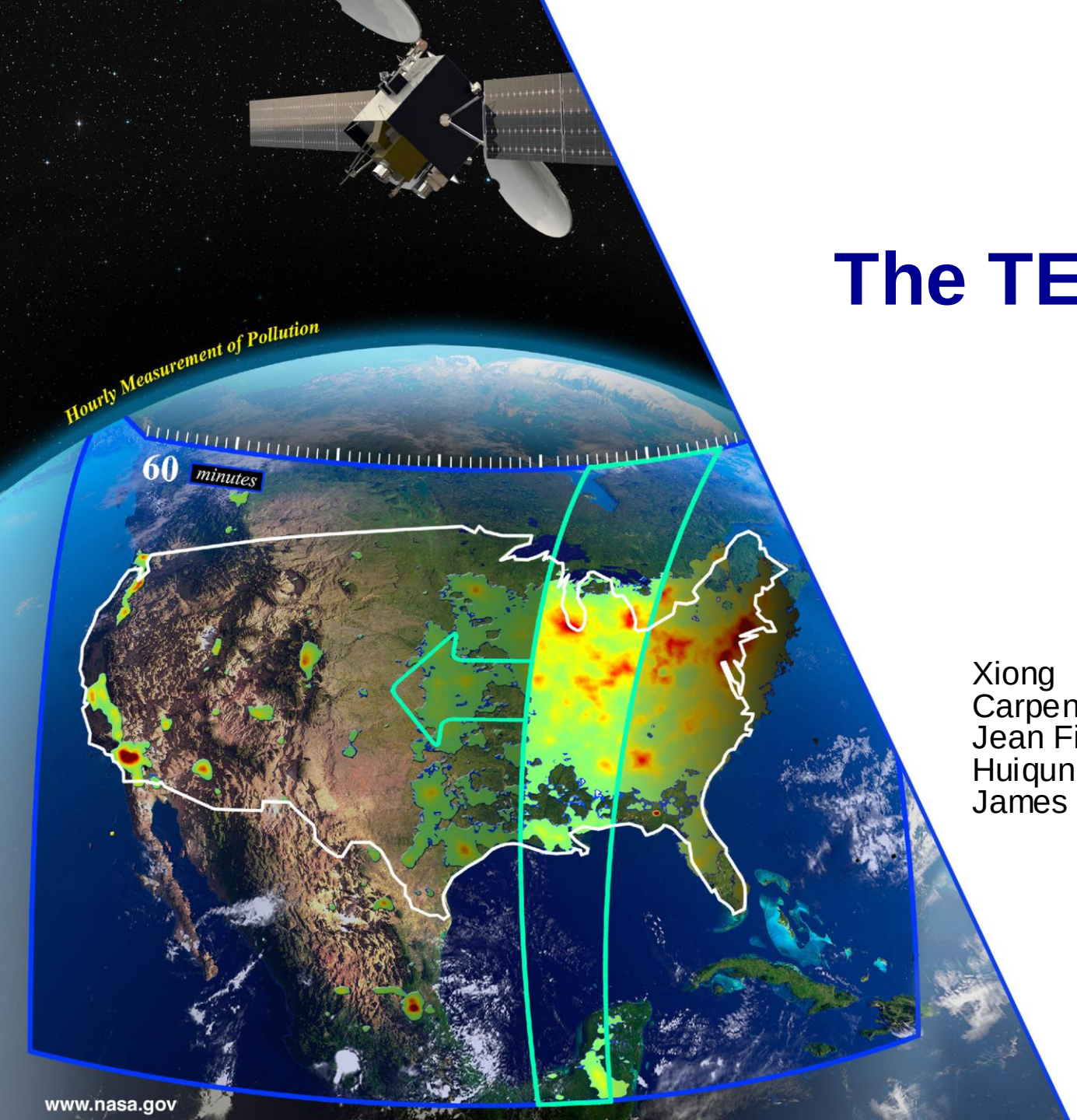


Tropospheric Emissions:
Monitoring of Pollution

The TEMPO satellite mission: Overview and status

Caroline Nowlan
Center for Astrophysics | Harvard & Smithsonian

Xiong Liu, Kelly Chance, Gonzalo González Abad, Laurel Carpenter, Chris Chan Miller, Heesung Chong, John Davis, Jean Fitzmaurice, Weizhen Hou, John Houck, Raid Suleiman, Huiqun Wang, James Carr, Barron Henderson, Luke Valin, James Szykman and the TEMPO Team

