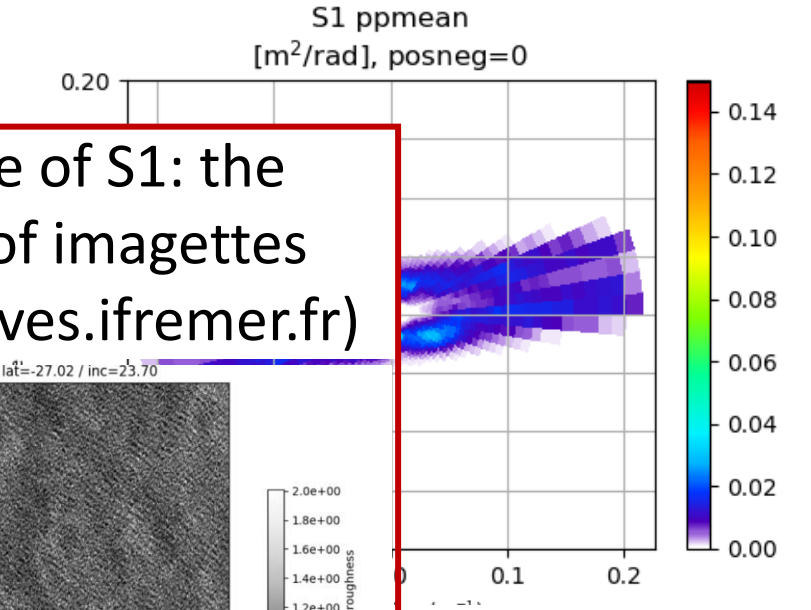
Swell from south Autralia

110°E 120°E 130°E 140°E 150°E 160°E 170°E

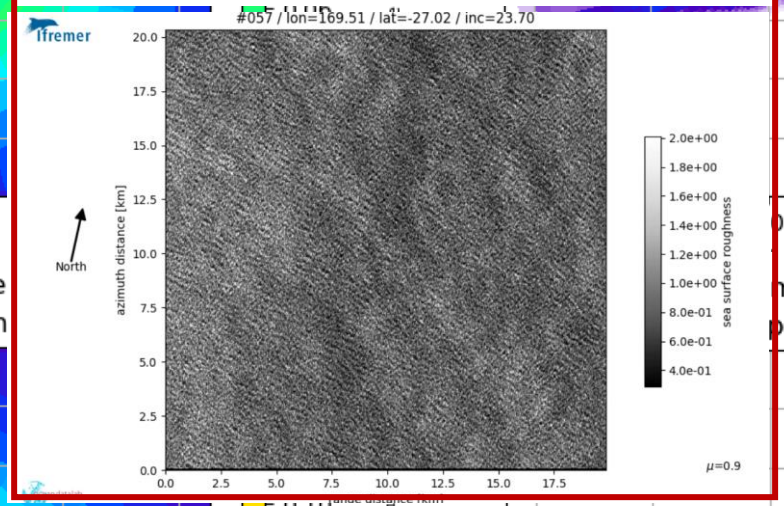
