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Evolution of air content in Greenland firn using the UW Community Firn Model

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Accurate calculations of ice-sheet mass loss are necessary for estimations of future sea-level rise. Surface-elevation changes are measured by satellite altimetry; however, firn-compaction models are needed to convert measured volume changes into mass changes. Uncertainty in firn-model predictions of density-depth profiles and their evolution remains among the largest contributors to uncertainty in those ice-sheet mass-balance calculations.
Using the UW Community Firn Model (CFM), we force an ensemble of published firn models with re-analysis-based temperature and accumulation-rate histories for Greenland (e.g. RACMO), in order to calculate histories of depth-density profiles and depth-integrated porosity (DIP).
In order to avoid start-up transients when we compare histories from various models, all of the models go through a spin-up phase in which the density-depth profile "forgets" its initial condition in the past. However, the models cannot completely forget the boundary conditions (i.e. the spin-up climate history). Because the climate of Greenland is not steady, and is not well known in past centuries, uncertainties in this spin-up climate history can propagate into uncertainties when driving the models with modern re-analysis data.
Because the models implicitly or explicitly incorporate a range of parameterizations of firn-compaction physics, the models also produce a corresponding range of transient responses to modern re-analysis forcing.
We explore the spread of results and range of uncertainty in depth-density profiles and DIP due to (a) spin-up climate uncertainties, and (b) firn-model choice, i.e. incorporated model physics.
Model parameters can be adjusted based on comparison with current-day density profiles, but non-uniqueness remains due to uncertain spin-up climate, and incomplete physics in the models.
The results illustrate the current diversity among firn-compaction models, and point to a role for firn-compaction models based on constitutive relationships derived using measured strain rates and micro-structural measurements on firn cores.