Nearshore Environmental Nowcasting Using Unmanned Vehicles

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INTRODUCTION

Present operational forecast modeling of nearshore waves and currents for amphibious operations and mine countermeasures is limited to simple one-dimensional models. While more sophisticated multi-dimensional models are available for operational use, high resolution bathymetry is required to make full use of their capabilities. Concomitant to the development of numerical models, unmanned underwater vehicles (UUVs) have become more tenable as reconnaissance and surveying devices.

The aim of this project is to develop a nearshore nowcasting system for operational use which blends bathymetric measurements from UUVs with other sources of bathymetry for input into a sophisticated numerical model for nearshore waves and currents. The model would be embedded in a comprehensive modular modeling system, capable of accessing forecast fields from databases for model initialization. The completed system will be used at regional operational centers, with a particular focus on aiding Navy SEAL teams.

Figure 1: REMUS Craft

DATA COLLECTION AND INTERPOLATION

One potential vehicle type for this work is the REMUS craft (Fig. 1), which has been developed for mine detection. Instantaneous water depth is recorded by the on-board side scan sonar. Additional processing is required to obtain the actual bathymetry.

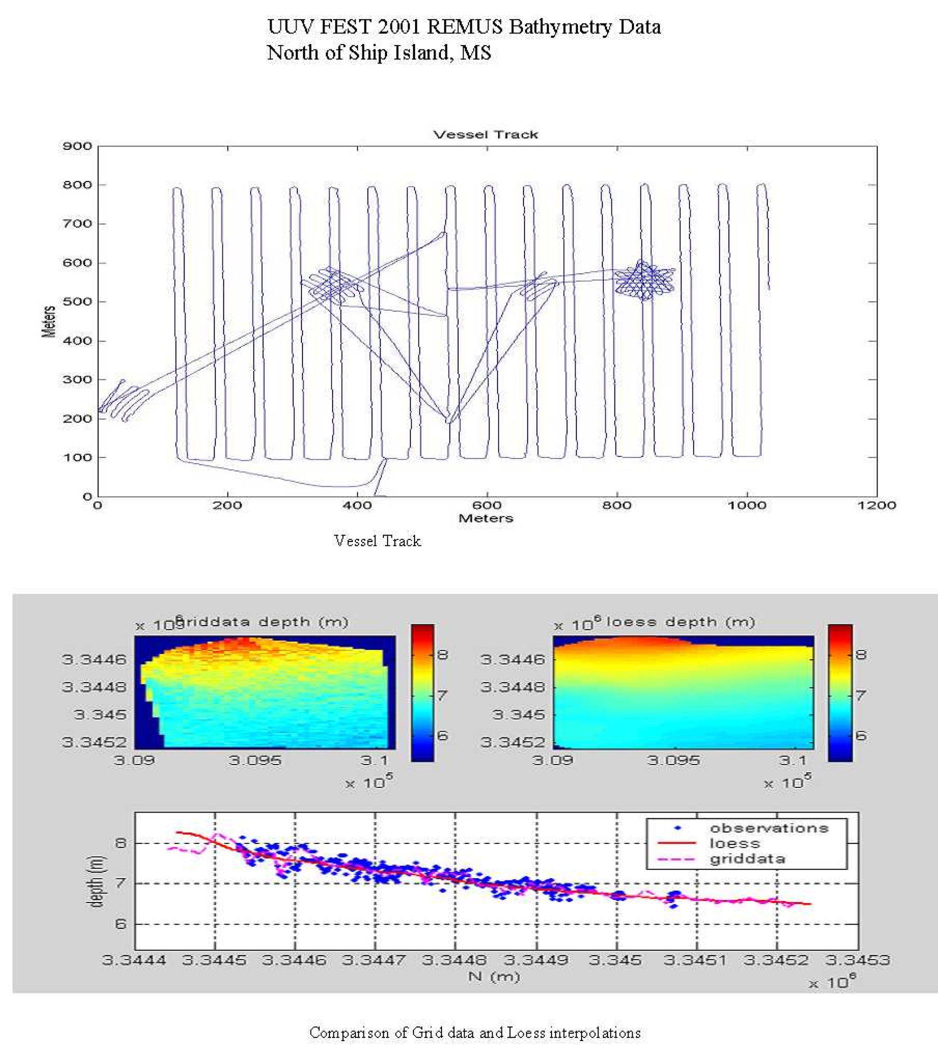

Figure 2. Blending of bathymetry from two sources – UUV measurements and gridded archived data. Top: UUV track. Bottom: Comparison between individual data sources and blended product

In UUV bathymetry measurements, cross-shore resolution is much higher than longshore resolution (Fig. 2, top). Naïve interpolation methods can thus lead to nonphysical features in the resulting bathymetric grid.

An optimal interpolation method similar to kriging has been developed and is presently being used to integrate data from disparate sources. The technique uses estimates of the correlation between observations to obtain a statistically optimal interpolated field; it also offers a measure of uncertainty in the final interpolated bathymetry. The method described here uses linear smoothing on the correlation fields to help reduce the normally-intensive computational cost of standard optimal interpolation techniques. An example showing an optimal blend of UUV tracks and archived gridded bathymetry is shown in Fig. 2 (bottom).

