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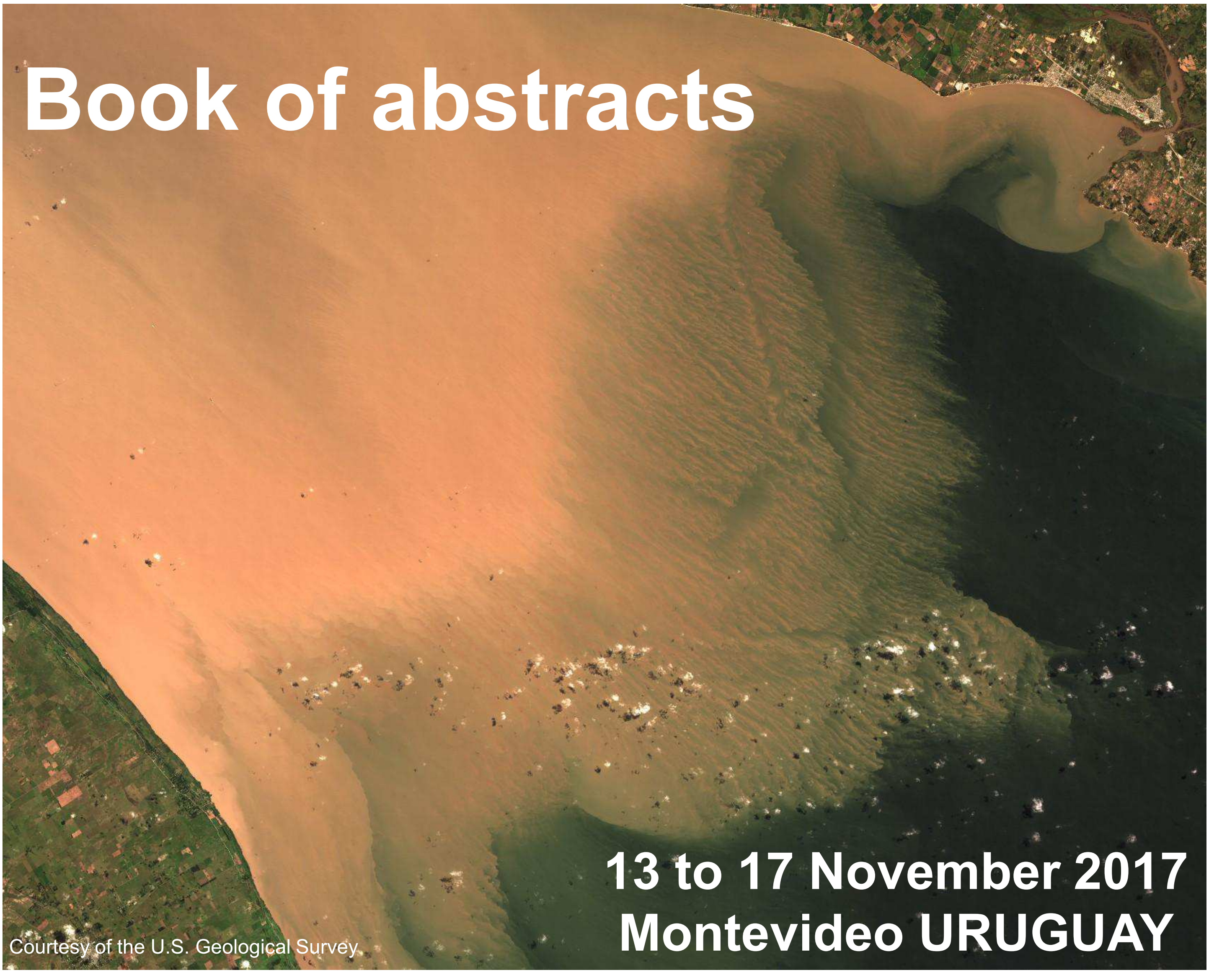

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Abstract
The mechanisms leading to the formation and maintenance of a Coastal Turbidity Maximum (CTM) along the Belgian coastline was investigated using a complex 3D numerical model. Interpretation of model results suggests that the sediment concentration in this CTM may have strongly increased as a result of human interventions in the 1980's. The large amount of sediment that became available then triggered self-organizing mechanisms that maintain or strengthen the CTM.

Introduction
A Coastal Turbidity Maximum (CTM) exists in the Belgian coastal zone, with elevated sediment concentrations up to ~100 mg/l near-surface and several g/l near the bed. These high suspended sediment concentrations lead to high maintenance dredging in the nearby Port of Zeebrugge (Fig. 1a) and its approach channels. However, despite the great costs associated with port maintenance, the mechanisms responsible for this CTM are poorly known. One of the potential mechanisms may be erosion of the seabed, which locally consists of consolidated mud (deposited there during lower sea levels earlier in the Holocene). Large quantities of mud may be eroded from the seabed due to human interventions, such as the seaward extension of the breakwaters of the Port of Zeebrugge (see Fig. 1b). A second potential mechanism is trapping by salinity-induced density currents: the CTM is located near the mouth of the Scheldt River. Additional mechanisms contributing to the CTM may be related to dredging and disposal strategies, tidal asymmetry, and residual circulation patterns.

