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Peripheral and near field relative sea-level predictions using GIA models with 3D and regionally adapted 1D viscosity structures

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Glacial isostatic adjustment (GIA) describes the viscoelastic response of the solid Earth to ice-sheet and ocean loading. GIA models determine the relative sea-level based on the viscoelastic deformations of the Earth interior including self-gravitation due to the loading of the water redistribution between ocean and ice and rotational effects. Choosing an Earth structure that adequately reflects the viscoelastic behavior of a region remains a challenge. For a specific region, the viscosity stratification can be inferred from present-day geodetic measurements like sea-level, gravity change and surface displacements or from paleo observations of former sea level. Here, we use a suite of geodynamically constrained 3D Earth structures that are derived from seismic tomography models and create regionally adapted 1D Earth structures to investigate to what extent regional, radially symmetric structures are able to reproduce the solid Earth response of a laterally varying structure. We discuss sea-level variations during the deglaciation in the near field (beneath the former ice sheet) and peripheral regions (surrounding the ice sheet) with focus on North America and Antarctica as well as Oregon and Patagonia. The suite of 3D Earth structures vary in transfer functions from seismic velocity to viscosity, i.e., in Arrhenius law and viscosity contrast between upper mantle and transition zone. We investigate how the relative sea-level predictions of the model suite members are affected due to the simplification of the Earth structure from 3D to 1D.

In general, our results support previous studies showing that 1D models in peripheral regions are not able to reproduce the 3D models' predictions, because the response depends on the deformational behavior beneath the adjacent ice sheet and the local structure (superposition). Furthermore, the analysis of the model suite members shows different response behaviors for the 1D and 3D cases, e.g., suite members with weaker dependence of viscosity on seismic velocity can predict lowest RSL for the 3D case, but largest RSL for the 1D case. This indicates the relevance of the 3D structure in peripheral regions. 1D models in the near field are more capable to reproduce 3D model response behavior. But also here, deviations indicate that the lateral variations in the Earth structure beneath the ice sheet influence local relative sea-level predictions.