Advancing Urban GHG Inventory Development for Science and Mitigation Management Needs

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Setup

- Urban-scale GHG inventories continue to increase in importance
- Part of scientific research (in many areas/disciplines)
- Part of practical policy implementation and guidance
- There are multiple communities engaged in urban-scale inventory development and application (engineering, public policy, carbon science, urban science, economics)
- They have different goals, methods, needs

- However, to optimize use for both science and policy and to progress as a more integrated community, there may be an opportunity for an improved framework. To do that we need to first assess what we have, what we don't, what the challenges are, what the opportunities are.

Goals

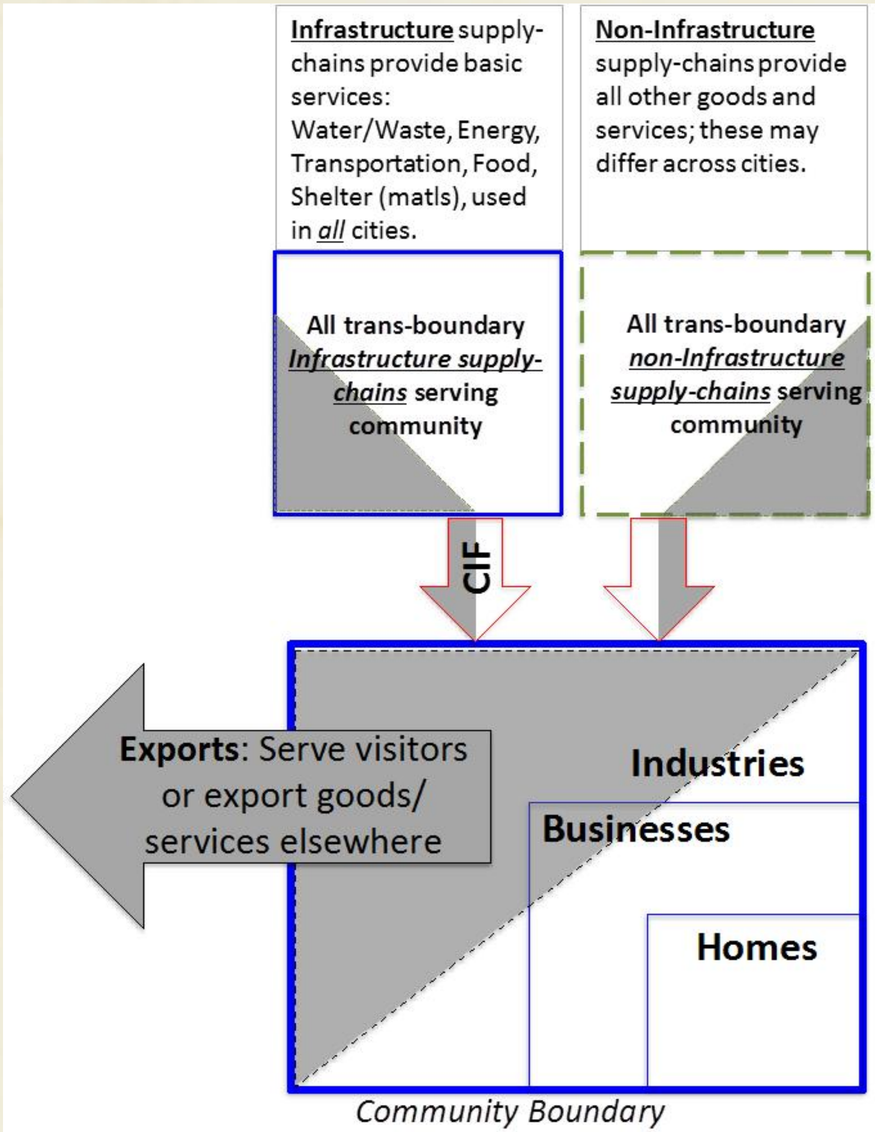
Workshop started us down path towards:

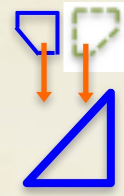
Goal 1: Identifying tools, data products, and information systems

Goal 2: Achieving comparability and consistency/uniformity

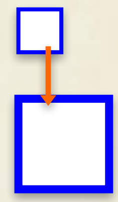
Goal 3: Specifying data needs and data opportunities

Inventory perspectives

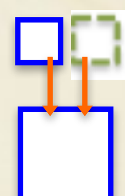




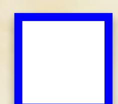
Consumption-Based Footprint (CBF) is represented by only areas in WHITE.



Community-Wide Infrastructure Footprint (CIF) is represented by the territorial GHGs plus GHGs in all trans-boundary infrastructure supply-chains.



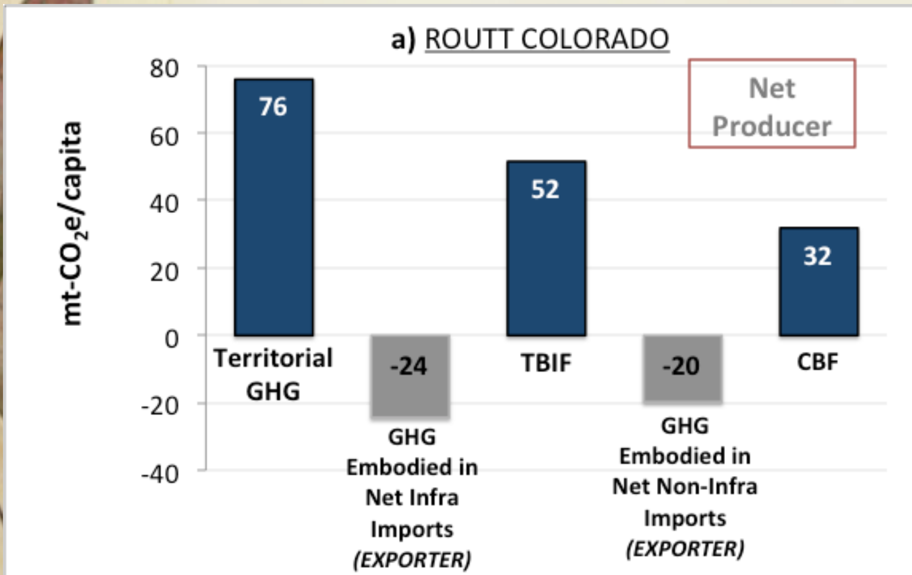
Total Footprint = Territorial plus all Trans-Boundary Supply-Chains.

