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Sea ice controls on Arctic water vapor content and transport: Discoveries from MOSAiC's pan Arctic Water Isotope Network (AWIN)

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One of the key changes of the global climate system is the loss of Arctic sea ice, particularly through its impact on ocean-atmosphere interactions. Enhanced evaporation under open-water conditions is widespread from places and periods previously precluded by perennial sea ice cover, leading to an increase in vapor uptake across the Arctic. However, the response of ocean-atmosphere system to sea ice loss varies significantly over time and space. To quantify these variations, the Arctic Water Isotope Network (AWIN) has been established to make continuous water vapor isotope measurements (δD, δ^{18}O, and d-excess) at seven land-based stations from Barrow, Alaska to Ny Alesund, Svalbard. This network has been supplemented by continuous mobile isotope data from the CiASOM project on the Polarstern ice-breaker throughout the MOSAiC "Arctic-drift" expedition. With this network, we comprehensively track water vapor from its source to sink, thereby demonstrating how it varies simultaneously across the entire Arctic Basin.

Here, we utilize AWIN measurements to specifically quantify how variations in sea ice extent and distribution affect moisture content, water vapor isotope traits, and transport along several critical storm tracks. By monitoring vapor isotopic changes in air masses advected from one site to another, we are able to track how much moisture is added along a given trajectory. We investigate several primary vapor transport pathways into the Arctic, including the North Atlantic/Greenland Sea, Baffin Bay, and the Bering Strait, and track the geochemical signature of this vapor as it transits along these well-established storm pathways into and within the Arctic. By quantifying

isotopic changes between our sites we: 1) identify the distinct isotopic fingerprint of moisture sourced by evaporation from Arctic seas that is critically dependent on variable sea ice conditions, 2) detect moisture addition into critical storm tracks as they transit across the Arctic, and 3) determine the spatial variability of this enhanced Arctic-sourced evaporation and moisture. We find that for every major storm track observed, the Arctic Ocean and surrounding seas are significant sources of enhanced moisture uptake, acting within an amplified water cycle.