Technische Universität Braunschweig

Institut für Flugführung

Meteorological Applications of Unmanned Aerial Systems

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Outline

Unmanned Aerial Systems and payload:

- M²AV
- ALADINA

Meteorological Applications:

- Afternoon transition (BLLAST)
- Polar boundary layer (Polarstern campaign)
- New particle formation (Melpitz)

Meteorological Mini Aerial Vehicle (M²AV)

- In operation since 2005
- Wing span: 2 m
- Air speed 22 m/s
- Weight: ca. 6 kg
- Payload: 1,5 kg
- Automatic turbulence measurement system (3D wind, temperature, humidity)
- Data acquísition rate: 100 Hz

Payload M²AV

3D Wind:

5-hole probe, GPS, IMU:

- 100 Hz data acquisition
- High accuracy during level flights

Humidity:

Vaisala Humicap:

- 0…98 %
- Response time: 1 s during flight
- High accuracy

Temperature:

Vaisala Pt1000:

- -40…+60 °C
- Respone time: 1 s im Flug
- High accuracy

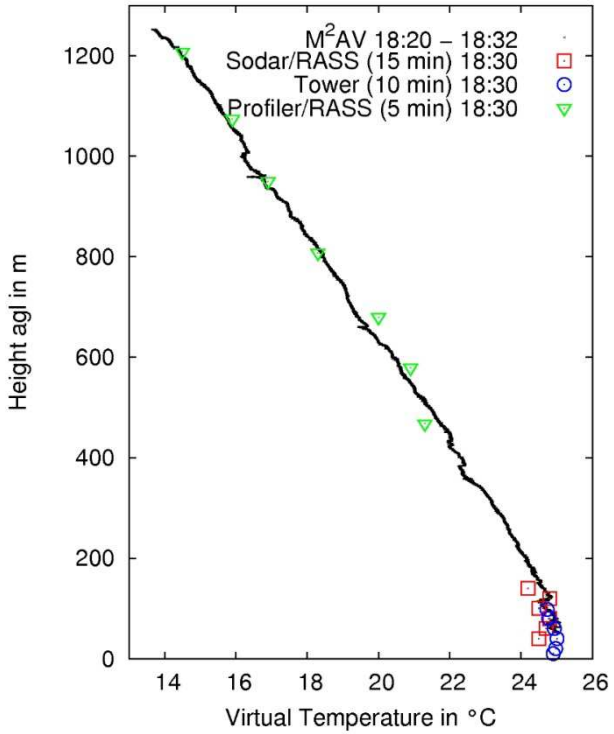
Thermocouple:

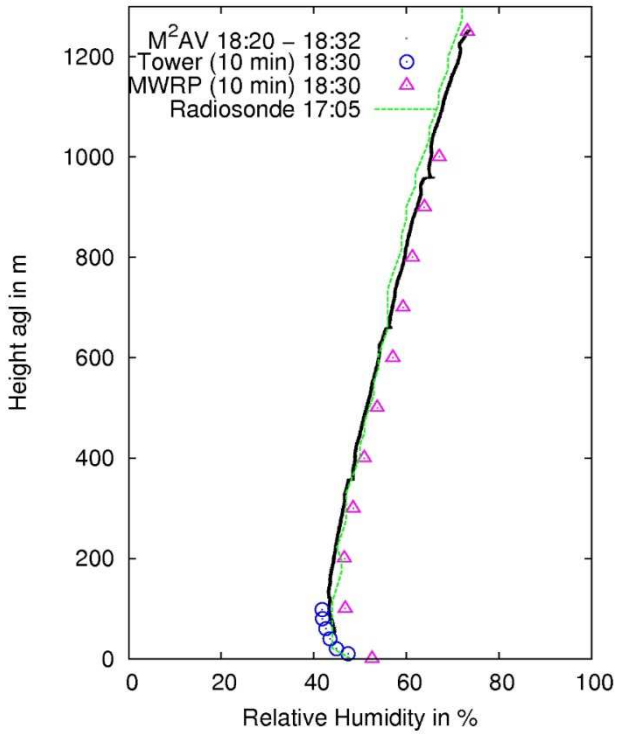
- -40…+60 °C
- Response time 0,05 s
- Bad long-term stability
- Development and fabrication at TU Braunschweig

→ Payload developed by Jens Bange, now professor at University Tübingen

Validation M²AV – Temperature, humidity

LITFASS-2009 (21.07.2009)



