Validation of the Fully-Coupled Air-Sea-Wave COAMPS System

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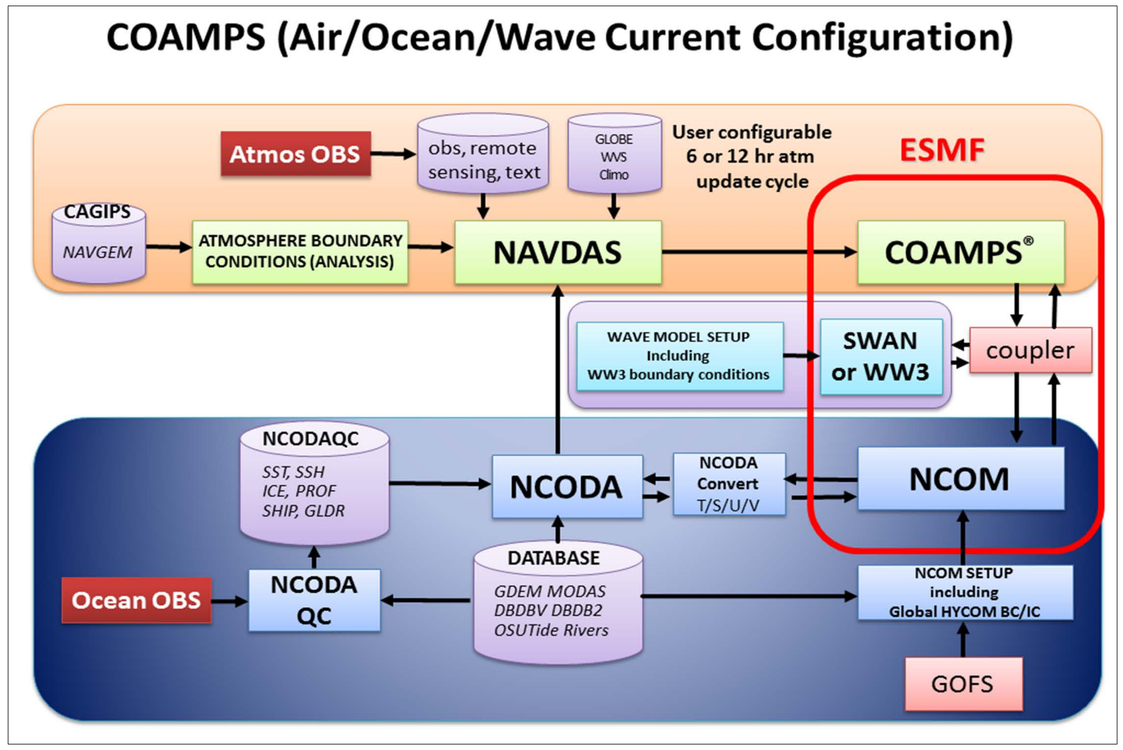
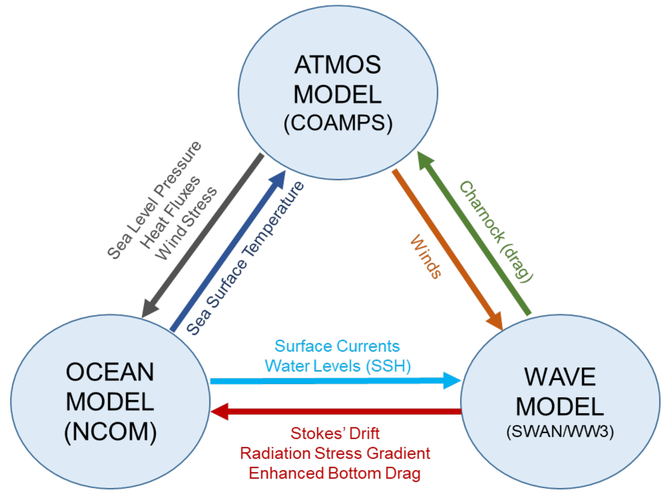
ABSTRACT

A fully-coupled, air-sea-wave numerical model, COAMPS®, has been developed by the Naval Research Laboratory to further enhance understanding of oceanic, atmospheric, and wave interactions. The fully-coupled air-sea-wave system consists of an atmospheric component with full physics parameterizations, and ocean model, NCOM (Navy Coastal Ocean Model), and two wave components, SWAN (Simulating Waves Nearshore) and WaveWatch III. Air-Sea interactions between the atmospheric and ocean components are accomplished through bulk flux formulations of wind stress and sensible and latent heat fluxes. Wave interactions with the ocean currents include the Stokes' drift, surface radiation stresses, and enhancement of the bottom drag coefficient in shallow water due to bottom wave orbital velocities. In addition, NCOM surface currents are provided to the wave models to simulate ocean to wave model interaction.

The fully-coupled COAMPS system was run for several regions at regional scales for the entire year of 2015, including the U.S. East Coast, Western Pacific, and Hawaii. Validation of COAMPS® includes observational data comparisons and evaluating operational performance on the High Performance Computing (HPC) system for each of these regions.

