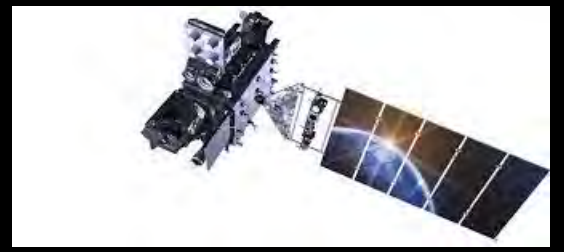
# NESDIS Perspectives of AiRMAPS 2025 Campaign

Shobha Kondragunta and Jeff Privette

National Environmental Satellite, Data, and Information Service

09/04/2024

# NOAA Climate Services: Value Chain

# NESDIS GHG Remote Sensing

## MONITORING

- Global 3D concentration fields: Methane and Carbon dioxide
- Annual budgets for releases from natural sources: Fire emissions, land vegetation products etc.

## EMERGING CAPABILITIES

- Carbon dioxide fluxes over urban areas in near real time
- Facility-level methane plume detection algorithms

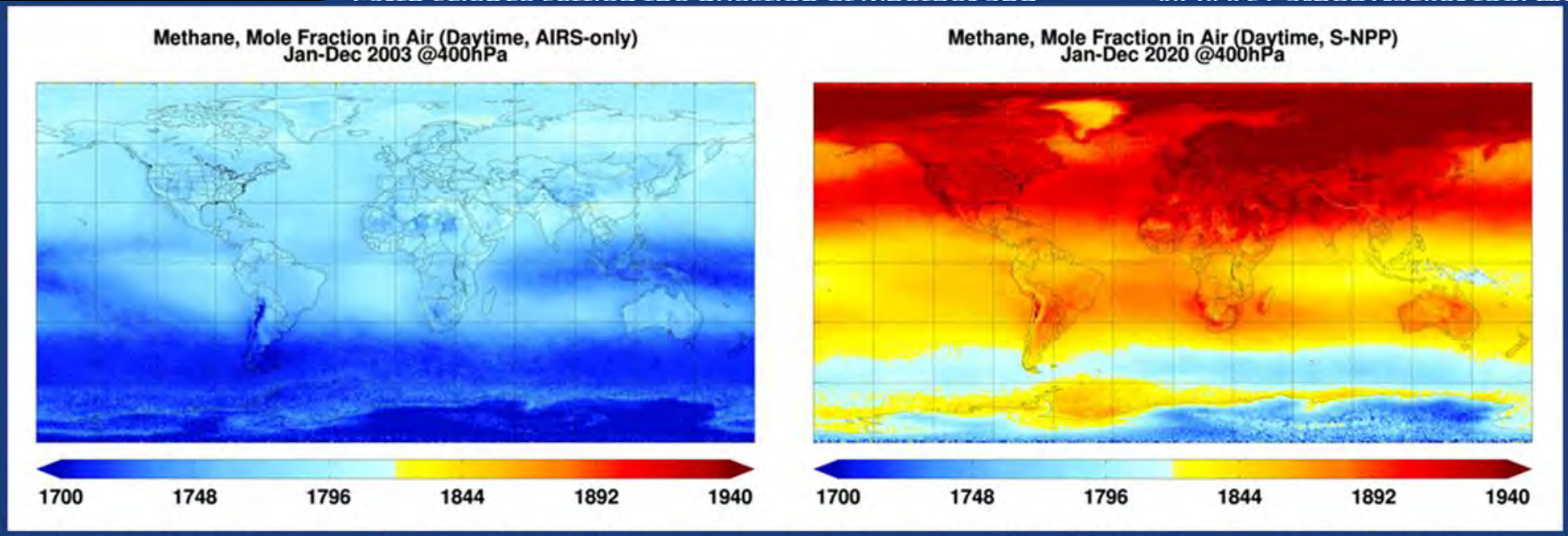
## SERVICES

- GHGSat tasking as needed to monitor methane leaks
- Develop capabilities to support state/local agencies monitoring methane from different source sectors
- Support climatologists with actionable GHG information

**NESDIS Priority:** Co-investing and co-development of GHG monitoring capabilities, calibration and validation of GHG measurements, ensuring standards are met, and long-term sustained operational archive and stability of the data.

# NOAA Satellites Track Trends in Greenhouse Gases

## From Both Human and Natural Sources




*The image on the left shows annual mean methane ($CH_4$) concentrations in 2003, as measured by NASA's AIRS sensor on the Aqua satellite. The image on the right shows the concentrations in 2020 as computed by the CrIS sensor onboard the S-NPP satellite. There is a significant increase in $CH_4$ in the atmosphere over this period of time.*

