Atmospheric Rivers over the Arctic with the ICON model

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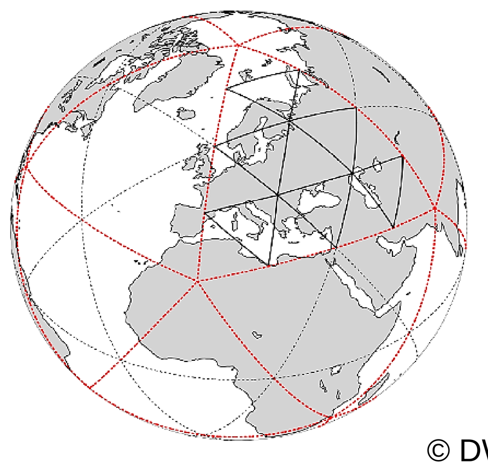
Motivation

- The Arctic temperatures warm faster than the ones of other regions, but the relative role of the individual feedback mechanisms contributing to 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, vertical mixing in the boundary layer, mixed-phase clouds).
- The high-resolution ICON[1] modelling framework is used with a grid refinement over the Arctic region (from 13 km down to ca. 2 km) and first time model assessment of atmospheric river related processes in the Arctic.



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ICON-NWP

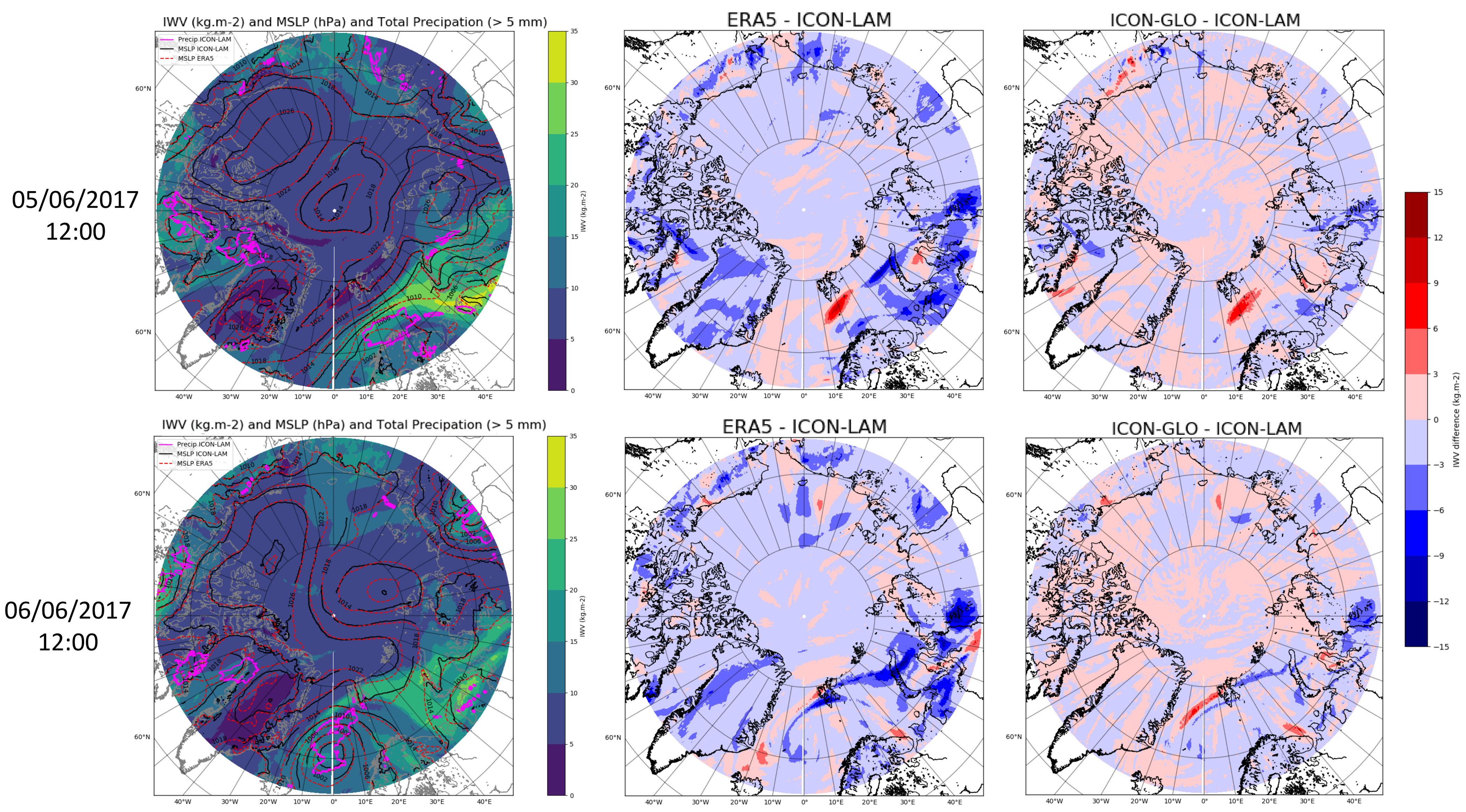
- **ICO**sahedral **N**onhydrostatic model in **N**umerical **W**eather **P**rediction mode
- Triangular grid: nearly homogeneous coverage of the globe ➡ avoids the so-called "pole problem"
- DWD global forecast runs at 13 km horizontal resolution.
- ICON Limited Area Mode (LAM): Pan Arctic simulations at 7 km resolution (and higher) with sea ice and SST as boundary conditions from the global run.

