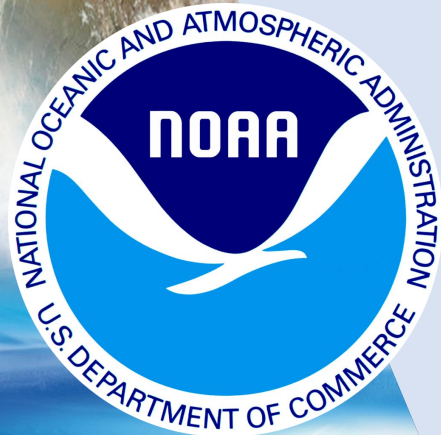


# Development of GeoXO Aerosol Detection Product



NOAA

National Satellite and  
Information Service

*Center for Satellite Applications and Research*

Disclaimer: The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the author(s) and do not necessarily reflect those of NOAA or the Department of Commerce.

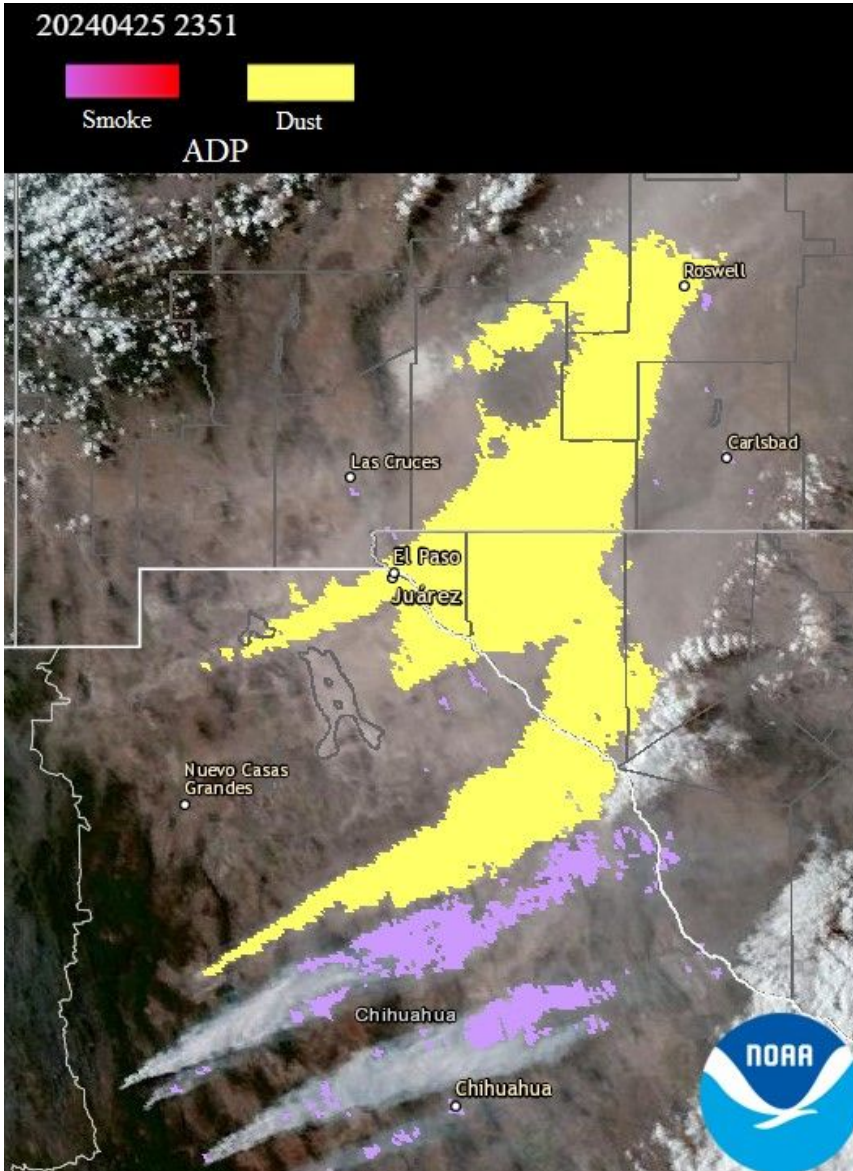
Pubu Ciren<sup>1,2</sup> and Shobha Kondragunta<sup>2</sup>

<sup>1</sup>IMSG@NOAA <sup>2</sup>NOAA/NESDIS/STAR

GeoXO ACX Science Team Meeting, 7 - 9 May 2024, College Park, MD

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

# Objective



- ❑ Wildfire smoke and blowing dust are becoming more frequent and dominant factors for air pollution.
- ❑ NOAA’s operational Enterprise Aerosol Detection Product (ADP), also called smoke/dust mask, provides smoke/dust flags at the pixel level from:
  - ❑ VIIRS: S-NPP, NOAA-20 and NOAA-21 (11 yrs. record)
  - ❑ ABI: GOES-16, -17 and -18 (~6 yrs. record)
- ❑ UV-Vis spectrometer on GeoXO ACX has better wavelengths for characterizing absorbing aerosols.
- ❑ Both GEMS and TEMPO’s UV-Vis spectrometer, currently in orbit, provide unique pathways for developing/testing NOAA GeoXO aerosol detection algorithm.

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.



- Adopted a hybrid algorithm for smoke/dust Detection
  - Extensively tested by using synergy between GEMS and AHI, TEMPO and ABI
- Utilizing synergy between ACX and GXI (both East and West, dual view)
- Cloud screening
  - Remapped cloud mask from Imager
- Outputs
  - 1. Smoke/dust mask 2. UV AAI (354/388 nm) 3. Visible AAI (412/440 nm)

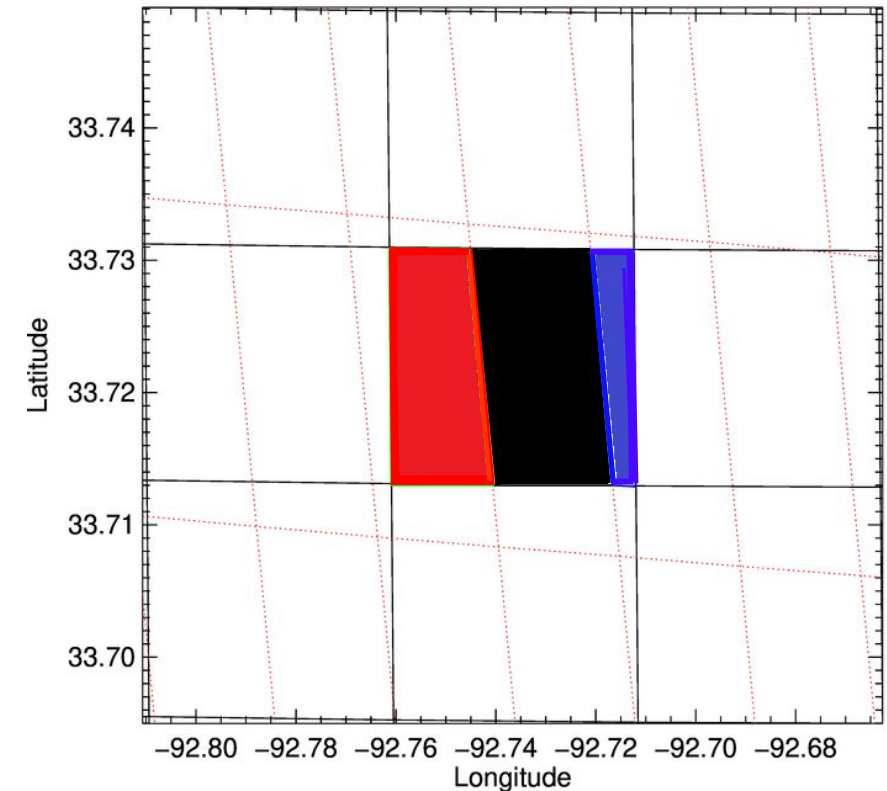
### Absorbing Aerosol Index

**ACX:** Visible AAI =  $-100[\log_{10}(R_{412}/R_{440}) - \log_{10}(R'_{412}/R'_{440})]$   
 UV AAI =  $-100[\log_{10}(R_{354}/R_{388}) - \log_{10}(R'_{354}/R'_{388})]$

**ACX/GXI: Dust Smoke Discrimination Index**

DSDI =  $-10[\log_{10}(R_{412}/R_{2250})]$

Red dotted line grid: GOES-16/ABI 2 km  
 Black line grid: TEMPO 2.0 x4.7 km



Weight=overlapped area/ABI pixel area

0.55    0.731    0.204

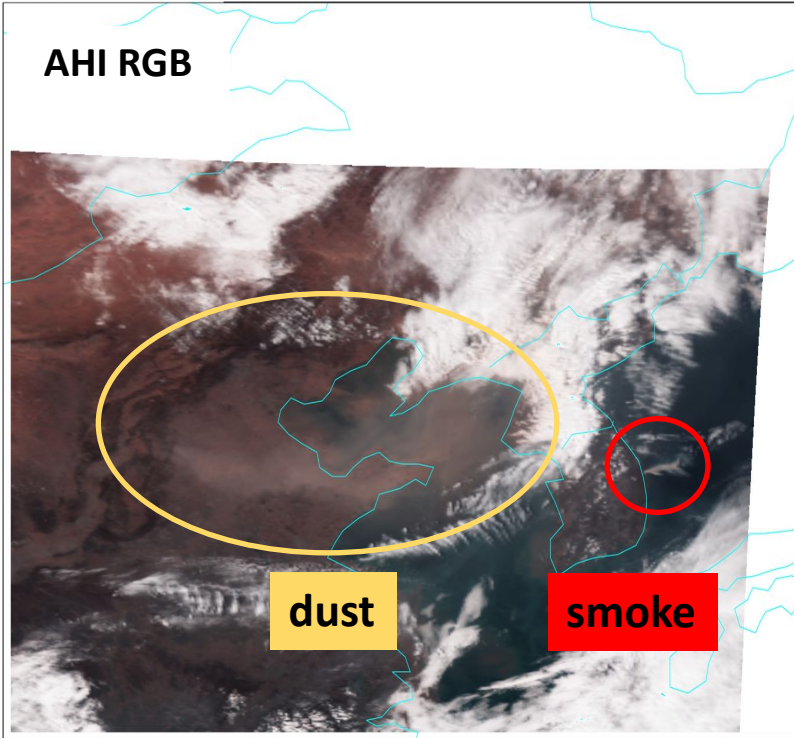
$$R = \frac{\sum_1^n w_i * R_i}{\sum_1^n w_i}$$

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.



