Impact of evaporation and precipitation on estuarine mixing relations

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Recent studies could link the quantities of estuarine exchange flows to the volume-integrated mixing inside an estuary, where mixing is defined as the destruction of salinity variance. These so-called mixing relations state that the mixing inside an estuary is given by its boundary fluxes which are quantified as Knudsen or Total Exchange Flow bulk values. So far, river runoff is the only freshwater flux included and the freshwater exchange due to precipitation and evaporation is neglected. Yet, the latter is the driving force of inverse estuaries, which could not be described by the existing relations. Therefore, this study adds evaporation and precipitation to complete the existing mixing relations. It is shown that these are included as an additional variance transport to the mixing relations. This further allows decomposing the mixing into a riverine and a surface transport contribution. The derived relations are tested against idealized two-dimensional numerical simulations of different combinations of freshwater forcing. The exact mixing, occurring in the model, can be directly diagnosed and compared to the estuarine mixing relations. Both agree exactly. Furthermore, the mixing relations are applied for the first time to a realistic three-dimensional numerical simulation, an annual hind-cast simulation of the Persian Gulf. The results show that the mixing contributions of river discharge and evaporation are almost equal, although the freshwater transport due to evaporation is about one order of magnitude larger than the river runoff.