Quantification of fossil fuel CO2 emissions at the building/street scale for a large US city

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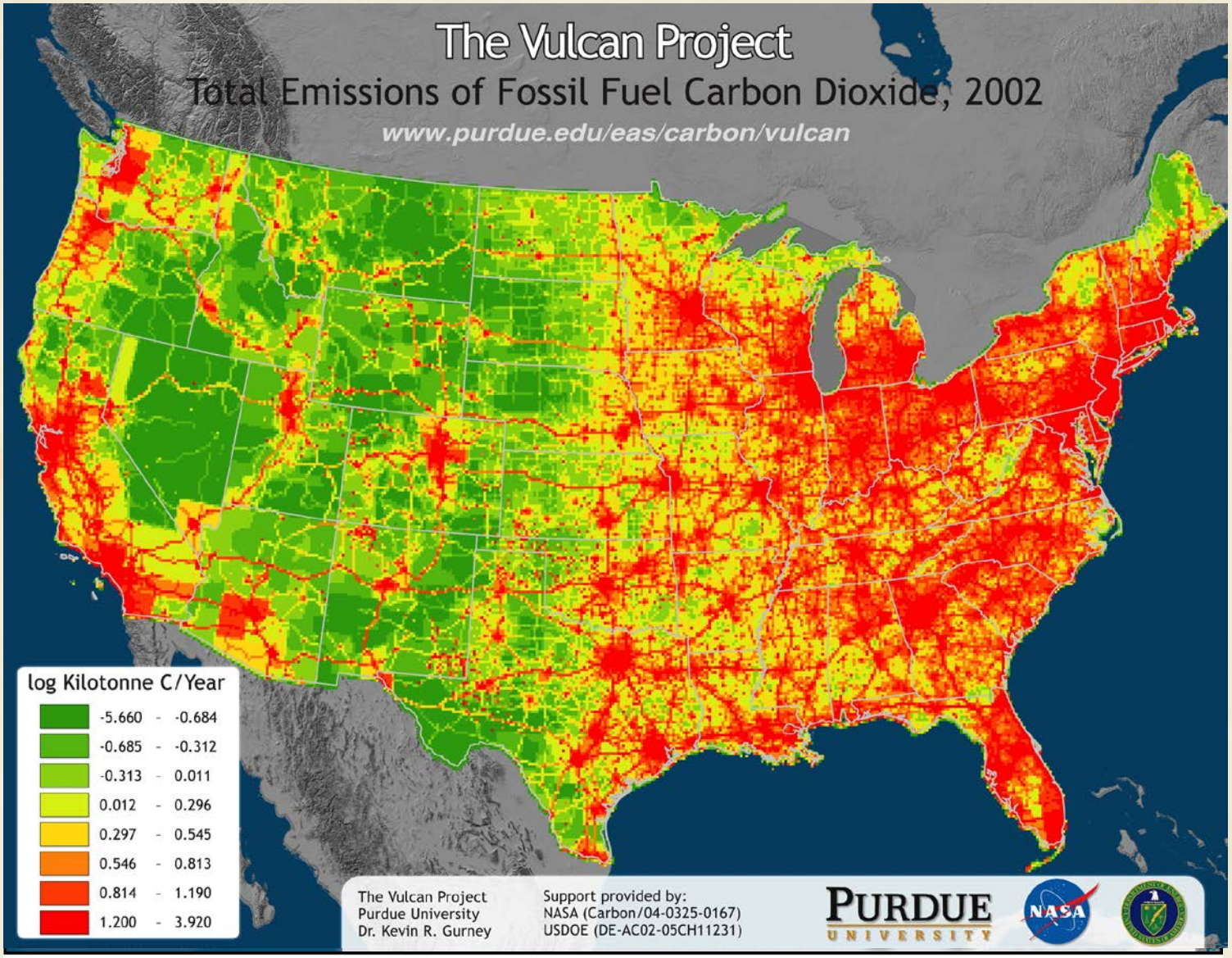
AnnMarie Eldering (for Kevin Gurney)
JPL, etc

