



6th NCEP/NWS Ensemble User Workshop

Upgrades to the Global Wave Ensemble Forecasting System

Mar 25 2014

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SRG at Environmental Modeling Center, NOAA/NCEP



Presentation Outline

- NCEP Global Wave Ensemble System
- Multi-Center Ensemble System
 - NCEP
 - FNMOOC
 - Environment Canada



NCEP Global Wave Ensemble System



- Overview
 - Overview
 - System description
 - Primary customer base
 - System changes
 - Expected benefits
 - Pre-implementation test results
 - Outlook



Current NCEP Global Wave Ensemble Forecast System

- Current NCEP Wave Ensembles System
 - Multi-grid wave ensemble system (MENS)
 - $1^\circ \times 1^\circ$ wave model grid
 - 20 ensemble members + 1 control
 - Continuous initial conditions per member from previous cycle
 - 10 day forecast using the GEFS bias corrected 10m wind
 - Outputs in ftpprd
 - Gridded mean, spread and probabilities of exceedence for Hs, Tp and U10
 - Gridded and point outputs for 20 + 1 ensemble members

Website: <http://polar.ncep.noaa.gov/waves/nfcens/viewer.shtml?-mesp->



Charter Overview

What's being changed in the system

- Expansion of field outputs
 - Current: U10, Hs, Tp, DirP, DirM
 - Upgrade, added: partitioned Hs, Tm, DirM (3 first partitions)
- Reduction, then expansion of point outputs
 - WW3 style point output, reduced from 152 to 94 locations
 - Some points off the grid, some old inactive buoys
 - Ensemble bulletins at 383 points, most multi_1 buoy or WFO locations (ex points not covered by grid, ~120 points left out)
- [Website](#)



Charter Overview

- When is upgrade scheduled: FY14Q3 (April 2014?)
- System description: NCEP Global-Scale Wave Ensemble System (NGWES)
 - 21 Members
 - Forcing: GEFS + MMAB hires ice analysis
- Primary customer base
 - OPC, NHC, FNMOC, Environment Canada
- Cycles/day: 4 daily cycle [00,06,12,18]Z
- Interdependencies in production suite:
 - Upstream: GEFS (grib2 + BiasCorr), GFS (SST), ICE Analysis (from GFS grib2)
 - Downstream: NFCENS



Charter Overview

Expected benefits to end users

- Improve longer range global wave prediction.
- Compliance to charter for expanding combined NCEP/FNMOC wave ensembles including Environment Canada.
- Expand reliability of longer range forecasts of hurricane waves.



Pre-Op Test Results

Two major changes impacting quality of output

1. Science/Code Changes

- New physics package
- Tolman & Chalikov (1996) -> Ardhuin et al (2010)
- Goodies: previous CCB's for multi_1 and GLW...

2. Spatial resolution increase

- From $1^\circ \times 1^\circ$ to $0.5^\circ \times 0.5^\circ$
- New grid, from 79.5°S to 79.5°N (now at 80°S to 80°N)
 - 79.5 is the magic number for CFL t-step = 450 (superstition?)



