EPIC Near-UV Aerosol Product: Status and Validation

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NASA Goddard Space Flight Center

Howard University Beltsville Campus
Fall Series Seminar
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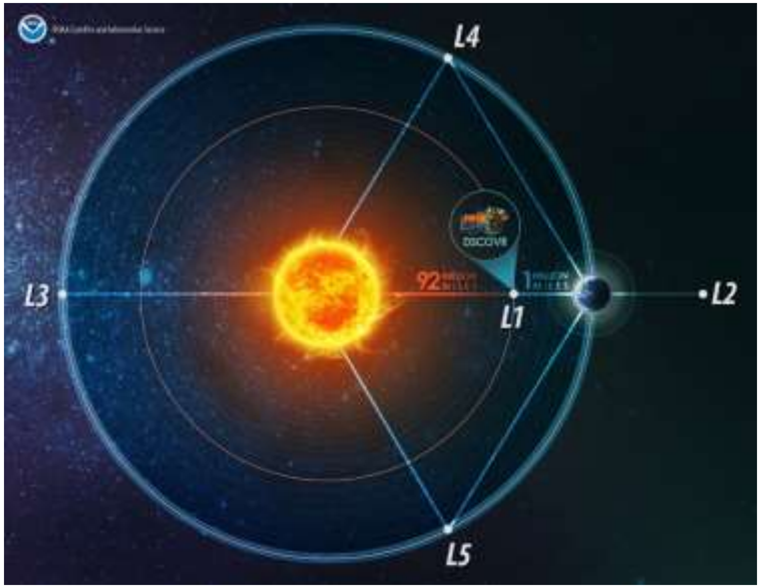
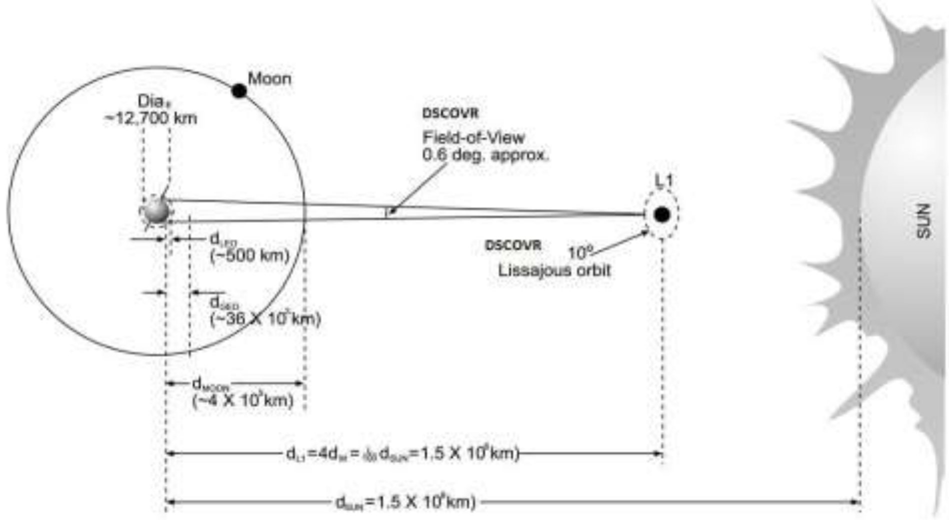
DSCOVR location in space

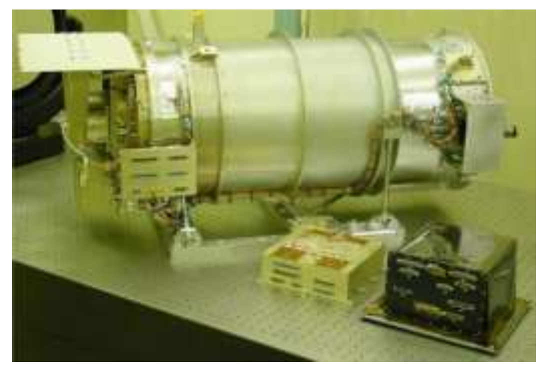


L1 and L2 points are advantageous for Earth remote sensing applications

Earth Panchromatic Imaging Camera – Deep Space Climate Observatory



EPIC actual FOV ~0.6 degrees



-EPIC is one of three sensors on the DSCOVR spacecraft.
-Launched on Feb. 11 2015
-Reached L1 point on June 8, 2015
-Observes the Sun-lit face of the Earth from sunrise to sunset every 66 minutes.
-Spatial Resolution ~ 18 km

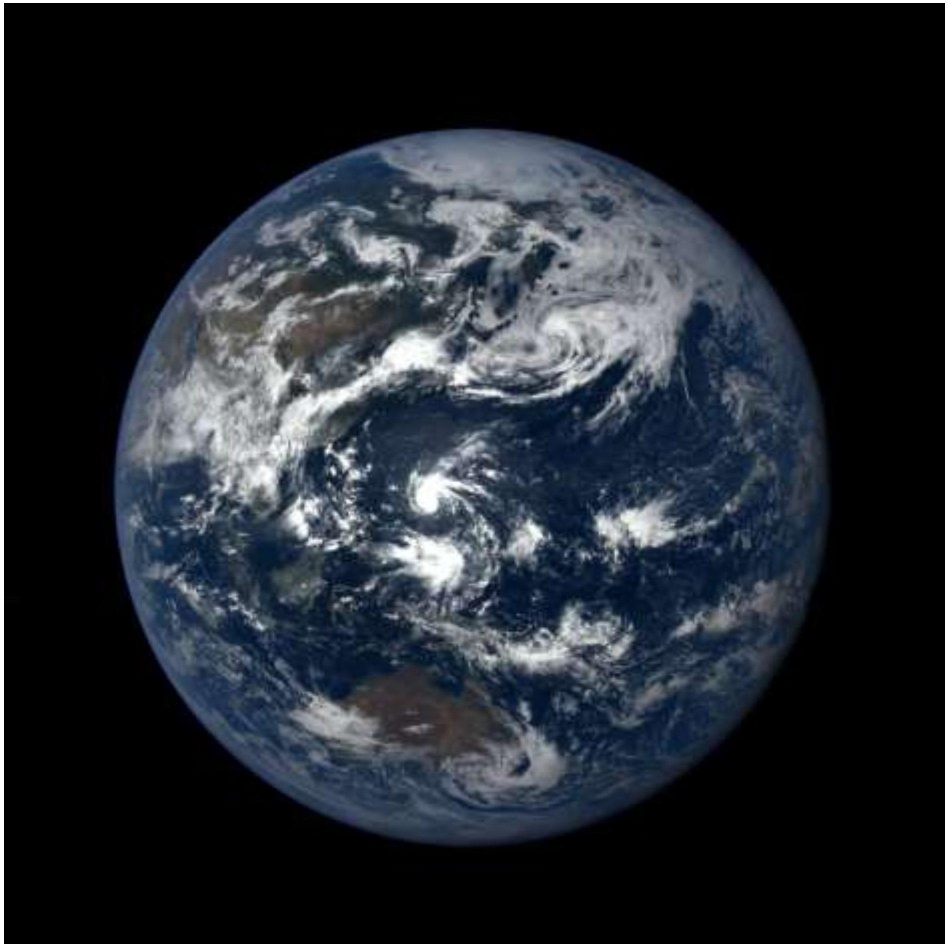
Marshak, A., et al., 2018: Earth Observations from DSCOVR EPIC Instrument, *Bull. Amer. Meteor. Soc.*, **99**, 1829–1850, doi:10.1175/BAMS-D-17-0223.1

EPIC Channels and Products

λ (nm)	FWHM (nm)	Nominal Product
317.5 ±0.1	*1 ±0.2*	*Ozone*
325 ±0.1	*2 ±0.2*	*Ozone*
340 ±0.3	*3 ±0.6*	*Ozone, Aerosols, Clouds*
388 ±0.3	*3 ±0.6*	*Aerosols, Clouds*
443 ±1	*3 ±0.6*	*Aerosols*
551 ±1	*3 ±0.6*	*Aerosols, Vegetation*
680 ±0.2	*2 ±0.4*	*Aerosol, Vegetation, Clouds, O_2 B-Band Reference*
687.75 ±0.2	*0.8 ±0.2*	*O_2 B-Band Cloud Height*
764.0 ±0.2	*1 ±0.2*	*O_2 A-Band Cloud Height, Aerosol Height*
779.5 ±0.3	*2 ±0.4*	*O_2 A-Band Reference, Vegetation*

Marshak, A., et al., 2018: Earth Observations from DSCOVR EPIC Instrument, *Bull. Amer. Meteor. Soc.*, **99**, 1829–1850, doi:10.1175/BAMS-D-17-0223.1

Moon Transit Movie



EPIC near UV Aerosol Products

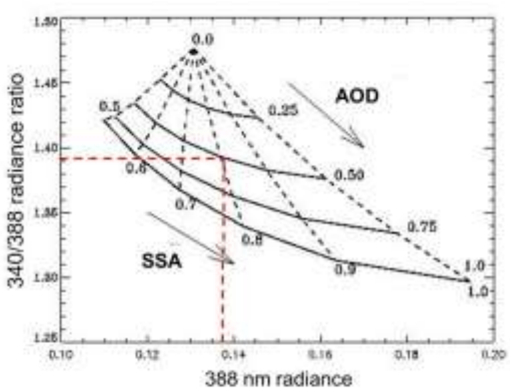
-UV Aerosol Index
-Aerosol Optical Depth (388 nm)
-Single Scattering Albedo (388 nm)

$$UVAI \quad -100\left\{\log\left[\frac{I_{340}^{obs}}{I_{388}^{obs}}\right]-\log\left[\frac{I_{340}^{cal}}{I_{388}^{cal}}\right]\right\}$$

Difference between observed and calculated UV Spectral Contrast

-UVAI is sensitive to AOD, aerosol layer height, Aerosol Absorption Exponent
-UVAI typical values vary from -1 (non-absorbing aerosols) to about 6 (large AOD tropospheric smoke and dust layers)
-Double-digit UVAI values are generally associated with high altitude absorbing aerosol layers (volcanic ash and carbonaceous particles)

