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Atmospheric water vapor monitoring above the Greenland Ice Sheet

H. C. Steen-Larsen (1), S. J. Johnsen (2), V. Masson-Delmotte (3), B. Stenni (4), C. Risi (5), and H. Sodemann (6)

(1) Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, USA, (2) Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Denmark, (3) Laboratoire des Sciences du Climat et de l'Environnement, CEA, Gif-Sur-Yvette Cedex, France, (4) Department of Geological, Environmental and Marine Sciences, University of Trieste, Italy , (5) Laboratoire de Météorologie Dynamique, Jussieu, Paris, France, (6) ETH, Institute for Atmosphere and Climate Science, Zürich, Switzerland

From ice cores drilled on the Greenland and Antarctic Ice sheet we are able to measure a suite of climate proxies. Of these climate proxies, one of the routinely measured is the water stable isotope ratio in terms of the ratio H218O/H216O and HD16O/H216O (known as δ18O and δD). Based on these relationships, the past temperatures of the site and source region can be estimated. The relation between the isotopic composition and temperature is based on direct observations with only limited understanding of the underlying physical processes. New insights into the physical properties of the hydrological cycle have recently been possible with development of field deployable laser-spectroscopy analyzers.

We present here measurements carried out during the 2010 field season, at the NEEM site in NW-Greenland (77.45 N 51.05 W, 2484 m a.s.l.). The field campaign lasted more than two months during June, July and August. The measurements were conducted in the clean air zone upwind from the NEEM camp. A 13-meter tower was erected and a system was sat up to take in air from six different levels of respectively 1.0, 1.5, 3.0, 7.0, 10.0, and 13.0 meters height above the snow surface. The isotopic composition of the vapor was measured for 15 minutes at each level before shifting to the next level. The isotopic water vapour was measured in continuous mode using a Picarro Inc. and a Los Gatos Inc. water vapor analyzer.

As part of the field deployment a comparison between the two different isotopic water vapor analyzers were carried out together with a validation of both the long and short-term stability of the systems. We conclude from these tests that both analyzers present a large reproducibility and stability, which gives merits to the obtained results.

We observe a clear diurnal cycle in the isotopic composition of the water vapor above the snow surface with amplitude of about 15 o/oo in δD. The diurnal isotopic composition follows the absolute humidity cycle. This indicates a large flux of vapor from the snow surface to the atmosphere during the daily warming and reverse flux during the daily cooling. The isotopic measurements of the flux of water vapor above the snow give new insights into the post depositional processes of the isotopic composition of the snow.

Over the complete field deployment we observe relative stable d-excess (d-excess = δD – 8xδ18O) level of about 20 o/oo only to be interrupted by intrusion of shorter periods lasting about 1-2 days with very high d-excess levels of up to 50 o/oo. We perform backtrajectory simulations and find that for periods with high d-excess level the air mass originates from the Arctic Ocean above the North American Continent. We explain the observed high d-excess by strong kinetic fractionation during evaporation from the sea into humidity-depleted air as it moves across the sea ice margin.

These new insights are valuable in our understanding of the climate signal deduced from the stable water isotopic signal measured in the ice cores drilled on the Greenland and Antarctic Ice Sheet.