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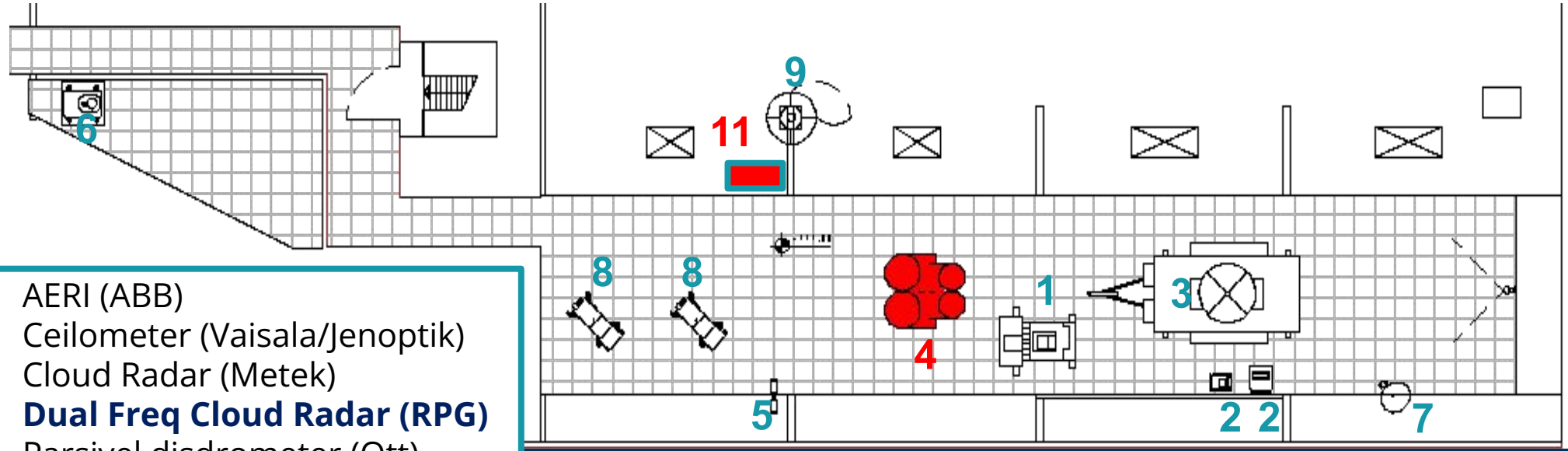
New dual-frequency cloud radar and Raman lidar at JOYCE: first observations and future perspectives

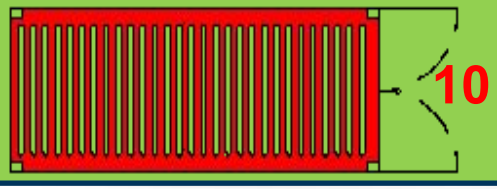
Lukas Pfitzenmaier, Bernhard Pospichal, Ulrich Löhnert, Andrea Burgos-Cuevas, Tobias Marke, Rainer Haseneder-Lind, Marcus Müller, Birger Bohn

CCRES/CLU Workshop, Matera – November 7th, 2024

The Jülich Observatory for Cloud Evolution JOYCE



1) AERI (ABB)
2) Ceilometer (Vaisala/Jenoptik)
3) Cloud Radar (Metek)
4) **Dual Freq Cloud Radar (RPG)**
5) Parsivel disdrometer (Ott)
6) Doppler Wind Lidar (HALO)
7) Micro Rain Radar (Metek)
8) Microwave radiometer (RPG)
9) Rain gauge Pluvio (Ott)
10) **Raman Lidar (Raymetrics)**
11) **Weather station (Campbell)**



JOYCE

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JoyDuRadO - JOYce DUal Frequency RADar Observation system

JoyDuRadO is an RPG system which consists out of 2 radar unites:

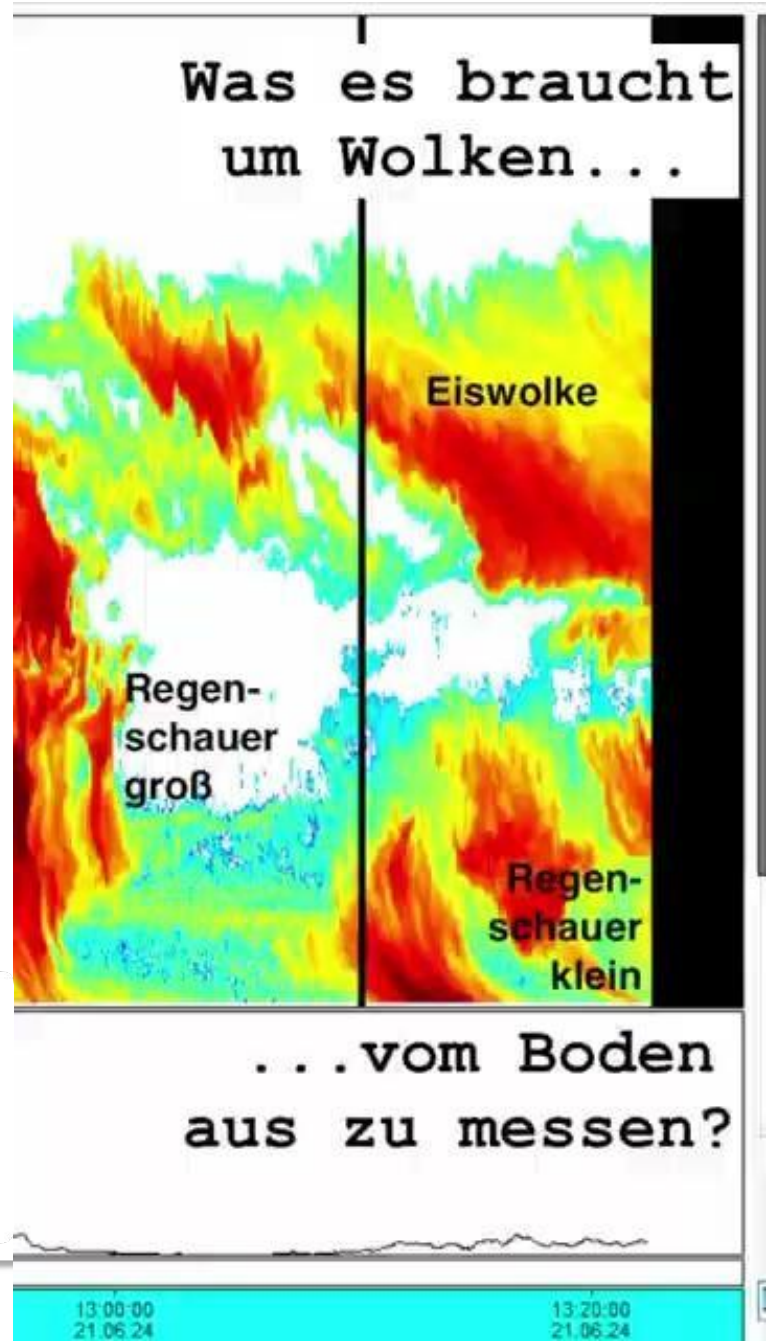
- JoyDuRad 35 – Ka-band radar
- JoyDuRad 94 – W-band Radar

