Name of research institute or organization:

École Polytechnique Fédérale de Lausanne (EPFL)

Title of project:

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

Project leader and team:

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

In 2003, the EPFL lidar group continued the operation of the multiwavelength elastic-Raman scattering lidar in the framework of the European Aerosol Lidar Network EARLINET. Atmospheric temperature at altitudes up to 17 km Above Sea Level (ASL), aerosol extinction at two wavelengths (355 and 532nm), backscatter at three wavelengths (355nm, 532nm, and 1064nm), and water vapor mixing ratio at altitudes up to 10 000 m ASL are the measured parameters. The measurements were taken every other week in favorable atmospheric conditions. Joint experiments with the Environmental Fluids Group of the Johns Hopkins University, Baltimore, US were also held in the period April-August and in December.

Additional measurements were taken during the first half of August 2003. This period was characterized by a stationary anticyclonic regime persisting over Western Europe, which blocked the normal continental currents and resulted in unusually high temperatures over the region. High pressure (675 mbar, +10 mbar), high temperatures (10-12 °C, + 5-7 °C), high humidity (up to 70% RH) and low wind (up to 2.5 m/s) were recorded at the Jungfraujoch station. The aerosol and water vapor lidar data taken during the period indicated Boundary Layer (BL) heights exceeding most of the time 4000 m. The daytime range corrected lidar signals presented in Fig. 1a clearly demonstrate the top of the BL between 4000 and 4500 m.

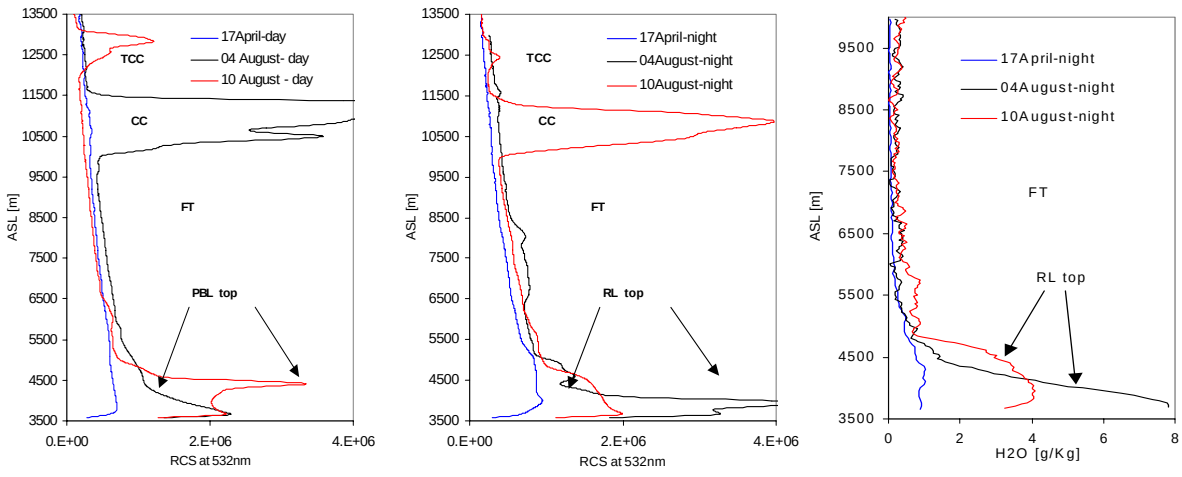

Fig.1 Backscatter range corrected lidar signals at 532 nm a) daytime b) nigthtime c) water vapor mixing ratio profiles; FT- Free Troposphere, CC Cirrus Cloud, TCC Thin Cirus Cloud, RL Residual Layer, PBL Planetary Boundary Layer

For comparison, the same figure shows a typical free-troposphere range corrected profile taken with the lidar in the spring. A residual layer characterized by enhanced aerosol backscatter (Fig 1b) and high specific humidity of up to 8 g/kg (Ffig.1c) was observed at altitudes of up to 4000-4500 m during nighttime. The high backscatter measured in the residual layer is probably partially due to this high specific humidity related to aerosol humidity growth.

Initial measurements of the aerosol extinction, water vapor, and temperature along a horizontal optical path above Aletsch glacier were carried out. The data will be used for a comparative study of the aerosol optical properties derived from the lidar and *in situ* measurements. The measurements were taken at night, under stable weather conditions with the lidar pointing in Southern direction. A map of the region with the lidar optical path marked with a dashed line is shown in Fig. 2a. Temperature and water vapor mixing ratio profiles are presented in Fig. 2c, together with a cross-section of the terrain below the lidar optical path. The extinction of the order of 10^{-4} m^{-1} (Fig 2b) and the water vapor mixing ratio values between 2.5 to 6.5 g/kg are relatively high and indicate hazy conditions. The temperature varies from +5° C at the station to almost 0° C above the deepest valley. Both, the water vapor mixing ratio and the temperature may suggest possible influence of the glacier topography. Note the general decrease of temperature and water vapor content above the valleys and the increase near the mountain relief.

