UNIVERSITÄT LEIPZIG

PrePEP 2025

Ground-Based Observations of Secondary Ice Production: A Case Study Showing Droplet Fragmentation during Refreezing Rain

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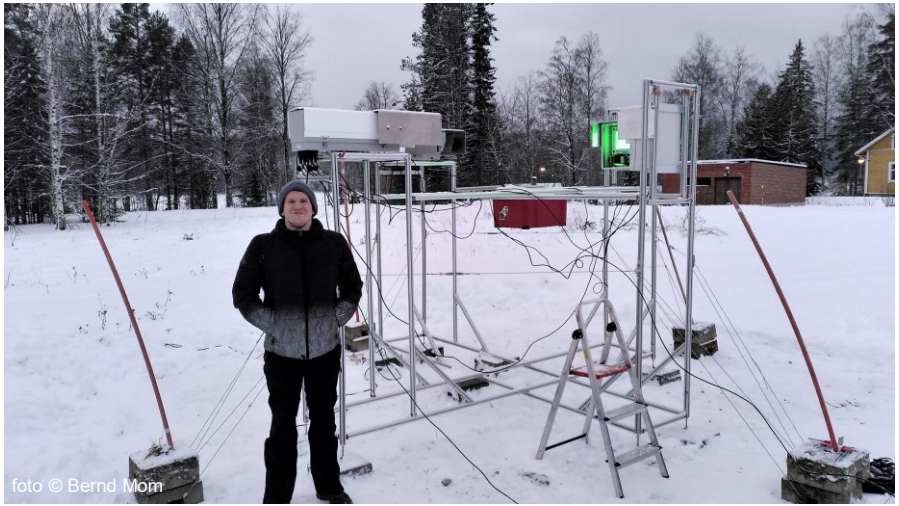
CAMPAIGN – EVALUATING MICROPHYSICAL PATHWAYS OF MIDLATITUDE SNOW FORMATION



Purpose: Integrated field work involving in situ measurements, remote sensing, and modeling

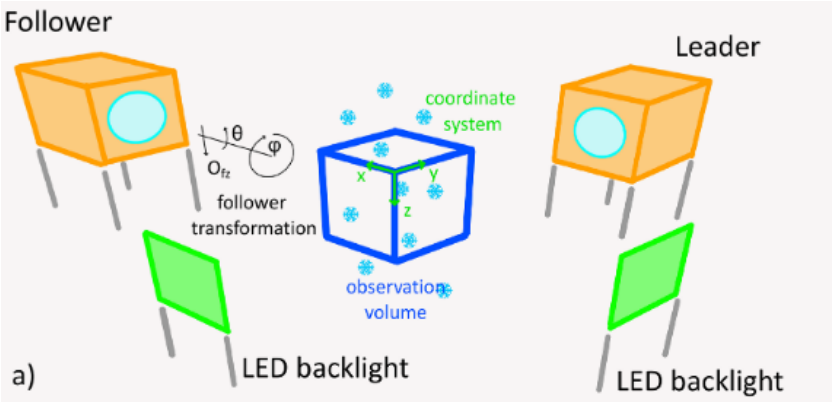
- 5 weeks fieldwork in Hyytiälä, Finland, Jan – March 2024
- 13 snowfall events

Goal: Quantitative comparison of model outputs and observations

Mesaurement Devices:

- Video In Situ Snowfall Sensor (VISSS)
- 94 Ghz vertically pointing cloud radar
- GRAW DFM 17 radiosondes

CAMPAIGN – DEVICE: VISSS



	VISSS3
Pixel resolution [µm px^{-1}]	46.0*
Obs. volume ($w \times d \times h$) [mm]	$47.1 \times 47.1 \times 58.9$
Frame size used [px]	1024×1280
Frame rate [Hz]	220
Effective exposure time [µs]	60
Working distance [mm]	1300