0° 10°S 20°S 30°S

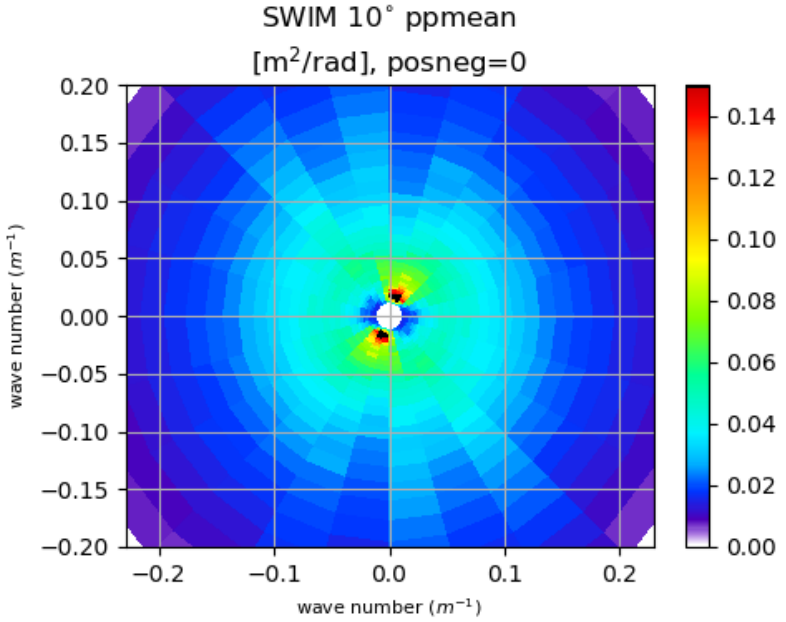


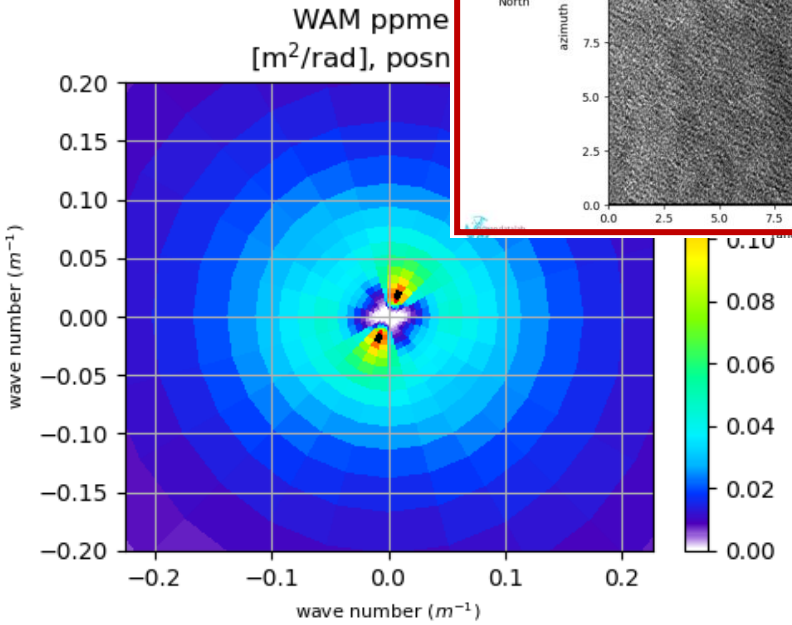


