Inter-annual variations of the snow-melt area and snow surface albedo in the Greenland ice sheet

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Rapid decline of the entire cryosphere in recent years is generally considered to be caused by global warming. However, estimates of the heat budget at the snow surface lead to the conclusion that the sensible heat transfer from air to snow by the air temperature rise by 0.8 K is only about 10 Wm/2. Consequently, it seems uncertain whether or not this amount of heat addition is large enough to cause the simultaneous decline of ice sheets, mountain glaciers, sea ice, and seasonal snow cover all over the world.

In this paper we have analyzed the dataset of snow-melt area in the Greenland ice sheet for the years 1979 - 2007 (available from the National Snow and Ice Data Center), which is estimated empirically from the satellite micro-wave observations by SMMR and SMM/I. It has been found that the seasonal expansion of snow-melt area is more significant during the periods when the sun is higher and sunshine duration is longer rather than during the periods when the air temperature is higher. On the other hand, the decadal growth rate of snow-melt area shows maximum values in the first half of September when the snow surface is covered with accumulated snow impurities, and minimum values in June and the second half of September when the surface is covered with clean or newly fallen snow. We have then analyzed the dataset of clear-sky surface albedo over the Greenland for the years 1981 - 2005 (available from the National Snow and Ice Data Center),which is estimated from visible imageries by making corrections for the effects of water vapor, cloud, and angles between the zenith and sun and satellite. Similar trends have been found in terms of the seasonal increase and the decadal growth rate for the snow surface albedo. These facts imply that the decadal growth of snow-melting in the Greenland ice sheet may be caused by the decrease in snow surface albedo (or by the increase in snow impurities) rather than by the rise in air temperature.