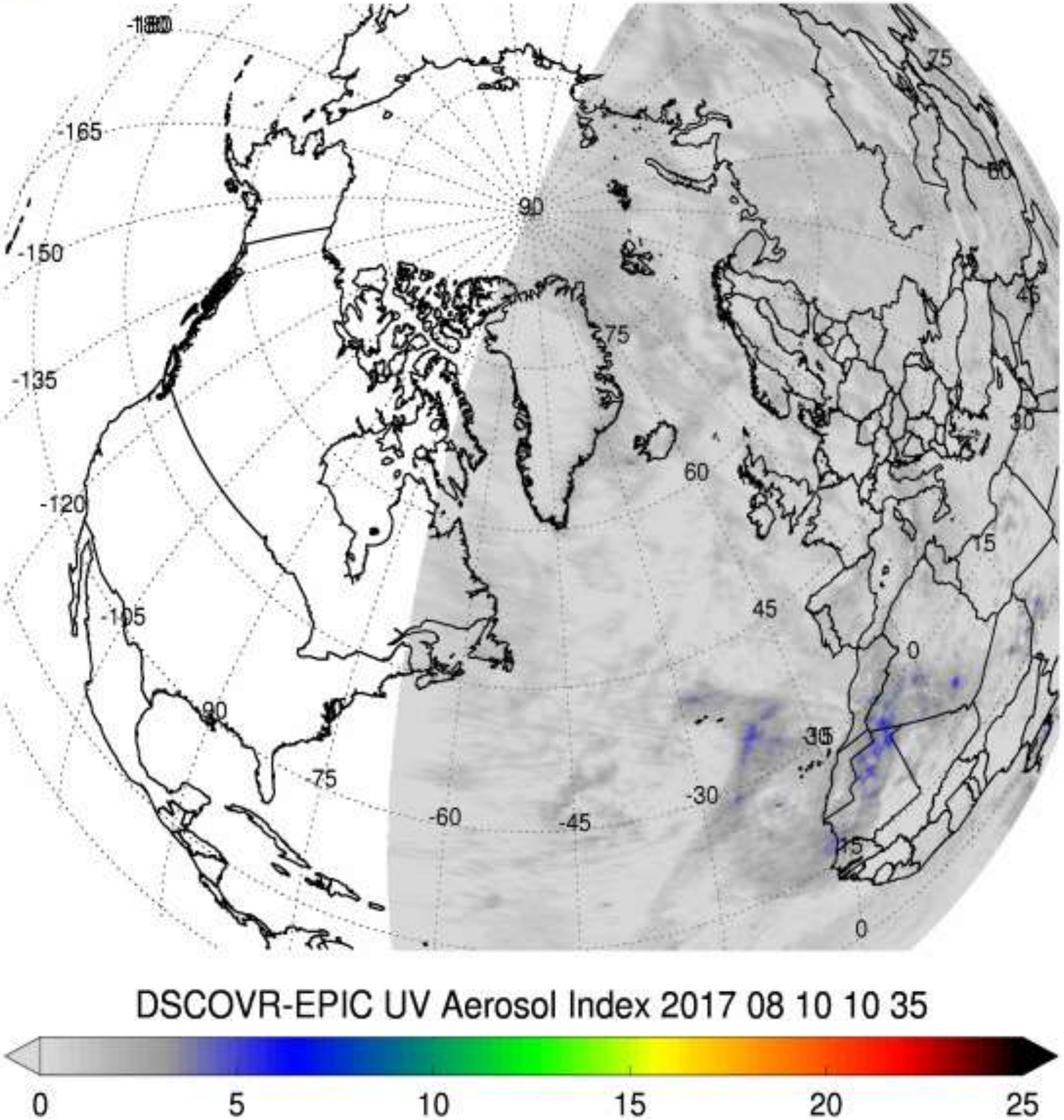
Quantitative Products



Inversion Scheme:
For a given aerosol type and layer height, satellite measured radiances at 340 and 388 nm are associated with a set of AOD and SSA values.

Marshak, A., et al., 2018: Earth Observations from DSCOVR EPIC Instrument, *Bull. Amer. Meteor. Soc.*, **99**, 1829–1850, doi:10.1175/BAMS-D-17-0223.1

PyroCb event of August, 2017
EPIC Version 3 L1b data



Current Status

- The near-UV aerosol algorithm (EPICAERUV) was applied to the entire record of EPIC Version 2 L1B.

- The product includes

    - *Aerosol Optical Depth*
    - *Single-scattering Albedo*
    - *Aerosol Absorption Optical Depth*
    - *UV Aerosol Index*
    - *Reflectivity*

    - *Above-cloud aerosol optical depth*
    - *Aerosol-corrected cloud optical depth*

    } **Testing mode**

- Testing of Version 3 L1B on EPICAERUV underway

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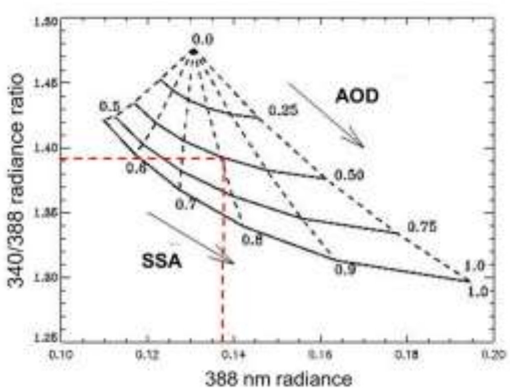

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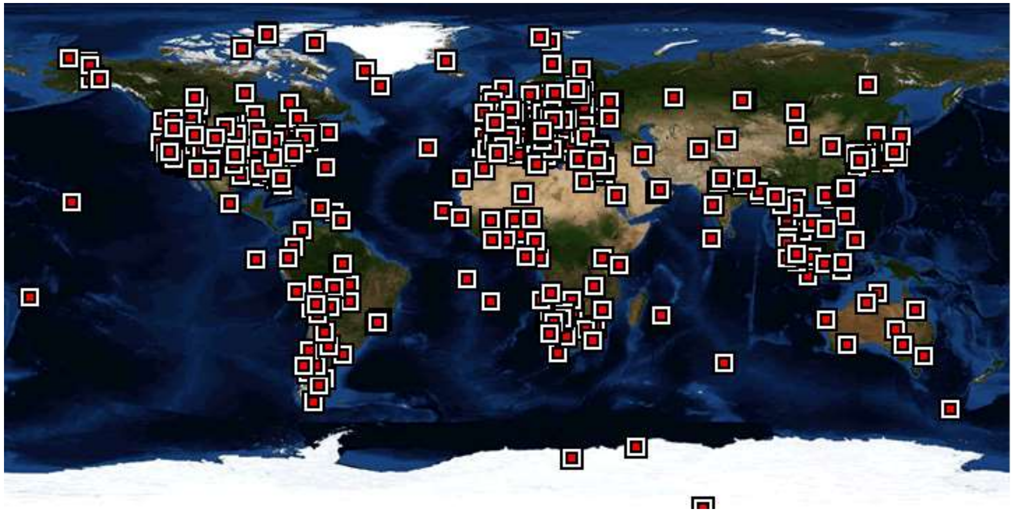
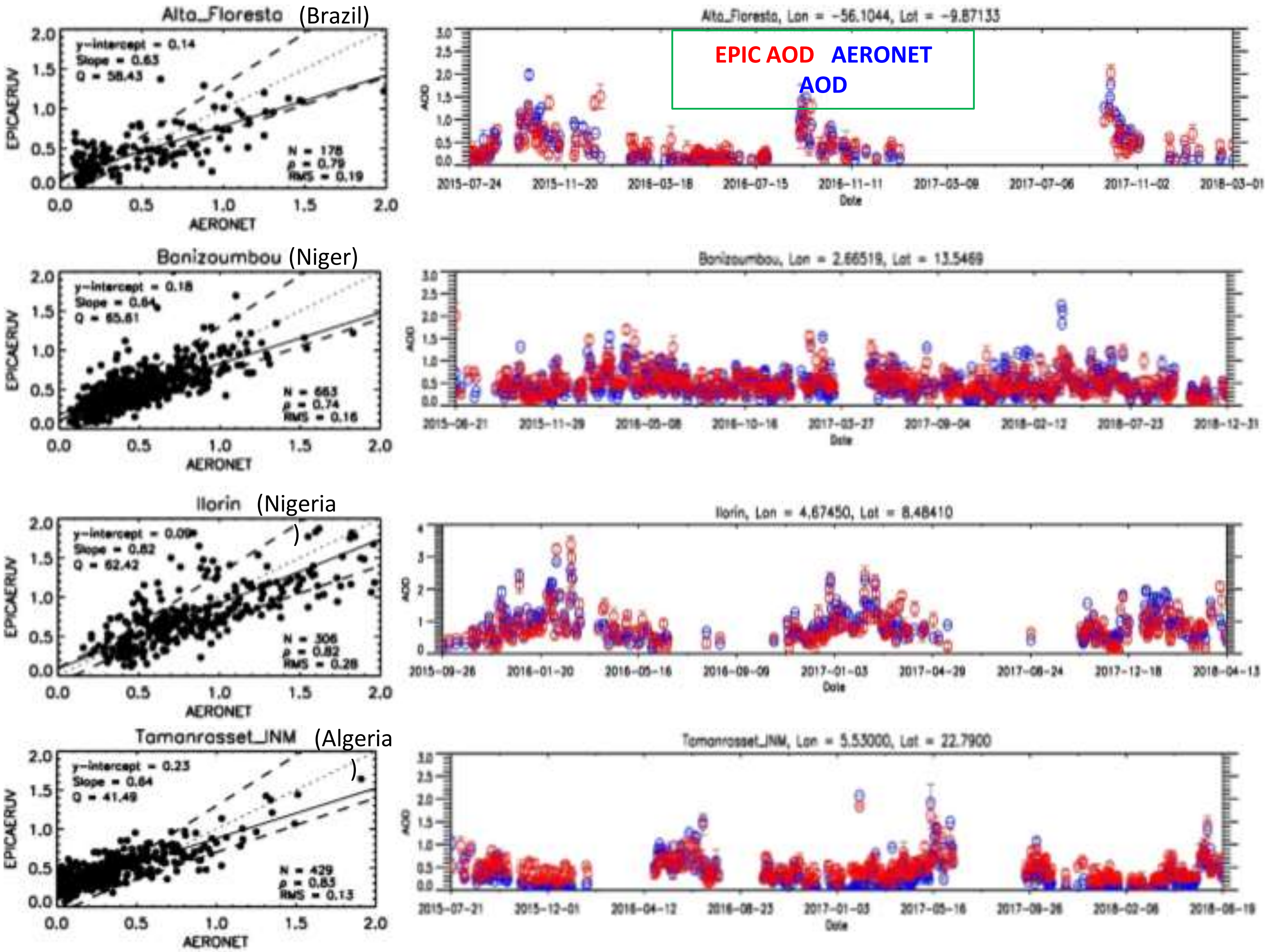
Validation of EPIC Aerosol Product

- Nearly 4-year long EPICAERUV retrievals are validated against ground-based AERONET data set.
- Both AOD and SSA products are evaluated.
- AERONET Version 3 dataset

