The Competition between Straining and Mixing in Controlling Estuarine Stratification

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The roles of straining and dissipation in controlling stratification are derived analytically using a vertical salinity variance method. In an estuary, the input of salinity variance comes only from the freshwater at the river boundary and the saltwater at the ocean boundary. Following the suggestion of Burchard and Rennau (2008) to refer to the destruction of salinity variance as ‘‘mixing’’, it is interesting to note that estuarine mixing acts almost exclusively on vertical salinity variance, i.e., stratification. Stratification is produced by converting horizontal variance to vertical variance via straining, that is, differential advection of horizontal salinity gradients, and stratification is destroyed by the dissipation of vertical variance through turbulent mixing.

A numerical model is applied to the Changjiang estuary to demonstrate the salinity variance balance and how it reveals the factors controlling stratification. Throughout the spring–neap tidal cycle, straining is almost always larger than dissipation, indicating a net excess of production of vertical variance relative to dissipation. This excess is balanced on average by advection, which exports vertical variance out of the estuarine region into the plume.

During neap tide, tidal straining shows a general tendency of destratification during the flood tide and restratification during ebb, consistent with the one-dimensional theory of tidal straining. During spring tide, however, positive straining occurs during flood because of the strong baroclinicity induced by the intensified horizontal salinity gradient.