Longitudinal Trends: Cities, Traffic, and CO_2




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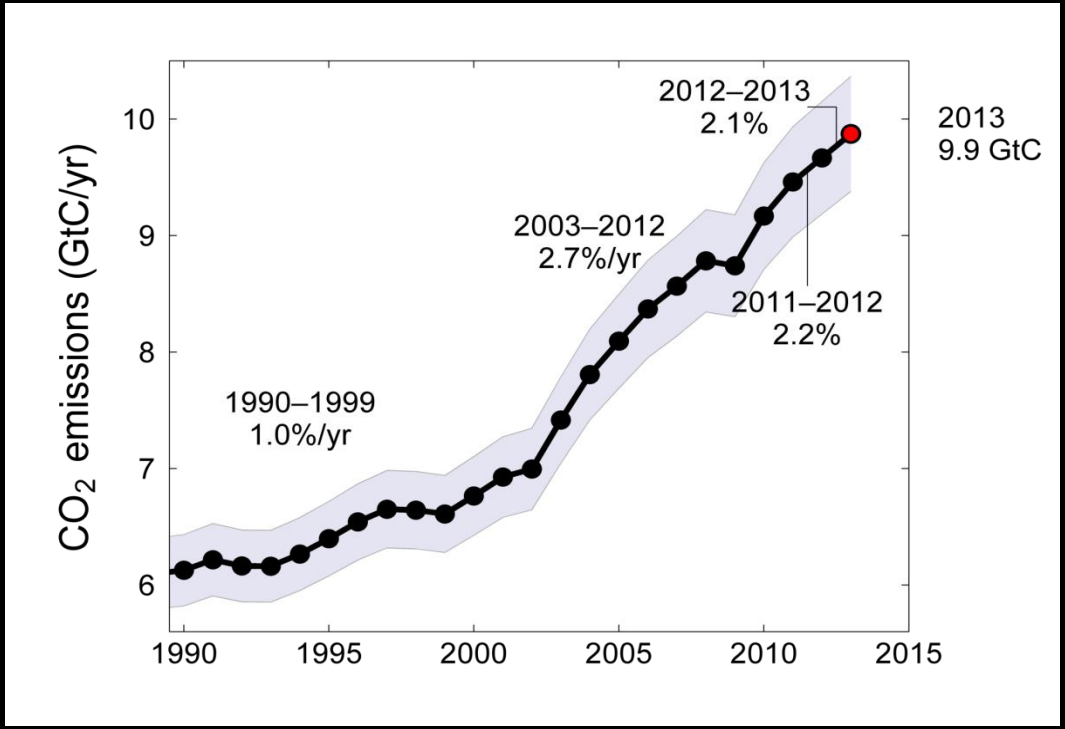
Urbanization and Fossil Fuel Emissions of CO_2

Urban areas are globally important for the carbon cycle

- 70% of energy-related CO_2 emissions
- 3% of global land cover; 50% of the population
- 70% of population forecast to become urban in 2050

Fossil Fuel CO_2 emissions are assumed to be the "best known" components of the global carbon cycle



- Urban emissions are still very uncertain
- Uncertainty is due to the lack of detailed, consistent source data available at regional / local scales
- Urban areas have large, concentrated, and highly variable carbon fluxes, making cities major elements of the carbon cycle
- Potential for cities to serve as "first responders" for climate action.

Le Quere et al. 2012; CDIAC; Global Carbon Project 2013

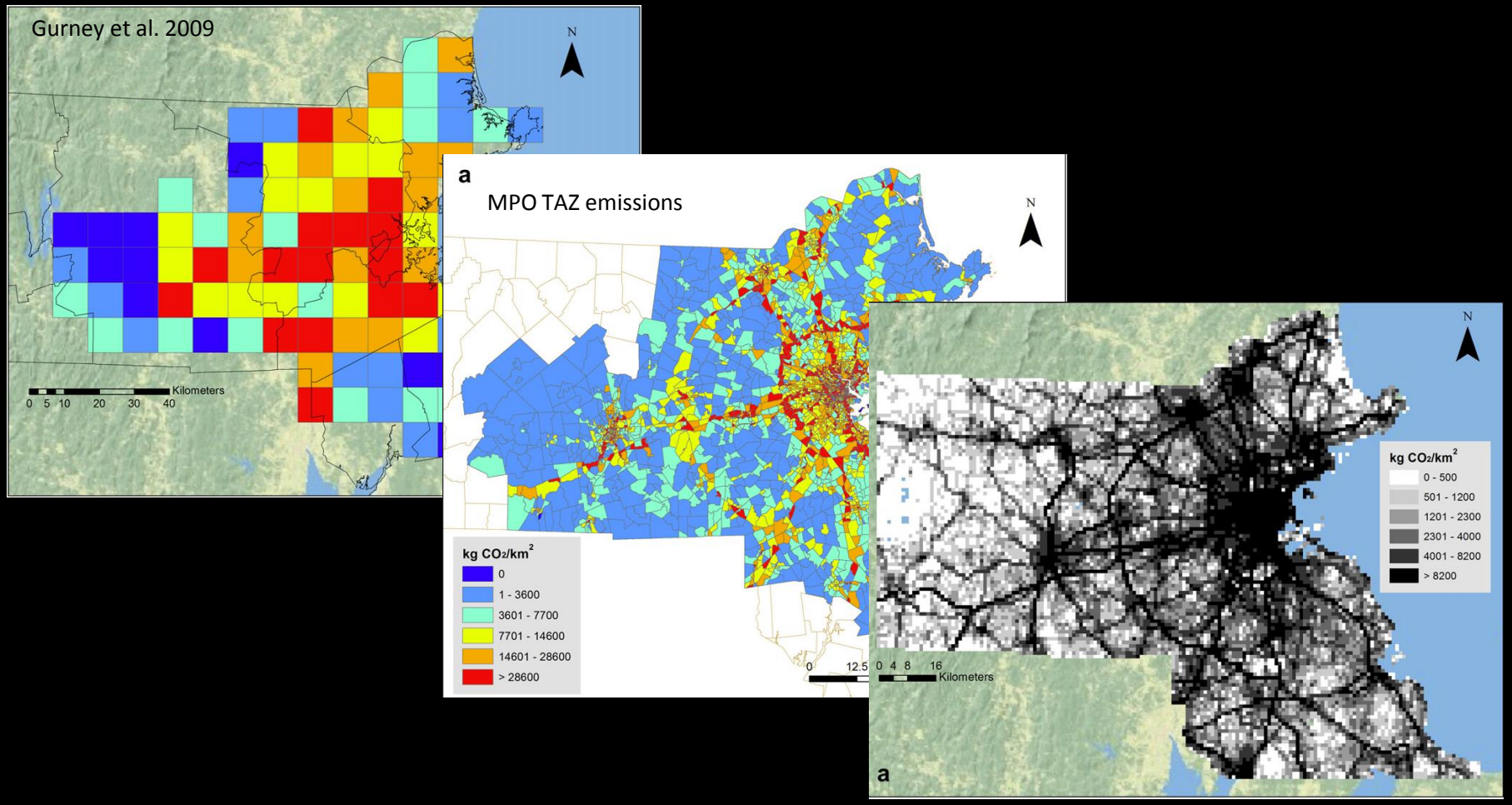
Focus on Regional Emissions Inventories

1. Monitoring, Reporting, and Verification of GHG emissions is largely a bookkeeping exercise at the national scale.
    - Cities and states are at the forefront of policy development to mitigate GHG emissions

2. Accurately forecasting emissions trends requires understanding the processes that drive fossil fuel consumption.
    - Data on emissions need to be at the same scale as covariates

