IMPACT OF USING SEVERAL ALTIMETERS FOR IMPROVING NUMERICAL WAVE ANALYSES AND FORECASTS

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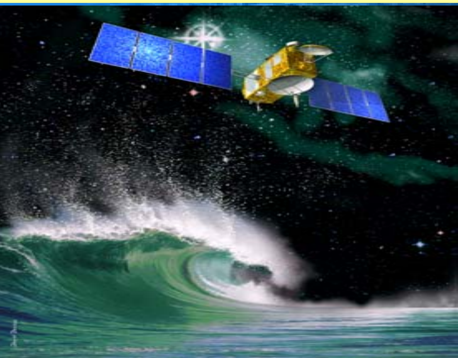
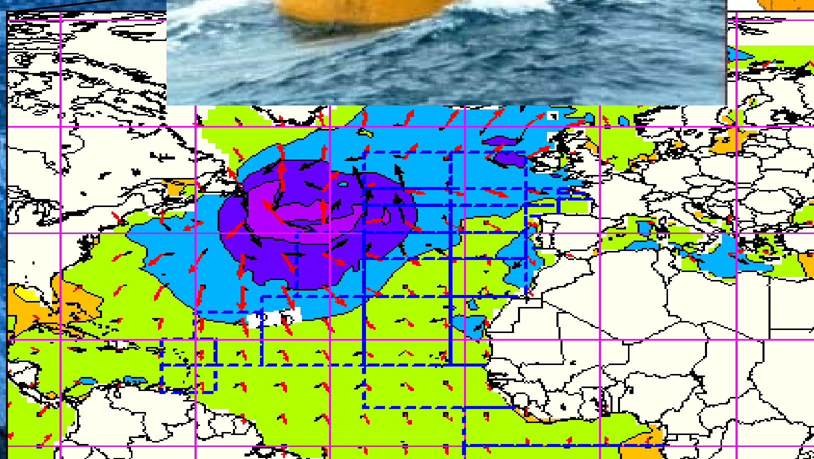
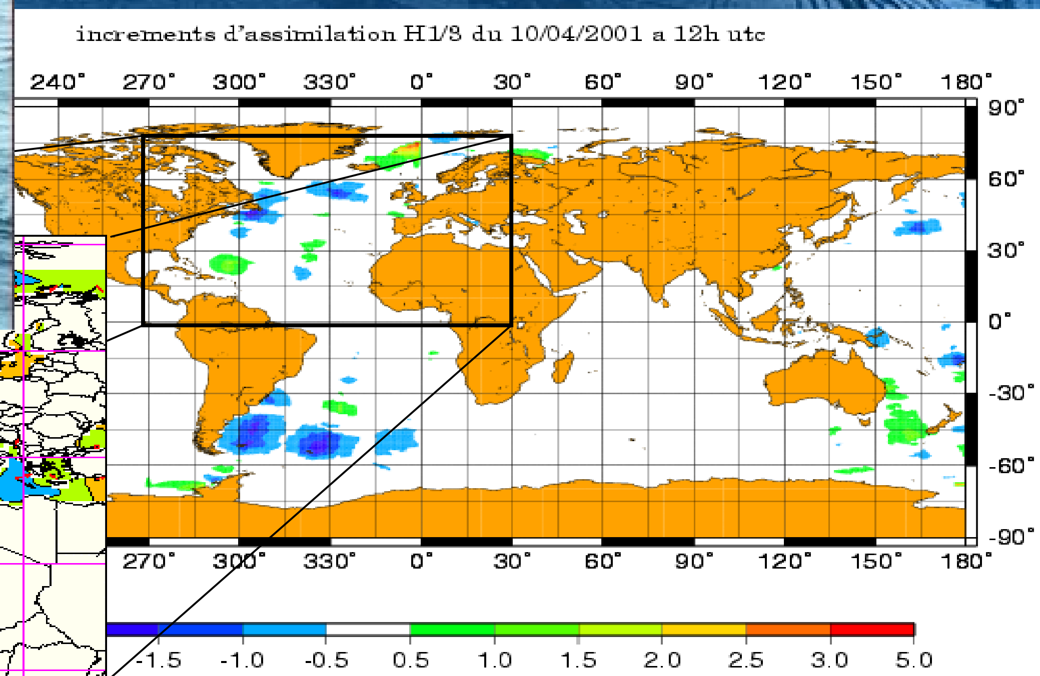
Present Wave Prediction system:







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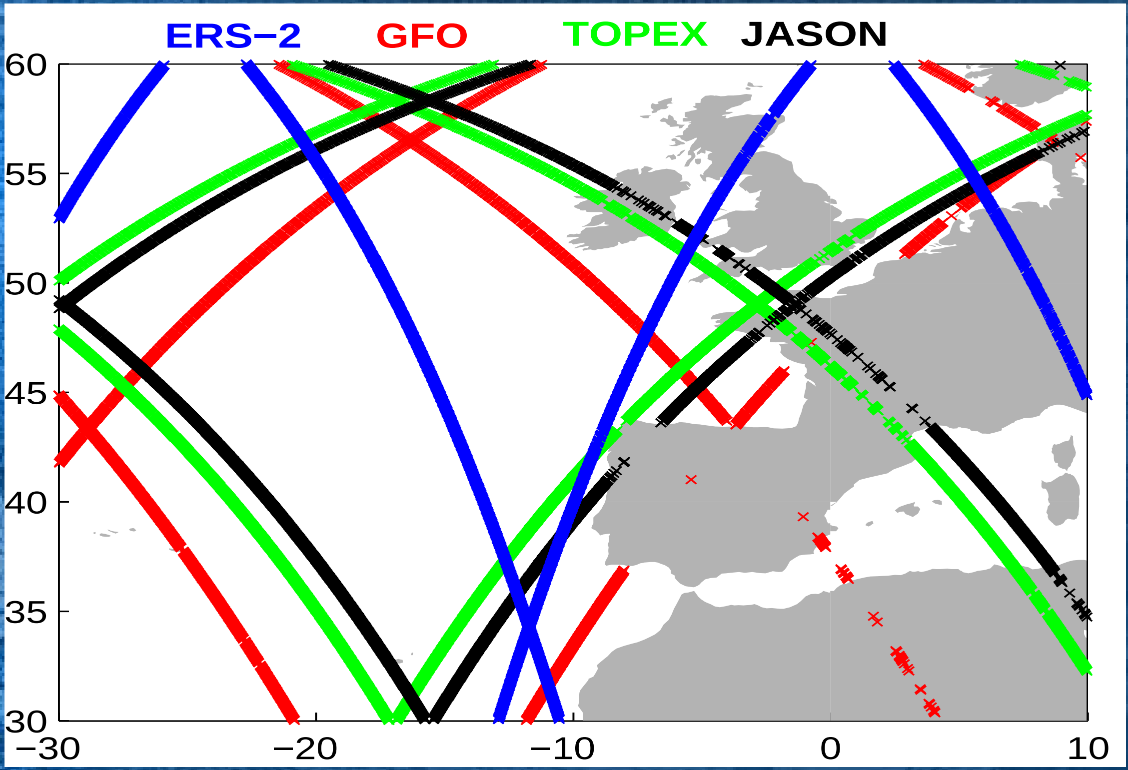
Flying altimeters from 1991