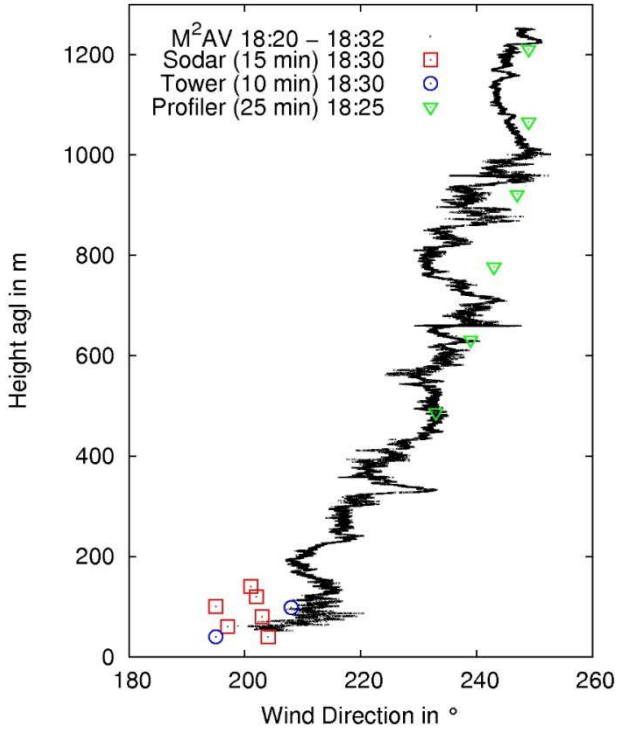


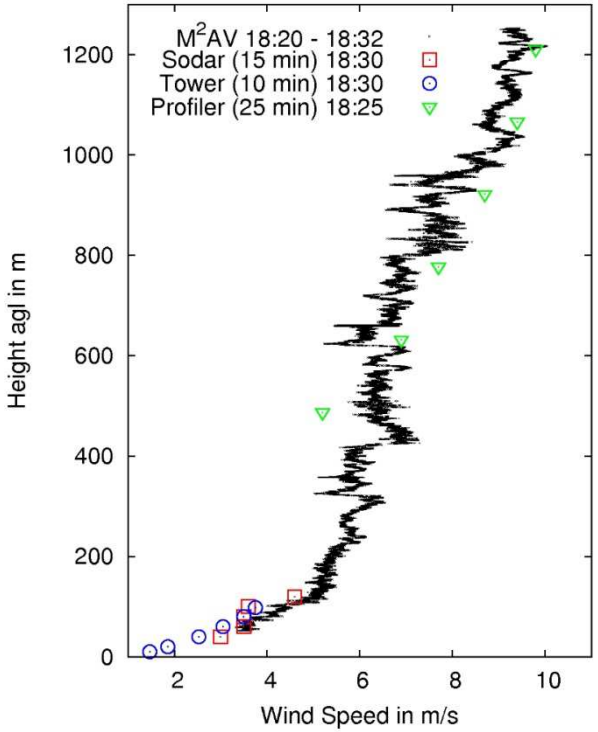
- very high accuracy
- very high vertical resolution

Martin et al., 2011

Validation M²AV – Wind

LITFASS-2009 (21.07.2009)

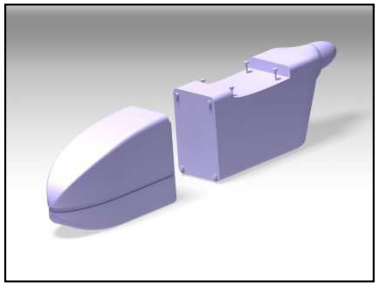




- very high accuracy
- very high vertical resolution

Martin et al., 2011

Application of Light-Weight Aircraft for Detecting In-situ Aerosol (ALADINA)



- Based on Carolo P360 airframe
- Wing span: 3,6 m
- Air speed 20 - 30 m/s
- max. take off weight: 25 kg
- Payload: 3 kg
- ALADINA in operation since 2013
- Data acquísition rate: 100 Hz
- Automatic turbulence measurement system (3D wind, temperature, humidity)
- Aerosol, black carbon, irradiance…

Project with Uni Tübingen, TROPOS Leizig, funded by German Research Foundation

ALADINA operation

- Flight permission of local CAA authorities
- Automatic flight (Research Onboard Computing System, ROCS of University Stuttgart)
- Takeoff / landing manually, visual contact with safety pilot required
- Maximum flight altitude 1000 – 1500 m (depending on CAA regulations)
- Maximum radius of operation 1 km

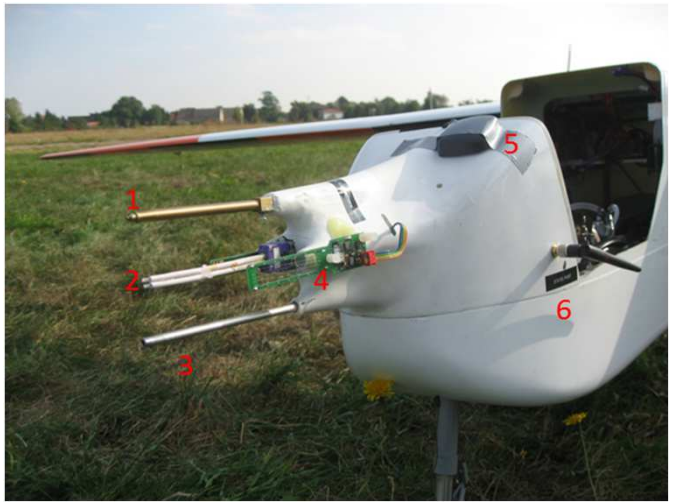
Ground control station (data / autopilot)

