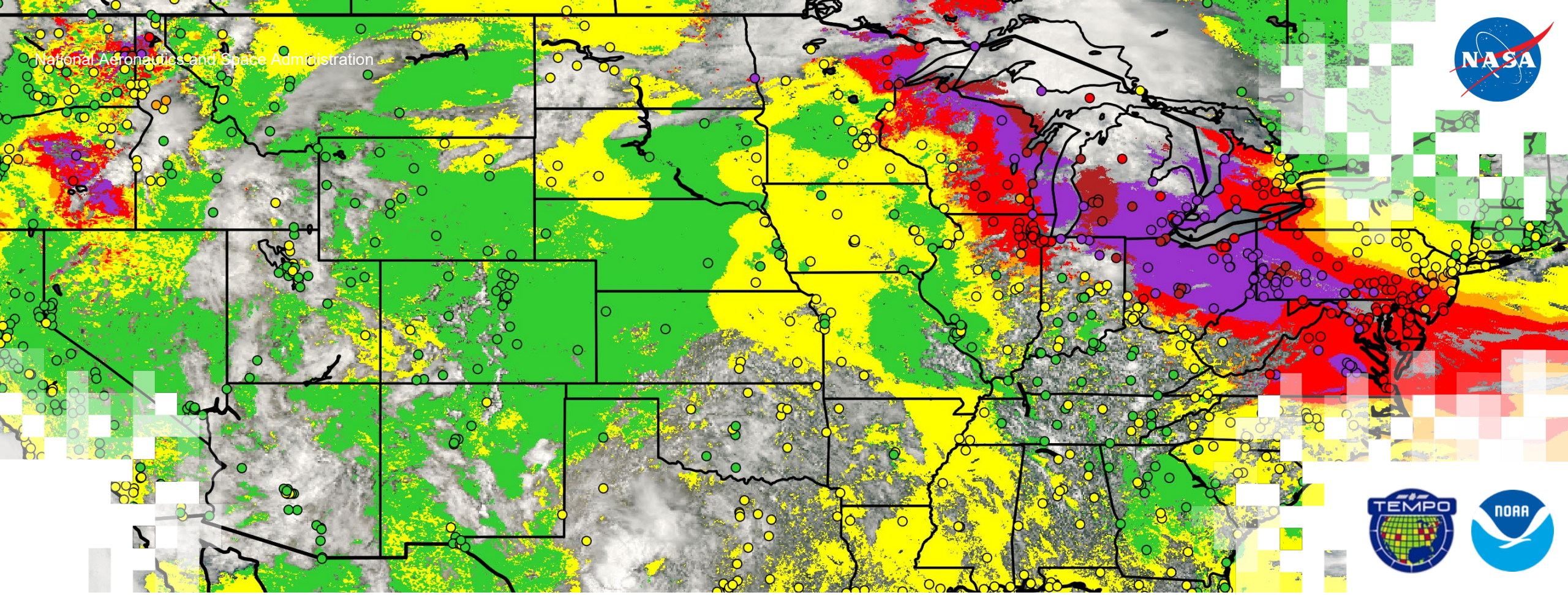
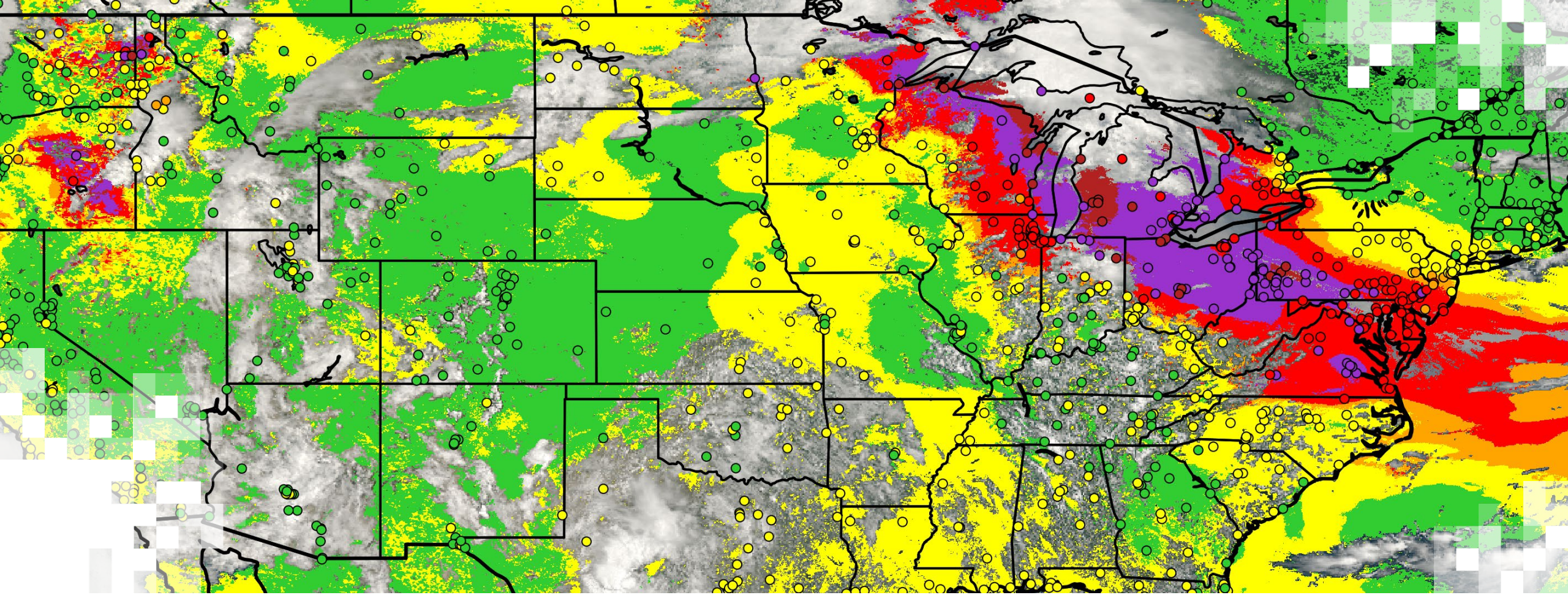


Geostationary Remote Sensing of Aerosols for Air Quality Applications in North America

Part 1: NOAA's TEMPO Aerosol Products for Hourly Aerosol Monitoring over North America

Caterina Mogno (UMBC & NASA GSFC), Amy Huff (STC at NOAA/NESDIS)

October 13, 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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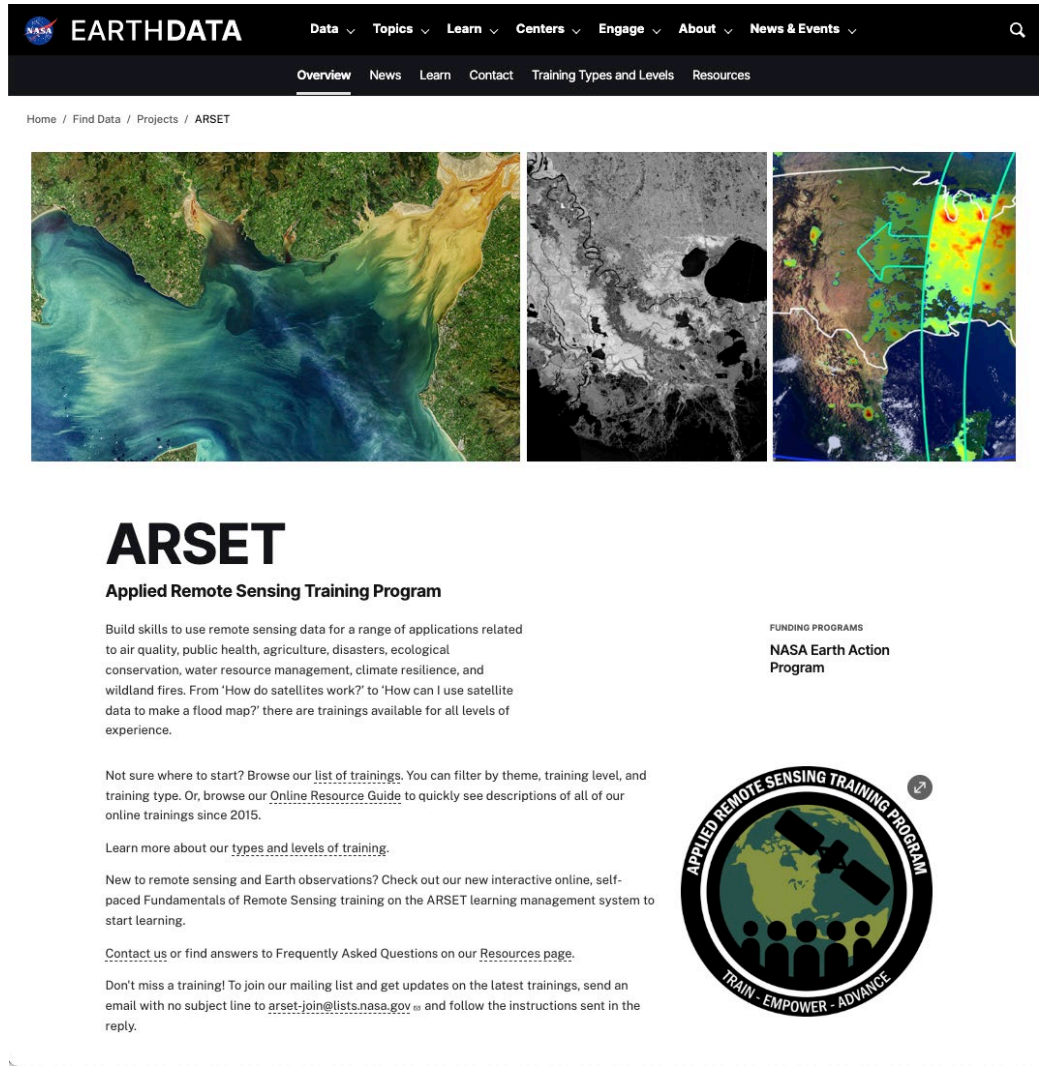


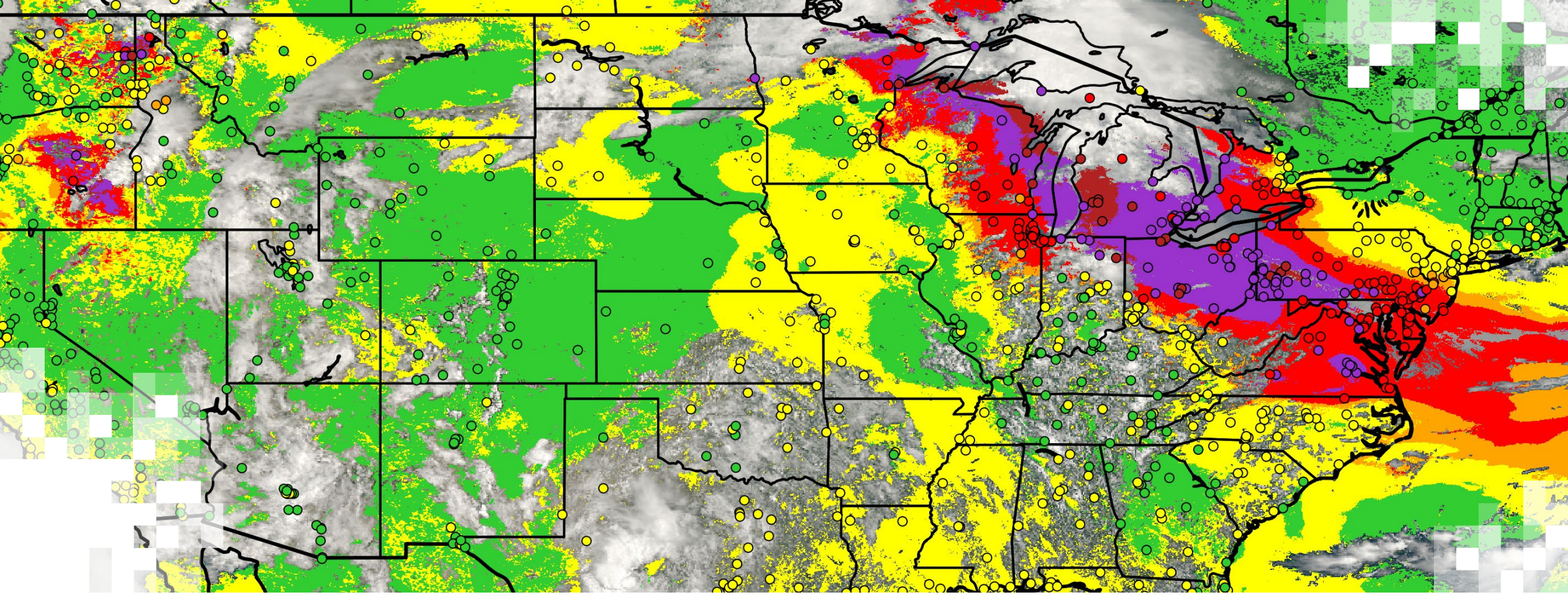
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- Only use open-source software and data
- Accommodate differing levels of expertise

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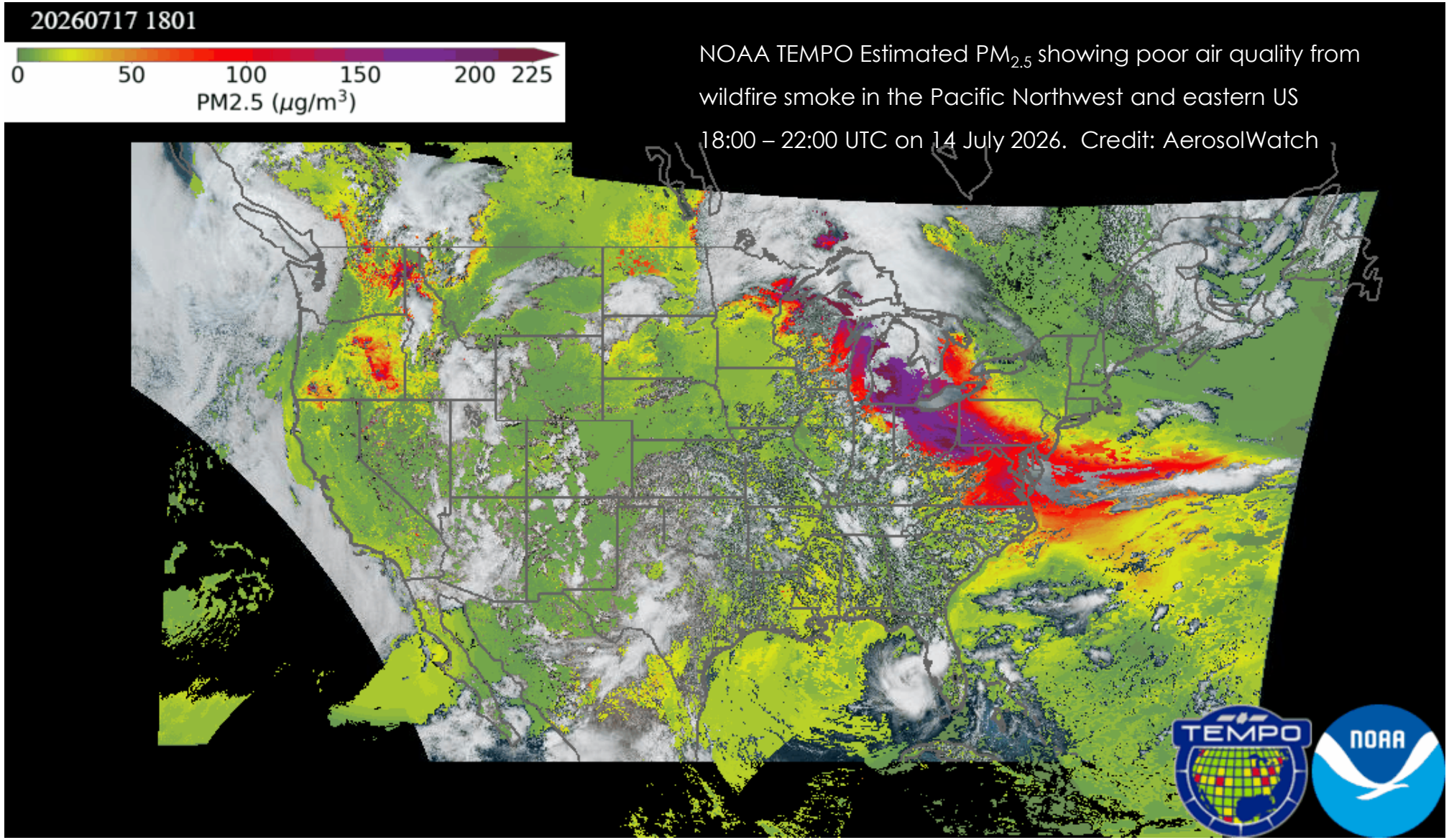




Geostationary Remote Sensing of Aerosols for Air Quality Applications in North America

Overview

The Geostationary Era of Air Quality



NOAA TEMPO Estimated $PM_{2.5}$ showing poor air quality from wildfire smoke in the Pacific Northwest and eastern US 18:00 – 22:00 UTC on 14 July 2026. Credit: AerosolWatch

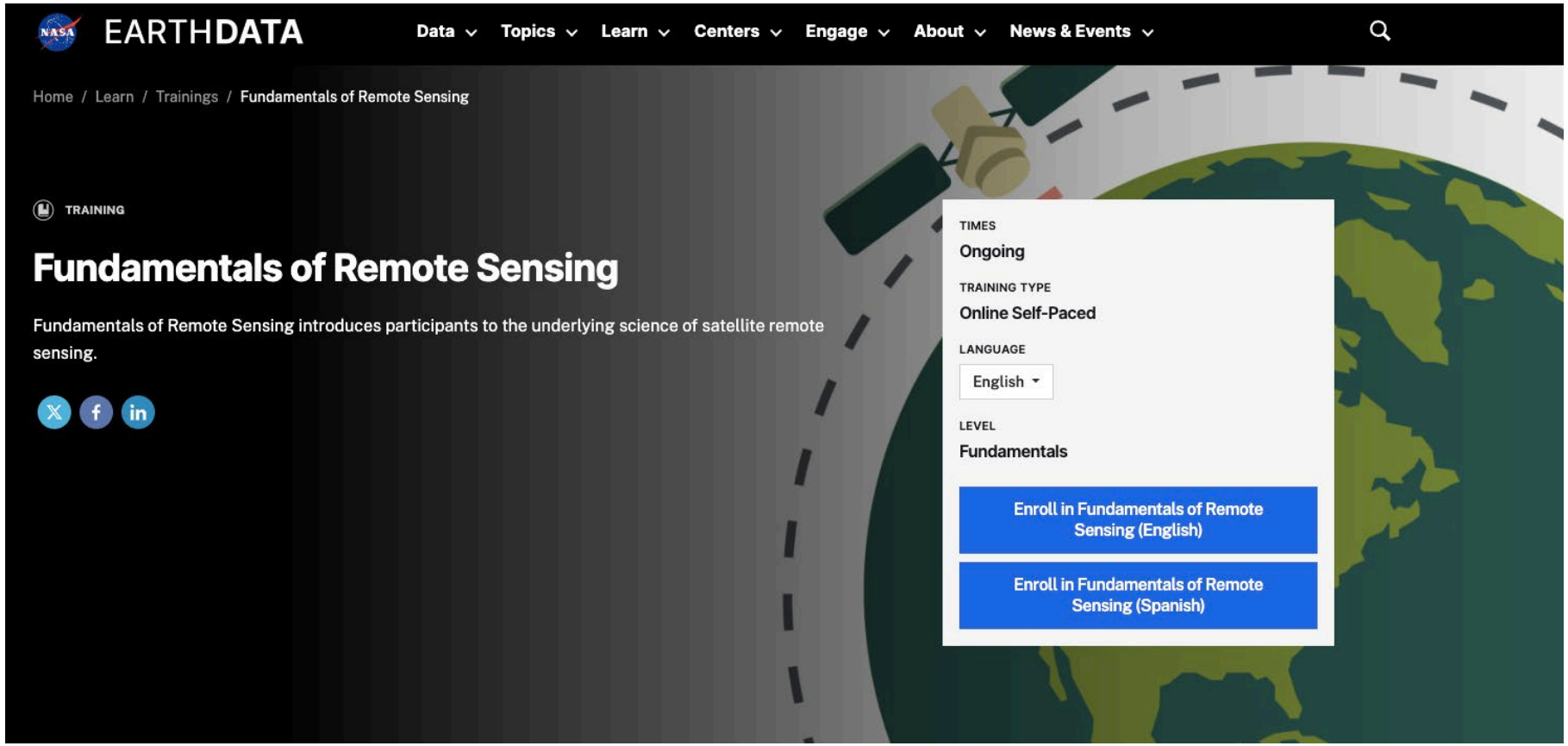
Training Learning Objectives

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

1. Describe the capabilities of the TEMPO instrument and its strengths and limitations compared to ABI on the GOES-R satellites.
2. Identify available TEMPO aerosol data products and recognize their characteristics, benefits, and limitations.
3. Use the AerosolWatch website to visualize near real-time and archived hourly TEMPO aerosol product imagery.
4. Interpret TEMPO aerosol imagery on AerosolWatch to analyze smoke and blowing dust events and anticipate their air quality impacts.

