

# TEMPO Aerosol Optical Centroid Height (AOCH) Algorithm and Synergy with ABI/GOES-R

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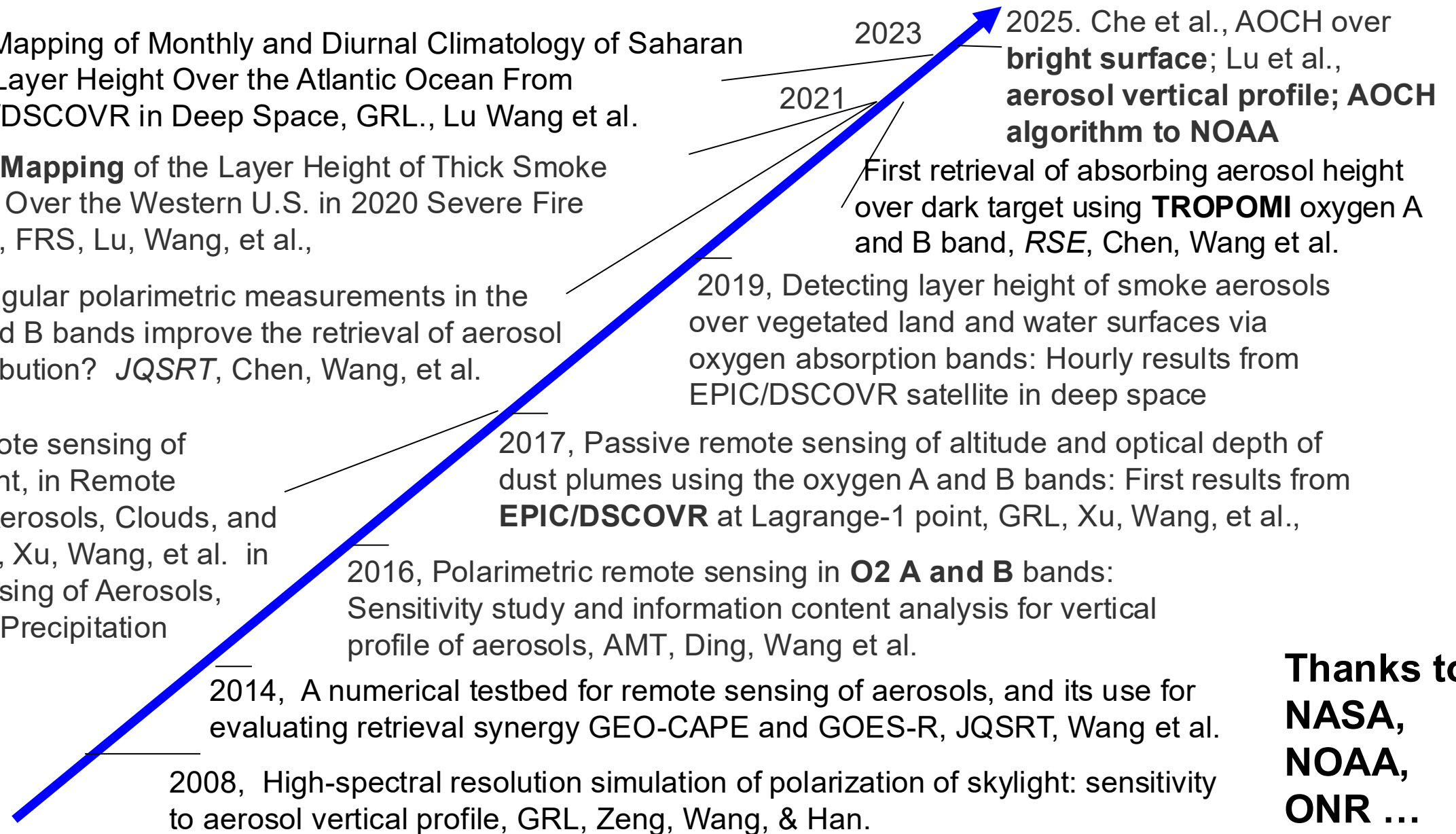
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*June 15, 2026, TEMPO DART Team meeting, Iowa City*



