ASSESMENT OF AN OPERATIONAL WAVE PREDICTION SYSTEM IN EXTREME CONDITIONS

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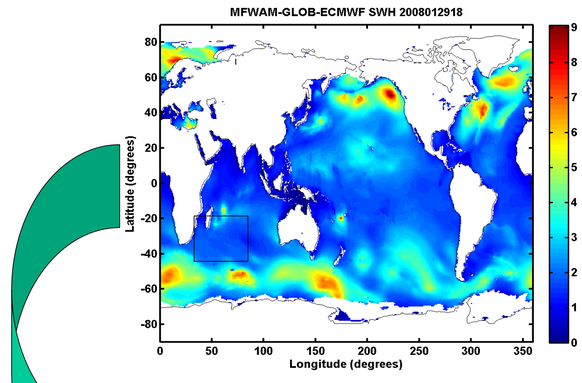
ABSTRACT

Meteo-France, the French National Weather Service is responsible for issuing tropical cyclone warning bulletins over an area covering part of the Indian Ocean, from one of the six tropical cyclone Regional Specialized Meteorological Centres (RSMCs) located at La Reunion island. A limited area Numerical Weather Prediction (NWP) model has been implemented to better forecast tropical cyclone conditions with a dedicated bogusing scheme. In order to forecast the sea-state in this area, an associated new operational wave model has been recently implemented. The new system is based on an improved third generation wave model and has been validated over three tropical cyclone seasons using significant wave height measurements derived from altimeters on board Jason-1, GFO and ENVISAT. Data have been collected, checked and corrected in order to build a consistent and homogeneous altimeter data set suitable for wave model validation. The new system and the validation results are presented here, with a particular attention to extreme wave conditions. Thanks to altimeter data, it is shown that the introduction of a new bogusing scheme in the 3DVAR ALADIN assimilation system has been greatly beneficial. The impact of using other wind input to the wave model, such as produced by ECMWF for wind analyses or by IFREMER for Blended scatterometer products, is also investigated.

- **MFWAM** is the new 3rd generation (3G) model of Meteo-France, derived from ECWAM (ECMWF wave model, Bidlot et al. 2005) modified by the introduction of new parameterizations of wave breaking and swell damping due to air-friction (Ardhuin et al. 2010) in the source fonction S(f,θ) of the balance equation described below for the directional wave spectrum F((f,θ) . It has been implemented first on a global grid with 0.5 °resol ution.



$$\frac{\partial F(f,\theta)}{\partial t} + c_g.\nabla F(f,\theta) + \frac{\partial}{\partial \theta}\left[(c_g.\nabla\theta)F(f,\theta)\right] = S(f,\theta)$$

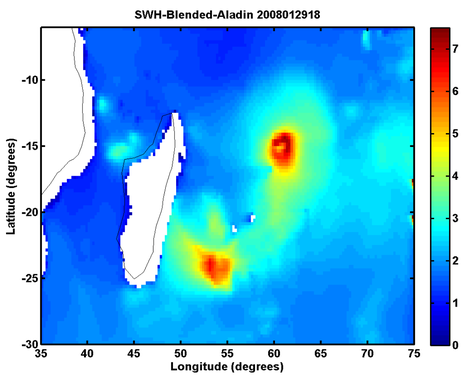
Main changes in the source function:

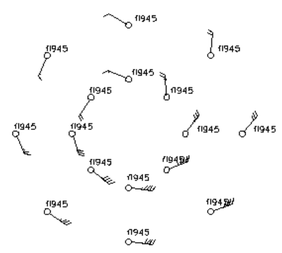
-non isotropic dissipation: better adjustment of mean direction and angular spreading

