



# Detecting Ethane over Oil & Gas Regions by CrIS/GXS and Synergies within GeoXO



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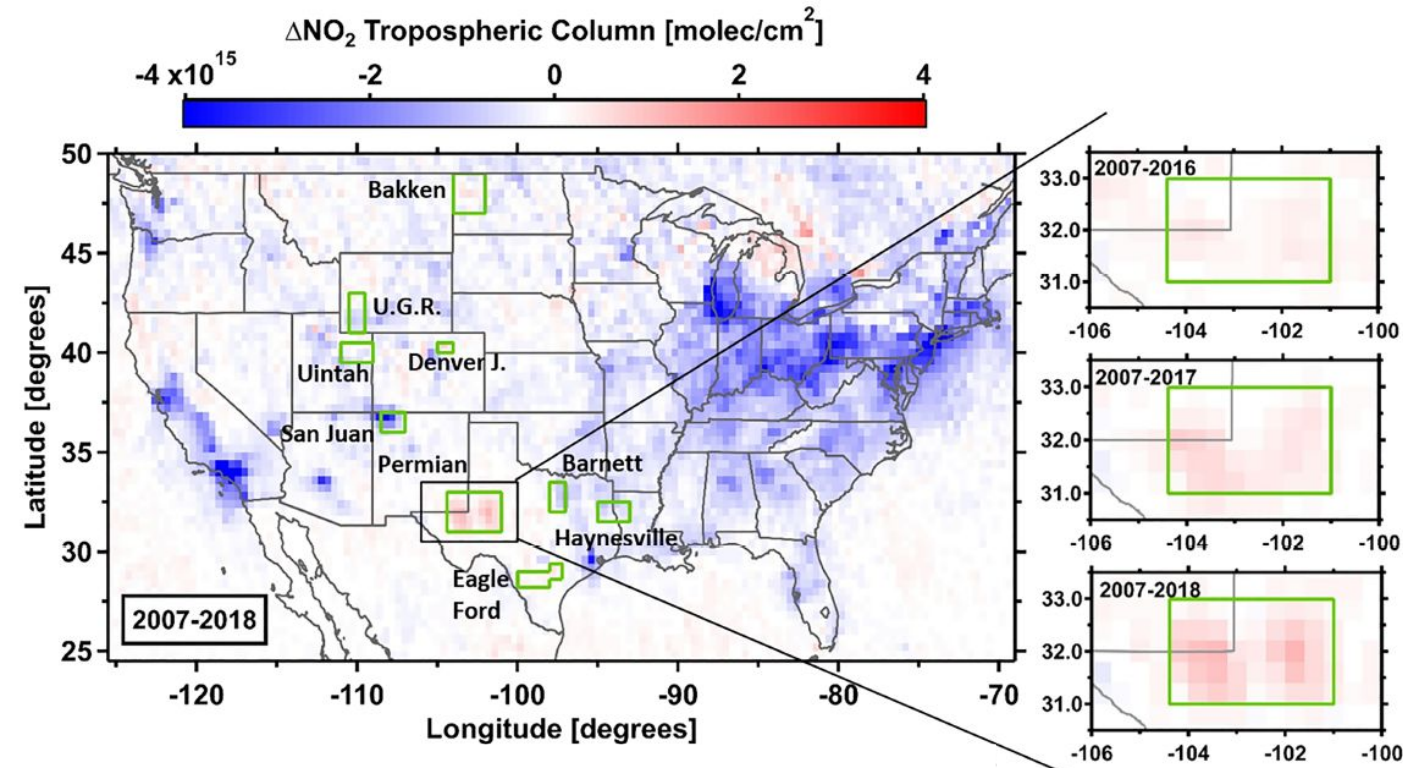


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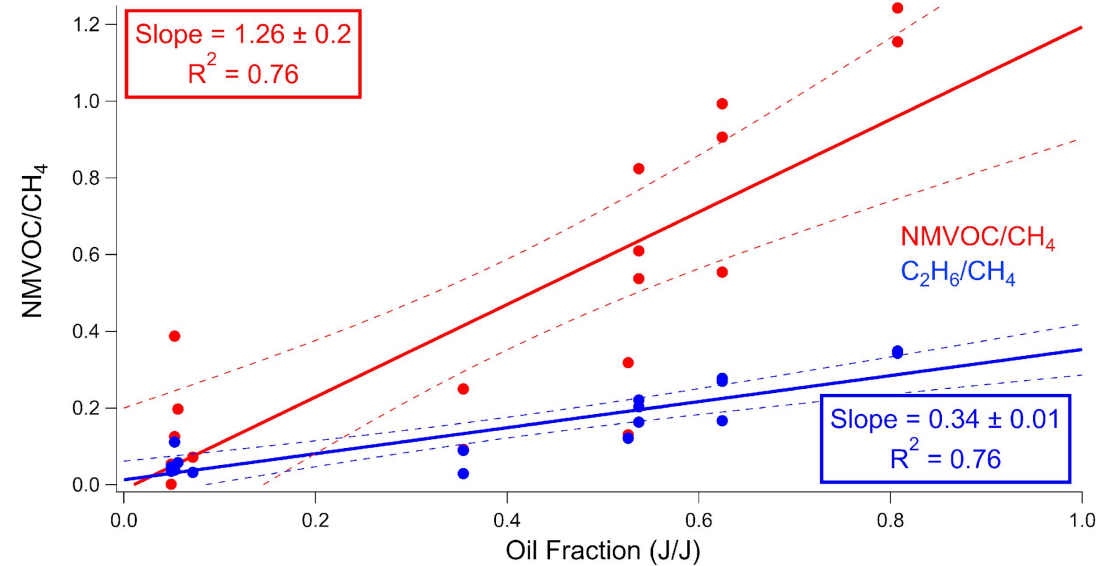
**Brian McDonald, Program Lead  
Atmospheric Composition Modeling**

# Motivation

- Rapid change in oil & gas production in past decade
- Ethane ( $C_2H_6$ ) is an oil and gas emitted tracer



Dix et al. (*Geophys. Res. Lett.*, 2020)



Francoeur et al. (*Environ. Sci. Technol.*, 2021)

