EPIC aerosol optical centroid height product: progress and its applications

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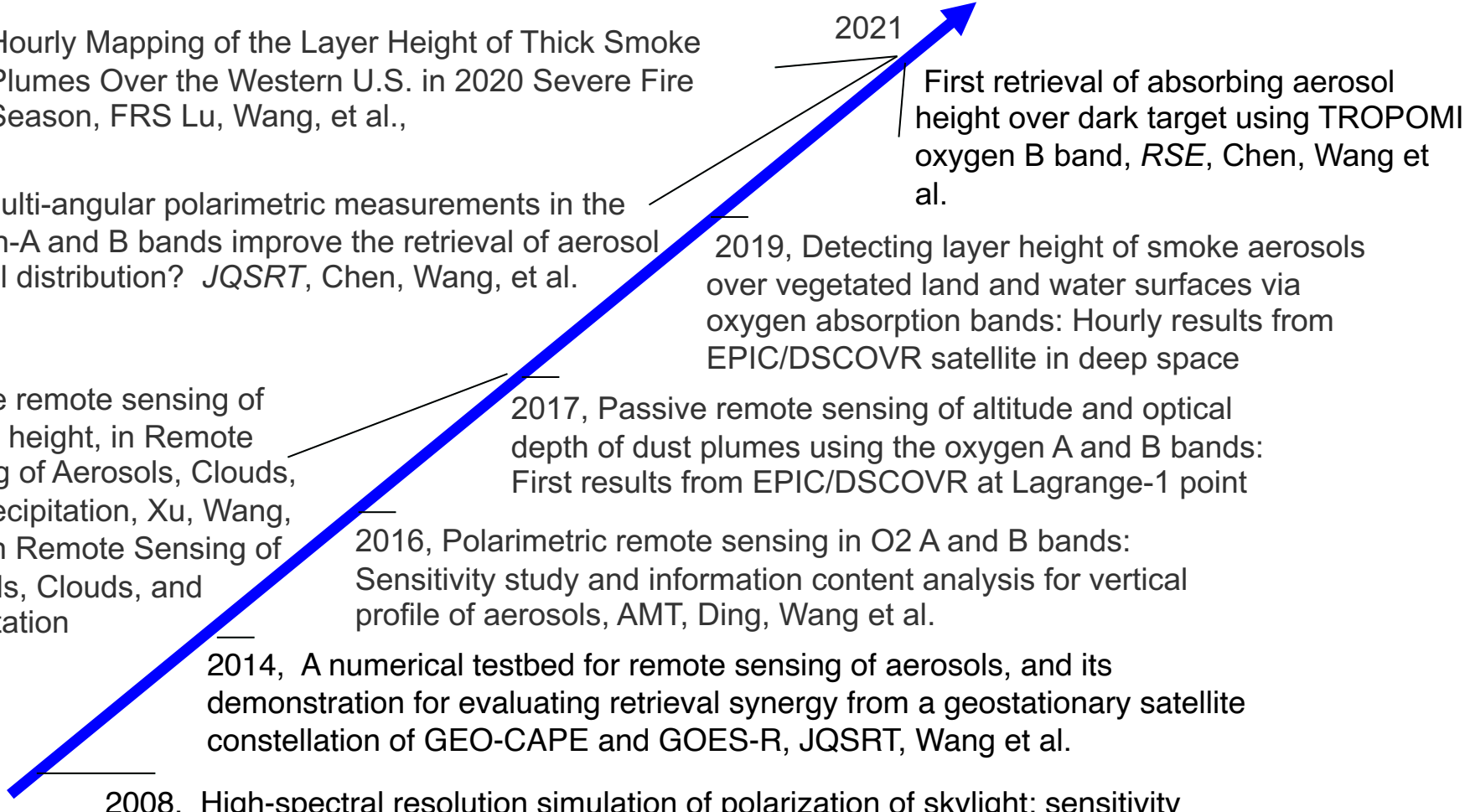
Our 15-year journey in passive sensing of aerosol layer height - supported by ONR, NOAA and NASA (TEMPO, DSCOVR, HAQ)



2021

Hourly Mapping of the Layer Height of Thick Smoke Plumes Over the Western U.S. in 2020 Severe Fire Season, FRS Lu, Wang, et al.,

First retrieval of absorbing aerosol height over dark target using TROPOMI oxygen B band, *RSE*, Chen, Wang et al.

Can multi-angular polarimetric measurements in the oxygen-A and B bands improve the retrieval of aerosol vertical distribution? *JQSRT*, Chen, Wang, et al.

2019, Detecting layer height of smoke aerosols over vegetated land and water surfaces via oxygen absorption bands: Hourly results from EPIC/DSCOVR satellite in deep space

Passive remote sensing of aerosol height, in Remote Sensing of Aerosols, Clouds, and Precipitation, Xu, Wang, et al. in Remote Sensing of Aerosols, Clouds, and Precipitation

2017, Passive remote sensing of altitude and optical depth of dust plumes using the oxygen A and B bands: First results from EPIC/DSCOVR at Lagrange-1 point

