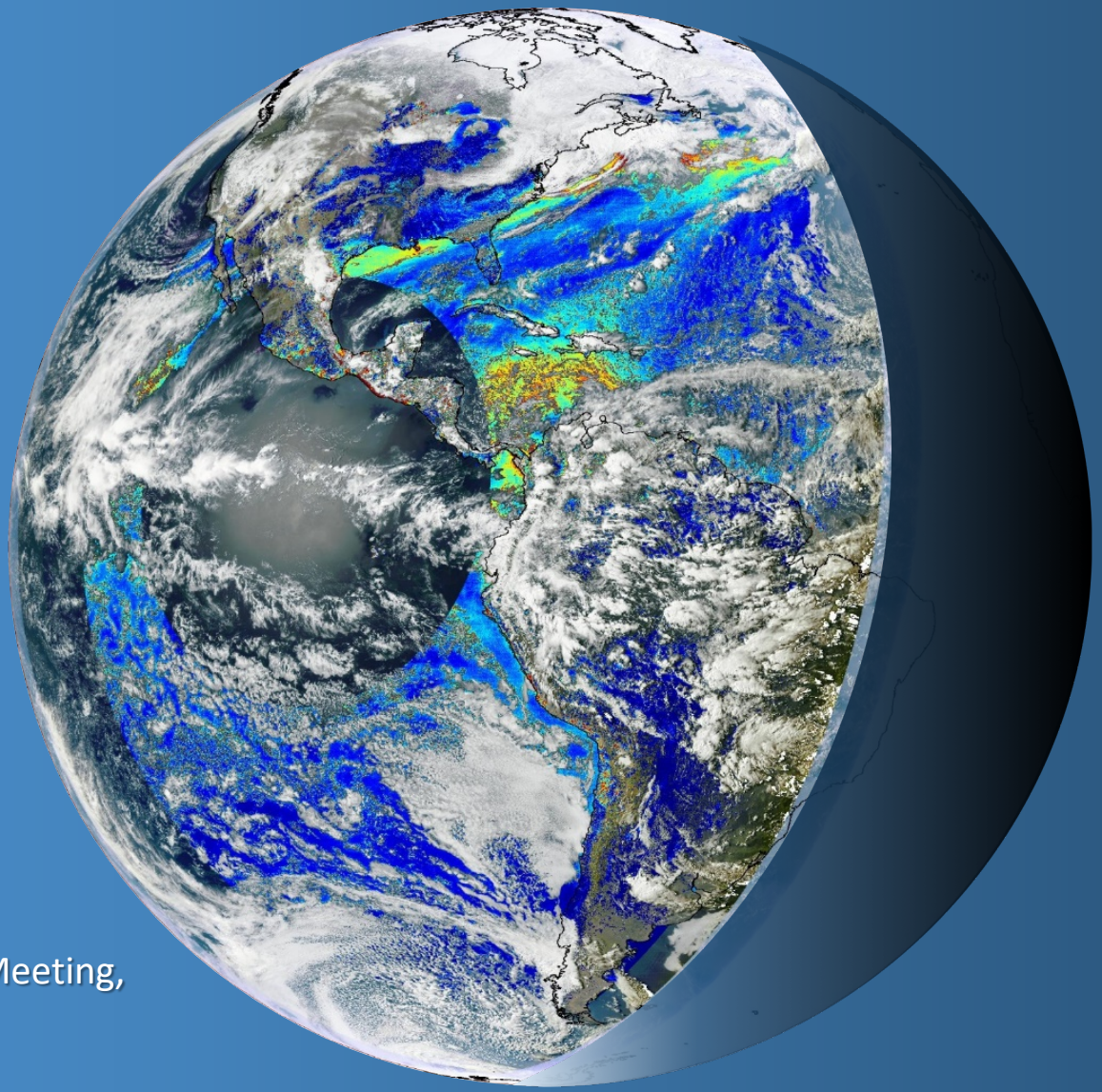
GOES-16 ABI AOD Algorithm and Product Validation



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Hongqing Liu (IMSG)

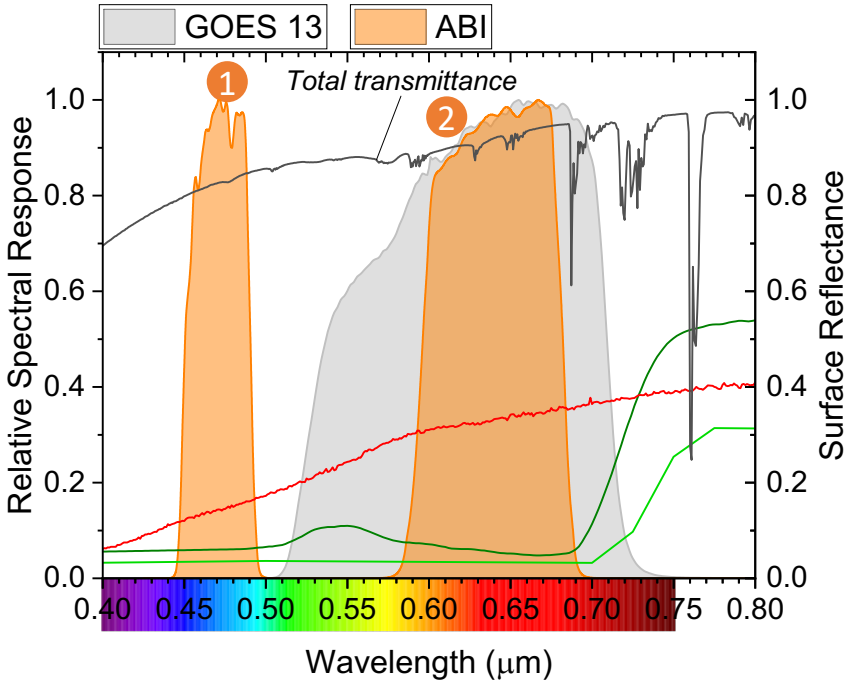
CEOS AC-VC-14 & GEO-CAPE Joint Meeting,
May 1-4, 2018, College Park, MD

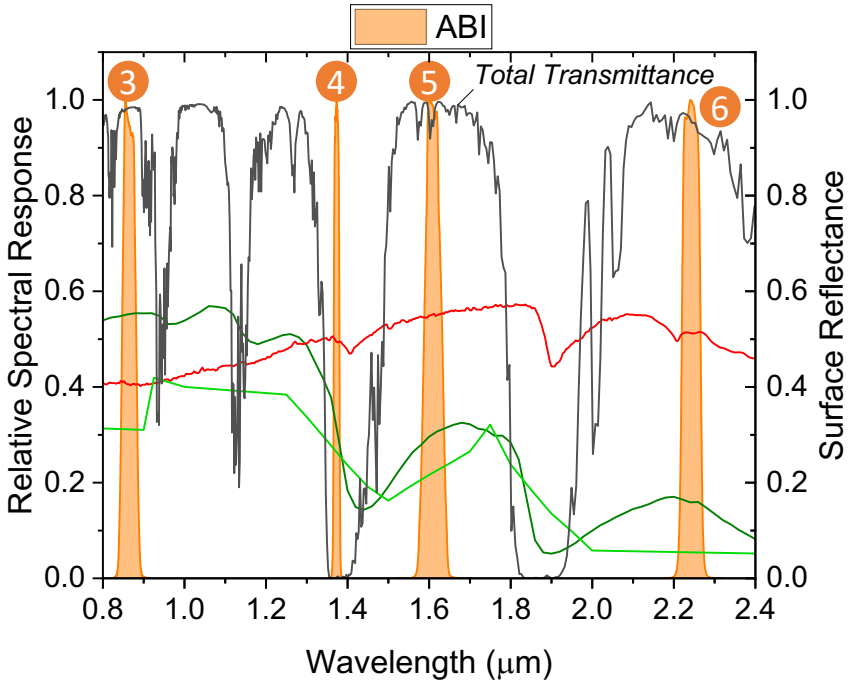
Outline

- ABI aerosol optical depth (AOD) algorithm
- ABI AOD product
- Evaluation
- The “Enterprise” AOD algorithm
- Synergy of “geo” and “polar” AOD
- Summary
- Useful documents

The ABI Aerosol Optical Depth (AOD) Algorithm

ABI Spectral Bands (1-6)





- ABI "aerosol" channels: 1, 2, 3, 5 and 6
  - Narrow channels
  - Relatively weak absorption by gases
  - **Onboard calibration!**

Channel-Role Matrix

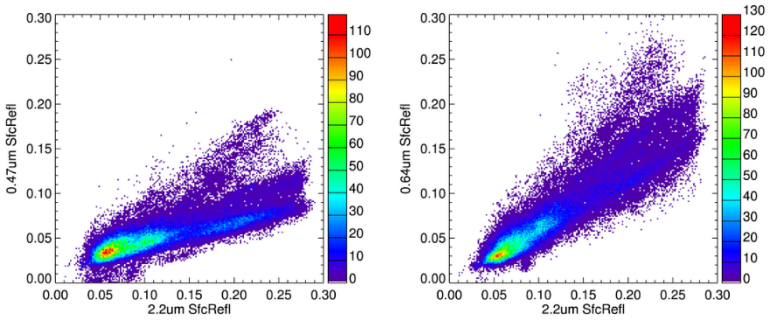
ABI Band	Central Wavelength (µm)	Retrieval		Internal Test	
		Land	Water	Land	Water
1	0.470	X		X	X
2	0.640	X	X	X	X
3	0.865		X	X	X
4	1.378			X	X
5	1.610		X	X	X
6	2.250	X	X	X	X
14	11.200			X	X

GOES-R AOD Algorithm (1)
Surface Reflectance

Land

- surface contribution is retrieved using the dark-target approach

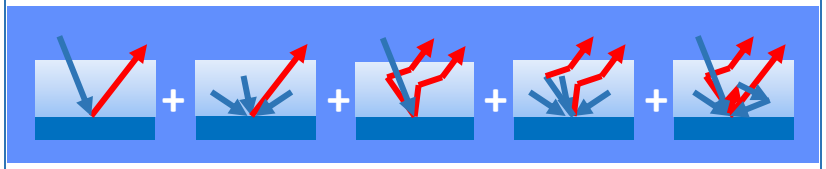
$$\rho_{0.47|0.64} = C(NDVI, \vartheta_s) \times \rho_{2.25}$$



- No retrieval for bright land

Water

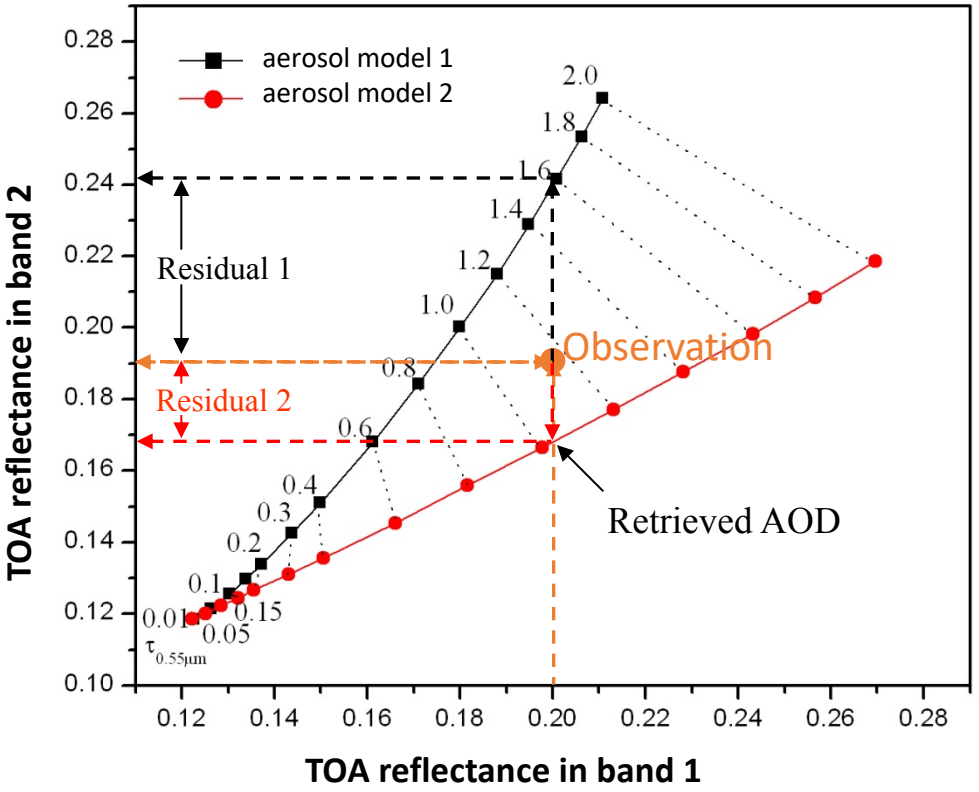
- surface contribution is calculated
  - water-leaving radiance (Lambertian)
  - whitecap (Lambertian)
  - sunglint (bi-directional)



