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Sensitivity tendencies in remote sensing of atmospheric aerosols.

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Remote sensing is a major tool for studying the interactions of solar radiation with the atmosphere, the surface and their influence on Earth's radiative balance. Over the last five decades, radiances measured by satellite-based sensors, from airborne instruments or from the surface have been used successfully to characterise the radiative properties of the Earth, oceans, atmospheric gases, aerosols, clouds, etc. One of the challenges of remote sensing is the development of inversion procedures for deriving information on atmospheric components and surfaces from their interaction with solar, terrestrial or artificial radiation. The inversion algorithms are particularly crucial for interpreting measurements of great complexity, where several unknowns must be derived simultaneously.

There is a large variety of remote sensing observations developed for monitoring properties of tropospheric aerosols: satellite and ground-based observations, both passive and active (lidar), spectral and multi-directional measurements, recording of only the intensity or also polarimetric properties, etc. Evidently, the scope and the accuracy of the aerosol information retrieved from these observations are very different, as are the assumptions and constraints used. This aspect always requires thorough considerations.

In this study, we propose an assessment of the fundamental tendencies in sensitivities of aerosol light scattering which is expected to be of help for understanding the full potential and limitations of aerosol remote sensing. To this end, a special "hierarchical" concept of the test evolution has been developed. The tests start from only single-scattering observations. Indeed, most of the aerosol remote sensing approaches rely on the manifestation of angular and spectral features in aerosol scattering properties determined by the aerosol scattering matrix, extinction, and absorption. Thus, if some retrieval limitations exist in the single scattering regime, then they most likely remain with some modifications in the presence of multiple scattering effects in the atmosphere. At the same time, the numerical tests only with single-scattering properties is much simpler and logistically easier than the tests with full modelling of atmospheric radiances including multiple scattering effects. Specifically, the importance of multi-angular and polarimetric observations, the possibilities to determine aerosol type and other important aspects were studied. The tendencies established with single-scattering tests are used for the analysis of limitations of some real ground-based and satellite retrieval approaches. The conclusions are illustrated both by the numerical tests with full account of multiple scattering and by analyses of real observations. The tests use the unique retrieval algorithm GRASP (Generalized Retrieval of Aerosol and Surface Properties, see Dubovik et al. (2014)) available as an open source software (http://www.grasp-open.com/).