Support from: NIST, JPL/CalTech, Knauf insulation, Showalter Trust

EPA EI meeting, 2012

Vulcan

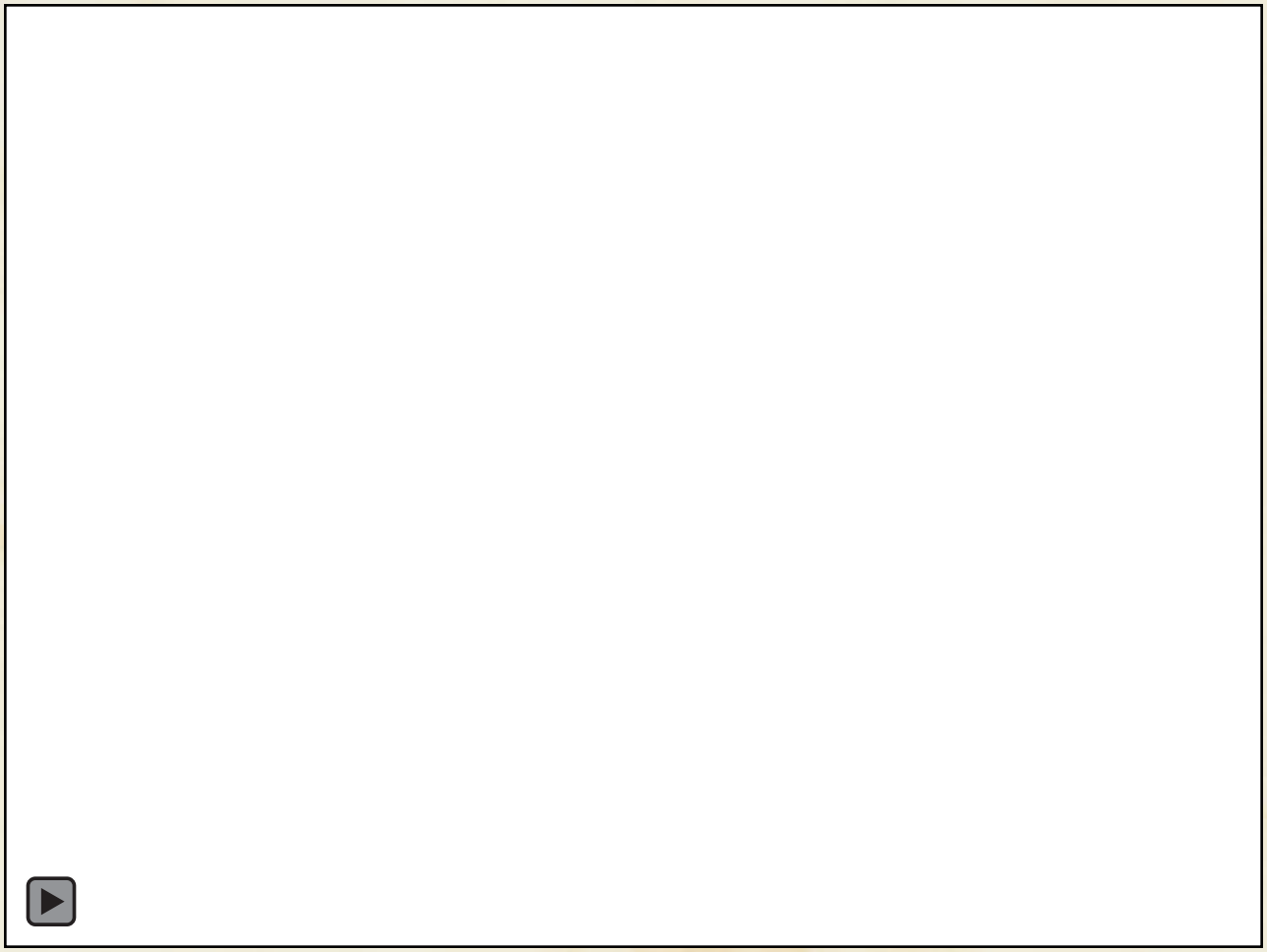
Version 2.2 now available



www.vulcan.project.asu.edu

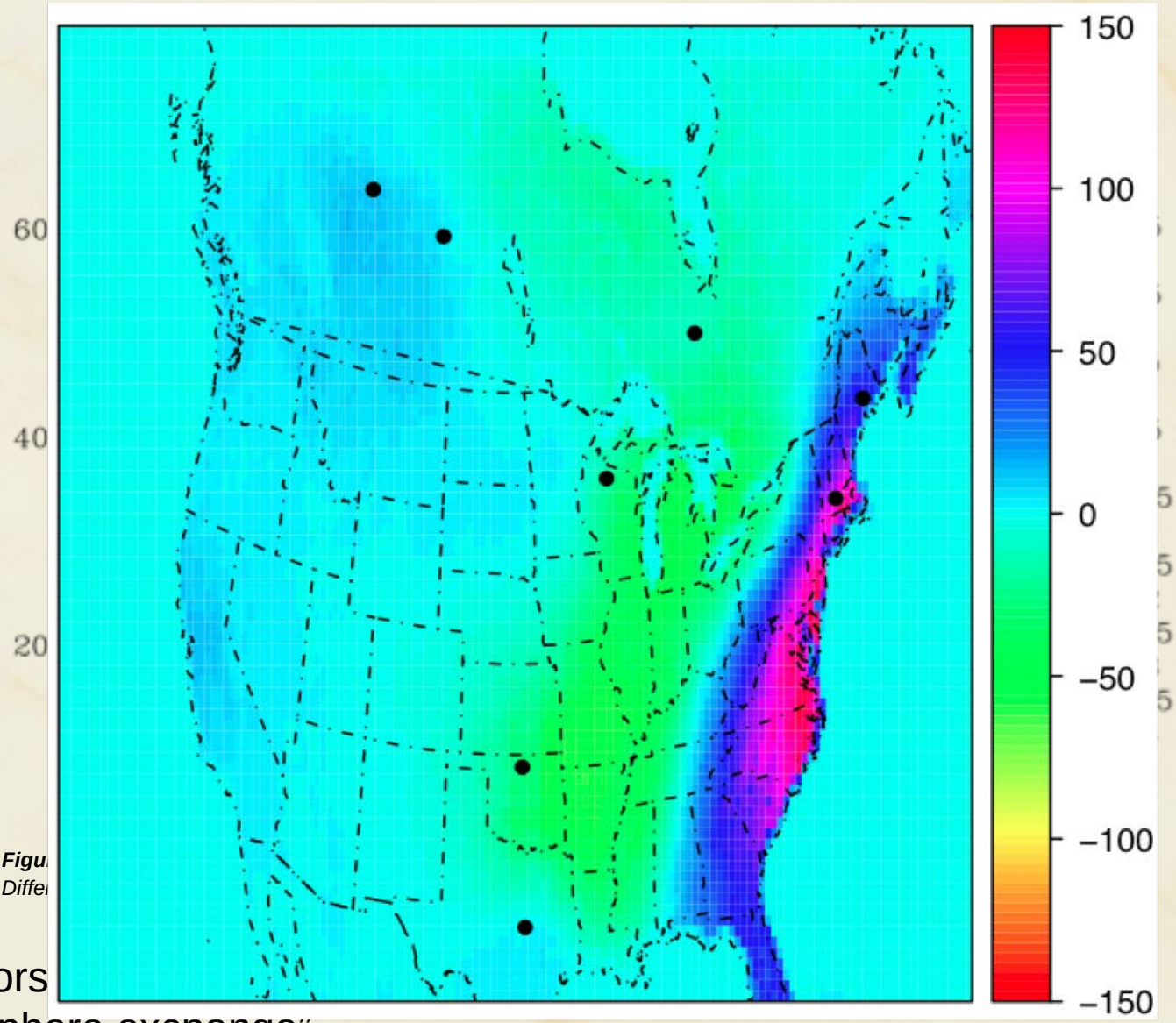
Gurney et al., *Env. Sci & Tech*, 2009

Transport



Andrysco, Gurney, Benes & Corbin, *Comp Graph & App*, 2008 (sim from RAMS)

Implications for inverse problem…..



Figu
Diffe

"Errors
biosphere excnange"

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

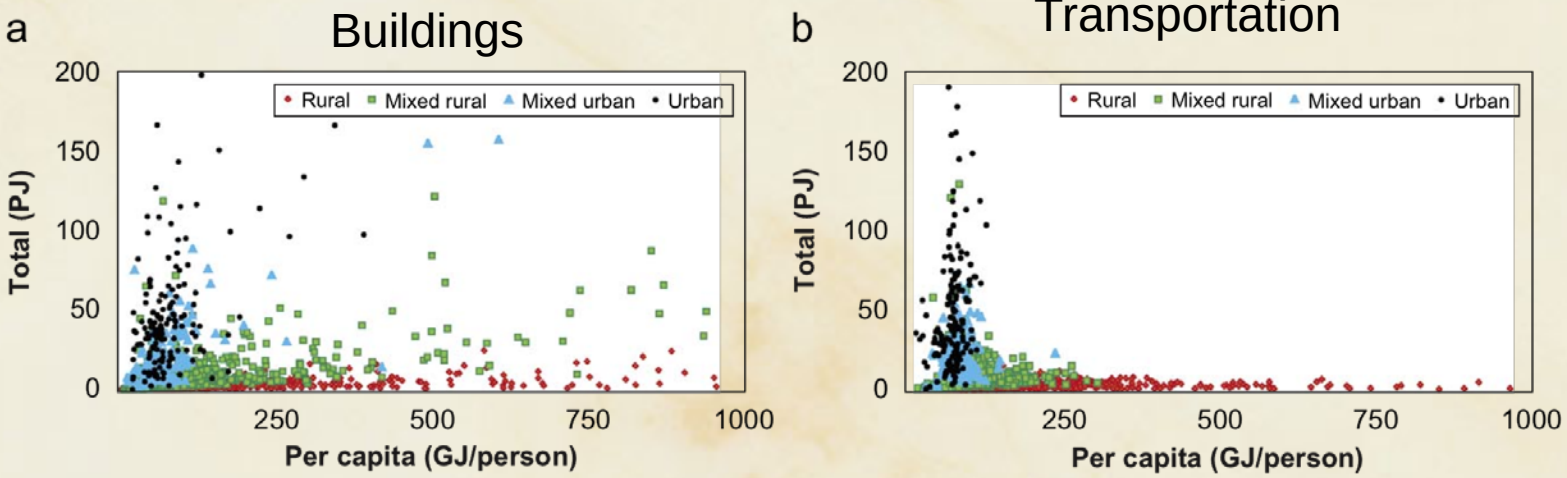
….. in socioeconomics

"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"

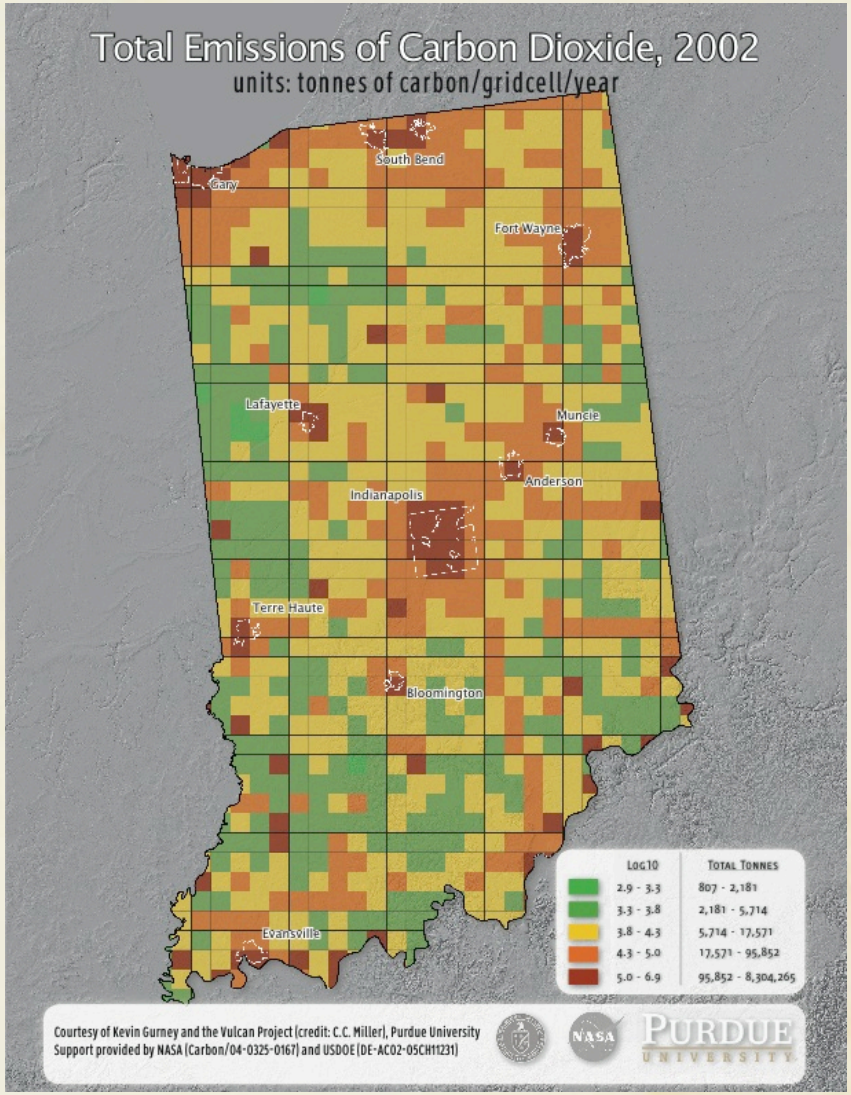
Cragg, Gurney, Zhou & Kahn, *Journal of Economic Inquiry*, accepted

