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Thermal structure of the Amery Ice Shelf from borehole observations and simulations

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The Amery Ice Shelf (AIS), East Antarctica, has a layered structure, due to the presence of both meteoric and marine ice. In this study, the thermal structures of the AIS are evaluated from vertical temperature profiles, and its formation mechanism are demonstrated by numerical simulations. The temperature profiles, derived from borehole thermistor data at four different locations, indicate distinct temperature regimes in the areas with and without basal marine ice. The former shows a near-isothermal layer over 100 m at the bottom and stable internal temperature gradients, while the latter reveals a cold core ice resulting from upstream cold ice advection and large temperature gradients within 90 m at the bottom. The three-dimensional steady-state temperature fields are simulated by Elmer/Ice, a full-stokes ice sheet model, using three different basal mass balance datasets. We found the simulated temperature fields are highly sensitive to the choice of dynamic boundary conditions on both upper and lower surfaces. To better illustrate the formation of the vertical thermal regimes, we construct a one-dimensional temperature column model to simulate the process of ice columns moving on the flowlines with varying boundary conditions. The comparison of simulated and observed temperature profiles suggests that the basal mass balance and meteoric ice advection are both crucial factors determining the thermal structure of the ice shelf. The different basal mass balance datasets are indirectly evaluated as well. The improved understanding of the thermal structure of the AIS will assist with further studies on its thermodynamics and rheology.