AiRMAPS

Airborne and Remote Sensing Methane and Air Pollutant Surveys

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

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.

NOAA Office of Atmospheric Research (OAR)

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

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

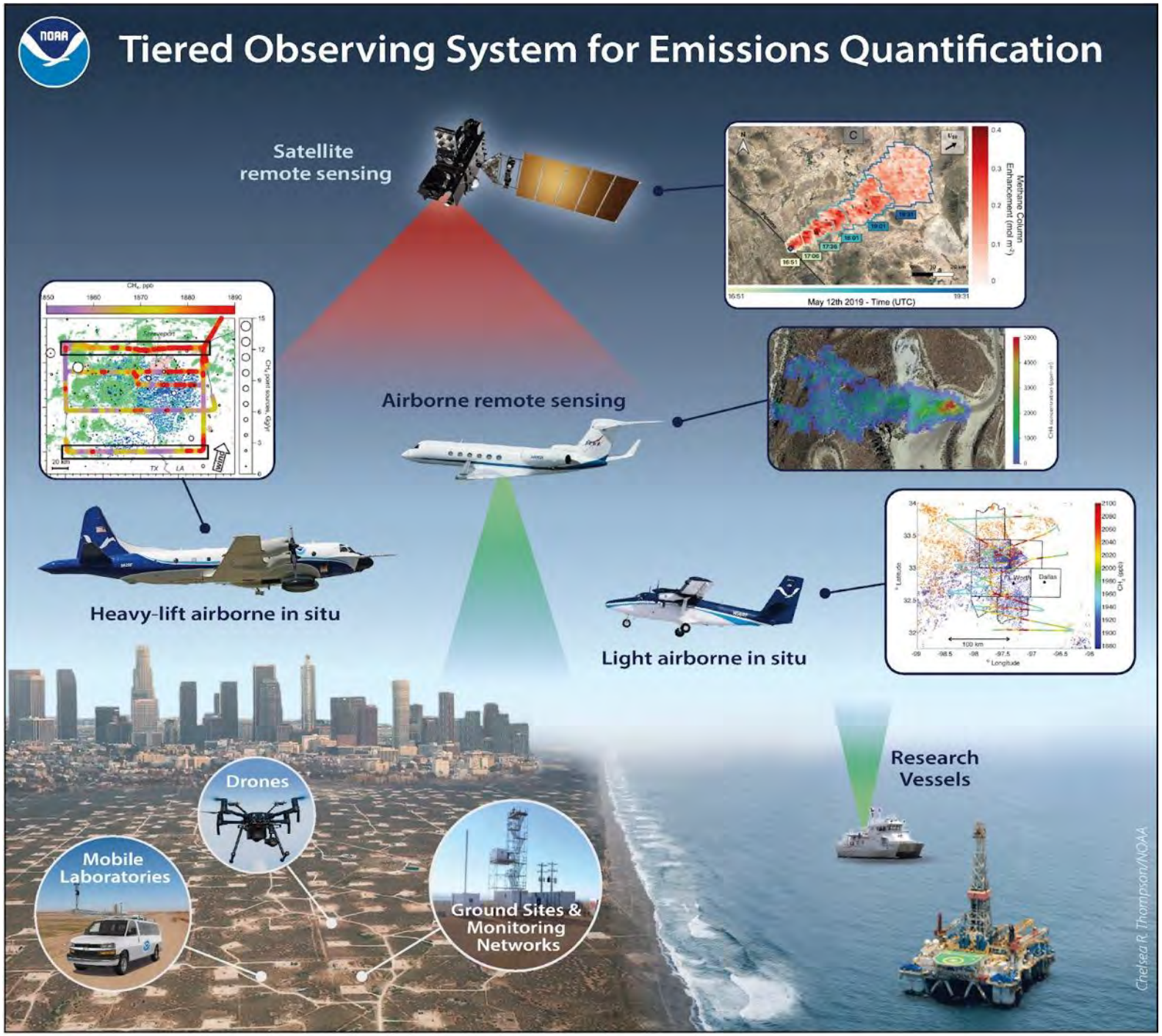
Global Monitoring Laboratory (GML): Colm Sweeney, Arlyn Andrews, Jeff Peischl

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



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 quality (UV-VIS) and GHG (SWIR) instruments

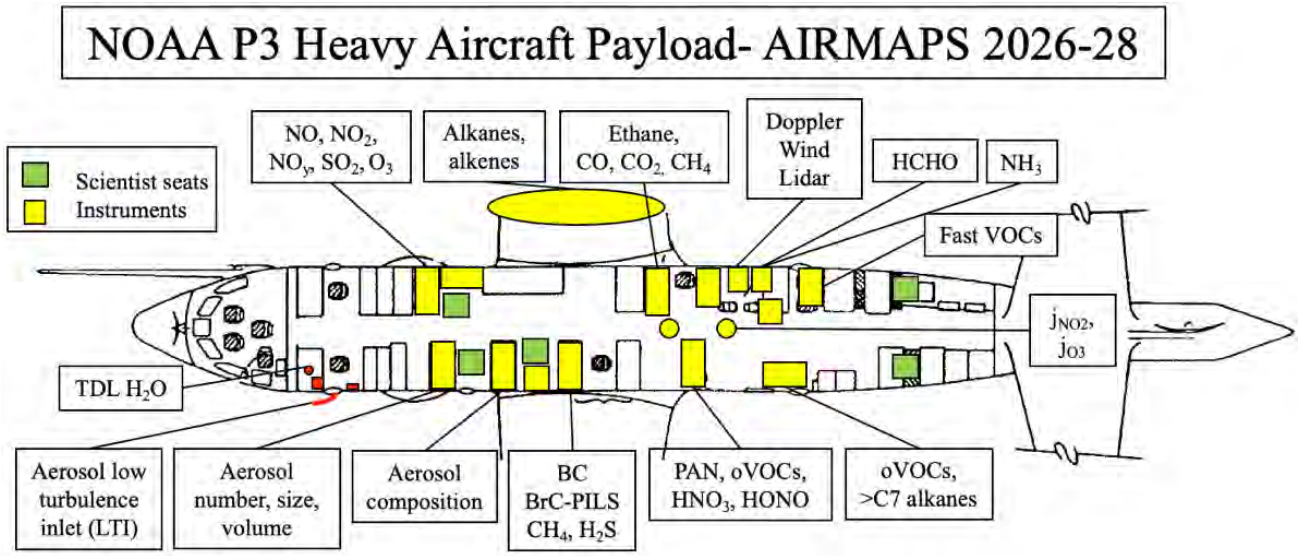
Partners: NOAA intends to execute this strategy in collaboration with other agencies and stakeholders

