Aerosol Assimilation into CERES data Processing Comparisons of MODIS Dark Target and Deep Blue & VIIRS Dark Target and Deep Blue

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Model for Atmospheric Transport and Chemistry (MATCH)

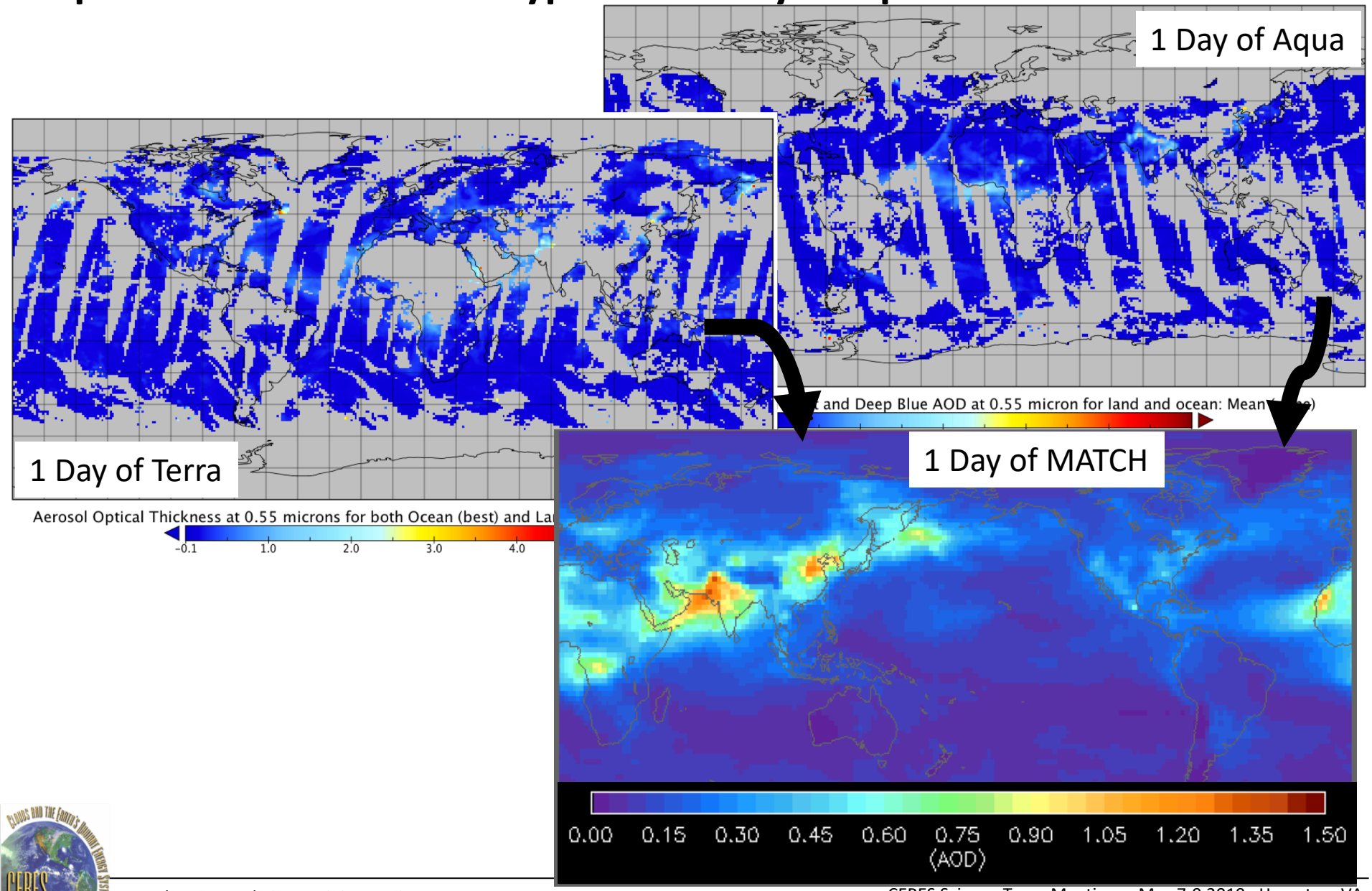
- MATCH is essentially a "small" GCM running chemistry package at ~2° spatial resolution, interpolates 3 hourly wind fields for 30min step for physics package.

- Assimilates MODIS aerosol optical thickness (hourly)
  - Collection 6.1 swath level Terra (MOD04_L2) and Aqua (MYD04_L2)
  - Dark Target Ocean, Dark Target Land, Deep Blue Land
    - Average where both exist.
  - Weights MODIS higher than climatological sources.
  - SYN1deg Ed4.1 is complete through Oct 2018.

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

- 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 runs in advance of RT calculations to provide <u>globally complete</u> maps of AOD and aerosol types at hourly temporal resolution.



Current concern is continuity of aerosol inputs as satellites/imagers change over time.

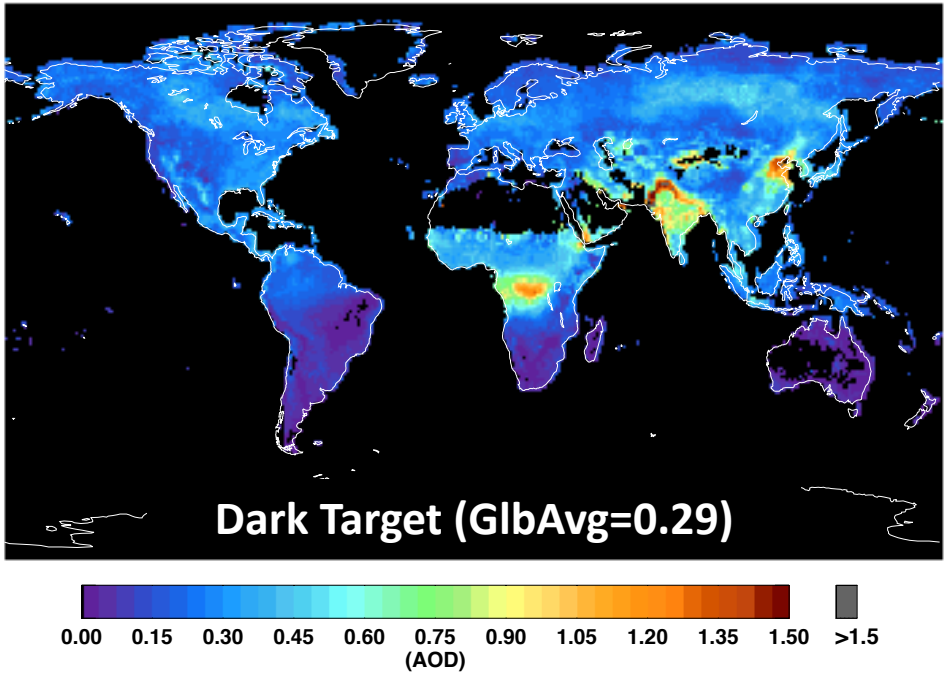
MODIS on Terra & Aqua

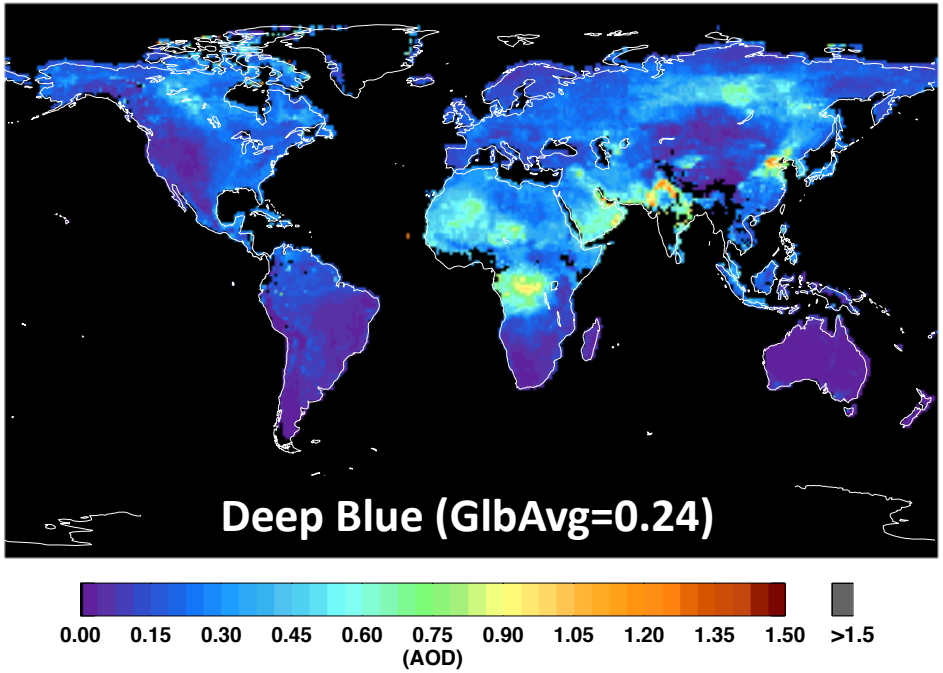
- Collection 6.1 using Deep Blue (land) & Dark Target (globally).
- Reprocessing SYN1Deg Ed4 using Col6.1 MODIS almost complete

VIIRS processing of SNPP

- GODDARD team processing VIIRS at SSEC, Deep Blue and Dark Target <u>globally</u>.
- Currently VIIRS is available from 03/2012 through 01/2019
  - Deep Blue lev2 & lev3 (monthly mean)
  - Dark Target: lev2 (6min granule)
- Comparing 5 years of VIIRS Deep Blue 06/2012 thru 12/2018.
- Processed 1 year of Dark Target 01-12/2015.