# 17-year journey of passive sensing of aerosol layer height



**Thanks to  
NASA,  
NOAA,  
ONR ...**

# New version of EPIC-AOCH algorithm with surface constraint

## Support operational TEMPO-AOCH product

### 1. Surface reflectance BRDF ( $R_s$ ):

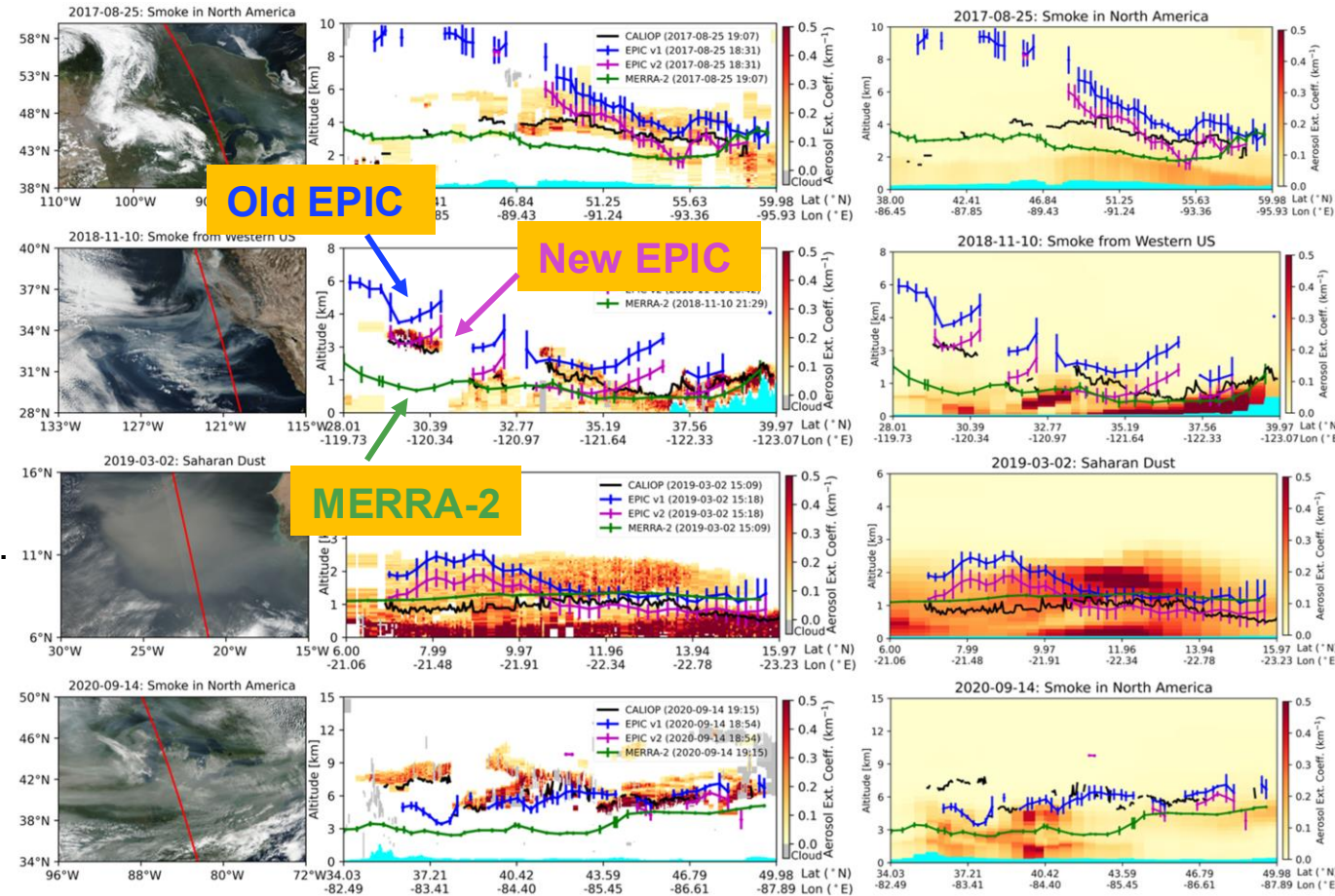
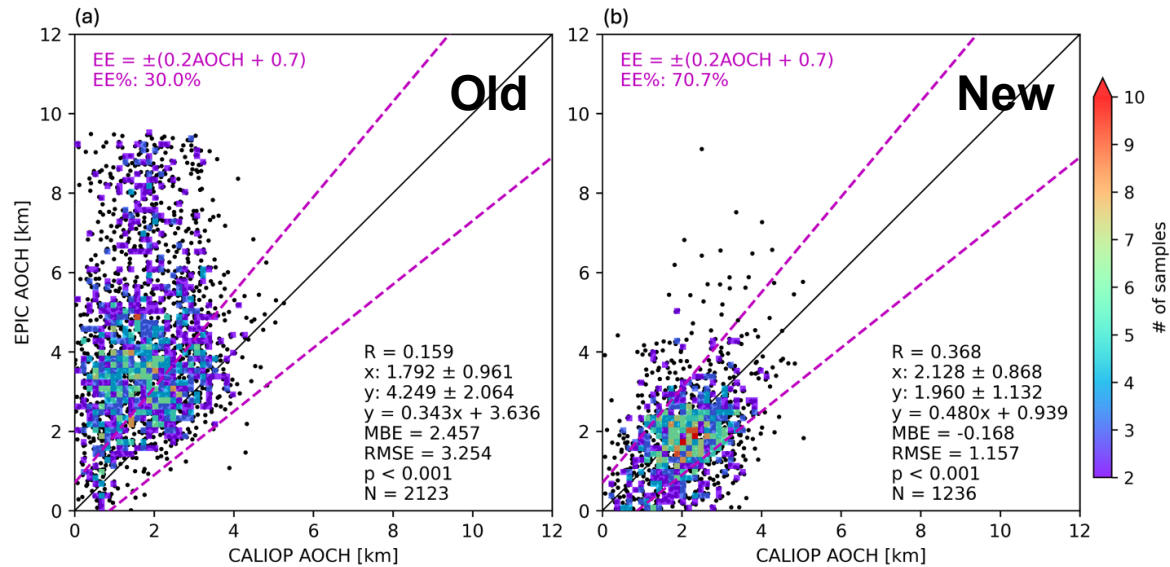
Optimal AOD and  $R_s$  minimizes cost functions at both 443 nm and 680 nm ( $k^{680} = \frac{R_s^{443}}{R_s^{680}}$ )

### 2. Climatology of surface reflectance ratio between 443 nm and 680 nm:

0.5°×0.5° seasonal data from 2020-2022 EPIC observations

### Validation with CALIOP AOCH:

The overestimation of old EPIC AOCH product is improved.