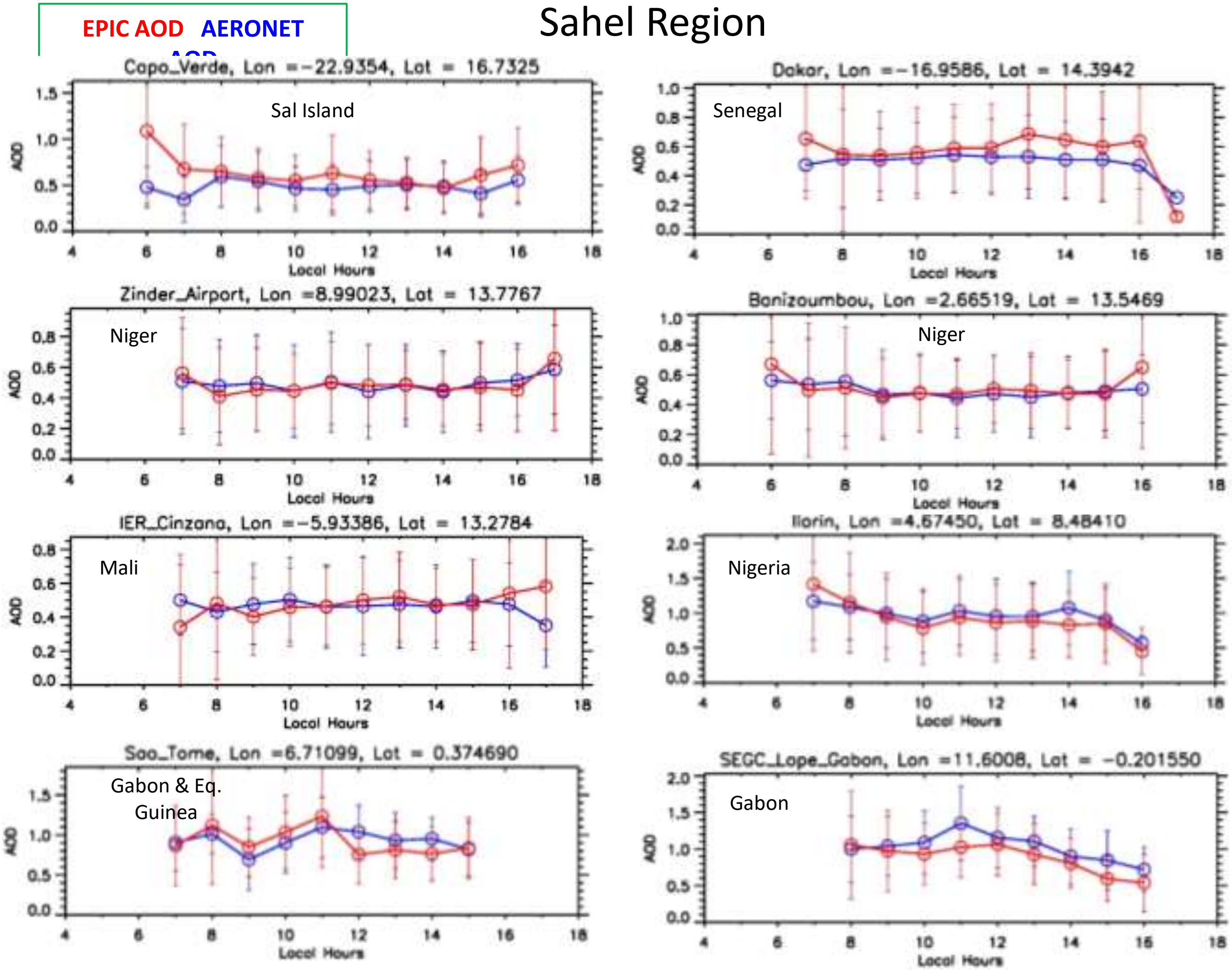
Globally distributed AERONET 2017





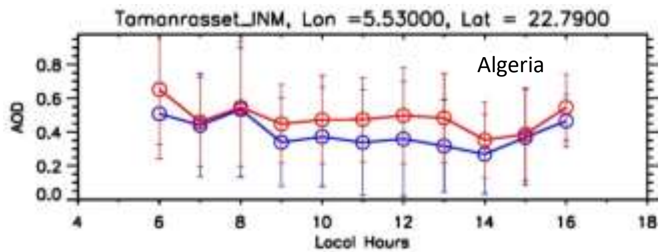
Alto_Floresta (Brazil)
y-intercept = 0.14
Slope = 0.63
Q = 58.43
N = 178
ρ = 0.79
RMS = 0.19
EPICAERUV
AERONET
Alto_Floresta, Lon = -56.1044, Lat = -9.87133
EPIC AOD
AERONET AOD
AOD
Date
Bonizoumbou (Niger)
y-intercept = 0.18
Slope = 0.64
Q = 65.61
N = 663
ρ = 0.74
RMS = 0.16
Bonizoumbou, Lon = 2.66519, Lat = 13.5469
Ilorin (Nigeria)
y-intercept = 0.09
Slope = 0.82
Q = 62.42
N = 306
ρ = 0.82
RMS = 0.28
Ilorin, Lon = 4.67450, Lat = 8.48410
Tamanrasset_INM (Algeria)
y-intercept = 0.23
Slope = 0.64
Q = 41.49
N = 429
ρ = 0.85
RMS = 0.13
Tamanrasset_INM, Lon = 5.53000, Lat = 22.7900

