# MOBILE LIDAR SYSTEM FOR ENVIRONMENTAL MONITORING

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## ABSTRACT

A versatile mobile remote sensing system for multidisciplinary environmental monitoring tasks on the Chinese scene is described. The system includes a 20 Hz Nd:YAG laser-pumped dye laser, optical transmitting/receiving systems with a 30 cm and a 40 cm Newtonian telescope, and electronics, all integrated in a laboratory, installed on a Jiefang truck. Results from field experiments on atomic mercury DIAL mapping and remote laser-induced fluorescence and break-down spectroscopy are given.


*Fig. 1. SCNU mobile remote sensing laboratory.*

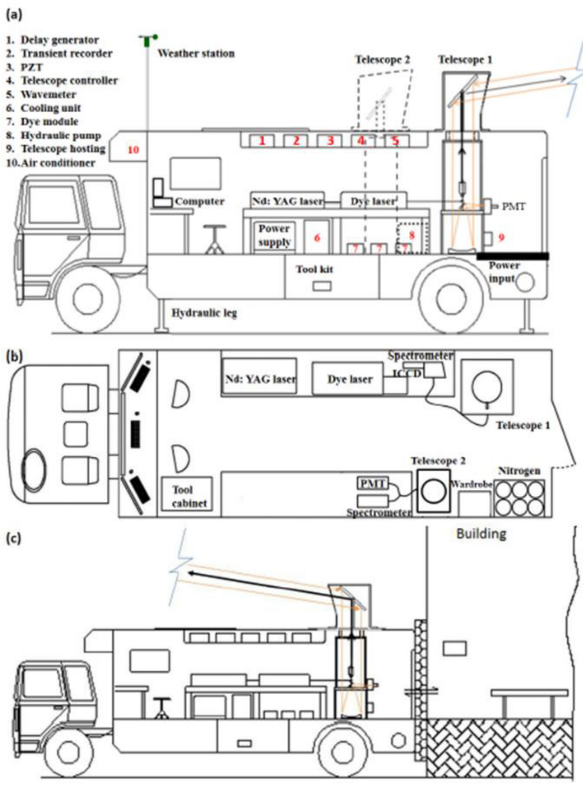


*Fig. 2. The SCNU lidar system in side view (a), top view (b) and, docked to the fixed SCNU laboratory in Guangzhou (c).*

## 1 INTRODUCTION

Environmental issues attract an ever increasing interest, and measures to improve the ambient living conditions are widely launched to reduce the impact of environmental pollution, not the least on the Chinese scene, where the situation is severe (see, e.g. [1]). Laser spectroscopy has proven as a powerful methodology for environmental studies, both in the laboratory and in remote-sensing applications. We here present a new and versatile mobile laboratory, which we have constructed at South China Normal University (SCNU) in Guangzhou. While specially adapted for laser radar applications, is also allows a wide range of laboratory studies to conveniently be pursued out in the field.

## 2 SYSTEM DESCRIPTION

The SCNU lidar system is a mobile unit with a large-size laboratory container, 7.5m x 2.4 m x 2.4 m, integrated on a Jiefang truck. A photograph of the system is shown in Fig. 1. Fig. 2a provides a side view, Fig. 2b a top view, while Fig. 2c shows the system in its docking position at the fixed SCNU laboratory in Guangzhou. While docked its full infra-structure is available for ordinary laser spectroscopy experiments pursued also in the fixed laboratory. The mobile system, in differential absorption lidar (DIAL) configuration [2], operates with a 20 Hz Nd:YAG-pumped dye laser, which, e.g., for atomic mercury monitoring is operating at 508 nm, frequency doubled to the 254 nm Hg absorption line, and providing a mapping range approaching 2 km. The choice of a dye laser, instead of an all-solid-state transmitter, e.g. an optical parametric oscillator (OPO) [3], is motivated by a better adaption to realistic field operating conditions. The system incorporates two vertically looking Newtonian telescopes (diameter 40, and 30 cm, respectively), both with roof-top folding mirrors. The system is fully controlled by LabVIEW software. A full description of the system and measurement examples are given in [4].

