



On the impact of the assimilation of multi-missions 5 Hz SWH in the regional wave model of CMEMS-IBI

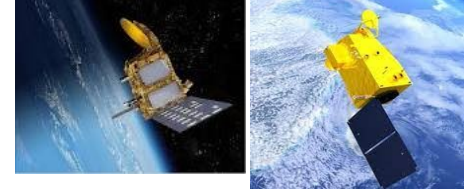
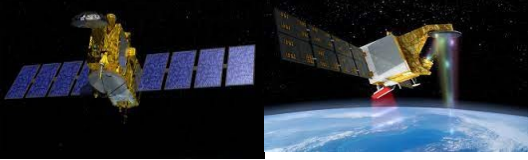
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Motivation



- The objective concerns the improvement of wave forecast in regional and coastal scales : consistency with SWH variability including wave-current interactions
- Exploring impact of the assimilation of multi-missions of 5 Hz SWH : better resolved wave data for small scale wave prediction
- Reliable wave products for downstream applications in the coastal ocean regions (overtopping, wave submersion, beach erosion,...) such Iberian Biscay Ireland and in the Copernicus Marine Service

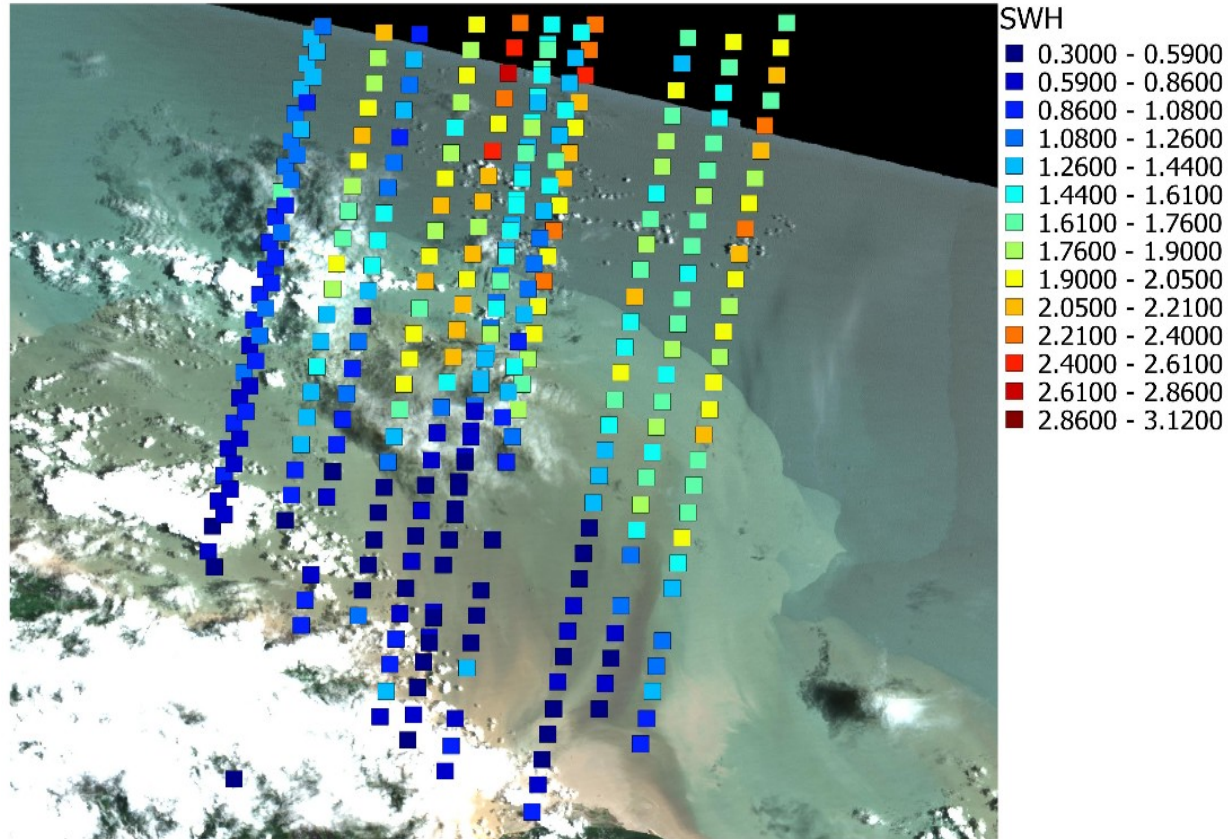
Ciaran storm in brittany



NRT 5 Hz SWH from CFOSAT-nadir

SWH nadir 5Hz

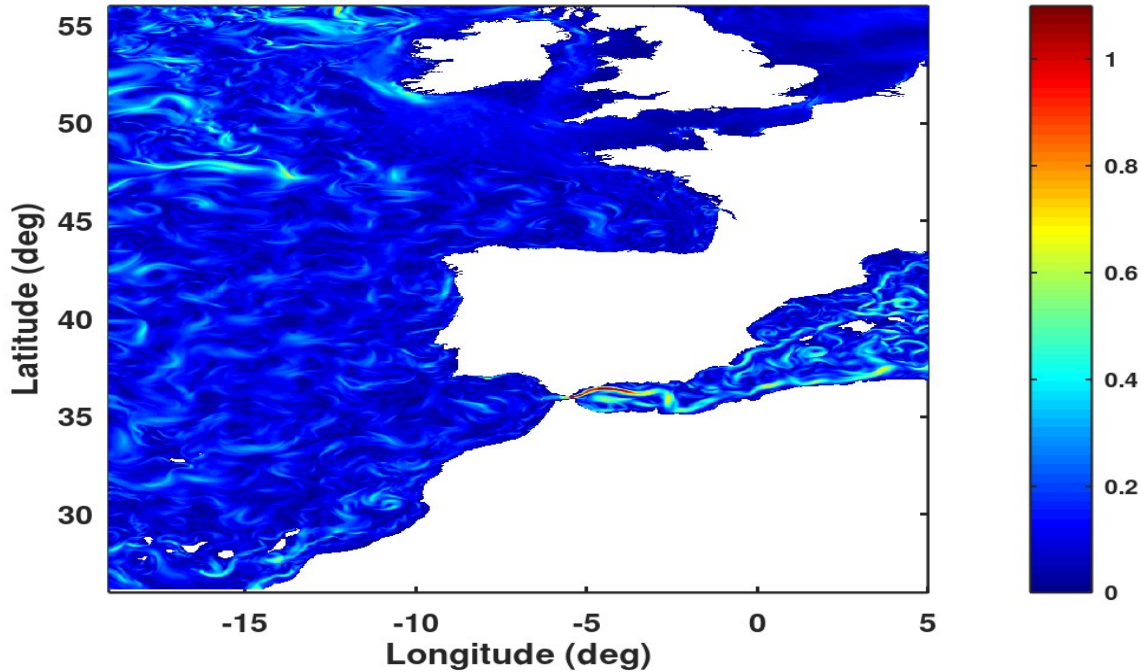
Increase of wave data with 5 Hz SWH in critical coastal Region affected by frequent Change in the bathymetry (moving sand bars) such as French Guyana



SWH decrease induced by changing bathymetry well captured by 5 hz processing of CFOSAT-nadir. Sentinel-2 image shows the bathymetry variability In the french Guyana