-wave breaking with threshold mechanism from the saturation spectrum

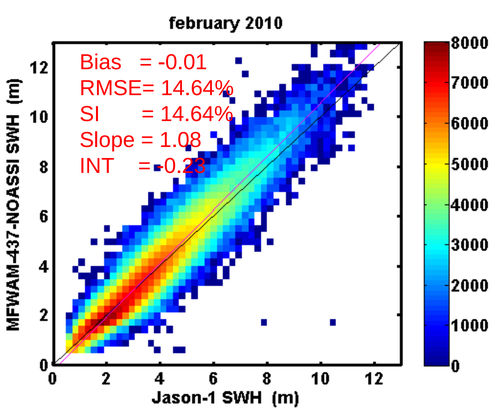
-swell damping due to air friction

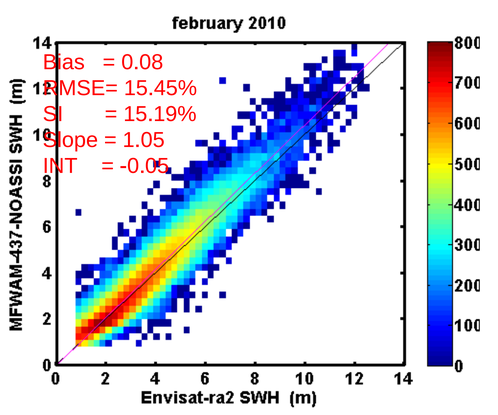
- A limited area Numerical Weather Prediction (NWP) model, ALADIN/REUNION, was implemented at La Reunion in 2006 with hurricane bogusing and has been improved in 2008 with the introduction of a 3D wind vortex based on hurricane advisories issued by la Reunion Hurricane Center. A regional MFWAM wave model nested in the global MFWAM model has been implemented recently, covering part of the Indian ocean with 0.25°resolution. It is driven by ALDIN/REUNION wind s. The vortex wind at one level is illustrated below. Winds calculated from a parametric model are introduced at several levels of the ALADIN model.

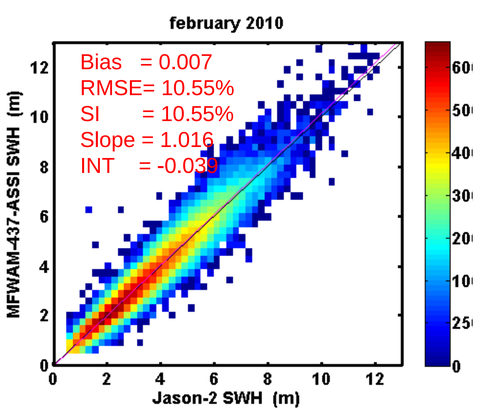


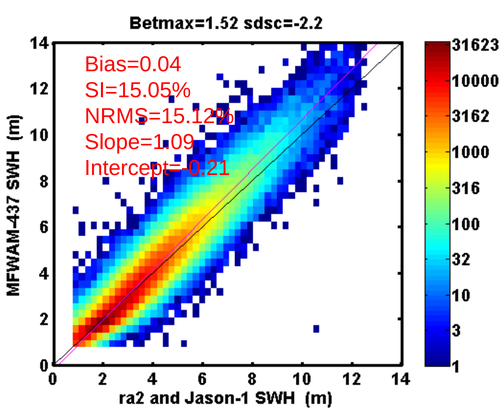


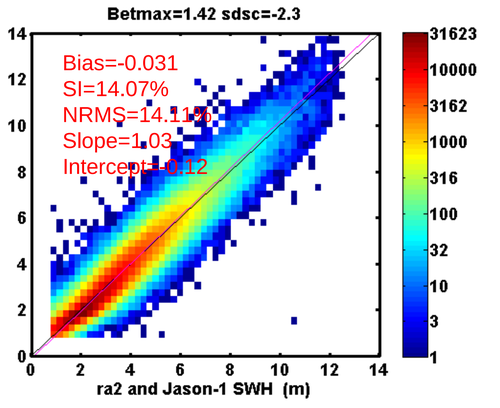
- Data on board TOPEX, GEOSAT Follow-On, Jason and ENVISAT, have been collected, checked and corrected in order to build a consistent and homogeneous altimeter global data base (Queffeulou et al. 2010). Blended winds derived from Scatterometers and NWP analyses (Bentamy et al. 2007) are also available in NRT.





