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Properties of aerosol and gases in the vertical profile during LAPSE-RATE campaign

David Brus[1], Jani Gustafsson[1], Ville Vakkari[1], Osku Kemppinen[2], Gijs de Boer[3,4] and Anne Hirsikko[1]

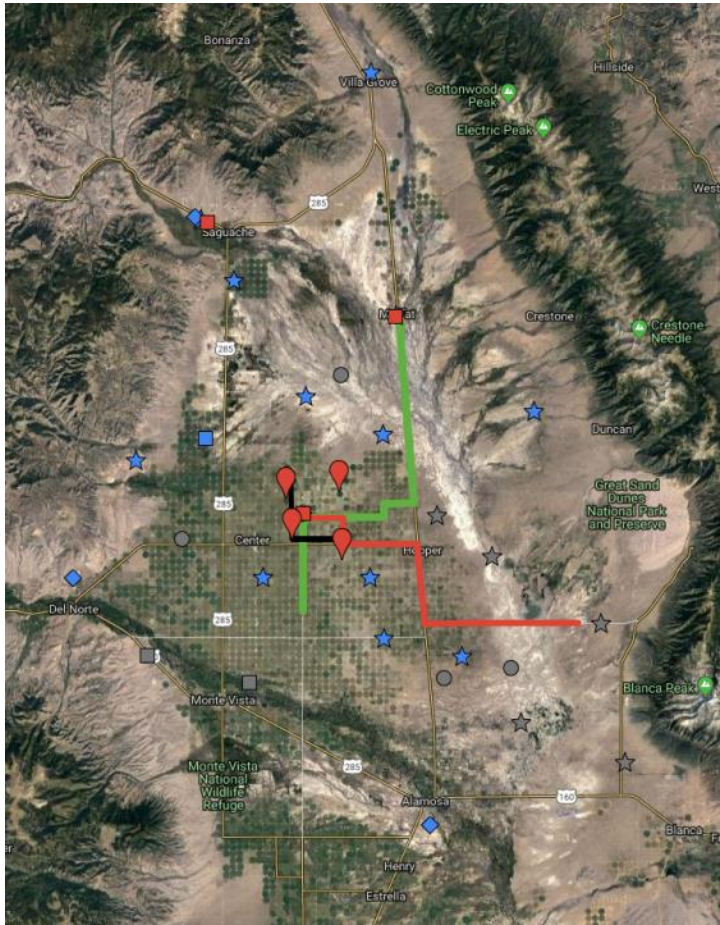
[1]Finnish Meteorological Institute, [2]Kansas State University, [3]University of Colorado and [4]NOAA

18.7.2019 Anne Hirsikko

LAPSE-RATE campaign San-Luis-Valley, Alamosa, CO - summer 2018

Lower **A**tmospheric **P**rocess **S**tudies at **E**levation - a **R**emotely piloted **A**ircraft **T**eam **E**xperiment

- FMI and Kansas state University joined as a team
- Campaign mostly focused on meteorological parameters and processes
- FMI measured also aerosols and GHGs in the vertical column



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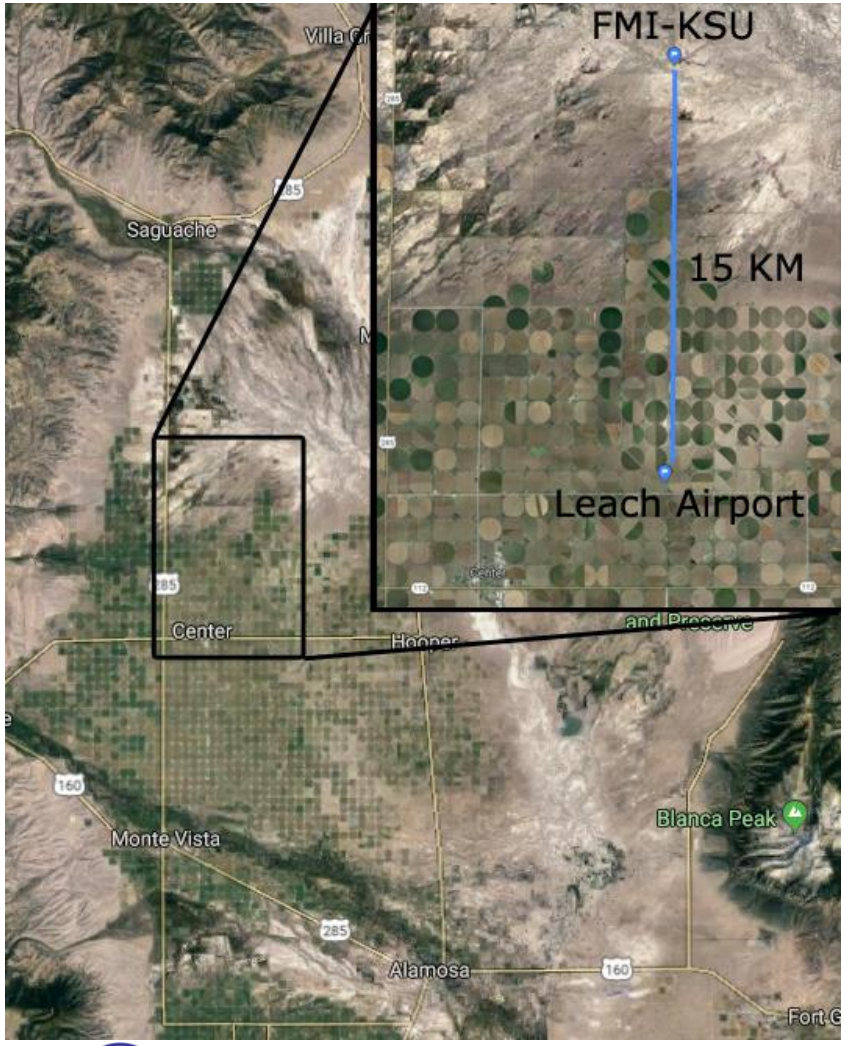
Measurement setup

