TAMEST Shale Task Force

Air Quality Impacts of Shale Oil and Gas Production in Texas

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Air Quality Impacts of Shale Oil and Gas Production in Texas

Today:

1. Briefly review science of air quality impacts
2. Summarize TCEQ project developing a Science Synthesis Report on these impacts
3. Review some Field Studies investigating these impacts (emphasis on NOAA studies)
4. Discuss some interesting results (as time allows)

Science of Air Quality Impacts

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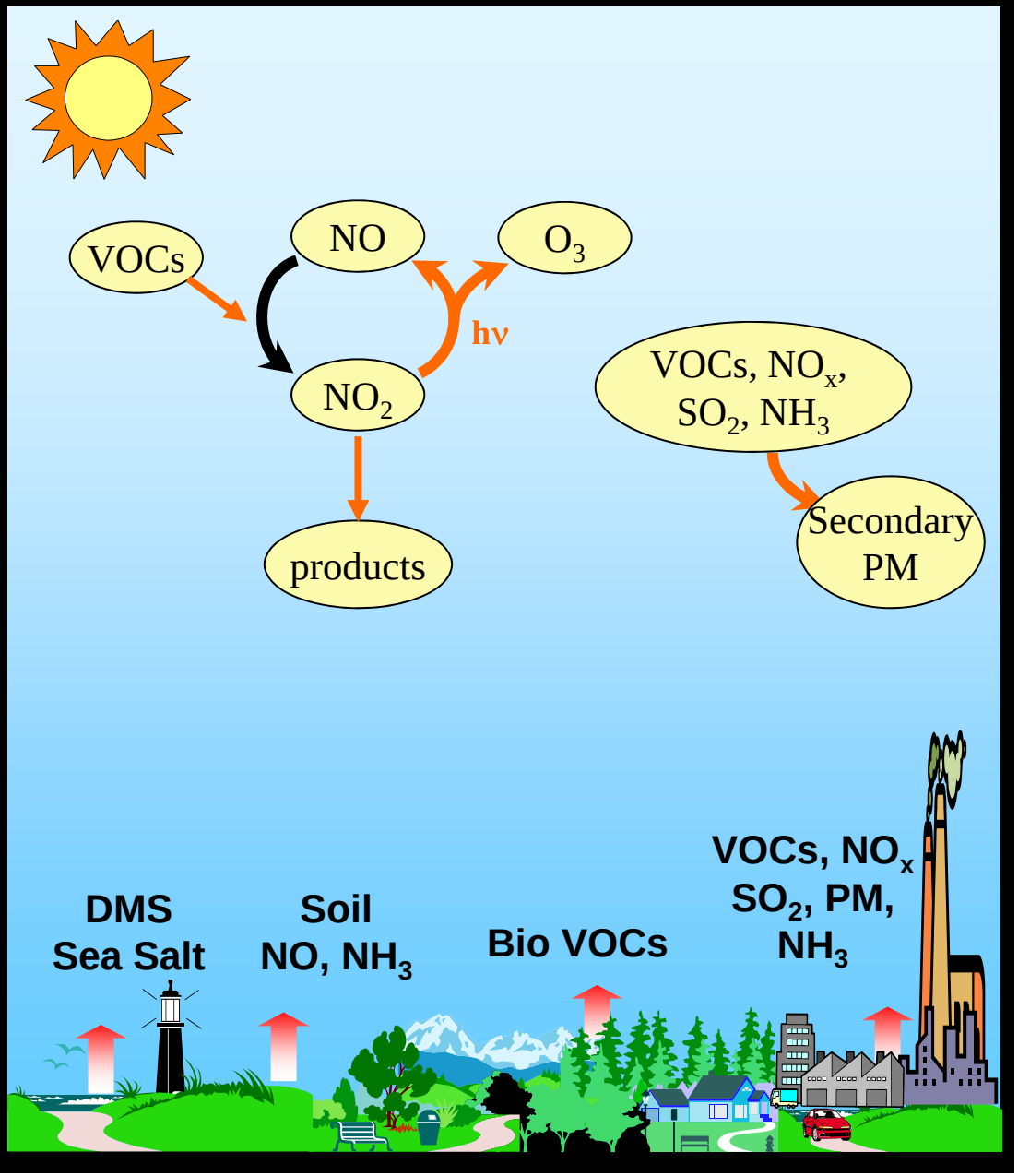
- Humans (industry, transport, electricity generation, farming, etc.) and nature (forests, soil, oceans, wildfires, etc.) emit a wide variety of species to the atmosphere.
- Primary pollutants can be directly harmful: CO, NO_2, SO_2, lead, toxic VOCs, particulate matter (PM)
- Chemistry in the atmosphere (largely driven by sunlight) yields secondary pollutants: ozone (O_3) and secondary PM.



Science of Air Quality Impacts

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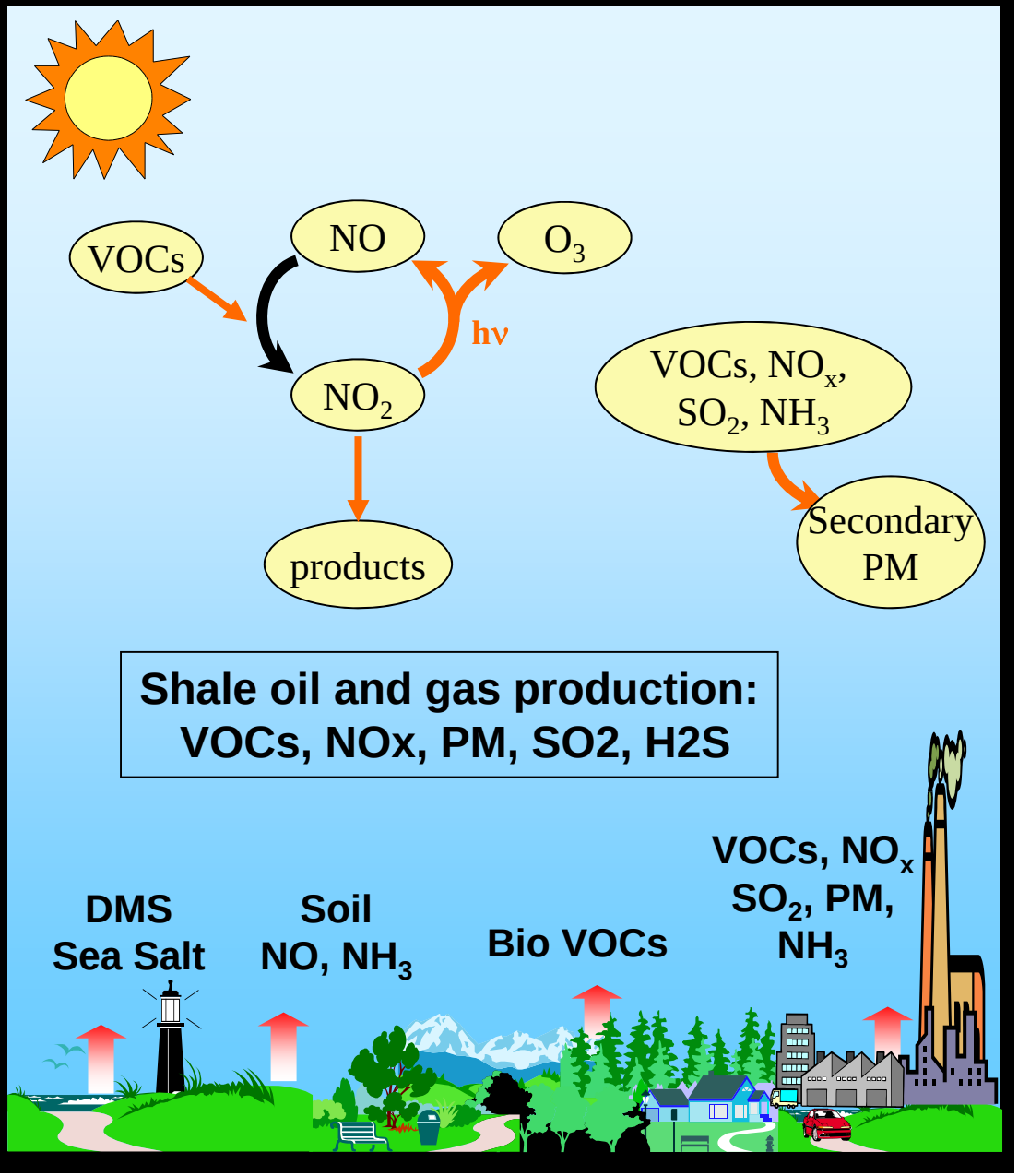
Primary pollutants can be directly harmful: CO, NO_2, SO_2, lead, toxic VOCs, particulate matter (PM)

Chemistry in the atmosphere (largely driven by sunlight) yields secondary pollutants: ozone (O_3) and secondary PM.

