TRACER-AQ preflight on September 8th, 2021

MOOSE flight view over Lake Huron in June 2021

Updated assessment of TROPOMI NO_2 and HCHO columns using airborne spectrometers during the MOOSE and TRACER-AQ *(and LISTOS)* field campaigns

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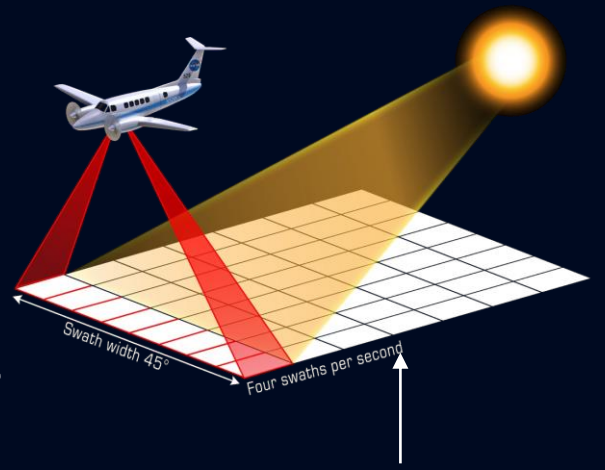
Airborne Measurements with GCAS

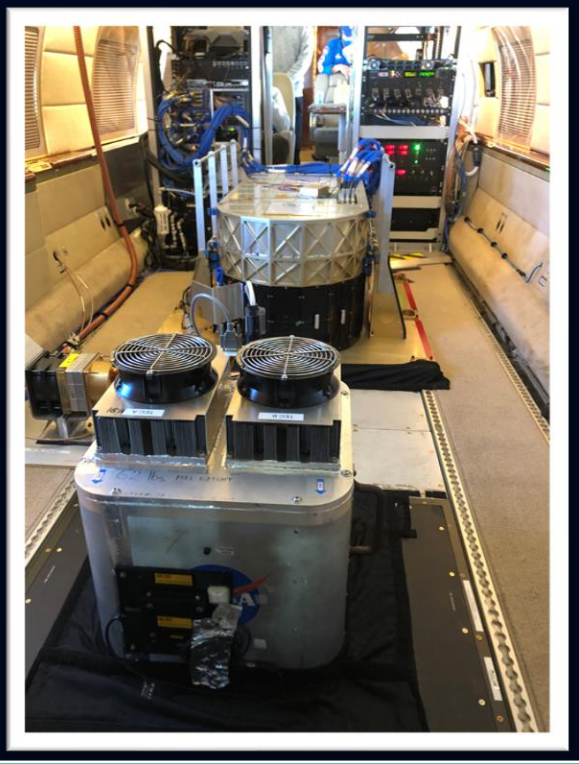
GEOCAPE Airborne Simulator (GCAS)

- ⇢Primarily been used to collect preparatory measurements for geostationary air quality observations as well as emissions mapping
- ⇢Altitude in 2021: FL280-FL390
- ⇢Measures spectra in the UV-VIS-(NIR) at high spectral and spatial resolution from which trace gas columns can be remotely retrieved via Differential Optical Absorption Spectroscopy
- ⇢Product/resolution in 2021: **NO_2 and HCHO at ~ 250x560 m and 750x1680 m, respectively**)



Sampling strategy for the airborne spectrometers operating in a push-broom configuration

Installed on the forward window port on the NASA G-V →

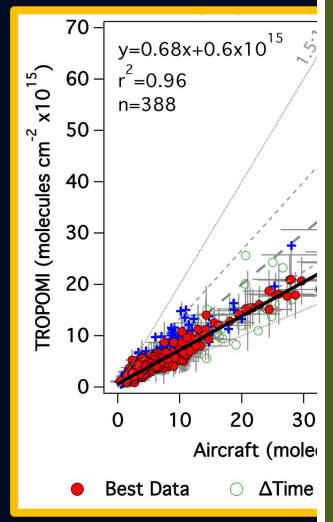


Retrieval Information is same as Judd et al., 2020 except *	
A priori profiles*	GEOS-CF 0.25 deg (12 km NAM-CMAQ in NYC)
Reference Correction*	Co-located with TROPOMI (Pandora in NYC)

Judd et al, 2020: https://doi.org/10.5194/amt-13-6113-2020

Previous Results from 2018 near NYC

- 13 flight days in New York City in 2018 as part of the Long Island Sound Tropospheric Ozo
- Coincidence Crite within ± 30 minute



- TROPOMI v1.2 NO_2 was ~20% lower than GCAS (13% explained by coarse a priori profile in TROPOMI)
- Similar results with Pandora (Aircraft showed no bias w.r.t. Pandora)

Judd et al, 2020: https://doi.org/10.5194/amt-13-6113-2020

Airborne Measurements in 2021 (extending to Gulfstream platforms)

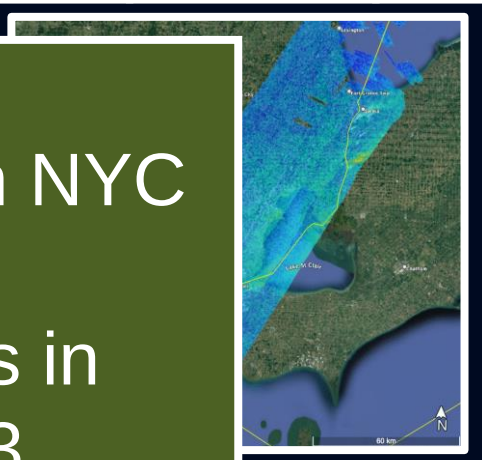
This presentation:

1. Aircraft data evaluation with Pandora in NYC (old) and Houston (new)
2. Updated perspective of previous results in NYC along with new v2 NO_2 results in 3 regions
3. Quick thoughts toward HCHO

Note: All results are preliminary

Michigan Ontario Ozone Source Experiment (MOOSE)