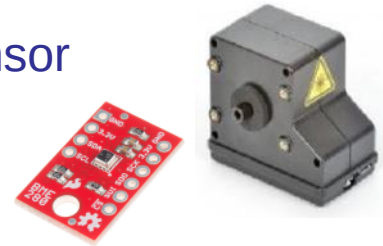
FMI - KSU team sampling location – 15 km N of the Leach airfield - located approximately 3.2 km ENE of Center, Colorado and 32 km NNW of Alamosa, Colorado.



- The location (2291 m asl.) - very quiet, surrounded by farmland, sporadically disturbed by the passing of local farm trucks.
- FMI-Flights under Certificates of Authorization (COAs) **up to 914 m agl,** KSU-under FAA Part 107, **121 m agl**
- FMI used 2x Tarot X6, KSU DJI Matrice 600 Pro
- FMI - 38 vertical profile flights and KSU - 33 flights

Instrumentation - modular approach

FMI Particle module:
Particle concentration 2x CPC TSI 3007 (cut-off D_{50} 7 and 14 nm)
OPC-N2 (0.3 - 17 µm)
T, RH, P - BME 280 Arduino sensor



FMI Ground module:
Particle concentration CPC TSI 3007 and OPC-N2,
T, RH, P - BME 280 Arduino sensor, TriSonica mini weather station – wind speed, direction, wind components

FMI Gas module:
Licor Li-840A – CO2 and water vapor
Vaisala GMP343 – CO2
T, RH, P - BME 280 Arduino sensor
Vaisala AQT410 (CO, O3, SO4, NO2, T, RH)

