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

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Leibniz Gemeinschaft

Leipzig Aerosol and Cloud Remote Observations System

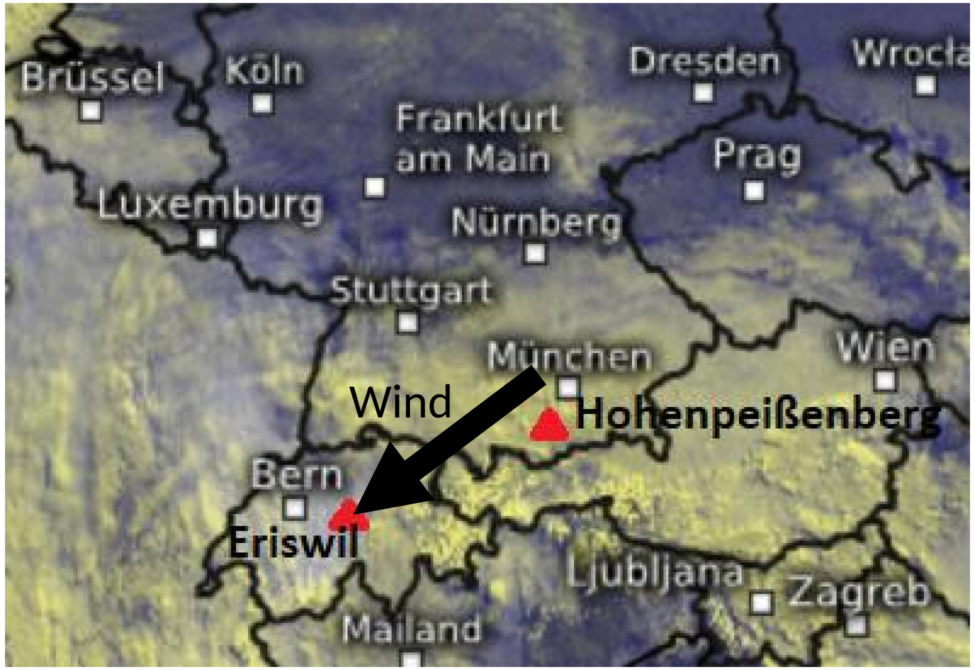
ACTRIS

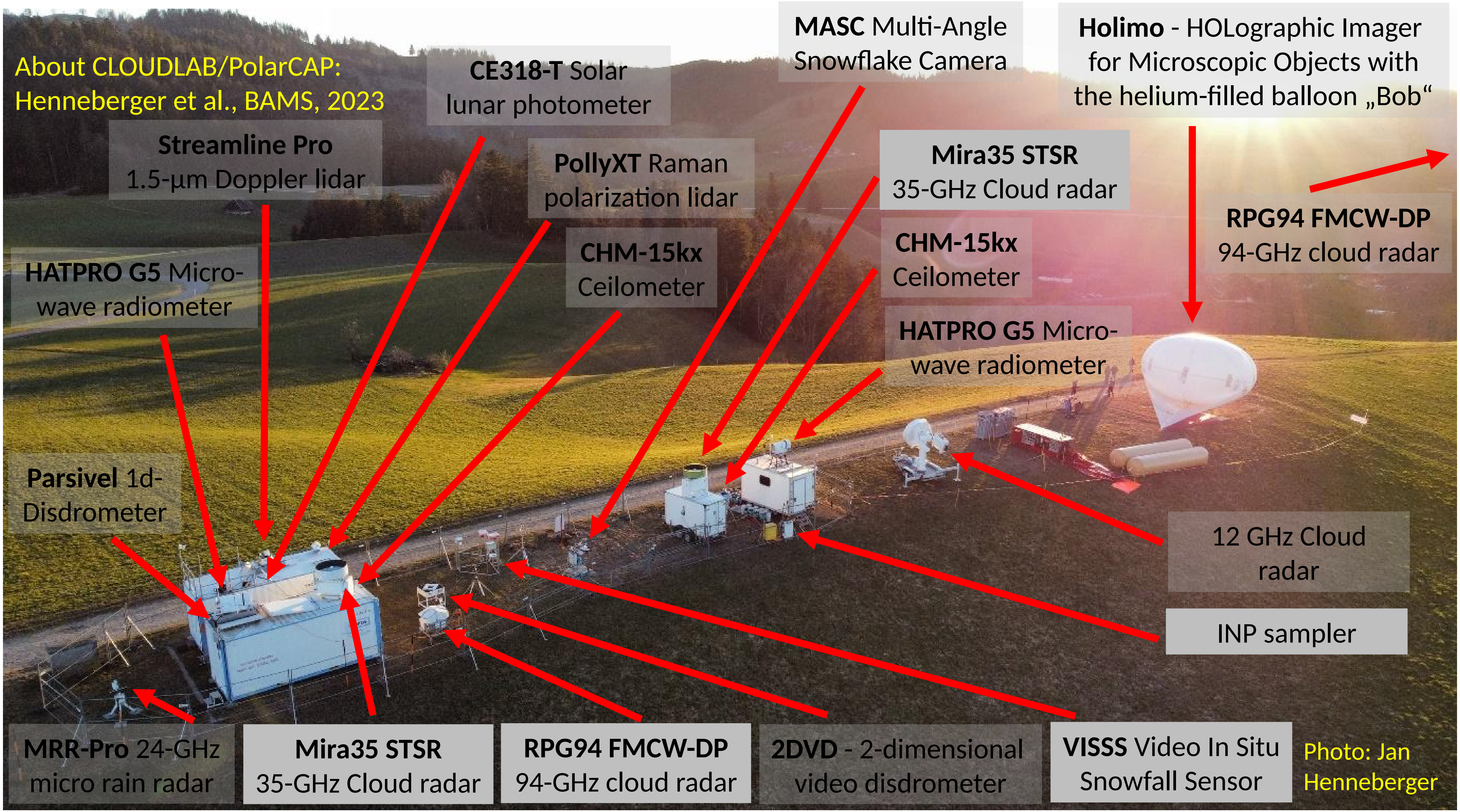
ETH zürich

TROPOS Leibniz-Institut für Troposphärenforschung

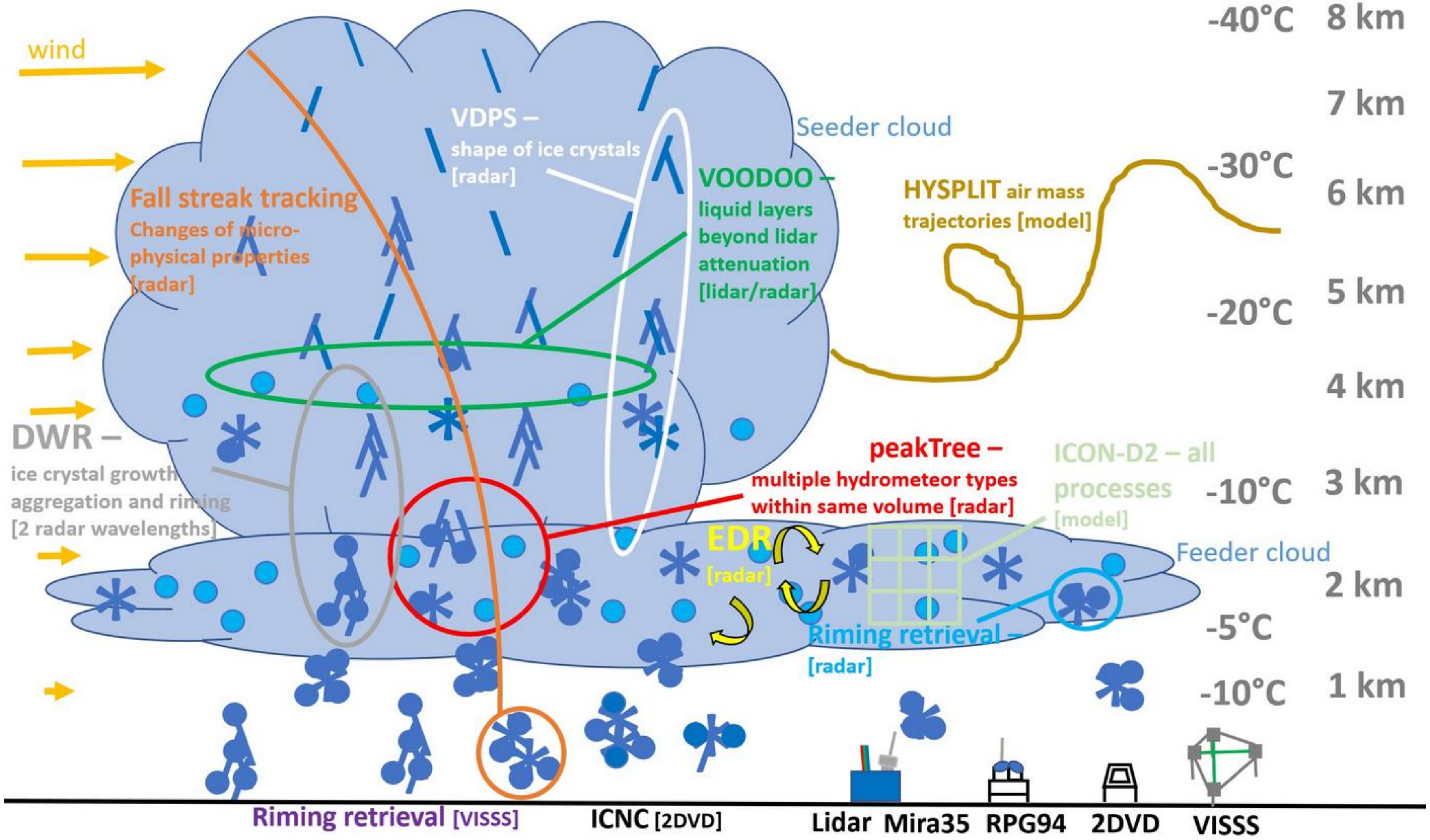
Motivation

- Improve the understanding of the formation, persistence and environmental impact of the long-lasting supercooled liquid stratus layer in Bise situations
- Approaches: Combination of remote-sensing, in situ, INP (ice-nucleating particles) sampling to:
  1. **Evaluate availabilty (lack!) and spatial distribution of ice nucleating particles (INP)** → **See poster #25**
  2. **Characterize the role of the supercooled stratus layer for precipitation formation via natural seeder-feeder processes → 8 Jan 2024, this presentation**