### Poster #23:

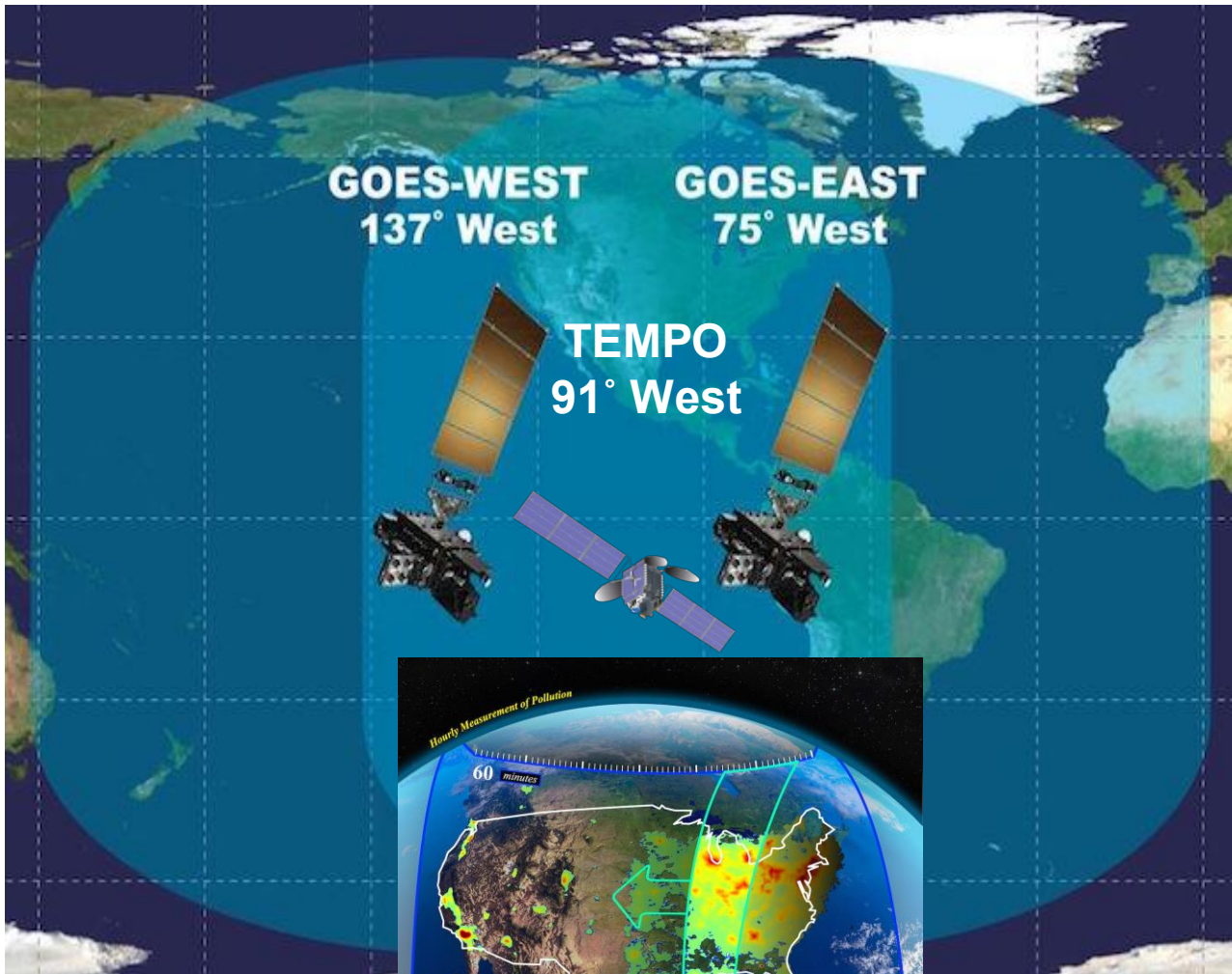
Retrieval of Aerosol Optical Centroid Height (AOCH) using TEMPO Oxygen B Band: Algorithm Development and Preliminary Results