Prerequisites

- Fundamentals of Remote Sensing. Online, self paced (~2 hours to complete)



Training Outline

Part 1

NOAA's TEMPO Aerosol Products for Hourly Aerosol Monitoring over North America

October 13, 2026

Part 2

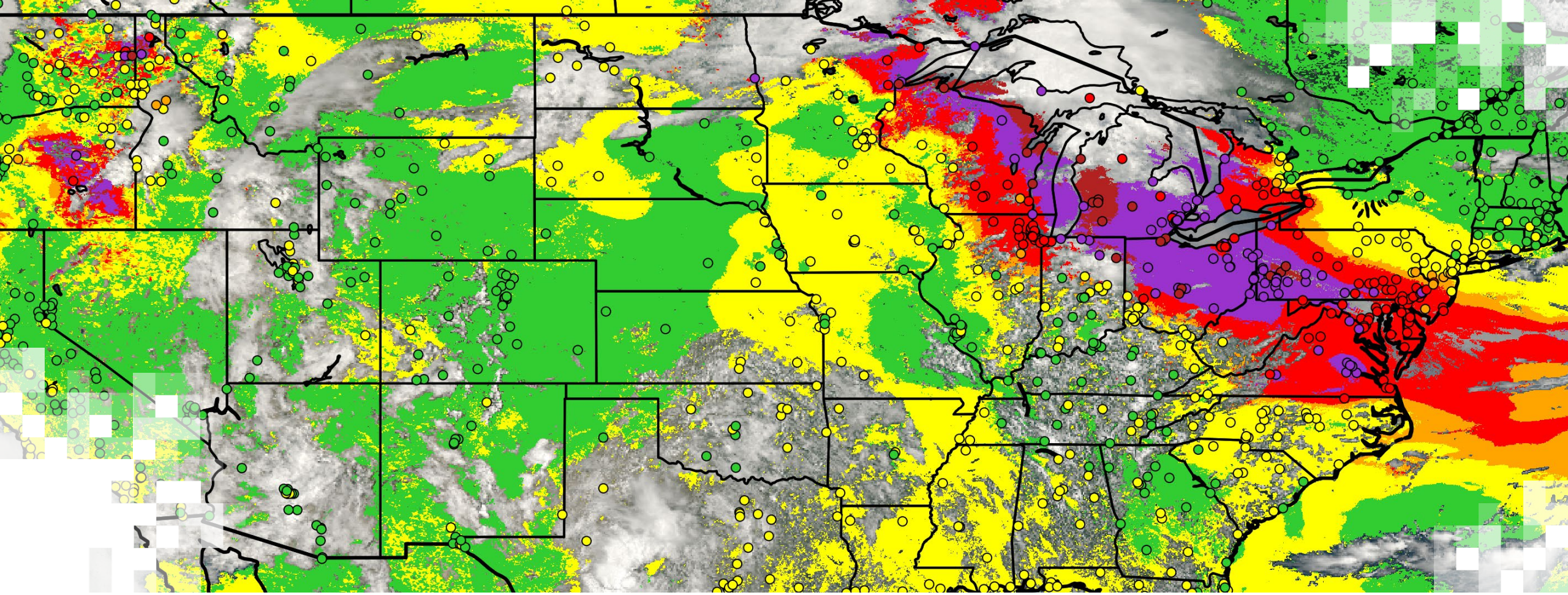
Analyzing TEMPO Aerosol Products Imagery for Smoke and Dust Case Study Events using NOAA's AerosolWatch

October 15, 2026

Homework

Opens Oct 15 – Due Oct 29 – Posted on Training Webpage

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



Geostationary Remote Sensing of Aerosols for Air Quality Applications in North America

Part 1: NOAA's TEMPO Aerosol Products for Hourly Aerosol Monitoring over North America

Part 1 – Trainers

Caterina Mogno

Assistant Research Scientist

University of Maryland Baltimore County & NASA GSFC



Amy Huff

Senior Scientist

STC at NOAA/NESDIS Aerosols Science Team



Part 1 Objectives

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

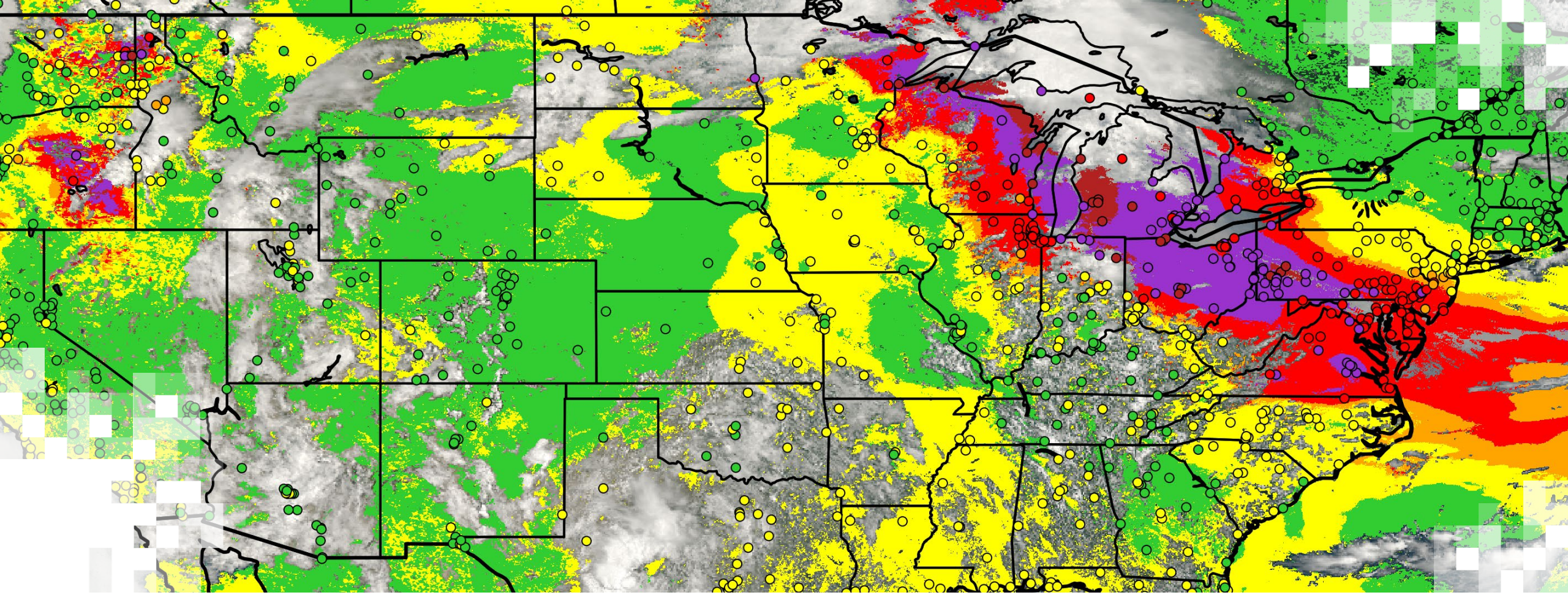
1. Describe the capabilities of the TEMPO instrument and its strengths and limitations compared to ABI on the GOES-R satellites.
2. Identify available TEMPO aerosol data products and recognize their characteristics, benefits, and limitations.

Part 1 Outline

- Geostationary instruments overview
- TEMPO aerosol products
- Summary
- Q&A session

How to Ask Questions

- To ensure we see your question, please locate the three dots ... to the bottom right of your training window.
- You will see a Slido/Q&A option. You may also see a standalone Slido tab or app.
- Please place all questions there and we will answer them during the Q&A session.
- 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.



Geostationary Instruments Overview

GEO Instruments for Aerosols Monitoring over North America

We will review the two primary missions and instruments currently relevant to geostationary aerosol air quality over North America:

TEMPO
Tropospheric Emissions: Monitoring of Pollution

GOES-R ABI
Geostationary Operational Environmental Satellites R Series - Advanced Baseline Imager

TEMPO Mission: Objectives

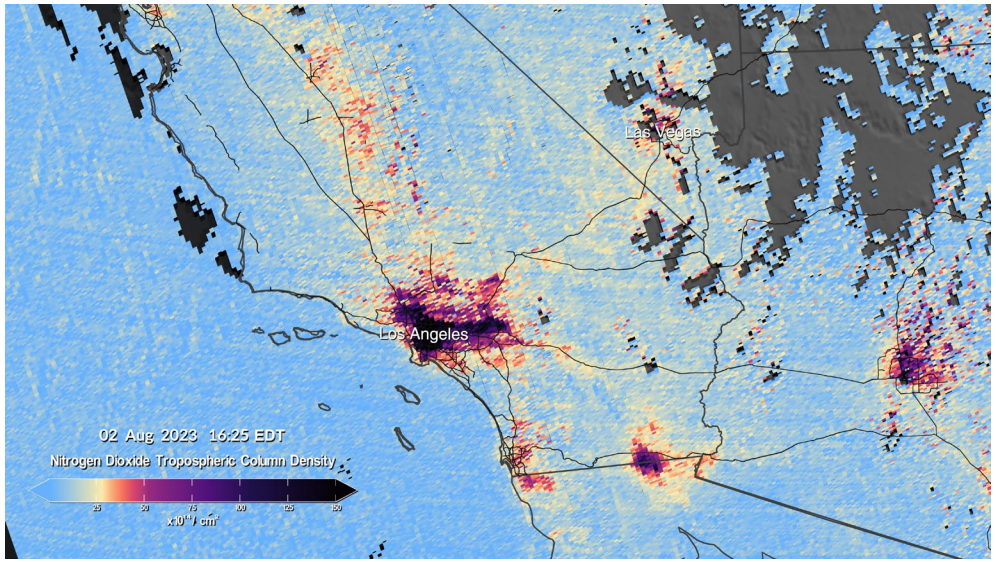
The **Tropospheric Emissions: Monitoring of Pollution (TEMPO)** is the first geostationary mission for hourly daylight air quality (AQ) monitoring over North America

Main Objectives

- High-resolution air quality data
- Health & environmental impact insights
- Improved AQ forecasts & alerts
- Inform AQ policy & regulation

In the Global Context:

North American node of an international geostationary Constellation for AQ across the Northern Hemisphere



NO_2 pollution detected by TEMPO over Southern California

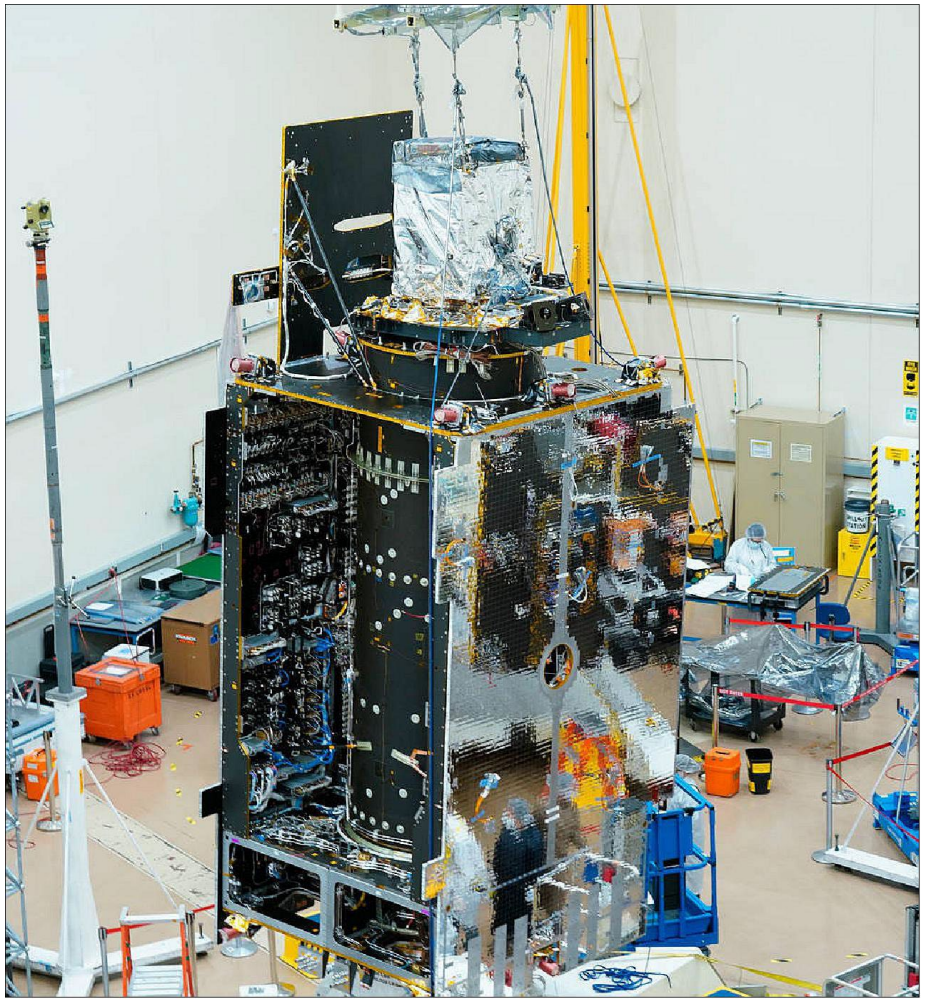
TEMPO Mission: Timeline

- **2012**: Mission selected as joint project between NASA with Smithsonian Astrophysical Observatory
- **April 7, 2023**: Launched into GEO orbit on SpaceX rocket
- **August 2, 2023**: First Light operations
- **October 19, 2023**: **nominal operations start**
- **June 19, 2025**: Base mission ended
  but extended through **September 2029**





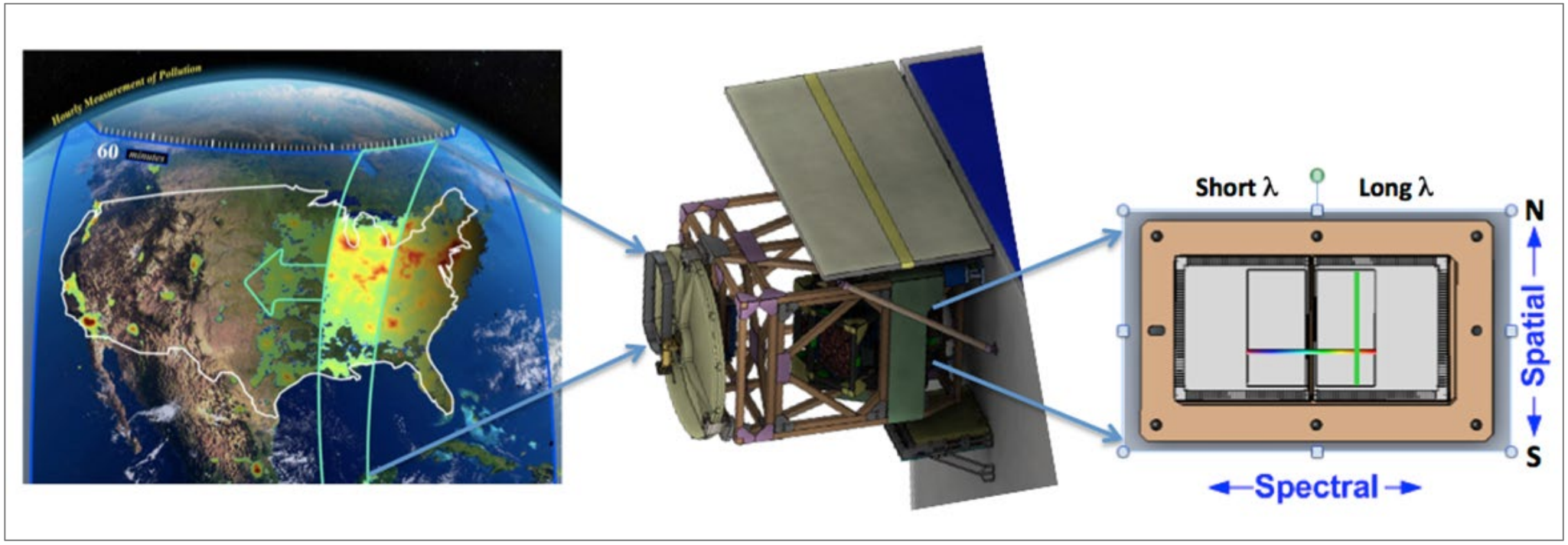
TEMPO launched from Cape Canaveral Space Force Station in Florida atop a SpaceX Falcon 9 rocket at 00:30 EDT (Credit: Walter Scriptunas/Center for Astrophysics | Harvard & Smithsonian)



The TEMPO payload rests atop the IS-40e spacecraft (Credit: Maxar)

TEMPO: Instrument Overview

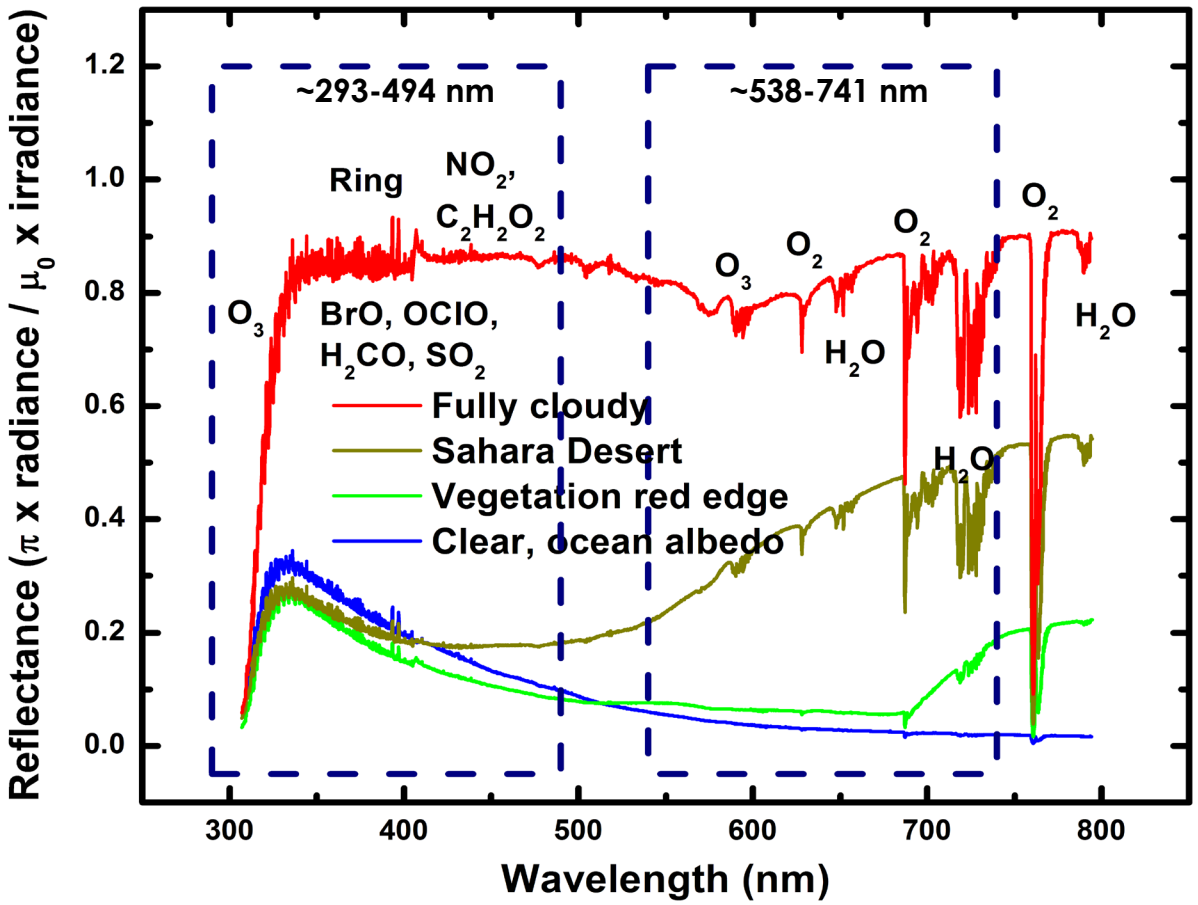
- **Instrument Type**: Hyperspectral Spectrometer
- **Primary Targets:** Trace gases and aerosol pollutants
- **Spectral Range:** UV/Visible (293–741 nm)
- **Spectral Resolution:** 0.6 nm with 0.2 nm sampling
- **Coverage:** North America (Mexico to Canada)
- **Operations:** Hourly daytime scans at ~2.0 × 4.75 km at center of Field of Regard



Right: TEMPO scan mirror window. center: schematic of the TEMPO spectrometer; left: Notional TEMPO Field of Regard (FoR) over North America; (Credit: NASA/BATC/SAO)

TEMPO's Spectral Resolution

~293–741 nm coverage (UV, visible) with a gap at ~494–538 nm.



