

# (1967) Nitrogen Dioxide Variability over the Gulf of Mexico

## in June 2024: In-Situ, Pandora, Satellite Views in SCOAPE II

BOEM  
BUREAU OF OCEAN ENERGY MANAGEMENT



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### Background: Gulf of Mexico Air Quality & Greenhouse Gases

The US Dept of Interior's Bureau of Ocean Energy Management (BOEM) has air quality (AQ) jurisdiction in the US Outer Continental Shelf including the Gulf of Mexico (GOM)

BOEM is mandated to ensure that emissions (e.g.,  $\text{NO}_2$ ) from oil and gas (ONG) facilities do not significantly affect the air quality of any US state. BOEM is also interested in ONG greenhouse gas emissions, particularly  $\text{CH}_4$ , but it relies on ONG operator reporting for GOM emissions inventories (Figure 1). Before BOEM and NASA joint work there were NO GOM AQ DATA

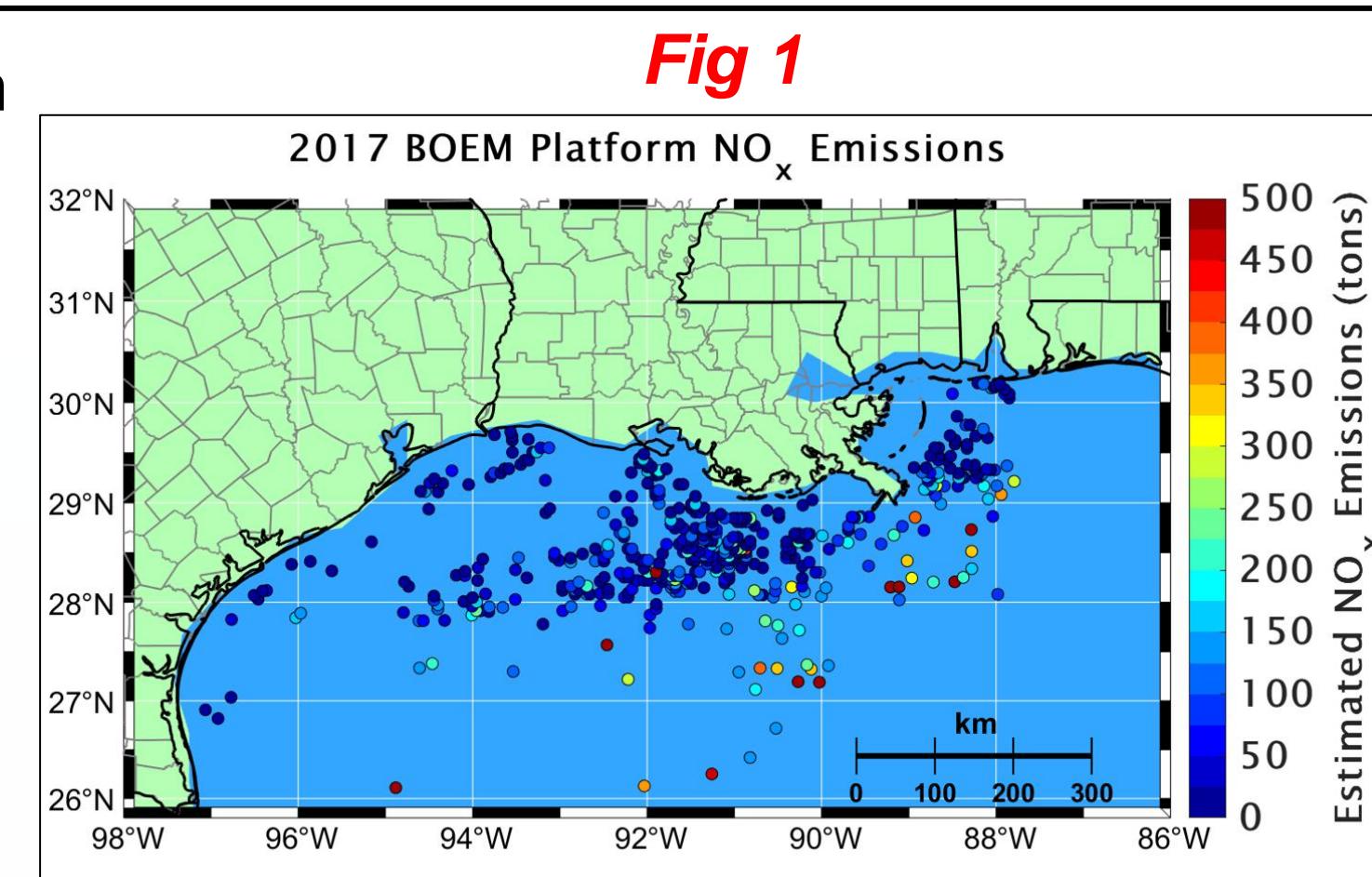


Fig 1. 2017 platform estimated  $\text{NO}_x$  emissions from BOEM's GOM inventory. A total of 457 platforms are shown. The individually lower-emitting, shallow water platforms (blue colors) far outnumber the large, higher-emitting deep-water platforms (green to red colors)

**Data needed to verify emissions inventories and understand GOM AQ and GHG impacts!**

### SCOAPE-II: 2-13 June 2024 Ship and AVIRIS-3 Measurements

BOEM & NASA evaluated satellite  $\text{NO}_2$  data during the May 2019 Satellite Coastal and Oceanic Atmospheric Pollution Experiment (SCOAPE-I). Thompson et al. (2023) addressed Can satellites be used to monitor GOM AQ? They concluded Yes. Accuracy is within ~5-15%

