

Vulcan: national high resolution quantification of fossil fuel CO₂ emissions

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EPA EI meeting, Aug 2012

Multiple datastreams transformed to CO₂

<i>Data Source</i>	<i>National Emissions Inventory (NEI)</i>				<i>ETS/CEM</i>	<i>NMIM NCD</i>	<i>Aero2k</i>	<i>Portland Cement</i>
Data Type	Non-road	Non-point	Point	Airport	Power Prod.	On road	Aircraft	Cement Prod
Measurement utilized	Activity/ population	CO	CO	CO	CO ₂	VMT/ population	CO ₂	Production
Incoming resolution: space/time	County/ Monthly	County/ Annual	Lat:Lon/ Annual	Lat:Lon/ Ann:Summer	Lat:Lon/ Hourly	County/ Monthly	1°x1°/ Monthly	
Conditioning data		Census, EIA sales (sector/state/ fuel/month), NARR T	EIA sales (sector/state/ fuel/month), NARR T			GIS Road Atlas/ Mobile 6.2		
Final resolution: space/time	County/ Monthly	Census tract/ Monthly	Lat:Lon/ Monthly	Lat:Lon/ Annual	Lat:Lon/ Hourly	Road Segment/ Hourly	1°x1°/ Monthly	Lat:Lon/ Annual
Sector	Transport	Comm. Res. Ind. Elec. Prod.	Comm. Res. Ind. Elec. Prod.	Transport	Elec. Prod.	Transport	Transport	Cement



CO₂ Emissions

Some QA/QC to EPA data. We reverse engineer for fuel
It is a **mix of data (observational) and model** - a "data product"

Estimation process

3 fundamental processes

1. CO₂ direct (95% of electricity production emit)
simple!
2. CO to fuel to CO₂ (Res, Comm, Ind, airport)

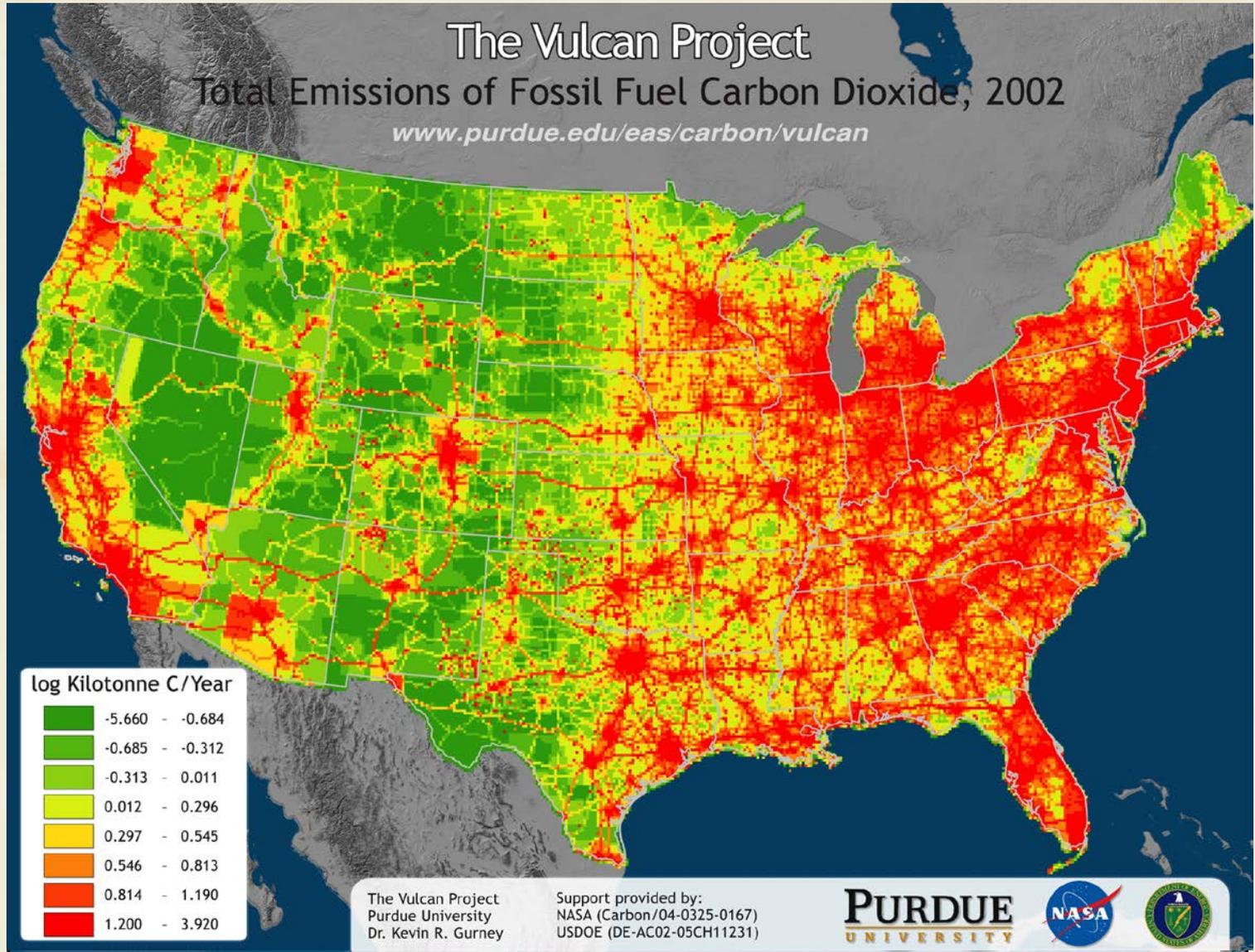
$$E_{n,f}^{CO_2} = \frac{E_{n,f}^g}{EF_{n,f}^g} HC_f \times EF_{n,f}^{CO_2} \times Ox\% \quad (g \text{ is CO, } f \text{ is fuel, } n \text{ is process})$$