TEMPO's spectral coverage (dashed blue boxes) overlaid on typical Earth reflectances. (Credit: TEMPO Collaboration)

Identifying Chemical Pollutants:

- UV-Visible bands
- Key trace gases: NO_2, O_3, SO_2, HCHO
- Aerosols presence

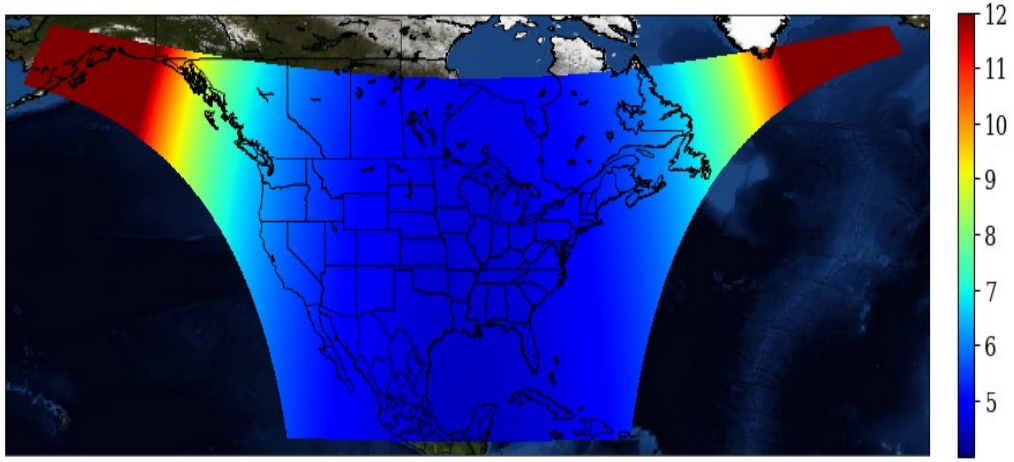
Identifying Aerosol Plumes:

- UV bands
- Aerosol layer height
- Aerosol Absorbing Index (AAI)
  → Smoke/dust type identification

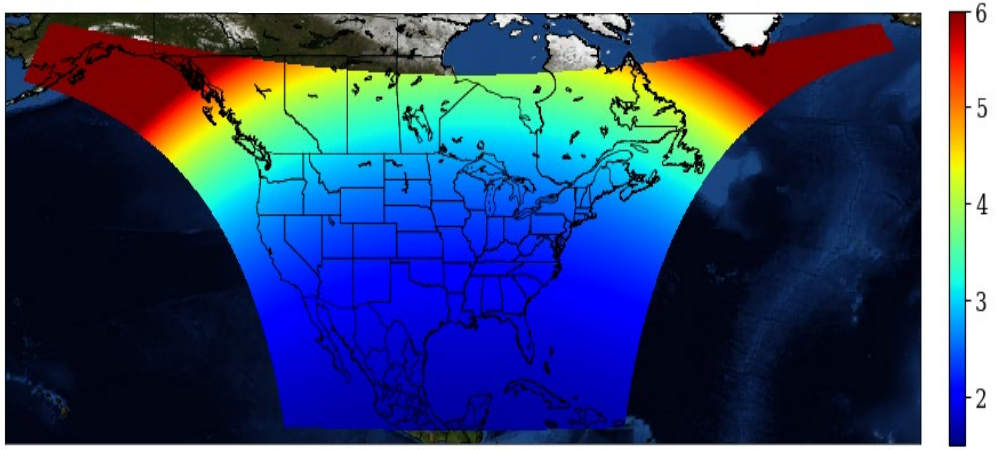
TEMPO's Spatial Resolution

Spatial resolution (or footprint) varies across the Field of Regard (FoR) due to the viewing zenith angle

TEMPO East-West Pixel Size



TEMPO South-North Pixel Size

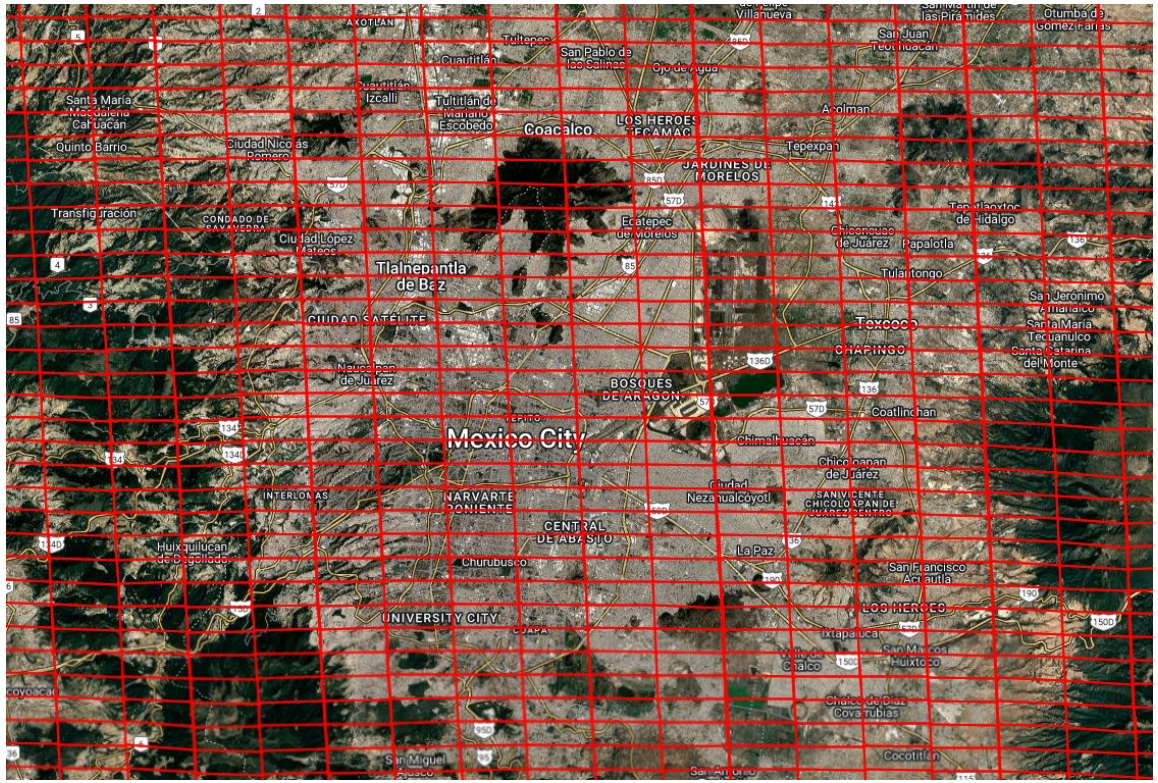


(Credit: Aaron Naeger, MSFC/TEMPO Applications)

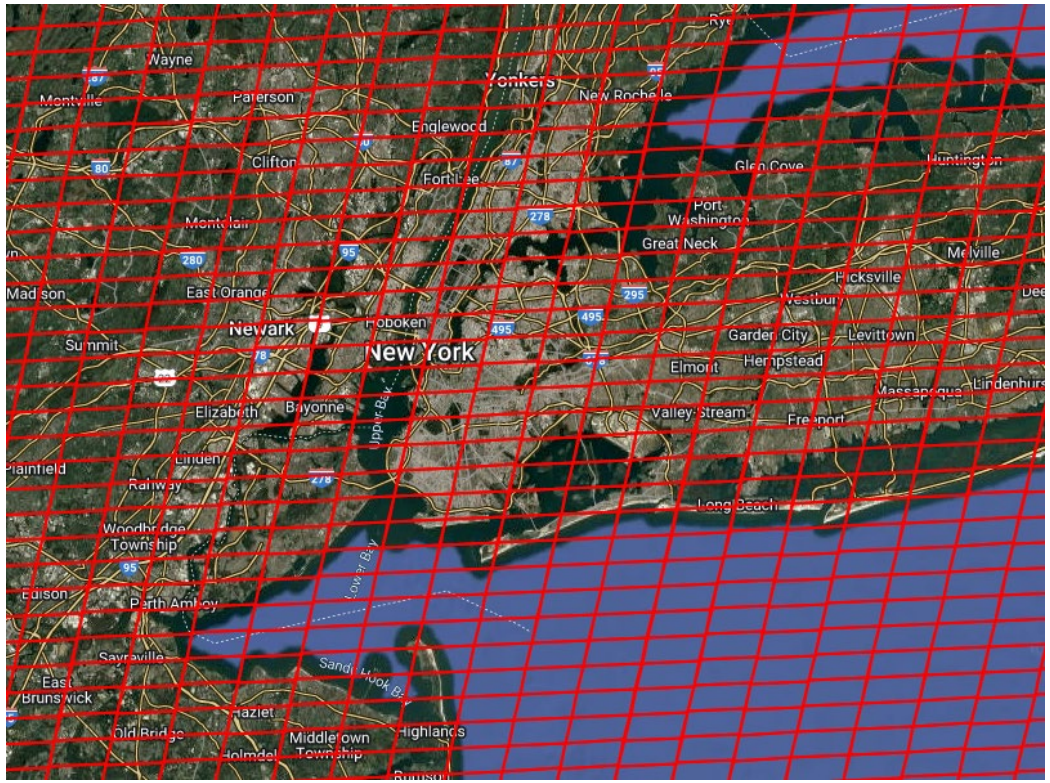
Location	N/S (km)	E/W (km)	VZA (°)
Center of FoR (33.5°N, 89.2°W)	2.0	4.8	39.1
Washington, DC	2.3	5.1	47.3
Seattle	3.3	6.5	62.5
Los Angeles	2.2	5.8	49.0
Boston	2.5	5.4	52.9
Miami	1.8	4.8	32.4
San Juan	1.7	5.4	35.8
Mexico City	1.6	4.7	24.6
Can. Oil Sands	4.2	5.7	67.4
Juneau	5.9	9.1	75.9

TEMPO's Spatial Resolution: Examples

Mexico City ~ 1.6 km x 4.7 km



New York ~ 2.4 km x 5.2 km

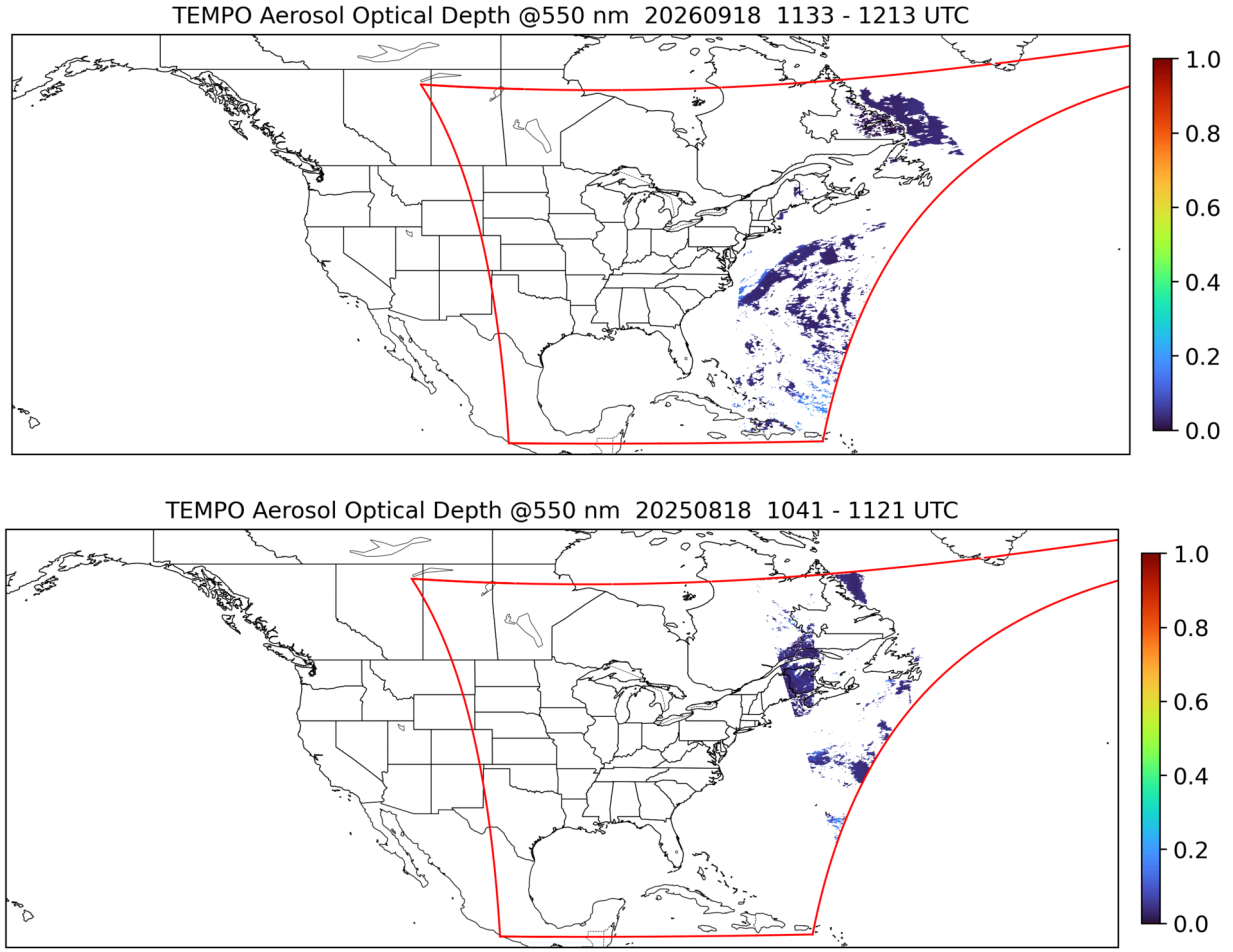


TEMPO's Temporal Resolution: Scanning Modes

Flexible scanning to maximize daylight coverage and capture rapid events:

- **Nominal Operations (Standard Scans):**
  - Hourly E–W scans (full domain)
  - 40-min optimized scans during dawn/dusk
  - Pre-sunrise twilight scans (city lights, auroras)

- **Special Operations (High-Frequency Scans):**
  - ≤10-min rapid regional scans
  - Wildfires, dust storms, volcanic eruptions
  - See the TEMPO **Operations Log** for dates



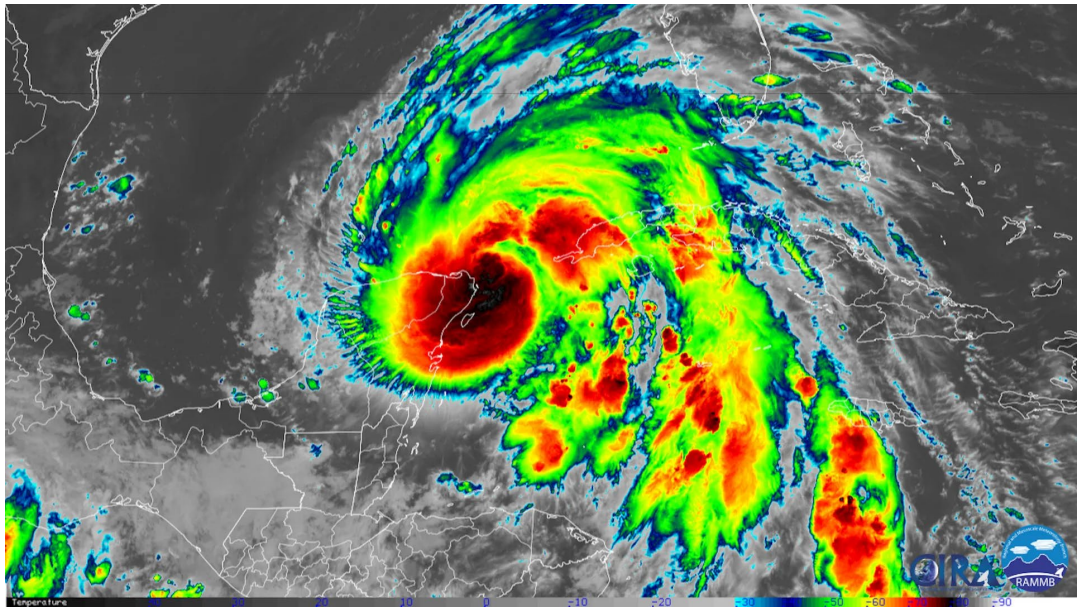
Example of Nominal Operations on Sep 18, 2026 (Top) and Special Operations on Aug 18, 2025 (bottom) (Credit: Aaron Naeger, MSFC/TEMPO Applications)

GOES-R Mission: Objectives

The **Geostationary Operational Environmental Satellites R Series (GOES-R)** is the U.S.'s latest generation of geostationary satellites, with continuous, high-res coverage of the Western Hemisphere.

Main Objectives:

- Detect environmental hazards & space weather
- Advanced imagery & atmospheric measurements
- Operational forecasting & early warnings
- Public safety & property protection



Hurricane Helene monitored by GOES-R satellites.

GOES-R Series Fleet

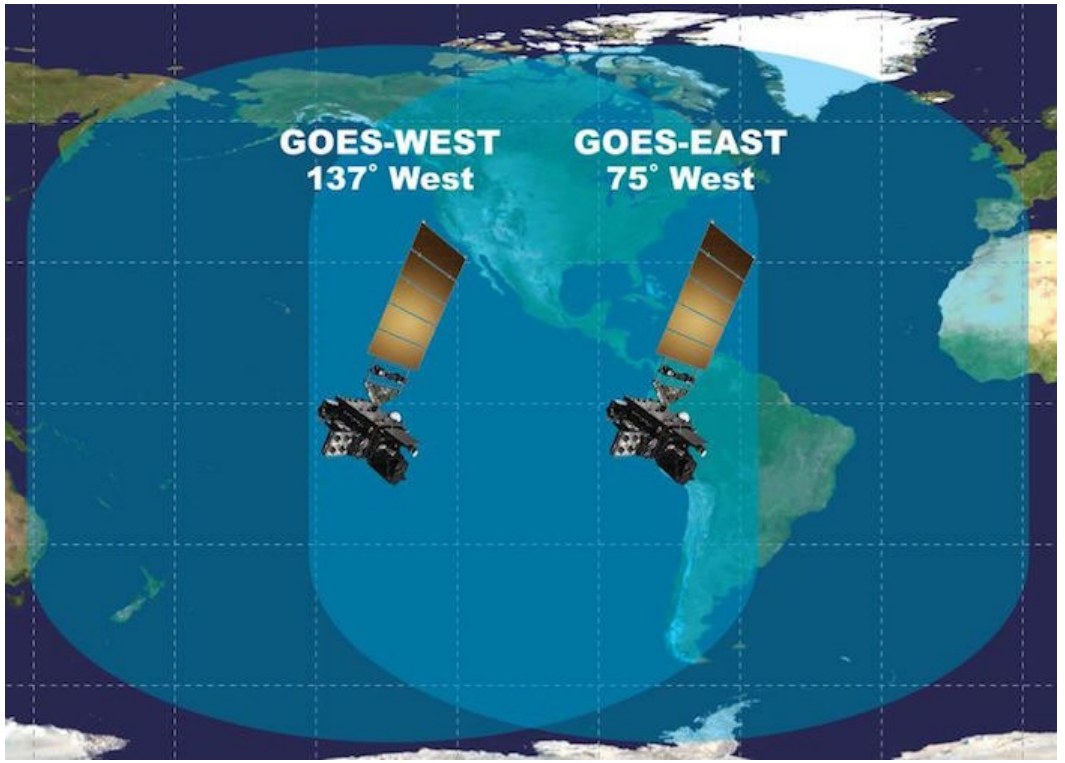
Current Operational Satellites

- **GOES East (GOES-19)**
  - Operational since April 2025 (launched as GOES-U)
  - Coverage: Americas, Atlantic Ocean to Africa

- **GOES West (GOES-18):**
  - Operational since Jan. 2023 (launched as GOES-T).
  - Coverage: western U.S., Alaska, Hawaii, Pacific to
  - Ocean to New Zealand.