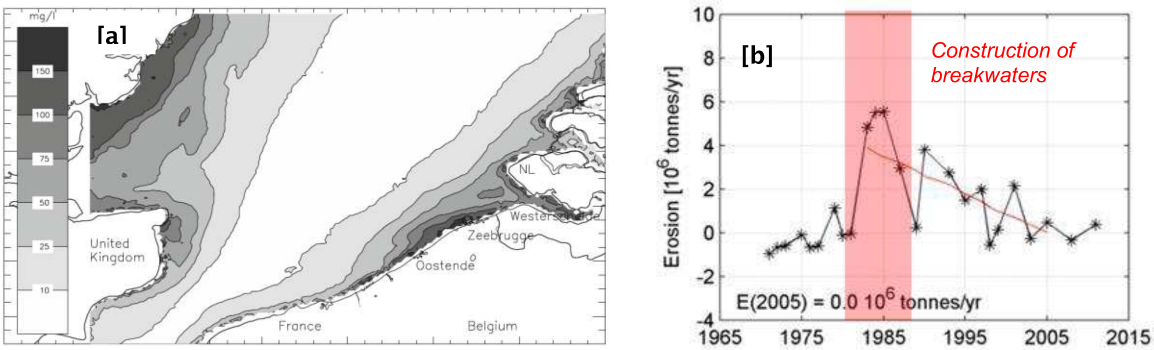

Fig. 1: The Zeebrugge coastal turbidity maximum (a, from Fettweis, 2010) and the erosion of mud following the extension of the breakwaters (in red) of the port of Zeebrugge

Approach
In order to investigate the processes responsible for the formation and maintenance of the CTM, a numerical model was setup. The overall strategies was to first setup and calibrate a complex 3D model in which all relevant processes and spatial scales are incorporated, and subsequently exclude individual processes to investigate their effect on the CTM. The model is setup with several mud fractions and with sand, and a dredging and disposal scheme based on actual dredging and disposal. Important features of this model include the effect of sediment on the density of the water-sediment mixture, a simple parameterization of near-bed hindered deposition, buffering of mud in the sandy seabed, and a local consolidated mud bed consisting of compact clays. The hindered deposition term is a simple way of accounting for several complex and poorly understood processes in the near-bed boundary layer related to hindered settling, flocculation, and consolidation which become important at high suspended sediment concentrations (SSC). The hydrodynamic model was calibrated against extensive datasets including waterlevels, velocity and salinity. The sediment module was calibrated against aggregated satellite observations, *in situ* long-term observations of SSC, and dredging volumes.

Results

The CTM can be generated with the model in two ways: through erosion of the underlying seabed or by including the hindered deposition term (Fig. 2). Over long timescales, erosion of the seabed cannot be responsible for the elevated sediment concentrations because a bed source is finite. After a certain amount of time the bed sediment would become depleted, and the sediment concentrations consequently would decrease. When hindered deposition is active, the CTM is maintained by salinity-driven and sediment-induced density effects (Fig. 3), effectively pushing the CTM towards the shore. However, hindered deposition is a process that becomes important at higher suspended sediment concentrations. This requires a condition in which sediment concentrations near the bed are already high. It is hypothesized that this initial state of elevated sediment concentrations is triggered by human interventions (such as the seaward expansion of the breakwaters illustrated by Fig. 1b). The large amount of sediment that became available triggered self-organizing mechanisms that maintain or strengthen the CTM.

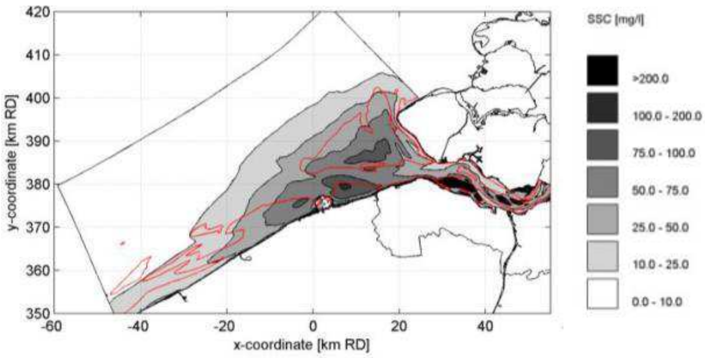

Fig. 2: Modelled average surface sediment concentration

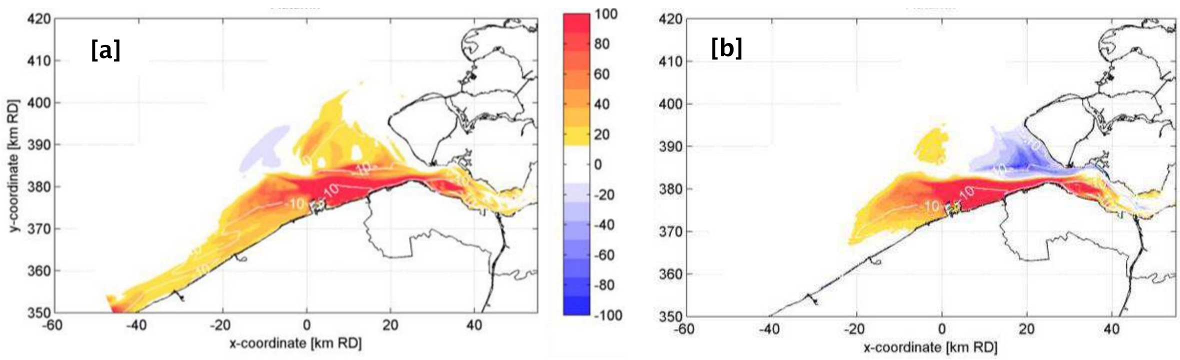

Fig. 3: Effect of sediment-induced density effects (a) and salinity (b) on the near-bed sediment concentration

References

Fettweis, M., Francken, F., Van den Eynde, D., Verwaest, T., Janssens, J., and Van Lancker, V., (2010). Storm influence on SPM concentrations in a coastal turbidity maximum area with high anthropogenic impact (southern North Sea). Cont. Shelf Res. 30, 1417–1427.