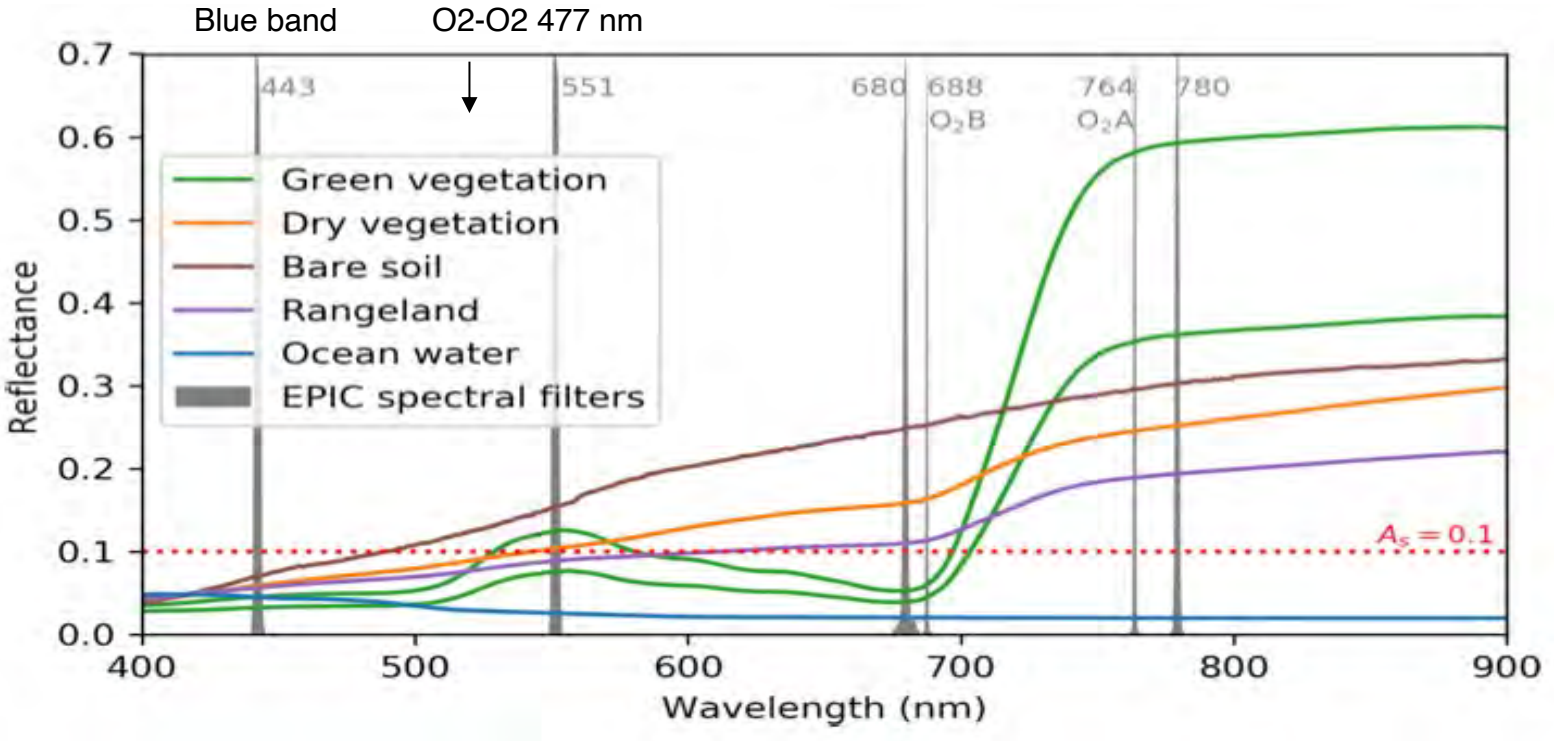
2016, Polarimetric remote sensing in O2 A and B bands: Sensitivity study and information content analysis for vertical profile of aerosols, AMT, Ding, Wang et al.

2014, A numerical testbed for remote sensing of aerosols, and its demonstration for evaluating retrieval synergy from a geostationary satellite constellation of GEO-CAPE and GOES-R, JQSRT, Wang et al.

2008, High-spectral resolution simulation of polarization of skylight: sensitivity to aerosol vertical profile, GRL, Zeng, Wang, & Han.

Advantages of O2 B-band

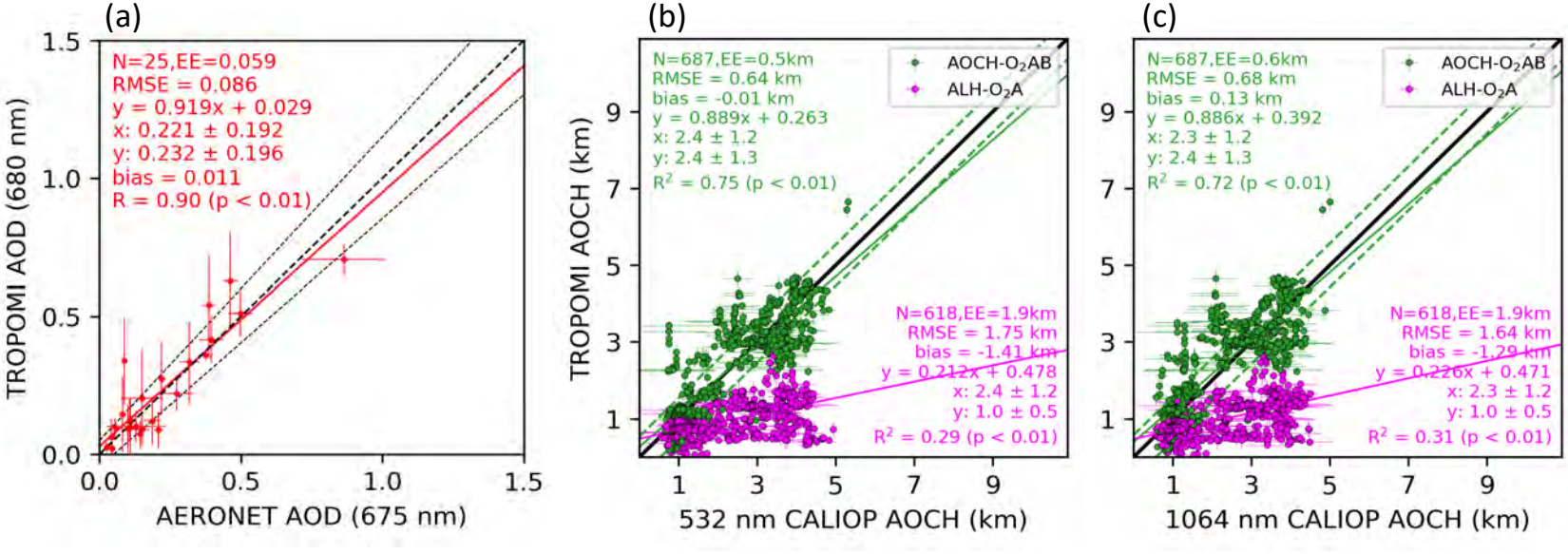
Xu, Wang, et al., 2019, AMT



O2 B-band has moderate absorption, stronger than O2-O2 at 477 nm and weaker than O2 A. O2 B-band also has very low surface reflectance, comparable if not lower than blue bands, due to Chlorophyll-a absorption.

