Development of a multispectral Raman and fluorescence lidar to study the atmospheric aerosols chemical composition

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The Lidar Division of CEILAP is developing a lidar (Light Detection and Ranging) to study the chemical composition of atmospheric aerosols in Argentinean Lidar Network. The instrument works with fluorescence, elastic and inelastic scattering in order to characterize the atmospheric particles in real time and with high spatial, temporal and spectral resolution. The transmission system is implemented by a Nd:Yag laser which emits in its first three harmonics (1064, 532 and 355 nm) at 10Hz. Reception is performed with two Newtonian telescopes. The main telescope has 50 cm diameter area and it is used to collect the fluorescence and Raman backscatter in coaxial arrangement with the laser beam. The second telescope has 20 cm diameter and it is used to recover Rayleigh and Mie backscatter in biaxial setup, with 532 nm orthogonal polarization. The Raman and fluorescence signals generated by laser interaction (532 or 355 nm) with the molecules composing atmospheric aerosols are processed with a multispectral acquisition system. The multispectral device consists of a Crossed Czerny-Turner spectrometer, a 32 channels hybrid photomultiplier and a photocount detection system which works at 15 m spatial and 4.5 nm spectral resolutions. This method allows to recover Raman and fluorescence spectrum within the atmospheric boundary layer and the first kilometers of the free atmosphere with temporal resolution better than an hour. The instrumental setup and the first aerosol studies in Buenos Aires region are presented and discussed.

Lidar setup:

