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Isochronal ice sheet model: Simulate englacial tracer transport to reconstruct past climates and ice sheet volumes

Andreas Born (1,2)

(1) University of Bern, Physics Institute, Climate and Environmental Physics, Bern, Switzerland (andreas.born@climate.unibe.ch), (2) Oeschger Centre for Climate Research, University of Bern, Switzerland

The full history of ice sheet and climate interactions is recorded in the vertical profiles of isotopic and other geochemical tracers in polar ice sheets. In addition, recent advances in radiostratigraphy uncover the englacial layering that contains information of past surface topographies and thus ice sheet volumes and sea level. Numerical simulations of these archives could afford great advances both in the interpretation of paleoclimatic tracers as well as to help improve ice sheet models themselves and future projections. However, fundamental mathematical shortcomings in existing ice sheet models subject tracers to spurious diffusion that renders such attempts unfeasible.

Here, we propose a new vertical discretization for ice sheet models that eliminates numerical diffusion entirely. Vertical motion through the model mesh is avoided by mimicking the real-world ice flow as a thinning of underlying layers. Simulations of the last glacial cycle are presented that show good skill in reproducing the reconstructed profile of the oxygen isotopic ratio ($\delta^{18}O$) and the age scale (http://www.climate.unibe.ch/~born/ice_model.html).