Assimilation of altimeters and ASAR wave data in the wave model MFWAM : A preparation study to the CFOSAT mission

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Outline

1- Motivation

2- Brief description of the new operational forecasting system

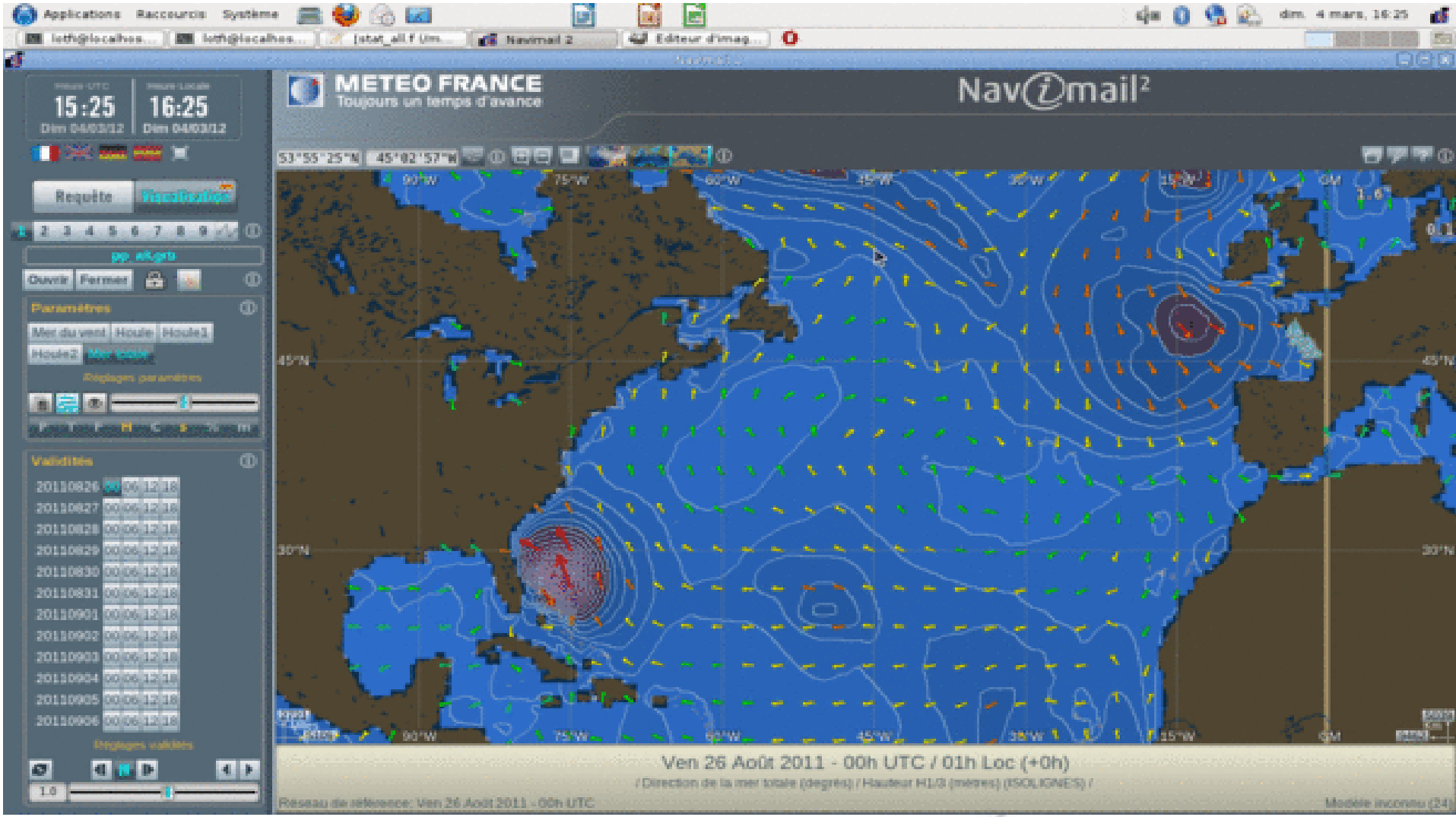
3- Main results on 1-year use of the assimilation system

4- Optimization of the assimilation scheme

5- Assimilation runs with synthetic SWIM wave spectra (CFOSAT mission)

6- Conclusions and future works

Relevance of using good swell conditions in the generation zone (Hurricane KATIA 2011)



Motivation

→ Assessment of the assimilation system in the new wave model MFWAM (improving the wave forecast)

→Evaluate the contribution of each instrument of satellite wave observations (SAR, altimeters,)

→perform OSSE's (synthetic data from SWIM instrument : in preparation to the CFOSAT mission. As wavelength cut-off is better than the ASAR one, it is needed to evaluate the impact on sea state forecast.

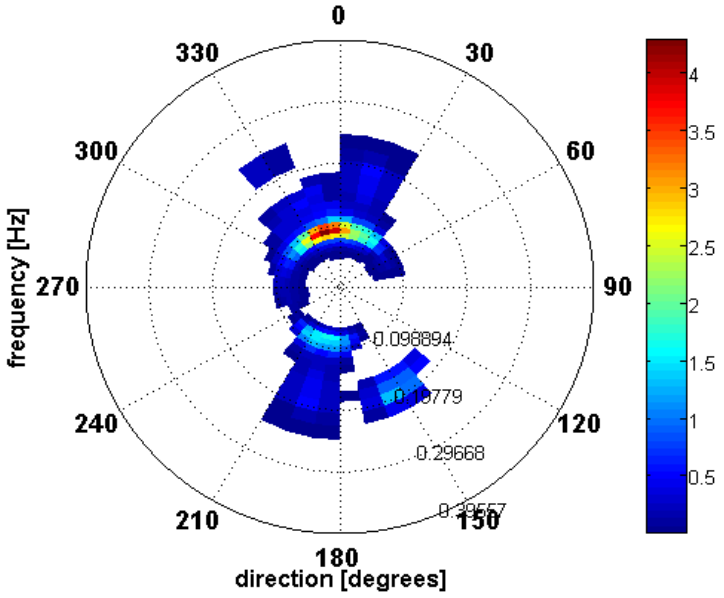
The assimilation of ASAR L2 wave spectra

- Available on the GTS of meteorological services since August 2010
- Robust Quality control procedure for ASAR wave spectra (Aouf et al. 2008)

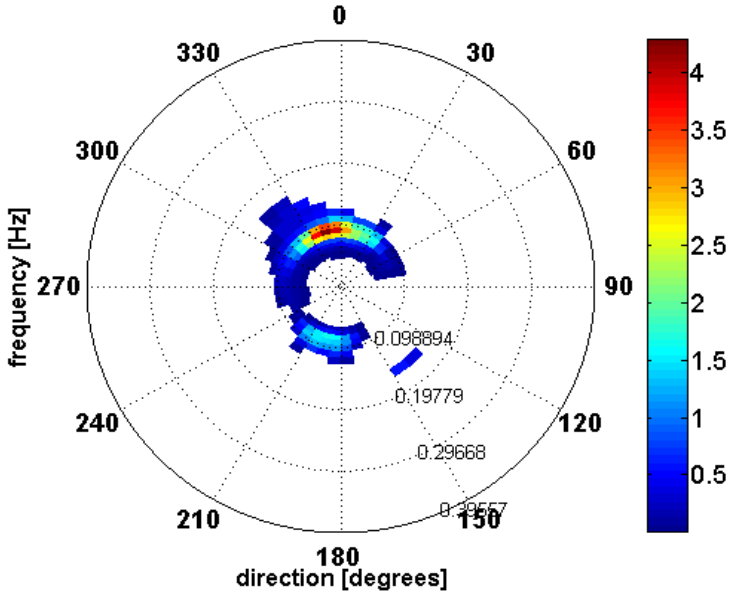
Threshold intervals for signal parameters (3<snr <30, NVI ASAR imagettes 1-1.6 and wind speed)

- Use of a variable cut-off for SAR wave spectra depending on the azimuthal cut-off, the orbit track angle and the wave direction from the model