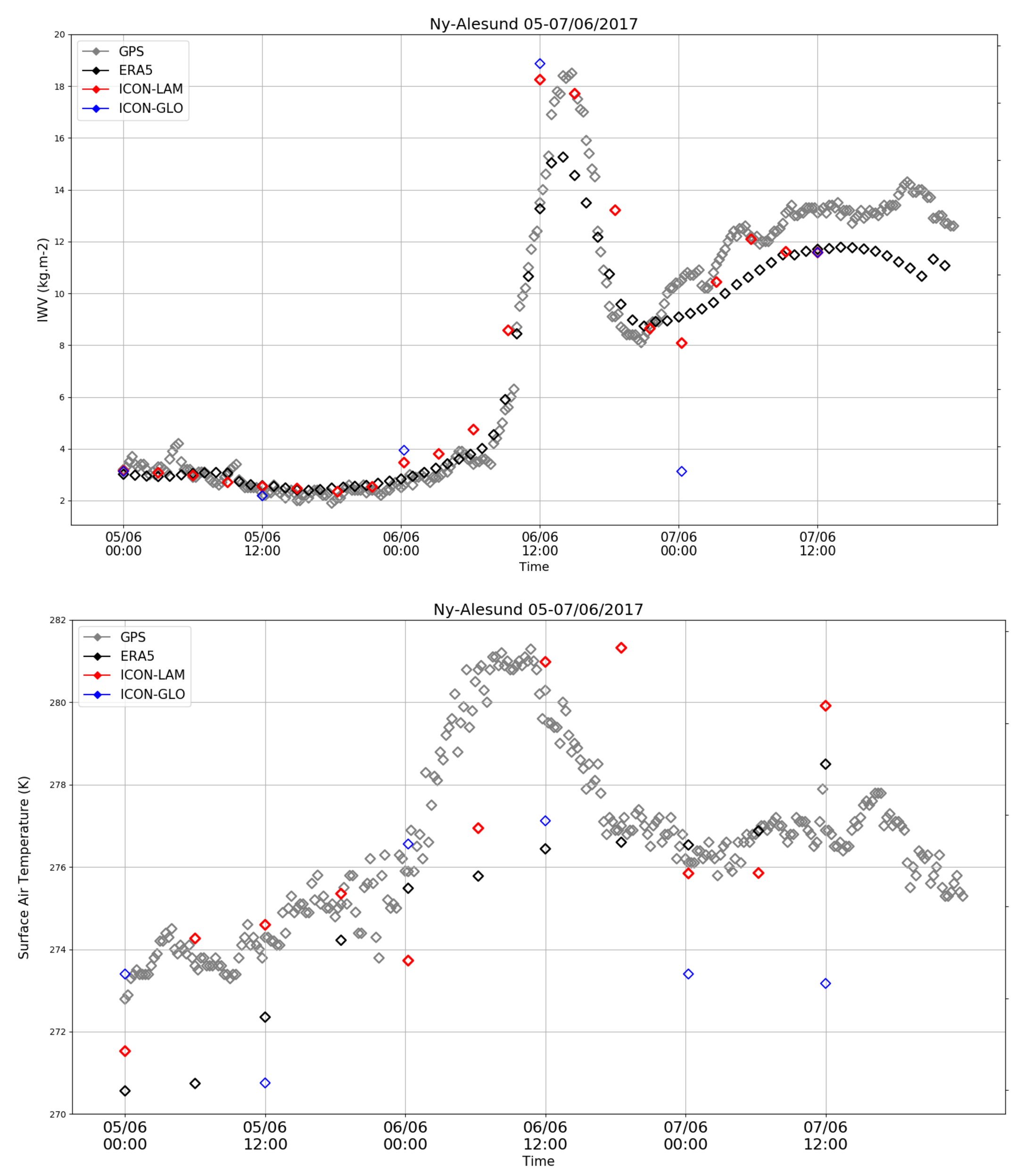
Atmospheric Rivers (ARs): important moisture intrusions

- ARs are river-style moisture flows from sub-polar regions. ARs explains 90% of poleward water vapor transport outside of the tropics[2], yet not well understood.
- How can ICON-LAM represent the spatiotemporal structure of ARs?
- What is the role of atmospheric rivers for precipitation and snowfall, and what are related impacts on surface and tropospheric warming?

