EGU21-5942, updated on 26 Nov 2022
https://doi.org/10.5194/egusphere-egu21-5942
EGU General Assembly 2021

Dynamic and Thermodynamic Impacts of Climate Change on Organized Convection in Alaska

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Organized convective systems produce heavier downpours and can become more intense with climate change. While organized convection is well studied in the tropics and mid-latitudes, few studies have focused on the physics and climate change impacts of pan-Arctic convective systems, where they can produce flash flooding, landslides, or ignite wildfires.

We use a convection-permitting model to simulate Alaska's climate under current and end of the century high emission scenario conditions. We apply a precipitation tracking algorithm to identify intense, organized convective systems, which are projected to triple in frequency and extend to the northernmost regions of Alaska under future climate conditions. The present study assesses the reasons for this rapid increase in organized convection by investigating dynamic and thermodynamic changes within future storms and their environments, in light of canonical existing theories for mid-latitude and tropical deep convection.

In a future climate, more moisture originates from Arctic marine basins and relative humidity over continental Alaska is projected to increase due to sea ice loss, which is in sharp contrast to lower-latitude land regions that are expected to become drier. This increase in relative humidity favors the onset of organized convection through more unstable thermodynamic environments, increased low-level buoyancy, and weaker downdrafts.

Our confidence in these results is increased by showing that these changes can be analytically derived from basic physical laws. This suggests that organized thunderstorms might become more frequent in other pan-Arctic continental regions highlighting the uniqueness and vulnerability of these regions to climate change.