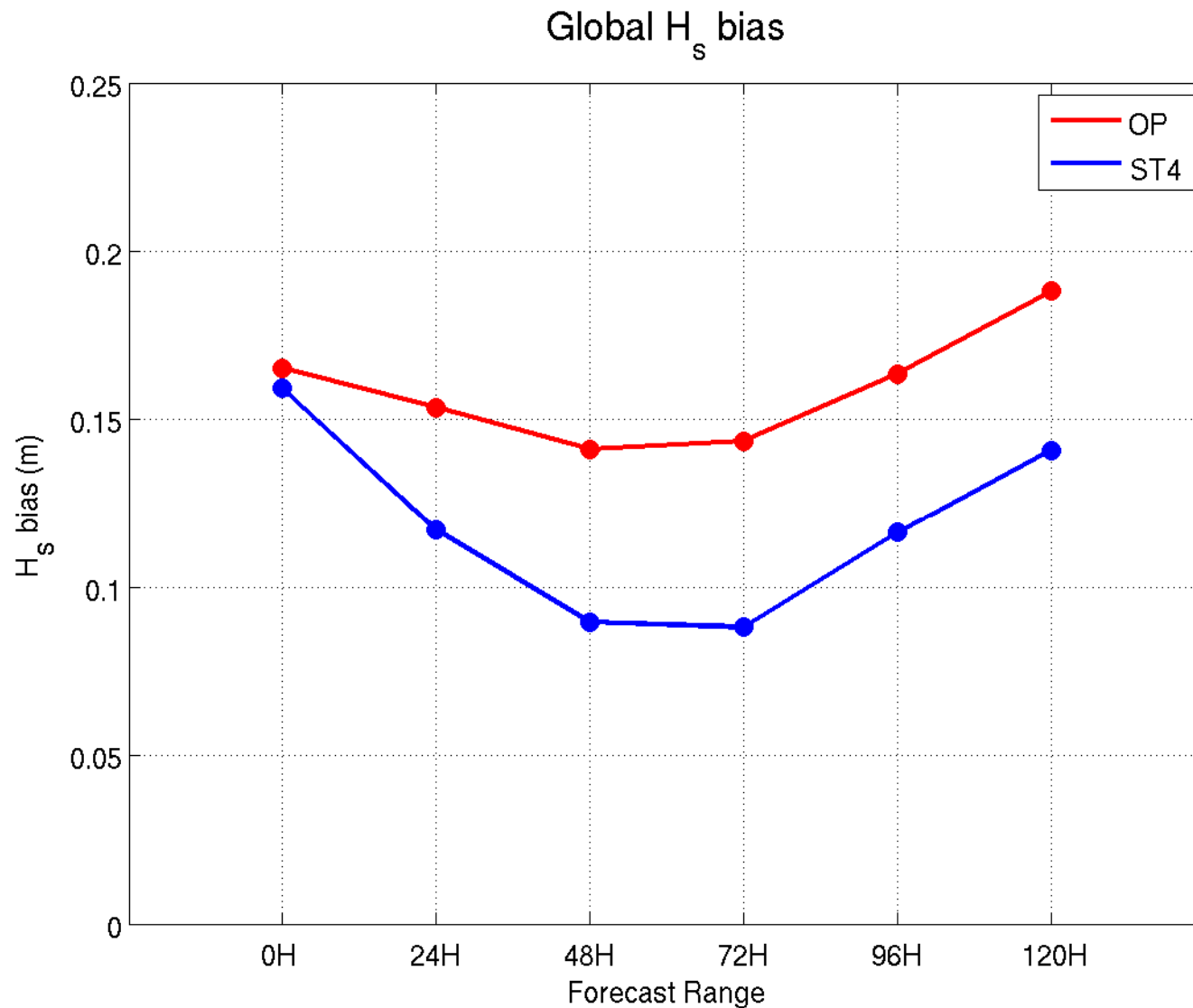
Pre-Op Test Results: Bulk

- Altimeter Hs Observations from J-1, J-2, EnvSat, Cryosat from GlobWave (Ifremer)
- 6 months global forecast (Mar-Aug 2012)
 - Physics upgrade validation
 - Operational ST2 vs Upgrade ST4 physics
- 2 ½ months global forecast (Mar-mid-May 2012)
 - Validation of impact from higher resolution grid