Measurement	Instrument	Source/Contributor
Continuous (1-sec) $\text{CH}_4$ , $\text{CO}_2$ , $\text{CO}$ , $\text{H}_2\text{O}$	Picarro G-2301	L. Ott/GSFC <b>Table 1</b>
Continuous (1-sec) $\text{CH}_4$ , $\text{HCHO}$ , $\text{H}_2\text{O}$	Picarro G-2307	L. Ott/GSFC
Continuous (1-min) $\text{NO}_2$	Teledyne API T500U	R. Stauffer/GSFC
Continuous (1-min) $\text{O}_3$	Thermo 49i	R. Stauffer/GSFC
Column $\text{NO}_2$ , $\text{O}_3$ , $\text{HCHO}$	Pandora Spectrometer	T. Hanisco/GSFC
Vertical (UAS) $\text{NO}_2$ profiles	GSFC-developed $\text{NO}_2$ sonde	T. Hanisco, S. Bailey/GSFC
Balloon-borne ozonesondes	En-Sci, Internet radiosondes	R. Stauffer/GSFC
Aerosol backscatter profiles, mixed layer height	Lufft CHM-8k Ceilometer	R. Stauffer/GSFC
Dozens of VOC species	VOC canister samples	D. Blake/UCI
Aerosol Optical Depth	MicroTops-II Sunphotometer	A. Smirnov/GSFC
T, RH, p, winds, GPS location	RMYoung, Trimble ABX GPS	R/V Point Sur

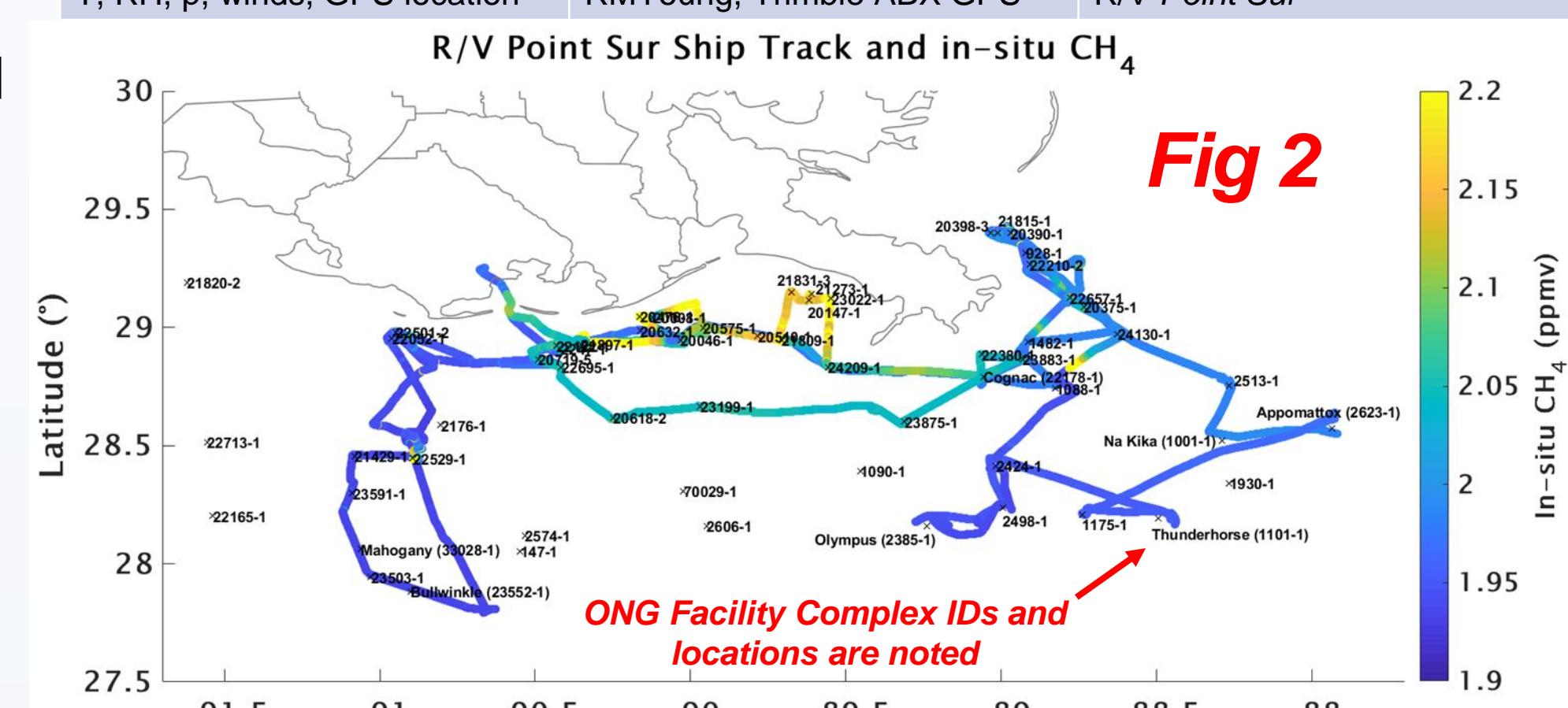


Fig 2

SCOAPE-I led BOEM to fund a June 2024 SCOAPE-II (Figure 2) to evaluate TEMPO & to sample  $\text{CH}_4$  emissions from ONG platforms. AVIRIS sampled  $\text{CH}_4$ . Both SCOAPEs took place on the R/V Point Sur. Point Sur measurements collected during SCOAPE-II are in Table 1

