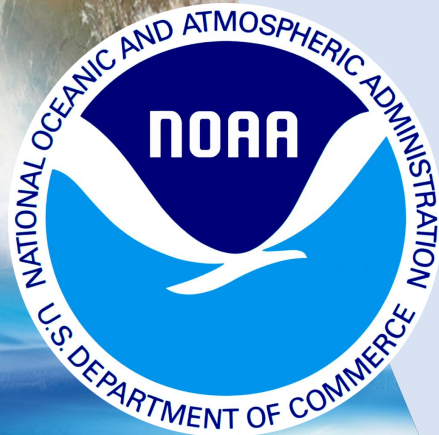# GeoXO ACX Aerosol Optical Depth and Layer Height Algorithm Development

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1. IMSG at NOAA; 2. NOAA

NOAA
National Satellite and Information Service
Center for Satellite Applications and Research

GeoXO ACX Science Team Meeting 2024
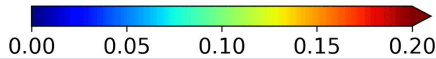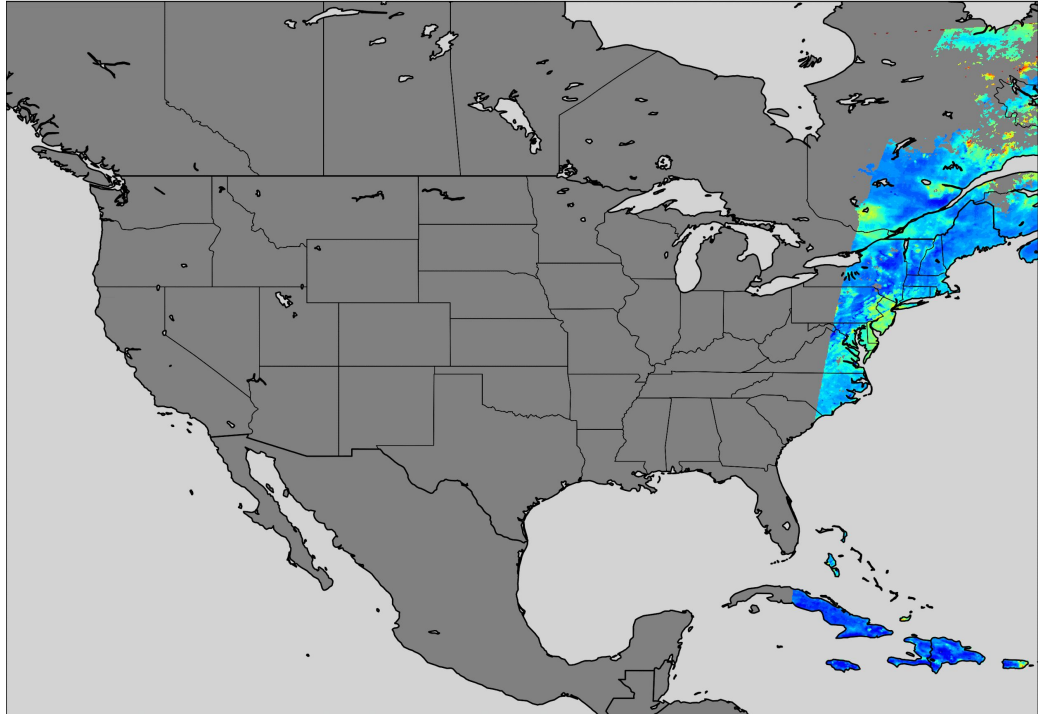May 8, 2024

