

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

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- Motivation for CloudLAB and PolarCAP
- Methods
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- Summary



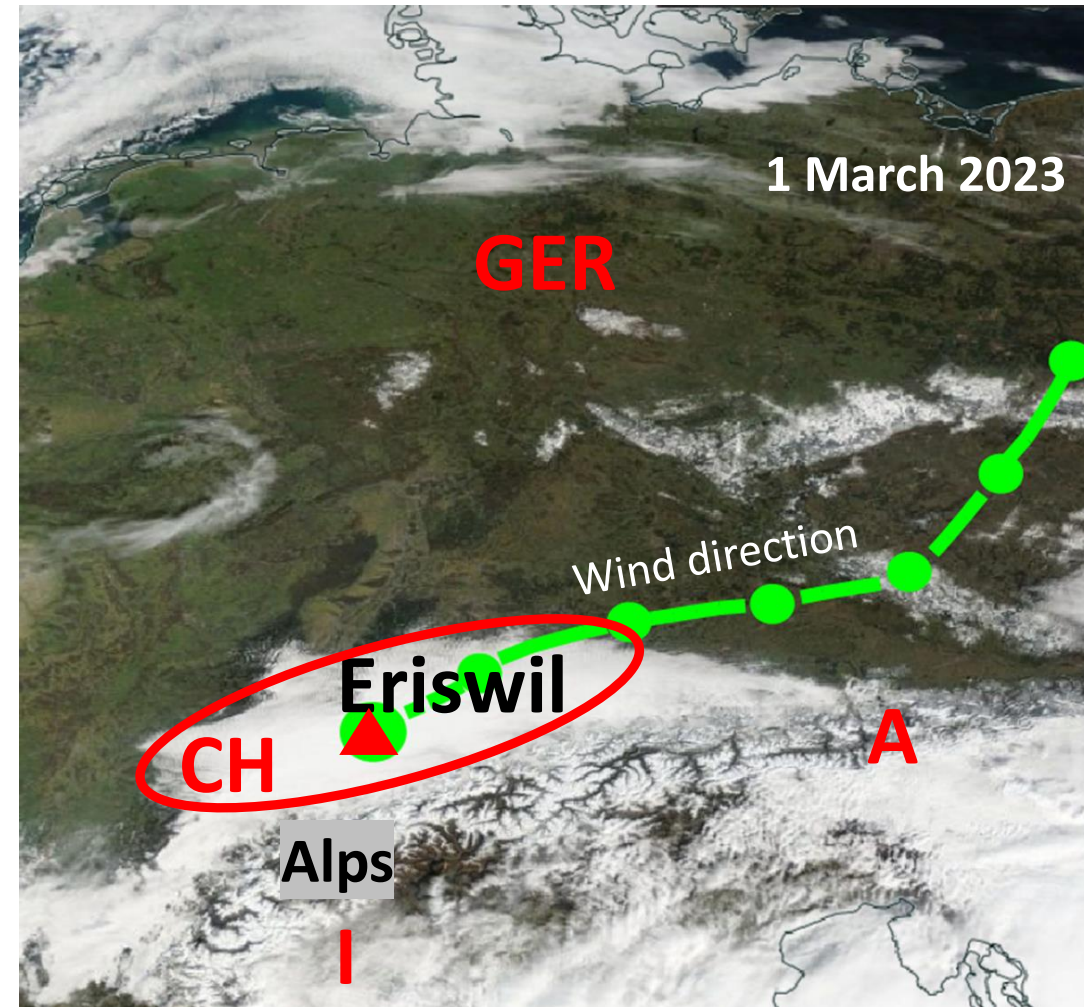
**ETH** zürich

**TROPOS**  
Leibniz-Institut für  
Troposphärenforschung

# Bise – typical weather in Swiss winter



<https://www.wetterzentrale.de/reanalysis.php?jaar=2023&maand=3&dag=1&uur=000&var=45&map=1&model=bra>



<https://worldview.earthdata.nasa.gov/?v=-6.39392472134954,42.27995324032231,23.419533387584295,56.13855290814701&t=2023-03-01-T12%3A21%3A13Z>