Canonical Mean July (2012-2017) AOD@550nm
MODIS Col 6.1 Dark Target & Deep Blue

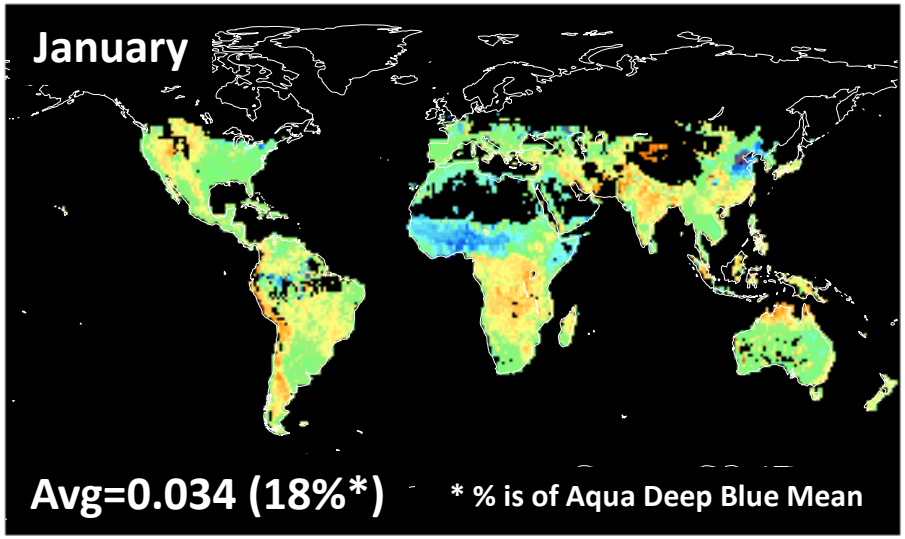


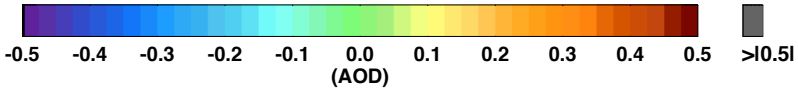


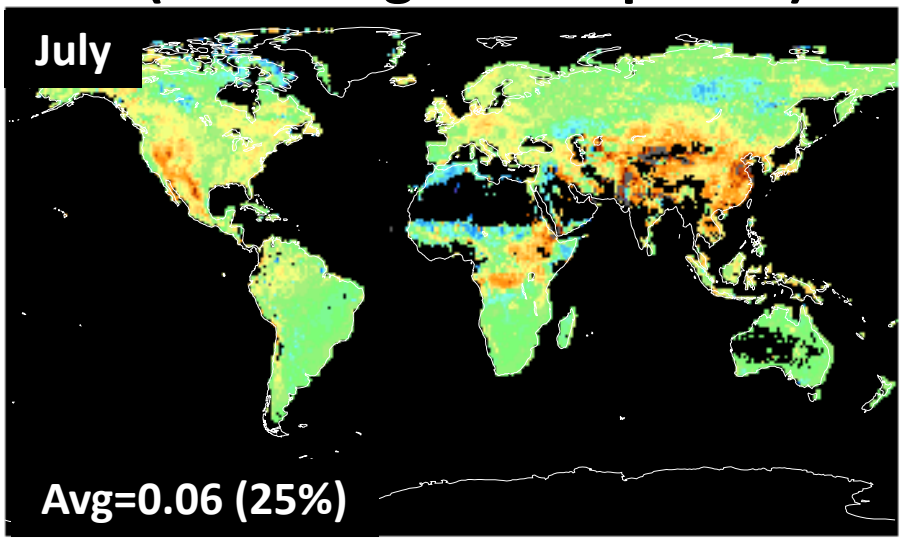
Where we have 5 years of data we show canonical monthly mean bias.
Standard Deviation maps are for the 60 month time series.
All AOD is at 550nm.

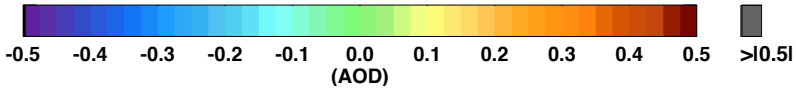
"MODIS" --> Aqua
"VIIRS" --> Soumi NPP

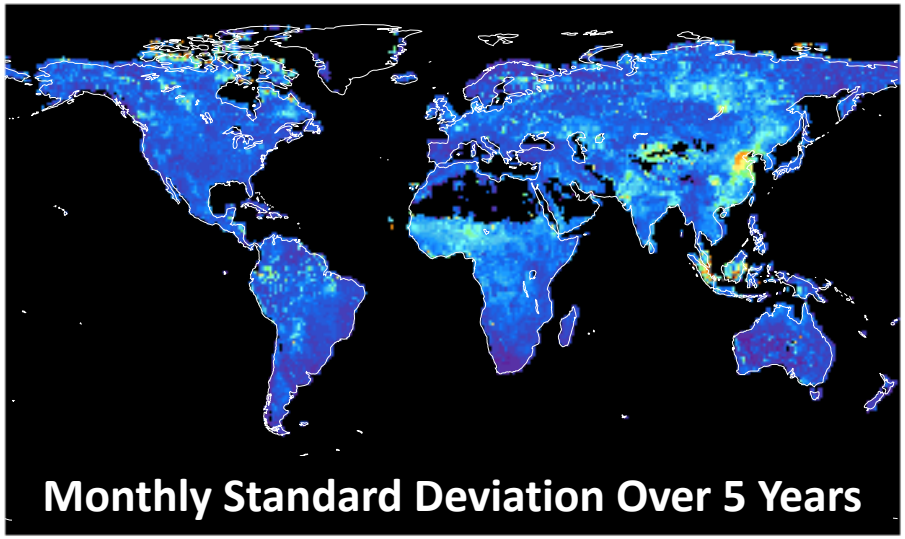
Canonical Mean Differences: MODIS (Dark Target - Deep Blue)

