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Extreme melt season traction variations recorded on the western Greenland Ice Sheet

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Basal traction is fundamental to the dynamics of glaciers and ice sheets. On the Greenland Ice Sheet meltwater delivery to the bed and evolving drainage efficiency and connectivity modulate traction producing a characteristic seasonal velocity response. While numerical modelling and basal pressure observations have linked these velocity variations to evolving subglacial drainage, a high-fidelity record of basal traction is needed to constrain the timing and magnitude of traction changes that modulate summer ice flow. We present a continuous summertime record of basal traction, basal ice deformation, and surface velocity measured at a densely instrumented field site in western Greenland. We use a five-station GPS network and englacial measurements of shearing and ice temperature to directly estimate the basal traction using the force balance method at the site-scale (100s of meters). Localized traction variations (10s of meters) are inferred via variations in the near-basal deformation field recorded by inclinometers installed directly above the basal interface. Combined, the data give a multi-scale perspective on how the basal traction changes during summer and relates to the conceptual model of melt season flow. Our results show the basal traction migrates between extremes during the melt season, with magnitudes greater than three times the average winter traction and near zero. The basal traction extremes correspond with the spring event, the inferred transition to efficient drainage, and the late summer velocity decline. The rapid strengthening and weakening of the basal interface show the complicated interaction of local and regional forcing that modulate melt season sliding. The near-basal deformation variations allow us to constrain the stress configuration and drainage state during each extreme traction period. Overall, the results allow us to refine the conceptual model for melt season traction changes and provide measured estimates of traction variations which can be used as quantitative targets for coupled drainage – ice dynamic models.

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