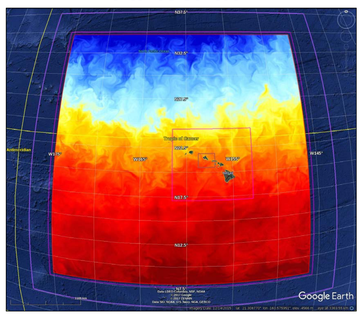
COAMPS (Air/Ocean/Wave Current Configuration)

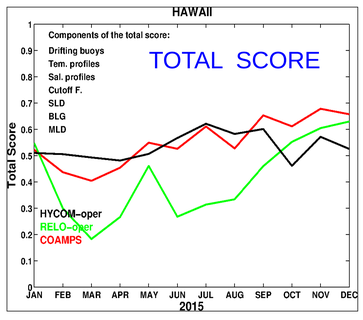


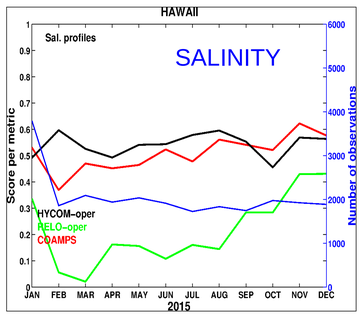


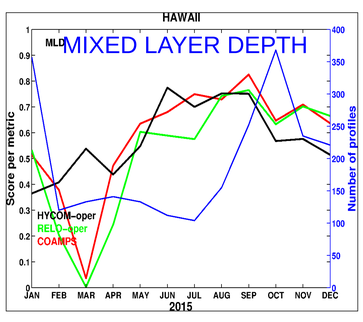
COAMPS passes variables from one model to the other through the Earth System Modeling Framework. The graphic above depicts the variables being passed to and from each individual model in COAMPS.

