

"Vulcan": high-resolution process-based fossil fuel CO₂ inventory project

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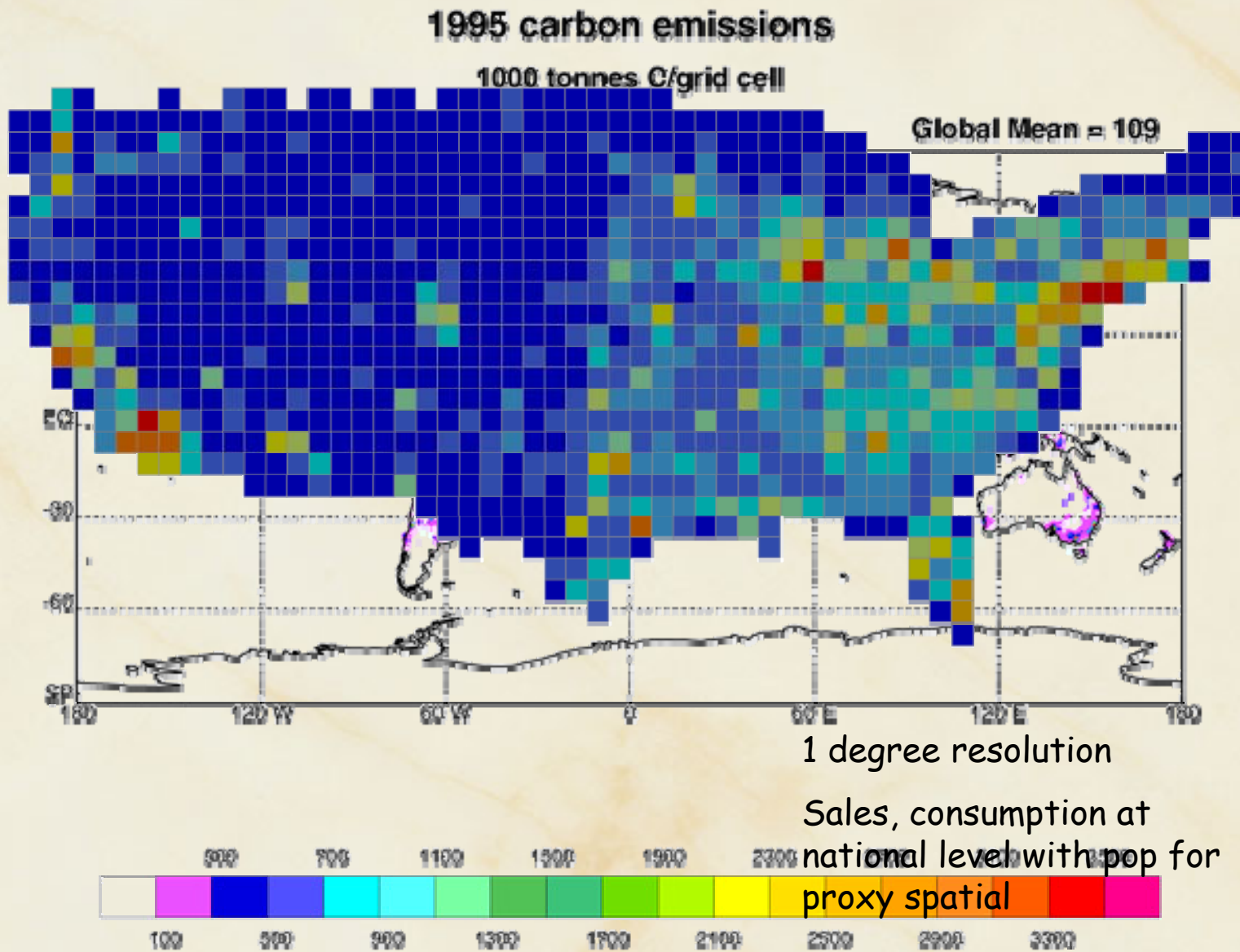
Google

Supported by:

- NASA 04-0325-0167, DOE DE-AC02-05CH11231
- Knauf Insulation, Showalter Trust

CO₂FFEE

What have we been using?



Manipulate existing AQ to generate CO₂

QA/QC

QA/QC

QA/QC

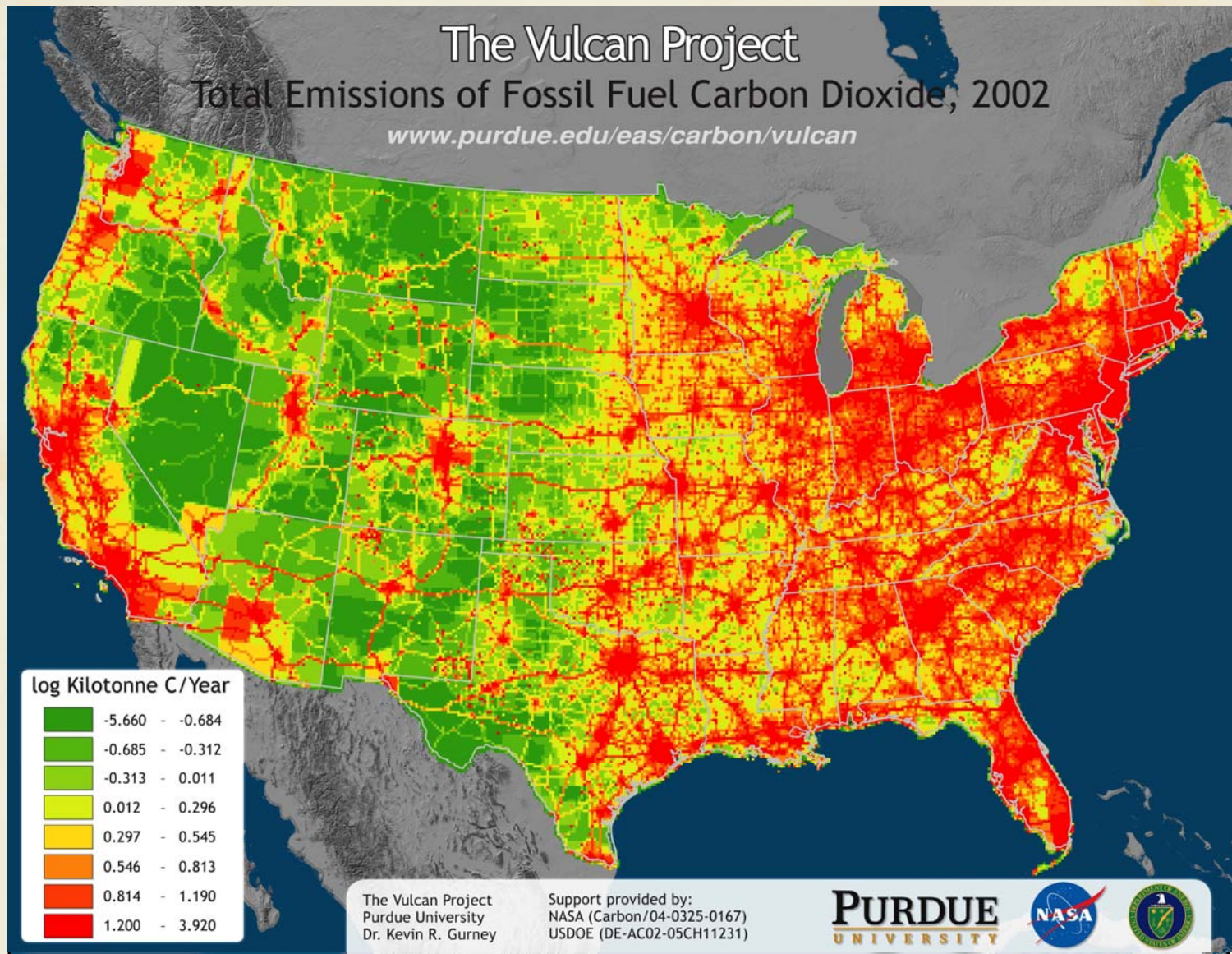
Data Source	National Emissions Inventory				ETS/CEM	NMIM NCD	Aero 2k
Data Type	Non-road	Non-point	Point	Airport	Power Production	On road	Aircraft
Pollutant Utilized	Activity/ population	CO	CO	CO	CO ₂	VMT/ population	CO ₂
Incoming Resolution: Space/Time	County; Monthly	County; Annual	Lat/Lon; Annual	Lat/Lon; Annual	Lat/Lon; Hourly	County; Monthly	1°X 1°; Monthly
Conditioning Data		Census; EIA sector/state/ fuel/month sales	EIA sector/ state/fuel/ month sales			GIS Road Atlas; Mobile 6.2	
Final Resolution: Space/Time	County; Monthly	Census tract; Month	Lat/Lon; Month	Lat/Lon; Annual	Lat/Lon; Hourly	Road segment; Hourly	1°X 1°; Monthly
Sector	Mobile	Comm. Res. Ind. Electric	Comm. Res. Ind. Electric	Mobile	Electric	Mobile	Mobile