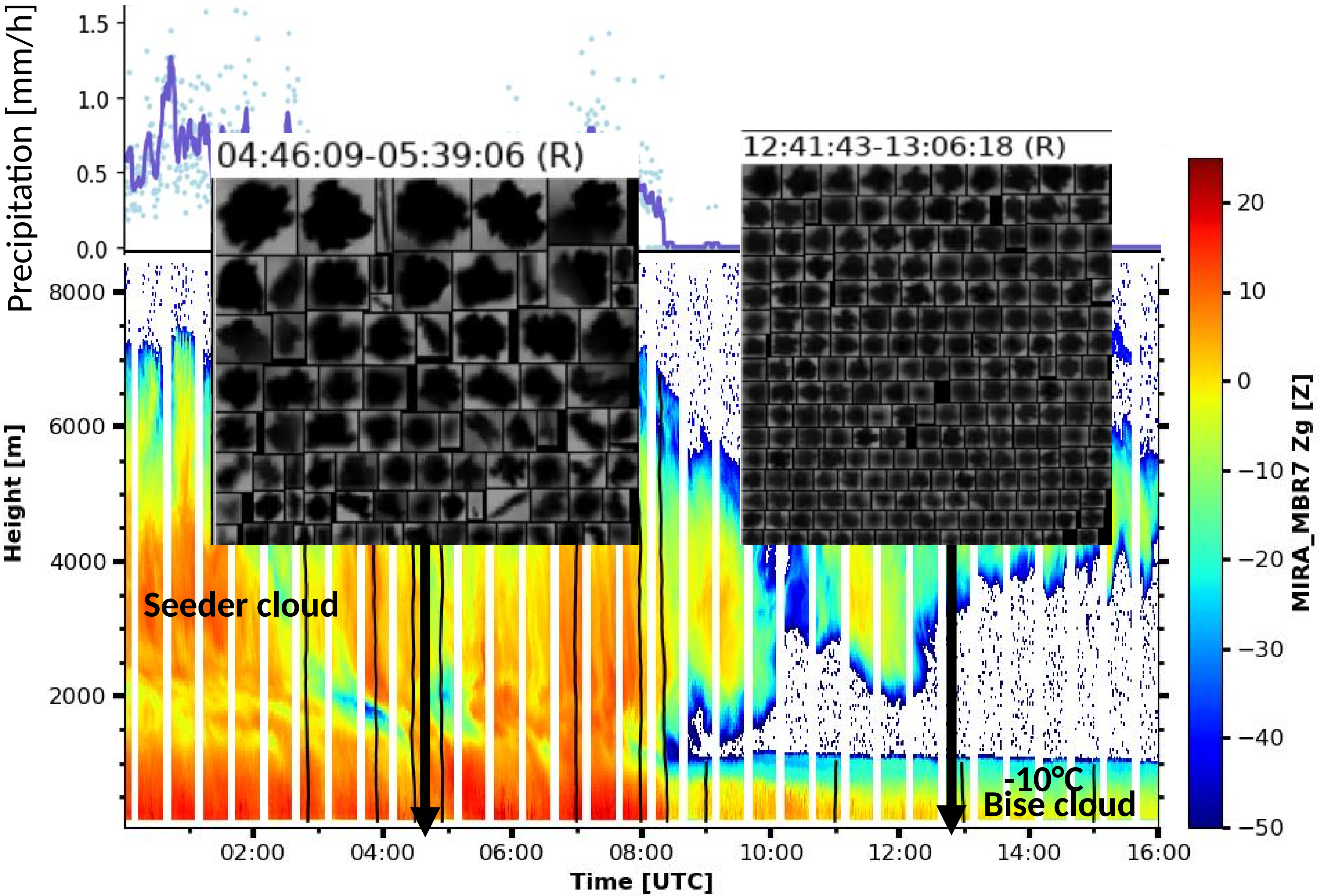


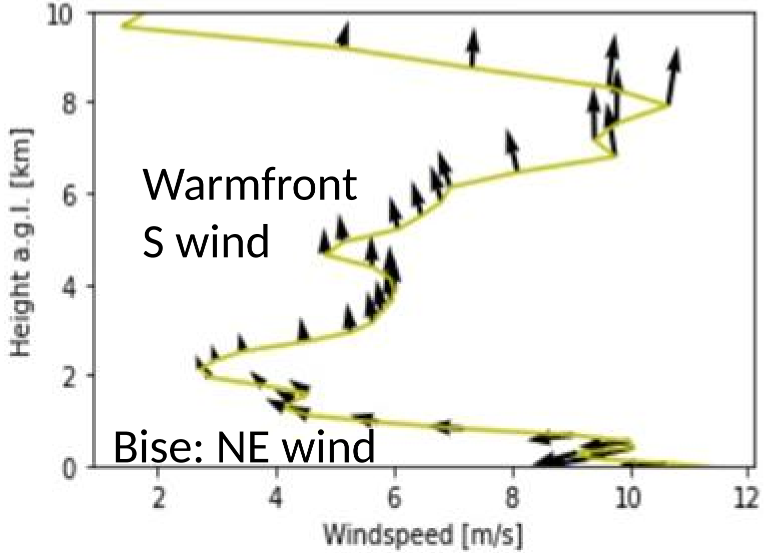

About CLOUDLAB/PolarCAP:
Henneberger et al., BAMS, 2023
CE318-T Solar lunar photometer
MASC Multi-Angle Snowflake Camera
Holimo - HOLographic Imager for Microscopic Objects with the helium-filled balloon „Bob“
Streamline Pro 1.5-µm Doppler lidar
PollyXT Raman polarization lidar
Mira35 STSR 35-GHz Cloud radar
RPG94 FMCW-DP 94-GHz cloud radar
HATPRO G5 Micro-wave radiometer
CHM-15kx Ceilometer
CHM-15kx Ceilometer
HATPRO G5 Micro-wave radiometer
Parsivel 1d-Disdrometer
12 GHz Cloud radar
INP sampler
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
Photo: Jan Henneberger