→ Platform: NASA LaRC G-III



nt – Air Quality

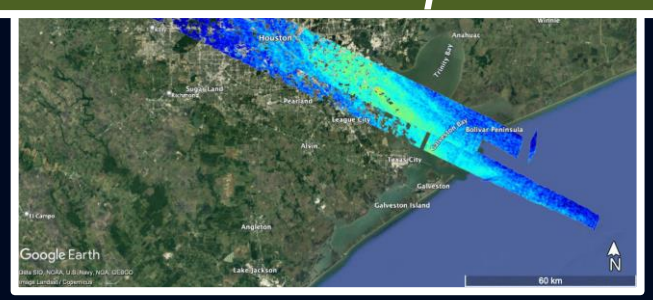
LaRC G-V

louston, Texas

→ 10 flight days: Up to 9.5 hours per flight day/3 maps per day

→ NO_2 product is compared to v2.2

→ HCHO product is compared to v2.2



Aircraft Evaluation with Pandora (NYC + Houston)

Comparison methodology:

→ Temporally nearest Pandora data point within 5-15 minutes of GCAS overpass (± min/max)

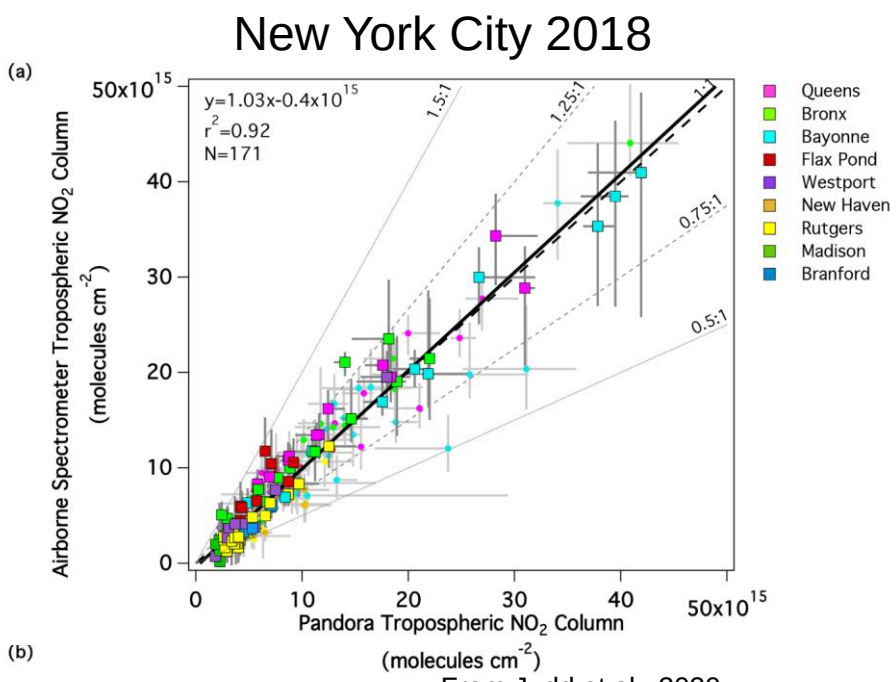
→ GCAS median column within 750 m (± 10th/90th percentile)

→ Pandora QA value of 0 or 10

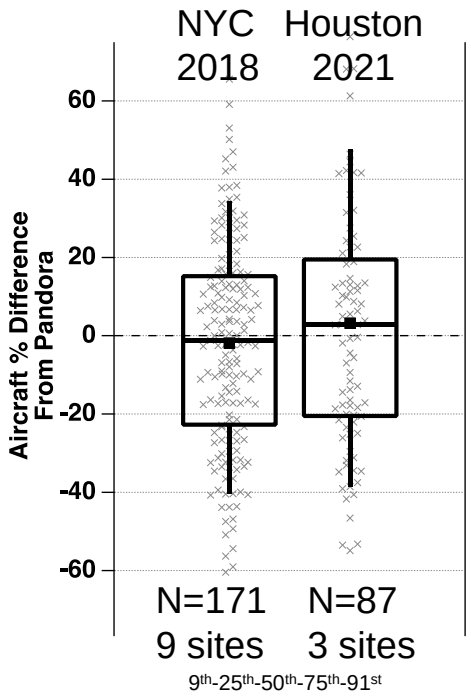
→ GCAS data is cloud-filtered

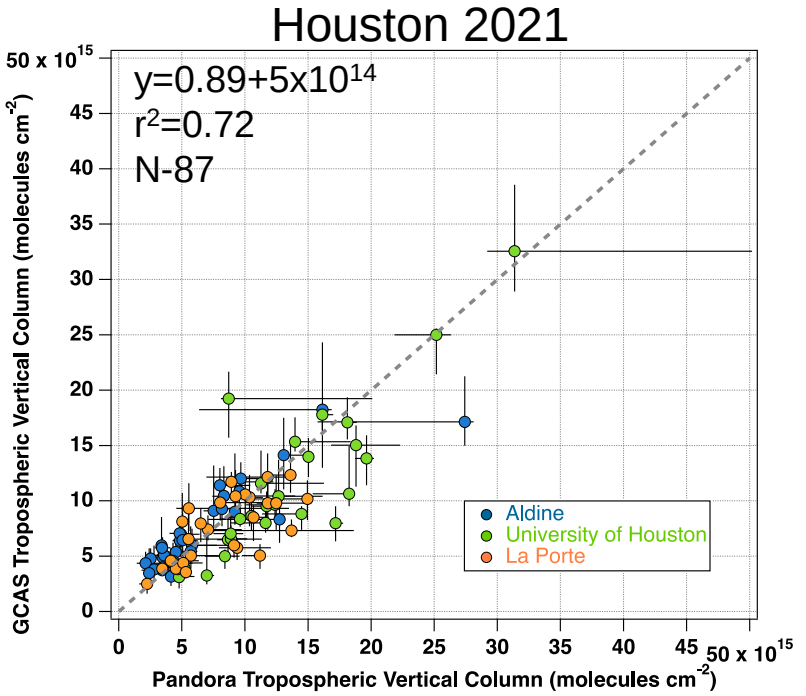
Pandora and airborne retrieval appear to agree within the same degree of percent differences between NYC (LISTOS) and Houston (TRACER-AQ)