On-Orbit Support

GOES-16 & GOES-17: primary on-orbit backups



Schematic of GOES-East and GOES-West respective field of regard. Note the overlap over North America and part of South America.

Note on GOES-R series Naming Convention:

Pre-Launch: Letter (e.g., GOES-U)➔ In-Orbit: Number (e.g., GOES-19)
➔ Active Role: Position (e.g., GOES East)

GOES-R Advanced Baseline Imager (ABI)

Advanced Baseline Imager (ABI): primary instrument for imaging Earth's weather, oceans, and environment (1 of 6 instruments on each GOES-R satellite)

Instrument Type: Multi-spectral imaging radiometer

Primary Targets: Clouds, weather, fire, smoke, and aerosols

Spectral Range: Visible to Longwave Infrared (0.47–13.3 μm)

Spectral Resolution: 16 bands (2 visible, 4 near-IR, 10 infrared)

Coverage: Full Disk, CONUS, and Mesoscale sectors

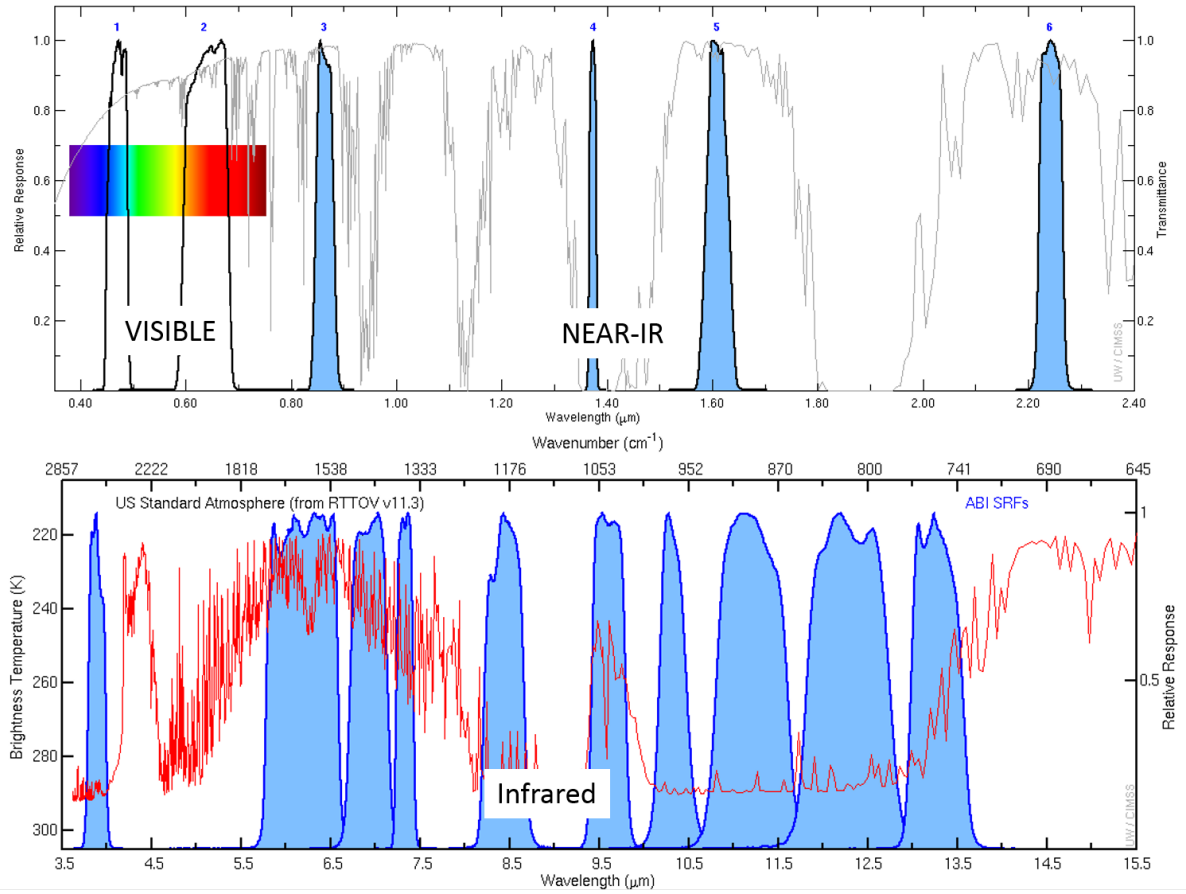
Operations: Continuous daytime & nighttime scans at 0.5–2 km resolution every 1–10 min during normal operations



ABI as part of the GOES-R instrument suite. (Credit: NOAA)

GOES-R ABI Spectral Resolution

- 16 spectral bands spanning 0.47 to 13.3 μm: 2 visible, 4 near-infrared, 10 infrared
- Spatial resolution: 0.5 km (Band 2),1 km (Bands 1, 3, 5), 2 km (remaining bands)



Spectral response functions for ABI's 16 bands across the UV-to-infrared range. Credit: Schmit et al. 2018).

Aerosol and Active Fire Monitoring:

- Multispectral bands → AOD retrievals
- SWIR → fire hot spots detection

Rapid Plume Tracking:

- High-frequency imagery
- daytime smoke
- dust storms and fire hot spots day/night

GOES-R ABI Temporal Resolution: Scanning Modes

M6 (flex mode):

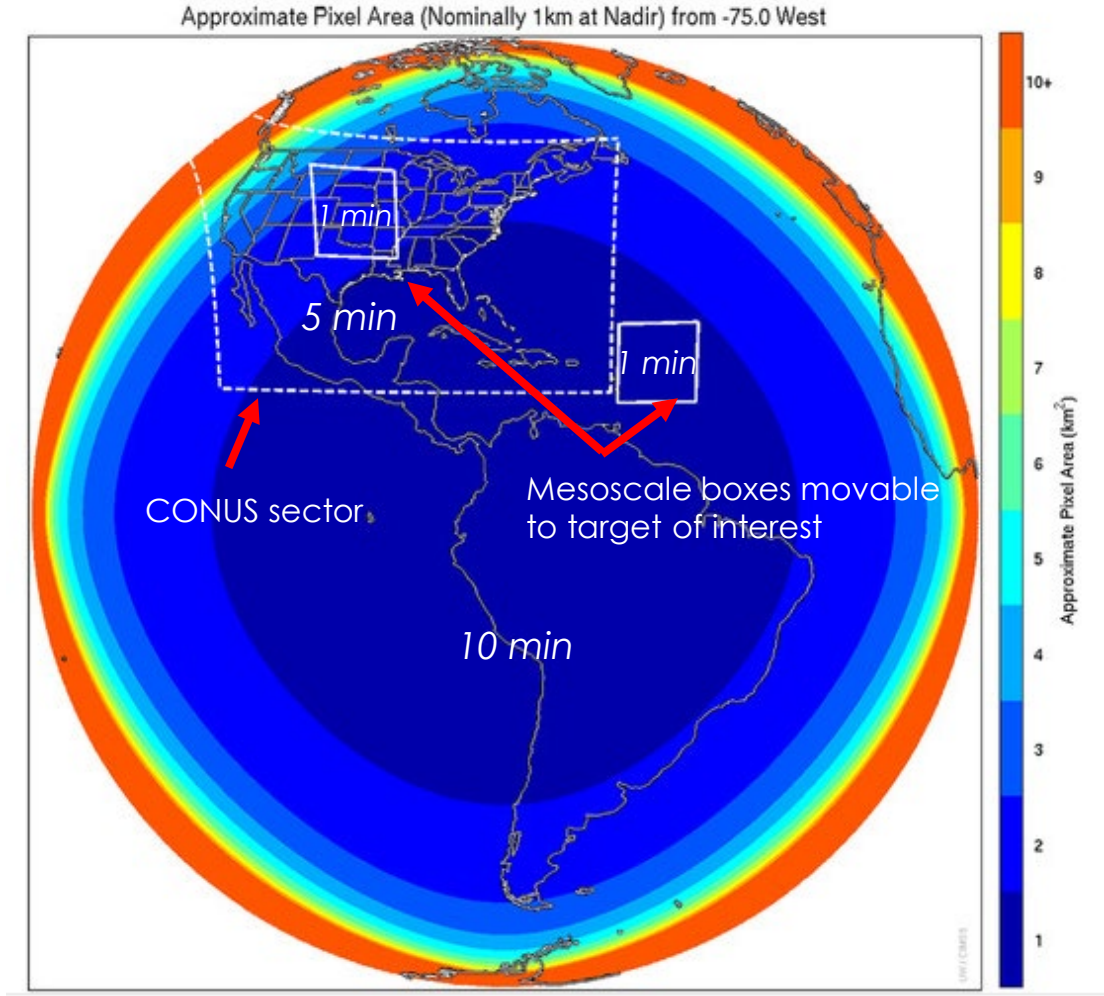
- Full Disk every 10 min, CONUS 5 min
- 2 x Mesoscale every 1 min
- Current default

M4 (continuous full disk mode):

- Full Disk only, every 5 min
- Used for calibration/testing

Mesoscale domains:

- 1,000 ×1,000 km, repositionable
- Used for rapid tracking of events



ABI flex mode M6 coverage for GOES-East. Colors show pixel area for nominal 1-km bands, which increases with view angle. (Credit Schmit et al. , BAMS 2017)

TEMPO and GOES-ABI Side by Side: Characteristics

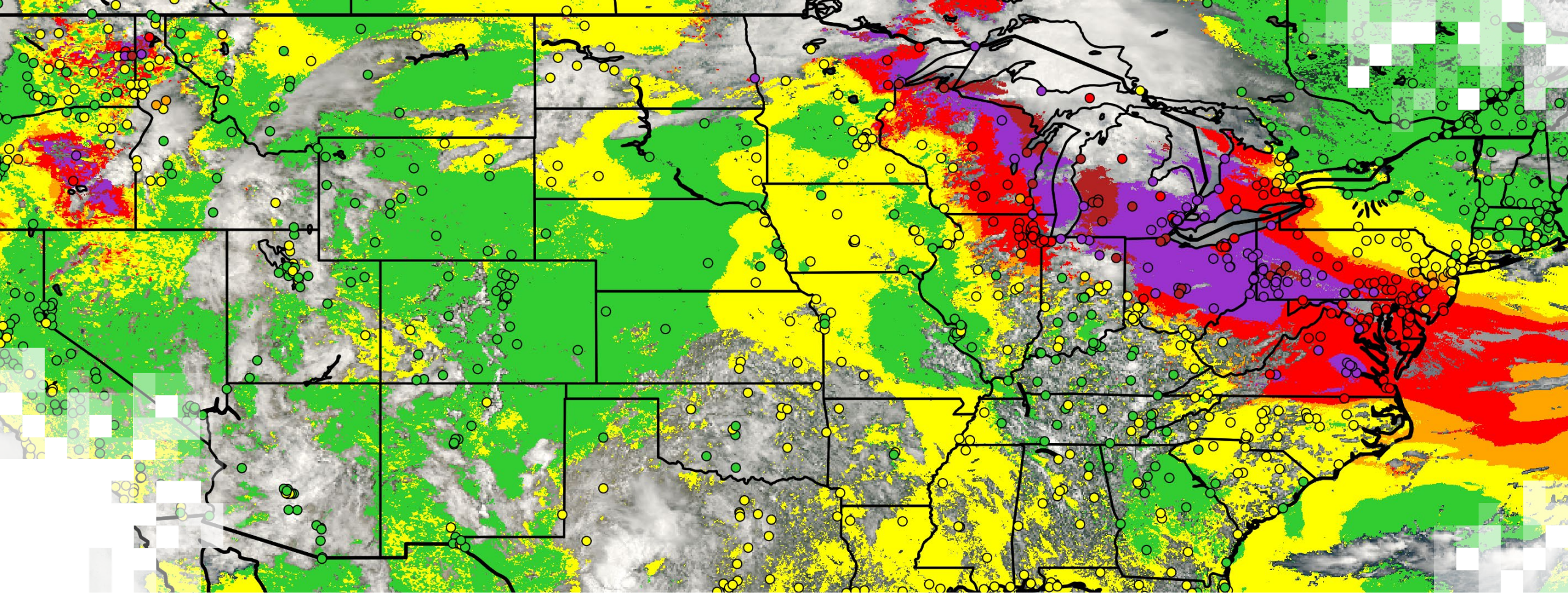
Feature	TEMPO	GOES-R ABI
Instrument Type	Hyperspectral Spectrometer	Multispectral Radiometer (Imager)
Primary Mission	Air Quality & Atmospheric Chemistry	Weather, Hazards & Environmental Monitoring
Spectral Range	UV and Visible (~293–741 nm) Thousands of continuous narrow bands	Visible, Near-IR, and Infrared 16 distinct wider bands
Key Detections	Trace gases (NO_2, O_3, HCHO) & Aerosols	Clouds, Fires, Smoke, Dust, Sea Surface Temperature
Spatial Resolution	~2.0 × 4.75 km (at center of FoR)	0.5 km to 2.0 km (at nadir; depends on the band)
Temporal Resolution	Hourly (Full Domain); 10 min (Special Operations)	10 min (Full Disk), 5 min (CONUS); 1 min (Mesoscale)
Coverage Area	Greater North America	Western Hemisphere (Full Disk)

TEMPO and GOES-ABI Side by Side: AQ Applications

	TEMPO	GOES-R ABI
Primary AQ Focus	**Atmospheric Chemistry:** Pollution, smog, and daytime emissions	**Hazard Onset and Transport:** Near real-time smoke, dust, and active fires
AQ Advantages	• **Trace Gases:** Tracks NO_2, O_3, HCHO (via UV-Vis bands) • **Aerosol Height:** Provides estimate of aerosol layer altitude in the troposphere (via UV bands) • **Diurnal Cycles:** Tracks daytime photochemical smog evolution	• **Rapid Tracking:** 1-10 min tracking of plume motion and AOD every 5-10 min • **24/7 Monitoring:** Tracks fire hot spots and dust day/night (via IR/SWIR) • **Early Warning:** Detects sudden fire/dust outbreaks
AQ Disadvantages	• **Night-Blind:** no chemistry or aerosol data after sunset • **Temporal Gaps:** Hourly scans miss rapid fire/dust initiation • **No Fire Intensity:** Lacks thermal bands to measure fire heat	• **No Trace Gases:** lacks UV-Vis hyperspectral • **Smoke Night-Blindness:** Smoke plumes are invisible to IR at night • **No Aerosol Height:** lacks UV band needed to estimate altitude of aerosols

References

- **NASA Earthdata, TEMPO Instrument**: https://www.earthdata.nasa.gov/data/instruments/tempo
- **Smithsonian Astrophysical Observatory, TEMPO**: Tropospheric Emissions: Monitoring of POllution https://tempo.si.edu/index.html
- **NOAA, GOES-R Mission**, Geostationary Operational Environmental Satellites. https://www.goes-r.gov/mission/mission.html
- **eoPortal, TEMPO** (Tropospheric Emissions: Monitoring of Pollution). European Space Agency. https://www.eoportal.org/satellite-missions/tempo#science-objectives
- **Schmit, T. J.,** Lindstrom, S. S., Gerth, J. J., & Gunshor, M. M. (2018). Applications of the 16 spectral bands on the Advanced Baseline Imager (ABI). Journal of Operational Meteorology, 6 (4), 3346. https://doi.org/10.15191/nwajom.2018.0604
- **Schmit, T. J.,** et al. (2017). A Closer Look at the ABI on the GOES-R Series. Bulletin of the American Meteorological Society, 98(4), 681-698. https://doi.org/10.1175/BAMS-D-15-00230.1



TEMPO Aerosol Products

ABI and TEMPO Aerosol Products Overview

Aerosol Product Algorithm	Satellite Input(s)	Data File Prefix(es)	Notable Data Variables	Data Processing Level	File Type
Aerosol Detection	ABI	OR_ABI-L2-ADPF OR_ABI-L2-ADPC OR_ABI-L2-ADPM	• Smoke/Dust Mask	Level 2	Gridded (ABI fixed grid*)
Aerosol Optical Depth	ABI	OR_ABI-L2-AODF OR_ABI-L2-AODC	• Aerosol Optical Depth	Level 2	Gridded (ABI fixed grid*)
Aerosol Detection	TEMPO & ABI	TEMPO-ABI-G19_ADP_L2	• UV AAI • Smoke/Dust Mask	Level 2	TEMPO granule
Aerosol Optical Depth & Layer Height	TEMPO	TEMPO_AODALH_L2	• Aerosol Optical Depth • Aerosol Layer Heigh	Level 2	TEMPO granule
Fine Particulate Matter ($PM_{2.5}$)	TEMPO & ABI	TEMPO-ABI_PM25_L4	• 1-hour average surface $PM_{2.5}$	Level 4	Gridded (ABI fixed grid*)

*The ABI fixed grid, also called the GOES imager projection, is a map projection based on the geostationary viewing perspective of the GOES-East or GOES-West satellite. The ABI fixed grid is an irregular grid: the Earth surface area covered by a data point at a specific horizontal spatial resolution increases as the distance from the satellite's nadir increases.