K-State Uni – 2x POPS Handix Scientific LLC
0.132 - 3.648 µm

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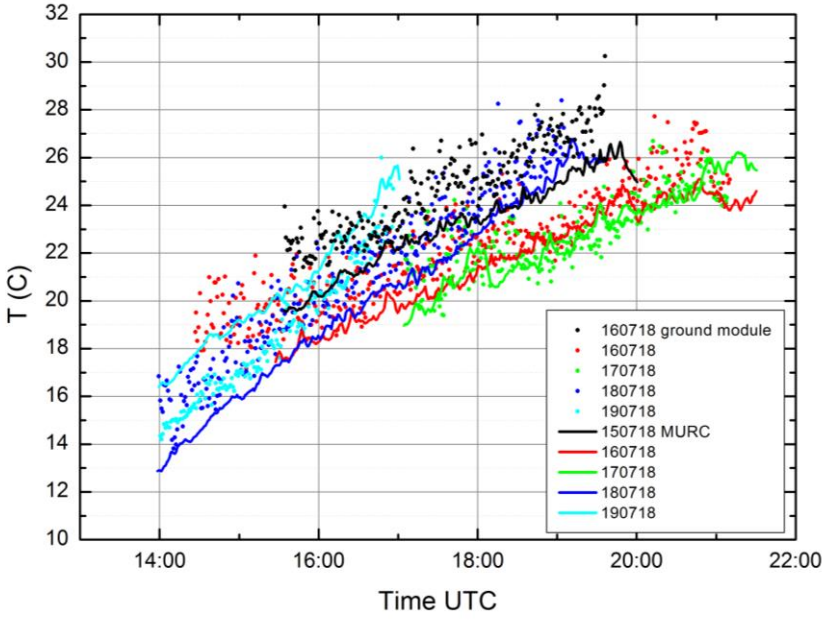
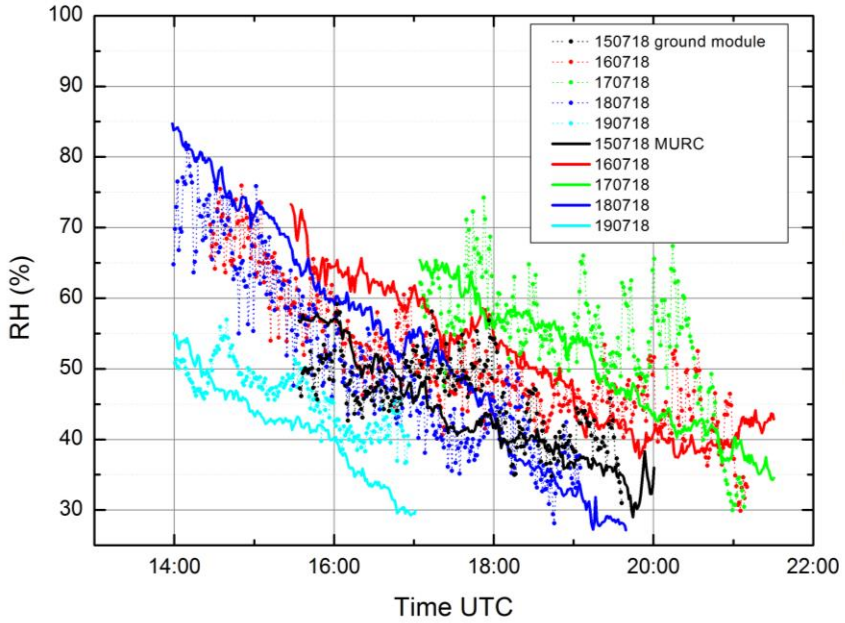
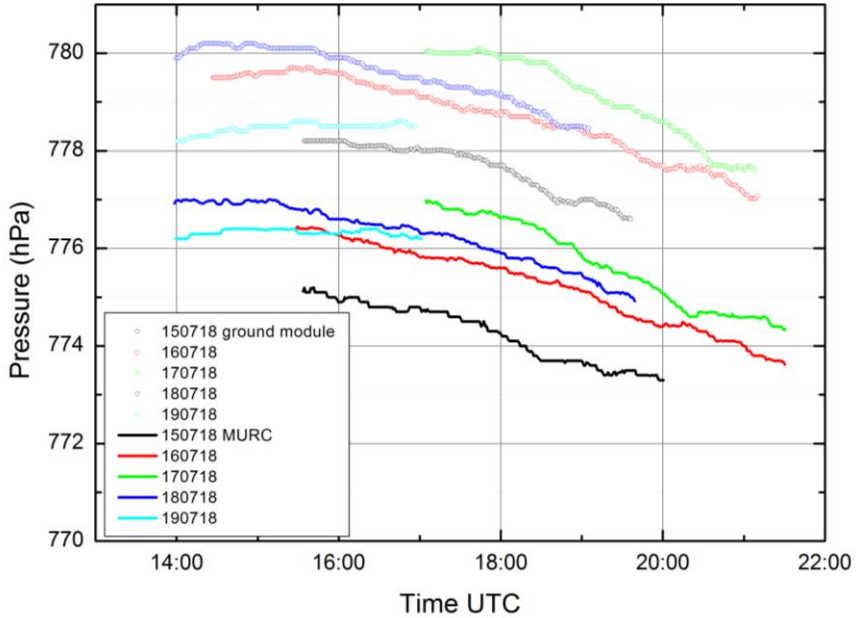
Quality of observations

Comparison of surface met data to the Mobile UAS Research Collaboratory (MURC)

- MURC – the closest reference measurements
- Differences between values were within accuracy of sensors
- Constant bias in pressure corresponds to 13 meters higher elevation of MURC sensors
- Comparison suggests T and RH homogeneously distributed over large area