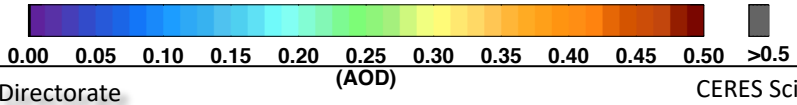






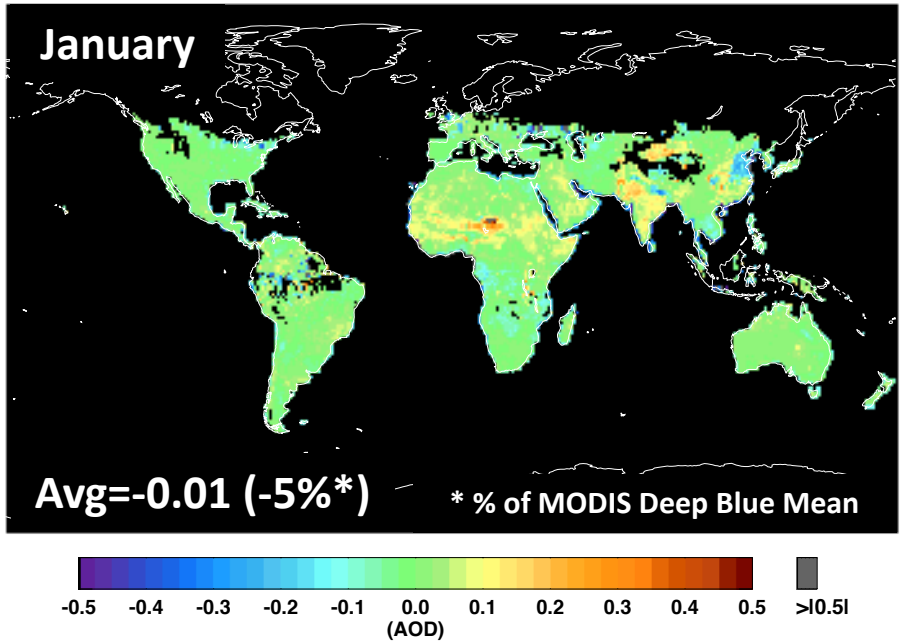


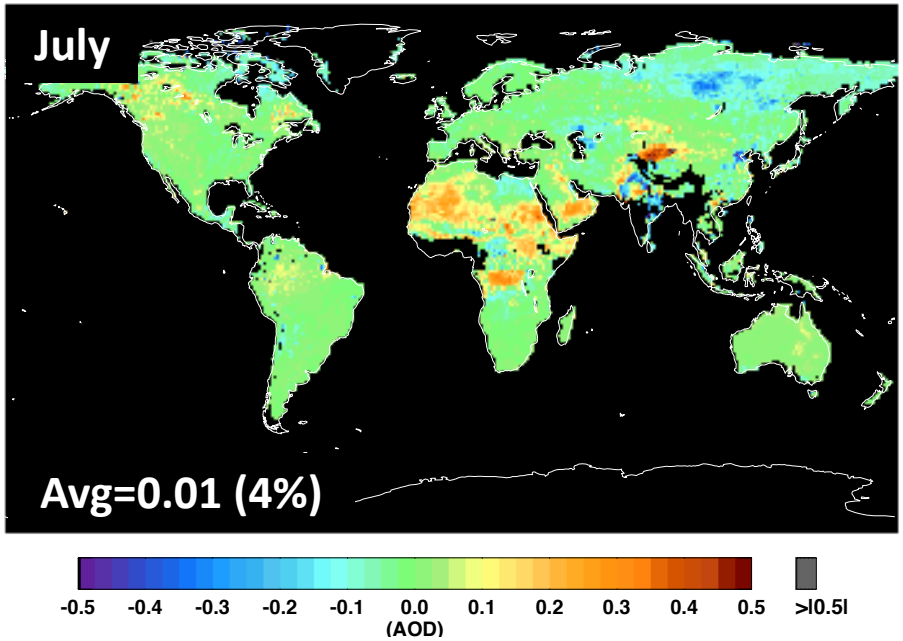


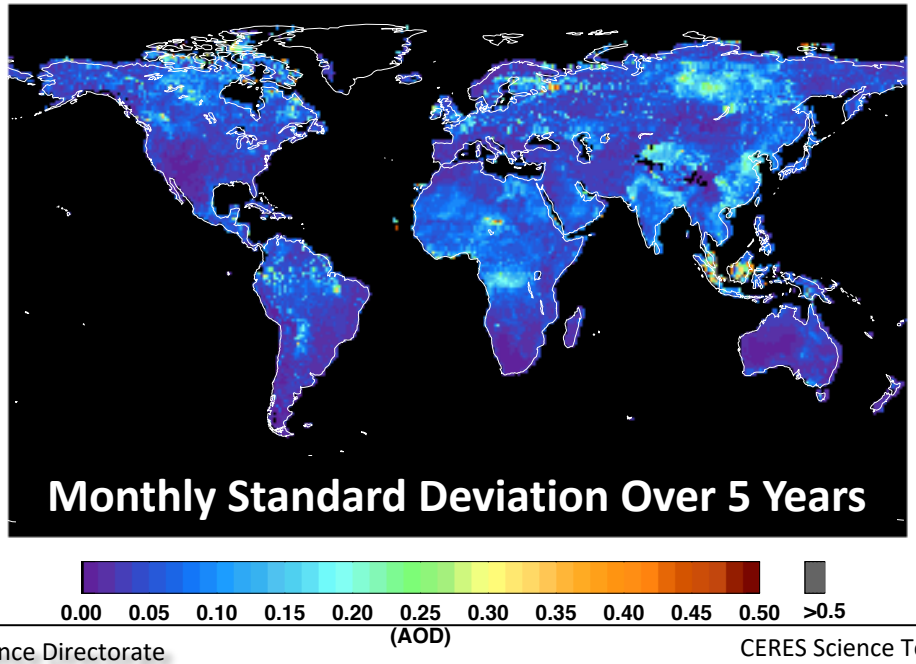


Same Instrument
Two Algorithms

Canonical Mean Differences: VIIRS - MODIS (Deep Blue)

