The impact of the cut-off on the combined assimilation of altimeters and ASAR wave spectra in the 3G wave model

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11th International workshop on wave hindcasting & forecasting
& 2nd coastal hazard symposium
18-23 janvier 2009

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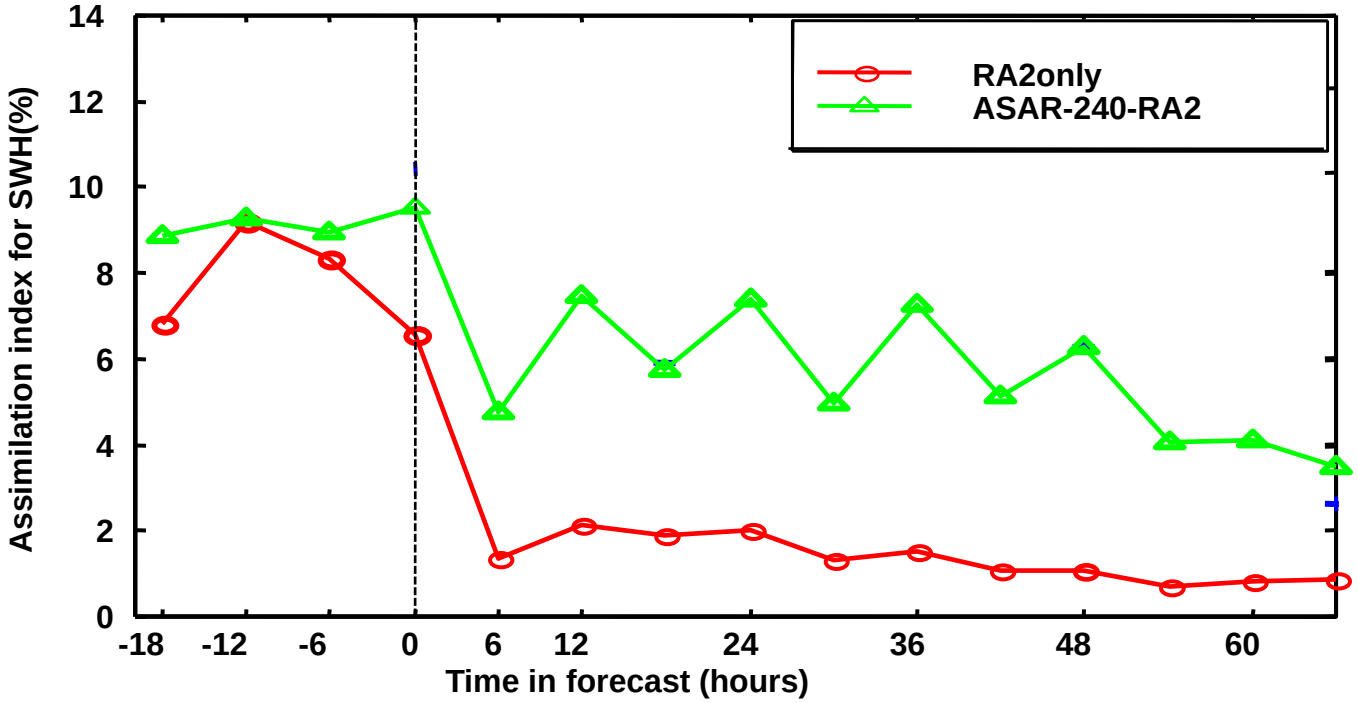
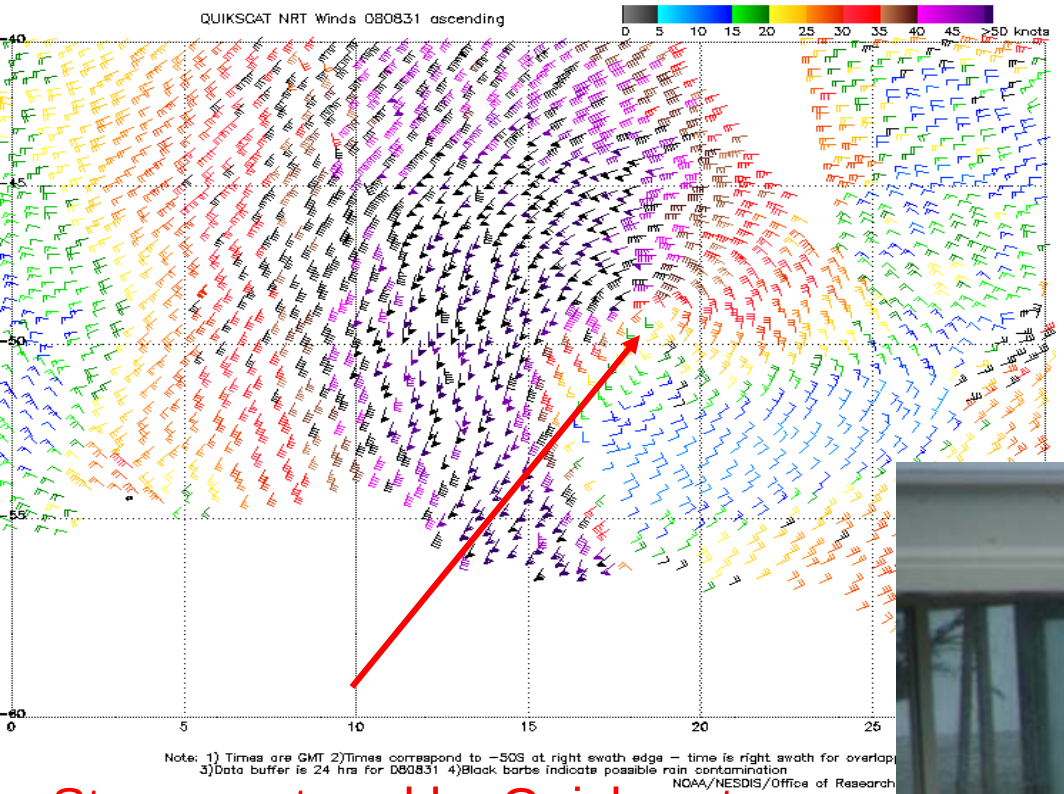
Motivation

- Better estimation of sea state parameters : improving both the wind sea and swell parts of the sea state by assimilating altimeters and ASAR wave spectra



- Better use of the cut-off on ASAR wave spectra : including more wave systems seen by ASAR in the range direction

Long swell generated on 31 August 2008 propagating to cape town

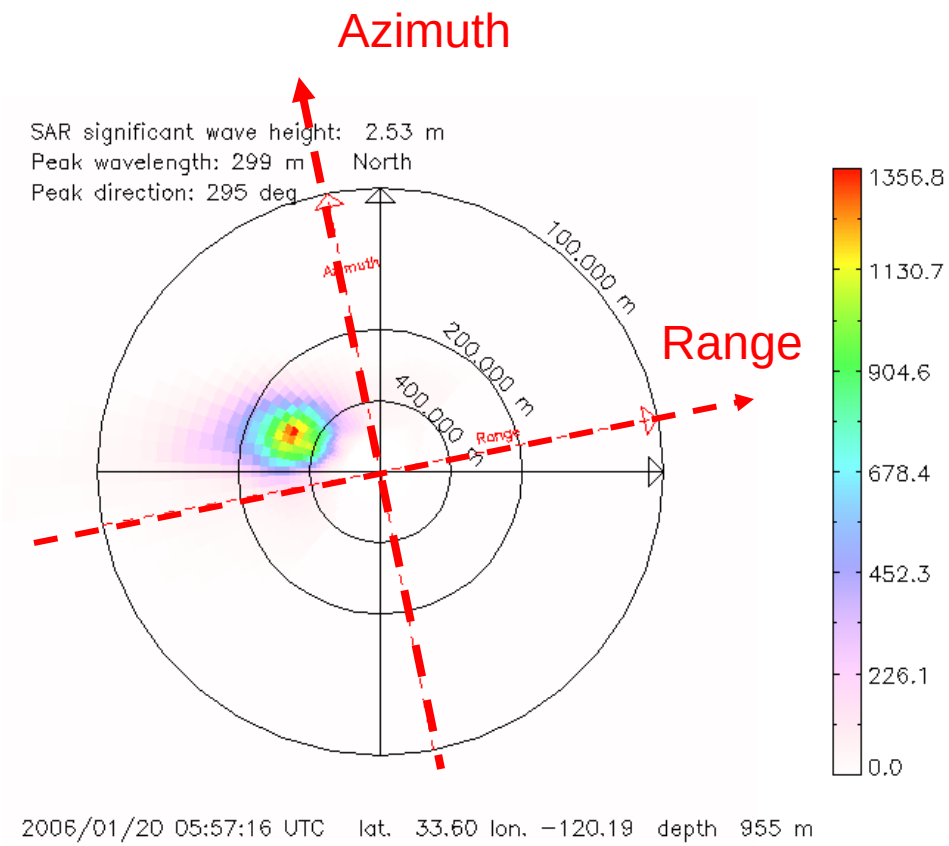


Storm captured by Quickscat South of South Africa

High swell with period of 20 s damages the coast at Cape town

- Using the system for high swell generated by strong storm (operational use ?)

