Atmospheric Rivers over the Arctic with the ICON model

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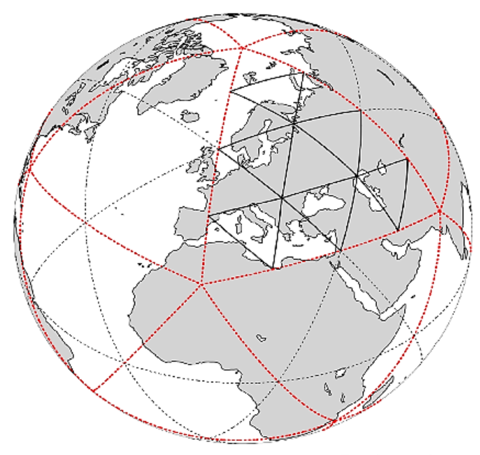
Motivation

- The Arctic warms faster than other regions, but the relative role of the individual feedback mechanisms contributing to the Arctic Amplification is still unclear.
- Aim: Improving the understanding of specific regional atmospheric feedbacks starting with model evaluation of spatiotemporal patterns of selected key processes: moisture intrusions and their particular cases - atmospheric rivers, boundary layer vertical mixing, mixed-phase clouds.
- The high-resolution ICON[1] modelling framework is used with a grid refinement over the Arctic (from 13 km down to 3 km) and first time model assessment of atmospheric river related processes in the Arctic.

ICON-NWP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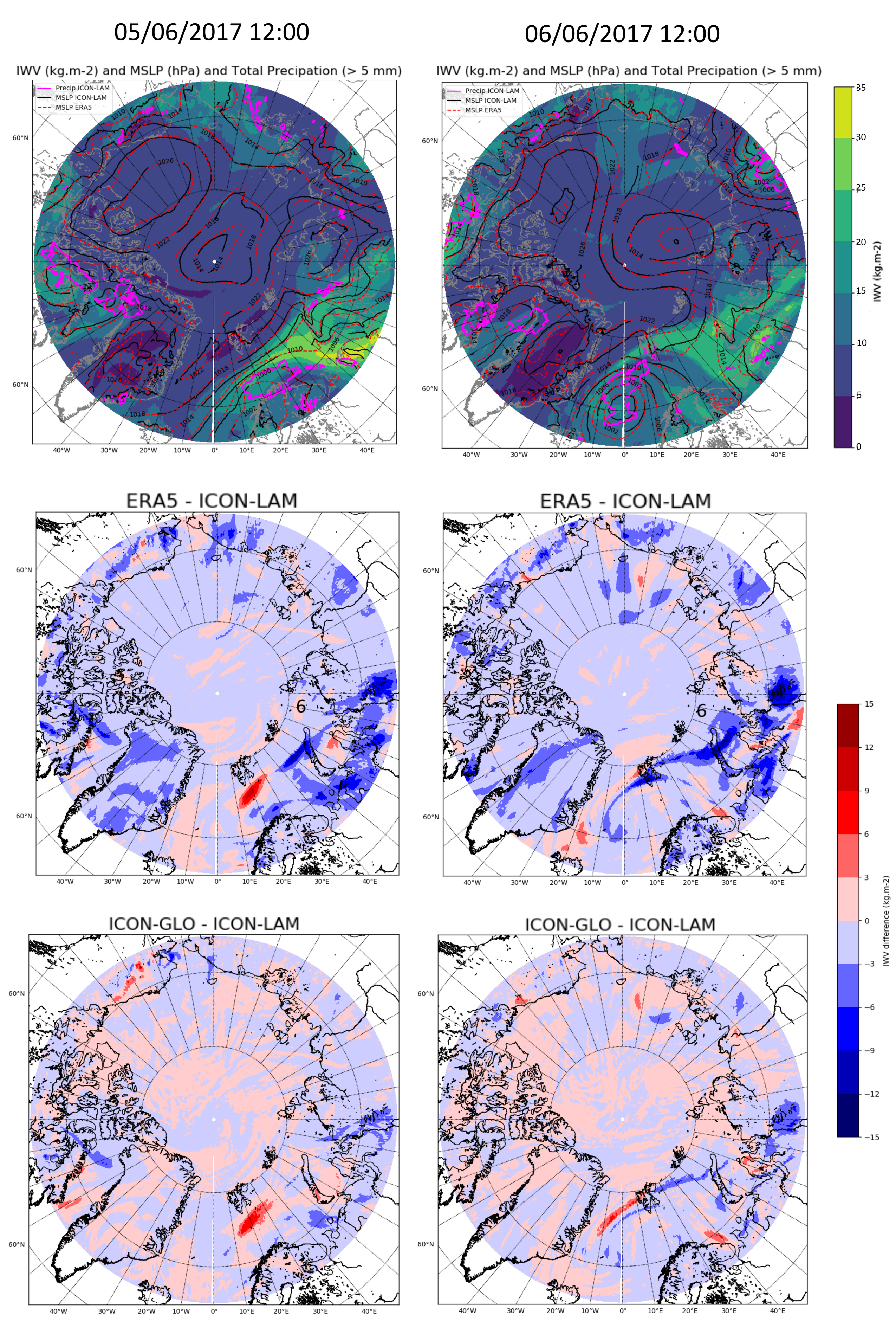
- **ICO**sahedral **N**onhydrostatic model in **N**umerical **W**eather **P**rediction mode.
- Triangular grid: nearly homogeneous coverage of the globe ➡ avoids the so-called "pole problem".
- DWD global forecast runs at 13 km horizontal resolution.
- ICON Limited Area Mode (LAM): Pan Arctic simulations at 6 km resolution (and higher) with sea ice and SST as boundary conditions from the global run.