Apply big set of retrievals to the big dataset



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



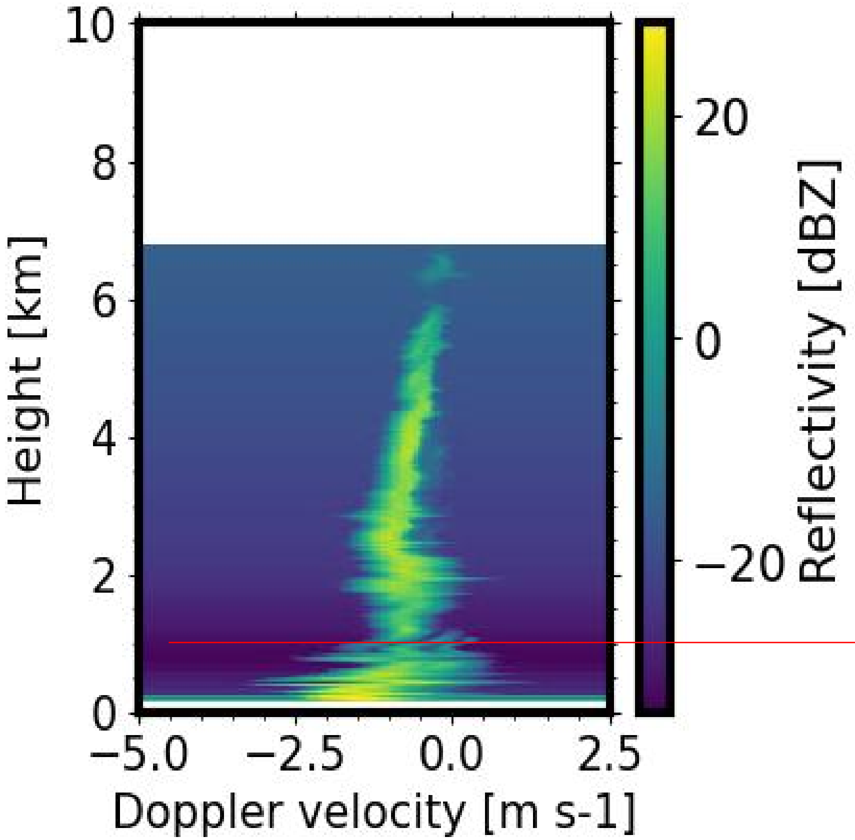


Precipitation enhancement due to seeder-feeder interaction

8 Jan 2024
Eriswil, Switzerland

