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Comparison of 1D vs 3D viscosity models for glacial isostatic adjustment

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Accurate calculation of displacements due to glacial isostatic adjustment (GIA) are essential for studies of tectonics, sea level projection, and the estimation of recent ice melting or other mass transport. However, most GIA studies to date have used a 1D viscosity model, with earth parameters varying only in the radial direction, while surface geology and seismic tomography show that the thickness of the lithosphere and the structure of the mantle also varies laterally. Therefore, models with 3D earth structure are needed. Using a 3D earth model requires finite element models, which are computationally expensive and hence make it difficult to compute a wide range of potential parameter values. Consequently, the question is for which application is a 3D model necessary, and for which parameters (and where) do 1D models give sufficiently accurate predictions?

In this study, we investigate the sensitivity of the GIA modeling to the earth structure, using the Abaqus finite element analysis software, an ice model assumed to be known, and various viscosity models. We start with Patagonia as a test region, because the 3D structure of the mantle is complex due to the proximity of the subduction of the Antarctic plate below South American and the Chile triple junction. In this region, the GIA contributes significantly to the regional recent rapid uplift.