

Zooming In and Out of Cities from Local, Regional, to Global Scales: Emissions, Air quality, Greenhouse Gases, and Carbon Cycling

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By definition, cities are where large numbers of humans live, work, and play in a concentrated area. Cities are responsible for a significant proportion of the world's emissions of greenhouse gases and air quality-relevant pollutants. As global populations increasingly reside in cities, the role of urban emissions in determining the future trajectory of climate change and human health is magnified. Consequently, two key research and societal questions include:

- 1) How do anthropogenic emissions vary as cities grow and change?
- 2) What controls current and future air quality in cities?

To address these questions, a number of research efforts have been started in the U.S. and beyond, focusing on observing atmospheric CO₂ and relating its variations to carbon emissions in cities. Because carbon emissions are intimately tied to socioeconomic activity through the combustion of fossil fuels, and many cities are actively adopting emission reduction plans, such urban carbon research efforts give rise to opportunities for stakeholder engagement and guidance on other environmental issues, such as air quality.

I report on past and ongoing research efforts in Salt Lake City, where one of the most comprehensive atmospheric monitoring systems in the world is located. The monitoring system includes dense observations of greenhouse gases and air quality as well as meteorology, making use of both stationary and mobile platforms, including light rail and Google Street View cars. These unique measurements enable researchers to “*zoom into*” the city, revealing a wealth of information with unprecedented granularity.

However, fine-scale information within cities alone does not suffice for understanding a city's air quality. Atmospheric flows cross artificial human boundaries, so cities are affected by sources hundreds of kilometers upwind, such as biomass burning and dust sources. Thus it is necessary to also “*zoom out*” to regional scales to determine the composition of air arriving at the city. I will show examples from the Western U.S., where the nexus of climate change and human activities have led to new air quality concerns and where the natural carbon cycle has undergone significant perturbations.

Finally, I will also discuss new efforts from my group to “*zoom out*” to global scales to estimate carbon emissions from cities around the world. This work makes use of NASA's recent measurements from satellites, such as the Orbiting Carbon Observatory-2. New analyses of the satellite CO₂ data indicate a scaling relationship between per capita emissions and urban density that shed new light on debates on this relationship in the published literature.