On the assimilation of Sentinel-3A wave data in the wave model MFWAM

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OUTLINE

1- Motivation

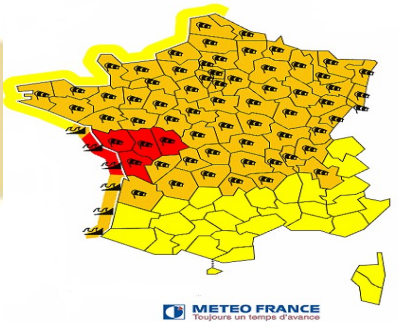
2- Data description and Methodology

3- Assimilation experiments

4- Results and validation

5- Conclusions and Future works

MOTIVATION



- To update the sea state forecasting system of Météo-France with latest altimeters missions : reliable wave submersion warning (VVS), improved products for Copernicus CMEMS-MFC.

- Evaluating the assimilation of Sentinel-3A in the operational wave model : assessing the impact and the quality control on the retrieved SAR mode wave data (see precedent work Aouf et al. OSTST-2015).

- Allowing the operational system to prevent extreme events at global and regional scales.

Sentinel-3A SRAL wave data and QC procedure

- sentinel-3A SRAL OGDR L2 wave products are downloaded in NETCDF format from EUMETSAT ftp : oda.eumetsat.int/SRAL_data (standard) period of validation from 24 June to 1 October 2016

- Quality control procedure is implemented before the assimilation in the wave model. The table here below shows the thresholds on etrieved signal and wave paraemters

Land flag (oceans)	0
RMS_SWH	<=0.6 m
SWH Min	0.3 m
SWH Max	16 m
σ0 Min	5 db
σ0 Max	20 db
Num. valid points	>=10

thresholds used for S-3A

After performing QC ~15-20 % of data are rejected.

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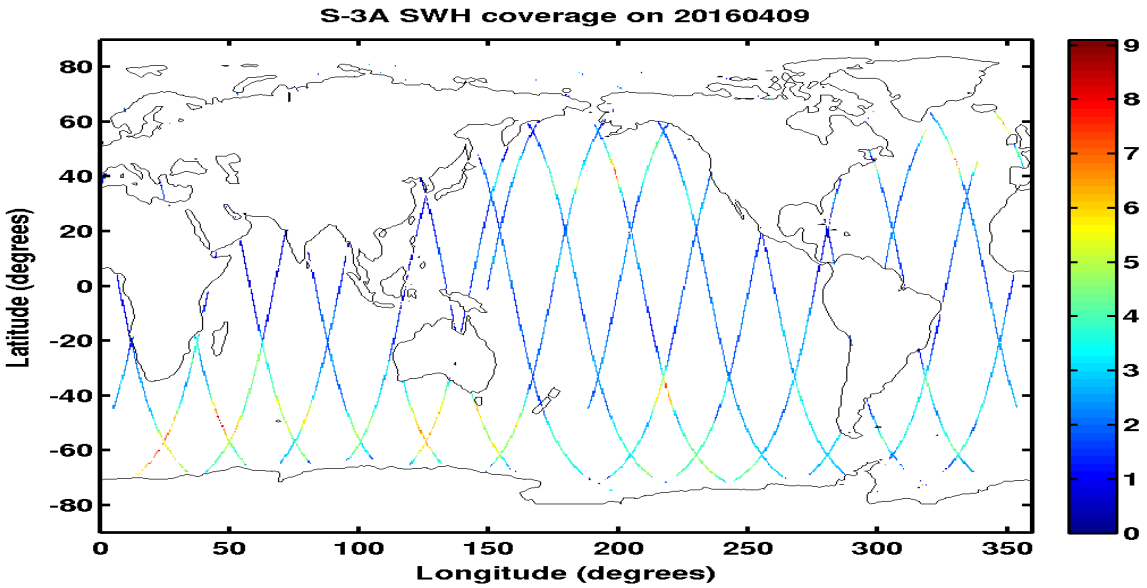
Projection of S-3A SWH on wave model grid

- Comparison with 3-hourly output from the operational global and regional MFWAM (MFWAM-OPER is using Ja-2, Saral and Cr-2)

- Assimilation of altimeters
  - → Optimal interpolation on SWH (Significant wave height)
  - → Correction of wave spectra using wave growth laws and assumptions



1-day global coverage of S-3A

S-3A wave obs are collocated with model grid points : Super-observations

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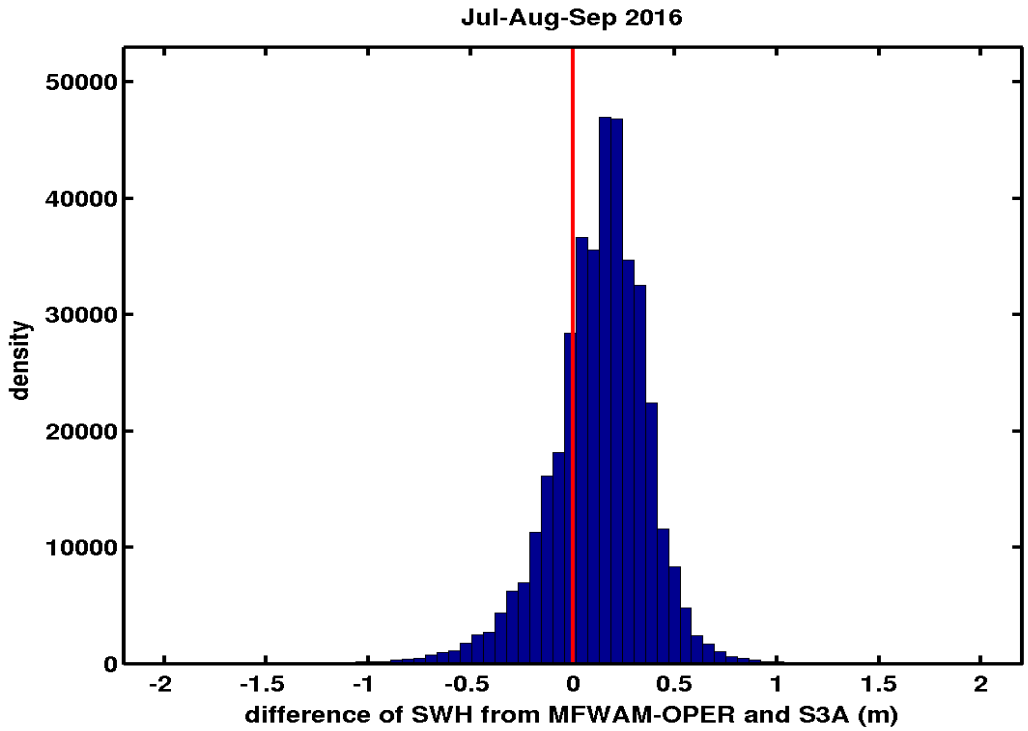
Comparison of SWH (step 3h)
S-3A vs MFWAM-OPER (Ja-2,Saral,Cr2 in)