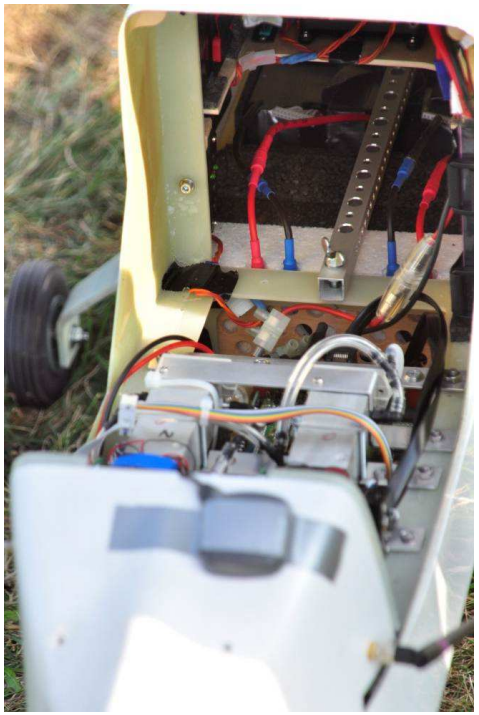
Safety pilot

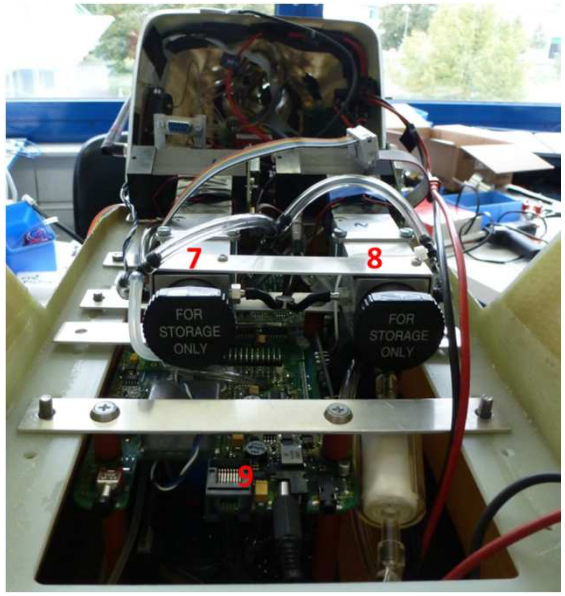
Research objective ALADINA

- Formation of new particles in the atmospheric boundary layer
- Vertical variability of aerosol, depending on thermal structure
- Horizontal variability on a small scale

Payload ALADINA



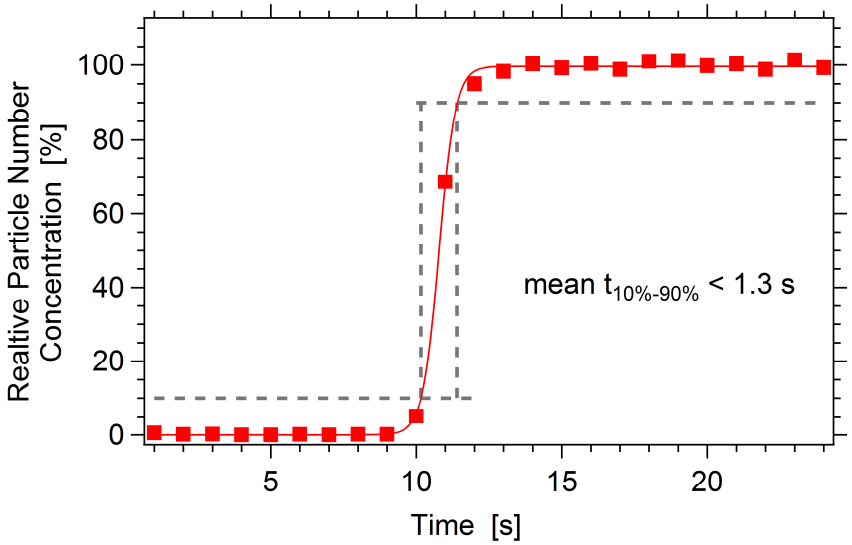




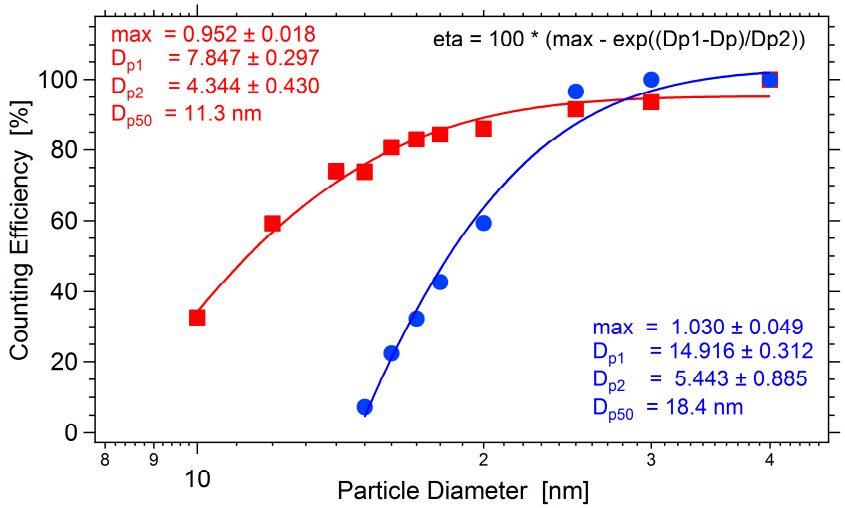
1 five-hole probe, 2 temperature sensor (Thermocouple) and humidity sensor P14 Rapid, 3 aerosol inlet, 4 fast temperature sensor (Fine wire platinum resistance thermometer), 5 GPS antenna, 6 telemetry antenna 7 first CPC 8 second CPC 9 OPC