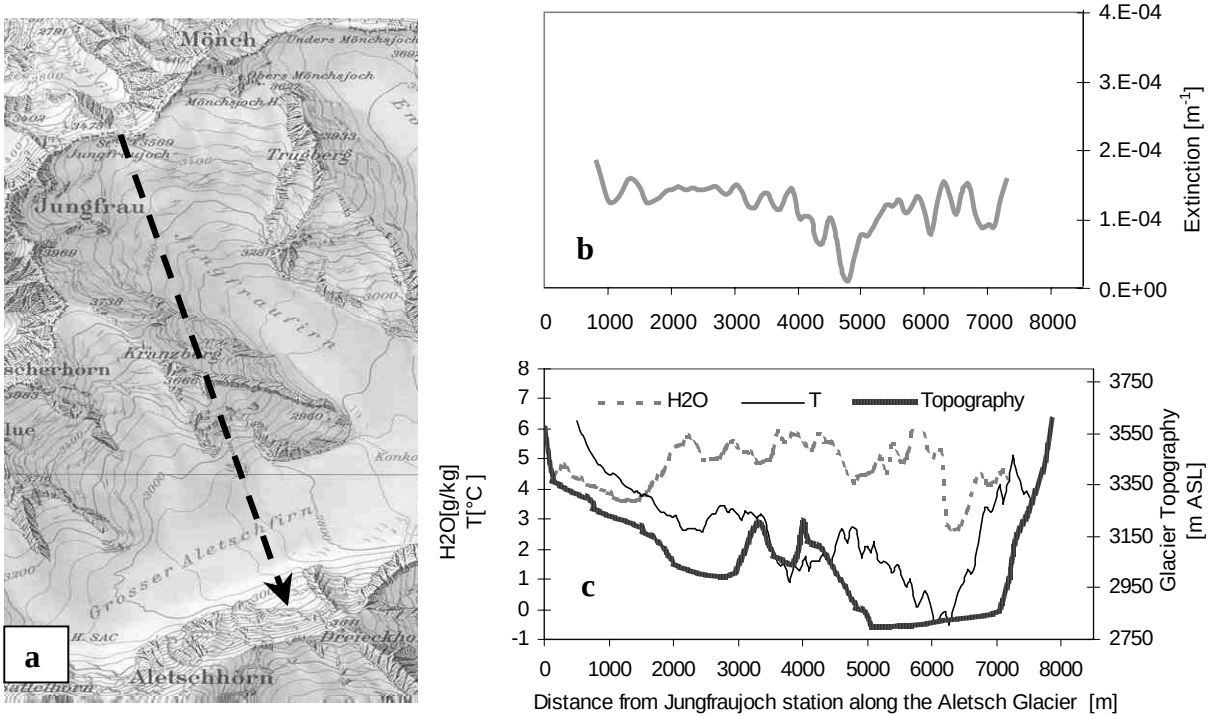

Fig. 2 a) Laser beam trajectory during the horizontal observations along an ~8-km-long path above the Aletsch glacier, b) total extinction coefficient, c) water vapor mixing ratio and temperature horizontal lidar profiles and the topography of the glacier below the laser beam path from a 1:100 000 map (Swiss Topographic Institute).

The example demonstrates the potential of the method to measure simultaneously atmospheric extinction, temperature, and water vapor over the glacier. Systematic

observations may bring useful data for the estimation of the atmospheric dynamics over complex terrains, particularly over covered by glaciers mountain surfaces.

As part of the cooperation between the EPFL's Laboratory of Air and Soil Pollution, and the Environmental Fluids Group of the Johns Hopkins University –Baltimore-US joint field experiment aiming to study the Boundary Layer (BL) dynamics over the Aletsch glacier were held from April to August 2003. The experiment combined simultaneous LIDAR observations from the Jungfraujoch Observatory (3580m) with Sonics anemometers measurements (glacier surface). The aerosols optical properties, temperature, and water vapor (LIDAR) as well as temperature, wind field and various turbulence parameters (Sonics anemometers) will be analyzed in different meteorological situations.

In November, test measurements of the upgraded by the EPFL team John Hopkins elastic scattering lidar were performed at Jungfraujoch. The lidar was verified against the EPFL system. The results of the intercomparison measurements are presented in Fig. 3 and demonstrate excellent agreement.

