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Self Help: Tributary water storage encourages ice stream initiation

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We extend the subject of probable water storage at the base of an ice sheet by examining the connection between the spatial variability of the hydropotential and the velocity dependent transmission of basal roughness to the surface. Gudmundsson (2003) completed the most comprehensive analysis of the transmission of basal variability to the surface and we use his equations to illustrate how the spatial variability of the hydropotential and, thus, the likelihood of greater water storage, is increased with increasing ice sliding speed. For periodic bed undulations with a wavelength set at some factor of the ice thickness, there is a threshold velocity above which closed subglacial basins will be possible. This dependence may play a role in the flow transition from tributary flow, where sliding dominates and increases with increased driving stress, and streaming flow, where sliding increases downstream even though driving stress decreases.

Recent observations by Gray and others (submitted) have identified inflations and deflations of the surface they hypothesize to be expressions of subglacial water movement out of and into subglacial basins. The locations and sizes of such basins can be predicted by calculating the hydropotential field, that is, the pressure field experienced by water at the bed and at the local ice overburden pressure. We repeat this calculation with the most current fields of surface and bed topography and show that the spatial variability of the hydropotential is far greater for ice streams than for either inland ice or interstream ridges. This result is not surprising given the dominance of the hydropotential on surface topography relative to basal topography.