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The impacts of intense moisture transport on the deep and marginal sea-ice zones of the Arctic during winter

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Over the past few decades observations have shown that the Arctic is warming at a much faster rate than the global average; a phenomenon know as polar amplification. This tendency for the high latitudes to warm at a disproportionate rate compared to the global average is also a robust feature of global climate model simulations and highlights the importance of climate research in this region.

The most often cited mechanism explaining polar amplification is the ice-albedo feed-back; a mechanism by which the surface albedo decreases as sea ice retreats in response to a warming climate. This in turn leads to a higher absorption of insolation and the melting of more ice. In recent years the role of the ice-albedo feedback mechanism as the main cause of polar amplification has been brought into question. GCM studies show a slight reduction of the total poleward energy transport in a warming climate; with the dry static component decreasing at a much faster rate than the moist component. This repartitioning of the poleward energy transport has implications for the formation of clouds in the Arctic, which induce a secondary warming by trapping escaping OLR. These cloud processes in the atmosphere can explain at least part of the recent temperature amplification in the Arctic; and indeed even aquaplanet model studies with zero sea-ice reproduce the polar amplification phenomenon.

Directionally, the ice-albedo feedback is a "bottom-up" process; inducing warming in the atmosphere from an increasing surface heat source i.e. more open ocean. The opening of more ocean surface is also consistent with the bottom amplified structure of warming in the Arctic. Here we present evidence for a mechanism in the atmosphere that matches with observations, but in fact acts the opposite direction i.e. "top-down", whereby moist air masses from lower latitudes, termed "moisture intrusions", travelling over the sea-ice increase the longwave down radiation and in turn induce a bottom amplified warming at the surface. There are an average of 14 such events that enter the polar cap each winter, driving about 50% of the seasonal variation in surface temperature over the deep Arctic.

We show that, over the last 30 years, the marginal ice-zones in the Barents, Labrador and Chukchi Seas have experienced roughly a doubling in the frequency of these intense moisture intrusion events during winter. Interestingly, these are the regions that have experienced the most rapid wintertime ice loss in the Arctic, raising the question: to what extent has the recent Arctic warming been driven by local vs. interannual/remote processes?