# Inclusion of Significant Wave Height Analysis to NCEP's UnRestricted Mesoscale Analysis (URMA)

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## Introduction

The National Centers for Environmental Prediction (NCEP) of NOAA provides weather guidance to the United States National Weather Service (NWS), according to the demands of our customers and the public. In this effort, two significant components of NWS operations are combined: wind-wave predictions and NCEP's UnRestricted Mesoscale Analysis (URMA). The approach is currently being developed at NCEP's Environmental Modeling Center (EMC).

From one side, NCEP's operational wave guidance products are provided at global and regional scales, within both deterministic and ensemble-based systems, e.g. [1-4]. NCEP's operational wave prediction systems are implementations of the WAVEWATCH III (WW3) model [5]. Currently the suite of operational wave systems does not include an assimilation nor an analysis component. From the other side, NCEP's Real Time Mesoscale Analysis (RTMA) [6] and its extension, URMA, both provide the highest quality gridded surface analysis. The latter systems are under continuous development to improve the analysis and, more often, to add new analysis variables to match those forecasted in the National Digital Forecast Database (NDFD) [7].

The expansion of URMA to include wave-height analyses is part of a broader effort, which aims at developing data assimilation and analysis components in NCEP's operational wave models. The project involves EMC scientists from the marine and mesoscale atmospheric branches, and its objective is to offer a new, high-resolution significant wave height (Hs) analysis product for the URMA domains to its customers and the general public.

## The Wave-Height component of URMA

URMA is an extended run of the RTMA, run six hours later in order to incorporate observations that arrive after the RTMA deadline. Both are high spatial (2.5km) and temporal (1h) resolution analysis systems for near-surface weather parameters. Their main component is NCEP's Gridpoint Statistical Interpolation (GSI) system [8] applied in two-dimensional variational mode, to assimilate in-situ and satellite-derived observations. As the Hs is a two-dimensional field, the URMA may be naturally extended in order to be used for its analysis [9].

In this framework, the GSI has been updated accordingly, in order to be compatible with the requirements for Hs analysis. A module for importing altimeter Hs measurements from three satellites (Jason-2, CryoSat-2 and Saral/Altika) has been introduced, including a multi-step quality control (QC) procedure based on the signal properties themselves, but also on the expected physical properties of the wave field. For the in-situ measurements of Hs (buoys and ships), the PREPBUFR format is used, as for the majority of conventional observational data for assimilation at NCEP. For all the data a gross error check is applied. In addition, for the extension of URMA to include the Hs analysis, the GSI code has been modified to accept variance and correlation lengths that vary in both spatial dimensions: latitude and longitude.

In its initial development phase, the URMA-Wave prototype has been implemented for the coastal areas around the continental US. The background Hs is provided by NCEP's global deterministic wave model system (Multi-1), which is interpolated to the URMA grid through a combination of linear and nearest neighbor interpolation. Multi-1 is forced with GFS winds and NCEP's high-resolution ice-analyses, as described in [1]. The background and error parameters of the covariance functions have been estimated based on two years of model and buoy data. The cycling of the Hs analysis is hourly, following the cycling of the rest of the URMA variables, and uses measurements and predictions from the last 3h before the analysis.

## Conclusions and Operationalization of URMA-Hs

As this is a new effort for wave data analysis and assimilation at NCEP, important groundwork was done in all components of the DA system, including standardizing the satellite altimeter data stream, developing a data quality control process, updating the GSI system, exporting and interpolating the Hs from WW3 and estimating the background and error inputs necessary for the URMA-Wave. Most of these steps will also be used in other components of a broader wave DA system which are under development, including a local ensemble transform Kalman filter (LETKF) probabilistic wave analysis and multi-dimensional variational analysis systems.

Currently, URMA-Hs runs only for the oceanic areas associated with URMA's CONUS domain, but after tests of its components and validation of the analysis, it will also be implemented for all domains distributed under the NDFD, including Puerto Rico, Hawaii, Guam and Alaska. The new URMA-Hs product is scheduled to be launched operationally with the next RTMA upgrade cycle, currently scheduled to be completed by December 2016.

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