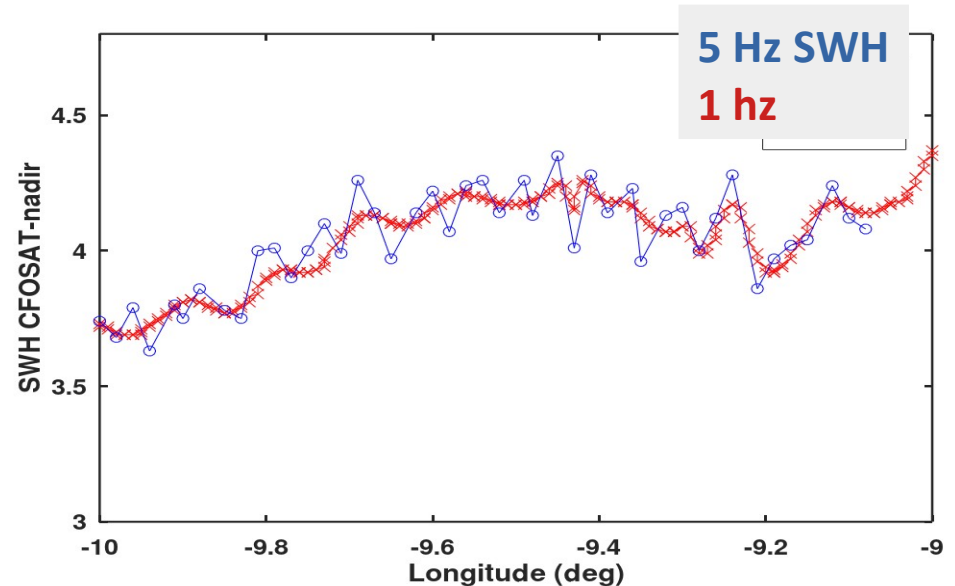
Benefit of 5 Hz for wave-currents interactions as for IBI ocean region

average surface current intensity IBI-PHYS 20210219



1-day average surface currents
From IBI-Phys of Copernicus
Marine Service (hourly surface
Currents)

5 Hz SWH are more consistent with
Small grid size 2-5 km

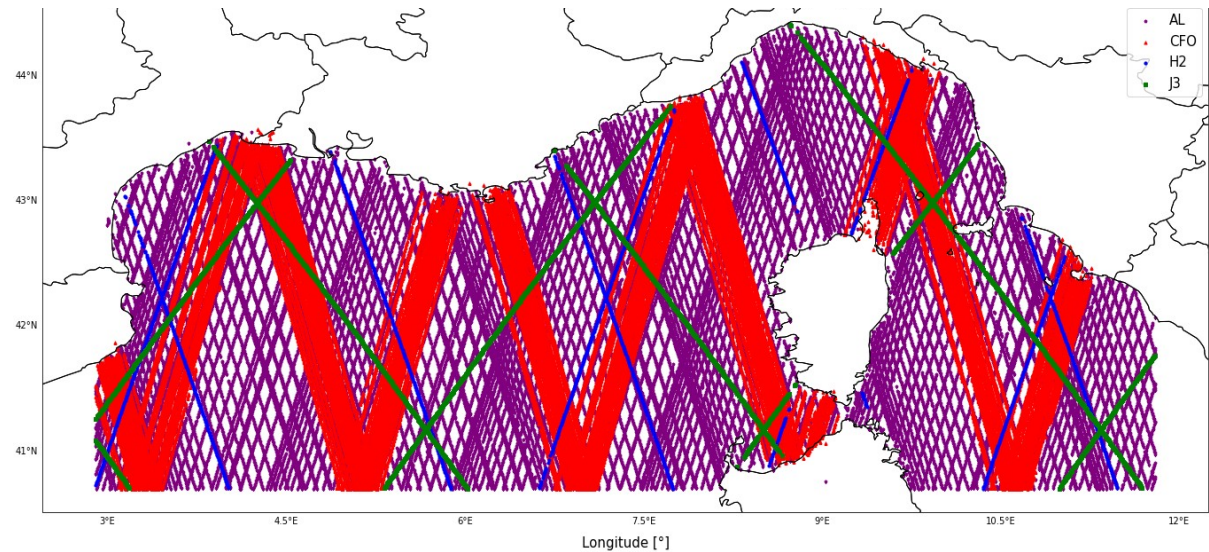


Nadir 5Hz L3 WAVE demonstration products

■ 4 satellite missions provided as demo products over one year: 2021

CFOSAT nadir
JASON3
ALTIKA
HY2B

Example in the Mediterranean sea



More SWH data in the coastal area (<20 km to the coast)

Data are here:

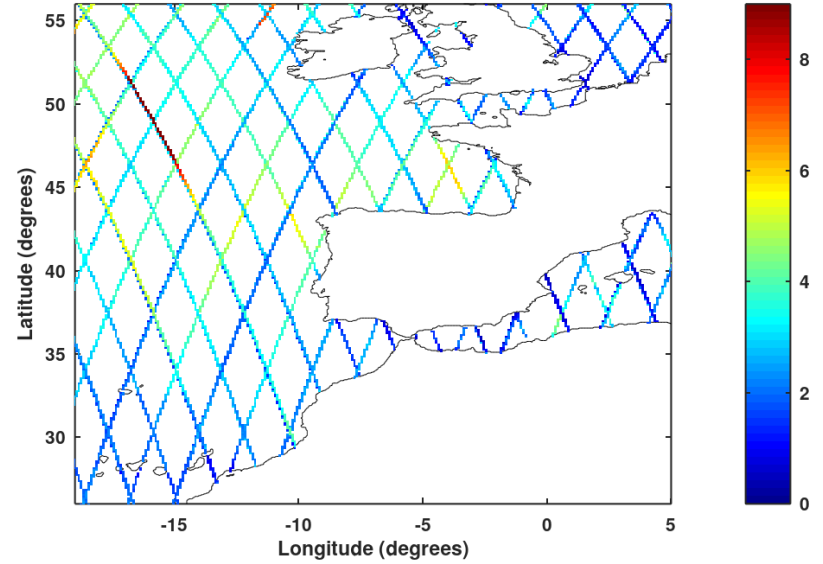
<https://www.avisosatellite.com/en/data/products/windwave-products/wave-experimental-products.html>



