Geophysical Research Abstracts
Vol. 15, EGU2013-11553, 2013
EGU General Assembly 2013

Calving fluxes and melt rates of Antarctic ice shelves

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Iceberg calving has been assumed to be the dominant mass loss term for the Antarctic ice sheet, with previous estimates of the calving flux exceeding 2,000 Gt yr^{-1}. More recently, the importance of melting by the ocean has been demonstrated close to the grounding line and near the calving front. To date, however, no study has reliably quantified the volume of bottom (sub-shelf) melt (BM) and the calving flux (CF) for the whole of Antarctica. The distribution of freshwater in the Southern Ocean and its partitioning between liquid and solid phase is, therefore, poorly constrained. Here, we estimate the mass budget of Antarctic ice shelves using satellite measurements of calving flux, grounding line flux and modelled ice shelf accumulation rates. We obtain a total calving flux of 938 ± 109 Gt yr^{-1} and a total net bottom melt of $1{,}130 \pm 241$ Gt yr^{-1}. Thus, about half of the ice sheet surface mass gain is lost through oceanic erosion before reaching the ice front and the calving flux is less than half the estimate derived from iceberg tracking. Calving is therefore not the most important term in the mass loss of the continent. In addition, the fraction of mass loss from bottom melt varies dramatically from $\sim$10 to 90% between ice shelves. We find that ice shelves with high melt ratios correlate well with those experiencing thinning and enhanced discharge, suggesting that a high melt ratio may be a good indicator of ice shelf vulnerability to changes in ocean temperature.