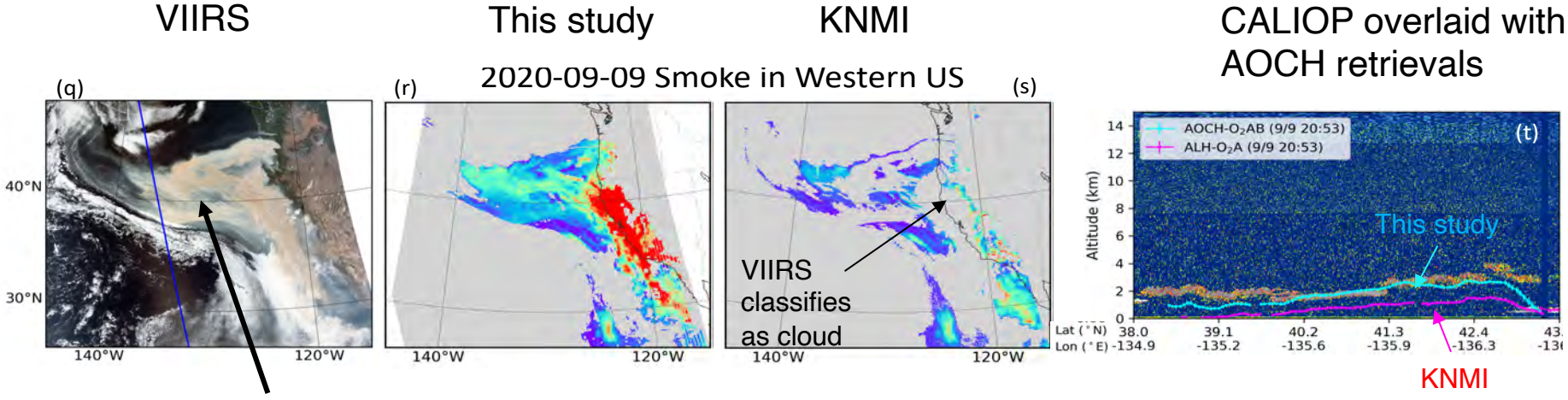
New Development/Results with primary use of TROPOMI O2 B-band

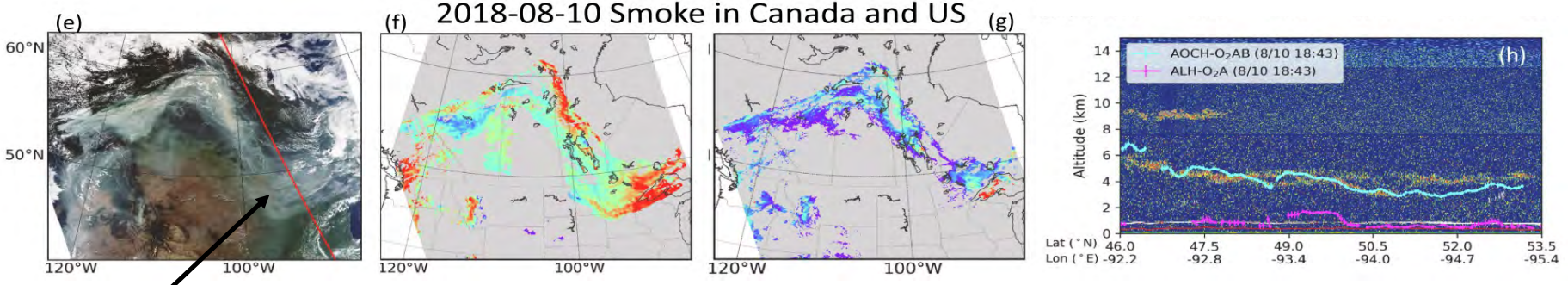
- Deriving Aerosol Optical Centroid Height (AOCH) and AOD by primarily using 420, 680, and 688 nm
- Surface reflectance from MODIS climatology and ASTER/USGS spectral reflectance library
- Aerosol optical properties derived from AERONET climatology (varying with region)
- Quasi-Gaussian distribution for the shape of aerosol vertical extinction profile
- Compared with CALIOP data for many many cases