Interquartile range in Houston is from -21% to 21% with a median of 2%



From Judd et al., 2020





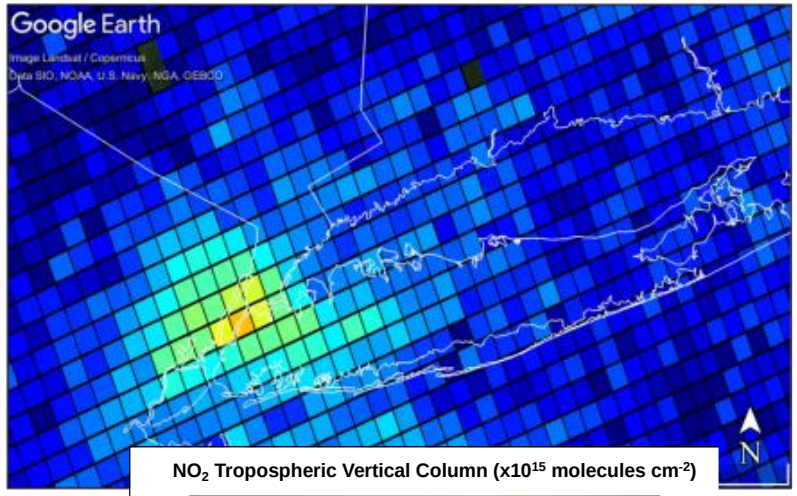
Future work to investigate site-by-site dependencies, particularly the lower airborne columns at the University of Houston

NO_2: GCAS vs. TROPOMI near NYC

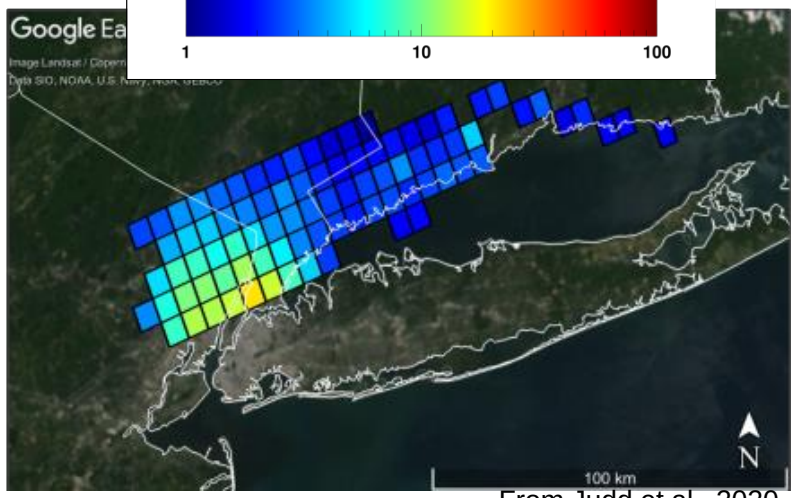
% mapped > 75% - CRF < 50% - Time Difference < 30 minutes