Histogram of difference



Bias=0.13
SI=10.9%
RMSE=12.1%
Slope=0.94
Intercept=0.27

Data collected : 391472

Positive bias : S-3A underestimates SWH

From Jul-Aug-Sep 2016

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Description of runs :
from June to September 2016

- **Test runs set-up**
  - Wave model MFWAM (global coverage 0.5x0.5° irregular grid and regional La Reunion 0.1x0.1°),
    wave spectrum in 24 frequencies (starting 0.035 Hz) et
    24 directions
  - ECMWF analyzed winds every 6 hours
  - Assimilation time step 6 hours

→ **Assimilation** of S-3A Sig. wave heights

→ **Assimilation** of Jason-3 sig. wave heights

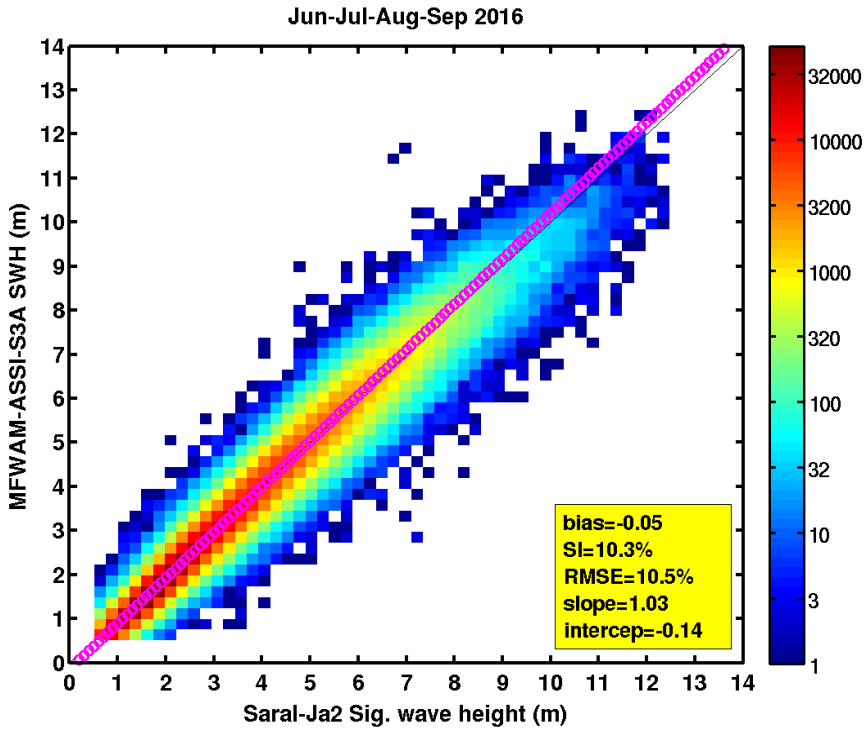
→ Combined assimilation of S-3A and SAR spectra of S-1A

→ **Control** run of MFWAM without assimilation

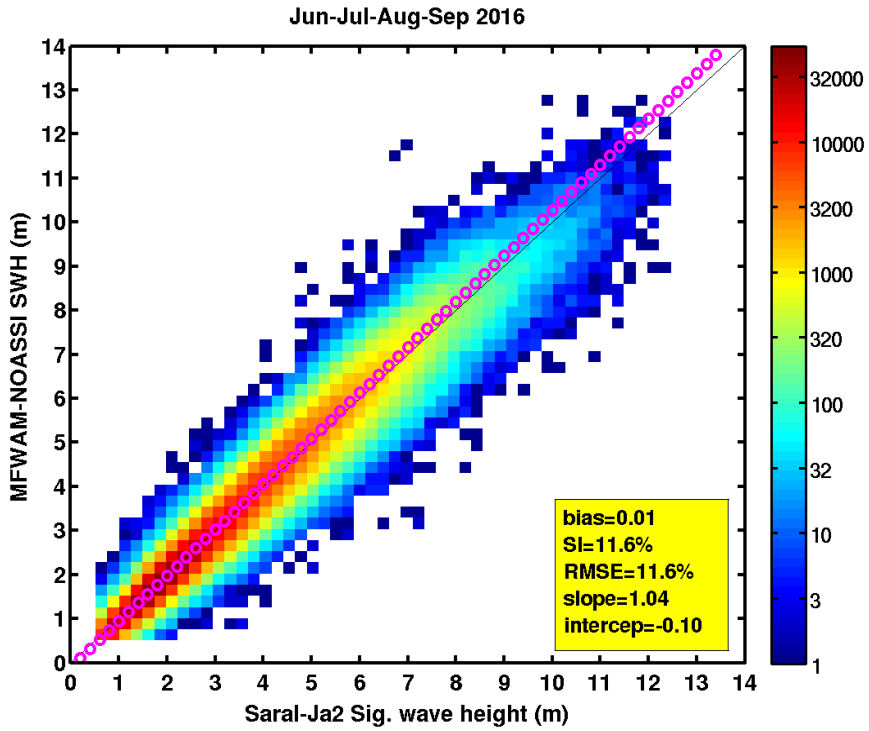
Validation with independent wave data (Saral, Ja-2 and Ja-3 and buoys)

Assimilation of Jason-3 Sig. Wave heights Validation with Saral and Ja-2

Assimilation of S3A



Without assimilation



Bias =-0.05
SI = 10,3%
RMSE = 10.5%
Slope = 1.03
Intercept = -0.14

Scatter index is well improved by ~11 %

Data collected : 631438

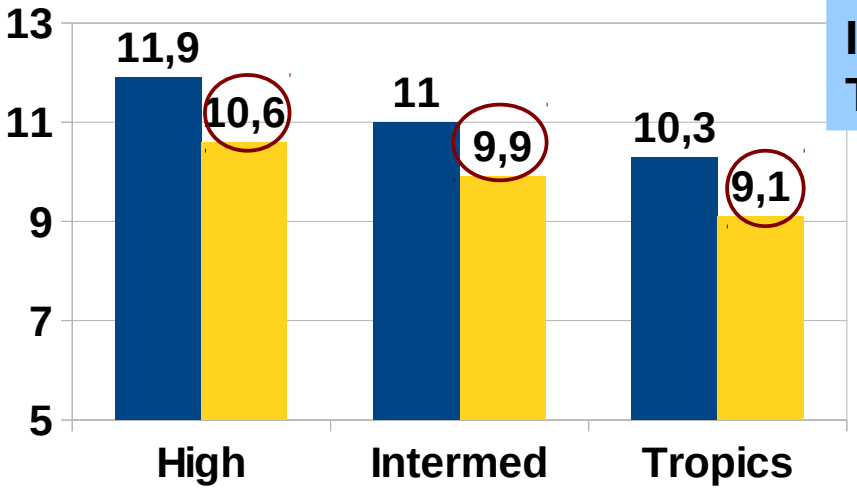
Period of Jun-Jul-Aug-Sep 2016

Bias=0.01
SI=11,6%
RMSE=11,6%
Slope=1.04
Intercept=-0.10

Assimilation of S-3A SWH in MFWAM
Validation in different ocean basins : Jun-Jul-Aug-Sep 2016

