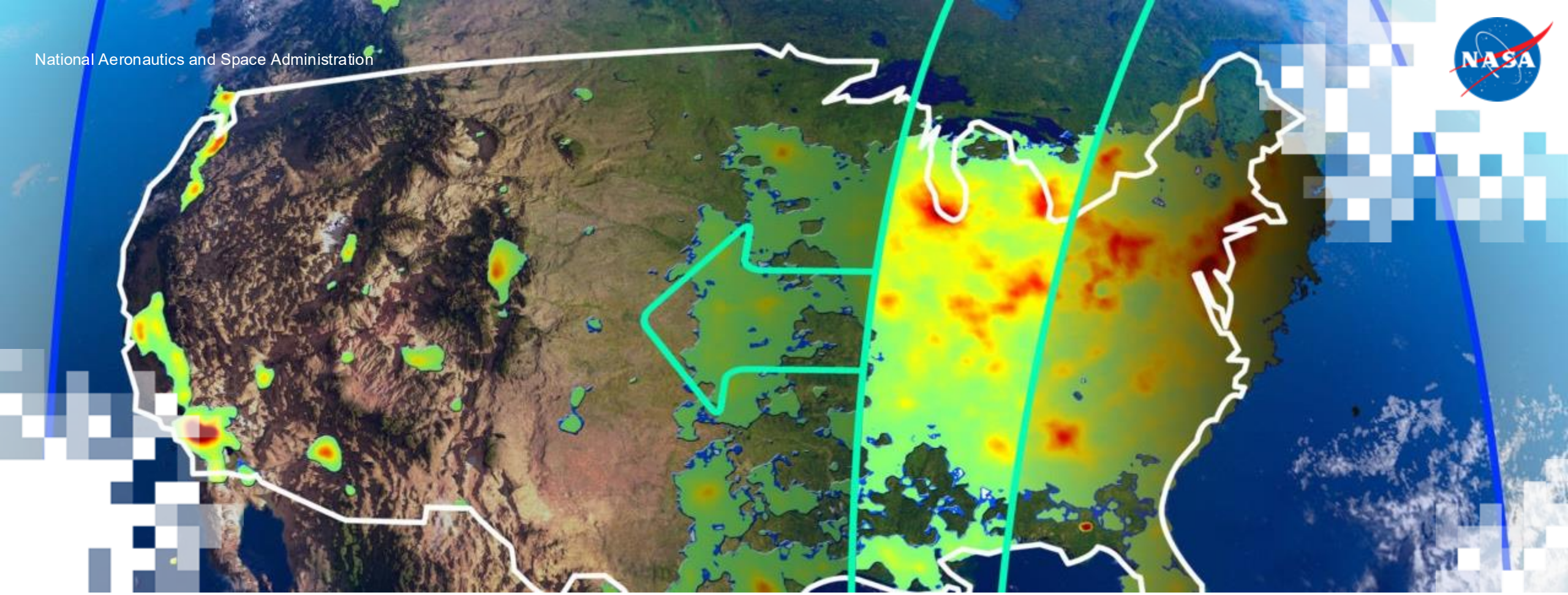
National Aeronautics and Space Administration

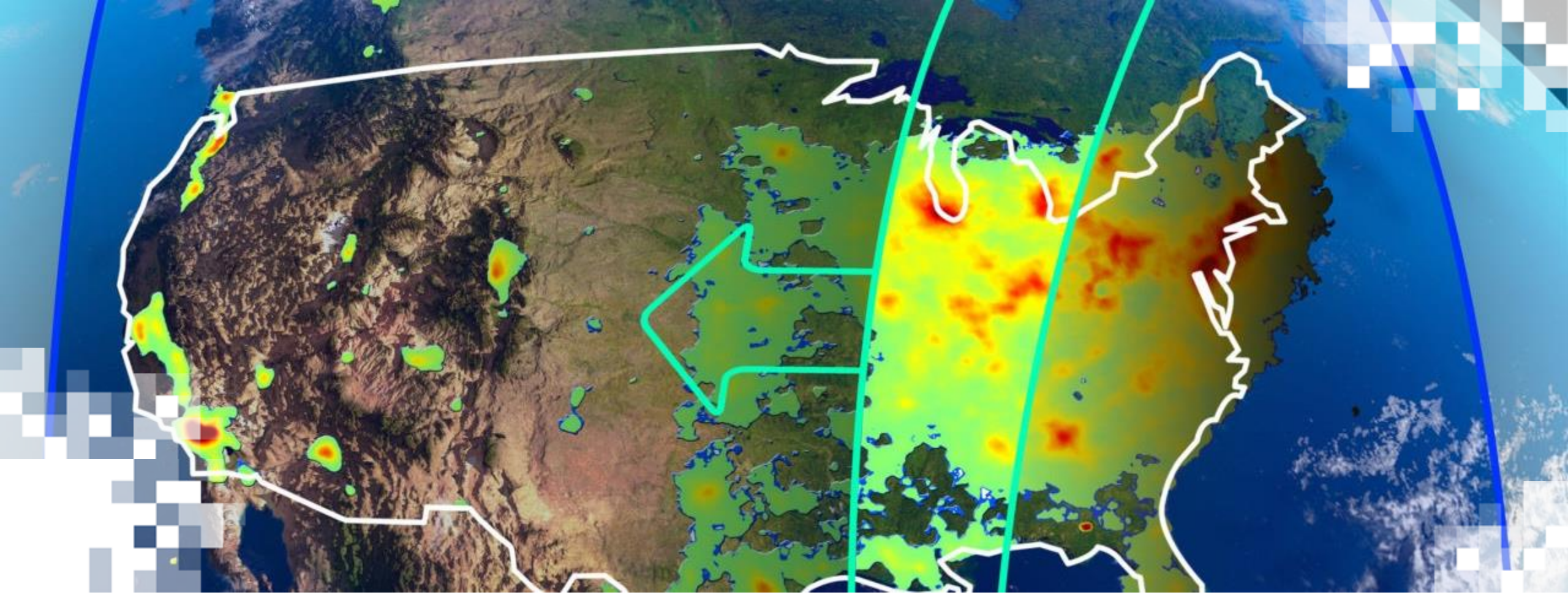


Geostationary Remote Sensing of Trace Gases for Air Quality Applications in North America

Part 1: North American Geostationary Trace Gas Data Products for Air Quality

Kristina Pistone (BAERI/NASA Ames), Aaron Naeger (NASA MSFC)

January 20, 2026



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- **ARSET provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools.**

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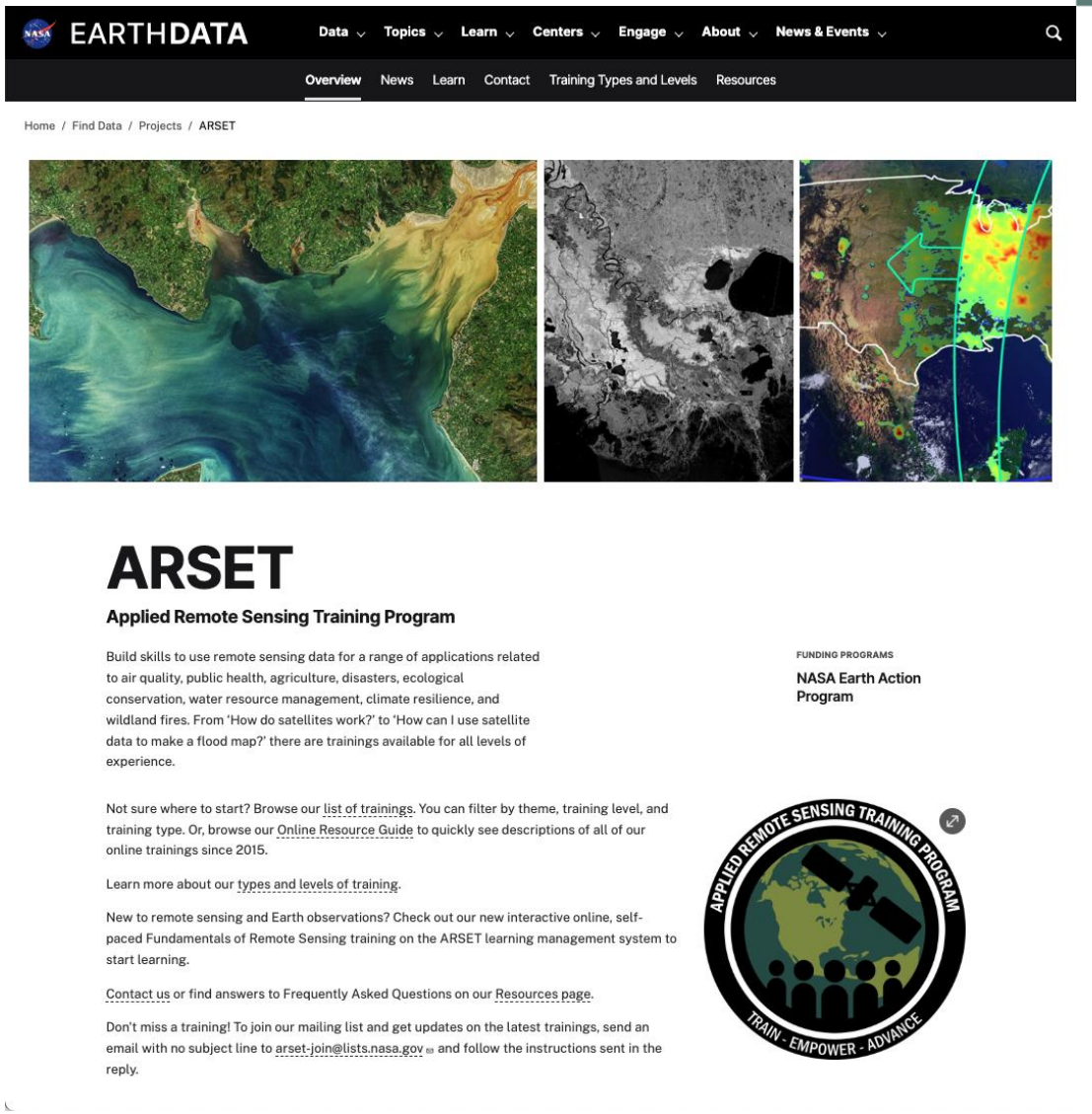
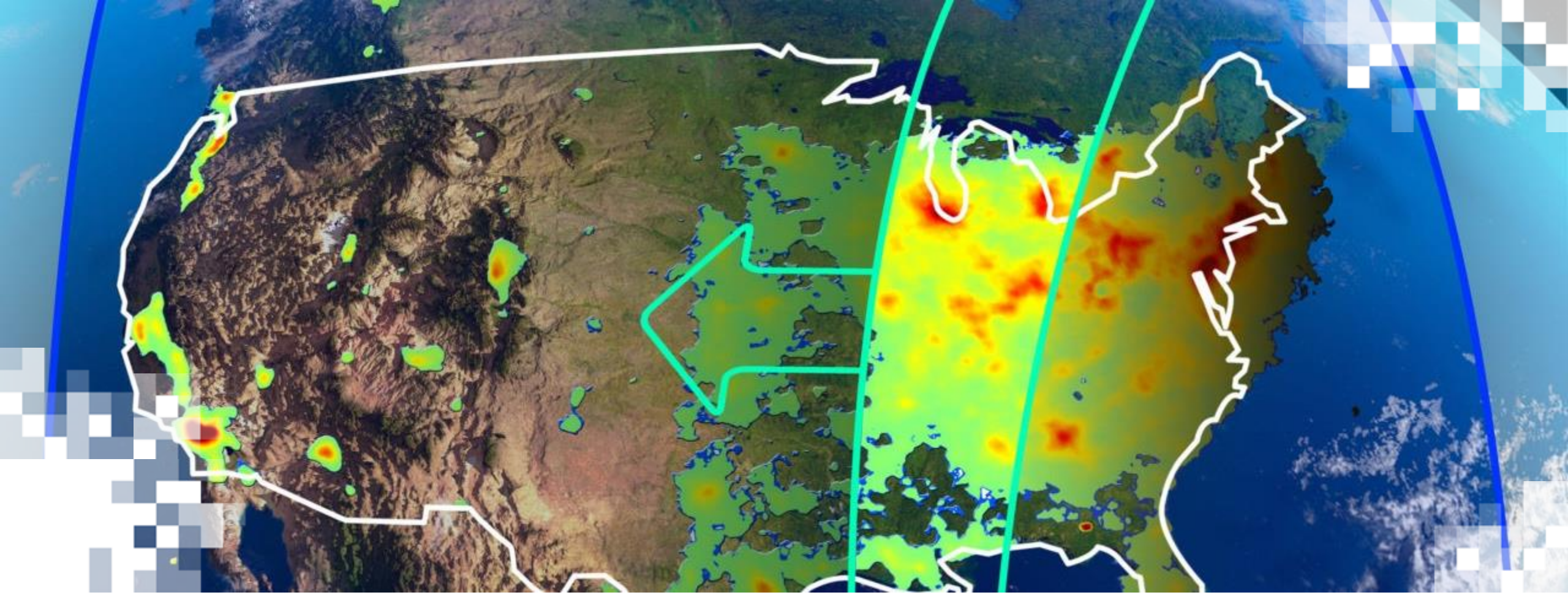




Geostationary Remote Sensing of Trace Gases for Air Quality Applications in North America

Overview

Source: NASA GSFC Scientific Visualization Studio
https://svs.gsfc.nasa.gov/5142/

Training Learning Objectives

By the end of this training, attendees will be able to:

- Describe the basic characteristics of TEMPO and its benefits and limitations compared to other air-quality-relevant missions and instruments
- Identify available trace gas data products from TEMPO and their associated characteristics
- Visualize hourly TEMPO trace gas data products using NASA Worldview for current and historical events
- Evaluate TEMPO trace gas products in Worldview to anticipate short-term air quality risks, such as high concentrations of ozone precursors
- Distinguish uses for TEMPO trace gas data products given cloud and solar zenith angle thresholds
- Determine the spatial patterns, temporal trends, and likely sources of trace gases related to wildfire smoke and urban area air pollution events using TEMPO data via Worldview

Prerequisites

- Fundamentals of Remote Sensing

Training Outline

Part 1

North American Geostationary Trace Gas Data Products for Air Quality

January 20, 2026

11:00 - 12:30 EDT

15:00 – 16:30 EDT

Part 2

Case Studies in Trace Gas Monitoring with North American Geostationary Sensors

January 22, 2026

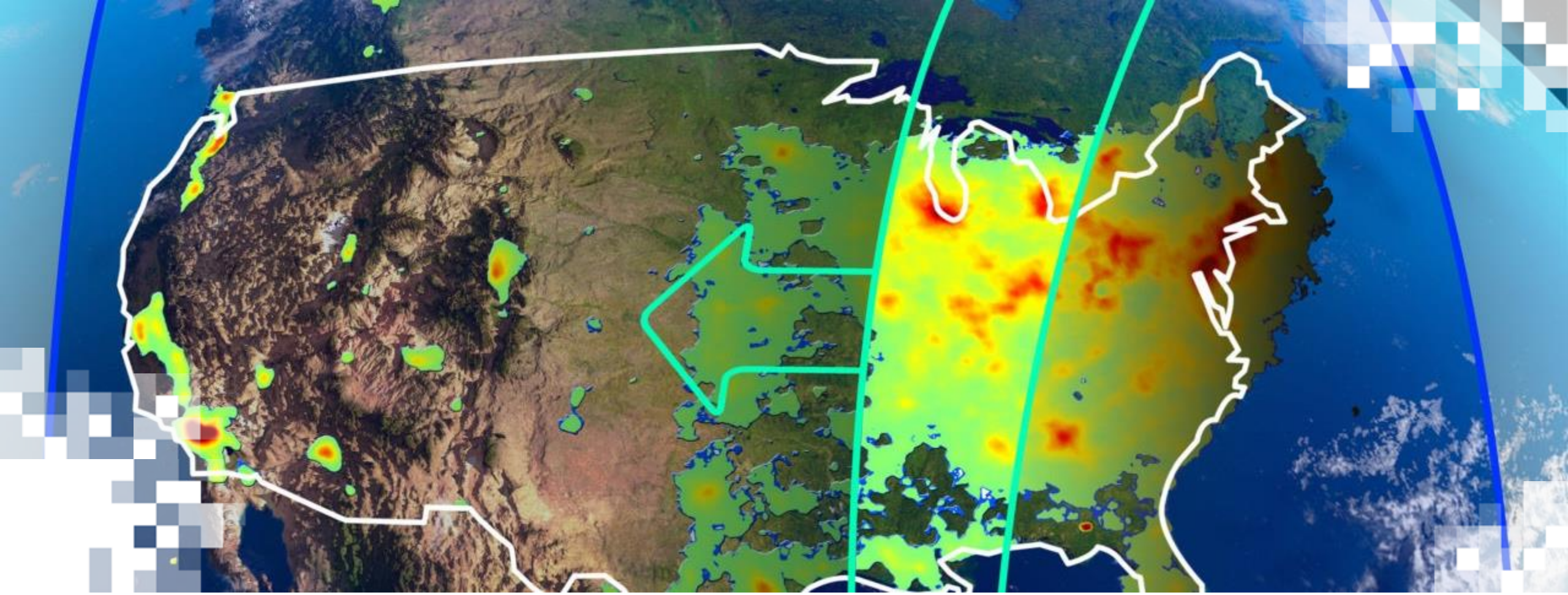
11:00 - 12:30 EDT

15:00 – 16:30 EDT

Homework

Opens January 22 – Due February 5– Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.



Geostationary Remote Sensing of Trace Gases for Air Quality Applications in North America

Part 1: North American Geostationary Trace Gas Data Products for Air Quality

Trainers

Kristina Pistone

Research Scientist

Bay Area Environmental Research Institute & NASA ARC

Aaron Naeger

TEMPO Mission Applications Lead

NASA MSFC

Part 1 Objectives

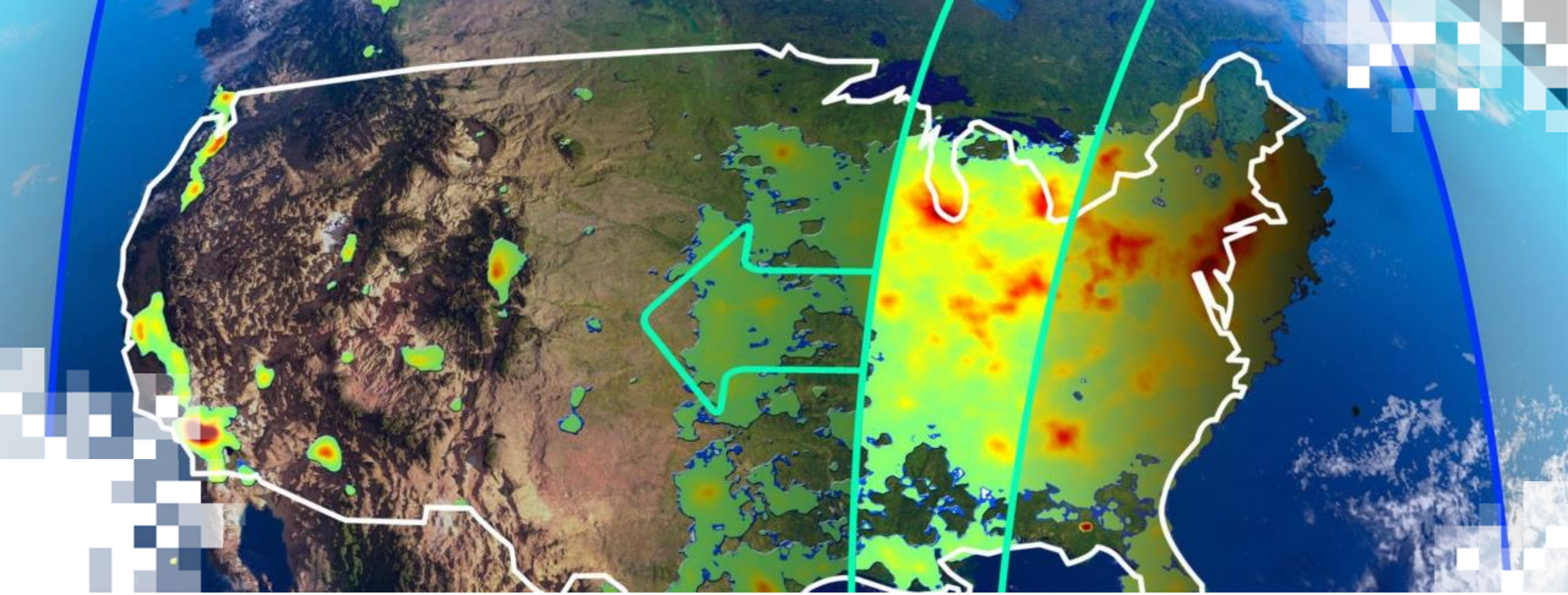
By the end of Part 1, attendees will be able to:

Within Part 1:

- Describe the basic characteristics of TEMPO and its benefits and limitations compared to other air-quality-relevant missions and instruments
- Identify available trace gas data products from TEMPO and their associated characteristics
- Distinguish uses for TEMPO trace gas data products given cloud and solar zenith angle thresholds
- Visualize hourly TEMPO trace gas data products using NASA Worldview for current and historical events

How to Ask Questions

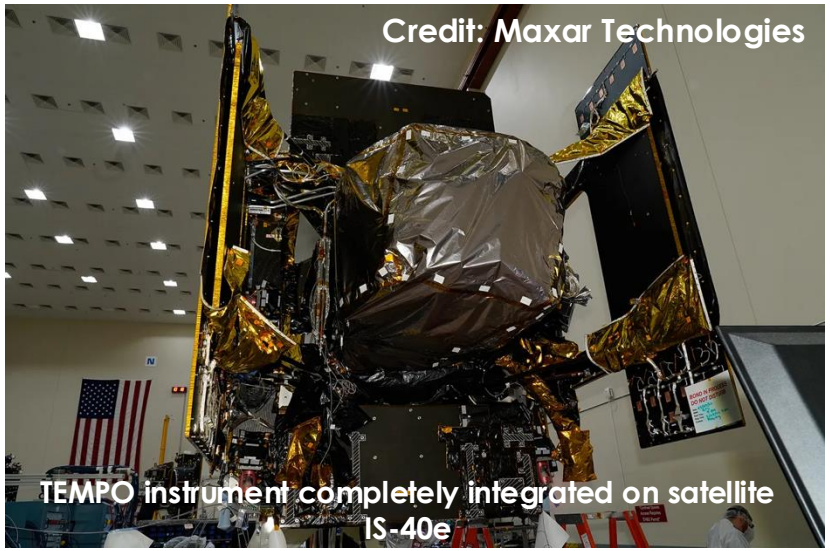
- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all of the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.



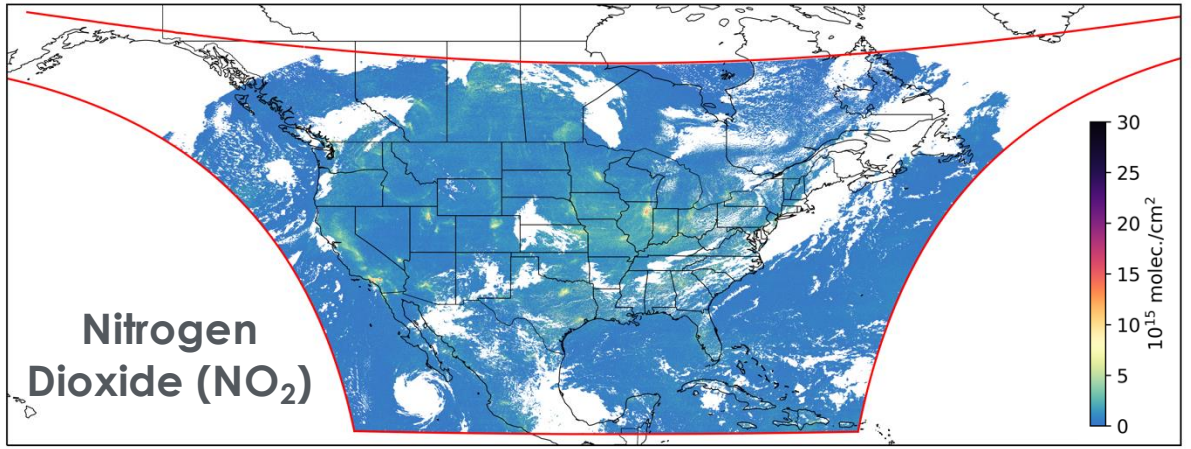
Overview of the TEMPO Instrument and Its Capabilities

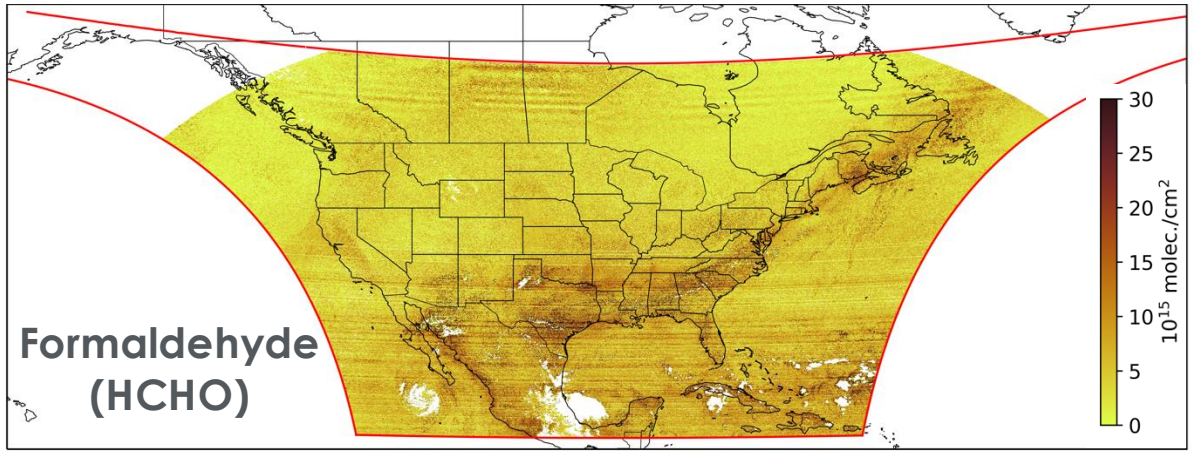
TEMPO Mission

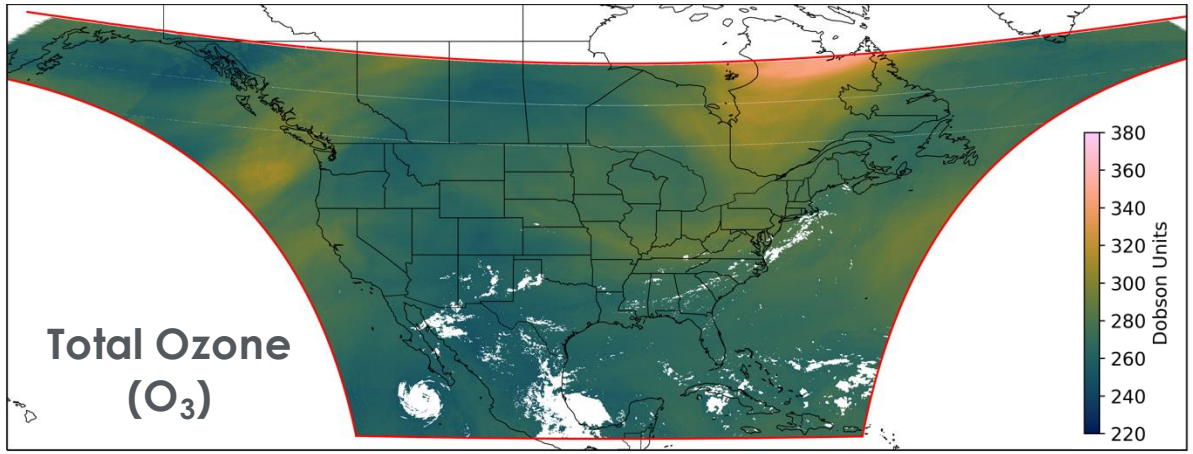
- To provide high-resolution measurements on air pollutants across North America every hour during daytime to:
  - Deliver revolutionary air quality data
  - Improve air quality forecasts and alerts
  - Better understand pollution sources
  - Inform policy and regulation
  - Enhance health studies from pollution exposures



TEMPO instrument completely integrated on satellite IS-40e

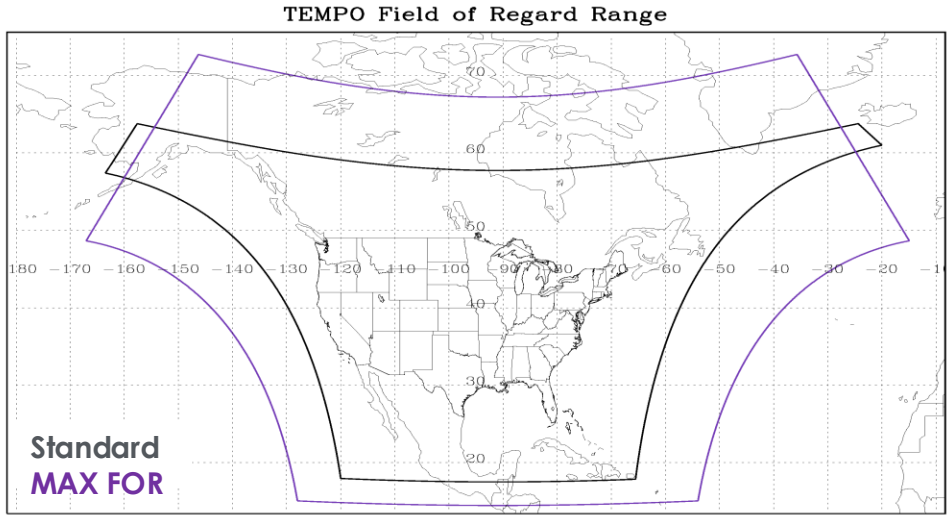




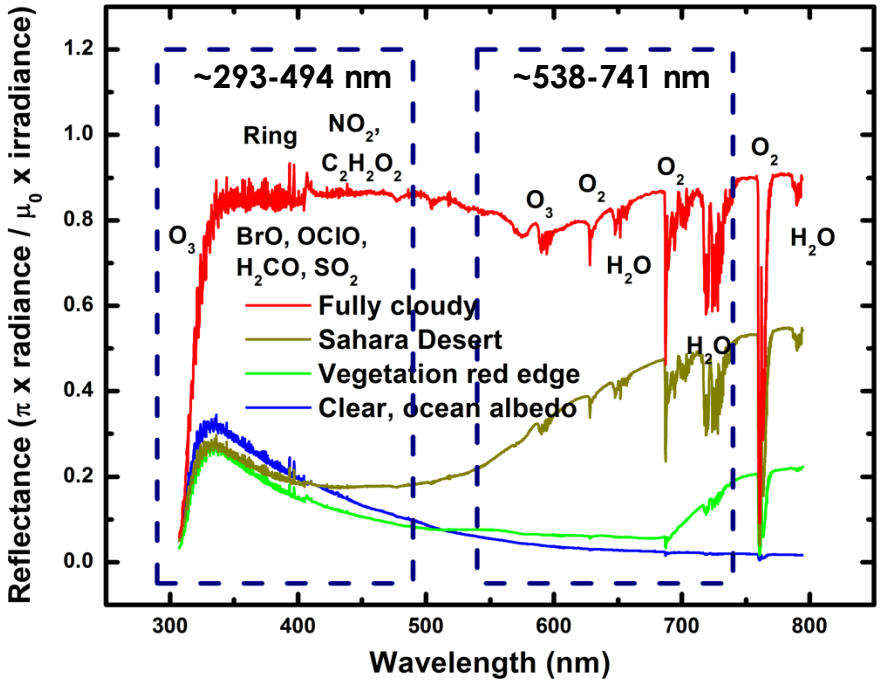


TEMPO Quick Facts

- NASA's first EVI selected in 2012 and joint project with Smithsonian Astrophysical Observatory
- Hyperspectral UV/Visible spectrometer sensitive to policy-relevant trace gases (NO_2, SO_2, O_3) and aerosols
- TEMPO Field of Regard (FoR) covers greater North America