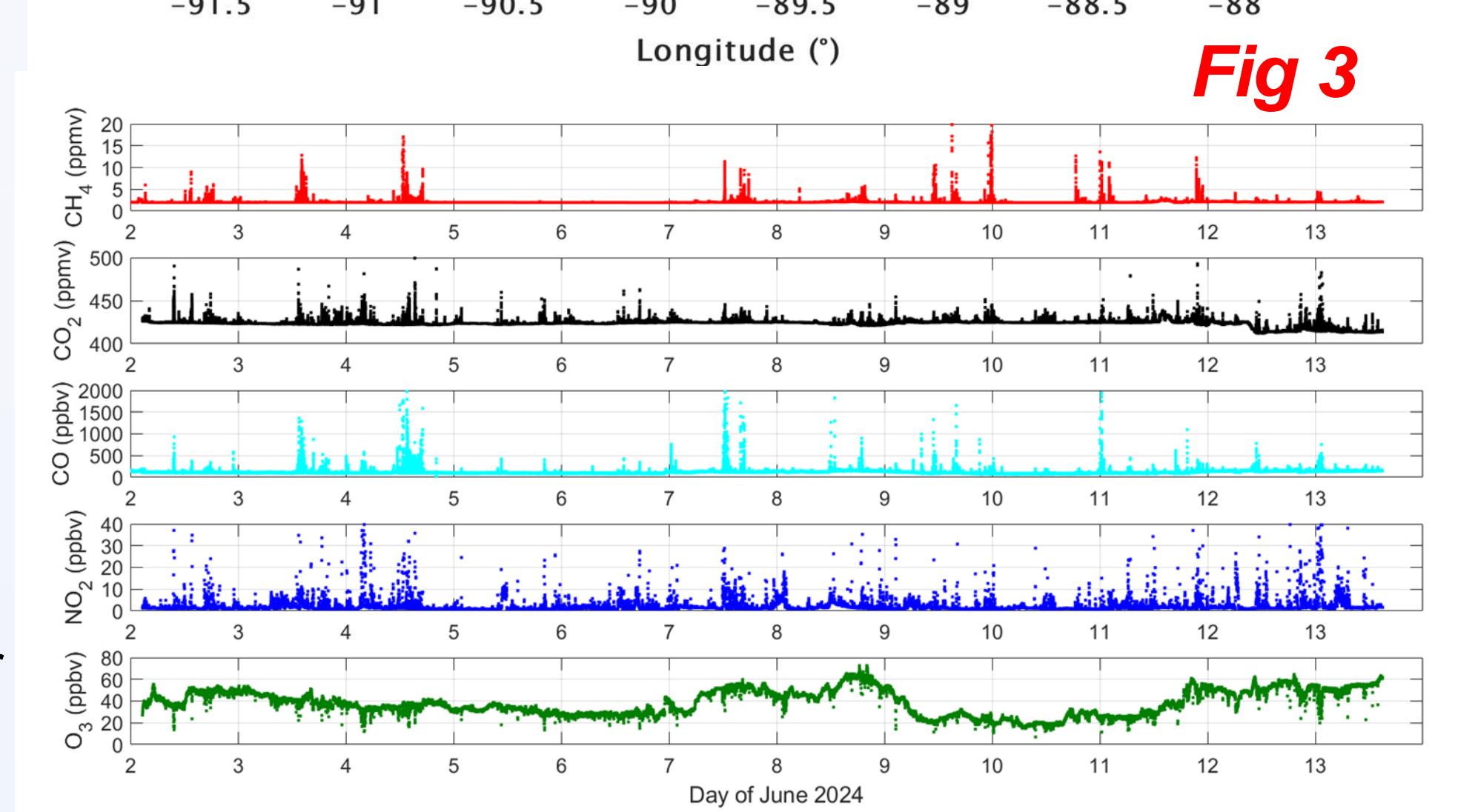


Fig 3

Full 12-day SCOAPE-II timeseries of in-situ trace gas measurements are shown in Figure 3. Dozens of spikes in  $\text{CH}_4$  occur near shallow water platforms (compare Figure 2). Large  $\text{NO}_2$  spikes more typical near deepwater platforms