CO₂ Emissions

QA/QC

Results

Version 1.1 now available

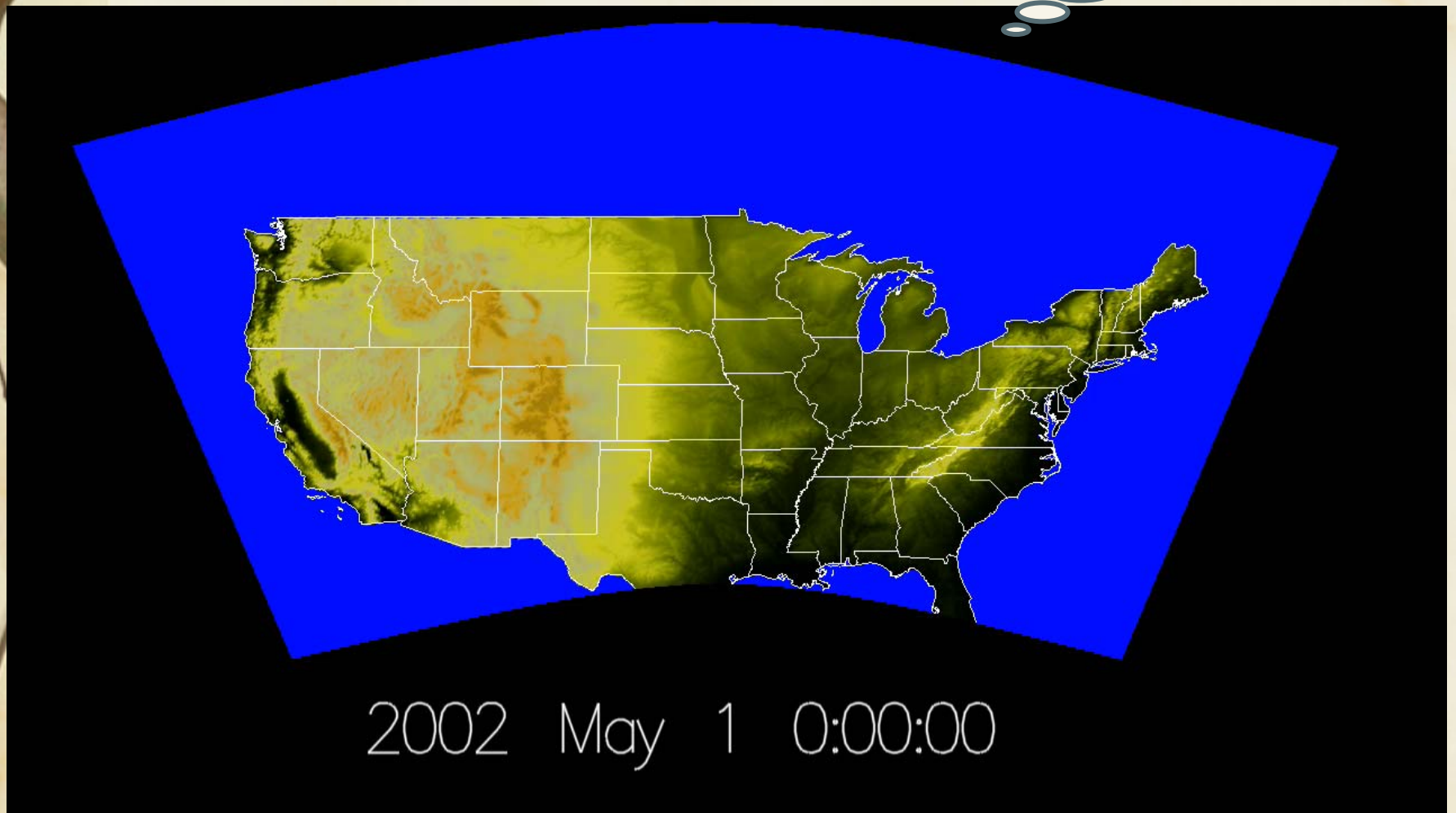


www.purdue.edu/eas/carbon/vulcan

Gurney et al., submitted, 2009

Transport

Over 200,000
YouTube views



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

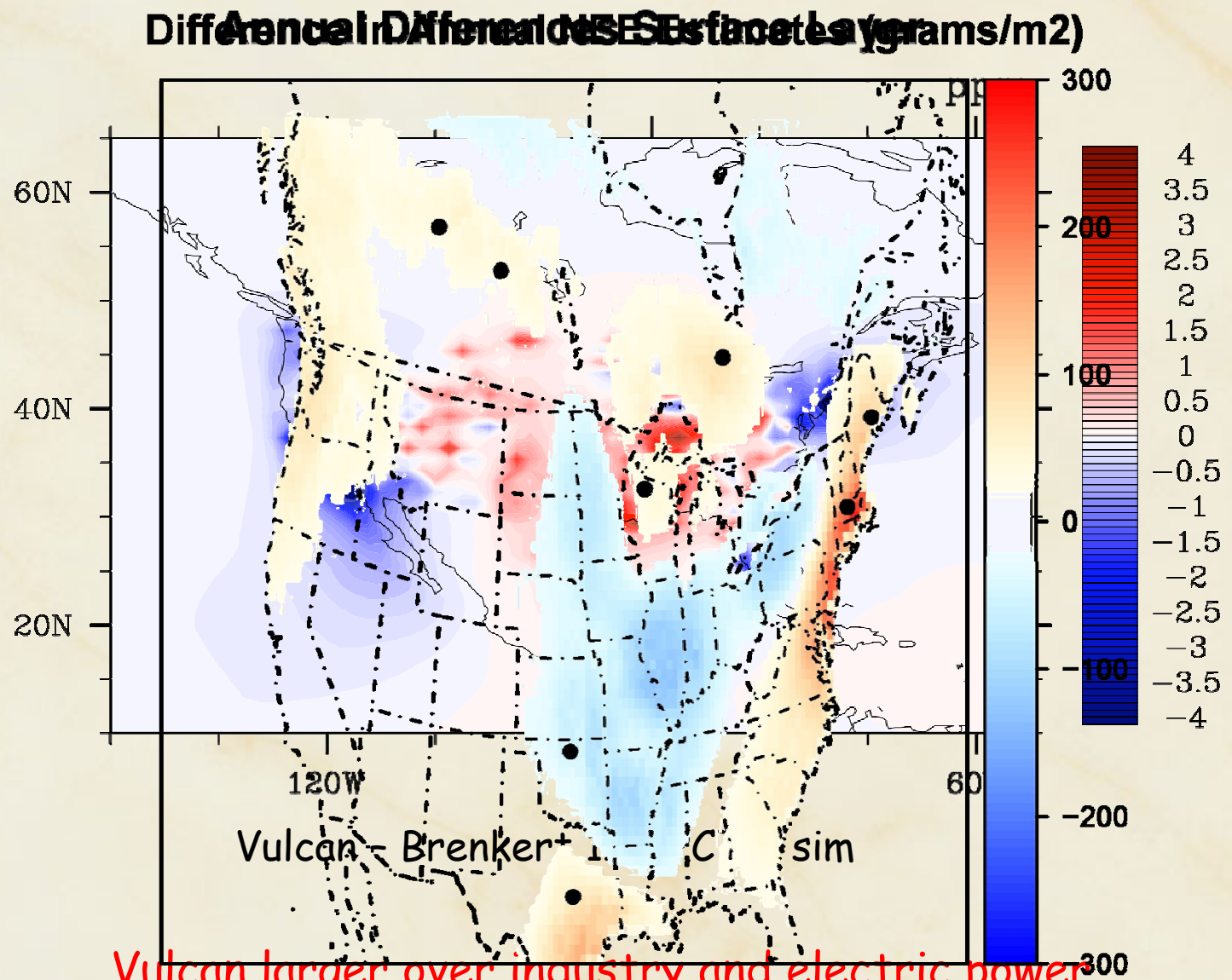


Google Earth

Run animation

Release: Thursday February 19, 2009
www.purdue.edu/eas/carbon/vulcan/GEarth/

Implications



Vulcan larger over industry and electric power,
lower over coastal population centers