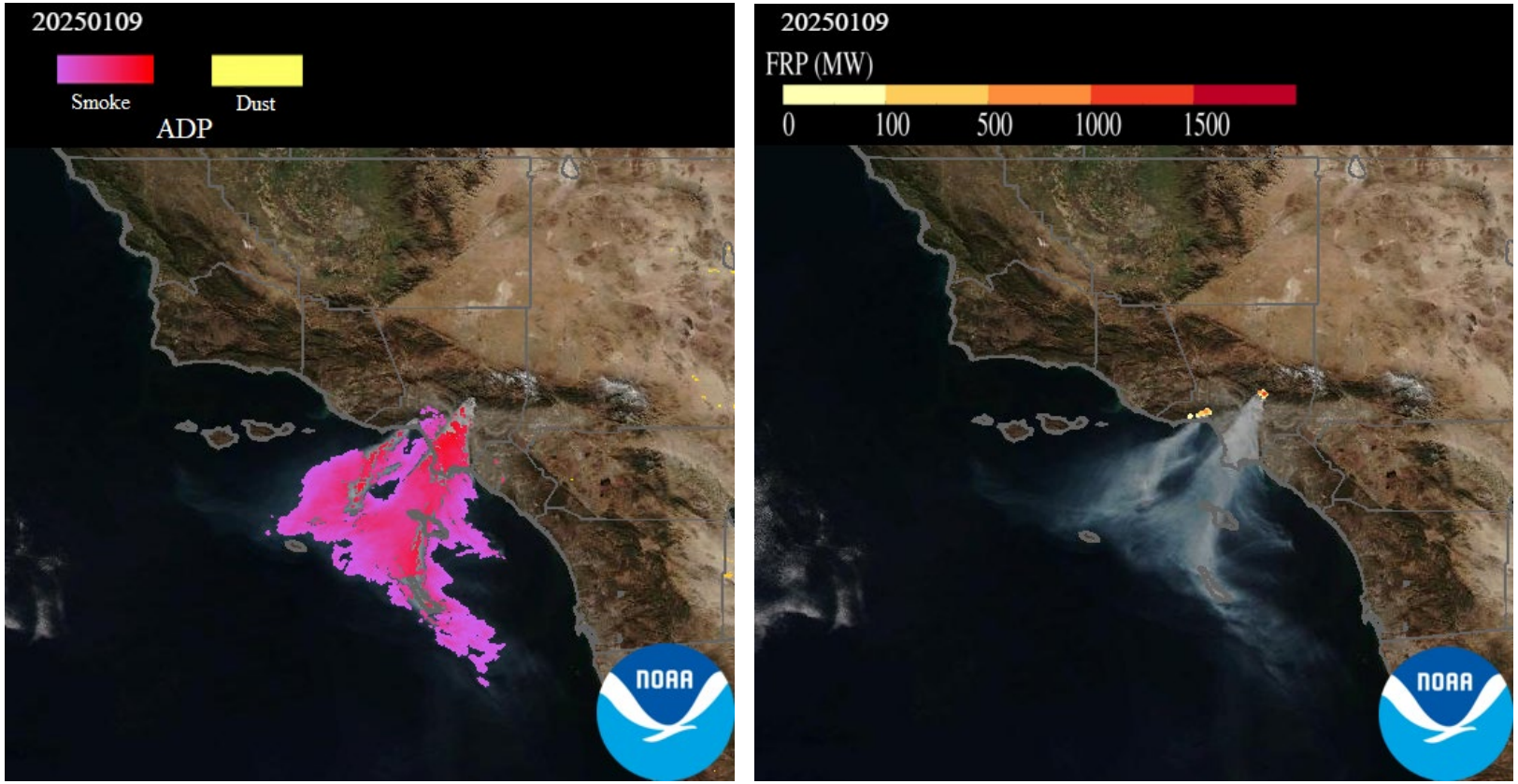
TEMPO Aerosol Algorithms

- "TEMPO aerosol products": shorthand in this training for products generated by algorithms that ingest TEMPO Level 1b (L1b) radiance (RAD) and irradiance (IRR) files
  - TEMPO algorithms also ingest **ABI L1b and/or L2 products**
- TEMPO aerosol algorithms use the **NRT version of TEMPO L1b RAD data**
  - Available faster than the "standard" version of TEMPO L1b RAD data
  - Results in shortest possible latency for TEMPO aerosol products!
    - Operational latency will be ~2 hours
    - Current research product latency can be (much) longer
- **TEMPO aerosol algorithms ingest other TEMPO L2 aerosol products:**



Review of Satellite Aerosol Products: Aerosol Detection Product (ADP)

- Aerosol Detection product is a **qualitative** indicator of smoke & dust aerosols
- Often referred to as the **Smoke/Dust Mask**
- Based on spectral threshold tests that separate absorbing aerosols (smoke and dust) from clouds and clear sky regions
- Helpful for identifying the presence of smoke or dust

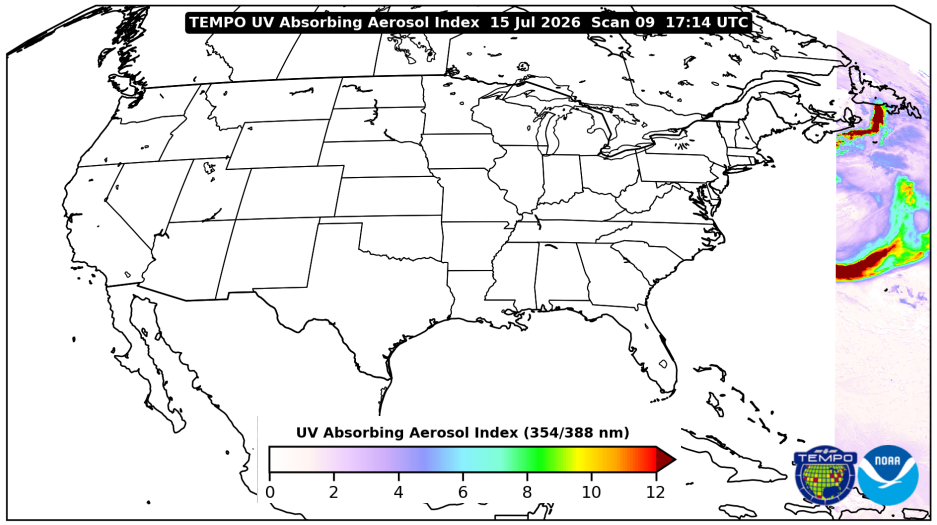


Smoke from Los Angeles wildfires January 9, 2025. Images from the AerosolWatch website.

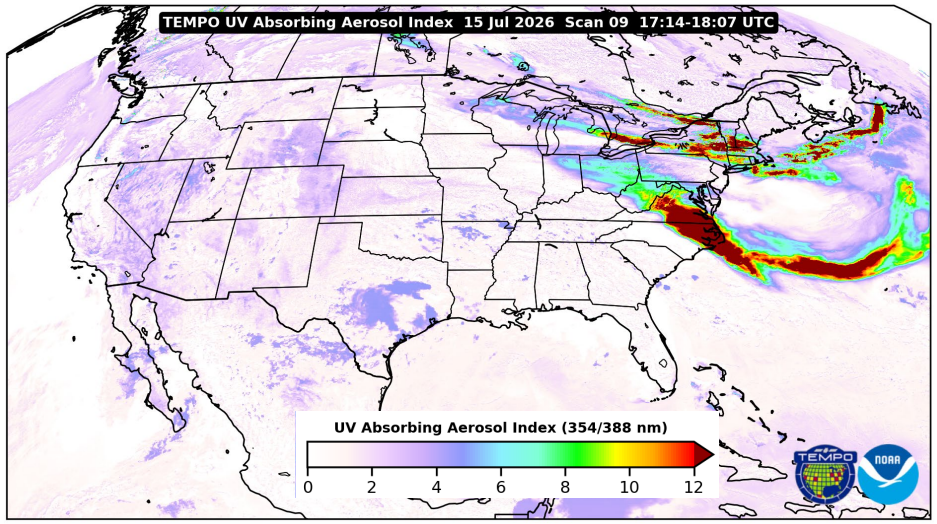
Specifications: TEMPO Aerosol Detection Product (ADP) Algorithm

- Hybrid algorithm: uses L1b radiances from TEMPO & ABI
  - **UV Absorbing Aerosol Index (AAI)**
    - Used as 1st step in determining Smoke/Dust Mask
    - Can be used on its own to highlight absorbing aerosols
  - **Smoke/Dust Mask**
    - Indicates presence and relative optical thickness of smoke or dust aerosols
- **Level 2** product; files are distributed as **granules**
- Domain: TEMPO Field of Regard (FoR)
- Spatial resolution: 2.0 km x 4.75 km (at center of FoR)

Example of individual TEMPO UV AAI granules



Example of full TEMPO UV AAI scan

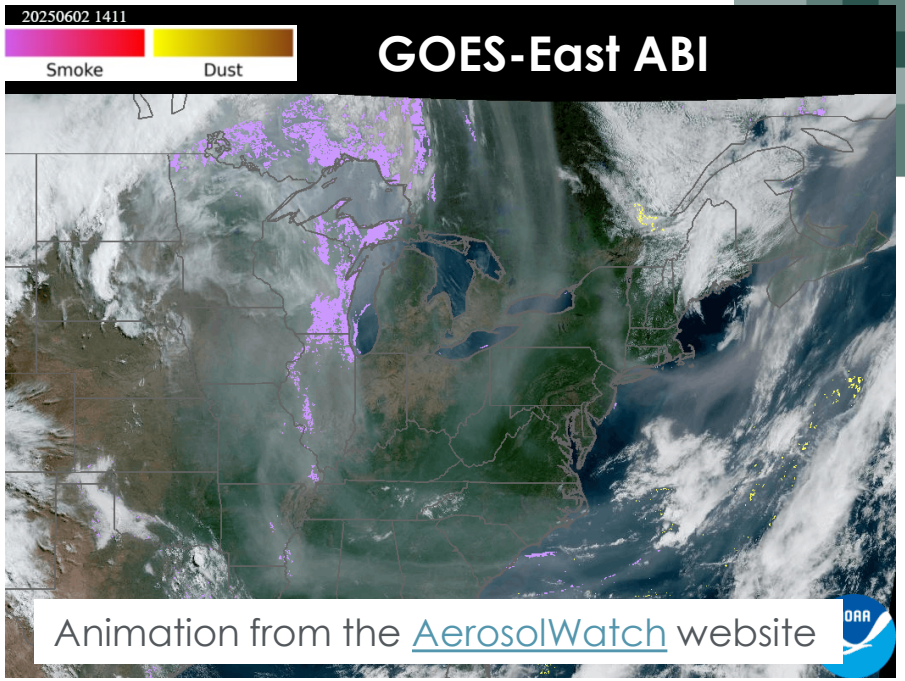


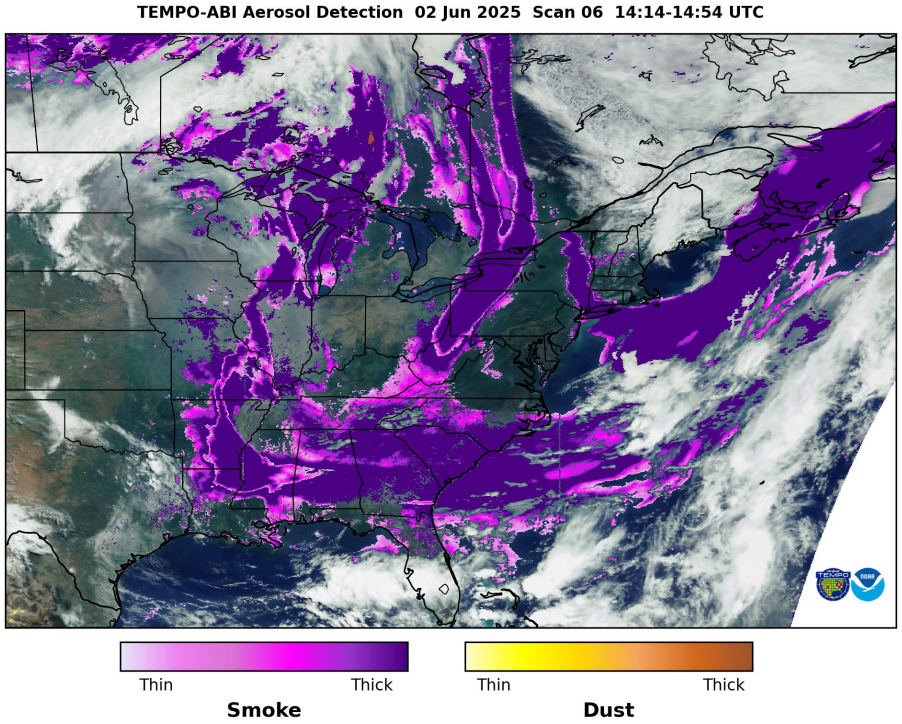
TEMPO & ABI Synergy: Smoke/Dust Mask

Smoke/Dust Mask	TEMPO	ABI

Strengths	• Retrieves smoke & dust across larger geographic extent
	  • Optically thinner smoke ABI misses
	  • Smoke/dust north & west of ABI's VZA cutoff
	  • Smoke on top of clouds
	• Relative intensity of smoke and dust (thin vs. thick)
		• More accurate for dust detection over ocean
		• Frequent observations:
		  • Every 10 min for Full Disk & CONUS
		  • Every 5 min for Mesoscale
		• Higher spatial resolution (less pixelated)

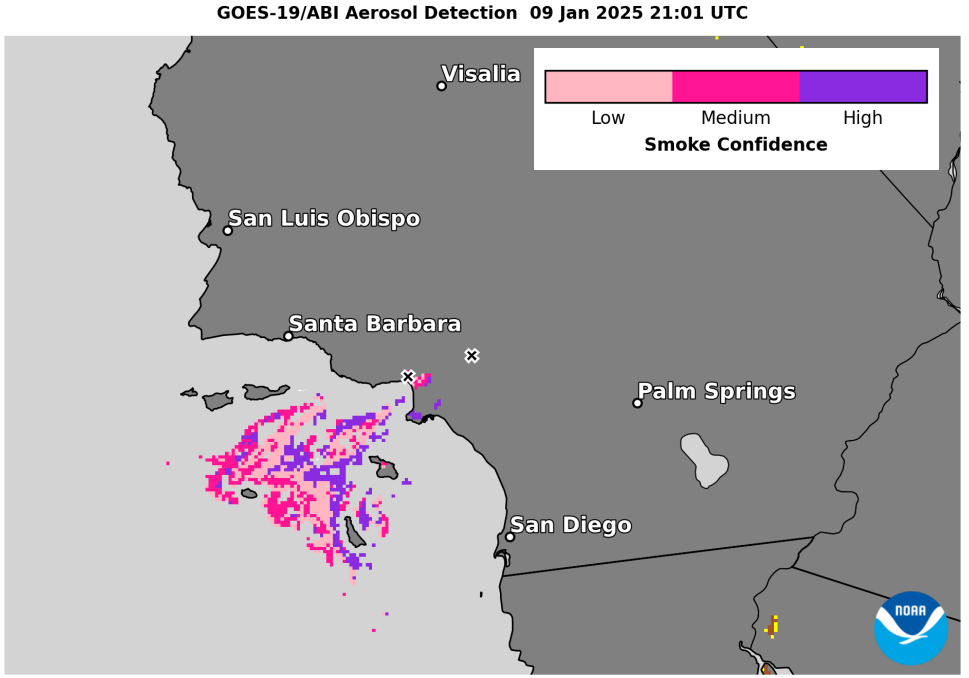
Limitations	• Slightly coarser spatial resolution • ~1 hour temporal resolution • False smoke detections over bright surfaces • Dust misclassified as smoke under certain conditions	• Binary flag: only indicates presence of smoke or dust • Retrievals at high VZA are not recommended

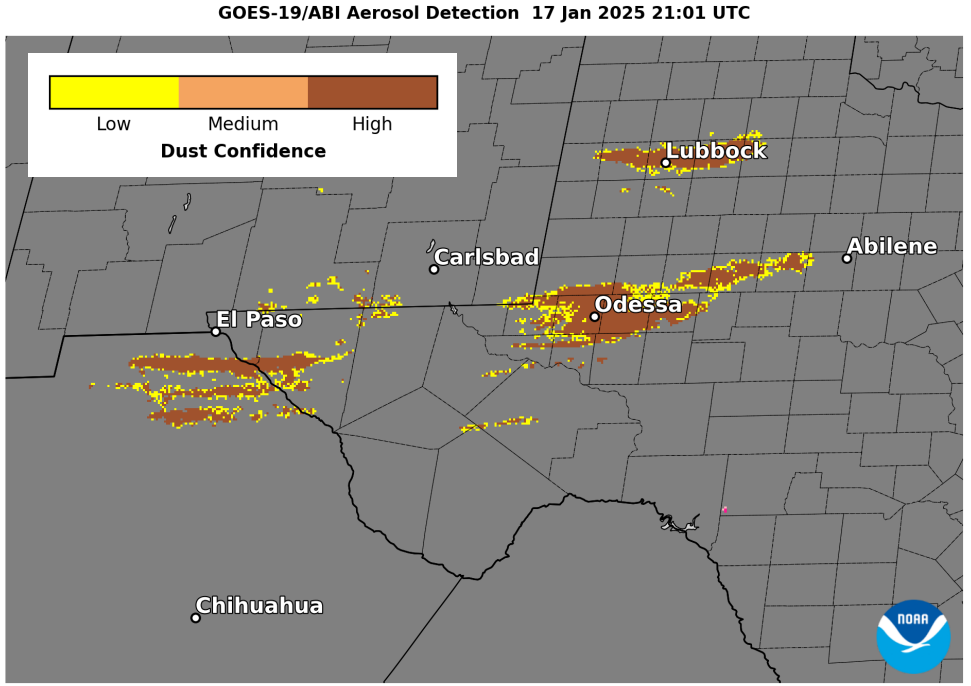




Data Confidence Flags: Smoke/Dust Mask

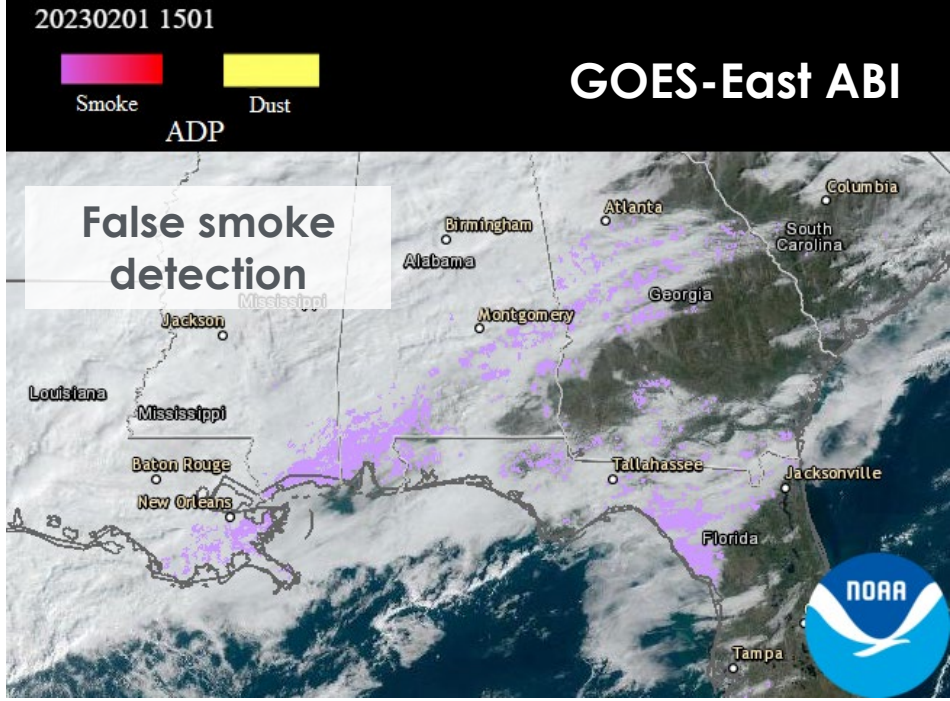
- Express overall confidence in smoke/dust retrievals
- Recommendation for TEMPO and ABI:
  - Qualitative applications:
    Use high + medium + low confidences
  - Quantitative applications:
    Use high + medium confidences
- Smoke/dust mask is not retrieved:
  - Over areas with snow/ice or clouds
    - Smoke over clouds "call-back" for TEMPO
  - At nighttime

