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Modeling the Greenland englacial stratigraphy

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Radar reflections from the interior of the Greenland ice sheet contain a comprehensive archive of past accumulation rates, ice dynamics, and basal melting. Combining these data with dynamic ice sheet models may greatly aid model calibration, improve past and future sea level estimates, and enable insights into past ice sheet dynamics that neither models nor data could achieve alone.

In this study, we present the first three-dimensional ice sheet model that explicitly simulates the Greenland englacial stratigraphy. Individual layers of accumulation are represented on a grid whose vertical axis is time so that they do not exchange mass with each other as the flow of ice deforms them. This isochronal advection scheme does not influence the ice dynamics and only requires modest input data from a host thermomechanical ice sheet model.

Using an ensemble of simulations, we show that direct comparison with the dated radiostratigraphy data yields notably more accurate results than calibrating simulations based on total ice thickness. We show that the isochronal scheme produces a more reliable simulation of the englacial age profile than Eulerian age tracers. Lastly, we outline how the isochronal model can be linearized as a foundation for inverse modeling and data assimilation.