Both frequencies on one scanner, optimized beam matching for dual wavelength technique

Measured variables: Ze, Vm, Sw, Skewness and Kurtosis and Doppler spectra

Full Polarimetric capabilities :

- additional variables Zdr, Phi, Kdp and RhoHV
- spectral polarimetric information
- Passive channels at 89 GHz and 35 GHz



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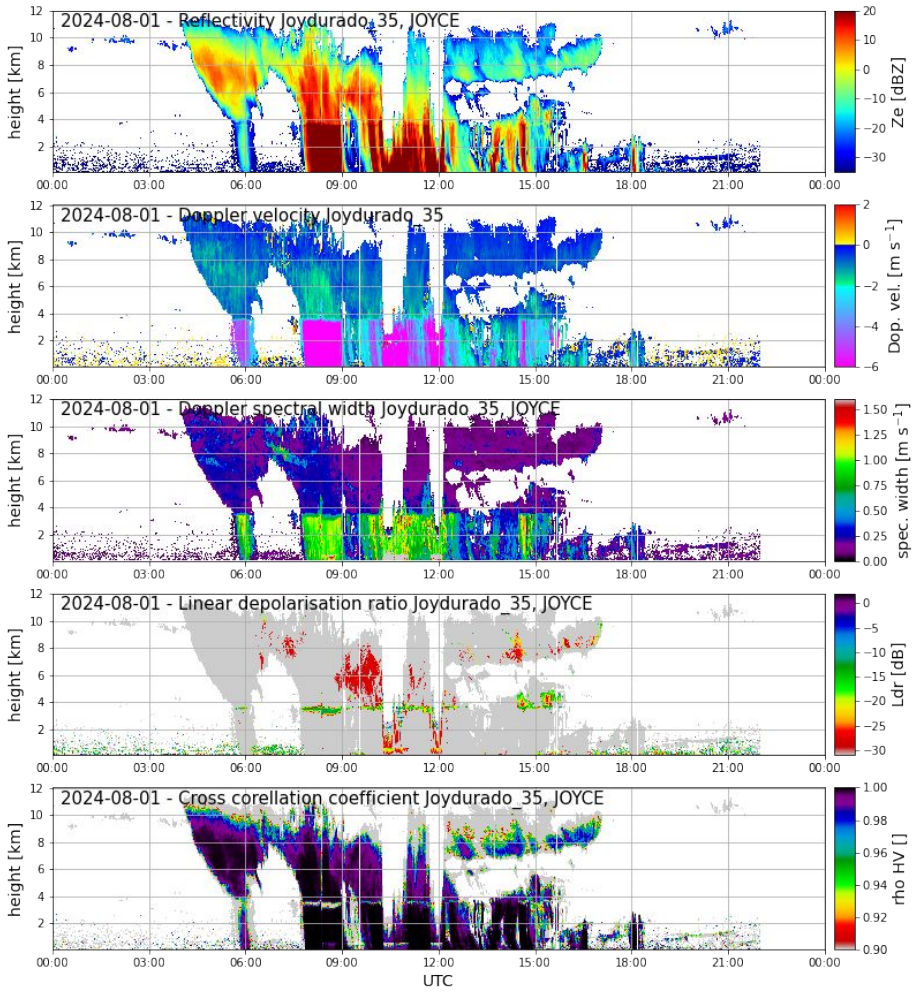
JoyDuRadO - JOYce DUal Frequency RADar Observation system – current status:

At the moment:

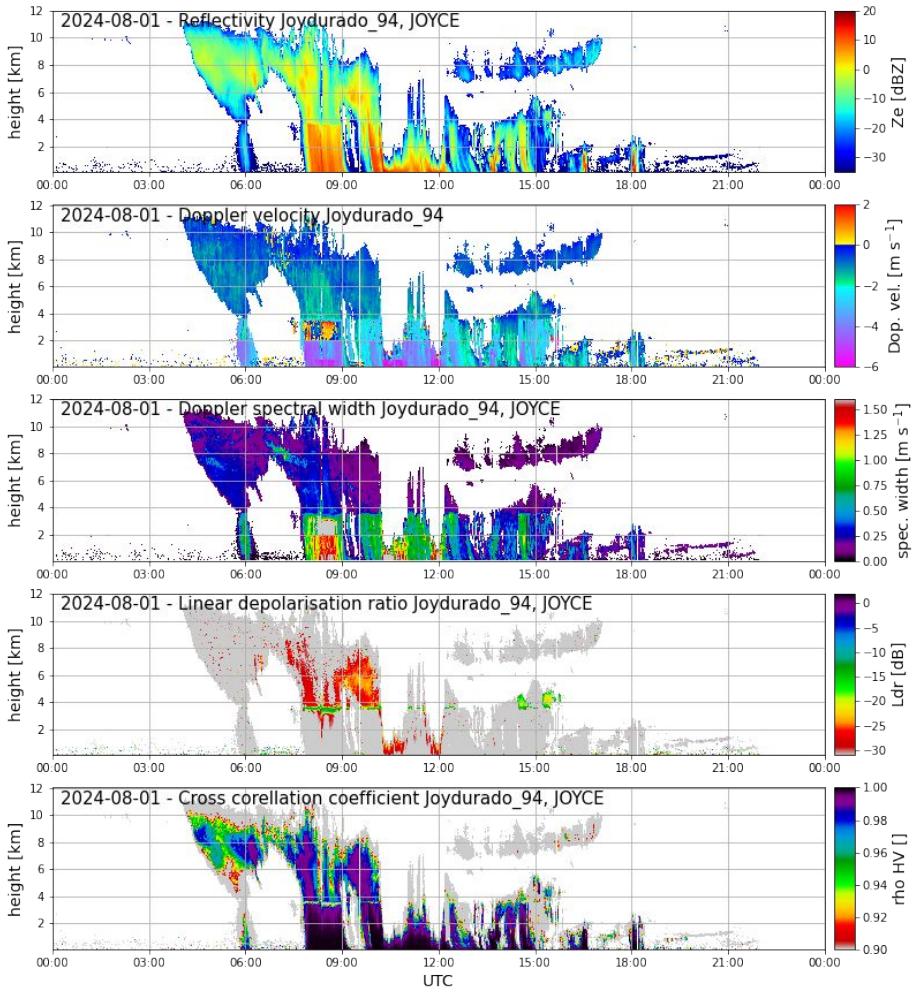
- Data are sampled
- Quick-looks are generated
  - Scans planned
  - Comparisons of frequencies
- Test during Herz Summer School 2024

