On the use of SMOS winds in the wave model MFWAM

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Workshop on Measuring high wind speeds over the ocean
Exeter, 15-17 November 2016

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OUTLINE

1- Motivation

2- Methodology and case of studies

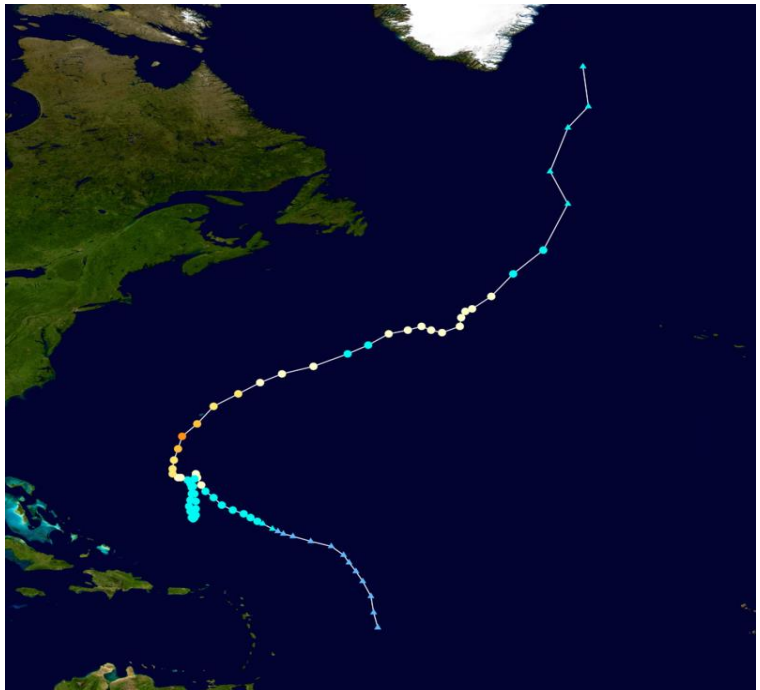
3- Results and validation

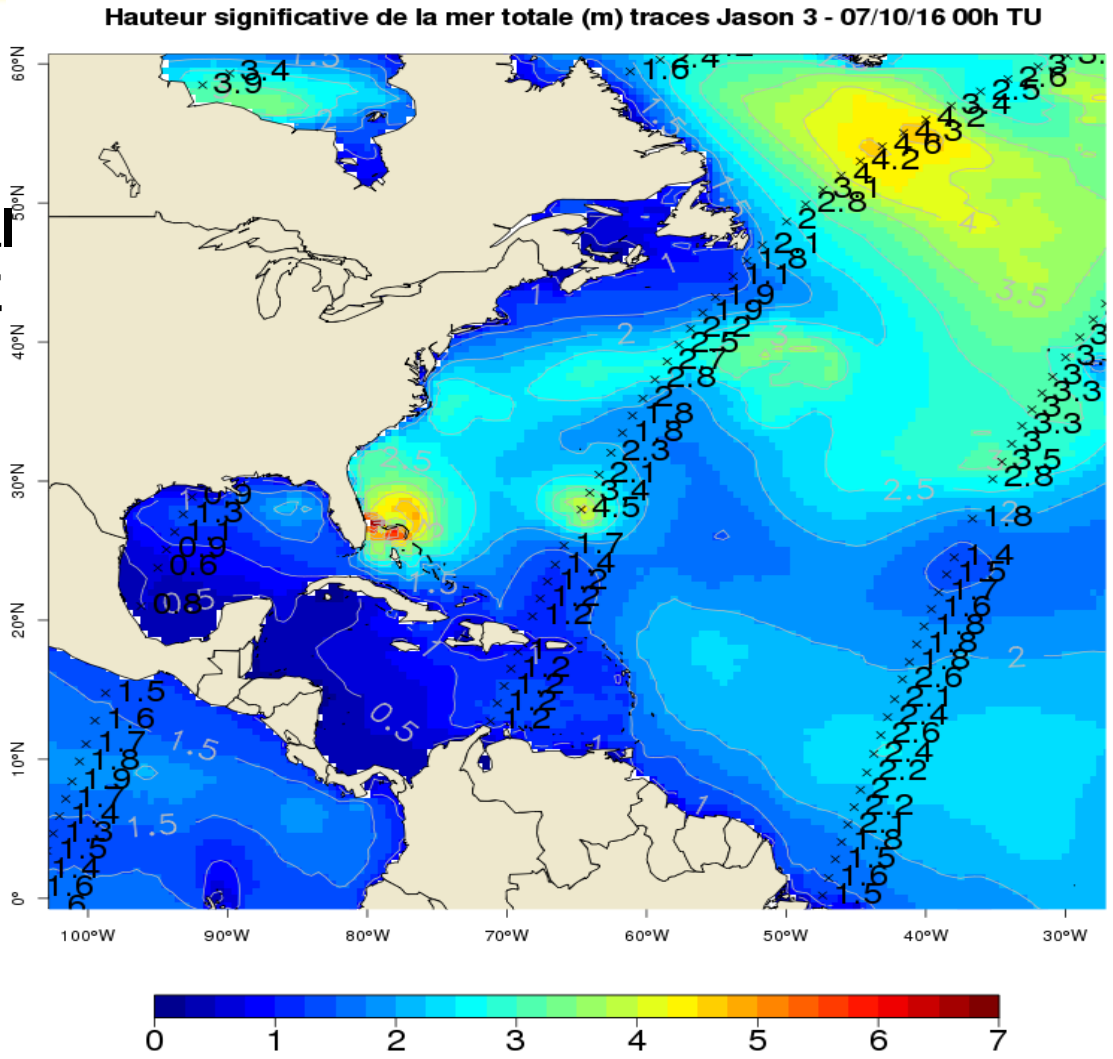
4- Conclusions

Relevance of the assimilation for operational sea state forecasting

Efficiency of the assimilation of altimeters during the tropical storms MATTHEW and NICOLE

Trajectory of NICOLE Trop. storm

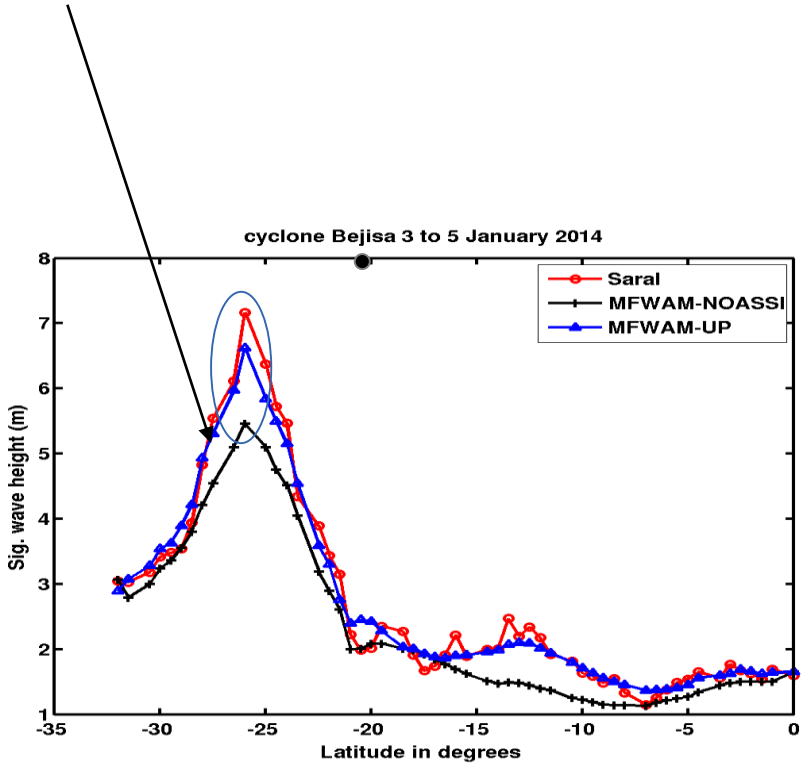




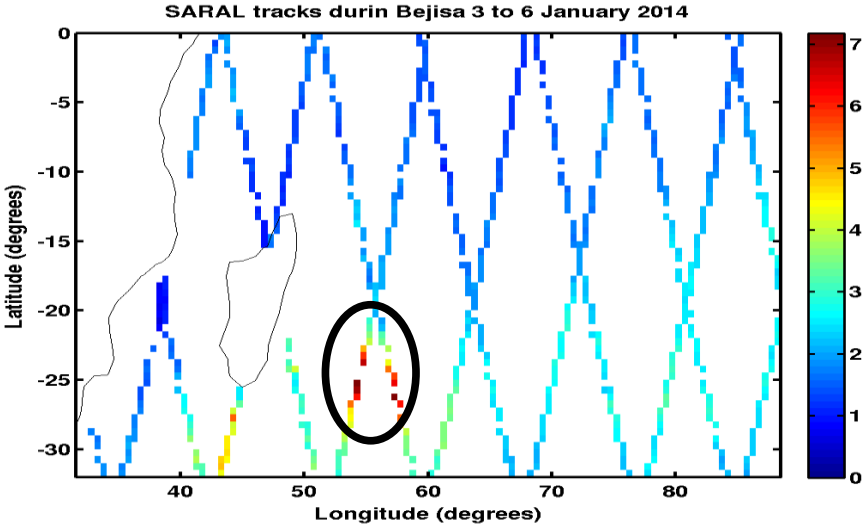
Overlap of Jason-3 SWH on the analysis From MFWAM on 7 October 2016 at 0:00UTC

Cyclonic season at indian ocean « La Réunion »

Strong underestimation of operational MFWAM because not accurate winds



SWH captured by Saral 3 to 5 january



Saral was not in time for the assimilation !