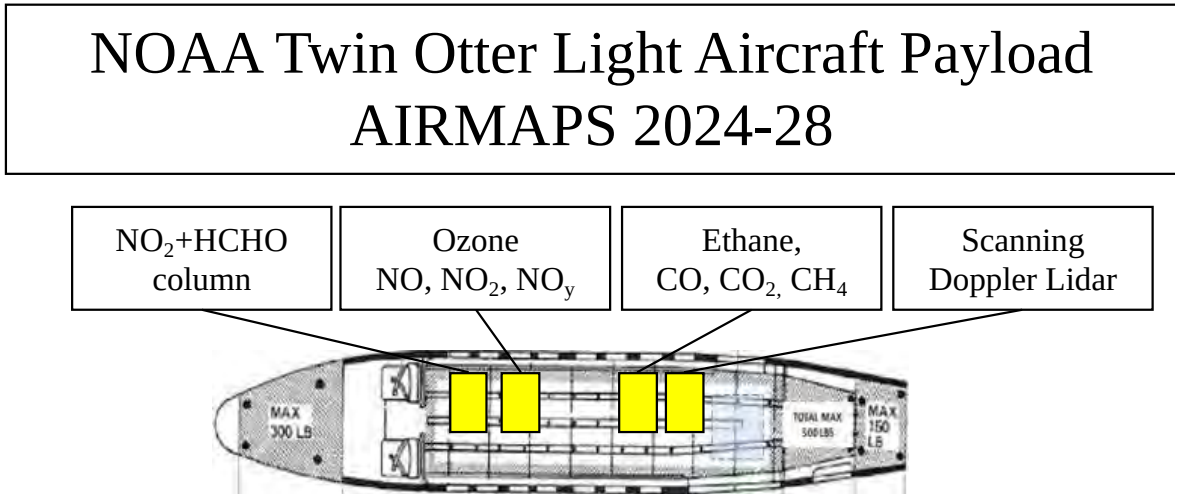
State agencies
Academic partners
Industry

NOAA Airborne Platforms

NOAA P-3

NOAA
Twin Otter

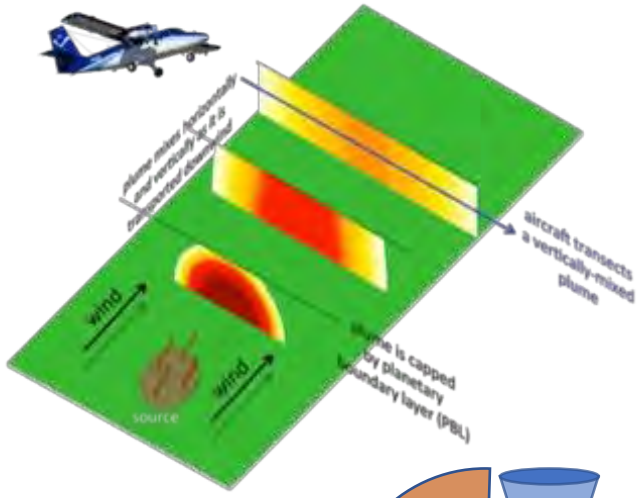




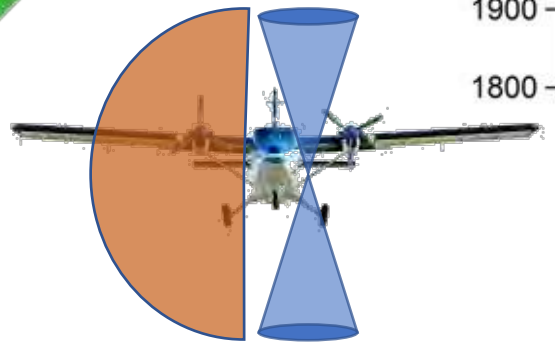
- NOAA **P3 heavy aircraft**: full payload for complete measurements of GHG and other pollutants (incl. HAPS)
- NOAA **Twin Otter light aircraft**: smaller payload for GHG, NO_x, O_3 and other tracers
- Both aircraft: Doppler wind lidar for dynamics & transport

