

Developing a Fuel-Based Inventory of Oil and Gas Emissions

Brian C. McDonald, Ph.D.

Brown University: Alan Gorchoy Negrón (lead author), Meredith Hastings

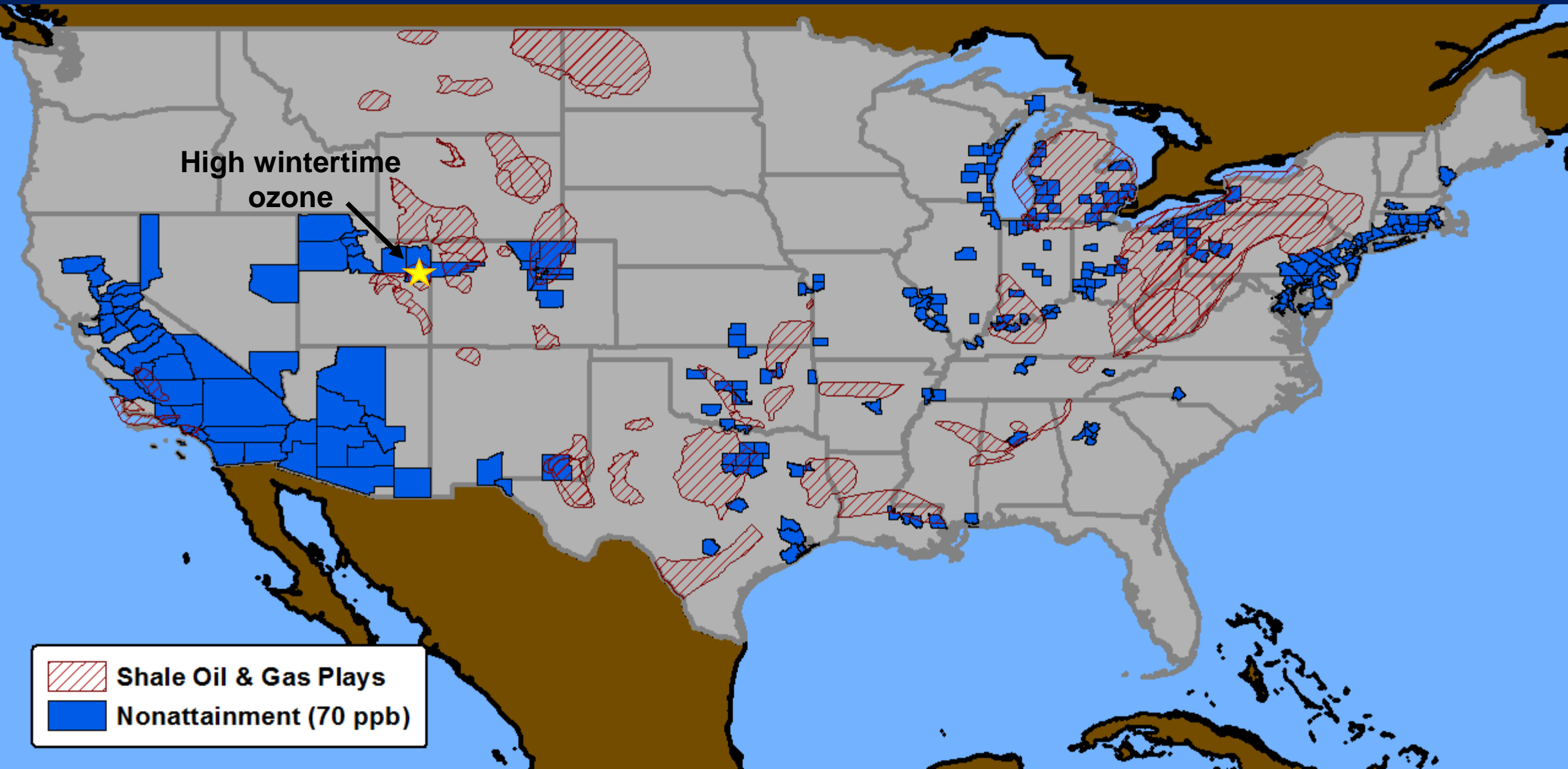
CU/NOAA: Stuart McKeen, Jeff Peischl, Jessica Gilman, Ravan Ahmadov, Gregory Frost, Thomas Ryerson, Chelsea Thompson, Michael Trainer

Acknowledgments: NCAR SOARS Scholarship programs



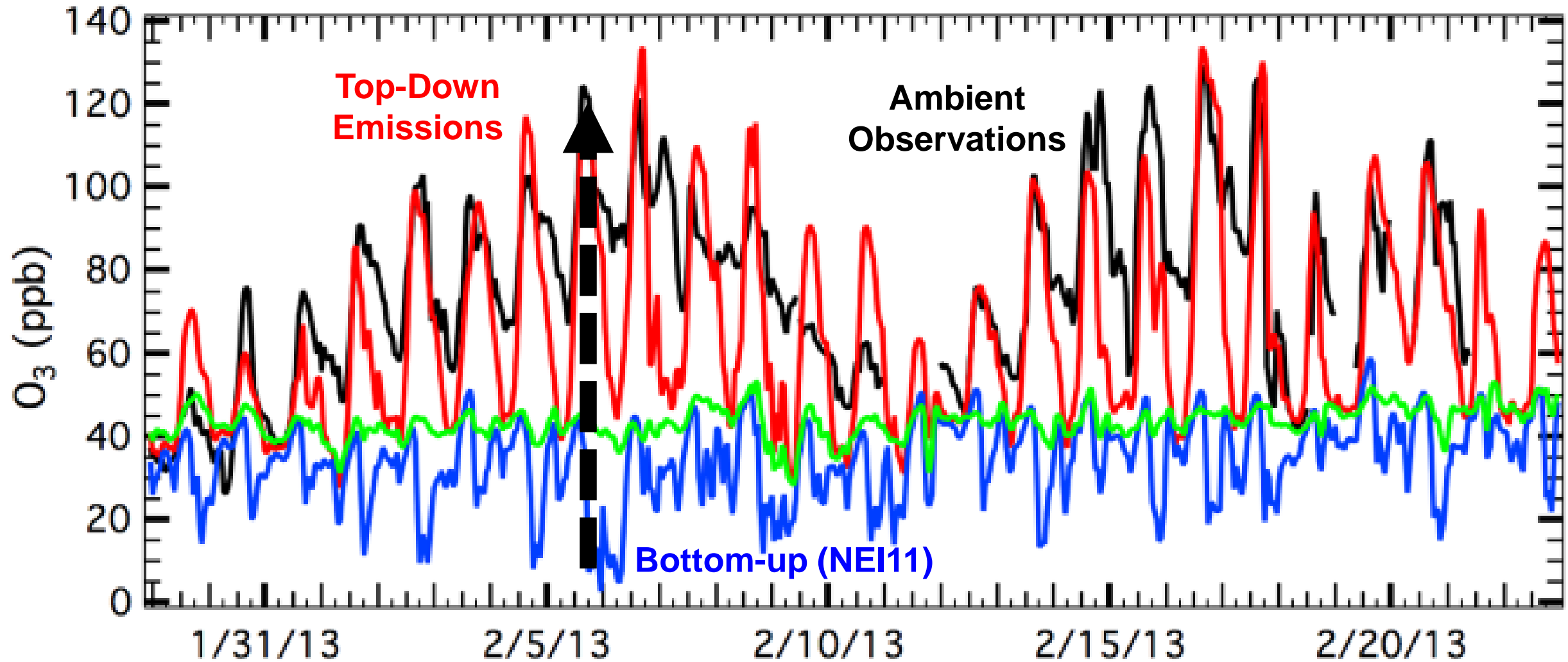
2017 International Emissions Inventory Conference

