Aerosol Assimilation Into CERES Processing (Where we've been – Where we're going?)

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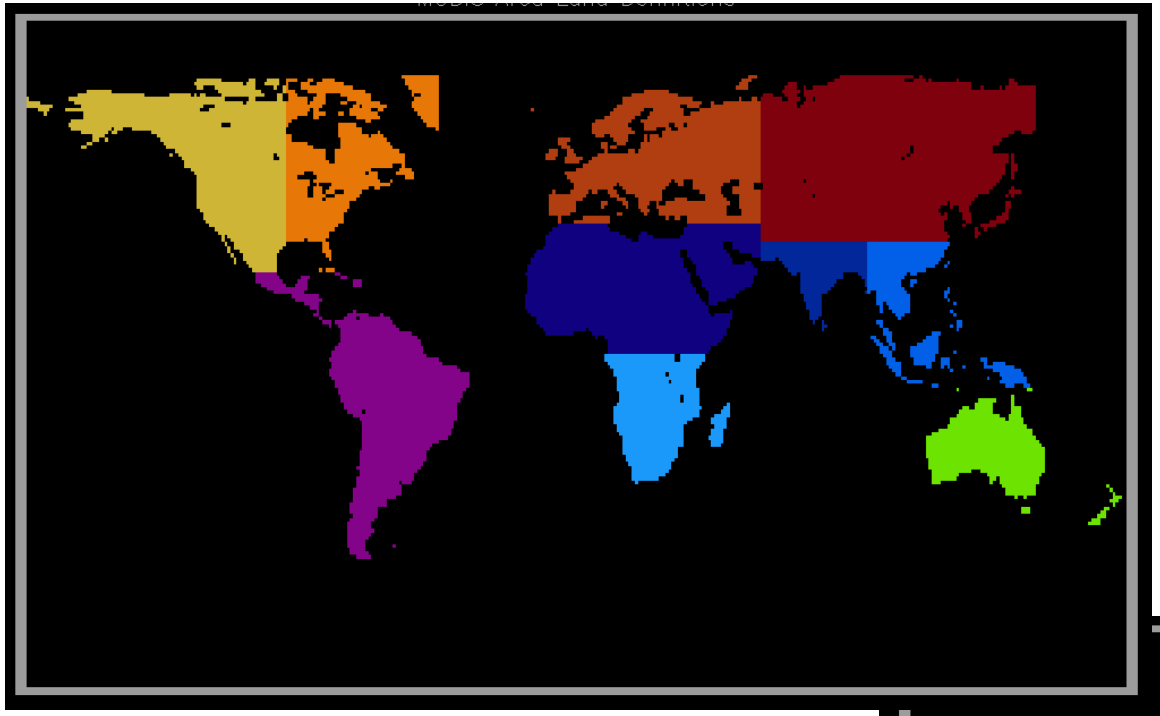
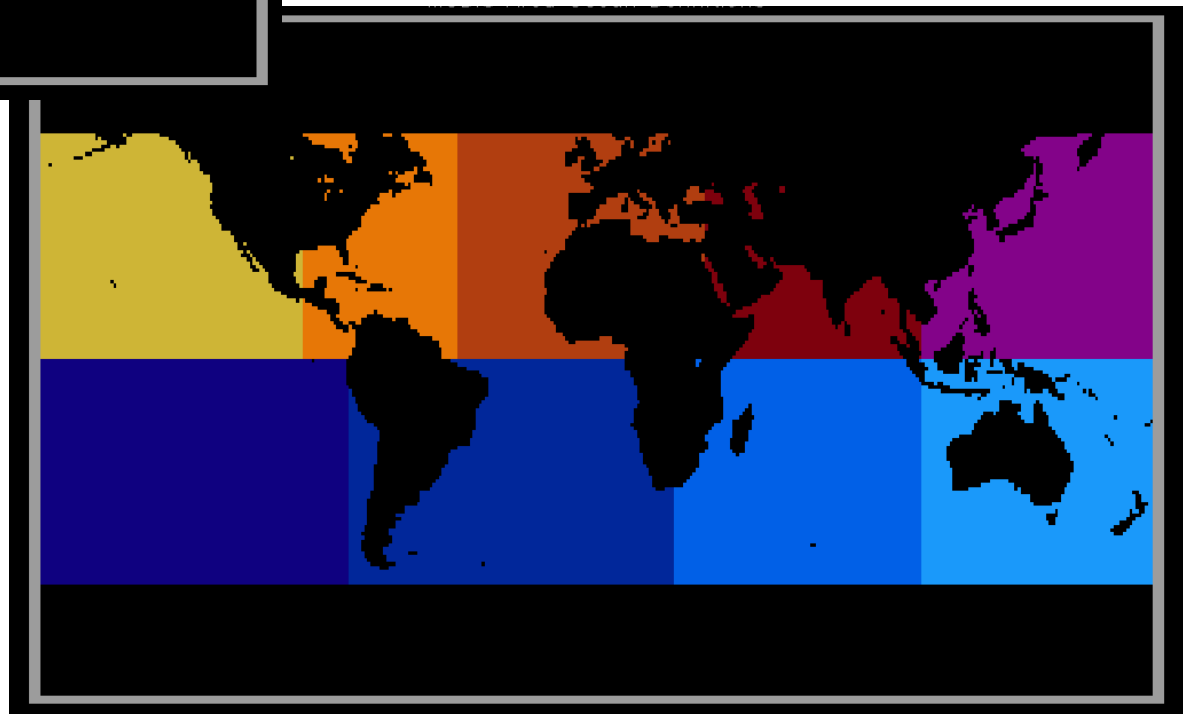
- Describe how aerosols are assimilated into CERES RT processing
- Compare currently available products.

(Unless otherwise noted MODIS AOD are from Aqua, CERES SYN1deg are Edition 4.)

Region Definitions



*Based on Sayer et al. 2014



Model for Atmospheric Transport and Chemistry (MATCH)

- Assimilates MODIS aerosol optical thickness (hourly)
  - Swath level Terra (MOD04_L2) and Aqua (MYD04_L2)
  - Dark Target Ocean, Dark Target Land, Deep Blue Land
  - Collection 5 through Mar 2017, Collection 6 beyond

- MATCH is essentially a small GCM running chemistry package at ~2◦ spatial resolution, interpolates 3 hourly wind fields for 30min step for physics package.

- Provides vertical extinction profiles of 7 aerosol types
  - Small Dust(<0.5µm) (Sinyuk et al. (2003))
  - Large Dust(>0.5µm) (Sinyuk et al. (2003))
  - Stratospheric (OPAC, suso)
  - Sea Salt (D'Almedia (1991) maritime)
  - Soot (OPAC, soot)
  - Soluble (OPAC, waso)
  - Insoluble (OPAC, inso)

MATCH II

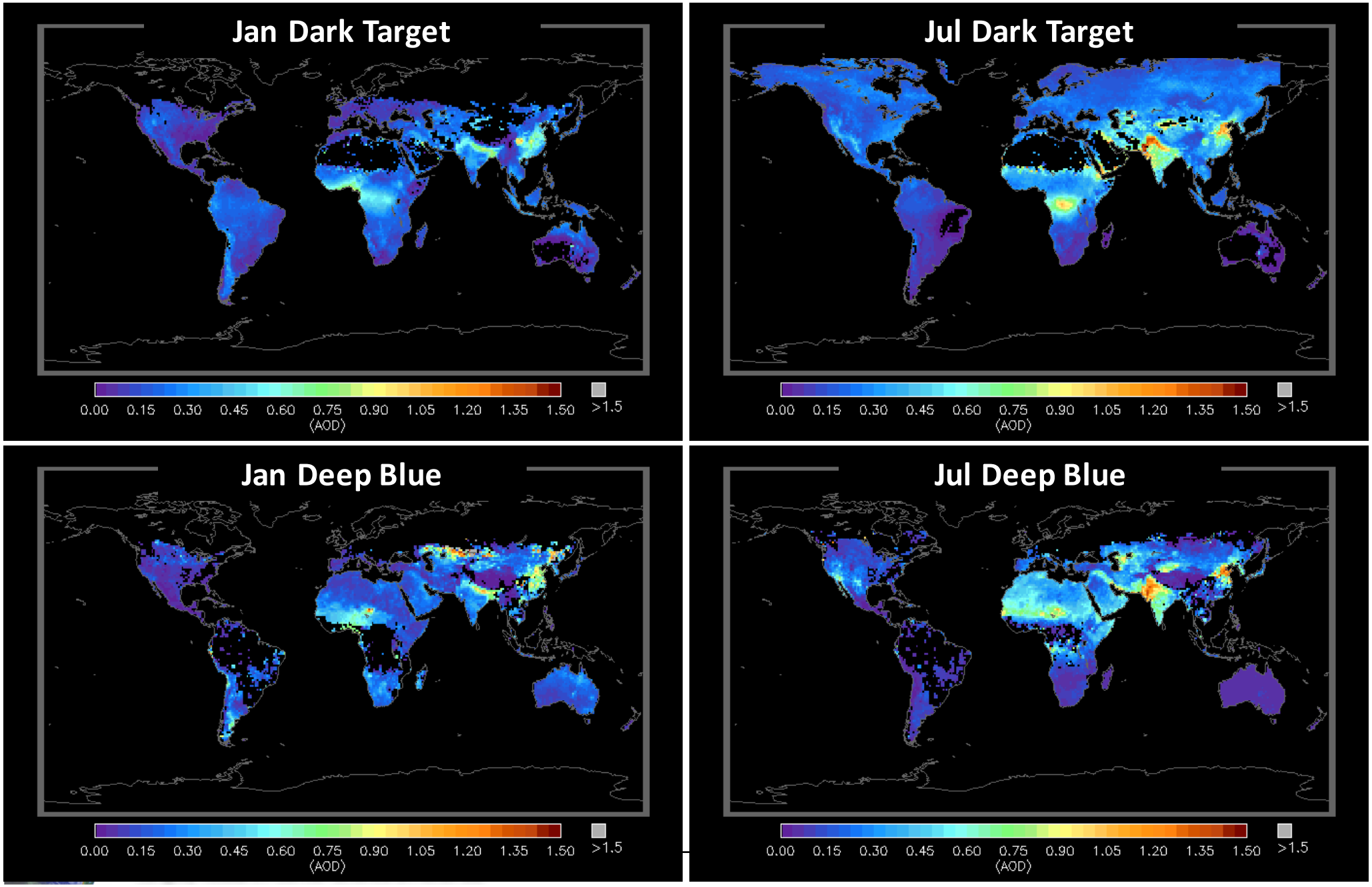
- Aerosol type determines optical property of aerosols
  - Single scatter albedo, scattering phase function
  - Langley Fu & Liou includes up to 7 weighted profiles.

- CERES SYN1deg Edition 3 used MATCH Edition 2:
  - Assimilate MODIS Collection 5 AOD
  - Goddard Dark Target(DT) Deep Blue (DB) over Land
  - If DT & DB exist it averages the two.

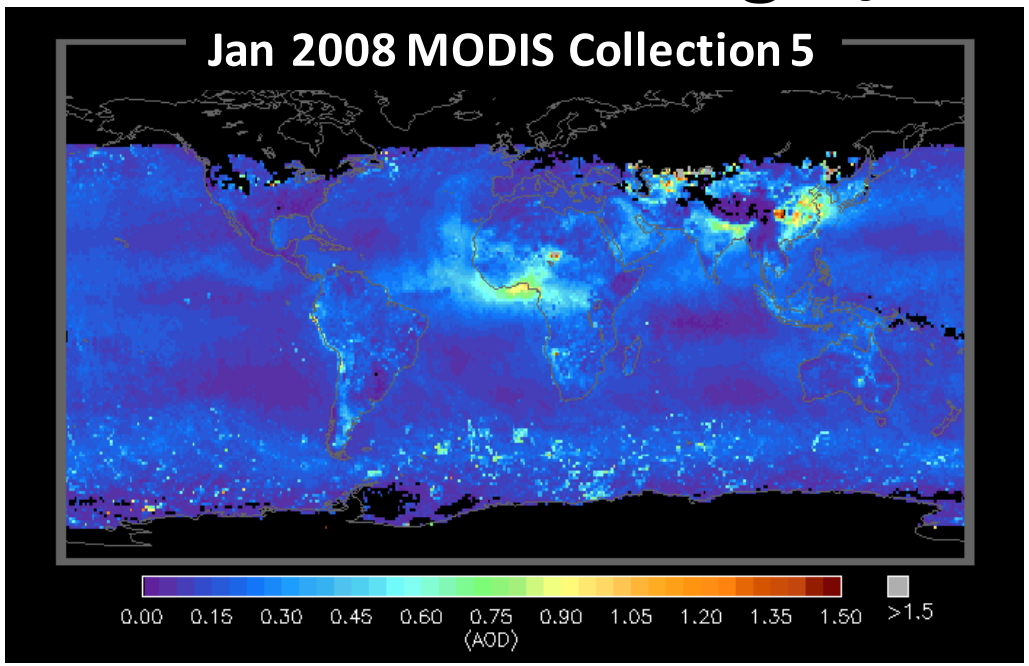
- CERES SYN1deg Edition 4 uses MATCH Edition 4:
  - Assimilate MODIS Col 5.1 through Feb 2017, Col 6.0 beyond
  - Dark Target /Land & Deep Blue Land
  - Weights MODIS higher than climatological sources.

