On the use of Saral/Altika wave data in the upgraded MFWAM : global and regional scales*

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SARAL/ALTIKA workshop, lac Constance 27 October 2014

* this work is dedicated to Jean-Michel Lefèvre

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OUTLINE

1- Motivation

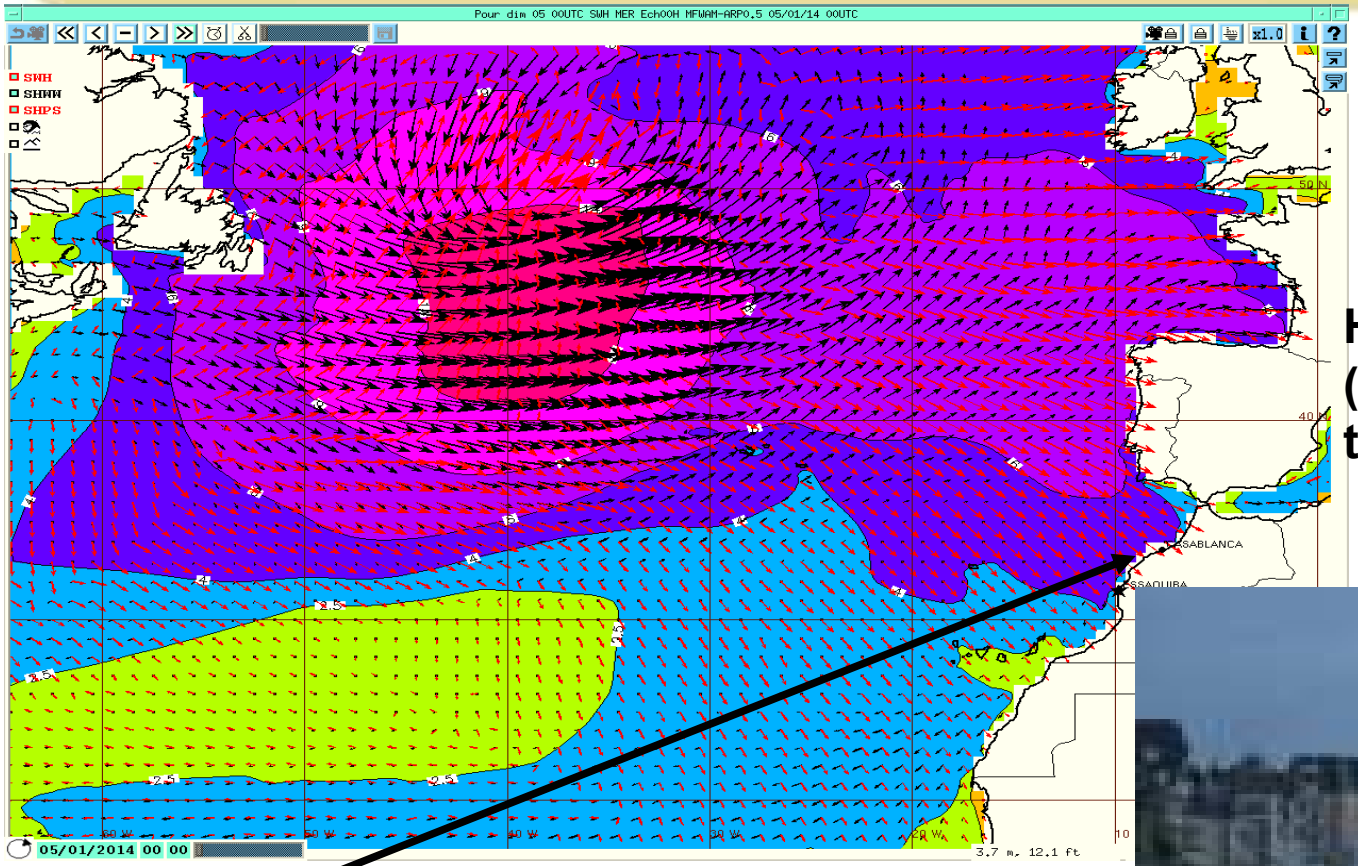
2- Saral/Altika in operations (winter storms)

3- Upgraded MFWAM (cyclone BEJISA)

4- Assimilation in regional model and results

5- Conclusions

Storm of begining of January 2014



6-hourly forecast from MFWAM starting on 5 January 0:00 (UTC) to 84h

High waves close to brittany (more than 10 m) and high tide coefficient

Waves flooding at St Malo bay

Long swell propagating to the Morrocan coast : SWH of 7 m and 18 sec of period (powerful swell)

MOTIVATION

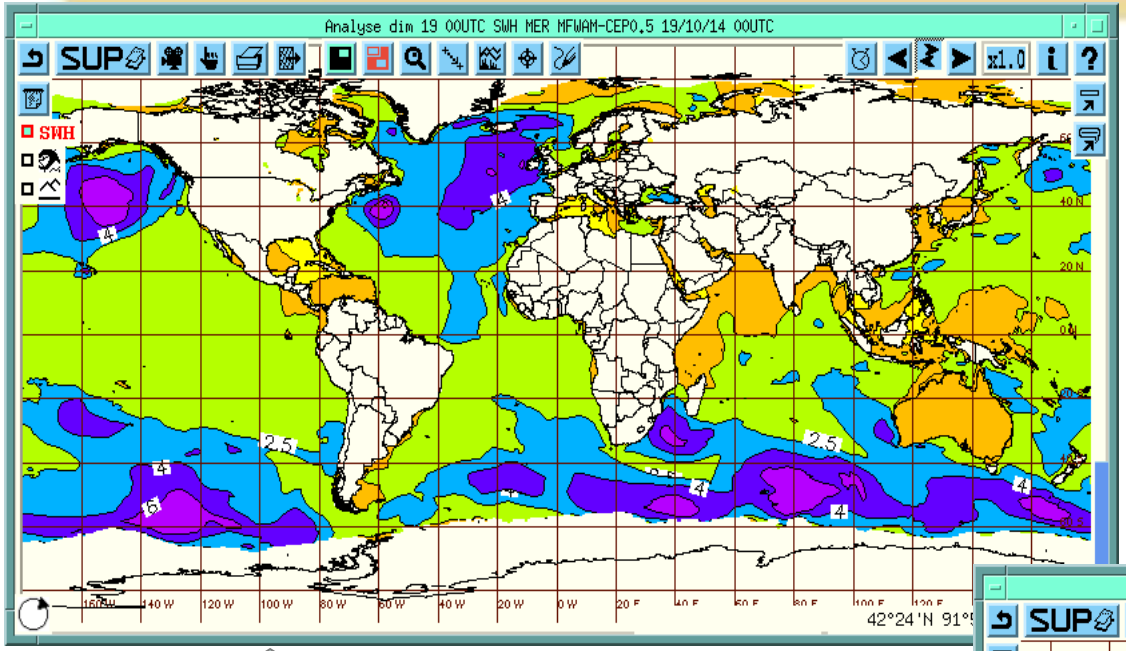
- **Ensure the most accurate sea state forecasting system :**

  ⇨ **safety of people and properties at coastal zone**
  ⇨ **safe navigation for ship routing**

- **update the assimilation system with the latest available satellite wave data**

- **Improve the wave model MFWAM : focus on ocean-atmosphere coupling consistency**

