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Climate-driven enhanced calving of shrinking Antarctic ice shelves

John Moore (1,2), Yan Liu (1), Xiao Cheng (1), and Rupert Gladstone (3)

(1) Beijing Normal University, College of Global Change and earth System Science, Beijing, China (john.moore.bnu@gmail.com), (2) Arctic Centre, University of Lapland, PL122, 96100 Rovaniemi, Finland, (3) Antarctic Climate and Ecosystems Cooperative Research Centre, University of Tasmania, Hobart, Tasmania, Australia

Iceberg calving from Antarctic ice shelves is driven by internal ice stresses, and changing climate. Quantification of iceberg calving styles and spatial distribution can identify vulnerable ice shelves and establish links between calving and basal melt. Here we use multi-source satellite data and model derived products to provide a first direct observation of annual iceberg calving events larger than 1 km^2 from all Antarctic ice shelves larger than 10 km^2 for the period 2005-2011. We developed and applied a new flow-line method to quantify cross-grounding line fluxes for the whole of Antarctica. Using these methods we provide a first complete estimate of Antarctic ice shelf mass balance and its change in recent times. We use surface features of ice shelves near the calving front, and the rift propagation speed, to classify iceberg calving into three previously documented styles: rift-opening calving and two styles of melt-related calving. Between 2005 and 2011 we measure an iceberg calving rate of 755 ± 24 gigatons per year (Gt/yr), and derive a basal melt rate of 1516 ± 106 Gt/yr. Net Antarctic ice shelf mass balance is slightly positive, as giant ice shelf advance dominates retreat of smaller systems. For ice shelves in negative mass balance, loss due to melt-induced calving (302 Gt/yr) is as important as from basal melting (312 Gt/yr), underlining that climate forcing is causing this retreat