Aerosol optical centroid height product: applications & progress

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Thanks to:
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Shobha Kongdragunta @ NOAA NESDIS

Our 15-year journey of passive sensing of aerosol layer height

2023

First Mapping of Monthly and Diurnal **Climatology** of Saharan Dust Layer Height Over the Atlantic Ocean From EPIC/DSCOVR in Deep Space, GRL., Lu Wang et al.

2021

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

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.,

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

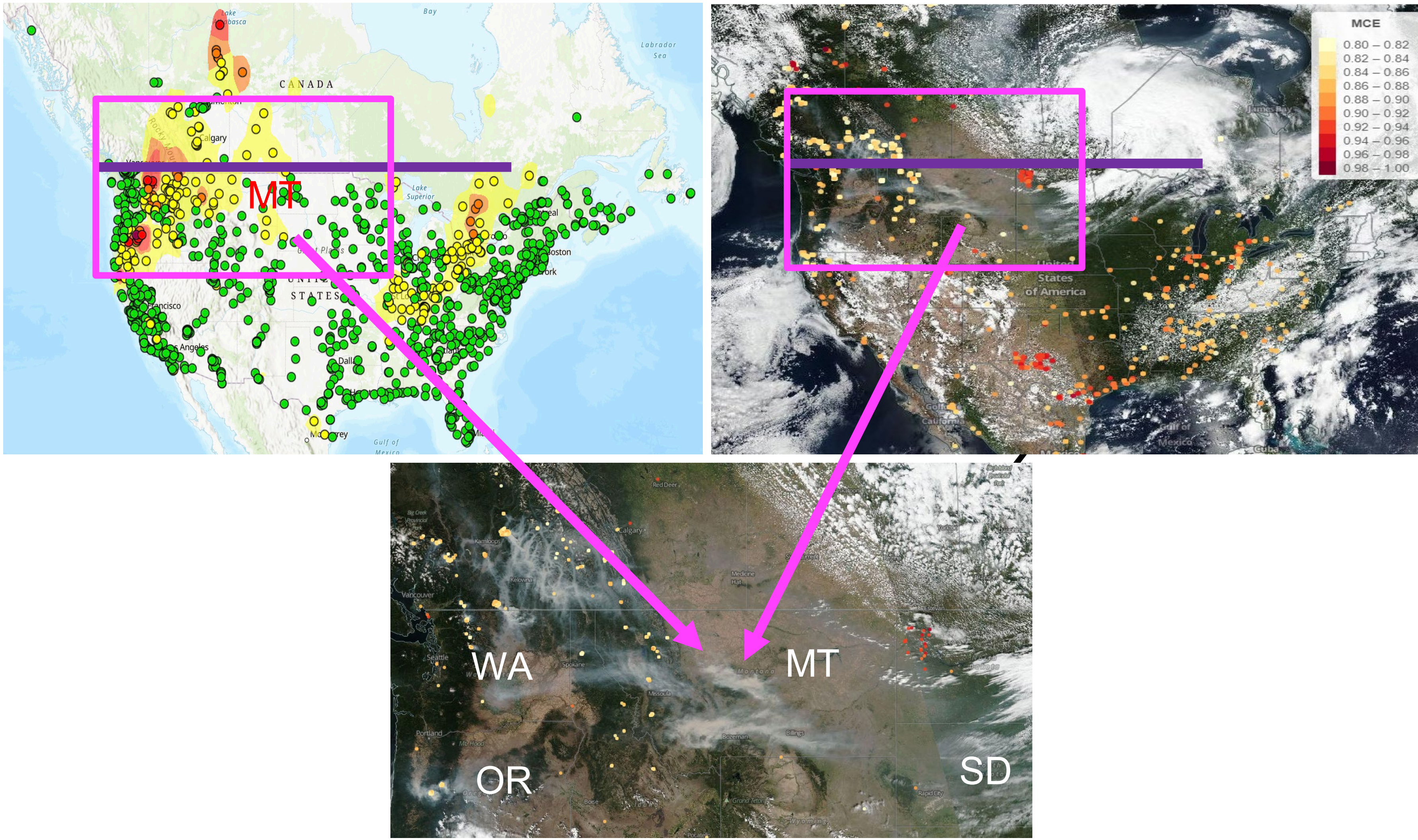
2017, Passive remote sensing of altitude and optical depth of dust plumes using the oxygen A and B bands: First results from EPIC/DSCOVR at Lagrange-1 point, GRL, Xu, Wang, et al.,

