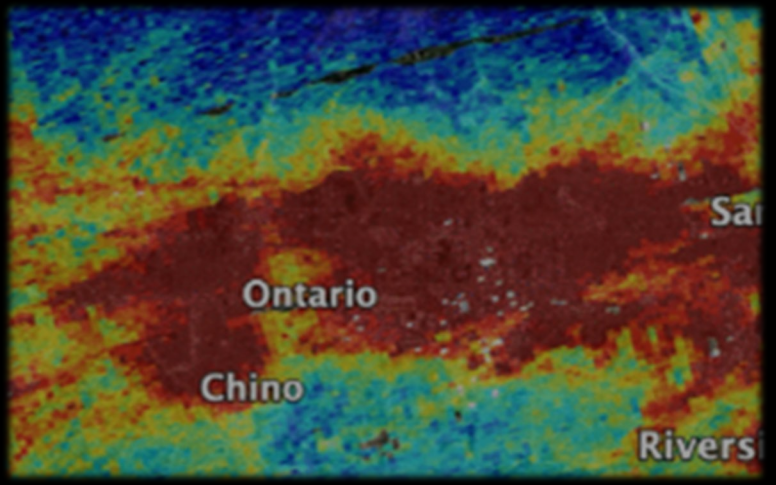
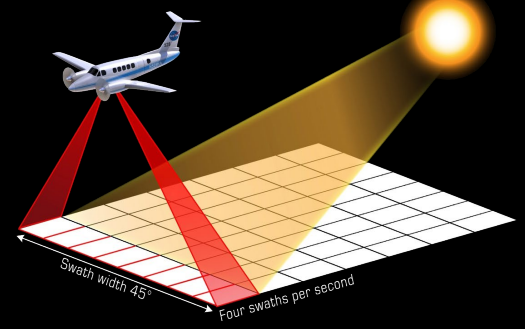





# TEMPO vs. STAQS GCAS

Most recent results for $NO_2$

*Laura Judd, NASA LaRC*

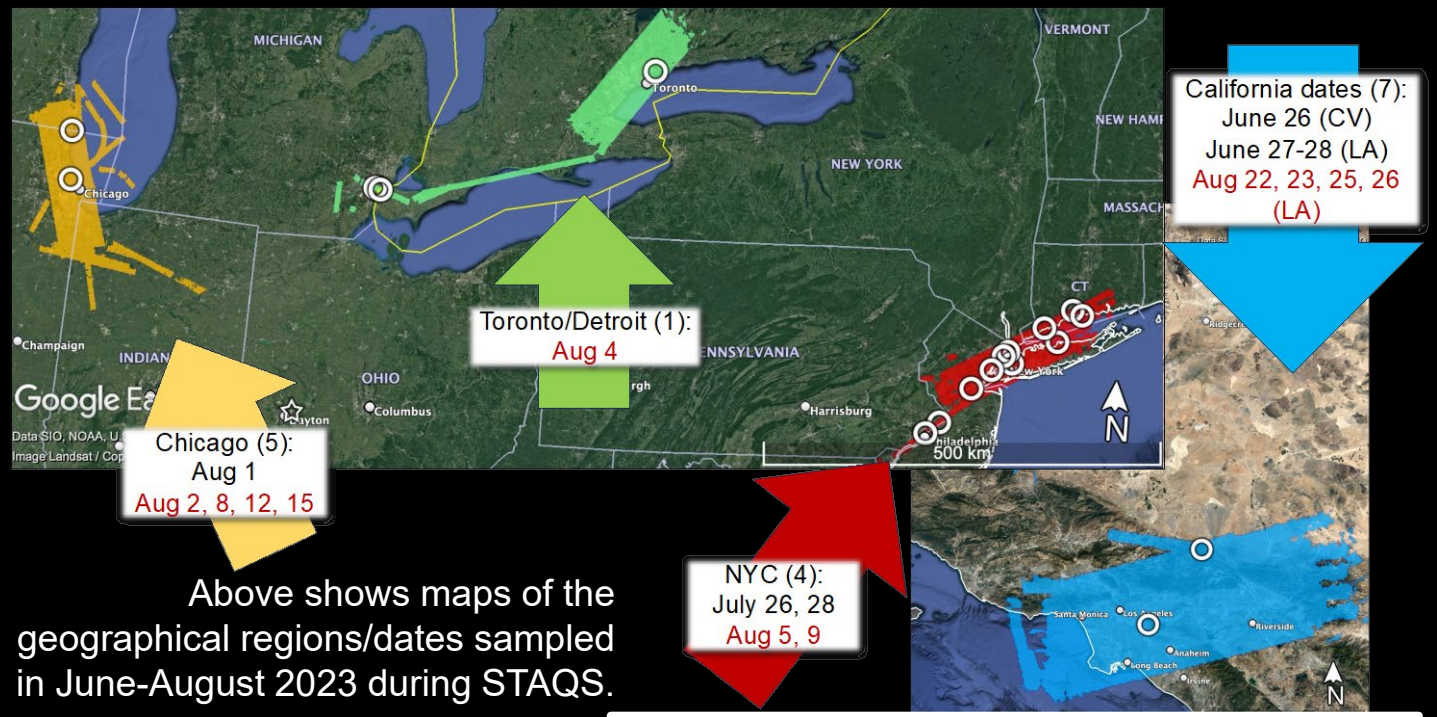
*Presented at the GEO-XO Meeting 2024*






# Synergistic TEMPO Air Quality Science

All STAQS data are publicly available!




Above shows maps of the geographical regions/dates sampled in June-August 2023 during STAQS.

The NASA DC8 for NOAA AEROMMA and GCAS on the Gulfstreams flew together all flight days except 2.