Methodology of the new cut-off



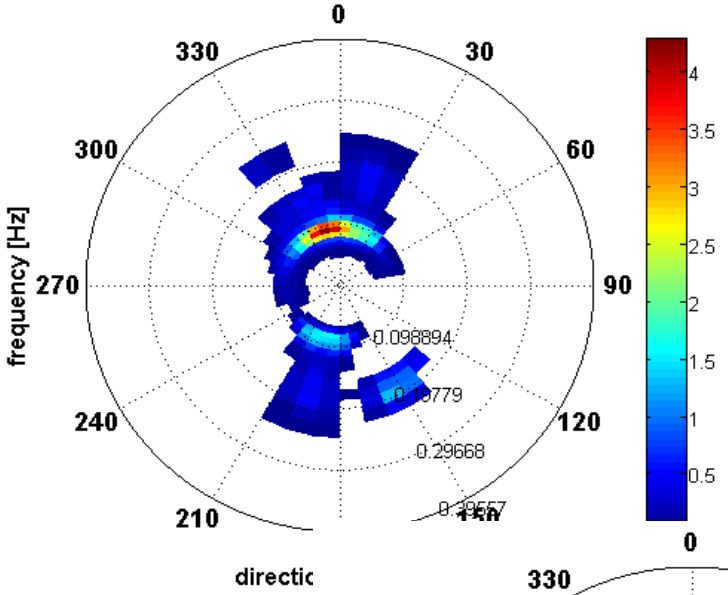
The azimuthal cut-off is provided by the level 2 Algorithms, but in the range direction ASAR can see smaller wavelengths (even wind sea)

$$\lambda r = \lambda a * \cos(\Phi + \alpha)$$

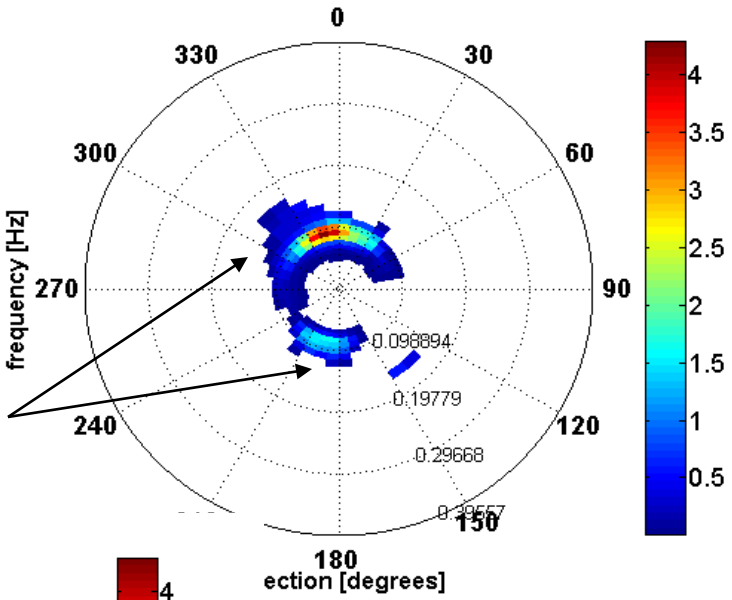
λa : azimuthal cut-off
λr : minimum cut-off (range)
ϕ : orbit track angle
α : wave direction from the model

Example of using the variable cut-off

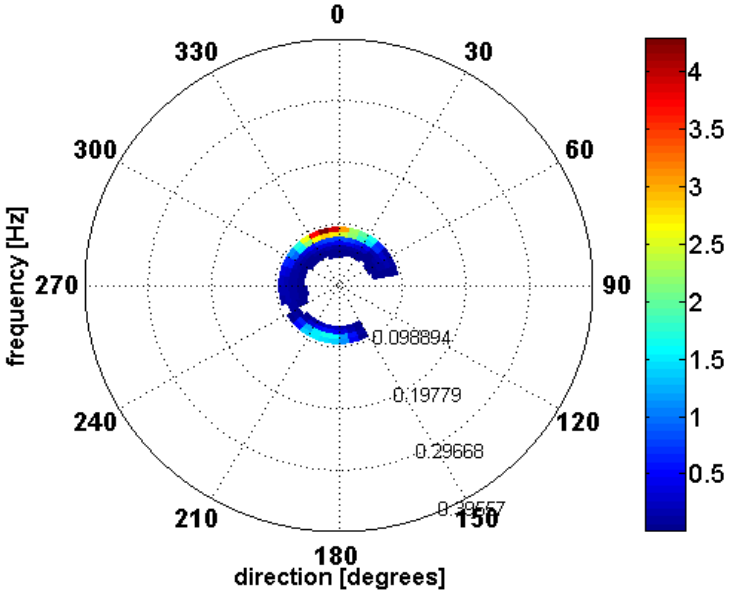
Original ASAR (before cut-off)



After variable cut-off



Fixed cut-off



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Conclusions

→ The variable cut-off has been implemented in the assimilation system :

- the validation shows a positive impact on the estimation of mean wave parameters in the periods of analysis and forecast

- increase of the assimilated wave partitions in the OI (~8%)

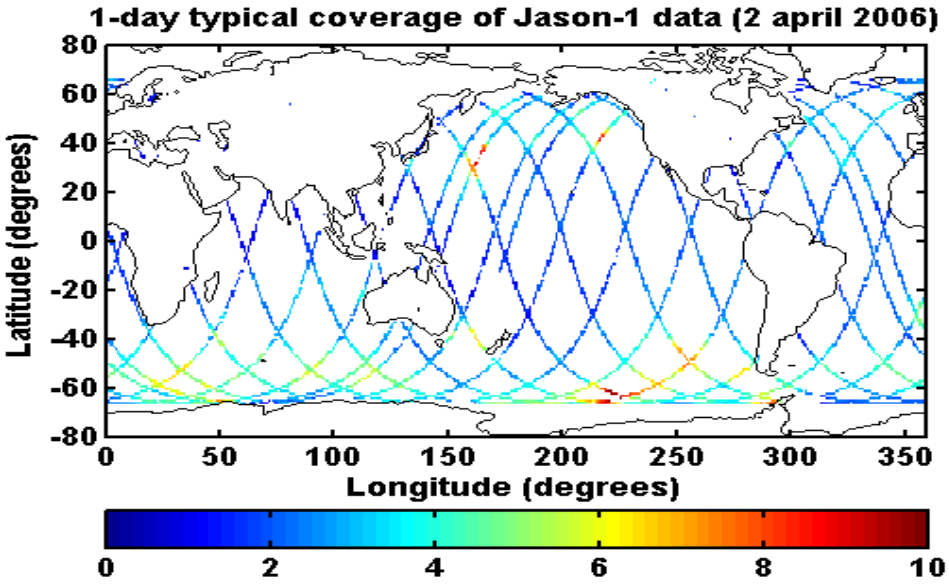
→ tracking high swell by using ASAR wave spectra in assimilation mode works well and can help forecasters to issue warning bulletins (in time …!)