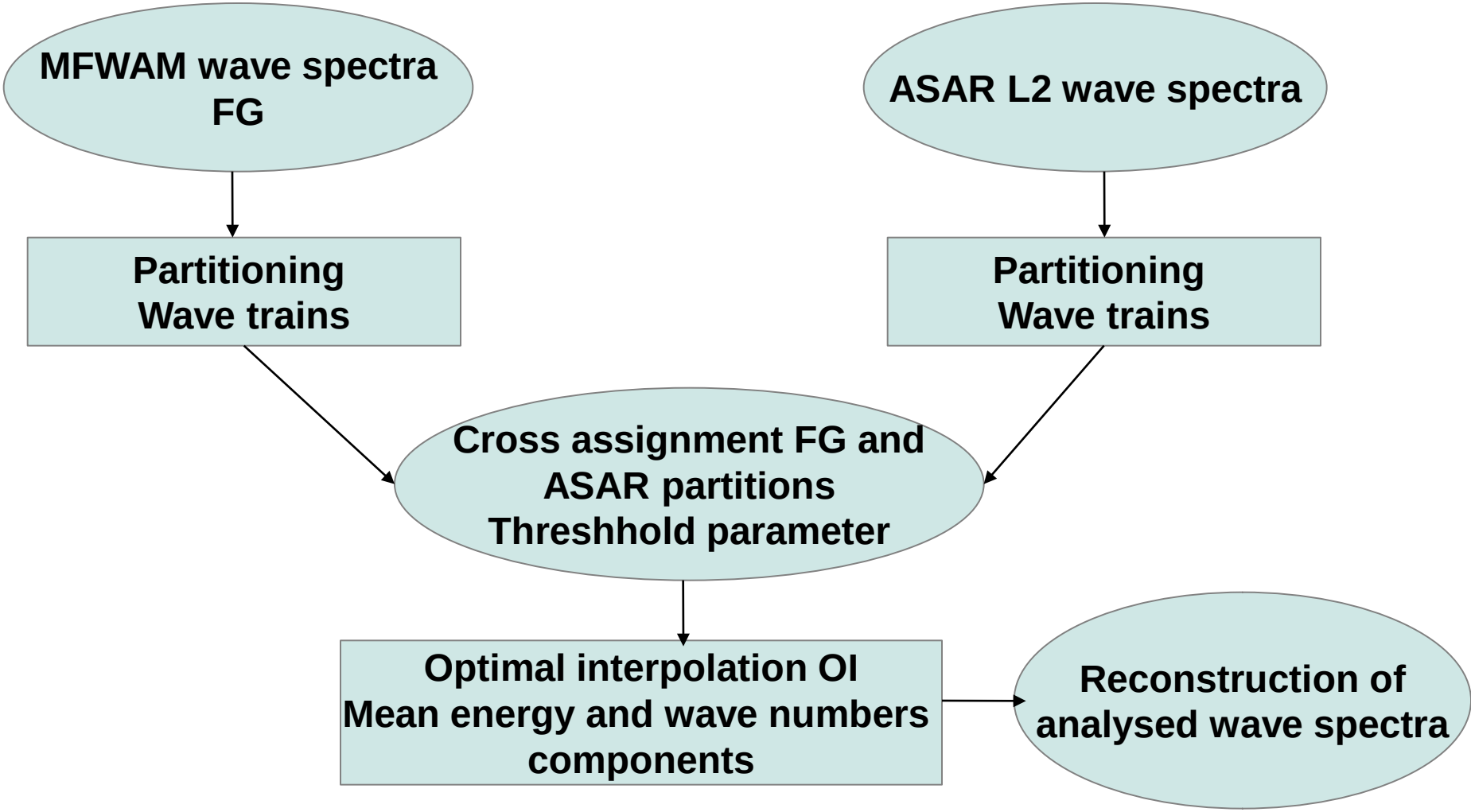
ASAR wave spectrum (before cut-off)



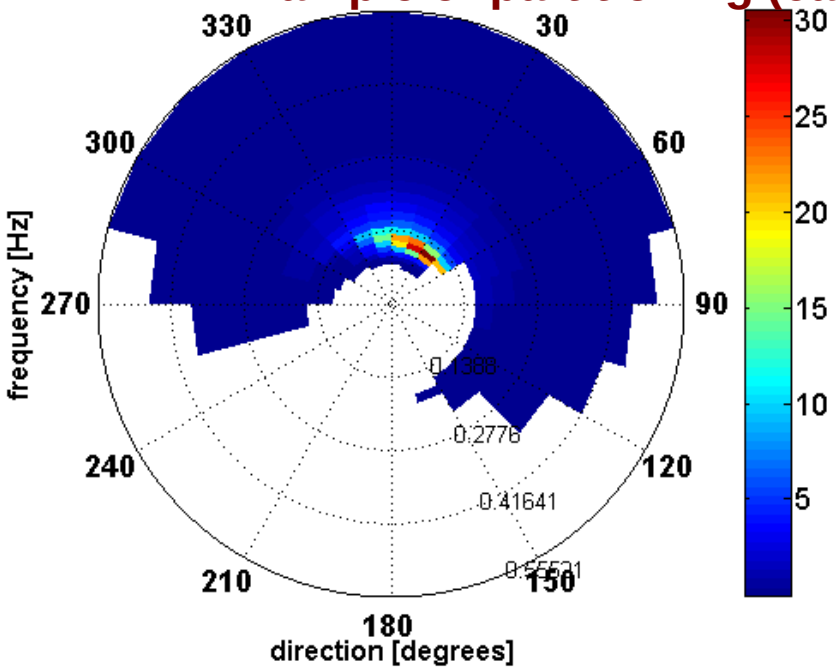
After using variable cut-off

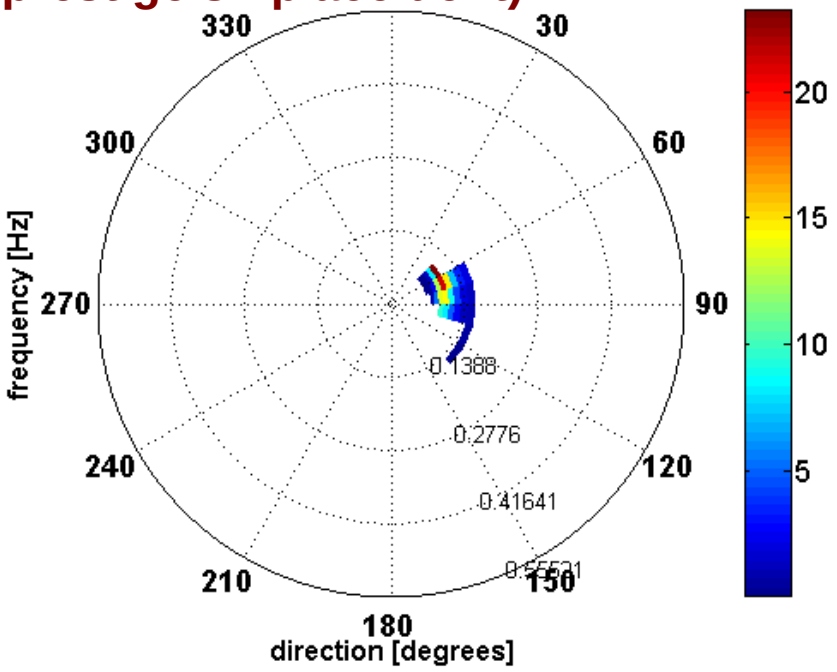


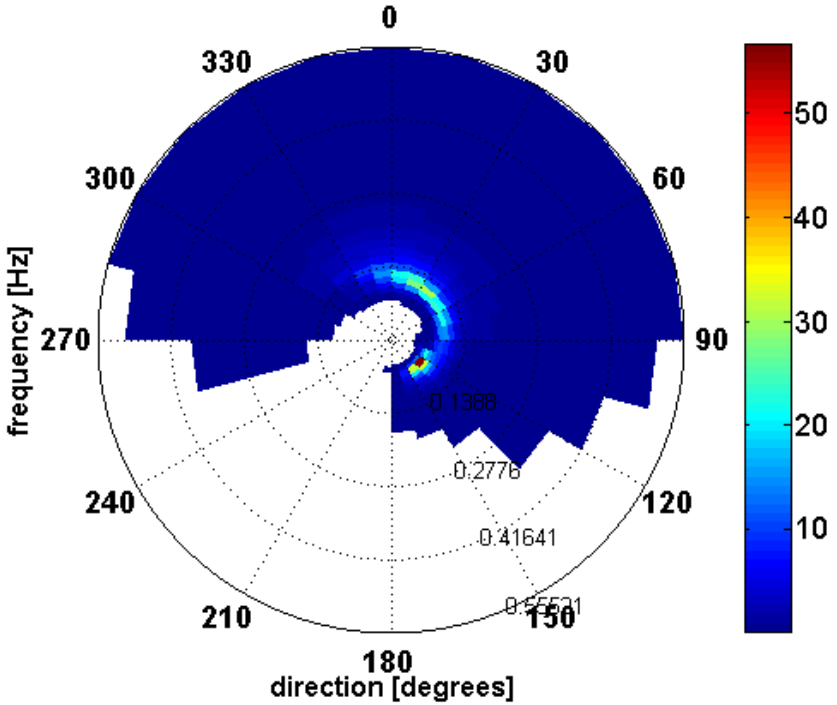
Description of the assimilation of ASAR L2 wave spectra