Shale oil and gas production is an additional, relatively new source of direct emissions located in different regions.



TCEQ Science Synthesis Report TAMEST Shale Task Force

PURPOSE: Provide a scientific synthesis of recent research pertaining to the air quality impacts of oil and gas development in Texas. Must be *policy relevant,* not *policy prescriptive*.

LEAD: Ramboll Environ is contracted to lead Synthesis; I have joined as a sub-contractor

TECHNICAL APPROACH: Working Groups of Scientists will address each of the guiding Science Questions.

TIMELINE:

- *March 31, 2017* – Ramboll-Environ briefs TCEQ at an in-person meeting in Austin, Texas. Rough drafts of all Question Responses must be complete.
- *June 1, 2017* – First draft of Report due
- *June 30, 2017* – Final Report due

TCEQ Science Synthesis Report TAMEST Shale Task Force

SCIENCE QUESTIONS:

1. Address the issues of most importance to policy makers of the State of Texas
2. Specific enough to provide a clear focus
3. General enough to cover emerging scientific issues.

Each question will be addressed, but it is not expected that comprehensive answers will be provided for any.

TCEQ Science Synthesis Report TAMEST Shale Task Force

SCIENCE QUESTIONS:

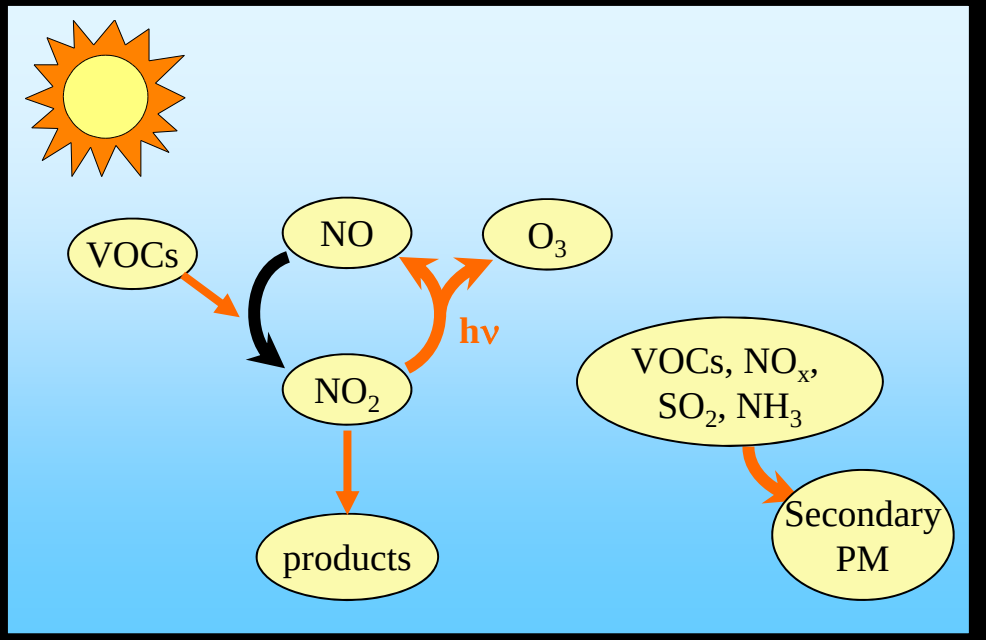
Emissions

- What are the emissions of ozone and PM precursors from oil and gas development in Texas?
- How do the magnitude and composition of these emissions depend upon variables such as composition of extracted oil and natural gas and technologies employed? What are the important parameters controlling how these emissions vary over time and area?
- How are these emissions divided between the various stages of fossil fuel extraction (exploration and production, product gathering and transmission, gas processing) and specific processes?
- How do these emissions in Texas compare to other regions of the U.S.?
- Are there gaps in our quantification of emissions that limit a full understanding of ozone and PM formation from these emissions?

TCEQ Science Synthesis Report TAMEST Shale Task Force

SCIENCE QUESTIONS:

Chemical Transformation



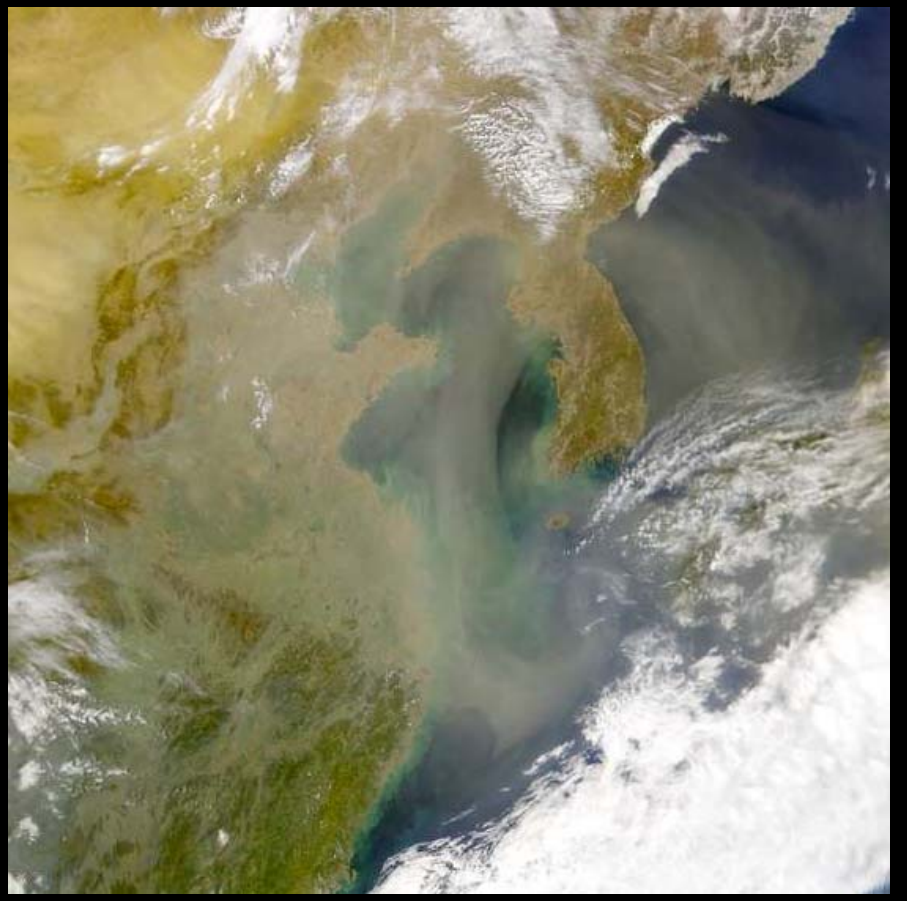
- What are the contributions of emissions from oil and gas development to ambient O_3 concentrations at regulatory monitors in Texas?
- Are there significant differences in O_3 and PM formation mechanisms between the major oil and natural gas basins in Texas?
- Are there important interactions between emissions from oil and natural gas development and emissions from other sources such as urban, point source, and biogenic, including crops and animal husbandry?
- Are there gaps in our understanding of chemical transformations that limit a full understanding of ozone and PM formation from oil and gas development emissions?

TCEQ Science Synthesis Report TAMEST Shale Task Force

SCIENCE QUESTIONS:

Transport and Meteorology

- What is the impact on other regions of Texas from O_3, PM, and their precursors transported from oil and natural gas development areas? How does the impact from oil and gas development compare to impacts from other sources, e.g., upwind cities, rural power plants, and biogenic emissions?
- What gaps remain to accurately attribute O_3 and PM formation to emissions source sectors throughout the state?