# Below vs above Bise clouds

~920 m ü. NN



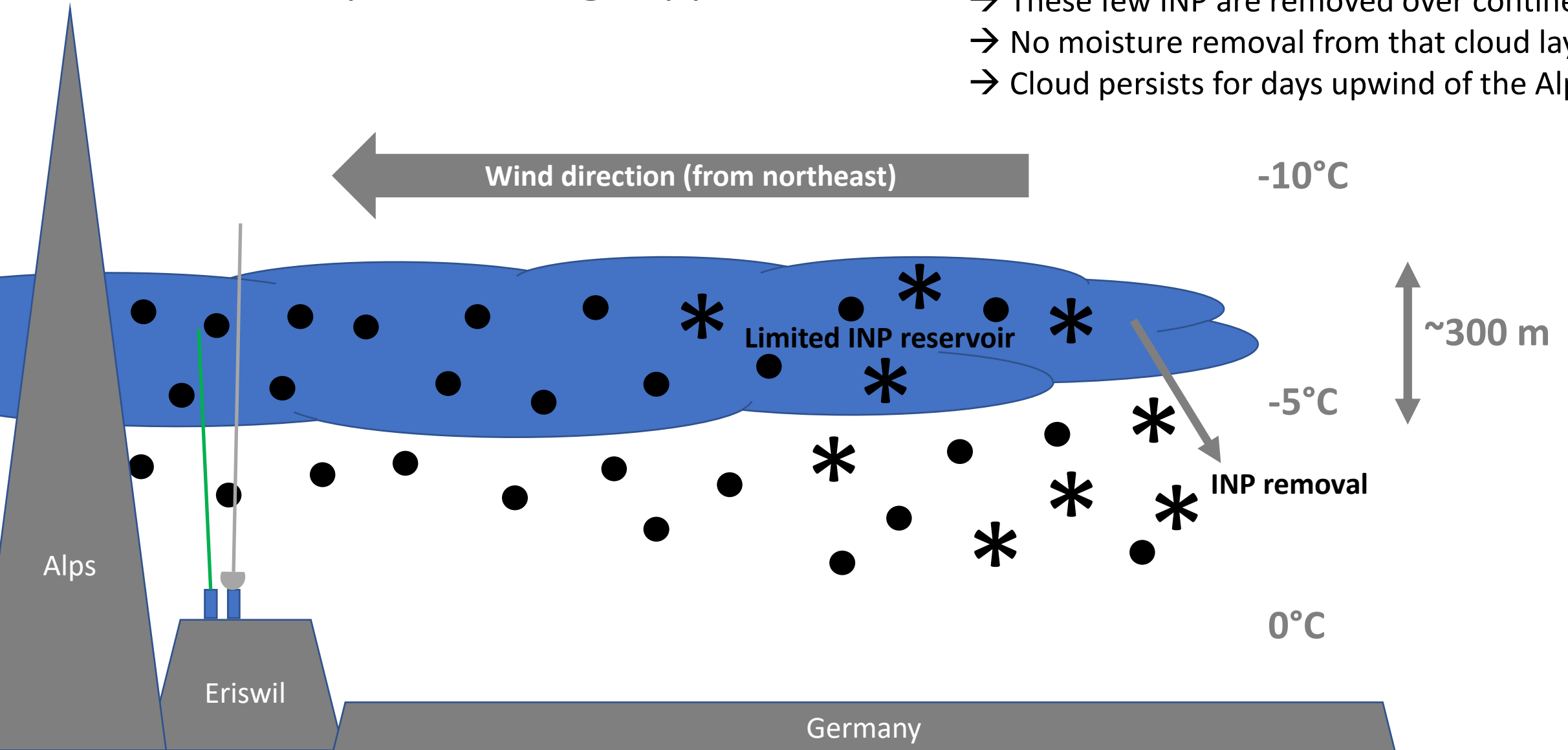
Above Bise clouds

~1300 m ü. NN



# Preliminary working hypothesis

- Many CCN from eastern Europe but few INP
- These few INP are removed over continent
- No moisture removal from that cloud layer
- Cloud persists for days upwind of the Alps





DFG SPP  
2115 PROM

# PolarCAP:

## → Polarimetric Radar Signatures of Ice Formation Pathways from Controlled Aerosol Perturbations

- Jointly with ERC project **CloudLAB** of ETH Zürich (U. Lohmann)
- Utilization of UAV-borne cloud seeding experiments and Holo-Balloon observations of ETH Zürich
- 2023-2025; 3 LACROS winter campaigns near Eriswil, CH
- **Goals:** microphysical closure; spectral-bin model development; forward operators
- 2 PostDocs (1 Obs, 1 Model)



(c) Jan Henneberger:  
First Cloudlab campaign  
2021/22

-10...0 °C

supercooled stratus

Seeding drone (ETH)

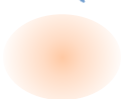
In-situ drone (ETH)

Holo-Balloon (ETH)