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

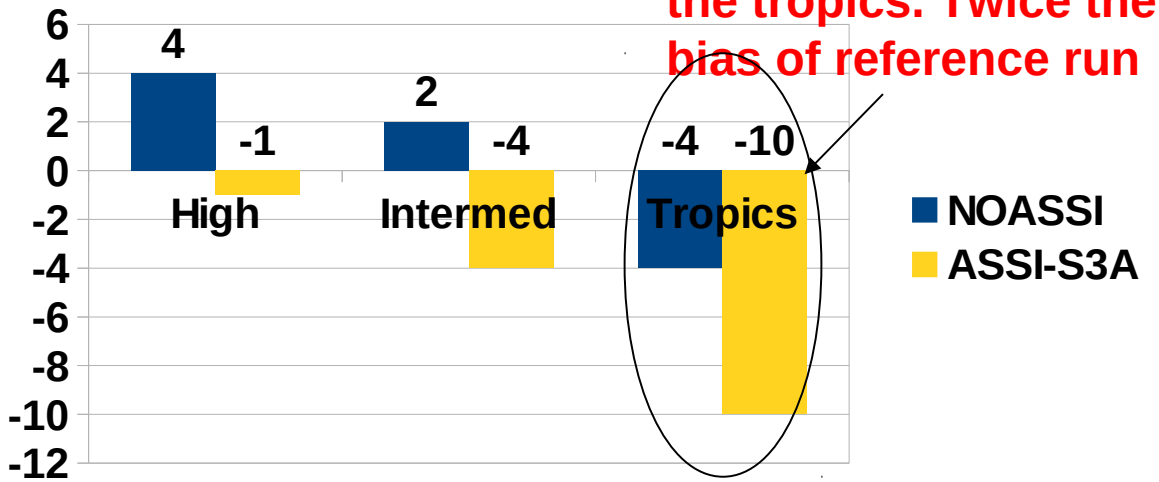
Scatter Index of SWH (%)



Collected data : 308580 498842 327469

The bias is degraded in the tropics. Twice the bias of reference run

Bias in cm

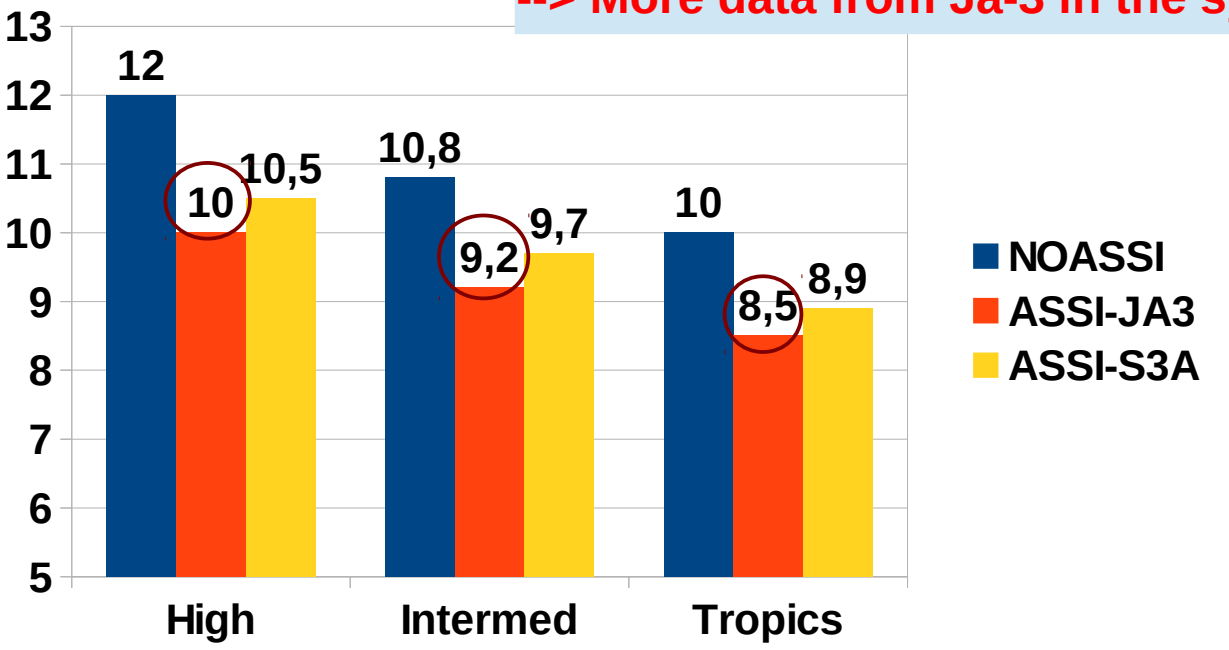


Validation with Saral and Ja-2

Assimilation of S-3A VS Assimilation of Ja-3
Validation in different ocean basins : Jul-Aug 2016

Ja-3 shows better performance than S-3A
--> More data from Ja-3 in the system

Scatter Index of SWH (%)



