Bimodal particle concentration profile retrieved from ground-based Lidar and CIMEL measurements

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Photometric measurements of solar extinction and sky radiance are currently used in inversion methods to retrieve microphysical values such as size and refraction index. However, this method cannot yield proper information regarding some microphysical (particle shape) and optical (backscatter, depolarization, lidar ratio) properties; and concentration values can be retrieved at a column-integrated basis only, lacking access to layer-by-layer information.

In the case of bimodal particle populations, accurate data is difficult to obtain concerning shape or composition for both modes. Such is, for example, the case in large-scale dust episodes, where North African dust is carried across the Mediterranean basin to Europe, and across the Atlantic Ocean to the Caribbean and the United States.

In these cases, dust episodes form mixtures with other particles produced in combustion processes, either natural or anthropogenic. The resulting population can be described as a mixture of two particle modes: a submicron-sized (fine) mode of combustion-produced particles, and a micron-sized (coarse) mode of dust particles. The assessment of the concentration of both particle modes is necessary to determine the physical and optical properties of the aerosol, with consequences in both local and global environments.

In the present work, a combination of column-integrated (CIMEL) and layer-by-layer (Lidar) measurements are used to retrieve detailed information regarding the distribution of both fine and coarse particle modes in each particular layer The particle size distribution (PSD) as retrieved from CIMEL inversion data is fitted to a bimodal log-normal size distribution. A solution is then chosen as a set of input parameters describing the composition (refraction index) and shape of both modes (fine and coarse), as well as the fine/coarse ratio. Particles in each mode are modelled as a 50% volume mixture of prolate and oblate spheroids with the same axial ratio.

A pre-calculated database of kernel functions (“BETA”), based on the T-matrix theory, is used to fit simulated data to experimental layer-specific parameters like particles extinction, backscatter and depolarization at several wavelengths, in order to retrieve the fine/coarse mode ratio and the full (fine+coarse) particle concentration. Once the full, layer-by-layer particle concentration has been obtained, simulated data can be compared to other CIMEL experimental measurements (asymmetry parameter at several other wavelengths).

Our approach does not resort to least-squares methods to obtain the best solution (“best” meaning “minimizing the difference between experimental and simulated data”). Instead, our approach is statistical: all solutions are considered acceptable as long as they agree to experimental data to within experimental uncertainty. By iterating the procedure for all possible kinds of particle shape and composition values, a set of acceptable solutions is obtained that can yield statistical information about fine and coarse mode distributions within each layer. The experimental uncertainty level can also be modified in order to get an assessment of the model's sensitivity

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