Characterization of estuary/ocean exchange in terms of the Kelvin and Ekman numbers

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The pattern of density-induced flow influenced by estuary's width, friction and Earth's rotation is investigated as a function of the Ekman (E_k) and Kelvin (K_e) numbers. The exchange flow is horizontally sheared under high frictional conditions ($E_k > 1$) independently of K_e. The exchange flow pattern is also horizontally sheared when $E_k \to 0$ and $K_e > 2$. In that case, however, the outflow is concentrated on the left (looking into the estuary in the northern hemisphere) portion of the cross-section and inflow appears on the right. Also under weak friction, the exchange pattern becomes more vertically sheared as $K_e < 1$. Bathymetry is not very influential in the weak friction exchange patterns. Finally, under $0.01 < E_k < 0.1$ the exchange pattern is both horizontally and vertically sheared for all widths. The horizontally sheared pattern is best defined in high K_e whereas the vertically sheared pattern dominates in low K_e. Observed patterns in various estuaries are categorized in the E_k *vs.* K_e parameter space.