AiRMAPS 2024-26

Airborne and Remote Sensing Methane and Air Pollutant Surveys

U.S. O&G Methane Emissions

NOAA Office of Atmospheric Research (OAR)

Chemical Sciences Laboratory (CSL): Steven Brown, Brian McDonald, Sunil Baidar, Carsten Warneke

Air Resources Laboratory (ARL): Xinrong Ren, Winston Luke

Global Monitoring Laboratory (GML): Colm Sweeney, Arlyn Andrews, Jeff Peischl

Climate Program Office (CPO): Monika Kopacz, Annarita Mariotti

NOAA National Environmental Satellite, Data and Information Service (NESDIS)

Center for Satellite Applications and Research (STAR): Shobha Kondragunta

National Centers for Environmental Invormation (NCEI): Jeff Privette

AiRMAPS

https://csl.noaa.gov/projects/airmaps/

AiRMAPS 2024-26

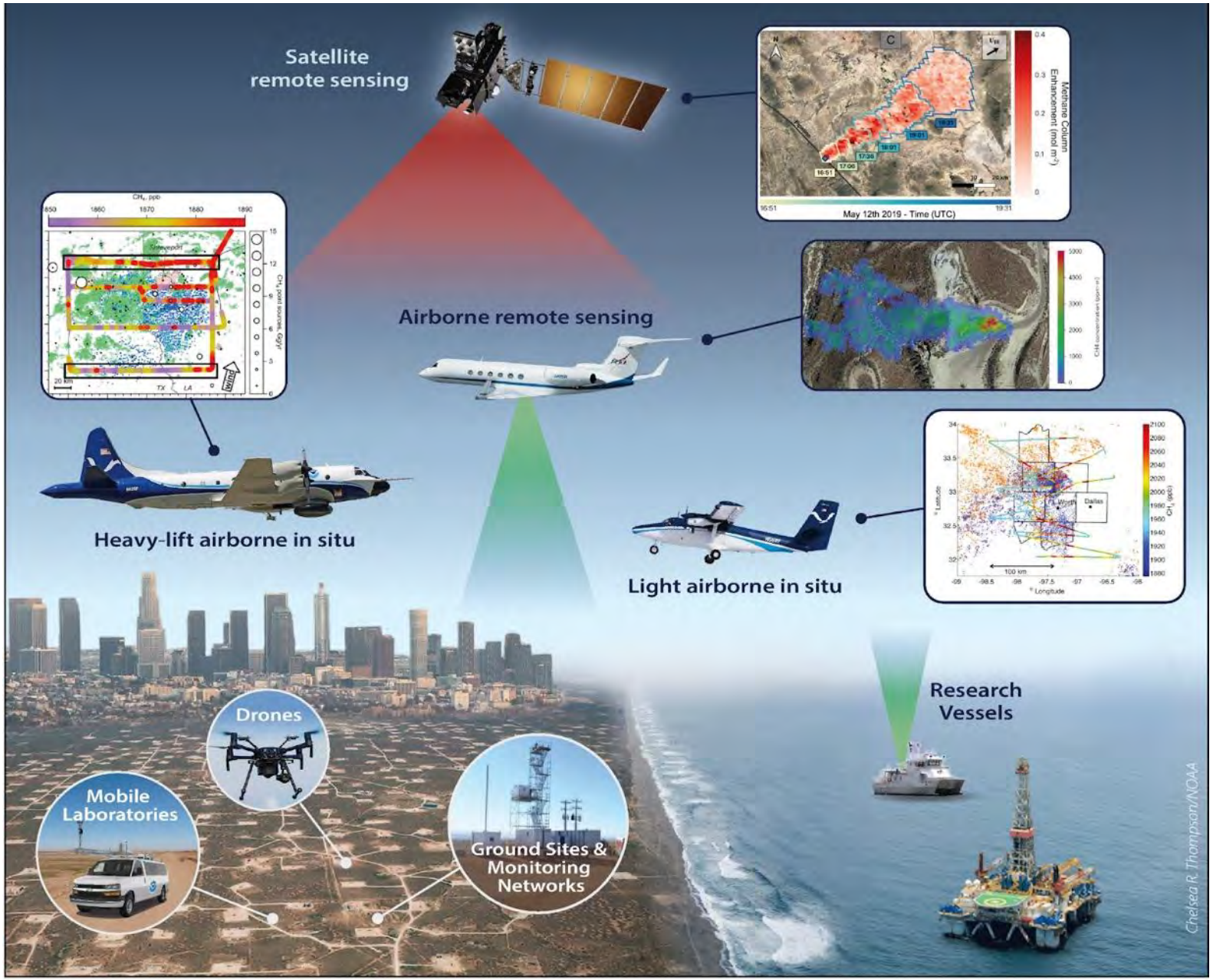
Airborne and Remote Sensing Methane and Air Pollutant Surveys

Objectives

1. Establish a current top-down evaluation of U.S. oil and gas (O&G) methane and air pollutant emissions;
2. Demonstrate the use and value of a tiered, integrated satellite, airborne and ground-based greenhouse gas (GHG) observing system;
3. Evaluate civilian and commercial spaceborne remote sensing methods and long-term monitoring for methane, other GHG and air pollutants; and
4. Quantify GHG and pollutant emissions and impacts from downstream O&G end use in urban testbeds.

Disclaimer:
AiRMAPS 2026 deployment is dependent on funding and aircraft availability and subject to change

Tiered Observing System for Emissions Quantification



NOAA OAR (CSL, ARL, GML, CPO): 3-5 year deployments of Twin Otter and P-3 aircraft

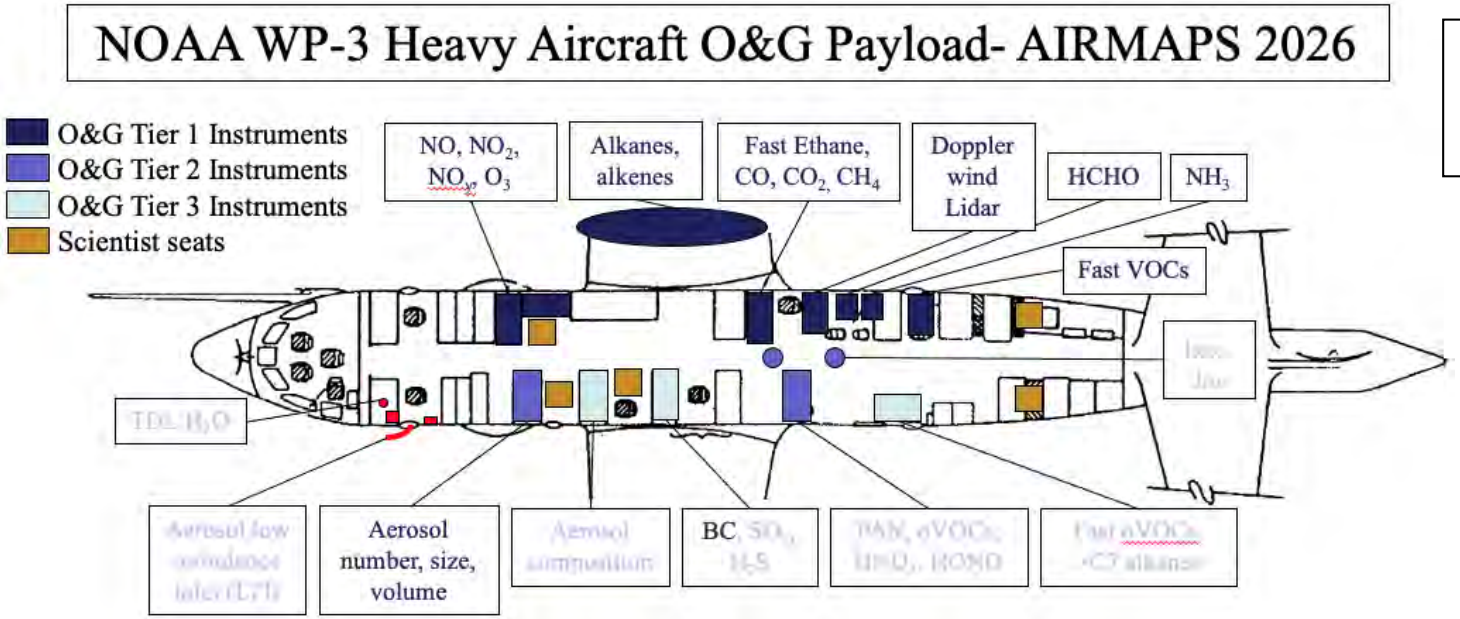
NOAA NESDIS: Partner with airborne observations to augment and validate satellite based air pollutant (UV-VIS) and GHG (SWIR) instruments

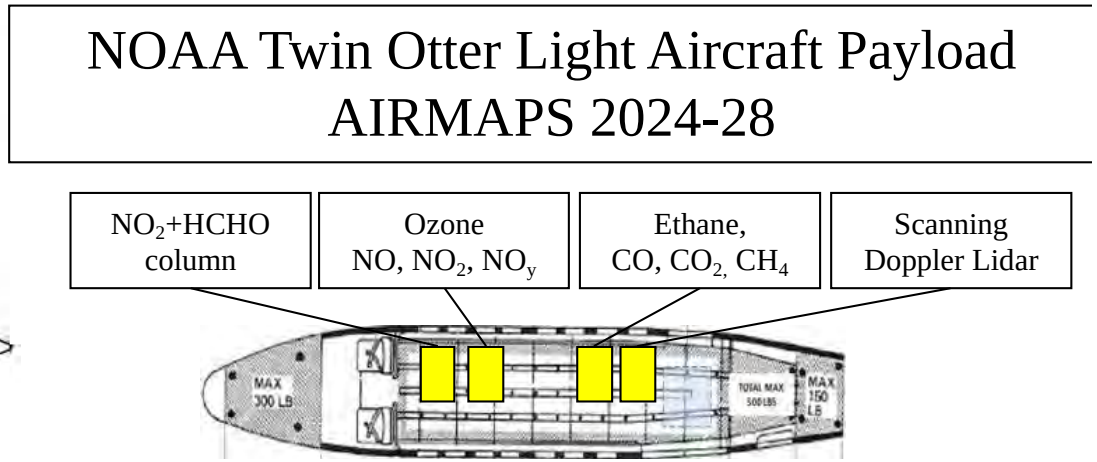
Partners: Collaboration with federal and state agencies, academic partners, industry, and stakeholders

