PolarCAP: Remote sensing and modelling of cloud microphysical processes in thermodynamically and aerosol-constrained super-cooled stratus clouds

Kevin Ohneiser, Patric Seifert, Willi Schimmel, Fabian Senf, Jan Henneberger, Fabiola Ramelli, Robert Spirig, Huiying Zhang, Anna Miller, Nadja Omanovic, Christopher Fuchs, Anja Hardt, Heike Wex, Markus Hartmann, Veronika Ettrichrätz, Anton Kötsche, Heike Kalesse Los, Maximilian Maahn, and Ulrike Lohmann

Leibniz Gemeinschaft

LACROS Leipzig Aerosol and Cloud Remote Observations System

ACTRiS

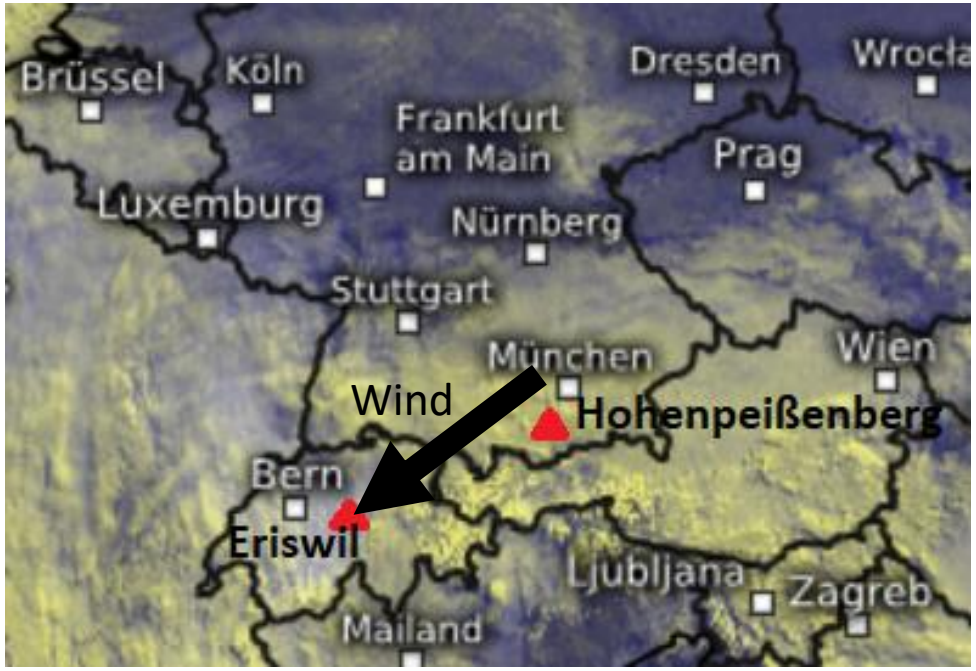
ETH zürich

TROPOS Leibniz-Institut für Troposphärenforschung

Motivation

- Understanding the formation, persistence and environmental impact of the long-last supercooled liquid stratus layer in Bise situations
- What to do in order to better understand supercooled liquid water clouds?
  - Remote-sensing, in situ, INP sampling
  - Artificial seeding → Cloudlab
  - For me: natural seder-feeder, INP contrast

Removal of INP after activation between Hohenpeißenberg and Eriswil?



Prerequisites for PolarCAP

SPOMC (PROM)

Hydrometeor ratios in mixed-phase

CORSIPP

(PROM-Phase 2, Kalesse/Maahn)

Observations part

(highlights: INP study and seeder-feeder case study)

best way to apply all existing retrievals:

- VOODOO (Willi)
- peakTree (Martin)
- Multiwavelength (DWR)
- Shape retrieval (Audrey: VDPS virtual distribution of particle shape)
- Shape retrieval (Majid: Spectrally resolved shape and orientation retrieval)

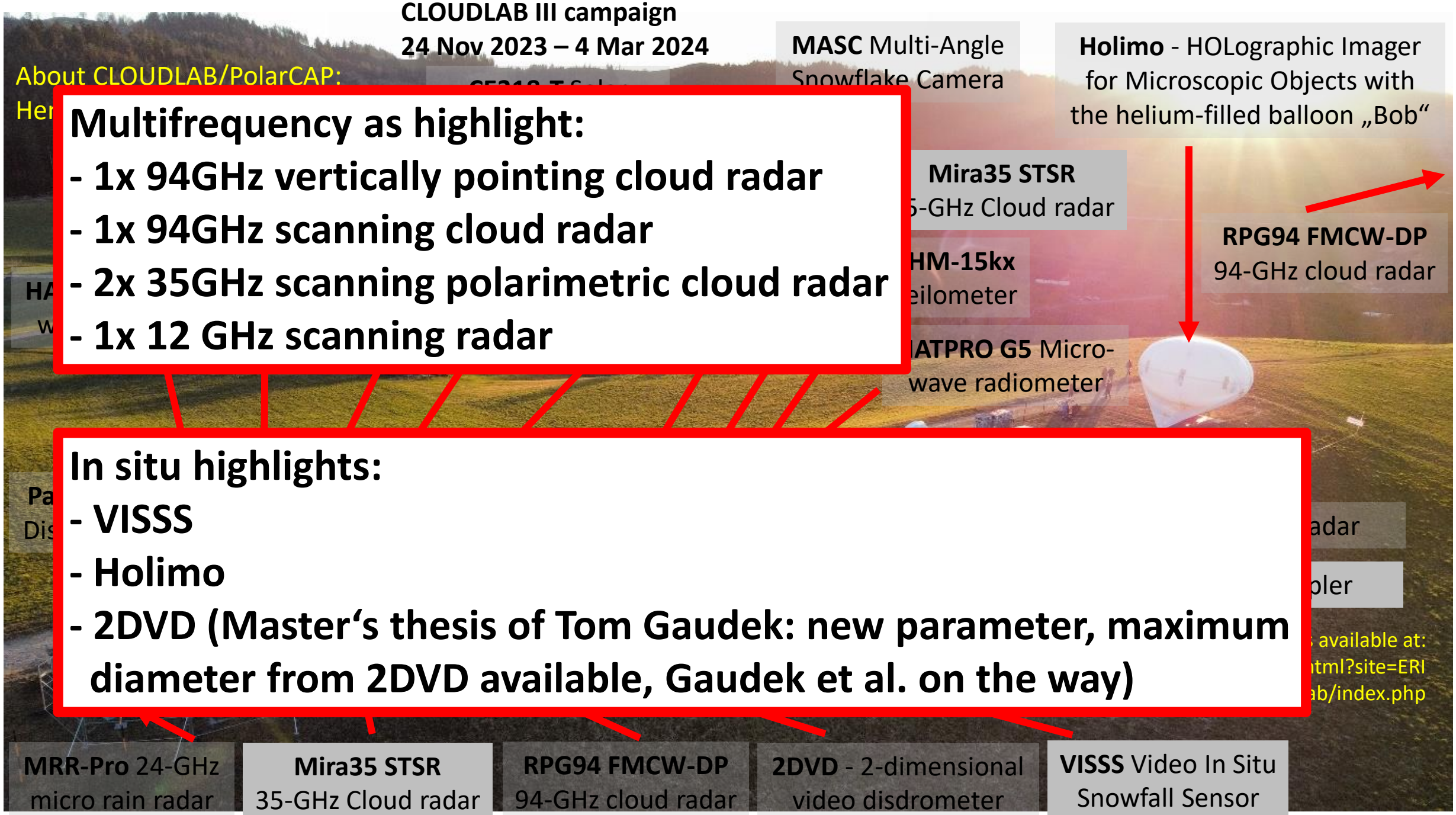
peakTree (TROPOS)