Doppler spectrogramm / Doppler spectrum

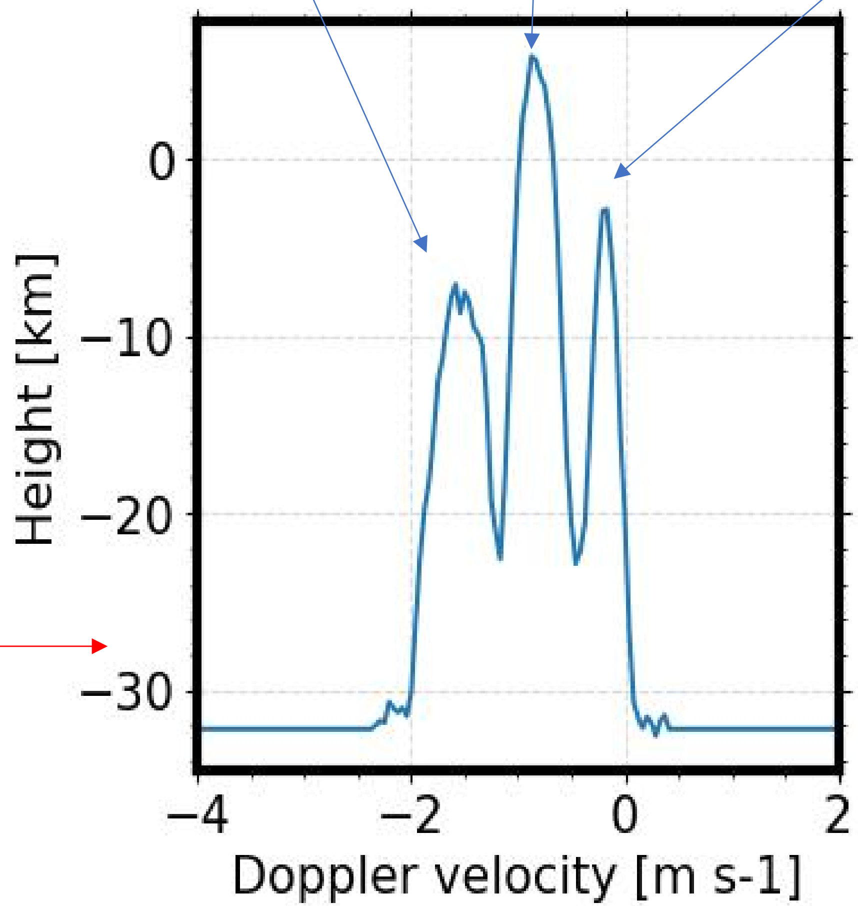
08:20 UTC
weak seeding



Seeding large ice crystals?

New peak small ice crystals
due to seeder-feeder interaction
or 3d-effect?

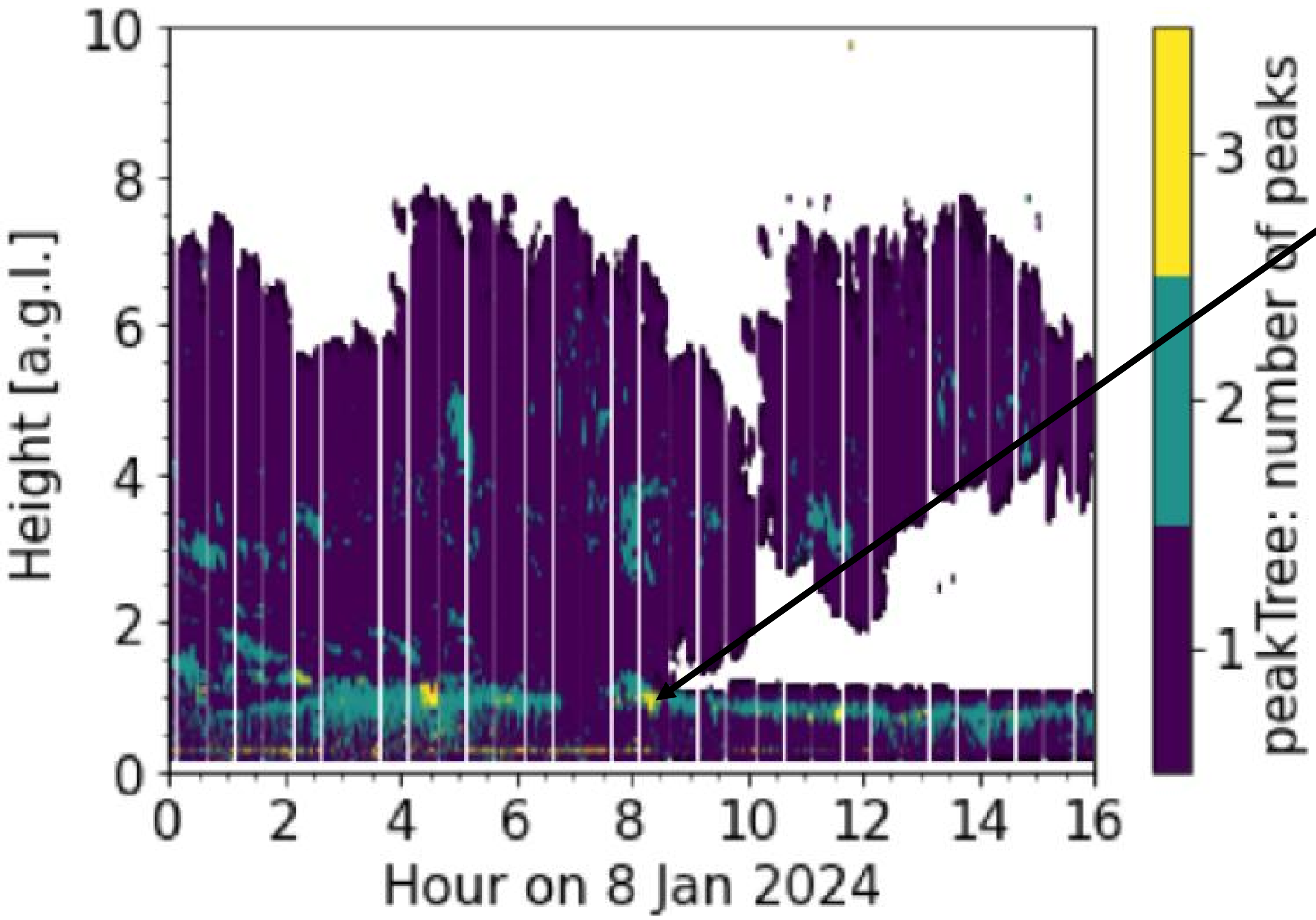
Bise liquid water?