*Lu et al. (2026), RSE, in review*

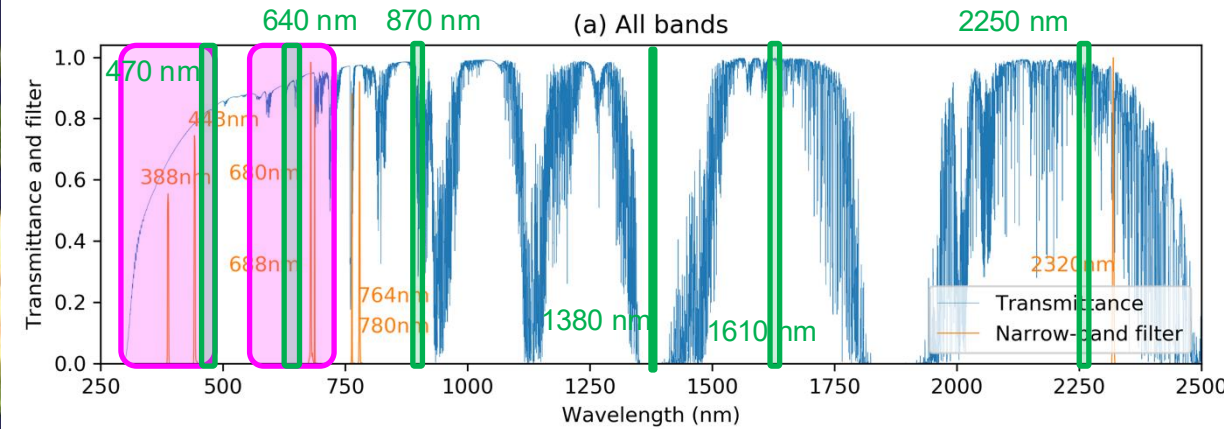
**Inderjeet Singh**

# Extend TEMPO capability: ABI/GOES-R

## TEMPO + GOES-R: Viewing from different angles and channels



### TEMPO: UV and VIS spectrometer



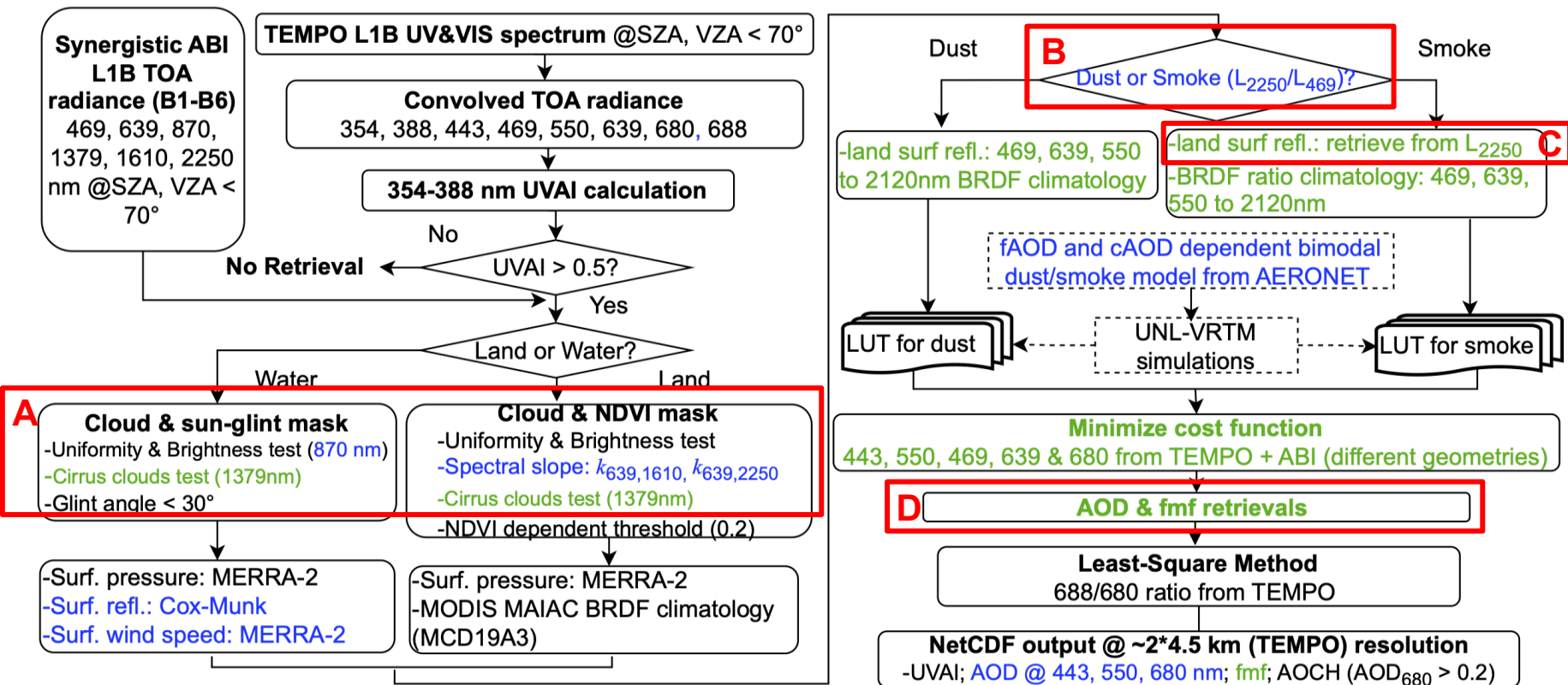
### GOES-West and GOES-East: ABI *(Jim Carr et al.)*

ABI Band (nm)	Native ABI Resolution (km)	Nesting within TEMPO Pixel Numbers (EW x NS)	Purpose
470	1	6 × 2	Aerosol, Cloud
640	0.5	12 × 4	
870	1	6 × 2	Vegetation
1380	2	3 × 1	Cirrus
1610	1	6 × 2	Snow/Ice
2250	2	3 × 1	Surface, Cloud

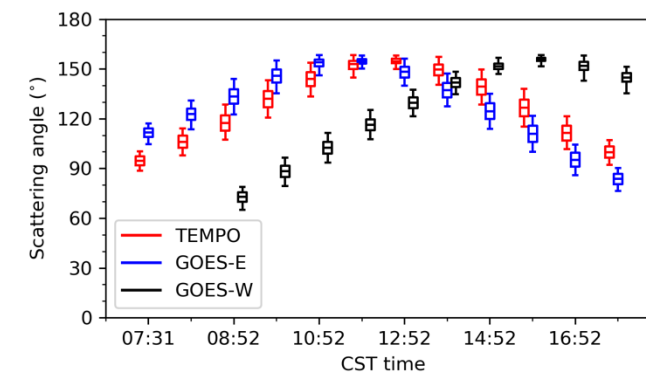
# Synergistic TEMPO and ABI measurements

## Multi-channel and multi-angle measurements help AOD and AODCH retrieval

### Flowchart for aerosol retrievals:



### Different scattering angles:



D. Potential to retrieve more information (e.g. fmf) of aerosols besides AOD and AODCH using multi-angle multi-channel measurements.

A. Include more NIR channels to improve cloud mask.

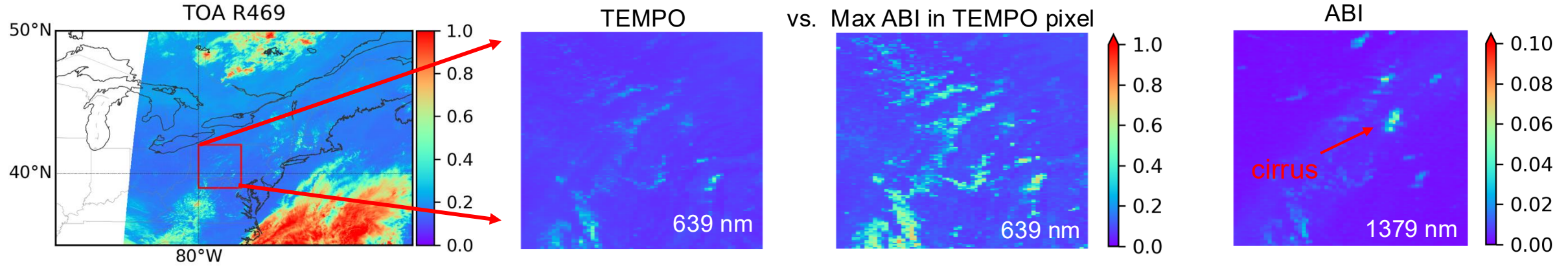
B. Help classify dust and smoke aerosols using the ratio between 2250 nm and 469 nm.