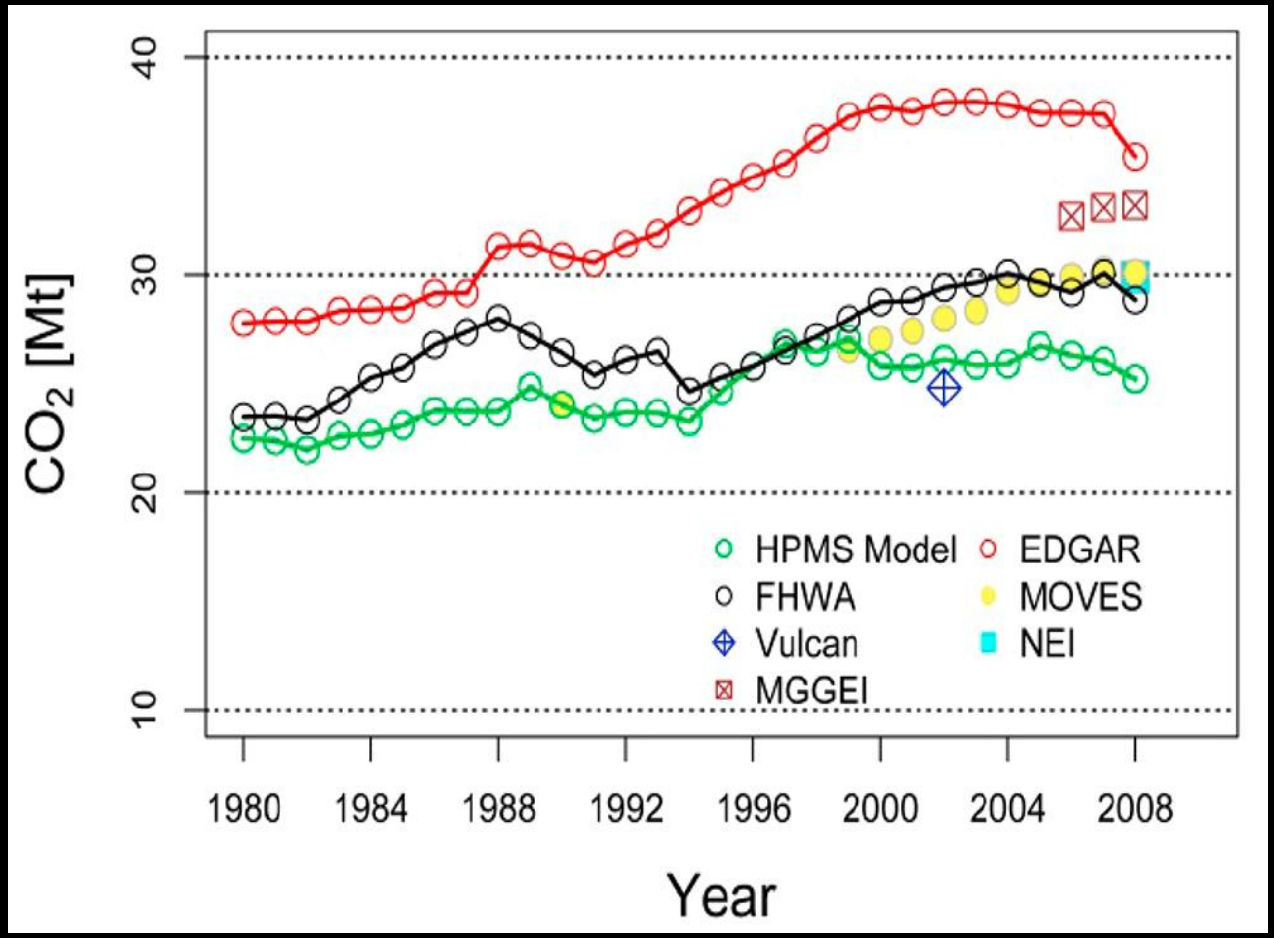
Vehicle Emissions of CO_2

- On-road transportation accounts for 28% of US fossil fuel CO_2 emissions.
- Initial work started with downscaling existing inventories



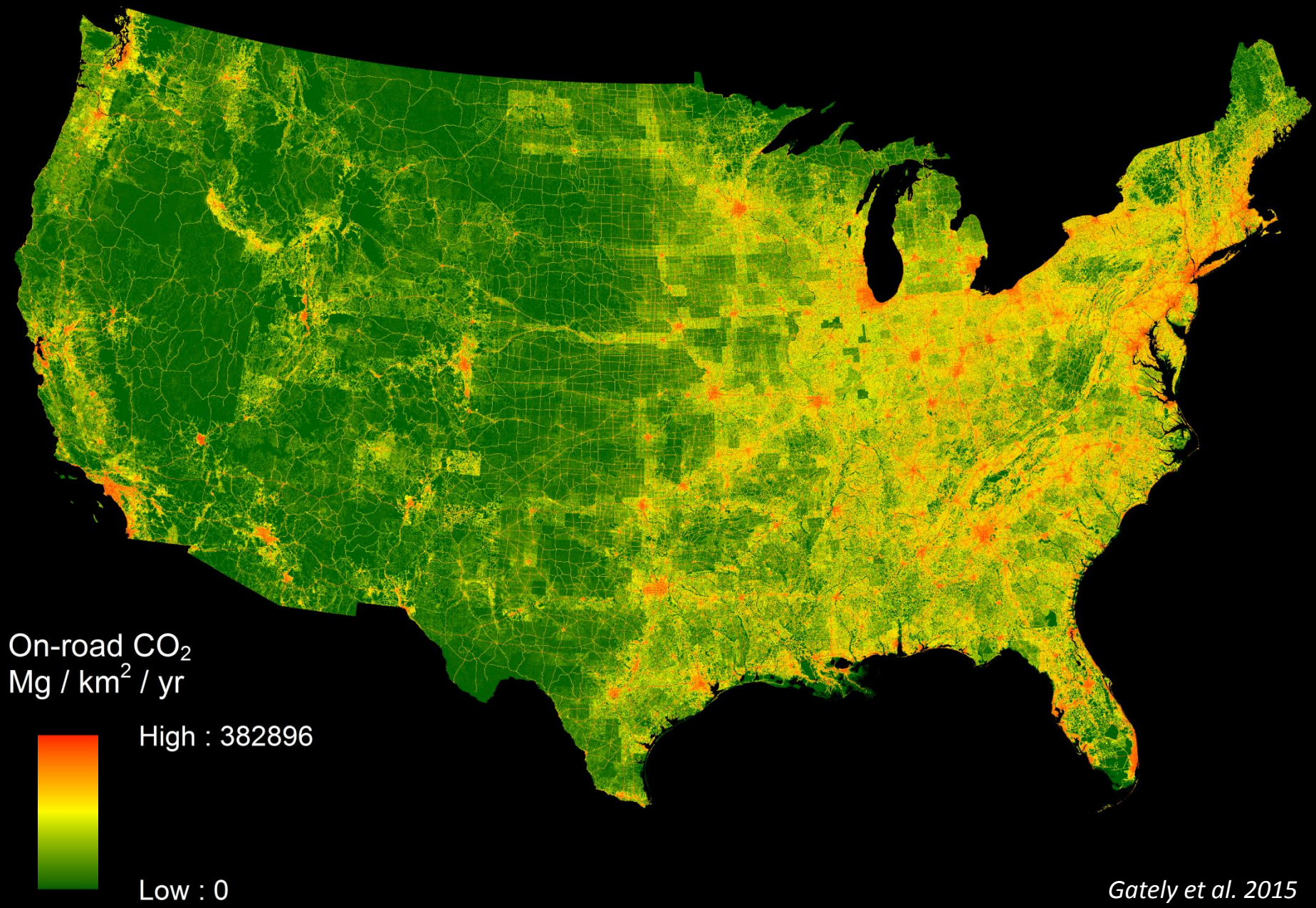
Brondfield MN, Hutyra LR, Gately CK, Raciti SM, and Peterson SA (2012)

