

CSIR-NLC MOBILE LIDAR – FIRST SCIENTIFIC RESULT

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ABSTRACT

In this paper, we present the obtained first scientific results from CSIR-NLC mobile LIDAR (*Light Detection And Ranging*) and its validation/comparison with other ground and space-borne measurements. The LIDAR results are compared using aerosol measurements from the Stratosphere Aerosol Gas Experiment (SAGE) and Optical depth derived from sun-photometer employed under AEROSOL ROBOTIC NETWORK (AERONET).

Index Terms— Atmospheric measurements, Remote sensing, Aerosols, Air pollution, Meteorology

1. INTRODUCTION

Light Detection and Ranging (LIDAR) has become an excellent tool for monitoring the atmosphere in a relatively short period of time (within a few seconds to minutes). Currently, LIDAR systems are used for studying the atmospheric structure and dynamics, trace constituents, aerosols, clouds, boundary and mixed layers and other meteorological applications [1].

Although ground based LIDAR systems are deployed for atmosphere studies in many developed countries, it is still a very novel technique for South Africa and African countries. There are currently two different LIDARs available in South Africa, located in Pretoria and Durban respectively. Both LIDAR systems have similar specifications which permits the establishment of simultaneous aerosol measurement studies. The Durban LIDAR is operated at University of KwaZulu-Natal as part of cooperation between the Reunion University and the Service d'Aéronomie (CNRS, IPSL, Paris) for climate research studies. It allows for studying the stratosphere-mesosphere (30-80 km) thermal structure and troposphere-stratosphere aerosol (8-40 km). The Council for Scientific and Industrial Research (CSIR) National Laser Centre in South Africa has recently designed and developed a mobile

LIDAR system (see Figure 1) to contribute towards atmospheric research in South Africa and African countries [2]. The CSIR mobile LIDAR [3] acts as an ideal tool for making aerosol/particulate measurements over Southern Hemisphere regions and this will encourage collaboration with other partners' in terms of space-borne and ground based LIDAR measurements. At present, the system is capable of providing vertical aerosol/cloud backscatter measurements for the height region from ground to 40 km with a 10 m resolution. The major advantage of the LIDAR is that it provides the vertical cross-section of cloud including the thickness which is important for better understanding the cloud dynamics and the earth-radiation budget [2]. The cloud information is also useful for predicting the convective systems and rain. The LIDAR measurements will also elucidate the aerosol concentration, optical depth, cloud position, thickness and other general properties of the cloud which are important for a better understanding of the earth-radiation budget, global climate change and turbulence.



Figure 1: CSIR-NLC-Mobile LIDAR system

2. SYSTEM DESCRIPTION

The LIDAR system comprises a laser transmitter, optical receiver and a data acquisition system. The complete LIDAR system is housed in a mobile van which facilitates to make measurements at different locations of interest. A Nd:YAG laser is used for transmission and is presently employed at the second harmonic (532 nm) with a repetition rate of 10 Hz. The receiver system employs a Newtonian telescope configuration with a 16 inch primary mirror. The backscattered signal is subjected to fall on the primary mirror of the telescope and is then focused toward to a plane mirror kept at an angle 45 degrees. It is detected by the Photo-Multiplier Tube (PMT) and the PMT output signal is transmitted to the transient digitizer and PC for analysis and archival. The data acquisition is performed by a transient recorder which communicates with a host computer for storage and offline processing of data. The transient recorder enables the recording of simultaneous analog and photon counting signals, which makes it highly suited to LIDAR applications by improving high dynamic range. More details about the system may be cited in the reference [3].

3. RESULTS

After the initial calibration and tests, the LIDAR was operated for the first time on 23 February 2008. The laser was directed vertically upward into the sky and the corresponding night was a cloudy sky (see Figure 2). There was a passage of cumulus clouds which is normally found at lower height region from 3 km to 5 km. Since these clouds are generally optically dense, light is prevented from passing through to higher altitudes.

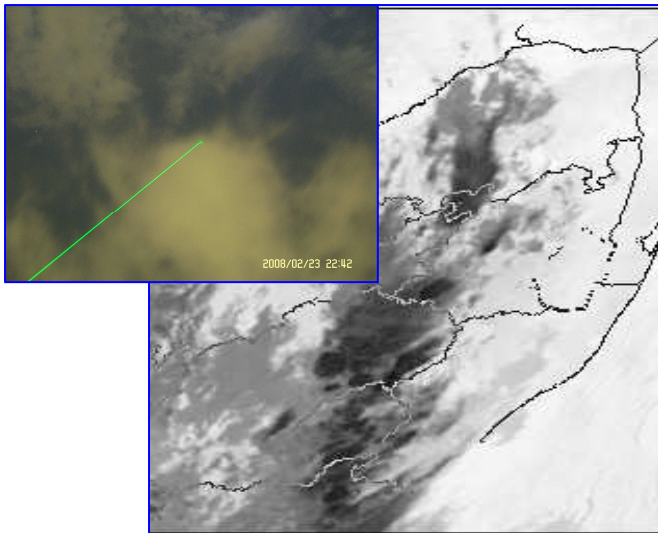


Figure 2: Illustrates the passage of cloud over LIDAR-site
(a) Photo (b) from METEOSAT.