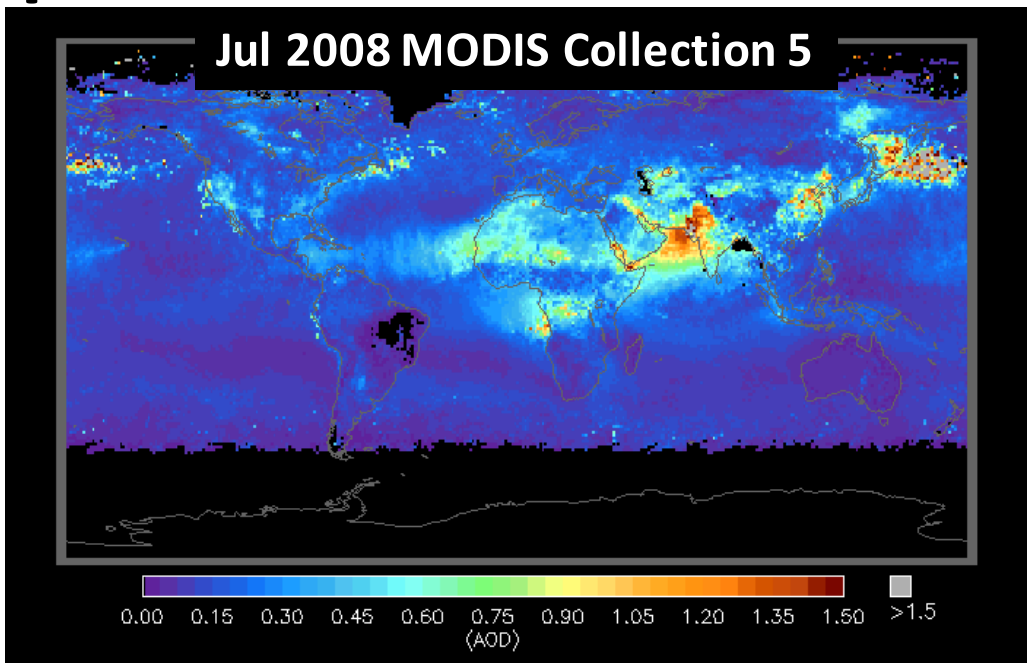
- More detailed explanation see David Fillmore

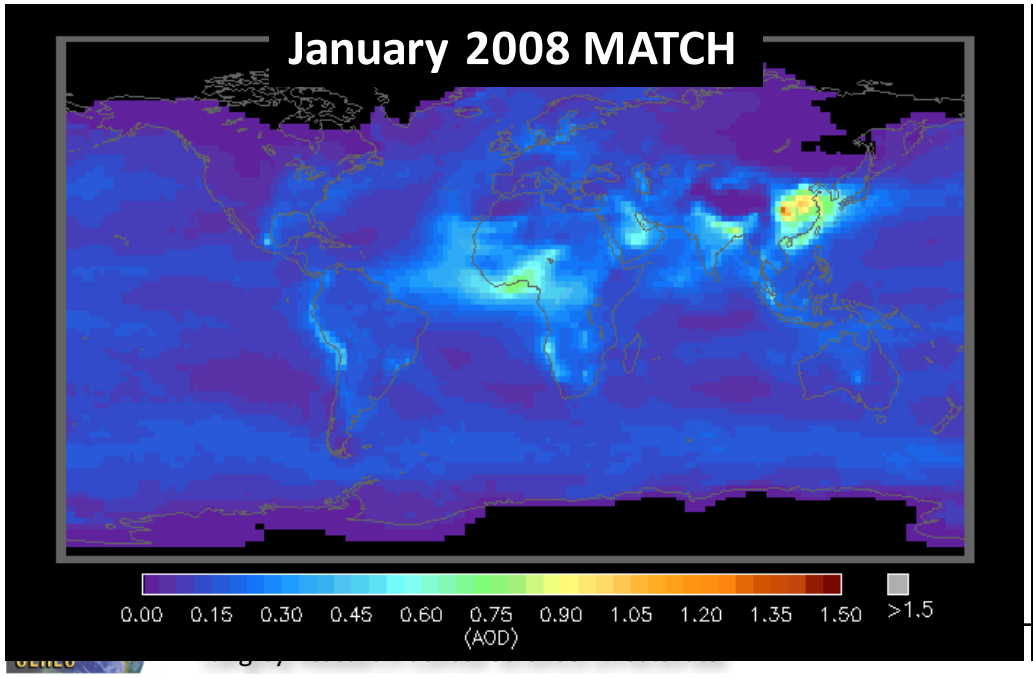
<u>Canonical</u> Monthly Means (2003-2017) AOD@550nm Collection 5 Dark Target & Deep Blue

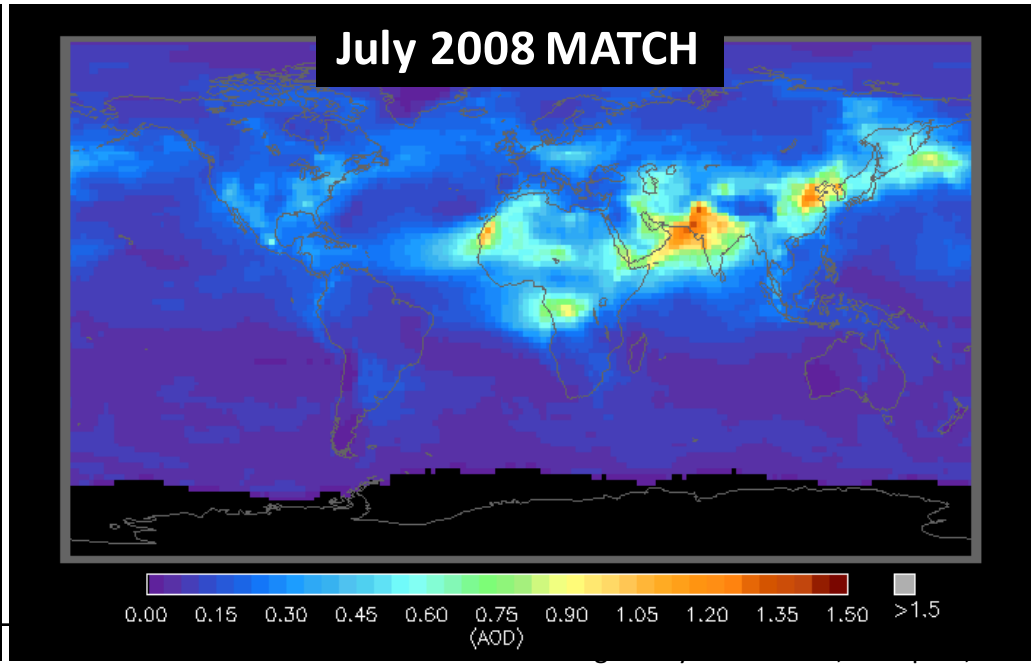


Monthly Means MYD08 AOD@550nm
Dark Target/Deep Blue & MATCH

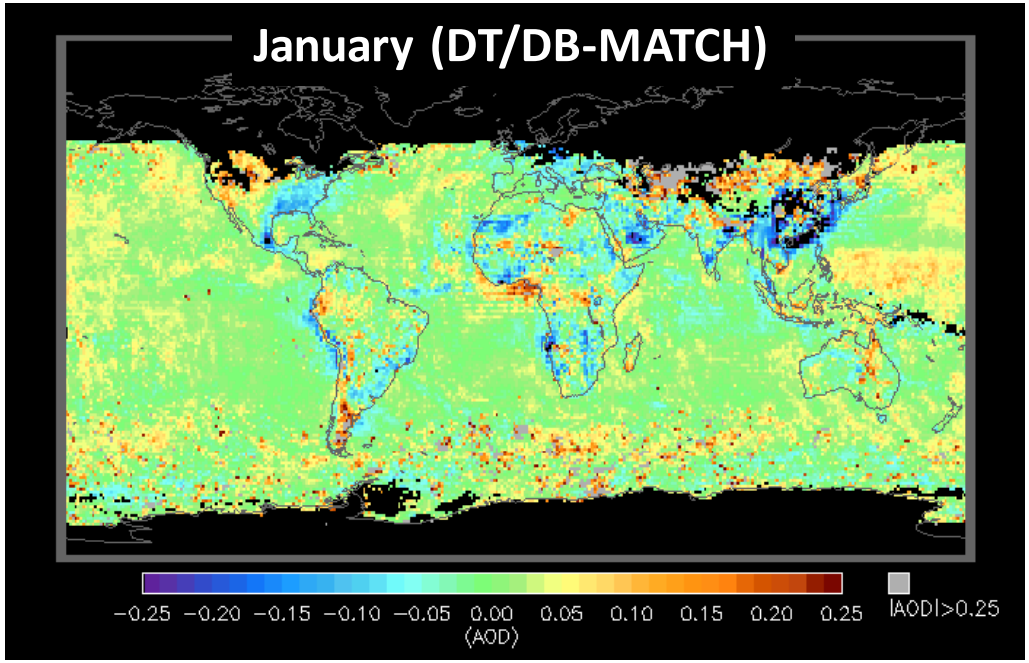


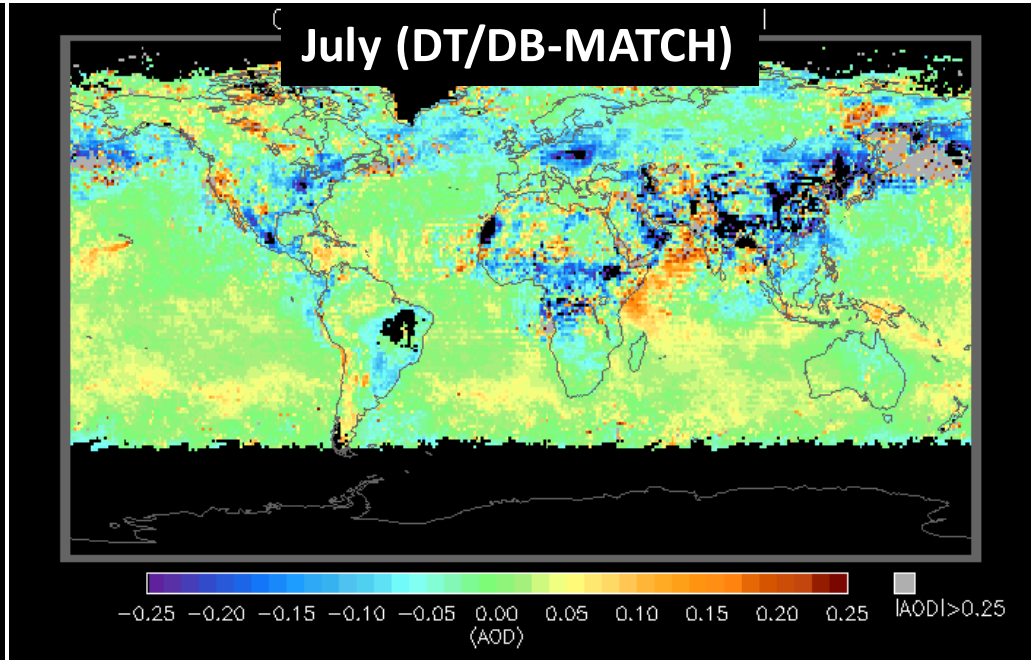


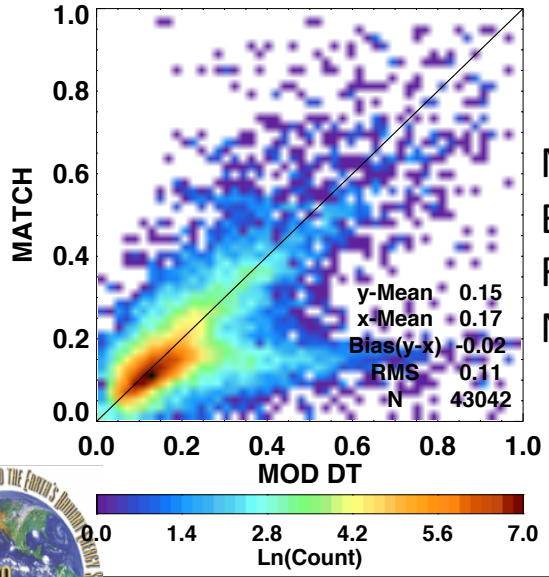




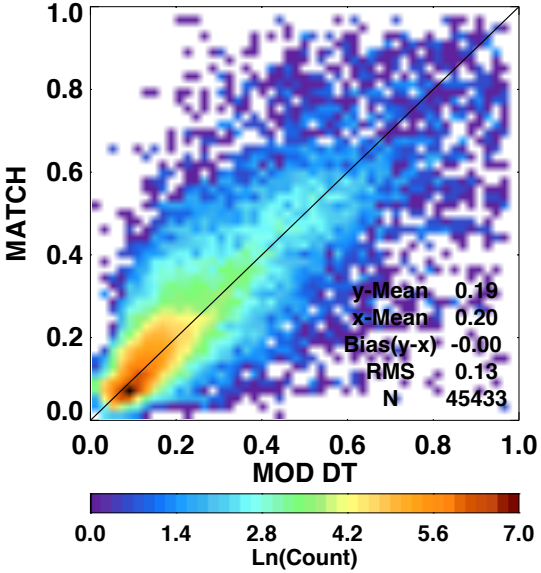
Monthly Means MYD08 (2007) AOD@550nm Bias (Collection 5-MATCH)