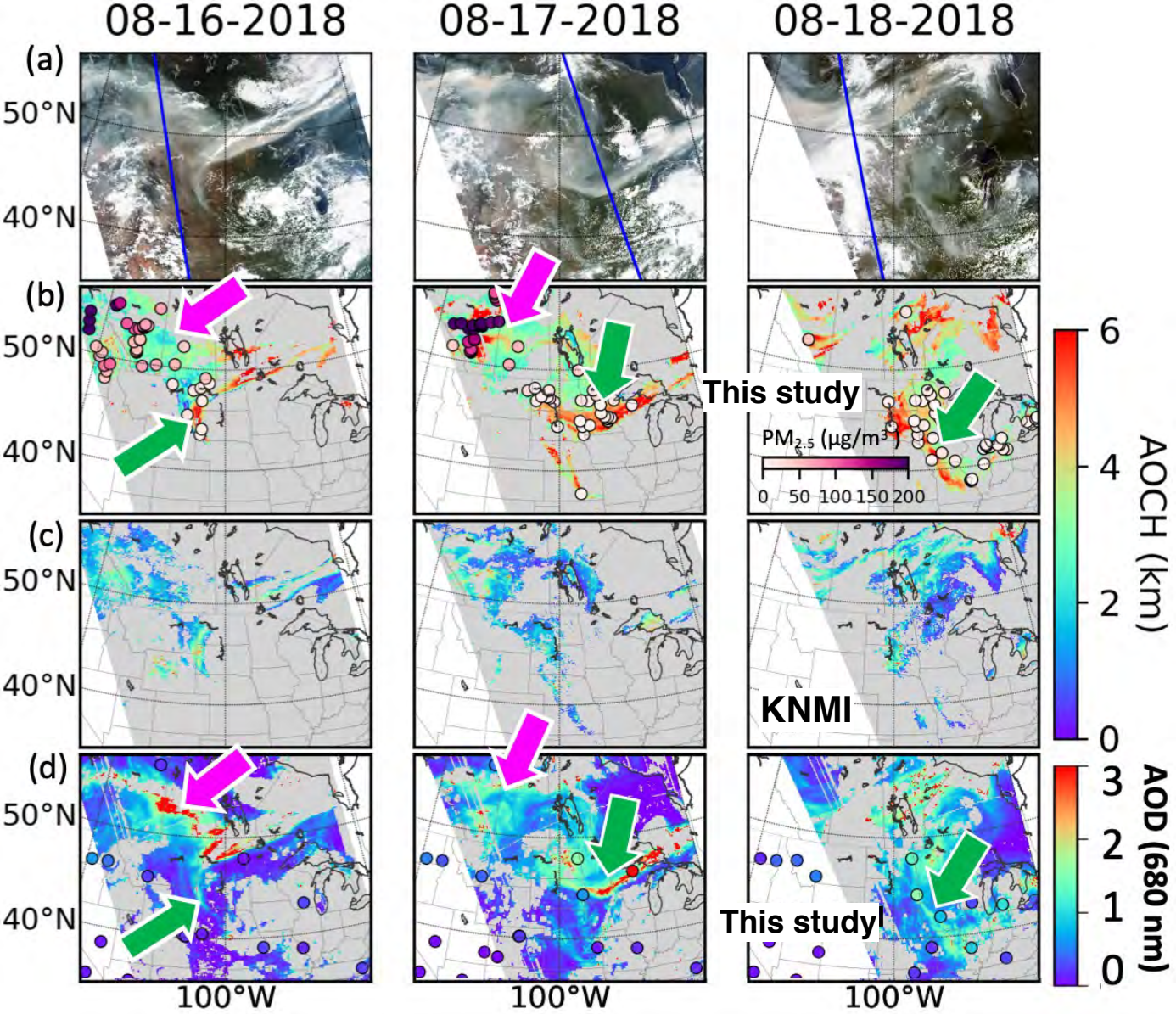


Chen, Wang, et al., 2021, RSE

Enhanced separation of clouds vs. aerosols by using spectral technique







Case Demonstration

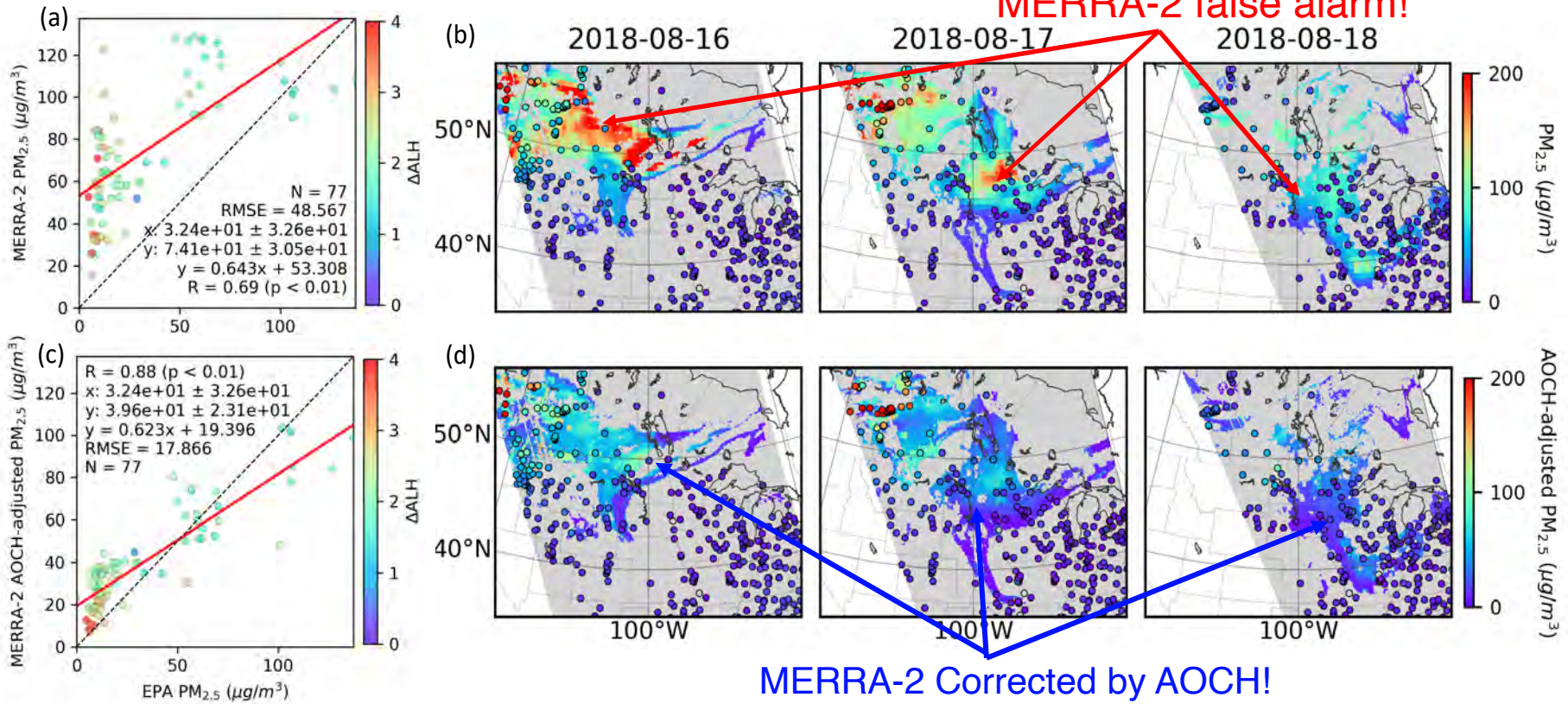
Air quality forecast is needed by the state & local communities to make advisories & decisions for mitigating public exposure to air pollution.

Exceptional event analysis requires "satellite imagery of plume with evidence of the plume impacting the ground".

Chen, Wang, et al., 2021.

