Continuous Measurements of the Vertical Distribution of tropospheric Ozone and Aerosols with an unattended Lidar System

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Objectives

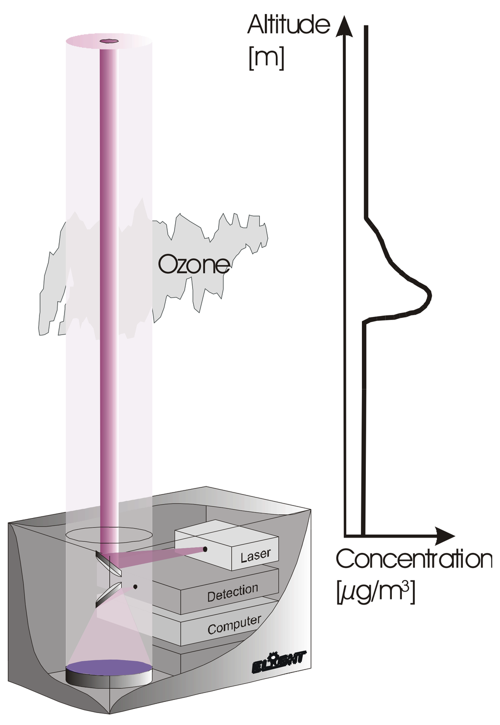
The objective of this part of the AFO project (ATF 23) is to obtain new information on the significance of vertical and horizontal transport processes for the ground level concentrations of Ozone and Aerosols. Measurements of the vertical distribution of Ozone and light extinction as a qualitative parameter for the aerosol distribution are carried out. The measurement device is the Ozone Profiler, an unattended Lidar system which provides continuously data of the vertical distribution of Ozone and Aerosols as extinction.

Measurement system

The Ozone Profiler is a compact Lidar system, which sizes 1.2 m x 0.85 m x 1.45 m (l x w x h) and weights approx. 450 kg. It is developed for an unattended operation with low maintenance and operational costs.

This compact system allows the monitoring of the vertical Ozone distribution from about 100 m pu to 2000 m with an accuracy of a few ppb and a spatial resolution down to several meters.

Furthermore, the system delivers information about the vertical distribution of Aerosols (as extinction), which is very important regarding the formation of secondary Aerosols by photochemical processes. Thanks to the parallel use of near field optics it is possible to carry out measurements in a range from under 200 m (operational point) to approx. 2000 m.



Measurement principle

To determine the spatial distribution of Ozone the DIAL technique is applied. It is based on the specific light absorption by molecules. According to the spectroscopic properties of the specific molecule (Ozone) the absorption depends on the wavelength of the incident light.

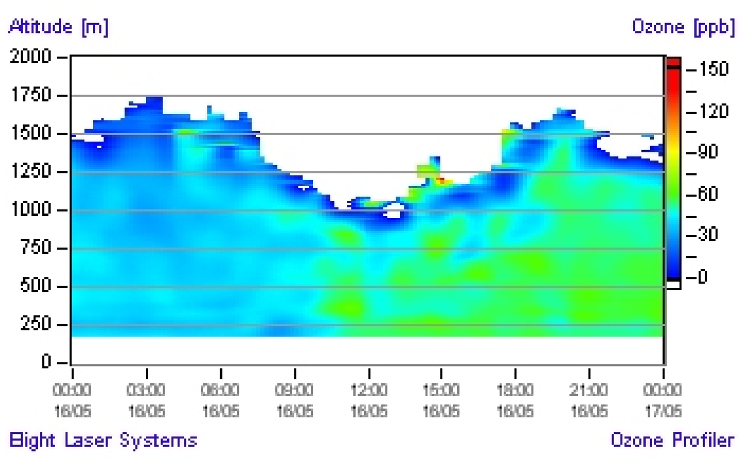
Therefore a DIAL system sends out laser pulses, alternating in two different wavelengths. One of the wavelengths ($_{on}$) is chosen for high selective absorption by Ozone. The other one is closely neighbouring but suffers nearly no absorption by Ozone ($_{off}$). In absence of this pollutant the atmospheric return signals on both wavelenghts are nearly equal.

If the laser beam meets higher concentrations of Ozone (as sketched in the figure), a significant difference in both signals is observed. This difference of the acquired signals allows to calculate the Ozone concentration as a function of the distance along the beam.

Measurement place

The Ozone Profiler was placed at Berlin Frohnau on the 23rd July 2001. The measurement place of the Profiler is close to the Frohnau tower and the measurement container no. 145 from the Berlin Network "BLUME".

This place allows, that measurement results obtained with the Profiler could compared to measurements of Pm10 and Ozone, measured with conventional devices, one placed on the tower at an altitude of 324 m and one device at ground level.

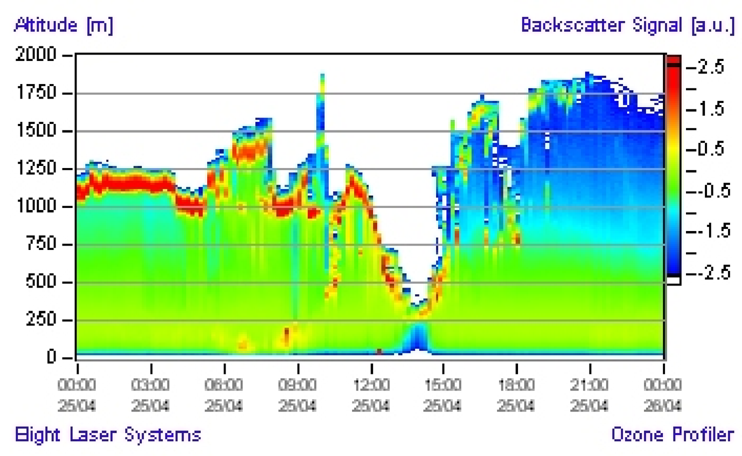


Measurement results

Ozone measurements were obtained with the Ozone Profiler for one year. The data availability was approx. 70 %.

The max. range strongly depends on the local weather conditions and the Ozone concentration as well. In this example the range decreased during noon time caused by higher backgrounds solar radiation.

Ozone often shows behaviour of layers or bubbles with variation in time and scale. A Lidar system offers the possibility to observe this behaviour in an excellent manner.



Aerosols

The figure on the left side shows for example the backscatter signals from 25th April 2002. The high variation of the altitudes of the clouds can perfectly be seen. After 9 pm the clouds disappeared completely and the backscatter signals are mainly caused by rayleigh scattering.

The height of the mixing layer often can be derived with that kind of information. The mixing height is especially important as an input parameter for the atmospheric modelling.

Higher loadings of particulate matter in the planetary boundary layer due to stronger backscatter signals. In the frame of this project the backscatter signals measured with the Ozone Profiler will be compared with PM 10 measurements.

Conclusions

For the first time an unattended Lidar System measured the vertical distribution of Ozone and Aerosols over one year. It delivered valuable information about mixing and transport processes of Ozone and Aerosols over Berlin. The evaluation of the data is not yet finished.

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