	High	Intermed	Tropics
Collected data :	**70476**	**144933**	**100963**

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

Validation with Saral

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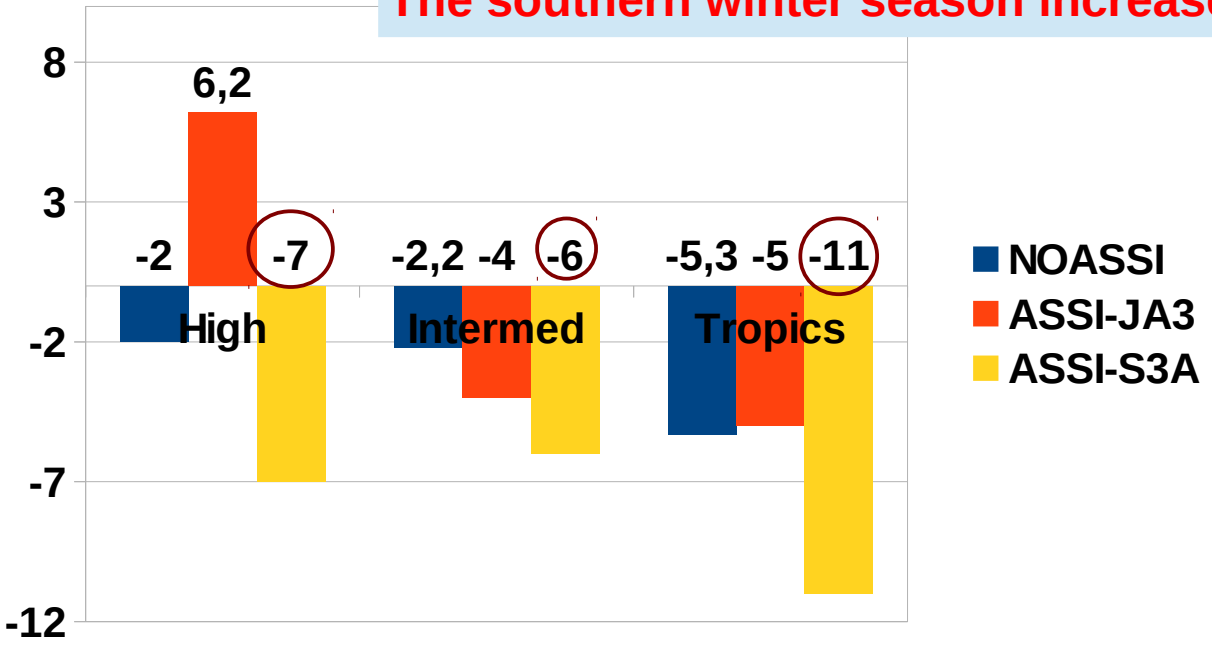
Assimilation of S-3A VS Assimilation of Ja-3
Validation in different ocean basins : Jul-Aug 2016

S3A shows enhanced bias in the tropics
The southern winter season increases the bias

Bias of SWH (in cm)



	High	Intermed	Tropics
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High Lat |Φ|> 50°
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Tropics |Φ|<20°

Validation with Saral

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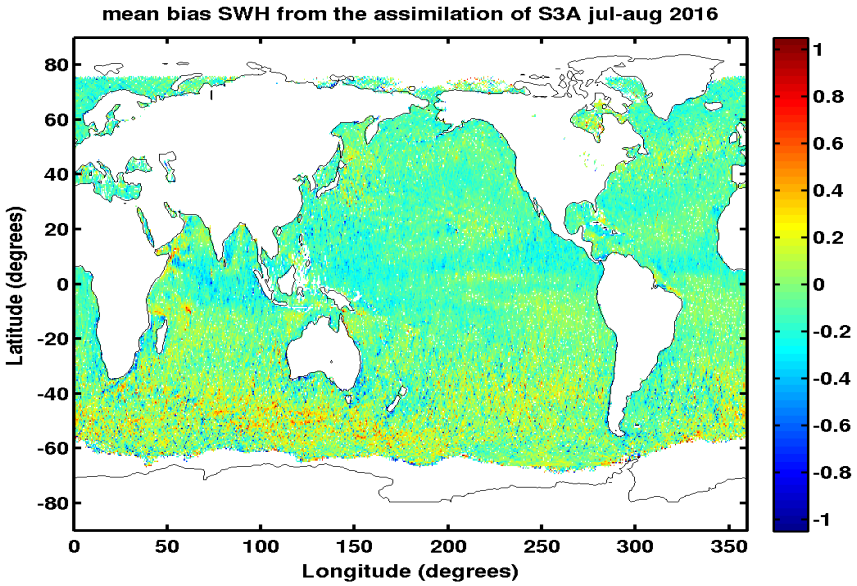
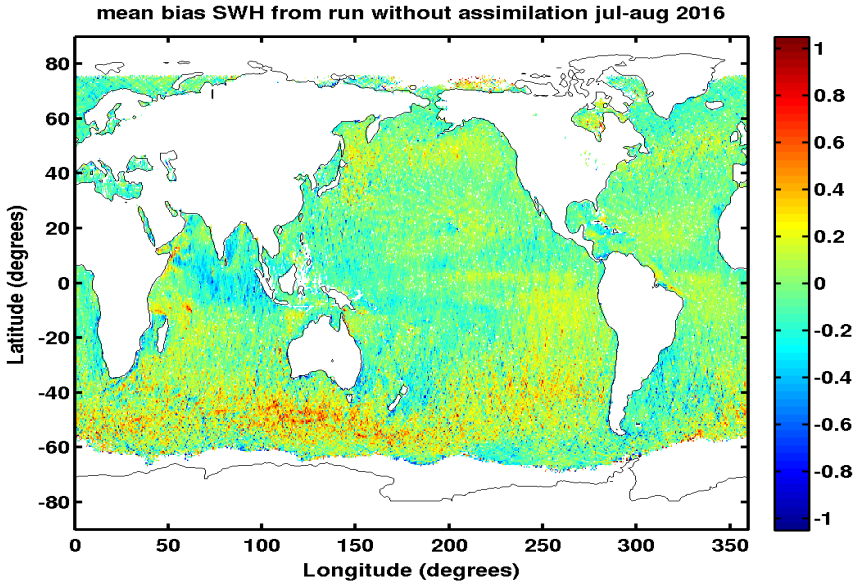
Bias map (in cm) of SWH before and after the assimilation of S-3A : Jul-Aug 2016

Assimilation of S-3A

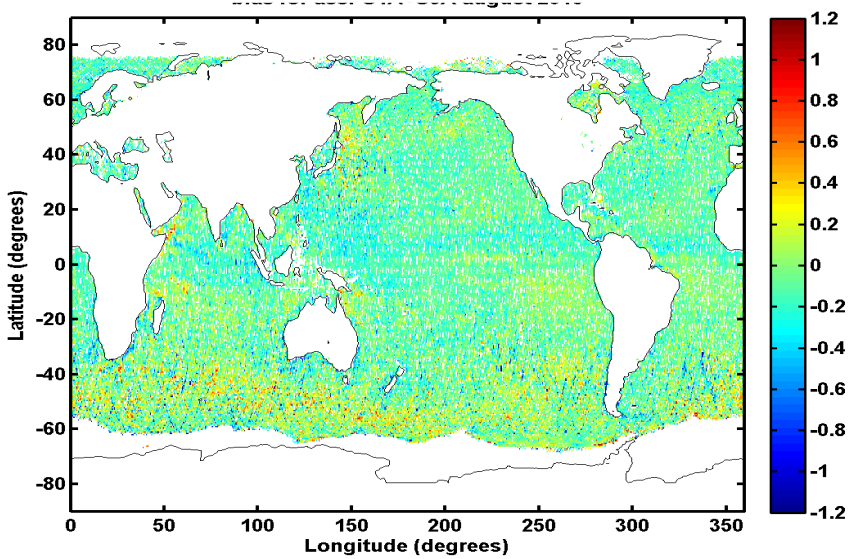


Without assimilation



Bias is well reduced globally after the assimilation (mostly in high latitudes)