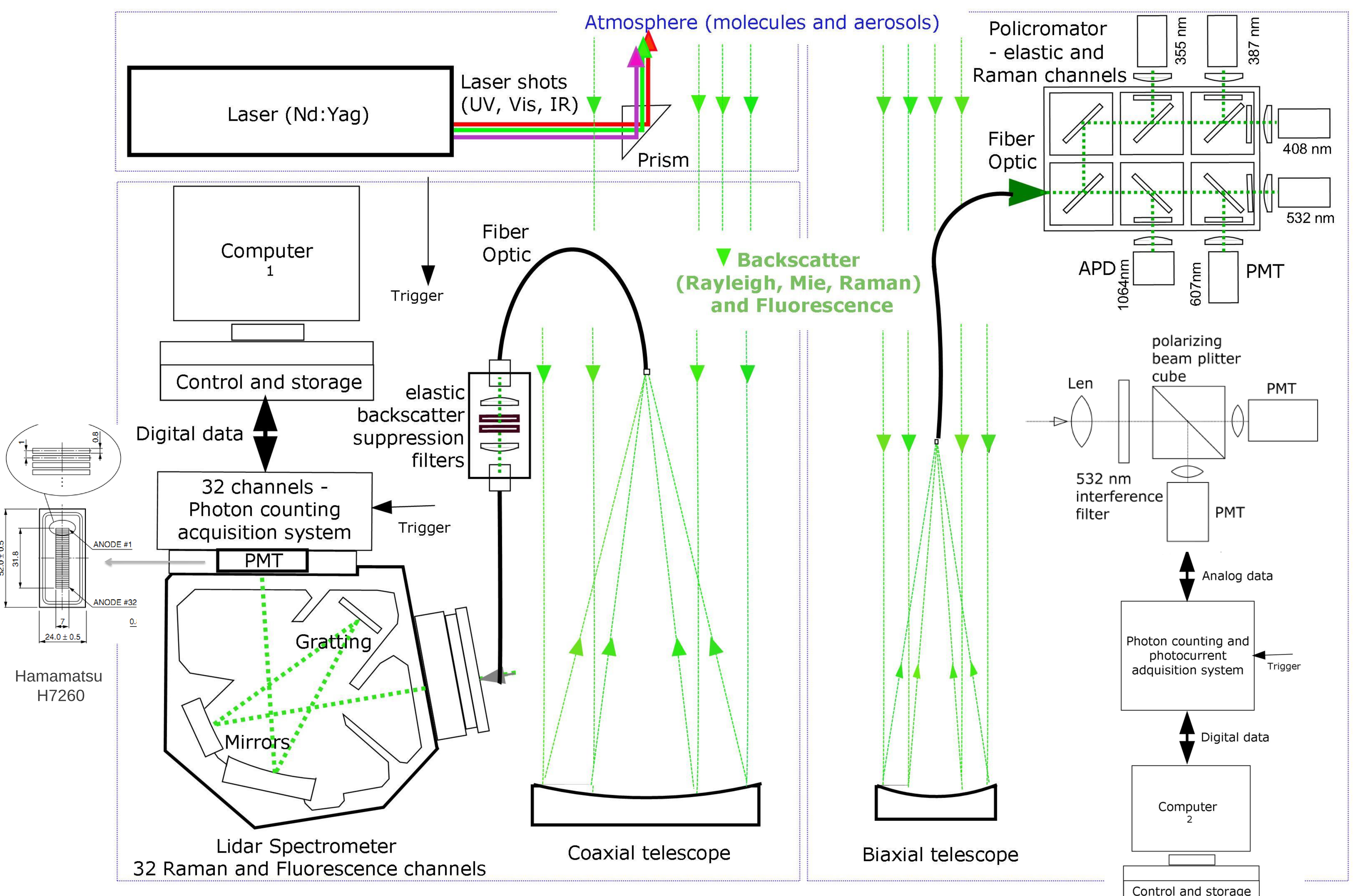

Figure 1. Multi-spectral Raman-Rayleigh-Mie-fluorescence lidar setup.

Figure 2. Images: (a) multiwavelength aerosol lidar, (b) multispectral lidar system, (c) Hamamatsu photomultiplier H7260 with 32 channels, (d) 50 cm and 20 cm Newtonian telescopes for recover the Raman-fluorescence and elastic backscatter, (e) 532 nm orthogonal polarization detector system, (f) polarization detector works in the 20 cm telescope.

Spectrometer calibration:

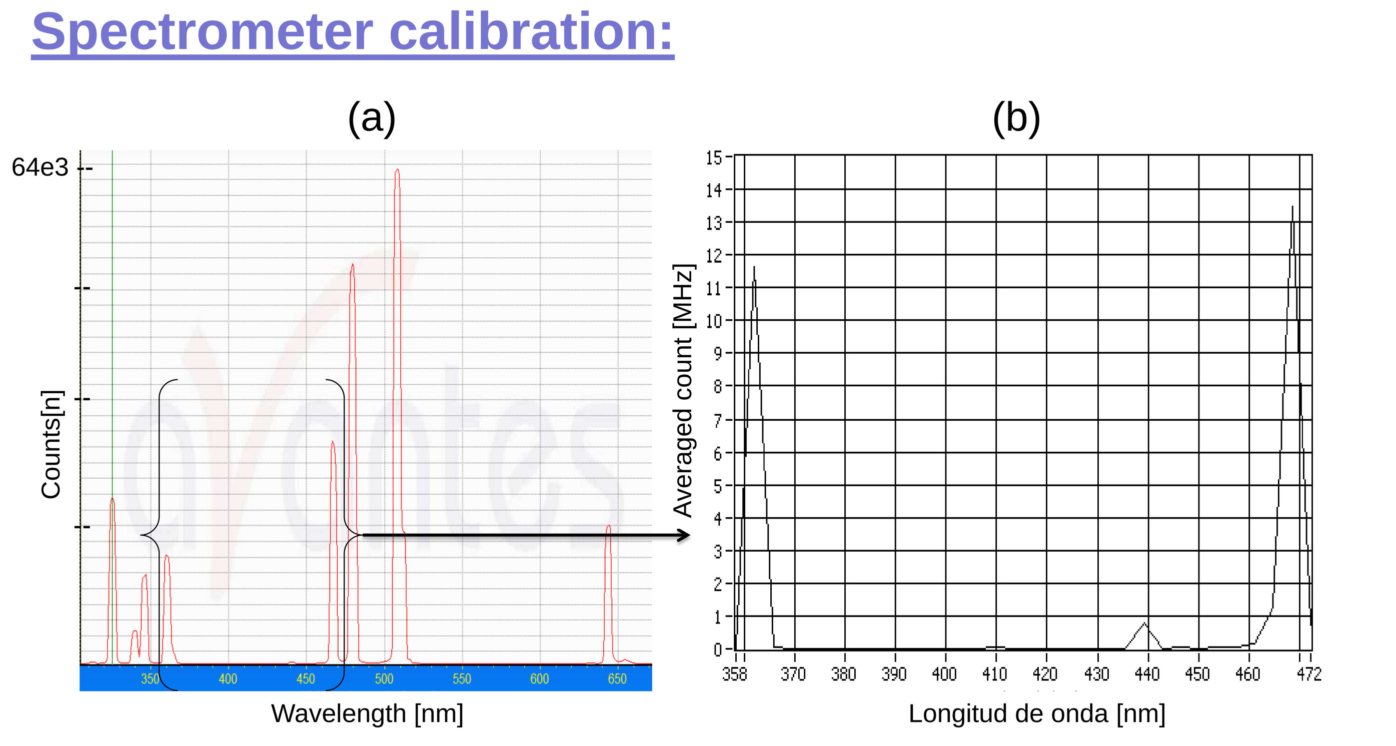

Figure 3. (a) Cadmium lamp spectrum measured with a Avan spectrometer. (b) Calibration of the lidar spectrometer using a 1800 lines/mm diffraction grating.