- Still testing the device and setting up processing and plotting

JoyDuRado35 – Ka-band 35 GHz



JoyDuRado94 – W-band 94 GHz



JoyDuRadO - Future perspectives: hydrometeor size

Make use of the new measurement values and parameters:

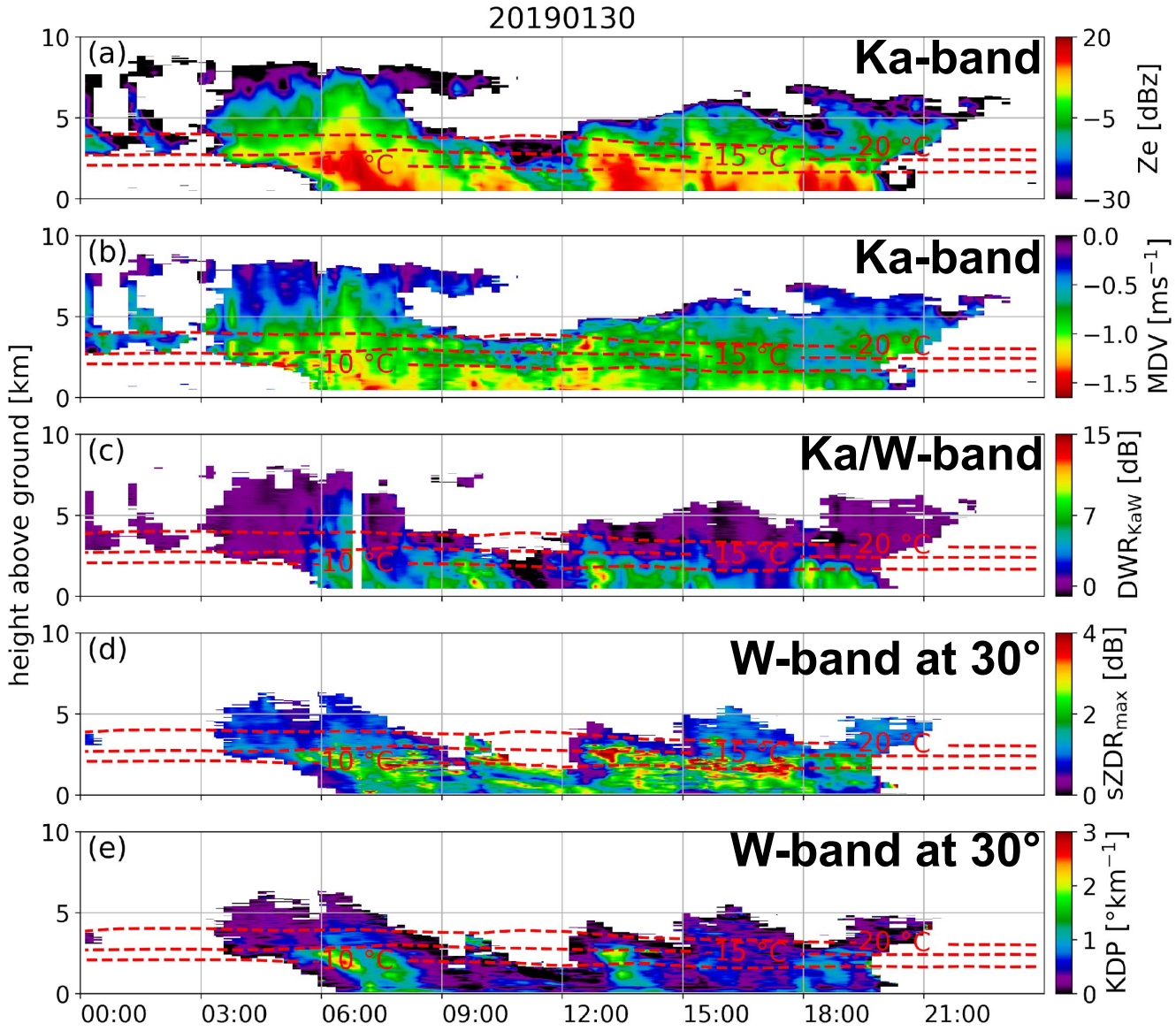
- Dual wavelength ratio
- Dual Doppler velocity
- Polarimetric variables

DWR for hydrometeor size receivals

Scans to obtain polarimetric variables

- for ice particle characterisation
- How can scans be used in ACTRIS?