Assimilation of S3A and SAR spectra of S1A slightly reduced the bias

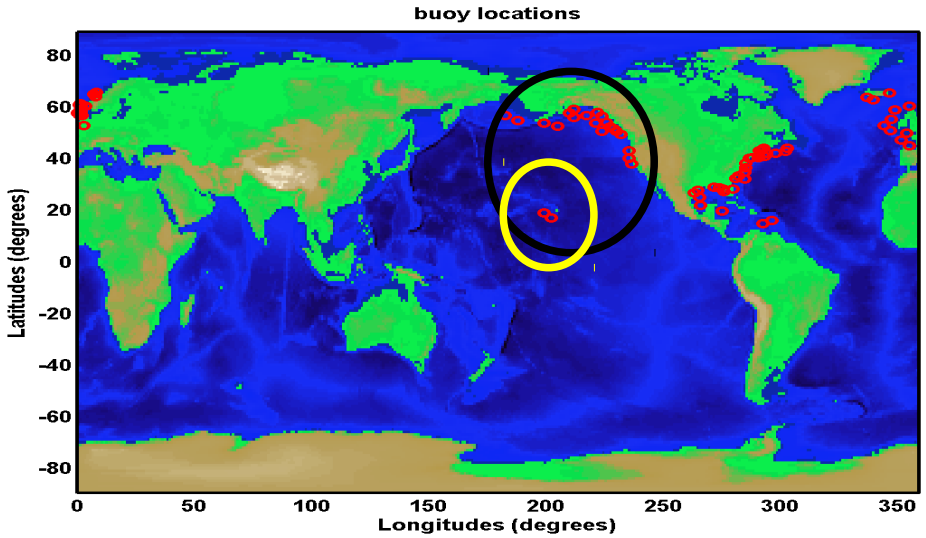


validation with Saral and Ja-2

Validation with buoys data (thanks to NDBC)
Statistical analysis for Sig . Wave Height

