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Investigating the conditions for large scale ice sheet instabilities with the GRISLI model

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Deep-sea records indicate that large ice sheets can undergo large scale surges. The most famous of such events are Heinrich events, which are thought to represent armadas of icebergs released by the Laurentide ice sheet into the North Atlantic. In the other hemisphere, it has been sugggested that the Antarctic ice sheet can also be subject to cyclic behaviour at the millenium time scale and at last the potential instability of the West Antarctic ice sheet (WAIS) has been the subject of considerable research.

Many modelling efforts have been carried on to understand the physical processes responsible of these instabilities but only a few of them deal with large scale behaviour of an entire 3D ice sheet (Payne, 1995, Marshal and Clarke, 1997, Calov et al, 2002). We present here experiments conducted with our 3D thermomechanical model, GRISLI (Ritz et al, 2001). In addition to the usual shallow ice approximation for grounded ice flow, GRISLI incorporates ice streams that are treated as dragging ice shelves (MacAyeal, 1989). We investigate under which circumstances GRISLI can reproduce instabilities (cyclic or not), how changes in surface elevation propagate inland and what is the impact of the ice streams treatment (high sliding velocity versus "MacAyeal" ice streams). The applications are done on the HEINO-ISMIP geometry (Heinrich Event INtercomparison) as well as on the Antarctic ice sheet (for which GRISLI was originaly developped).