Vertical profiles of aerosol properties from 3-wavelength elastic lidar signals and collocated sun/sky photometer measurements

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Lidars represent nowadays the best devices to retrieve aerosol vertical profiles. Aerosol effects on climate depend on the vertical distribution of aerosol properties. As a consequence, several numerical approaches have been developed to invert lidar signals at multiple wavelengths to particle parameters. Most lidar system can only provide elastic lidar signals during daytime. Therefore, the development/improvement of numerical procedures based on elastic lidar signals is of peculiar importance. [1] have developed a numerical tool (LIRIC, LIdar/Radiometer Inversion Code) to retrieve vertically resolved aerosol microphysical properties by combining backscatter coefficient measurements at 3 wavelengths and sun/sky radiance measurements. This activity was performed in the frame of European Project Aerosol Clouds, and Trace gases Research InfraStructure Network (ACTRIS, http://www.actris.net/). A technique which relies on a constrained iterative inversion (CII) procedure and graphical framework (GF) has recently been used by [2] to estimate the dependence on altitude of the aerosol fine mode radius and of the fine mode contribution to the aerosol optical thickness. It is denoted as CII-GF technique. The performance of LIRIC and the CII-GF technique have been analyzed in this study to investigate their ability in characterizing the dependence on altitude of aerosol properties from elastic lidar signals at 355, 532, and 1064 nm, respectively, and collocated AERONET sun/sky photometer aerosol products. In addiction to extinction coefficient and lidar ratio (LR) vertical profiles at the lidar wavelengths, LIRIC provides the vertical profiles of fine- and coarse-mode particle concentrations and of the fine mode fraction. The CII technique assumes that LRs are height independent and uses GF to estimate the aerosol fine-mode-fraction and fine-modal-radius vertical profiles. The used classification framework allows estimating the dependence on altitude of the aerosol fine-modal-radius and of the fine-mode-fraction from the angstrom exponent spectral difference versus the 355-1064 nm-angstrom exponent plot. Three case studies representative of typical aerosol scenarios of the Central Mediterranean have been selected to investigate the performance of LIRIC and the CII-GF technique and evaluate benefits and weaknesses. The comparison of the LIRIC extinction coefficient profiles with the corresponding profiles from the CII-procedure has revealed that the differences varied with altitude and wavelength and decreased with the λ-2 increase. As a consequence, the differences between the angstrom exponents from LIRIC and the CII procedure varied with z and the wavelength pair. angstrom exponents are good indicators of the dominant aerosol size. Then, the results on the angstrom exponent inter comparison have clearly indicated that the differences between LIRIC and corresponding CII-aerosol parameters were mainly linked to the altitude dependence of the aerosol particle size embedded in the aerosol products from the two numerical techniques. In fact, the plot on the GF of the angstrom exponent spectral difference versus the 355-1064 nm-angstrom exponent retrieved from the two techniques has revelated that CII-procedure data points were on average spread on a framework region revealing that the fine modal radius was height dependent while, the LIRIC data points were on average located on a curve with nearly constant fine modal radius. This last result is due to the LIRIC request that the integral of the retrieved concentration had to match the AERONET-derived column volume concentrations. Note that the analysis of the three case studies has clearly revealed that the differences between the aerosol products from LIRIC and the corresponding ones from the CII-procedure were quite large when aerosol from different sources and/or from different advection routes were located at the altitudes sounded by lidar. Aerosol properties were weakly dependent on z on the 12 September, 2011 study case. As a consequence, we found that the differences between the LIRIC aerosol products and corresponding ones from the CII-GF procedure were on average smaller than the ones resulting from the other two study cases. The main weak point of the CII tech-

nique is due to the assumption, the CII-retrieved angstrom exponents were height-dependent, as a consequence of their large sensitivity to the bulk absorption coefficient. It is shown that the combined use of both numerical procedure could allow a better characterization of the dependence on altitude of aerosol properties from 2-wavelength elastic lidar signals.
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