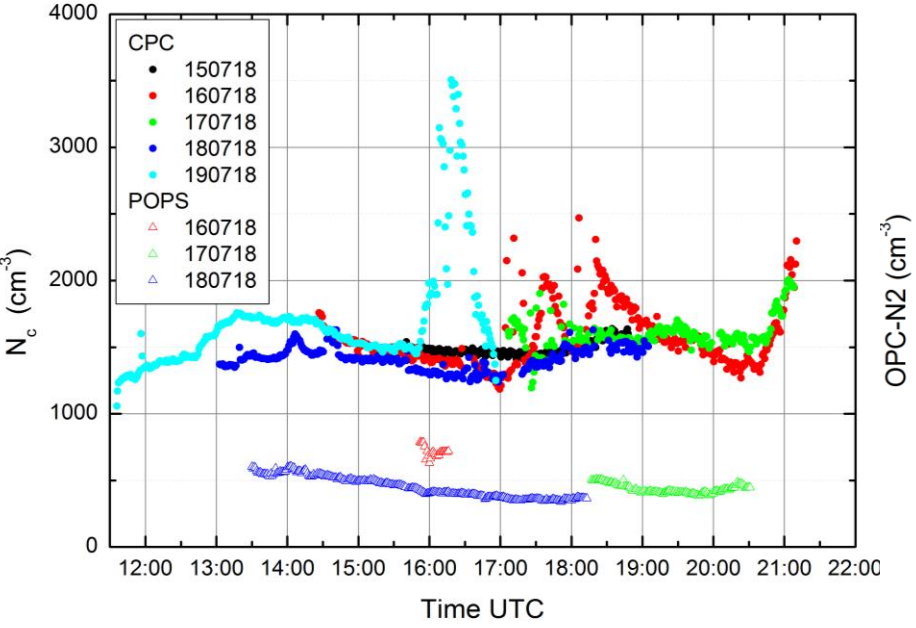


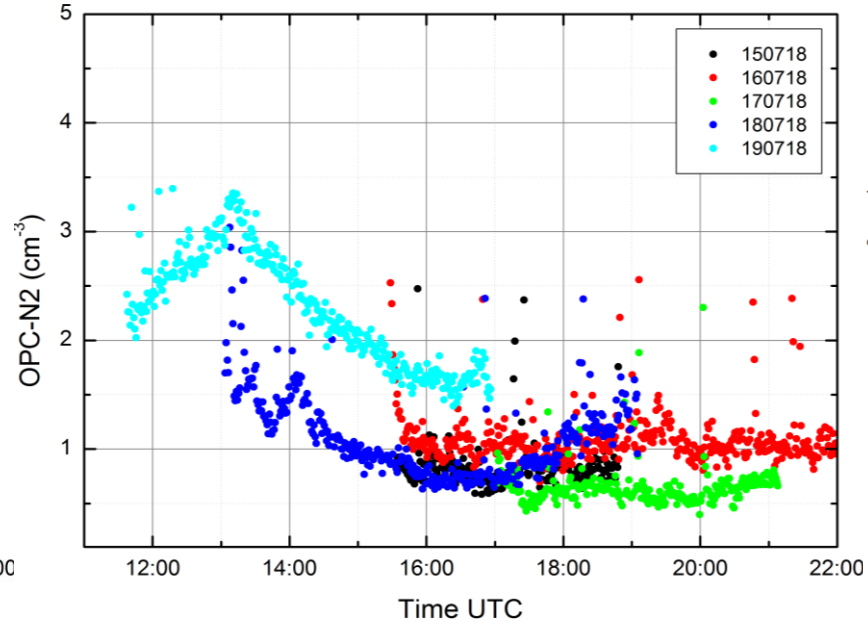


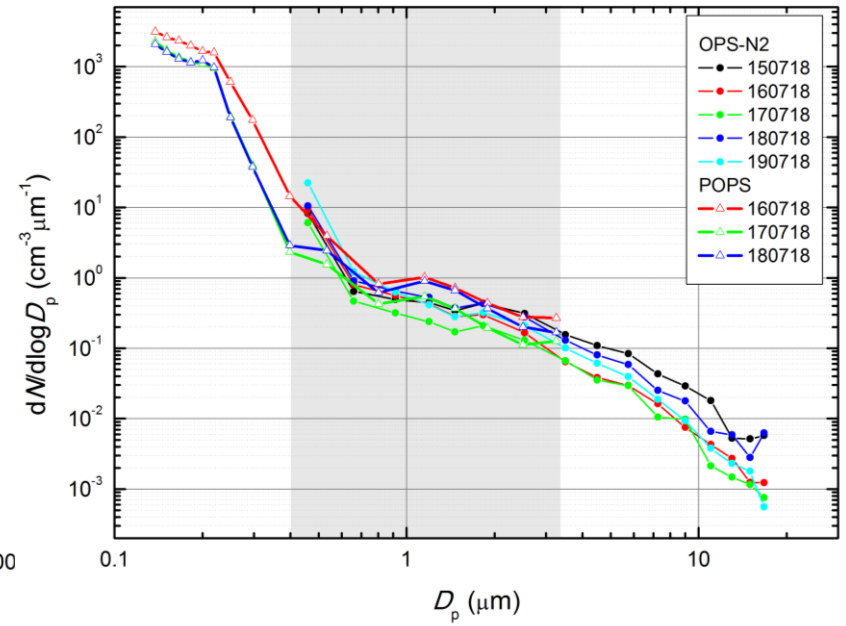


Aerosol particles at the surface - total, big particles, size distributions

- No reference aerosol measurements during LAPSE-RATE
- Total particle number concentrations and particulate matter mass concentrations **typical for rural areas**







