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The Structure of Three-Dimensional Tide-Induced Current. Part II: Residual Currents

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ABSTRACT

A simple method of computing the second-order, three-dimensional, tidally-induced residual current is presented. The depth-averaged residual current and the mean-surface gradient from the depth-averaged equations are first computed, assuming that the bottom friction is linearly proportional to the depth-averaged residual current. The frictional coefficient is proportional to the amplitude of the first-order oscillating current and inversely proportional to the depth of the water column. Using the computed values of the mean-surface gradient, the vertical variation of the residual current for various forms of the vertical eddy viscosity can be computed numerically.

An example of the computation is shown for a tidal wave that propagates perpendicularly to a straight coast and has all the variables independent of the longshore direction. The direction of the computed Lagrangian residual current disagrees with the previous study by Johns and Dyke (1972) who simplified the computation by applying the bottom boundary layer approximation and assuming that there was no residual current in the frictionless layer. The dynamics of the residual current is discussed and explained.

This simple method does not include in the bottom stress the deviations resulting from the advection, surface stress, Coriolis effect, and the relationship between the friction coefficient and the vertical eddy viscosity. Detailed analyses of these deviations are presented. The simple method can be improved by including these deviations. For the example studied here, the accuracy of the solution obtained without including the deviation in the bottom stress is found to be generally within ~ 20–30%.

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