Mud Transport in the Upper Sea Scheldt under climate change: from 2013 to 2050

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Introduction: Understand possible impacts of future climate change on mud transport in the Upper Sea Scheldt is important for ensuring safety and a sustainable development in this region. Thus, under the framework of "Integraal Plan Boven Zeeschelde", a 3D mud transport model is developed (Smolders *et al.*, 2018) for studying the current situation (2013) and system evolution in future scenarios (2050).

Methods: In order to assess the influence of climate change, different future scenarios in 2050 are devised, with changes in the following aspects:

- Bathymetry: a new sustainable bathymetry is created, with additional de-embanked areas, controlled reduced tidal areas and flood control areas, aiming for better navigation and protection of the river banks (IMDC, 2015).
- Sea level rise: the "low" scenario (CL, +15cm); and the "high" scenario (CH, +40cm).
- Tidal range: the increased (Aplus, +30cm) and reduced (Amin, -40cm) tidal ranges near Schelle and further upstream in the Upper Sea Scheldt are implemented by changing bottom friction in the Western Scheldt.
- Upstream discharge: Discharges in 2050 (Q2050) are obtained based on statistical analysis, with higher values at Melle and Dender.

The evaluation of future scenarios consists of two steps: 1. assess the influence of the sustainable bathymetry along by replacing the current bathymetry in 2013; 2. evaluate the range of influence from climate change through two different sets of boundary conditions, a mild scenario "AminCL+Q2050" and a more severe combination "AplusCH+Q2050". For better analyzing the 2050 scenarios, several kinds of explanatory parameters are computed. For instance, harmonic analysis is performed to water level and velocity for showing the changes in hydrodynamics; tidal asymmetry is quantified with several indicators according to different definitions; the mean sediment transport rates are decomposed into an advective (closely related to local discharge), a tidal pumping and a residual term. This way of decomposition can reveal the contributions from each mechanism and help with interpretation of the difference in mud transport.

Results: The mud model predicts slightly lower concentrations upstream while using the sustainable bathymetry in 2050. This is consistent with the slight decrease in the ebb dominance of the system near upstream boundary, and the slight decrease in bottom shear stress. When changing the boundary conditions to 2050, the main effect on concentrations upstream is the change in upstream sediment input (which is higher in both AminCL and AplusCH due to higher discharge). Combining with the changes of tidal asymmetry in this region, upstream concentrations increase in both 2050 scenarios. Another noticeable aspect is that AplusCH gives even higher SSC upstream compared to AminCL, making it a scenario with most significant effects as expected.

Discussion: The scenario analysis shows sea level rise in 2050 results in higher ebb velocities, thus a more ebb-dominant system in the Upper Sea Scheldt. This also means the system tends to have more net transport towards downstream. The change of tidal range is always combined with sea level rise. But it still can be seen that decreasing tidal range tends to result in longer ebb phase and more seaward transport, whereas increasing tidal range could lead to shorter ebb phase and more landward transport. Although the decomposition of sediment transport is based on cross-sectionally averaged, it can still reveal that, the advective transport due to discharge is more important compared to tidal pumping mechanism for the Upper Sea Scheldt. But the effect of changing upstream discharge decays towards downstream as transects becomes larger.

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