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and sinks (when carbon
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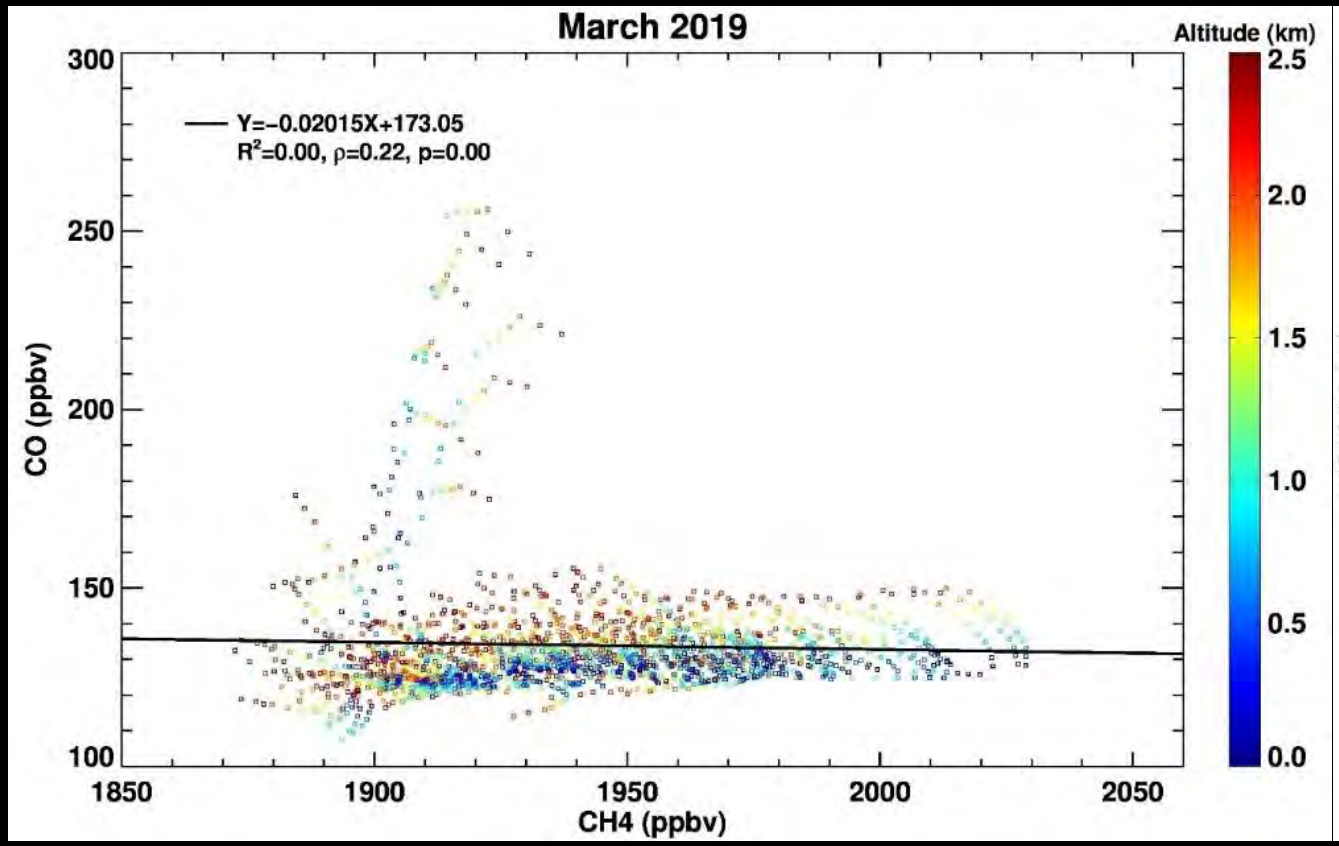
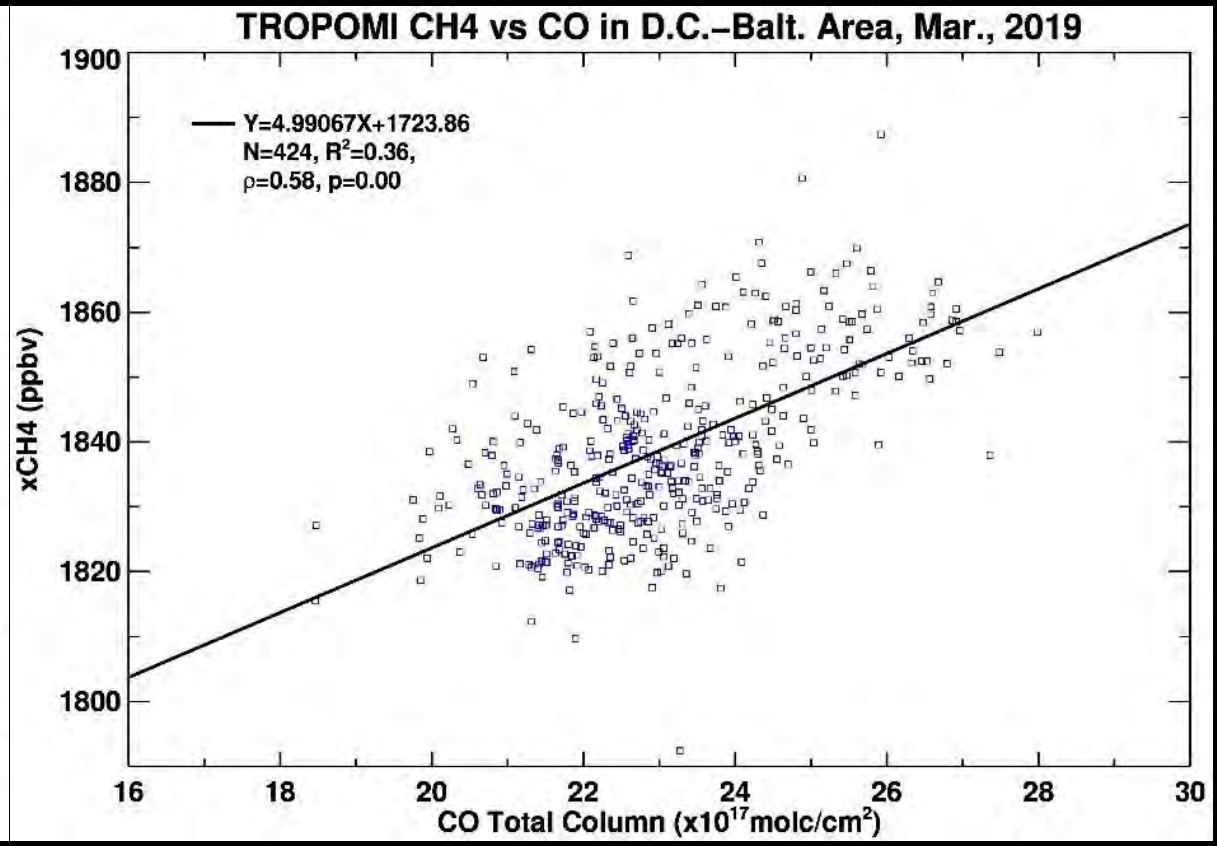
bservations depend on a
variety of sensors, from
satellite systems.

