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The effect of glacial isostatic adjustment on ice sheet evolution in Eurasia; a comparison of a self gravitating viscoelastic earth model and a flexural model

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The isostatic depression of the solid Earth as a result of ice loading can reach about one third of the ice thickness, and so crustal subsidence of up to 1km is common for large ice sheets. Local precipitation and melt both depend on surface elevation, so it is clear that an accurate treatment of the vertical deformation due to isostatic adjustment is important. Different types of earth model are used to model the isostatic response to ice sheets, ranging from Cartesian (flat earth) local or elastic lithospheres with a single relaxation time to account for temporal behaviour to spherical, three-dimensional models of the crust-mantle system. We have performed synthetic experiments to assess the dynamical response of an ice sheet model to different types of earth model and model parameters. The resulting ice sheet geometries depend on the response times of the earth model as well as the growth rate of the ice sheet. Differences in lithospheric strength cause large changes in the modelled ice sheets, with decreasing ice volumes for increasing rigidities due to the sensitivity of the ice sheets to differences in bedrock deformation in the ice margin. We used schematic experiments to compare an often used Cartesian model with an elastic plate and a single relaxation time (ELRA) to a self gravitating viscoelastic earth model (SGVE). No ELRA model was able to reproduce the SGVE response completely, due to the fact that the models have an intrinsically different spatial response. When applied to a full transient glacial cycle in Eurasia even the best fitting ELRA model underestimated the ice volume at the LGM by 30 percent. Moreover, the optimum values for the effective flexural rigidity and relaxation time varied over a transient glacial run and with parameters of interest. Our results indicate that the commonly used value of 3000 years for the relaxation

time in ELRA models is too short for Eurasia by at least 2000 years. We conclude that for Eurasia these two types of earth model are incompatible. Results from Le Meur and Huybrechts (1996) for a study in Antarctica suggested the opposite, indicating that Antarctica is not representative for all Pleistocene ice sheets.

Le Meur, E. and P. Huybrechts, 1996. A comparison of different ways of dealing with isostasy: examples from modelling the Antarctic Ice sheet during the last glacial cycle. Annals of Glaciology (23): 309-317.