Oil & Gas Regions Near Many Projected Ozone Nonattainment Areas

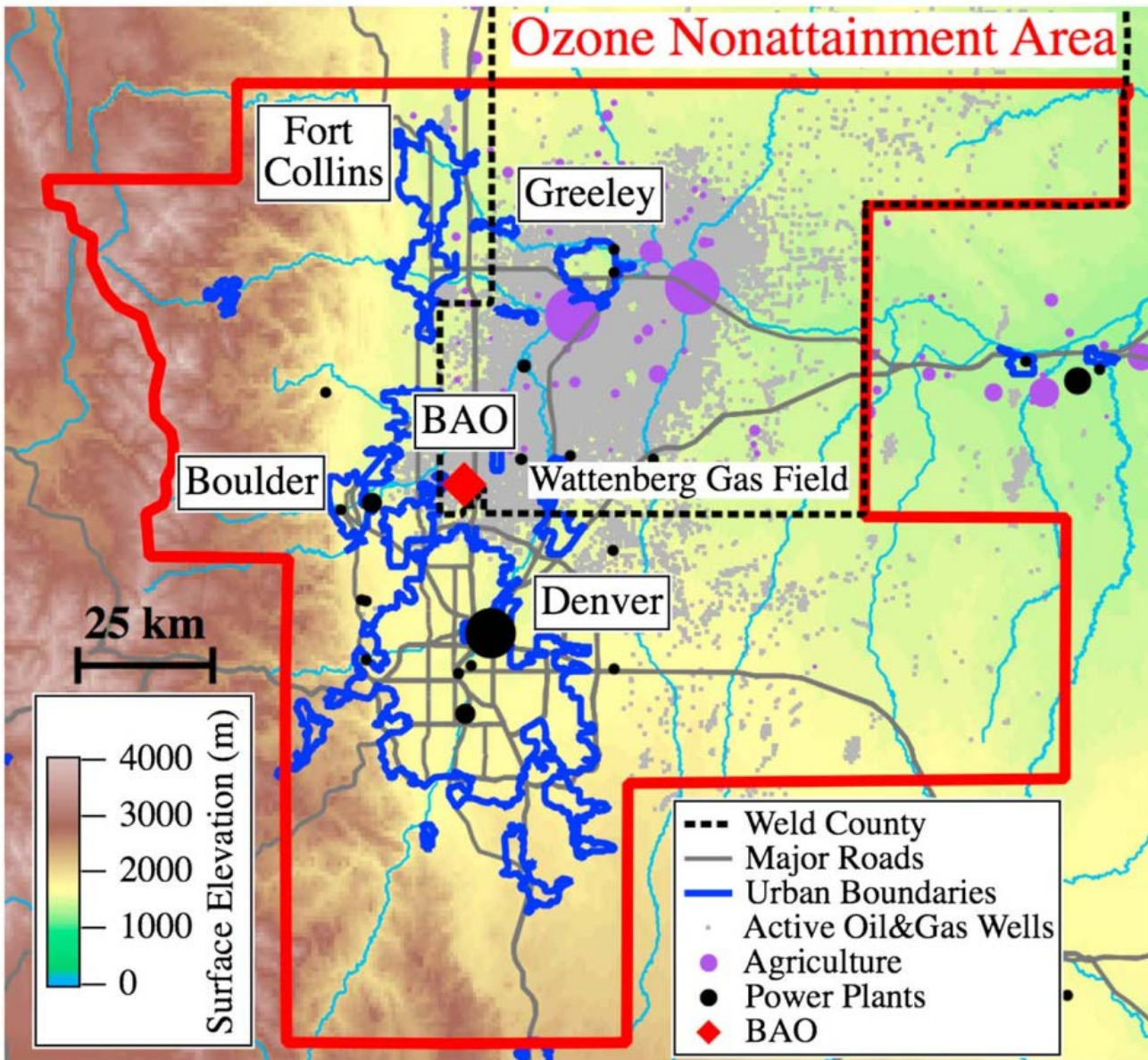


High Wintertime Ozone in Uinta Basin, Utah

O&G NO_x decreased by $\sim 4\times$, VOC increased by $\sim 2\times$



Oil & Gas Impacts in an Urbanized Region (Denver Front Range)

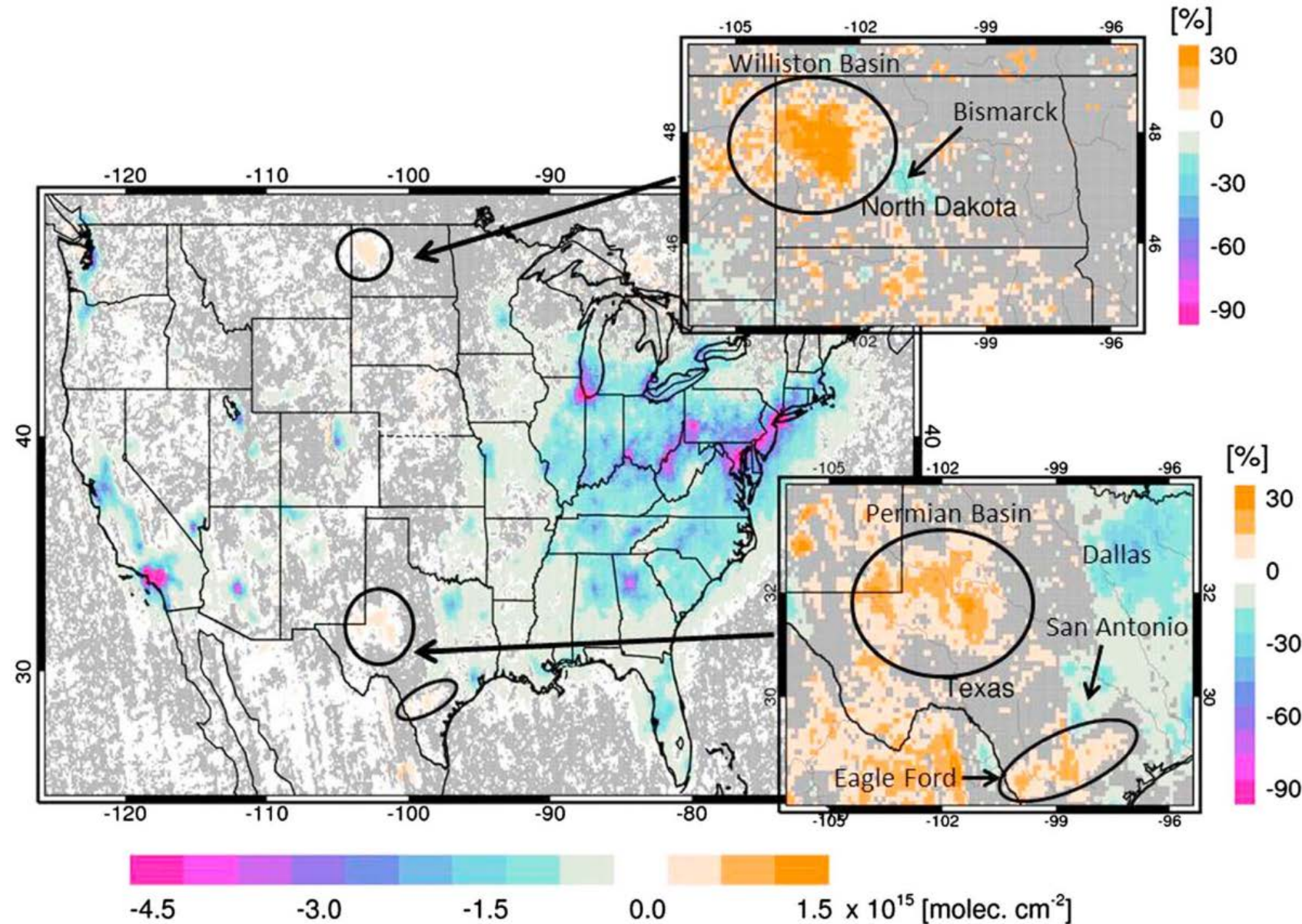


Recent studies suggest ozone in Denver Front Range is

- **Sensitive to NO_x emissions**
[McDuffie et al. *J. Geophys. Res.* 2016]
- **Transitioning to NO_x Sensitivity**
[Abeleira and Farmer *Atm. Chem. Phys.* 2017]

Figure from McDuffie et al. (*J. Geophys. Res.* 2016)

Increasing NO₂ Observed over Some O&G Regions from Space



**Increasing
over W. Texas and
North Dakota
(2005-14)**

Research Objectives

(1) Construct a fuel-based inventory of oil & gas emissions

- Estimate NO_x from combustion-related emissions
- Compare with NEI 2014 and EPA Oil and Gas Tool

(2) Compare with “top-down” emissions derived from three NOAA-led field measurement campaigns

- Uinta Basin Wintertime Ozone Study (UBWOS) in 2012-13
- Southeast Nexus Study (SENEX) in 2013
- Shale Oil & Natural Gas Nexus Study (SONGNEX) in 2015

Fuel-Based Estimate of Oil & Gas NO_x Emissions

$$\text{Emissions} = \text{Activity (kg CO}_2\text{)} \times \text{Emission Factor (g/kg CO}_2\text{)}$$



Exploration

- e.g. drilling, fracturing, trucking
- Off-road diesel fuel (EIA)



Production

- e.g. dehydrators, heaters, compressors
- NG on-site fuel (EIA)

**EPA Oil & Gas Tool
+
Literature Review**

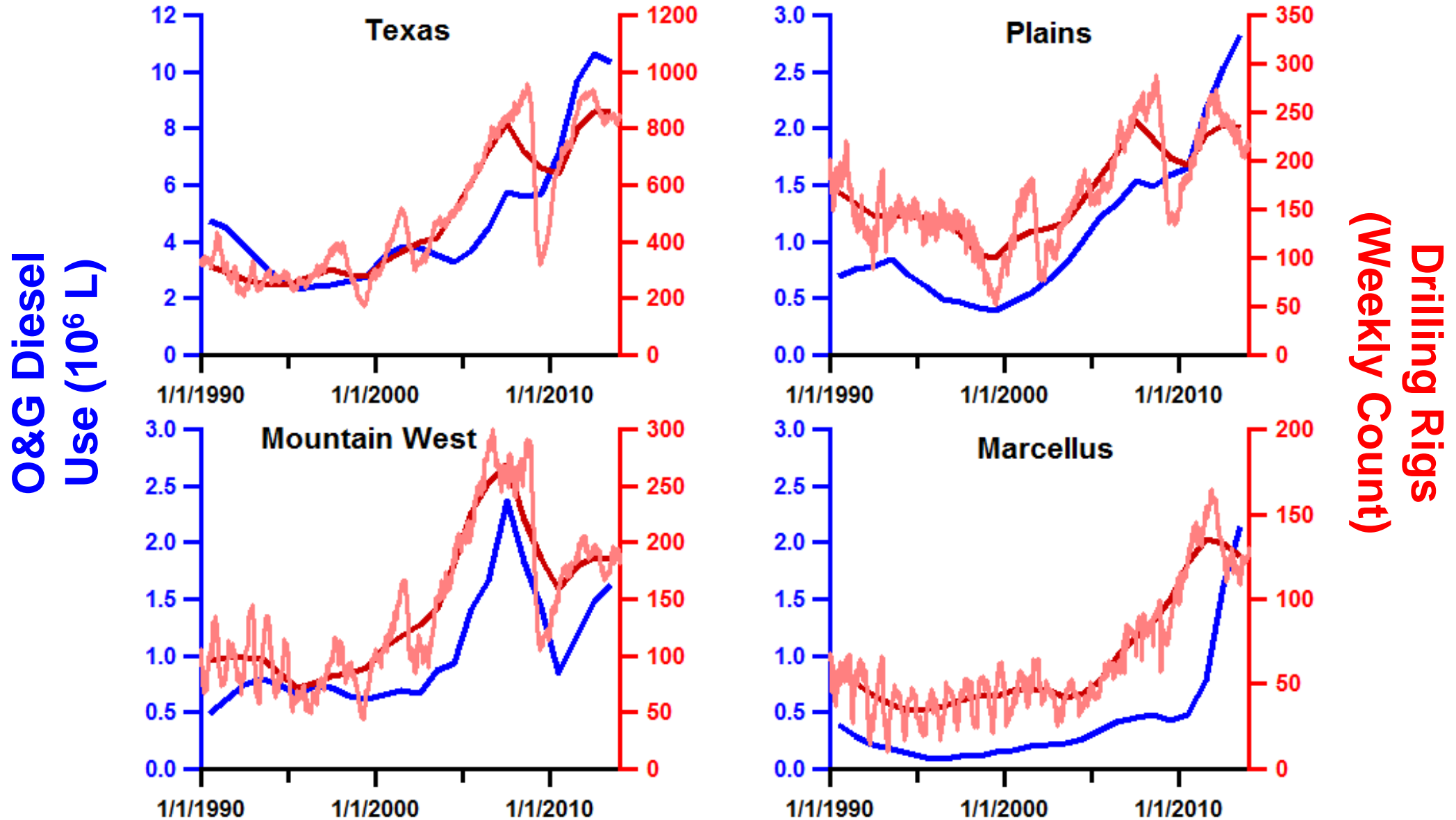
NG Processing Plants

- CO₂ emissions reported at facility level (EPA)

