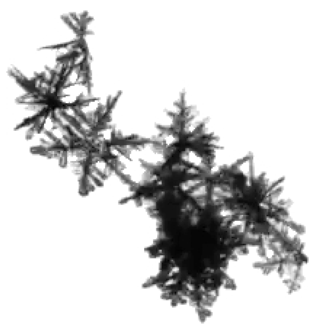
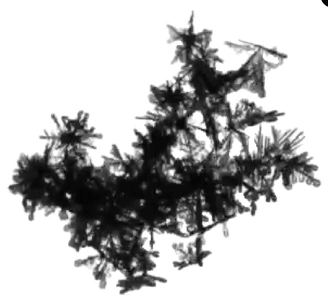
Karlsruhe Institute of Technology

Institute of Meteorology and Climate Research (IMKTRO)
Troposphere Research

Secondary Ice Production in the ICON model: Case study



Julian Meusel[1], Corinna Hoose[1], Nils Pfeifer[2], Maximilian Maahn[2]
[1] Karlsruhe Institute of Technology, [2] Leipzig University
Correspondence: Julian Meusel – julian.meusel@kit.edu



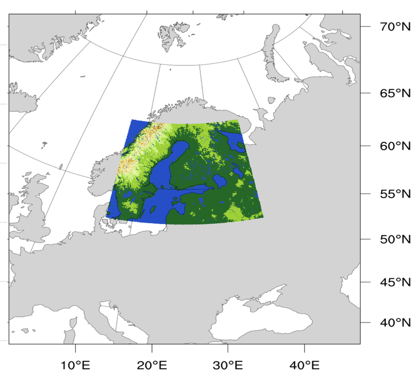
Motivation

Due to the limited understanding of the **interaction** between ice crystals, liquid water, cloud dynamics, and aerosols during precipitation formation, there are significant **uncertainties** in representing microphysical processes, such as **riming and aggregation**, in numerical model simulations.

- To tackle these uncertainties, the ICON model is set-up in a limited area mode on a domain centered around the forestry field station of Hyytiälä
- Observations from both the cloud and precipitation radar, along with the VISSS, are utilized to evaluate the model

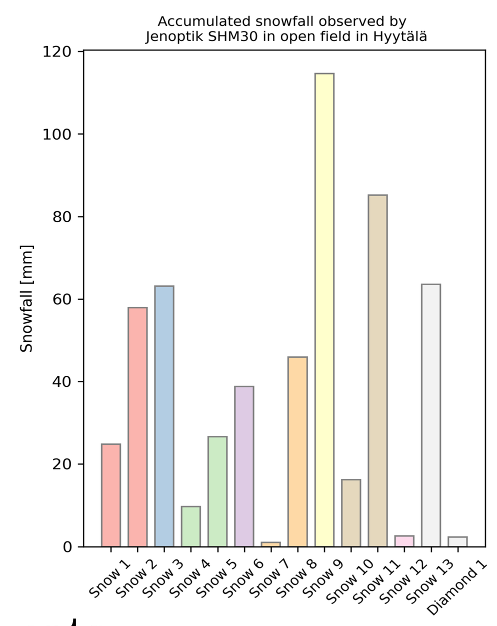
Simulation Setup

Model version	ICON 2024.10 [1]
Horizontal Grid	2 km grid resolution and 450 096 cells
Vertical levels	65, 13 half levels in the lowest 1000m, lowest full level at 10m a.g.l.
Initial & boundary data	ICON-EU analyses, 3 h update
Time step	12 s
Initialization time	16.02.2024 00:00 UTC
Integration time	48 h
Microphysics	2-Moment microphysics [2]