• ERS-1 & ERS-2	ESA	35 day repeat cycle	July 1991 & April 1995
• TOPEX-POSEIDON	NASA CNES	10-day	August 1992
• GEOSAT Follow-On	US NAVY	17-day	February 1998
• JASON_1	NASA CNES	10-day	December 2001
• ENVISAT RA-2	ESA	35-day	March 2002

→At present 5 altimeters are flying together, leading to high coverage and sampling.: only data from ERS-2 where assimilated

1-day altimeter sampling (from Queffeulou 2003)



- ENVISAT is on the same orbit as ERS-2 (30 minute shifted) .
- TOPEX and JASON are very close
- To use the data from these 5 altimeters, one have to check the consistency of the measurements from one satellite to another one.

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- In this study, we present an impact study using several altimeters (up to 3).
- The wave model used is WAM-C4 at a resolution of 1x1 degrees. With the assimilation package from Lionello et al (1992).
- We performed global assimilation experiments for a period of one month.
- Altimeters data have been corrected according to Queffeulou's relations (2003).

Description of the assimilation experiments:

One month

spin-up period (4 days)	assimilation period (19 days)	Forecast period (8 days)

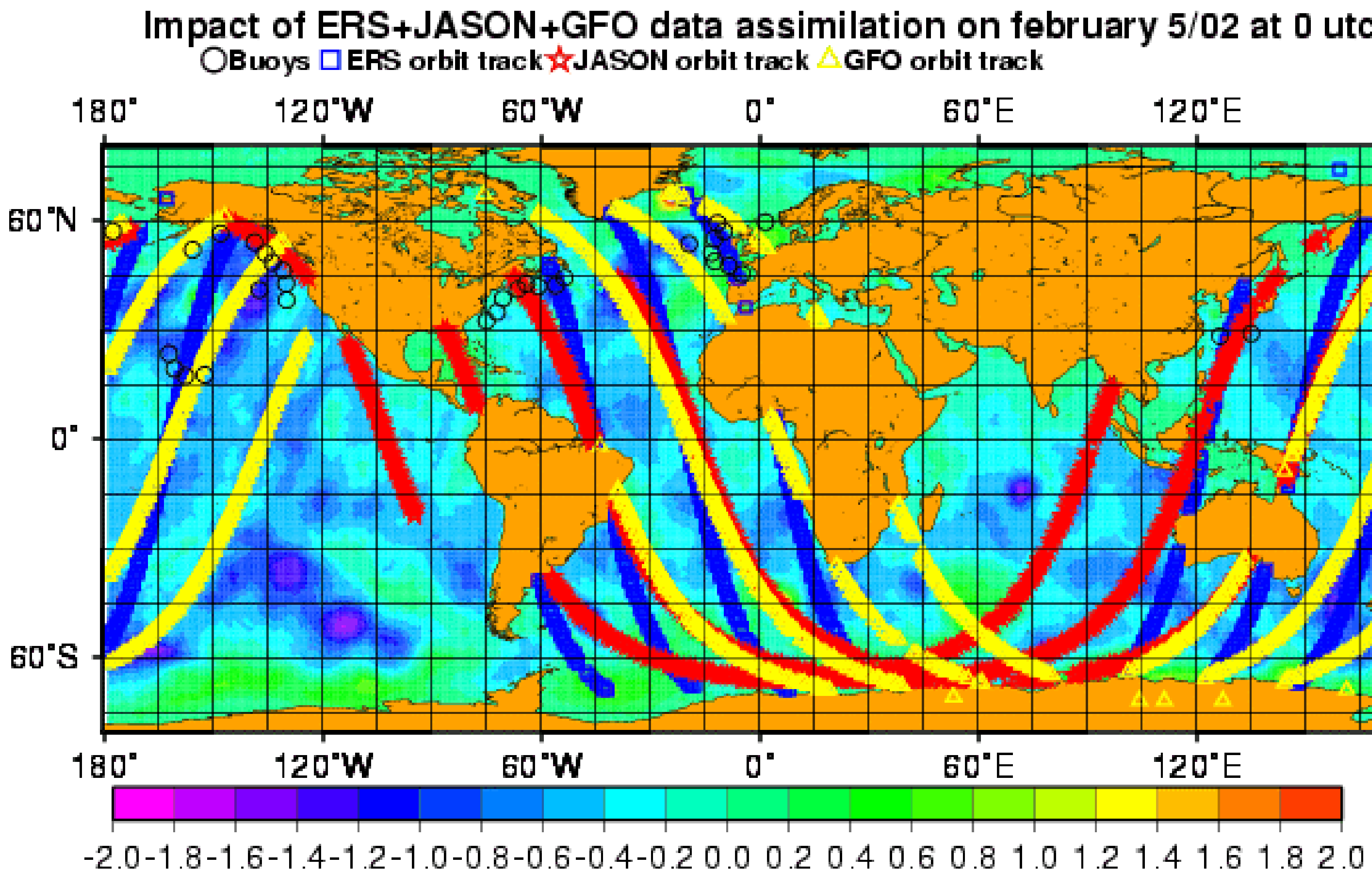
Assimilation period:

- NoAssi (No data)
- ERS2
- ERS2 +JASON
- ERS2+JASON+GFO

Forecast period:

1. Assi-NoAssi
2. Assi-GFO (1,2 alt.)
3. Assi-Buoys (1,2,3 alt.)

Assi of ERS+JASON+GFO – No-Assi



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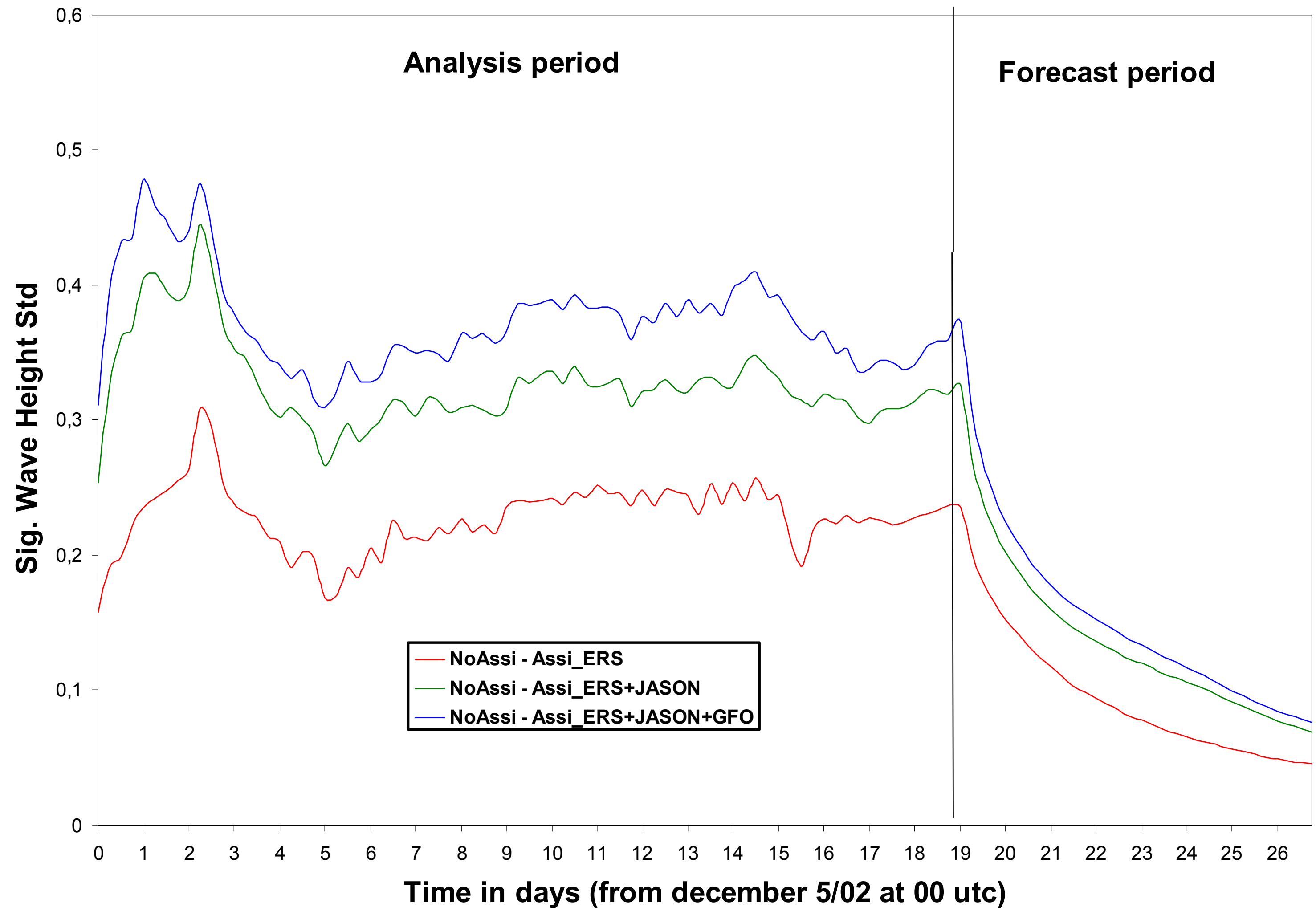

- Any additional altimeter increases the impact of the assimilation

STD (m) time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM and No-Assi . The vertical line marks the end of data assimilation in WAM

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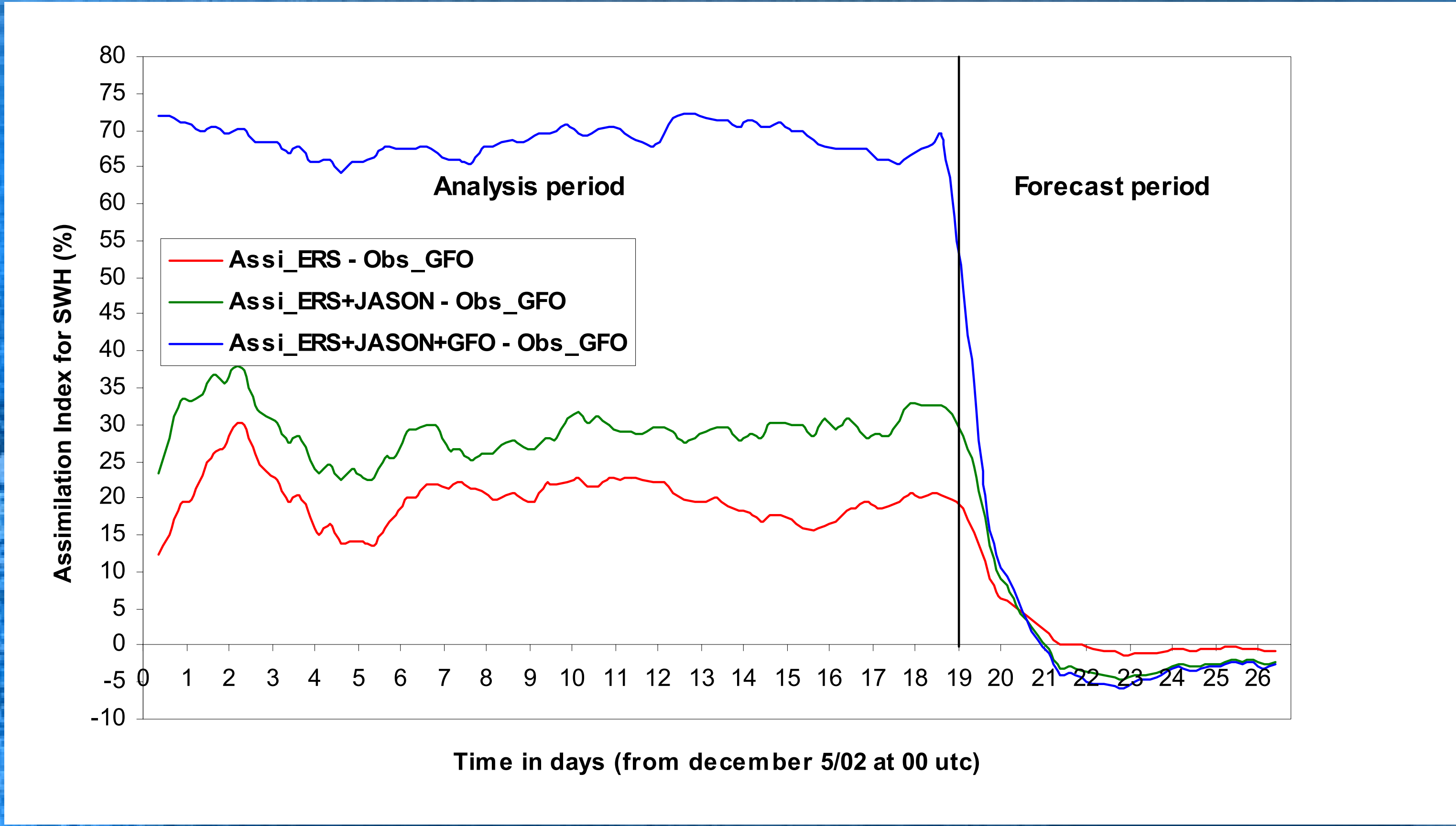
Impact of using,1 or 2 altimeters: Comparison with GFO data