Pre-Op Test Results: Bulk

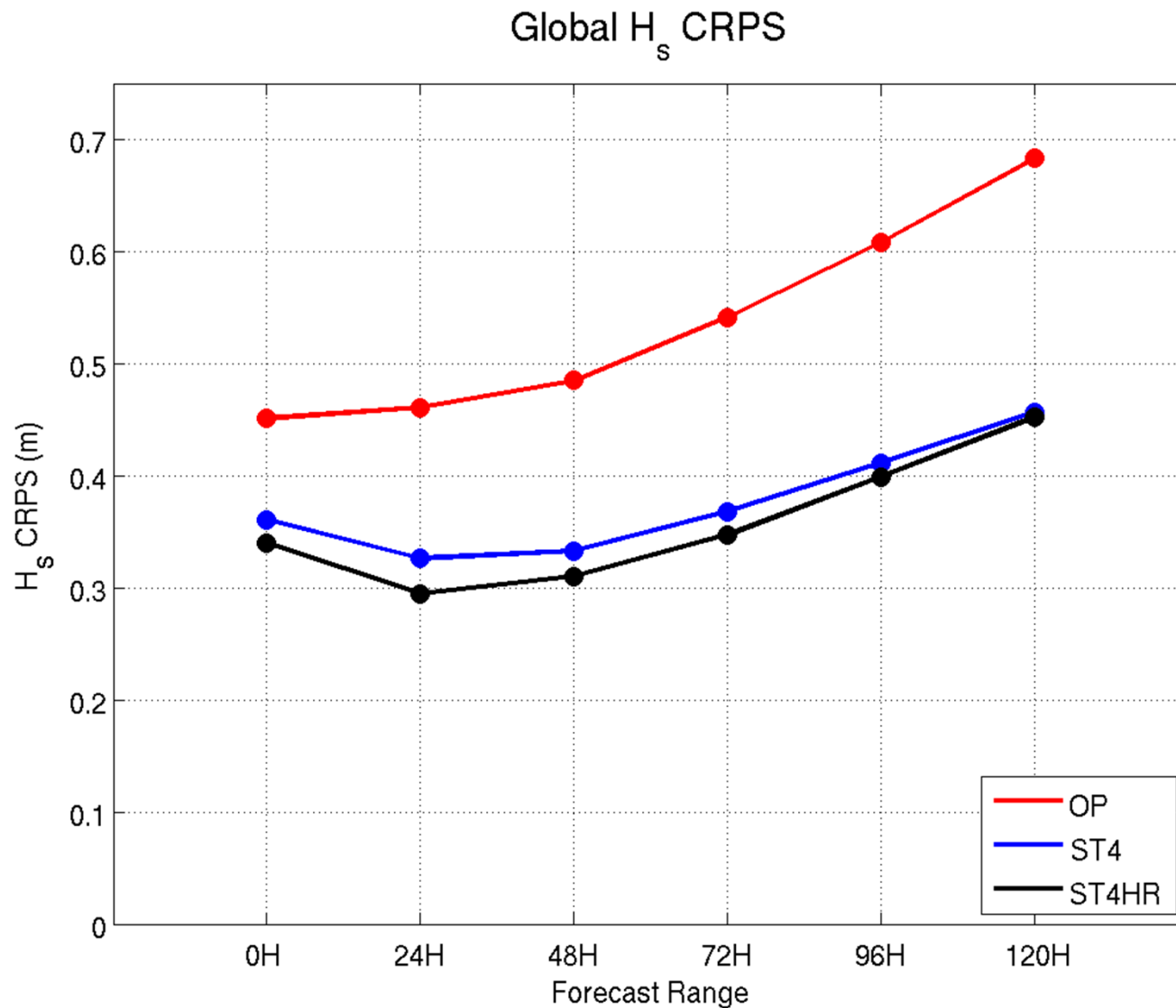
Physics upgrade validation





Pre-Op Test Results: Bulk

High resolution grid upgrade validation



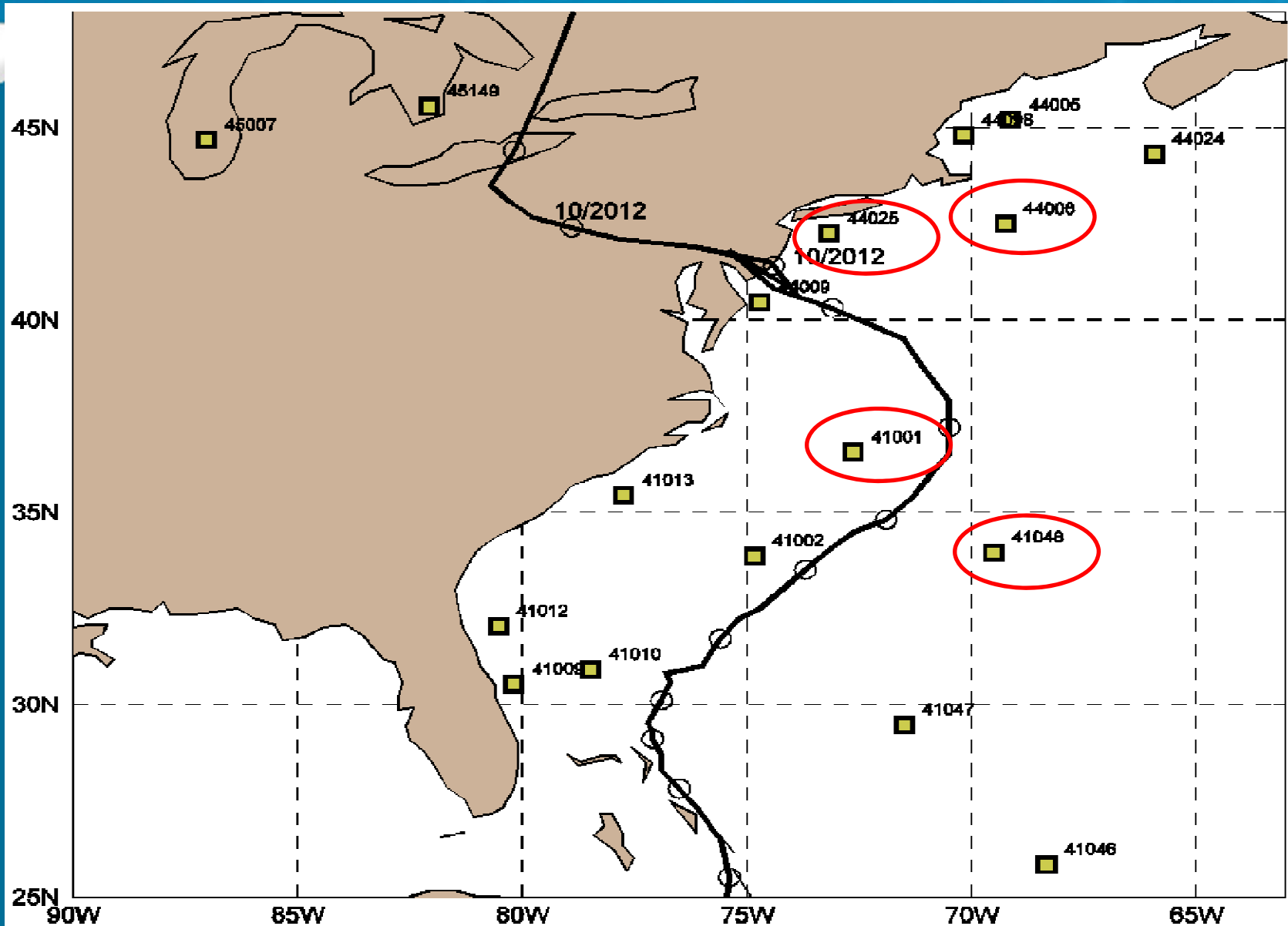


Pre-Op Test Results: Sandy

- Hurricane Sandy: end of Oct 2012
- 23 buoys recorded Hs > 6m
- Selected 4 buoys with Hs > 9m
 - Closest to track