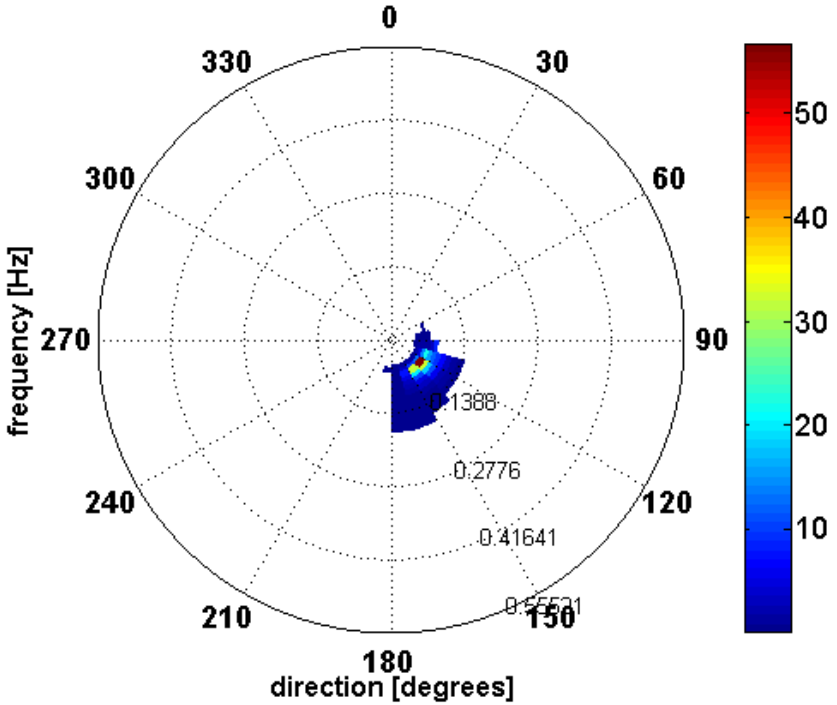


Example of partitioning (case of prestige ship accident)





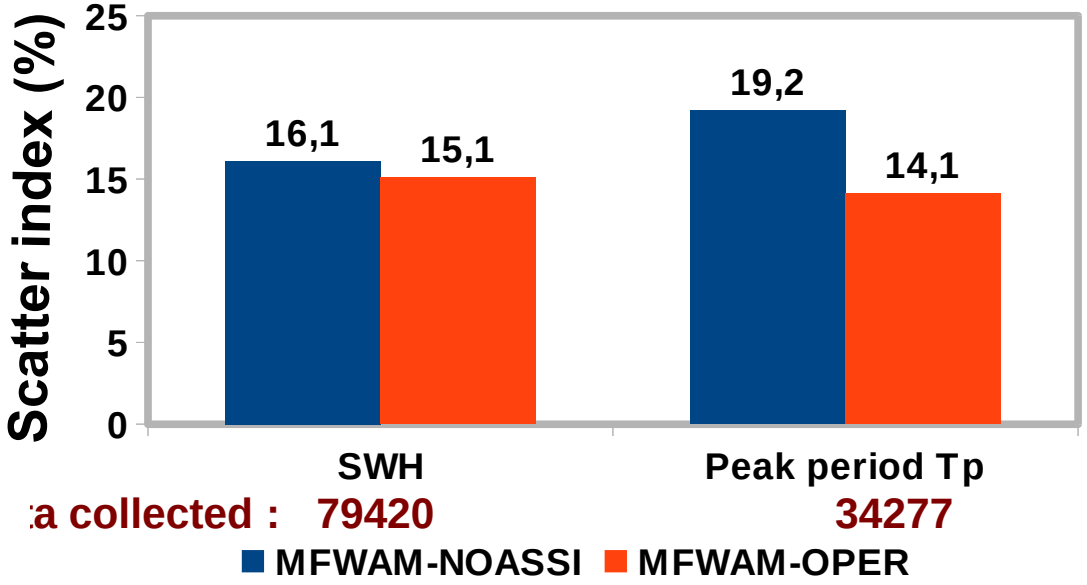


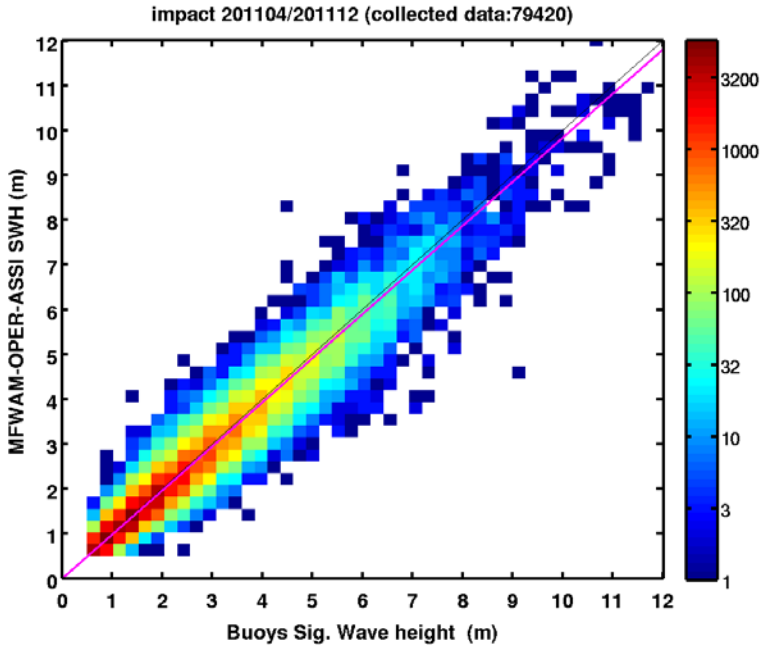


New wave forecasting system of Meteo-France:

- Global version of the model MFWAM is running at 55 km resolution driven by wind forcing from IFS/ECMWF and ARPEGE, the grid is irregular in longitude
- The wave spectrum resolution is 24 directions and 30 frequencies
- The assimilation uses altimeters (Jason-2 and Ra-2) and ASAR L2 wave spectra since 17 March 2011. the time step is 6 hours and the analyses are produced 2 times a day (R0 and R12)
- The output of 32 mean wave parameters is produced every 3 hours and archived in the MF data base (BDAP)
- Boundary conditions are produced for regional models

Comparison MFWAM operational with Sig. Wave Height and Tp from buoys





Operational with assimilation of SAR Jason-2 and Envisat Ra2

April to December 2011

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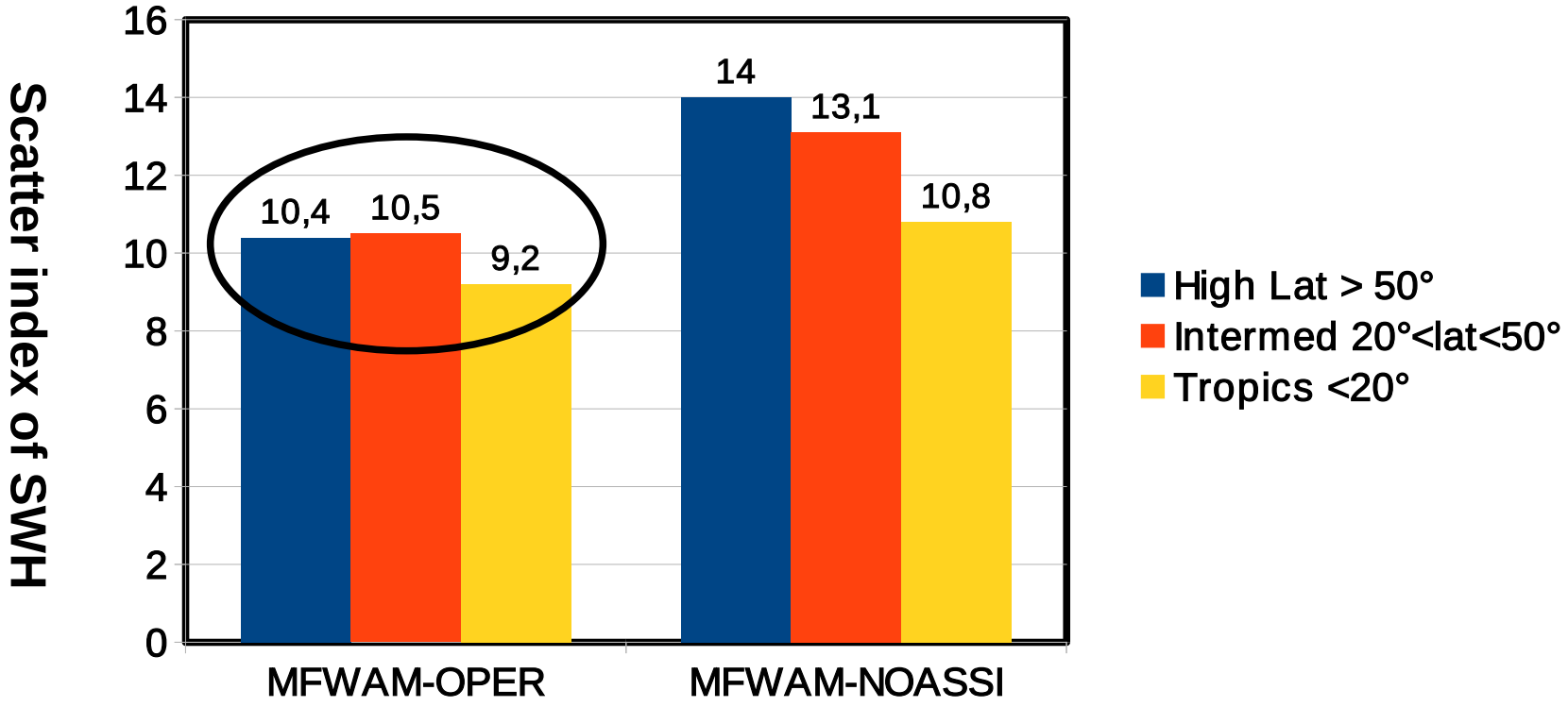
Output from MFWAM operational forecasting system
Validation of with Jason-1 Sig. Wave height (off assimilation)