Cyclone BEJISA during 3 January 2014

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MOTIVATION

- Evaluating the impact of wind data on the wave forecast for high winds conditions (Cyclones) : SMOS, WINDSAT are candidates ?

- Improving the wave submersion warning system for the indian ocean

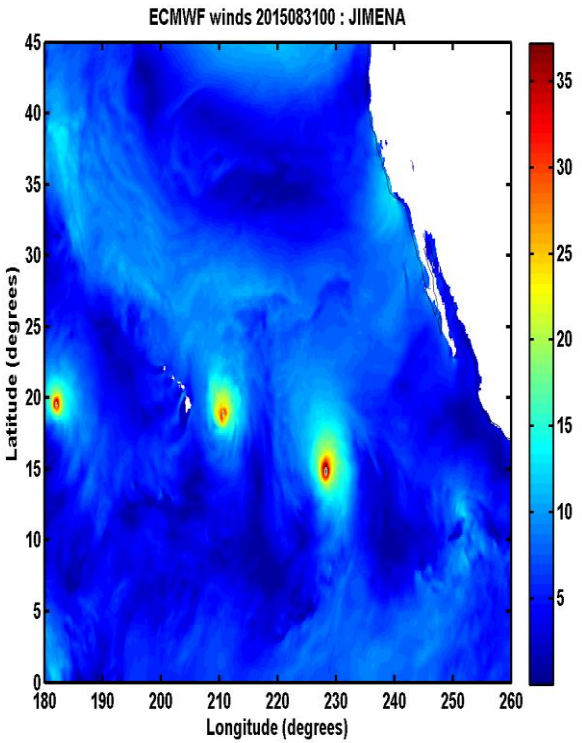
Storm Hercules

Damages caused by typhoon Haiian

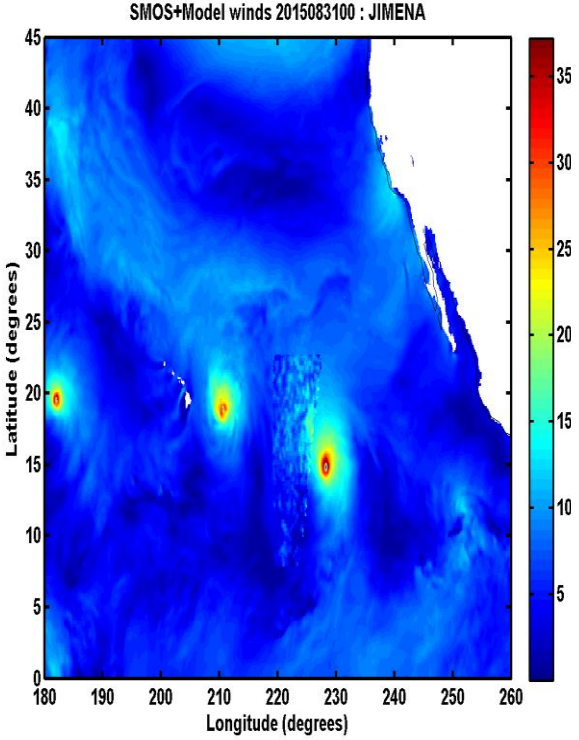
Methodology

- preparing the radiometer winds (SMOS and WINDSAT)
- keeping the resolution of SMOS winds (0.1° without averaging)
  And using the wind directional properties from the atmospheric model ECMWF (0.1°)
- replace at the model winds by the SMOS (or WINDSAT) wind patches at the Retrieved areas.

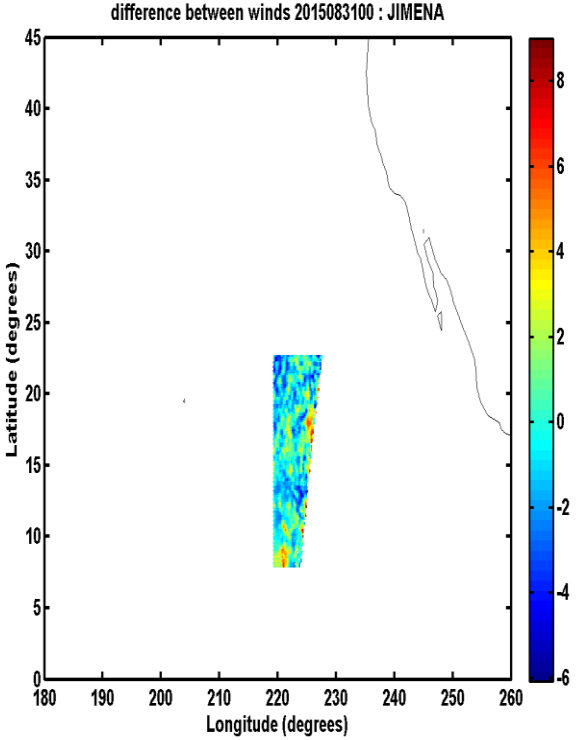
ECMWF



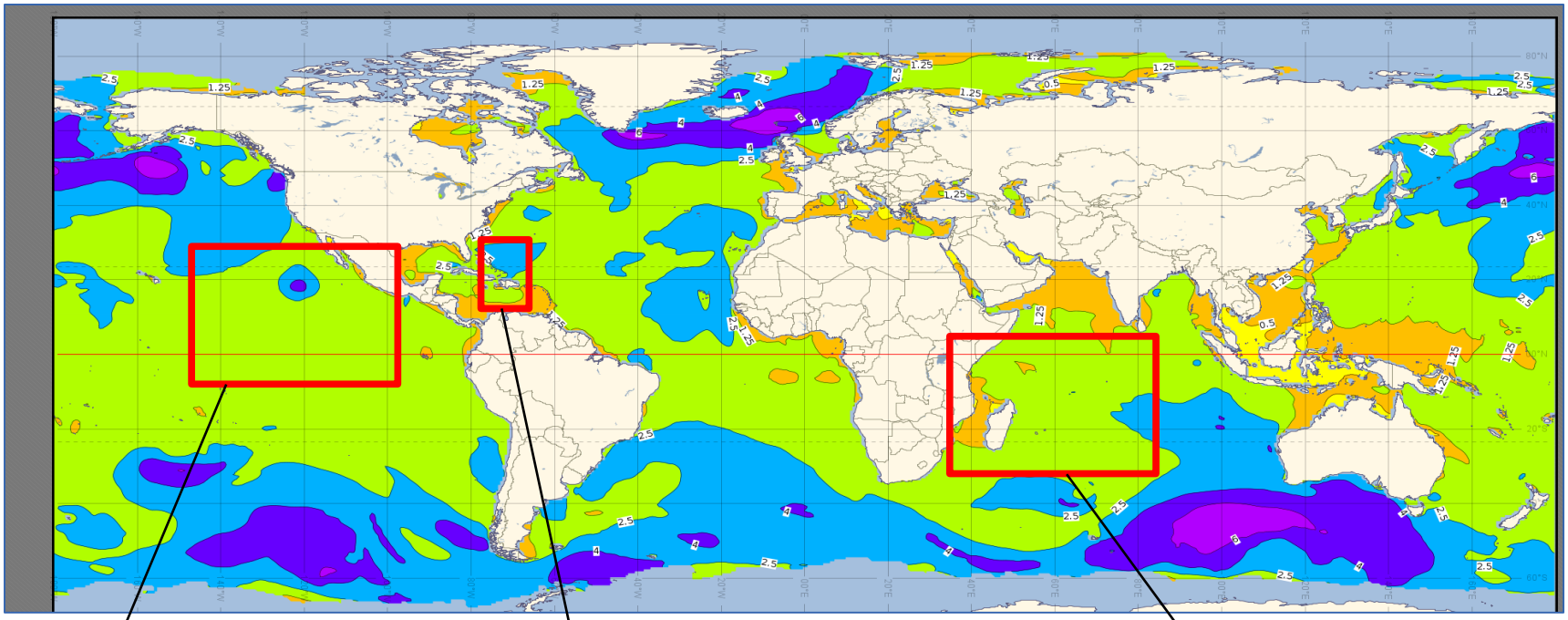
SMOS+model



difference 31 Aug. 0.00UTC



Description of runs



MFWAM-0.1°
Lat : 180°E to 260°E
Lon : 0° to 45°N

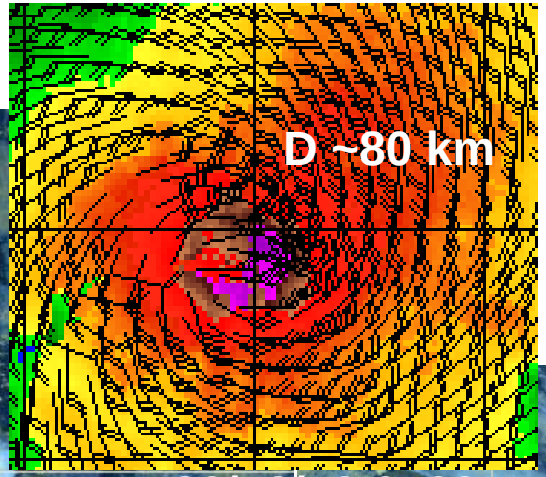
High resolution
Coastal WW3 200 m

MFWAM-Reunion 0.1°
Lat : 31.5°E to 88.5°E
Lon : 0° to 32°S

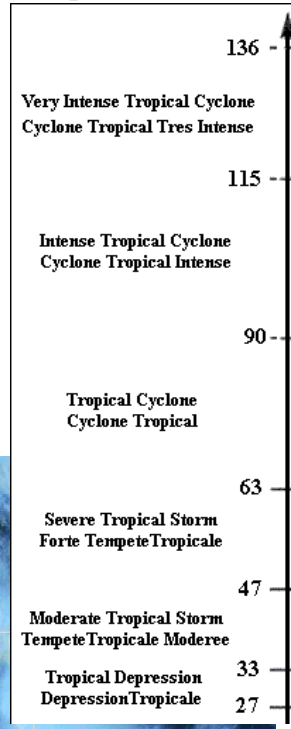
Cyclone cases implented with nested MFWAM model (BC from global):
Indian ocean : Bejisa, Fobane 2014
East-Pacific : Ignacio and Jimena 2015
Atlantic : Igor 2010 (nested coastal model for West Indies 200 m)

