Technische Universität Braunschweig

DFG Deutsche Forschungsgemeinschaft

AWIPEV 79°N Arctic Research Base Ny-Ålesund

TROPOS Leibniz Institute for Tropospheric Research

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# Airborne measurements of ultrafine aerosol particles during melting season 2024 using UAV and tethered balloon – Overview and first results

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# AIDA – Airborne Aerosol Measurements in Ny-Ålesund

"**A**erosol variability and **I**nteraction with ambient conditions based on small-scale vertical and horizontal **D**istribution of **A**rctic measurements" *(DFG founded project 519822612 – 3 years)*


*Ground-Based Research Stations*

*ALADINA*


Picture: Esther Horvath

*BELUGA*

**Measurement period: 19th May – 7th June 2024**

Joint project of TROPOS Leipzig and TU Braunschweig

# Research Goals of AIDA

1) What is the **vertical and the horizontal small-scale variability of NPF** (New Particle Formation) at a complex Arctic site - influenced by multiple surface conditions and clouds?

2) Which thermodynamical, meteorological, and turbulent **processes trigger NPF** and cause or suppress (especially in the vertical distribution) transport of NPF?

3) Observations on small-scales **transferable to different years and locations**?

**Approach:**

→airborne measurements of aerosol, meteorological parameters and radiation

→simultaneous deployment of two airborne systems ALADINA and BELUGA

→vertical and horizontal profiles up to 1 km altitude

# Motivation for Airborne Aerosol Measurements in Ny-Ålesund

Ny-Ålesund is the best-suited measurement location:

- **Continuous observations** of meteorology (e. g. radiation), aerosol properties, precursor gases
- Different **wind regimes** induced by complex orography and contrasting surface conditions
- Direct measurements above **multiple surface conditions** possible within 1 km distance

**Advantages of joint measurements during melting season**:

- best conditions for NPF during spring – summer transition: snow melt, high solar radiation and biological activity
- our mobile systems add spatial data to ground-based observations to understand the 3-D picture of Kongsfjord
- first time combination of BELUGA and ALADINA

# ALADINA - Uncrewed Aircraft System

Flight conditions:

- wind speed < 15 m $s^{-1}$
- Visual Flight Rules (not inside clouds)
- no precipitation

Technical information:

- flight duration 40 min
- constant cruising speed 28 m $s^{-1}$
- payload 4.5 kg
- live data observation
- heated inner compartment (25°C)
- fast turnaround time of ~20 min
- electrically powered (5 kW)

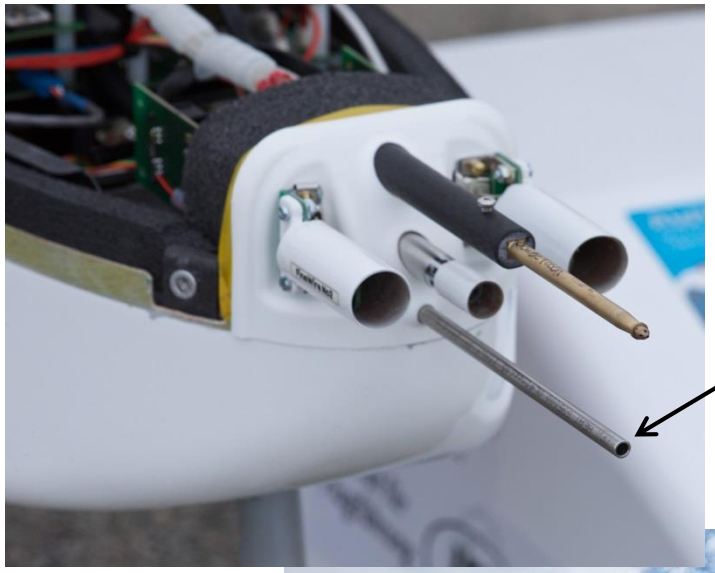
Aerosol instruments:

- 2x CPCs (TSI model 3007)
- 1x OPC (Met One Instruments model GT-526S)

# ALADINA - Version 4 Atmospheric Instrumentation

| Variable | Sensor | Measuring range |
|---|---|---|
| Temperature | FWRT, TSYS01, HMP110 | -20 to +50 °C |
| Relative humidity | Rapid P14, HMP110 | 0-100 % RH |
| 3D Windvector | Multi hole probe, TU Braunschweig | 0-35 m $s^{-1}$ |
| Solar (reflex) radiation | 2 Pyranometers (EKO ML-020VM, EKO Instruments) | 0-1400 W $m^{-2}$ |
| Surface temperature | IR thermometer MLX90614 | -70 to 380 °C |
| Aerosol particle number concentration | CPC1 (model 3007, TSI Incorporated) | ~5 nm - 2 µm |
| Aerosol particle number concentration | CPC2 (model 3007, TSI Incorporated) | ~20 nm - 2 µm |
| Size distribution of aerosols | OPC (model GT-526S, Met One Instruments) | 0.39-10 µm (6 channels) |