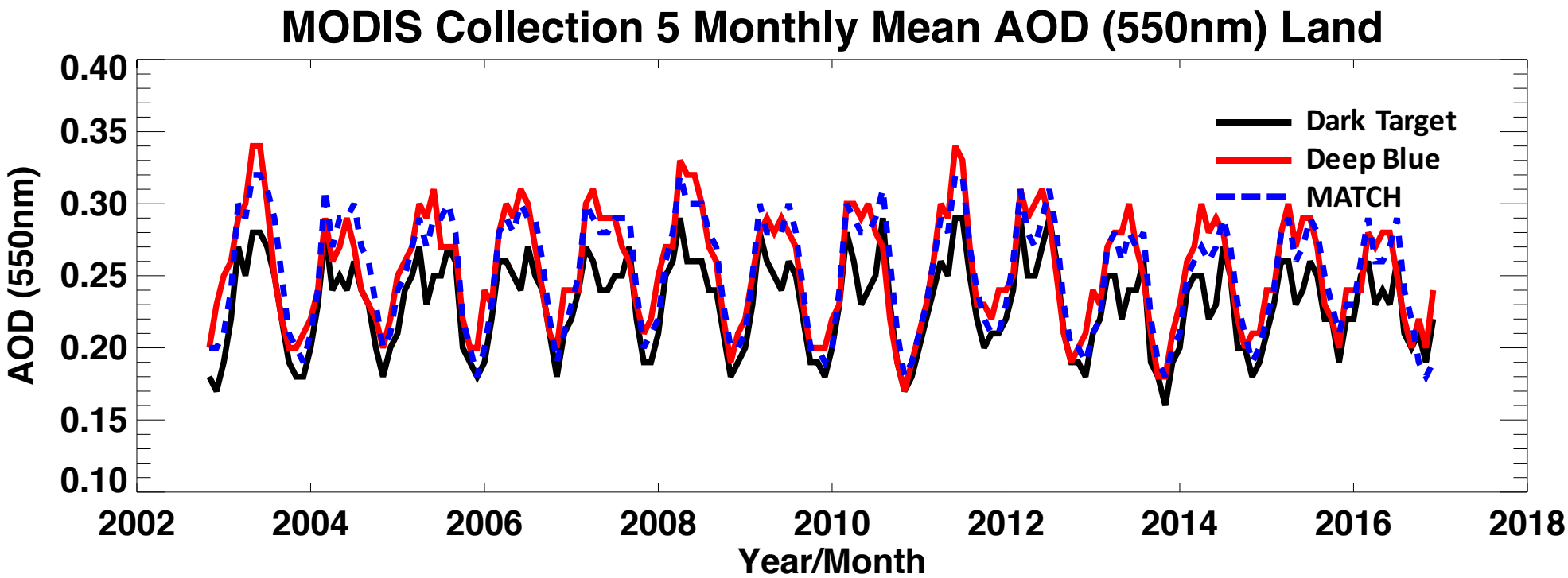


MODIS Mean: 0.17
Bias: -0.02
RMS: 0.11
N: 43158



MODIS Mean: 0.20
Bias: -0.00
RMS: 0.13
N: 45433

Monthly Mean AOD Land (DT/DB/MATCH)

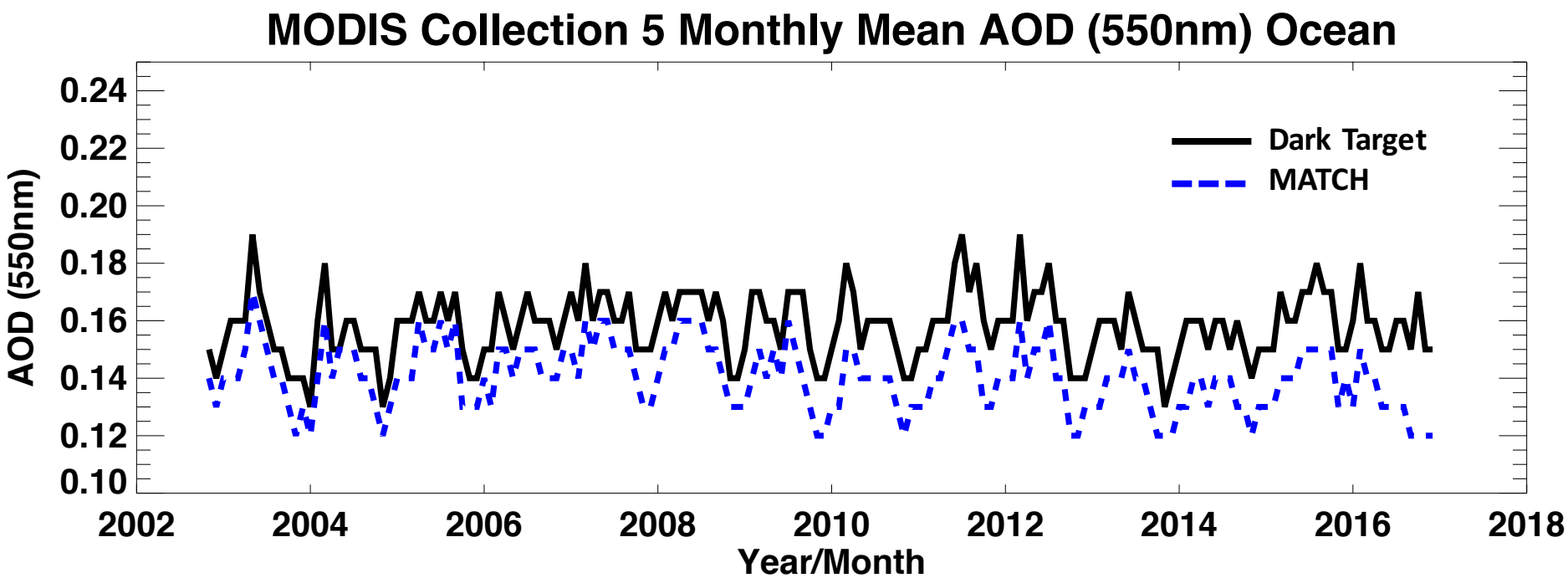


Dark Target - Deep Blue	
Dark Target Mean:	0.23
Deep Blue Mean:	0.25
Bias:	-0.024
RMS:	0.030
Corr:	0.87

MATCH-Dark Target	
Dark Target Mean:	0.23
MATCH Mean:	0.25
Bias:	0.022
RMS:	0.026
Corr:	0.95

Deep Blue/MATCH	
Deep Blue Mean:	0.25
MATCH Mean:	0.25
Bias:	-0.002
RMS:	0.017
Corr:	0.90

Monthly Mean AOD Ocean (DT/MATCH)



MATCH-Dark Target	
Dark Target Mean:	0.16
MATCH Mean:	0.14
Bias:	-0.018
RMS:	0.019
Corr:	0.81

That was a quick overview of what's been done and how it works.
Where do we go from here?

MODIS on Terra & Aqua

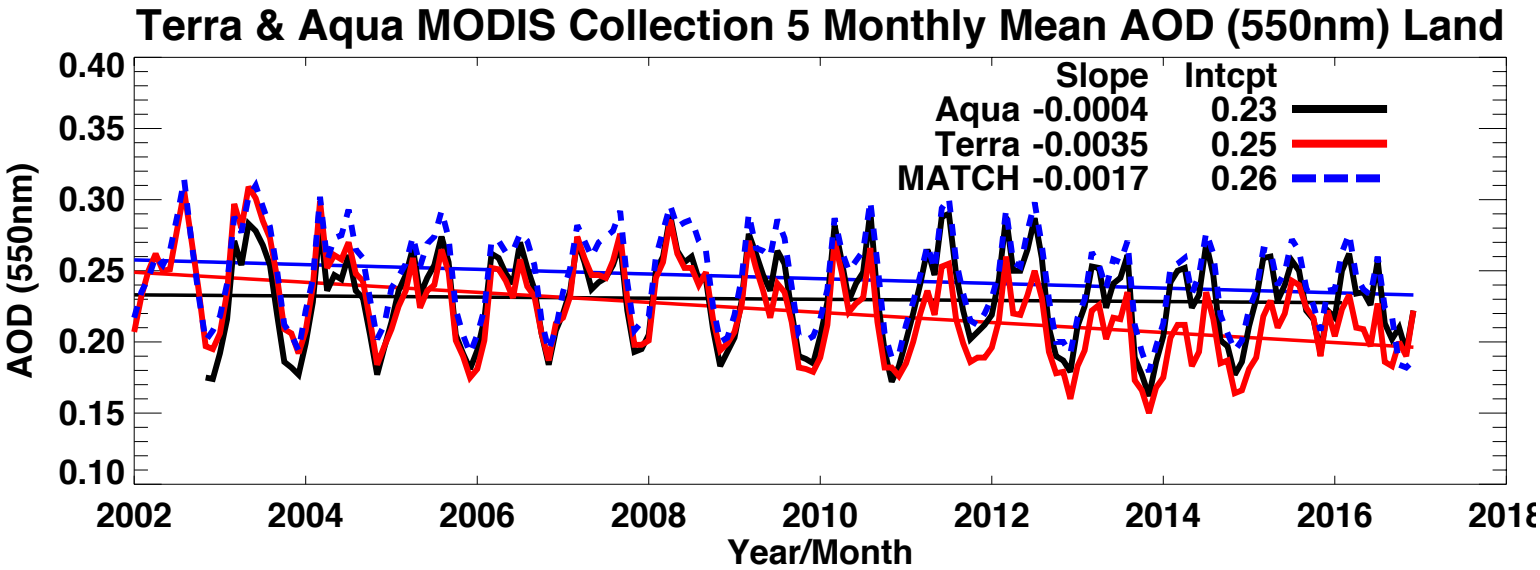
- Collection 6.1 has a 'combined' DT/DB product.
- Start processing deep blue over ocean.
- Terra Collection 5.1 has negative trend.

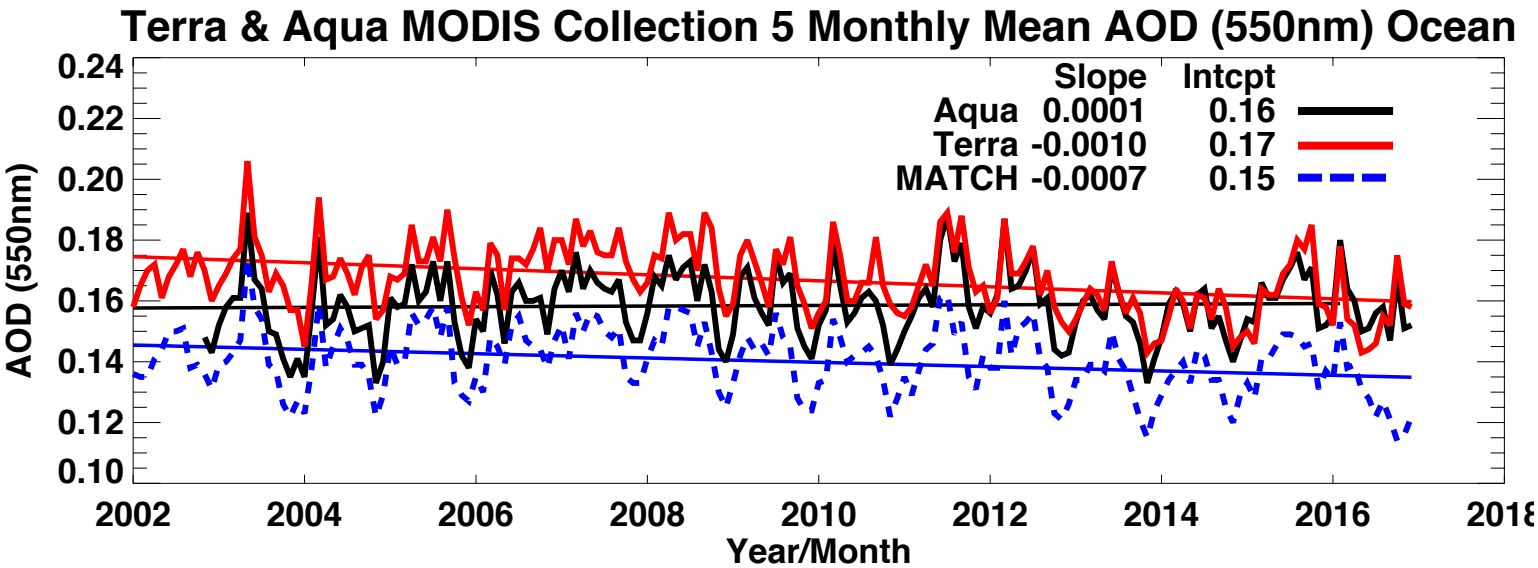
VIIRS processing on SNPP

- GODDARD is beginning to process VIIRS using Deep Blue algorithm.
- NOAA has an AOD product from VIIRS.
- Might not fund processing of VIIRS dark target.

