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Ice sheet growth with laterally varying bedrock relaxation time

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Isostatic response of the bedrock, or glacial isostatic adjustment (GIA) in included in most ice sheet models. This is important because the surface elevation determines the mass balance and thereby implicitly also the strength of the mass balance feedback where higher surface elevation yields lower temperatures implying less melt and vice versa. Usually a single relaxation time or a set of relaxation times is used to model the response everywhere on Earth or at least for an entire ice sheet. In reality the viscosity in the Earth's mantle, and hence the relaxation time experienced by the ice, varies with location. Seismic studies indicate that several regions that were covered by ice during the last glacial cycle are underlain by mantle in which viscosity varies with orders of magnitude, such as Antarctica and North America.

The question is whether such a variation of viscosity influences ice evolution. Several GIA models exist that can deal with 3D viscosity, but their large computation times make it nearly impossible to couple them to ice sheet models. Here we use the ANICE ice-sheet model (de Boer et al. 2013) with a simple bedrock-relaxation model in which a different relaxation time is used for separate regions. A temperature anomaly is applied to grow a schematic ice sheet on a flat earth, with other forcing mechanisms neglected. It is shown that in locations with a fast relaxation time of 300 years the equilibrium ice sheet is significantly thinner and narrower but also ice thickness in neighbouring regions (with the more standard relaxation time of 3000 years) is affected.