Lidar remote sensing of atmospheric aerosols: specific addressing of the carbon aerosol and new particle formation events

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In the continuity of our contributions presented at former EAC conferences (Manchester, Granada), our group has developed new lidar remote sensing methodologies to partition two or three-component particle mixtures (David et al., 2013). Moreover, we here present the results of two recently published Optics Express papers, dedicated to two new lidar methodologies addressing i) the carbon aerosol in the atmosphere (Miffre et al., 2015), ii) new particles formation events in the atmosphere (David et al., 2013), which is new.

Lidar remote sensing of the carbon aerosol with light-induced-incandescence (LII-lidar)

The carbon aerosol (for example, soot particles) is nowadays recognized as a major uncertainty on the Earth's climate and human public health. In (Miffre et al., 2015), we coupled lidar remote sensing with Laser-Induced-Incandescence (LII) to allow retrieving the first vertical profile of very low thermal radiation emitted by the carbon aerosol, in agreement with Planck's law, in an urban atmosphere over several hundred meters altitude. Figure 1 hence presents the first lidar remote observation of the incandescence of the carbon aerosol in the atmosphere after its heating by the laser lidar pulse (LII-lidar). Apart from the elastic and inelastic Raman channels, the observed spectrum exhibits a continuously increasing spectrum that we could adjust with Planck's law, as a clear optical signature of the presence of light-absorbing particles in the low troposphere. Moreover, we could set the corresponding formalism of this LII-lidar methodology and record the first vertical profile of LII from carbon aerosol as published in (Miffre et al., 2015).

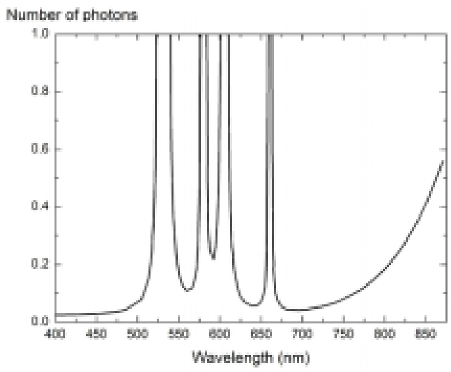

Figure 1. Measurement of the first LII-lidar signal in the Lyon troposphere: the spectrum can be adjusted with Planck's law.

Lidar remote sensing new particle formation events

If all the ingredients initiating nucleation are still being unrevealed, Dupart et al. (2012) however recently identified a new pathway for new particle formation (NPF) in the presence of non-spherical mineral dust particles. In this context, in (David et al., 2014), awarded as June 2014 OSA Spotlight, we identified the optical requirements ensuring an elastic lidar to be sensitive to such NPF-events in the atmosphere. Our new methodology is based on the use of a sensitive and accurate UV-polarization lidar. The UV-wavelength acts as a size discriminator, while the polarization acts as a shape discriminator. Hence, provided that a sufficiently high sensitivity and accuracy are achieved on the UV-polarization lidar, newly formed spherical sulfuric acid particles can be remotely detected, as enhanced by the observed Figure 2 backscattering enhancement on the spherical backscattering coefficient.

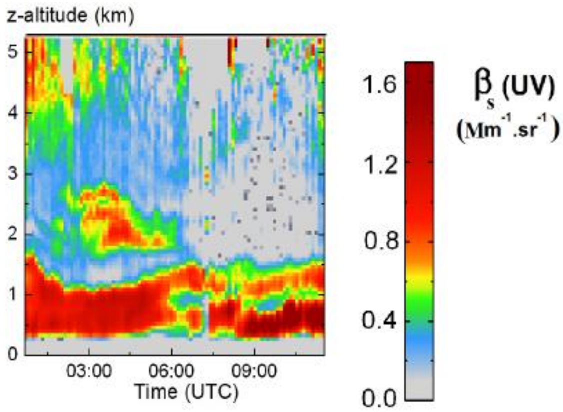

Figure 2. Time-altitude map of the spherical lidar particles backscattering coefficients enhancing an NPF-event promoted by mineral dust (red area around 2 km).

Both papers proceed with the same methodology by identifying the optical requirements from numerical simulation (Planck and Kirchhoff's laws in (Miffre et al., 2015), Mie and T-matrix numerical codes in (David et al., 2014), then presenting lidar field case studies. We believe that these new atmospheric lidar methodologies, may be useful for climate, geophysical, as well as for fundamental purposes. The presentation (oral or poster) will hence focus on these aspects.

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