Use MODIS Col 6.1

Terra Collection 5.1 has a slope in the AOD (corrected in 6>)

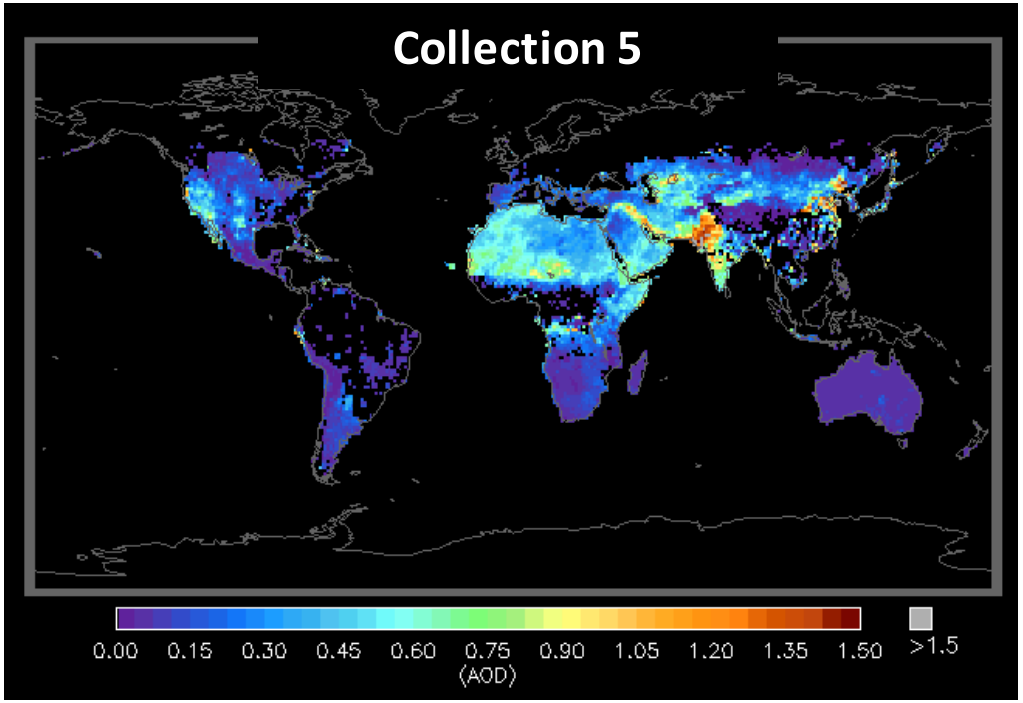


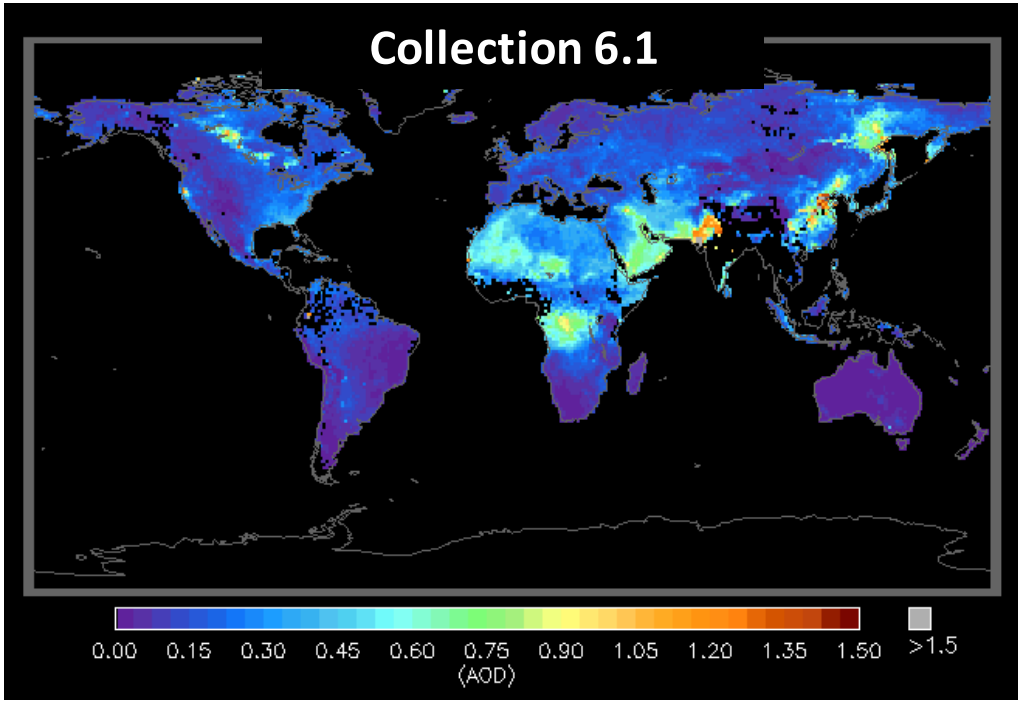


Use MODIS Col 6.1

Much greater spatial coverage in 6/6.1.

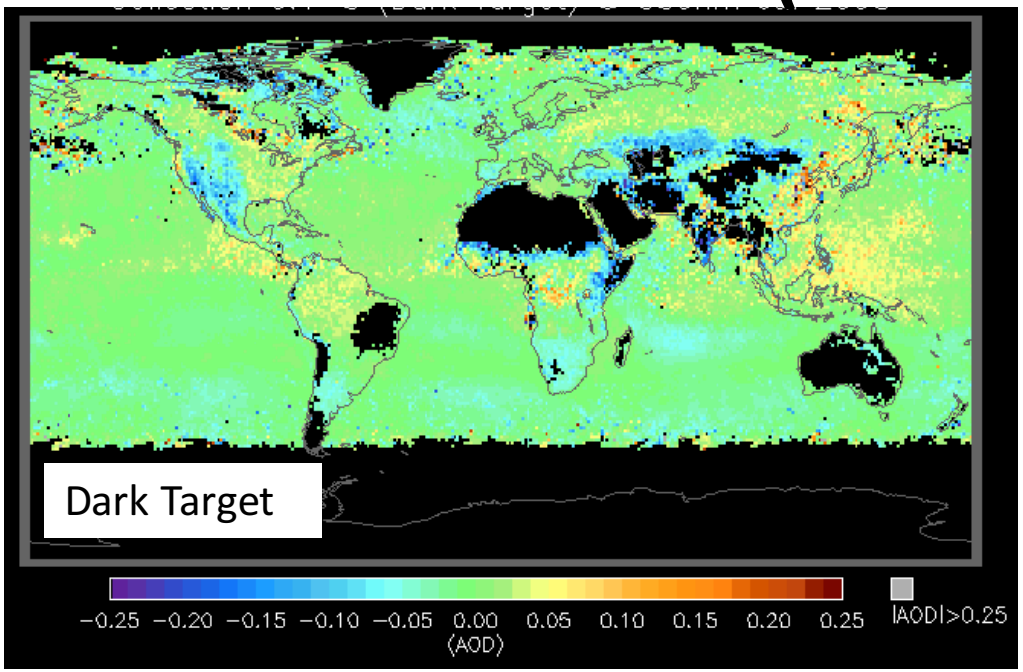
Deep Blue AOD (550nm) for Jul 2008

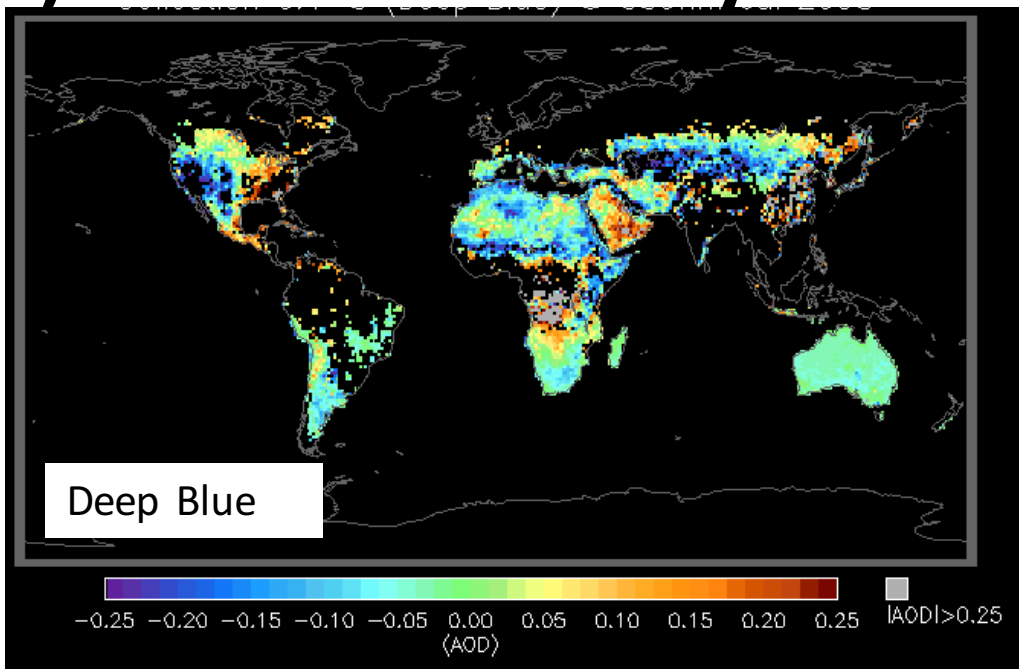


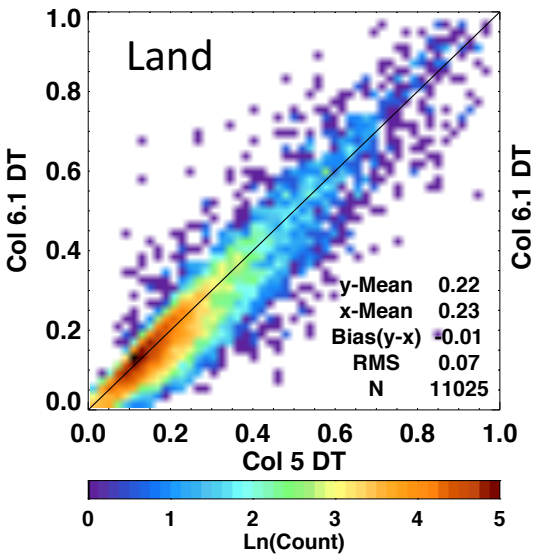


Significantly more retrievals across N America, N Russia, Amazonia & Congo regions.

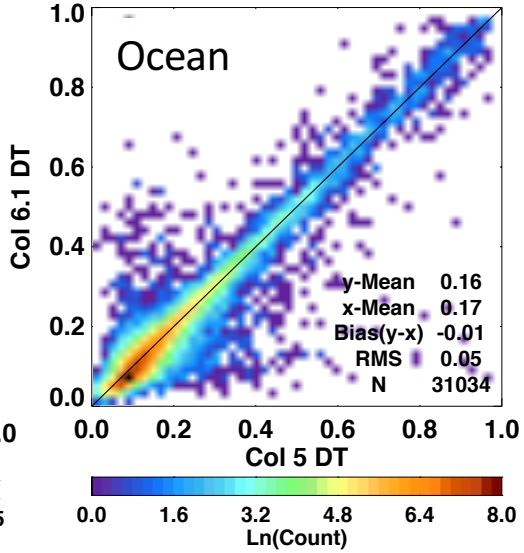
Difference in AOD (550nm) Col6.1-Col5.1 July 2008



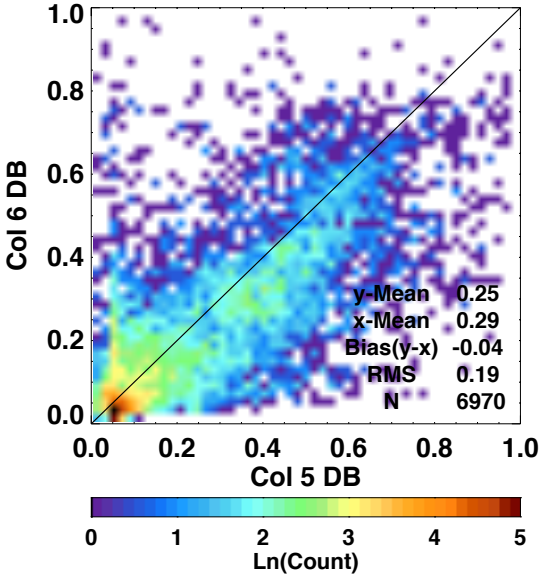




C5 Mean: 0.23
C6.1 Mean: 0.22
Bias: 0.01
RMS: 0.07

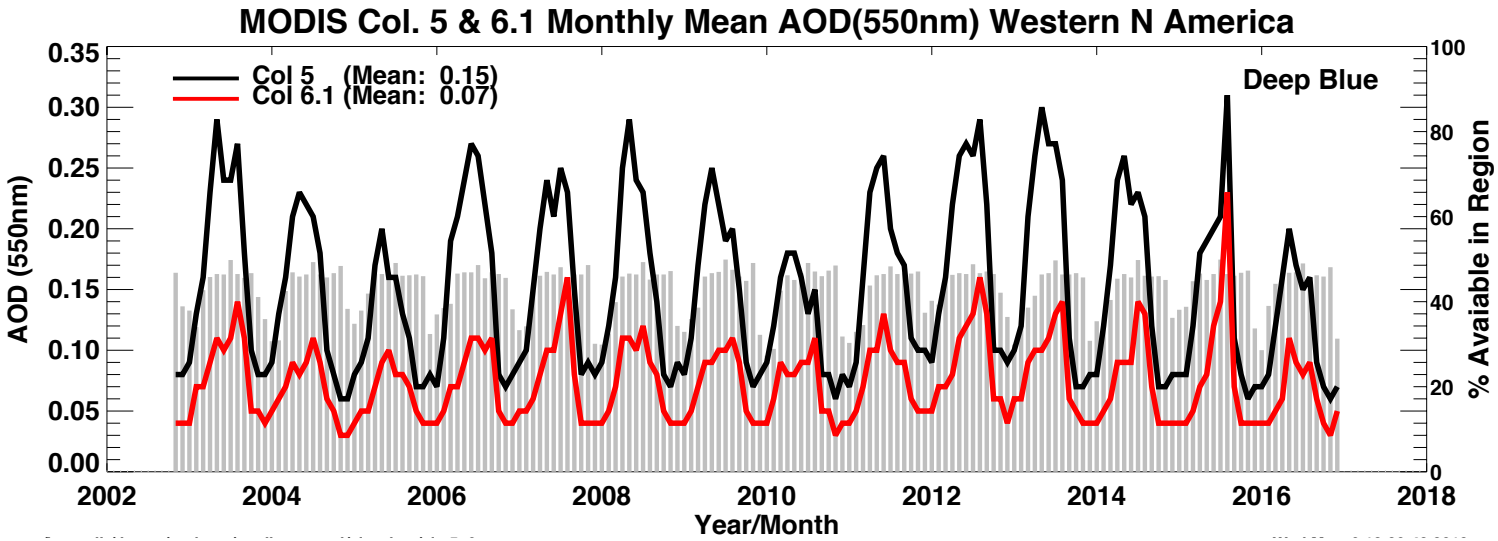


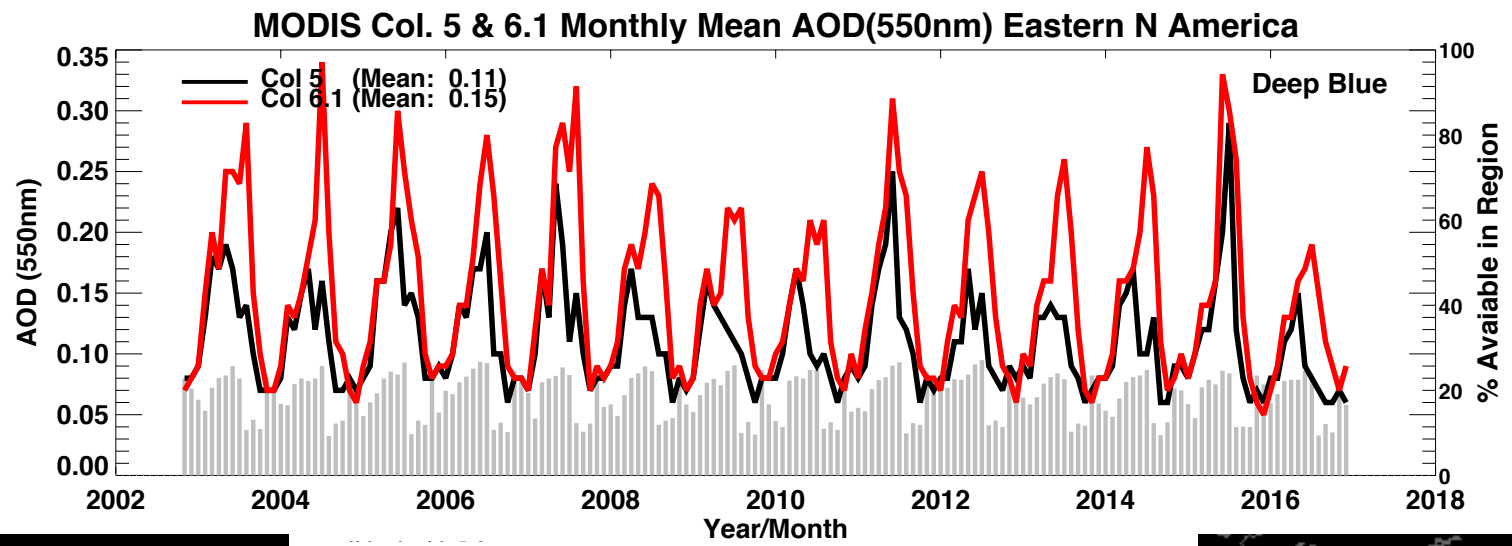
C5 Mean: 0.17
C6.1 Mean: 0.16
Bias: -0.01
RMS: 0.05