Assimilation Index time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM and of the SWH from GFO data. The vertical line marks the end of data assimilation in WAM.

$$AI = \frac{RMSN - RMSA}{RMSN} * 100(\%)$$

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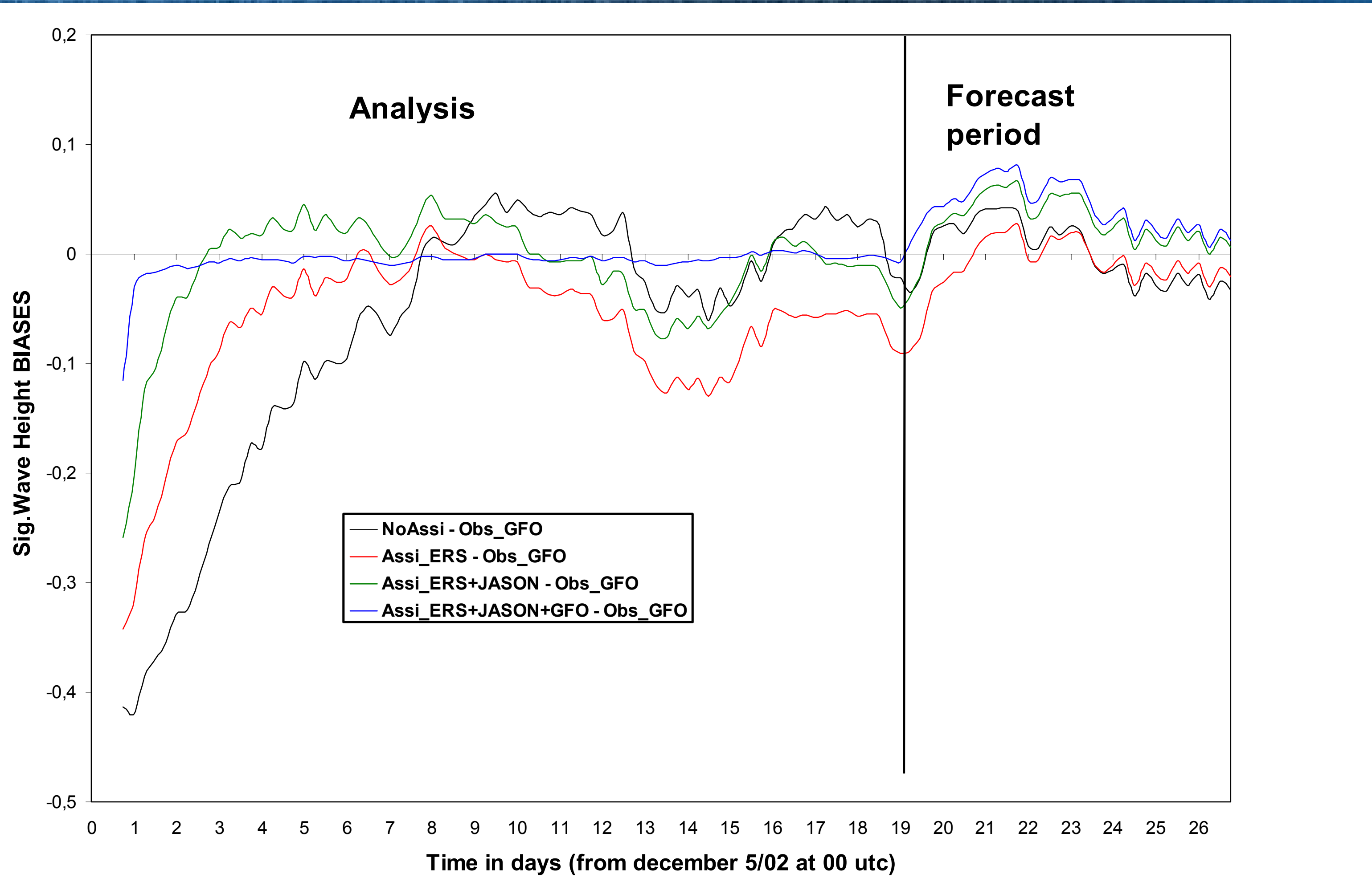
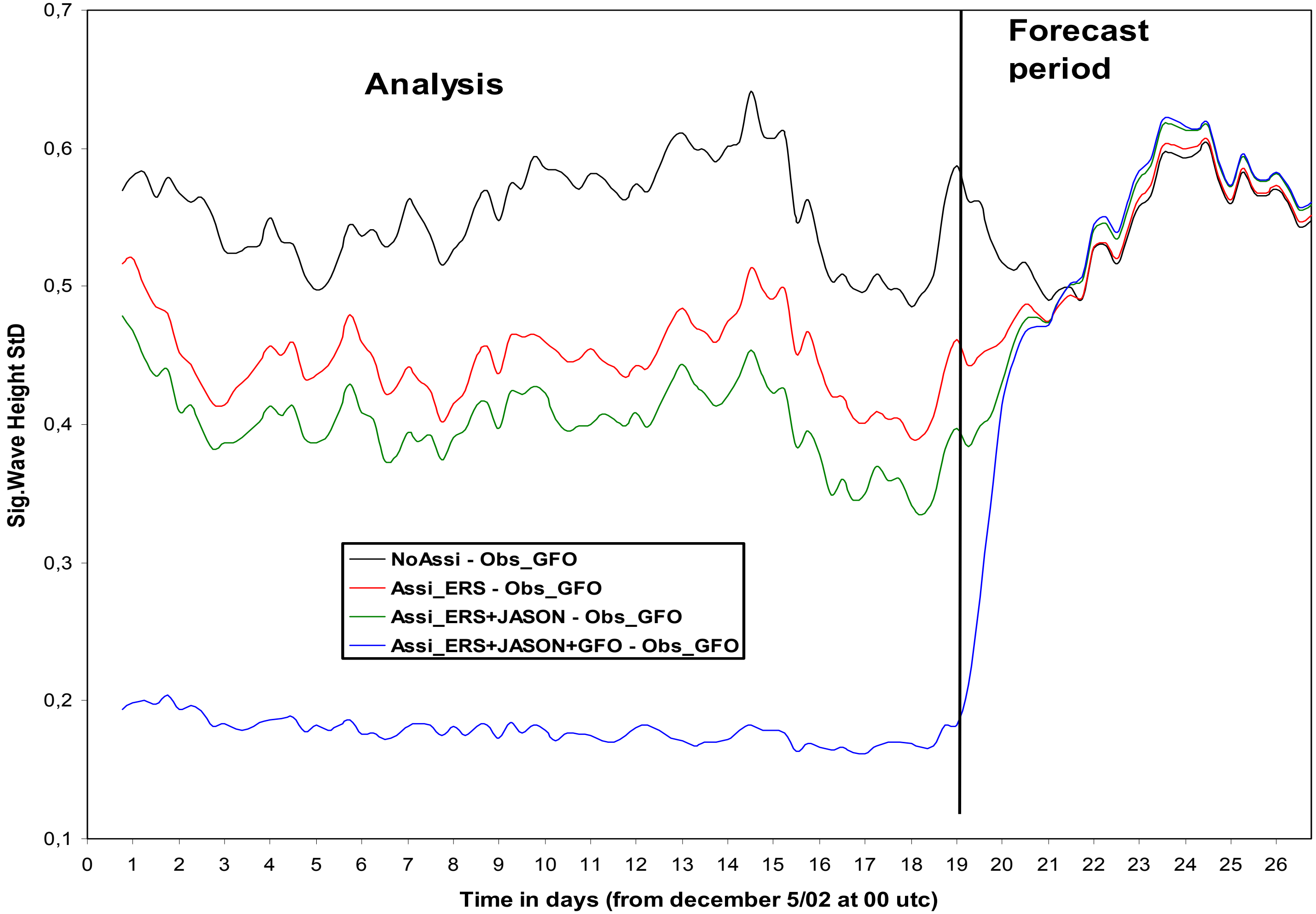


