Interannual variation of snow grain size on Greenland ice sheet retrieved from MODIS data –difference between Terra, Aqua and their composite –

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Surface albedo in accumulation area of Greenland ice (GrIS) sheet mainly controlled by variation of snow grain size because snow impurity concentration is low. Recent warming in the Arctic could accelerate snow metamorphism and thus bring snow grain growth. Possible cause of recent darkening in accumulation area of GrIS is snow grain growth, which has a positive feedback to the further warming in the Arctic. Satellite remote sensing is an efficient tool for monitoring of snow parameters. However, long-term variation of satellite sensor sensitivity may affect the retrieval result of grain size as well. MODIS onboard Terra and Aqua is one of the most suitable satellite sensors to retrieve snow grain size, but it is reported that the sensor degradation of Terra/MODIS is more significant than Aqua/MODIS (Polashenski et al., 2015). Hence, it could affect the long-term variation of snow grain size retrieved. Recently, sensor sensitivity-corrected data set of Terra and Aqua/MODIS (C6) were released (Lyapustin et al., 2014). Using these data, we retrieved surface snow grain size (Rs1) on GrIS from Terra and Aqua independently, with the algorithm based on a look-up table (LUT) method (Stamnes et al., 2007) at the wavelength of 1.24 μm. The LUT for bidirectional reflectance distribution function was calculated with a radiative transfer model for the atmosphere-snow system (Aoki et al., 2000) using a snow shape model employing Voronoi columns and aggregates (Ishimoto et al., 2012).

To analyze long-term variation of Rs1, monthly mean for all snow-covered area in GrIS was calculated from monthly mean image of Rs1, which is calculated from the daily images of Rs1 on GrIS. Comparing monthly mean Rs1 between Terra and Aqua, the monthly mean values of Rs1 derived from Terra were slightly smaller than those from Aqua. The differences are almost less than 10%. Since the year of launch differs between Terra and Aqua, we compared the interannual trend of Rs1 during the same period from 2003 to 2016 for Terra and Aqua. Both interannual trends from April to September agree well each other. Then, we calculated composite Rs1 from Terra and Aqua, by which we investigated variation of Rs1 for 2000-2016. The result shows that interannual trend of Rs1 is the largest (+32 μm/decade) in July and small positive in April, May, June and August, and negative in September. However, this situation changes for plateau area higher than 3 km, for which the largest interannual trend of Rs1 is relatively small (+14 μm/decade) in July and furthermore small positive in April, May, June and August, and small negative in September. These results means the snow surface grain size on GrIS has an increasing tend except for September during 2000-2016 and thus contributes to albedo reduction.

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