3. VMT/fuel efficiency to CO₂ (onroad, nonroad)

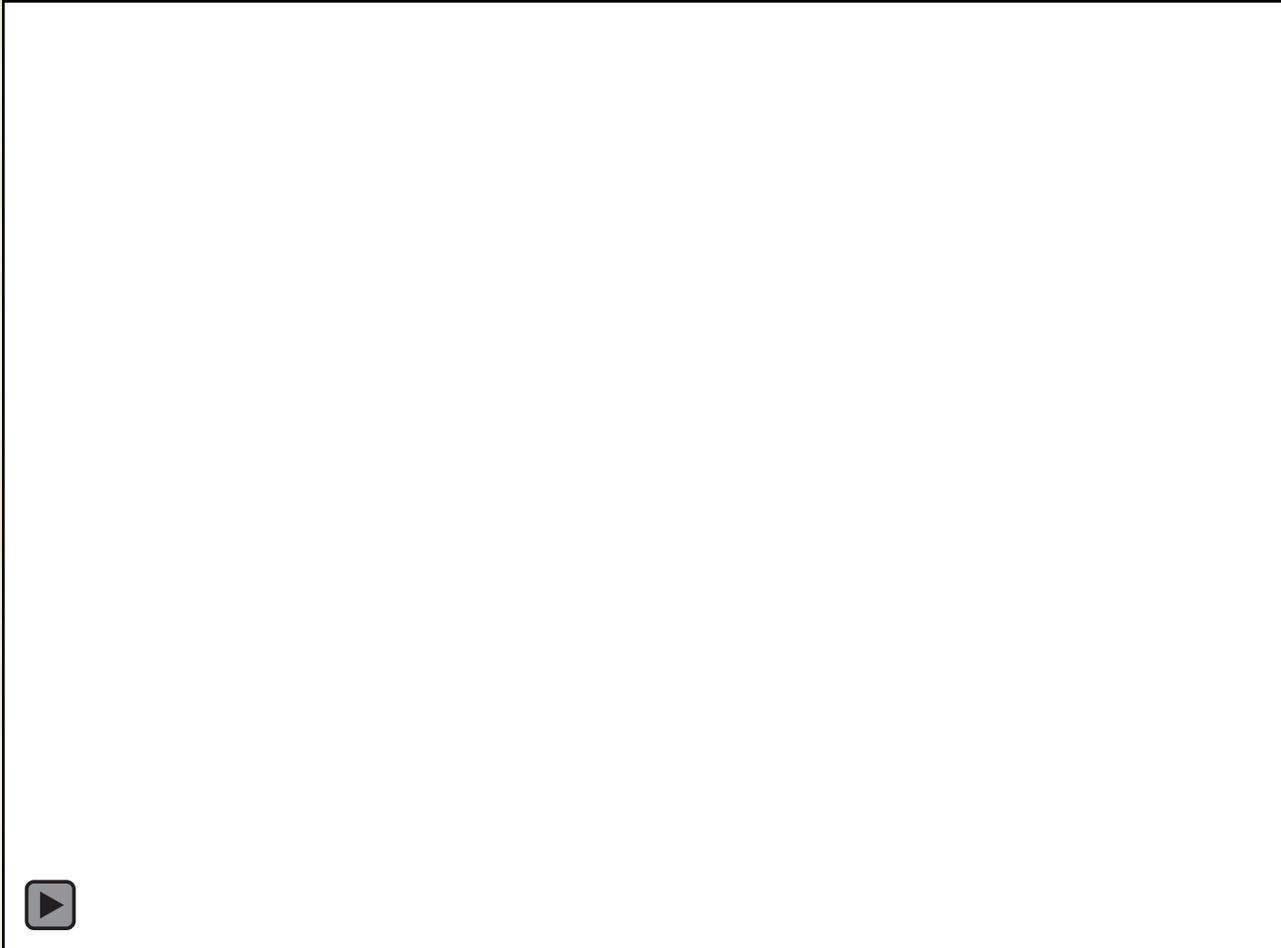
$$C_C^{V,X} = VMT_C^{V,X} \times CF^V$$
$$CF^V = \left(\frac{C}{\sum_{Y=1}^N \pi_Y^V \times Eff_Y^V} \right) \times Ox\%$$

Vulcan

Version 2.2 now available



Transport



Implications for inverse problem.....

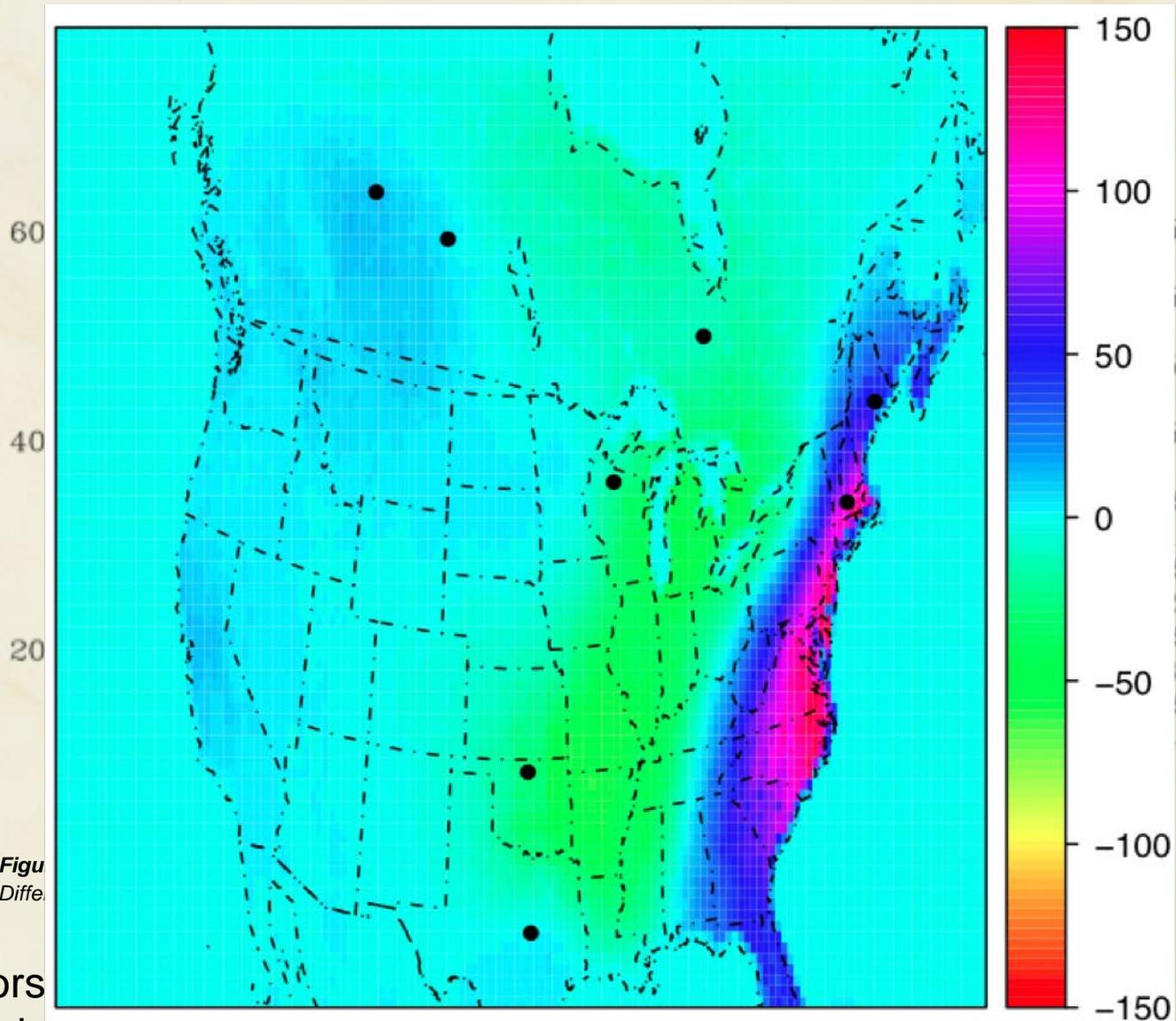


Figure
Differences

“Errors
biosphere exchange”

Gurney et al., *Env. Sci & Tech.* 2009
Corbin, et al., *GRL*, 2010
Schuh et al., *Biogeosci. Disc.*, 2010