Atmospheric Rivers (ARs): important moisture intrusions

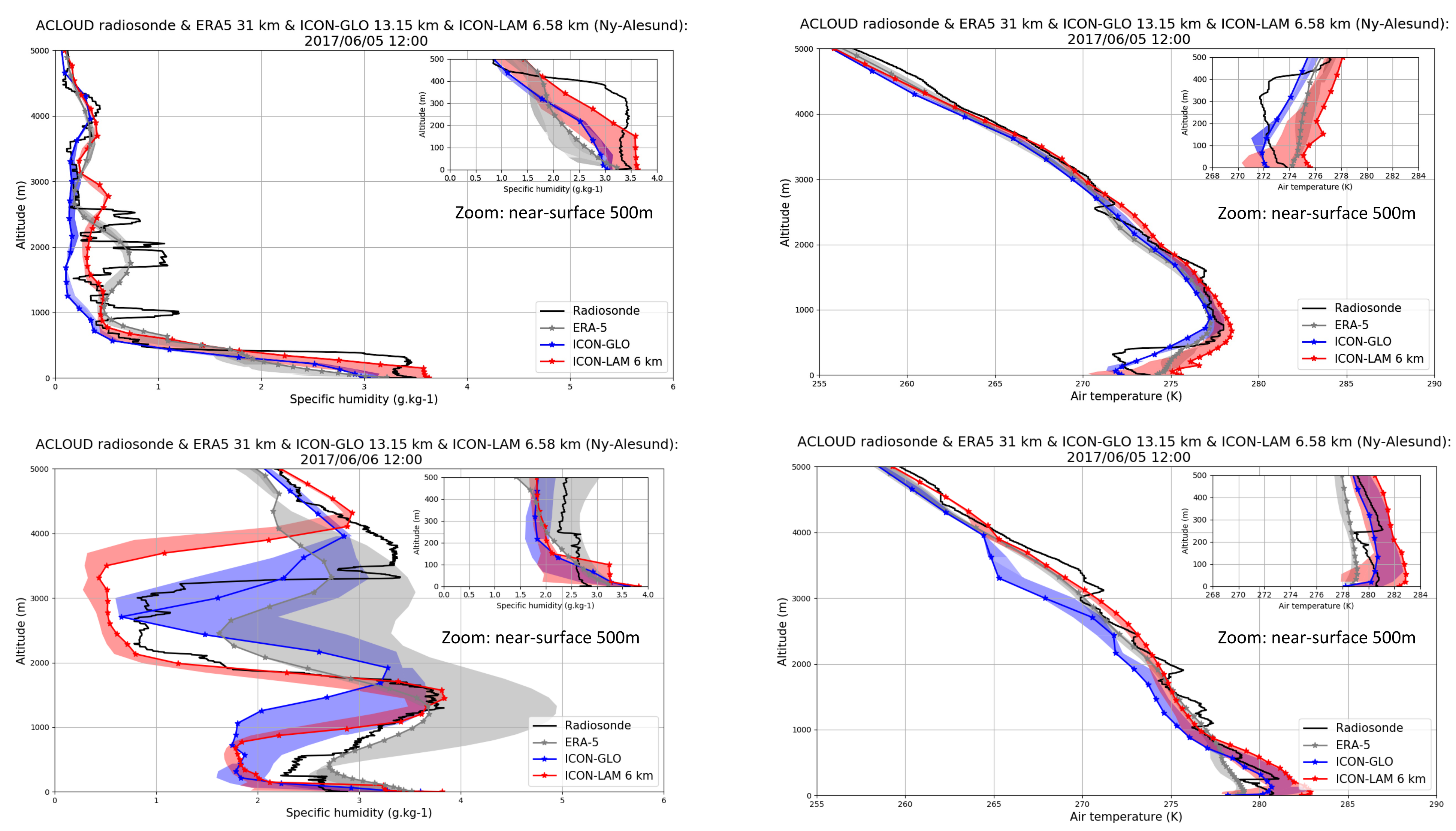
- ARs represent river-like atmospheric moisture transport from lower latitudes. ARs explain 90% of poleward water vapor transport outside of the tropics[2], with important impacts in both polar regions[3,4], yet not well understood.
- How can ICON-LAM represent the spatiotemporal structure of ARs?
- What is the role of ARs for precipitation (both snowfall and rainfall), and what are related impacts on surface and tropospheric warming?