BEJISA : Second system of cyclonic season 2013-2014
Fast and explosive intensification (>+30 kt in 24hours)

Courtesy of Sébastien Langlade
and Olivier Bousquet



Ascat 30/12/13 0530Z



+63 kt

29/12/13, 1224Z, N18, DT 32 kt (60 km/h)

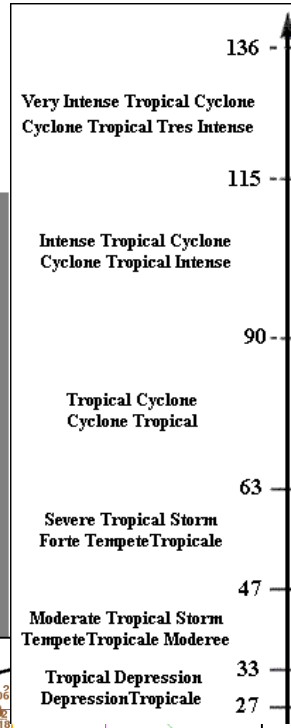
30/12/13, 1213Z, N18, CTI 95 kt
« pinhole eye », D ~10 km

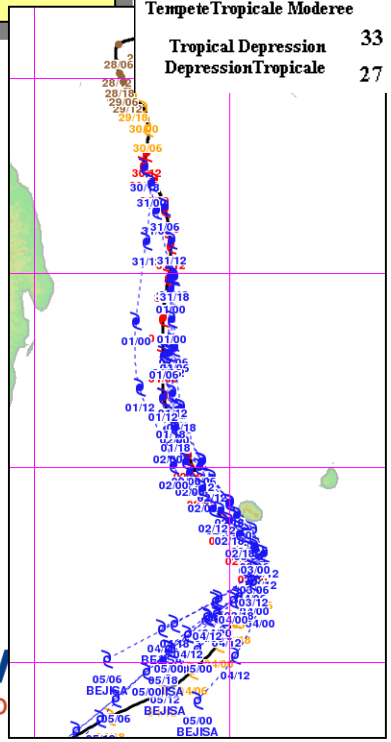
BEJISA

Béjisa trajectory (29/12/14 – 05/01/14)

Courtesy of Sébastien Langlade (DIRRE) and Olivier Bousquet

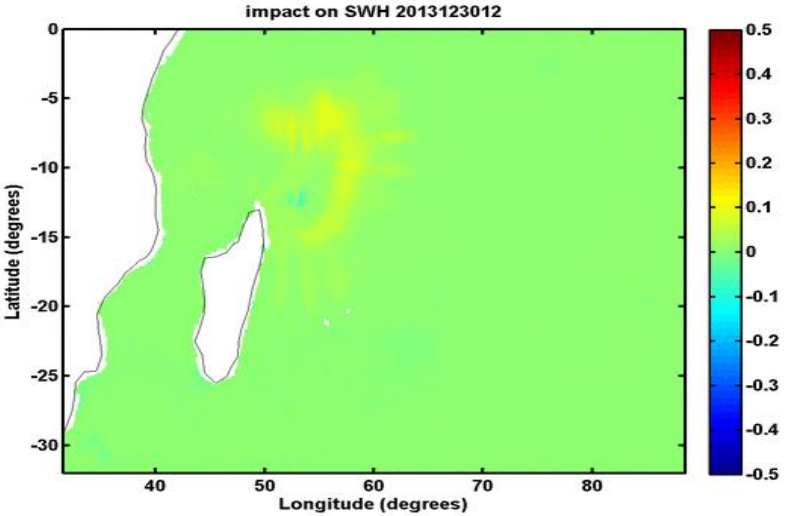
- Cyclogenèse près des Farquhar: Très inhabituel pour un cyclone menaçant les Mascareignes (1 cas similaire cyclone BENJAMINE, janv. 1979, passe au stade de FTT à l'Est de La Réunion)
- Très bonne prévisibilité de la trajectoire jusqu'à 66h avant le passage au plus près.
- 2ème alerte rouge la plus précoce à La Réunion (24h avant DUMILE)



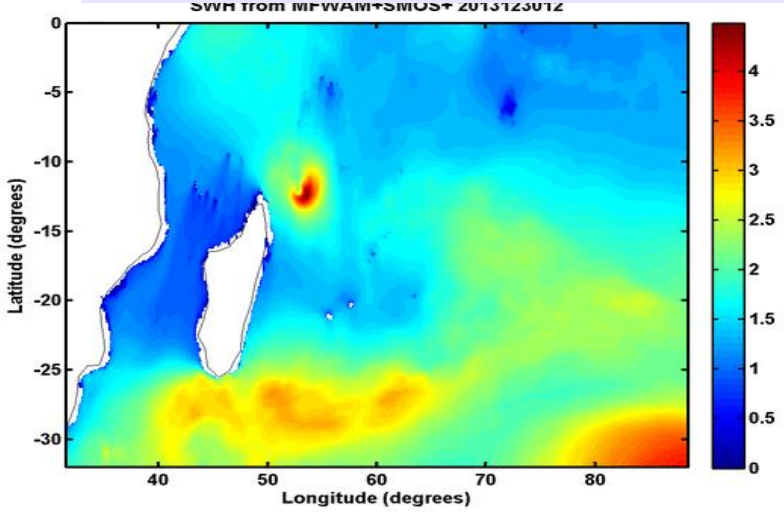


Cyclone BEJISA 2014

6-hourly difference of SWH

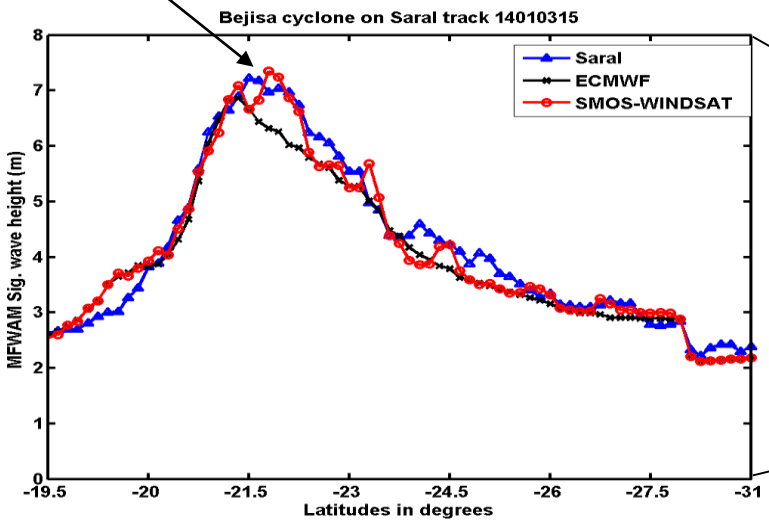


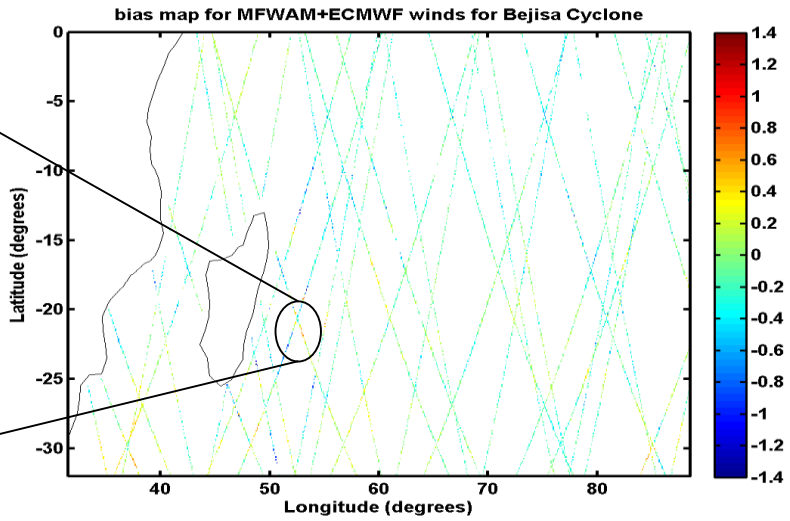
6-hourly SWH from MFWAM with SMOS+model winds 30/12 to 03/01