HAQAST Meeting
June 4, 2024

Smithsonian

Tropospheric **E**missions: **M**onitoring of **Po**llution

- Hourly daytime air pollution measurements over North America
- NASA's first Earth Venture Instrument (EVI), selected in 2012
- **Geostationary orbit** means TEMPO can scan the continent continuously
  → High temporal resolution
  → High spatial resolution
- Baseline data products:
  - Nitrogen dioxide
  - Formaldehyde
  - Ozone (total and profile)

Credit: NASA's Scientific Visualization Studio

TEMPO Scanning

Nominal scans

- 2048 North/South pixels
- 1181 East/West steps per hour
- 2 x 4.75 km^2 at center of field of regard

Optimized scans

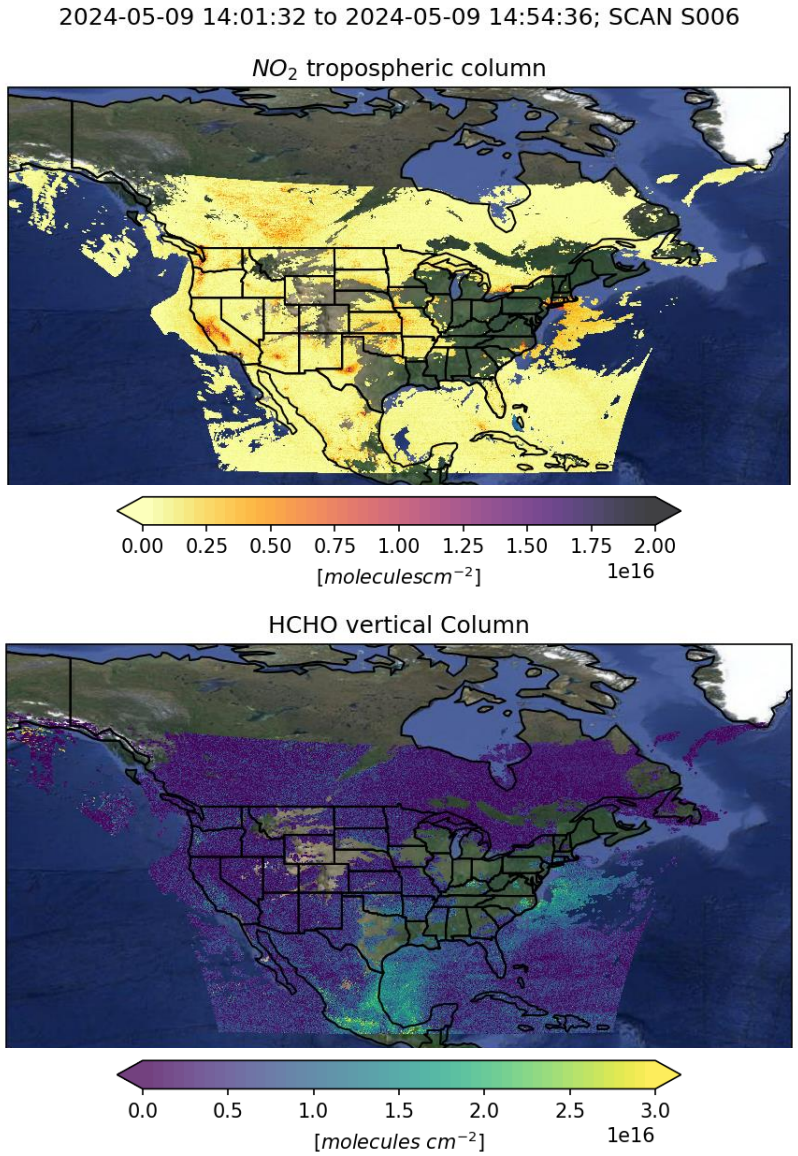
- Higher temporal resolution AM and PM scans over coasts (40 minutes)

Twilight scans (city lights)