rovide the most accurate
's Joint Polar Satellite

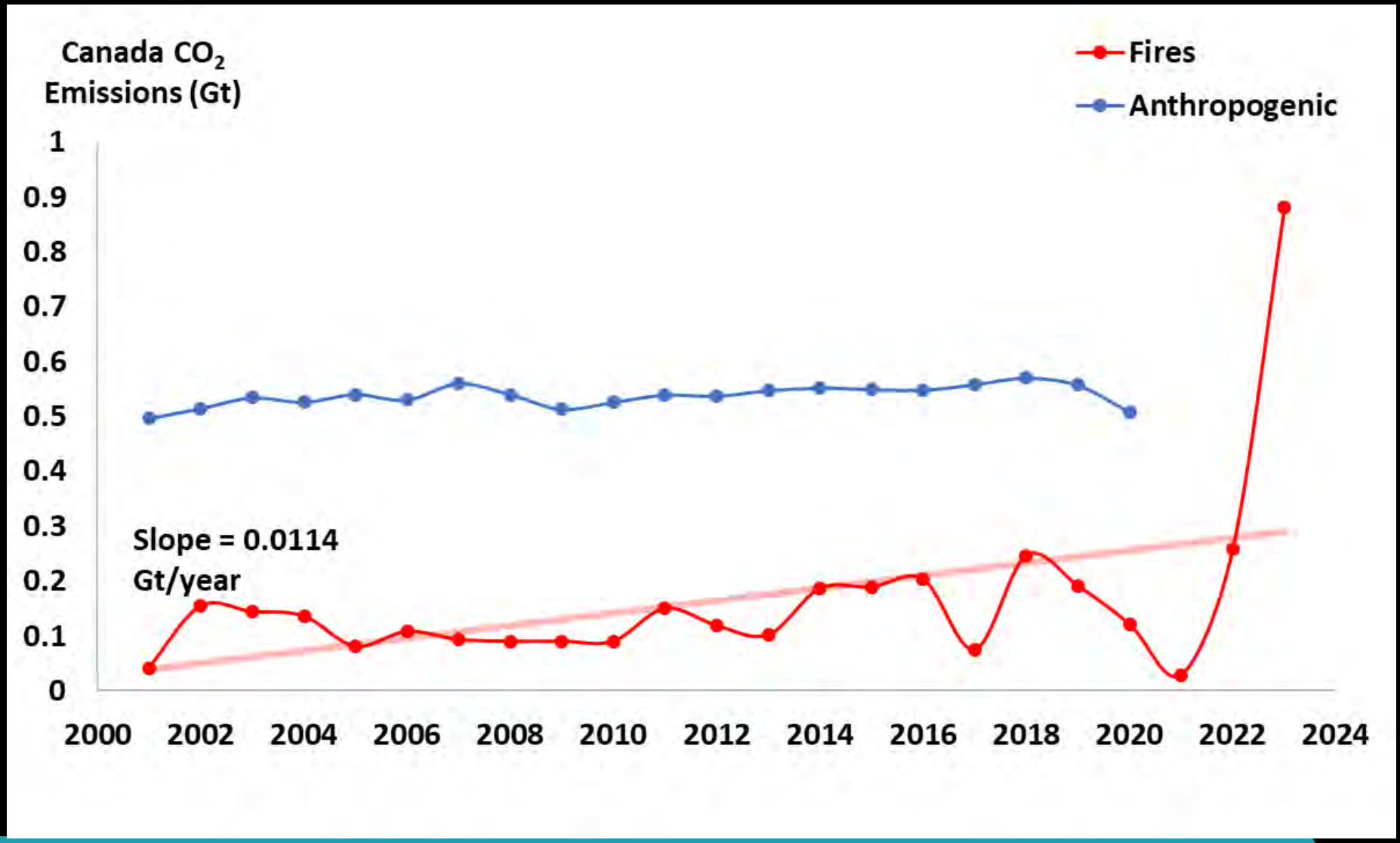


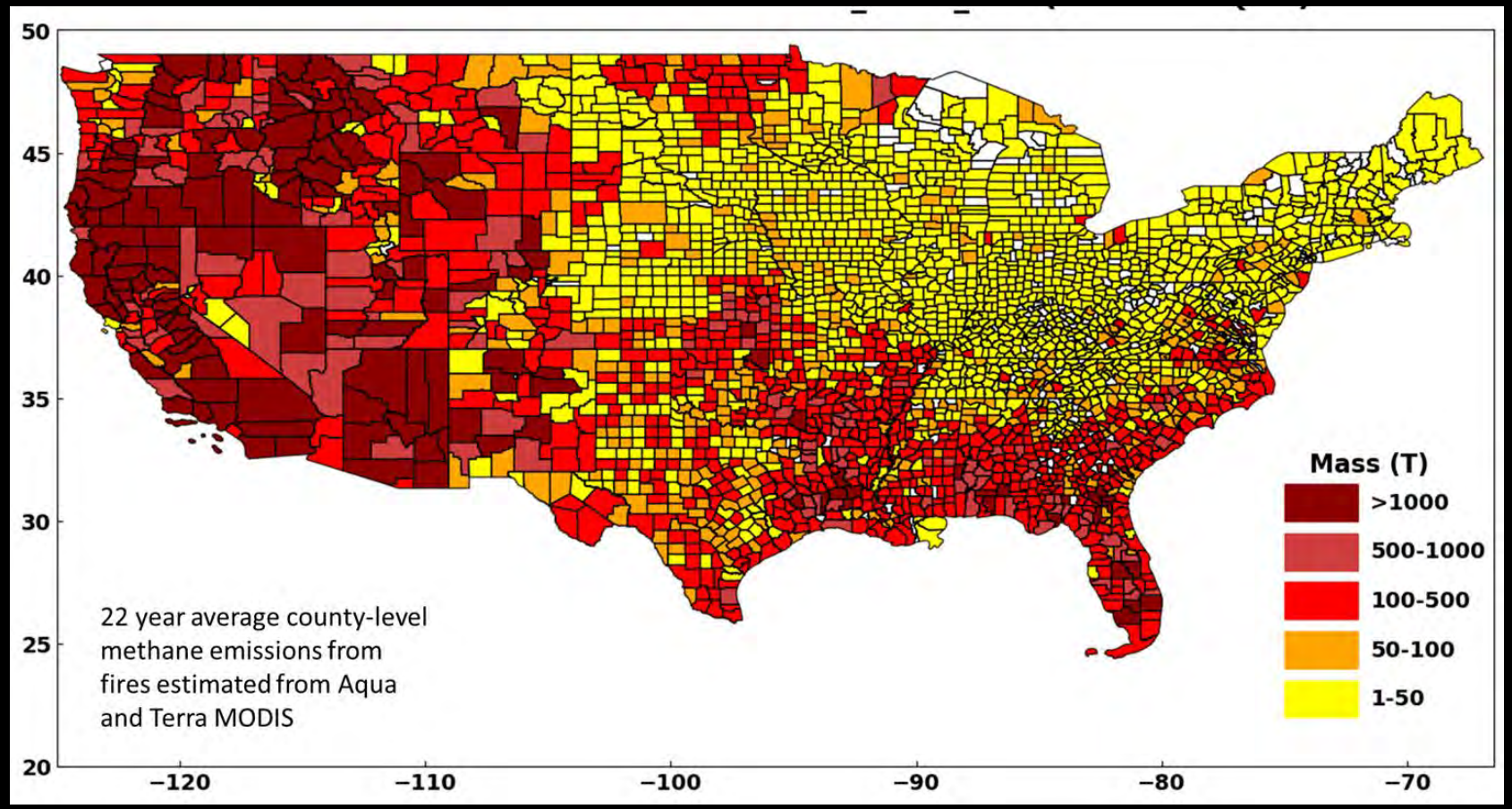

Satellite sensor capabilities vary. While CrIS monthly methane and carbon dioxide retrievals are good for assimilation due to their sensitivity to free tropospheric changes, they are not very useful for understanding atmospheric processes such as near surface changes.

# GHG emissions from fires are not insignificant

*Regionally, contribution of fires to GHG budget can surpass anthropogenic sources as was the case for 2023 Canadian fires.*