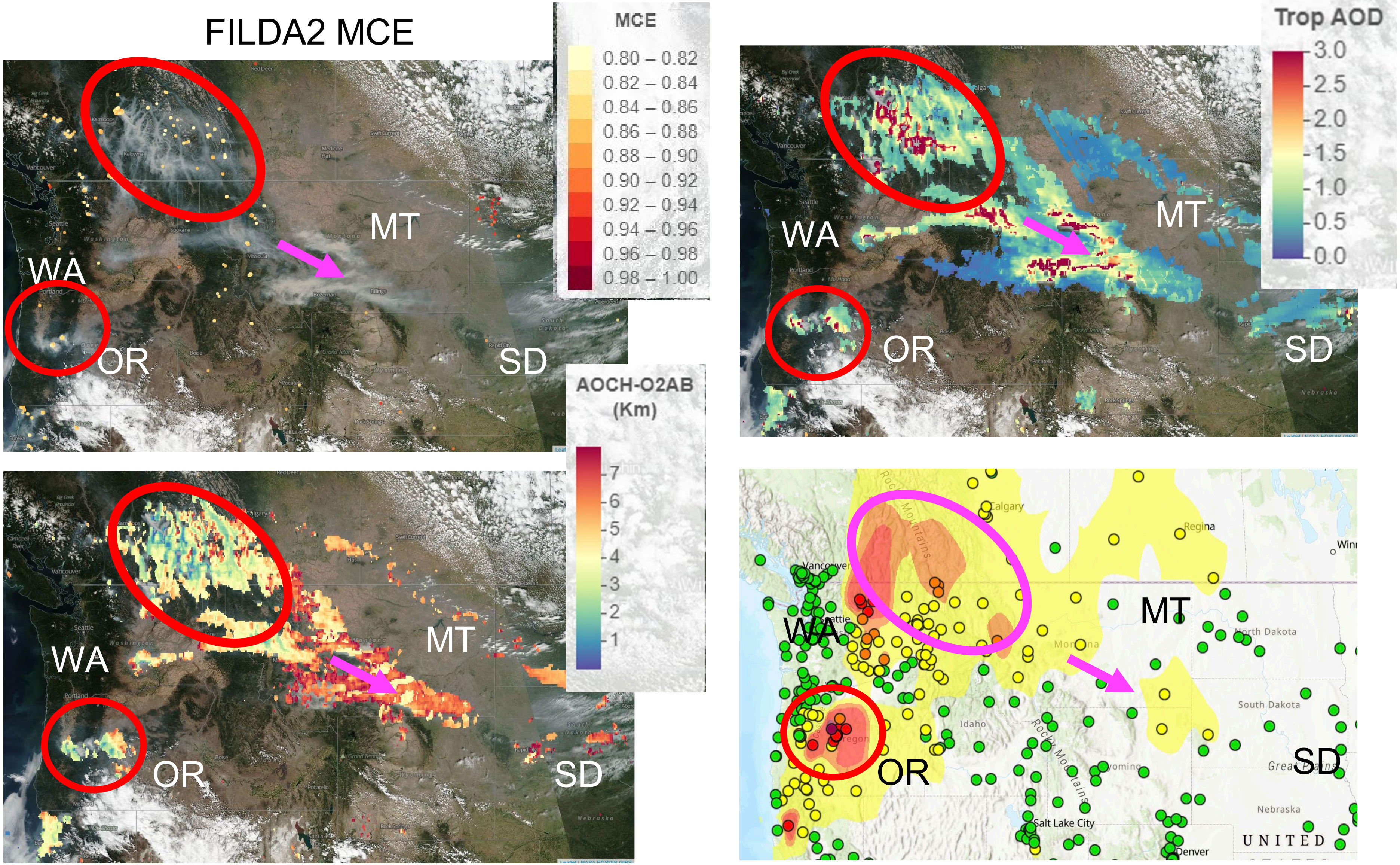
2016, Polarimetric remote sensing in **O2 A and B** bands: Sensitivity study and information content analysis for vertical profile of aerosols, AMT, Ding, Wang et al.