$N_{5\text{-}20}$

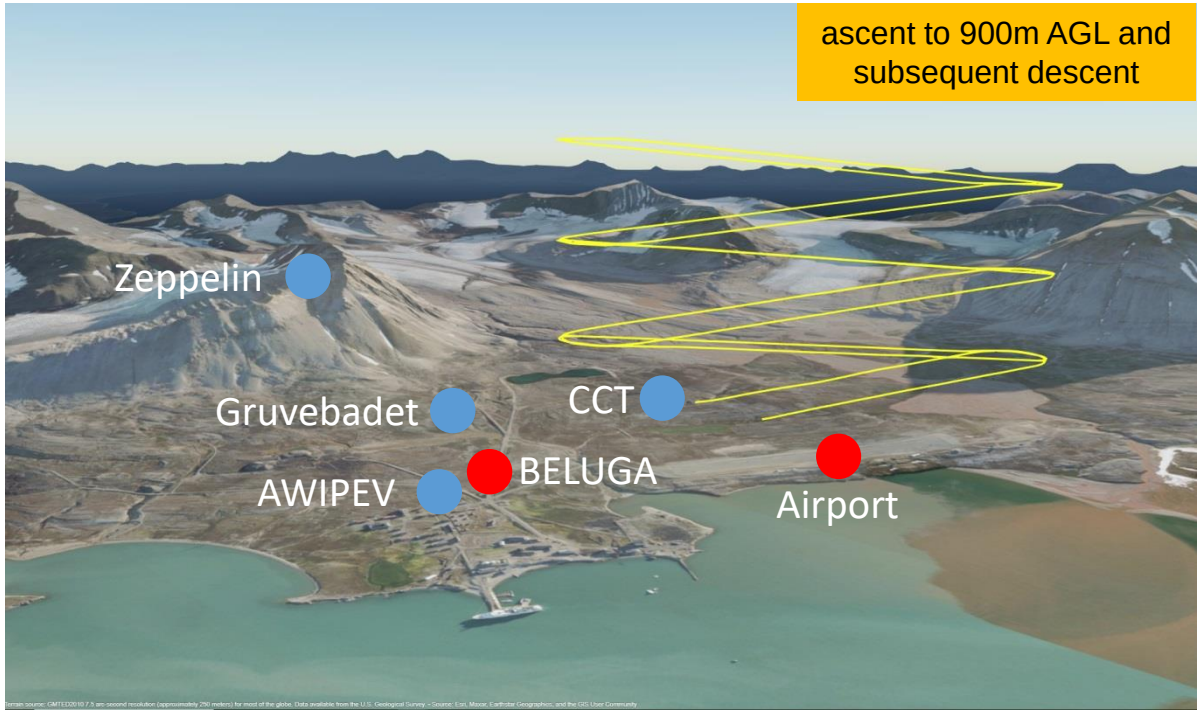


inlet to aerosol instrumentation

100 Hz sampling rate

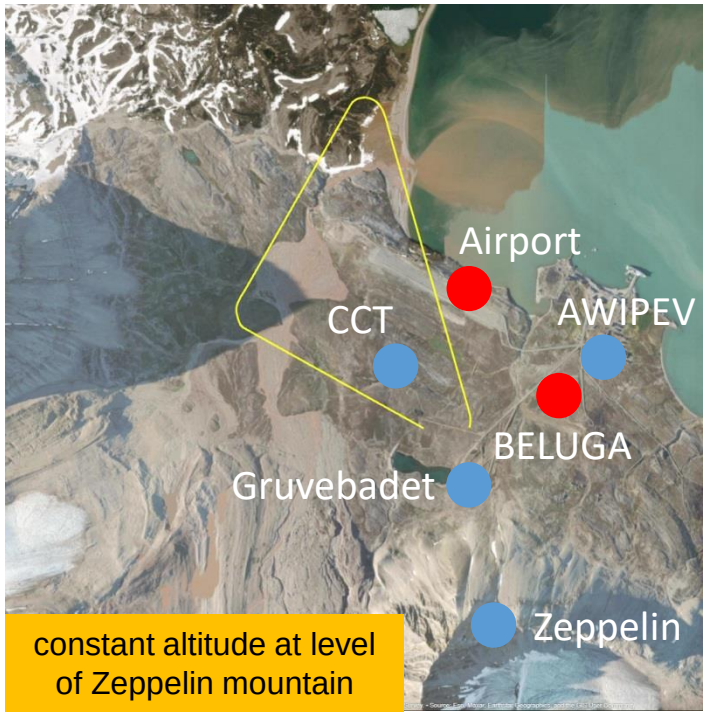
# ALADINA – Flight Profiles performed in Ny-Ålesund

## a) Vertical flight profile




- min. altitude airport ground level (~35 m MSL)
- max. altitude 1000 m AGL
- ~7 minutes per ascent/descent
- geometry 1.7 km x 0.2 km

## b) Horizontal flight profile




- const. altitude at level of Zeppelin mountain and 100 m below and 100 m above (plus extra altitudes depending on ABL and NPF event)
- ~3 minutes per horizontal profile
- geometry ~ 1.5 km x 1.5 km

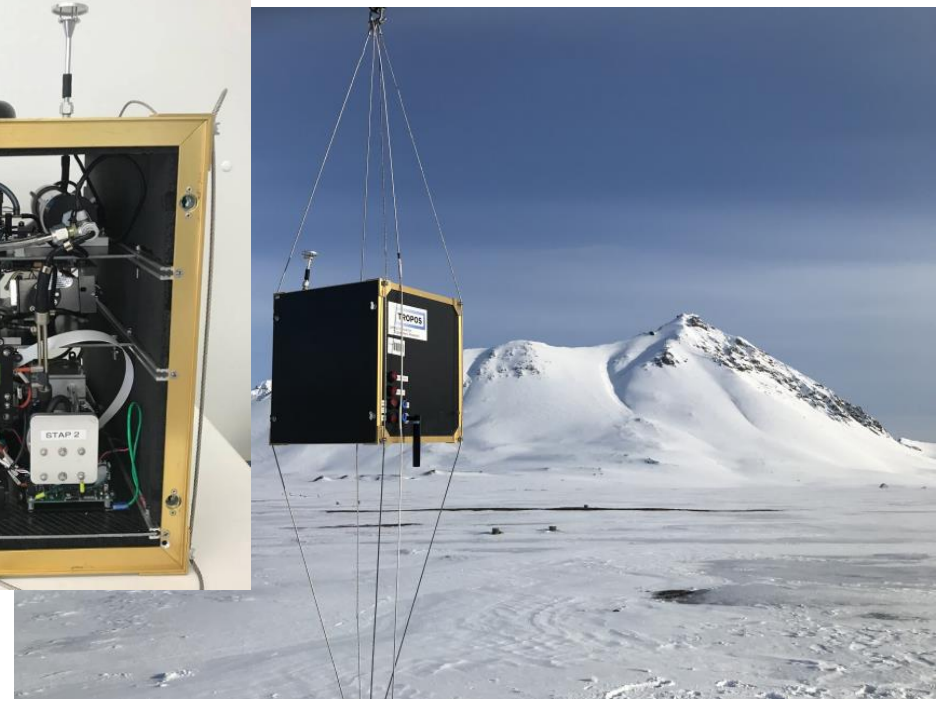
# BELUGA (Balloon-bornE moduLar Utility for profilinG the lower Atmosphere)

The tethered balloon system allows for :

- Small scale vertical measurements up to 1500 m altitude
- Sampling at constant altitude
- Measurements through clouds
- A variable instrument payload up to 15 kg

# BELUGA

**CAMP** (**C**ubic **A**erosol **M**easurement **P**lattform)



## Aerosol measurements:

- Two Condensation Particle Counter (CPC, TSI 3007, m

  Particle number concentration above **8 nm** → $N_8$
  Particle number concentration above **12 nm** size → $N_{12}$

- Portable Optical Particle Spectrometer (POPS, Handix):

  Number size distribution between **150 and 2500 nm** → $\mathbf{N_{150}}$

- Single-Channel Tricolor Absorption Photometer (STAP, Brechtel):

- Particle absorption at 3 wavelengths (**450, 525 and 624 nm**)

## Meteorological Payload:

Standard Meteorology (STD)

Temperature, pressure, humidity, wind speed and direction

# BELUGA

**mSEMS (m**iniaturized **S**canning **E**lectrical **M**obility **S**izer**) Box**

First field application of new instrument setup with a lightweight particle size spectrometer