Airborne Methods for Quantifying Emissions

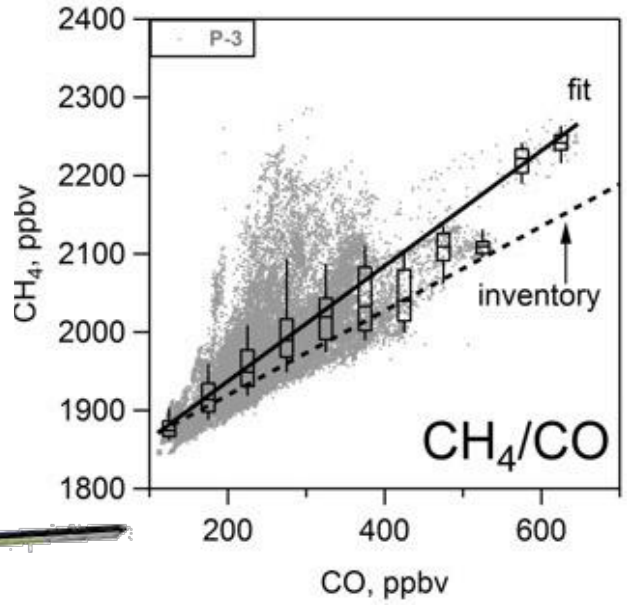
Mass Balance



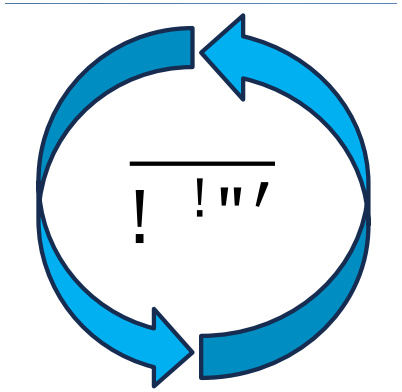
Doppler lidar + column DOAS



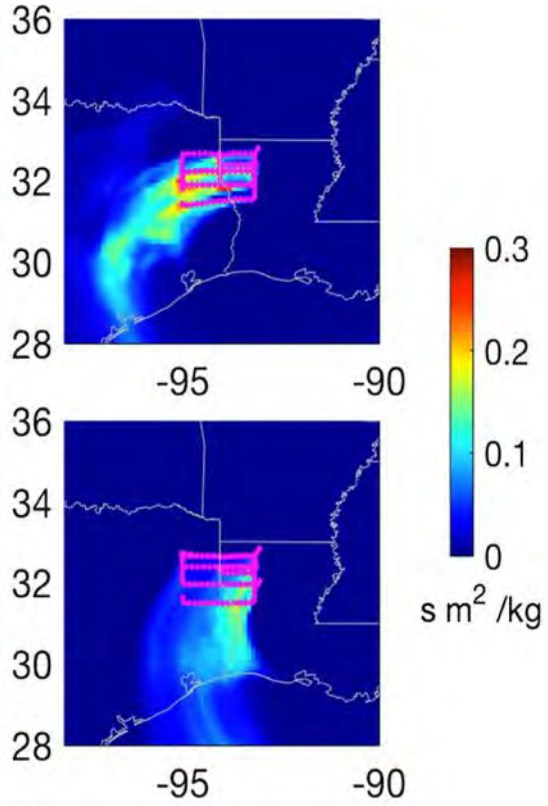
Tracer Relationship



Eddy Covariance

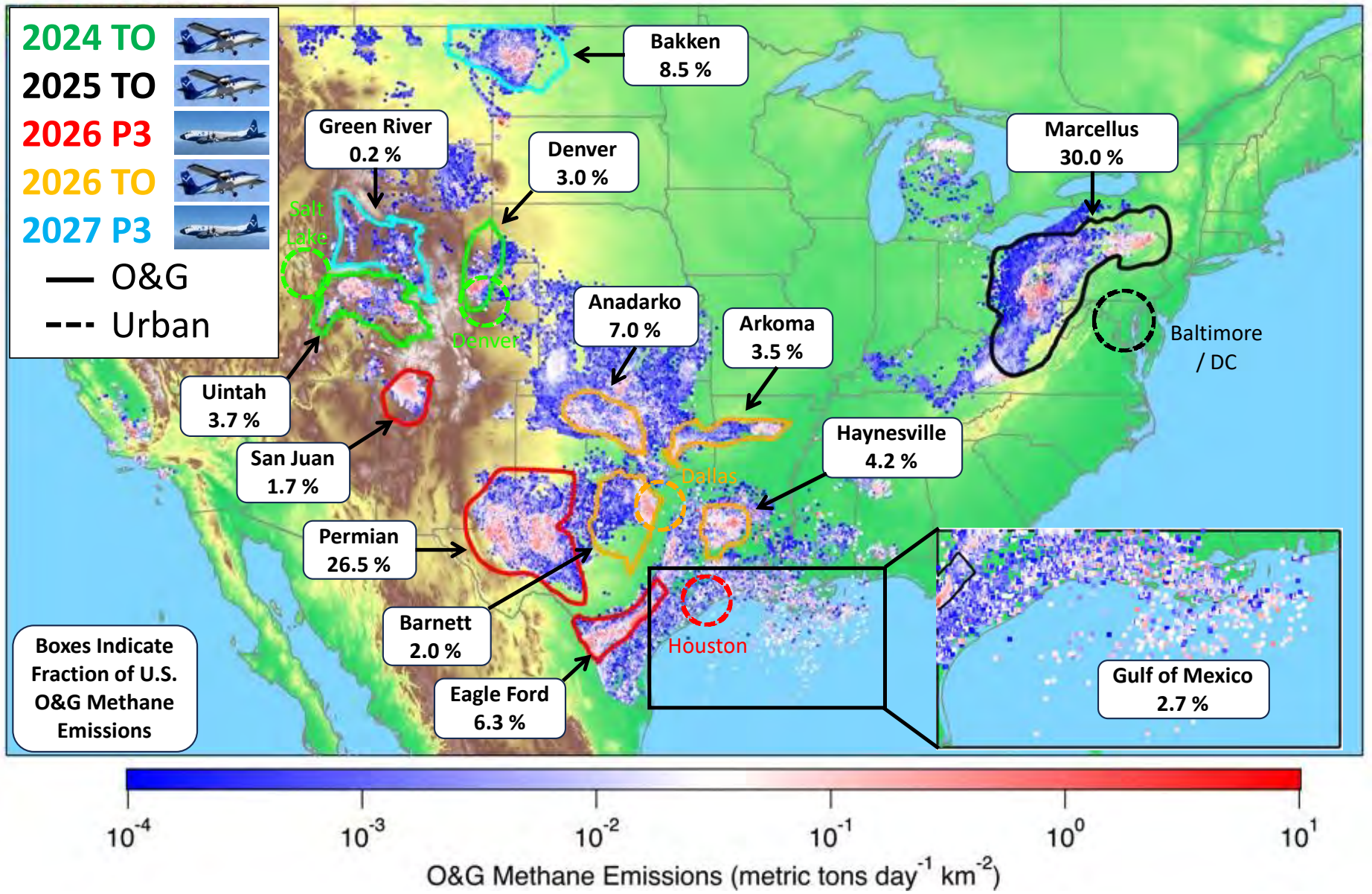


Inverse Modeling



- 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

Airborne Surveys & Schedule



2024

Oil & Gas: Denver Julesburg Basin, CO; Uinta Basin, UT

Urban: Denver, CO; Salt Lake City, UT

2025

Oil & Gas: Marcellus

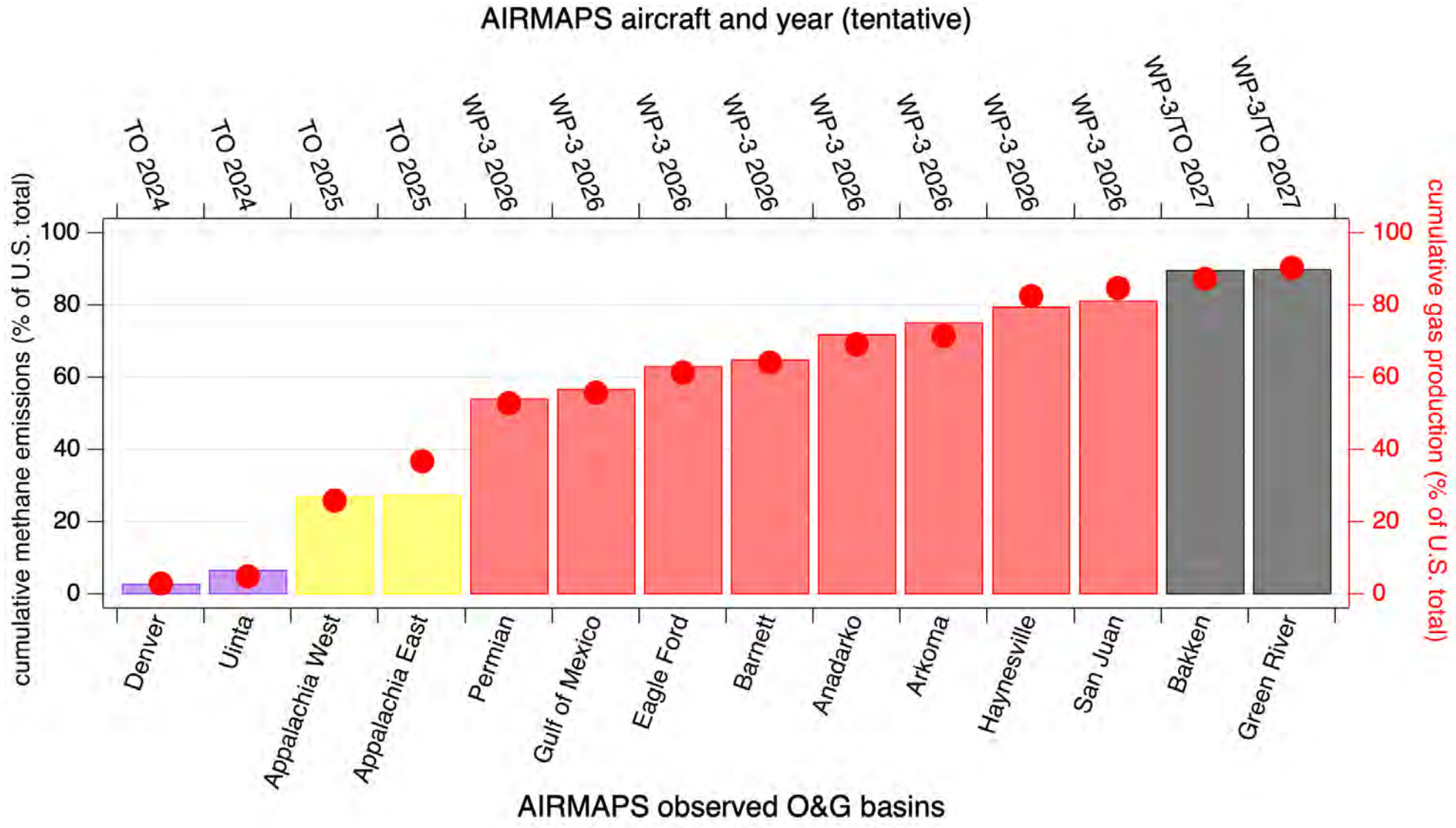
Urban: Baltimore – DC

2026

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

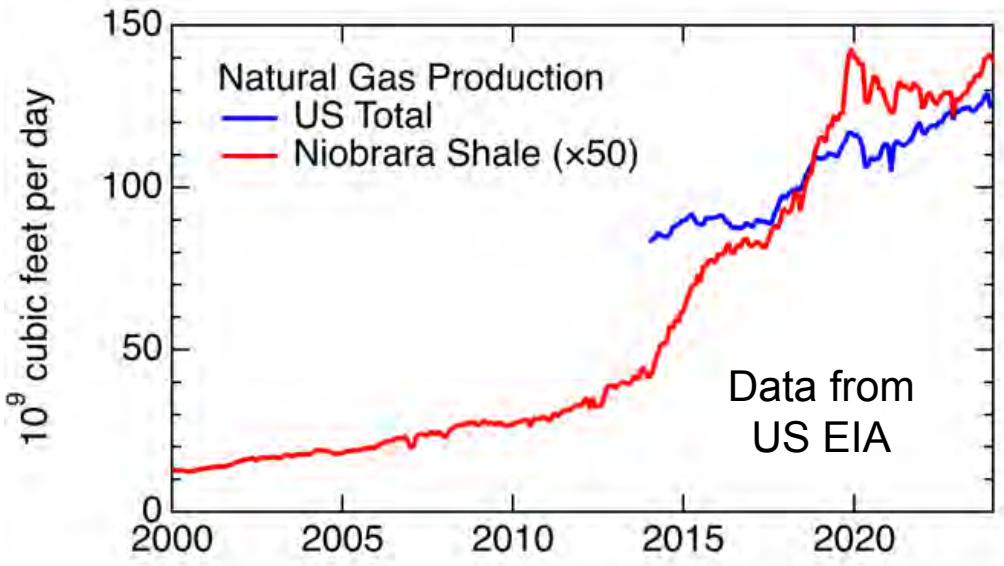
Urban: Dallas, Houston

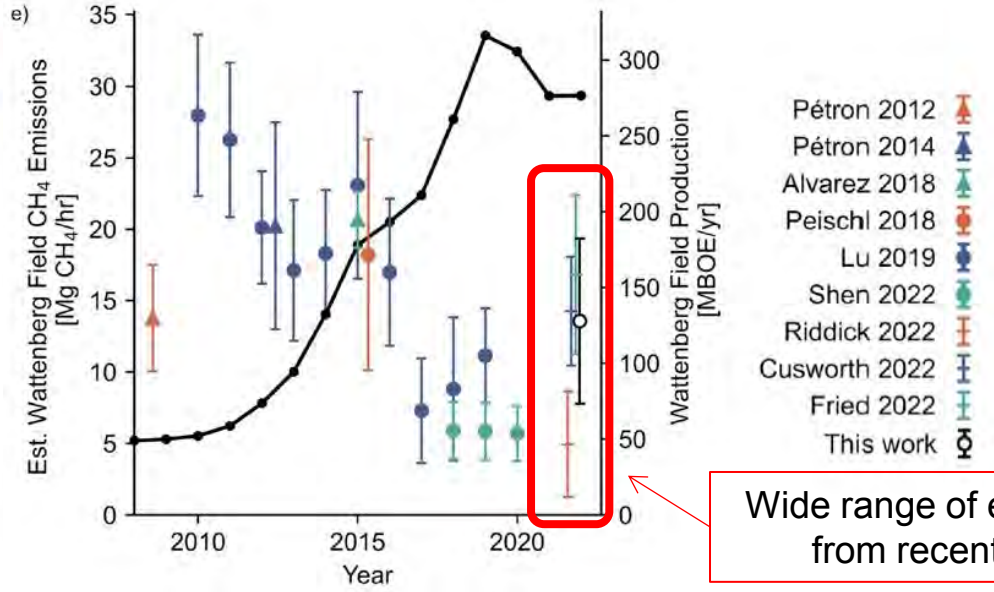
Airborne Surveys & Schedule



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

AiRMAPS 2024 Colorado