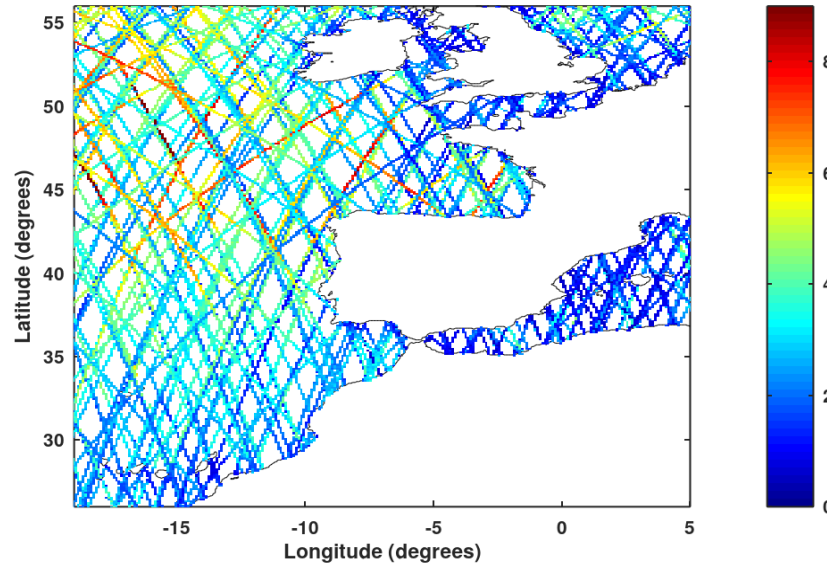
Data coverage in IBI ocean region

CFOSAT 5 hz only

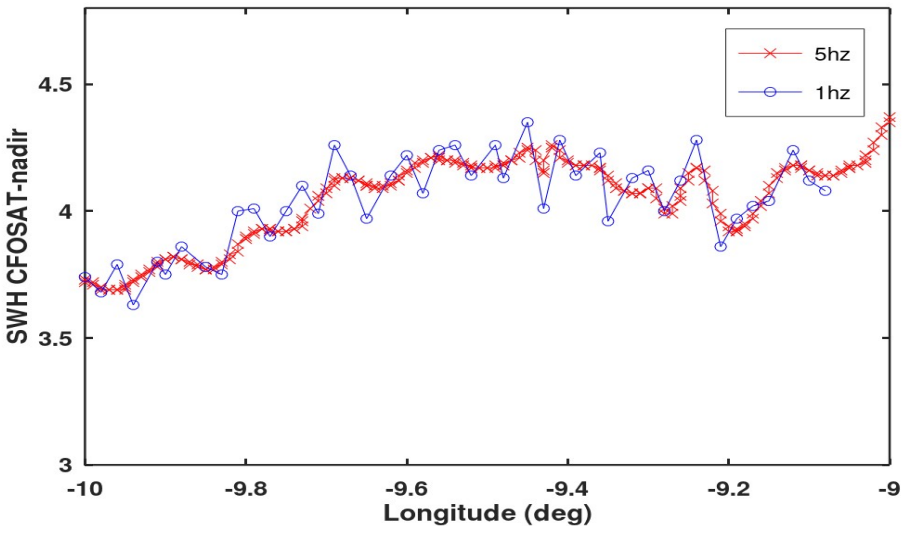
track CFOSAT 5 hz



track multi-missions 5 hz



**Better coverage from
5 hz Multi-missions
(CFOSAT, J3, Saral, H2B)**



Model runs

- Wave model MFWAM for Iberian-Biscay-Ireland regional configuration with grid size of 5 km and spectral resolution of 24 directions and 30 frequencies.

- Nested in CMEMS-global waves, which provides Spectral boundary Conditions

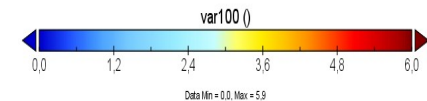
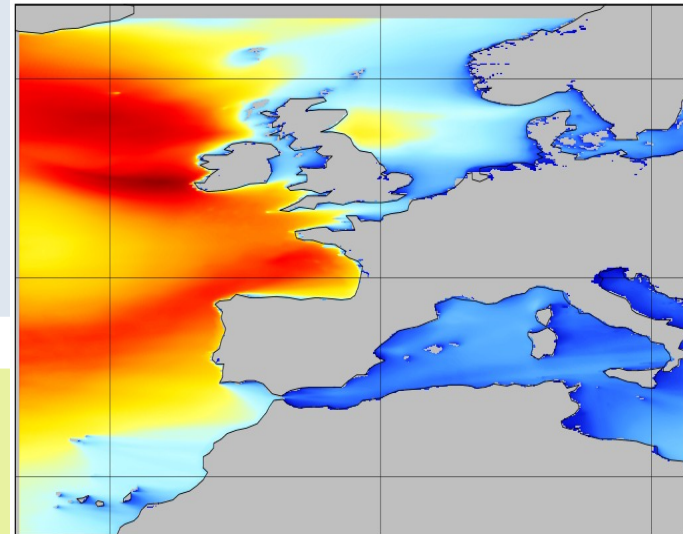
- 3-Hourly wind forcing from IFS-ECMWF atmospheric System

- Several model runs have been performed for the period Jan-March 2021 :

- Assimilation of multi-missions 5 Hz SWH (CFO, J3, H2B, SARAL)
- Assimilation of CFOSAT 5 Hz SWH
- Baseline run without assimilation

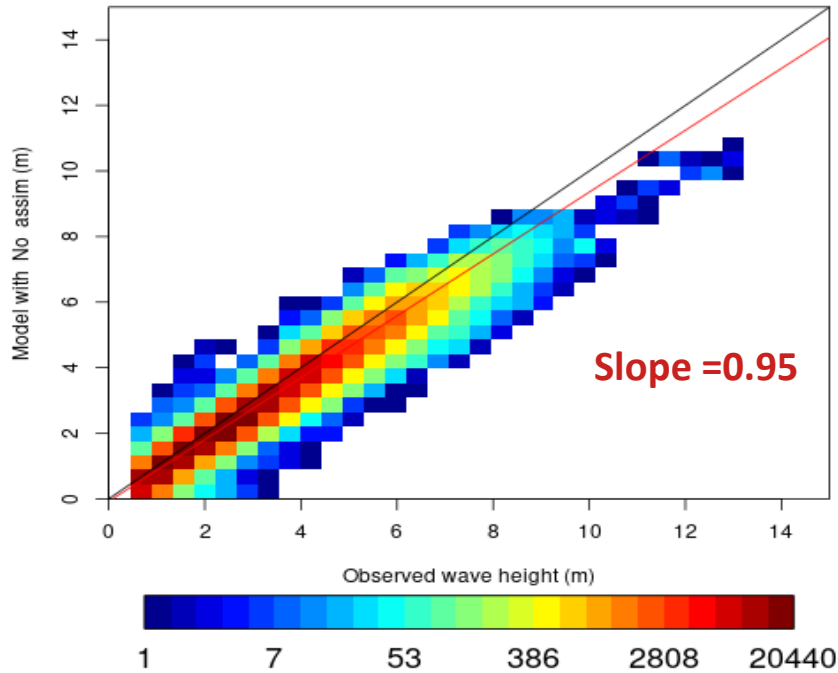
- Small scale Validation (nearest ~5 km) with independent altimeters SWH and SUMOS drifting buoys

average SWH 3 february 2021

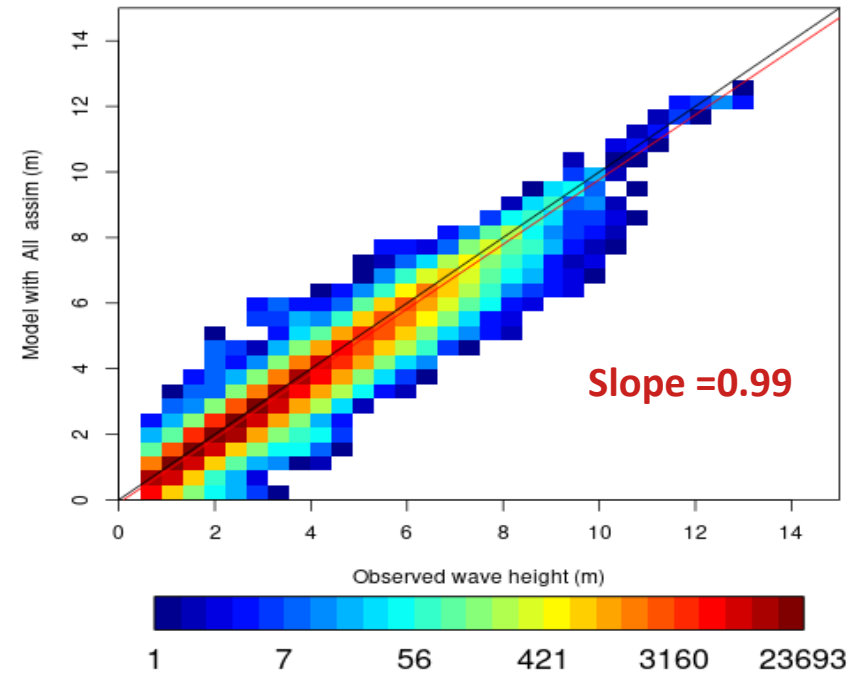


Scatter plots of SWH from model MFWAM : period Jan-Mar 2021

Without DA



With DA of Multi-missions 5 Hz



Better slope after the assimilation and significant improvement of scatter Index of SWH, particularly for high SWH