Disclaimer : TEMPO L1B data courtesy of NASA and all results are preliminary.
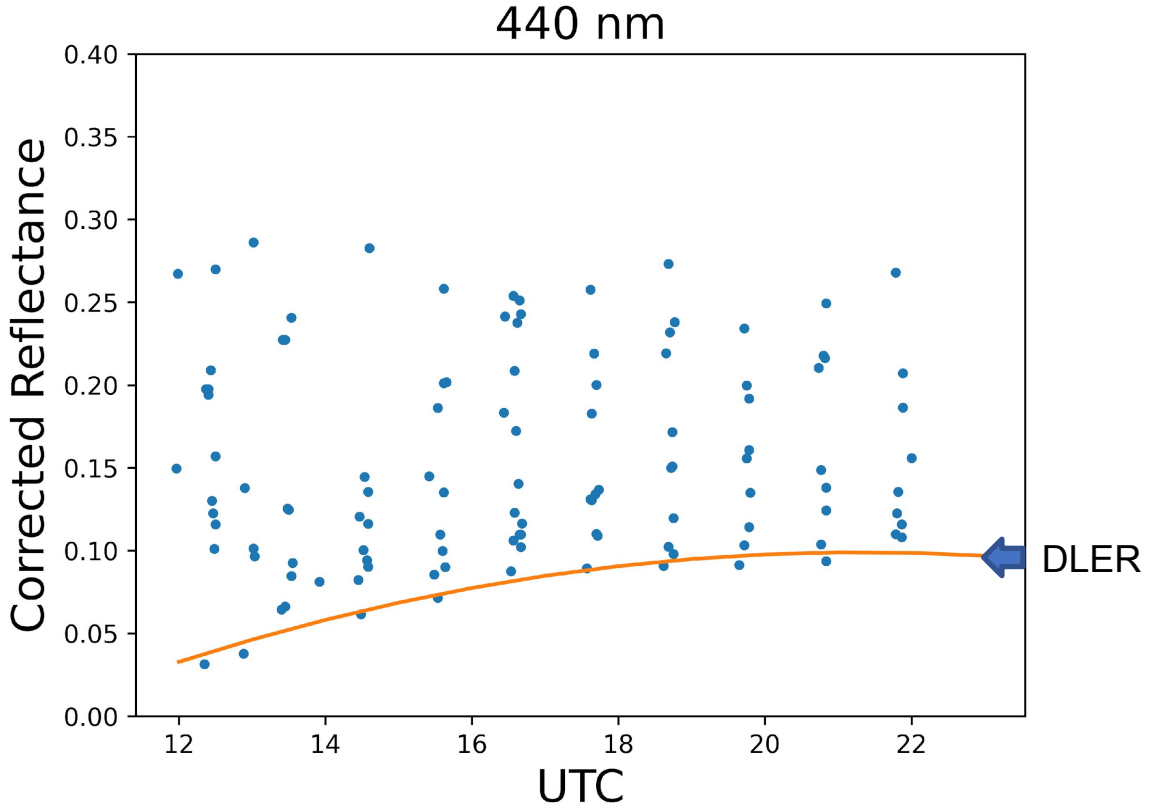
Aerosol Retrieval Algorithm Development

- The algorithm retrieves AOD and ALH
  - Adapt AOD retrieval algorithm from VIIRS and ABI
  - Adapt ALH retrieval algorithm using O_2 bands by Chen et al. 2021

- Spectral selection
  - Hyperspectral measurements are convolved to the bands 354, 388, 416, 440, 494, 670, 687.75 nm using a triangle function

- Look-up Table (LUT) generation
  - TOA reflectance of the bands for different AOD, ALH, surface reflectance, surface pressure, and Sun-satellite geometry
  - Smoke, dust, generic aerosol models
  - UNL-VRTM

- Directional Lambertian Equivalent Reflectivity (DLER) Database
  - Regridded into fixed grid (0.1 degree for TROPOMI and 0.05 degree for TEMPO)
  - Atmospheric correction using 0.025 background AOD (from AERONET analysis)
  - Generate lower bound using historical data
  - $A_{DLER} = A_{LER} + c_0 + c_1\theta_v + c_2\theta_v^2 + c_3\theta_v^3$ for TROPOMI; Hourly DLER for TEMPO

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

Example TEMPO DLER at 440 nm animation (August, 2023)

