Real-time measurement of atmospheric carbon monoxide combined with mid-infrared wavelength modulation spectroscopy

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Carbon monoxide (CO) is emitted from incomplete combustion of fossil fuels and biomass. It affects the concentration of CO_2 and CH_4 through the reactions with hydroxyl radicals. The major method of the measurements of CO is NDIR. This method is highly sensitive and highly stable. There are a lot of data of the concentration of CO measured with NDIR, but they show only hourly average. In this study, we observed CO concentration in the atmosphere with a mid-IR laser absorption spectrometer that uses a 4.69 μm quantum cascade laser with wavelength modulation spectroscopy (WMS).
The absorption line for the measurements of CO was at 2131.63 cm^{-1}. The laser was scanned at 1.10 Hz. The beam was collimated with CaF_2 lens and introduced into the cell. The optical path length was 29.91 m. The signal from a photodetector was processed by the lock-in amplifier.
To assess signal stability and detection limit, 1.02 ppm CO gas was introduced into the WMS system. The precision (1 σ) of the measurement for 7 hours was 4.18 ‰.
For the measurement of the detection limit of this instrument, we collected the signal of different CO mixing ratio and made the calibration curve. From the slope and the averaged baseline deviation, the detection limit (SNR = 2) was found to be 10 ppb.
Measurements of outside air were conducted on the Kashiwa campus of The University of Tokyo over February 8-11, 2017. During the measurements of ambient air, the calibration was performed every 6-9 hours.
Outside air measurements were conducted over February 8-11, 2017. The CO mixing ratio during the measurements ranged from 0.11 ppm to 0.60 ppm. In the daytime of February 10, the wind brew from northwest. There are no big industrial areas in that direction. So the CO concentration was low and steady. There are some spikes in CO concentration. These may be attributed to cars passing near the observation point.
We performed in situ measurements of CO mixing ratios in ambient air with a near-IR laser absorption spectrometer using WMS. We successfully detected CO mixing ratio change in the ambient air instantly.