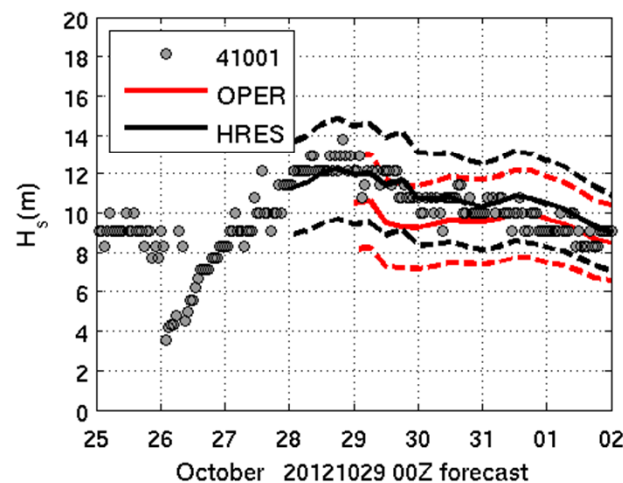
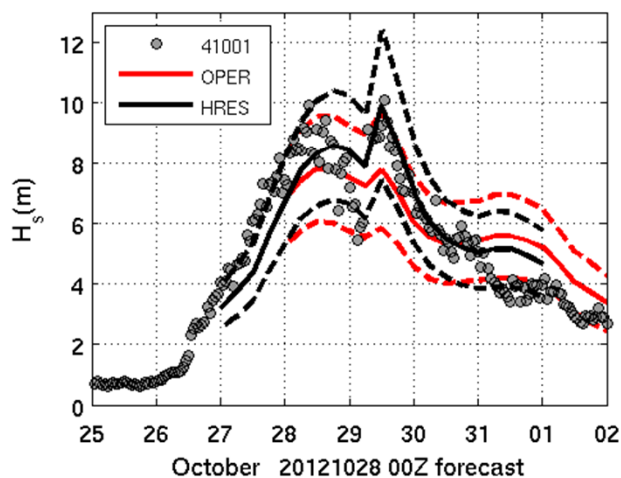
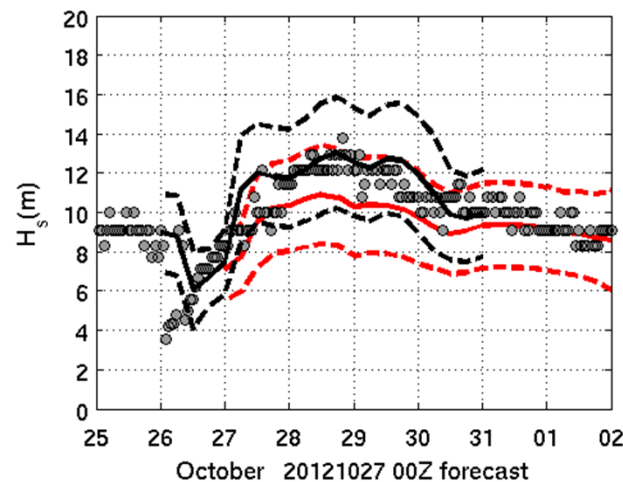
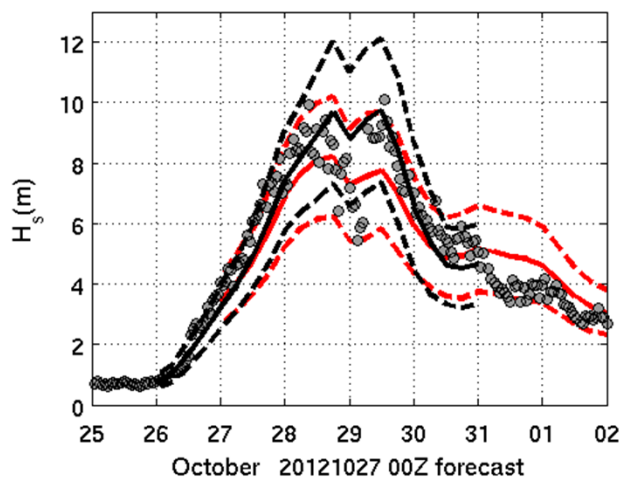


Pre-Op Test Results: Sandy



Pre-Op Test Results: Sandy

H_s during Hurricane Sandy (10/2012). Buoy 41001





NCEP Wave Ensemble Systems

- Outlook
- Global
 - Operational Implementation (2014)
 - Increase resolution to $0.5^\circ \times 0.5^\circ$
 - New physics
 - Name change → GWES
 - Freak/Rogue wave prediction product (2015)
 - Coupling with GEFS via NEMS (2016)
 - Neural-networks downscaling for coastal ensembles (2016)
- Great Lakes Ensemble System (2015/2016)
 - Joint project with Environment Canada
- Hurricane/HWRF wave ensemble system (2016)



NCEP Wave Ensemble Systems

- Problems
 - Increased resolution requires significant increase in compute resources.
 - Wave models have two internal grids: spatial and spectral
 - Current upgrade (first in 6 years):
 - Spatial resolution: 4 x resources
 - Physics upgrade 1.3 x resources
 - Spectral resolution: 2 x resources
 - Total of 8 to 10 x resources
 - Swell propagation in the EnKF world
 - Swell requires continuity of strong storms between cycles
 - Track of storm systems must be consistent between GEFS cycles
 - [Dynamic fetch](#)
 - Will they be consistent for EnKF?
 - Working with GEFS developers to test