The pixel at GSFC

**TEMPO DLER 440 nm 12 UTC**

- Regridded into 0.05 degree spatial resolution
- Data binned into 1-hr bin and lowest atmospheric corrected reflectance at 440 nm is selected
- Derived from 25 days of L1b data in August
- DLER for the other bands are also obtained (354, 388, 416, 494, 670, 688 nm)
- Similar approach was used to obtain VIIRS surface reflectance for bright surface (Zhang et al. JGR,2016)
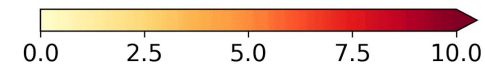
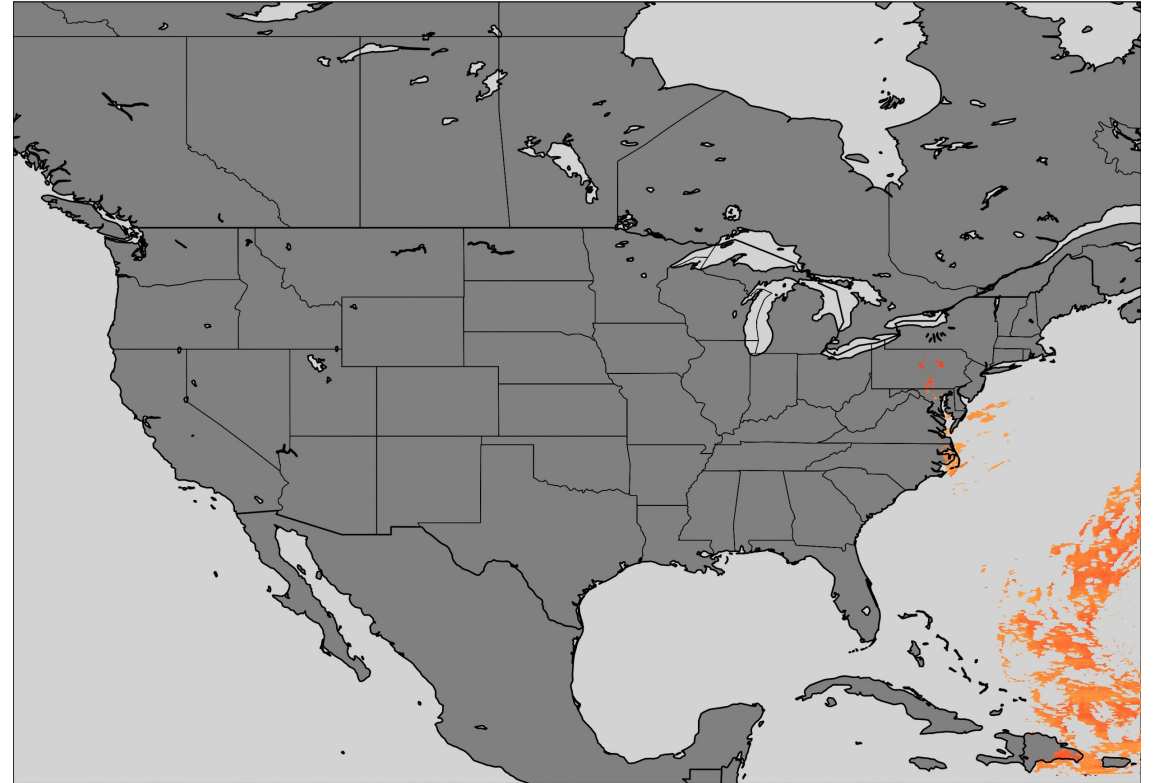Disclaimer：TEMPO L1B data courtesy of NASA and all results are preliminary.
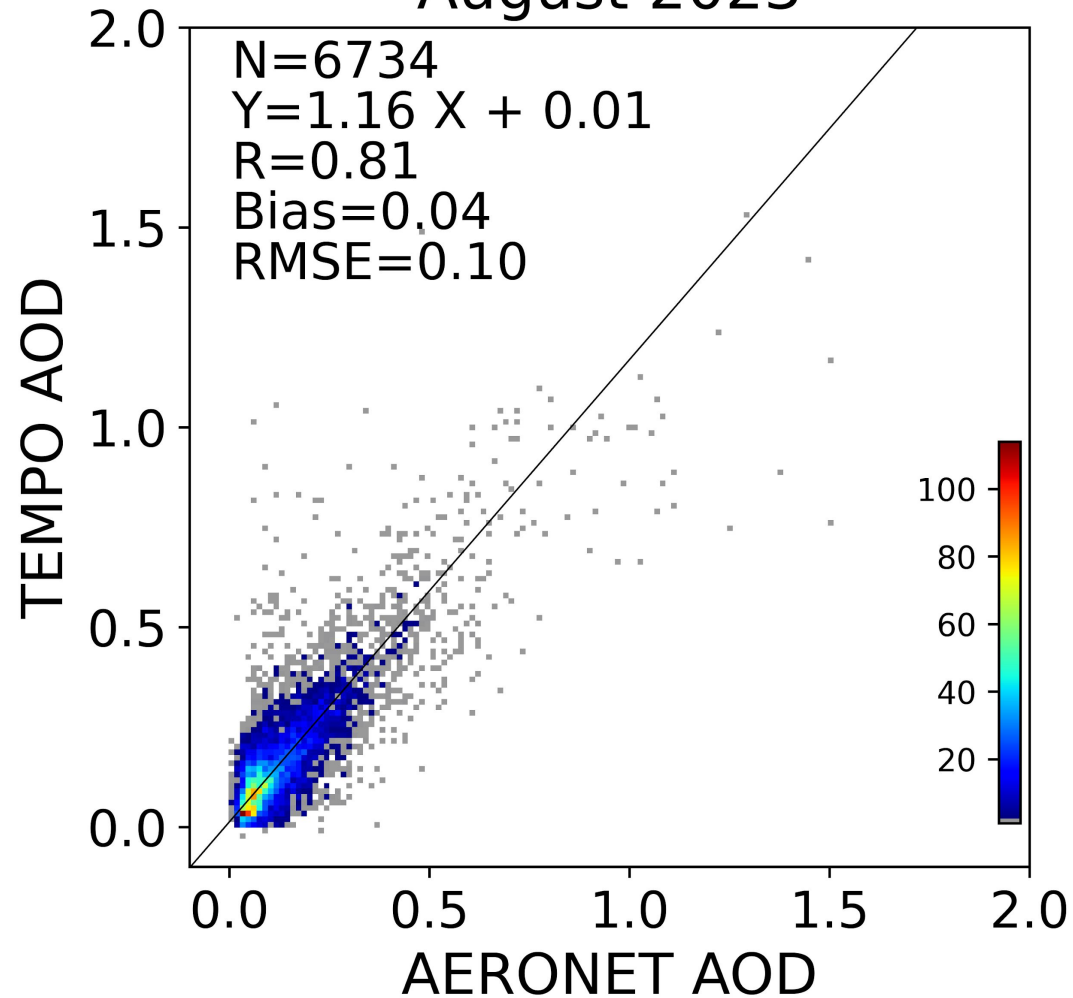
Example TEMPO retrieval August 19, 2023

