

# Monitoring of Urban Air pollutant and Greenhouse Gases using Lidar Techniques in Seoul

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**Abstract:** This study introduces the pilot deployment of a scanning lidar system in urban area for the continuous monitoring of particulate matters (PM) and greenhouse gases (CO<sub>2</sub>) emission. Through this monitoring we identified emission blind spots over urban environment that necessitate additional management strategies.

## 1. Introduction

In densely populated urban areas such as Seoul, various sources of air pollution contribute to deteriorating air quality and climate change. Construction activities, vehicular emissions, and residential activities generate a complex mixture of pollutants, including particulate matter and greenhouse gases like CO<sub>2</sub>. [1-2] Scanning lidar systems are now widely used for wide-area monitoring of pollutants, offering insights into emission patterns and identifying emission hotspots. In this context, the deployment of scanning lidar systems in urban environments, such as Seoul, represents a novel approach to detecting pollutant emissions. This initiative aims to enhance our understanding of the dynamics of air pollution, facilitating the formulation of effective mitigation strategies and policies to improve air quality and work towards carbon neutrality.

Meteorological information, as input for a machine learning algorithm. Through this approach, we were able to calculate PM mass concentrations effectively across the entire Seoul metropolitan area.

## 2. Lidar equipment & Data Analysis

In this study, we utilized two types of scanning lidar systems: an elastic lidar for particulate matter (PM) monitoring and a Raman lidar for CO<sub>2</sub> monitoring (refer to Figure 1). The elastic lidar system was deployed to monitor PM concentrations in the atmosphere, while the Raman lidar system was specifically designed for the measurement of CO<sub>2</sub> levels. The data analysis methods for each equipment also were presented in Figure 2. Especially in PM monitoring, we proposed a novel method for calculating PM mass concentrations. Instead of using conventional methods, we utilized data from the fine dust monitoring sensors distributed throughout Seoul, along with

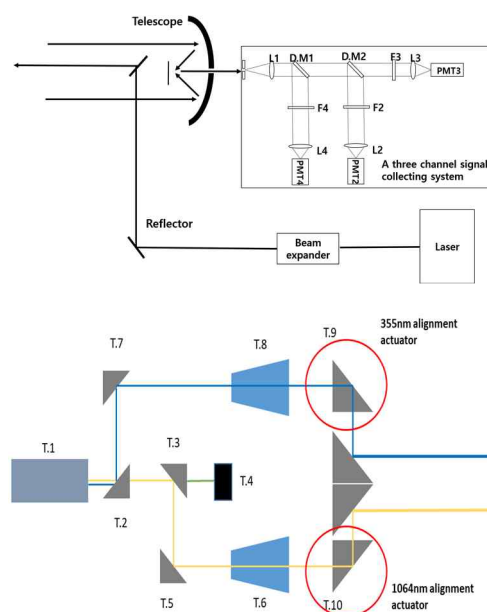
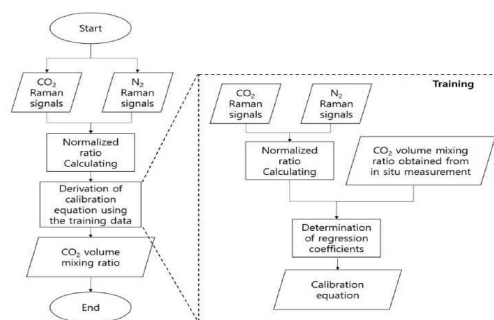


Figure 1. Schematics of lidar system (top) CO<sub>2</sub> Raman lidar (bottom) PM monitoring lidar



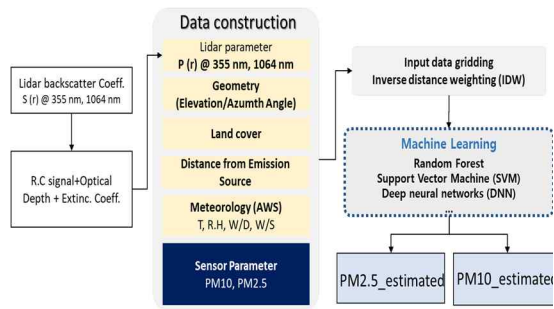


Figure 2. Flow charts of data analysis (top) CO<sub>2</sub> Raman lidar [3] (bottom) PM monitoring lidar