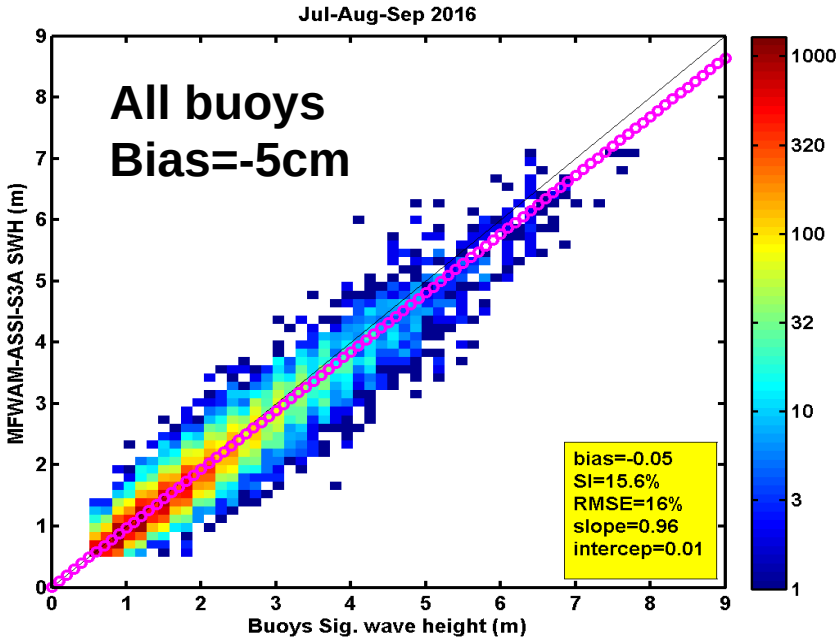
Pacific zone

	Assi-S3A	Noassi
Bias (cm)	-11	-4
SI (%)	13.9	15.0
NRMSE(%)	15.2	15.2



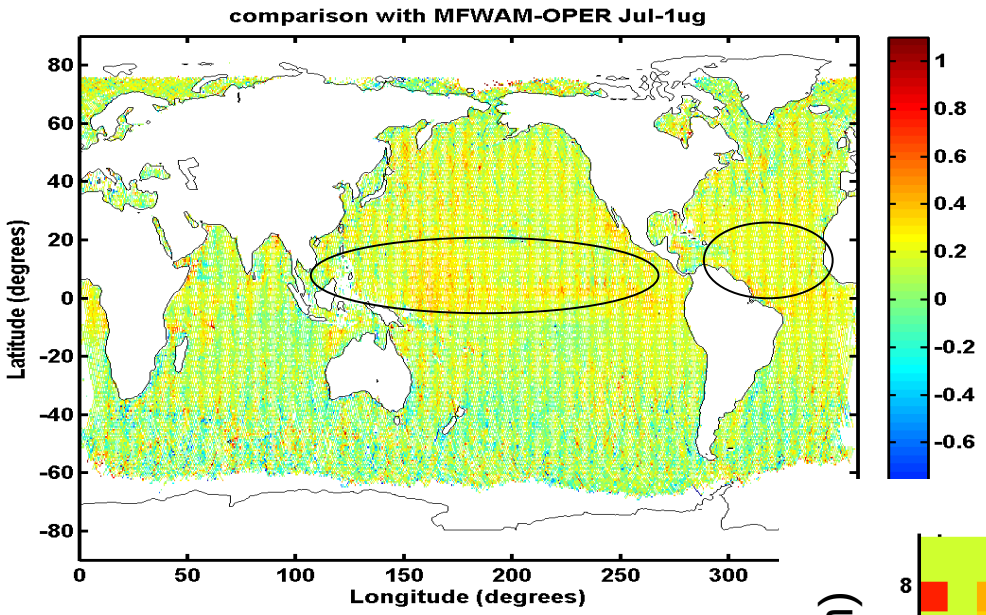
Haiwaian buoys

	Assi-S3A	Noassi
Bias (cm)	-12	-6
SI (%)	11.8	11.8
NRMSE(%)	13.5	12.3



July-August-September 2016

Focus on bias : comparison Operational MFWAM with S-3A

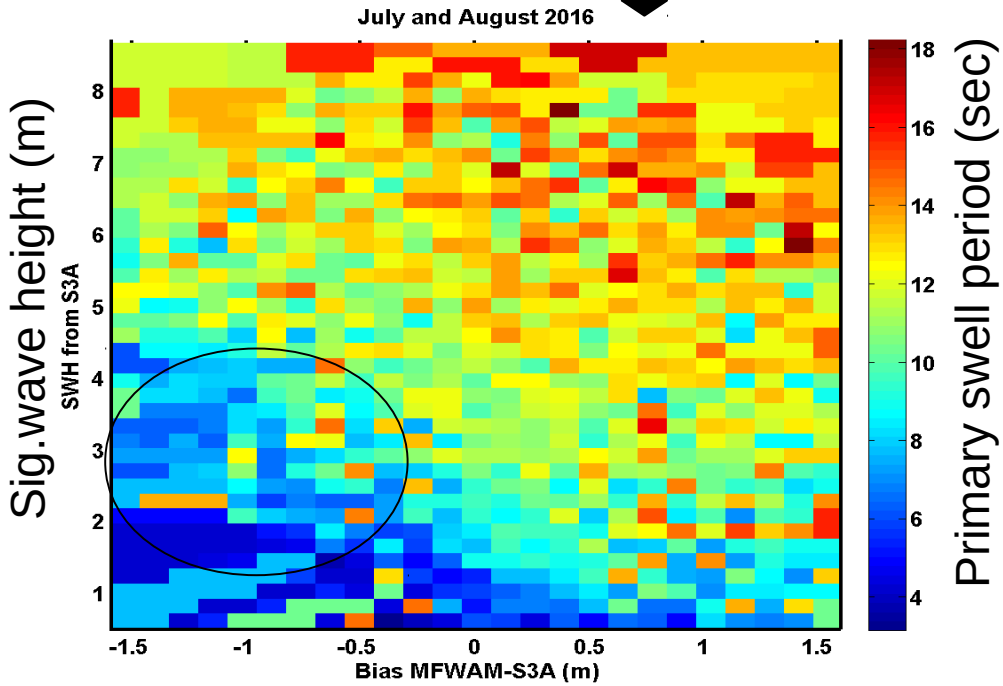


Sentinel-3A with MFWAM-OPER

July and August 2016

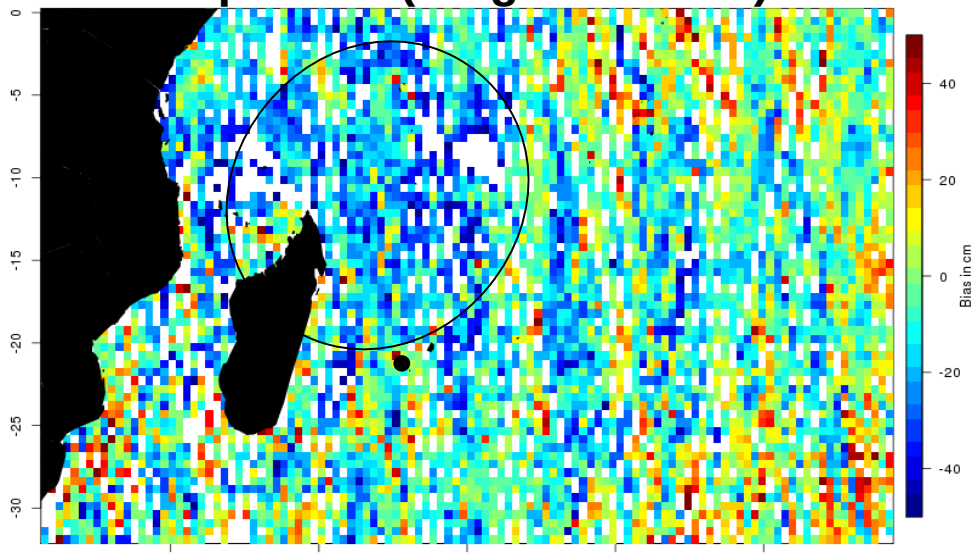
S-3A underestimates SWH in the tropics for SWH <3 m and swell dominant regime

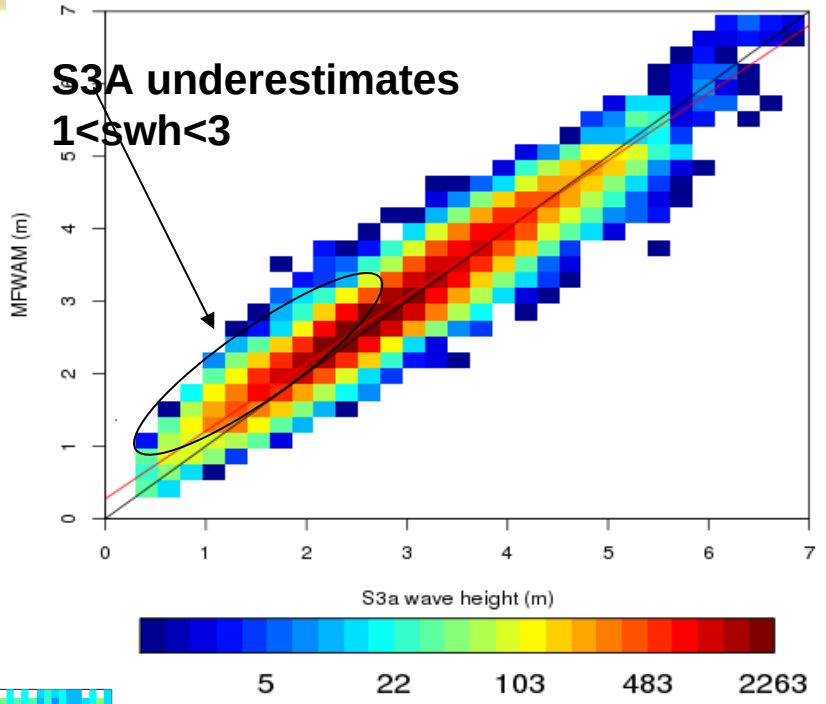
Mostly intermediate and longer swell are affected by the bias



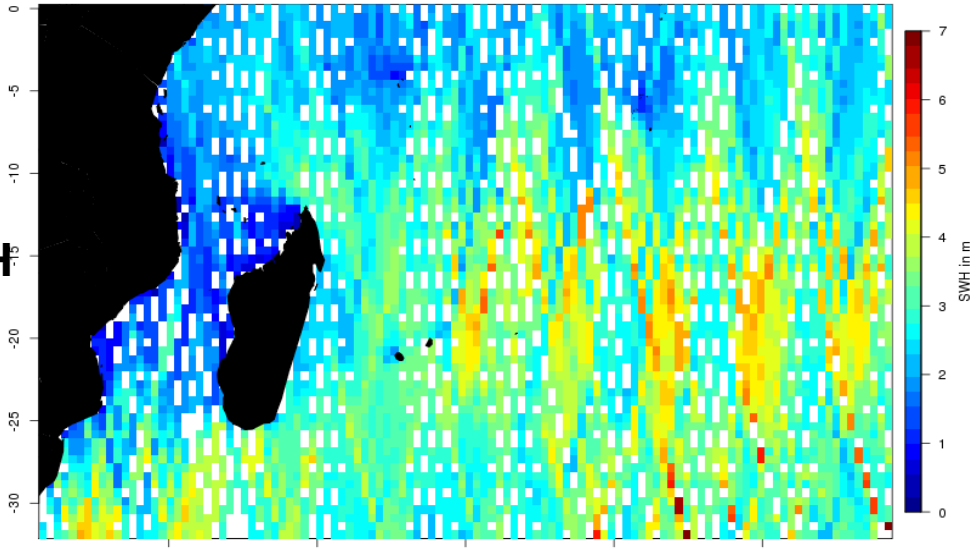
S-3A vs Regional MFWAM-REUN (10 km)
July 2016