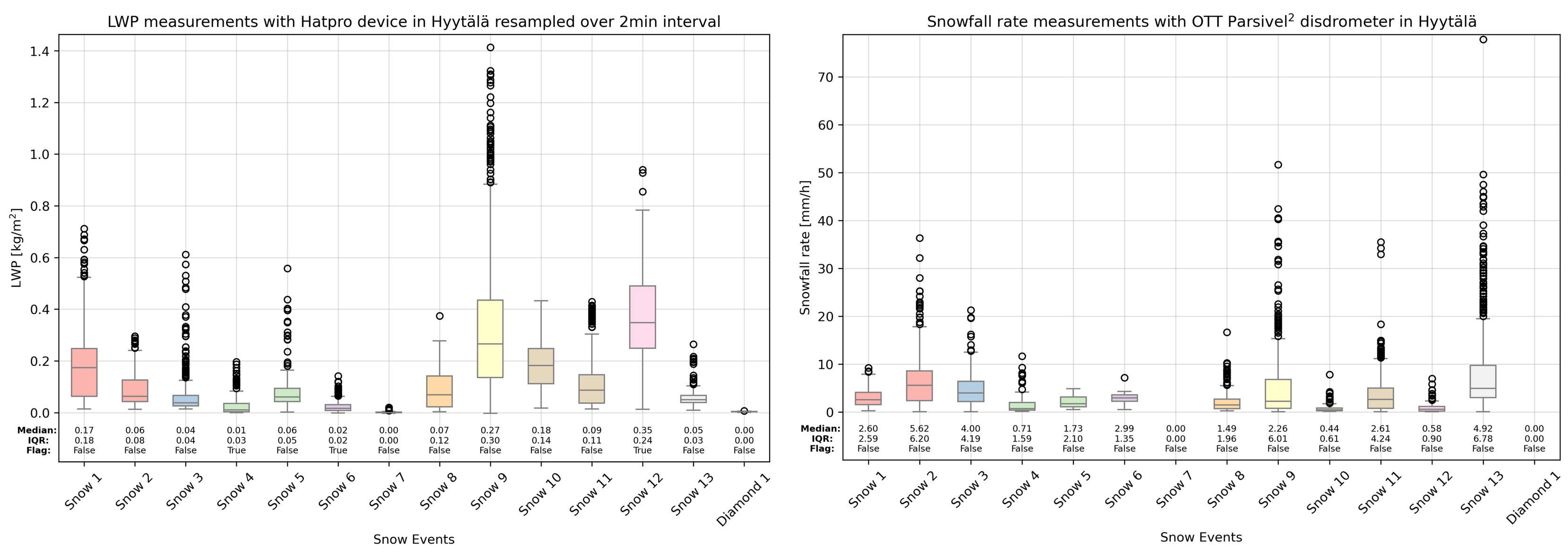


IOP Hyytiälä

- 5 weeks field campaign @Hyytiälä forestry field station in Finland
- We have launched 10 heated and 27 unheated Graw DFM-17 radiosondes during snowfall events
- Snowfall events for different synoptic situations
  - ➢ Warm and cold fronts, cyclone and diamond dust
  - ➢ Light snow to heavy snowfall
- Beautiful dendrites to heavily rimed particles