Since starting the assimilation of ASAR directional wave spectra and both Jason-2 and Ra2 atlimeters wave heights

Statistics for different ocean basins



Collected Jason-1 data: 1701942

April to December 2011

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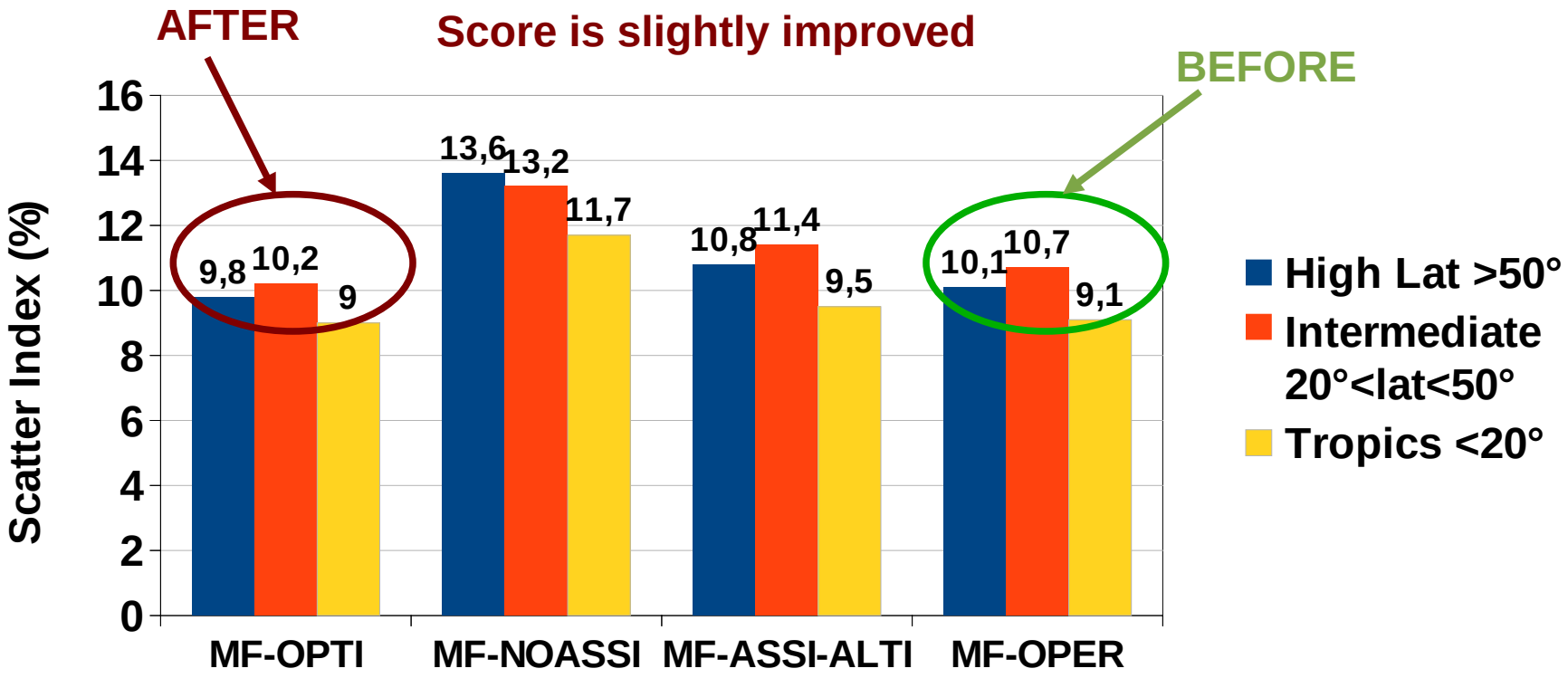
Optimization of the assimilation scheme

- Adjustment of the correlation legnth and the distance of influence of the ASAR wave spectra
- Adjustment of threshhold level for combining two peaks of partitions when they are close to each other
- Smoothing of the filling gaps between the analysed partitions in order to reconstruct the analysed wave spectrum
- Reject the partition when the wave height of the partition is less 30 cm in order to avoid noisy spectrum
- Run test of 3 months (April to June 2011)

Optimization of the assimilation scheme
Validation with Jason-1 Sig. Wave height (off assimilation)



MF-OPTI : MFWAM with the optimized assimilation scheme
MF-NOASSI : MFWAM without assimilation
MF-ASSI-ALTI : MFWAM with assimilation of altimeters only
MF-OPER : MFWAM operational (with assimilation of SAR and Ja2 and Envisat)

3 month test : April to June 2011

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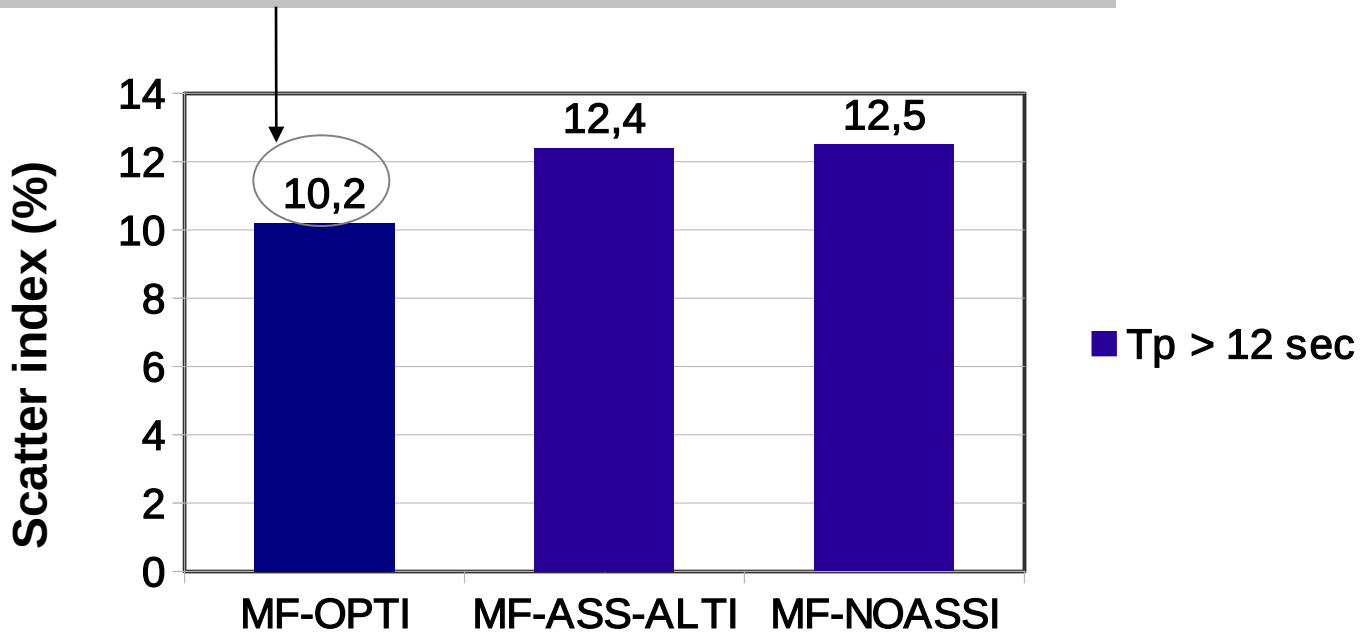
impact of the ASAR on peak wave period (Tp>12 sec)

Total contribution of ASAR L2 (improved by 18%)



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3 month test : April to June 2011

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Description of SWIM on CFOSAT

Ku-Band radar (13.2-13.6 GHz)

