Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts

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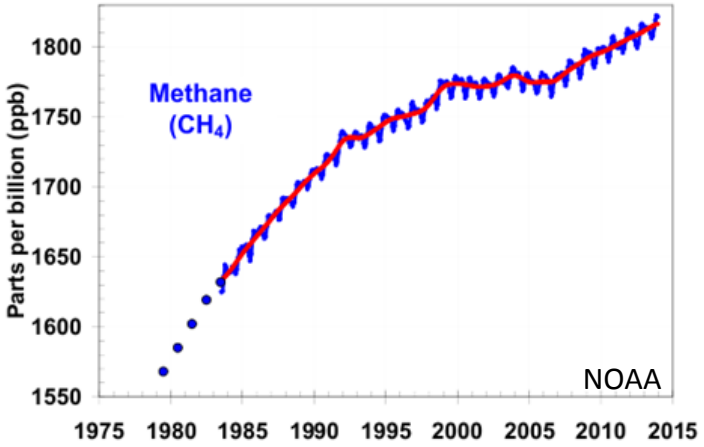
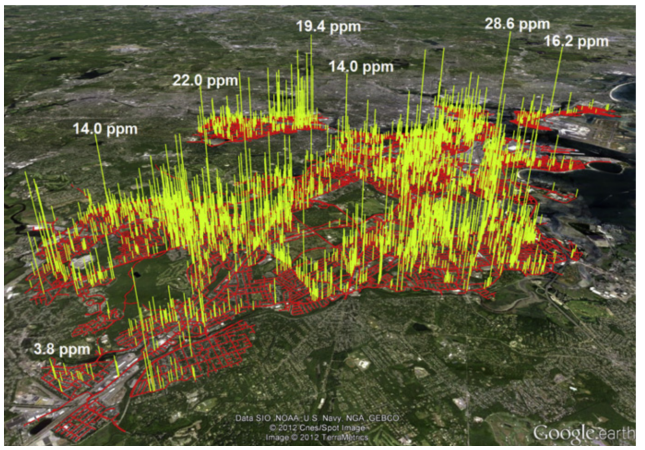
Motivation

- **Global Atmosphere Perspective**
  - Methane (CH_4) is a potent, yet short-lived greenhouse gas
  - The drivers of the increasing global CH_4 burden are not understood
- **Local Perspective**
  - Need for quantitative information on the <u>mass of CH_4</u> emitted and the <u>volume of NG</u> lost to the atmosphere





Phillips et al., 2013

Study Objectives & Approach

Determine with an Atmosphere-Based Method:

1. CH_4 emissions from the whole urban area from measured ΔCH_4
2. Contribution of natural gas to CH_4 emissions by compare C_2H_6-CH_4 ratios in the atmosphere and pipeline
3. Fraction of NG imported to the region lost to the atmosphere ("loss rate")

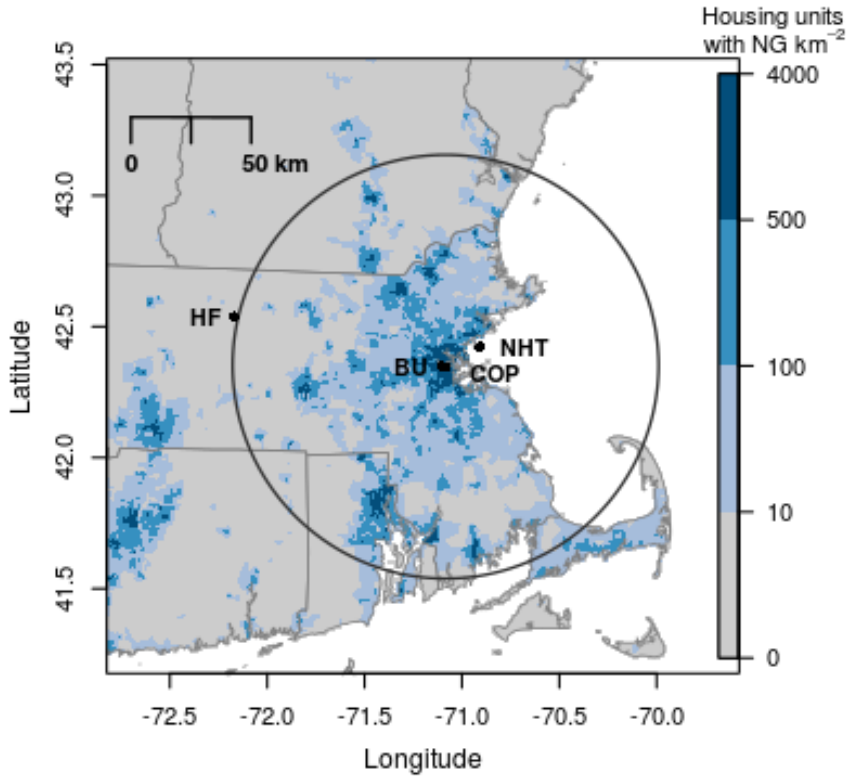
Study Boundaries:

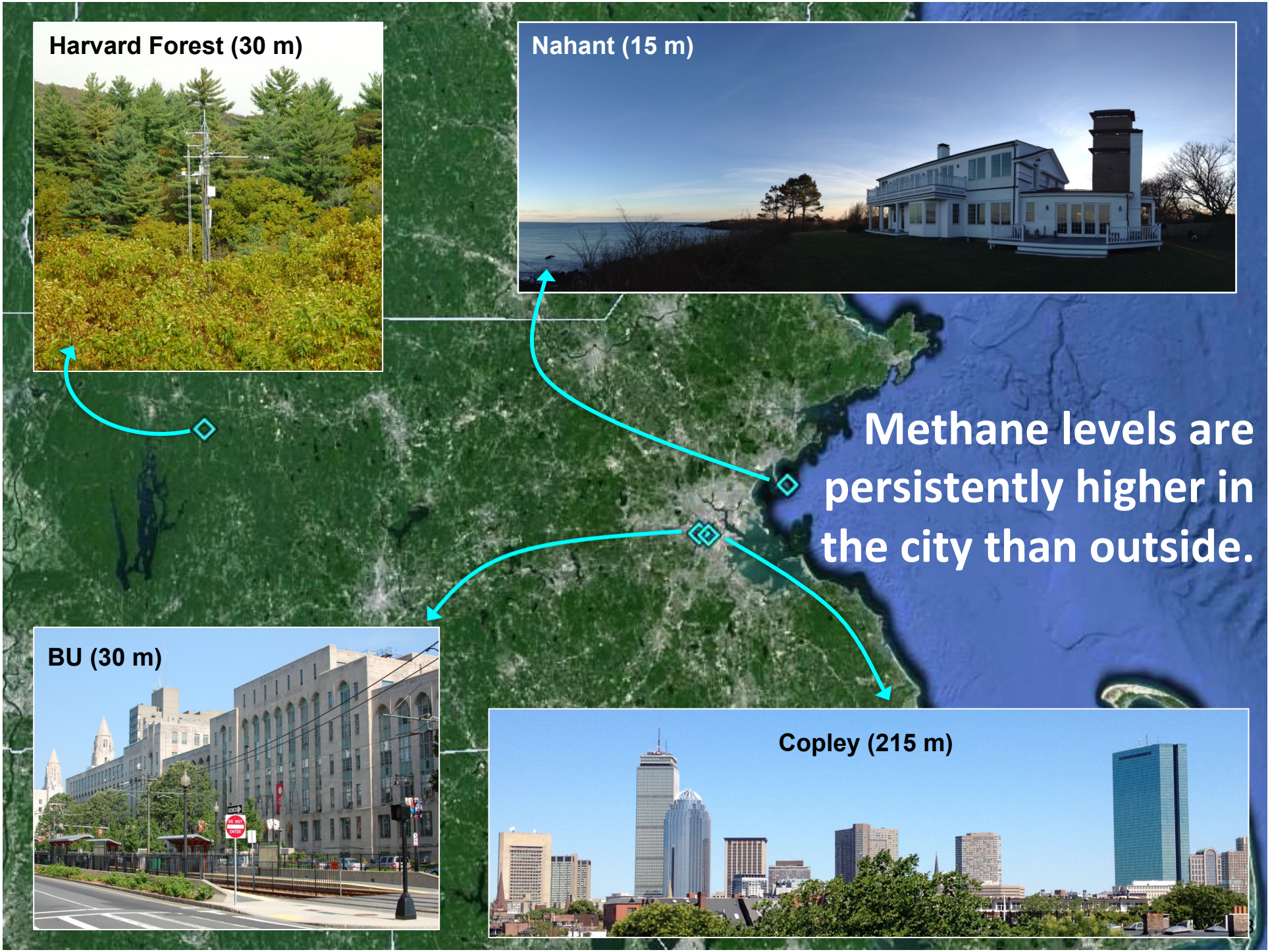
Area:

90-km radius circle centered on Boston (18,000 km^2 land area)