Analysis of an Arctic Atmospheric River: ICON-LAM, ICON-GLOBAL, ERA5 vs Observations

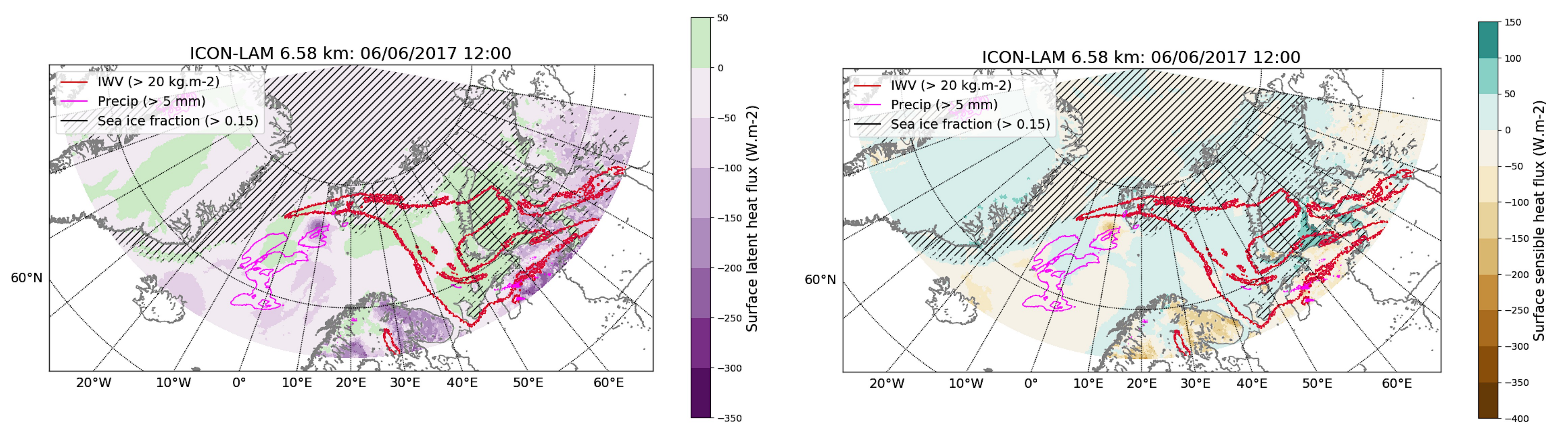
- ICON-GLOBAL: 13.15km res., 3-hourly output, 90 v. levels (top: 75km)
- ICON-LAM: 6.58 res., hourly output, 70 v. levels (top: 23km)
- ERA5[5]: 31km res., hourly output, 137 v. levels (top: 80km)
- Obs: radiosonde & GPS at Ny-Alesund[6] during ACLOUD[7] campaign



