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Mechanisms for subglacial lake drainage and outbursts

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Despite the large amount of subglacial lakes present underneath the East Antarctic Ice Sheet and the melt processes involved, the hydrology beneath the ice sheet is poorly understood. Subglacial lakes may lie at the origin of enhanced ice flow, hence forming the onset. In that sense, Lake Vostok can be considered as the onset of an enhanced ice-flow feature, more precisely the onset of the Totten Glacier catchment (Pattyn et al., 2005, JGLAC). As long as subglacial water remains in the lake cavity, a stable ice flow pattern might be expected. However, a change in subglacial potential gradients might lead to a subglacial lake outburst, hence discharging excess water through a subglacial drainage system underneath the ice sheet, resulting in an ice flow speedup. We employed a full Stokes numerical ice sheet model that takes into account the ice flow over subglacial water bodies in hydrostatic equilibrium with the overlying ice. Sensitivity experiments were carried out for changes in surface slope characteristics - related to changes in accumulation patterns - so as to investigate their influence on the subglacial potential gradient and the impact on subglacial lake drainage. Experiments clearly demonstrate that small changes in surface slope are sufficient to start a subglacial drainage event. Furthermore, subglacial lake outbursts may displace much more water than would be estimated from changes in surface elevation characteristics, as ice sheet dynamics rapidly adapt to changes in the ice-sheet / subglacial lake environment.