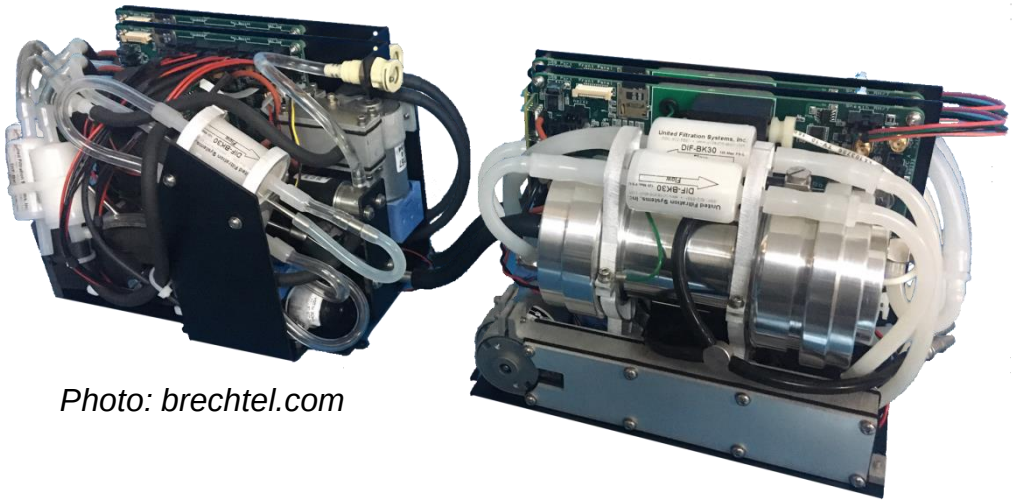
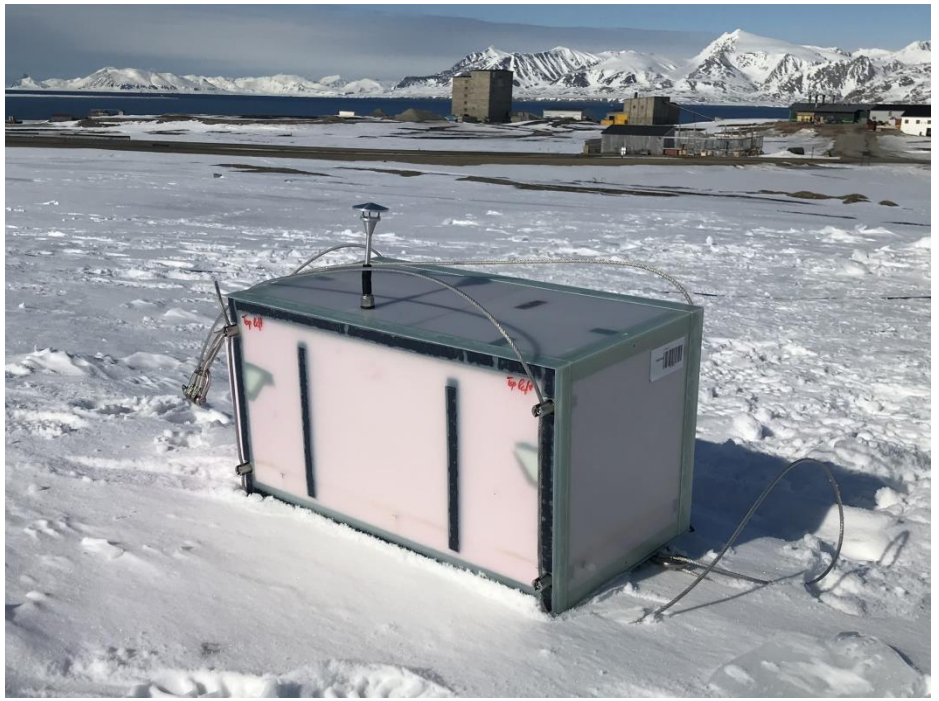


*Photo: brechtel.com*

mSEMS **particle size distribution** measurements:

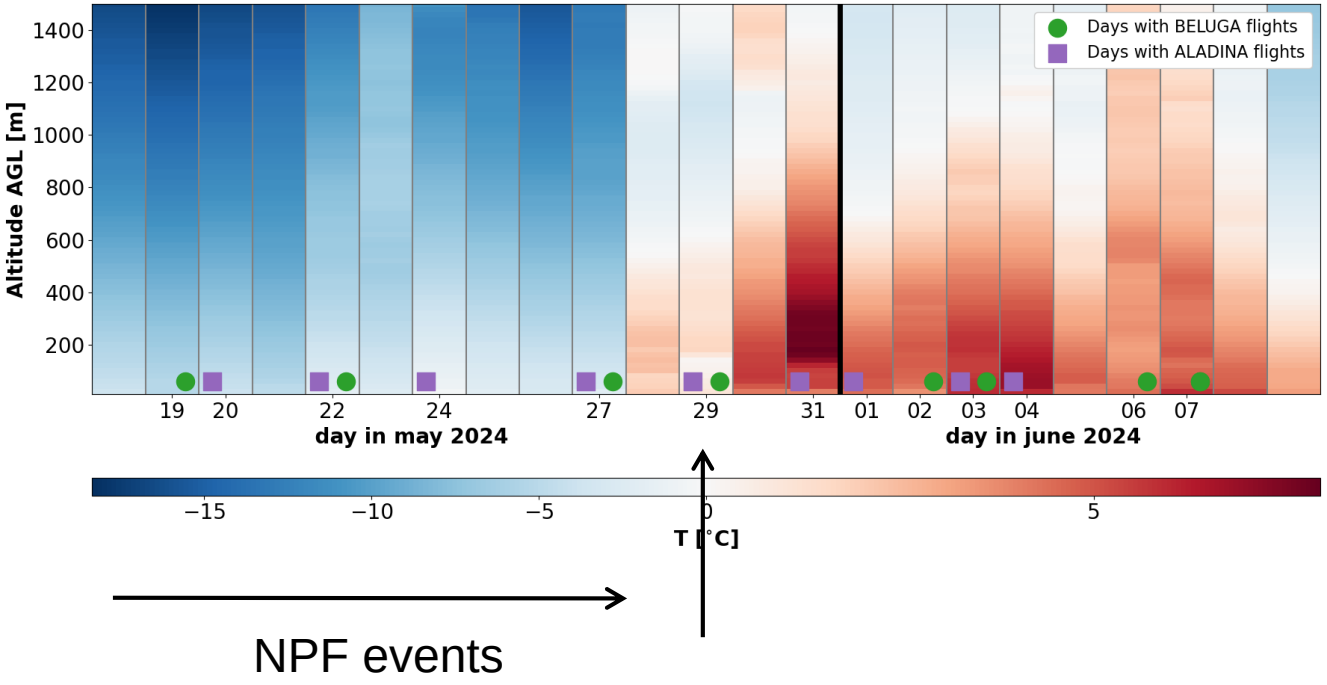
- between 8 and 300 nm
- 30 size bins
- Scanning time: 1 min
- GRIMM X-Ray charger

+ CPC ($N_8$) and POPS



# Campaign Overview

- 40 measurement flights on 9 days with ALADINA, a total of 136 profiles and 35 hours of data
- 45 measurement flights on 8 days with BELUGA, a total of 90 profiles
- parallel measurements with both systems on 4 days