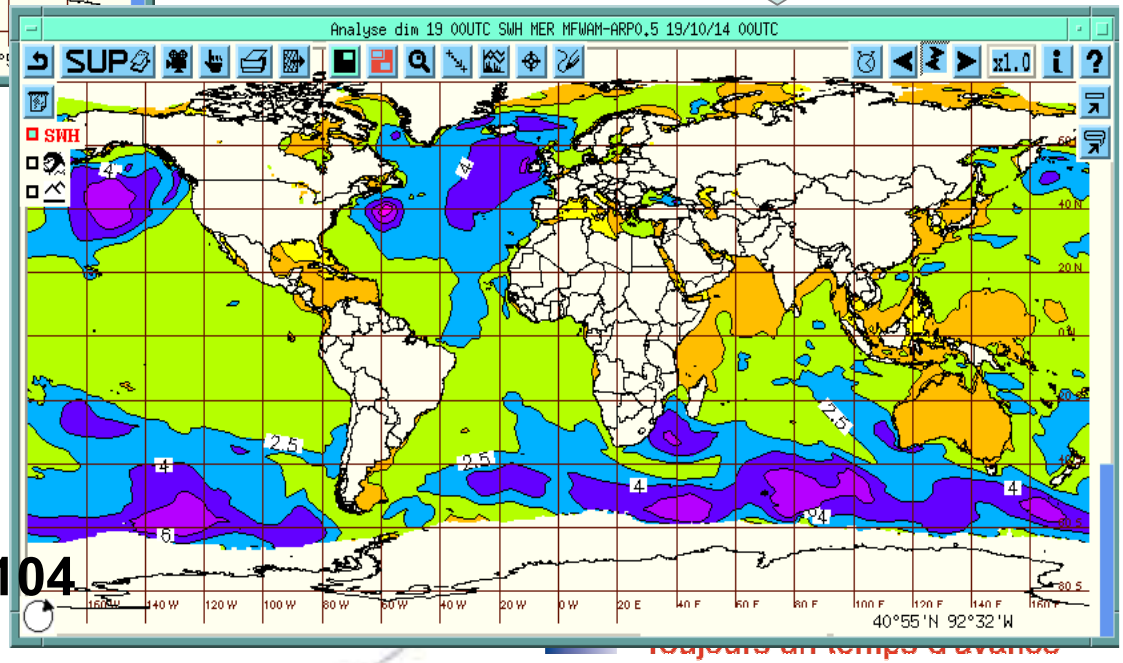
Operational global wave forecasting system at Météo-France



MFWAM-CEP

Two global wave models MFWAM (0.5°) forced by analyzed ARPEGE and ECMWF winds
Three altimeters (Jason-2, Saral and Cryosat-2) are assimilated every 6 hours since 23 April 2014

MFWAM-ARPEGE



In operations :
SARAL since 10 December 2013
Cryosat-2 since 23 April 20141

Snapshots of SWH on 19 october 2104
At 0:00 (UTC)

MFWAM versus ECWAM

Météo-France operational

Computing code IFS-36R4
Global with resolution 0.5°

Dissipation source term from new physics (Ardhuin et al. 2010)

Air-friction swell damping term (Ardhuin et al. 2010)

With assimilation from altimeters (Jason-2, Saral, CR2)

Winds from ECMWF-IFS

ECMWF operational

Computing code IFS-40R1
Global with resolution 0.12°

Dissipation source term from Janssen and Bidlot (2005)

swell damping term (Janssen)

With assimilation from altimeters (Jason-2)

Winds from ECMWF-IFS

Selected comparison period
january to April 2014

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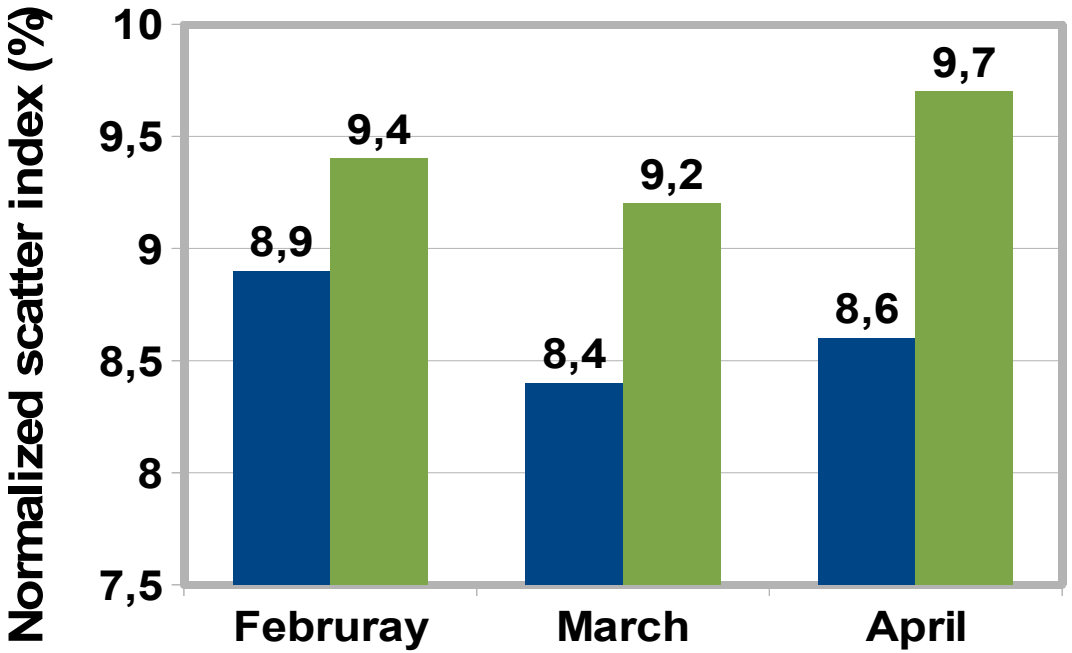
Impact of using SARAL/Altika wave in operational MFWAM vs ECWAM



MFWAM is the operational wave model of Météo France assimilating Jason-2 and Saral
ECWAM is the operational wave model of ECMWF Assimilating Jason-2 only

Both wave models are using the same wind forcing from ECMWF atmospheric model

Comparison with Cryosat-2 from February to April (until 23) 2014

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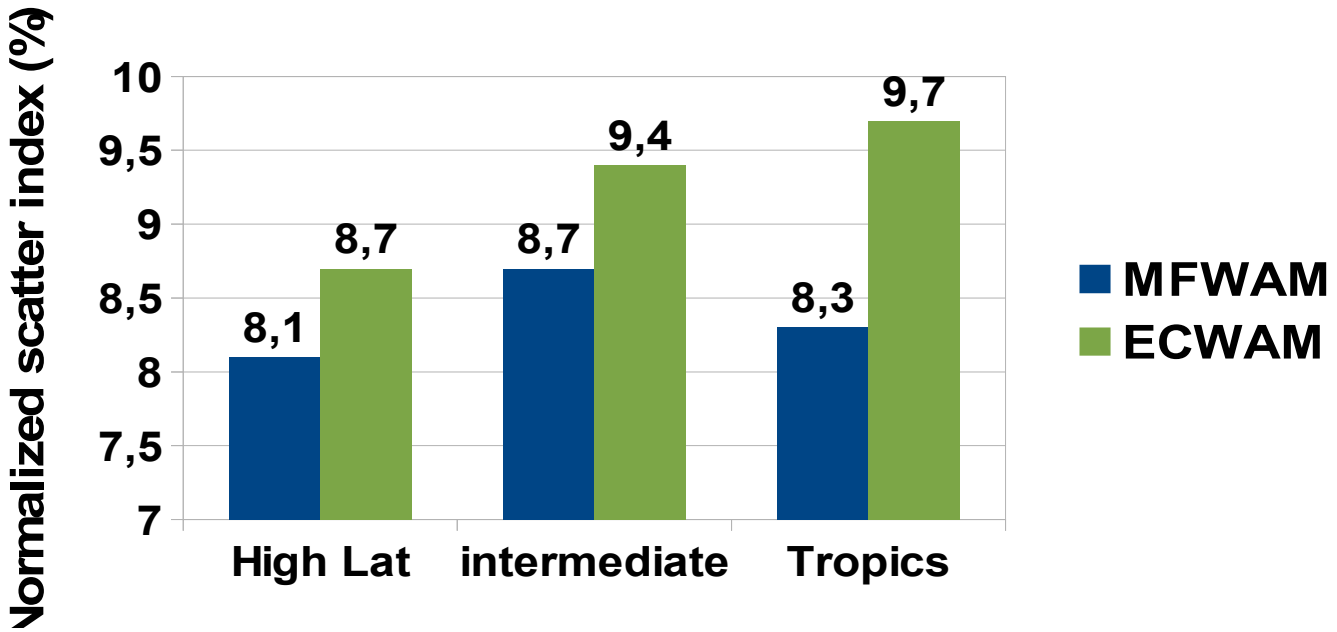
Impact of using SARAL/Altika wave for different ocean basins : MFWAM vs ECWAM