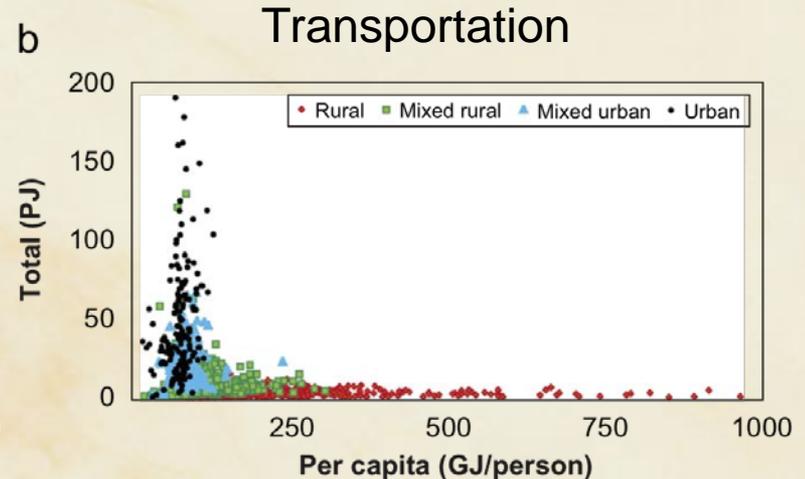
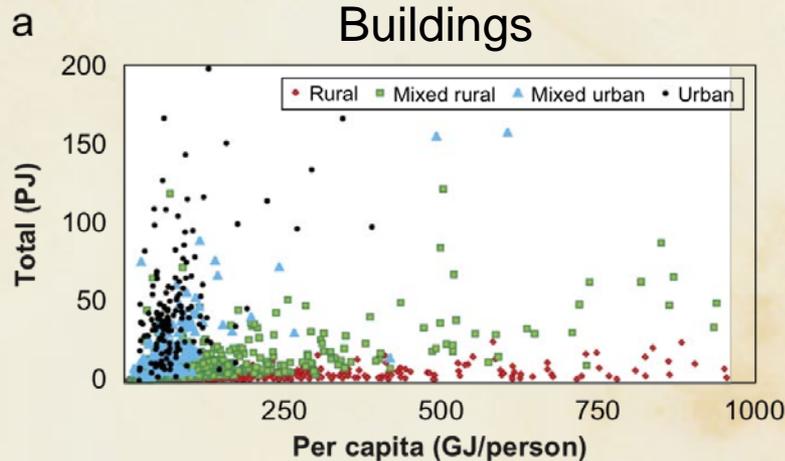
..... in socioeconomics

“This paper uses several geographical data sets to document that *conservative, poor areas have higher per-capita carbon emissions* than liberal, wealthier areas.

....Representatives from such areas are shown to have much lower probabilities of voting in favor of greenhouse gas emissions reduction legislation”

Cragg, Gurney, Zhou & Kahn, *Journal of Economic Inquiry*, accepted

..... in energy analysis



Parshall, Gurney, Hammer et al. *Energy Policy*, 2009

National-level

2002 Vulcan / DOE comparison (MtC/year)

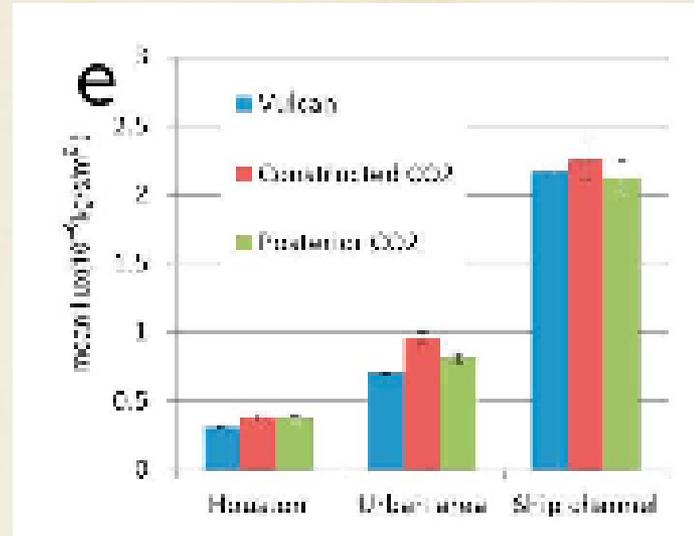
<i>Sector</i>	<i>DOE/EIA</i>	<i>Vulcan</i>	<i>% diff</i>
<i>Commercial</i>	62.4	66.5	6.3
<i>Industrial</i>	282.1	285.8	1.3
<i>Residential</i>	100.6	101.8	1.2
<i>Mobile</i>	532.9	551.4	3.4
<i>Electric</i>	615.7	618.9	0.5
<i>Total</i>	1593.8	1624.3	1.9
<i>uncertainty</i>	3-5%	-11.7/+9.4%	

DOE/EIA -- "Emissions of Greenhouse Gases in the United States" [2009].

- Data sources are ~60% independent
- Fugitive and bunker represent ~3%
- Vulcan greater than DOE/EIA in onroad primarily