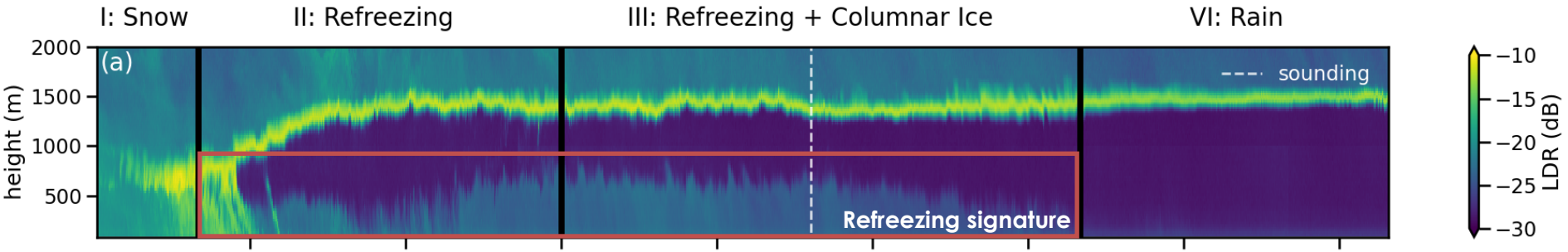
Maahn et al., 2024, Introducing the Video In Situ Snowfall Sensor (VISSS)

- **2** high resolution images
- Constrained sampling volume
- Open-source design

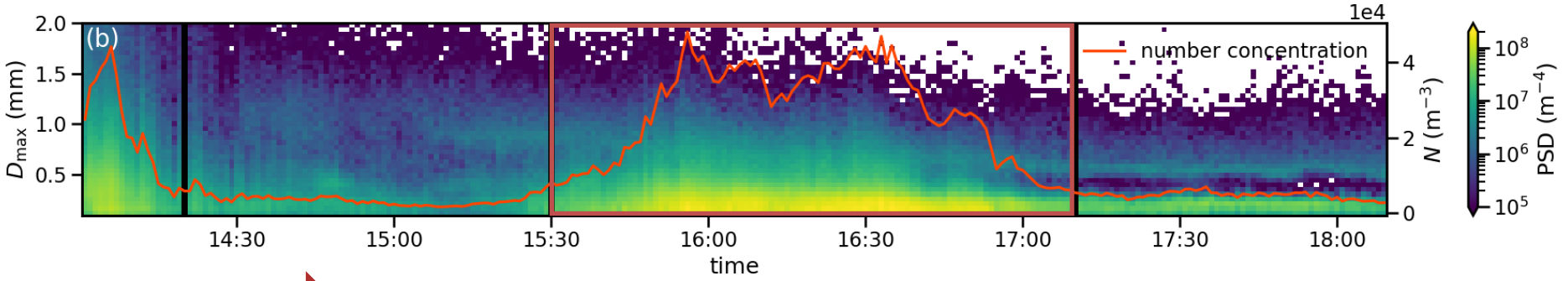
Goal: Retrieving process parameters from VISSS data, like secondary ice processes

CASE STUDY – REFREEZING EVENT 16.02.2024

94 GhZ vertically pointing cloud radar:



VISSS:

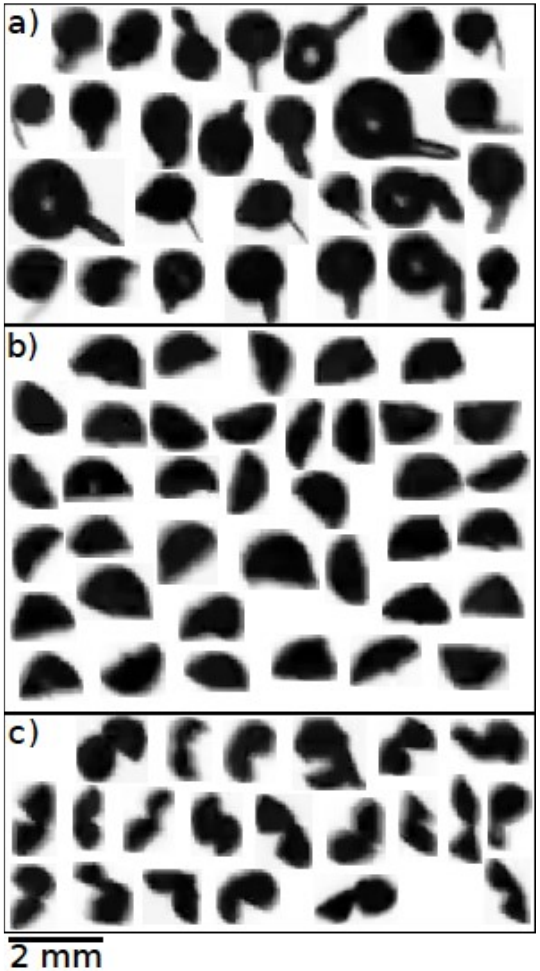


Secondary ice production by droplet fragmentation?