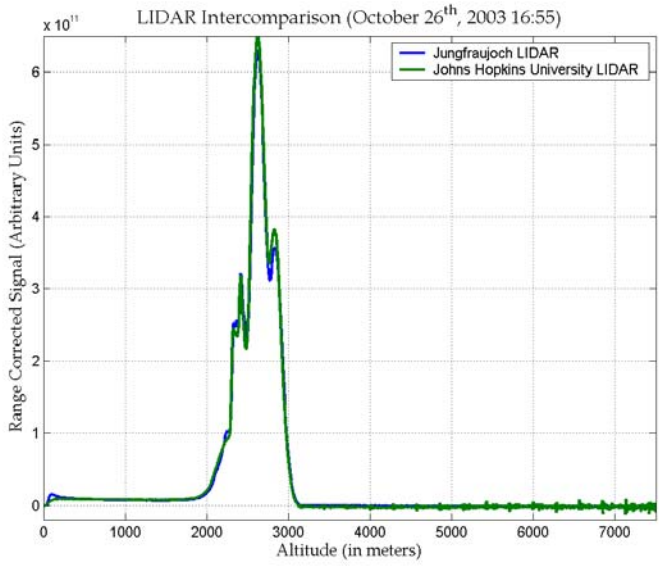

Fig.3. Intercomparison measurements of the EPFL and John Hopkins University lidar systems

A new transmitter for the lidar, based on the 76 cm astronomical telescope was designed, built and tested at the EPFL. The transmitter produces simultaneously six wavelengths - 266, 284, 304, 355, 532 and 1064 nm. The radiation at 266, 284, 304 nm will be used for ozone measurements by the Differential Absorption Lidar (DIAL) method and the other frequencies will be employed in water vapor, temperature and aerosol monitoring. The transmitter is based on an 1.6 J, 30 Hz repetition rate Nd:YAG laser (Continuum Powerlite 9030) with built-in second (532 nm) and fourth (266 nm) harmonic converters. The third harmonic radiation (355 nm) is produced by an additional converter from the remaining after the fourth harmonic generation 1064 and 532 nm radiation. The 284 and 304 nm wavelengths for the ozone channel of the lidar are generated from the fourth harmonic radiation in a high-pressure nitrogen Raman converter. To reduce the beam divergence and to prevent the Coude mirrors that deliver laser radiation to the atmosphere from damage, the multiwavelength beam

is expanded by a 20 X reflective beam expander. The transmitter is in preparation for installation in the Sphinx observatory.

Key words:

Multi-wavelength lidar, Raman lidar, pure rotational Raman scattering, aerosols, backscatter and extinction coefficients, vertical profiles, troposphere, water-vapor mixing ratio, temperature, Jungfraujoch site, EPFL

Internet data bases:

http://lpas.epfl.ch/lidar/research/LidarJungfrau/Jungfrau.html

Collaborating partners/networks:

EARLINET **-E**uropean **A**erosol **R**esearch **LI**dar **NET**work
Paul-Scherrer Institute
ISM: Payerne station
Institute of Atmospheric Optics-Tomsk, Russia

Scientific publications and public outreach 2002:

Refereed journal articles

D. Gerber, I. Balin, D. Feist, N. K¨ampfer, V. Simeonov, B. Calpini, and H. van den Bergh, "Ground-based water vapour soundings by microwave radiometry and Raman lidar on Jungfraujoch (Swiss Alps)",Atm. Chem. and Phys. Discuss., **3**, pp 4833-4856, 2003.

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R Jimenez, M. Taslakov, V. Simeonov, B. Calpini, F. Jeanneret, D. Hofstetter, M. Beck, J. Feist, and H.van den Bergh, Ozone detection by differential absorption spectroscopy at ambient pressure with a 9.6 μm pulsed quantum-cascade laser, Appl. Phys. B (2003) DOI: 10.1007/s00340-003-1358-5.

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Conference papers

A. Papayanis, G. Tsaknakis, D. Balis, A. Chaikovski, F. de Tomasi, I. Mattis, V. Mitev, G. Pappalardo, J. Pelon, C. Perez, S. Puchalski, V. Rizi, L. Sauvage, V. Simeonov, N. Spinelli, T. Trickl, G. Waughan, M. Weininger, V. Matthias, A. Haagard, M. Alpers and A. Castanho, Three years of observations of Saharan dust outbreaks over Europe monitored by a coordinated LIDAR network in the frame of the EARLINET project, *Sixth International symposium on tropospheric profiling-Needs and Technologies*, September 14-20, 2003 Leipzig, Germany, p. 225.

Theses

Ioan Balin, Monitoring of atmospheric water vapor, temperature, and aerosol by a multi- wavelength elastic-Raman lidar Data books and reports, PhD thesis EPFL, to be defended on 14 March 2004.

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