UNIVERSITÄT LEIPZIG

Faculty of Physics and Earth Sciences
Institute for Meteorology

LEIPZIG INSTITUTE FOR METEOROLOGY
Remote Sensing and Arctic Climate System

Investigation of virga with active remote sensing in Ny-Ålesund, Svalbard

Andreas Foth[1], Beril Aydin[1], Linnu Bühler[2], Christian Buhren[2], Kerstin Ebell[2], Mario Mech[2], Lukas Monrad-Krohn[1], Sabrina Schnitt[2], Andreas Walbröl[2], **Maximilian Maahn[1]** and Heike Kalesse-Los[1]

[1]Leipzig Institute for Meteorology, Leipzig University, Leipzig, Germany
[2]Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany,
Contact: andreas.foth@uni-leipzig.de

Hypothesis:

Atmospheric sublimation and evaporation are not only influenced by large-scale atmospheric drivers but also by small-scale (sub)cloud properties and impact cloud properties through feedback mechanisms.

Question:

How much precipitation sublimates or evaporates sub-cloud at different Arctic sites?

1. Objective

- precipitation rate can be retrieved from radar reflectivity (Z_e)
- subcloud precipitation reduction of ~20% [Maahn et al., 2014]
- local effects: land-sea circulation, katabatic winds
- atmospheric models struggle with simulation of sublimation rates

→ Feedbacks might be altered by shift from snowfall to rain (and sublimation to evaporation) in a warming Arctic

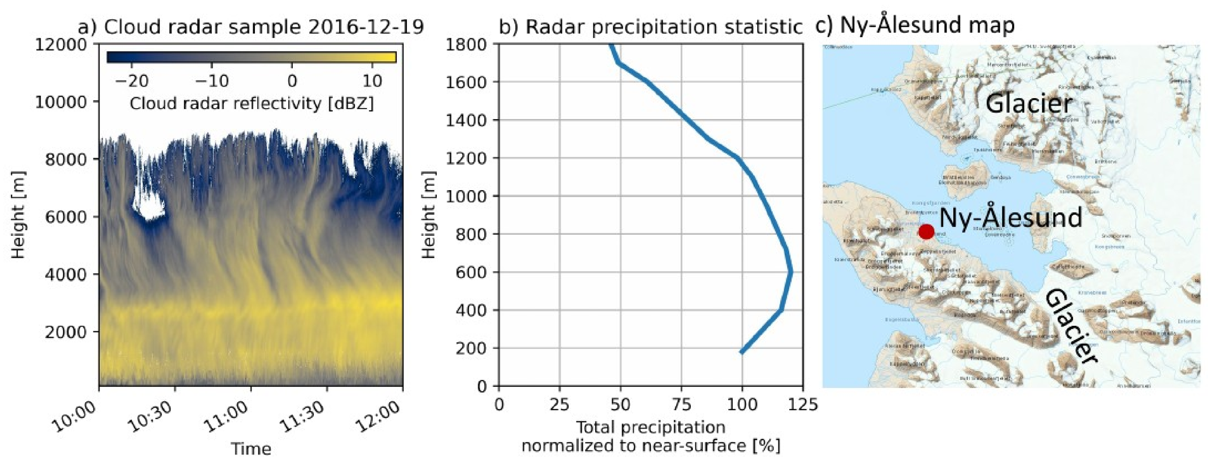

Fig. 1: Motivation for studying sublimation at Ny-Ålesund. a) Cloud radar observation of partial sublimation on 2016-12-19 b) Total precipitation amount as a function of height normalized to near-surface precipitation based on one year of observations c) Map of area (source: Norwegian Polar Institute).