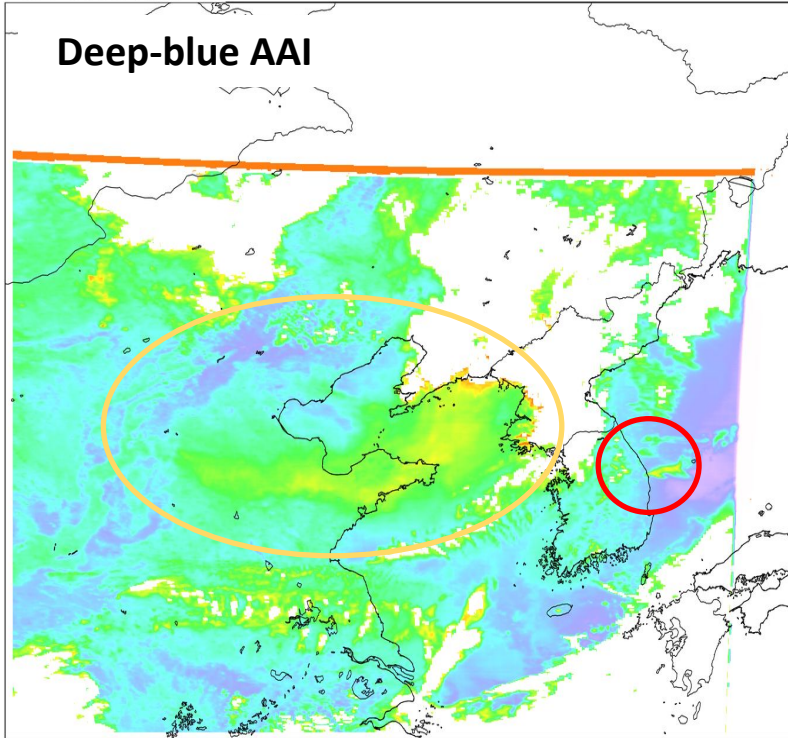
# Absorbing Aerosol Index: Deep-Blue vs. UV Wavelengths

20220304.0545

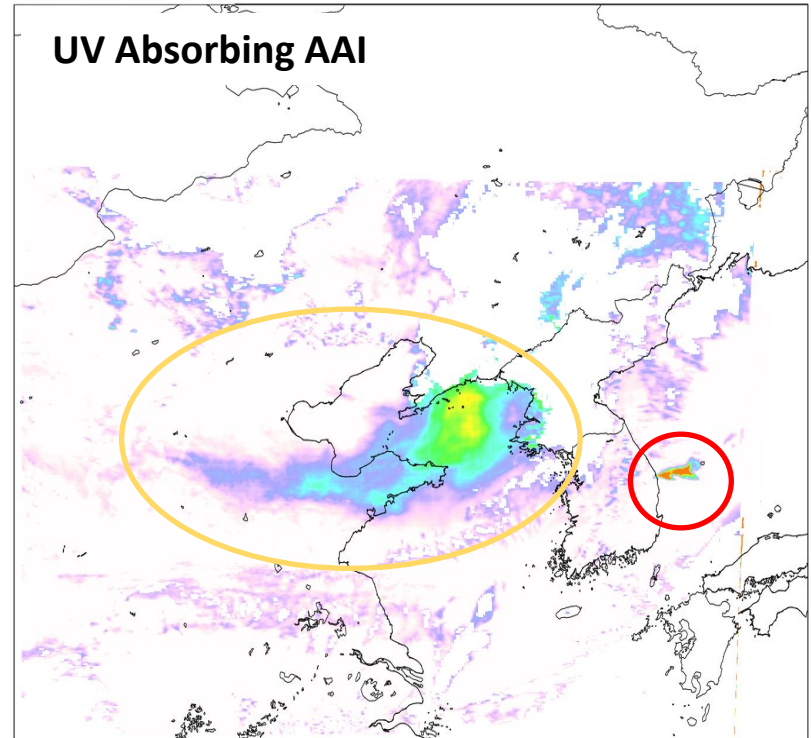


20220304 05:45 UTC

20220304.0545 GEMS



20220304.0545 GEMS



**Smoke/dust have stronger absorption at UV wavelengths compared to longer wavelengths.**

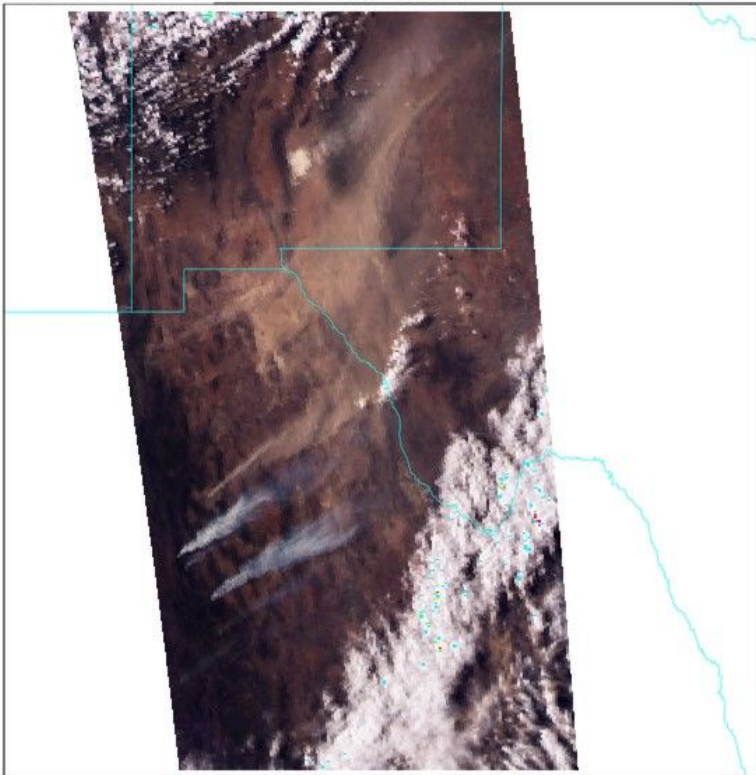
Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.



# Advantages of UV Algorithm Path for Detecting Smoke and Dust

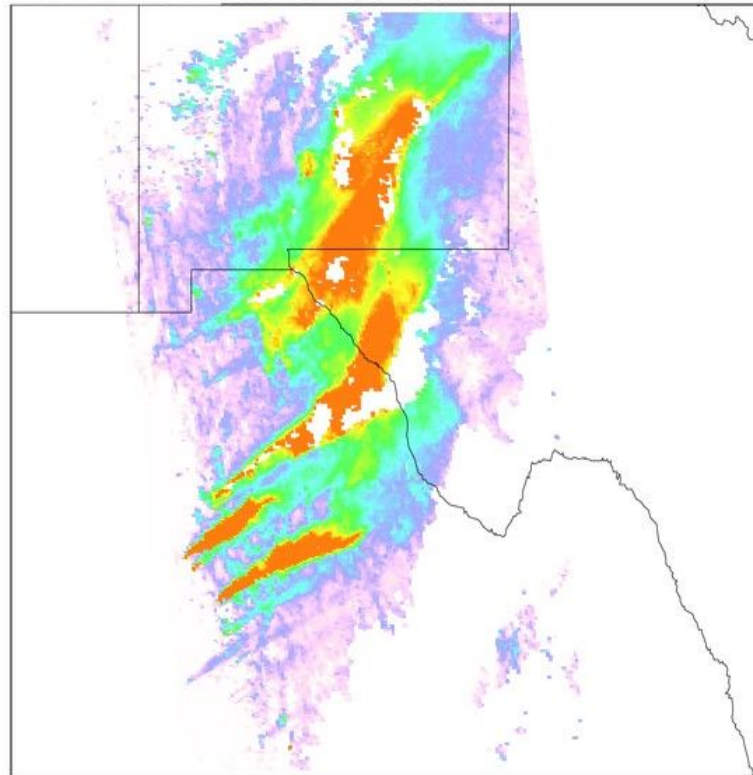
TEMPO RGB

20240425T233648Z S015G04



TEMPO UV AAI

20240425T233648Z S015G04

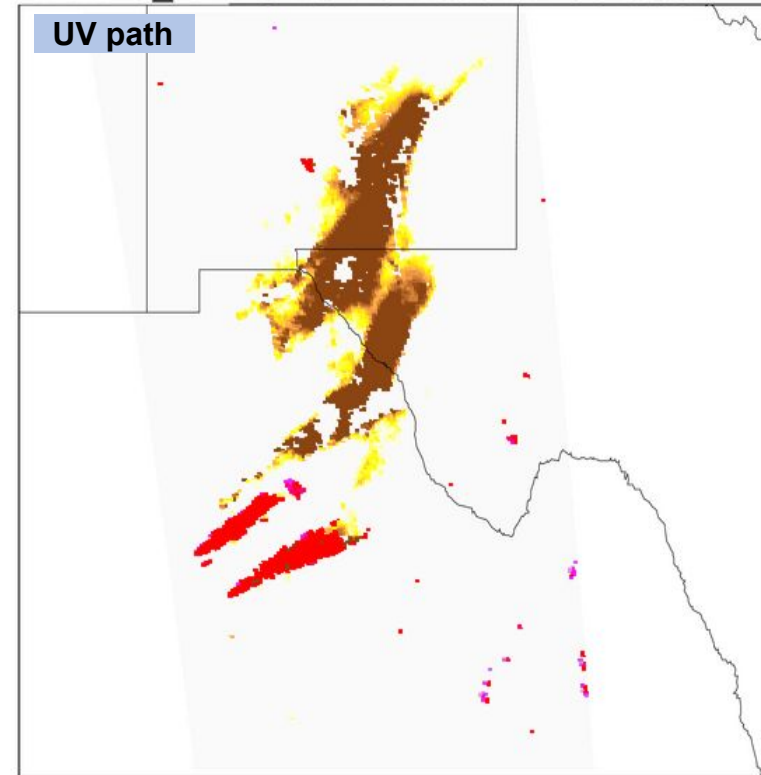


UV Absorbing Aerosol Index (354/388 nm)