TEMPO AOD 20230819 1115UTC
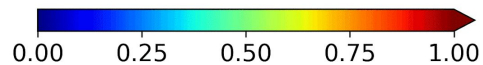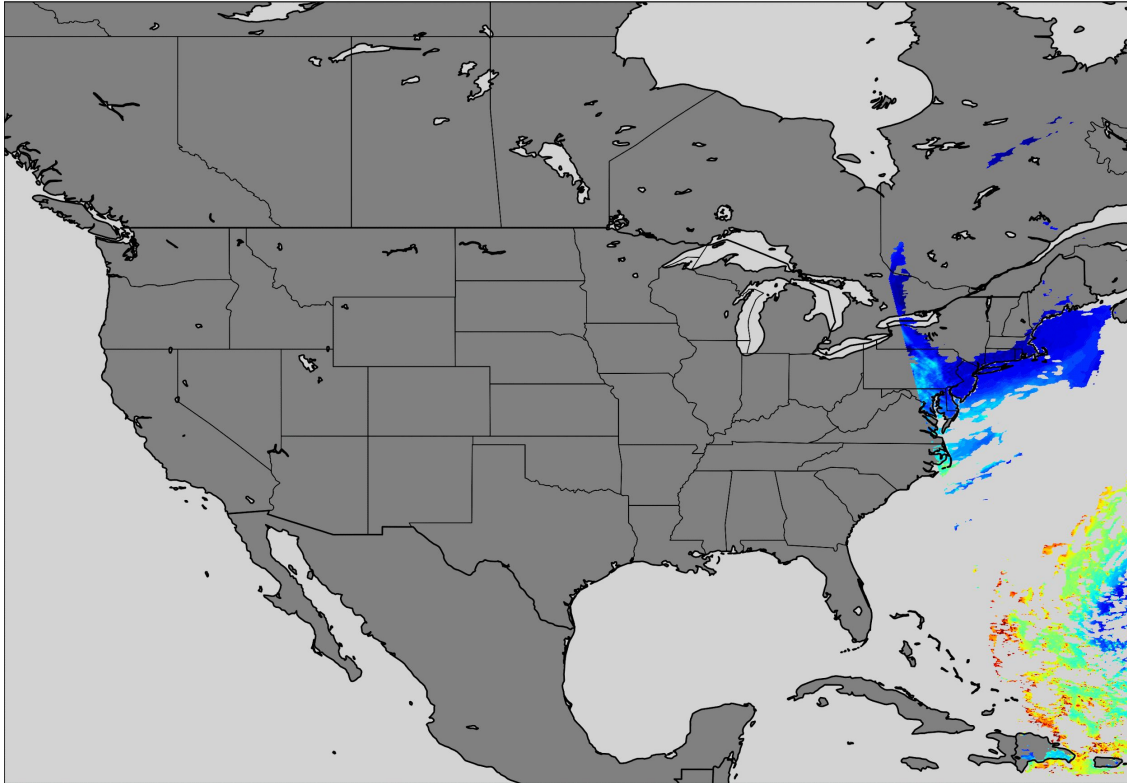
TEMPO ALH (km) 20230819 1115UTC   (AOD>0.3)