NPF events

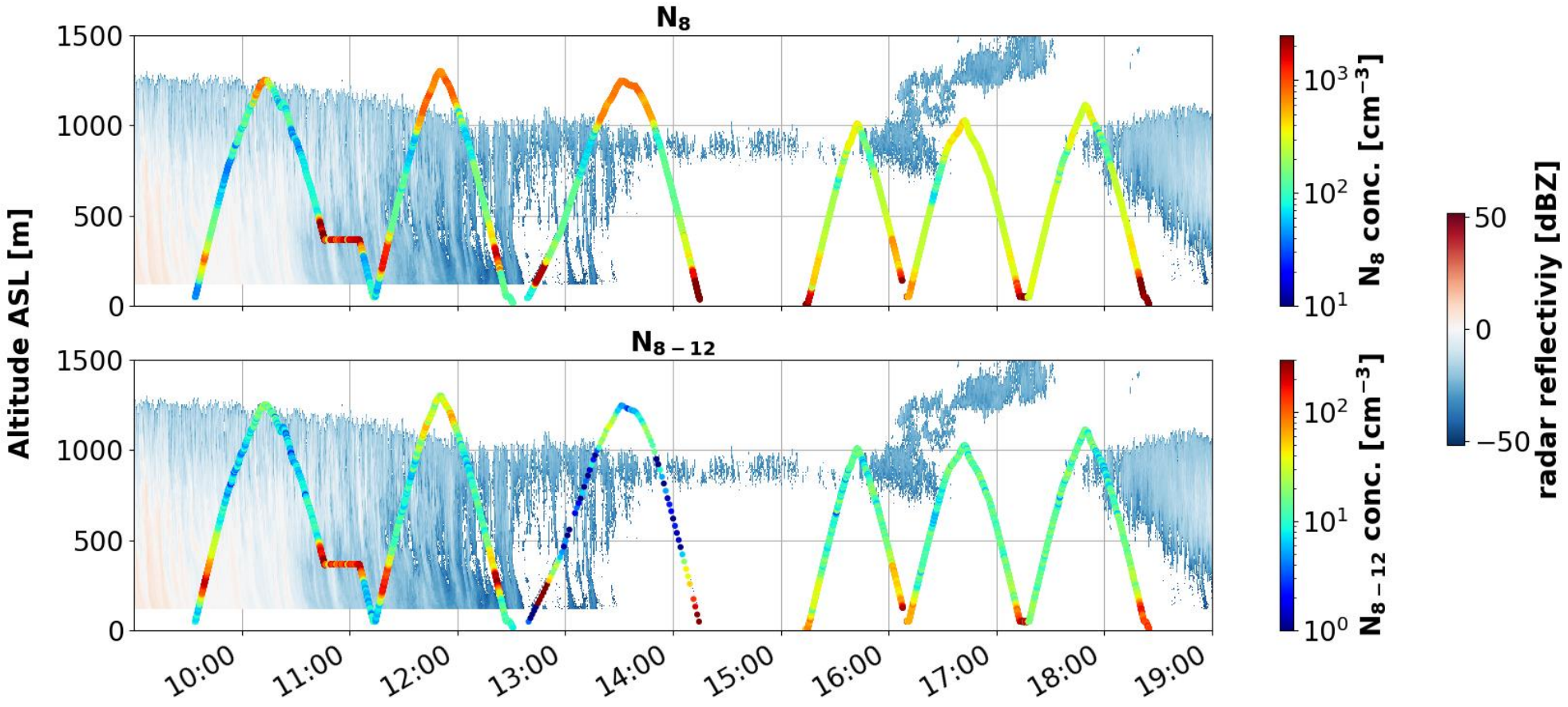
13th May

10th June

Cloud related NPF event → NPF events at low altitude →

large particles non-event days

# First Results: 29th May



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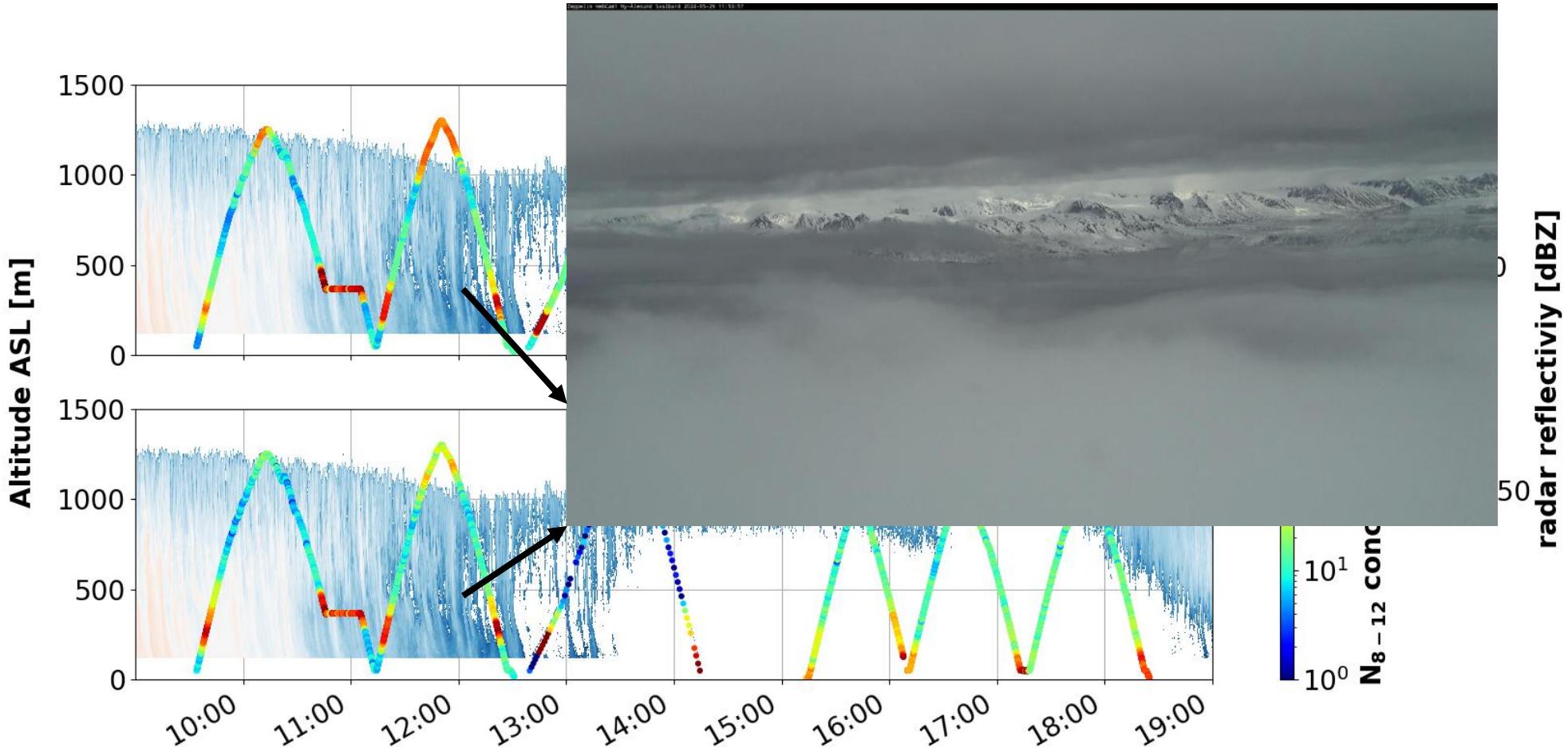