CPC average 1551 cm^{-3}
(min 1211 & max 2249 cm^{-3})
POPS average 532 cm^{-3}
(min 338 & max 787 cm^{-3})

OPC-N2 average 1.2 cm^{-3}
(min 0.7 cm^{-3} & max 5.3 cm^{-3})

POPS and OPC-N2 overlap well over eight size bins between 0.46 to 3.5 µm

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Vertical profiles - T and RH

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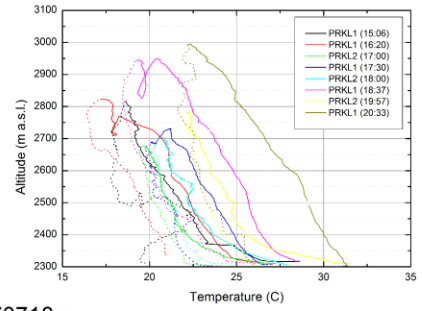

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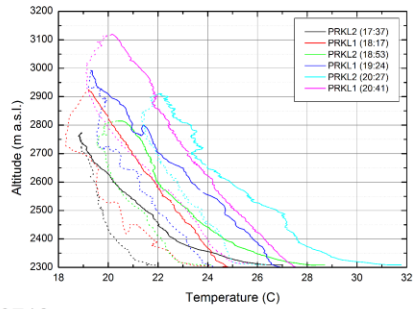

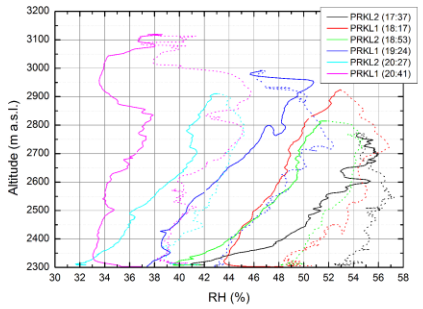

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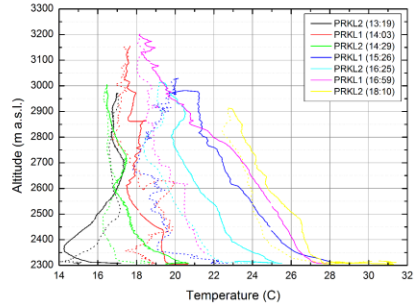

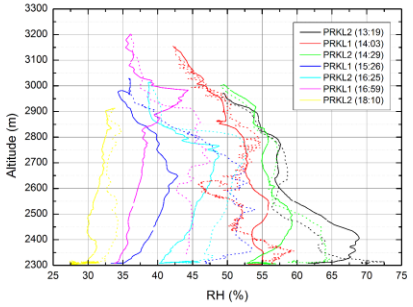

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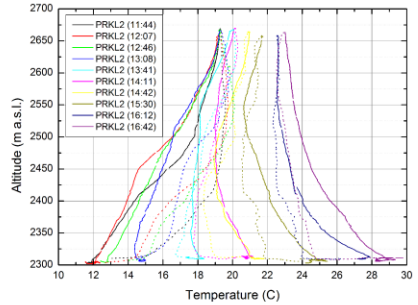
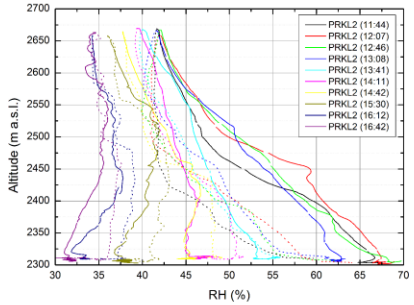




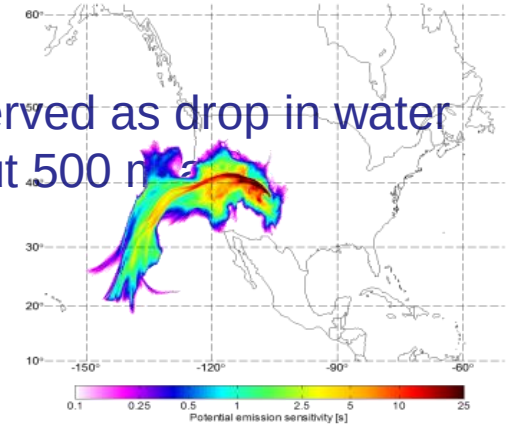
- The measured profiles showed quite a strong hysteresis in observed temperature and relative humidity profiles.
- The hysteresis is a result of the flight strategy, where the goal was to reach as high altitudes as possible in very short time. The BME280 Arduino sensor response was not fast enough to equilibrate to the fast change of ambient conditions.
- Ascent rates were approximately 5-8 and descent rates were about 2-5 ms^{-1}