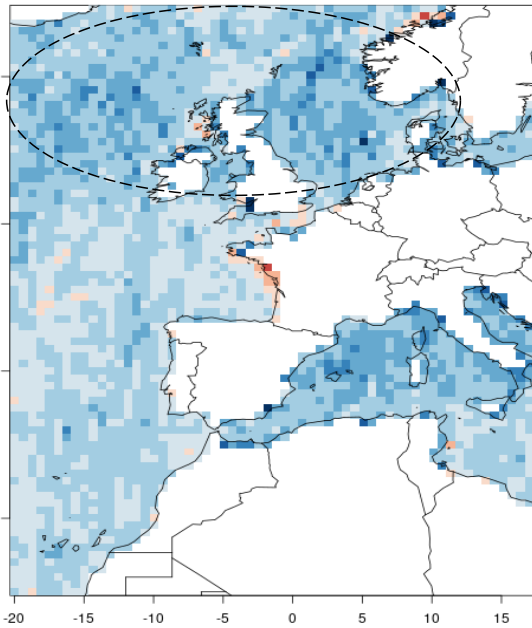
Comparison with independent altimeters SWH (Sentinel-3 and CR2)

Validation of SWH from different runs with independent altimeters

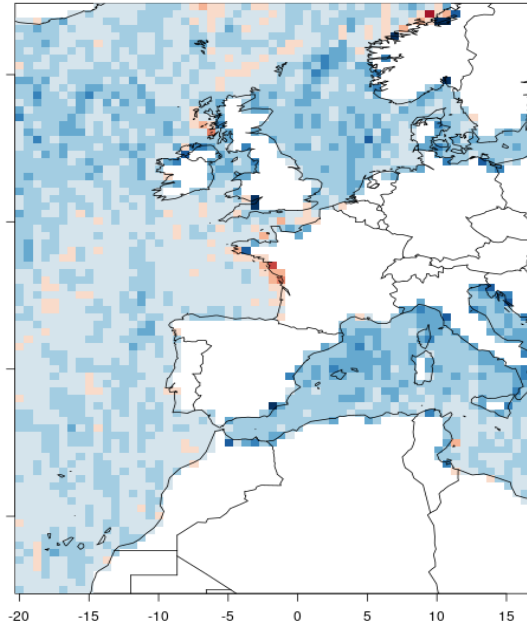
Jan-Mar 2021

Bias maps of SWH (max range in colorbar 1 m)

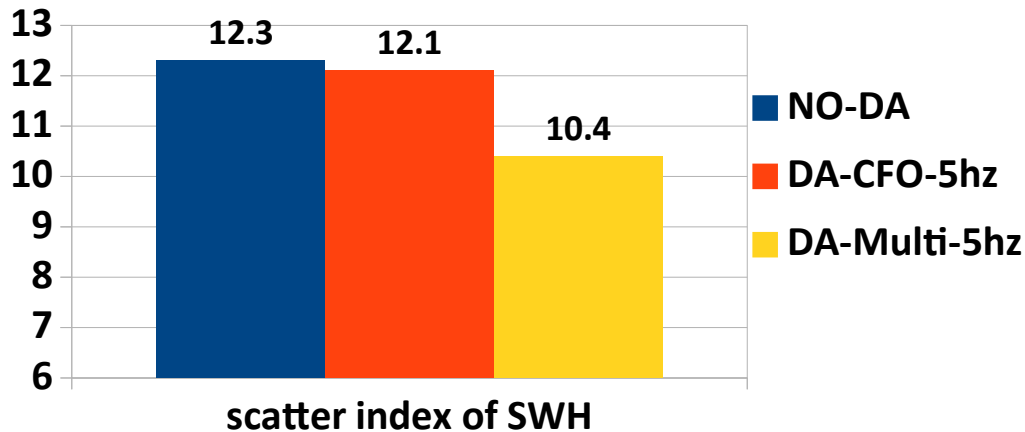
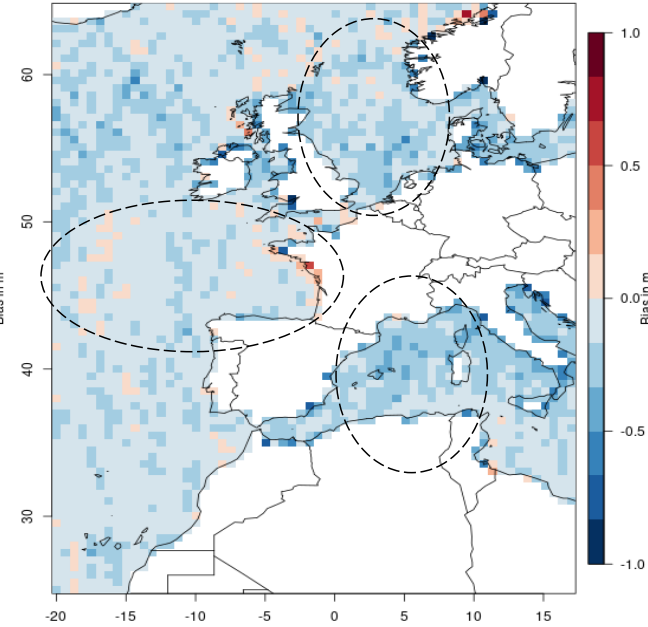
Without DA (~-24 cm)



DA-CFO (~-18 cm)



DA-Multi-missions (~-14cm)

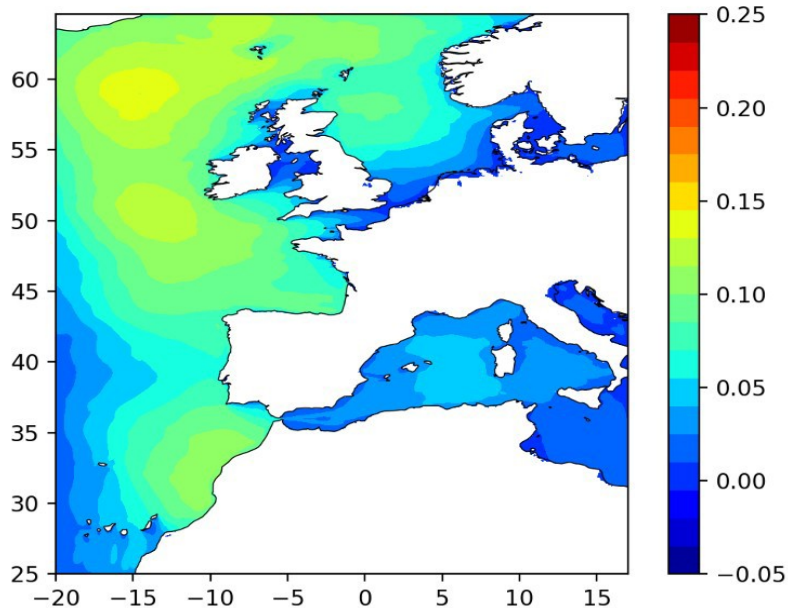


Good SWH bias reduction
In North-East Atlantic, North
Sea and western Med sea

Comparison of impact on SWH between 1mission and multi-missions February 2021

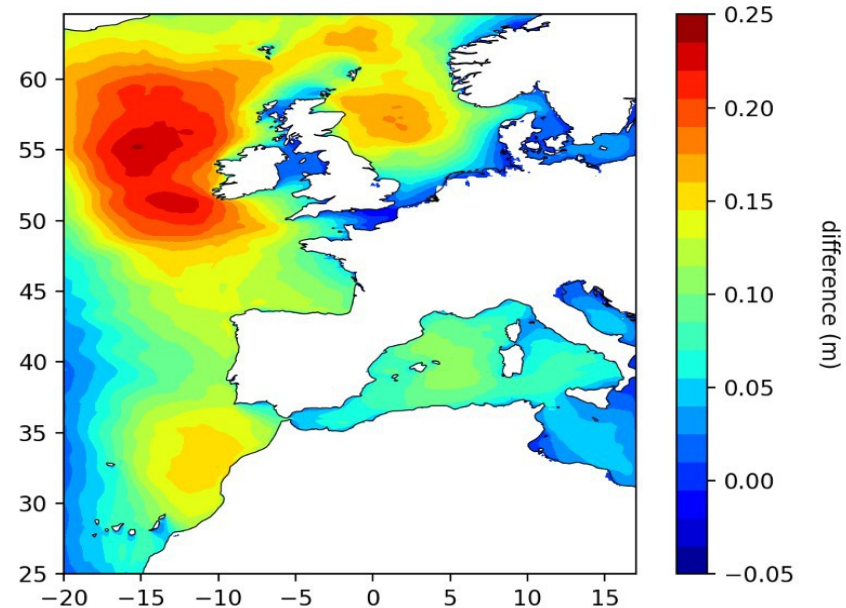
Average difference of SWH (w/wo CFO-5hz)