NOAA Airborne Platforms

NOAA P-3

NOAA
Twin Otter

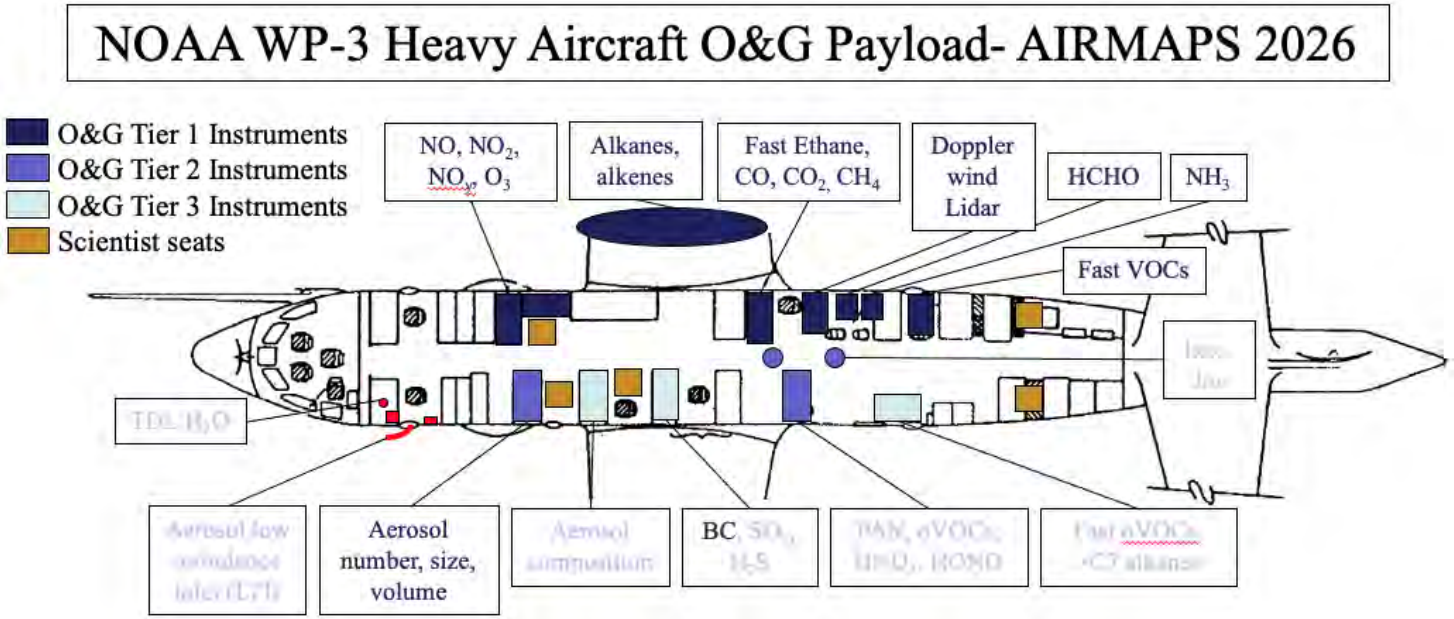




- NOAA **P3 heavy aircraft**: full payload for complete measurements of GHG, AQ and other pollutants (incl. HAPS)
- NOAA **Twin Otter light aircraft**: smaller payload for GHG, NO_x, O_3 and other tracers
- Both aircraft: Doppler wind lidar for dynamics & transport

NOAA Airborne Platforms

NOAA P-3



NOAA CSL confirmed payload:

GHG, NOx/O3
VOCs (cans GC, PTR-MS, fast ethane)
I-CIMS
aerosol size and composition, BC

Not confirmed (partners or CSL):

Wind lidar
HCHO
NH_3

Source apportionment and AQ impacts:

ethane, NH_3, alkanes
oVOCs, Cl-species

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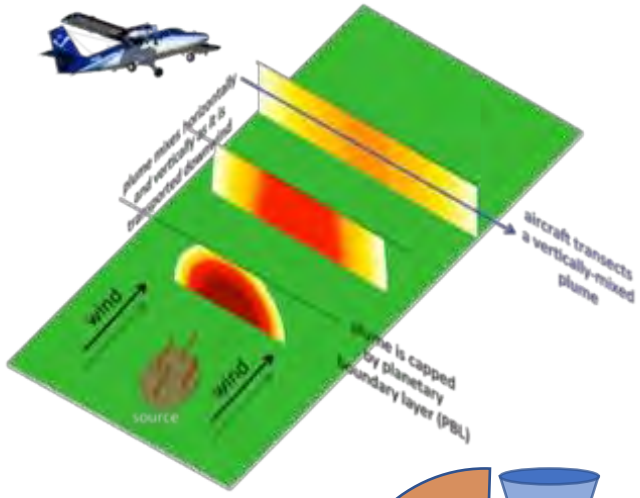
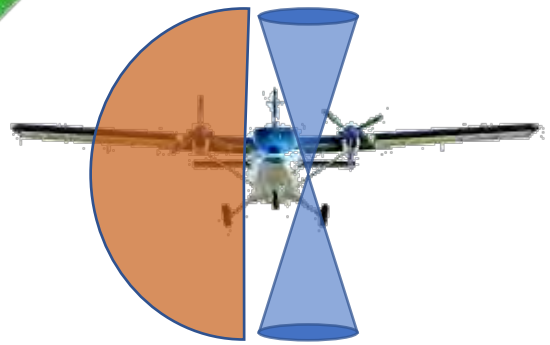
In-situ Airborne Methods for Quantifying Emissions