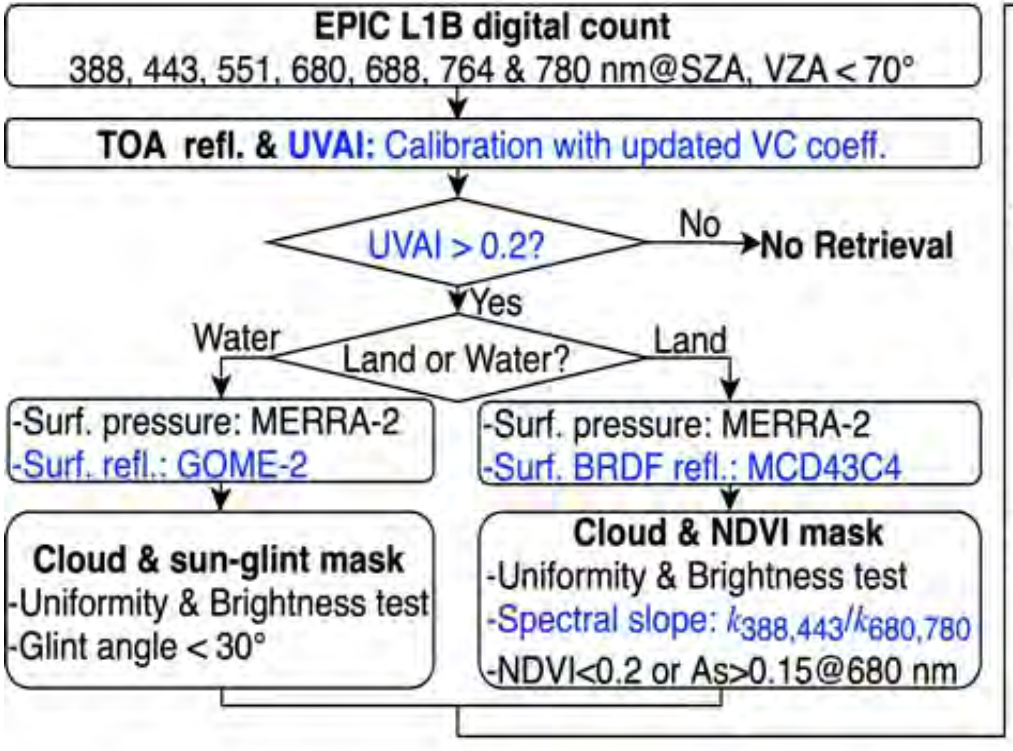
Improvement on prediction and analysis

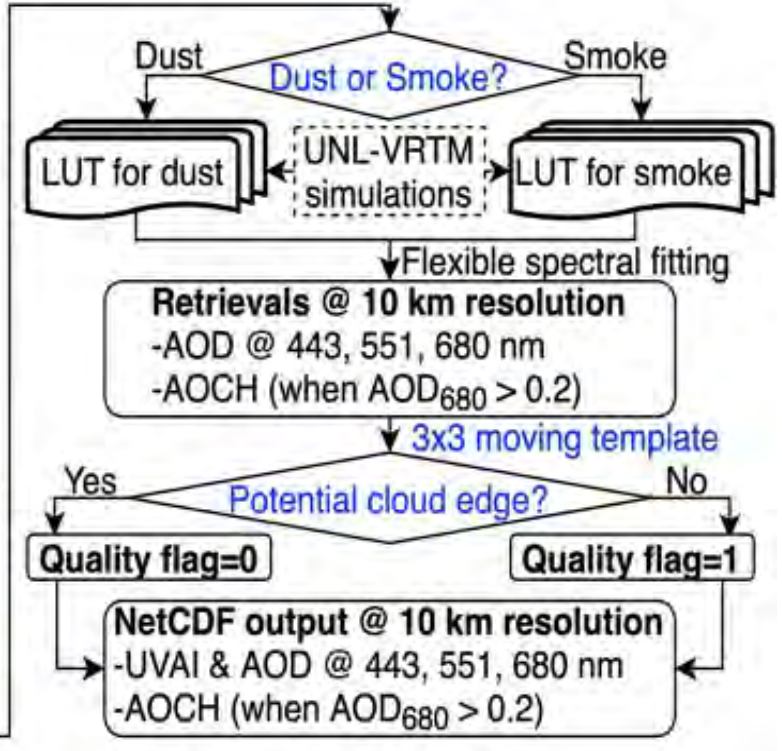
- Aerosol layer height is one of the most needed information air quality mangers wants (based on HAQAST group discussion on air quality forecast in smoke conditions).



Chen, Wang, et al., 2021.

Algorithm


EPIC L1B digital count
388, 443, 551, 680, 688, 764 & 780 nm@SZA, VZA < 70°
TOA refl. & UVAI: Calibration with updated VC coeff.
UVAI > 0.2?
No
No Retrieval
Yes
Water
Land or Water?
Land
-Surf. pressure: MERRA-2
-Surf. refl.: GOME-2
-Surf. pressure: MERRA-2
-Surf. BRDF refl.: MCD43C4
Cloud & sun-glint mask
-Uniformity & Brightness test
-Glint angle < 30°
Cloud & NDVI mask
-Uniformity & Brightness test
-Spectral slope: $k_{388,443}/k_{680,780}$
-NDVI<0.2 or As>0.15@680 nm


Dust
Dust or Smoke?
Smoke
LUT for dust
UNL-VRTM simulations
LUT for smoke
Flexible spectral fitting
Retrievals @ 10 km resolution
-AOD @ 443, 551, 680 nm
-AOCH (when AOD_{680} > 0.2)
3x3 moving template
Yes
Potential cloud edge?
No
Quality flag=0
Quality flag=1
NetCDF output @ 10 km resolution
-UVAI & AOD @ 443, 551, 680 nm
-AOCH (when AOD_{680} > 0.2)