23 February 2008

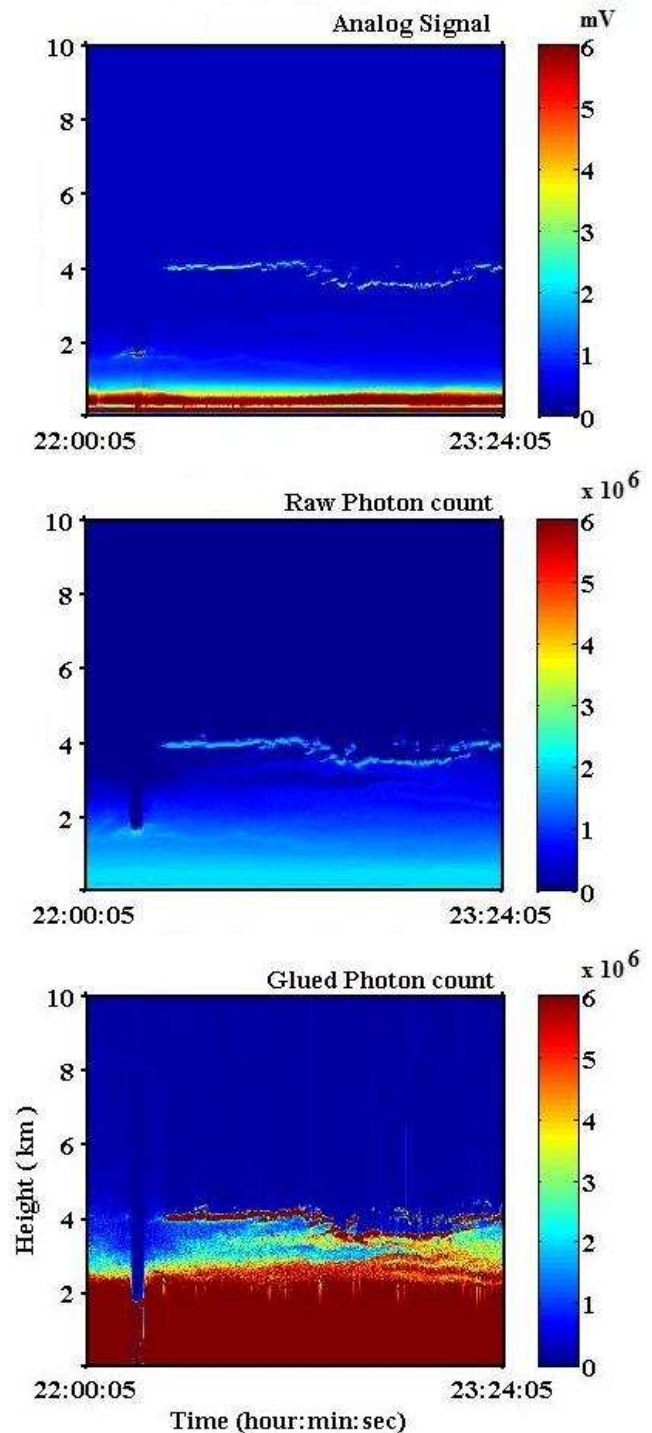


Figure 3: Height-time-colour map of LIDAR backscatter signal returns for 23 February 2008.

The present LIDAR data acquisition is capable of simultaneously acquiring data with a high range resolution (10 m) via both the analog and photon count channels. Our first observations were carried out for more than two hours

on 23 February 2008 night. Figure 3 shows the temporal evolution of the backscattered LIDAR signal in different forms, i.e., analog, photon count and glued photon count. Basically the glued photon count results are obtained by combining both analog and photon count signals appropriately (see. Sharma et al., 2009). It is evident from the figure that the combined (glued) signal better illustrates the structured atmosphere in comparison to the other two. The above three forms of backscattered signal clearly reflect the presence of low level cloud at around 3.5-4.5 km (see Figure 3). Figure 3 clearly distinguishes the cloud observation from normal scattering from background aerosol/particulate matter. It shows the sharp enhancement during the presence of cloud at around 3.8 km in the beginning of the experiment and then also shows the cloud passage that had slowly moved down to 3.5 km. This figure demonstrates the capability of LIDAR to observe the cloud thickness (less than 300 m). The measured high resolution data is also important when studying cloud morphology. Apart from the cloud observations, the lower height regions indicate high intensity signal returns which is due to the presence of lower atmosphere aerosols.