Average difference of SWH w/wo 5Hz alti DA
CFOSAT only - Février 2021



Average difference of SWH (w/wo Multi-5hz)

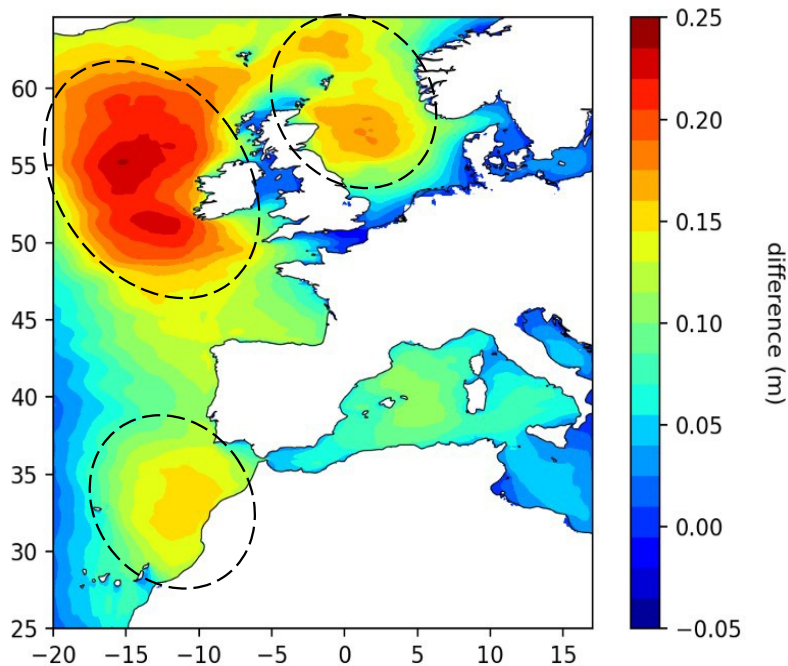
Average difference of SWH w/wo 5Hz alti DA
CFOSAT+Altika+Jason3+Hy2B - Février 2021



➔ The assimilation corrects the strong underestimation from control model run :
positive difference values in colorbars

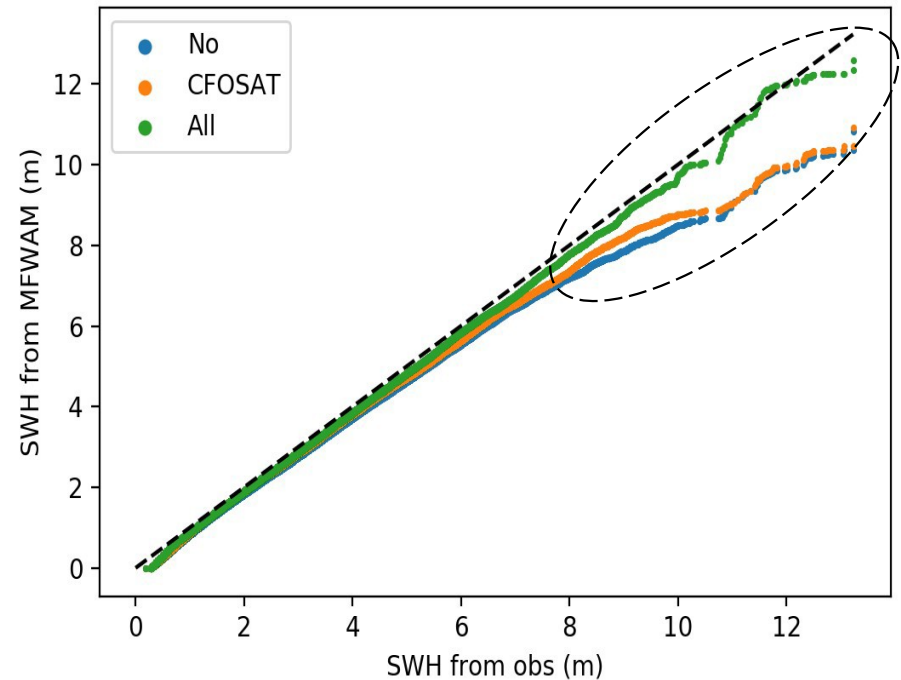
Comparison of PDF of SWH from different MFWAM-IBI runs

Average difference of SWH with and without DA of multi-missions 5 hz for February 2021



Three typical ocean regions affected
By the assimilation : North-East Atlantic,
North sea and Moroccan off-shore and
Coastal regions.

QQ-plot of SWH from model and altimeters

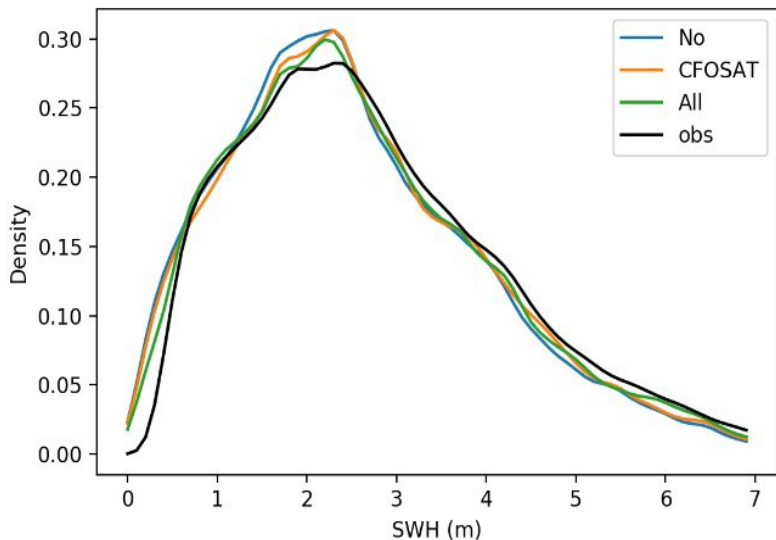


Clearly better PDF when using multi-missions
5 hz SWH, particularly in high SWH values (>7 m)

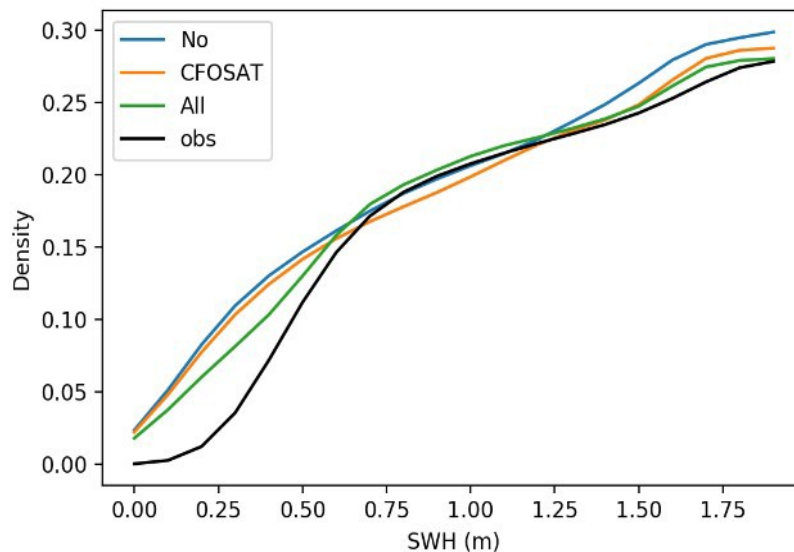
Comparison of PDF between SWH from model runs and independent altimeters

