Annual variation in the extent of bare ice and dark ice on the Greenland Ice Sheet derived from AVHRR and MODIS data set

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Greenland Ice Sheet (GrIS) surface albedo reduction has been remarkable in recent years. Expansion of bare ice and dark ice area is one of the factors for significant darkening on the edge part of the GrIS surface. The expansionary trend of the bare ice and dark ice extent has been revealed from the analysis using MODIS satellite images (Shimada et al., 2016). However, the behavior of the GrIS surface state before the 2000 has not been investigated. In this study, we aim to investigate the annual variation in the bare ice and dark ice area during melting season (June, July and August) from 1979 using a long-term satellite data set. We created three months melting season composite bare ice and dark ice classification data from daily composite reflectance data sets of AVHRR and MODIS described in Hori et al. (2017). The near-infrared reflectance (λ = 0.86 μm) and visible reflectance (λ = 0.66 μm) were used for bare ice and dark detection. We investigated the difference of the bare ice and dark ice retrieval results revealed with the same threshold in the red and near-infrared reflectances between the two both satellite data sets in the duplicate observation period (during 2000 to 2008). The results showed that the bare ice and dark ice extent using AVHRR was larger than the MODIS result and the two bands of reflectance derived from AVHRR were lower than MODIS. Therefore, the thresholds for bare ice and dark ice detection were adjusted in order to fit the AVHRR result to MODIS result and remove the bias. The thresholds were determined to be maximum the Cohen's Kappa coefficient based on the comparison of surface ice type spatial distribution from AVHRR and MODIS. From the analysis using adjusted thresholds, the biases of the bare ice and dark ice extent were reduced from 92,636 km^2 and 12,183 km^2 to 9,625 km^2 and 5,719 km^2, respectively (Figure 1). The continuous bare ice and dark ice extent using bias removed AVHRR (1979 to 1999, except 1980) and MODIS (2000 to 2017) dataset showed positive trend in the whole region of the GrIS (Figure 2). Bare ice extent was gradually expanded from 1979, however dark ice extent was rapidly expanded after 2007. We are going to investigate the driving factor of the bare ice and dark ice extent variations.

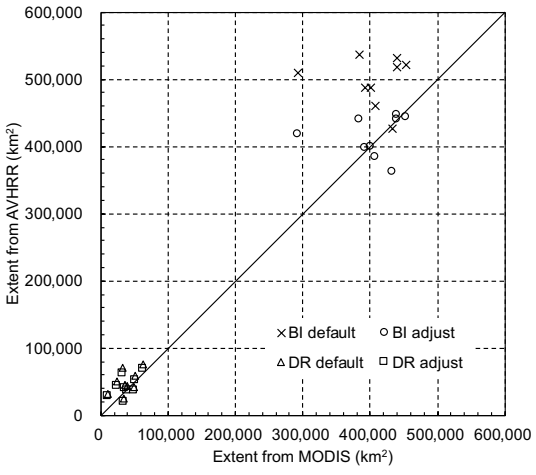

Figure 1. Comparison of the bare ice and dark ice extents retrieved using default threshold and adjusted threshold.

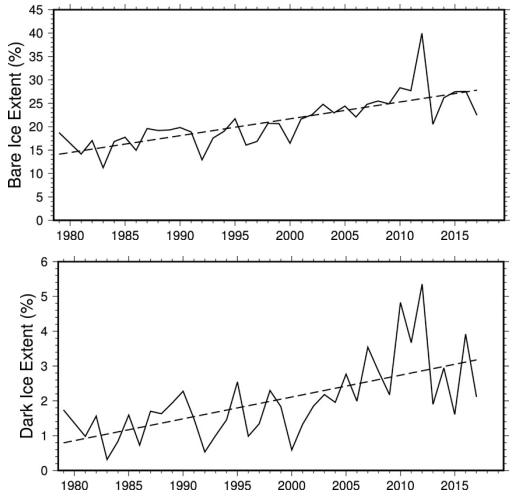

Figure 2. Bare ice and dark ice extent annual variations and trend during 1979 to 2017.

References

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