- No retrieval in glint

GOES-R AOD Algorithm (2)
AOD Retrieval

- Separate algorithms for land and water.
- MODIS and early VIIRS heritage. (*Tanre et al.*, 1997; *Remer et al., 2005; Levy et al., 2007, Vermote et al., 2007*)
- **Simultaneous retrieval of AOD and aerosol type by comparing calculated and observed reflectances at multiple wavelengths.**



- **Water:** 4 fine and 5 coarse mode models
- **Land:** generic, dust, smoke and urban models

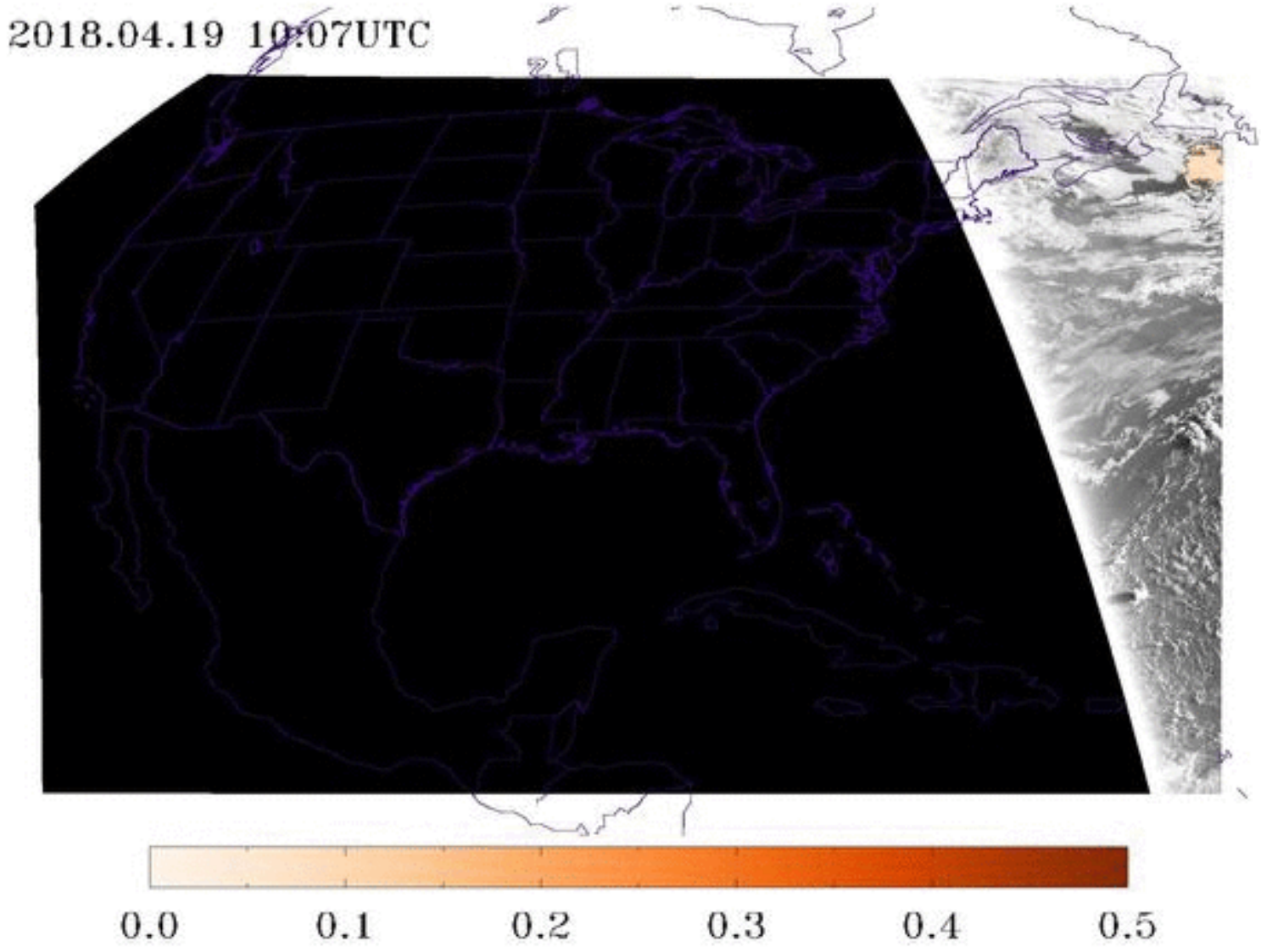
Internal Tests

Condition	Quality Level			Applies to		Detected by	
	No Retrieval	Low	Medium	Land	Ocean	External Mask	Internal Tests
Invalid input data	X			X	X		X
Cloud	X			X	X	X	X
Snow/Ice	X			X	X	X	X
Ephemeral Water	X			X			X
Sun Glint	X				X		X
Bright Land Surface	X			X			X
AOD Out of Range		X		X	X		X
Low Sun (solzen > 80°)		X		X	X		X
Low Satellite (satzen > 60°)		X		X	X		X
E & I cloud tests contradict		X		X	X	X	X
Coastal		X		X	X	X	
Shallow Inland Water		X			X	X	
High Inhomogeneity		X		X	X		X
High Residual		X		X	X		X
Cloud/Snow Adjacency			X	X	X		X
Shallow Ocean			X		X	X	
Probably Clear			X	X	X	X	
Medium Inhomogeneity			X	X	X		X
Medium Residual			X	X	X		X

AOD Product

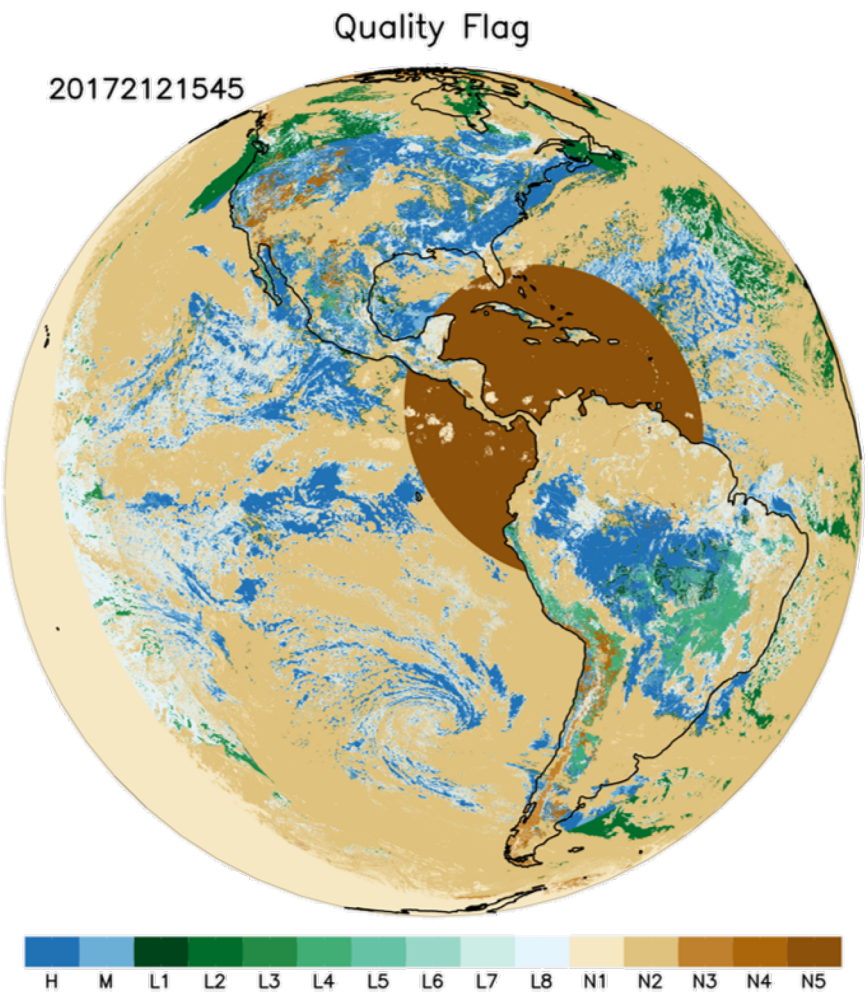
- **Products in file:**
  - 550-nm Aerosol Optical Depth for Full Disk and CONUS in range -0.05 to +5
  - Quality flag (0=good; 1=medium, 2=low, 3=not produced)
  - Mean, max, min and standard deviation of 550-nm AOD (and in bands used for AOD retrieval
- **In Beta maturity status since May 24, 2017**
  - Beta product is minimally validated and may still contain significant errors; not recommended for operational use.
  - ***Disclaimer: The GOES-16 data are preliminary, non-operational data and are undergoing testing. Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized.***
- **Availability:**
  - NOAA's Comprehensive Large Array-Data Stewardship System at https://www.class.ncdc.noaa.gov after product passed Provisional Review (review scheduled for June 2018)

5-minute Medium+High Quality AOD



Quality Flags (Example)

07/31/2017 at 15:45 UTC



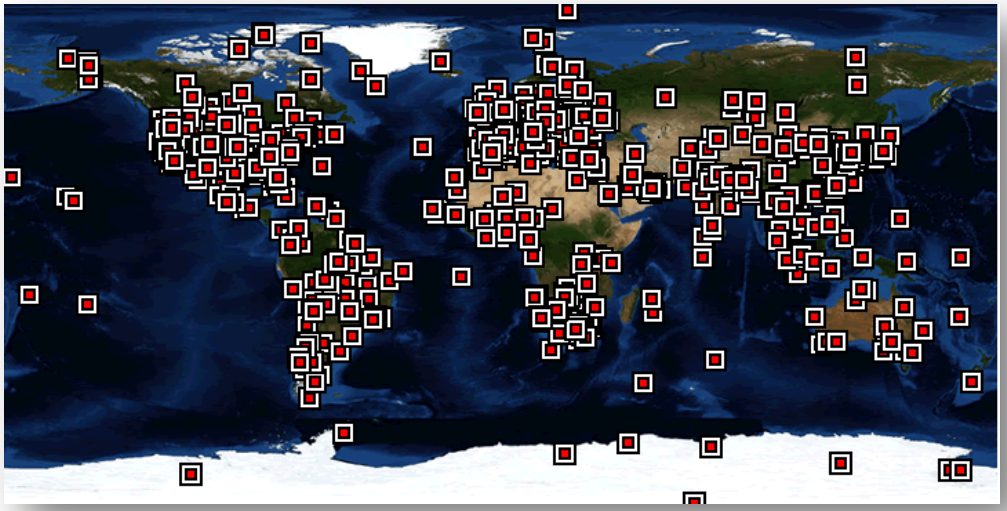
H	High
M	Medium
L	Low
L1	Contradicting Cloud Masks
L2	Low Satellite Angle
L3	Low Sun Angle
L4	Out of Spec Range
L5	Coastal Area
L6	Shallow Inland Water
L7	High Residual
L8	High Inhomogeneity
N	No Retrieval
N1	Invalid Input
N2	Cloud
N3	Snow
N4	Bright Land Surface
N5	Sun Glint