….. in energy analysis



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

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

Hestia Overview – BUILDING/ROAD SEGMENT ESTIMATION

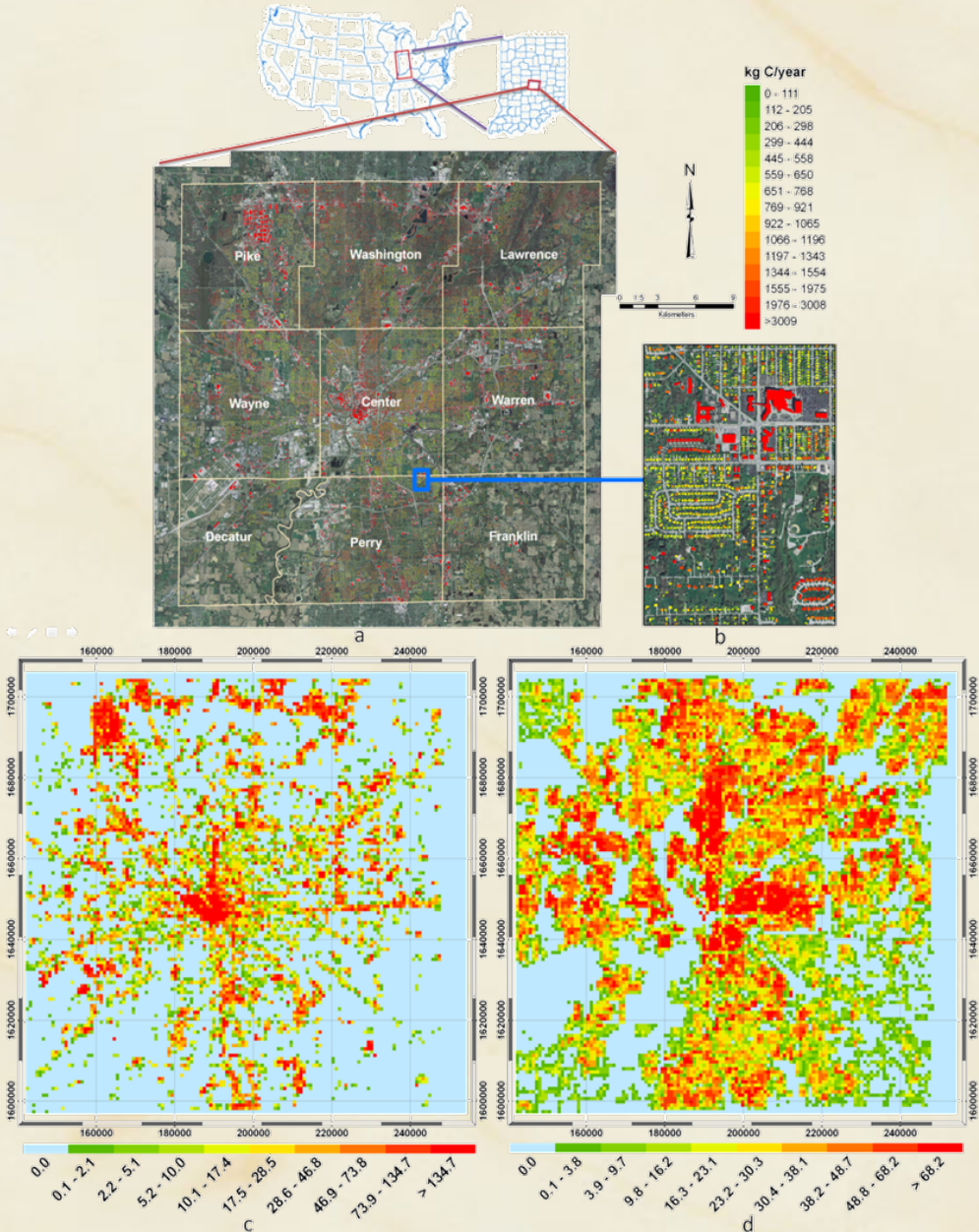
All point sources:
Vulcan

All nonpoint buildings: thermo "skin" model

Transport:
Vulcan with local MPO traffic and fleet

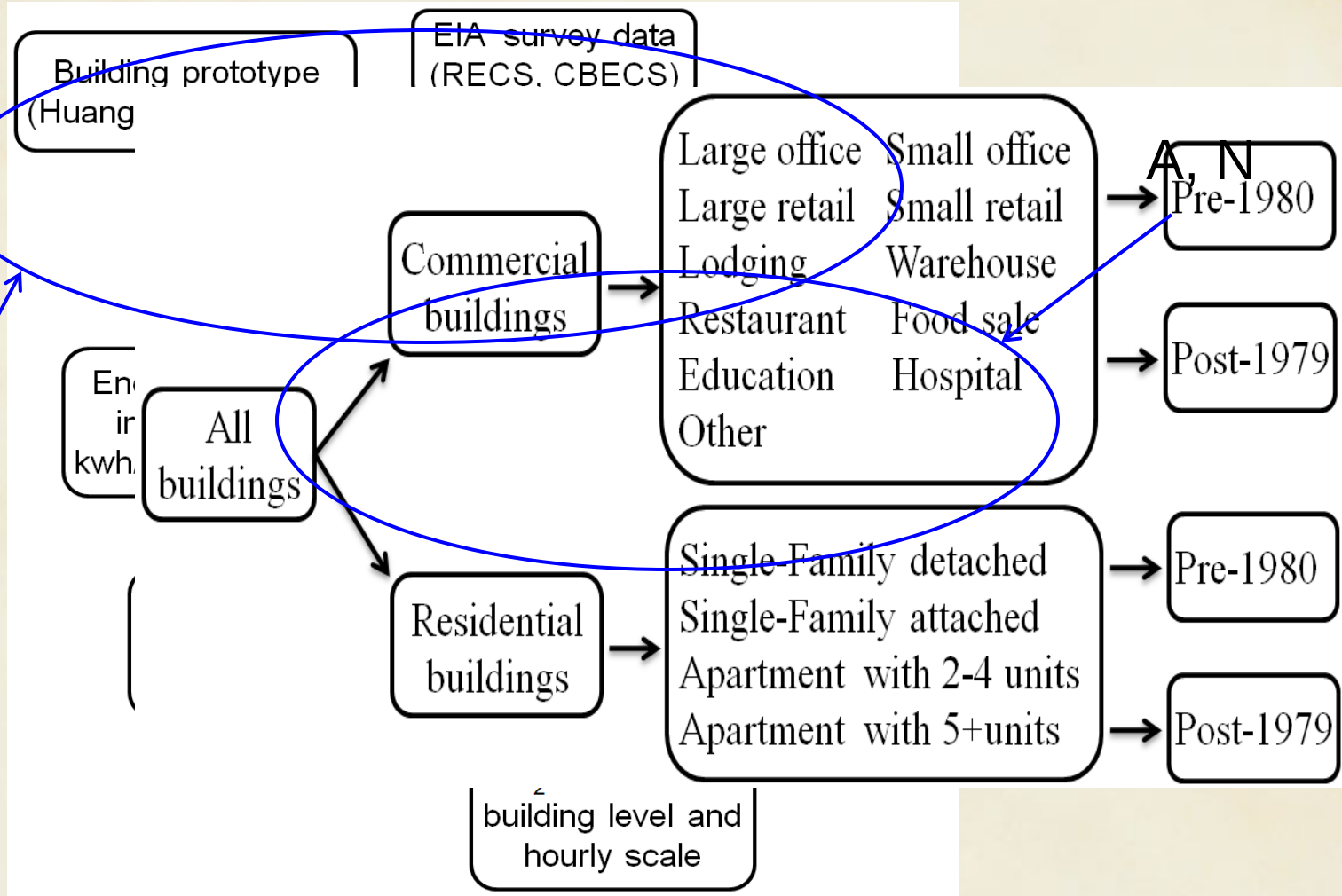
Aircraft, nonroad:
Vulcan

Cement:
Vulcan



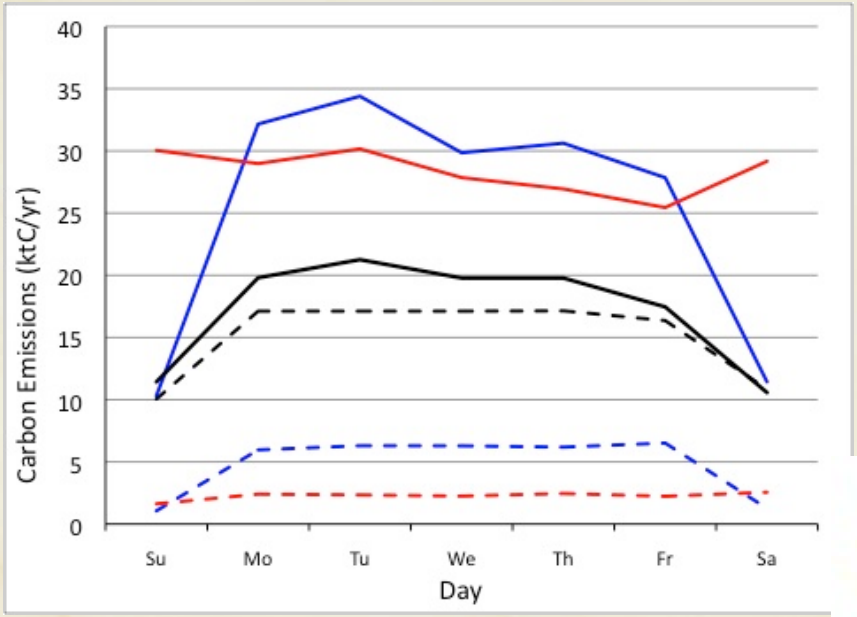
Buildings (residential, commercial and industrial)

$$E^{Fuel}_{building(i)} = EUI^{t} \times A_{building(i)} \times N_{building(i)}$$



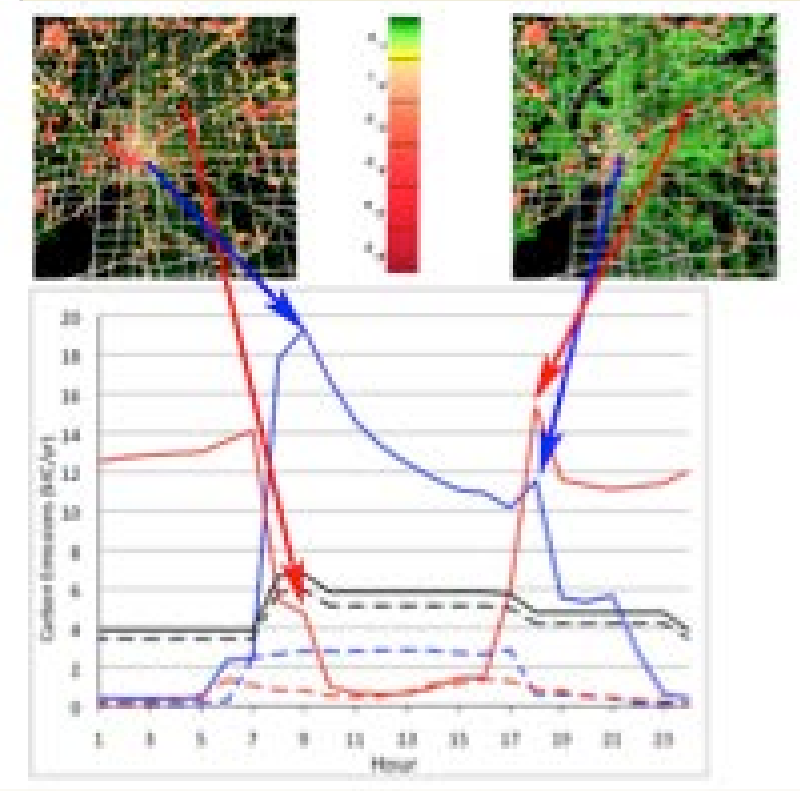
Zhou & Gurney, *Carbon Management*, 2010