Multipeak signatures caused by seeding

Doppler spectrum at 1km, 8:20 UTC

PeakTree – automatic Doppler peak identification



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

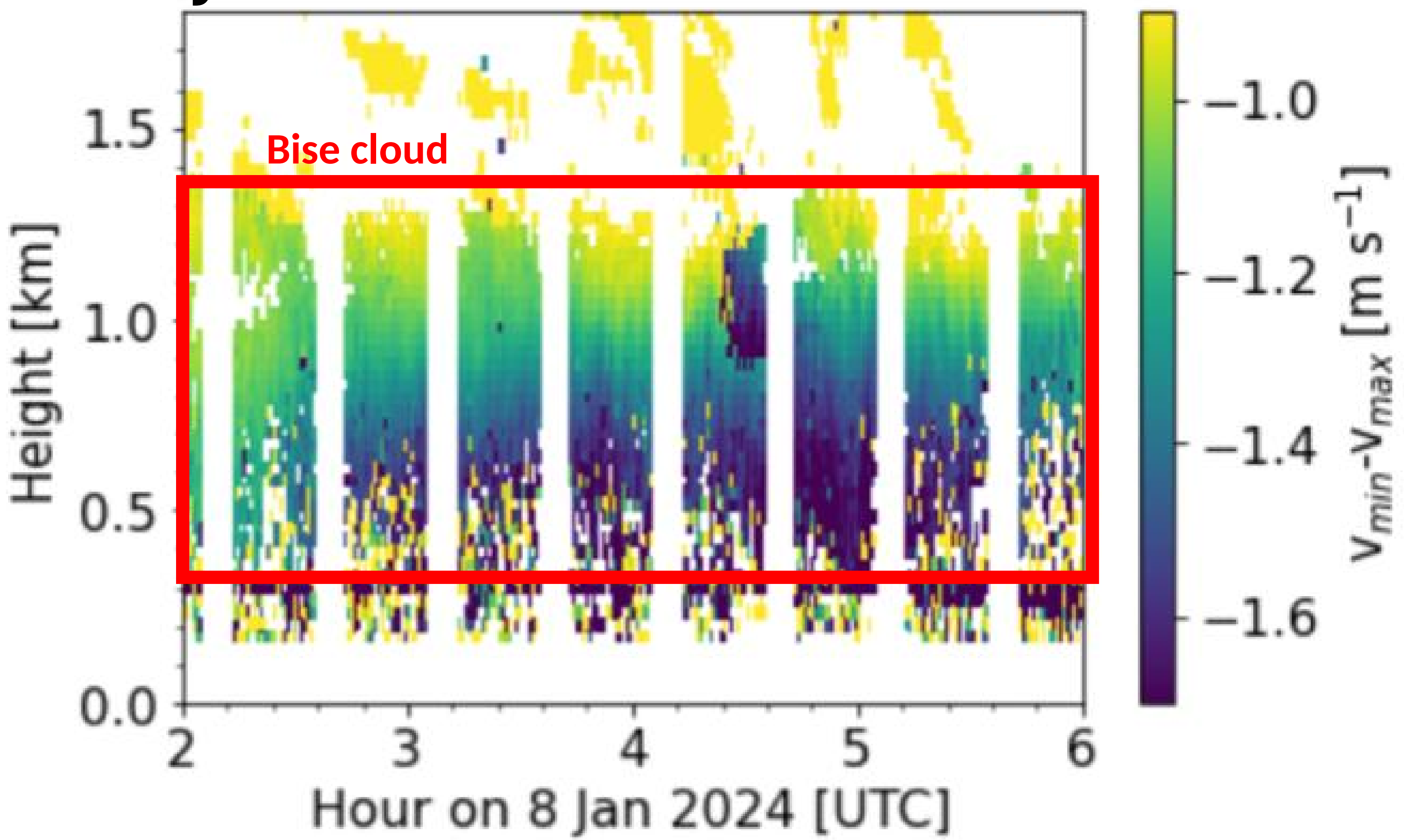
Water and ice coexists and riming can take place