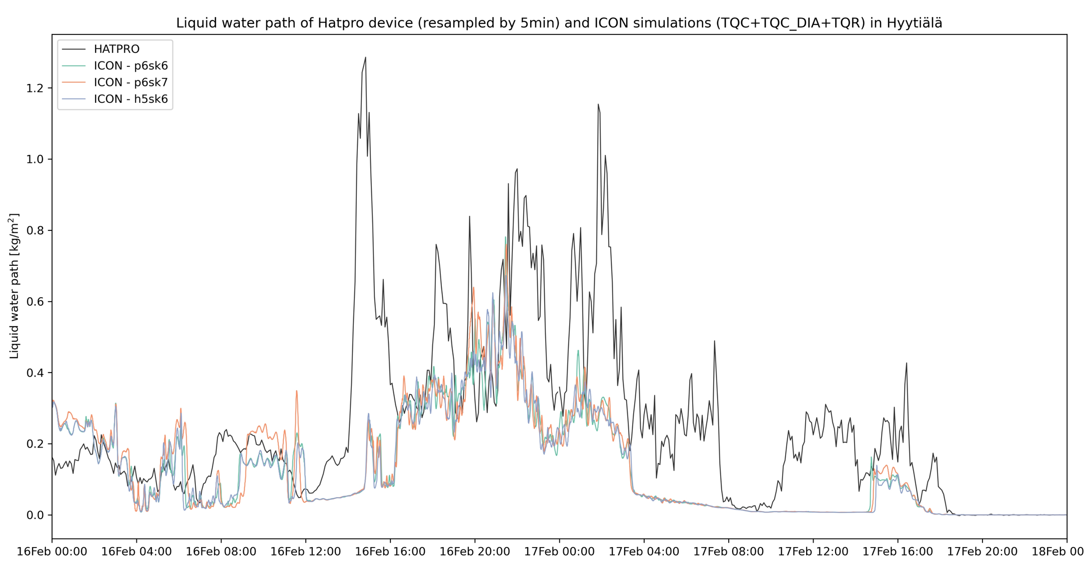


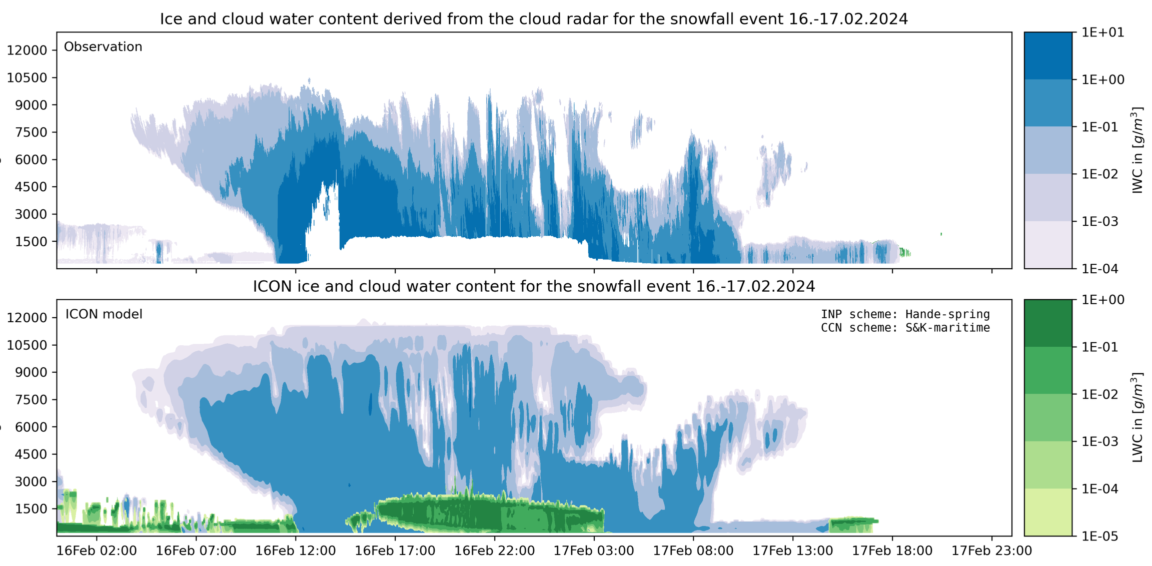
Summary of the observed snowfall events