Bias (m) time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM and GFO data. The vertical line marks the end of data assimilation in WAM



STD (m) time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM and GFO data. The vertical line marks the end of data assimilation in WAM

- Significant impact on biases and StD during analysis period.
- In the forecast period, the impact kept longer (>7 days) in term of biases than in term of STD (2 days).

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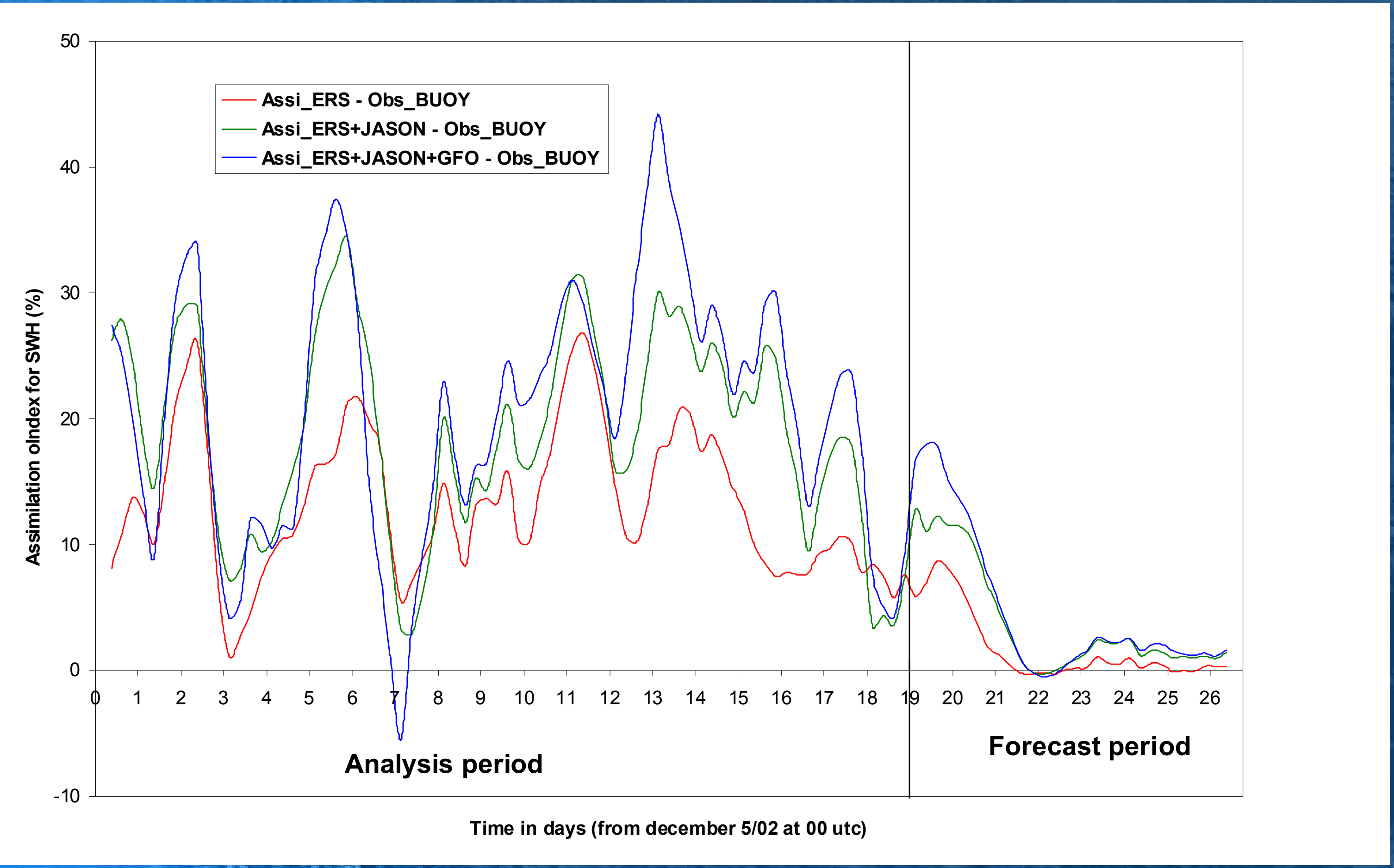
Impact of using,1,2, and 3 altimeters: Comparison with buoy data



Bias time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM of the SWH from GFO measurements. The vertical line marks the end of data assimilation in WAM.

ERS (13%), ERS+JASON (18%), ERS+JASON+GFO (22%)

