

E3SM's Skill at Simulating the Drivers of Surface Melt on the Greenland Ice Sheet

The Greenland Ice Sheet (GrIS) is the primary cryospheric source of global sea-level rise, and at least half of its mass loss acceleration since the 1990s originates from surface melt. We compare E3SM's surface energy budget and related atmospheric conditions with in-situ measurements from automatic weather stations and reanalyses. Due to the footprint-size differences and uncertainties in observations in polar regions, a direct comparison of the magnitude of surface melt is problematic. Instead, we focus on the temporal variability and spatial patterns of the surface energy budget and related atmospheric conditions to evaluate the physical processes that cause surface melt. Observational data and the Regional Atmospheric Climate Model (RACMO) show that the daily variability of surface melt is dominated by sensible heat exchange (51±4% of the time during melt seasons), enhanced by the increasing vertical mixing during katabatic winds. This dominance of sensible heating on the daily timescale is robust from 1979-2019 and in most drainage basins, including the southwestern basin which contributes the most to surface mass loss. On high sensible heating days, the GrIS is largely controlled by a high-pressure system with strong downslope winds and clear-sky conditions. On high longwave heating days (the second-largest contributor), the GrIS is largely controlled by a low-pressure system with warm advection coming from the ocean or the south, introducing higher cloudiness. We assess E3SM's skill at reproducing these dominant patterns and processes that drive Greenland surface melt.