Validation of GFS/GEFS-wave Prototypes

Matthew Masarik[1], Ricardo Campos[2], Jessica Meixner[3], Ali Abdolali[4], Saeideh Banihashemi[1], Ali Salimi-Tarazouj[1], Avichal Mehra[3]

[1]Lynker at NOAA/NWS/NCEP/Environmental Modeling Center [2]CIMAS at NOAA/AOML [3]NOAA/NWS/NCEP/Environmental Modeling Center [4]Formerly at Lynker at NOAA/NWS/NCEP/Environmental Modeling Center

matthew.masarik@noaa.gov

Introduction

- The spectral wave model, WAVEWATCH III (WW3), is a component in the current version of NOAA's deterministic forecast suite, the Global Forecast System (GFS), and the ensemble forecasting suite, the Global Ensemble Forecast System (GEFS).
- Prototype simulations testing new development capabilities leading up to the next versions of GFS/GEFS are routinely conducted.
- This poster looks at the performance of WW3 in the recent prototypes, using a Python-based statistical validation package, called WW3-tools.
- This package is being developed at the NOAA/NWS National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC) in collaboration with the Cooperative Institute for Marine & Atmospheric Studies (CIMAS), and was designed for validating and visualizing WW3 simulations.
- National Data Buoy Center (NCBC) and Copernicus data sets can be used for point output validation, and altimeter mission data for verifying gridded output.
- The performance of WW3 will be assessed by validation of the wave significant height field (Hs) and the wave spectrum at buoy locations.

Unified Forecast System

- The Unified Forecast System (UFS) is a community-based, coupled, comprehensive Earth modeling system. It spans applications from regional to global and multiple forecast horizons. This poster is focusing on the UFS model, using the global, coupled applications targeting the operational Global Forecast System (GFS) and the Global Ensemble Forecast System (GEFS).
- The targeted model for both systems is a coupled atmospheric model using the FV3 dynamical core and the Common Community Physics Package CCPP, the ocean model MOM6, the Community Sea Ice Model (CICE6) and the WAVEWATCH III model. For the ensemble application the aerosol model GOCART is also included, but results are not shown here.
- The wave model sends feedback to the atmospheric model via the surface roughness and sends Stokes drift to the ocean model.