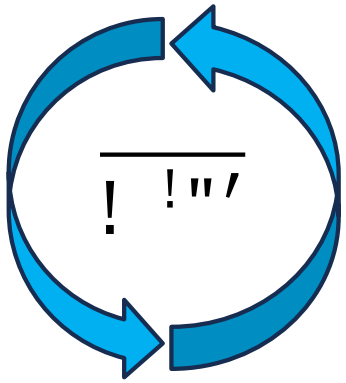
Mass Balance



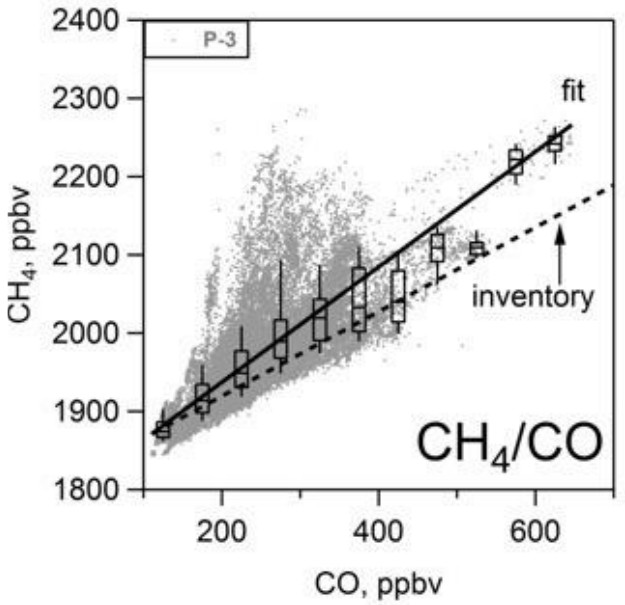
Doppler lidar + column DOAS



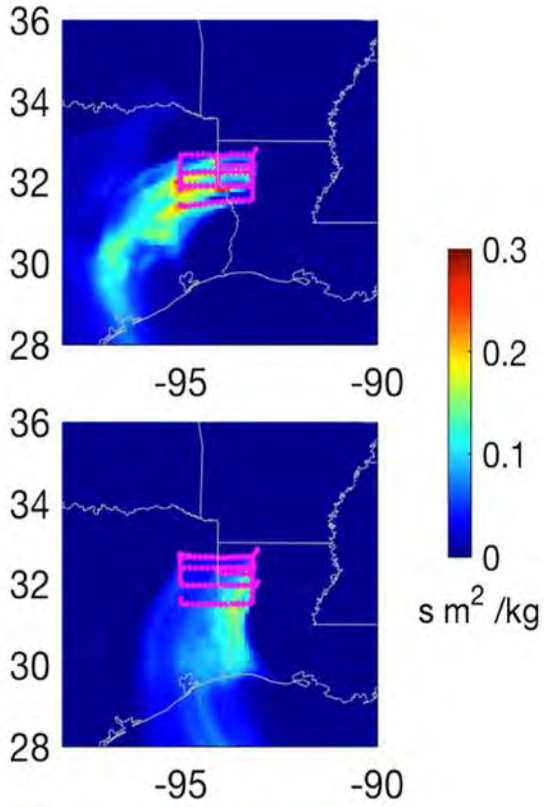
Eddy Covariance



Tracer Relationship



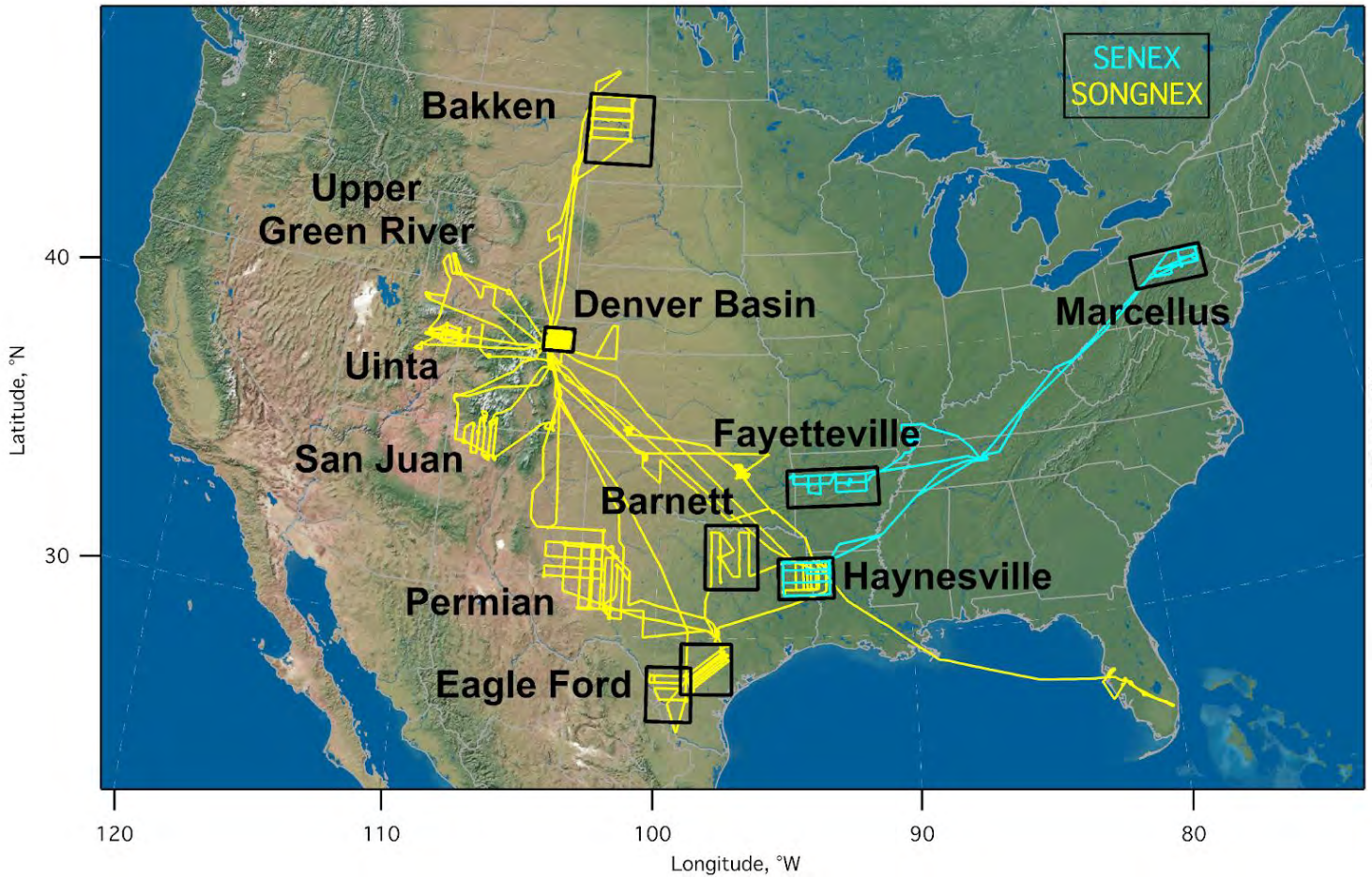
Inverse Modeling

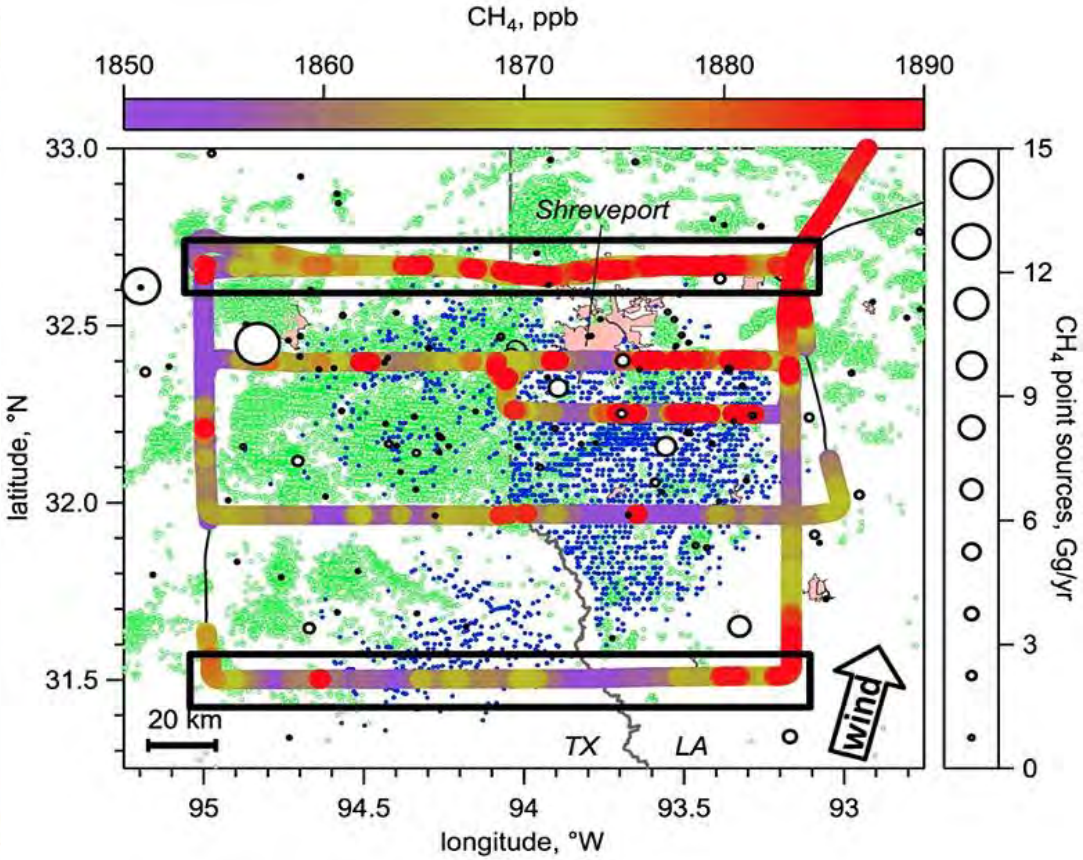


- NOAA CSL has used all four methods for emissions quantification using airborne, multi-species measurements
- Incorporation of Doppler lidar for wind fields and boundary layer depth improves mass balance