# Research Objectives

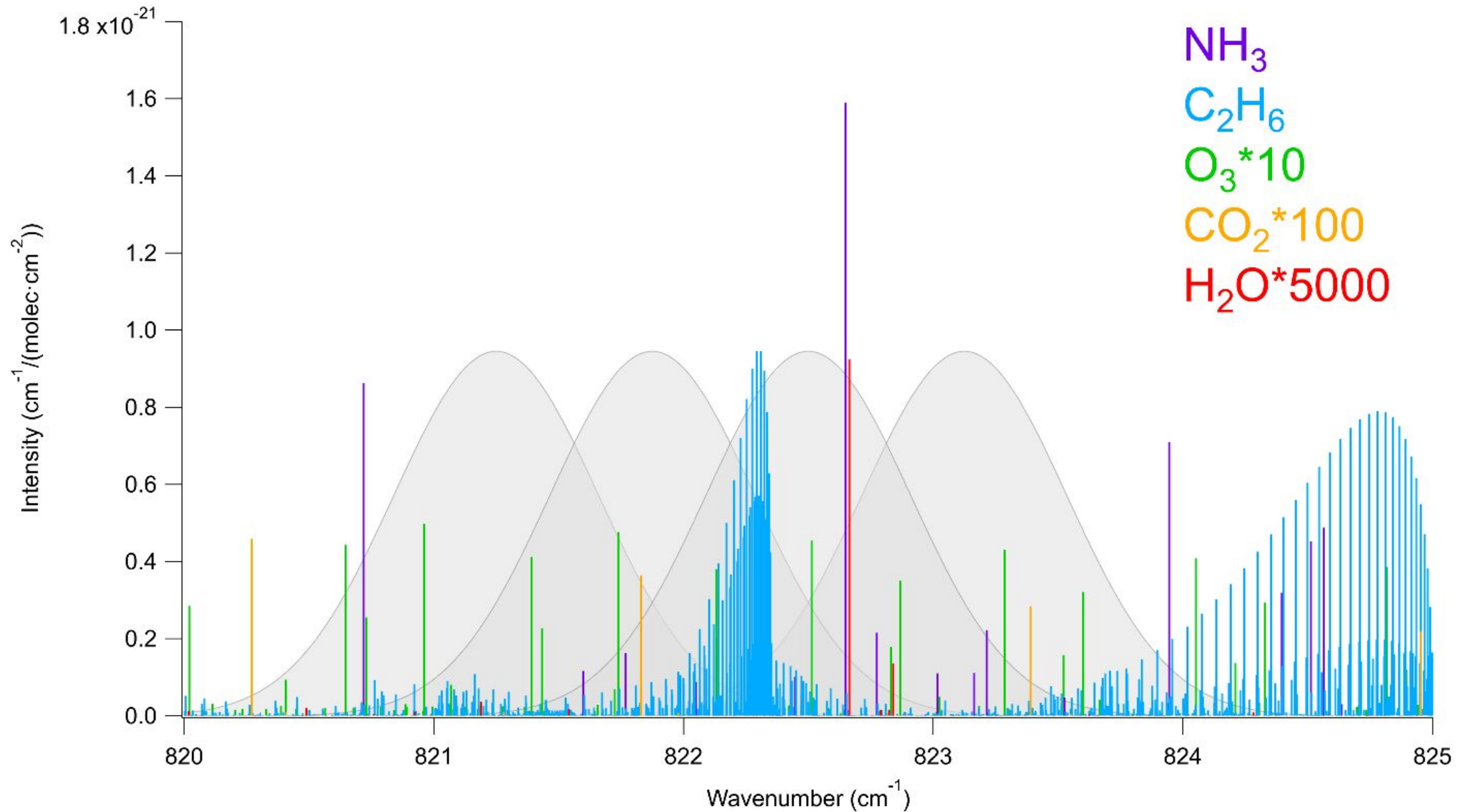
- (1) Demonstrate ability to retrieve O&G  $C_2H_6$  from Cross-track Infrared Sounder (CrIS)
- (3) Evaluate in conjunction with 2015 O&G field campaign
- (4) Compare CrIS trends with expected production and emission intensity trends
- (5) Identify synergies with other GeoXO instruments