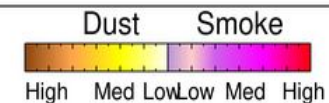


TEMPO+GOES 16

TEMPO\_ABI 20240425T233648Z S015G04



UV path



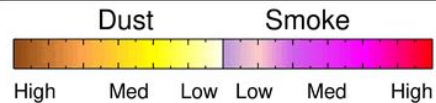
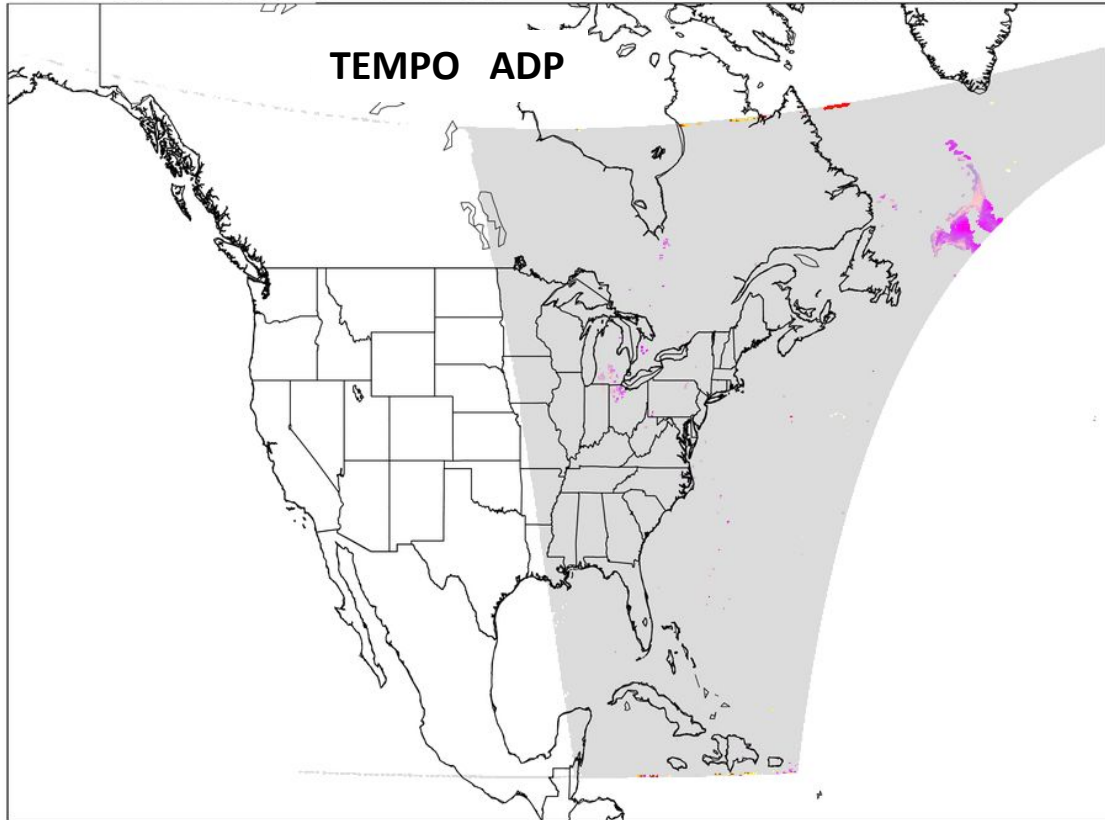
04/25/2024

More sensitivity and better coverage of ADP via UV path

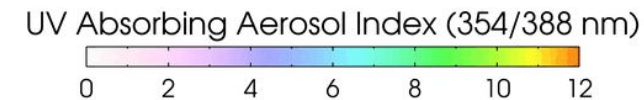
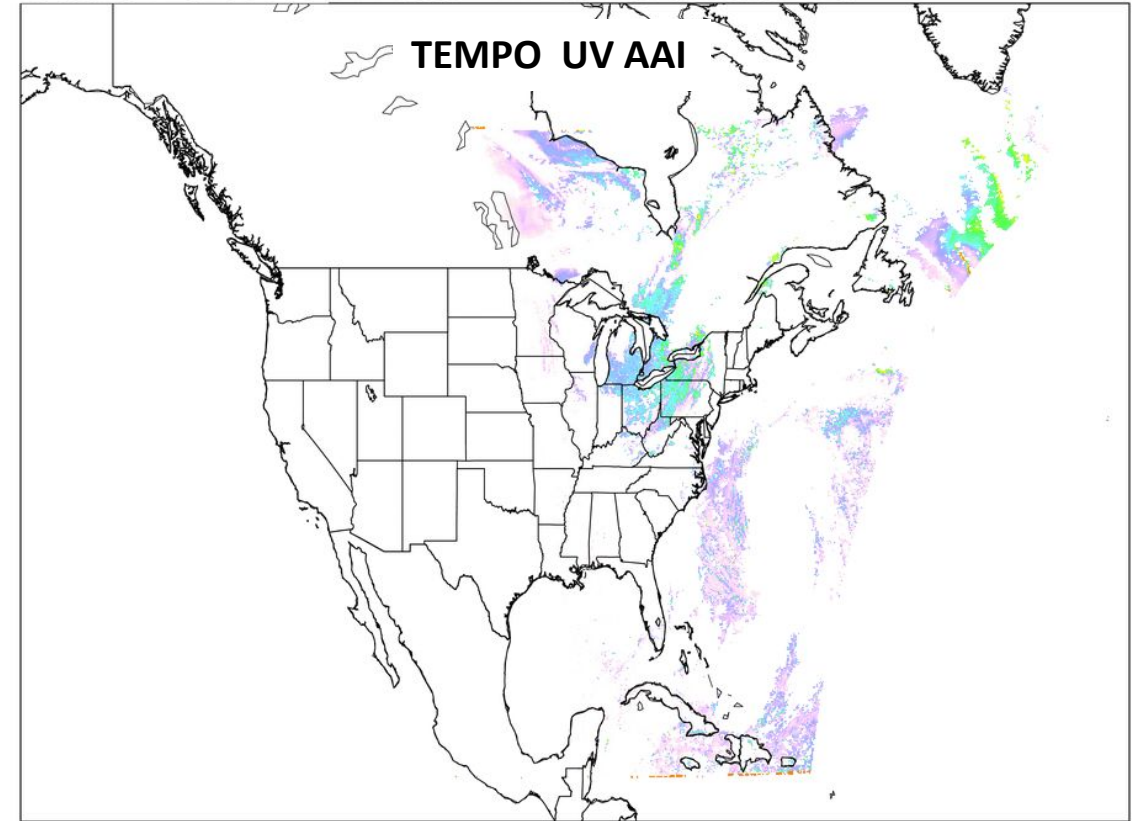
Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

# TEMPO Hybrid ADP Captures the Movement of Smoke Plumes (08/30/2023)

TEMPO\_ABI Scan:01 20230830 T111656-121253Z Granule:01-10



Scan:01 20230830 T111656-121253Z Granule:01-10



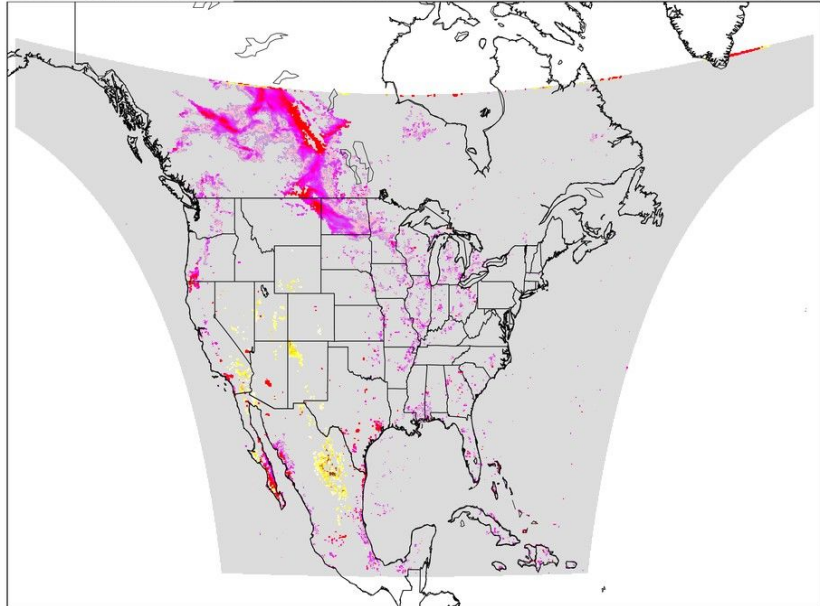
- Residual cloud contaminations are still seen, slightly noisy smoke mask.
- High values of UV AI appear over the bright surface at certain time steps, mostly due to surface BRDF effect.

**Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.**

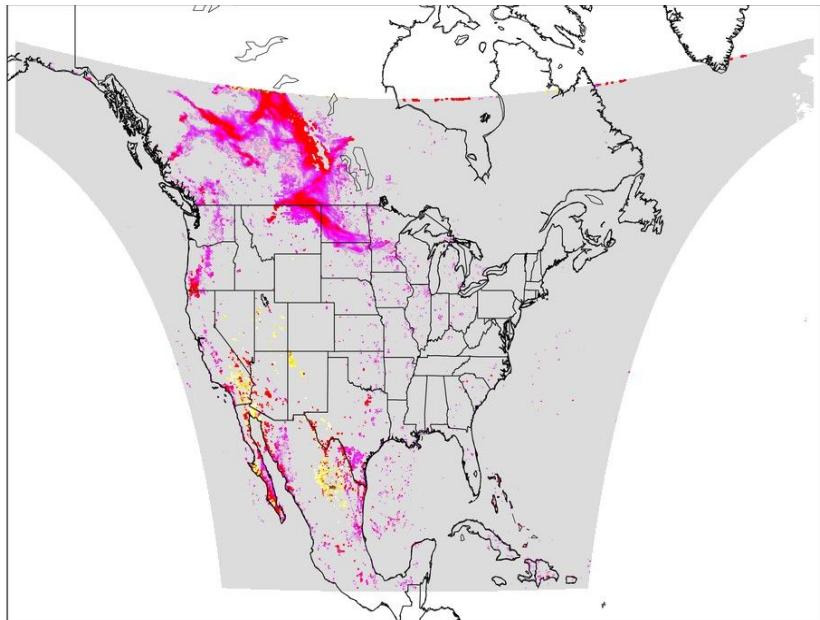
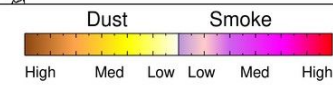