30 June 2018

TROPOMI Tropospheric NO_2

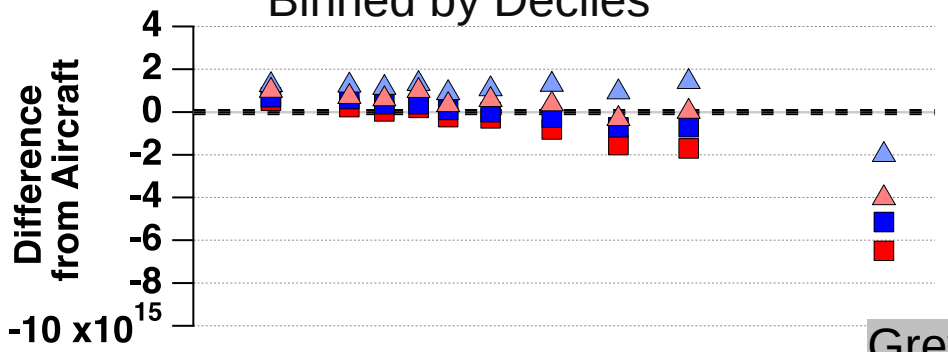


TROPOMI Scale Airborne Pixels

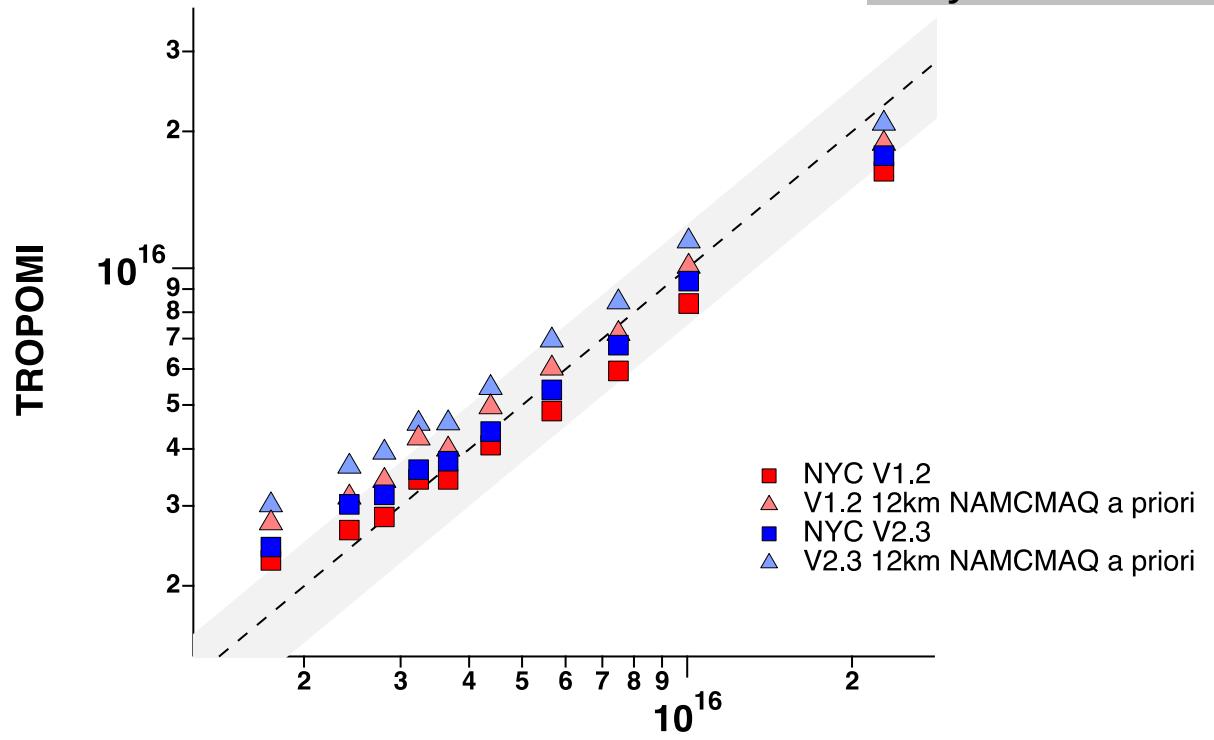


From Judd et al., 2020

Binned by Deciles

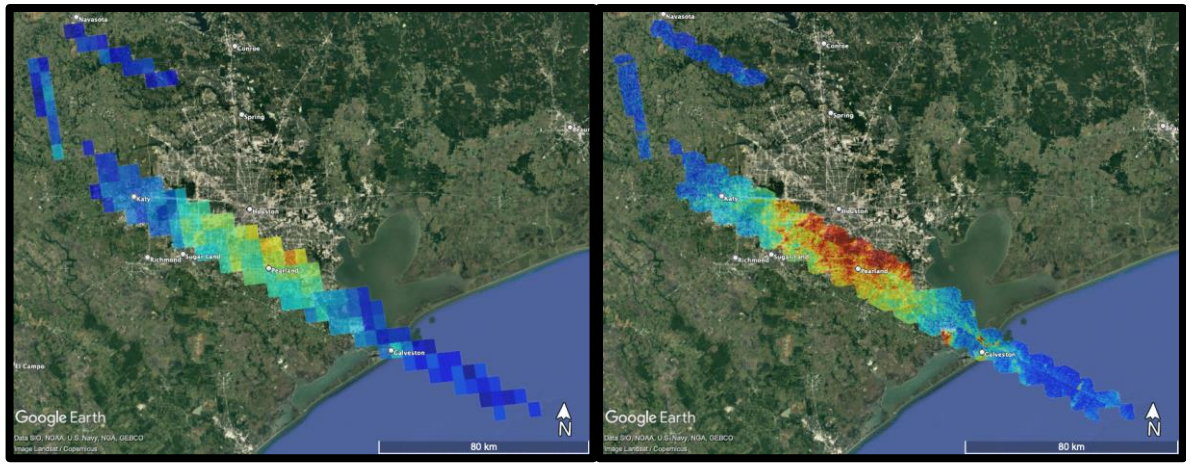


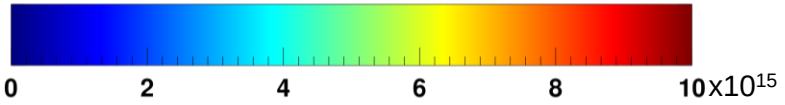
Grey areas are +/- 25%



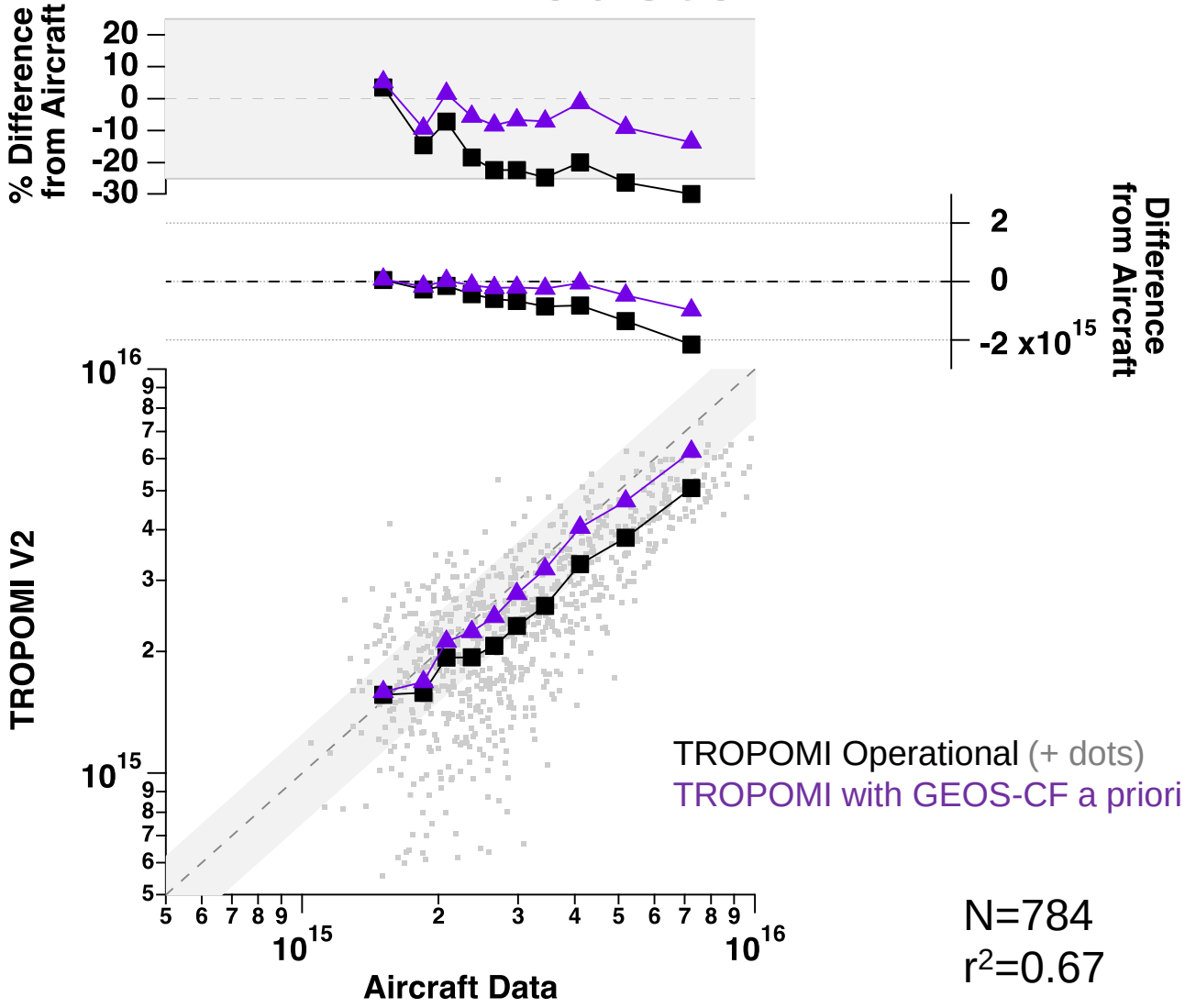
NO_2: GCAS vs. TROPOMI 2021 Flights

% mapped > 75% - CRF < 50% - Time Difference < 30 minutes