Plan

- Motivation
- Méthodology of the variable cut-off
- Description of the assimilation system
- Results and validation
- Case studies of high swell (18 Mars 2008)
- Conclusions and perspectives

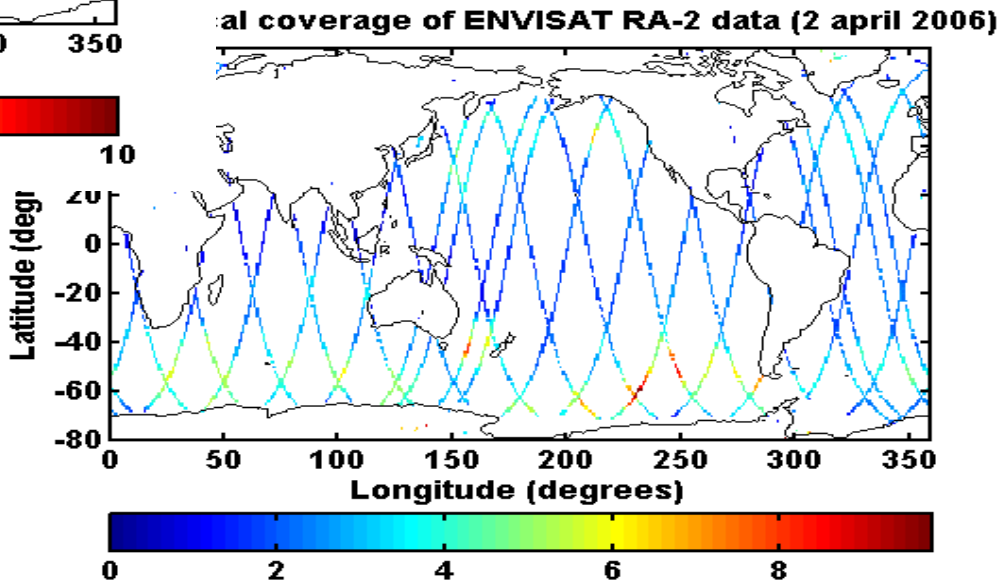
Assimilation of altimeter data from Jason-1 and Ra-2

Jason-1



Example pf 1-day altimeter data

ENVISAT RA-2



Good correction of the total wave height mainly wind sea part

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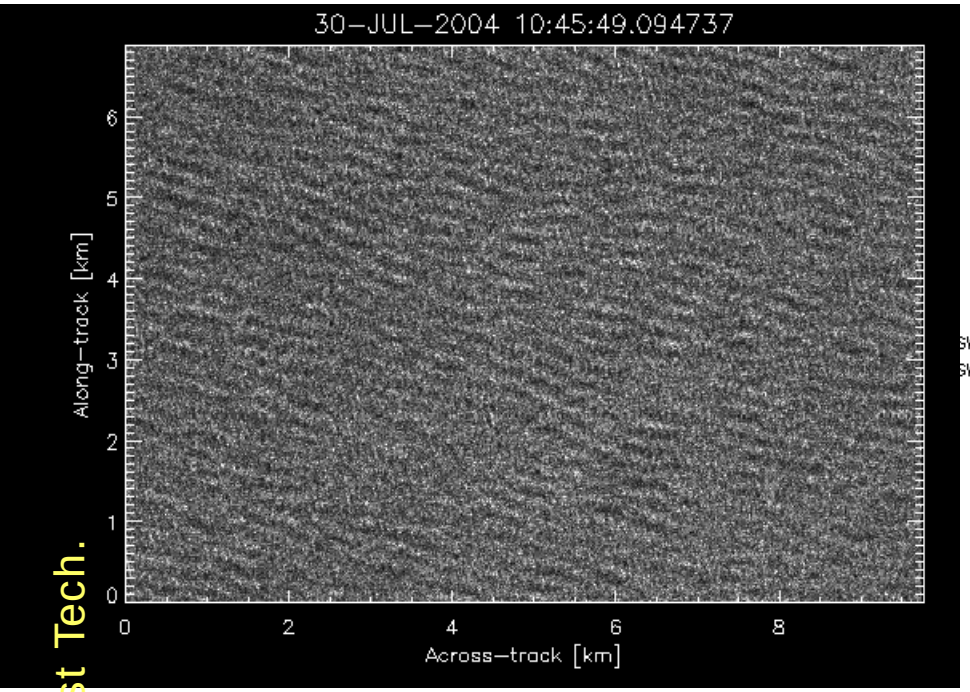
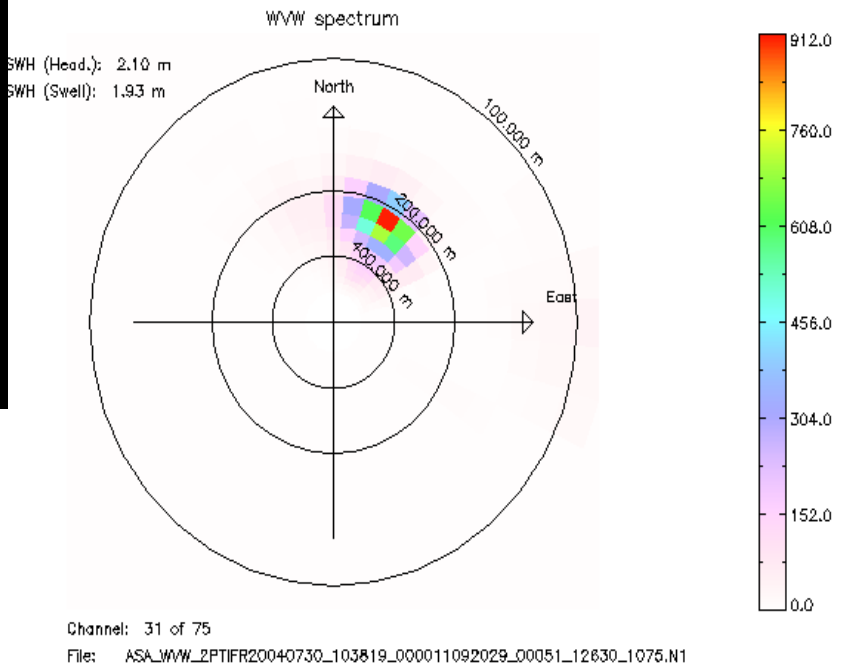
The ASAR level 2 wave mode provides:

Geophysical parameters
- Partial Wave spectrum
- Wind speed estimate

+ many others parameters related to the signal





Courtesy of Boost Tech.

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Assessement of quality control for ASAR L2 wave products

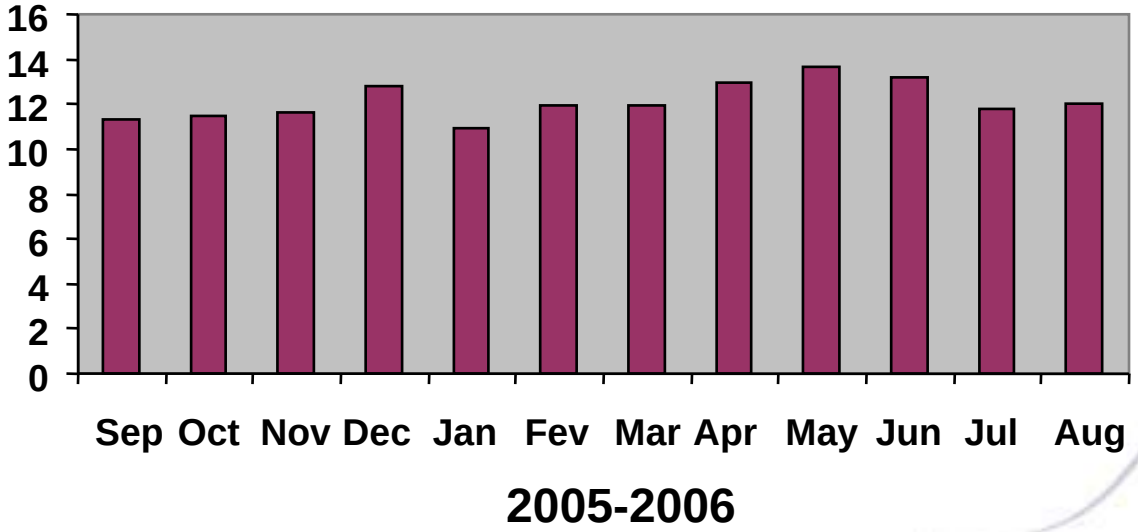
- Quality control for ASAR wave spectra (see Aouf et al.2008)

  → ratio of signal to noise (3<r <30)

  → normalized variance of image (1-1.6)

  → wind speed (2-17 m/s)