**Purpose:** To integrate TEMPO satellite observations with traditional air quality monitoring to improve understanding of air quality science for increased societal benefit

**GCAS was integrated on both the JSC G-V (before 16 Aug) and LaRC G-III (after 22 Aug)**

→ Resolution: 250 x 560 m
→ Retrieval window: 425-460 nm
→ A priori: MCD43A1 BRDF kernels over land and 3% Lambertian + sun glint kernel over water and GEOS-CF atmosphere
→ AMFs are retrieved via the GEO-CAPE tool thanks to SAO (a VLIDORT package)

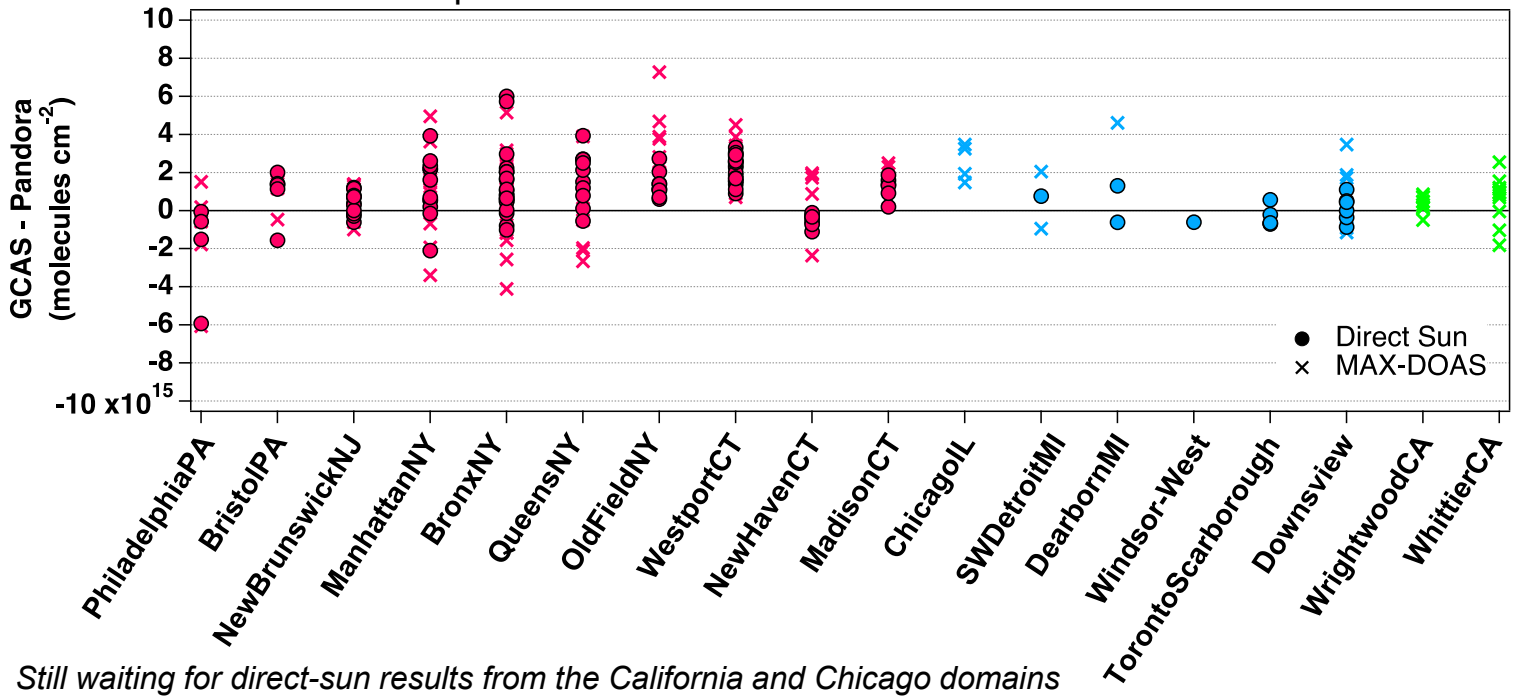
→ Cloud filtered using a count rate threshold in the $NO_2$ fitting window
→ More info: Judd et al. (2019) and Judd et al. (2020) with exception of the GEOS-CF profile input

# GCAS Validation with Pandora

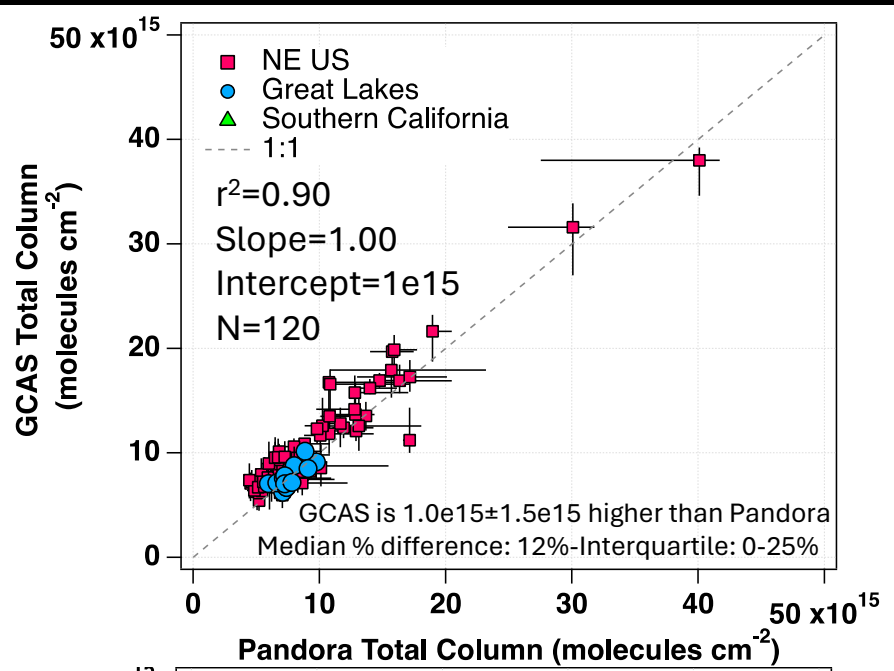
**GCAS has a nearly 1:1 relationship with the PGN Pandora observations (well within 25%). Comparisons indicate a slight high bias of ~1E15**

