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Simulation-Based Inference of Surface Mass Balance of Antarctic Ice Sheets

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Uncertainties in surface mass balance (SMB) have the potential to significantly impact modelled ice thickness and ice-flow dynamics. A common approach is to reconstruct the surface mass balance history from the internal ice stratigraphy as imaged by radar. Particularly for intermediate and deeper layers, this requires accounting for deformation by ice flow using ice-dynamic forward models in an inverse framework. Numerous approaches to do so exist, but many of them are tailored to specific stratigraphy datasets and do not include uncertainties.

Previous work used simulation-based inference (SBI) to infer the SMB rates of steady state ice shelves, solving velocities using the shallow shelf approximation [1]. The approach not only estimates the spatially varying SMB field but also their uncertainties. We adapt this framework to infer SMB on grounded ice, where flow is dominated by internal deformation rather than longitudinal stretching. The forward model used in this study calculates velocities by solving the shallow ice approximation. The resulting velocities are used as input to an isochronal tracer scheme which calculates the stratigraphy of the ice [2]. Initial testing of our method is conducted on an idealized ice sheet, namely the Vialov profile. In future work, we aim to infer for the SMB history along a radar transact of Derwael Ice Rise in East Antarctica, where internal stratigraphy data is available. Our method provides a new uncertainty aware approach to estimate the SMB field on grounded ice.

[1] Moss et al.: Simulation-Based Inference of Surface Accumulation and Basal Melt Rates of an Antarctic Ice Shelf from Isochronal Layers (2023).

[2] Born: Tracer transport in an isochronal ice-sheet model (2017).