Overlap simulation:

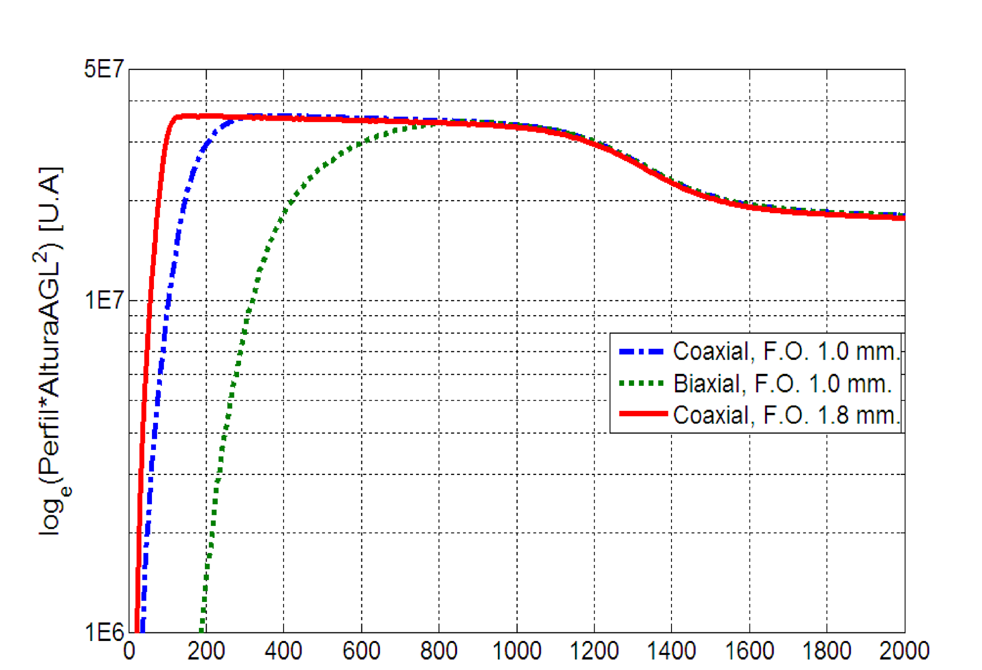

Figure 4. Simulations of the transmitter-receiver geometry functions in the Raman-fluorescence (blue line, -.-) and elastic (green line, ...) setup.

Preliminary results:

Night measurement on January 17, 2014.