- Data out of range represents in average 10-12 %



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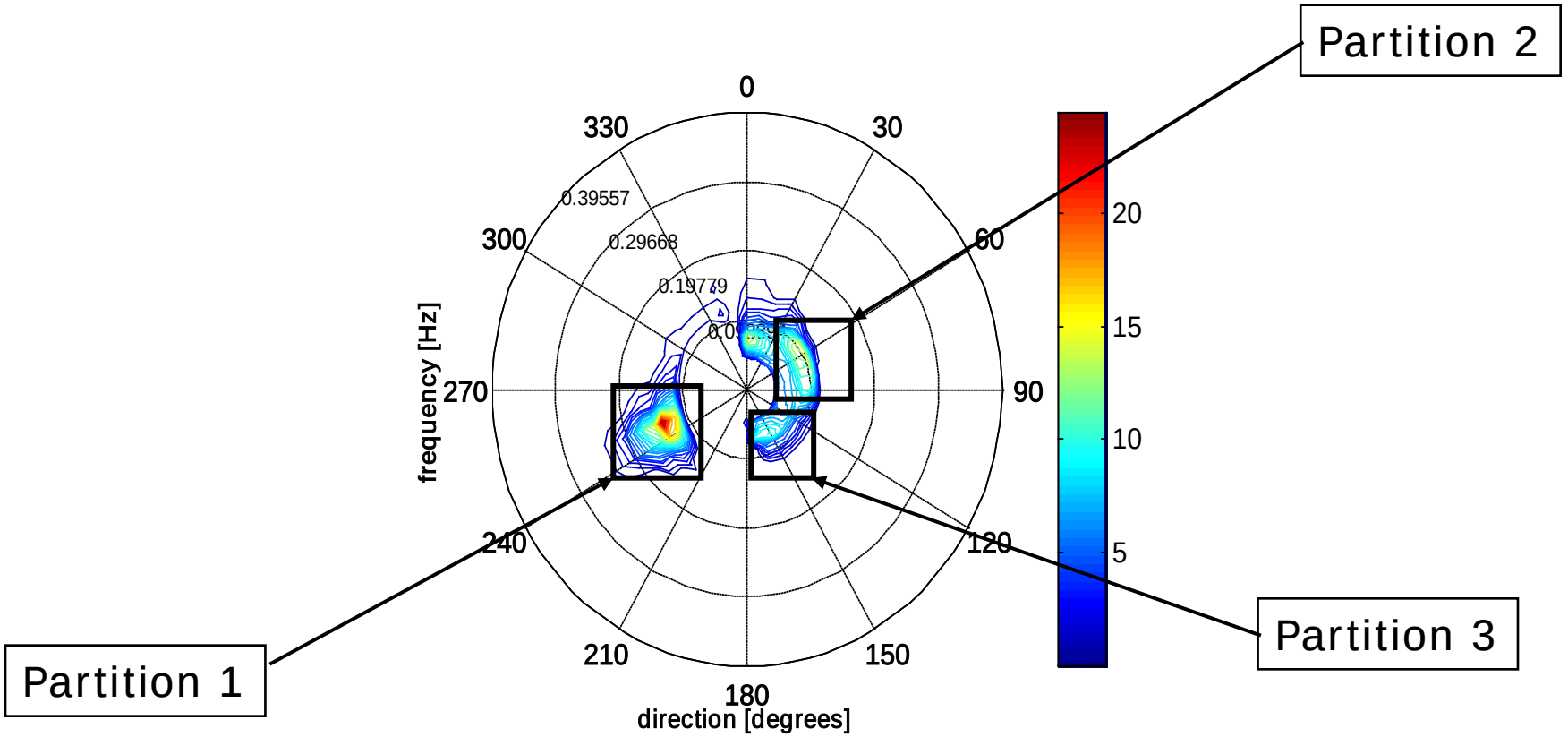
Description of the assimilation scheme

- Decomposition in partitions of the wave spectrum (first guess and observation)



Each partition is described by Its mean parameters

Description of the combined assimilation

- Assimilation of RA2 and Jason-1
  - → Optimal interpolation (total wave height and wind speed)
  - → Correction on wind sea part of the wave spectrum (power laws)

- Procedure for ASAR directional wave spectra
  - → **Partitioning** principle (decomposition in dominant wave trains)
  - → **Cross-assignment** between first guess and observed partitions (km-ko < tuned value)
  - → **Optimal interpolation** on mean parameters of the selected partitions (wave energy and wavenumber components)
  - → **Reconstruction** of the analyzed wave spectra

Description of test runs over 3-months of data

- **Test runs set-up**
  - Wave model WAM-C4 (global 1x1°in lat-lon), wave spectrum in 24 frequencies (0.044-0.39 Hz) and 36 directions
  - 6-hourly analysed ECMWF wind fields
  - Assimilation every 3-hour (3h time-window)
  - Assimilation period from 1 March 2006 to 1 June 2006

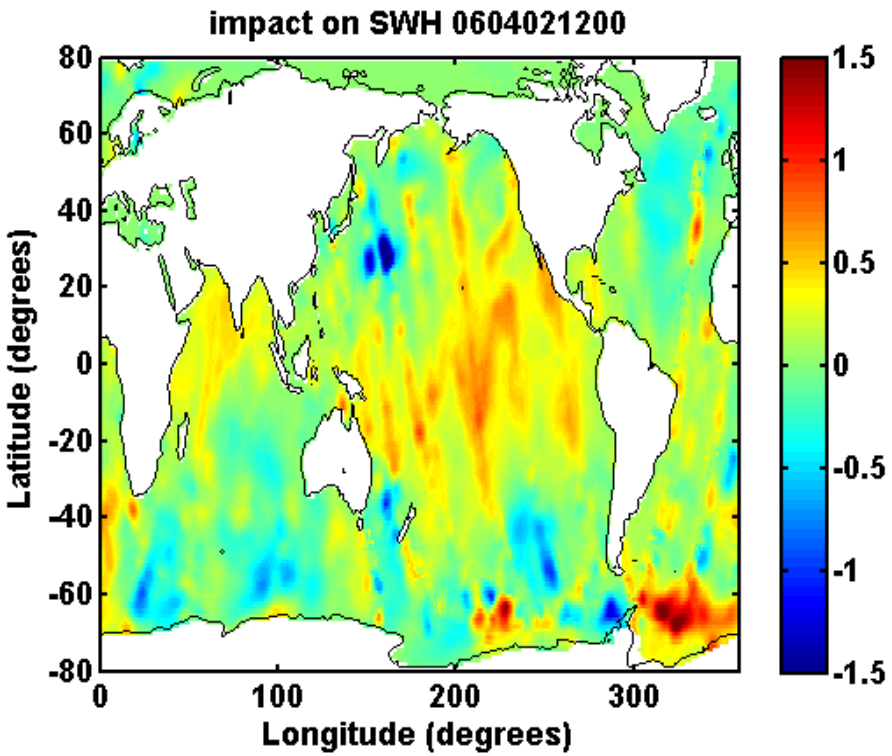
→ **Assimilation** of **ASAR** wave spectra and Ra-2 and Jason-1 altimeters wave height over a **3 month** period. The new cut-off is activated.

→ **ASAR** wave spectra and Ra-2 and Jason-1 altimeters wave height with a fixed wavelenght cut-off of 200 meters

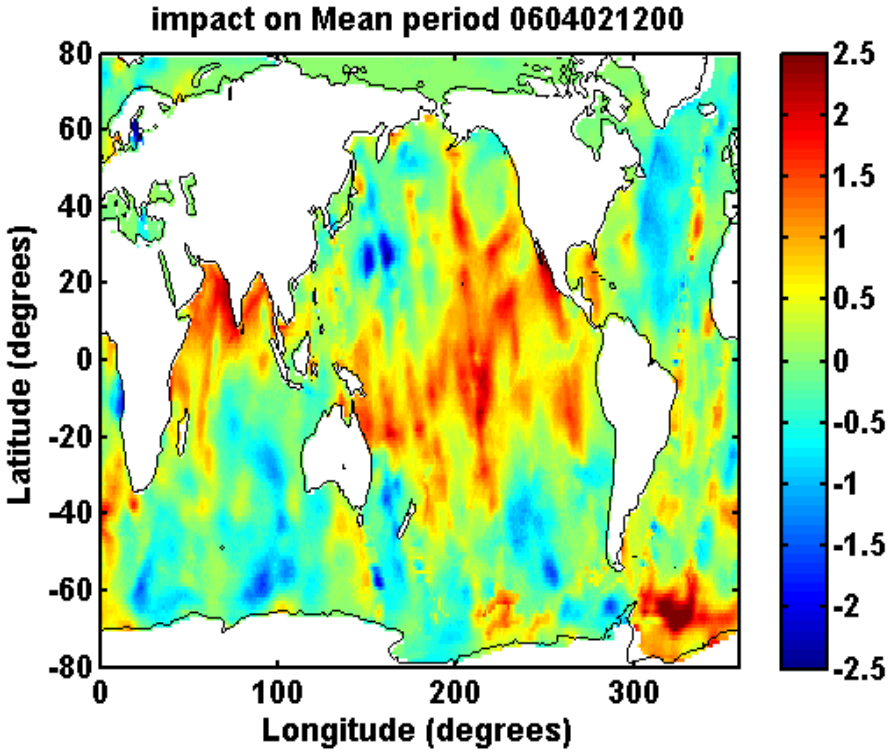
→ **Reference** run **without assimilation**

