Measurements of Raman scattering and fluorescence from atmospheric aerosols by a mutil-channels lidar spectrometer system

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Abstract

To better understand and quantify aerosol radiative forcing and reduce the uncertainty of its climate effect, it is of vital importance to realize the aerosol components classification and quantification. For this purpose, we developed a powerful lidar system employed a multi-channels spectrometer, with capabilities of providing high spatial and temporal resolution measurements of Raman scattering and fluorescence from atmosphere aerosols. Preliminary result shows lidar system well performance. The on-going measurement will make us get more observation data to better understand aerosol characterizations.

1. Introduction

Atmospheric aerosols are a suspension of solid, liquid or multi-phases of particulate matter with a wide size ranges from several nanometers to hundreds of micrometers [Georgakopoulos et al., 2009]. Previous studies have shown that atmospheric aerosols have a significant impact on regional and globe climate in the past decades [e.g., Haywood and Boucher, 2000; Ramanathan et al., 2001; Li et al., 2004; Huang et al., 2009]. Aerosols could scatter and absorb shortwave and longwave solar radiation, thereby can result in altering the radiance balance of the Earth-atmosphere system [e.g., Haywood and Shine, 1995; Tegen et al., 1996]. On the other hand, aerosols can act as cloud condensation nuclei (CCN) and ice nuclei (IN) during cloud formation stage, which leads to modify the microphysical and radiative properties, amount, and lifetime of clouds [e.g., Penner et al., 2001; Ramaswamy et al., 2001; Forster et al., 2007].

Lidar offers some remarkable advantages for accurately determining the vertical structure of atmospheric aerosols and their related optical properties. A lots of ground-based and space-borne lidar systems have been used to investigate optical properties of atmospheric aerosols and cloud over the world, such as MPLNET [Welton et. Al., 2001], ERUONET [Bosenberg et al., 2003], AD-NET [Sugimoto et al., 2006] and CALIPSO [Winker et al., 2003]. To better understand and quantify aerosol radiative forcing and reduce the uncertainty of its climate effect, it is of vital importance to realize the aerosol components classification and quantification. For this purpose, we developed a powerful lidar system employed a multi-channels spectrometer, with capabilities of providing high spatial and temporal resolution measurements of Raman scattering and fluorescence from atmosphere aerosols.

2. Lidar system

The multi-channels lidar spectrometer system we have developed works on the basis of the Raman scattering and laser-induced fluorescence (LIF) techniques. It employs a high power laser Infinity-40 and a big telescope with 1-m diameter, those were used to measure profiles of stratosphere Ozone before. The receiver used a Licel Multispectral Lidar Detector which mainly based on an F/3.7 Crossed Czerny-Turner spectrograph, a grating (1200gr/mm) and a PMT array with 32 photocathode elements. The detector could simultaneously detect a wide spectrum about 178 nm. A diachronic filter was used to separate most of elastic signals (~99.5%) for depolarization measurement.

3. Preliminary result

NIES compact Mie lidar measurements showed that there was an apparent aerosol layer below 2 km at the bottom of troposphere, with small depolarization ratio and quite large color ratio (1064nm/532nm), as shown in fig. 1. That means a lot of spherical coarse particles. However, it is difficulty in classifying and quantifying aerosol components only with elastic signals.

LIF technique has been developed being capable to identify the presence of biological material. Fig 2 shows a wide spectrum including elastic signal, Raman signal and fluorescence excitation at 355 nm, was detected at 23:30 (Local time) on 4 August, 2011. The peak and intensity of fluorescence depends on aerosol type and concentration. A wide fluorescence spectrum could be obtained below 2km corresponding to the aerosol layer.

4. On-going work

We developed a powerful lidar system employed a multi-channels spectrometer, with capabilities of providing high spatial and temporal resolution measurements of elastic, Raman scattering and fluorescence from atmosphere aerosols. The on-going measurement will make us get more observation data, which would be mostly probability of better classification and quantification of atmospheric aerosols.