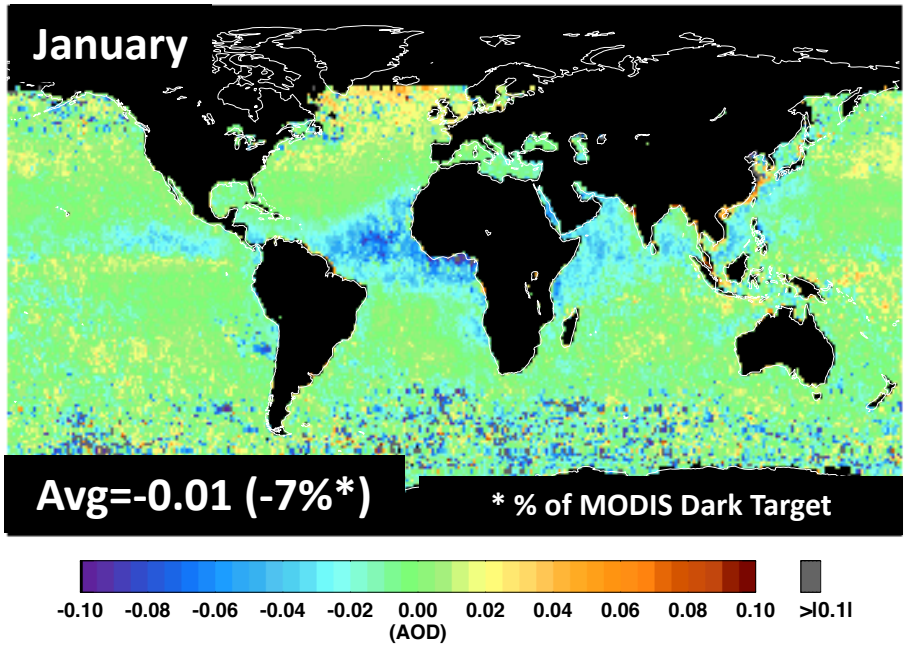


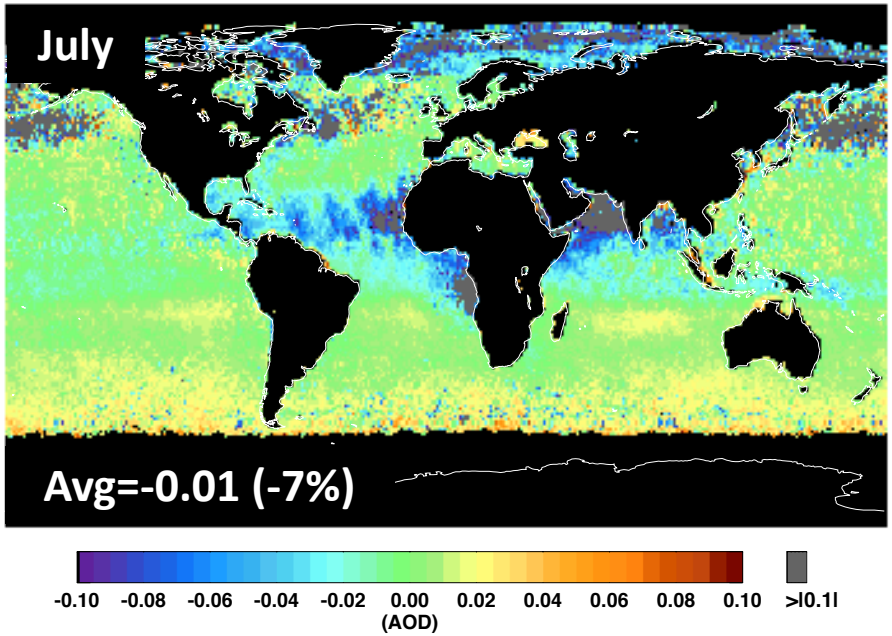


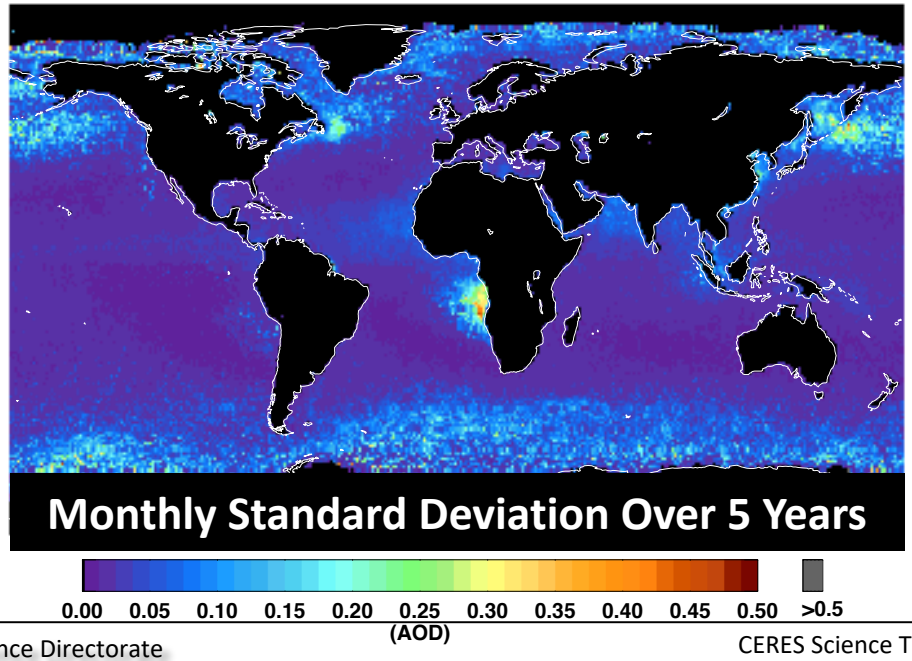


Different Instruments Same Algorithm

Canonical Mean Differences: VIIRS Deep Blue - MODIS Dark Target

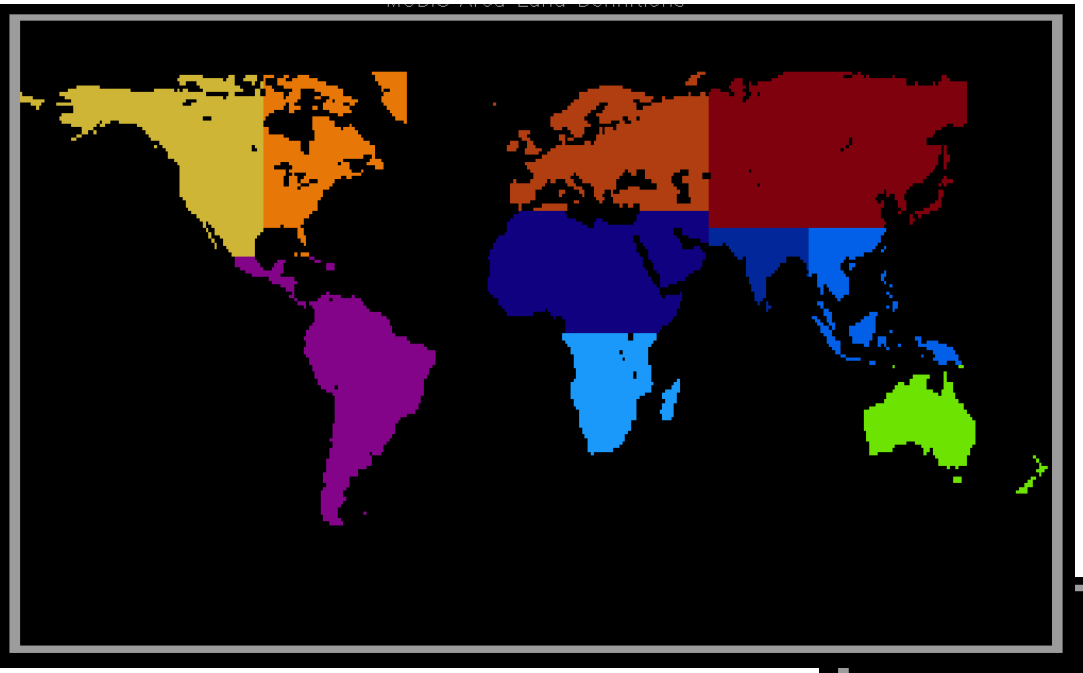


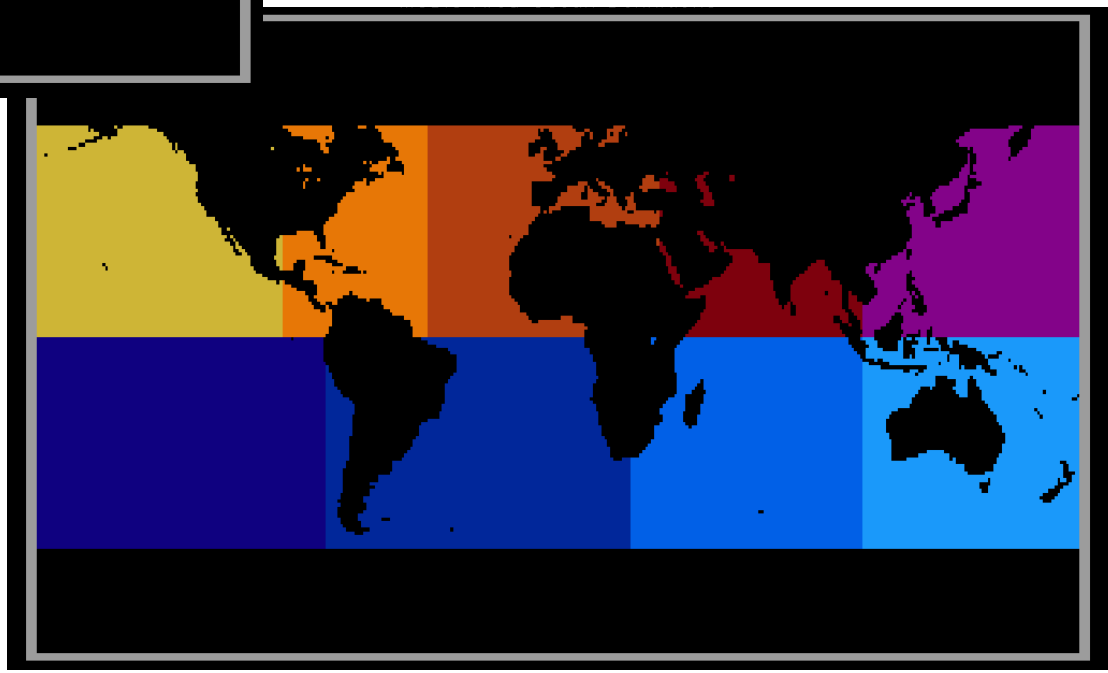




Different Instruments Different Algorithms

Region Definitions*

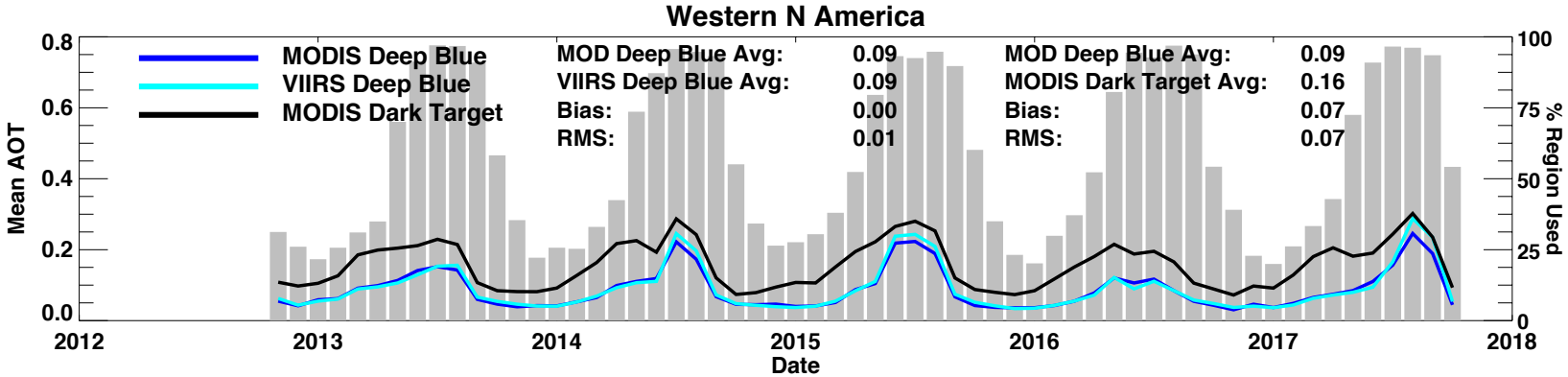


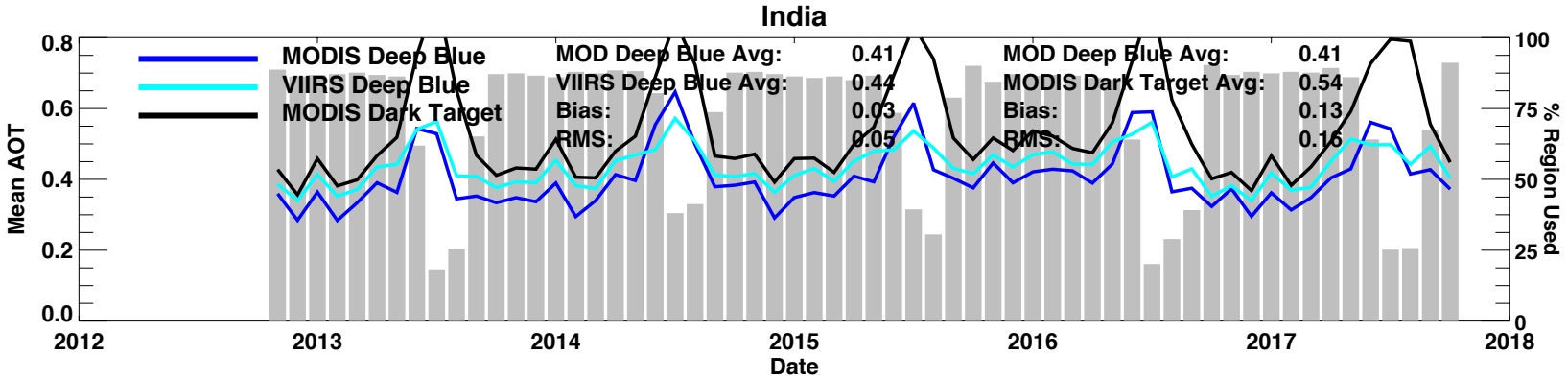


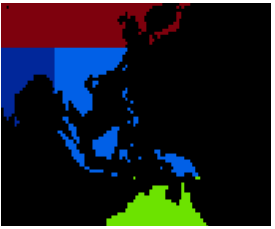
*Based on Sayer et al. 2014

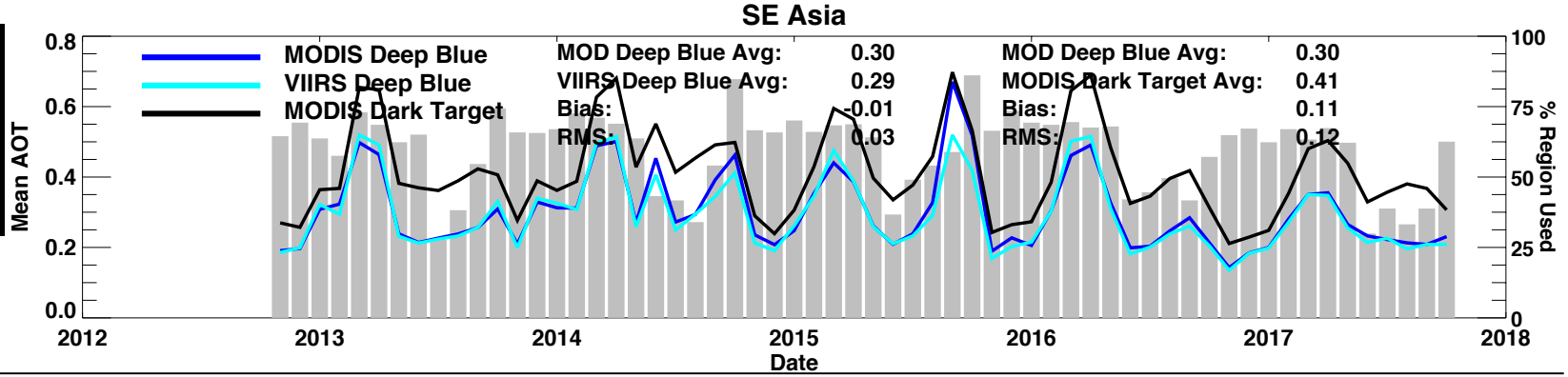
Following plots show regional means where all three methods have data within the region defined. Grey bars indicate % of grid boxes used in the average of the region for each month.

