ASSESSING CARBON DIOXIDE EMISSIONS FROM U.S. LARGE CITIES

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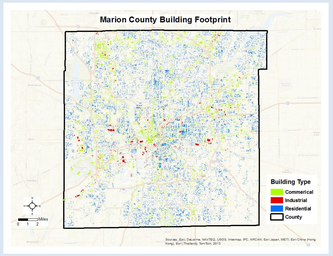
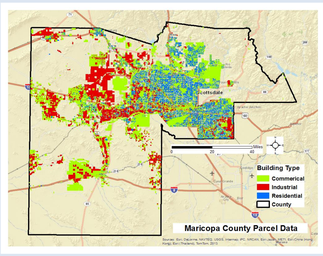
Introduction

Carbon dioxide (CO_2) emissions, a primary greenhouse gas, are quantified at fine spatial and temporal scales. In our research project, named "Hestia", we estimate CO_2 emissions from natural gas, coal, and petroleum sources. We use a 'bottom-up' approach in which CO_2 emissions are estimated from each individual building and road segment on an hourly basis during a particular year. Our first estimation is based on the year 2002 in conjunction with our previous "Vulcan Project". Based on the Vulcan Project, we then can apply the CO_2 emission factor for other years. We calculate the CO_2 emissions from different sectors including residential buildings, commercial buildings, roads, railroads, airports, industrial facilities, and electrical production facilities. Our first Hestia city is Indianapolis, which is situated within Marion County, IN. We have quantified the annual CO_2 emissions hour-by-hour for this city as well as the Marion County. The methodologies used for Indianapolis will set a basis for other Hestia cities. Currently, we are working on Phoenix, Salt Lake City and Los Angeles Metro area. Not only quantifying the CO_2 emissions from each individual city or county, our goal is to perform a cross-analysis among different urban settings as well. The results obtained will be beneficial for city planners, environmental planners, or other interested parties in the efforts to lower CO_2 emissions.

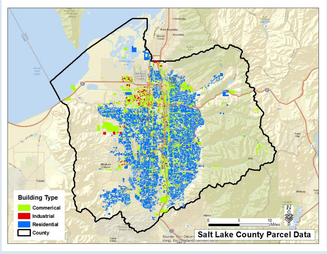
Hestia Prototype Cities



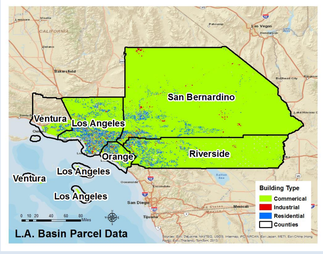
Indianapolis
(Marion County)



Phoenix
(Maricopa County)



Salt Lake City
(Salt Lake County)



L.A. Metro Area
(Los Angeles, Orange, Riverside, San Bernardino, and Ventura Counties)

Fig 1. Hestia prototype cities overlaid with the parcel data or building footprint.

Data Sources & Methods

We estimate CO_2 emissions from different building sectors including residential buildings, commercial buildings, point/non-point sources industrial buildings, electricity generation facilities, airports, marine ports, roads/non-roads, and railroads. The following are examples of data sources that we utilize:-

- *Parcel data/building footprints.* We use this data for building type classification. We classify the parcel data into 8 residential building types (e.g. large/small apartments, single/multiple family) and 22 commercial building types (e.g. large/small office, large/small retail, hotels, restaurants, education), and 22 industrial building types (e.g. paper products, wood products, chemicals). Each of these buildings is further categorized according to the year-built as before 1980 and after 1980.

- *AADT (Annual Average Daily Traffic) and ATR (Automated Traffic Recorder).* This data is used to estimate the CO_2 emissions from road segments based on the traffic count. We also combine this data with the TIGER road layer to determine the traffic count according to different road types.

- *Point sources (for both commercial and industrial buildings).* We use the reports from the EPA's registry facility ID. We visually inspect these points and geo-locate the locations by using Google and Bing Maps to make sure these points are located correctly.

- *CBECS (Commercial Buildings Energy Consumption Survey), RECS (Residential Energy Consumption Survey), and MECS (Manufacturing Energy Consumption Survey).* We use the values reported in these data to calibrate our dataset at a regional scale.

- *The Vulcan Project.* The Vulcan Project estimates CO_2 emissions for the entire United States at the county level. We use these findings as the basis for our 'bottom-up' approach for the Hestia Project.

Furthermore, we also utilize eQUEST, NMIM, ArcGIS, and computer programming languages to calculate CO_2 emissions hour-by-hour from different sectors. NetCDF package will be produced and provided for the interested parties. NetCDF files can also be produced at different spatial scales such as 1 km or 250 m grid cells.