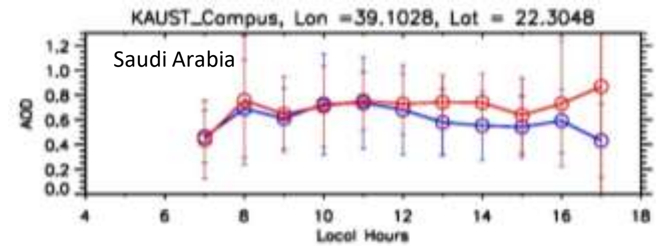
Sahel Region

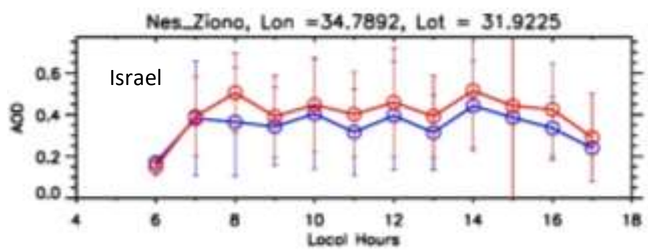


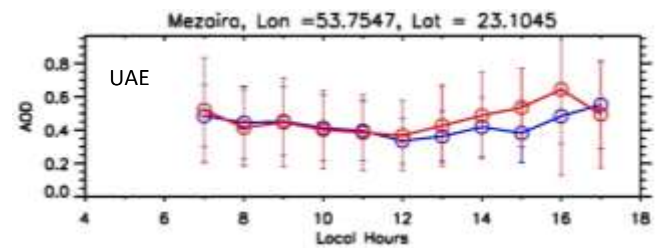
Desert Region

EPIC AOD **AERONET AOD**

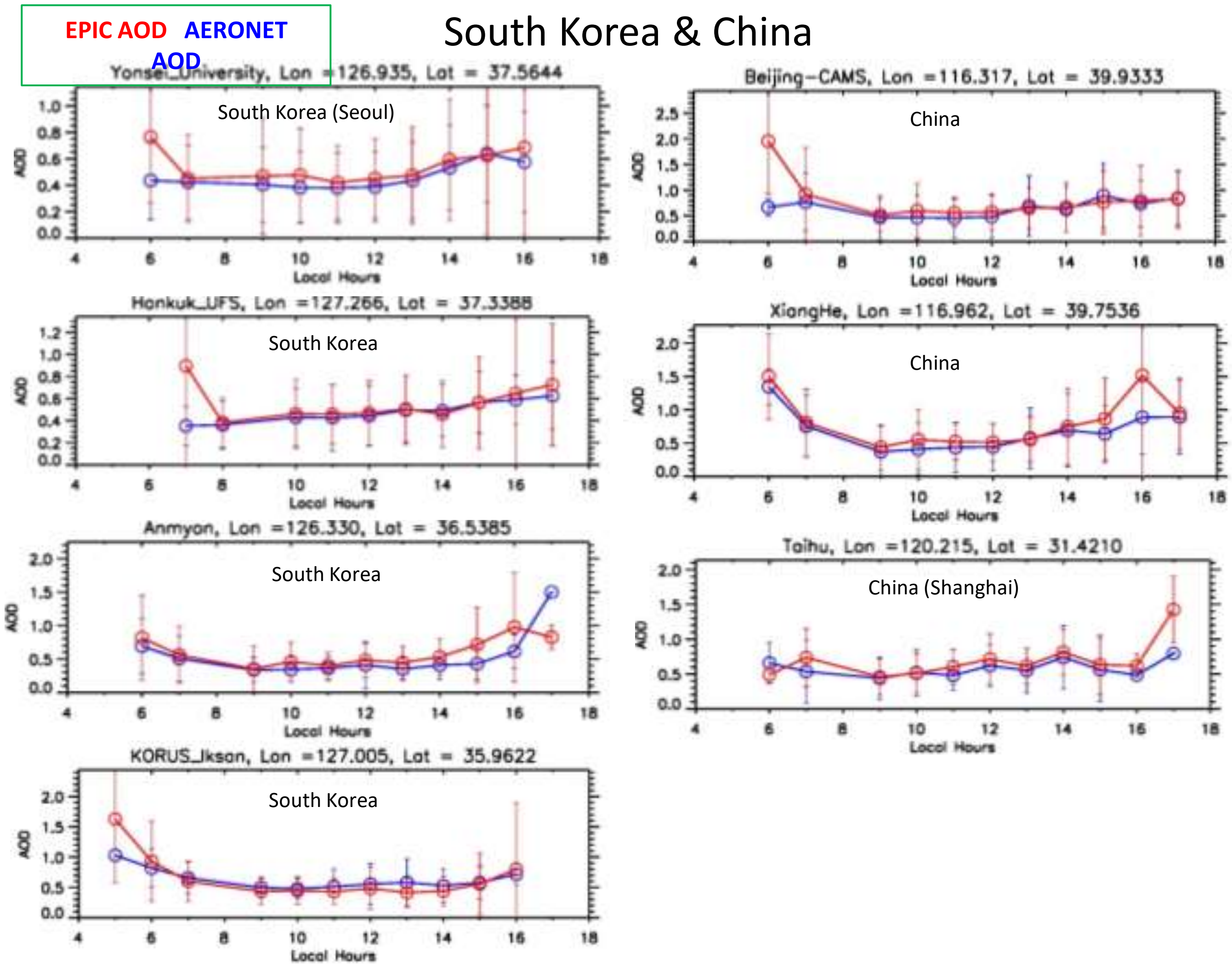




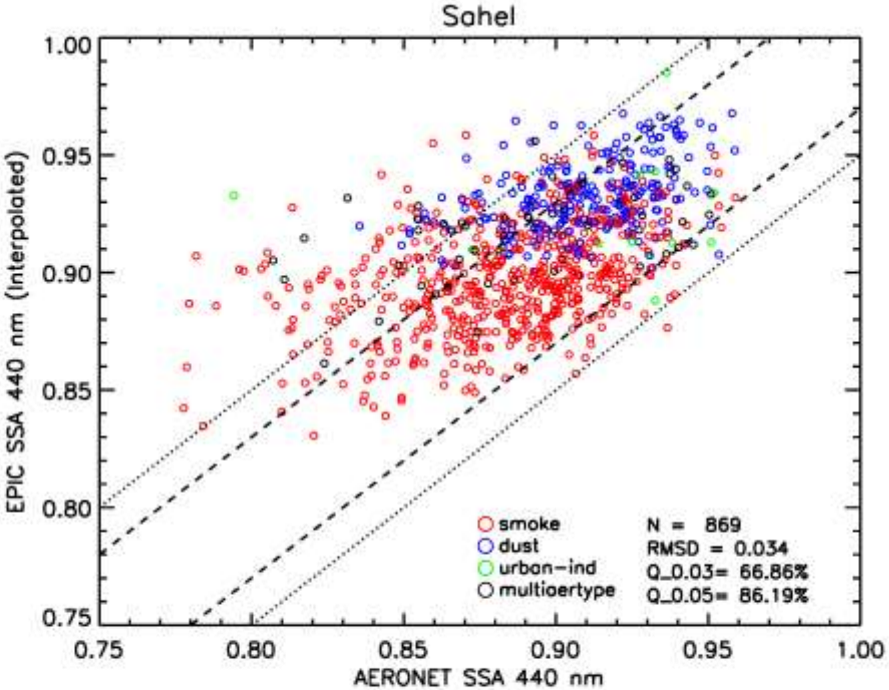


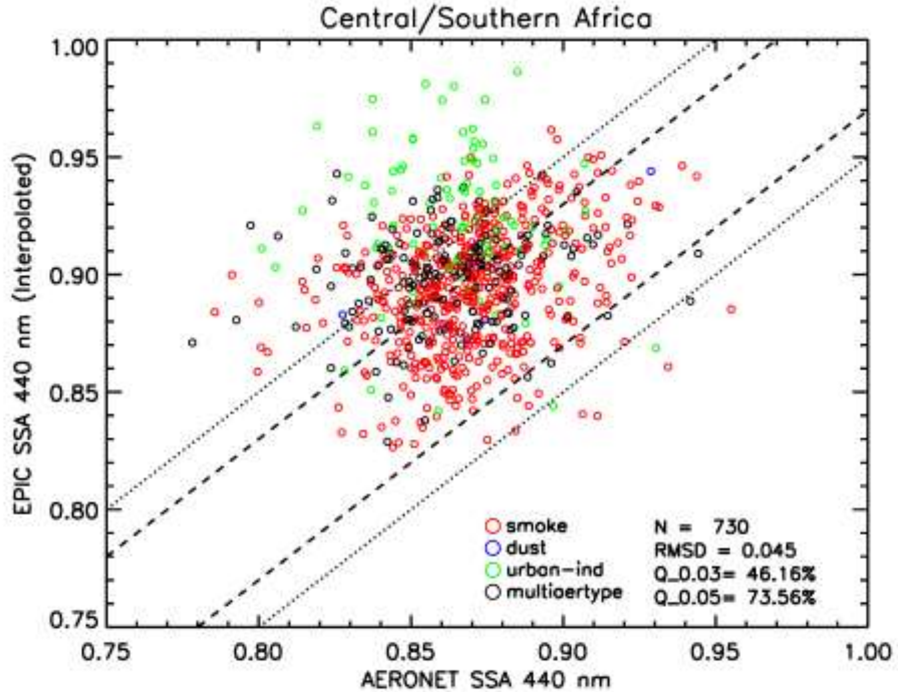


South Korea & China



Single Scattering Albedo Evaluation





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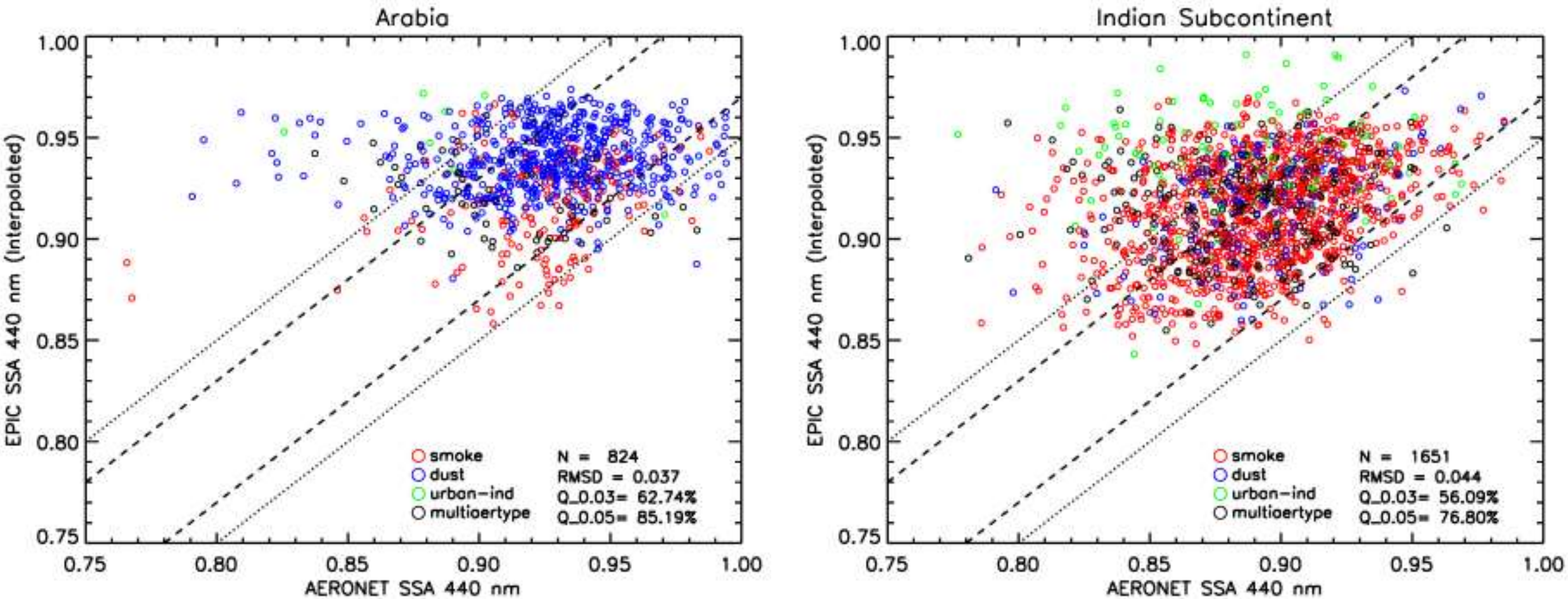