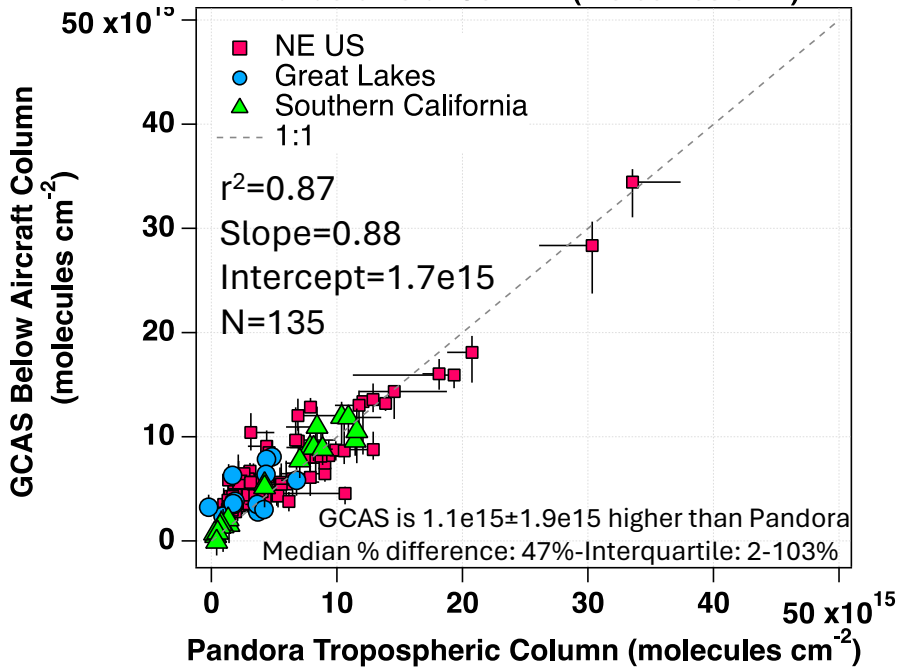
Right plots show the median GCAS value within 750m of the Pandora site during the overpass. Vertical bars are the 25th-75th percentile within that 750m radius. The Pandora value is the nearest in time where the horizontal bars represent the max/min within 15 minutes of the GCAS overpass.

Bottom plot shows the absolute difference between the measurements.

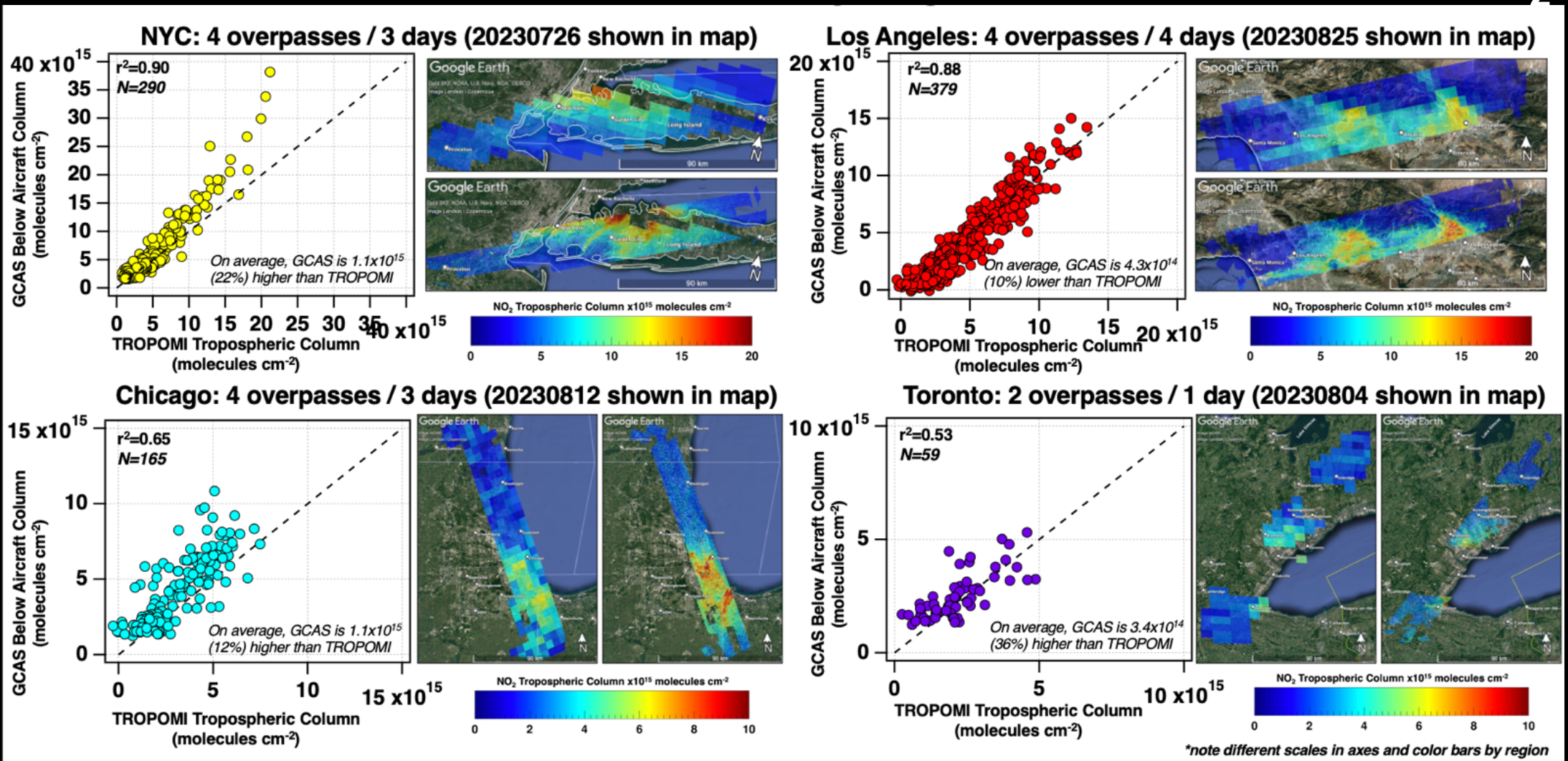



*Still waiting for direct-sun results from the California and Chicago domains*



# Satellite Validation: TROPOMI with STAQS GCAS $NO_2$




*Each regional scatter plot shows TROPOMI tropospheric $NO_2$ columns that were at least 75% mapped by GCAS within ± 0.5 hours from the TROPOMI overpass. The GCAS value represents a spatially averaged column over the TROPOMI pixel area.*