Collected data : 43688 86790 56068

High Lat $|\Phi|> 50°$
Intermediate lat $20°<|\Phi|<50°$
Tropics $|\Phi|<20°$

Comparison with Cryosat-2 for February to April (until 23) 2014

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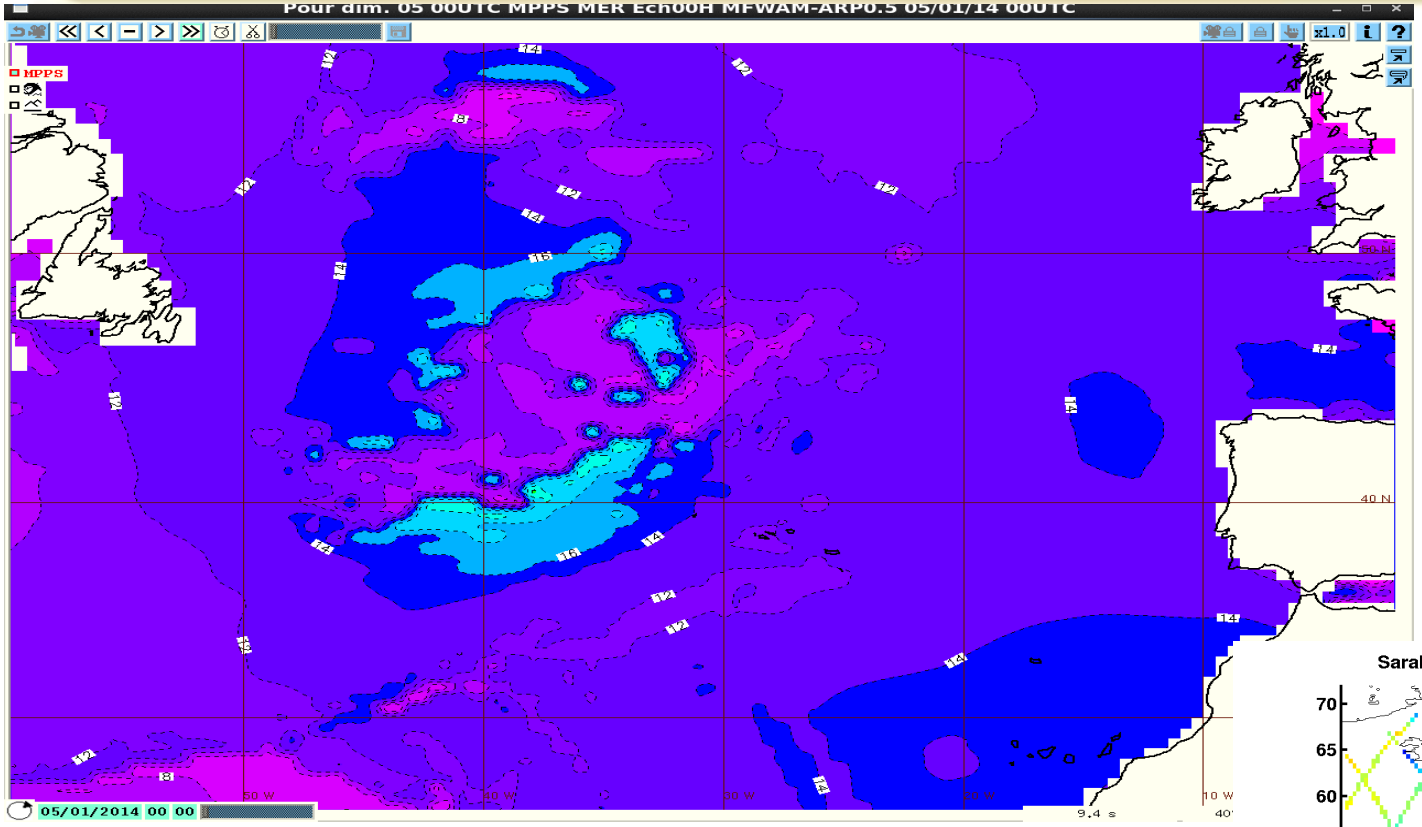
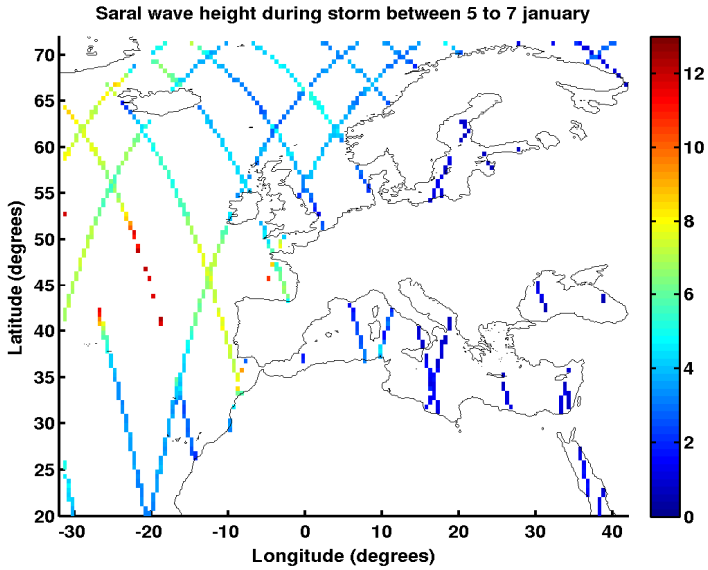
January storm in north atlantic and western european coasts



