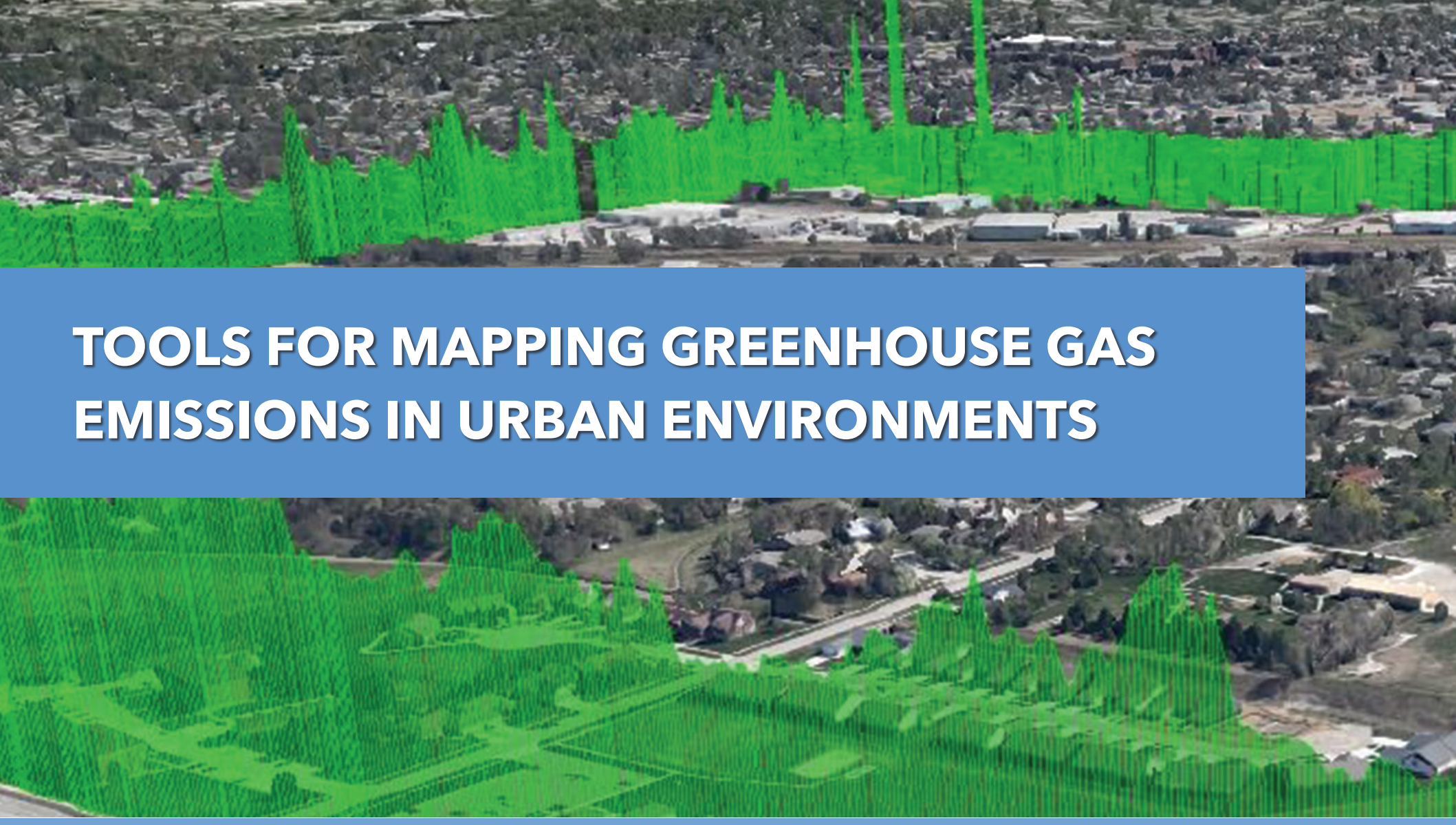


TOOLS FOR MAPPING GREENHOUSE GAS EMISSIONS IN URBAN ENVIRONMENTS

In urban environments, greenhouse gas emissions are complex and numerous. Automated instruments make detection and mapping easier. Automated mapping is an important tool for climate research, leak detection and evaluating threats to human health.

First reported October 23, 2015, a wellhead blowout and methane leak at the Porter Ranch natural gas storage facility in southern California forced thousands of residents from their homes. This event highlighted the need for effective leak detection and characterization of methane plumes, especially in populated areas.