Courtesy of A. Schuh

Evaluation

2002 Vulcan fossil CO₂ (GtC/year) evaluation

<i>Sector</i>	<i>DOE/EIA (MtC/year)</i>	<i>Vulcan (MtC/year)</i>	<i>% diff (Vulcan - EIA)</i>	<i>EPA (MtC/yr)</i>
Commercial	62.4	65.4	4.8%	516.3 379.1 72.6 64.6
Industrial	289.1	282.7	-2.2%	
Residential	100.2	100.5	0.3%	
Mobile	515.1	553.8	7.5%	
<i>onroad</i>		440.2		
<i>nonroad</i>		49.8		
<i>aircraft</i>		64.8		
Electric	616.3	615.9	-0.1%	
Total	1583.1	1618.3 (-2.7% / +11.1%)	2.2%	

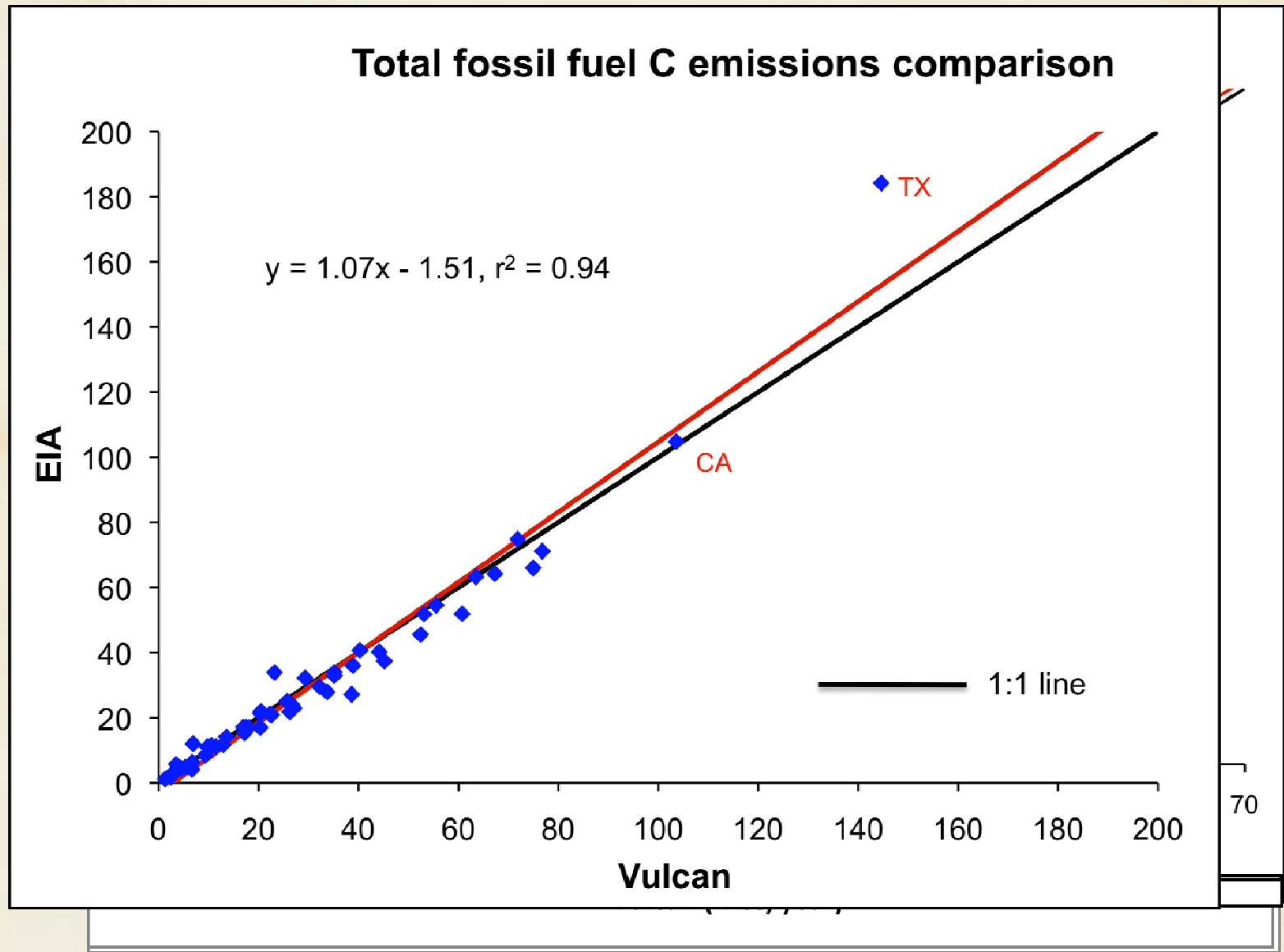
fixed

¹ DOE/EIA [2007].

