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
Dr. Marian Taslakov, Ioan Balin, Remo Nessler, Pablo Ristori

Project description:

The LIDAR project was established in the year 2000 to study the atmospheric properties of the higher troposphere by means of a lidar technique. The optical properties of the atmosphere in the UV, visible and the Near IR regions of the spectra, the vertical aerosol and water vapor distribution, and atmospheric temperature are the parameters measured on regular basis. Aerosols affect the heat balance of the earth, both directly, by having impact on the solar and terrestrial radiations, and indirectly by influencing the formation and properties of clouds and by changing the chemistry of greenhouse gases. Water vapor is an atmospheric constituent of fundamental importance for the climate in the troposphere as the most important greenhouse gas. It also plays many roles in stratospheric chemistry and dynamics. The non-homogeneous distribution of aerosols and water vapor are the cause for the largest uncertainties in the evaluation of the earth radiation budget and their in-depth study is of primary importance.

Regular measurements of the vertical aerosol distribution have been taken in the frame of the **E**uropean **A**erosol **R**esearch **LI**dar **NET**work – EARLINET. The network was established in January 2000 to perform studies of the general characterization of the vertical aerosol distribution and its dependence on season, weather regime, diurnal cycle, and local effects, and also to investigate the temporal and spatial development of the aerosol properties. Analytical back-trajectories provide information about the origin of the observed aerosols and about the synoptic patterns corresponding to the lidar measurements. At present 21 aerosol lidars located all over Europe contribute to the project. In the framework of the EARLINET project the EPFL lidar has been operating every other week since April 2000.The aerosol extinction at two wavelengths (355 and 532 nm), backscatter at three wavelengths (355 nm, 532 nm, and 1064 nm) and depolarization ratio at 532 nm are the parameters measured on a regular basis at altitudes of up to 10000 m Above Sea Level (ASL). The aerosol backscatter coefficients at 355 nm, 532 nm, and 1064 nm are derived from the elastic signals by the Fernald method. More precisely, the backscatter and extinction coefficients at 355 nm, 532 nm are calculated by the Raman method using the corresponding vibrational nitrogen signals. Two different polarization states with planes of polarization parallel and perpendicular to the polarization plane of the transmitted beam are measured at 532 nm to define the depolarization ratio which is an important indicator of the aerosol particles shape.

Based on the lidar data, first attempts for defining the aerosol size distribution have been made in cooperation with the group of Dr. Kristiner Böckmann from the

Mathematical Institute of Potsdam University, Germany. The results were compared with in-situ measurements taken by the group of Dr. Baltensperger from the Paul-Scherrer Institute (PSI). Joint field measurements with the PSI in the frame of the GLACE project were performed in July 2002 in order to compare the aerosol parameters retrieved from the lidar data and the in-situ measurements done by the PSI. For this campaign, the lidar was upgraded with a steering mirror that makes possible horizontal measurements in order to achieve closer conditions for comparison between the two types of data.

In addition to the aerosol, water vapor mixing ratio measurements up to the tropopause are taken regularly. The water vapor mixing ratio is derived from the nitrogen (387 nm) and water vapor (408 nm) Raman signals. The results are consistent with simultaneous balloon measurements performed by MeteoSwiss. In the framework of COST action 723 measurements with four different techniques; lidar, microwave radiometry, standard balloon-sonde and cryogenic balloon sondes will be used to provide altitude profiles of atmospheric water vapor from the ground to the mesosphere on a routine basis. This is a joint project among the Institute of applied physics- University of Bern, MeteoSwiss and the EPFL.

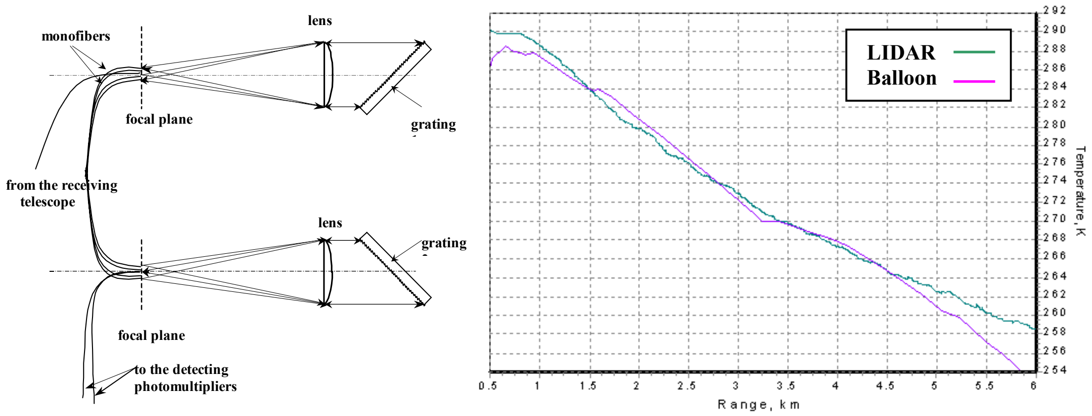

Fig.1. Optical layout of the new temperature module of the EPFL lidar system (left). A lidar temperature profile compared to a balloon measurement (right).

As part of a continuous upgrade of the lidar, a temperature channel has been developed and installed in cooperation with the group of Dr. Yuri Arshinov from the Institute of Atmospheric Optics-Tomsk, Russia. The measurement technique is based on the temperature dependence of spontaneous pure rotational Raman scattering on atmospheric nitrogen and oxygen. The spectral separation of the four bands from the rotational spectra (two from the Stokes and two from the anti-Stokes bands) used in the measurements is carried out by a double-grating polychromator. The optical layout of the temperature module is shown in Fig.1 (left). The channel has been in operation since May 2002, enabling nighttime measurements. A temperature profile measured by the lidar is shown in Fig 1 (right) compared to balloon measurements taken by SwissMeteo at Payern. The future employment of an additional Fabri-Perot interferometer for better spectral separation of the optical signals will decrease dramatically the solar background and will make possible daytime operation. Temperature is an important input parameter for defining air density and relative humidity and the vertical temperature profile will be useful for other projects ongoing at the station, such as the measurements of atmospheric species by passive FTIR spectroscopy.

In the near future, the lidar will be equipped with DIAL channels for tropo-spheric/stratospheric ozone measurements. A new laser source has already been purchased for this purpose with funds from Swiss National Science Foundation.

The first encouraging experiments for remote control of the laser and the acquisition system of the lidar via an Internet connection from the EPFL show the feasibility of remote operation. Remote operation will allow us to take measurements at any time of our convenience, in suitable meteorological conditions instead of the one-week-in-a-fortnight-regime measurements that are being performed at present.

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 Mathematics, Potsdam Univ. Germany
Institute of Atmospheric Optics-Tomsk, Russia

Scientific publications and public outreach 2002:

Refereed journal articles

Larchevêque, Gilles, I. Balin, R. Nessler, Ph. Quaglia, V. Simeonov, H. van den Bergh, and B. Calpini, Development of a multiwavelength aerosol and water vapor lidar at the Jungfraujoch Alpine Station (3580m ASL) in Switzerland, Appl. Opt., **41**, 2781-2790, 2002.

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