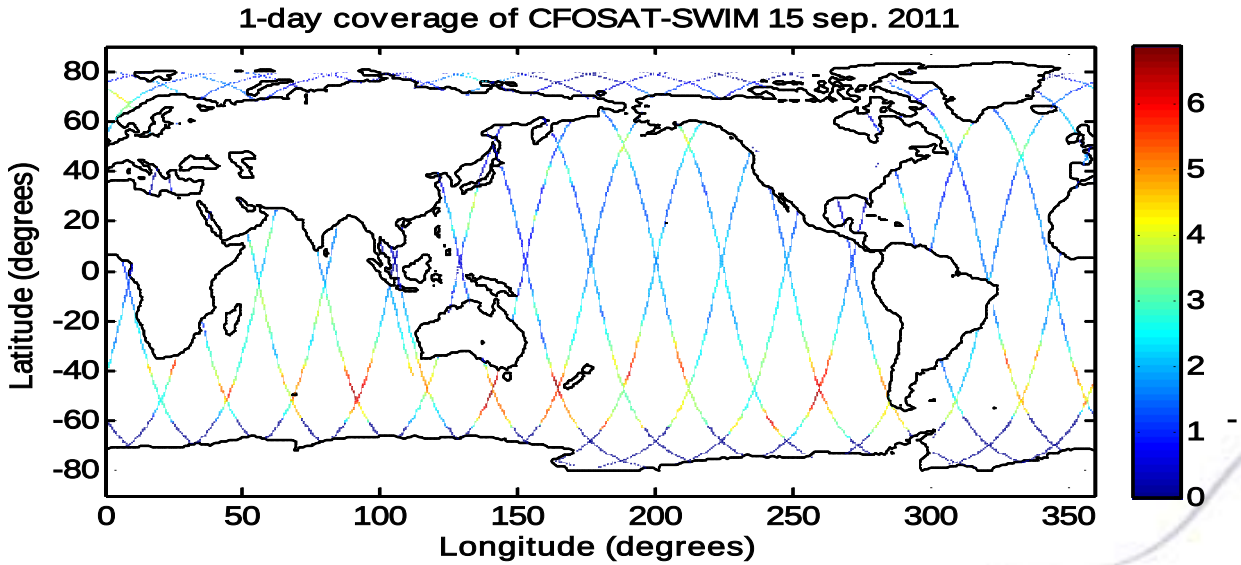
Multibeam (6 incidences 0-2-4-6-8-10°) alternatively illuminated within 218 ms

Scanning in azimuth (5.7 rpm)

Horizontal final resolution within footprint, after processing): 35 m in the look direction (18 km perpendicular)

Maximum scanning radius: 88 km (10° incidence)

Synthetic significant wave height from SWIM (time window 6 hours)



Example of 1-day coverage CFOSAT (SWIM instrument

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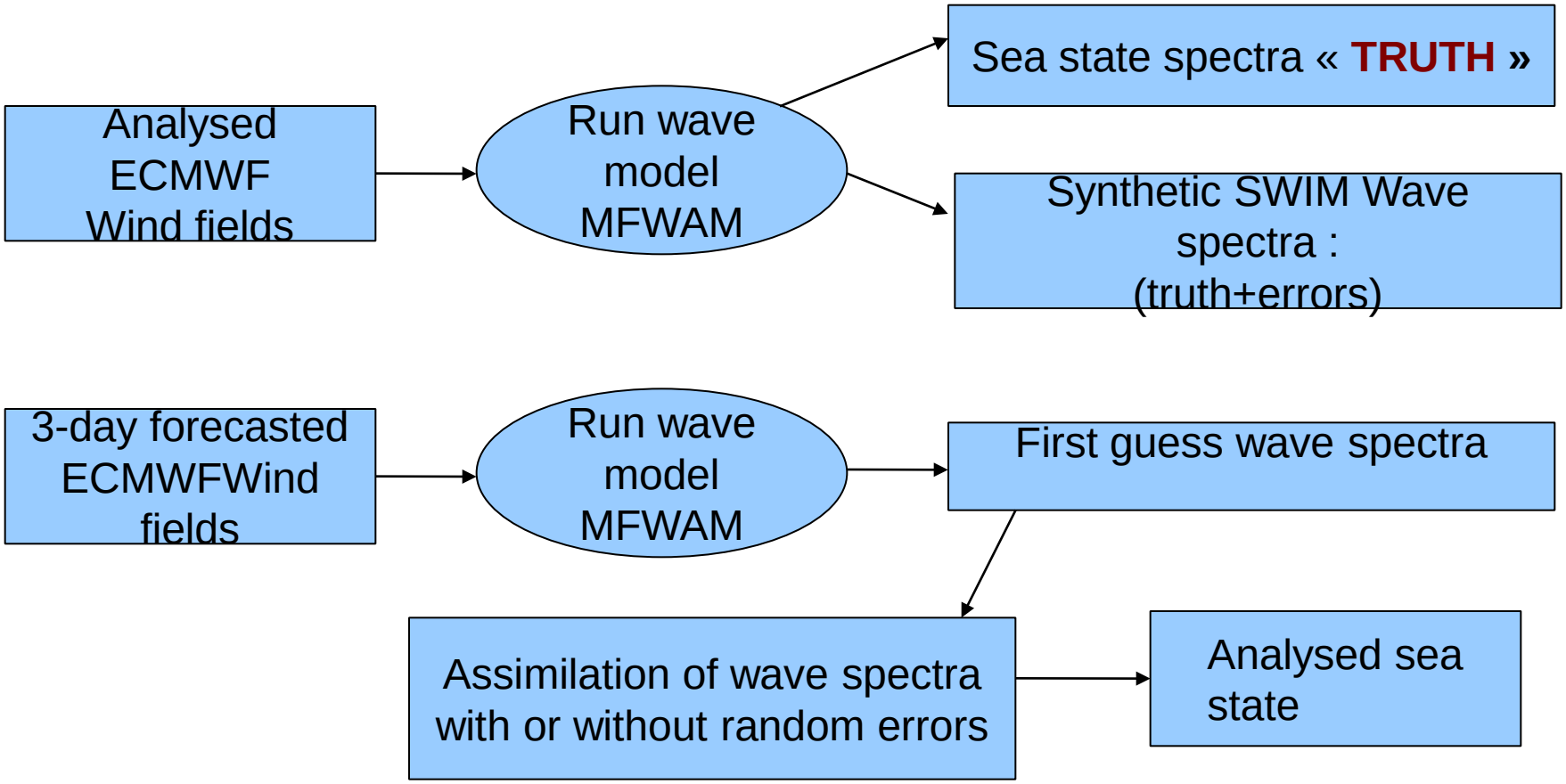
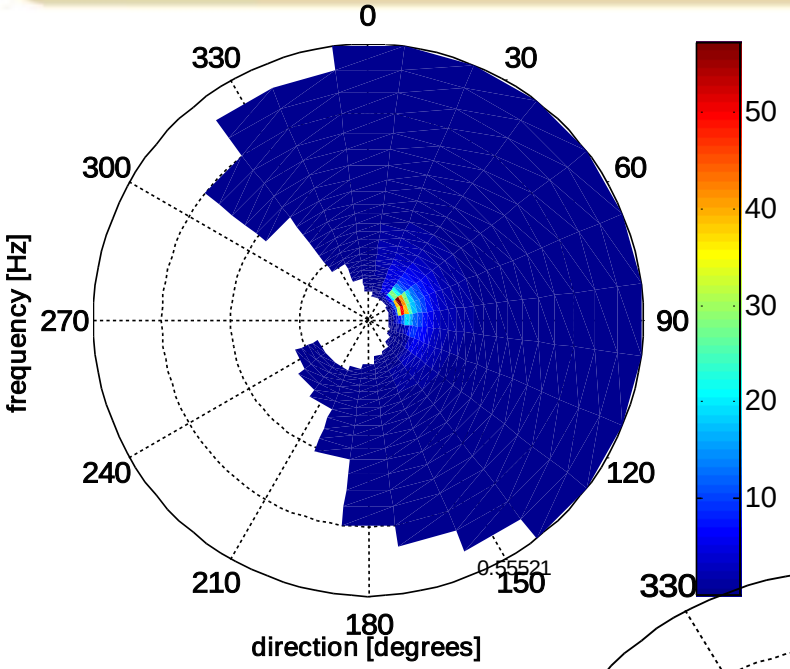
Methodology of OSSE's