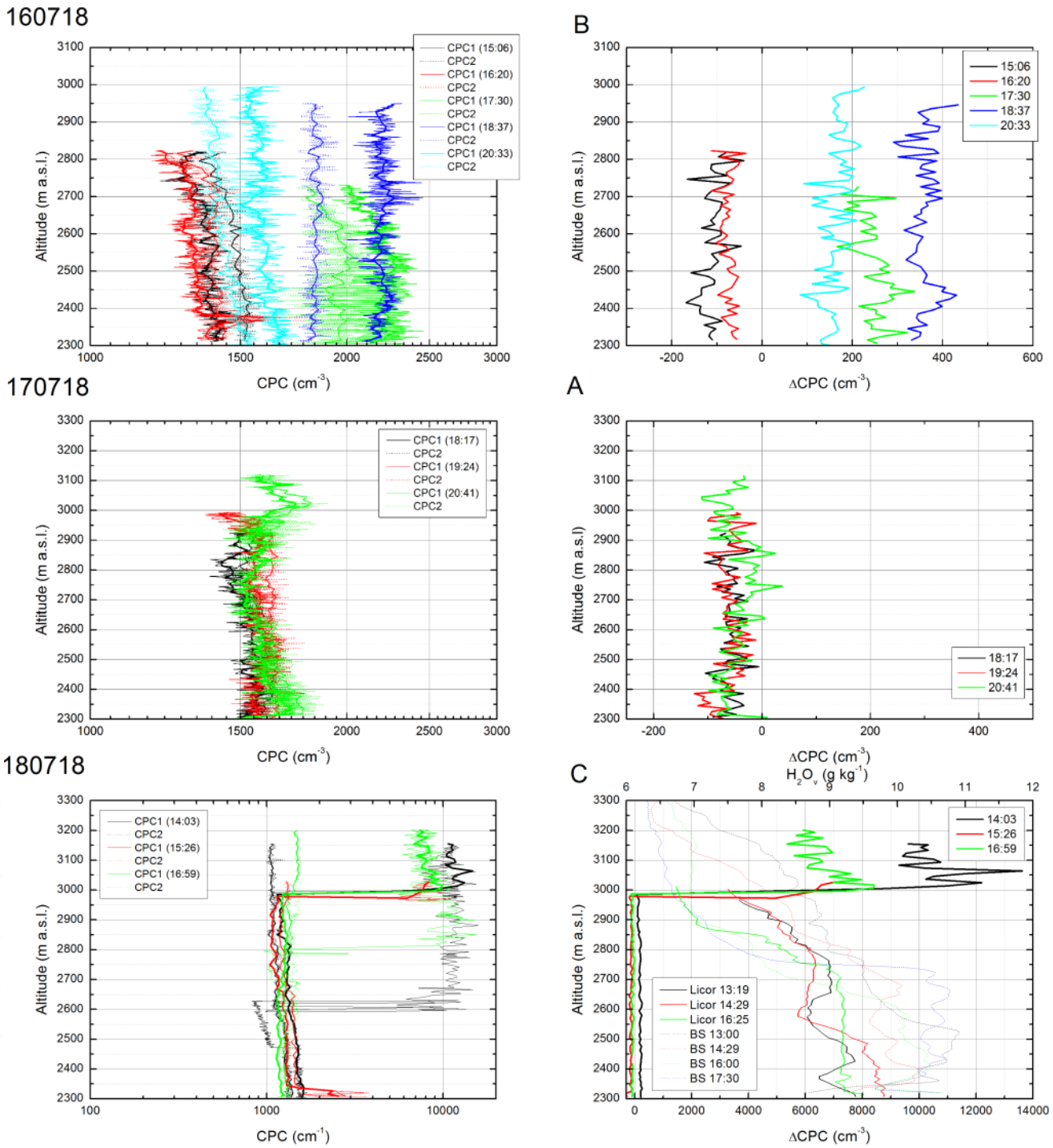
Results

Vertical profiles - Total aerosol and NPF events

A) None, B) Weak and C) Strong (>3000 m asl)

- Uplift of precursor vapors from lower (< 2 km from surface) to higher altitudes.
- Flexpart dispersion model for July 18th 96h backwards, arriving at 20:00 UTC at 1000 m a.g.l.
- The air masses <4000 m a. s. l. and 72-96h before arrival originate from above continent. The uplift of continental air masses containing NPF favorable precursors over the Rocky Mountains is then plausible.
- Decoupling of the PBL observed as drop in water vapor concentration at about 500 m