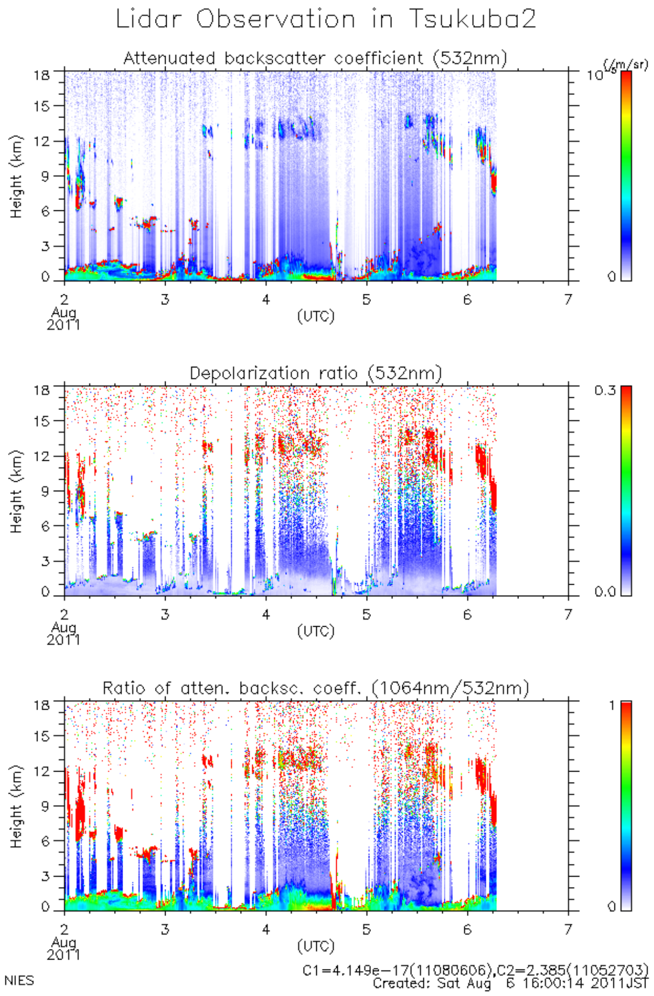

Fig. 1 Vertical structure of atmospheric aerosols and cloud measured by NIES compact Mie lidar in Tsukuba for 2-6 August, 2011

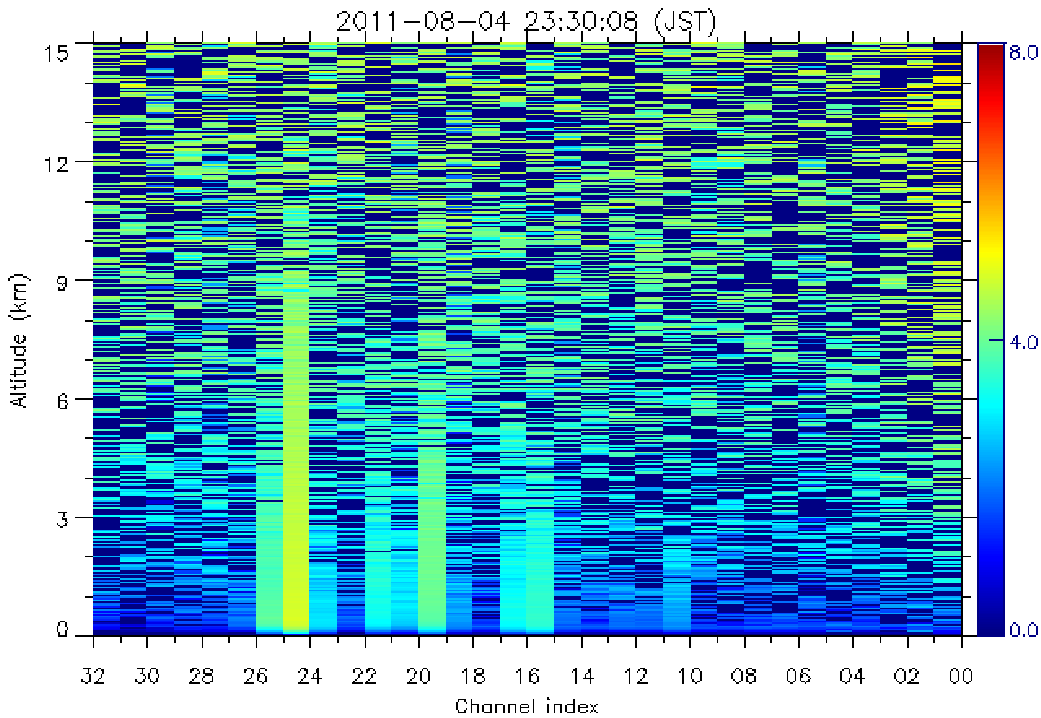

Fig. 2 Measurements of elastic scattering, Raman scattering and fluorescence excitation at 355nm from atmosphere at 23:30 on 4 August, 2011. Spectral range and bandwidth are 178nm and 5.79 nm respectively.

5. References

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