**Continuous Emissions
Monitoring (CEMS)**

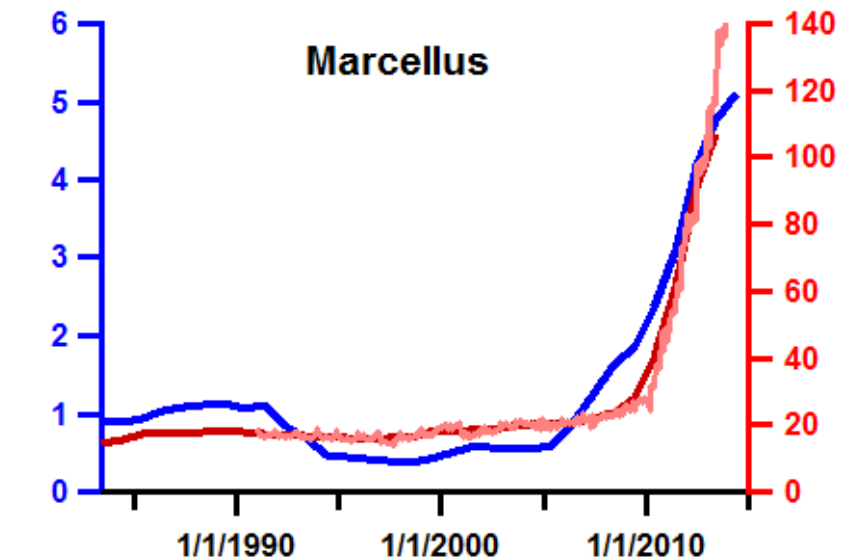
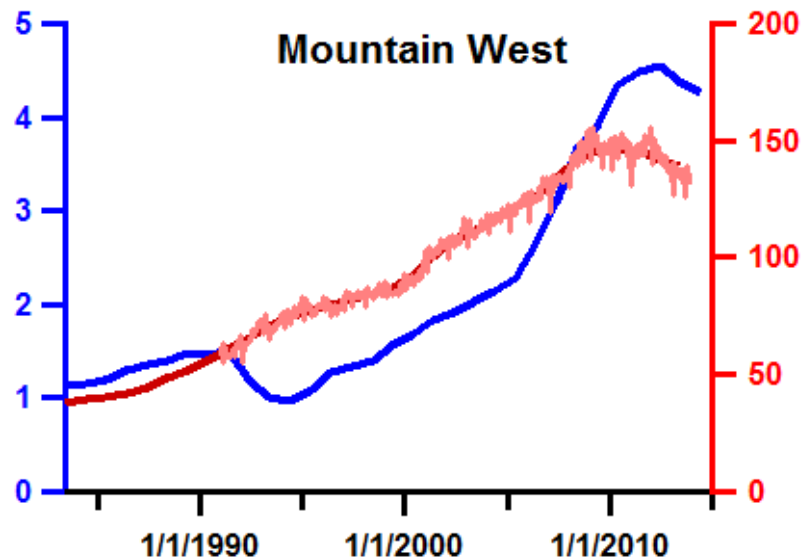
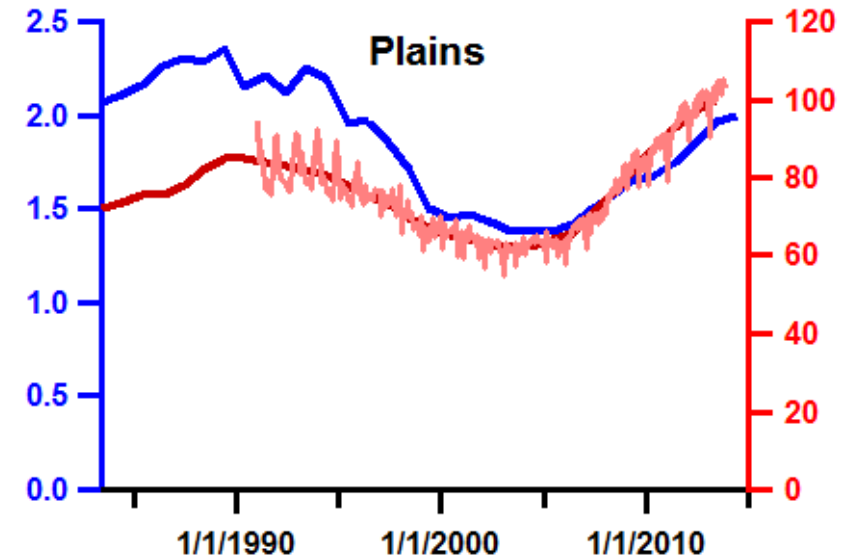
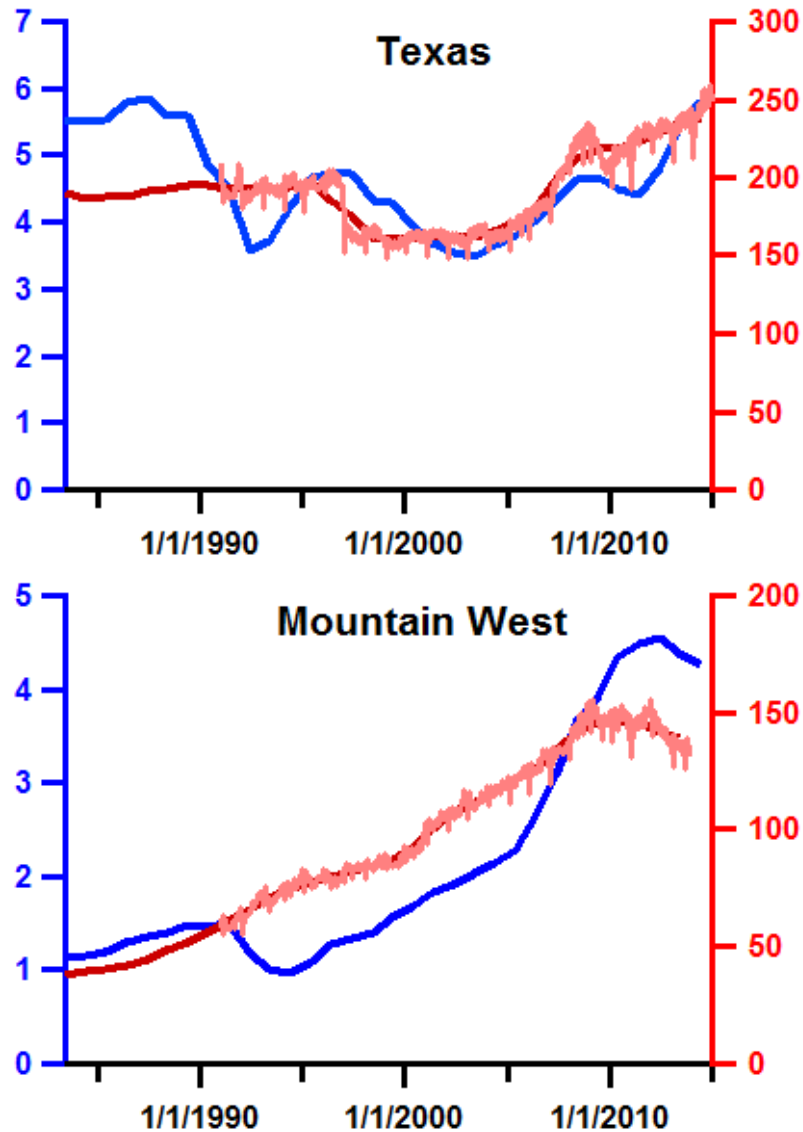