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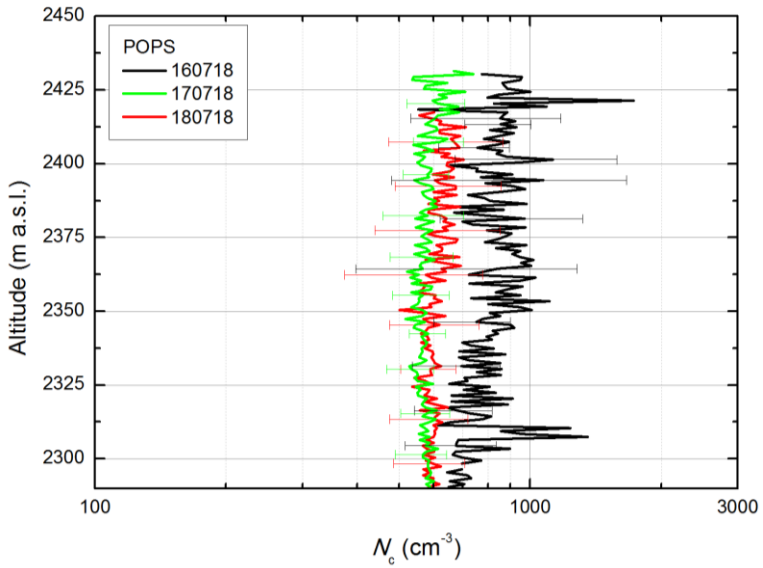
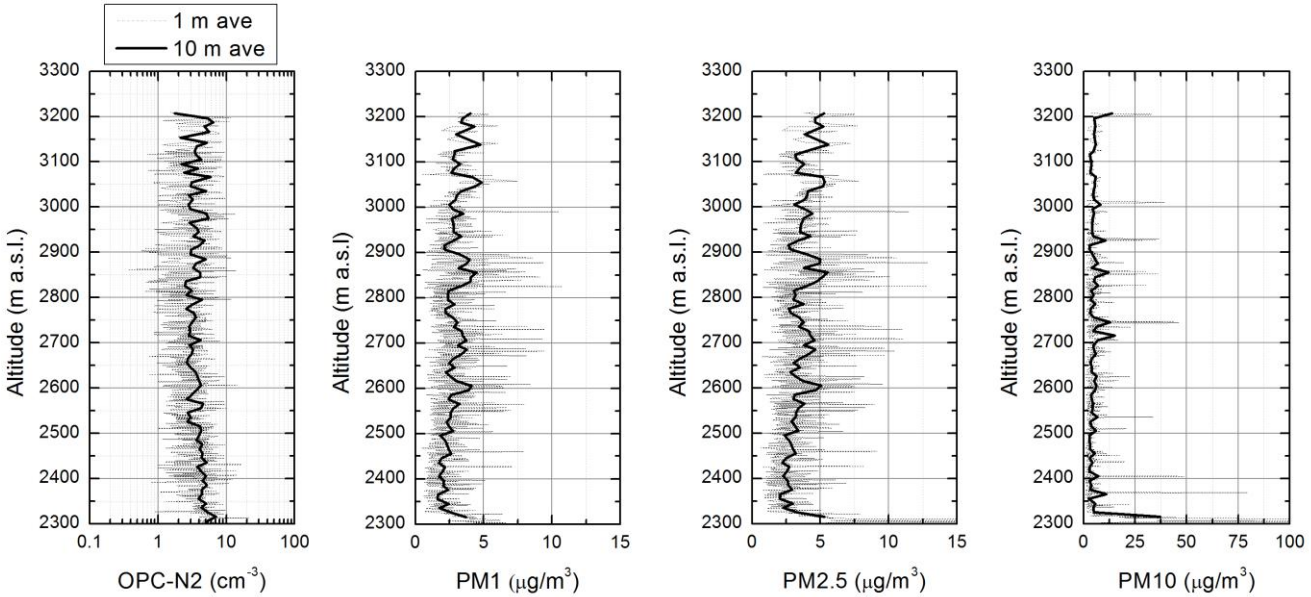
POPS and OPS-N2 vertical profiles

- POPS vertical profiles up to 145 m agl with no concentration variation in height neither day-to-day.
- Within well mixed BL



- Number concentrations with OPC-N2 (averaged over campaign) show little variation as a function of height



