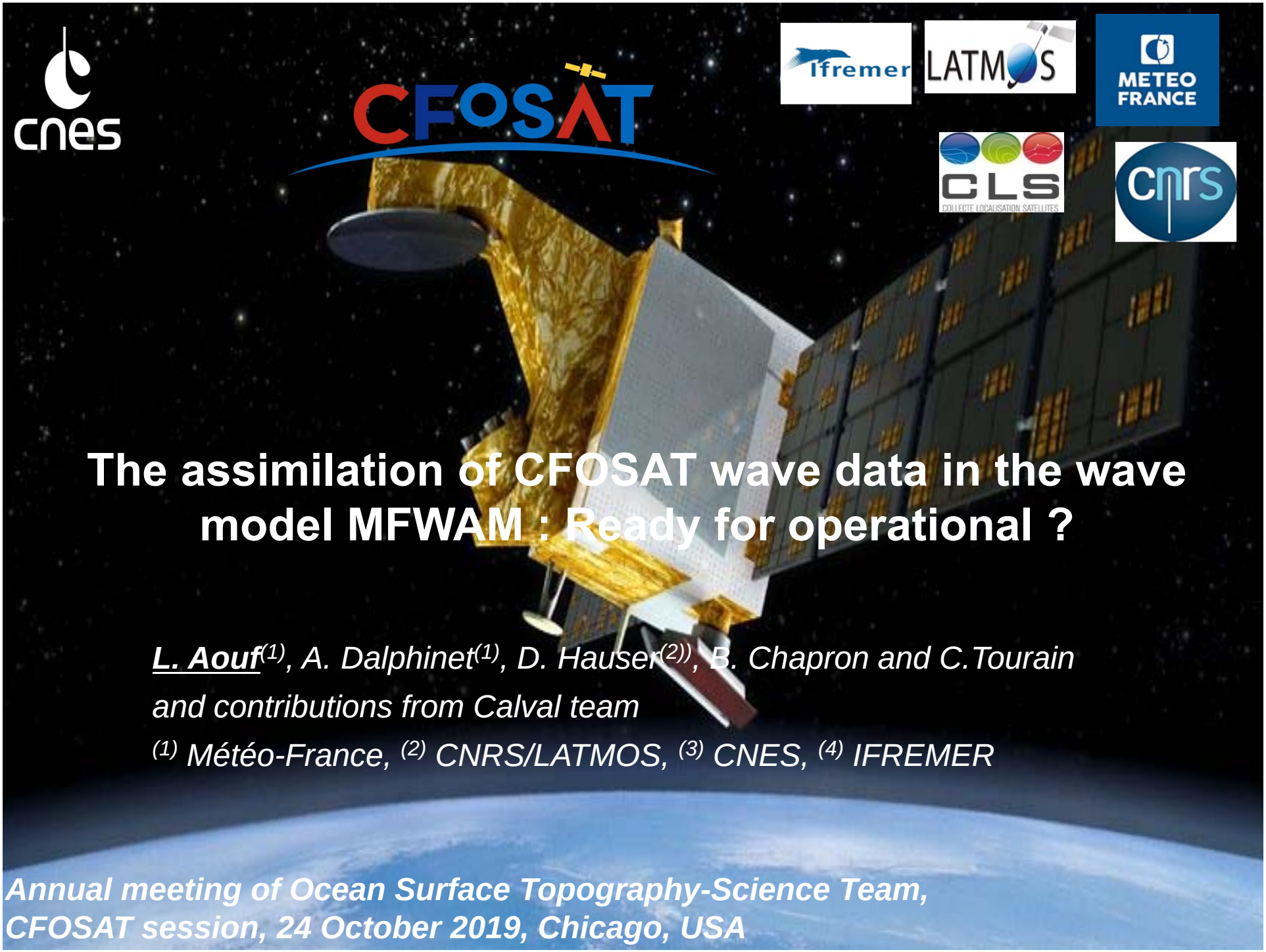


The assimilation of CFOSAT wave data in the wave model MFWAM : Ready for operational ?

L. Aouf[(1)], *A. Dalphinet*[(1)], *D. Hauser*[(2))], *B. Chapron and C.Tourain*

and contributions from Calval team

(1) Météo-France, (2) CNRS/LATMOS, (3) CNES, (4) IFREMER

Annual meeting of Ocean Surface Topography-Science Team, CFOSAT session, 24 October 2019, Chicago, USA

OUTLINE

1- Motivation

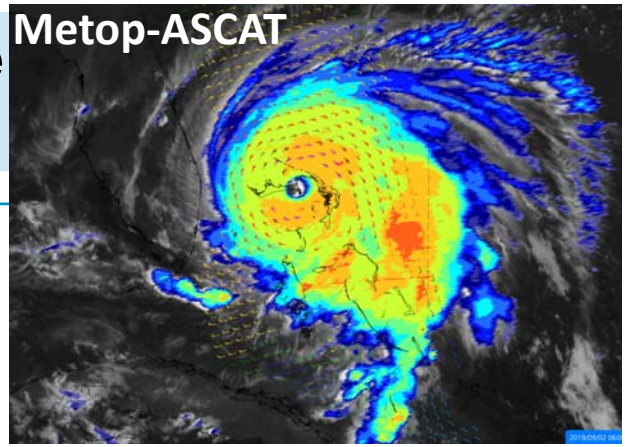
2- Data and methodology

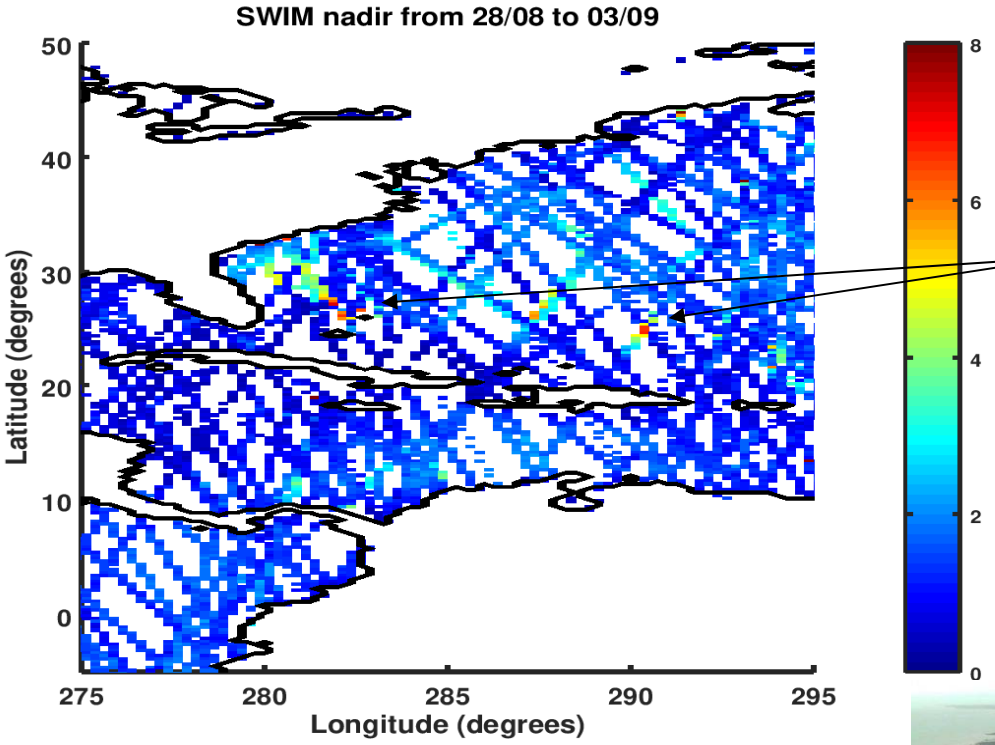
3- Results and discussions

4- capability of CFOSAT in storm cases

5- conclusions

Relevance of CFOSAT wave data in extreme weather conditions : Hurricane DORIAN





High waves captured by SWIM during Hurricane DORIAN

Damages induced by waves Flooding in Bahamas

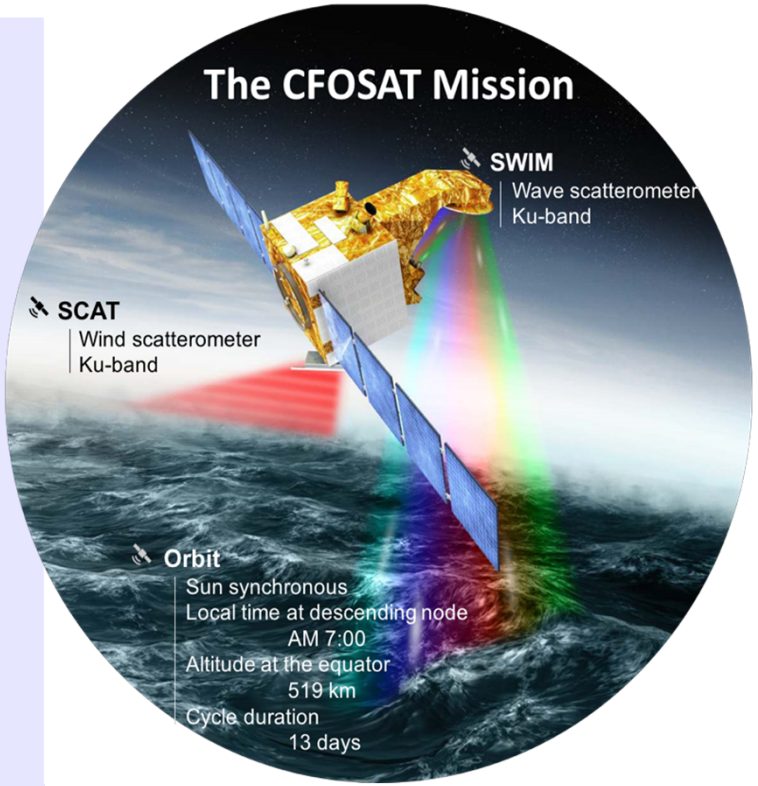
➔ **Assimilation of CFOSAT wave data ensures the best estimate of integrated wave parameters**

Motivation

◆ Upgrading the operational wave forecasting with CFOSAT data : improvement of the wave submersion warning