Combined NCEP/FNMOC Global Wave Ensemble Product

Wave Modeling Group



Combined NCEP/FNMOC Global Wave Ensemble Product

- Outline
- Current NCEP Wave Ensembles System
- FNMOC Ensembles System
- Previous evaluation
- Scope
- Benefits
- External Evaluation Outcomes
- Outlook



Current NCEP Global Wave Ensemble Forecast System

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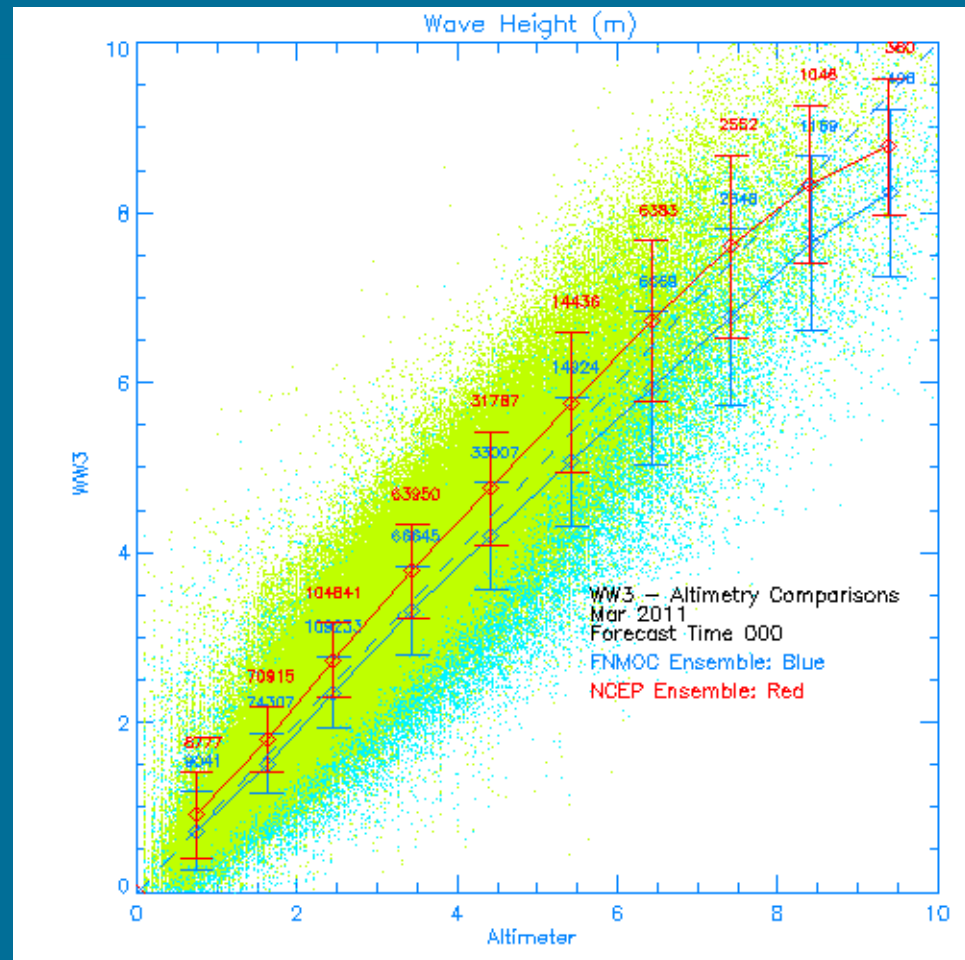
Current FNMOC/Navy Global Wave Ensemble Forecast System

- FNMOC Ensembles System
 - Shared wave model code (WAVEWATCH III)
 - Shared $1^\circ \times 1^\circ$ wave model grid
 - Same number of ensemble members (20)
 - 10 day forecasts
- Above properties will facilitate combination of products
- Differences
 - Initial conditions
 - Forcing wind fields (GEFS x NOGAPS EFS)
 - Ice concentrations and SST (GDAS vs NCODA)
- Combined system with improved mean ensemble products and better statistical information (probabilities of exceedence)