Structure preserving Doppler spectra separation

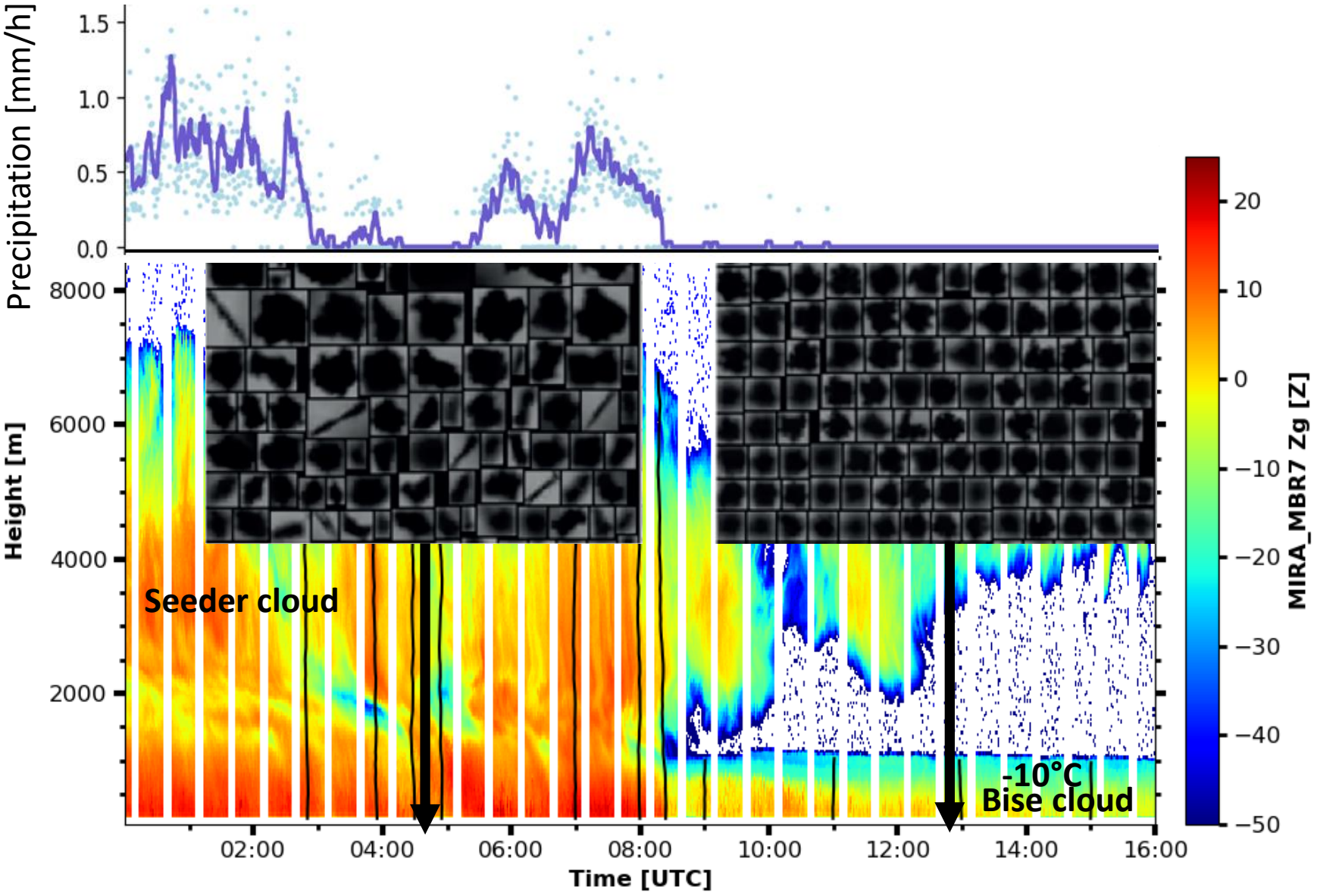
IcePolCKa-Phase 2

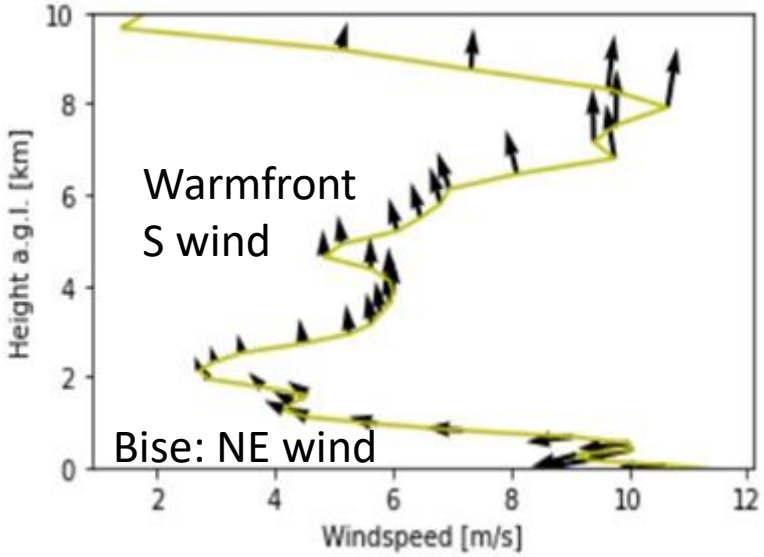
(PROM-Phase 2, Ewald/Zinner)

Coordinated scans of multi-lambda radars; radar forward operators


CLOUDLAB III campaign
24 Nov 2023 – 4 Mar 2024
About CLOUDLAB/PolarCAP:
MASC Multi-Angle Snowflake Camera
Holimo - HOLographic Imager for Microscopic Objects with the helium-filled balloon „Bob“
Mira35 STSR
-GHz Cloud radar
RPG94 FMCW-DP
94-GHz cloud radar
HM-15kx
eilometer
ATPRO G5 Micro-wave radiometer
Multifrequency as highlight:
- 1x 94GHz vertically pointing cloud radar
- 1x 94GHz scanning cloud radar
- 2x 35GHz scanning polarimetric cloud radar
- 1x 12 GHz scanning radar
In situ highlights:
- VISSS
- Holimo
- 2DVD (Master‘s thesis of Tom Gaudek: new parameter, maximum diameter from 2DVD available, Gaudek et al. on the way)
MRR-Pro 24-GHz micro rain radar
Mira35 STSR 35-GHz Cloud radar
RPG94 FMCW-DP 94-GHz cloud radar
2DVD - 2-dimensional video disdrometer
VISSS Video In Situ Snowfall Sensor