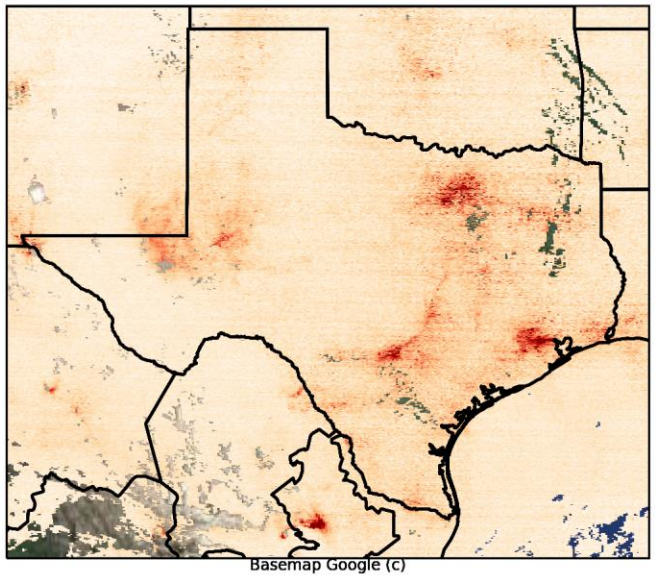
- Performed during darkness, before morning scans

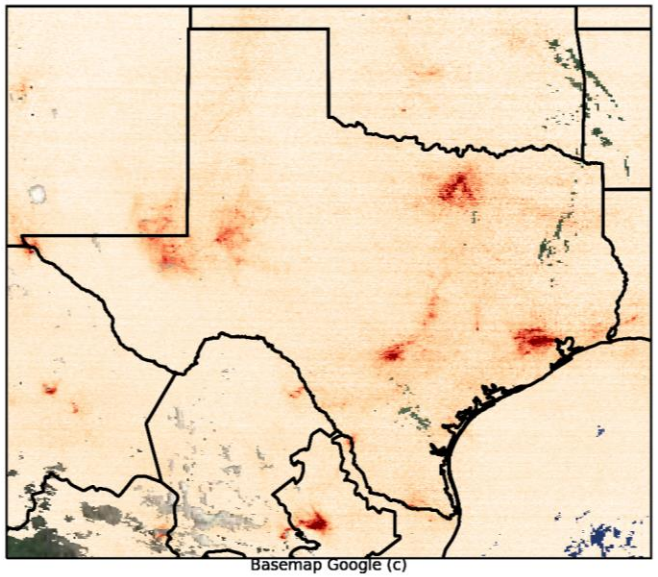
High-time resolution scans

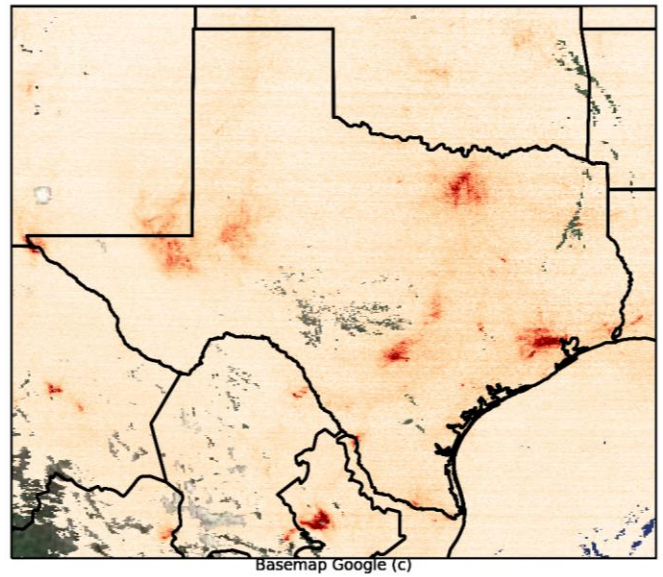
- Frequent scans (5 to 10 minutes) over selected longitudes
- Rare → can be requested but need strong science justification



TEMPO NO_2: Texas







TEMPO Timeline

Date	Details
7 April 2023	Launch
June-July 2023	TEMPO power on + dry-out, cool down, etc.
2 August 2023	**First light**
19 October 2023	Nominal Operations

Public Release	Details
V01	Limited 3 weeks released in February 2024
V02	Level 1 (radiances) released in February 2024
V03	Level 1 updated, Level 2/3 NO_2, HCHO, total O_3 released May 2024 Currently 13 May 2024 onwards; reprocessing has begun.

