Name of research institute or organization:

# École Polytechnique Fédérale de Lausanne (EPFL)

Title of project:

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

Project leader and team:

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Project description:

In 2007, the EPFL lidar group continued the upgrade of the multiwavelngth elastic-Raman scattering lidar with an ozone channel. During the reporting period the work was directed mostly towards software development, although some hardware development was carried out too. First, ozone profiles were measured with the lidar. The lidar profiles are in good agreement with balloon measurements carried out simultaneously by MeteoSwiss.

Data treatment routines in MATLAB and Mathematica have been developed in order to treat the raw lidar datasets and to perform inter-comparison with the parallel balloon data. A flow chart of the algorithm for calculating ozone concentration can be found in Figure 1. Prior to the ozone calculation, the vertical profiles of temperature and air molecular number density are calculated from meteorological balloon sonding data. Ozone absorption cross-sections corrected for temperature are then calculated using the vertical temperature profile and literature data. The raw lidar data is corrected for the offset due to background radiation and detector dark noise. In order to obtain higher ozone profile accuracy the background corrected signal has to undergo a signal averaging process responsible for the smoothing of the signal and the deriving of its slope. The spatial averaging over contiguous bins results in a decrease of the probability of inaccurate slopes due to signal noise and system-internal recording processes. This algorithm is based on a moving filter with an increasing with the range filter size. Since the signal intensity falls down with the square of the distance, the filter size is increasing parabolically with the distance, in order to compensate for the loss of signal to noise ratio.

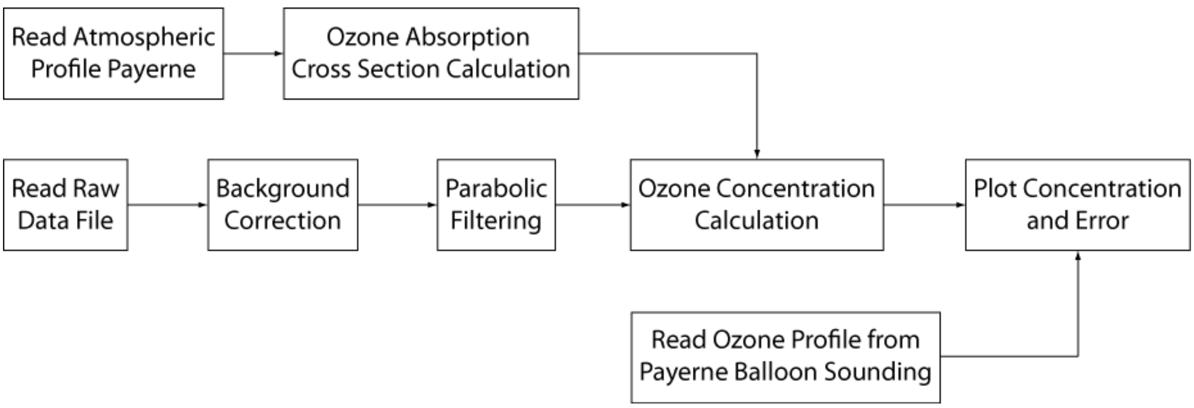


**Figure 1**: Flow chart description of the algorithm for calculating ozone profiles from the Jungfraujoch ozone UV DIAL system

After filtering, ozone concentration [mol/cm$^2$] is deduced. At the end the ozone lidar profile can be compared against an ozone profile measured from an ECC ozone launched from Payerne. The whole algorithm was programmed in 2007 and was first tested with datasets from other lidar measurements.

First data sets have been measured and treated with the MATLAB and Mathematica data routine. An example of such measurement compared to the balloon sounding is shown in (Figure 2). The two profiles show very good agreement between 2.5 and 4.8 km above ground level (agl) or 6.1- 8.4 km asl even though the distance between the balloon launching site and Jungfraujoch is more than 80 km. A possible reason for the differences in the ozone concentration between the lidar and the balloon data that reaches up to 30% is the fact that the two instruments measure different air masses. For example, the fast increase in the ozone concentration seen by the lidar above 5.5 km (9.1 km asl) could be due to a local intrusion of stratospheric masses.