Oil & Gas Diesel Fuel Use Scales with Drilling Activity



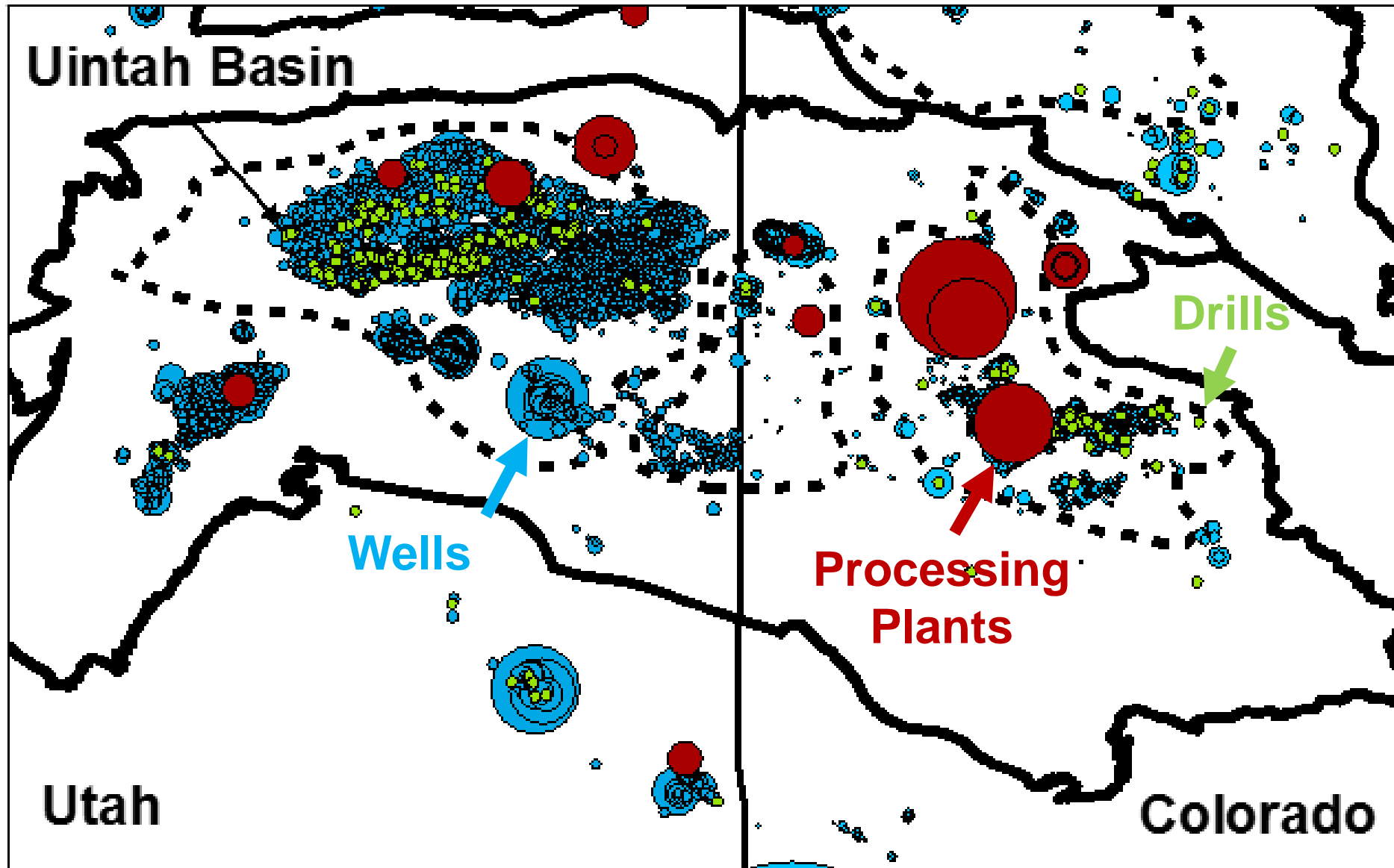
Oil & Gas Natural Gas Use Scales with Natural Gas Production

O&G Natural Gas
Use (10^{12} L)

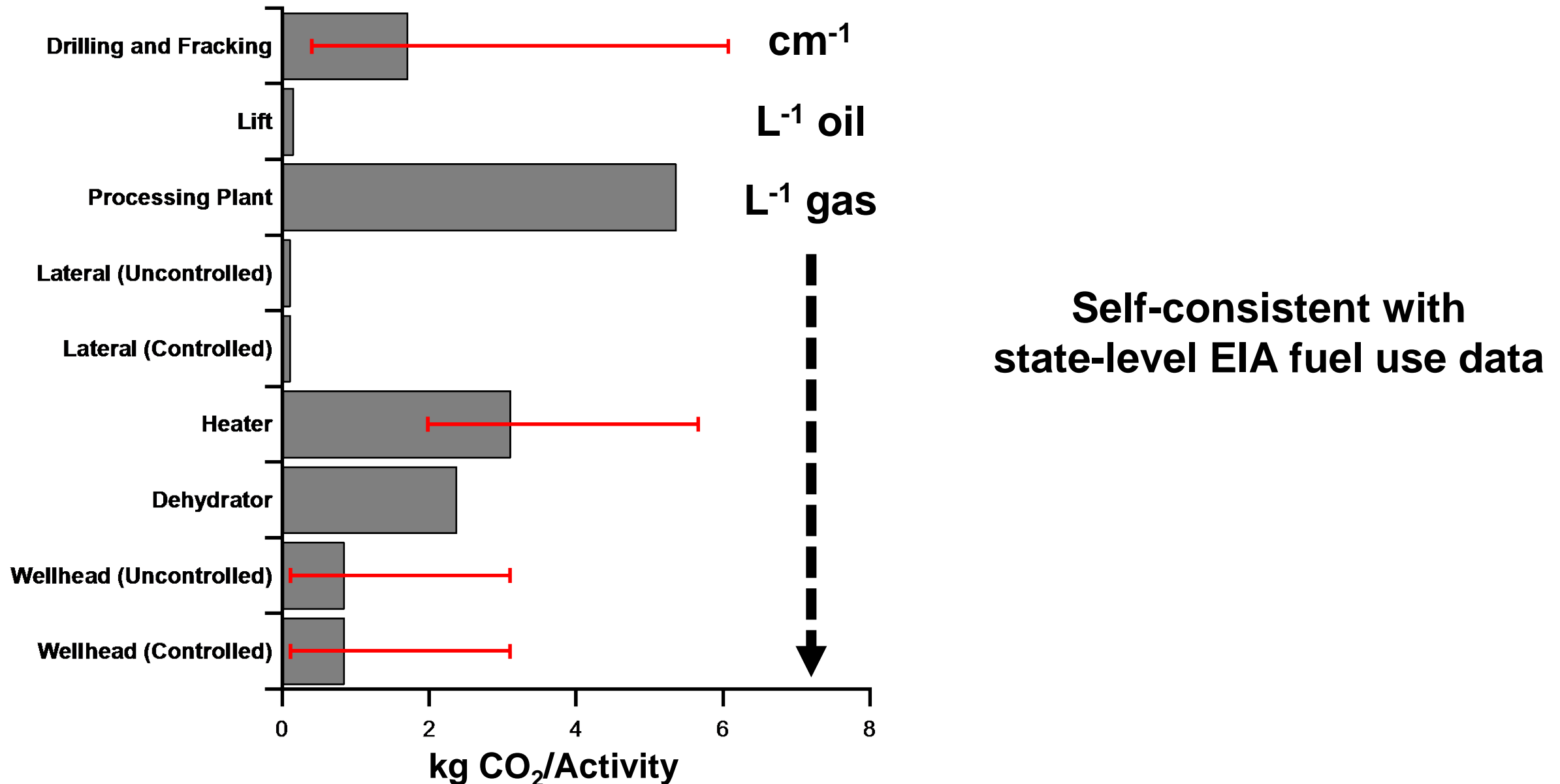


Natural Gas
Production (10^{12} L)

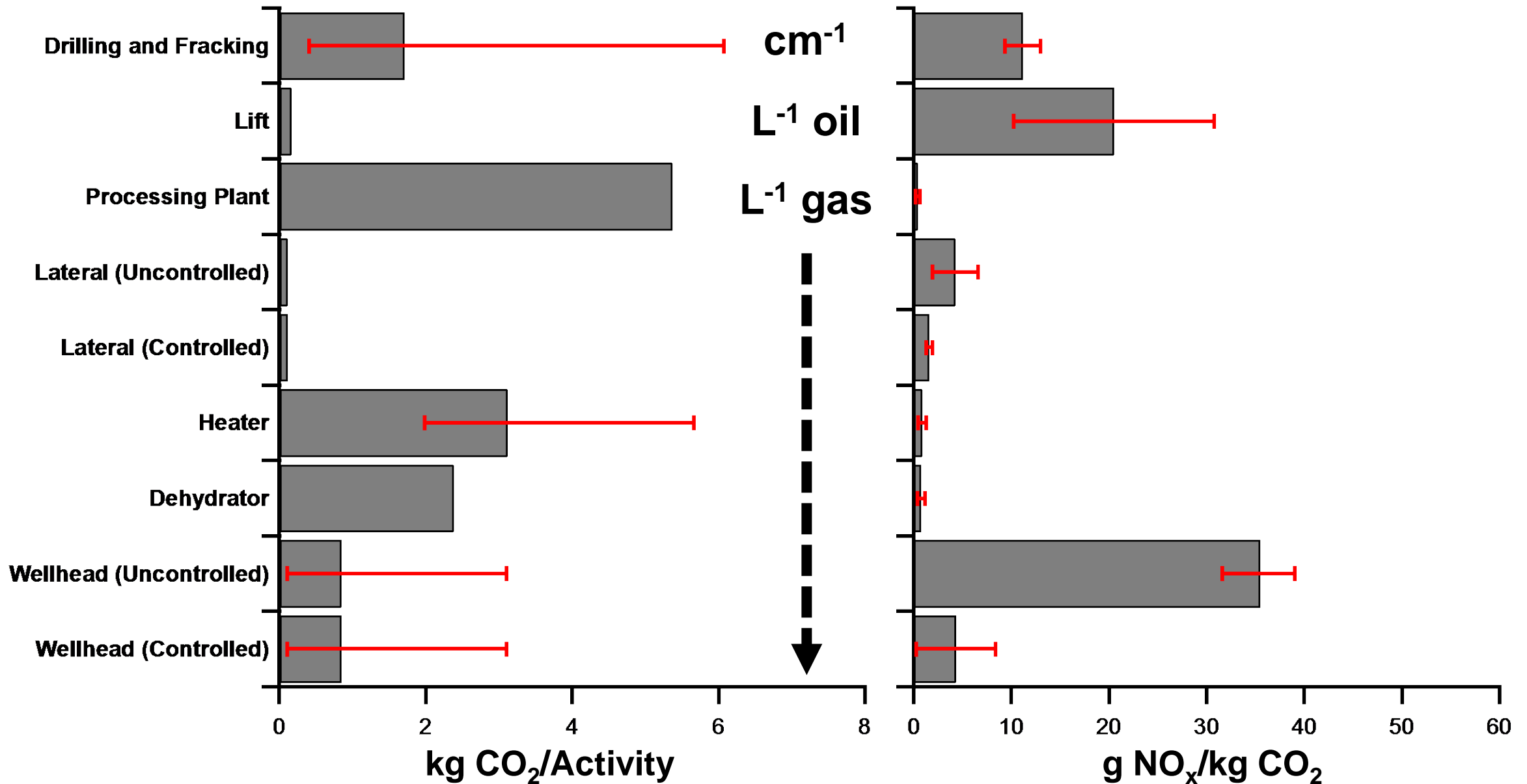
Spatial Surrogates to Downscale State-Level Fuel Data