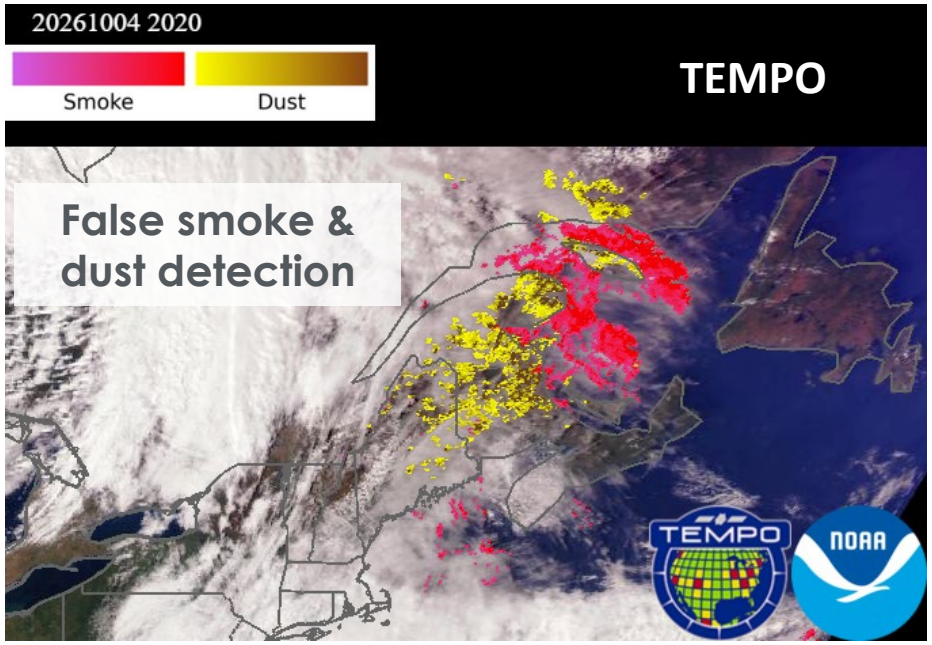


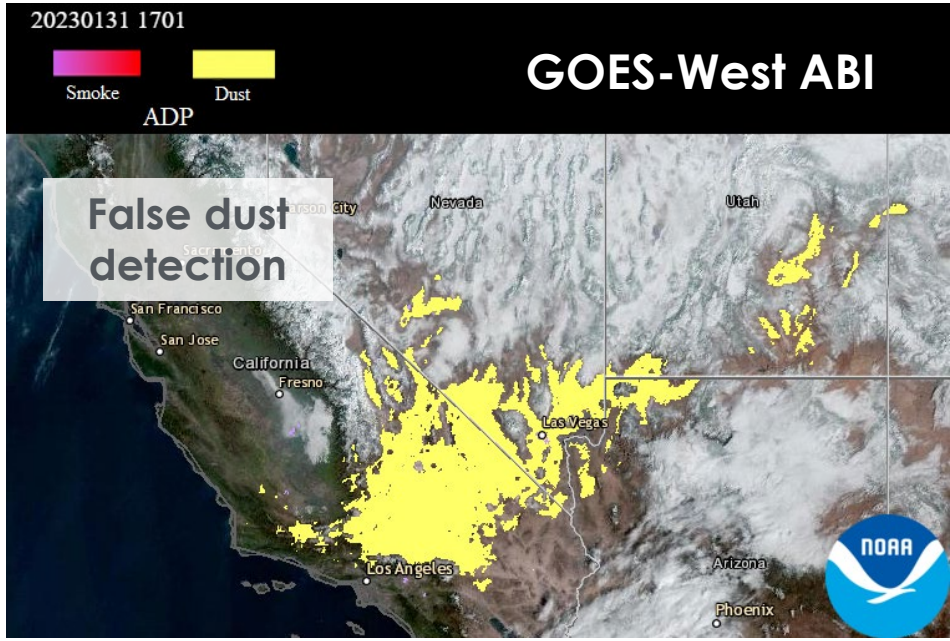


Things to Know: Using Smoke/Dust Mask

- Most accurate for thick smoke/dust over dark surfaces (e.g., water, vegetation)
  - Less accurate over bright surfaces
- Gaps can occur in smoke detection for thick smoke plumes
  - Upstream ABI Cloud Mask misidentifies thick smoke as cloud
- False detections can occur for regions with large satellite viewing zenith angle (VZA) or large solar zenith angle (SZA) in the early morning & late afternoon



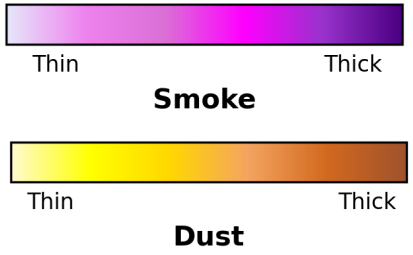


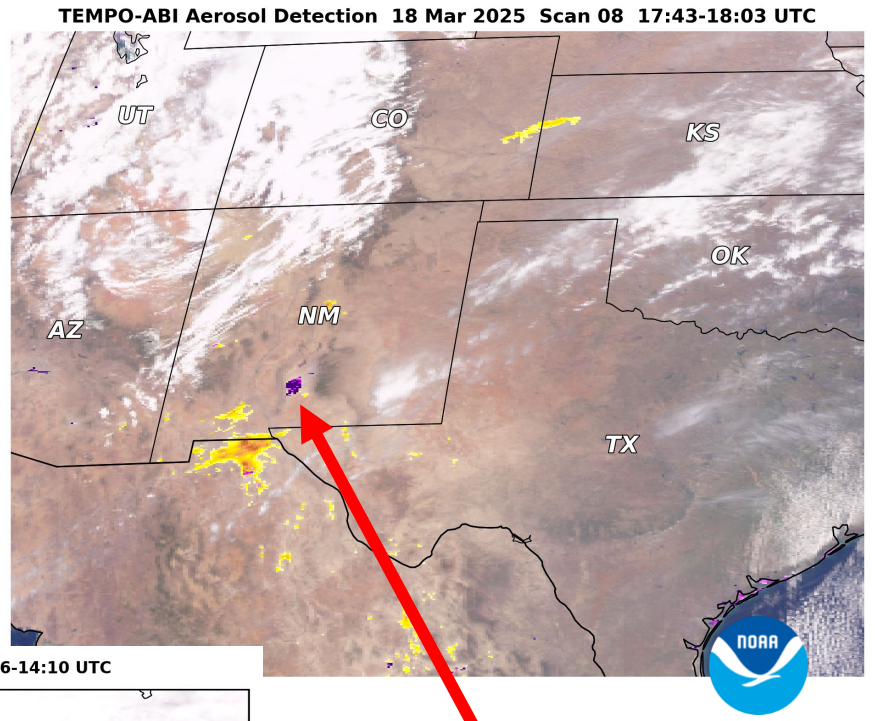


Images from the AerosolWatch website

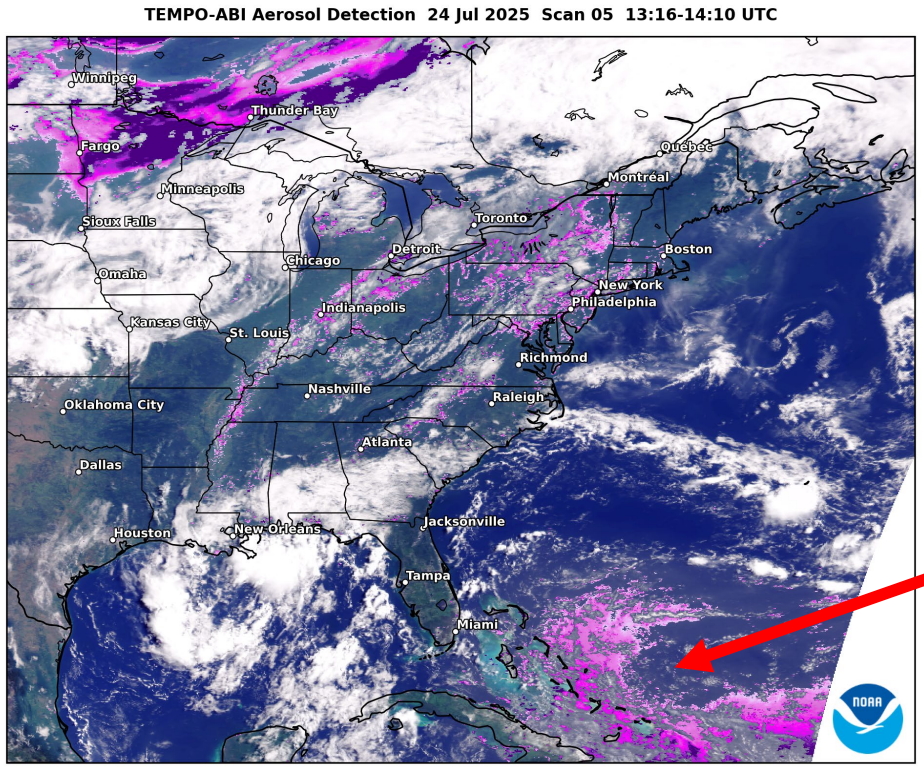
Additional Things to Know: TEMPO Smoke/Dust Mask

- False smoke detections may occur over very bright surfaces.
- Thin dust plumes over vegetated surfaces may be misclassified as smoke.
- Saharan dust over ocean may be misclassified as smoke.
  - ABI dust mask typically has high accuracy for dust over ocean.





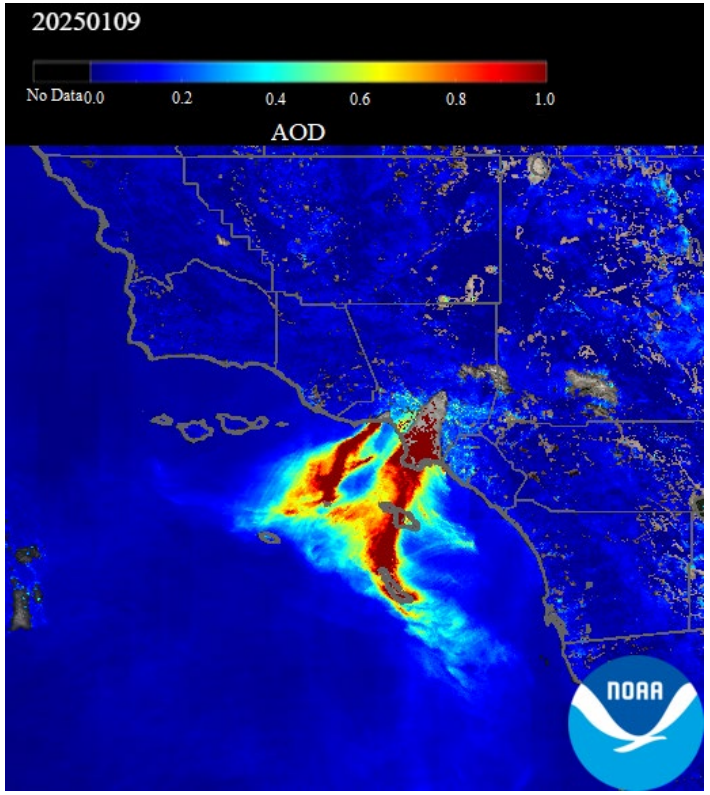
False smoke detection over very bright surface (White Sands National Monument)

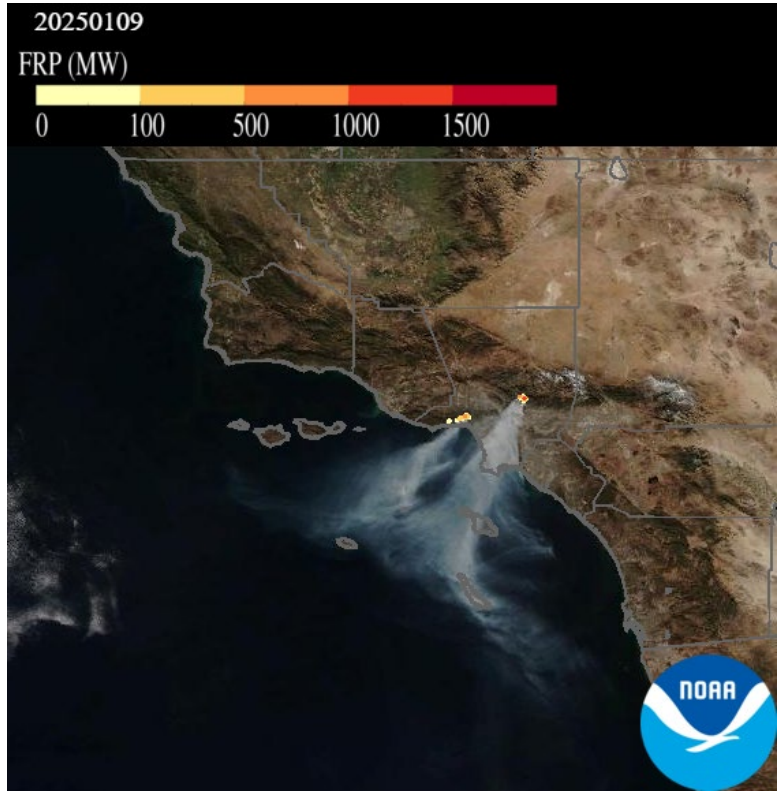


Saharan dust over ocean misclassified as smoke

Review of Satellite Aerosol Products: Aerosol Optical Depth (AOD)

- AOD is a **quantitative** measure of aerosol loading
- Unitless; values typically 0-1 in North America
  - Larger values correspond to high concentrations of aerosols
  - Lower values for clean/clear atmosphere
- Column measurement; no info about the altitude of aerosols in the atmosphere
- Surface $PM_{2.5}$ can be estimated from AOD



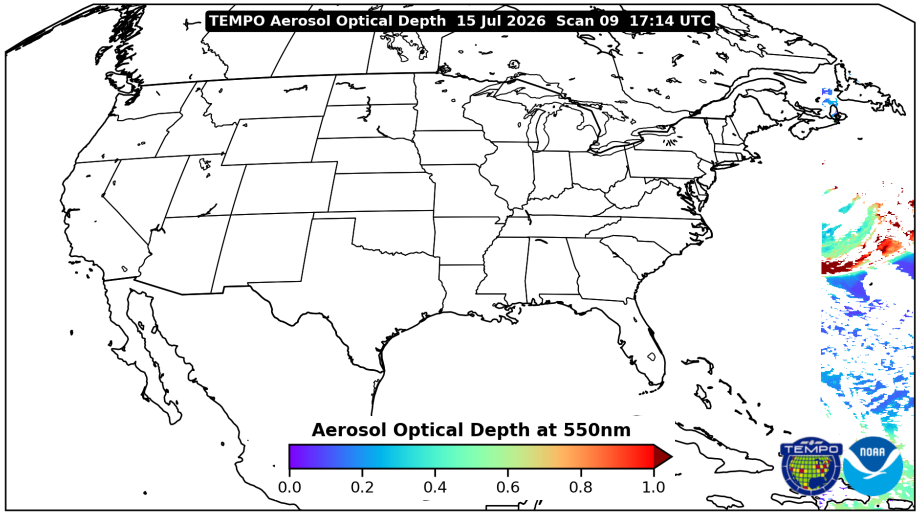


Smoke from Los Angeles wildfires January 9, 2025. Images from the AerosolWatch website.

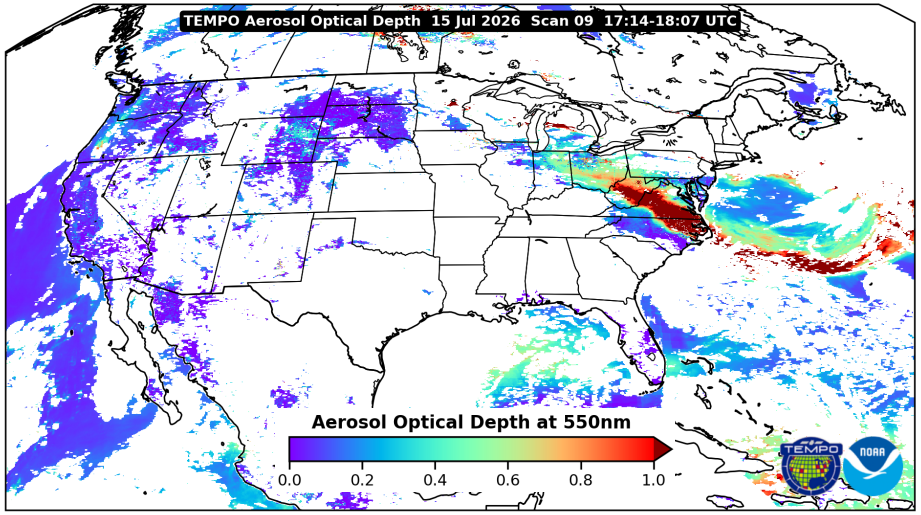
Specifications: TEMPO Aerosol Optical Depth-Aerosol Layer Height Algorithm

- Combined TEMPO algorithm
  - **Aerosol Optical Depth (AOD)**
    - Measure of extinction of radiation by aerosols due to absorption and scattering
    - Reported for 550 nm light
  - **Aerosol Layer Height (ALH)**
    - Estimated altitude of aerosols (with the most extinction) in the troposphere
    - Height relative to the surface, not sea level
    - Uses ratio of TEMPO's convolved 670 nm and 688 nm bands
    - Only retrieved for aerosols with AOD ≥0.2
- **Level 2** products; files are distributed as **granules**
- Domain: TEMPO Field of Regard (FoR)
- Spatial resolution: 2.0 km x 4.75 km (at center of FoR)

Example of individual TEMPO AOD granules



Example of full TEMPO AOD scan



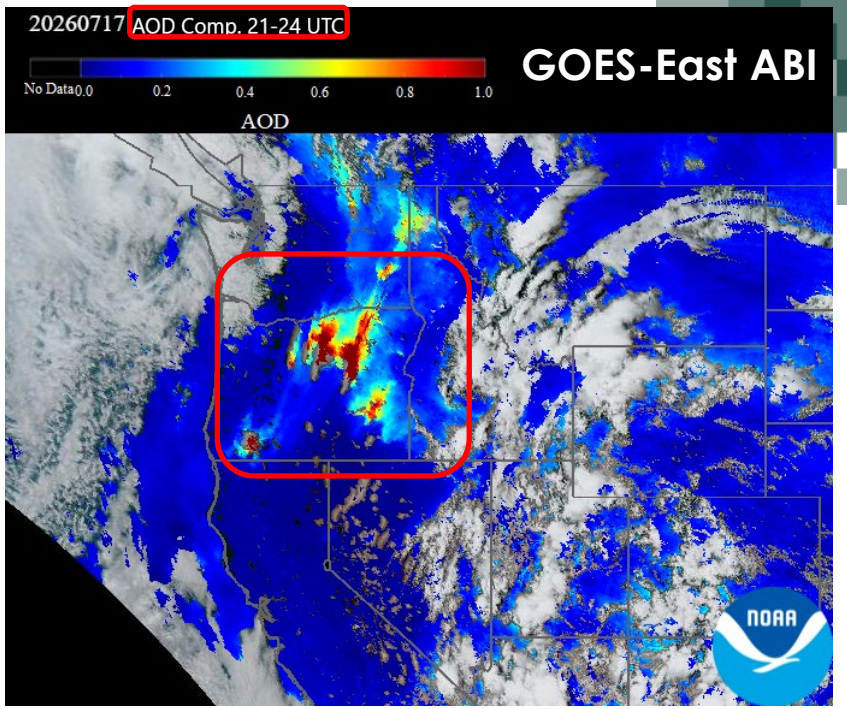
TEMPO and ABI Synergy: AOD

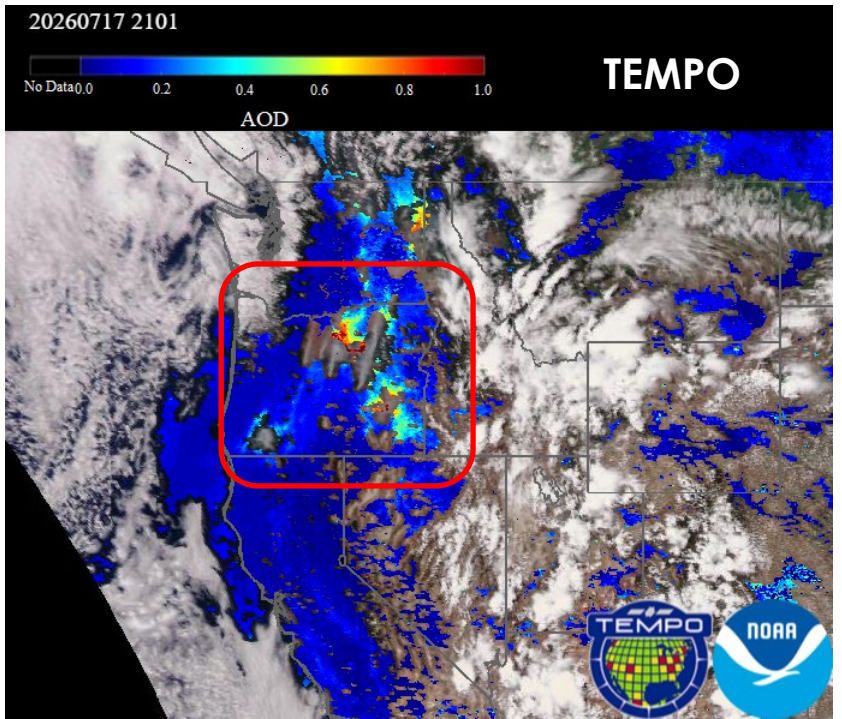
AOD	TEMPO	ABI

Strengths	• Algorithm uses TEMPO Smoke/Must Mask to differentiate aerosol type
	  • Increases accuracy and geographic coverage of AOD, especially for dust
		• Frequent observations:
		  • Every 10 min for Full Disk & CONUS
		• AOD composite (average) smooths gaps in individual AOD timesteps
		• Higher spatial resolution (less pixelated)

Limitations	• Slightly coarser spatial resolution • ~1 hour temporal resolution	• Dust retrievals can be under-estimated or missed, especially over land • No Mesoscale sectors for AOD