### Vertical In-Situ $\text{NO}_2$ Profiles

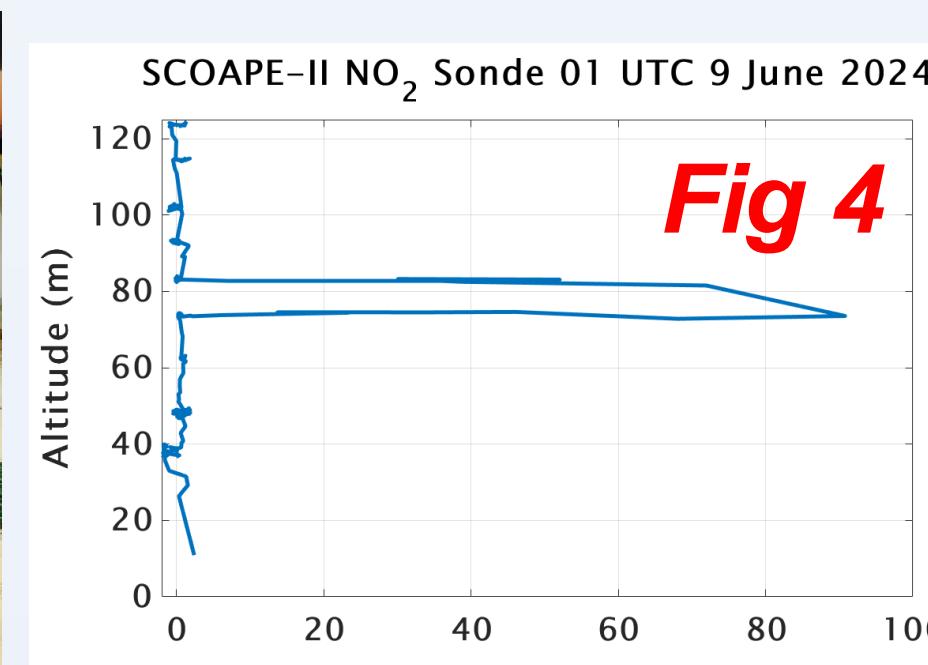
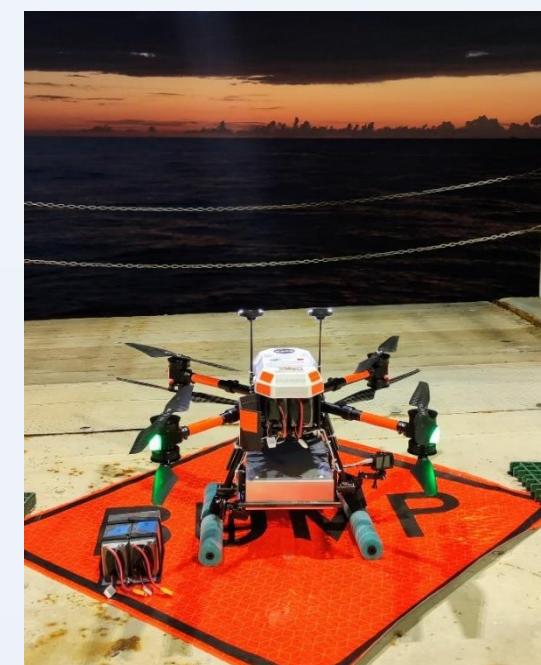


Fig 4



Vertical  $\text{NO}_2$  profiles were collected on a UAS platform (Left) with flights up to 200 m. Example shows  $\text{NO}_2$  plume near platform 21897-1 (Right), up to 90 ppbv at 70 m (Figure 4). Vertical  $\text{NO}_2$  profiles link satellite  $\text{NO}_2$  data to "nose-level" pollution and AQ

### Satellite $\text{NO}_2$ Measurements: TROPOMI & Midday TEMPO

SCOAPE-II shipboard, in-situ Pandora columns of  $\text{NO}_2$  are compared to TROPOMI and TEMPO  $\text{NO}_2$  measurements during the campaign. TROPOMI (left) and TEMPO (right) tropospheric  $\text{NO}_2$  columns for SCOAPE-II show ONG platform "hotspots" (e.g., Fedkin et al., 2024; Fig 5)