Hestia Residential, Commercial, Industrial



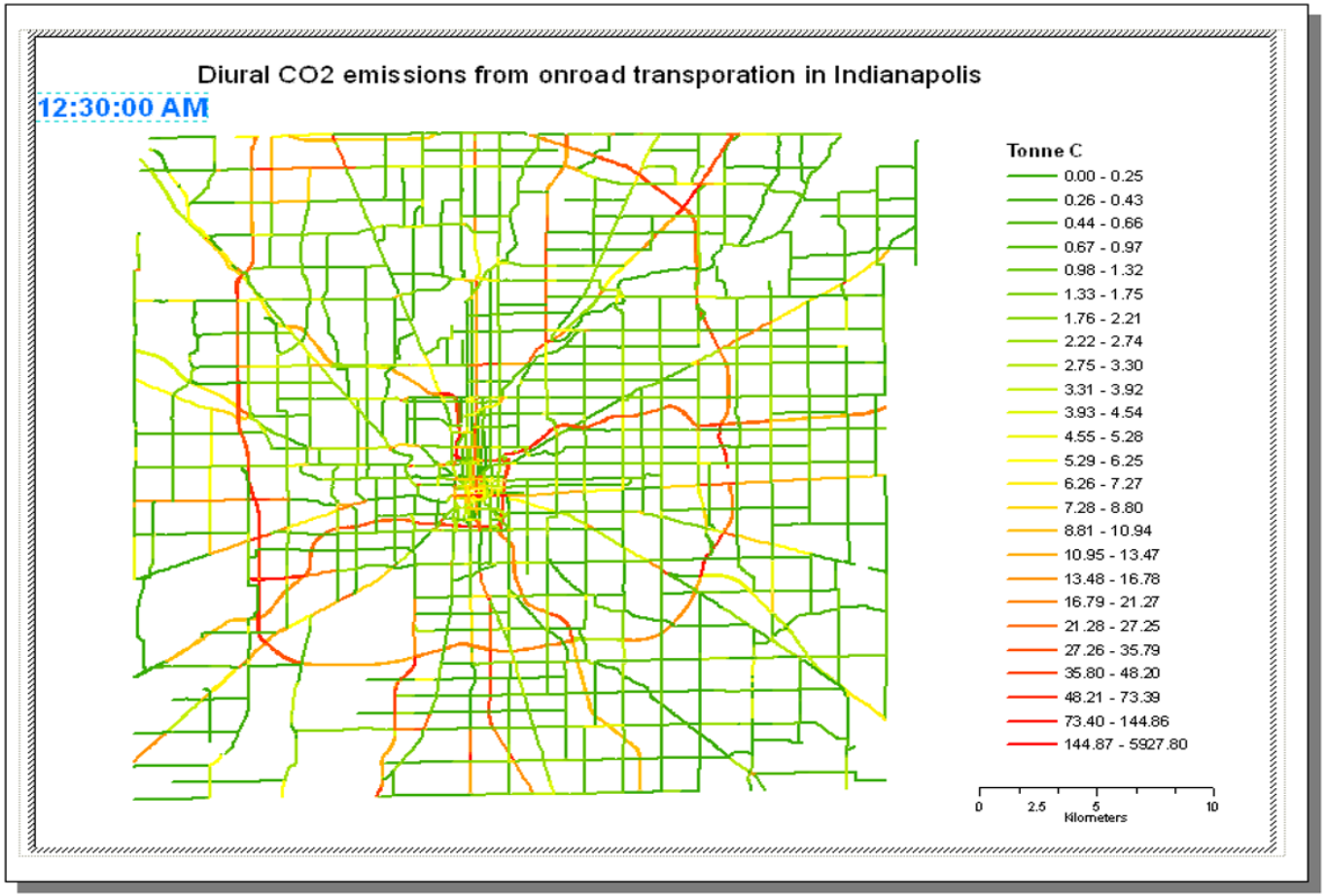
Building schedules based on Tset, surface temp, DOE building survey data