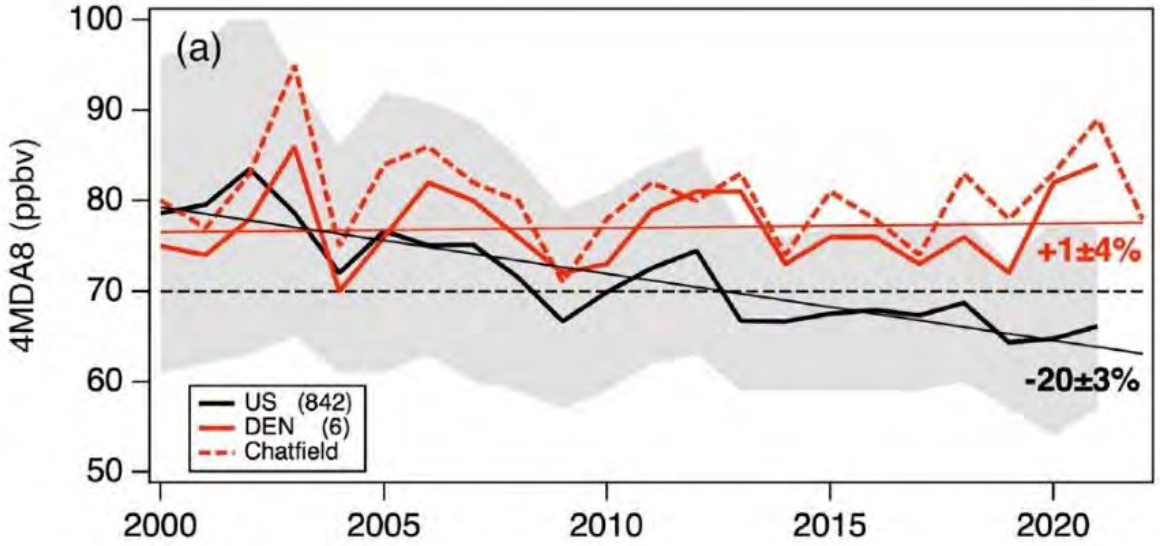




Mead GRL 2024

Top down methane emissions show declines despite rapidly rising production

Wide range of emissions estimates from recent measurements



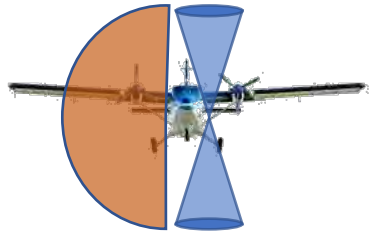
Langford JGR 2023

Colorado Front Range remains in ozone non-attainment despite declining U.S. trend

Pollutants from Oil & Gas development have been suggested as one reason for this trend

AiRMAPS 2024 Colorado: AMMBEC

Airborne Methane Mass Balance Experiment in Colorado, July 1 – 14 2024



NOAA Twin Otter (In-situ CH_4, NO_x, column NO_2, Doppler lidar): 22 individual flights, 12 flight days, ~75 flight hours

NASA King Air (AVIRIS-3 CH_4 imaging spectrometer): 9 individual flights /flight days, ~45 flight hours

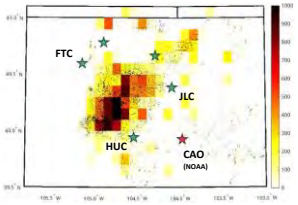
NOAA Air Resources Car (NOAA's ARC) (In-sit CH_4, NO_x, other trace gases): 11 drive days

