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Differences in Seasonal Melt in Greenland for Summer 2016 and 2017 - upGPR to determine liquid water percolation, retention and accumulation over the last two melt seasons

Achim Heilig (1), Olaf Eisen (2), Michael MacFerrin (3), Marco Tedesco (4), and Xavier Fettweis (5)

(1) Munich University, Geophysics Institute, Earth and Environmental Sciences, Munich, Germany (heilig@r-hm.de), (2) Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research, Bremerhaven, Germany, (3) Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO USA, (4) Lamont-Doherty Earth Observatory, Columbia University, (5) Department of Geography, University of Liège, Liège, Belgium

While summer 2016 air temperatures were above long term average over the entire Greenland ice Sheet (GrIS), melt in summer 2017 was considered as significantly below average, which may lead to an even positive surface mass balance in 2017 for the GrIS. However, apart from surficial extent of melt, only very little is known about effects of melt induced changes for snow and firn such as liquid water content, percolation depth and mass fluxes. To overcome this deficit, we installed an upward-looking radar systems (upGPR) 3.5 m below the snow surface in May 2016 close to Camp Raven (66.4779N/ 46.2856W) at 2120 m a.s.l. within the deep percolation zone of the GrIS. The radar is capable to monitor quasi-continuously changes in snow and firn stratigraphy, which occur above the antennas. For summer 2016, we observed four major melt events, which routed liquid water into various depths. The last event in mid-August resulted in the deepest percolation down to about 2.5 m beneath the surface. For the subsequent summer season in 2017, liquid water percolation barely reached the previous summer horizon until 15 August. In consequence, seasonal mass flux into underlying firn was strongly different for summer 2016 and 2017 at the site. While until mid-August 2016, melt events transferred a cumulative mass of almost 60 kg m^{-2} from the surface into firn, in 2017, for the same time period, no mass flux beneath the previous summer horizon has been observed. Comparisons with results predicted by the regional climate model MAR are in very good agreement in terms of specific surface accumulation, while neither the temporal evolution of density, nor bulk liquid water contents nor percolation depths agree with upGPR data. Such inaccuracies bias simulations of changes in snow and firn and limit our understanding of effects of water percolation as well as water retention in firn. A multi-year summer monitoring with upGPR may lead to a valuable data base for melt effects in perennial firn. At the current stage, we have continuous observations for a very strong melt season and a below average melt in 2017. We are looking forward to monitor even more extreme events to provide temporally continuous in-situ data for a large variety of melt years in perennial firn within the percolation zone of the GrIS.