Development of low-cost high-spectral-resolution lidar using compact multimode laser for air quality measurement

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Quantitative measurement of aerosol profiles is essential to assess the effect of aerosols on the air quality. High-spectral-resolution lidar (HSRL) method is useful to measure aerosol extinction coefficient independently from aerosol backscatter with high sensitivity. Low-cost and robust HSRL systems are required for spreading quantitative measurement of aerosols worldwide. A single-mode laser is typically used as the light source of HSRL because it is suitable for separating atmospheric scattering into Mie and Rayleigh components efficiently, but single-mode lasers are costly compared to multimode lasers widely used for aerosol lidars. Moreover, most of HSRLs need to tune laser wavelength to the spectral peak of high resolution spectral filters, and such tuning system is sensitive to measurement environments (e.g., temperature).

Recently an HSRL using a multi-longitudinal, single-transverse mode laser was proposed. In the proposed system, a scanning interferometer with the same mode spacing as the multimode laser was used for the spectral filter. By scanning the interferometer for the range of one fringe, interference contrast, which contains aerosol backscatter information, was obtained at each height through fitting analysis of the scan data. The interference contrast and fringe position were calibrated with the reference signals taken from the part of the transmitted laser. Therefore the system does not require feedback controls for the laser and interferometer. The proposed system was less expensive than the conventional HSRLs with single-mode lasers, but it was less efficiency because a long interferometer was used to have the same mode spacing as the used commercial laser, which had a long optical cavity length (~60 cm).

In this study, we propose a low-cost HSRL system using a compact multimode laser, which is newly designed to increase the measurement efficiency compared to the previous study using a commercial multimode laser. The laser mode spacing is matched to the free spectral range of the receiver interferometer optimized for HSRL measurement. As a result, the laser has a short cavity length and large mode spacing, but spectral width of the laser mode should be narrow comparable to single-mode lasers. To satisfy above conditions, we develop a laser that comprises a master oscillator and a power amplifier. In this presentation, we present the configuration of the HSRL system and an evaluation of developed laser using a scanning interferometer. Examples of continuous aerosol measurement with the multimode HSRL are also shown.