A performance baseline for the representation of clouds and humidity in cloud-resolving ICON-LEM simulations in the Arctic

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1. Motivation & Objectives

The ICON model is being used more and more to study the changing climate of the Arctic. This complements observations which are difficult to obtain in this region. Originally though, ICON has been tuned for the mid-latitudes which differ in many ways from the high North. Additionally, there is a great interest in clouds as these still cause high uncertainties in future climate projections. Therefore, we have two main objectives:

1. Understand how well the ICON model can capture the atmospheric dynamics in the Arctic.
2. Focus on the model performance regarding clouds and humidity.

2. Data & Methods

Large Eddy Model (ICON-LEM):

- Simulation work-flow consisting of two simulations per day (see schematic)
- ICOsahedral Non-hydrostatic model (ICON)
- 5 Months of simulations (Aug. to Dec. 2020)
- Two-moment microphysics
- No convection parameterization
- Heterogeneous surfaces

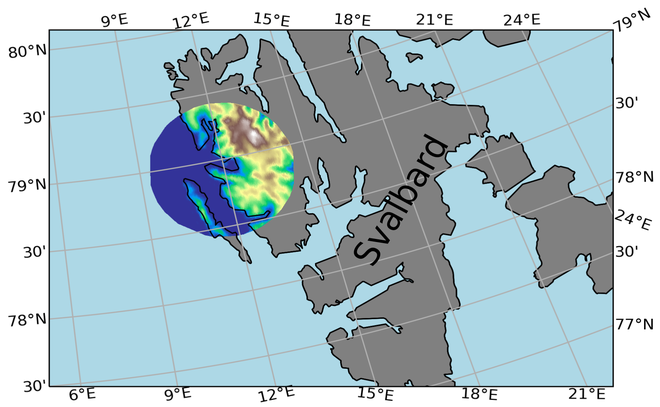
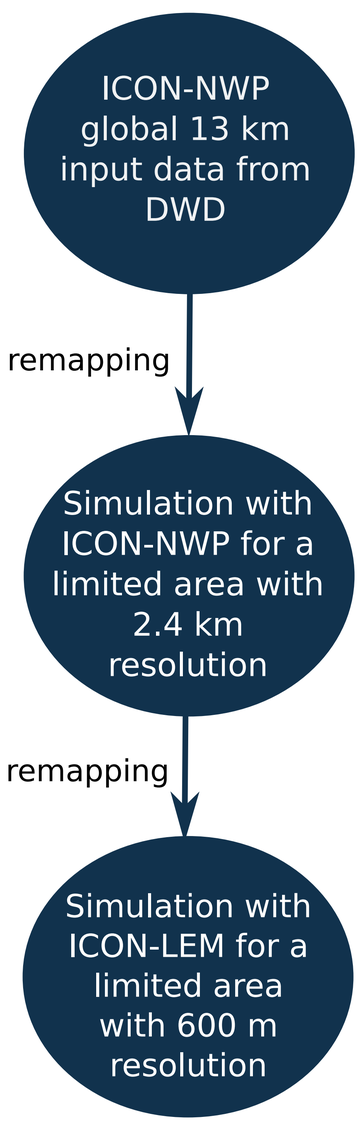


Fig. 1: Simulation domain used in ICON-LEM.



