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Modelling ice rise englacial temperature profiles to constrain past ice-sheet dynamics

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Present-day englacial temperatures are the product of the millennial-scale histories of ice flow and thermal boundary conditions experienced by an ice sheet. Vertical englacial temperature profiles extracted from boreholes drilled at ice divides record past ice dynamics and changing external forcings. Bindschadler (1990) estimated the timing of grounding of Crary Ice Rise, Ross Sea, by minimizing the mismatch between modelled and measured temperature profiles. This approach has huge potential if future boreholes are drilled at Antarctic ice rises in locations suspected of undergoing significant dynamics change. Yet, the uncertainties inherent in this approach must be carefully assessed to target and maximize the utility of borehole drilling. Here, using a 1D vertical heat flux model, we simulate the evolution of temperature as a function of depth in six locations with slow-flowing, cold-based ice in the Weddell and Ross Sea sectors of the West Antarctic Ice Sheet. The locations were chosen using output from the Parallel Ice Sheet Model (PISM) as which are most likely to have ungrounded and regrounded during the last deglaciation (i.e., through last 20 k.y.). We use the shallow ice approximation assuming horizontally isothermal ice and no basal sliding. Several parameters, accounting for timing and duration of grounding/ungrounding events, surface temperature evolution, accumulation rate, ice-thickness change, geothermal heat flux and vertical velocity, are varied to generate a range of different temperature profile outputs. Uncertainties associated with each parameter are then evaluated using a Monte-Carlo approach, yielding a statistical account of model sensitivity to key variables. We highlight that the precision needed to infer timing of grounding increases with the duration of grounded ice flow. Results presented here can help in choosing future ice drilling sites, and provide useful constraints on inferring past forcings and changing boundary conditions from in-situ temperature-depth measurements.