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

August 2023

N=6734
Y=1.16 X + 0.01
R=0.81
Bias=0.04
RMSE=0.10

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

TEMPO retrievals of AOD for 20231116 fire case in VA and comparison to ABI AOD
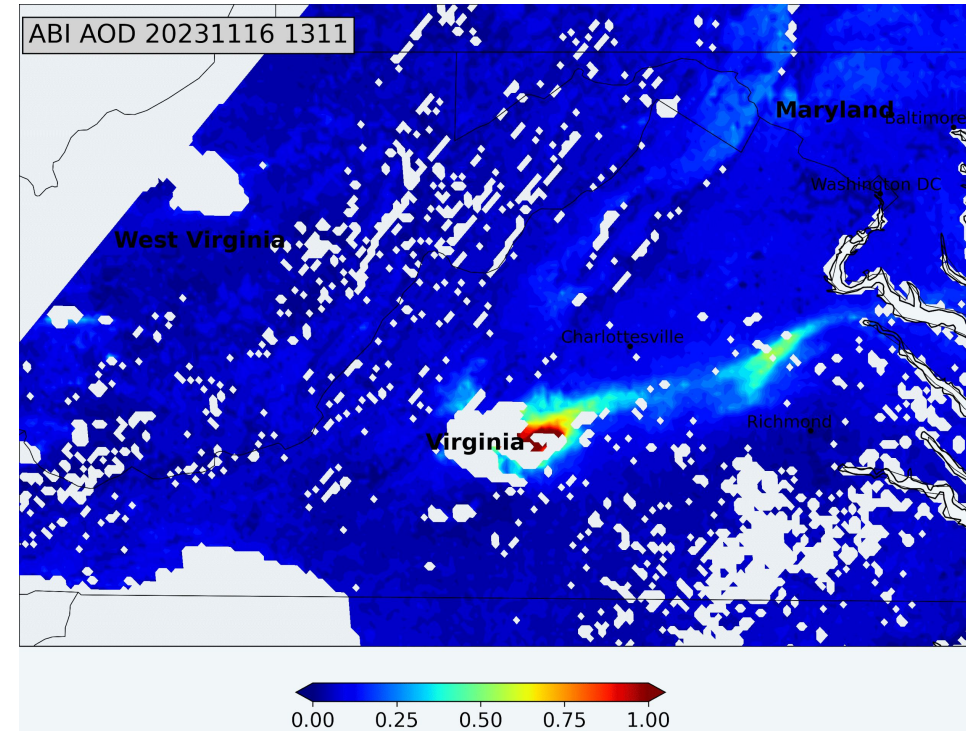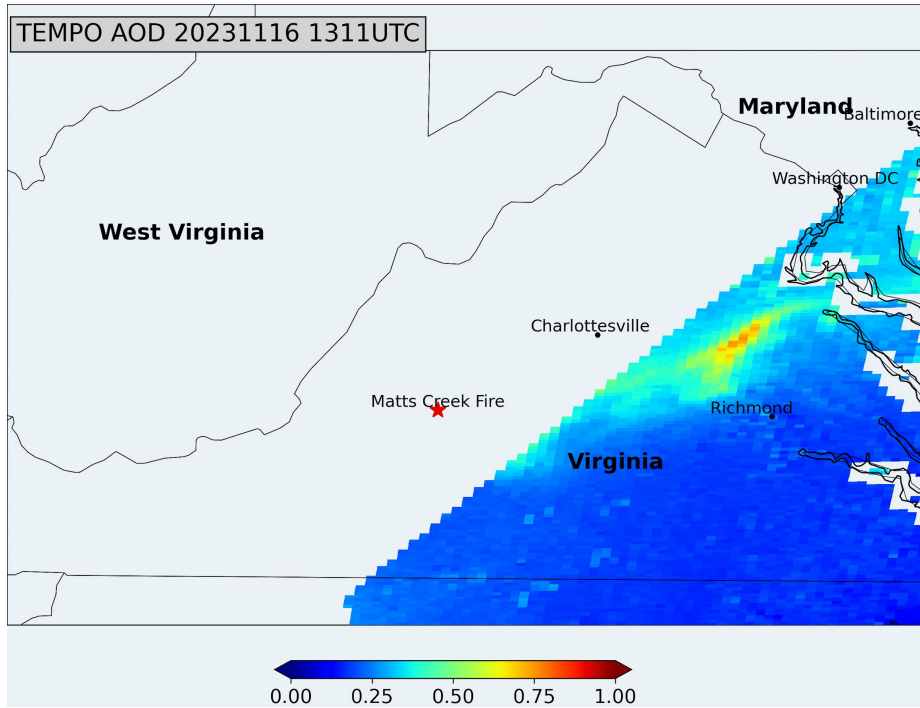
