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Raman and elastic lidar techniques for aerosol observation at CIAO

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Tropospheric aerosols are of great importance for several aspects of our life, from climate to safety, from air quality to natural hazards. For both climate and health, the aerosol vertical distribution is a crucial point. It is essential to know amount and properties of aerosol located at the ground in near-real time and, from the climate point of view, the aerosol vertical layering is a critical point for aerosol-clouds interaction study, and aerosol radiative impact and transport mechanism studies. Only high-resolution vertical profiles allow the inspection of stratospheric and free-tropospheric layer dynamics and the investigation of complex effects of mixing processes that influence the microphysical and optical properties of aerosols and clouds and the related nucleation mechanisms. In this context, lidar is nowadays the state-of-art technique for the aerosol study. Aerosol profiling with high resolution both in time and in vertical dimension provided by lidar techniques represents a powerful tool to study the vertical structure of aerosol field and its temporal and spatial evolution.
There are different lidar techniques for aerosol study. The most simple lidar techniques, the elastic-backscatter lidar, is widely used all around the world, providing information about aerosol layering with high vertical and temporal resolution. Elastic lidar is now operational also on-board CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations), the first satellite-borne lidar mission specifically designed for aerosol and cloud study. Since April 2006, CALIPSO is providing high vertical resolution profiling of aerosol and clouds on global scale. However, this technique is affected by significant uncertainties due to a priori assumptions in the lidar signal inversion.
On the contrary, Raman lidar systems overcome this difficulty and provide independent backscatter and extinction measurements. In particular, the multi-wavelength Raman aerosol lidar represents the most advanced lidar technique and has been demonstrated to be the unique technique able of providing range-resolved aerosol microphysical properties, even though it is still very expensive in terms of system operation and time-consuming inversion.
The present work reports an overview of aerosol lidar observations using Raman and elastic techniques accordingly to the most recent results obtained at CNR-IMAA Atmospheric Observatory (CIAO). In particular, the performance of Raman and elastic backscatter lidars in monitoring desert and volcanic dust layers in the whole troposphere is discussed pointing out the sensitivity limits in aerosol layer detection, in term of optical depth, and the limits in the retrieval of aerosol optical and microphysical properties for both the techniques. The uncertainties and the assumptions associated to both the lidar techniques are also discussed.