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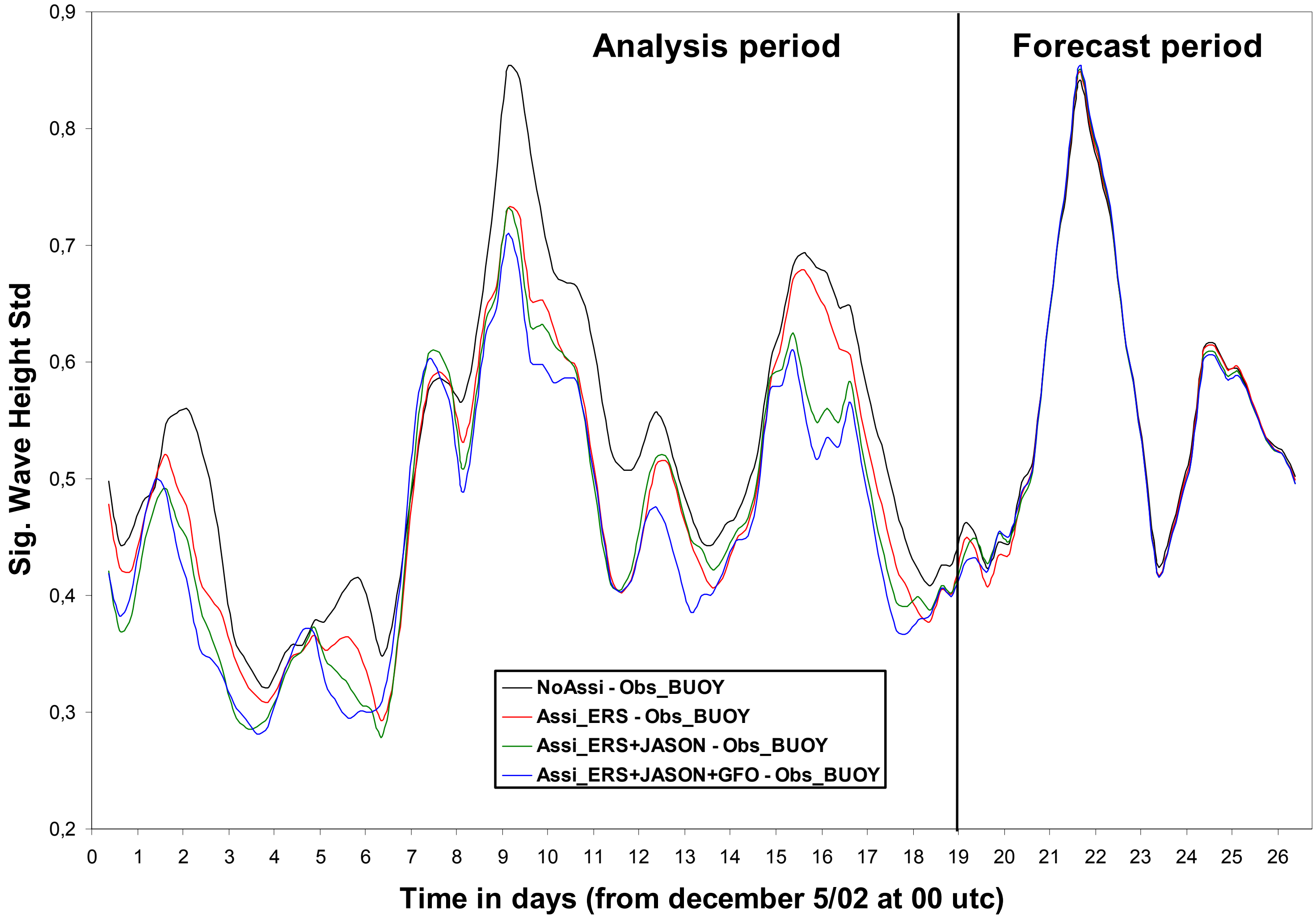

STD (m) time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM and buoys measurements. The vertical line marks the end of data assimilation in WAM

NoAssi (0.58 m), ERS (0.53 m), ERS+JASON (0.52m), ERS+JASON+GFO (0.50m)

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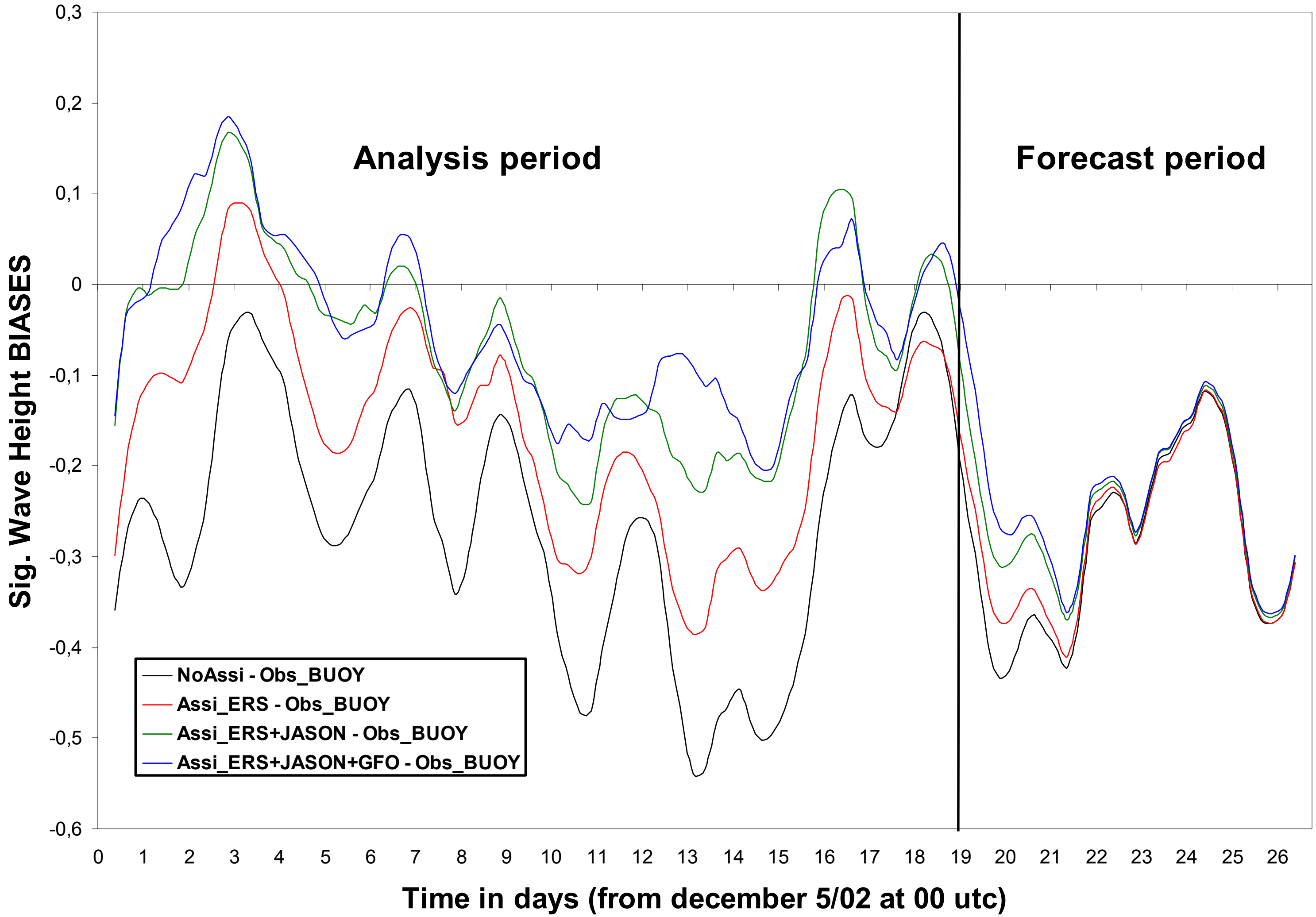

Bias (m) time series of the SWH obtained with assimilation of 1, 2, 3 altimeters in WAM and buoys measurements. The vertical line marks the end of data assimilation in WAM

NoAssi (-0.3 m), ERS (–0.2 m), ERS+JASON (-0.105m), ERS+JASON+GFO (-0.085)

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Summary

The inter-calibration of altimeters is an important issue for improving the analyses and forecasts when using several altimeters.