C. Improve surface reflectance simultaneous retrieval using NIR.

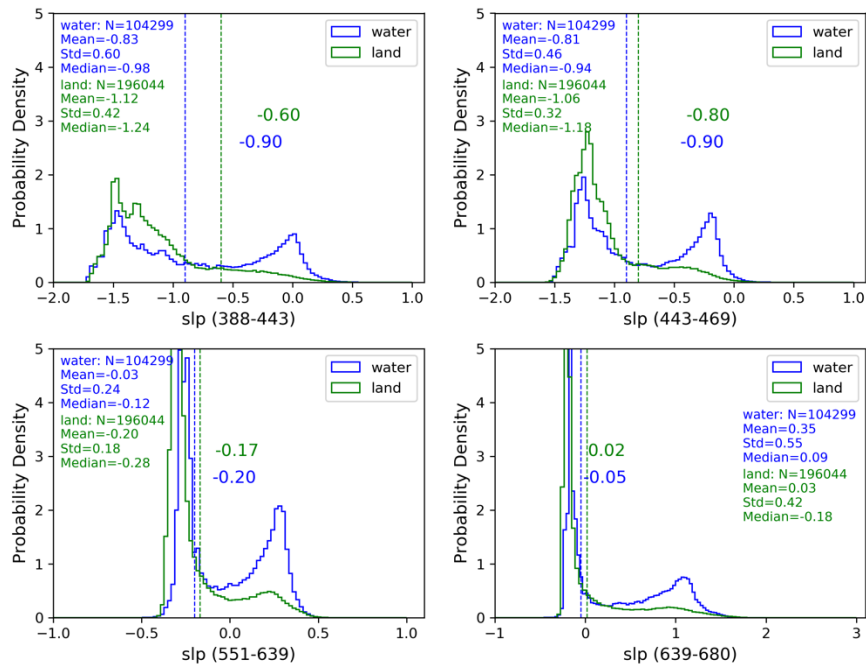
# Cloud screening combining TEMPO and ABI channels

## High resolution ABI channels help identify subpixel clouds

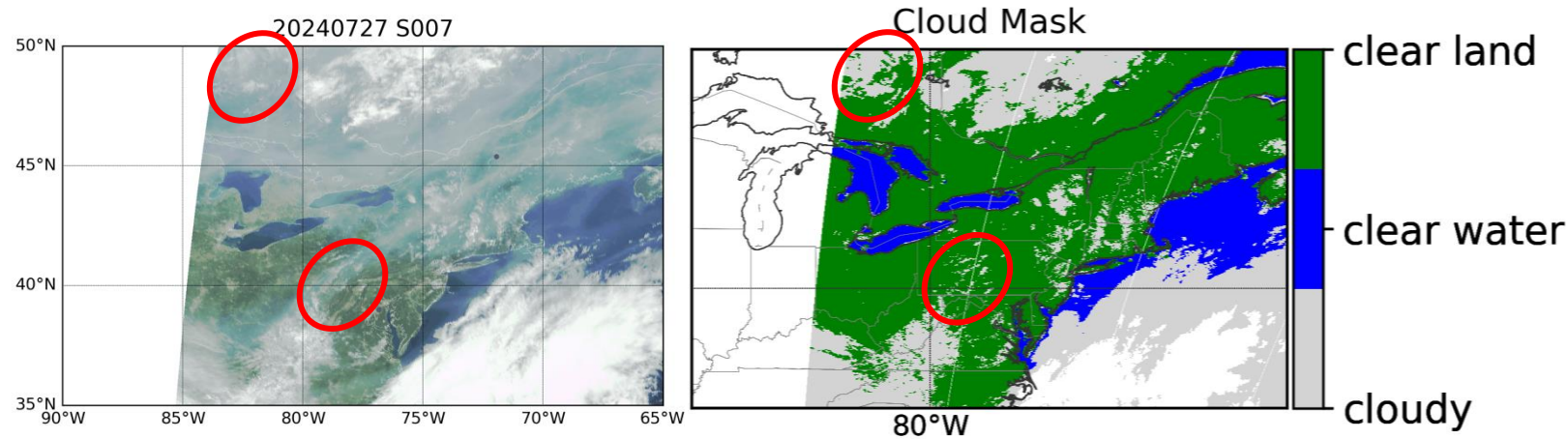
- Reflectance tests (TEMPO + ABI):**



- TEMPO spectral slopes:**



- Cloud mask results:**



- High spatial resolution of ABI VIS channels (0.5-2 km) help identify subpixel clouds. Spectral slopes and additional NIR bands of ABI improve the classification of clouds (including cirrus) and smoke plume.

# Simultaneous surface BRDF retrieval from ABI

Assume the signal at 2250 nm is from surface only under cloud-free conditions

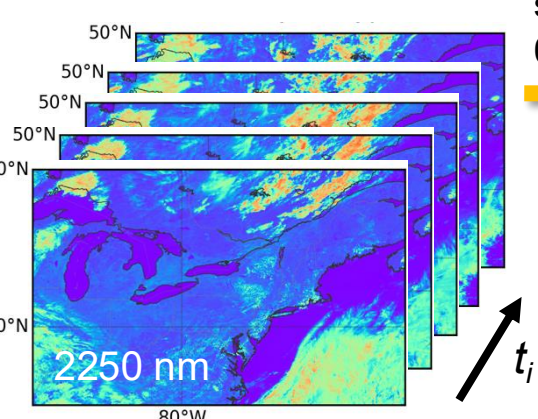
• **BRDF model:**

$$R_s(\theta_0, \theta_v, \varphi, \lambda) = K_{iso}(\lambda) + K_{vol}(\lambda) f_{vol}(\theta_0, \theta_v, \varphi) + K_{geo}(\lambda) f_{geo}(\theta_0, \theta_v, \varphi)$$

$\theta_0$  : solar zenith angle     $\theta_v$  : viewing zenith angle  
 $\varphi$  : relative azimuth angle     $\lambda$  : wavelength

• **Retrieval process:**

Multiple scenes during each day ( $t_i$ )



Mask water surface ( $R > 0.12, n_t < 5$ )