Doppler spectrum for cloud microphysical property retrievals



Plot from van Terzi et al., 2022

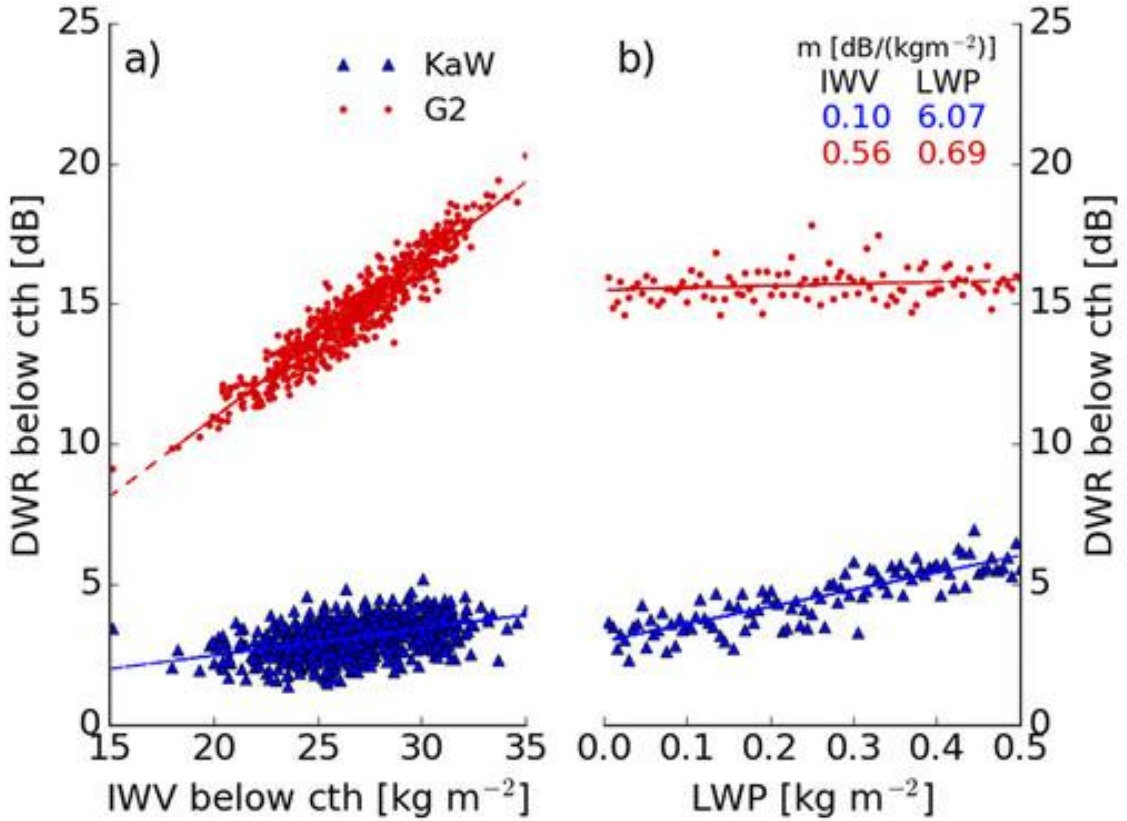
JoyDuRadO - Future perspectives: water profiling

DWR for liquid water profiling

Make use of the attenuation in the Ka- and W-band to estimate liquid water content within liquid clouds and watervapour

Use instrumental synergy with
- Microwave radiometers
- New Raman Lidar

Investigate profiling capabilities within the lower troposphere



Plot from Schnitt et al., 2020

JoyDuRadO - Future perspectives: water profiling

DWR for liquid water profiling

Make use of the attenuation in the Ka- and W-band to estimate liquid water content within liquid clouds and watervapour

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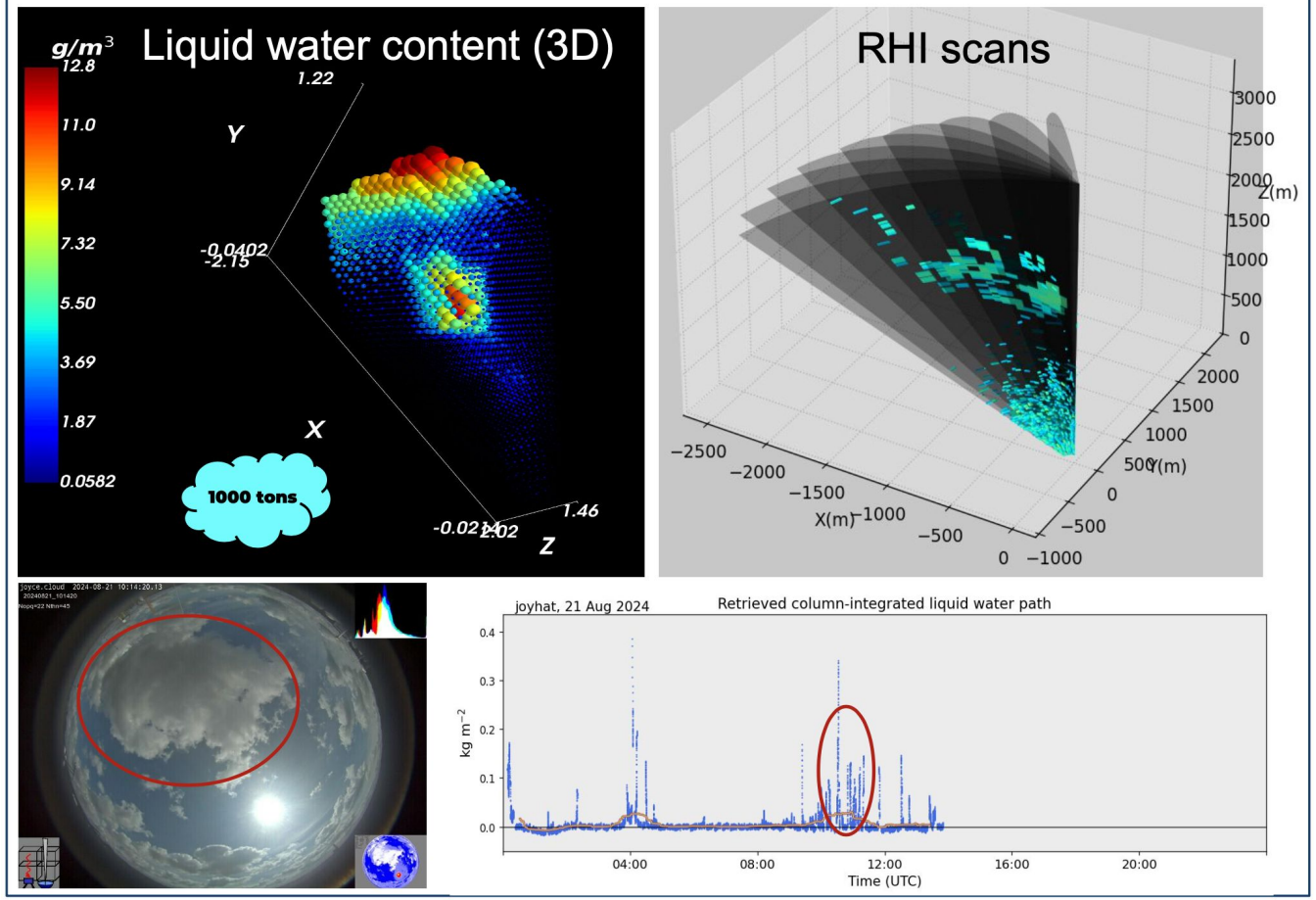
5. Results: Cloud Water Mass Estimation

