Quantifying thermal power plant CO_2 emissions from CO_2 total column measurements with portable FTIR spectrometers

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Emissions of carbon dioxide (CO_2) from large point sources such as thermal power plants and steel plants account for approximately 40% of the world’ s energy-related CO_2 emissions. Nowadays, the CO_2 emissions from thermal power plants have been quantified based on CO_2 column abundances obtained by airborne and satellite-borne remote sensing. In the present study, we evaluated precisions in CO_2 emission estimates from simpler and more inexpensive ground-based CO_2 column measurements. To this end, we conducted two measurement campaigns for one month each during October 2018 and October–November 2019 to measure CO_2 column abundances using two portable Fourier transform infrared (FTIR) spectrometers (EM27/SUN) around a thermal power plant in Japan. In addition, wind profiles in the planetary boundary layer and meteorological parameters at the ground were observed by a Doppler lidar and a meteorological observation system, respectively. We assumed that the CO_2 plume rises by a certain height depending on heat emission rate and wind speed at the stack top, and that the horizontal distribution of CO_2 column enhancement relative to the background can be represented by a Gaussian plume model. Because the shape of the plume is disturbed by turbulence, the observed CO_2 column and meteorological data were averaged into 10 min bins to mitigate that effect. The wind speeds at an effective plume height and the plume widths necessary for CO_2 emission estimates were obtained or estimated from the observed values, and highly variable wind directions were retrieved simultaneously with the CO_2 emission. We compared the CO_2 emissions estimated from the observed data with those converted from hourly fuel consumptions, and it was found that the standard deviation (1 σ) of the differences was ~20%.

Keywords: carbon dioxide, thermal power plant, emission amount, remote sensing

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