Natural seeding event of ice crystals into low-level supercooled cloud



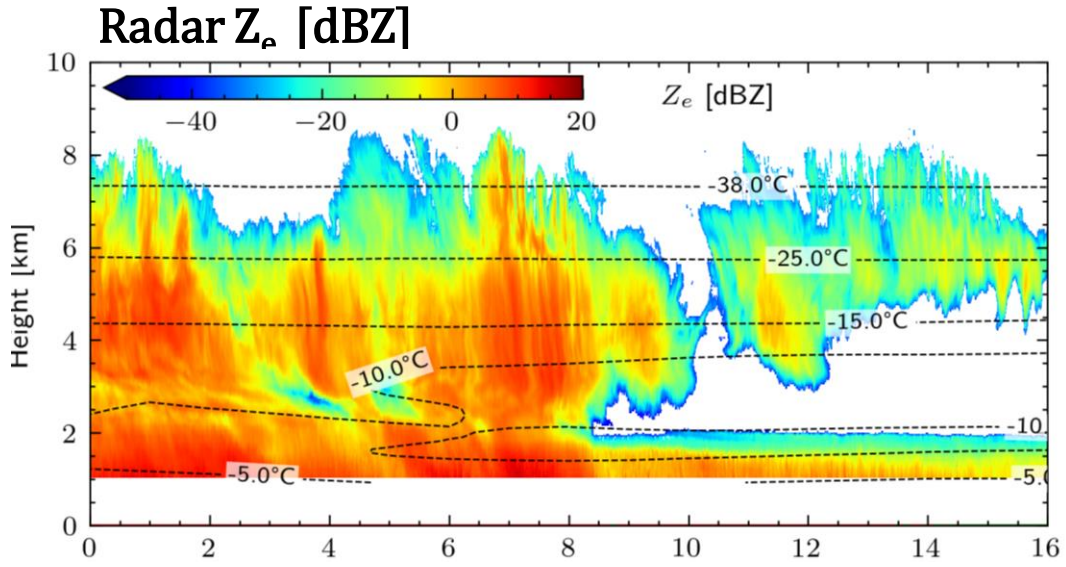


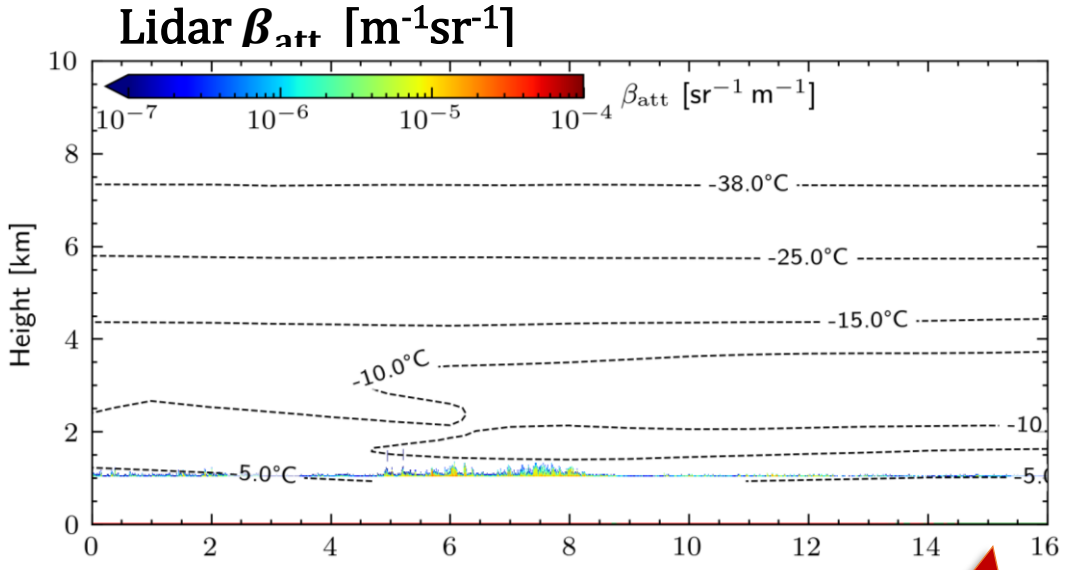
Precipitation enhancement due to seeder-feeder interaction