2. Instrumentation

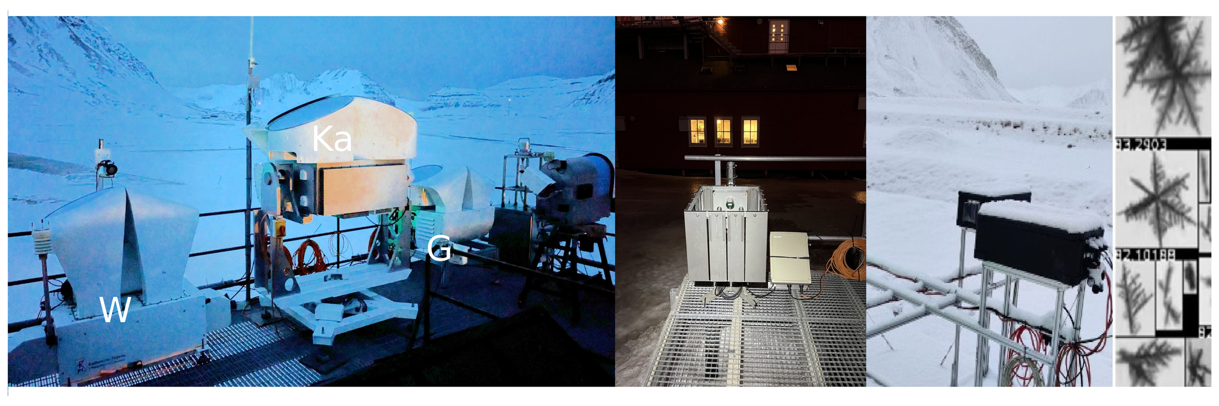

Fig. 2: Instrumentation: W, Ka and G-band cloud radar (left panel), laser disdrometer (middle) and Video-In-Situ Snowfall Sensor (VISSS, right)

- Location: AWIPEV base Ny Ålesund, Svalbard (see Fig. 1 c)
- W, Ka and G-band cloud radar
- Ceilometer
- Laser precipitation monitor (disdrometer)
- Video In-Situ Snowfall Sensor (VISSS, Maahn et al., 2024)

3. Virga detection tool – Virga Sniffer

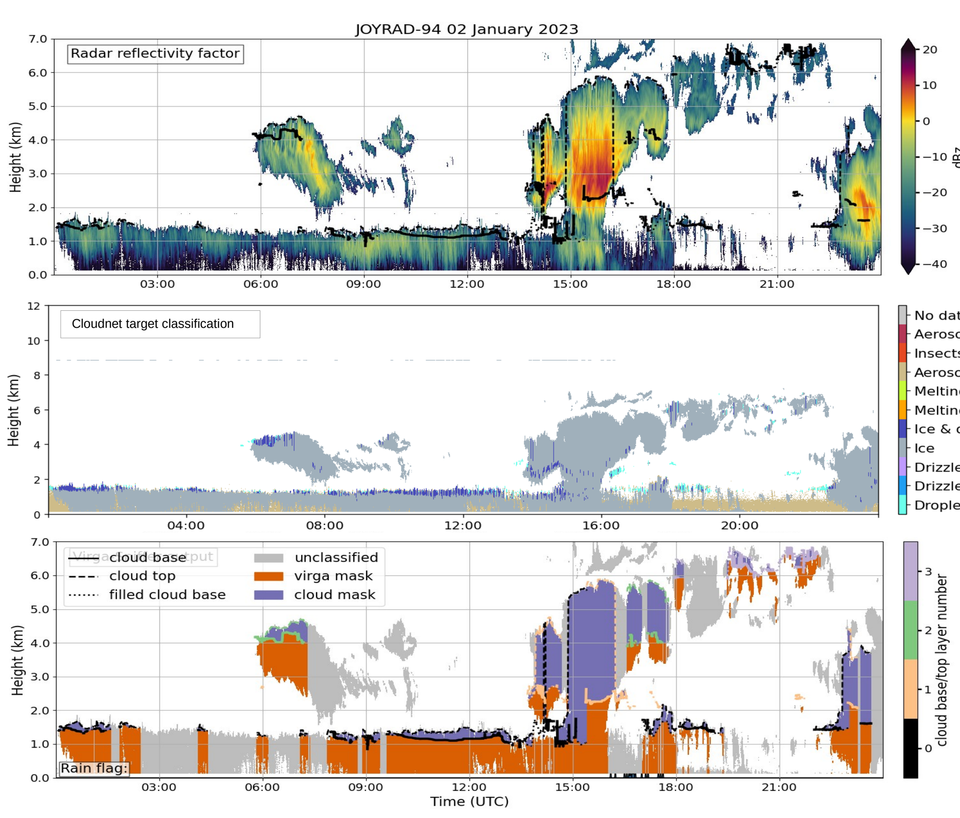

Fig. 2: Virga Sniffer : (a) cloud radar reflectivity factor and ceilometer cloud base (black line), (b) Cloudnet target classification according to Illingworth et al. (2007) and Virga Sniffer output.