PickUp Mobile Atmospheric Sounder (PUMAS): Doppler lidar at Platteville, CO

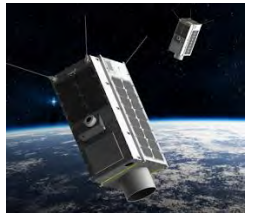
TOPAZ Ozone Lidar: Boulder, CO

CDPHE Mobile Optical Oil and gas Sensor of Emissions (MOOSE)

CSL Mobile Laboratory: Detailed GHG, VOC, NO_x

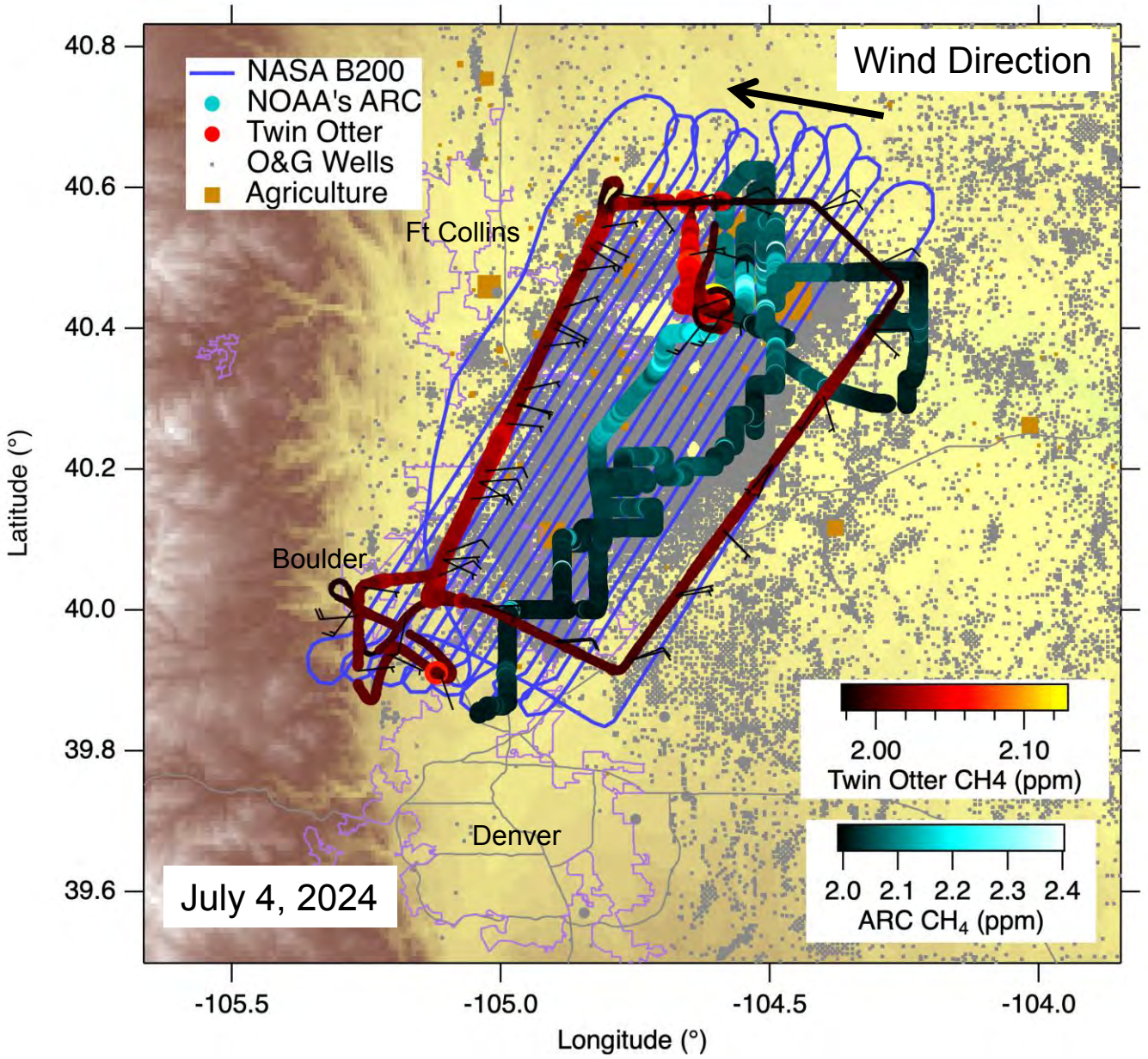


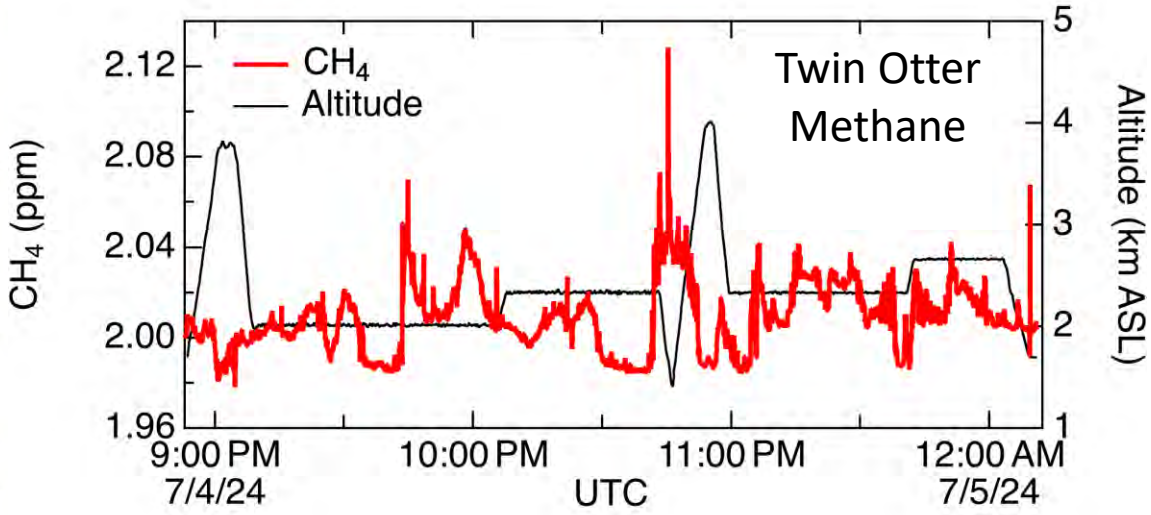
Penn State DJ Tower Network

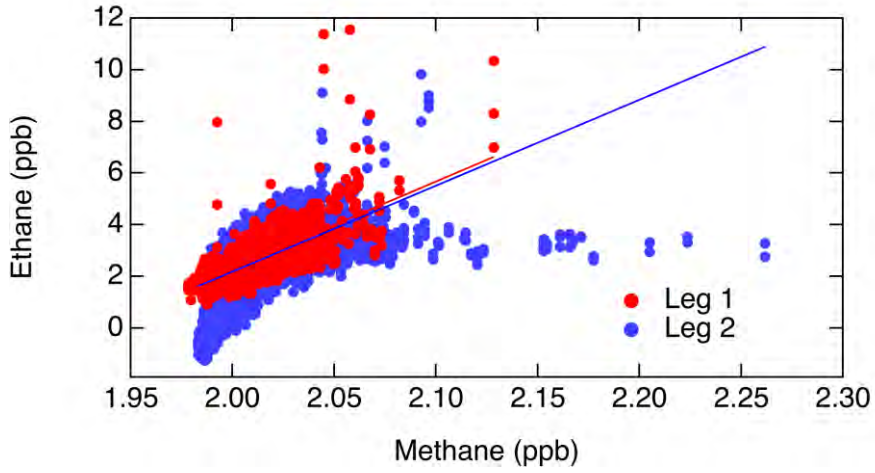


GHGSat data from NESDIS

Coordinated Aircraft & Mobile Lab Methane