Period Jan-March 2021

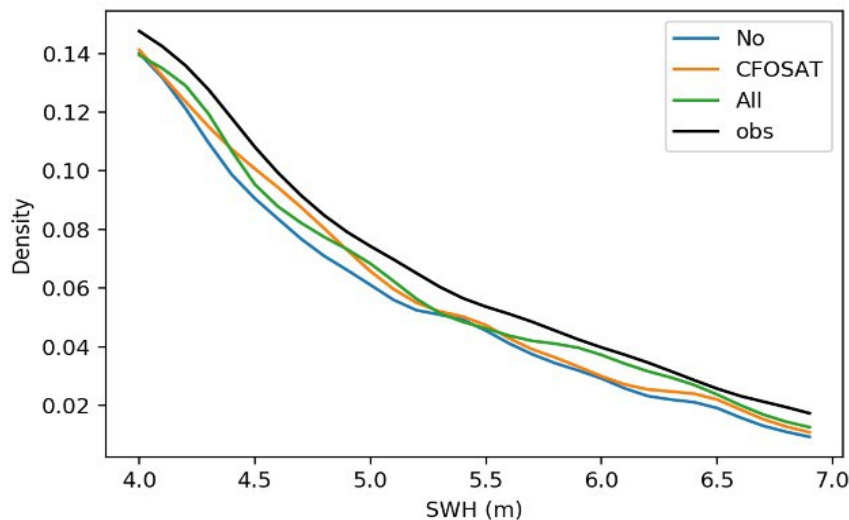
PDF of SWH



PDF of SWH



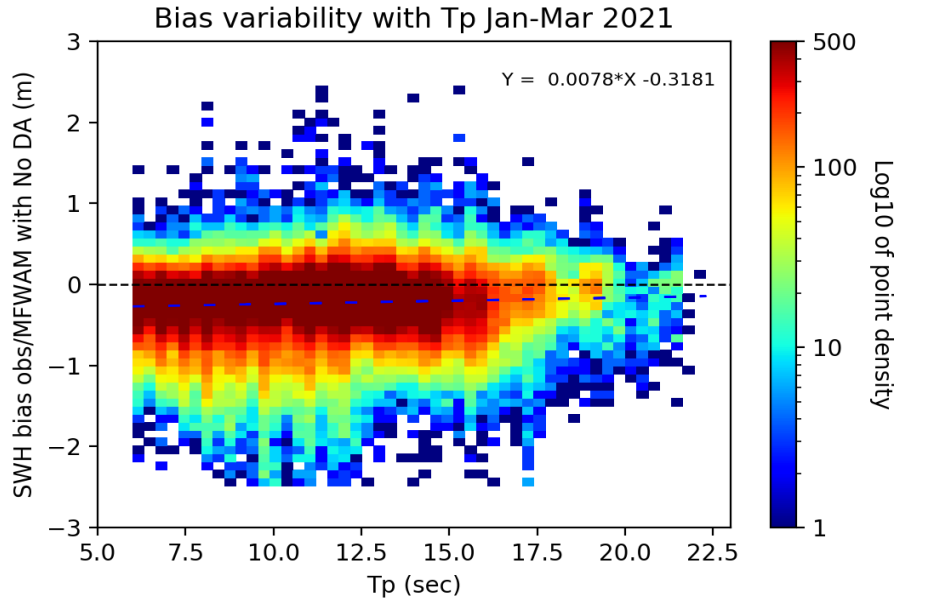
PDF of SWH



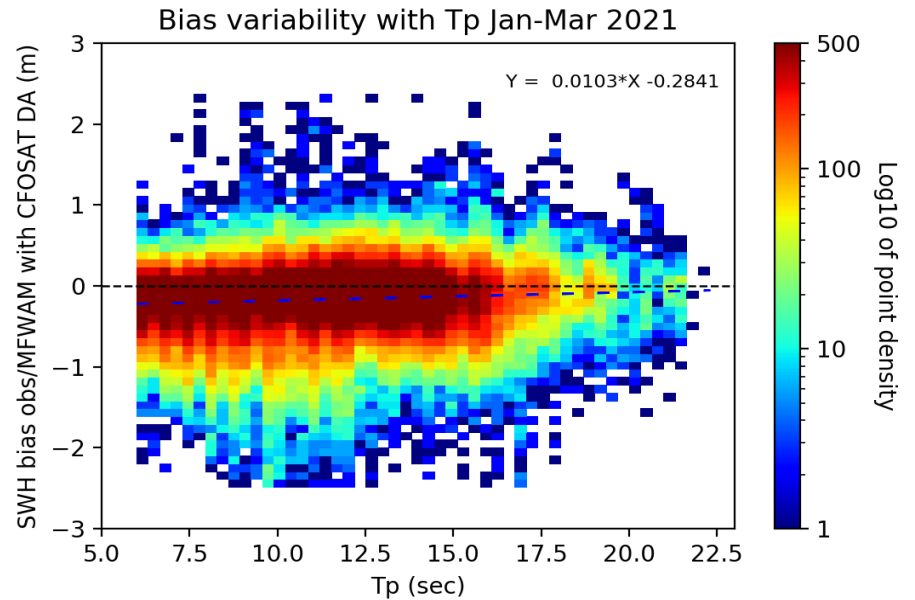
The assimilation of 5 hz induces a better consistency between PDF of SWH from Model and independent altimeters. DA of Multi-missions captures A better variability of small and large SWH

