EGU22-7822
https://doi.org/10.5194/egusphere-egu22-7822
EGU General Assembly 2022

Complex basal motion of a Greenland Ice Sheet tidewater glacier

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Uncertainty tied to the mechanics of the fast motion of the Greenland Ice Sheet plagues sea-level rise predictions. Much of this uncertainty arises from imperfect representations of physical processes in constitutive relationships for basal slip and internal ice deformation, with continued misalignment between model output and borehole field data. To investigate further, we model two isolated cuboid domains from the fast-moving Sermeq Kujalleq (a.k.a Store Glacier), incorporating temperate ice rheology (softer ice at the melting point) and statistically realistic variogram-generated bed topography. Our results indicate a hitherto unappreciated complexity in ice-sheet basal motion over rough beds. Realistic topographic variability leads to highly variable basal slip rates (from <10 to >70% of surface velocity over ~1km), complex and variable deformation patterns, and a basal temperate ice layer that varies greatly in thickness in agreement with borehole observations (from <10 to >150 m). Velocity variations at the relatively smooth upper boundary of the temperate ice layer are significantly less variable, indicating that the slim basal temperate ice layer is an important control on ice motion. These results suggest that inversion procedures for basal traction over rough beds (including parts of Antarctica) may also be accounting for deformation within a temperate ice layer, which is problematic if the inclusion of a temperate ice layer and rough topography means commonly used basal slip relationships are no longer applicable.