

# Working Towards Dark Target Aerosol Product Synergy Among Geostationary Orbit (GEO) and Low Earth Orbit (LEO) Sensors

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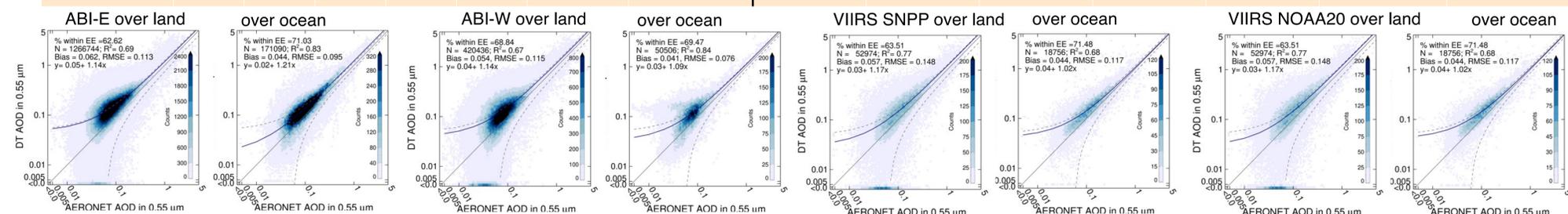
## Motivation

- To have a consistent aerosol retrieval applied to various sensors onboard both low earth orbit (LEO) satellites and geostationary satellites (GEO) we develop the Dark Target (DT) package, based on the MODIS operational DT algorithm.
- The DT package is applied to the Advanced Baseline Imager (ABI) on board both GOES East (ABI-E) and GOES West (ABI-W), the Advanced Himawari Imager (AHI) on board the Himawari satellite over the western Pacific, the Visible Infrared Imaging Radiometer Suite (VIIRS) on board the LEO Suomi-National Polar-orbiting Partnership (SNPP) and JPSS-NOAA20 satellite, as well as to MODIS on board Terra (MOD) and Aqua (MYD). Aerosol products are produced from 2019 - 2020 and then evaluated against AERONET and Marine Aerosol Network (MAN).
- Note DT package MODIS Terra and Aqua product are slightly different than operational C6.1 product. The validation of DT package MODIS product are shown here.
- Error statistics are generated, and uncertainty sources are investigated for all products.
- LEO satellites are global in nature and GEO satellites are regional. Intercomparisons among these products are performed for common regions.

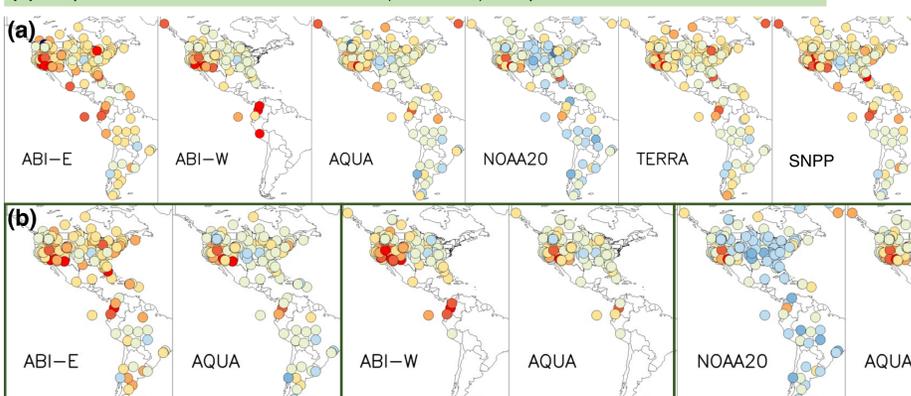
## Error Statistics Against AERONET/MAN

The collocation window is 20 km spatially and +/- 15 mins temporally. 2019 & 2020 year was validated. **Land Ocean**  
The Expected Error over land:  $0.1 \pm 20\%AOD$ , over ocean :  $0.05 \pm 15\%AOD$   
(MAN validation results are in parenthesis)