Evaluation

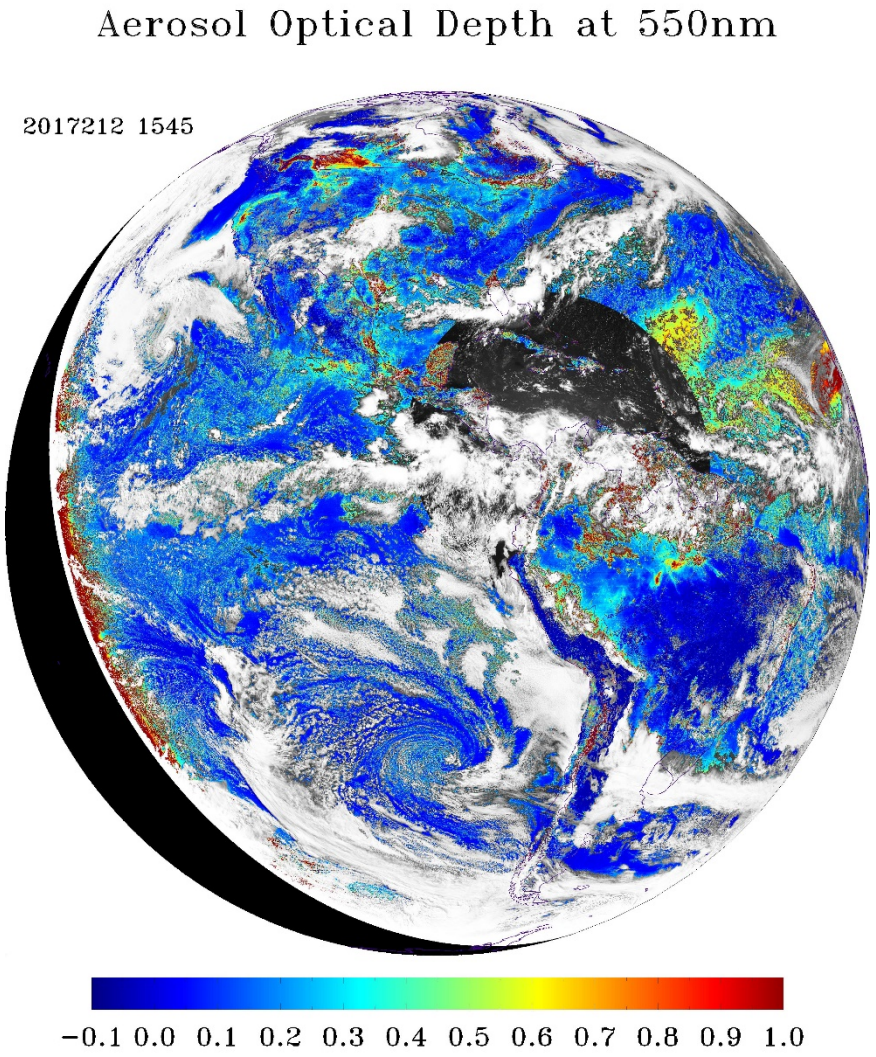
Reference Data for Validation

AERONET:

- Ground-based Aerosol Robotic Network (AERONET) provides high-quality comprehensive data of aerosol properties. (*Holben et al. 1998*)
- Widely used for evaluating satellite retrievals and model simulations in the aerosol community.



Low + Medium + High Quality AOD



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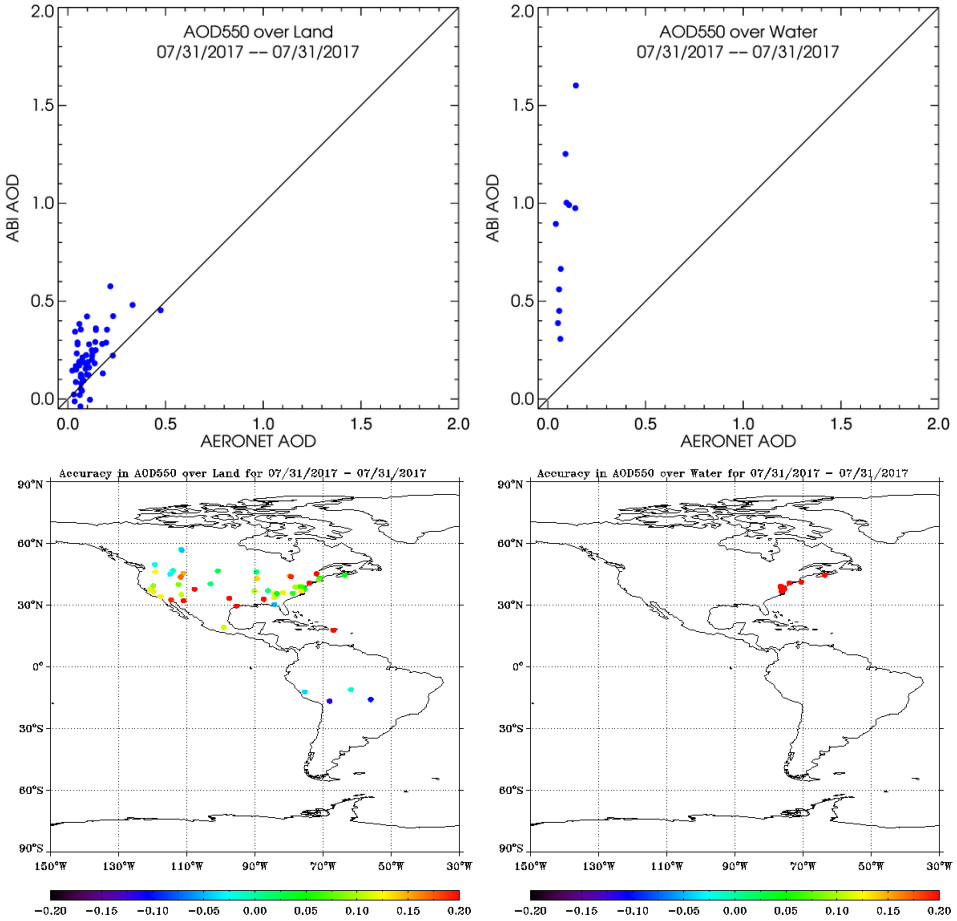
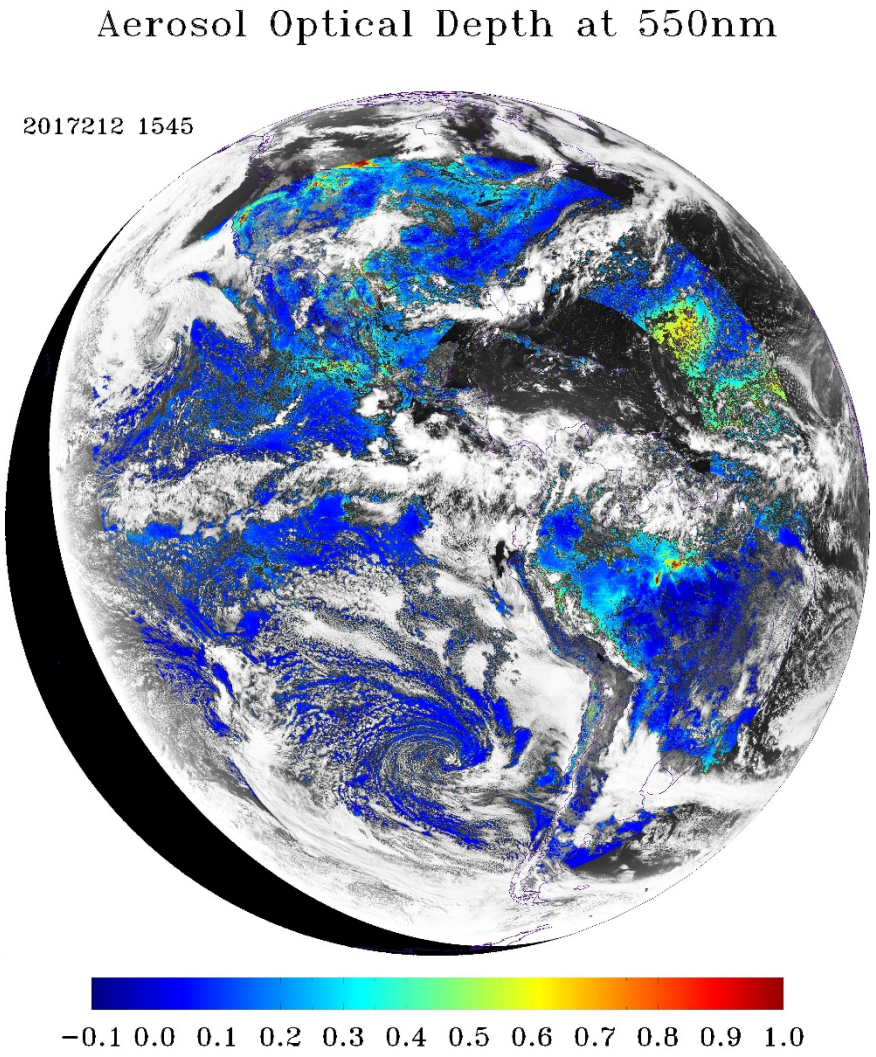


Medium + High Quality AOD



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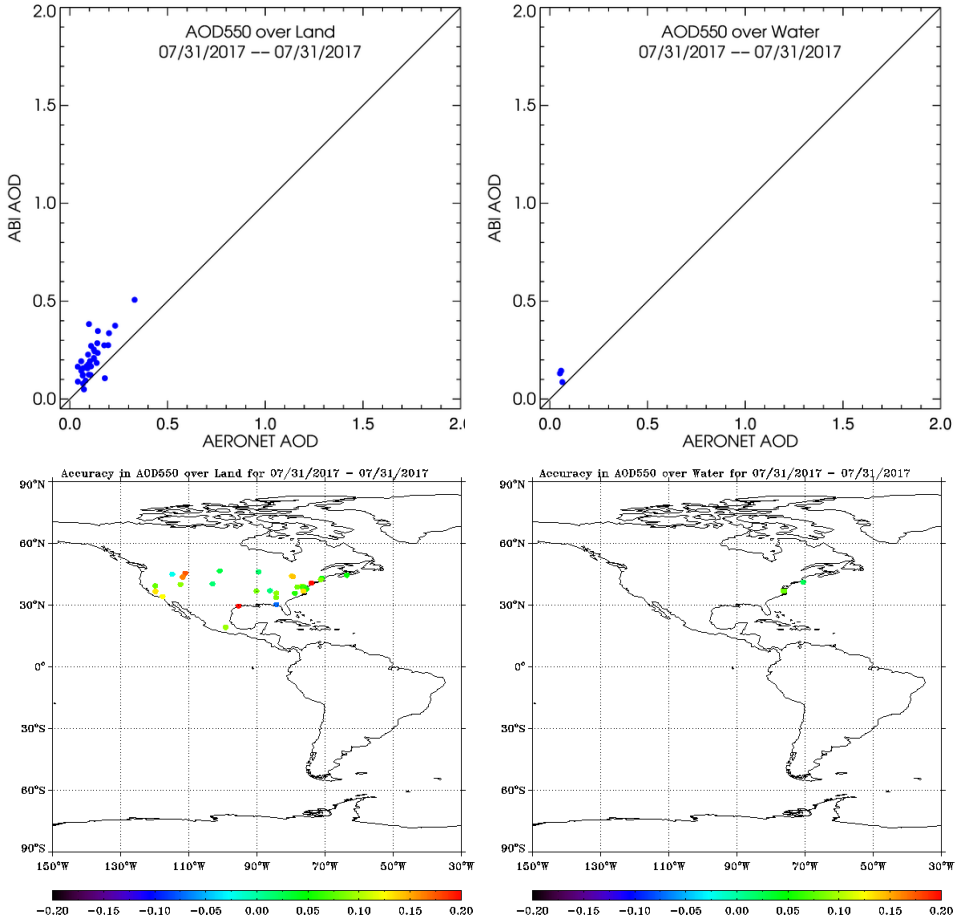
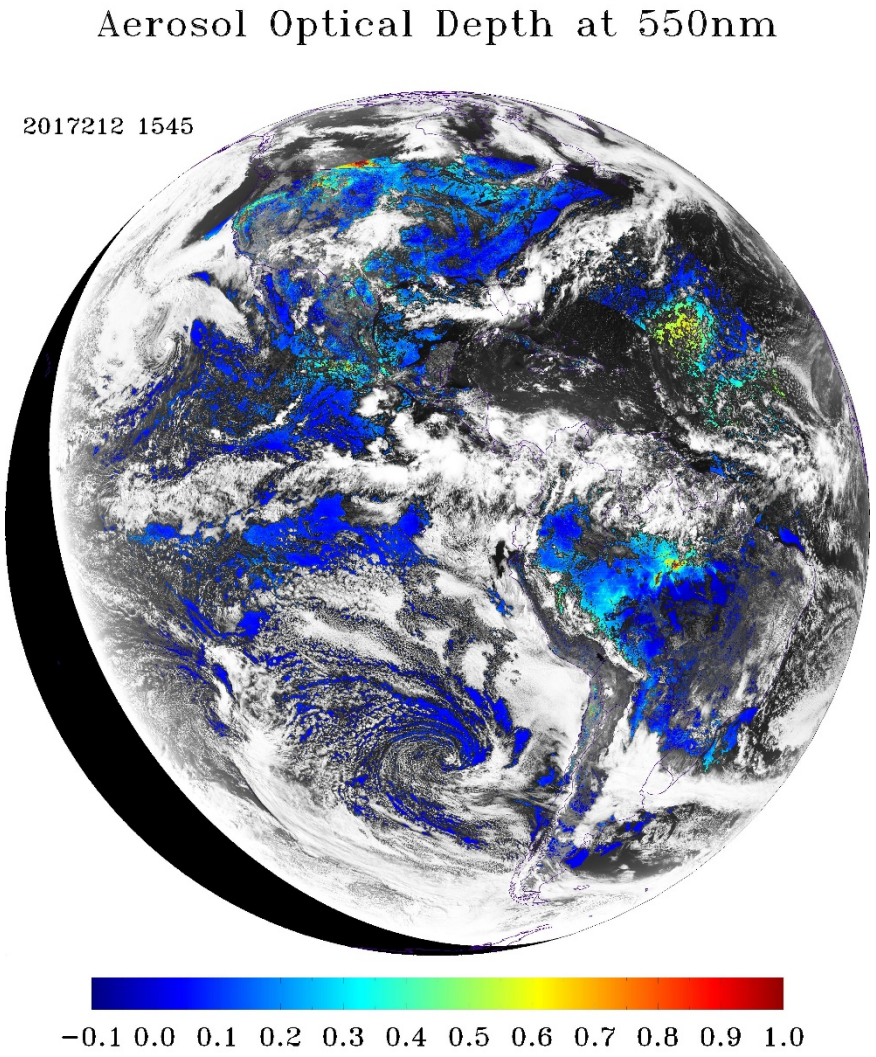