## 3 ATMOSPHERIC MONITORING

Mercury is a particularly severe heavy-metal pollutant [5-8], and is also an interesting geophysical tracer gas [9,10]. China uses 500-700 tons of mercury annually and has severe mercury pollution problems in certain areas [6-8, 11]. We have used the mobile system in measurements of the vertical distribution of atmospheric mercury in the Chinese cities of Guangzhou, Zhengzhou and Xi´an. Concentrations were often found to be around 5 ng/m$^3$. In contrast, very high concentrations were observed in the mercury mining area of Wanshan, Guizhou province. An example of Hg DIAL measurements in this area is shown in Fig. 3, where concentrations in excess of 150 ng/m$^3$ were observed. Our system can readily be used for studying other important atmospheric pollutants, such as $NO_2$, $SO_2$, $O_3$, and NO around 440, 300, 280 and 226 nm, respectively. Examples of recordings relating to $SO_2$ are shown in Fig. 4.

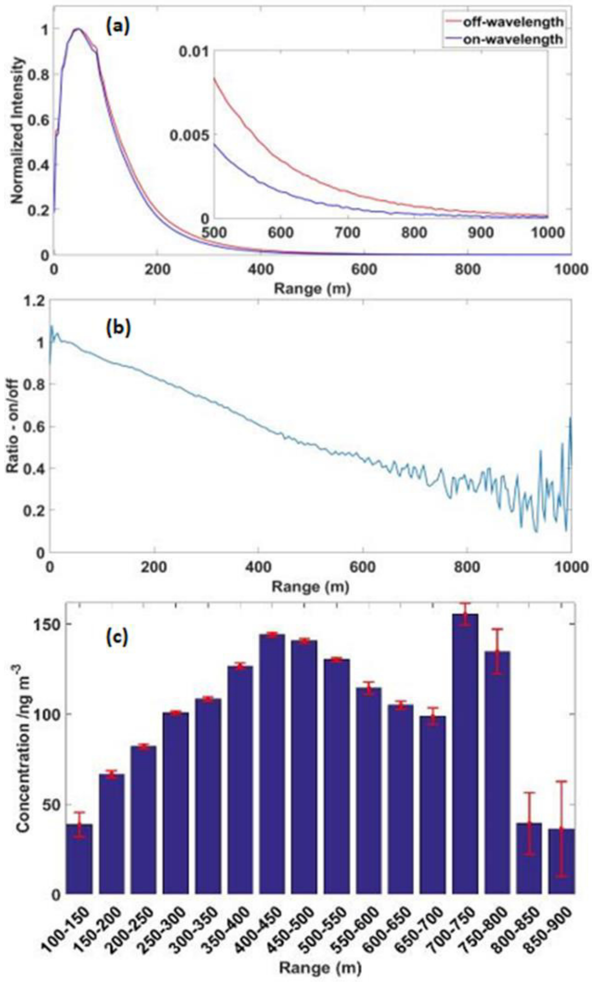


*Fig. 3. Differential absorption lidar (DIAL) measurement of atomic mercury in the Wanshan abandoned mercury-mining area in China. a) on- and off-resonance lidar returns around 254 nm b) DIAL curve c) evaluated range-resolved mercury concentrations.*

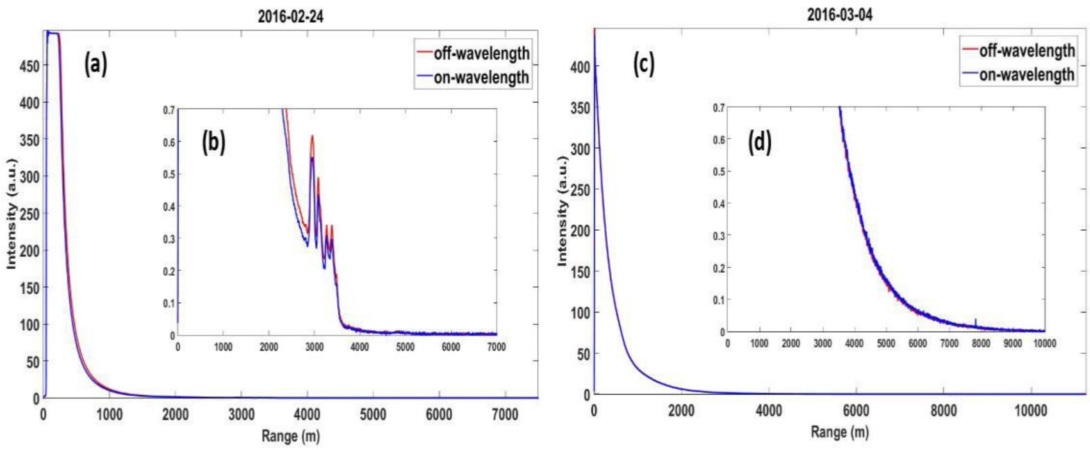


*Fig. 4. Lidar curves close to 300 nm ($SO_2$ monitoring). a,b) Termination in cloud. c,d) 10 km return.*