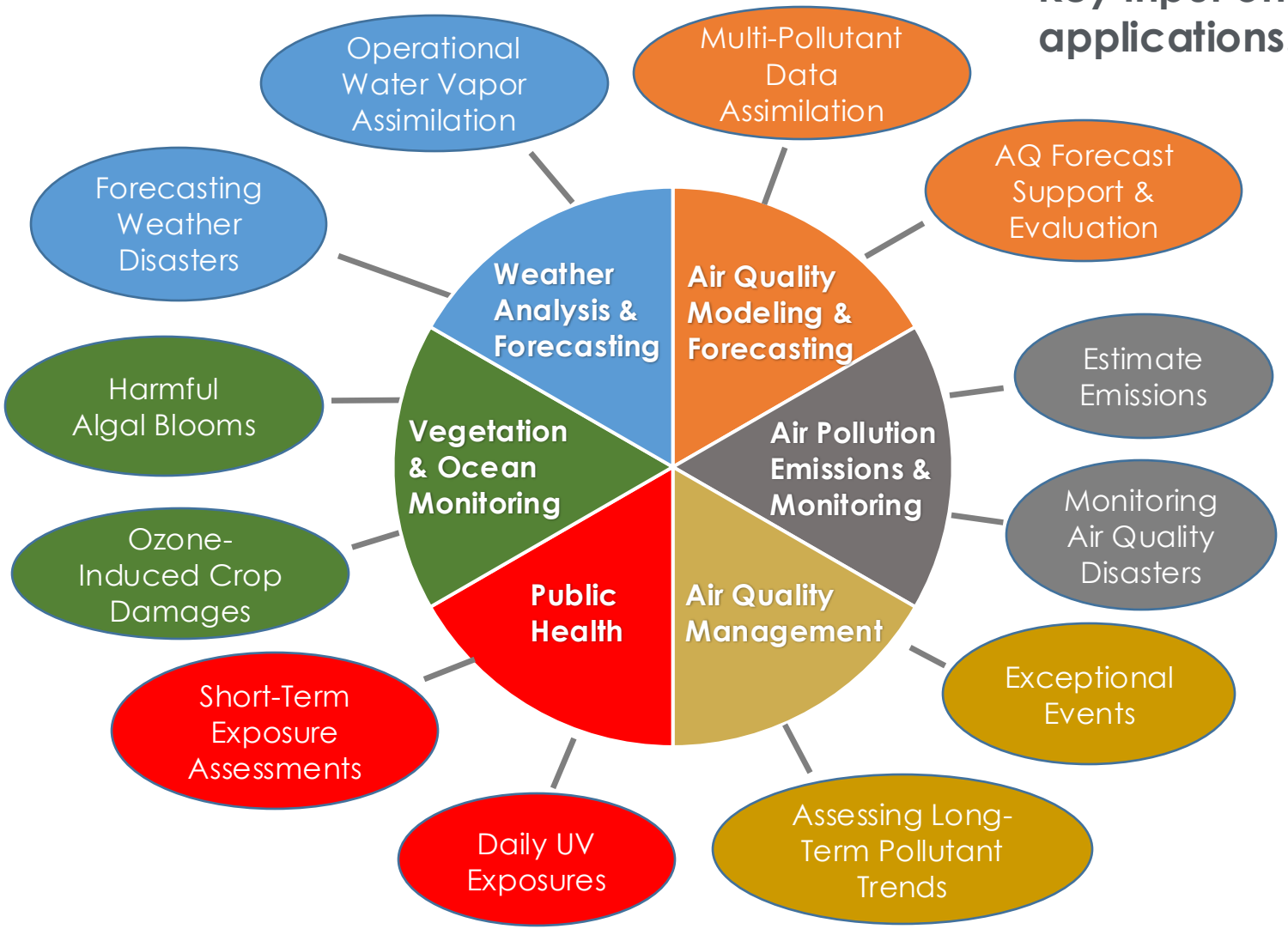


- April 7, 2023: Launched into GEO orbit on SpaceX rocket
- August 2, 2023: First Light operations
- October 19, 2023: Nominal operations commence
- June 19, 2025: Base mission ended, but extended through September 2026

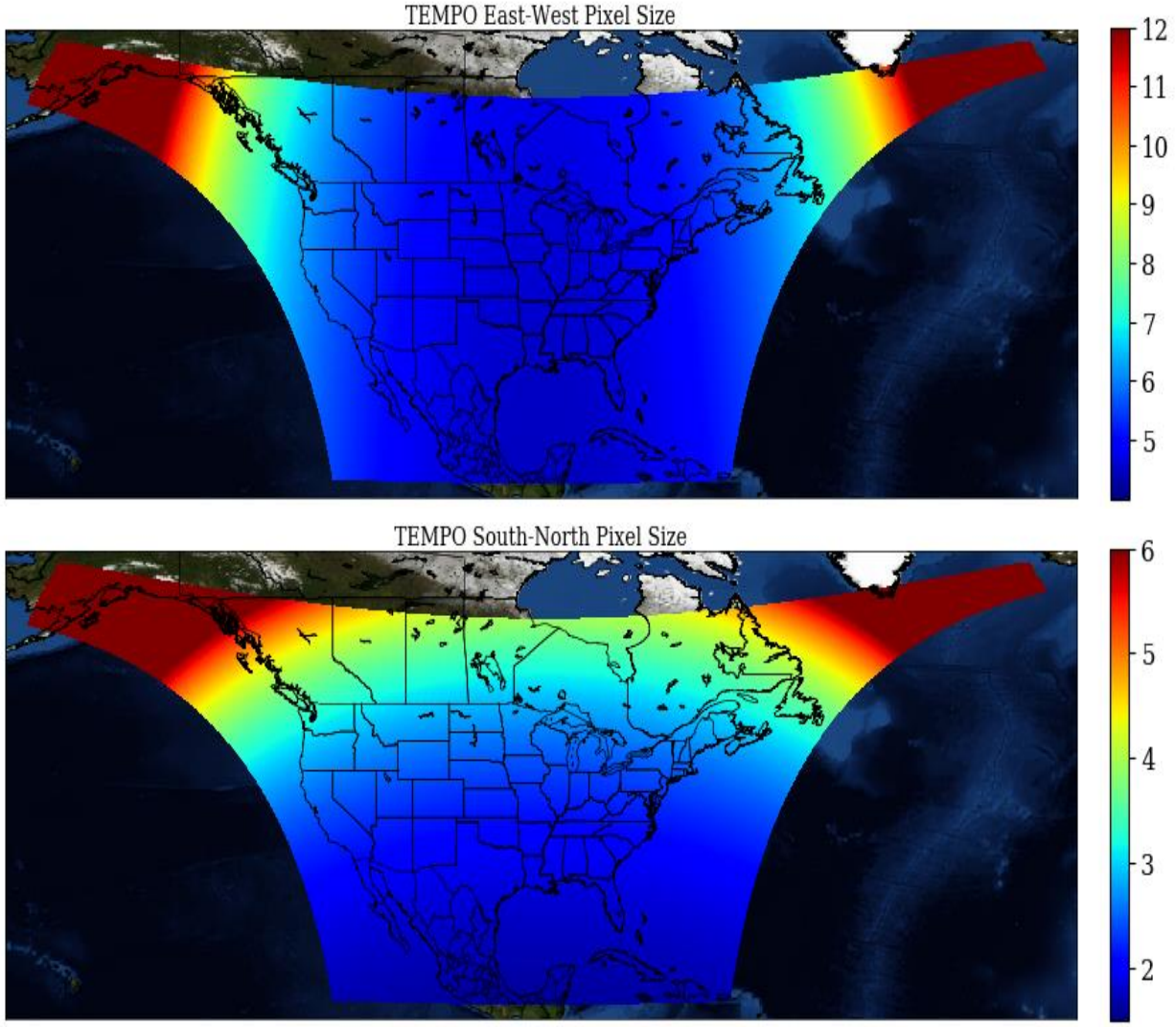


Core Applications of TEMPO

Early adopters provided key input on TEMPO core applications.



TEMPO's Footprint Size Across the Field of Regard



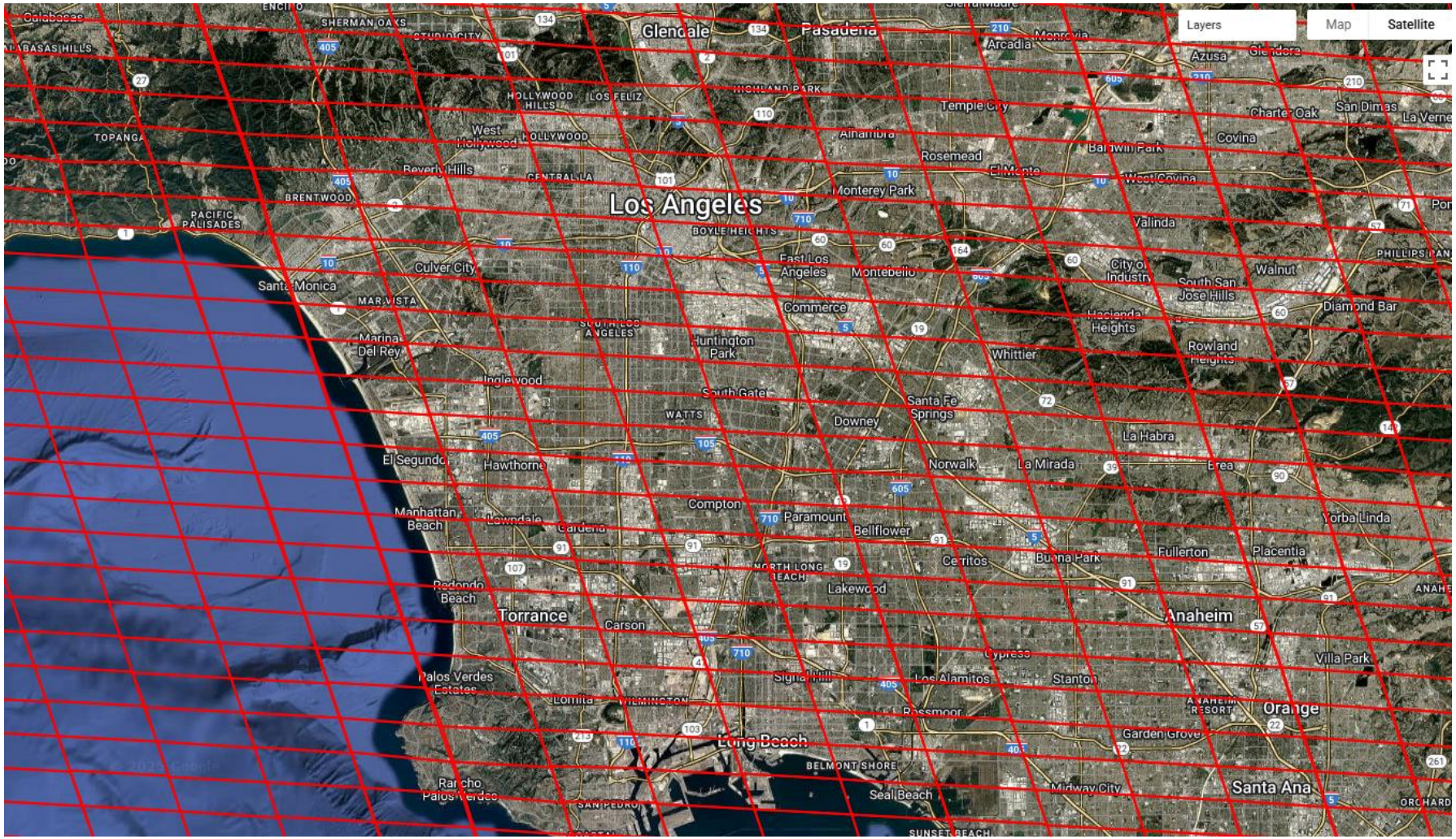
@Center of Field of Regard

33.7°N, 91.7°W

Location	N/S (km)	E/W (km)	VZA (°)
33.7°N, 91.7°W	2.0	4.8	39.1
Washington, DC	2.3	5.1	47.3
Seattle	3.3	6.5	62.5
Los Angeles	2.2	5.8	49.0
Boston	2.5	5.4	52.9
Miami	1.8	4.8	32.4
San Juan	1.7	5.4	35.8
Mexico City	1.6	4.7	24.6
Can. Oil Sands	4.2	5.7	67.4
Juneau	5.9	9.1	75.9

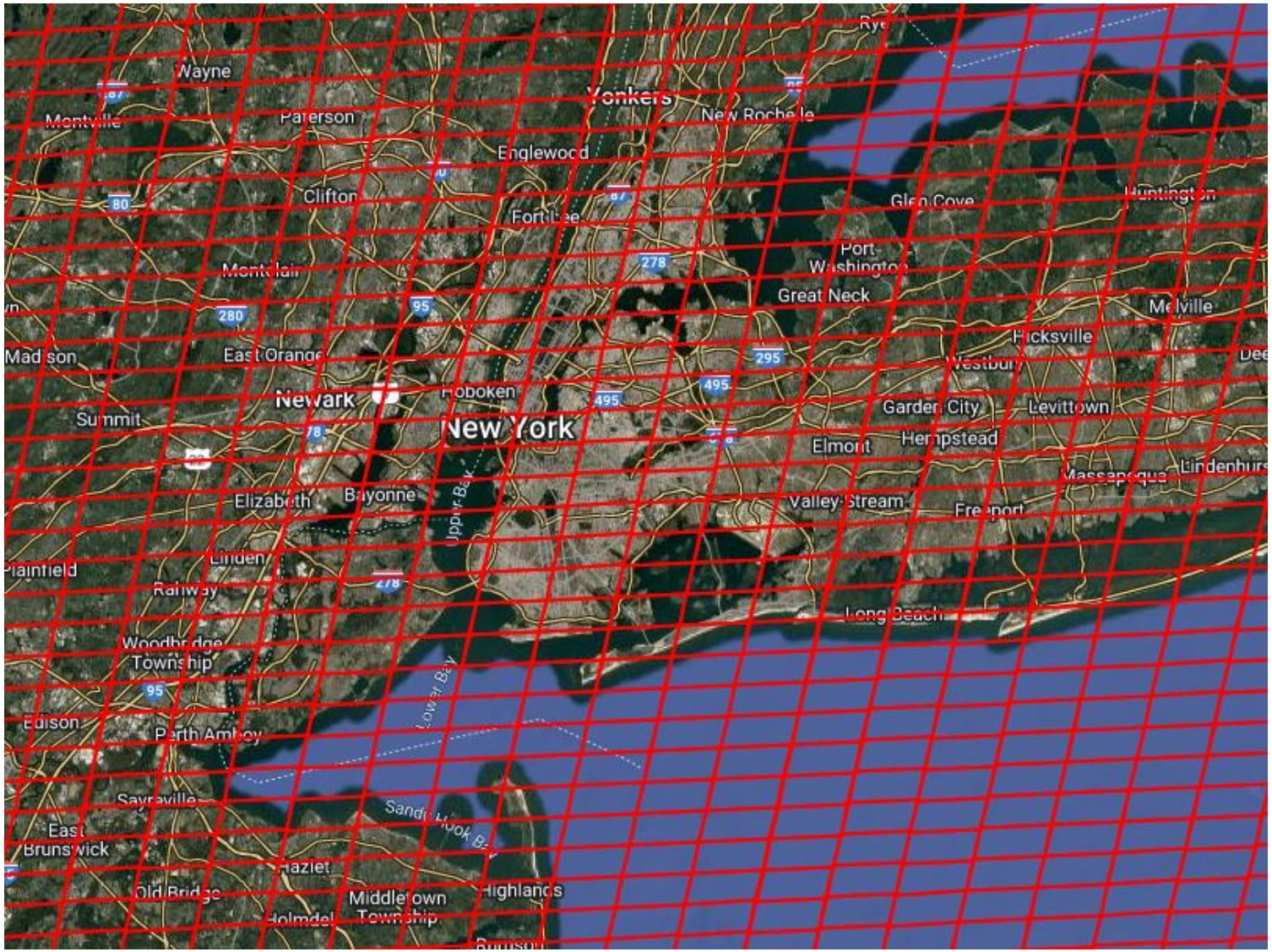
TEMPO's Footprints Across Los Angeles

~ 2.2 km x 5.8 km



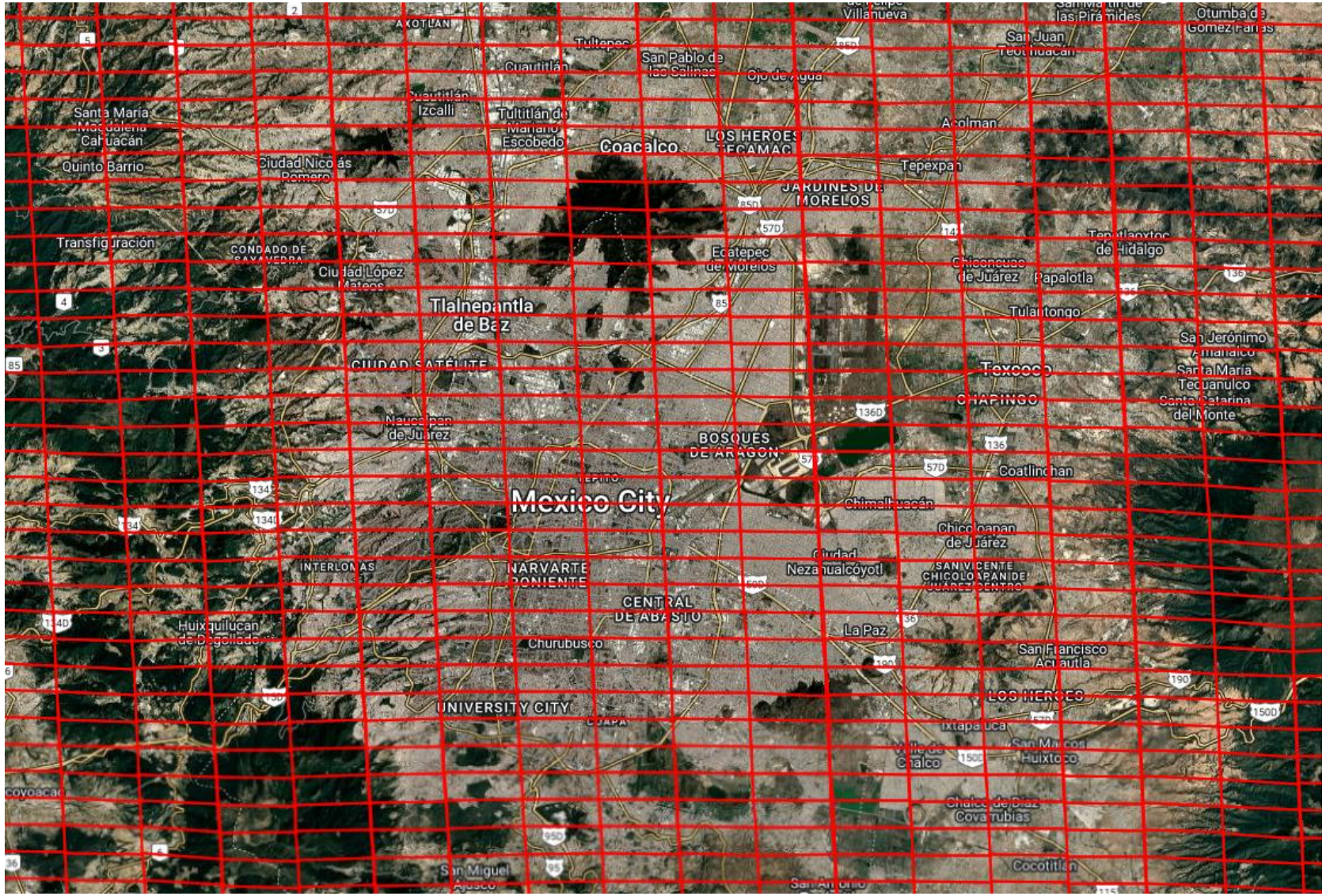
TEMPO's Footprints Across New York City

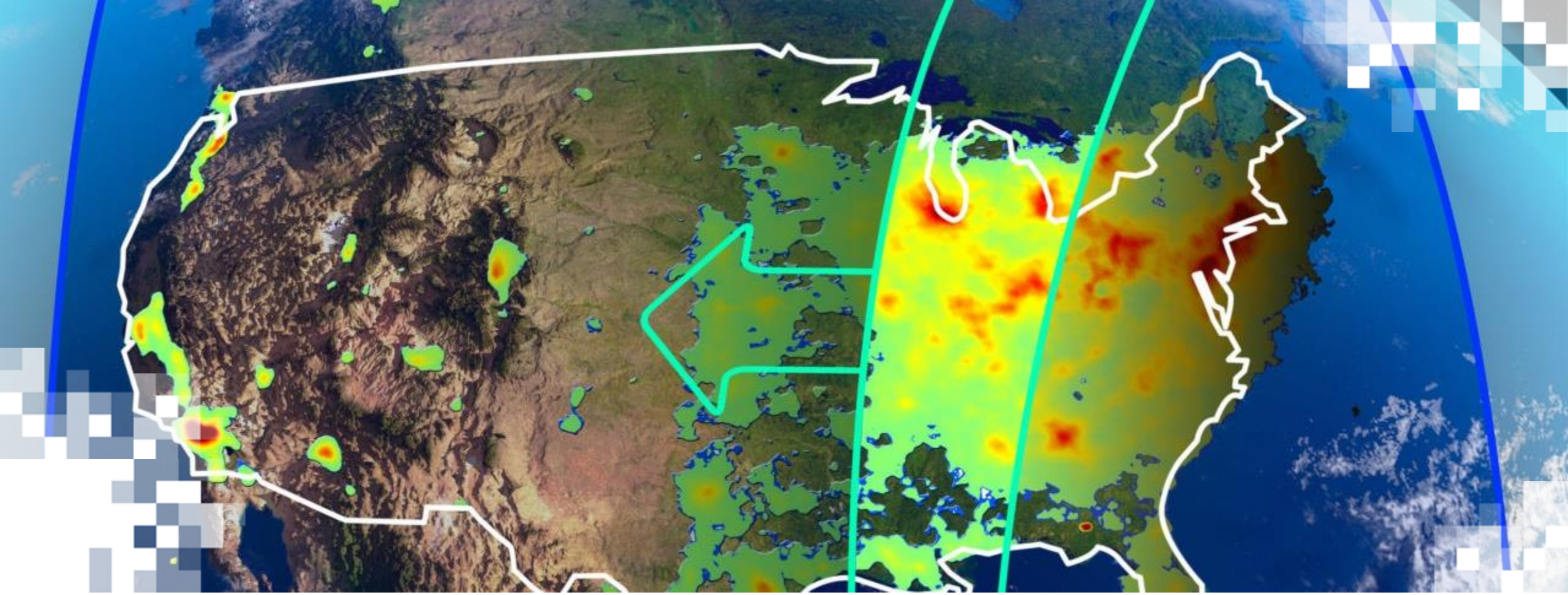
~ 2.4 km x 5.2 km



TEMPO's Footprints Across Mexico City

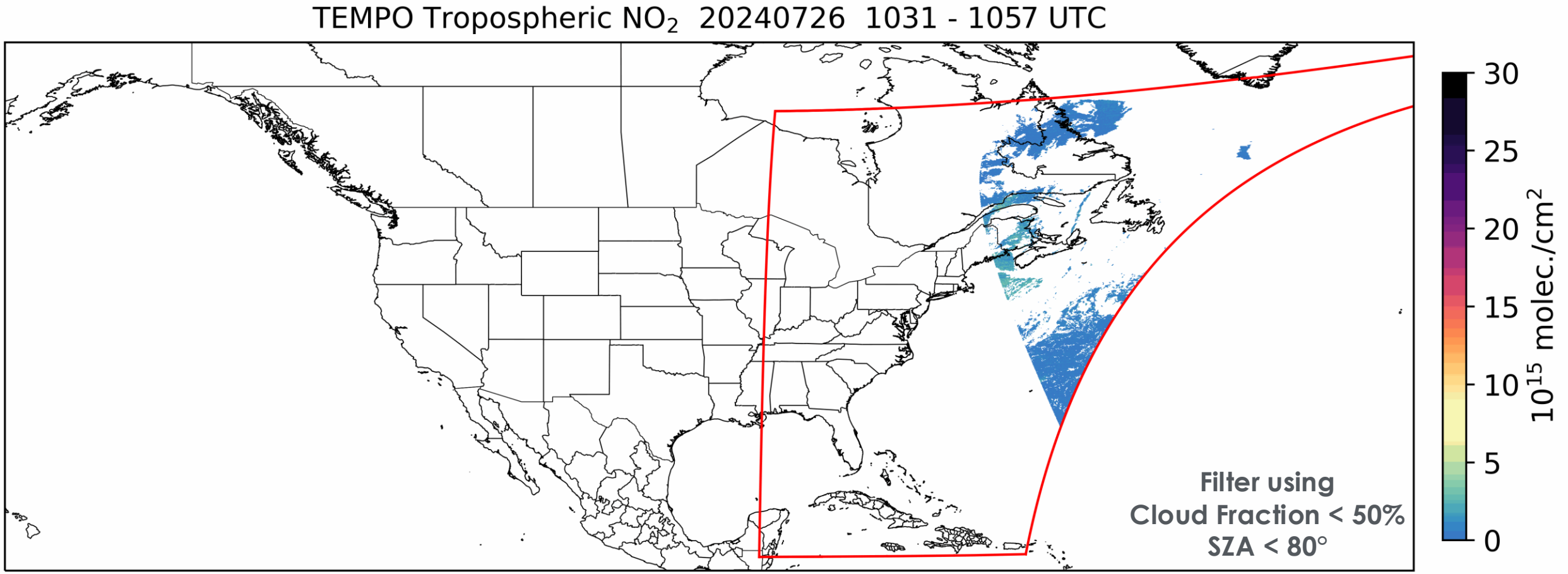
~ 1.6 km x 4.7 km





TEMPO Operational Scan Modes

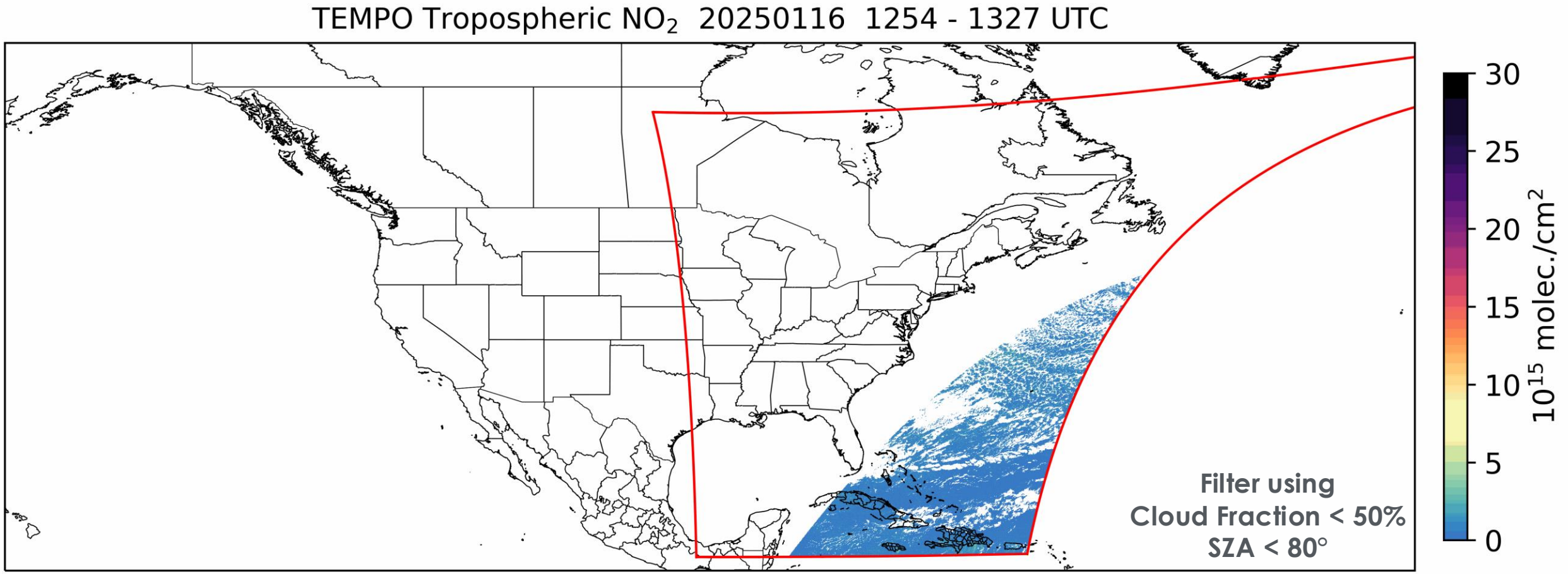
Nominal Operational Scans – Example for July 26, 2024



Nominal operations consist of both:

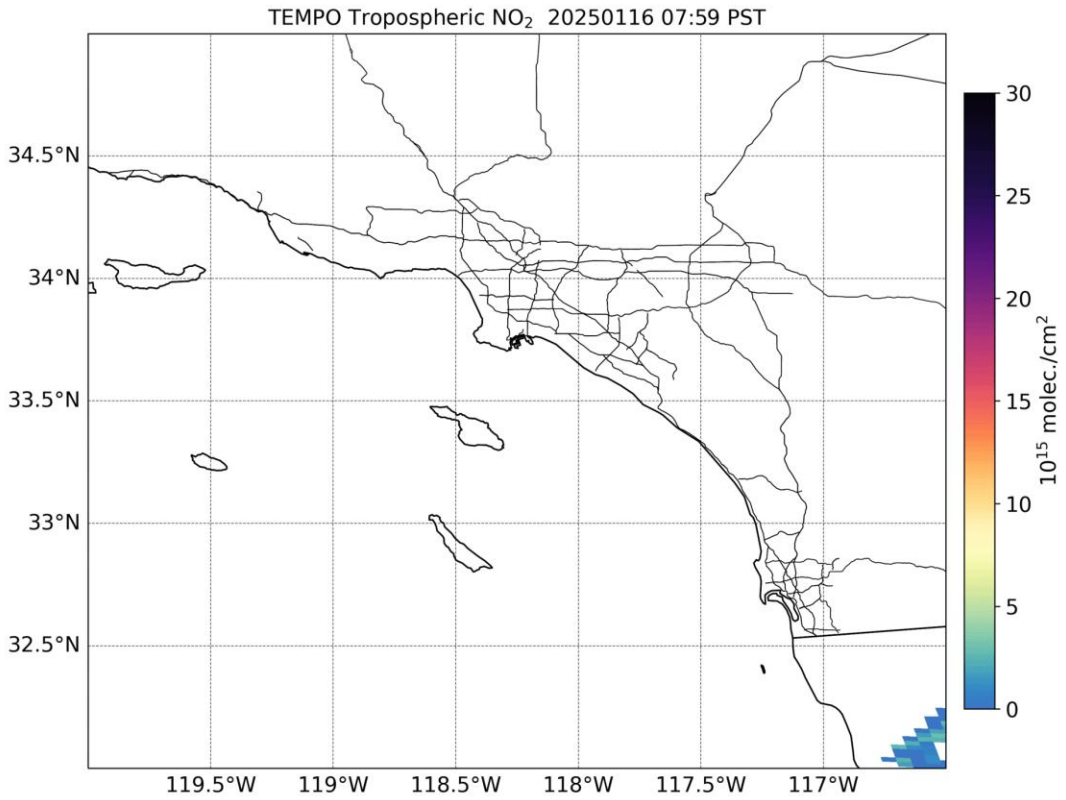
- Standard (hourly) daytime scans over full FoR and
- "Optimized", shorter (30-40 minute) morning and afternoon scans over daylight portions of FoR

Special Operation Scans – Example for January 16, 2025

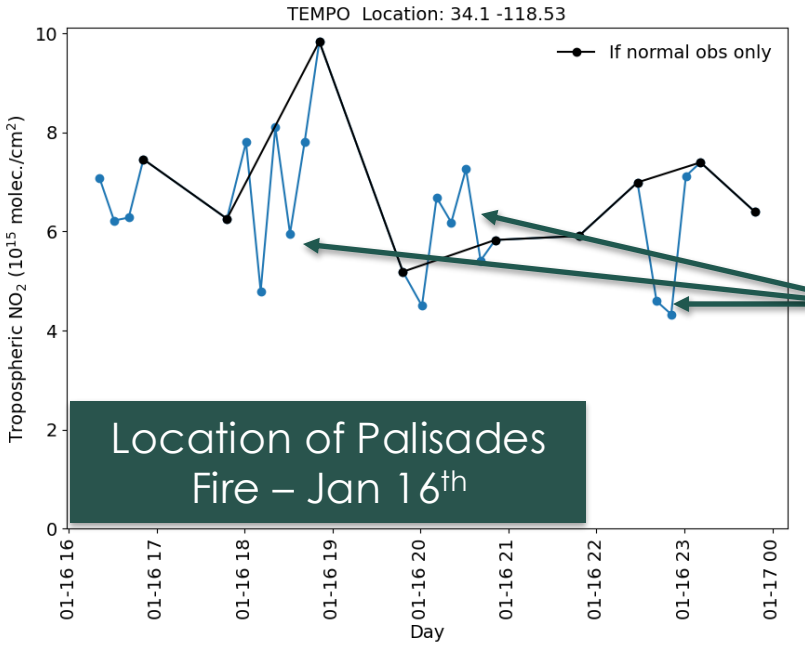


- Special operations scans (~10 minutes) were conducted for a 4-day period starting Jan. 16-19, 2025, over the West Coast every other hour throughout the daytime.