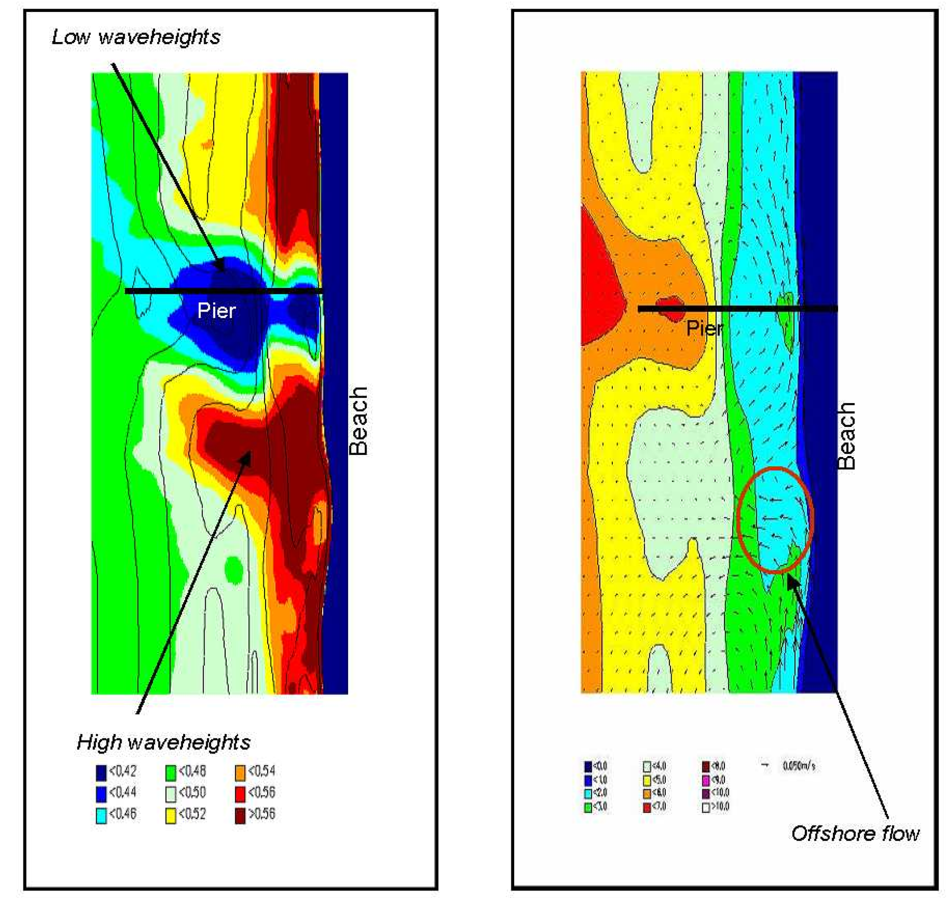

Figure 3. Waveheight and nearshore current predictions for Duck, NC

NEARSHORE MODELING SYSTEM

The optimal bathymetry is then used as the bottom boundary condition for the nearshore numerical model, DELFT3D. DELFT3D uses the wave model SWAN to provide radiation stress gradients and other required wave parameters to the three-dimensional hydrodynamic model (FLOW). Model output includes spatially-varying waveheights, longshore currents, rip currents, and surf zone parameters.

An example of DELFT-3D output is shown in Fig.3. The initial condition is a wave spectrum approaching shore normal to the beach. Even with this homogeneous condition, the high degree of variability in the bathymetry results in correspondingly fine structure in the waveheight and nearshore current fields.