commercial
residential
industrial

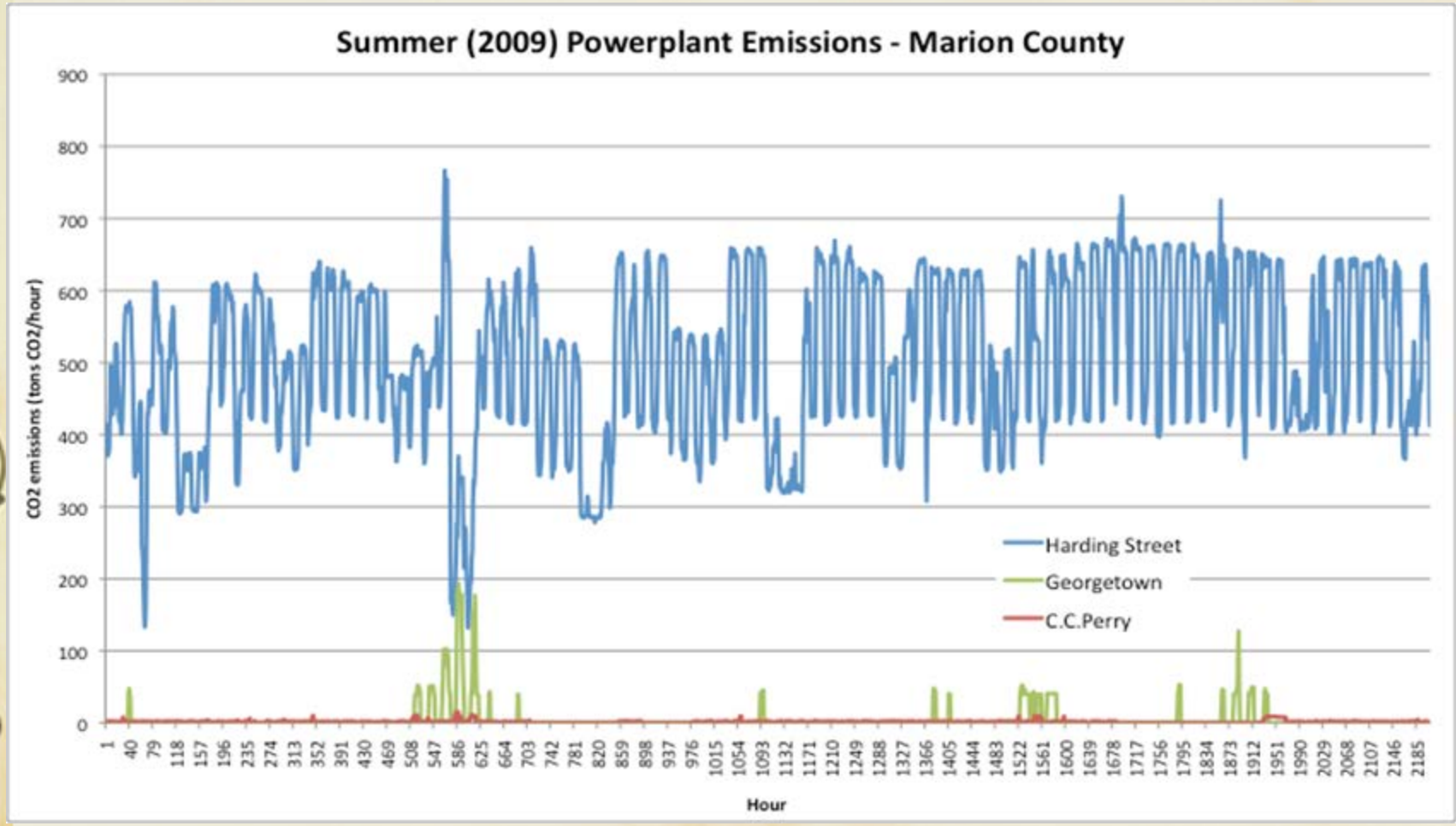


Onroad

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



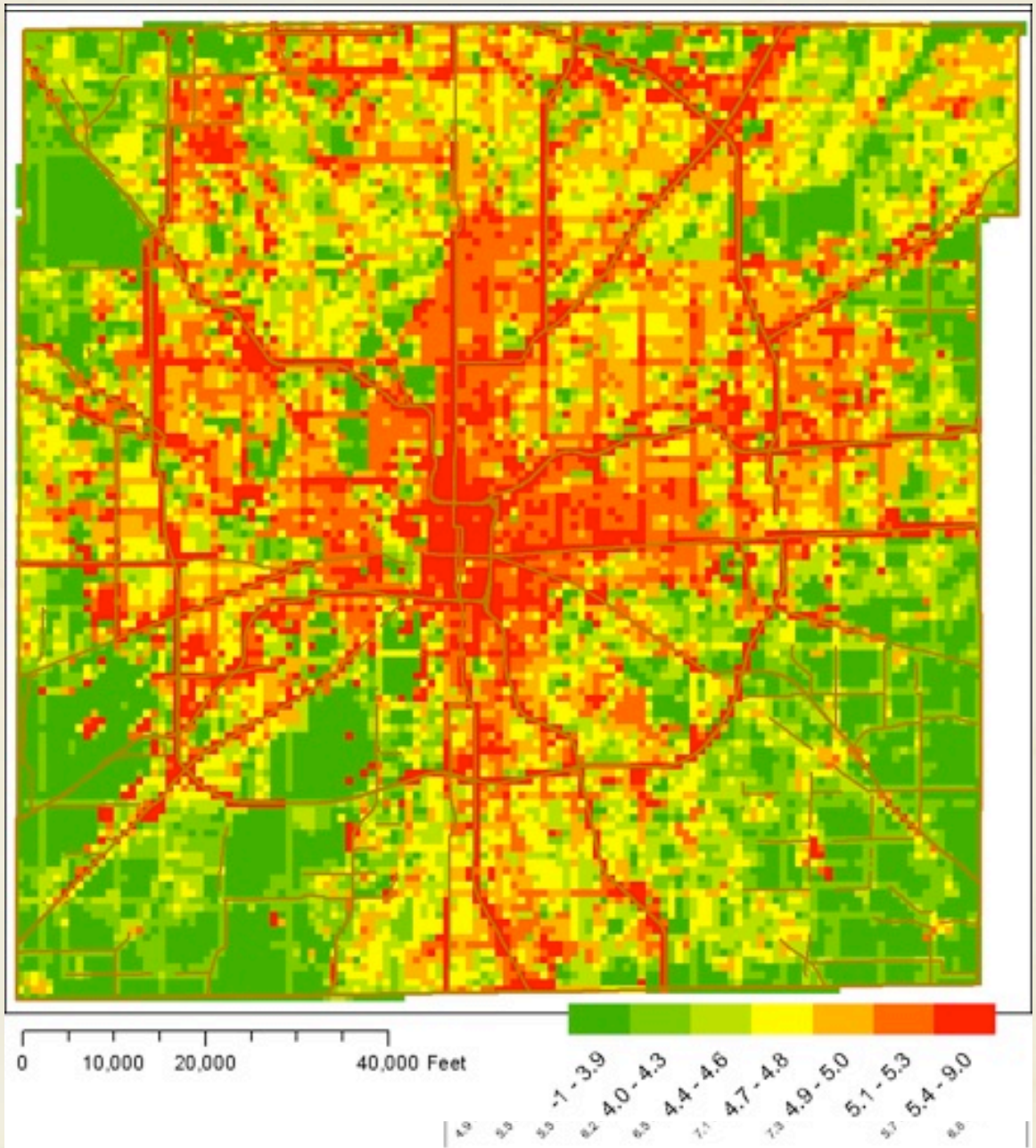
Electricity Production



3 CEMS hourly data + 7 additional annual small facilities

Thank you EPA (CAMD) and DOE EIA

Indianapolis results



Commercial

Residential

Industrial

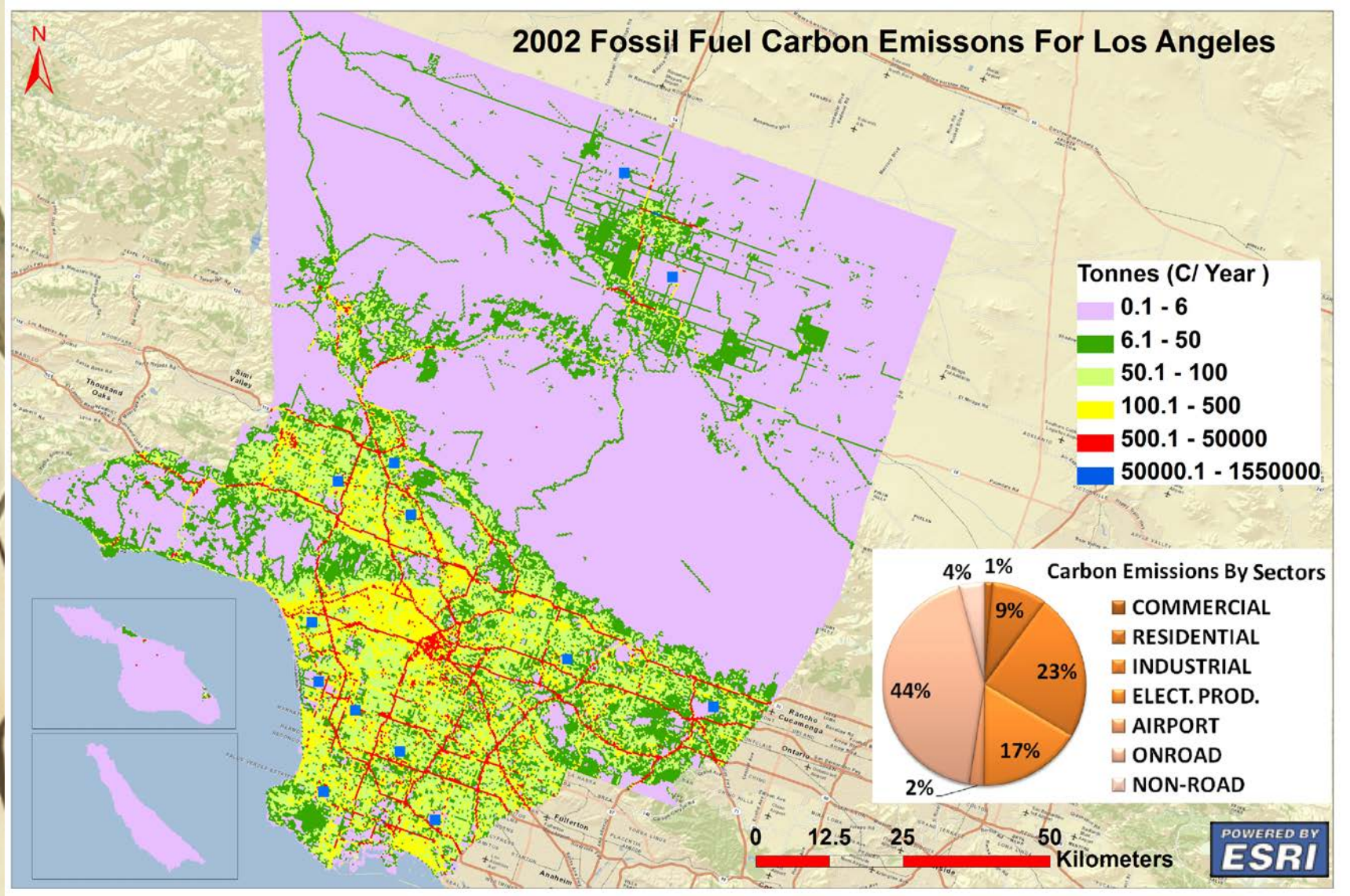
Elec & Air

Onroad

Total

Indianapolis movie

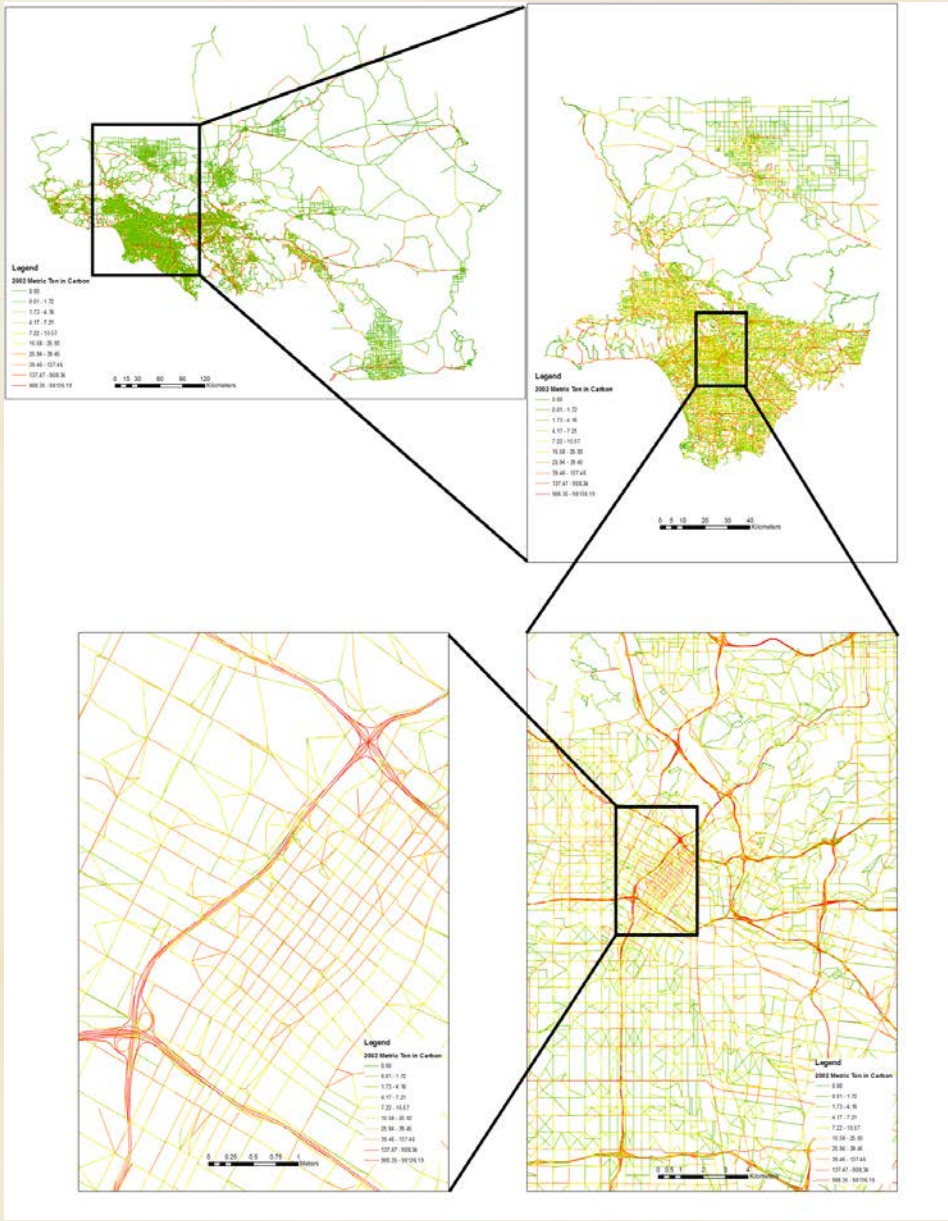
LA county


2002 Fossil Fuel Carbon Emissons For Los Angeles
N
Tonnes (C/ Year)
0.1 - 6
6.1 - 50
50.1 - 100
100.1 - 500
500.1 - 50000
50000.1 - 1550000
Carbon Emissions By Sectors
COMMERCIAL
RESIDENTIAL
INDUSTRIAL
ELECT. PROD.
AIRPORT
ONROAD
NON-ROAD
4%
1%
9%
23%
44%
17%
2%
0
12.5
25
50
Kilometers
POWERED BY ESRI