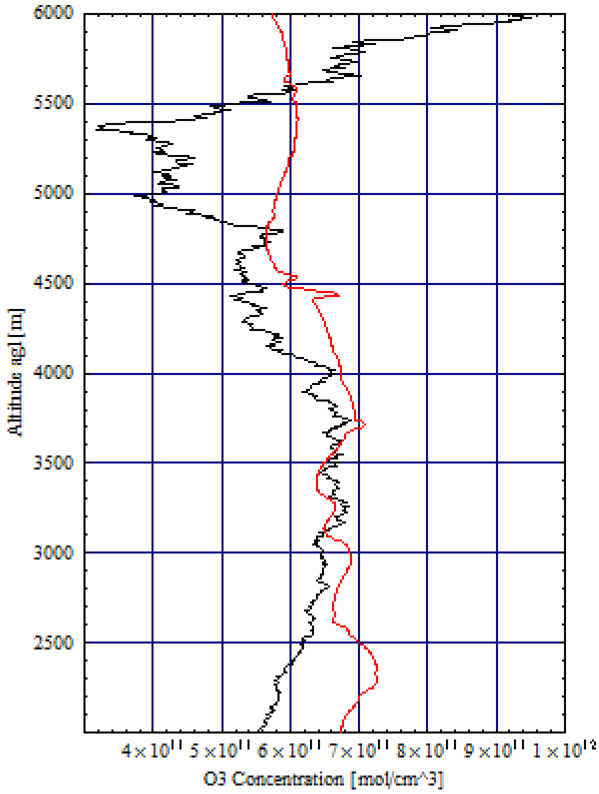


**Figure 2**: Lidar ozone profile above Jungfraujoch (3580 m asl) measured with the UV DIAL system (black line). The MeteoSwiss balloon sounding concentration is plotted as a red line.

At present the operational range of the lidar is limited to 6-7 km agl. The limitation comes from the maximum transmited laser energy and the laser beam quality. We expect a 1.5 fold increase in distance by deployng a new harmonic cristals setup, that gives 20 % higher energy and by deploying a new emission scheme which alows 3 times lower beam divergence. Both hardware upgrades were developed in 2007 and will be deployed in 2008.

The ozone data together with the data from the existing water vapor and temperature channels will be used to study troposphere-stratosphere exchange (STE).

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://lpas.epfl.ch/lidar/research/LidarJungfraujoch/Jungfrau.html

Collaborating partners/networks:

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

Scientific publications and public outreach 2007:

**Refereed journal articles**

Amodeo A., J. Bösenberg, A. Ansmann, D. Balis, C. Böckmann, A. Chaikovsky, A. Comeron, V. Mitev, A. Papayannis, G. Pappalardo, M. R. Perrone, V. Rizi, V. Simeonov, P. Sobolewski, N. Spinelli, D. V. Stoyanov, T. Trickl, M. Wiegner - EARLINET: the European Aerosol Lidar Network - Optica Pura y Aplicada, of the Optical Spanish Society, **39**, N. 1-10, 2006.

**Conference papers**

Pappalardo G., Jens Bösenberg, Aldo Amodeo, Albert Ansmann, Arnoud Apituley, Lucas Alados Arboledas, Dimitris Balis, Christine Böckmann, Anatoly Chaikovsky, Adolfo Comeron, Volker Freudenthaler, Georg Hansen, Valentin Mitev, Doina Nicolae, Alexandros Papayannis, Maria Rita Perrone, Aleksander Pietruczuk, Manuel Pujadas, Jean-Philippe Putaud, Francois Ravetta, Vincenzo Rizi, Valentin Simeonov, Nicola Spinelli, Dimitar Stoyanov, Thomas Trickl, Matthias Wiegner - *EARLINET-ASOS: European Aerosol Research Lidar Network-Advanced Sustainable Observation System* - American Meteorological Society Annual Meeting 2007, January 2007, S. Antonio, Texas, USA. in print

**Theses**

Pablo Ristori, "Development of a high spatial and temporal resolution water vapor Raman lidar for turbulent observations" EPFL thesis No. 3963 (2007).

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