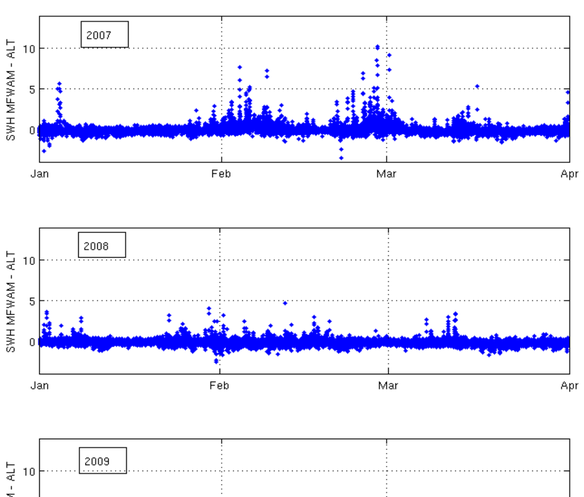


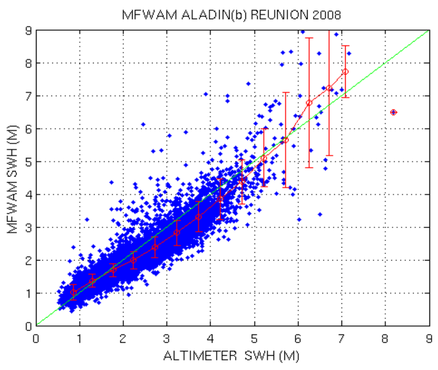


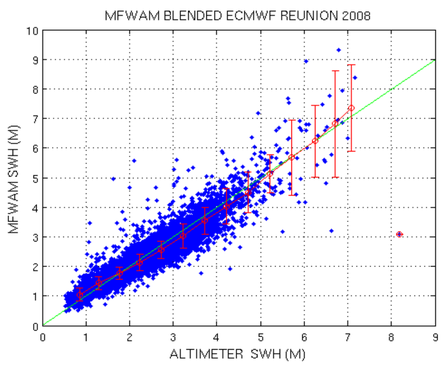


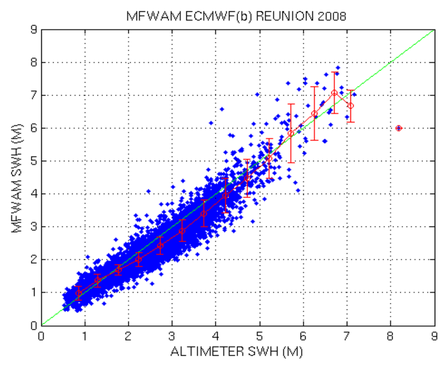
- The impact of data assimilation of altimeter data on board Jason and Envisat has been evaluated. Data from two altimeters has been used in the assimilation period and data from a third altimeter has been used for the validation. Thanks to the assimilation of the two altimeters, the scatter index (relative dispersion of the error) is 10.5% instead of about 15% without assimilation.

Scatter diagram of SWH from MFWAM versus SWH from altimeters. On the left picture, the new parametrization has been calibrated mainly according to buoy measurements. On the right picture, the set of coefficients used in the new parametrization has been calibrated thanks to altimeter data, distributed homogeneously over the ocean.The Scatter Index has been reduced to 14% instead of 15%.

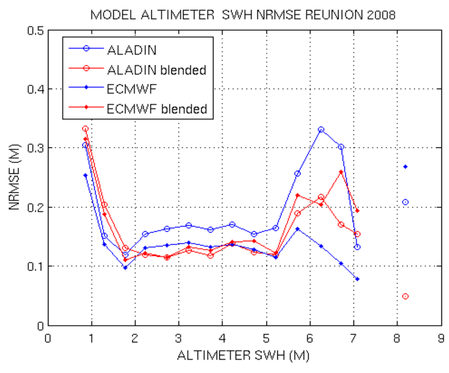


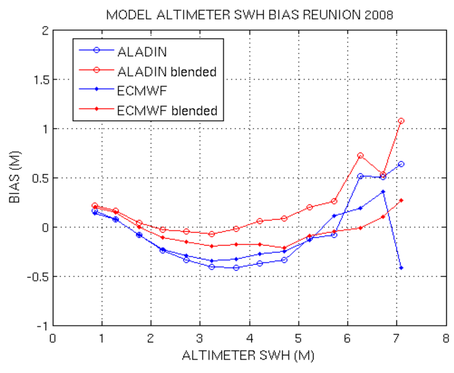


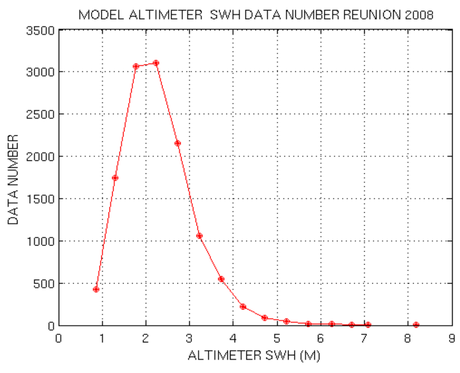




- Scatter diagramm of SWH from MFWAM versus SWH from Altimeters. When using blended winds, the dispersion of the error and the error biases are significantly reduced.







Differences between model and altimeter data 3 tropical cyclone seasons (2007, 2008, 2009). In 2007, before the intoduction of the new bogusing, differences are very high in cyclone vents.

CONCLUSIONS

- The operational wave models MFWAM driven with ALADIN/REUNION over the Indian ocean and driven with IFS/ECMWF winds at global scale have been validated over 3 tropical cyclone seasons, in high winds conditions. In term of error bias and error dispersion, the global model performs slightly better.

- The new parametrization of the wave breaking has been tuned thanks to altimeter data. The error dispersion and error bias have been reduced in comparison with the initial tuning derived mainly from buoys measurements collected during one full year (2007).

- Assimilation of altimeter data has been tested in the new MFWAM model. The reduction of the error is very significant in the analysis period when using 2 altimeters. A third one has been used to estimate the impact of the assimilation.

- Blended winds (Scatterometer + ECMWF wind analyses or Scatterometer + ALADIN wind analyses) have been tested for high wind conditions during 3 seasons (2007-2008-2009). Significant improvements have been noticed when using such blended winds compared with the operational ECMWF or ALADIN wind analyses.

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October 18-21, 2010