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Relative Changes in Tidal Ranges on the Northern Hemisphere since the Last Glacial Maximum

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Ocean tidal dynamics depend on several factors of which some have experienced considerable changes since the last glacial maximum (LGM). Mainly driven by deglaciation-induced sea-level rise and altered oceanographic conditions, these changes comprise (i) the global bathymetric conditions that control ocean tide resonances, (ii) shallow-water energy dissipation in shelf seas, (iii) deep-ocean energy dissipation by internal wave drag, and (iv) sea-ice energy dissipation affected by the reduced sea-ice coverage. The corresponding changes in tidal range and energy dissipation (e.g., Wilmes and Green, 2014) with respect to modern-day tidal conditions are important for reconstructing paleo-oceanographic conditions with a direct impact on paleoclimatic simulations and, e. g., the interpretation of sea-level markers that depend on the actual tidal range.

In this contribution, we present paleo tidal simulations obtained with the purely hydrodynamic ocean tide model TiME2021 (Sulzbach et al. 2021), which was updated with a sea-ice friction parametrization. Applying bathymetry changes due to glacial isostatic adjustment and internal dissipation changes due to paleo ocean stratification and paleo sea-ice coverage, we find the latter effect (iv) to be of minor importance. For a timespan ranging from modern-day conditions to 21 ky before present, simulations were performed on a rotated numerical grid that ensures high accuracy in the Pan-Arctic region which is known to have drastically changed in the semidiurnal tidal regime from micro- to mega-tidal (e.g., Velay-Vitow and Peltier, 2020). We find the phenomenon of Arctic Megatides being highly sensitive to the employed parametrization of Self-Attraction and Loading (SAL), which can be locally approximated or included to full extent by considering a global load Love number approach. For a cylindrical, analytical model of the Arctic basin, the observed behavior of the Arctic tidal regime can be directly related to properties of the lowest-order Arctic Kelvin wave, so, it can be traced back to bathymetric changes.

In line with other studies, we find tidal energy dissipation especially in the deep ocean to be strongly increased during the LGM. We further present charts for different epochs displaying relative changes in the tidal range with respect to modern conditions that show deviations of several meters in critical regions (Arctic Ocean, South China Sea, Baffin Bay). The employed

approach is based on simulations of two major partial tides per tidal band (M2, K2 and O1, K1) and the linear admittance theory. This information is aimed to be used with sea-level markers that are sensitive to tidal levels in order to improve the consistency of paleo sea-level reconstructions.

References:

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