# NESDIS's Support for the National GHG Strategy

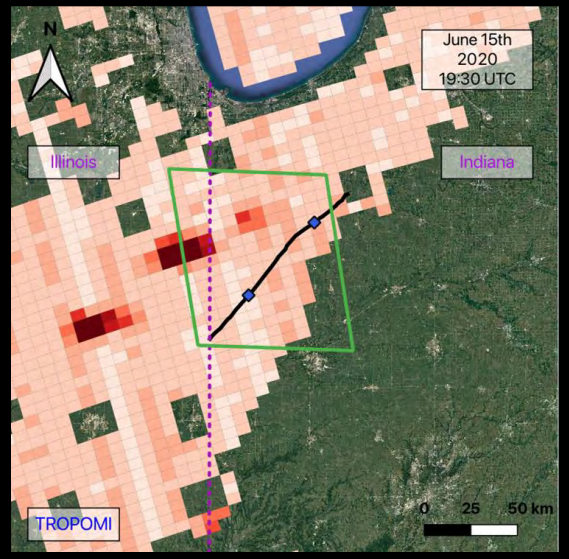



***NOAA processing of GHG emissions from fires***

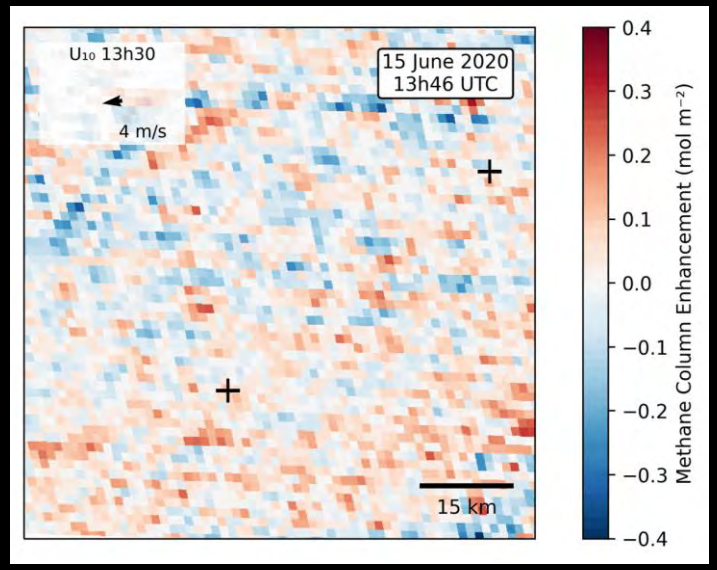
| Satellites | Time Period | Coverage |
|---|---|---|
| Terra and Aqua MODIS | 2000 - 2023 | Global, daily 0.1º, 0.25º, C384, C96 |
| SNPP, NOAA-20, NOAA-21 VIIRS | 2012 - 2023 | Global, daily 0.1º, 0.25º, C384, C96 |

# NESDIS's Support for the National GHG Strategy

***S5P TROPOMI***




***GOES-16 ABI***





Partnership with Harvard University. Three year committed NOAA funding to PI Daniel Varon

