Hourly Analysis of Significant Wave Height by the UnRestricted Mesoscale Analysis System at NCEP

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Introduction

The National Centers for Environmental Prediction (NCEP) of NOAA provide weather guidance to the United States National Weather Service (NWS). The UnRestricted Mesoscale Analysis (URMA) is designed as an extension to the Real-Time Mesoscale Analysis System [1] to provide the most accurate, gridded analysis of near-surface sensible weather elements, cloud fields, and significant wave height (SWH) with a six-hour lag. The URMA products are disseminated to forecasting offices, serve as the *analysis of record* for the National Digital Forecast Database [2], and are used in calibrating the National Blend of Models [3]. Since version 2.6, implemented in December of 2018, the URMA has provided a SWH analysis for the Contiguous United States (CONUS) [4]. This paper explores the expansion of URMA for SWH to Alaska (AK), Hawaii (HI), and Puerto Rico (PR) – the OCONUS – domains, as well as the system upgrades in the next URMA generation, version 2.7.

URMA System for Significant Wave Height

URMA is a two-dimensional application of the community Gridpoint Statistical Interpolation (GSI) data assimilation system [5], which was recently upgraded to provide an analysis of SWH. The nominal spatial resolution of the analysis is 2.5 km for CONUS, HI, and PR, and it is 3 km for AK. SWH observations are currently assimilated from five satellites: Jason-2 and -3, Cryosat-2, Saral/Altika, and Sentinel-3; and also from in-situ SWH (buoys, drifters, and ships of opportunity). The background field is provided by the operational deterministic wave prediction system, known as multi_1, based on the WAVEWATCH III® model [6]. The preprocessing of the background is independent of the prediction system; and is based on the wgrib2 utility [7], which primarily involves interpolating and re-projecting the SWH background field on the appropriate URMA domain. Advantages of this upgrade include i) a significant reduction of the preprocessing time, by approximately ten times, and ii) the GSI can provide analysis of SWH with background fields from any wave model or blend of SWH predictions, even with different resolutions.

The default GSI background error properties were also calibrated for nearshore applications; the error variance is set to $0.4 m^2$ and the correlation length 150km. For the four URMA domains, both variance and correlation lengths were estimated locally and provided through external files. An analysis of monthly model prediction and buoy data for 2015 and 2016 provided the estimated values of the background error. The length of the temporal window of the analysis is 3 hours according to the estimated temporal decorrelation length and the real-time availability of the SWH observations.

Analysis of Significant Wave Height for OCONUS

The URMA was deployed and calibrated for the three URMA OCONUS domains. The analysis was verified regarding bias and Root Mean Square Error (RMSE). As expected, the error statistics of the analysis are significantly reduced in comparison with the error statistics of the background field, Figure 1. One limitation is the small number of observations, for instance for PR, there are only three permanent, nearshore buoys and no satellite coverage.

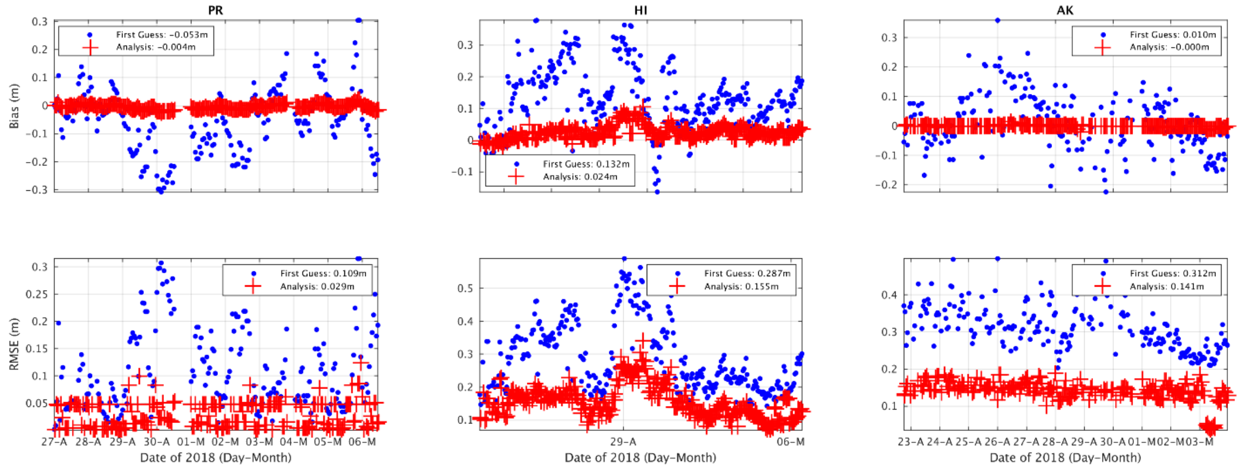

Figure 1. Time series of error statistics (top: bias, bottom: RMSE) for PR, HI and AK (from left to right), of the first guess (blue) and the analysis (red).

Summary

With the next upgrade of NCEP's mesoscale analysis systems tentatively scheduled for the first quarter of 2019, URMA will provide analysis of SWH for most domains of the NWS (CONUS, AK, HI and PR) and it will satisfy a long-awaited request by forecasters and others stakeholders. As the first effort in wave data analysis at NCEP, major operational components were upgraded to achieve these results from the URMA. These upgrades include the standardization of the wave data streams and modifications to the core of the GSI and to the pre- and post-processing of the URMA.

For all the domains, the difference between the analysis and observations was significantly decreased in comparison with the difference of the background field from the observations. The average bias is in principle 0 m and the RMSE is reduced more than 50 percent, lying at the order of the observations' uncertainty. The limiting factor for increasing the accuracy of the analysis is the lack of observations and the location of the existing observations especially for the smaller domains (HI and PR), where satellite observations are less frequent.

By adding the SWH to URMA, the main benefit for the research and operational communities is the development of a complete and transferable methodology for the analysis of SWH. Additional benefits include that it is based on publicly available, community software, follows well laid out steps, has undergone extensive testing in four different operational configurations, and is relatively computationally efficient.

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