Pathways of Atmospheric Rivers in the Arctic: Dynamics, Moisture Transport, and Impacts on Sea Ice in April 2020

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Abstract

In recent decades, the Arctic has warmed nearly four times faster than the global average, undergoing profound environmental changes. A key contributor to this accelerated warming is the meridional transport of atmospheric water vapor. Intense intrusions of moisture and heat, known as atmospheric rivers (ARs), are rare at high latitudes but are projected to increase in frequency and intensity under global warming. A deeper understanding of AR dynamics and their impacts on the cryosphere is essential for assessing Arctic environmental changes and improving future projections.

This study examines an AR pair from April 2020 using a combination of Eulerian and Lagrangian methods, along with observational data from the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition. T The event consisted of two distinct ARs that followed separate pathways - one across Siberia and the other across the Atlantic - before converging in the central Arctic within the span of one week. Large-scale atmospheric circulation patterns reveal that each AR was steered by a quasi-stationary cyclone-anticyclone couplet, facilitating sustained northward transport of moisture and heat. Notably, the Siberian AR was associated with extreme heat anomalies exceeding 20○C, while the Atlantic AR primarily delivered abundant moisture.

Backward air parcel trajectories calculated using LAGRANTO provide new insights into the complex dynamics of Arctic ARs, highlighting their distinct pathways and moisture source regions. Furthermore, our analysis identifies a strong negative correlation (-0.87) between AR-induced temperature increases and observed sea ice melt in the Barents-Kara Sea.

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