**Overall, GCAS and TROPOMI compare quite well ($r^2$=0.83) with close 1:1 agreement in columns up to at least 10x10¹⁵ molecules cm⁻².**
Tropospheric slant columns are even more correlated ($r^2$=0.93; not shown).
Biases appear to be largest in Chicago and NYC where TROPOMI is consistently lower than GCAS on the days sampled.

# Example day: August 12th, 2023

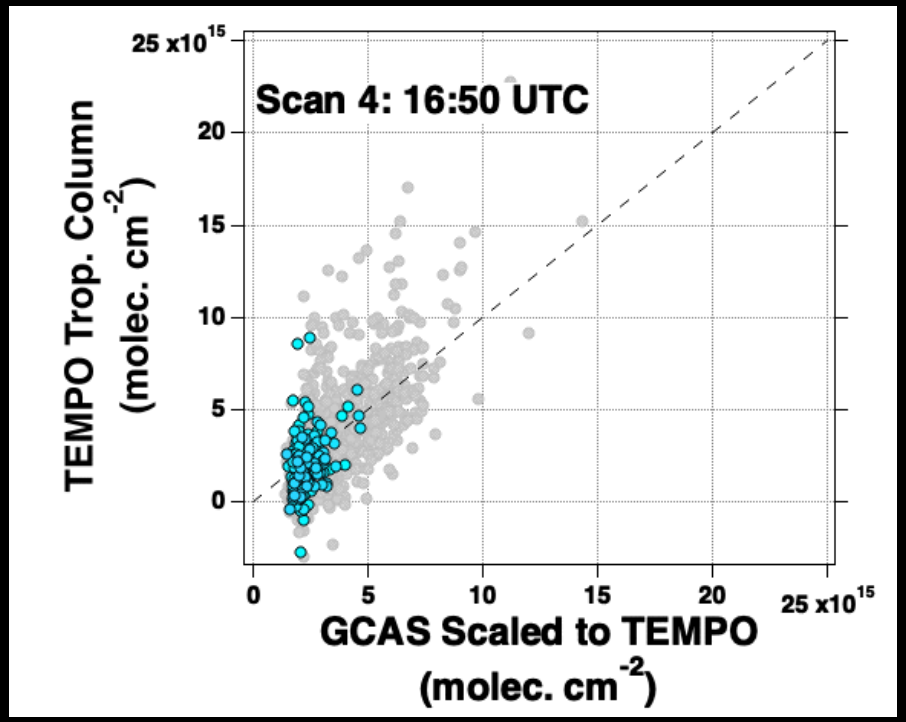
Comparison criteria
- TEMPO has a qa=0 and effective cloud fractions less than 0.3
- GCAS is subset +/- 30 minutes from TEMPO observations and includes only cloud free data

Conditions:
Cloud bank in the morning delayed flight
Small cumulus impacts in afternoon

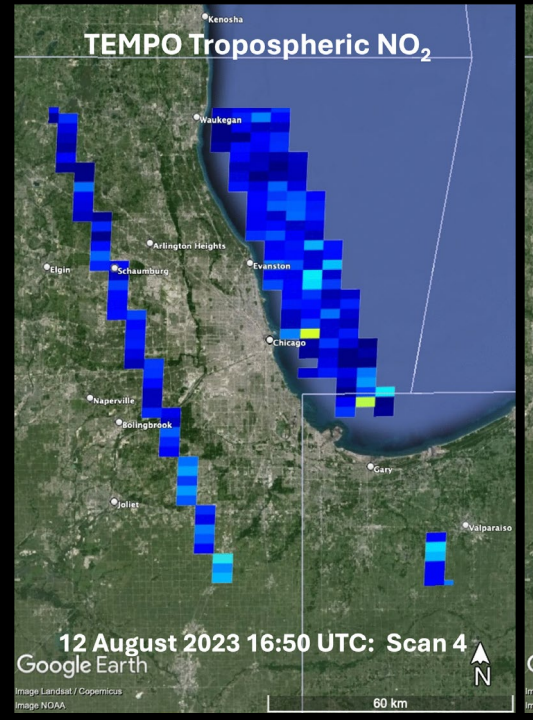
# Scans=5
# Pixels=1033
$r^2$=0.45
Y=1.7x-2.3e15

Median bias:
7% (0.2e14)

Interquartile:
-37%:30%
(-1.1e15-1.0e15)

