Exploring the Relationship between Arctic Cyclones, Atmospheric Rivers and Their Impacts on Energy and Moisture Transport in the Arctic

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Abstract

Atmospheric rivers (ARs) are crucial pathways for atmospheric moisture transport into, and within, the polar regions. ARs significantly impact the Arctic climate system by enhancing atmospheric heat and moisture transport and strongly influence the local surface energy budget (SEB). Studies further indicate that these large SEB anomalies are often linked to increased cyclone activity. This study evaluates the role of AR-cyclone interactions on AR heat and moisture transport and their impacts on surface radiation, with a specific focus over the Arctic Atlantic sector-a region strongly influenced by the mid-latitude storm track, where AR-cyclone associations are most frequent during non-summer seasons. First, varying AR-cyclone distance thresholds are tested to determine the proportion of ARs associated with cyclones and analyzing their spatial and seasonal characteristics across the different AR-cyclone distance thresholds. Next, we investigate how AR-cyclone interactions influence atmospheric heat (moist static energy, MSE) and moisture (integrated vapor transport, IVT) transport by comparing these quantities between ARs associated with cyclones and those occurring independently, while also examining how these effects vary across different distance thresholds. Additionally, we evaluate AR impacts on surface radiation (with a focus on downward longwave radiation), revealing the extent to which ARs and cyclones independently and collectively drive surface radiation anomalies. Through composite analysis, we explore how cyclone strength, AR intensity, and their relative positioning collectively drive atmospheric heat and moisture transport across different distance thresholds. Ultimately, this study provides new insights into the complex interactions between Arctic ARs and cyclones, advancing our understanding of the Arctic climate system.

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