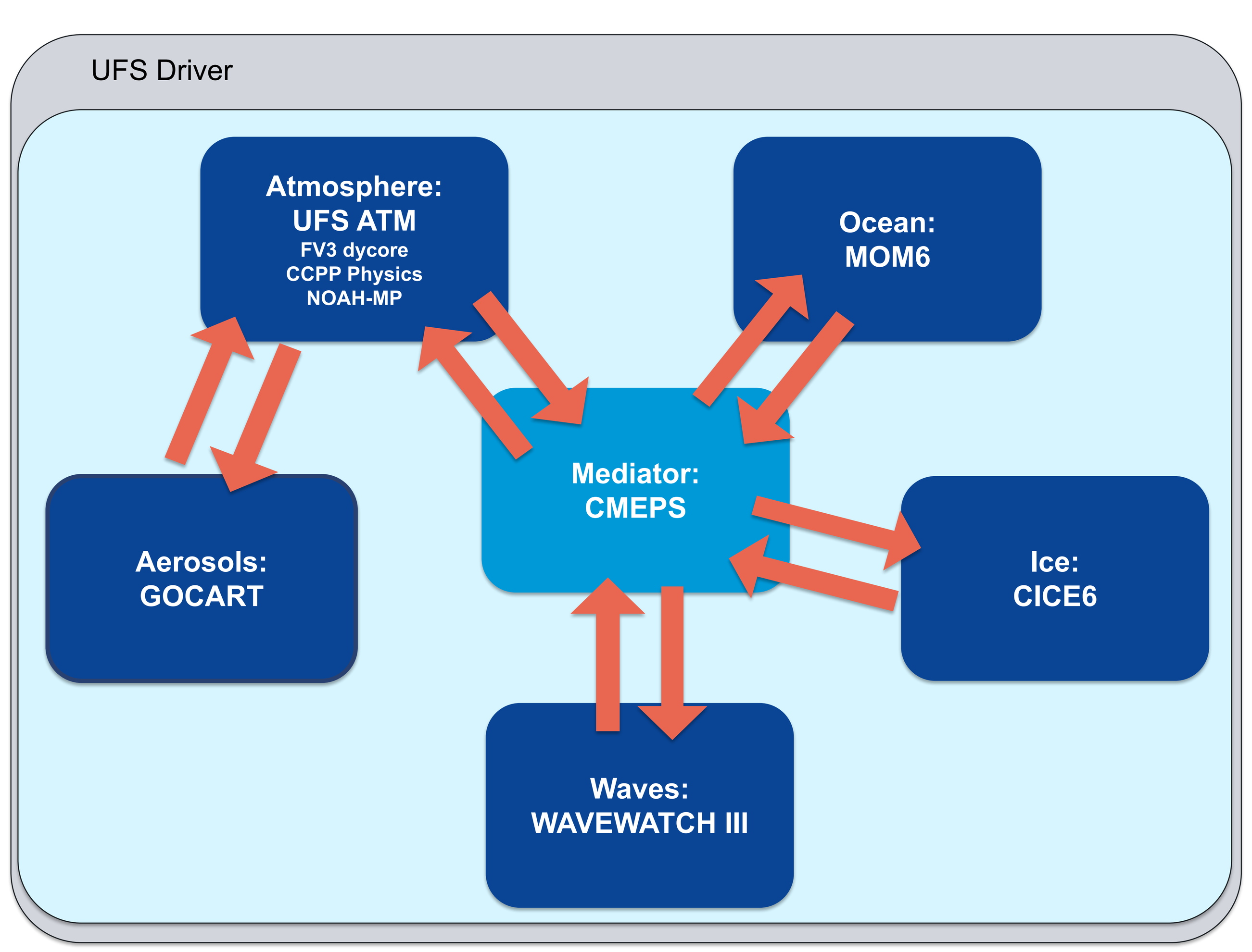

Figure: A schematic diagram of the global coupled UFS model.

High Resolution Prototypes

- To prepare for GFSv17, a series of prototypes experiments will be conducted. This poster shows results from HR1 as HR2 has just completed.
- The wave model in these prototypes are a 1/4° tripolar grid and is using ST4 physics. Future prototypes will move to unstructured grids.
- The high resolution prototypes cover three periods:
  - *Winter:* Dec. 03, 2019 – Feb. 25, 2020, cold start forecasts at 00Z cycle every 3 days, 16 day forecast
  - *Summer*: June 1– Aug. 30, 2020, cold start forecasts at 00Z cycle every 3 days, 16 day forecast
  - *Hurricane*: July 20, 2020 – Nov 20th, 2020, cold start forecasts at 00Z cycle everyday, 7 day forecast