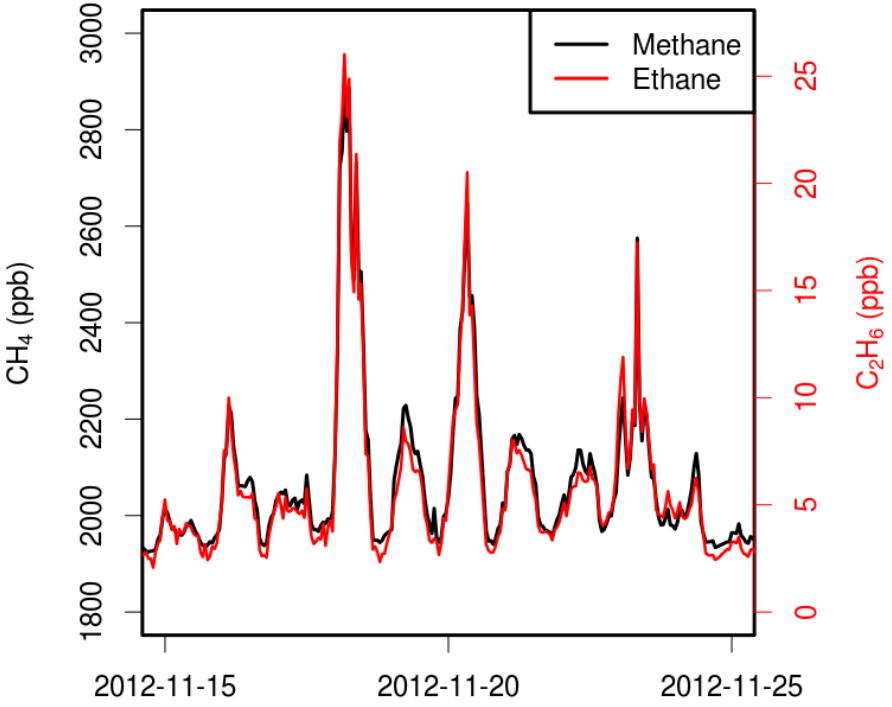
Time Period:

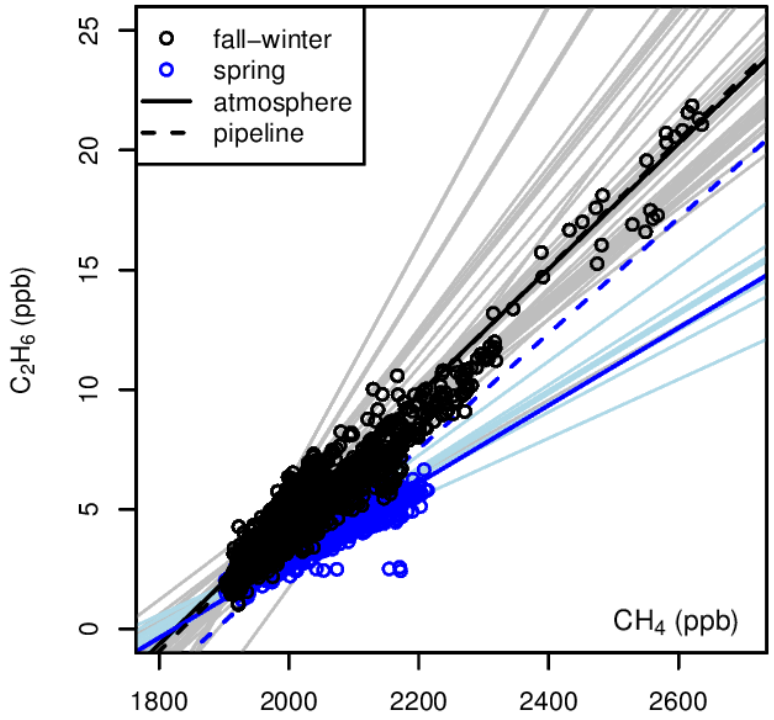
Sept, 2012 – Aug, 2013 (1 yr)




Harvard Forest (30 m)
Nahant (15 m)
Methane levels are persistently higher in the city than outside.
BU (30 m)
Copley (215 m)