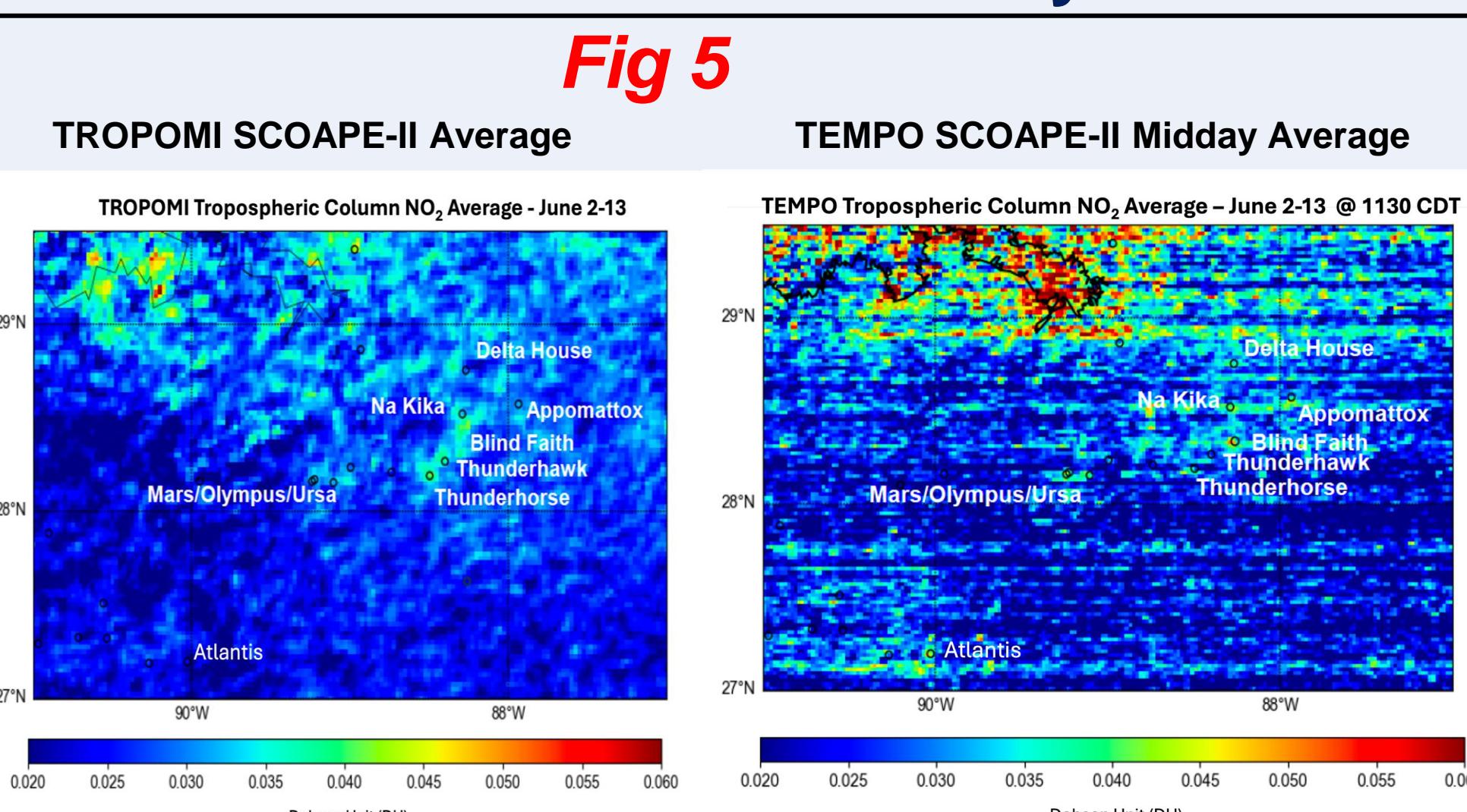


Fig 5

### Pandora and Satellite $\text{NO}_2$ Comparisons

These comparisons are made midday, for the TROPOMI overpass  $\text{NO}_2$  columns and for the 1130 Local Time TEMPO measurement. In Figure 6 overpass comparisons are illustrated with the R/V Point Sur (shipboard) Pandora  $\text{NO}_2$  columns. Pandora readings are often 50% higher than TEMPO whereas TROPOMI and Pandora are very similar. In Figure 7 comparisons are made with a coastal Louisiana Pandora at Cameron, operated for BOEM. In both cases the TROPOMI correlations are better than those from TEMPO, for which algorithm optimization is still in progress.

