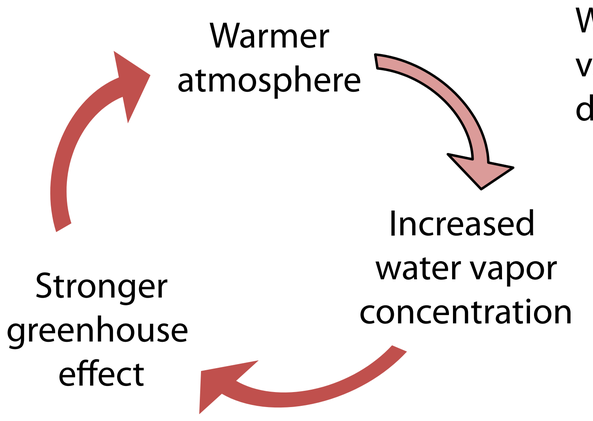
Local processes modifying atmospheric humidity around Ny-Ålesund, Kongsfjorden

R. Gierens[1], L. Hayo[1], T. Kiszler[1], V. Schemann[1] , M. Maturilli[2], K. Ebell[1]

[1] Institute of Geophysics and Meteorology, University of Cologne (Germany), [2] Alfred Wegener Institut (Germany)

1. Water vapor feedback[1]



Warmer air *can* contain more water vapor, but amount of humidity depends on sources/sinks

- More open sea → more evaporation (?)
- Changes in transport from lower latitudes?
- More water vapor → more clouds and precipitation?

Role of local processes vs. remote forcing in modifying atmospheric humidity?

2. Objectives & Observational set-up

Measurements at AWIPEV, Ny-Ålesund

Fjord environment characterized by:

- Orography
- Glaciers
- Heterogeneous surface types (open water, snow, ice, tundra)

→ Local sources of water vapor & distribution of humidity in Kongsfjorden?

→ Relative importance of local processes compared to advection?

Fig. 1: Map from Svendsen et al. 2002[2]. The red star shows the location of the AWIPEV station.

Microwave radiometer (MWR)

- Standard observation for integrated water vapor (IWV) and liquid water path (LWP)
- 360° azimuth scans at 30° elevation angle 2 times/hour

→ along path IWV and LWP

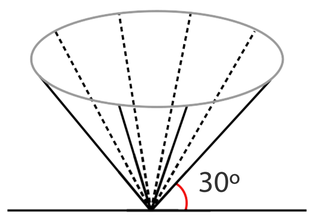


Fig 2: Sketch of MWR scan pattern.

3. Humidity advection

Atmospheric river (long narrow band of enhanced water vapor transport) event on 6 June 2017

→ Rapid increase & decrease in IWV when atmospheric river passes Ny-Å. (Fig. 4 top)

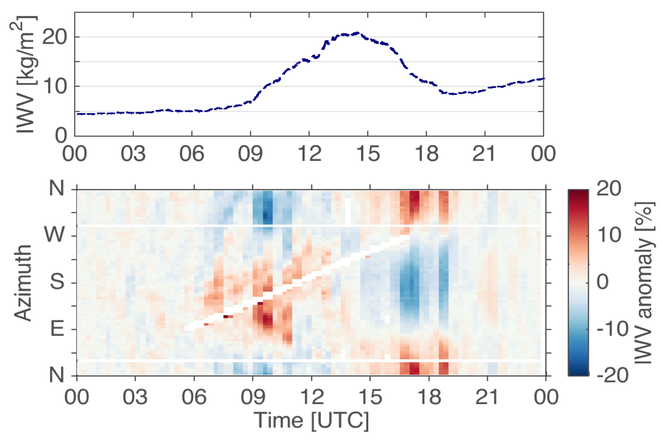


Fig. 4. Top: Time series of IWV (zenith measurement). Bottom: IWV anomaly at a given measured azimuth angle relative to the mean of each azimuth scan.

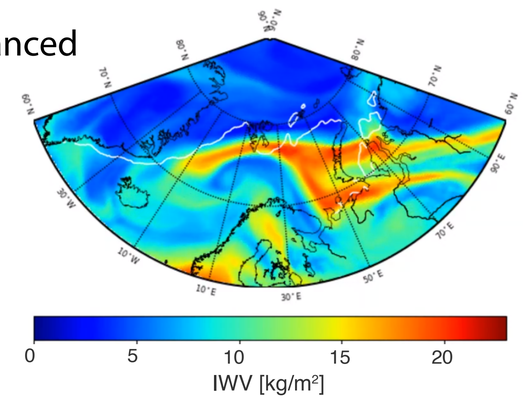


Fig. 3: IWV from ERA5 at 6 June 2017 6 UTC. Courtesy of M. Lauer.

→ Increase (decrease) in IWV is seen first in S-SE direction (Fig. 4 bottom), corresponding to the movement of the atmospheric river over Ny-Ålesund

4. Humidity variability related to local processes

Cases without humidity advection or clouds selected to reveal local influences.