Special Operation Scans – Example for January 16-17, 2025

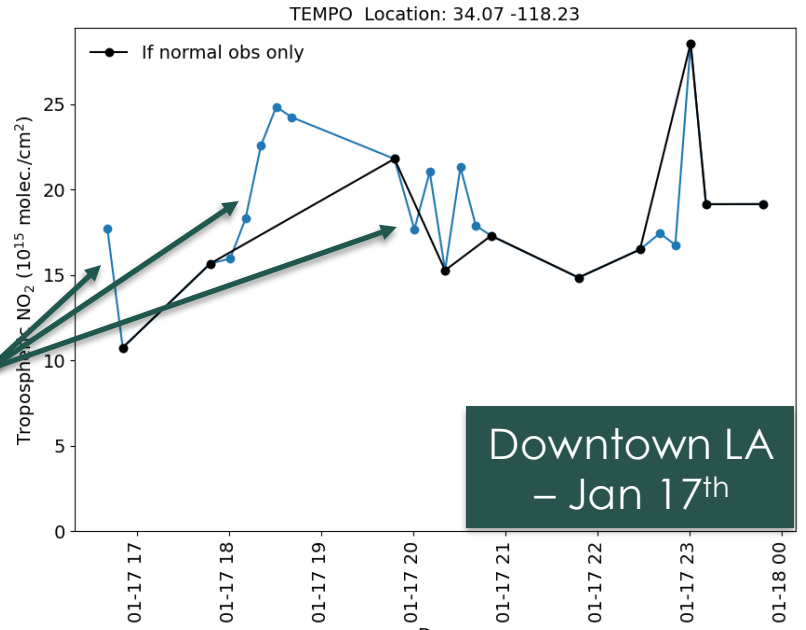


- Special scans observed variability in NO_2 columns which were not captured by standard scans.



Smoldering from the Palisades wildfire likely contributing to the NO_2 fluctuations observed by the special operations

Special scans observed strong NO_2 variability in downtown Los Angeles the morning of Jan. 17th, which was not captured by standard scans



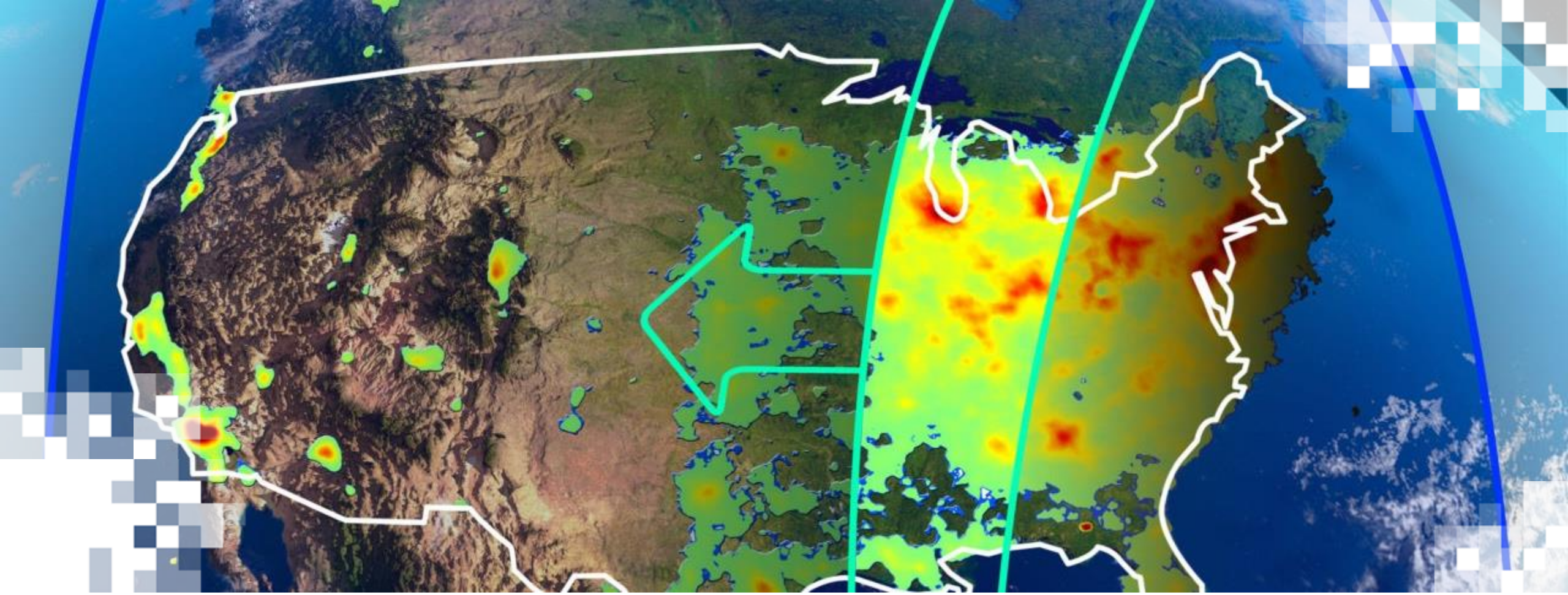
TEMPO Operations Log

- Days when special operations were conducted can be found in the TEMPO [Operations Log]

QR Code for TEMPO Operations Log

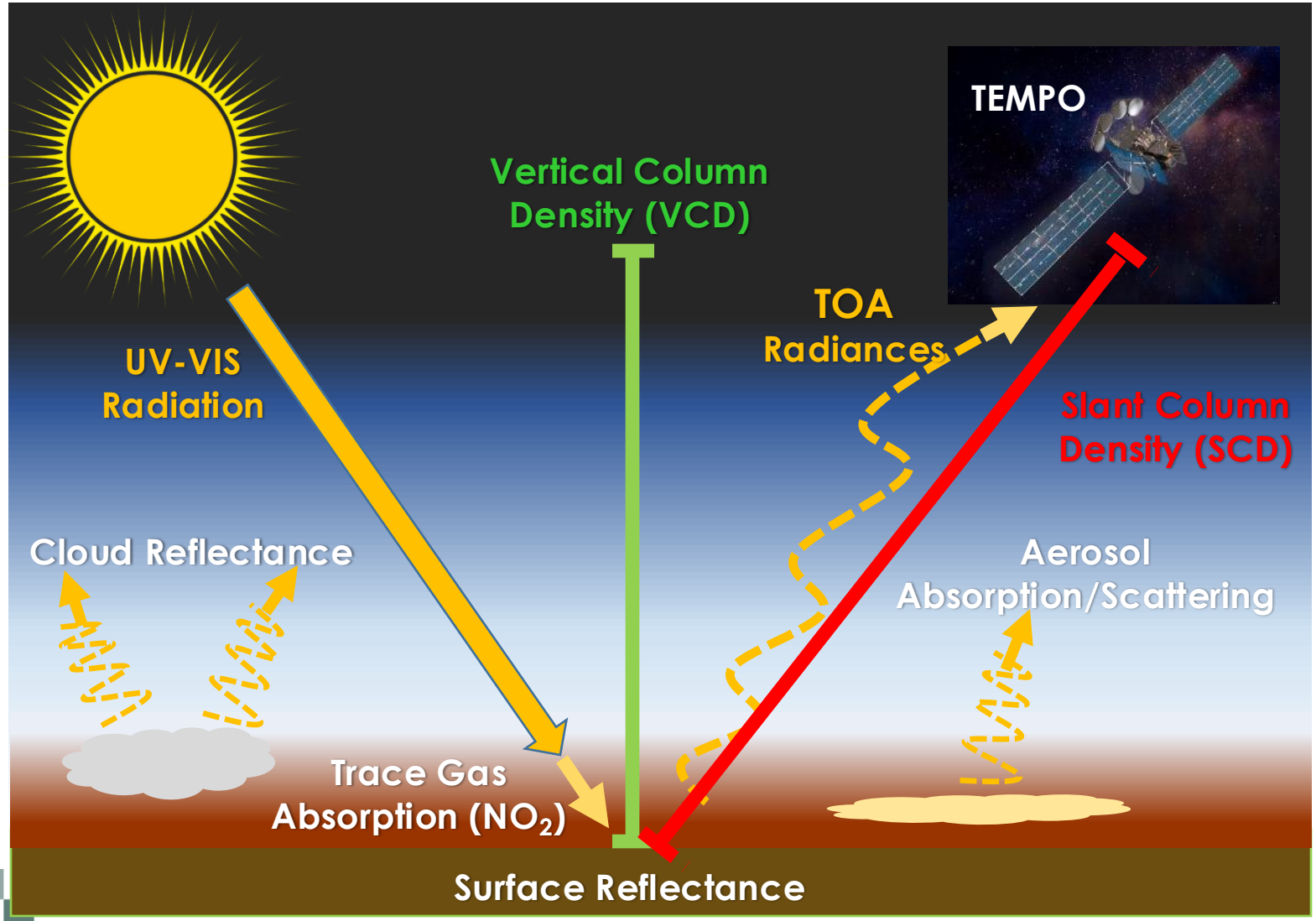
Screen capture of section of operations log denoting a special operation:

01/16/2025	**Solar Cal WD** Citilights measurements, east-coast twilight scans are 6.27 sec exposures and will cover only the region from just eastward of Cape Cod to just westward of Chicago, yielding 4 scans per session. The west-coast twilight scans are ~12.6 sec (2 coadds), 01/16-01/22.
01/16-01/19/2025	**Special obs**: 10-min scans of the LA region on 16-19 Jan (Thu-Sun). alternating hourly with FoR scans.
01/23/2025	**Solar Cal WD** Citilights measurements, area scans (~12 sec, 2 coadds), 01/23-01/29.



TEMPO Trace Gas Products

How does TEMPO observe trace gas pollutants?



TOA = Top-Of-Atmosphere

- TEMPO's trace gas products are reported as **Vertical Column Densities (VCDs)** derived from satellite-measured **TOA Radiances**, **Slant Column Densities (SCDs)**, and sun and satellite viewing conditions
- **VCDs** provide information on the target trace gas within a standard-ized atmospheric column.

Deriving Slant to Vertical Column Data in TEMPO Retrievals

$$VCD = \frac{SCD}{AMF}$$

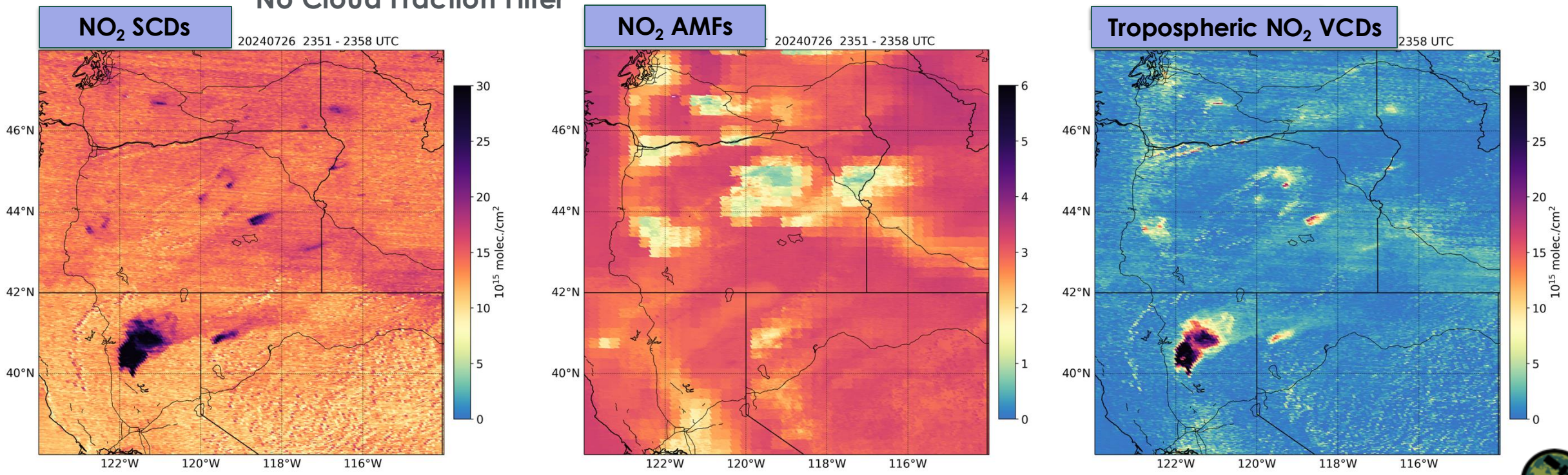
SCD – Slant Column Density

AMF – Air Mass Factor

VCD – Vertical Column Density

- TEMPO's trace gas retrievals are retrieved through the following process:
  - Derive **Slant Column Densities (SCDs)** from measured TOA radiances
  - **Vertical Column Densities (VCDs)** calculated using **Air Mass Factors (AMFs)**
  - **AMFs** calculated offline using radiative transfer model and input from a global 3-D atmospheric composition model [i.e., Goddard Earth Observing System Composition Forecasting (GEOS-CF) System]

No Cloud Fraction Filter

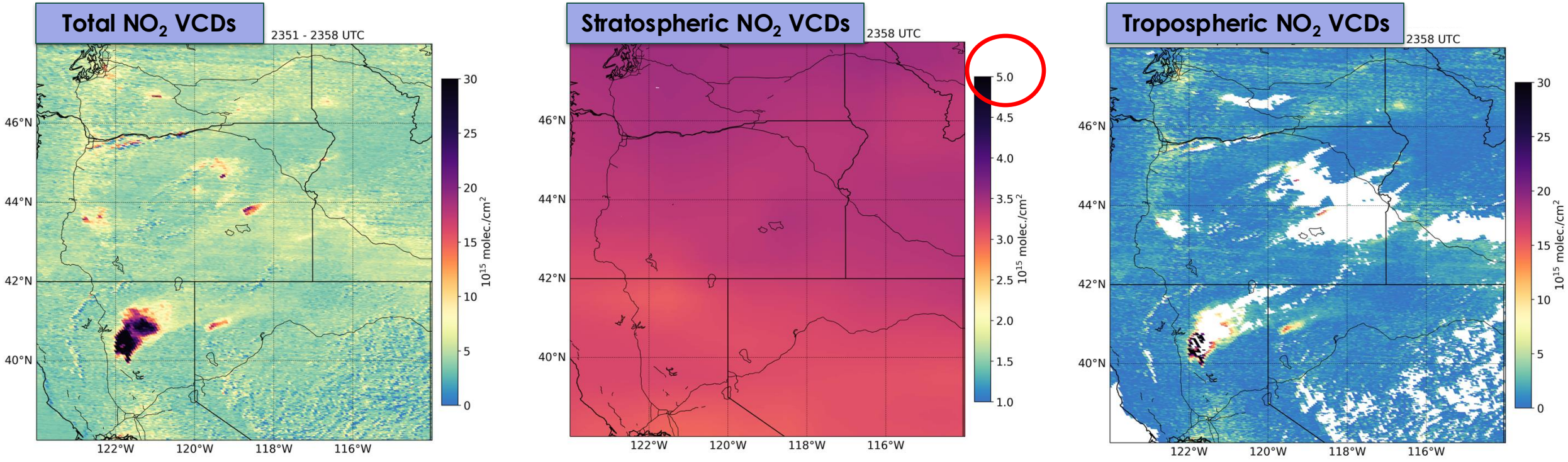


Stratosphere-Troposphere Separation in TEMPO Retrievals

- The stratosphere-troposphere separation method estimates the stratospheric NO_2 VCDs based on the SCDs, AMFs, and NO_2 columns from the GEOS-CF forecast (a priori).
- The stratospheric NO_2 VCDs are then subtracted from the total NO_2 VCDs to arrive at the tropospheric NO_2 VCDs. (note different scale, middle figure).
- Quality assurance variables can be used to filter lower quality (i.e., larger uncertainty) data.

No Cloud Fraction Filter

Filter using
Cloud Fraction < 50%
SZA < 80°



TEMPO Data Products: Baseline + SNWG NRT + NOAA Aerosol

Level	Product	Filename	Source	Notable File Variables	Resolution (km^2) *
L1	Radiance	RAD	Baseline + SNWG	Calibrated, Geolocated Radiances	2.0 x 4.75
L2	Cloud	CLDO4	Baseline + SNWG	Cloud Fraction, Cloud Pressure	2.0 x 4.75
	Ozone Total Column	O3TOT	Baseline	Total Column O_3, UV Aerosol Index, Quality Flag	2.0 x 4.75
	Nitrogen Dioxide	NO_2	Baseline + SNWG	Tropospheric VCD, Total VCD, Cloud Fraction, Main Data Quality Flag	2.0 x 4.75
	Formaldehyde	HCHO	Baseline + SNWG	Total VCD, Cloud Fraction, Main Data Quality Flag	2.0 x 4.75
	Ozone Profile	O3PROF	Baseline	O_3 Profile, Tropospheric O_3 column, Cloud Fraction	**8.0 x 4.75**
	AOD & ALH	AODALH	NOAA	AOD, ALH, Data Quality Flag	2.0 x 4.75
	Aerosol Detection Product (ADP)	ADP	NOAA	Dust/Smoke Discrimination, UV Absorbing Aerosol Index	2.0 x 4.75
L3	Same as **L2**	Same as **L2**	Baseline +SNWG	Same Variables as **L2**	0.02°x 0.02°*
L4	Surface $PM_{2.5}$	PM25	NOAA	Hourly $PM_{2.5}$ Estimation	2 km x 2 km

AOD: Aerosol Optical Depth

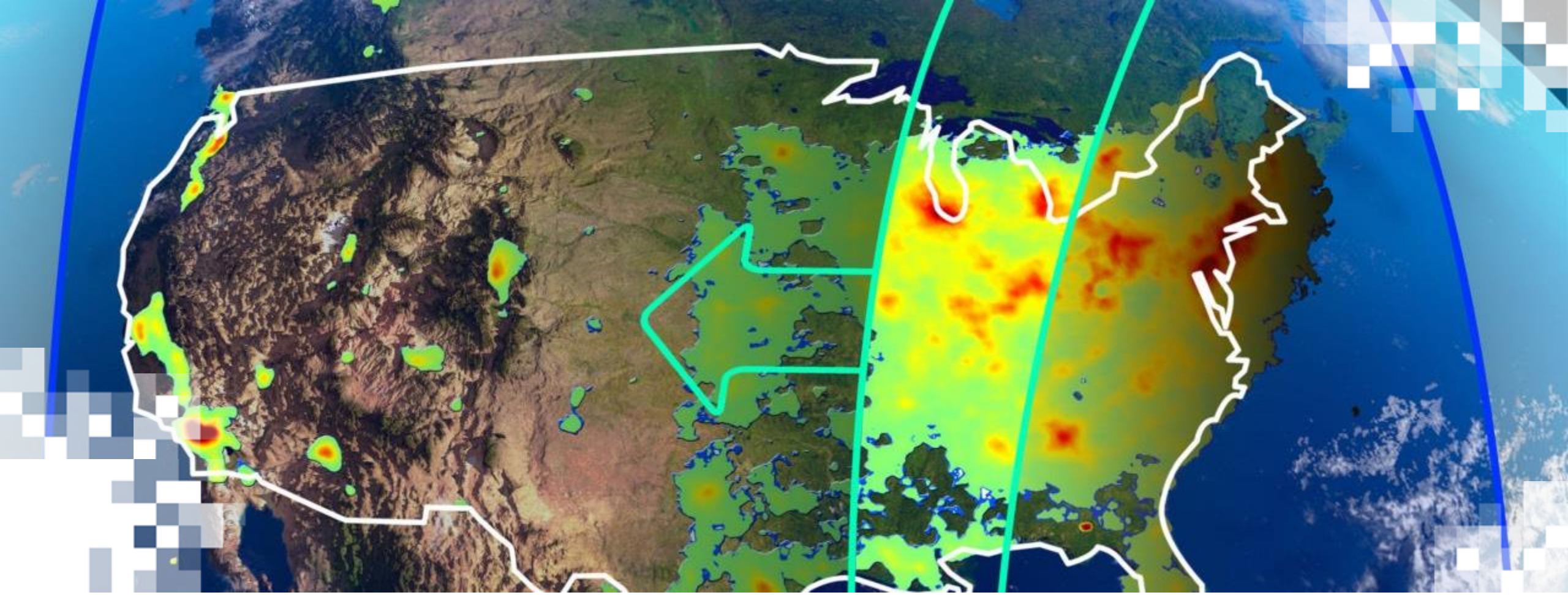
ALH: Aerosol Layer Height

SNWG: Satellite Needs Working Group (low latency version)

NOAA: National Oceanic and Atmospheric Administration

* @Center of Field of Regard 33.7°N, 91.7°W

* O3PROF L3 Product → 0.04 x 0.04° Resolution



TEMPO Level 2 vs. Level 3 Products

TEMPO Level 3 Product Methodology

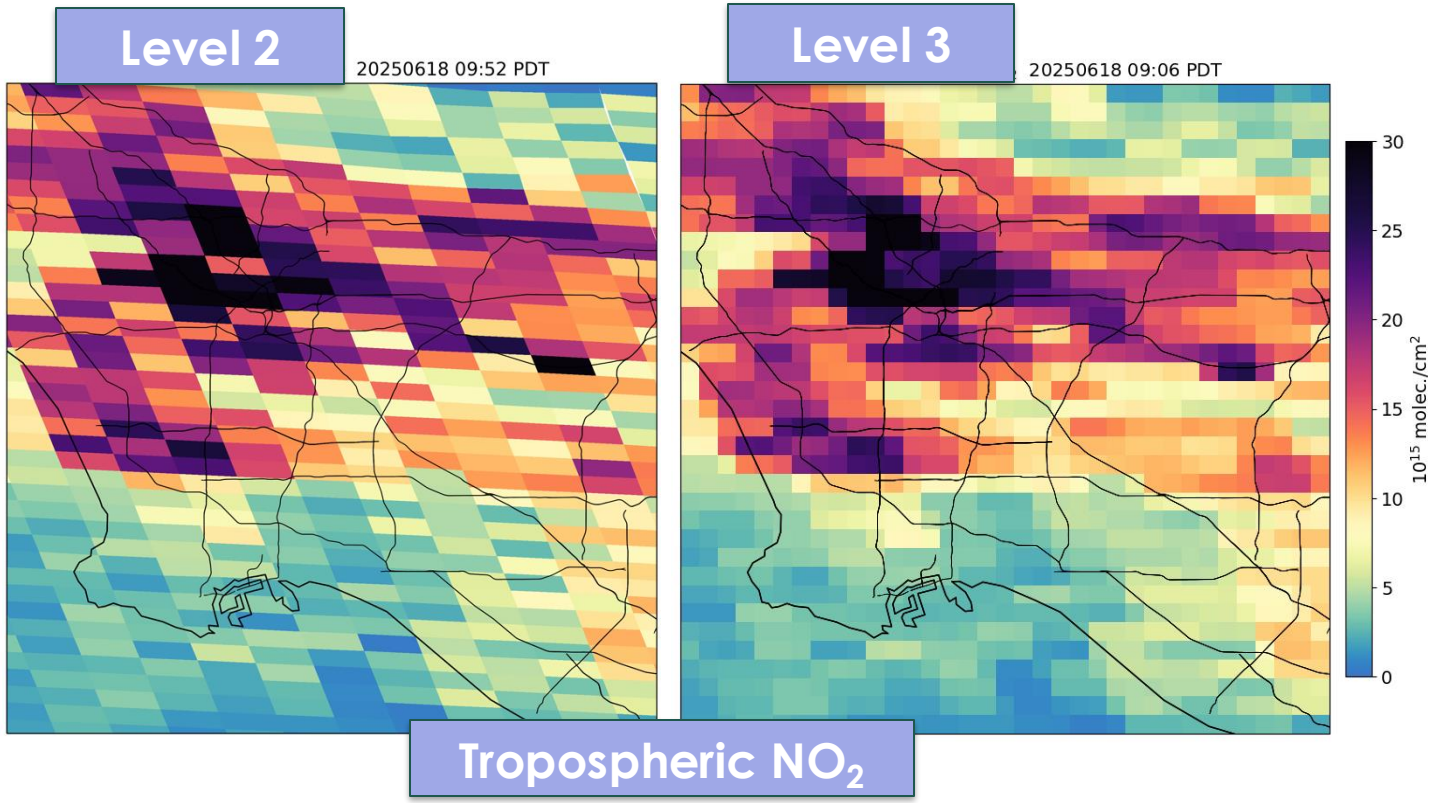
- Level 3 data products area created from regridded Level 2 data
  - area-weighted approach to a 0.02°grid for NO_2, HCHO, and total O_3, and 0.04° grid for O_3 profile product
- The method (see equation below) is purely geometric regridding where the contributions to a grid point are weighted by the geometric area of overlap of each level 2 pixel (footprint).

