Hourly, Daily, and Seasonal Patterns of Atmospheric CO_2 Along an Urbanization Gradient

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Cities occupy less than 3% of global land area, but are estimated to produce nearly three-quarters of anthropogenic CO_2 emissions (IEA 2008). Therefore, these small geographic features exert a disproportionate influence on atmospheric CO_2 concentrations on multiple spatial scales. However, the patterns of CO_2 in urban areas are controlled not only by anthropogenic emissions, but also by biogenic and micrometeorological processes. The aggregate behavior of these diverse processes on atmospheric CO_2 concentrations represents a critical gap in our understanding of the terrestrial carbon cycle, complicating efforts to develop a framework for regulation and verification of carbon emissions.

In order to better understand these drivers of atmospheric CO_2 in an urbanized area, we analyzed measurements of atmospheric CO_2 made from towers in Boston, Worcester, and Harvard Forest (Petersham), Massachusetts. These locations span the urban-rural gradient of central and eastern Massachusetts, allowing detection of the factors contributing the atmospheric CO_2 signal in this region. Our results show significant differences between the sites on hourly, seasonal, and annual timesteps. The annual mean CO_2 mixing ratios were 408.2 ± 0.2, 401.5 ± 0.4, and 393.0 ± 0.3ppm at Boston, Worcester, and Harvard Forest, respectively. Across the gradient, peak CO_2 concentrations were observed in winter, corresponding with the timing of maximum anthropogenic emissions (Gurney *et al*. 2009) and minimum biogenic uptake. Midday CO_2 concentrations in the summer demonstrate significant drawdown (≥ 10 ppm) from the 24-hour median value across all three sites, highlighting the importance of biogenic fluxes, even at the highly urbanized Boston site.

These data represent a critical component of a model-data framework designed to make high-resolution inferences about sources and sinks of atmospheric CO_2. We will use the Stochastic Time Inverted Lagrangian Transport model to estimate surface fluxes on the basis of the time series data at our three locations. The results from this work will allow us to directly connect the influence of anthropogenic processes to observed atmospheric CO_2 for verification of future greenhouse gas agreements and treaties.

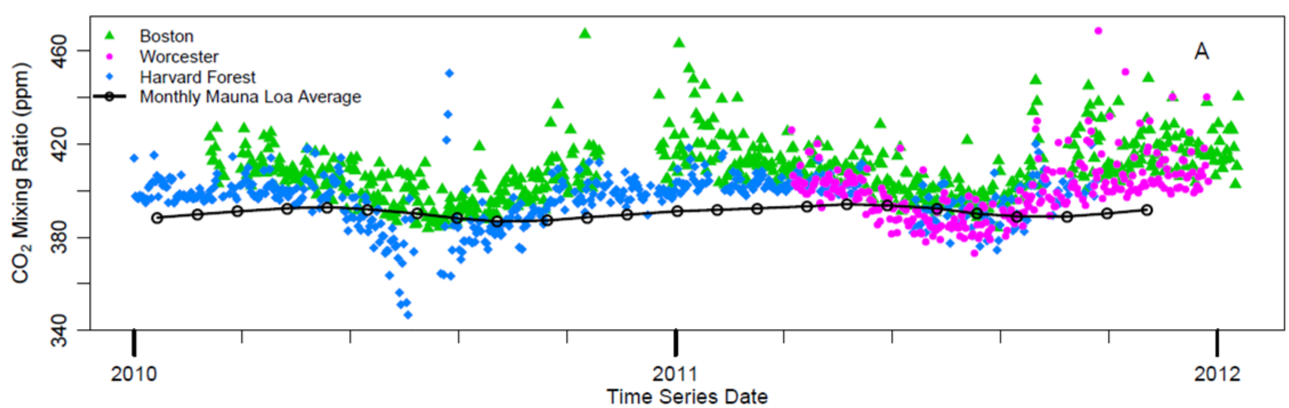

Figure 1. Time series of daily averaged CO_2 concentrations at Boston, Worcester, and Harvard Forest, Massachusetts.