Relative contributions to suspended sediment variability under extreme events (Gironde Estuary, France)

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Motivation

- Extreme events likely modify the interplay of forcings (tides, river discharge and winds) impacting estuarine suspended sediments and their spatial variability
- Traditional statistical approaches rely on high-frequency data at fixed stations, being spatially limited and unable to distinguish the contribution of winds
- Machine learning captures complex non-linear interactions between forcings and suspended sediments
- Spatially-resolved relative contributions support management strategies
- The Gironde Estuary is well-sampled; being an excellent laboratory study site

Data

"CurviGironde" numerical modeling; hourly*

Tidal currents
Water level
Depth
Surface suspended sediments (SSC)

*Reanalysis data (ECMWF-ERA5**): wind*

Field data

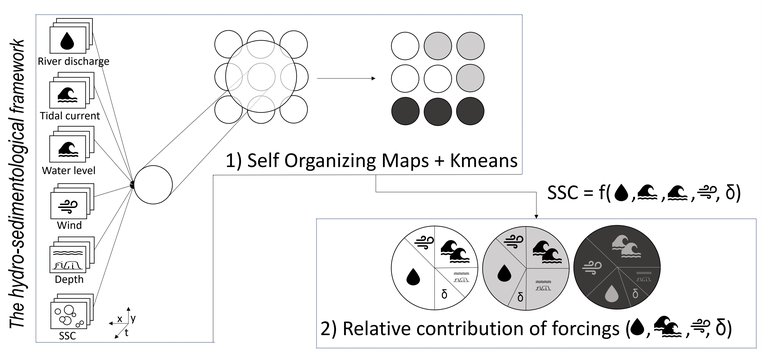
River discharge (http://www.hydro.eaufrance.fr/)
Winds (https://meteofrance.com/)
*Turbidity*** (MAGEST https://magest.oasu.u-bordeaux.fr/)*

Gironde Estuary, France

***Proxy for SSC

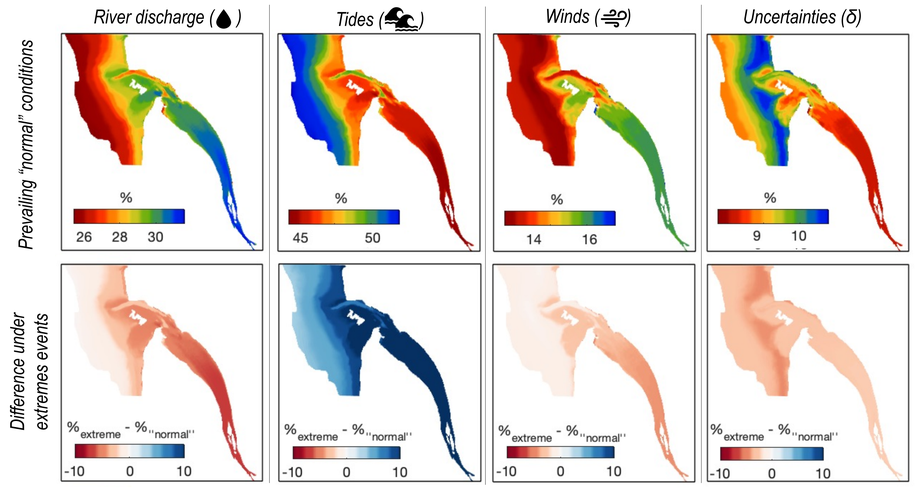
Methods

- CDF-matching of ECMWF-ERA5 winds with field wind data
- Spatial interpolation of river discharge
- Standardization of datacubes at hourly frequency and 300m pixel resolution
- Extremes events as P90th from 30+ years of and data



Results

1. Spatial relative contribution of forcings to suspended sediment variability



Overall impacts of forcings to surface sediment variability are ordered as:

> >

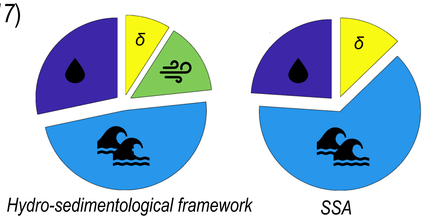
Spatial contribution of winds is quantified for the first time in the Gironde Estuary

Influence of tides on sediment variability increases during extreme events

2. Intercomparison exercise with a traditional method (Singular Spectral Analysis - SSA) as described *in Jalon-Rojas et al. (2017; DOI: 10.1016/j.ecss.2017.02.017)*

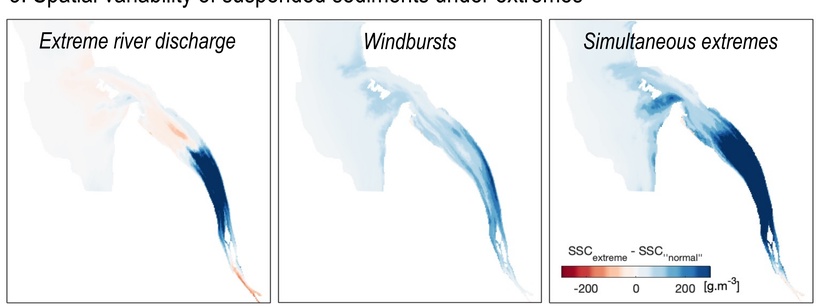
% results with the proposed framework are coherent with SSA at Le Verdon station

SSA did not distinguish role of winds



Hydro-sedimentological framework *SSA*

3. Spatial variability of suspended sediments under extremes



- *Extreme events lead to overall increase of suspended sediments along estuary*
- *Simultaneous extremes yield largest mean differences in SSC*

Take home messages

The unsupervised machine learning self-organizing maps combined with an explanatory approach synthesizes the complex hydrodynamical and sedimentological estuarine variability.

The hydro-sedimentological framework provided spatially resolved estimates on (1) the influence of tides, river discharge, and winds on suspended sediment variability and (2) accounted for uncertainties.

The influence of tides, river discharge, and winds is not only spatially quantified but also diferentiated between prevailing conditions and extreme events;

Tide is the main forcing mechanism controlling sediment variability in the Gironde Estuary

The relative contribution of forcing mechanisms on the variability of suspended sediments exhibits a small spatial variability

The relative role of tides increases during extreme events

Data availability

* 'CurviGironde' data by Diaz et al. (2023) is under license CC-BY-NC-SA 4.0 (for non-commercial use and share alike https://creativecommons.org/licenses/by-sa/4.0/).

** ECMWF-ERA5: the results contain modified Copernicus Climate Change Service information 2020. Neither the European Commission nor ECMWF is responsible for any use that may be made of the Copernicus information or data it contains.

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