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Using cosmogenic exposure dates to evaluate modeled Greenland Ice Sheet behavior

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Cosmogenic exposure dates represent an untapped data set for evaluation and calibration of ice sheet models on Greenland. Ice sheet models contain simplified numerical descriptions of many processes affecting real ice sheets, including ice flow, surface mass balance, isostasy, and basal sliding. These models provide a crucial means of filling spatial and temporal gaps between paleo-data, and projecting the future behavior of ice sheets in a warming world. Such models must be tuned to data before their results can be considered reliable. Cosmogenic exposure dating of bedrock, erratic boulders, and trimlines on nunataks in Antarctica is often used to tune ice sheet models, but this approach has not been applied in Greenland due to the lack of appropriate topographic "dipsticks." Here, we demonstrate how cosmogenic exposure dates can be used to evaluate ice sheet model results in Greenland. Our starting point is a recently-published, 125 ka-long run with the ice sheet model SICOPOLIS (sicopolis.greveweb.net; Greve et al. 2011, Annals of Glaciology 52, 23-30). For each 10 km square ice sheet model grid cell that contains exposure dates, we project the elevations of the sample sites onto a hypsometric curve constructed using a finer-resolution digital elevation model. The hypsometric curve and the modeled history of ice thickness within each grid box determines when each sampled point became exposed. We then compare the model-predicted exposure times to the cosmogenic-derived apparent exposure times. Model-data agreement is relatively good where and when the margin is terrestrial (near Kangerlussuaq in western Greenland), but poorer where the ice margin interacts with the water (near Jakobshavn, on Store Koldewey Island, and in Scoresby Sund). We comment on the partitioning of residuals between model problems and geomorphic issues in the data. This work is novel because it 1) provides a new methodology for comparing ice sheet model results to chronologic data, and 2) helps refine an ice sheet model that is being used to project future sea level change due to enhanced Greenland Ice Sheet mass loss.