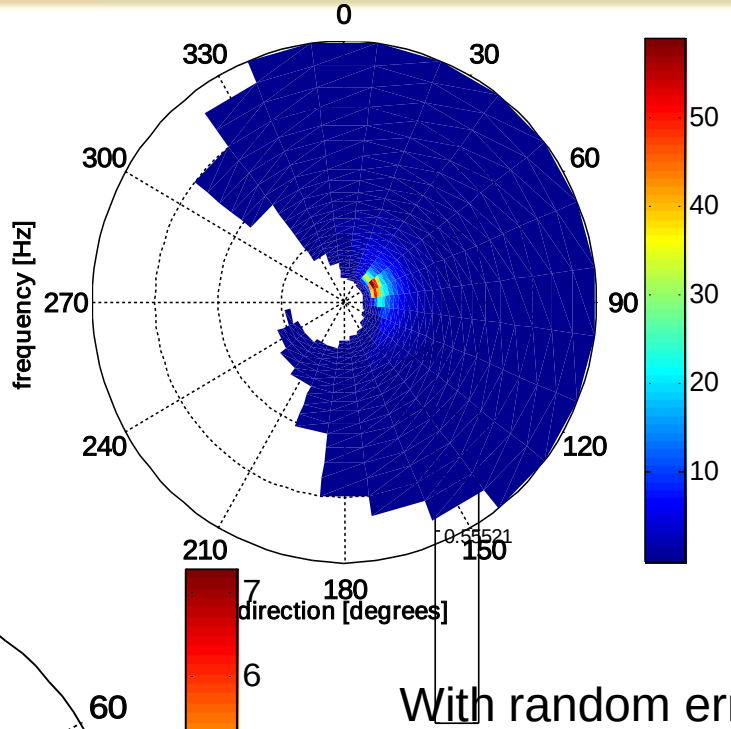


→ The rms errors of significant wave height of the first guess are about 18.2% in reference with altimeters

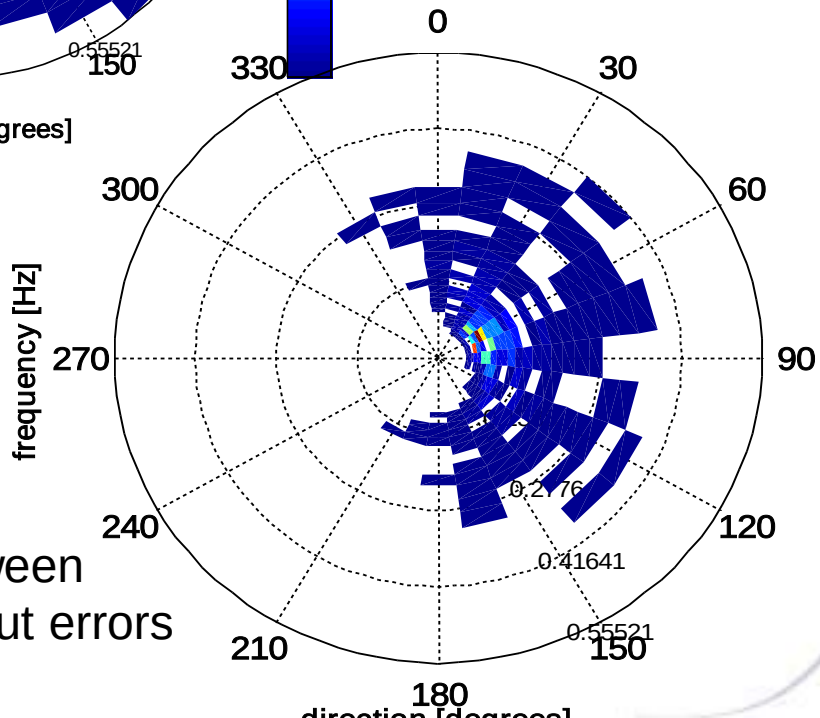
Random number to simulate SWIM instrument errors



No errors



With random errors



difference between
With and without errors

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Description of test runs

- Assimilation is performed during 1 cycle of CFOSAT (13 days) every 6 hours starting from 12 September 2011 at 12:00 (UTC)
- Model resolution of 0.5° and wave spectrum in 24 directions and 30 frequencies

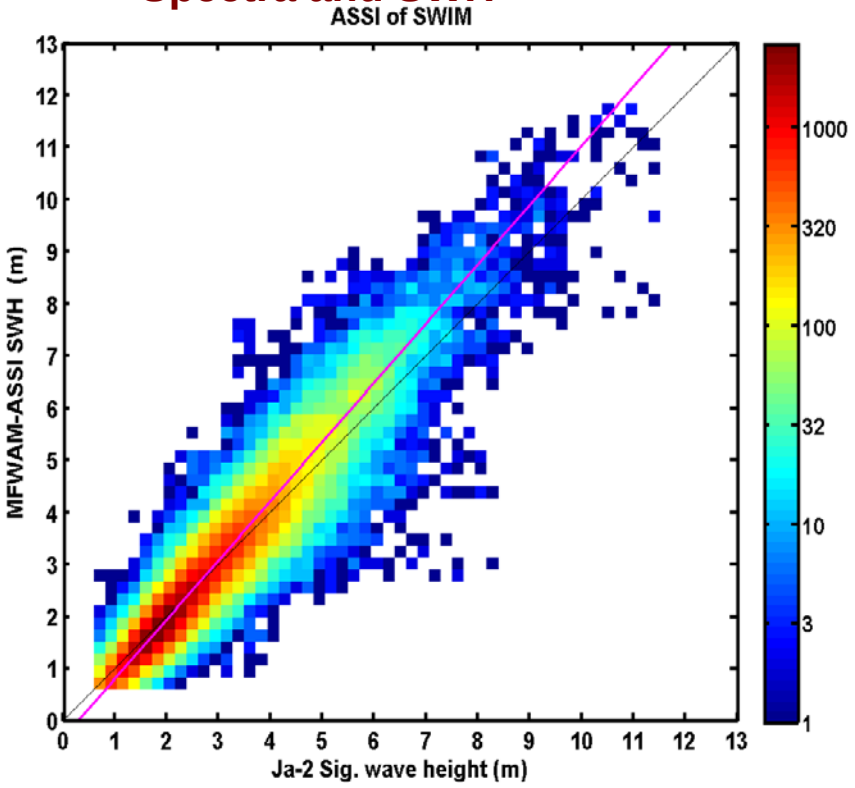
- Several test runs :

MFWAM with synth wave spectra and SWH from SWIM (no instrument errors)	**MFWAM with synth. wave spectra and SWH from SWIM (with random errors: 6% for SWH)**	**MFWAM with synth. wave spectra and SWH from SWIM and ASAR L2 wave spectra**	**MFWAM with synth. SWH from SWIM only**	**MFWAM without assimilation**

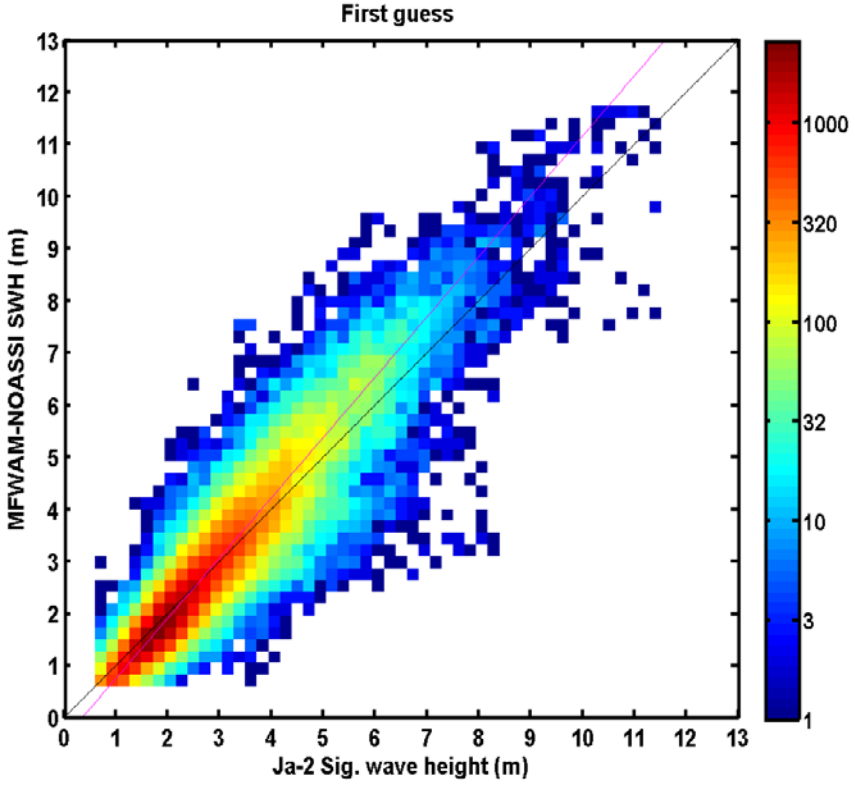
- Validation with the « truth » wave parameters and also with altimeters (Jason-2) and buoys