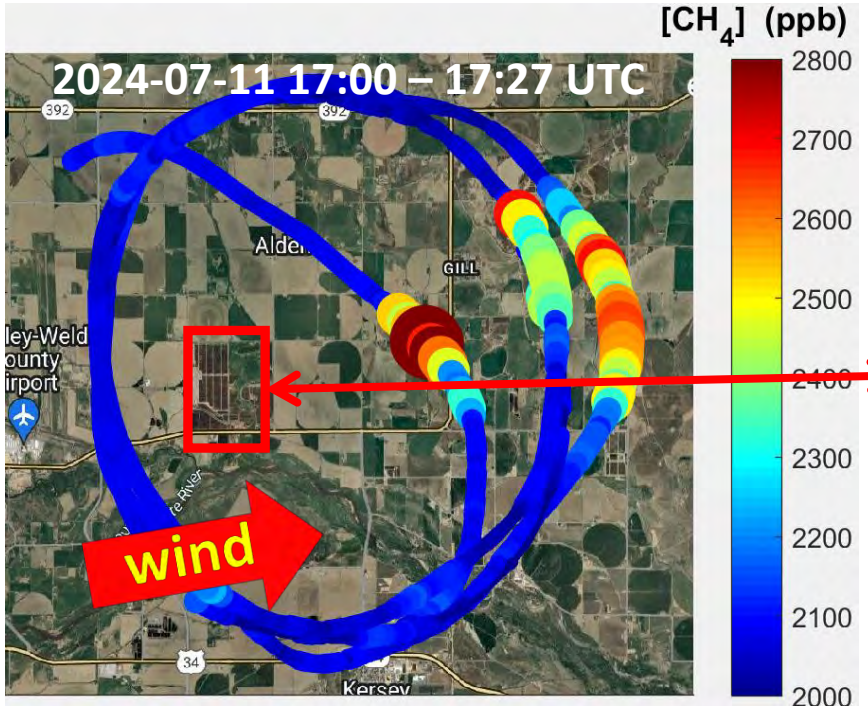




Coincident Measurements of CAFO Methane Emissions

Boundary layer mass balance

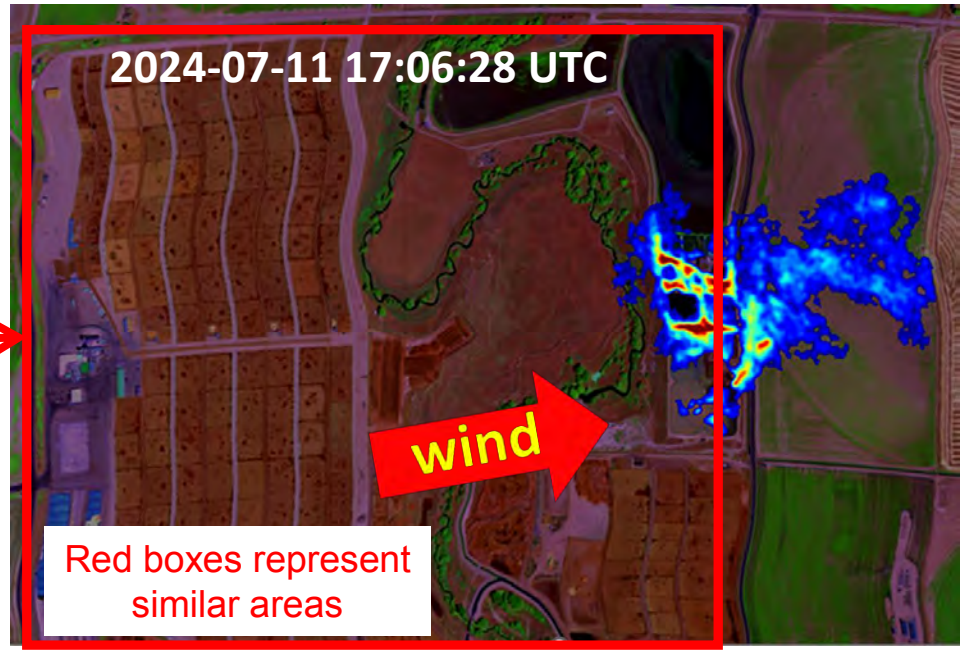
In-situ methane from NOAA Twin Otter



Twin Otter data from Xinrong Ren

Remote sensing plus inverse modeling

Remote sensed methane from NASA JPL King Air

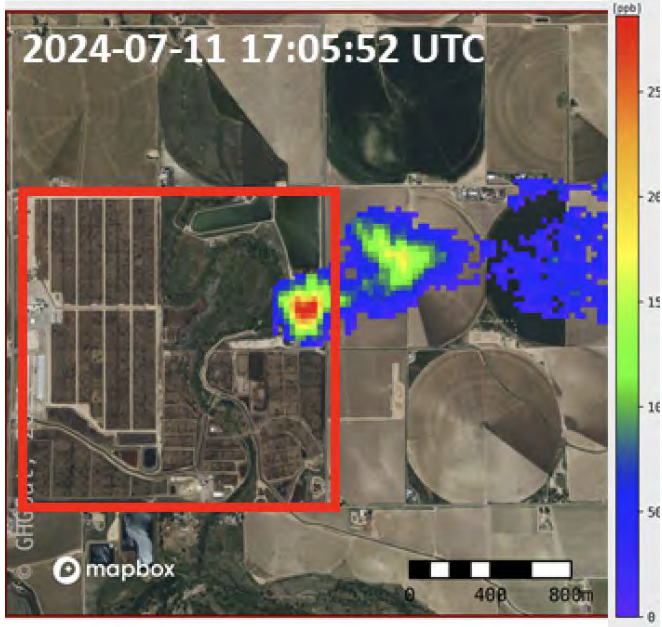


AVIRS Image from Andrew Thorpe

Tasking of commercial satellite