Massachusetts Vehicle CO_2 Emissions – 1980 to 2008



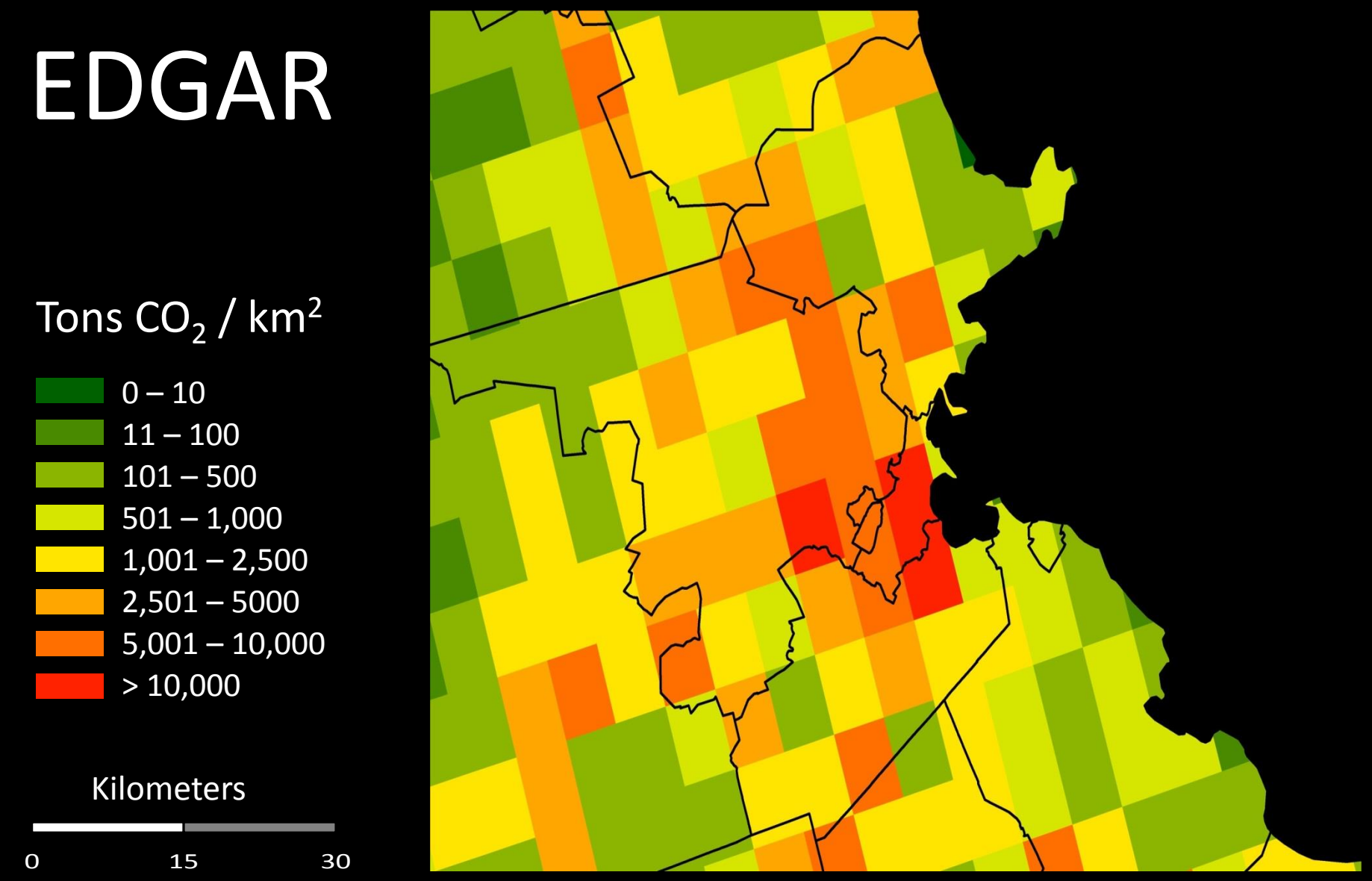
Gately CK, Hutyra LR, and Sue Wing I (2013)

DARTE – Database of Road Transportation Emissions



Gately et al. 2015

EDGAR


Tons CO_2 / km^2
0 – 10
11 – 100
101 – 500
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1,001 – 2,500
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> 10,000
Kilometers
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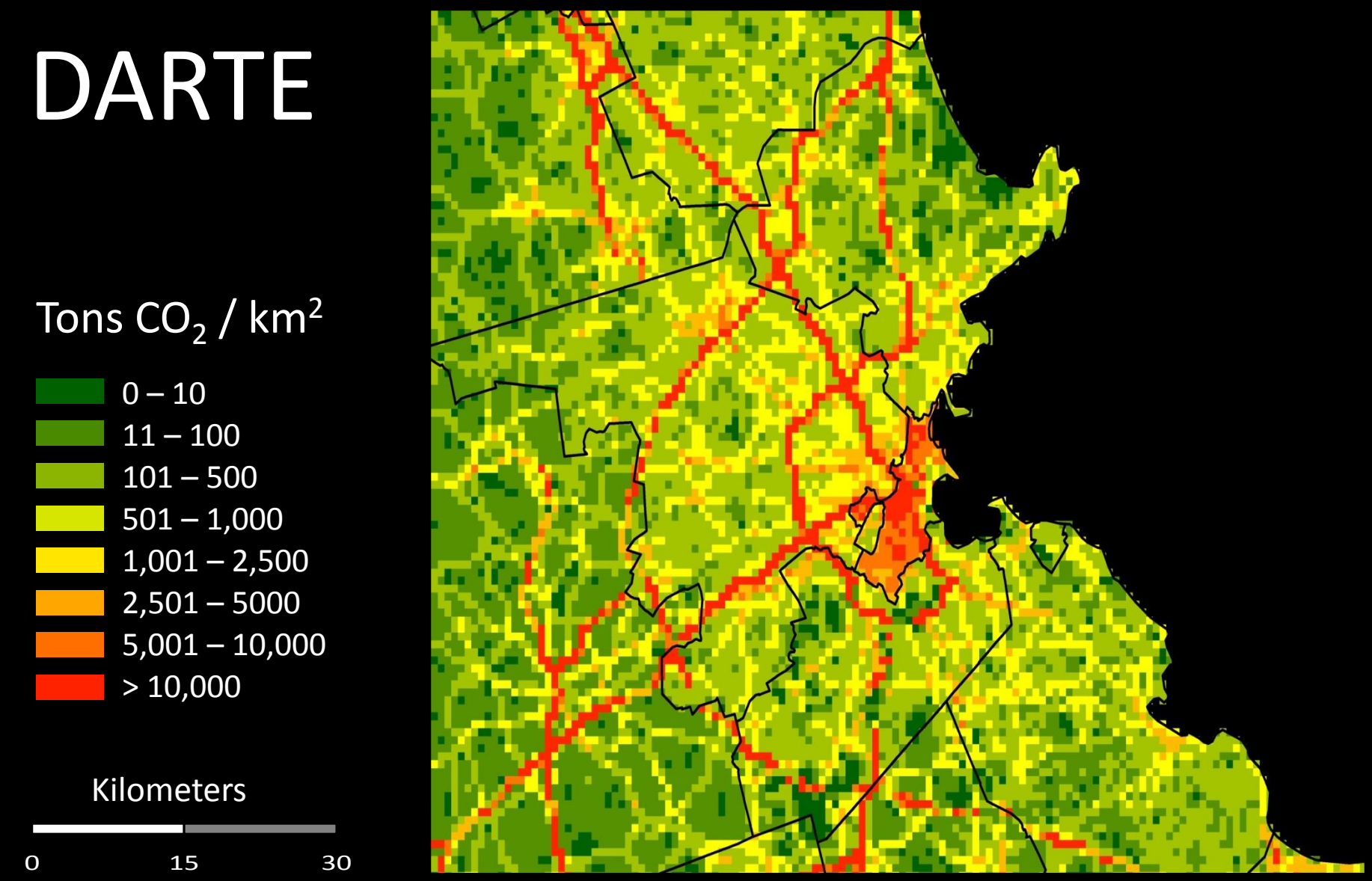
15
30