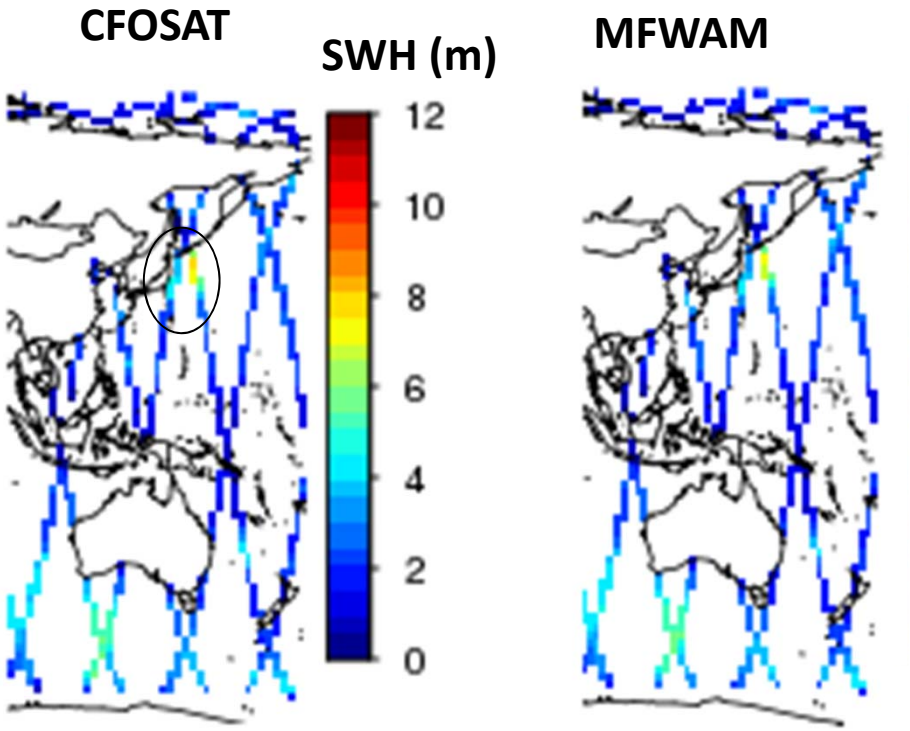
◆Evaluate the SWIM Level 2 wave data in the assimilation system of Météo-France :
➔ Contribution of Nadir SWH and SWIM wave spectra at different beams (6, 8 and 10°)

◆ Preparing the assimilation to operational use in Copernicus Marine service (CMEMS-MFCs) for global and regional systems



Monitoring the quality of SWIM 1Hz nadir SWH

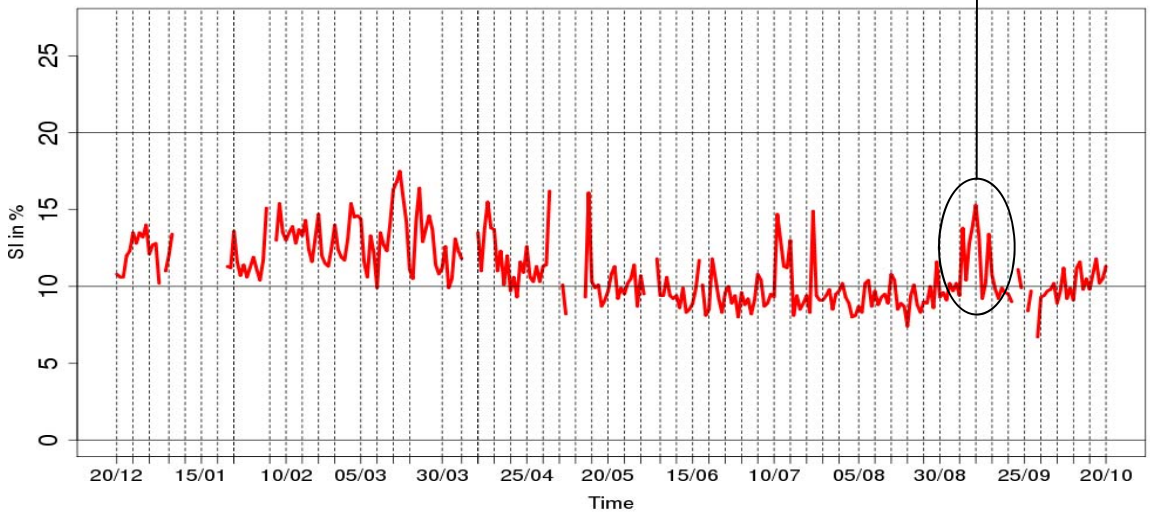
SWH captured during typhoon Hagibis (12 Oct. 2019)



➔ **Routinely comparison with operational MFWAM which is assimilating including altimeters and SAR spectra from S1**

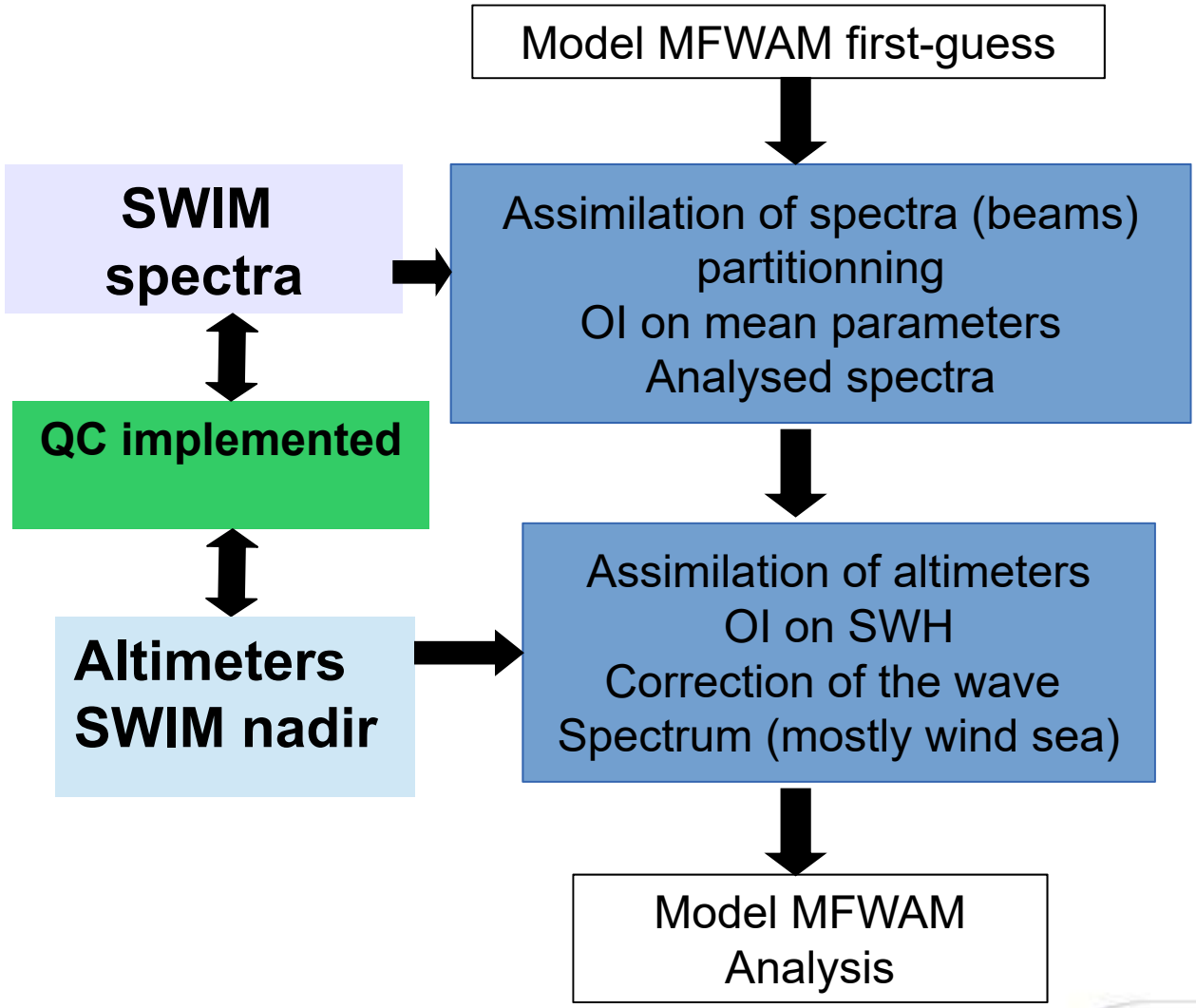
Cyclonic events Inducing high SWH

Scatter index (%) time series



Good scatter index of SWH roughly ~10 %
From December 2018-20 October 2019

Description of combined assimilation system



Data set for CFOSAT science team (26 April to 21 May 2019)

◆ Quality control procedure implemented to qualify SWIM wave data to the assimilation in the model MFWAM. Use of along track mask because of speckle noise.

◆Use of MFWAM with grid resolution of 0.5° and forcing from IFS-ECMWF winds

◆Several assimilation runs have been performed :

- SWIM nadir SWH 1 Hz
- SWIM nadir 1Hz and combined spectra
- SWIM combined wave spectra
- SWIM several beams (6, 8 and 10°)

◆Optimization of assimilation parameters : cross-assignment threshold reduced to keep only the best swim wave trains in the assimilation (<0.05)

◆Azimuthal cut-off roughly 0.121 Hz on SWIM spectra (sensitivity tests)

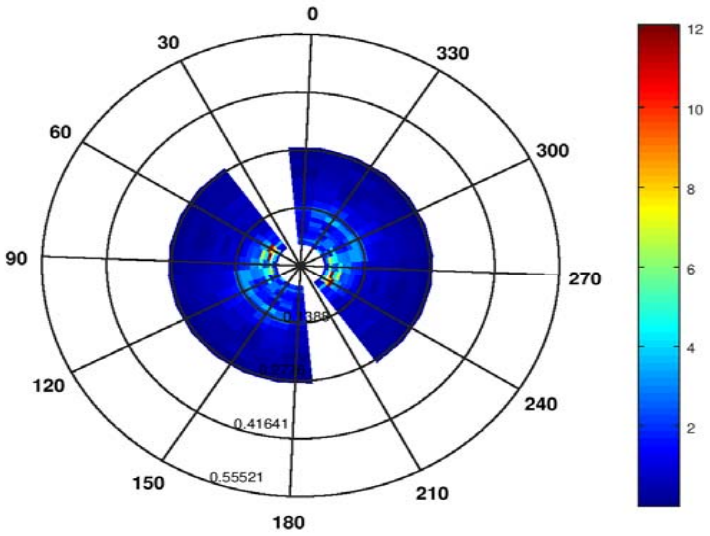
◆Validation with independent altimeters and buoys data

METEO FRANCE

SWIM watching high waves generated by high latitudes storms
Period from 26 April – 20 May 2019

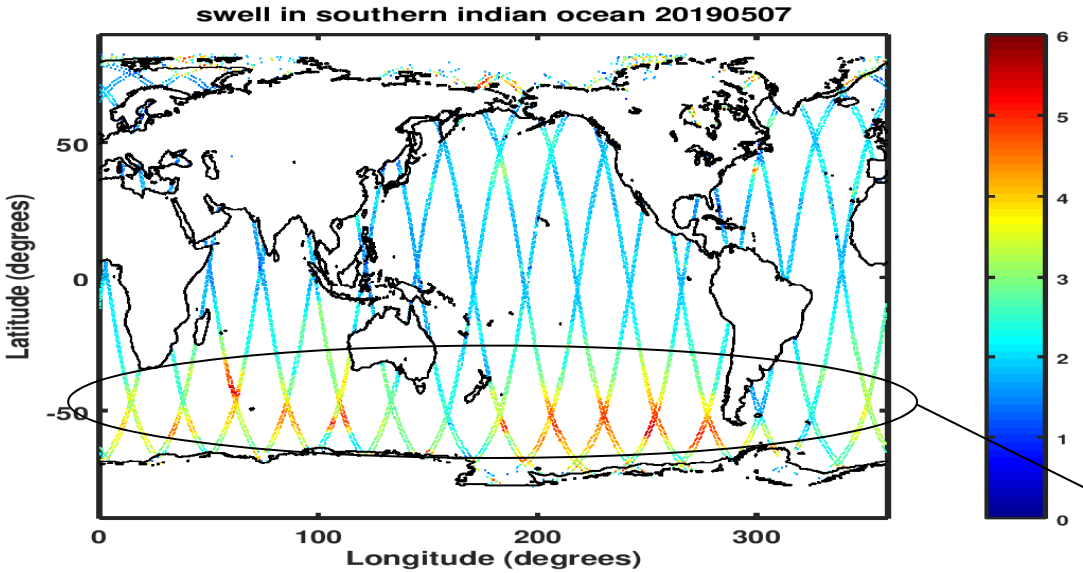
◆Quality control procedure implemented to qualify SWIM wave data to the assimilation in the model MFWAM

