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Measurements of Carbon Dioxide, Carbon Monoxide, and Other Related Tracers at High Spatial and Temporal Resolution in an Urban Environment

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The ability to quantify the sources and sinks of carbon dioxide on the urban scale is essential for understanding the atmospheric drivers to global climate change. In the ‘top-down’ approach, overall carbon fluxes are determined by combining remote measurements of carbon dioxide concentrations with complex atmospheric transport models, and these emissions measurements are compared to “bottoms-up” predictions based on detailed inventories of the sources and sinks of carbon, both anthropogenic and biogenic in nature. This approach, which has been proven to be effective at continental scales, becomes challenging to implement at the urban scale, due to poorly understood micrometeorological atmospheric transport models and high variability of the emissions sources in space (e.g., factories, highways, residences) and time (rush hours, factory shifts and shutdowns, residential energy usage variability during the day and over the year). New measurement and analysis techniques are required to make sense of the carbon dioxide signal in cities. Here we present detailed, high spatial- and temporal-resolution greenhouse gas measurements in Silicon Valley in California. The synthesis of two experimental campaigns is presented: real-time measurements from two ten-meter urban ‘towers,’ and ground-based mobile mapping measurements. Real-time carbon dioxide data from a nine-month period are combined with real-time carbon monoxide, methane, acetylene, and carbon 13 measurements to partition the observed CO_2 concentrations between different anthropogenic sectors (e.g., transport, residential) and biogenic sources. The carbon monoxide to carbon dioxide ratio is shown to vary over more than a factor of two from season to season or even from day to night, indicating rapid and frequent shifts in the balance between different carbon dioxide sources. Clear differences are seen between the two urban sites, which are separated by 7 km. Further information is given by the carbon 13 signature and by acetylene, another tracer that provides complementary information to carbon monoxide as an indicator of combustion. In spring and summer, the combined signal of the urban center and the surrounding biosphere and urban green space is explored. These methods show great promise for quantifying and partitioning carbon dioxide emissions in an urban and mixed urban / ecological setting.