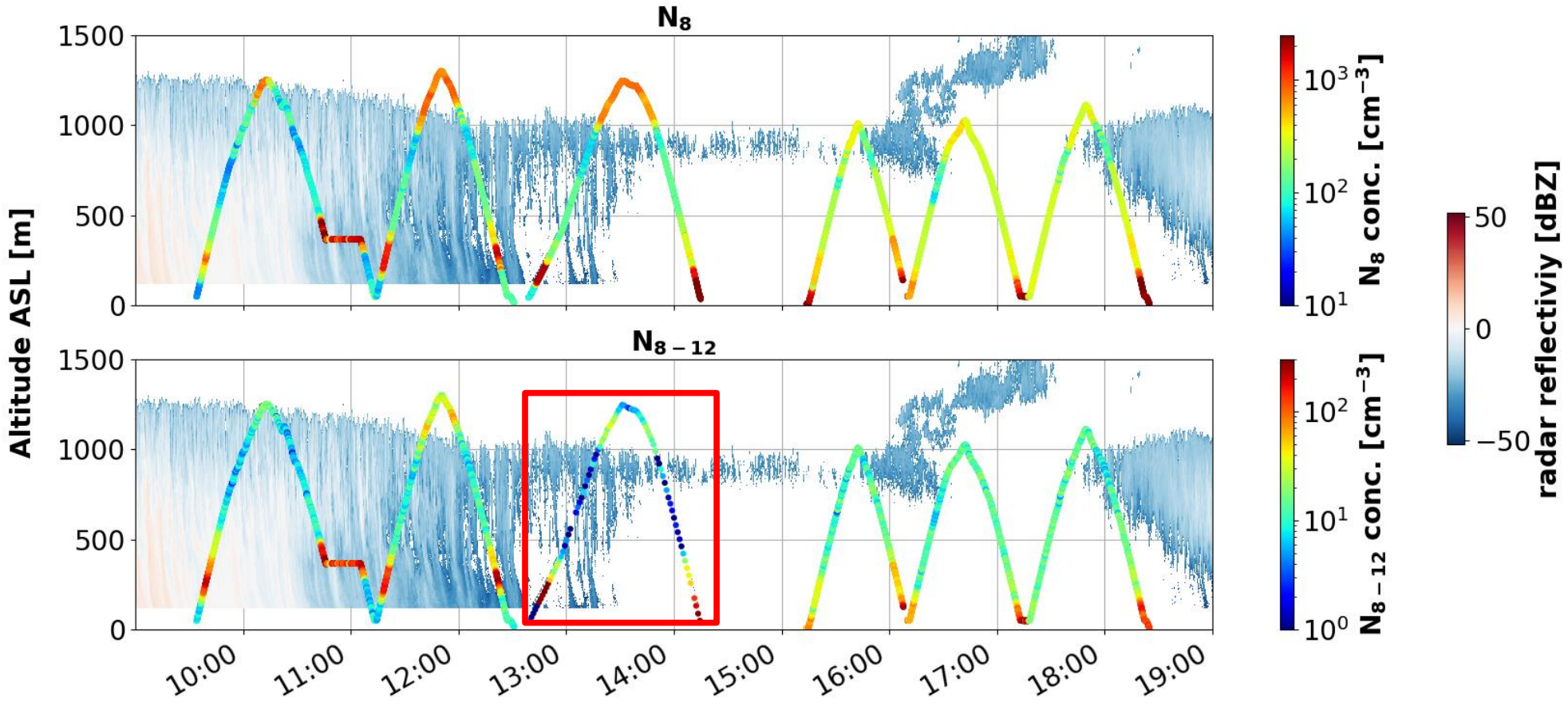
# First Results: 29th May

*Photo: Webcam Zeppelin Mountain, 11:57 UTC*

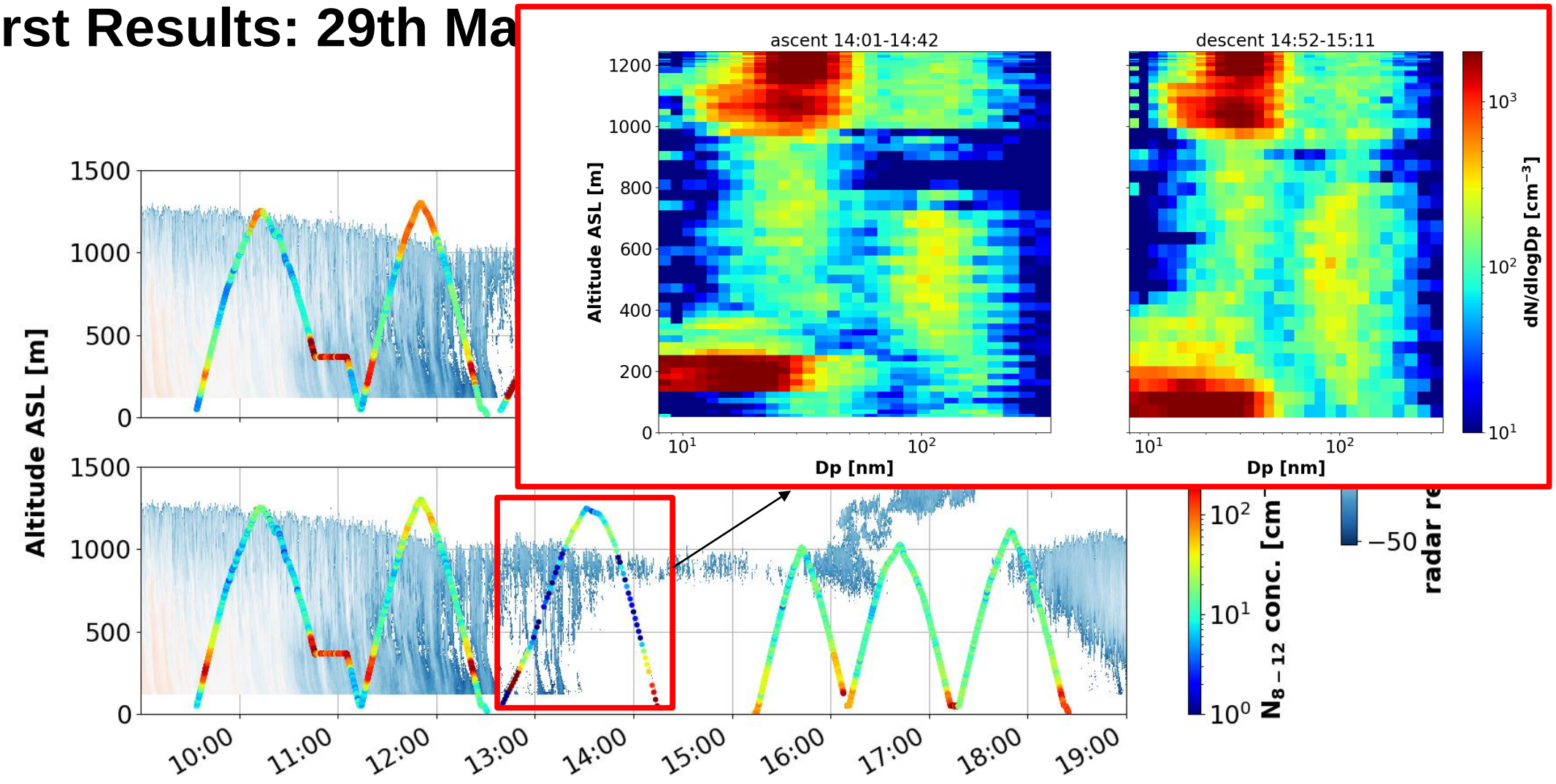


# First Results: 29th May




Thanks to Kerstin Ebell for Cloud radar data!

