Spatiotemporal variations of on-road CO_2 emissions for Maricopa County, Arizona

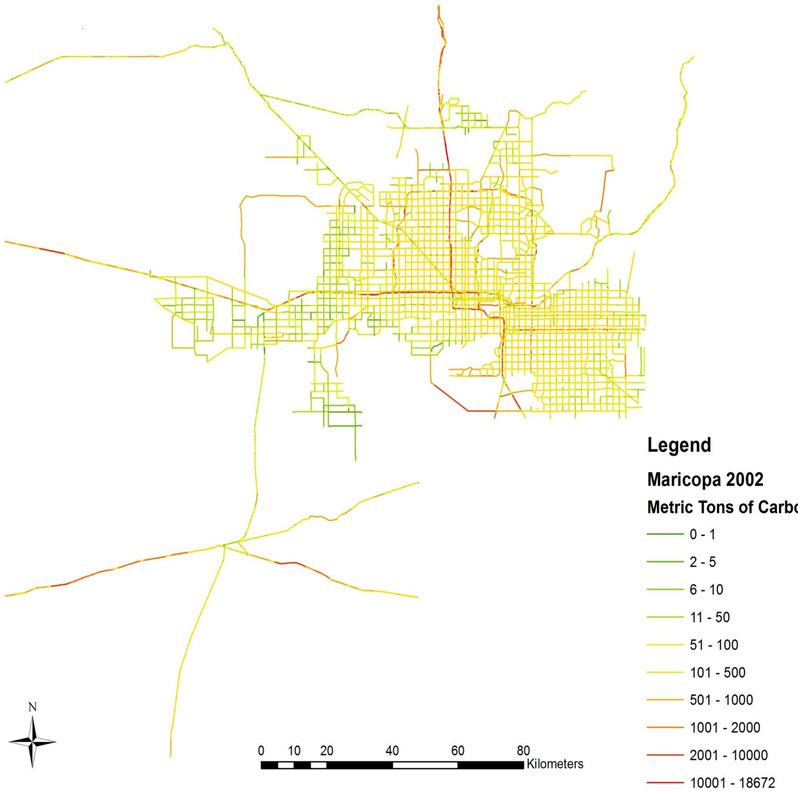
Yang Song, Kevin R Gurney

School of Life Sciences, Arizona State University, Tempe, AZ, United States.

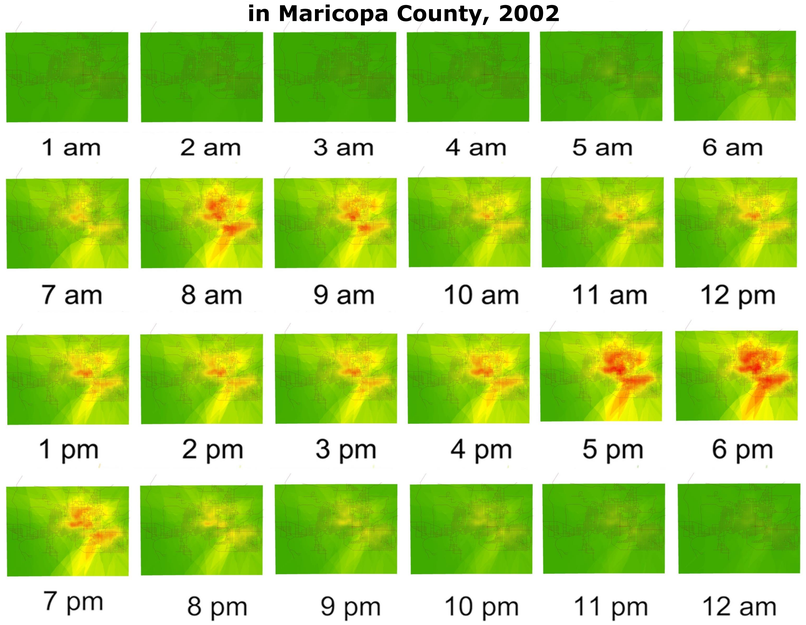
Email: ysong23@asu.edu
Phone: 480-332-6749

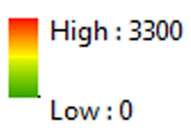
ARIZONA STATE UNIVERSITY

On-road CO_2 emissions in Maricopa County, 2002



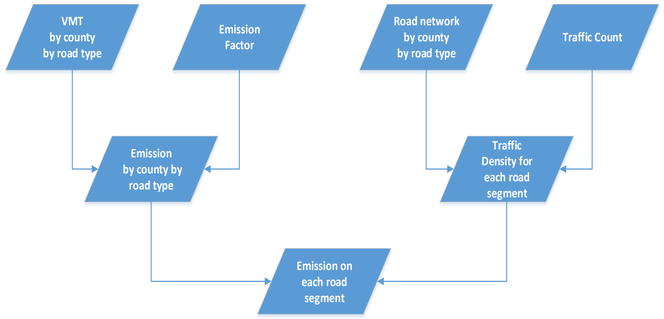
Weekday Traffic data in the 24 hour cycle in Maricopa County, 2002





INTRODUCTION

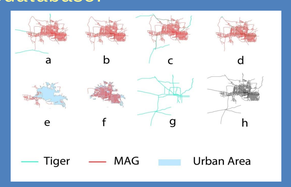
Quantification of the spatial and temporal characteristics of atmospheric CO_2 flux is a difficult yet essential component of carbon cycle research. The significance of fossil fuel carbon emissions in carbon budget/inversion studies stimulates the need for precise, complete and robust quantification of fossil fuel CO_2 emissions (Gurney, et. al., 2007). Previous research on urban greenhouse gas inventories mostly focused on trend analysis and emissions categorization instead of interactive geospatial analyses and data exploration. In order to utilize atmospheric CO_2 measurements in a complete carbon monitoring system, the emission data product must be constructed with explicit space and time details (Gurney, et. al., 2012).