Baseline TEMPO Data Products

Level	Product	Validation Status
L1	Irradiance NRT	Beta
	Radiance NRT	Beta
	Radiance (twilight – city lights)	Beta
L2	Clouds NRT	Beta
	NO_2 NRT	Beta
	HCHO NRT	Beta
	O_3 (total)	Beta
	O_3 (profile)	Release on hold
L3	L2 gridded to 0.02° × 0.02°	

Satellite needs working group has funded TEMPO NRT products (expect in 2025)

NOAA to product NRT aerosols

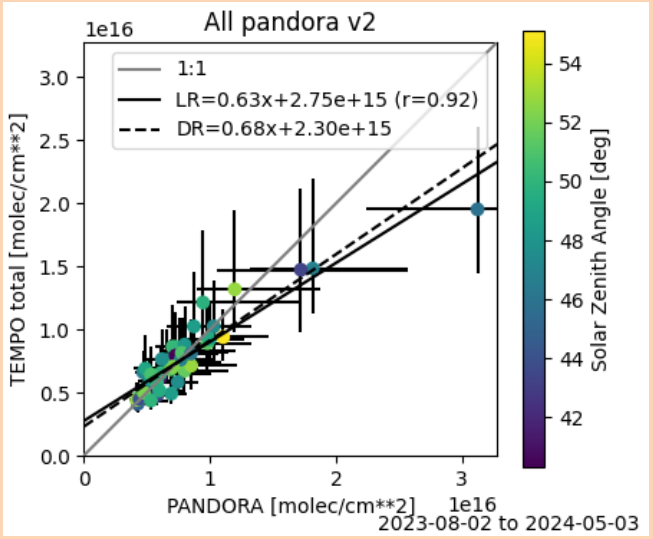
Research products:
Aerosols, SO_2, ocean color, city lights

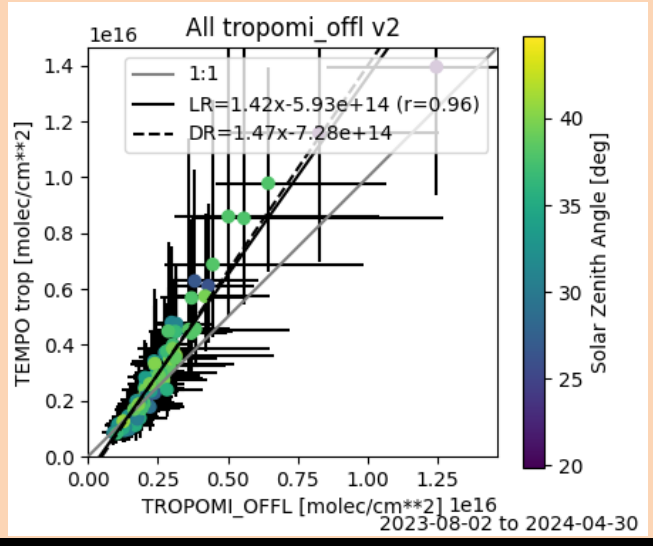
Future SAO products:
H_2O vapor, glyoxal, BrO, HNO_2

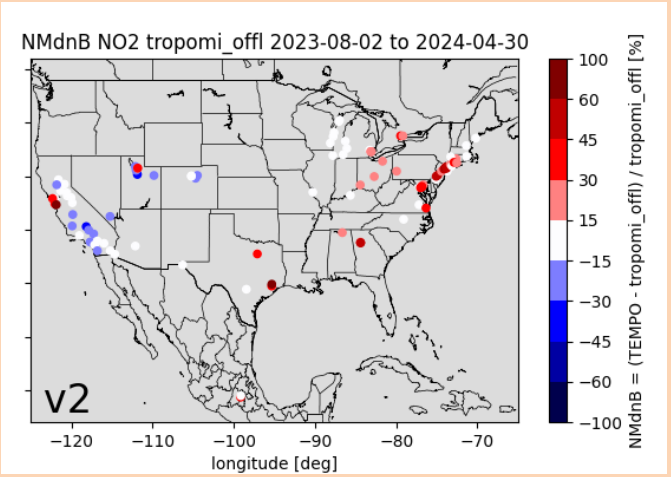
*__Beta__: "minimally validated", publication "not recommended and highly discouraged"
→ Hope to go to __provisional__ status after validation team approval