First atmospheric evaluations

Brioude et al. regional inversion: "excellent" match to Vulcan

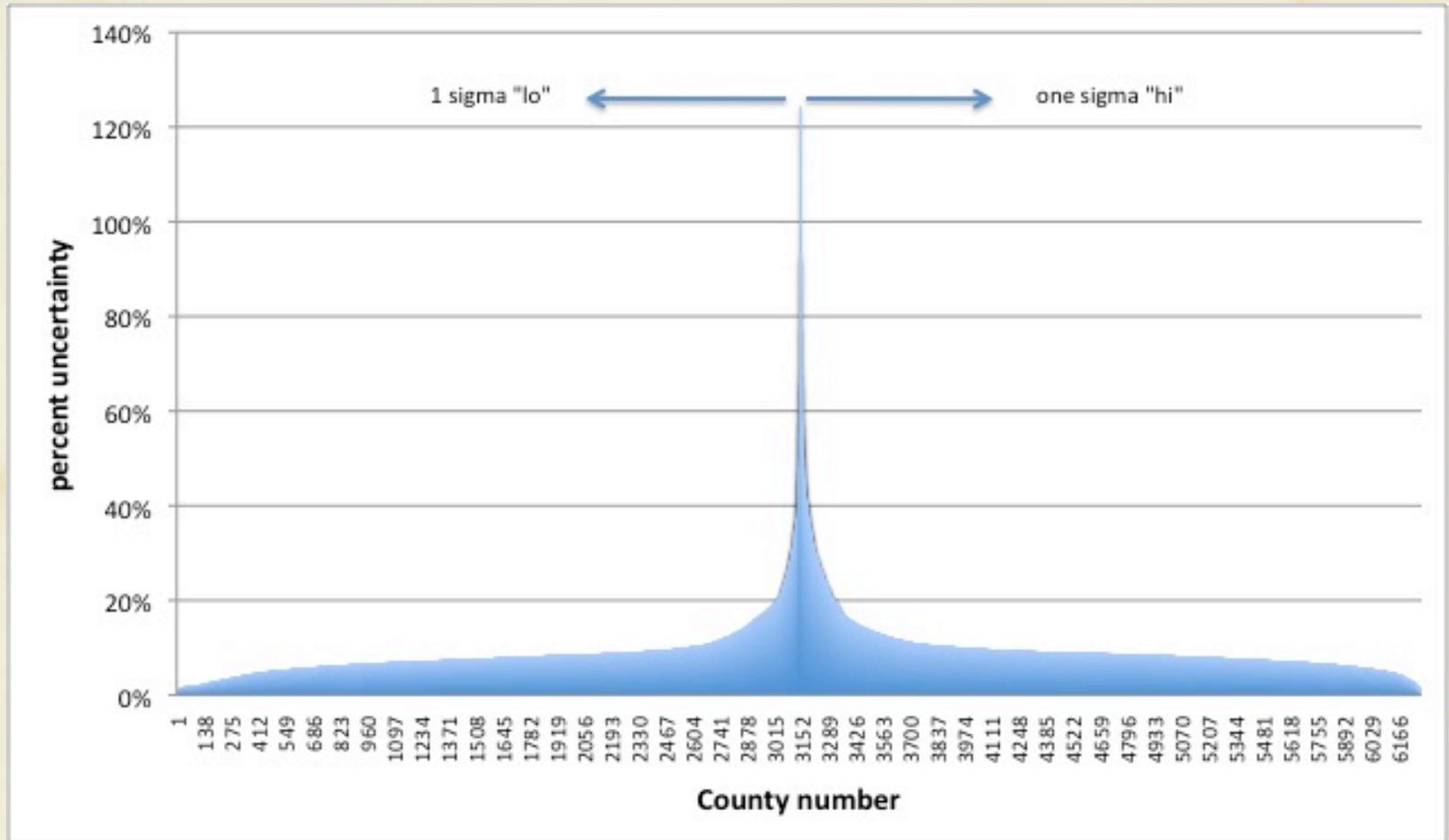


Sacramento 2009: Calculated CO₂ff flux

Transect	Calculated flux (MtC/yr)
6	3.4
7	3.2
8	3.1
9	3.0
Vulcan inventory	3.0

Simple, preliminary

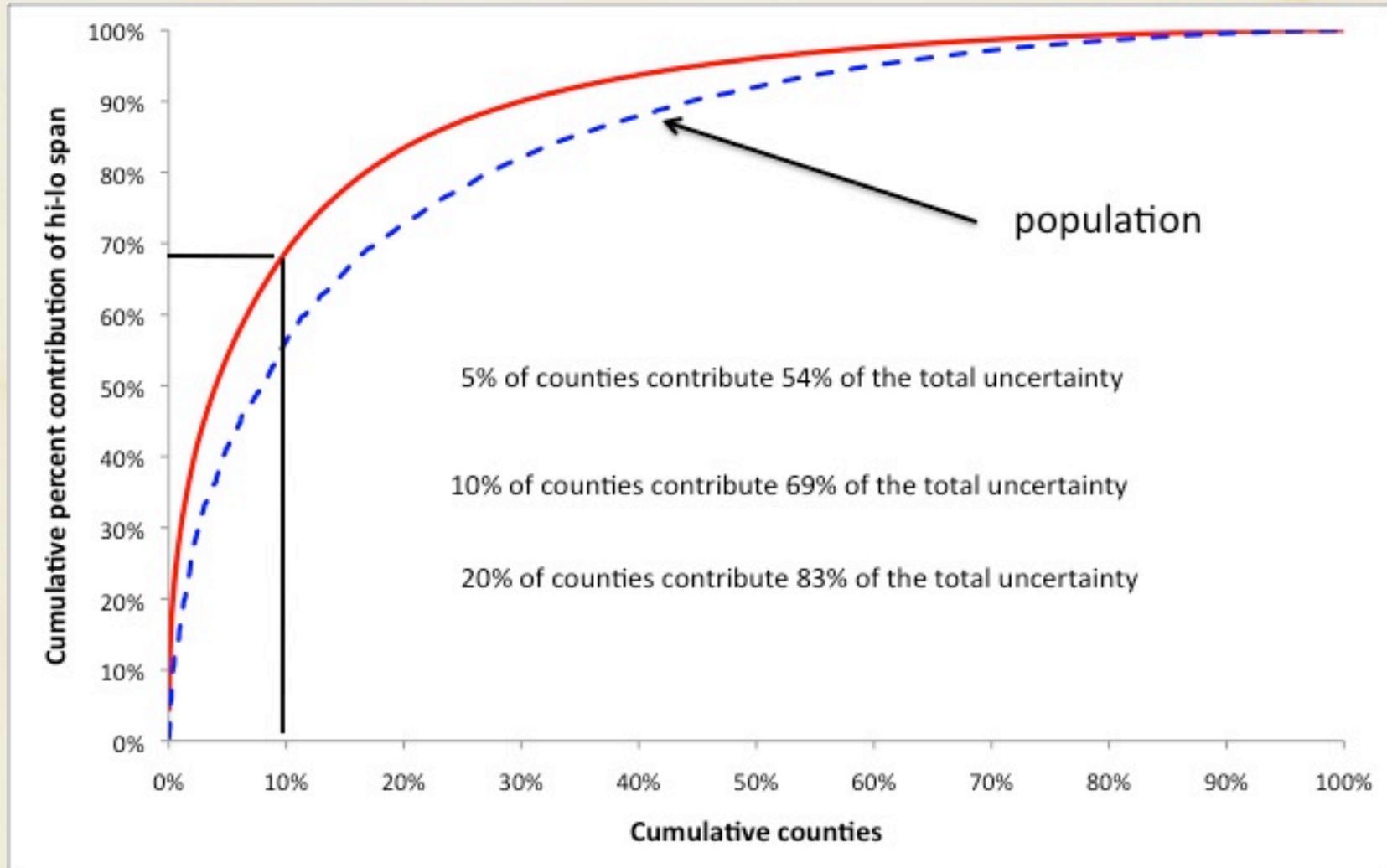
Uncertainty at county/annual level



Expected lognormal distribution.

No correlated structure (in space or time)... yet.

Cumulative weighted uncertainty



Context for this level of uncertainty

10% uncertainty is ~160 MtC/year (0.16 GtC/yr)



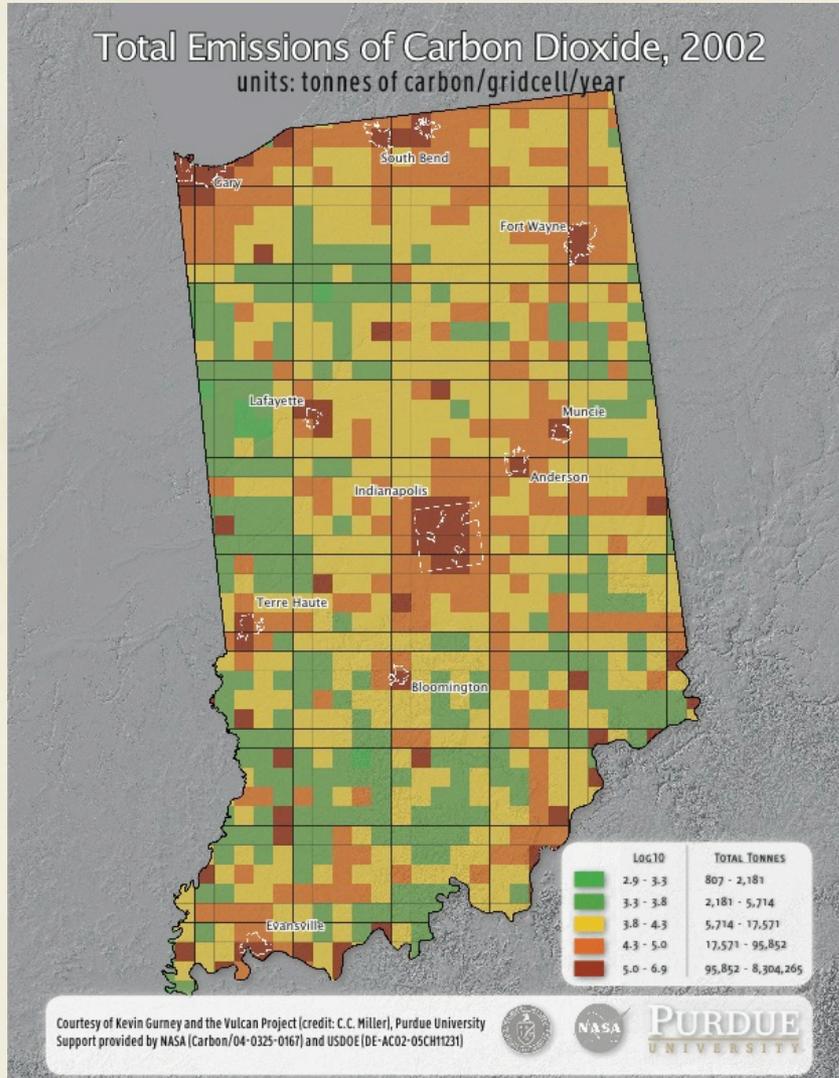
1.8 X proposed 7% Kyoto target for the US

1.5 X 2007 Australia fossil fuel CO₂ emissions

~ **entire** bottom-up estimated US forest sink

~ **entire** 2007 UK fossil fuel CO₂ emissions

One person's high-res is another's low-res



Vulcan is the wrong data product for point measurements or urban scale comparisons.....

