EGU22-7062, updated on 09 Aug 2022
https://doi.org/10.5194/egusphere-egu22-7062
EGU General Assembly 2022

Isotope measurements of the Arctic water cycle and exchange processes between seawater, sea ice, and snow during MOSAiC

Moein Mellat[1], Martin Werner[2], Camilla Francesca Brunello[2], Dorothea Bauch[3,4], Ellen Damm[1], Daiki Nomura[5], Alessandra D'Angelo[6], Jeffrey M. Welker[7,8,9], Martin Schneebeli[10], and Hanno Meyer[1]

[1]Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, 14401 Potsdam, Germany (moein.mellat@awi.de)
[2]Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, 27515 Bremerhaven, Germany
[3]Leibniz-Laboratory, University of Kiel CAU, Germany
[4]GEOMAR Helmholtz Centre for Ocean Research, Germany
[5]Field Science Center for Northern Biosphere, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido 041-8611, Japan
[6]University of Rhode Island, Graduate School of Oceanography, Narragansett, Rhode Island, United States
[7]Ecology and Genetics Research Unit, University of Oulu, Oulu, Finland
[8]University of the Arctic (UArctic), Rovaniemi, Finland
[9]Department of Biological Sciences, University of Alaska Anchorage, Anchorage, AK, United States
[10]WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

For the past two decades, the Arctic water cycle changed rapidly due to surface air temperatures (SATs) increasing at twice the global rate. Terrestrial ice (i.e. Greenland Ice Sheet) and marine sea-ice loss, alterations of ocean circulation patterns, and shifting atmospheric moisture sources and transport are some of the most pronounced changes caused by the Arctic amplification, fostering increased humidity levels. Stable water isotopes ($\delta^{18}O$, $\delta^{2}H$) and the secondary parameter *d-excess* are valuable tracers for hydrological changes, including how these shifts may affect the global climate system. However, it is only recently that we are using precipitation and water vapor networks to resolve water isotope patterns and processes in the Arctic. However, a fully coordinated study of the entire water cycle attributes year-long including sea ice, ocean water, vapor, and precipitation has until recently has been absent. The Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition provided a unique opportunity to collect, analyze, and synthesize discrete samples of the different hydrological compartments in the central Arctic, covering a complete one-year seasonal cycle using a combination of ship-based, the pan-Arctic Water Isotope Network (PAPIN). These observations can lead to new insights into coupled ocean-atmosphere climate processes operating in the Arctic, especially during extreme events, sea ice formation, sea ice retreat, and during a dichotomy of synoptic weather patterns over the MOSAiC-year.

We present the isotopic traits of more than 2,200 discrete samples (i.e., seawater, sea ice, snow, brines, frost flowers, lead ice, ridge ice, and precipitation) collected during MOSAiC. Snow has the most depleted $\delta^{18}O$ values (-16.3 ± 9.1‰; the number of samples N=306), whereas seawater is the

most enriched $\delta^{18}O$ compartment (-1.5 ± 0.9‰; N=302) of the Arctic water cycle. Precipitation throughout the Arctic Basin varied from -10‰ to -35‰. Snow profiles are gradually enriched in $\delta^{18}O$ from top to bottom by ~20‰ partially due to sublimation of deposited snow, as well as snow metamorphism and its effects on the water isotopes. Second-year ice (SYI) is isotopically relatively depleted in $\delta^{18}O$ (-4.2 ± 2.6‰; N=200) compared to first-year ice (FYI) (-0.7 ± 2.1‰; N=635) and insulated FYI (i.e. FYI grown at the bottom of SYI) (-1.7 ± 2.4‰; N=214). The latter is likely caused by post-depositional exchange processes with snow. Open water leads (-1.6 ± 2.4‰; N=137) and melt ponds (-2.1 ± 2.7‰; N=109) on the surface of sea ice contribute to the moistening of the atmosphere in the Arctic on a regional scale.

Our dataset provides an unprecedented snapshot of the present-day isotopic composition of the Arctic water cycle during an entire year. The coupling of these discrete samples data with the continuous measurements of atmospheric water vapor may shed light on the relative contribution of snow, sea ice, seawater, open water leads, and melt ponds both spatially and temporally to regional and local moisture levels in the Arctic. Stable water isotopes will ultimately contribute to resolving the linkages between sea ice, ocean, and atmosphere during the critical transition from frozen ocean to open water conditions.