

Probabilistic Wave Forecasting and Ensemble-Based Data Assimilation at the US National Weather Service

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The National Centers for Environmental Prediction (NCEP) global wave ensemble system (GWES) has been providing operational wave forecasts for the US National Weather Service (NWS) since 2008. The GWES consists of a 20-member ensemble forced with NCEP-GEFS bias-corrected wind data, and one control run with NCEP's deterministic GFS model. After upgrades undertaken in July 2014, the GWES runs on a spherical grid with $1/2^\circ$ resolution in longitude and latitude, and uses an efficient wave-generation physics package following Ardhuin et al. (2010). The current system provides high-quality deep-water wave forecasts, also generating products for applications in nearshore areas and under hurricane forcing conditions, a feature that results from a close interaction between three NCEP centers: the Environmental Modeling Center (EMC), the National Hurricane Center (NHC), and the Ocean Prediction Center (OPC). An example of output from the GWES¹ is provided in Figure 1.

NCEP Global Wave Ensemble Run 2015/03/31 6Z: 240h Forecast
Ensemble Hs Mean (contour,m) and Spread (shaded,m) 2015/04/10 06Z

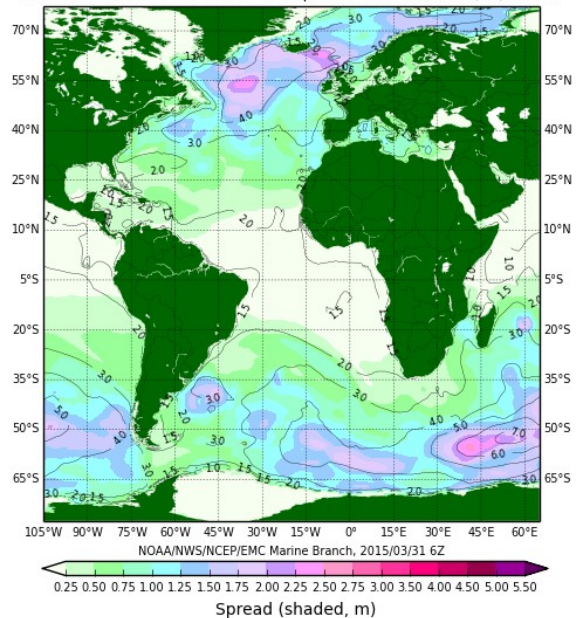


Figure 1 Graphical output from the GWES for 31 Mar 2015

Since 2011, the NWS and the US Navy have combined outputs from their global wave ensemble systems into the first operational multi-center forecast system providing probabilistic ocean wave forecasts. Products from the NCEP/FNMOC Combined Wave Ensemble (NFCENS) are distributed by the NWS and made available to the general public. Computed from 41 combined wave ensemble members, the new product outperforms deterministic and probabilistic forecasts and nowcasts of significant wave heights (Hs) issued separately at each forecast center, at all forecast ranges. Detailed results are described in Alves et al. (2013).

¹ GWES forecasts are made available via <ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/wave/prod/> and <http://polar.ncep.noaa.gov/waves/viewer.shtml>.

The successful implementation of the NFCENS has brought new opportunities for collaboration with Environment Canada (EC). EC is in the process of adding new global wave model ensemble products to its existing suite of operational regional products. The planned upgrade to the current NFCENS wave multi-center ensemble includes the addition of 20 members from the Canadian WES. With this upgrade, the NFCENS will be renamed the North American Wave Ensemble System (NAWES). As part of the new system implementation, new higher-resolution grids and upgrades to model physics using recent advances in source-term parameterizations are being tested.

Through a collaboration with the Argentinian Naval Hydrographic Service, NCEP is developing an ensemble-based data assimilation system, consisting of an implementation into the GWES of the 4D-LETKF proposed by Etala et al. (2015). The 4-D scheme initializes a full 81-member ensemble in a 6-hour cycle. The LETKF determines the analysis ensemble locally in the space spanned by the ensemble, as a linear combination of the background perturbations. Observations from three altimeters and one scatterometer are used. Preliminary results from a prototype system running at NCEP are shown in Figure 2. Note that the LETKF allows for introducing innovations to the analysed wave heights over a wider region than other conventional data assimilation approaches, which is a welcome feature considering the usually sparse wave data available globally.

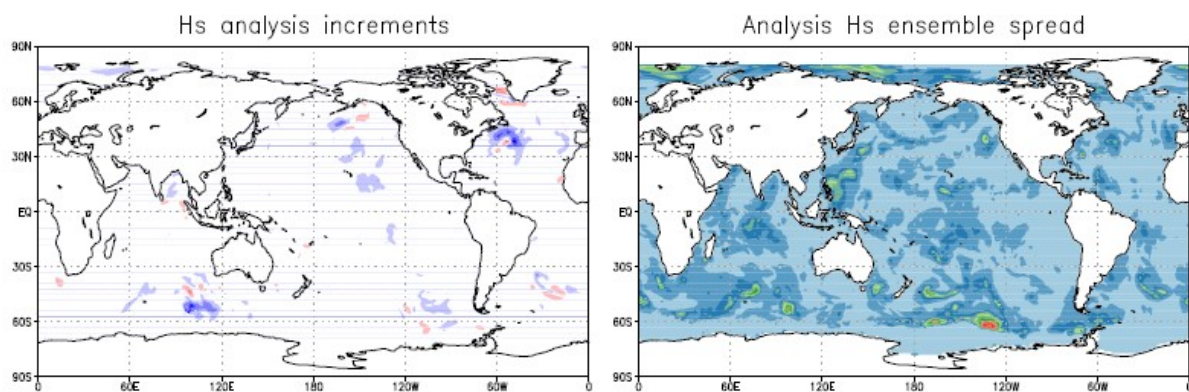


Figure 2 LETKF analysis increments for the ensemble mean significant wave height, 18 Sep 2014 00UTC.

References

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