Lidar Mapping of a Mixture of Aerosol Concentrations in a Varying Atmosphere

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Abstract

In several recent applications dealing with lidar measurement of atmospheric pollution (see, for example, Cahen, 1984), two basic assumptions are made:

1) The investigated aerosol layer is the only particulate material within the scattering volume

2) The contribution of the gaseous atmosphere to the lidar backscattering signals can be estimated and deducted from the total backscattering measurements

It is useful to note that the second assumption is of less relevance when the turbidity ratio is relatively high, i.e. when the contribution to the scattered light by the Rayleigh molecules is negligible compared to the backscattering by the aerosol particles.

In tropospheric measurements the molecular scattering against aerosol can be neglected in many paractical applications. A method which permits an unknown but considerable contribution of the molecular scattering in the stratosphere (or in the troposphere when applicable), was described by Cohen and Kleiman (1978).

However, in several realistic cases, both assumptions may introduce inaccuracies to the analysis. This is due to the fact that lidar measurements of plume concentrations and number densities are performed in the

vicinity of other sources of particulate pollutions. Such sources can originate from nearby natural dusty environment or urbanic artificial pollution forming a varying background which is constantly present in the investigated atmosphere. The situation is even more complicated when more than one source of different background aerosols are present (more than one source includes the case of low turbidity values, when the molecular contribution has to be taken into account separately).

In the method discussed a generalized method which allows the elimination of the above mentioned assumptions was developed using multiparameter lidar measurements. The different parameters can be several wavelengths, polarization properties of the scattered light, scattering angles, or any combination of these parameters.

The basic requirements of the method are as follows:

a. The background aerosol, although varying in concentration, has a known (experimentally or theoretically) dependence on the changing parameter, i.e. if the background is the molecular atmosphere the only required coefficient for the method would be λ^{-4} behavior when changing the wavelength. The knowledge of the air density is not required.

b. When measuring echoes from an atmospheric volume in two consecutive time steps and/or two adjacent distances, the background aerosol, as well as the investigated plume, is allowed to change in number densities. However, it is assumed that it retains the same optical coefficient per unit mass (in particular - the backscattering coefficient).

Taking into consideration the fact that the separation of two adjacent lidar echoes is only limited by the spatial resolution of the lidar pulse: Δ R (being typically of the order of a few meters), this requirement is met in most practical pplications.