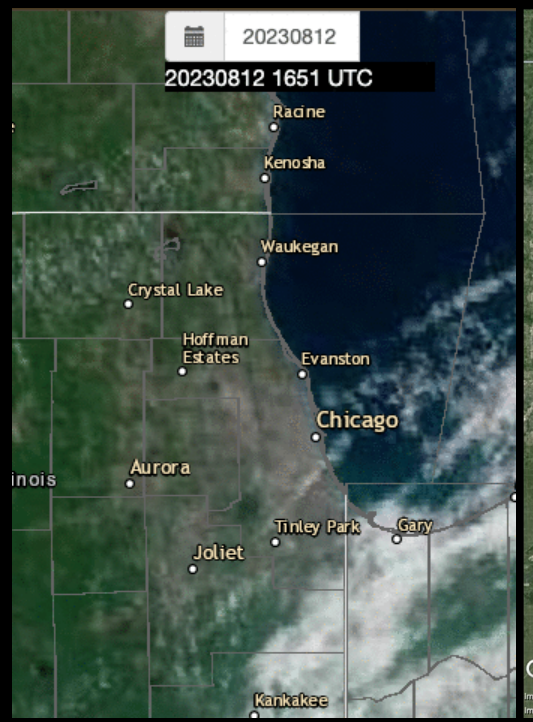


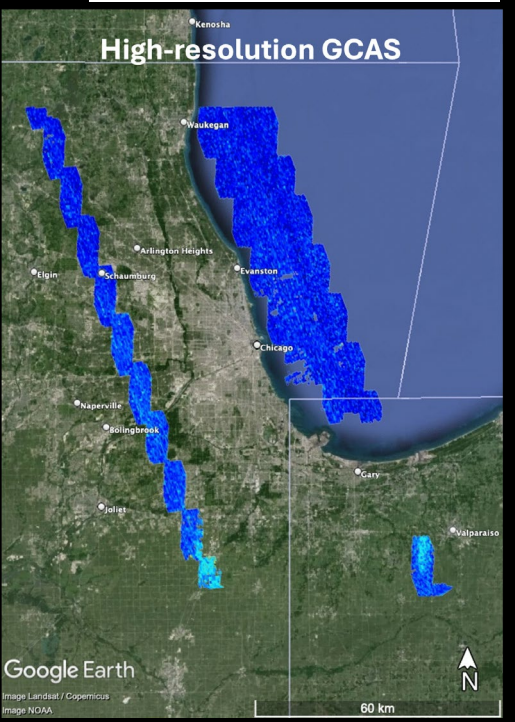

Grey: all coincidences—Color: labeled scan










*"Unofficial TEMPO Data: Not for Public Release"*

# Example day: August 26th, 2023

Comparison criteria

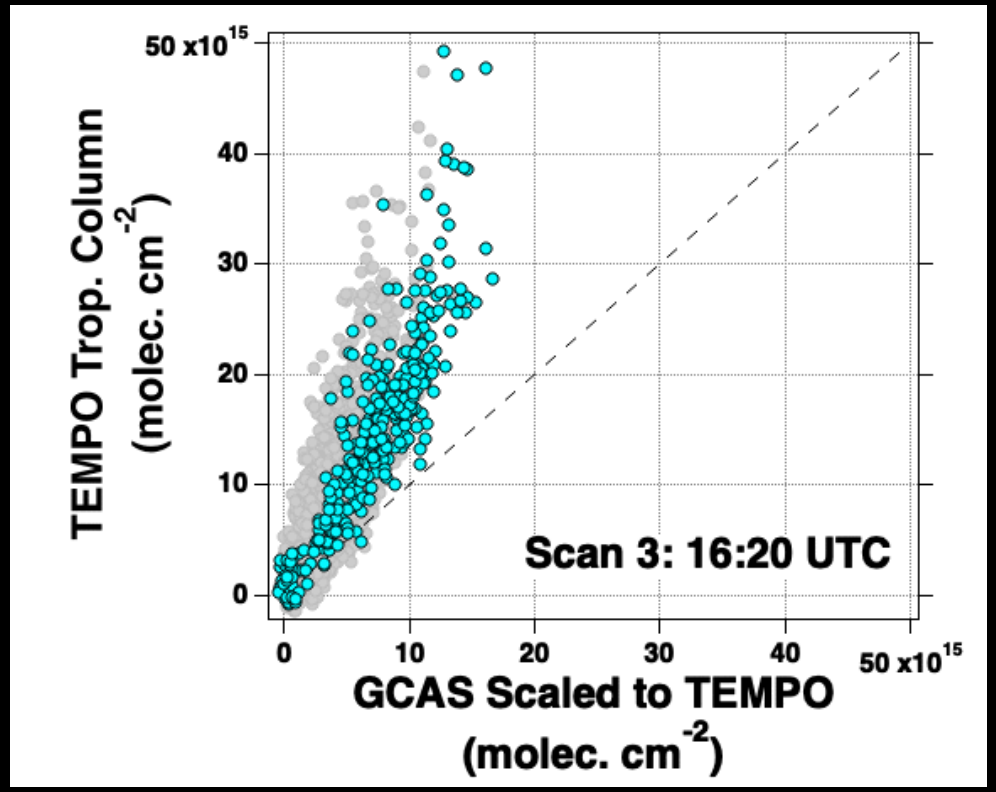
- TEMPO has a qa=0 and effective cloud fractions less than 0.3
- GCAS is subset +/- 30 minutes from TEMPO observations and includes only cloud free data

Conditions: Cloud free (some marine stratus VERY early in the morning offshore)/sea-breeze midday

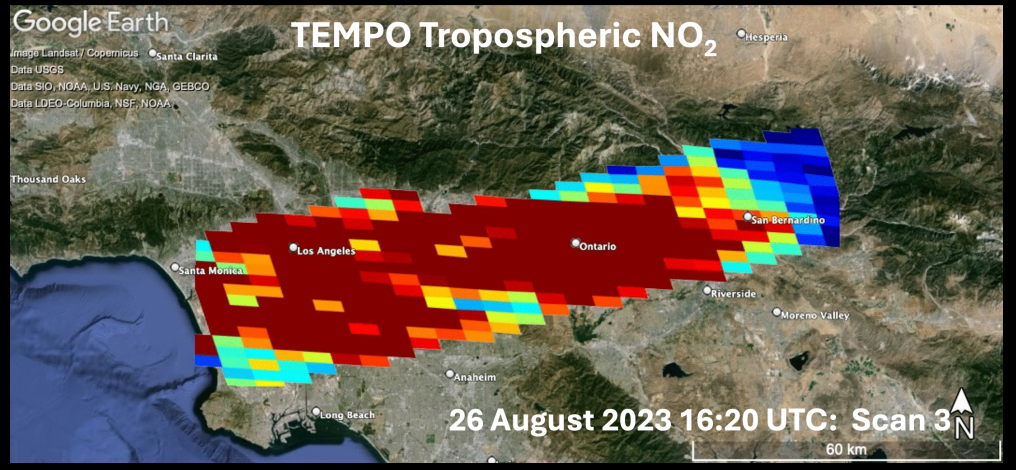
# Scans=7
# Pixels=2035
$r^2$=0.72
Y=2.56x-0.7e15

