Development of the Nearshore Wave Prediction System (NWPS)

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1. Introduction

The demand for high-resolution forecasts of coastal processes (wind, water levels and waves) from the National Weather Service (NWS) has been steadily increasing over the past decade. Such forecasts are produced from observations and model guidance combined within the Advanced Weather Interactive Processing System (AWIPS, Fig. 1). The global operational WAVEWATCH III® wave model (WWIII, Tolman 2009), run by the NWS's National Centers for Environmental Prediction (NCEP) and available through AWIPS, does not provide sufficient resolution to capture high-resolution nearshore processes (Fig. 2). Centralized modeling at NCEP at these nearshore scales would require an excessive amount of computing resources and administration. In addition, regions differ with respect to the relevant physical processes, requirements for grid resolution, and so on. For these reasons, the NWS is following an approach of decentralizing the nearshore wave and circulation computations (Fig. 3). Coastal Weather Forecasting Offices (WFOs) have begun using local implementations of the Simulating Waves Nearshore (SWAN) wave model (Booij et al. 1999), driven by wave boundary conditions from the WWIII model, provided by NCEP. With these systems, called IFP-SWAN and SR-SWAN, forecasters are able to apply their own locally-developed forecast wind fields to the nearshore wave model. Also, any local model development (e.g. with partnering universities) can be fed back to NCEP, creating a spiral development pattern.

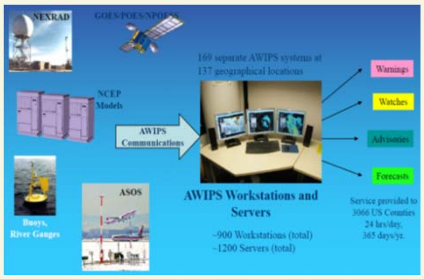

Figure 1: The Advanced Weather Interactive Processing System (AWIPS) combines various data sources including satellite, radar, weather buoy and aviation-related observations, as well as numerical model results (model guidance) from NCEP, in a single display environment for forecasters at WFOs and national centers to interpret. Based on these data, a number of products are prepared, including warnings, watches, advisories and forecasts.

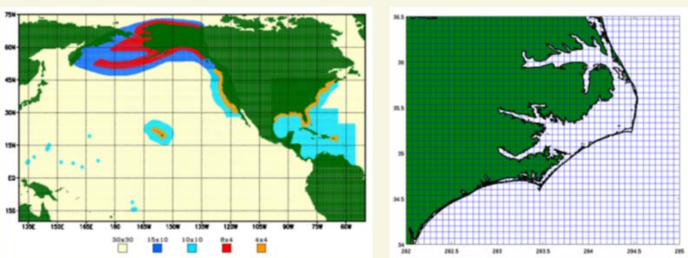

Figure 2, Left: Present Multigrid WWIII two-way nested mosaic computational grid, showing a global grid resolution of 30x30 arc min, and detailed regions with resolutions of down to 4x4 arc min. **Right:** Shelf-scale 4x4 arc min grid over the domain of responsibility of WFO Morehead City, showing the relative coarseness of the grid compared to coastal features.

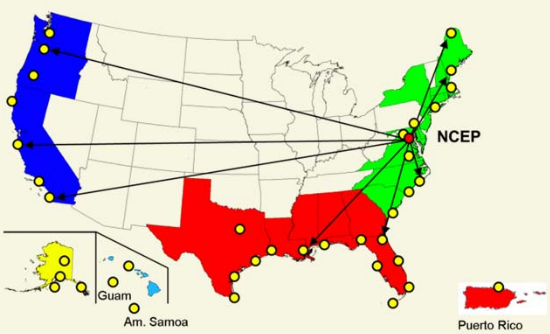

Figure 3: Concept of decentralized computing of nearshore wave and circulation model guidance. NCEP provides central support and forcing data, but each coastal WFO (yellow dots) in each of the NWS regions (colors) runs its own local model.

2. The Nearshore Wave Prediction System

The Nearshore Wave Prediction System (NWPS) is being developed as an extension to IFP-SWAN and SR-SWAN, to consolidate them and extend the implementation to all NWS regions and WFOs (Fig. 3). It is anticipated that the new NWPS system will be implemented as part of the baseline of AWIPS II, which is to replace the present AWIPS system. It has the following features:

- NWPS is to be run locally, routinely or on demand, using SWAN or a newly-developed nearshore version of WWIII.
- NWPS is expected to be included in the AWIPS II baseline for sustainability.
- The system addresses regionally-specific, high impact issues in the nearshore (surf breaking, wave-current interaction, etc.) and enables enhanced levels of service to customers through new products.
- Driven by forecaster-developed winds from the Graphical Forecast Editor (GFE) in AWIPS II, wave boundary conditions from NCEP's WWIII, and water levels and currents from ESTOFS and RTOFS (see Section 3).
- Includes wave partitioning and spatial and temporal tracking, so that model output can be used directly in the development of gridded wave forecasts (see Section 3).
- In the future, a two-way coupling between the wave model (WWIII or SWAN) and the ADCIRC coastal circulation model will be implemented (see Section 3).

