weather.msfc.nasa.gov/tempo/

Tropospheric Emissions: Monitoring of Pollution

Hourly Measurement of Pollution

Smithsonian Astrophysical Observatory

http://tempo.si.edu/

Tropospheric Emissions: Monitoring of POllution (TEMPO) Mission

ARSET Training

Tuesday, October 11, 2022

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NASA MSFC

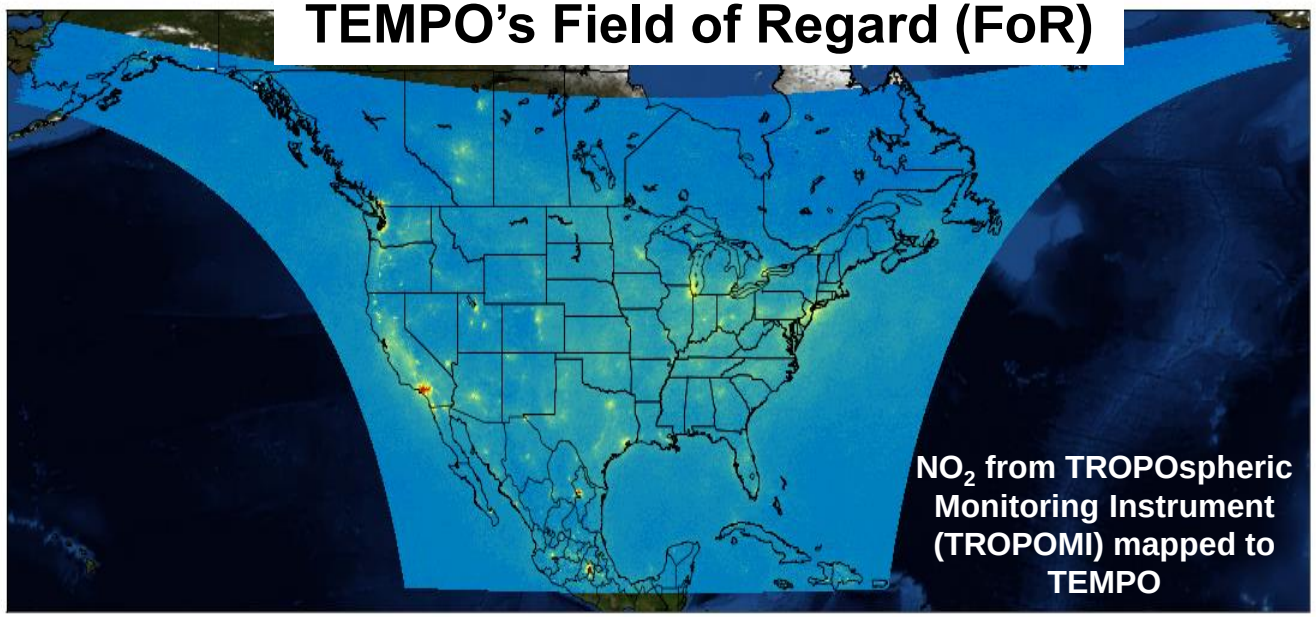
U.S. Government sponsorship acknowledged.

SPORT

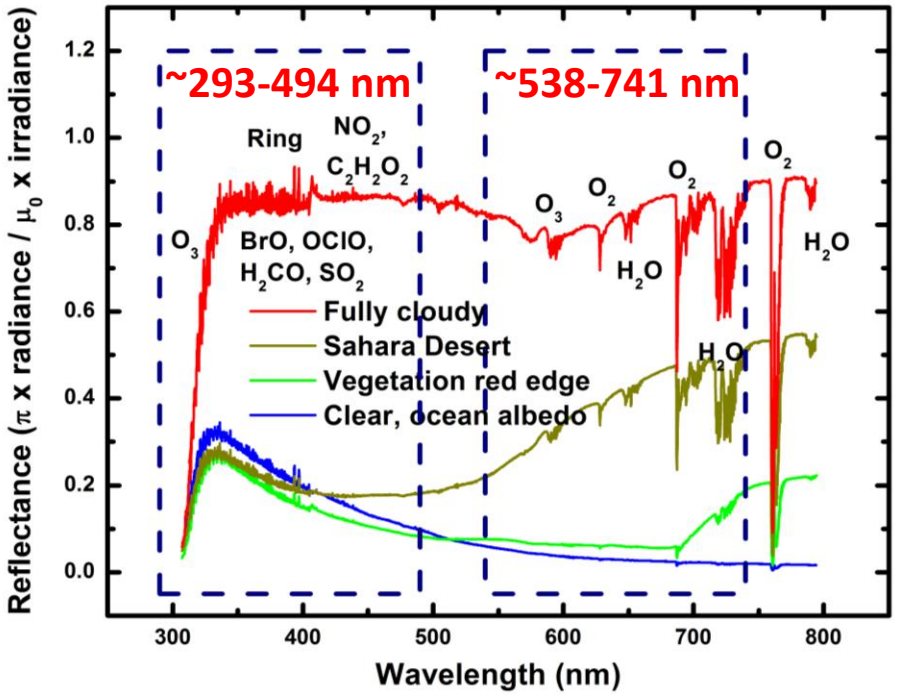
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