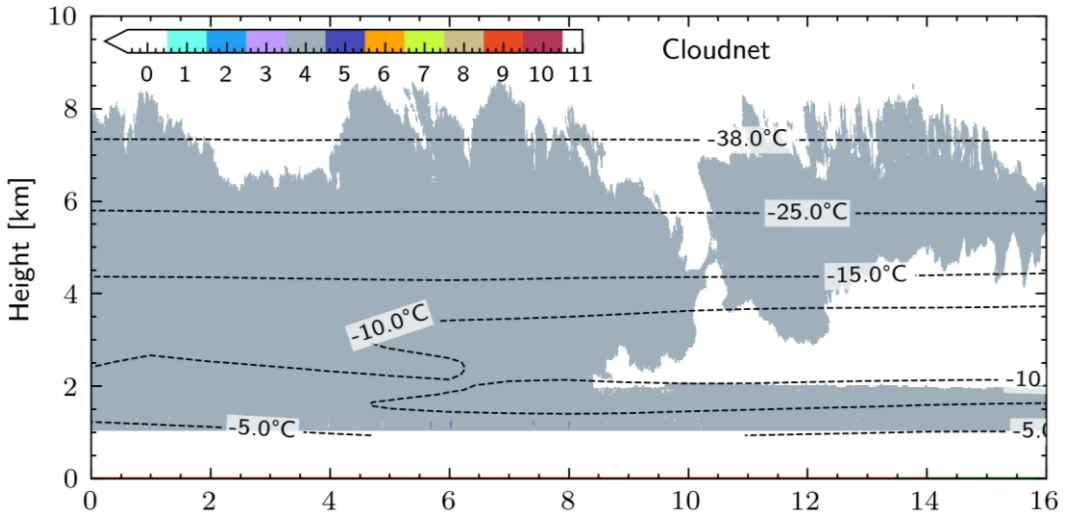
8 Jan 2024

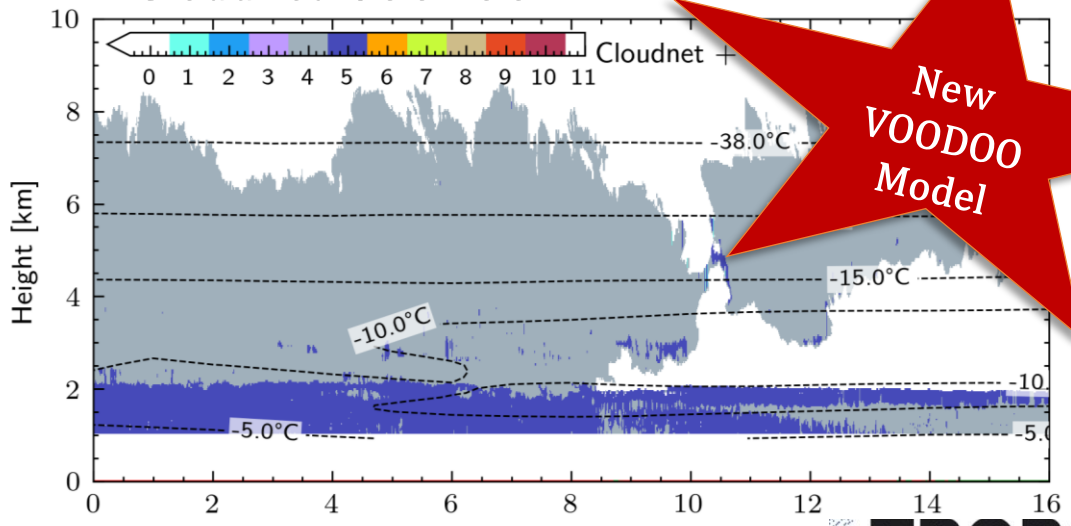
Eriswil, Switzerland

Issue with Low Level Liquid Clouds and Cloudnet









New VOODOO Model

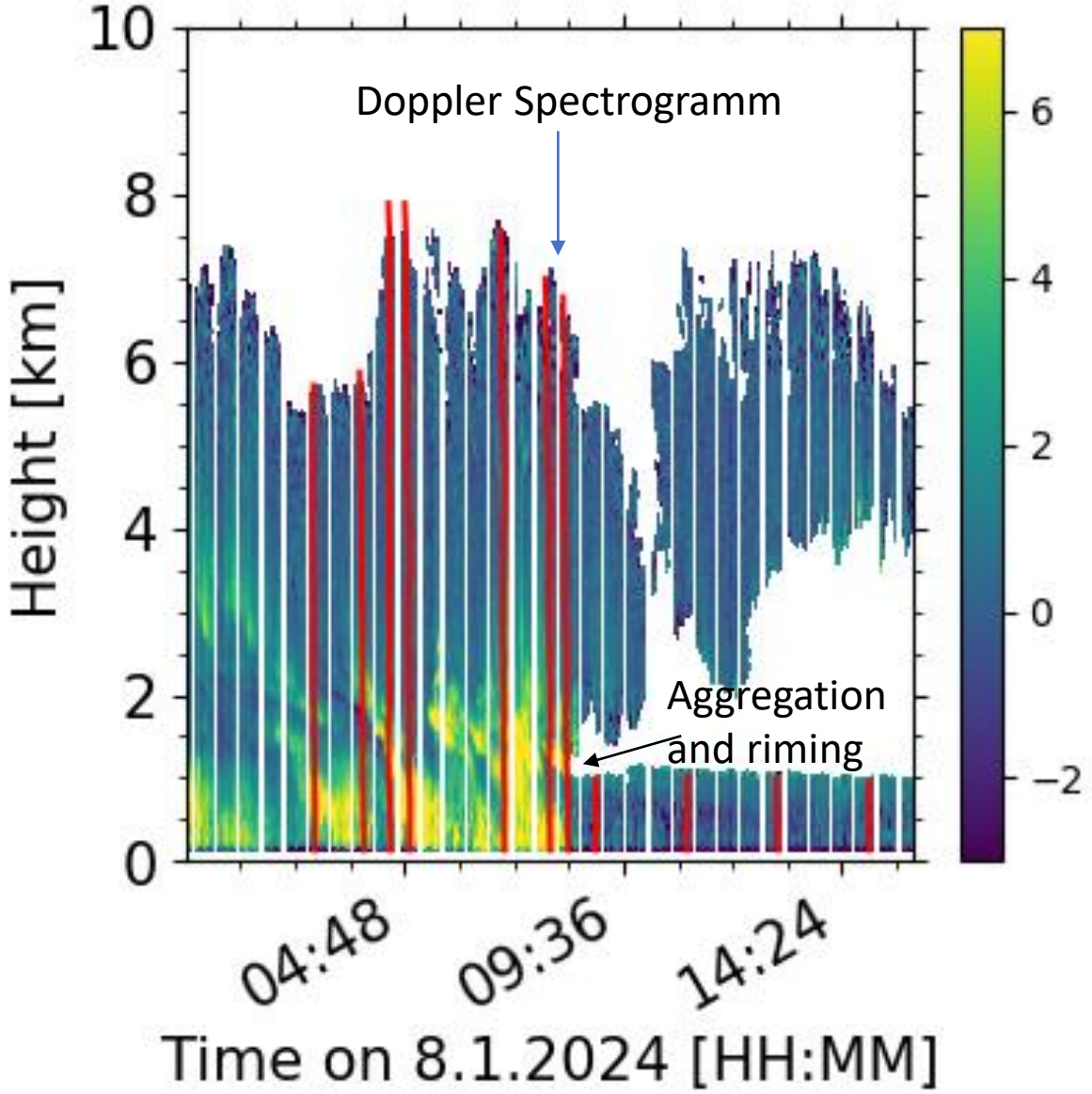
height [km]

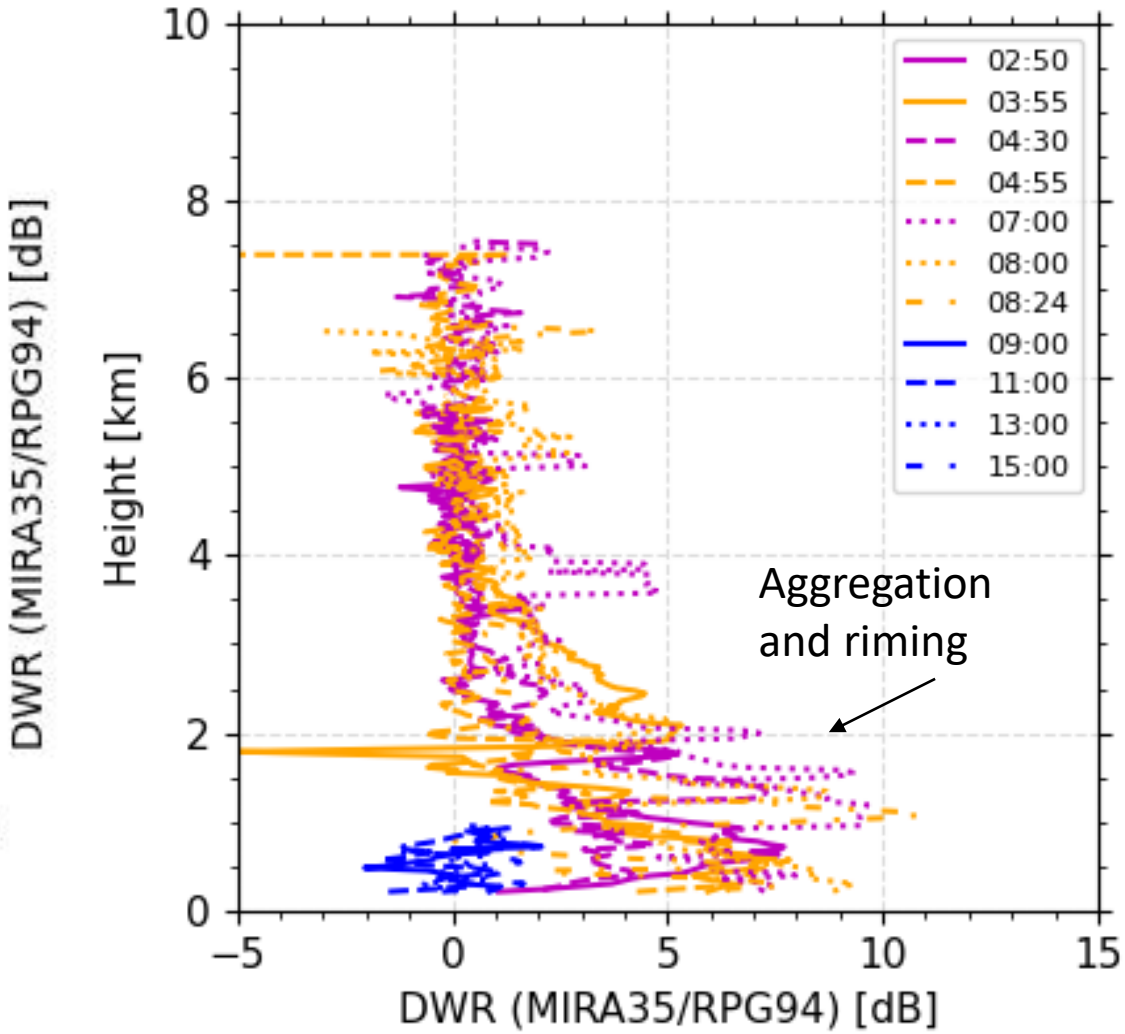
time [UTC]