Characterisation modified aerosol sensors

2 CPC (condensation particle counter)
1 OPC (optical particle counter)



Response time < 1.3 s

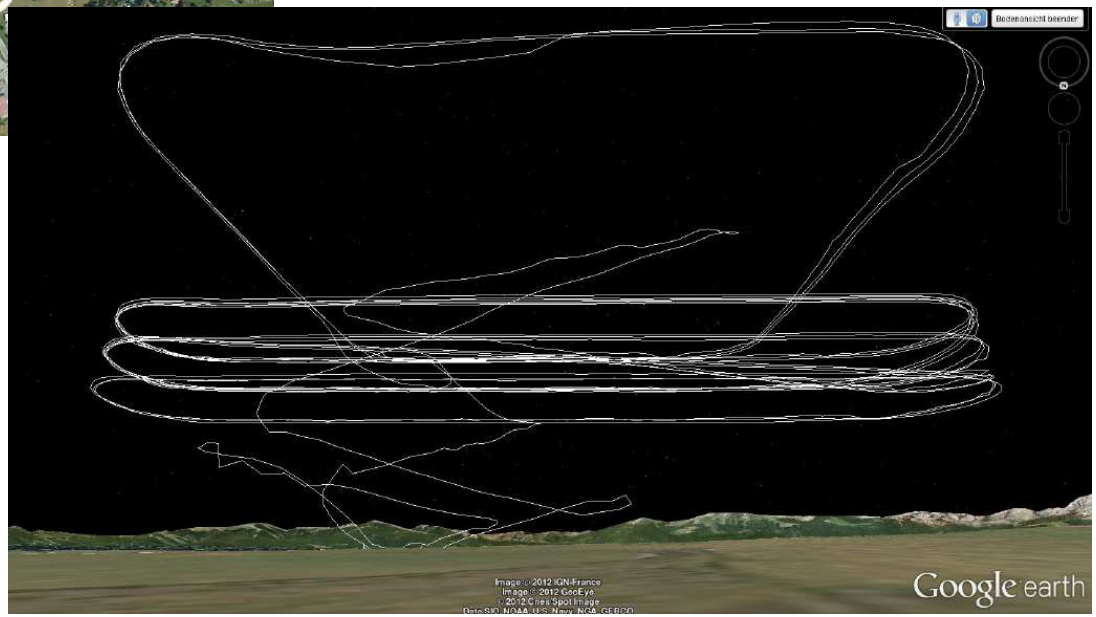


Minimum detection diameter
- 11 nm
- 18 nm

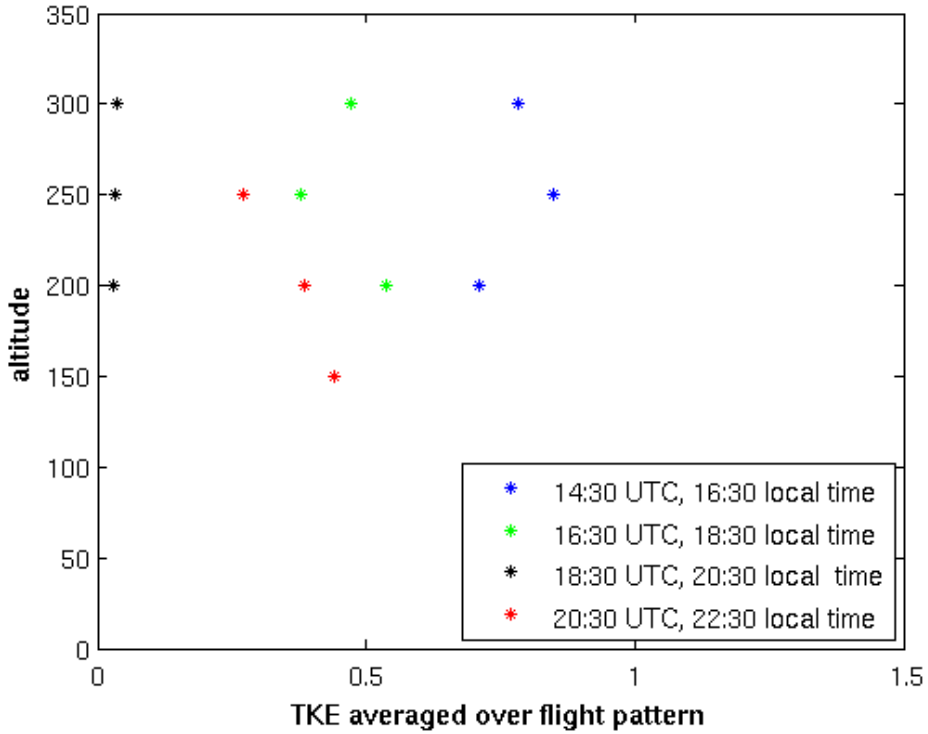
Altstädter et al., AMT, 2015

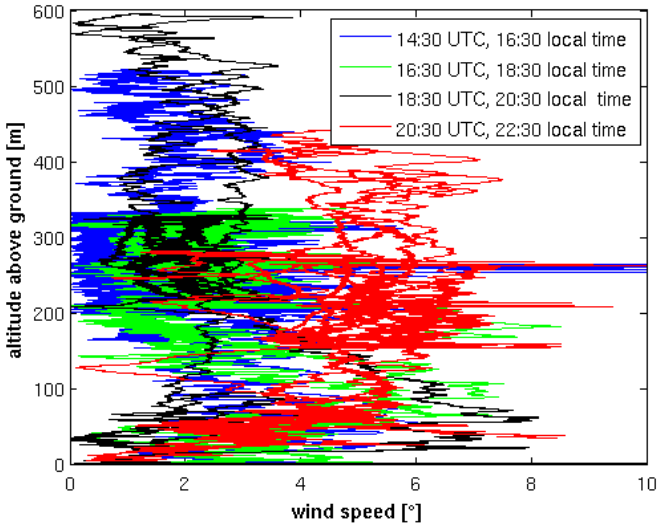
Afternoon transition (BLLAST)

