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Large-scale circulation associated with moisture intrusions into the Arctic during winter

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Observations during recent decades show that there is a greater near surface warming occurring in the Arctic, particularly during winter, than at lower latitudes. Understanding the mechanisms controlling surface temperature in the Arctic is therefore an important priority in climate research.
The surface energy budget is a key proximate control on Arctic surface temperature. During winter, insolation is low or absent and the atmospheric boundary layer is typically very stable, limiting turbulent hear exchange, so that the surface energy budget is almost entirely governed by longwave radiation. The net surface longwave radiation (NetLW) at this time has a strikingly bimodal distribution: conditions oscillate between a 'radiatively clear' state with rapid surface heat loss and a "moist cloudy" state with NetLW $\sim$ 0 W m-2. Each state can persist for days or weeks at a time but transitions between them happen in a matter of hours. This distribution of NetLW has important implications for the Arctic climate, as even a small shift in the frequency of occupancy of each state would be enough to significantly affect the overall surface energy budget and thus winter sea ice thickness.
The clear and cloudy states typically occur during periods of relatively high and low surface pressure respectively, suggesting a link with synoptic-scale dynamics. This suggestion is consistent with previous studies indicating that the formation of low-level and mid-level clouds over the Arctic Ocean is typically associated with cyclonic activity and passing frontal systems . More recent work has shown that intense filamentary moisture intrusion events are a common feature in the Arctic and can induce large episodic increases of longwave radiation into the surface.
The poleward transport of water vapor across 70N during boreal winter is examined in the ERA-Interim reanalysis product and 16 of the Coupled Model Intercomparison Project Phase 5 (CMIP5) models, focusing on intense moisture intrusion events. A total of 298 events are objectively identified between 1990 and 2010 in the reanalysis dataset, an average of 14 per season, accounting for 28% of the total poleward moisture transport across 70N. Composites of sea level pressure and potential temperature on the 2 potential vorticity unit surface during intrusions show a large-scale blocking pattern to the east of each basin, deflecting midlatitude cyclones and their associated moisture poleward. The interannual variability of intrusions is strongly correlated with variability in winter-mean surface downward longwave radiation and skin temperature averaged over the Arctic. The 16 CMIP5 models are validated with respect to the reanalysis dataset and a subset of 7 models is chosen as best representing intrusions. Intrusions in the representative concentration pathway 8.5 scenario (RCP8.5) from these 7 models are analyzed between 2060 and 2100. Positive trends in the moisture transported by intrusions are noted. The mechanisms behind these trends are examined in each of the models, dynamically and thermodynamically, with regard to the positioning of the storm track and climatological jets in a moistening atmosphere.