Reducing Horizontal Pressure Gradient Errors In 3D σ-Coordinate Coastal Hydrodynamic And Transport Model

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The sigma coordinate transformation is commonly used in three-dimensional coastal and estuarine models (e.g. POM, ECOM3D, DELFT-3D, EFDC). However, it is well known that this coordinate transformation introduces additional terms and produces computation error in calculation of horizontal pressure gradient terms. When a steep bottom slope exists in navigation channels, the error in pressure gradient calculation can cause significant errors in velocity field and sediment transport.

In this study, a new algorithm is presented to reduce the numerical errors induced by the calculation of horizontal pressure gradient term in sloping navigation channels. The basic concept of this algorithm is to re-organize the pressure terms in sigma coordinate system to avoid the subtractions of two large horizontal pressure terms. To accomplish this objective, 2nd order Lagrangian interpolation method was firstly used to obtained salinity profile in the water column. Secondly, rather than calculating horizontal pressure and its gradient, the horizontal salinity difference at sigma grid center was determined. Finally, the horizontal pressure gradient in the water column is calculated from the horizontal salinity gradient. A stepwise bottom boundary condition (Huang and Spaulding 2002) was adopted for steep slopping bottom boundary.

The algorithm has been tested in a case of steep sloping channel using a 3D Environmental Fluid Dynamic Model Code (EFDC). Numerical tests were performed in absence of external forcing and with a horizontal uniform stratification to exam the pure numerical error from calculation of the pressure gradient force. Results indicate that conventional approach in dealing with horizontal pressure gradient terms causes spurious surface elevation, velocity field, and sediment transport. In comparison, the employment of the algorithm given in this study significantly reduce numerical errors in predicting surface elevation, currents, and sediment transport in navigation channels. Application of the improved model code in Apalachicola Bay is presented

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