On December 21, 2015, The South Coast Air Quality Management District (SCAQMD) began using LI-COR's LI-7700 Open Path Methane Analyzer—mounted on a moving vehicle—for automated monitoring of fugitive methane emissions. At the Porter Ranch site, they repeatedly detected significant increases in CH_4 concentrations exceeding 50 ppm when measured from a road 1.5 miles away from the leak.

This article examines tools for measurement and mapping of carbon dioxide (CO_2), methane (CH_4) and water vapor (H_2O) concentrations and/or fluxes in urban environments. Mapping integrates spatial data with concurrent observations of greenhouse gas concentrations and/or fluxes. City planners, researchers, and developers can use these data when designing industrial, energy, transportation, and residential infrastructure. The data may also be used for regulatory and emergency response purposes. Direct measurements of methane and other greenhouse gases are important not only for detecting fugitive emissions such as leaks, but also for addressing climate change and urban air quality.

Mapping CO_2 Concentrations

Urban environments have been shown to have ambient CO_2 concentrations much higher than surrounding rural areas, resulting in domes of CO_2-enriched air. These CO_2 domes tend to show variation on time scales as long as seasons or as short as days, and can track changes in community behavior. It has been suggested that while CO_2 at typical ambient concentrations poses little or no direct health risk to humans, it may still serve as a valuable air quality indicator in urban environments. Increases in CO_2 concentration are correlated with increases in ground level ozone and particulate matter, and may actually enhance ozone production.

CO_2 domes can be characterized by sampling CO_2 concentrations at heights of a few meters or less above the ground using a portable gas analyzer along transects across the area of interest. By sampling CO_2 concentrations concurrent with location data, a clear picture of how ambient CO_2 concentration varies across the landscape can be built.

LI-COR® Biosciences makes a turnkey solution for measuring and mapping CO_2 concentrations. The LI-8100A Automated Soil Gas Flux System—equipped with the optional CO_2 Mapping Kit—can continuously measure and record atmospheric CO_2 concentrations at a fixed height while walking or driving. An integrated GPS unit provides location data.

Data collected in continuous mode can be formatted for display in Google® Earth using the KML converter application installed with the LI-8100A Windows® application software. The KML converter supports export of any variable included in the file to an extruded track, where elevation of the track above ground is directly proportional to the measured value. This gives a visual representation of concentration, making it easier to spot peaks in concentration.

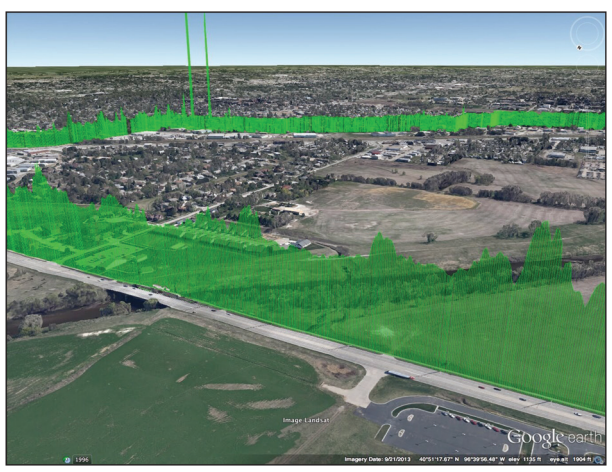
Urban Flux Measurements

Scientists have studied the exchange of CO_2 between natural ecosystems and the atmosphere in remote rural areas around the globe for many years. Now, with concerns over increasing greenhouse gas emissions and industrial pollutants, many studies have been launched to understand the details surrounding urban carbon fluxes. By comparing the carbon dioxide and water vapor budgets of agricultural or natural ecosystems against those of urban areas, we can gain better insight into turbulent fluxes of heat, H_2O, and CO_2 in urban areas. This, in turn, will provide insight into the fate of urban air pollutants such as particulate matter, nitrogen oxides, and volatile organic compounds.

Eddy covariance is a common method for measuring turbulent fluxes. It relies on continuous gas and wind speed measurements from high resolution instruments on fixed towers. Results represent fluxes from a large area upwind of the flux tower. Urban areas feature multiple point sources and non-uniform surfaces that affect eddies. These factors make instrument selection and placement critical to success.

Measuring ground level CO_2 concentrations with the LI-8100A Automated Soil Gas Flux System.