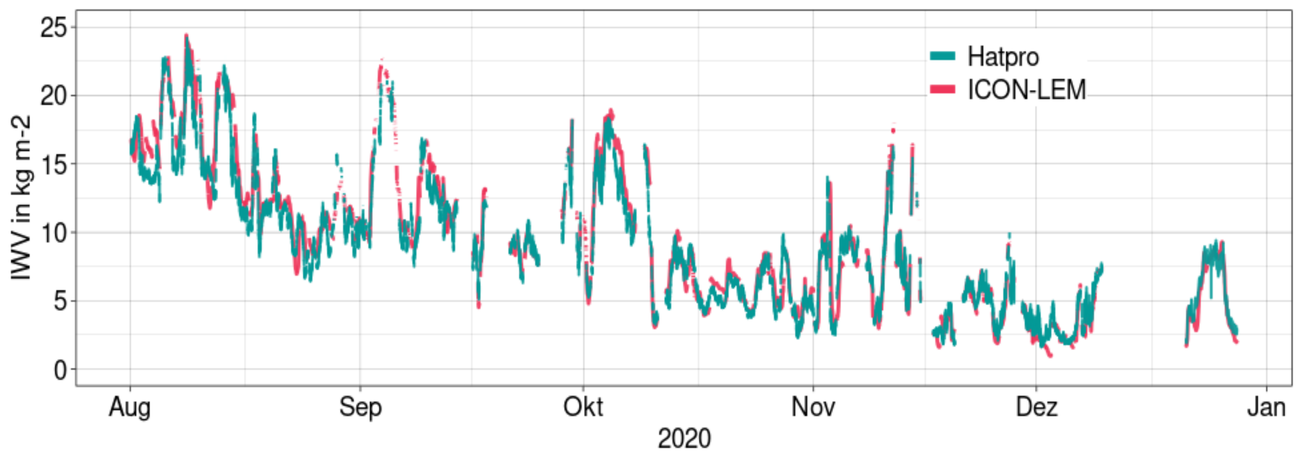
Observation Data:

- Supersite "AWIPEV" in Ny-Ålesund
- Radiosondes once a day
- Rain gauge
- IWV, LWP: Microwave radiometer (HATPRO)
- Cloudnet classification data for hydrometeors

3.1 Integrated water vapour (IWV)

- Very small bias (0.21 kg m^{-2}) in ICON-LEM compared to HATPRO
- Clear decrease of IWV towards winter (Fig. 2)
- Slightly higher IWV for clear sky cases measured by HATPRO

Fig. 2: IWV from HATPRO and ICON-LEM for the analysed period.

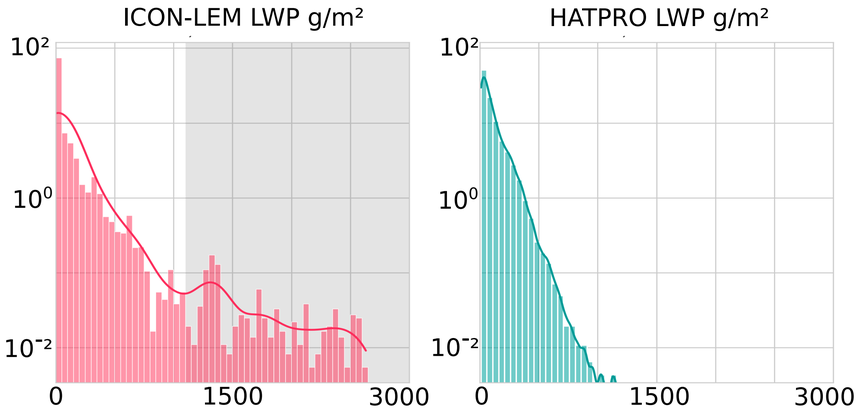


3.2 Liquid water path (LWP)

- ~30% less pure liquid and mixed-phase clouds than observed
- LWP in ICON-LEM shows larger positive skewness (Fig. 3)
- Cloud occurrence in ICON-LEM 8 % higher than observed

Limitation: No HATPRO LWP measurements during precipitation events.

Fig. 3: Occurence of LWP for ICON-LEM and HATPRO. The grey shaded area marks values with higher uncertainties.



4. Summary & Outlook

- Analysis of several months of high-resolution simulations
- Good agreement of large scale variables and wind flow (not shown)
- Too many pure ice clouds in ICON-LEM -> too efficient ice production
- Too high cloud occurrence in ICON-LEM
- Insights into local scale variability of humidity show stark difference between fjord and land (not shown)

Next steps: Using aquired knowledge to evaluate cloud microphysical processes in greater depth. Creating an overview of which microphysical processes of 2-mom. scheme are most important for mixed-phase clouds.