DARTE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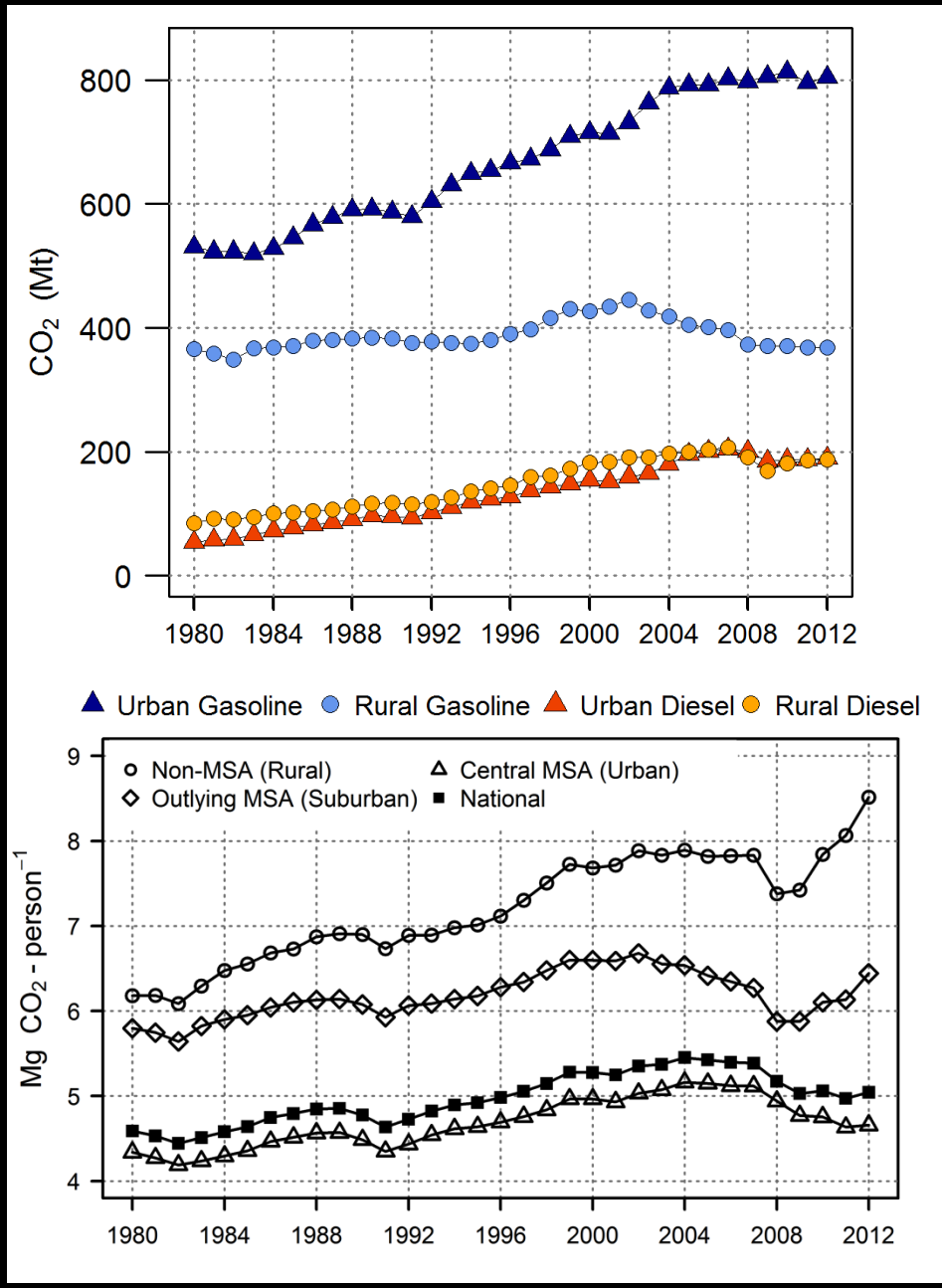
Fossil Fuel Emissions

Urban areas are responsible for 80% of on-road emissions growth since 1980 and for 63% of total 2012 emissions.

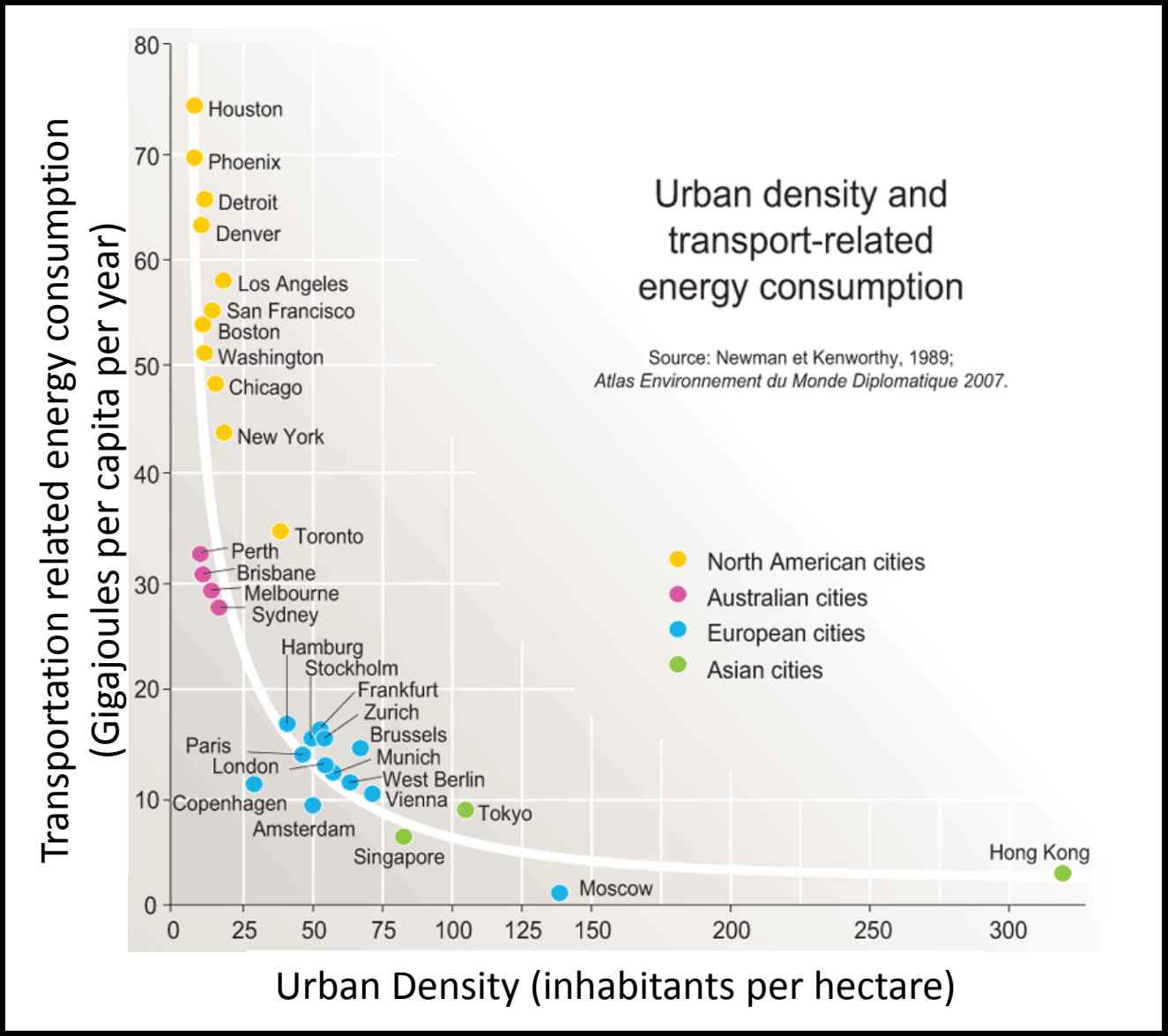
US urban population grew by 81 million people (49%; 1980-2010); urban per capita emissions grew by 15%.