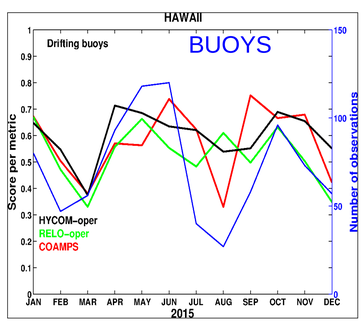
HAWAII

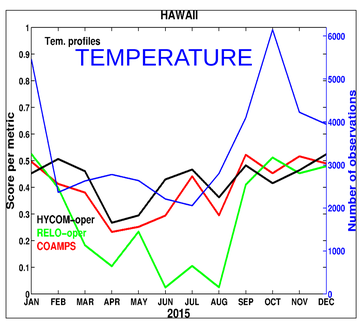




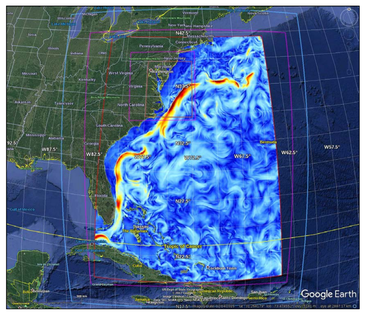


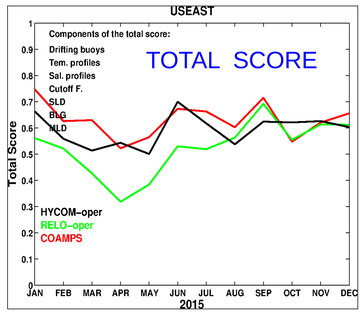


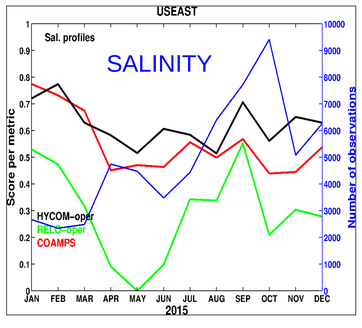


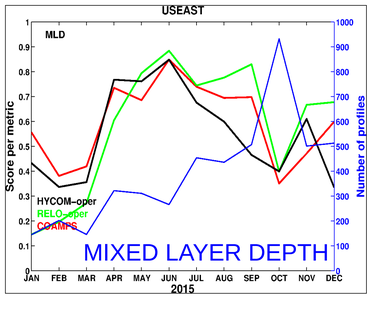


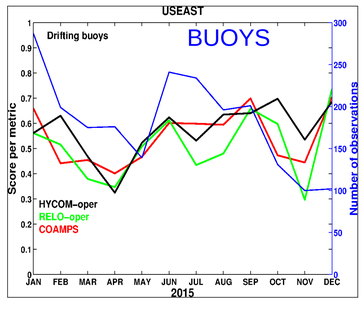
U. S. EAST

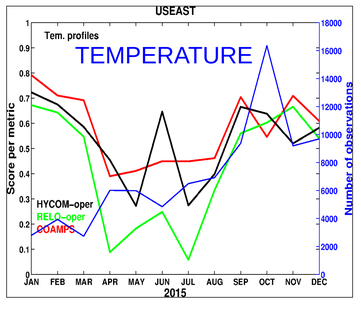




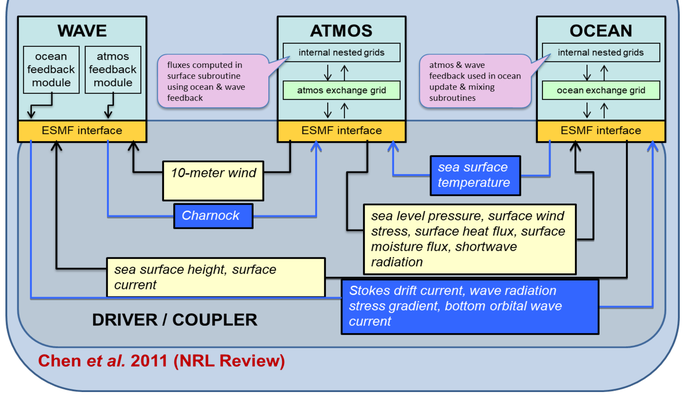






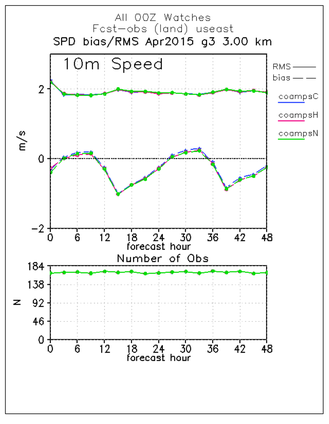


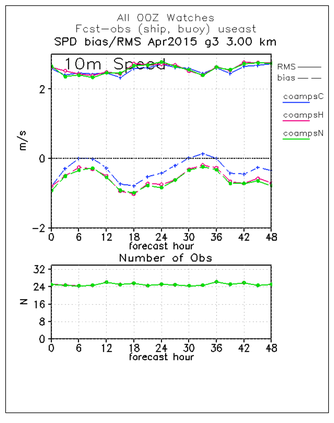
COAMPS Coupling Interface

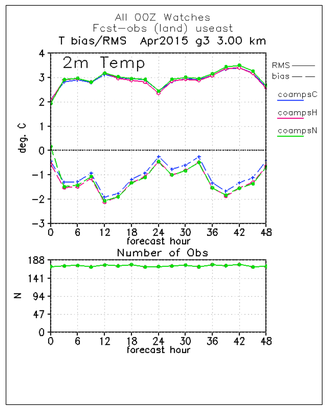


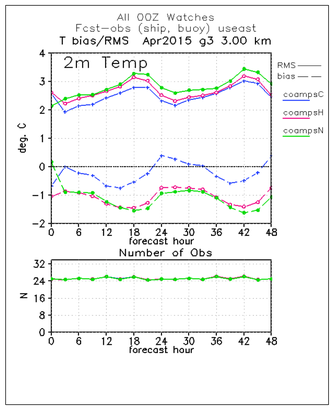
Chen *et al.* 2011 (NRL Review)

U. S. East Atmospheric Model Validation







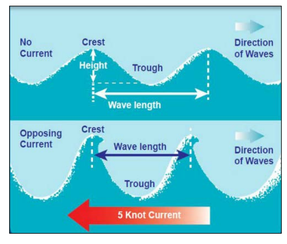


Wave Effects on Ocean Currents

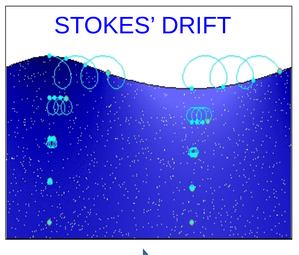
- Stokes drift current (SDC):
  - Current speed tends to be increased with addition of SDC
  - Enhanced vertical mixing in the surface mixed layer associated with the SDC (increased shear) tends to decrease currents (cancellation effect)
  - SDC tends to increase bottom stress
- Wave-radiation stress due to horizontal gradients of the energy of the surface waves (loss of momentum).
- Enhanced vertical mixing due to Langmuir cells (LCs) and Langmuir turbulence in moderate to strong winds (Kantha and Clayson (2004) McWilliams et al. (1997))

Ocean Effects on Waves

- Primary: Ocean currents affect the spectral action density, *N*, through group velocity gradients (refraction and straining). (e.g. in simple shoaling, $C_g \downarrow$, $N \uparrow$)
- Secondary: Changes in wave steepness affects source/sink terms in deep water



OCEAN ➡ WAVE



WAVE ➡ OCEAN

CONCLUSIONS

Work is continuing to assess air/ocean/wave model coupling and interactions in COAMPS. For the coupled and uncoupled model comparisons shown for both Hawaii and the U.S. East, there are significant improvements in the coupled model when compared to the uncoupled ocean model (RELO NCOM). Salinity and temperature profiles are significantly improved with the coupled model. Atmospheric model coupling to both NCOM and SWAN show improvements, especially in the atmospheric boundary layer temperature and wind profiles. More accurate heat fluxes are also associated with higher-resolution NCOM SSTs versus NAVGEM (global atmospheric model) SSTs. Higher-resolution wind forcing, especially associated with higher wind speed events contributed to improved significant wave heights and NCOM surface ocean current speeds in the coupled model.

ACKNOWLEDGEMENTS

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