Aerosol scenario effect in elastic lidar data inversion for lidar ratio estimation: A case study over a coastal dust-influenced area

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ABSTRACT

A subject widely investigated by a lot of groups working in aerosol research is the estimation of the lidar (extinction-to-backscattering) ratio (LR). This parameter, like the backscattering coefficient, depends mainly on the aerosol chemical composition, particle shape and size distribution.

For elastic lidars, this LR estimation is crucial for data inversion. For that reason, this elastic lidar retrieval approach must be carefully applied in realistic aerosol conditions when a single contribution of one-type aerosol is not only found. Ansmann (2006) already addressed to this question on satellite lidar observations, finding a significant underestimation of the LR when a two-layer aerosol system was observed from space. Tesche et al. (2009) also found large discrepancies in LR (532 nm) values obtained from the comparison between SAMUM 2006 (ground-based campaign) and CALIPSO (spaceborne measurements) results.

The Santa Cruz de Tenerife Observatory (SCO, AEMET) is a subtropical station (28.5ºN 16.2ºW, 52 m a.s.l.) selected for lidar observations since it is a coastal site frequently invaded by Saharan dust intrusions. Regarding this fact, marine contribution to aerosol profiling is steady. Therefore, under dust loading conditions, dust properties, including the LR determination, as retrieved by elastic lidar inversion algorithm, are affected by marine aerosol contamination, in case it is not considered some way in that inversion method.

In this work, we present an 'experimental' procedure based on the supposition of what aerosol scenario is present in each case, taking into account a two-component aerosol (marine and dust particles) is present in a well differentiated two-layer atmosphere: the Boundary Layer (BL) and the Free Troposphere (FT). Therefore, under dust intrusion situation, two aerosol scenarios are, at least, proposed for lidar data retrieval: 1) a 'pure dust' scenario where dust particles are supposed to be the only aerosol present in the overall atmosphere, and, 2) a 'mixed dust' scenario where a mixture of marine and dust particles are present in the boundary layer (BL), and only dust in the free troposphere (FT). By this procedure the marine aerosol contribution is considered as a source of uncertainties introduced in that particular LR determination for vertical dust characterization.

A 4-day dust intrusion case study as occurred in March 2008 over SCO site is investigated to illustrate this procedure. An elastic Micro Pulse Lidar v.3 (MPL-3) is used for height-resolved observations. That 4-day dust intrusion over SCO is also confirmed by AERONET (AErosol Robotic NETwork) data in the period of 13-16 March 2008. No-dusty conditions were found before and after that dust episode.

Lidar-retrieved LR values (AERONET daily mean AOD as constraint) are obtained for each aerosol scenario (see Figure 1). In particular, for the 'mixed dust' case, the LR at FT heights (LR^{FT}) has been estimated depending on the fixed LR^{BL} (LR at BL heights) value: 25 sr (extreme case with only marine particles), 35 sr (well mixed state with both marine and dust particles) and 45 sr (mixed state with a major contribution of dust respect to marine particles), in the BL layer. Selected LR ranges for three aerosol types (as reported by Muller et al., 2007) are also indicated in Figure 1 (dashed lines) for comparison purposes.

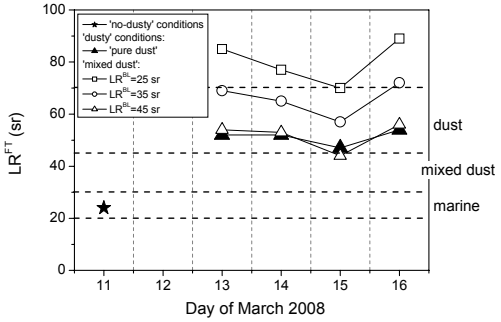

Figure 1. LR retrieved values for both aerosol scenarios. See text for details.

These results show an underestimation of LR values when the 'pure dust' scenario is considered respect to the 'mixed dust' one. Similar results are previously reported by other authors (Ansmann, 2006; Tesche et al., 2009).

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