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Feedbacks of schematic sea-level rise induced topographic changes of the Wadden Sea on tidal dynamics

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Tidal flats of the Wadden Sea (German Bight) have not only high ecological value but also play a significant role for coastal defense as they dissipate tidal and wave energy in the foreshore area. Tidal flats are endangered by accelerated sea level rise, which is predicted by global climate models to occur already this century. Tidal flats of the Wadden Sea are capable to adapt to a certain degree of sea-level rise by growth due to the generation of accommodation space and a landward net sediment flux induced by tidal asymmetry (e.g. Dronkers 1986). However, there is a large range of proposed critical rates of sea-level rise with regard to tidal flat growth limitations, i.e. loss of tidal flats (e.g. van Goor 2003, Dissanayake et al. 2012). The morphodynamic response of the Wadden Sea to sea level rise of the 21st century is therefore highly uncertain.
Topographic changes of tidal flat morphology may reinforce or compensate hydrodynamic effects, which arise from sea-level rise alone. This question is investigated in this study, by applying a range of schematic changes to the Wadden Sea topography. This allows us in combination with specific sea-level rise scenarios to detect feedbacks on tidal dynamics. The topography scenarios comprise globally homogenous set-ups with identical changes in all tidal flats as well as regionally varying scenarios. These scenarios of potential morphological changes are based on empirical models describing relationships between tidal dynamics and the evolution of shallow estuaries or tidal basins on one hand (e.g. Friedrichs and Aubrey 1988, Stive et al. 1998) and results of process-based model studies on the other hand (e.g. van Maanen et al. 2013, Becherer et al. 2015).
In this study the numerical model UnTRIM (Casulli and Walters 2000) is applied, which allows the use of unstructured grids to optimally represent the complex topography of the German Bight and its tidal flats.
A detailed analysis of tidal characteristic values generally shows a lowering of tidal low water and an elevation of tidal high water in the combined sea-level rise and topography scenarios compared to the sea-level rise scenarios without topographic change.
The results indicate that changes in e. g. tidal range due to sea-level rise alone are reinforced in many areas of the German Bight by topographic changes considered most likely. These changes are in the same order of magnitude as changes of tidal characteristic values due to different tidal dynamics under sea-level rise conditions alone. Hence, considering the morphodynamic response of the Wadden Sea is essential to estimate the full range of possible changes in tidal dynamics induced by sea-level rise.