TEMPO Quick Facts

TEMPO's Field of Regard (FoR)

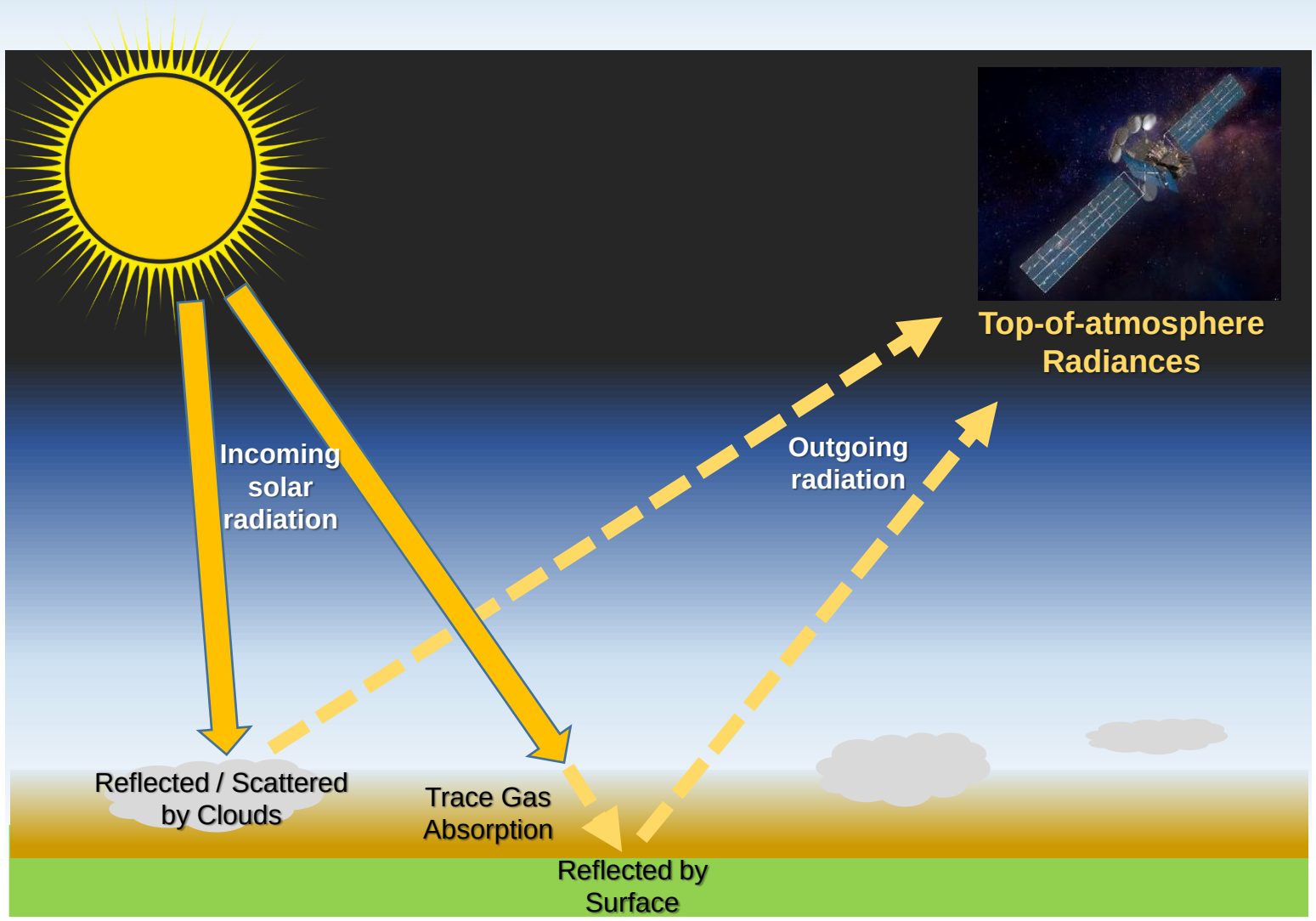


- NASA's first Earth Venture Instrument (EVI) selected in 2012 & first host payload
- TEMPO will observe atmospheric pollution every daylight hour at high spatial resolution from Geostationary Earth Orbit.
- UV/Visible grating spectrometer is sensitive to **policy-relevant pollutants (NO_2, SO_2, O_3)** and aerosols.



- Capability to distinguish between boundary layer from free tropospheric and stratospheric O_3
- TEMPO instrument integration with host satellite, Intelsat 40e, was recently completed in June.
- Launch is expected early March 2023 (target March 1) to 91°W longitude (Baseline mission: 20 months).
- Member of a geostationary satellite constellation for observing pollution over Northern Hemisphere

Measuring Trace Gases from TEMPO



- TEMPO will measure the intensity of backscattered UV and visible radiation which is influenced by surface and atmospheric conditions.
- Retrieval algorithms will derive slant column densities (SCDs) from measured radiances in known trace gas absorption spectral windows.
- Trace gas column density is the total number of molecules of a given gas along the light path.
- SCD is converted to vertical column density to provide information on a trace gas right above the TEMPO footprint.

