Investigating the representation of clouds and humidity in high-resolution simulations in the Arctic using ICON-LEM

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Key points

- 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 in the model
- Too high cloud occurrence in ICON-LEM
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- Insights into local scale variability of humidity show stark difference between fjord and land.

1. Motivation & Objectives

Atmospheric models can be used to study the changing climate of the Arctic. They complement observations and are used to understand atmospheric processes. Many processes related to clouds, though, have not fully been explained yet and are difficult to simulate[1].The main objectives therefore are:

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.

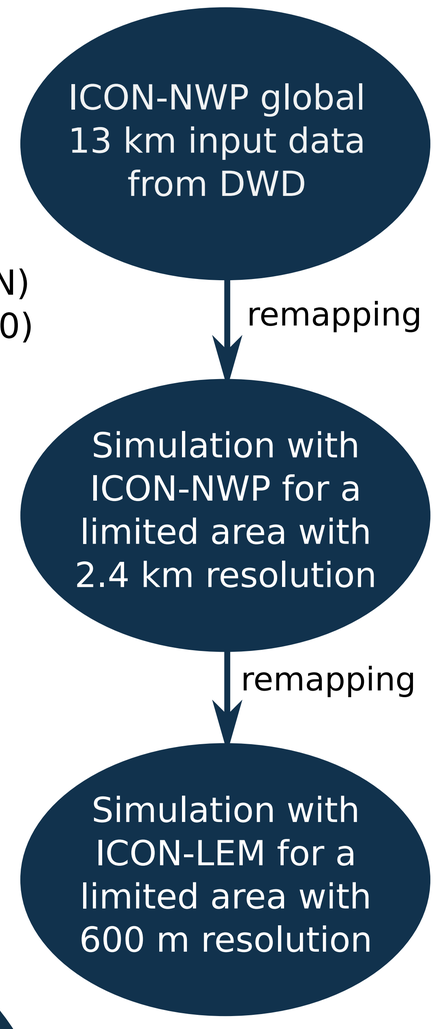
2. Data & Methods

Large Eddy Model (ICON-LEM):

- Simulation work-flow consisting of two simulations per day (see schematic)
- ICOsahedral Non-hydrostatic model (ICON)
- 5 Months of simulation (Aug. to Dec. 2020)
- Two-moment microphysics
- No convection parameterization
- Heterogeneous surfaces
- 3D turbulence scheme

Observation Data:

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



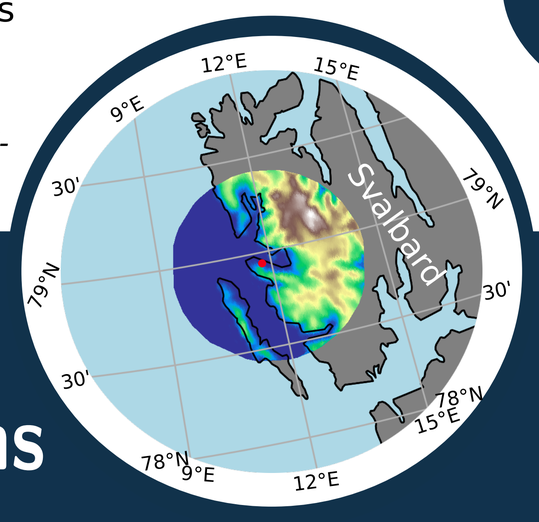
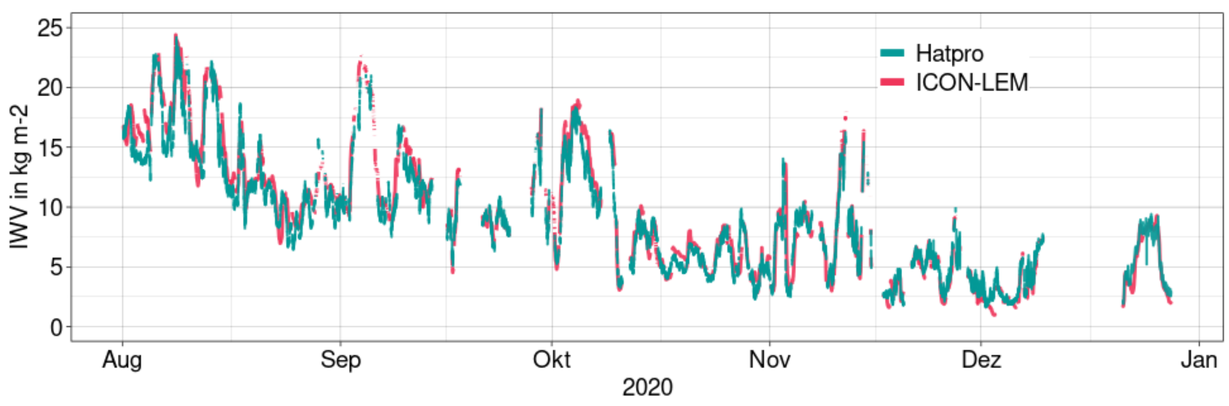