COSMO-SPECS



Ice crystal

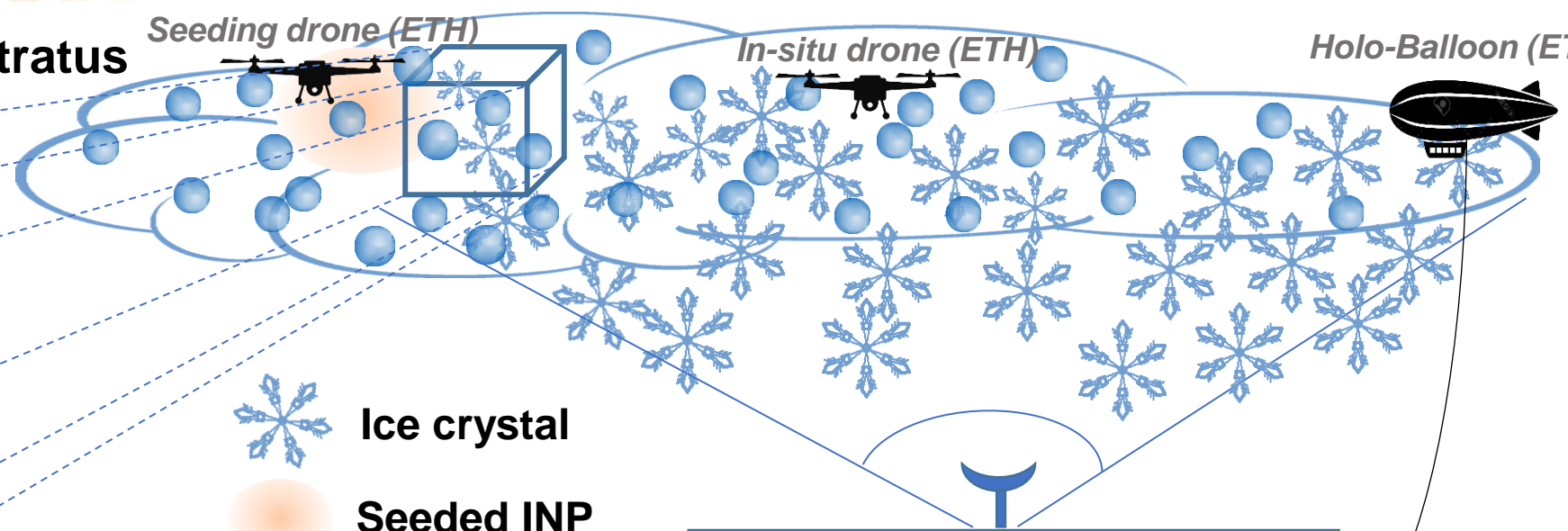
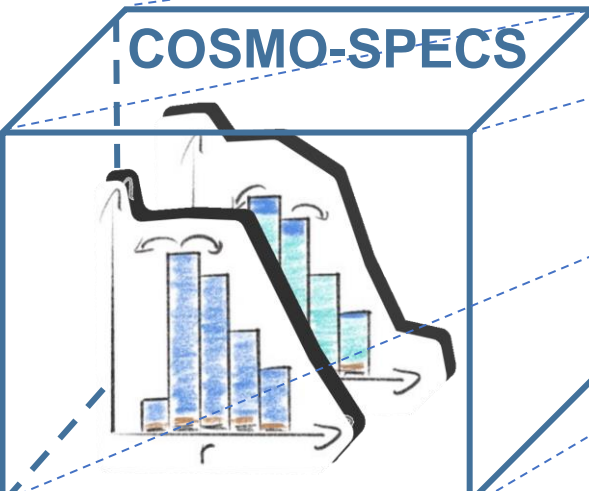


Seeded INP



Cloud droplet

LACROS + ETH remote sensing



# Measurement setup in Eriswil

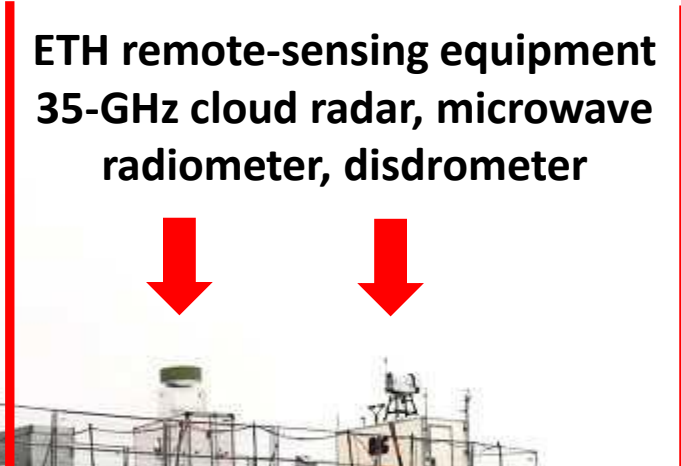
**TROPOS remote-sensing  
equipment LACROS**