# TEMPO ADP Dual View is Comparable to VIIRS ADP

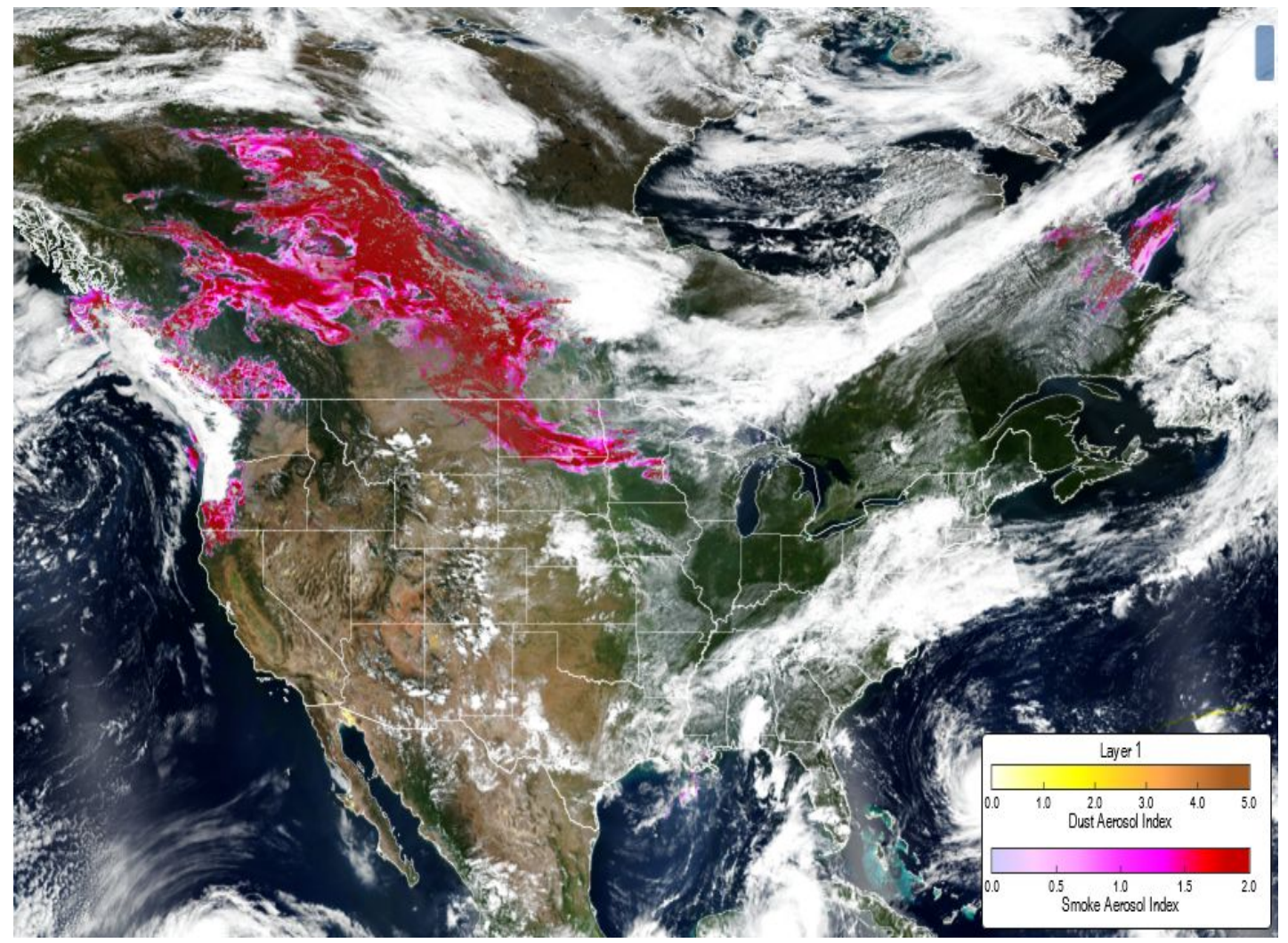
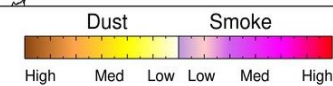
Suomi NPP VIIRS ADP August 28, 2023



TEMPO+GOES-18



TEMPO+GOES-16



Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

# Summary

- ❑ NOAA has developed a GeoXO ACX/GXI hybrid aerosol detection algorithm that is run in near real time on TEMPO operational data.
  - Preliminary results show that the hybrid algorithm generally works well
  
- ❑ A new UV algorithm path is being developed to take advantage of TEMPO (ACX)'s UV wavelengths.
  - More accurate smoke/dust detection.
  
- ❑ The ACX/GXI hybrid algorithm was also tested with GEMS and AHI data.
  - Initial results indicate the hybrid algorithm is capable of identifying both smoke/smog and dust plumes.

## Next Steps:

- ❑ Subpixels cloud screening using ABI/GXI high spatial resolution bands will be implemented.
  
- ❑ DLER developed for AOD retrieval will be applied for calculating UV and Visible AAI.

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.



# Backup slides

# NOAA Enterprise Aerosol Detection Algorithm

- One algorithm working on observations from multiple sensors including both GEO and LEO platforms.
- Uniform input and output structure.

IR-Visible Path

GOES-16/ABI

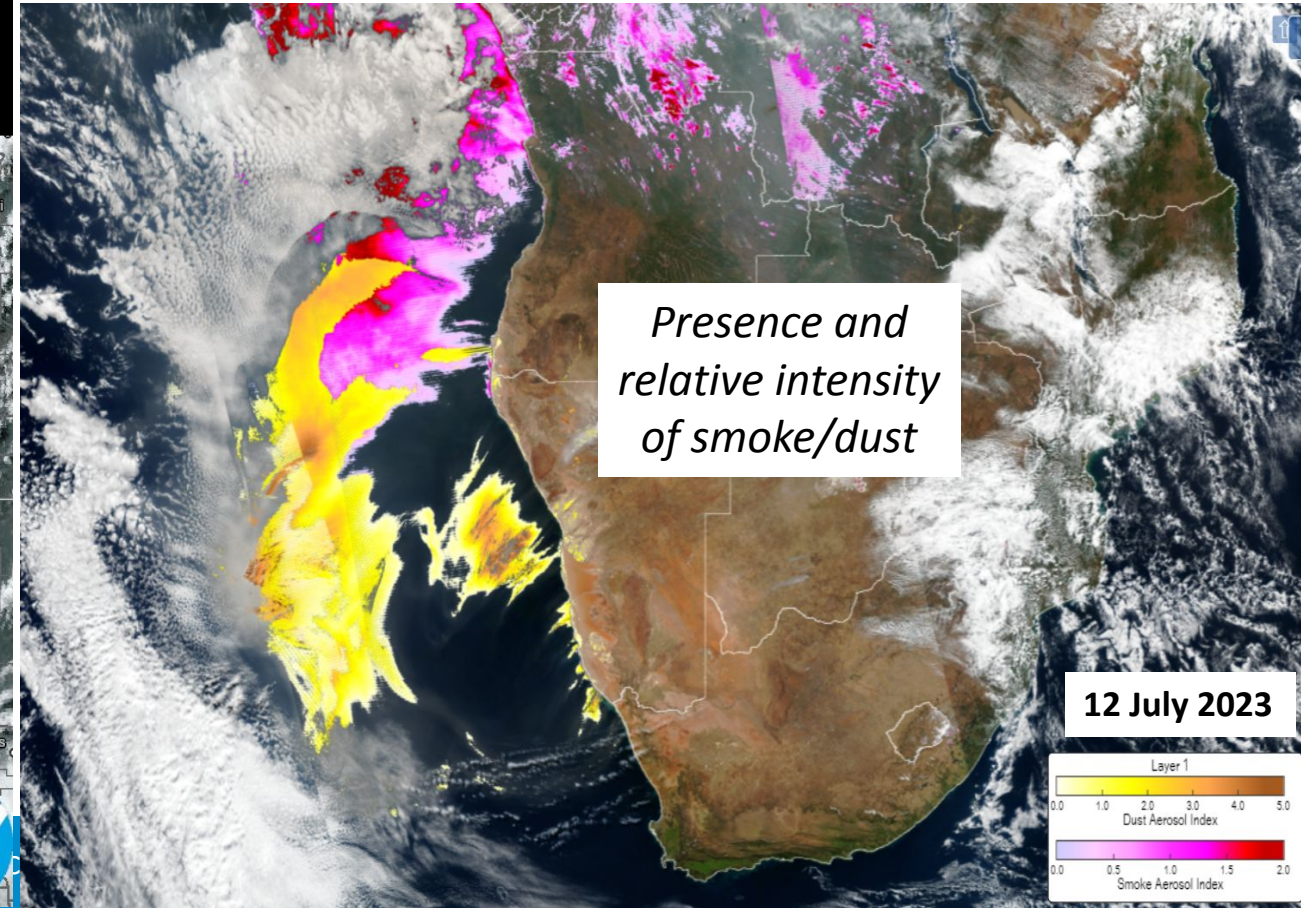
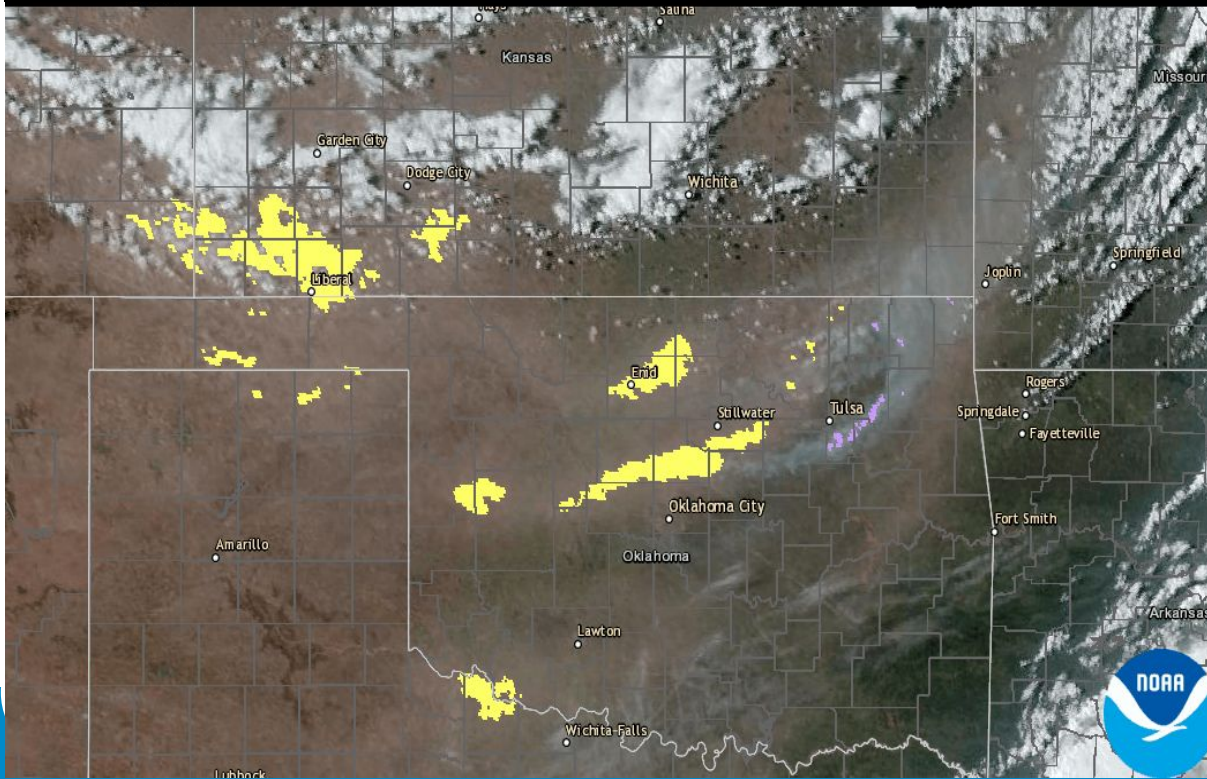
Deep-Blue Path