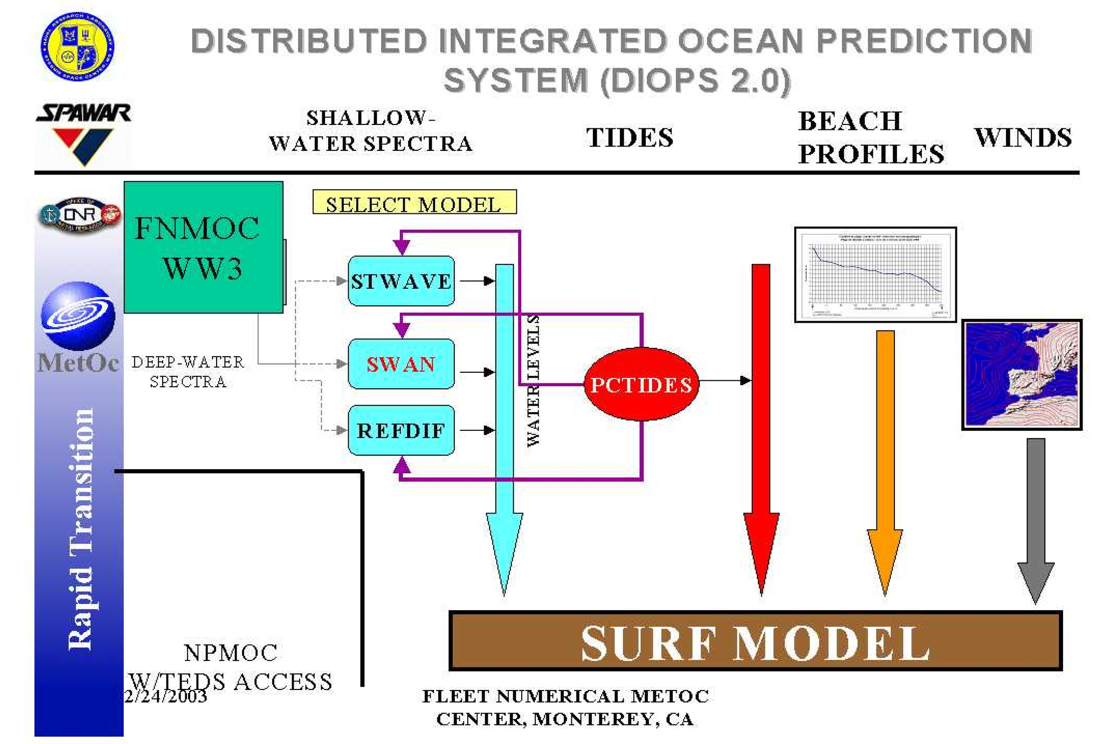

Figure 4. Information flow and modular structure of DIOPS

The DELFT-3D model is presently being integrated into the Distributed Integrated Ocean Prediction System (DIOPS), a modeling system which automatically obtains initial conditions from operational global models to force regional scale models in areas of interest. Fig. 4 shows an example of this information flow to the SURF model.

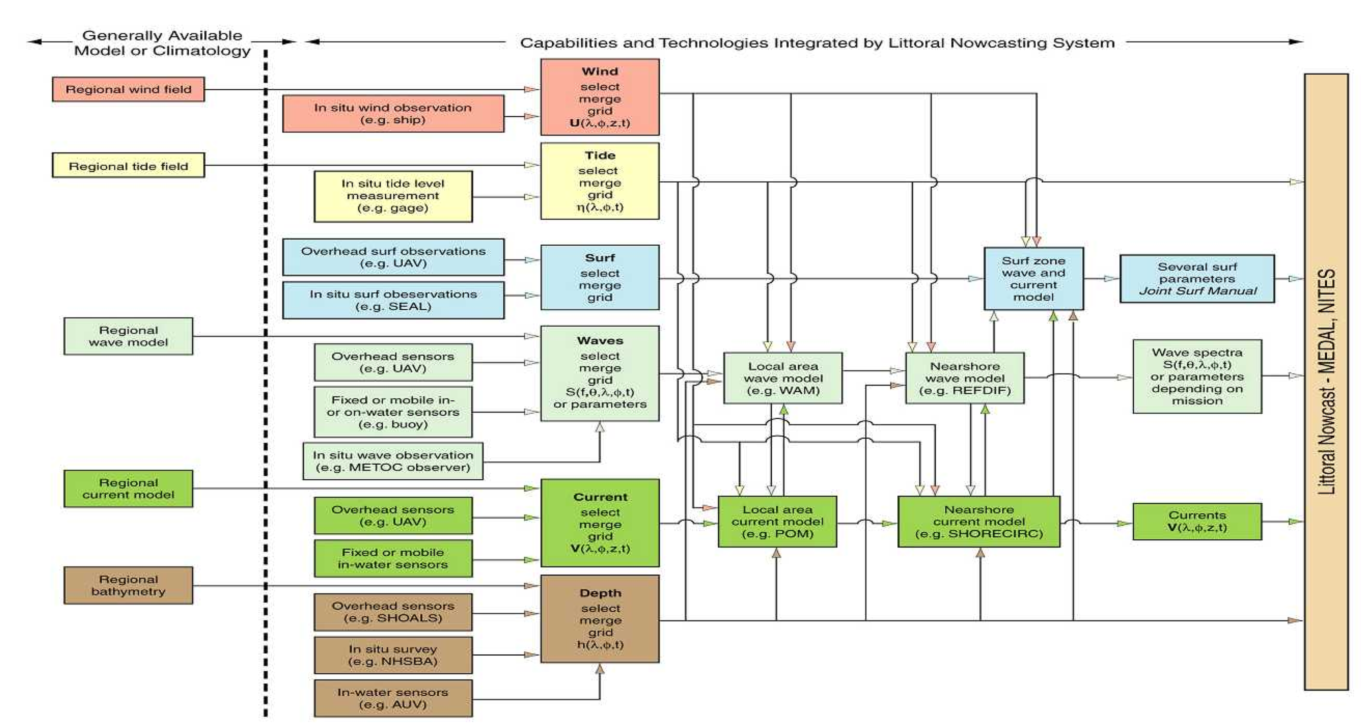

Figure 5. Schematic diagram of the littoral nowcasting system

Fig. 5 shows a schematic diagram of the completed system, with full integration into existing data flow structures detailed. Output from the system will also be archived in databases for use in tactical decision aids.

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