Impact of combined assimilation (ASAR+Ra-2+Jason-1) in the analysis period

Significant wave height



Mean period



Difference between run with assimilation and the control run (without assimilation)

2 Avril 2008 at 12:00 (UTC)

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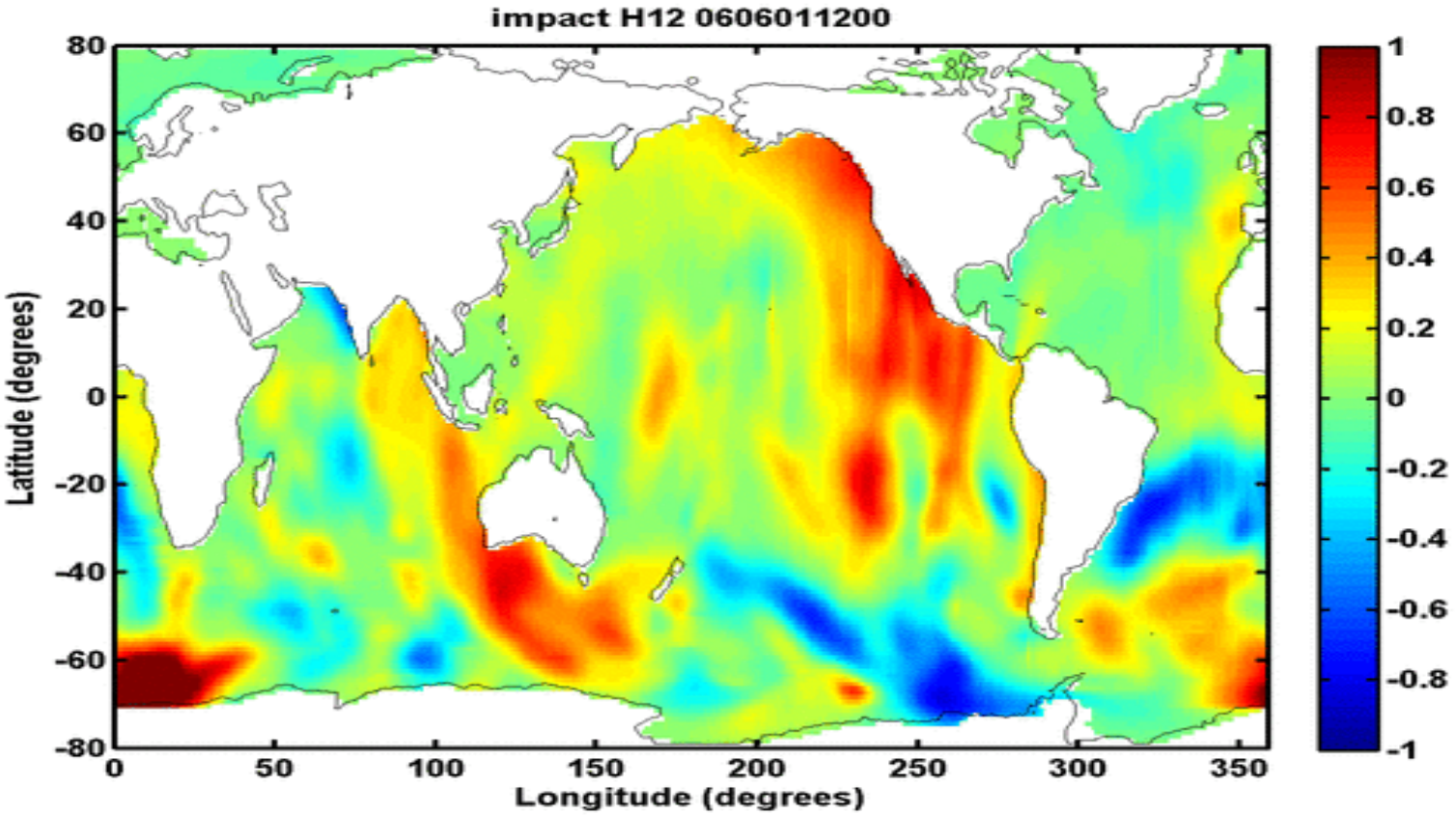
Impact of the combined assimilation (ASAR+Ra-2+Jason-1) in the period of forecast

Wave height H12 (waves > 12 s)



Difference between run with assimilation and the control run (without assimilation)

Step of 12 hours since 1 June 2006 at 12:00 (UTC)

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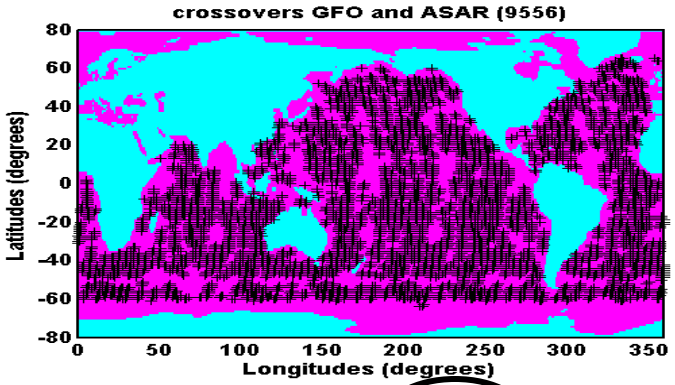
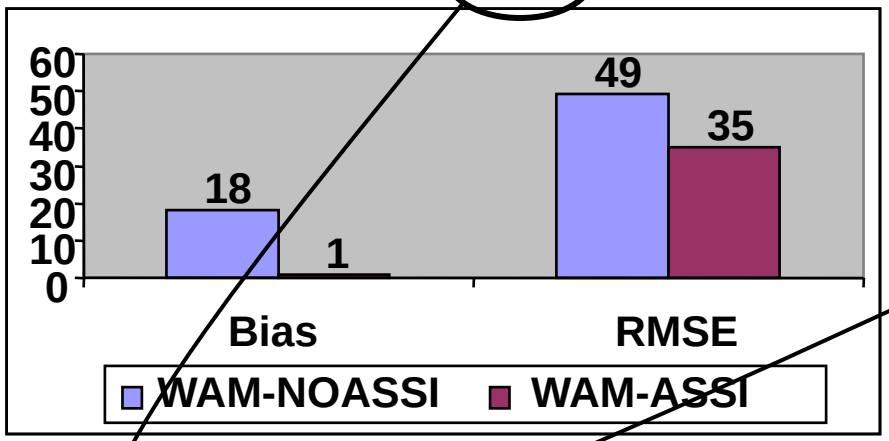
Validation of significant wave height with altimeter GFO at crossovers with ASAR