TCEQ Science Synthesis Report TAMEST Shale Task Force

WORKING GROUPS:

Scientists from:

- Ramboll Environ (4)
- Federal Agencies (8 from NOAA, 2 from NASA)
- Universities (8 total from University of Texas at Austin, Texas A&M University, Colorado State University, Yale University, University of California - Berkeley, and Purdue University)
- Energy Company (1 from Chevron Energy Technology Company)
- Environmental Advocacy Group (1 from Environmental Defense Fund)

Review of Field Studies

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Dallas-Fort Worth (Barnett Shale) field campaigns

- Initiated in 2010
- Augmented set of measurements at Eagle Mountain Lake site in Tarrant County, Texas in the summer of 2011

Strengths:

- Comprehensive chemistry measurements
- Operate for weeks – encounter a variety of meteorological conditions

Weakness:

- Observations limited to a single location

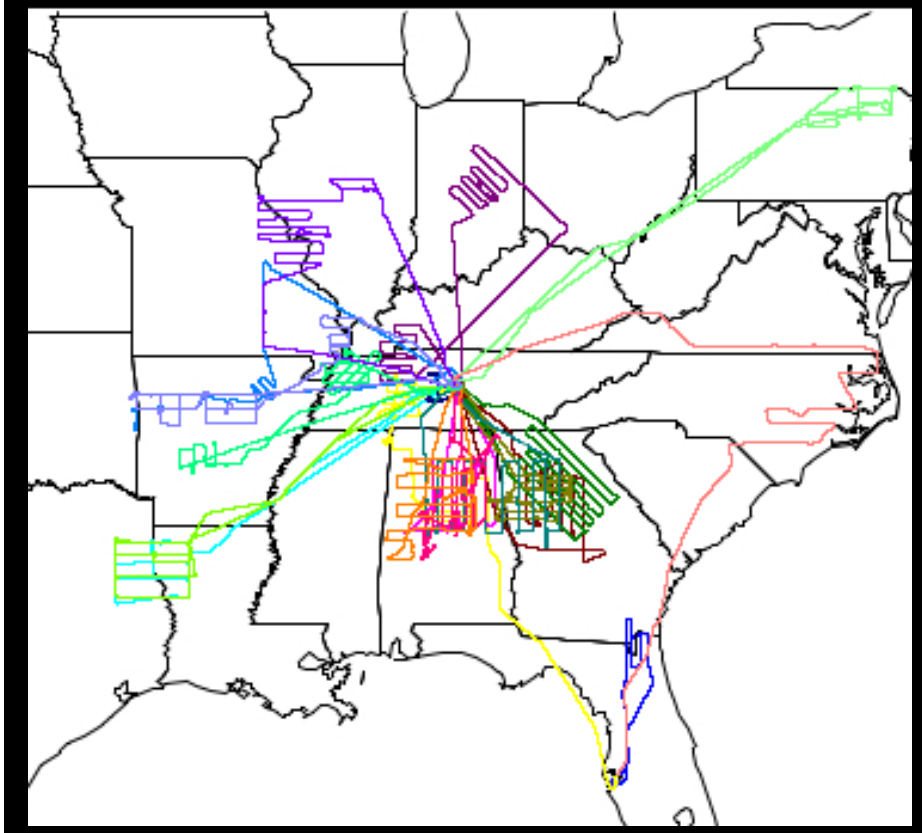
Review of Field Studies

TAMEST Shale Task Force

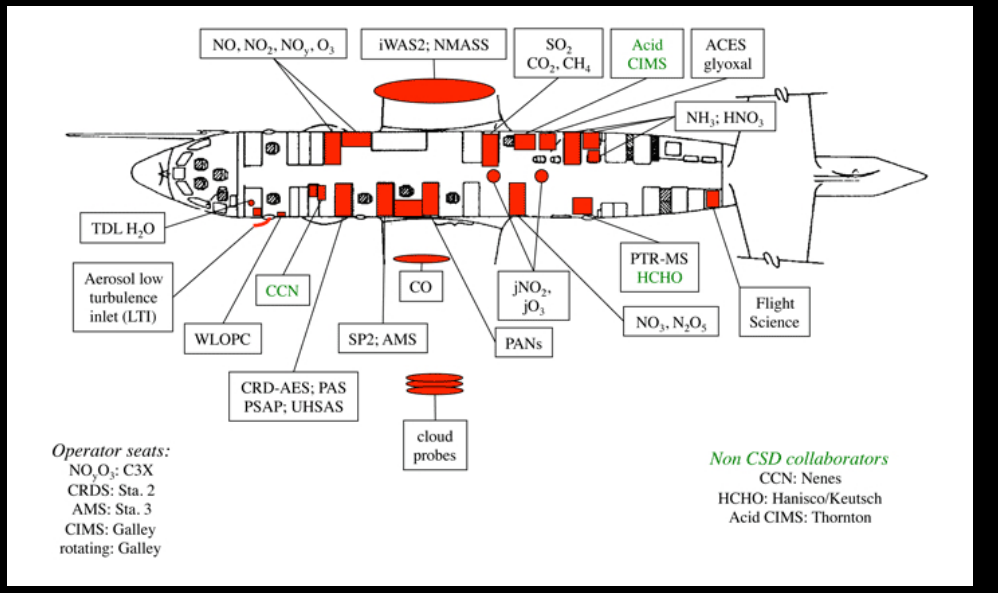
Southeast Nexus of Air Quality and Climate Change (SENEX)

NOAA field mission – June-July 2013

www.esrl.noaa.gov/csd/projects/senex/



NOAA WP-3D flying laboratory



PI: Joost de Gouw (Joost.deGouw@noaa.gov)

Review of Field Studies

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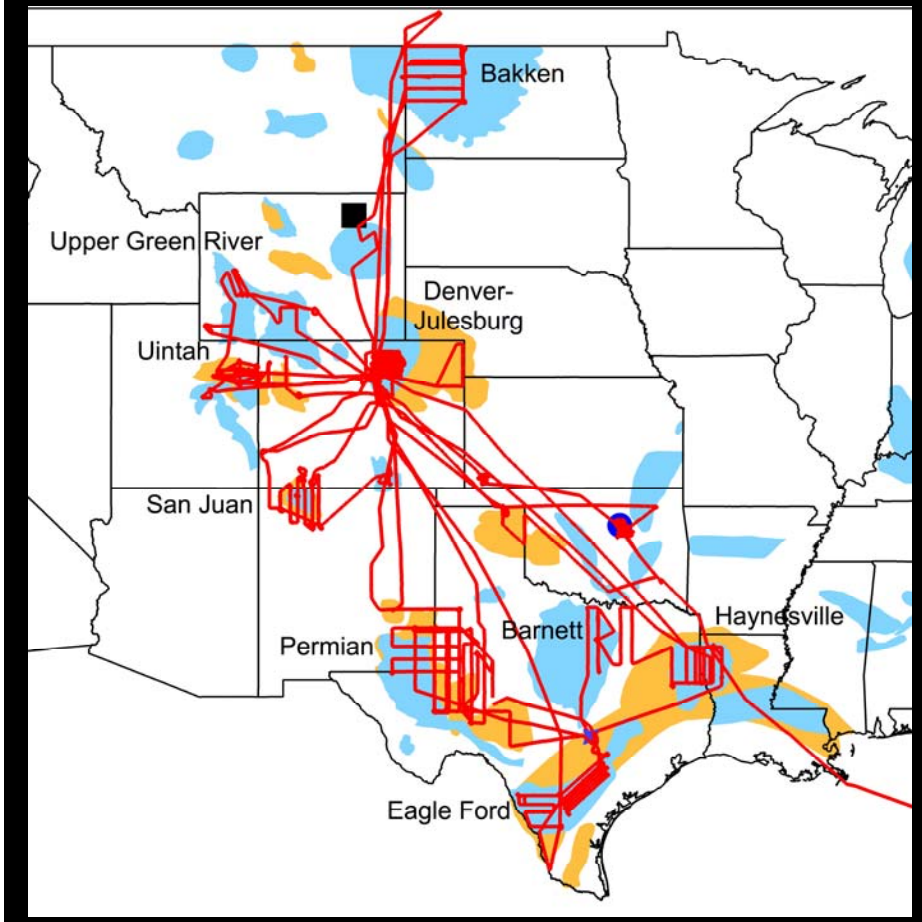
Shale Oil and Natural Gas Nexus (SONGNEX)
NOAA field mission - March-April 2015
www.esrl.noaa.gov/csd/projects/songnex