Fig. 1: Simulation domain used in ICON-LEM. Red dot is Ny-Ålesund location.

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 analysed period.



3.2 Liquid water path (LWP)

Limitations: No reliable HATPRO LWP measurements during precipitation events.

- ~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

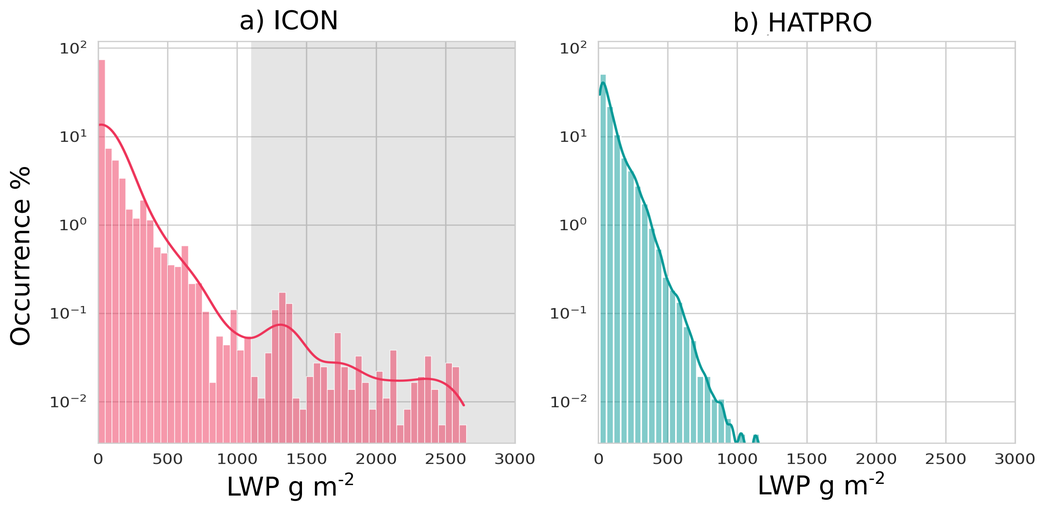


Fig. 3: Occurence of LWP for ICON-LEM and HATPRO. Values with larger uncertainties shaded grey.

3.3 Local humidity variability

- Comparison of relative humidity below 1 km using radiosondes
- Two modes in radiosonde distribution of rel. humidity (Fig. 4)