Combined Wave Ensembles Product

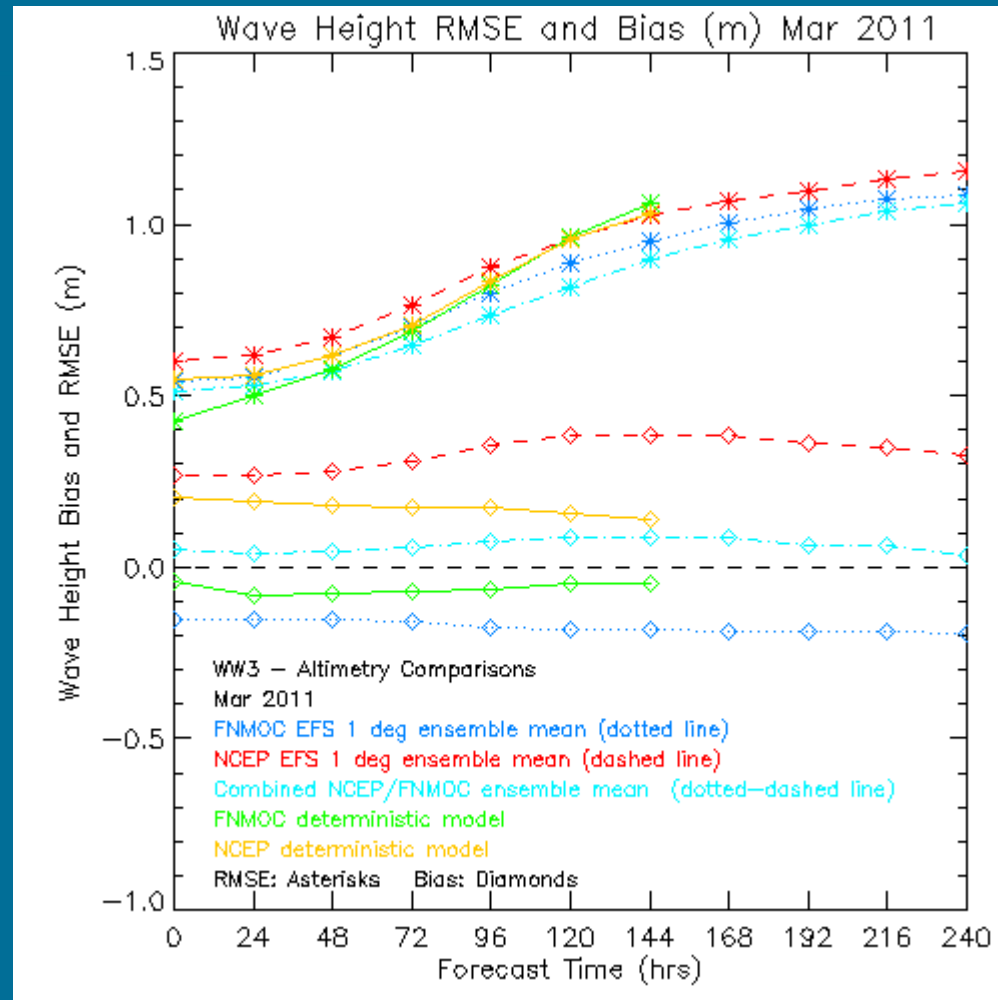
- Evaluation Mar 2011
 - WW3 vs Altimeters
 - Combination tracks well cloud (more spread)
 - Hints that combined products would increase model skill and improved statistics: NCEP biased high, FNMOG biased low.





Combined Wave Ensembles Product

- Regression testing
 - WW3 vs Altimeters
 - Combination:
 - Reduces bias
 - Reduces RMSE





NCEP/FNMOC NWW3 Ensemble Evaluation

**Scott Stripling and
Jessica Schauer
NHC/TAFB**



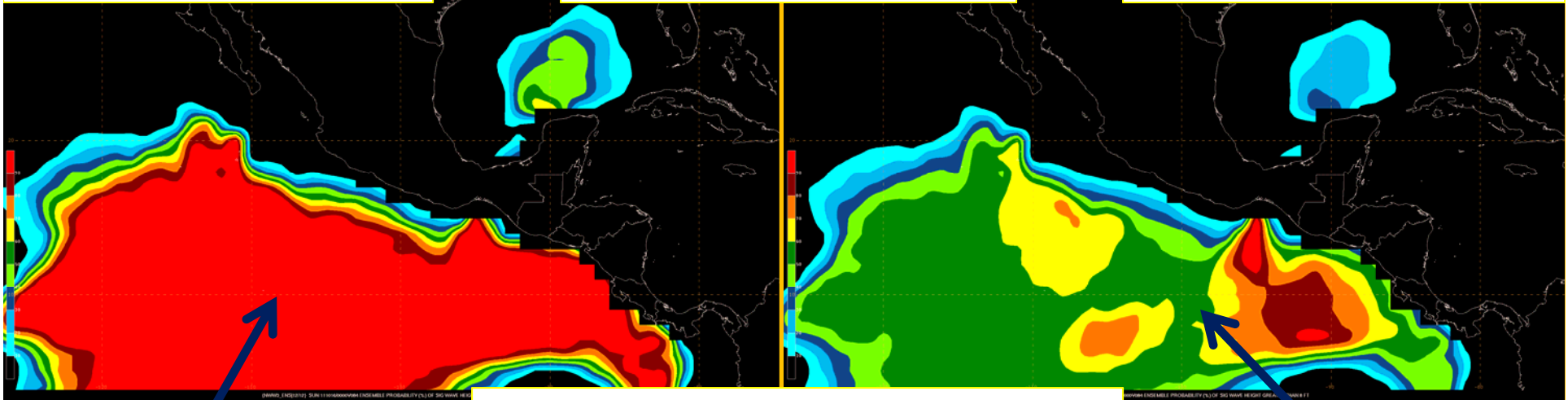
Strengths

- The new NCEP/FNMOC NWW3 ensemble probabilistic forecasts show significantly more variability (uncertainty) than the operational NWW3 ensemble
- The new NCEP/FNMOC NWW3 ensemble varies more from the operational MWW3 output than the operational NWW3 ensemble
- The new NCEP/FNMOC NWW3 ensemble mean showed frequent improvement over both the operational MWW3 and the NWW3 ensemble when compared to observations
- The introduction of the FNMOC ensemble members to the NCEP NWW3 ensemble suite seems to have toned down the slight high SWH bias TAFB forecasters have noted in our AOR