Previous O&G Measurements

Peischl et al 2015
Yuan et al 2015





Mass balance and
eddy covariance flights

Previous O&G Measurements

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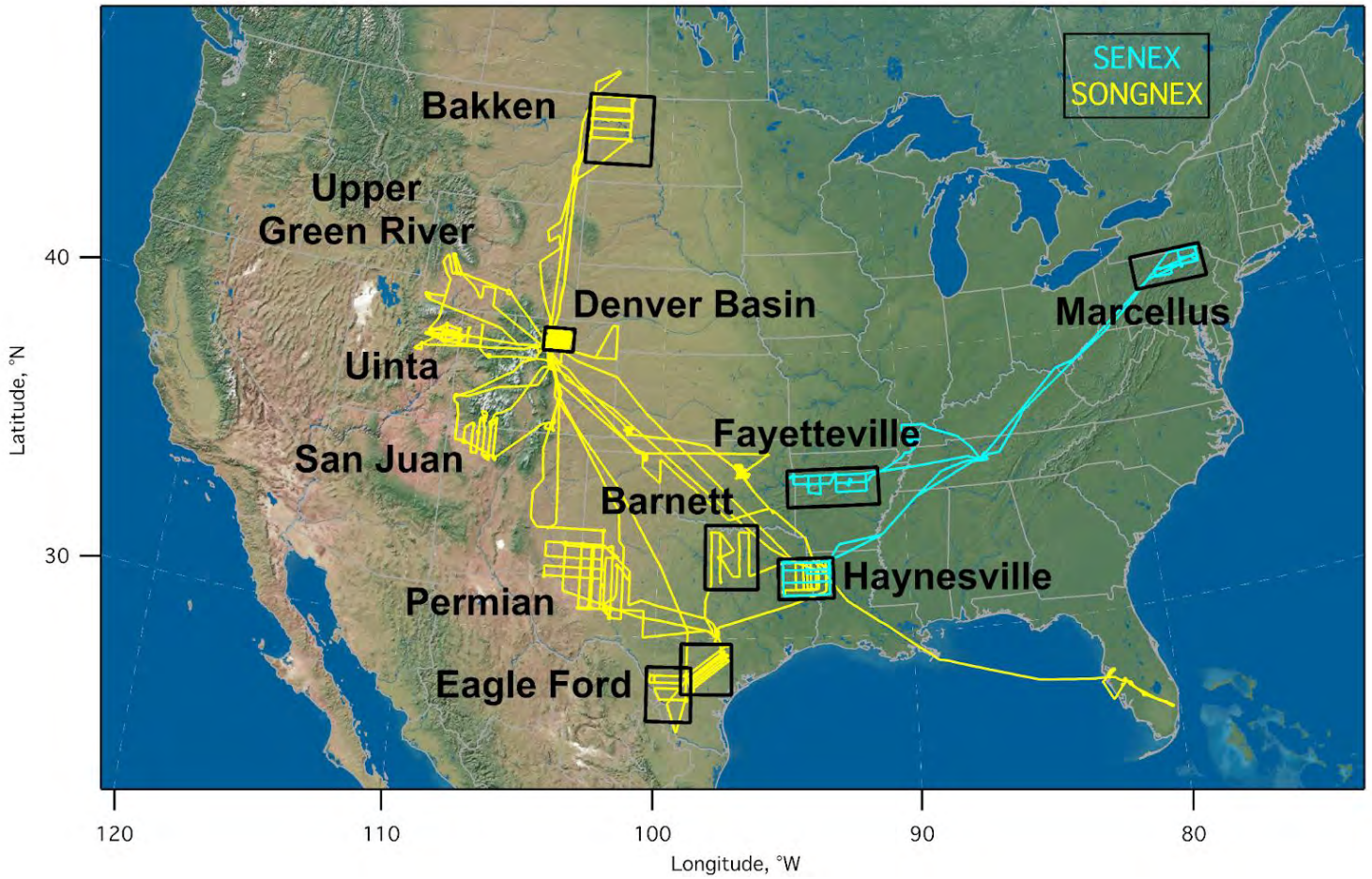
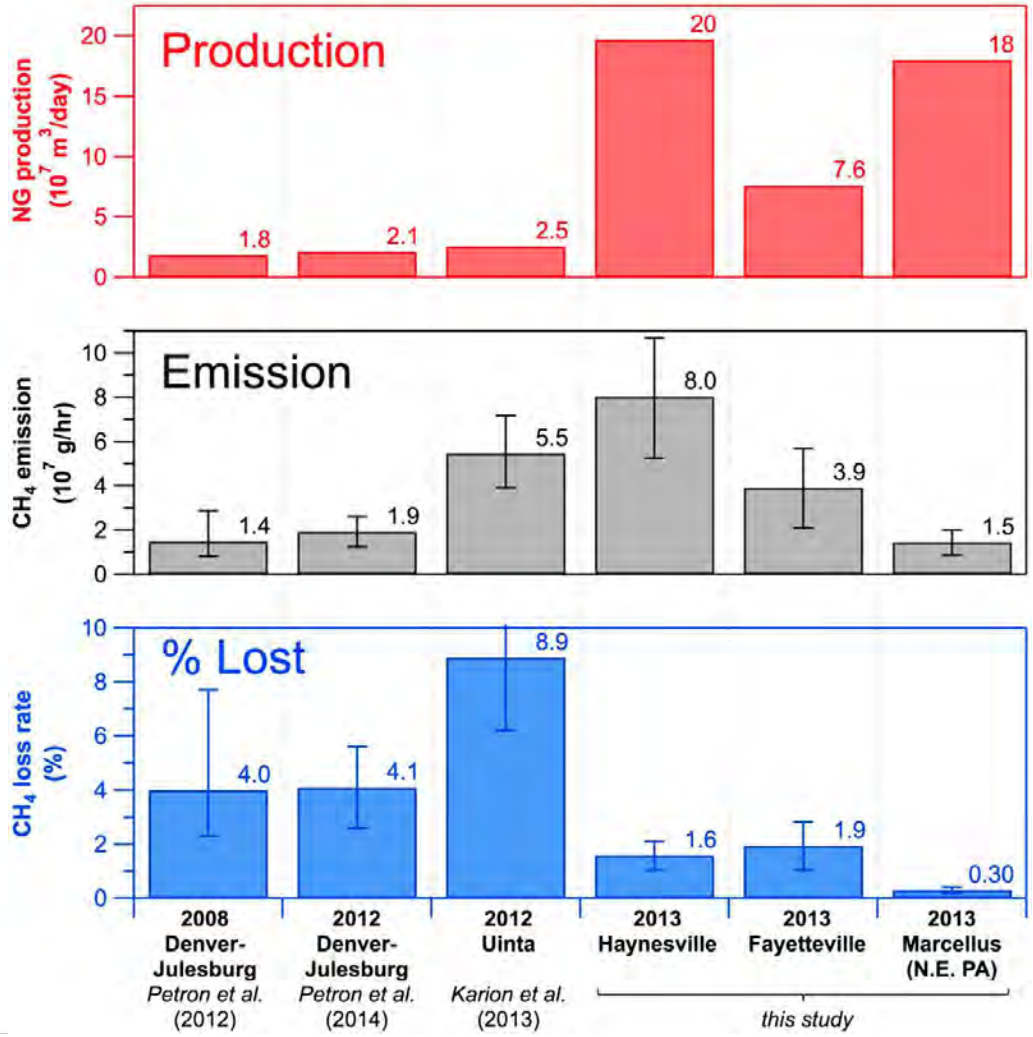
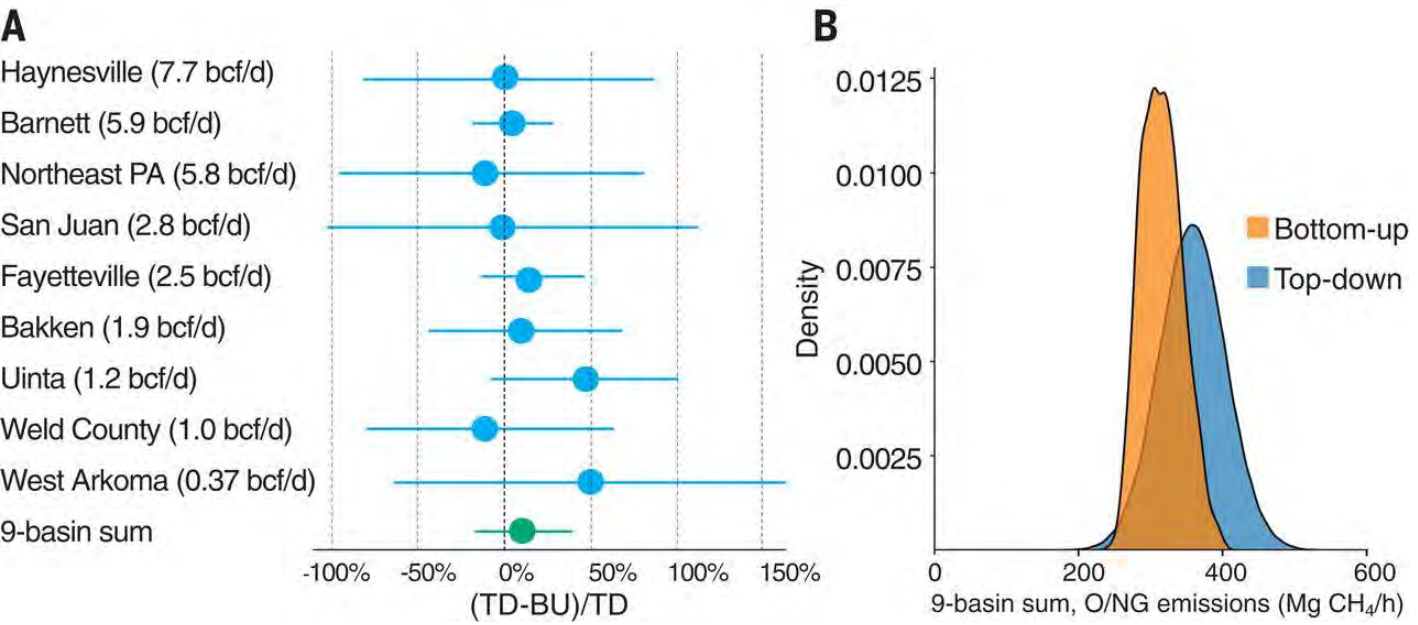




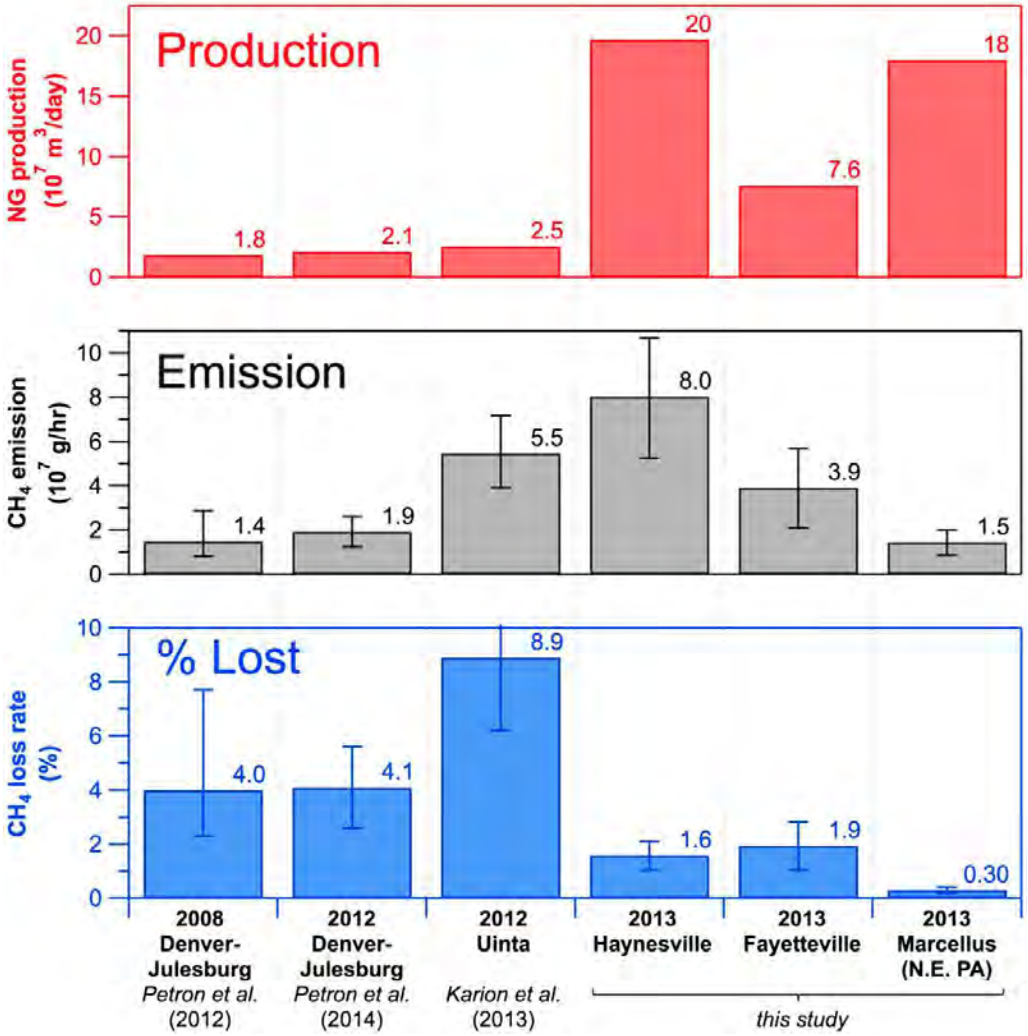
Mass balance and eddy covariance flights