$$V(j) = \frac{\sum(a(j,i) * v(i))}{\sum a(j,i)}$$

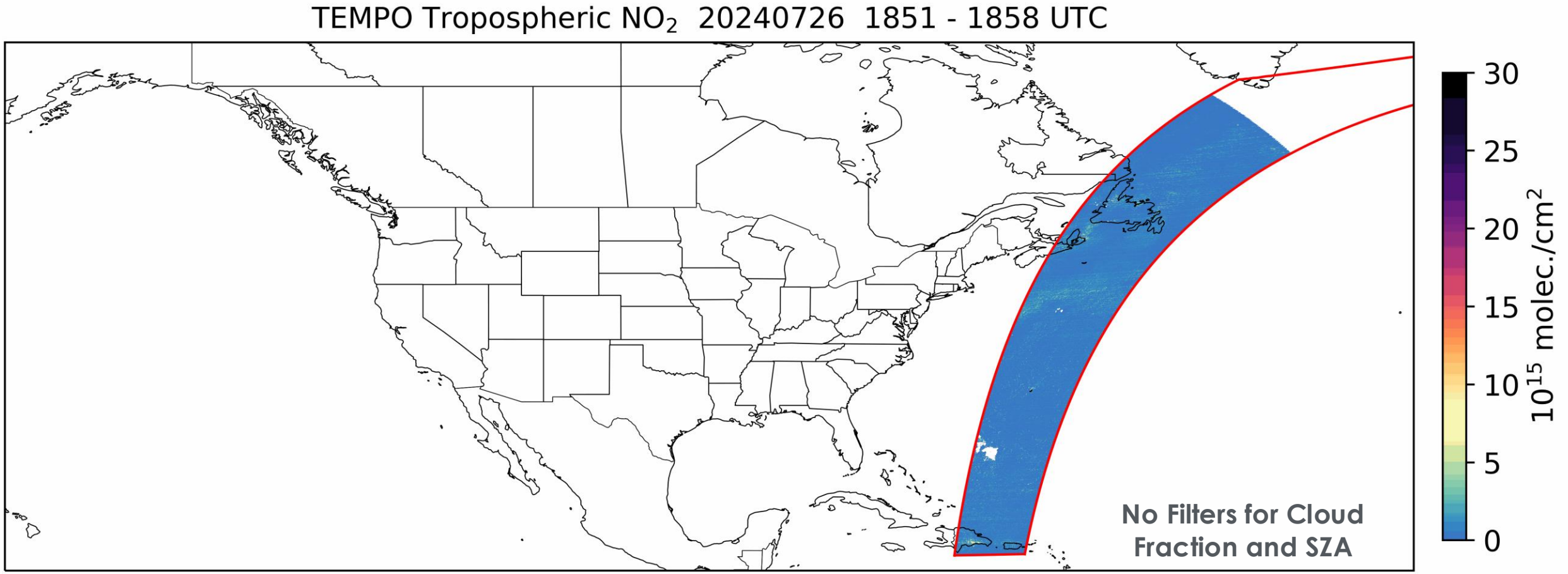
a(j,i) = Polygonal area where Level 2 pixel, i, overlaps Level 3 grid point, j

v(i) = Value of Level 2 pixel, i

V(j) = Computed area-weighted mean value for Level 3 grid point, j

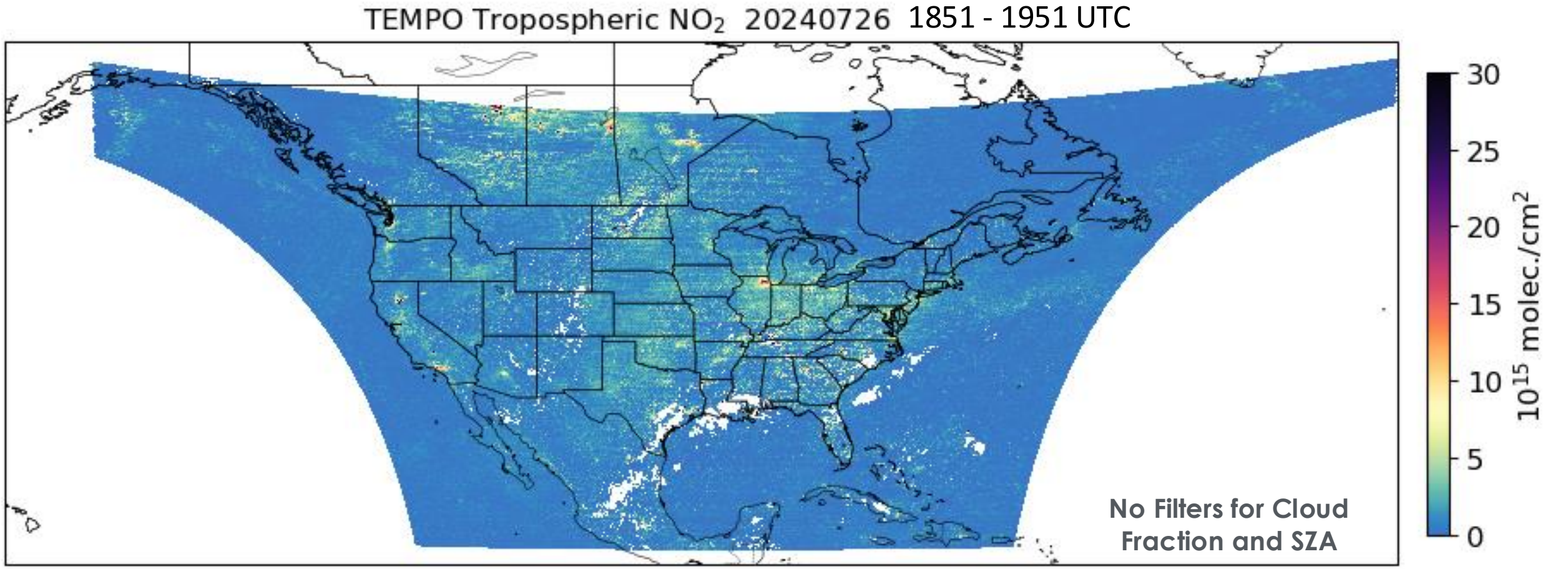


Level 2 Granule Data Across TEMPO FoR – July 26, 2024



- 9 different level 2 data granules compose the full TEMPO FoR during the hourly, standard operations.
- **Note: This changed from 10 different data granules starting September 29, 2023.**

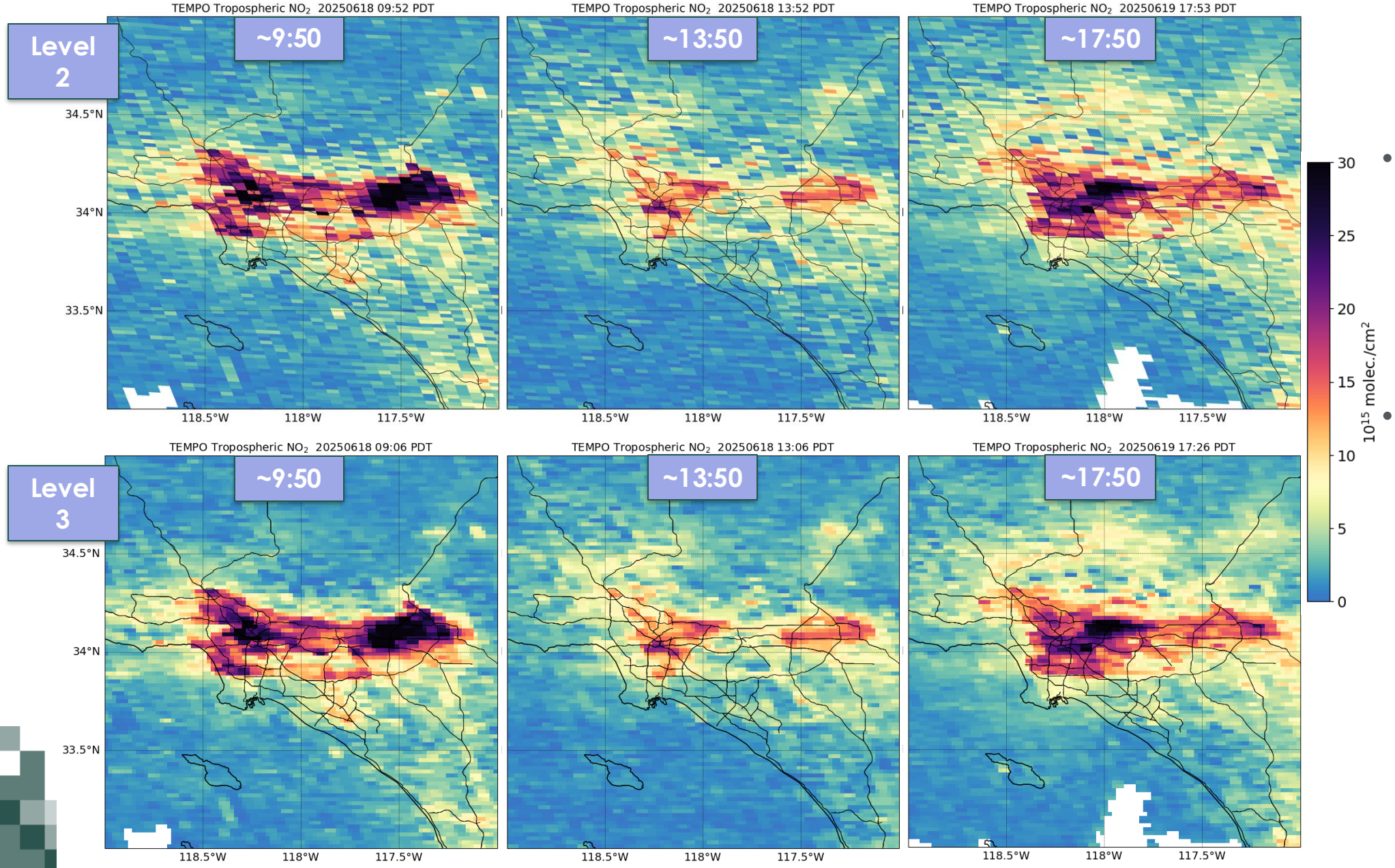
Level 3 Scan Data Across TEMPO FoR – July 26, 2024



- Level 2 granules are regridded using an area-weighted approach onto a regular 0.02° grid across the TEMPO FoR to produce the level 3 scan files.

TEMPO Level 2 vs. Level 3 NO_2 Comparison

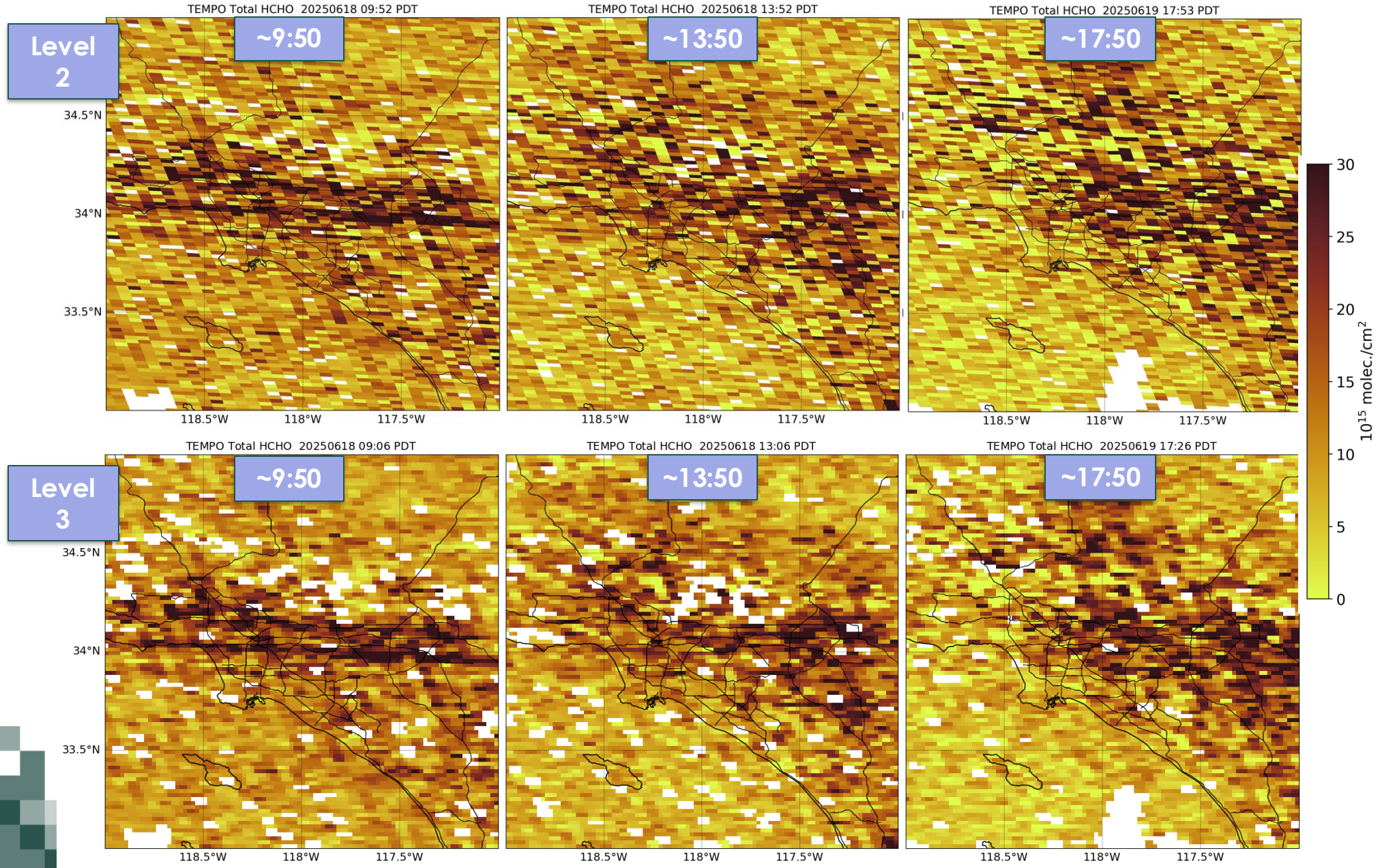
Filter using
Cloud Fraction < 50%
SZA < 80°



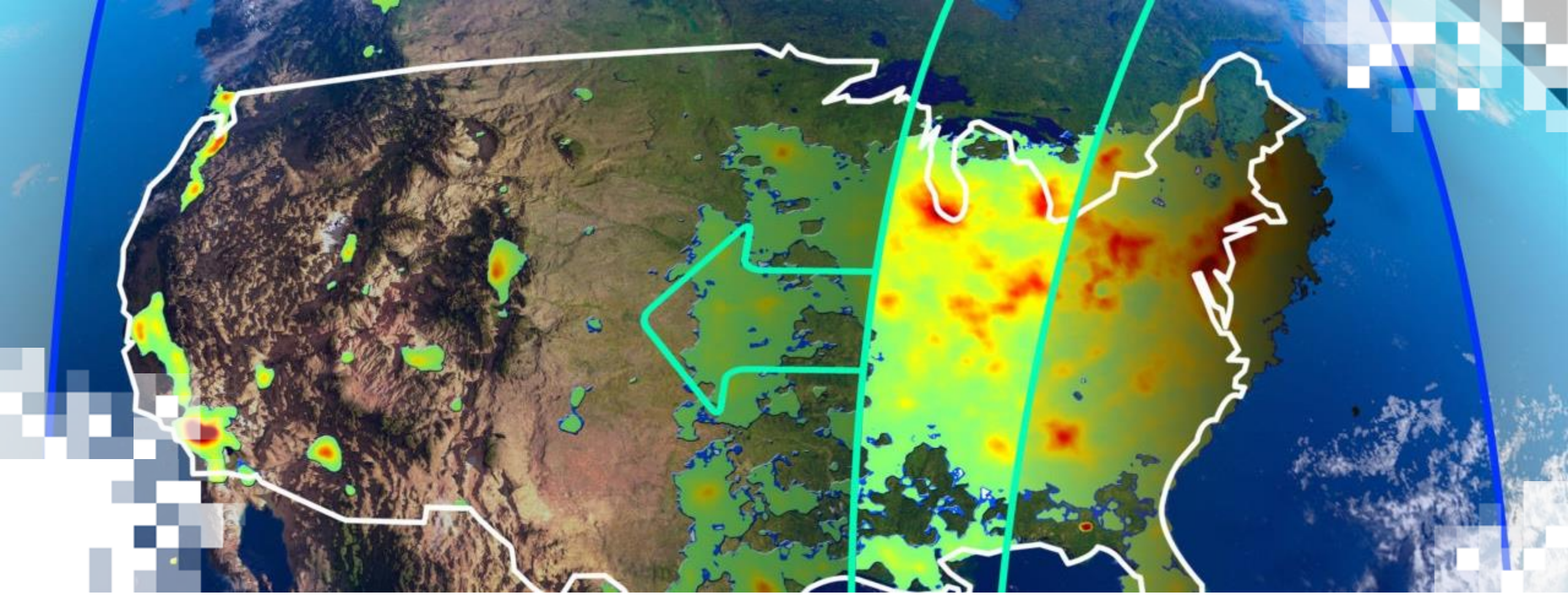
- Level 3 NO_2 maps have a smoother appearance compared to the level 2 NO_2 maps.
- Areas of large NO_2 gradients and fine-scale hot spots can appear noticeably different between the level 2 and level 3 maps.

TEMPO Level 2 vs. Level 3 HCHO Comparison

Filter using
Cloud Fraction < 50%
SZA < 80°



- The level 3 HCHO maps are smoother, similar to the NO_2 comparison.
- HCHO retrieval is noisier than NO_2, leading to larger HCHO gradients and differences between the level 2 and level 3 data.



Quality Assurance & Data Filtering

* Latest Recommendations for Version 4 Product Release *

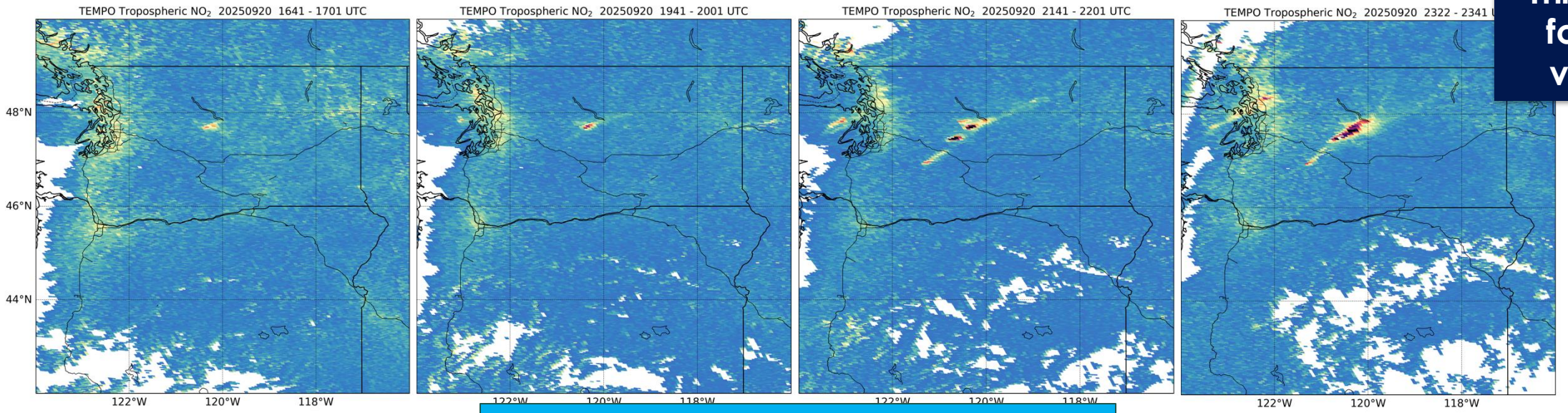
Quality Assurance Recommendations – TEMPO NO_2 & HCHO

QA Parameter	Variable (group)	Range	Qualitative Use (Worldview)	Quantitative Use
Effective Cloud Fraction (ECF)	**eff_cloud_fraction** (support_data)	0 – 1.0	< 0.5	< 0.1
Solar Zenith Angle (SZA)	**solar_zenith_angle** (geolocation)	0 – 90°	< 80°	< 70°
Main Data Quality Flag	**main_data_quality_flag** (product) **"0"** = High-quality **"1"** = Suspect due to AMF & viewing geometry **"2"** = Outlier retrievals or no successful AMF calculation	0 to 2	< 2	= 0

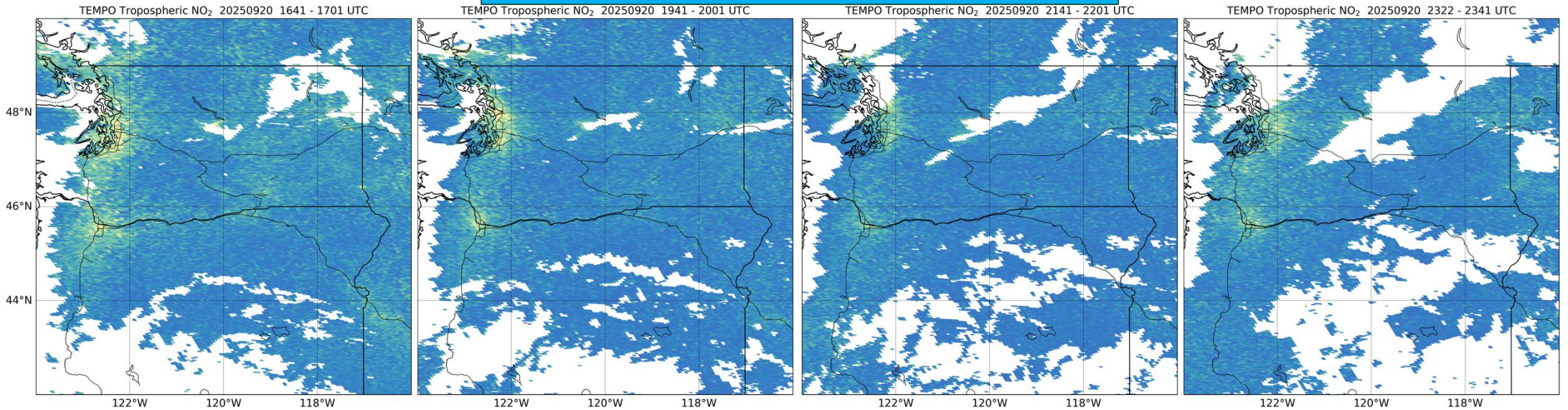
Comparing Quality Assurance Thresholds – TEMPO Tropospheric NO_2

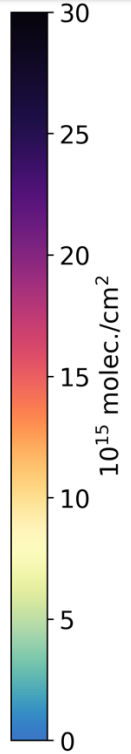
Cloud Fraction < 50%, SZA < 80°, Flag < 2

Thresholds used for Worldview visualizations



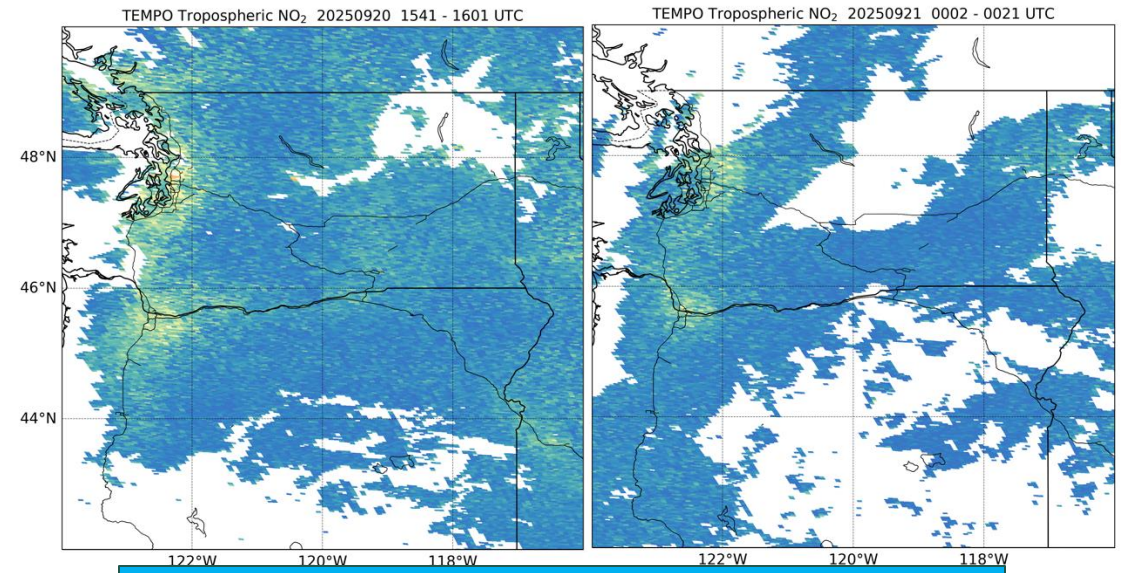
Cloud Fraction < 10%, SZA < 80°, Flag = 0



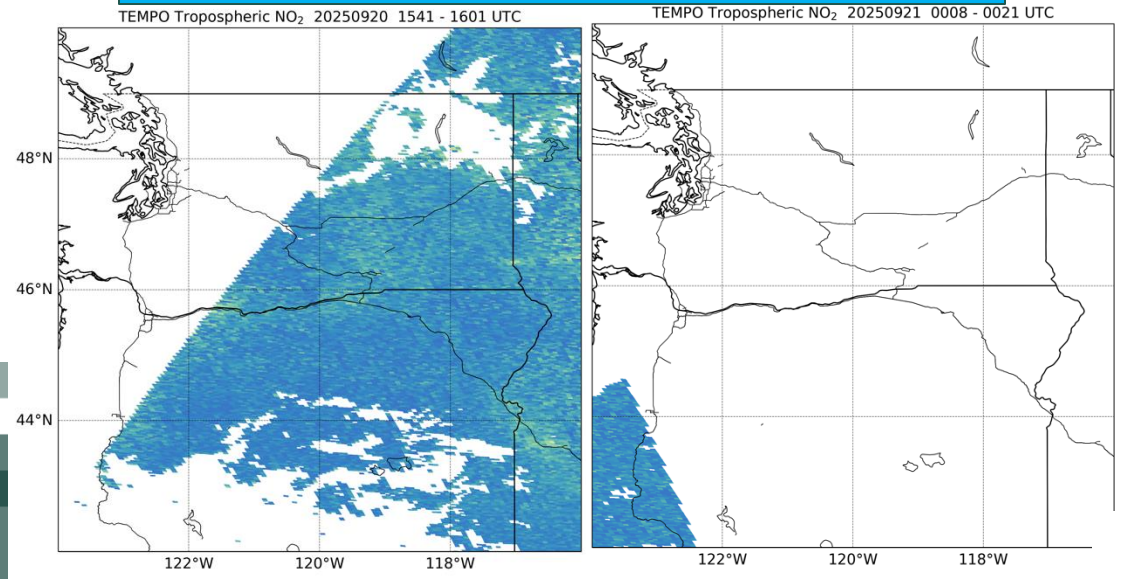


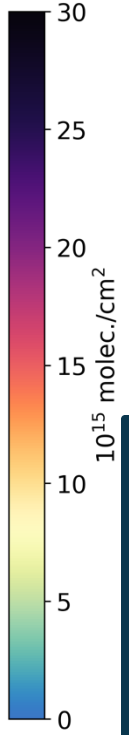
Comparing Quality Assurance Thresholds – TEMPO Tropospheric NO_2

Cloud Fraction < 10%, **SZA < 80°**, Flag = 0

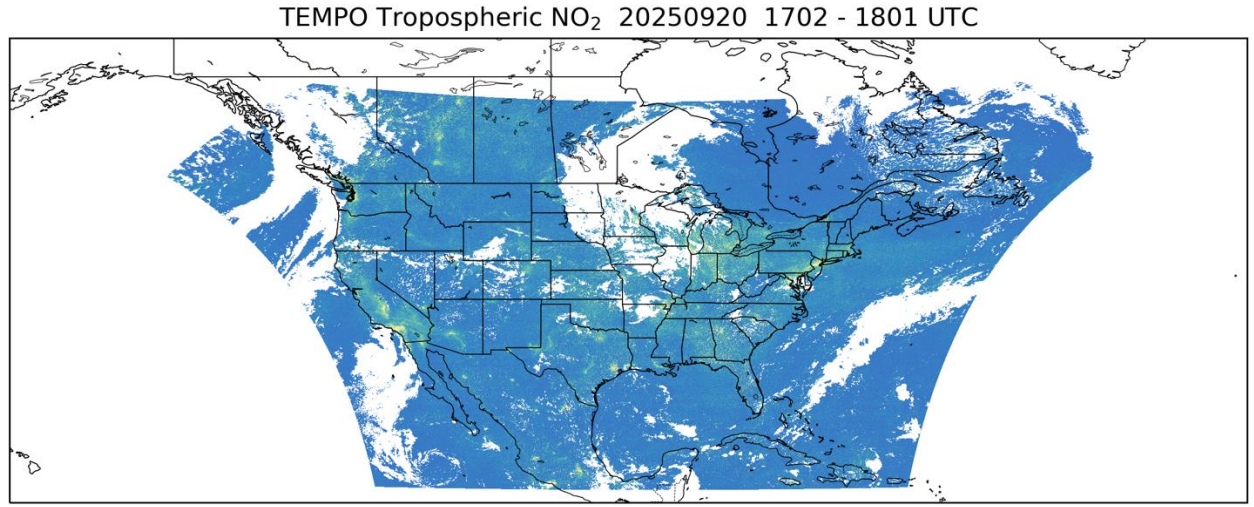


Cloud Fraction < 10%, **SZA < 70°**, Flag = 0

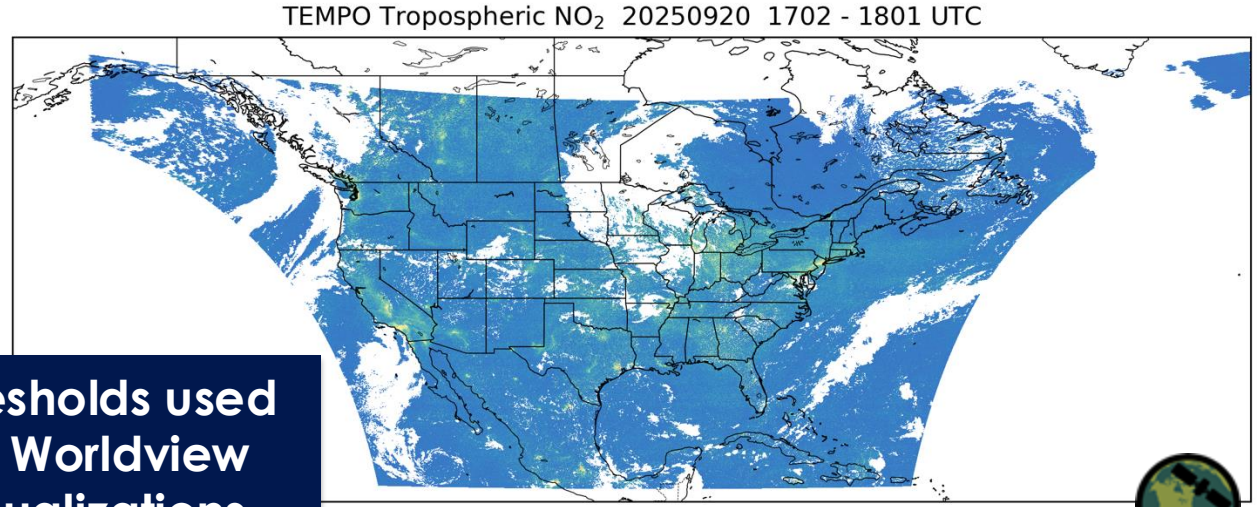




Cloud Fraction < 50%, SZA < 80°, **Flag = 0**



Cloud Fraction < 50%, SZA < 80°, **Flag < 2**



Thresholds used for Worldview visualizations

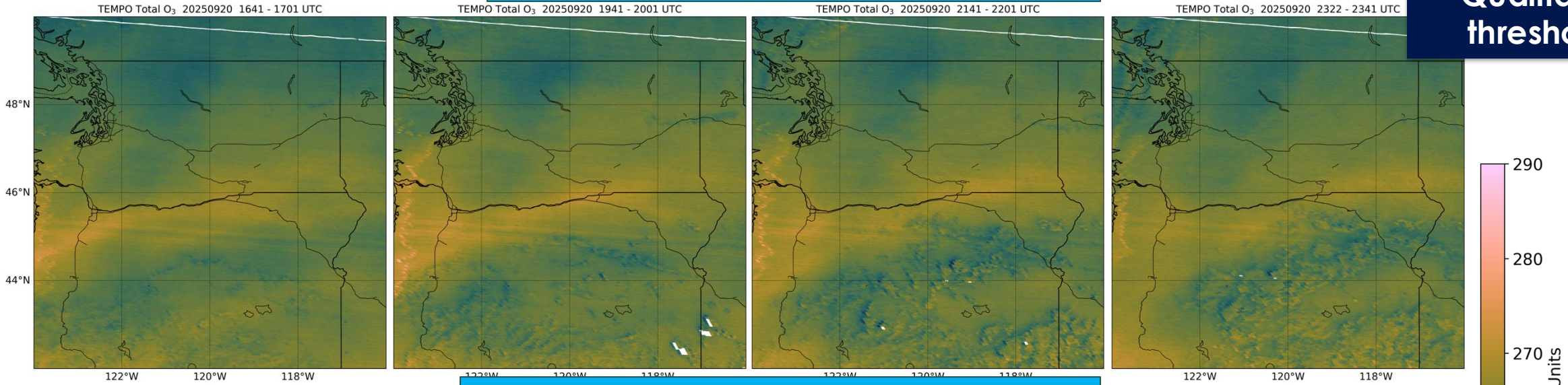
Quality Assurance Recommendations – TEMPO Total Column O_3