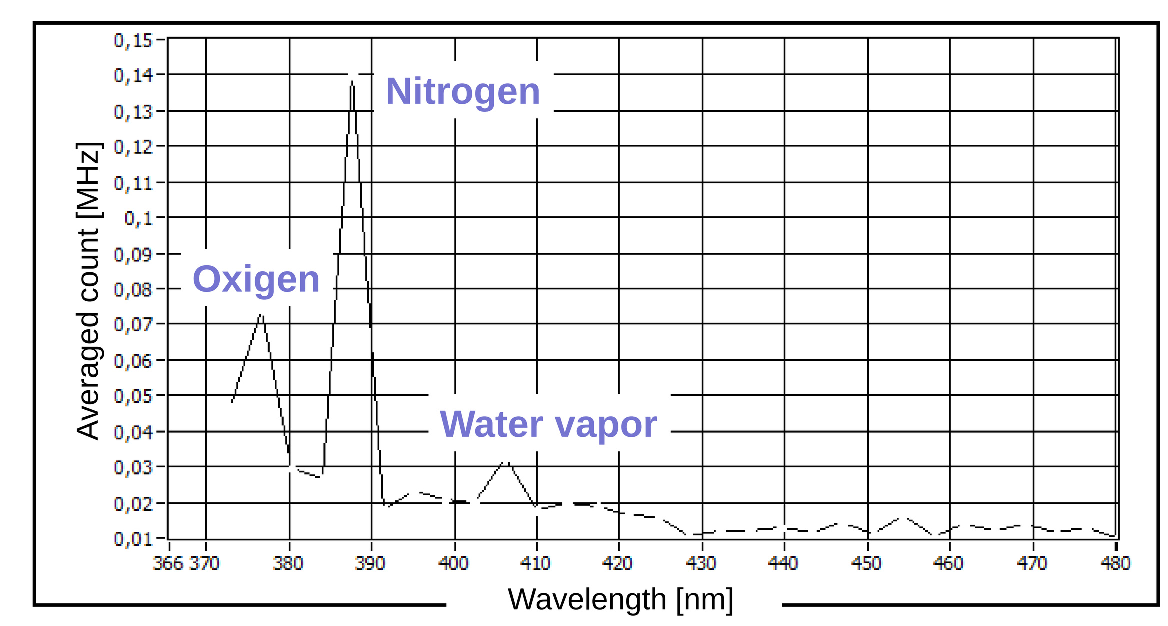

Figure 5. Lidar spectrum of 32 photoconut channels with 4 nm bandwidth, 15 m vertical spatial resolution integrated between 120 and 7795 m, time averaging of 102412 shoots between 21:12 and 22:33 h (local time). Raman measurements of Nitrogen (387 nm), oxygen (376 nm) and water vapor (408 nm), generated by the 355 nm laser wavelength, are shown.