SNPP/VIIRS

20230331 2201



*Presence of smoke/dust*

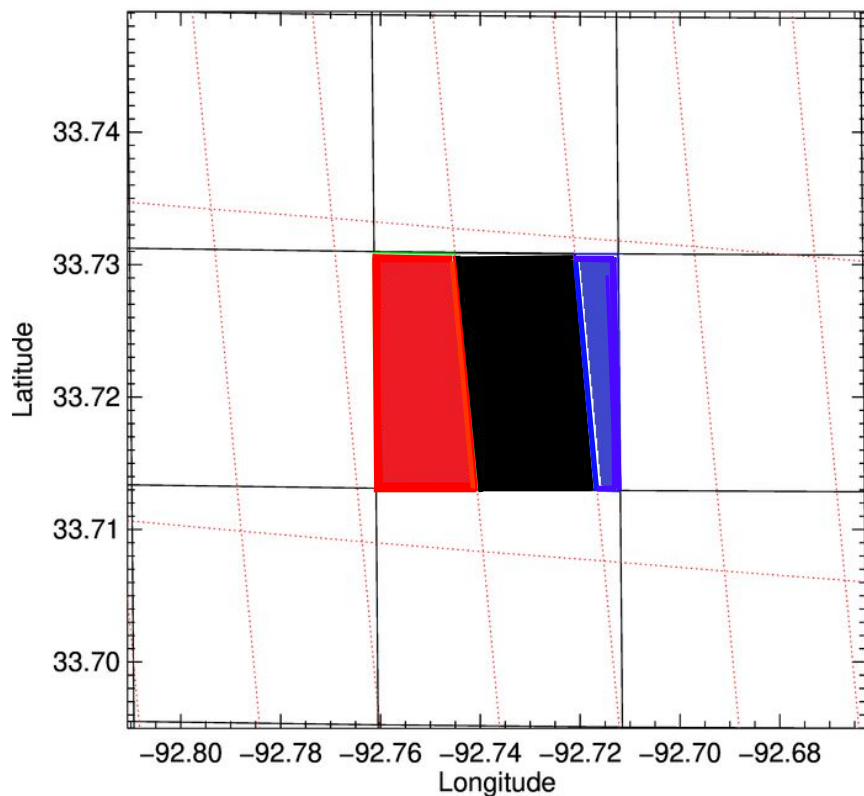




# Co-registration Tables for ABI Bands to TEMPO Bands

Red dotted line grid: GOES-16/ABI 2 km

Black line grid: TEMPO 2.0 x4.7 km



Weight=overlapped area/ABI pixel area

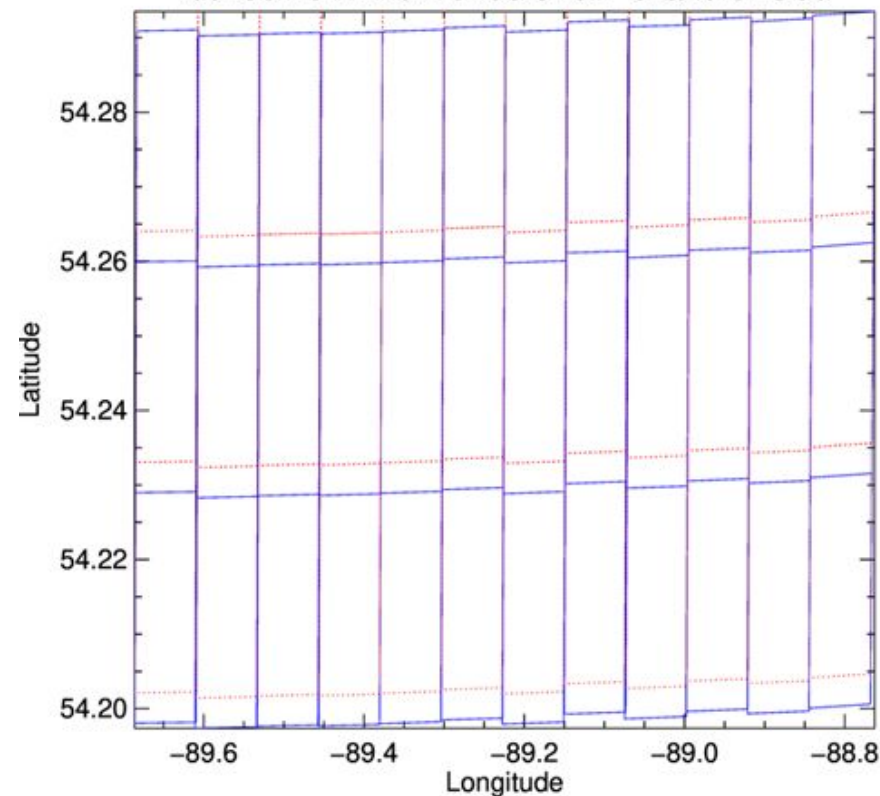
0.55    0.731    0.204

$$R = \frac{\sum_1^n w_i * R_i}{\sum_1^n w_i}$$

*R*: remapped reflectance    *n*: no. of ABI pixels  
*w<sub>i</sub>*: weight at pixel *i*    *R<sub>i</sub>* - ABI reflectance at pixel *i*

Visible Band    UV Band

col:001:012 Row:0100:0102 Granule=G05



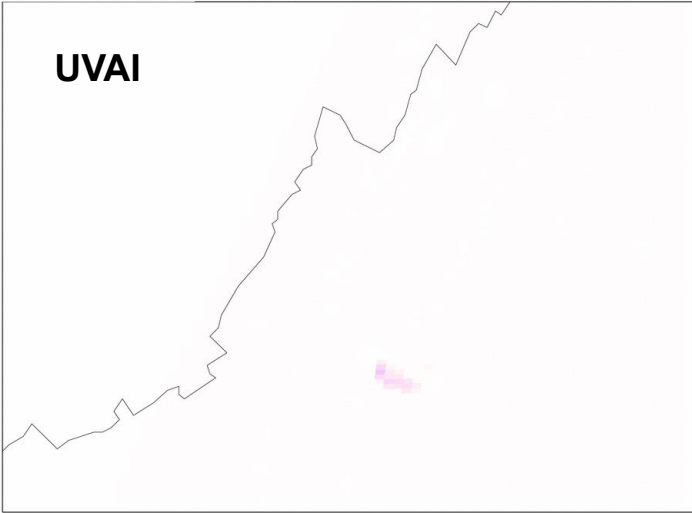
- Larger than ~2% difference w/o tables
- Small north to south shift between UV and Visible band

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

# TEMPO Hybrid ADP Example: Matts Creek Fire, VA (11/16/2023)

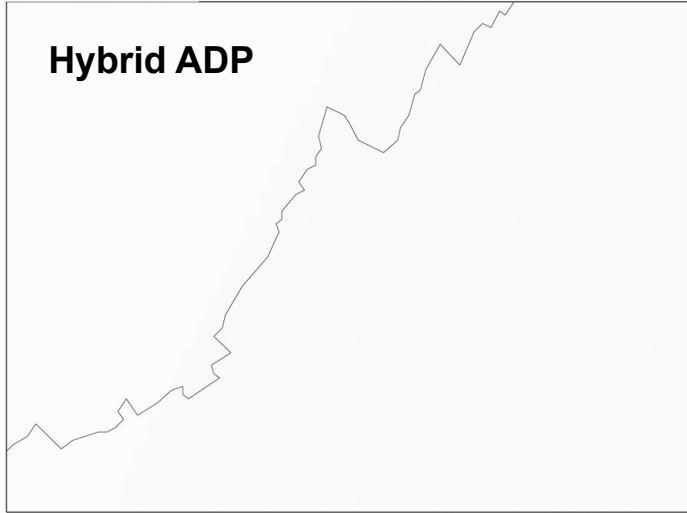
TEMPO+GOES 16

20231116T120414Z S001G03



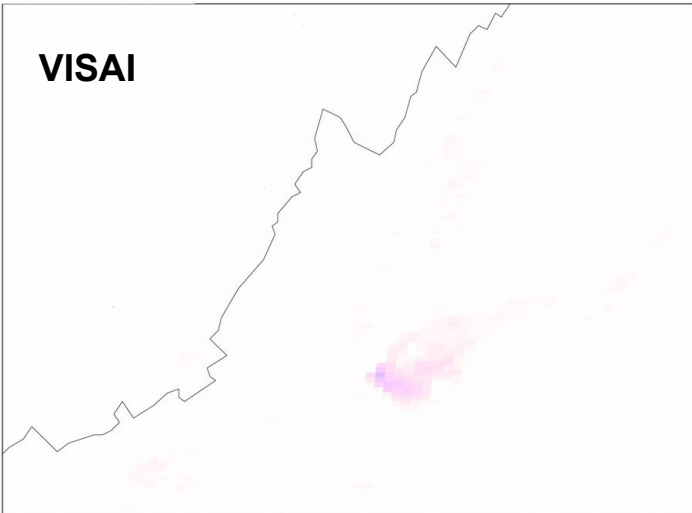
UV Absorbing Aerosol Index (354/388 nm)  
0 2 4 6 8