- The Virga-Sniffer is a tool to detect virga
- Virga: precipitation which completely evaporates or sublimates before reaching the surface
- originally developed for trade wind clouds [Kalesse-Los et al., 2023]

based on:
- cloud radar reflectivity
- cloud base height from ceilometer
- surface rain flag from laser disdrometer or rain gauge (at least for ship measurements)

4. Results

- Virga fraction describes the fraction of virga profiles within all precipitation profiles" (so that 50% means half of the profiles with precipitation are virga)

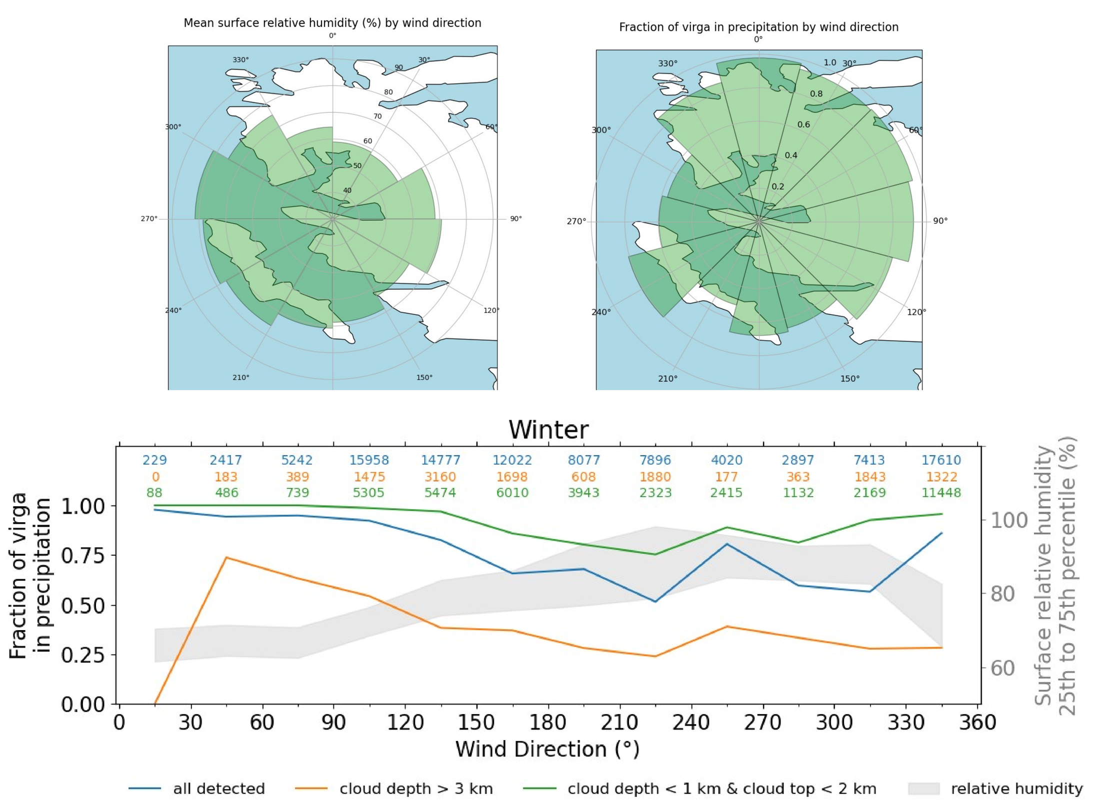

Fig. 4: Polar projections of the mean surface relative humidity (top left) and the virga fraction (top right) over Ny Ålesund during winter time (2023). Bottom: Virga fraction for different cloud depths (colors) and interquartile range of relative humidity over wind direction. The numbers denote the absolute numbers of occurrence.

- Dryer air near ground level during easterly winds leading to higher virga fraction
- Large fraction means less precip reaches ground (more evaporation and sublimation cases)
- The lower the subcloud relative humidity, the higher the virga fraction
- Similar findings for other seasons

5. Intensive observation period: IOP4H2O

- 20 Jan 2025 – 10 Mar 2025 at AWIPEV
- remote sensing observation, surface precipitation rate estimates
- humidity profiles from novel G-band radar
- 78 additional radio soundings, additional laser precipitation monitor
- additional snow sampling with snow particle counter – sublimation of blowing snow
- observation on Feb 25, 2025, show sub cloud evaporation of rain within a dry layer during easterly winds