MMAV operation at „Site 1“ during BLLAST 2011



Afternoon transition (BLLAST)



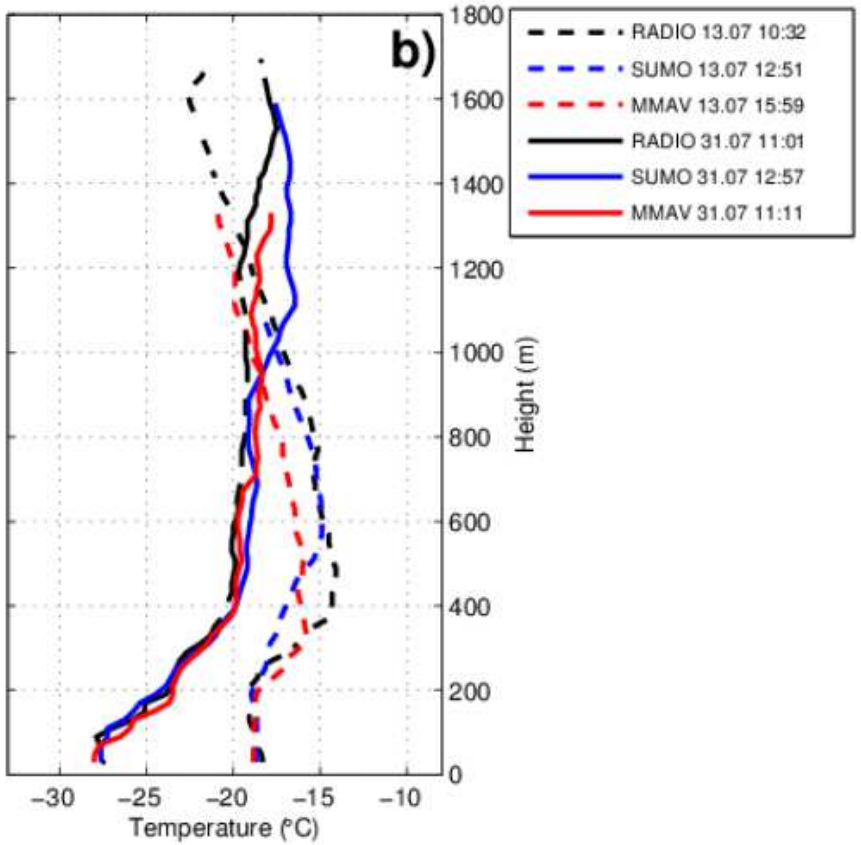


Preliminary results!