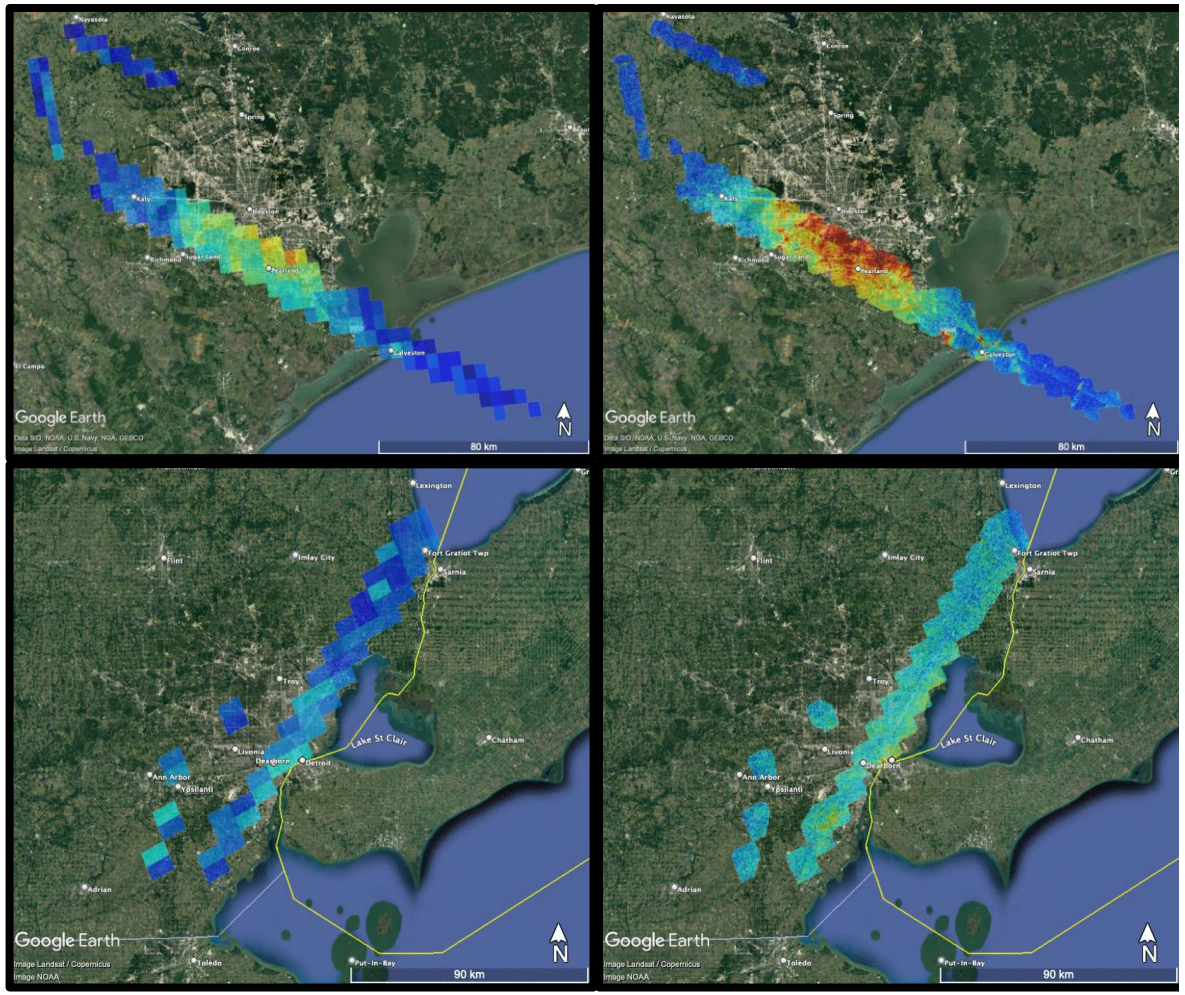


Houston

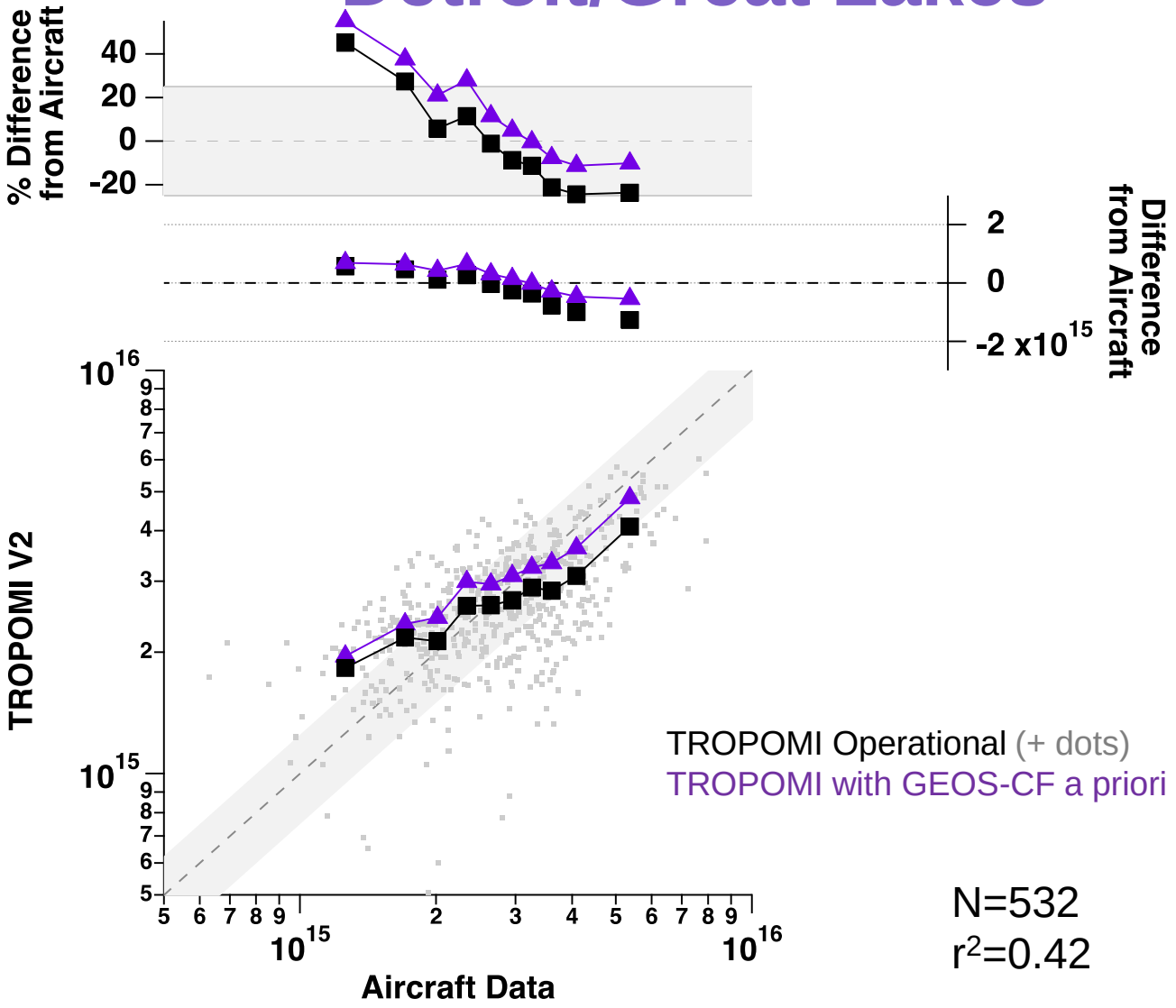


NO_2: GCAS vs. TROPOMI 2021 Flights

% mapped > 75% - CRF < 50% - Time Difference < 30 minutes

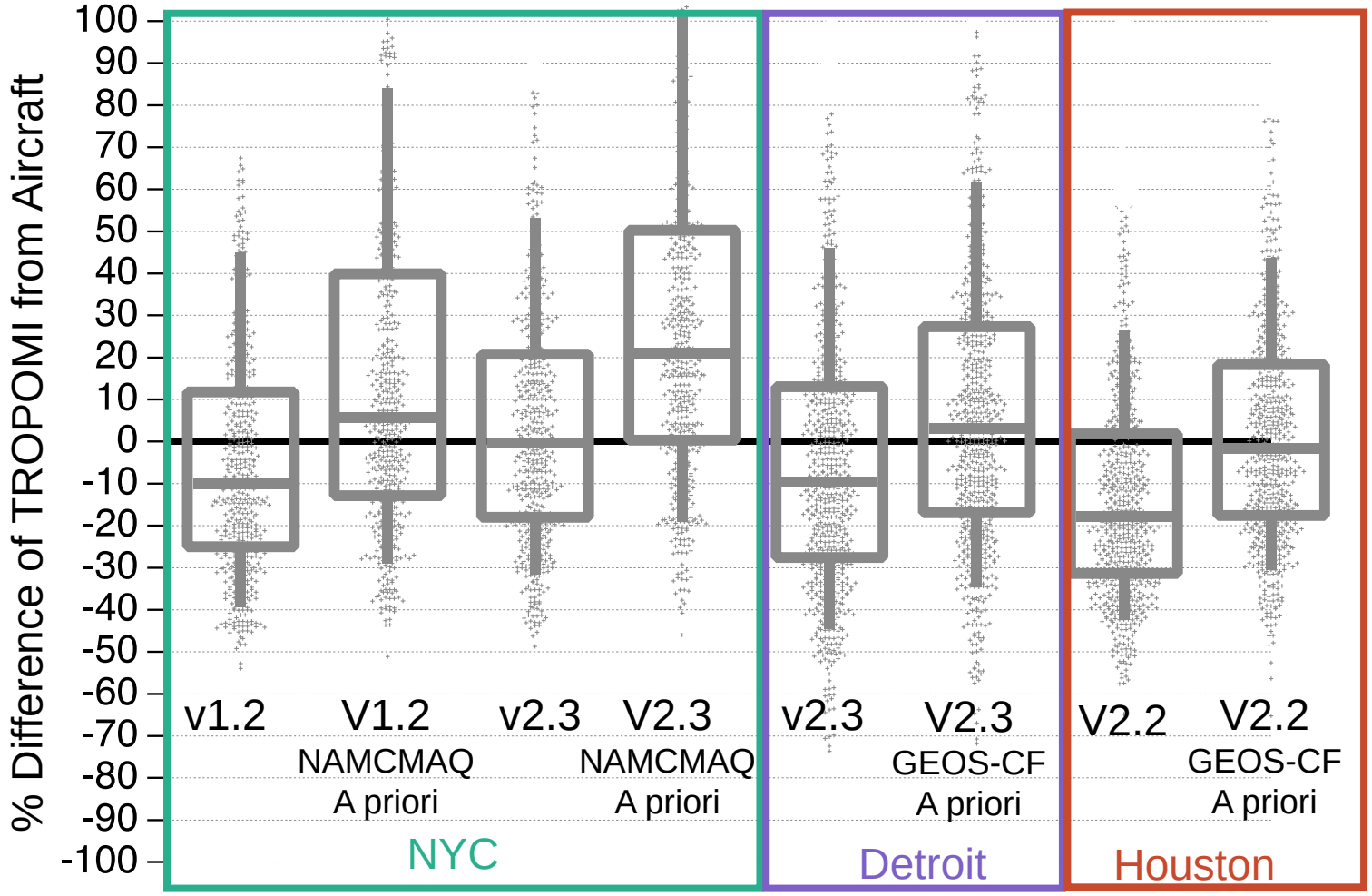


Detroit/Great Lakes



NO_2: GCAS vs. TROPOMI All Flights

Summary: Percent Difference for Airborne columns exceeding 2x TROPOMI Tropospheric VC precision (median 0.9-1.5 E15)



Whiskers are the 9th and 91st percentile