TEMPO\_ABI 20231116T120414Z S001G03



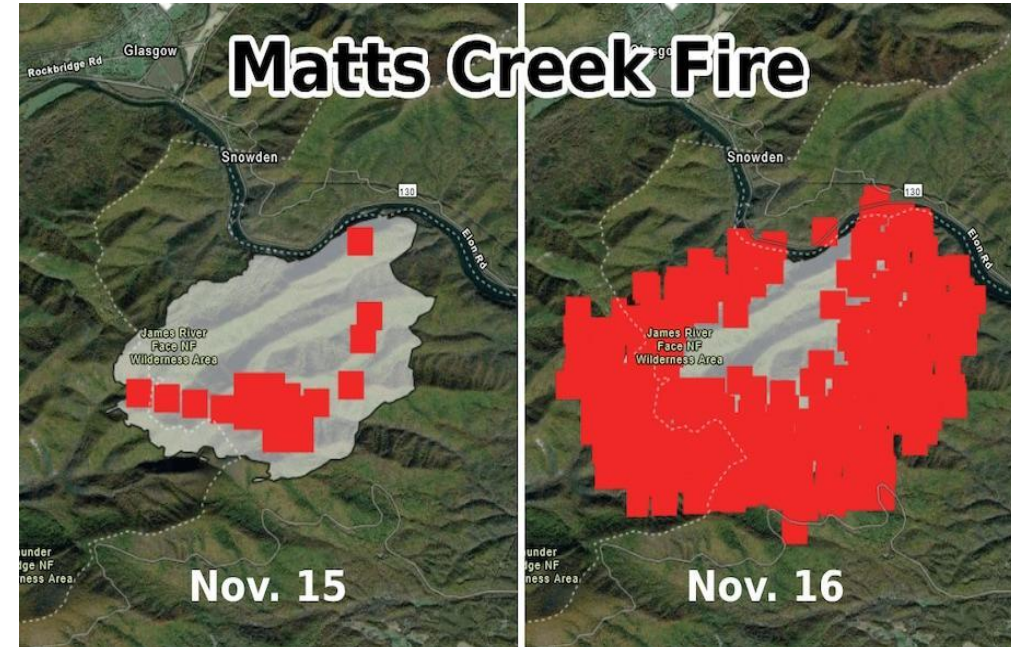
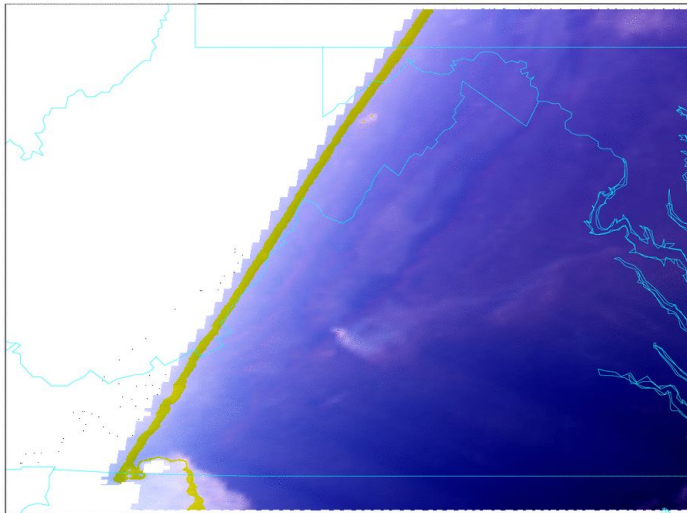
Dust Smoke  
High Med Low Low Med High

20231116T120414Z S001G03



Deep-blue Absorbing Aerosol Index (412/440 nm)  
0 2 4 6 8

20231116T120414Z S001G03



Washington Post: Matts Creek Fire activity. (NASA FIRMS)

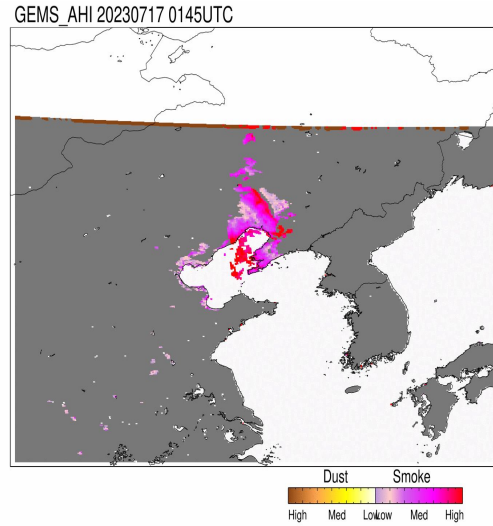
- The fire started on Nov 12 through Nov 22, with a total burned area of 11,000 acres, and degraded air quality.
- JPSS EPS ADP detected the smoke plume
- TEMPO+GOES16 hybrid ADP is able to capture the dynamic of smoke plumes very well with associated high UVAI and VISAI values.

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

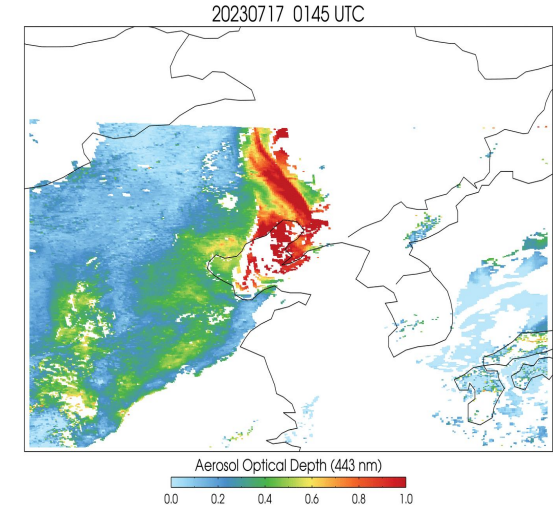


# Hybrid ADP Test Case: - Smoke intrusion from Siberia wildfires (July 17, 2023 04:45 UTC)

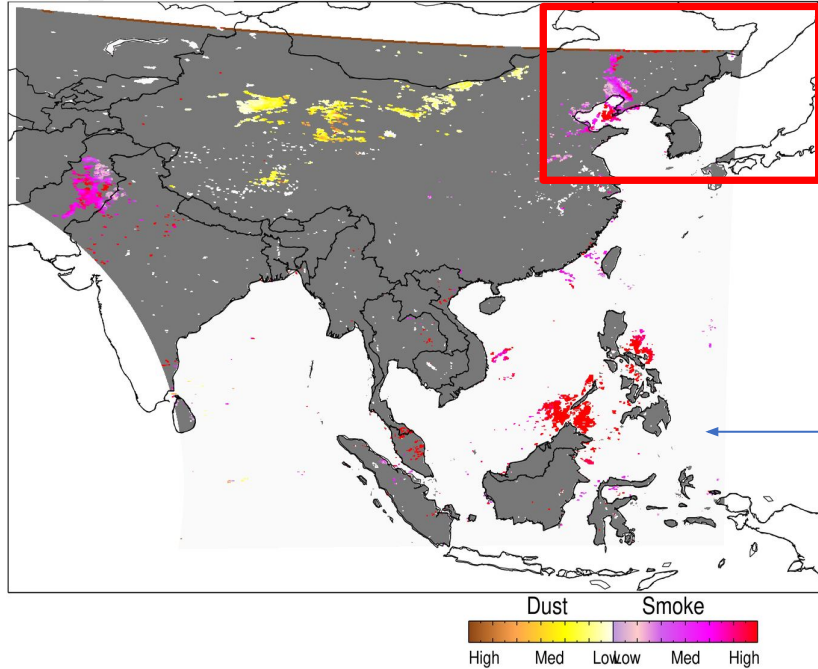
NOAA Hybrid ADP



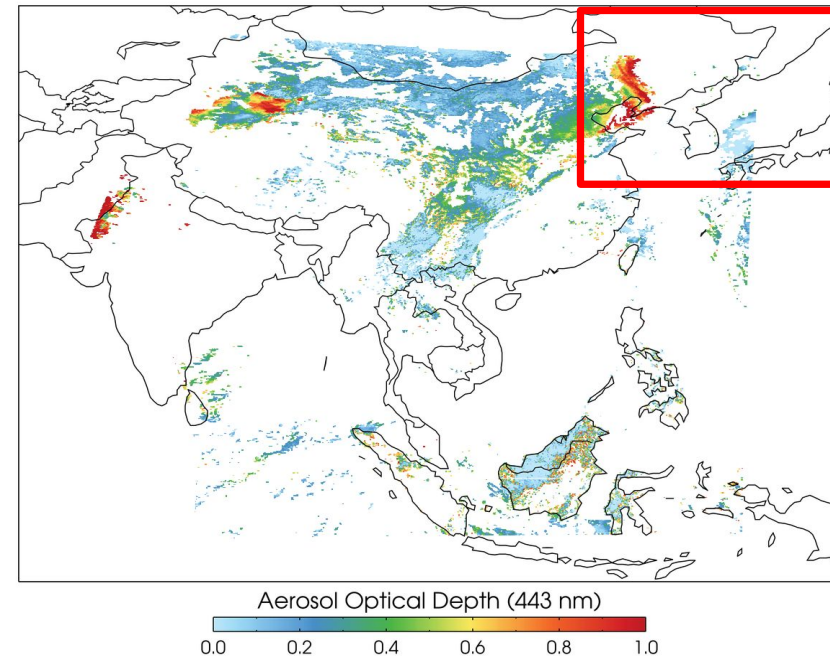
GEMS operational AOD  
( at 443 nm)