All information is spread into a 10 km grid cell.

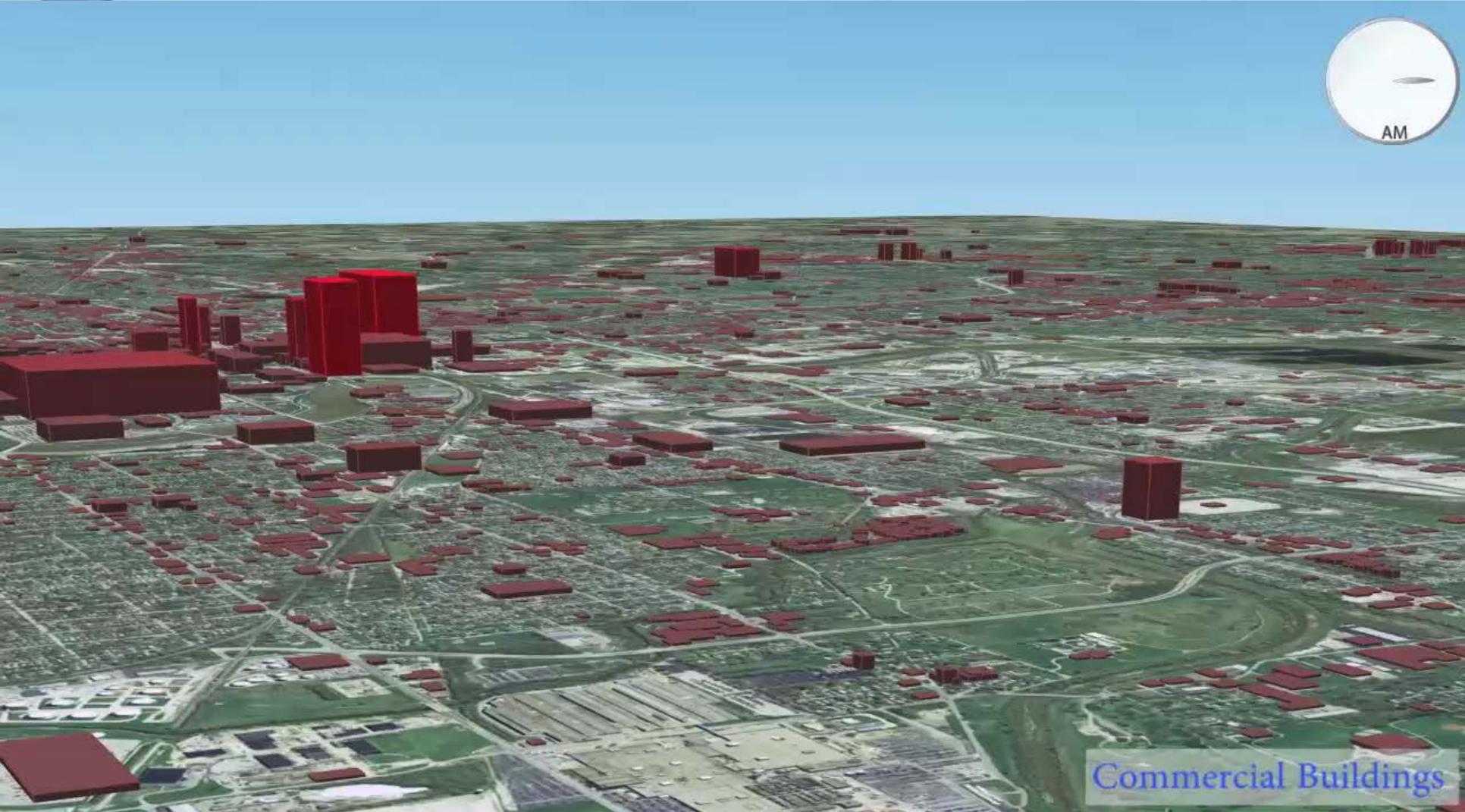
Hestia

Greek goddess of the hearth fire



www.hestia.project.asu.edu

Indianapolis movie



Commercial Buildings



Conclusions

- Vulcan - an emissions data product for the US
- Now at urban landscape scale for 2 cities (3- **Phoenix** by end of summer)
- Preliminary comp. to atmos obs. **looks promising**
- Sub-state comparison: **ONGOING** (*utility & atmos obs*)
- Aiming at *verification (CMS) AND mitigation*

Near-term advances

- **Multiyear Vulcan** (1999 to 2008)
- Vulcan nonpoint now at [census block level](#)
- Online dynamic **access to data** (shapefiles, native, gridded)
- Expanding to **Canada and Mexico**
- **Global Vulcan** (FFDAS with nightlights, roads, powerplants, population, etc - calibrated to Vulcan)

Seasonal CO₂ Emissions

Thank You!

