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A new mechanism for Heinrich events: Role of the feedbacks between ice streams, ice shelves and ocean from a conceptual model to a 3D ice sheet model

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It is now often accepted that Heinrich events are associated with internal oscillations of the Northern Hemisphere ice sheets leading to periodical large surges of ice in the ocean. It has been proposed that these large-scale surges likely occur when basal ice reaches the melting point in regions where subglacial sediment allows very strong sliding. Attempts to simulate such mechanism in the framework of the shallow ice approximation (SIA) indeed succeeded to produce oscillations (HEINO experiments). However these results are still controversial because the oscillation periods were very dependent on numerical methods and, more importantly, because the SIA does not take into account longitudinal stresses and is thus not suitable when there are strong gradients in velocity. Using a 3D ice sheet model, GRISLI, in which ice streams velocities are obtained with the MacAyeal equation and thus longitudinal stresses are accounted for, no oscillations can be obtained with only the ice sheet-ice stream system.
We suggest here that feedbacks between ocean, ice shelves and ice streams play a significant role in the production of ice surges. With a conceptual ice sheet-ice shelf-ocean model we demonstrate the ability of this simple model to produce instabilities of the Northern ice sheets in agreement with several features suggested by data. Finally, by replacing the conceptual ice-sheet-ice stream model by GRISLI, we still get oscillation although with a different shape and period.
The realism of this new mechanism for Heinrich events has to be demonstrate by replacing the conceptual ocean model by a more sophisticated ocean model.