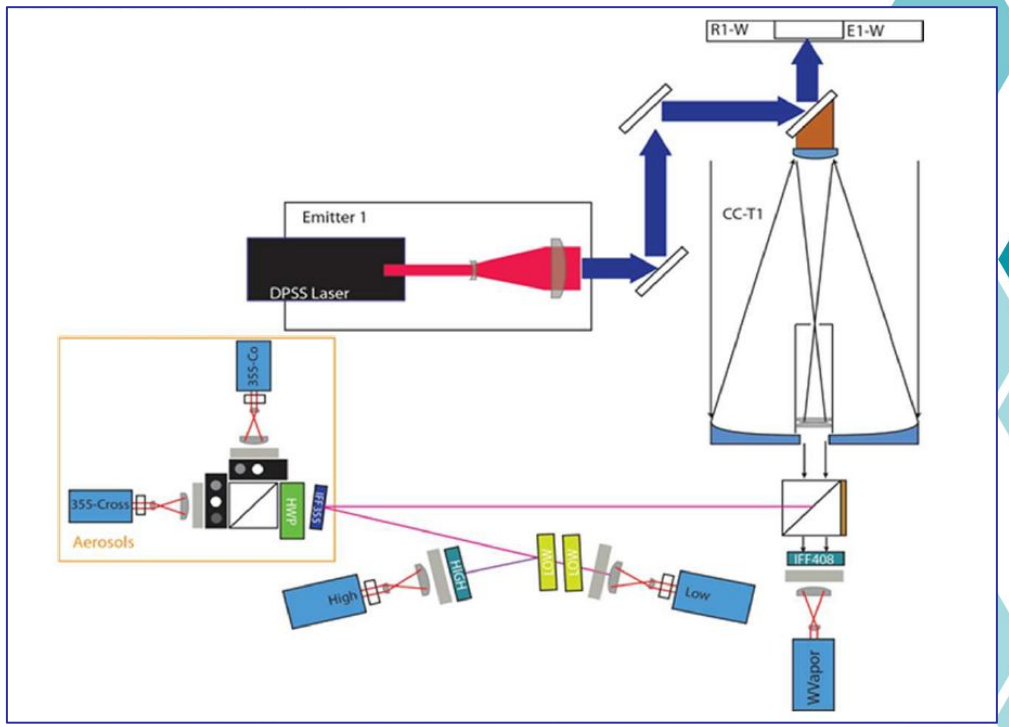


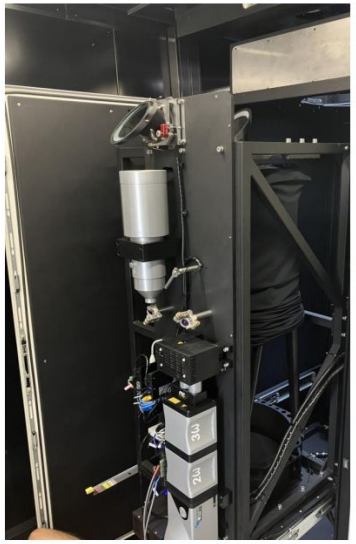
Herz Summer school 2024
Alexander Gerco Jong, Iliana Koutsoupi, Moritz Müller, Matheus Tolentino de Silva (Bernhard Pospichal)

Raman Lidar

- High-power Raman Lidar (355 nm)
- Raman channels for temperature and water vapour profiling
- Depolarization for aerosol profiling
- ACTRIS CARS compatible

- Delivery in July 2024
- Until now only preliminary operation, still some improvements necessary





Raman Lidar – First Measurements, Current issues

Current Issues

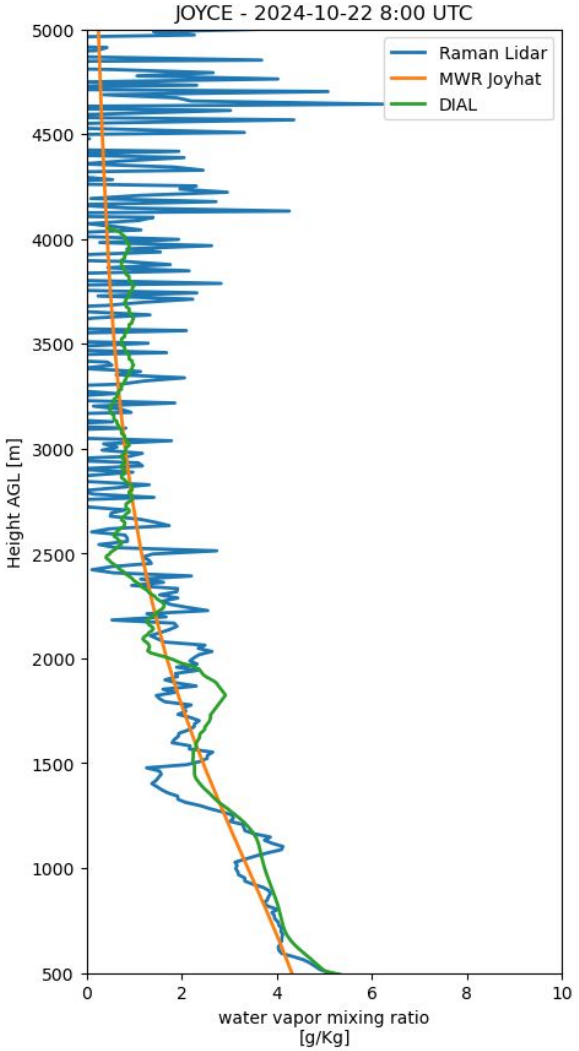
- Laser Reliability
- Low-J channel: low intensity
- WV-channel: connectivity issues