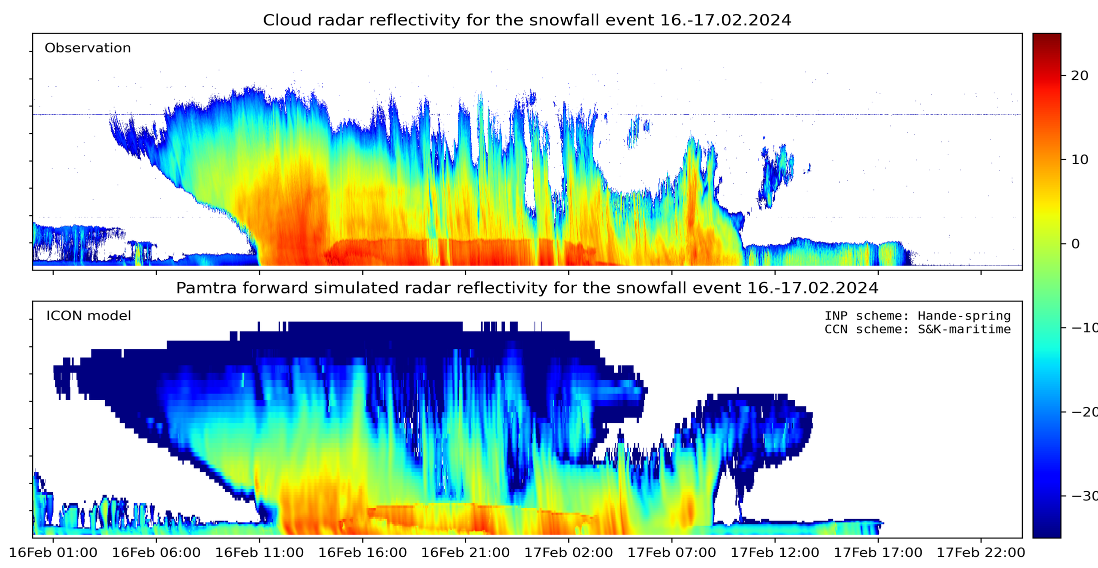


Case study: 16.02.24

Comparison of LWC from Hatpro observations, IWC and LWC retrievals and cloud radar observations