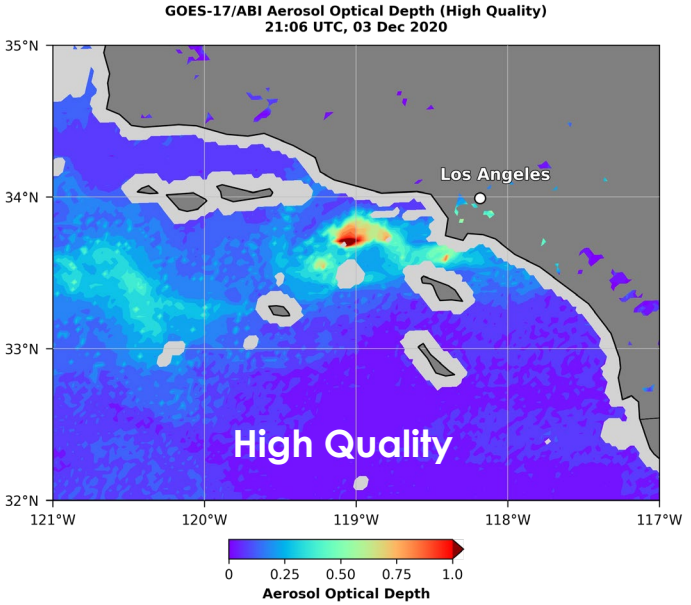
Images from the AerosolWatch website

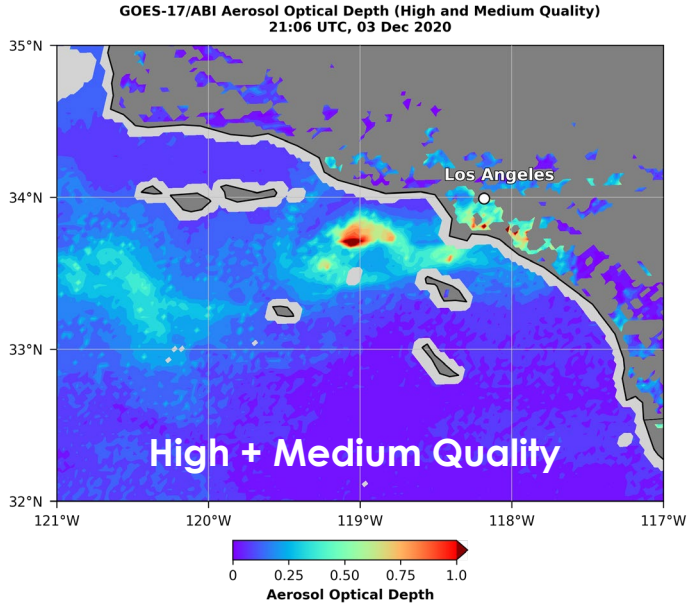


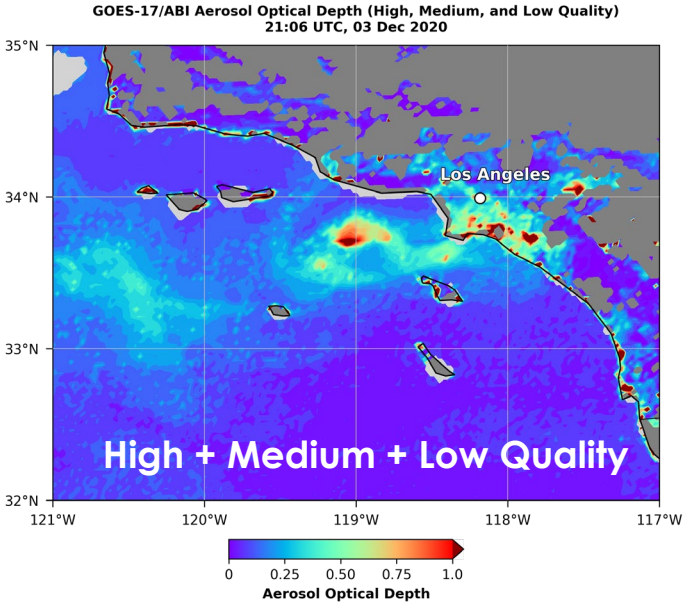


Data Quality Flags: AOD

- Express overall confidence in AOD retrievals
- Recommendation:
  - TEMPO:
    - Use high quality for all applications!
  - ABI:
    - Qualitative applications:
      Use high + medium ("top 2") quality
    - Quantitative applications:
      Use high quality only
- AOD is not retrieved:
  - Over areas with clouds, snow/ice, ephemeral (land) or shallow (ocean) water, sun glint
  - At nighttime

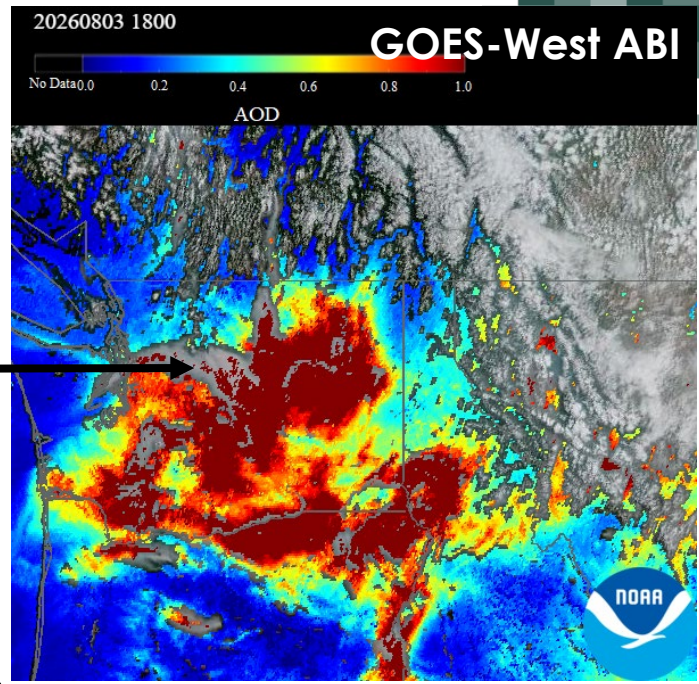






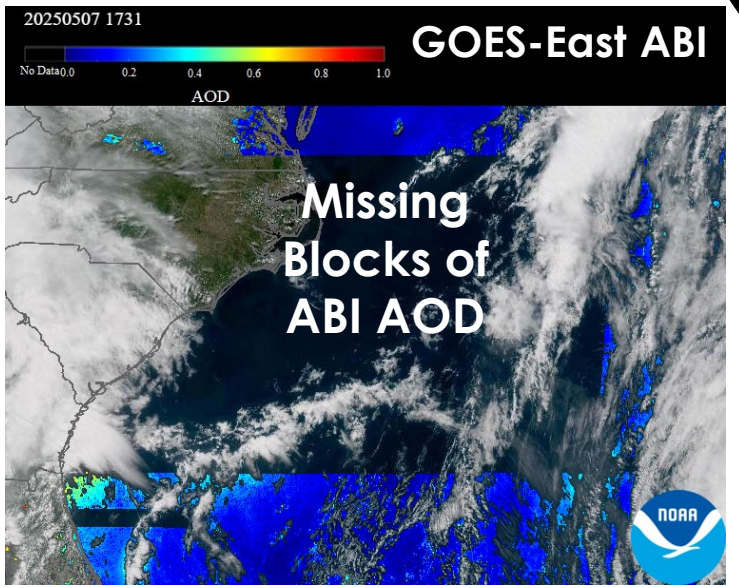
Things to Know: Using AOD

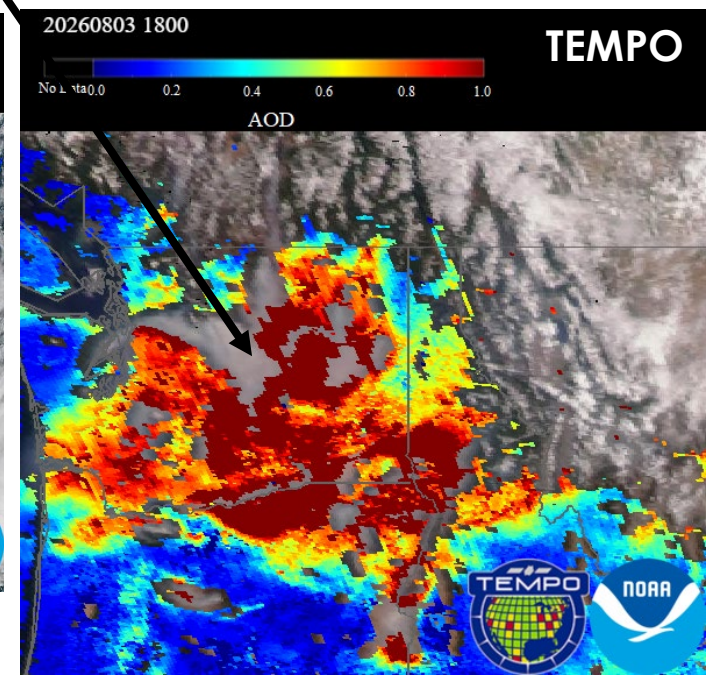
- Gaps can occur in TEMPO & ABI AOD retrievals for thick smoke plumes
  - Upstream ABI Cloud Mask product misidentifies thick smoke as cloud
- "Cloud contamination" can cause anomalously high TEMPO & ABI AOD adjacent to clouds
- TEMPO & ABI AOD are vertical column retrievals; no information about the altitude of aerosols in the atmosphere
  - **Use new TEMPO Aerosol Layer Height product for estimated altitude of aerosols**
- Blocks of missing ABI AOD can occur randomly



Missing AOD in thick smoke plumes

Images from the AerosolWatch website

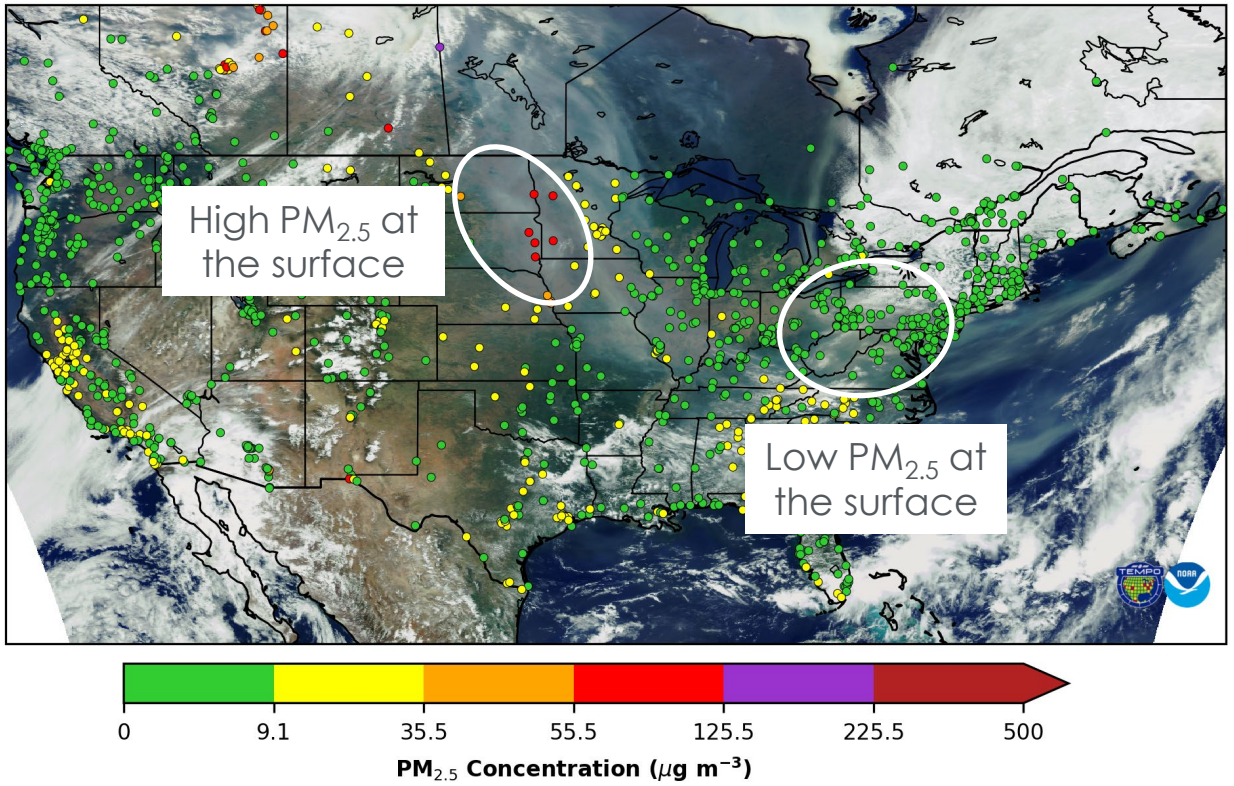




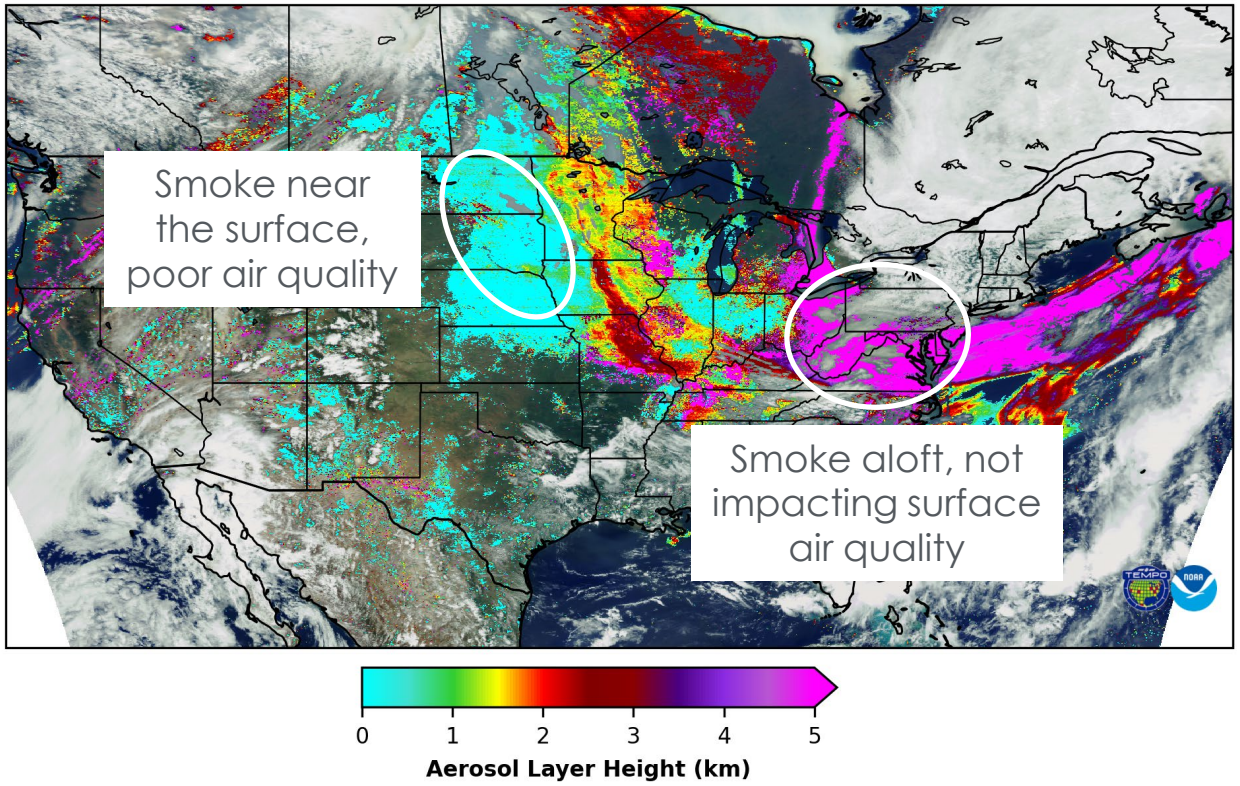
New! Height of Aerosols in the Atmosphere from TEMPO

Aerosol Layer Height enhances Aerosol Optical Depth measurements with a 3-D view of smoke.

Fine Particles (1-Hour Average) Observed by Regulatory Monitors 01 Jun 2025 17:00 UTC



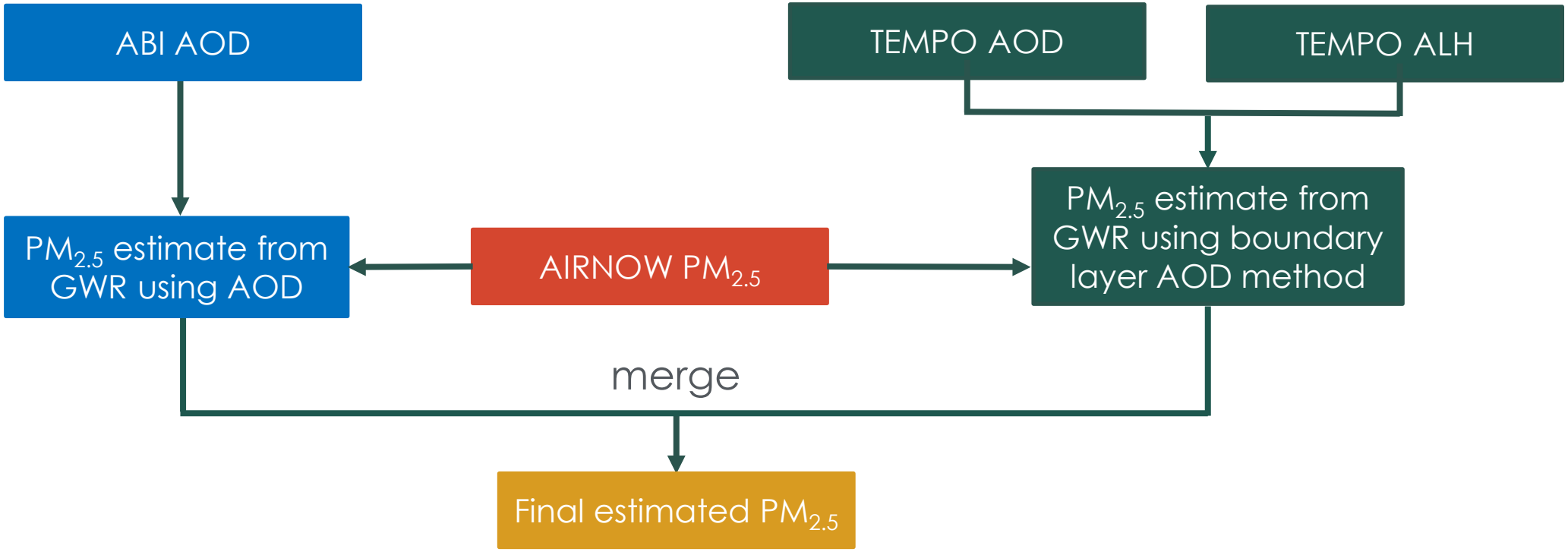
TEMPO Aerosol Layer Height 01 Jun 2025 Scan 09 17:14-18:07 UTC



Specifications: Estimated Surface $PM_{2.5}$ Algorithm

- **Geographically Weighted Regression (GWR)** algorithm
  - Weighting depends on the distance b/w AirNow monitors & location where $PM_{2.5}$ is estimated
  - Model parameters dynamically updated every hour

- Surface $PM_{2.5}$ concentration ($\mu g/m^3$)
  - 1-hour average by "clock hour" (e.g., 13:00-13:59)
- **Level 4** product; uses the ABI fixed grid
- Domain: CONUS, southern Canada, northern Mexico* & the Caribbean*
- Spatial resolution: 2.0 km at nadir