Swell wave period from
5 January 0:00 (UTC) to 84H

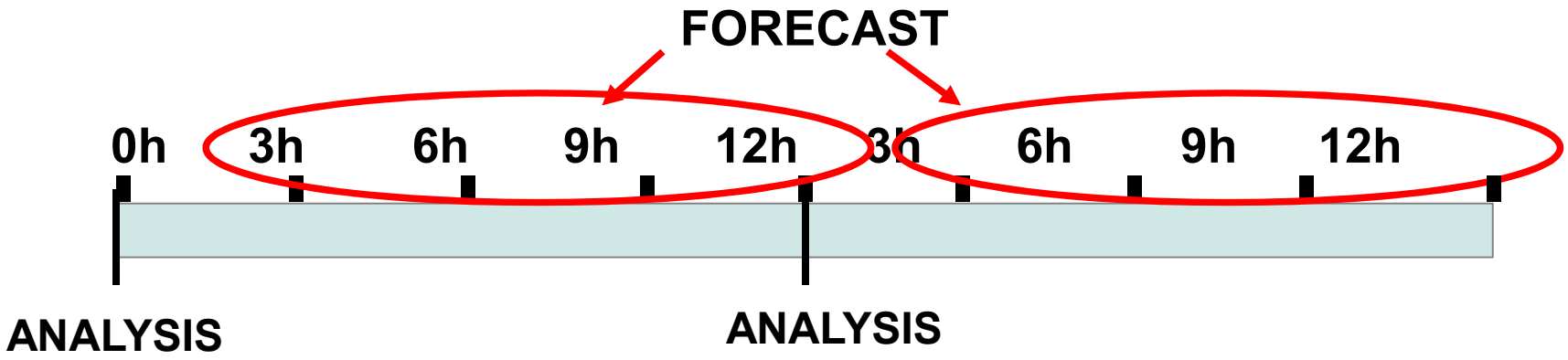
Long swell propagating to the Morrocan coast : SWH of 7 m and 18 sec of period

SWH captured by SARAL



Control of the forecast in january 2014

Impact of Saral on the forecast



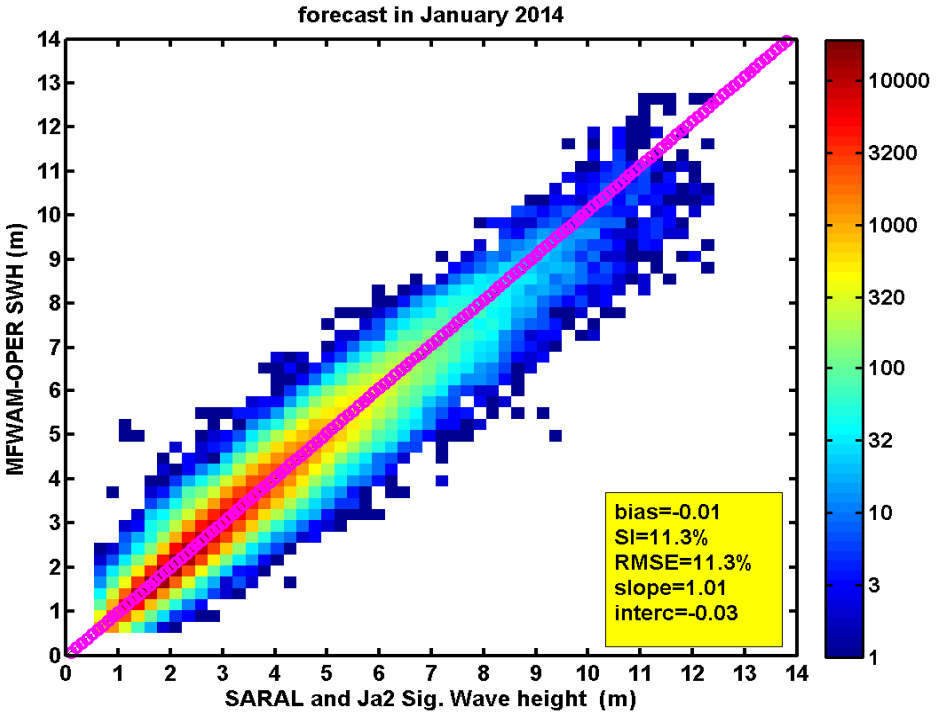
ANALYSIS : assimilation of altimeters and use of analyzed winds (reference time 0:00 and 12:00)

FORECAST : the assimilation is switched off and use of forecasted winds

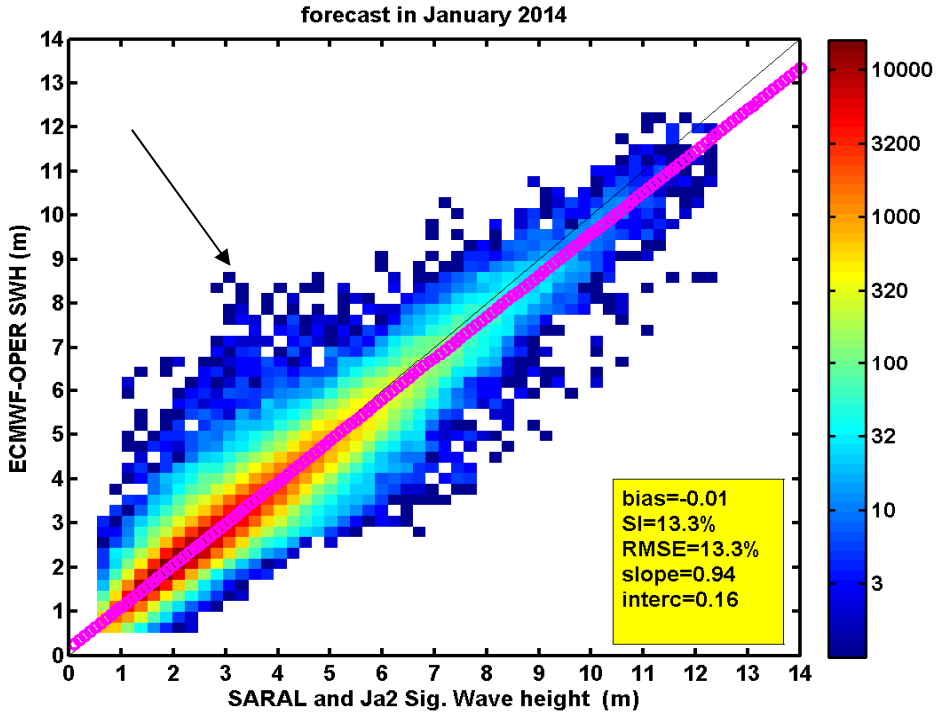
⇨ **Example of validation in the forecast period :**
only forecasted SWH are considered after the analysis