MMAV Antarctica, Polarstern 2013

Pictures: M. Hoppmann, M. Krüger, AWI

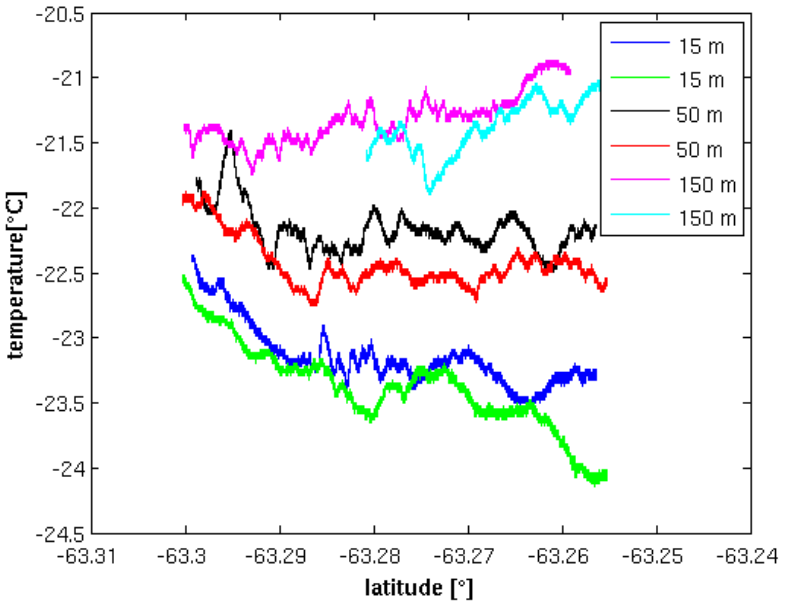
MMAV Antarctica, Polarstern 2013



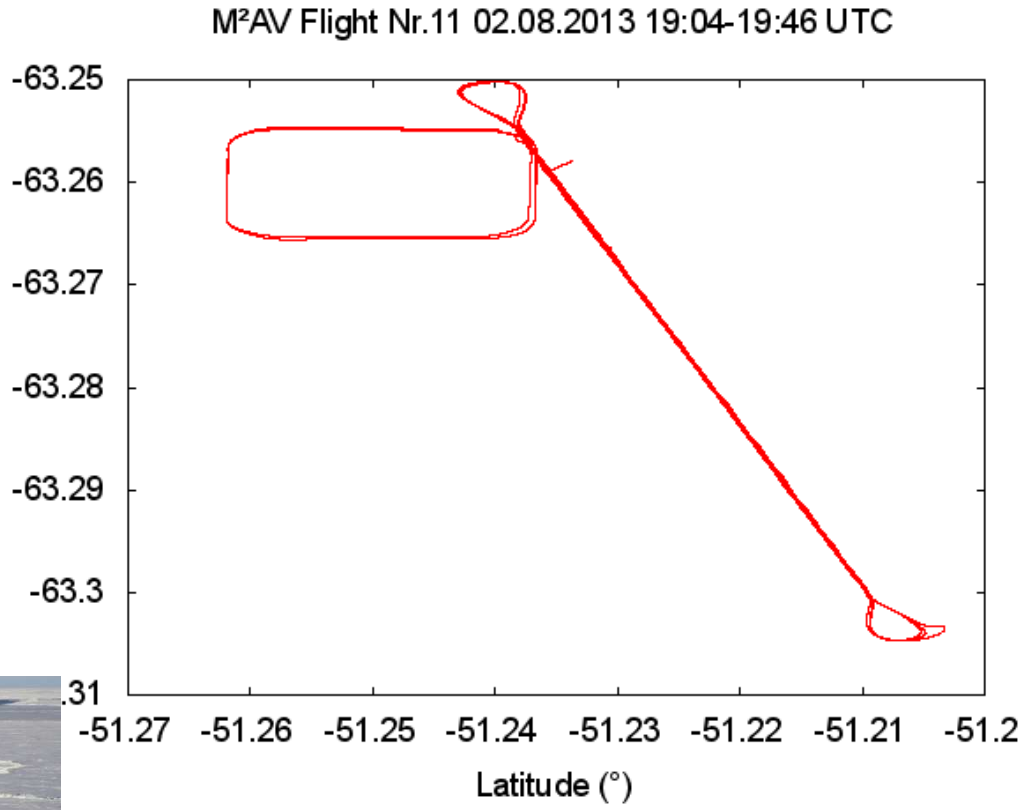
Tisler et al., accepted to Polar Research, 2015

- Winter atmosphere above sea ice
- small-scale structure of the atmospheric boundary layer
- Ground-based temperature inversions
- Intercomparison UAS/ radiosonde
- Influence of leads

MMAV Antarctica, Polarstern 2013



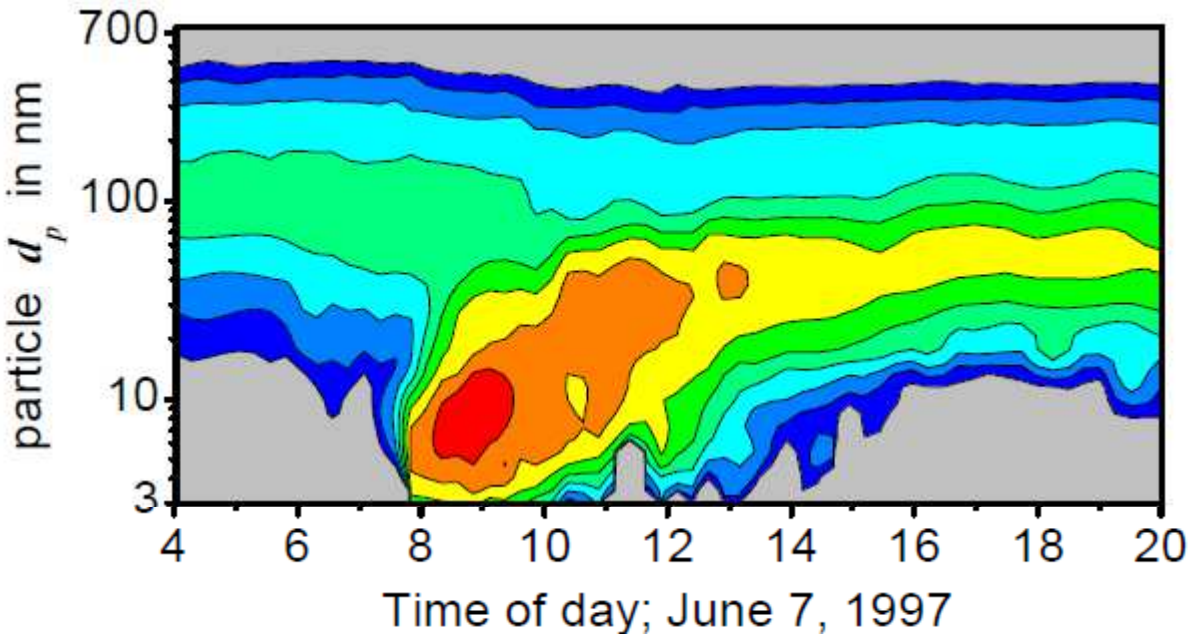
Picture: C. Lüpkes, AWI



Preliminary results!

