Geophysical Research Abstracts
Vol. 21, EGU2019-10232, 2019
EGU General Assembly 2019

Modeling firn densification through the evolution of microstructural properties

Brita I. Horlings (1), Kaitlin Keegan (2), Edwin D. Waddington (1), Mary R. Albert (2), and Zoe Courville (3)

(1) Department of Earth & Space Sciences, University of Washington, Seattle, USA, (2) Thayer School of Engineering, Dartmouth College, Hanover, NH, USA, (3) Cold Regions Research and Engineering Laboratory, Hanover, NH, USA

Uncertainties in firn-densification rates derived from models give the largest uncertainty in estimates of ice-sheet mass loss by repeat satellite altimetry. Most existing firn-densification models are empirical, and tend to perform poorly when applied outside their climate calibration range and during transient climate. We are building a 1-D Lagrangian firn-densification model that will solve for densification through the evolution of primary microstructural parameters (e.g., grain radius, grain neck size, grain coordination number) using micro-CT data from site USP50, near South Pole. We develop a model that evolves microstructural parameters over time in each firn parcel, based on grain boundary sliding, grain growth, and bond growth theory, and driven by current parcel temperature, overburden load, and microstructural state at each time step. An effective viscosity can be derived from the evolving microstructural state, and can be applied in a viscous constitutive relation to densify each firn parcel. Analysis in 2-D and 3-D for raw binary images from micro-CT data on a well-dated 120 m core from USP50 Camp are used to infer empirical coefficients for microstructural parameter-evolution equations. We quantify the evolution of key microstructural parameters and compare modeled and measured viscosity and density profiles from specific sites across Antarctica; preliminary results show promising agreement and a basis for revolutionary future firn-densification studies.