liquid droplets | mixed phase | ice

TROPOS

Dual wavelength ratio 35/94GHz

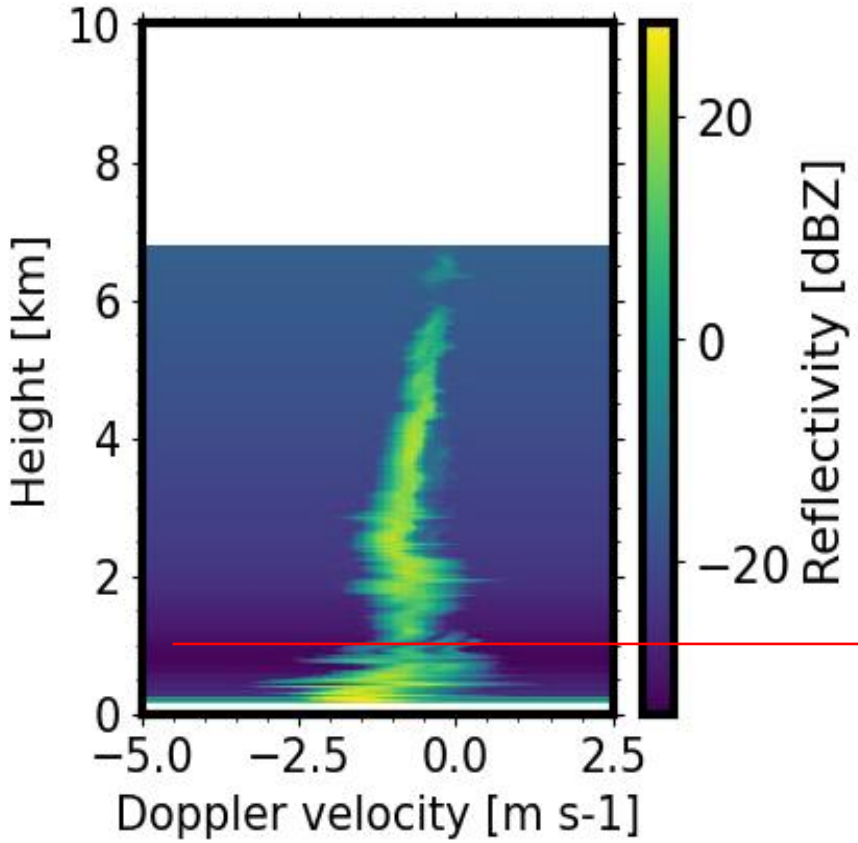




Seeding leads to DWR of 8dB
→ Aggregation and Riming

Doppler spectrogramm / Doppler spectrum

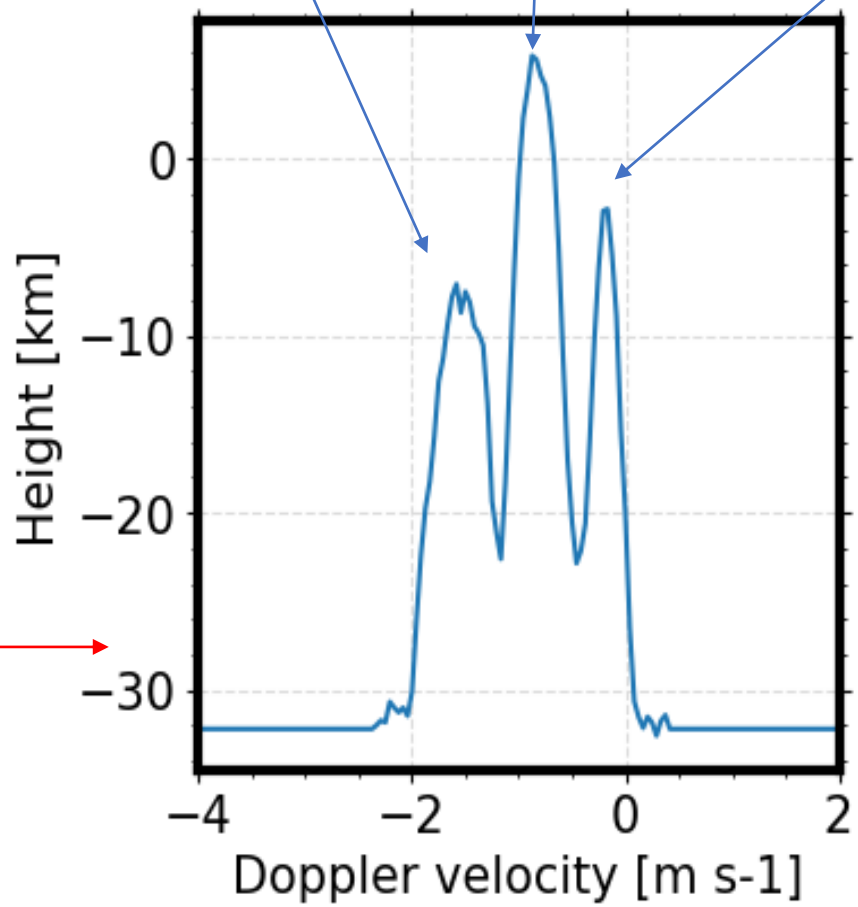
08:20 UTC
weak seeding



Seeding large ice crystals?

New peak small ice crystals
due to seeder-feeder interaction?