² This represents the % difference between the DOE/EIA and the Vulcan estimate.

Vulcan uncertainty - range of CO EF variation

Evaluation: EIA SEDS





Strengths/Weaknesses

Strengths:

- It exists!
- Infrastructure - flexible sourcecode
- Comprehensive - all fossil-based CO₂
- Consistent methodologically
- Process-oriented, segmented (sector, sub-sector, fuel [48])

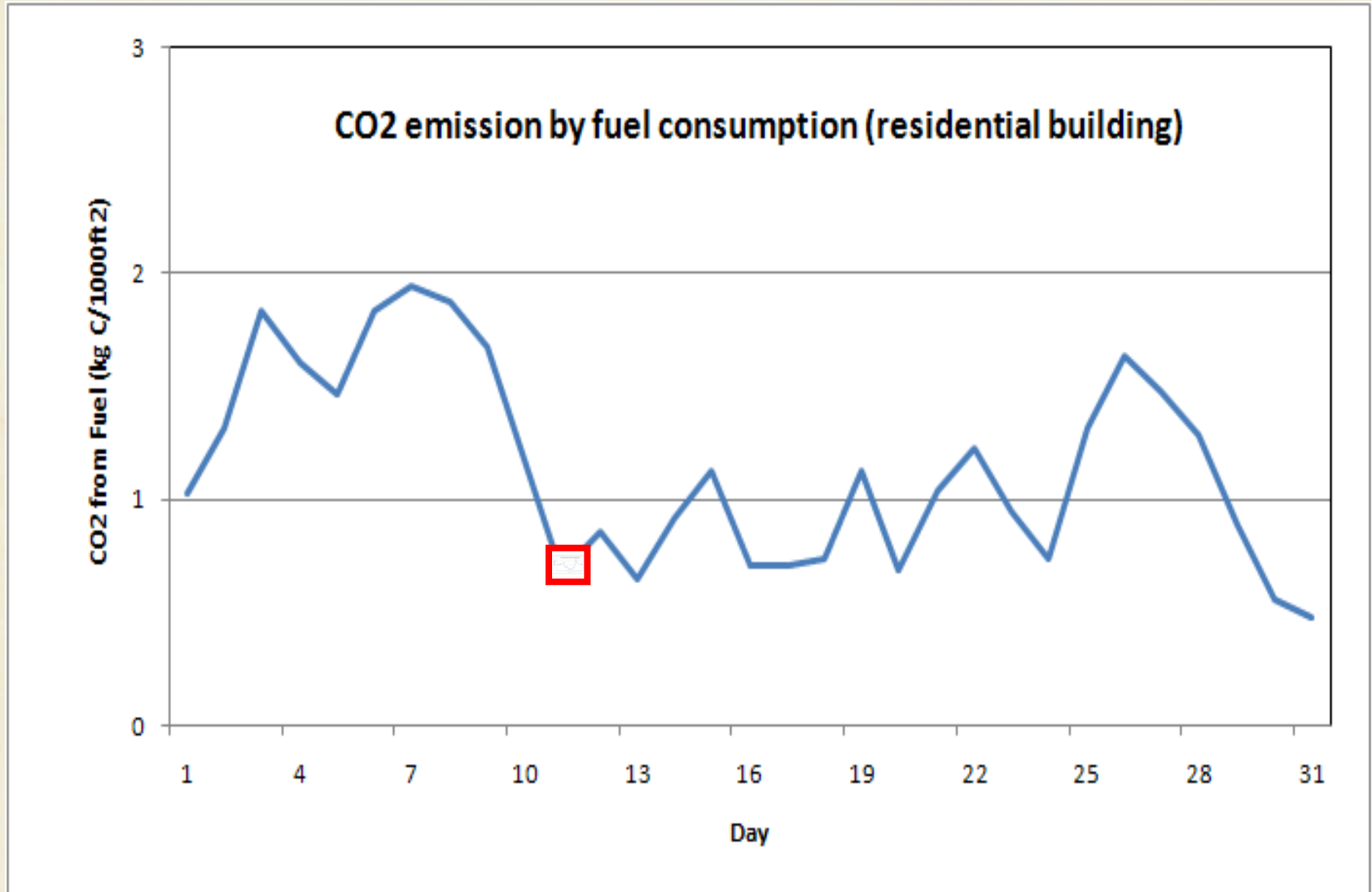
Weaknesses:

- CO EF linkage (overcome with throughput)
- Limited evaluation options (formal unc)
- Core data streams dependant on external QA/QC
- Spatial downscale of area sources
- Temporal downscale on res/comm/ind
- Currently ONLY CO₂



