

Evaluation of the effect of climate change on the muddy deposits in the flood plain of the Loire Estuary and on the turbidity maximum (C3E2 Project- French research program)

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The project C3E2 (Consequences of Climate Change on Estuarine Ecogeomorphology – French research program: ‘Gestion et Impacts du Changement Climatique’ driven by MEDDE) proposes to contribute to the evaluation of the effect of climate change on the evolution of the morphology of estuaries. Two approaches are implemented, both based on numerical modelling coupling the morphodynamic aspects:

- One studies the morpho-sedimentary response of schematic estuaries, defined from different geometrical characteristics and environmental conditions representative of French estuaries.
- The second is applied to the estuary of the Loire, where the existence of long time series allow for validation of the 3D model hydro-sedimentary (mud sediment) already operational; secondly, this estuary has the distinction of having preserved natural areas on which the interactions between vegetation and physical processes can be studied. The importance of a high bank between main channel and floodplain is here to overcome, particularly in view of a change in frequency of flooding.

This is the second part of the applied to the Loire estuary project that is developed in this paper with the assessment of the impact of climate change on the mud dynamic and particularly on deposits in the floodplains.

Description of the 3D model hydro-sedimentary

The model is based on the Telemac-3D system. The simulated area is about 90km inland and 40km offshore. The model is forced with the daily discharge of the Loire river, the astronomical tide level, variation of mean sea level due to meteorological conditions, waves and wind conditions. This operational 3D model is calibrated and validated in the inner estuary: sea levels, currents, salinity, sedimentology including turbidity of mud transport and bed level evolutions in mud (Walther *et al.*, 2012).

The model proved to be able to reproduce a full annual cycle of the dynamics of the maximum turbidity in the Loire Estuary without any assumption regarding the bathymetric state of the estuary. The model has been adapted and refined on submersible areas to accommodate drainage channels, with a minimum mesh size of 10m on the northern mudflats of the estuary of the Loire.

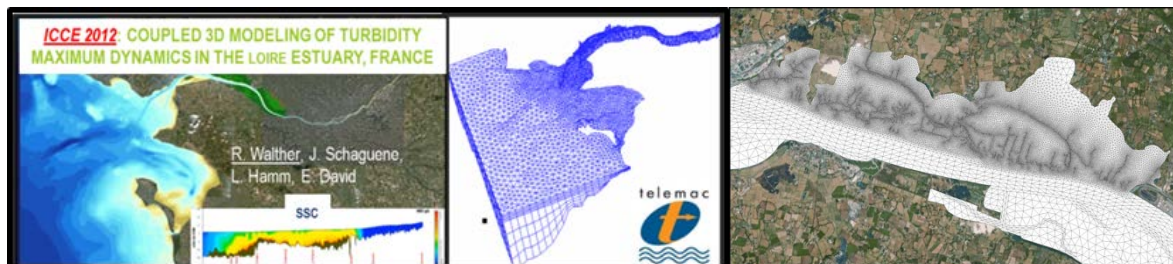


Fig. 1. View of the 3D hydro-sedimentary model and refinement northern mudflats of the Loire Estuary.

Validation of the 3D hydro-sedimentary model in the submersible area

An important, measurement campaign on a submersible area was effected in 2012 with spring tide conditions in water level, salinity, SSC and mud deposit. The model was compared to these measurements to calibrate and validate the exchanges between Loire and submersible area. It appears that the model was able to reproduce the short-term dynamics and long-term dynamics in the floodplains (deposits) (partially presented in Intercoh (Lehir *et al.*, 2013).

Analysis of the model results provided a better understanding of the dynamic in these areas.