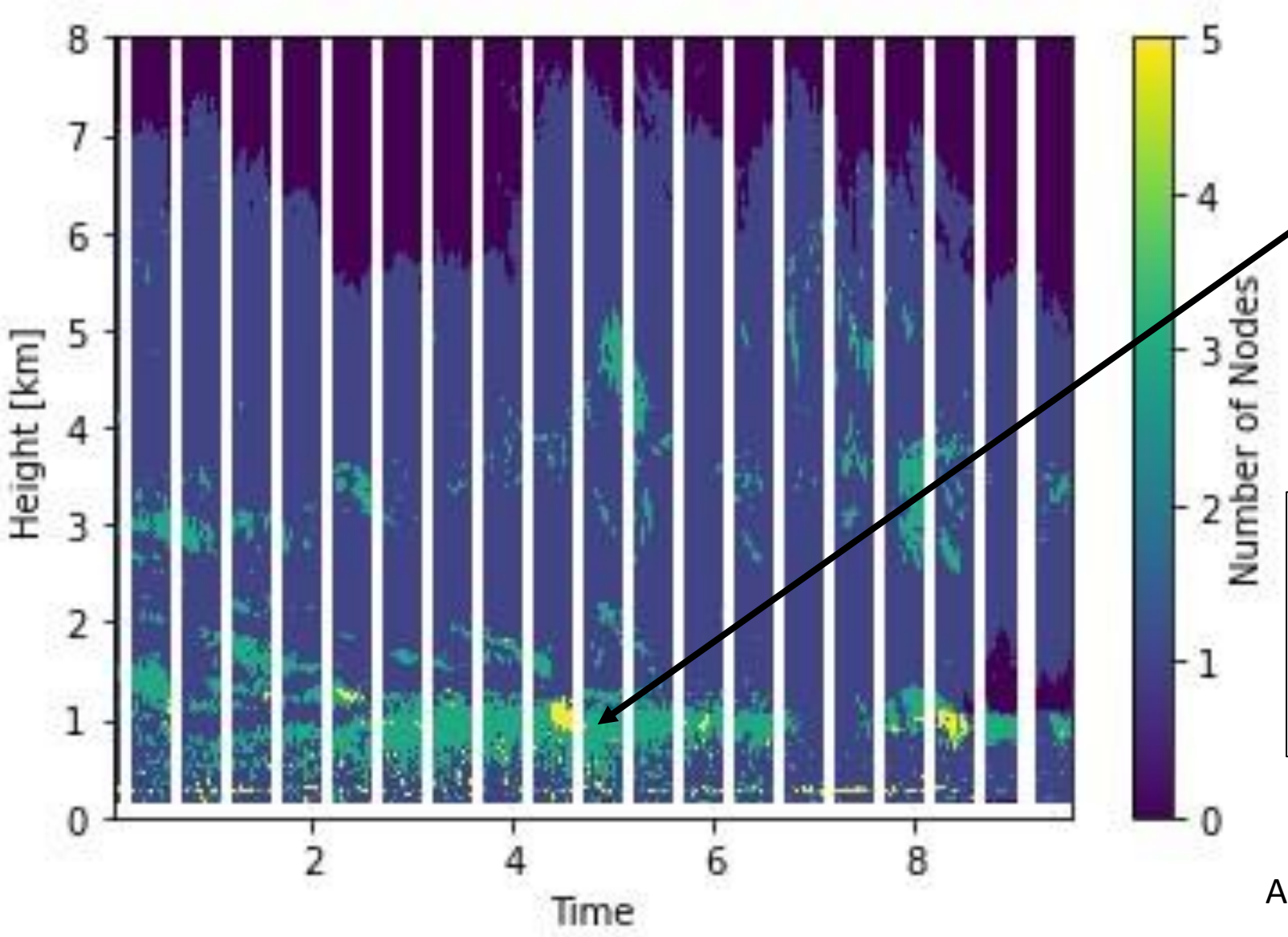
Bise liquid water?



Doppler spectrum at 1km, 8:20 UTC

Multipeak signatures caused by seeding

PeakTree – automatic Doppler peak identification



When seeding ice crystals reached the Bise cloud – number of particle modes increased

Water and ice coexists and riming can take place

Widespread multi-peak Doppler spectra at interface layer of seeder and feeder cloud

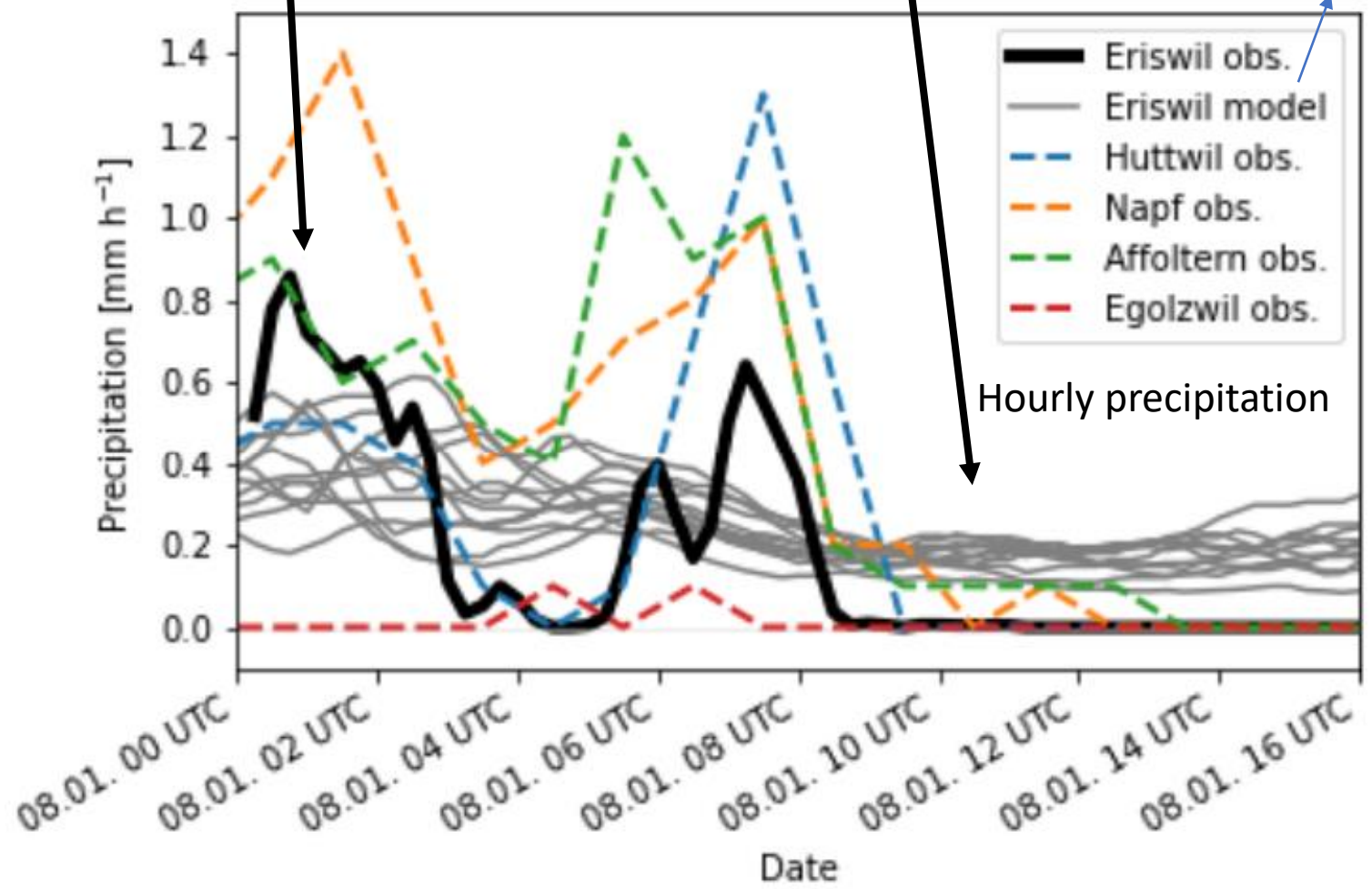
About PeakTree: Radenz et al, AMT, 2019

Precipitation: Spatial representativeness & model intercomparison

Precipitation underestimated by model during seeding

Precipitation overestimated by model during Bise cloud – lack of INP?