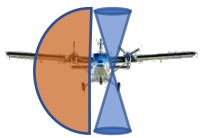
Remote sensed methane

GHGSat



AiRMAPS 2024 Utah: USOS

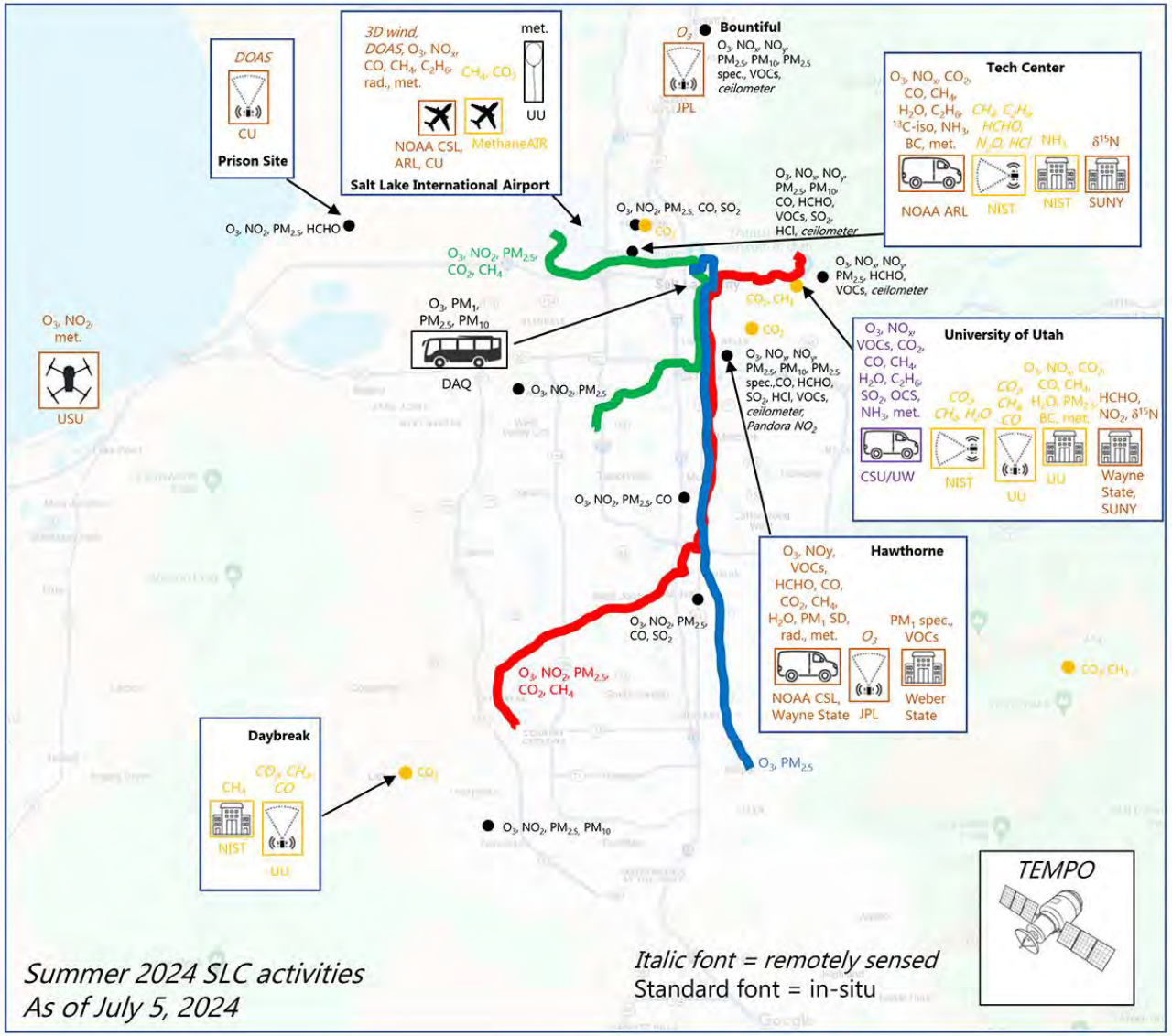
Utah Summer Ozone Study, July 15 – August 18 2024



25 flights, 12 flight days, ~90 flight hours

19 drive days

10 drive days
35 days stationary



Ongoing measurements:

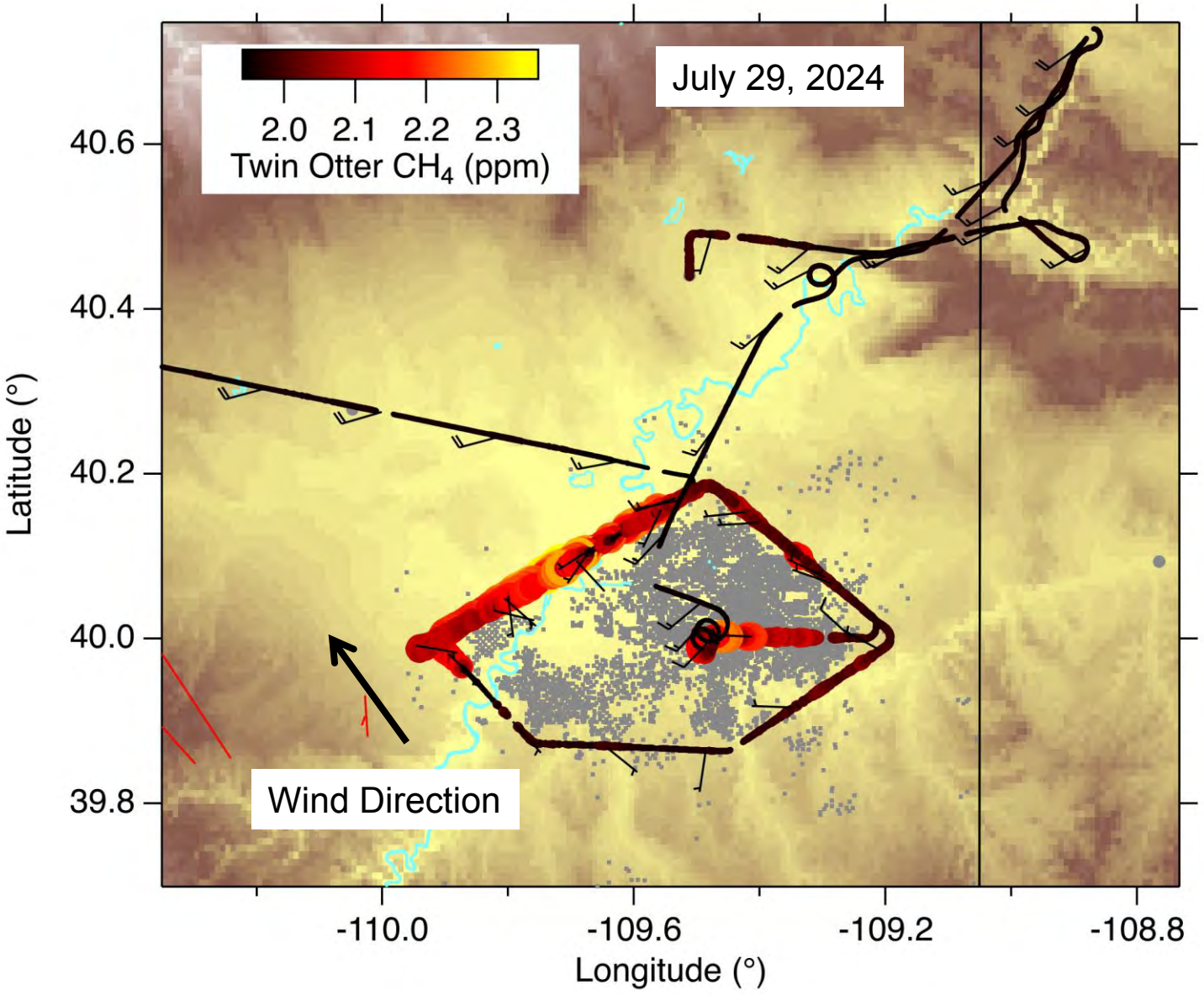
- DAQ monitoring
- UUCON monitoring
- UTA TRAX (approximate routes)
- UTA Electric bus fleet
- Daily radiosonde launches