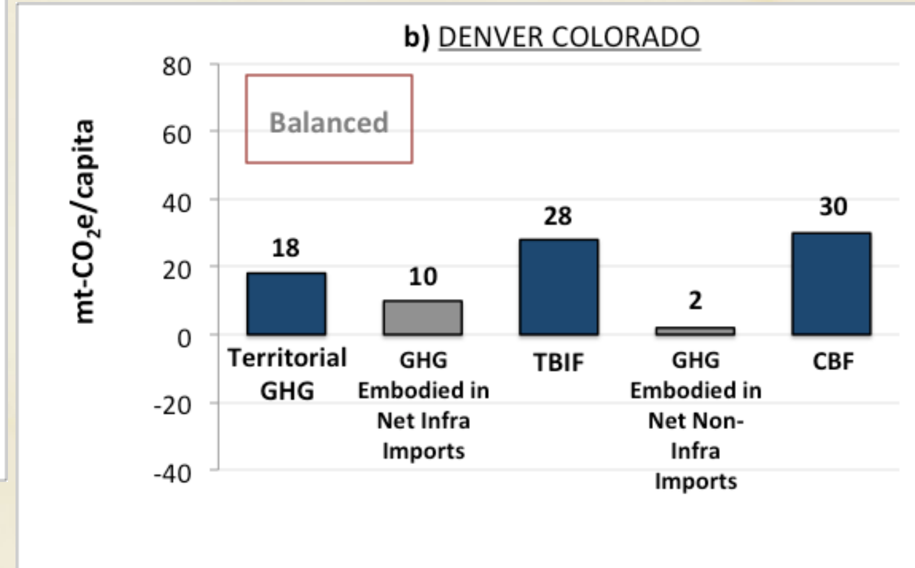


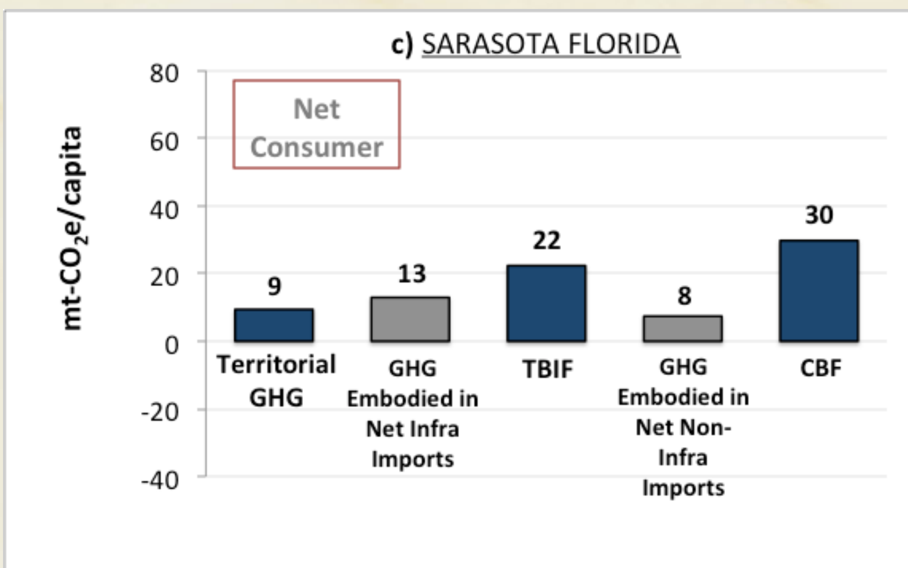
In-Boundary (IB) represents GHGs within the community boundary.

Source: *Chavez & Ramaswami (2013)*

Inventory perspectives

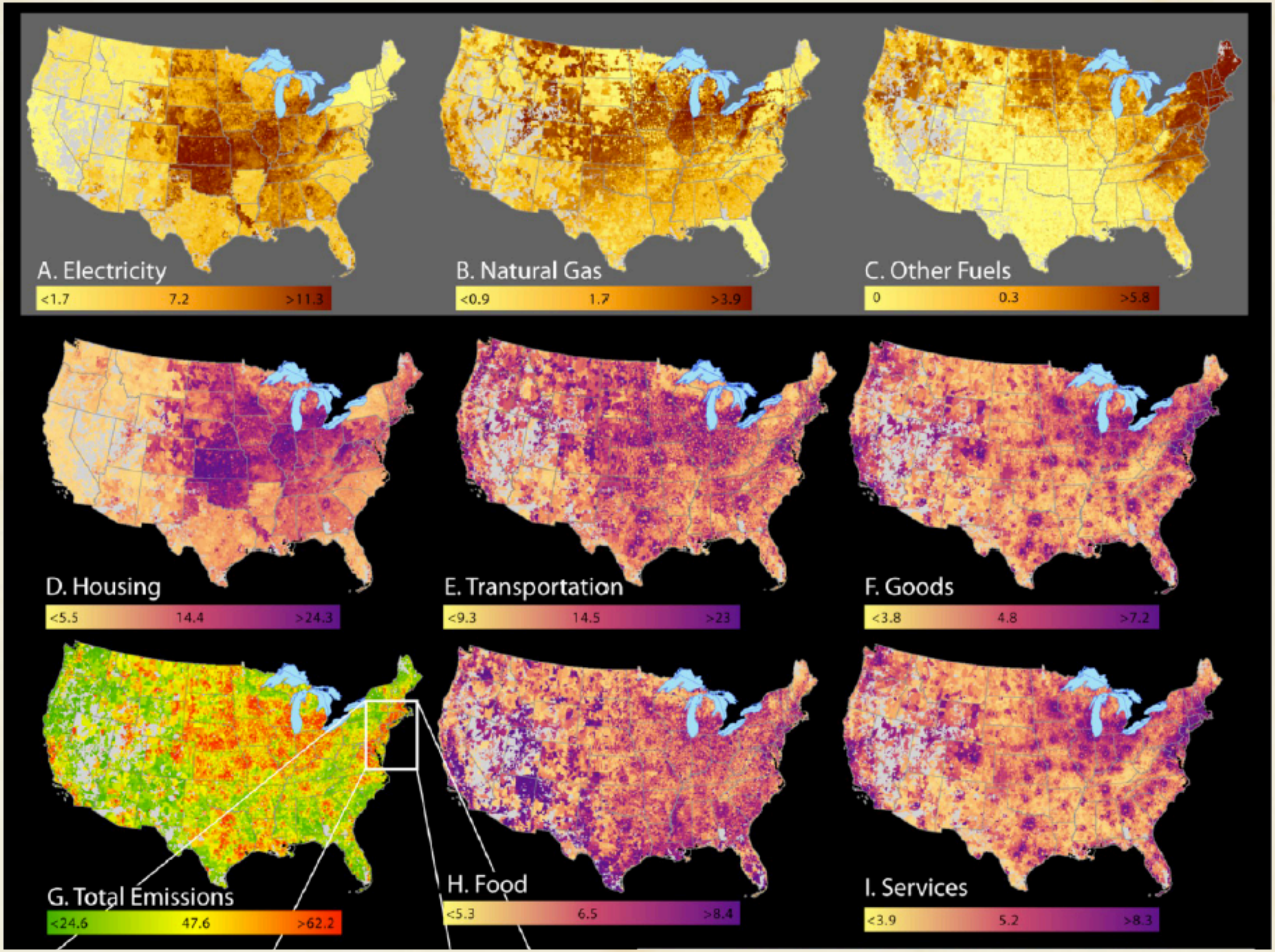






Source: *Chavez & Ramaswami (2013)*

Spatially-explicit consumption inventory



Jones & Kammen, 2014

Spatially-explicit consumption inventory

Methodologically different from the solely “scope 1” inventories

Primarily driven by MV regression from socioeconomics (which economists typically refer to as “top-down”)

