Satellite-derived snow grain size over the Greenland Ice Sheet and its relationships with climate indices

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Remarkable amount of melt water that covered the sea ice surface near Qaanaaq, the northwest Greenland in June, 2019 became a hot topic all over the world. Surface mass balance simulated with the NHM-SMAP regional climate model for overall Greenland Ice Sheet (GrIS) in this mass balance year indicated the second lowest amount of annual surface mass balance following to that in 2012 since 1980. This is a symbolic event to actualize the increased surface melting of the GrIS and peripheral glaciers/ice caps which has been ongoing after the middle of 1990s. Although this is due mainly to global warming, the recent surface darkening (albedo reduction) could accelerate the surface melting. In accumulation area of GrIS the surface albedo is controlled by change of snow grain size because less contribution of light absorbing snow impurity to albedo reduction. In particular, the near-infrared (NIR) albedo strongly depends on snow grain size. We retrieved the optically-equivalent snow grain radius (R_{s1}) at the topmost snow layer in accumulation area of GrIS from Moderate Resolution Imaging Spectroradiometer (MODIS) data from 2000 to 2019. The interannual trend of monthly averaged value of Rs1 in July was +12 μm/decade with a large up and down variation. Comparing these results with the North Atlantic Oscillation (NAO) index and the Arctic Oscillation (AO) index, the July-averaged Rs1 was correlated strongly with the NAO index ($R = 0.711$, $p<0.01$) and not with AO index ($R = 0.364$, $p>0.1$). In a scatter plot between Rs1 and the NAO index, only the value of R_{s1} in 2012, the warmest summer since 1980, deviated from the regression line, suggesting that the year 2012 was exceptionally warm year.