Land Regional Monthly Means AOD (2012-2017)

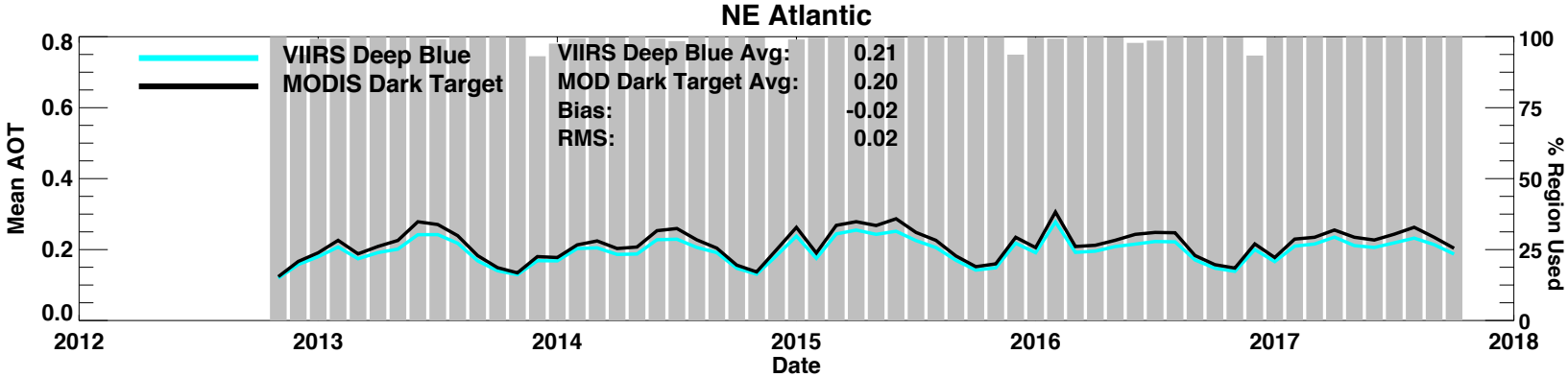


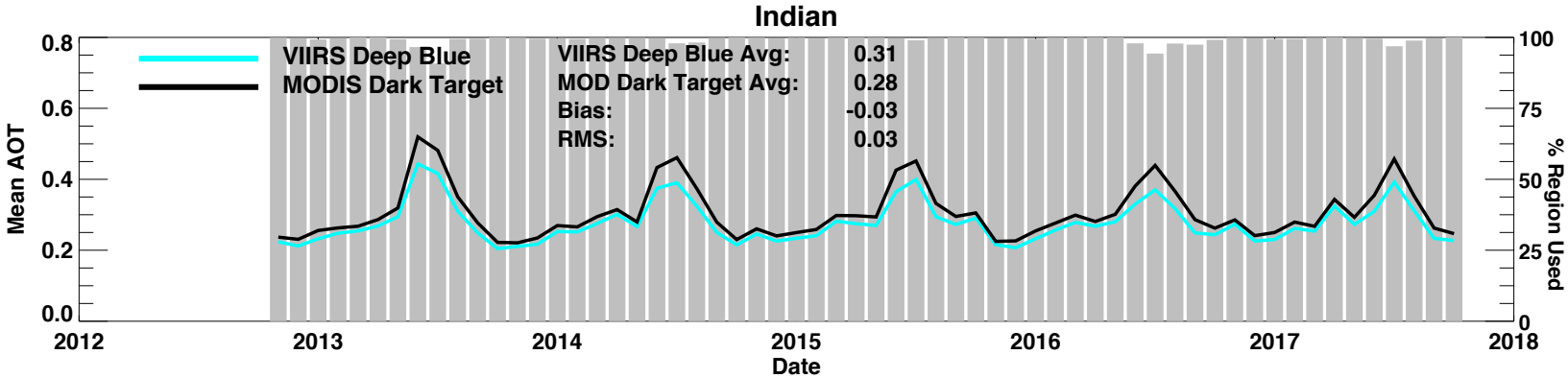


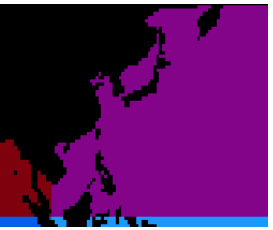


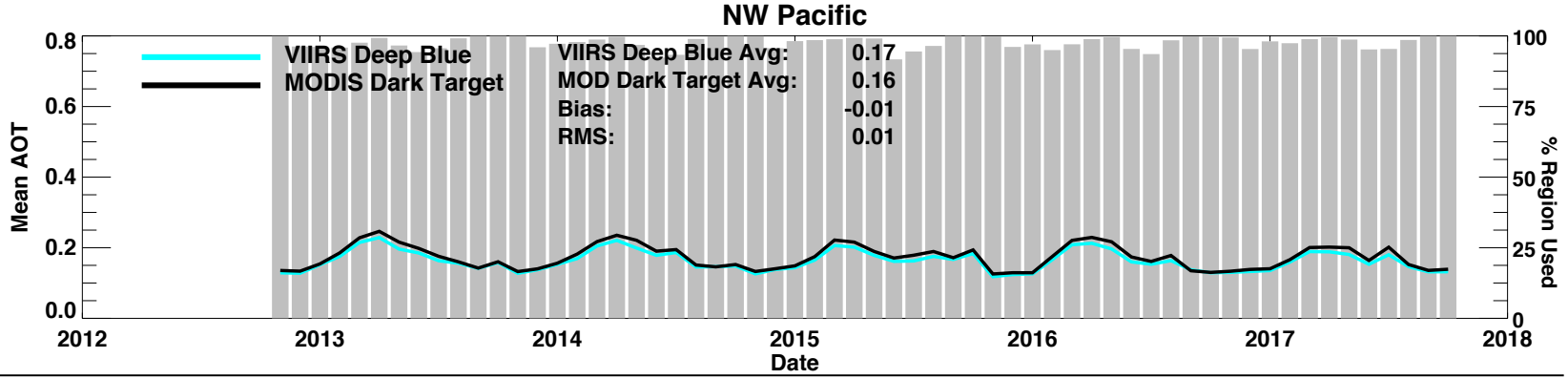


Ocean Regional Monthly Means AOD (2012-2017)









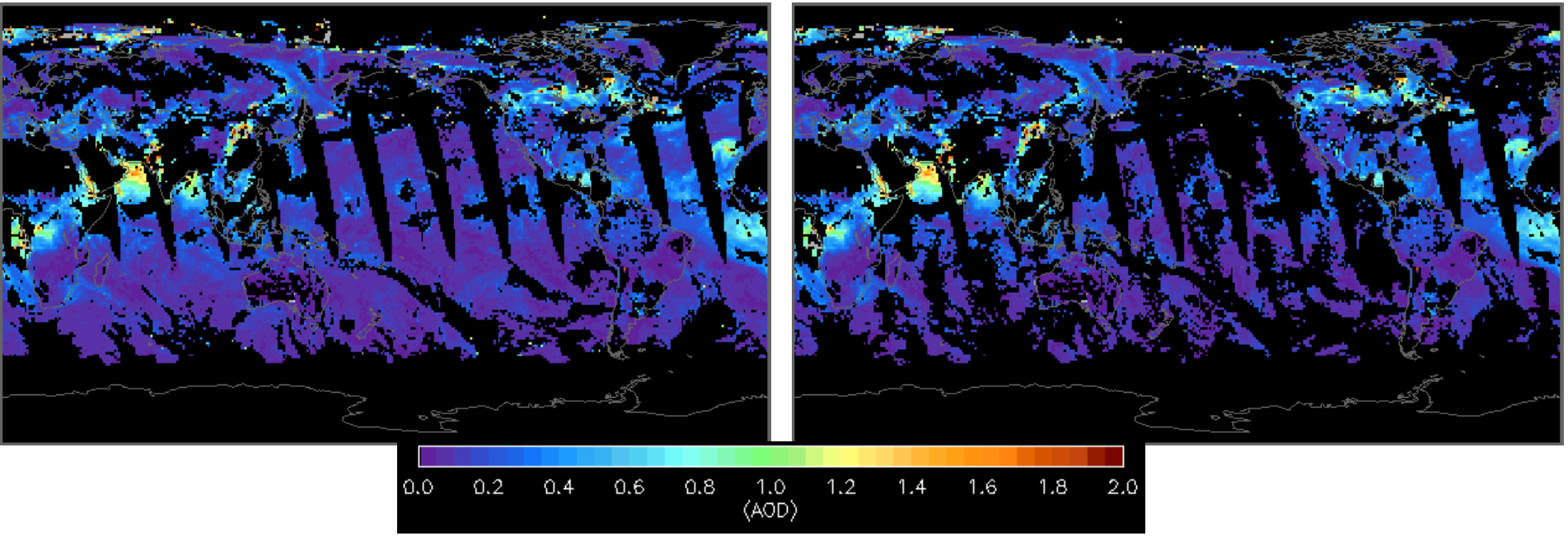
Land Regional AOD Mean Bias in % (x-Aqua DB) (2012-2017)

