

Manuscript TC-2020-219:

Atmospheric extremes triggered the biggest calving event in more than 50 years at the Amery Ice shelf in September 2019.

By D. Francis et al.

We have changed the title and added a sentence to the abstract to underscore the role of the ocean slope in the calving event as suggested by the reviewer and the editor.

Below is the new abstract and key words.

Many thanks for your feedback and valuable comments.

Atmospheric extremes caused high oceanward sea-surface slope triggering the biggest calving event in more than 50 years at the Amery Ice shelf.

Abstract

Ice shelf instability is one of the main sources of uncertainty in Antarctica's contribution to future sea level rise. Calving events play a crucial role in ice shelf weakening but remain unpredictable and their governing processes are still poorly understood. In this study, we analyze the unexpected September 2019 calving event from the Amery Ice Shelf, the largest since 1963 and which occurred almost a decade earlier than expected, to better understand the role of the atmosphere in calving. We find that atmospheric extremes provided a deterministic role in this event. A series of anomalously-deep and stationary explosive twin polar cyclones over the Cooperation and Davis Seas which generated tides and wind-driven ocean slope leading to fracture amplification along the pre-existing rift, and ultimately calving of the massive iceberg. The calving was triggered by high oceanward sea-surface slopes produced by the storms. The observed record-anomalous atmospheric conditions were promoted by blocking ridges and Antarctic-wide anomalous poleward transport of heat and moisture. Blocking highs helped in (i) directing moist and warm air masses towards the ice shelf and in (ii) maintaining stationary the observed extreme cyclones at the front of the ice shelf for several days. Accumulation of cold air over the ice sheet, due to the blocking highs, led to the formation of an intense cold-high pressure over the ice sheet, which helped fuel sustained anomalously-deep cyclones via increased baroclinicity. Our results stress the importance of atmospheric extremes in ice shelf dynamics via tides and sea surface slope and the need to be accounted for when considering Antarctic ice shelf variability and contribution to sea level, especially given that more of these extremes are predicted under a warmer climate.

Keywords: Ice shelf calving, icebergs, Amery Ice Shelf, East Antarctica, blocking highs, polar cyclones, explosive cyclones, sea surface slope.