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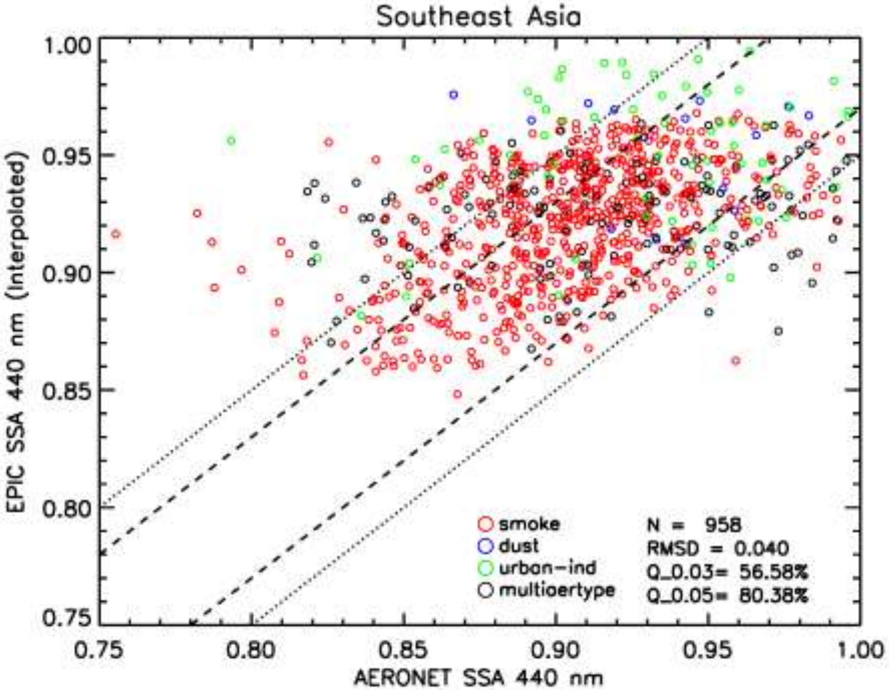
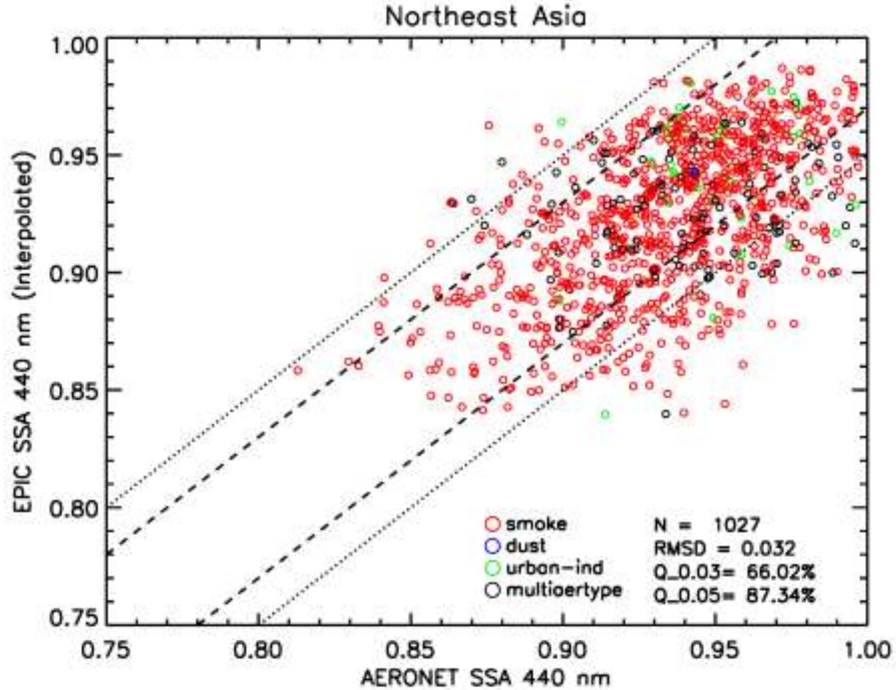
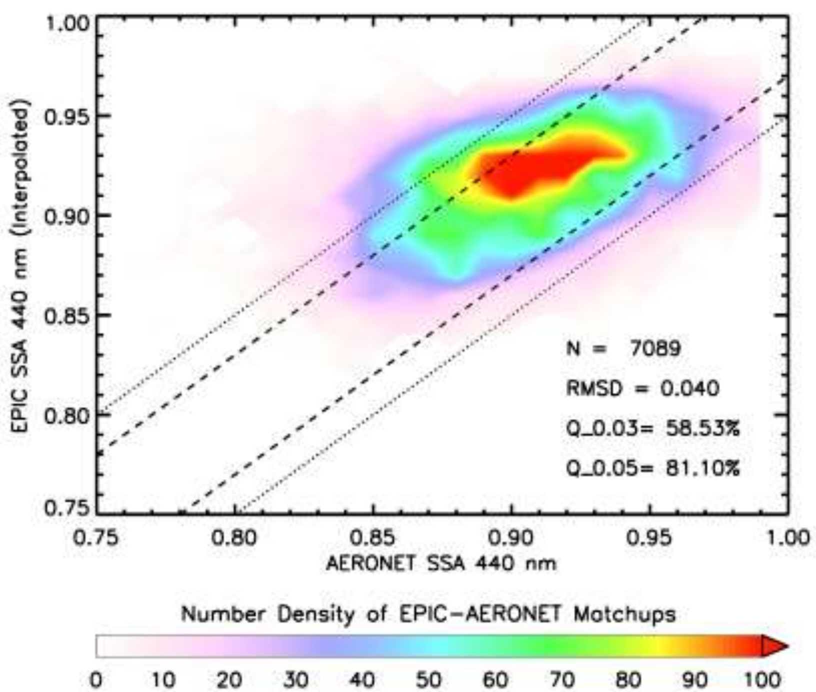
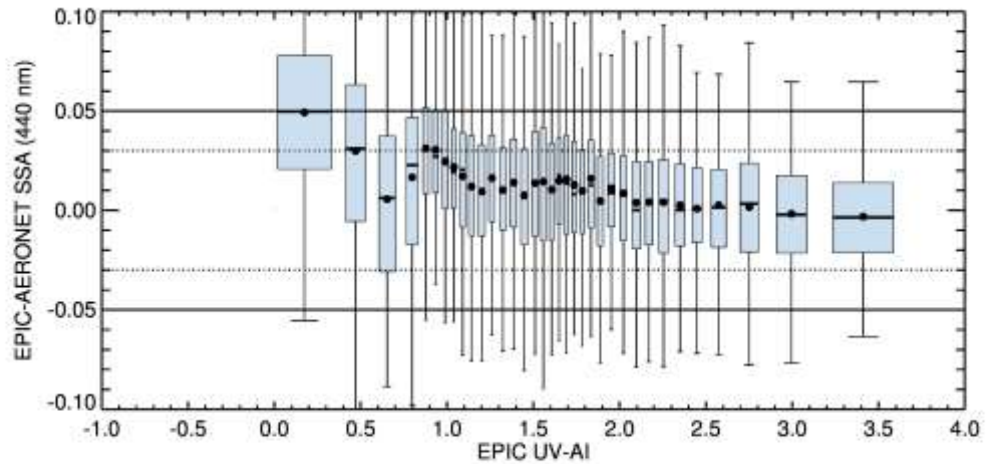
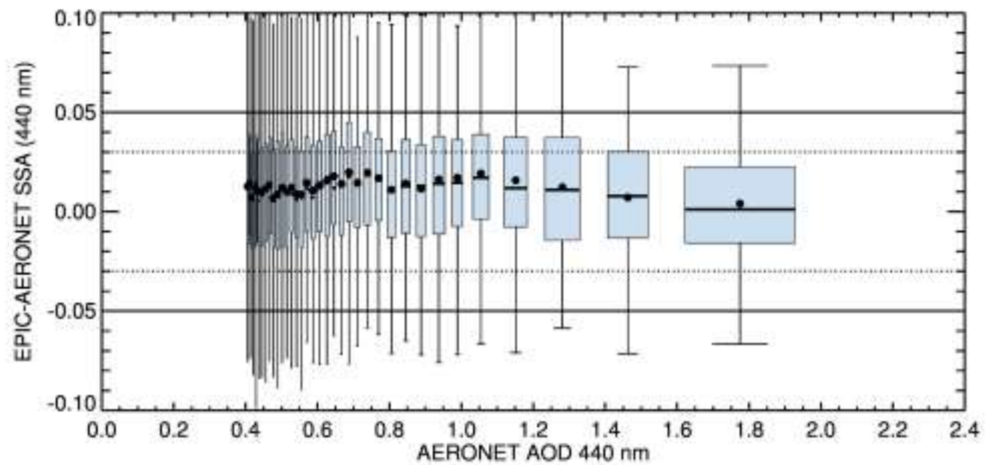




Summary of Single Scattering Albedo Evaluation







Nearly 60% and 80% matchups are within 0.03 and 0.05

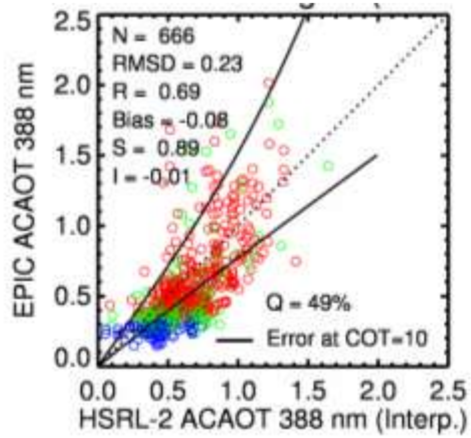
Validation
EPIC Above-cloud AOD

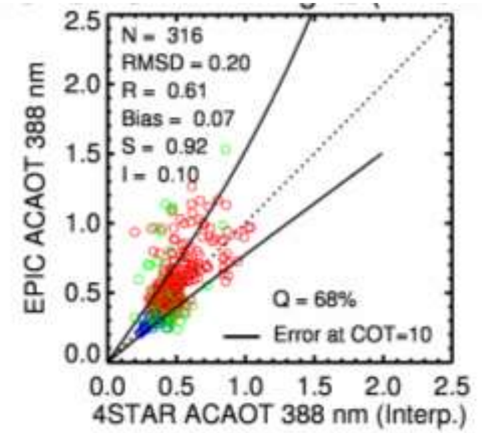
Against

ORACLES airborne measurements

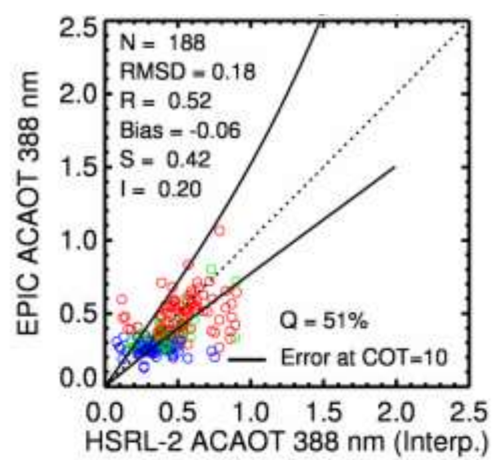
>50% matchups are within expected uncertainties