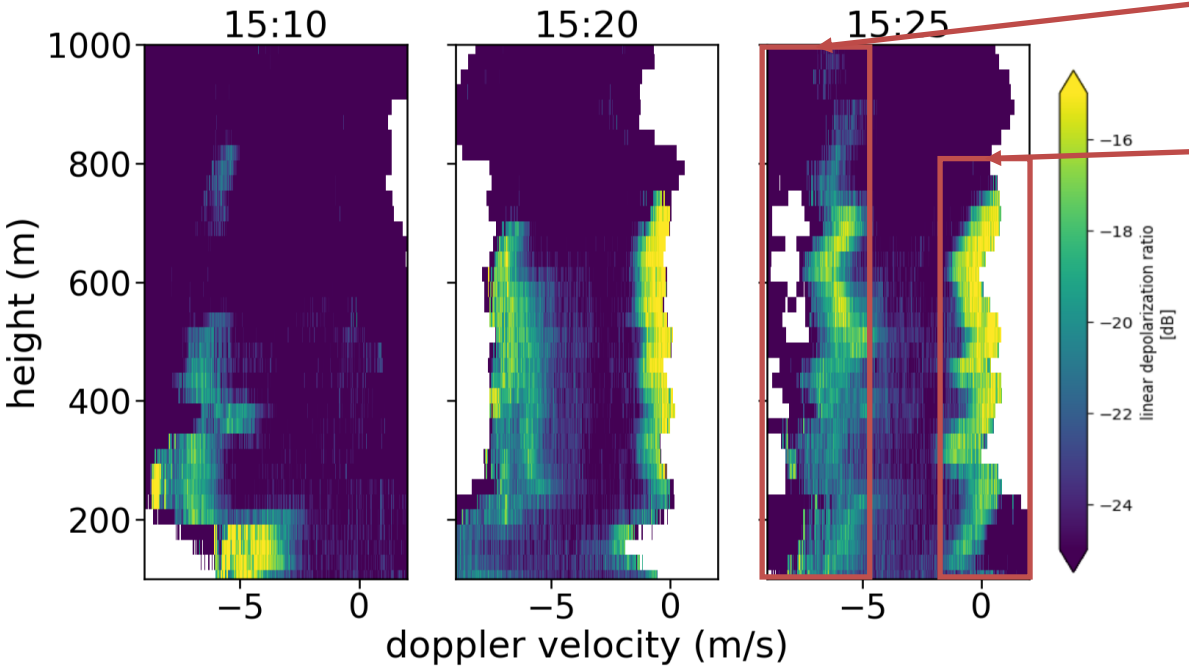
CASE STUDY – DEFORMATIONS

Modes of droplet shattering:

a) Spicular bubble burst
b) Breakup
c) Incomplete breakup



CASE STUDY – ORIGIN OF COLUMNAR ICE



Ice pellets (bulged or broken)

Columnar Ice

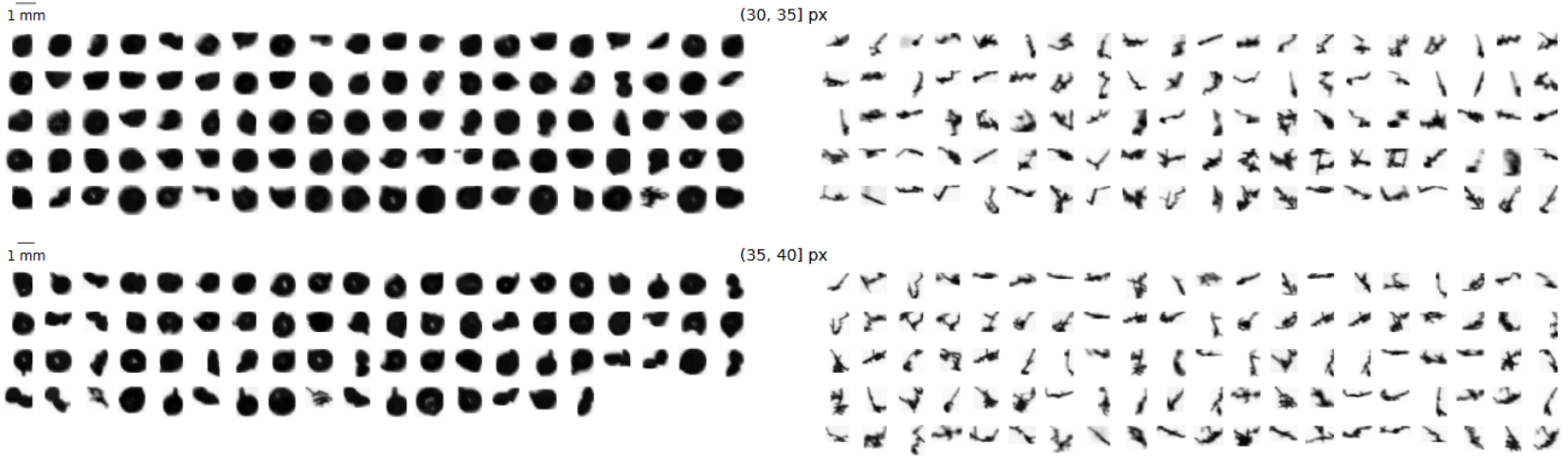
- 2nd slow particle mode at 800m
- Between 15:10 and 17:00, together with explosion in concetration