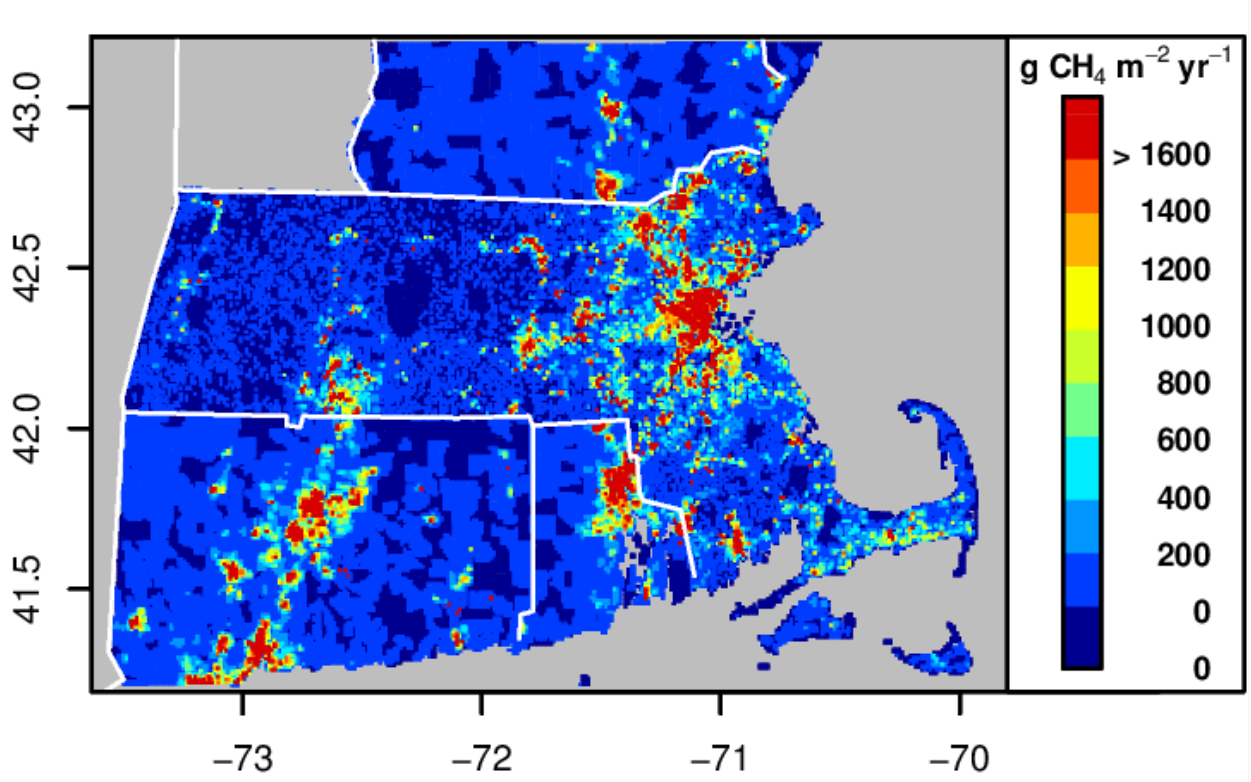
Ethane and methane are closely correlated in the urban atmosphere with a ratio similar to that in pipeline gas.





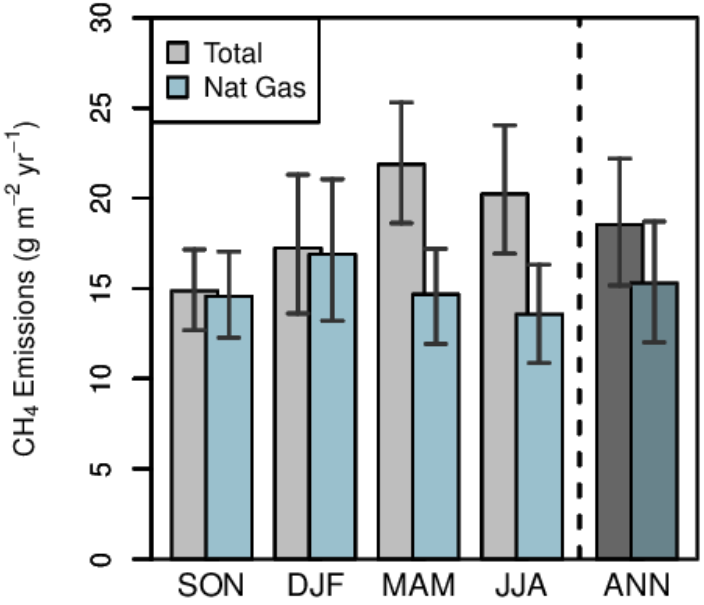
	C_2H_6 / CH_4 (95% CI)		Natural Gas contribution to ΔCH_4
	Atmosphere	**Pipeline**	
Cool (Oct 2012-Jan 2013)	2.6 % (2.5, 2.8)	2.7 % (2.7, 2.7)	**98 %** (92, 105)
Warm (May-June 2014)	1.6 % (1.4, 1.7)	2.4 % (2.3, 2.5)	**67 %** (59, 72)