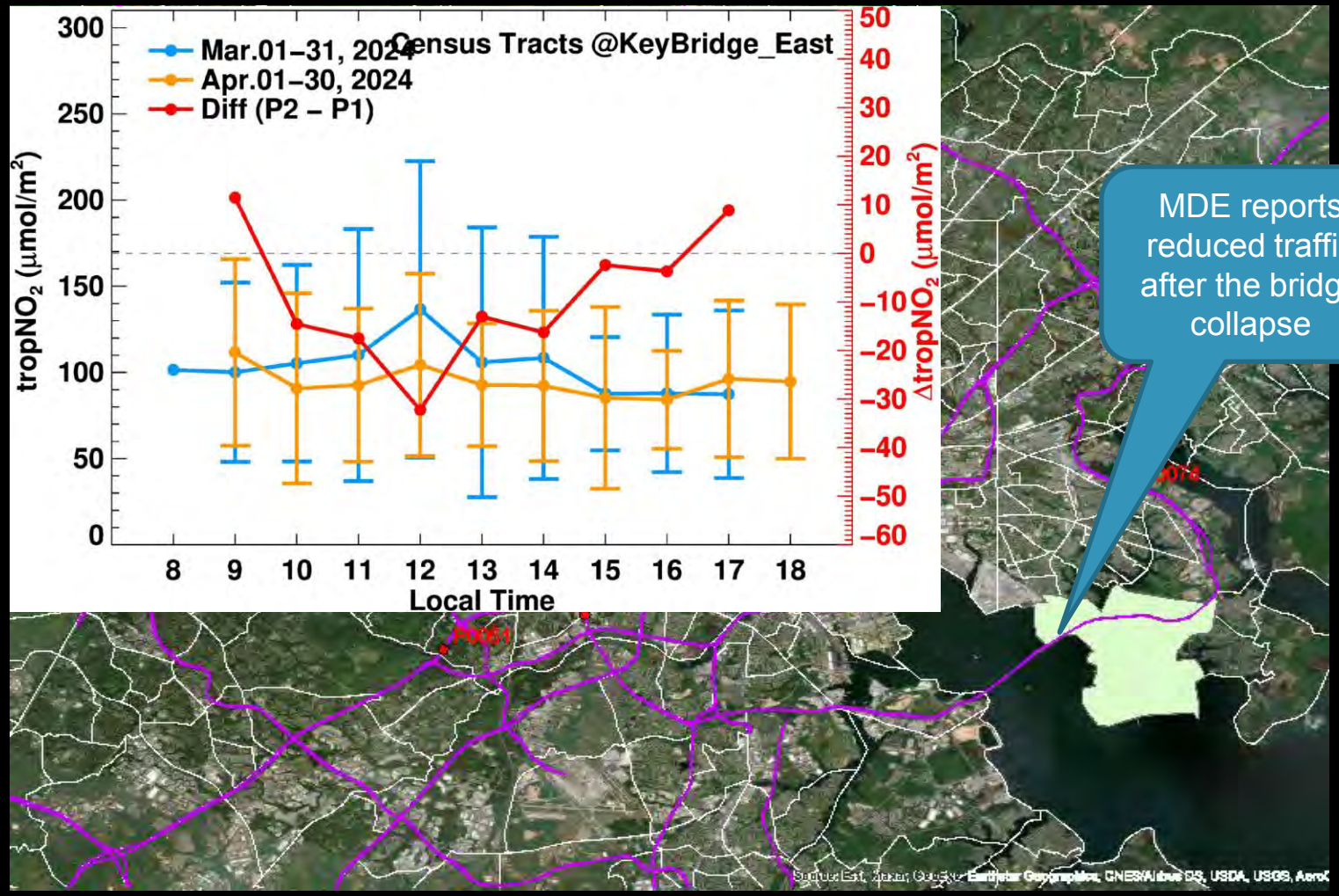
***Calibration and validation is essential work at NOAA***

NESDIS conducting opportunistic controlled release experiments of methane during pipeline blowdown events to evaluate ABI methane retrievals

# Deriving Hourly $CO_2$ Emissions from $NO_2$

**In urban areas dominated by fossil fuel combustion, $NO_2$ and $CO_2$ are co-emitted**

**Could we derive $CO_2$ emissions using $NO_2$ as a proxy?**



# Deriving Hourly $CO_2$ Emissions using TEMPO $NO_2$ as a Proxy

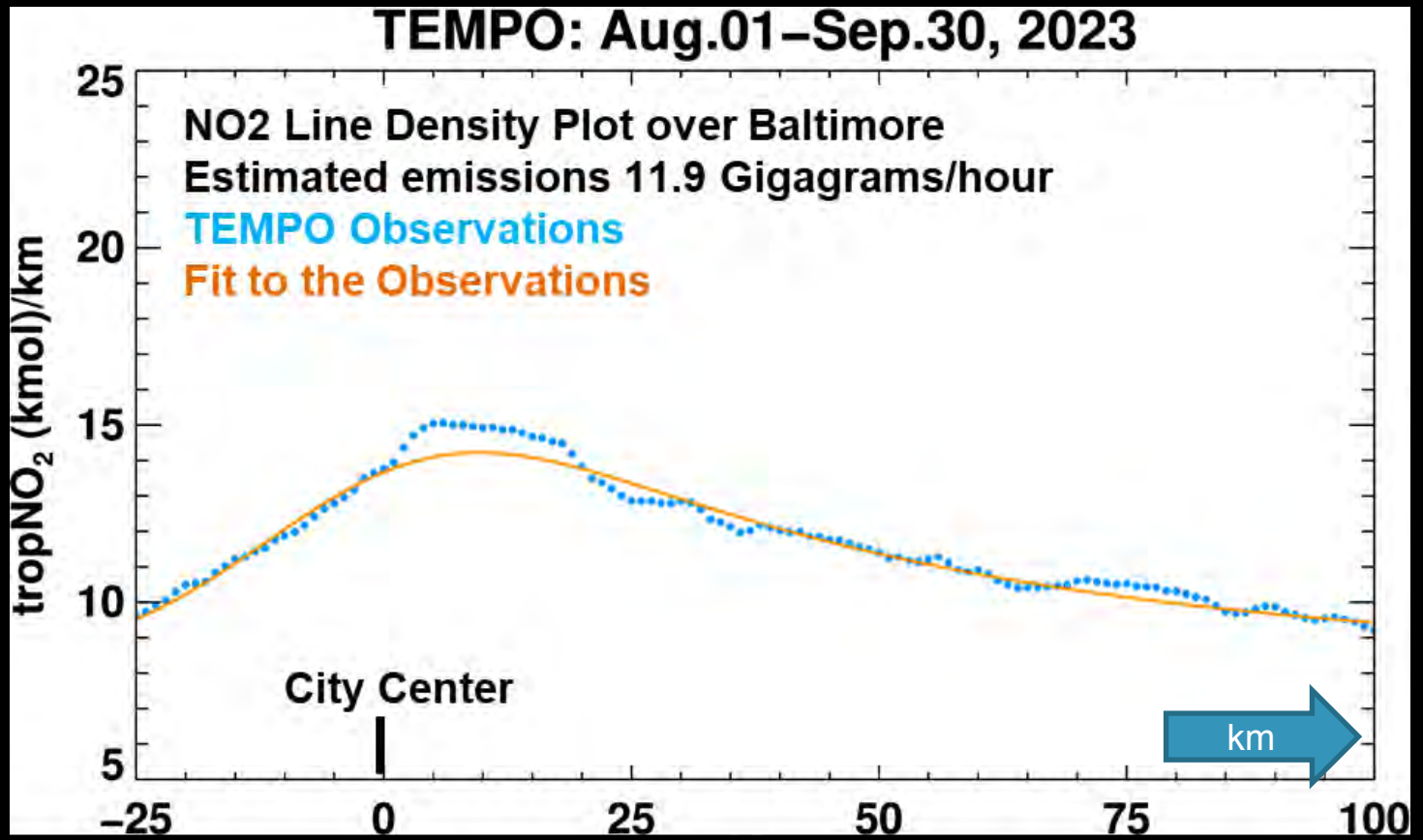
$$f(x) = \alpha\left[\frac{1}{x_0}e^{\left(\frac{\mu}{x_0}+\frac{\sigma^2}{2x_0^2}-\frac{x}{x_0}\right)}\Phi\left(\frac{x-\mu}{\sigma}-\frac{\sigma}{x_0}\right)\right]+B$$