# First Results: 29th Ma

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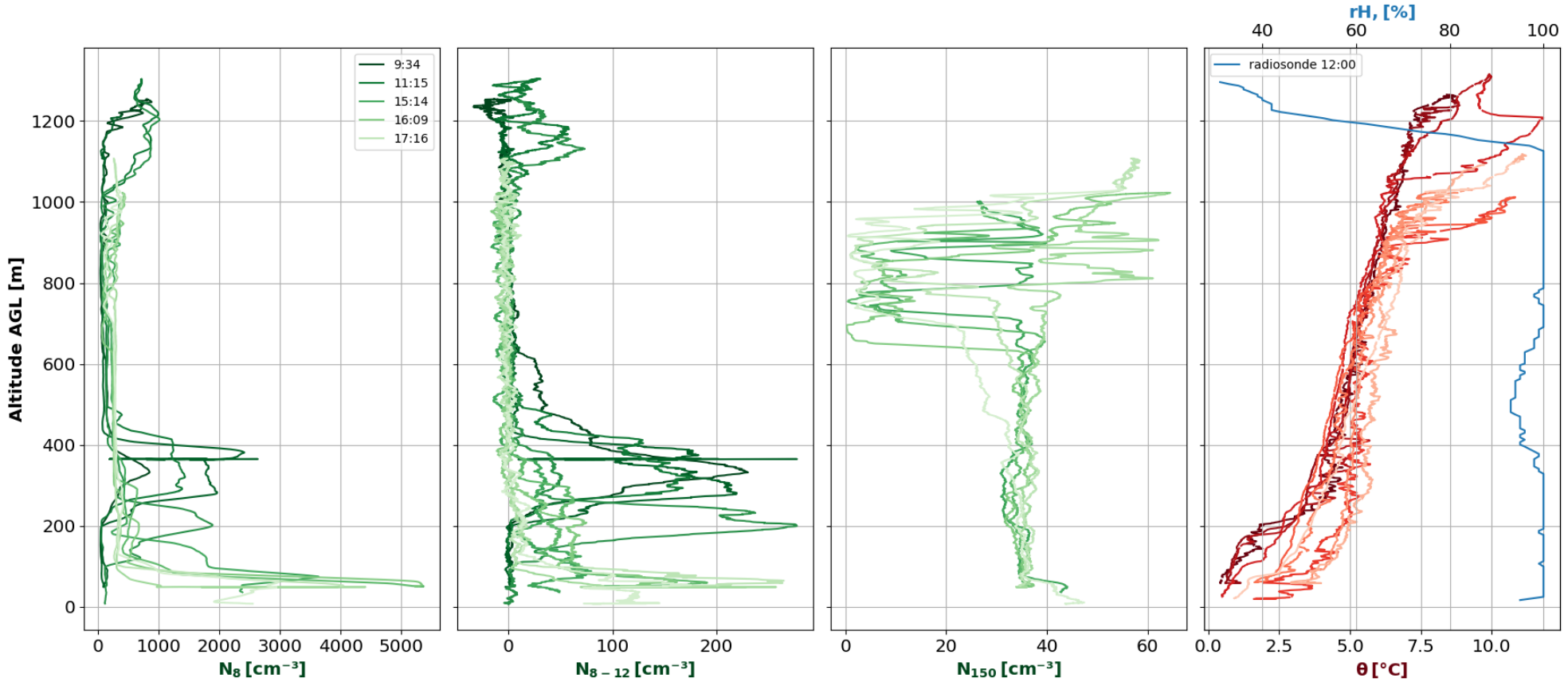
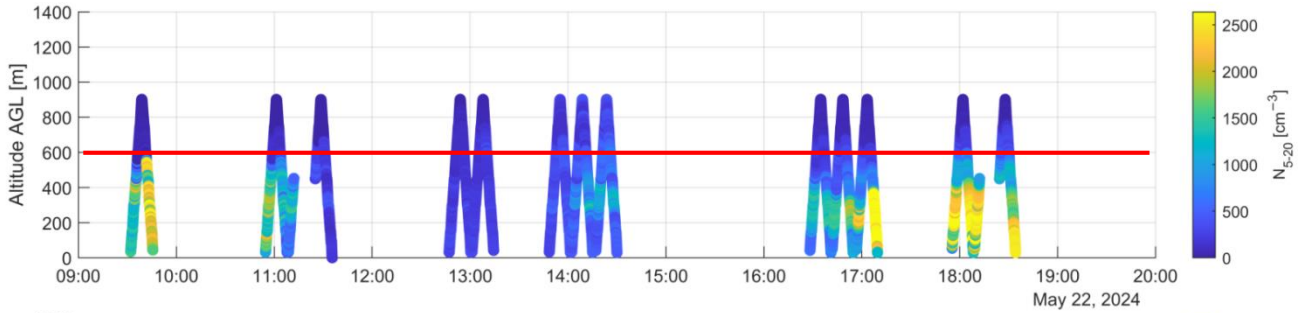
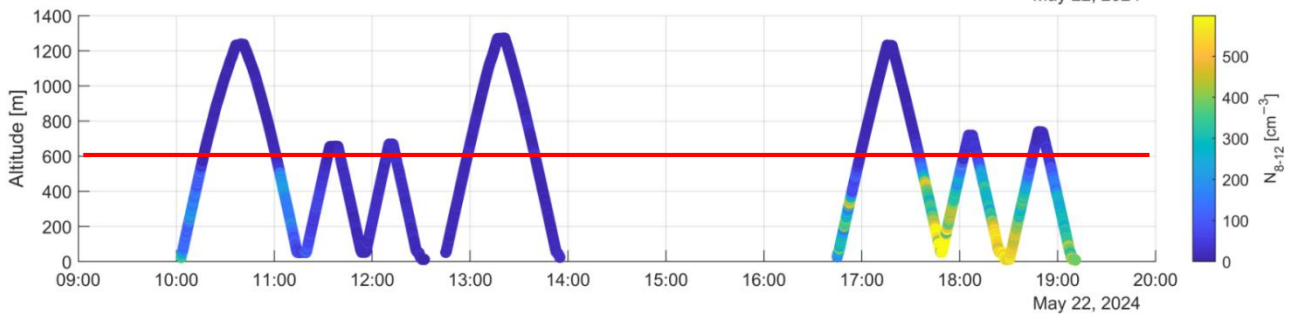
# First Results: 29th May



