A Local Eddy Viscosity Parameterization for Estuarine Exchange Flow

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A new parameterization for the estuarine turbulent eddy viscosity coefficient is developed considering the influence of wind forcing and feedback between stratification and shear. The emerging tidally averaged eddy viscosity profile is parameterized as parabolic under well-mixed conditions, and is composed of a skewed-Gaussian-like form for the upper layer, and a parabolic form for the bottom layer under stratified conditions. The precise shape of the profiles depends parametrically on the bottom boundary layer thickness, the bulk Richardson number, and the Wedderburn number. The parameterized eddy viscosity profiles show excellent agreement with profiles obtained from numerical models. To explore the importance of vertical change with regard to exchange processes, an analytical model is designed. This one-dimensional model is based on a balance between frictional forces and pressure gradient. The resulting exchange flow is analyzed over the relevant parameter space that is associated with horizontal and vertical stratification through the bulk Richardson number, and the bi-directional wind stress via the Wedderburn number. Down-estuary wind enhances the up-estuary flow near the bottom and down-estuary flow near the surface driving an exchange flow pattern typically associated with gravitational circulation. Up-estuary wind results in either a two-layer inverted circulation opposing the gravitational circulation, or a three-layer flow that is up-estuarine at the surface with classical two-layer circulation underneath. Three-layer flow emerges with a weak wind. With increasing runoff velocity, three-layer flow transitions to a single layer flow under weak stratification conditions.