CrIS proxy for GXS to observe  
key atmospheric composition species

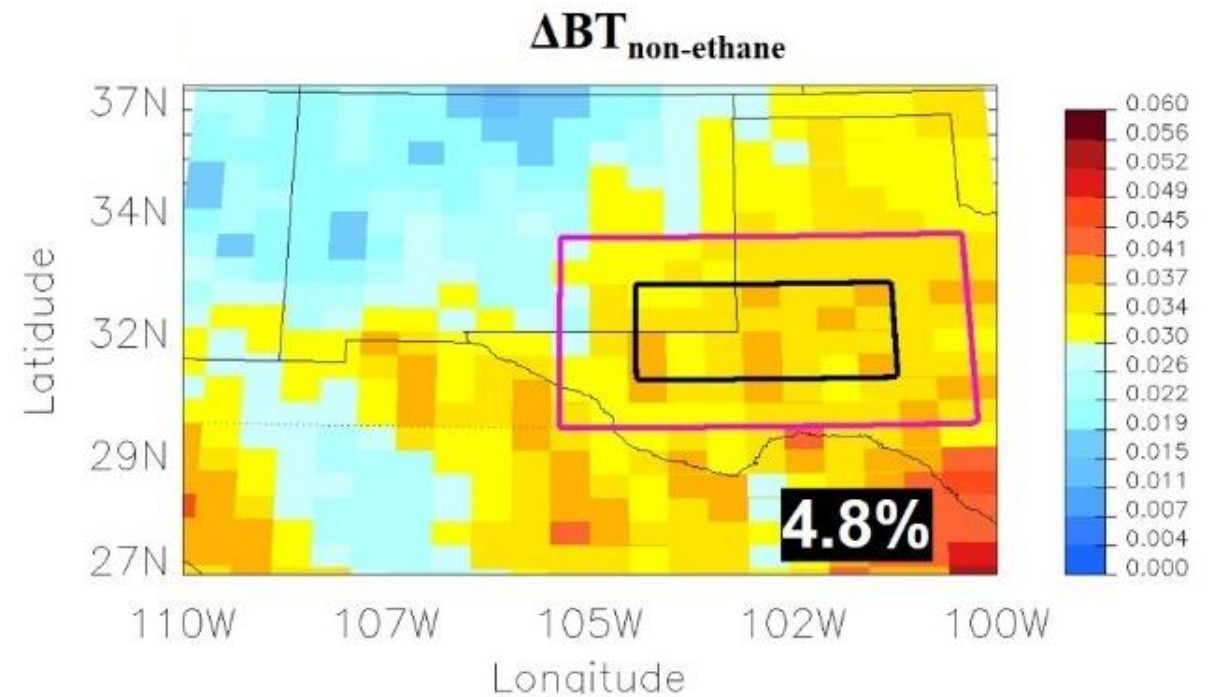
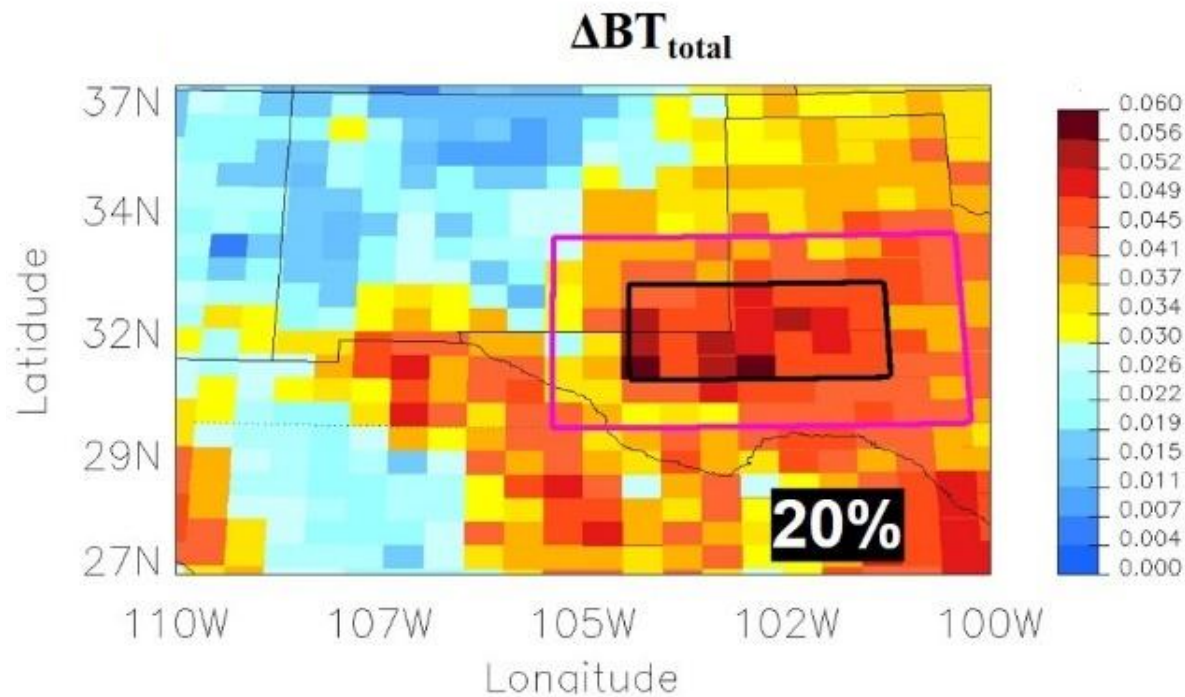
Onboard NOAA-20 since 2017  
and Suomi-NPP since 2011

# HITRAN Absorptions Between 820 and 825 $\text{cm}^{-1}$



# Simulating CrIS with VLIDORT to Isolate Ethane Absorption

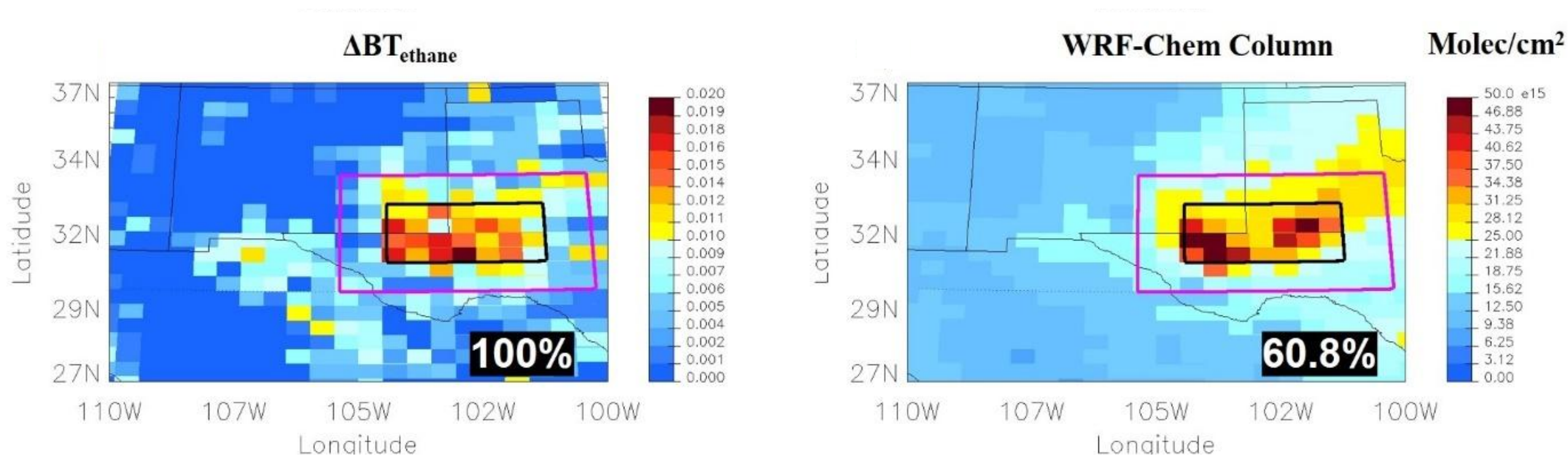
$$\text{Ethane dBT} = 0.5 * (\text{BT}(821.25) + \text{BT}(823.125) - \text{BT}(821.875) - \text{BT}(822.5))$$



NASA Community Long-term Infrared Microwave  
Coupled Atmospheric Product System  
(CLIMCAPS) radiances corrected for clouds

CLIMCAPS retrieved variables:  
Temperature(p), water vapor(p), CO<sub>2</sub>(p), CH<sub>4</sub>(p),  
Reflectance, Solar and Satellite Angles

