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Monte Carlo inversion of firn layers observed in firn cores and radar images - a validation of a dynamic firn compaction model

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Recent studies of ice sheet mass loss have shown the importance of understanding the firn compaction at the surface. The ongoing mass changes of the Greenland Ice Sheet have been extracted by correcting altimetry data from the ICESat mission with a firn compaction model. The result shows that the changes in firn compaction over the observation period are the most important correction factor when converting the measured volume change into mass change. However, little knowledge about the spatial variability of the applied parameterization is available.
In this study, a simple empirical firn model that is forced with the output of high-resolution (5km) regional climate model (HIRHAM5) is applied. The model is inverted using a Monte Carlo method, in order to fit available observations from firn cores and internal layering seen by remote sensing radar measurements. The internal layering is observed using radar measurements penetrating the upper part of the firn column in the interior part of Greenland. The observed layers from the radar data can be used as an in-situ validation of the firn model resolving a large spatial coverage.
The combination of observation from the firn cores and radar measurements gives the possibility to assess the biases in the individual inversions performed to optimize the firn parameterization. This model validation gives a good confidence in using the model to address important questions. Questions such as; how large is the firn compaction correction relative to the changes in the elevation of the surface observed with remote sensing altimetry? What model time resolution is necessary to resolve the observed layering? What model refinements are necessary to give better estimates of the surface mass balance of the Greenland ice sheet from remote sensing altimetry?