Thanks to Bedrich Benes & Michel Abdul-Massih

Hestia Overview - BUILDING/ROAD SEGMENT ESTIMATION

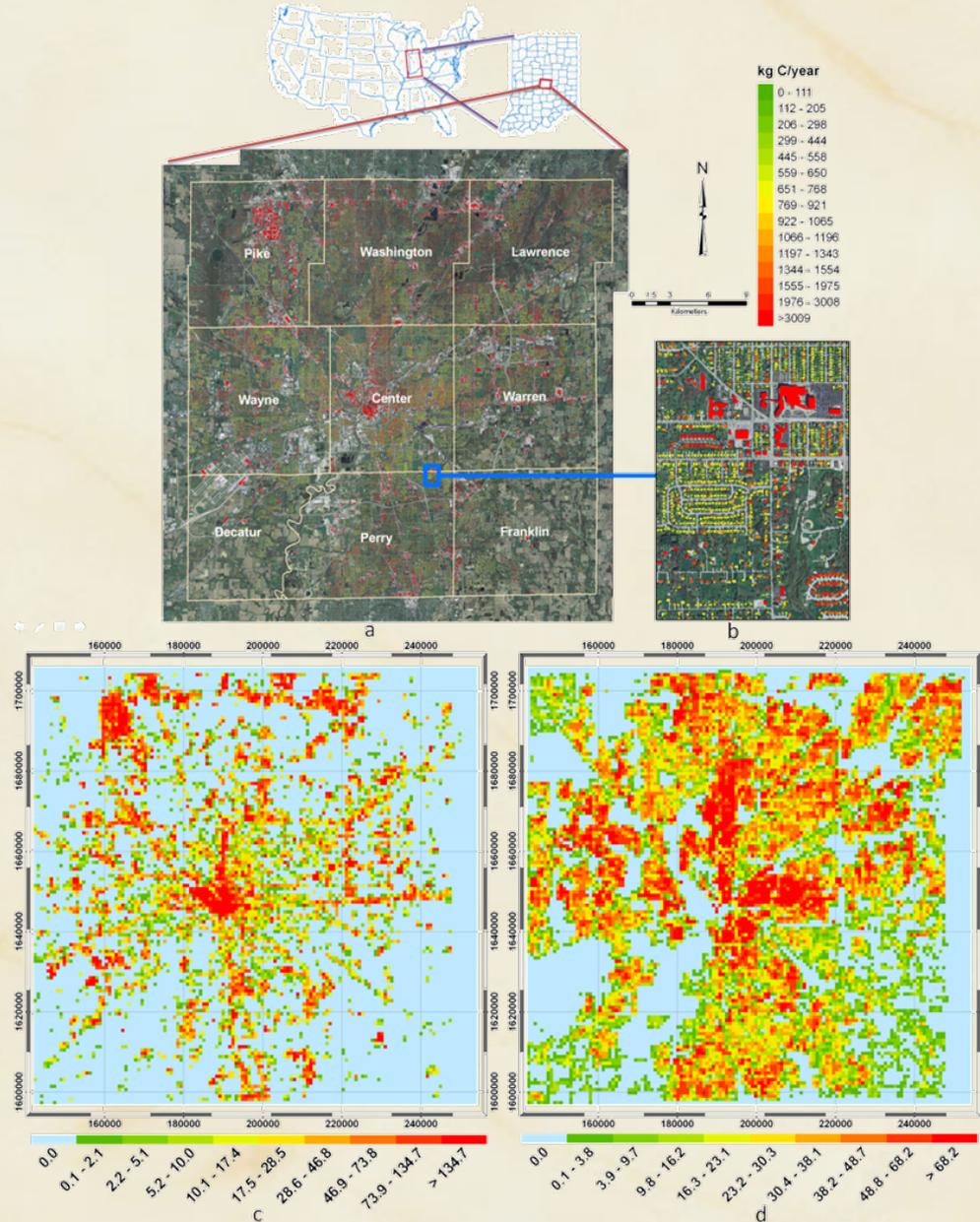
All **point** sources:
Vulcan

All **nonpoint**
buildings: thermo
"skin" model

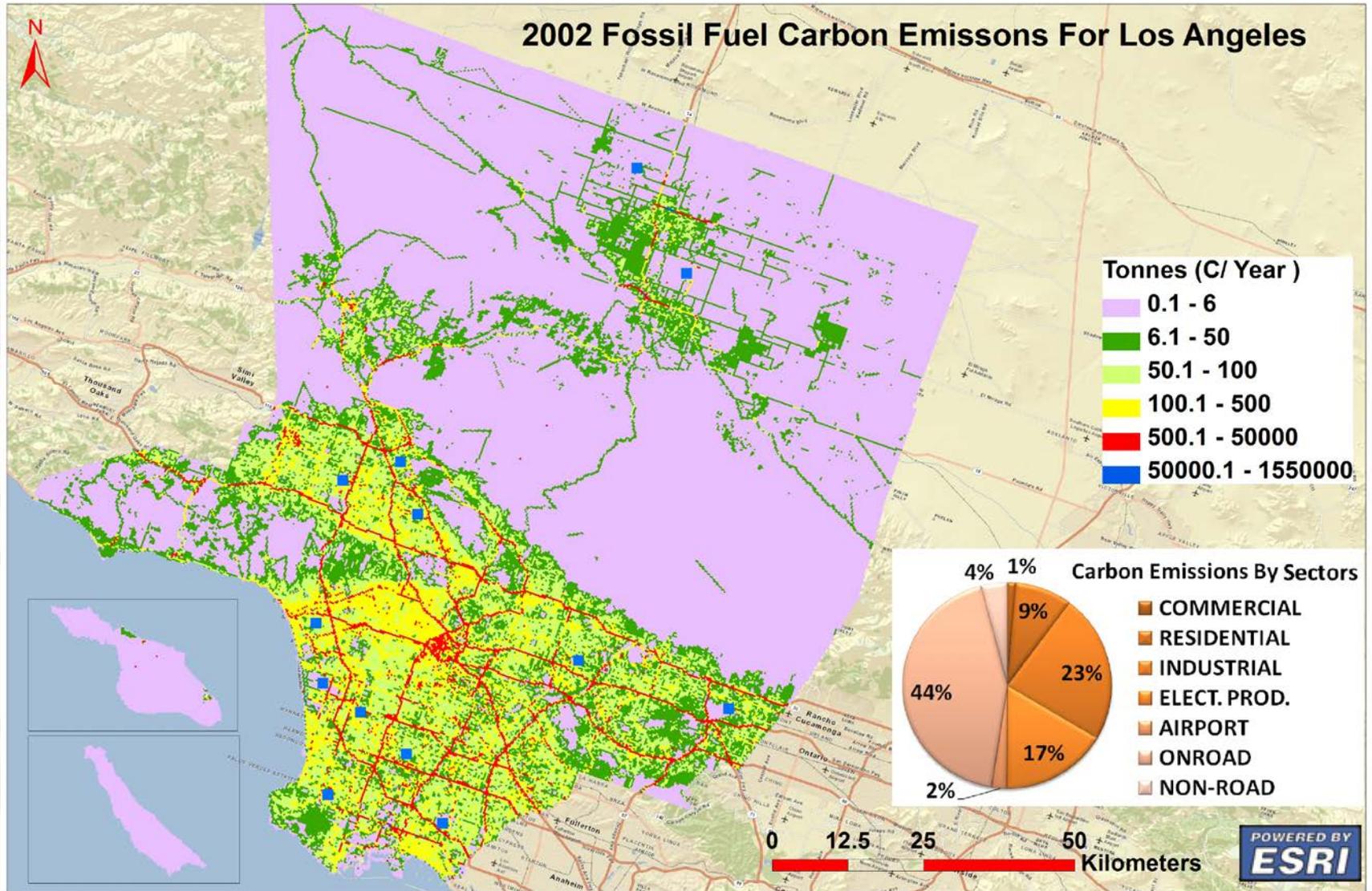
Transport:
Vulcan with local
MPO traffic and
fleet