MFWAM forced by SMOS catched better the peak

SWH

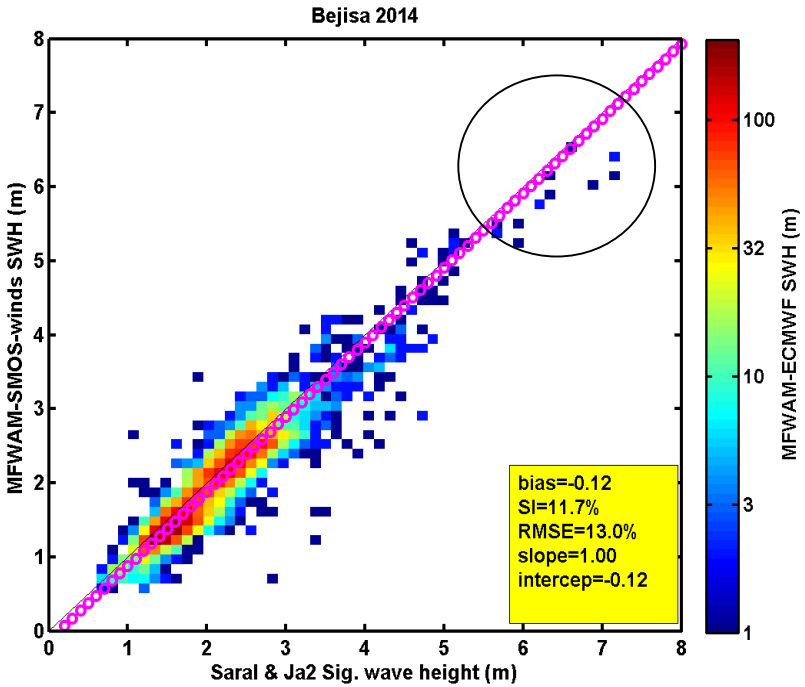




Black : M+ECMWF Red : M+SMOS+ Blue ; Saral

Validation with altimeters (Ja-2 and Saral) BEJISA 2014

MFWAM+ECMWF



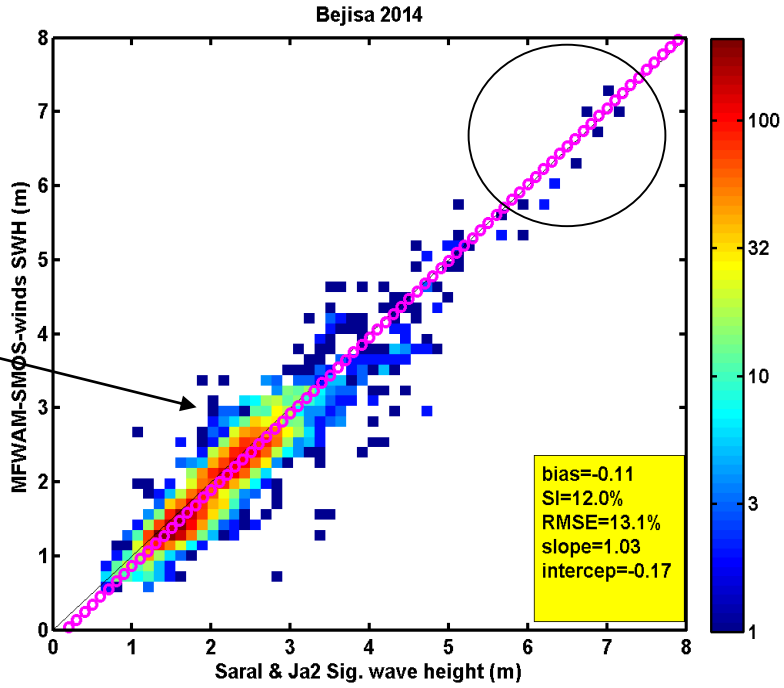
Strong bias reduction

For SWH>5 m

	M+ECMWF	M+SMOS
Bias (cm)	-38	-18
SI (%)	4.8	4.3
RMSE(%)	7.8	5.2

slightly more spread

MFWAM+SMOS+WSAT

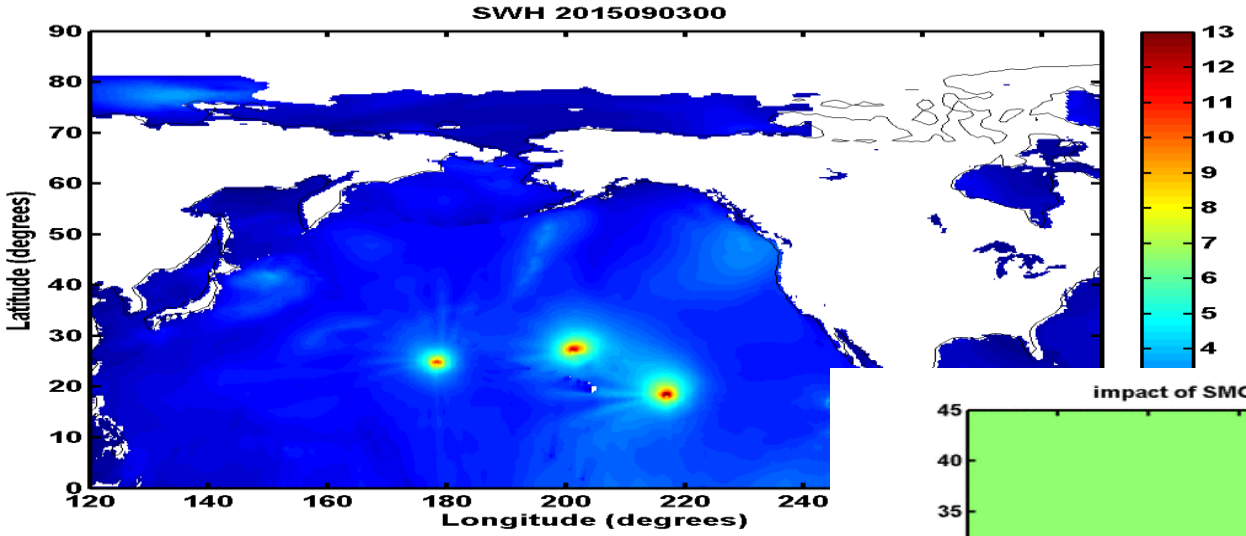


All SWH

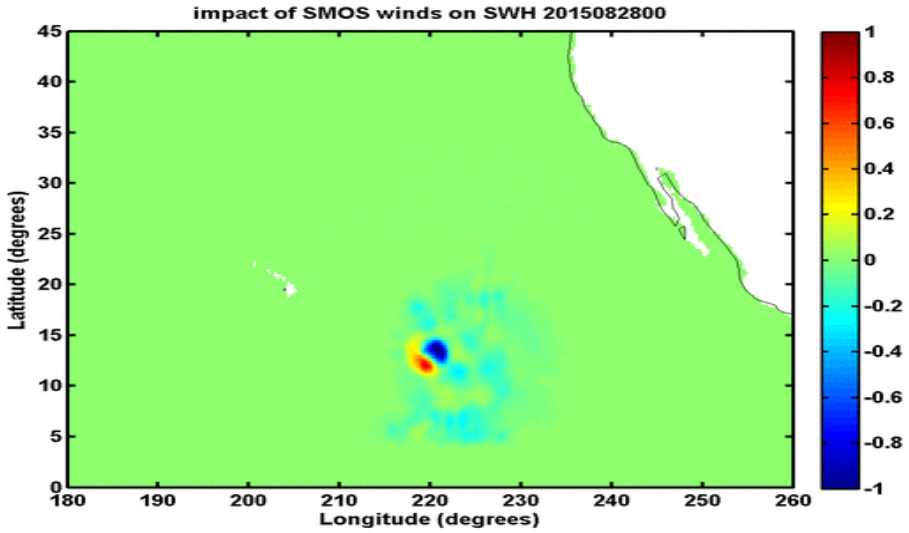
	M+ECMWF	M+SMOS
Bias (cm)	-12	-11
SI (%)	11.7	12.0
RMSE(%)	13.0	13.1

The golden week : Jimena and Ignacio cases

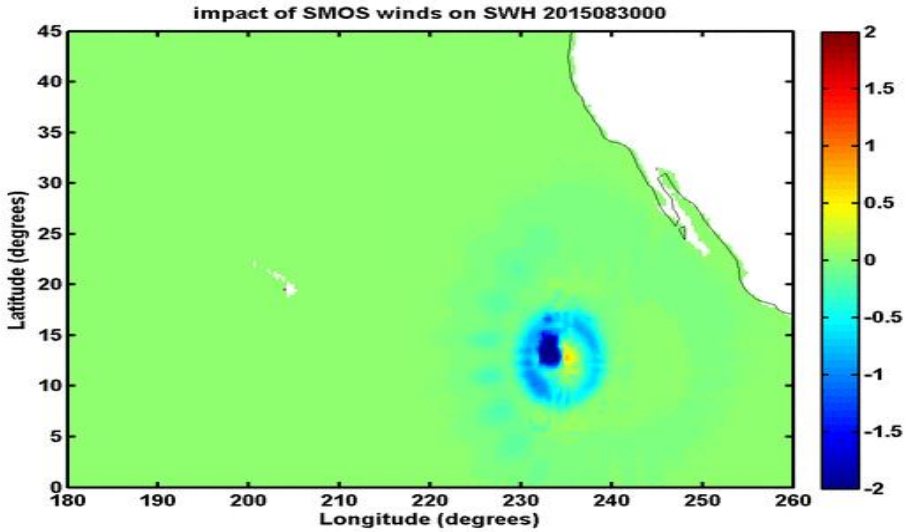
Snapshot from global MFWAM



IGNACIO
(28/08 to 02/09)



JIMENA
(30/08 to 04/09)



Difference of SWH of MFWAM with SMOS+ and ECMWF winds.