QA Parameter	Variable (group)	Range	Qualitative Use	Quantitative Use
Quality Flag	**quality_flag** (product) **0** = highest-quality **1** = Glint contamination **2** = SZA > 84° **5** = SO2 present **<1024** = ONLY disregard radiance/irradiance data which are missing or contain errors	0 to 32768	< 1024	= 0 (best) = [1, 2, 5] (adequate)
Effective Cloud Fraction (ECF)	**fc** (product)	0 – 1.0	No Filter	< 0.5
Solar Zenith Angle (SZA)	**solar_zenith_angle** (geolocation)	0 – 90°	< 80°	< 80°
Viewing Zenith Angle (VZA)	**viewing_zenith_angle** (geolocation)	0 – 90°	< 80°	< 80°

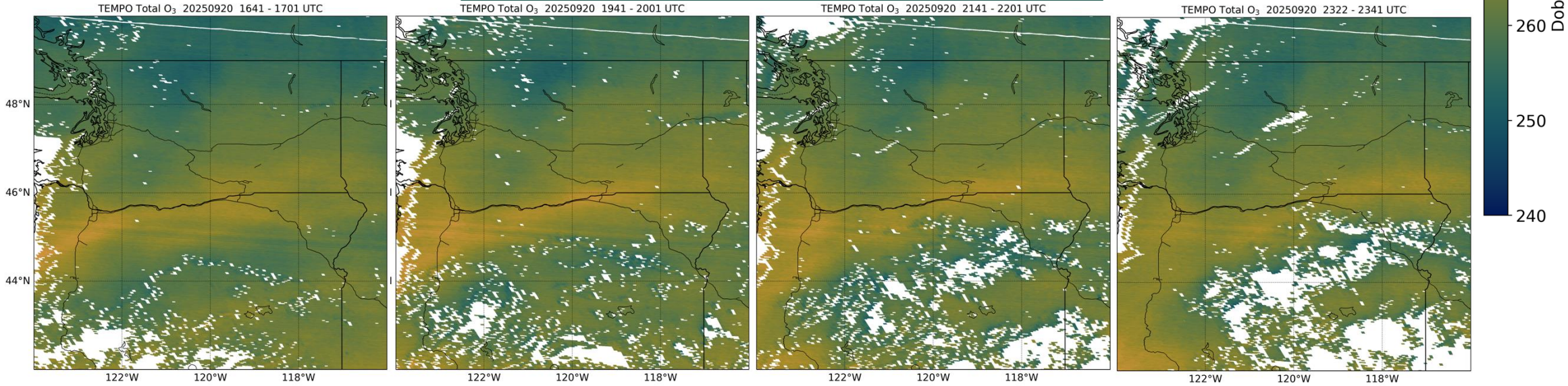
Comparing Quality Assurance Thresholds – TEMPO Total Column O_3

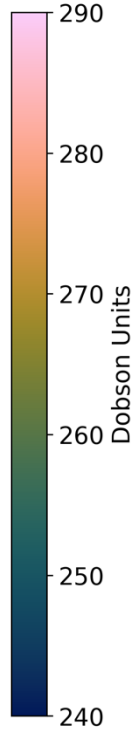
Quality Flag < 1024, SZA < 80°, VZA < 80°

Qualitative thresholds

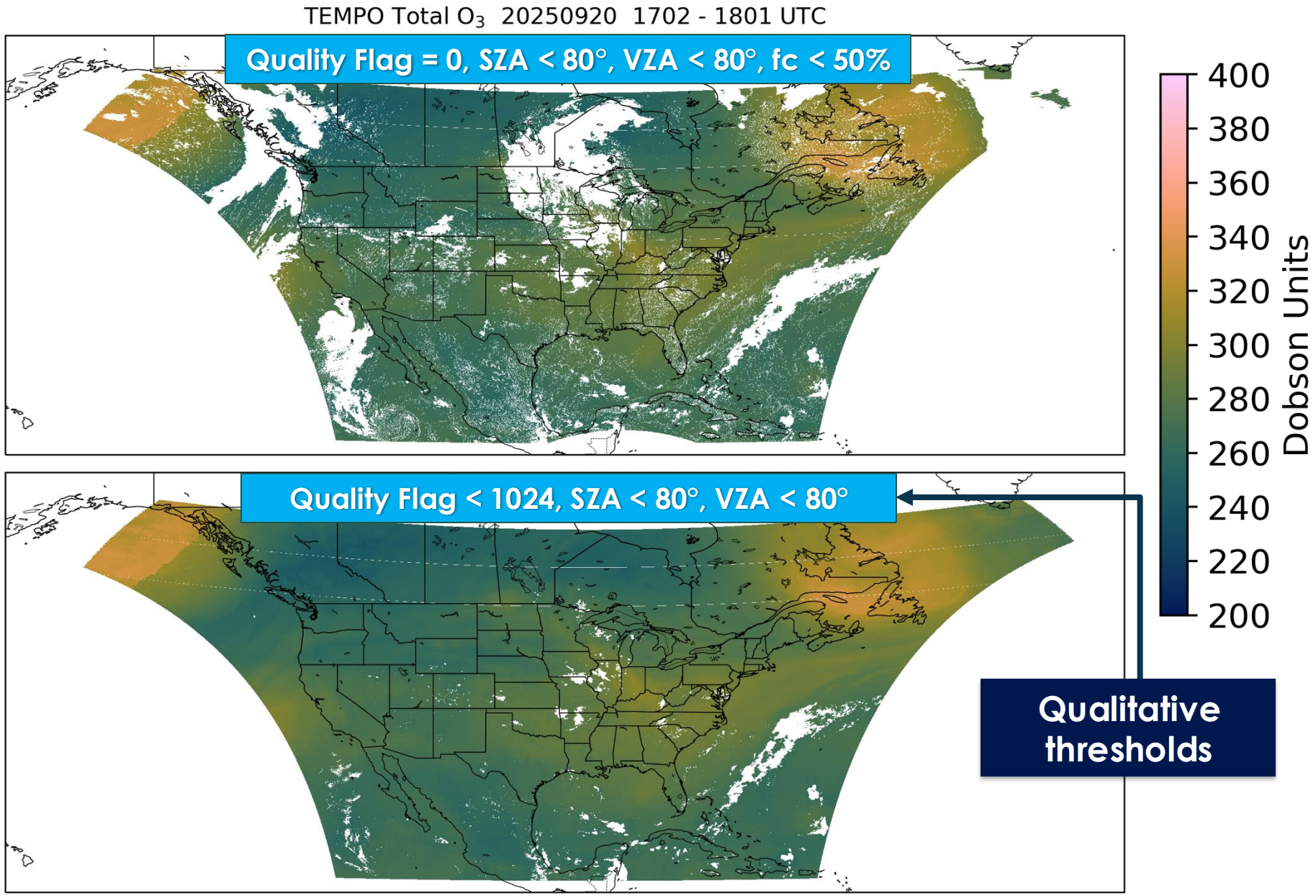


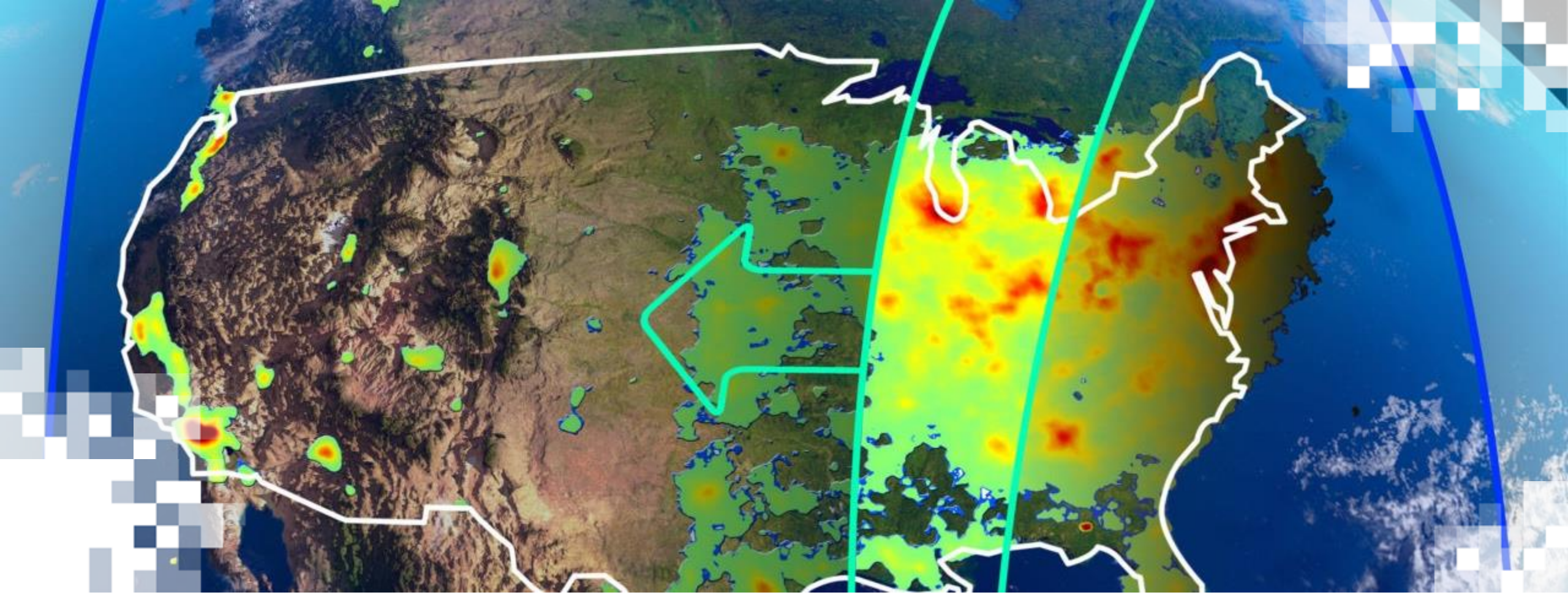
Quality Flag = 0, SZA < 80°, VZA < 80°, fc < 50%