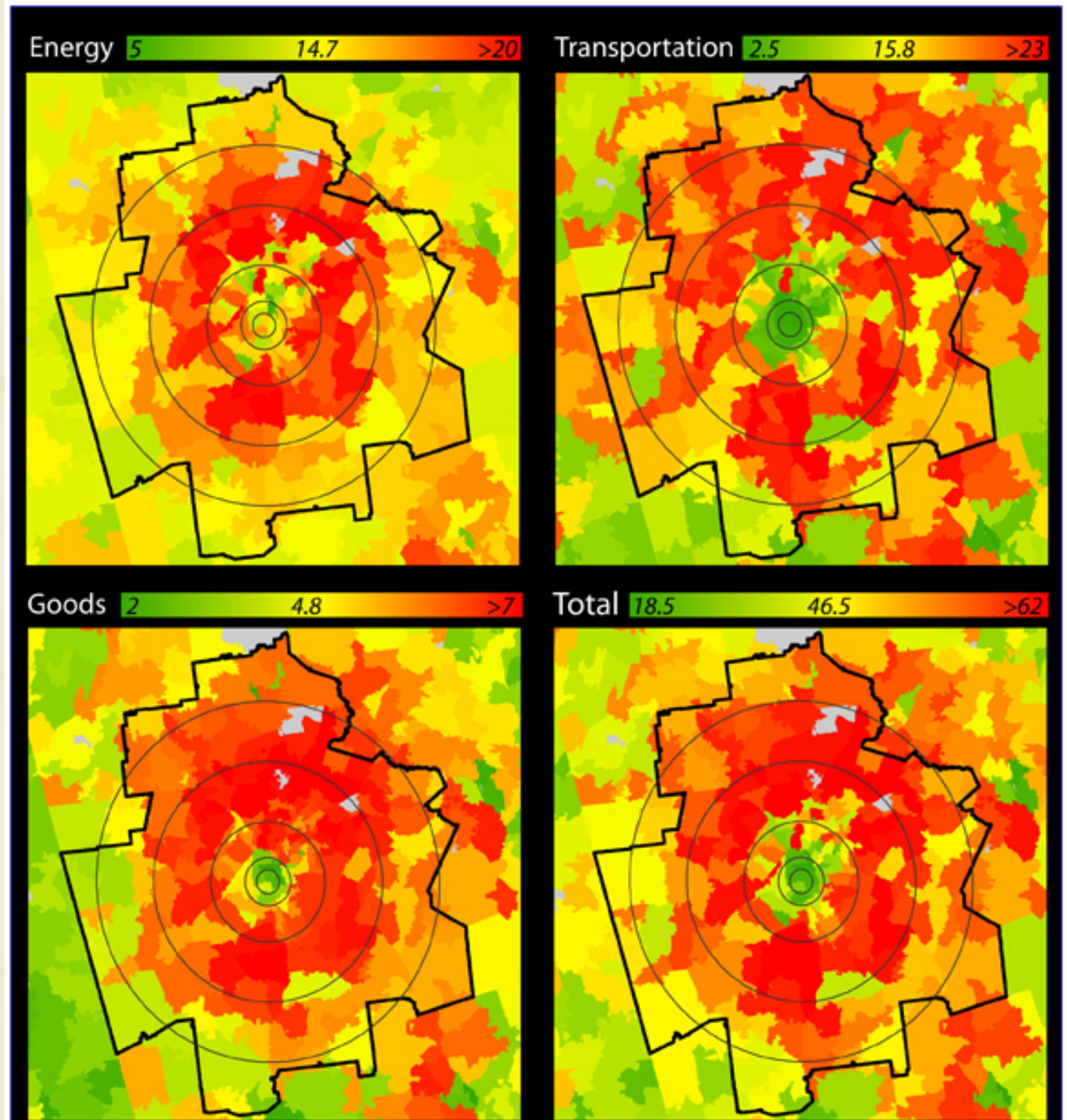
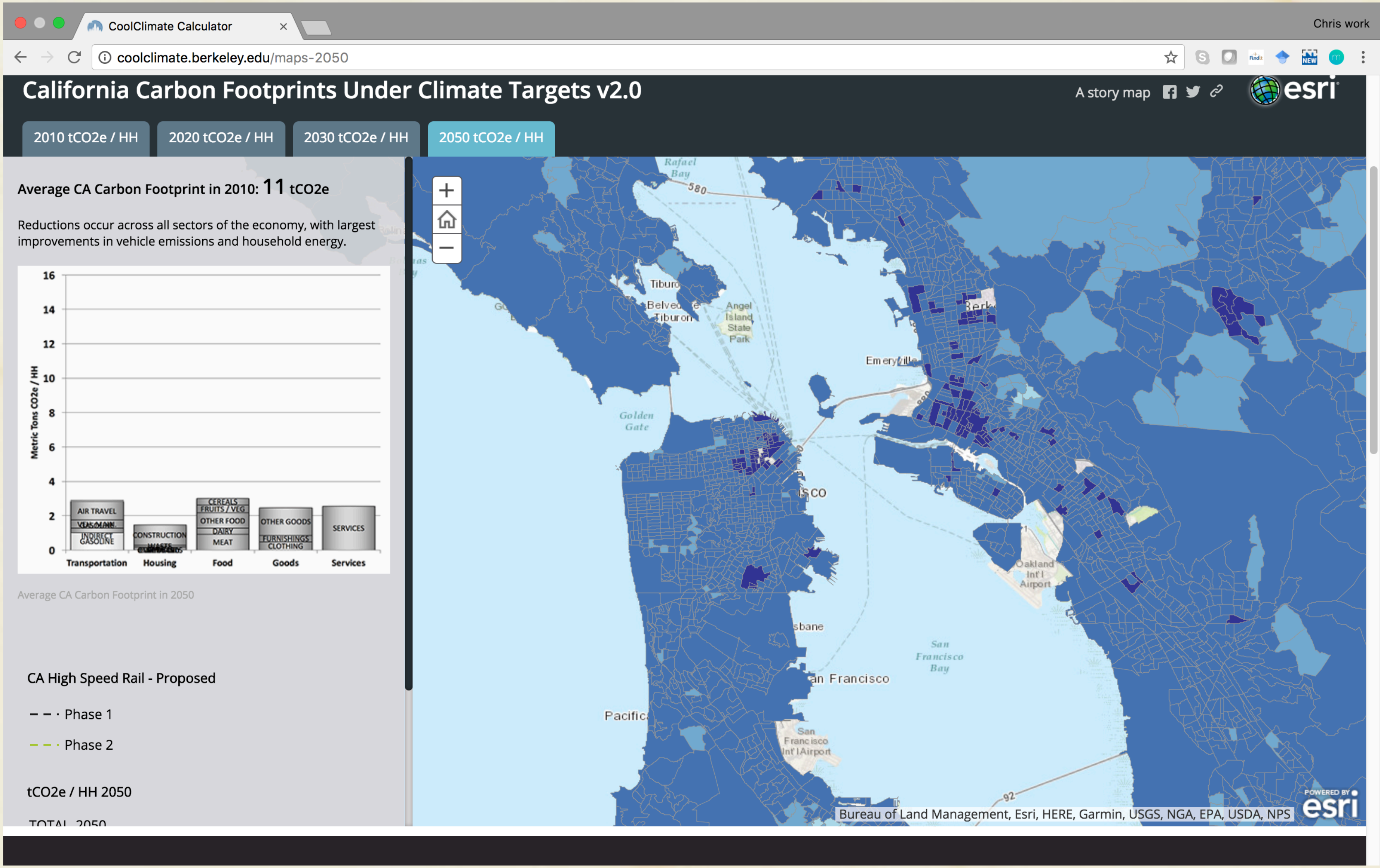


