Grounding Line migration and ocean basal melting: competing effects in the simulated retreat of the Storfjorden (Svalbard) ice stream during the last deglaciation

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Abstract

Several recent studies show that ice shelves and marine-terminating glaciers around Antarctica are thinning (Paolo et al., 2015), especially in the sector of the marine-based West Antarctic Ice Sheet (WAIS). This thinning is primarily caused by the basal melting occurring where the warm Circumpolar Deep Water reaches the ice shelves cavities (*e.g.*, Pritchard et al., 2012, Rignot et al., 2013). In addition, advection of warm water below ice shelves can potentially induce a substantial retreat of the grounding-line. Theoretical boundary layer studies such as Weertman (1974) or Schoof (2012) suggest that abrupt changes in volume and extent of marine-based ice sheets can occur because of the grounding-line instability in coastal regions where the bedrock is retrograde. The Svalbard/Barents/Kara Seas *palaeo*-Ice Sheet (SBKSIS) was a so-called marine-based ice sheet, as its largest portion rested several hundreds of meters below the sea level on the Barents and Kara Seas floor. From a bathymetric point of view, there is a strong similarity between the SBKSIS at the Last Glacial Maximum (LGM, around 21,000 years ago) and the present-day WAIS, as pointed out first by Mercer (1970). In fact, both polar regions are characterized by a wide continental shelf of few hundred of meters depth. Therefore, in order to understand the present and the future evolution of the WAIS it can be important to identify, reconstruct and analyze the dynamical processes driving the past retreat of the SBKSIS from the western Barents Sea continental margin. In this study, the post-LGM retreat of the Storfjorden ice stream in the north-western Barents Sea is simulated by means of two hybrid SIA/SSA thermomechanical Ice Sheet Models (ISMs) and constrained by existing geomorphological and geophysical data (*e.g.*, Rebesco et al., 2011, 2013, Lucchi et al., 2013). Since the two ISMs differ mainly in the complexity with which the grounding-line migration is treated, we are able to evaluate the impact of the grounding-line dynamics on the Storfjorden ice stream retreat. In addition, we investigate the sensitivity of the ice stream retreat to ocean temperature changes during the deglaciation. Two different ocean basal melting formulations (Martin et al., 2011 and Pollard & DeConto, 2012) are forced with ocean temperature and salinity from a coupled atmosphere-ocean transient simulation of the last 21,000 years (Liu et al., 2009). Results from our simulations suggest that if the grounding-line migration is not included in the ISMs, the ocean basal melting has a strong control on the Storfjorden ice stream retreat and dominates the changes induced by the grounding-line retreat. Conversely, when the grounding-line migration is included in the ISMs the Storfjorden ice stream retreat is primarily driven by the grounding-line dynamics and the atmospheric forcing rather than by the oceanic forcing. This suggest that to project the Antarctic response to ongoing and future ocean warming, a close look to the

grounding-line treatment is needed, in order to provide the right balance between the various competing processes in act in the WAIS.

Keywords: "modeling", "grounding-line-migration", "ocean-melting", "ice-streams"

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