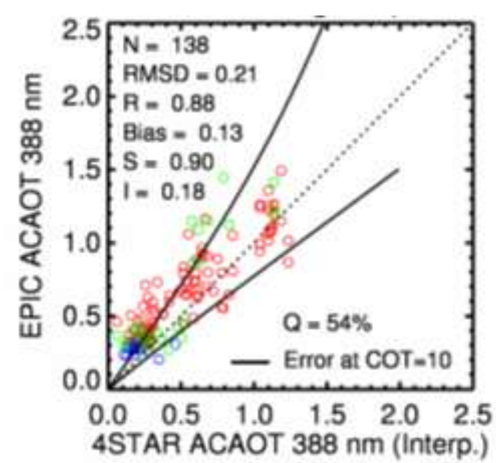
2016



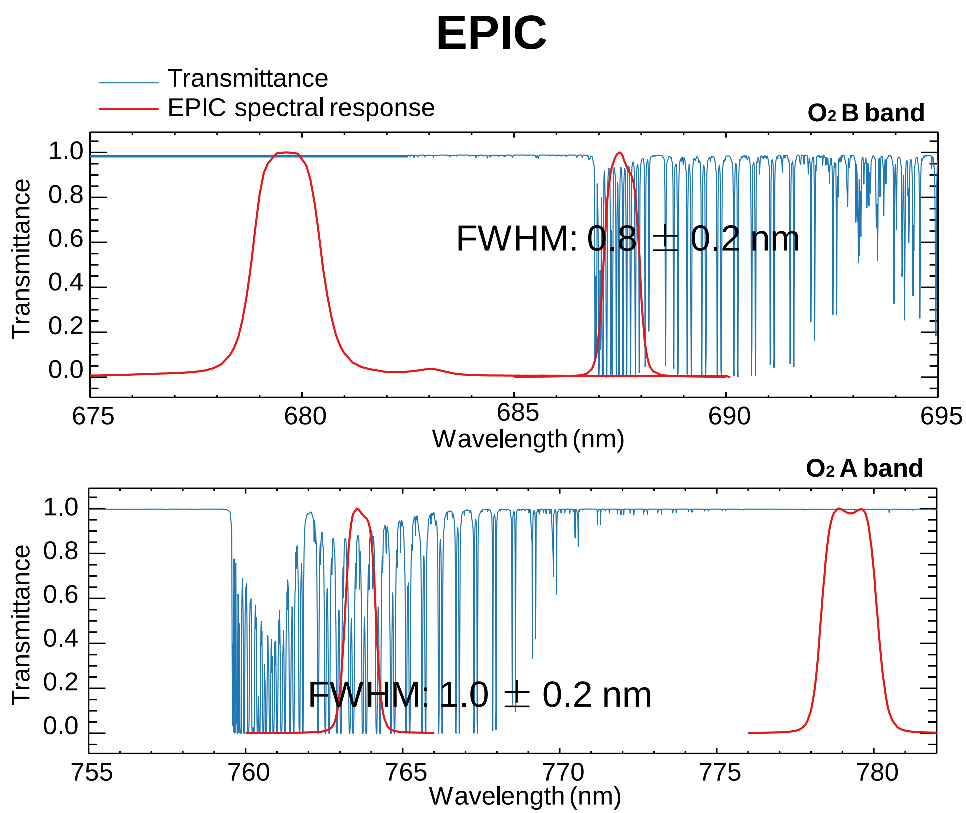


2017



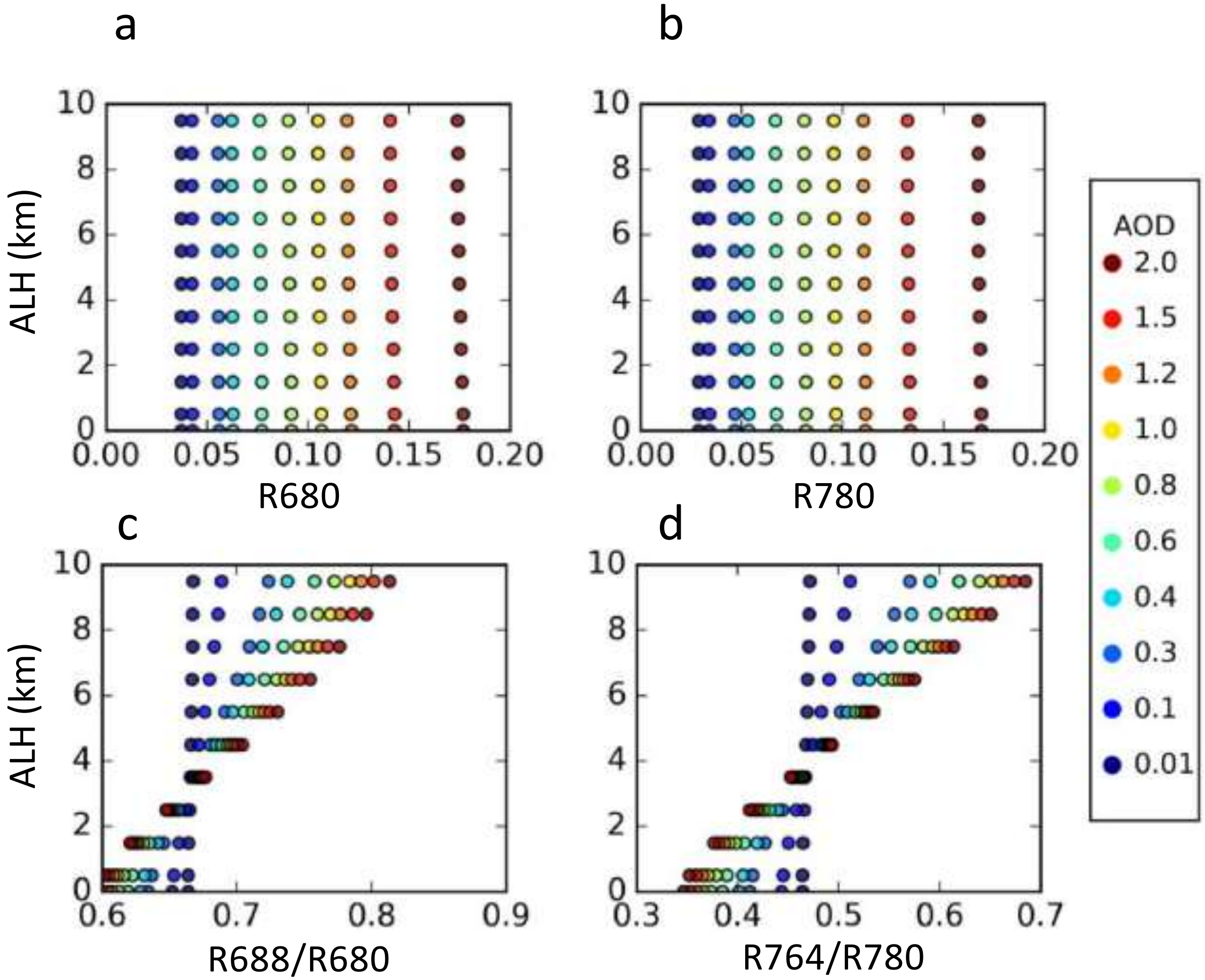


Aerosol Layer Height from O2 A and B bands of EPIC

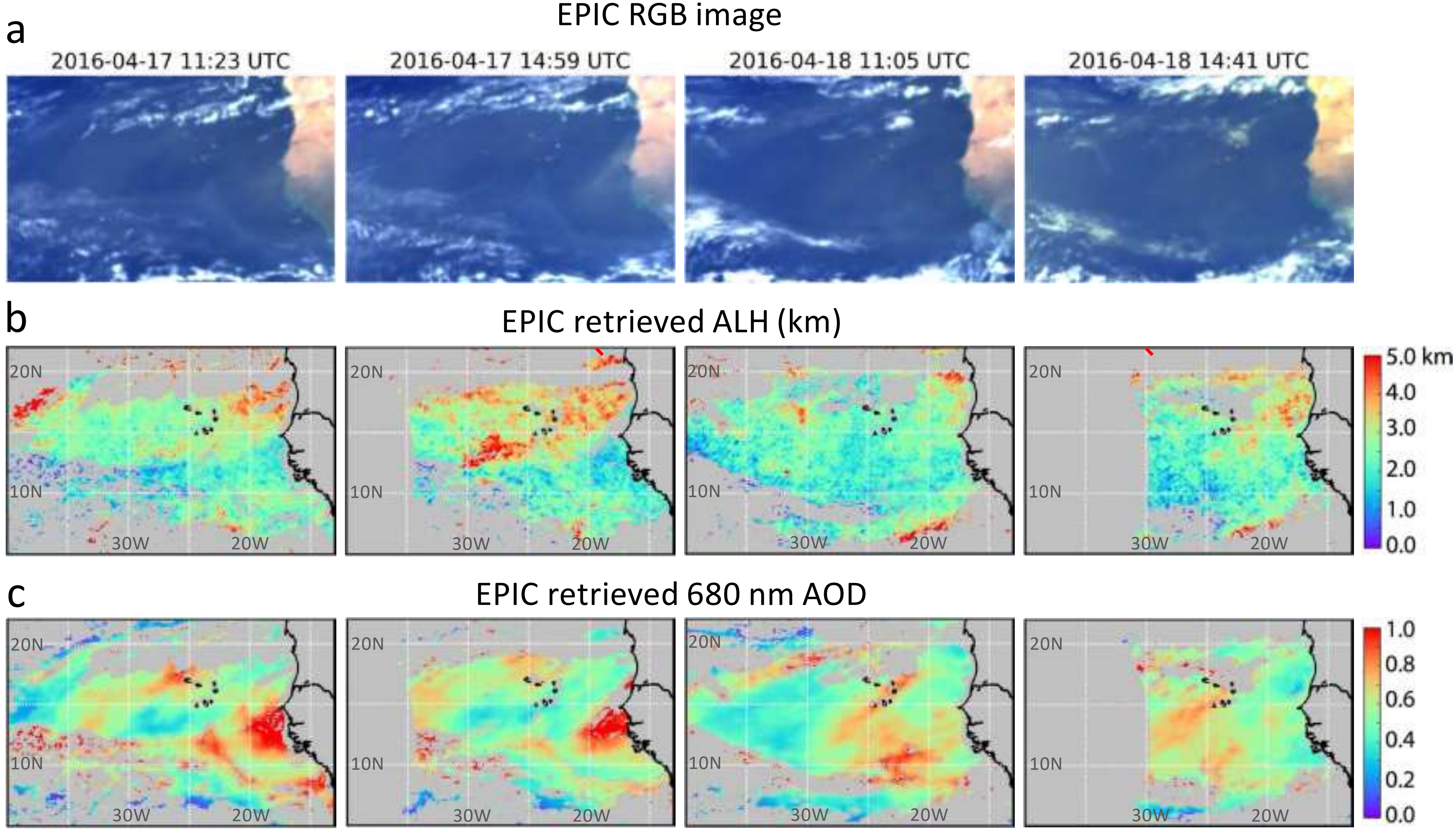


Xu, X., J. Wang, Y. Wang, J. Zeng, O. Torres, Y. Yang, A. Marshak, J. Reid, *and* S. Miller *(*2017*),* Passive remote sensing of altitude and optical depth of dust plumes using the oxygen A and B bands: First results from EPIC/DSCOVR at Lagrange-1 point*,* Geophys. Res. Lett.*,* 44*, doi:*10.1002/2017GL073939.

