EGU21-365
https://doi.org/10.5194/egusphere-egu21-365
EGU General Assembly 2021
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

Lagrangian analysis of the dynamical and thermodynamic drivers of large-scale Greenland melt events during 1979-2017

Mauro Hermann, Lukas Papritz, and Heini Wernli
ETH Zurich, Institute for Atmospheric and Climate Science (IAC), Department of Environmental Systems Science (D-USYS), Switzerland (mauro.hermann@env.ethz.ch)

We systematically investigate the dynamical and thermodynamic processes that lead to 77 large-scale melt events affecting high-elevation regions of the Greenland Ice Sheet (GrIS) in June-August (JJA) 1979-2017. For that purpose, we compute 8 day kinematic backward trajectories from the lowermost ~500 m above the GrIS. The key synoptic feature accompanying the melt events is an upper-tropospheric ridge over Southeast Greenland associated with a surface high-pressure system. This circulation pattern is favorable to induce rapid poleward transport (up to 40° latitude) of warm (~15 K warmer than climatological air masses arriving on the GrIS) and moist air masses from the lower troposphere to the western GrIS and subsequently to distribute them in the anticyclonic flow over north and east Greenland. During transport to the GrIS, the melt event air masses cool by ~15 K due to ascent and radiation, which keeps them just above the critical threshold to induce melting.

The thermodynamic analyses reveal that the final warm anomaly of the air masses is primarily owed to anomalous horizontal transport from a climatologically warm region of origin. However, before being transported to the GrIS, i.e., in their region of origin, these air masses were not anomalously warm. Latent heating from condensation of water vapor, occurring as the airstreams are forced to ascend orographically or dynamically, is of secondary importance. These characteristics were particularly pronounced during the most extensive melt event in early July 2012. In this event, importantly, the warm anomaly was not preserved from anomalously warm source regions such as North America experiencing a record heat wave. Considering the impact of moisture on the surface energy balance, we find that radiative effects are closely linked to the air mass trajectories and enhance melt over the entire GrIS accumulation zone due to (i) enhanced downward longwave radiation related to poleward moisture transport and a shift in the cloud phase from ice to liquid primarily west of the ice divide and (ii) increased shortwave radiation in clear-sky regions east of the ice divide.

The temporal evolution, positioning, and intensity of synoptic scale weather systems deserve further attention as they are responsible for strong and partly opposing atmospheric forcing of the GrIS surface mass balance. Also, the mechanisms identified here are in contrast to melt events in the low-elevation high Arctic and to midlatitude heat waves, where the upper-tropospheric ridge is essential to induce adiabatic warming by large-scale subsidence. Given the ongoing increase in

the frequency and the melt extent of large-scale melt events, the understanding of upper-tropospheric ridges over the North Atlantic, i.e., also Greenland blocking, and its representation in climate models is crucial in determining future GrIS accumulation zone melt and thus global sea level rise.