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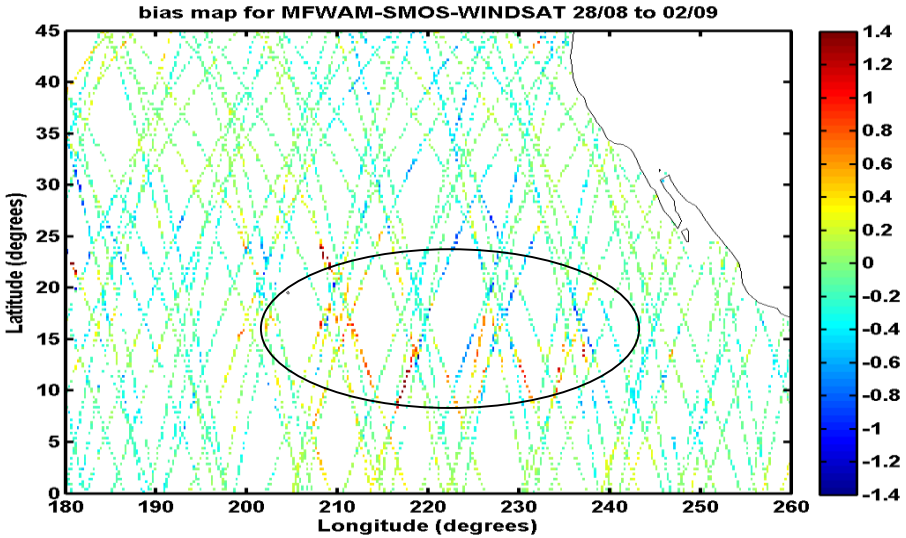
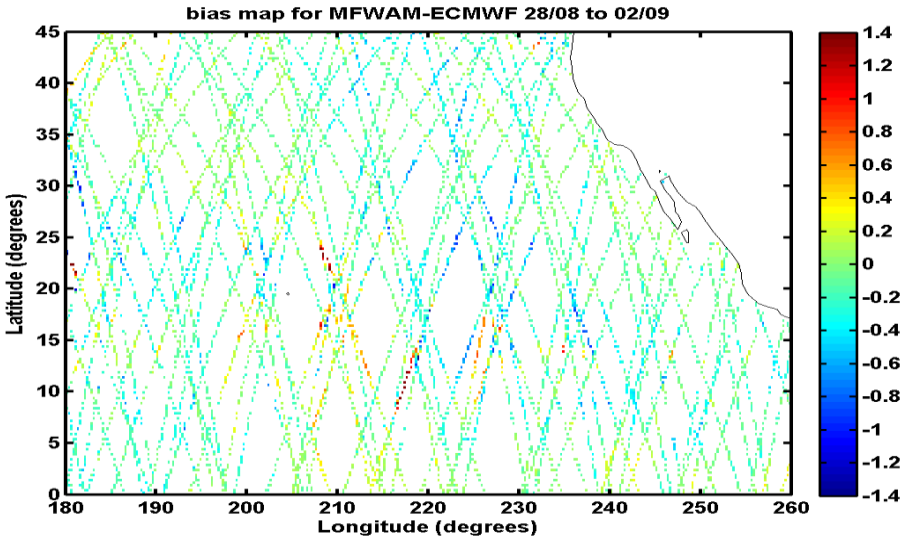
Comparison with altimeters (Jason-2 and Saral)
JIMENA 2015



MFWAM+SMOS+

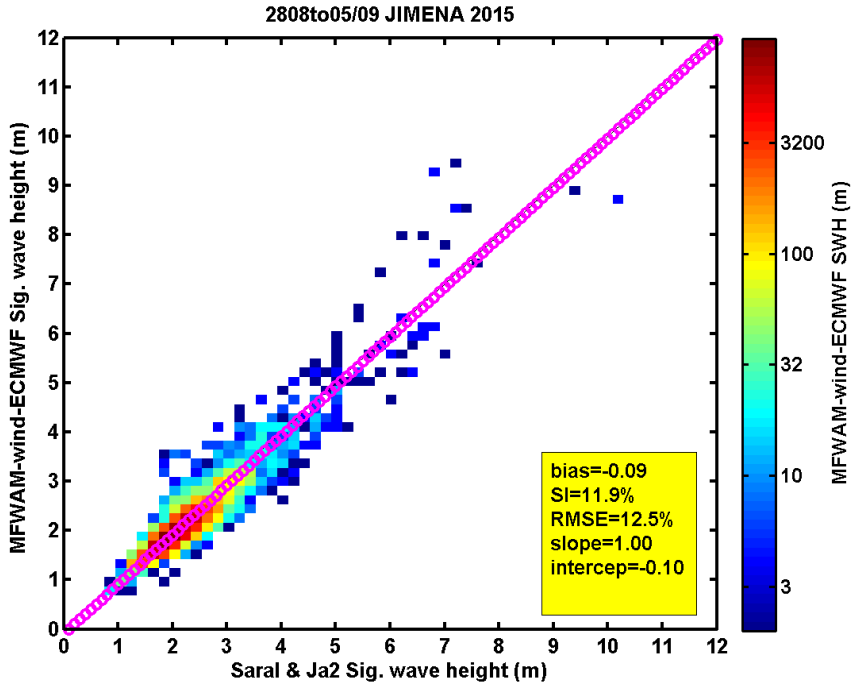
Enhanced higher waves when using SMOS+WSAT

MFWAM+ECMWF



Validation with altimeters (28 Aug. To 5 Sep. 2015 JIMENA 2015

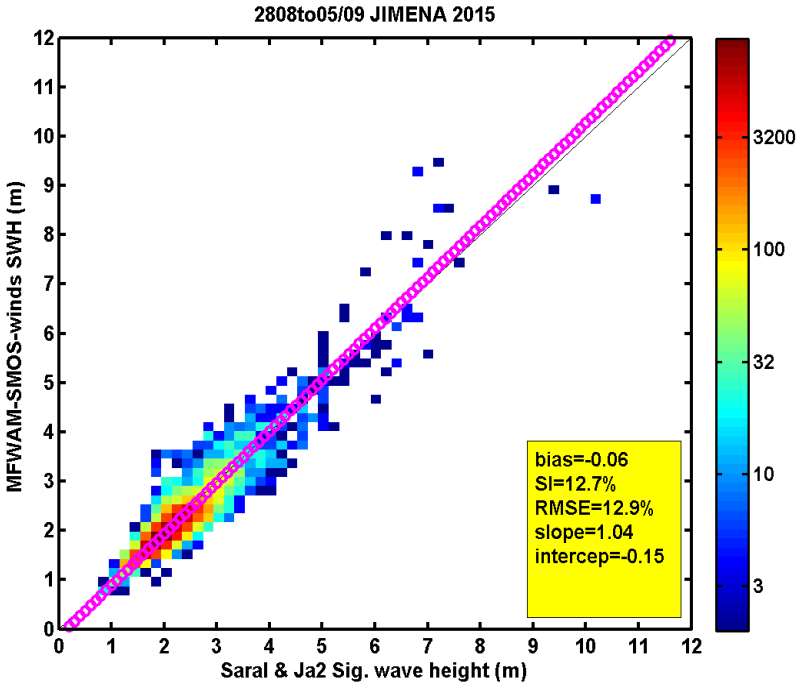
MFWAM+ECMWF



Better scatter index for SWH>5 m

	M+ECMWF	M+SMOS
Bias (cm)	-3	+6
SI (%)	14.9	14.3
RMSE(%)	14.9	14.3

MFWAM+SMOS+WSAT



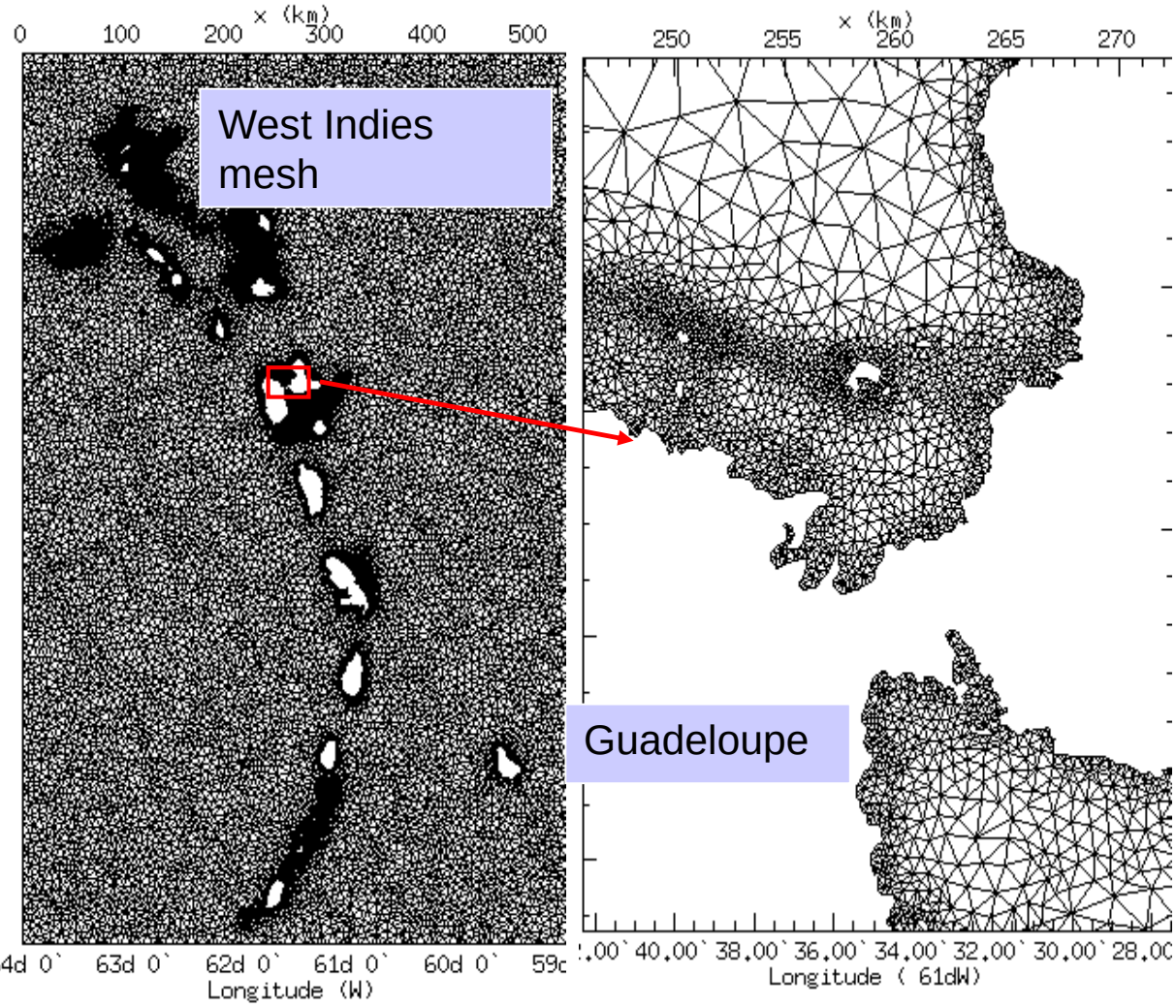
For All SWH the bias is slightly improved. however scatter index is increased (from 11.9 to 12.7 %), mostly because of discontinuties In the wind field (very sensitive to waves 2 to 4 m)