Strengths – Variability Compared to NWW3

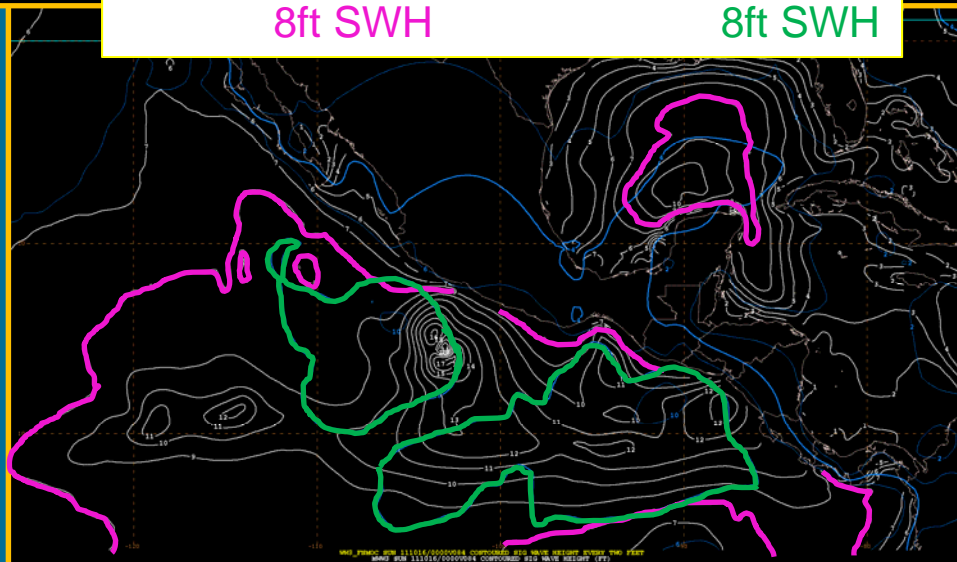
FH84 from 1012/12Z runs



8ft SWH

8ft SWH

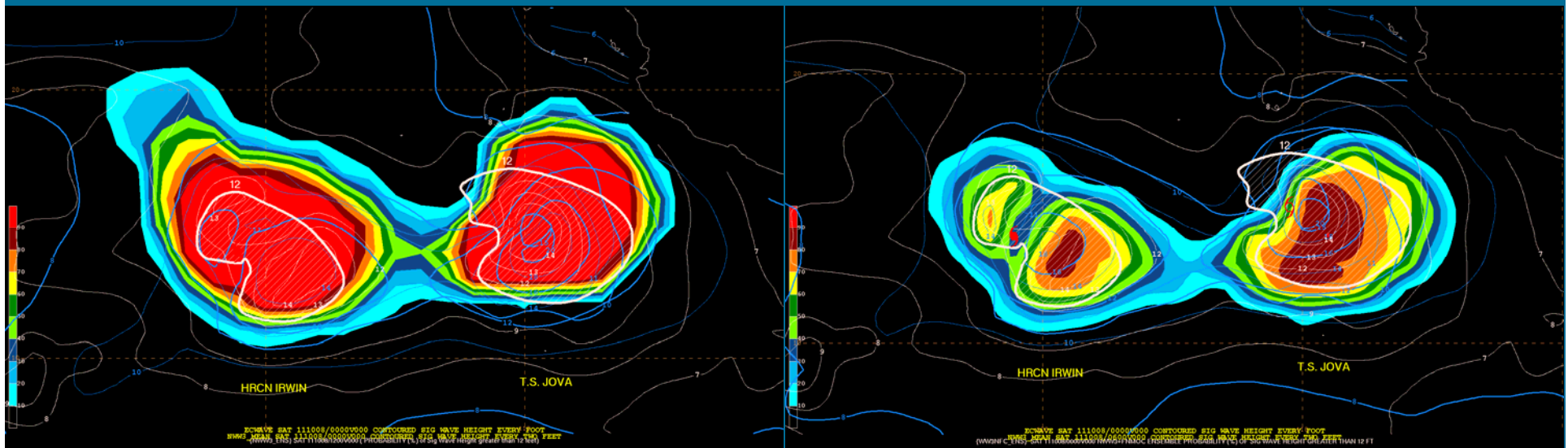
NCEP NWW3 ensemble show large area of 90% chance of 8 ft seas. Area is nearly identical to the MWW3 8 ft SWH contour



NCEP/FNMOC ensembles show more uncertainty in the area of SWH 8 ft or greater



Strengths – NCEP/NWW3 FNMOC Ensemble Probabalistic Forecasts Generally An Improvement Over the NCEP NWW3 Ensemble



12 ft SWH analysis for Hurricane Irwin and T.S. Jova based on model consensus and observations, including several recent altimeter passes. NCEP NWW3 ensemble SWH > 12 ft probabilities, left, yield modest gradients, while “bull’s eyes” and stronger gradients are depicted by NWW3 FNMOC ensemble, right. In this case, comparison of ensembles provides high forecaster confidence.



