Water vapor transport in the turbulent PBL measured over heterogeneous terrain using multiple LiDAR systems

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Why water vapor?

Cloud formation / atmospheric humidity

Climate response

PBL

Free troposphere

Water vapor

Entrainment

Precipitation

Turbulence

Evapotranspiration

Fluxes of latent heat

Soil Moisture

Soil Moisture

Water vapor

Evapotranspiration

Fluxes of latent heat

Soil Moisture

Why water vapor?

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Motivation – Why water vapor?

- Water vapor is relevant for multiple processes on many temporal and spatial scales.

- Vertical fluxes of latent heat throughout the entire PBL are a key feature inside the energy balance closure problem.

- The influence of heterogeneous terrain on tropospheric water vapor is of special interest.

- LiDARs are predestined for temporally and vertically high resolved measurements of water vapor throughout the PBL.
Data and experimental setup

- The KIT ATMONSYS LiDAR system has been operated with a new DIAL setup (EGU2020-16517) for the first time at the CHEESEHEAD campaign in 2019, aiming towards deeper understanding of PBL responds to spatial surface heterogeneity.
- In the following, first insights in data from the ATMONSYS WV DIAL are given for a randomly picked date (25.09.2019).
- The combination of 3 Doppler wind LiDARs next to the ATMONSYS delivers direct information on the movement of water vapor.

**CHEESEHEAD**

The Chequamegon Heterogeneous Ecosystem Energy-balance Study Enabled by a High-density Extensive Array of Detectors

WV: Water vapor
DIAL: Differential Absorption LiDAR
Experimental setup

- The doppler LiDARs have been operated in a **virtual tower setup**.
- A very **tall tower** with meteorological instrumentation next to the LiDARs allows for proper **signal calibration**.

**q**: specific humidity  
**T**: Temperature  
**v/w**: Wind speed  
**DL**: Doppler wind LiDAR  
**i.a.: q**

The doppler LiDARs have been operated in a virtual tower setup. A very tall tower with meteorological instrumentation next to the LiDARs allows for proper signal calibration.
1-min average data on a random sunny day reveals **time periods** with **low data accuracy**. This is most probably due to **vibrations** of the internal **air conditioning** system, leading to unseeded laser pulses.

Can those errors be „smoothened“ by a correction function?
Possible methods to detect unseeded laser operation are the signal strength of $\lambda_{off}$ or signal ratios in different heights.

Missing structures of correlation plots show, that there seems to be no physical relationship for potential error removing functions.

Thresholds in signal strength of $\lambda_{off}$ combined with the ratio of signal strengths in upper and lower heights are combined as filter criteria.
Filter criteria reliably remove unrealistic outliers.

Unfortunately, depending on the general daily quality of measurements, the available data amount has to be reduced to ensure proper data quality.
Data comparison

- **Technical issues** with the LiDAR system led to the need of unexpected efforts in the improvement of data quality.

- As a further step, vertical **wind data** from the doppler LiDAR will be **combined with the water vapor** DIAL data to actually describe the transport of water vapor.
Take home message

- The new ATMONSYS water vapor DIAL has measured reasonable data during the CHEESEHEAD campaign, although technical issues caused time periods with unplausible outliers.

- This biased data due to unseeded laser operation is captured well by filter criteria and can therefore be removed. This finally allows water vapor data analysis in further steps.

- The implementation of an aerosol retrieval will deliver information on aerosol distribution soon. This data is expected to be free of such biased time periods as there haven’t been issues with the quality of the laser pulses in this wavelength.