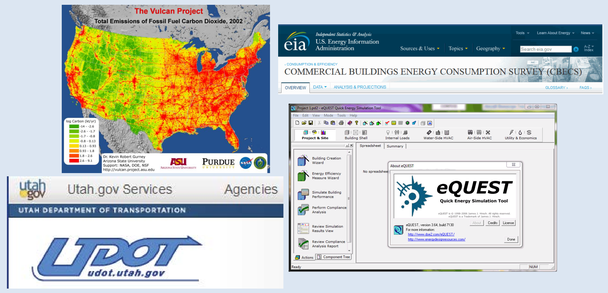


Fig 2. Examples of data sources

Results/Products

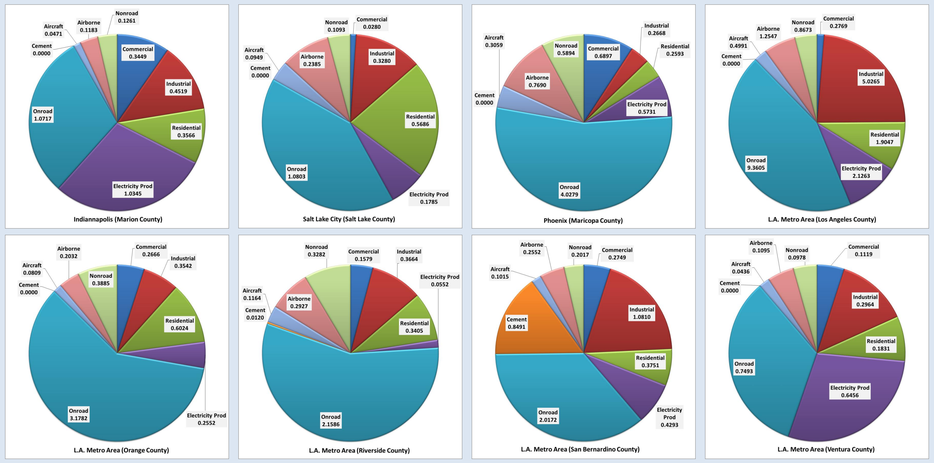


Fig 3. Results from Vulcan Project by county, 2002. Units: million tons of carbon.

Fig 3 shows the CO_2 emission distribution among the counties (Vulcan Project). Onroad sector is the largest CO_2 contributor. The CO_2 emission for other sectors vary according to the type and size of the buildings within that county. For the Hestia Project, we estimate CO_2 emissions from a finer scale, i.e., from buildings/parcels and road segments. For example, Fig 4 shows CO_2 emissions from commercial, residential, and industrial sectors on the hourly basis.

We are currently working on Phoenix, Salt Lake City, and Los Angeles. The results from these cities will allow us to perform a cross-analysis at an urban and county scales.

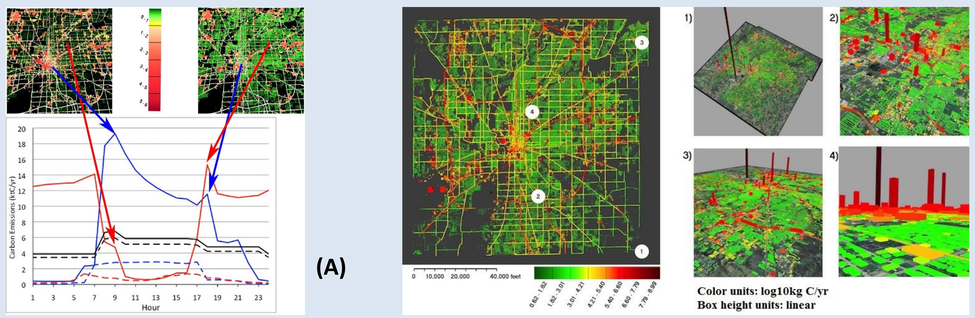


Fig 4. CO_2 emissions for Indianapolis and Marion County. (**A**) Summer (Apr-Sept, dashed lines) vs. Winter (Oct-Mar, solid lines) profiles for the residential (red lines), commercial (blue lines), and industrial (black lines) sectors. The insets show commercial (downtown) and residential sectors at 9 a.m. and 6 p.m. (**B**) Total fossil fuel CO_2 emissions in 2002. Numbers on the left image correspond to the blow-up images to the right.

Publications/Websites

1. Gurney, K., Mendoza, D., Zhou, Y., Fischer, M., Miller, C., Geethakumar, S., & Can, S. R. (2009). High resolution fossil fuel combustion CO_2 emission fluxes for the United States. *Environmental Science and Technology*.
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3. Zhou, Y., & Gurney, K. (2010). A new methodology for quantifying on-site residential and commercial fossil fuel CO_2 emissions at the building spatial scale and hourly time scale. *Carbon Management*, *1*(1), 45–56. doi:10.4155/cmt.10.7

Vulcan Project: http://vulcan.project.asu.edu/
Hestia Project: http://hestia.project.asu.edu/index.shtml

Acknowledgements

Vulcan Project: NASA, Grant Carbon/04-0325-0167;DOE Grant DE-AC02-05CH11231
Hestia Project: National Institute for Standards and Technology grant 104336; Purdue Climate Change Research Center and the Purdue Showalter Trust; JPL/CalTech SURP grant; University of Utah grant