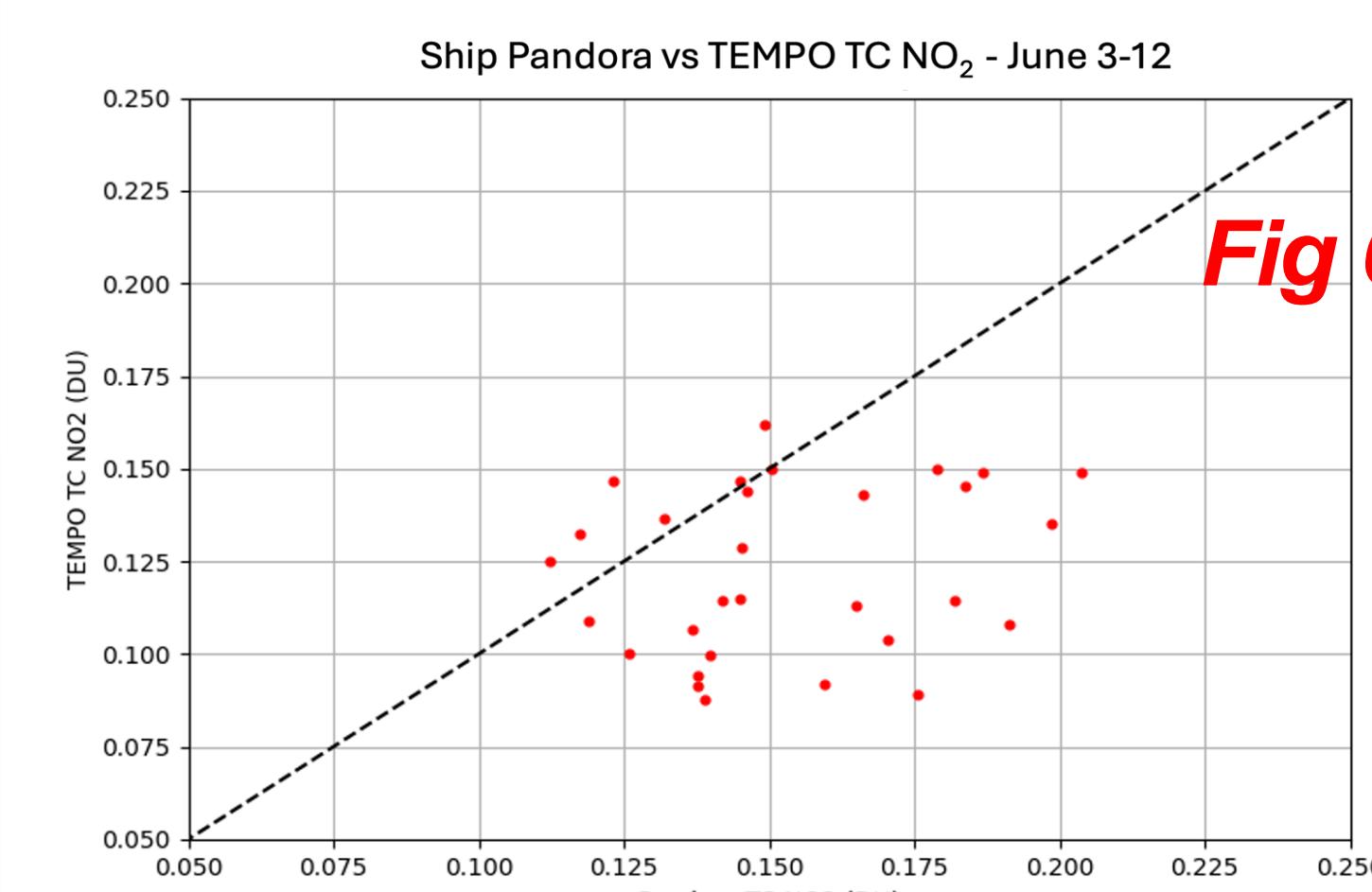


Fig 6a

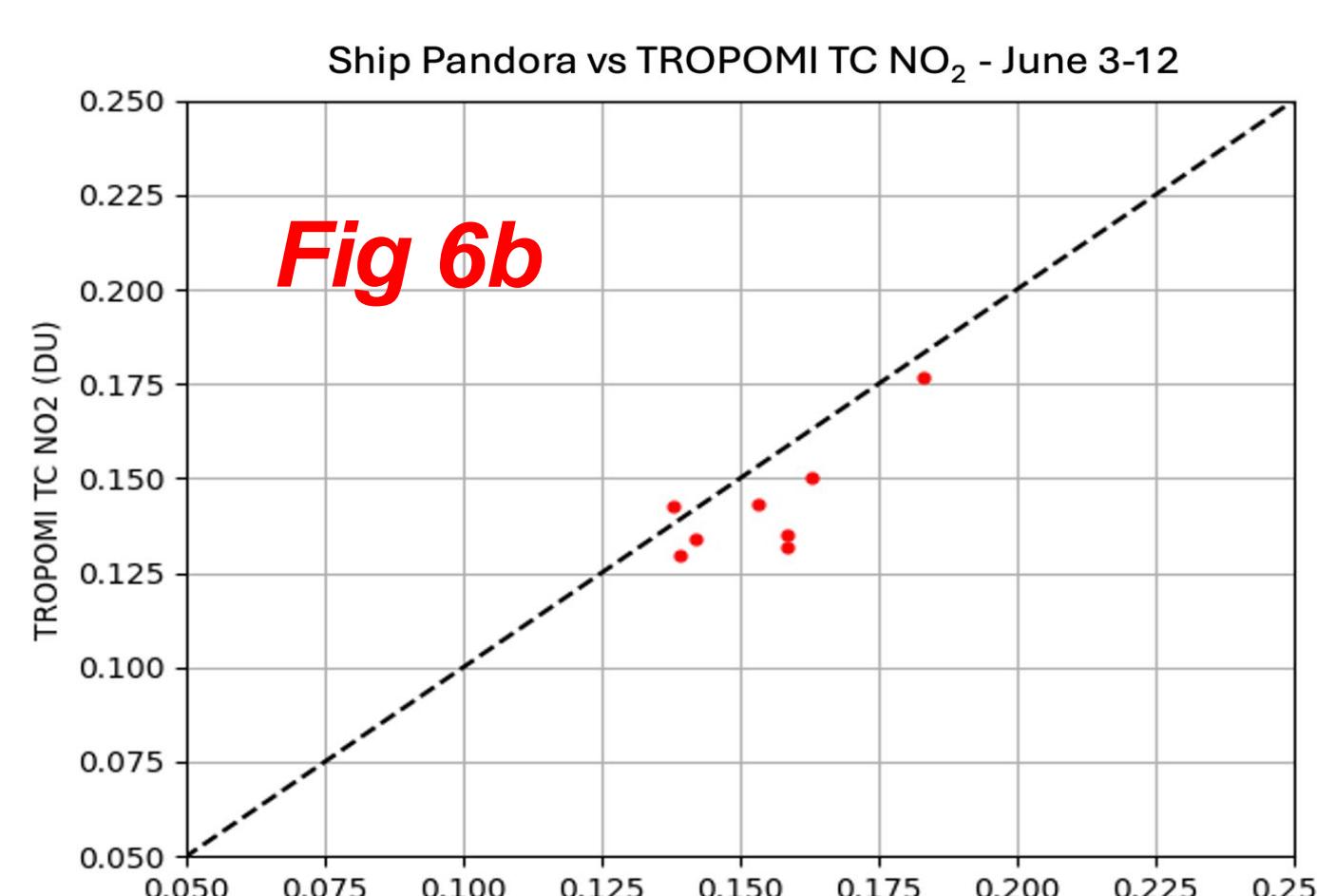


Fig 6b

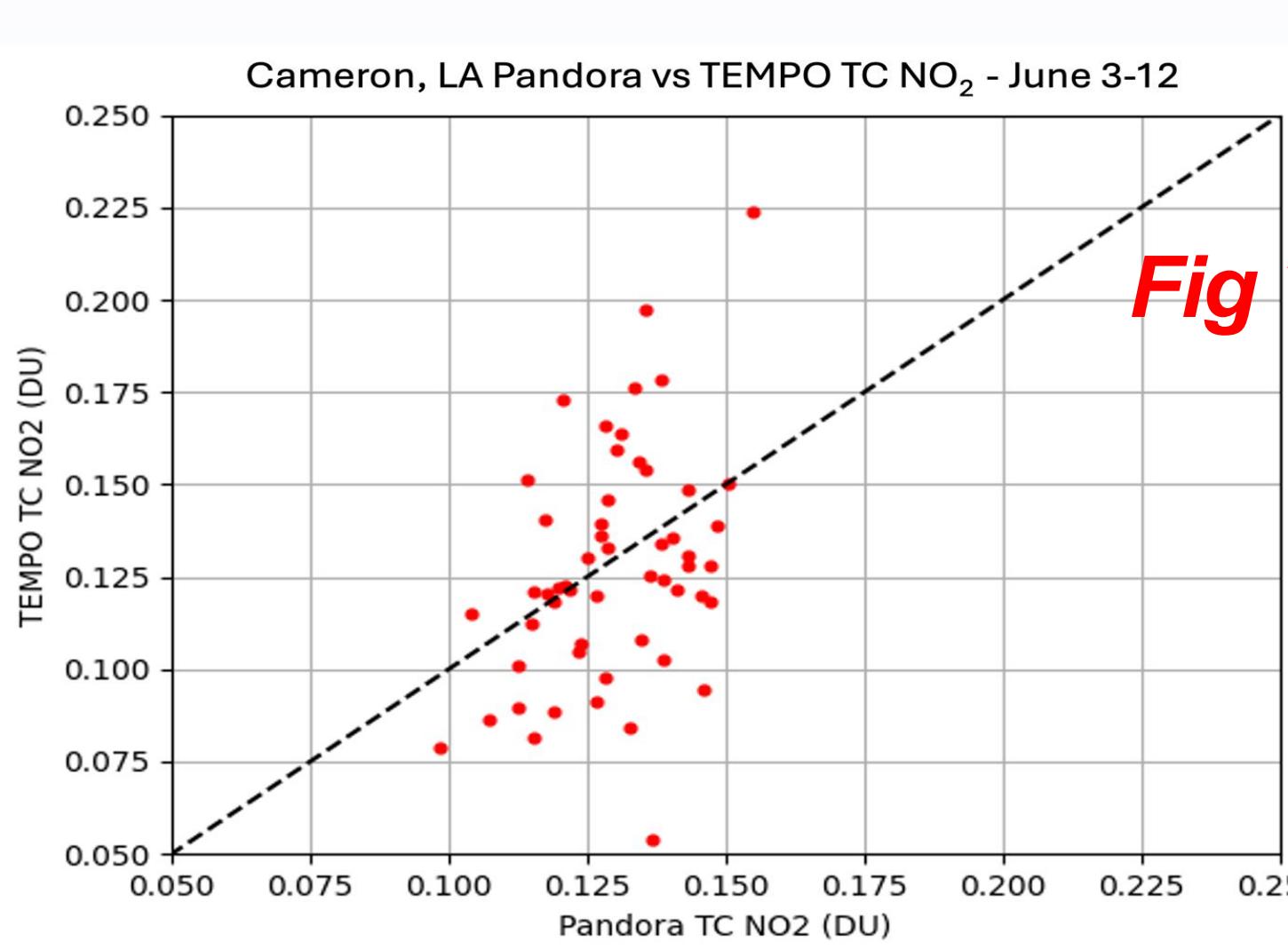


Fig 7a

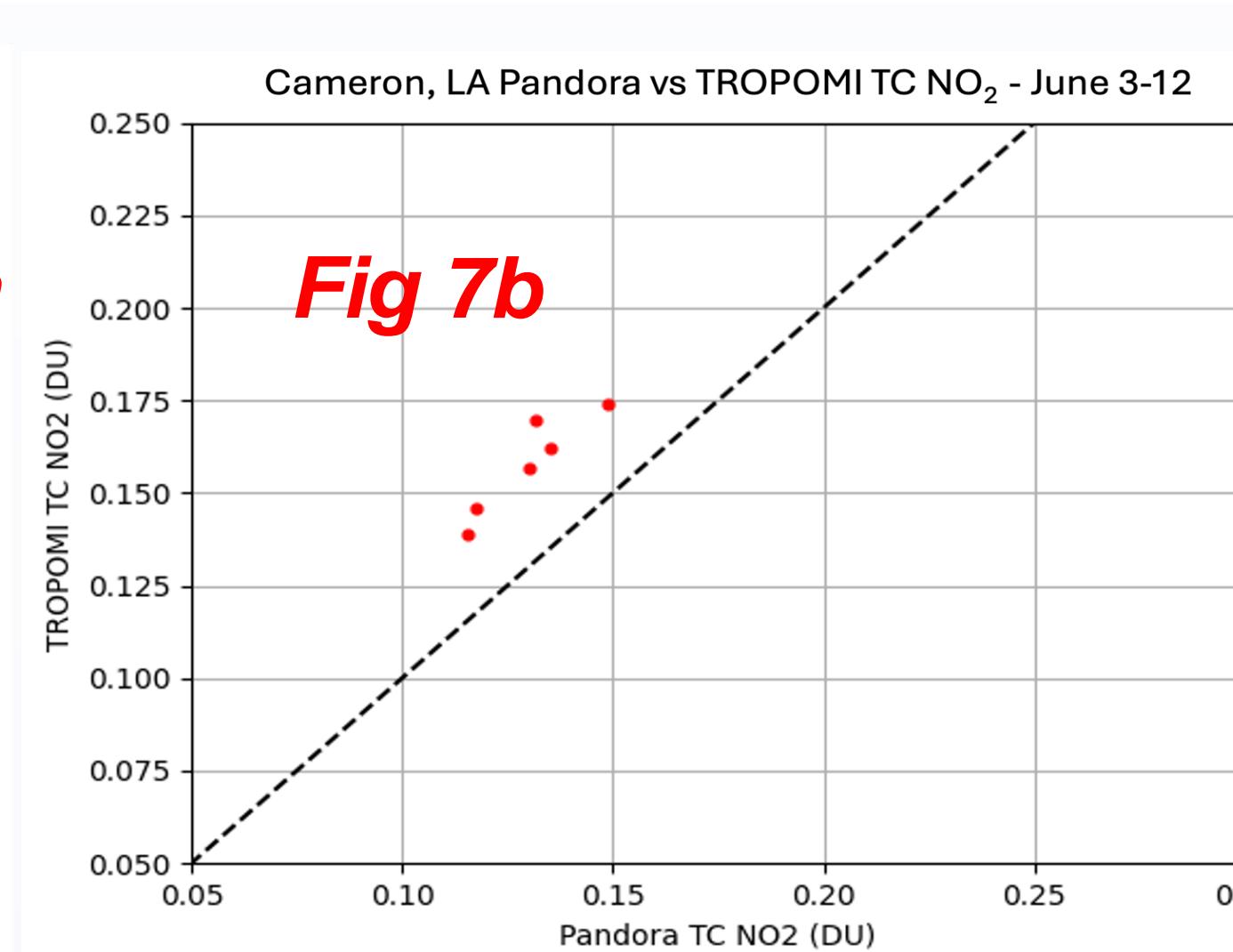


Fig 7b

### SCOAPE-II Add-on (Oct. 2024 GCAS) and Data Availability

#### NASA/GSFC's GEO-CAPE

Airborne Simulator (GCAS) collected below-aircraft column  $\text{NO}_2$  amounts during seven SCOAPE-II follow-on flights, 7-14 October 2024. Initial results (Figure 8) indicate that drill ships, which explore the Gulf to help install oil-producing platforms, are as large or larger emitters of  $\text{NO}_2$  than the permanent platform locations. GCAS data will be compared to TEMPO & TROPOMI  $\text{NO}_2$  measurements for the Oct. period, as well as June SCOAPE-II Pandora measurements.