$$\tau = \frac{x_0}{w}$$

$$E = 1.32\cdot\frac{\alpha}{\tau} = 1.32\frac{\alpha w}{x_0}$$

$$E_{CO2} = E_{NOx} * Ratio_{CO2/NOx}$$

- Derive $CO_2$ emissions for top 50 urban areas in the US (population > 1 million);
- Use observed winds from GOES;
- After launch, rely on CO2M and GOSAT-GW $CO_2/NO_2$ ratios;
- Conduct aircraft observations of $CO_2$ and $NO_2$ to validate estimates of TEMPO $CO_2$;
- Ron Cohen offered a few suggestions that we would like to explore as well.




Effort tied to GRA²PES and Urban-GEMMS

# Can AiRMAPS Help Answer Key AQ Questions

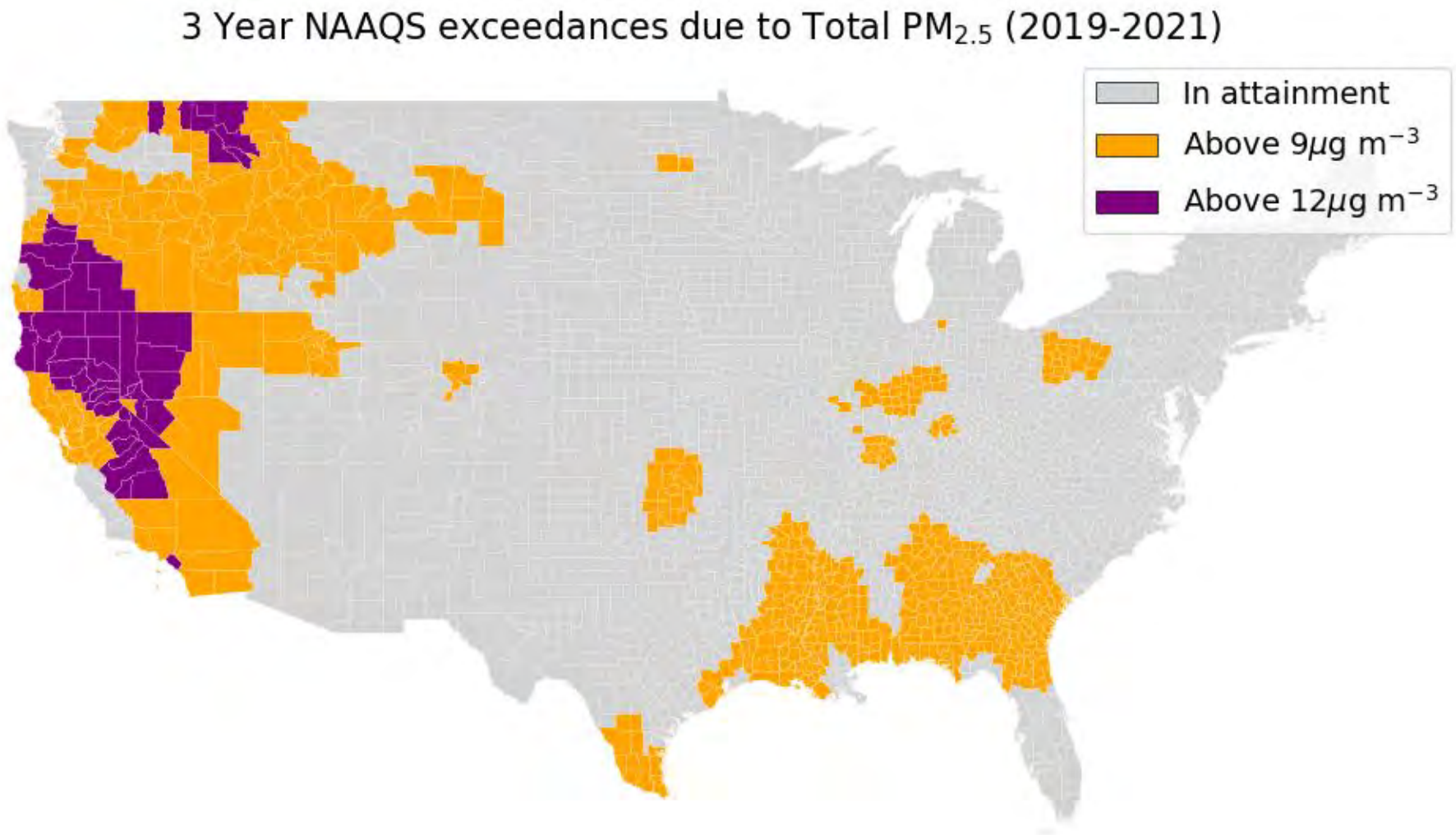
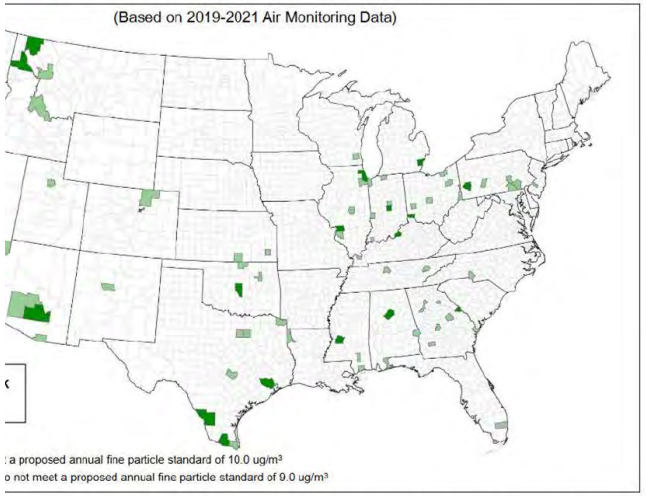