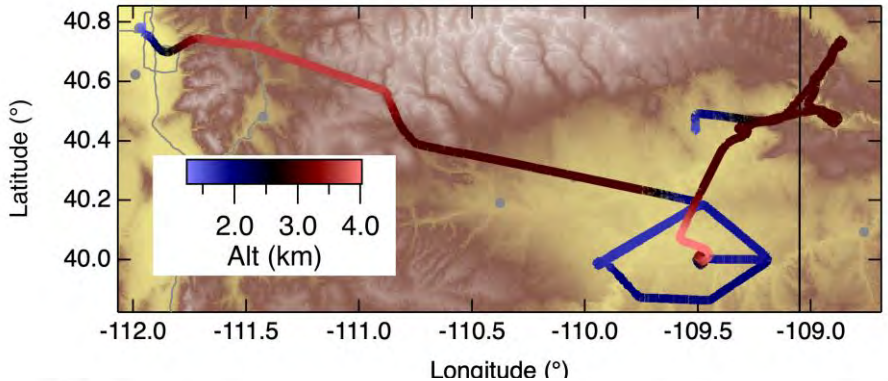
Summer 2024:

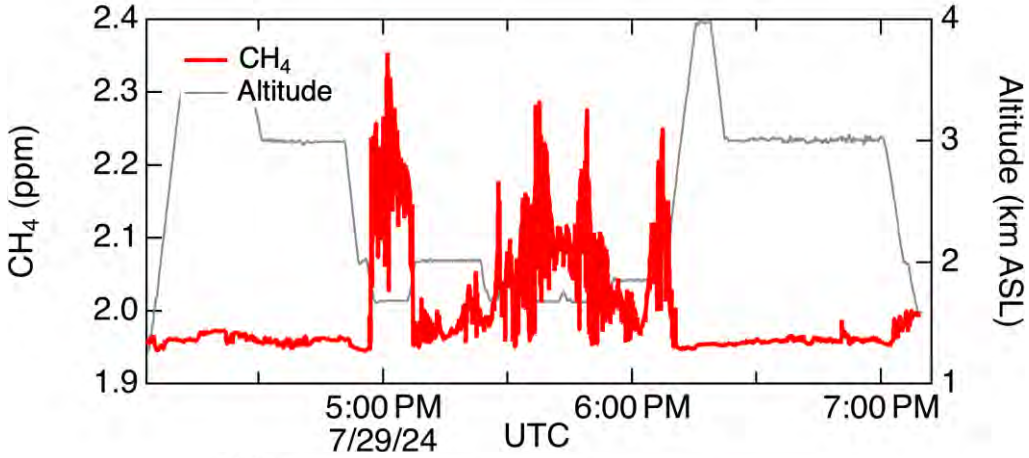
USOS	SLC-SOS	MEEPC
July 15 – Aug 9 or 18	Aug 1 - 30	Aug 1 – 30 or continuous

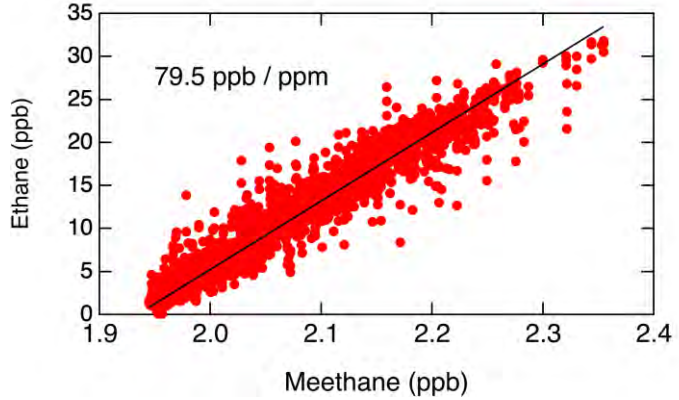
- Aircraft
- Mobile lab
- Upward-facing remote sensing
- Long-path remote sensing
- Additional ground-based in-situ measurements
- Drone

Uinta Basin Methane Mass Balance Flight

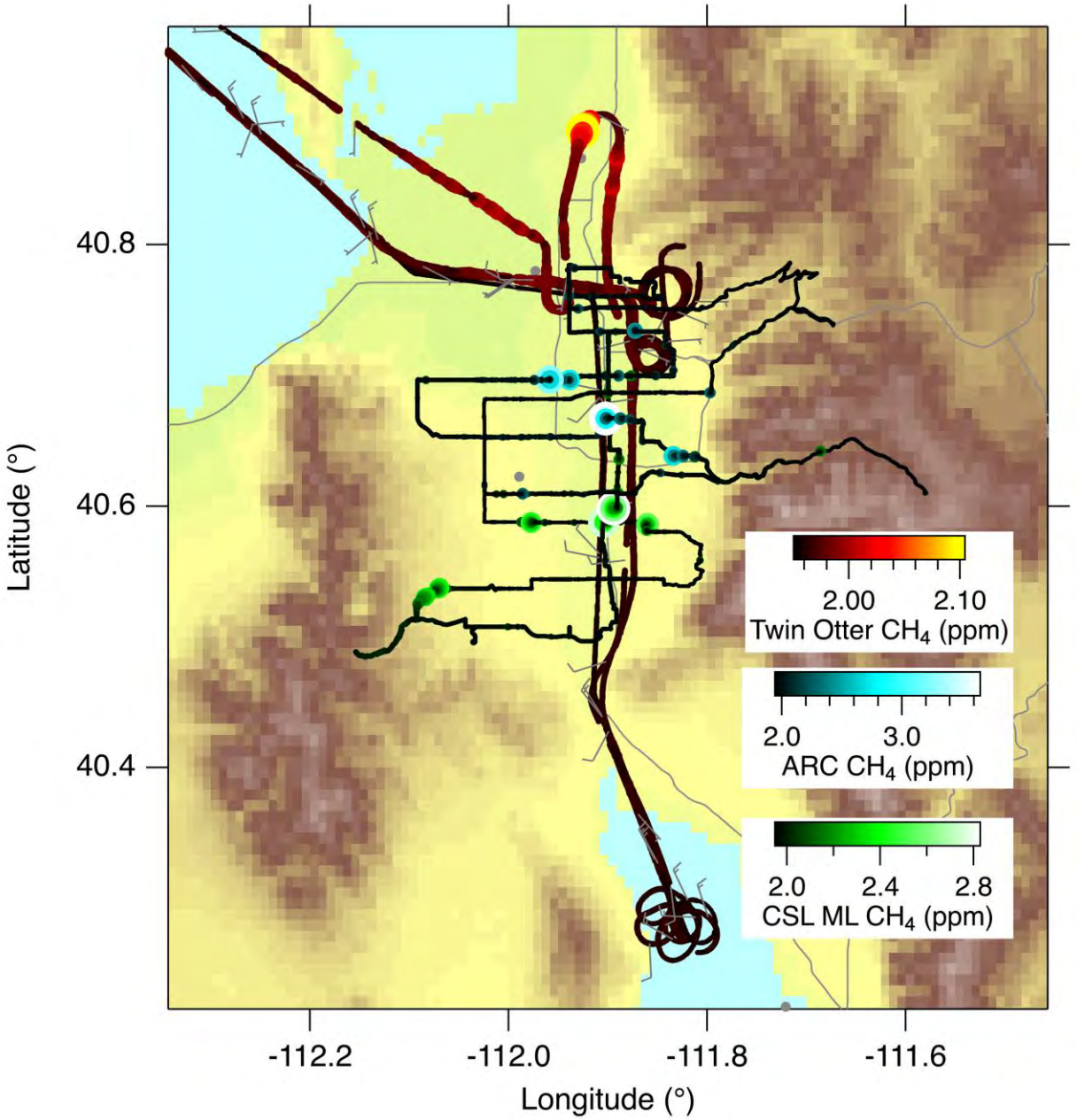








Salt Lake City Urban Methane



Twin Otter

ARC

Mobile Lab