High Quality AOD



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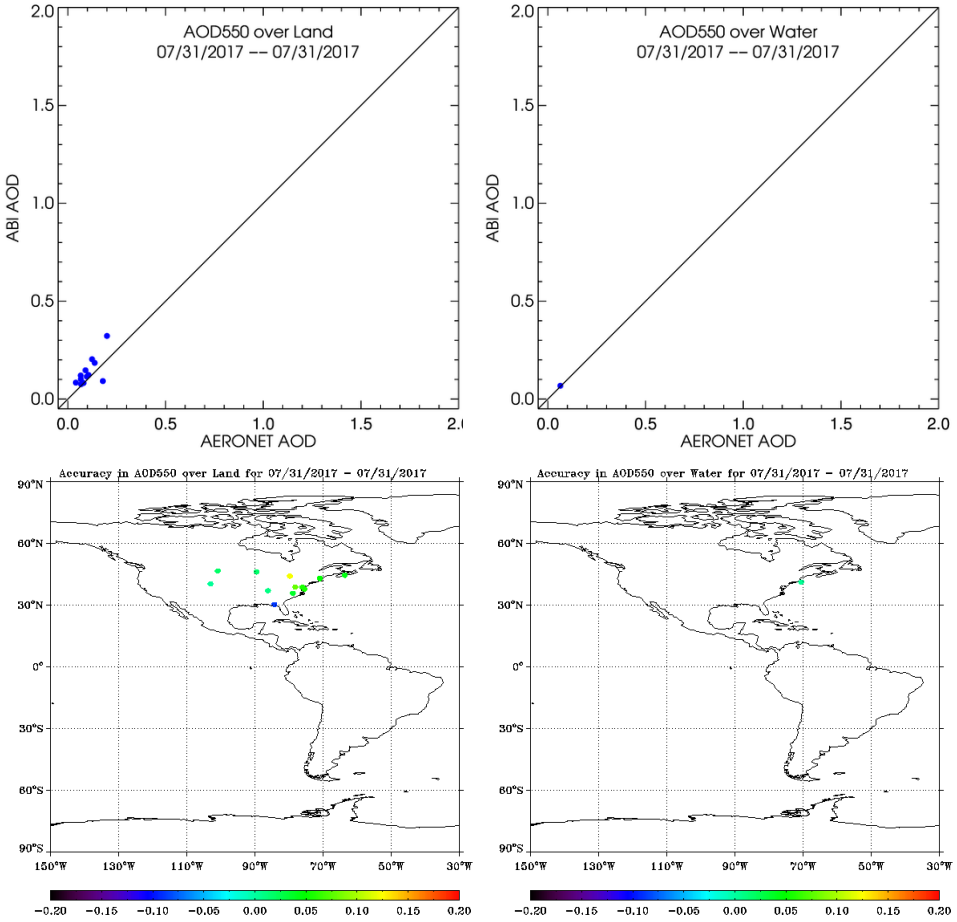
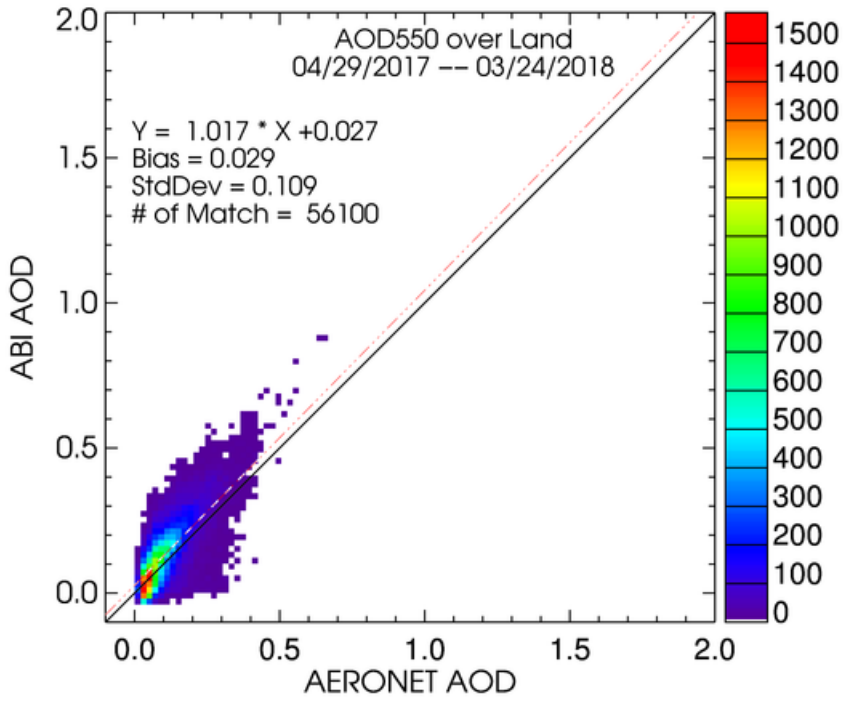
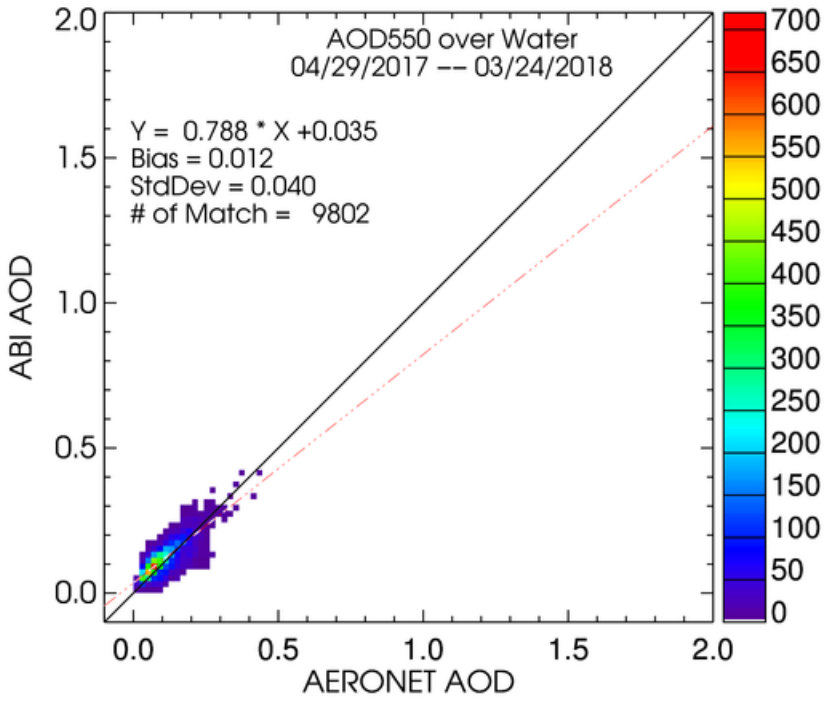


Validation with AERONET

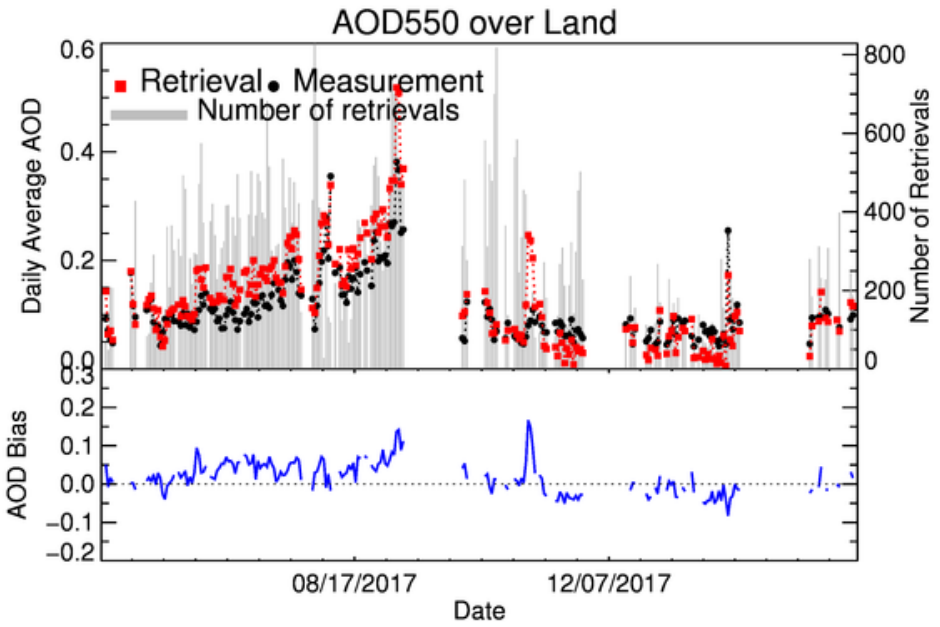




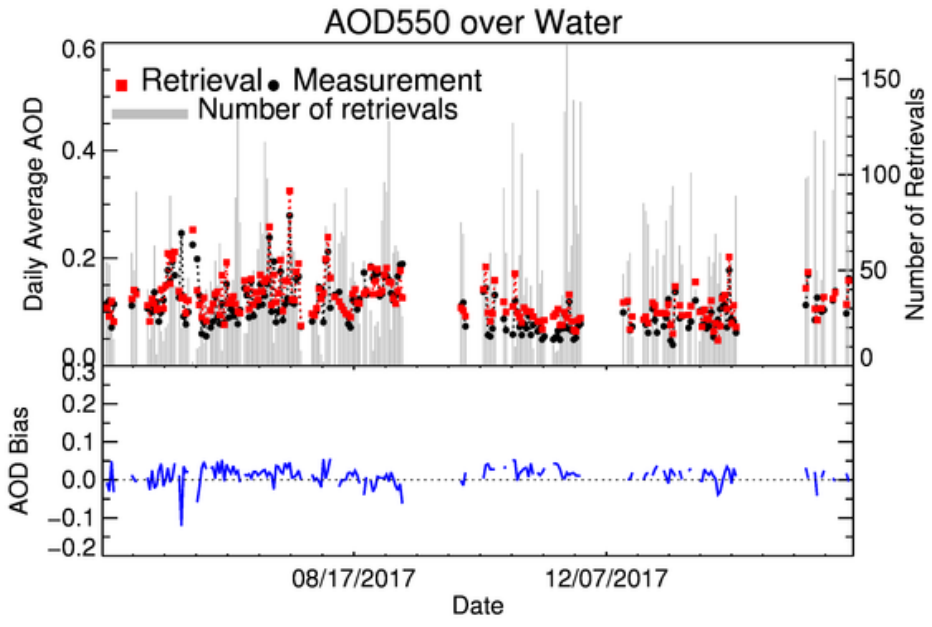
- Time period: 04/29/2017 – 03/24/2018
- **High quality AOD**
- Bias and StDev: mean and standard deviation of ABI-AERONET differences