Figure 3: Household Carbon Footprints, Atlanta Metropolitan Statistical Area

Jones & Kammen, 2014

Spatially-explicit consumption inventory

Interactive carbon footprint mapping tool for California 2010-2050



Courtesy: Chris Jones

Lessons from international urban inventories

	SCOPE	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6s	**TOTAL**
GWP		(1)	(21)	(310)				
Units		kt CO_2 e.	kt CO_2 e.	kt CO_2 e.	kt CO_2 e.	kt CO_2 e.	kt CO_2 e.	kt CO_2 e.
ENERGY								
a) Stationary Combustion								
Electricity (incl. T&D losses)[i]	1,2,3	3,758	2.37	6.15	ND	ND	ND	3,766
District energy and CHP	1,2	ND	ND	ND	ND	ND	ND	ND
Energy from waste	1	ND	ND	ND	ND	ND	ND	ND
Commercial & Institutional[ii]	1	517	1.39	1.15	ND	ND	ND	520
Residential	1							
Manufacturing Industries & Construction	1	1,005	0.82	2.43	ND	ND	ND	1,008
Other[iii]	1	61.2	0.13	0.69	ND	ND	ND	61.4
b) Mobile Combustion					ND	ND	ND	
Road transportation: LDVs[iv]	1	**2,821**	**12.2**	**73.3**	**ND**	**ND**	**ND**	**2,906**
Road transportation: trucks	1							
Railways	1	ND	ND	ND	ND	ND	ND	ND
Domestic aviation[v]	3	**908.7**	**0.13**	**7.88**	**ND**	**ND**	**ND**	**916.7**
International aviation	3							
Domestic marine[vi]	3	**65.4**	**0.11**	**0.64**	**ND**	**ND**	**ND**	**66.1**
International marine	3							
Other	1	ND	ND	ND	ND	ND	ND	ND
c) Fugitive Sources		ND	ND	ND	ND	ND	ND	ND
INDUSTRIAL PROCESSES								
Mineral industry[vii]	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Chemical industry	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Metal industry	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Electronics industry	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Other	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Solvent and product use	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
AFOLU	1	ND	ND	ND	ND	ND	ND	ND
WASTE								
Solid waste disposal on land	1,3	Neg.	1,012	Neg.	ND	ND	ND	1,012
Wastewater handling	1,3	ND	ND	ND	ND	ND	ND	ND
Waste incineration	1,3	ND	ND	ND	ND	ND	ND	ND
TOTAL		**9,136**	**1,029**	**92.2**	**ND**	**ND**	**ND**	**10,256**

	Activity Data			**Emissions Factor**			**Total GHGs**
	Value	**Units**	**Tier**	**Value**	**Units**	**Tier**	**t CO_2 e**
ENERGY[i]							
Electricity (on-site renewable)[ii]	ND	GWh	N/A	ND	t CO_2 e / GWh	N/A	ND
Electricity (grid)[iii]	6270	GWh	1	601	t CO_2 e / GWh	1	3,766,275
Diesel Oil	26,221	TJ	1	75.1	t CO_2 e / TJ	1	1,970,361
Fuel Oil	10,820	TJ	1	77.6	t CO_2 e / TJ	1	840,136
Gasoline	20,187	TJ	1	72.3	t CO_2 e / TJ	1	1,459,614
Jet Kerosene	12,709	TJ	1	72.1	t CO_2 e / TJ	1	916,693
Kerosene	1,640	TJ	1	72.3	t CO_2 e / TJ	1	118,534
LPG	1,910	TJ	1	63.2	t CO_2 e / TJ	1	120,784
Marine Fuel Oil	668	TJ	1	78.2	t CO_2 e / TJ	1	52,209
INDUSTRIAL PROCESSES[iv]	Neg.	kt		Neg.	t CO_2 e / kt		Neg.
WASTE							
Solid waste disposal on land	669.3	kt	1	1.512	t CO_2 e / t	2	1,011,953
Wastewater handling	ND	kt BOD		ND	t CO_2 e / kt BOD		ND
Waste incineration	ND	kt		ND	t CO_2 e / kt		ND
AFOLU	ND			ND			ND

Local presence best for data collection

- University, source inside the local government, dedicated consultant/graduate student

Incentives for city officials must be clear

- Access to finance, city-to-city competition, PR/marketing, meeting carbon reduction goals

Conforming to a standard is difficult

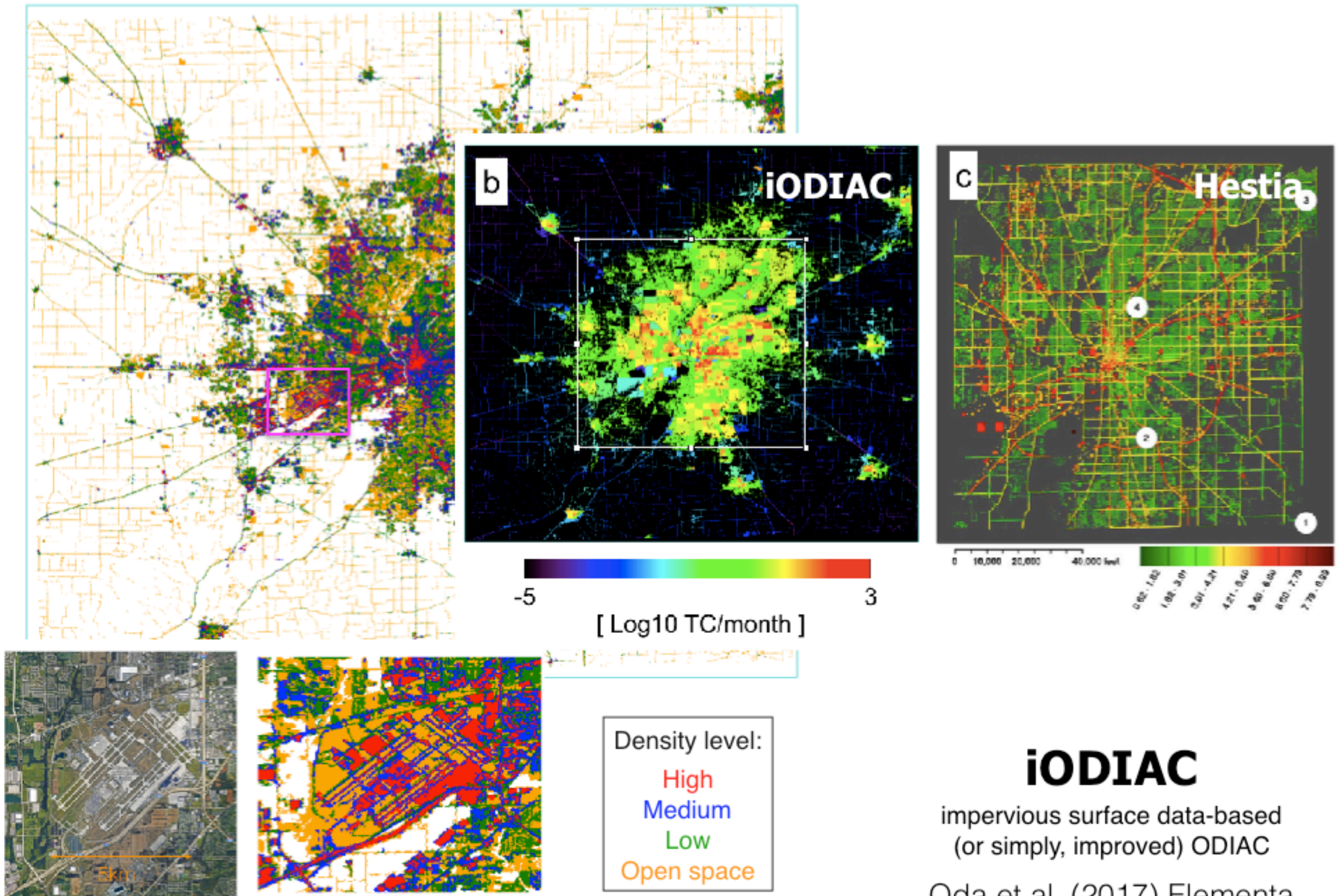
- Great in theory for cross-city or temporal comparisons, data availability and collection methods vary between cities and over time