Previous O&G Measurements

Alvarez et al 2018



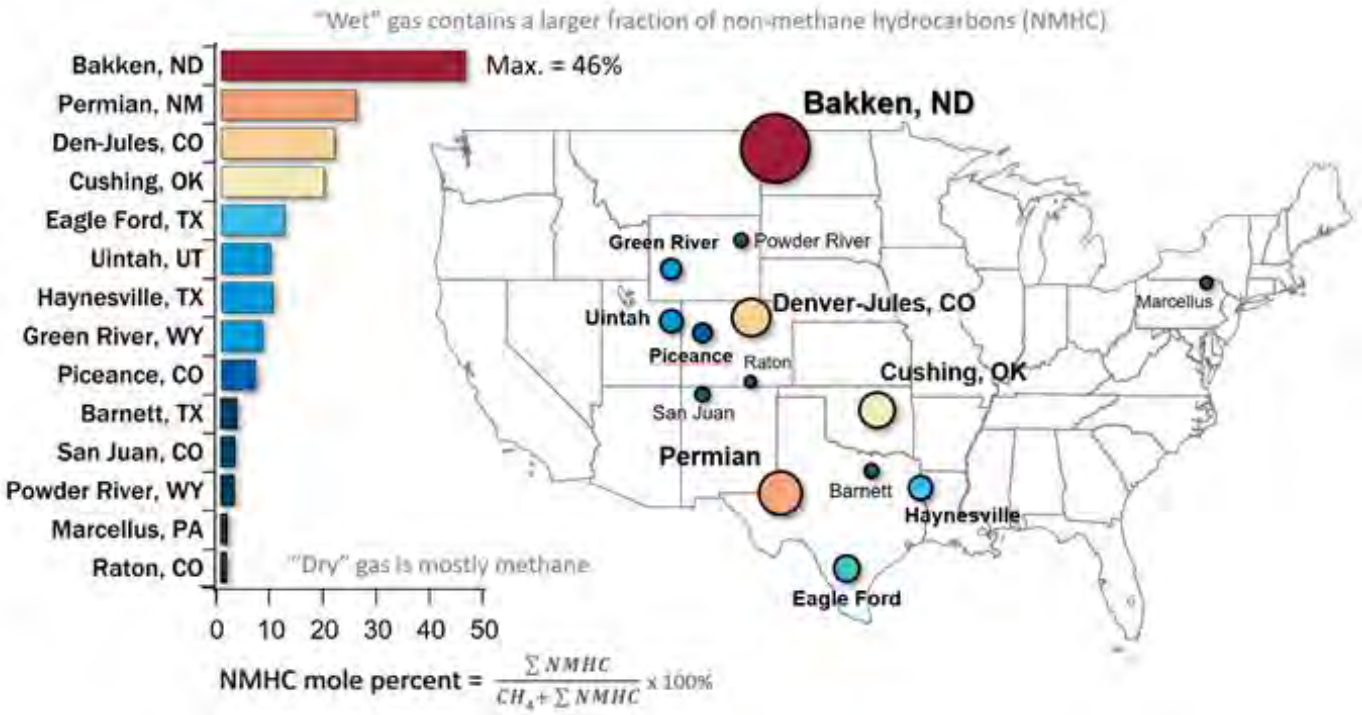
Peischl et al 2015



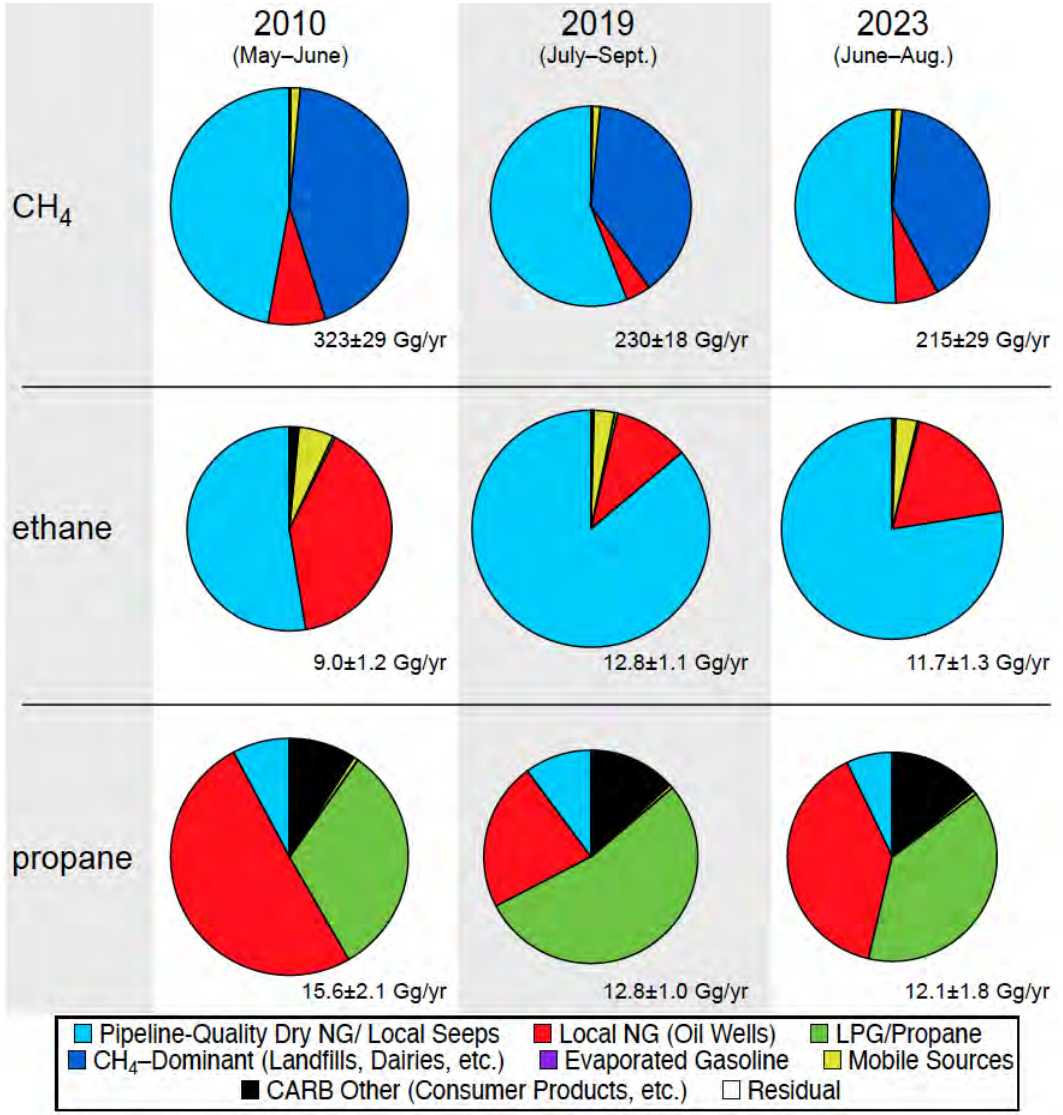
Mass balance and eddy covariance flights

Previous O&G Measurements

Gilman et al 2013



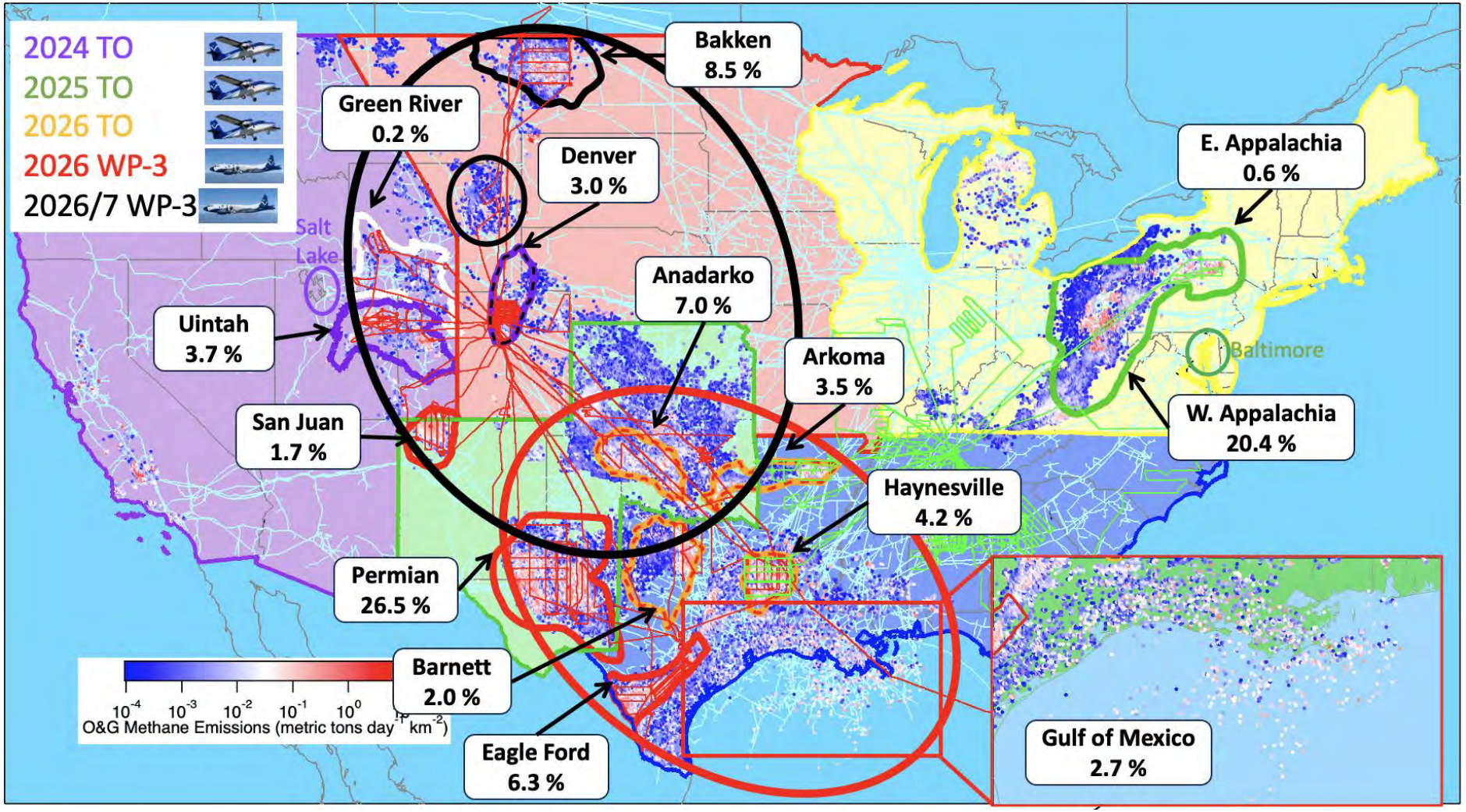
NMHC composition and AQ measurements



Source apportionment in the LA Basin for methane, ethane and propane from three aircraft data sets

Schafer et al 2013

Airborne Survey Strategy & Proposed Schedule



- 150 P3 and TO flight hours out of Austin, TX
- Include off-shore
- Spring 2026 (anticipated)