ICON D2

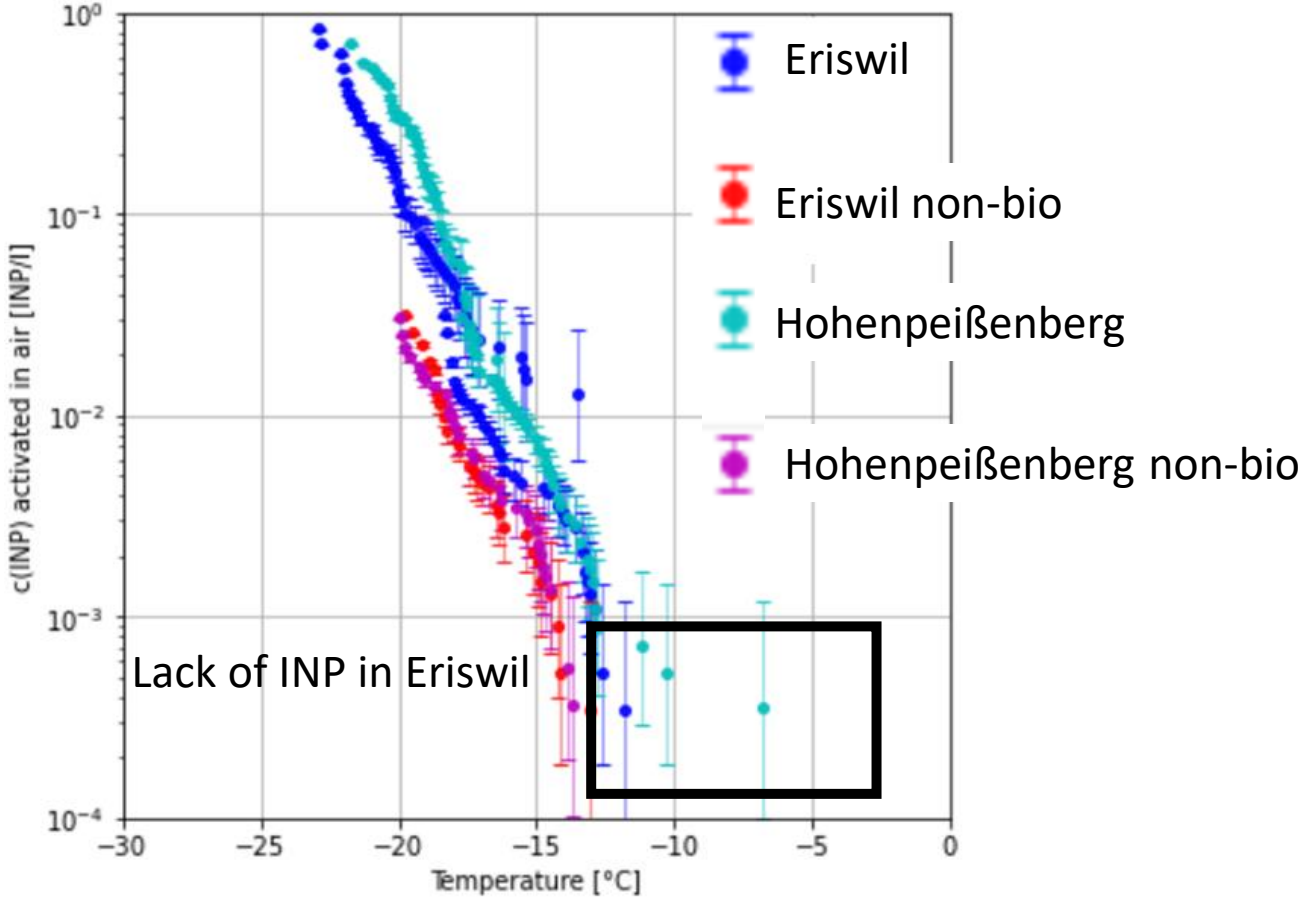


Hourly precipitation

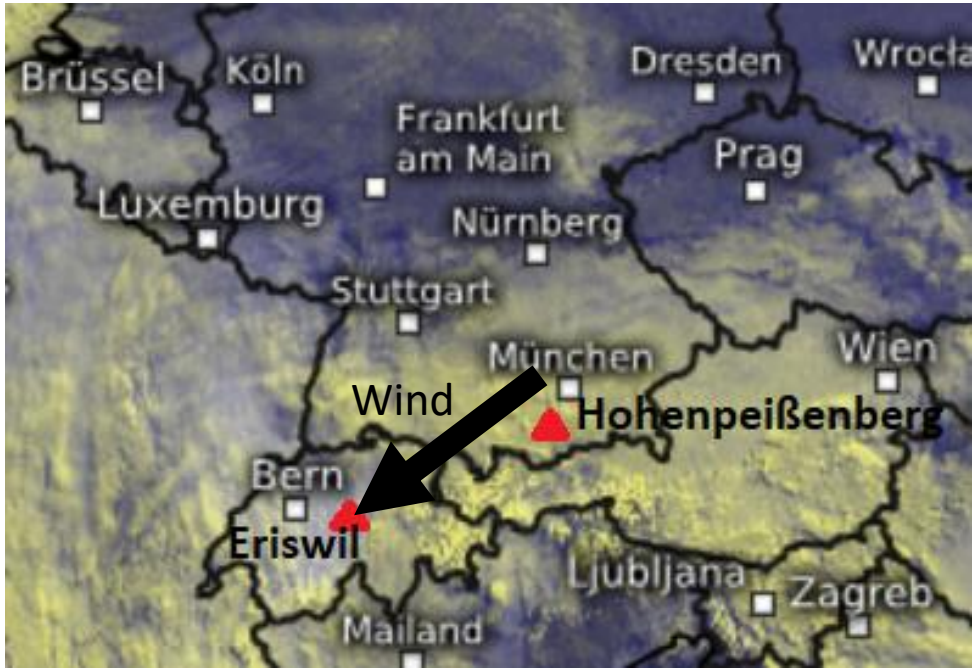
Huttwil, Napf, Affoltern, Egolzwil

ICON D2 underestimates seeder-feeder effect but overestimates ice precipitation from stratus layer