Consumption-based inventories make options for emissions reduction (and financing) tangible

Courtesy L. Sugar

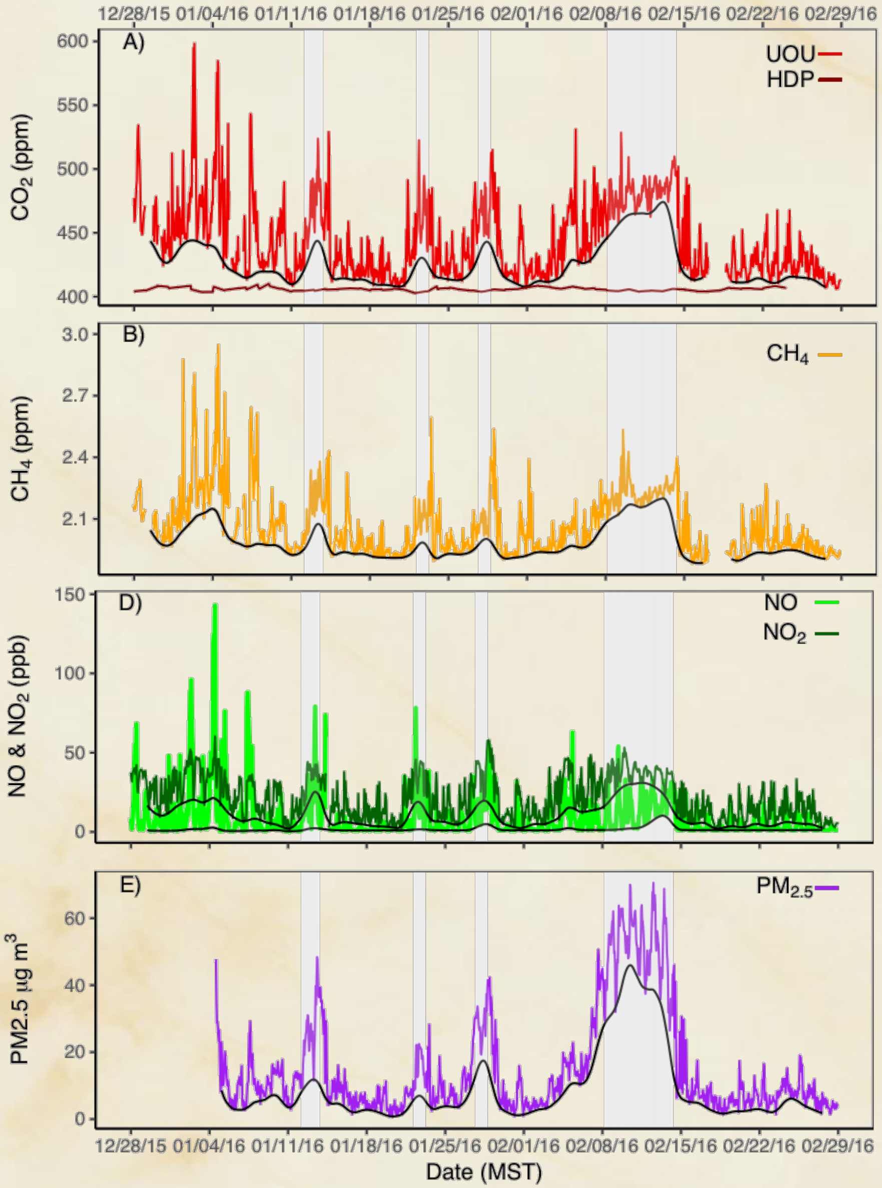
Use of remote-sensing

Local reported EI + Remote sensing data?



Ongoing urban intensives: SLC

Time Series on Univ. of Utah Campus of CO_2 and Criteria Pollutants

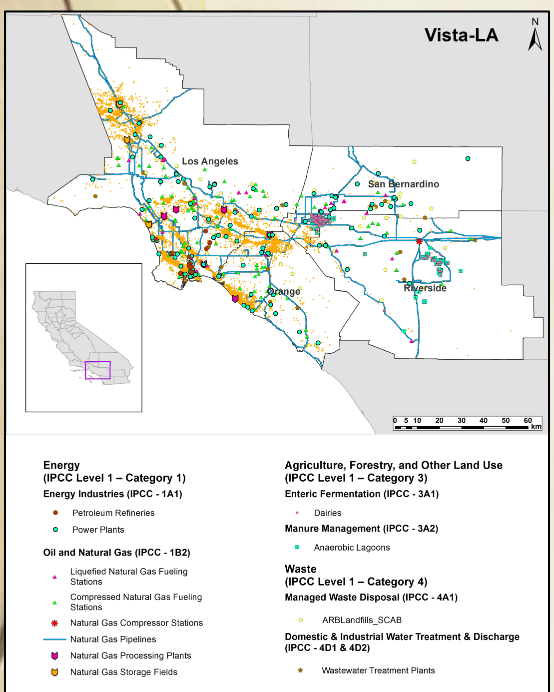


(Bares et al., In Preparation)