	ABI-E	ABI-W	AHI	MYD	MOD	VIIRS_SNPP	VIIRS_NOAA20	ABI-E	ABI-W	AHI	MYD	MOD	VIIRS_SNPP	VIIRS_NOAA20
% within EE	62.62	68.84	46.38	74.07	67.59	63.51	68.89	71.03 (84.1)	69.47 (89.3)	57.40 (85.67)	82.63 (90.96)	77.01 (86.96)	71.48 (79.82)	81.54
r <sup>2</sup>	0.69	0.67	0.70	0.80	0.81	0.77	0.77	0.83 (0.85)	0.84 (0.64)	0.77 (0.82)	0.86 (0.90)	0.81 (0.93)	0.68 (0.8)	0.58
Bias	0.062	0.054	0.143	0.021	0.034	0.057	-0.007	0.044 (0.012)	0.026 (0.017)	0.054 (0.023)	0.023 (0.018)	0.034 (0.023)	0.044 (0.036)	0.026
RMSE	0.113	0.115	0.300	0.106	0.111	0.148	0.112	0.095 (0.066)	0.076 (0.043)	0.115 (0.061)	0.059 (0.041)	0.076 (0.050)	0.117 (0.084)	0.120
slope	1.14	1.14	1.32	1.03	1.02	1.17	0.99	1.21 (1.11)	1.09 (1.18)	0.91 (1.24)	0.92 (1.00)	0.96 (1.00)	1.02 (1.21)	0.95
offset	0.05	0.04	0.05	0.02	0.03	0.03	-0.01	0.02 (-0.01)	0.03 (0.00)	0.07 (0.00)	0.03 (0.02)	0.04 (0.02)	0.04 (0.01)	0.03
#	1266K	420K	270K	31K	34K	53K	52K	171K (122K)	50K (9.5K)	92K (50K)	6K (2K)	6K (3K)	19K (15K)	18K



(a) DT from each sensor compared with AERONET  
(b) DT products collocated with DT AQUA (< 10 mins) compared with AERONET

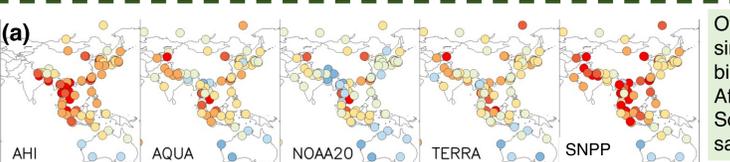


Overall, overland MODIS show lowest biases. NOAA20 has low bias over land. ABI-W and SNPP shows good agreement with AERONET at eastern/central U.S. ABI-E has high bias over both east and west coast of U.S.

Over land AOD Bias (DT-AERONET) at green over ABI domain

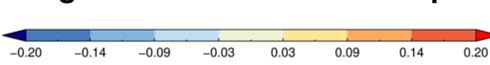
Compare (b) to (a), when sampling is restricted, two major changes occur:  
• Cloud masking differences due to finer/coarser spatial resolution of native pixels.  
• Observing geometry differences

Compared to the total statistics (a), AQUA under SNPP sampling shows the minimum bias over U.S; both ABI-E and SNPP show reduced bias at most of the sites as well. ABI-W show increased bias over western US after collocated with AQUA. SNPP is as good as AQUA after sampling change except at west coast. NOAA20 shows a lot more negative bias after collocation.



Over land under AHI domain, MODIS Aqua, Terra and NOAA20 show similar magnitude of bias, while AHI and SNPP show much higher bias, especially at edge of the disk. After collocation, both AHI and SNPP show reduced bias over Southeast Asia. NOAA20 shows a stronger low bias with Aqua sampling. Aqua bias show no trend of change after collocation.

