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Multi-decadal trend analysis of tidal constituents in the Spanish estuaries

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This work presents the analysis of the tidal harmonic constituent variability in 93 Spanish estuaries of the Iberian Peninsula, with a view to address the physical and biotic sensitivity of these estuaries to global change. These estuaries range from tidally-dominated estuaries (e.g., such as the Guadalquivir estuary in the Gulf of Cádiz) and rias (e.g., Ría de Vigo) to salt-wedge deltaic systems (e.g., Ebro in the Mediterranean Sea). Over 20 years of data of sea level from the Spanish Ports network [Pérez-Gómez (2015), PhD Thesis, 978-84-88740-06-9] were analyzed by means of short-time harmonic analysis. Seasonal and nodal variations were removed, among others. Average tidal mass exchange rates between the estuary and inner shelf, tidal energy dissipation by friction, bulk Richardson number, and salt intrusion indices [Prandle & Lane (2015), ECSS 160, 60-68] were computed using multi-decadal trends in the tidal constants at each estuary. The results suggest that some major estuaries (e.g., Guadalquivir, Vigo, and Ebro) show a decreasing trend in their respective main tidal constituents near the mouth (-0.1+/-0.03 (M2), -0.045+/-0.010 (M2), and -0.0022+/-0.0010 (K1), respectively). Sea level rise during the last 20 years could favor the increase. However, in this work we hypothesized that the greatest impact on the tidal constants trends is probably due to the reduction of freshwater discharges. Changes in river flows impact on salt intrusion, stratification and thus vertical eddy viscosity distribution. The decrease in stratification due to the decrease in river flows during the last 20 years favors that frictional influence reaches the upper layers of the water column, reducing the tidal amplitudes. Also remarkable is the increase of the tidal amplitudes near the head in the Guadalquivir estuary (0.01 cm/year) despite the tidal amplitude reduction at the estuary mouth. This is apparently due to a regime shift due to the deepening of the main channel for navigational purposes and the concomitant increase in suspended sediment concentrations.