		West N America	East N America	Europe	NE Asia	Cent & S America	N Africa Middle East	India	SE Asia	S Africa	Australia /Oceania
Aqua DB	Mean	0.09	0.13	0.15	0.24	0.14	0.34	0.41	0.30	0.19	0.06
SNPP DB	Bias	3	-6	-5	-1	7	20	7	-3	-1	52
Terra DB	Bias	1	9	6	-0	8	-1	4	5	3	-7
Aqua DT	Bias	79	25	17	26	37	-2	32	36	29	42
Terra DT	Bias	116	51	40	39	44	0	37	40	36	57

SNPP VIIRS processing of Dark Target

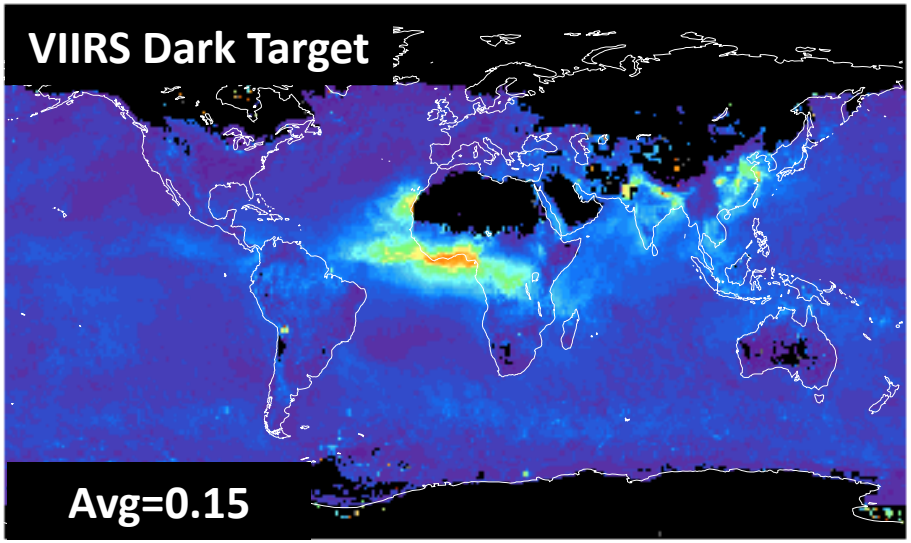
- Have 1 year of Dark Target 01-12/2015.
- 6-minute granules were converted to daily then monthly averages.
- Data come with confidence flags (example below).

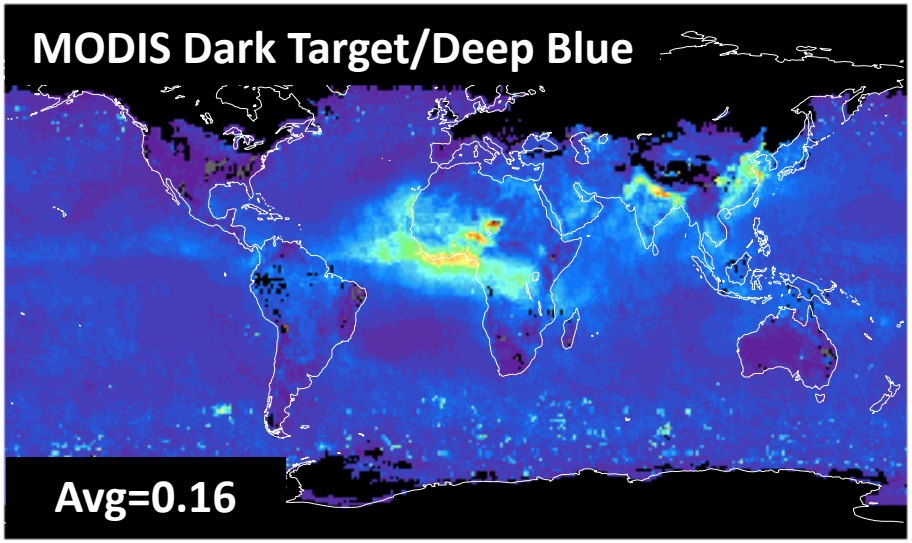
Daily Averages for July 10, 2015

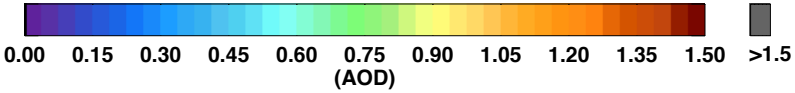


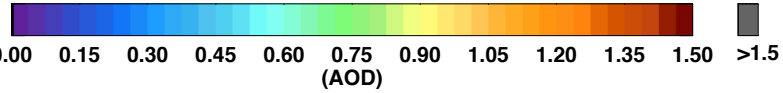
For the VIIRS Dark Target only have 1 year so following maps are simple monthly means

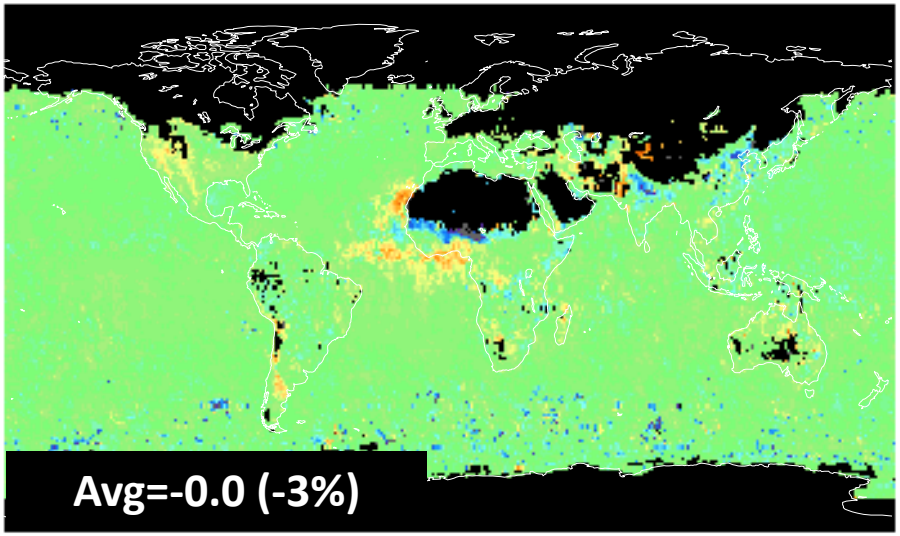
Mean January 2015, VIIRS Dark Target - MODIS Combined