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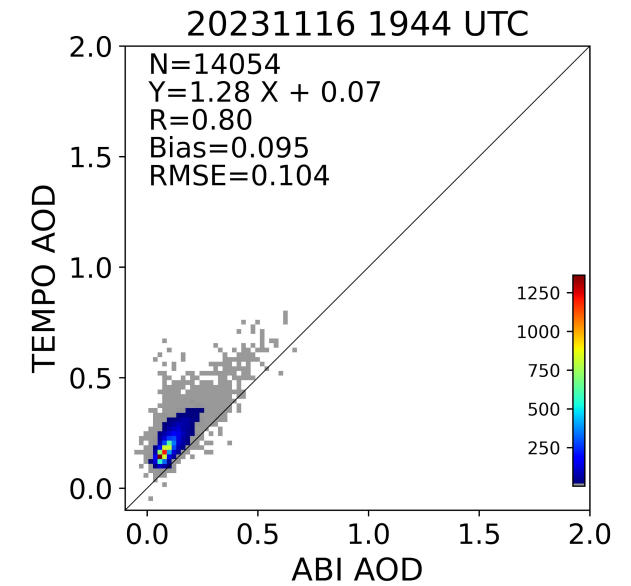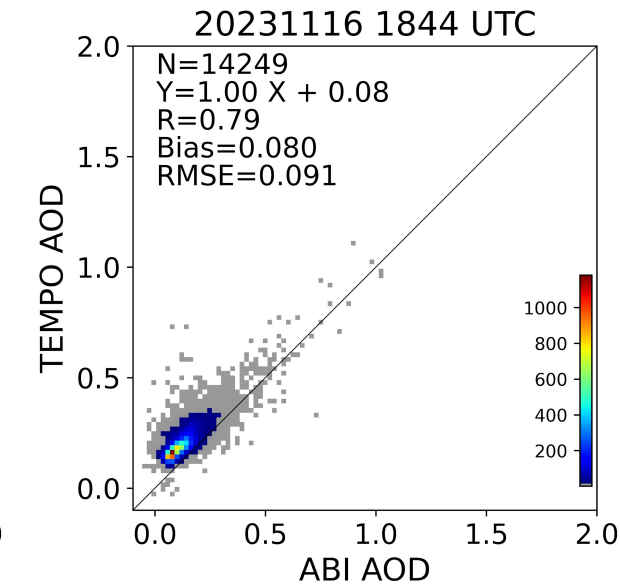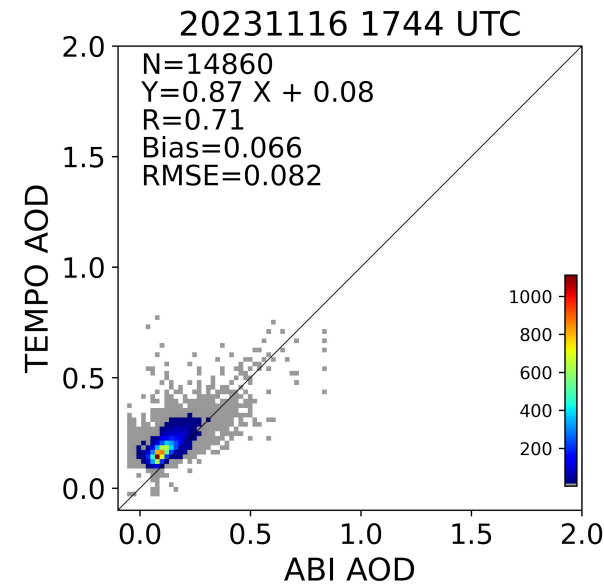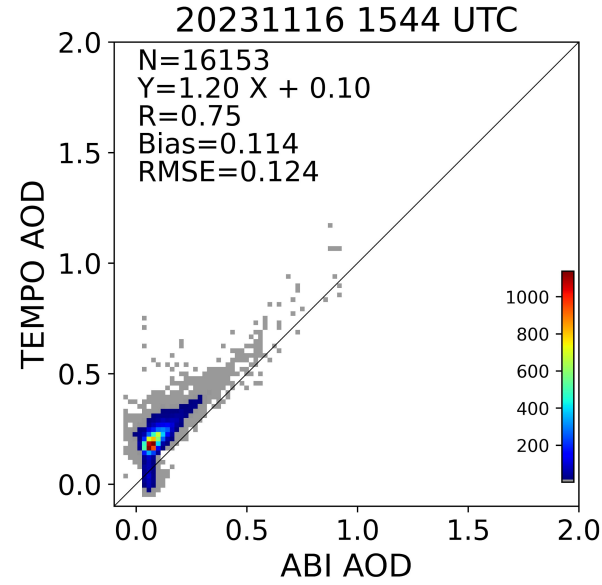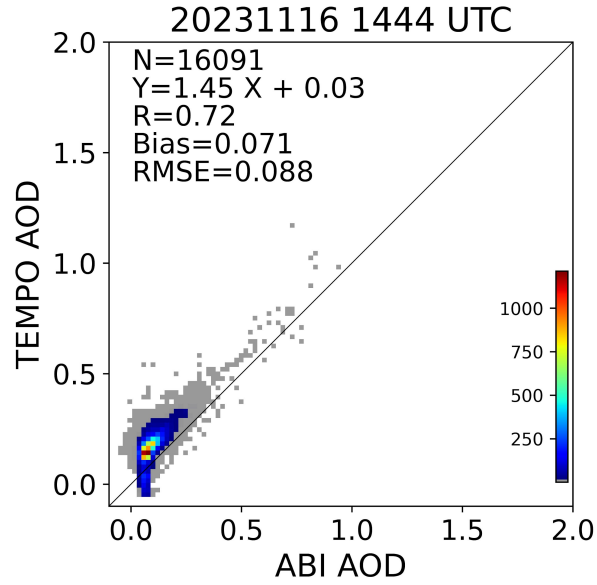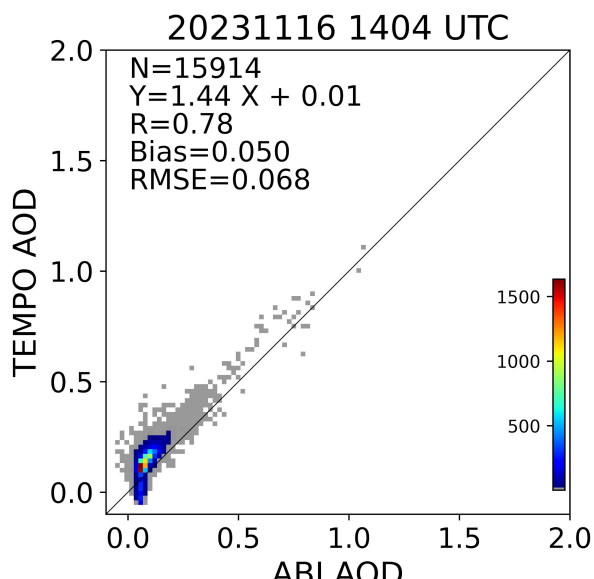
TROPOMI ALH retrieval vs CALIOP ALH