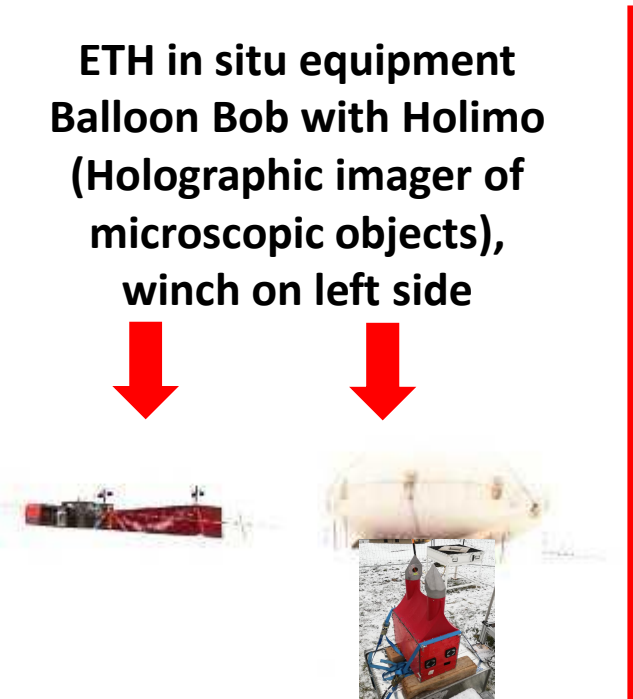
**Meteo Swiss  
wind profiler**

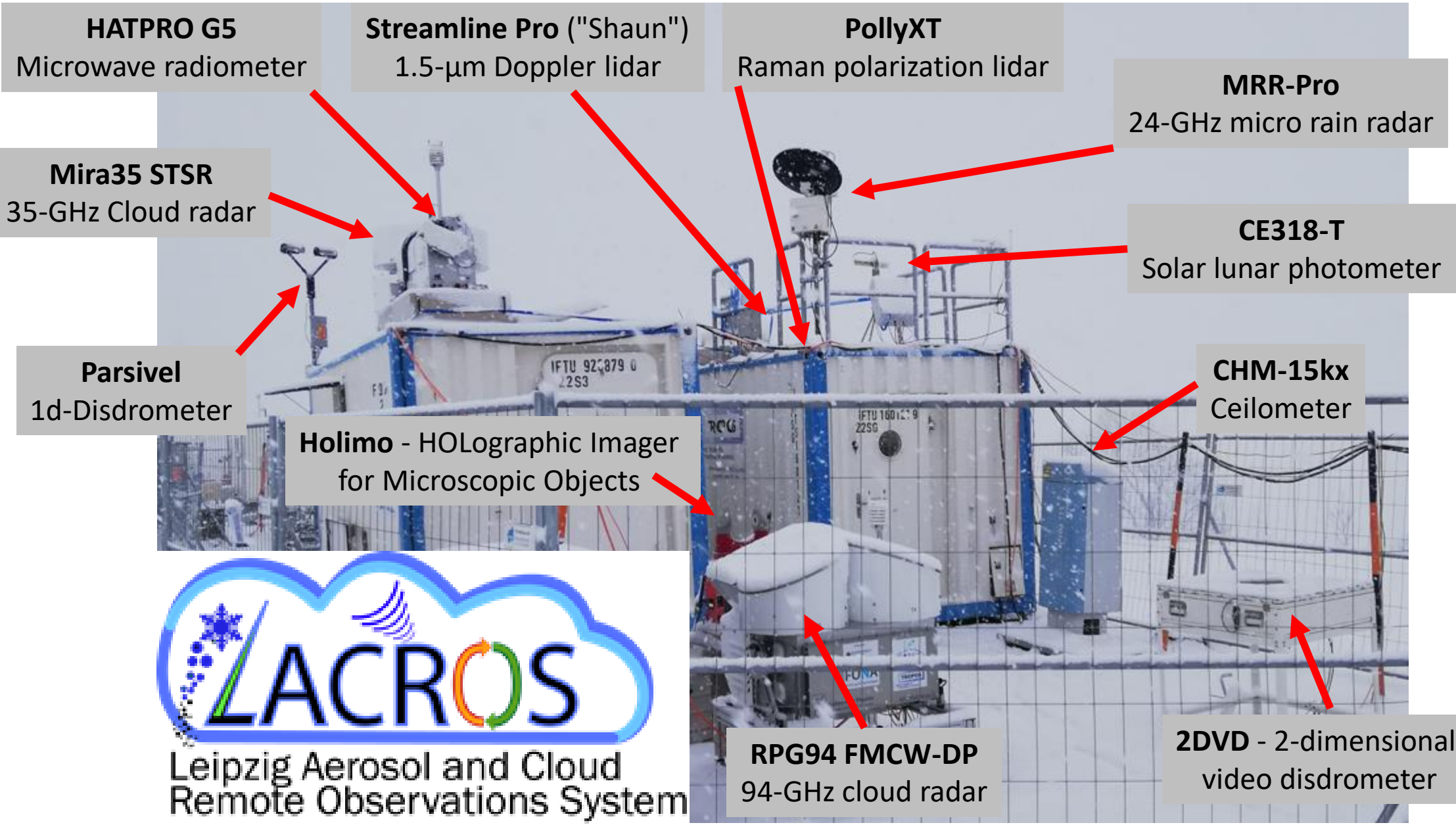


**ETH remote-sensing equipment  
35-GHz cloud radar, microwave  
radiometer, disdrometer**



**ETH in situ equipment  
Balloon Bob with Holimo  
(Holographic imager of  
microscopic objects),  
winch on left side**