INP measurements during northeasterly winds

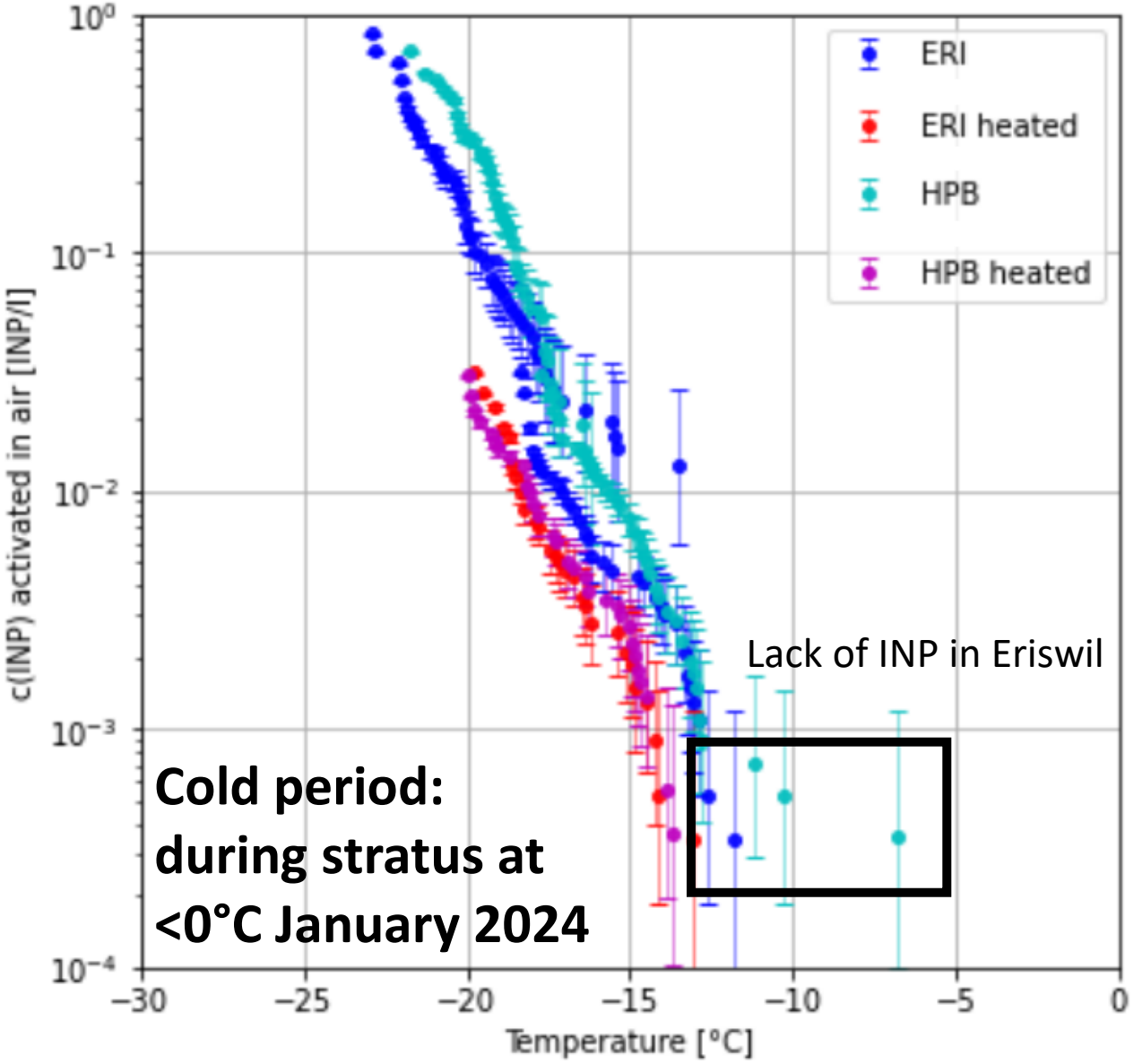


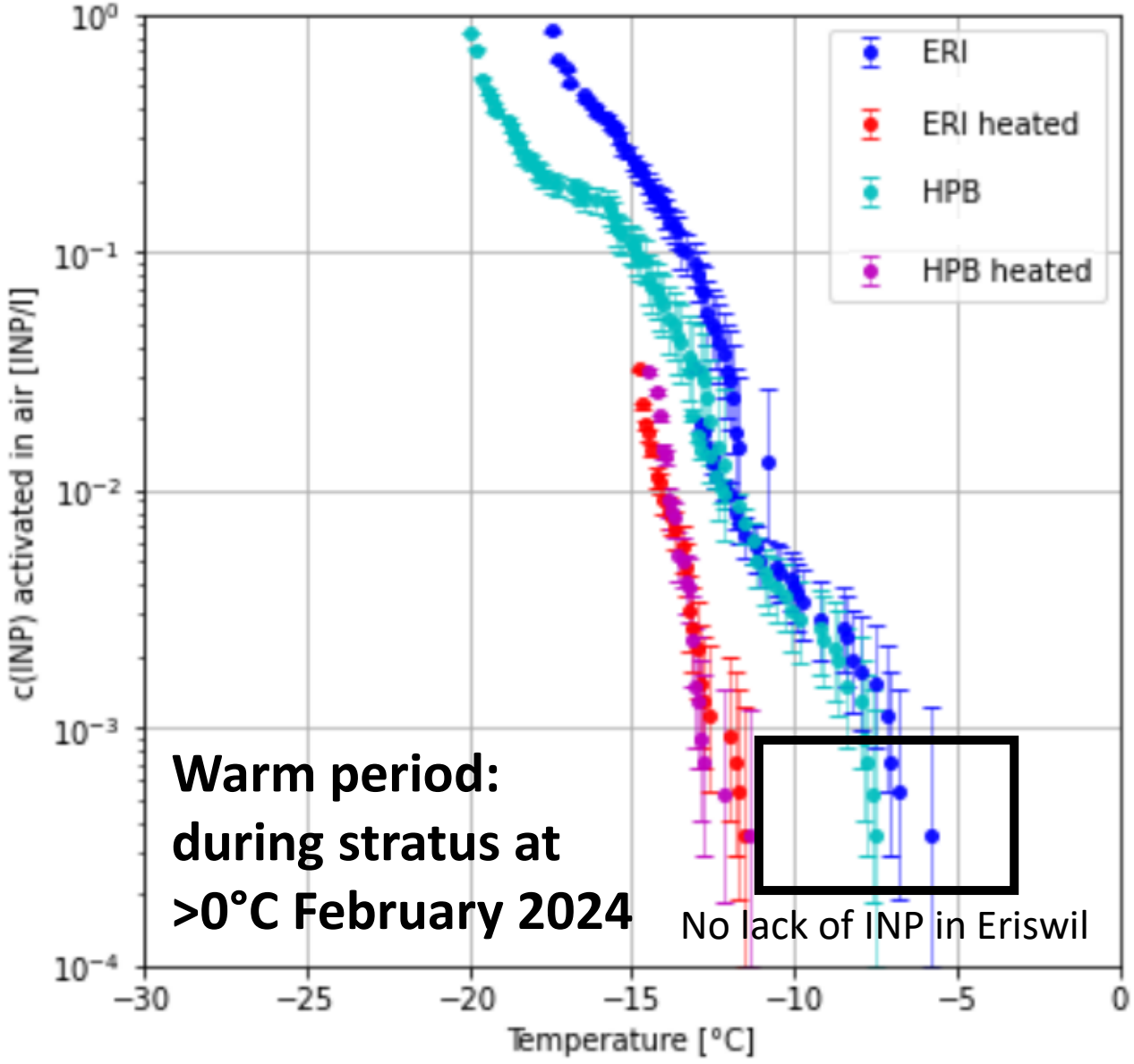
Cold period: during stratus at <0°C 8 January 2024 (~-10°C)



Indications for INP removal during the way from Hohenpeißenberg to Eriswil

INP measurements during northeasterly winds (trajectories from Hohenpeißenberg to Eriswil)





Summary

- Lack of understanding of wintertime stratus cloud decks over central Europe
  - Formation? Persistence? Impact on meteorological processes?
- Case study from 8 Jan 2024 with natural seeding effect was shown

I) Natural seeder-feeder mechanism characterized

- Feeding stratus layer lead to precipitation enhancement
- Weather model (ICON D2) underestimates seeder-feeder effect but overestimates precipitation from the stratus (Bise-cloud) layer

II) INP removal along cloud trajectory during cold Bise situations

- Lack of INPs at -10°C in Eriswil only on 8 Jan 2024 (cold Bise, T>-10°C), not on 28 Feb 2024 (warm Bise, T>0°C), both with northeasterly winds
- INP activation and removal upwind of Eriswil!