◆Thresholds on sigma0 and SWH for nadir level 2 and cross-assignment distance for partitions of the wave spectra



Example of retrieved wave spectrum from beam 6°

Sig. Wave height during 7 May 2019

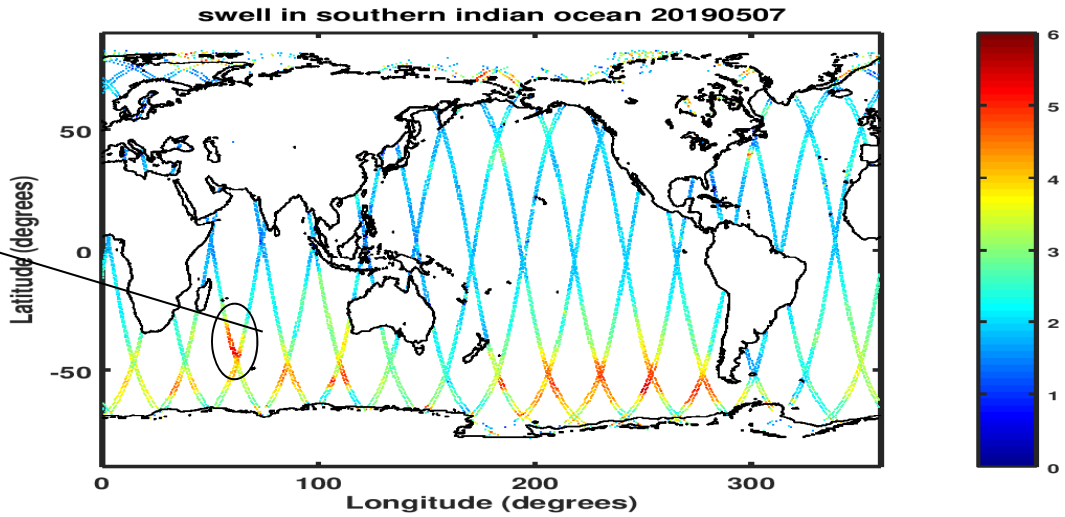


Long swell starting points welll captured by SWIM

METEO FRANCE

Example of swell in the indian ocean 7 may 0:00
early start of southern winter storms