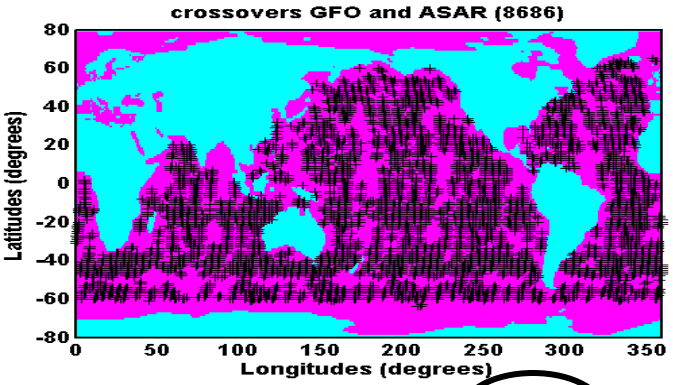
cut-off variable



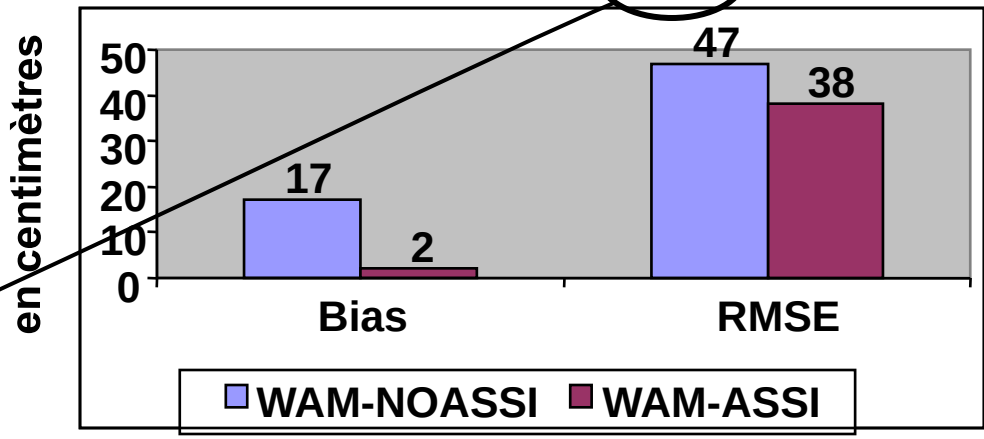
Nb crossovers: 9556



cut-off constant



Nb crossovers: 8686



→ **Significant reduction of RMS errors (AI) by 28.4 % and 24.6%**

→ Increase of crossovers in the analysis (~8%)

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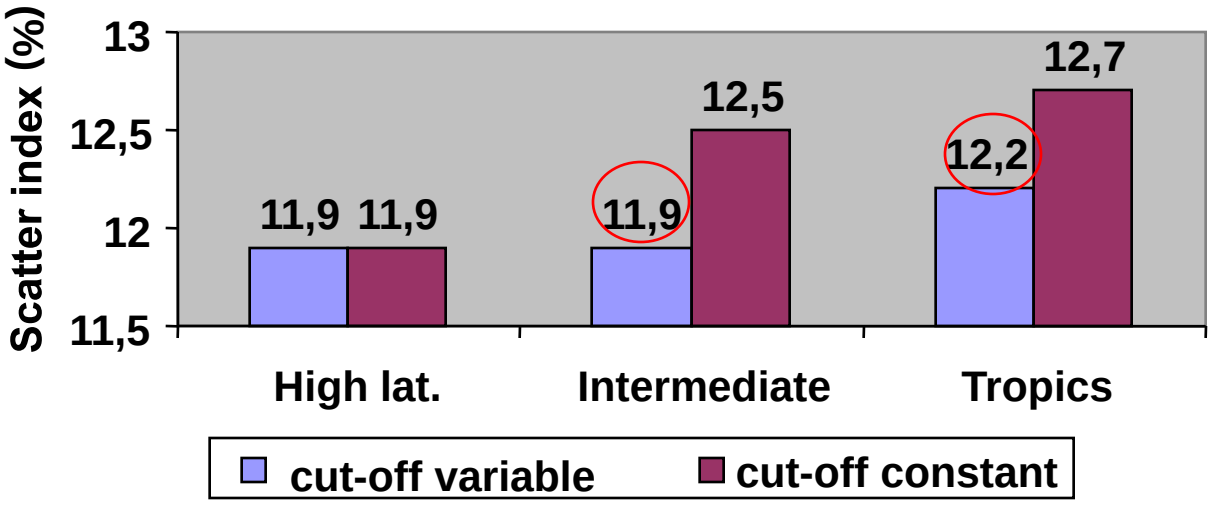
Impact of the combined assimilation at GFO orbit tracks (Mar-May 2006)

Statistical analysis of Significant wave heights



Intermediate latitude $|\Phi|>50°$
recorded GFO data: 83540

Intermediate latitude $20<|\Phi|<50°$
recorded GFO data: 98502

Intertropical region: $|\Phi|<20°$
recorded GFO data: 62020

→RMSE are reduced by 27.7 and 27.2 % for the new cut-off and fixed one respectively

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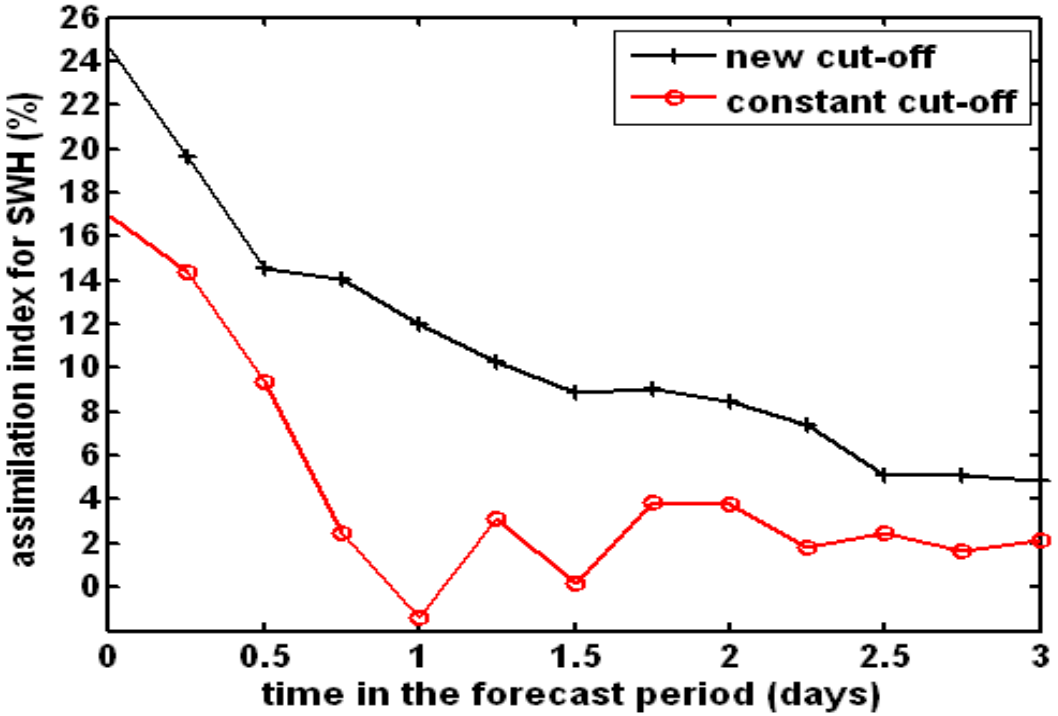
Impact of combined assimilation ofASAR+Ra-2+Jason-1 in the forecast period

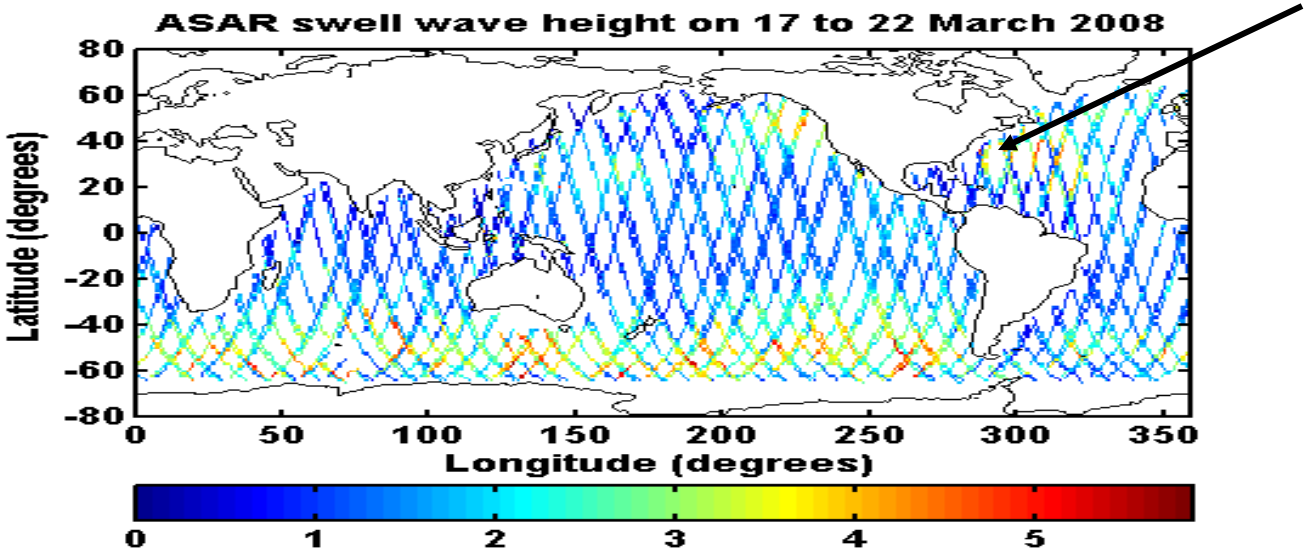
→ positive impact for significant wave height in the forecast period : better performance when new cut-off is activated