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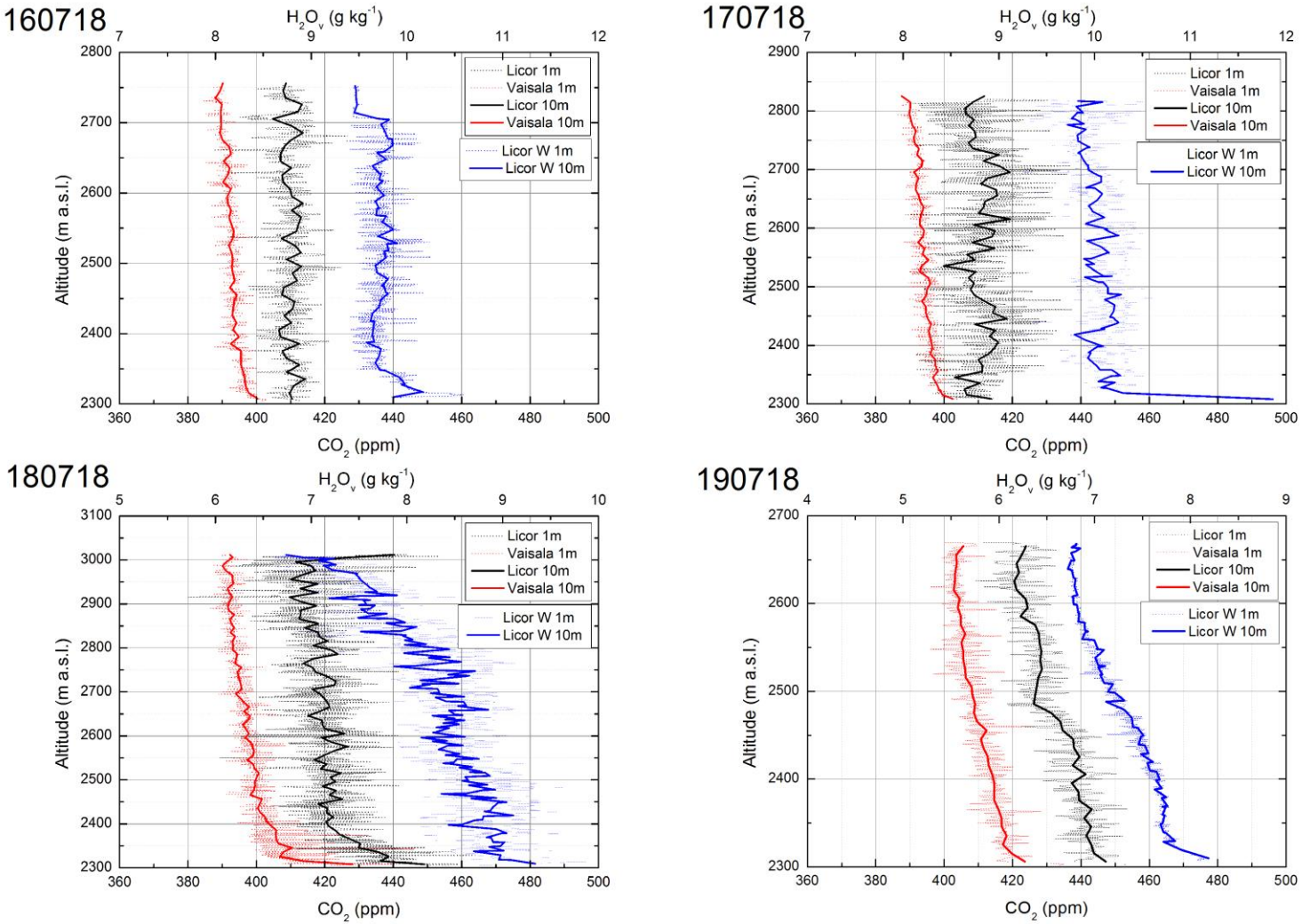
Licor Li840A- CO_2 and water vapor
Vaisala GMP343 – CO_2

- **Very little variation in CO_2** concentrations was observed as a function of altitude indicating a well-mixed boundary layer.

- However, **elevated surface concentrations** were observed.

- Discrepancy in CO_2 concentration 10-20 ppm found between Licor and Vaisala sensors – most probably due to inaccurate pressure correction in Vaisala proprietary algorithm, since both sensors measure the same at sea level (±3 ppm).



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Conclusions

- Measurement setups were confirmed to operate reliably resulting in scientifically sound observational dataset from the studied environment.
- As an example, two types of new particle formation events, sources and sinks of CO2, and water vapor, and meteorological parameters in the atmospheric vertical profile were measured during the short experiment.
- Such observations characterizing atmospheric phenomena of this specific study area would have not been possible in other way, and thus, demonstrate power of UASs as new, promising tools in atmospheric and environmental research.