TEMPO Data Products

Level	Product	Key Outputs	Res km^2 *	Freq/Size
L0	**Digital counts**	Reconstructed digital counts	2.0 x 4.75	Daily/hourly
L1-b	**irradiance**	Calibrated & quality flags		daily
	radiance	Geolocated, calibrated, viewing	2.0 x 4.75	Hourly, granule
L2 ★	**Cloud**	Cloud fraction, cloud pressure	2.0 x 4.75	Hourly, granule
	O_3 (Ozone) profile	O3 profile, tropospheric & 0-2 km O3 column, errors	**8.0 x 4.75 (TBD)**	Hourly, granule
	Total O_3	Total O3, Aerosol Index, cloud fraction	2.0 x 4.75	Hourly, granule
★	**NO_2** (Nitrogen Dioxide)	SCD, strat./trop. VCD, uncertainties	2.0 x 4.75	Hourly, granule
★	**HCHO** (Formaldehyde)	SCD, VCD, errors	2.0 x 4.75	Hourly, granule
	$C_2H_2O_2$ (Glyoxal)		2.0 x 4.75	Hourly, granule
	H_2O (Water Vapor)		2.0 x 4.75	Hourly, granule
	BrO (Bromine)		2.0 x 4.75	Hourly, granule
★	SO_2 (Sulfur Dioxide)	SCD, VCD (PBL,TRL,TRM,TRU,STL)	2.0 x 4.75	Hourly, granule
★	**Aerosol**	AAI, UVAOD, UVSSA, AOCH, VISAOD	**8.0 x 4.75**	Hourly, granule
	TEMPO/GOES-R Synergistic	Radiance, aerosol, cloud & mask, fire/hotspot, lightning, snow/ice, etc.	2.0 x 4.75	Hourly, granule
L3	**Gridded L2**	Same as L2	2 x 2 (TBD)	Hourly, scan
L4	**UVB**	UV irradiance, erythemal irradiance, UVI	TBD	Hourly, scan

★ **Proposed near real-time products (latency ~2-3 hours)**

** Center of Field of Regard

SCD: Slant Column Density
VCD: Vertical Column Density

AAI: Aerosol Absorption Index
UVAOD/VISAOD: UV/VIS Aerosol Optical Depth
UVSSA: UV Single Scatter Albedo
AOCH: Aerosol Optical Centroid Height

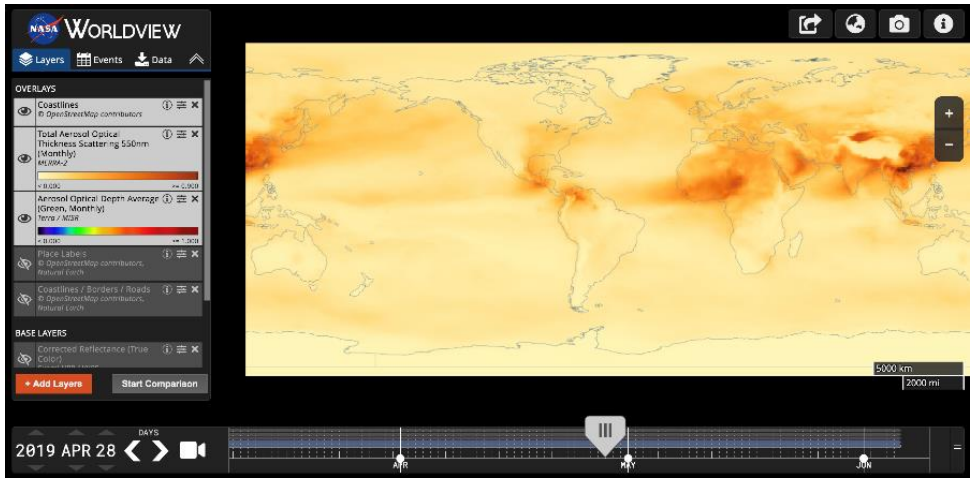
Black text: Baseline products; **Orange text**: Additional / proposed products

Operational Timeline & Data Distribution

Timeline based on March 2023 launch

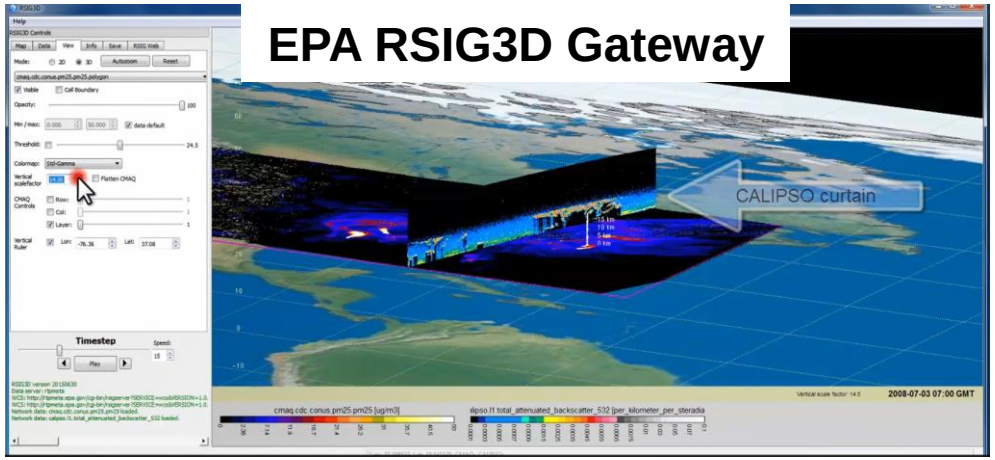
- TEMPO commissioning phase from mid-June – mid Sept 2023
- Nominal operation: ~6 months after launch
- Plan to release level 1b data ~4 months after commissioning phase (Jan 2024) and **level 2 and 3 data ~6 months after commissioning phase (March 2024)**
- Data will be **publicly available** via NASA Earthdata Search in netCDF4/HDF5 format.
- Latency of standard (Offline) products ~3-6 hours, except for ozone profile (~24-hour latency).
- **Latency of ~2-3 hours for proposed near real-time (NRT) products.**
- Baseline mission length is 20 months with possible 10+ year lifetime depending on senior review extensions.