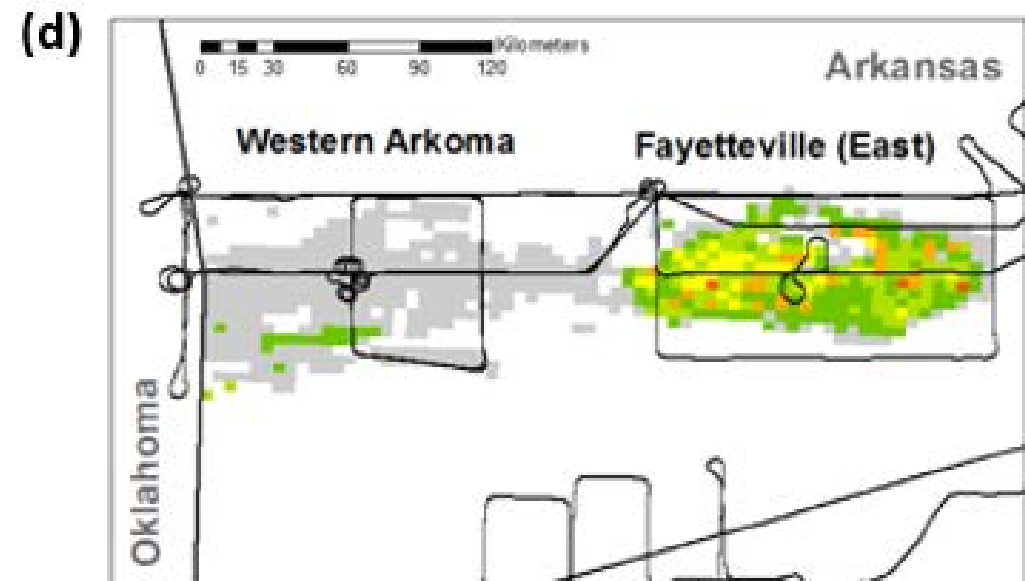
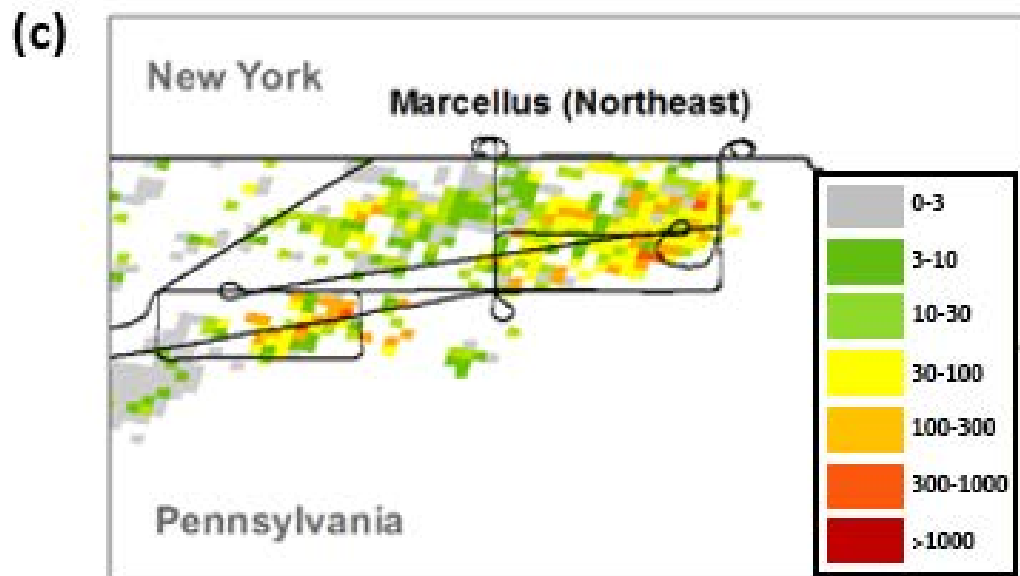
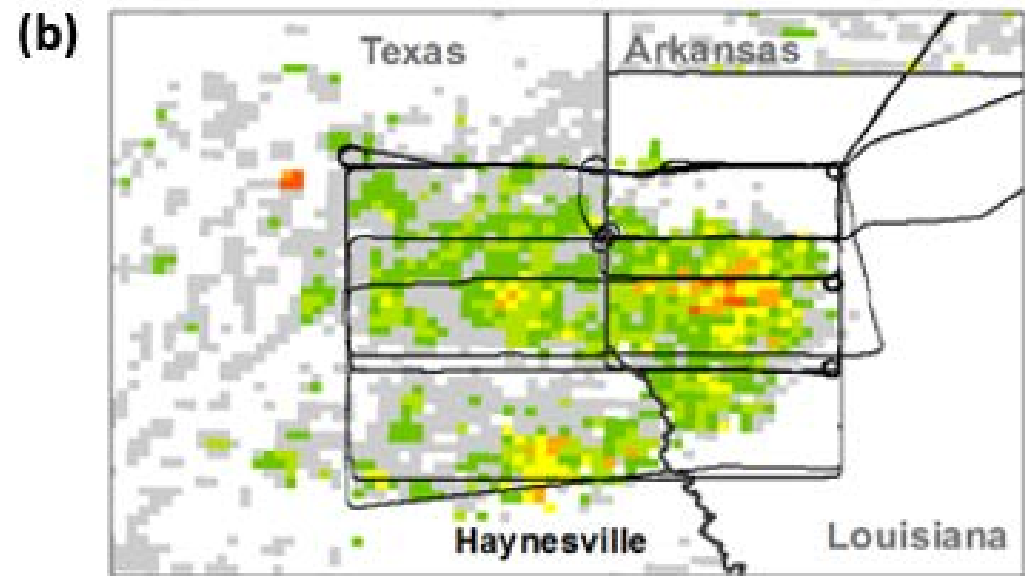
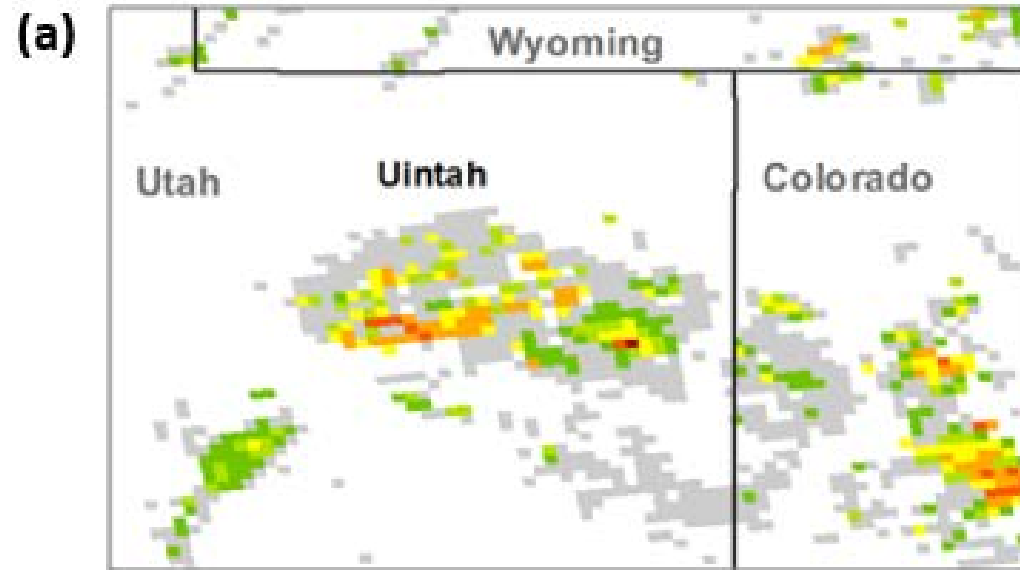
CO₂ Emission Factors for Major Oil & Gas Engine Sources