**HATPRO G5**  
Microwave radiometer

**Streamline Pro ("Shaun")**  
1.5-µm Doppler lidar

**PollyXT**  
Raman polarization lidar

**MRR-Pro**  
24-GHz micro rain radar

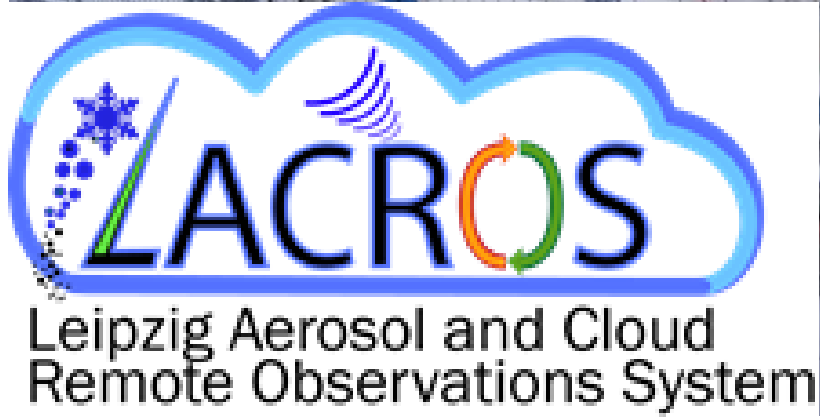
**Mira35 STSR**  
35-GHz Cloud radar

**CE318-T**  
Solar lunar photometer

**Parsivel**  
1d-Disdrometer

**CHM-15kx**  
Ceilometer

**Holimo - HOlographic Imager**  
for Microscopic Objects



**RPG94 FMCW-DP**  
94-GHz cloud radar

**2DVD - 2-dimensional**  
video disdrometer

# PolarCAP - Research questions

- First chance to evaluate of microphysical retrievals (**Obs**)
  - Unique chance of co-located holographic in-situ imagery aboard tethered balloon
- Role of contact and immersion freezing in stratocumulus seeding experiment (**Model**)
- Role of secondary ice formation and ice multiplication (**Obs**, **Model**)
  - Depending on temperature-range of observed stratus layers
- Challenge the process understanding in models: (**Model**, **Obs**)
  - Constraining the efficiency of ice-nucleating substances
  - Linking microphysical time scales to stratus decay times
- Advance coupling of cloud model simulations and radar forward operators (**Model**)





# Overview of product status

Retrieval	Status
Cloudnet	<ul style="list-style-type: none"><li>• Available</li></ul>
VOODOO (Detection of supercooled liquid)	<ul style="list-style-type: none"><li>• Data quality issues (radome icing)</li><li>• Processing until summer</li></ul>
PeakTree (Detect co-existing ice and liquid water droplets in clouds)	<ul style="list-style-type: none"><li>• Data format issues</li><li>• Possibly available until summer</li></ul>
Fallstreak tracking	<ul style="list-style-type: none"><li>• Available</li></ul>
Dual wavelength ratio	<ul style="list-style-type: none"><li>• Available</li></ul>
Ice crystal number concentration	<ul style="list-style-type: none"><li>• To do</li><li>• In-house (Bühl 2019) &amp; CAPTIVATE</li></ul>
Polarimetric shape retrieval	<ul style="list-style-type: none"><li>• Not possible for MBR7 (MIRA35 TROPOS)</li><li>• Not yet tested for MBR5</li></ul>

# Campaign calendar CLOUDLAB

Winter 2021-2022

Winter 2022-2023

Winter 2023-2024

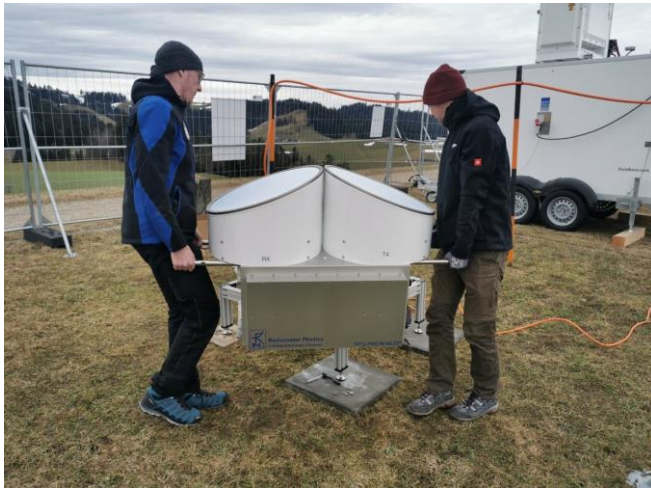
Winter 2024-2025

- Prerequisite for PolarCAP project starting in winter 2022-2023
- Article for BAMS