✓NASA WorldView



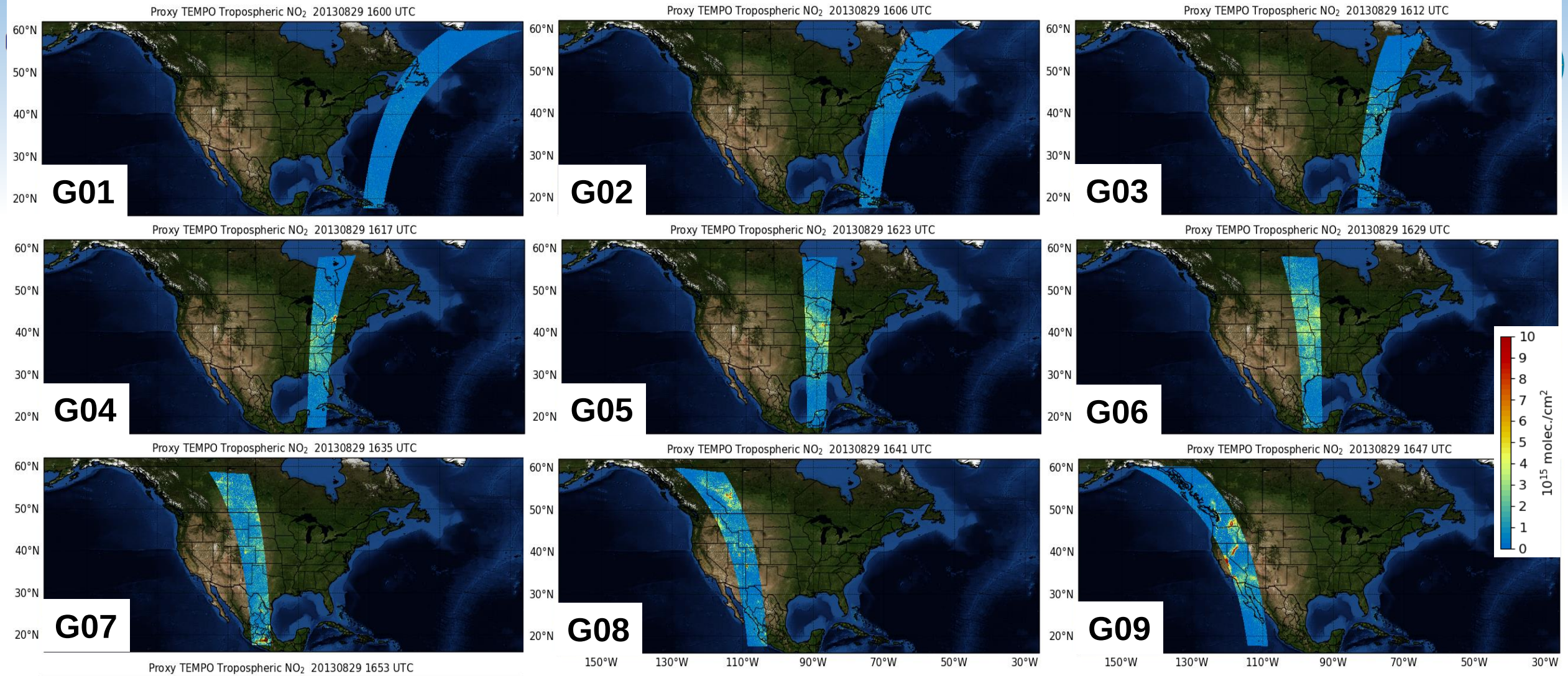
TEMPO imagery will be available in Worldview

EPA RSIG3D Gateway



TEMPO data can be served directly through the EPA RSIG.
https://www.epa.gov/hesc/remote-sensing-information-gateway

Adapted from slides at TEMPO STM 2020 & EAWNov2021 (Jeff Walter, Tim Larson)



- TEMPO L2 data files will be distributed in granules across the FoR
  - Full hour scans will consist of 10 granules containing ~120 mirror steps (complete FoR ~1226 mirror steps)
  - Enable more efficient distribution of TEMPO data, especially near real-time data

Join EA Program here!