2024

Oil & Gas: Denver Julesburg Basin, CO

Urban: Salt Lake City, UT

2025

Oil & Gas: Southwest Marcellus Shale

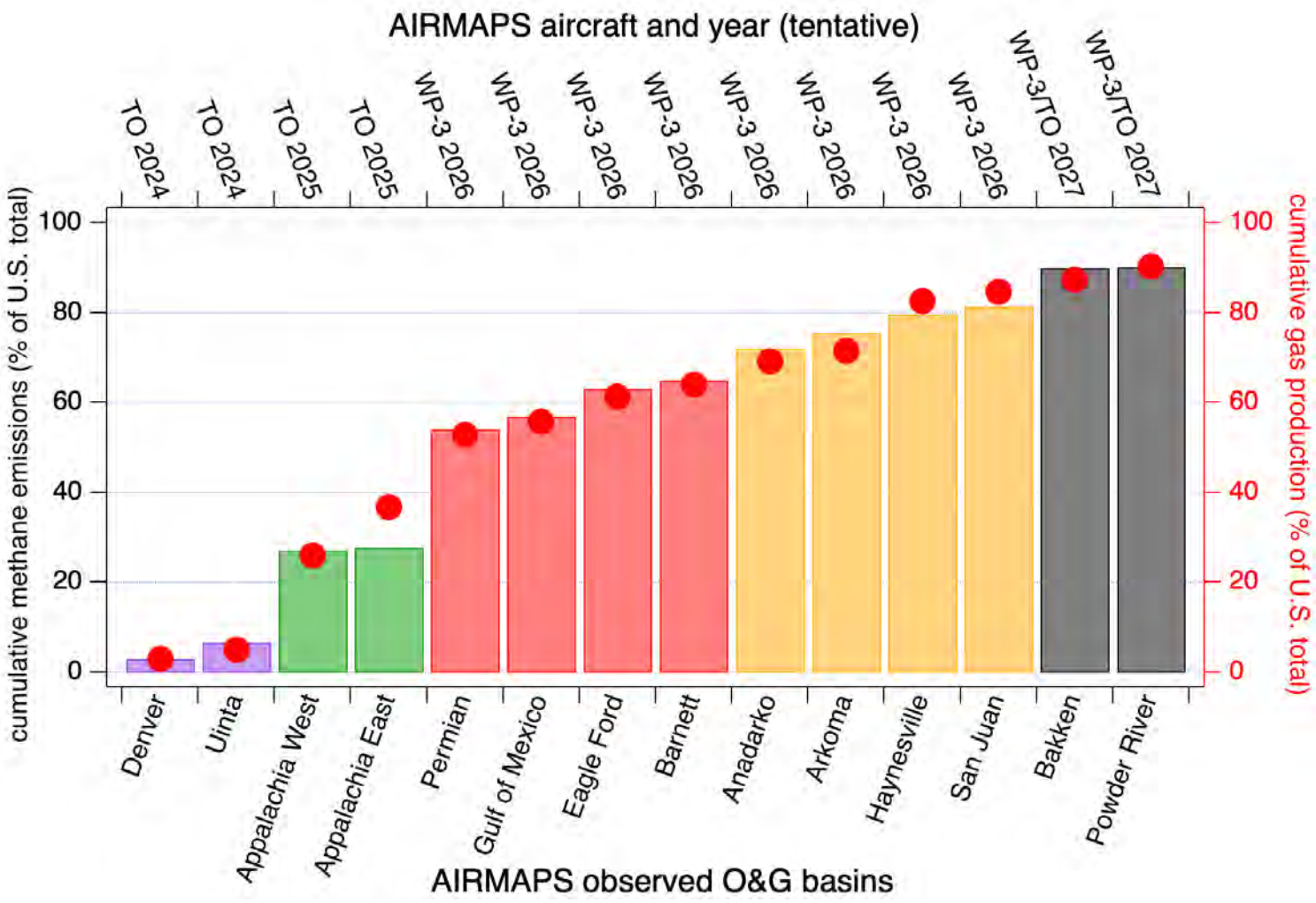
Urban: Baltimore – DC

2026

Oil & Gas: TX, OK, LA, AR, Gulf of Mexico

Urban: Texas

Airborne Survey Strategy & Proposed Schedule



O&G targets with P3 and TO:

- Tier 1: ~4 flights
- Tier 2: 2-3 flights
- Tier 3: >1 flight

Targets within each basin:

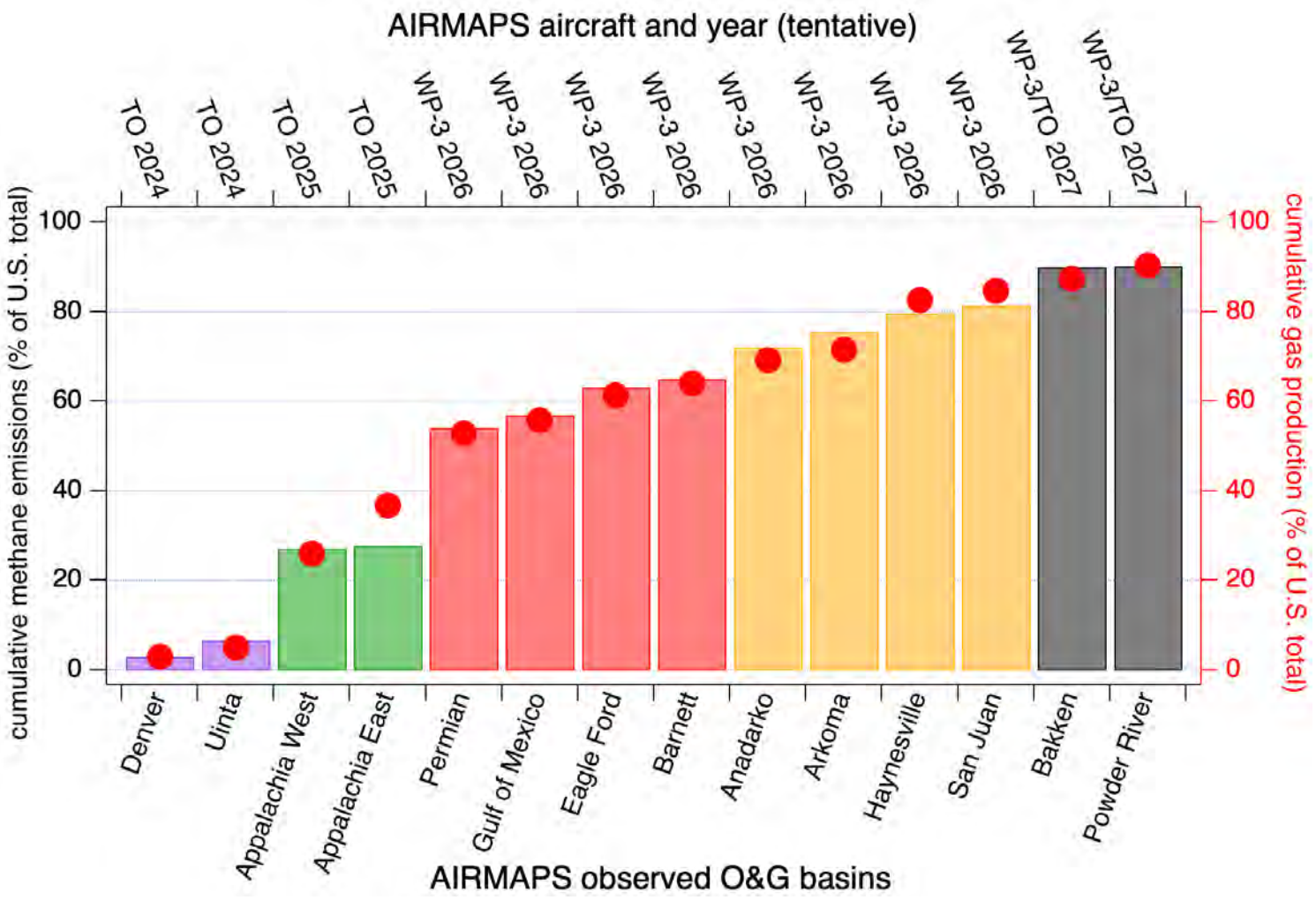
- regional surveys (on-shore and off-shore)
- point sources (compressor station, liquefaction, …)
- pipelines and junctions

Other targets:

- coal mines, landfills, CAFOs, urban
- air quality implications (incl. urban, rural, and EJ)

Two aircraft platforms (Twin Otter and P-3) plan to survey ~ 90% of U.S. O&G methane emissions

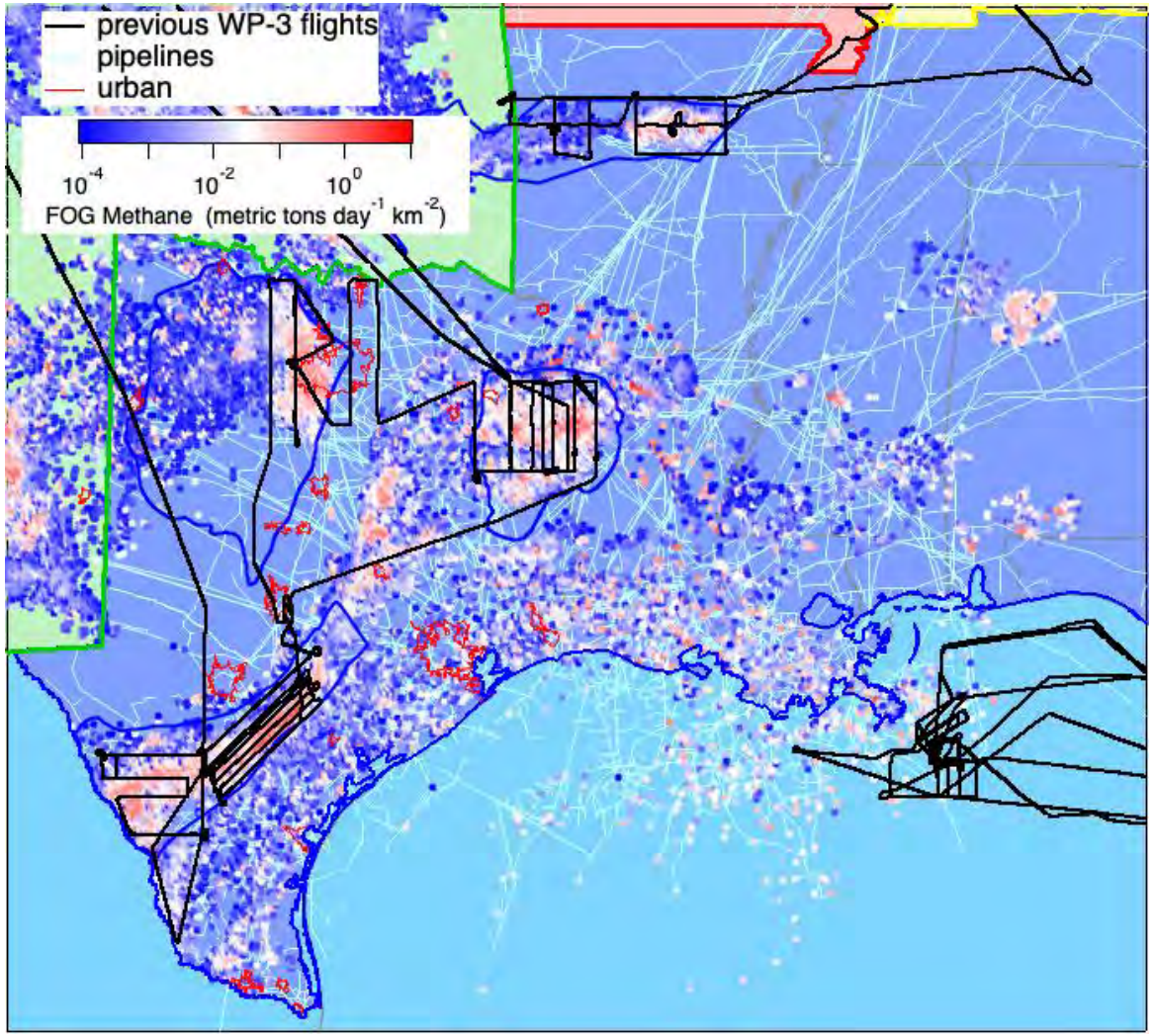
Airborne Survey Strategy & Proposed Schedule