TEMPO and ABI Synergy: ALH

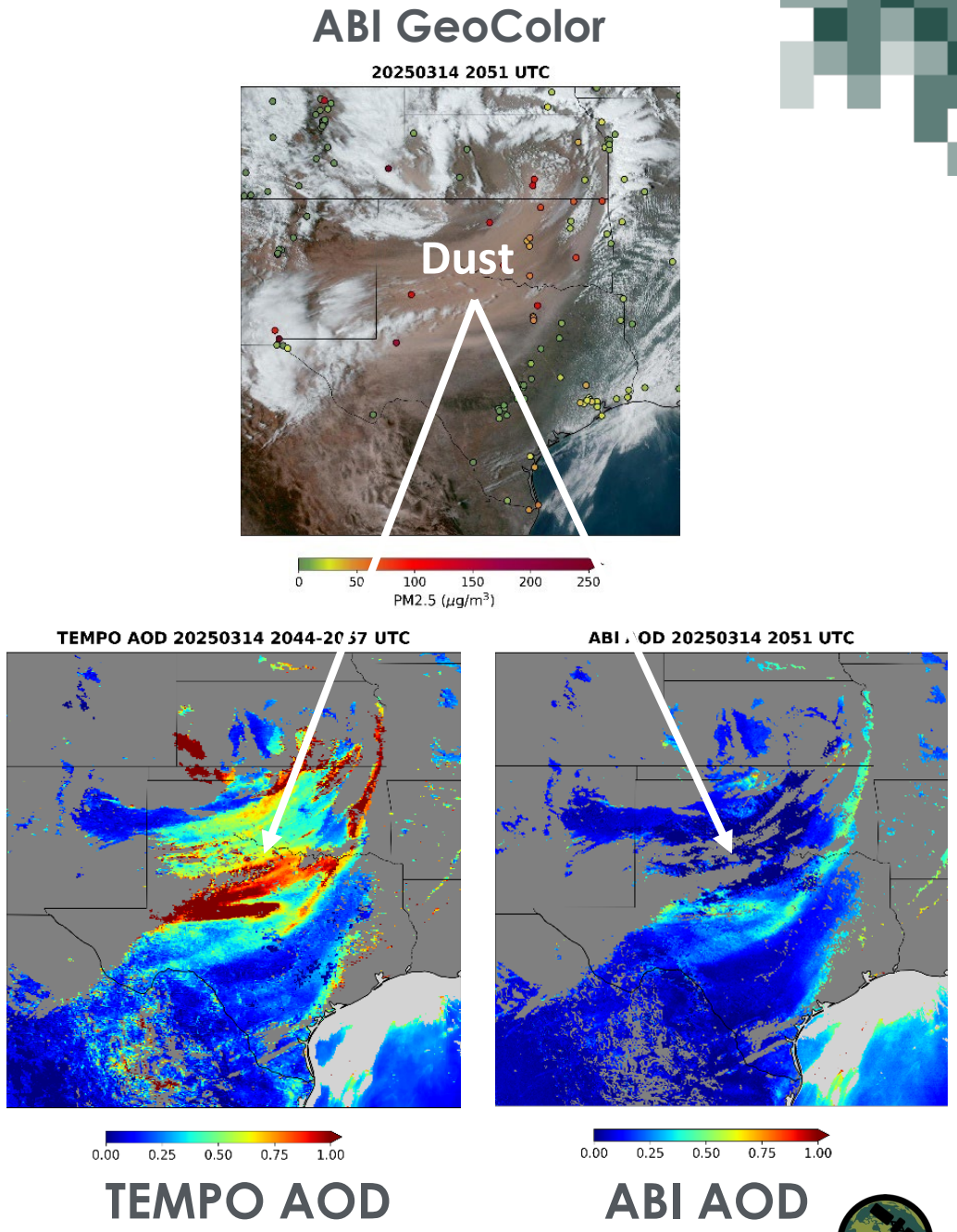
$PM_{2.5}$	TEMPO	ABI

Strengths	• Algorithm incorporates TEMPO ALH to estimate AOD in the boundary layer
	  • Increases accuracy, especially when ALH >3 km
	• TEMPO AOD dust retrievals are more accurate with greater spatial coverage
		• 12:1 ratio of ABI:TEMPO AOD observations
		  • More chances for retrievals, especially over areas with clouds
		• $PM_{2.5}$ estimates available when TEMPO AODALH granules are missing

Limitations	• No retrievals where TEMPO AODALH granules are missing (e.g., during Special Operations)	• Relies on AOD (no ALH product) • ABI AOD retrievals for dust can be under-estimated or missed

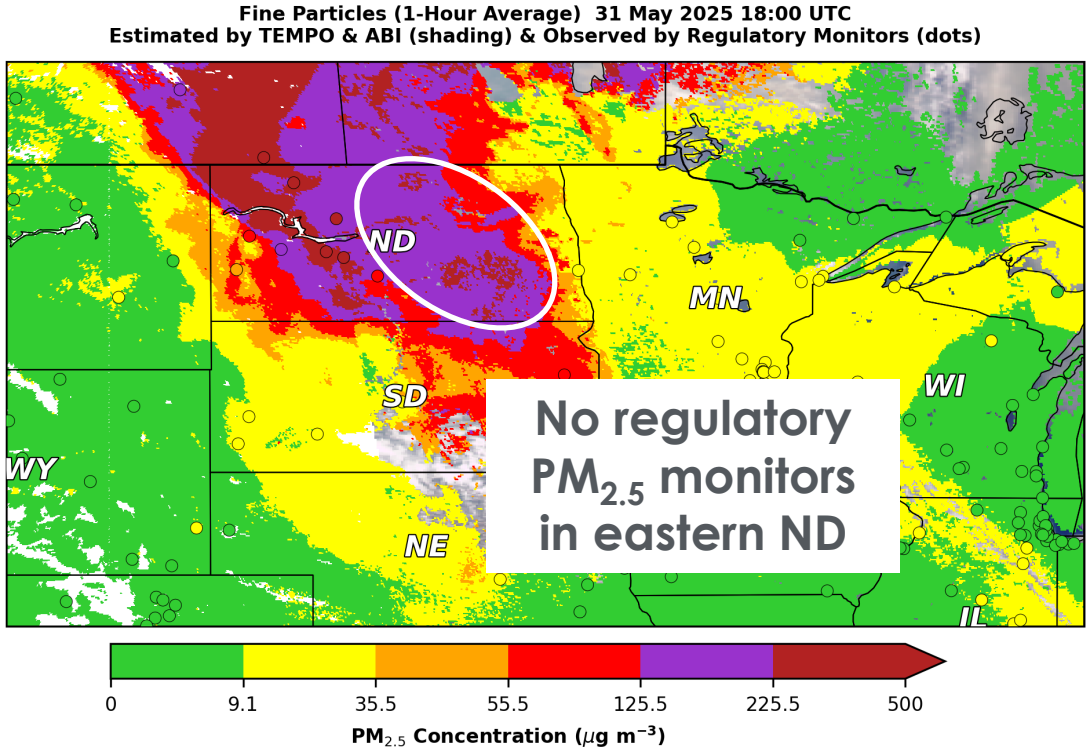
TEMPO $PM_{2.5}$ is **not** averaged with ABI $PM_{2.5}$ when:

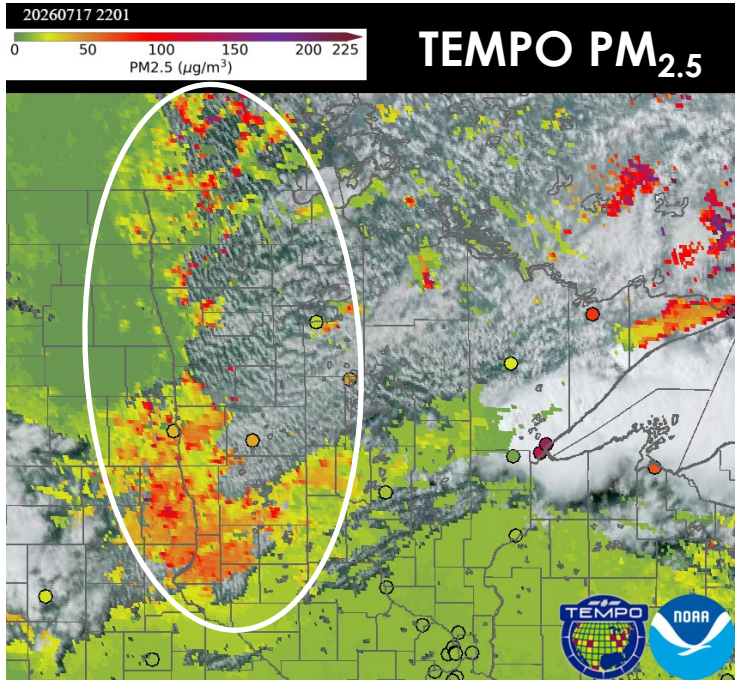
1. Aerosol is aloft in the atmosphere (ALH >3 km)
2. Aerosol is identified as dust



Things to Know: Using 1-Hour Estimated Surface $PM_{2.5}$

- Fills gaps in the national AirNow regulatory $PM_{2.5}$ monitor network
- No data quality/confidence flags!
- Cloud contamination of TEMPO and ABI AOD introduces noise & impacts the accuracy of estimated $PM_{2.5}$
  - Worse for TEMPO estimated $PM_{2.5}$, especially along cloud edges





Noisy estimated $PM_{2.5}$ retrievals

Things to Remember: ABI vs. TEMPO Aerosol Products

ABI Aerosol Products

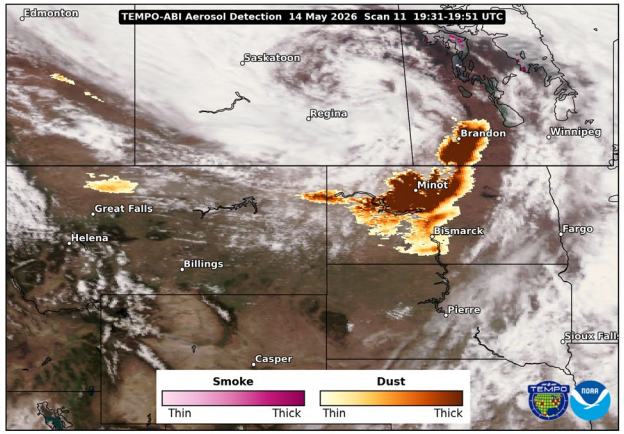
- Observations every 5-10 minutes
- Fast latency
  - Data available ~10 minutes after observation
- Slightly higher spatial resolution
  - Imagery is less pixelated
- Operational missions
  - 24/7 support for satellites and data flow
  - Data/imagery are almost always there when you need them!
- No information on aerosol height in the atmosphere
- Aerosol products have proven performance (Provisional to Full validation)

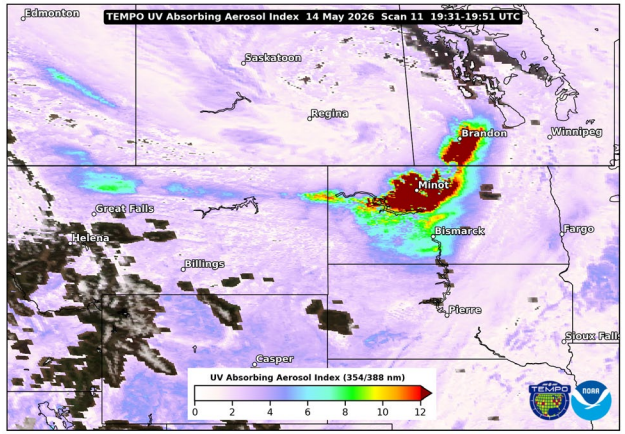
TEMPO Aerosol Products

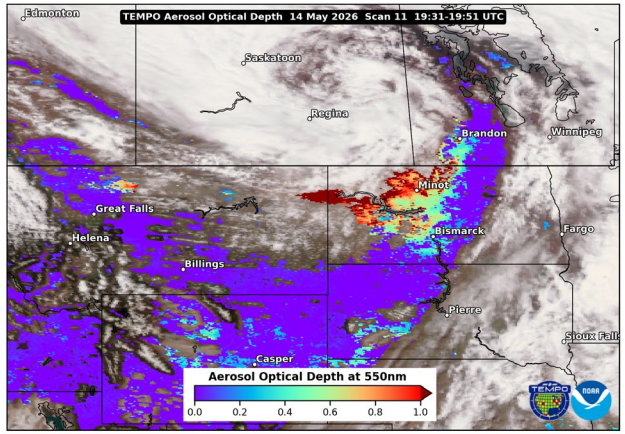
- Observations every ~1 hour
- Slower latency
  - Data available ~2 hours after observation (when products are operational ~Spring 2027)
- Slightly coarser spatial resolution
  - Imagery is more pixelated
- Research mission
  - Periodic interruptions in NRT observations & data flow
  - Sometimes data/imagery are missing
- New! Aerosol Layer Height product
- Aerosol products are new & performance is still being evaluated (updates are ongoing)

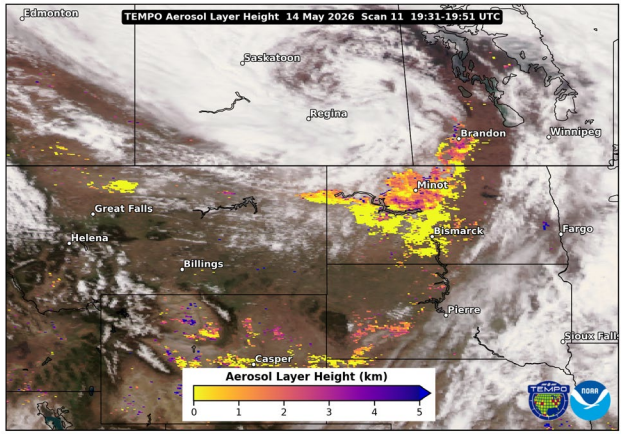
Summary: TEMPO Enhances ABI Aerosol Products

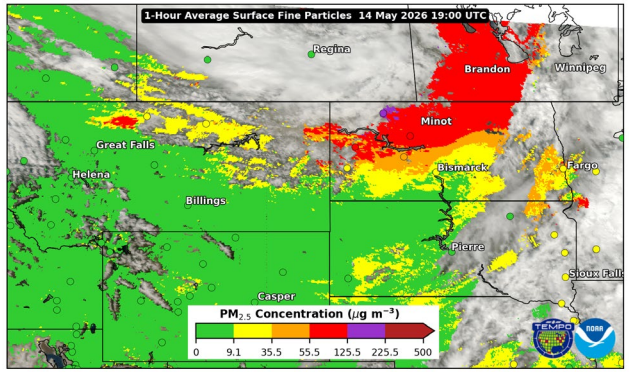
- TEMPO's UV/Visible hyperspectral observations enhance NOAA's geostationary aerosol products from ABI
  - **New products!** UV Absorbing Aerosol Index (UV AAI), Aerosol Layer Height (ALH)
  - **Improved products!** Smoke/Dust Mask, AOD, 1-hour average estimated surface $PM_{2.5}$
- **Use all available TEMPO (& ABI) imagery to get a full picture of a smoke or dust event!**

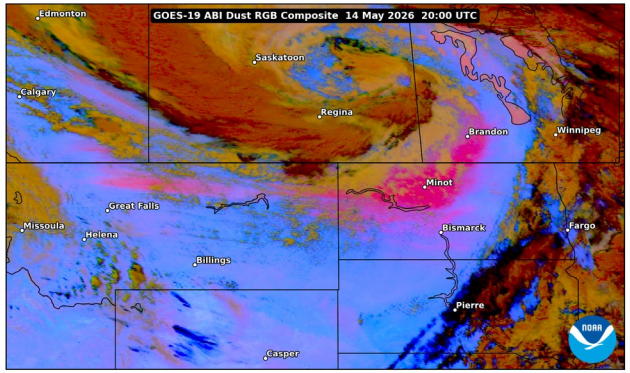






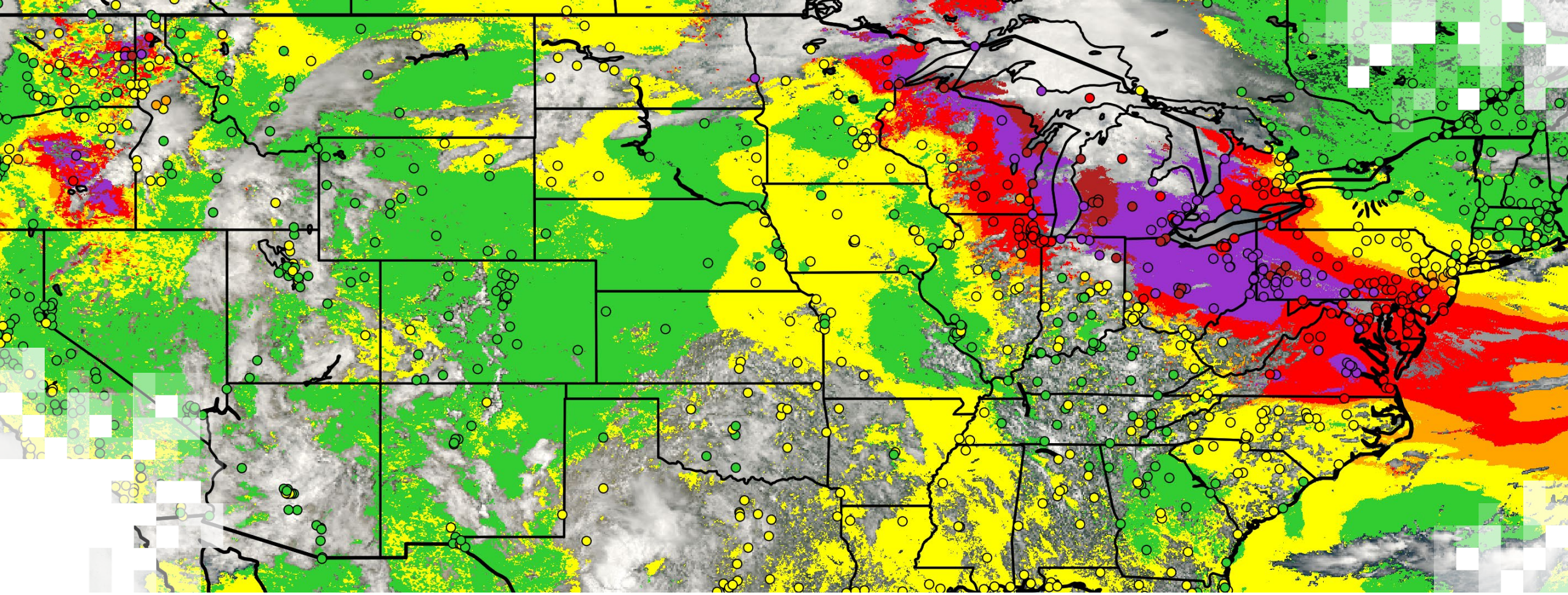






References

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- **Liu, H.**, Zhou, M., & Laszlo, I. (2018). GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Suspended Matter/Aerosol Optical Depth and Aerosol Size Parameter. NOAA NESDIS Center for Satellite Applications and Research. https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/docs/GOES-R_ABI_AOD_ATBD_V4.2_20180214.pdf
- **Zhang, H.**, Kondragunta, S., & Ciren, P. (2025). TEMPO aerosol optical depth and aerosol layer height retrieval algorithm. Journal of Geophysical Research: Atmospheres, 130, e2025JD044082. https://doi.org/10.1029/2025JD044082
- **Zhang, H.**, Kondragunta, S., & Wei, Z. (2026). Hourly PM2.5 estimates from TEMPO and ABI aerosol retrievals using geographically weighted regression. Earth and Space Science, 13, e2025EA004959. https://doi.org/10.1029/2025EA004959
- TEMPO Aerosol Product Users' Guides



Part 1: NOAA's TEMPO Aerosol Products for Hourly Aerosol Monitoring over North America

Summary

Summary

- TEMPO and GOES-R/ABI provide geostationary AQ over North America

- Instrument comparisons
  - TEMPO: hyperspectral UV/Vis, provides trace gas and aerosols; hourly
  - ABI: multi-channel Vis/IR, tracks smoke and dust; sub-hourly to minute scale

- ABI monitors rapid transport, TEMPO reveals chemical composition

- TEMPO and ABI observations are complementary
  - ABI's products are frequent and in near-real time but lack aerosol vertical structure
  - TEMPO's aerosol product suite delivers vertical structure and near-surface air quality information
  - Review all the available geostationary products to get a full picture of an air quality event!

- TEMPO products have hourly availability and will have ~2–3 hr latency when operational

Looking Ahead to Part 2

In Part 2 we will:

- Use the NOAA AerosolWatch website to view near real-time and archived TEMPO and ABI aerosol product imagery
- Analyze TEMPO and ABI aerosol imagery on AerosolWatch for a recent wildfire smoke event and a blowing dust event:
-
  - Overview of AerosolWatch
  - Case Study 1: Smoke Event, exercise in AerosolWatch
  - Case Study 2: Dust Event, exercise in AerosolWatch


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!