$R_{TOA,i}(2250)$   
at cloud free  
land pixels

**Assumptions:**

1. At 2250 nm,  $R_{TOA,i} = R_{s,i}$
2.  $K_{iso}, K_{vol}, K_{geo}$  won't change within each day

$$R_{s,1}(\theta_{0,1}, \theta_{v,1}, \varphi_1, 2250)$$

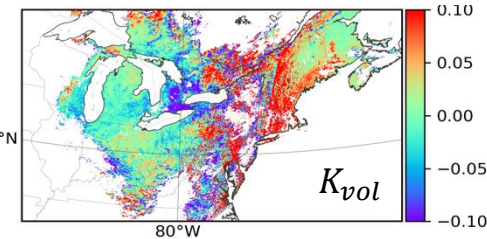
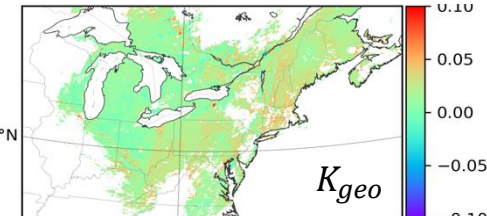
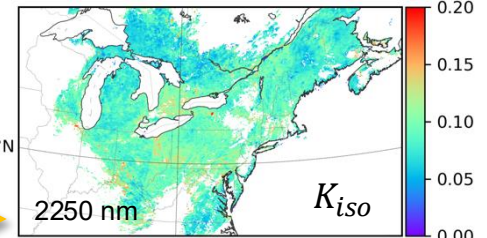
$$R_{s,2}(\theta_{0,2}, \theta_{v,2}, \varphi_2, 2250)$$

$$R_{s,3}(\theta_{0,3}, \theta_{v,3}, \varphi_3, 2250)$$

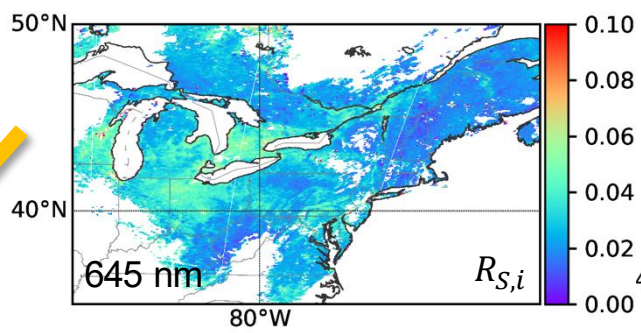
...

$$R_{s,i}(\theta_{0,i}, \theta_{v,i}, \varphi_i, 2250) \quad (i \geq 5)$$

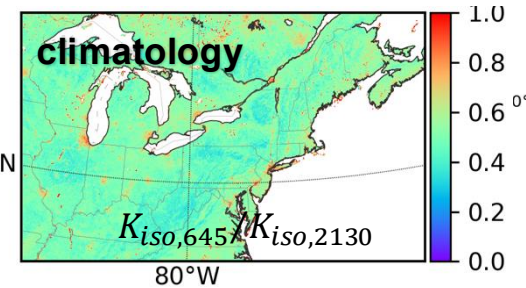
Optimization  
(least square)



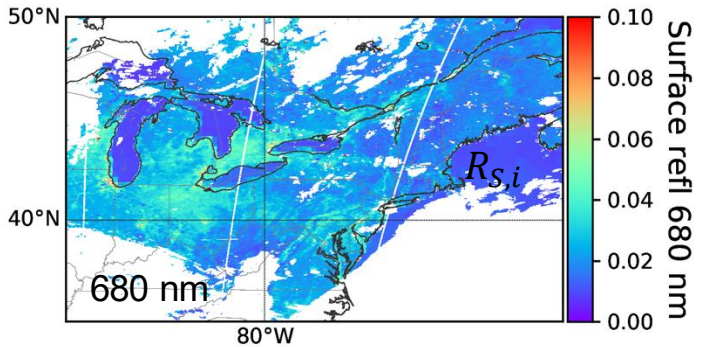
NDVI  
dependent  
linear  
regression



TEMPO  $\theta_{0,i}, \theta_{v,i}, \varphi_i$



MDOIS MAIAC



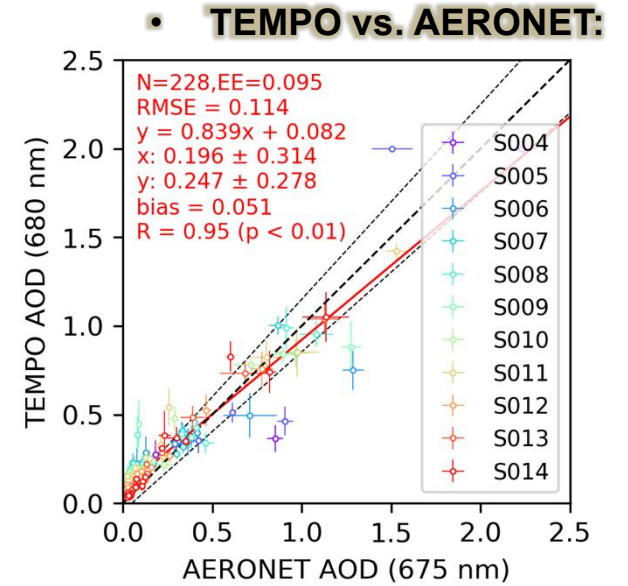
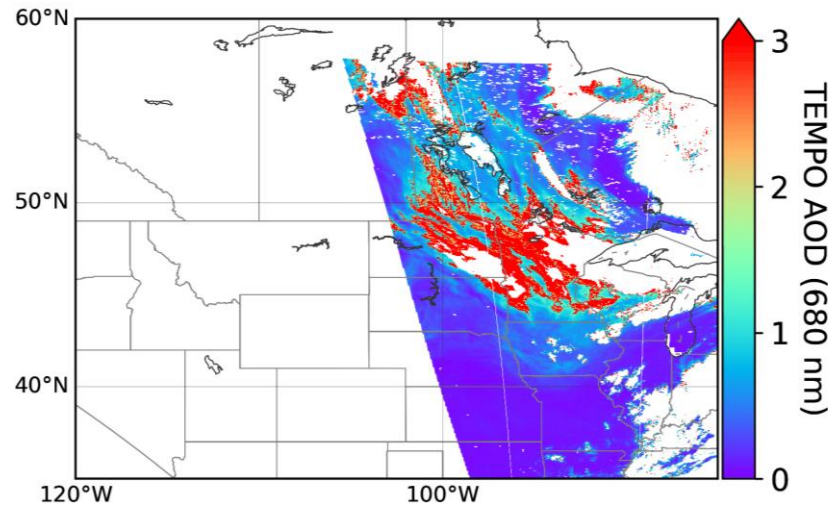
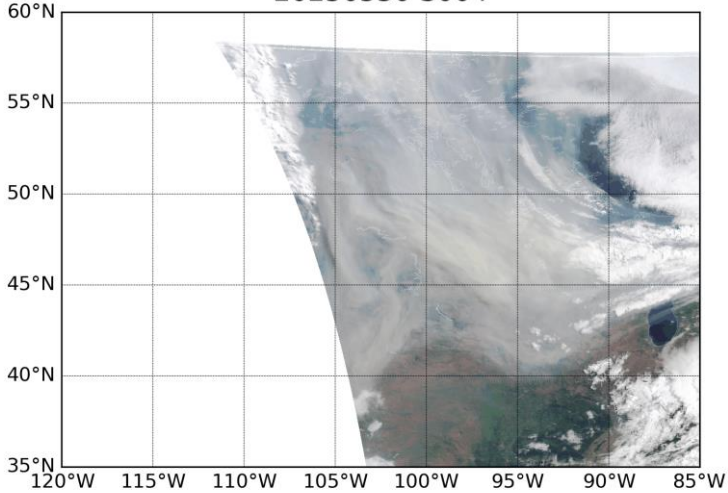
(Xu, X. et al. AMT, 2019; Chen X. et al., RSE, 2021)