Aircraft, nonroad:
Vulcan

Cement:
Vulcan

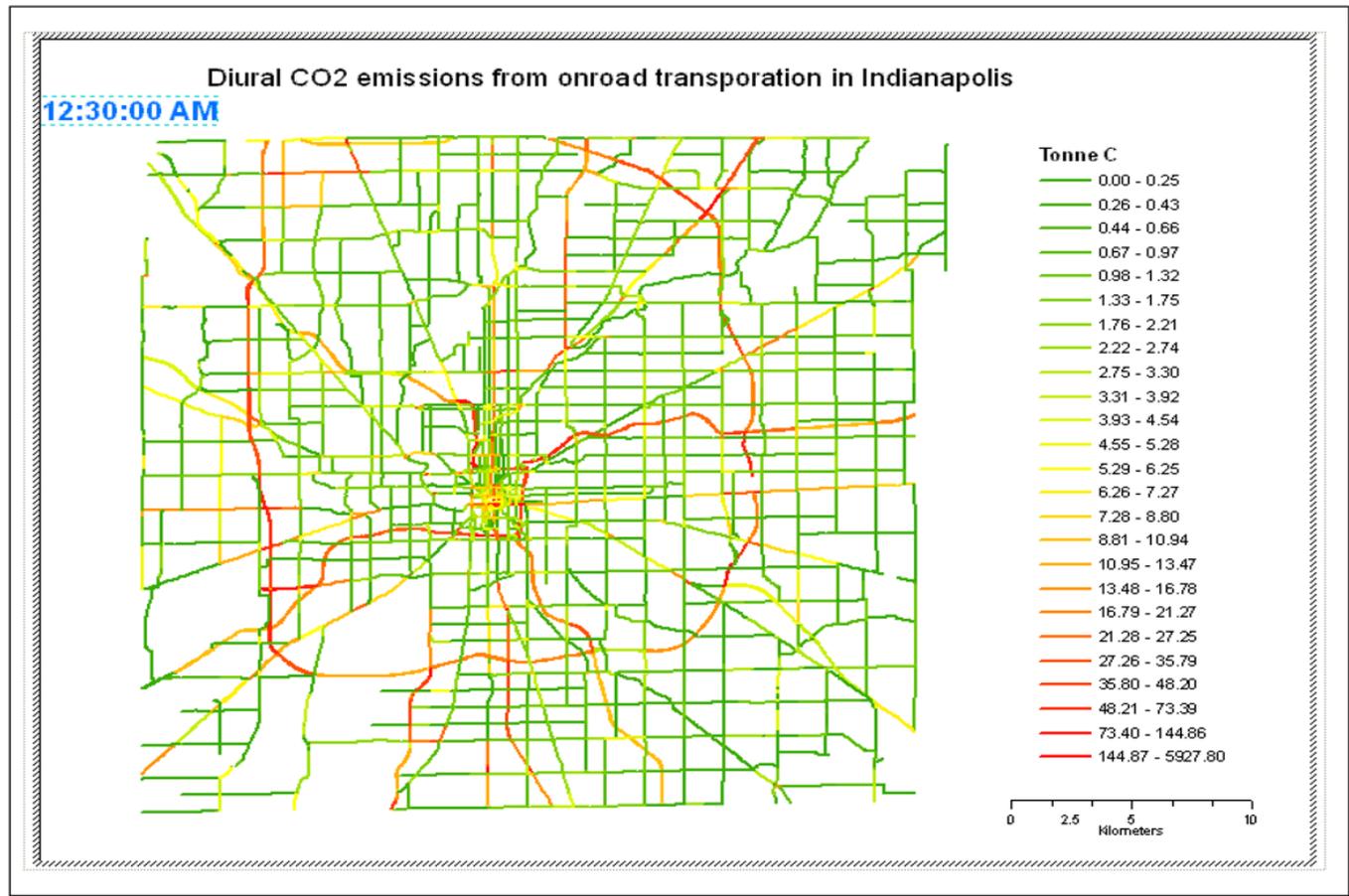


LA county

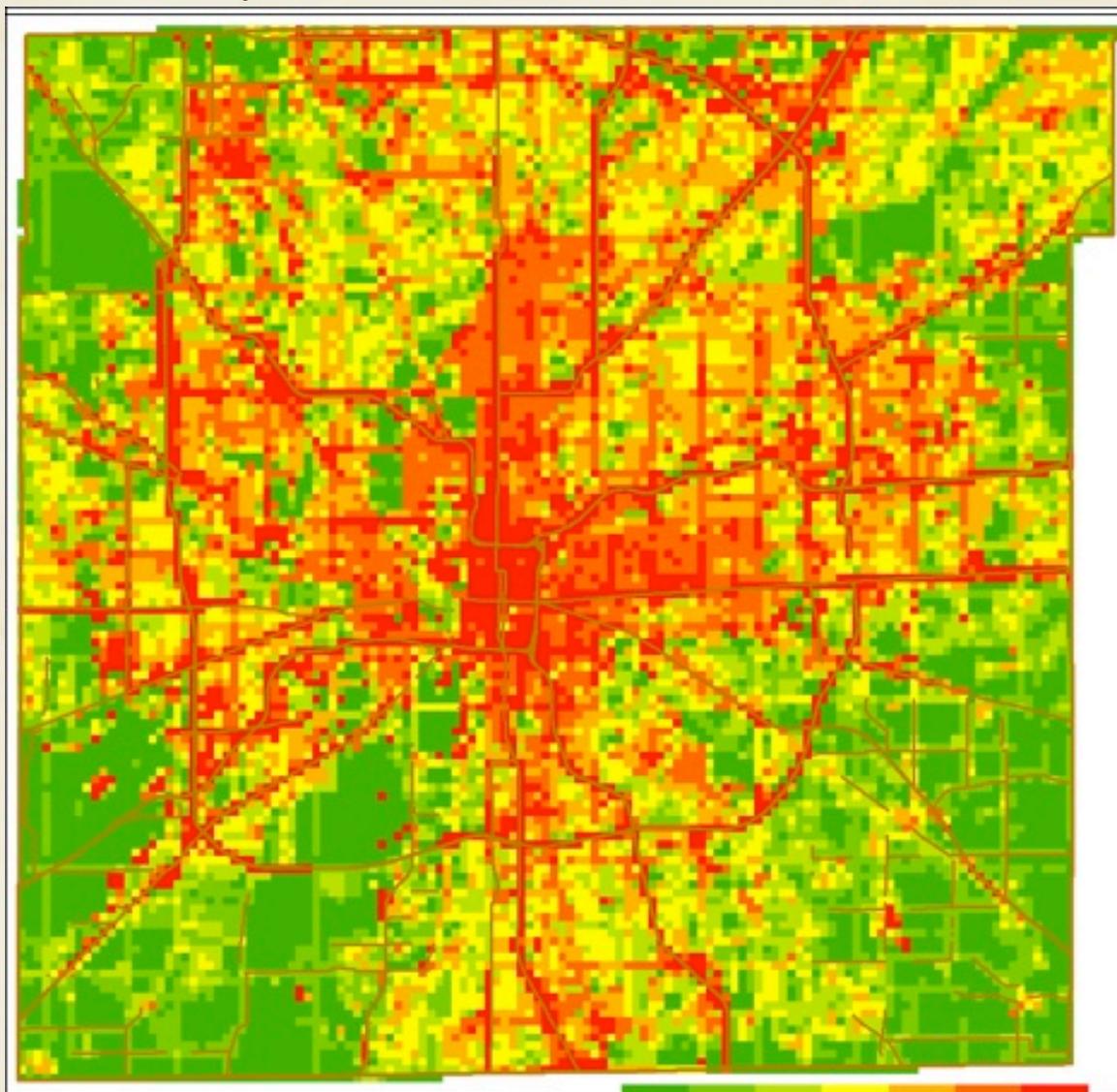


Onroad

- County-level VMT, fleet age/type, fuel eff. & Mobile6.2
- Distribute in space/time with AADT (10,000) & ATR data (20)