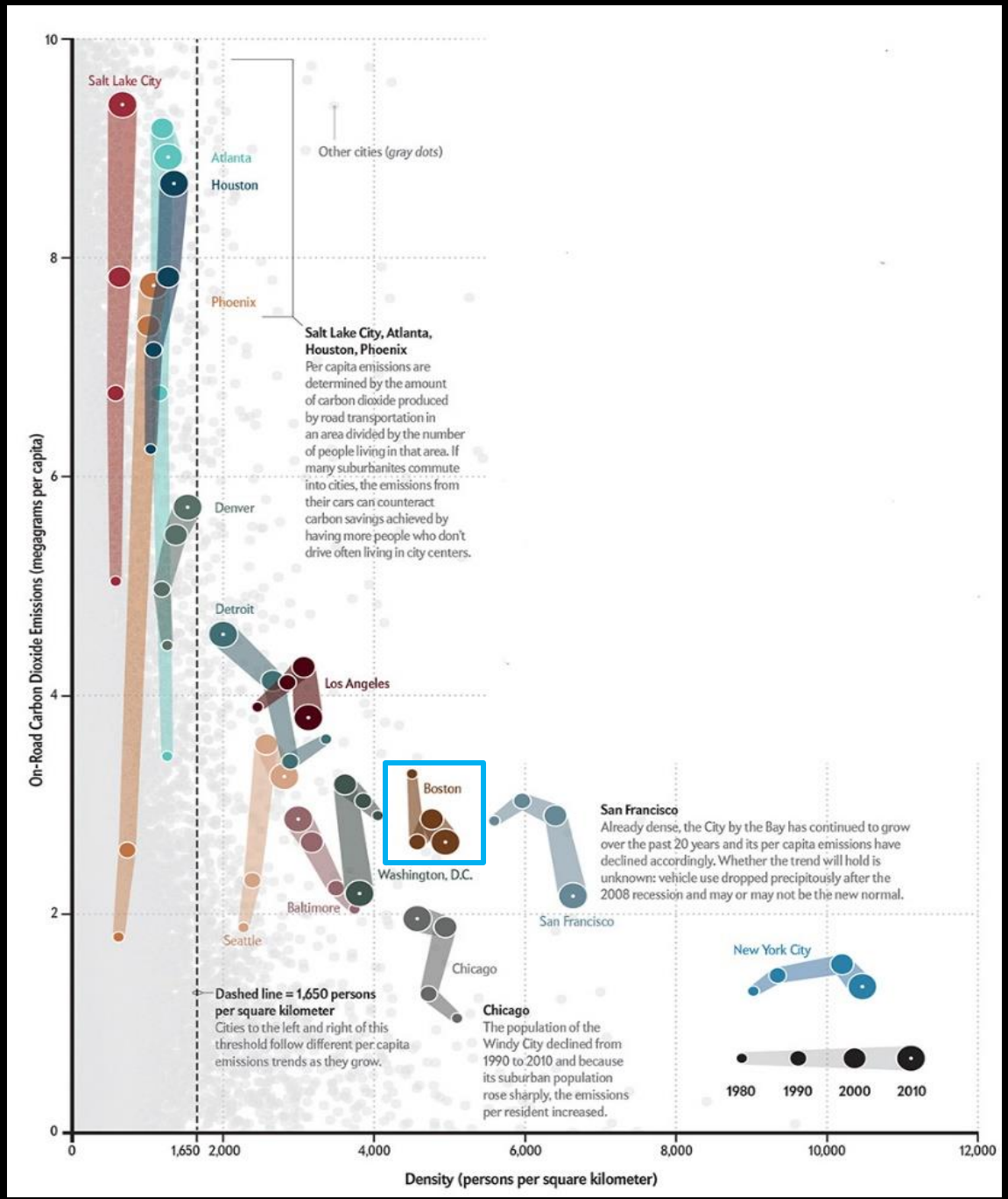
Rural area population declined slightly from 1980 to 2010, rural per capita emissions rose by 22% over that time.



Gately CK, Hutyra LR, and Sue Wing I, (2015)