Progress

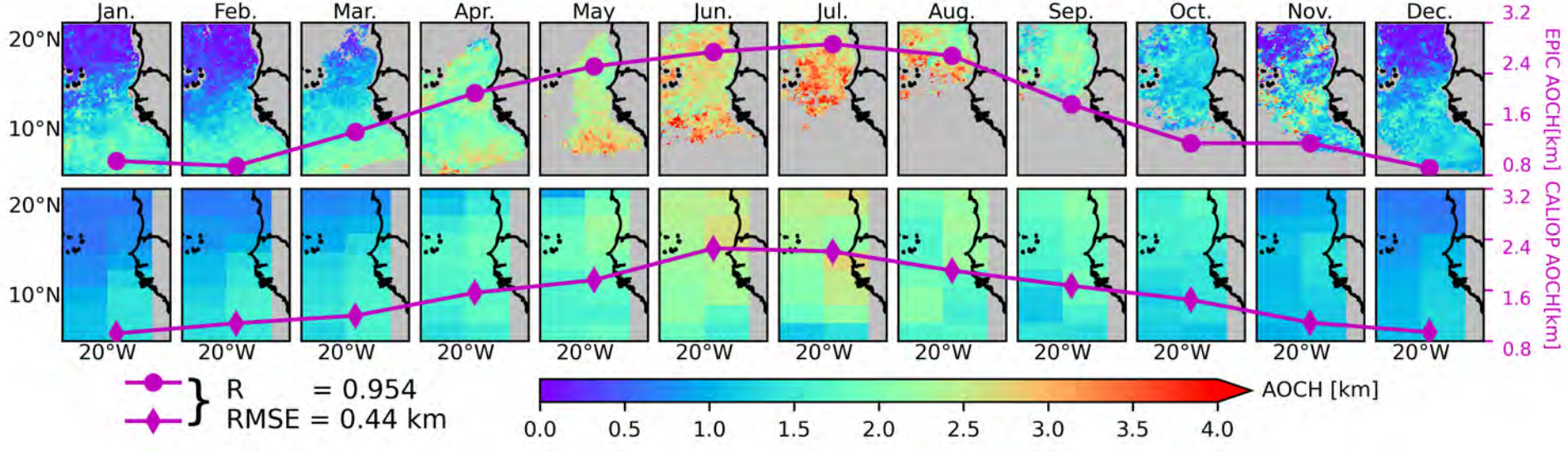
- Working with Marshall Sutton, the version-1 code has been tested and validated in GSFC.

DSCOVR_EPIC_L2_AOCH_01_20220804215736_03.nc

- It is in the process to add description for Product Data Record with the ASDC.
- Studied the feasibility to retrieve AOCH over the bright surface
- Look at the possible impacts of Sun glint and Earth curvature on UVAI calculation

EPIC vs. CALIOP

Aerosol Optical Centroid Height (AOCH)