Impact of Saral/Altika in the period of forecast
MFWAM vs ECWAM

MFWAM-OPER



ECMWF-OPER



Better of ~15 %

Bias = 0.01
SI = 11.3%
RMSE = 11.3%
Slope = 1 .01
Intercept = -0.03

Data collected : 357349

January 2014
comparison with SARAL and JA2

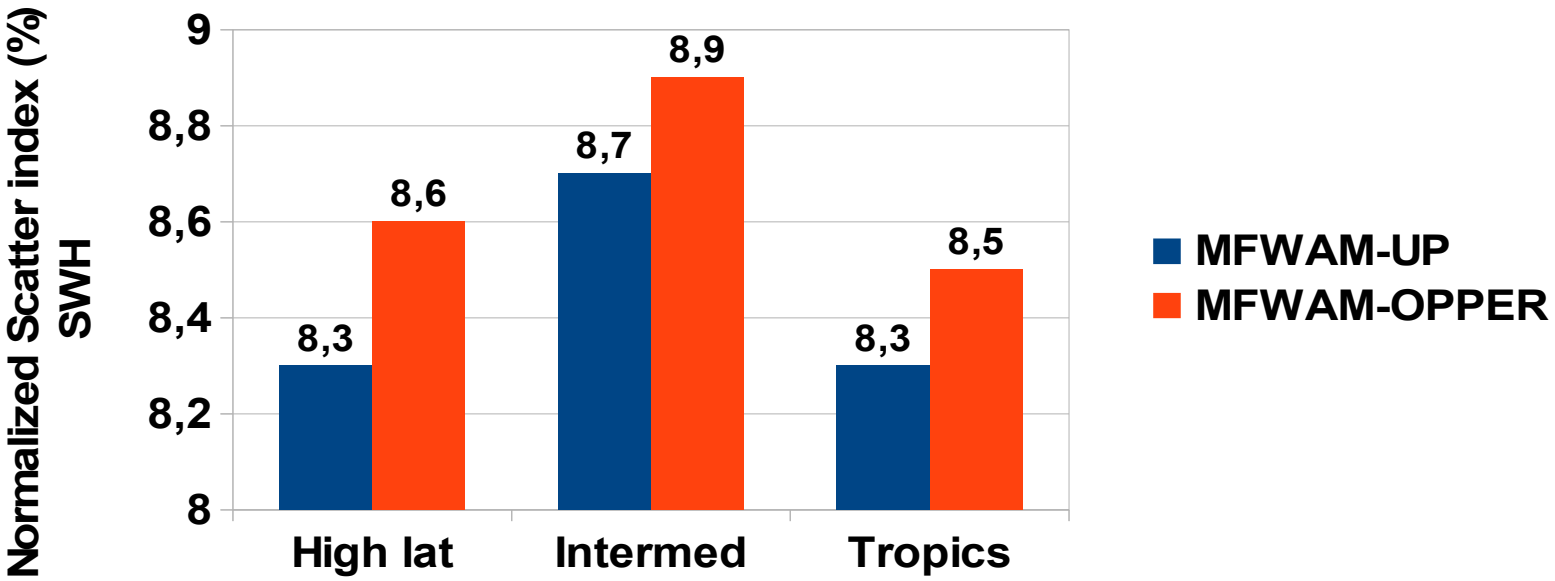
Bias=0.01
SI=13.3%
RMSE=13.3%
Slope=0.94
Intercept=0.16

ANCE d'avance

Toward an upgraded MFWAM (issued from MYWAVE project)

- Update of the code (IFS-38R2) : improved propagation scheme
- Improved bathymetry (better subrid for islands)
- Smoothing function Rayleigh type for the source term of swell
- damping induced by air friction at the sea surface
- Adjustement of whithcapping dissipation term :
  better variation of the drag coefficient with the sea state
  (future coupling between wave model MFWAM and AROME)
- Adjustement of the coefficients in the non-linear interaction source term

The assimilation of SARAL and Jason-2 in the MFWAM-UPGRADE



High Lat $|\Phi|> 50°$
Intermediate lat $20°<|\Phi|<50°$
Tropics $|\Phi|<20°$

Slightly improvement (~4%) with the upgraded MFWAM

3-month (February, March and April) validation with Cryosat-2 wave heights

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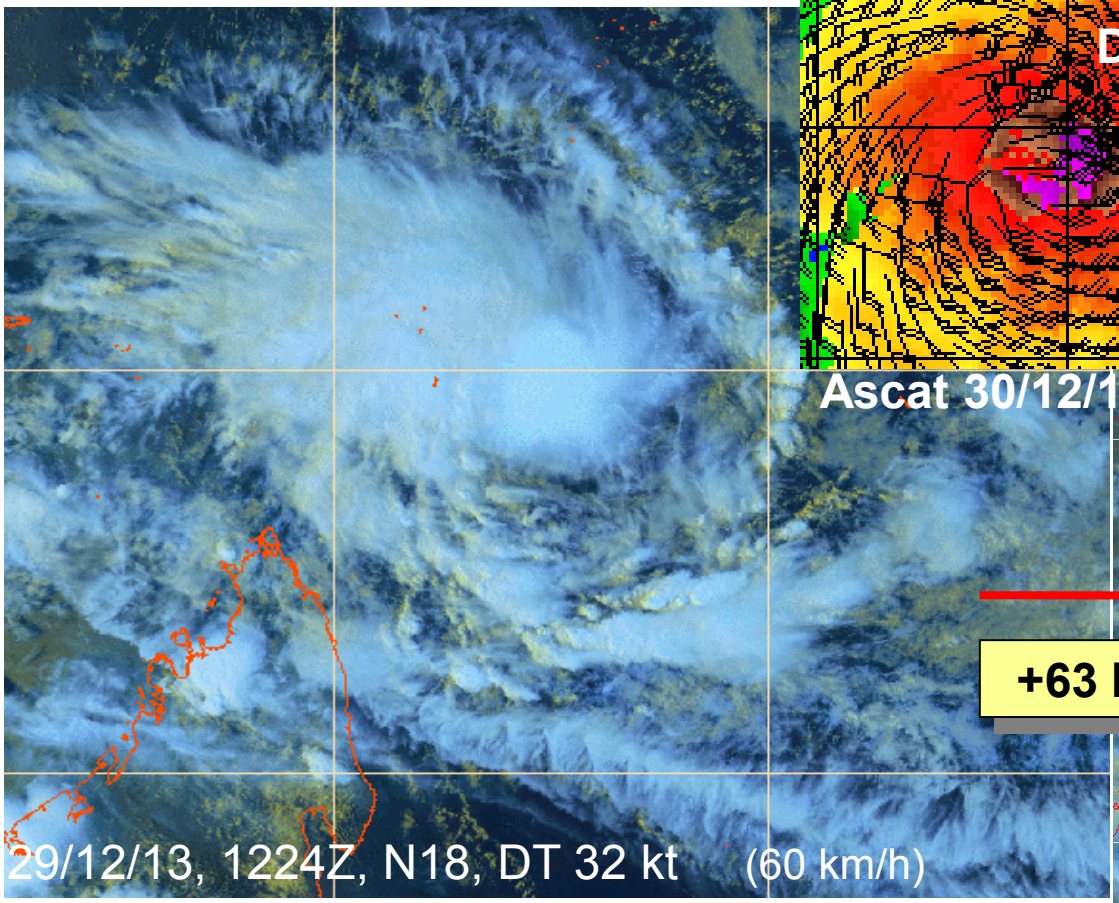
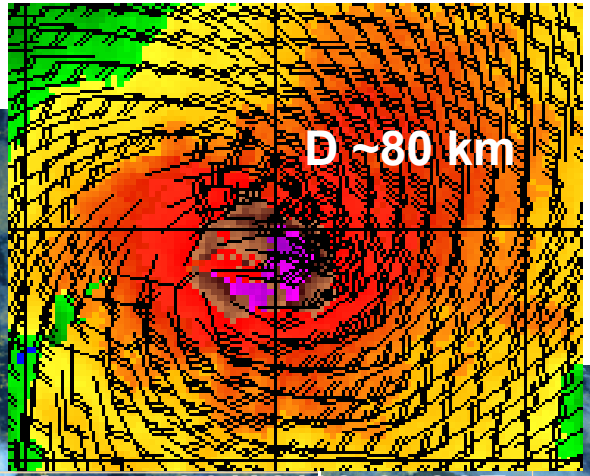
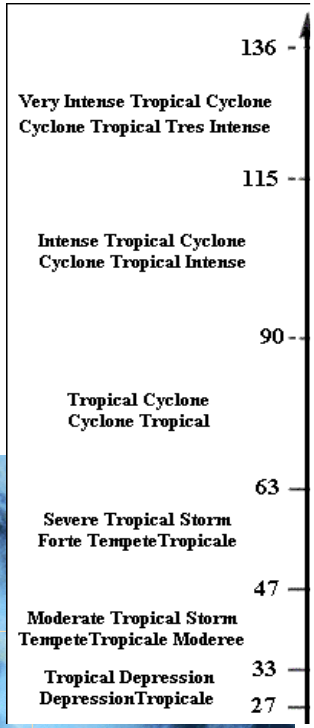
BEJISA : Second system of cyclonic season 2013-2014
Fast and explosive intensification (>+30 kt in 24hours)

