Sea-level rise impact on European shelf tide dynamics

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Abstract content

Sea-level rise (SLR) affects not only the total water level, but can also modify the tidal dynamics. Several studies investigated the SLR effect on the tide of the Western European continental shelf, analysing the tidal dynamics (mainly the M2 component) for various SLR scenarios or coastal defence schemes.

The present study aims at completing existing knowledge, using a modelling based approach, investigating 11 uniform SLR scenarios from -0.25 to +10m, and analysing the effect on high/low tide water level as well as the amplitude and phase tidal components. Sea-level rise scenarios include the present sea-level, as well as several idealized scenarios that correspond to plausible sea-levels for more or less distant past or future. On the one hand, the -0.25m scenario can be considered as a low bound for the preindustrial sea-level. On the other hand, positive SLR scenarios correspond to more or less plausible sea-levels in the future: according to IPCC, a rise of sea-level of +25cm is likely by 2046-2065 whatever the climate change scenario, and the likely range for high emissions scenarios reaches 0.5 to 1m by 2100. While higher SLR scenarios are not excluded by 2100, sea-level will continue to rise beyond 2100, and it is likely to reach values of several meters by 2200 and beyond. Finally, the +10m SLR scenario corresponds to a situation where most Greenland and west-Antarctic ice-sheets have melted.

Assuming that coastal defences along the present day shoreline are maintained and upgraded, the patterns of increase / decrease of high tide level (annual maximum water level) are almost stationary in most of the area (70%), with an increase in most of the domain and a decrease mainly in the Western English Channel. These changes are globally varying linearly with the SLR, till the +2m SLR scenario, with rate ranging between -15% and +15% of SLR. The main patterns are: (1) a decrease in the Western English Channel, (2) an increase in the Irish Sea, Southern North Sea and German Bight. The analysis of tidal component contributions shows that high tide level changes patterns are not exactly similar to M2 pattern changes (e.g. along the French Atlantic coast, high tide level increases whereas M2 amplitude decreases). This highlights the need to take into account all the components when analysing SLR effect on the tide. The main changes in the maximum water level result from the changes of the M2, S2, N2, M4 and MS4 components. Sea-level rise pushes several areas (e.g. Atlantic coast, Irish Sea) closer to resonance, leading to the increase of the resonant tidal components (especially semi-diurnal or quart-diurnal, depending on the area).

The linear behaviour of tide dynamics with the SLR is highly sensitive to the coastal defence strategy (i.e. let flood or not), the high tide level varying much less linearly with SLR when flooding is allowed, like for instance in the German Bight. However, several areas appear not sensitive to this choice, such that the estimated trends there are highly probable: an increase of ~6% SLR (resp. decrease of ~15% SLR) in the North of Irish Sea (resp. in the Western English Channel).

Finally, preliminary investigations show that, at least, for the non-uniform SLR scenario we computed, the high water level is very weakly sensitive to the (non)-uniformity, local rates of increase/decrease (relative to local SLR) being similar to the ones obtained from uniform SLR scenarios.