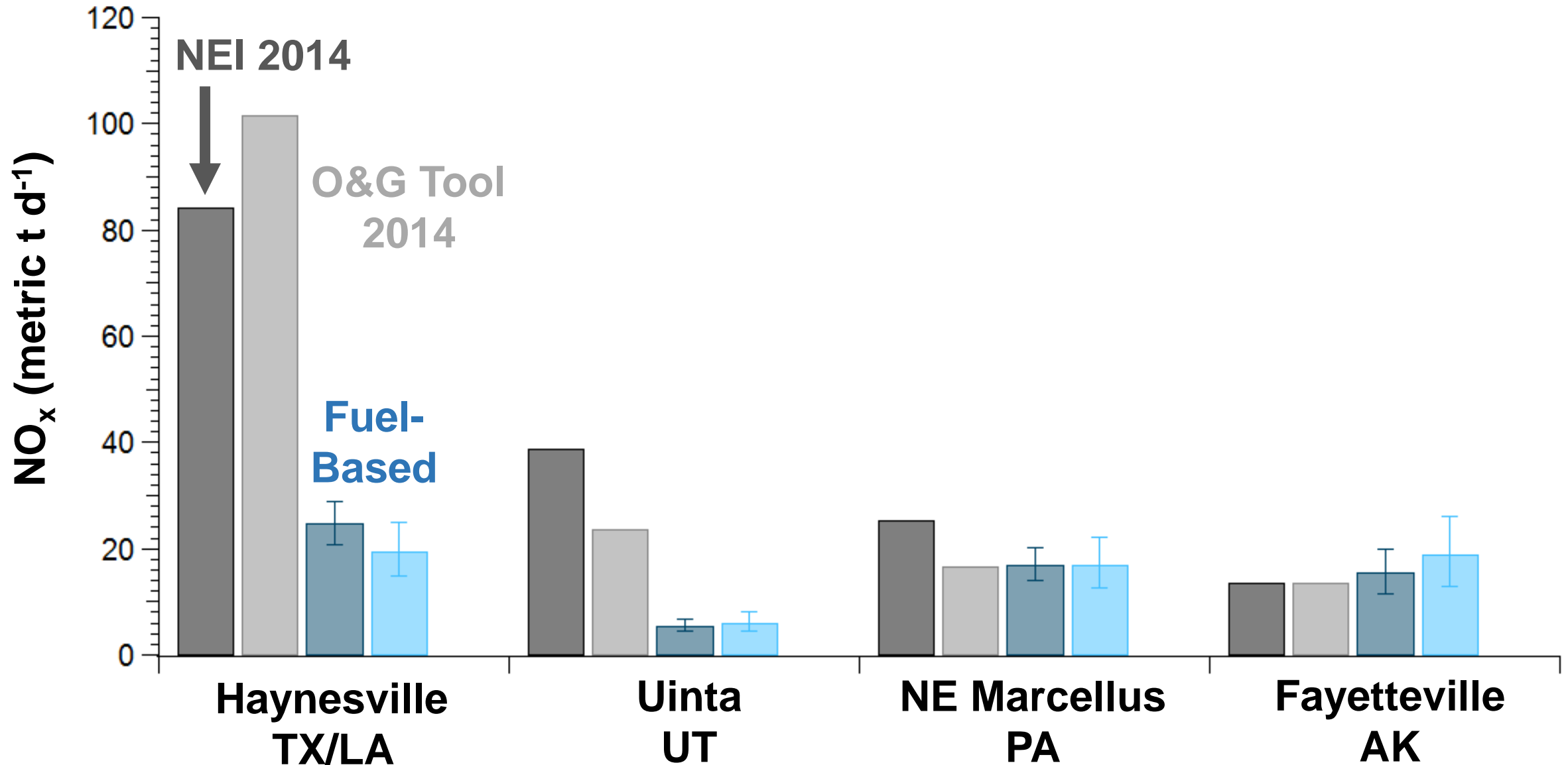
CO₂ Emission Factors for Major Oil & Gas Engine Sources



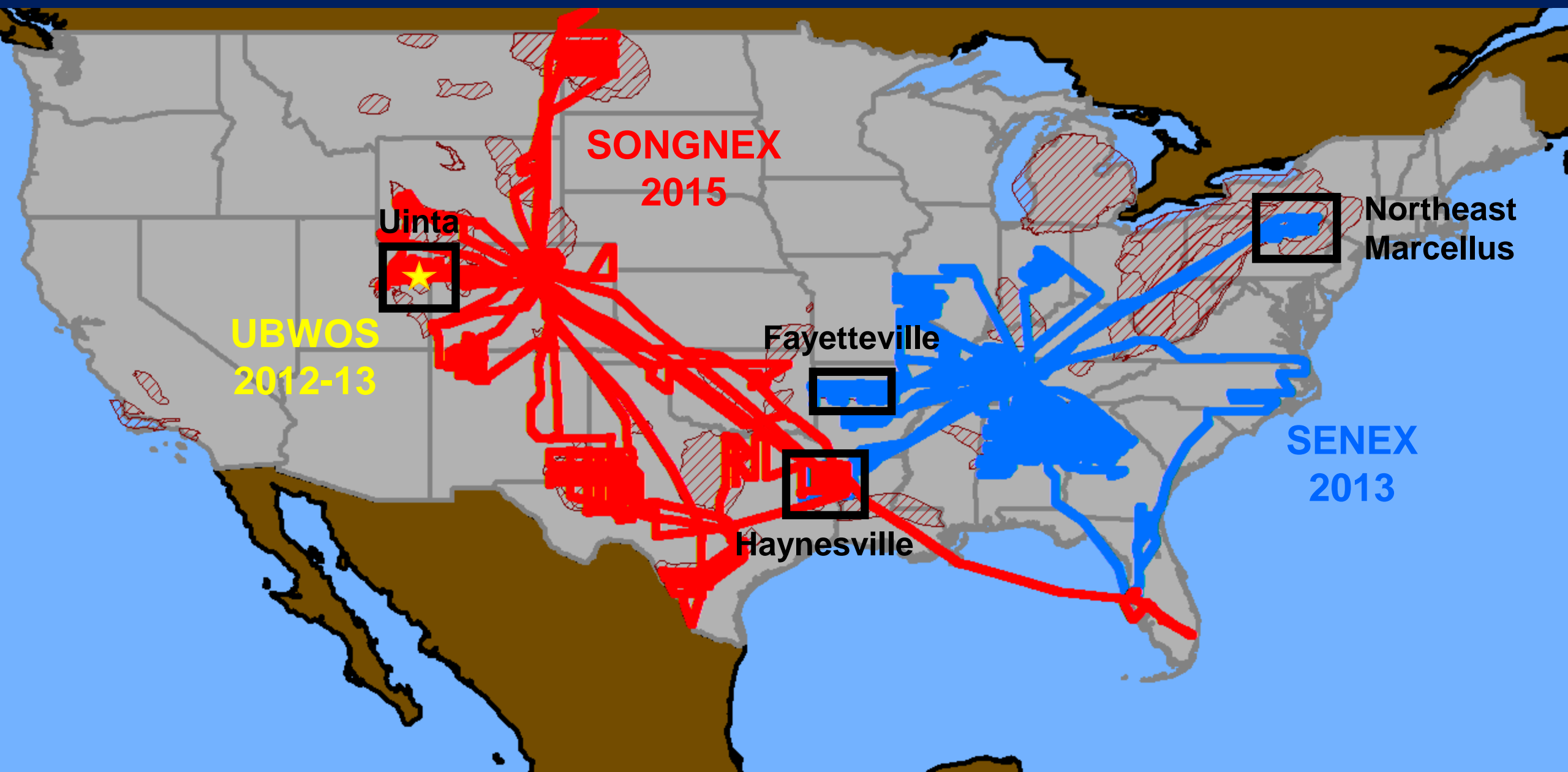
Examples of Gridded Fuel-Based Oil & Gas NO_x Inventory



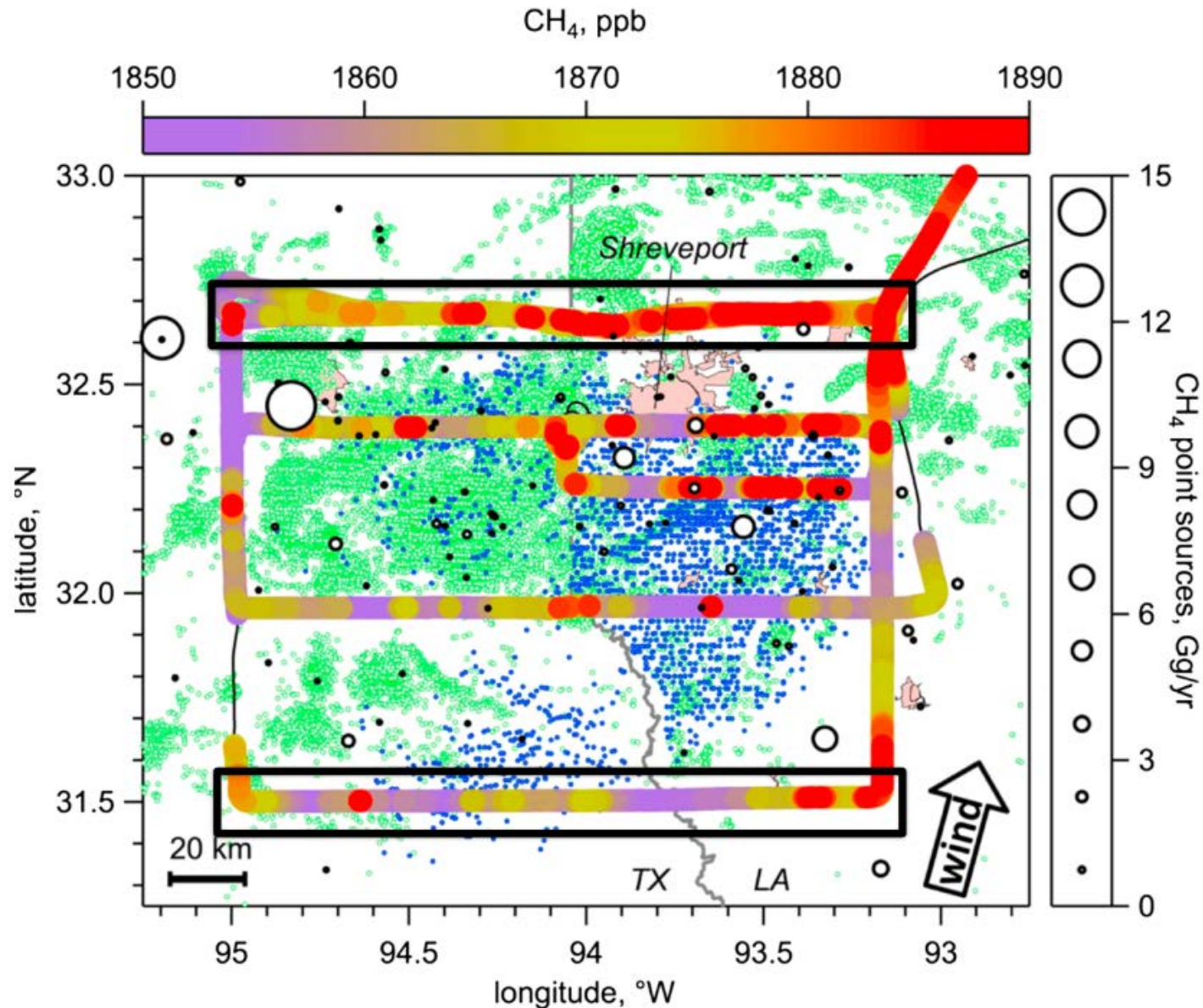
Comparison of Top-Down and Bottom-Up Emission Inventories