# 22nd May // Joint Measurements during interrupted NPF Event

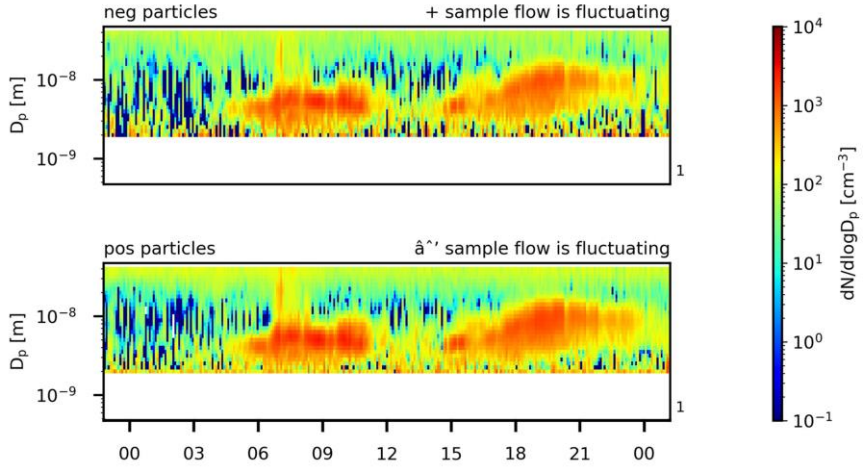

Picture: Esther Horvath




NW

S/SE (from 15 UTC)




NAIS data* at Zeppelin Observatory (ZEP):

*preliminary data provided by Dominic Heslin-Rees (Stockholm University)

- interrupted NPF event (also at ZEP+GRU) within two periods 6-11:30 UTC and 14-21 UTC
- occurrence of UFP below 600 m



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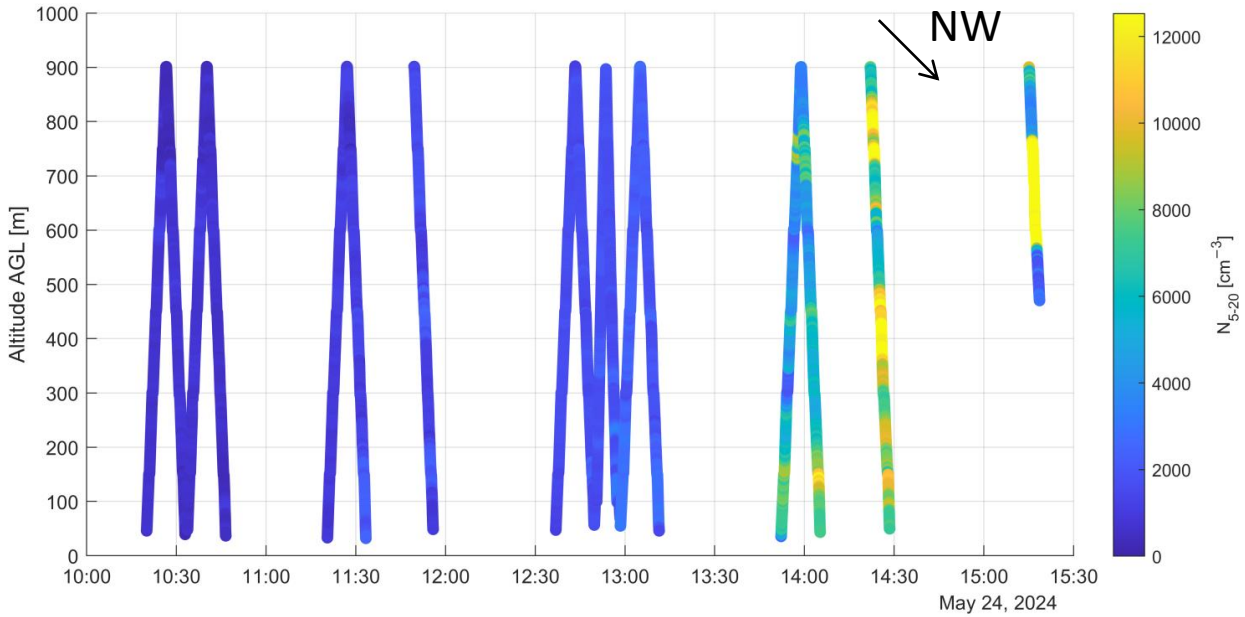
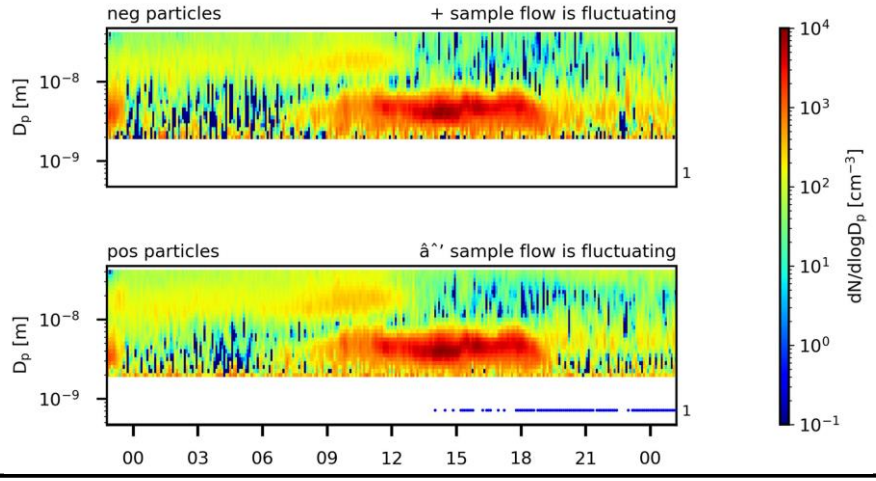
# 24th May // High UFP Concentration without Particle Growth

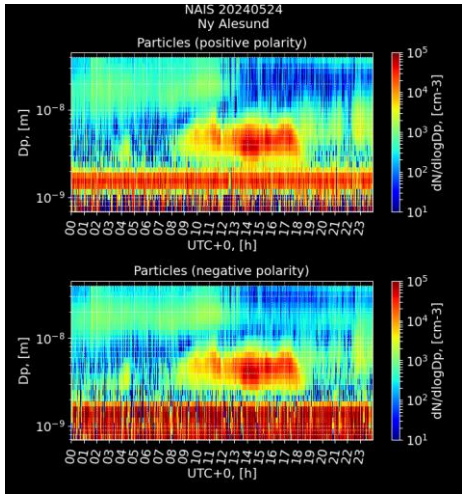



- high wind speeds during measurements, increasing up to 12 m/s
- high UFP concentration between 9-19 UTC observed throughout vertical profiles up to 900 m altitude
- max. concentration $N_{5\text{-}20}$ ~15,000 cm$^{-3}$ (preliminary data)
- high UFP concentration without particle growth simultaneously observed at Zeppelin and Gruvebadet (but stopped ~1h earlier at GRU)