Comparing Quality Assurance Thresholds – TEMPO Total Column O_3



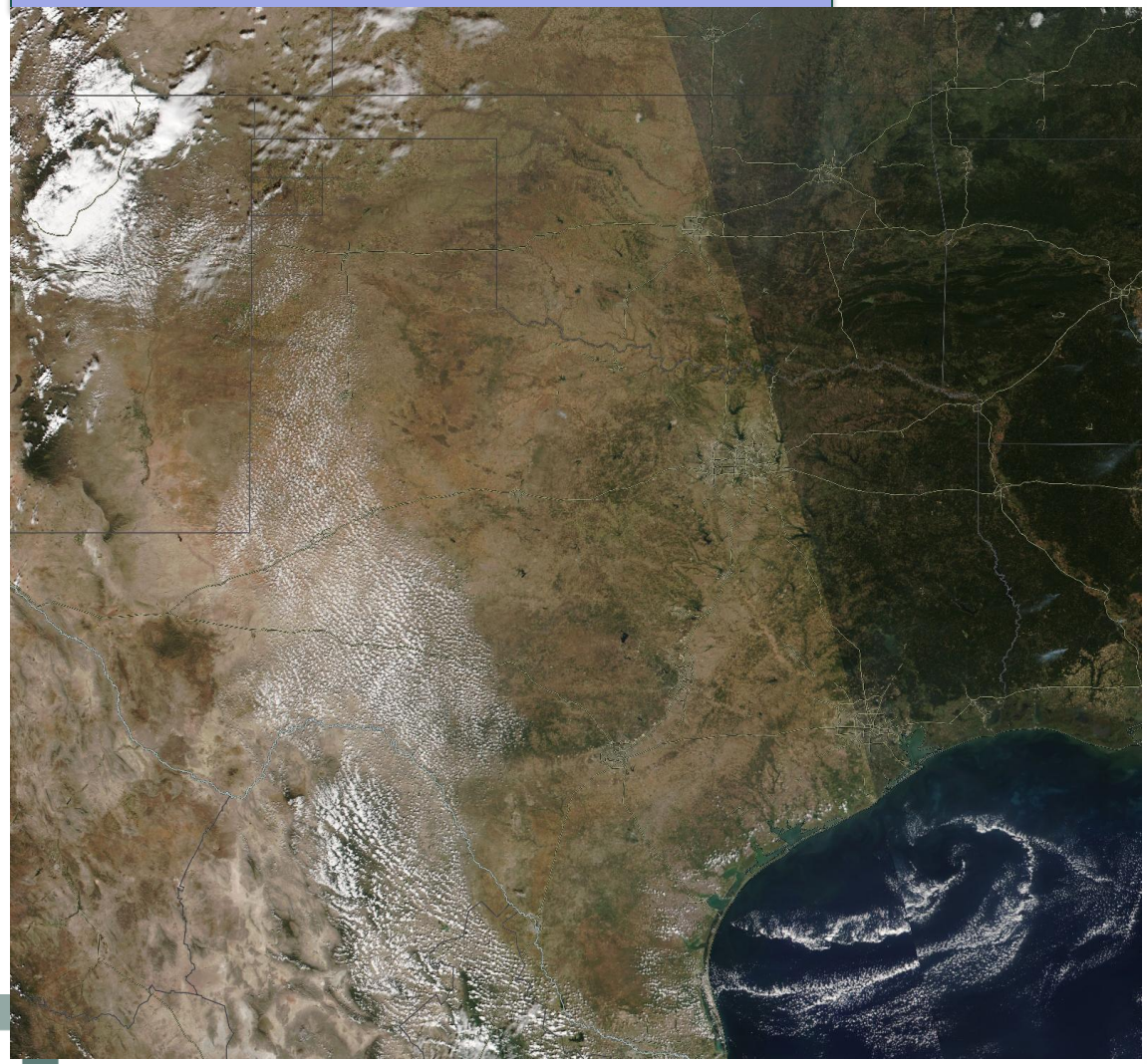


TEMPO Level 2 Trace Gas Examples

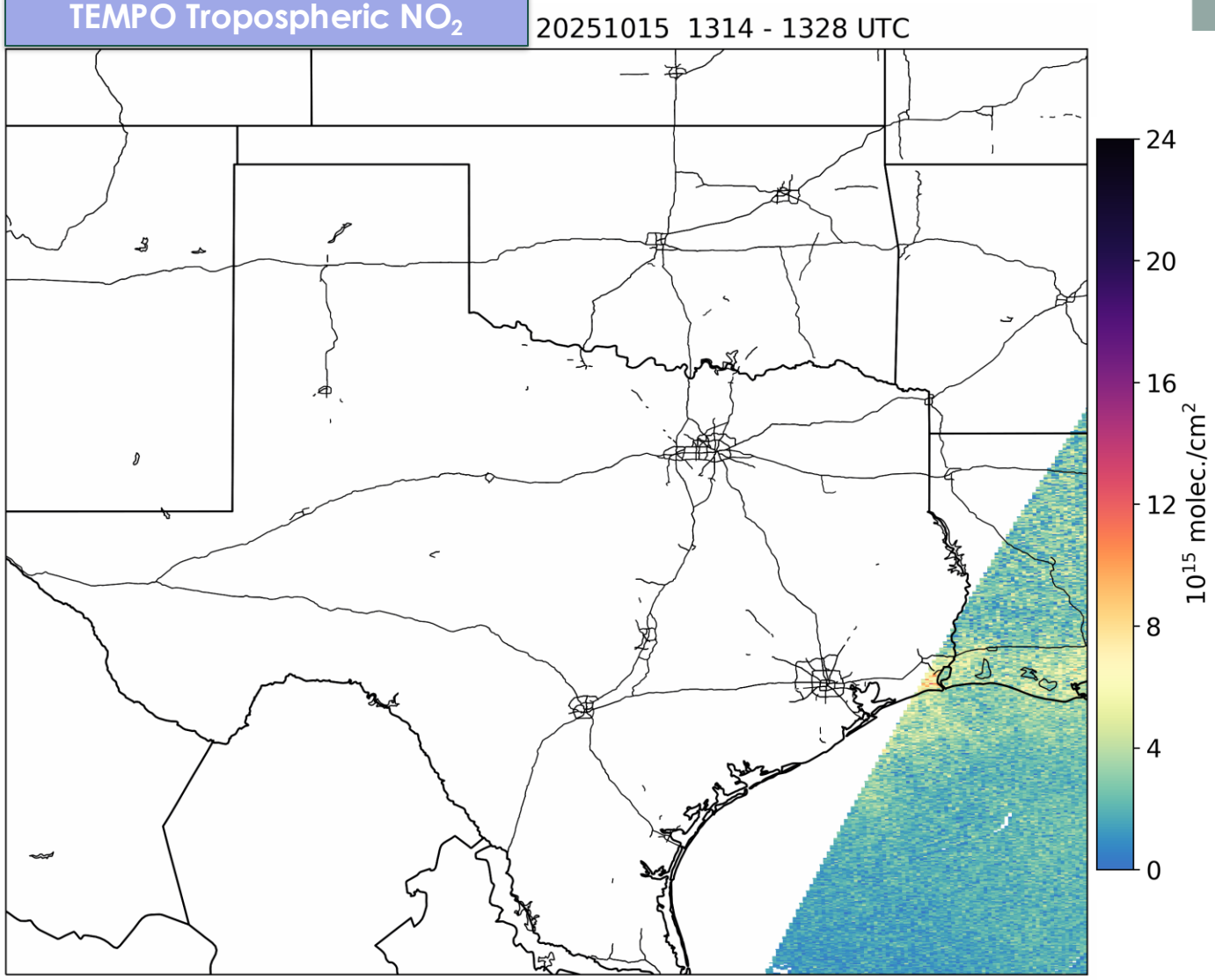
South U.S. Zoom NO_2 – October 15, 2025

Filter using
Cloud Fraction < 50%
SZA < 80°

NOAA-20 VIIRS True Color ~20:10 UTC



TEMPO Tropospheric NO_2

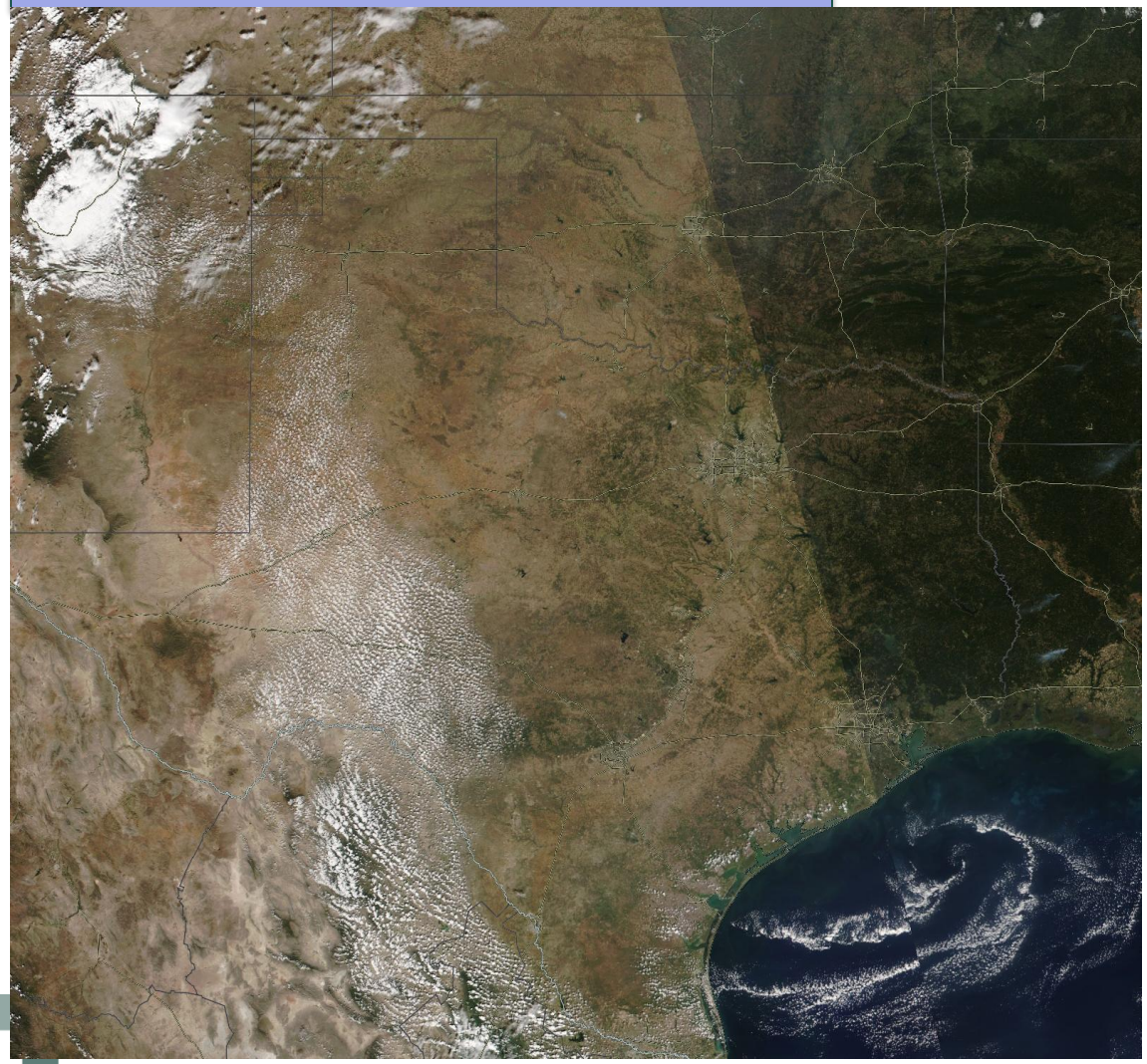


1-Day Animation of Tropospheric NO_2 VCDs from TEMPO

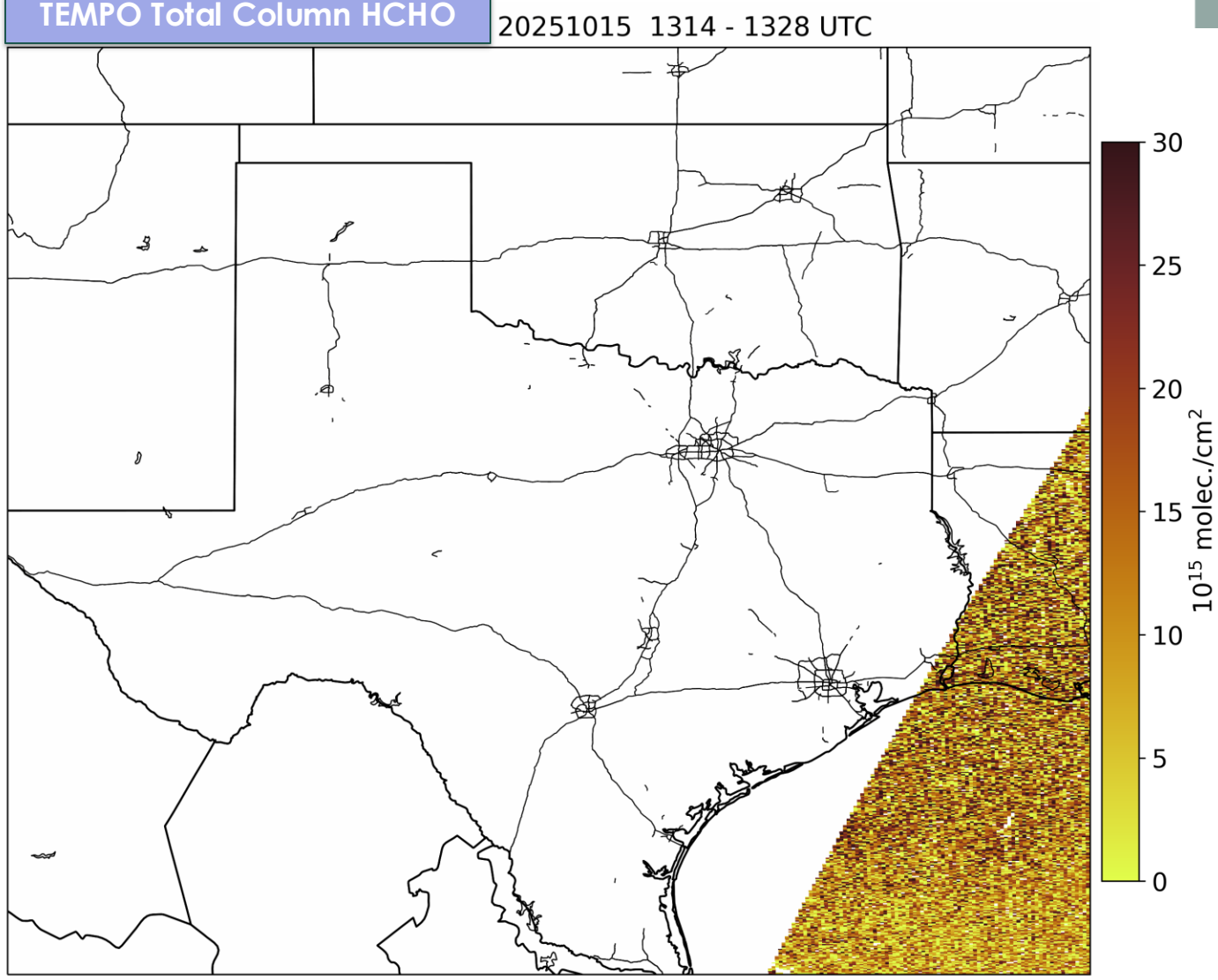
South U.S. Zoom HCHO – October 15, 2025

Filter using
Cloud Fraction < 50%
SZA < 80°

NOAA-20 VIIRS True Color ~20:10 UTC



TEMPO Total Column HCHO

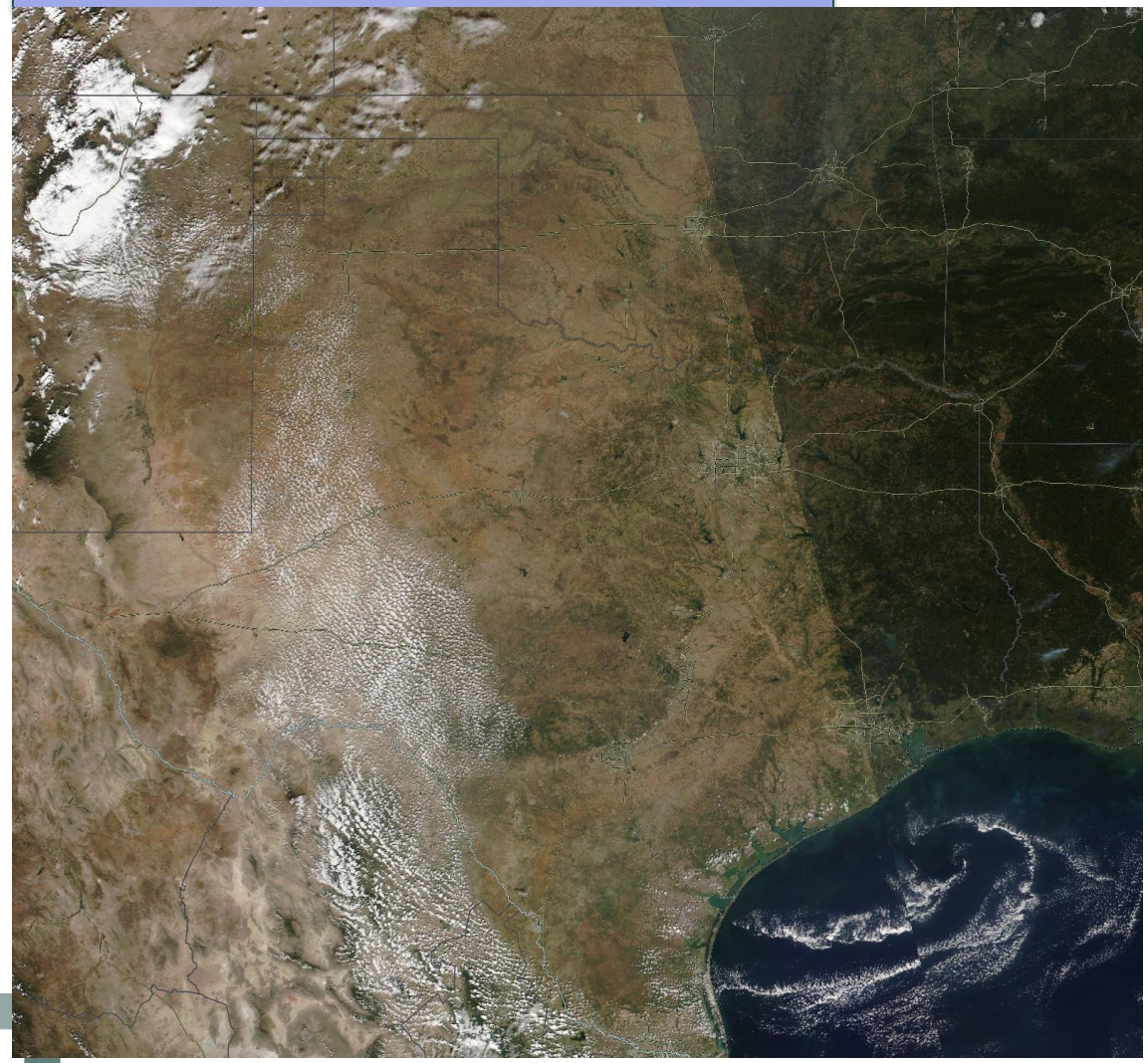


1-Day Animation of Total HCHO VCDs from TEMPO

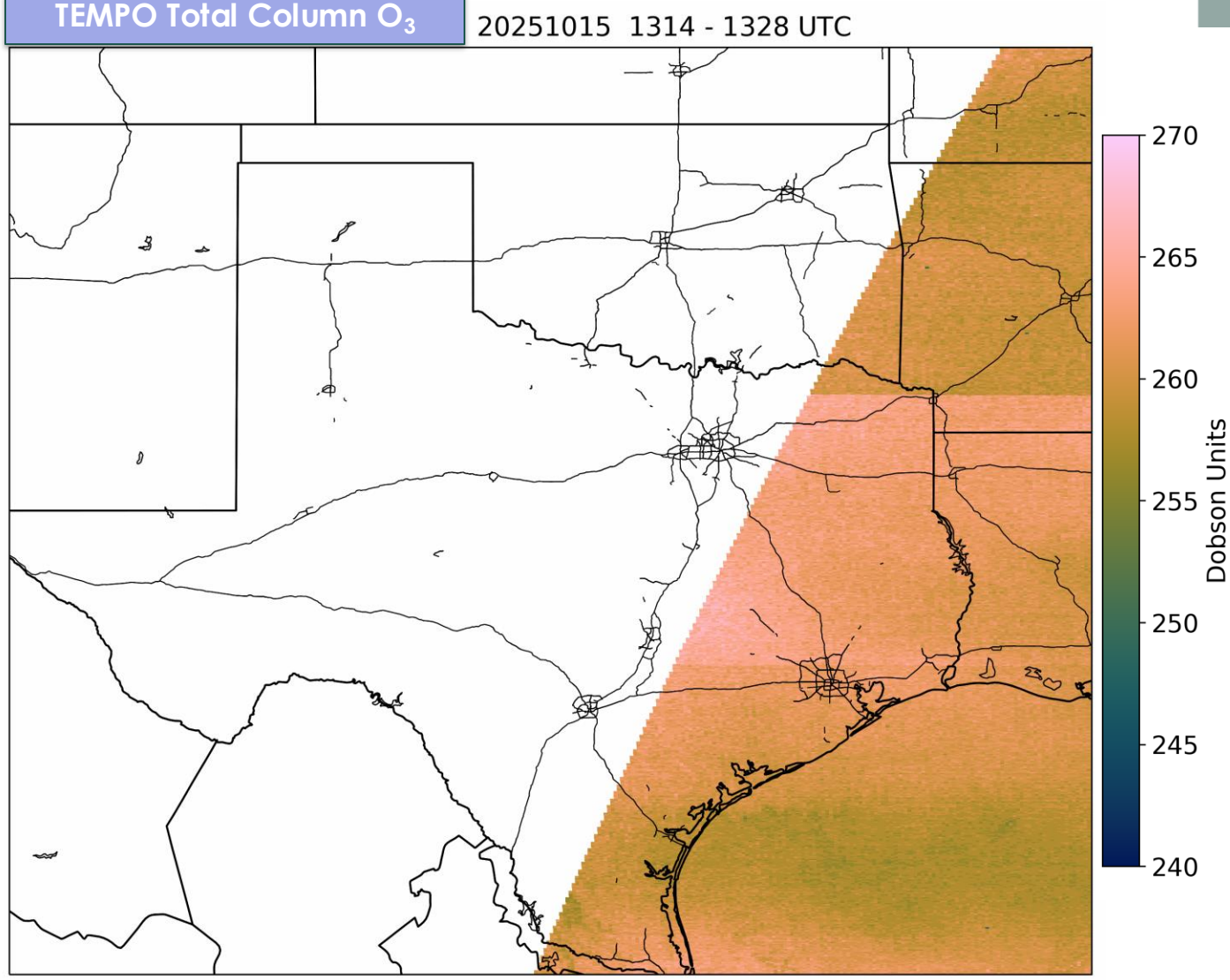
South U.S. Zoom O_3 – October 15, 2025

Filter using
SZA < 80°
Flag < 1024

NOAA-20 VIIRS True Color ~20:10 UTC



TEMPO Total Column O_3

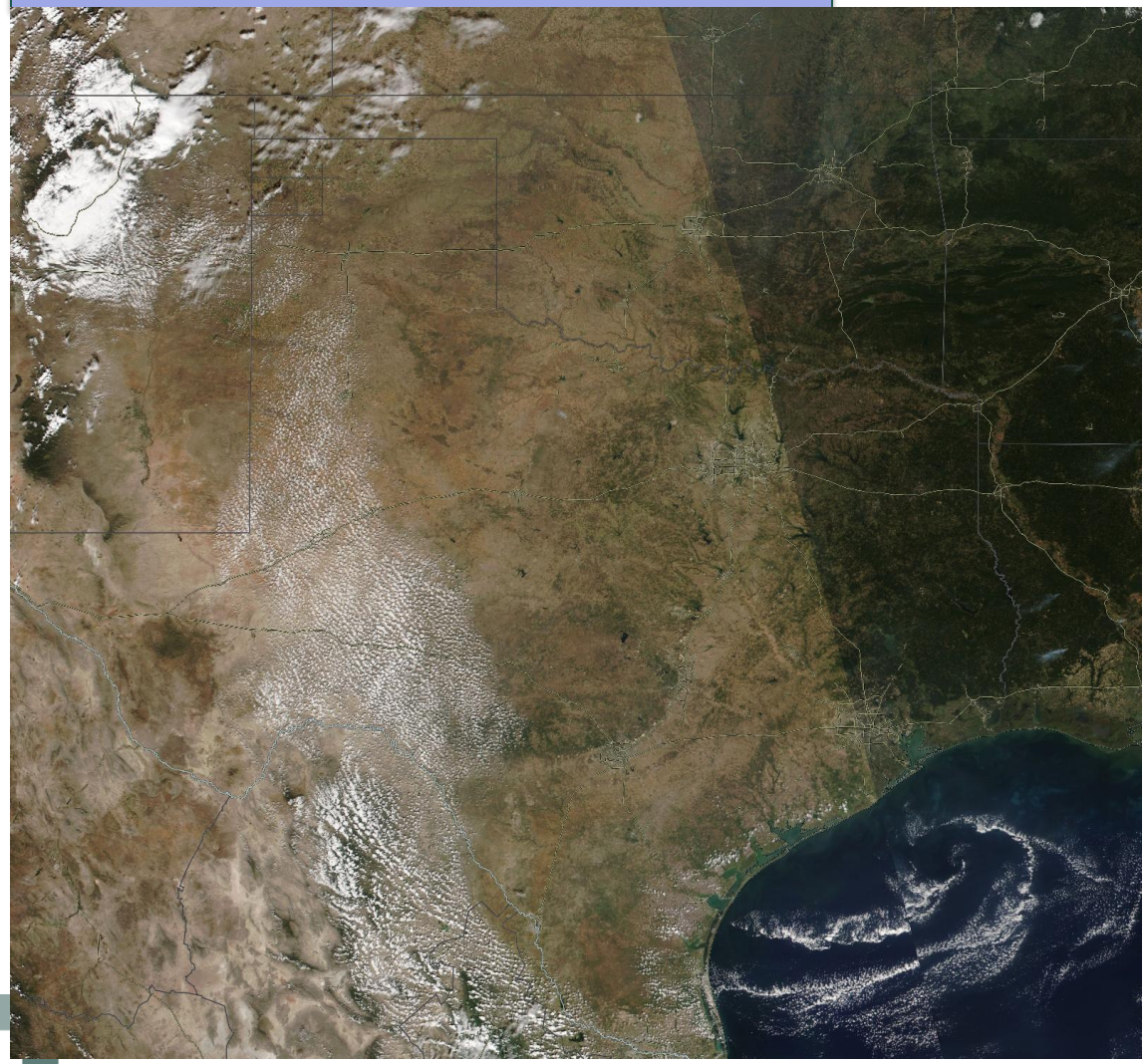


1-Day Animation of Total Column O_3 from TEMPO

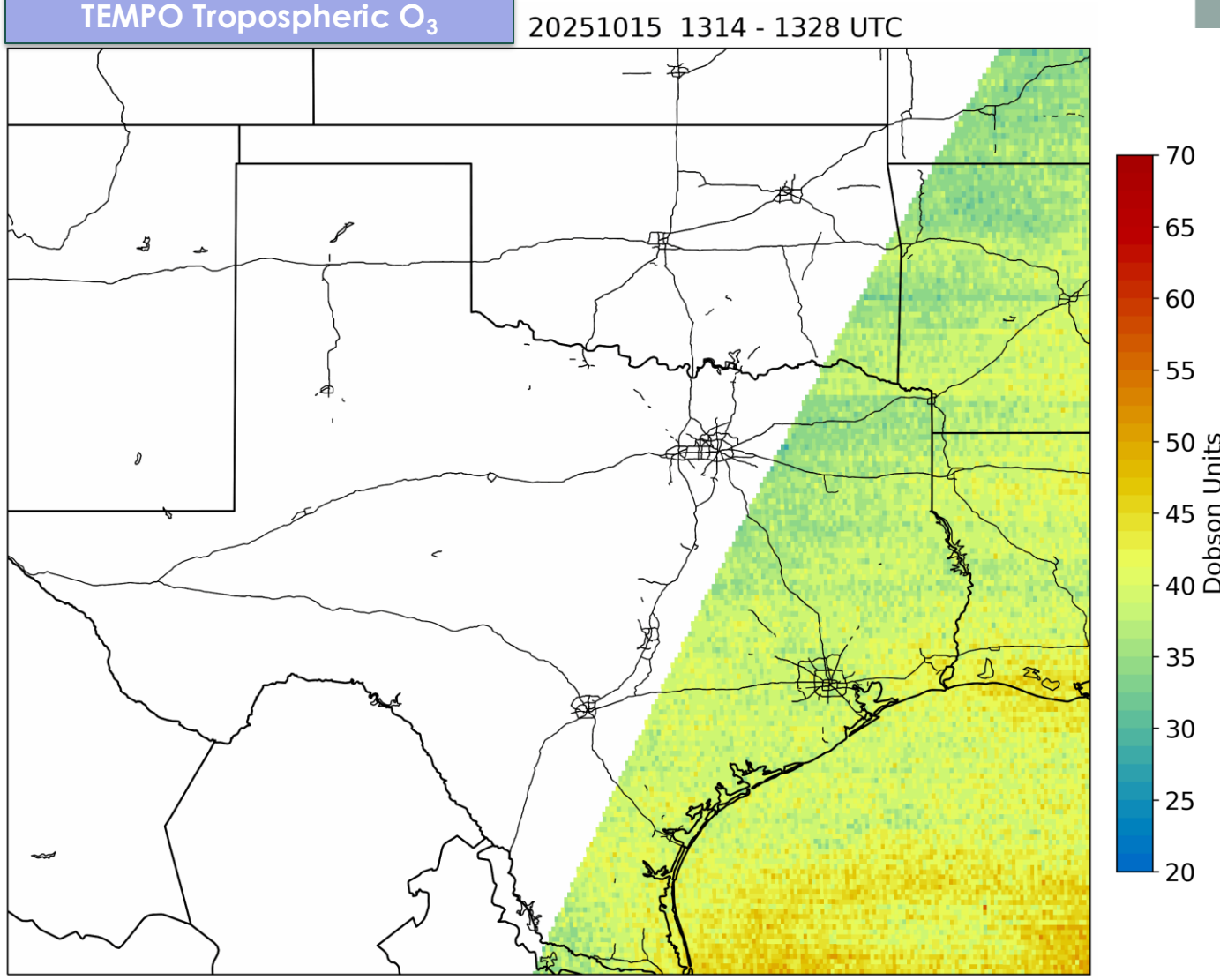
South U.S. Zoom Tropospheric O_3 – October 15, 2025

Filter using
Cloud Fraction < 50%
SZA < 80°

NOAA-20 VIIRS True Color ~20:10 UTC



TEMPO Tropospheric O_3

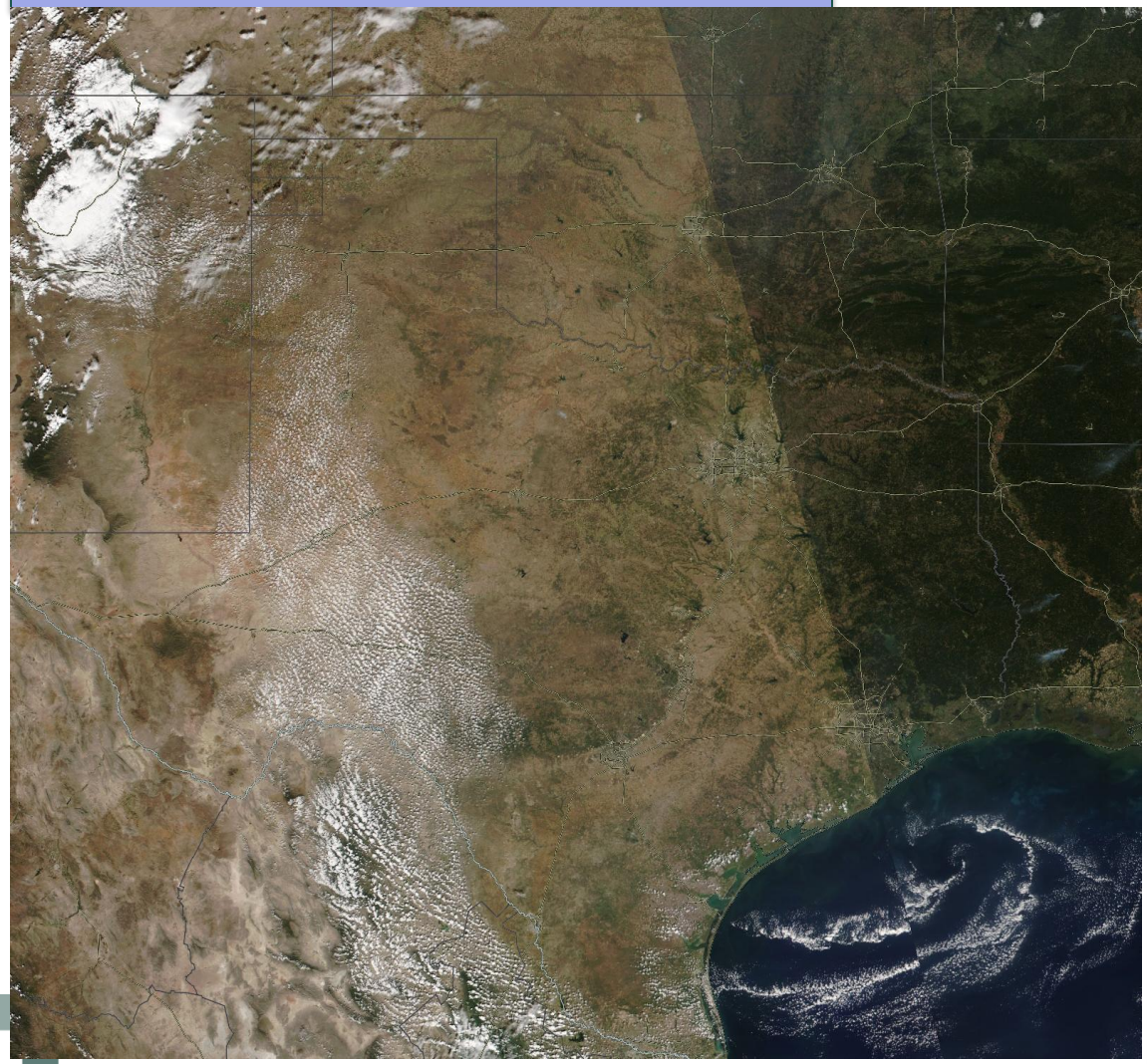


1-Day Animation of Tropospheric O_3 Columns

South U.S. Zoom 0-2 km O_3 – October 15, 2025

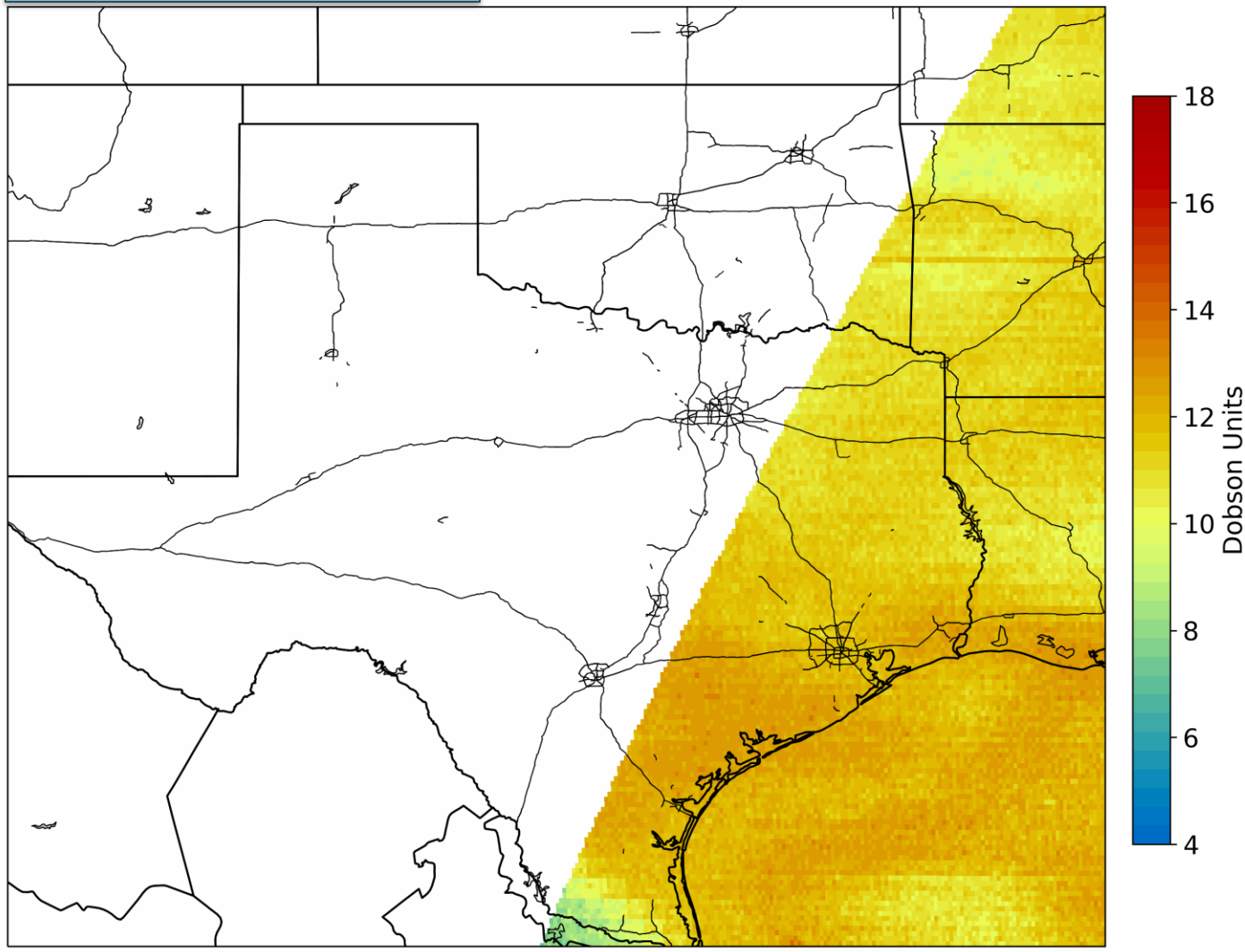
Filter using
Cloud Fraction < 50%
SZA < 80°

NOAA-20 VIIRS True Color ~20:10 UTC



TEMPO 0-2 km O_3

20251015 1314 - 1328 UTC

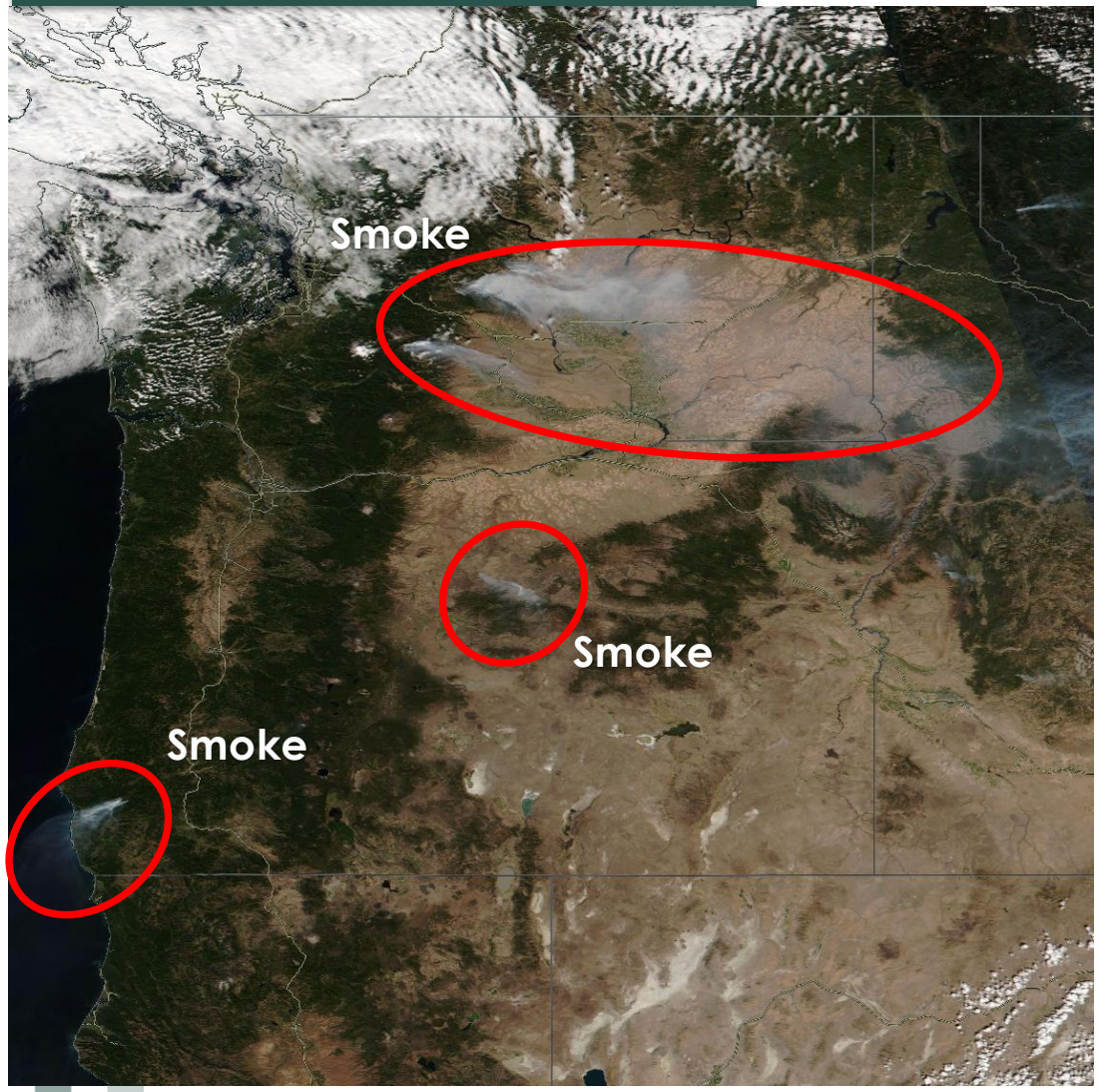


1-Day Animation of 0-2 km O_3 Columns

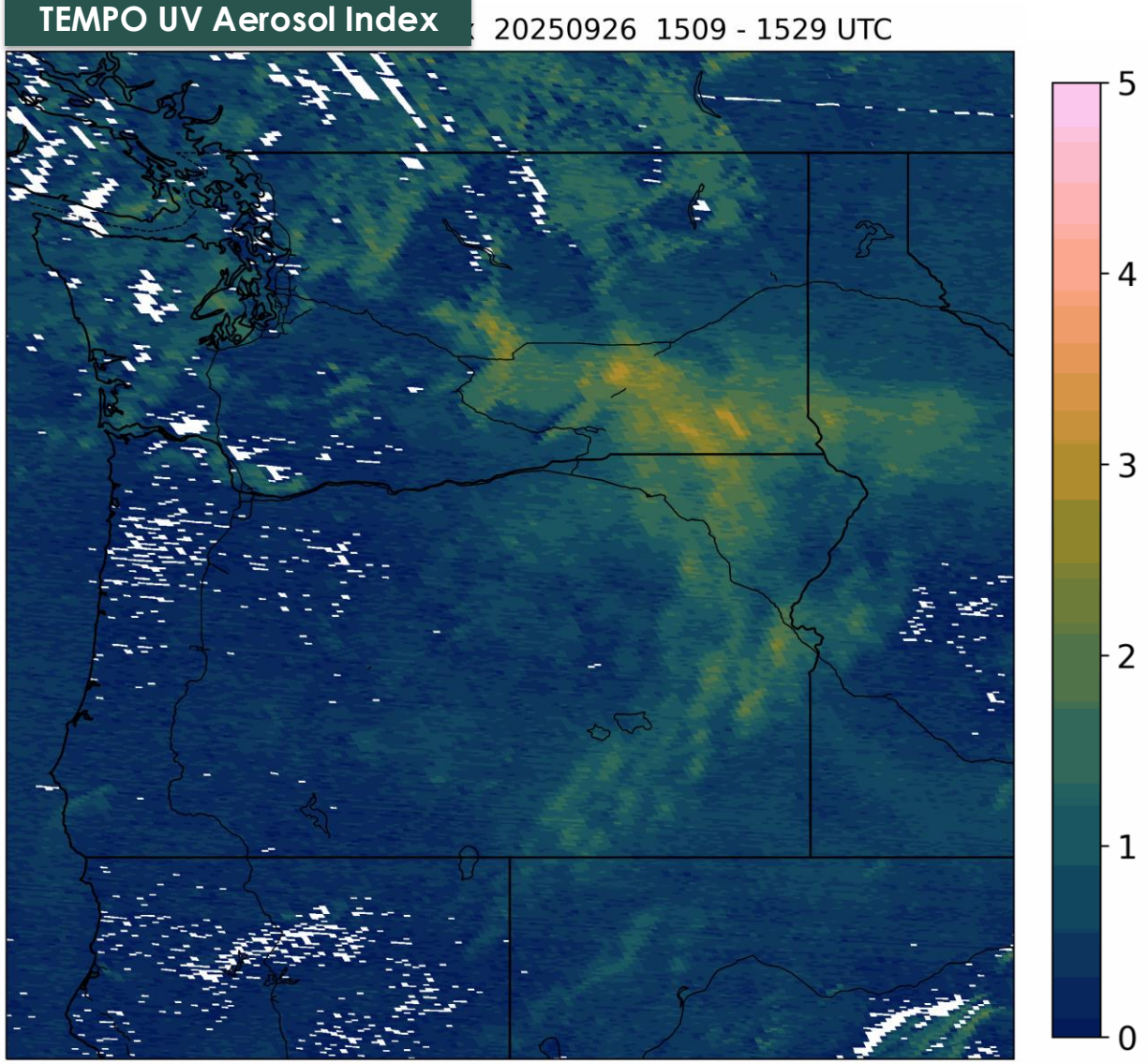
West U.S. Zoom – September 26, 2025

Filter using
SZA < 80°

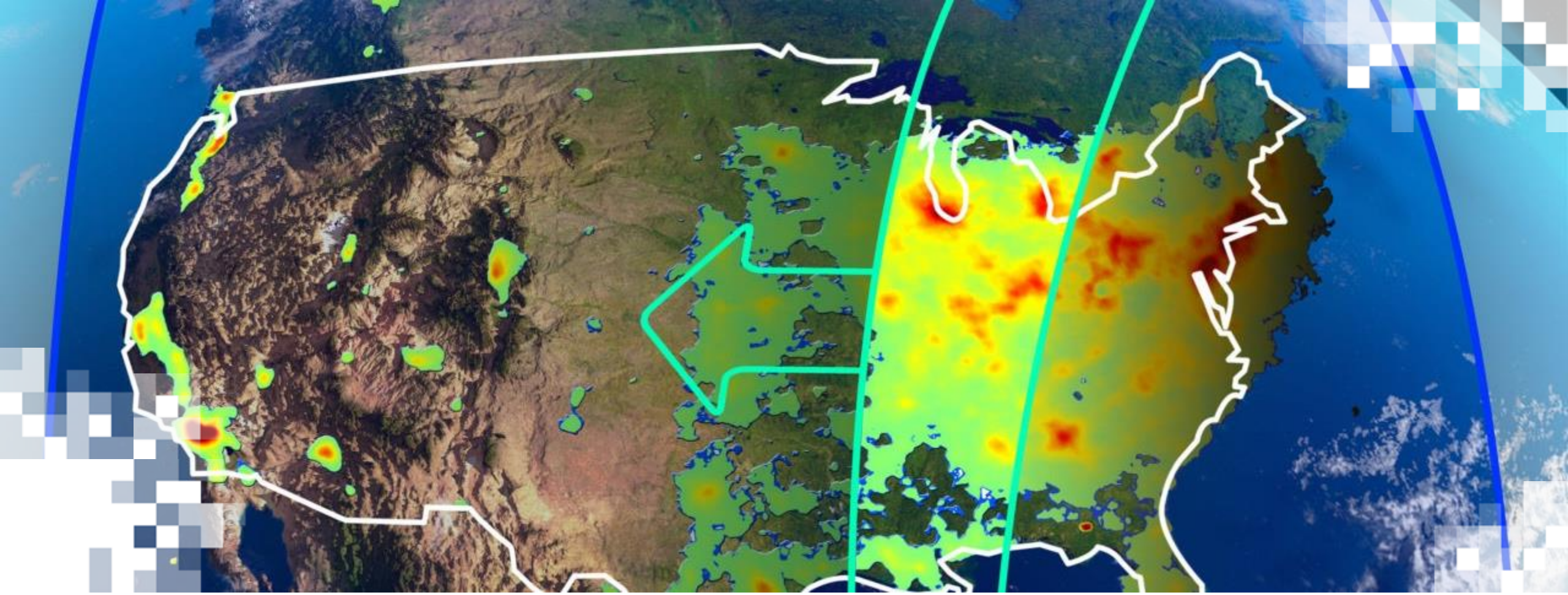
NOAA-20 VIIRS True Color ~21:15 UTC



TEMPO UV Aerosol Index



1-Day Animation of UV Aerosol Index

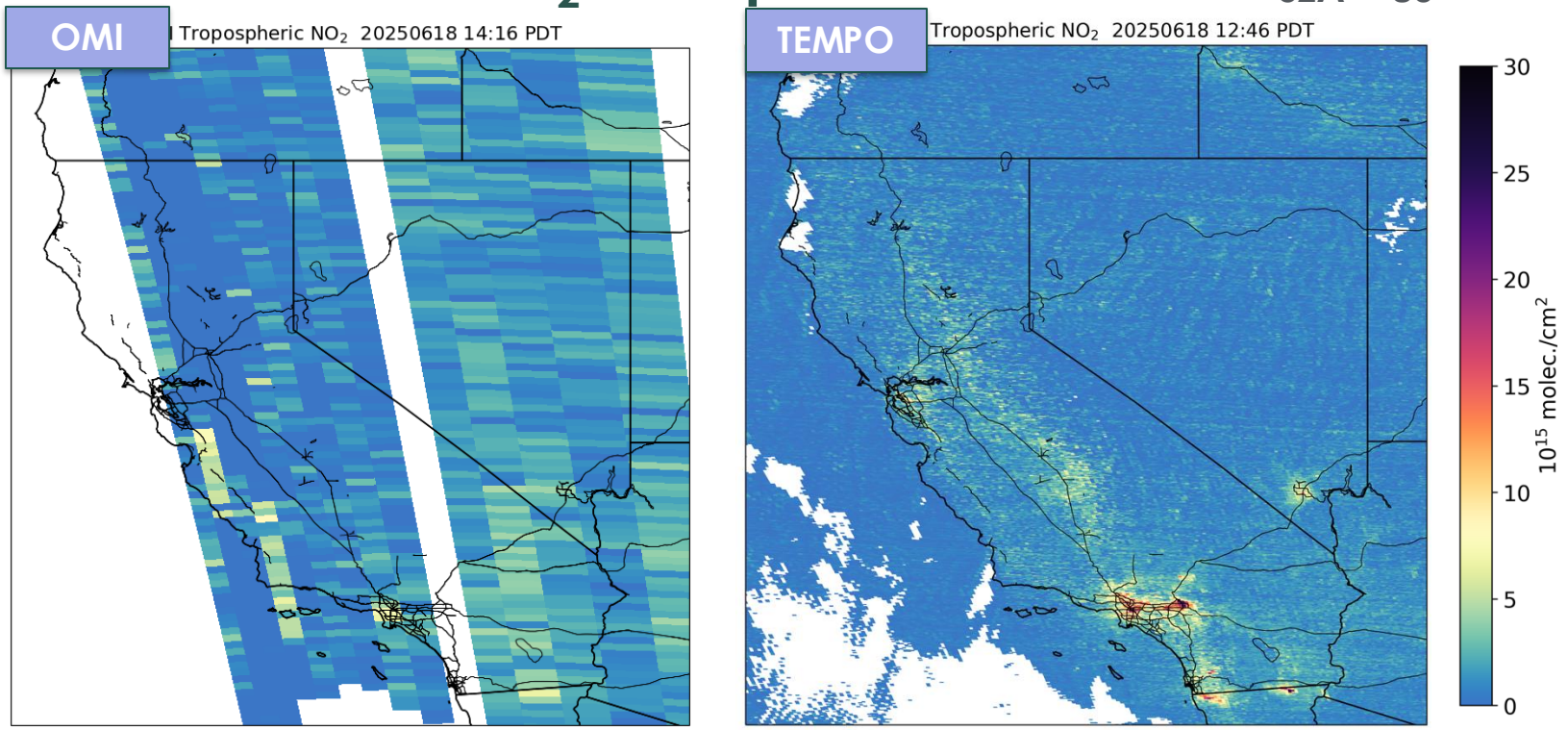


TEMPO vs. OMI and TROPOMI

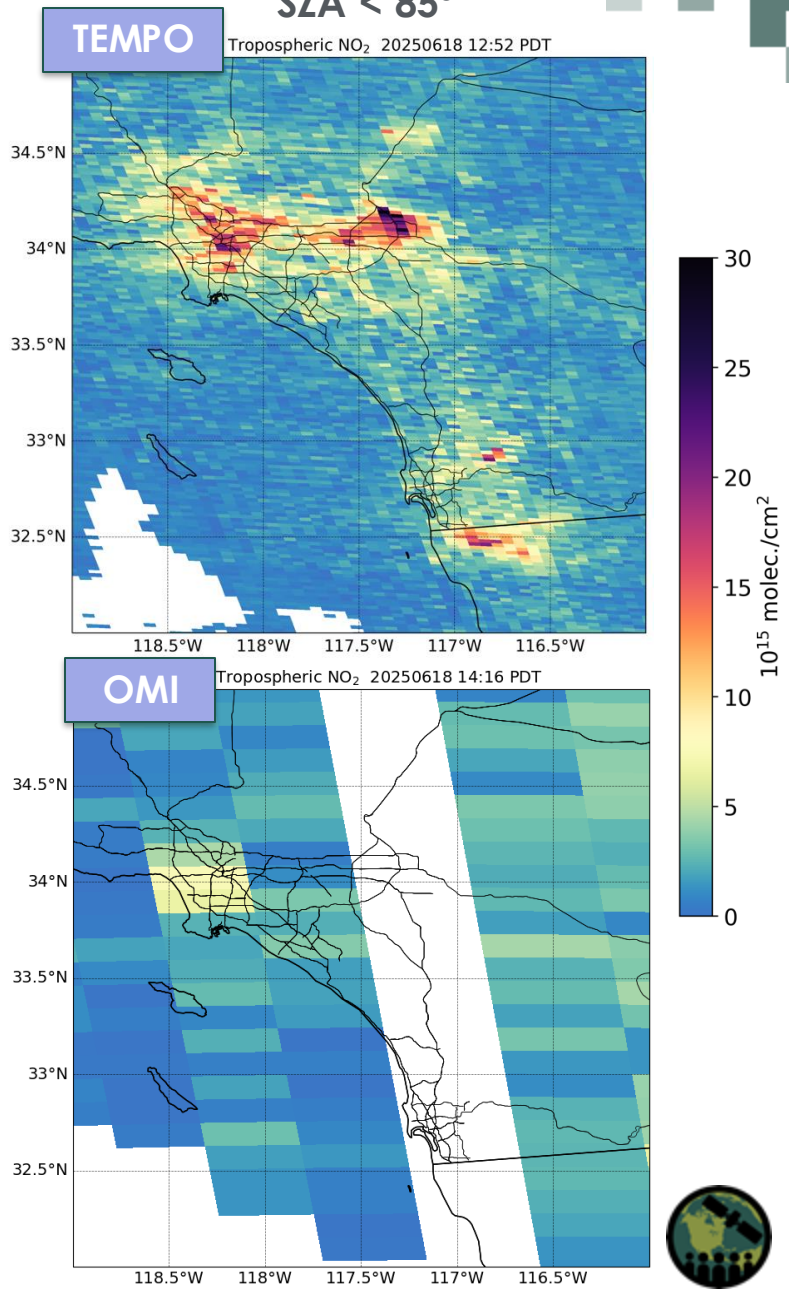
* Results based on Version 3 TEMPO Products *