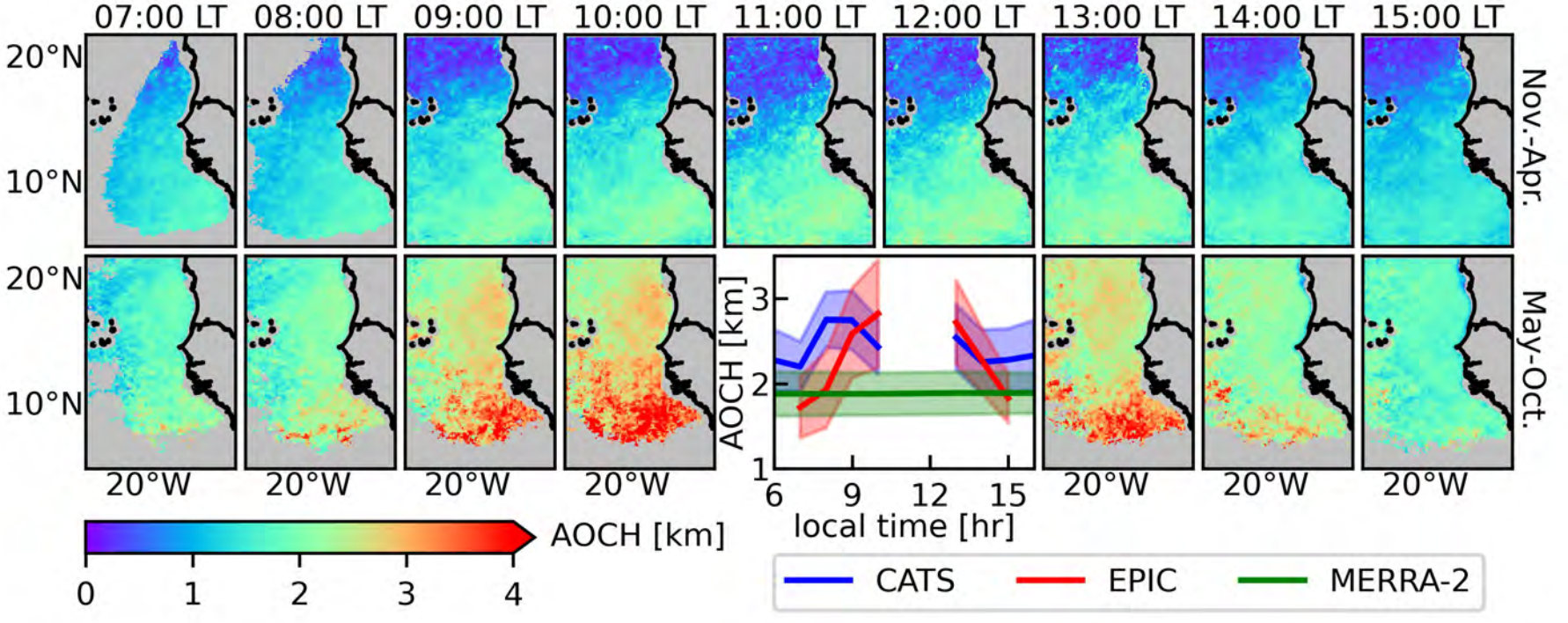


Top : EPIC retrieval: 2015.06-2019.06, at 20-30 km resolution

Bottom : CALIOP level3: 2006.06-2019.06, at 2.5 x 5 degree resolution

Peak at summer, lowest at winter

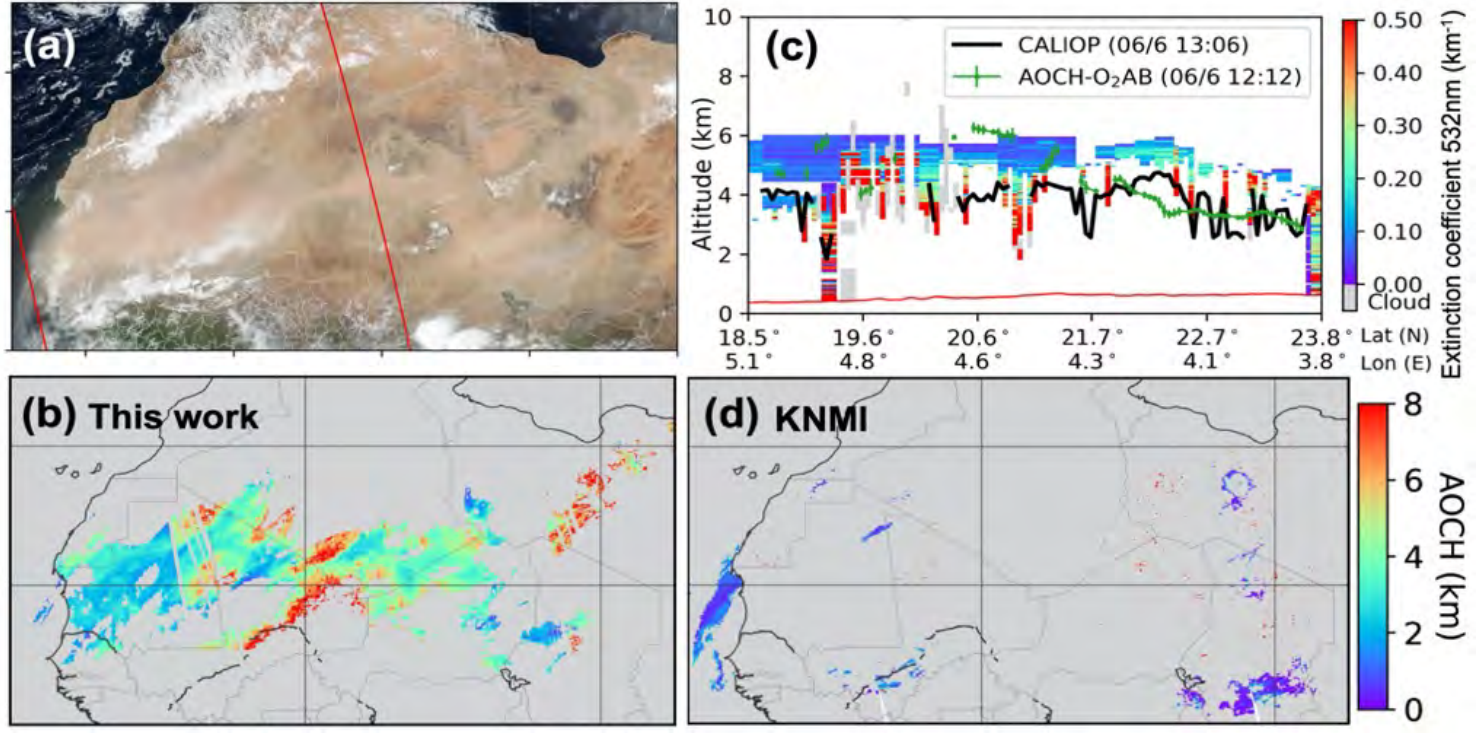
EPIC's uniqueness:
Hourly climatology of Saharan dust height
EPIC v.s. CATS v.s. MERRA-2



Both EPIC and CAT agree that high height around noon; Low at early morning & late afternoon
MERRA-2 shows little variation.

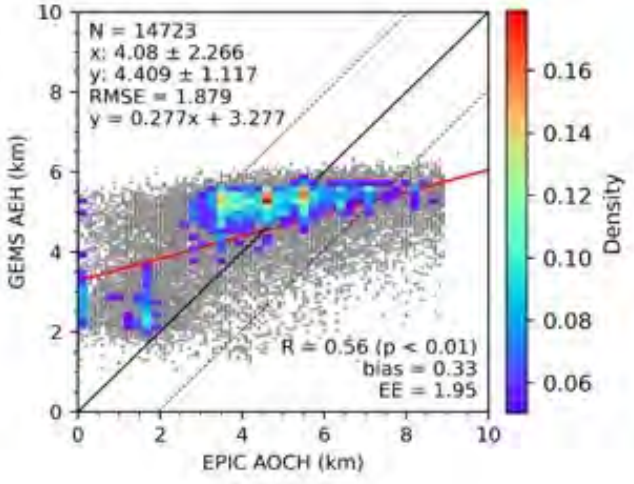
Retrieval of AOCH over the bright surfaces