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.

AQ Applications http://fireaq.uiowa.edu for weekly briefing of FireAQ this summer




FILDA2 MCE
MCE
0.80 – 0.82
0.82 – 0.84
0.84 – 0.86
0.86 – 0.88
0.88 – 0.90
0.90 – 0.92
0.92 – 0.94
0.94 – 0.96
0.96 – 0.98
0.98 – 1.00
Trop AOD
3.0
2.5
2.0
1.5
1.0
0.5
0.0
AOCH-O2AB
(Km)
7
6
5
4
3
2
1
WA
OR
MT
SD
Calgary
Regina
Vancouver
Seattle
Montana
North Dakota
South Dakota
Idaho
Oregon
Wyoming
Rocky Mountains
Salt Lake City
Denver
Nebraska
Great Plains
UNITED

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First Mapping of Monthly and Diurnal Climatology of Saharan Dust Layer Height Over the Atlantic Ocean From EPIC/DSCOVR in Deep Space

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Key Points:

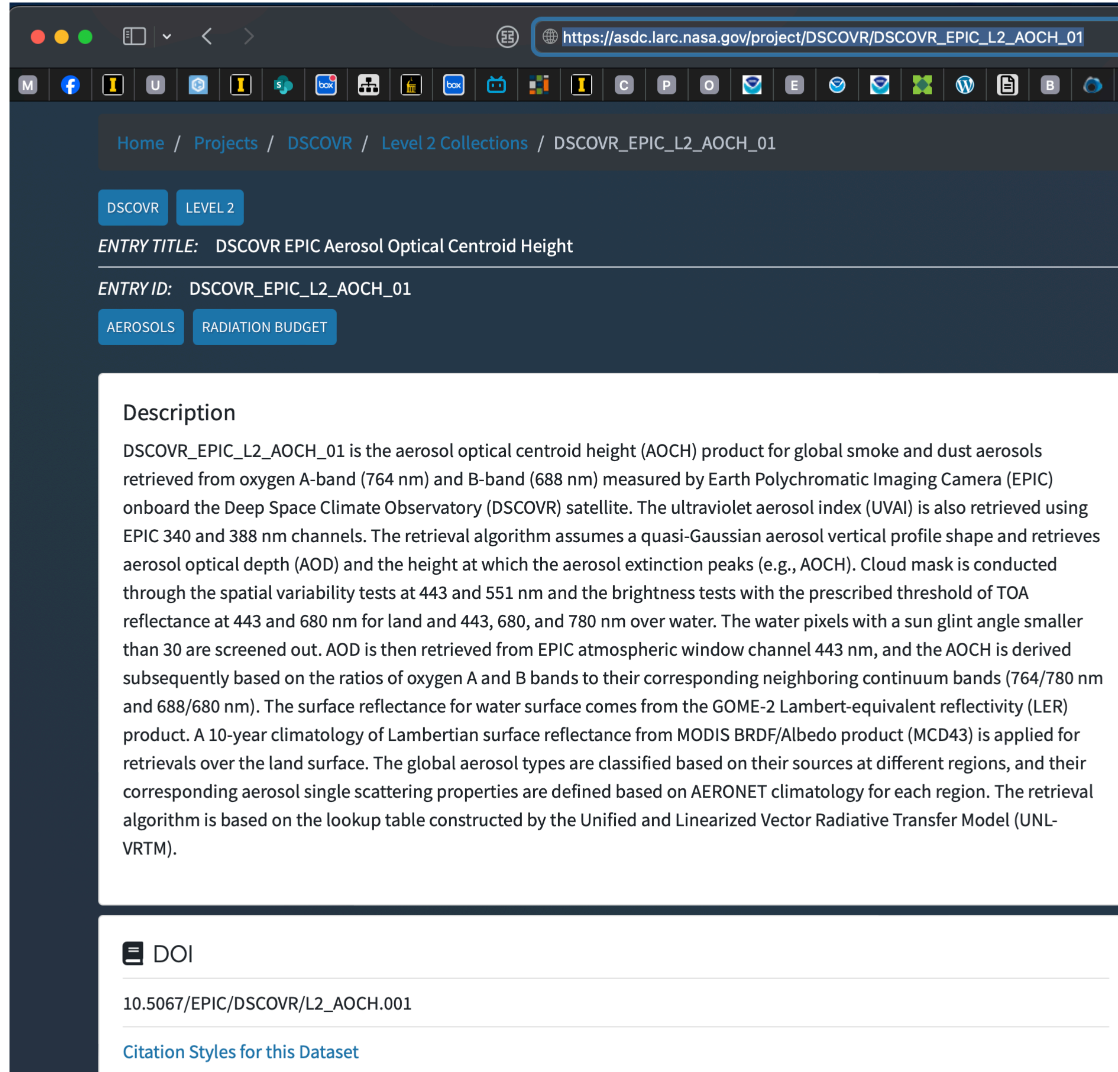
- Hourly and monthly climatology of Saharan dust layer height distribution over the ocean is first mapped from passive remote sensing (Earth Polychromatic Imaging Camera)
- The climatology agrees with that from spaceborne lidars and attests to the deficiency in model reanalysis of dust height diurnal change
- A combination of active and passive sensing techniques to study process for time-varying 3D aerosol distribution climatology