SWH bias variability with Peak period T_p : Jan-Mar 2021

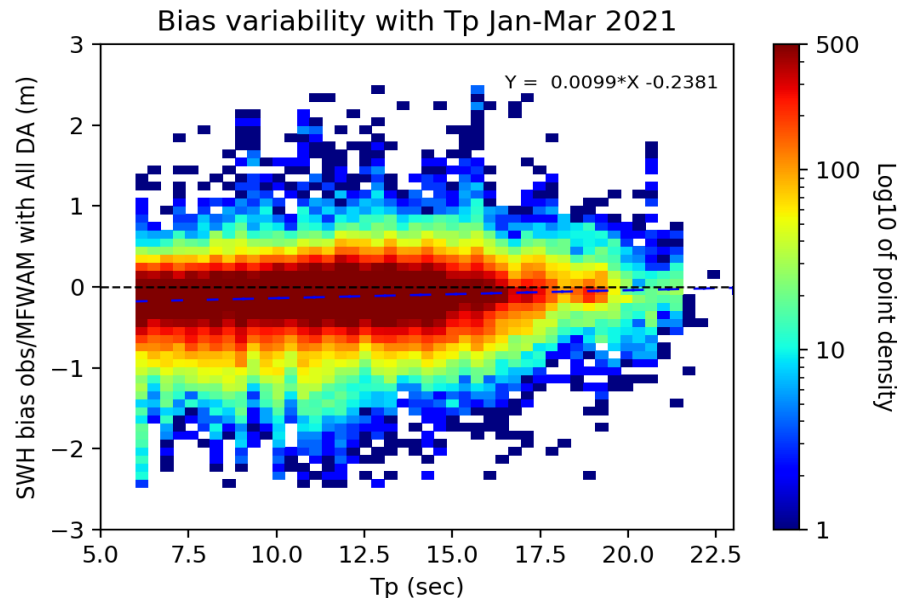
Without DA



With DA CFO-5 hz



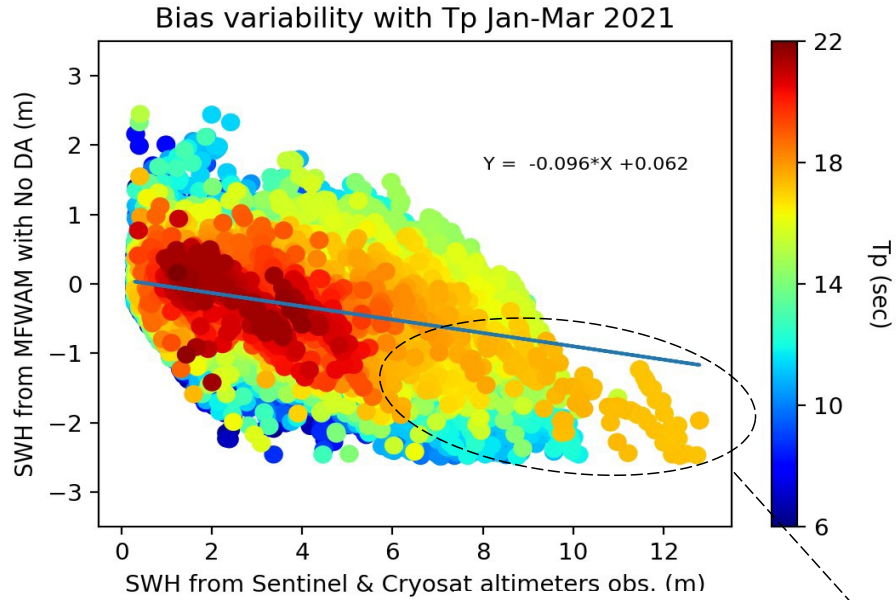
**Strong bias reduction
For all scales of T_p
(wind-waves and
Swell).
Use of multi-missions
enhances the impact
For long swell
($T_p > 14$ sec)**



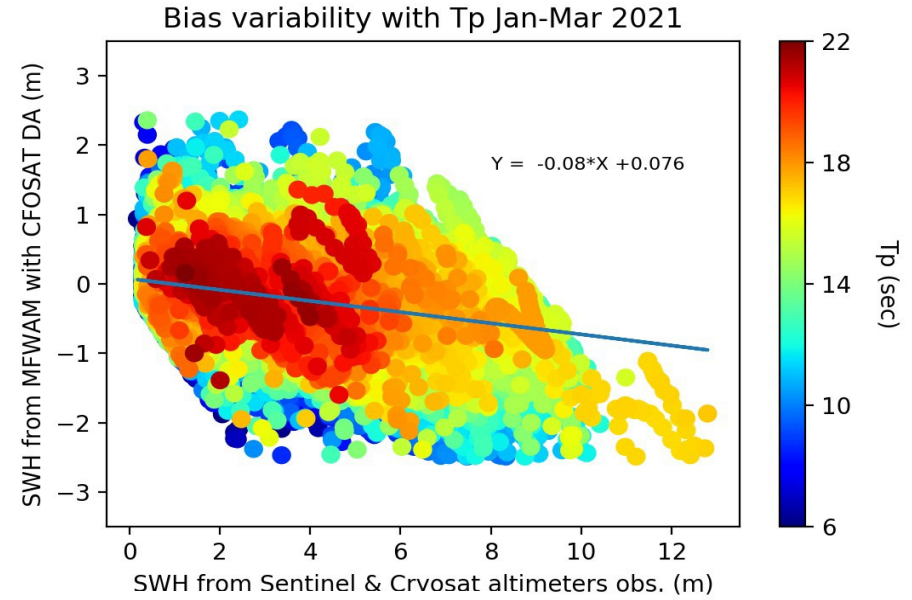
With DA Multi-5 hz

SWH bias variability with Peak period T_p : Jan-Mar 2021

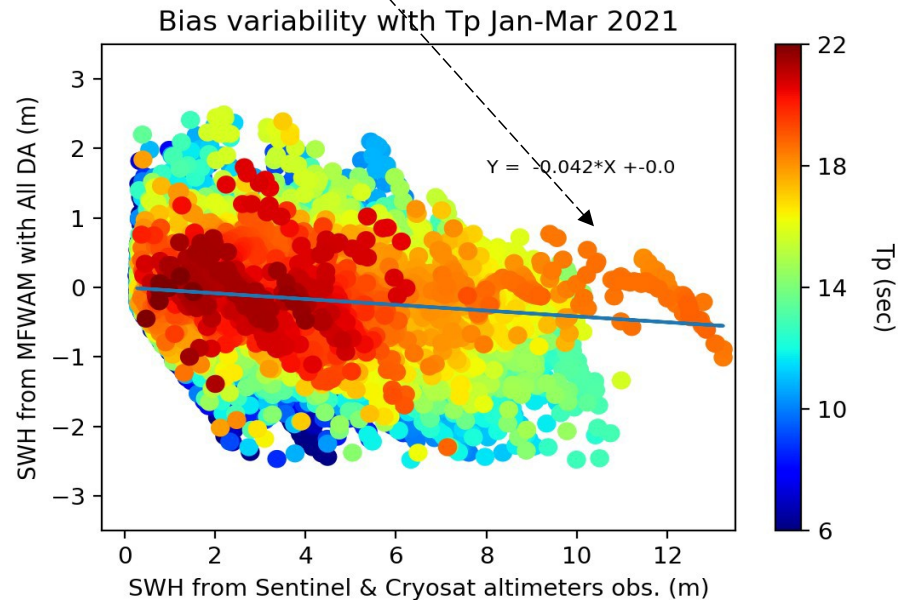
Without DA



With DA CFO-5 hz



Remarkable SWH bias Reduction for high SWH And long swell. The slope is significantly improved Compared to without DA

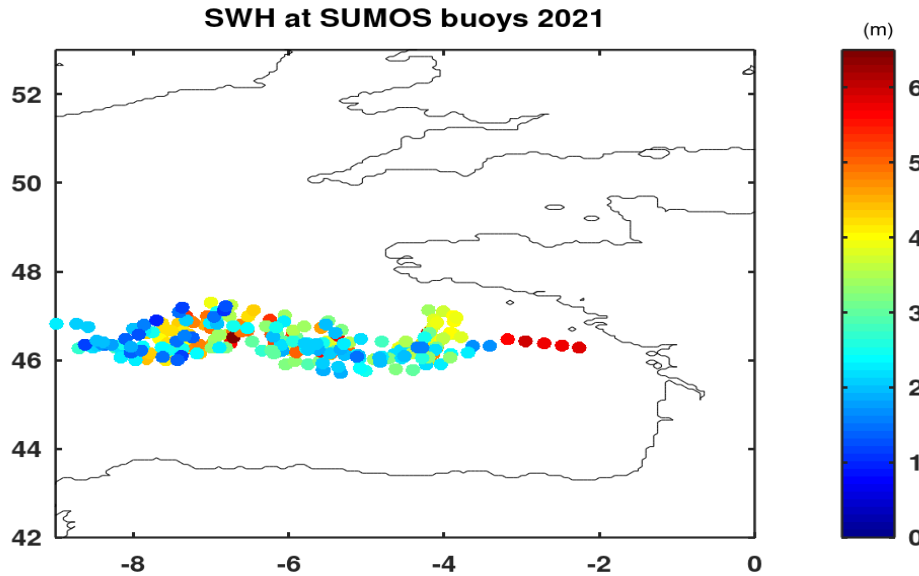


With DA Multi-5 hz

Comparison with wave drifting buoys of SUMOS Campaign Period from 12 Feb to 4 March 2021

