Impact of physics upgrades to NCEP's wave modeling suites

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Introduction

The Environmental Modeling Center (EMC) of the National Centers for Environmental Prediction (NCEP) is tasked with providing numerical guidance for forecasts of wind driven short waves for the National Weather Service (NWS). EMC maintains a range of wave modeling suites[1] – the global ocean wave, the hurricane wave, the ensemble wave and the regional Great Lakes wave modeling suites. All of these models are driven by the multi-grid WAVEWATCH III® driver (Tolman, 2008), using the default physics package of Tolman and Chalikov (1996). In the summer of 2012 EMC started upgrading the physics package in its modeling suites. This upgrade is now complete and this document reflects the increase in model skill in the global and hurricane wave systems. The Great Lakes and Ensemble wave modeling systems are reported on in separate documents.

Physics Package

The new physics package that has been implemented in the NCEP operational models is the Ardhuin et al. (2010) physics package. This package uses a wind input term that follows the ECWAM input (Janssen, 2004) very closely, with some reduction for high frequency and high wind input. The dissipation formulation includes a swell dissipation term and a wave breaking term that is made up of a saturation based dissipation term and a cumulative wave breaking term.

Results

A multi-grid modeling system has been in operations at NCEP since the beginning of 2008. This multi-grid system consists of a mosaic of two way nested grids with resolutions ranging from 0.5° – 0.067°. The new physics package was introduced into the global wave model in May 2012. Figure 1 shows the model skill scores since 2008. The skill scores have been computed using month long records

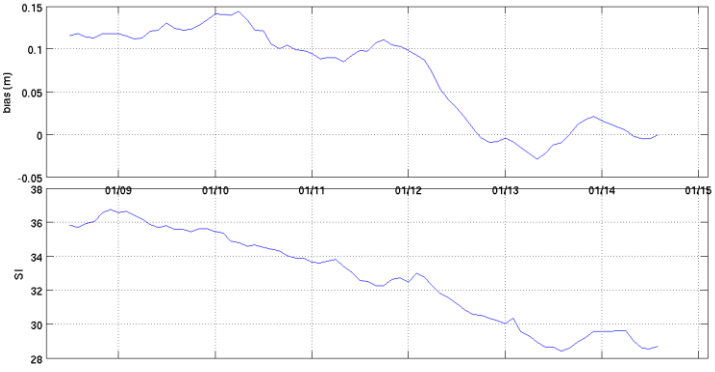

Figure 1: Skill scores of the global wave model for the 72 hour forecast. The x axis represents time as MM/YY.

[1] A new modeling system that is being developed for the near shore region is described in a separate paper

from all the available buoys maintained by the National Data Buoy Center (NDBC). A running average is used to remove seasonal patterns. Skill scores include the model bias and Scatter Index. Overall there has been a regular improvement in model skill due to improvements in wind guidance. However, a big limitation of the earlier physics package in the wave model was the inadequate dissipation of the swell fields, particularly of swells traveling across the Pacific Ocean. The new physics package takes care of this issue as can be clearly seen in the overall reduction in model bias beginning in early 2012. A spatial plot of model biases (figure not shown here) clearly shows this trend.

The new physics package was also introduced into the hurricane wave system, which is driven by a combination of global winds (outside the hurricane domain) and hurricane model winds (inside the hurricane domain). The hurricane domains cover the Western Atlantic (US East Coast) and Eastern Pacific (US West Coast) waters. Figure 2 shows the comparison of the overall wave energy (represented by the significant wave height here) at NDBC buoy 41001 as hurricane Sandy went past the buoy. The overall build up in wave energy is well represented in both physics packages, but the response of the new physics is much better as the eye of the hurricane (indicated by the drop and subsequent increase in wave height) passes near the buoy. This was true at other buoy locations as well as for other hurricanes. Apart from overall wave energy, the new physics package has a much better representation of the wave spectra in the model (figure not shown) leading to a better prediction of swell arrival times.

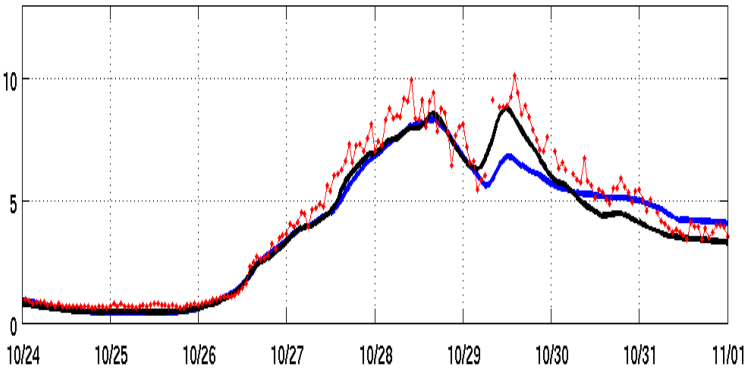

Figure 2: Significant wave height (Hs) at NDBC buoy 41001 during hurricane Sandy. Red - data ; Blue - old physics ; Black - new physics. X axis is time in MM/DD format

In conclusion, the new physics package does a better job in representing the processes associated with wave dynamics across multiple scales and has improved skill scores in all model system suites in operation at NCEP.

References

Ardhuin, F., W. E. Rogers, A. V. Babanin, J. Filipot, R. Magne, A. Roland, A. van der Westhuysen, P. Queffeulou, J. Lefevre, L. Aouf and F. Collard, 2010 : Semiempirical dissipation source functions for ocean waves. Part I: Definition, calibration and validation, *J. Phys. Oceanogr.*, **40**, 1,917 – 1,941

Janssen, P. A. E. M., 2004 : The interaction of ocean waves and wind. *Cambridge University Press.*

Tolman, H. L. and D. V, Chalikov, 1996 : Source terms in a third generation wind wave model, *J. Phys. Oceanogr.*, **26**, 2,497 – 2,518

Tolman, H. L., 2008 : A mosaic approach to wind wave modeling. *Ocean Mod.,* **25,** 35 – 47