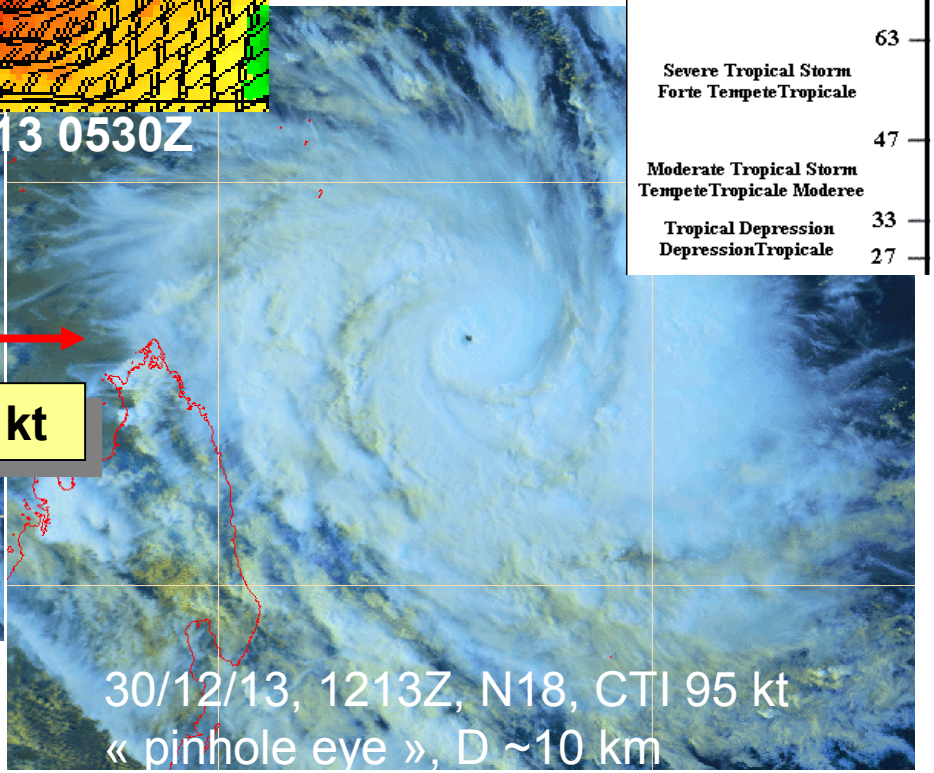
Courtesy of Sébastien Langlade







+63 kt

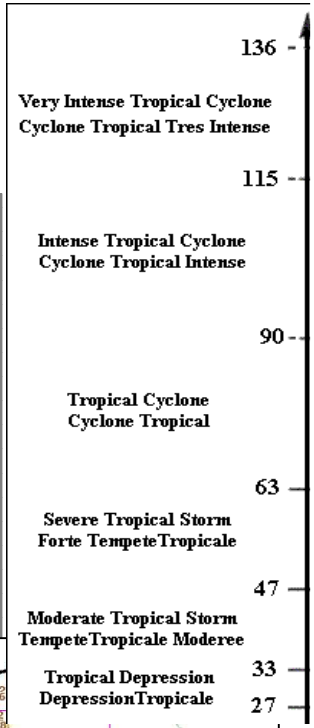


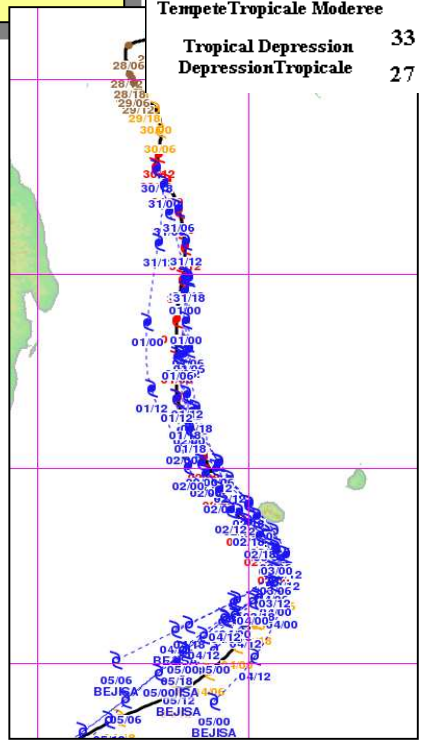
BEJISA

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

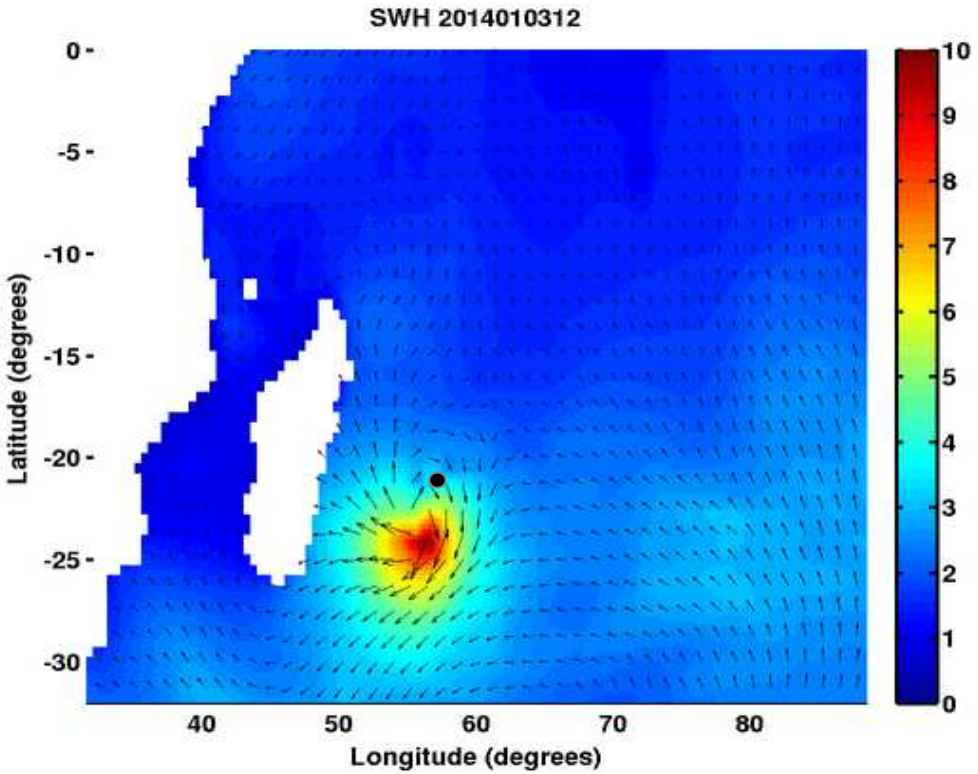
Courtesy of Sébastien Langlade (DIRRE)

- 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)

