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Draping or overriding: The effect of horizontal stress gradients on internal layer architecture in ice-sheets

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Internal isochronic layers in ice-sheets show two characteristic relationships to the basal topography: either they override it, with layers above the crests of rises lying more or less flat; or they drape over it, with the layers following the rises and falls in basal topography. A mechanical theory is presented which shows that overriding is the expected behaviour when topography wavelengths are comparable with or less than the ice thickness, while draping occurs at longer wavelengths. This is shown with analytical perturbation solutions for Newtonian fluids, numerical perturbation solutions for non-linear fluids, and finite element solutions for non-linear fluids and large amplitude variations. Variation in the bed due to topography and changes in the basal boundary condition are considered, both for fixed bed and sliding beds, as well as three-dimensional flows and thermo-mechanically coupled flows.

Results of these full mechanical system calculations are compared with those from the shallow ice approximation and the longitudinal stress approximation. Some of the calculations are carried out for zero accumulation, where the age of the ice and therefore isochrone geometry are not defined. It is shown that there is a close relationship between isochrones and geometries, and that they behave similarly when the wavelength of forcing divided by the ice thickness is small compared with the ratio of ice velocity and accumulation rate.