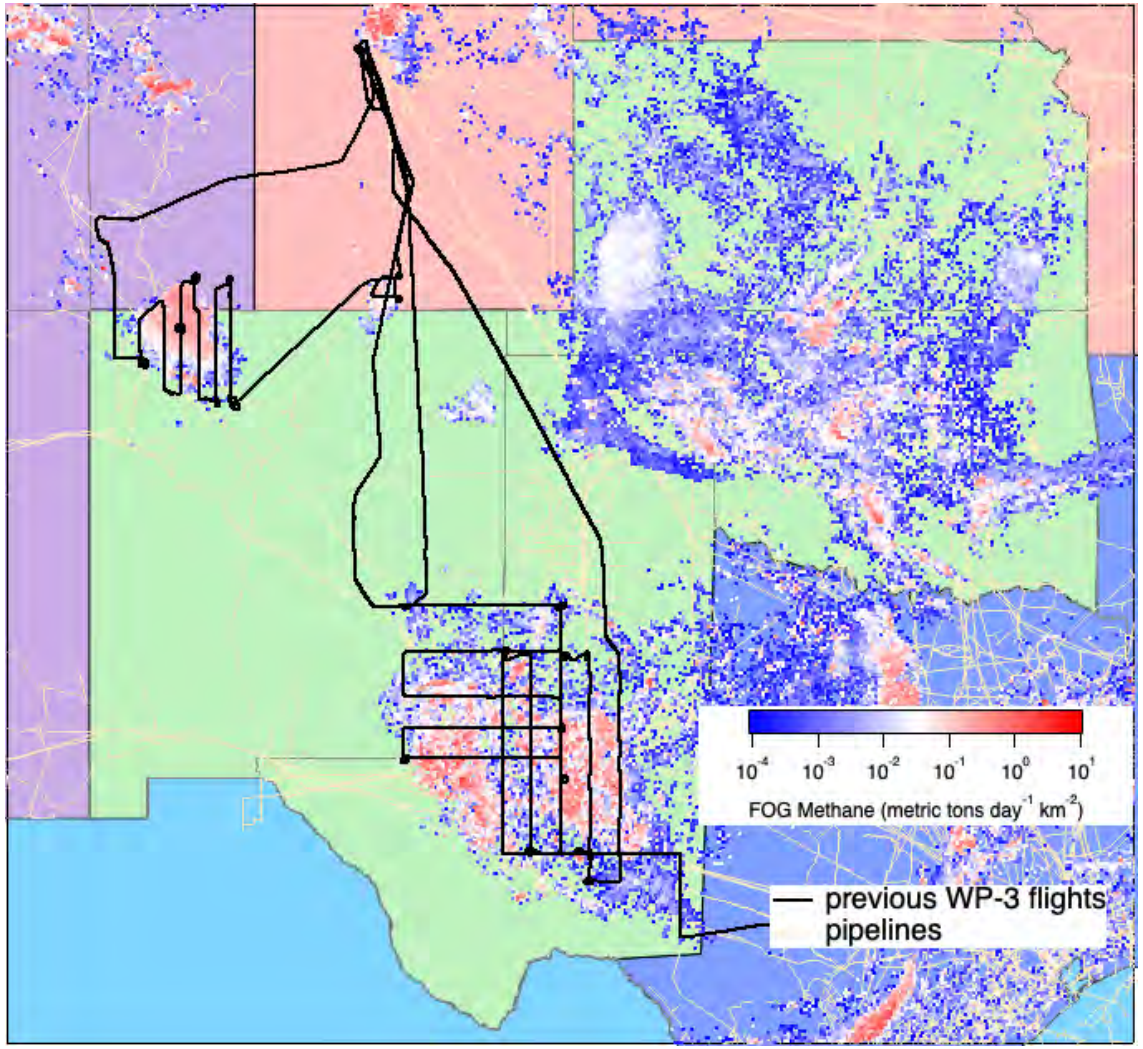


2024 (Twin Otter 150 h)			
~7 x Denver ~14 x Salt Lake (Jul-Aug)	**O&G Tier 1 ~ 7 flights**	**O&G Tier 2 ~ 4 flights**	**Urban Tier 1 ~ 10 flights**
	DJ Basin	Uinta	Salt Lake
2025 (Twin Otter 150 h)			
~20 x DC/Balt. (July-Aug)	**O&G Tier 1 ~ 10 flights**	**O&G Tier 2 ~ 10 flights**	**Urban Tier 1 ~ 10 flights**
	Southwest Marcellus	Northeast Marcellus	DC/Baltimore
2026 (Twin Otter 150 h)			
~20 x Austin (late spring)	**O&G Tier 1 4-5 days each**	**O&G Tier 2 3-4 days each**	**O&G Tier 3 1 day each**
	Anadarko	Barnett	Permian
	Haynesville		Eagle Ford
	Arkoma		
2026 (WP-3 120-150 h)			
~20 x Austin (April)	**O&G Tier 1 4 flights each**	**O&G Tier 2 3 flights each**	**O&G Tier 3 1 flight each**
	Permian	Barnett	Arkoma
	Offshore Gulf	Eagle Ford	Haynesville
			Anadarko
2026 or 2027 (WP-3 50 h)			
~5 x Broomfield (October)	**O&G Tier 1 4 flights each**	**O&G Tier 2 1-2 flights each**	
	Bakken	DJ Basin	
		Green River	

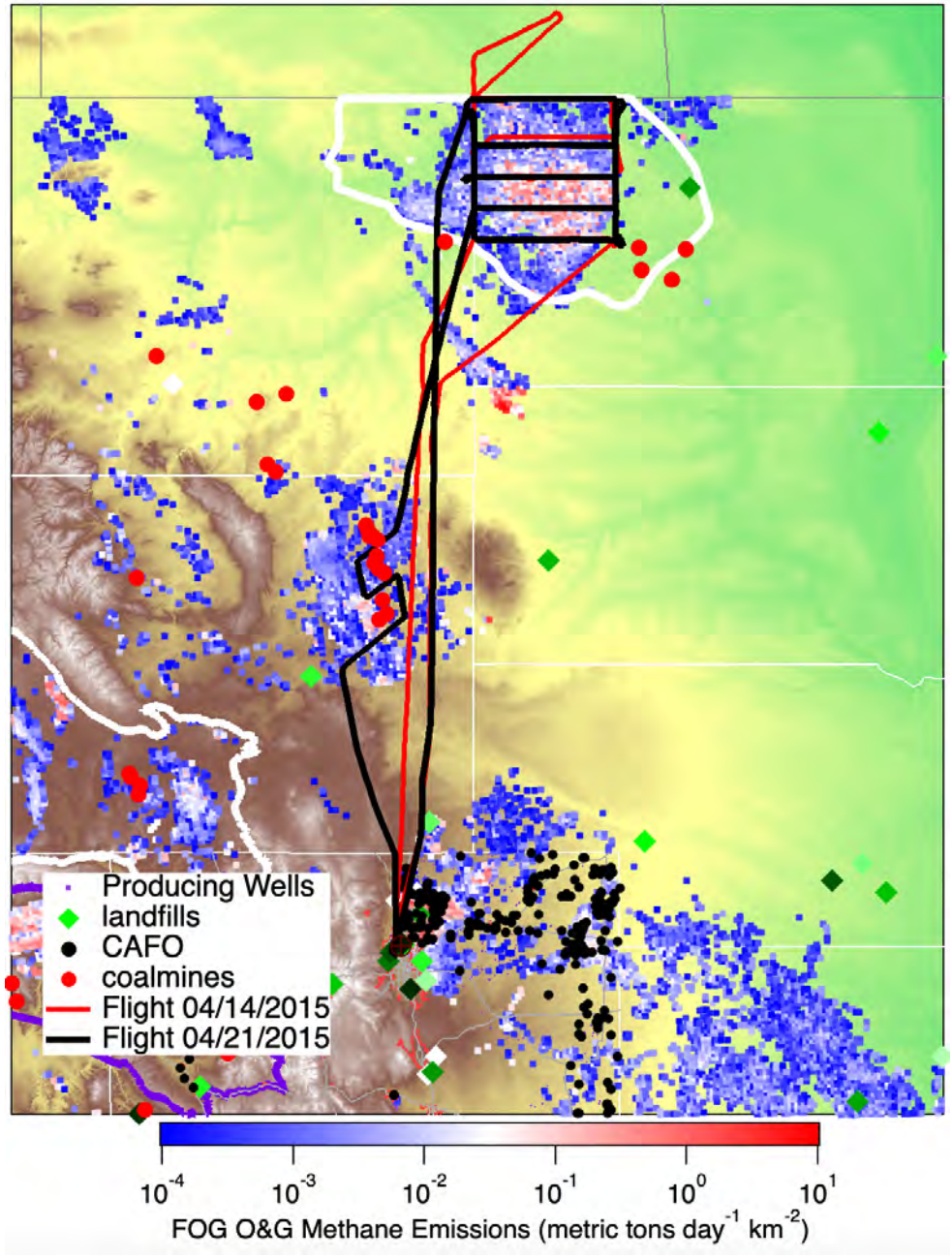
Two aircraft platforms (Twin Otter and P-3) plan to survey ~ 90% of U.S. O&G methane emissions