TEMPO Application Focus Areas

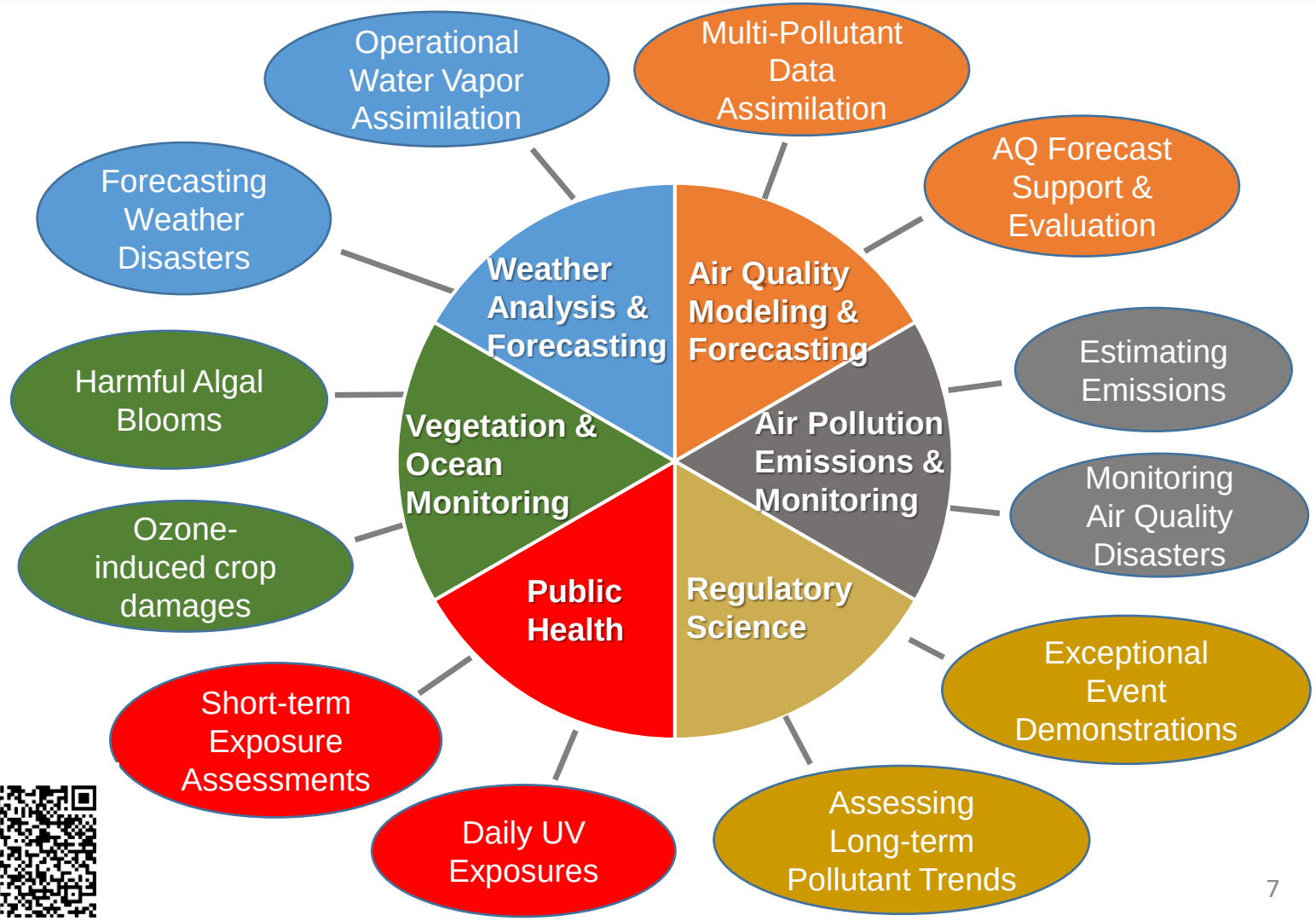
Smithsonian

TEMPO Early Adopter Studies

- **Observing NO_2 pollution inequality**
  - TEMPO will provide new insight into the identity and timing of emission sources and atmospheric drivers of pollution inequality at intra-urban scales.
- **Dust storm monitoring**
  - Dust storms in North America are mostly short-lived, occurring a few hours before sunset. TEMPO will provide new monitoring capabilities of active dust emission areas.
- **Short-term public health outcomes**
  - Hourly gaseous pollutants from TEMPO will enable acute exposure assessments in epidemiological studies of asthma exacerbations.

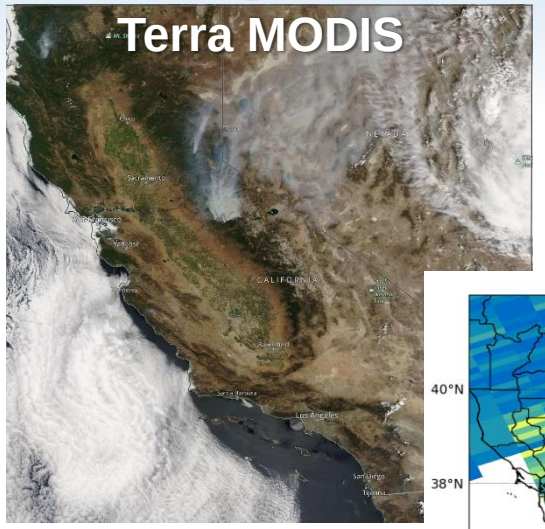
Green Paper here!

