Laboratory evaluation of the lidar Particle Depolarization Ratio (PDR) of sulfates, soots and mineral dust at 180.0° lidar backscattering angle

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Lidar remote sensing of sulfates, soot or mineral dust (Bravo-Aranda et al., 2015; Haarig et al., 2018) is a major source of global data on these aerosols. This task is however challenging at least as the measured particles depolarization ratio (PDR) is that of a particles mixture. To face such a complexity, lidar partitioning algorithms have been developed allowing to retrieve the backscattering coefficient specific to mineral dust among two or three-component particle external mixtures (Tesche et al., 2009; David et al., 2013). Despite this major advance, the intrinsic depolarization of mineral dust, soot or pollen particles still needs to be revealed. This task is render complicated by the complexity itself of the studied particle samples which exhibit a wide range of sizes, shapes and mineralogy (highly-irregular nonspherical particles for dust, fractal aggregates for soot). As a result, no analytical solution of the Maxwell's equations exists for such complex-shaped particles allowing to numerically evaluate the lidar PDR of such aerosols. Numerical approximations have then been applied but the underlying assumptions must be carefully checked and for that a laboratory experiment at 180.0° lidar backscattering angle is coveted.

In this context, a controlled-laboratory polarimeter at lidar exact backscattering angle has been built at Lyon University (France) to provide precise evaluations of the lidar PDR of pure aerosols at lidar exact backscattering angle of 180.0° (Miffre et al., 2016). Based on the scattering matrix formalism, this Pi-polarimeter evaluates the lidar PDR at 355 and 532 nm wavelengths simultaneously. Hence, for the first time to our knowledge, have been evaluated in laboratory the lidar PDR of freshly-emitted soot aggregates (Paulien et al., 2021) and that of inorganic / organic sulfates (Dubois et al., 2021), which is key for quantifying the direct radiative forcing of sulfates in the presence of organic compounds, thus more clearly resolving the impact of sulfates on the Earth's climate. Moreover, the lidar PDR of various mineral dust samples (silica, hematite, Arizona dust as well as Asian dust) could be accurately measured in laboratory at 180.0° lidar angle. Hence, for the first time to our knowledge, the dependence of the lidar PDR with the dust particles size, the mineralogy and the wavelength (355, 532) could be revealed (Miffre et al., 2022).

The oral presentation will present our laboratory Pi-polarimeter at 180.0° lidar backscattering angle and details the methodology to retrieve accurate evaluations of the lidar PDR of various inorganic / organic sulfates, soot-fractal aggregates, then mineral dust samples, as above stated (Miffre et al., 2022). The link between the laboratory measured intrinsic depolarization and the lidar-observed field lidar PDR will be discussed. We hence believe this work may interest the European Lidar community as it may be applied to help better understanding 2λ-polarization lidars which are operated worldwide every day.