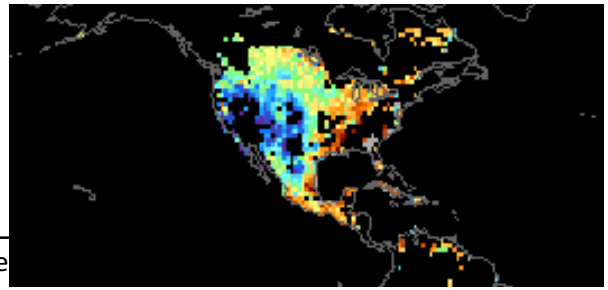
C5 Mean: 0.29
C6.1 Mean: 0.25
Bias: -0.04
RMS: 0.19
N: 6970

AOD (550nm) Col5.1/6.1* (NE & NW America)

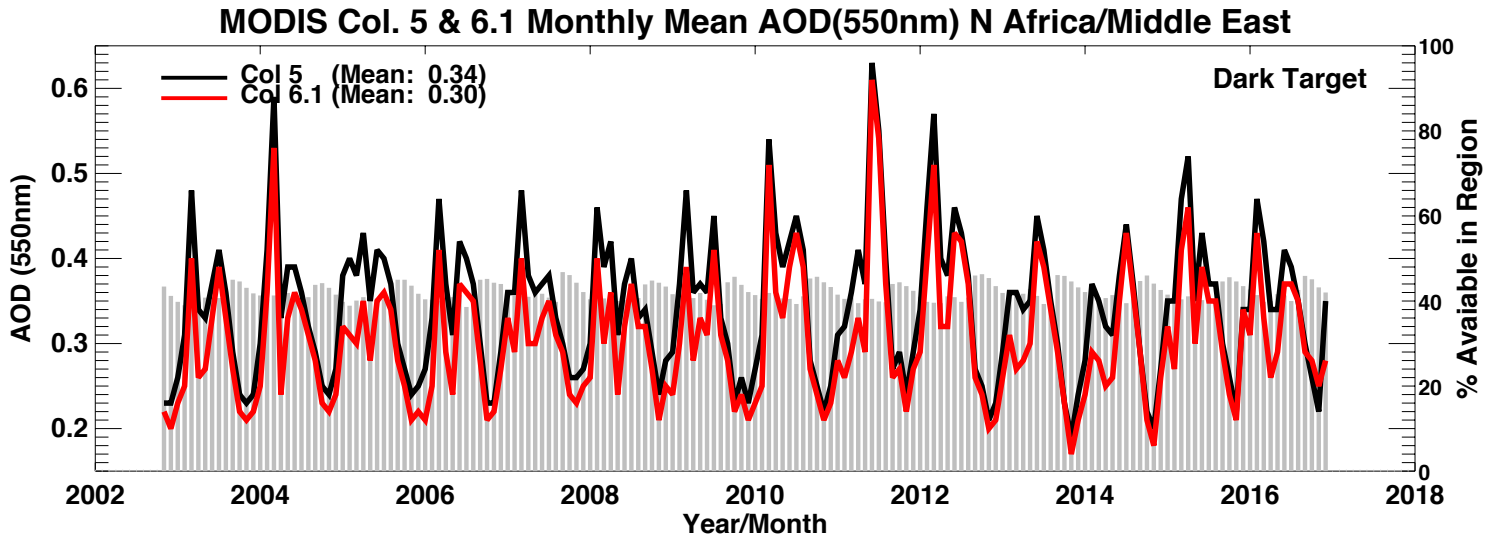


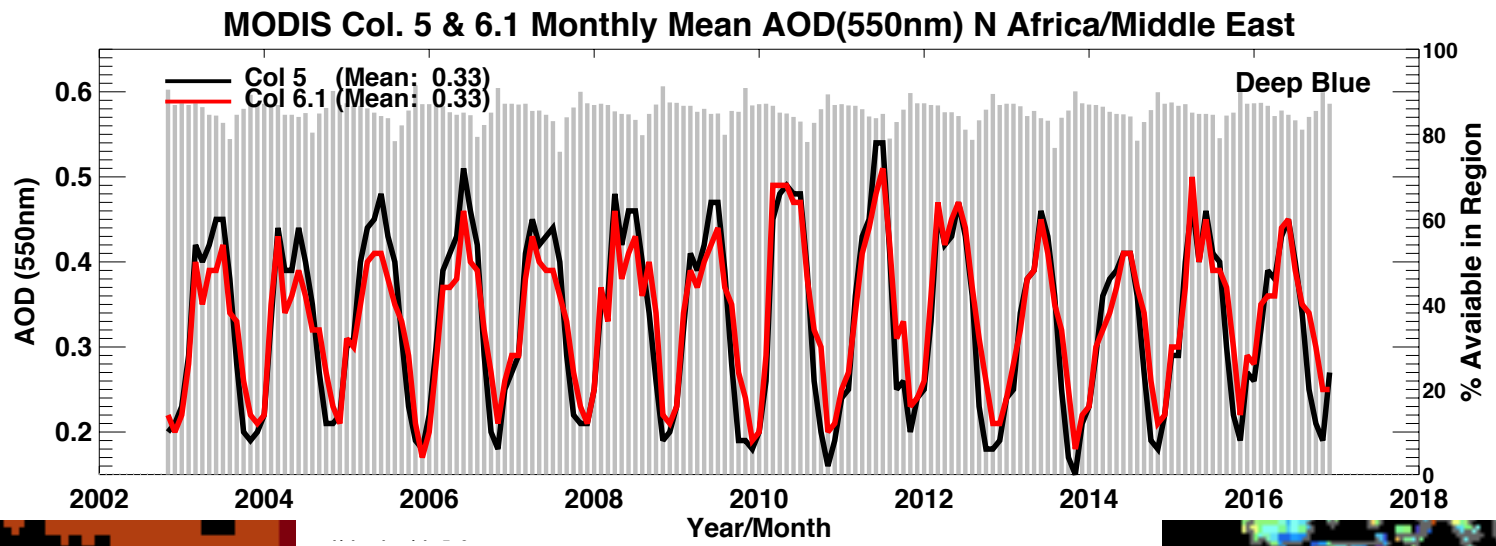


*Each monthly average includes only points where both Collection 5.1 & 6.1 had values for a grid box for the region. "% Available" indicates samples available for the defined region.

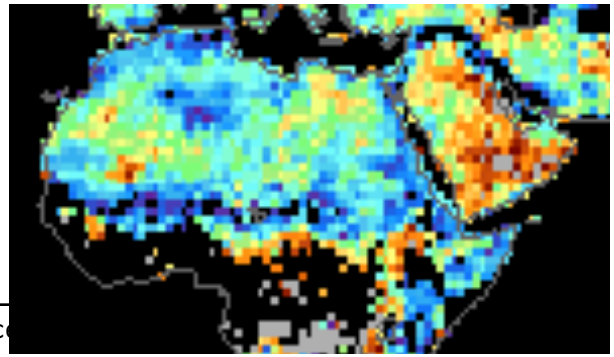


AOD (550nm) Col 5.1/6.1* (N Africa Middle East)





*Sampling is not matched between DT & DB.



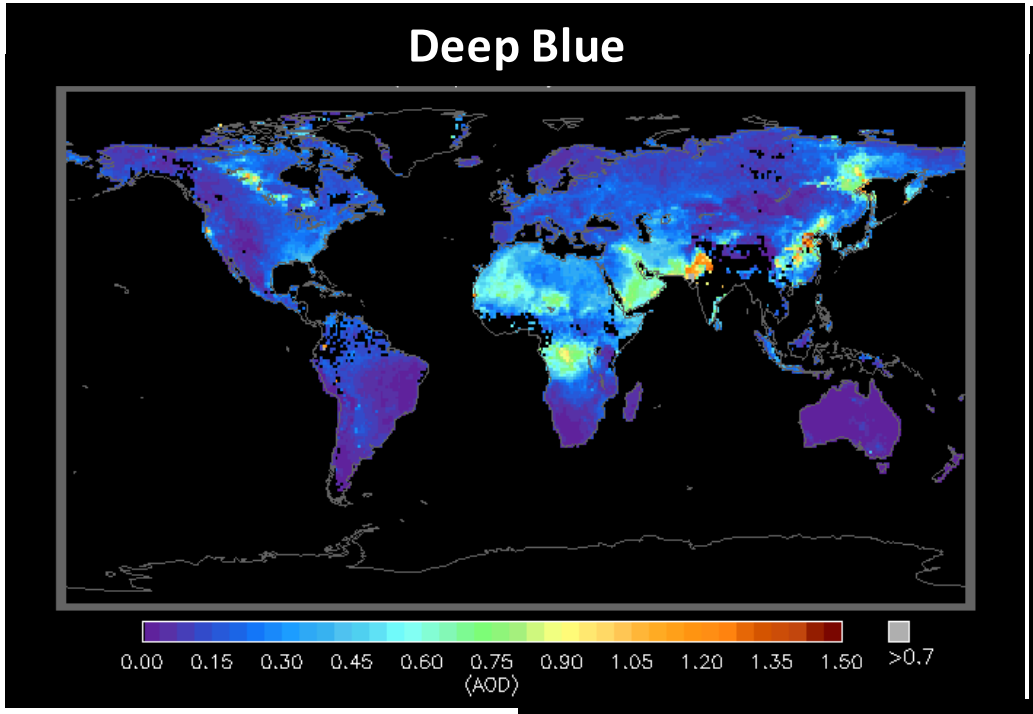
MODIS Col6.1 Combined Product

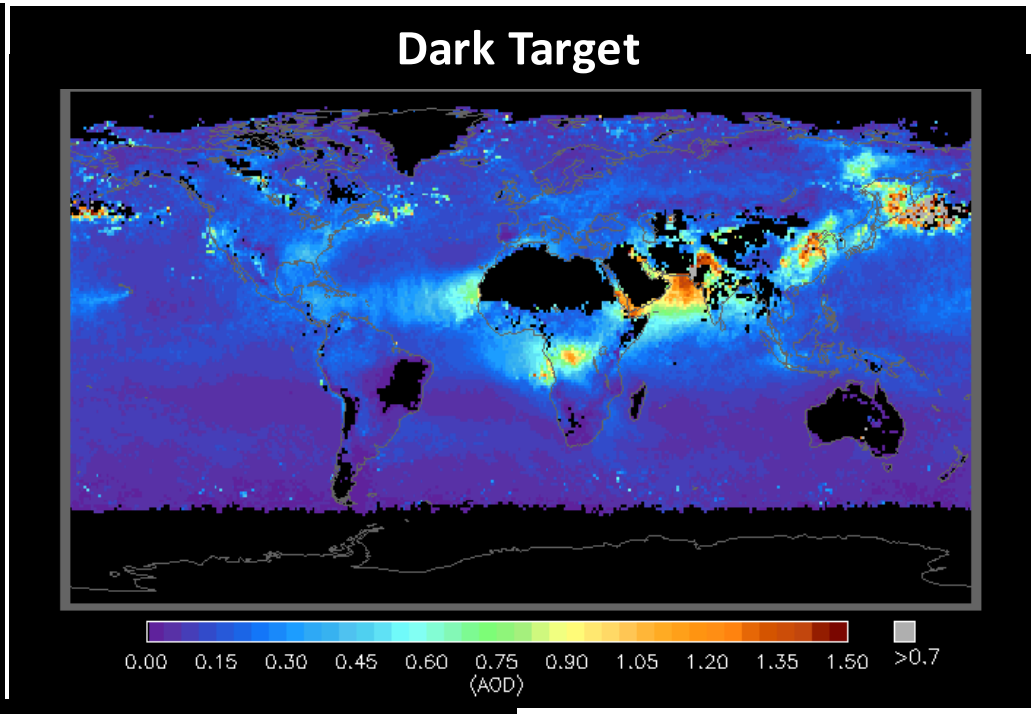
- MATCH chooses Dark Target or Deep Blue if only one is available.
- MATCH averages the two if both are available.

