UV Raman lidar measurements of relative humidity for the characterization of aerosol and cloud microphysical properties

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ABSTRACT

The lidar measurements discussed in this paper were performed in Potenza (40°38'45"N, 15°48'32" - Southern Italy) by the DIFA-Univ. of BASILicata Raman lidar system (*BASIL)*. The major feature of *BASIL* is its capability to perform high-resolution and accurate measurements of atmospheric temperature, both in daytime and night-time, based on the application of the rotational Raman lidar technique in the UV [1]. Besides temperature, *BASIL* is capable to provide measurements of particle backscatter at 355 and 532 nm, particle extinction at 355 nm, particle depolarization at 355 and water vapour mixing ratio both in daytime and night-time. Relative humidity measurements are obtained from simultaneous water vapour and temperature measurements. These parameters represents a suitable ensemble of measurements for the study of meteorological processes.

Specific case studies are considered and discussed to assess relative humidity lidar measurement capability in presence of aerosols and clouds. Measurements of aerosol backscatter as a function of relative humidity are reported and discussed, highlighting the swelling tendency of hygroscopic aerosol for large relative humidity values.

1. INTRODUCTION

Relative humidity is a key atmospheric parameter which controls cloud formation and aerosol optical properties. Accurate relative humidity measurements are fundamental to characterize cloud and aerosol radiative properties and related microphysical processes. Relative humidity measurements are also a precious tool to study upper tropospheric humidification due to cirrus sublimation, and to investigate the convective boundary layer and the passage of fronts.

Model studies have demonstrated that relative humidity (RH) has a critical influence on aerosol climate forcing [2]. The role of relative humidity on aerosol radiative properties has been investigated in transport models by assuming humidity growth factors for various aerosols [3]. However, the dependence of hygroscopic growth of aerosol particles on relative humidity and particle chemical composition is poorly understood. The swelling of hygroscopic aerosol particles at large relative humidity values has important implications in terms of aerosol direct effect on climate [4].

Hygroscopic aerosols can also act as Cloud Condensation Nuclei (CCN) for cloud droplets formation (aerosol indirect effect), and consequently aerosol swelling can alter cloud coverage, therefore influencing the planetary albedo.

Few attempts have been performed to measure particle backscatter or extinction over a large range of relative humidities. Ferrare et al. [5,6] measured particle backscatter as a function of relative humidity for values of RH not exceeding 80 %. Wulfmeyer and Feingold [4] reported measurements of particle backscatter at relative humidity levels close to 100 %, revealing a strong hygroscopic growth of aerosol particles when relative humidity values exceed 80-85 %. Wulfmeyer and Feingold [4] used a water vapour DIAL systems and considered a methodology applicable only in cloudy conditions and in presence of an adiabatic convective boundary layer. The present paper considers the application of a Raman lidar system which includes temperature measurement capability, allowing simultaneous measurements of relative humidity and aerosol optical properties in any atmospheric condition. Results are reported for a specific case study in the presence of highly hygroscopic aerosol particles, which illustrate the large variability of particle backscatter as a function of relative humidity for values of RH up to 100 %.

2. RESULTS

BASIL is described in more detail in reference [7]. Figs. 1 and 2 show the evolution with time of particle backscatter at 355 nm and relative humidity, respectively, on 6-7 September 2004. These figures reveal a strong correlation between the particle backscatter and the relative humidity fields in the planetary boundary layer for a large portion of the measurement record to be attributed to aerosol hygroscopic growth. We focused our analysis on the time-height section highlighted by the white box in figures 1 and 2 (between 01:06-02:46 UT and 1.2-2.5 km). Within this sub-portion on the measurement record backscattering coefficient and relative humidity are found to experience a large variability, with relative humidity values often in excess of 80 %. Particle backscatter has been plotted versus relative humidity for all data points within the sub-portion. Dependence of particle backscattering on relative humidity is illustrated in fig. 3. These results reveal a substantial increase in particle backscattering when relative humidity increases above 80 %, which testifies the swelling tendency of hygroscopic aerosol for large relative humidity values. It is to be pointed out that the planetary boundary layer for this case study is characterized by a uniform aerosol distribution and limited horizontal advection (verified through model analysis) and consequently correlation between relative humidity and particle backscattering is most likely to be attributed to aerosol hygroscopic growth. More results of the assessment of relative humidity lidar measurement capability in presence of aerosols and clouds will be discussed at the conference, with particular emphasis on aerosol hygroscopicity.

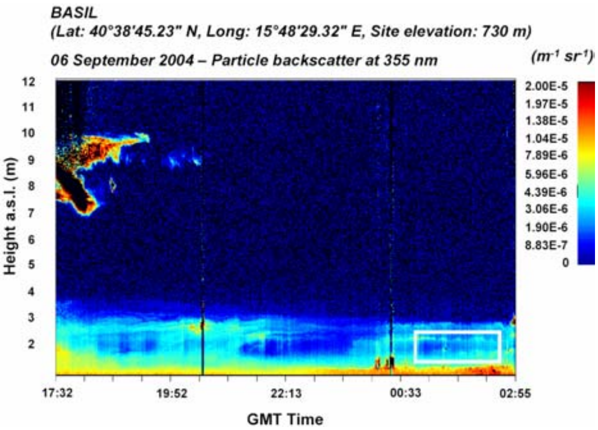

Fig. 1 Time evolution of particle backscattering coefficient at 355 nm on 6 September 2004.

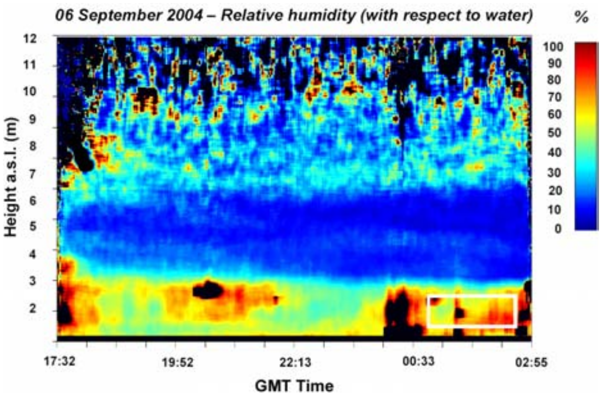

Fig. 2 Time evolution of relative humidity on 6 September 2004.

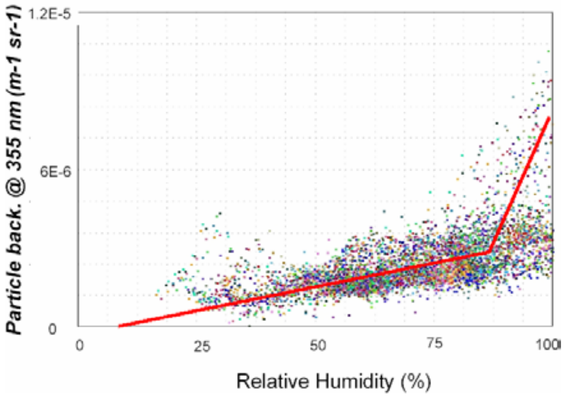

Fig. 3: Particle backscatter versus relative humidity for all data points within the selected sub-portion.

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