Bias map in cm (range -40 to 40)





Mean of SWH on july 2016



Bias=-0,09
SI=8,8%
RMSE=27 cm
Slope=0.93
Intercept=0.27

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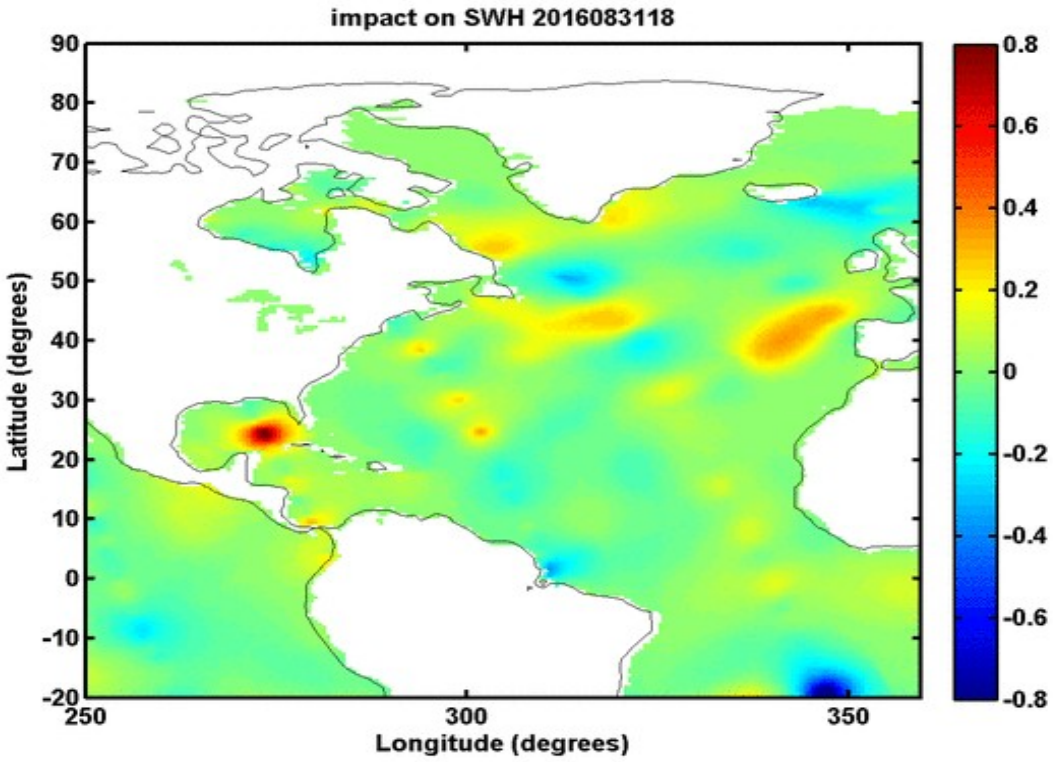
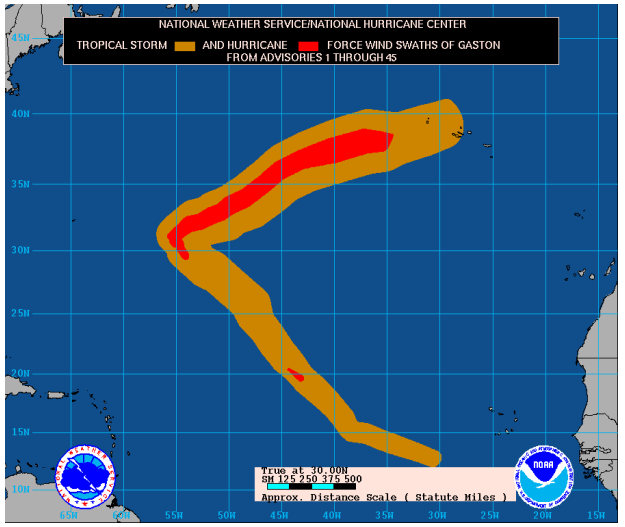
Impact of the assimilation of S-3A : Forecast period during GASTON

Sentinel-3A



Tropical storm GASTON (Atlantic)



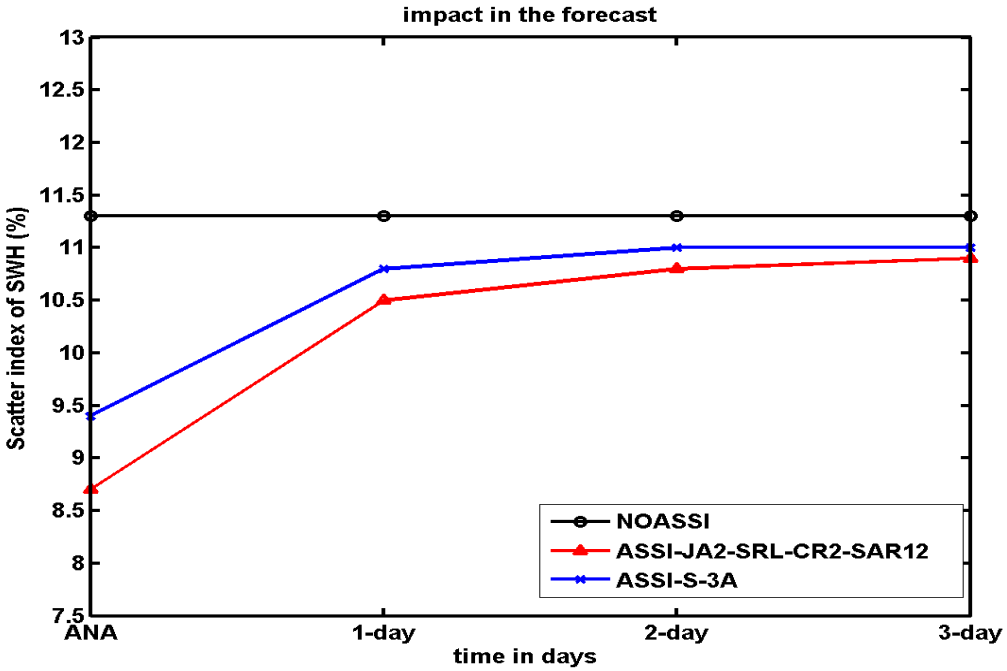
Difference between runs of MFWAM with and without assimilation