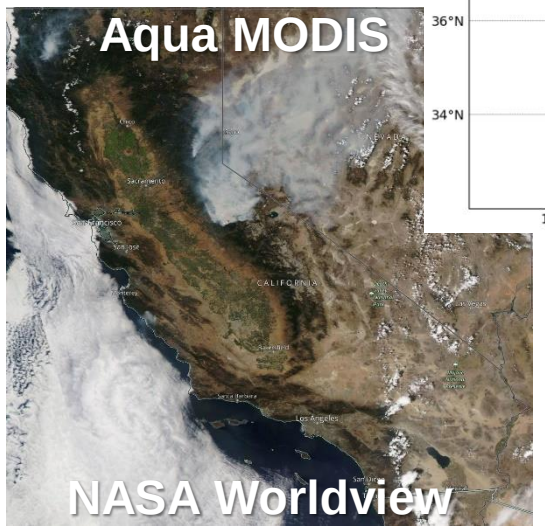
TEMPO data will enable new and enhanced health and air quality applications



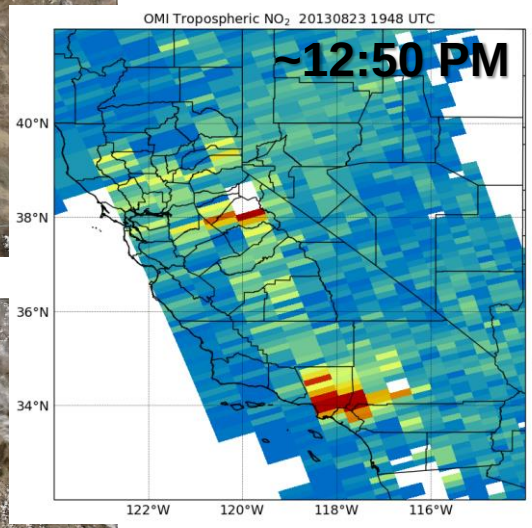
Monitoring Precursor Gases with TEMPO

Aug. 23, 2013

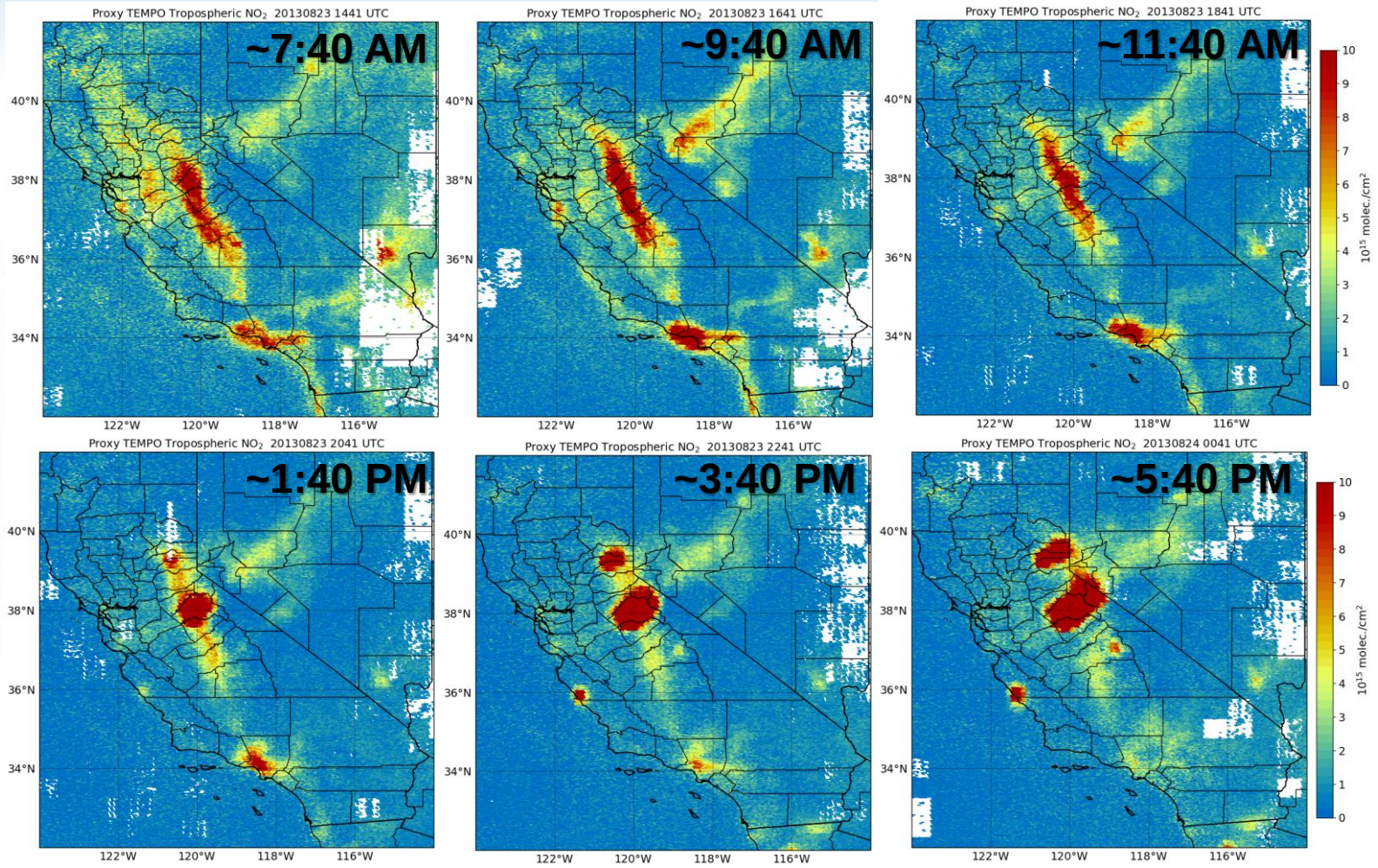