Flight Strategy out of Austin





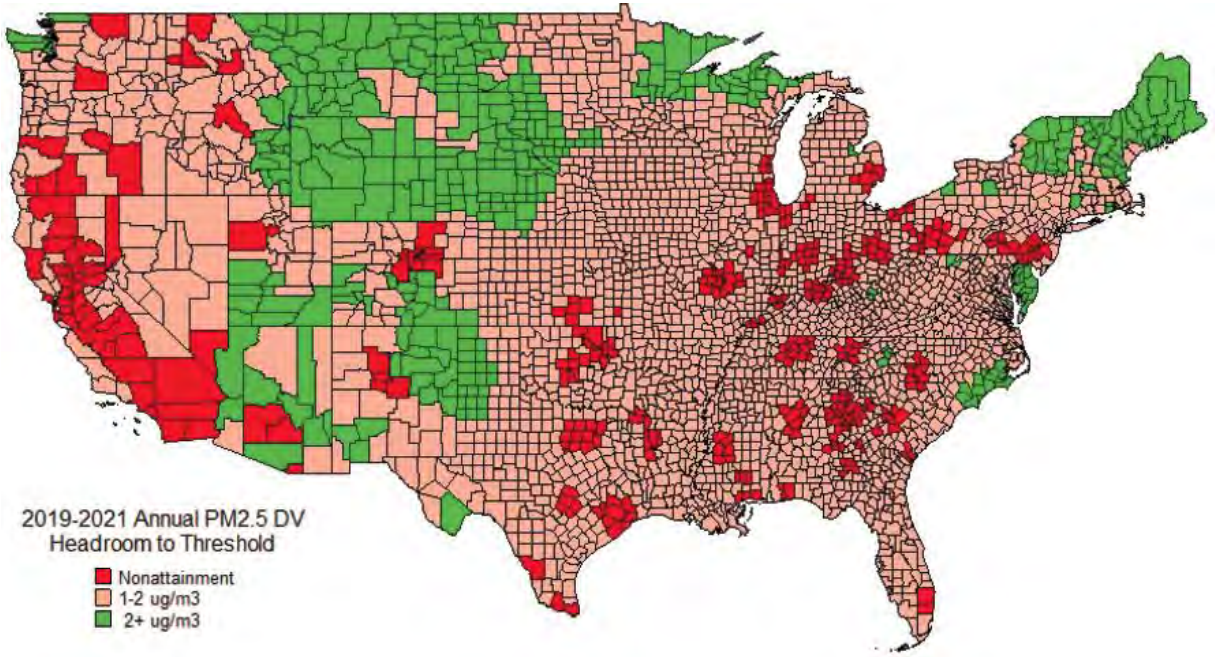
Flight Strategy for Bakken



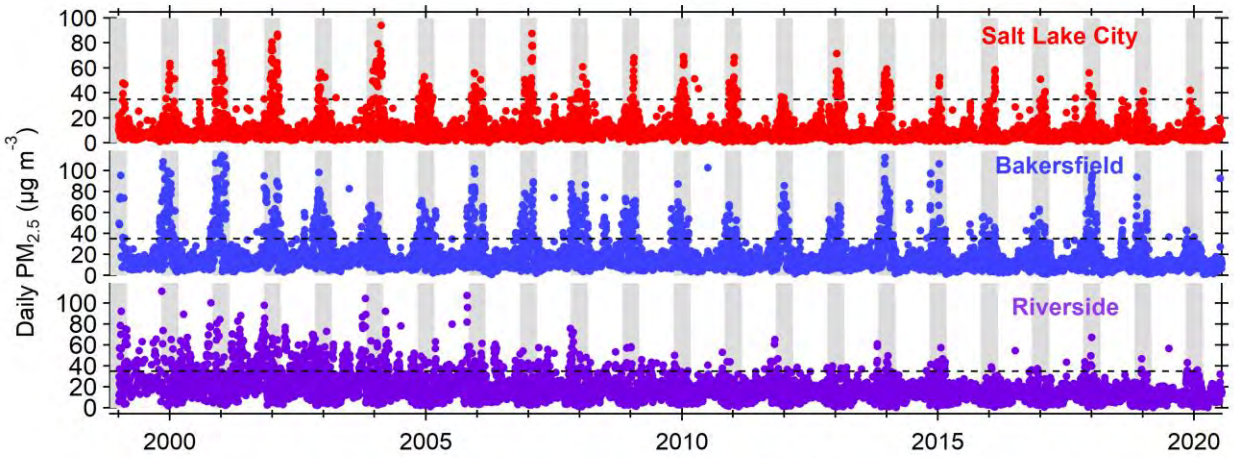
Bakken most uncertain:

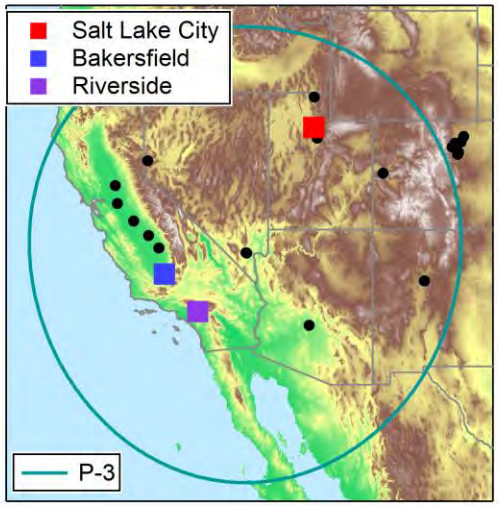
- Suitcase flights in 2026 or extra flights in 2027
- DJ and Green River on the
- pipelines and junctions
- AQ implications (incl. urban, rural, and EJ)

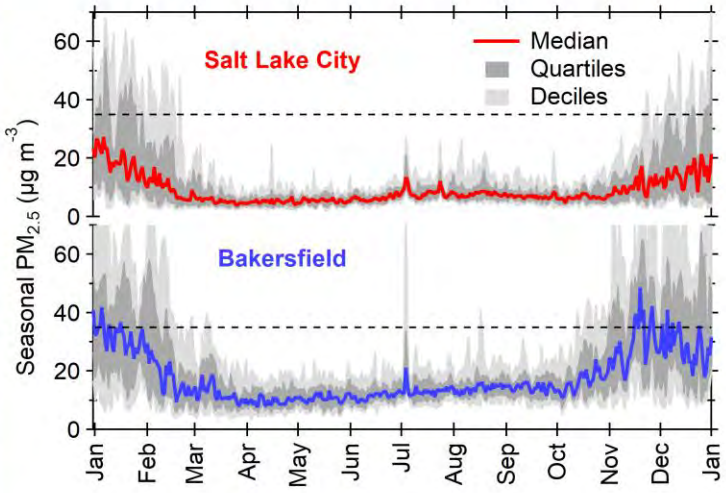
AiRMAPS 2026-28 Urban: Southwest U.S.



Hallar et al., BAMS 2021







Stella Environ. Mag. 2023

Counties in non-attainment with new 9 µg m^{-3} annual PM standard

High winter season PM in western U.S.

Collaborative with NSF

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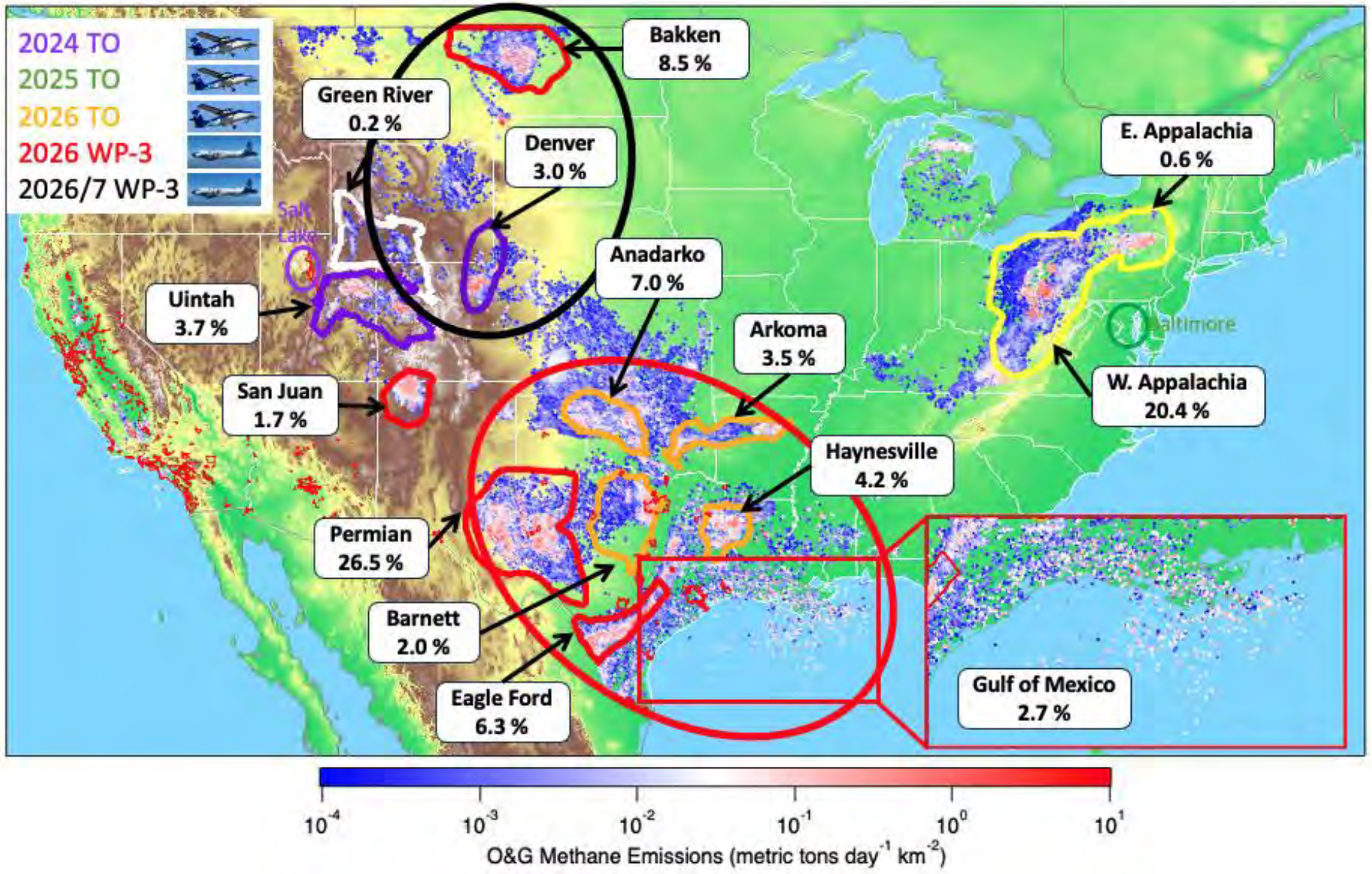

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