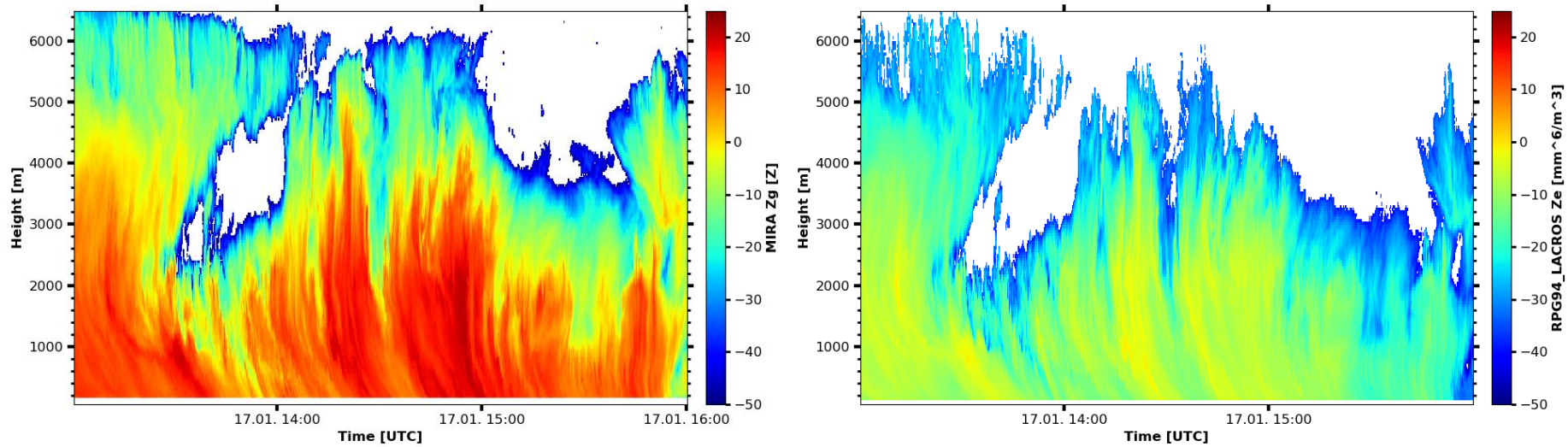
- Develop scan strategy
- 2DVD – Holimo comparisons
- Experience on-site

- Improved scan strategy
- Warm seeding cases
- Repeat dispersion experiment with other lidar settings
- More on-site presence