AOD & AOCCH retrieval

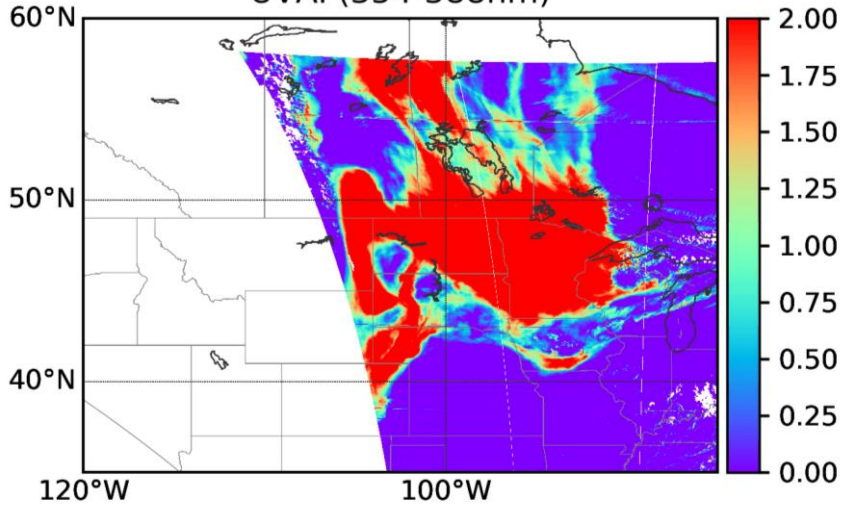
# AOD and AODCH retrieval for smoke plume

## TEMPO UV, VIS, O<sub>2</sub> B band + ABI NIR band

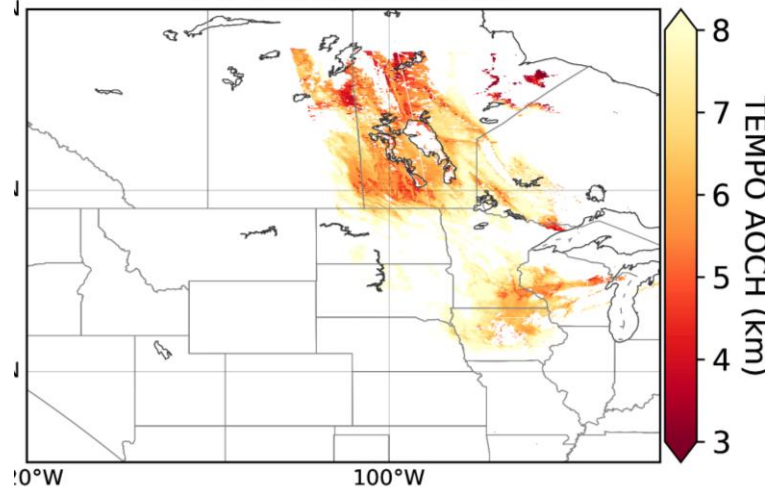
20250530 S004



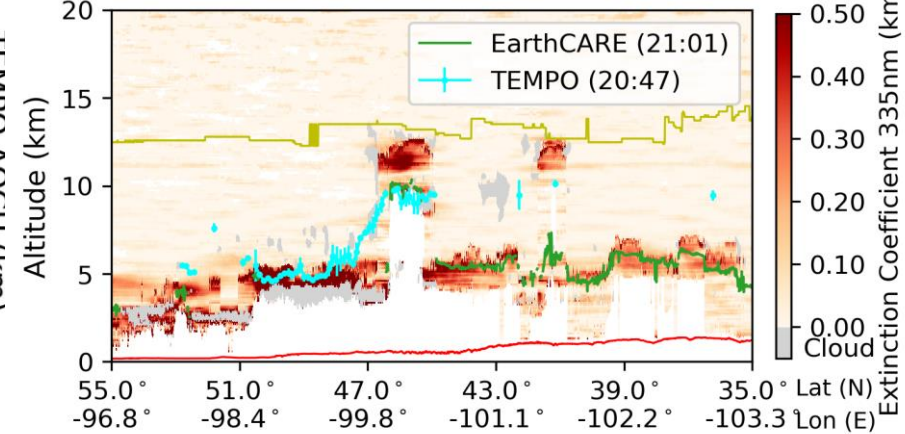
UVAI (354-388nm)



TEMPO 20250530 13:07



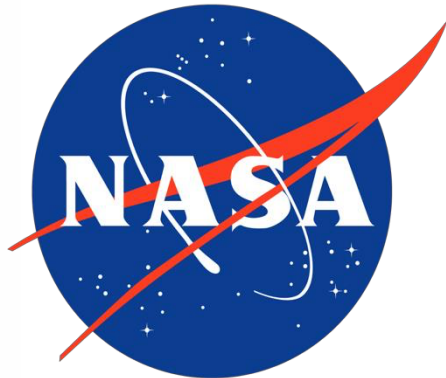
• **TEMPO vs. ATLID/EarthCARE:**  
2025/05/30



- AOD retrieval is highly correlated with AERONET ( $R > 0.9$ ) but overestimated with small bias ( $\sim 0.05$ ).
- AODCH retrieval is comparable with ATLID/EarthCARE.

