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Precipitation isotope ($\delta^{18}O$, $\delta^{2}H$, d-excess) seasonality across the Pan-Arctic during MOSAiC

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Stable isotopes of oxygen and hydrogen in precipitation ($\delta^{18}O_P$, $\delta^{2}H_P$, d-excess) are valuable hydrological tracers linked to ocean-atmospheric processes such as moisture source, storm trajectory, and seasonal temperature cycles. However, characteristics of $\delta^{18}O_P$, $\delta^{2}H_P$ and d-excess and the processes governing them are yet to be quantified across the Arctic due to a lack of long-term empirical data. The Pan-Arctic Precipitation Isotopes Network (PAPIN) is a new coordinated network of 24 stations aimed at the direct sampling, analysis, and synthesis of precipitation isotope geochemistry in the north. Our ongoing event-based sampling provides a rich spatial dataset during the Multidisciplinary drifting Observatory for the Study of Arctic Climate ("MOSAiC") expedition and new insight into coupled climate processes operating in the Arctic today. To date, precipitation $\delta^{18}O$ and $\delta^{2}H$ data (2018-2019) exhibit pronounced spatial and seasonal variability that broadly conforms to theoretical and observed understanding: (1) decreasing $\delta^{18}O_P$/ $\delta^{2}H_P$ with increasing latitude and elevation, (2) decreasing $\delta^{18}O_P$/ $\delta^{2}H_P$ with increasing continentality, and (3) increasing $\delta^{18}O_P$/ $\delta^{2}H_P$ with increasing SAT. However, event-based sampling reveals remarkable variability among these relationships. For example, our observed Arctic mean summer -latitude slope of -0.3‰/degree of latitude is 50% smaller than the annual latitude effect in the mid-latitudes (-0.6‰/degree). This rate decreases to -0.1‰/degree of latitude in Finland and Russia, while in Alaska and northern Canadian a -0.7‰/degree latitudinal rate is observed. Similarly, we observe marked spatial differences in mean $\delta^{18}O$-temperature coefficients. Using back-trajectory analysis, we attribute these nuances to divergent moisture sources and transport pathways into, within, and out of the Arctic, and demonstrate how atmospheric circulation processes drive changes in isotope geochemistry and climate that are linked to sea ice concentration. For example, Alaska moisture derived from the North Pacific Ocean, Sea of Okhotsk, and the Bering Sea remains relatively enriched in $^{18}O_P$/^{2}H due to higher sea surface temperatures, whereas moisture originating from ice-covered seas to the north is characterized by relatively depleted values. This is the first coordinated network to quantify the spatial patterns of isotopes in precipitation, simultaneously, across the entire Arctic. In combination with a Pan-Arctic network of continuous water vapor isotope analyzers, our process-level studies will resolve the patterns and processes

governing the $\delta^{18}O$, $\delta^{2}H$ and d-excess values of the Arctic water cycle during the MOSAiC expedition and beyond.

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