NOAA-led Campaigns Available to Constrain Oil & Gas Emissions



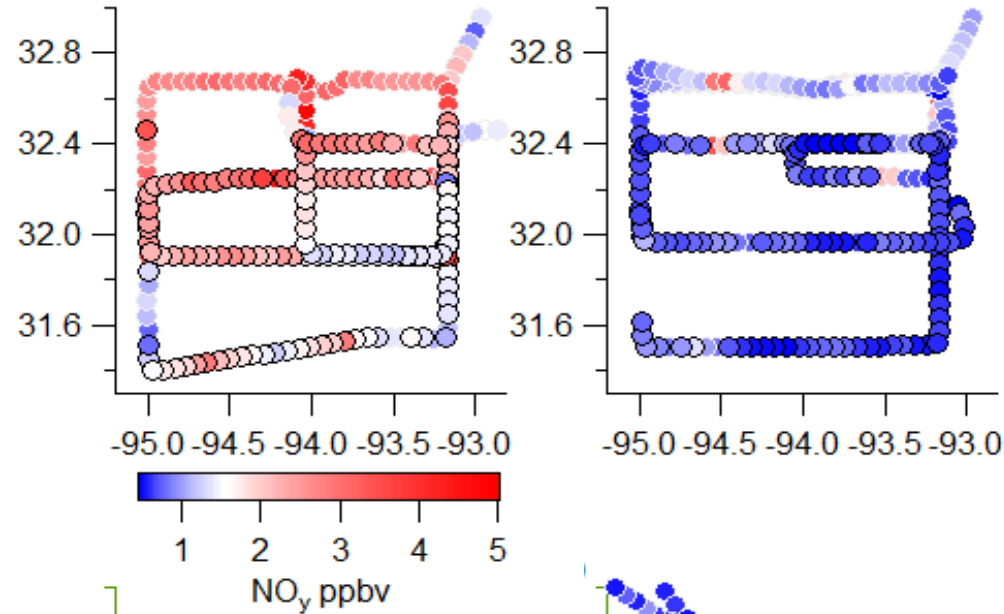
Top-Down Methane Emissions Derived from Aircraft



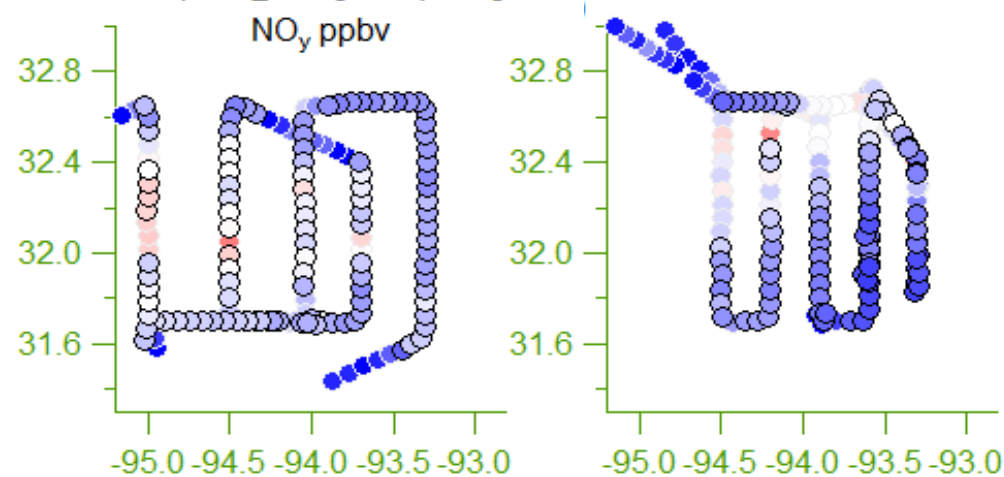
Example of CH_4 measurements in flights over Haynesville Basin

Simultaneous Aircraft Measurements of NO_y (Haynesville)

**SENEX
2013**



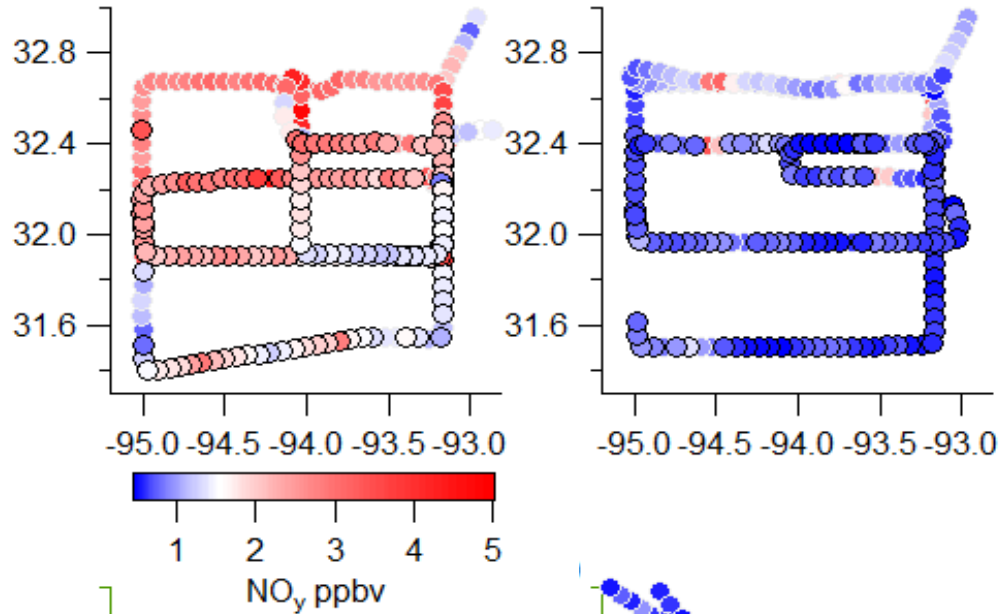
**SONGNEX
2015**



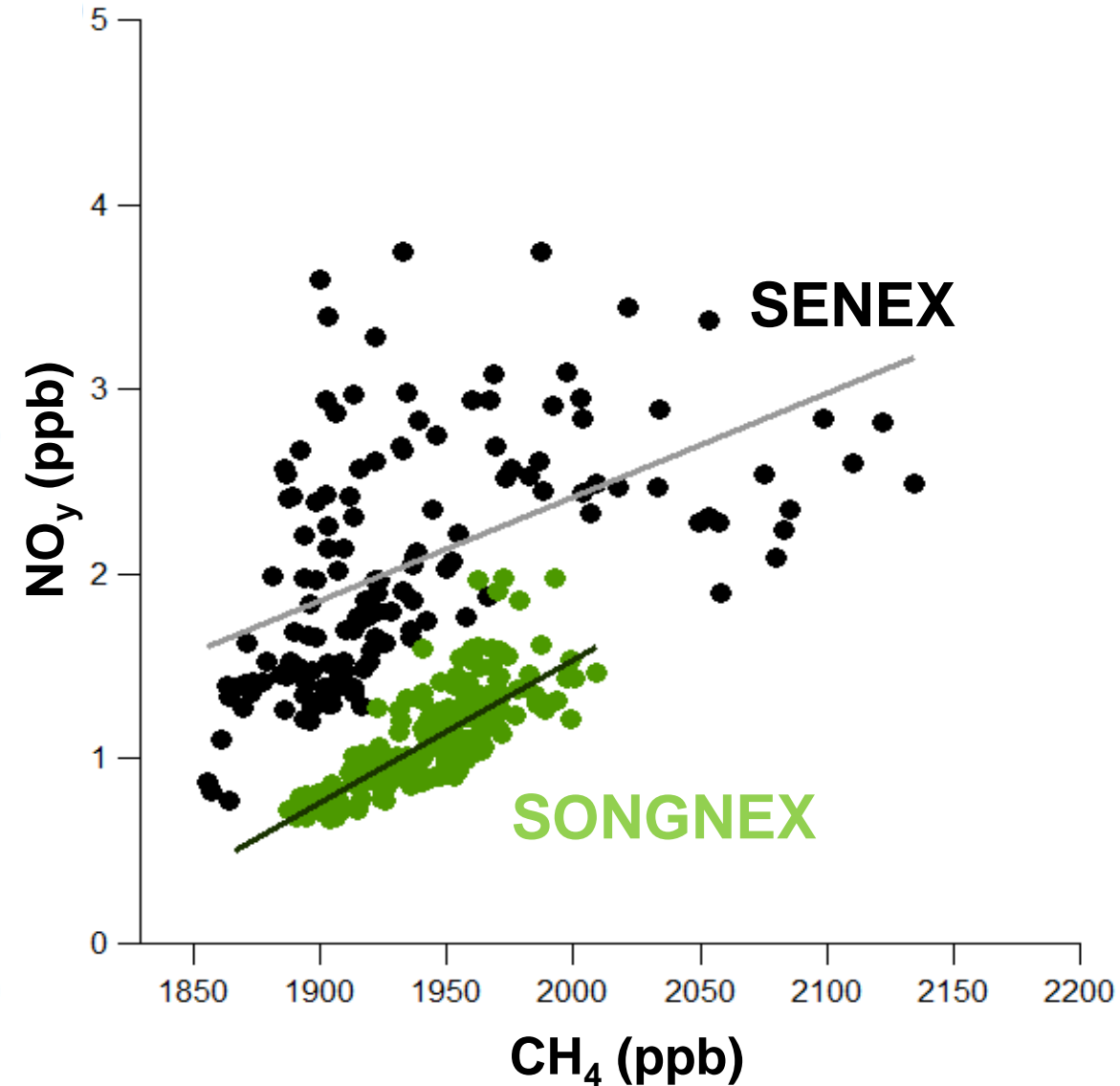
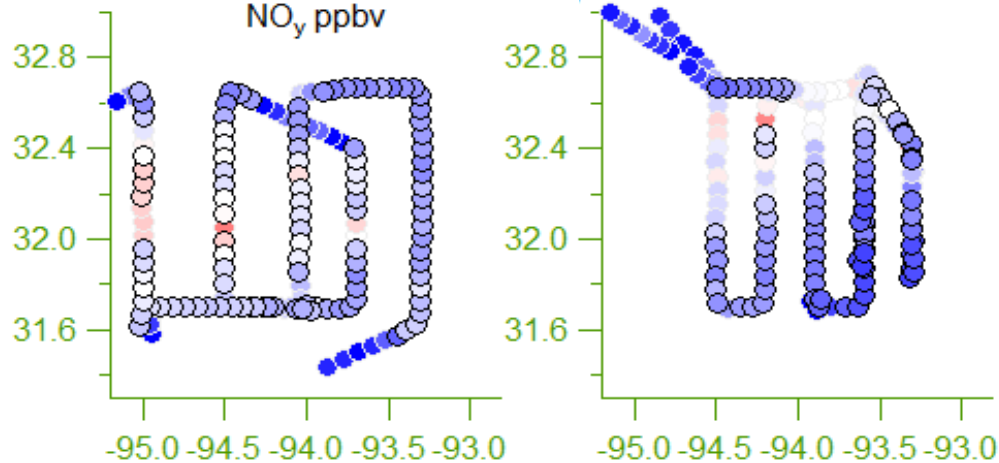
**Four research flights over
Haynesville Basin**

