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Evaluation of cryo-hydrologic warming as an explanation for increased ice velocities in the wet snow zone, Sermeq Avannarleq, West Greenland

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Wintertime satellite derived ice surface velocities, from 2001 through 2007, suggest an increase in ice velocity in the wet snow zone of Southwest Greenland. We present a thermo-mechanical model to evaluate the influence of surface meltwater runoff on englacial temperatures, via cryo-hydrologic warming (CHW), as a possible mechanism to explain this velocity increase at Sermeq Avannarleq. The model incorporates CHW through a previously published dual-column parameterization. We compare model simulations with (i) CHW active over the entire ice thickness ("base case CHW"), (ii) CHW active only in the surface 80 m of the ice sheet ("surface CHW"), and (iii) "no CHW" to represent a traditional thermo-mechanical model. The horizontal extent
of CHW is prescribed based on equilibrium line altitude position, and thus incorporates the upstream expansion of the ablation zone over the past decade. The "base case CHW" simulations reproduce the observed increase in inland ice velocity between 2001 and 28 2007 reasonably well. The "no CHW" and "surface CHW" simulations significantly underestimate observed ice surface velocities in both epochs. The higher ice velocities in the "base case CHW" simulations are attributable to both decreased basal ice viscosities associated with increased basal ice temperatures, and an increase in the extent of basal sliding permitted by temperate bed conditions. Only the temperate bed extent predicted by the "base case CHW" simulation is consistent with independent observations of basal sliding. Based on our sensitivity analysis of CHW, we evaluate alternative explanations for an increase in inland ice velocity, and suggest CHW is the most plausible mechanism.