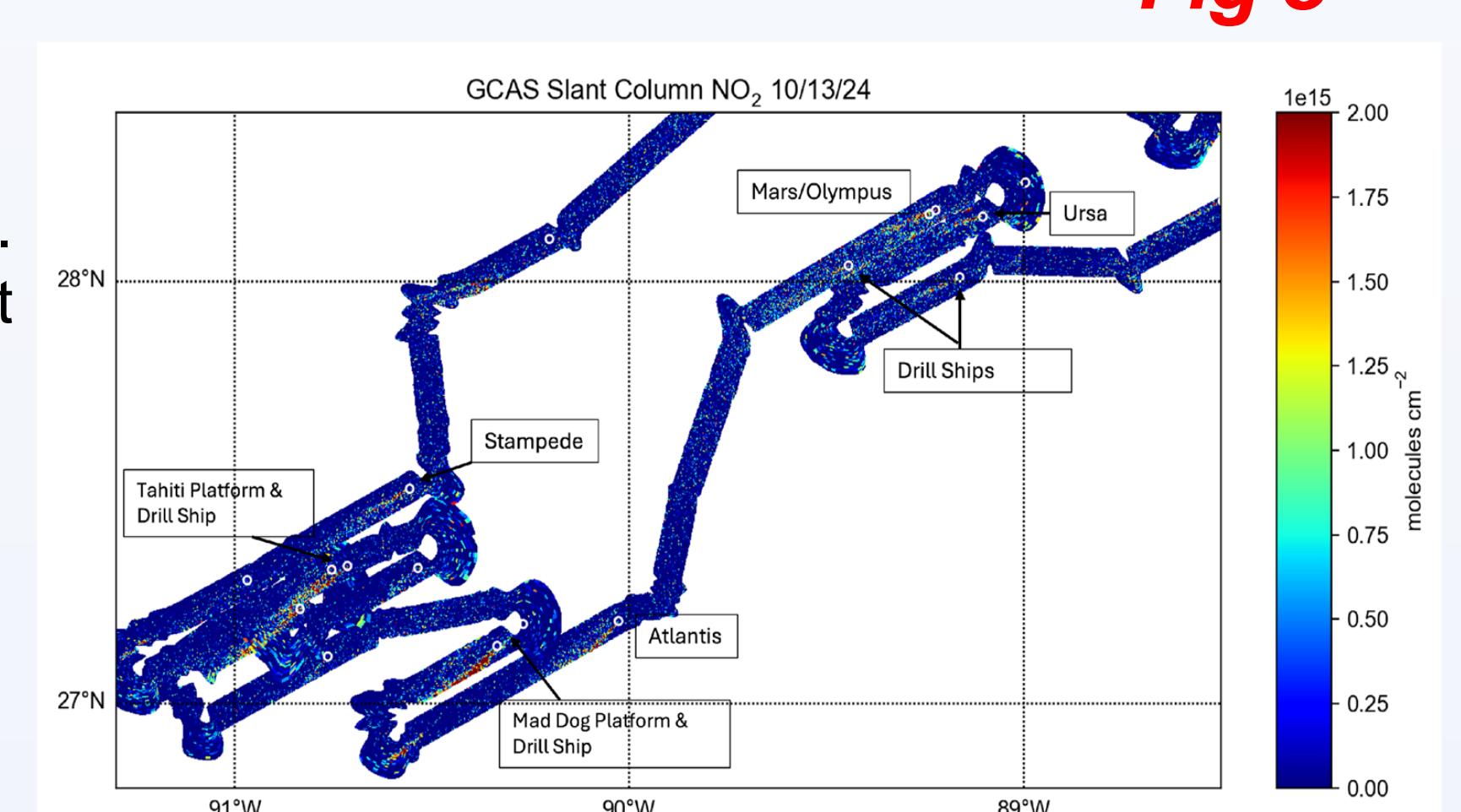


Fig 8



### Contact and Data Information, References

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We have a lot of data. Want to use it? Contact [ryan.m.stauffer@nasa.gov](mailto:ryan.m.stauffer@nasa.gov), scan the QR code above! Also at AGU:

Poster Tuesday: Fedkin et al: Assessment of  $\text{NO}_2$  Columns... A21I-1870

Talk Thursday: Stauffer et al: Ship, Satellite and Aircraft-based Views.... A42E-08  
SCOAPE Publications:

Thompson et al., (2023), "Two Air Quality Regimes in Total Column  $\text{NO}_2$  over the Gulf of Mexico in May 2019: Shipboard and Satellite Views"

<https://doi.org/10.1029/2022EA002473>

Fedkin et al., (2024), "Satellite  $\text{NO}_2$  trends and hotspots over offshore oil and gas operations in the Gulf of Mexico", Earth and Space Science, 11, e2023EA003165. <https://doi.org/10.1029/2023EA003165>

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