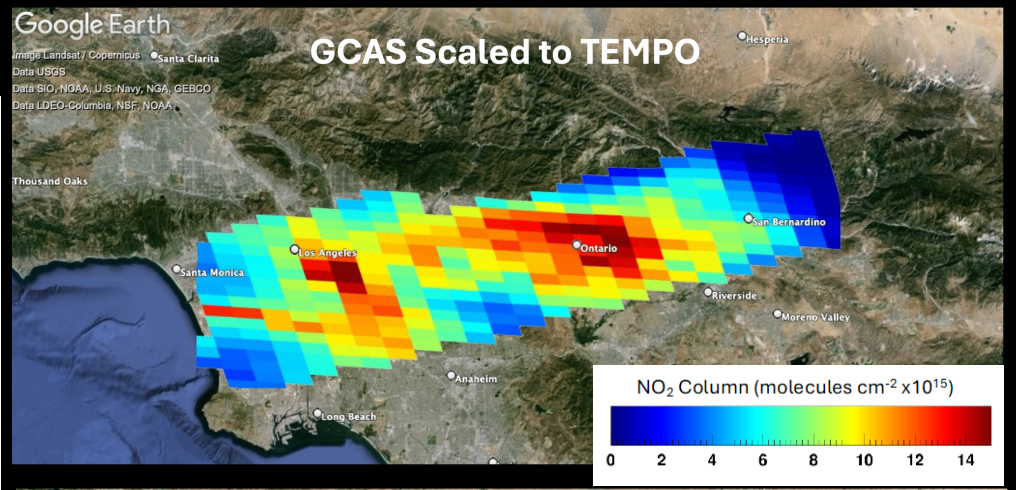
Median bias:
117% (3.1e15)

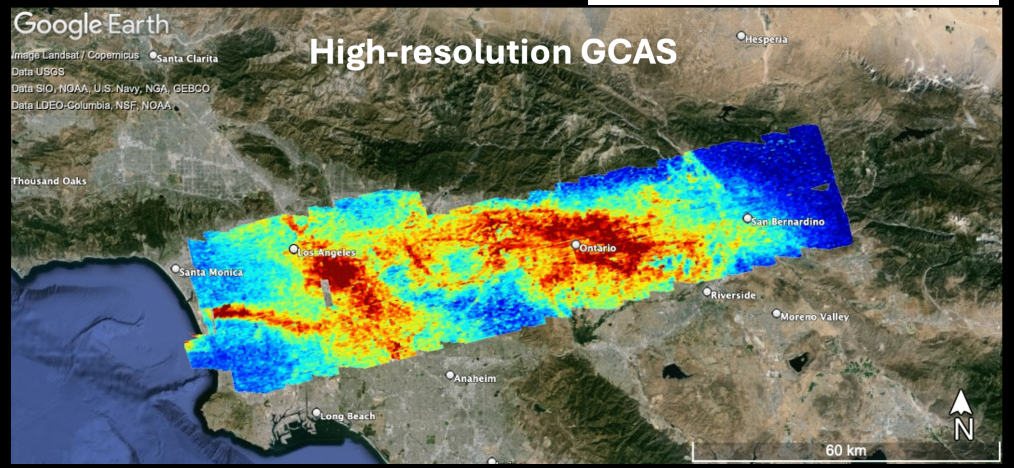
Interquartile:
58%-217%
(1.1e15-7.1e15)