High-Quality AOD Time Series
All Sites

LAND



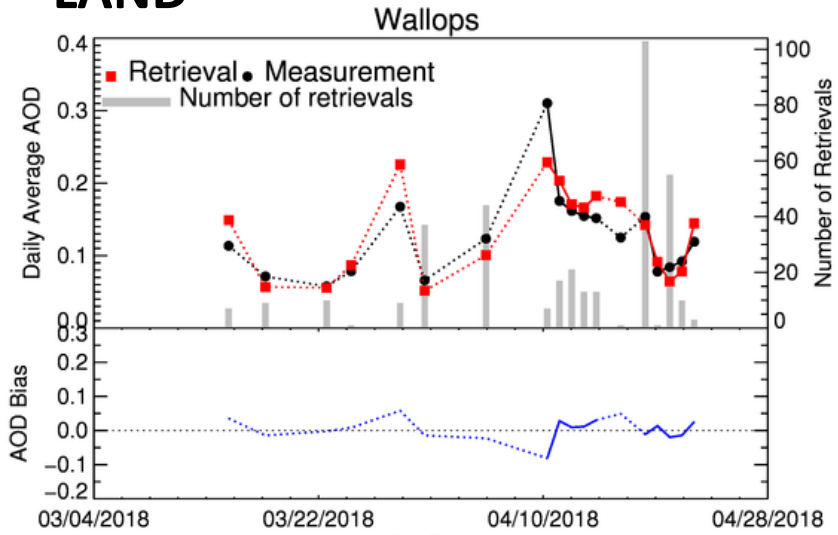
Water

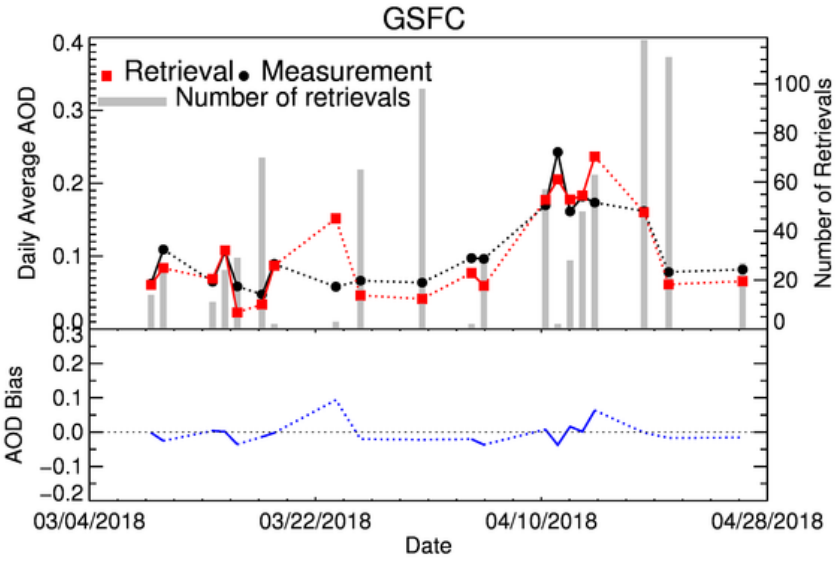


- Co-located ABI-AERONET matchup data for 04/29/2017-03/24/2018.
- Retrieval generally follows AERONET.
- Apparent seasonal bias over land; slight positive bias but no apparent trend.

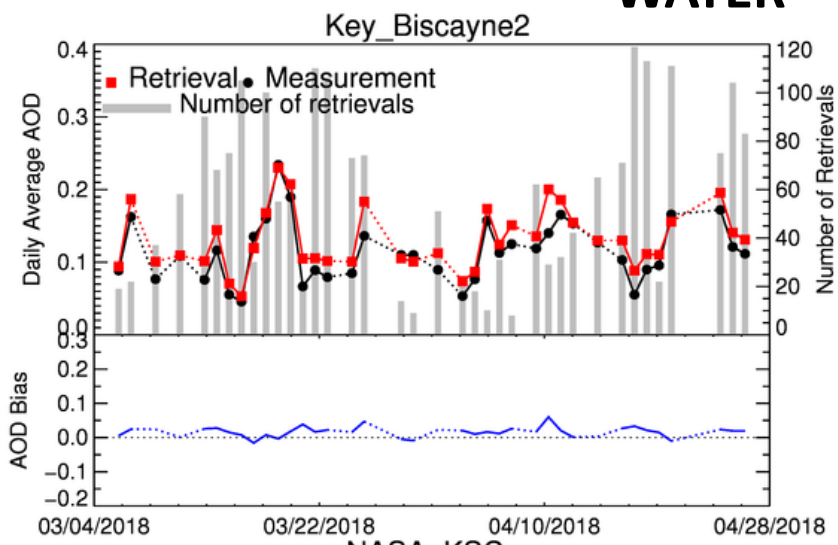
High-Quality AOD Time Series
Selected Sites

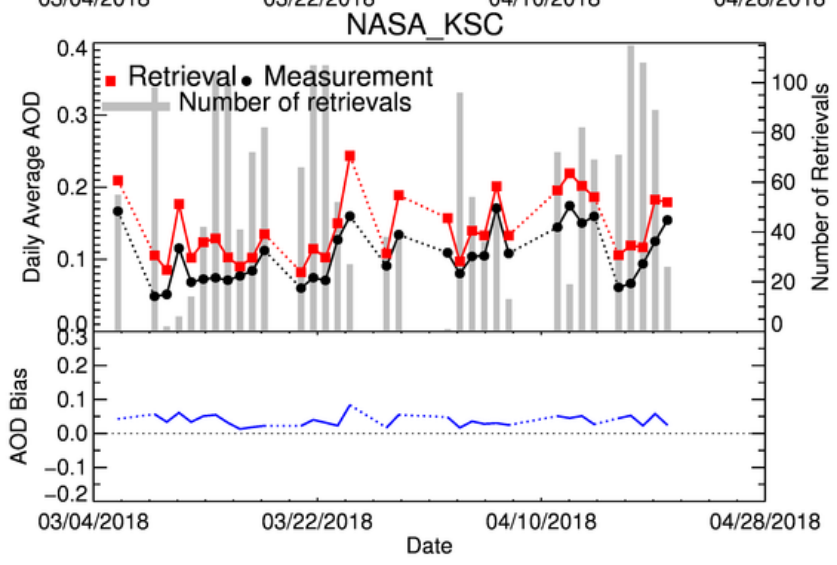
LAND





WATER

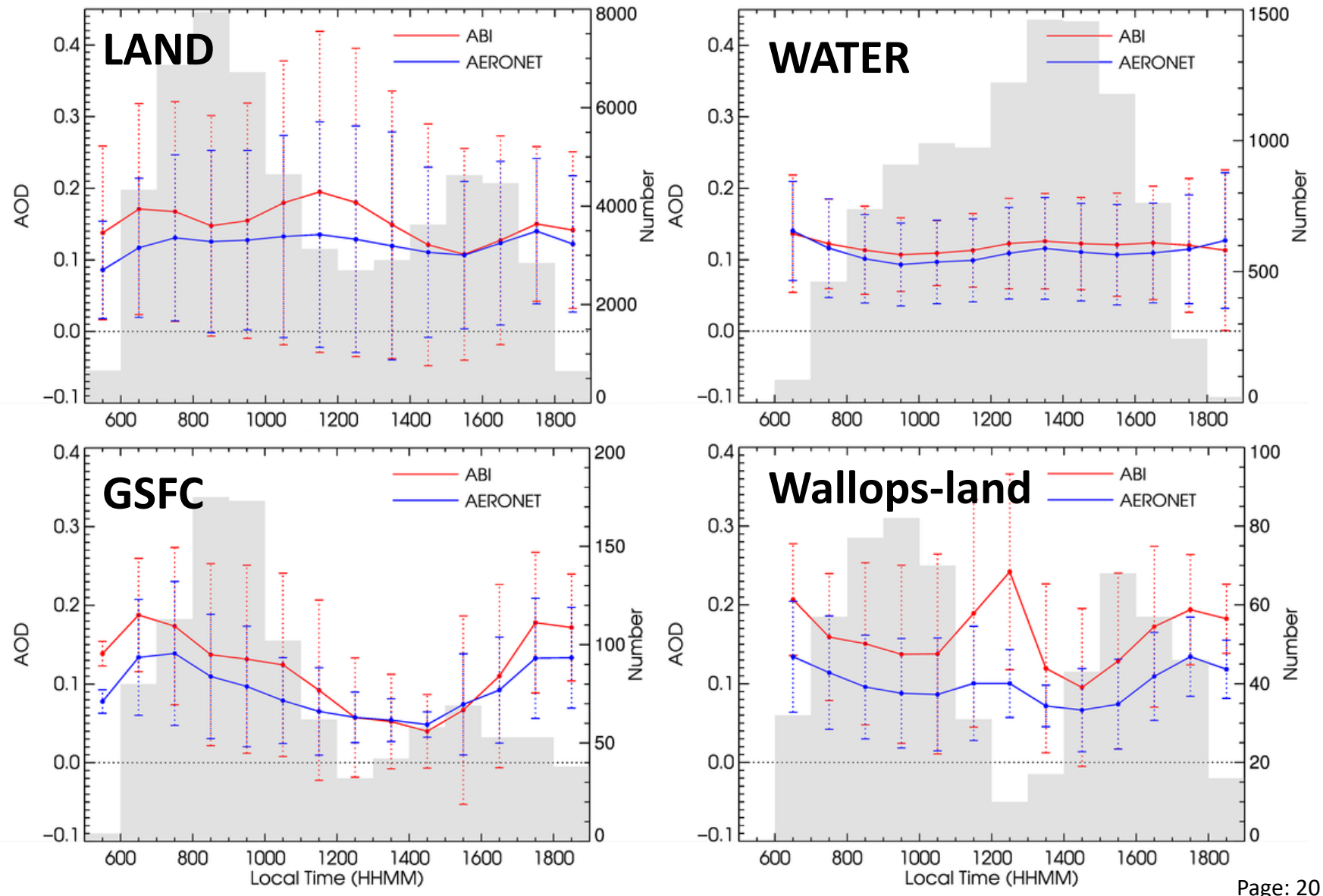




Co-located ABI-AERONET CONUS dataset for 03/06/2018 – 04/26/2018.

