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Effects of horizontal residual circulation on salinity distribution in estuaries

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Tidal pumping, which is caused by residual horizontal circulation, is an important but ill-understood mechanism of tidal flow that produces longitudinal salt dispersion. Although in the central saline part of estuaries with a strong salinity gradient, gravitational (vertical) circulation is the most important factor for mixing and dispersion, in the sea-ward part of wider estuaries, where the density gradient is small, tidal pumping is the main mixing mechanism. In classical literature, the importance of this type of circulation is recognised, but no efforts have been made to quantify this mechanism in terms of a longitudinal dispersion coefficient.

There are two types of residual circulation: Shearing of the tidal flow through preferential flood and ebb channels and interaction of the tidal flow with the irregular bathymetry. Residual ebb-flood circulation is an important mechanism for moving pollutants and transporting salinity upstream against a mean discharge of fresh water, for which no adequate theory exists as yet. In order to model the effects of residual horizontal circulation, a simple model of an ideal flood-ebb channel system estuary in MATLAB has been developed to analyze the mechanism of residual circulation by flood-ebb channels in conjunction with salinity. The results show how this mechanism depends on the length of the branches in relation to flow parameters, such as tidal velocity amplitude or tidal excursion. Subsequently these findings have been confronted with the real case of the Western Scheldt estuary in the Netherlands by used of the mathematical model DELFT3D.