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

About PeakTree: Radenz et al, AMT, 2019
Vogl et al., EGUsphere 2024

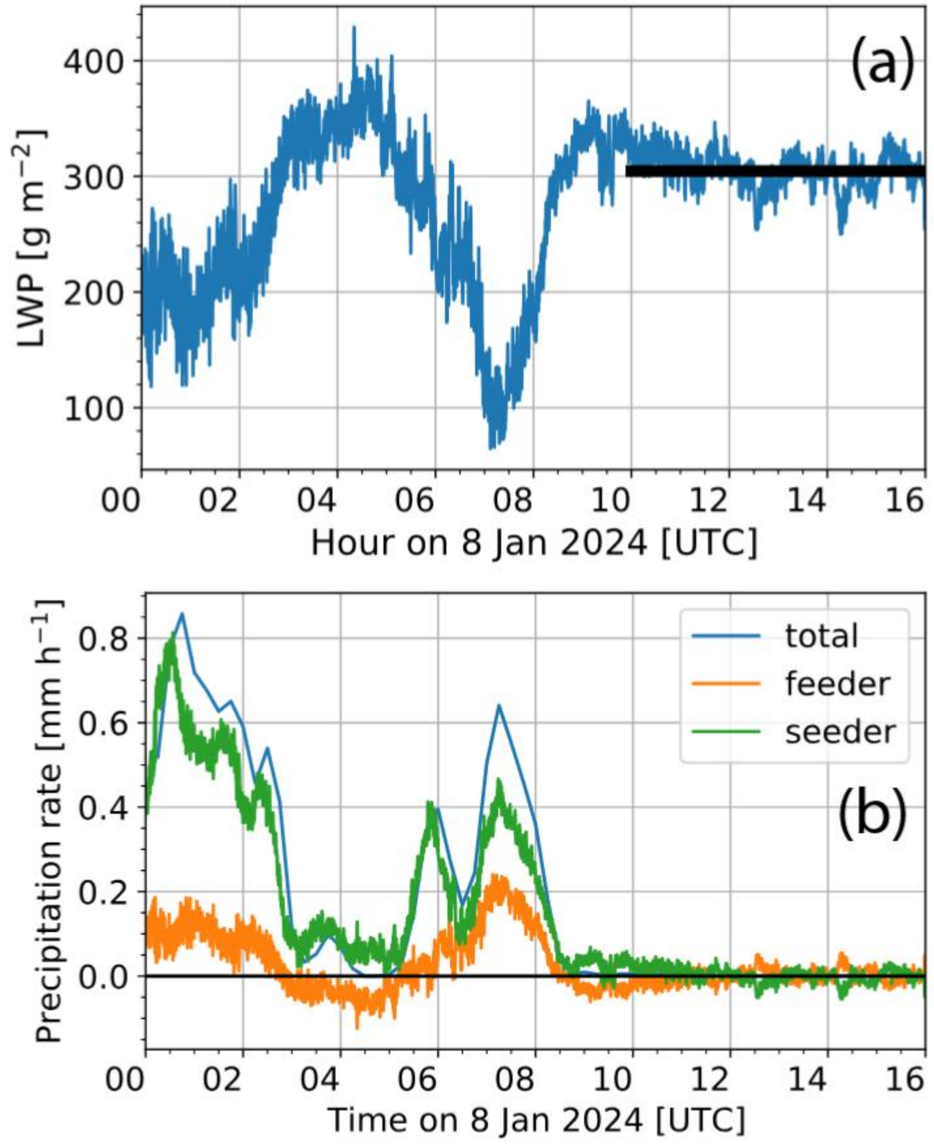
Signal of riming also in peakTree

Estimate riming probability by evaluating the difference between min and max Doppler velocity



- **Particles fall with 0.8m/s at Bise cloud top (these are aggregates from seeder cloud, for more information see poster of Audrey Teisseire)**
- **but with more than 1.7m/s at cloud base,**
- **Transition from aggregates to graupel**

Quantification of precipitation enhancement of seeder-feeder interaction via LWP measurements



- Higher precipitation during times with lower LWP
- Approx. 10-30% of the total precipitation is provided by the Bise cloud → consistent with literature (modeling studies and observations)