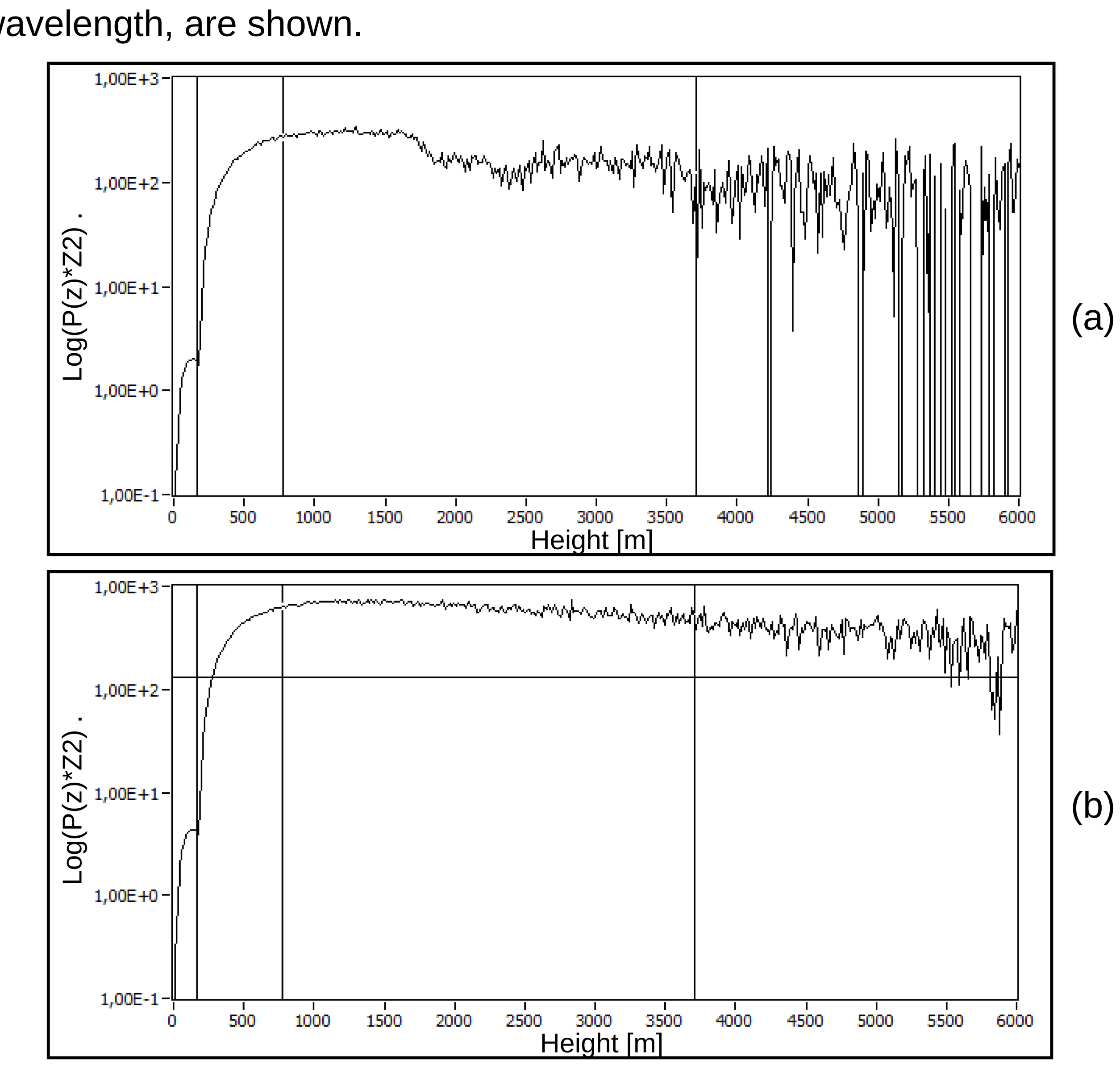

Figure 6. Raman backscatter profiles of (a) water vapor (408 nm) and (b) oxygen (376 nm).

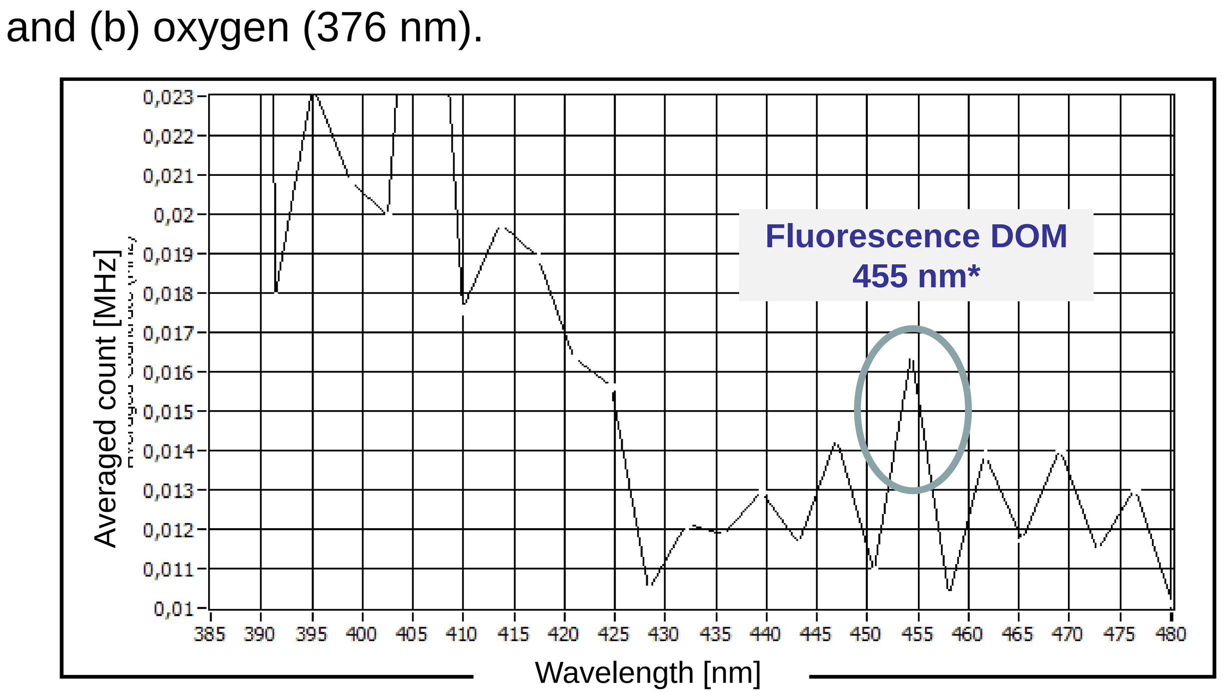

Figure 7. Lidar spectrum in which a fluorescence structure around of 455 nm is identified. It is characterized as dissolved organic material. *Dissolved organic matter (DOM): R. Barbini, F. Colao, R. Fantoni, C. Micheli, A. Palucci, and S. Ribezzo. Design and application of a lidar fluorosensor system for remote monitoring of phytoplankton . ICES Journal of Marine Science, 55: 793–802. 1998. Article No. jm980404.

Future prospects: A new telescope of 60 cm diameter is being installed to improve the signal to noise ratio of the Raman and fluorescence return signals.

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