OMI



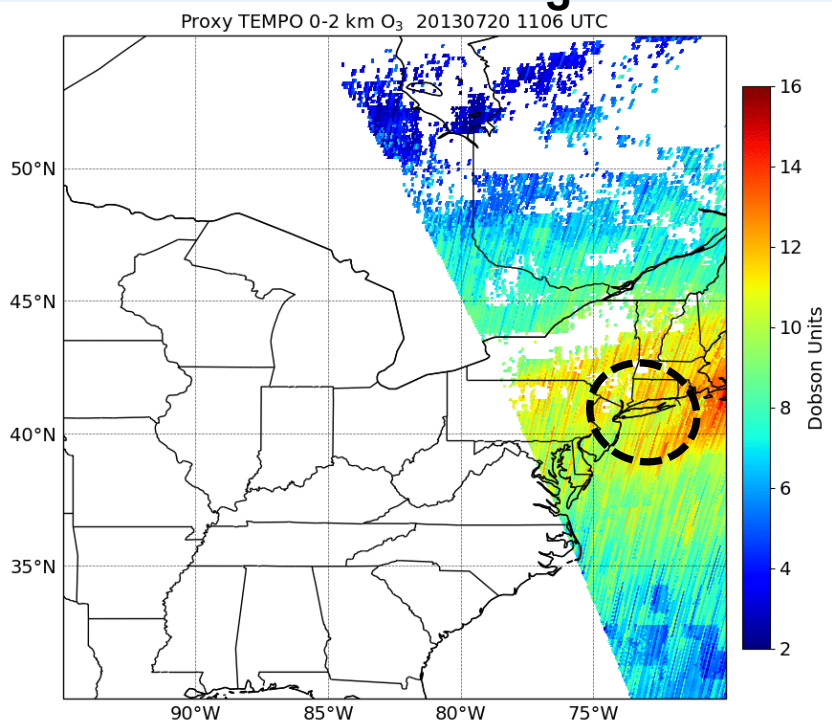
TEMPO Proxy Data



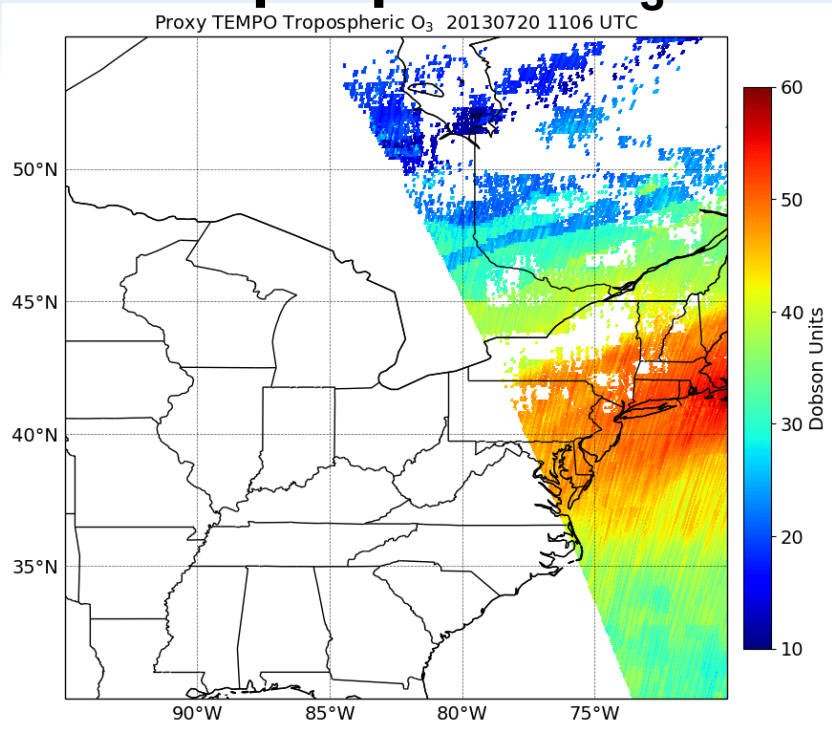
- TEMPO will observe the rapidly varying NO_2 columns within wildfire smoke plumes and across urban areas and traffic corridors.