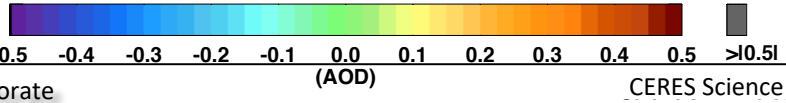






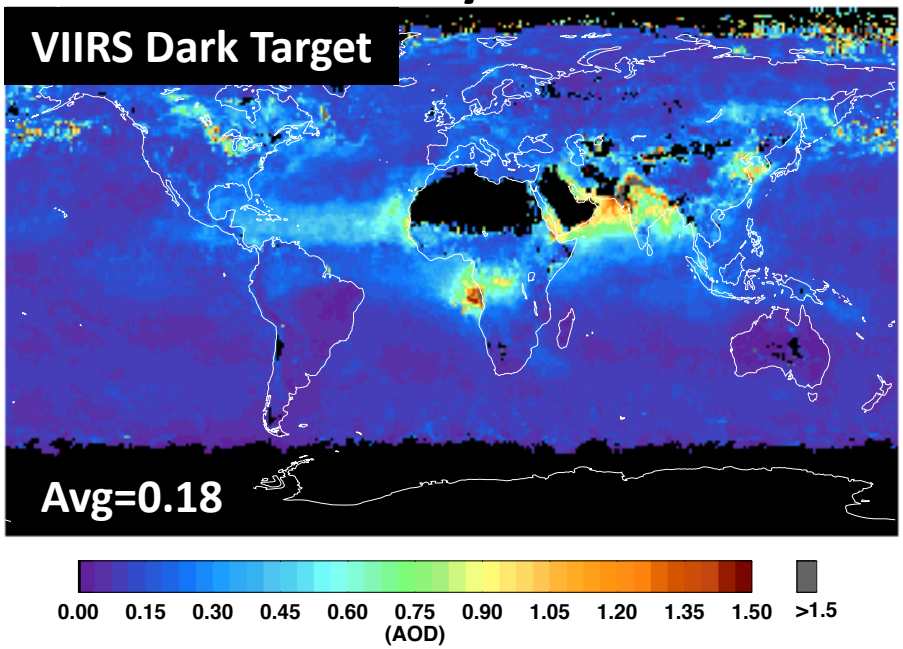


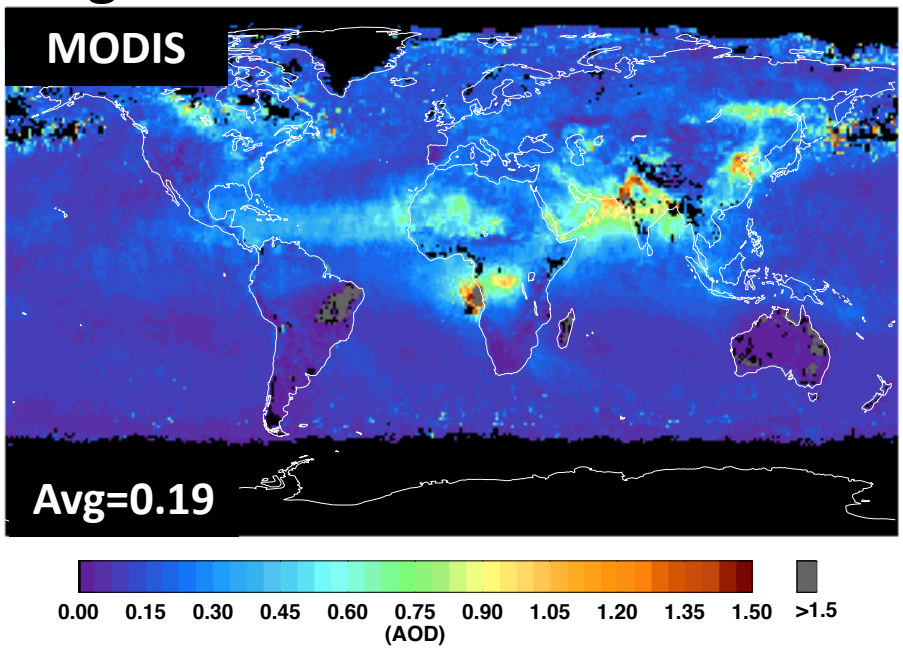


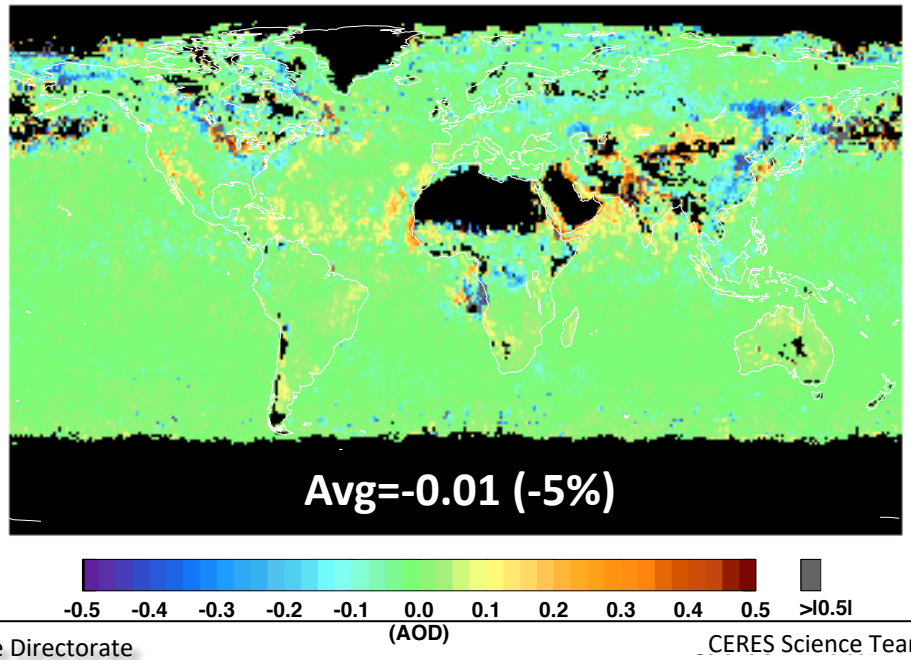


Different Instruments Different Algorithms

Mean July 2015 VIIRS Dark Target - MODIS Combined

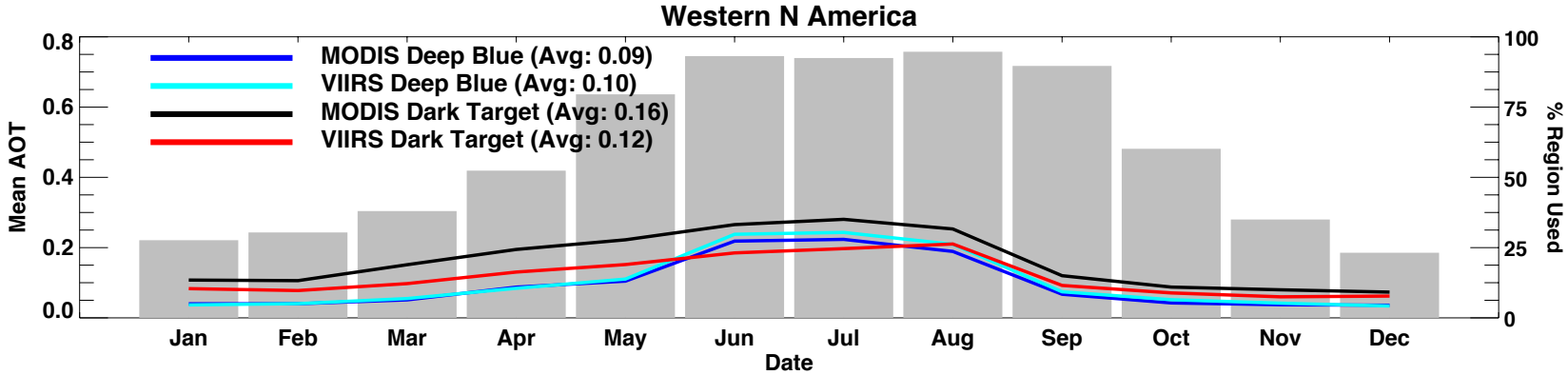


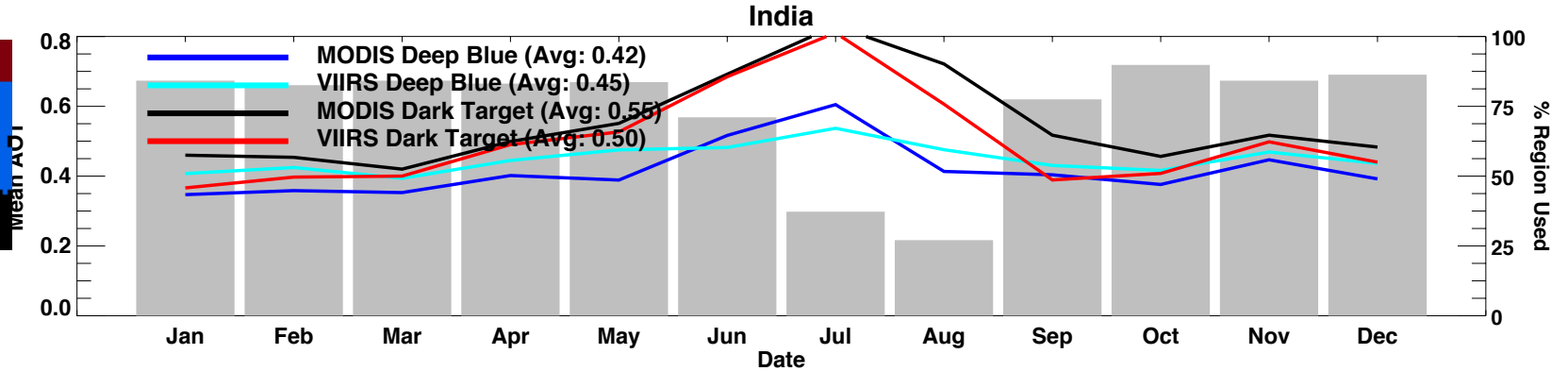


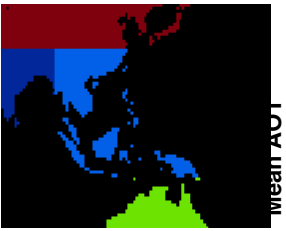


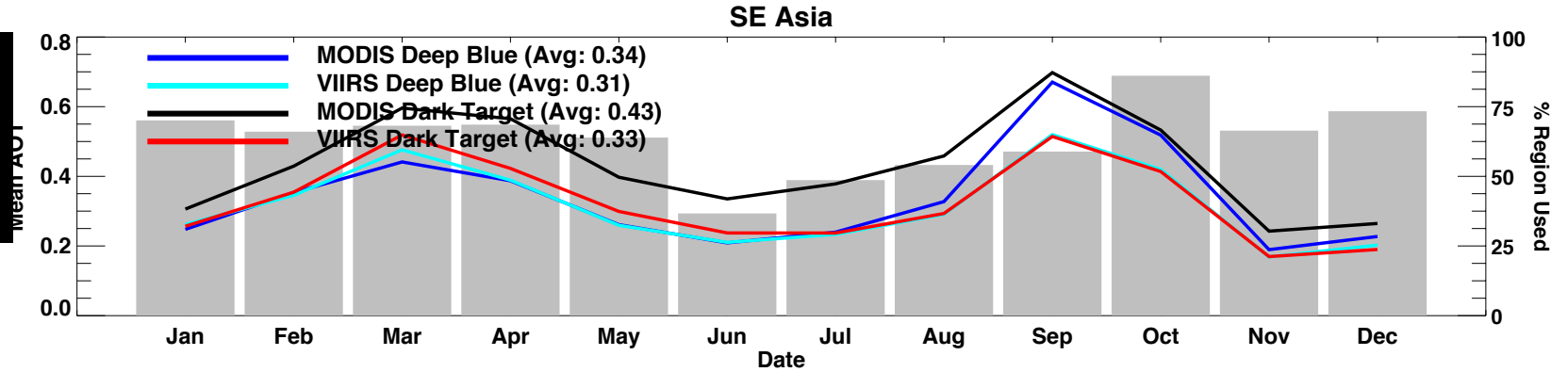
Different Instruments Different Algorithms