It is important to note here that this experiment was carried out using 2 neutral density (ND) filters which attenuates 99% of the backscattered signal. This means that the backscattered signal represented in the colour-map and in the height profiles corresponds to only 1 % of the signal. The ND filters are employed to avoid signal saturation due to the presence of dense clouds at lower height regions which significantly interrupts the laser to pass through. In future, we will remove the filters to allow a greater percentage of the backscattered signal to observe and investigate higher altitude regions.

3.1. Comparison between the lidar measured aerosol extinction and SAGE-II

The SAGE-II provides a height profile of aerosol extinction co-efficient for the height region from 0.5 km to 40 km and is available for the public domain (http://eosweb.larc.nasa.gov/project/sage2/table_sage2.html). We have downloaded about 20 years of data for the Southern Africa region and individual monthly mean profiles of aerosol extinction co-efficient at 520 nm have been obtained. Figure 4 displays the integrated aerosol extinction co-efficient from LIDAR (23 February 2008) and SAGE-II (February – Southern Africa region). The LIDAR aerosol extinction profiles are derived by following the signal inversion technique as described by Klett, (1981) [4], It is noted here that the LIDAR profiles are presented up to the height region where the SNR is found to be reasonable, i.e. up to 4.5 km.

23 February 2008

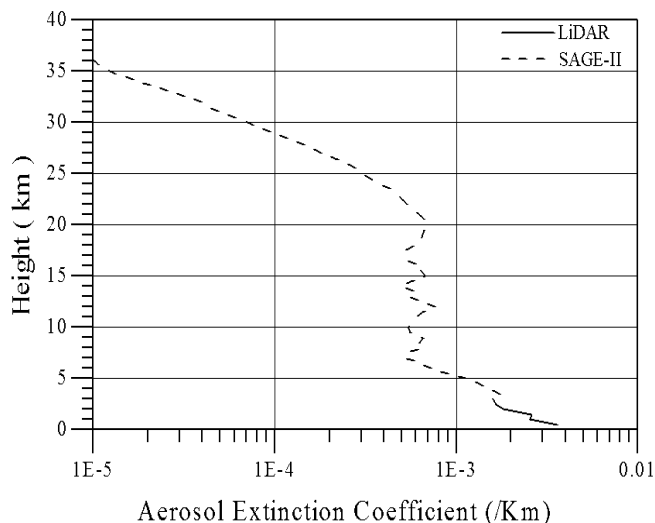


Figure-4: Height profile of aerosol extinction derived from LIDAR and SAGE-II.

As described in the earlier section, the presence of low level cloud may not allow the laser beam to interact with the atmosphere above this height region. Otherwise, one would be able to identify the continuity of the extinction profile obtained by both LIDAR and SAGE-II which illustrates that the value obtained is reasonable in the sense of approximate magnitude.

3.2. Comparison between the lidar measured aerosol optical depth and sun-photometer (AERONET) data

The aerosol extinction co-efficient obtained using the LIDAR and SAGE-II satellite data, are combined appropriately to get the height profile of aerosol-extinction from ground to 40 km (see Figure 4) and then integrated for obtaining the Aerosol Optical Depth (AOD). The AERONET (Aerosol network) programme provides the continuous optical depth information for Johannesburg (nearer to Pretoria) for approximately 8 years. We have used such long term data sets to obtain the monthly mean AOD and compared with the LIDAR plus SAGE II measured. We have obtained the AOD value of 0.324 from LIDAR and SAGE II and the February AOD variability is 0.297 ± 0.0712 (from AERONET data). Hence, it is clear that the LIDAR and SAGE-II derived optical depths are within the monthly variations obtained from the Sun-Photometer. The small discrepancy in the magnitude might be due to different reasons, such as types of instruments used, place of operation and time period of measurements, etc.

4. CONCLUDING REMARKS AND FUTURE PERSPECTIVES

In this paper, we have explained the first results of the CSIR Mobile LIDAR. The obtained results are compared/validated with satellite and photometer measurements. The comparison shows a reasonable agreement with the measurements.

Our future plans include the field campaign measurements in and around South Africa, the qualitative industrial pollutant measurements, 3-D measurements using an XY scanner, a two channel LIDAR system, water-vapour measurements, the implementation of Differential Absorption LIDAR (DIAL) and ozone measurements.

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6. REFERENCES

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