Numerical modelling of subglacial erosion and sediment transport and its application to the North American ice sheets over the last glacial cycle

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ABSTRACT: Present-day sediment distribution offers a potentially strong constraint on past ice sheet evolution, however, glacial system models (GSMs) cannot address this while lacking proper representations of subglacial sediment generation and transport. Incorporating these elements in GSMs is also required in order to quantify the impact of changing sediment cover on glacial cycle dynamics.

Toward this goal, we present a subglacial process model that incorporates mechanisms for sediment production, entrainment, transport, and deposition. Bedrock erosion is calculated by an abrasion law based on Hallet's model and a novel quarrying law parameterized as a function of subglacial cavitiy extent. These process-oriented eroison laws are compared against a simple empirical relationship between erosion rate and the work done by basal stress. The incorporation of loose debris in the basal ice is modeled by regelation intrusion and depends strongly on basal water pressure. The entrained debris is subsequently transported along the ice sheet's internal velocity field and vertically mixed through a diffusion equation that represents folding and thrust faulting. The inclusion of vertical mixing lowers the basal debris concentration and allows more regelation entrainment. Soft bed deformation is included as an advective component within the subglacial sediment, the rheology of which is assumed to be weakly non-linear. Deposition occurs whenever the basal ice is debris-laden and the melting rate exceeds the entrainment rate.

The model is coupled to the MUN 3D GSM, which includes a newly developed subglacial hydrology module. The GSM itself has been subject to Bayesian calibration for North American and Eurasian deglaciation and thus a probabilistic ensemble of deglacial chronologies is available. With this calibrated ensemble, we compare the range of calculated sediment thickness fields and cumulative erosion over the last glacial cycle against the present-day pattern of glacigenic sediment and the geological estimates of glacial erosion over North America, respectively.

ALL ARE WELCOME!!!