Monitoring Ozone with TEMPO

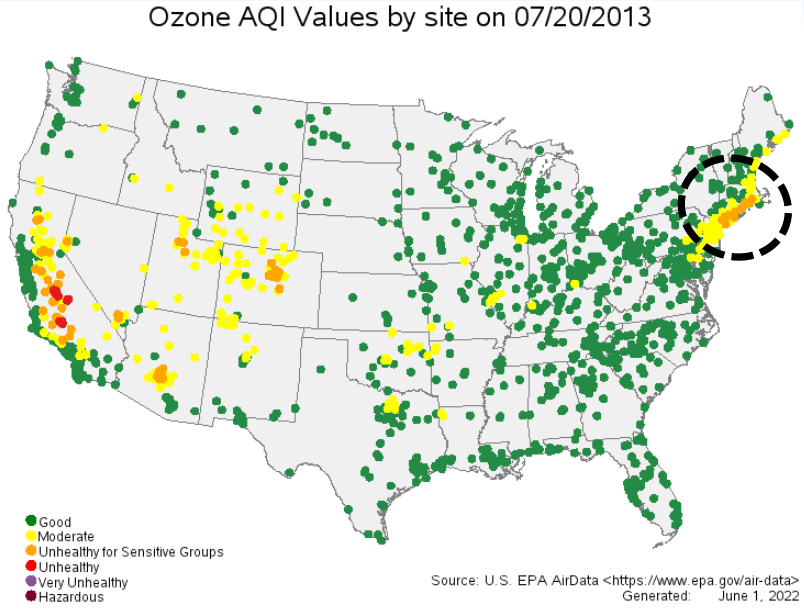
0-2 km O_3



Tropospheric O_3

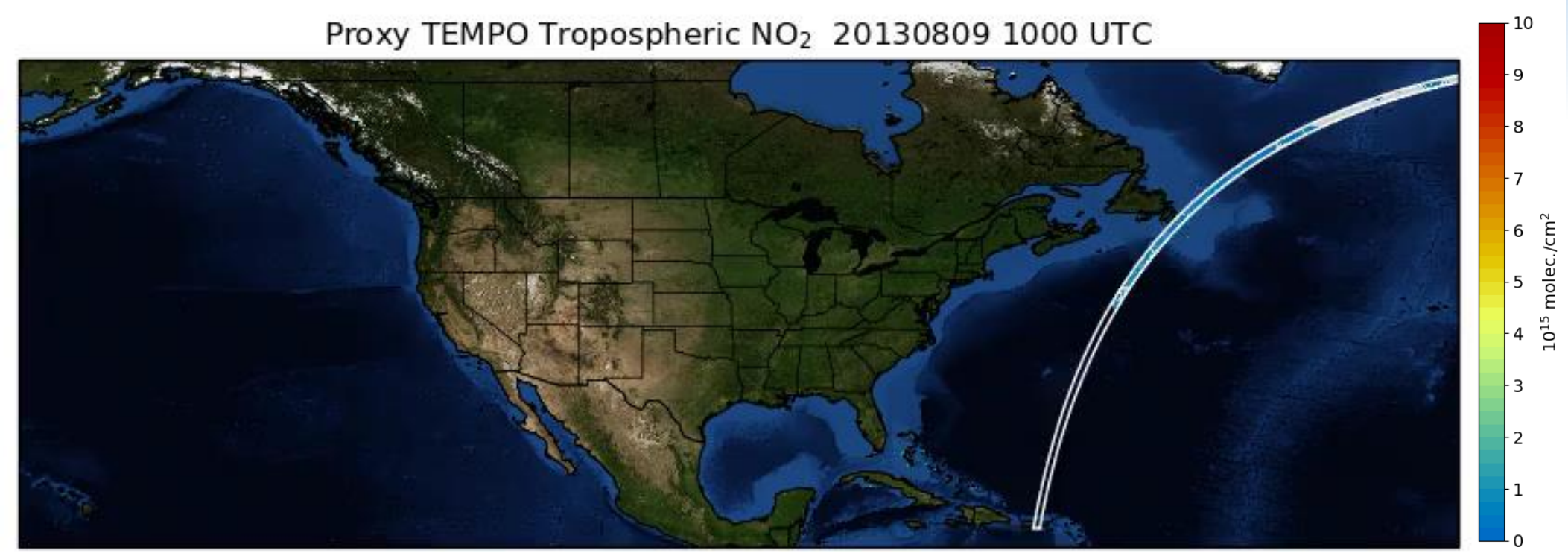


July 20, 2013



- TEMPO will be able to track O_3 pollution in the tropospheric layer throughout the daytime.
- Proxy O_3 profile product demonstrates the sensitivity of the TEMPO instrument to O_3 pollution in the lower troposphere.
- **TEMPO will provide new information on O_3 pollution within the layer of air where people live.**

A Day in the Life of TEMPO



- TEMPO will perform standard (nominal) East-West hourly daytime scans consisting of ~1226 mirror steps across the Field of Regard (FoR) over Greater North America.
- Sub-hourly scans will also be performed:
  1) Optimized scans across the East and West during sunrise and sunset periods, respectively, when SZA is too high (> 80°) over portions of the FoR to complete a nominal hourly scan
  2) **Special operations for dedicated experiments over a subset of mirror steps / time intervals (e.g., <= 10 minutes)**