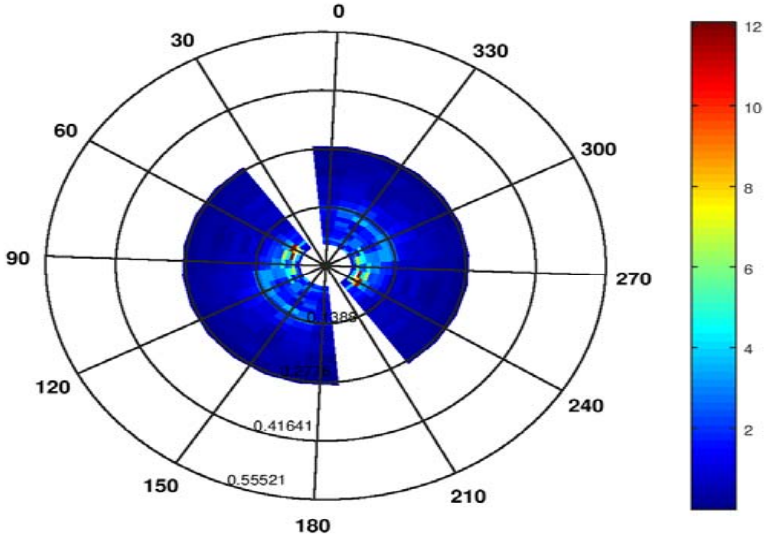
Location 64.2° E
40° .5° S

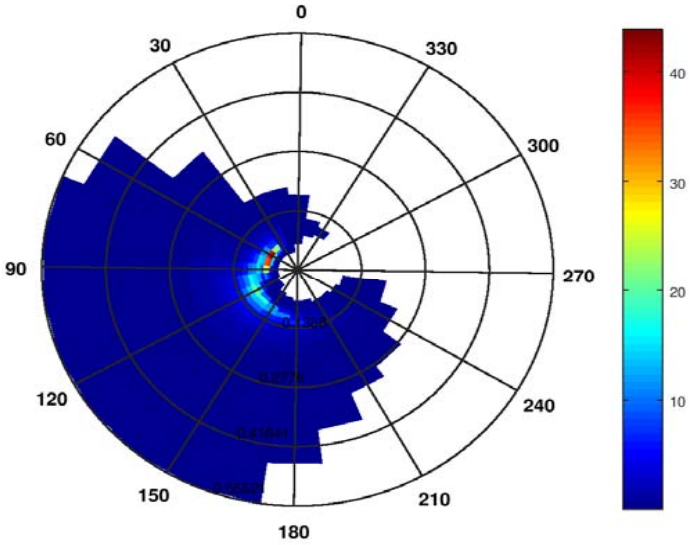


SWIM beam 6°

Good description of directional properties by SWIM

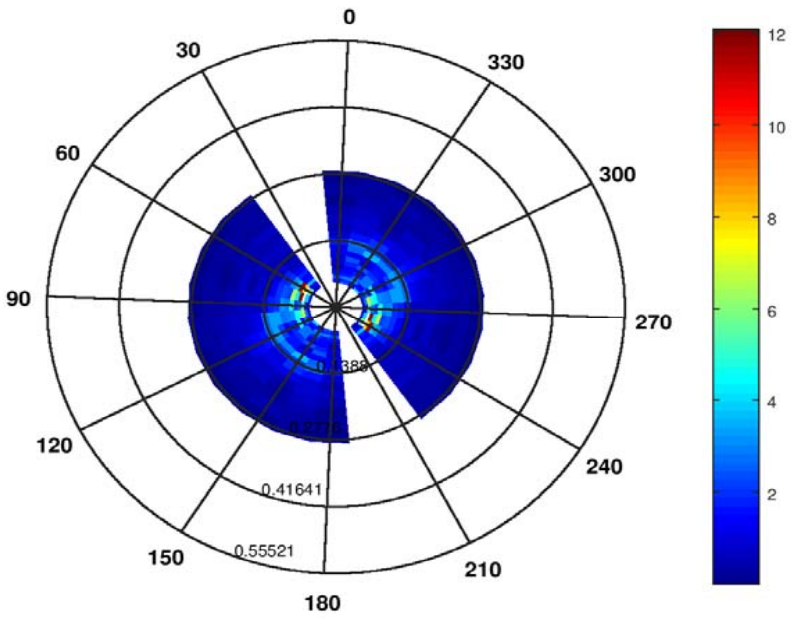
MFWAM-first guess



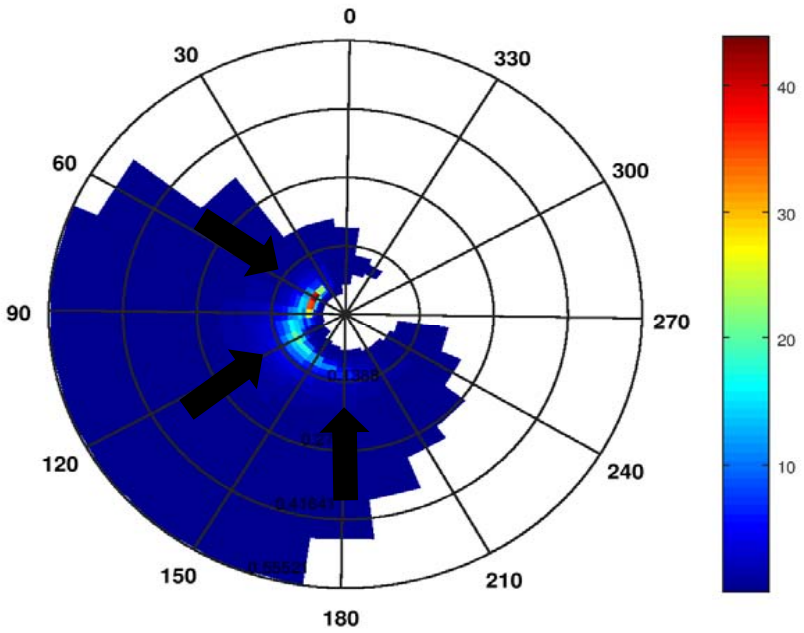


Swell in the indian ocean

SWIM beam 6°

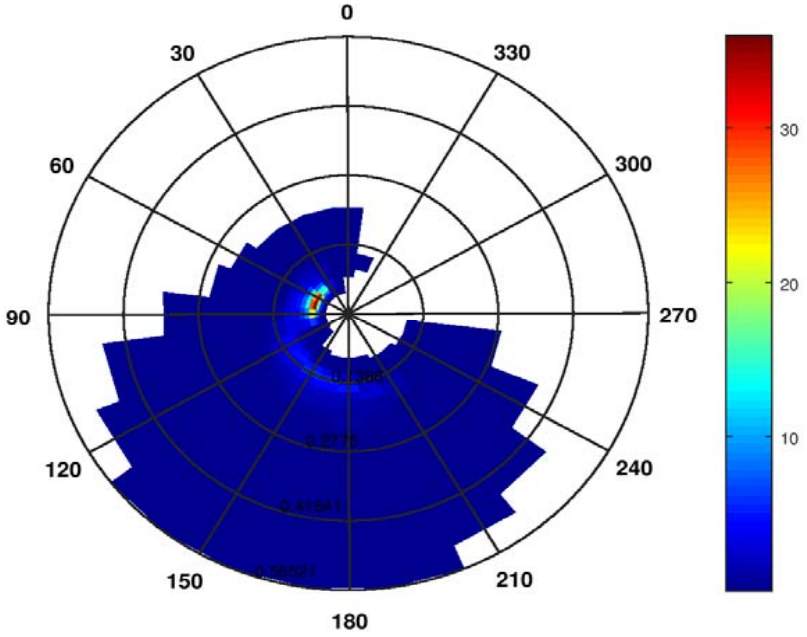


MFWAM-first guess



Correction of the energy partition overestimated by the model

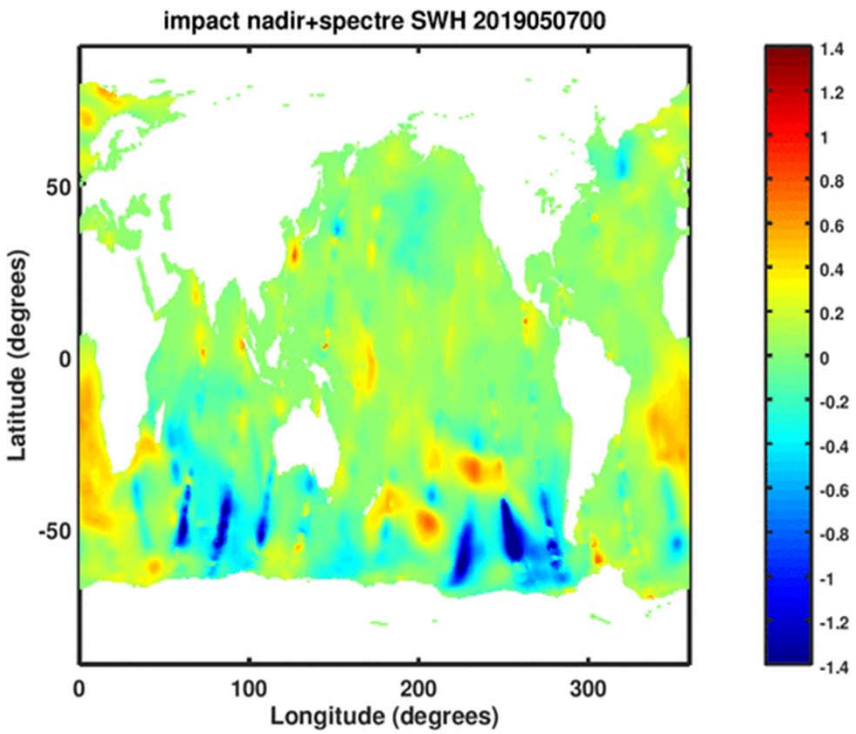
MFWAM-analysis



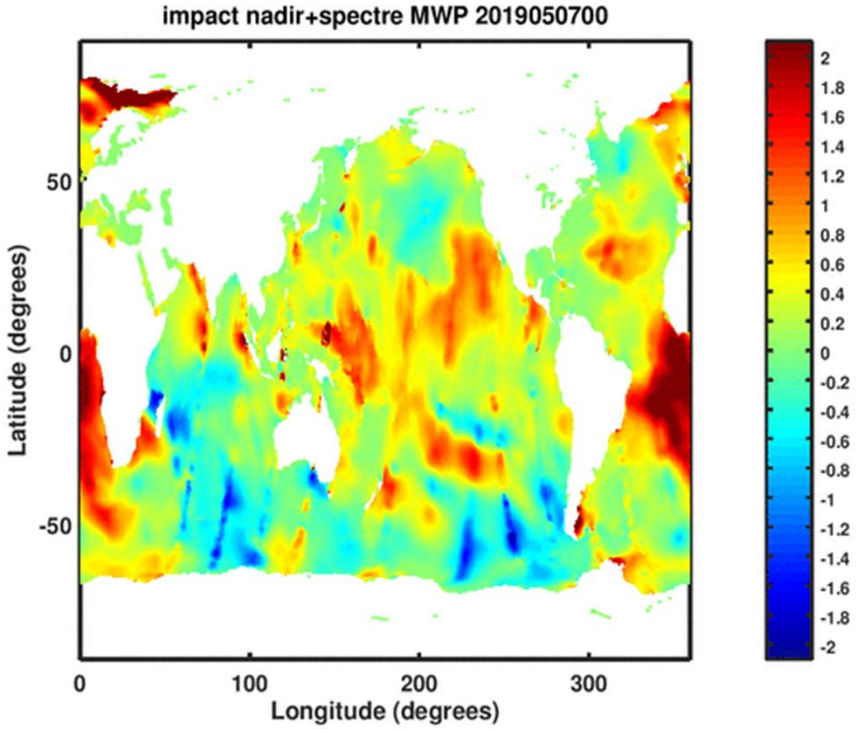
METEO FRANCE

Impact of the assimilation of nadir SWH and spectra beam 6° provided by SWIM

Sig. Wave Height



Mean wave period



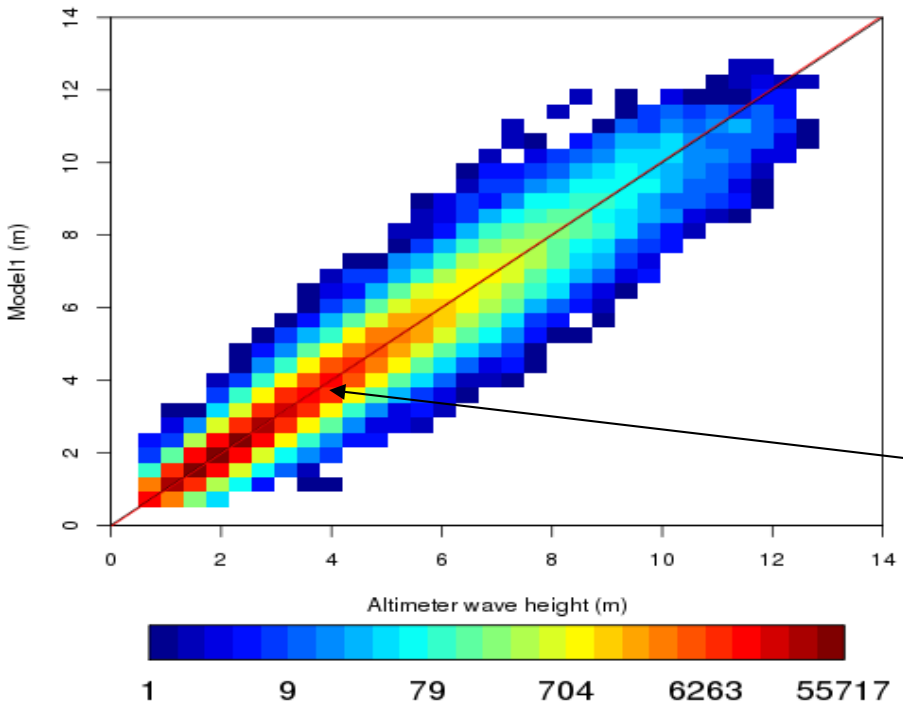
6-hourly difference of wave parameters from runs with and without assimilation of SWIM wave data, starting On 7 May at 0:00 until 8 May 2019 at 18:00

significant impact on mean period roughly 2 seconds on the propagation tracks of swells

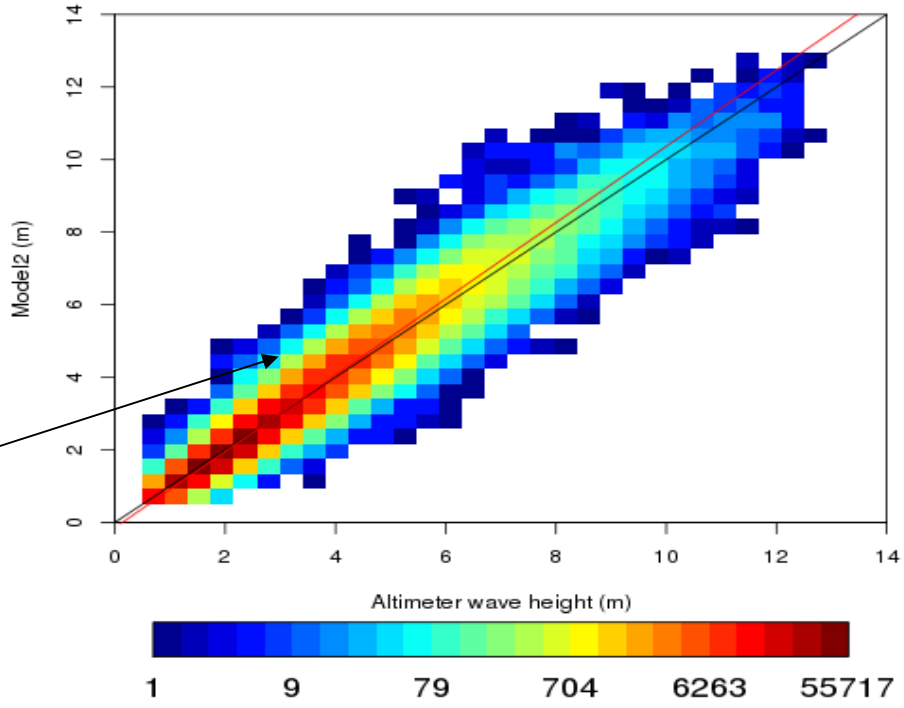
Period of run from 25 April to 20 May 2019

Impact of the combined assimilation
Scatter plots of SWH

Assimilation of SWIM-L2 (Nadir+ spectra beam)



Without assimilation



Bias=-0.01
SI=10.6 %
RMSE=10.6%
Slope=1.01
Intercep=-0.04

Better slope and significant improvement of Scatter index after the assimilation of SWIM L2 (Nadir+ spectra 6°) by ~17%

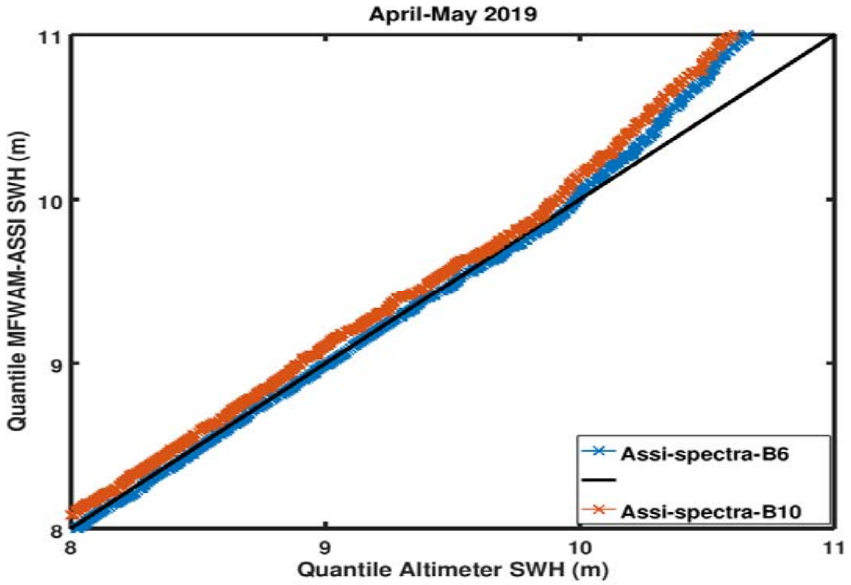
Bias=-0.01
SI=12.6 %
RMSE=12.6%
Slope=1.05
Intercep=-0.14

METEO FRANCE

Validation with Jason-3, Saral and S3A

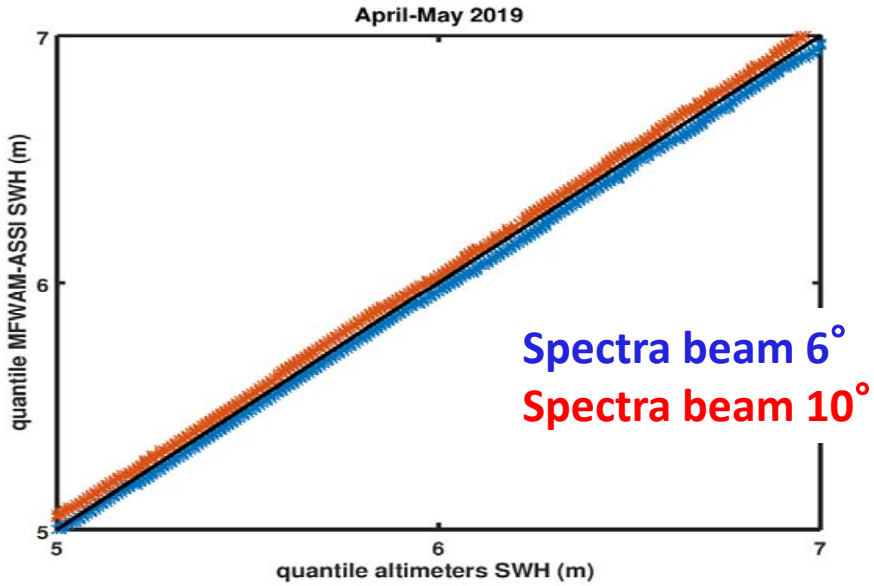
Assimilation of SWIM spectra beam 6° vs beam 10°

For SWH between 8 and 11 m



Qqplots show slightly better fit for the assimilation of spectra beam 6° than the ones from beam 10° , in particular for SWH larger than 5 meters.