- https://asdc.larc.nasa.gov/project/DSCOVR/DSCOVR_EPIC_L2_AOCH_01

Level-2 data product:

DSCOVR_EPIC_AOCH_01 data production in ASDC/LaRC.

Thanks to Marshall Sutton and EPIC project team in GSFC to make the RTO happen.



https://asdc.larc.nasa.gov/project/DSCOVR/DSCOVR_EPIC_L2_AOCH_01

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DSCOVR LEVEL 2

ENTRY TITLE: DSCOVR EPIC Aerosol Optical Centroid Height

ENTRY ID: DSCOVR_EPIC_L2_AOCH_01

AEROSOLS RADIATION BUDGET

Description

DSCOVR_EPIC_L2_AOCH_01 is the aerosol optical centroid height (AOCH) product for global smoke and dust aerosols retrieved from oxygen A-band (764 nm) and B-band (688 nm) measured by Earth Polychromatic Imaging Camera (EPIC) onboard the Deep Space Climate Observatory (DSCOVR) satellite. The ultraviolet aerosol index (UVAI) is also retrieved using EPIC 340 and 388 nm channels. The retrieval algorithm assumes a quasi-Gaussian aerosol vertical profile shape and retrieves aerosol optical depth (AOD) and the height at which the aerosol extinction peaks (e.g., AOCH). Cloud mask is conducted through the spatial variability tests at 443 and 551 nm and the brightness tests with the prescribed threshold of TOA reflectance at 443 and 680 nm for land and 443, 680, and 780 nm over water. The water pixels with a sun glint angle smaller than 30 are screened out. AOD is then retrieved from EPIC atmospheric window channel 443 nm, and the AOCH is derived subsequently based on the ratios of oxygen A and B bands to their corresponding neighboring continuum bands (764/780 nm and 688/680 nm). The surface reflectance for water surface comes from the GOME-2 Lambert-equivalent reflectivity (LER) product. A 10-year climatology of Lambertian surface reflectance from MODIS BRDF/Albedo product (MCD43) is applied for retrievals over the land surface. The global aerosol types are classified based on their sources at different regions, and their corresponding aerosol single scattering properties are defined based on AERONET climatology for each region. The retrieval algorithm is based on the lookup table constructed by the Unified and Linearized Vector Radiative Transfer Model (UNL-VRTM).

DOI

10.5067/EPIC/DSCOVR/L2_AOCH.001

Citation Styles for this Dataset

Retrieval algorithm comparison

ALH retrieval algorithms	Used channels (nm)	Aerosol model	Aerosol type	Retrieved parameters	Spatial resolution	Profile assumption
GEMS-AEH	477 (O_2-O_2)	Fixed aerosol model for three aerosol types (same with GEMS AOD retrieval)	Dust, smoke, non-absorbing	• AOD @ 354nm, 443 nm, 500 nm (from AERAOD) • Aerosol effective height	3.5 × 8 km	[(1-exp[-1]) ×τ] on Quasi-Gaussian distribution with 1 km half-width
EPIC-AOCH	688/680 (O_2 B) 764/780 (O_2 A)	AOD-dependent smoke model (dust) from AERONET climatology	Dust, smoke (UVAI > 1.5 or 1)	• AOD @ 680 nm • Aerosol optical central height	30 × 30 km	Peak height on Quasi-Gaussian distribution with 1 km half-width
TROPOMI-AOCH O_2AB					0.05° × 0.05°	