TEMPO vs. OMI NO_2 Comparison

TEMPO Filter using Cloud Fraction < 50% SZA < 80°



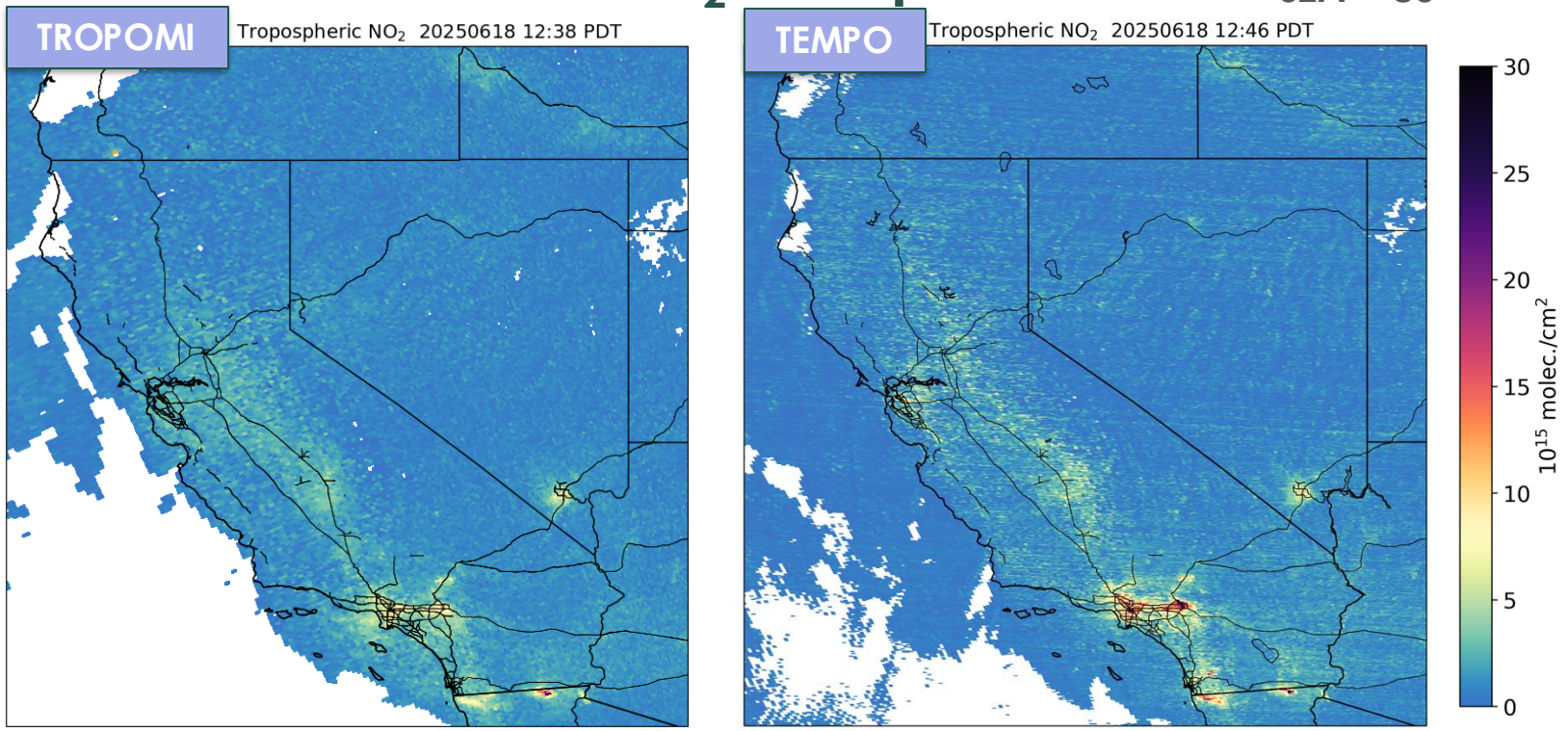
OMI Filter using Cloud Fraction < 30% SZA < 85°



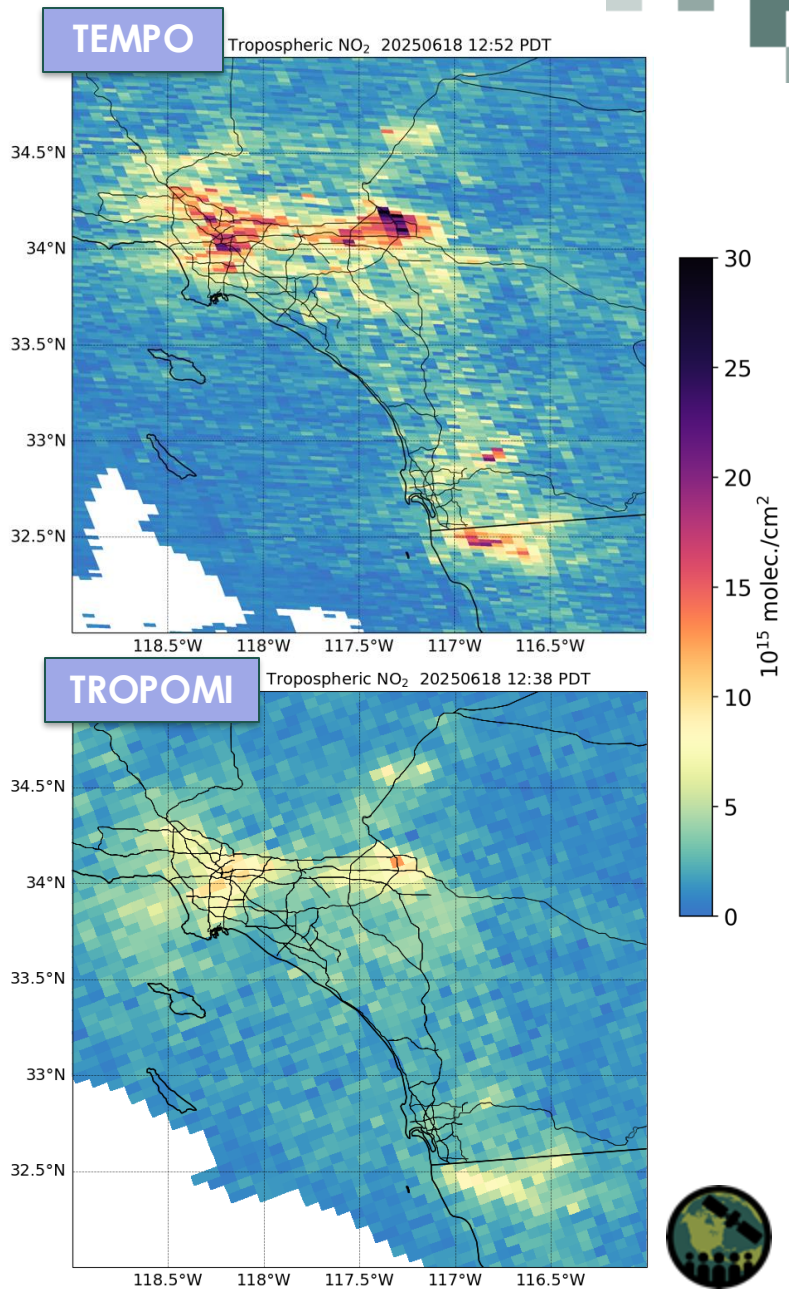
- NASA's Low-Earth orbiting OMI (Ozone Monitoring Instrument), launched in 2004, provides midday observations of air pollutants across the globe at a spatial resolution of 13 km x 24 km (at nadir).
- TEMPO NO_2 tropospheric VCDs are larger than OMI in urban areas including Los Angeles, Las Vegas, and Mexicali.
- TEMPO's much higher spatial resolution of ~ 2.1 km x 5.6 km compared to OMI's is contributing to the NO_2 differences between the two sensors.

TEMPO vs. TROPOMI NO_2 Comparison

TEMPO Filter using
Cloud Fraction < 50%
SZA < 80°



TROPOMI Filter using
QA < 0.75

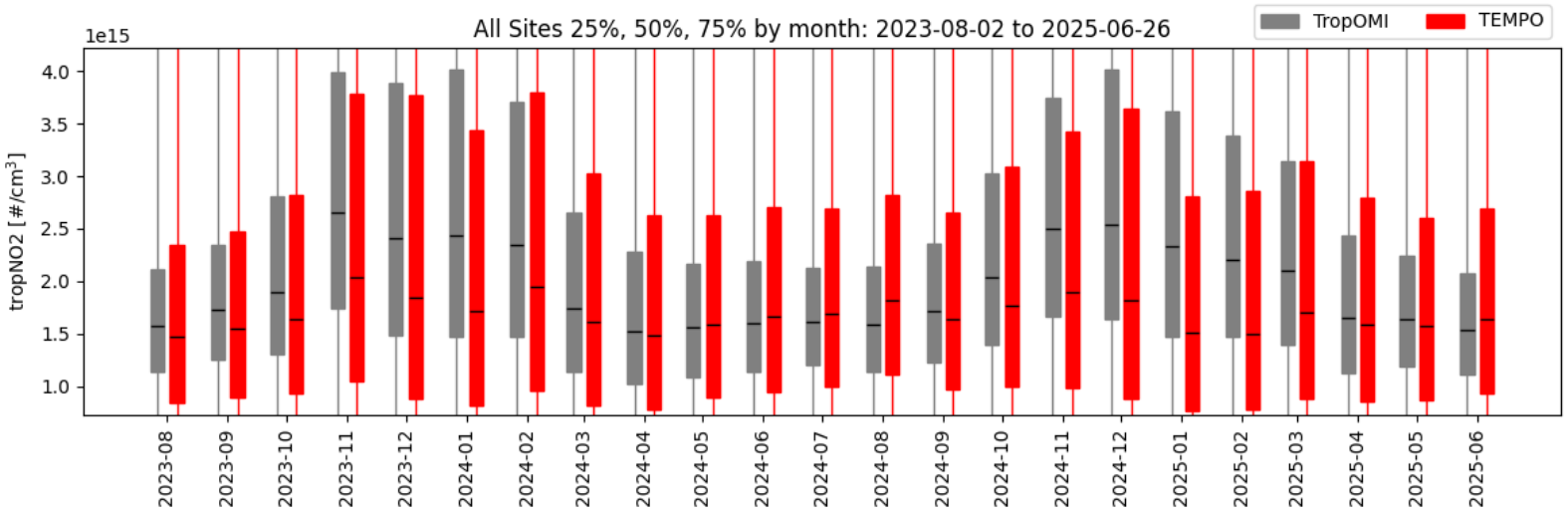


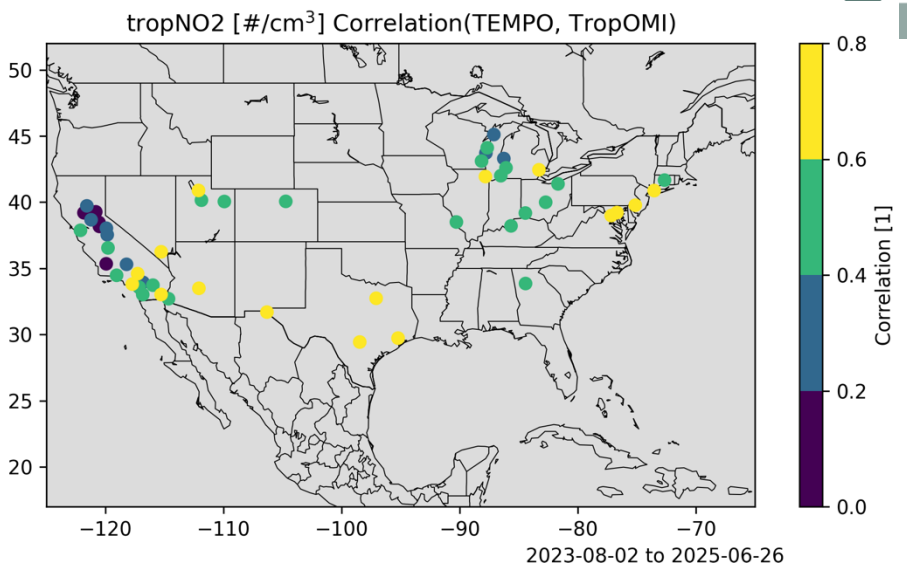
- Low-Earth orbiting TROPOMI (Tropospheric Monitoring Instrument), launched in 2017, provides midday observations of air pollutants across the globe at a spatial resolution of 5.5 km x 3.5 km (at nadir).
- TEMPO NO_2 tropospheric VCDs are larger than TROPOMI in urban areas including Los Angeles, San Diego, and Tijuana.
- TEMPO's higher resolution is likely contributing to slight NO_2 differences.

TEMPO vs. TROPOMI NO_2 Comparison

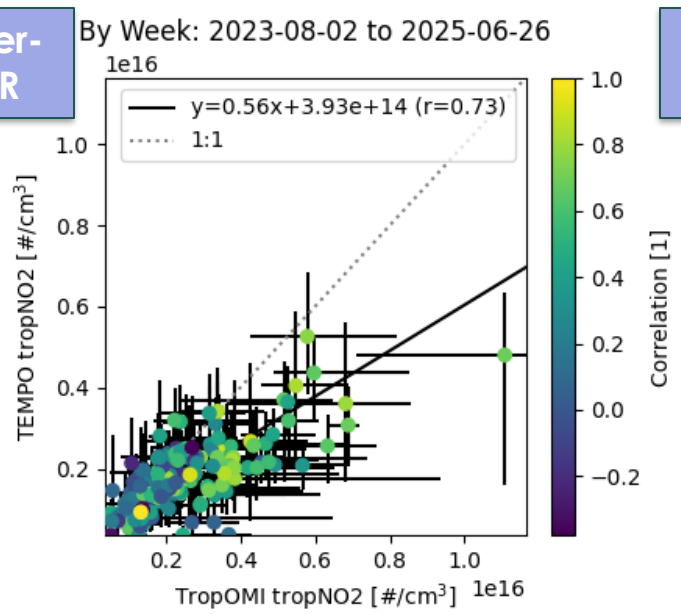
TEMPO Filter using
Cloud Fraction < 15%
SZA < 70°

TROPOMI Filter using
QA < 0.75

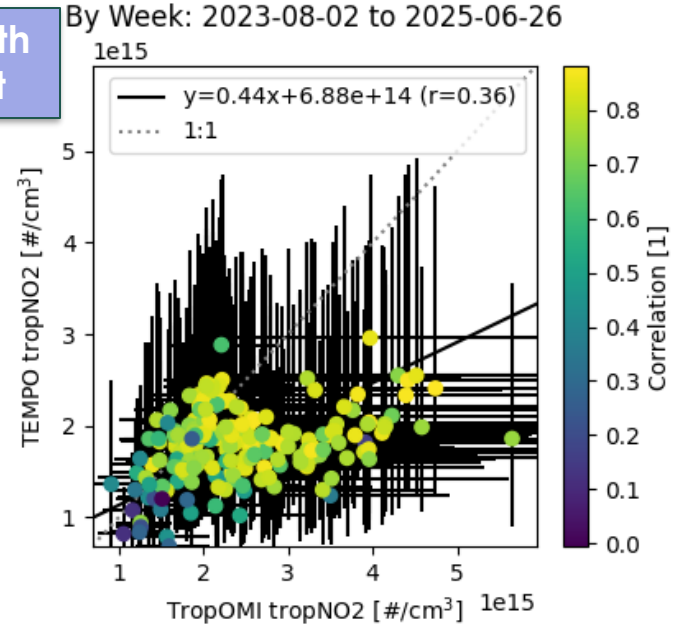




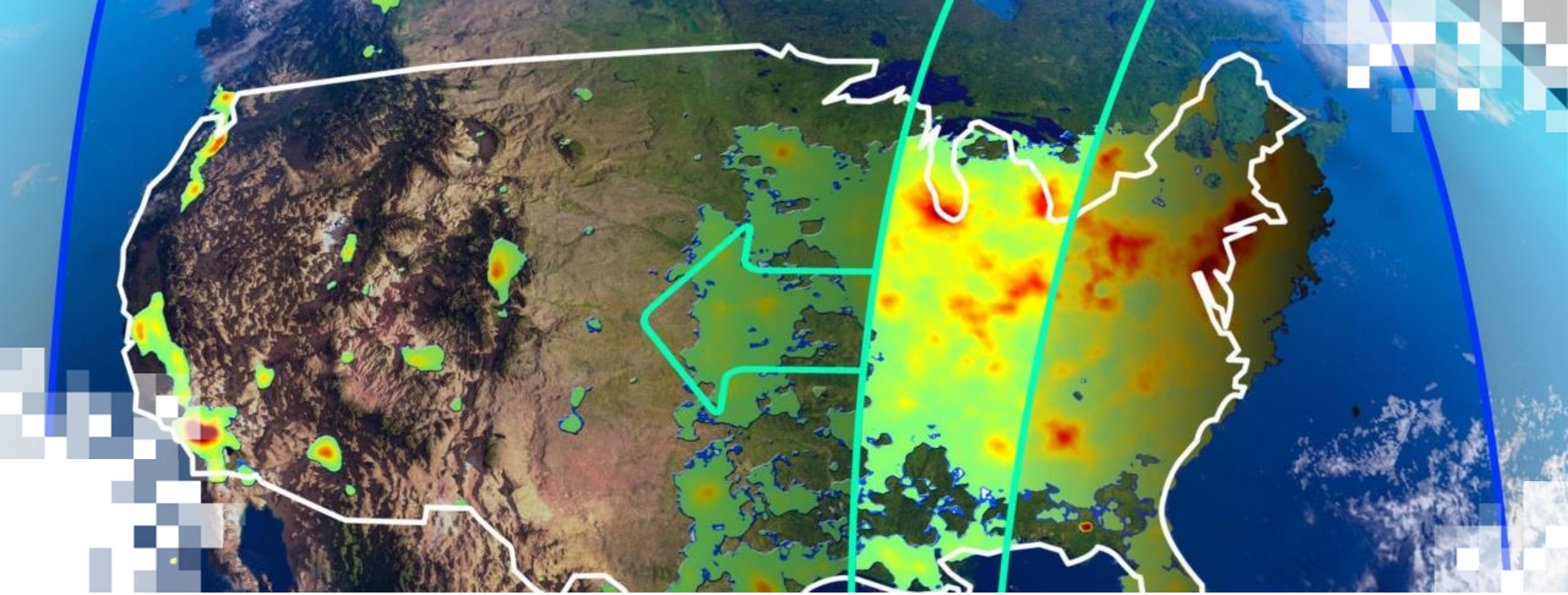
Boulder-NCAR



LA South Coast



- TEMPO is higher than TROPOMI at locations of interest, with NMB (normalized mean bias) of 19%.
- However, TEMPO is lower than TROPOMI in Nonattainment Areas (NAA) with NMB of -11%.
- TROPOMI may have high bias in low NO_2 conditions.
- Better correlations between TEMPO and TROPOMI in Boulder compared to Los Angeles.



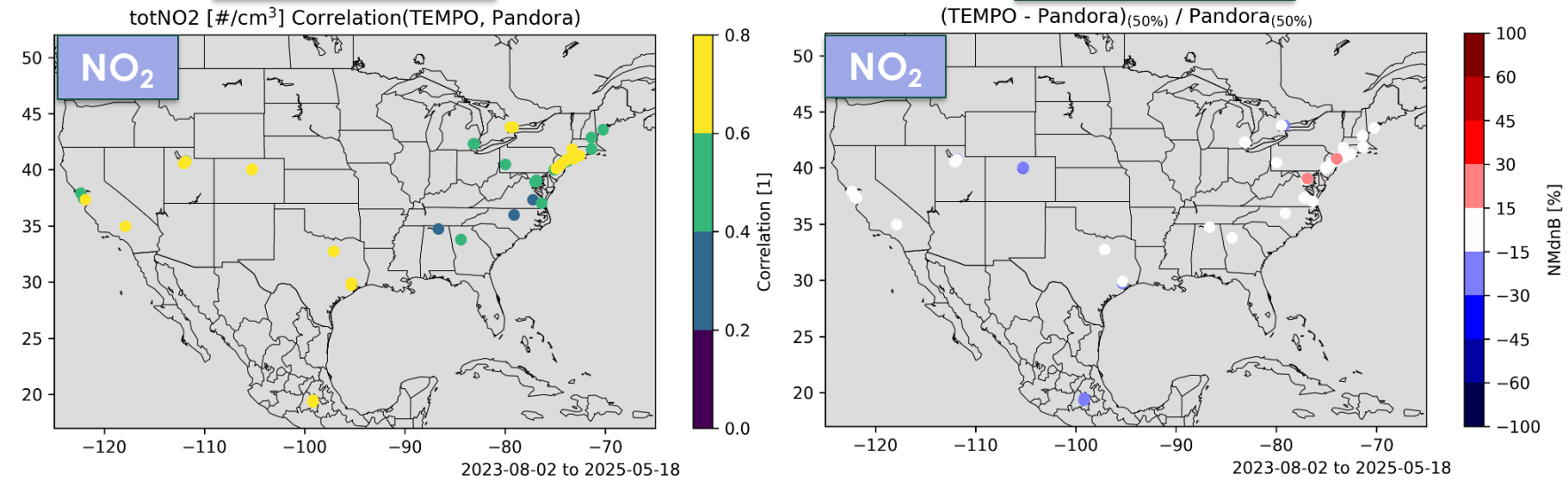
Validation of TEMPO Products

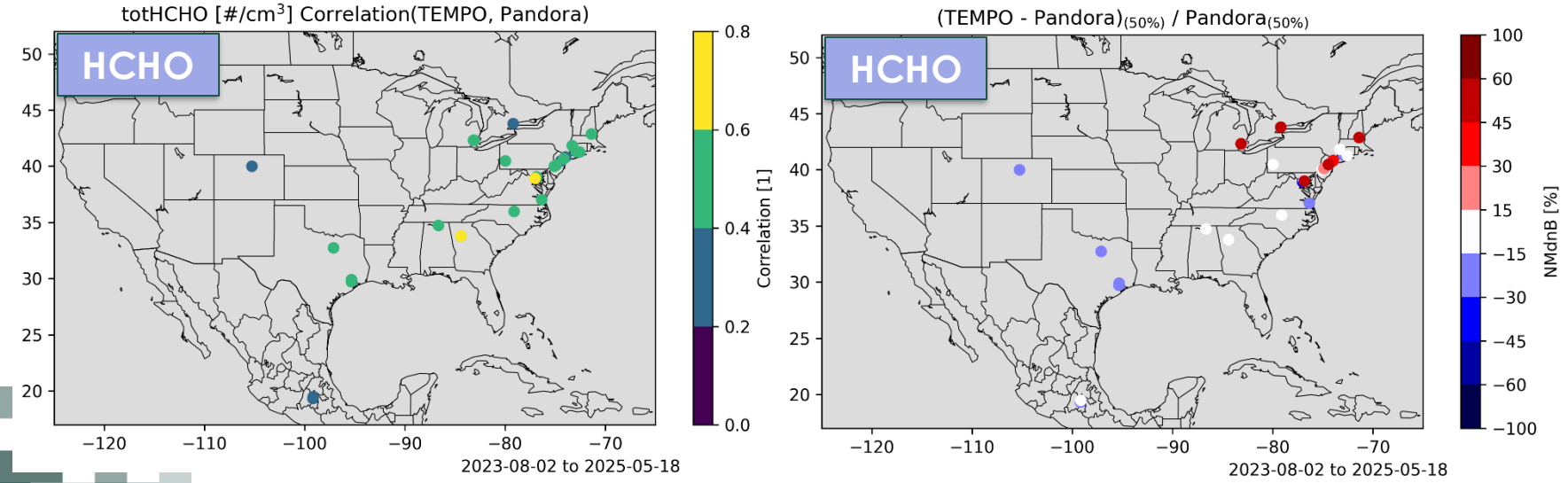
* Results based on Version 3 TEMPO Products *

TEMPO Validation at Pandora Network Sites

Filter using
Cloud fraction < 15%
SZA < 70°

Correlation | **Mean Biases**





TEMPO NO_2 –

- Reproduces spatial variability
- Low fractional biases by locations
- Correlates well at most sites
- Even reproduces relatively small intra-regional urban/rural gradients quite well

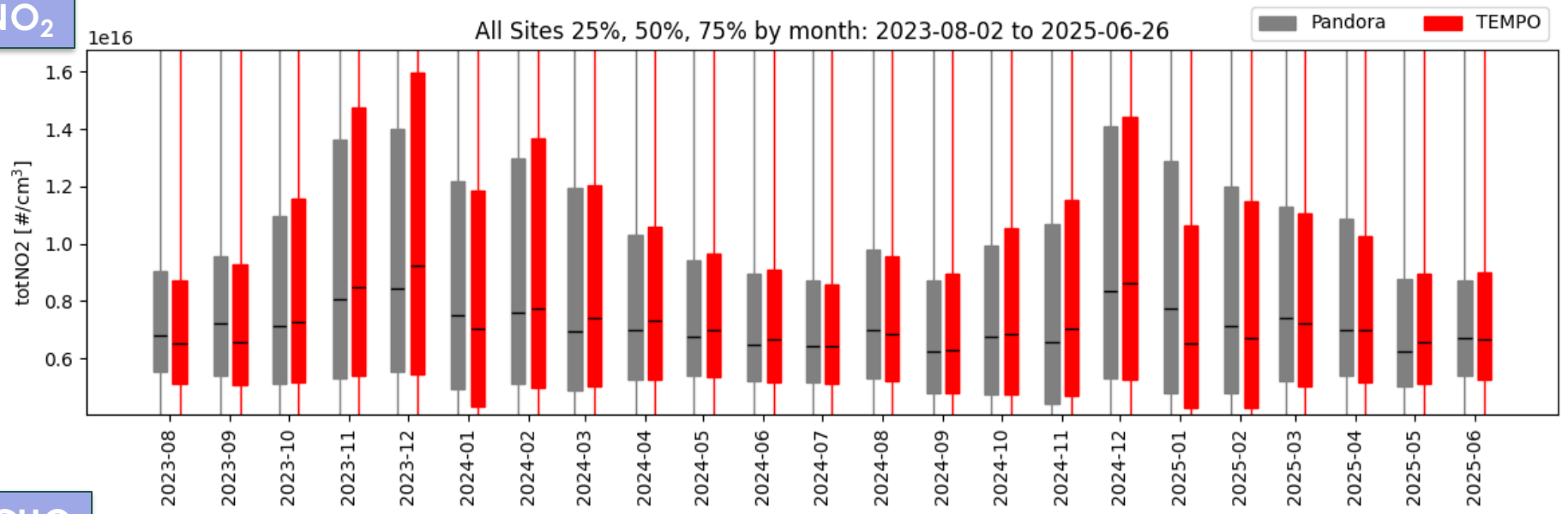
TEMPO HCHO –

- Correlates at the site-level
- Has reasonable bias with some individual sites needing investigation
- Site-specific time correlation
- Intra-regional site-level gradients are challenging, perhaps due to pixel averaging