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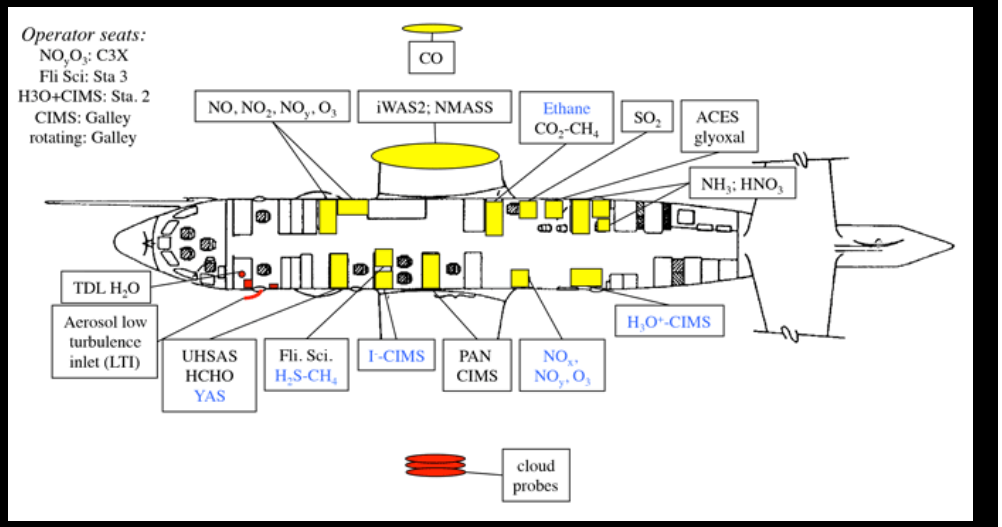

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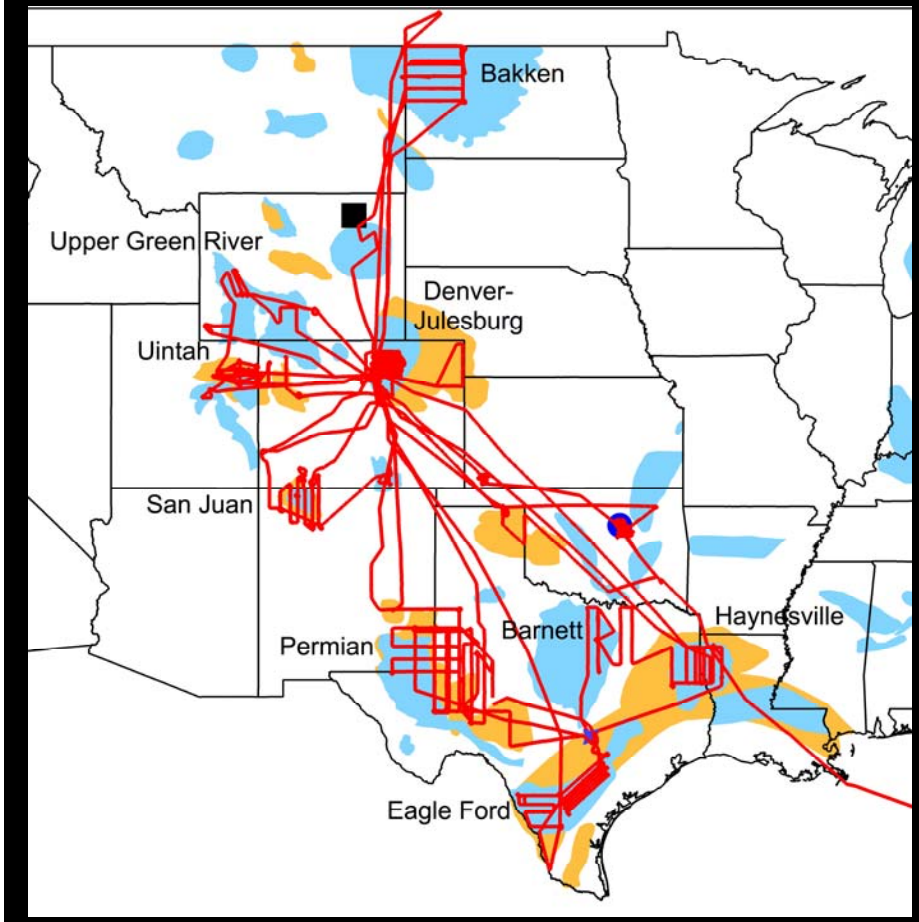

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NOAA Airborne Field Studies

Strengths:

- Comprehensive chemistry measurements
- Mobile platform – sample downwind plumes
- Compare and contrast oil and gas basins throughout the country

Weaknesses:

- Expensive – very limited time coverage
- Poor statistics – only very limited (one or a few) days of sampling in a given basin.

Some interesting results

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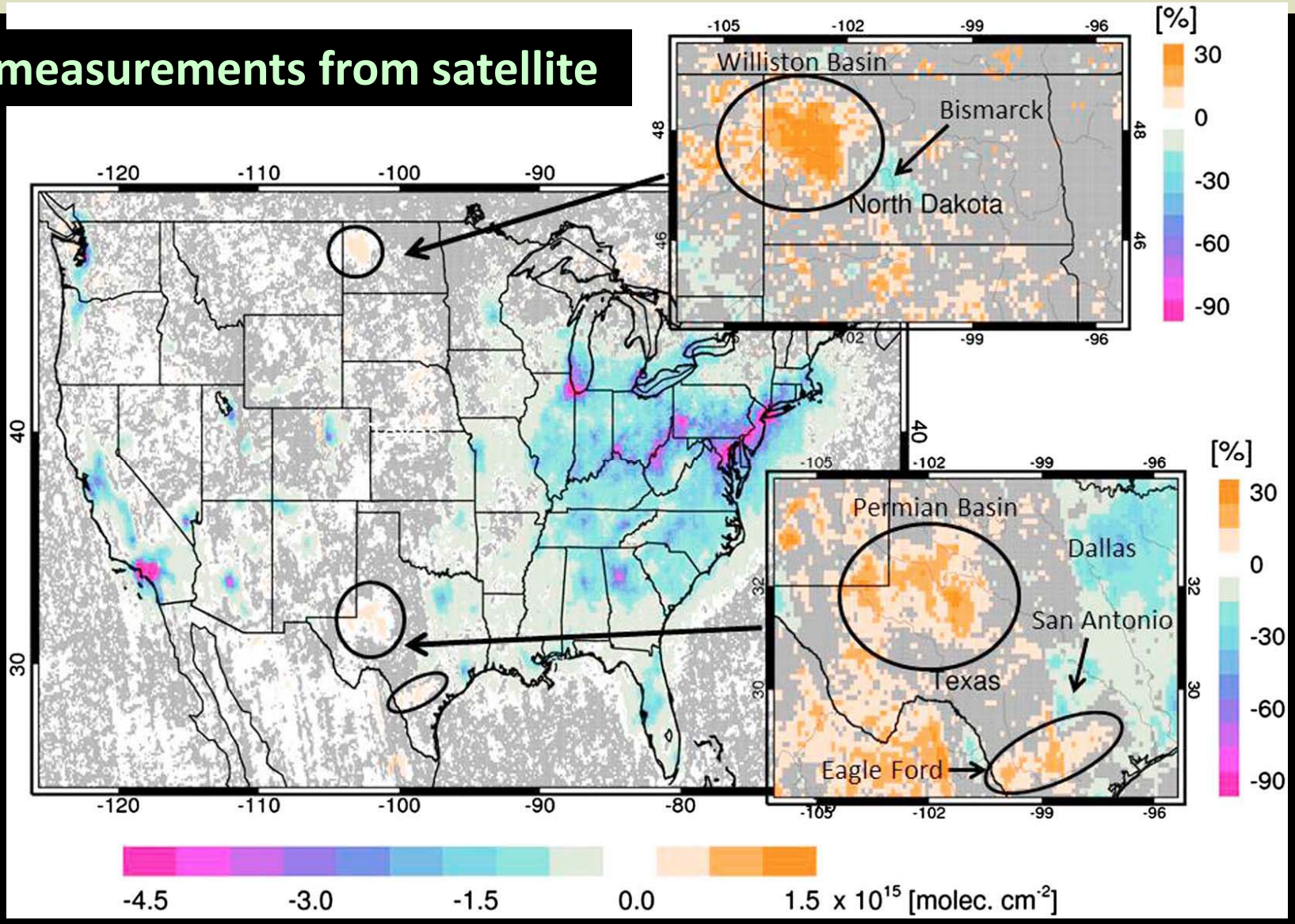
NO_2 measurements from satellite



