Development of 2-Channel (532 nm and 355 nm) Mobile LIDAR for Mapping Particulate Matter in the Atmosphere

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ABSTRACT

In this paper, we describe the development of 2-Channel (532 nm and 355 nm) mobile LIDAR system for studying atmospheric particulate matter. The system is currently tested in house at the Council for Scientific and Industrial Research – National Laser Centre (CSIR-NLC), Pretoria, South Africa. The obtained initial results are presented here.

INTRODUCTION

LIDAR studies on particulate matter (0.5 and 0.3 microns) elucidate their distribution and concentration in the atmosphere. Particulate matter plays a key role in physical and chemical atmospheric processes at both local and global scales. The complexity of these processes have been largely reviewed in literature and LIDAR measurements have contributed greatly to better understanding the role of atmosphere dynamics and particle microphysics. By making observations on a pre-determined spatial scale (from sites to regions) it is possible to calculate atmospheric mass transport, and, through trajectory analysis to back-track the location of plume sources, e.g. biomass burning. The atmospheric backscatter measurements of Aerosols (solid particles floating in the air, formed by a combination of different pollutants), can be used to identify the stratification of pollutants and will enable the classification of the source regions, such as industrial, biological and anthropogenic sources. Studies on boundary layer structure play an important role in determining the atmospheric pollutants transport and dispersion, as it is directly dependant on the flows of mass, energy and momentum from the earth's surface.

SYSTEM DESCRIPTION

A mobile LIDAR system is developed at the Council for Scientific and Industrial Research (CSIR) National Laser Centre (NLC), Pretoria (25° 44' S; 28° 11' E), South Africa. The system currently employed for atmospheric remote sensing including aerosols, clouds, boundary and mixed layers and other meteorological applications.

The CSIR-NLC lidar is being operated on an ad-hoc basis, since February 2008. The initial results obtained from the above system proves that the capability and study region [Sivakumar et al., 2009]. More recently, the above system has been upgraded into two channel, in terms of transmission and reception at 532 nm and 355 nm based on the used Nd:YAG laser at 2nd and 3rd Harmonic (see. Figure-1). Additional receiving optics has been included to distinguish the backscattered signal. Basically, a narrow band filter and dichroic mirror is used to reject any signal away from the chosen wavelength band. The results presented here correspond to the initial test measurement performed on 23 May 2010. The LIDAR is operated at 532 nm and 355 nm wavelength and is capable of providing the backscatter information from ground to 40 km with the range resolution of 10 m. Here, we present the first test results obtained from the 2-channel measurements.

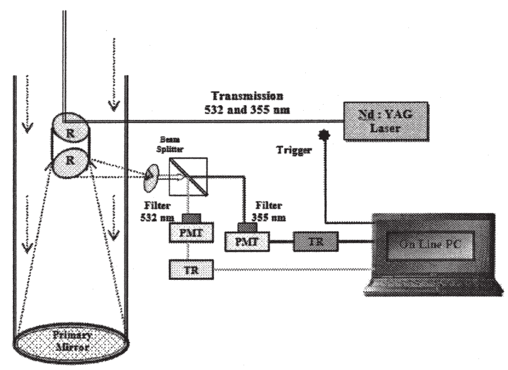

Figure 1. Schematic diagram of 2-Channel CSIR-NLC mobile LIDAR system

INITIAL RESULTS

The measured signals (raw data) are in the form of Analog (in-terms of voltage) and Photon (Digitized signal in term of number of photons). It is achieved through a commercially available data acquisition system. Later, the obtained analog and photon count datasets are combined effectively to improve the dynamic range and signal to noise ratio, i.e., glued data. More details about the system and data acquisition are available in our early publication [Sharma et al., 2009]. Figure-2 demonstrates the backscattered signal obtained in two different wavelengths (532 nm and 355 nm). The glued signal illustrates the backscattered photon counts upto the height region of about 12 km and the signal intensity is found to be slightly different when comparing with 532 nm and 355 nm. In order to differentiate the signal received between the wavelengths, the ratio of 355 nm to 532 nm is presented in figure-3. Figure-3 illustrates the difference in signal arising from above 7 km which indirectly confirms the presence of smaller size particulates of less than 0.532 μm but greater than 0.355 μm. Hence, by the two wavelength system, one will be

