Impact of Ocean basal melting formulations: Pine Island and Totten glaciers case study

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Abstract

The collapse of Antarctic ice shelves and the related shrinking of the Antarctic ice sheet induced by the loss of buttressing is projected as a consequence of ongoing and future climate changes. In particular one of the major concerns is about the future sensitivity of the West Antarctic Ice Sheet (WAIS) to the ongoing ocean warming. The reason for concern comes from the WAIS favourable unstable dynamical conditions (Schoof, 2007), being the ice sheet grounded below the sea level on a bedrock characterized, for a large part, by a retrograde slope (sloping downwards toward the sheet centre). Of particular interest is the Pine Island Glacier area, which is considered to be the largest contributor to sea-level rise (SLR) for the WAIS and with a grounding line that has already retired of several kilometers in the last recent years (Sheperd et al.,2012; Park et al., 2013). Another interesting area is represented by Totten Glacier that is characterized by the largest thinning rate in East Antarctica and an estimated potential contribution to SLR of at least 3.5 m (Flament et al, 2012; Greenbaum et al., 2015).

The key process that potentially dominates the grounding line dynamics is the ice-ocean interaction but, despite its importance there is still no clear consensus about which treatments of ocean basal melting, among the ones available at present (e.g. Helmer and Olbers, 1989; Jenkins, 1991; Martin et al., 2011; Pollard and de Conto, 2012), has to be considered the most robust and reliable.

By means of idealized numerical experiments performed with the finite-elements state-of-the-art ice-flow model Ua (Gudmundusson, 2012), we test the sensitivity of Pine Island and Totten Glacier to different ocean basal melting treatments, including a 1D plume model (Jenkins, 1991) coupled to the ice-flow model. Since the effects of the ocean on ice might not be linear, but heavily influenced by the mean background climate state, we also evaluate the sensitivity to temperature and salinity perturbation applied to present ocean condition.

Keywords: ice-ocean interaction, grounding line, Antarctica, ice modeling

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