**Figure 2. Areas That Would Likely Not Meet the Proposed $PM_{2.5}$ NAAQS Based on Their 2019-2021 Design Values**




mental Protection Agency (EPA), Proposed Decision for the Reconsideration of the Quality Standards for Particulate Matter (PM), at https://www.epa.gov/system/files/ M%20Maps%20-%202022%20proposal%20%282%29.pdf.

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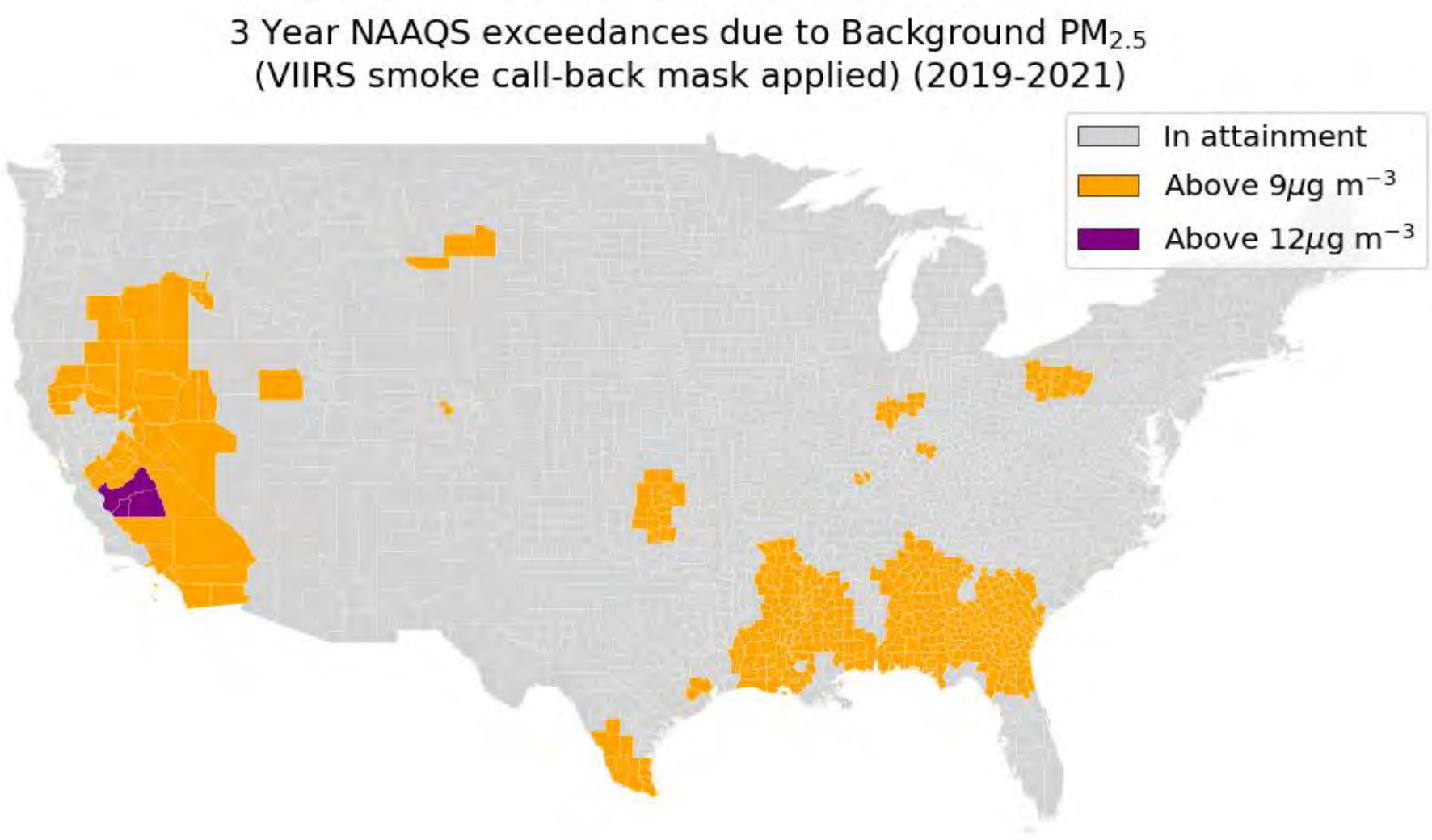


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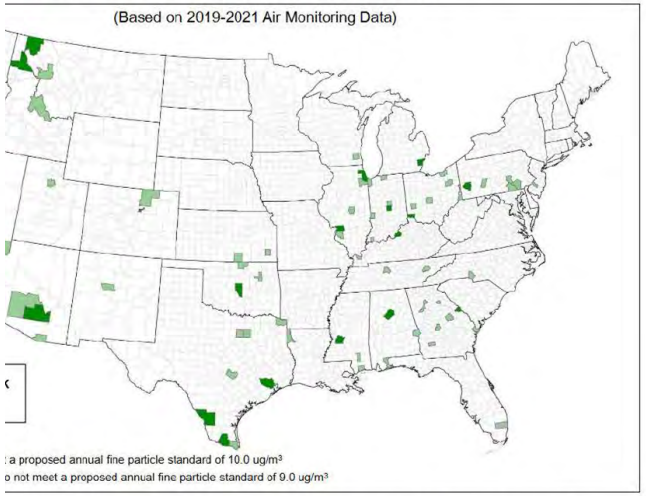