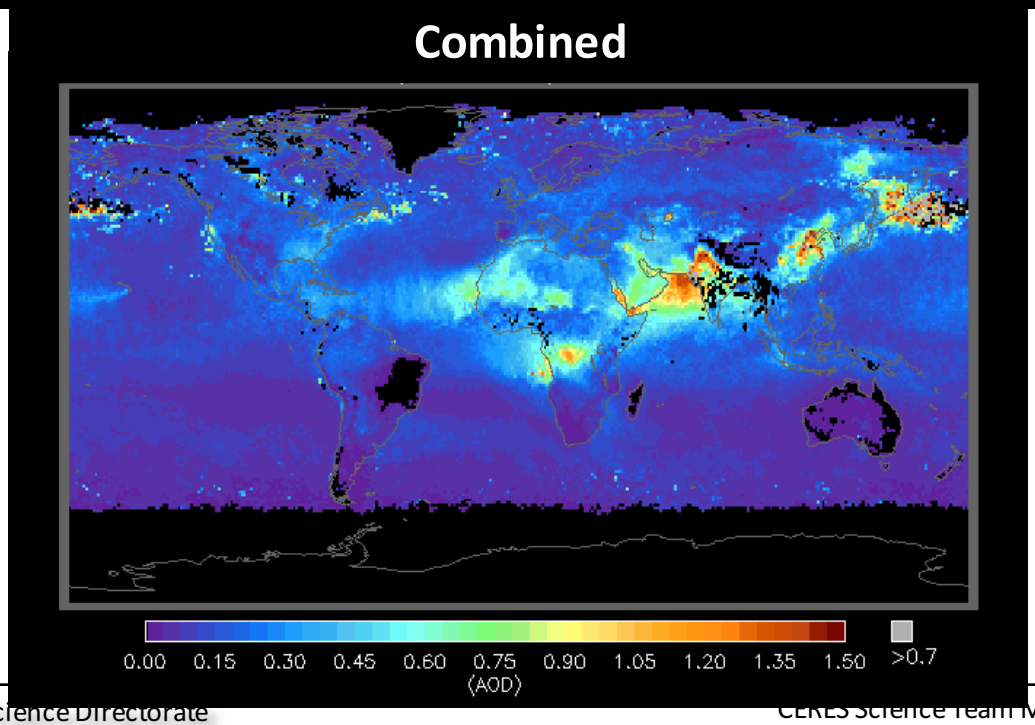
MODIS has a Combined Product Method (Collection 6 and 6.1) :

- Use monthly MYD13C2 NDVI data (0.25°)
- NDVI ≤ 0.2 use Deep Blue
- 0.2 ≤ NDVI ≤ 0.3 use Deep Blue
  - Whichever has the better QA.
  - If both have QA=3 then average.
- NDVI ≥ 0.3 use Dark Target
- Ocean – Dark Target (ocean algorithm)

MODIS Col6.1 Combined Product (Jul 2008)

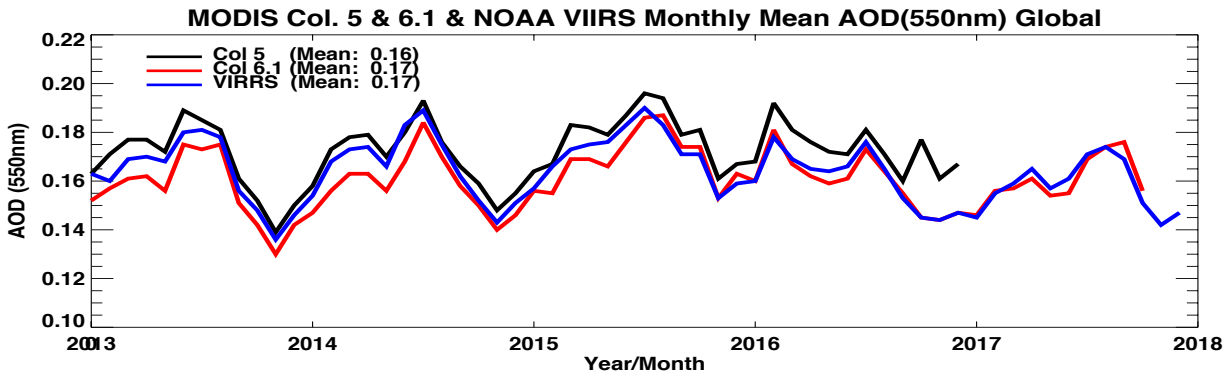


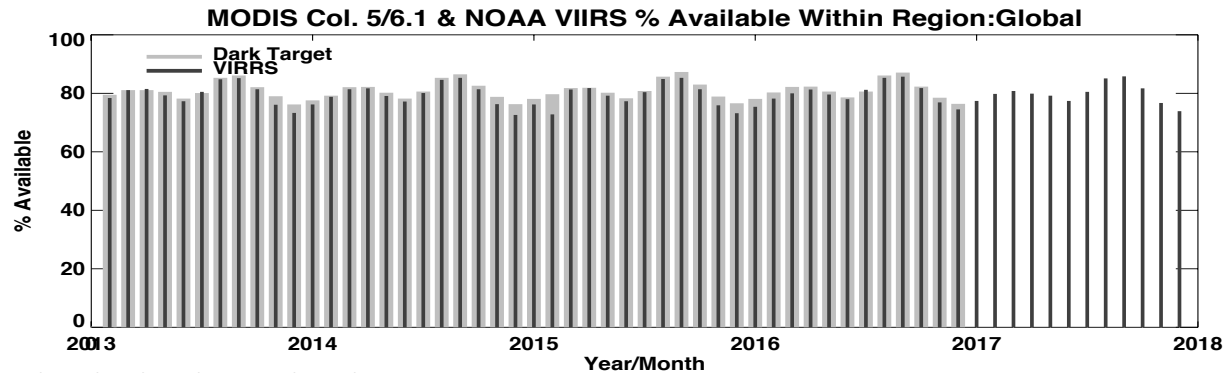


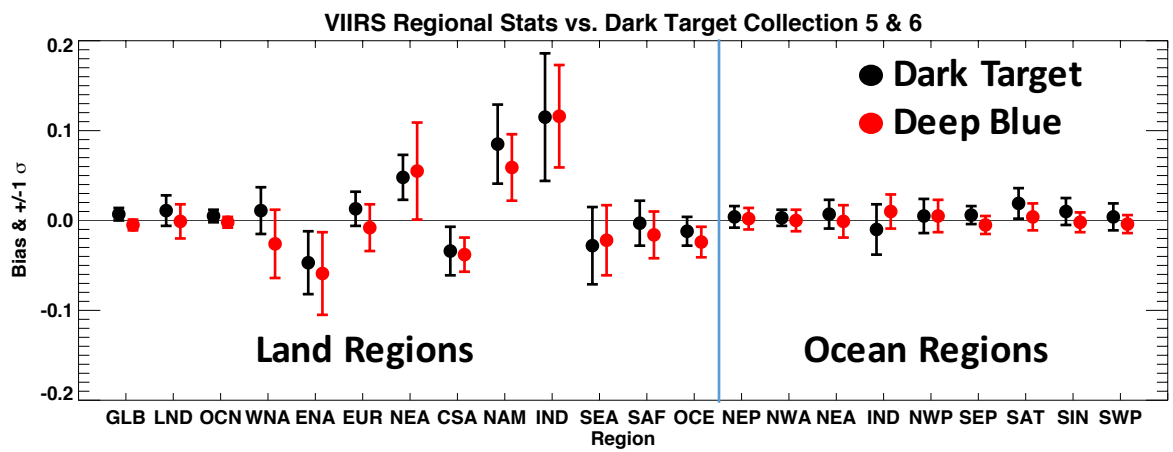


What About VIIRS Aerosols?

NOAA* has produced AOD @550nm from 2013 through 2017

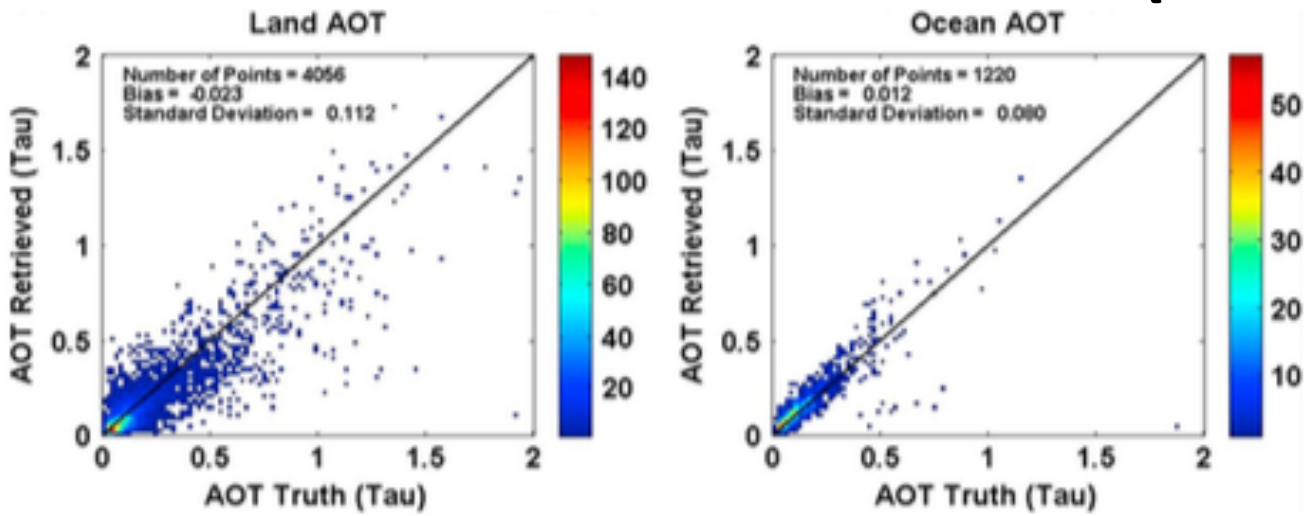






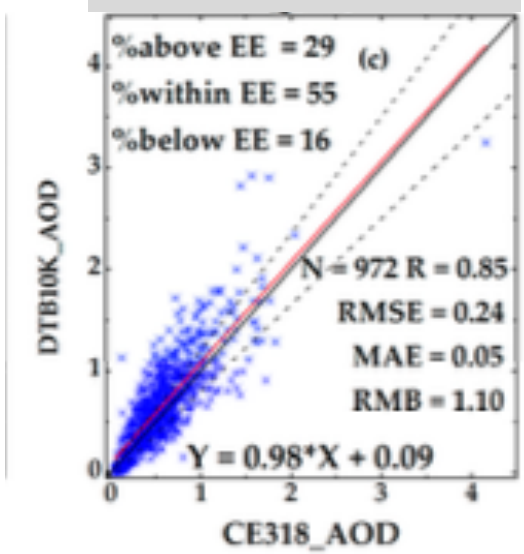
*https://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/products_gridded.php

NOAA VIIRS Aerosols: Validation (AERONET)

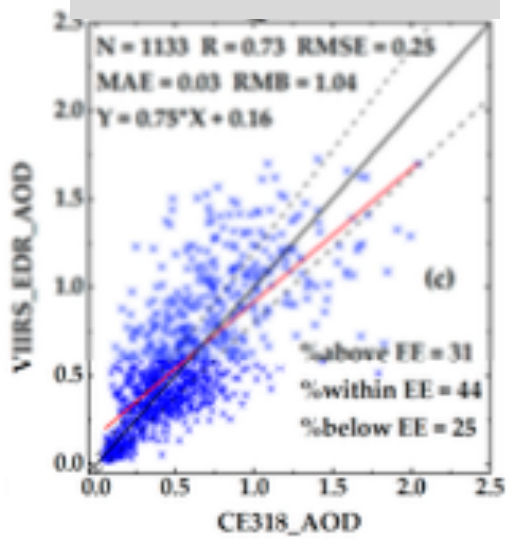


Jackson et al: "Suomi-NPP VIIRS aerosol algorithms and data products" (2013)