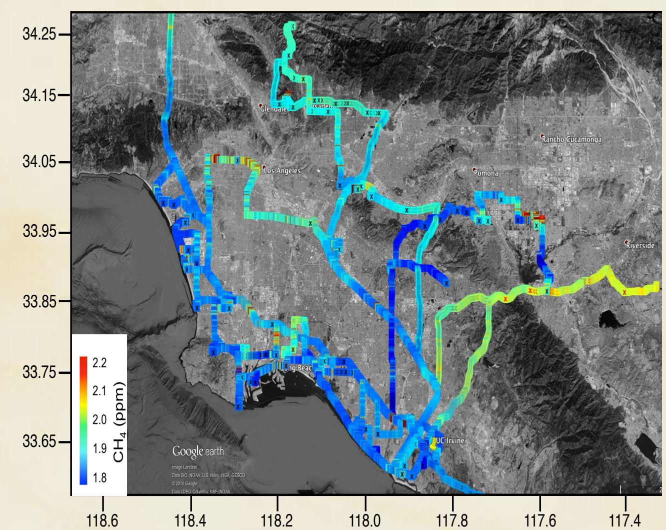
Ongoing Urban Intensives: LA & CH_4

- CH_4 signal in integrated urban air masses exceeds inventory (CH_4/CO, CH_4/CO_2)
- Source apportionment: more ff derived CH_4 than in inventory
- CH_4 hotspots are ubiquitous, some from uninventoried sources

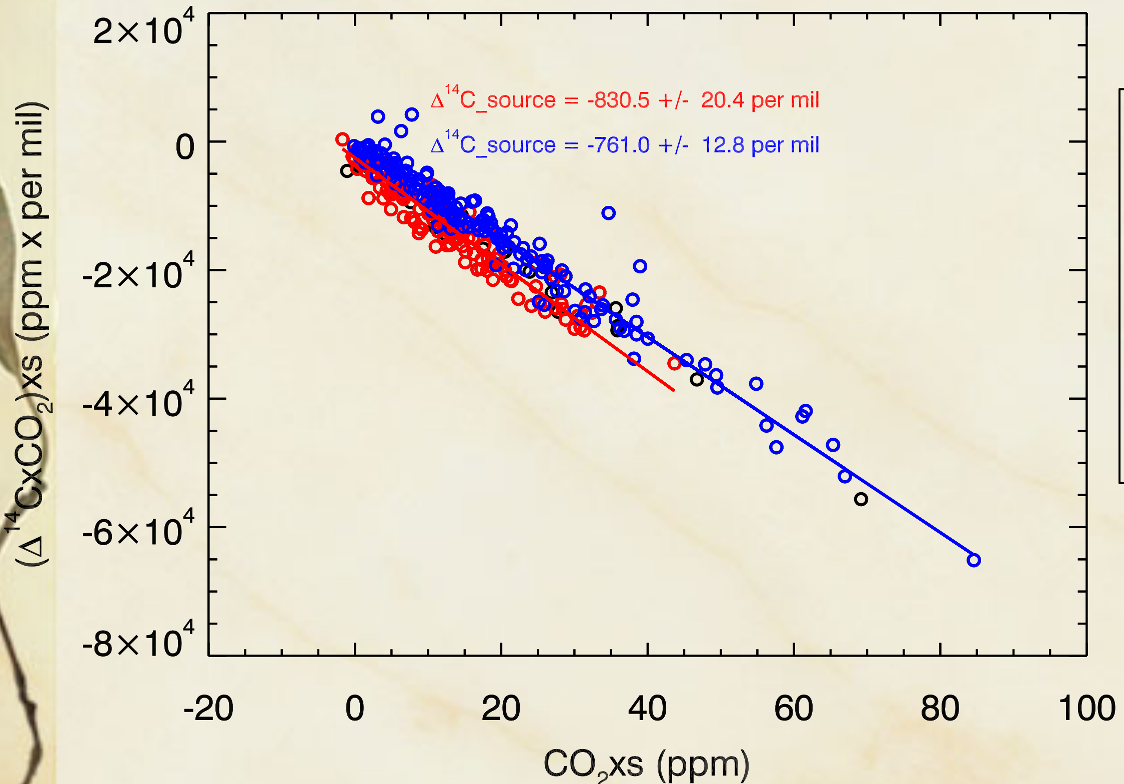
Hopkins et al., *J. Geophys. Res.*, 2016



Most CH_4 hotspots of unknown origin are from fossil sources



Ongoing Urban Initiatives – LA & bio



Why is CO_2bio so high?

- Ethanol in gasoline (~ 3 %)
- Human Respiration (~ 5 %)
- Urban ecosystems 10-15%: parks, lawns, golf courses, etc. ?

Winter: -760 per mil → CO_2xs is 24% biogenic

Summer: -830 per mil → CO_2xs is 17% biogenic

Courtesy: John Miller

Ongoing urban intensives: Boston & bio

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Soil respiration contributes substantially to urban carbon fluxes in the greater Boston area☆

Stephen M. Decina [a, *], Lucy R. Hutyra [b], Conor K. Gately [b], Jackie M. Getson [b], Andrew B. Reinmann [b], Anne G. Short Gianotti [b], Pamela H. Templer [a]