Pandora and TROPOMI Comparisons (V02)

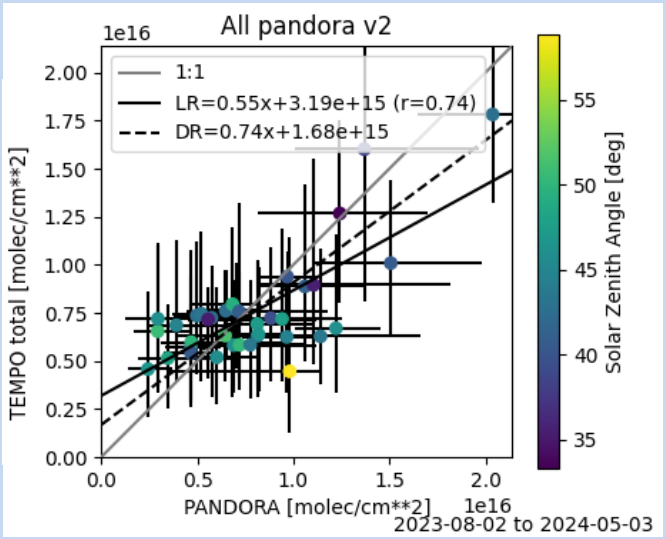
NO_2

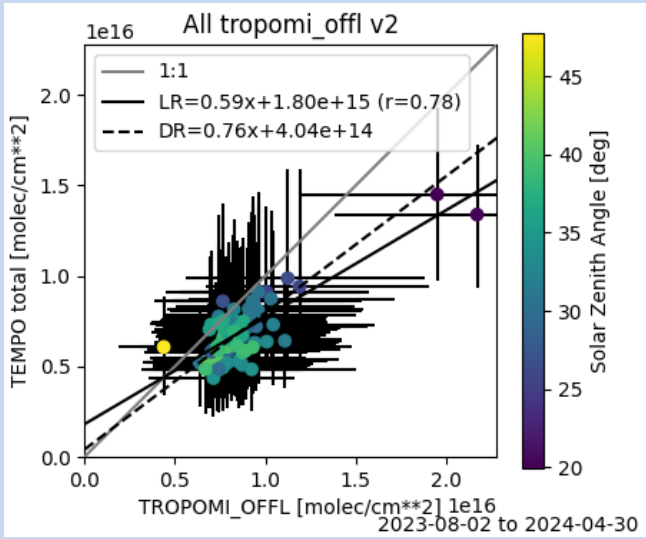


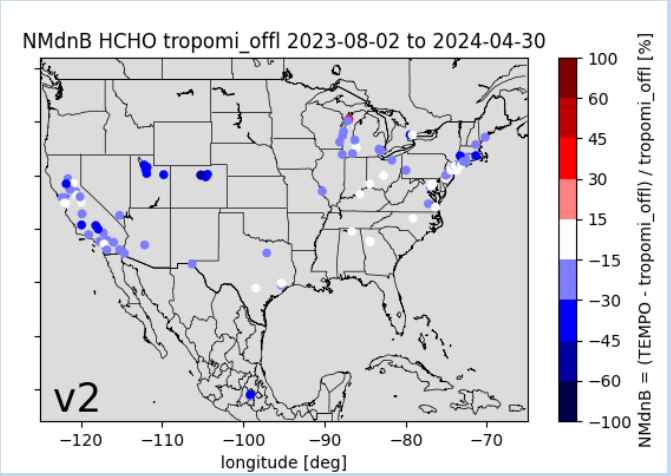




HCHO







[Credit: Barron Henderson, Luke Valin, Jim Szykman]