Duncan et a., (2016), A space-based, high-resolution view of notable changes in urban NOx pollution around the world (2005–2014), *J. Geophys. Res. Atmos., 121*, doi:10.1002/2015JD024121

Some interesting results

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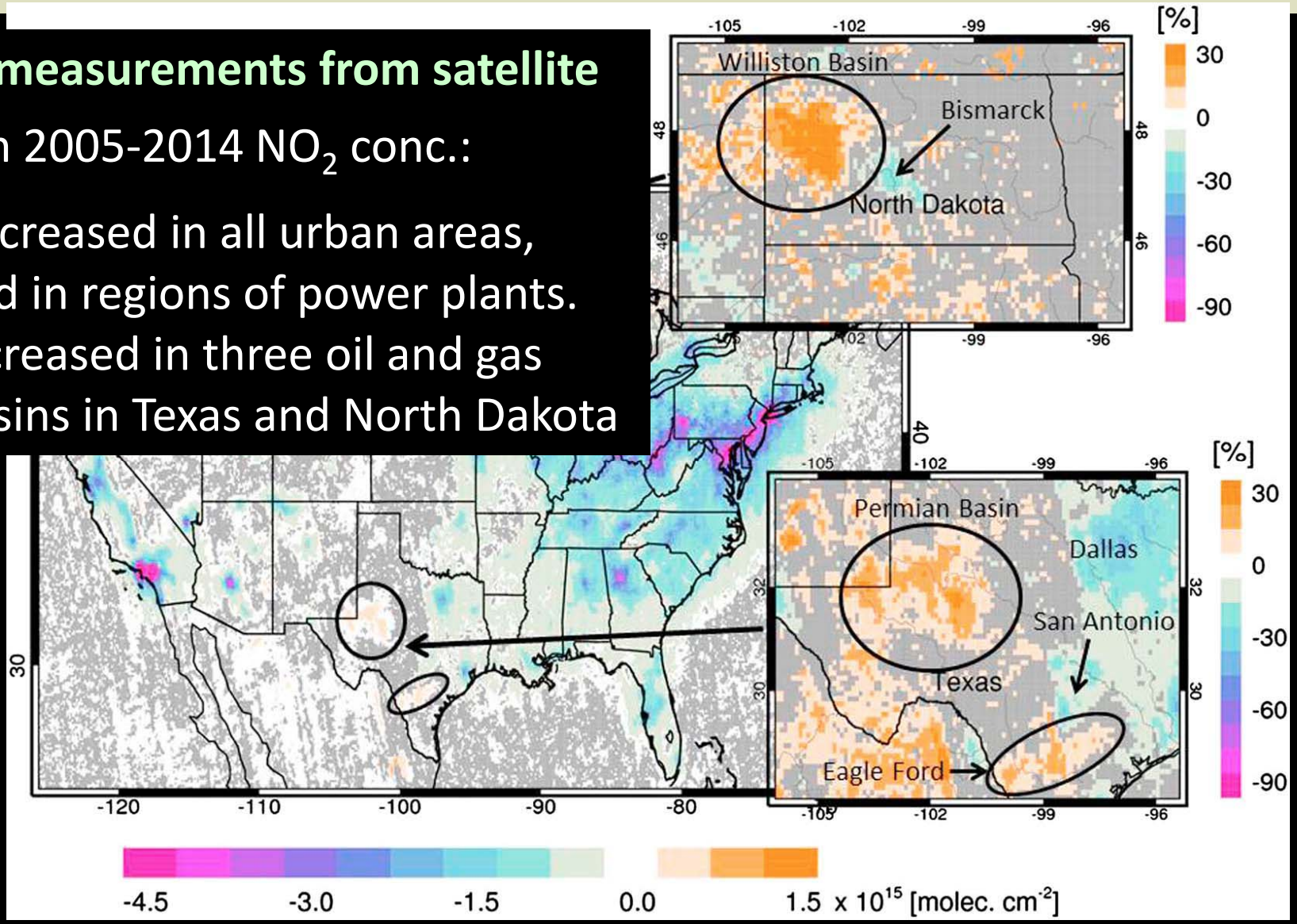
NO_2 measurements from satellite

From 2005-2014 NO_2 conc.:

- Decreased in all urban areas, and in regions of power plants.
- Increased in three oil and gas basins in Texas and North Dakota



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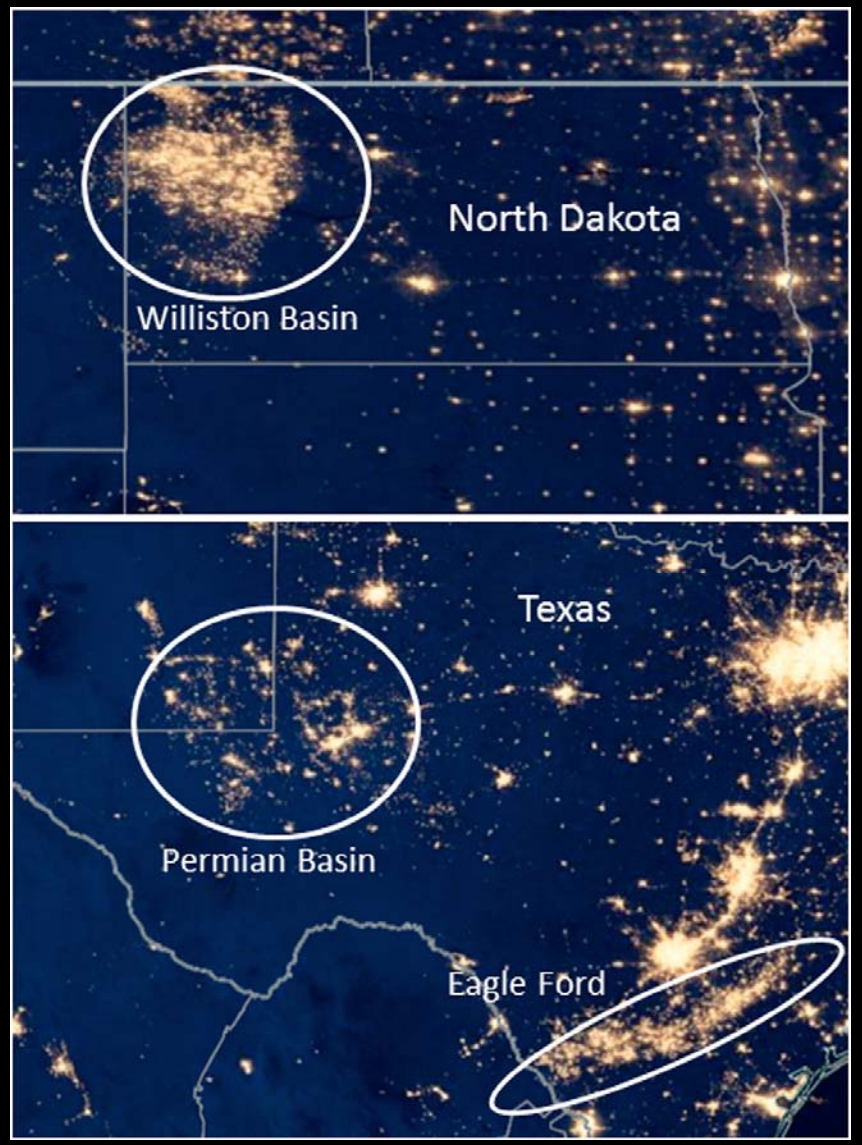
- Decreased in all urban areas, and in regions of power plants.
- Increased in three oil and gas basins in Texas and North Dakota
- These three basins have large amounts of associated gas flaring (rural night lights).

Is flaring the dominant source of NOx emissions?