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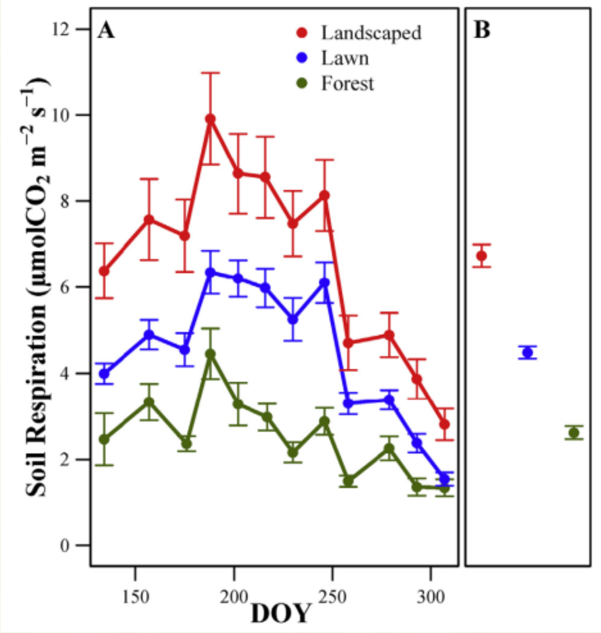
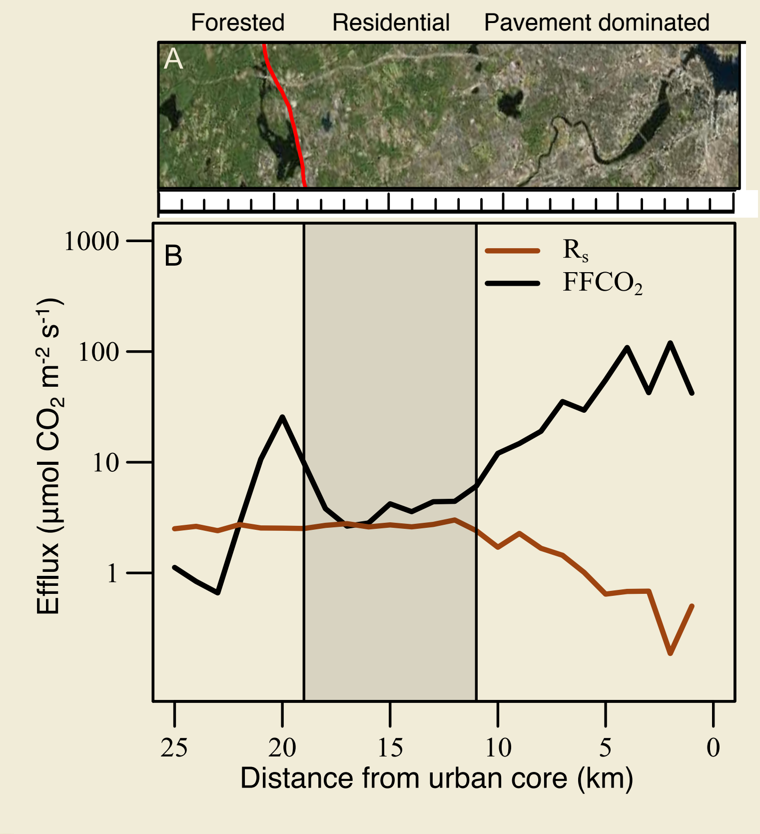
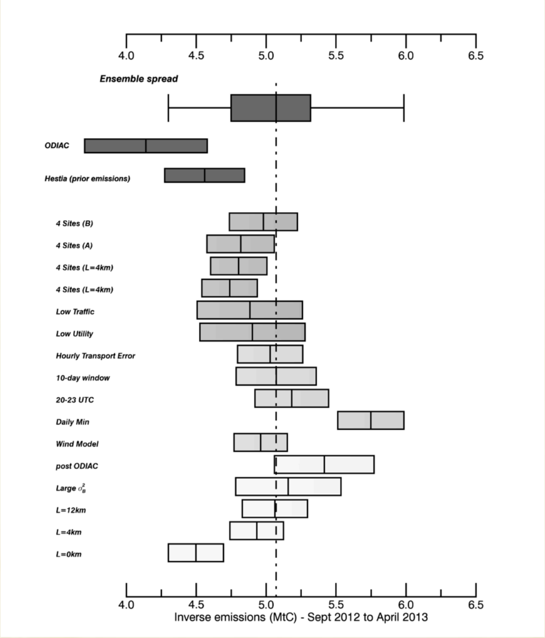


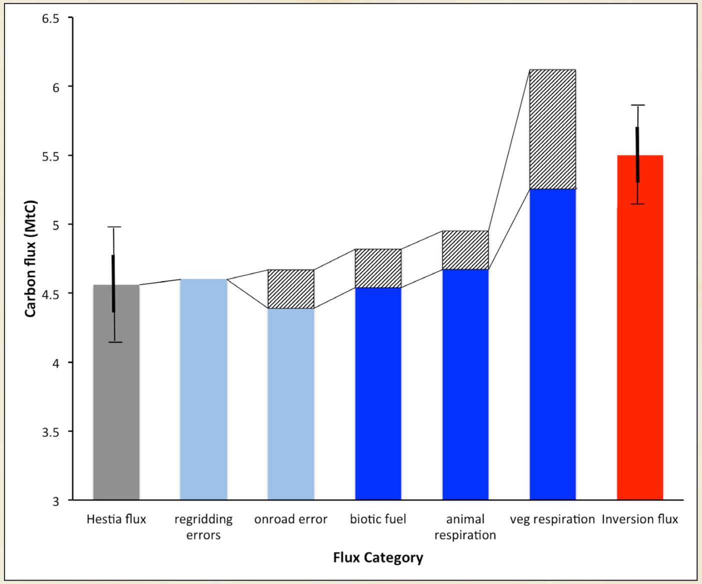


INFLUX and reconciliation

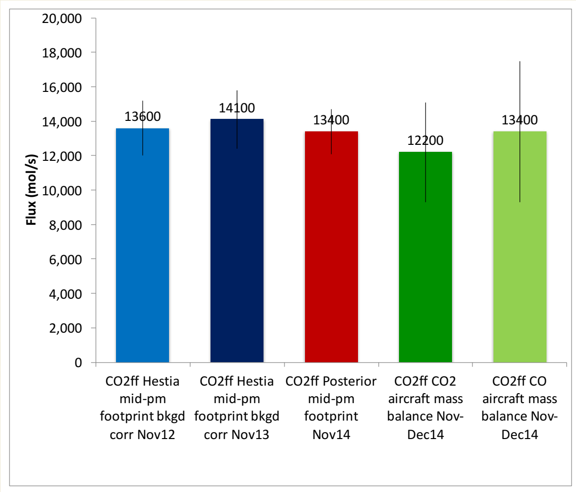
INFLUX: Whole-city emissions for 2012-2013