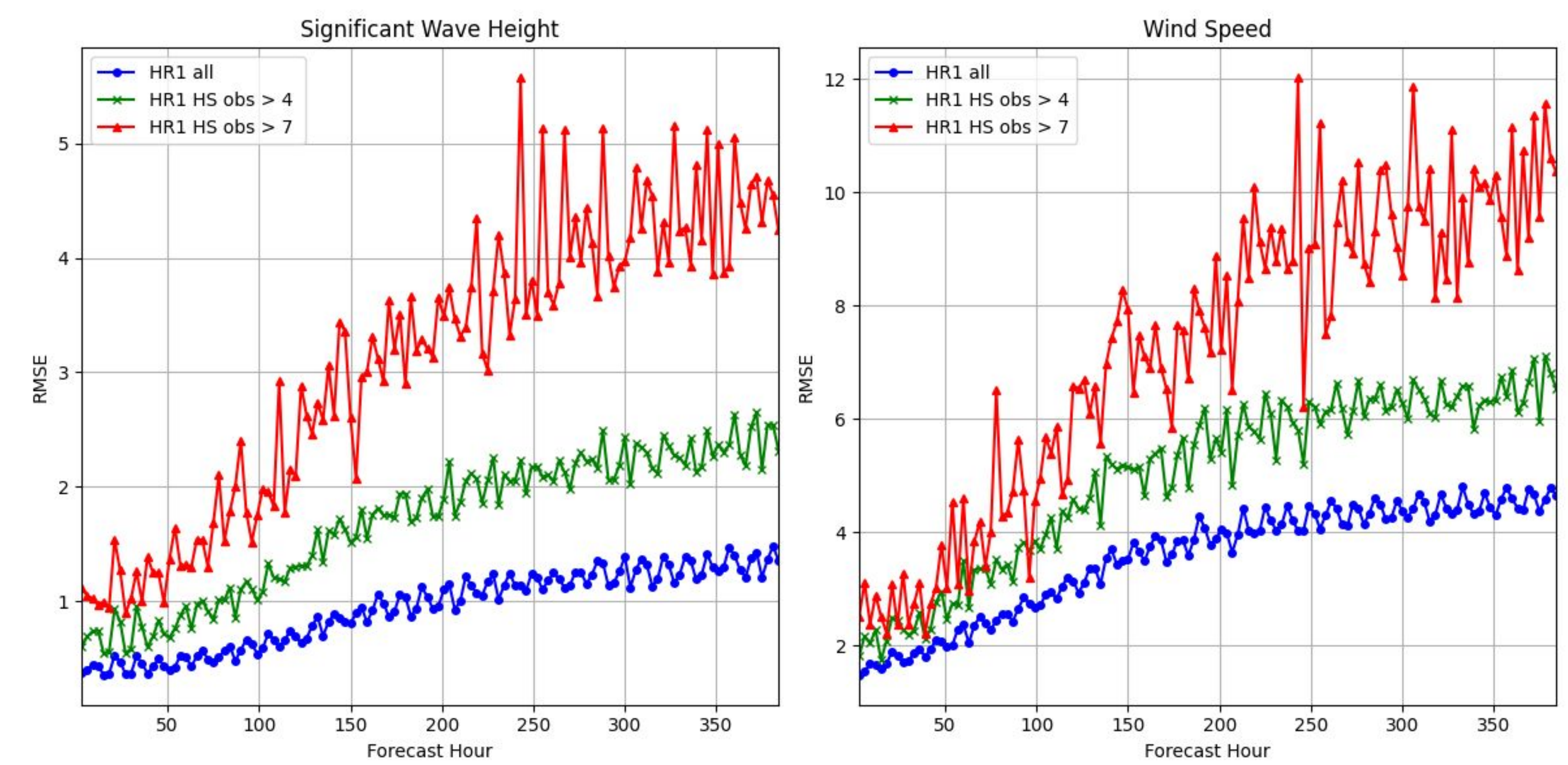

Figure: These figures show Root Mean Square Error (RMSE) of HR1 *winter* results of Significant wave height and wind speeds comparing against satellite observations. We have subdivided the results for significant wave height categories to better understand the model performance in areas with high seas.