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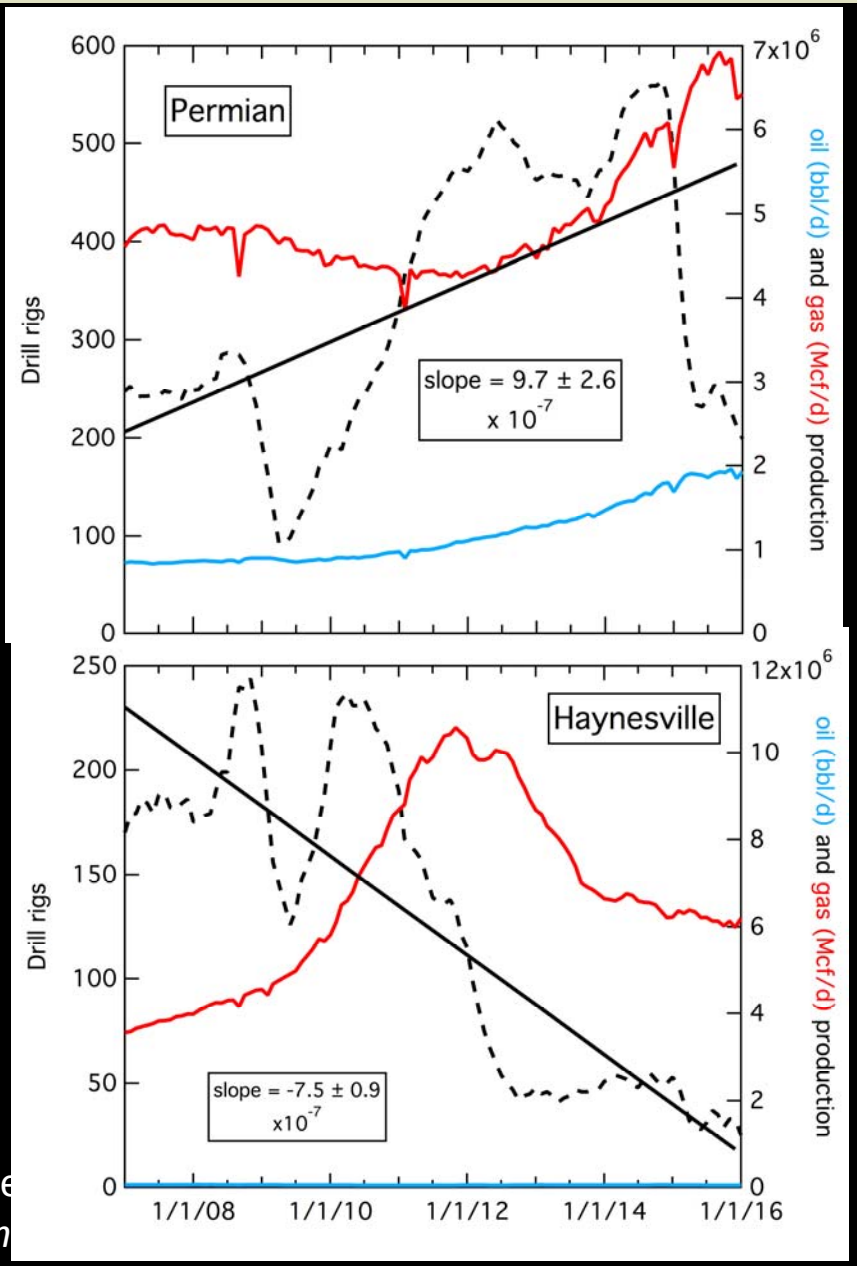
Or do NOx emissions more closely follow drilling and well completion?

Basins with NOx increases show drilling increases over the period of that period



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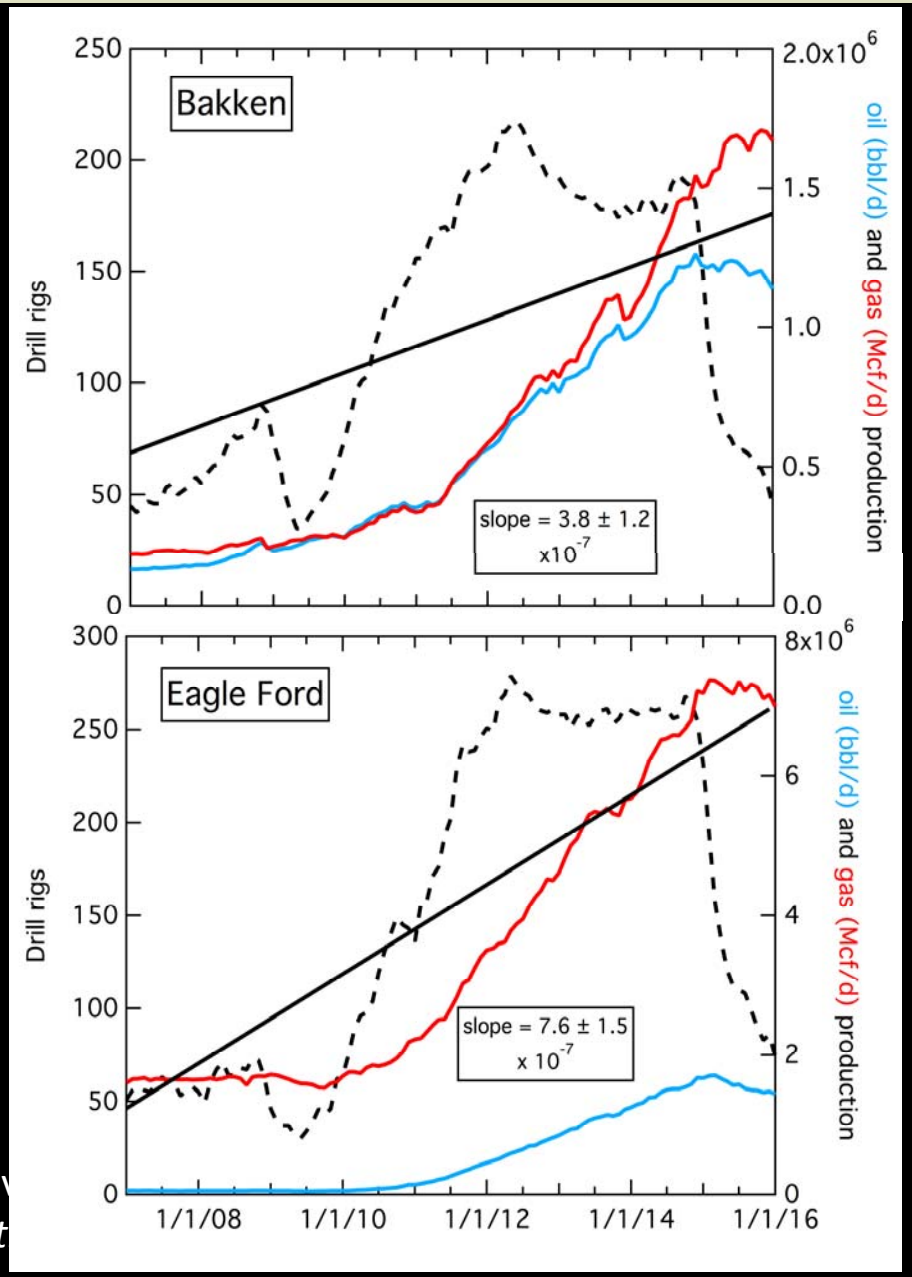

