Atmospheric Rivers in the Changing Arctic: Impacts and Trends over the Past Four Decades

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In recent decades, the Arctic has been warming at a rate 3-4 times faster than the global average, a phenomenon known as Arctic Amplification (AA). Concurrent with AA is the rapid moistening of the Arctic atmosphere and increases in weather extremes at the synoptic time scale, ranging from rapid sea ice loss, rain-on-snow events to heatwaves. Atmospheric rivers (ARs), filaments of intense moisture transport in the atmosphere, are responsible for most of the atmospheric moisture transport into the Arctic. When ARs intrude into the Artic, the warm and moist air carried by them can lead to enhanced downward longwave radiation and subsequent surface warming. Based on an hourly reanalysis dataset, we first characterize wintertime high Arctic warm extremes during 1980-2021. The large-scale circulation driving these warm extremes is identified. Using an AR detection algorithm, the impacts of Arctic ARs and their roles in driving these warm extremes are further quantified. We explicitly show that ARs play a key role in directly driving these events. Given the importance of ARs in driving the Arctic weather extremes, we next investigate the Arctic AR trends in recent decades. Using multiple sources of datasets, we show that, contrary to the uniform positive trend in climate simulations, the observed Arctic AR frequency increases by twice as much over the Atlantic sector compared to the Pacific sector in 1981-2021. We further find that the observed phase shift of the Interdecadal Pacific Oscillation (IPO) and Atlantic Multidecadal Oscillation (AMO) is key in reconciling the discrepancy between the observed trend and the simulated trend. Given the dominant role of IPO and AMO in the Arctic AR decadal variability, we further demonstrate how their historical statistics can be used to constrain future Arctic AR changes.

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