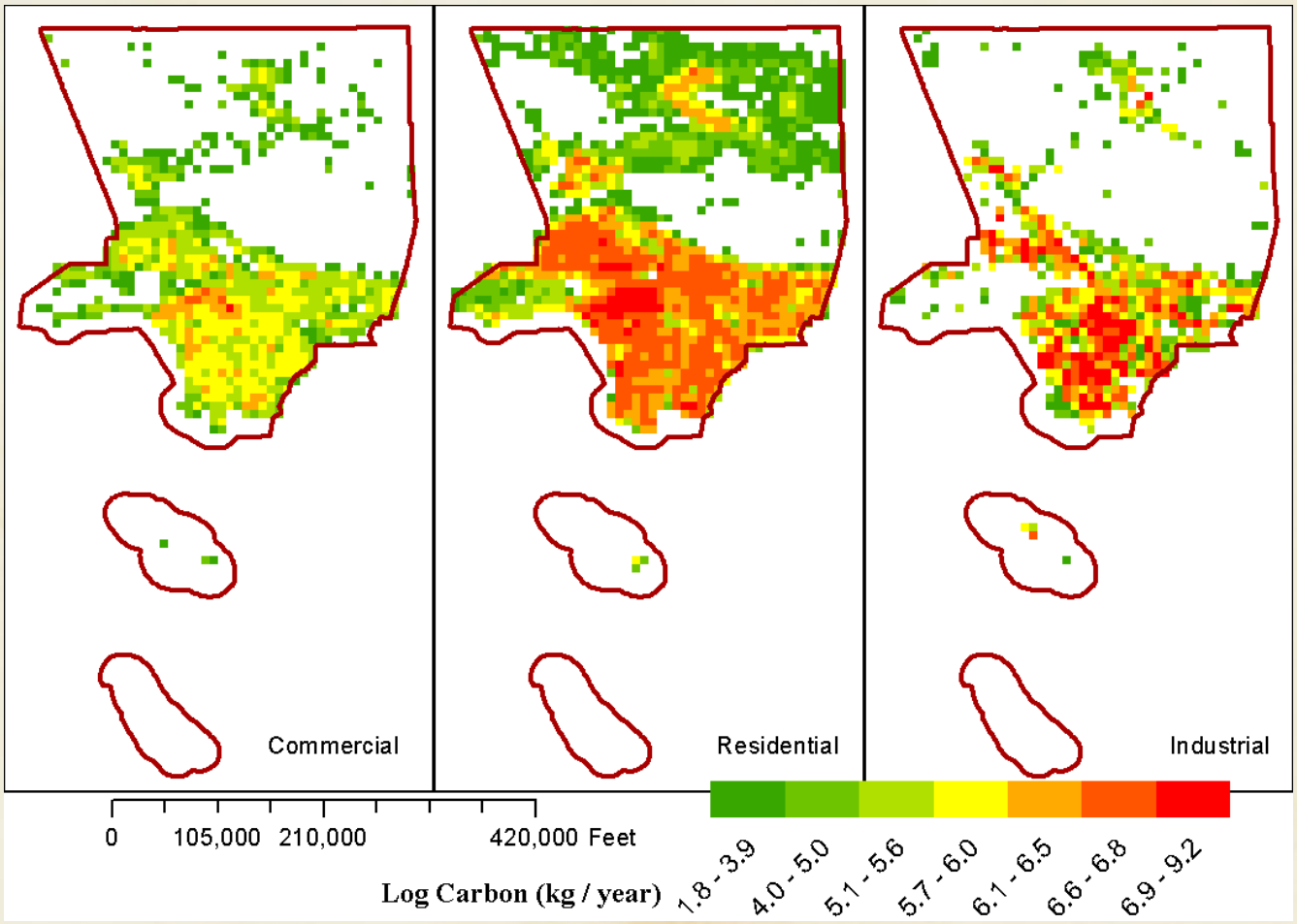
LA onroad emissions

Though much labor to get, we have a very dense traffic dataset for 5 counties.

Optimized counts from TransCad

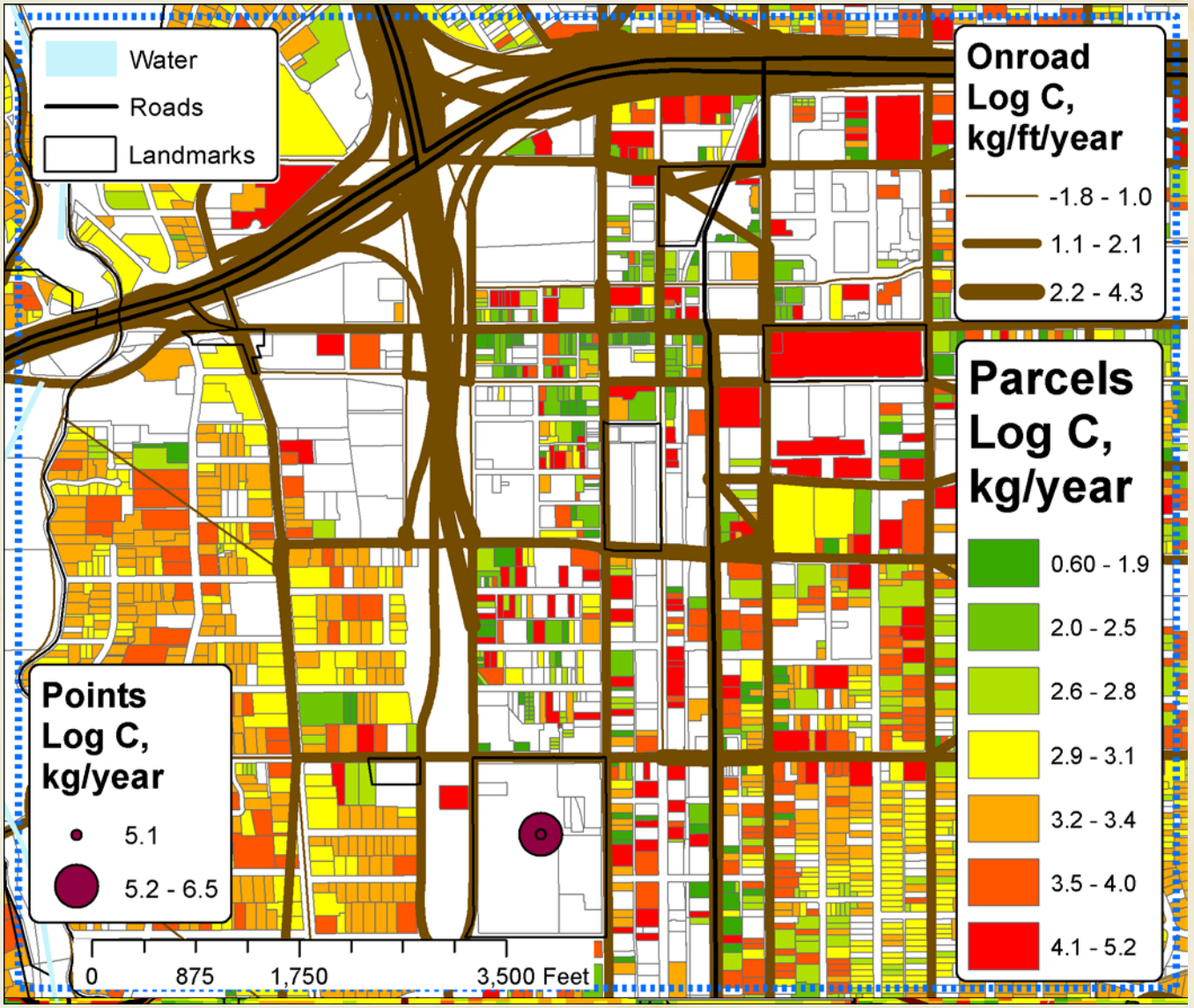


LA county



Aggregated to 2.5 km

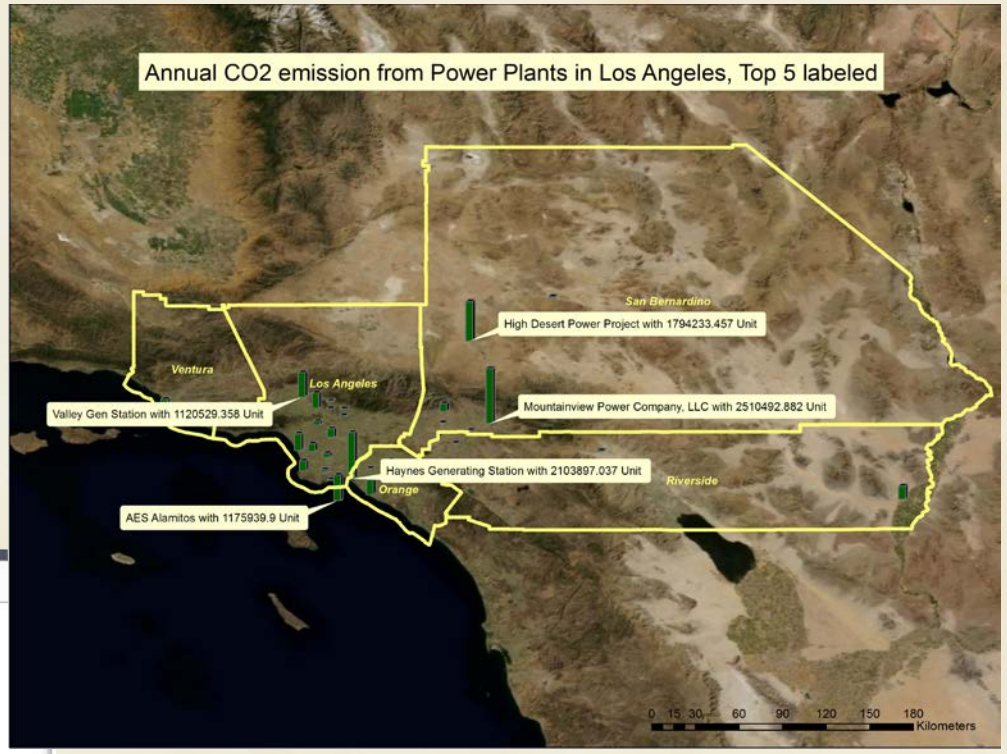
Pasadena

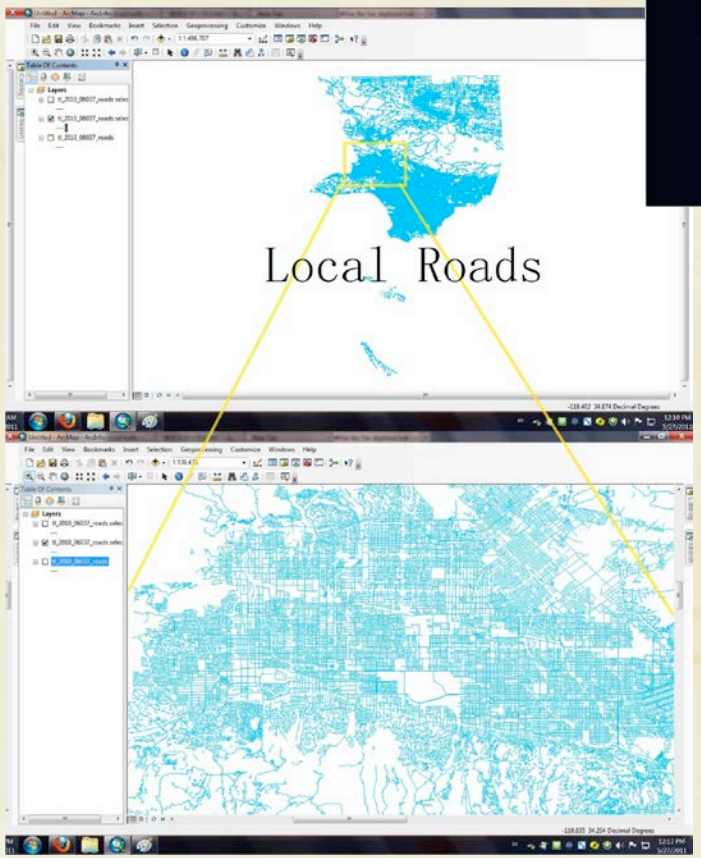

Water
Roads
Landmarks
Onroad Log C, kg/ft/year
-1.8 - 1.0
1.1 - 2.1
2.2 - 4.3
Parcels Log C, kg/year
0.60 - 1.9
2.0 - 2.5
2.6 - 2.8
2.9 - 3.1
3.2 - 3.4
3.5 - 4.0
4.1 - 5.2
Points Log C, kg/year
5.1
5.2 - 6.5
0
875
1,750
3,500 Feet

Los Angeles

Will have complete data product for 5 counties.

