



Current and future darkening of the Greenland ice sheet

Marco Tedesco (1,2), Julienne Stroeve (3,4), Xavier Fettweis (5), Stephen Warren (6), Sarah Doherty (6), Erik Noble (1), Patrick Alexander (1,2)

(1) CUNY, CCNY, EAS, NY, United States (mtedesco@sci.ccny.cuny.edu), (2) THE GRADUATE CENTER OF THE CITY UNIVERSITY OF NEW YORK, (3) NATIONAL SNOW AND ICE DATA CENTER, UNIVERSITY OF COLORADO, BOULDER, USA, (4) UNIVERSITY COLLEGE LONDON, LONDON, UK, (5) UNIVERSITY OF LIEGE, LIEGE, BELGIUM, (6) UNIVERSITY OF WASHINGTON, SEATTLE, WA, USA

Surface melting over the Greenland ice sheet (GIS) promotes snow grains growth, reducing albedo and further enhancing melting through the increased amount of absorbed solar radiation. Using a combination of remote sensing data and outputs of a regional climate model, we show that albedo over the GIS decreased significantly from 1996 to 2012. Further, we show that most of this darkening can be accounted for by enhanced snow grain growth and the expansion of areas where bare ice is exposed, both of which are driven by increases in snow warming. An analysis of the impact of light-absorbing impurities on albedo trends detected from spaceborne measurements was inconclusive because the estimated impact for concentrations of impurities of order of magnitude found in Greenland is within the albedo uncertainty retrievable from space-based instruments. However, neither models nor observations show an increase in pollutants (black carbon and associated organics) in the atmosphere over the GIS in this time period. Additionally, we could not identify trends in the number of fires over North America and Russia, assumed to be among the sources of soot for Greenland. We did find that a 'dark band' of tilted ice plays a crucial role in decreasing albedo along the west margin, and there is some indication that dust deposition to the GIS may be decreasing albedo in this region but this is not conclusive. In addition to looking at the direct impact of impurities on albedo, we estimated the impact of impurities on albedo via their influence on grain growth and found it is relatively small ($\sim 1-2\%$), though more sophisticated analysis needs to be carried out. Projections obtained under different warming scenarios consistently point to a continued darkening, with anomalies in albedo driven solely by the effects of climate warming of as much as -0.12 along the west margin of the GIS by the end of this century (with respect to year 2000). Projected darkening is likely underestimated because of an underestimation in melting and because the model used to project albedo does not account for the influence of light-absorbing impurities.