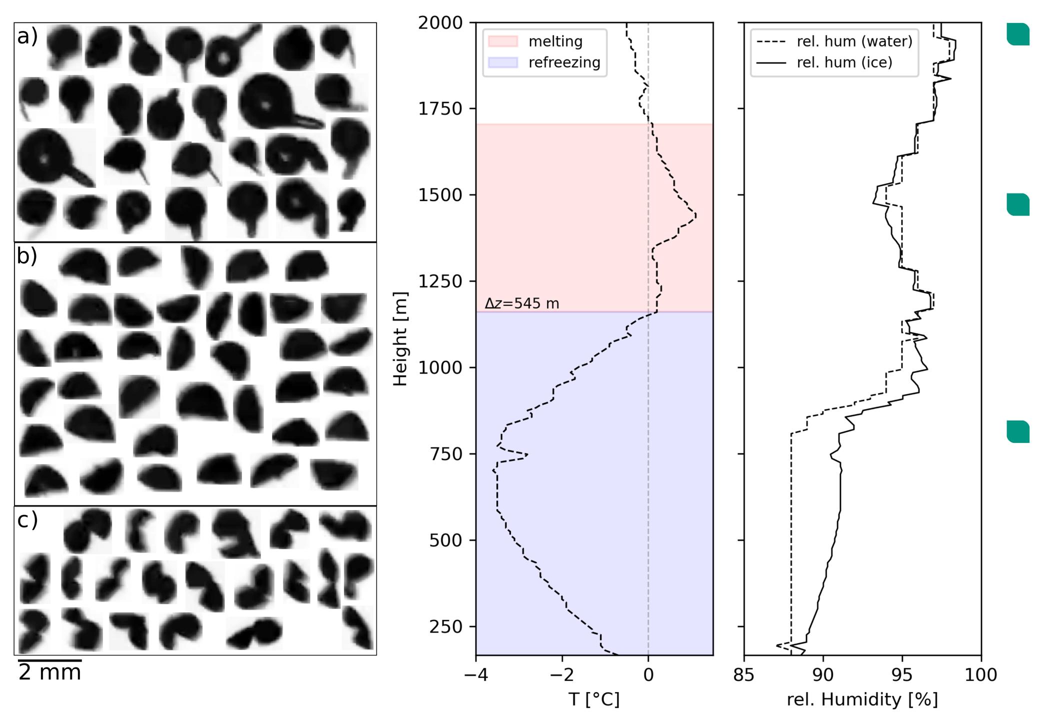




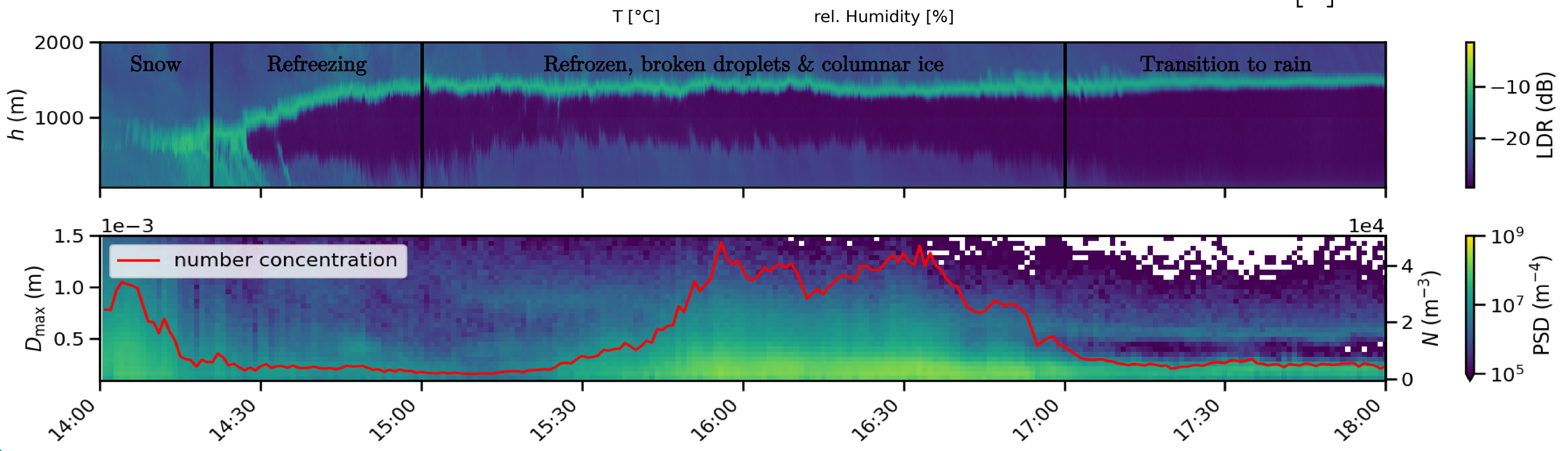


- ICON underestimates LWC, but there is high uncertainty in the LWP of the Hatpro device due to rain.
- The cloud structure is well simulated. However, ICON underestimates the IWC. Due to errors in the LWC retrieval, a comparison is not possible.
- ICON underestimates high radar reflectivity during both snowfall and rainfall.