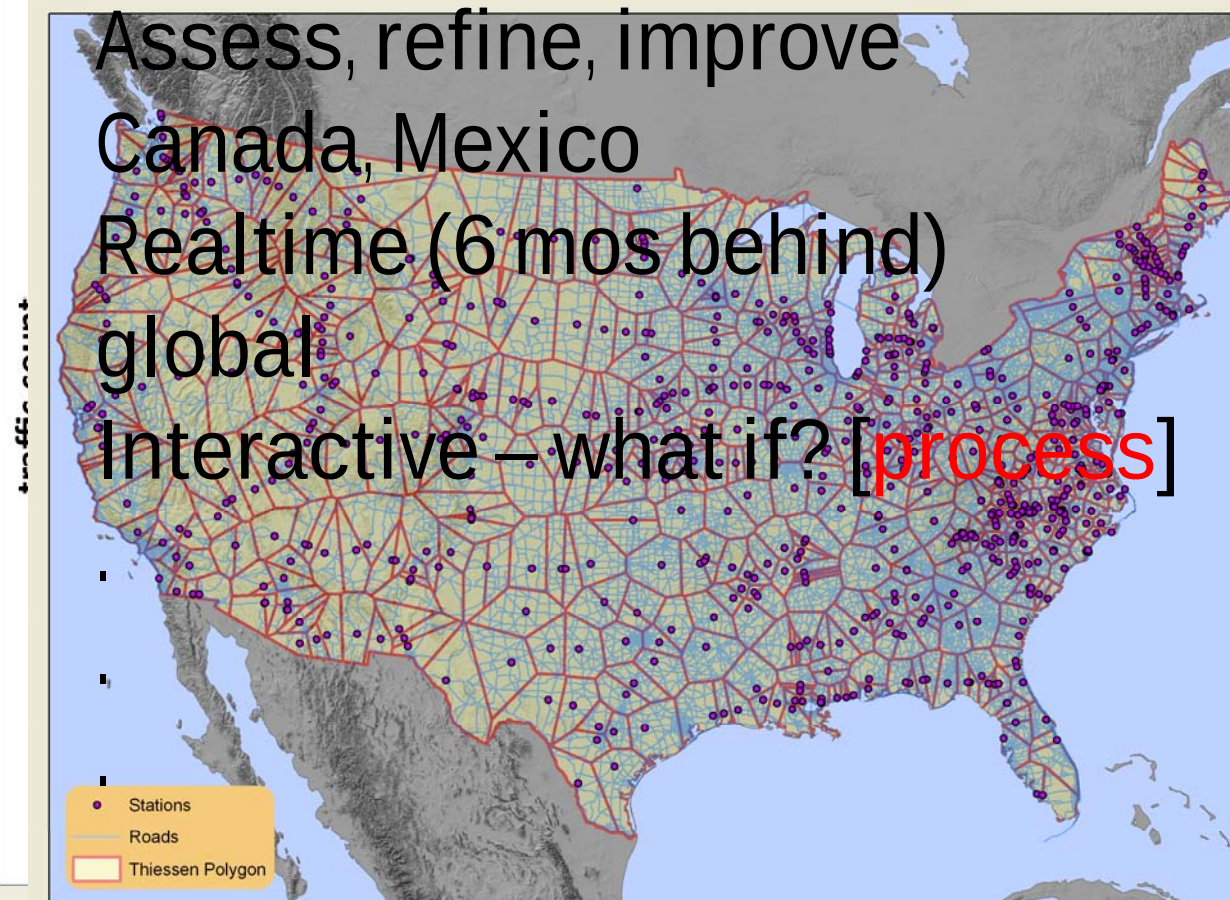
Mobile VMT
may be
weakest

Hestia Pilot



Improving space and time

Improving mobile temporal structure: FOIA request turned up >6000 traffic monitoring stations



An opportunity

- Inventory/**accounting**/reporting of GHGs: regulation-driven



- space/time, comprehensive behavior/energy/material flow **system**

Assimilation,

tions)

- Atn

Multiple added benefits:

- what-if capability (mitigation)

- Local decision support

- Economically efficient

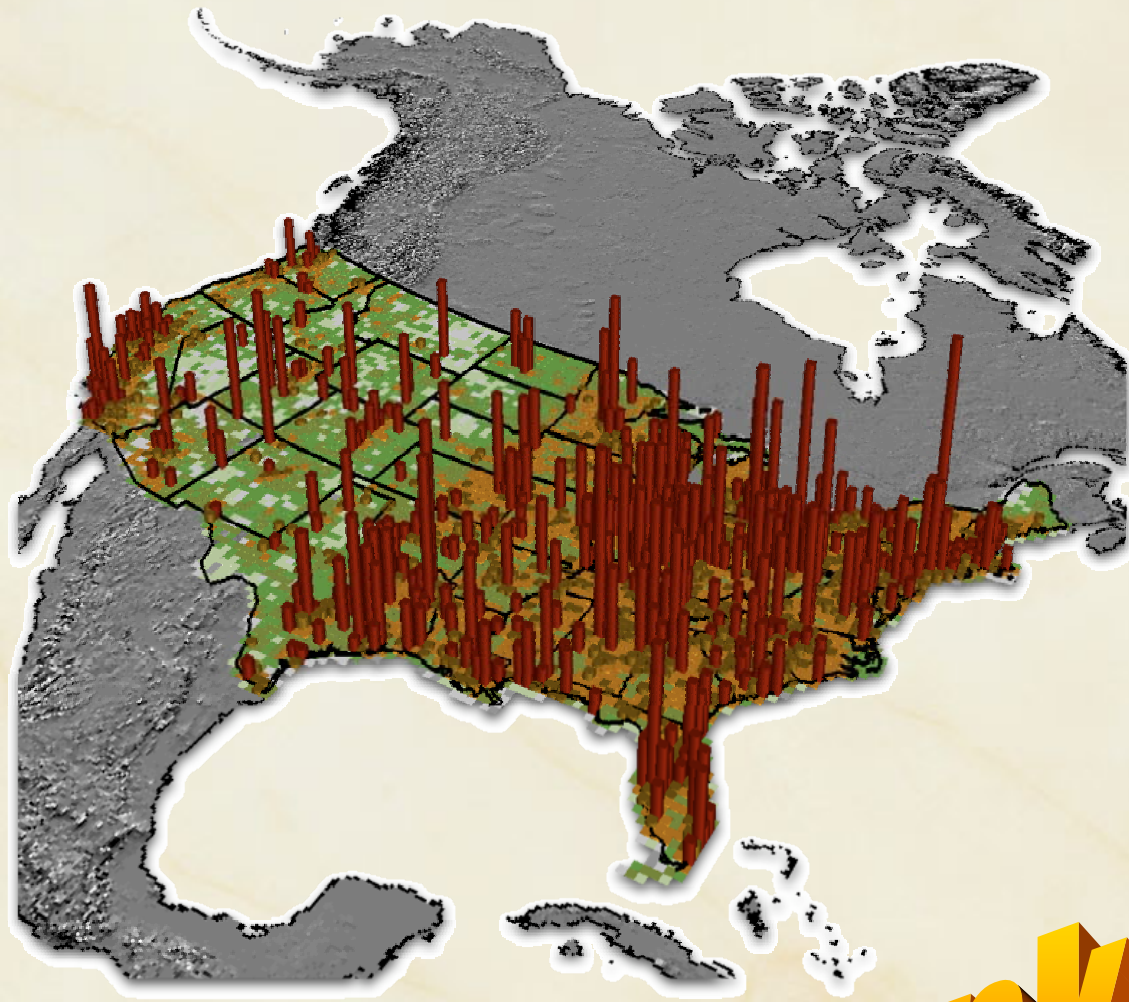
- Other science (energy systems, sociology, demography)

- Leverage error down

- Comparative analysis

- Scale independent

- Avails of multiple data streams



Thank You!

Public empowerment

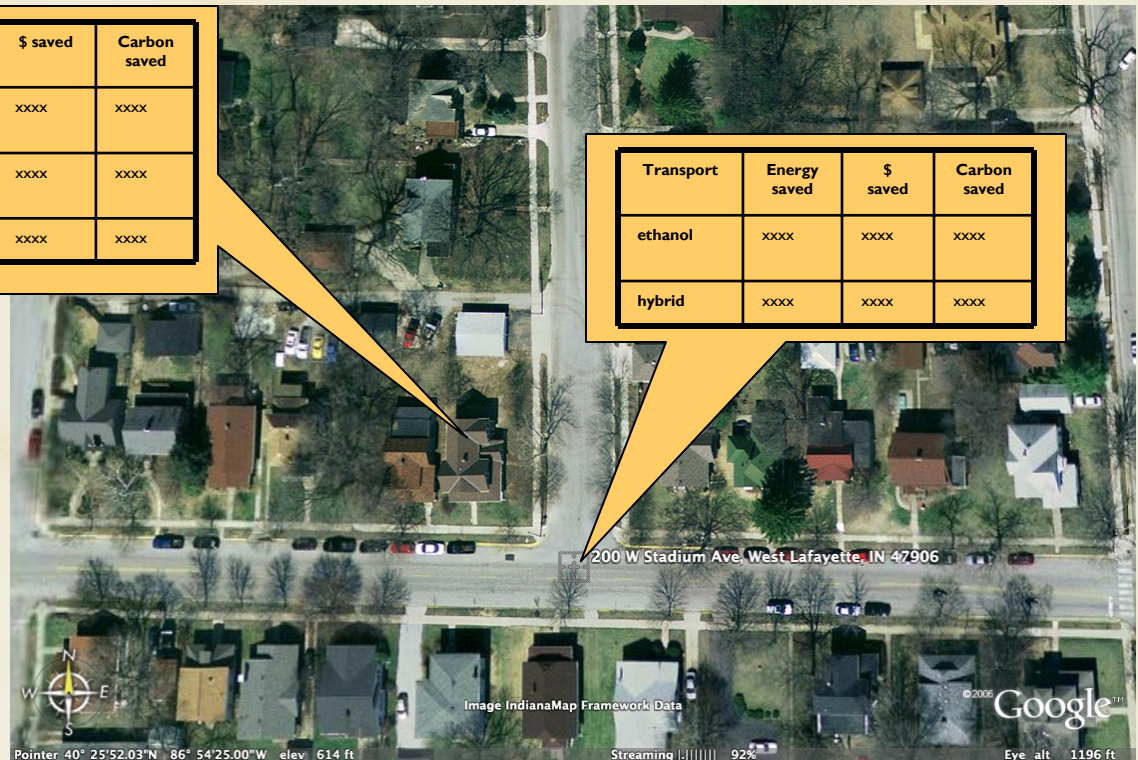
Offers an *unprecedented, visceral* connection to "solution technology"

