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Measurements of water vapor, aerosol, contrails, and cirrus clouds at the Meteorological Observatory Lindenberg

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Introduction

From April to October 2003 measurements have been performed with a mobile Aerosol Raman Lidar (MARL) at the Meteorological Observatory in Lindenberg (MOL, 14.5°E, 52.5°N). The aim of this extensive campaign was the investigation of tropospheric water vapor, cirrus clouds and contrails over a longer period of time.

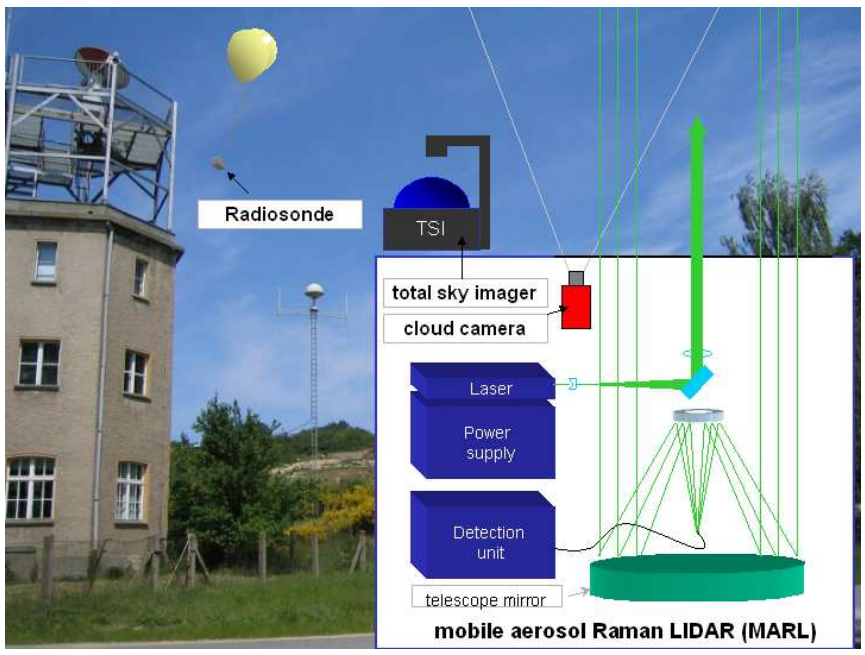
Instruments in operation during the campaign

Radiosondes: → Profiles of relative humidity up to the tropopause
Type: Vaisala RS80A with special ground check

Raman Lidar: → Aerosol and cloud backscatter profiles
→ Depolarization and color indices of clouds and aerosol
→ Water vapor profiles from 0.5 to 10 km

Cloud Camera: → Characterization of cirrus and identification of condensation trails.

Total sky imager: → Cloudiness
Type: Yankee TSI 800



Meteorological Observatory Lindenberg: MARL@MOL Instrumentation

Total sky images:. The TSI continuously monitors the complete sky (1 picture per minute) and measures the cloudiness.

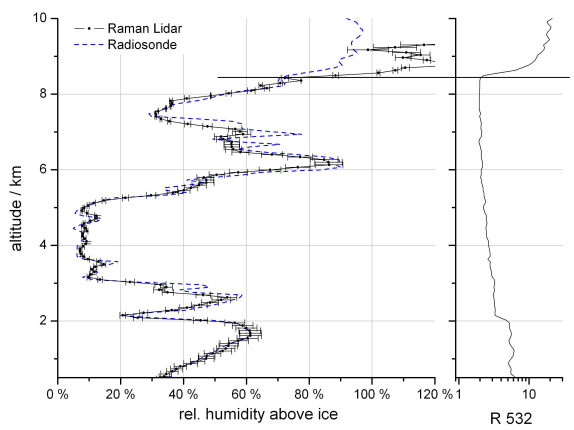
Summary :

- **During the MARL@MOL campaign 700 hours of Lidar data have been acquired, accompanied by cloud camera observations.**
- **In about 50% of that time thin or subvisual cirrus clouds have been detected.**
- **Numerous contrails have been identified.**
- **A detailed analysis of the differences of the optical and micro-physical properties of the particles in these types of clouds is currently being conducted. Preliminary results suggest, that the optical properties, namely the depolarization is different in natural cirrus and those influenced by aircraft exhausts.**
- **Aerosol in the free troposphere is unusually abundant. Some events can be traced back to forest fires, others to Saharan dust outbreaks.**
- **The comparison between water vapor profile measurements between lidar and radiosondes (Vaisala, RS-80A) yields very good agreement in the range between 0.5 and 8 km and outside of clouds.**