Emissions and Population Density

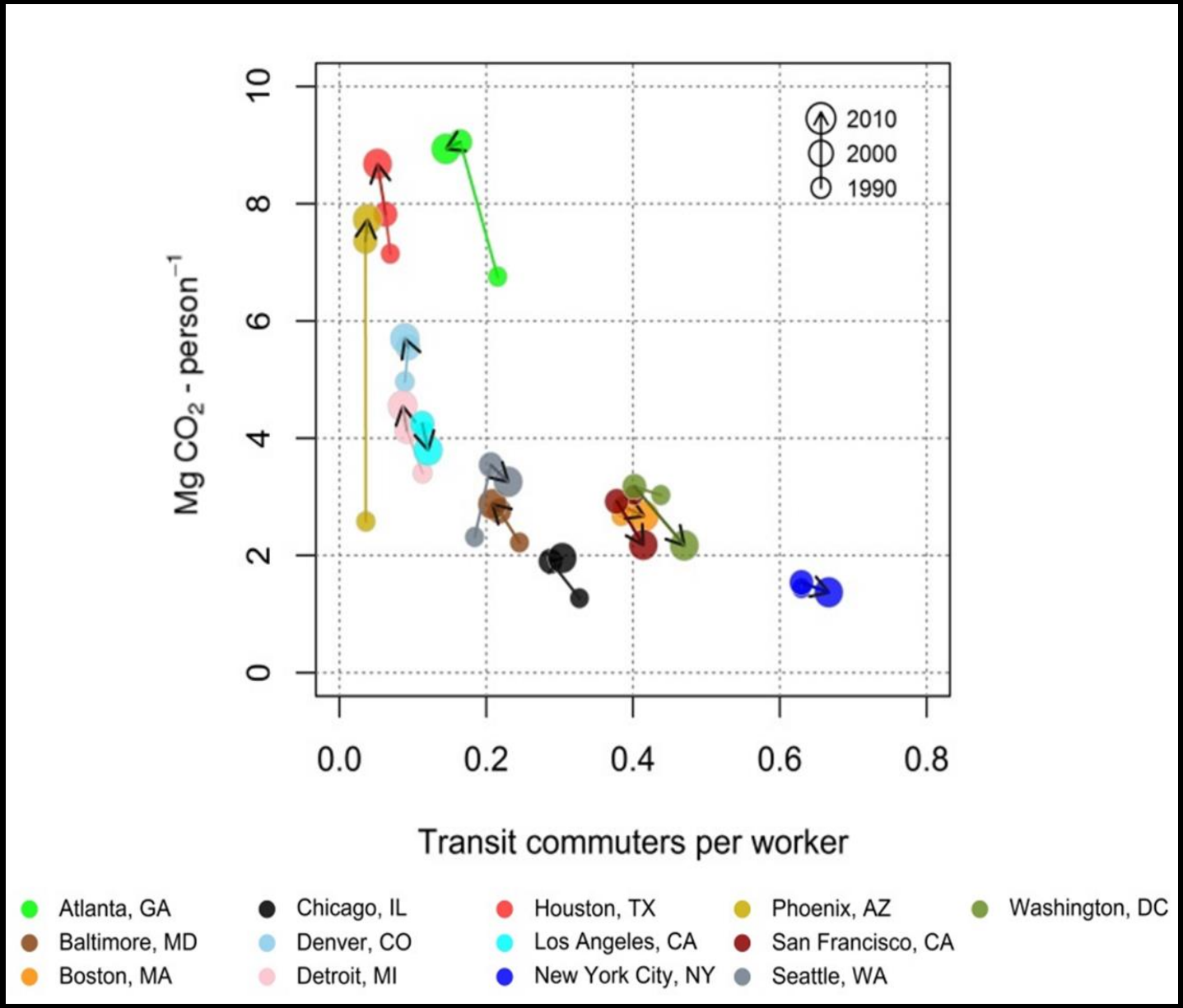


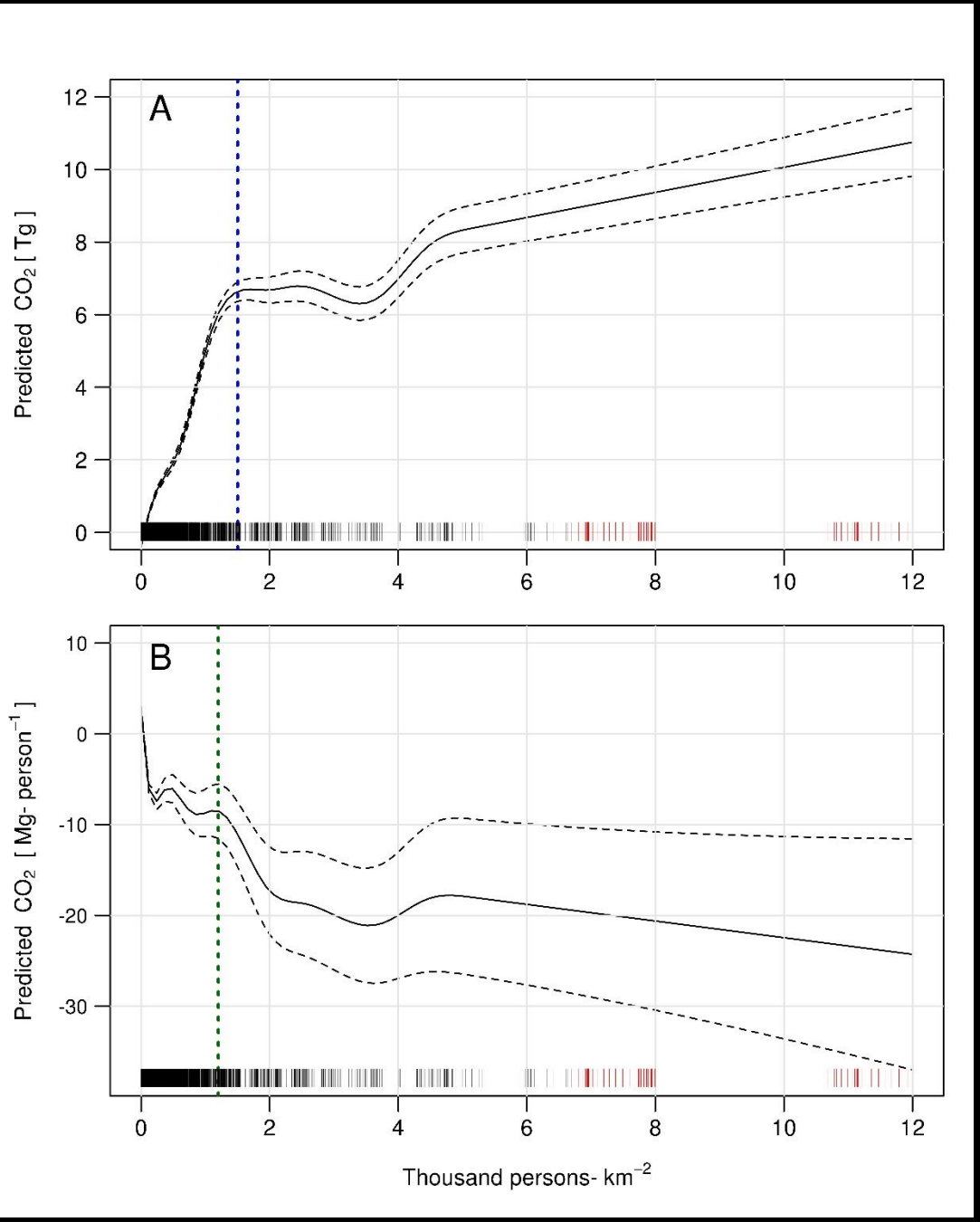


City-Specific Trends

- Per capita emissions decrease in cities that are already very dense
- Cities with recent suburban expansion see emissions grow
- Unit of measure is important

Emissions and Public Transit





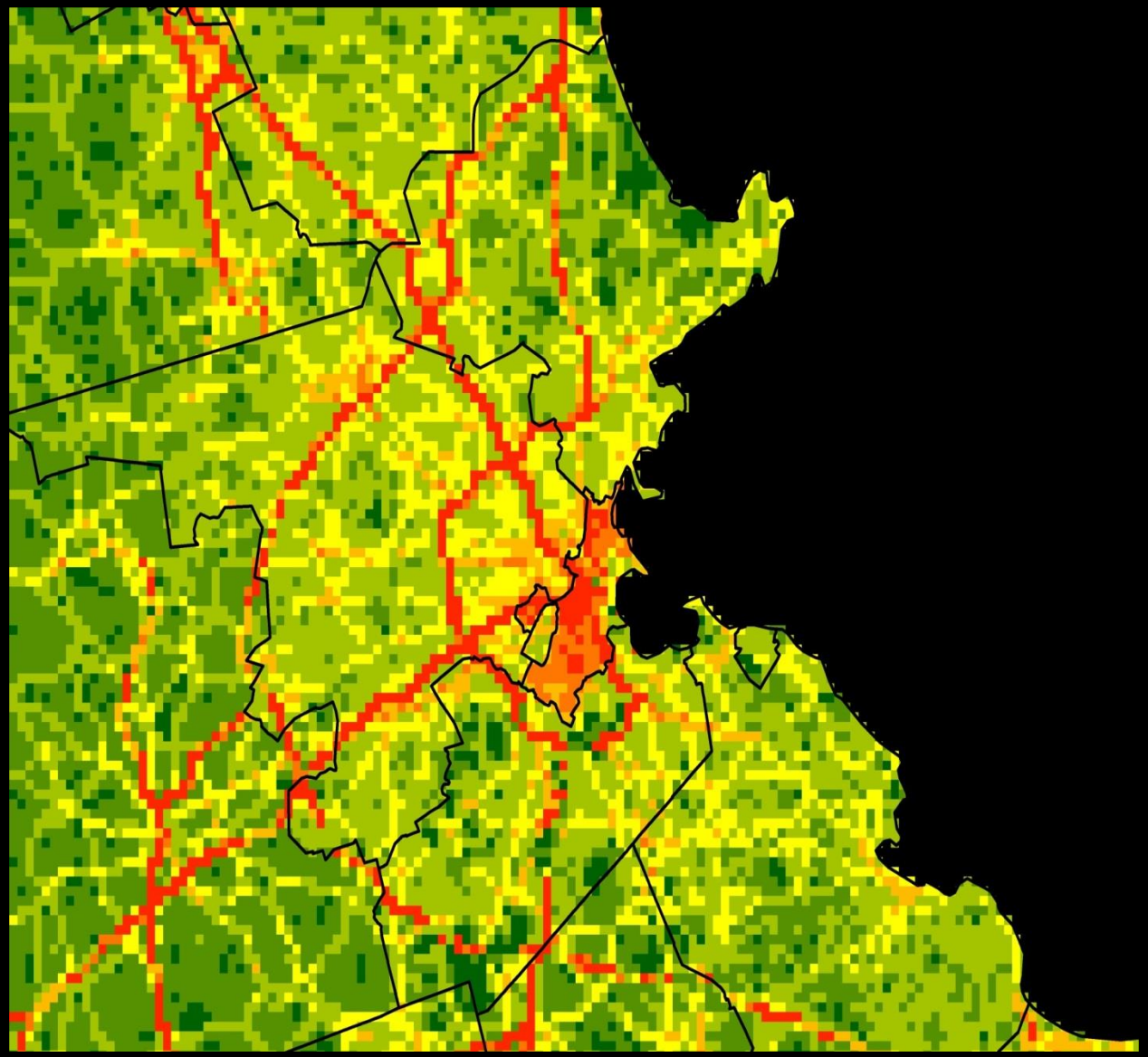
National Trends

- Total emissions increase as population increases
- Per capita emissions decrease, but at varying rates
- Largest effect in cities that are already dense
- Total emissions flatten at densities > 1,650 persons / km^2