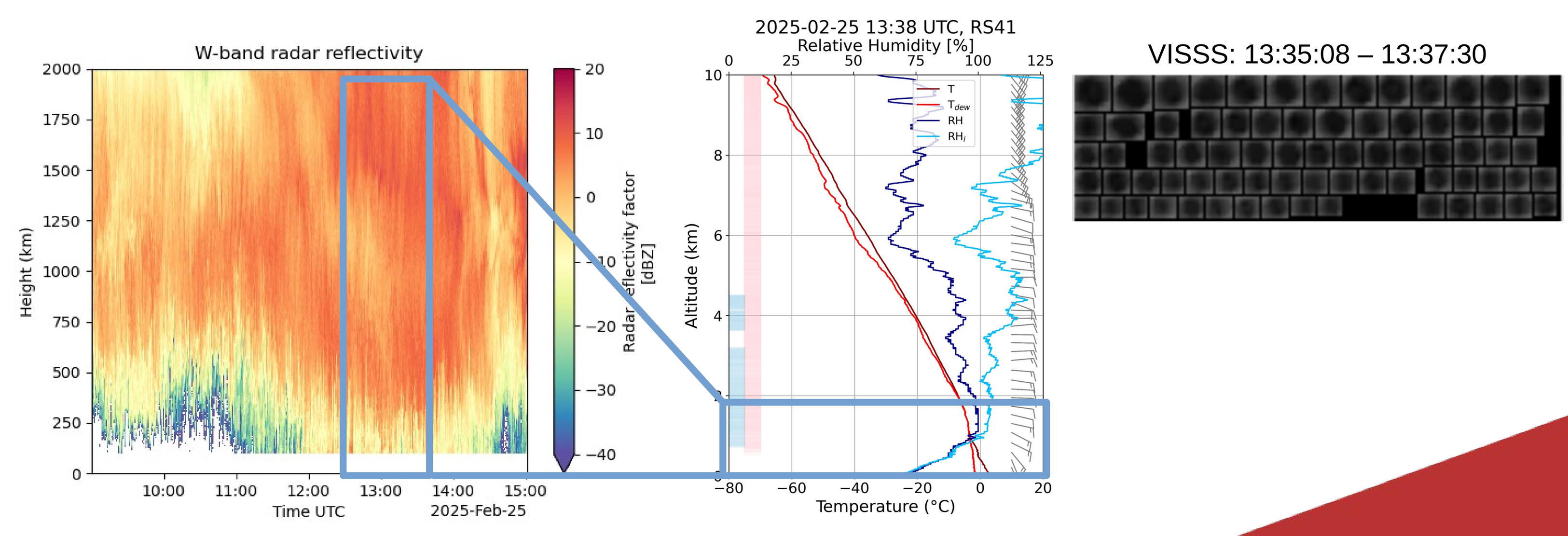

Fig. 5: Measurement example of a sublimation case at AWIPEV in Ny Ålesund on Feb 25, 2025: W-band radar (left), sounding (center) and VISSS (rigth).

Acknowledgement:

This research has been supported by the Deutsche Forschungs-gemeinschaft (DFG, German Research Foundation) – project no. 268020496 – TRR 172, within the Transregional Collaborative Research Center "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms (AC)3".

References:

- Kalesse-Los, H., Kötsche, A., Foth, A., Röttenbacher, J., Vogl, T., and Witthuhn, J.: The Virga-Sniffer – a new tool to identify precipitation evaporation using ground-based remote-sensing observations, Atmos. Meas. Tech., 16, 1683–1704, https://doi.org/10.5194/amt-16-1683-2023, 2023.
- Illingworth, A. J., Hogan, R. J., O'Connor, E. J., Bouniol, D., Brooks, M. E., Delanoé, J., Donovan, D. P., Eastment, J. D., Gaussiat, N., Goddard, J. W. F., Haeffelin, M., Baltink, H. K., Krasnov, O. A., Pelon, J., Piriou, J.-M., Protat, A., Russchenberg, H. W. J., Seifert, A., Tompkins, A. M., van Zadelhoff, G.-J., Vinit, F., Willén, U., Wilson, D. R., and Wrench, C. L.: Cloudnet: Continuous Evaluation of Cloud Profiles in Seven Operational Models Using Ground-Based Observations, B. Am, Meteorol, Soc, 88, 883–898, https://doi.org/10.1175/BAMS-88-6-883, 2007.
- Maahn, M., Burgard, C., Crewell, S., Gorodetskaya, I. V., Kneifel, S., Lhermitte, S., Van Tricht, K., and van Lipzig, N. P. M.: How Does the Spaceborne Radar Blind Zone Affect Derived Surface Snowfall Statistics in Polar Regions?, J. Geophys, Res, Atmos, 119, 13604–13620, https://doi.org/10.1002/2014JD022079, 2014.
- Maahn, M., Moisseev, D., Steinke, I., Maherndl, N., and Shupe, M. D.: Introducing the Video In Situ Snowfall Sensor (VISSS), Atmos. Meas. Tech., 17, 899–919, https://doi.org/10.5194/amt-17-899-2024, 2024.