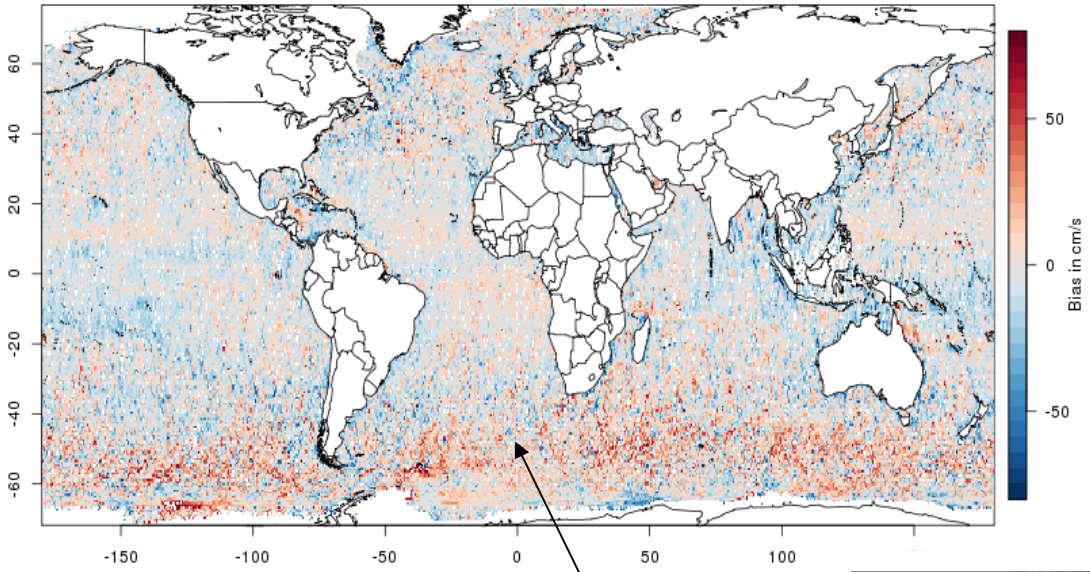
For SWH between 5 and 7 m



Period of April and May 2019
Validation with altimeters

Bias maps of SWH : 26 April – 20 May 2019
Impact of the assimilation of SWIM L2 (nadir+beam spectra 6°)

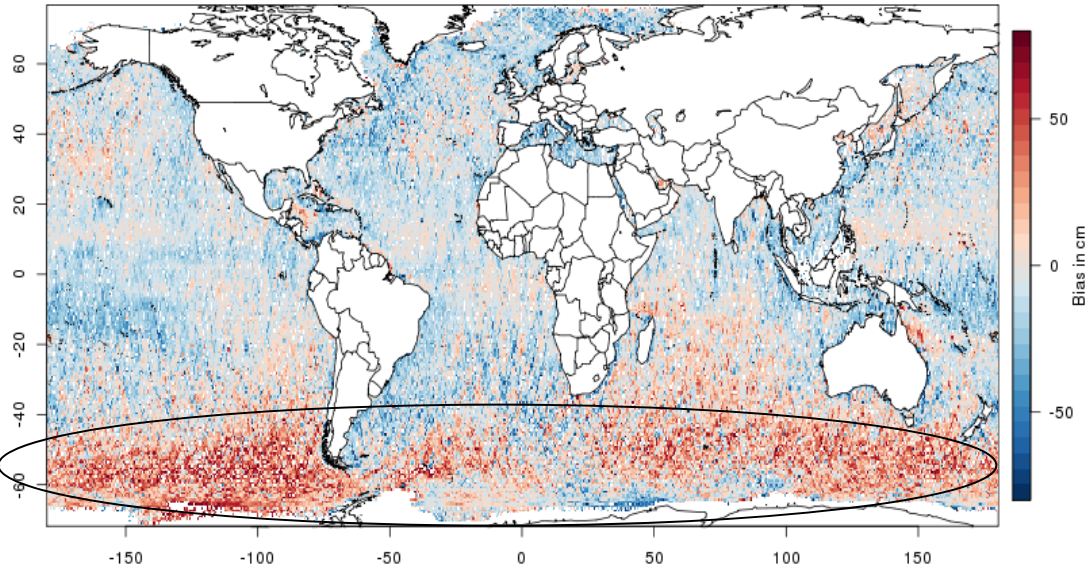
Assimilation of SWIM L2 (nadir+spectra)



Bias significantly reduced in high latitudes of Southern ocean, North-Atlantic and in intermediate latitudes

Maximum range 60 cm

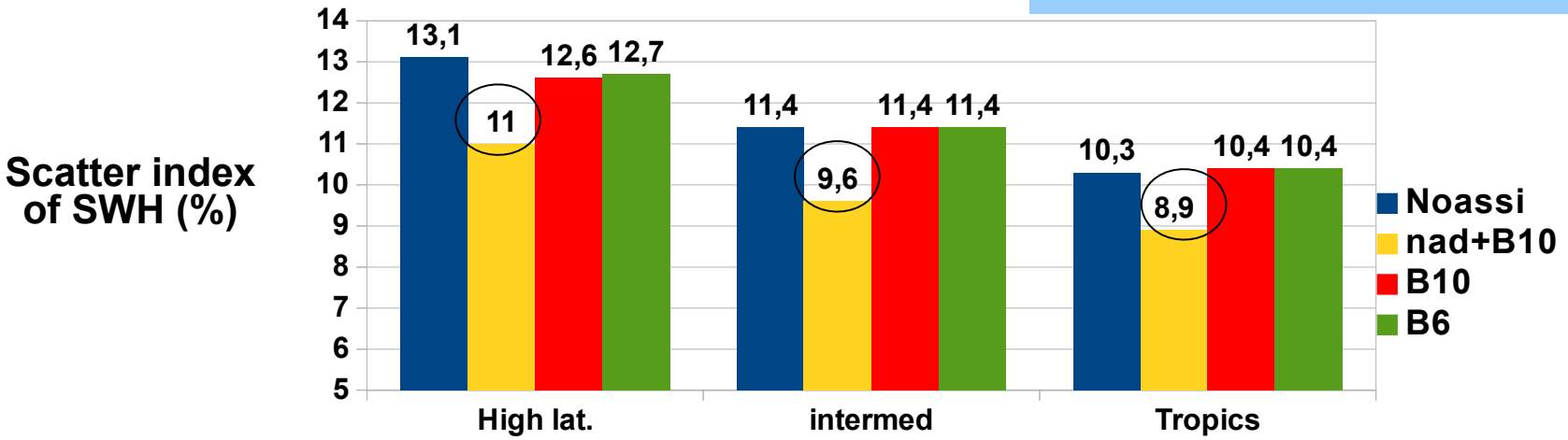
Without assimilation



Comparison with SWH from Jason-3, Saral and S3A

Performance of the assimilation in different ocean basins

High Lat |□|> 50°
Intermediate lat 20° <|□|<50°
Tropics |□|<20°



Good performance of the combined assimilation of Nadir SWH and beam 10 spectra from SWIM : SI significantly improved In high and intermediate latitudes and the tropics (in circles).

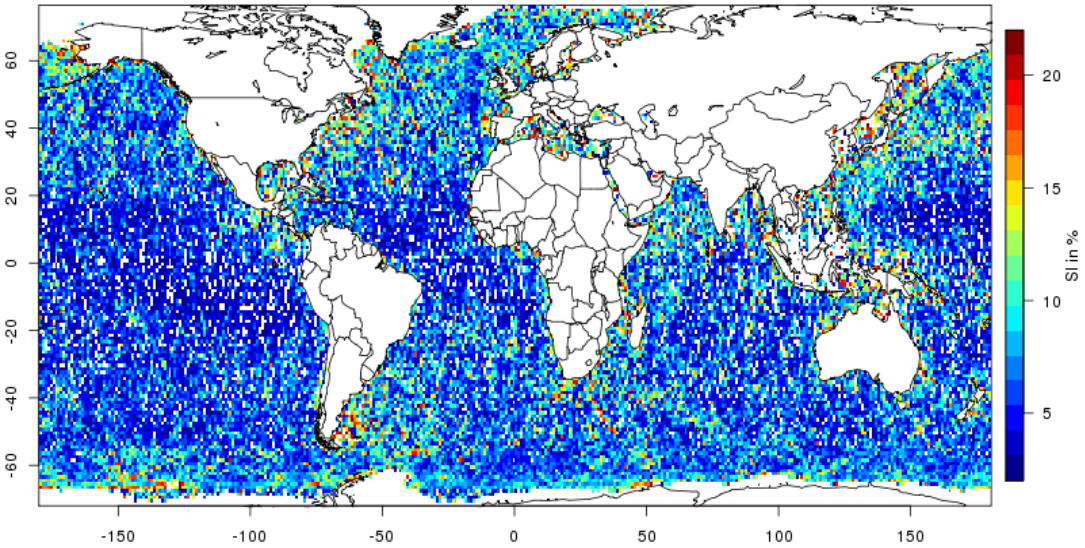
Same performance between beam 10° and 6° , improvement in high Latitudes only (slightly better for beam 10).