MODIS DT vs. Obs

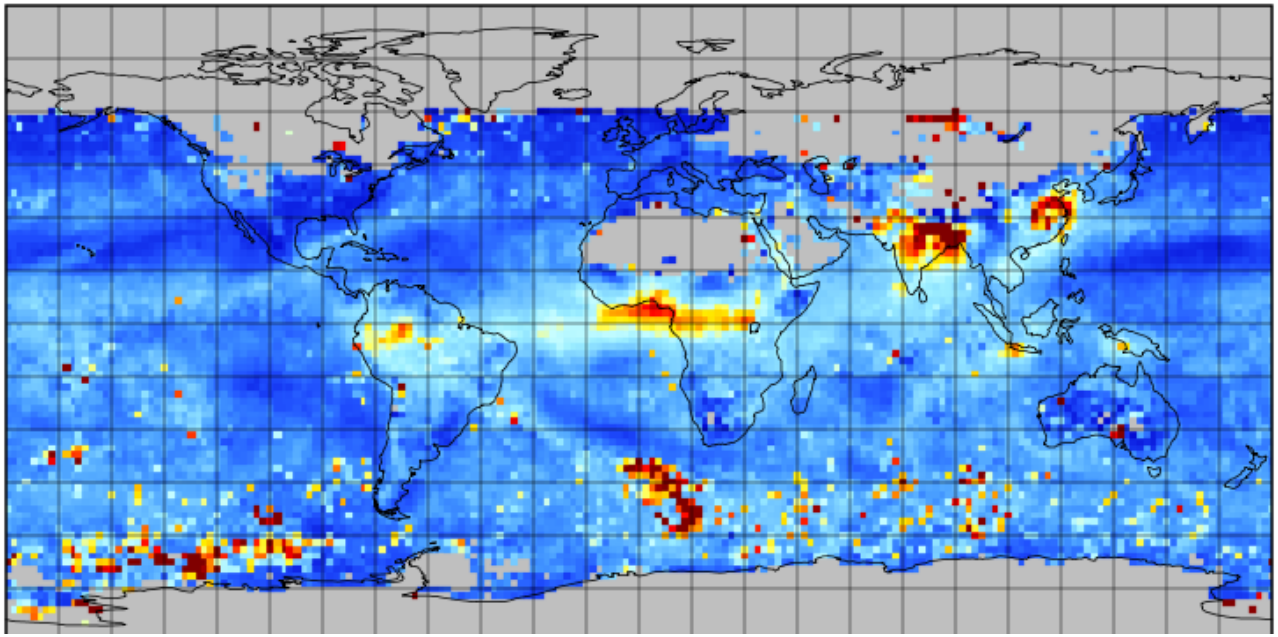


VIIRS AOD vs. Obs

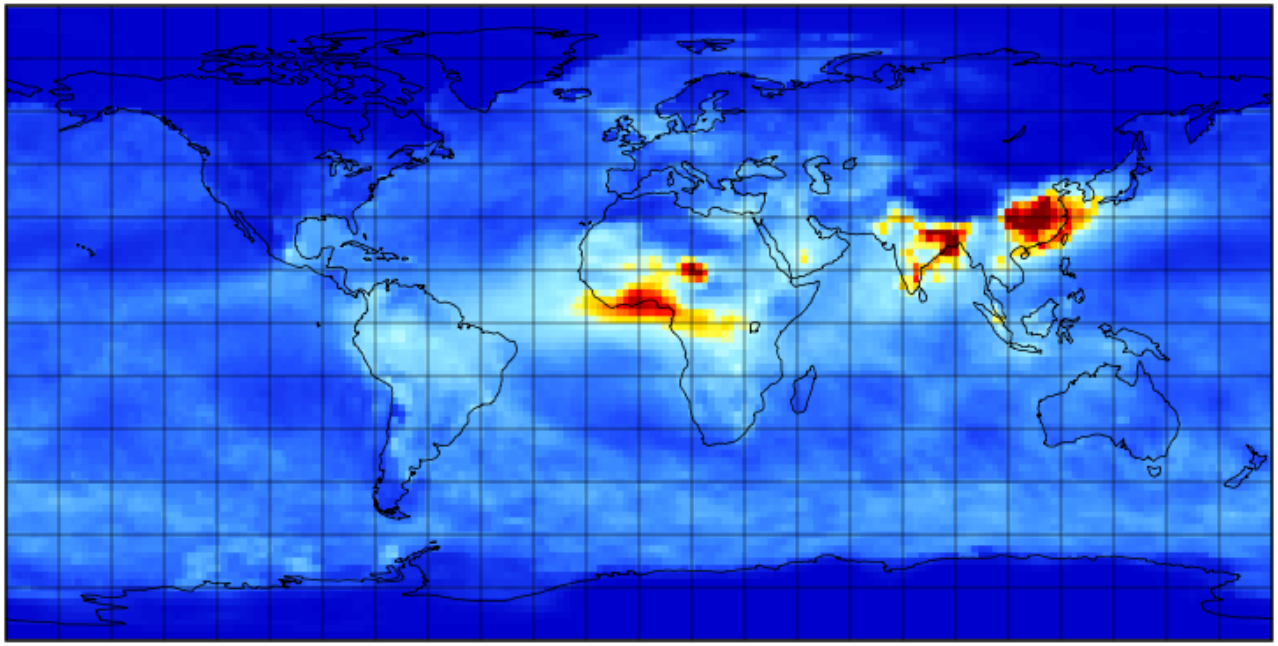


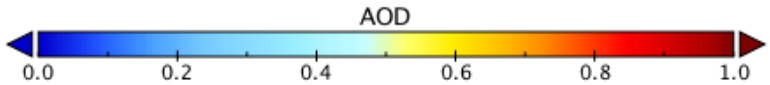
He et al. "Performance of the NPP-VIIRS and Aqua-MODIS Aerosol Optical Depth Products over the Yangtze River Basin" (2018)

NPP VIIRS Dark Target January 2016



MATCH with NPP VIIRS Dark Target January 2016



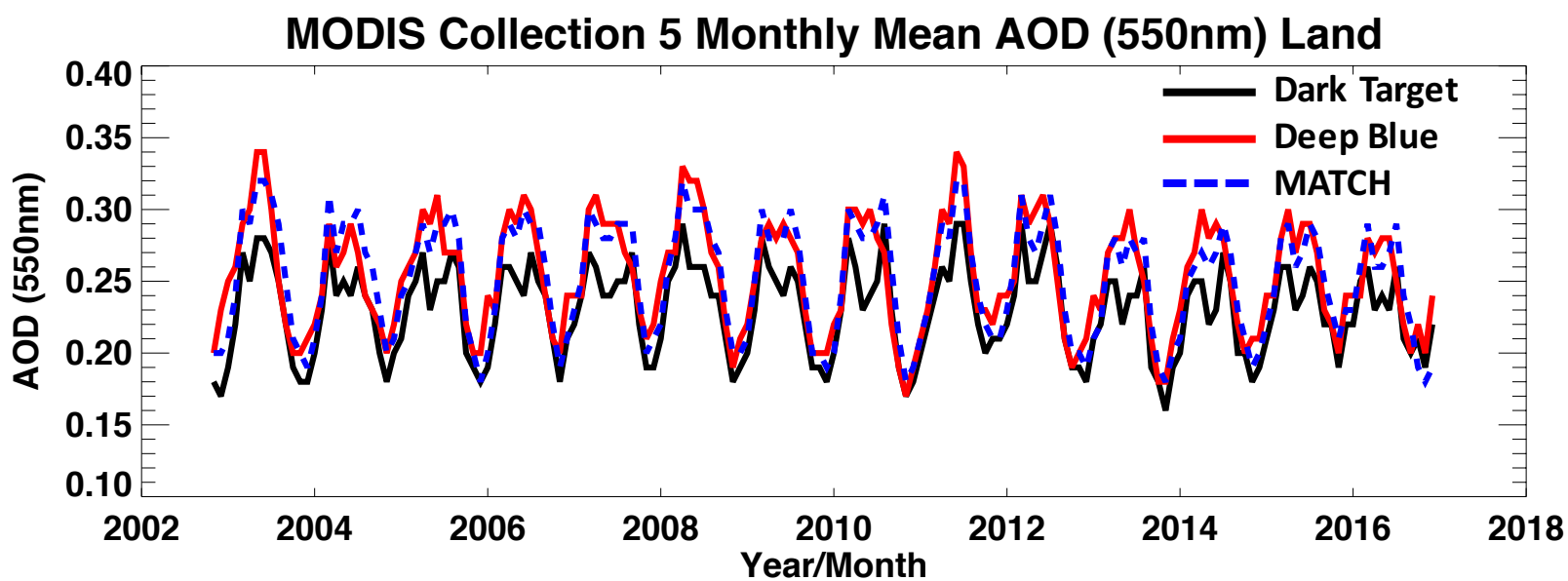


Summary

If available use MODIS Collection 6.1 DT/DB combined.

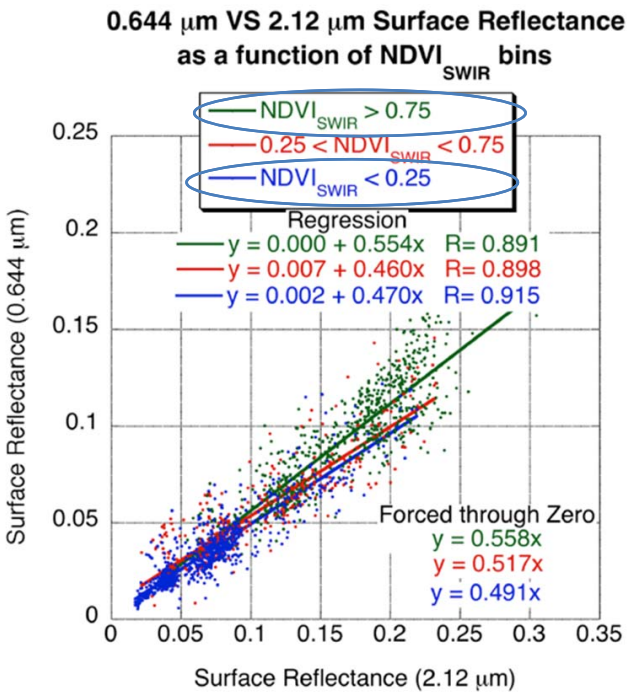
If Dark Target is not processed for VIIRS, will Deep blue process over the land & ocean? May have a deep blue ocean by the end of the month.

VIIRS from NOAA looks OK but with potential issues over brighter surfaces/areas of high optical depth compared to MODIS Dark Target?

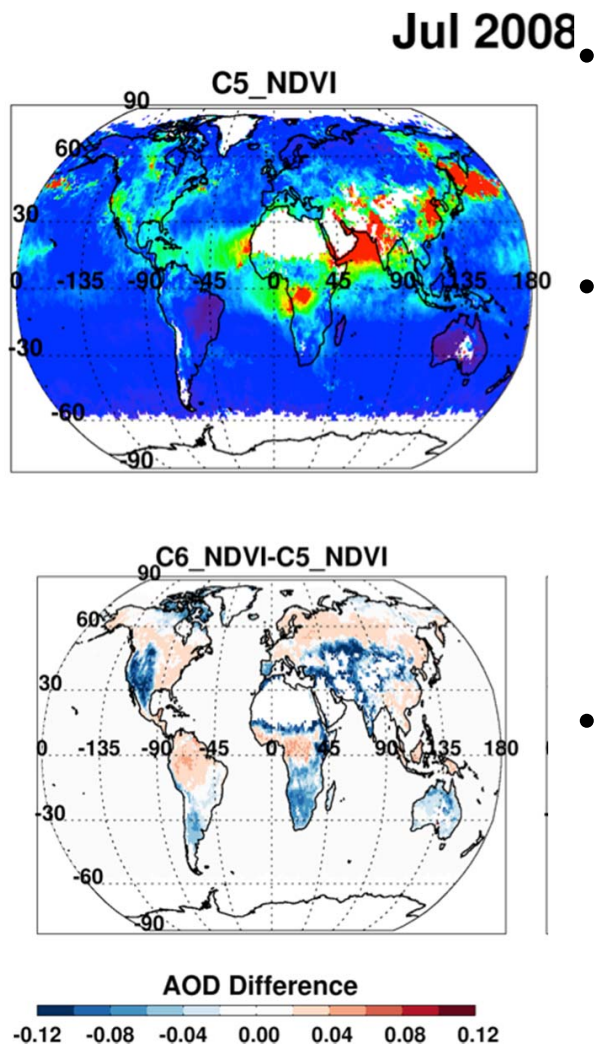


Extra Slides

Major bug fix: surface reflectance relationship to NDVI_swir

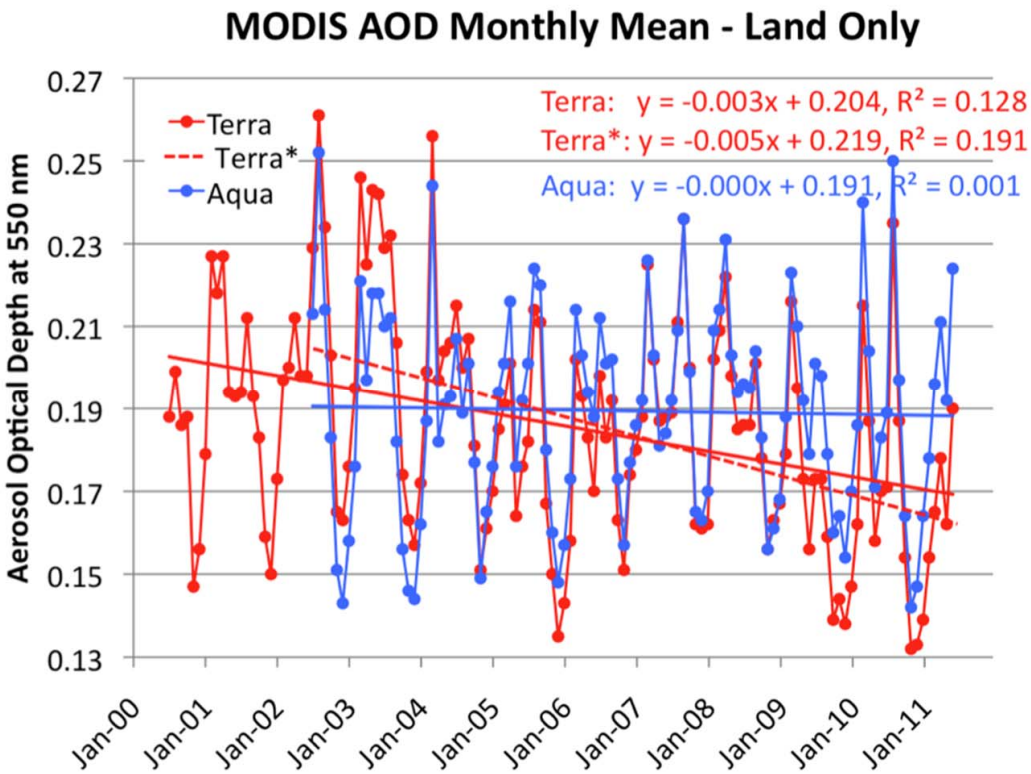


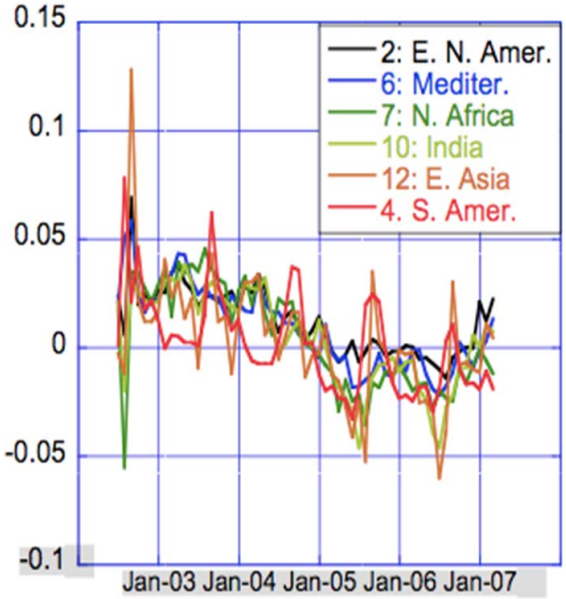
These labels were reversed
Resulting in coding error