Secondary ice production during droplet refreezing

CLASSIFICATION

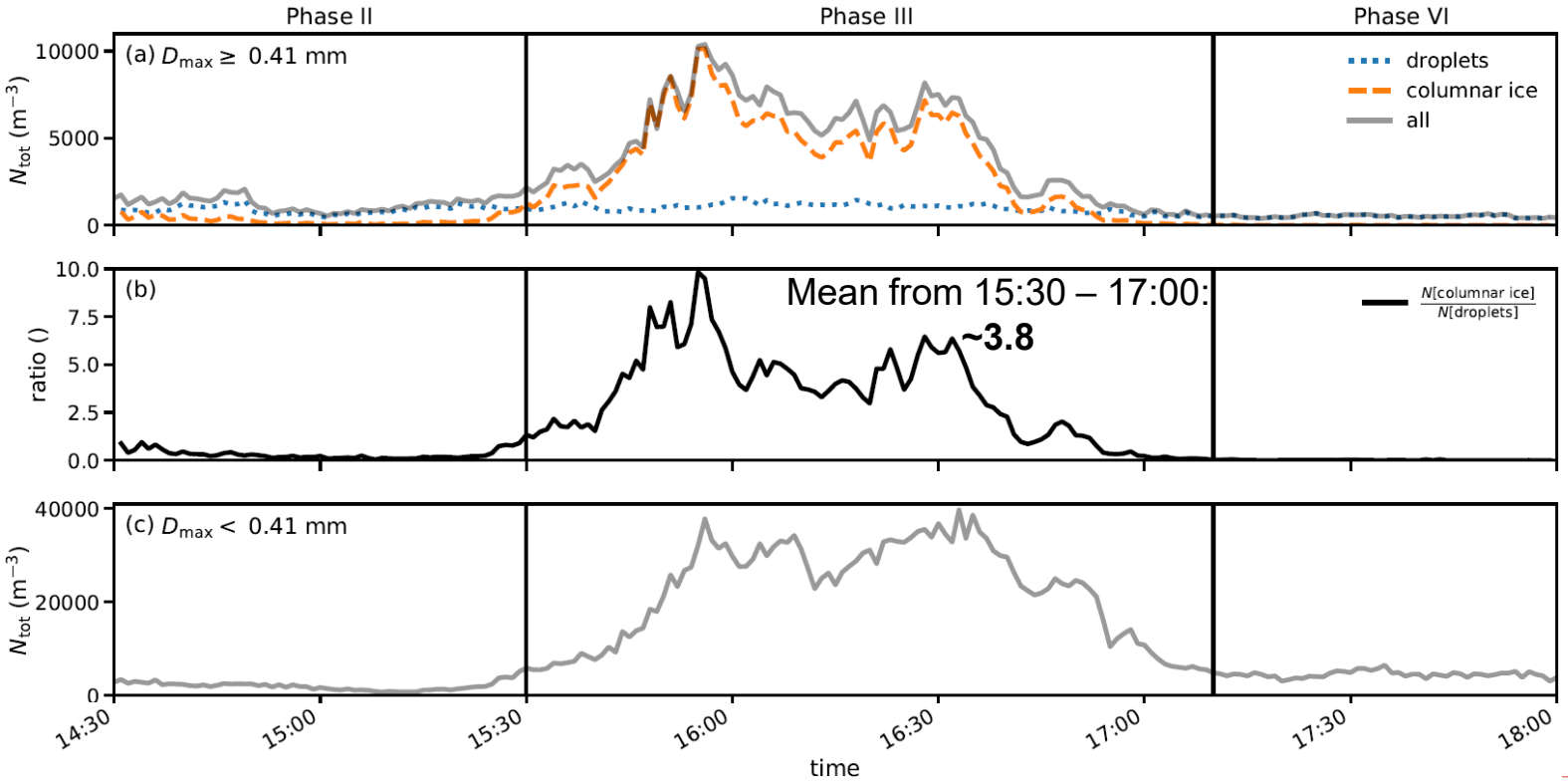
(Size dependent) Threshold in Complexity : $\chi = \frac{Perimeter}{2\sqrt{\pi Area}}$