Lauvaux et al., 2016

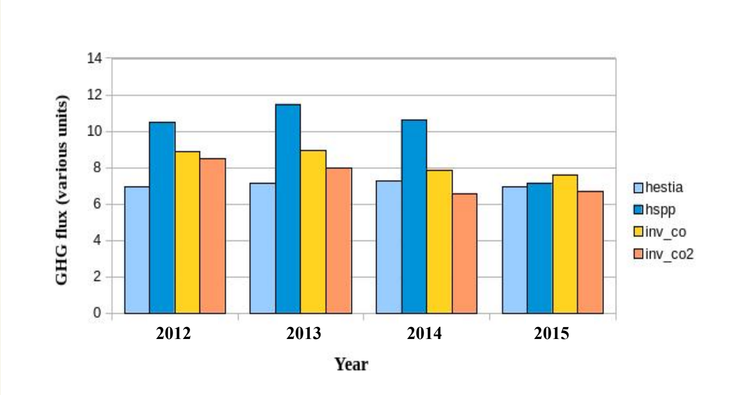


Gurney et al., 2017



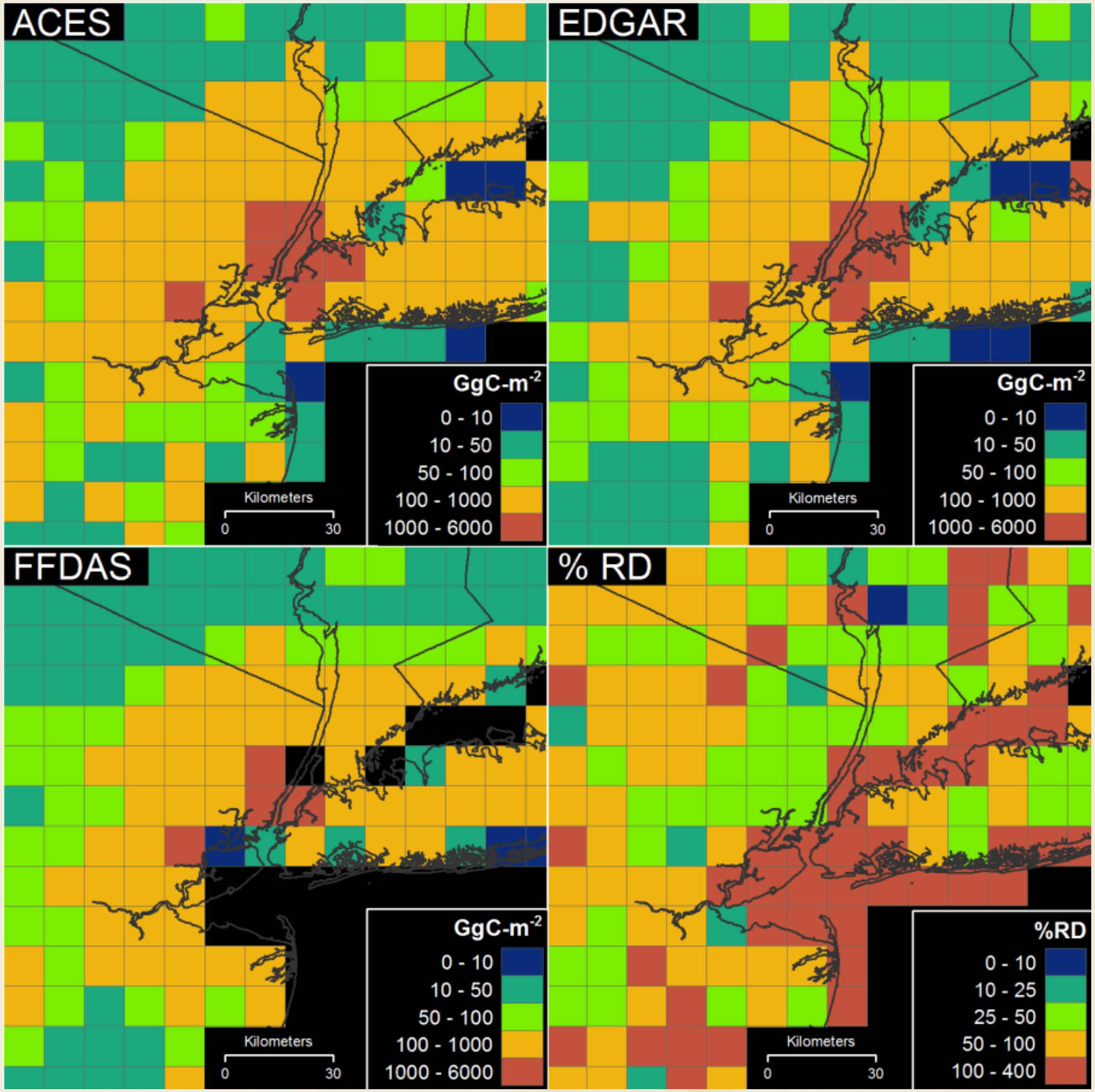
Turnbull et al., in prep

Comparison of CO_2 urban emissions from the Indianapolis area Over 2012-2015 to Hestia



Different inter-annual variability across methodologies but similar 4-year trend

Intercomparisons just starting



Gately and Hutyra (in review)

Existing stakeholder services: ICLEI

- **Global network of 1,500 cities, towns and regions in 108 countries**
- **Expertise** on low-carbon, ecomobility, resource-efficiency, resilience, biodiversity, health, green economy, smart infrastructure, smart city, sustainable procurement
- Provide **policy and technical guidance, tools, peer-learning and exchange** to local and subnational governments
- Through our work we **impact over 25% of the global urban population.**

Courtesy: Sam Yewdall

Stakeholder "matrix"

Level of sophistication of urban stakeholder needs

Complexity of solution

Identify major emitters and anomaly detection	Quantification of total GHG emissions	Assessment of GHG emissions per sector	Tracking annual and long-term emission changes	Understand short-term emission changes and spatial patterns	Process understanding of emissions and tracking of mitigation impacts
Inventory validation (A1)	Inventory or emission model (A2)	Sector-specific inventory or emission model (A3)	Continuously updated inventory or emission model (A4)	Temporally and spatially disaggregated inventory or emission model (A5)	Process-based emission model using real-time emission data
Mobile surveys (B1)	Mass-balance (B2) Radon tracer method (B3)	Multi-tracer ratio observations (B4)	Radon tracer method (B5) Multi-tracer observations (B6)	Mobile surveys (B7) Repeated mass-balance	Dedicated field campaigns (
Remote sensing (C1)	DAS using short-term observations (C2)	*DAS using dense observations(C3)* *DAS using multi-species data*	DAS using long-term observations (C4)	*DAS using dense observations (C5)*	FFDAS DAS using multi-species

Courtesy: Phil DeCola

Summary Themes

There remains apples/oranges in top-down/bottom-up AND across the bottom-up

Very different methods/opportunities/challenges for $FFCO_2$, CH_4, Bio-sourced – criteria AQ linkage remains an opportunity (and a challenge)

We have just begun “intercomparison” (we have enough alternatives to start)

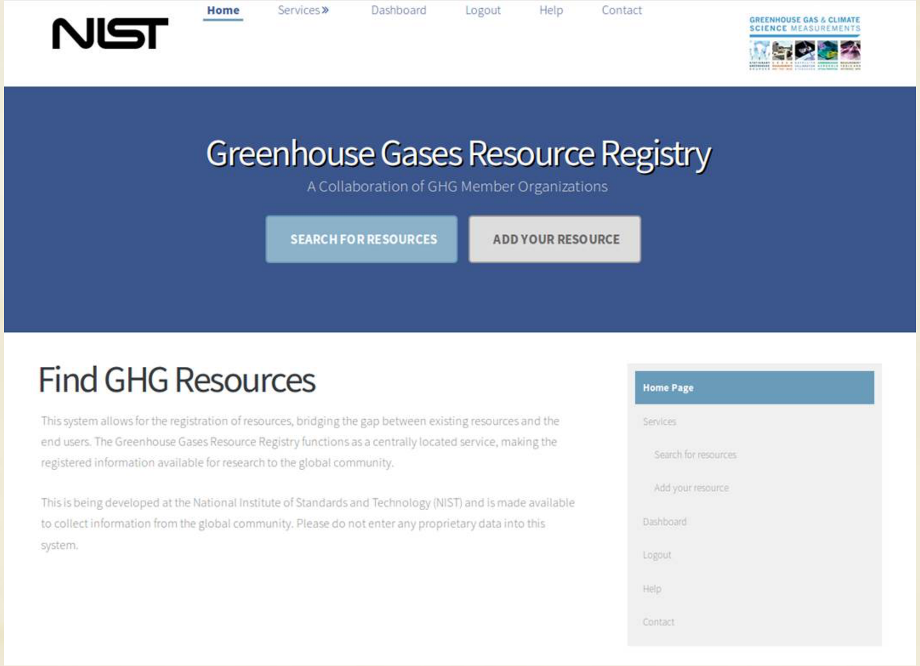
Need lots more “iteration” with stakeholders

We have started on two “action-items”

Action-items

1) Establishment of a registry for inventory results – all scales and methods

- Customizable for the GHG domain
- Can be deployed at different sites
- More tomorrow



2) Dialogue/planning with EPA on generating a spatially-resolved CO2 inventory

We (me) will generate a written report on the findings, consensus, challenges, disagreements etc.