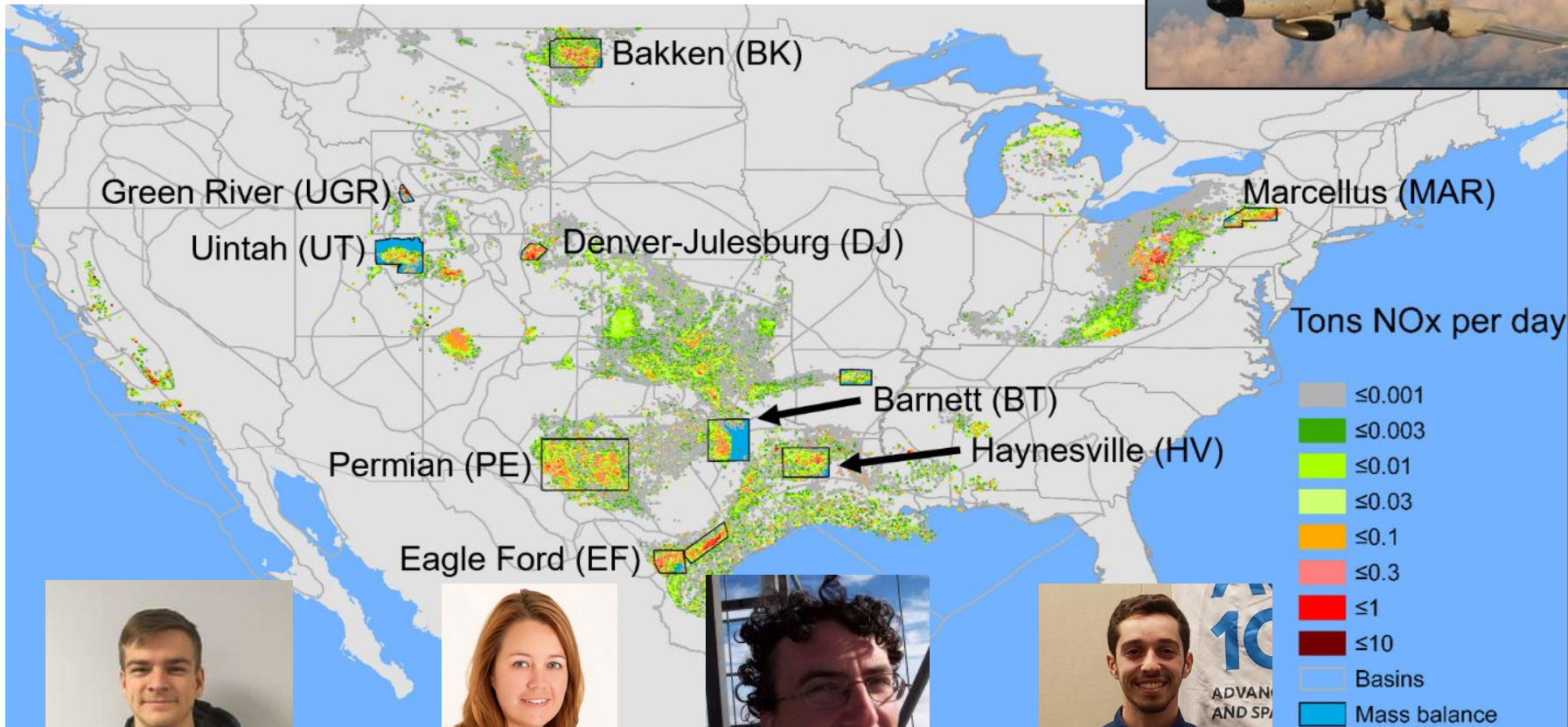
# CrIS dBT Compared with WRF-Chem Simulations (2020)



Full year simulations with the Fuel-based Oil & Gas (FOG) inventory from Francoeur et al. (2021)

# Aircraft-Derived Fuel-based Oil & Gas Inventory

NOAA P3 aircraft campaigns over oil and gas regions in 2013-15, to be updated with AIRMAPS 2024-28



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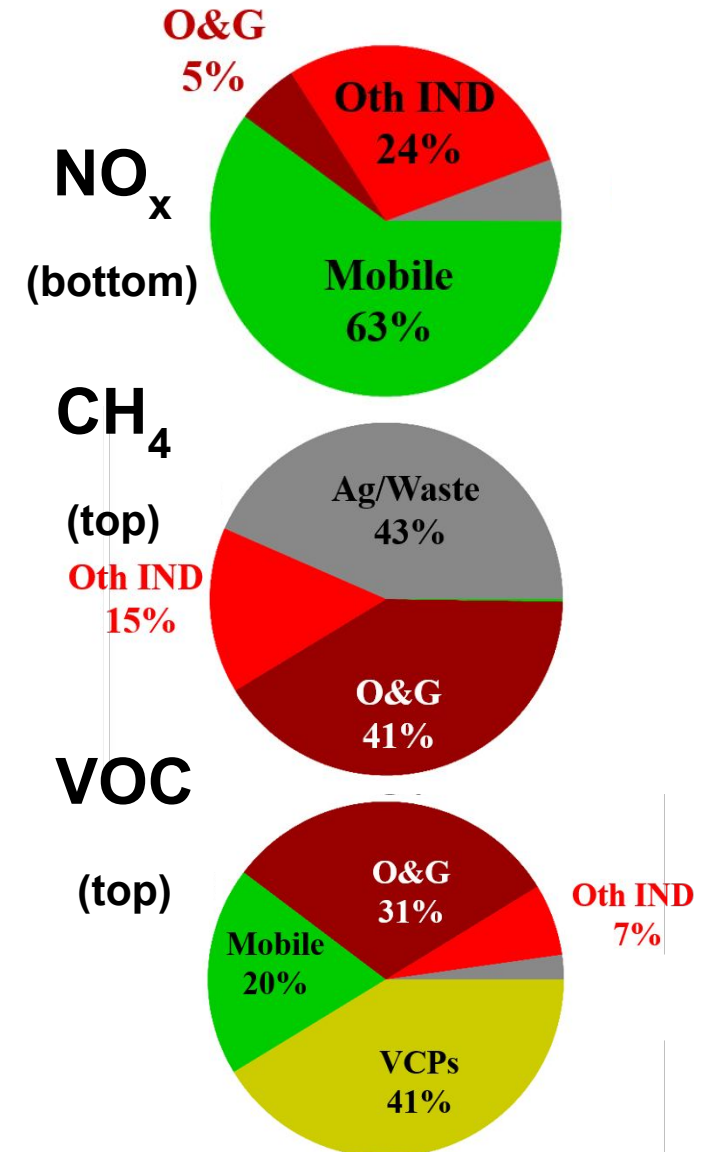
Jessica Gilman  
(NOAA)