Links consumers and producers within a digital world where a consumer has control over options

Insulation	Energy saved	\$ saved	Carbon saved
R13 to R15	xxxx	xxxx	xxxx
R15 to R18	xxxx	xxxx	xxxx
windows	xxxx	xxxx	xxxx

Transport	Energy saved	\$ saved	Carbon saved
ethanol	xxxx	xxxx	xxxx
hybrid	xxxx	xxxx	xxxx

Climate change in
The living room
Leveraged off of
now-familiar platform



Some attributes

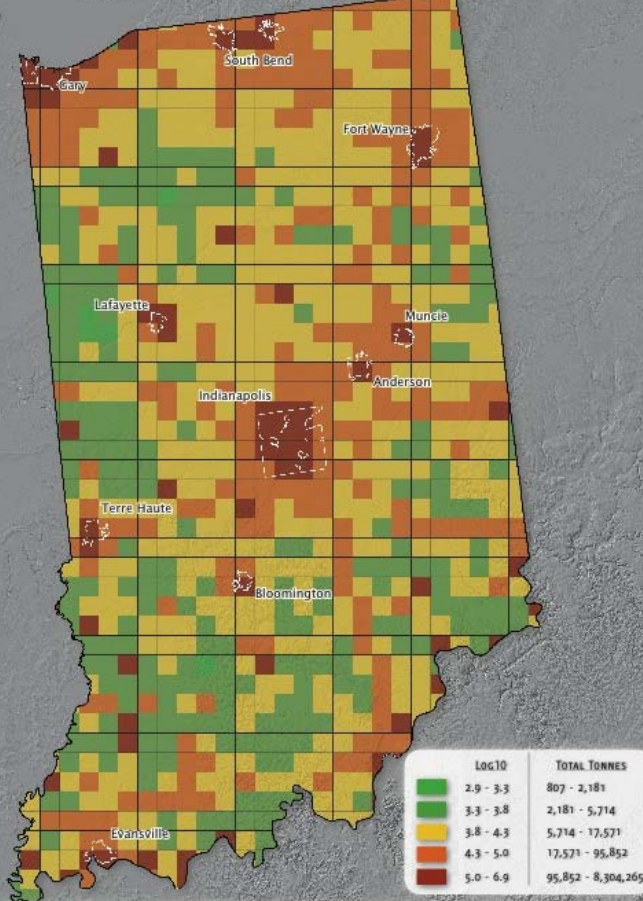
- Methodological consistency
 - 2-way data structure
 - Grassroots == world
 - National goals to local action
 - Efficiency
 - Urban comparison
 - Everybody trades
 - Assessment, verification
 - Visualize solutions/connections
- Scientific credibility, ensure value



Downscale?.....**TRANSCEND SCALE**

Extension/Application

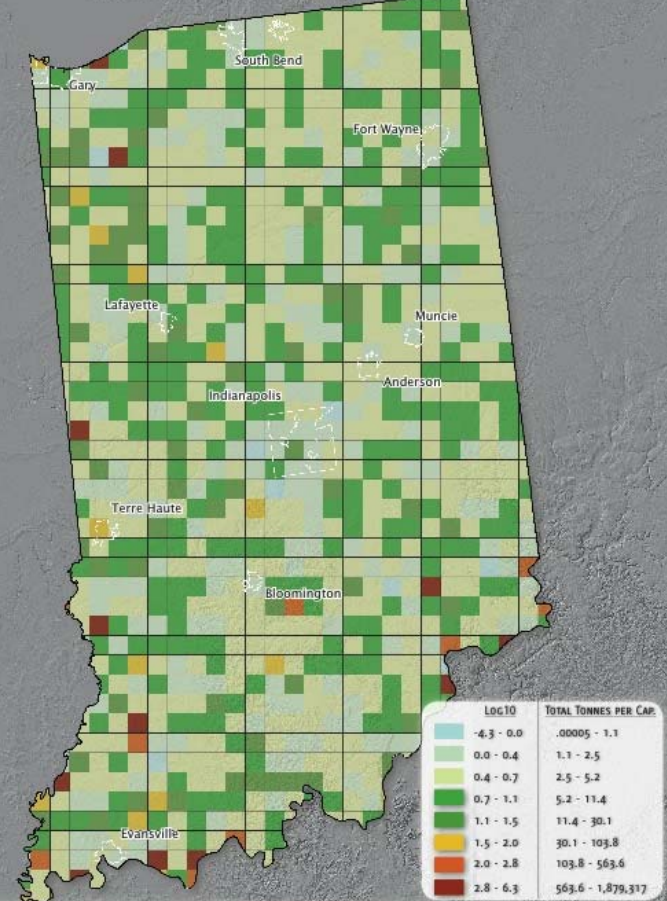
Total Emissions of Carbon Dioxide, 2002
units: tonnes of carbon/gridcell/year



Courtesy of Kevin Gurney and the Vulcan Project (credit: C.C. Miller), Purdue University
Support provided by NASA (Carbon/04-0325-0167) and USDOE (DE-AC02-05CH11231)



Total Per Capita Emissions of Carbon Dioxide, 2002
units: tonnes of carbon/gridcell/year