Simultaneous Retrieval of AOD and ALH

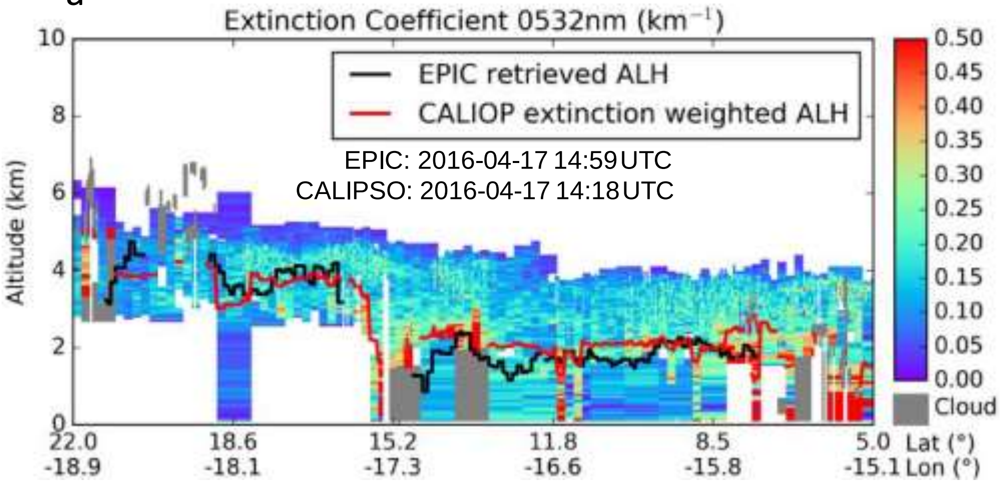


Retrieval of plume height and AOD

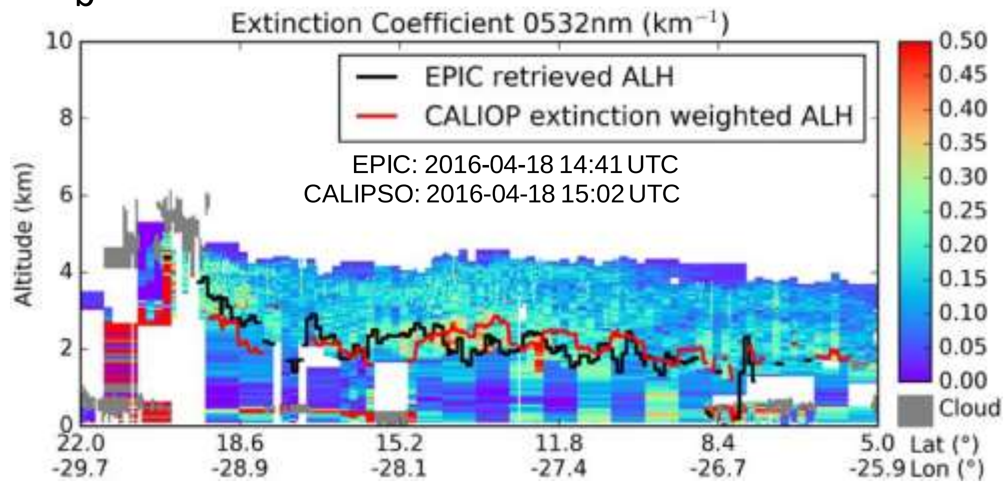


Validation with CALIOP and MODIS data

a

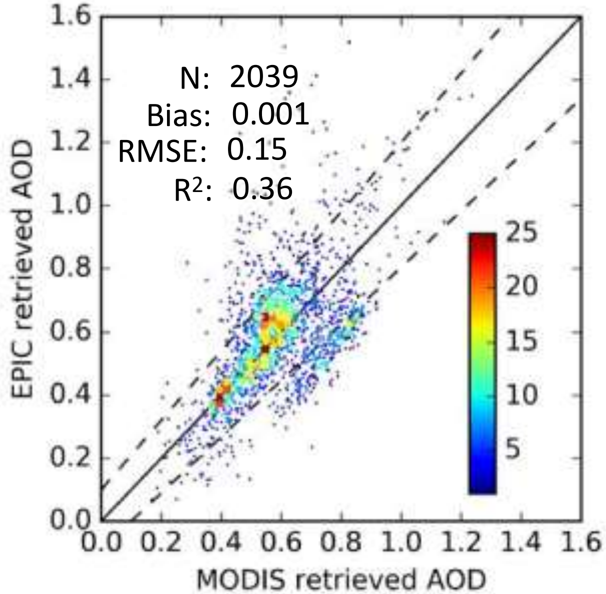


b



AOD evaluations

a



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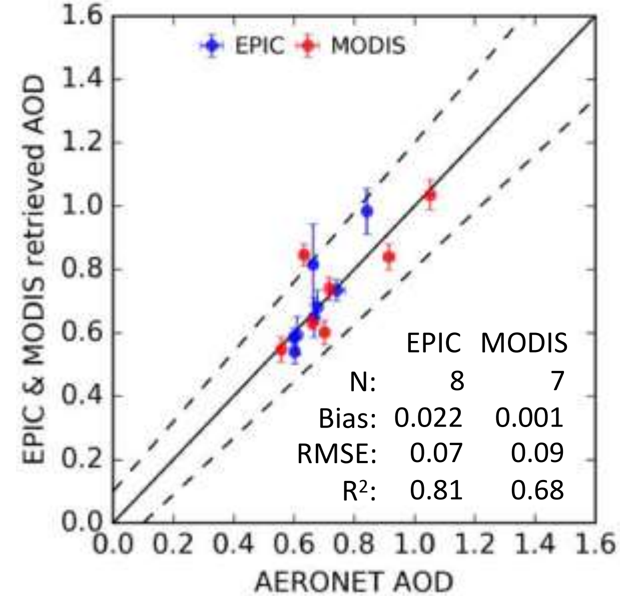
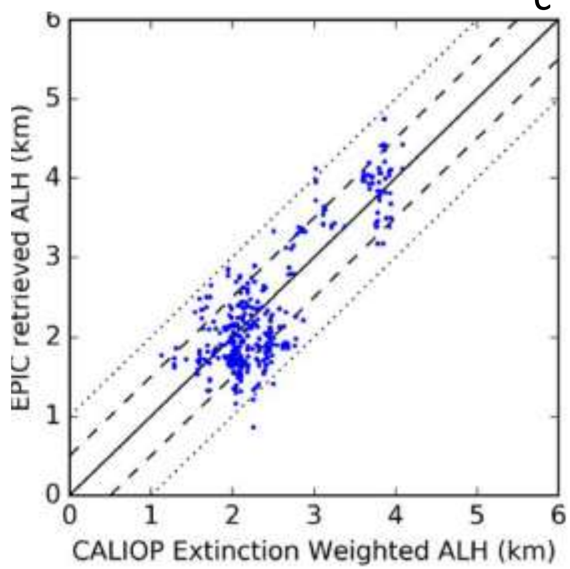


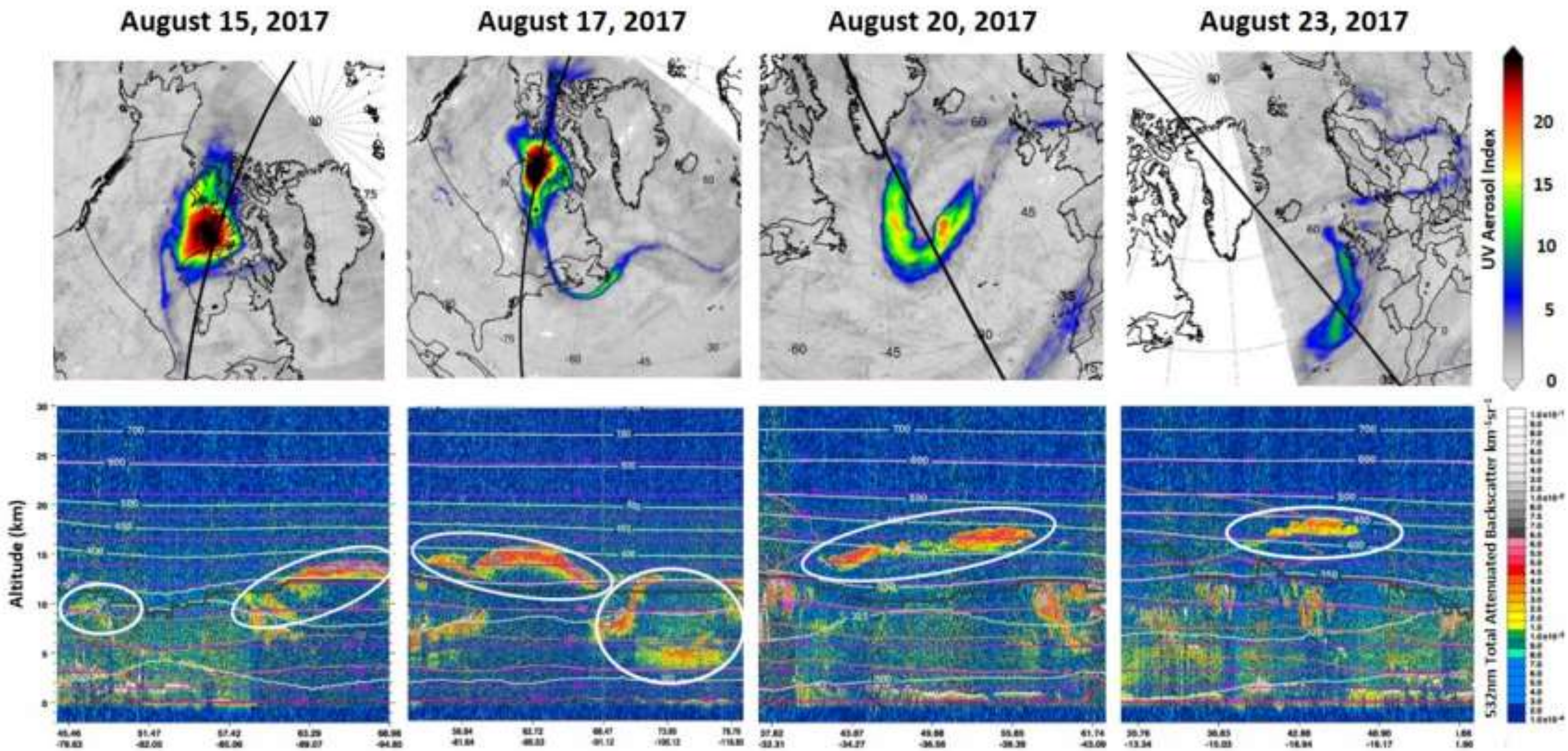
c



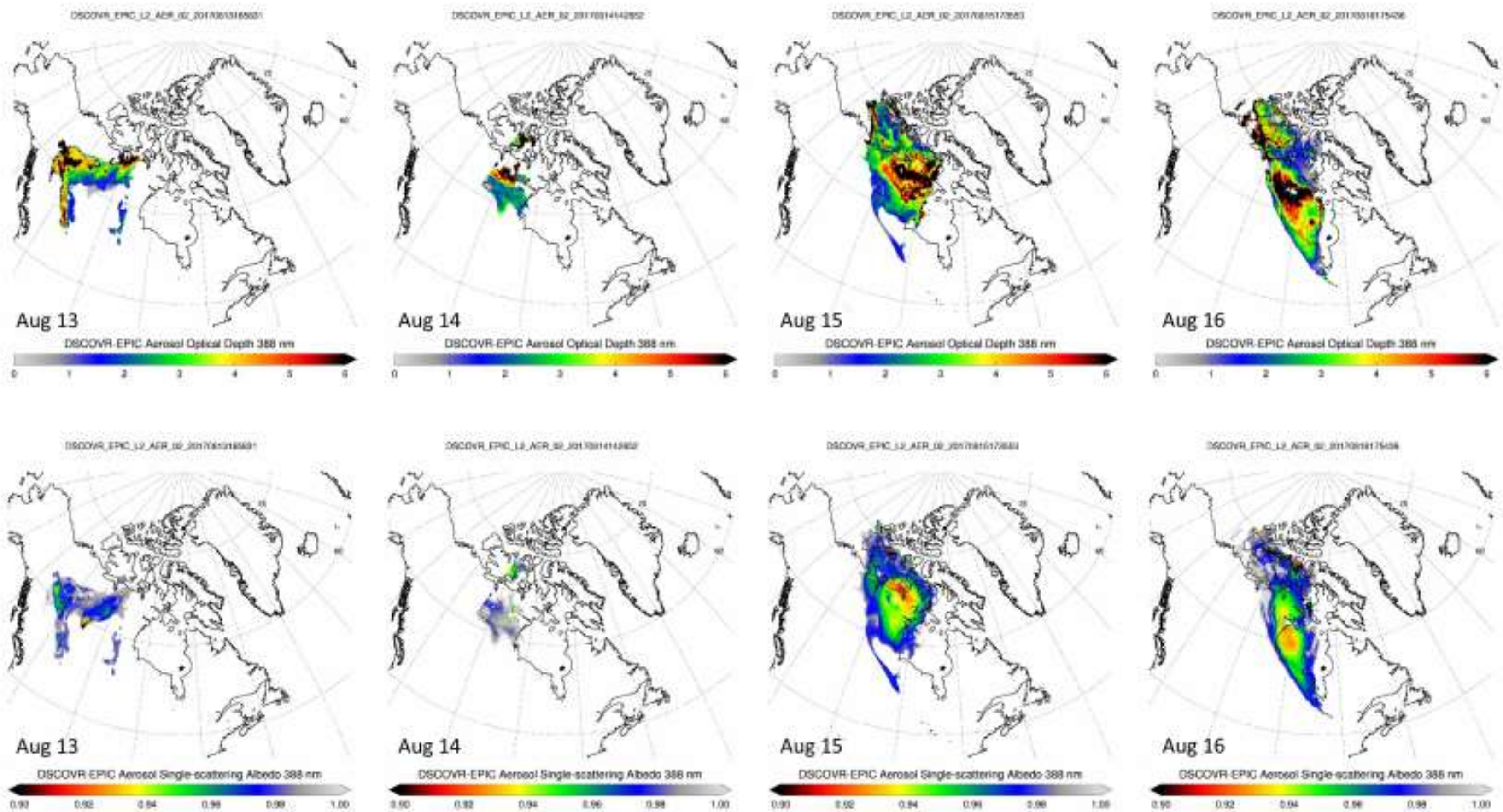
Stratospheric Injection of Massive Smoke Plume from Canadian Boreal Fires in 2017: EPIC verification of self-lifting of carbonaceous aerosol layers