GEMS\_AHI 20230717 0445UTC



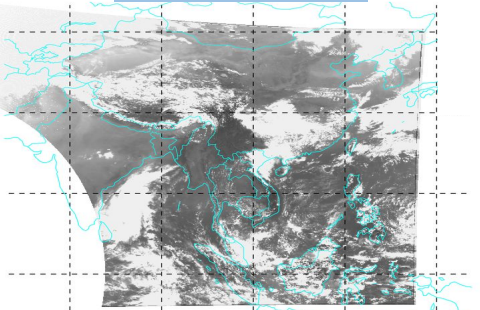
20230717 0445 UTC



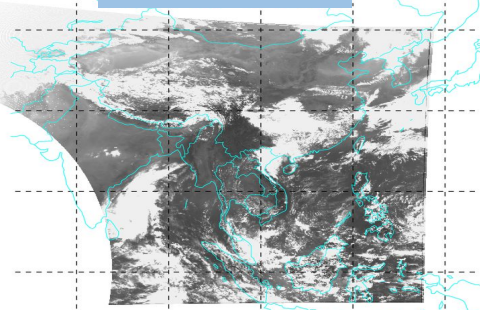
# GeoXO ACX/GXI Hybrid ADP Algorithm Tested Using GEMS and AHI Data

03/04/2022

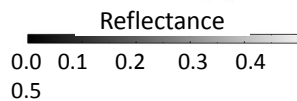
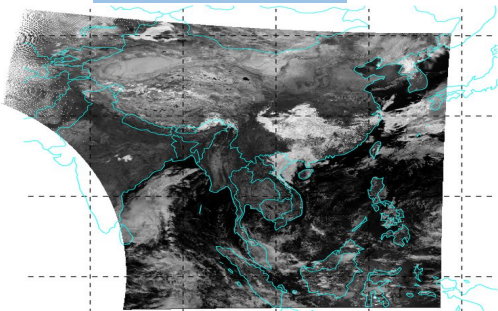
GEMS: 412 nm



GEMS: 440 nm

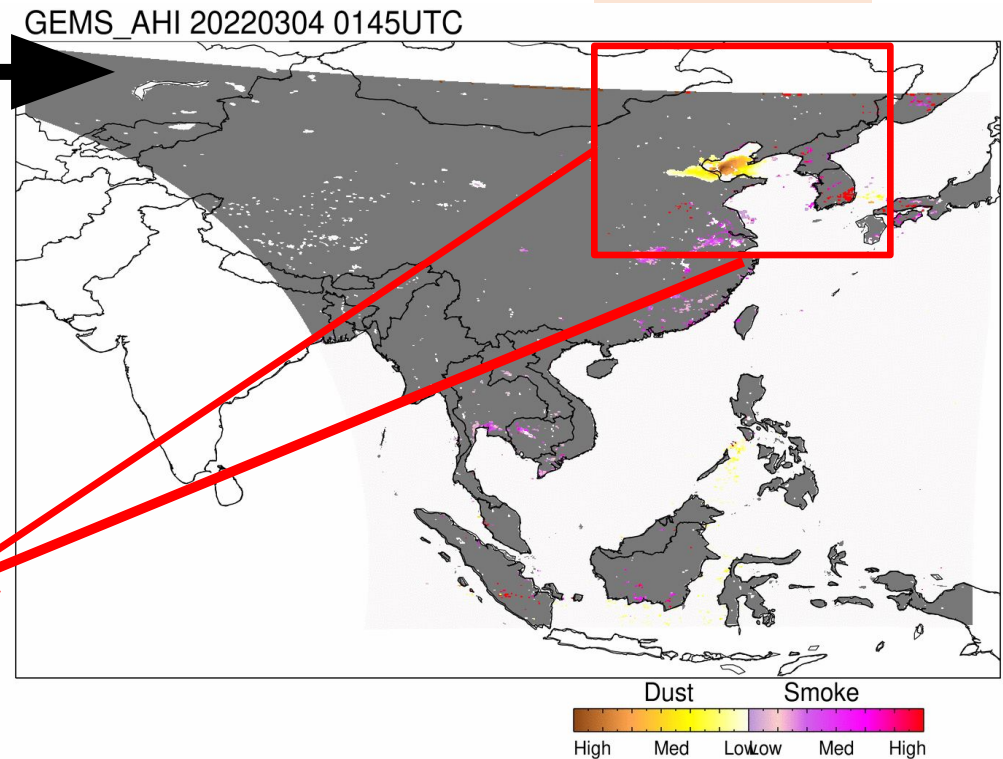
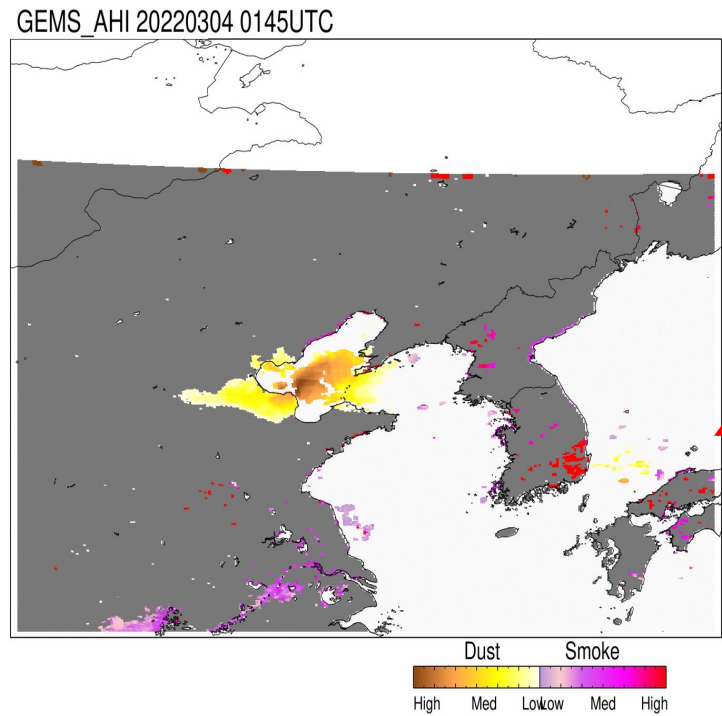