Assimilation of SWIM synthetic wave data : Validation with Jason-2 Sig. Wave height

assimilation of Synthetic SWIM wave Spectra and SWH



Run without assimilation

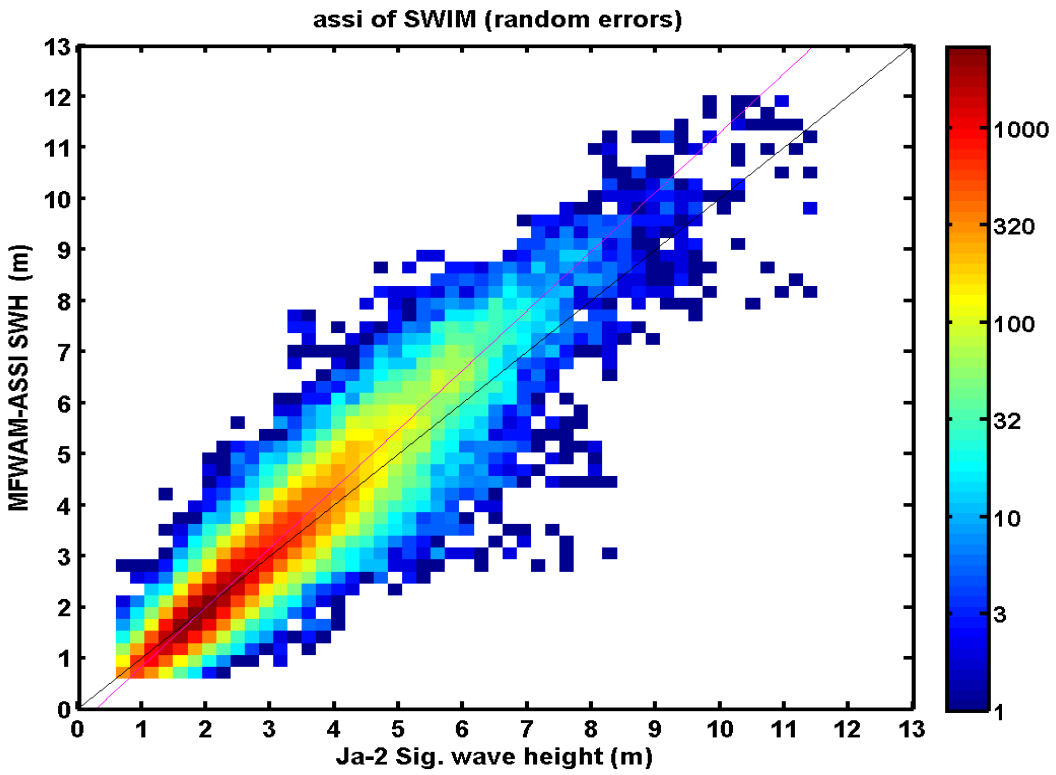


Bias = 0.02
SI = 16.1%
NRMS = 16.1%
Slope = 1 .14
Intercept = -0.33

Data collected : 79357

Bias=0.01
SI=18.2%
NRMS=18.2%
Slope=1.16
Intercept=-0.41

Assimilation of SWIM wave products disturbed by random errors



Bias = 0.09
SI = 16.5%
NRMS = 16.9%
Slope = 1 .16
Intercept = -0.33

Increase of scatter index by 2.5% when adding instrument errors

Test run of 1-cycle CFOSAT tracks

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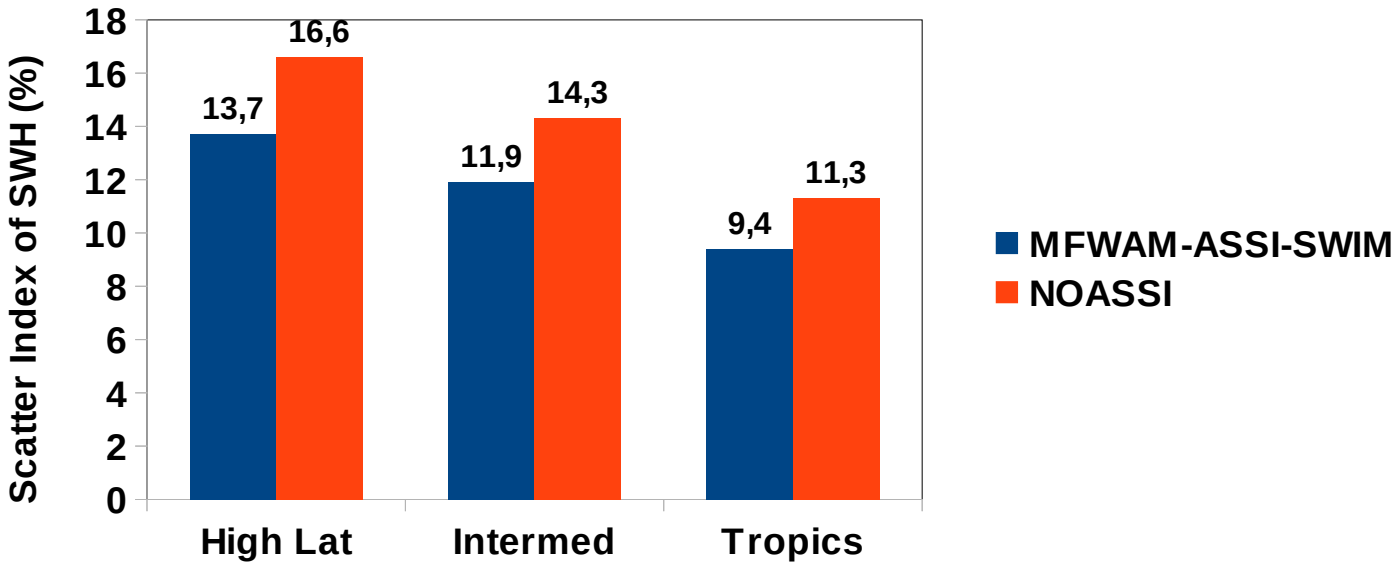
Assimilation of SWIM synthetic wave data : Validation with Truth Sig. Wave height

Statistical analysis at Ja-1 and Ja-2 locations



High Lat : |Φ| > 50°
Intermediate ocean domain : 20° < |Φ|< 50°
Tropics : |Φ| < 20°

Test run of 1-cycle CFOSAT tracks

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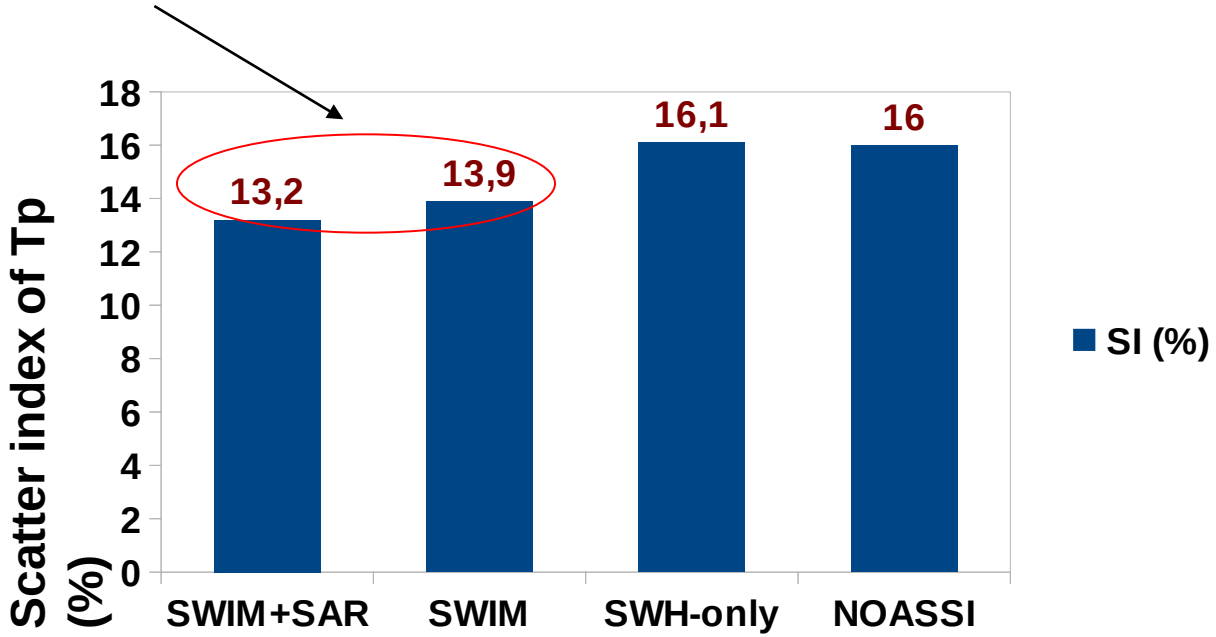
Assimilation of SWIM synthetic wave data : Validation with buoy peak period Tp

impact of using directional wave spectra



SWIM+SAR : MFWAM with assimilation of SWIM and ASAR (ENVISAT)
SWIM : MFWAM with assimilation of synthetic wave spectra and Sig. wave heights
SWH-only : MFWAM with assimilation of Sig. Wave heights only
NOASSI : MFWAM without assimilation