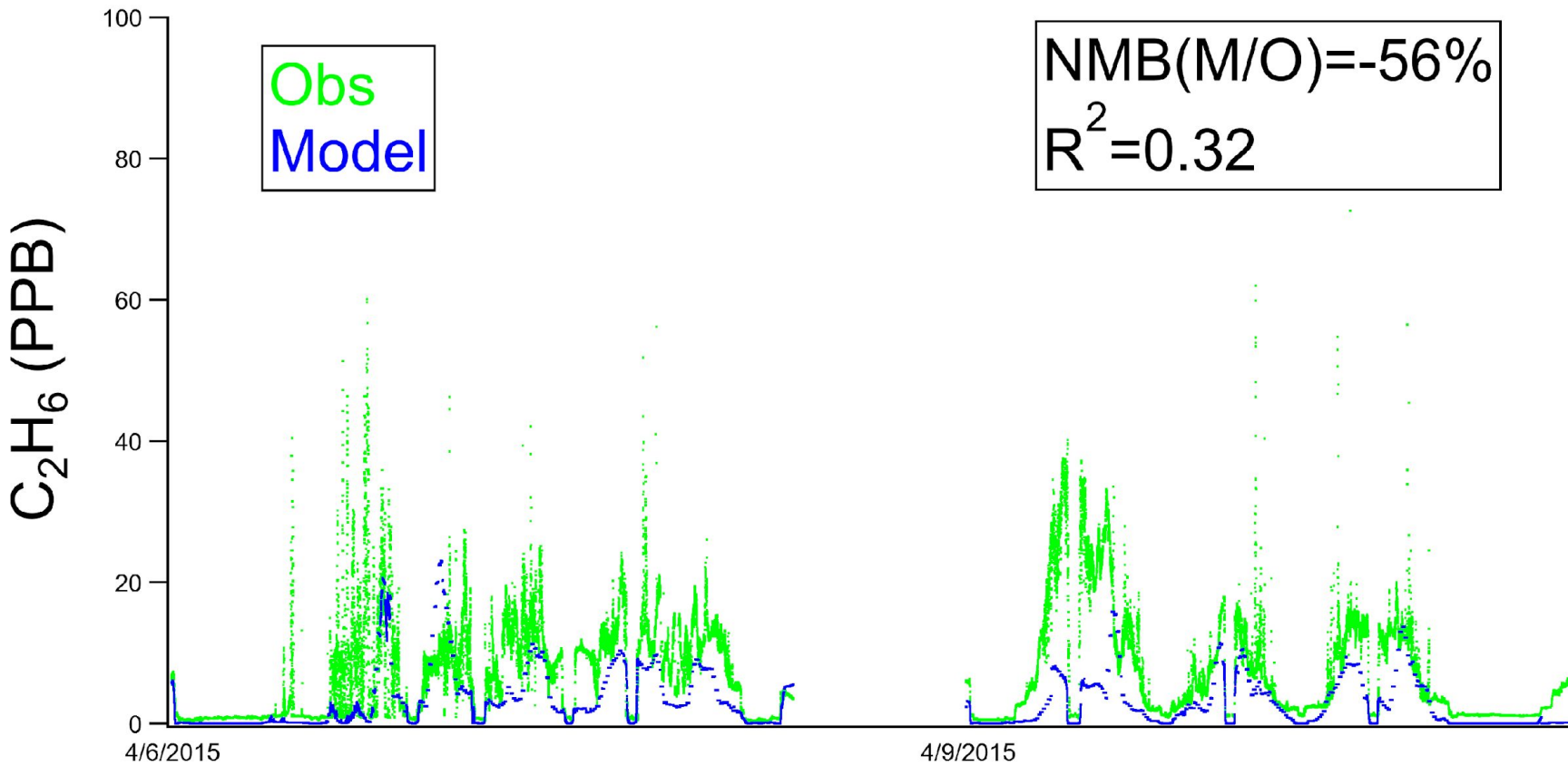
Jeff Peischl  
(NOAA)



Alan Gorchoy-Negron  
(NOAA)



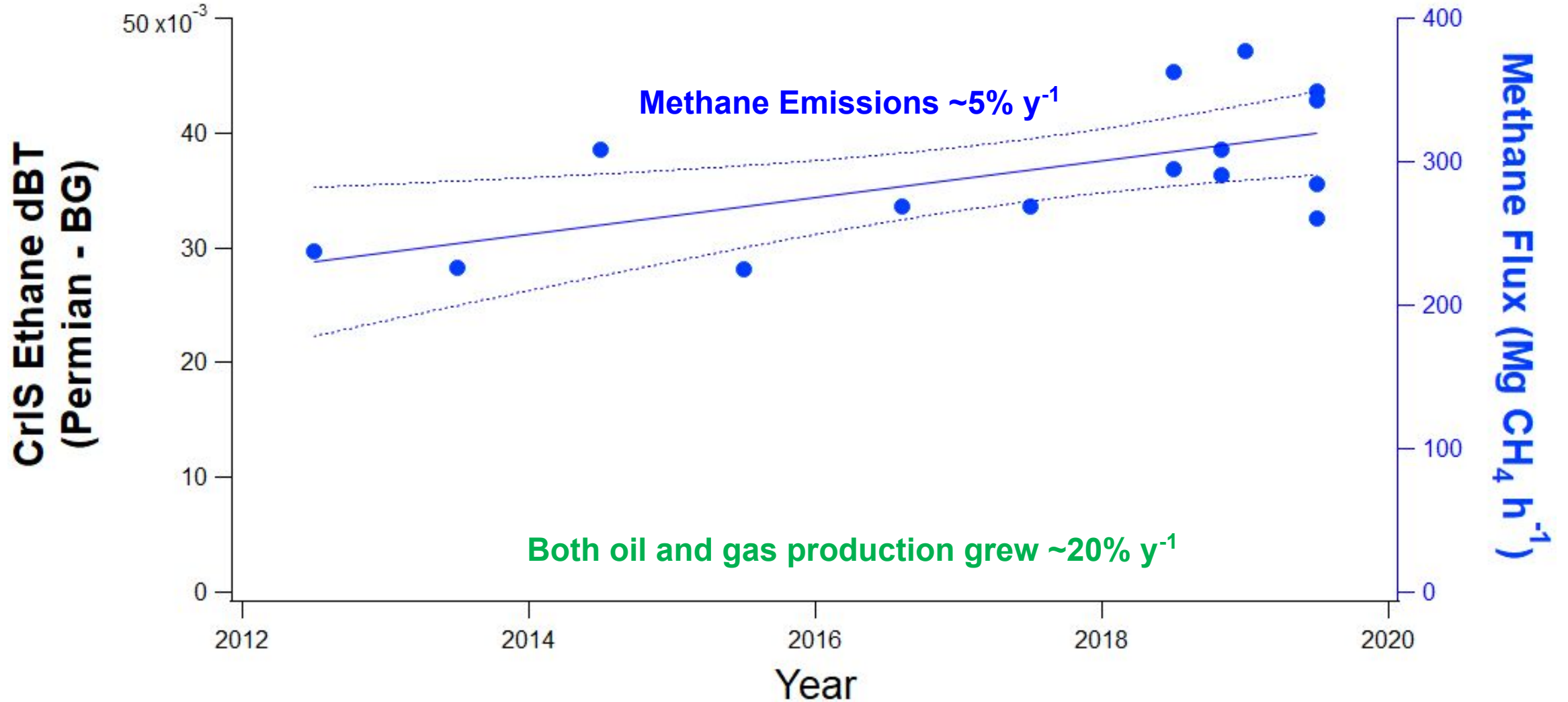
# In-Situ Evaluation of Oil & Gas Ethane during SONGNEX 2015