Urban flux research has been ongoing for several years in cities such as Baltimore (U.S.A), Montreal (Canada), and London (UK). In addition to ecosystem and climate change research, the eddy covariance method can be used for applications such as regulatory and industrial monitoring. Learn more about existing urban flux research from the International Association for Urban Climate and the Urban Flux Network (see http://www.urban-climate.org/). Additionally, you can contact LI-COR for information about instrumentation and software for flux stations.

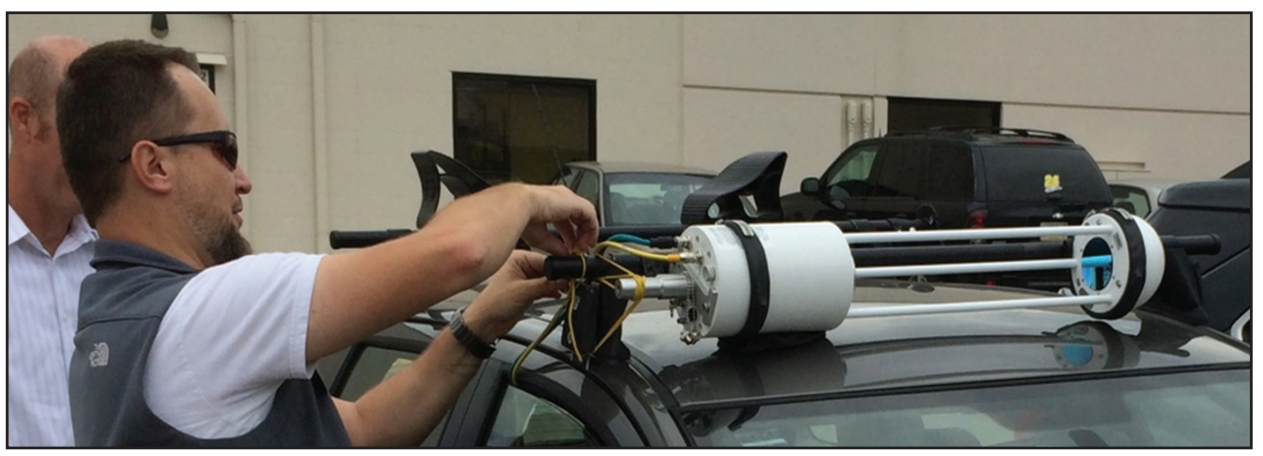


Map of CO_2 concentration along a roadway using data from the LI-8100A with CO_2 Mapping Kit.

High Resolution Methane Mapping

The LI-7700 Open Path Methane Analyzer was developed in 2010 as the first low-power, high resolution methane analyzer for stationary eddy covariance flux sites. This analyzer has also performed well on mobile platforms including planes, ships, and road vehicles. It delivers a time response of 40 times per second with a resolution of 0.01 ppm CH_4. The resulting CH_4 map would be resolved every 0.5 meters, even when driving 50 mph. Installation requires care but does not require an expert. Maintenance involves cleaning the mirrors of the analyzer in the same way one would clean a camera lens or expensive sunglasses.

Eddy covariance flux station with LI-COR's LI-7500RS Open Path CO_2/H_2O Analyzer (left) and LI-7700 Open Path Methane Analyzer (right).



Dr. George Burba, LI-COR Principal Scientist, preparing an LI-7700 Open Path Methane Analyzer for mobile use.

In addition to the South Coast Air Quality Management District (SCAQMD), successful LI-7700 methane mapping trials have been conducted by Princeton University, Colorado State University (along with Google and the Environmental Defense Fund), the Italian National Research Council, GCRG - San Diego State University, and the GFZ German Research Center for Geosciences. Trials show that high resolution CH_4 maps derived from data collected by the LI-7700 can be used to locate gas leaks for public safety, regulatory, and compliance purposes.

Elevated methane readings can be caused by natural gas leaks, vehicle emissions, or biological processes. Fortunately, there are ways to distinguish between various source types. In Colorado, every natural gas leak that was identified by mobile methane mapping with the LI-7700 was later confirmed manually by the utility company. In Denver and Ft. Collins, an automated survey found 97 small leaks, 39 medium leaks, and 6 large leaks, totaling 1508 L/min, enough to provide service to 721 homes.

LI-COR scientists are collaborating with other researchers to develop recommended procedures for creating maps from data collected by the LI-7700 in conjunction with a GPS system. Contact LI-COR Biosciences for the latest tools, software, and recommendations for measuring and mapping methane emissions, CO_2 emissions, and turbulent fluxes.

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