Grey: all coincidences—Color: labeled scan

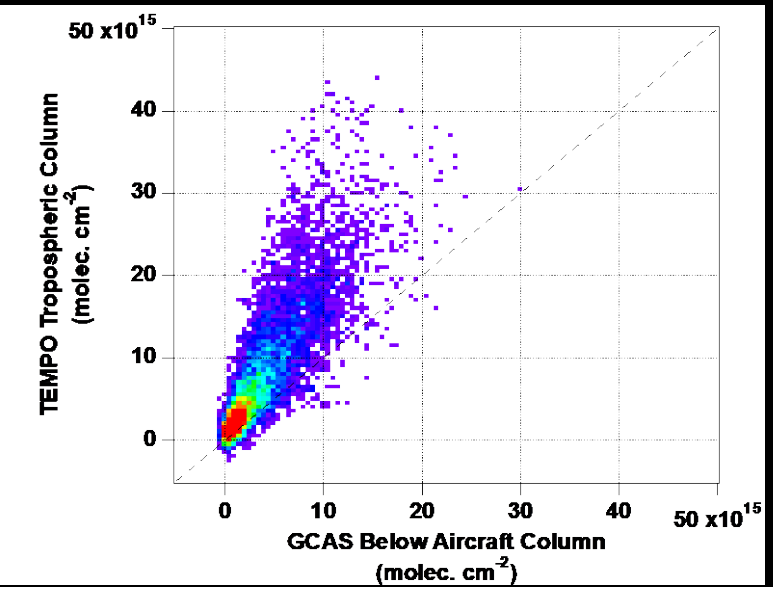



*"Unofficial TEMPO Data: Not for Public Release"*

# Los Angeles: August 22nd & 25-26th

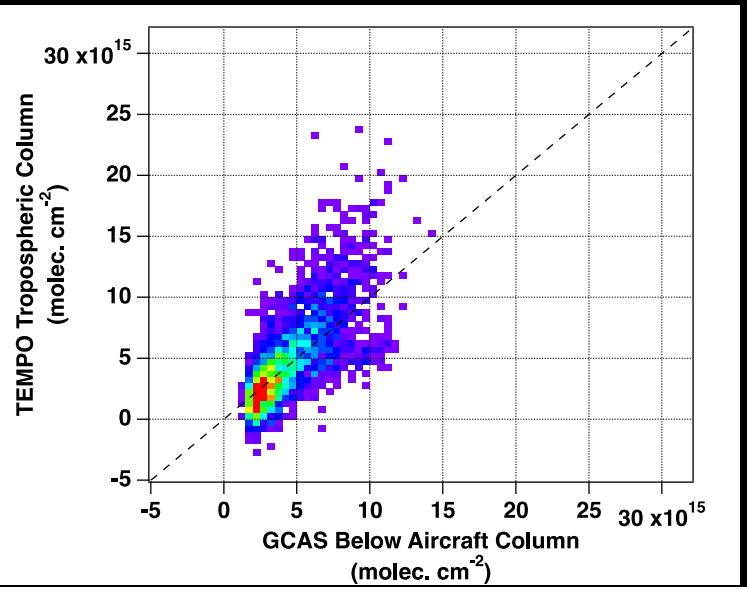



# Scans=24
# Pixels=6499
$r^2$=0.66
Y=2.1x-0.6e15

Median bias:
84% (2.6e15)

Interquartile:
29%:167%
(0.8e15-6.5e15)

# Chicago: August 2nd & 12th & 15th

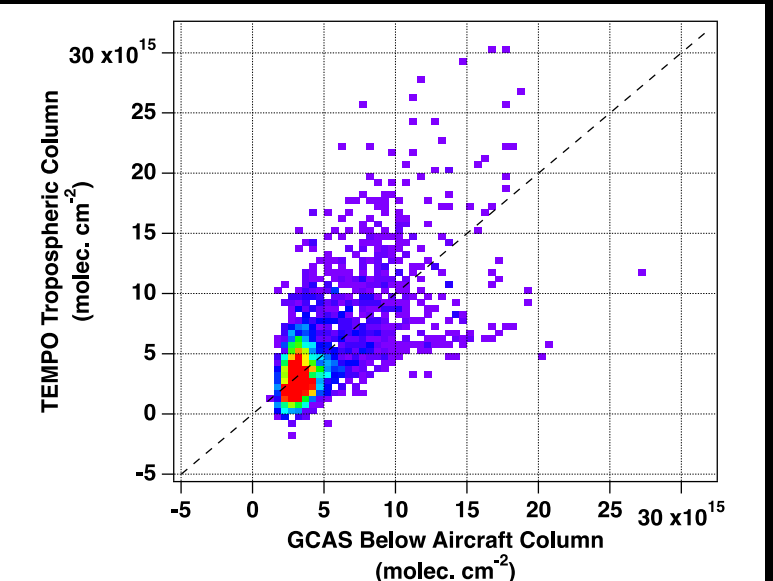



# Scans=14
# Pixels=2787
$r^2$=0.53
Y=1.6x-2.2e15

Median bias:
0% (0.002e15)

Interquartile:
-33%:35%
(-1.2e15:1.5e15)

# NYC: August 5th & 9th

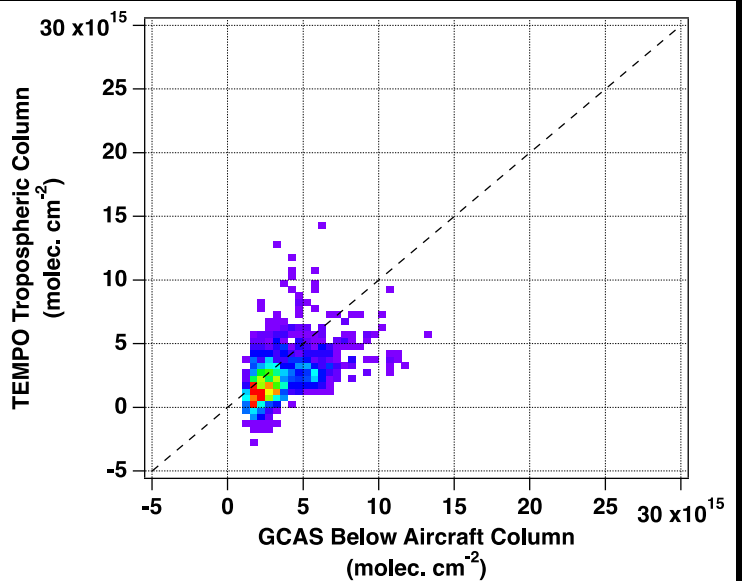



# Scans=14
# Pixels=3581
$r^2$=0.44
Y=1.4x-1.4e14

Median bias:
-1% (-0.3e15)

Interquartile:
-35%:32%
(-1.3e15:1.1e15)

# Toronto: August 4th




# Scans=9
# Pixels=1283
$r^2$=0.25
Y=1.0x-1.1e15

Median bias:
-38% (-1.1e15)

Interquartile:
-5%:-61%
(-0.1e15:-2.0e15)

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# Looking ahead

Continued $NO_2$ Validation and updates with V3 and other versions

→Analysis by time of day

→Deep dive into Los Angeles to look for causes of bias

→Deep dive into other cities to investigate pixel-to-pixel variance:

Cloud free scenes only? Cloud impacts in known cloud free scenes? Surface reflectance/type?

→Other ideas?

Contributions to validation documentation/manuscript writing

HCHO validation with GCAS

HSRL2 tropospheric/near-surface ozone?

Lessons learned under GEMS from ASIA-AQ?