WRF-Chem simulated with the Fuel-based Oil & Gas (FOG) inventory from Francoeur et al. (2021)

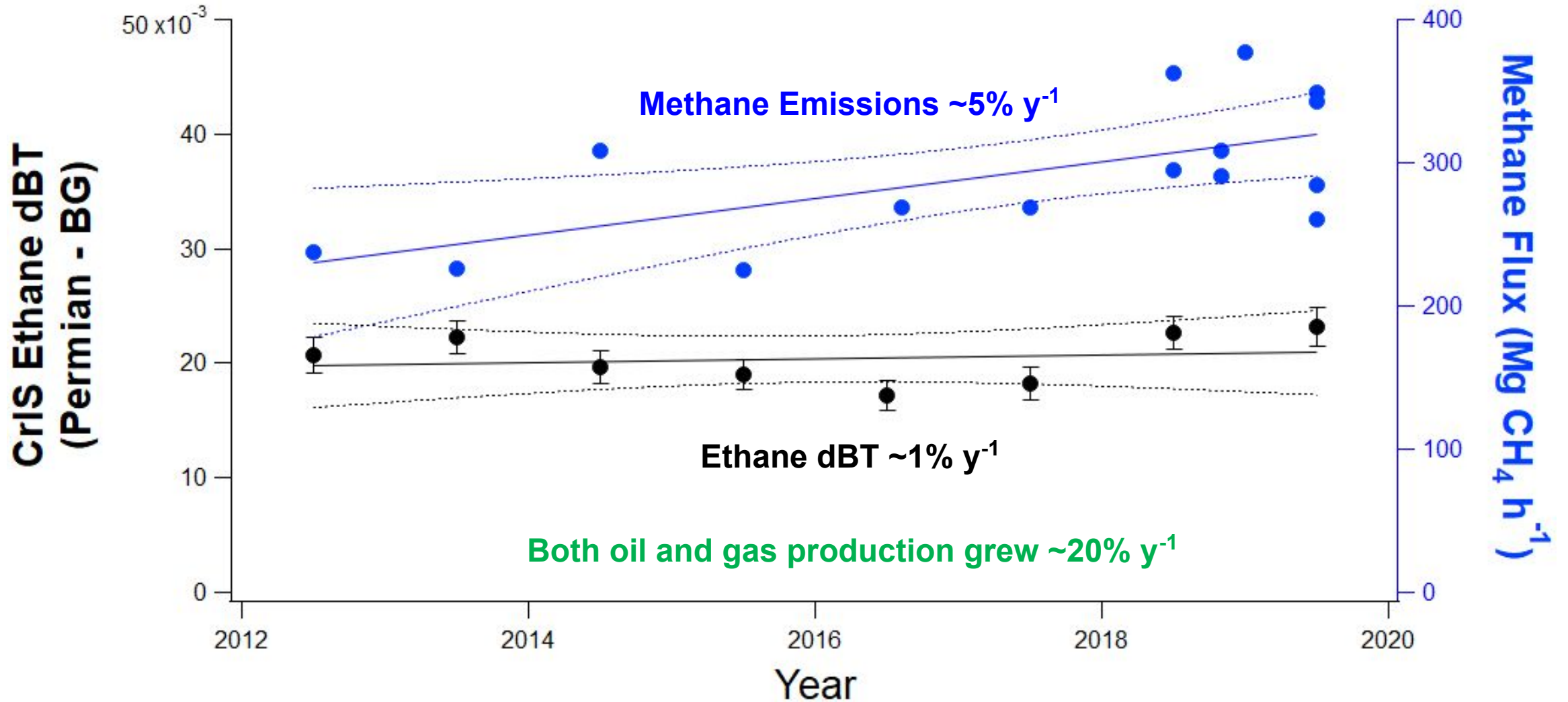


# Trend in CrIS Ethane dBT compared w/ Expected Permian Emissions



Trend in Permian O&G methane based on GOSAT by Lu et al. (*PNAS*, 2023) + TROPOMI