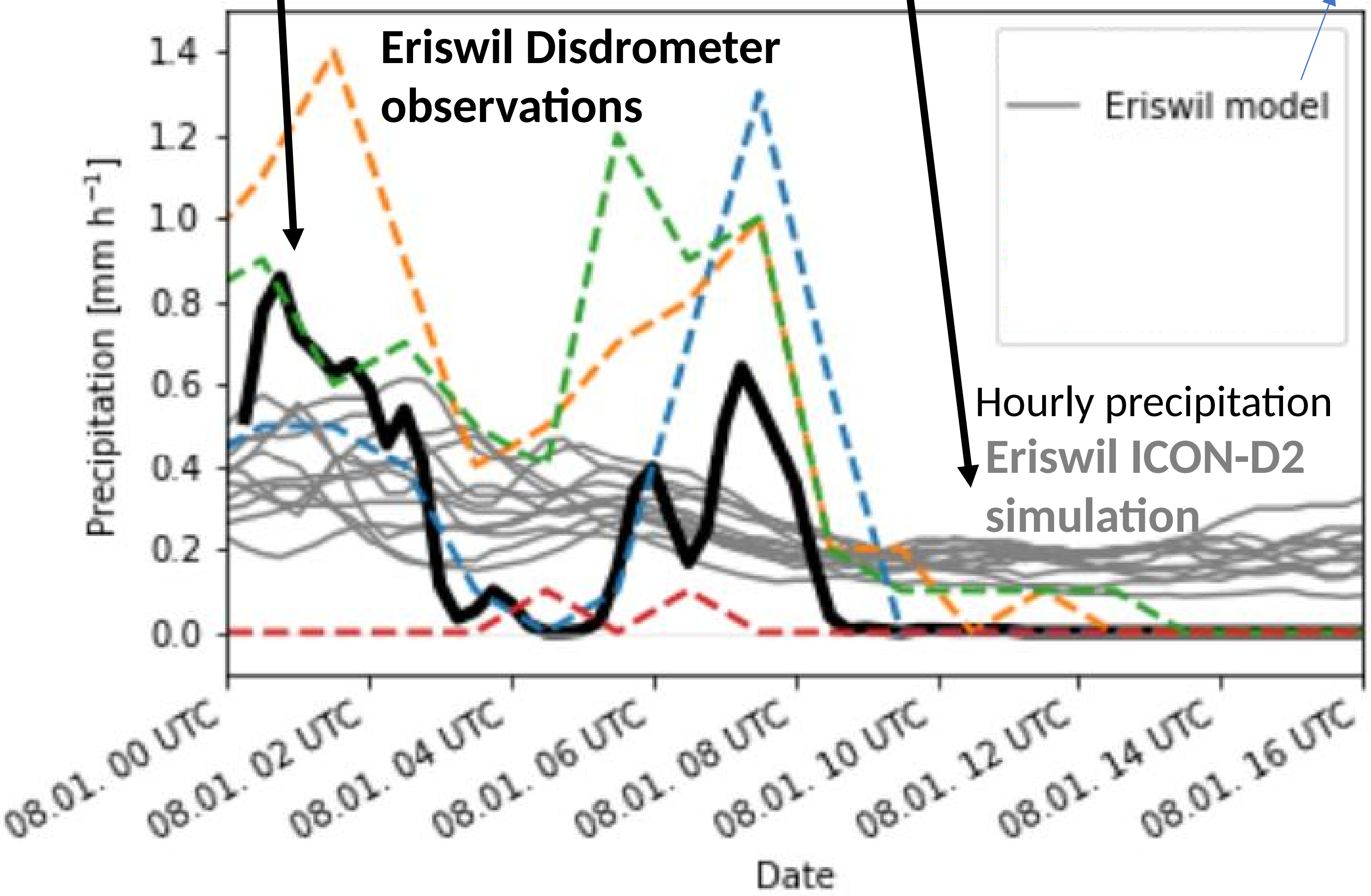
Work in progress

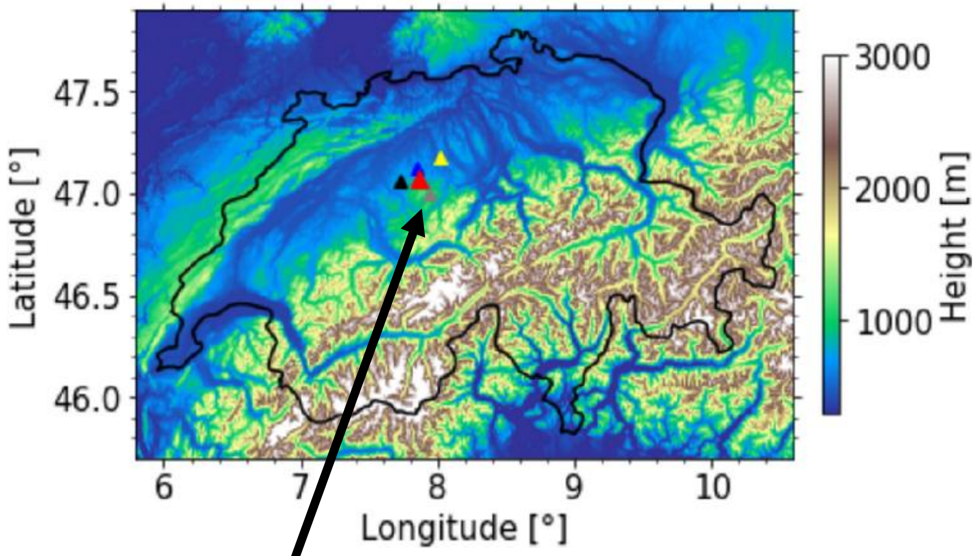
Precipitation: Spatial representativeness & model intercomparison

Precipitation underestimated by model during seeding

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

ICON D2





▲Eriswil, ▲Huttwil, ▲Napf, ▲Affoltern, ▲Egolzwil

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

Summary

- Case study from 8 Jan 2024 with natural seeding effect was shown
  1) Seeder-Feeder process increases precipitation by about 10-30%
  2) No precipitation formation in stand-alone supercooled stratus layer
  3) Water and ice coexisted, interacted and formed graupel on the way through the cloud
- Weather model (ICON D2) was found to:
  1) underestimate the seeder-feeder effect
     - wrong representation of seeder-feeder process within the model?
  2) overestimate precipitation from the stratus (Bise-cloud) layer
     - impact of low ice nucleating particle (INP) concentrations? See Poster #25
- This study Ohneiser et al., 2025 will be submitted to ACP soon