Torres et al., Stratospheric Injection of Massive Smoke Plume from Canadian Boreal Fires in 2017 as seen by DSCOVR-EPIC, CALIOP and OMPS-LP Observations, 2019, JGR (under review)

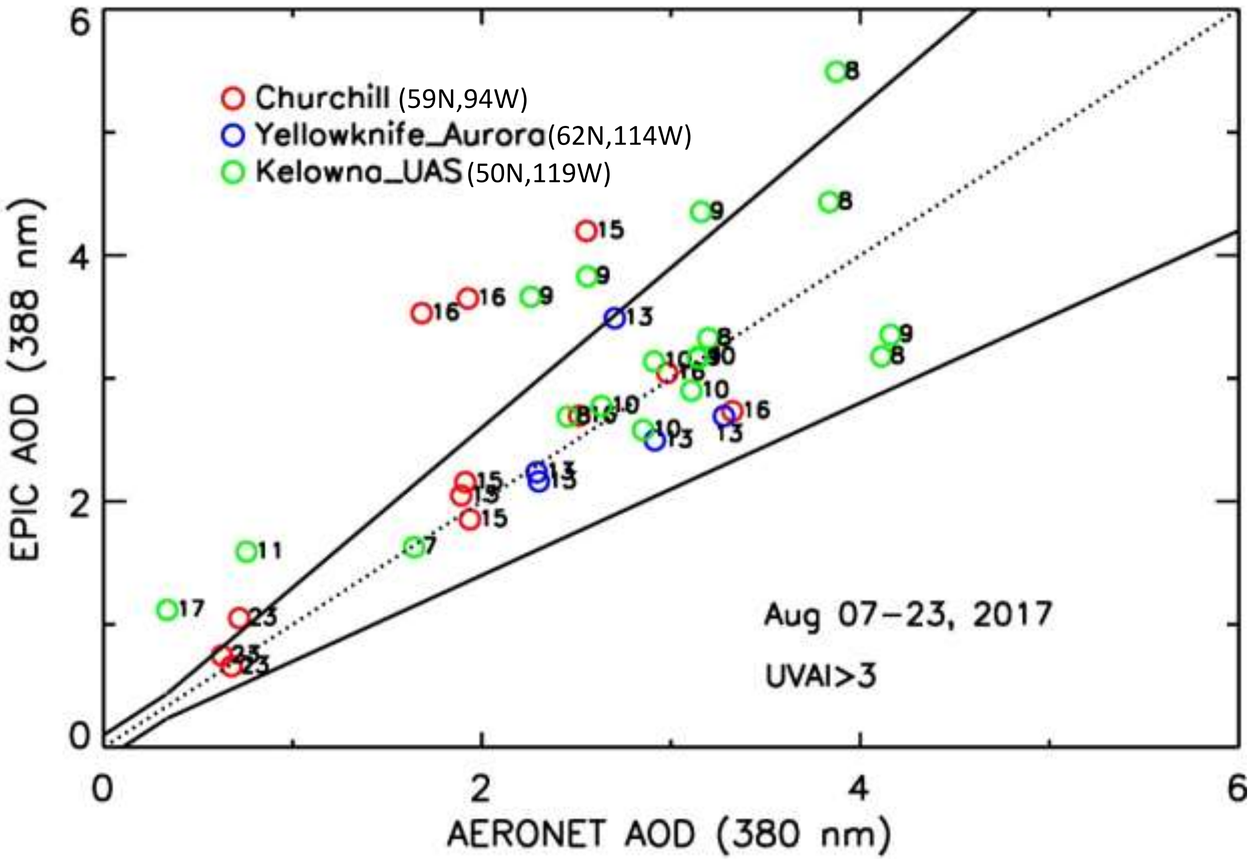
EPIC and CALIOP view

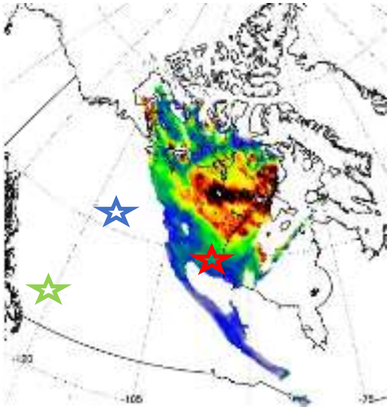


ALH constrained EPIC AOD/SSA Retrievals



EPIC-AERONET AOD comparison





Comparisons at the Kelowna_UAS site use standard EPICAERUV retrievals
Other sites use ALH (> 10 km) constrained research algorithm

Stratospheric Aerosol Mass Calculation

$$M = \Sigma \frac{4}{3} \rho r_{eff} A \boldsymbol{\tau_{str}} \boldsymbol{f}(r_{eff})$$

ρ is the carbonaceous aerosol particle mass density in g-cm^{-3} (0.79 -1.53)

r_{eff} is the radiatively effective radius

A is the effective geographical area associated with retrieved τ_{str}

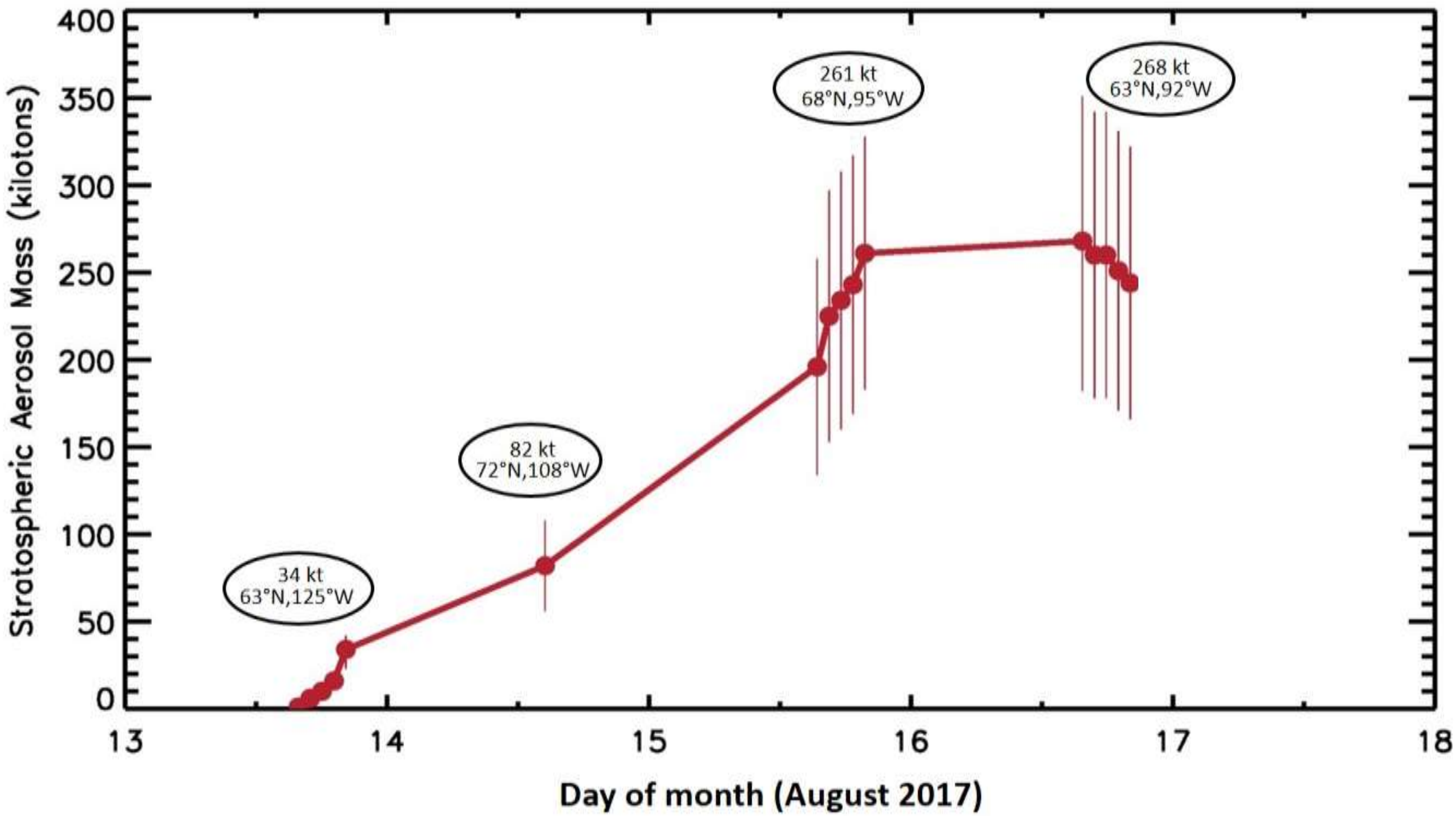
$f(r_{eff})$ is a dimensionless extinction-to-mass conversion factor, averaging over particle size distribution, defined as

$$f = \int_0^\infty r^2 n(r) \partial r \Big/ \int_0^\infty r^2 Q_{ext}(r) n(r) \partial r$$

n(r)dr is the assumed number particle size distribution,
Q_{ext} *(r)* is the extinction efficiency factor calculated using Mie scattering theory

Standard EPICAERUV particle size distribution for carbonaceous aerosols (AERONET-based)

Time line of EPIC-derived Carbonaceous Aerosol Injection in the Stratosphere



-Large day-night differences in aerosol mass injection rates are apparent.

-Observed day-night differences are consistent with solar heating processes such as production of secondary organic aerosols (photooxidation) and self-lofting resulting from aerosol absorption of solar radiation.