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Does full Stokes matter in simulating ice sheet flow?

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At the core of ice flow modeling lies the momentum balance. While a full Stokes (FS) system is the most comprehensive and physically relevant model used in simulating large ice flow on continental scales, it rarely sees application even in recent years. Being the most thorough model, and a saddle point problem in nature, FS numerical simulations suffer from high storage requirements and systems of equations that are not only difficult to solve, but often also unstable in combination with iterative solvers. It is for this reason, that the modeling community has relied on simplified mathematical models, such as the three-dimensional Higher-Order (HO) approximation which neglects horizontal gradients of vertical velocities and bridging effects. Therefore, the question remains – can simplified models accurately resolve ice flow behavior, especially in areas with bedrock undulations? To further investigate this question and quantify the potential mismatch is the goal of this study, as it compares simulation results from FS and the much less computationally expensive HO model, obtained on a subset within the North East Greenland Ice Stream (NEGIS) and using the highly parallelized Ice Sheet System Model (ISSM). We inverted for basal friction and conducted a 50yr relaxation run defining, together with a temperature field from a paleo-spin up, an initial state. Subsequently, we run transient simulations with present day climate in two horizontal resolutions (at and below one ice thickness) which are analysed for characteristic variables like resistive stresses.