# Trend in CrIS Ethane dBT compared w/ Expected Permian Emissions

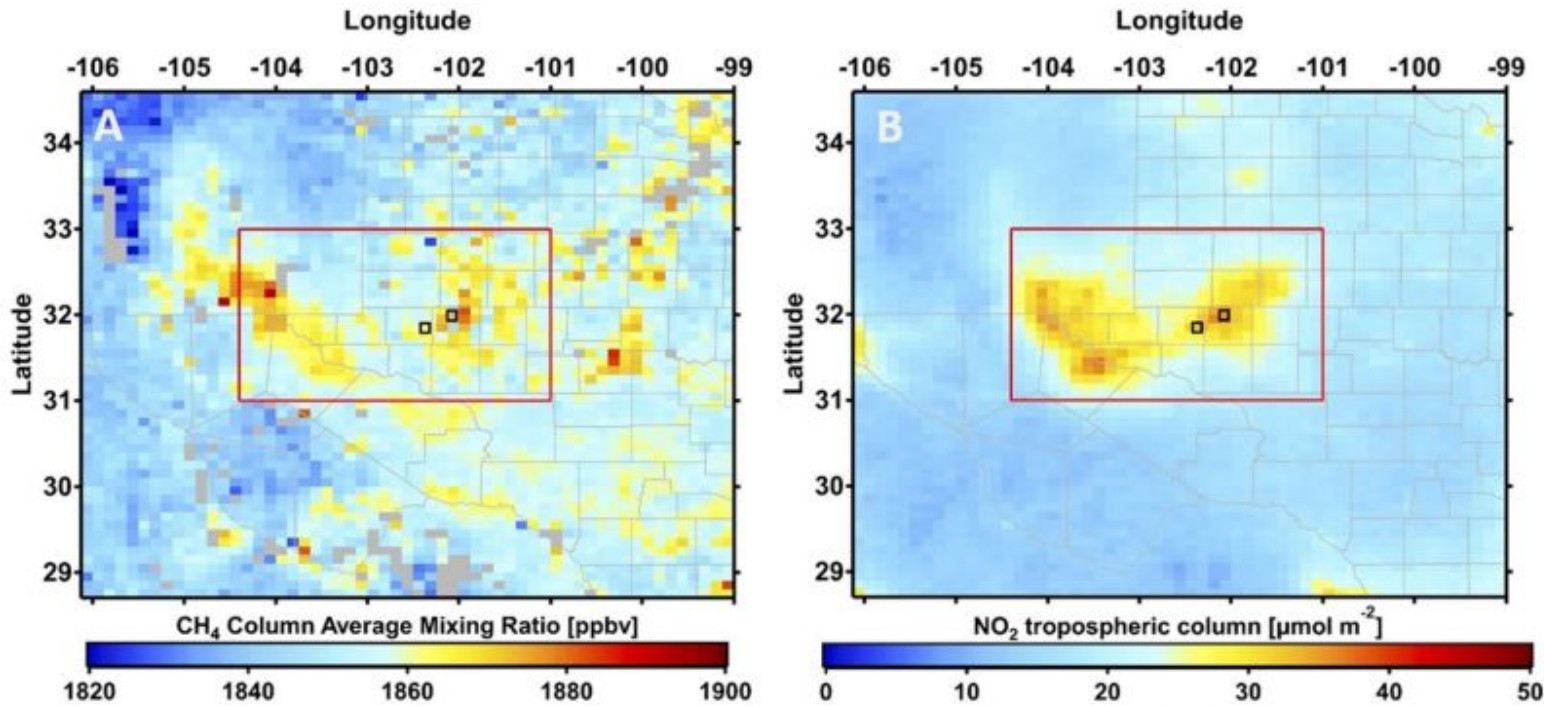


Trend in Permian O&G methane based on GOSAT by Lu et al. (*PNAS*, 2023) + TROPOMI

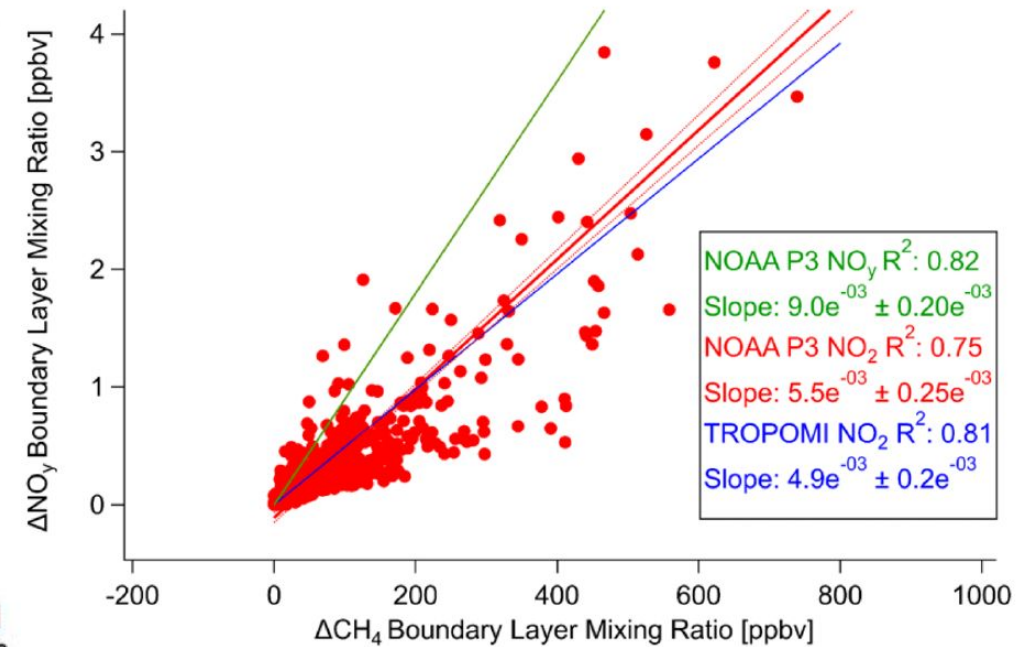
# Oil & Gas CH<sub>4</sub> Enhancements Associated with NO<sub>2</sub> (ACX / GXS)

Enhancements in TROPOMI CH<sub>4</sub> also observed where enhancements in NO<sub>2</sub> from drilling and production, distinguishes from other sources of CH<sub>4</sub> (e.g., agriculture)

Satellite ratios of NO<sub>2</sub>/CH<sub>4</sub> similar to those measured by NOAA P3 over O&G basins