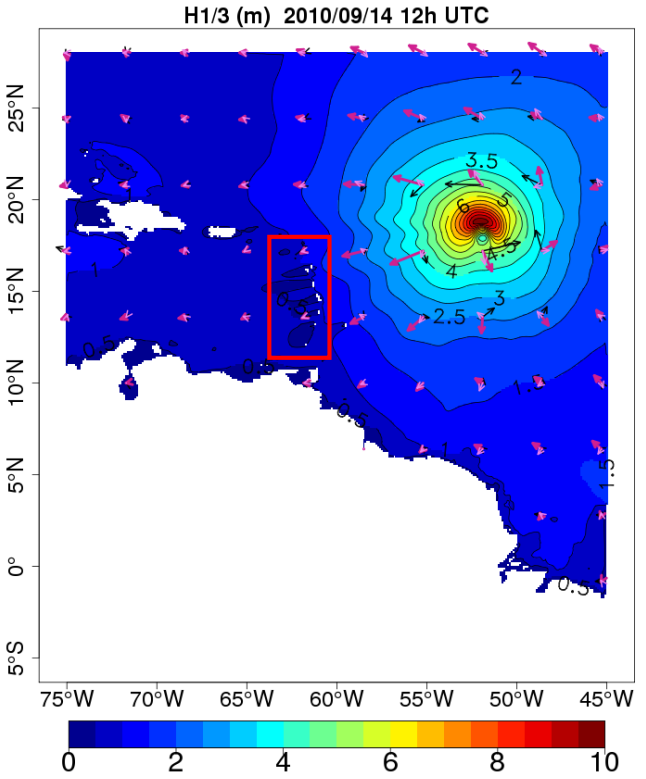
Description of coastal WW3

Same parametrisation as MFWAM in deep water

Irregular mesh on coasts

- From 200 m nearshore up to 10 km in deep water
- Adapted to geometry of coasts





vigilance vagues/submersion

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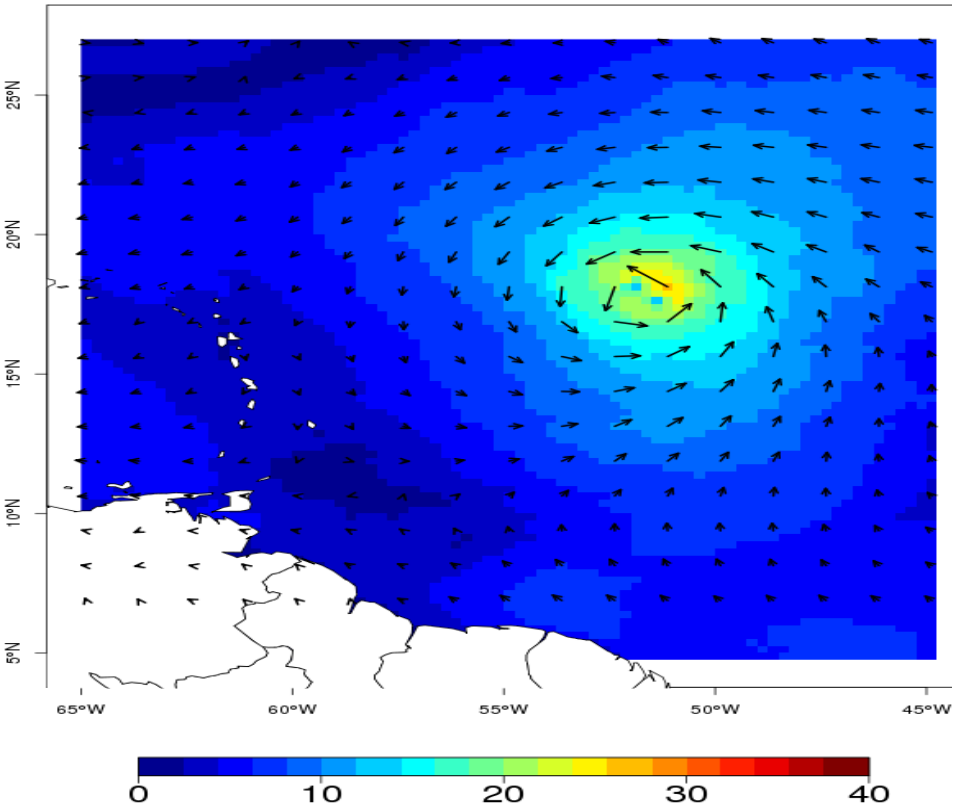
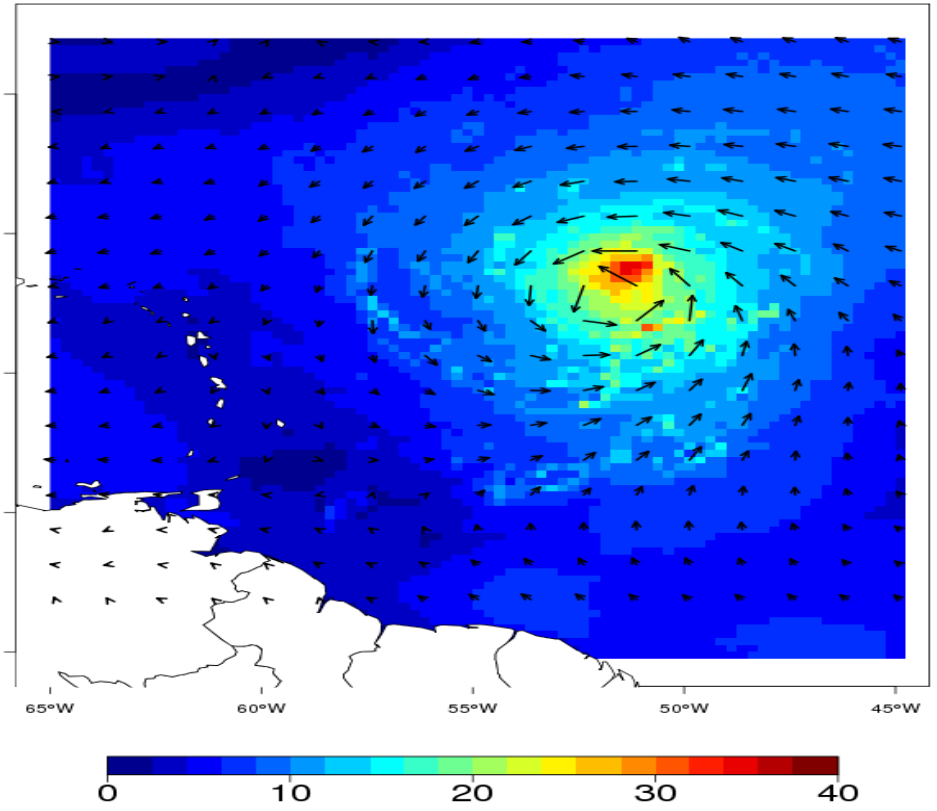
Hurricane IGOR 2010