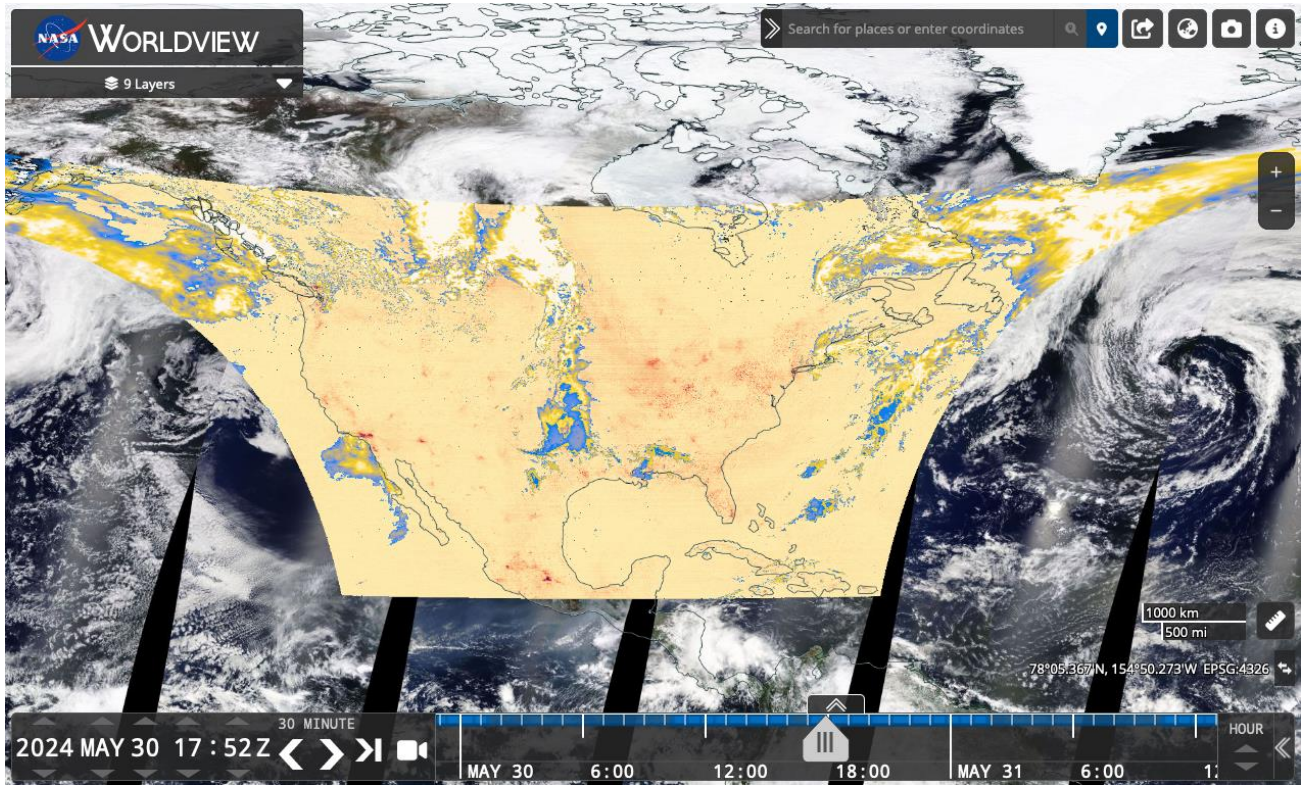
** TROPOMI comparisons are for Pandora locations + ozone non-attainment areas*

Getting TEMPO Data

- TEMPO data now publicly available through NASA Atmospheric Science Data Center
  - 13 May 2024 onward
  - Now reprocessing from August 2023

- Multiple tools:
  - Earthdata Search, OPeNDAP
  - NASA Worldview
  - ArcGIS services
  - RSIG (EPA)

- For more information check out:
  - **User Guide**
  - Daily log
  - Validation plan
  - Validation reports (coming soon)
  - Algorithm Theoretical Basis Documents (drafts available upon request, not yet reviewed)



- NASA Webinar recording for new users: https://youtu.be/meySKqVuVT0?si=uiLTRXsgtKIGS_OT

Summary and Outlook

- TEMPO operations are nominal
- NO_2, HCHO, total O_3 now publicly available
- Validation team starting to examine V03
- Priorities for V04:
  - Radiances → improve absolute calibration, tests on wavelength shift trends, polarization, advance validation to provisional
  - NO_2, HCHO, cloud → improve surface albedo, cloud fraction bias, HCHO background correction, North/South striping
  - Total O_3 → latitude-dependent bias
  - Continued development and release of O_3 profile product
- Near-real time products estimated for middle of 2025


TEMPO