# Conclusions

- An improved EPIC AOCH algorithm with more surface constraints is being used for retrieving AOD and AOCH from TEMPO (in collaboration with SAO).
- Combining TEMPO UV-VIS including O<sub>2</sub> B bands with synergistic ABI NIR band from GOES-R helps classify cloudy pixels and retrieve surface reflectance simultaneously in aerosol retrieval.
- Preliminary results of TEMPO-ABI AOD and AOCH retrievals are robust. Compared with AERONET, AOD shows the strong correlation ( $R > 0.9$ ), but is slightly overestimated. TEMPO-ABI AOCH retrieval is comparable with ATLID/EarthCARE.
- Further improvement and development of this TEMPO-ABI AOCH algorithm, as well as the its test/fusion of Version 4 TEMPO data are still ongoing. More information about aerosol model will be expected.



## Acknowledgements

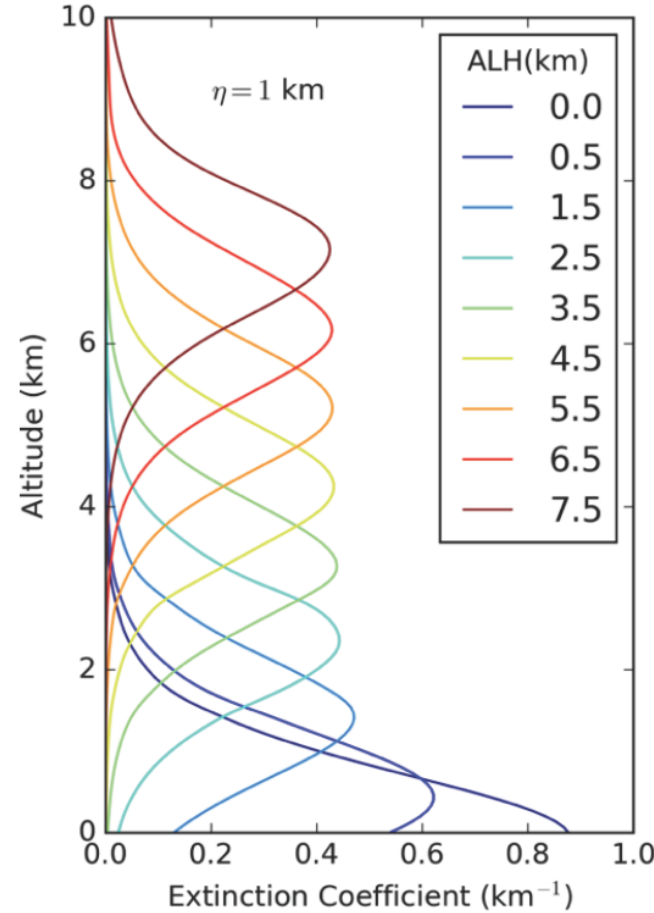
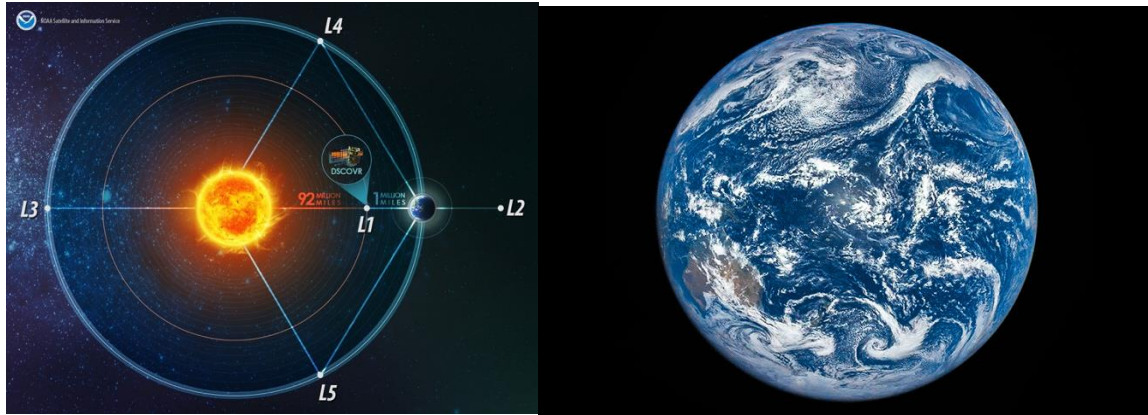
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Jun Wang ([jun-wang-1@uiowa.edu](mailto:jun-wang-1@uiowa.edu))

**Backup**

# Previous work: AOCH retrieval from O<sub>2</sub> absorption band

EPIC/DSCOVR at Lagrange-1 orbit

quasi-Gaussian distribution



$$\tau_A(z) = C \frac{\exp(-h|z-H_{\text{peak}}|)}{[1+\exp(-h|z-H_{\text{peak}}|)]^2}$$

$$\eta = \frac{\ln(3+\sqrt{8})}{h}$$

- Xu et al. (2017), Geophys. Res. Lett.
- Xu et al. (2019), Atmos. Meas. Tech.
- Chen et al. (2021), Remote Sens. Environ
- Lu et al. (2021) Frontier RS.
- Lu et al. (2023), Geophys. Res. Lett
- Kim et al. (2025), AMT