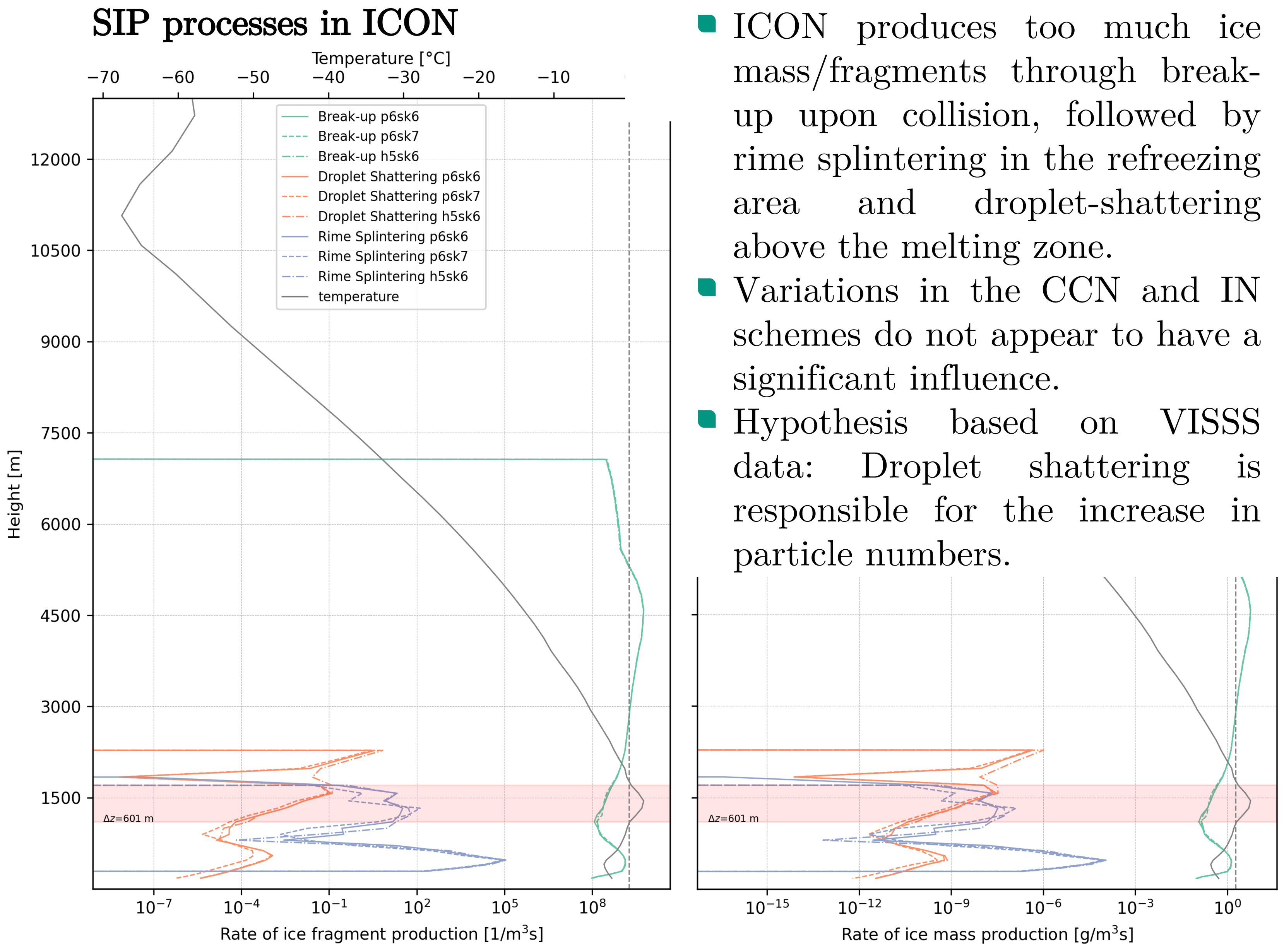
Droplet-shattering process in VISSS data



- VISSS [5] captures droplet freezing and shattering (a,b,c).
- The melting & freezing areas are very well captured with the radio sounding at 16:18 UTC.
- The bright band, melting and freezing areas can be clearly seen in the LDR measurements of the cloud radar [3].



SIP processes in ICON



- ICON produces too much ice mass/fragments through break-up upon collision, followed by rime splintering in the refreezing area and droplet-shattering above the melting zone.
- Variations in the CCN and IN schemes do not appear to have a significant influence.
- Hypothesis based on VISSS data: Droplet shattering is responsible for the increase in particle numbers.

Future work: Choose a reference IN/CCN-scheme & perform more sensitivity tests by scaling; Further investigation of the ice processes and SIP rates, add missing ones; More post-processing (with emvorado & Pamtra); LDR analysis; ICON simulations with P3-scheme

References: [1] https://www.icon-model.org/ [2] Seifert, Beheng, 2006 [3] https://cloudnet.fmi.fi/ [4] https://pamtra.readthedocs.io [5] Maahn et al., 2023

Abbreviations: SIP=Secondary Ice Process; LWC=Liquid Water Path, IWC=Ice Water Path; CCN=Cloud Condensation Nuclei; IN=Ice Nuclei; LDR=Linear Depolarisation Ration

Universität Leipzig
Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation