Simplified Calculation of Constituent Tidal Currents and Height from HF Radar Profiles across the Mouth of Bays and Sounds

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ABSTRACT

A dominant part of the circulation in nearly enclosed bays, estuaries, or sounds is dictated by tidal inflow at its mouth, called co-oscillatory forcing. The remaining flow component is usually due to winds. HF radar measurements across the region at the entrance can be used to extract the sinusoidal tidal velocity constituents along a line across the mouth. We use this complex (i.e., amplitude and phase) spatial profile at different times of the tidal cycle as the boundary excitation condition to solve a scalar second-order partial differential equation (PDE) for tide height. For the boundary condition over the remaining enclosing coast, the flow normal to the shore is taken to be zero. The bathymetry of the bay is included in this scalar PDE. This is then solved by a powerful finite-element code, PDE2D. From the tide height distribution, the velocity circulation is simply calculated as its gradient.

We present results applying this method to simple, canonical bay shapes and bathymetries. The effect of the bottom shape is studied, as well as the different excitation profiles at the mouth. Both tide height and vector current field are calculated and compared for the different geometries and excitations. Our future studies are applying this to Long Island Sound, where three SeaSondes straddle the mouth at the Eastern end, owned and operated by University of Rhode Island and University of Connecticut. Our studies reported here of canonical bay and bottom shapes serves as a guide and check in applications to these real-world situations.

To our present lowest order of approximation, friction and dissipative effects that cause tidal-phase time lags at different points are neglected. Higher-order nonlinearities are also neglected. Both of these effects are being included in subsequent studies. The main advantage of our method for co-oscillatory tidal analysis is simplicity: it avoids the complexities and computational requirements of full-up numerical primitive equation methods (like the Princeton Ocean Model). The goal is to provide this as an algorithmic tool to run on the standard PCs that control and process data for the many HF radars being operated in bays. From a radar-measured profile of the tidal constituents across the mouth. we hope to estimate tidal circulation and tide heights throughout the bay, in areas well away from the entrance where HF radars make their measurements.