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Large-scale ice-sheet modelling with horizontal stress gradients

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The increased understanding of the specific roles played by longitudinal/membrane stresses in ice-sheets mean that an ice-sheet model which includes such stresses can now be specified. It must contain sufficient physics to be able to represent (i) grounding line motion and the grounding line boundary layer; (ii) the role of longitudinal stresses in propagating ice-stream transients; (iii) the role of longitudinal/membrane stresses in delocalizing dissipative heating; and (iv) the role of warming of the upper surface in horizontal stress transmission. Numerical computations using spectral methods comparing the results of 3D higher order approximations (i.e. Blatter-type models) and 2D vertically integrated equivalents (super-MacAyeal models) are presented, as well as full Stokes solutions. Vertically integrated works very well for flat bottomed ice-streams, but is less accurate in the presence of high-relief topography. The vertically integrated solutions require much less computation. Spectral methods are inappropriate for models of the current and former ice-sheets. A finite difference implementation of the vertically integrated model is presented and an unconditionally stable marching scheme is assessed.