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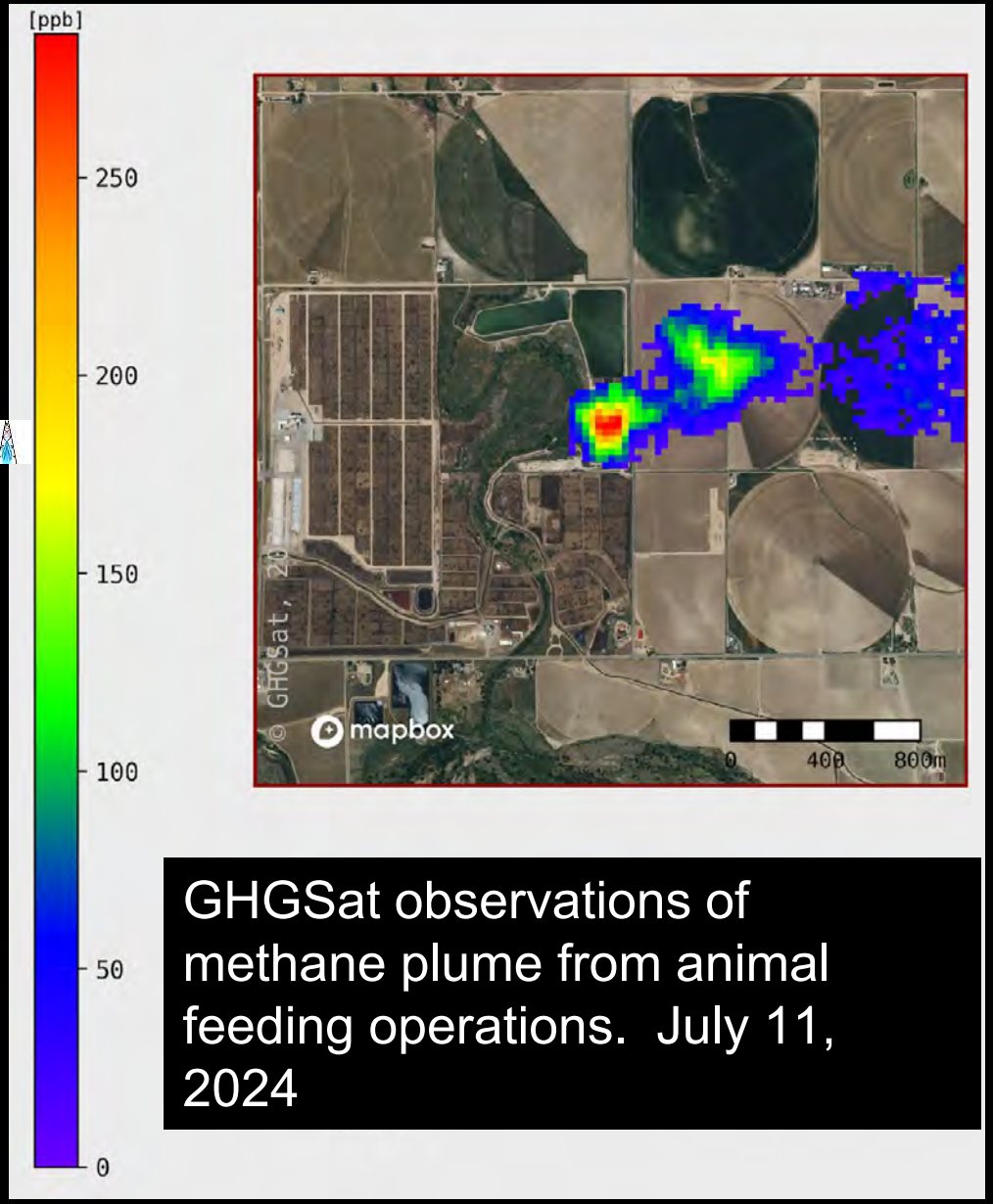
# Understanding Commercial Satellite Data

- In collaboration with Colorado Department of Public Health and Environment, OAR conducted 23 aircraft flights to make methane measurements over different source sectors such as landfills, power generation facilities, animal feeding operations, waste water treatment facilities etc.
- NESDIS tasked five GHGSat methane observations. One successful image capture simultaneous with NOAA Twin Otter and NASA King Air.




GHGSat observations of methane plume from animal feeding operations. July 11, 2024

# Monitoring Methane from Different Source Sectors

- Oil and gas industry
- Landfills
- Wastewater treatment facilities
- Energy sector
- Animal feeding operations
- Large methane leaks
- Etc.

*NESDIS will support AiRMAPS by tasking GHGSat, using its EULA, to make simultaneous observations as needed to establish calibration and validation of small satellite GHG retrievals.*

# GeoXO Constellation

(Preliminary, pending program approval)

**GEO-West**

Visible/Infrared Imager
Lightning Mapper
Ocean Color

**GEO-Central**

Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload

**GEO-East**

Visible/Infrared Imager
Lightning Mapper
Ocean Color

Can AiRMAPS campaign and other testbed activities by EPA, state/local agencies make a case for a methane instrument on GeoXO?

# Conclusions

- Along with methane observations, if possible make $NO_2$ and $CO_2$ observations over Baltimore;
- Plan for air quality ($PM_{2.5}$ and trace gas precursors) in the Southeastern states where satellite data are showing non-attainment of the new fine particulate standard
- Support NOAA requested controlled release experiments with special aircraft flights
- Make the case for a methane instrument on the GeoXO-Central

# Discussion

- Goals for coordinated experiment
  - Full mapping of landfills with ground monitors, aircraft in situ, aircraft remote sensing, commercial satellite tasking etc.  Not one off but for a duration (a few months) to observe
    - Heterogeneity of landfill methane emissions
    - Diurnal variation in methane emissions
- Gaps and needs not discussed at this workshop
  - Simultaneous $NO_2$ and $CO_2$ observations over Baltimore
- Stakeholder needs, especially at the state level
  - NESDIS already working with MDE in different ways. NESDIS AA and MDE Director of Air Program exchanged letters
  - NESDIS supporting EPA with GHG inventory verification


MDE 2021 Report