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

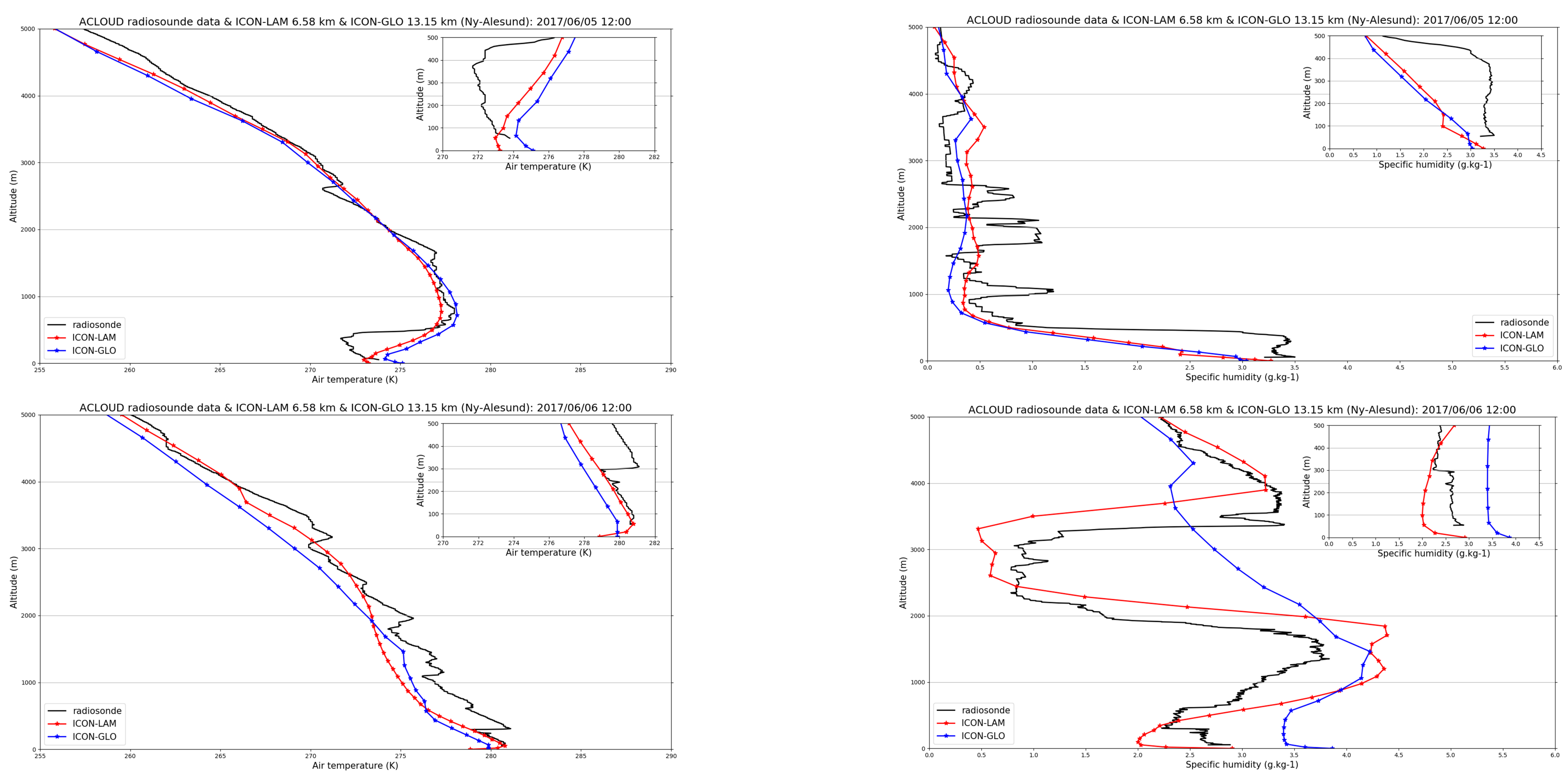
- ICON-GLOBAL: 13.15km reso., hourly output, 90 v. levels (top: 75km)
- ICON-LAM: 6.58km reso., hourly output, 70 v. levels (top: 23km)
- ERA5: 31km reso., hourly output, 137 v. levels (top: 80km)
- Obs: radiosonde & GPS at Ny-Alesund[3] during ACLOUD[4] campaign





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

- Realistic representation of temporal evolution of IWV in ICON-LAM and ICON-GLOBAL.
- Temperature evolution not fully represented in ERA5 and ICON-GLOBAL; 6h lag for temp. max. in ICON-LAM.



- ICON shows realistic temperature profile (but no elevated inversion) with 5 K temperature increase on 06/06/17.
- ICON-LAM humidity profile closer to obs.: moisture intrusion relatively well captured.

Outlook

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

References:
[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] **Shields** et al., 2018: *Atmospheric River Tracking Method Intercomparison Project (ARTMIP): project goals and experimental design*. GMD, doi:10.5194/gmd-11-2455-2018.
[3] **Maturilli** et al. 2017: *Arctic warming, moisture increase and circulation changes observed in the Ny-Ålesund homogenized radiosonde record*. TAC, doi:10.1007/s00704-016-1864-0.
[4] **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