reduction of RMSE in %

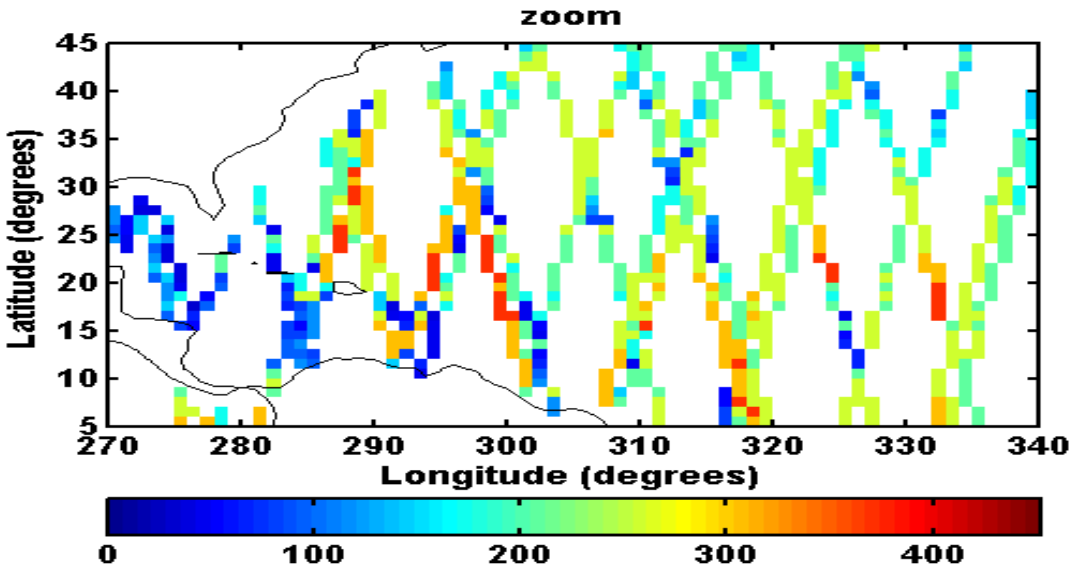


Comparison of Sig. Wave height at GFO orbit tracks

Case of high swell in the carribean sea on March 18, 2008



H12 wave height
For waves > 12 sec



ASAR Peak
wavelength

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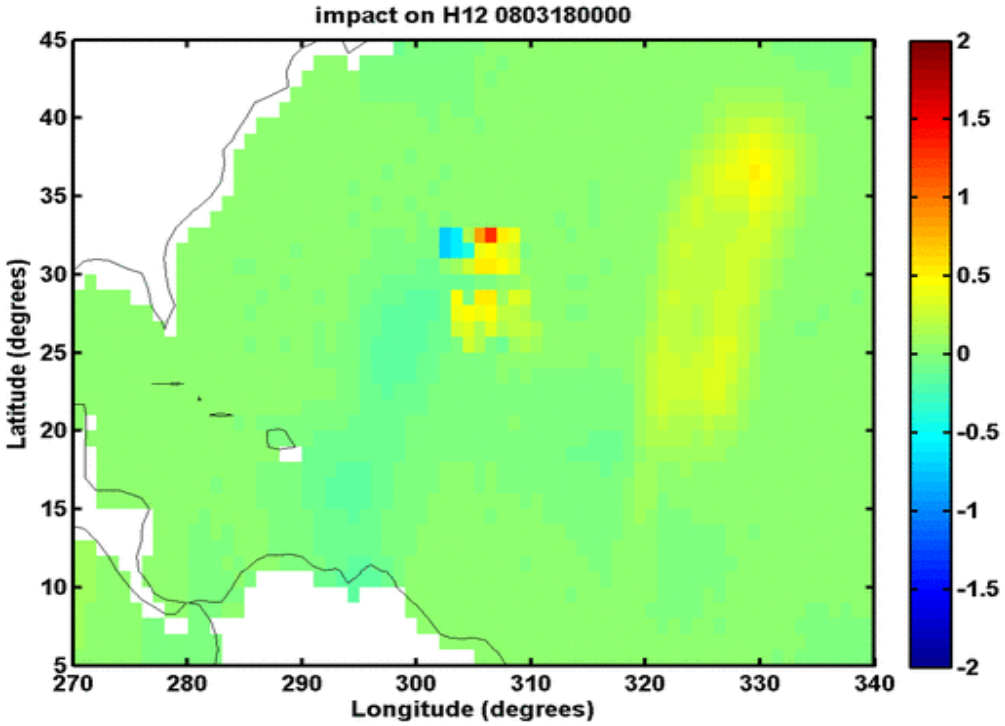
Benefit of using ASAR for tracking high swell (wave period 17-18 sec)

- assimilation run performed from March 17, 2007 at 0:00 (UTC) until March 22, 2008 at 18:00 (UTC)

Step of 3h
From march 18 2008 at 0:00 (UTC)



Impact on H12 (waves>12 sec)

Difference between run with assimilation and the control run (without assimilation)

Case of high swell recorded on march 18, 2008 in the french islands (carribean)

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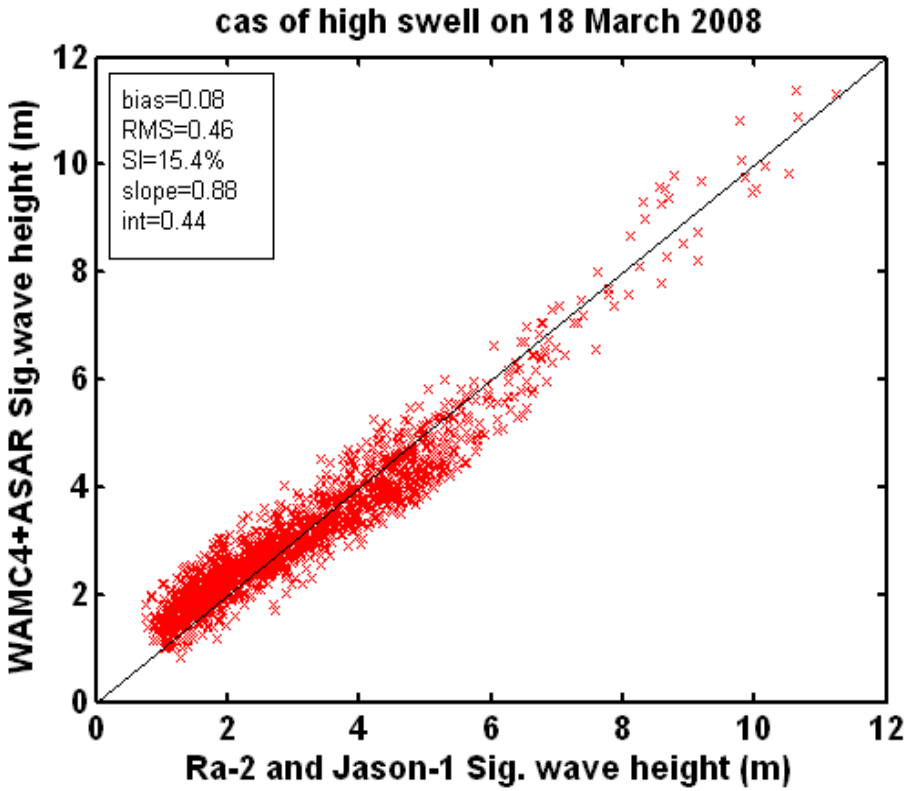
Validation with altimeters on 18 Mars 2008



Validation with altimeters
Ra-2 and Jason-1
Domain : 90°W-20°W,5°N-45°N
Recorded data : 1820

→ Reduction of the RMSE of sig. wave height by 6.8%

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Conclusions and future works