Validation with SWH from Jason-3, Saral and S3
26 April- 20 May 2019

METEO FRANCE

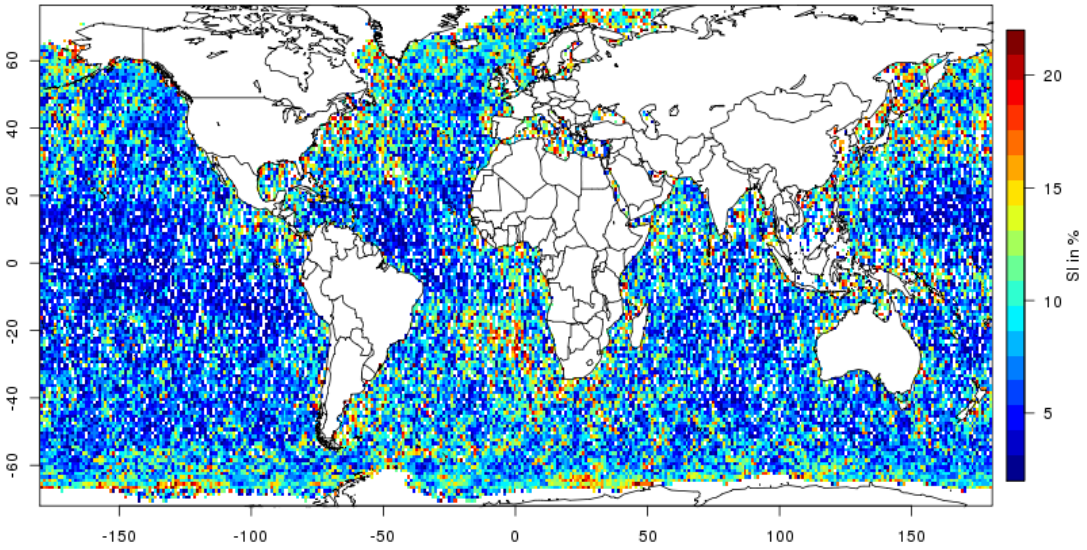
Scatter index maps (in %) of SWH
26 April to 20 May 2019

Assimilation of Nadir+spectra (beam 10°)



Clearly better SI globally when Using Nadir and wave spectra from SWIM L2

Without assimilation



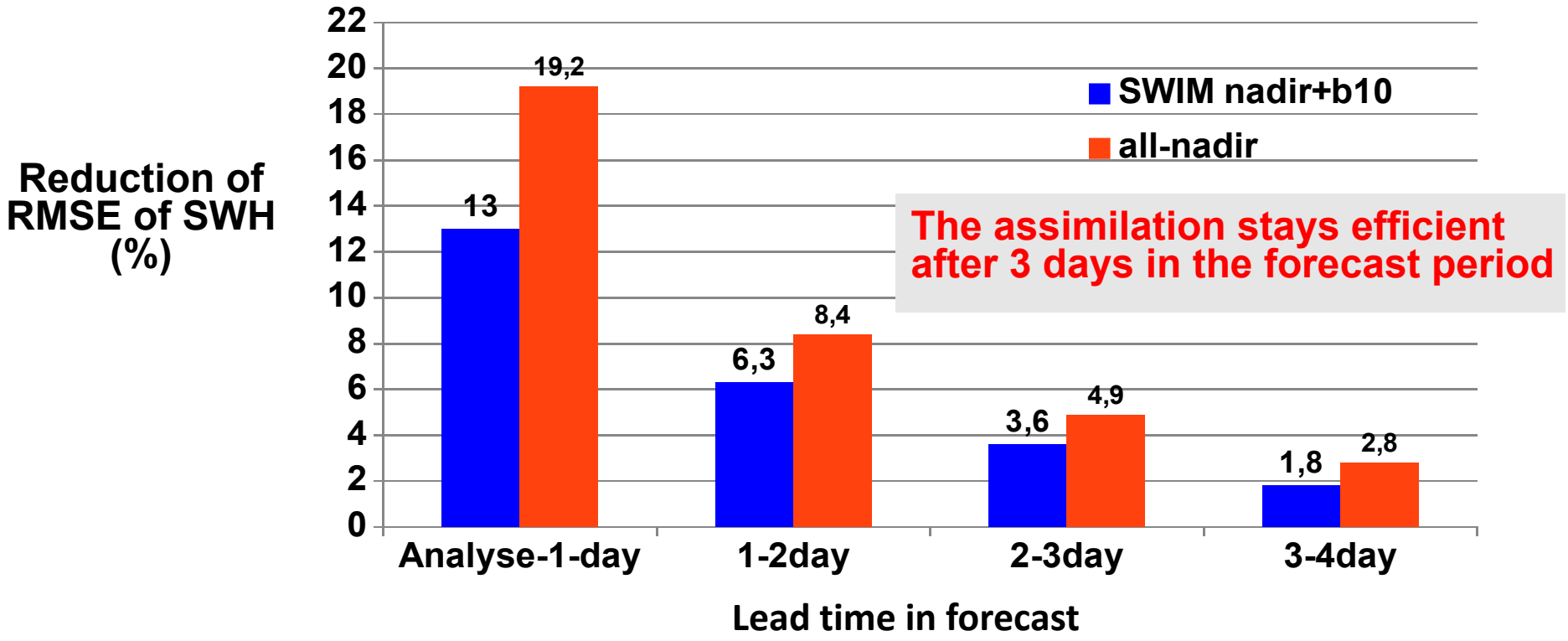
Blue is good
Red is bad

Comparison with SWH from Jason-3, Saral and S3A

Impact in the context of operational configuration during the forecast period

All nadir : Ja3+S3+CR2+SARAL+CFOSAT

Significant improvement in the forecast



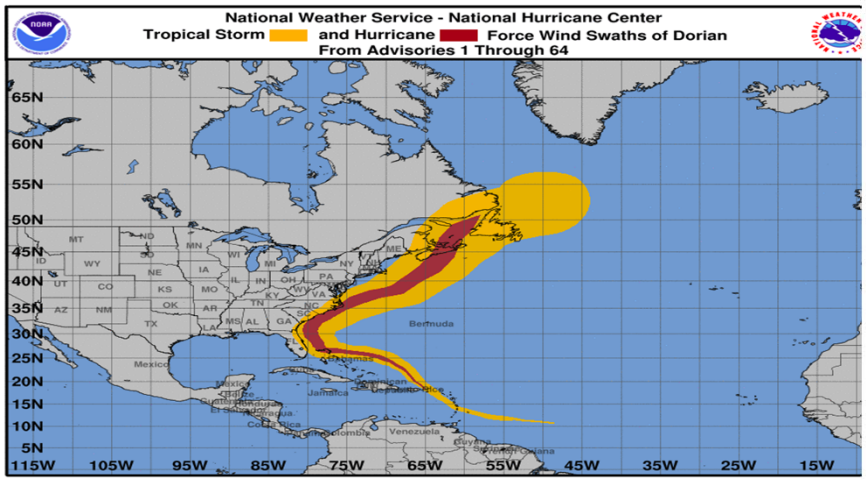
The assimilation stays efficient after 3 days in the forecast period

Analysis with DA | **forecast No DA**

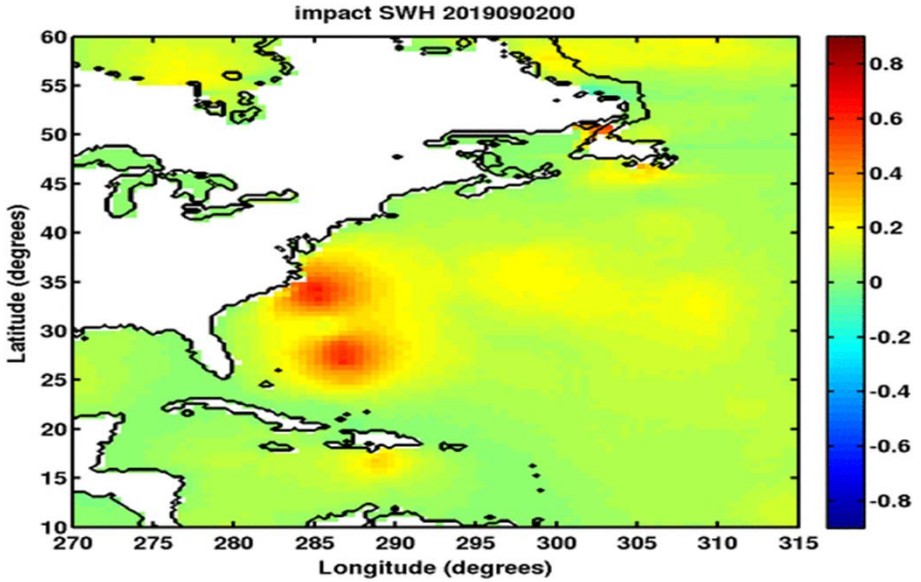
Validation with altimeters (Jason-3 and Saral)

METEO FRANCE

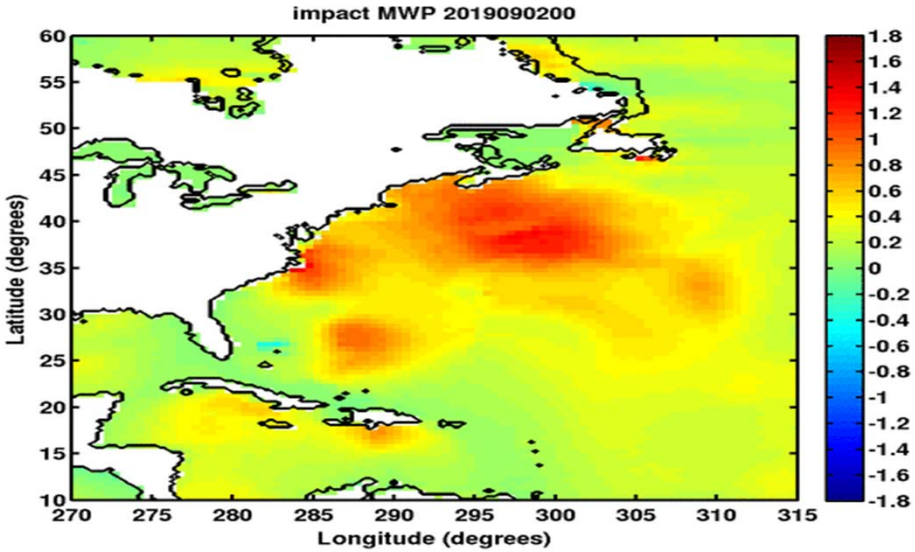
Impact of the assimilation of SWIM data during hurricane DORIAN (Sep. 2019)