Diurnal Changes

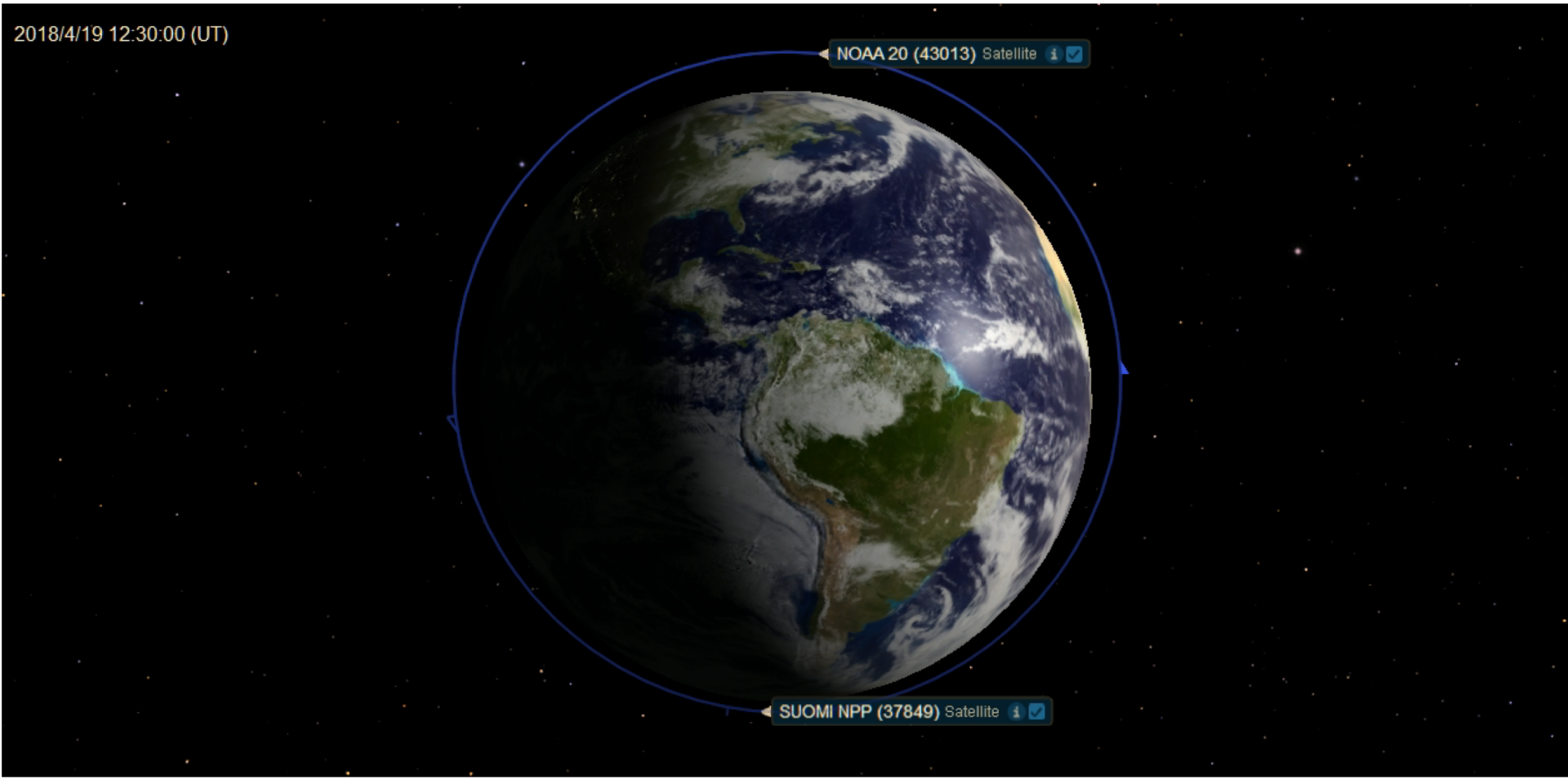
Matchup data for 04/29/2017-03/24/2018



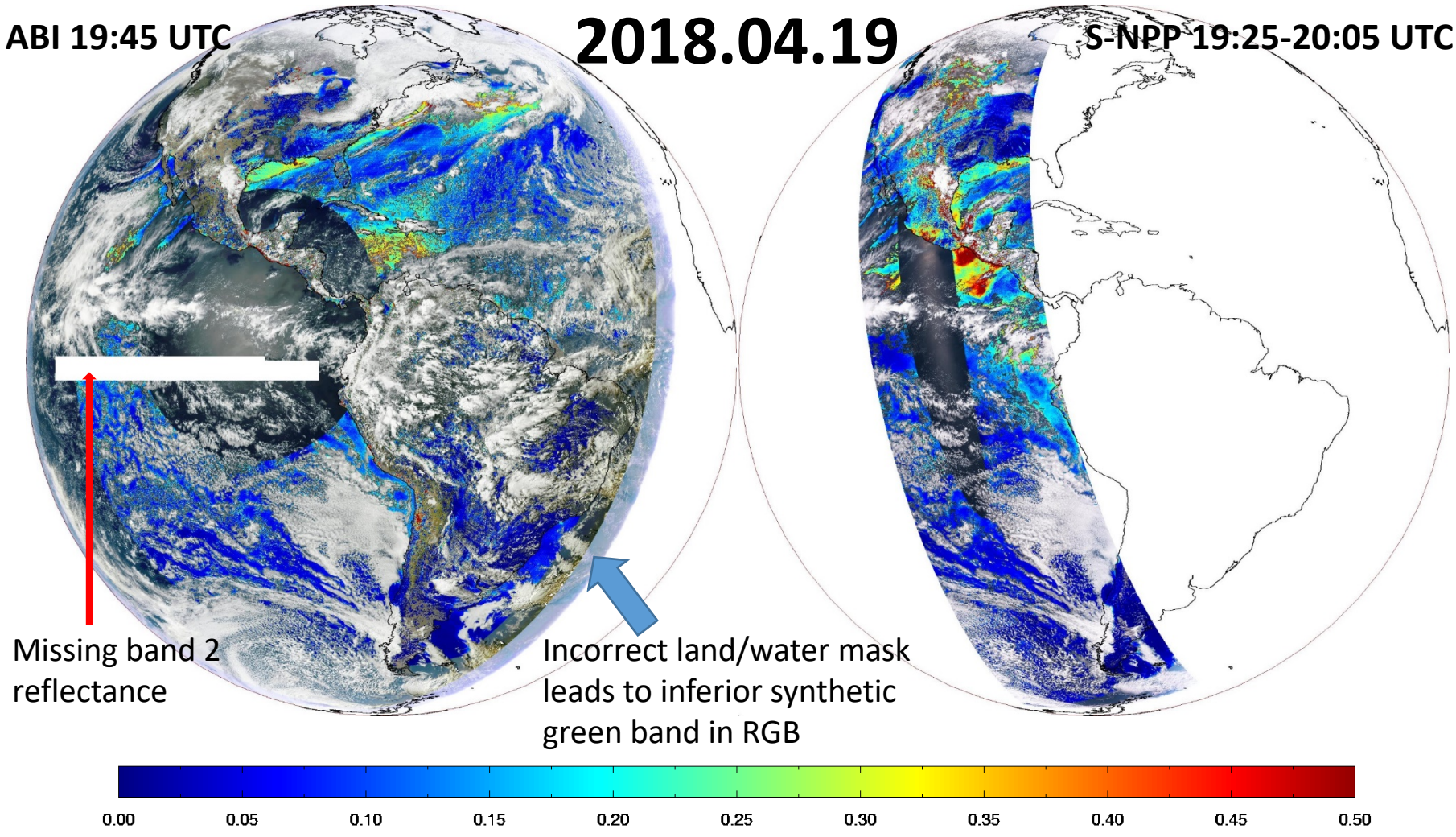
“Synergy” of Geostationary and Polar AOD