Operational

- Elastic Aerosol Products (Klett, Raman, PLDR)
- Daytime WV retrieval

Not Operational

- Nighttime WV retrieval
- T retrieval



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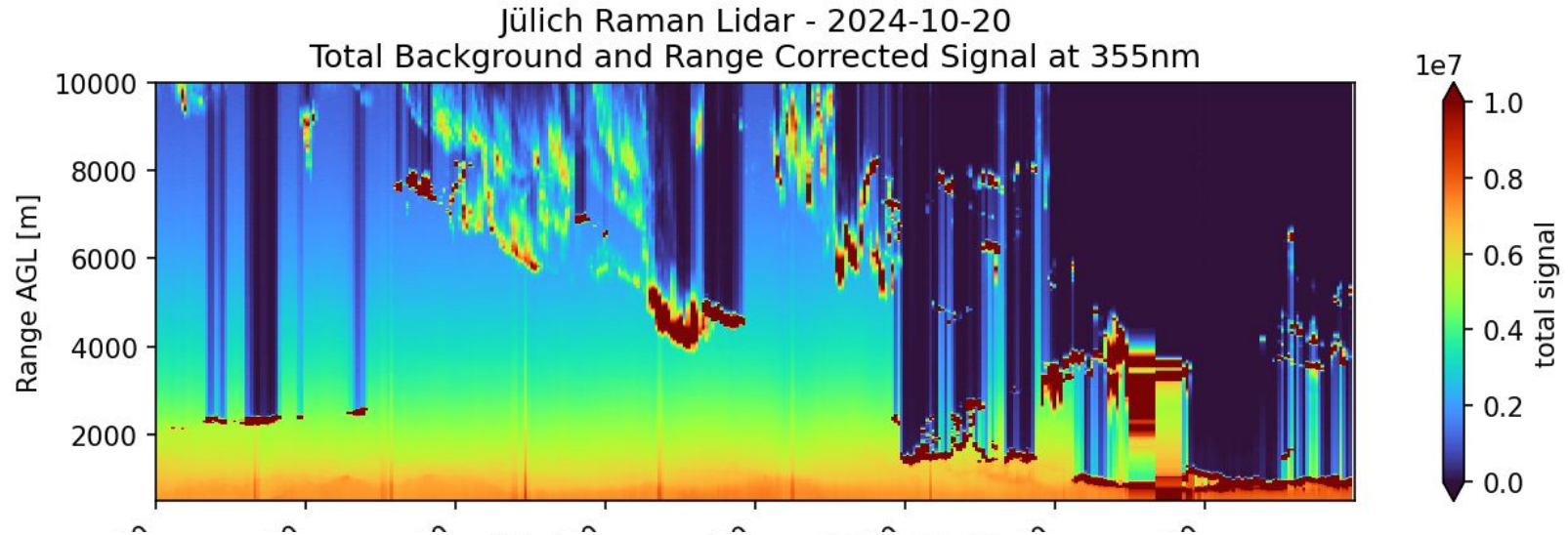
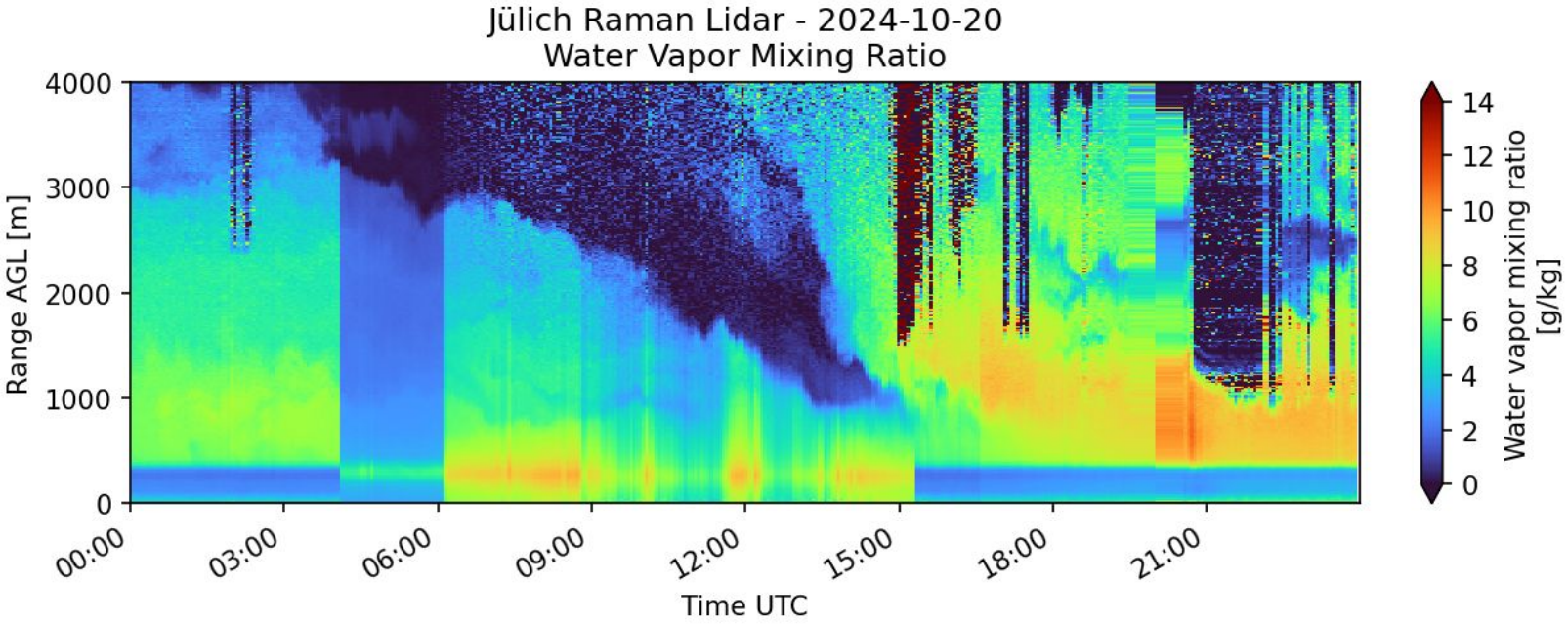
Raman lidar – preliminary profiles