Current Project:

- Partnering with CTPS on a NSF-funded project to quantify vehicle emissions at very high resolutions for the Boston MPO region
- Evaluate impact of traffic congestion on emissions of air pollutants and greenhouse gases
- Identify local hotspots of emissions

DARTE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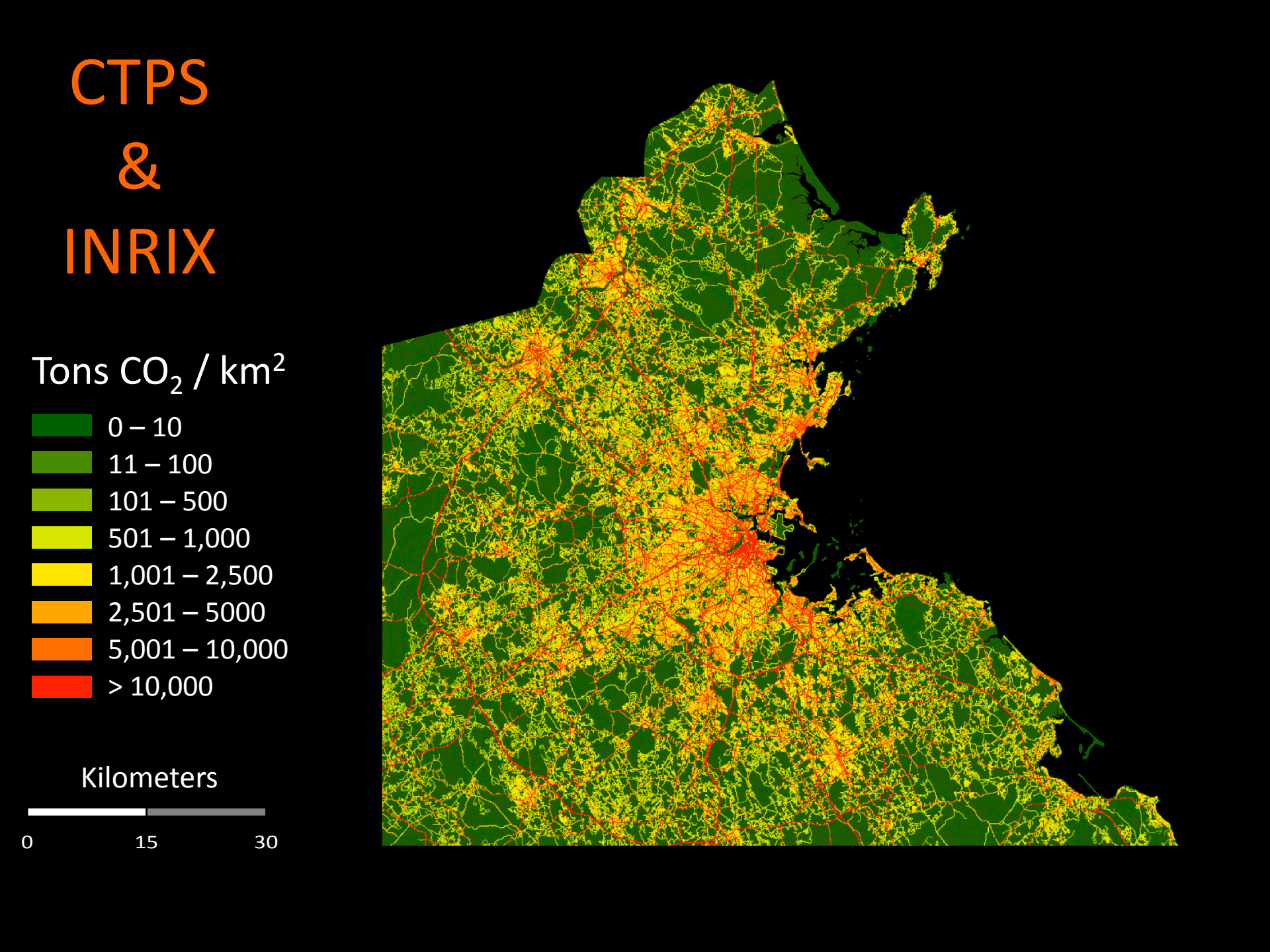
CTPS & INRIX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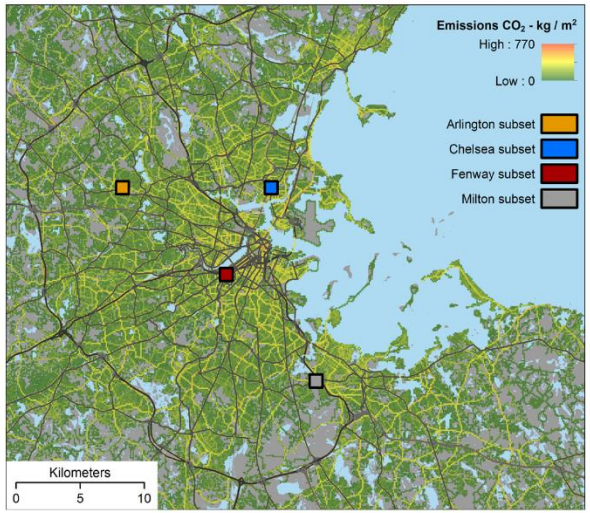
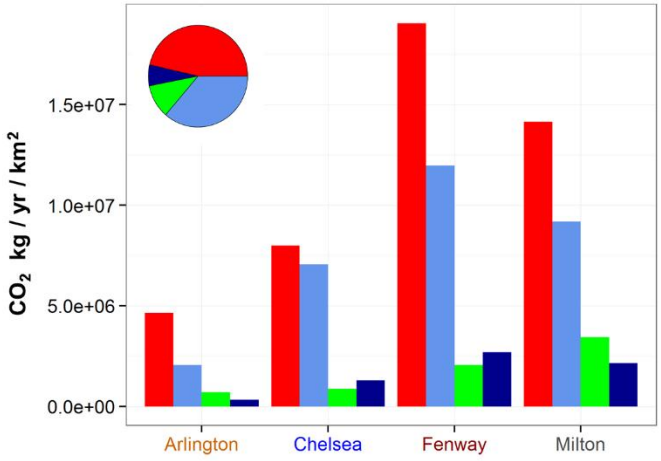
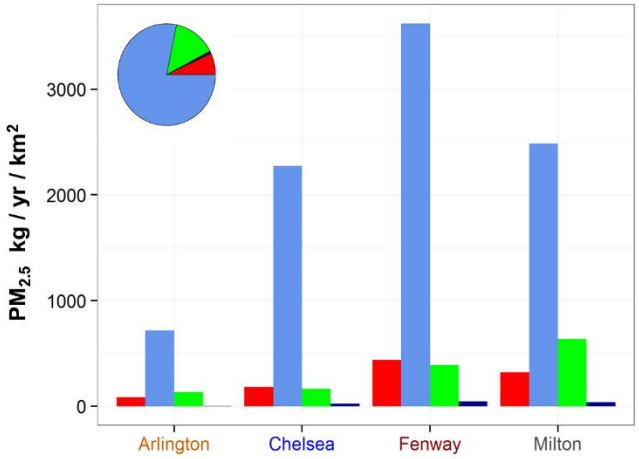
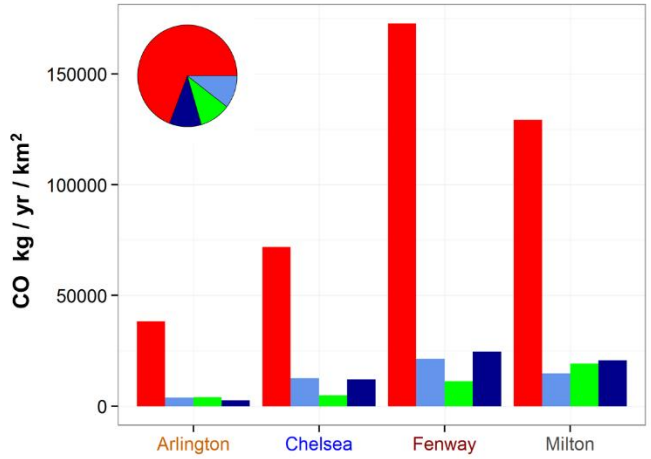
Local Patterns