**To be defined**

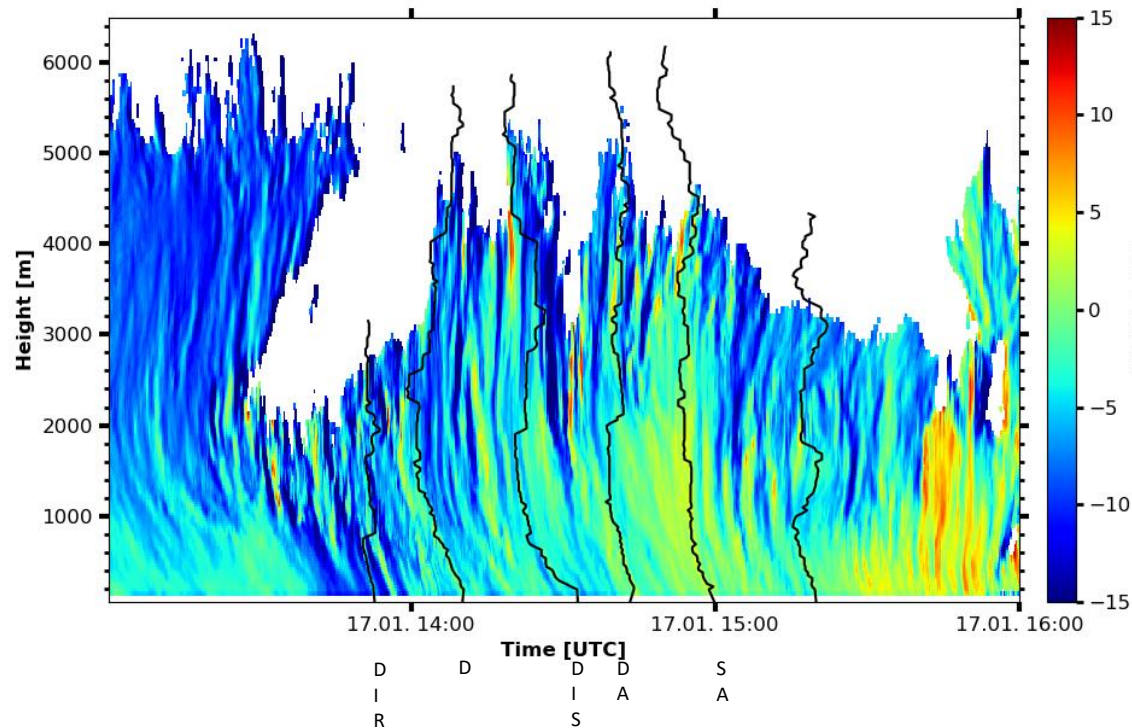


# Calculate dual wavelength ratio between RPG94 and Mira35



Combine DWR with fall  
streak tracking algorithm

Detect potential liquid layers

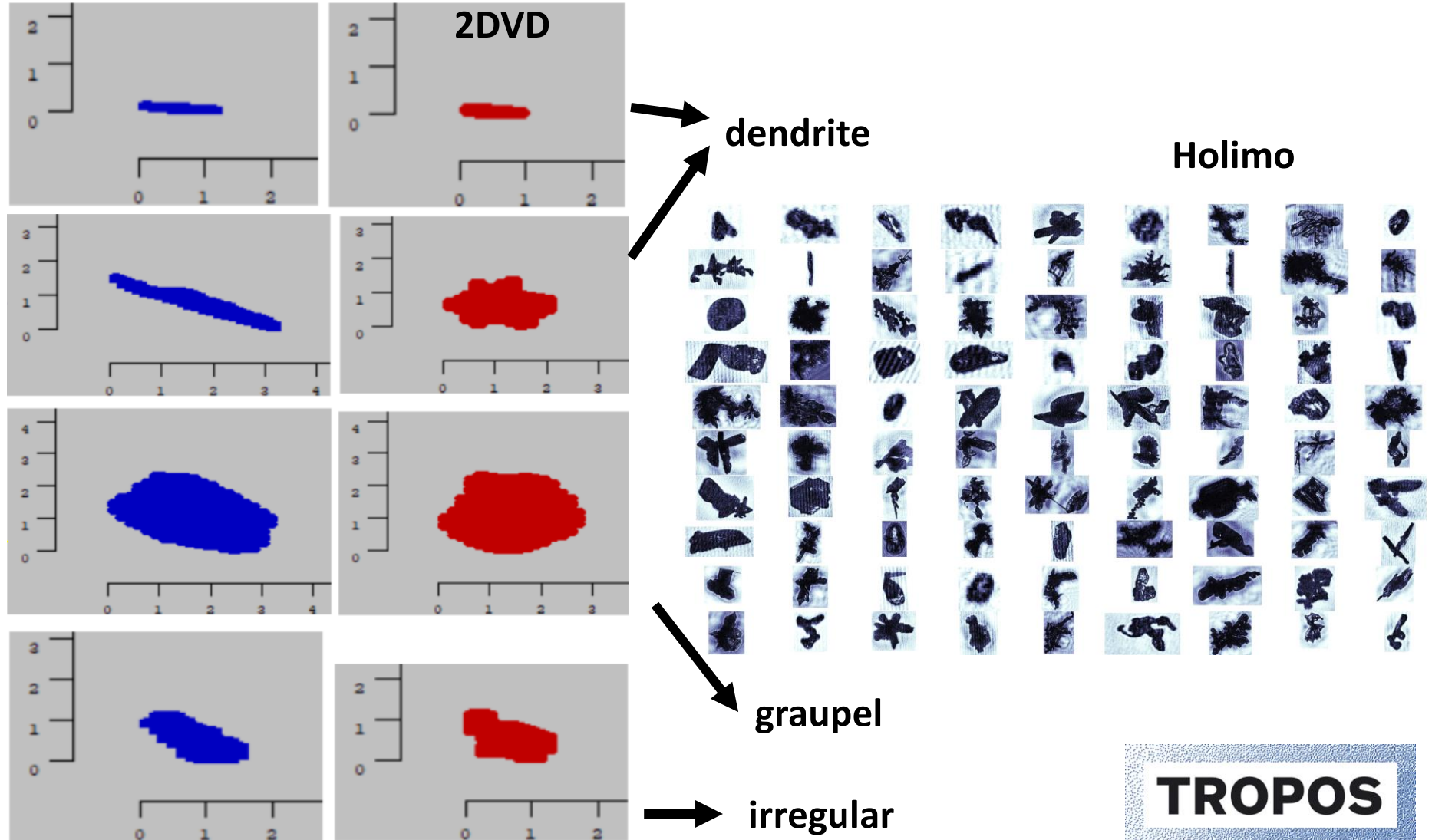
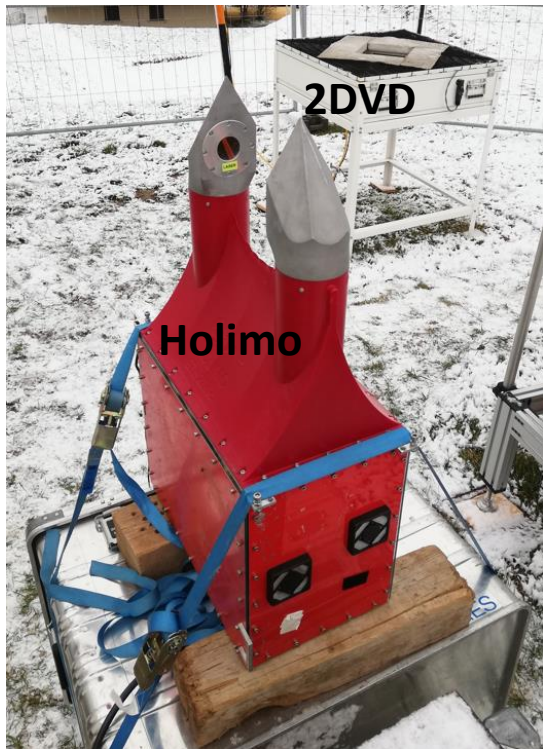


