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The summer 2012 Greenland heat wave: monitoring water vapour isotopic composition along an atmospheric river event

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In July 2012, an extreme warm event occurred in Greenland, leading to surface melt over almost all the ice sheet. This event was recorded in the isotopic composition of water vapour measured by the IASI satellite along the transport pathway and at two sites where continuous in situ surface vapour isotopic measurements were conducted, situated at a coastal station of South Greenland (Ivittuut) and further North on top of the ice sheet (NEEM, NW Greenland). These observations allowed us to monitor the isotopic composition of the air mass at different stages of its advection towards Greenland, which can inform on processes along this trajectory, such as cloud properties and moisture sources. In addition, two simulations of this event, using the atmospheric general circulation models LMDZiso and ECHAM5wiso equipped with water stable isotopes and nudged towards large scale wind fields, are investigated. Furthermore, a regional high-resolution model was used to study the moisture transport to Greenland during this event using tagged water tracers of the North Atlantic ocean and coastal land evaporation.

Using moisture source diagnostic based on the Lagrangian particle dispersion model Flexpart, we show that this 2012 heat wave event corresponds to moisture sources located over the subtropical Atlantic Ocean, where intense evaporation was caused by dry air masses associated with the US intense summer drought. This moisture was then advected northward along a narrow band, due to a very stationary surface cyclone southwest of Greenland, reached southern Greenland and Ivittuut coastal station on July 9^{th}, travelled along the west coast of Greenland, continued eastwards above the ice sheet and arrived above the NEEM deep drilling camp on July 11^{th}.

Surface isotopic observations during the event show larger variations at NEEM than in Ivittuut, strongly reducing the isotopic and deuterium excess latitudinal gradient usually observed between South and North Greenland. This feature clearly deviates from a simple Rayleigh distillation process. LMDZiso and ECHAM5wiso correctly simulate the magnitude of humidity and temperature peaks in both surface sites, associated with a strong isotopic enrichment and a deuterium excess decrease all over Greenland. Small biases are observed on temperature, humidity as well as isotopes, with an underestimation of deuterium excess variability, which is typical for these models at those sites. IASI observations are compared to model outputs along the transport path in the free troposphere (3-6 km) where the remote sounder is most sensitive to δD variations.

The fingerprint of this unusual atmospheric event in future Greenland ice cores will likely be a major melt layer, as already recorded in 1889, where a similar event has probably also occurred (Neff et al. JGR submitted). Our isotopic observations provide new insights for understanding Greenland ice core records of extreme warm events.