Test run of 1-cycle CFOSAT

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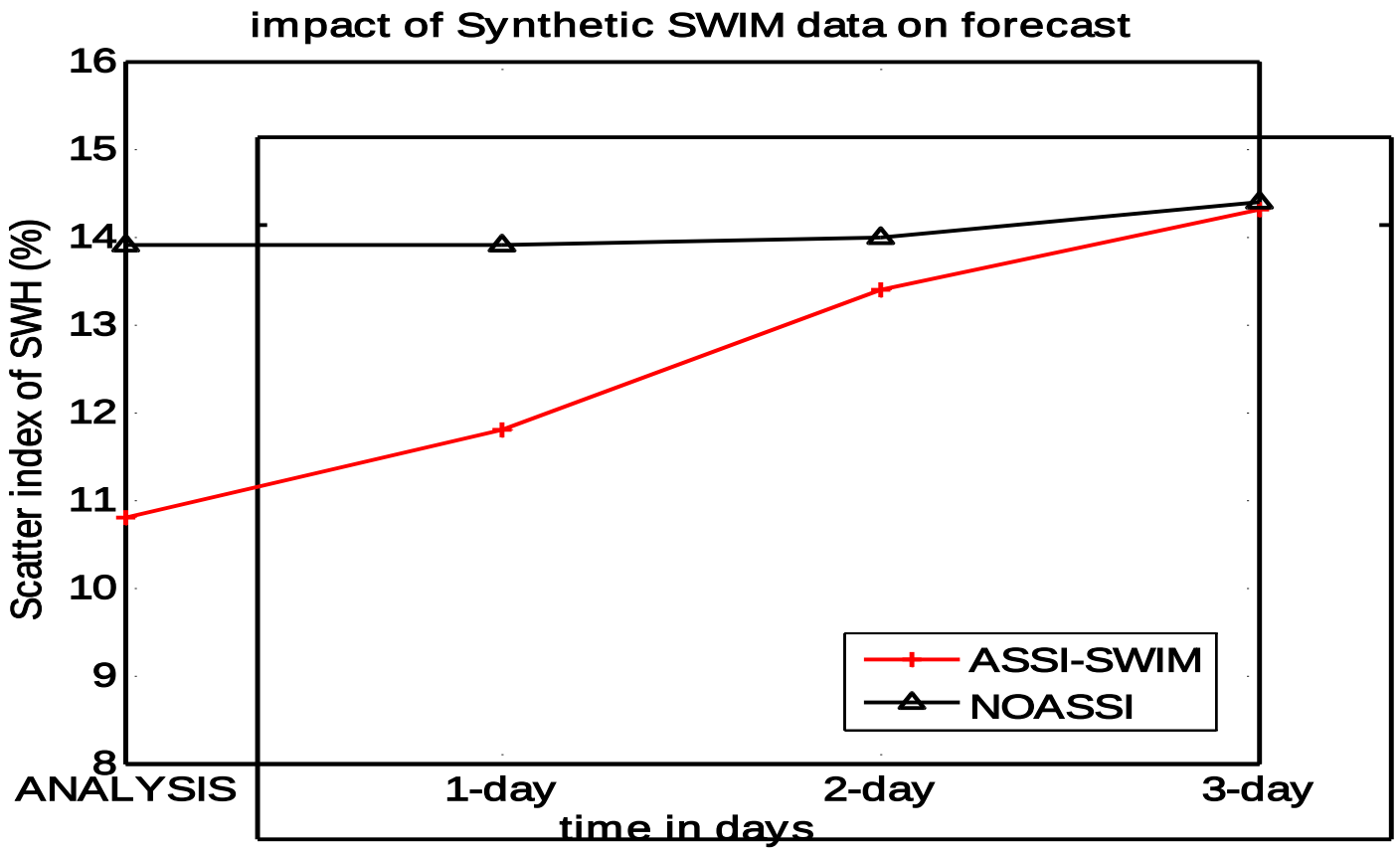
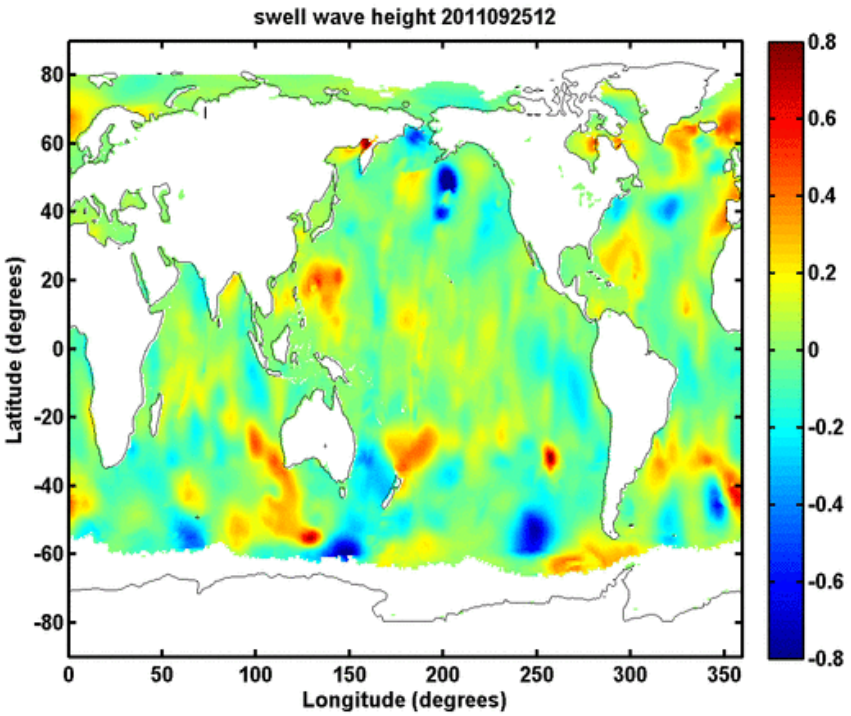
Impact of the assimilation of synthetic wave spectra and SWH from SWIM

Comparison with TRUTH significant wave height at Jason 1 & 2 orbit tracks

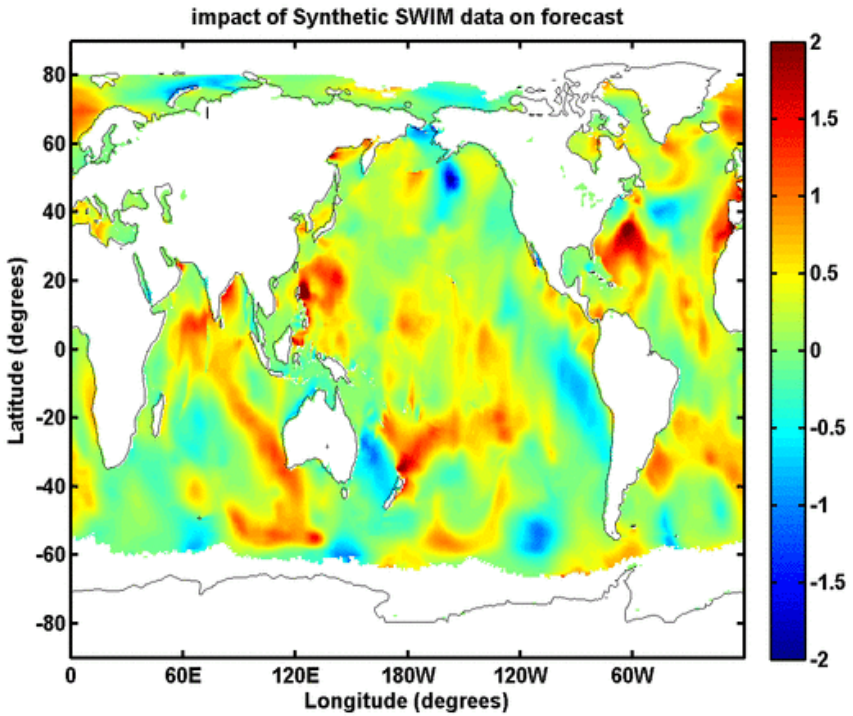


The impact of the assimilation of synthetic wave spectra : Forecast period

Swell wave height



Mean wave period



Difference between runs of MFWAM with and without assimilation

2-day forecast starting from 25 September 2011, by step of 6 hours

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Conclusions

→ The assimilation system improves significantly the wave analyses (SI of SWH less then ~10% refering to altimeters)

→ The contribution of directional wave spectra in the assimilation is clearly showed for the peak period Tp>12 sec :

→ the use of ASAR improves the analyses by more than 20% (waiting for sentinel-1 and CFOSAT mission)

→ The assimilation of synthetic wave spectra shows the same trend of impact as for ASAR. The random error degrades slightly the the impact.

→ The impact of the assimilation stays efficient until 3 days in the forecast period

Conclusions and future works

→ Use of synthetic wave spectra provided by FAWASSI (CNES simulator for SWIM) : more precise instrument errors

→ Perform sensitivity tests with several wavelengths cut-off