RETRIEVAL OF RELATIVE HUMIDITY FROM CSIR-NLC MOBILE LIDAR BACKSCATTER MEASUREMENTS

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1. INTRODUCTION

Backscatter LIDAR (LIght Detection And Ranging) measurements are considered useful for the derivation of atmospheric aerosol extinction profiles. The role of aerosols on climate change, by their direct and indirect effects on the Earth's radiative budget, remains an elusive parameter in our quantitative assessment of the factors controlling our climate. One of the important factors is the change of aerosol optical properties in environments with variations in relative humidity (hygroscopic factor). As aerosols are subjected to variations in relative humidity, their size may increase, and changes in their refractive index may also occur. An increase in aerosol backscattering is then observed. Consequently, more radiative energy may be reflected back into space, creating an overall cooling effect.
The retrieval of relative humidity from the aerosol backscatter co-efficient in relation to the time of measurement is a significant method for classifying hygroscopic and non-hygroscopic aerosols load profiles. Furthermore in correlation with other retrieval methods of the physical–chemical properties and size distribution of the aerosol particles along the LIDAR line, this method gives a clear insight to gain a more qualitative assessment of the hygroscopic effect on aerosols physical–chemical properties.

A simple model calculation is proposed based on the assumption of coating spheres. Using the spherical Neumann functions as one of the two general Bessel functions needed to describe the potential functions in the coating. The hygroscopic aerosols are dependant on the relative humidity (Rh)[1,2,3]. The model parameterizes the scatterer's growth factor to assess the hygroscopic effect on aerosol backscatter and this enables the retrieval of relative humidity (Rh).

A mobile LIDAR system is being developed at the Council for Scientific and Industrial Research (CSIR) National Laser Centre (NLC), Pretoria (25°5° S; 28°2° E), South Africa. At present, the CSIR-NLC mobile LIDAR can provide aerosol backscatter measurements for the height region from ground to 40 km with a height resolution of 10m. The CSIR-NLC mobile LIDAR has been operated at the University of Pretoria during October 2008 for a better understanding of the atmosphere's boundary layer evolution and aerosol (solid particles suspended in the air) concentrations. The experimental data was collected over 23 hours from 16 October, 16h00 to 17 October 15h00. The above data sets were used to determine the retrieved relative humidity and compared with Irene (near to Pretoria) weather balloon humidity measurements. The results of the comparative study are presented in this paper.

2. METHOD OF ANALYSIS

The method used for retrieving relative humidity from the aerosol backscatter co-efficient was followed by Hanel et al., (1976), i.e. the growth of hygroscopic aerosols is a function of relative humidity based on theoretical considerations in the change of aerosol optical properties. Based on this, the relation between the relative humidity (Rh) and backscattering coefficients (β) can be described as,

$$\left(\frac{\beta^{a}(\lambda,r)}{\beta^{a}_{reff}(\lambda,r)}\right)=a\left(1-\frac{Rh}{100}\right)^{-b}.$$

Here, $\beta^{a}_{reff}(\lambda,r)$ is taken at a relative humidity (Rh) value of 70 %, noted from the Irene Balloon borne measurements. We have considered the Irene weather station data, as it closer to the Pretoria site. It was found from earlier research and observational studies from Rheinstein numerical results for water coated spherical aerosol backscattering, that the aerosol reference backscatter coefficients $\beta^{a}_{reff}(\lambda,r)$ was found to be 0.0005 $(km.sr)^{-1}$. The other two constants, '*a*' and '*b*' are calculated based on the best numerical fit to the data (in a least square sense and trial and error). Yields values of the regression coefficients of a = 0.43 and b = 0.3, with an R^2 (Regression co-efficient) equal to 0.85 indicating a best value for the present set of data.

3. RESULTS

Based on the above method, the LIDAR-derived aerosol backscatter co-efficient was used for two different timings (coherent to the radiosonde launch time), and the relative humidity (Rh) was calculated. Two different cases for 17 October 2008 (00 UTC and 09 UTC) were presented. Only two different times were available as the radiosonde observations over Irene were available only for two times a day.

Figure 1 shows the comparison between the measured and model simulated relative humidity by Radiosonde and LIDAR. Both profiles show a close agreement for the 1-6 km height region and greater deviations are observed at higher altitudes. The early hour observations (00UTC) show a good agreement up to 4 km and the later one (09 UTC), up to 5.5 km. The difference in the values is found to be within 8 -13 %. This difference of 8-13 % is found to be acceptable, when considering that the radisosonde relative humidity measurements have errors in the order of 8-10 %.

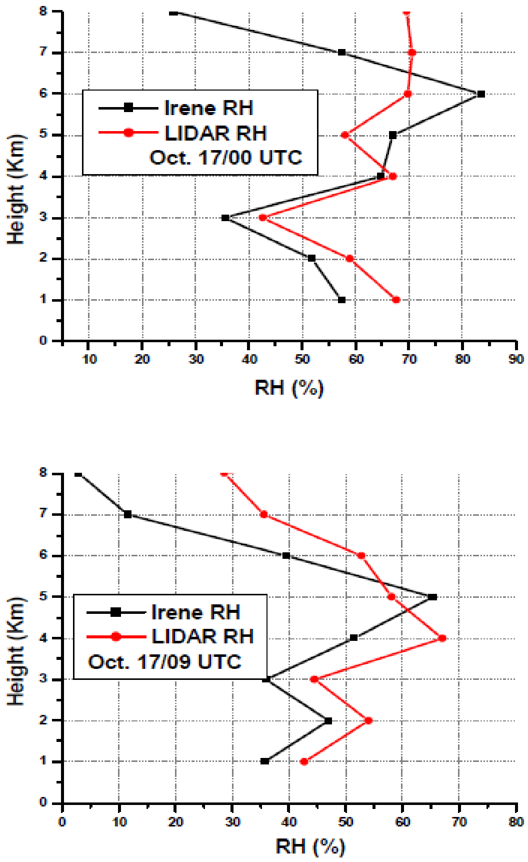

Figure-1: Height profile of relative humidity derived from LIDAR aerosol backscatter co-efficient and the radiosonde measured.

The observed difference in the magnitude may be attributed to the assumptions followed by the model-simulated and the LIDAR-measured data. The contribution of non-hygroscopic aerosols and theoretical model approximation may also attribute for the under estimation of the backscatter coefficient. In general, the results are in good agreement and these further addresses the possibility for classifying aerosols into hygroscopic and non-hygroscopic species. Additional, based on the temperature information (from radiosonde measurements), we found that the disagreement between both the simulated and LIDAR retrieved data arises when the temperature falls below zero degrees (figures are not shown). However, hygroscopic aerosol model-based retrieved Rh profile shows a greater deviation below zero degrees Celsius, due to the insignificant amount of water vapour at and below this temperature.

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