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Observations of the boundary layer structure and aerosol properties over Xi'an using an eye-safe Mie scattering Lidar

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ABSTRACT

An eye-safe micro-pulsed Mie scattering lidar (MPL) system at a wavelength of 532 nm was built for routine observations of atmospheric optical properties of the lower troposphere. The lidar is operated in an analog mode with three-dimensional (3D) scanning capability. Observations were carried out for obtaining detailed information of the urban boundary layer (UBL) over Xi'an, China. The parameters that can be measured include aerosol extinction coefficient and optical depth (AOD), structure of the UBL, and the mixed layer depth (MLD). The results indicate that the height of UBL shows both temporal and spatial variations over Xi'an. It is generally lower in the early morning and dusk than during the daytime. MLD is driven by the convective air motions and strongly correlated with the aerosol diurnal changes which tend to fall during night and rise during day.

1. Introduction

As the lowest part of the troposphere, the atmospheric boundary layer (ABL) is directly influenced by the earth's surface, and is of most importance for entire earth atmosphere and ecosystem [1]. Over urban areas, the friction associated with the high density of buildings as well as the human activities results in a more complex ABL [2]. Radiosonde and sodar are the traditional tools for collecting information on ABL, including temperature, humidity, pressure and wind velocity [3–5]. However, these instruments cannot provide sufficient information about the ABL due to the lack of high temporal and spatial resolution. Lidar has been proved to be one of powerful tools to provide continuous observations of the ABL structure, cloud and aerosol properties with high spatial and temporal resolution.

Therefore, Mie lidars have been widely used in detection of optical properties of aerosols and clouds, and investigation of the city air pollution [6–12]. Most of existed Mie lidars are usually employed to achieve an effective detection range with a photon counting detection mode, which are more suitable for detection in a clean atmosphere. For detection of the lower troposphere with highly concentrated aerosols, signal saturation of lidar return can be resulted in, which will lead to large uncertainties of measurements in the lower troposphere. Therefore, a micro-pulsed Mie scattering lidar (MPL) under an analog detection mode with a large dynamic range, small blind zone and 3D scanning detection was developed and built in the Xi'an University of Technology.

Xi'an, the capital of Shaanxi Province in China, with population of 8.5 million, is located in the hinterland of the Yellow River basin in the central China's Guanzhong Plain and belongs to a semiarid climate. It is in an immediate downstream region of the source of dust storms in northwest China. In addition, Xi'an is the most

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developed industrial city in the northwest China, thus, urban environmental pollution problem is very prominent, particularly, the particulate matter pollution caused by human activities is becoming more serious in this area. Therefore, study of the characteristics of ABL over the Xi'an area can provide the necessary basis for the study of semiarid climate changes in the China's western region and the improvement of air quality over Xi'an.

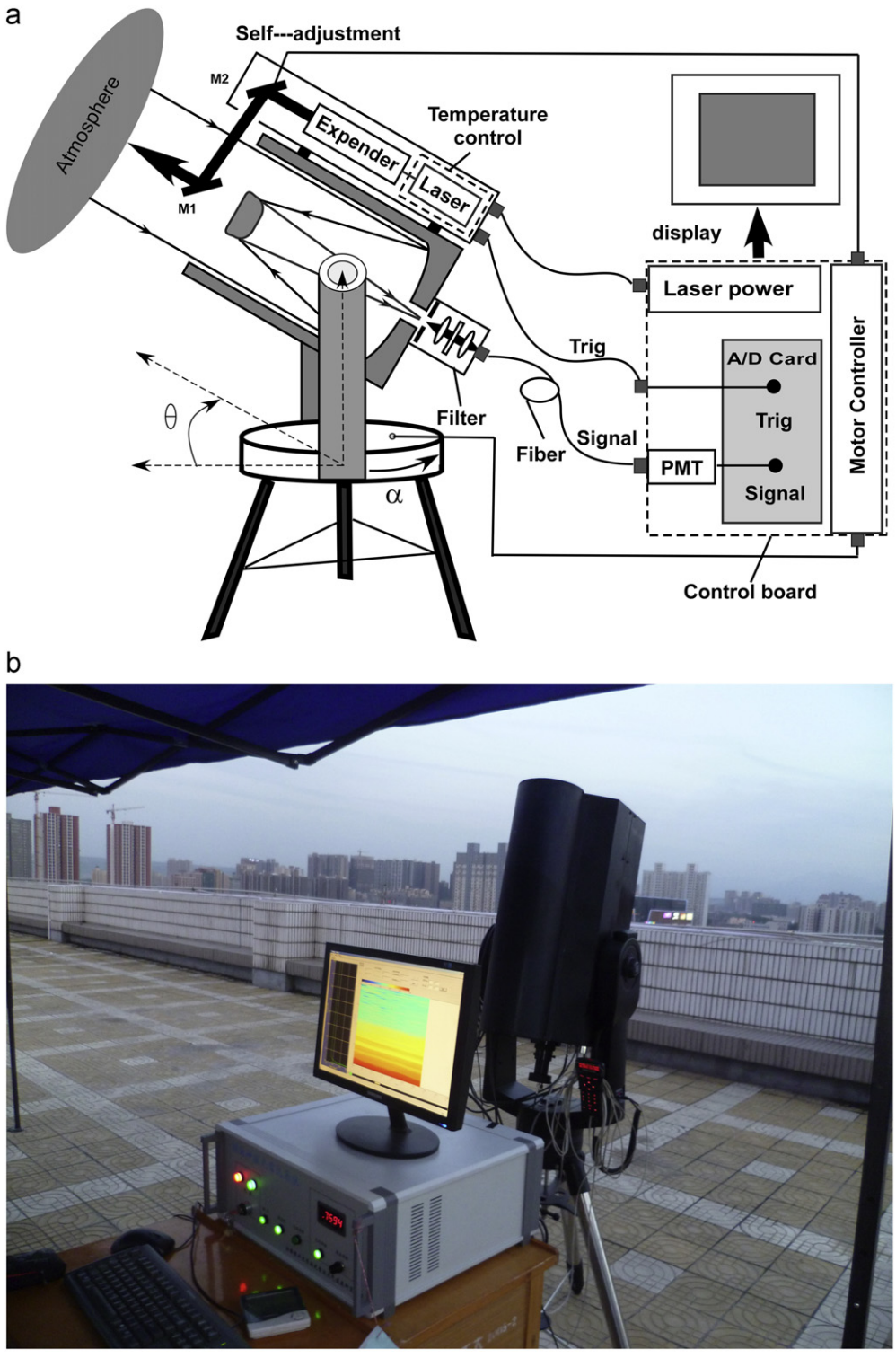

Fig. 1. (a) Schematic diagram of the MPL (b) image of the MPL.