Name of research institute or organization:

École Polytechnique Fédérale de Lausanne (EPFL)

Title of project:

Study of atmospheric aerosols, water, ozone, and temperature by a LIDAR

Project leader and team:

Dr. Valentin Simeonov, project leader
Prof. Hubert van den Bergh, head of the Laboratory for Air and Soil Pollution (LPAS)
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Project description:

In 2008, the work on the upgrade of the EPFL lidar with an ozone channel continued and first ozone profiles have been acquired. The efforts were directed mostly towards emitting-setup improvement and data treatment procedures.

A modified beam transmitting system was designed at the EPFL and installed on the lidar at the beginning of 2008. The modifications of the transmitter aimed to extend the operational range of the lidar to lower and higher altitudes. This was achieved by decreasing the distance between the lidar transmitter and receiver axes and by reducing the output divergence of the laser beam by a beam expander. In the new design (Figure 1), the prism used to direct and steer the output laser beam in the atmosphere is positioned at its closest possible position (approximately 0.75m) from

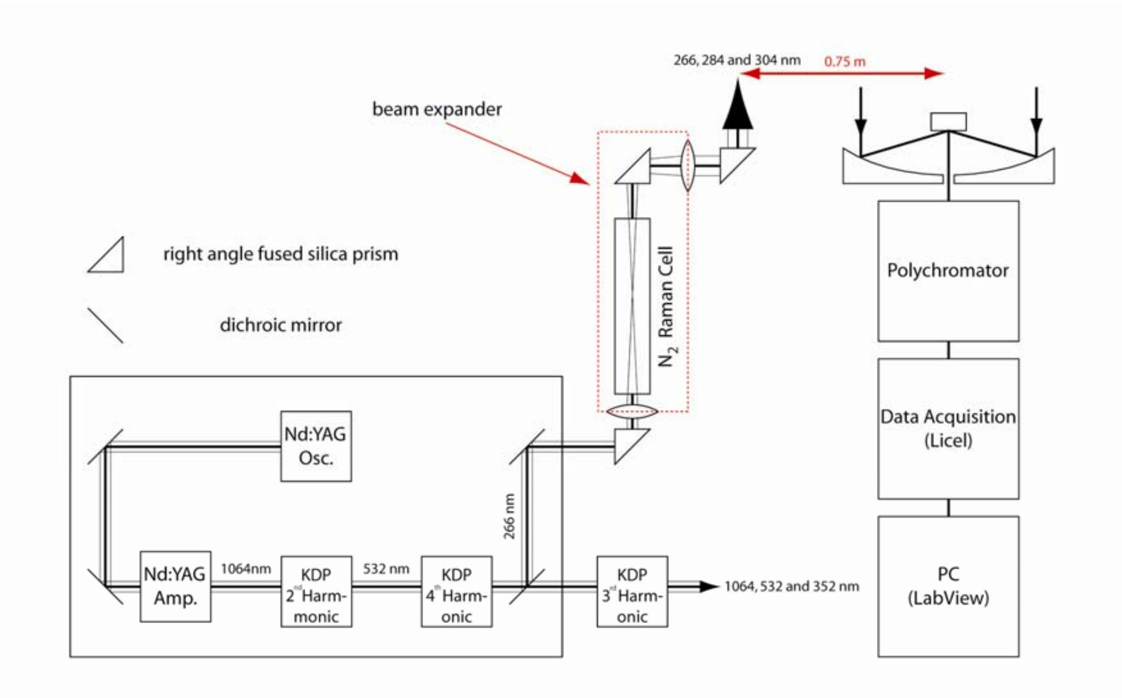

Figure 1: Modified transmitter receiver setup.

the telescopes axis. The beam expander is formed by the entrance lens of the Raman cell (0.6 m focal length) and an additional 2 m FL positive lens, installed just before the steering prism. The expander reduces the laser beam divergence by a factor of three. The modifications in the transmitter required changes in the position of the telescope field stop. Optical modeling of the lidar, performed by the ray-tracing software OSLO 6, showed, that a 2 mm displacement of the field stop reduces the full overlap altitude to approximately 2 km AGL. Further displacement leads to decreasing the overlap height but at the price of loosing the high-altitude signal.

The software development was focused on the completion of adequate evaluation tools. Data treatment is now performed by either Mathematica or by MATLAB graphical user interface.

