Temporal and spatial variabilities in recent surface mass balance at EGRIP, Greenland

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Temporal variability in surface mass balance (SMB) on the Greenland ice sheet is important for understanding the mass balance of the ice sheet. Additionally, knowledge of the spatial variability in SMB at ice core drilling sites helps to interpret the spatial representativeness of SMB data obtained from a single ice core.

To investigate the spatiotemporal variability in recent SMB in the East Greenland Ice Core Project (EGRIP) area in the northeastern Greenland ice sheet, pit observations were made at six sites in the summers of 2016-2018. Depths of those pits are 4.01 m for Pit 1, 3.18 m for Pit 2, 2.01 m for Pit 3 and 4, 2.22 m for Pit 5, and 2.01 m for Pit 6, respectively. In all pits, snow samples for the measurement of snow density and stable water isotope ratios ($\delta^{18}O$ and δD) were collected at 0.03 m intervals from the snow surface to the bottom of the pits. Snow samples for water isotope analyses were melted, and the $\delta^{18}O$ and δD values were measured with a dual-inlet mass spectrometer (Thermo Fisher Scientific, Delta V) using an equilibrium method.

In all pits, depth profiles of water isotope ratios showed clear seasonal variations. Dating based on those seasonal variations indicated that Pit 1 covered 2006-2016, Pit 2 covered 2009-2016, Pits 3 and 4 covered 2013-2017, Pit 5 covered 2012-2017, and Pit 6 covered 2014-2018. We calculated annual SMB between one summer and the next in the EGRIP area using the data from Pits 1-6 (Fig. 1). The annual SMB differed among the pit sites. This difference was likely caused by post-depositional redistribution of snow due to wind erosion and snowdrift. However, the multiple-site averages of annual SMBs in 2009–2017 ranged from 134 to 157 mm w.e. yr^{-1} (average 146 mm w.e. yr^{-1}) if the data for 2011-2012 and 2012-2013 (which were affected by snow melting and re-freezing due to the surface melting in summer 2012) are averaged. This indicates that annual SMBs in the EGRIP area were nearly constant in 2009-2017. The average value of 146 mm w.e. yr^{-1} is approximately 50% higher than the average for 1607-2011 (Vallelonga et al., 2014). The site-to-site difference in annual SMBs in the EGRIP area indicated that single-site observation in this area can provide SMBs for each year, including a maximum ±30% uncertainty from the multiple-site averages without the effects of surface melting and re-freezing. Furthermore, five- and seven-year averages of annual SMBs for each pit were consistent with those calculated from the multi-pit data in the same period. This suggests that the five- to seven-year average of annual SMBs at one site might cancel out the effect of wind erosion and snow drift, and thus could be regarded as the areal average SMB in the EGRIP area.

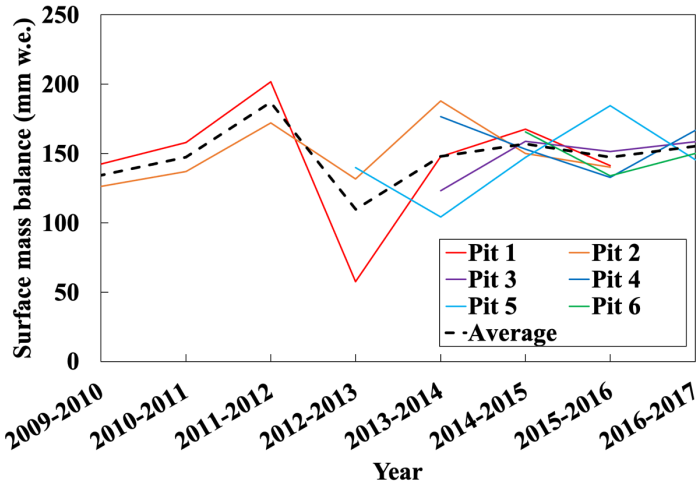

Fig. 1. Variations in annual SMBs.

Reference

Vallelonga, P., et al., Initial results from geophysical surveys and shallow coring of the Northeast Greenland Ice Stream (NEGIS), The Cryosphere, 8(4), 1275–1287, doi: 10.5194/tc-8-1275-2014, 2014.