Consistent Enhancements in NO_y and CH_4 Observed (Haynesville)

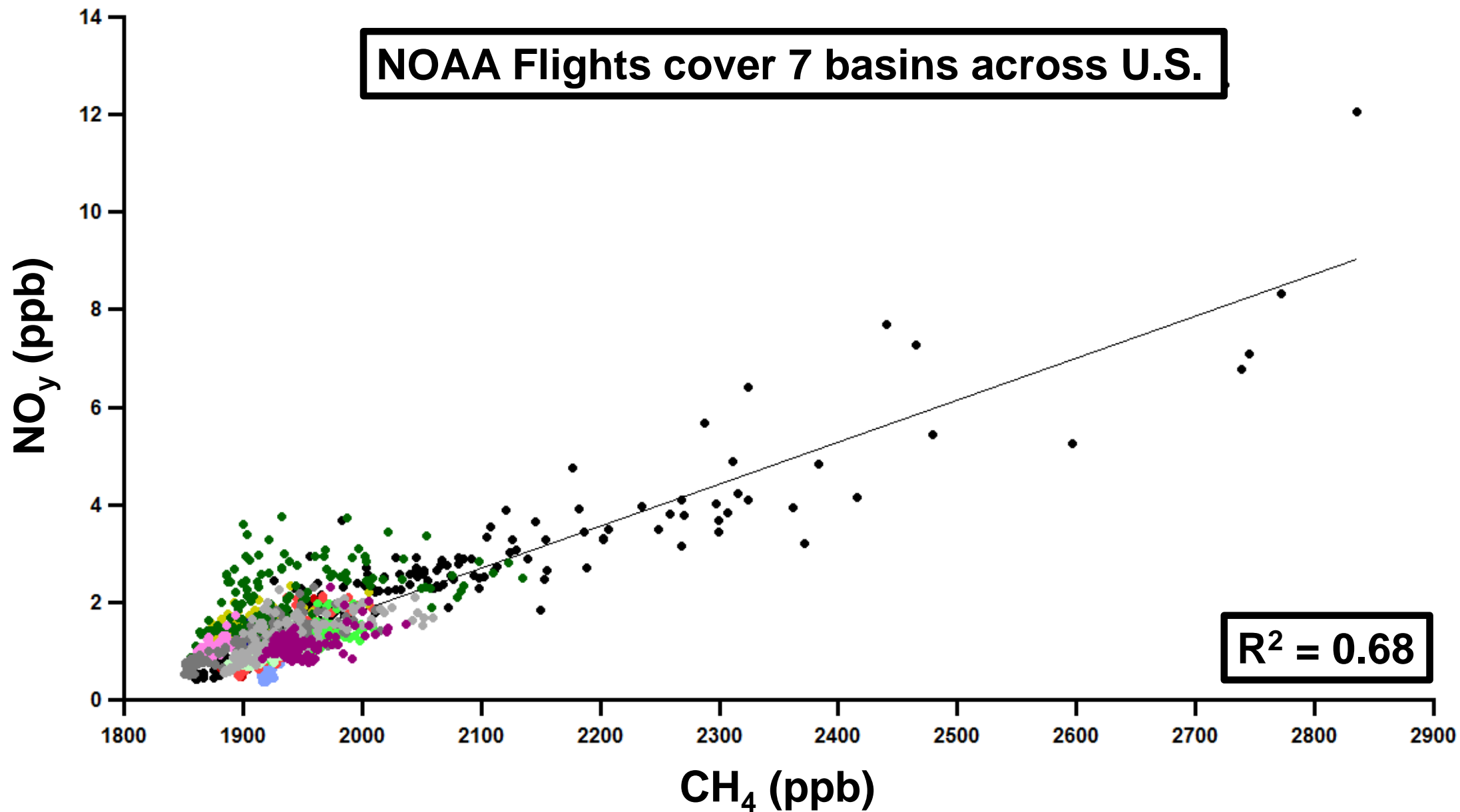
SENEX
2013



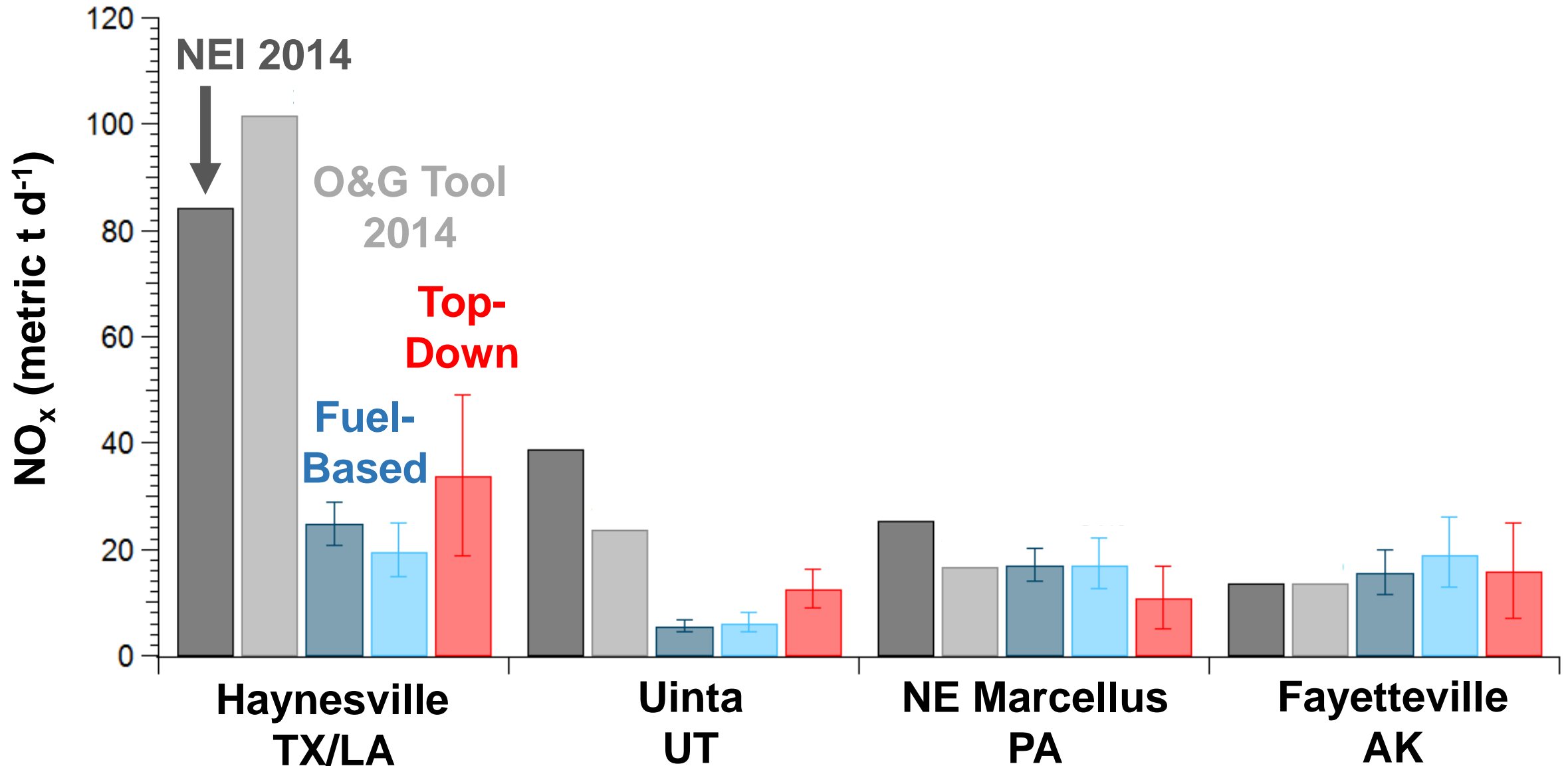
SONGNEX
2015



Correlation of NO_y/CH_4 Also Observed Across Many O&G Basins



Comparison of Top-Down and Bottom-Up Emission Inventories



Summary

- ❖ **Developed fuel-based inventory for oil & gas NO_x emissions**
 - Biggest differences between fuel-based inventory and NEI in activity
- ❖ **Bottom-up NO_x emissions evaluated with “top-down” emissions**
 - NO_y/CH₄ correlation consistently observed over oil and gas basins
 - Evidence for overestimate in oil & gas NO_x in NEI, but varies by basin
 - Fuel-based inventory consistent with observations