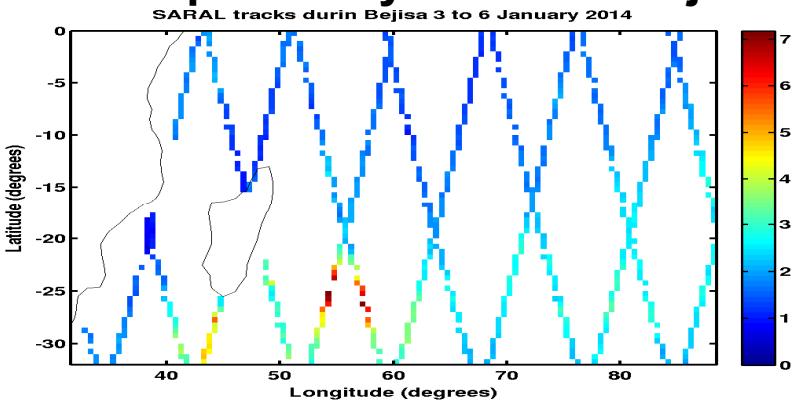


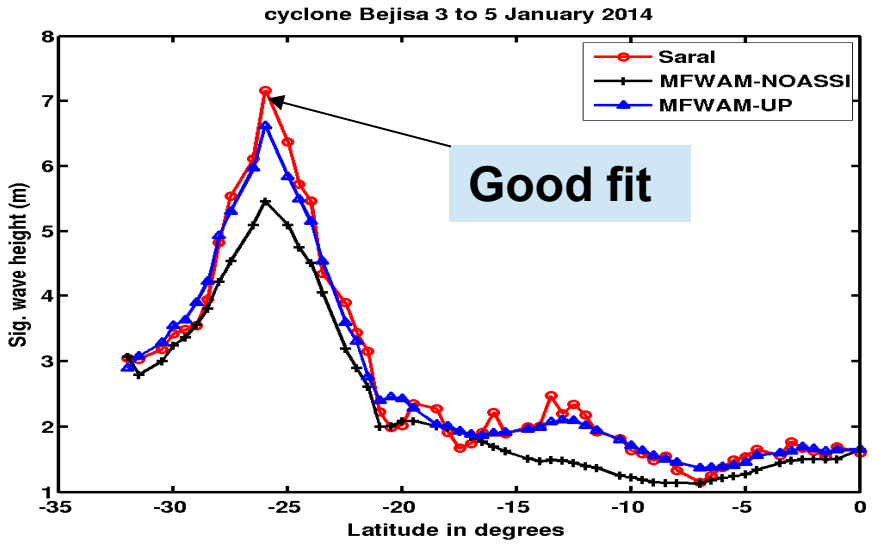


Impact on Cyclonic season at indian ocean « La Réunion »



SWH captured by Saral 3 to 5 january





6-hourly Sig. Wave heights from MFWAM-OPER from 3 (6:00 UTC) to 5 (0:00 UTC) January 2014

Cyclone BEJISA during 3 January 2014

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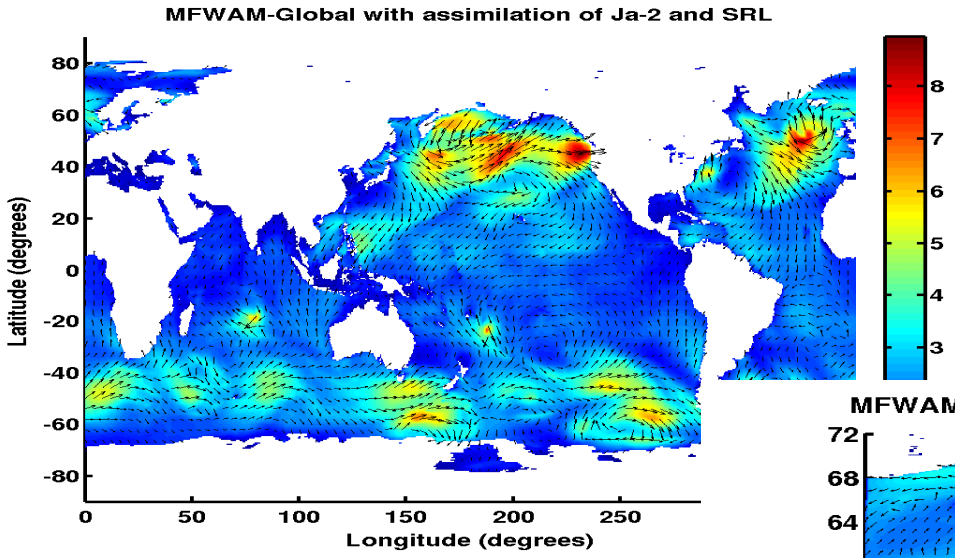
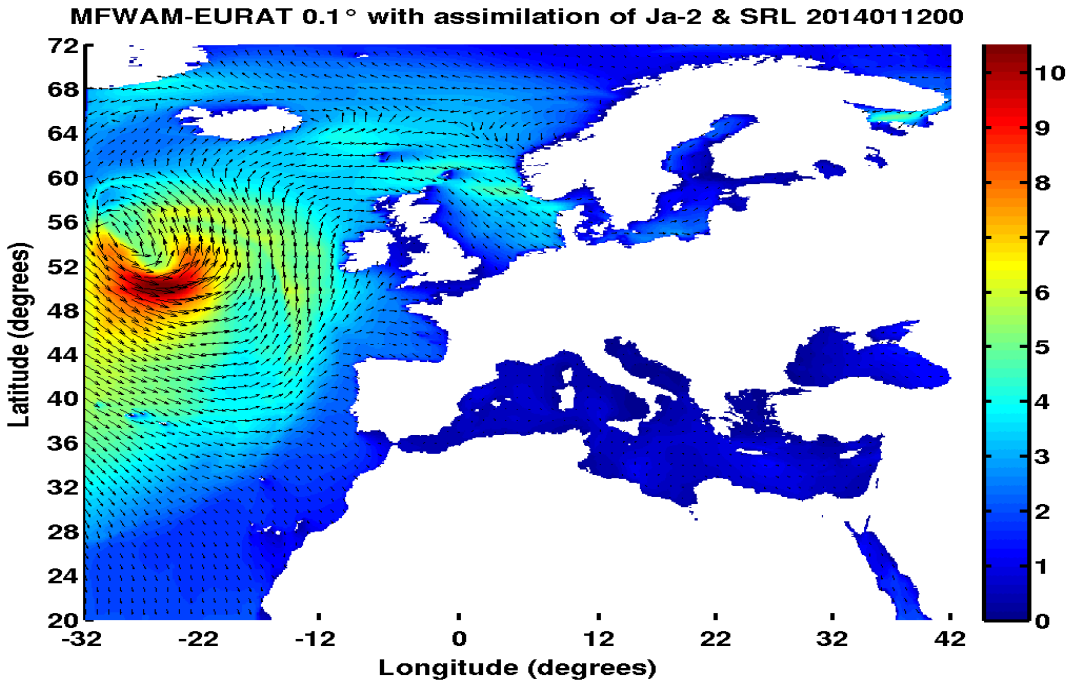
The assimilation in high resolution regional model MFWAM-EURAT



Global MFWAM with Assimilation of Jason-2 and Saral

Boundary conditions to regional MFWAM Europe-Atlantic 0.1° forced by ARPEGE winds