Indianapolis results

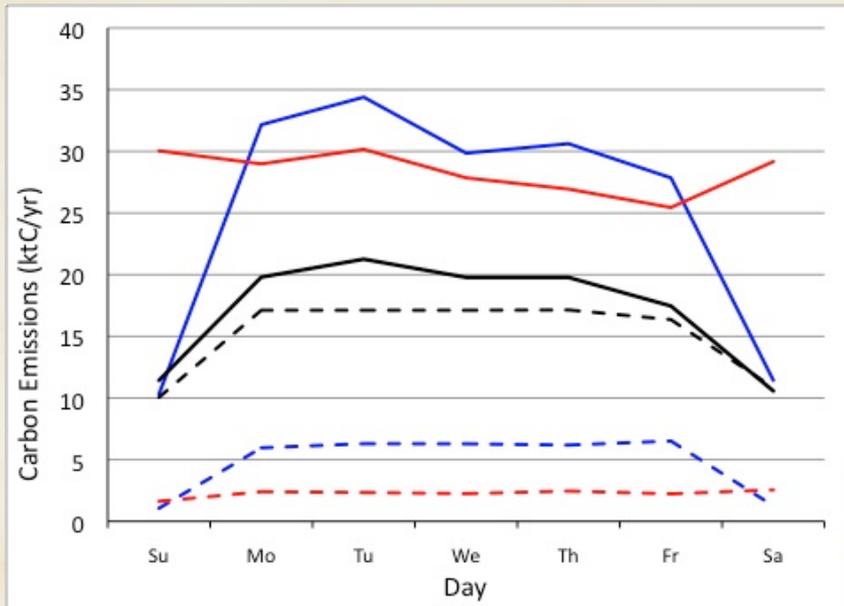


Commercial
Residential
Industrial
Elec & Air
Onroad
Total

0 10,000 20,000 40,000 Feet

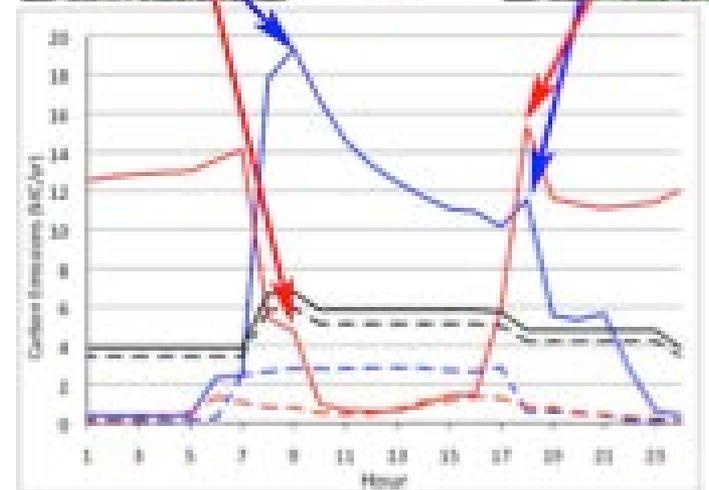
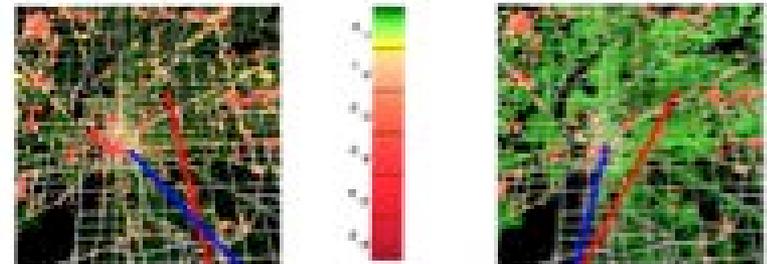
4.9 5.0 5.1-3.9 6.2 4.0-4.3 6.3 4.4-4.6 7.1 4.7-4.8 7.3 4.9-5.0 5.1-5.3 5.7 5.4-9.0 6.6

Hestia Residential, Commercial, Industrial

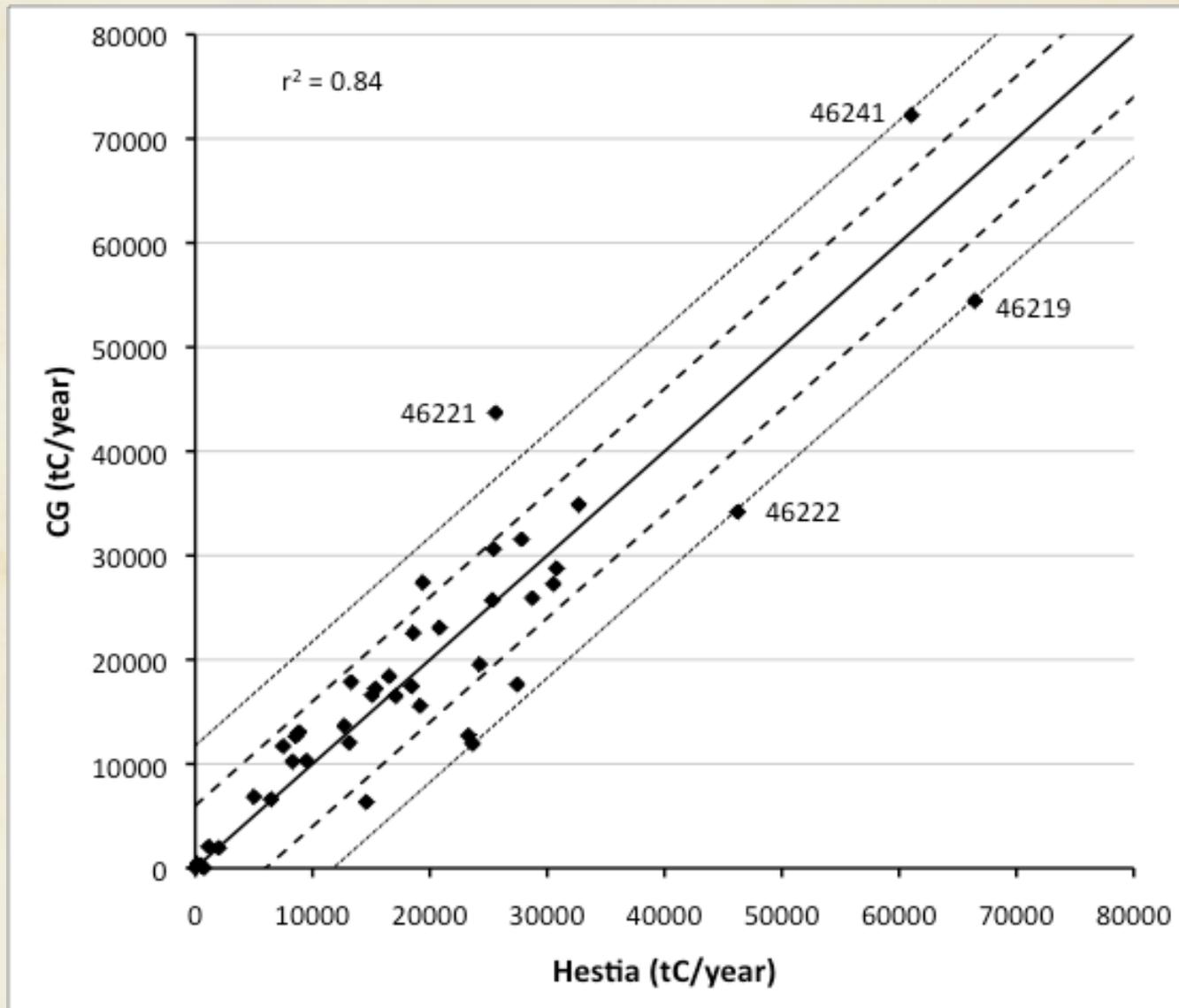


Building schedules based on Tset, surface temp, DOE building survey data

commercial
residential
industrial



Comparison to utility data (NG)



2002 v 2009, so imperfect comparison.....and other suppliers exist!

Uncertainty at county/annual level