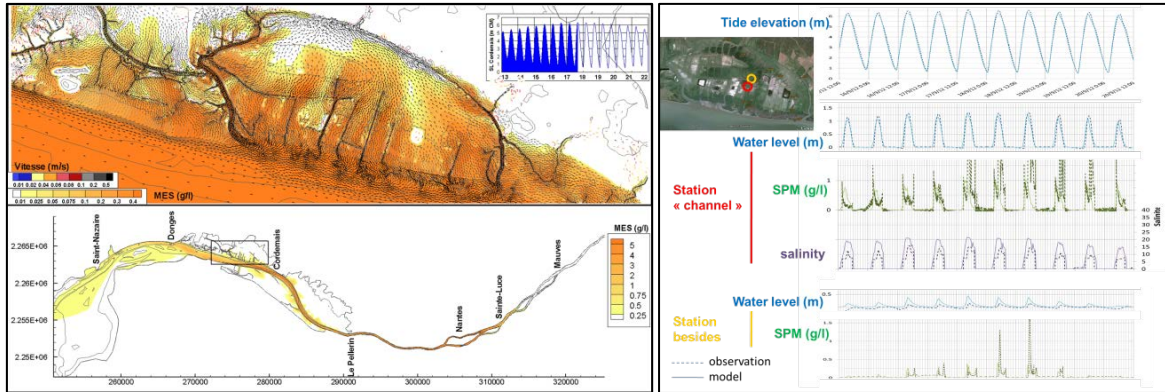


Fig. 2. Suspended sediment concentration during spring tide and submersion of mudflats and grasslands.

Evaluation of the morphodynamic submersible area during the period 2010-2040

Since the computation time, a modelling methodology was developed to simulate the changes of submersible areas until about 2040. The 3D hydro-sedimentary model simulates a year in real time every 5 years, with a morphological factor in the area of deposit for consolidated sediment. At each iteration, the Loire bathymetry is updated from the riverbed evolutions pre-calculated by a sand model.

Four scenarios of climate change were established and used in simulations. Evolution of submersible areas and new dynamics in maximum turbidity are analysed for each scenario.

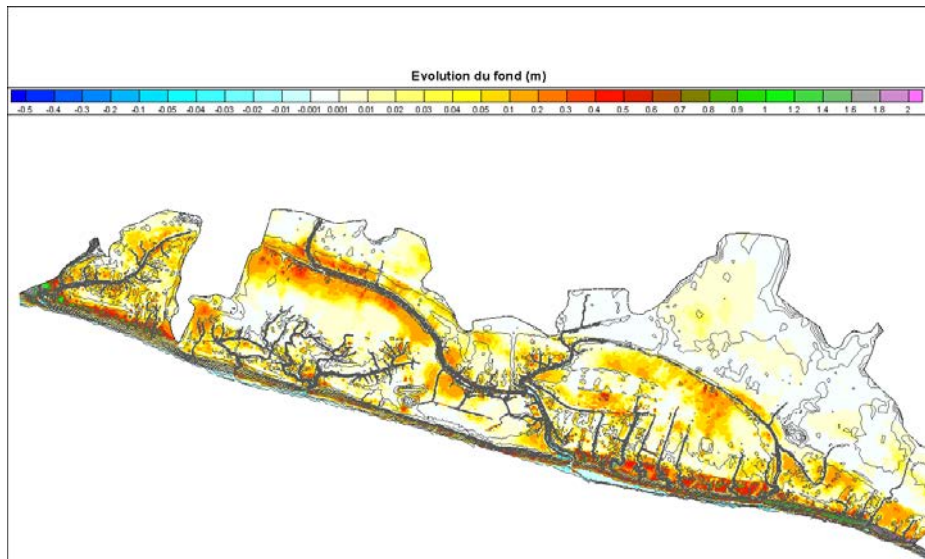


Fig. 3. Example of calculated evolution of the bed on mudflats and grasslands between 2010 and 2040 for one climate change scenario.

References

- Lehir P., R. Walther, F. Cayocca, P. Bassoullet, H. Jestin and R. Verney. 2013. C3E2: Consequences of climate change on estuarine ecogeomorphology. IntercoH 2013 Conference, Gainesville (FL), 21-24 Oct.
- Walther R., J. Schaguene, L. Hamm and E. David. 2012. Coupled 3D modelling of turbidity maximum dynamics in the Loire Estuary. Coastal Engineering Proceedings 1(33).