Regional over Land Error Map



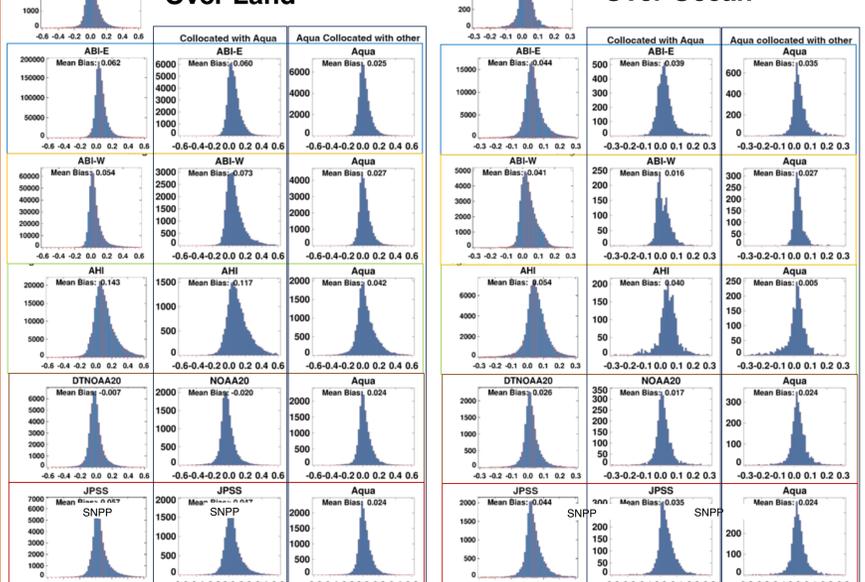
AOD Bias (DT-AERONET) at green wavelength over AHI domain over land

**Conclusion** Level 2 AOD products from Dark Target package on 7 sensors are publicly available via LAADS. Validation against AERONET/MAN and evaluation among products themselves show that DT products have good agreement especially for MODIS Aqua/Terra, and VIIRS on NOAA20. ABI-E/W show similar error histogram as Aqua. We expect further improvement in data quality with corrections on surface BRDF effects and cloud filtering. (<https://ladsweb.modaps.eosdis.nasa.gov/archive/allData/5019>)

## Acknowledgement

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## Error Histogram Over Land



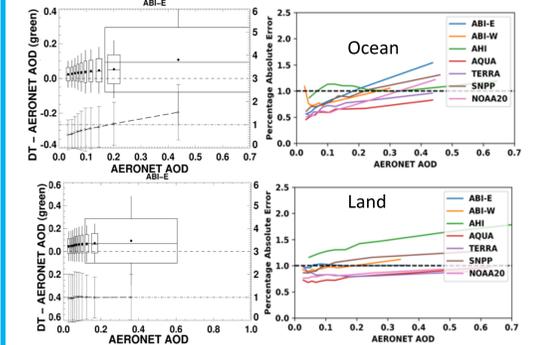
Over land most of products have similar error distribution while VIIRS SNPP and ABI-W show larger high bias tail and AHI show wider error distributions.

## Other parameters introduced bias are checked including fine mode fraction, surface reflectance, viewing zenith angle, and scattering angle.

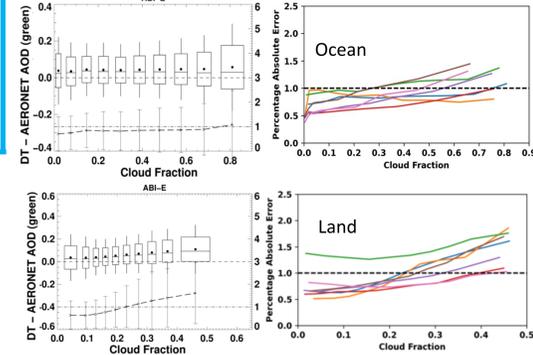
They are not shown in here due no significant trend are found among these parameters, with one exception: surface reflectance. The analyses of surface reflectance impacts on DT retrieval is conducted in (Kim et al., 2023)

## Uncertainty Analyses

Percentage Absolute Error =  $\text{abs}(\text{Bias}) / \text{AOD}$  at expected error  
Equal number bins in bias box plots.



Over ocean, MODIS diagnostic error are under the EE range. Over land, ABI-E, MODIS, VIIRS NOAA20 all have good performance.



Over ocean, minimum cloud fraction impact are found in ABI-E, ABI-W, and Aqua. Over land, cloud impacts are much larger but Aqua and NOAA20 although still have increased bias, remains under EE.

Most of the products has decreased bias as function of Solar Zenith Angle, except over land for AHI. For geostationary sensors (AHI, ABI-E), increased bias at large SZA > 70 is observed over land.