ALH (km) 20200910 2034UTC

532 nm Extinction Coefficient (20200910 21:34-21:42)

- CALIOP ALH
- TROPOMI ALH

August-September, 2020

N=519
Y=1.38 X -1.45
R=0.67
Bias=0.915
RMSE=2.598

For UVAI > 1.0
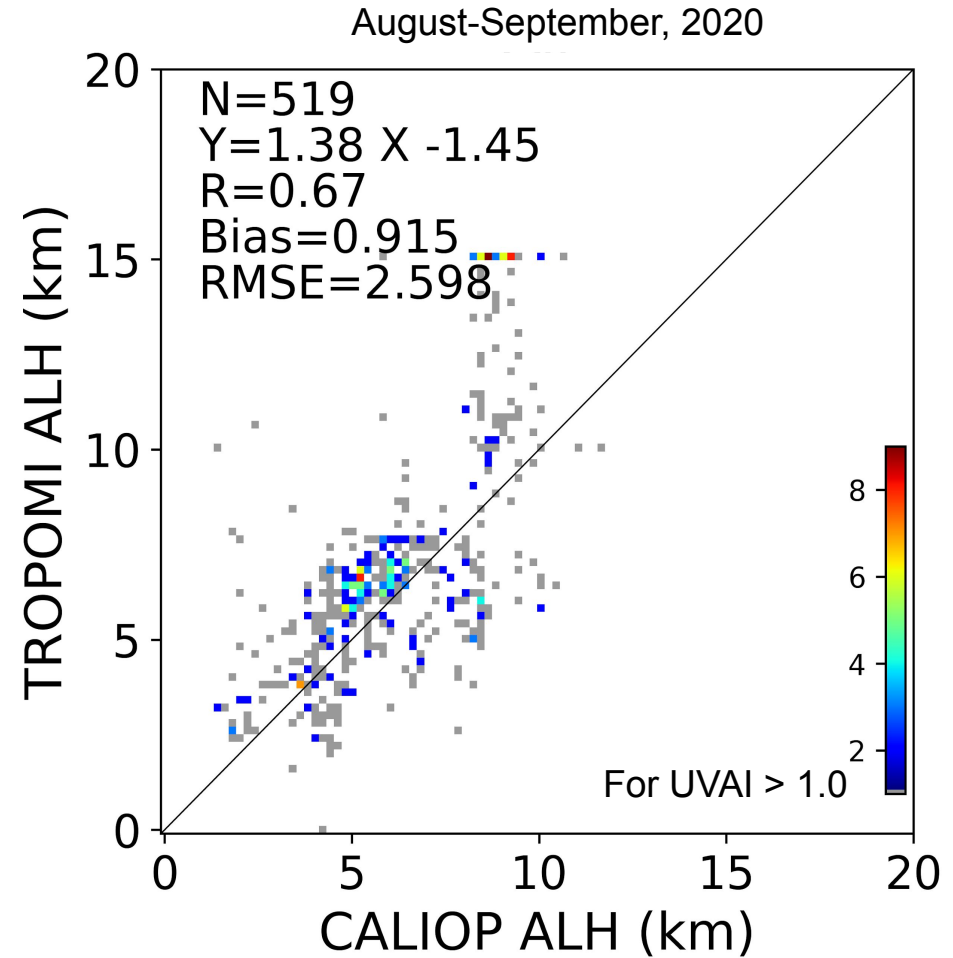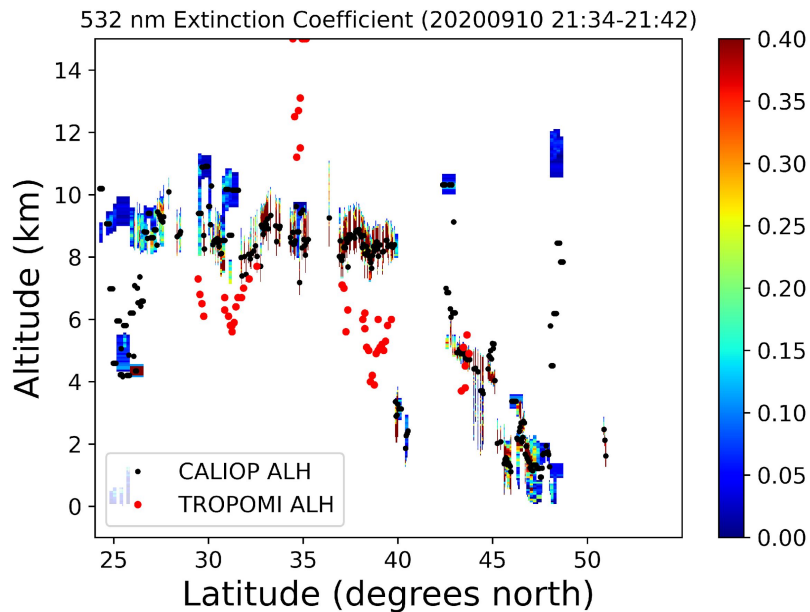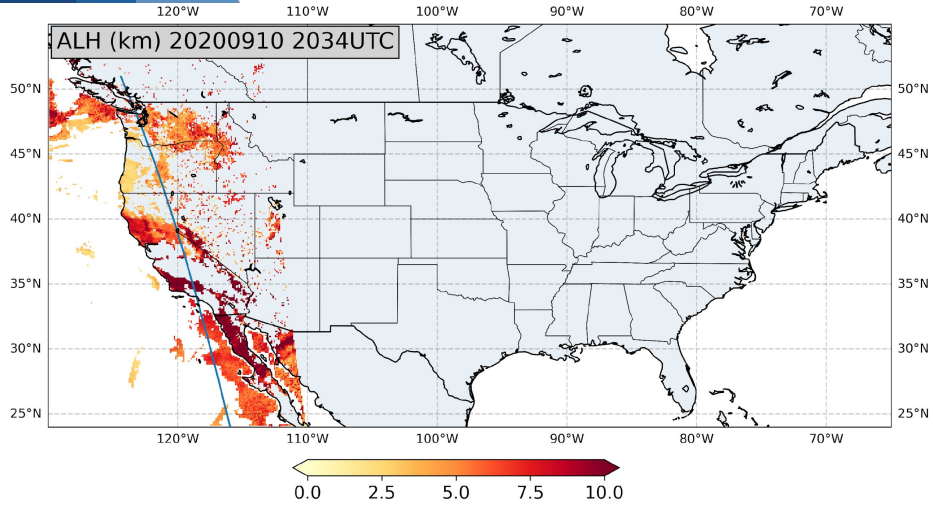
$$ALH = \frac{\sum_{i=1}^{n} \beta_i \, Z_i}{\sum_{i=1}^{n} \beta_i}$$