METHODS

Spatial Allocation

The road atlas for Maricopa County was a combination of the local road network data provided by Maricopa Association of Governments (MAG), urban area definition by U.S. census and major roads based on Tiger geodatabase.



a) Rural primary roads (highlighted)
b) Urban primary roads (highlighted)
c) Rural secondary roads (highlighted)
d) Urban secondary roads (highlighted)
e) Rural local roads (outside blue polygon)
f) Urban local roads (inside blue polygon)
g) Primary and secondary roads from Tiger
h) Final combination of road atlas

MAG provided 2007 Annual Average Daily Traffic (AADT) data for interstates and arterials in Maricopa County. The Vehicle Miles Traveled (VMT) for each road segment was calculated by multiplying the AADT with corresponding road segment length.
The 2002 on-road emission for Maricopa County was calculated based on the National Mobile Inventory Model (NMIM), which utilizes VMT data from National County Database (NCD) and EPA emission factors. The emission was then allocated by road type and the VMT proportion on each road segment.

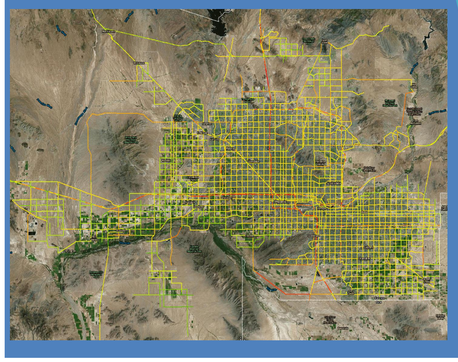
Temporal Allocation

MAG provided 15-minute interval traffic count data on the above-mentioned road segments. Each segment was collected for 24 hours. Combining with the weekly, monthly and seasonal traffic scaling factors (also provided by MAG), the temporal profile for 8760 hours of a typical year was constructed. The annual CO_2 emissions were distributed according to each hourly fraction of traffic counts. For segments that are outside the scope of MAG data, the temporal profile was constructed based on the Federal Highway Administration's (FHWA) permanent automatic traffic recorder (ATR) network data. Due to the fact that ATR stations are unevenly distributed in space, we created Thiessen polygons such that each road segment was linked to the nearest neighboring ATR station. The hourly profile for each individual station was then combined to create a "climatology" of CO_2 emissions in time on each road segment.

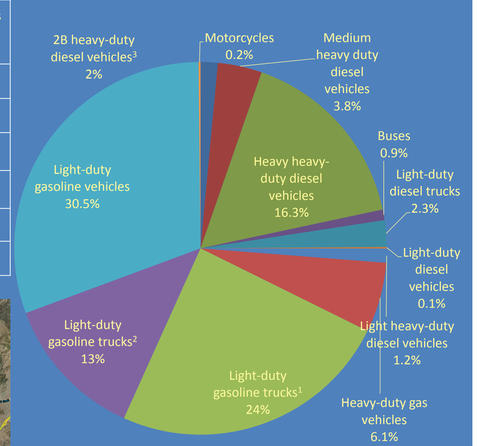
RESULTS

On-road CO_2 emissions by road type in Maricopa County, 2002

Road Type	CO_2 emissions (MtC/yr)	CO_2 emissions (%)	Length (km)	Length (%)	CO_2 emissions linear density (tC/km)
Rural Primary Roads	0.25	6.1%	138.5	7.6%	1784.1
Urban Primary Roads	2.26	56.1%	70.9	3.9%	31841.1
Rural Secondary Roads	0.16	4.1%	167.8	9.2%	979.5
Urban Secondary Roads	0.91	22.7%	166.9	9.1%	5473.5
Rural Local Roads	0.04	1.1%	242.9	13.2%	172.5
Urban Local Roads	0.40	9.9%	1047.4	57.0%	384.1



On-road CO_2 emissions by vehicle type in Maricopa County, 2002



[1] Light-Duty Gasoline Trucks 1 weigh 0-3750 lbs for loaded vehicle weight
[2] Light-Duty Gasoline Trucks 2 weigh 3751-5750 lbs for loaded vehicle weight
[3] 2B Heavy Duty Diesel Vehicles weigh 8501-10000 lbs for loaded vehicle weight

DISCUSSIONS

- Majority of on-road CO_2 emissions in Maricopa County are from interstates I-10 and I-17. State Route 51, 60 and State Highway Loop 101, 202 consist the secondary biggest emissions.
- Urban road segments inside Loop 101 and 202 generally have higher emissions compared to road segments in suburban/rural area in west Maricopa.
- The temporal distribution showed that the peak hour of CO_2 emission is from 8am to 9am in the morning and 5pm to 6pm in the afternoon, primarily focused in Phoenix, Scottsdale, Mesa and Chandler, which is consistent with 2007 MAG report on freeway congestion.
- Future study may focus on the spatial allocation of on-road CO_2 emission by vehicle types, which may provide decision and modeling support for mitigation policies related to fuel price change.

REFERENCES

Gurney, K.R, et. al., (2007), Research needs for process-driven, finely resolved fossil fuel carbon dioxide emissions, *EOS Trans. Amer. Geophys. Union*, 88(49),542-543.

Gurney, K.R., Razlivanov, I., Song, Y. Zhou, Y., Benes, B., Abdul-Massih, M. (2012) Quantification of fossil fuel CO_2 at the building/street scale for a large US city, *Environmental Science and Technology*, 46 (21), pp 12194– 12202

Maricopa Association of Governments, 2007 Freeway Bottleneck Map in MAG Region

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation under grant number BCS-1026865, Central Arizona-Phoenix Long-Term Ecological Research (CAP LTER).