Table 1. Specification of CO<sub>2</sub> Raman Lidar

Component	Specification
Laser	Nd:YAG Laser Wavelength : 355 nm Pulse energy : 80mJ Beam divergence : < 1.5 mrad Repetition rate : 20 Hz
F2	CO <sub>2</sub> Raman channel (371.7nm)
F3	N <sub>2</sub> Raman channel (386.7nm)
F4	355 nm filter
PMT2	CO <sub>2</sub> channel (R9880U-201)
PMT3	N <sub>2</sub> channel (R9880U-201)
PMT4	355 nm channel (R9880U-201)
Telescope	6 Inch Schmidt Cassegrain
Beam Expander	5X, fixed beam expander
Detector	TR40-16bit3U

Table 2. Specification of PM monitoring Lidar

Component	Specification
Transmitter	Diode Pumped Solid State Q-Switched Laser Wavelength : 355 nm/ 1064 nm Pulse energy : 2.5mJ Beam divergence : <0.06 mRad Repetition rate : 2 kHz

Receive part	200 mm Schmidt Cassegrain < 0.3 mrad (FOV) > 7 km (Measurement range) < 10 m (Range Resolution) Photon Counting system
Scan system	-10 ~ 90° (Vertical range) 0 ~ 360° (Horizontal range) < 1° (Angular resolution) < 30 min. (Observation cycle)

### 3. Measurement Examples

Figure 3a shows an example of PM monitoring using scanning lidar and the map showing the distribution of particulate matter within the observed range. Through the particulate matter distribution map, high-concentration areas of PM within the observation radius can be monitored in real-time.

In Figure 3b, it is evident from the CO<sub>2</sub> Raman lidar observations that a substantial amount of CO<sub>2</sub> is being emitted from the stacks of the nearby combined heat and power plant.

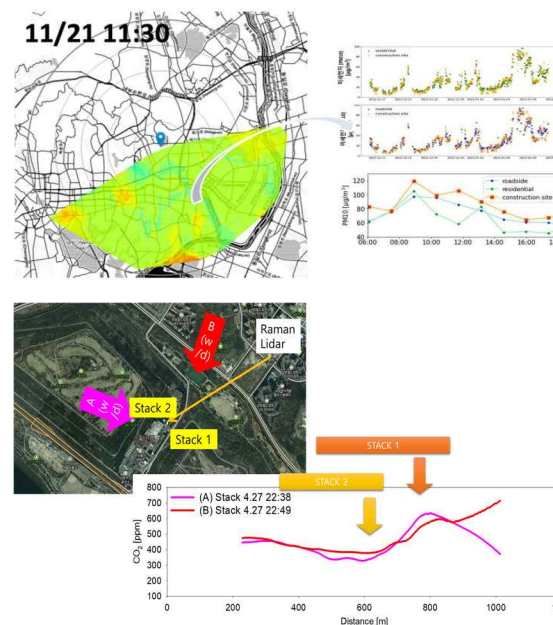


Figure 3. Example of lidar measurements (a) distribution of PM (b) Retrieval of CO<sub>2</sub> concentration

#### **4. Summary and Outlook**

The result of investigating the cause of PM and CO<sub>2</sub> in real-time maps derived using lidar system for areas identified with high concentration matched with existing major emission sources of dust and CO<sub>2</sub> in Seoul. These lidar technologies can be actively utilized in Seoul's efforts to improve air quality and mitigate greenhouse gas emissions. The city of Seoul is also striving to enhance air quality monitoring through the use of such technologies.

#### **5. References**

- [1] Kim and Lee, "Trend of Air Quality in Seoul:Policy and Science", *Aerosol and Air Quality Research*, 18, 2131-2156 (2018)
- [2] Choi et al., "Analysis of the National Air Pollutant Emission Inventory (CAPSS 2016) and the major cause of Change in Republic of Korea, *AJAE*, 14(4) (2020)
- [3] Kim et al., "Development of Raman Lidar for Remote Sensing of CO<sub>2</sub> Leakage at an Artificial Carbon Capture and Storage Site," *Remote Sensing* 10(9), 1439 (2018)

#### **Acknowledgement**

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