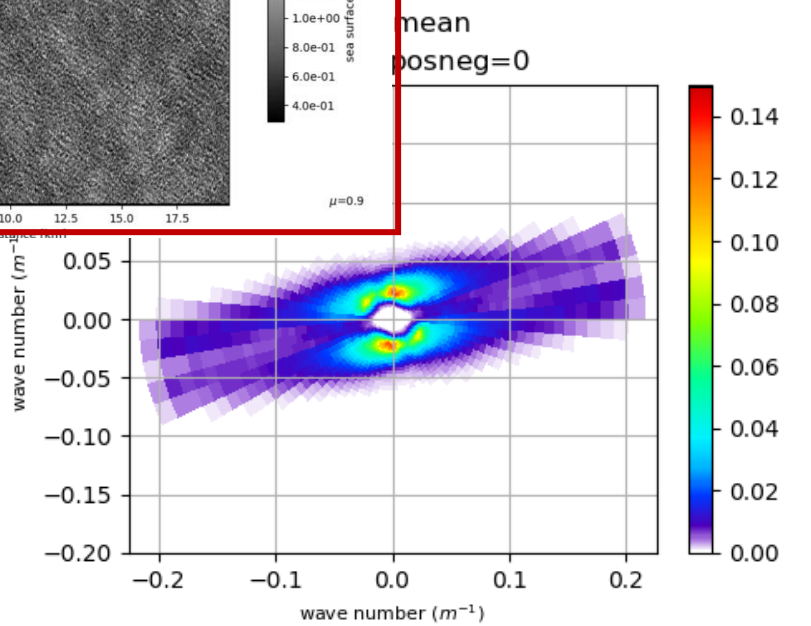


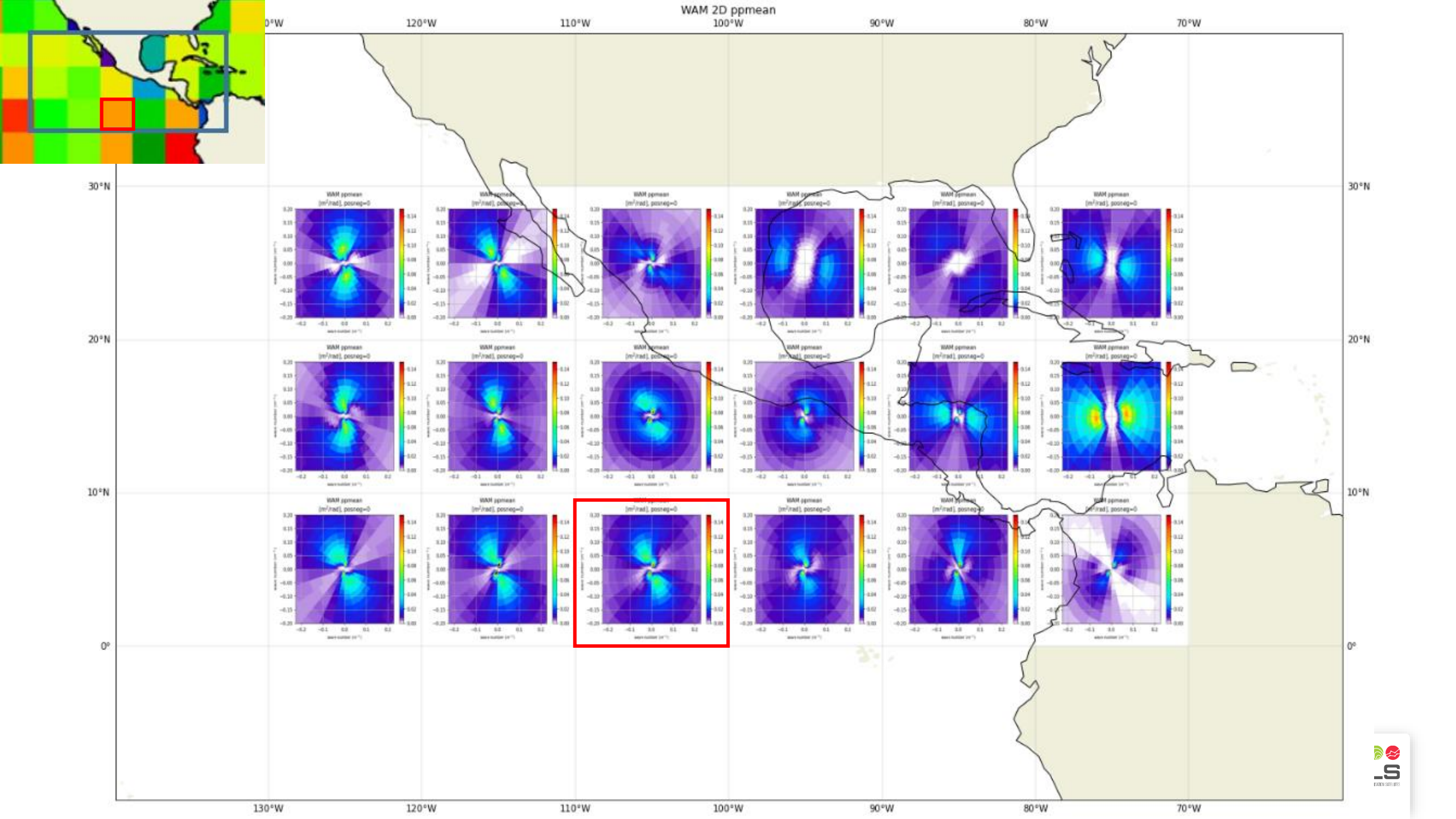
Advantage of S1: the existence of imagettes (https://xwaves.ifremer.fr)

