Geophysical Research Abstracts
Vol. 20, EGU2018-5609, 2018
EGU General Assembly 2018

Contributions of clouds to Greenland's surface melt: multi-year observations from automatic weather stations

Wenshan Wang (1), Charles Zender (1), Dirk van As (2), Paul Smeets (3), Michiel van den Broeke (3), and Nathaniel Miller (4)

(1) University of California Irvine, Irvine, United States, (2) Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark, (3) Institute for Marine and Atmospheric Research, Utrecht University (UU/IMAU), Utrecht, Netherlands, (4) University of Colorado Boulder, Boulder, United States

Clouds have a strong impact on surface radiation fluxes and may have triggered multiple massive melt events in the Arctic. However, harsh and distinctive physical conditions there make it difficult to obtain the regular and reliable in-situ observations of clouds and radiation necessary to study the cloud radiative effects (CRE). In this study, we use radiation observed by 30+ automatic weather stations (AWS) all over Greenland, facilitated by a radiative transfer model, to establish the first ground-truth dataset of surface CRE temporal variability and spatial distribution in Greenland's melt season. We then use our novel dataset of CRE estimated from in-situ measurements to evaluate the surface CRE estimated by five well-known large-scale datasets from satellite retrievals, reanalyses, and climate models.

Clouds currently warm Greenland during most of the melt season. However, seasonal CRE shows contrasting trends in the accumulation and ablation zones. CRE increases from May to July in the accumulation zone, mainly due to enhanced longwave CRE by cloud fraction and liquid water content. CRE decreases from May to July in the ablation zone, mainly due to strengthened shortwave CRE by surface albedo reduction. These different trends in different geographical regions explain a dispute in previous CRE studies: A study at Summit, Greenland exhibits a seasonal trend similar to that in the accumulation zone. Studies over sea ice exhibit ablation-zone-like seasonal trends. Moreover, the contrasting seasonal trends of longwave CRE indicate different cloud formation mechanisms in the ablation and central accumulation zones.

CRE generally decreases with elevation, forming a "warm center" spatial distribution. In the accumulation zone, both longwave and shortwave CRE decrease with elevation. In the ablation zone, shortwave CRE with its strong spatial variability dominates the decreasing CRE trends towards coasts.

We then evaluate five well-known gridded datasets by assessing their CRE spatial distributions against AWS estimates and examine their cloud-radiation physics as well as simulations of the major CRE determinants. CRE areal averages from the five datasets are similar (all around $10\,\mathrm{W\,m^{-2}}$). CRE estimates from MERRA-2, ERA-Interim, and CERES CRE estimates agree with in-situ estimates and reproduce the "warm center" distribution. However, the NCAR Arctic System Reanalysis (ASR) and the CESM Large ENSemble community project (LENS) show strong warming in the south and northwest, forming a "warm L-shape" CRE distribution. Discrepancies are mainly caused by longwave CRE in the accumulation zone. MERRA-2, ERA-Interim, and CERES successfully reproduce cloud fraction and its dominant positive influence on longwave CRE in this region. On the other hand, longwave CRE from ASR and LENS correlates strongly with ice water path instead of with cloud fraction or liquid water path.

This study provides the first surface CRE estimate over the entirety of Greenland using multi-year high-quality in-situ observations. It identifies the unique features of CRE temporal and spatial distributions, and uses them to evaluate the verisimilitude of large-scale observations and simulations. Our new methods and findings improve understanding of and ability to predict cloud-related contributions to the increasing widespread melting events in Greenland and, by extension, other polar regions.