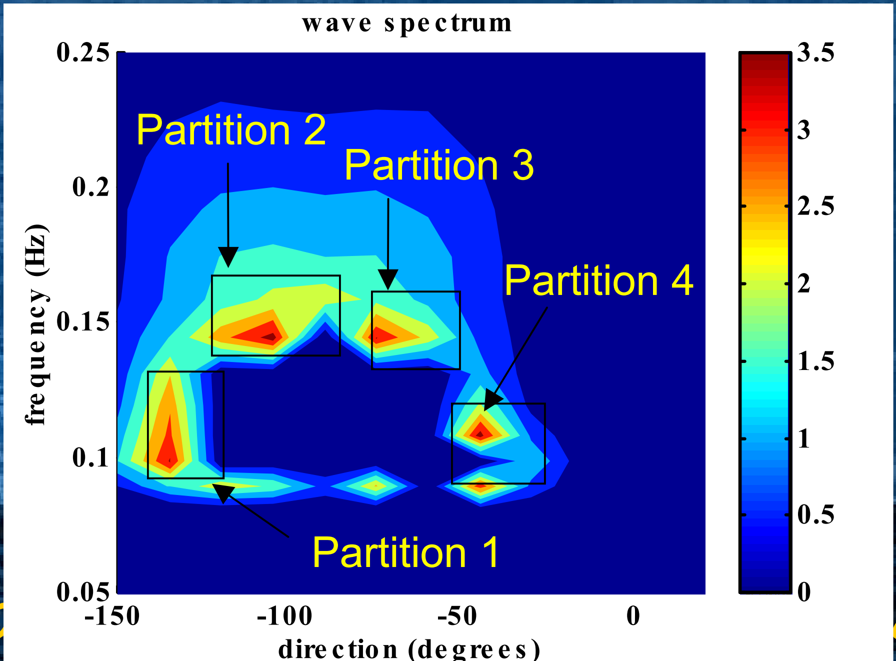
On the average the impact it of 13% with 1 altimeter, 18% with 2 altimeters and 22% with 3 altimeters when buoys are taken as reference.

The impact decreases in time during the forecast period and becomes very small after two days forecast.

According to studies from Aouf et al. 2003, the limitation of the impact of the assimilation of altimeter data in the forecast is partly due to the limited information used with altimeters (only SWH). It has been shown that one can increase the positive impact and its duration when assimilating spectral information, but mainly for the low frequency part of the wave fields (Swells). The high frequency part is strongly driven by predicted winds that are not affected by the assimilation of the data.

2. Description of the assimilation scheme

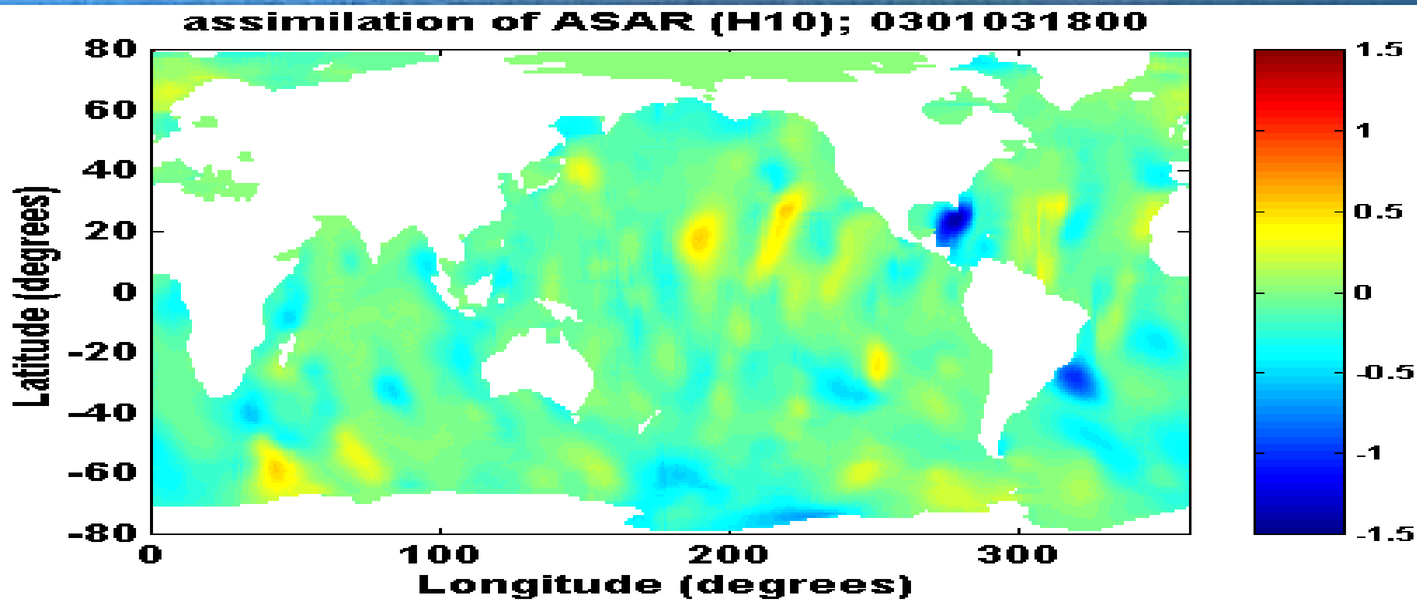
- Decomposition in partitions of the wave spectrum (first guess and observation)
- Cross-assignement between equivalents modeled and observed wave systems (wind sea, swell, mixed sea,…)
- Optimal interpolation on mean parameters of the selected partitions
- Reconstitution of the analyzed wave spectra



