Ice-shelf damming in the glacial Arctic Ocean: Dynamical regimes of a basin-covering kilometre-thick ice shelf

Johan Nilsson, Martin Jakobsson, Chris Borstad, Nina Kirchner, Göran Björk, Raymond T. Pierrehumbert, & Christian Stranne

nilsson@misu.su.se

Recent geological and geophysical data suggest that a 1 km thick ice shelf extended over the glacial Arctic Ocean during Marine Isotope Stage 6, about 140 000 years ago. Here, we analyse the development and equilibrium features of such an ice shelf. We find that the dynamically most consistent scenario is an ice shelf with a nearly uniform thickness that covers the entire Arctic Ocean. Further, the ice shelf has two regions with distinctly different dynamics: a vast interior region covering the central Arctic Ocean and an exit region towards the Fram Strait. In the interior region, which is effectively dammed by the Fram Strait constriction, there are strong back stresses and the mean ice-shelf thickness is controlled primarily by the horizontally integrated mass balance. If the surface accumulation and mass flow from the continental ice masses are sufficiently large, the ice-shelf thickness grows to the point where the ice shelf grounds on the Lomonosov Ridge. Using a one-dimensional ice-dynamic model, the stability of equilibrium ice-shelf configurations without and with grounding on the Lomonosov Ridge are examined. We find that the grounded ice-shelf configuration should be stable if the two Lomonosov Ridge grounding lines are located on the opposites sides of the ridge crest. This result shares similarities with the classical result on marine ice-sheet stability of Weertman, but interactions between the Amerasian and Eurasian ice-shelf segments modifies the cross-ridge mass flux and its response to deglaciation.