Observations

Water Vapor

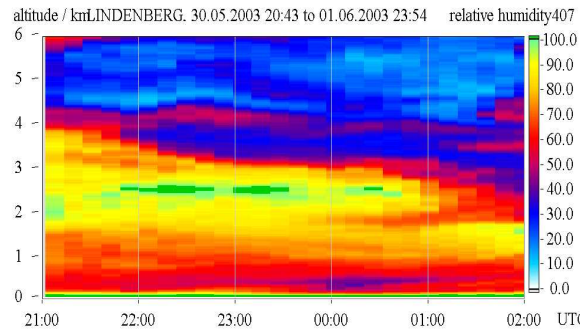
Comparisons Lidar - Radiosonde



thin cirrus cloud

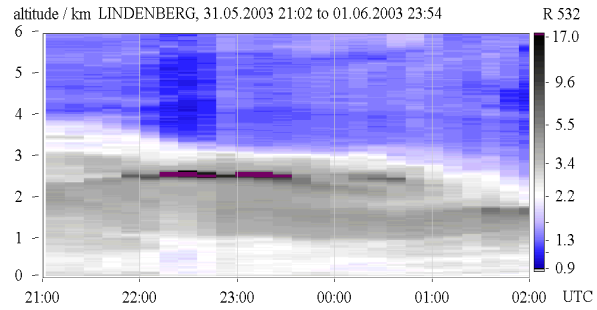
Comparison of lidar (black) and radiosonde (blue) measurements of water vapor (in terms of the relative humidity). The sonde was started at 22:45 of June 17 2003 and reached 10 km about half an hour later. The graph at the right hand side shows the backscatter ratio profile determined by the lidar at the same time (22:53 - 23:05, 20,000 shots). Up to the thin cirrus cloud in 8.5 km altitude the measurements by the radiosonde and lidar agree very well.

The color plot below shows the relative humidity above water obtained from Lidar data of May, 31th to June, 1st 2003.



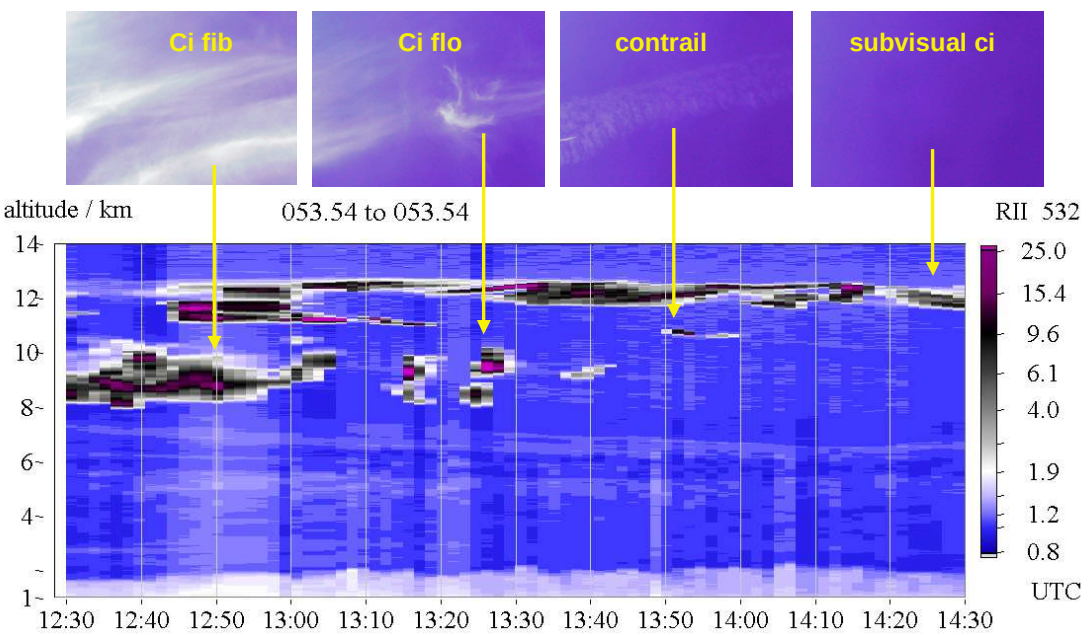
Aerosols

The plot below shows the backscatter ratio at 532 nm from Lidar data of May 31st to June 1st 2003 with a high aerosol load up to 4 km. The regions where the rel.humidity (above water) exceeds 100% in the plot above correspond to regions with very high backscatter ratios (>10) in the panel below which are indicating cloud formation.



In the graph from August 8th shown below, haze layers can be seen in the altitude range between 2.5 and 8 km. These are remnants from forest fire plumes from Portugal, where heavy forest fires occurred around August 5th.

Cirrus and contrails



Data of clouds and aerosol measured by Marl in Lindenberg on August, 8th 2003. The upper pictures show cirrus cloud and contrails photographed by the cloud camera. The clouds are identified in the lidar data. Thus, the height and optical properties like the optical depth, the color index and the depolarization can be determined. Based on the closest radiosonde data, the relative humidity at which the clouds occur can be estimated.