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Trends in turbidity in the fluvial section of a highly turbid macrotidal estuary, the Gironde in SW France, based on continuous in-situ monitoring

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The fluvial-estuarine system of the Gironde (SW France) is one of the largest European estuaries, in terms of surface area and of annual mean discharge. The upstream tidal asymmetry and subsequent tidal pumping are the main mechanisms that develop a pronounced Turbidity Maximum Zone (TMZ) characterized by high suspended sediment concentrations (SSC), over 1 g/L in surface waters. Freshwater inflow and tidal cycles are the major factors that affect the size, position and concentration of the TMZ along the estuary axis. In the context of global change, the decrease in freshwater flows (changes in rainfall, upstream land use) and sea level rise may lead to a progressive upstream displacement and an increasing persistence of TMZ, close to the uppermost limit of tidal influence. Understanding and predicting trends of turbidity are then crucial for a better present and future evaluation of the estuarine processes, as well as for a more sustainable management and planning of the landscape. At present, these tasks are difficult due to the limited available data, mainly obtained in the lower reaches. The upper Gironde estuary consists of two tidal rivers (Garonne and Dordogne), where sections are narrow, and where SSC and sediment fluxes are particularly sensitive to changes on river flow. Up to recently, the upper reaches were still poorly documented.
Since 2004, as a part of the MAGEST network, a real-time continuous system records turbidity at representative stations of the fluvial (Bordeaux and Portets on the Garonne River; Libourne on the Dordogne River) and central estuary, aims to establish a long-term reference database. In this work, we present 9-years of records of turbidity for analysis and discussion of the trends at the limit of freshwater influence at different time scales. The turbidity sensor (Endress and Hauser, CUS31-W2A) measures values between 0 and 9999 NTU (9999 NTU correspond to about 8 g/L).
Continuous measurements reveal the temporal changes in turbidity due to deposition-resuspension processes related the tidal cycles, and to changes in fluvial discharges. In particular, only such a continuous record can capture turbidity signatures of a flood peak that often occur for a few hours. For the Gironde estuary, we show that turbidity maxima during flood events are 4-10 times lower compared to TMZ values during a drought period. There are marked seasonal differences in daily-averaged turbidities, from about 10 to nearly 9999 NTU, in both the Garonne and Dordogne Rivers. We found a pronounced interannual variability in the concentration and persistence of the TMZ according to hydrological conditions. In the Garonne River, the mean concentration and duration of TMZ presence are 2845 NTU - 93 days and 4134 NTU - 250 days during a wet and dry year, respectively. The dependence of turbidity on tidal range varies in function to river flow and the stronger relationships are observed for discharges below 150m3/s. By analyzing the turbidity evolution during the installation and expulsion of TMZ, we show that the relationship between turbidity and discharge follows a hysteresis patterns during these transition periods.