NAIS data* at Zeppelin Observatory (ZEP):

*preliminary data provided by Dominic Heslin-Rees (Stockholm University)




NAIS data** at Gruvebadet (GRU):

**preliminary data provided by Matthew Boyle (Helsinki University)



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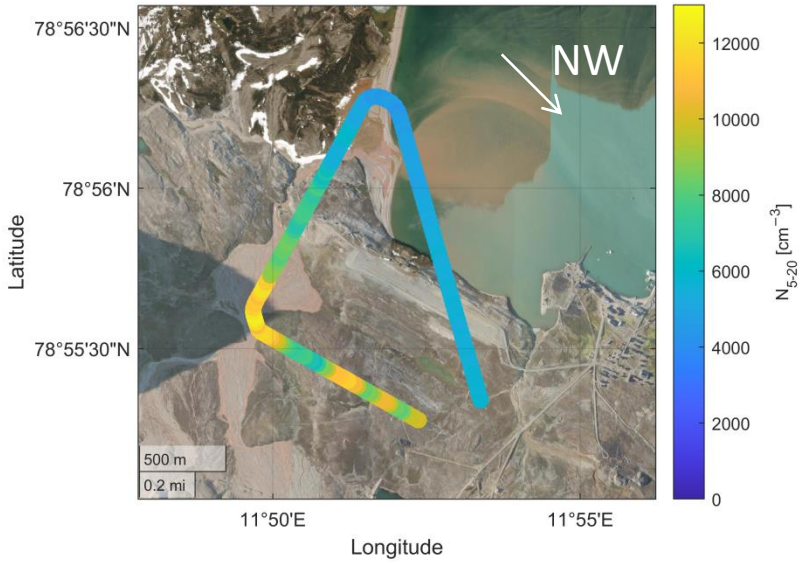
# 24th May // Horizontal Variability of UFP Concentration


3 horizontal flight profiles with constant altitude :

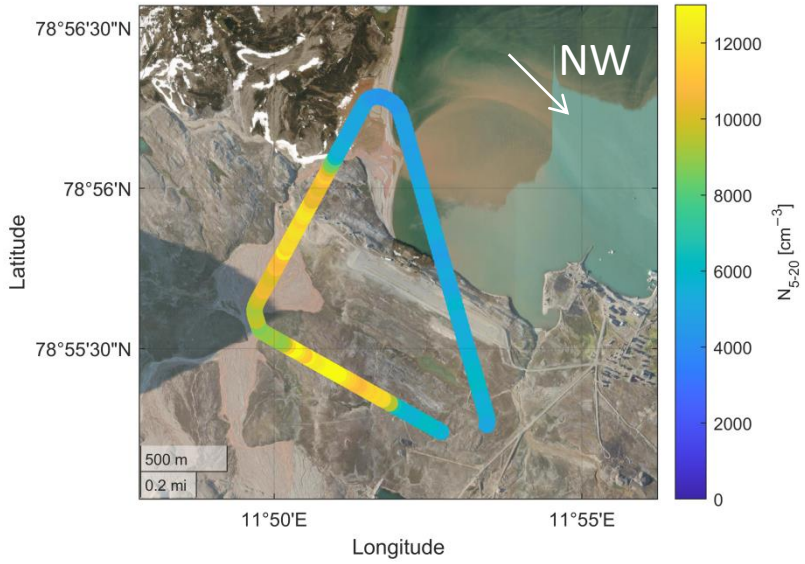
a) 200 m below ZEP
b) at ZEP level
c) 100 m above ZEP

# 24th May // Horizontal Variability of UFP Concentration

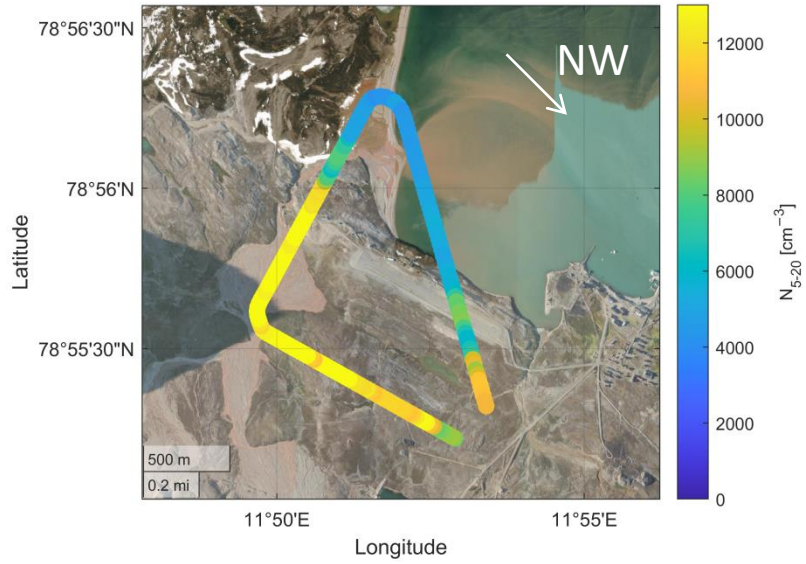
a) 200 m below ZEP (230 MSL)




b) at ZEP level (430 MSL)




c) 100 m above ZEP (530 MSL)




- significant difference of UFP concentrations in the horizontal distribution at 3 altitudes
- higher UFP concentration during flight leg above land close to mountains
- correlation with high wind speed during measurements (NW up to 12 m/s)?

# Outlook

19th May – 7th June 2024

Next steps:

- post-processing of measurement data in progress
- contribution to QuIESCENT Arctic Workshop in October (by Malte)

We are interested in additional data to complete the picture:

- AWIPEV KARL (Koldewey Aerosol Raman Lidar)
- Micro-pulse Lidar Measurement (Arctic MPL)
- Zeppelin observatory: meteorological parameters (temperature, humidity, wind, …), DMPS, APS, chemical composition
- Regional comparison (e. g. pollution and NPF days): Villum Research Station, Longyearbyen, Norway mainland
- Satellite data?
- Data models: local wind?
- Any ideas to interpret individual NPF events

# Thank you on behalf of the AIDA team!

# Acknowlegdements

Aerosol-Variabilität und Interaktion mit Umgebungsbedingungen basierend auf der kleinskaligen vertikalen und horizontalen Verteilung bei Messungen in der Arktis (AIDA) - DFG Projekt 519822612
https://gepris.dfg.de/gepris/projekt/519822612
https://www.researchinsvalbard.no/project/4e320000-e75e-92e8-3086-08db730c53ce/project-info

AWIPEV Projekt: AWIPEV_0031 (RiS ID 12274)
http://www.atmo-projects.net/awipev/awipev-abstract.php?PROJECT=AWIPEV_0031

AWIPEV Base: French - German Arctic Research Base at Ny-Ålesund / Spitsbergen
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