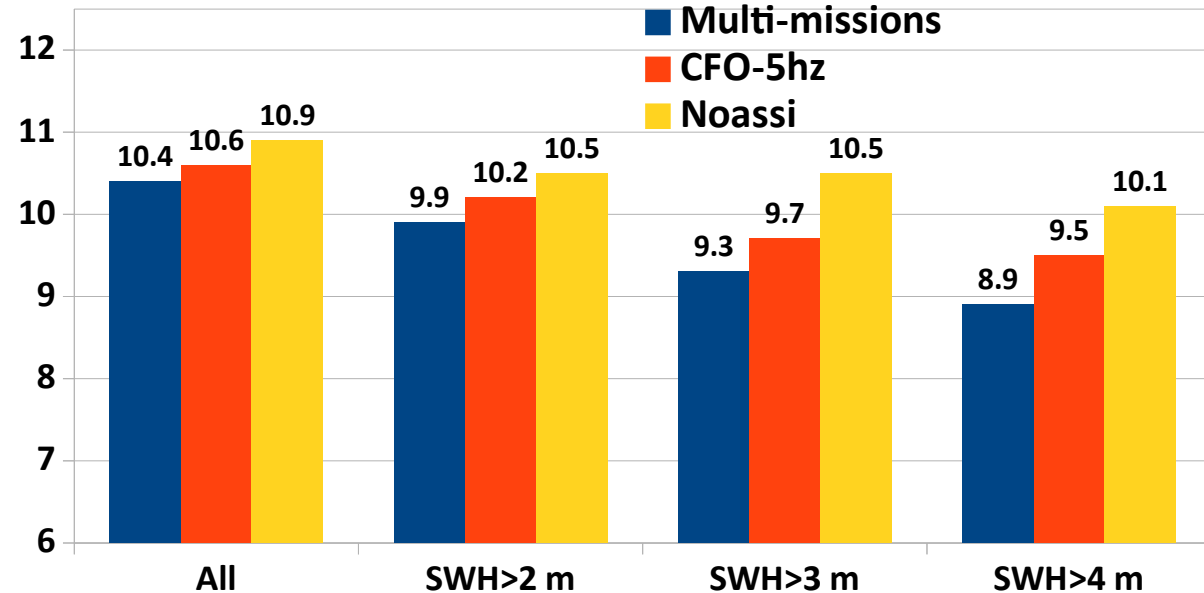


SWH from SUMOS drifting buoys



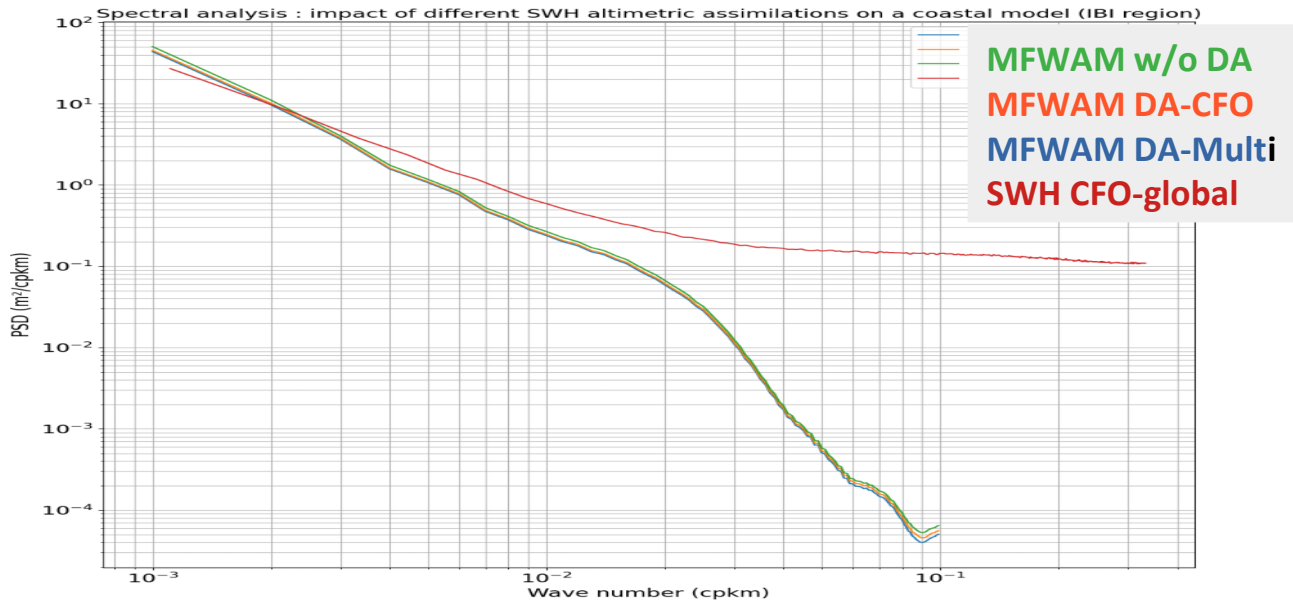
DA of SWH 5 Hz mutli-missions enhances the reduction of scatter index of SWH, Particularly for high SWH Values

SI of SWH for different ranges of SWH



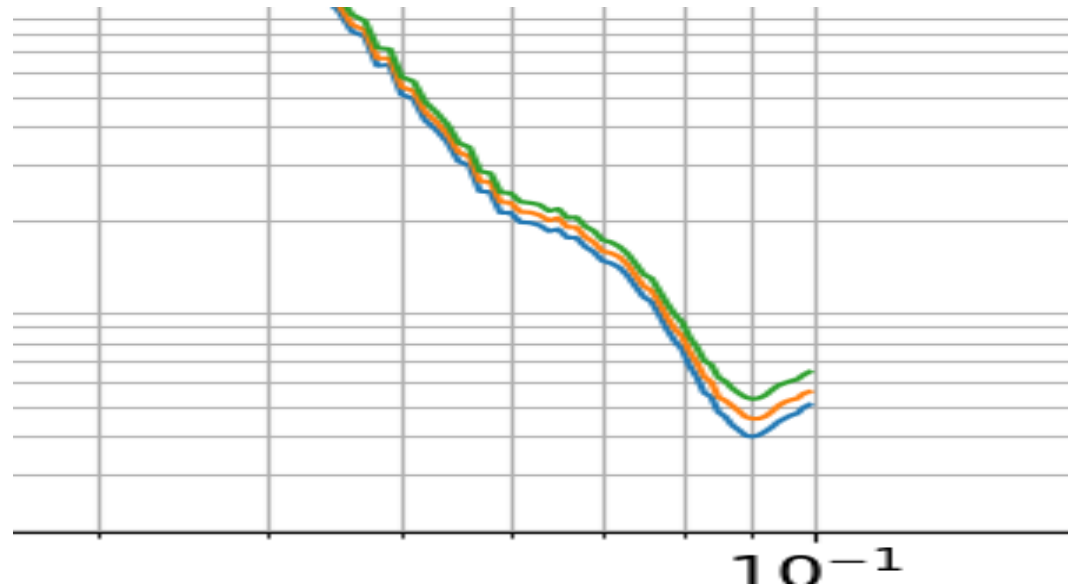
For SWH > 4 m the SWH Bias decreases from -21 cm for without DA to -8 cm for DA of Multi-missions

Spectral analysis of SWH for IBI



Zoom on the slope

Better description of SWH small Scale variability (~ 1 km) when Using 5 hz data in the model MFWAM.



Key messages

- The assimilation of multi-missions 5 Hz SWH reveals significant positive impact on high resolution wave forecast, particularly for near the coastal areas.
- Small scale validation with Sumos buoys shows better capturing of high wave height events
- Promising perspectives for operational coastal wave models : only CFOSAT-nadir is providing NRT 5 hz SWH
- On going work for adapting the assimilation scheme in terms of correlation length depending SWH variability from open ocean to coastal