SWH



Mean period

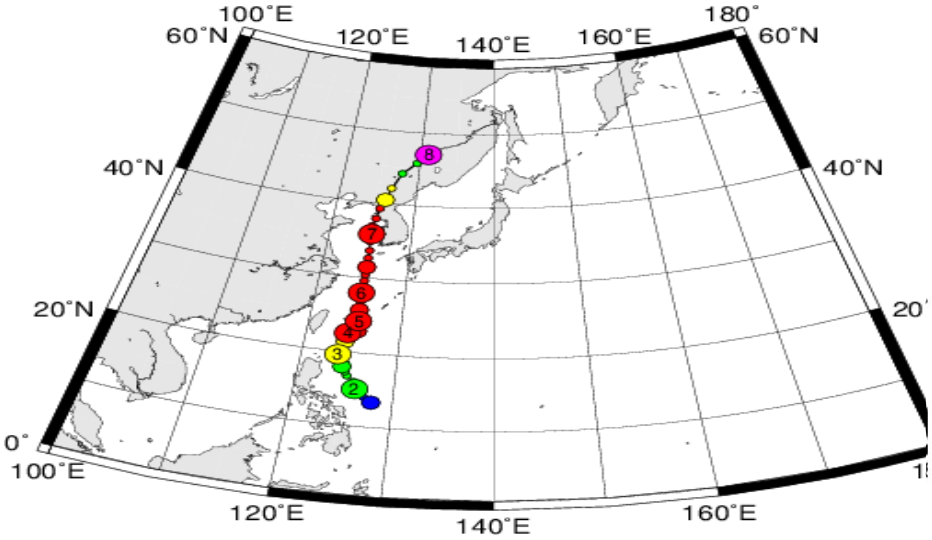


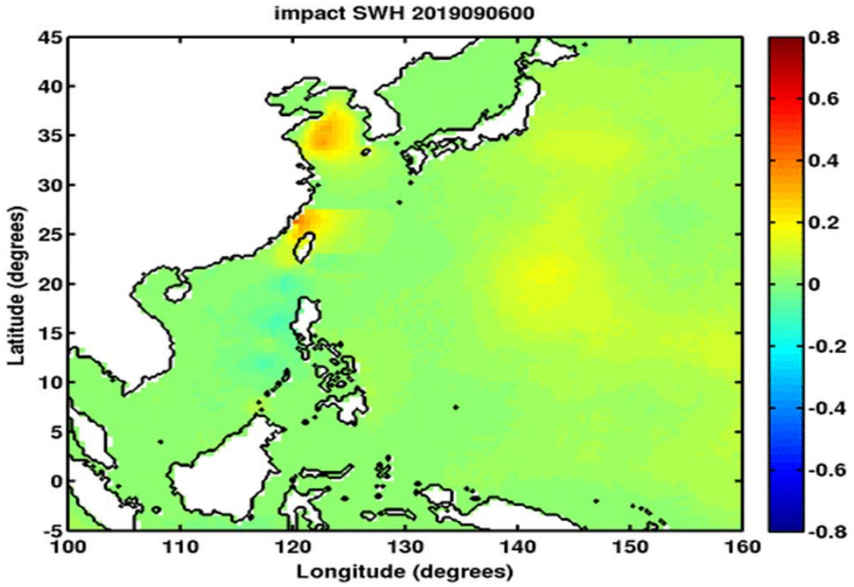
During this event the assimilation of SWIM induces an improved SI of SWH by roughly 16 % in comparison with altemeters

6-hourly difference of wave parameters From 02/09 until 04/09

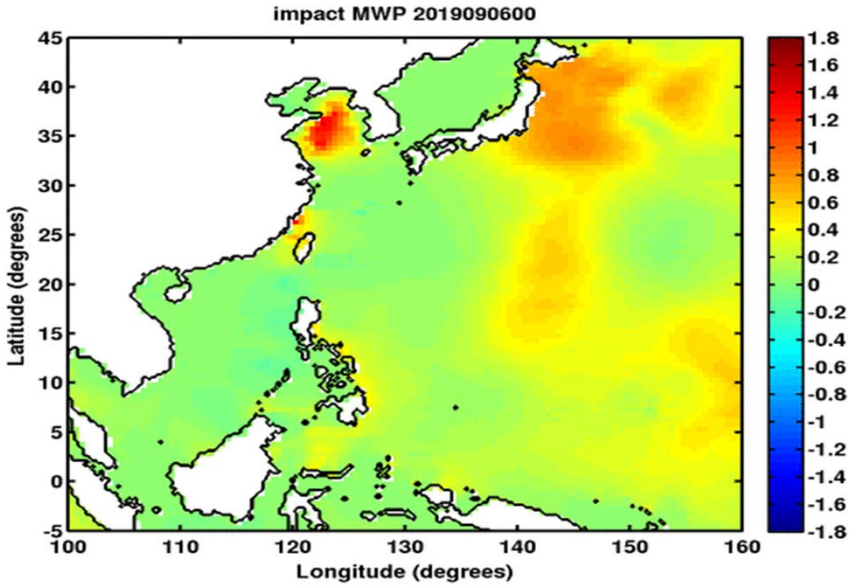
Impact of the assimilation of SWIM in west Pacific Typhoon LingLing (Sep. 2019)

SWH





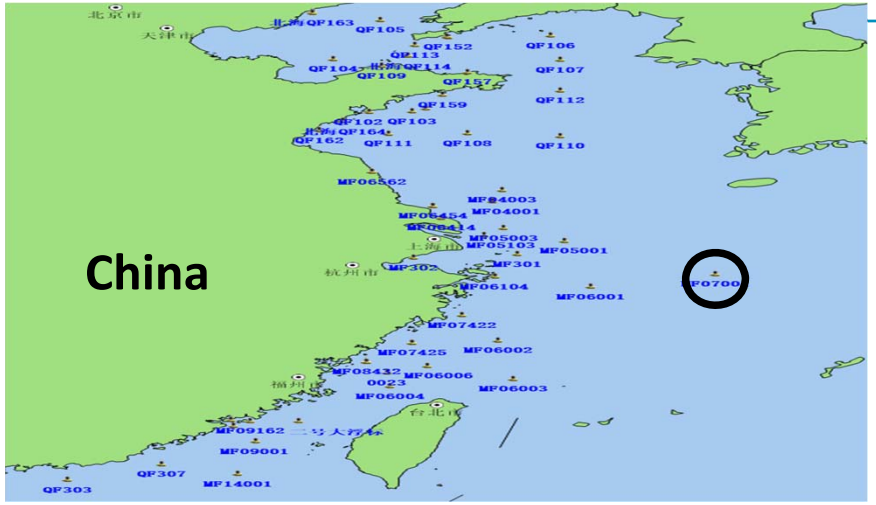
Mean period



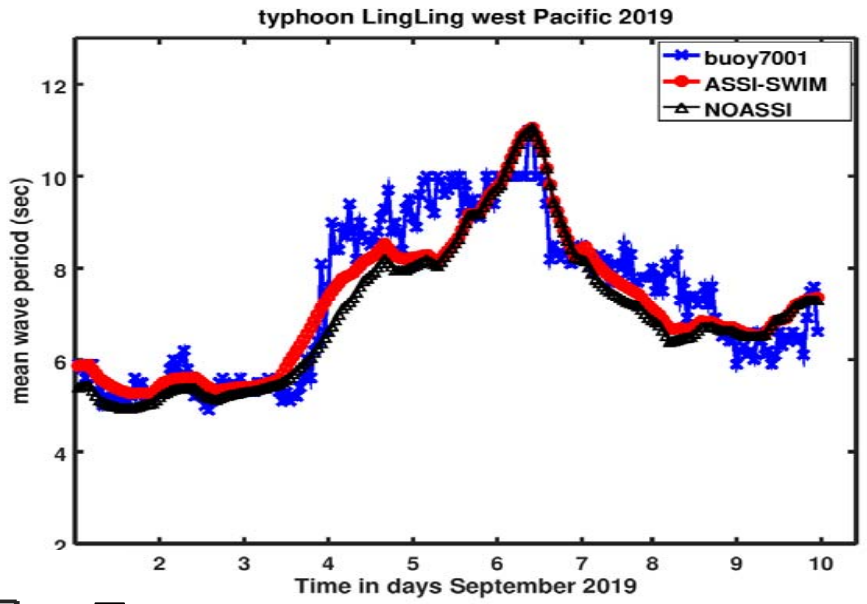
During this event the assimilation of SWIM induces an improved SI of SWH by roughly 16 % in comparison with altemeters

6-hourly difference of wave parameters From 06/09 until 08/09

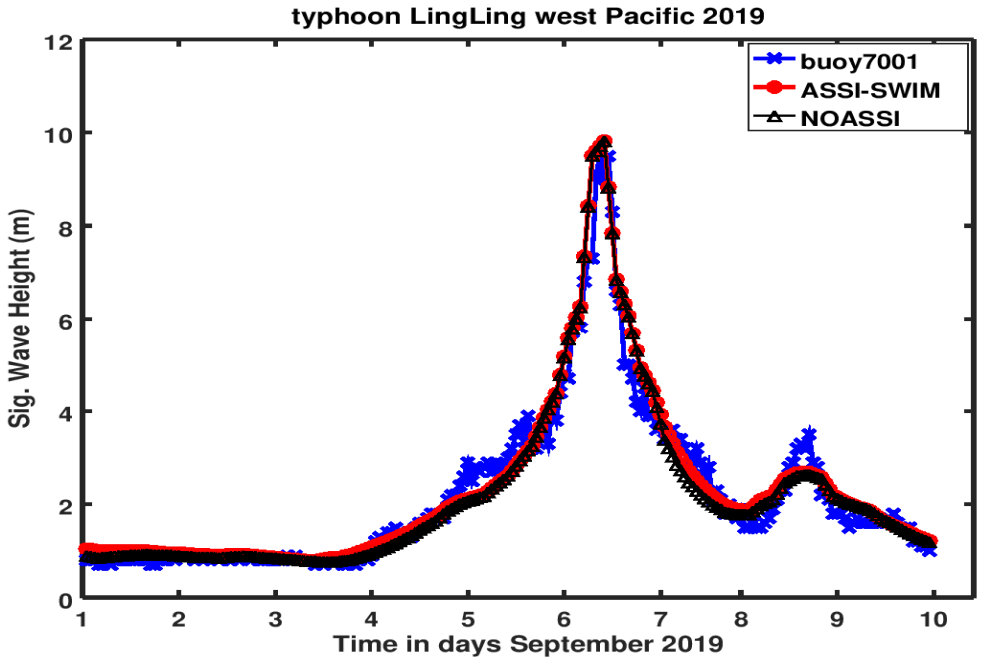
Typhoon LingLing September 2019 Performance at NMEFC buoy 07001



Time series of Mean wave period



Time series of SWH



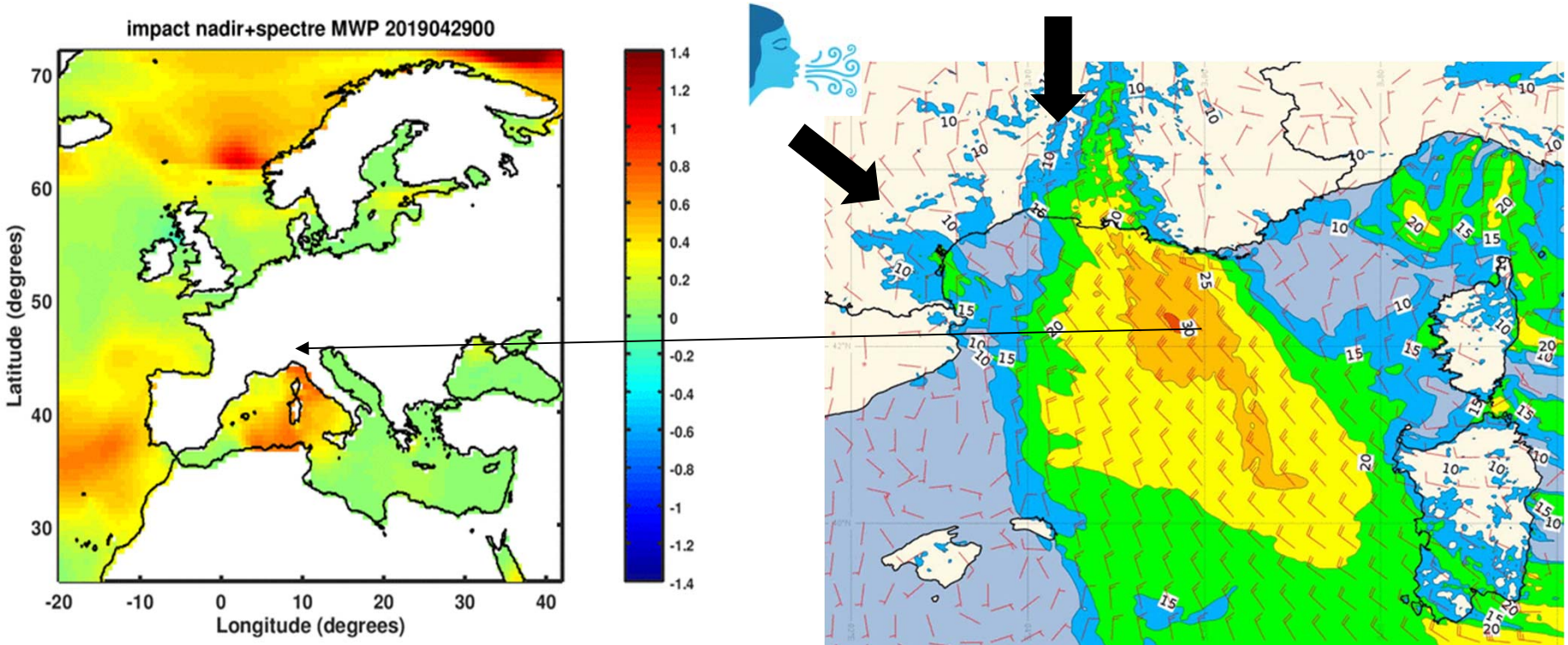
Bias and scatter index for MWP are well improved from -0.32 to -0.11 Sec and from 9.7 to 8.9 %, respectively