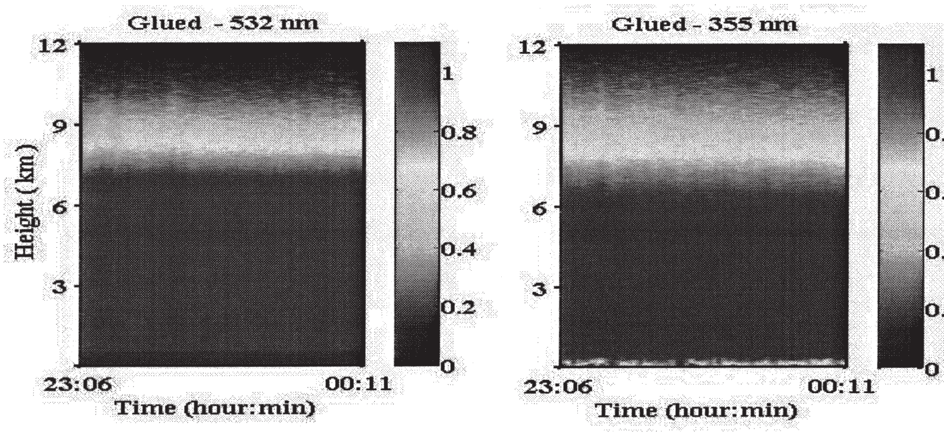

Figure-2. Height-time-colour map of LIDAR signal returns at two different wavelengths 532 nm and 355 nm for the night of 23-24 May 2010.

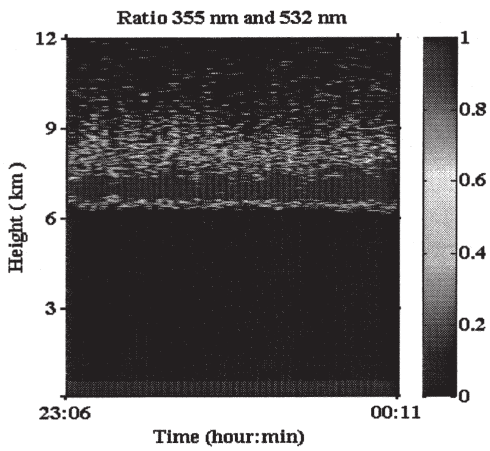

Figure-3. Height-time color map of the ratio of the glued signal measured between 355 nm and 532 nm.

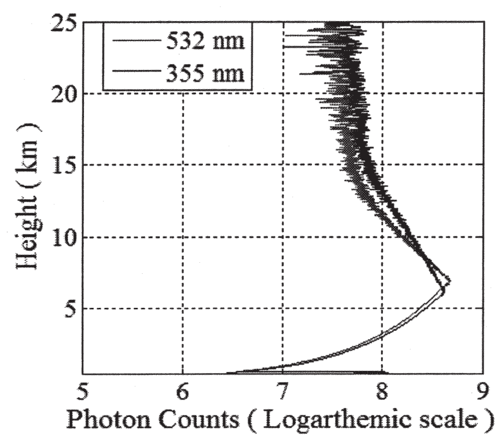

Figure-4. Height profile of the mean range corrected photon counts at two different wavelengths (532 nm and 355 nm).

able to infer the existence of different particulate size matter in the atmosphere. The present observations have continued for about an hour and the averaged range-corrected signal (see Figure-4) over the observation time shows the backscattered signal up to about 20 km.

FUTURE PERSPECTIVES

We have further plan to upgrade the system into 3-Dimensional (in future) and to measure water vapour concentrations in the lower atmosphere.

ACKNOWLEDGEMENTS

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