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Some interesting results

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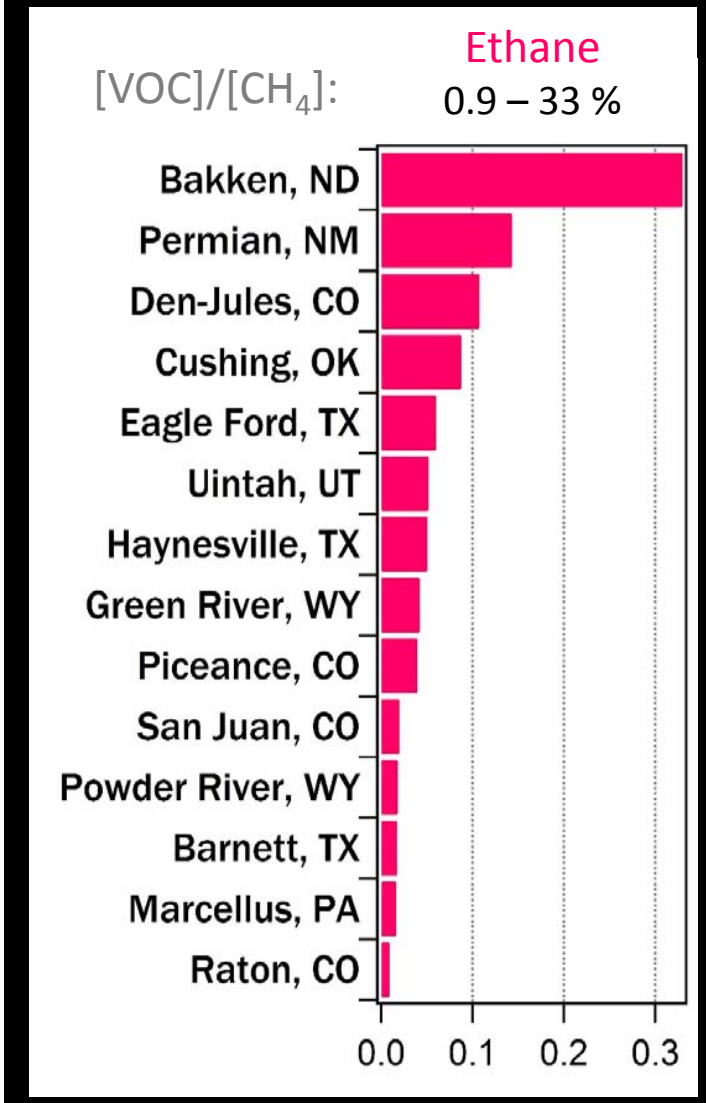
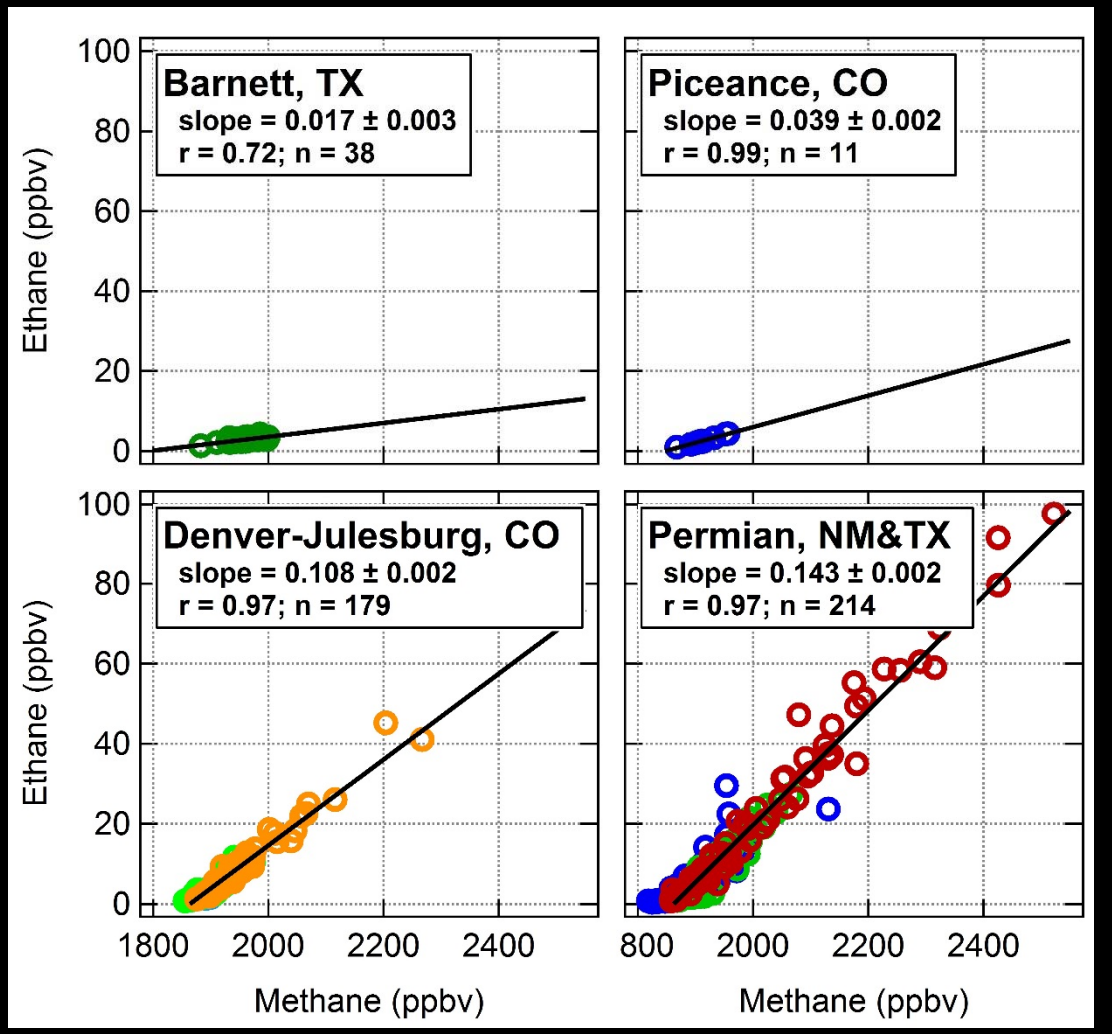
Comparison of VOC composition between air basins – NOAA P3 data



[VOC]/[CH4] Enhancement Ratios



J. Gilman, NOAA

Some interesting results

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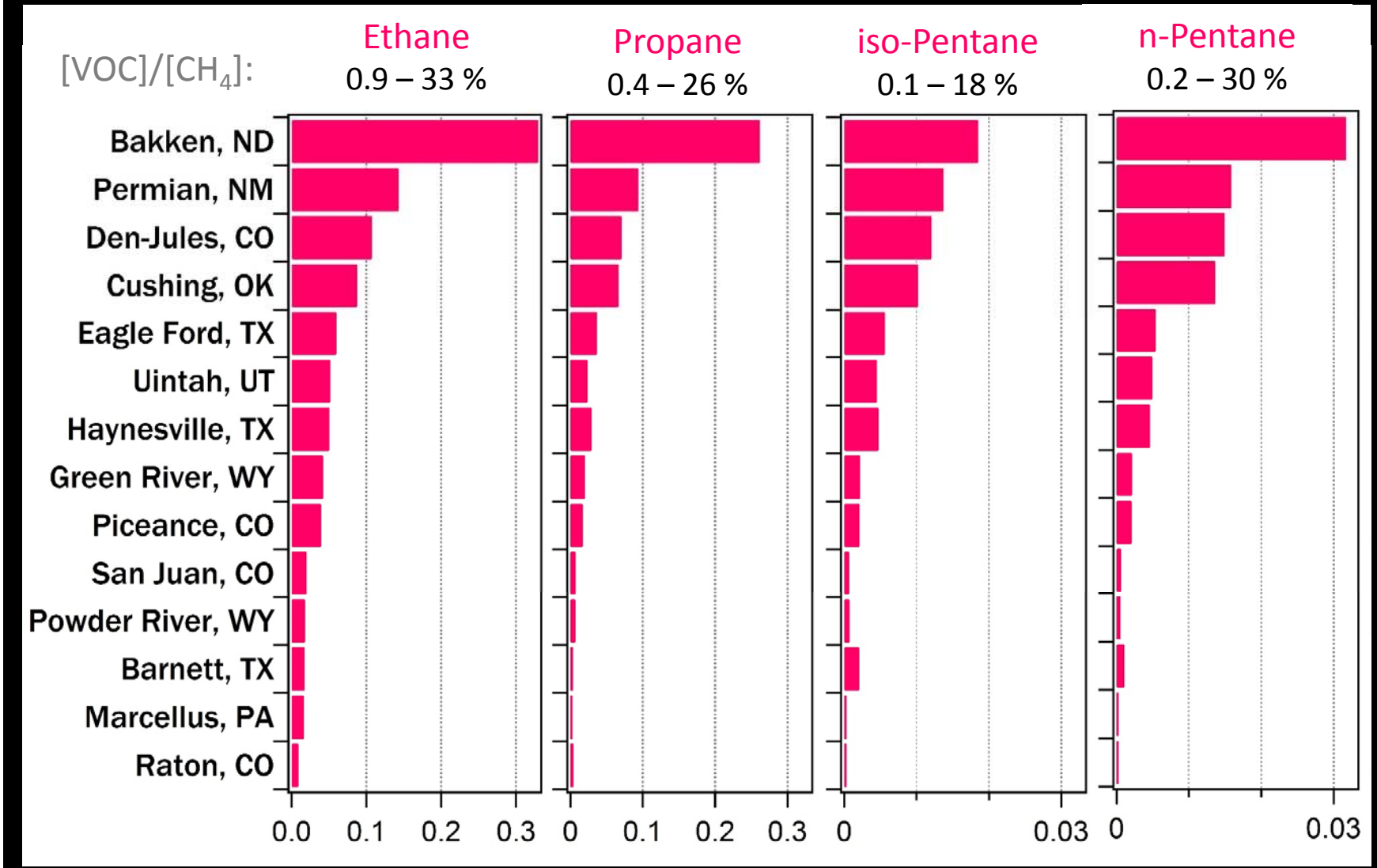