Filling in sunglint and other holes in geo AOD

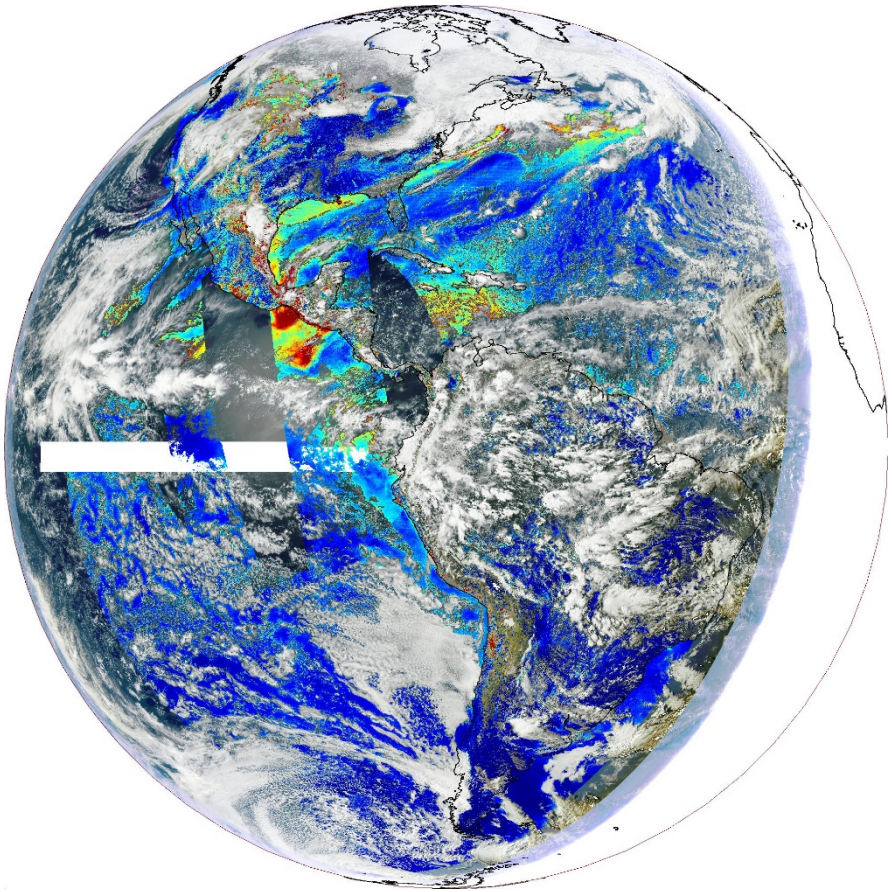
S-NPP and NOAA-20 from GOES-16



GOES-16 ABI and S-NPP VIIRS AOD

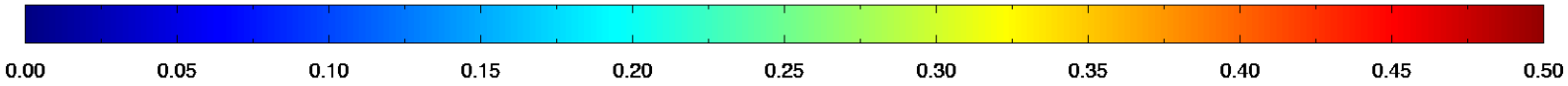


GOES-16 ABI and S-NPP VIIRS AOD

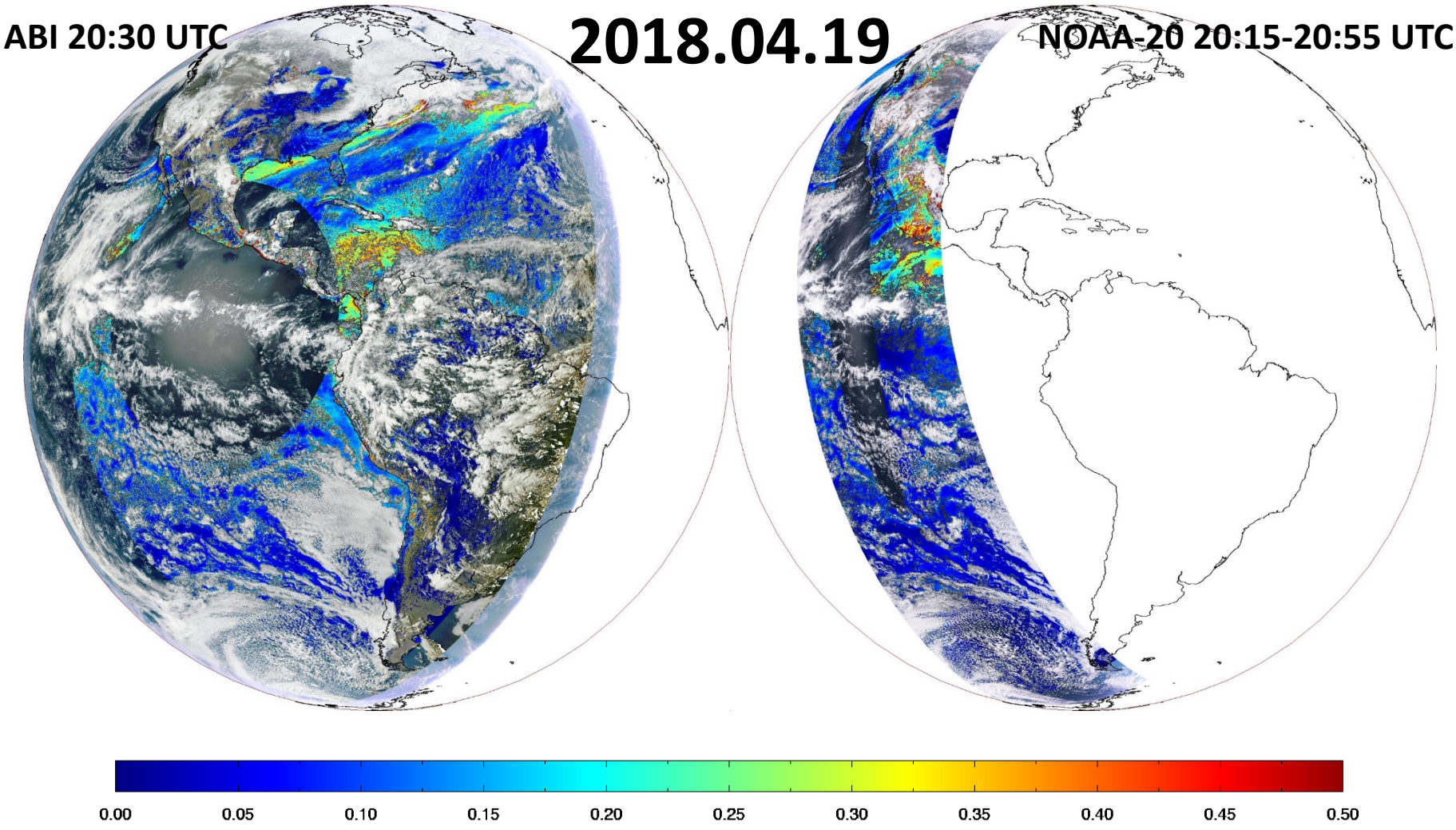


2018.04.19

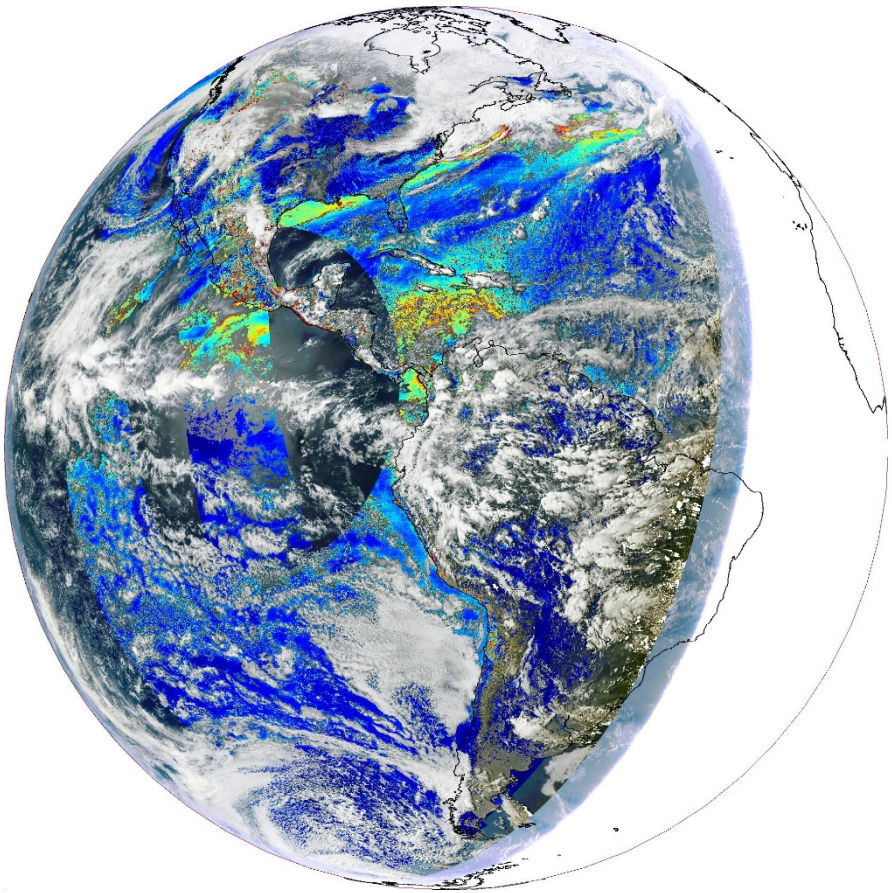
- ABI 19:45 UTC
- S-NPP 19:25-20:05 UTC
- Combined ABI and VIIRS AOD makes more complete AOD field



GOES-16 ABI and NOAA-20 VIIRS AOD

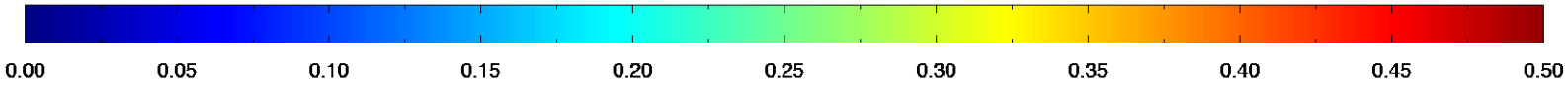


GOES-16 ABI and NOAA-20 VIIRS AOD



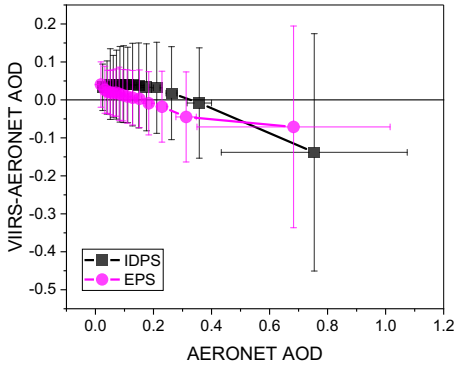
2018.04.19

- ABI 20:30 UTC
- NOAA-20 20:15-20:35 UTC
- Combined ABI and VIIRS AOD makes more complete AOD field

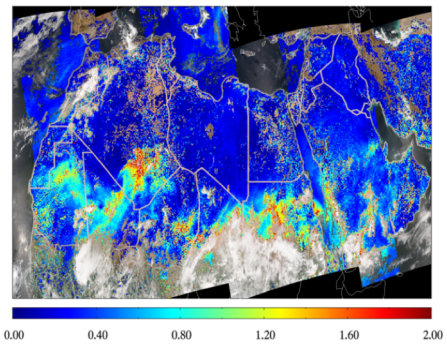


“Enterprise (EPS)” AOD Algorithm

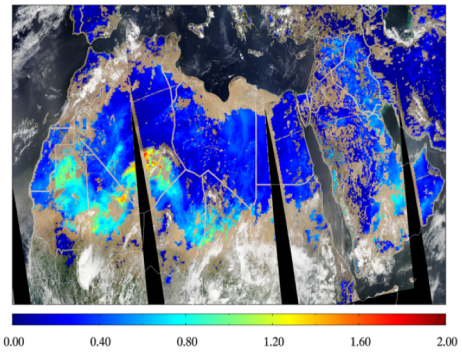
- STM’s goal is to update/switch to “Enterprise” (EPS) version.
- Runs operationally at NOAA since July 2017 with VIIRS on Suomi-NPP (and on NOAA-20)
- For land, combines two flavors of the Dark Target method
  - **SW-scheme:** more accurate 0.488 µm (M3) surface reflectance from 0.672 µm (M5) for low AOD
  - **SWIR-scheme:** more accurate 0.488 µm (M3) surface reflectance from 2.25 µm (M11) for high AOD
- Retrieves over bright snow-free land using 0.1°x0.1° database of M3/M5 and M1/M5 surface reflectance ratios



VIIRS AOT 20130823



MODIS deep blue AOT 20130823



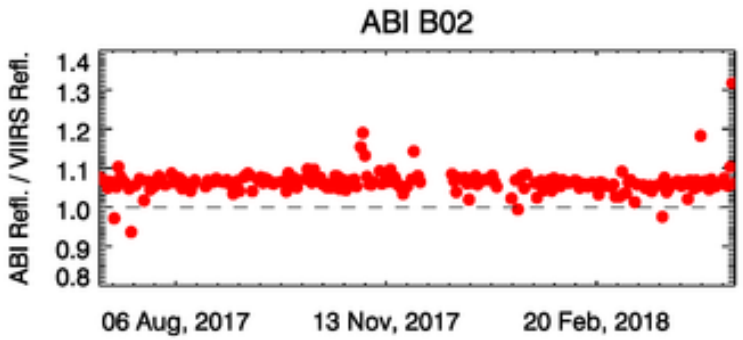
Summary

- ABI AOD algorithms over water and land are based on MODIS and VIIRS heritages.
- CONUS/Full disk AOD is every 5/15 minutes.
- **As of now (05/04/2018) GOES-16 ABI AOD is beta**
- Provisional: Jun 2018; Full validated: Sep 2018
- STM goal is to switch algorithm from Baseline to “Enterprise (EPS)” (AOD over snow-free bright surface; improved retrieval of high AOD, etc.)
- Working on deriving solar & view angle dependent surface reflectance relationships (need large volume of data)

Useful Documents

At http://www.goes-r.gov/resources/docs.html :

- Advanced Baseline Imager (ABI) Fact Sheet
- ABI Bands Quick Information Guides
- ABI Suspended Matter/Aerosol Optical Depth and Aerosol Size Parameter – Algorithm Theoretical Basis Document
- GOES-R Product Definition and Users' Guide (PUG) Volume 5 (L2+ Products)