→ The use of a variable cut-off :

- improves the estimation of mean wave parameters in the periods of analysis and forecast
- increases the assimilated wave partitions in the OI, (~8%)

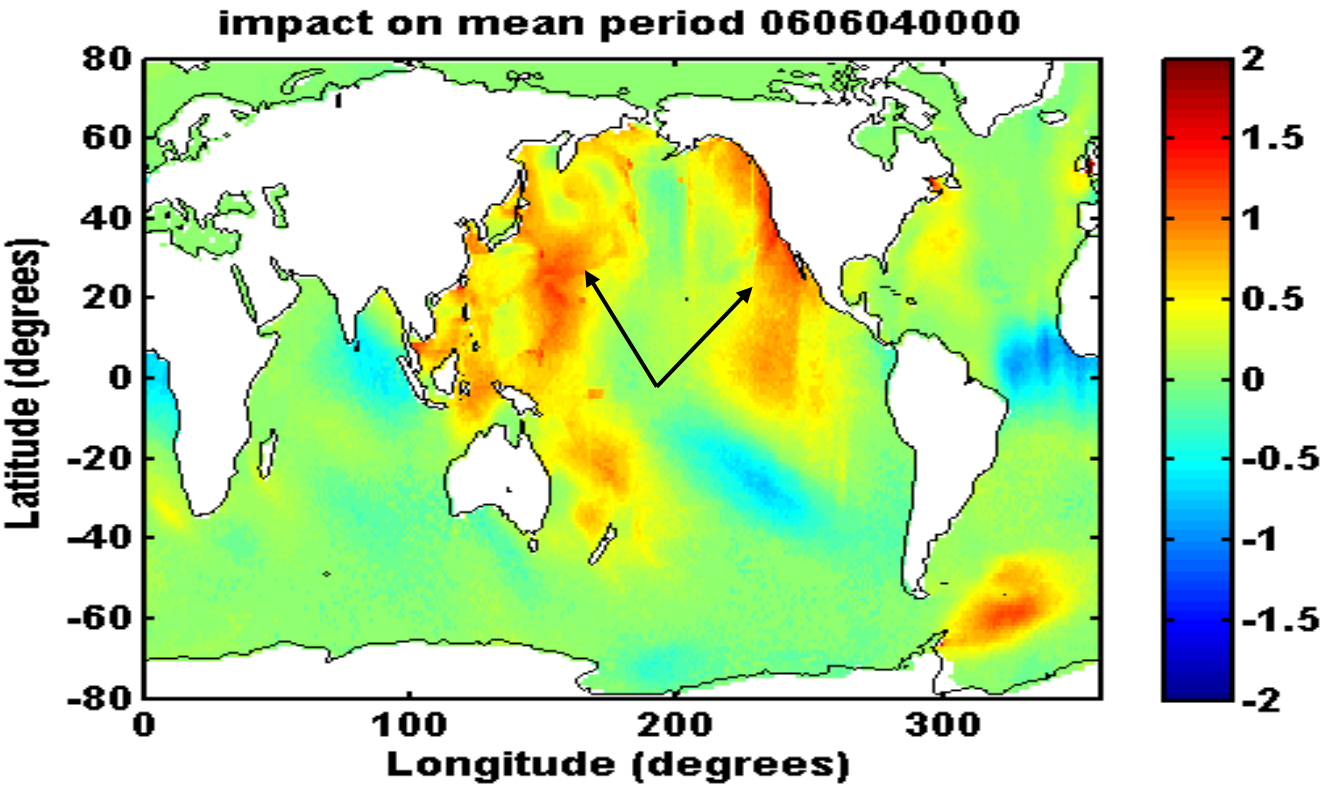
→ Longer assimilation tests are ongoing and validation with NDBC buoys will be investigated

→ tracking high swell by using ASAR wave spectra is a promising tool for operational use (help forecaster to issue warning bulletins)

→ Implementing the assimilation system in the new wave model of Météo France MFWAM (résolution 0.5°x0.5°, Optimization of the OI)

Impact of the combined assimilation (ASAR+Ra-2+Jason-1) in the period of forecast

Période moyenne



4 June 2006 at 0:00 (UTC)
3-day forecast

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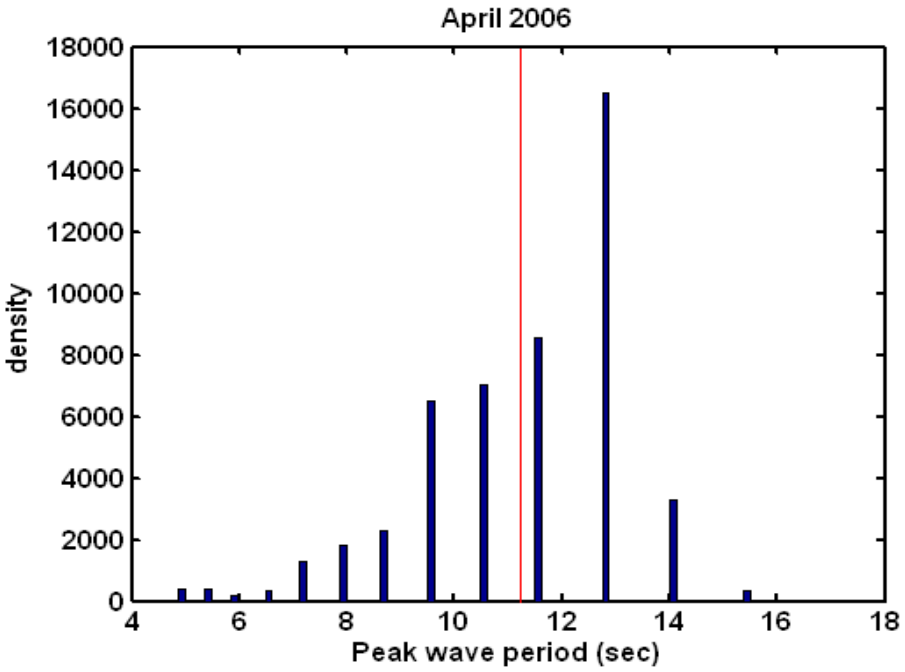
The distribution of ASAR L2 mode wave parameters

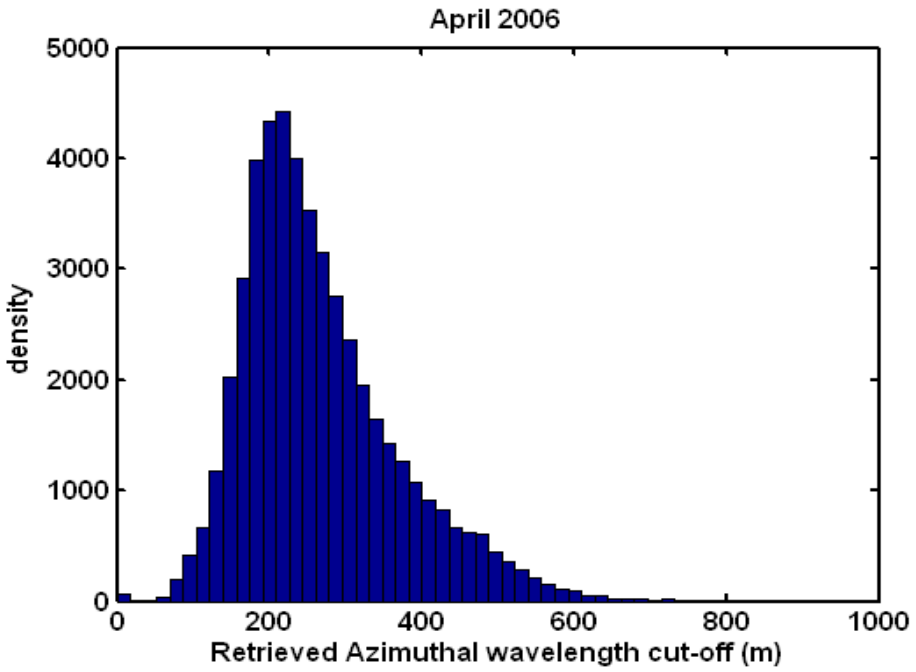
- The analysis of the following wave parameters makes the decision for the choice of a fixed cut-off in the assimilation system

ASAR peak wave period



The average peak wavelength ~200 meters

Azimuthal wavelength cut-off



The average wavelength cut-off ~260 meters

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