ECMWF winds



ECMWF+SMOS winds



Directional properties of the wind field are taken from the model

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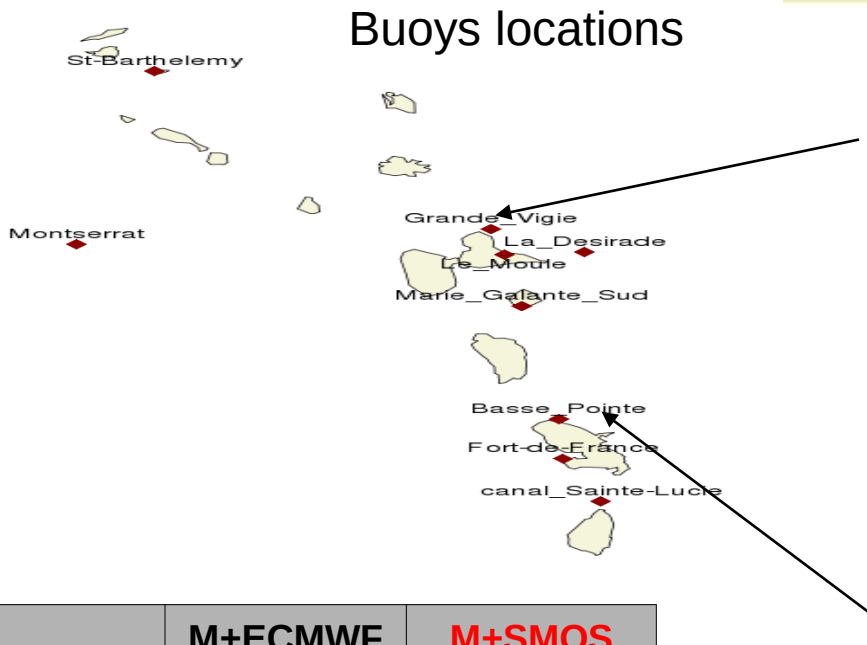
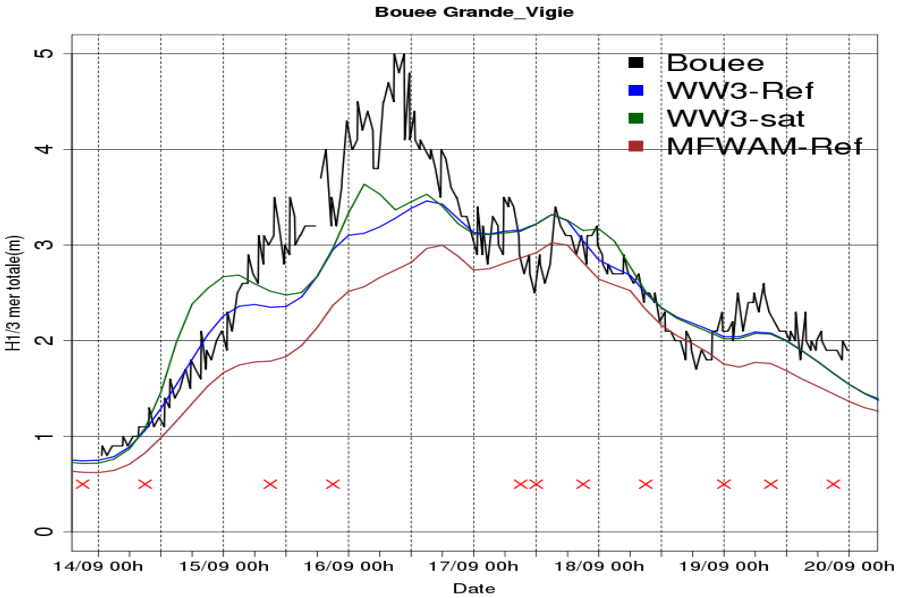
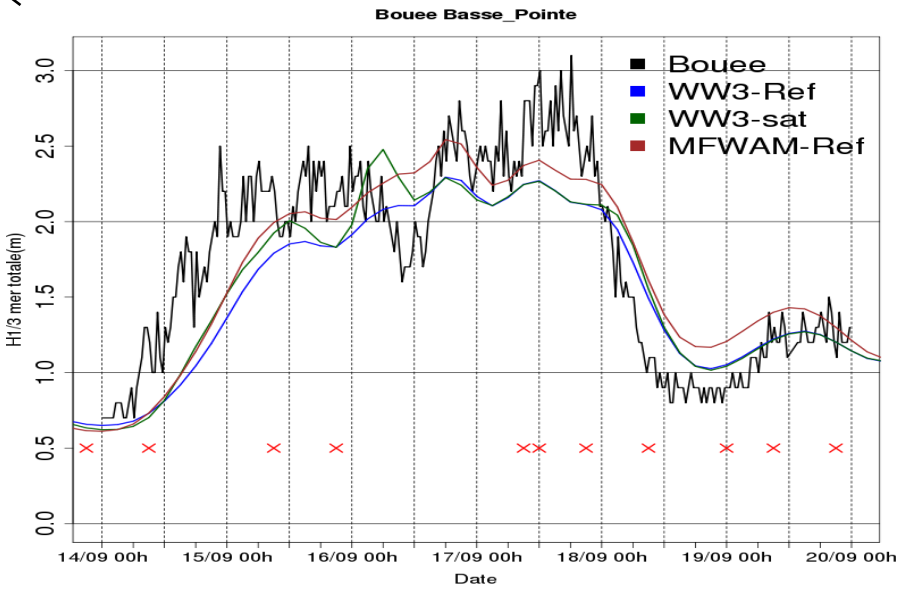
High resolution coastal wave model for the West indies IGOR (2010)





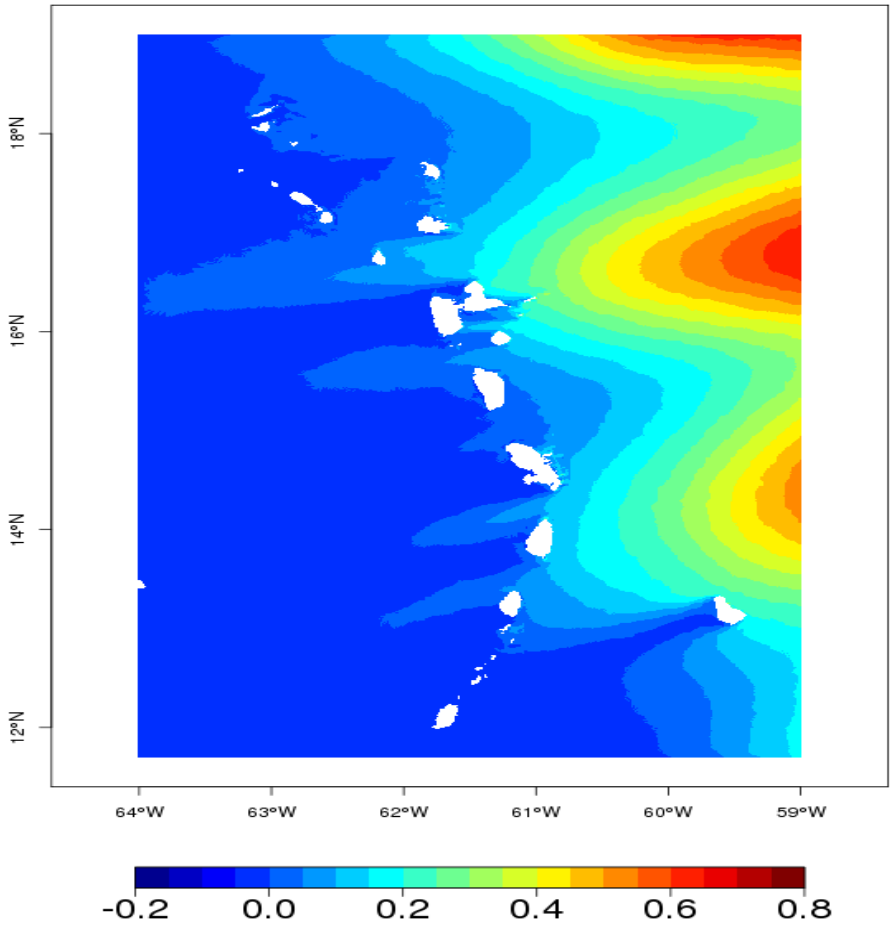


	M+ECMWF	M+SMOS
Bias (cm)	-42	-36
SI (%)	16.1	16.6

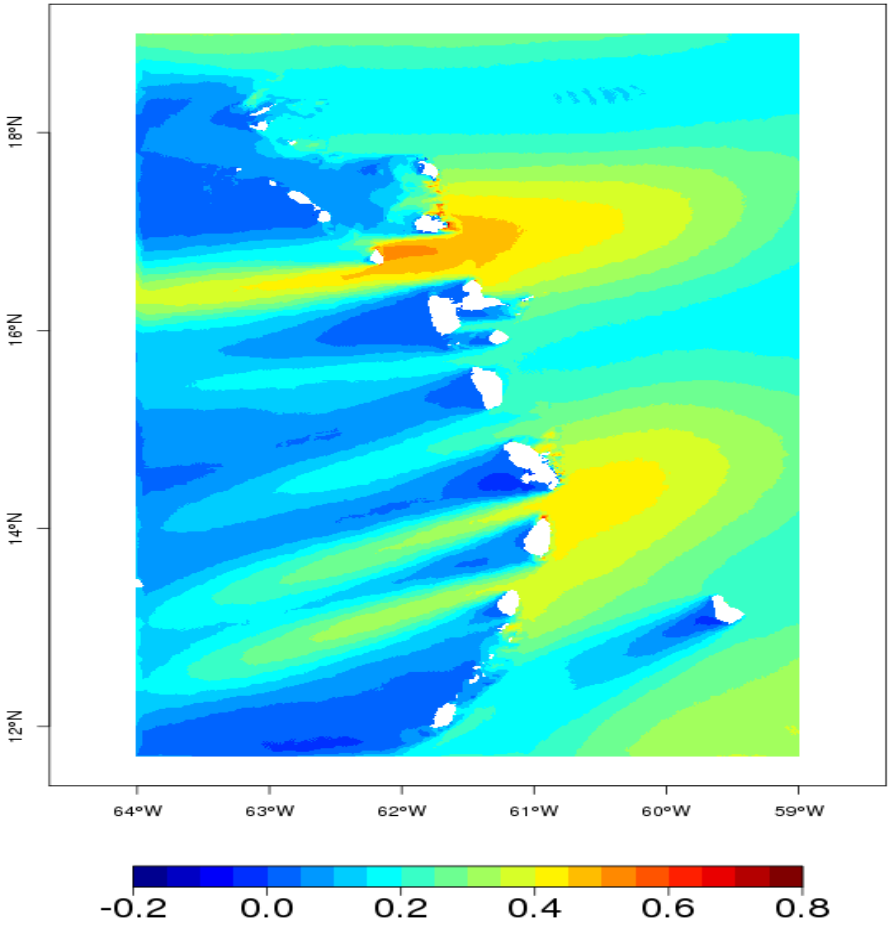
13 SMOS and WSAT forcing over 64 Wind forcing have been used in the coastal model. The bias is reduced by 15 %, however the scatter is slightly increased.