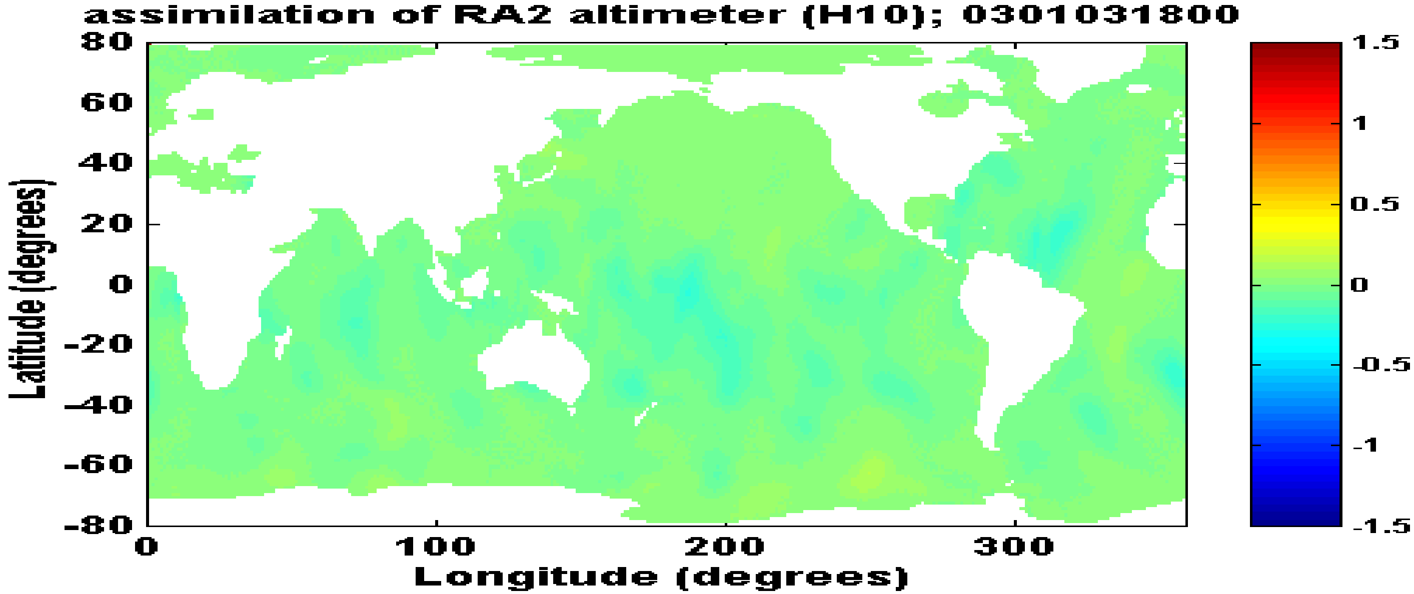
For each partition, mean parameters are computed (energy, direction, frequency)

FORECAST PERIOD

Impact on H10 (swell) 18 hours after the end of assimilation January 3 at 18:00 GMT



Assimilation of ASAR wave spectra



Assimilation of altimeter RA2

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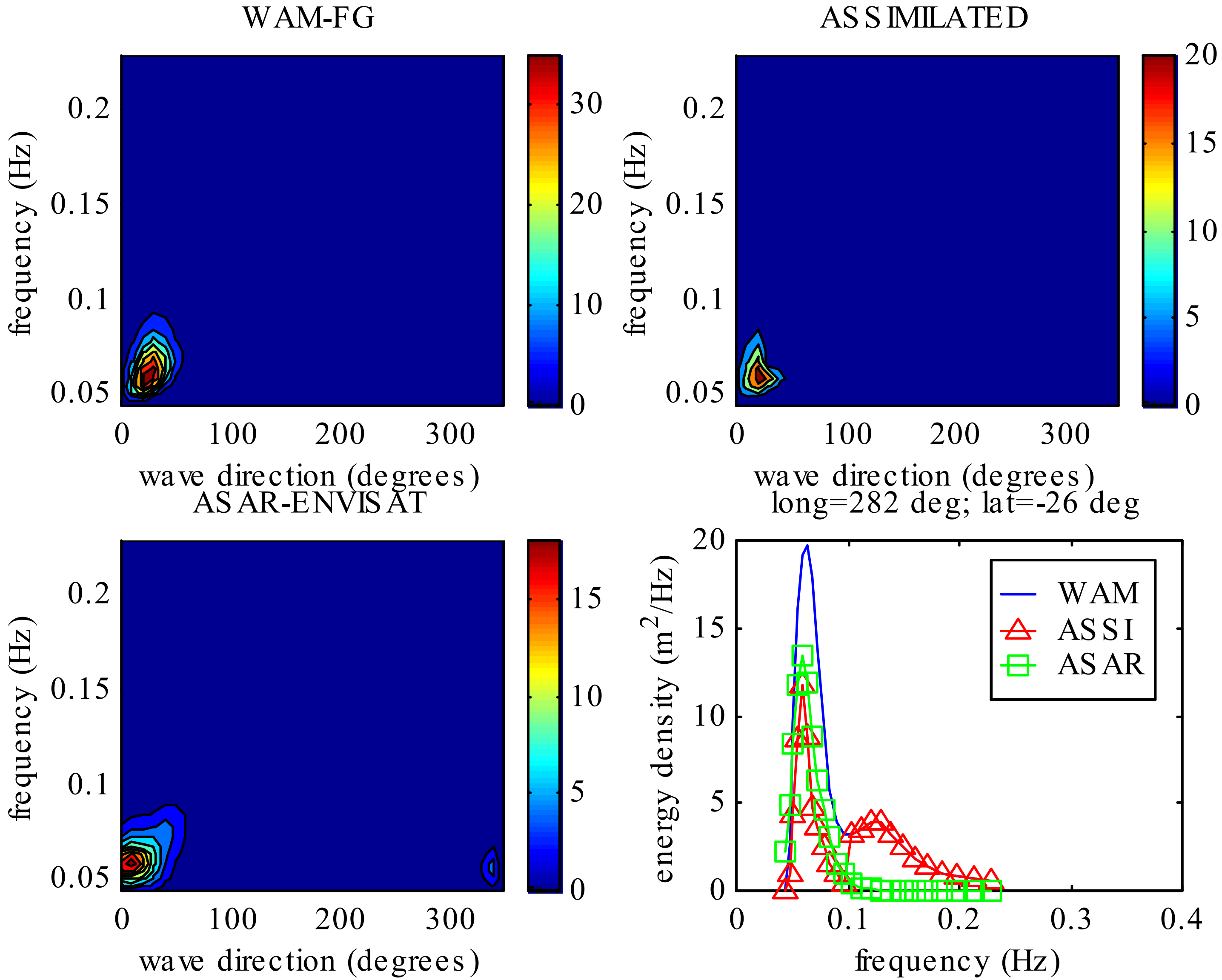
Assimilation of Spectral data (Supported by CNES, col. With CETP and IFREMER)



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Conclusions

→ Interest of multi-altimeters assimilation

→ Interest of spectral information for wave forecasting demonstrated for SWIMSAT type information

→ Confirmed with ENVISAT data, however further tests are under progress to better eliminate spurious spectra from ENVISAT with the use of a larger data set (ESA Inverted spectra from IFREMER and Inverted spectra from DLR).

→ Studies with combined information (swh + spectral) have to be done