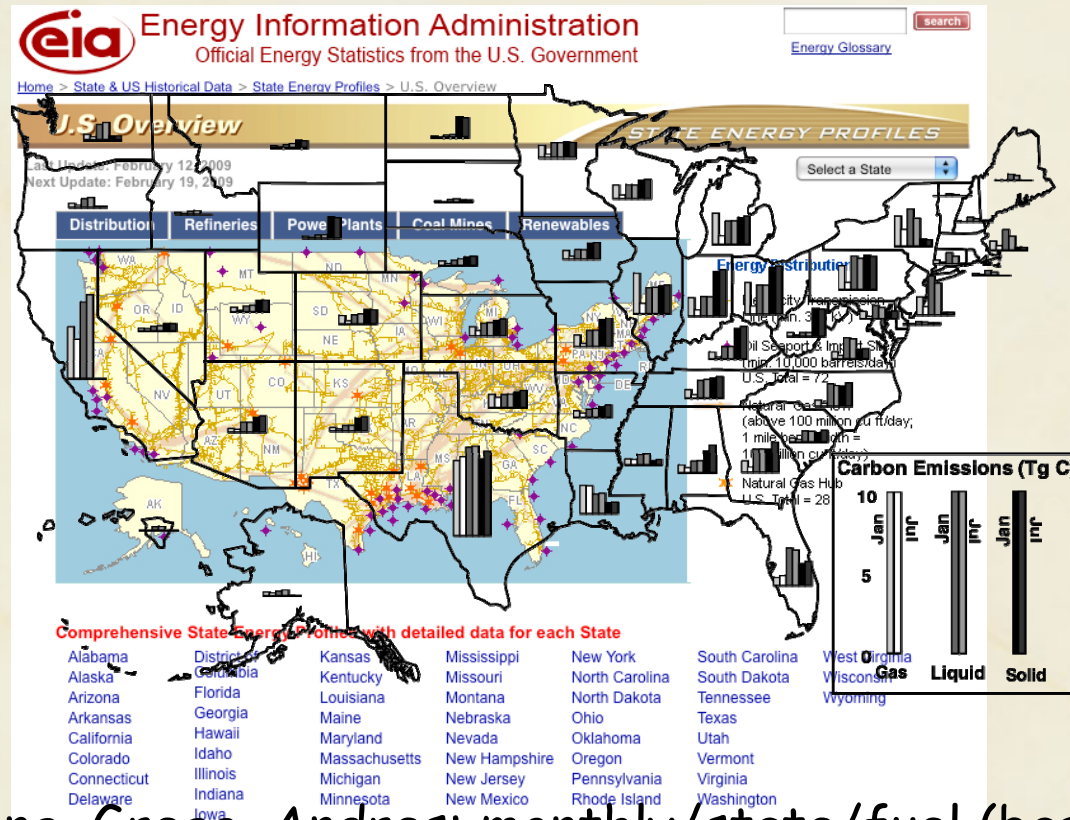


Courtesy of Kevin Gurney and the Vulcan Project (credit: C.C. Miller), Purdue University
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DOE et al. United States estimates

EIA State Energy Data System: ~supply-based. Annual state/fuel/sector CO₂ emissions



Gregg & Andres, 2008

Blasing, Gregg, Andres: monthly/state/fuel (based on DOE/EIA data)



Scope

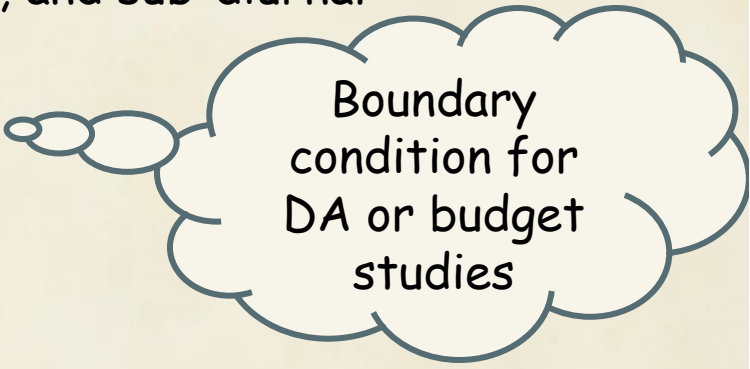
Initial *operational* goals:

Achieve fossil fuel C emissions (CO_2 , CH_4 , CO) for North America at scales that are <50 km, and sub-diurnal

Multiple years

As close to real-time as possible

Data driven, include isotopes



Boundary
condition for
DA or budget
studies

Added value results:

FF-specific diagnosis, attribution, prediction, decision support

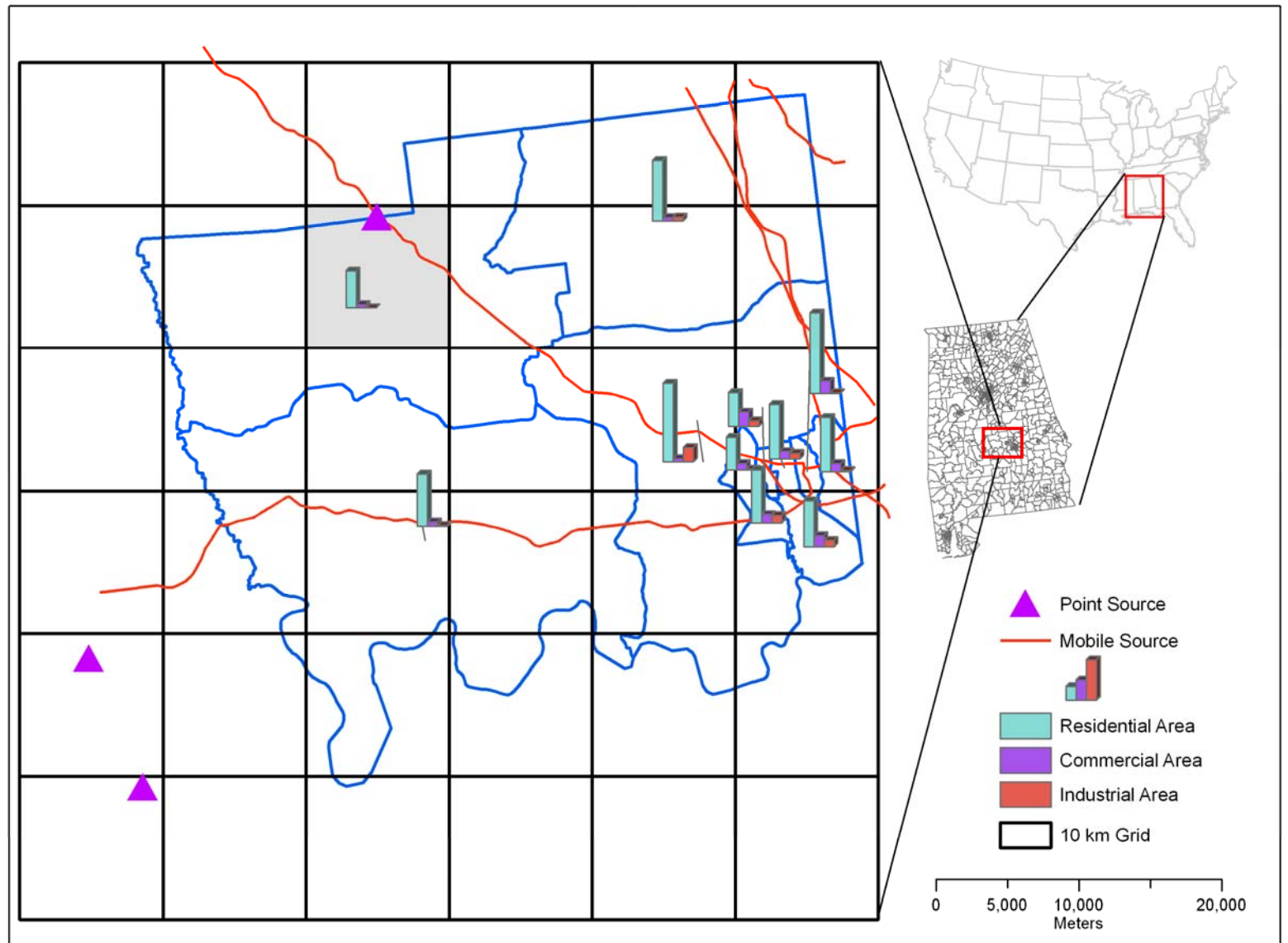
Powerful linkage to human dimensions

Powerful outreach tool with multiple meanings and value

To do this:

Process-based model/data product (analogue to TBM development)..... Energy, economics, demography, sociology
move beyond "inventory"

Vulcan Methods

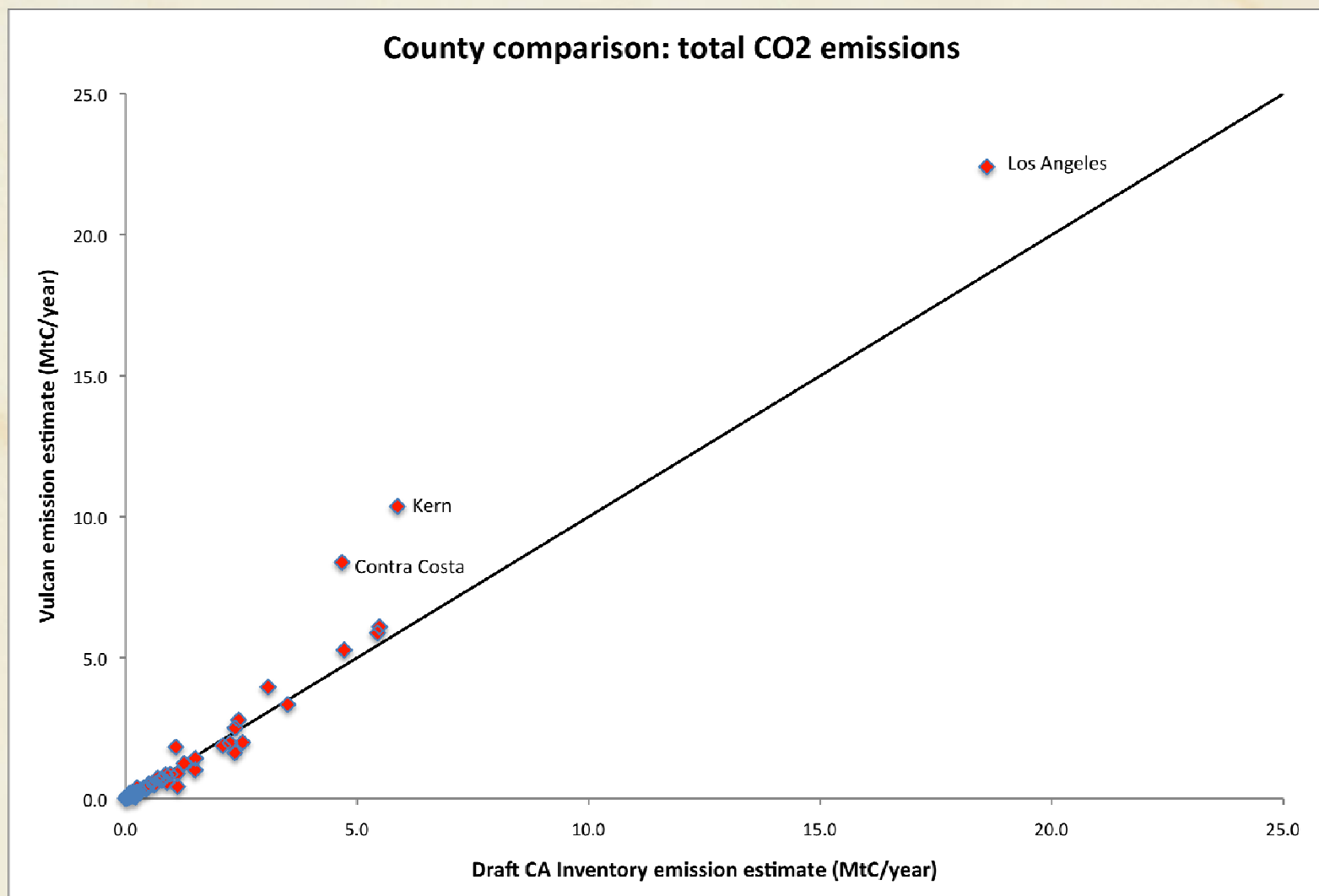


Hestia



www.purdue.edu/climate/hestia

Evaluation: CA data (preliminary)





Methods: key details

Emissions data sources:

- National emissions inventory (**NEI**) for CO/NO_x
 - Strengths (process, points, fuel)
 - Weaknesses (area estimated, limited QA/QC)
- **CEMS** for power production: CO₂ direct, hourly
- NMIM **NCD** for onroad (VMT, fleet, efficiency, speed)

Spatial:

- Area (resid/comm) at county/annual/fuel/process, downscale w/ **US census/FEMA data**
- Onroad is month/county/road/vehicle/fuel, downscale w/ **GIS road atlas**

Temporal:

- Electricity production - provided (acid rain leg)
- Onroad downscale by **WIM** studies & **traffic monitoring**
- Res/Com/Ind: **EIA** state level, **building model/Temp**

QA/QC:

- big offenders corrected, but **more to do**.



Vulcan/Hestia Long-term plans

- Hestia across US
- **Connect** supply (production) with demand (combustion) in explicit, process-driven manner.
 - Electricity grid, pipeline system, geosequestration
- **Web 2.0** concept: interactive platform
 - Public, local managers/knowledge feeds directly into "system"
 - Powerful engagement
- Move towards **urban-scale process model** that allows for scenario building



Near-term plans

No funding needed:

- Refine, improve, assess
- Canada & Mexico & thorough uncertainty analysis
- Analysis/evaluation via atmospheric measurements (^{14}C , CO)
- Nonroad spatial allocation (rail, CMV)
- Mining local knowledge
- Cement module

Pending proposals:

- Socio-economic analysis
- 1980 to 6 months behind real time (Google)

Nearing proposal submission:

- Global version: combine data assim, European highres, nightlights
- Interactive - what if? Capability (NSF DMUU)
- Improved web-serving



Emerging Policy Context

EPA proposed rule aimed at cap and trade

- > 25 ktonnes CO_2 eq across subset - gets to ~50% of GHG

We will ingest, compare, evaluate, place in time

- All fuel supply (not emission!) - gets to 85-90% of GHG

Without space/time, cannot utilize atmos measurements

We must build supply/demand relationships (process!)

A Bigger Vision

operational

lifecycle climate driver system

.....Near real time realization of all climate drivers
and their upstream dynamics (EPA, DOE, NOAA...)

- Interactive, online, intelligent
- Cradle to grave on drivers
- Scenario capability
- All climate drivers
- Multi-tiered sensors (eg: gas, elec remote)
- Atmosphere integrating measurements
- Google Earth ('ish) platform
- multiple data streams, realtime feeds
- industry, science, policy, public, air quality

incubator

Research feeds from academia et al., (NASA, NSF, NOAA...)

- Energy/emissions
- Production emissions
- Land-surface
- Atmospheric measurements
- Remote sensing
- *In situ* sensor development