Fig. 4 presents a schematic architecture of the NWPS system inside of AWIPS II. Observational data and model guidance from NCEP is transmitted over the Satellite Broadcast Network (SBN) and stored in the EDEX data server. These data can be visualized in the CAVE user interface, where the wind forecast grids are produced by the forecaster. These are sent back to the EDEX server, from where they are ingested into NWPS. In addition, external data can be ingested via ftp or the Local Data Manager (LDM). NWPS then runs SWAN or WWIII (in future coupled with ADCIRC) and produces nearshore wave (and circulation) results, which are again sent to the EDEX server. These can be visualized in CAVE, and are subsequently posted to the National Digital Forecast Database (NDFD). Additional input streams and output formats are provided for use outside of AWIPS II by third parties.

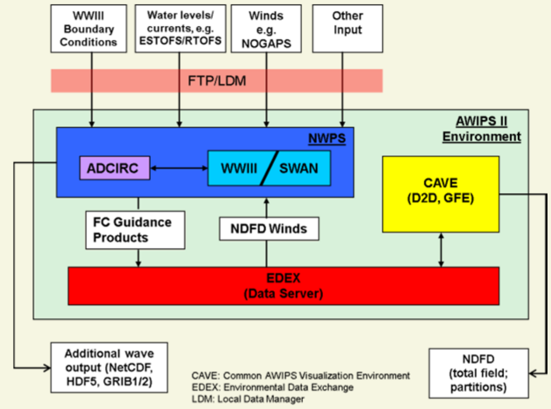

Figure 4: Schematic architecture of the NWPS system within the AWIPS II structure. Significant components are the EDEX data server for main data storage, the CAVE visualization environment and the NWPS wave and circulation modeling module.

3. Features: Partitioning and wave-current interaction

In order to provide forecasters with a comprehensive overview of the wave systems in their region of responsibility, the directional wave spectrum at each grid point is partitioned using the inverse watershed method of Hanson and Phillips (2001). With this method, various coherent regions of variance density in the directional spectrum are identified as separate partitions (Fig. 5). To ensure spatial and temporal coherence, these partitioning results are consolidated into wave systems by means of spatial and temporal tracking algorithms (Devaliere et al. 2009). The resulting wave systems are presented in terms of spatial fields and Gerling-Hanson time series plots. The latter show the progression of the wave height, period and direction of the various wave systems in time, along with the variation of local wind (Fig. 5).

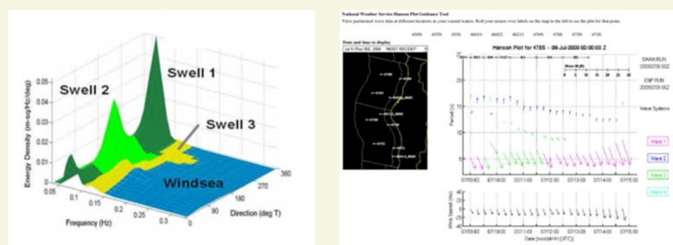

Figure 5, Left: Example of a directional wave spectrum decomposed into a number of partitions (Tracy et al. 2007). **Right:** Gerling-Hanson plot showing the time evolution of various wave systems in the domain of responsibility (insert).

The nearshore wave models inside of NWPS use surface current fields from NCEP's Real Time Ocean Forecast System (RTOFS Atlantic, Mehra and Rivin 2010), a 3D baroclinic circulation model based on the HYCOM model, to capture the influence of coastal currents such as the Gulf Stream. In the future, coastal surge and tide levels will be ingested from the Extratropical Surge and Tide Operational Forecast System (ESTOFS, Funakoshi et al. 2011), a 2D barotropic model for the North Atlantic based on the ADCIRC model. The global version of RTOFS will be implemented operationally at NCEP in the 4th quarter of 2011, and there are plans to extend ESTOFS to the U.S. West Coast and Pacific. To capture high-resolution coastal interaction effects between waves and the general circulation (wave steepening in tidal inlets, wave-induced surge, etc.), a two-way coupling between WWIII and ADCIRC is being implemented, along the lines of the coupling for SWAN and ADCIRC developed by Dietrich et al. (2011). This coupled system will receive boundary conditions from NCEP's WWIII and ESTOFS, and perform a coupled wave-current computation locally at each WFO, again using forecaster developed wind fields (Fig. 6).

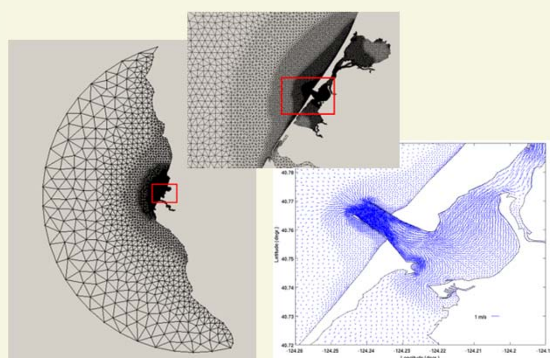

Figure 6: Unstructured grid for the coupled computation of waves and current at WFO Eureka (Northern California). Bottom right-hand panel shows vector plot of tidal currents through the Humboldt Bay harbor entrance.

4. References

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