Impact of SMOS winds on high resolution WW3
Hurricance IGOR (2010)

14 Septembre 2010 at 12:00 UTC



15 Septembre 2010 at 0:00 UTC



Difference of SWH from reference and SMOS forcing runs

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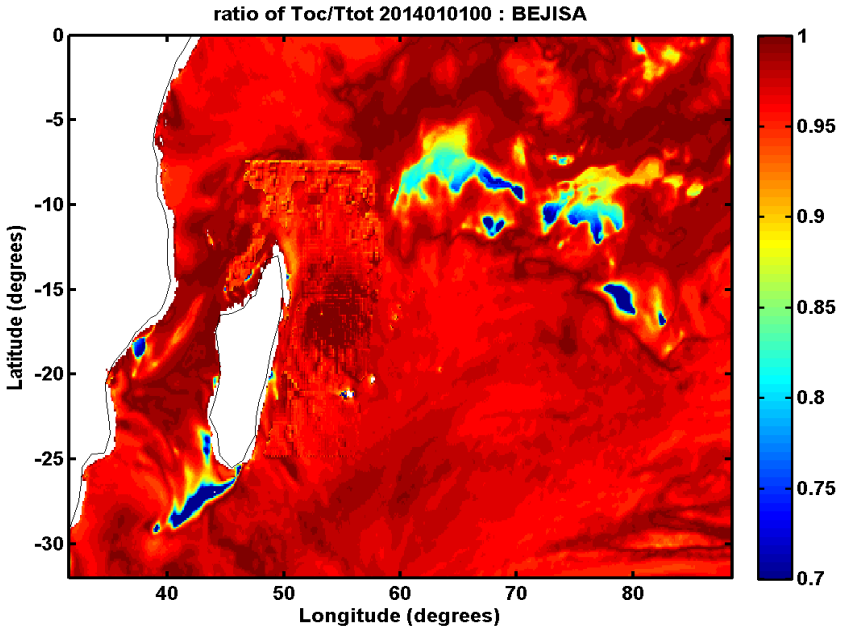
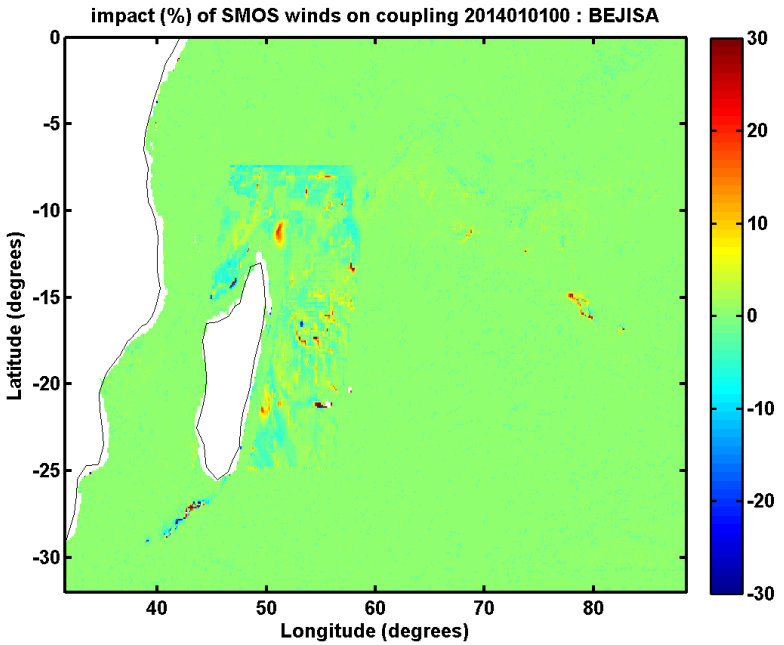
Impact SMOS+ winds on coupling parameters

The water side stress (breivik et al. 2014) computed by the wave model is : $\blacklozenge_{oc}=\blacklozenge_{a}-\blacklozenge_{in}-\blacklozenge_{ds}$, where $\blacklozenge_{a}$ is the air side stress, $\blacklozenge_{in}$ is the momentum flux absorbed by the waves and $\blacklozenge_{ds}$ is the momentum produced by the dissipation of breaking

Example of ratio $\blacklozenge_{oc}/\blacklozenge_{a}$



Difference of stress (%) with and without SMOS winds



Snapshots on 1 January 2014 at 0:00 (UTC)

Conclusions

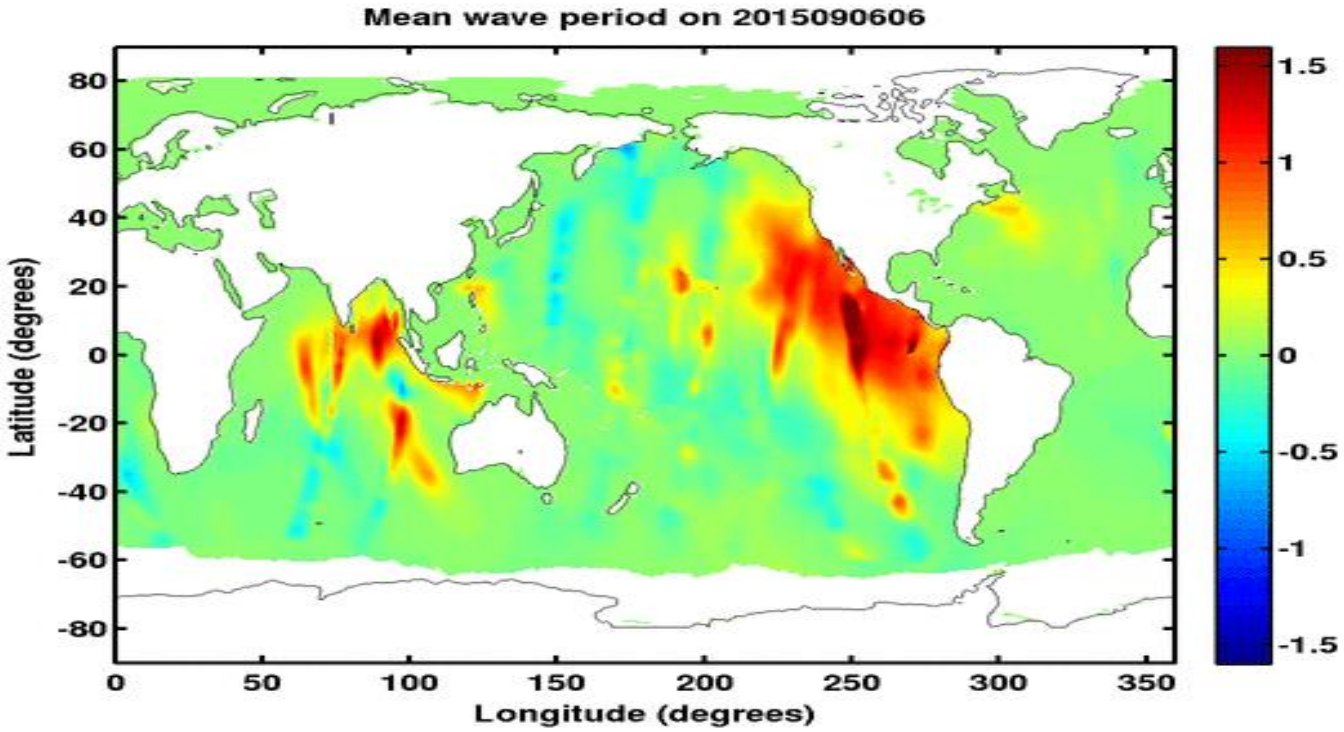
- The use of SMOS and WINDSAT winds showed good skill to reduce significantly the bias of SWH for high waves (SWH> 5 m). Good candidates to improve the wave forecast in cyclones conditions

- Slight increase of the scatter for lower waves is indicated. This is mostly induced by some discontinuities of SMOS wind field. Improvements are expected to make the wind field smoother

- Coupling MFWAM with ocean model in tropical cyclone will be the challenge of the future works

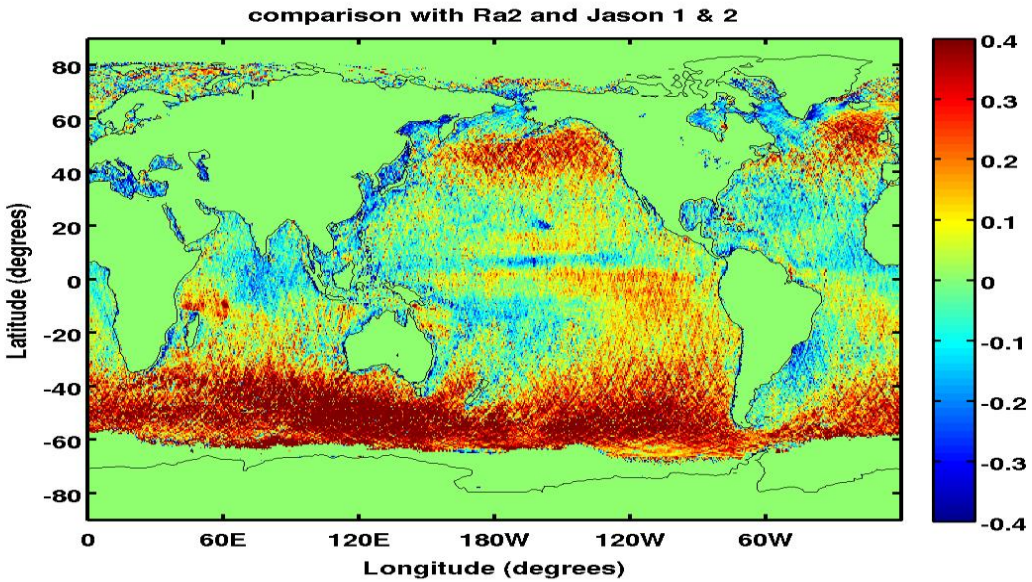
Impact of the assimilation of SAR sentinel-1A in the forecast period

Mean wave period



Difference of wave parameters with and without assimilation of S1A Snapshots with a step of 6 hours in the period of forecast starting on 6 september 2015 at 0:00 UTC until 8 september at 0:00

Improvements of the wave model regarding to southern storms



Old version MFWAM

MFWAM since Nov.2014

Bias maps
Comparison with altimeters
Sep-Oct-Nov 2011