- D – Dendrites    I – Irregular
- R – Rimed        N – Needles
- A – Aggregates   S – Heavy snowfall



# 2D- video disdrometer measurements vs Holimo measurements (side by side)

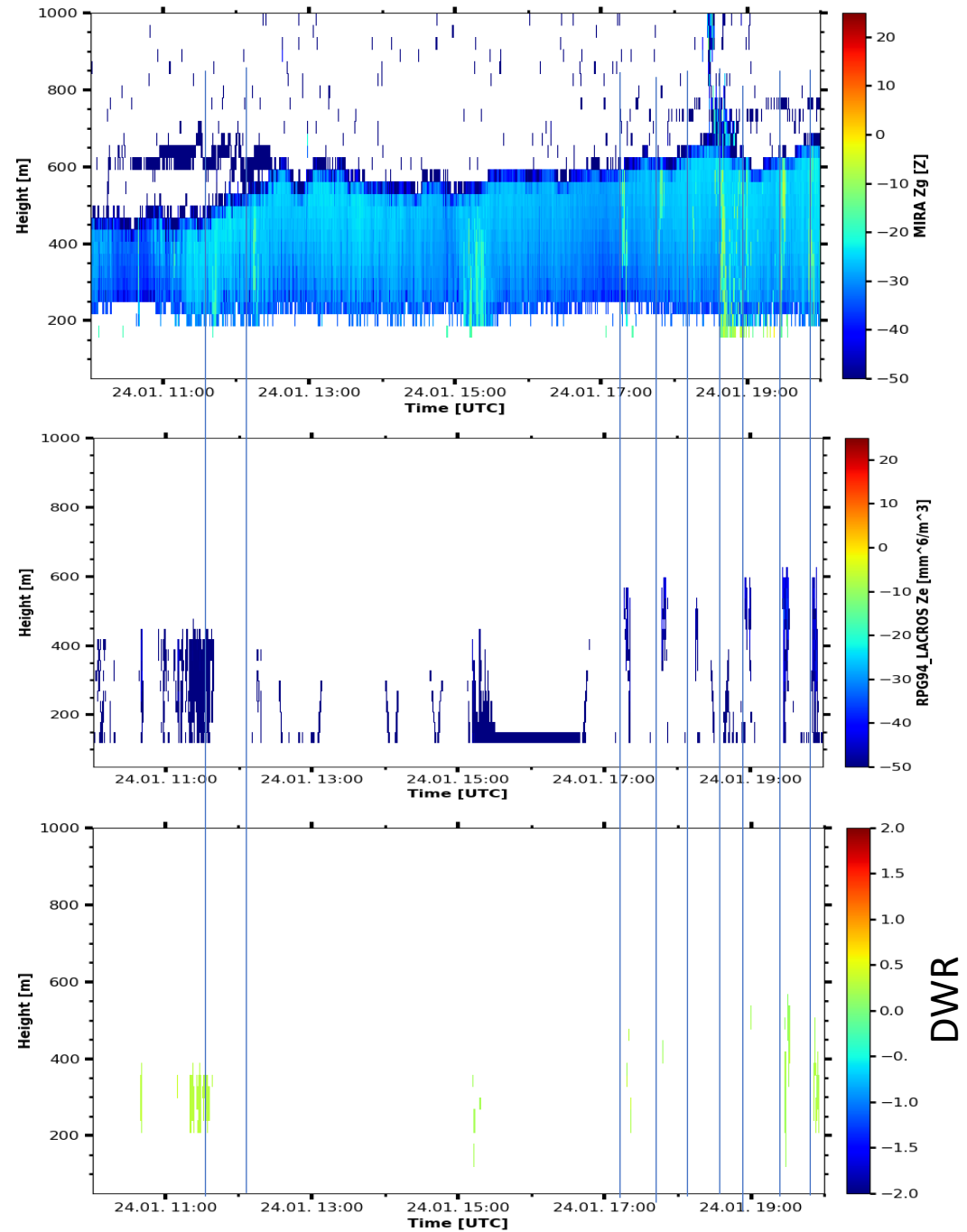
17 January 2023,  
13:52-13:55 UTC  
Observations of dendrites,  
rimed graupel,  
and irregular ice crystals



# Seeding experiments on 24 Jan 2023

## - Calculate dual wavelength ratio

Low reflectivity for the RPG94 – problems with icing



# Conclusions / Outlook

- First chance to evaluate of microphysical retrievals
- Unique chance of co-located holographic in-situ imagery aboard tethered balloon
- Role of secondary ice formation and ice multiplication
- Next winter campaign very important to measure more remaining scenarios