Case 1: Persistent spatial anomaly

11 February 2021

Case 2: No humidity anomaly

29 January 2021

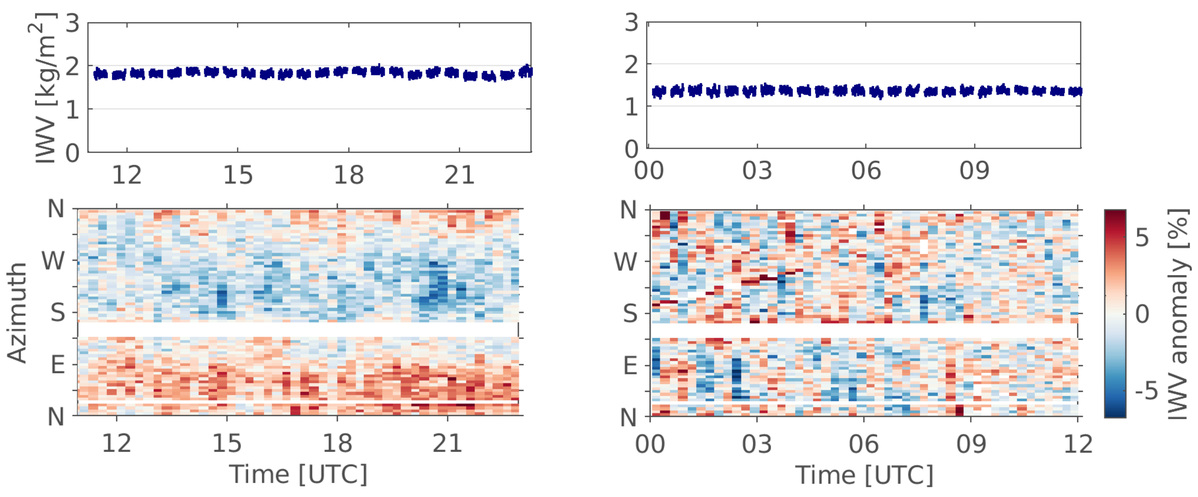


Fig. 5: As Fig. 4, for Case 1 (11 February 2021) on the left and for Case 2 (29 January 2021) on the right.

Case 1: Higher IWV in N-E direction (over water), lower in S-W direction (over land)

→ Evaporation from fjord increasing IWV?

Case 2: Stronger wind speed

→ Prevents a detectable humidity anomaly from forming?

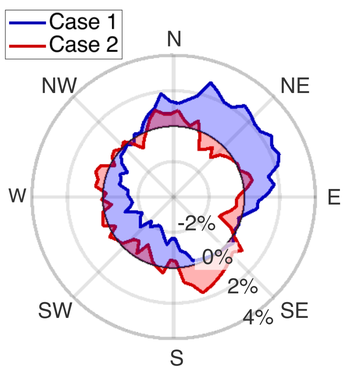


Fig. 6: Mean anomaly at each azimuth angle for both cases.

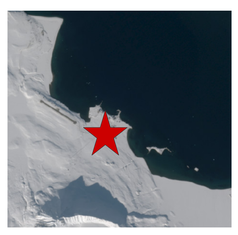


Fig. 7: Satellite image, source: https://toposvalbard.npolar.no[3]. Red star shows the location of the measurement.

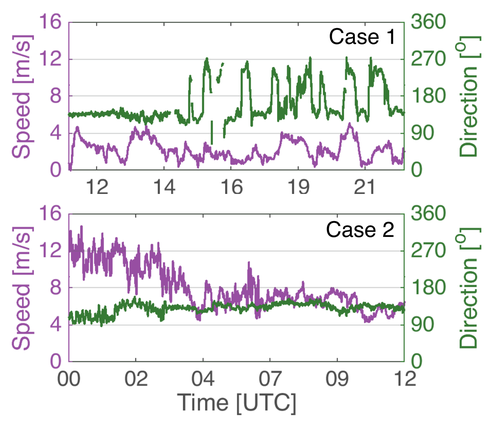


Fig. 8: 10 m wind speed (purple, left axis) and direction (green, right axis) for Case 1 (top) and Case 2 (bottom).

5. Challenges

- Off-zenith measurements sensitive to instrument tilt
- Low amount of water vapor difficult to retrieve, no data during rain
- Combination of path integrated variables (MWR technique) & shallow boundary layer (common at Ny-Å.) make detecting local processes difficult

6. Conclusions & Outlook

- Weak signals of local processes modifying atmospheric humidity detected
- Advection event clearly visible in MWR scans

Perspectives

- Statistical analysis using long term data set
- Combination with ICON model to facilitate process understanding
- Variability of cloud liquid water

References

1- Ghatak, D. and Miller, J. (2013), Implications for Arctic amplification of changes in the strength of the water vapor feedback, J. Geophys. Res. Atmos., 118, 7569–7578.
2- Svendsen et al. (2002), The physical environment of Kongsfjorden–Krossfjorden, an Arctic fjord system in Svalbard, Polar Research, 21(1), 133-166.
3- Provided by the Norwegian Polar Institute.

Acknowledgements:

We gratefully acknowledge the support from the Transregional Collaborative Research Center (TR 172) "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms (AC)3", which is funded by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft). Furthermore, we wish to thank our colleagues from AWI for their support and sharing of data, as well as the team at AWIPEV for their continuous effort that keeps the measurements running.

rgierens@uni-koeln.de