AHI: 2250 nm



**Absorbing Aerosol Index**  
 $AAI = -100[\log_{10}(R_{412}/R_{440}) - \log_{10}(R'_{412}/R'_{440})]$

**Dust Smoke Discrimination Index**  
 $DSDI = -10[\log_{10}(R_{412}/R_{2250})]$



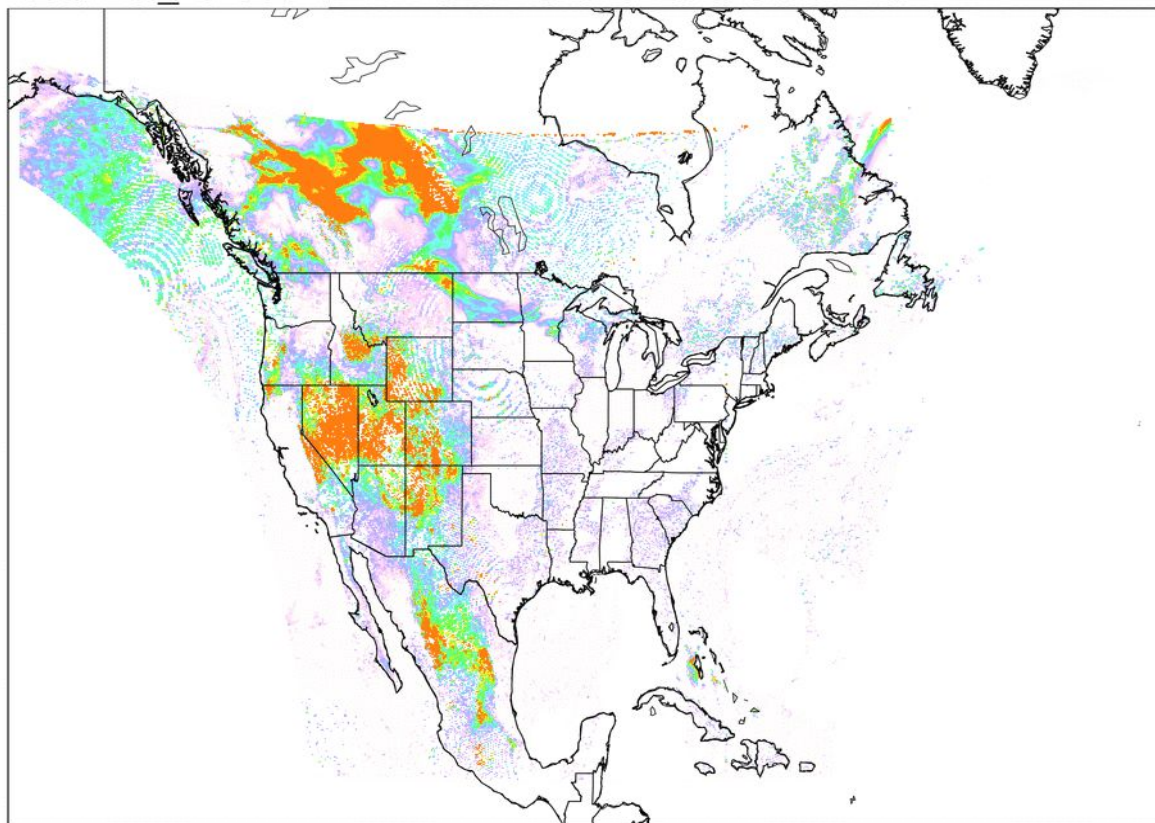


# TEMPO Hybrid ADP Example: Smoke plumes from Canadian Forest Fires (08/30/2023)



Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

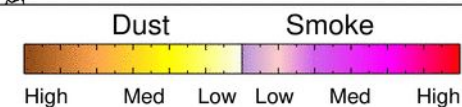
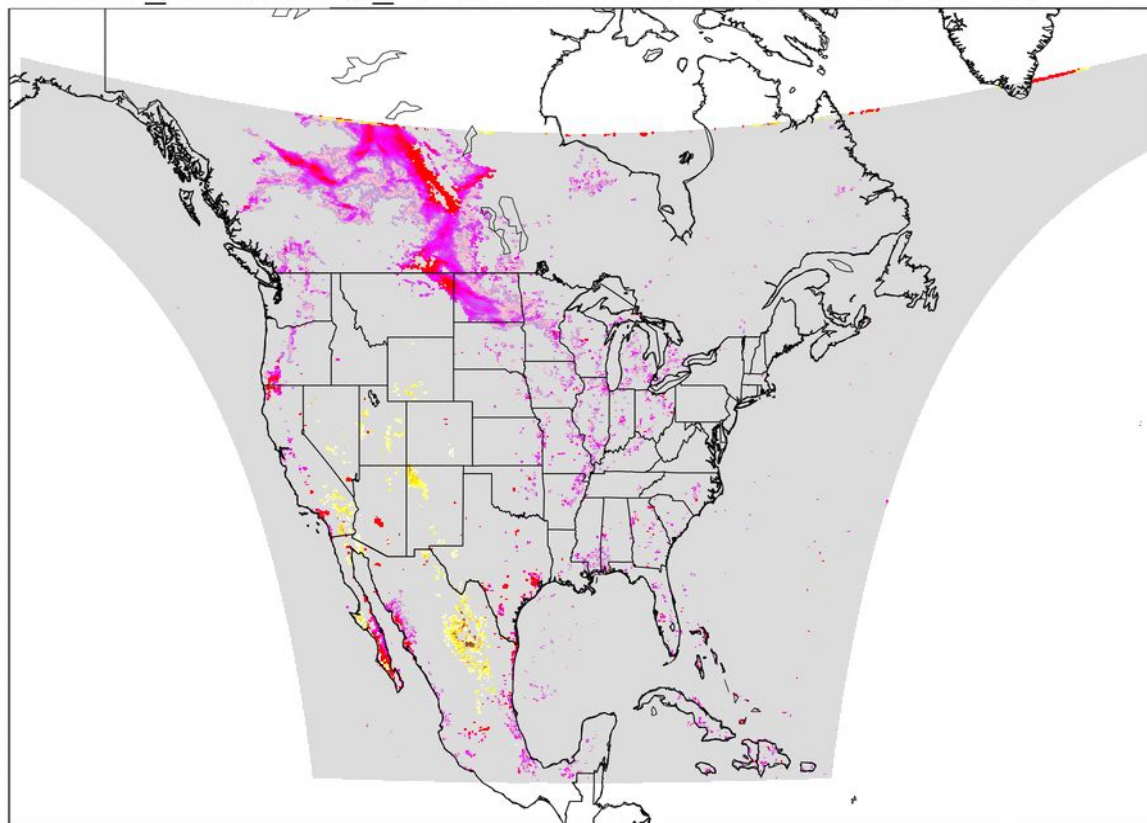
Scan:10\_20230828-T172319-181916Z Granule:01-10



UV Absorbing Aerosol Index (354/388 nm)



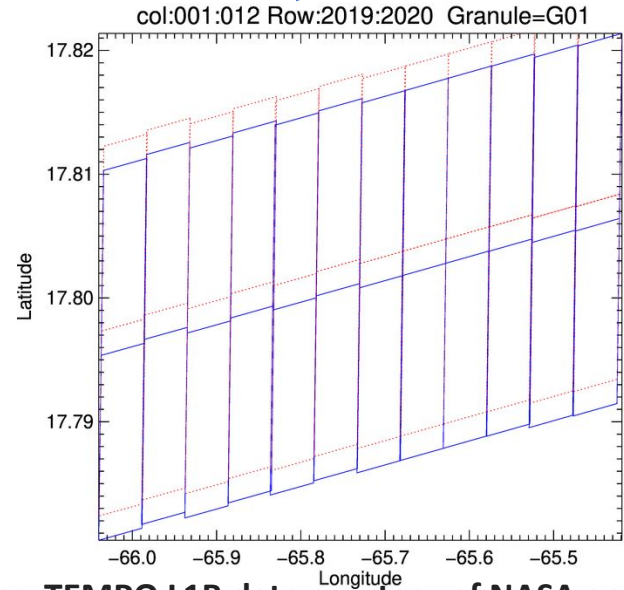
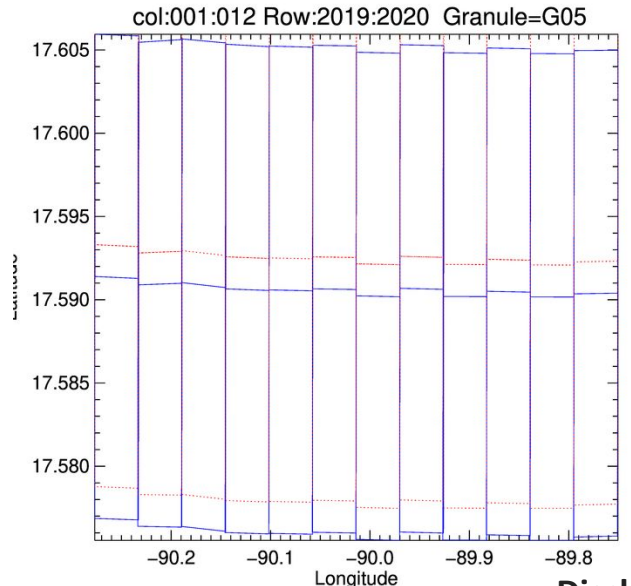
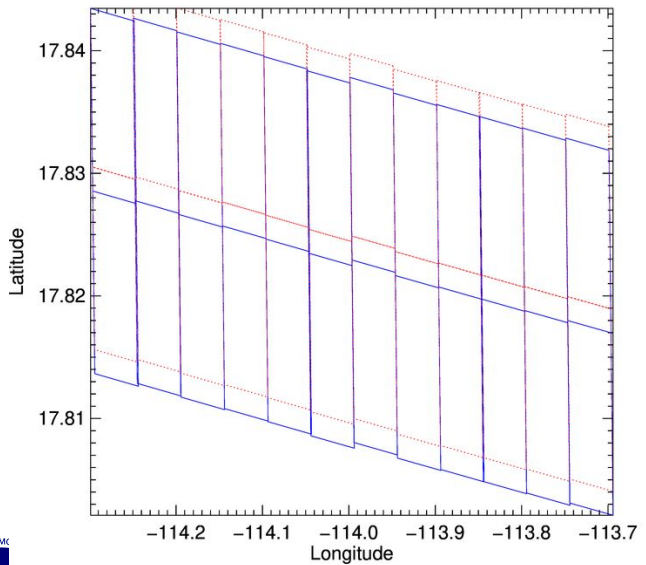
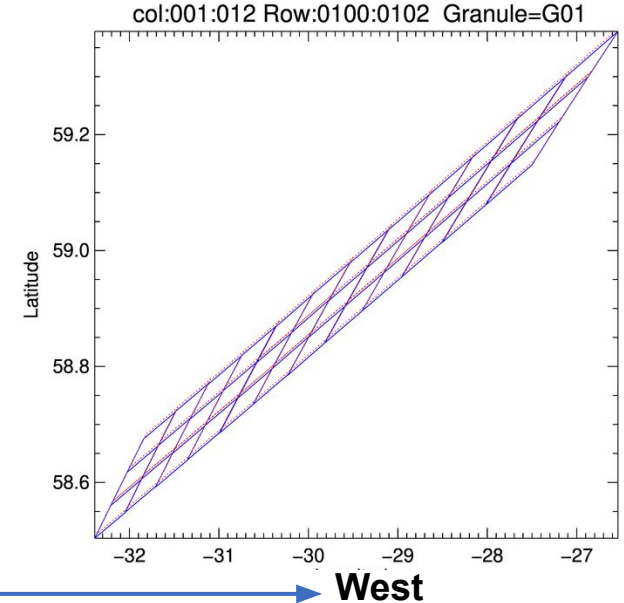
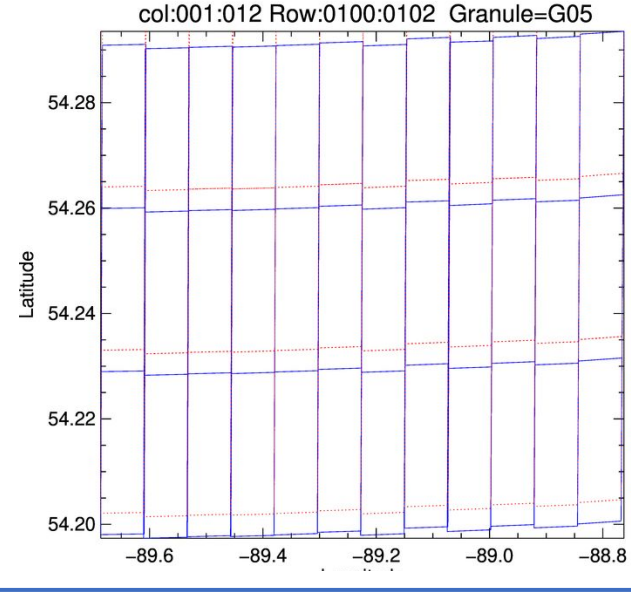
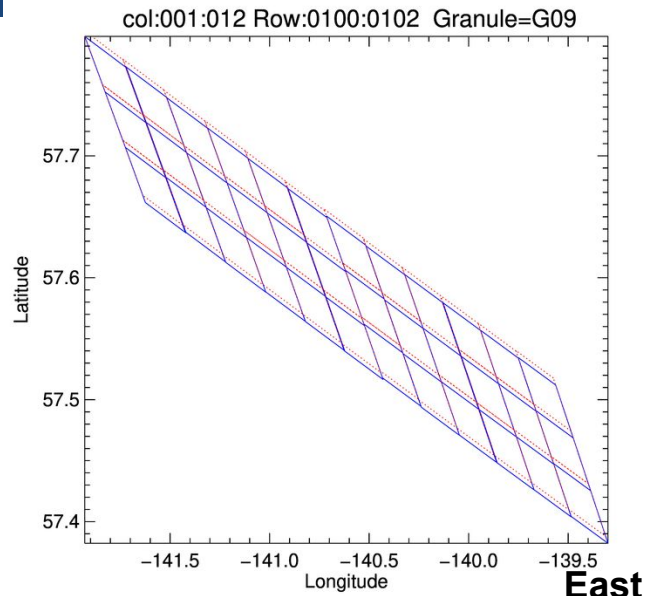
TEMPO\_ABI Scan:10\_20230828-T172319-181916Z Granule:01-10



- TEMPO ADP captures the development of smoke plumes from the forest fire.
- Residual cloud contaminations are still seen as shown in slightly noisy smoke mask.
- High values of UV AI are seen over bright surface at certain time steps, mostly due to surface BRDF effect
- DLER developed for AOD retrieval will be applied to reduce the impact of surface BRDF.



# Co-registration Tables for ABI UV Band to Vis Band



Vis Band

---

UV Band

---

Disclaimer: TEMPO L1B data courtesy of NASA and all results are preliminary.

- A small north to south shift is seen between TEMPO UV and Visible band.