For SWH the scatter index is Slightly improved from 17.9 to 17.2 %

Impact of the assimilation of nadir SWH and spectra beam 6°

Mean wave period

Winds from AROME-1km : Mistral/tramontane wind regime : rapid wave growth in short limited fetch (weakness of wave models)



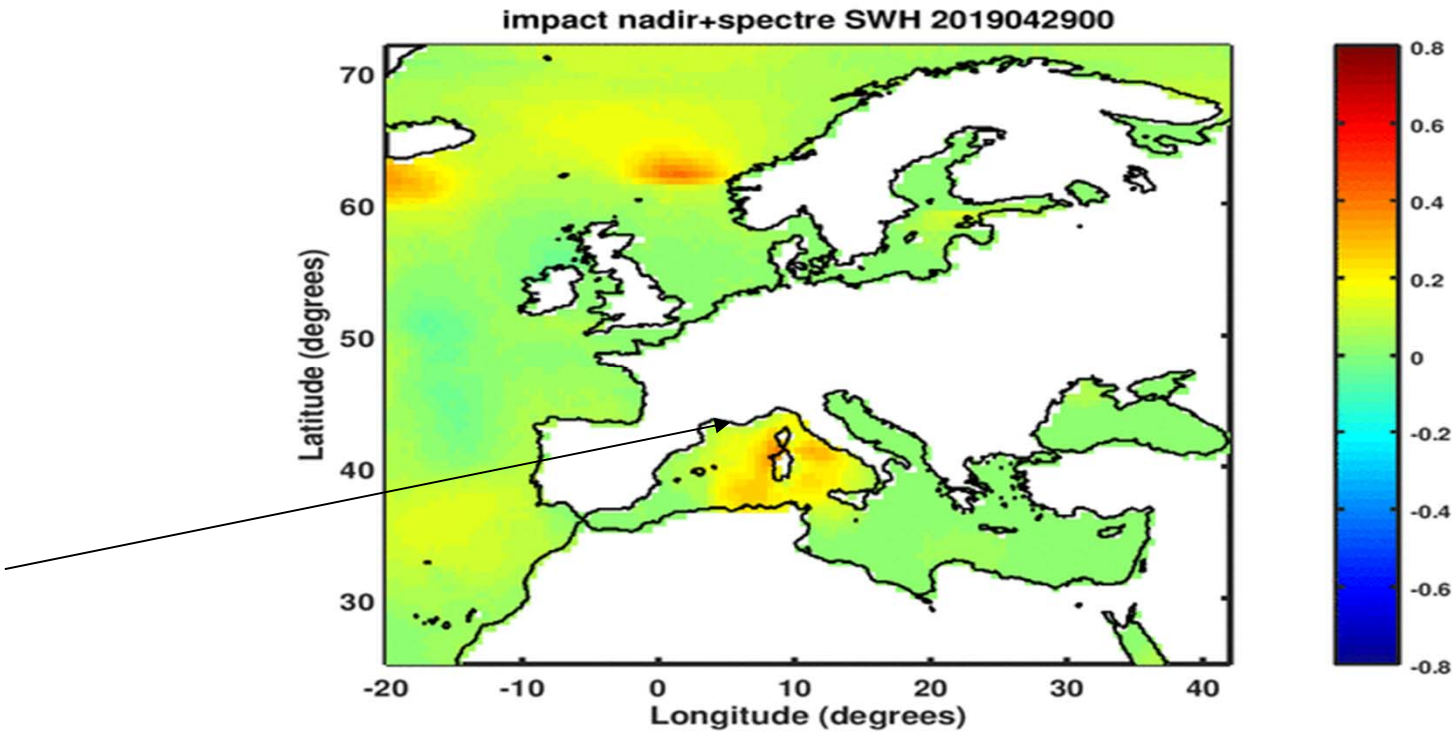
6-hourly difference of wave parameters from runs with and without assimilation of SWIM wave data, starting On 29 April at 0:00 until 30 April 2019 at 06:00

significant impact on mean period roghly 2 seconds after the passage of CFOSAT

Mediterranean case 29 April 2019

Impact of the assimilation of nadir SWH and spectra beam 6°
Mediterranean case 29 April 2019

Sig. Wave Height



6-hourly difference of wave parameters from runs with and without assimilation of SWIM wave data, starting On 29 April at 0:00 until 30 April 2019 at 06:00

significant impact on SWH roughly 1 m after the passage of CFOSAT

Mediterranean case 29 April 2019

Conclusions

■ The assimilation of SWIM L2 Nadir and beam 6° or 10° spectra shows significant improvement of SWH in the analysis and forecast period :
➔This opens the use of SWIM-nadir SWH operationnaly.

■ The CFOSAT data are well skilled to correct efficiently models misfits in storms events (cyclones, typical mediterranean cases)

■ The assimilation of SWIM beam 6° and 10° gives slightly same performance regarding to SI of SWH. Retrieval Improvements are still needed to enhance the impact of the assimilation of partitions (work in progress).

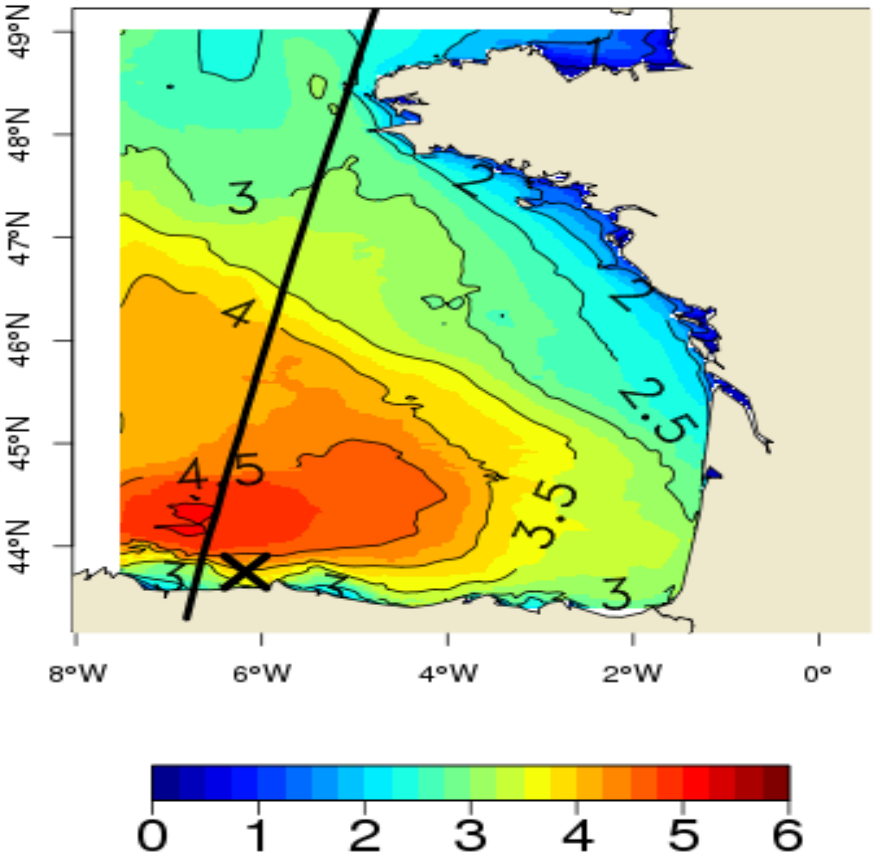
■ The assimilation of 5-Hz SWH from CFOSAT shows a positive impact for coastal wave froecasting (See Dalphinet et al. Poster)

METEO FRANCE

Join the team of CFOSAT data users !

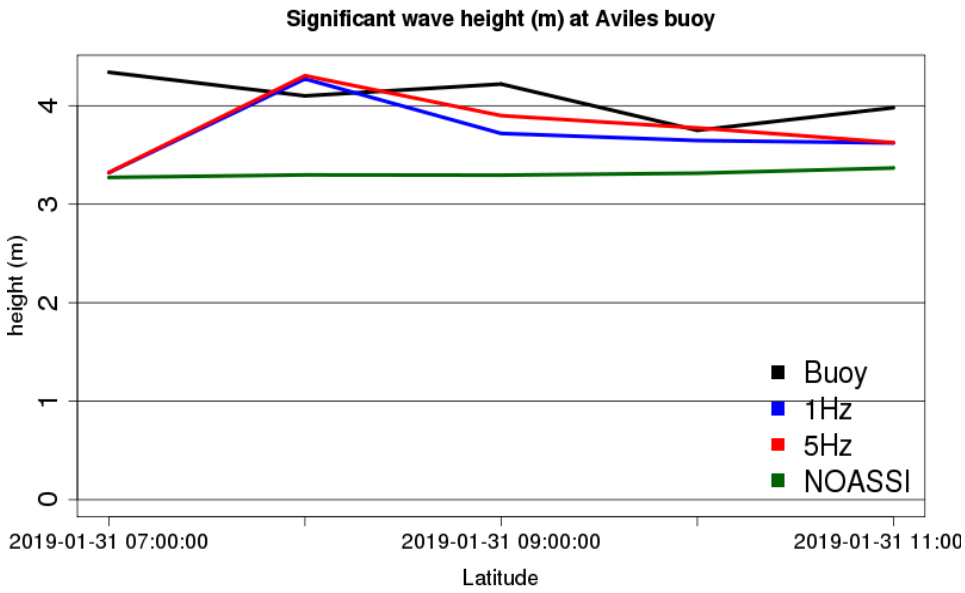
Impact of 5Hz SWH for coastal wave model
(See Alice Dalphinet poster)

31 january 2019 at 08:00



The assimilation of 5-Hz induces a SWH closer to the buoys : promising for coastal applications

Along track SWH



Comparison with Aviles spanish Coastal buoy

METEO FRANCE