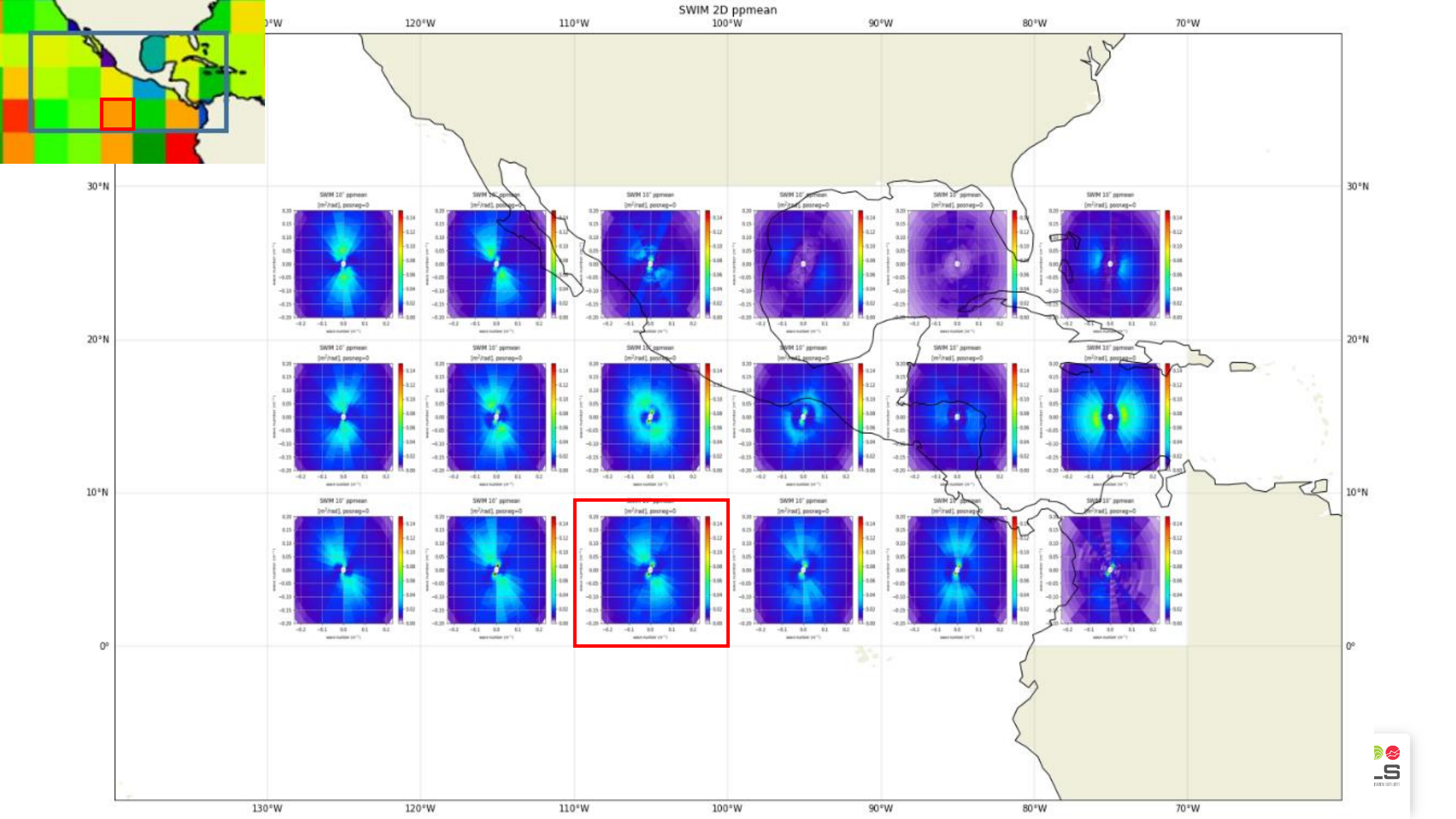


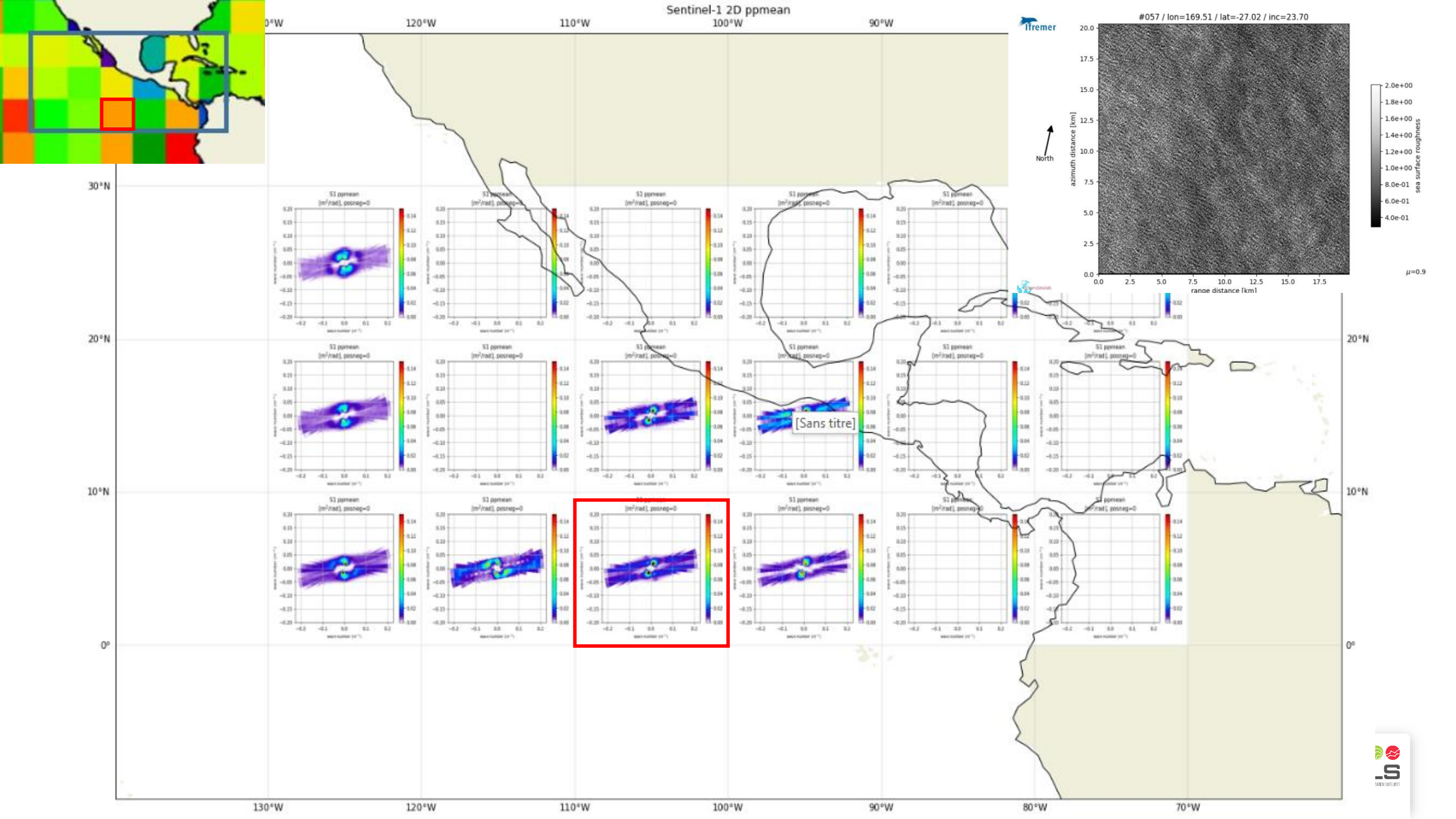


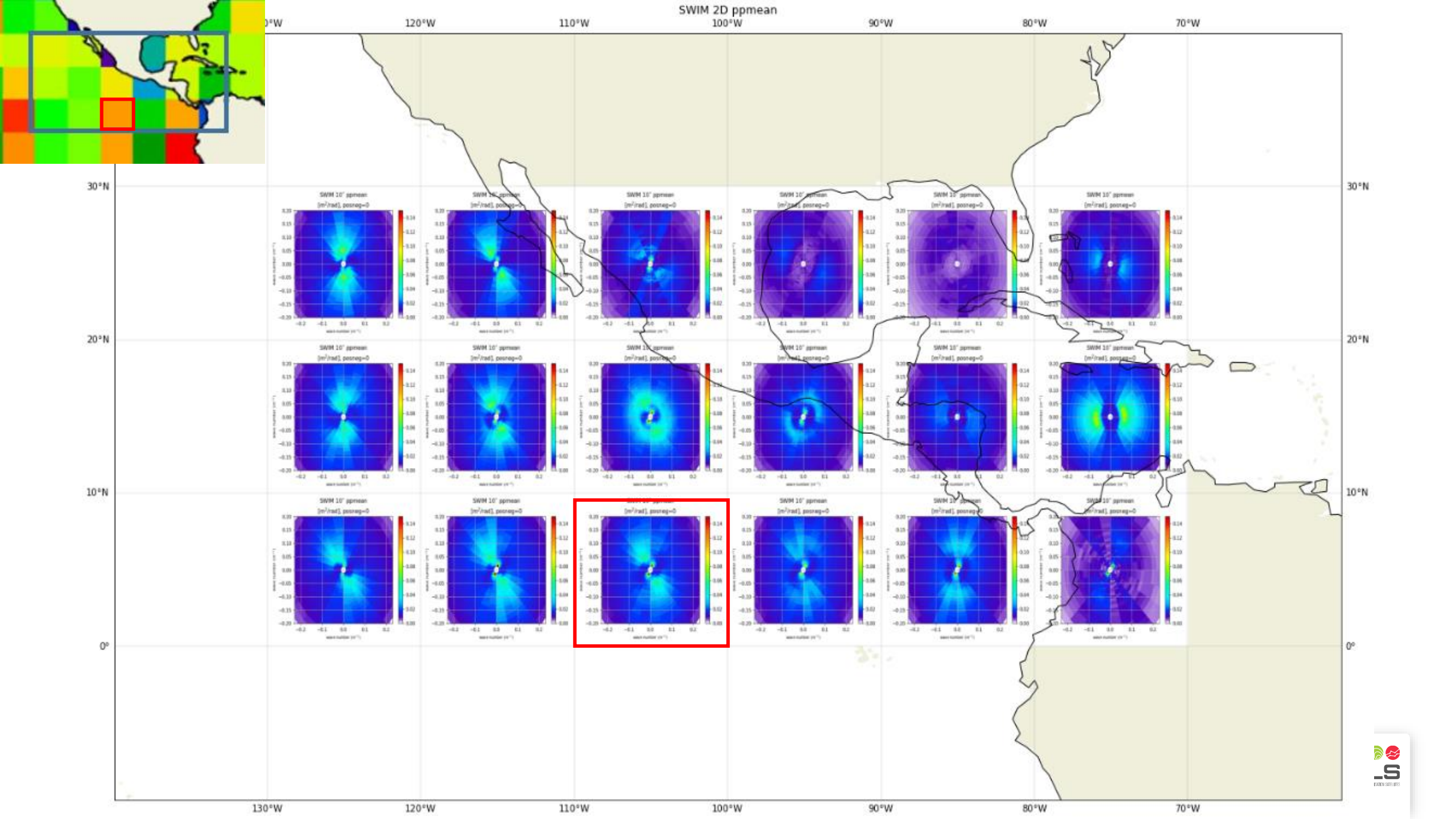


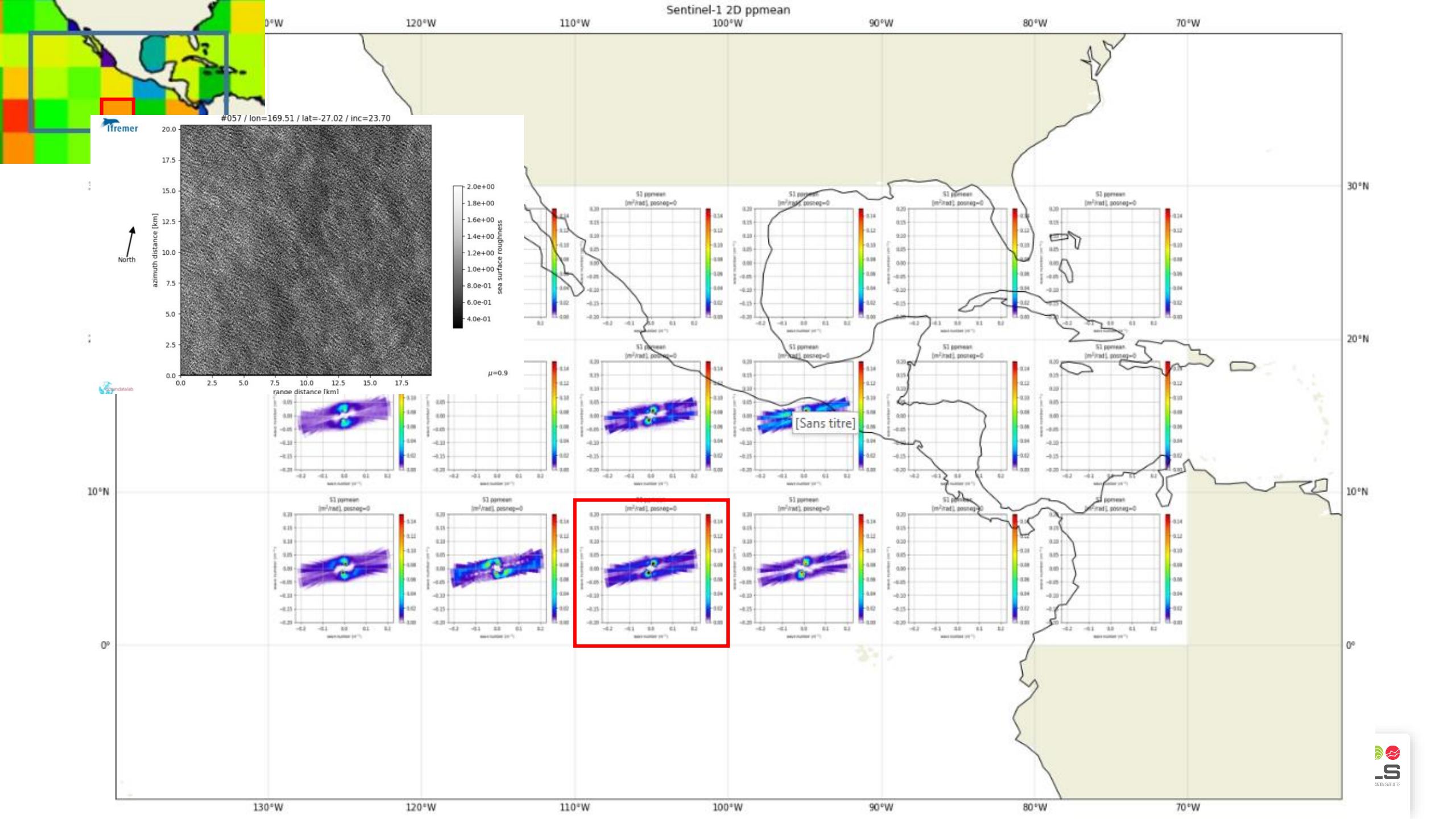


