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Investigating the potential for "water piracy" in North East Greenland

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The incorporation of subglacial processes in ice flow models remains a challenge while at the same time observational evidence increasingly underscores the important role liquid water plays in ice flow dynamics. One of the many problems ice flow models face (that also includes scarcity of data at the bed and the deformational properties of water-saturated sediments) is the different time-scales on which the processes operate. For example, observations indicate that subglacial water may be re-routed to a neighbouring ice stream in response to changes in surface elevation. This implies that ice flow models have to allow for changes in ice flow mode where, depending on the basal properties, the flow may be dominated by deformation or basal sliding. The re-routing of water between neighbouring ice streams is often termed “water piracy” and in this study we demonstrate that the potential for water piracy exists even in regions with very small surface elevation changes.
We use a simple, vertically integrated, 2D-plane ice flow model based on the shallow ice flow approximation to model the large-scale changes in surface elevation of North East Greenland in response to gravity and mass balance. Considering time-scales of 100-500 years the model predicts changes in elevation of less than a metre per year which is in agreement with data from remote sensing. We then calculate the corresponding changes in hydrological pressure potential and use evidence from radio-echo sounding data to identify areas with basal melting and thus potential liquid water production. The corresponding change in hydrological pressure potential in response to the surface elevation changes is sufficient to divert the subglacial water to different pathways. This change in subglacial water pathways could be sufficient to change the ice flow mode from deformation to sliding and might initiate speed-up and/or slow-down of the ice streams at the margins of the basin.