New particle formation

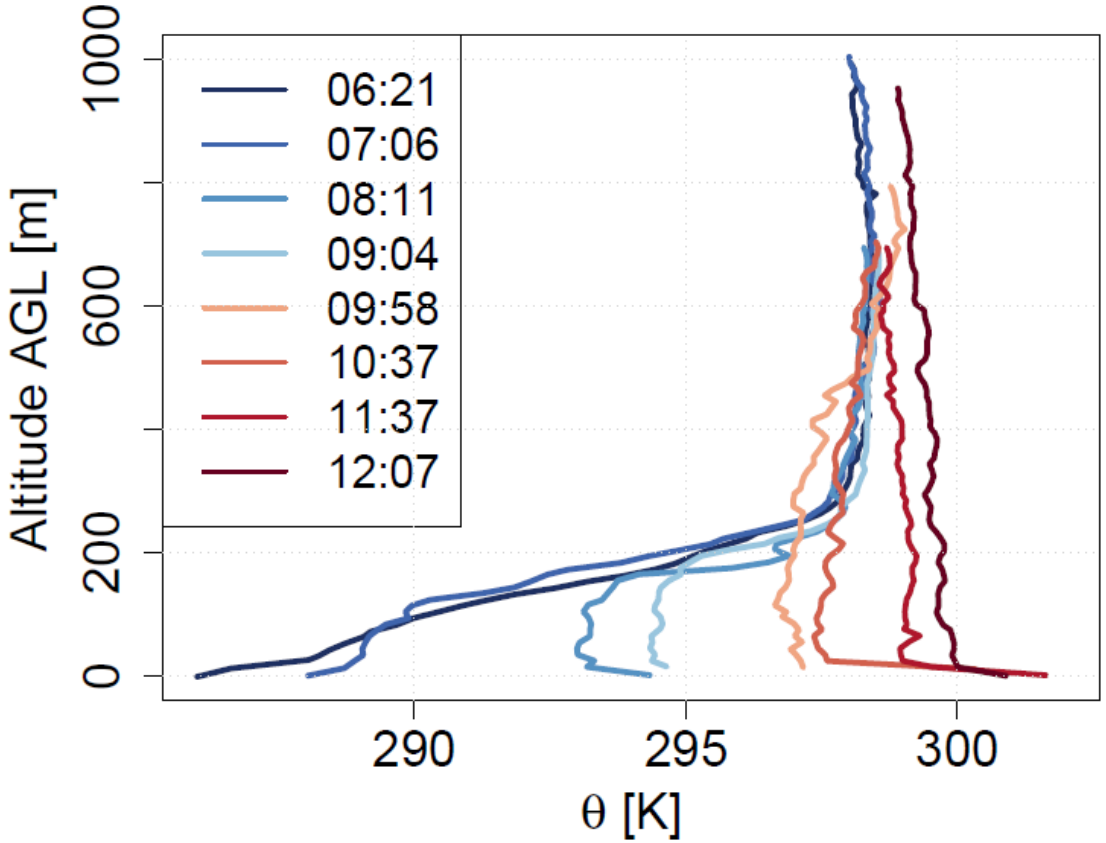
Ground-based observations:



Birmili and Wiedensohler, GRL, 2000

New particle formation

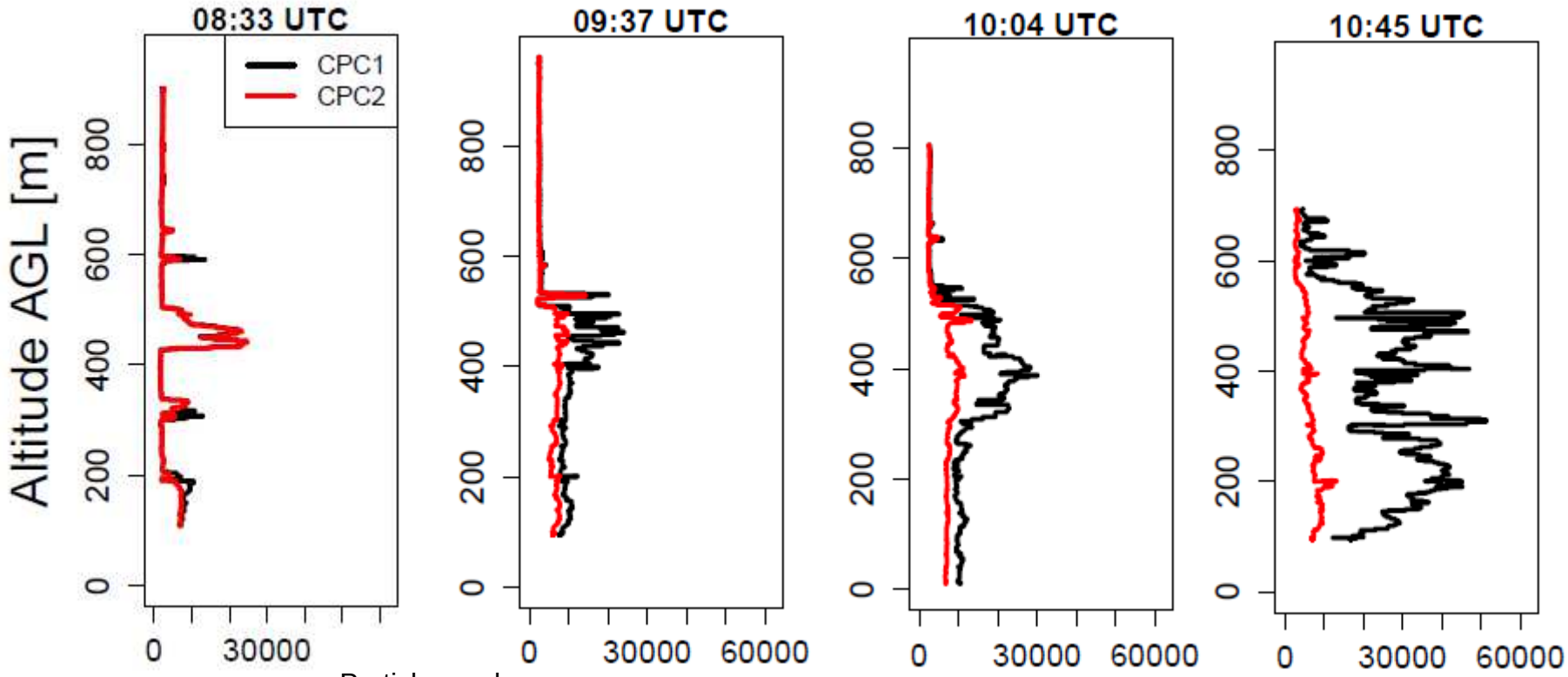
Vertical profiles of potential temperature during morning transition