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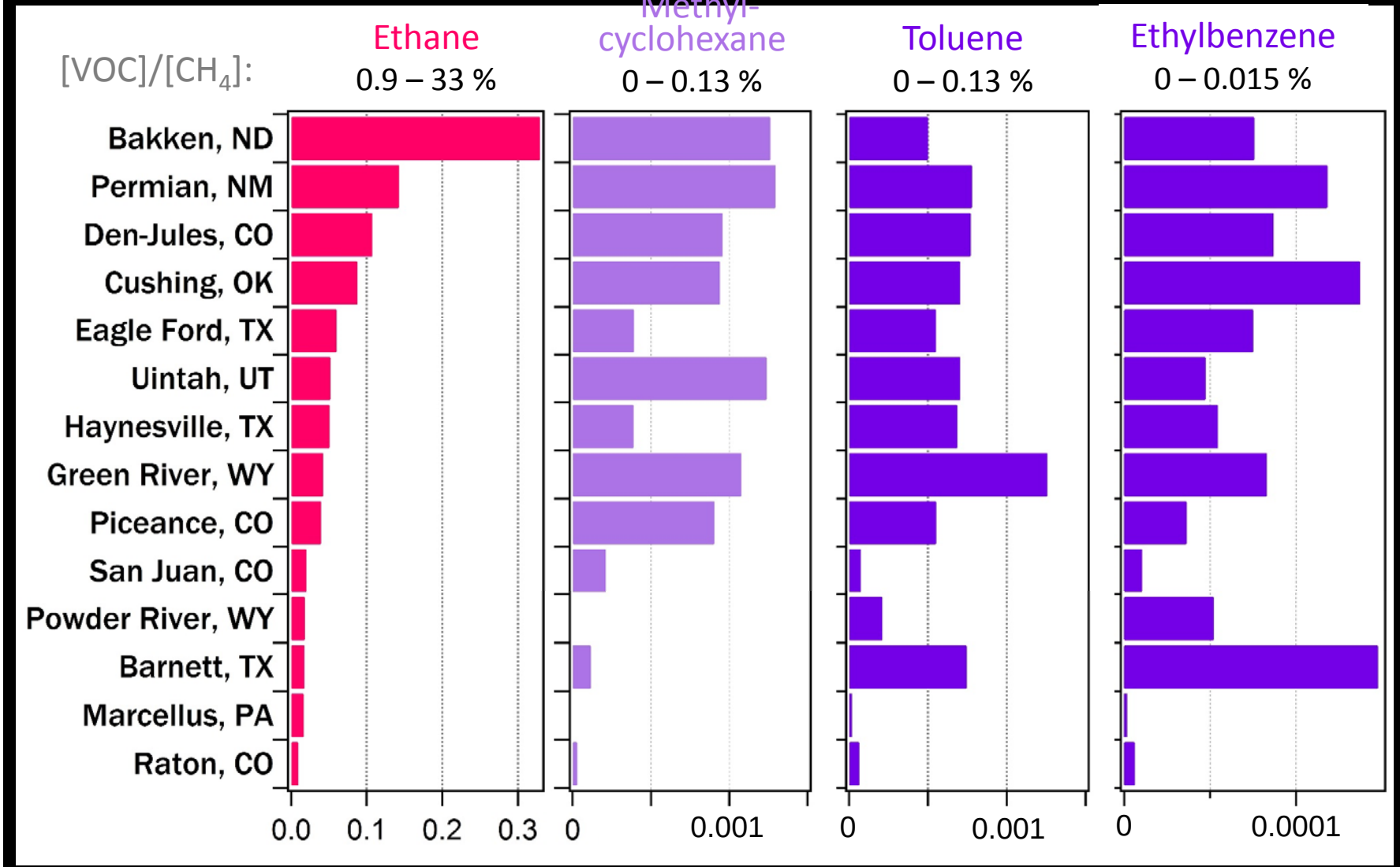

J. Gilman, NOAA

Some interesting results

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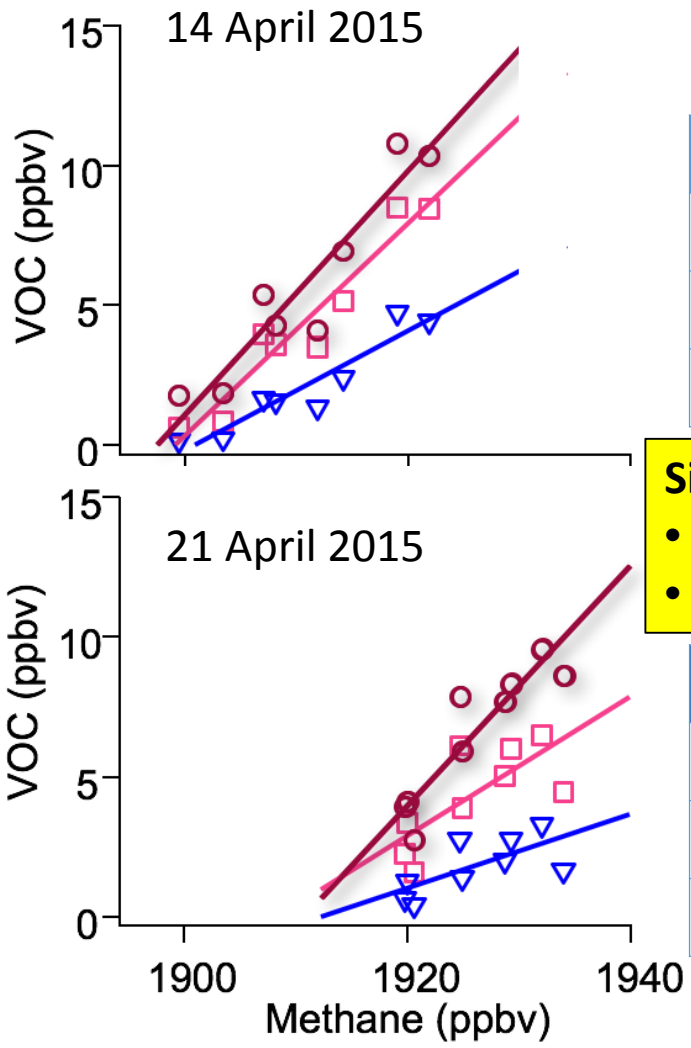
VOC fluxes in Bakken, ND

$Flux_{VOC} = Flux_{CH4} * ER_{[VOC]/[CH4]} * (MW_{VOC}/MW_{CH4})$



$Flux_{CH4} = 0.30 \pm 0.15$ Tg CH_4 yr^{-1}

from Peischl et al. (previous work)

VOC	$ER_{[VOC]/[CH4]}$	r	MW_{VOC}	$Flux_{VOC}$ (Tg yr^{-1})
Ethane	0.43 ± 0.06	*0.94*	30	0.24 ± 0.12
Propane	0.38 ± 0.04	*0.96*	44	0.31 ± 0.16
n-Butane	0.21 ± 0.03	*0.94*	58	0.23 ± 0.12

Similar analyses will be performed for:

- **All oil and natural gas basins**
- **All measured VOC species**

1.5 to 3.0 % of global emissions

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Ethane	0.43 ± 0.06	*0.91*	30	0.24 ± 0.12
Propane*	0.25 ± 0.09	*0.72*	44	0.17 ± 0.10
n-Butane*	0.13 ± 0.05	*0.69*	58	0.15 ± 0.08

*C_3-C_8 ERs are ~35% lower than 14 April 2015

J. Gilman, NOAA

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Thank You for Your Attention