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## Total Exchange Flow in the Guadalquivir River Estuary

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The Total Exchange Flow (TEF) analysis framework computes the exchange flow in estuaries using isohaline coordinates. The TEF represents a paradigm for exchange flow estimates that is consistent with (steady-state) Knudsen-bulk values, and naturally allows quantifying mixing, which in turn controls the inflow and outflow fluxes of water and salinity.

This study provides preliminary estimates of TEF along the Guadalquivir River Estuary (Spain) at seven notable cross-sections during low river flows. The analysis combines observations recorded between 2008 and 2011 by a real time monitoring network and analytical model output for a well-mixed M2+M4 tidal flow with oscillating salinity. Exchange profiles and volume and salinity transports sorted by salinity classes are computed.

The results indicate that bulk along-channel TEF estimates decrease upstream. Incoming and outgoing water volume transports are about 10% larger than previous estimates based on gravitational circulation only. The largest net incoming water volume transport, viz. approx. 300 m<sup>3</sup>s<sup>-1</sup>, is attained at the lower part of the estuary, near where the largest salinity gradient is observed. This value is about 12-fold the normal river flow from the head dam at Alcalá del Río. Its corresponding representative TEF bulk salinity value is 20 psu, whereas the representative value for outflows at the same location is about 16 psu. In the middle part of the estuary, incoming TEF bulk volume values below 150 m<sup>3</sup>s<sup>-1</sup> are obtained. As expected, negligible values are obtained in the upper part of the estuary near the head dam. Mixing completeness is larger than 75% at all cross-sections, thereby evidencing the poorly-stratified character of the Guadalquivir estuary.

Regarding the effects of tidal asymmetry, the inclusion of the M4 tidal constituent in the analysis does not improve significantly the TEF estimates (less than 1% at all cross-sections), although it might be the case in other estuaries or coastal seas. This ensues that the covariance between salinity and current seems to play a more important role in exchange flow in the Guadalquivir estuary.