Platis et al., submitted to Boundary-Layer Meteorology, 2015

New particle formation

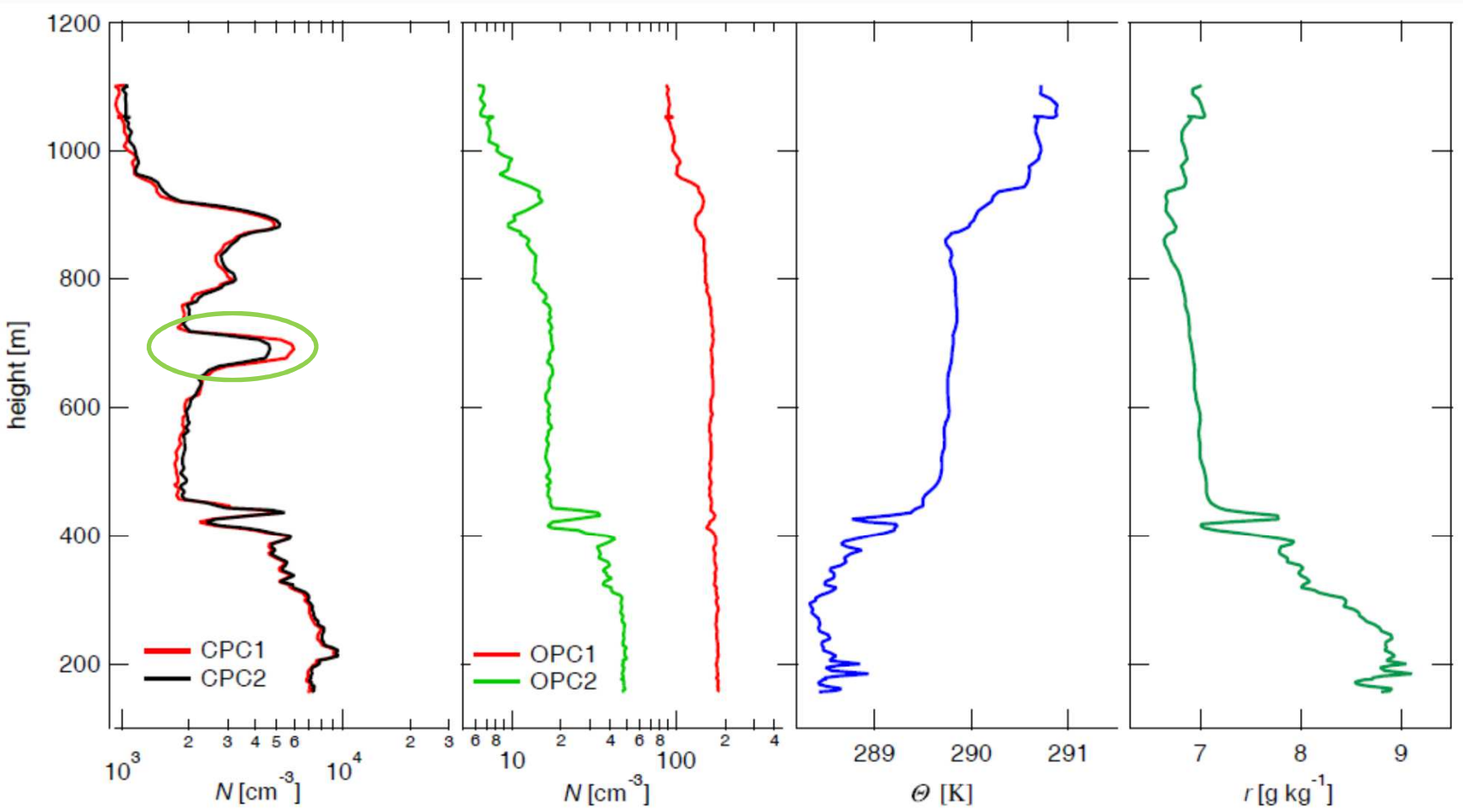
Vertical profiles of aerosol concentration
(CPC1 > 5 nm, CPC2 > 10 nm)



Particle number concentration [1/cm^3]

Platis et al., submitted to Boundary-Layer Meteorology, 2015

New particle formation



Altstädter et al., AMT, 2015

… ready for new projects

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