Global Dust Optical Depth Climatology Derived from CALIOP And MODIS Aerosol Retrievals on Decadal Time Scales: Regional and Interannual Variability

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Image credit (NASA GSFC)

## **Background and Motivation**



Long-term satellite-based **dust** AOD observations are needed for studying the DRE, the seasonal/interannual variabilities, and climatological trend of dust aerosols

## Methodology and Objectives

Sensors	Retrieve Scope	Relevant variables used to derive DAOD	References	We pro
MODIS	Ocean	AOD, fine mode fraction	Kaufman et al. 2005	(2007- <b>data</b> o
			Yu et al.2009, 2020	extinct
MODIS	Land	Spectral SSA, Angstrom exponent	Ginoux et al. 2010;	a <b>glob</b> CALIO
			Pu and Ginoux, 2017	(Public
CALIOP	Globe	Profiles of backscatter and depolarization ratio	Yu et al. 2015a	

We produced a decadal (2007-2019) **climatological data** of DAOD and dust extinction vertical profile on a **global scale** based on CALIOP observations. (Publicly available)

Scientific Questions:

- How are shape-based CALIOP and size-based MODIS DAOD retrievals different from each other?
- What are the potential reasons for the differences?
- What are the seasonal and interannual (decadal trends) of DAOD based on the two DAOD retrievals?

### UMBC Dust Detection and AOD Partition

## CALIOP (Shape)

V.

# MODIS (Size)





#### **DAOD** comparison



# **WUMBC** DAOD comparison



#### DAOD comparison Sahara Desert (a) Middle East (b) Eastern Asia (c) 2.0 2.0 2.0 20 y=0.864x+(-0.044)Good agreement y=0.855x+(0.057)y=0.262x+(0.031) $R^2 = 0.133$ 60°5 180+ 150°W 120°W 90°W 20 60\*W 30\*W 10+E 60<sup>+</sup>E 901E 120+5 $R^2 = 0.435$ (aova) CALIOP (DAOD) (DAOD) 1.0 1.0 0.5 15 bad agreement 15 Internal mixing of dust? 40 10 CALIOP 0.5 0.5 20 0.0 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 0.00 0.25 0.50 0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 1.50 1.75 2.00 0.75 1.00 1.25 MODIS (DAOD) MODIS (DAOD) TAT (d) CRB (e) MED (f) 1.50 1.0 0.6 300 100 y=0.508x+(0.009) y=0.711x+(-0.013) $R^2=0.709$ y=0.548x+(-0.012) $R^2 = 0.355$ 200 1.25 Good agreement $R^2 = 0.594$ 0.5 250 80 0.8 (DAD) 0.75 0.50 (DAOD) (DAOD) 150 200 60 150 0 3 dollo do 100 40 OAL 100 50 20 0.2 0.25 50 0. 0.00 0.8.0 0.8:0 0.6 0.8 1.0 0.4 0.2 0.4 0.6 0.8 1.0 1.2 1.4 0.2 0.4 0.1 0.2 0.3 0.5 0.6 MODIS (DAOD) MODIS (DAOD) MODIS (DAOD) IND (i) ARB (h) 1.50 1.50 1.2 y=0.673x+(0.007) 60 y=0.376x+(-0.006) y=0.047x+(0.025) $R^2 = 0.010$ $R^2 = 0.656$ $R^2 = 0.309$ 1.25 1.25 1.0 300 50 (001.00 0.75 0.50 bad agreement (DAOD) (a 1.00 0.75 150 40 Cloud contamination? 200 0.75 0.75 0.50 0.6 30 10 40 Internal mixing of dust CAL 20 100 50 0.25 0.25 10 0.00.0 ..... 0.00 0.2 0. 0.4 0.6 0.8 1.0 1.2 1.4 0.2 0.4 0.8 1.0 1.2 1.4 0.8 1.0 0.6 0.0 0.2 0.40.6 1.2

MODIS (DAOD)

MODIS (DAOD)

MODIS (DAOD)

#### Decadal DAOD Trend

None of the 9 dust-laden regions shows a clear DAOD trend except for the NWP region. In **NWP**, both MODIS- and CALIOP-based DAOD show a decreasing trend of  $-1.50\% yr^{-1}$  and  $-1.58\% yr^{-1}$ , respectively.

Further analysis shows that this **DAOD decreasing trend in NWP** is mainly attributed to the decrease of DAOD in **spring** season at a rate of  $-2.6\% yr^{-1}$  based on MODIS and  $-3.0\% yr^{-1}$  based on CALIOP.

We found an obvious declining trend of DAOD in EAS-5 (**Southern Gobi Desert**) at a rate of  $-3.7\% yr^{-1}$  based on MODIS and  $-2.8\% yr^{-1}$  based on CALIOP.



#### Decadal DAOD Trend



- We produced a climatological data of Dust AOD and extinction profile based on CALIOP observation on a global scale.
- CALIOP and MODIS are based on different characteristics of dust aerosols to separate dust aerosol from others, and then retrieve DAOD. CALIOP is shape-based; MODIS is size-based.
- DAOD values retrieved from two sensors are different. It has two major uncertainty sources: 1) uncertainties in TAOD retrievals 2) different dust partition methods based on different dust characteristics

Summary

- The correlation of DAOD retrieved from CALIOP and MODIS is generally good in dust-laden regions.
- The interannual variability based on two DAOD retrievals show that there is a decreasing trend of DAOD in NWP, which is mainly attributed to the decline of DAOD in spring season. The decreasing of DAOD in NWP is mostly due to the decline of DAOD in Southern Gobi Desert. This change of DAOD is significantly correlated with the change of vegetation in the area.

# UMBC Questions?

# Great to see everyone online Stay healthy and safe!

## **JMBC** DAOD in the Source Regions



# RC

## Dust AOD w.r.t. total AOD

0.15

0.08

0.04

0.00

-0.04

-0.08

0.15

0.15

0.08

0.04

0.00

-0.04

0 1

-0.08

180° 120°W

60°W









DAOD (MODIS-CALIOP)





180° 120°W 60°W



60°E

09

120°E 180°







**Cloud Fraction** 

1.00

0.96

0.92

0.88

0.84

0.80

0.60 0.40

0.20

0.00

1.00

0.96

0.92

0.88

0.84

0.80

0.60 0.40

0.20 0.00

1.00

0.96

0.92

0.88

0.84

0.80

0.60 0.40

0.20

0.00









DAOD/TAOD (MODIS-CALIOP)



0.36

0.24

0.12

0.00

-0.12

-0.24