It is **preliminary**





JPL SURP project: Feasibility of CMS in megacity

Annmarie Eldering, Stan Sander, Riley Duren, Charles Miller

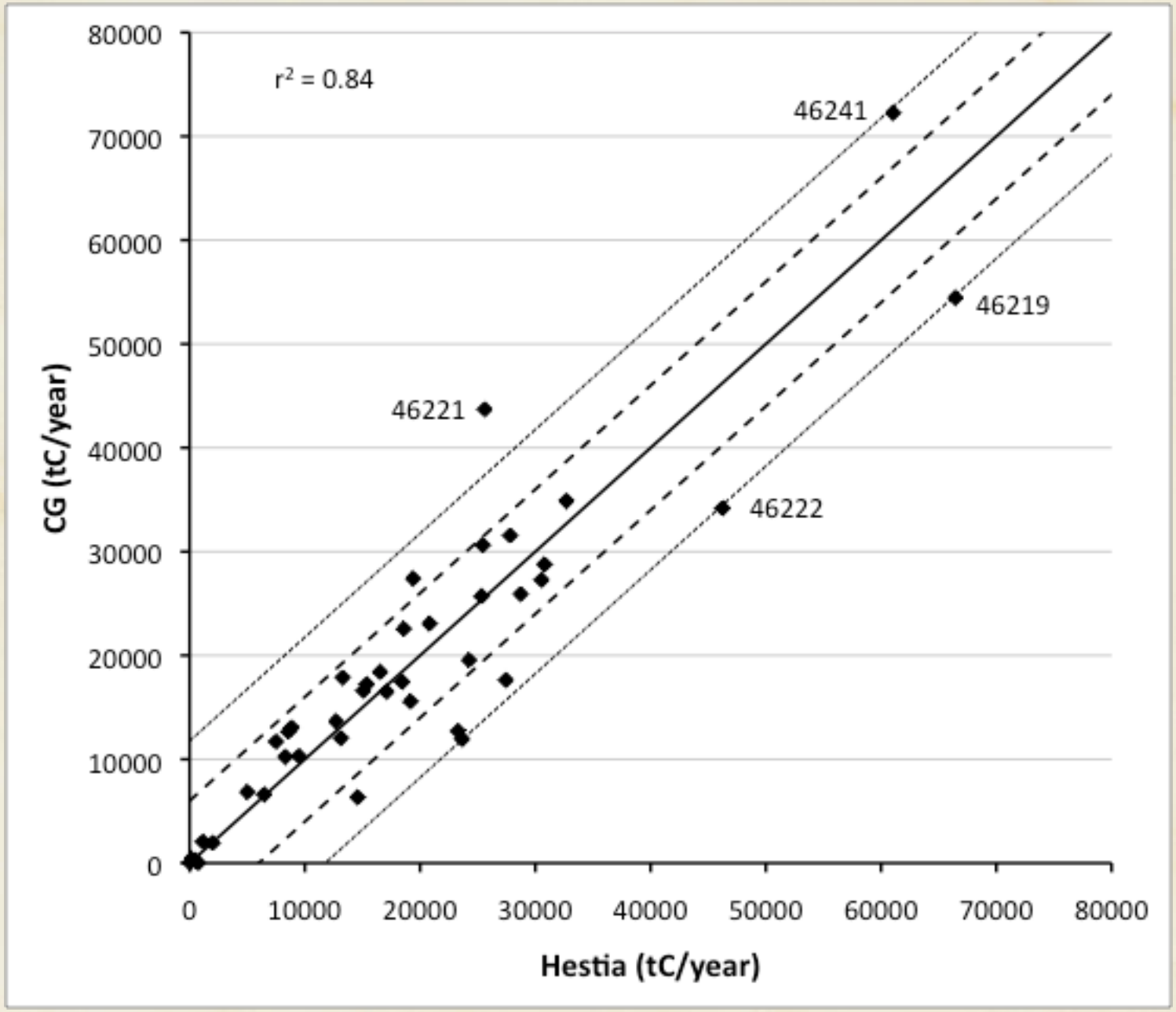
Conclusions

- We can generate model/data flux estimation at the building/road segment level
- We view this as a scientific emissions data product not a regulatory inventory
- Broaden conceptualization of the verification challenge
  - Integrate emissions data product not just as prior but as attribution system.
  - A goal of the emission data products is mitigation guidance
  - Gross trend detection is an understandable start, but an underwhelming long-term goal.
- need to continue the LA work – move from preliminary
- NON-US cities will pose **new challenges**. Calibrated RS will be important