Continued data collection with SCOAPE2 (June 2024) and HAMAQ (Mexico City and other location with TBD date)

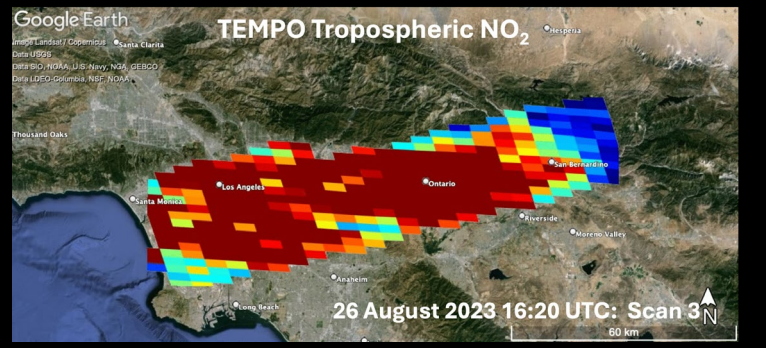
*Thailand sunrise from ASIA-AQ in March 2024*

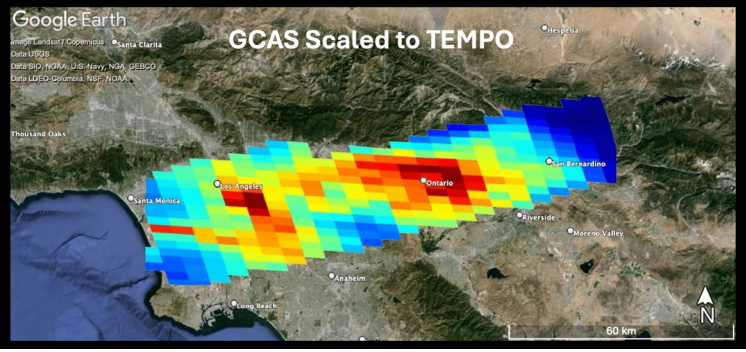
# Backup slides

# Los Angeles Aug 26th

*Not imaged in this presentation is August 22nd and 25th. Results are similar between days*



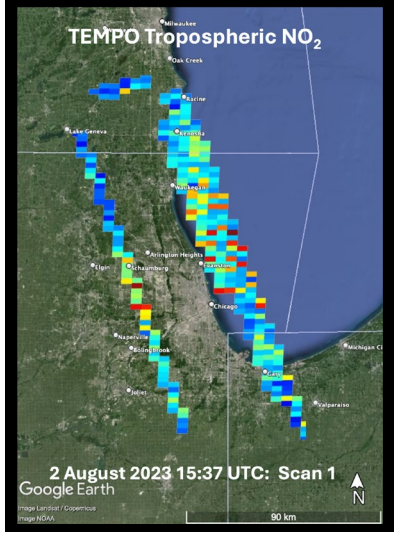



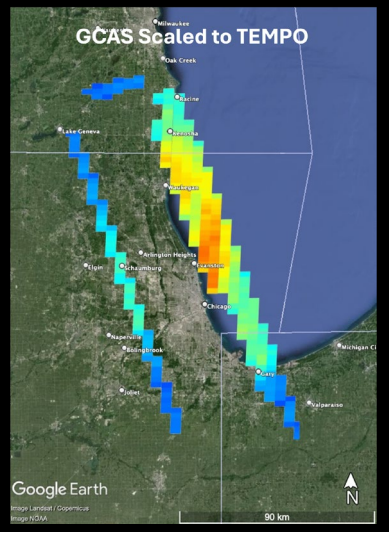




# Chicago: Aug 2nd

*August 2nd coincides with first light. This day was pretty impacted by cirrus clouds (above the flight altitude of GCAS)*

*Not imaged in this presentation is August 15th (mostly one raster mid afternoon due to clouds)*



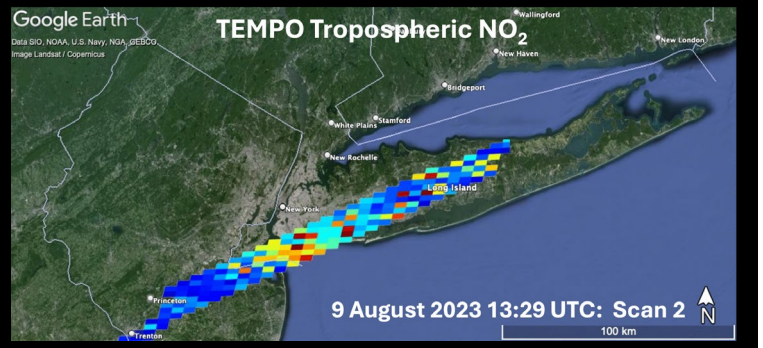


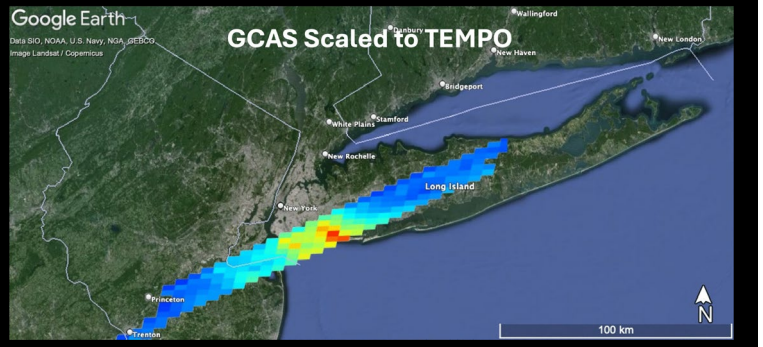


# NYC: Aug 9th




*Not imaged in this presentation is August 5th which has two rasters before getting cirrus impacted*



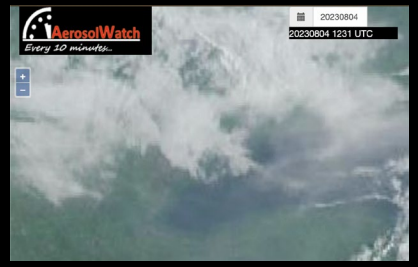

# Toronto: Aug 4th

*August 4th is the only day in Toronto. The day was impacts by low level clouds.*










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