BAMS Paper, Dec 2013

- Results of evaluation became a BAMS paper
 - [Dec 2013](#)



TROPICAL METEOROLOGY'S ANCESTRY

FORECASTING OCEAN WAVES

ANTICIPATING RARE EVENTS

THE NCEP–FNMOC COMBINED WAVE ENSEMBLE PRODUCT

Expanding Benefits of Interagency Probabilistic
Forecasts to the Oceanic Environment

BY JOSE-HENRIQUE G. M. ALVES, PAUL WITTMANN, MICHAEL SESTAK, JESSICA SCHAUER,
SCOTT STRIPLING, NATACHA B. BERNIER, JAMIE MCLEAN, YUNG CHAO, ARUN CHAWLA,
HENDRIK TOLMAN, GLENN NELSON, AND STEPHEN KLOTZ

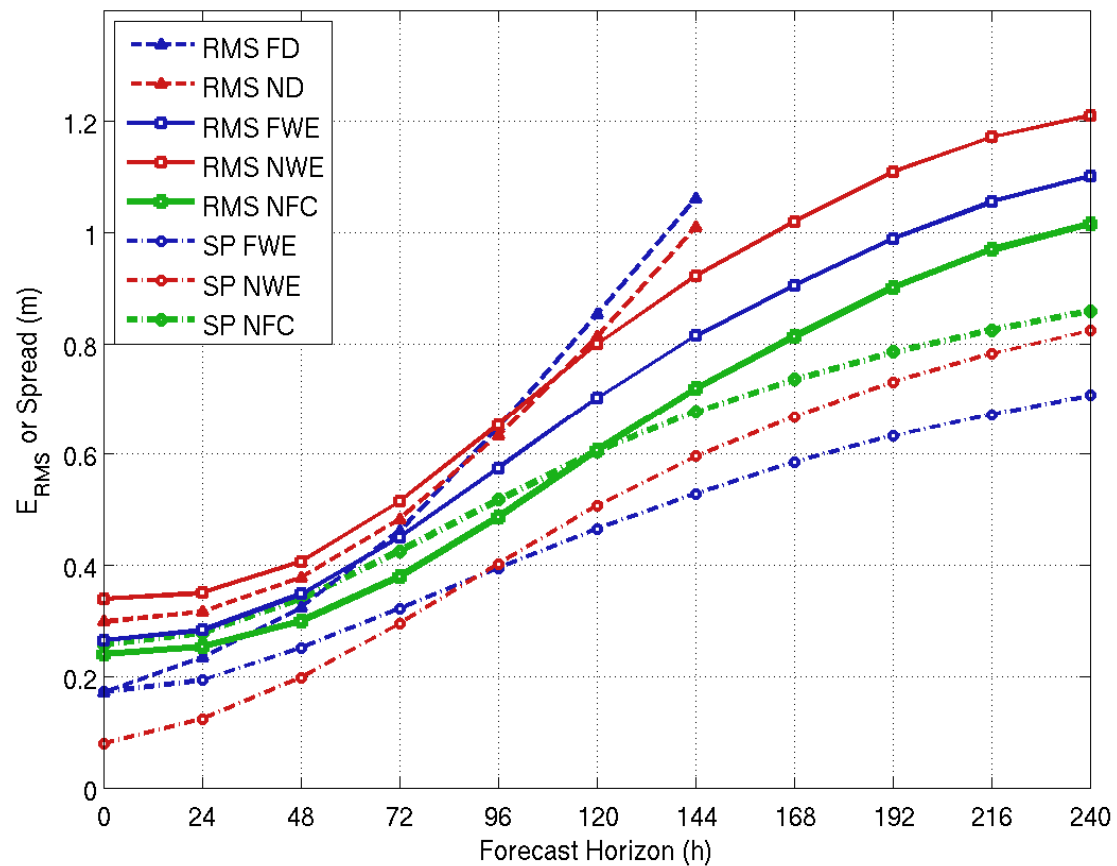
The first multicenter collaborative ensemble to make probabilistic ocean wave forecasts—
operational for two years now—performs better than the ensemble systems and
deterministic forecasts of individual centers.

**PULSE OF
THE TROPICS**
THE MADDEN–JULIAN
OSCILLATION



BAMS Paper, Dec 2013

- Results of evaluation were expanded to include 2011-2012 altimeter data
- Combination:
- Reduces bias
- Reduces RMSE





Combined NCEP/FNMOC Global Wave Ensemble Product

- Outlook

- Increase resolution to $0.5^\circ \times 0.5^\circ$
 - After FNMOC upgrades system
- 20 additional members from Environment Canada's wave ensemble system (2015)
- New name: North American Wave Ensemble System – NAWES (2015)
- Integration to NAEFS (2015)
 - Data distribution, formats, validation etc