With V2 of the NO_2 product, we see a much better agreement with airborne observations especially in polluted areas

Thoughts to investigate further:

Higher biases with NAMCMAQ in NYC are attributed to two factors:

(1) Cloud shielding effects as described in Judd et al., 2020, which appear to be worse in v2.

(2) Lack of free tropospheric sensitivity in the regional model run

Potential directions:

- *Comparisons between TROPOMI v2 NO_2 and Pandora in NYC and Houston*
- *Applying GEOS-CF model runs during LISTOS*
- *Deeper dive into reference assumptions, free tropospheric contributions, and cloud impacts.*
- *How will this look for v2.4?*

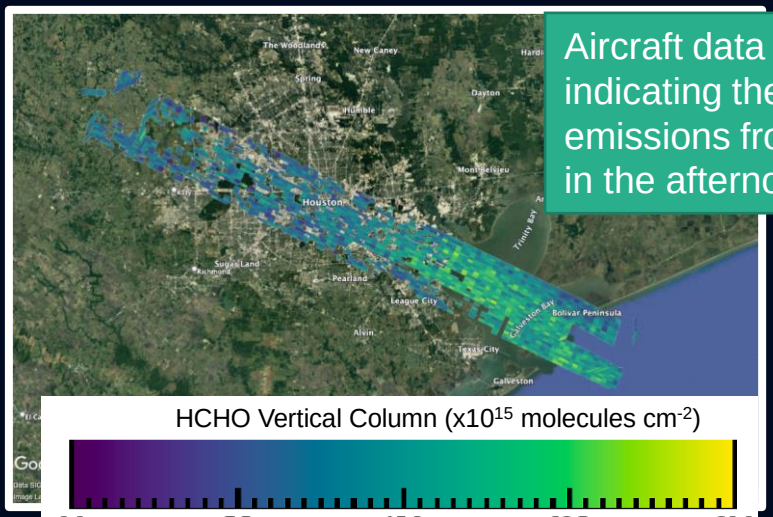
Open to other thoughts!

HCHO: Pandora Direct-sun v. GCAS

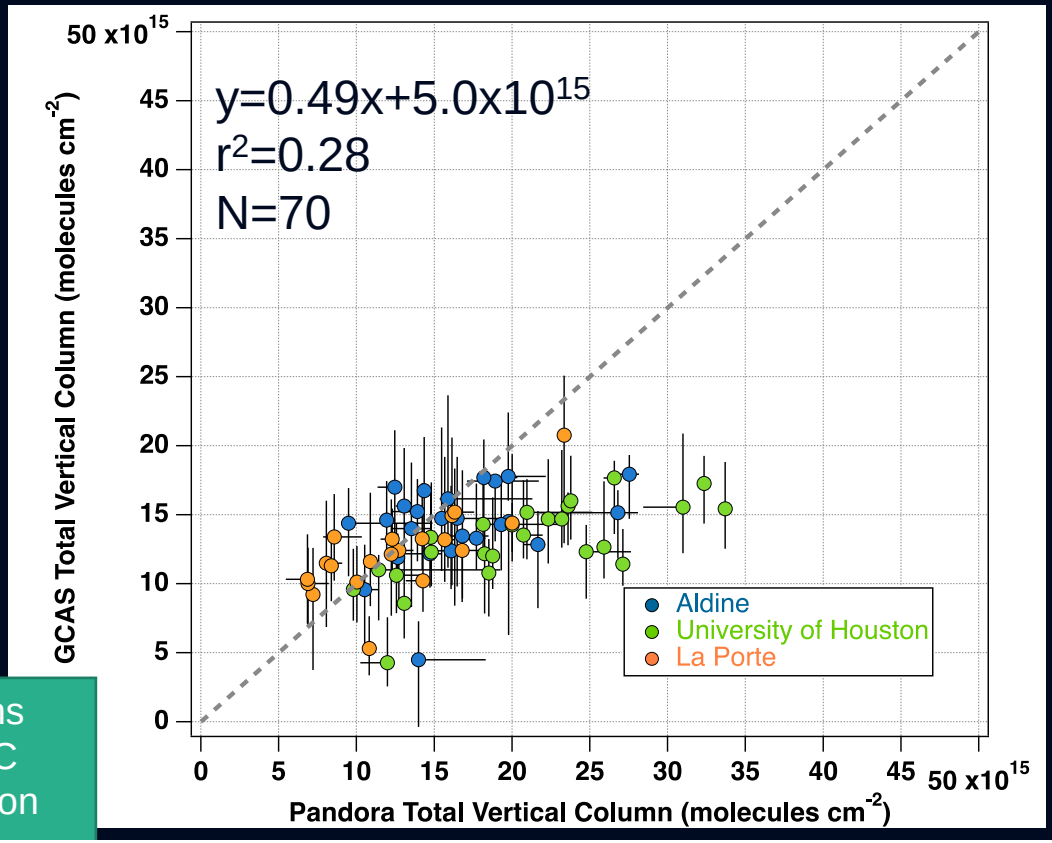
Aircraft data lacks the dynamic range observed by Pandora and appears to have some solar geometry influences early in the day.
Further investigations are needed.