Quasi-Gaussian distribution

$$\beta(z) = \frac{\exp(-\sigma_H|z - \mathrm{H}|)}{[1 + \exp(-\sigma_H|z - \mathrm{H}|)]^2}$$

η: half width (1 km), $\sigma = \ln(3 + \sqrt{8})/\eta$

EPIC & TROPOMI, Aerosol Optical Central Height (AOCH)

H same as in the definition in the algorithm

β_{AOCH} : extinction coefficient of peak height

GEMS, Aerosol Effective Height (AEH) V2.0

$$\frac{\int_0^{AEH} \beta(z)dz}{\int_0^{TOA} \beta(z)dz} = 1 - e^{-1}$$

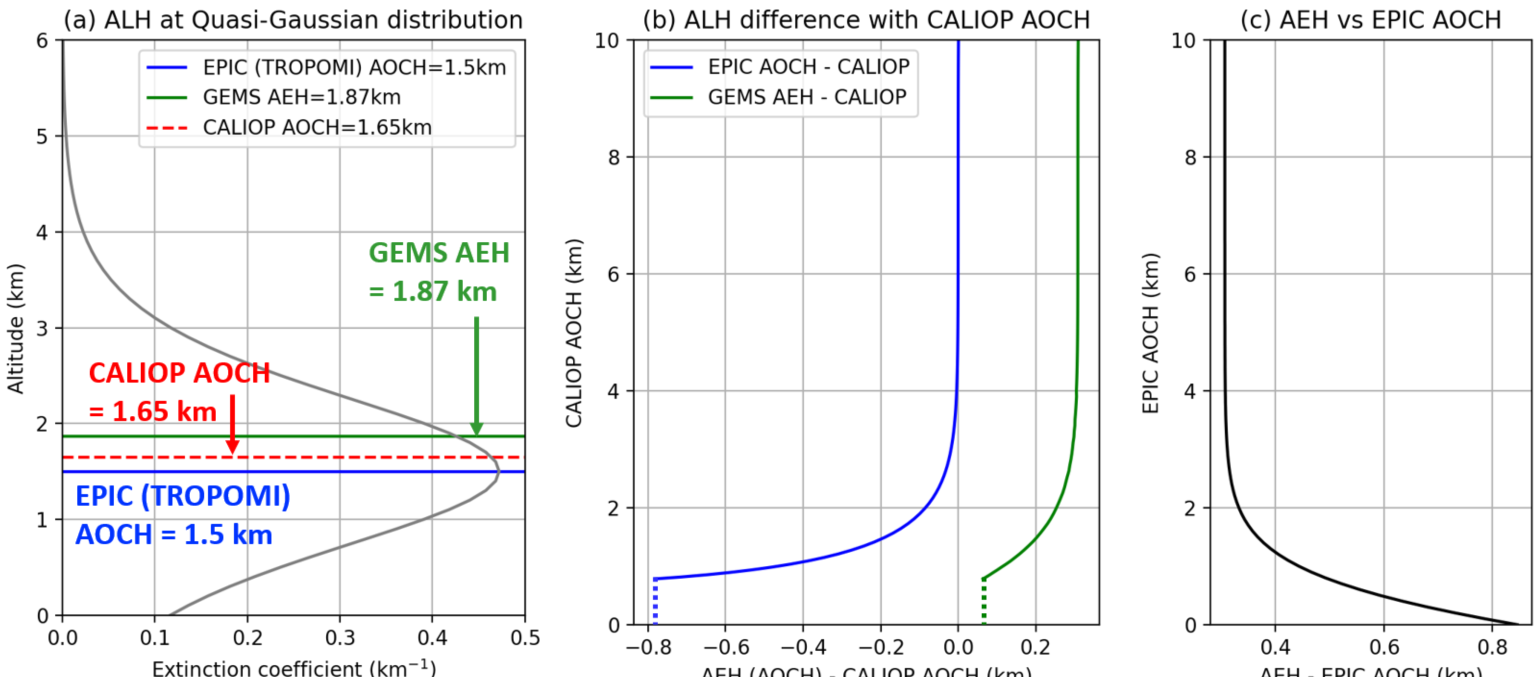
β_{AEH} : extinction coefficient of the e-folding height