1-day forecast starting from 31 Aug. 2016 at 18:00, by step of 6 hours

Validation with Saral and Ja-2

Impact of the assimilation of S-3A : Forecast period

Performance of scatter index of SWH in the forecast :



Black : reference run

Red : assim of Ja2+SRL +CR2+SAR

Blue : assimilation of S-3A

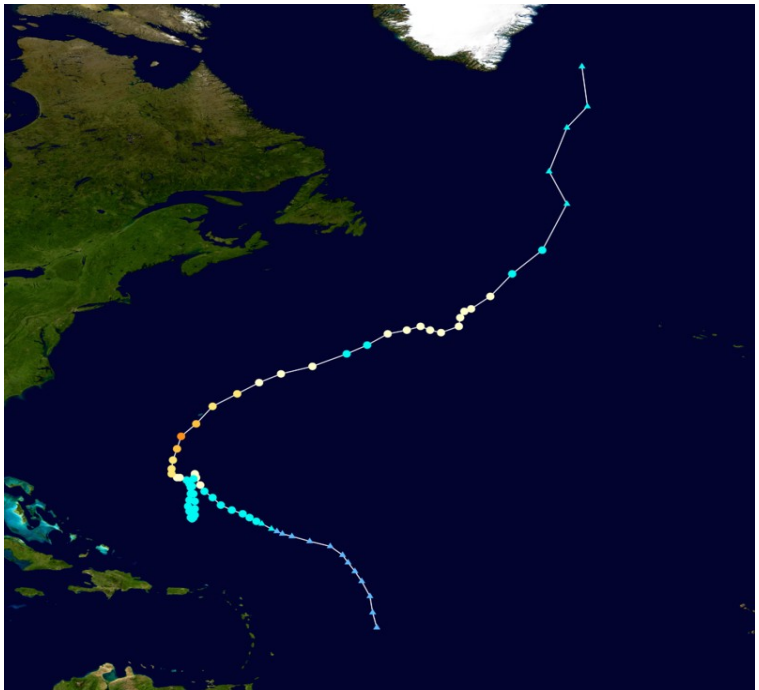
Conclusions and future works

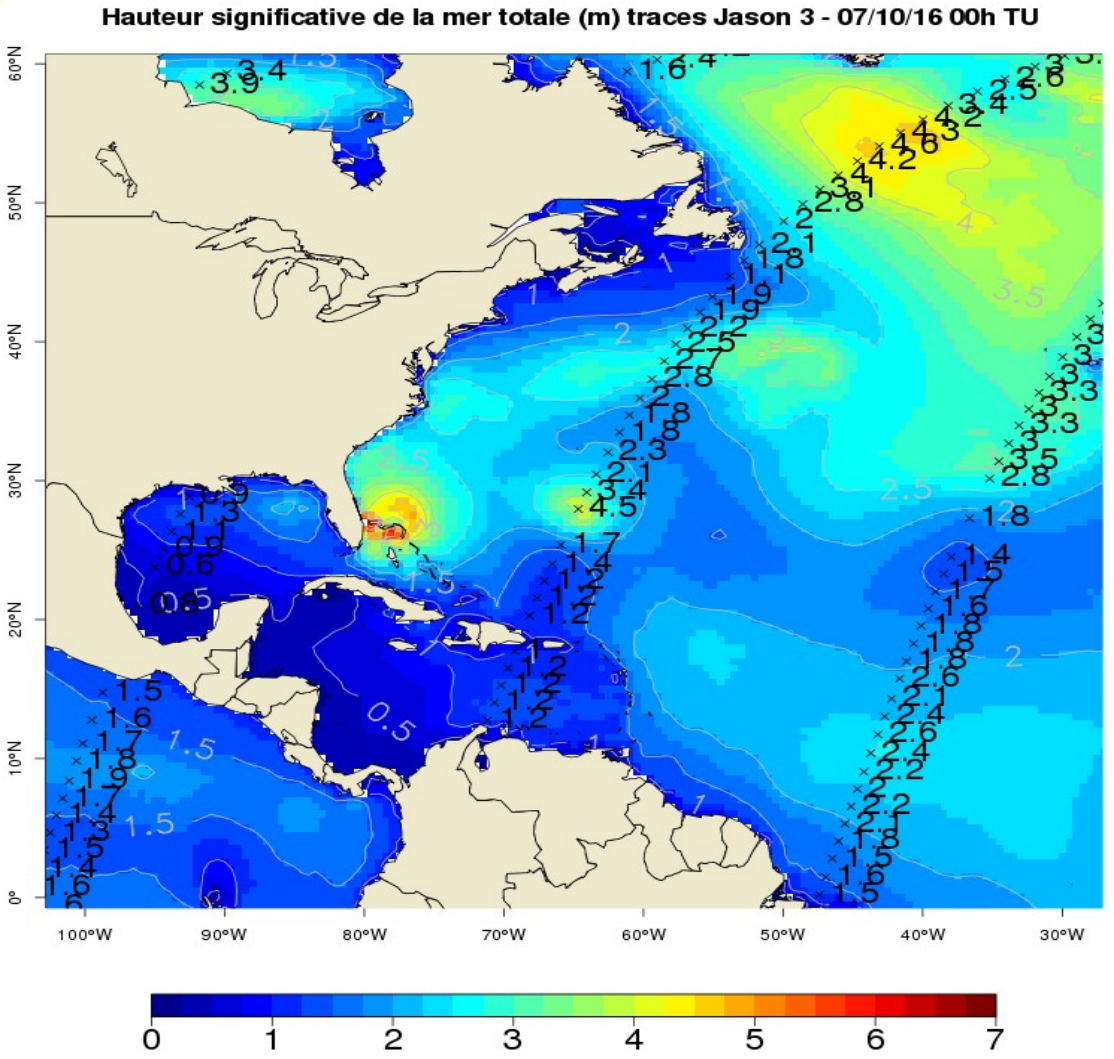
- **The assimilation of S-3A shows a positive impact in the analysis and forecast. However the impact in the tropics is small (<1 %) because of the strong bias of S3A wave height.**

- **Bias of S-3A significant wave height is well identified : comparison with both altimeters and buoys confirmed the trend. The southern winter induces a more pronounced bias (Pacific and indian oceans).**

- **The study shows that mostly swell wave regime is affected by the bias. The combined assimilation of S-3A and SAR spectra of S-1A shows slight improvement (needs more investigations when S-1A will be operational).**

- **Further tests will be performed on upgraded processing of S-3A wave data from ESA/EUMETSAT**





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