Land Region Monthly Mean AOD (2015)

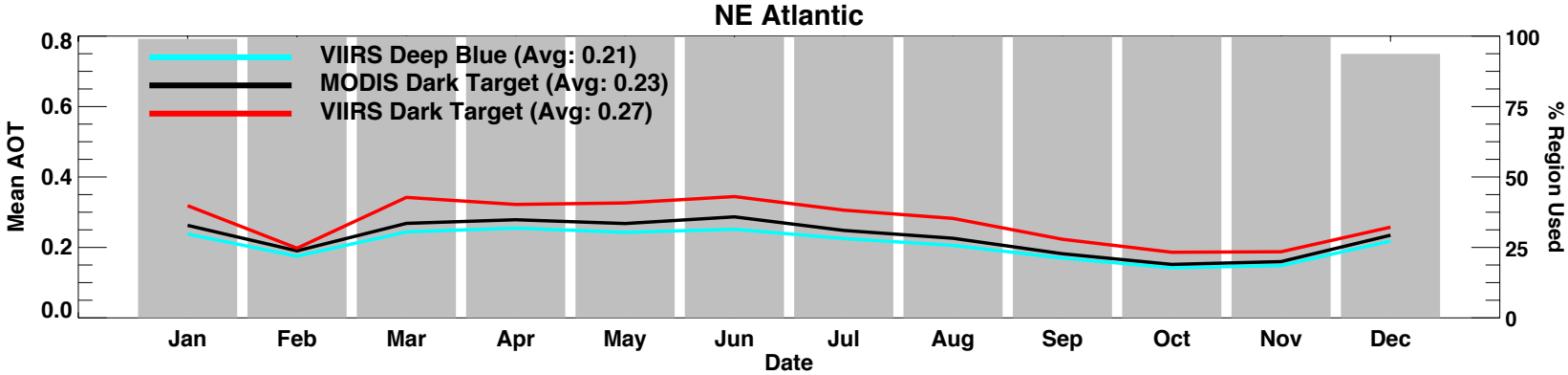


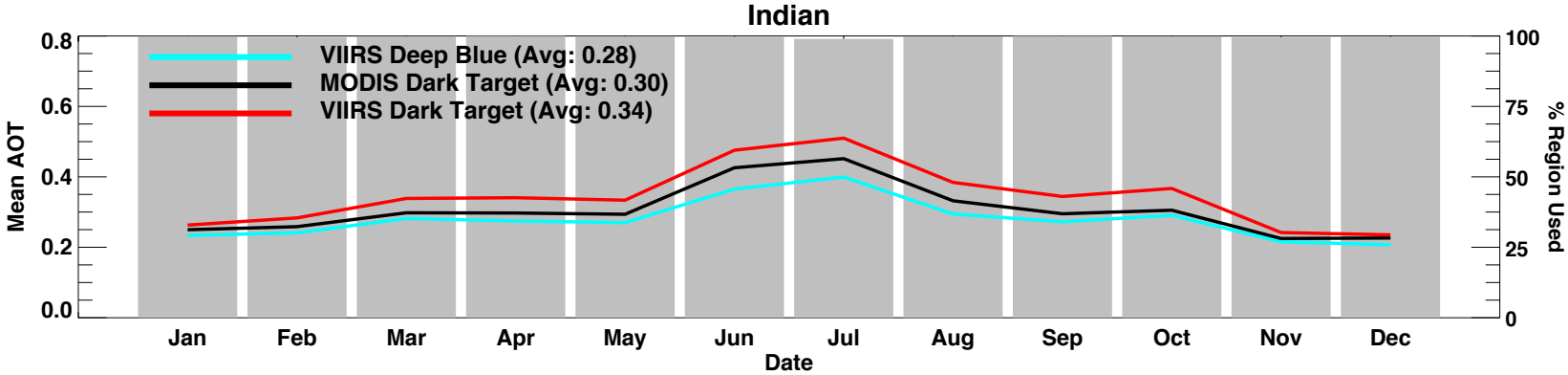


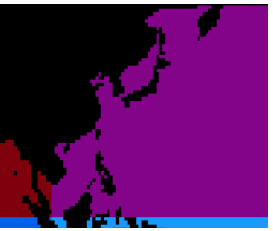


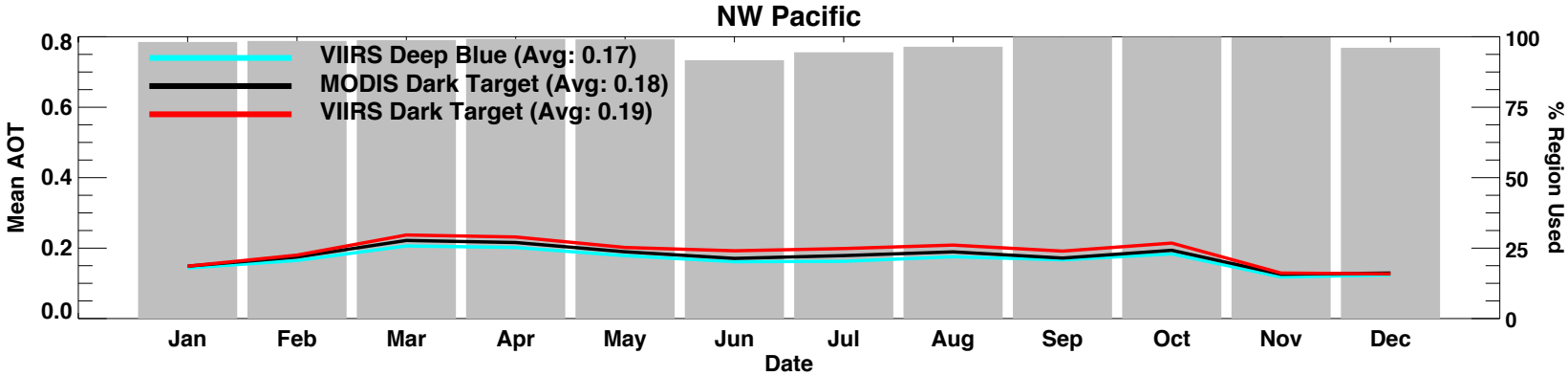


Ocean Region Monthly Mean AOD (2015)









Summary

- Maps show regional variability, maximums in high aerosol loading areas.
- Dark target generally biased high relative to MODIS & VIIRS Deep Blue.
- That bias is often seasonal, peaking in NH summer.
- Bias is largest over the Indian region, during the monsoon (smallest sample but very consistent.)
- Over the ocean the algorithms agree quite well.
- Worst bias for ocean regions again is in the Indian Ocean during the monsoon season.

- For VIIRS Dark target, I expected agreement with the MODIS Dark Target (similar to agreement between MODIS and VIIRS Deep Blue .)
- VIIRS Dark Target matched better with the MODIS Deep Blue and VIIRS Deep Blue over land, MODIS Dark Target remains an outlier in most regions.
- Time series indicate there are exceptions to this rule depending on region and month.

Overall it looks good. AOD from the SNPP DB & DT will not produce a 'shock' to the continuity of the time series.

		West N America	East N America	Europe	NE Asia	Cent & S America	N Africa Middle East	India	SE Asia	S Africa	Australia /Oceania
Aqua DB	Mean	0.09	0.13	0.15	0.24	0.14	0.34	0.41	0.30	0.19	0.06
SNPP DB	Bias	0.00	-0.01	-0.01	-0.00	0.01	0.04	0.03	-0.01	-0.00	0.03
Terra DB	Bias	0.00	0.01	0.01	-0.00	0.01	-0.01	0.02	0.02	0.01	-0.00
Aqua DT	Bias	0.07	0.03	0.03	0.06	0.05	-0.01	0.13	0.11	0.05	0.02
Terra DT	Bias	0.10	0.07	0.06	0.10	0.06	0.00	0.15	0.12	0.07	0.03

		West N America	East N America	Europe	NE Asia	Cent & S America	N Africa Middle East	India	SE Asia	S Africa	Australia /Oceania
Aqua DB	Mean	0.09	0.13	0.15	0.24	0.14	0.34	0.41	0.30	0.19	0.06
SNPP DB	σ	0.00	0.01	0.01	0.02	0.01	0.01	0.04	0.03	0.02	0.02
Terra DB	σ	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01
Aqua DT	σ	0.03	0.03	0.02	0.04	0.02	0.05	0.08	0.05	0.03	0.02
Terra DT	σ	0.02	0.02	0.02	0.04	0.02	0.05	0.08	0.05	0.02	0.01