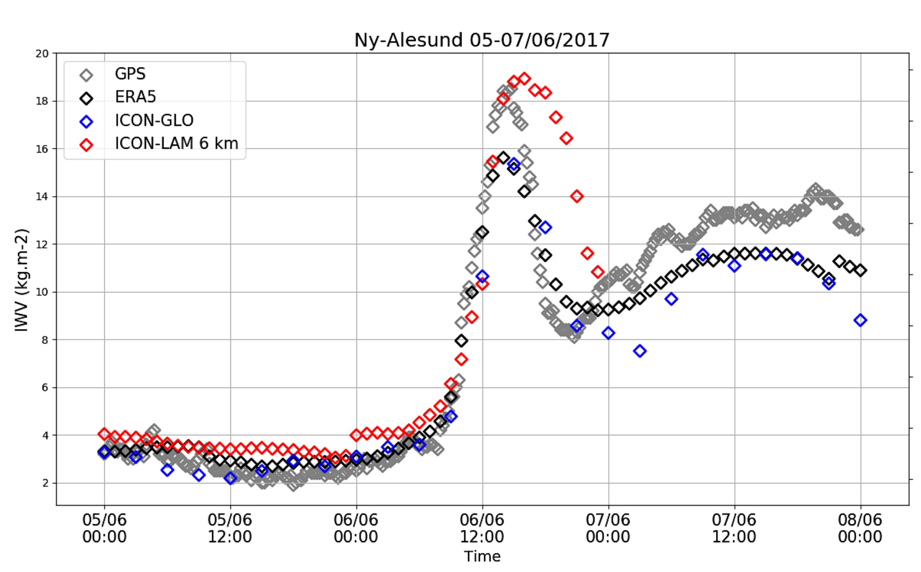
- AR visible from Integrated Water Vapor (IWV) pattern from ICON-LAM.
- Shift of the AR location in ICON-LAM compared to ERA5 and ICON-GLOBAL.



- ICON-LAM humidity profile closer to observations: moisture intrusion in ca. 1500m well captured (lines: Ny-Alesund location, shadings: 4 closest points).
- ICON shows realistic temperature profile with 5K increase from 05/06 to 06/06/17.



- South of AR: latent HF dominates (evapo.) with low pressure & precipitation.
- Within AR: evapo. suppressed and sensible HF towards the surface (warm air over cold surface).



Realistic representation of temporal evolution of IWV in ICON-LAM, ICON-GLOBAL and ERA5.

Outlook

- Continue ongoing AR analysis (IWV, precip, surface fluxes, 3D structure,…).
- Sensitivity of AR to boundary & initial conditions.
- AR case studies with campaign observations (ACLOUD/PASCAL, HALO, MOSAiC).

[1] **Zängl** et al. 2015. *The ICON (ICOsahedral Nonhydrostatic) modelling framework of DWD and MPI-M: Description of the nonhydrostatic dynamical core*. *QJRS*, doi:10.1002/qj.2378.
[2] **Nash** et al. 2018: *The role of atmospheric rivers in extratropical and polar hydroclimate.* Journal of Geophysical Research: Atmospheres, 123, 6804– 6821. https://doi.org/10.1029/2017JD028130
[3] **Neff**, 2018: *Atmospheric rivers melt Greenland.* Nature Clim Change 8, 857–858 (2018). https://doi.org/10.1038/s41558-018-0297-4
[4] **Gorodetskaya** et al. 2014: *The role of atmospheric rivers in anomalous snow accumulation in East Antarctica*,. Geophys. Res. Lett., 41, 6199– 6206, doi:10.1002/2014GL060881.
[5] **Copernicus Climate Change Service** (C3S) (2017): *ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate*. Copernicus Climate Change Service Climate Data Store (CDS), *date of access*. https://cds.climate.copernicus.eu/cdsapp#!/home
[6] **Maturilli** et al. 2017: *High resolution radiosonde measurements from station Ny-Alesund (2017-06)* [data set]. PANGAEA, doi: 10.1594/PANGAEA.879822
[7] **Wendisch** et al. 2019: *The Arctic Cloud Puzzle: Using ACLOUD/PASCAL Multi-Platform Observations to Unravel the Role of Clouds and Aerosol Particles in Arctic Amplification*, BAMS, doi:10.1175/BAMS-D-18-0072.1.

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REKLIM Helmholtz-Verbund Regionale Klimaänderungen | MOSAiC International Arctic Drift Expedition | ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG | HELMHOLTZ GEMEINSCHAFT