# A Local Eddy Viscosity Parameterization for Estuarine Exchange Flow: Stratification & Wind Entrainment

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Structure and intensity of estuarine exchange flow depend significantly on the eddy viscosity Av profile which is dynamically linked to various forces (e.g., gravitational, tidal, wind-driven). The impact of winds on the exchange flow is complex due to its direct (local and remote changes in shear and density stratification) and indirect (modifications to Av profiles) contributions. This study aims (i) to include wind entrainment effects in the tidally averaged Av parameterization; (ii) to develop an analytical one-dimensional model for the wind driven exchange flow by using this novel parameterization and assess the tidally averaged dynamics over a relevant physical parameter-space, subdomains of which have not yet been explored numerically. This one-dimensional model is based on a balance between frictional forces and pressure gradient, calibrated with a tidally-resolving one-dimensional water-column model with second-moment closure. Structure and intensity of the resulting exchange flow profiles are analyzed with respect to three dimensionless parameters (the unsteadiness of boundary layer mixing Un, scaled-directional wind stress W, and horizontal stratification Si). While down-estuarine winds enhance the gravitational circulation, up-estuarine winds result in either a two-layer inverted circulation opposing the gravitational circulation, or a three-layer flow (favored by relatively strong Si, weak W, and moderate Un) that is up-estuarine at the surface with classical two-layer circulation underneath. Relative thicknesses of surface and bottom boundary layers affect both the intensity and the inflection depth of the exchange flow layers. Up-estuarine winds with $W \gtrsim 0.5$ yield unstable stratification and reduce the exchange flow intensity with increasing W.