The Spring-Neap Cycle of Straining and Mixing in a Partially Mixed Estuary

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Abstract

The stratification of Delaware Bay exhibits large spring-neap variations, triggered by changes in mixing intensity associated with the modulation of tidal velocity. The dynamics of stratification variation were quantified via the salinity variance equation in numerical simulations of the estuary. This approach demonstrates that stratification arises from the conversion of horizontal variance to vertical variance via straining.

Straining occurs both in the along-estuary direction, due to the interaction of the along-estuary shear flow with the along-estuary salinity gradient, and in the lateral direction, due to cross-estuary salinity gradients and shear in the cross-estuary flow. During spring tides, lateral straining is of comparable importance as along-estuary straining in producing stratification, with the most intense lateral strain occurring along the flanks of the channel near the end of the flood tide. Along-estuary strain is strongest in the channel during the ebb, and it dominates during neaps.

The Simpson number is used to distinguish the relative importance of tide-generated shear stress and baroclinicity in driving the strain. Density-driven shear dominates lateral straining, whereas tide-generated and density-driven shear both contribute to longitudinal straining. Indeed, as Hansen and Rattray pointed out more than half a century ago, horizontal density gradients have an important dynamical role even in weakly stratified estuaries.