- Vehicle type strongly influences emissions
- Regional variations are large
- Highways dominate, but local arterials are significant too



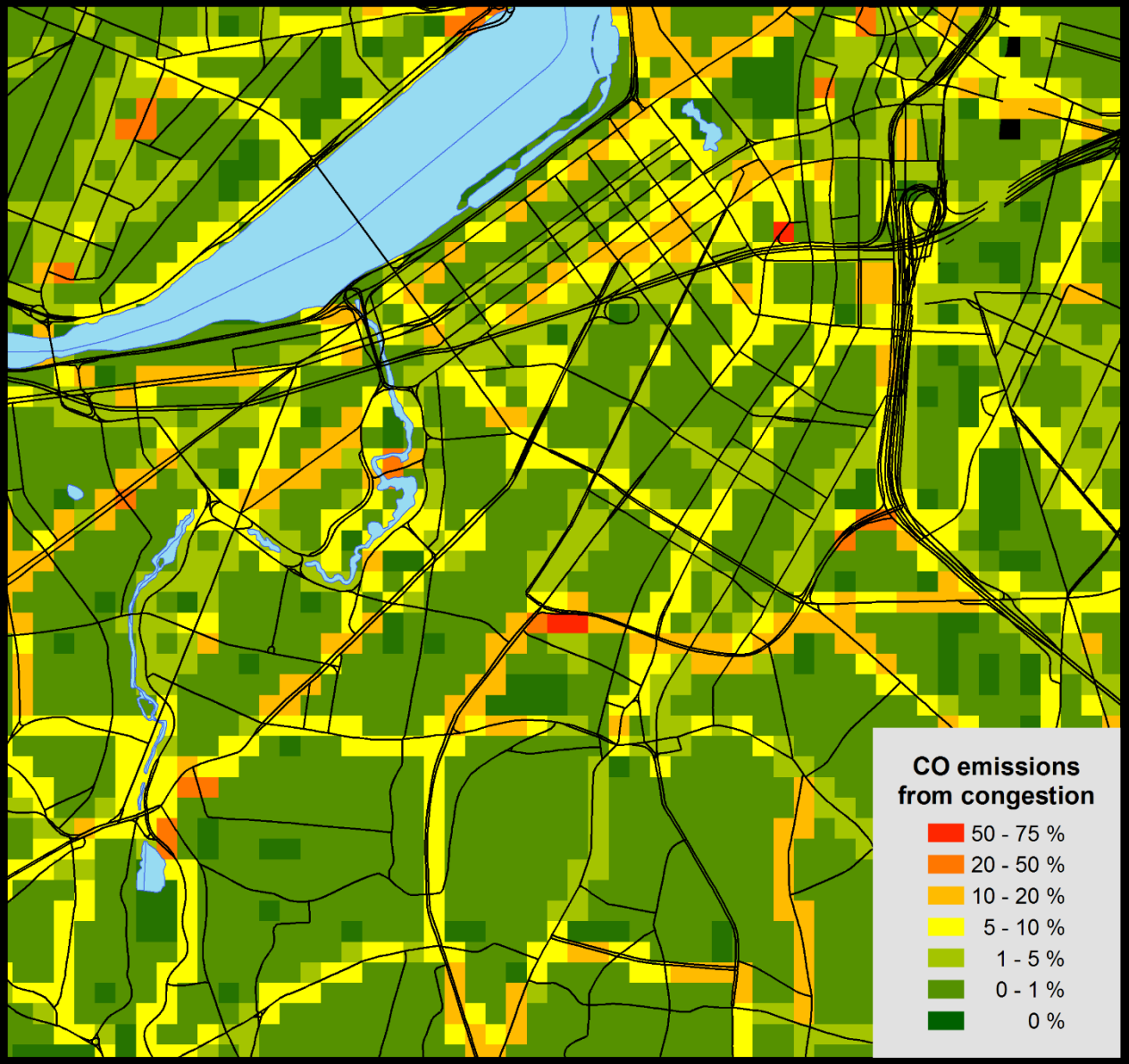






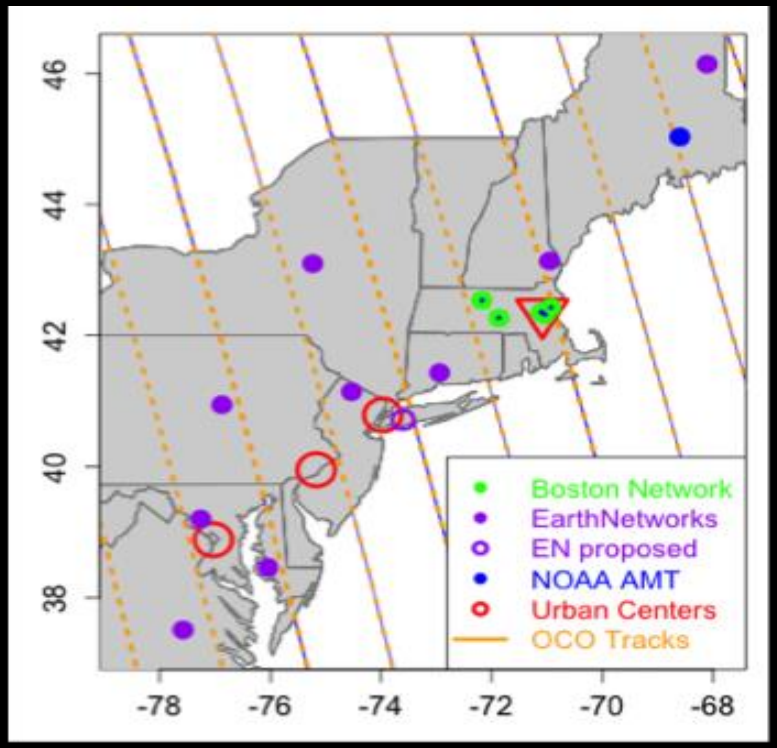
Congestion Effects

- Congestion increases emissions on most major urban roads
- Local effects are significant
- Small relative to total regional emissions
- Carbon Monoxide
  - MPO region: 2 – 6 % reduction
  - Local Corridors: 25 – 50%



Regional Carbon Monitoring System

- Boston-DC megalopolis corridor
- Integrated measurement network
  - Ground and Space-based sensors
- Atmospheric modeling framework
- High-resolution CO_2 Inventory of:
  - Anthropogenic emissions
  - Biologic emissions
- Emissions verification and monitoring



ACKNOWLEDGEMENTS

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4. Gately CK, Hutyra LR, Sue Wing I, 2015. Cities, Traffic, and CO_2: A multidecadal assessment of trends, drivers, and scaling relationships. *Proc. Natl. Acad. Sci., 112(16), 4999-5004.*