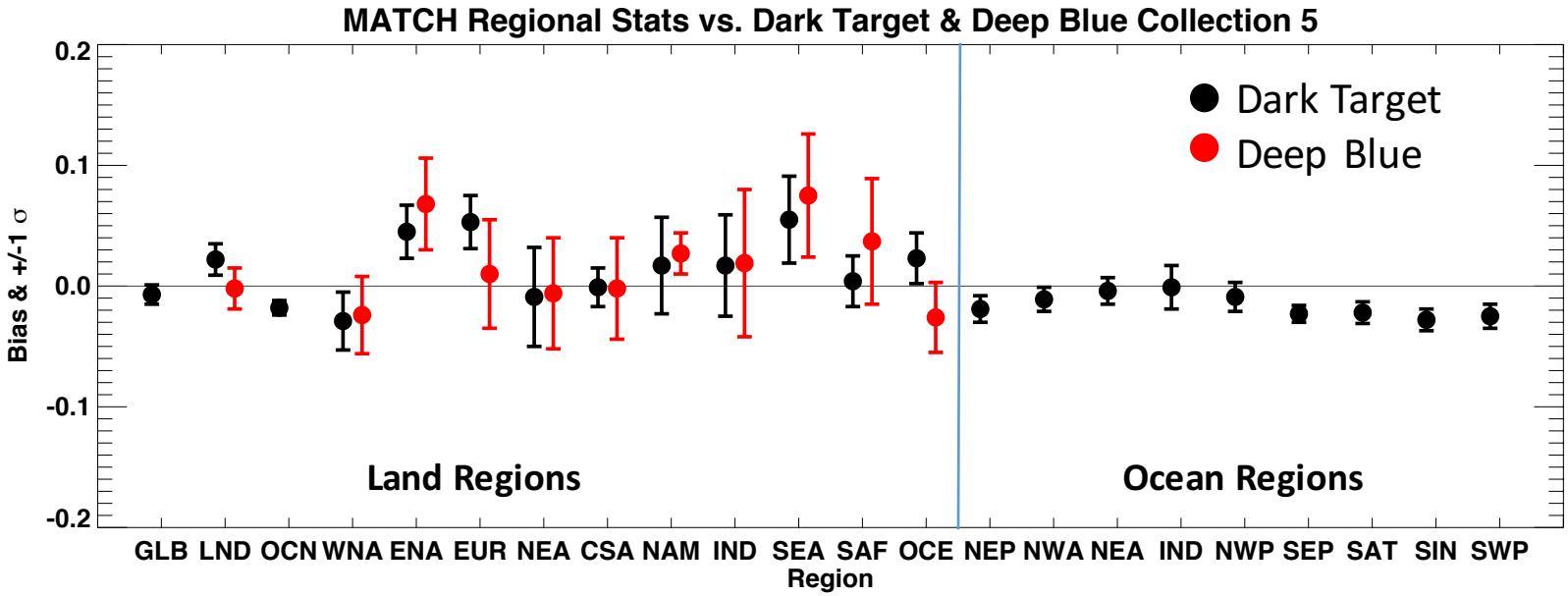
- Coding error from C5 continued to C6
- Surface reflectance dependence on NDVI_swir was reversed
- New: Reduces super-high bias for semi-arid regions.

C5: Trends Terra ≠ Aqua

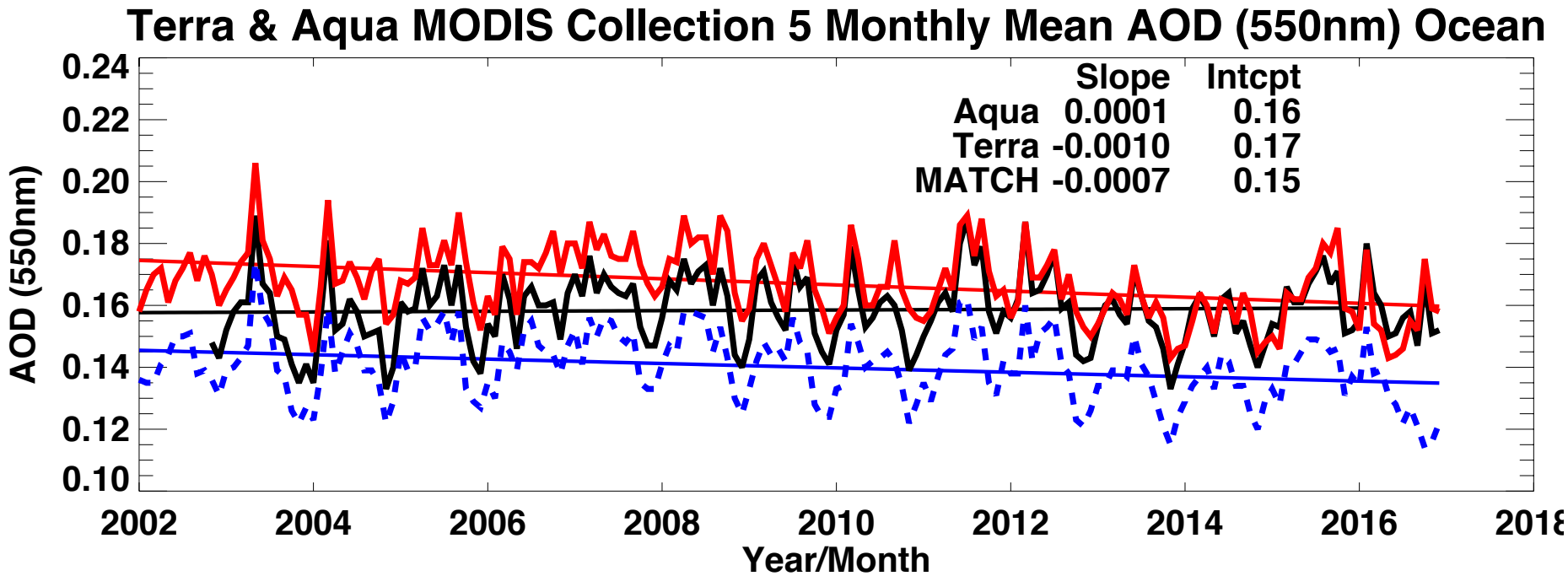




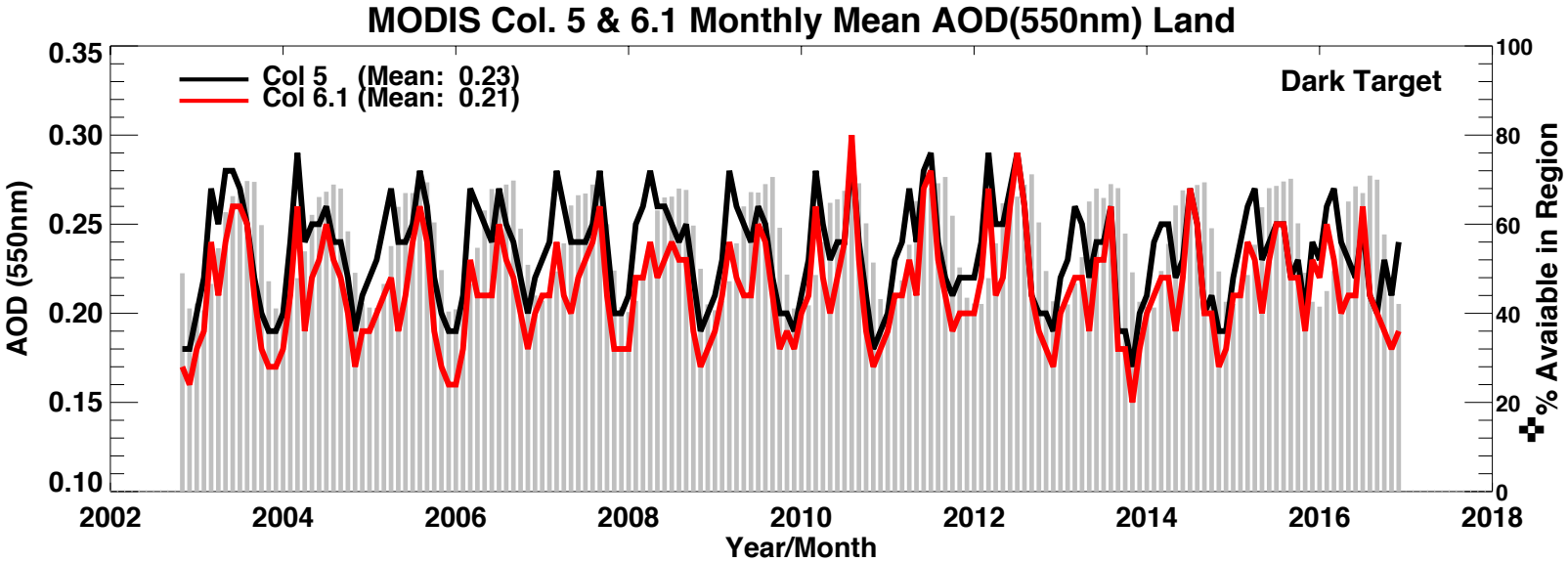
- Over land, Terra *decreases* (-0.04/decade), Aqua *constant*
- Terra / Aqua divergence is the same everywhere on the globe!
- **Artificial Terra trend traced to degrading of Terra's calibration**

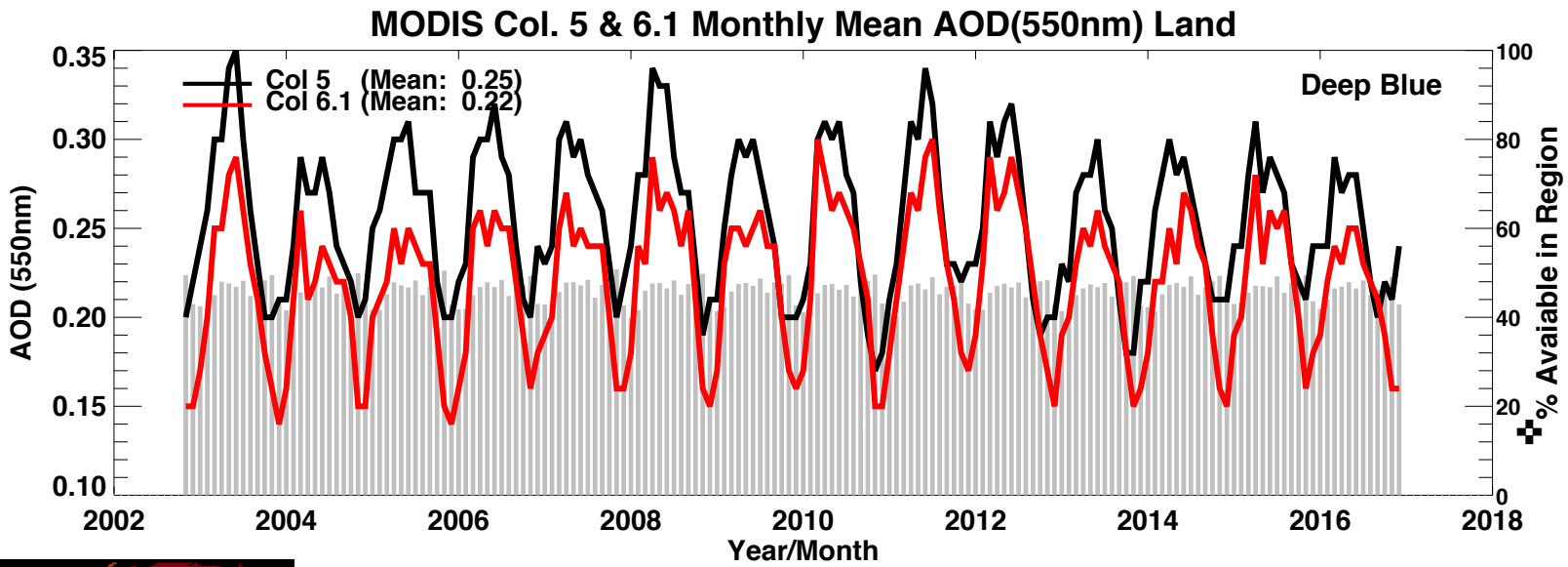


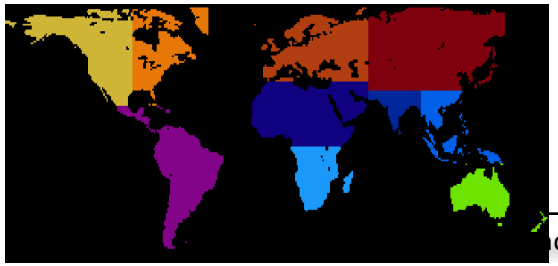
Over land MATCH is influenced more by Deep Blue so smaller impact on CERES if dark target is lost over land.


Terra & Aqua MODIS Collection 5 Monthly Mean AOD (550nm) Ocean
Slope Intcpt
Aqua 0.0001 0.16
Terra -0.0010 0.17
MATCH -0.0007 0.15
AOD (550nm)
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year/Month

AOD (550nm) Col5 and Col6.1 "All Land*"







*Each monthly average includes only points where both Collection 5 & 6.1 had values for a grid box for the region. (But not the same for DT & DB.)

✣"% Available" indicates samples available for the defined region.