1. Introduction

The U.S. national VDatum program has been providing datum products and software to vertically transform geospatial data between a variety of vertical datums, including tidal, orthometric, and ellipsoidal vertical datums. The tidal datums are the important references for a broad coastal applications, including flood forecasting, inundation modeling and mapping for tsunamis and storm surges, water control, flood occurrence rate map, navigation charting, topographic mapping, etc. To improve model accuracy and thus to further reduce the uncertainty in the VDatum products, the ongoing U.S. West Coast VDatum update project will employ a conceptually simple-tides assimilation scheme based on linearized shallow water equations to optimize/improve offshore tidal boundary conditions for the ADCIRC tidal model.

2. Method

The data assimilation scheme we used here is similar to Egbert et al. (1994). We denote the dynamic and observations systems for tidal water level and velocity field as Eqs. (1) and (2), respectively:

\[ \begin{align*}
\dot{S} &= L(S - d) \\
\dot{d} &= Lu - R(\dot{S} - d)
\end{align*} \]

Where \( S \) is the shallow water equation operator, \( L \) is forcing term, \( d \) is the observed state variable fields, \( L \) is the projection operator projecting the state variables into the observation location. The combination of Eqs. (1) and (2) is an over-deterministic system of equations.

To solve the problem, the cost function \( J(u) \) to compromise Eqs. (1) and (2) is defined as

\[ J(u) = (Lu - d)\trans(Lu - d) + (S_o - f)\trans(S_o - f) \]

where \( S_o \) and \( f \) are the observation and model error covariance matrices, respectively.

In deep ocean we assume the dynamic equation (1) is linear. Then the reprojector approach (Egbert et al., 1994) can be used to minimize the cost function \( J(u) \). The system are solved using finite element method.

3. Results and Discussion

The data assimilation scheme described in previous section was applied to the 151 BPR data. Four principal tidal constituents (M2, S2, O1, and K1) were modeled. Computational time for each is about 45 min on a PC using Matlab. Fig. 3 a-d show the global solutions for amplitude and phase for the four tidal constituents. Model results at 38 open-coast tide stations at the US West Coast were plotted along with the observations as in Fig. 4. Table 1 summarizes the model error in the amplitudes for both datasets.

4. Conclusion and Future Work

We have presented and applied the data assimilation scheme to assimilate deep ocean BPR data for global ocean tides. The good model-data comparisons at 38 open coast tide stations validate the approach. This scheme will then be applied to an upgrade of US West Coast VDatum.

We are in the process of compiling high resolution CUSP shoreline data and collecting the latest NOS bathymetry survey data for US West Coast. These data will be used to develop a high resolution VDatum tide model, which can well resolve major bays, rivers, intra-coastal waterways, breakwaters, etc. This regional model will be used to further improve the current version of global tidal model.

References


Powell and Neeraj Saraf at CSDL for their administrative support; Richard Ray for providing the BPR data; Hurt Hess and Alexander Kurapov at CSDL for discussion, Jason-1 reveals buried tectonic structure, Science, Vol. 346, no. 6205, pp. 65-67, doi: 10.1126/science.1258213.