Lidar depolarization ratio for soot fractal aggregates: application to tropospheric and stratospheric smoke

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Lidars are valuable instruments for vertical profiling of aerosols with the capability to remotely probe their radiative properties. Polarization-sensitive lidar systems, or polarimetric lidars, resolve the linear depolarization ratio (LDR) of light backscattered from an illuminated volume of atmospheric constituents. The LDR is a reliable and quantitative parameter that yields information about the aerosol-particle morphology. For example, the LDR can be used to discriminate spherical and non-spherical particle shapes. Generally, the LDR values are small (<5%) for anthropogenic aerosols such as smoke but are greater (20%) for dust, ice in clouds, or volcanic ash. The LDR values for carbonaceous soot particles, however, are less well known. These particles are created during incomplete combustion of biomass and fossil fuel (e.g., diesel and kerosene) and consist of complex aggregates of ultrafine spherical particles. Several studies have been undertaken to compute the LDR of soot aggregates to aid the interpretation of polarimetric lidar measurements. A major challenge with soot aggregates is that their morphology is complex and evolves with time from freshly emitted to aged smoke. Moreover, recent measurements report unexpectedly high LDR values for stratospheric smoke from a biomass-burning event. Such considerations motivate further modeling of how light scatters from soot, and in particular, the broadband backscattering behavior. Here, we model the broadband LDR for soot fractal aggregates from the ultraviolet to infrared wavelengths. Simulation results are presented based on the DDA and MSTM methods for two different fractal aggregates: chain-like aggregates and super-aggregates.

References

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