Thanks to Bedrich Benes & Michel Abdul-Massih

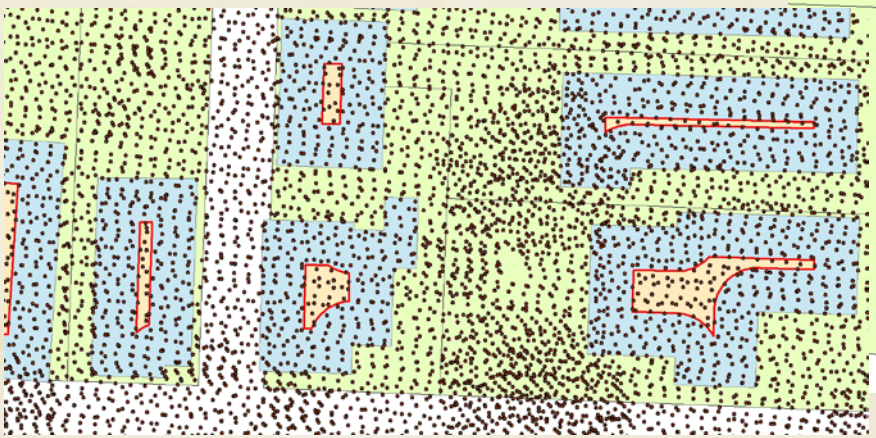
Extra slides

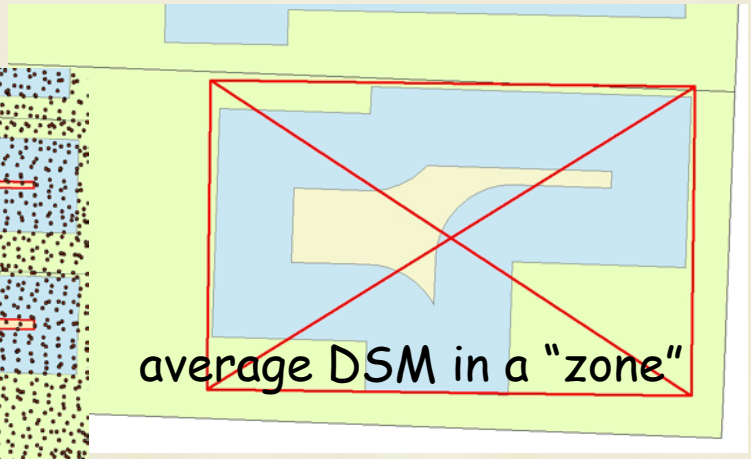
Comparison to utility data



Buildings continued

Total square footage ("A") – use DSM/DEM data

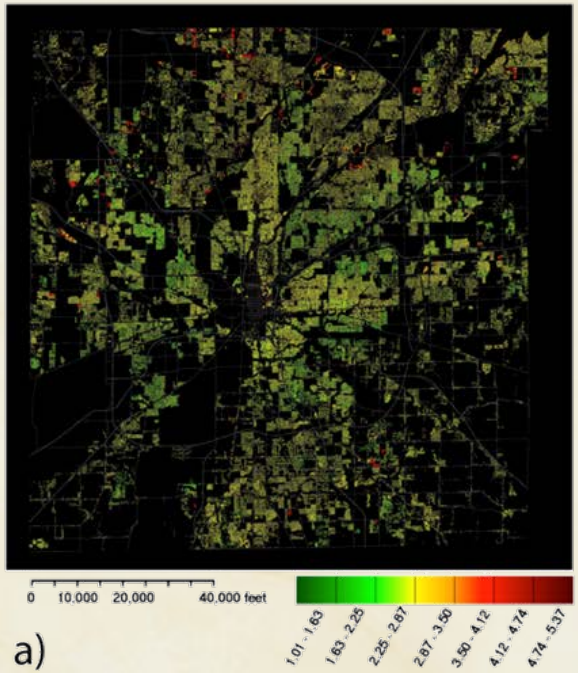




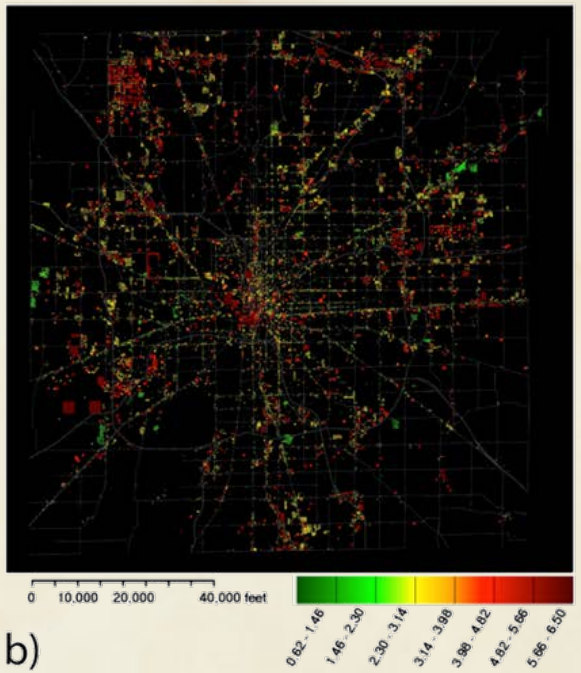
manual revisions for tall buildings

A = floor area x (DSM-DEM)/AWH

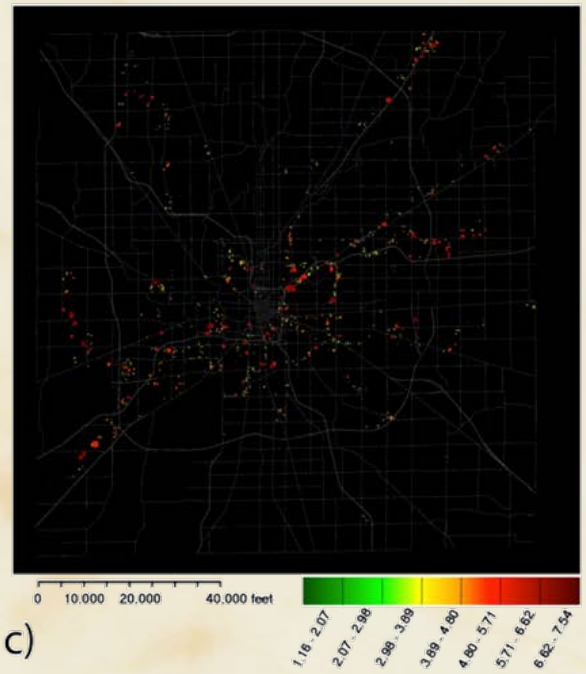
At native res



a)



b)



c)

"total hestia" paper under revew at *Env Sci & Tech*

Multiple datastreams transformed to CO_2

Data Source	*National Emissions Inventory (NEI)*				*ETS/CEM*	*NMIM NCD*	*Aero2k*	*Portland Cement*
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

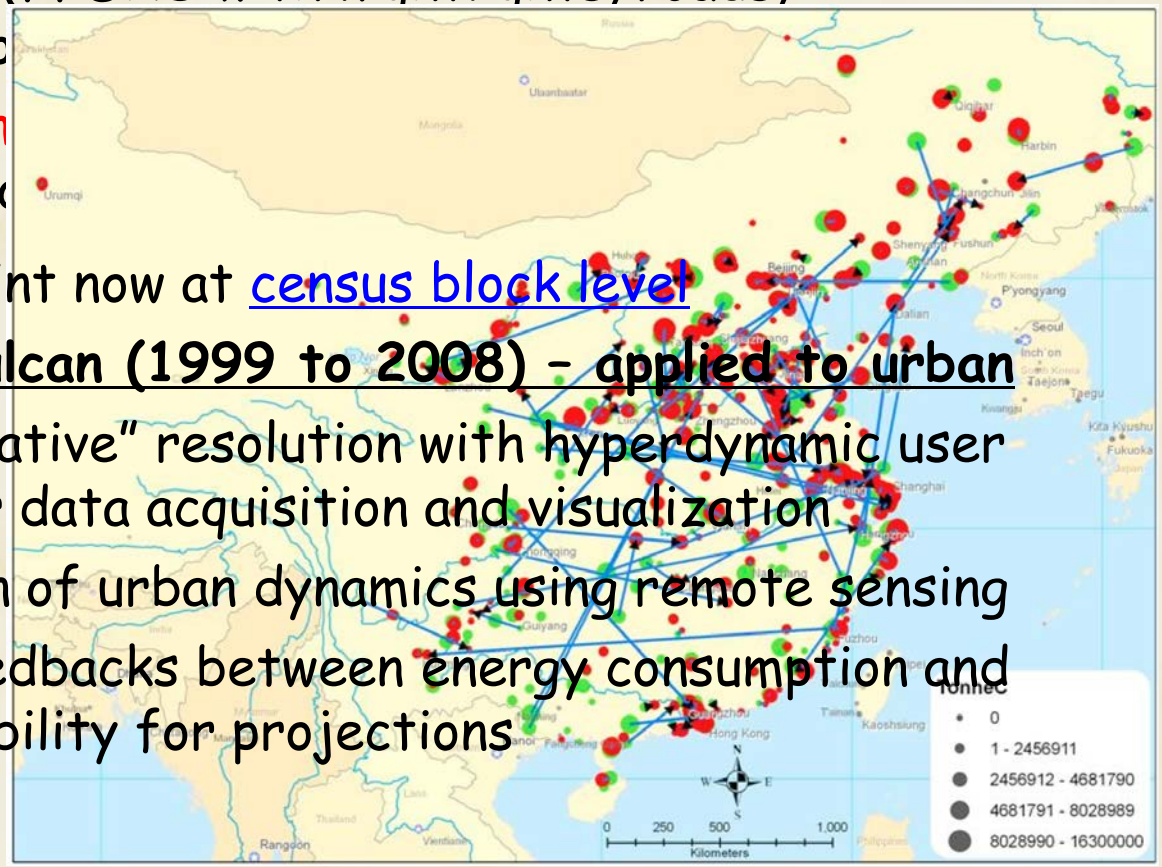
CO_2 Emissions

Peeves:

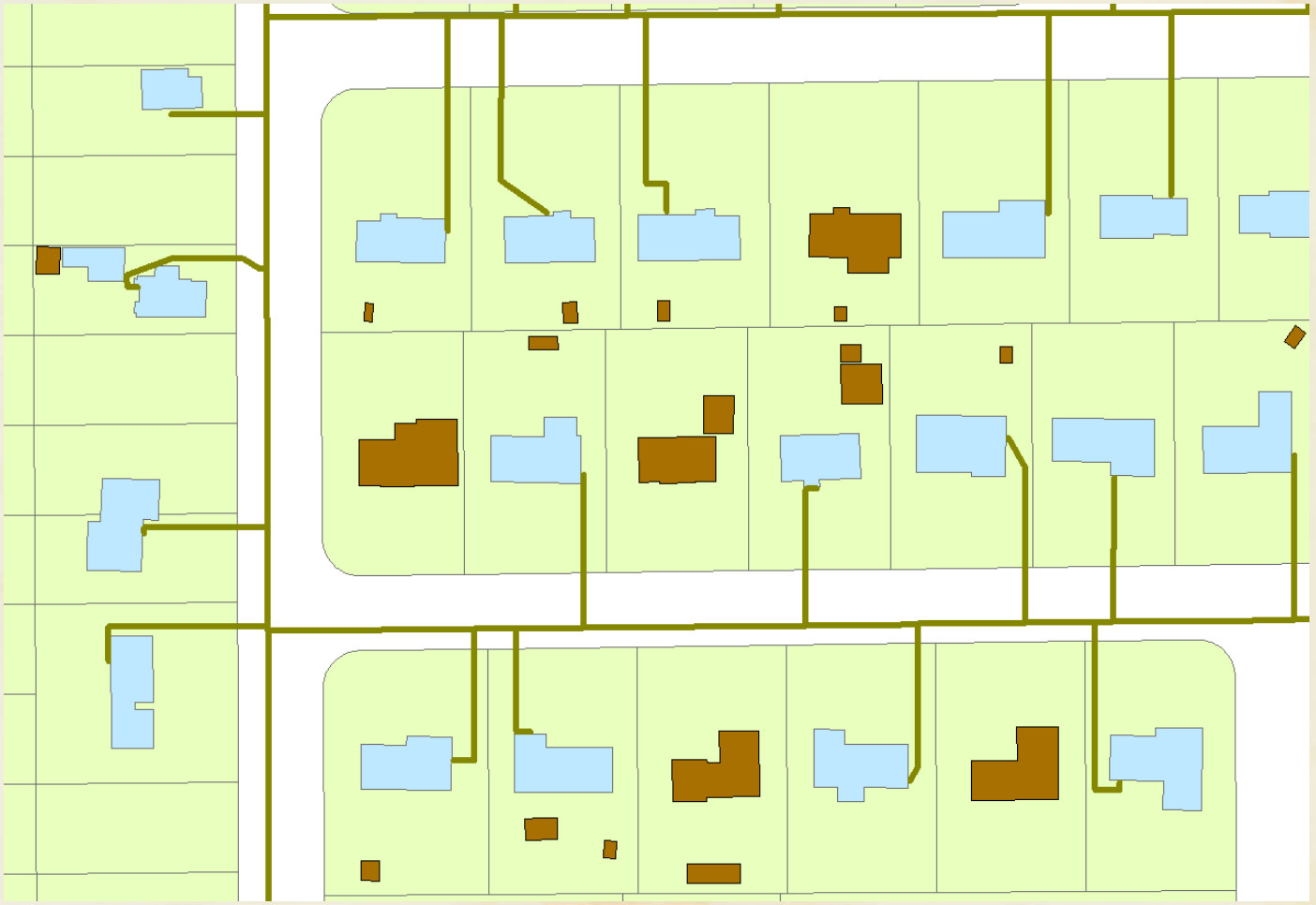
It is a mix of data and model (yes, different data)
I use "data product" NOT "inventory"….it is a scientific, independent data product.

Ongoing

- Starting Phoenix now – preliminary by end of summer
- Expanding Vulcan to Canada and Mexico
- NightSat – high res nightlights: proposed
- Global Vulcan (FFDAS with nightlights, roads, powerplants, p
- Crowd-sourcin (paper forthc
- Vulcan nonpoint now at census block level
- **Multiyear Vulcan (1999 to 2008) – applied to urban**
- Release at "native" resolution with hyperdynamic user interface for data acquisition and visualization
- Extrapolation of urban dynamics using remote sensing
- Exploring feedbacks between energy consumption and climate variability for projections



Buildings continued – natural gas pipelines



pipeline feed information.
37% of buildings in Indianapolis DO NOT have pipelines.