Ocean-driven thinning of Totten and Denman Glaciers, the two primary outlets of the Aurora Subglacial Basin in East Antarctica

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The Aurora Subglacial Basin (ASB) in East Antarctica contains at least 3.5 meters of eustatic sea level potential in ice grounded below sea level primarily draining through the Totten and Denman Glaciers located along the Sabrina and Knox Coasts, respectively. The ice surface elevation in the Totten and Denman grounding zones has been lowering steadily since the beginning of the satellite altimetry record (Zwally et al., 2015) and their grounding lines are retreating (Konrad et al., 2018). The ice within the ASB is believed to have collapsed and advanced multiple times since the onset of largescale glaciation (Aitken et al., 2016; Young et al., 2011) so it is imperative to understand what is driving the contemporary changes.

Basal melting of the Totten Glacier Ice Shelf (TGIS) was recently shown to be driven by warm, modified Circumpolar Deep Water (mCDW) that enters the ice shelf cavity through a system of seafloor troughs (Greenbaum et al., 2015; Rintoul et al., 2016) connecting to a reservoir of mCDW that has been observed on the nearby continental shelf since 1996 (Bindoff et al., 2000). Totten Glacier is also susceptible to seasonal surface melting owing to its relatively northern latitude. Using airborne ice penetrating radar data we show that the ocean actively melts large channels into the ice shelf base that grow to over two kilometers wide and 350 meters deep with steep walls and flat terraces characteristic of rapid melt. We also apply airborne surface radar analyses to show that the near surface of the ice shelf (within the firn layers) undergoes widespread melting in warm years as indicated by the closest available automatic weather stations. The natural vulnerability of the TGIS to surface and basal melting is concerning given recent numerical modeling results indicating that ocean melting and surface melt-induced hydrofracture and ice cliff failure could cause substantial retreat into the ASB (DeConto and Pollard, 2016).

Denman Glacier drains through the Shackleton Ice Shelf (SIS), the seventh largest and the most northern ice shelf in Antarctica outside the Antarctica Peninsula. Denman's rapid coastal thinning and the high rate of basal melt rate observed on the SIS (Rignot et al., 2013), combined with our knowledge of mCDW access to the TGIS, suggest that ocean-driven thinning could be responsible for changes in the ASB's western outlet, as well. However, the sub-ice shelf bathymetry and nearby ocean state of the SIS have not been known well enough to confirm that hypothesis. Here we present a new sub-ice shelf bathymetry compilation for the eastern SIS derived from an airborne gravity inversion using a geological model constrained by seafloor depth estimates. Depth constraints were estimated from airborne-deployed bathythermograph sensors and depth to basement solutions from airborne magnetics data. The new bathymetry reveals at least one seafloor trough deep enough to allow mCDW observed by Autonomous Pinniped Bathythermographs (tagged seals) near this location to reach the grounding line. Finally, we use ice core data acquired nearby to confirm that atmospheric temperatures have not been high enough since at least 1931 to explain the thinning observed in the Denman grounding zone. These results confirm that both outlets of the ASB, via Totten and Denman Glaciers, are vulnerable to ocean-driven retreat also known to be responsible for rapid thinning of several glaciers in West Antarctica.

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