TEMPO vs. Pandora Across All Sites Per Month

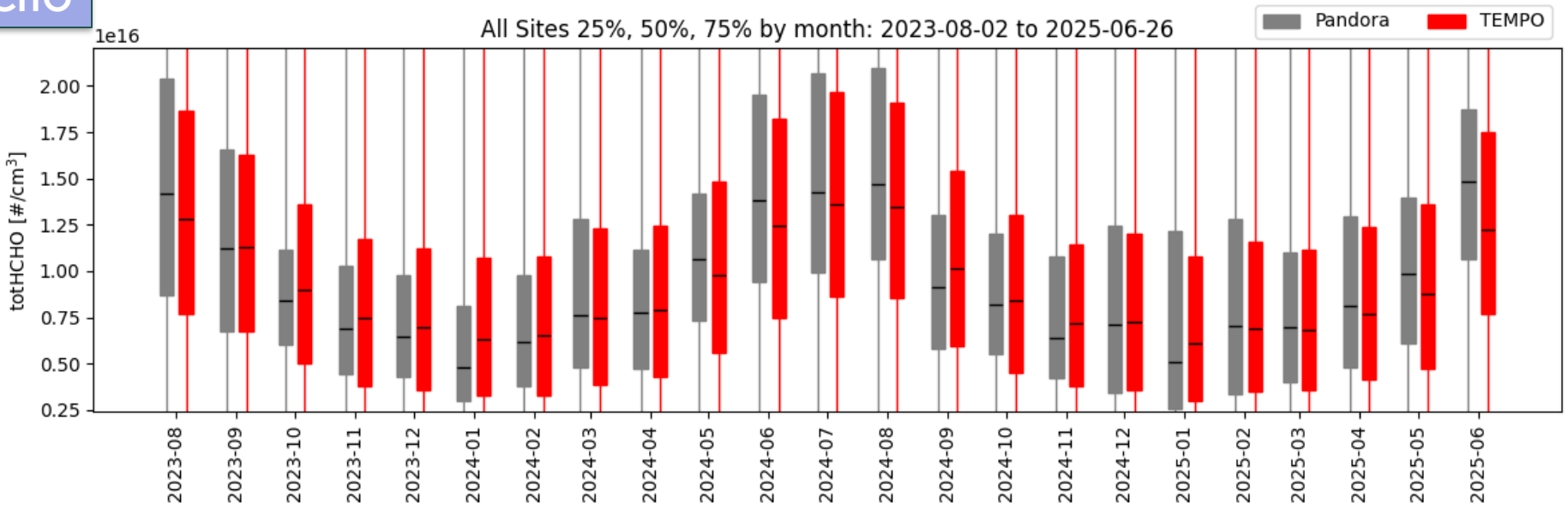
Filter using
Cloud fraction < 15%
SZA < 70°

NO_2



TEMPO **NO_2** captures Pandora seasonal pattern (r=0.82) with good bias (NMB=3%)

HCHO

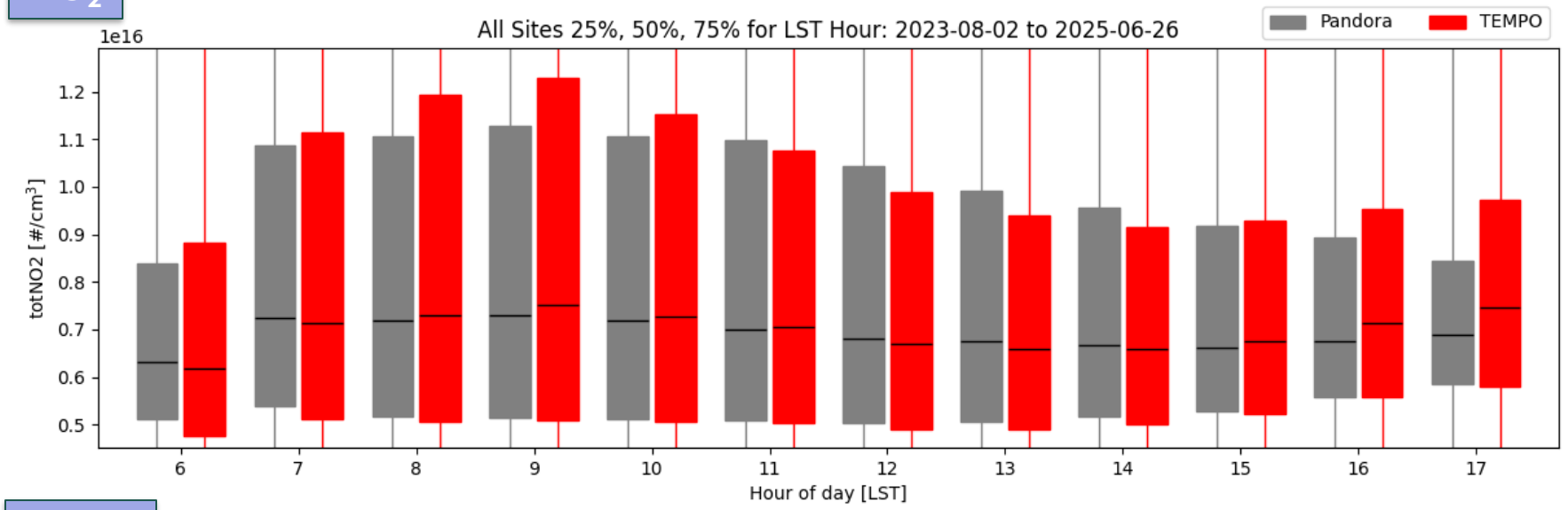


TEMPO **HCHO** captures seasonal pattern (r=0.98) with good bias (NMB=-3%)

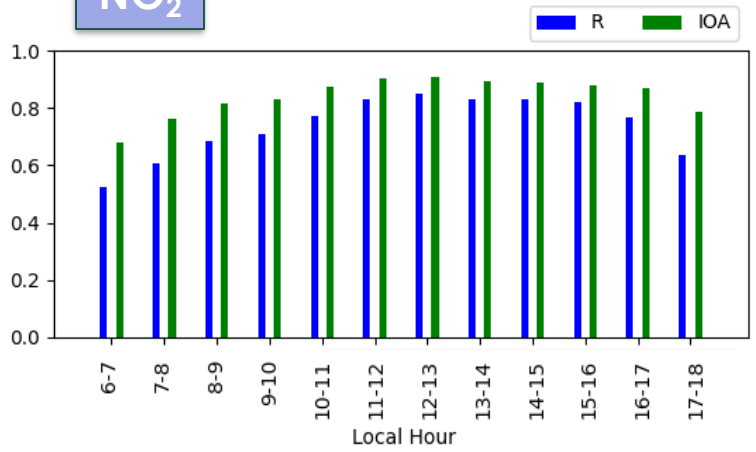
TEMPO vs. Pandora Across All Sites Per Hour of Day

Filter using
Cloud fraction < 15%
SZA < 70°

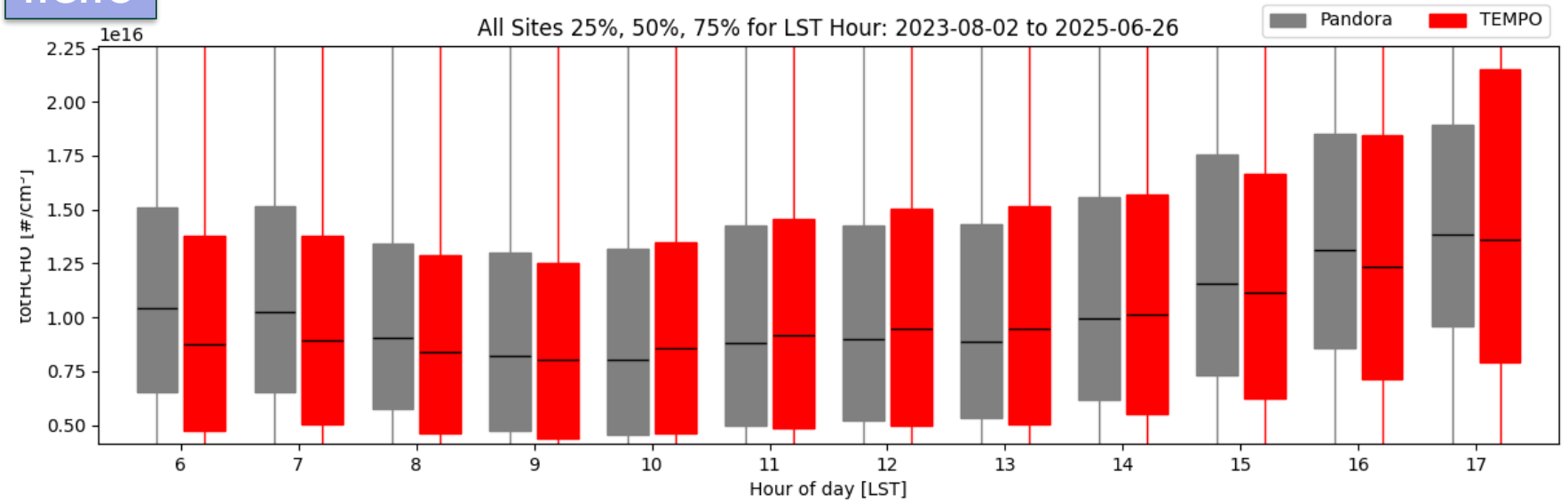
NO_2



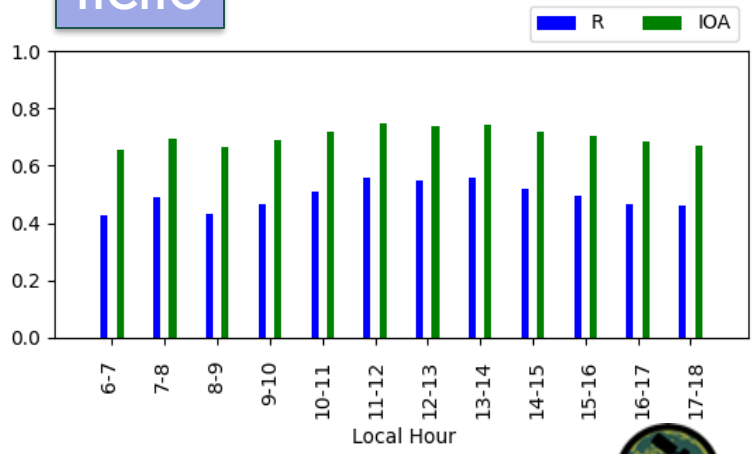
NO_2

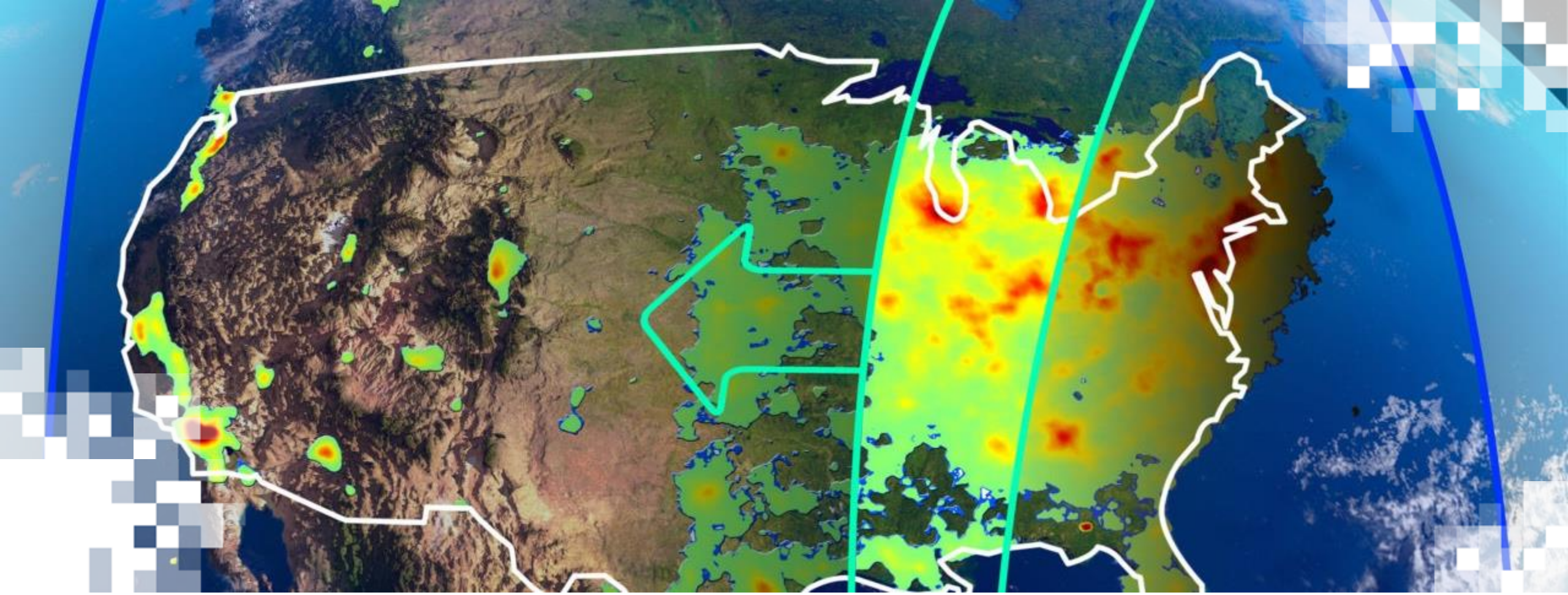


HCHO



HCHO





TEMPO Data Visualization in Worldview

Practice Visualizing TEMPO data in Worldview

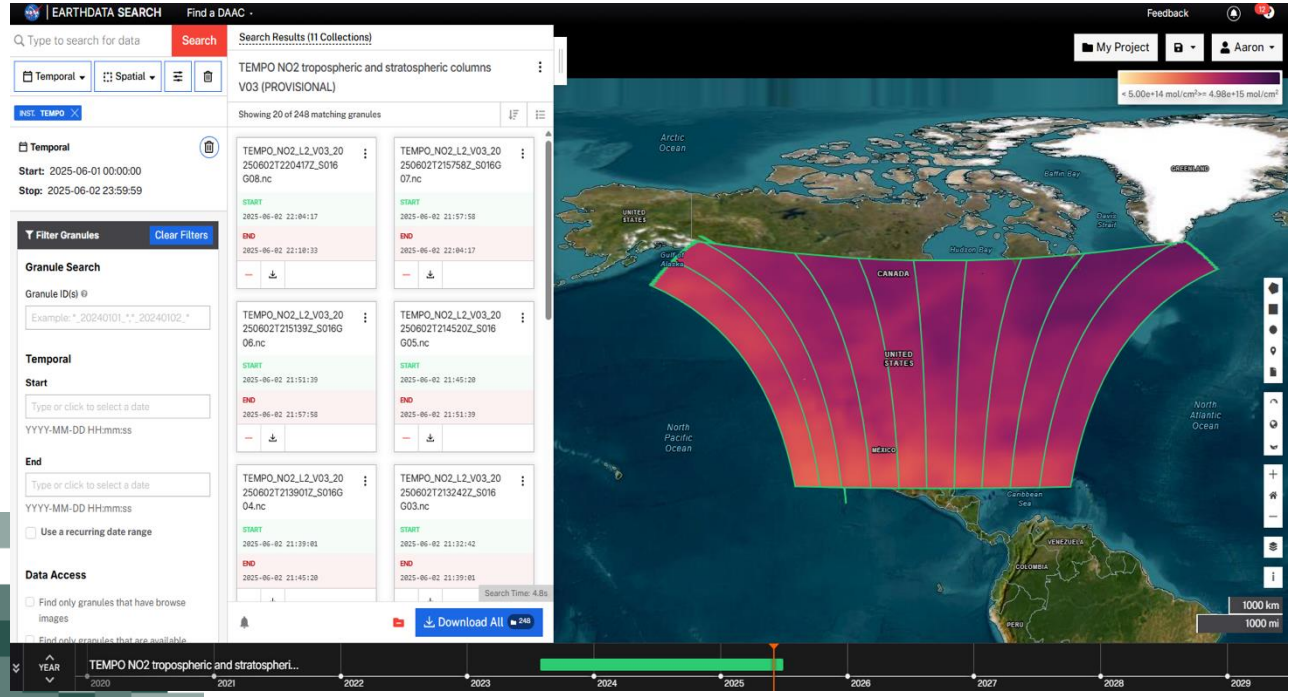
- Open NASA Worldview
- Navigate to Los Angeles, California, USA on January 9, 2025
- Add Layers
  - Search for "TEMPO"
  - Add trace gas level 2 and 3 product layers

- Direct Link to TEMPO trace gas data in Worldview

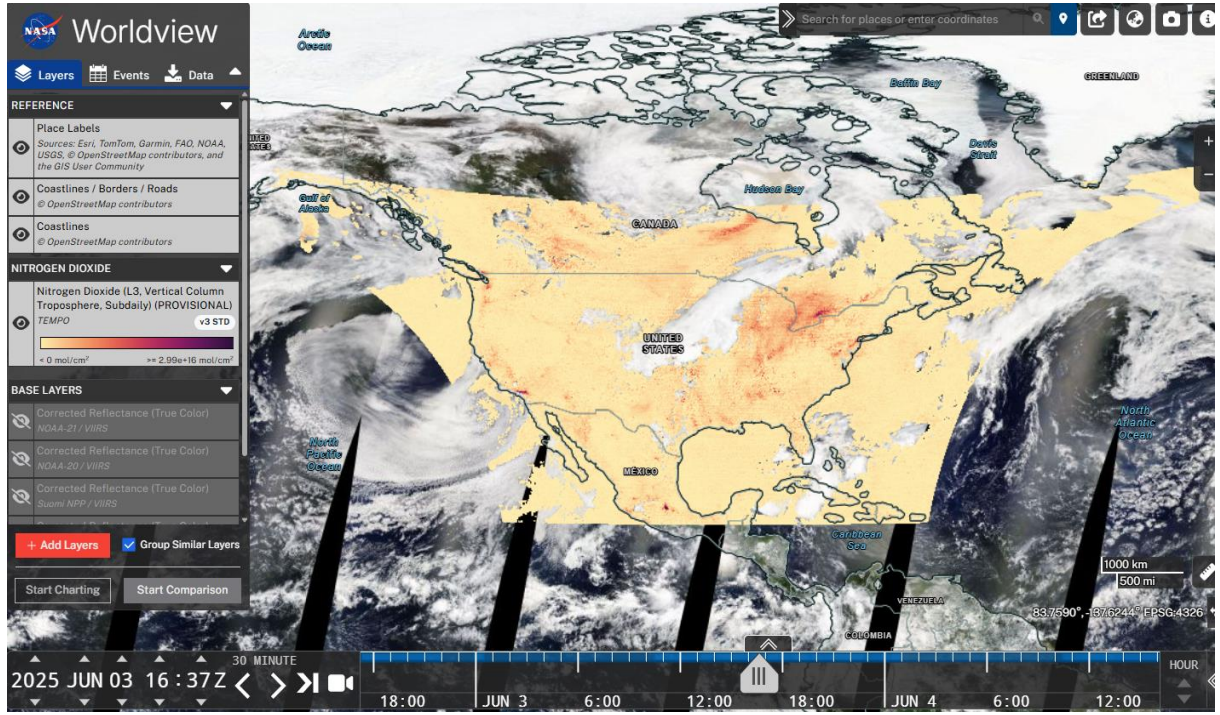
Data Access & Visualization Tools (1)

- List of data access, visualization tools, and user guides can be found at:
  - https://asdc.larc.nasa.gov/project/TEMPO
- NASA SPoRT Viewer provides TEMPO visualizations:
  - https://weather.ndc.nasa.gov/sport/viewer

Earthdata Search for Downloading TEMPO Data



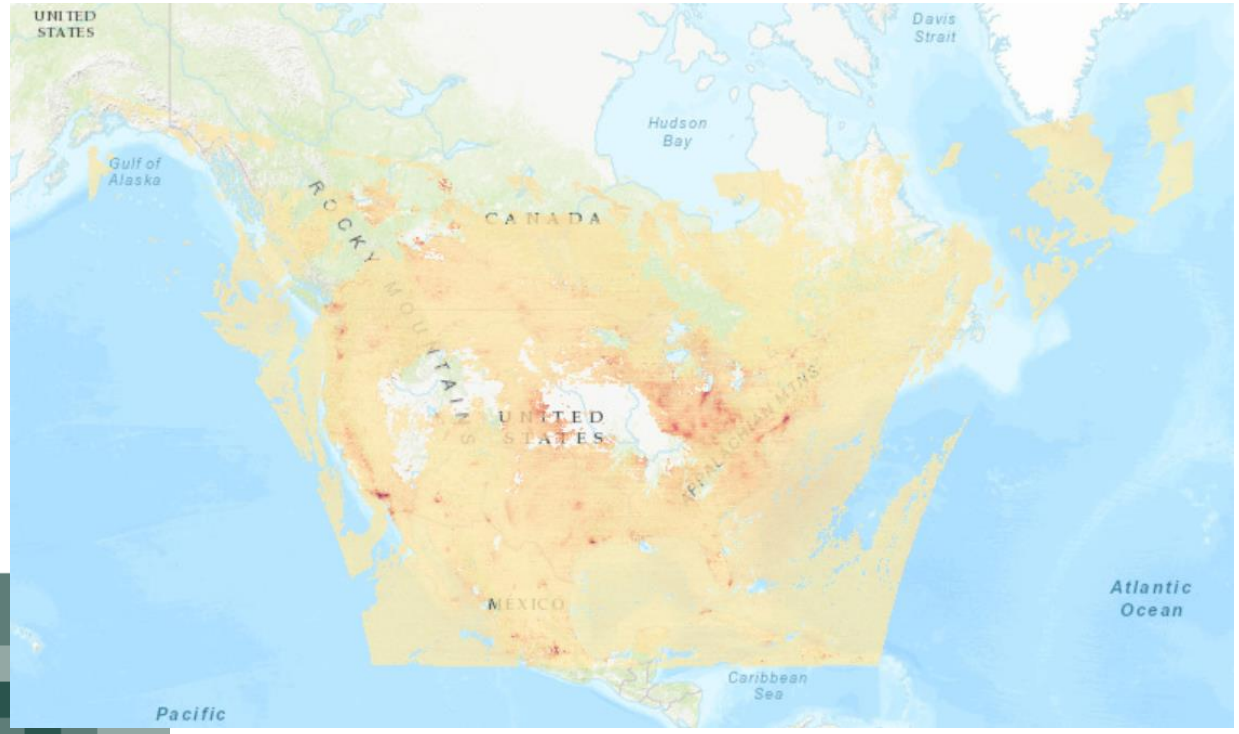
Worldview for Visualizing TEMPO Data



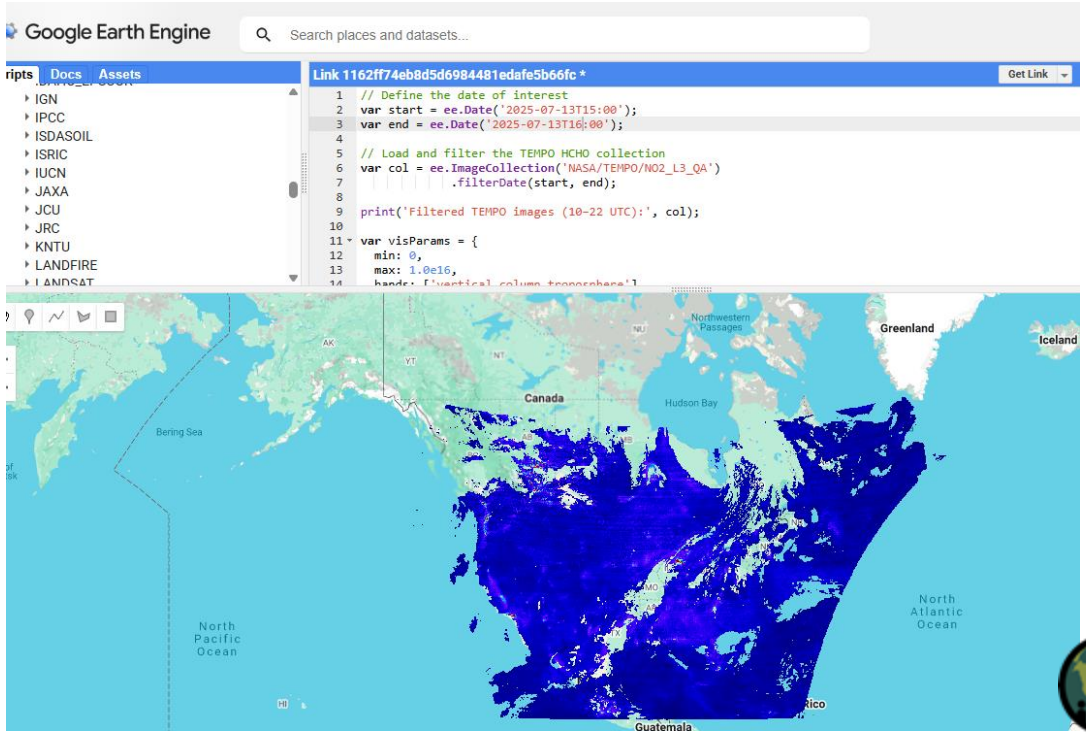
Data Access & Visualization Tools (2)

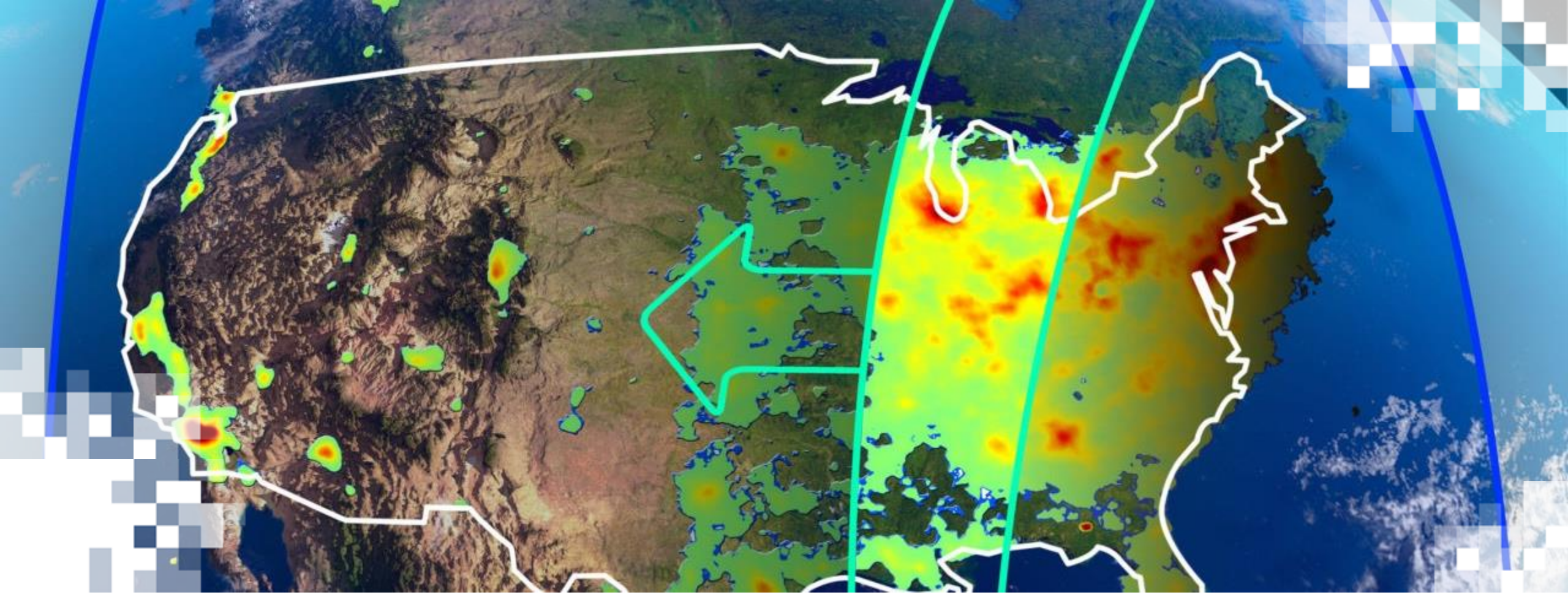
- NASA Living Atlas provides TEMPO visualizations:
  - https://nasa.maps.arcgis.com/home/
- Google Earth Engine provides TEMPO visualizations:
  - https://developers.google.com/earth-engine/datasets/catalog/

Living Atlas



Google Earth Engine





Part 1:
Summary

Summary of TEMPO Geostationary Trace Gas Products for Air Quality

- TEMPO's hyperspectral capability across ultraviolet to visible wavelengths enables retrieval of criteria trace gas pollutants in the troposphere at unprecedented spatial and temporal resolution across greater North America.
- TEMPO observes small-scale emission sources and fine-scale pollutant gradients that have not been adequately resolved by prior satellite missions.
- Its geostationary hourly daylight observations and special observation modes allow for monitoring rapidly evolving pollutants, supporting air quality analysis & forecasting.
- TEMPO's provisional NO_2 and HCHO products show overall good agreement to the Pandora validation network and TROPOMI data.
- O_3 profile product (currently in beta version) offers enhanced capabilities to monitor and characterize ozone concentrations in the tropospheric layer.
- NASA Worldview applies TEMPO quality assurance suitable for qualitative visualization.
- For quantitative analysis, users need to apply quality assurance variables to level 2 and 3 products, removing TEMPO data with larger errors or uncertainties from their analysis.
  - Using strict quality assurance tends to remove large NO_2 columns from wildland fire smoke.

Looking Ahead to Part 2

- Evaluate TEMPO trace gas products in Worldview to anticipate short-term air quality risks, such as high concentrations of ozone pre-cursors.
- Determine the spatial patterns, temporal trends, and likely sources of trace gases related to wildfire smoke and urban area air pollution events, using TEMPO data via Worldview.
  - Case 1: Colorado Front Range Fires and Ozone Exceedance Event
  - Case 2: Urban Air Quality Conditions and Major Pollution Sources in Eastern Texas

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 01/22/2026
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 02/05/2026**

- **Certificate of Completion:**
  - Attend both live instructor-led sessions (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Contact Information

Trainers:

- Aaron Naeger
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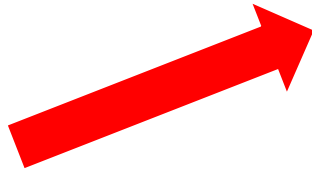
  - kristina.pistone@nasa.gov

- ARSET Website
- ARSET YouTube

Resources

- NASA Worldview for Visualizations of TEMPO and OMI:
  - https://worldview.earthdata.nasa.gov/
- Google Earth Engine for Visualizations of TEMPO and TROPOMI:
  - https://developers.google.com/earth-engine/datasets/catalog/
- Copernicus Data Space Ecosystem for Visualizations of TROPOMI:
  - https://dataspace.copernicus.eu/explore-data/data-collections/sentinel-data/sentinel-5p



- TEMPO Validation Results:
  - https://gaftp.epa.gov/Air/aqmg/bhenders/share/TEMPO/
- TEMPO Green Paper (Living document of proposed TEMPO experiments):
  - https://weather.ndc.nasa.gov/tempo/publications/TEMPO-Green-Paper.pdf


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!