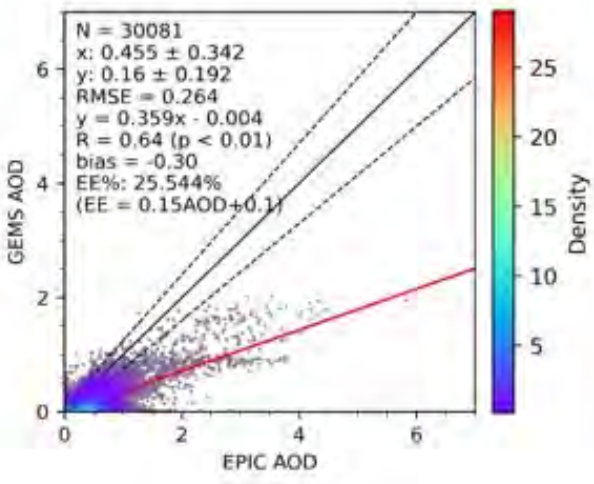
preliminary; work in progress

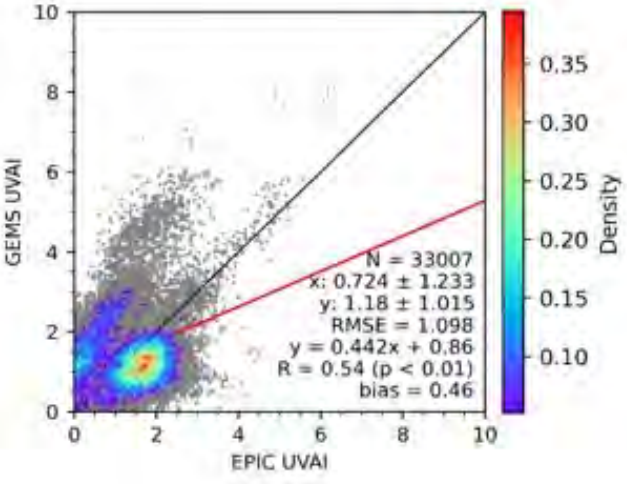


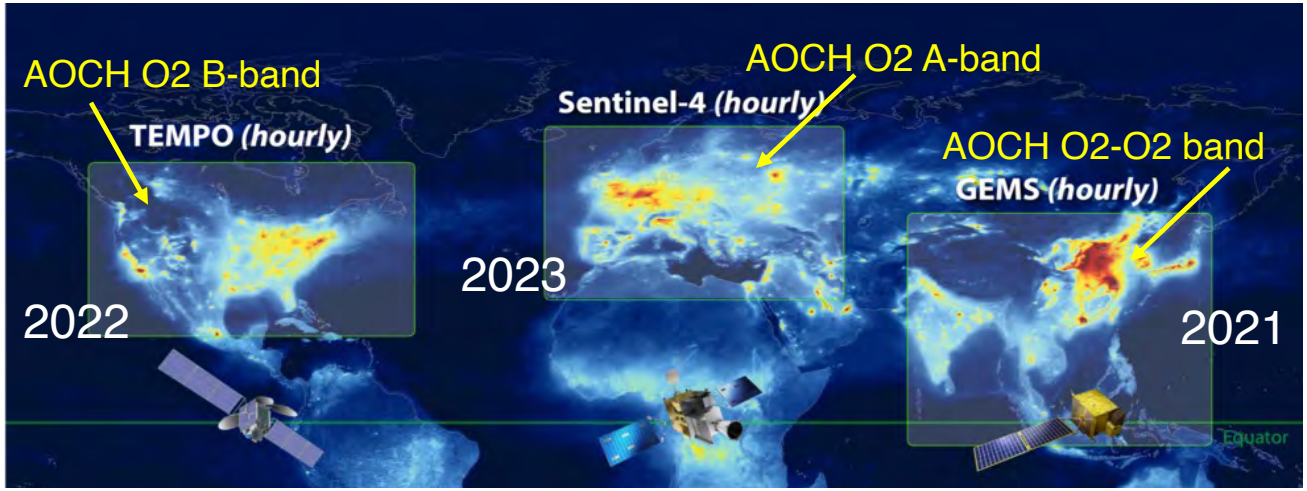
Using EPIC to tie the GEO-ring

first trial to compare with GEMS, future for TEMPO & Sentinel-4

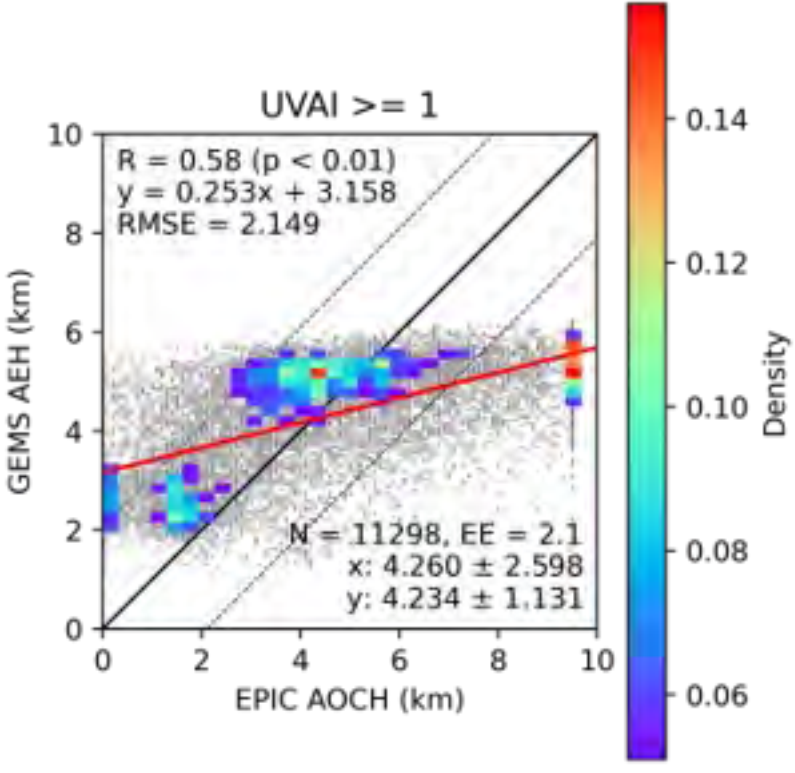


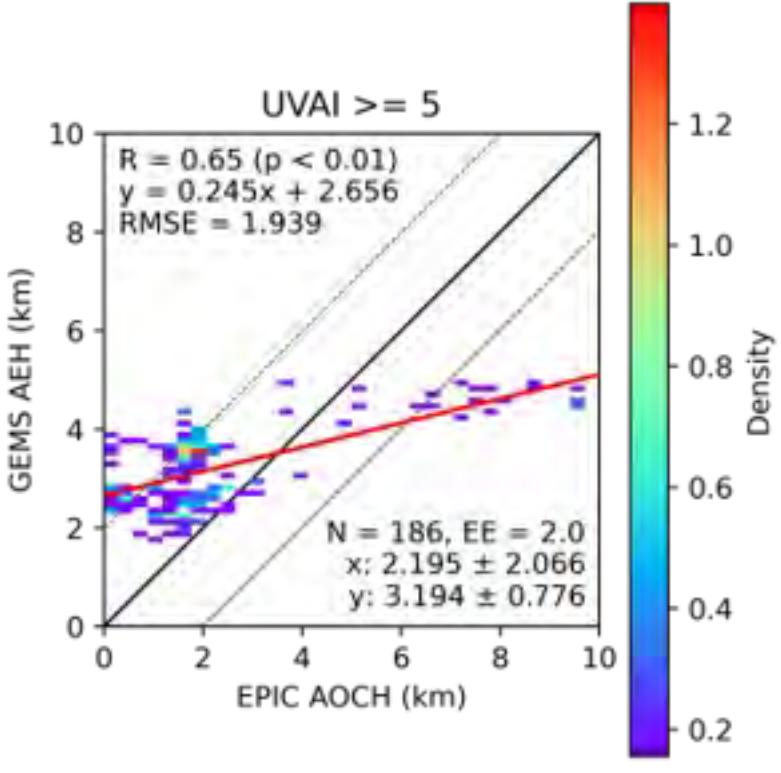






Evaluation as a function of UVAI





Summary

EPIC data is uniquely positioned for:

- **Climate studies of diurnal variation of aerosol layer height climatology**
  - DSCOVR/EPIC can help provide monthly climatology of dust plume height with a much finer spatial resolution than CALIOP.
  - DSCOVR/EPIC can uniquely provide the hourly climatology of Saharan dust height.

- **Air quality studies to estimate surface PM2.5 and characterize smoke vertical transport**

- **Good progress were made to generate EPIC AOCH data.**