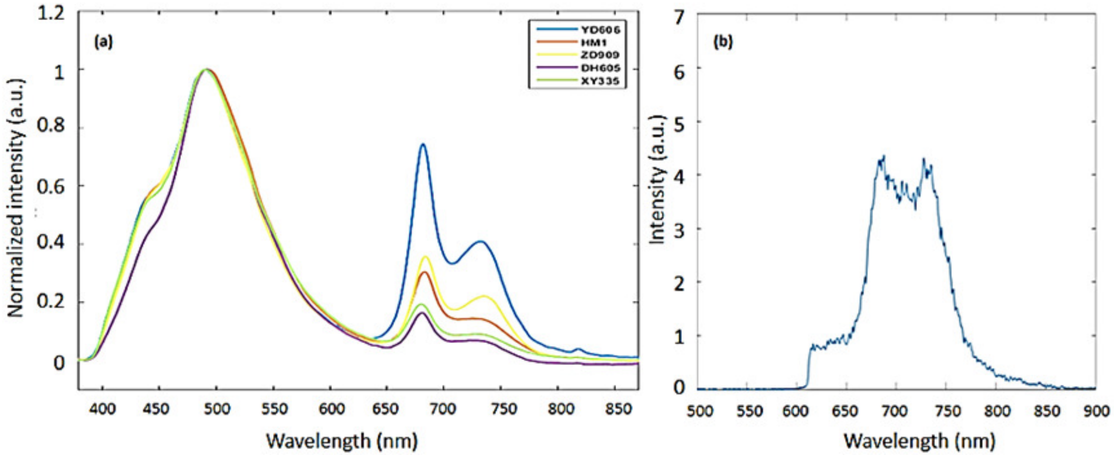


*Fig. 5. Laser-induced fluorescence measurements on agricultural crops. a) shows recordings of 5 different types of maize, measured at 30 m range with 355 nm excitation. b) shows a recording of rice at 120 m distance and using 532 nm excitation.*

## 4 REMOTE LASER-INDUCED FLUORESCENCE MEASUREMENTS

Remote laser-induced fluorescence (LIF) measurements enable the monitoring of important properties of solid and liquid targets [12,13]. We have used the new mobile laboratory in field work in Zhengzhou and Xinyang, Henan Province [14]. Examples of recordings of remote vegetation targets (maize and rice) are shown in Fig. 5. Fluorescence properties can yield information on environmental stress and the level of fertilizer available. Likewise, the status of facades of historical buildings can be assessed [15]. A spectrometer is fiber-optically coupled to the output of the lidar receiving telescope in these measurements, where harmonics of the Nd:YAG laser (at 532, 355, or 266 nm) can be utilized. For day-light recordings, influence of ambient light is suppressed by using a gated and intensified detector.

## 5 REMOTE LASER-INDUCED BREAK-DOWN SPECTROSCOPY MEASUREMENTS

Laser-induced break-down spectroscopy (LIBS) is a much employed technique for studying the elemental composition of samples, mostly in the laboratory environment [16]. It is also possible to perform LIBS remotely using a lidar system [17,18]. We have used our new mobile system for such measurements, and an example is shown in Fig. 6. A soil sample is measured at 15 m distance, as well as in the laboratory. A spectrometer with a gated and intensified detector was again used, in order to allow delayed spectral monitoring of the recombining plasma, which then exhibits a multitude of sharp and characteristic elemental spectral lines. The availability of nutrients can be assessed, as well as the presence of, e.g. heavy-metal soil pollutants.

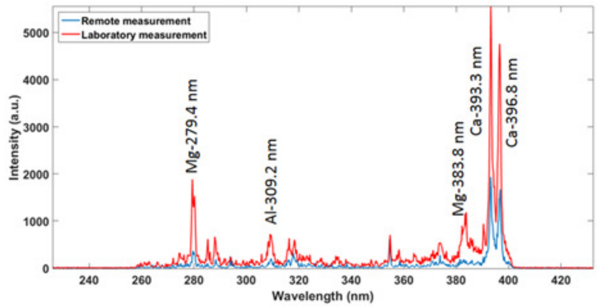


*Fig. 6. LIBS recordings for a soil sample located at 15 m distance from the measurement system, as well as when kept in the laboratory are shown, with sharp spectral lines due to Mg, Al, and Ca.*

Further measurement examples will be discussed.

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