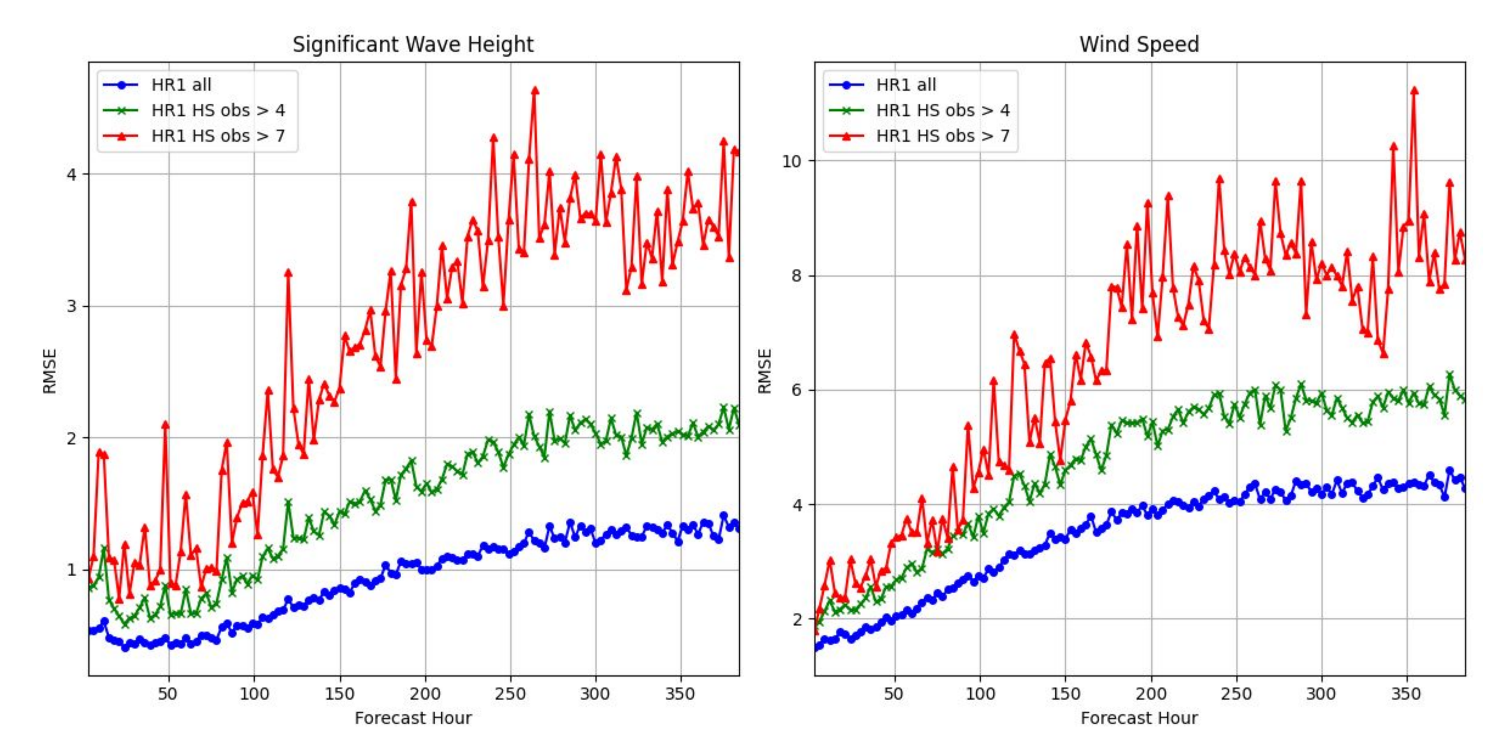

Figure: These figures show Root Mean Square Error (RMSE) of HR1 *summer* results of Significant wave height and wind speeds comparing against satellite observations. We have subdivided the results for significant wave height categories to better understand the model performance in areas with high seas.

- Summary :
  - The initial condition sources are slightly different for Winter and Summer and we will look to improve on Summer initial conditions.
  - Additional work will continue to expand the validation and prepare for future unstructured grids.
  - Lastly, we will look to improve the performance of the wave component before the operational implementation and increase the model resolution to something closer to what is expected for operations.

Ensemble Prototypes

- To prepare for GEFSv13, a series of prototypes have been run to test various updates of the model and configuration. The latest is "EP4" and some example validation updates are shown here. EP4 is a coupled global UFS model with atm-ocn-ice-wav components.
- EP4:
  - Time span covers 3 years: Fall 2017-Summer 2019 + Fall 2020 - Summer 2021
  - The wave model is 1/4° grid and is using ST4 physics and the same parameters as GEFSv12