The first measurements with the modified system were taken in April-May. The lidar profiles were compared to balloon-borne ozone sondes. Sondes are launched by the Swiss Meteorological Institute (SMI) from Payerne (491 m ASL, 46° 55' 06.20" N. 6° 57' 20.54" E) three times a week (Monday, Wednesday and Friday) at noon. A comparison between the lidar and the sonde ozone measurements is shown in the left panel of Figure 2. The lower detection range of the lidar is at 2 km AGL in accordance with the estimates given by the physical and optical restrictions of the system. The lidar and sonde profiles show almost constant ozone concentration up to 7 km, followed by a rapid increase until approx. 8 km, and almost steady concentrations above this height. The 8 km altitude corresponds to the tropopause height as derived from the temperature profile measured by the radiosonde. The observed fluctuations of the ozone concentration at higher altitudes may be ascribed to variations in the local meteorological conditions. Wind shear in the upper troposphere can be one of the factors responsible for the variations in the ozone number density. The two profiles show very good agreement with differences generally lower than 30 %. and less than 20% below 4 km Bigger discrepancies in the measured ozone concentrations were observed in the tropopause and the lower stratosphere regions with a maximum difference of 60 % at the beginning of the tropopause (7.8 km). The discrepancies between the two profiles are not surprising and can be explained mainly by the atmosphere dynamics and the fact that the two instruments are measuring different atmospheric volumes due to inevitable differences in time and the position in space of the probed atmospheric part. The initial difference in the space between the sonde and the lidar was approx 100 km and varies with time as seen from the sonde trajectory shown in Fig. 3. Another reason for the discrepancies is the underestimation of the ozone concentrations by about 20% by the electrochemical cell detector of the sondes known from comparisons to ozone photometers.

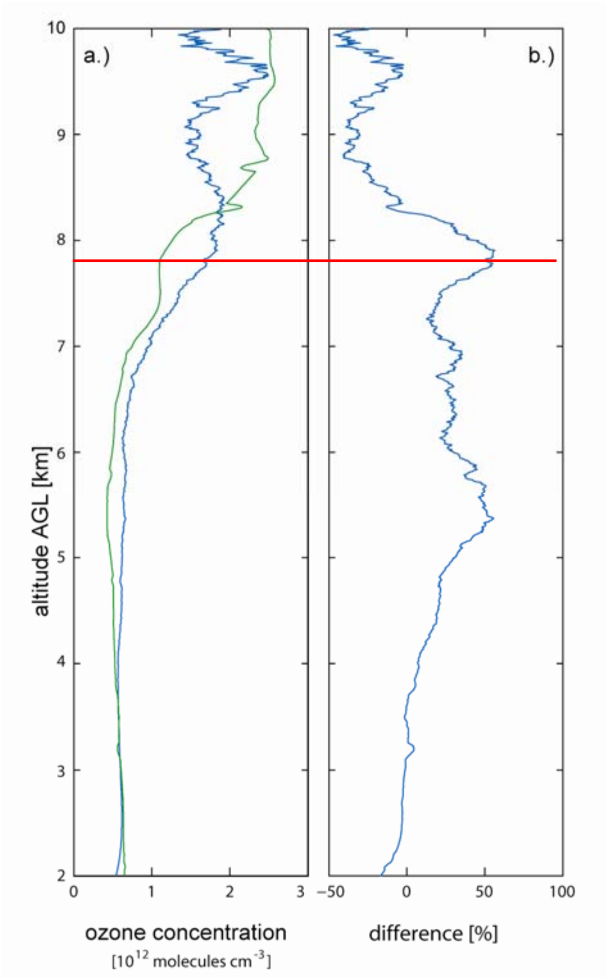

Figure 2: Left panel: ozone concentrations measured by the lidar (blue) and the balloon sonde (green) taken on May 7th 2008. Right panel: difference between the lidar and sonde concentrations. The tropopause height derived from the sonde temperature profile is marked by a horizontal red line.