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

Summary

- The aerosol optical depth and aerosol layer height retrieval algorithm was developed for GeoXO ACX

- The LUT and surface DLER database were built

- The preliminary retrieval results from TEMPO compare well with AERONET and ABI AOD

- The algorithm was also evaluated for ALH using TROPOMI data and the results compare well to CALIOP ALH

- Further development is ongoing so that the algorithm can select aerosol models dynamically using ADP product

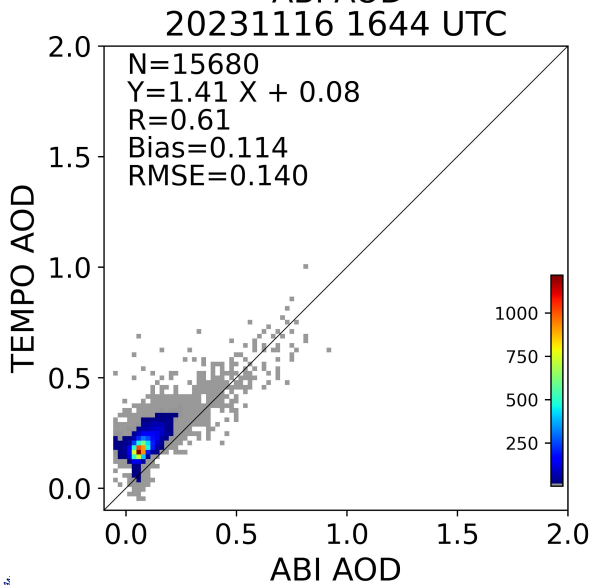- The ground ceilometer data will be explored to validate ALH retrievals

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

backup

AOD and ALH Retrieval Flow Chart

Input TROPOMI/TEMPO L1B convolve to bands 354nm, 388nm, 416nm, 440nm, 494nm, 670nm, 688nm (O_2B), meteorological data

Remove cloudy pixels (ABI cloud mask, internal test)

Land or Water?

Water → Calculate surface reflectance using empirical surface reflectance equation at 670 nm, 688 nm

Retrieve AOD at 550 nm using 670 nm TOA reflectance and LUT using smoke model 1

AOD>1.5? — No / Yes

Repeat previous step using smoke model 2

Land → Loop through AOD at 550 nm to find the one that gives the surface reflectance ratio as the prescribed between 440 nm and 670 nm bands using LUT using smoke model 1

Diff between retrieved and database surface at 440 nm> 0.05 — Yes → Retrieve AOD using 440 nm DLER and TOA reflectance

No → AOD>1.5? — Yes → Repeat previous steps using smoke model 2

Calculate surface reflectance at 688 nm using prescribed surface reflectance ratios from DLER

Use 670nm/688nm ratio to determine ALH from LUT by minimizing the residue
$$[1 - (R_{c_{688}}/R_{c_{670}})(R_{o_{670}}/R_{o_{688}})]^2$$

Output AOD and ALH

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