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Relevance of different spectral techniques to describe estuarine suspended sediment dynamics based on a high-frequency, long-term turbidity dataset

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Sediment dynamics in estuaries are complex and strongly variable over time scales ranging from seconds to years. Various forcings (turbulence, tides, river inflow, wind waves, morphological and climatic changes) may cause the temporal and spatial variability of suspended sediment (SS) concentrations. The evaluation of these SS dynamics by in-situ measurements have traditionally faced three difficulties: (1) the quantification of low-frequency variability that requires continuous measures over long time periods; (2) inevitable gaps in data limiting the post-processing; (3) the need for recording other environmental variables in the same period and at a coherent sampling frequency. To record a high-frequency and long-term turbidity dataset, an automatic monitoring network (MAGEST) has been implemented in the Gironde estuary, a macrotidal and highly turbid system in the South-West France, in 2004. This 10-year turbidity time series is rather unique in European estuaries, enabling the evaluation of SS dynamics at all the significant time scales in one single analysis of the dataset. To achieve this, several methodologies of data analysis using different approaches are available, but their relevance, especially for the more recently developed ones, is almost unexplored. In this work, we present the test of four spectral techniques to the analysis of a high-frequency turbidity time series of an estuary such as the Gironde, to discuss advantages and limitations of each method. We compare the Power Spectral Analysis (PSA), the Singular Spectral Analysis (SSA), the Wavelet Transform (WT) and the Empirical Mode Decomposition (EMD). Advantages and limitations of each method are evaluated on the basis of five criteria: efficiency for incomplete time series, appropriateness for time-varying analysis, ability to recognize processes without the need of complementary environmental variables, capacity to calculate the relative importance of processes, and capacity to identify long-term trends. The SSA is the only analysis, among the four tested, to reach all the criteria and its potential is detailed through examples. We also show how the methods can complement each other. This evaluation contributes to progress in the understanding of sedimentary dynamics in estuaries, but also may be very useful to the time series analysis of other environmental variables.