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Annual estimates of basal melting and calving from Antarctic ice shelves during 2010-2019

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Ice shelves play a crucial role in controlling rates of ice discharge across Antarctica's grounding lines. Mass loss from ice shelves, predominately due to basal melting and calving, can reduce the buttressing force provided by ice shelves, leading to increased grounded ice discharge. Despite the importance of ice shelves, existing estimates of calving and freshwater fluxes from ice shelves have utilised disparate datasets valid for inconsistent time periods or have relied on simplifying assumptions, resulting in a limited account of the health of many ice shelves and little indication of processes driving ice shelf mass imbalance.

Here, we quantify calving and basal melt fluxes at annual temporal resolution during 2010 to 2019. Our annual measurements account for annual variations in ice velocity and basal melt rate for 183 ice shelves, and annual variations calving front position for 34 major ice shelves (accounting for ~90% of the ice shelf area). On average during the study period, a calving flux of 1283±109 Gt yr^{-1} is roughly equal to a melt flux of 1247±149 Gt yr^{-1}. Inter-annual variations in the fluxes of both basal meltwater and calving mean that the melt contribution to ice shelf mass loss varies between 35% and 62%, with the lowest contributions in years with large calving events. These large (>100 Gt) calving events are rare (8 events during 2010-2019), yet account for 35% of the total ice shelf calving flux, highlighting the importance of large calving events for ice shelf mass balance over short time scales. Eighty percent of ice shelves, including many in East Antarctica, are melting at or faster than their balance rates, indicating that ocean-driven erosion of ice shelf grounding lines is widespread around Antarctica. Furthermore, we find a significant and strong positive correlation (R=0.68) between basal melt flux and grounding line discharge, implying that ocean-driven melt may pace grounded ice loss from Antarctica.