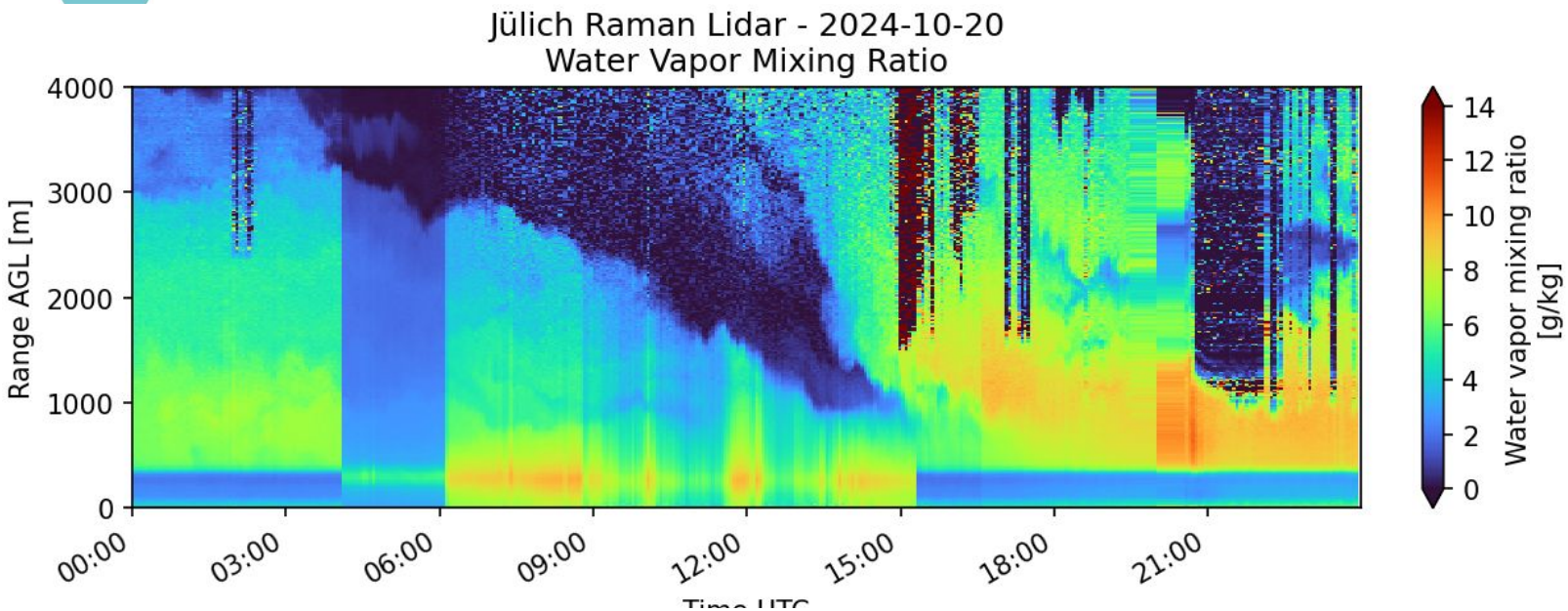


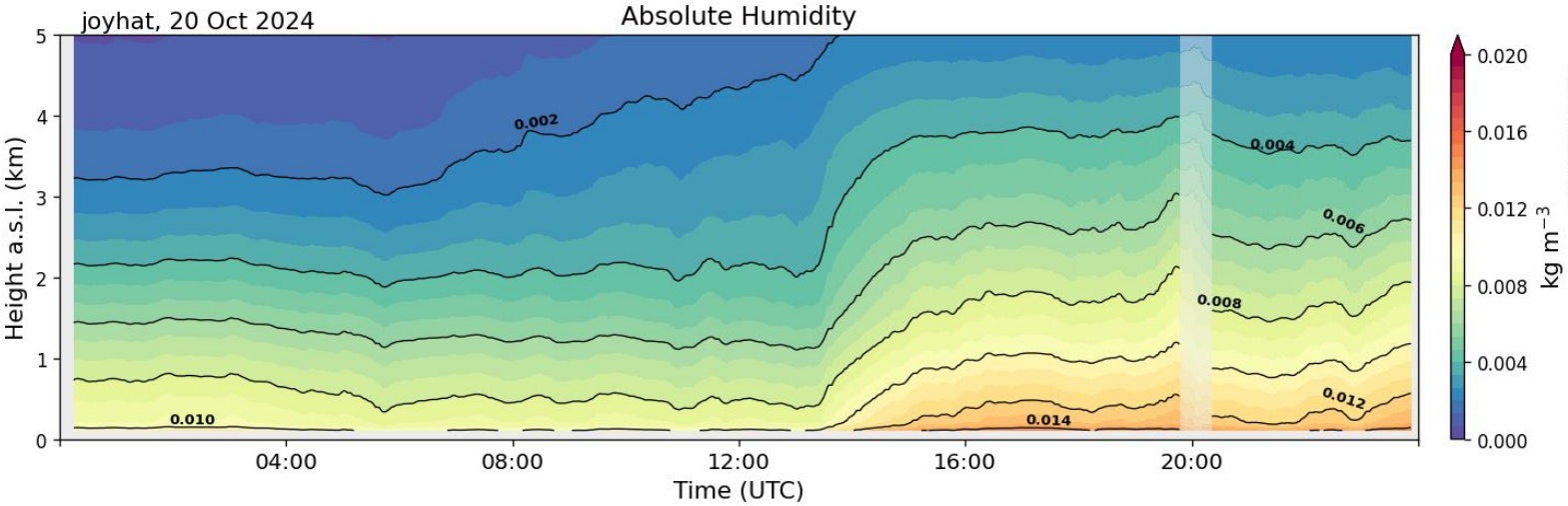
Range corrected elastic signal already ok