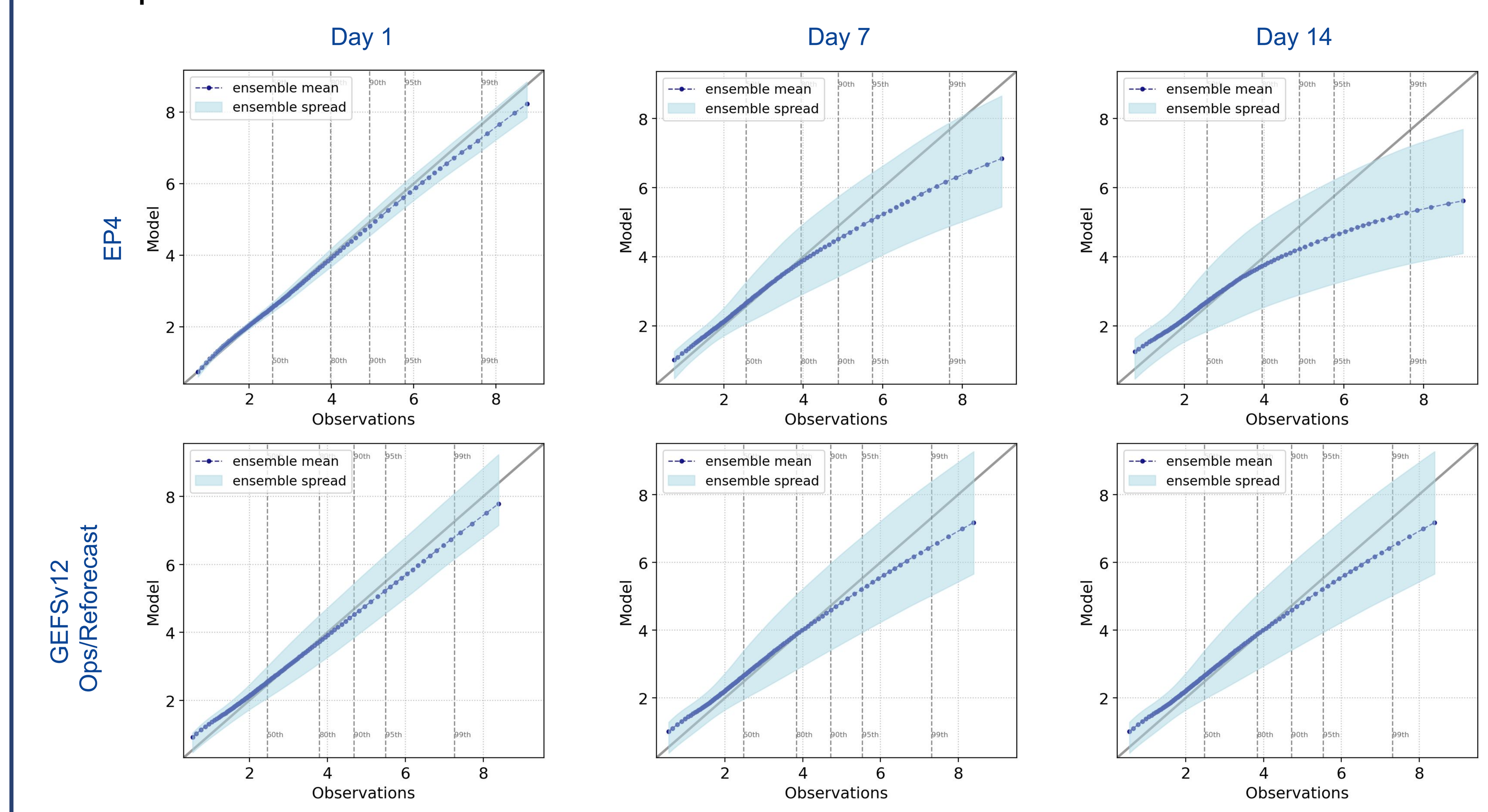

Figure: The following shows Q-Q plots of Significant Wave Height. The top row is the EP4 model output and the bottom row is a combination of GEFSv12 reforecast (2017-2019) and GEFSv12 operations (2020-2021). The observations used for comparison is JASON3 and NDBC buoys.

Summary and Future Work

- The WAVEWATCH III model is included in multiple UFS applications including coastal, hurricane and global applications. The wave model is currently in operations in GEFSv12, GFSv16 and HAFSv1.
- The wave component in the UFS can feedback to ocean and atmospheric components in hurricane and global models and to the surge model in coastal applications.
  - Future applications could include coupling to additional components (aerosols, ice) and including nearshore or lake models in other applications.
- Work is ongoing to improve both the wave component and the full coupled model for the the future operational implementations of GEFSv13 and GFSv17
- We continuously are looking to improve our validation techniques and expand our existing tools.

References

The WAVEWATCH III® Development Group (WW3DG), 2019: *User manual and system documentation of WAVEWATCH III® version 6.07*. Tech. Note 333, NOAA/NWS/NCEP/MMAB, College Park, MD, USA, 326 pp. + Appendices.