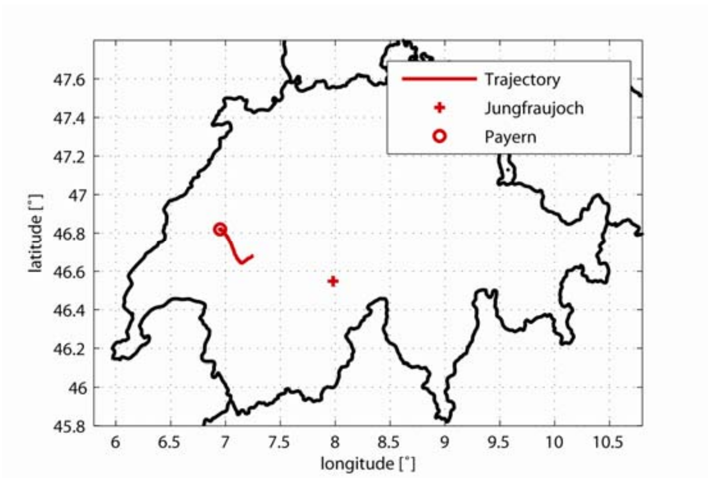

Figure 3: Trajectory of the balloon sonde launched at SMI in Payerne on noon of May 7th 2008.

During the same period short time series were also taken with the lidar. The time series shown in Figure 4 consists of five single measurements. As can be seen from the figure, air masses containing higher ozone concentration were observed above 7 km during almost the whole observation period. The decrease in the ozone content at the highest part of the profile seen at approx 12.40 h could be ascribed to short-term variations of the tropopause height.

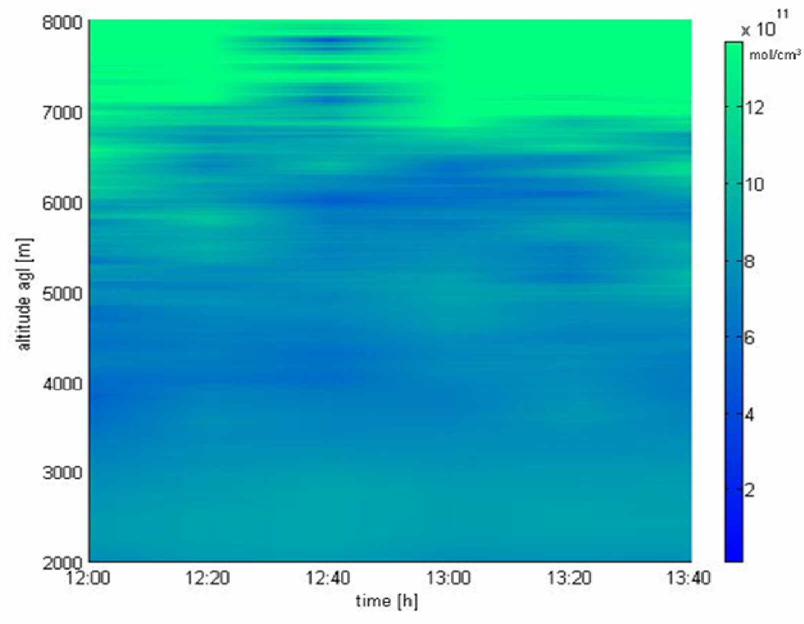

Figure 4: Example of a short time series measurement.

The measurements during the second part of the year were interrupted because of various technical problems related to the laser source and its supporting systems. Some of the problems lead to a serious damage of the laser. The work on fixing up the laser is ongoing and we expect to resume measurements at the beginning of 2009.

Key words:

Multi –wavelength lidar, Raman lidar, pure rotational Raman scattering, aerosols, backscatter and extinction coefficients, troposphere, water-vapor mixing ratio, temperature, ozone, STE.

Internet data bases:

http://eflum.epfl.ch/

Collaborating partners/networks:

EARLINET – European Aerosol Research Lidar NETwork
Federal Office of Meteorology and Climatology MeteoSwiss
Institute of Atmospheric Optics – Tomsk, Russia

Scientific publications and public outreach 2008:

Conference papers

T. Dinoev, P. Ristori, B. Calpini, H van den Bergh, M. parlange and V. Simeonov *Meteorological water vapour Raman lidar- Calibration*, 24 th International Laser Lidar Conference, pp. 1045-1047, 23-27 June 2008, Boulder, Colorado US.

I. Serikov, M. Froidevaux, P. Ristori, V. Simeonov, Y. Arshinov, S. Bobrovnikov, H. van den Bergh, M. Parlange, *A temperature and water vapour Raman lidar: Calibration and field tests*, 24 th International Laser Lidar Conference, pp. 1033-1038, 23-27 June 2008, Boulder, Colorado US.

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