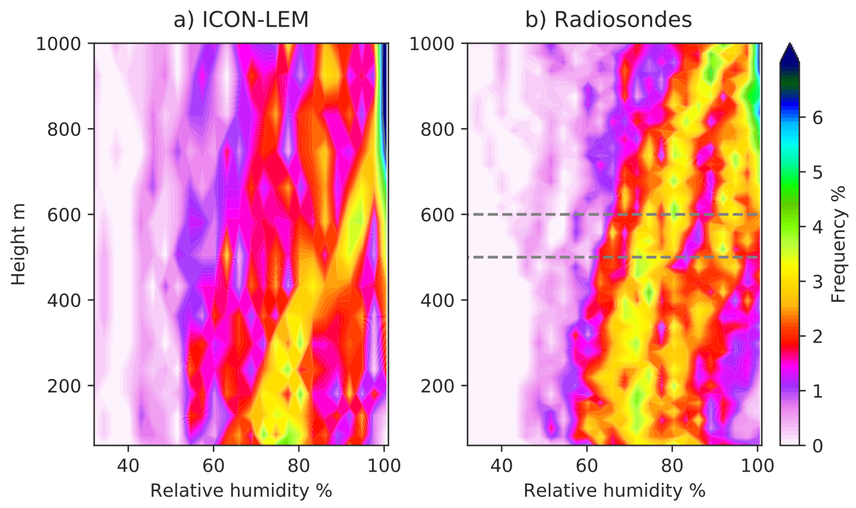
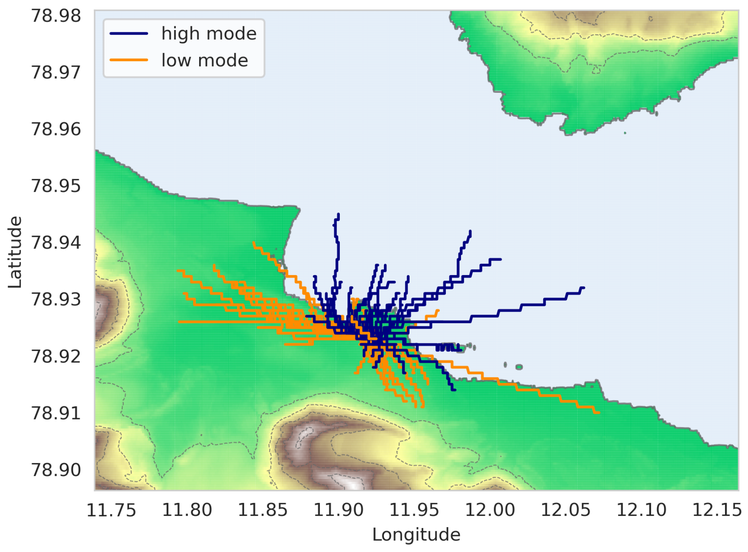


Fig. 4: Occurence of relative humidity with height from a) ICON-LEM and b) radiosondes. Dashed lines at 500 and 600 m.



- Two sets of drifting tracks were found: 1. over land, 2. over the fjord which coincide with drier (land) and moister air (fjord).

Fig. 5: Radiosonde drifting track sets over land (orange) and the fjord (blue).

- Distinction of sets based on mean relative humidity between 500 and 600 m (Fig.6)

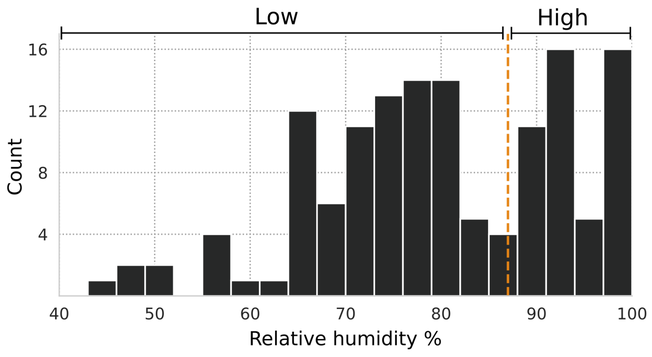


Fig. 6: Distribution of mean relative humidity between 500 and 600m taken form radiosondes.

REFERENCES
1: Kay et al. (2016), Recent Advances in Arctic Cloud and Climate Research
Kiszler et al. (submitted), A performance baseline for the representation of clouds and humidity in cloud-resolving ICON-LEM simulations in the Arctic, JAMES