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Coupling modelling and satellite observations to constrain subglacial melt rates and hydrology

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Meltwater forms at the base of the Antarctic Ice Sheet due to geothermal heat flux (GHF) and basal frictional dissipation. Despite the relatively small volume, this meltwater has a profound effect on ice-sheet stability, controlling the dynamics of the ice sheet and the interaction of the ice sheet with the ocean. However, observations of subglacial melting and hydrology in Antarctica are limited. Here we use numerical modelling to assess subglacial melt rates and hydrology beneath the Antarctic Ice Sheet. Our case study, focused on the Amery Ice Shelf catchment, shows that total subglacial melting in the catchment is 6.5 Gt yr^{-1}, over 50% larger than previous estimates. Uncertainty in estimates of GHF leads to a variation in total melt of ±7%. The meltwater provides an extra 8% flux of freshwater to the ocean in addition to contributions from iceberg calving and melting of the ice shelf. GHF and basal dissipation contribute equally to the total melt rate, but basal dissipation is an order of magnitude larger beneath ice streams. Remote-sensing observations, from CryoSat-2, indicating active subglacial lakes and ice-shelf basal melting constrain subglacial hydrology modelling. We observe a network of subglacial channels that link subglacial lakes and trigger isolated areas of sub-ice-shelf melting close to the grounding line. Building upon this Amery case study, we expand our analysis to quantify subglacial melt rates and hydrology beneath the entire Antarctic Ice Sheet.