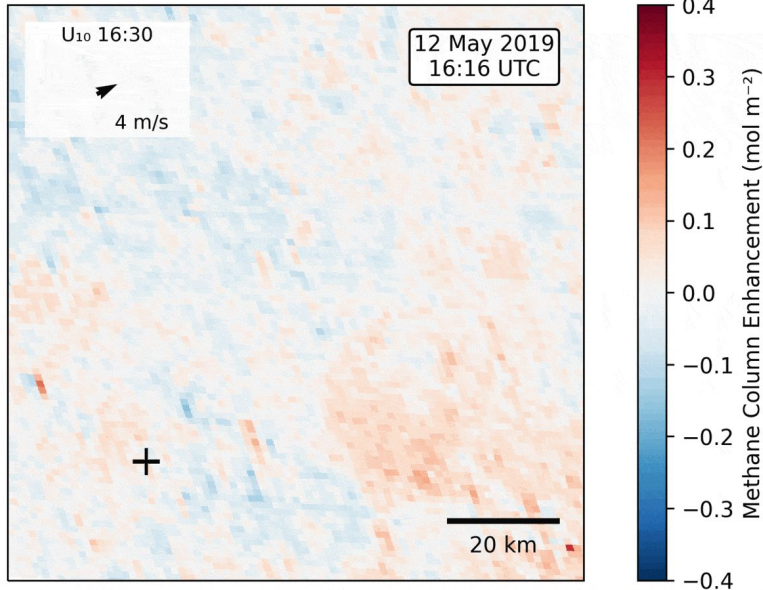


de Gouw et al. Nat. Sci. Rep., 2020

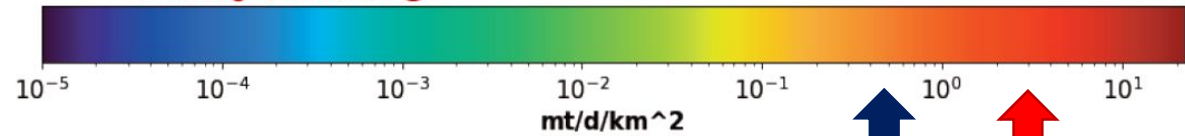
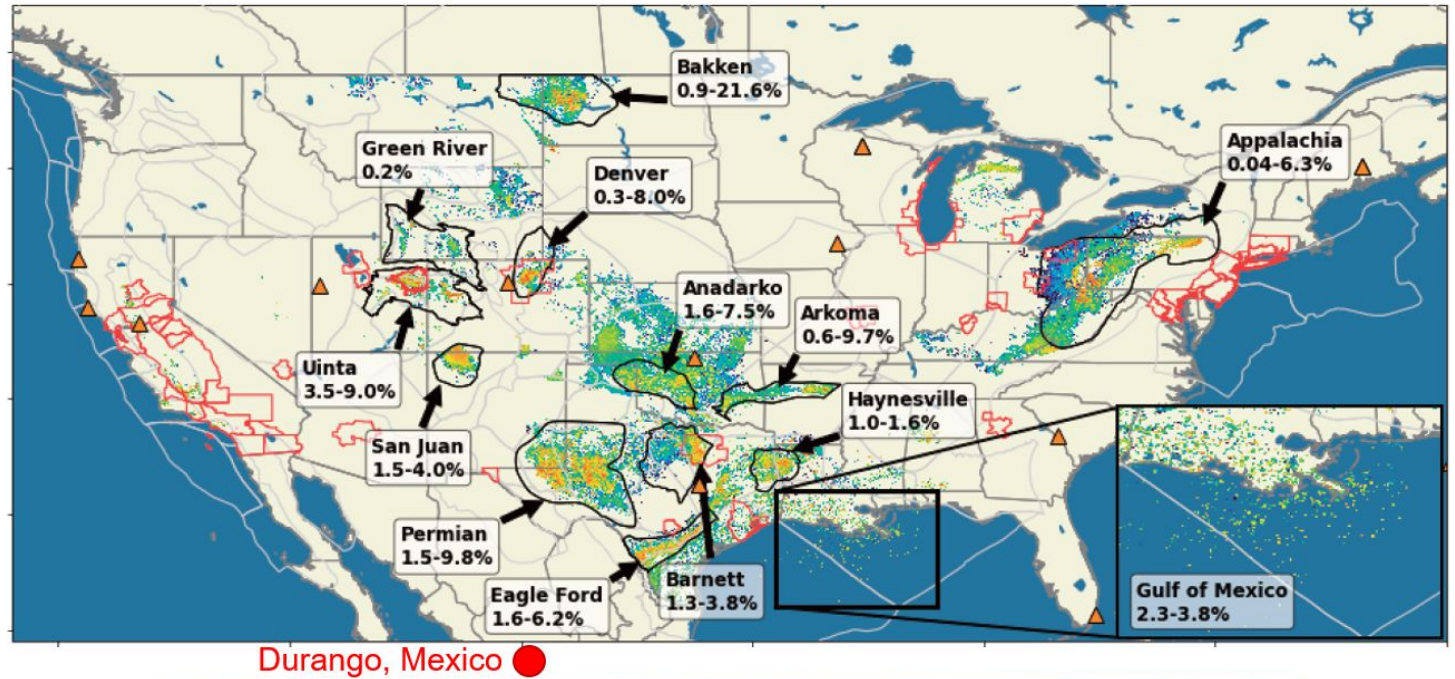


Francoeur et al. ES&T, 2021

# GOES ABI Observes Transient Large Super-Emitters (GXI / GXS)



Watine-Guiu et al., 2023



GOES ABI methane detection can improve:

- accounting of super-emitter events in bottom-up inventories (intensity + duration)
- methane anomaly detection in near real-time emissions satellite data assimilation system



Daniel Varon  
(Harvard)



Shobha Kondragunta  
(NOAA)

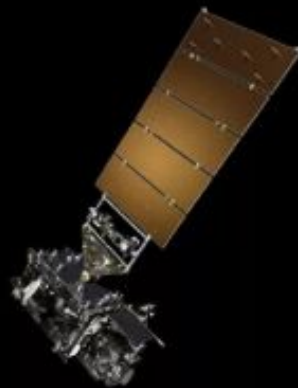
# Summary

- Ethane can potentially be retrieved by CrIS between 820 and 825  $\text{cm}^{-1}$
- Preliminary trend in CrIS ethane dBT consistent with decreasing methane intensity offsetting growth in production
- Higher enhancement in CrIS ethane dBT than in WRF-Chem, consistent with model evaluation with NOAA P3



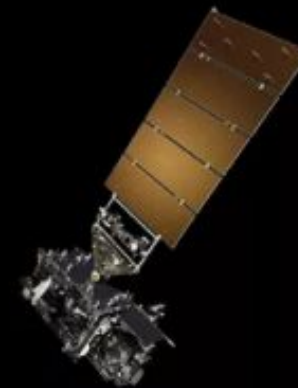
**GEO-West**

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