CALIOP, Aerosol Extinction Weighted Height :

$$AOCH_{CALIOP} = \frac{\sum_{i=1}^{n} \beta_{ext,i} \Delta Z_i Z_i}{\sum_{i=1}^{n} \beta_{ext,i} \Delta Z_i}$$

Z_i: altitude, ΔZ_i:layer of thickness of vertical layer i,
$\beta_{ext,i}$: extinction coefficient (km $^{-1}$) at vertical level i

Comparisons of height definition



- EPIC (TROPOMI) and CALIOP AOCH converge (are the same) for AOCH at ~ 4 km and above.
- GEMS AEH show height dependent positive bias compared to CALIOP AOCH. This bias becomes constant (0.3 km) for height beyond ~ 3 km.
- For further analysis, we converted into same definition for apple-to-apple comparison.

Theoretical basis of retrieving aerosol profile with PCA

- **PCA is used to extract the major vertical variation modes (EOFs) of the aerosol profile shapes from CALIOP.**

- **Decouple the AOD and shape of aerosol profile, i.e., $x = (\tau_0, w_1, w_2, w_3)$**
  - **Normalize the CALIOP aerosol profiles by AOD before PCA**

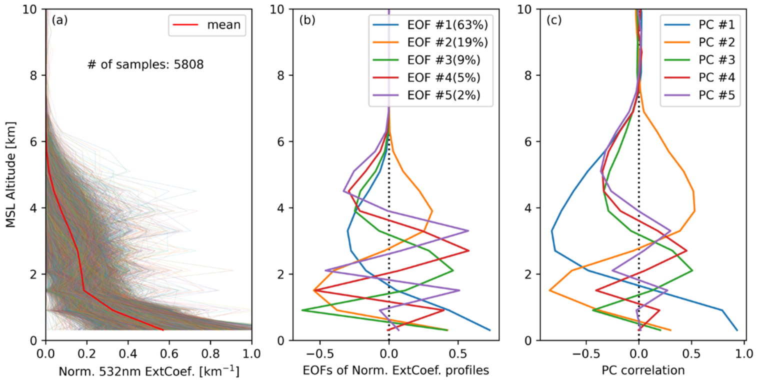
$$\beta_{\text{ext}}(z) = \tau_0\left(\sum_{i=1}^{n} w_i E_i(z) + \overline{\beta'_{\text{ext}}}(z)\right)$$

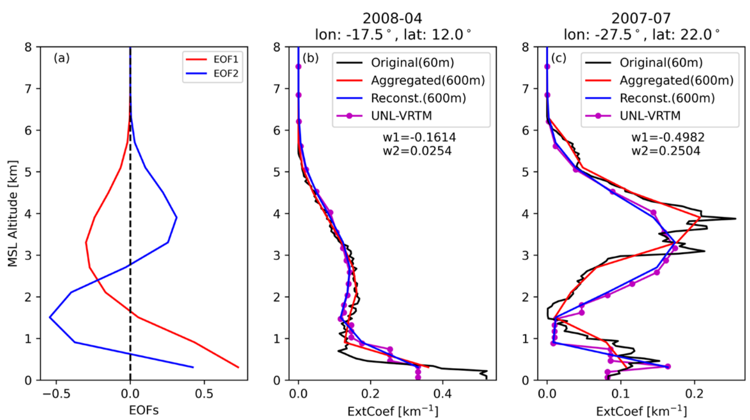
$$\int_0^{\text{TOA}} \left(\sum_{i=1}^{n} w_i E_i(z) + \overline{\beta'_{\text{ext}}}(z)\right) dz = 1$$

- E_i is EOF (eigenvector);
- w_i is weighting coefficient of EOF;
- $\overline{\beta'_{\text{ext}}}(z)$ is mean of normalized aerosol extinction profiles;
- τ_0 is column AOD

Retrieve only 2 EOF weights: vertical aggregation

Each CALIOP aerosol extinction profile is normalized and aggregated to 600 m vertical resolution.





First 2 EOFs explain ~82% of total variability in the vertical.

It is feasible to retrieve the Saharan dust profiles using PCA technique.