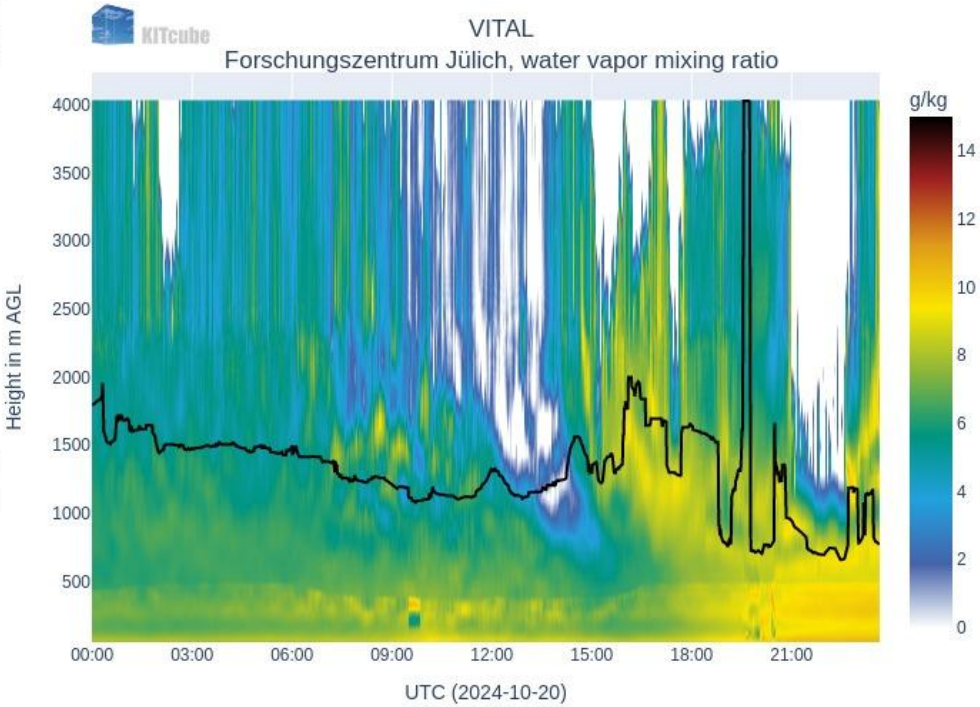
Water vapour and temperature profiles still need improvement (calibration, sensitivity)

Raman lidar - Comparison water vapor profiles





Raman Lidar (top left) – still calibration issues
DIAL (bottom right) – temporary installation by KIT
MWR (bottom left)



Future work /Applications

Dual-frequency radar:

- Determination of hydrometeor size (dual-frequency ratio)
- Hydrometeor concentration and shape (polarimetry/scanning)
- Cloud geometrical size distribution
- Cloud liquid water profiling (synergy with microwave radiometer and Raman lidar)

Raman lidar:

- Better understanding of water vapour around clouds
- Synergy products with Doppler lidar and microwave radiometer
- Determination of heat and moisture budgets in the ABL (mixing diagrams)

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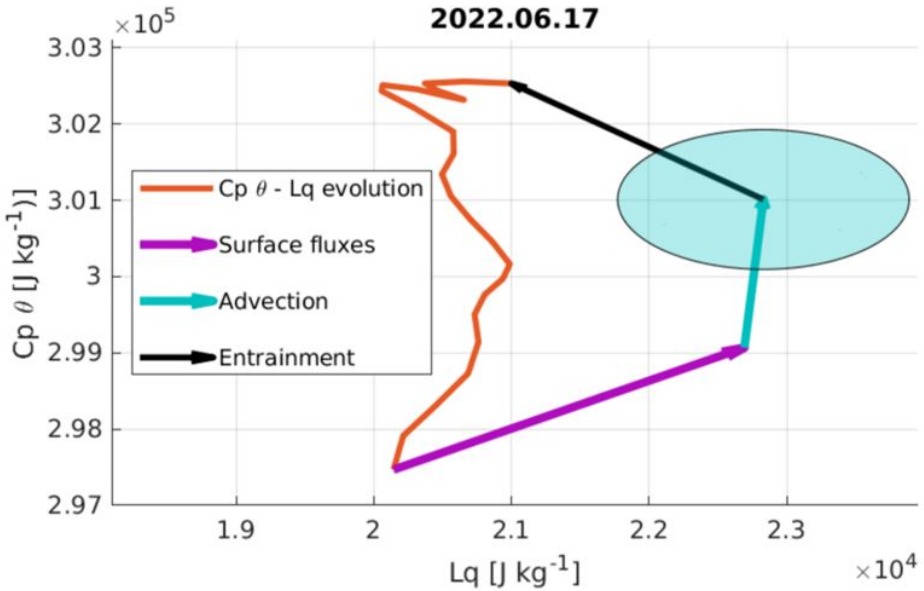
Synergistic approaches to assess energy budgets in the ABL

We are currently implementing the mixing diagram approach (Santanello et al. 2009) utilizing:

- Temperature and humidity (from MWR)
- Surface fluxes (from ICOS station)
- Advection of temperature and humidity (synergy MWR-DWL)
- Entrainment estimated as residual vector in energy space



Ongoing work and future perspective with Raman lidar:

- Evaluate the uncertainties and implement the possible capabilities of the advection synergy
- High vertical and temporal resolution of the Raman lidar, together with DWL velocities, will allow to measure temperature and humidity fluxes at higher elevations in the ABL

Make possible to quantify entrainment via direct measurements at ABL heights, instead of as a residual vector

Better understanding interactions ABL-free troposphere

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Thank you