Droplets (liquid or ice) | Columnar Ice (Monomers + Aggregates)



Classification Error < 5% for Hydrometeors > 0.41 mm

CONCENTRATIONS



- Ratio as **proxy** for **effectiveness**
- **Transient** Process
- Effectiveness is **lower limit** due to **smaller particles**

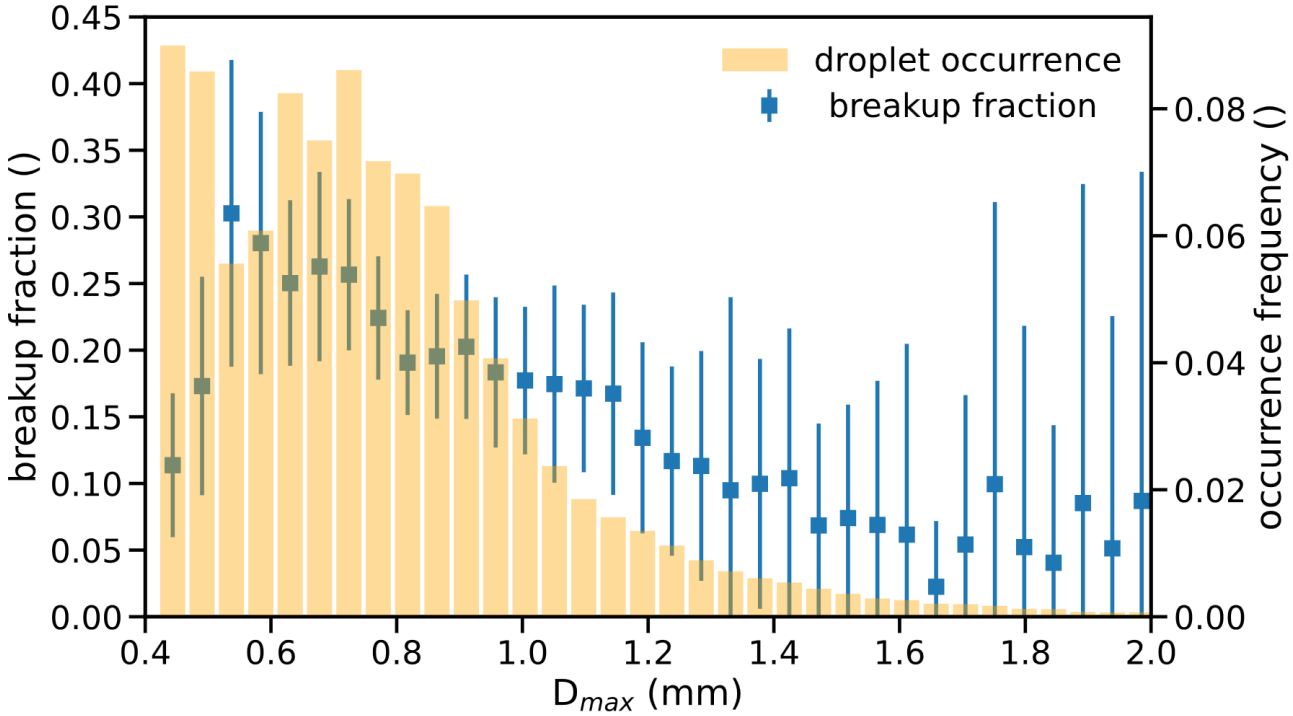
WHICH FRACTION OF DROPLETS IS BROKEN?

Threshold in aspect Ratio (AR)

AR ≈1

AR ≈ 0.5

- Bimodal droplet distribution
- Maximum of Breakup fraction at 0.5 mm



SUMMARY

- Identification of a likely **droplet fragmentation** event with in-situ + radar
- Confirmation of **breakup modes** from the lab
- Constraining the **effectiveness** by comparing concentrations
- Characterized **geometry of broken droplets** with behavior differing from previous lab studies

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THANK YOU FOR YOUR ATTENTION!


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