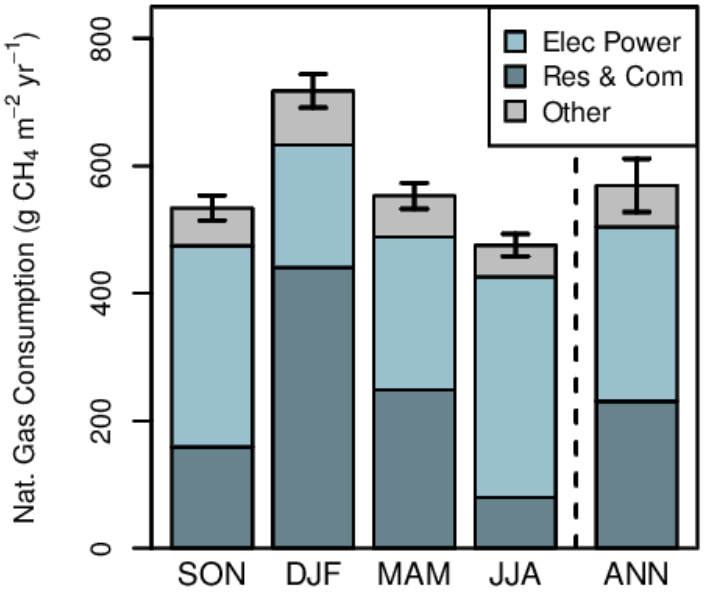
Natural Gas Consumption
Reconstructed Geographical Distribution

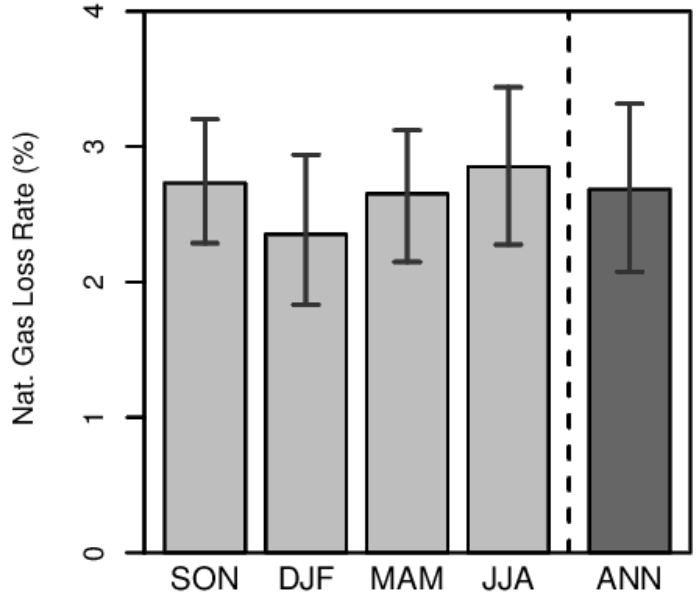


- Base data: EIA monthly-state-sectoral consumption
  - Includes all sectors – Electric power, Residential, Commercial, Industrial, Vehicle fuel, Pipeline & distribution use
- Spatially disaggregated by:
  - Building square footage by fuel-type (Residential, Commercial)
  - Power plant location (Electric, Industrial, Commercial)

Results Summary







Annual Avg Loss Rate = 2.7 ± 0.6 %

*Captures emissions from all NG activities in region: transmission, distribution, end-use, LNG importation & storage, CNG vehicles

*Lack of seasonality may indicate that losses do not depend strongly on seasonally varying component of the NG system, or that multiple compensating processes are contributing.

Significance of Emissions

- **Volume** of Lost Gas: 15 billion scf y^{-1} , 6 scf $person^{-1}$ d^{-1}
- **Value** of Lost Gas: $90 million y^{-1}

Comparison with Official Emissions Data

Total Emissions = Emission Factor x Activity Factor

- **EPA GHG Inventory** (Distribution, Transmission & Storage): **0.7%**
- **MA GHG Inventory** (Distribution, Transmission & Storage): **1.1%**
  * most valid comparison, but not perfect
- **GHG Reporting Programs** (EPA & MA): **0.6 (0.4-1.6) %**

- All 3 inventories use same EFs and progressively more specific AFs
- Updated national EFs (Lamb et al. 2015) suggest even lower emissions