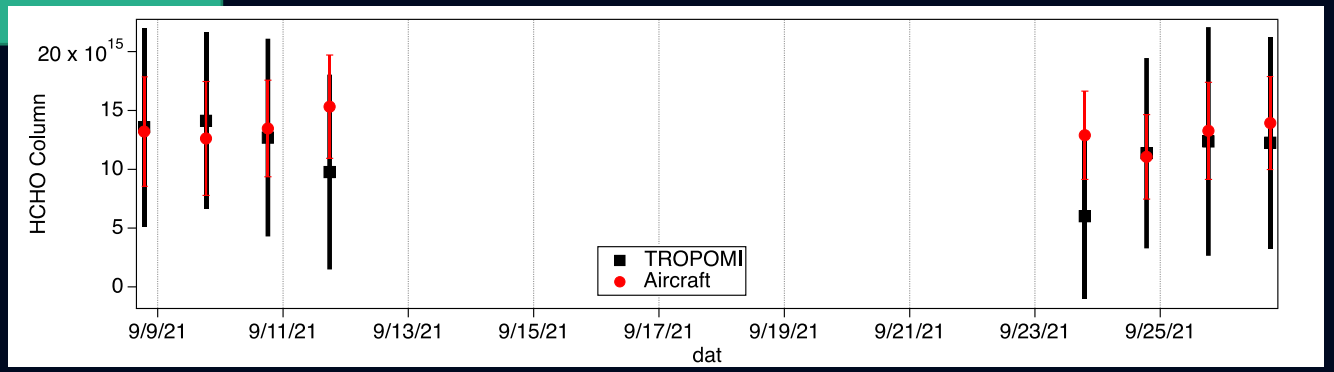
Comparison methodology:

→ Temporally nearest Pandora data point within 15 minutes of GCAS overpass (± min/max)
→ GCAS median column within 2250 m (± 10th/90th percentile)
→ Pandora QA value of 0 or 10
→ GCAS data is cloud-filtered



Aircraft data show spatial patterns indicating the break down of VOC emissions from the Houston region in the afternoon.





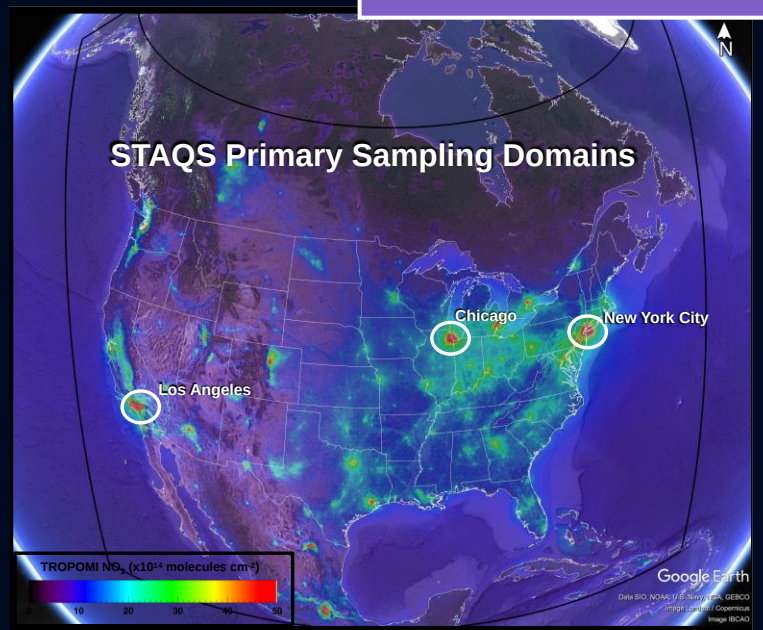
Concluding Thoughts & Future Opportunities

- ⇢In 2021, we expanded available flight data coincident with TROPOMI by ~200% during MOOSE and TRACER-AQ (adding complexities with new environments and new retrievals!)
- ⇢V2 of the NO_2 TROPOMI product improves low biases in polluted areas enhanced by higher resolution a priori NO_2 profiles (e.g., GEOS-CF)
- ⇢Attention should be paid to the cleaner/transition to polluted regions with discussion on expectations on how to validate with airborne and satellite measurements at these scales
  - ⇢ Importance of reference assumptions, free tropospheric impacts.
- ⇢TRACER-AQ data from aircraft and Pandora may also be used to compare to TROPOMI HCHO, but further analysis is needed on the validate these measurements.
- ⇢All airborne data publicly available at https://www-air.larc.nasa.gov/missions/tracer-aq/

Synergistic TEMPO Air Quality Science

June-August 2023:
Under TEMPO→Airborne mapping of NO_2, HCHO, Ozone, Aerosols, CO_2 and Methane

Collaborations with NOAA and other federal, state and academic partners for in situ airborne sampling.



Targeting 4 flight days in each domain