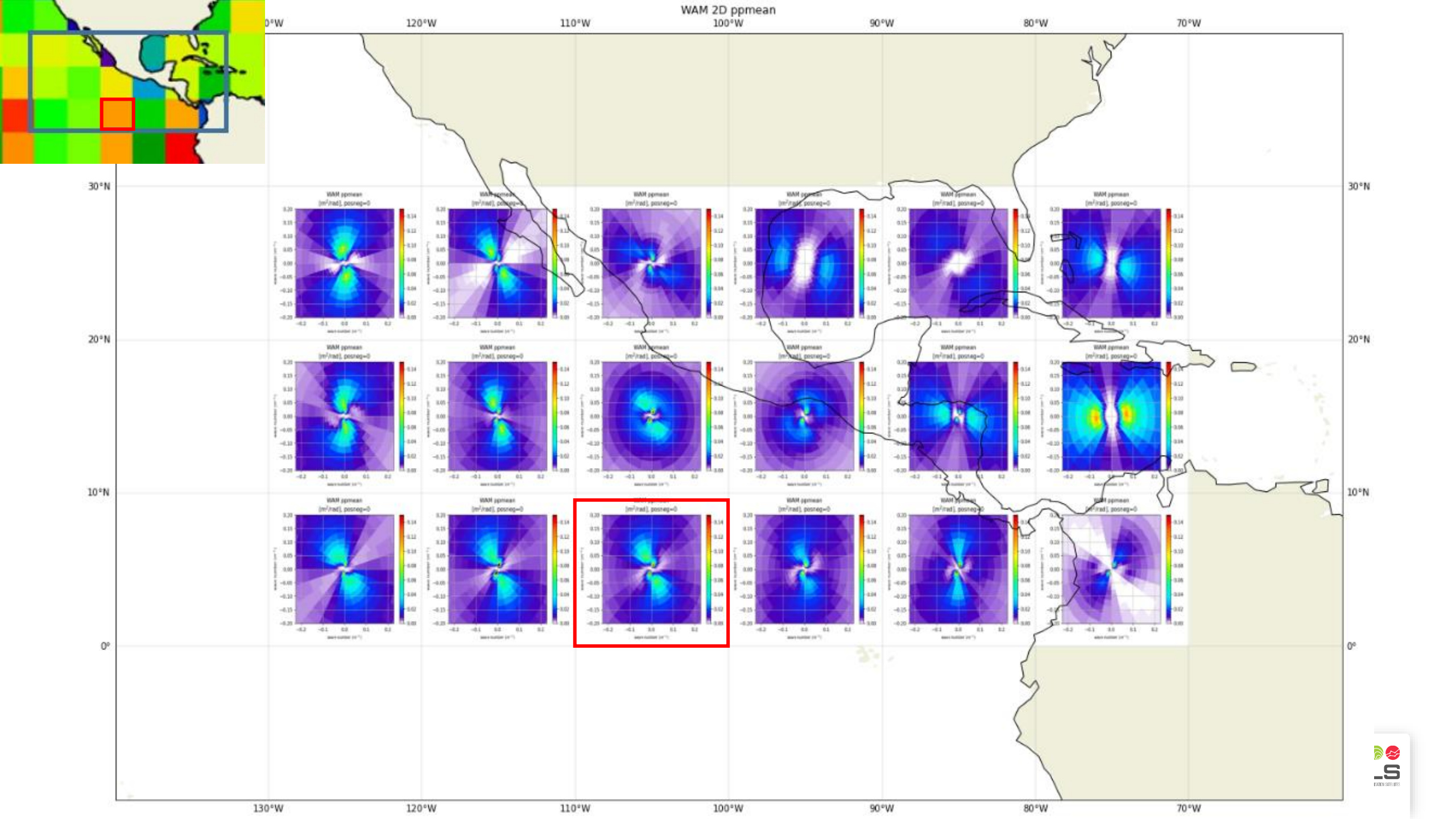

WAM 2D ppmean
120°W
110°W
100°W
90°W
80°W
70°W
30°N
20°N
10°N
0°
130°W


SWIM 2D ppmean
120°W
110°W
100°W
90°W
80°W
70°W
30°N
20°N
10°N
0°
130°W


Sentinel-1 2D ppmean
#057 / lon=169.51 / lat=-27.02 / inc=23.70
Ifremer
North
azimuth distance [km]
range distance [km]
sea surface roughness
μ=0.9
[Sans titre]
130°W
120°W
110°W
100°W
90°W
80°W
70°W
30°N
20°N
10°N
0°


SWIM 2D ppmean
120°W
110°W
100°W
90°W
80°W
70°W
30°N
20°N
10°N
0°
130°W


Sentinel-1 2D ppmean
#057 / lon=169.51 / lat=-27.02 / inc=23.70
Ifremer
North
azimuth distance [km]
range distance [km]
sea surface roughness
μ=0.9
[Sans titre]
130°W
120°W
110°W
100°W
90°W
80°W
70°W
30°N
20°N
10°N
0°


WAM 2D ppmean
120°W
110°W
100°W
90°W
80°W
70°W
30°N
20°N
10°N
0°
130°W