Modular Data Assimilation System for Significant Wave Height: The Example of Local Ensemble Transform Kalman Filter for the National Weather Service

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Introduction

The National Centers for Environmental Prediction (NCEP) of the National Oceanic and Atmospheric Administration (NOAA) provides the operational wave forecast for the U.S. National Weather Service (NWS). As part of ongoing efforts to improve forecasting, the NCEP's Environmental Modeling Center (EMC) is developing an ensemble-based data assimilation system, based on the Local Ensemble Transform Kalman Filter (LETKF) [1], the existing operational Global Wave Ensemble System (GWES) [2], and the operationally available satellite and in-situ observations.

Methodology

The data assimilation system is modular and driven externally by a bash script. A flowchart of the system, including its modules and advantages is shown in Figure 1. The LETKF is a computationally efficient implementation of the varied Ensemble Kalman Filter methods. It uses an ensemble of numerical forecast model runs to estimate the background error covariance and assimilates observations when they occur rather than aggregating them at a fixed analysis. In order to apply LETKF to the wave field, the LETKF system developed for ocean models [3] was adapted to meet the wave field data assimilation requirements; significant wave height (SWH) is assimilated in this case. The forward operator for the SWH is an independent module which handles in-situ and altimeter observations of SWH from four satellites (Jason-2, Jason-3, CryoSat-2 and Saral/Altika, approximately 240k observations per day) and includes a multi-step quality control procedure.

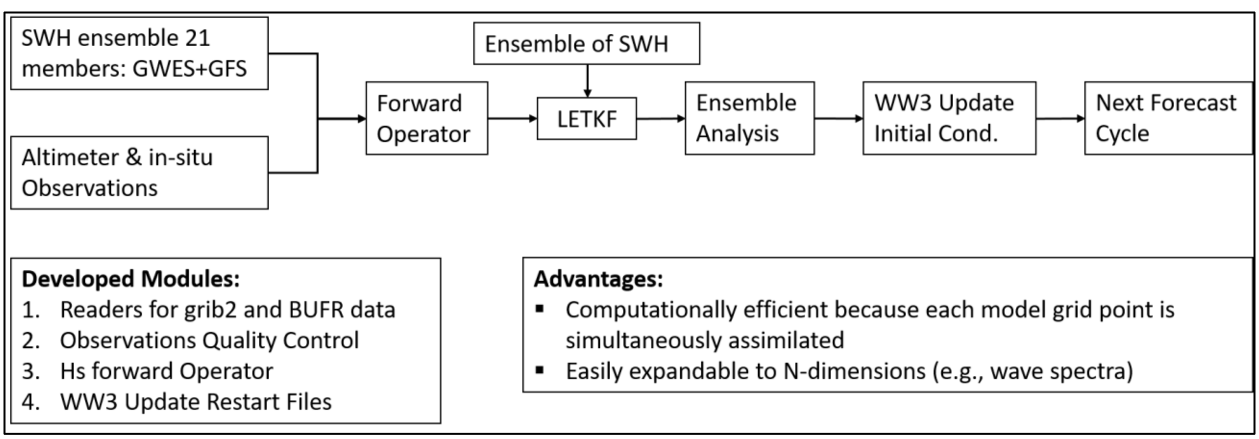

Figure 1. Upper: Flowchart of the modular LETKF DA system for SWH in the framework of the NWS operational guidance. Lower Left: List of the developed modules transferable any wave DA system. Lower Right: List of major advantages of the system.

The GWES is based on WAVEWATCHIII® [4] and it consists of a 20-member ensemble forced with NCEP-GEFS bias corrected wind data, and one control run with NCEP's deterministic GFS model. Each member runs on a spherical grid with 0.5 degree resolution in longitude and latitude, and uses the ST4 wave physics. In this report, results from a similar system for the Gulf of Mexico with spatial resolution 0.25 degrees are presented.

Results

Results from the LETKF-Wave prototype for three consecutive forecast cycles from the April 6, 2017 are shown in Figure 2. The bias of the analysis has been reduced significantly, at least 100 percent in most of the cases. The preliminary results show that using SWH analysis fields as initial conditions for the next prediction cycle is significant for 12h.

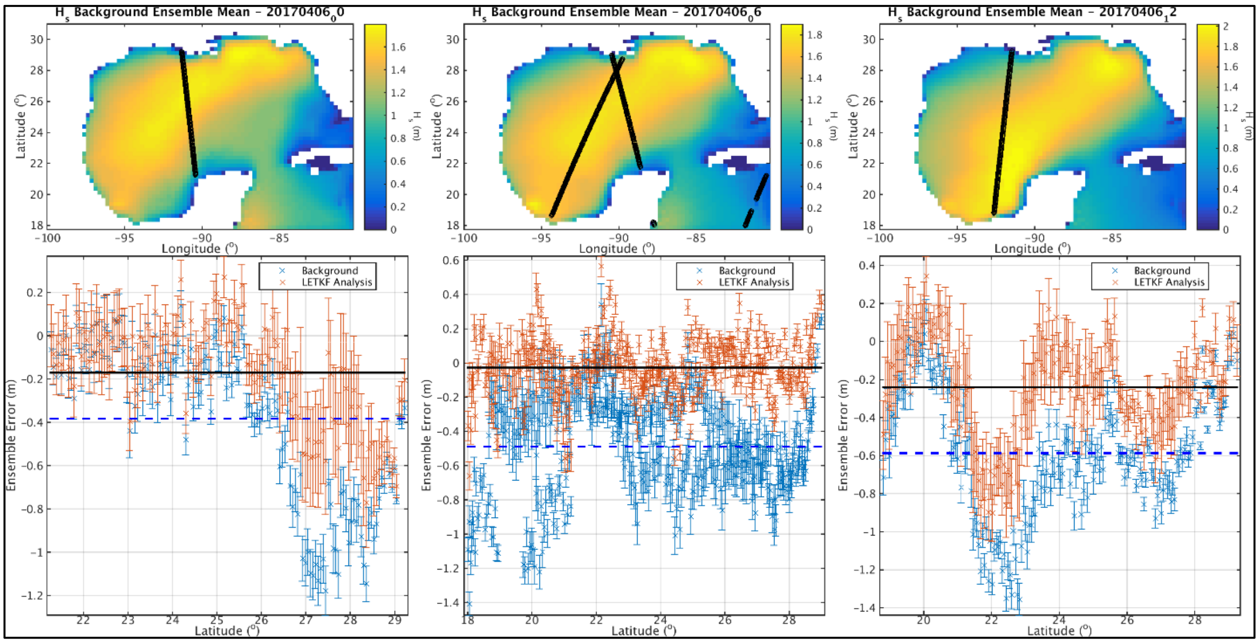

Figure 2.Upper panel: The predicted field of SWH, the black cycles show the locations for the satellites observations. Lower panel: The mean difference of the observed SWH from the background (blue) and the analysis (orange) at the observation locations as function of latitude; the error bars show the spreading of the ensemble. The blue dashed line and the black solid line are the mean bias of background and analysis accordingly.

Summary

The preliminary results from the wave data assimilation suite show great potential for improved NWS wave forecasts. This modular approach is compatible with variational and ensemble-based approaches and is easily expandable. Currently, the LETKF for SWH is under extensive validation and verification at a global scale.

References

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