(64-240329-C) **Spatial and Temporal Variability of CH_4 and CO_2 across New York City**

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Urban areas are the largest global source of greenhouse gas (GHG) emissions and cities dominate air pollutant emissions. Cities and states across the U.S. and worldwide have begun to target greenhouse gas reductions as their primary climate mitigation policy. New York State and City have some of the most progressive methane mitigation policies in the U.S.: The NYS 2019 Climate Leadership and Community Protection Act (CLCPA) calls for a 40% cut in GHG emissions below 1990 levels by 2030 and 85% by 2050, with the remaining 15% offset by carbon capture. In order to meet these targets, the city is developing policy to encourage emissions reductions; however, it is critical for this to be able to identify and quantify the emissions sources and to track progress towards emissions reduction as policies are implemented. While bottom-up GHG inventories include emissions from known sources, some emission rates from individual source sectors remain highly uncertain and are likely underestimated compared to top-down measurements.

In order to better understand this discrepancy, we deployed an open-path dual-comb spectroscopy (DCS) system to obtain horizontal path-integrated measurements of CO_2 and CH_4 concentrations across km-scale paths in New York City over a three-month time period in summer and one-month in winter. The DCS system was located at the City University of New York (CUNY) Advanced Science Research (ASRC) building in the Harlem borough of northern Manhattan, New York City. We observe large temporal and spatial variability of greenhouse gas concentrations (Fig 1), with diurnal and weekly patterns as well as non-regular plumes. CH_4 enhancements were often 1 ppm or higher, with many plumes lasting for over 1-hour periods. We are able to attribute some of these plumes to nearby sources, in particular, several waste-water treatment facilities. While most measurements are consistent between beam paths, some time periods show significant differences in gas concentrations when switching beam paths. Similarly, DCS measurements often agree with point sampling measurements on the CUNY ASRC building, but sometimes show differences that reveal information about spatial extent of plumes. High variability of CO_2/CH_4 ratios are observed, indicating a variety of combustion and not combustion related sources contributing to the atmospheric greenhouse gas composition. Comparison between observations ratios predicted by emissions inventories suggest that the inventories underestimated CH_4 sources. Finally, we compare the observations to several *in situ* sensors located in NYC as well as the surrounding area to constrain the total emissions.

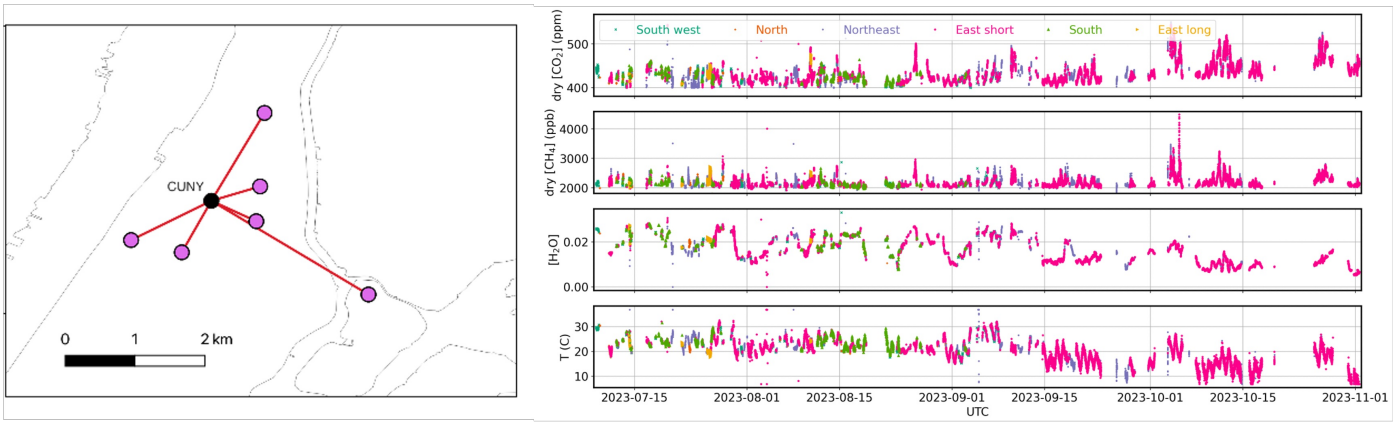

Figure 1. (left) Map of DCS beam paths. (right) Time series of DCS observations in summer-fall 2023.