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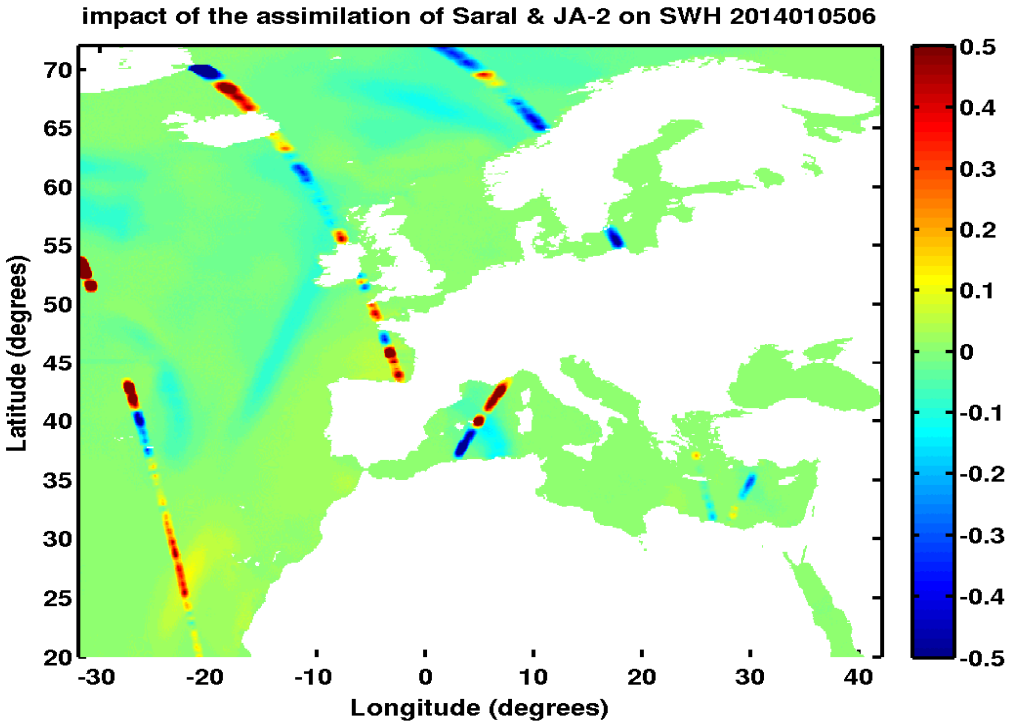
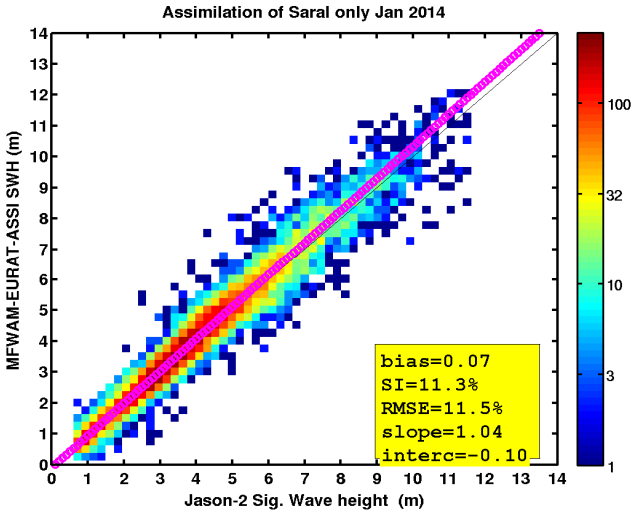
Impact of the assimilation of Saral and Jason-2

Difference from SWH with and without assimilation



5 January 2014 at 06:00 UTC

The impact of SARAL only



Improvement of the scatter Index of SWH by ~6 %

1-month test on January 2014

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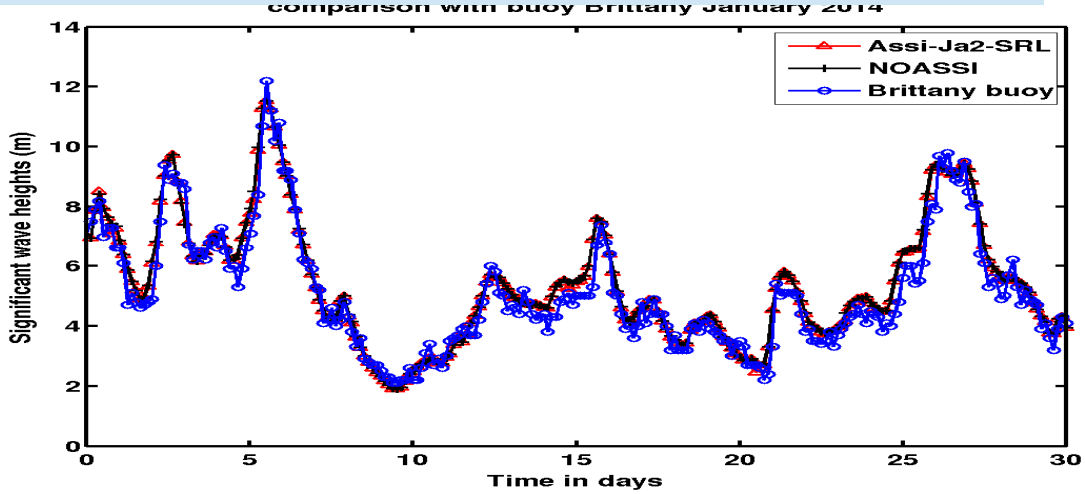
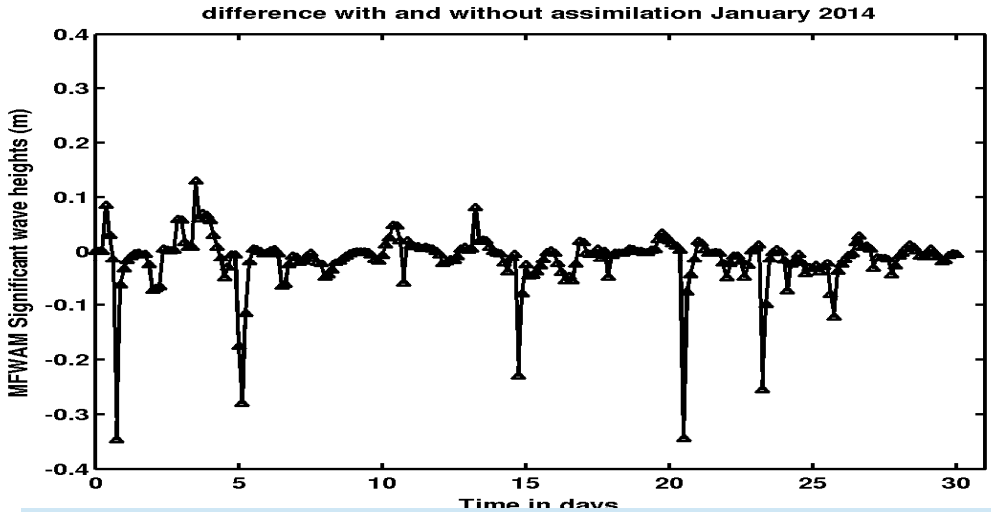
Validation with buoy Brittany
January 2014

Time series of SWH from model and buoy



Location of buoy Brittany



Improvement of the Root mean square errors (NRMSE) from 10.3 % (Noassi) to 9.9 % (Assi-Ja2 -SRL)

Difference of SWH from MFWAM with and without assimilation

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Conclusions

- Last winter storms were well forecasted by the MFWAM system : thanks to altimeters data (just in time SARAL ☺)

- The upgraded MFWAM is underway to operational use (probably in mid November)

- The assimilation of altimeters in regional MFWAM-EURAT (10 km) has showed a positive impact (roughly 6 % improvement when using Saral only).

- The assimilation of altimeters in the regional MFWAM for the indian ocean (La Réunion) is highly recommended as shown in case of cyclone Bejisa