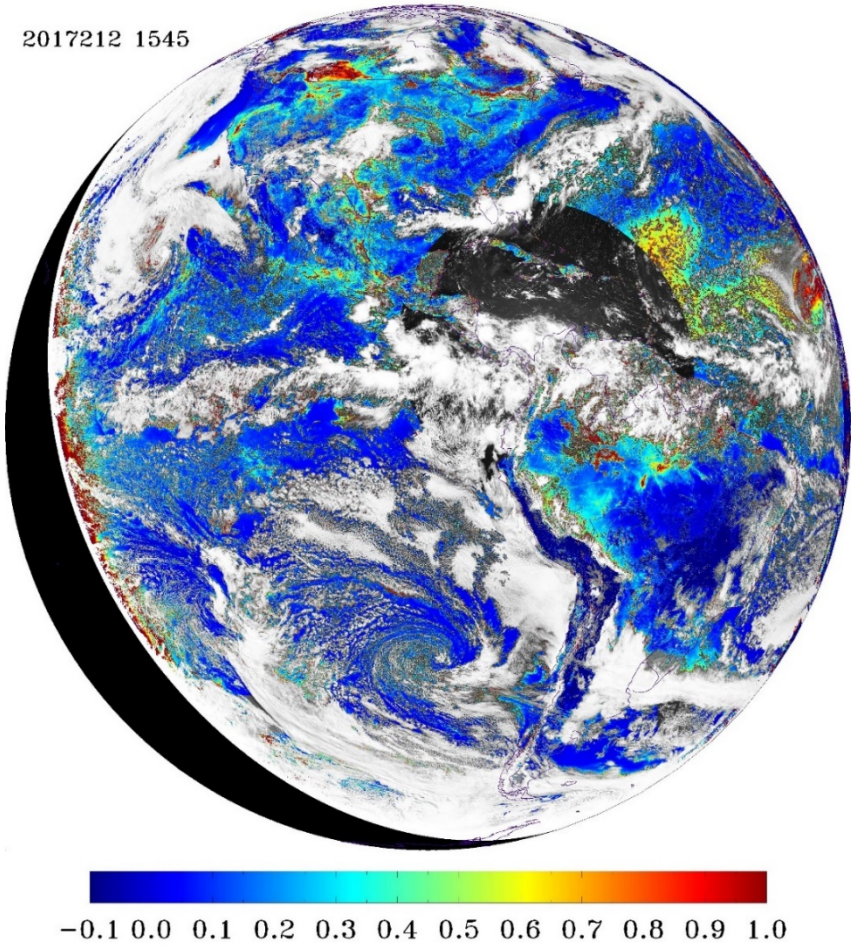


Impact of 7% ABI Band 2 Calibration Bias

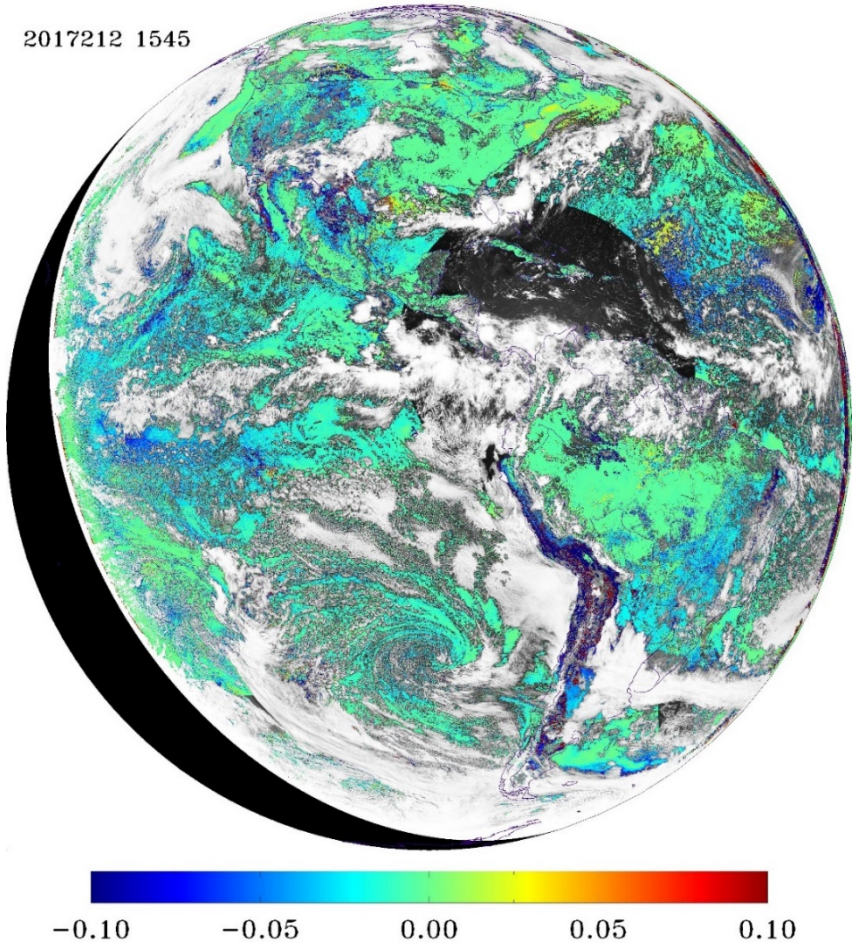
All-Quality 550-nm AOD

07/31/2017 at 15:45 UTC

From Unchanged Reflectances

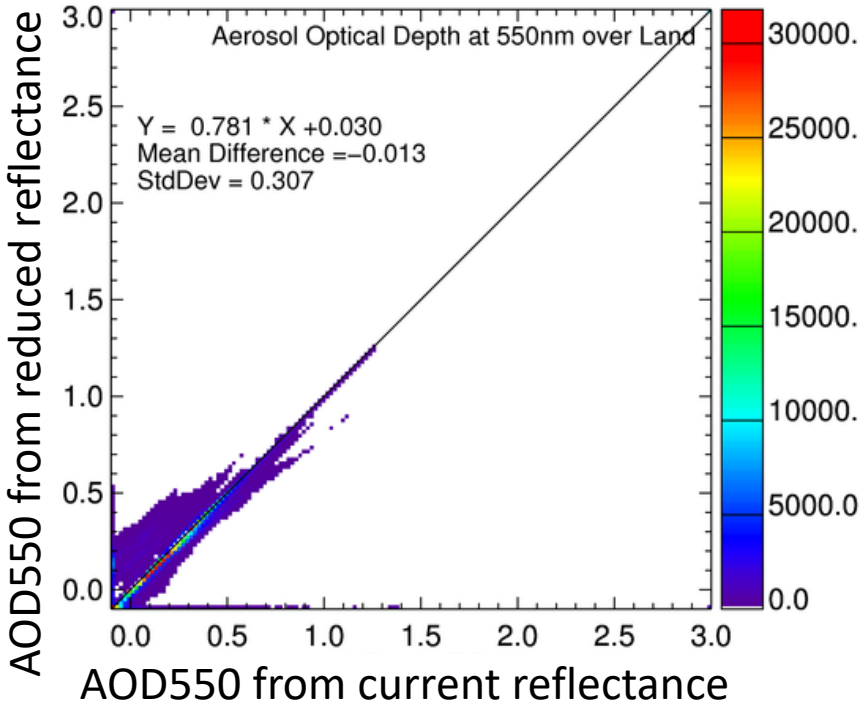


Reduced-Unchanged Difference

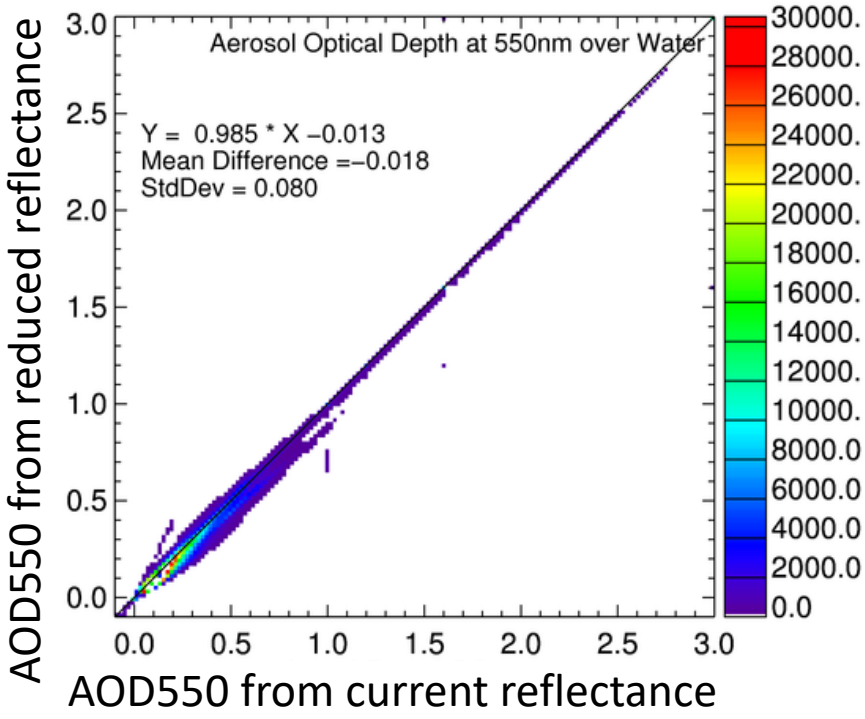


Reduced vs. Unchanged

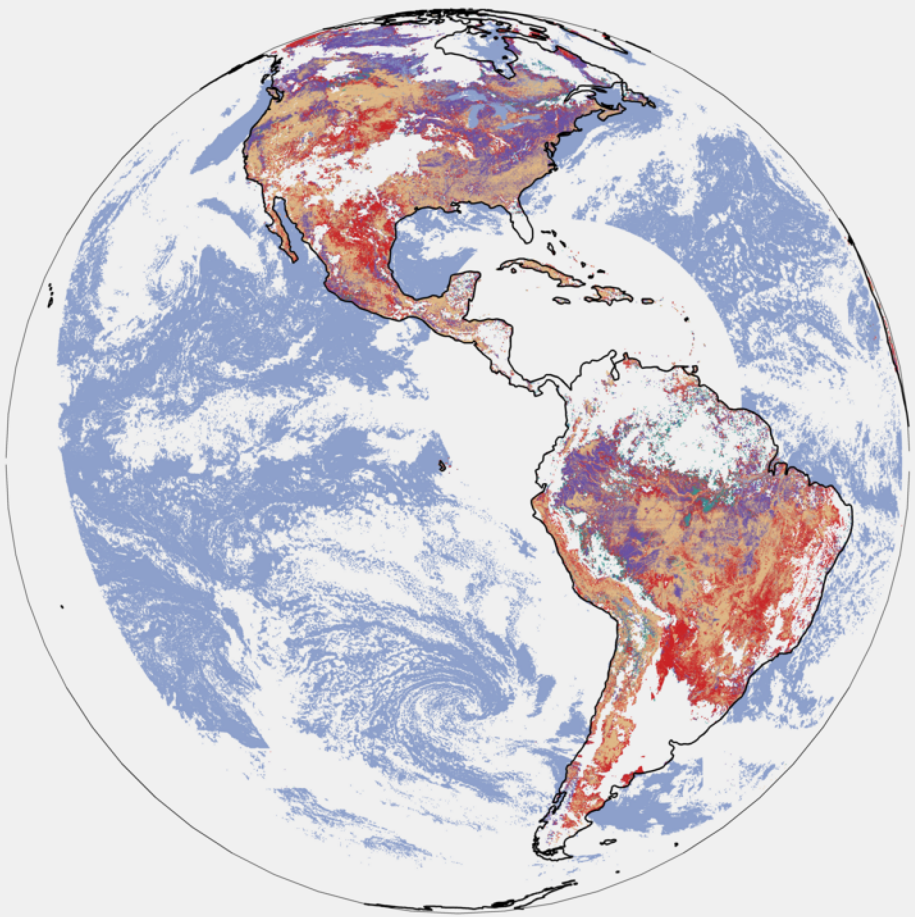
LAND



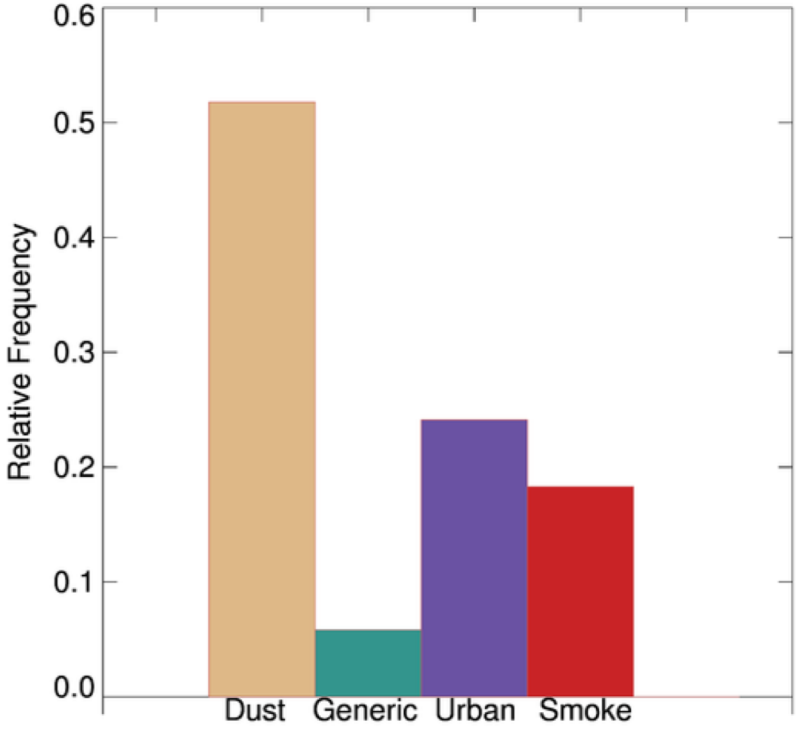
WATER



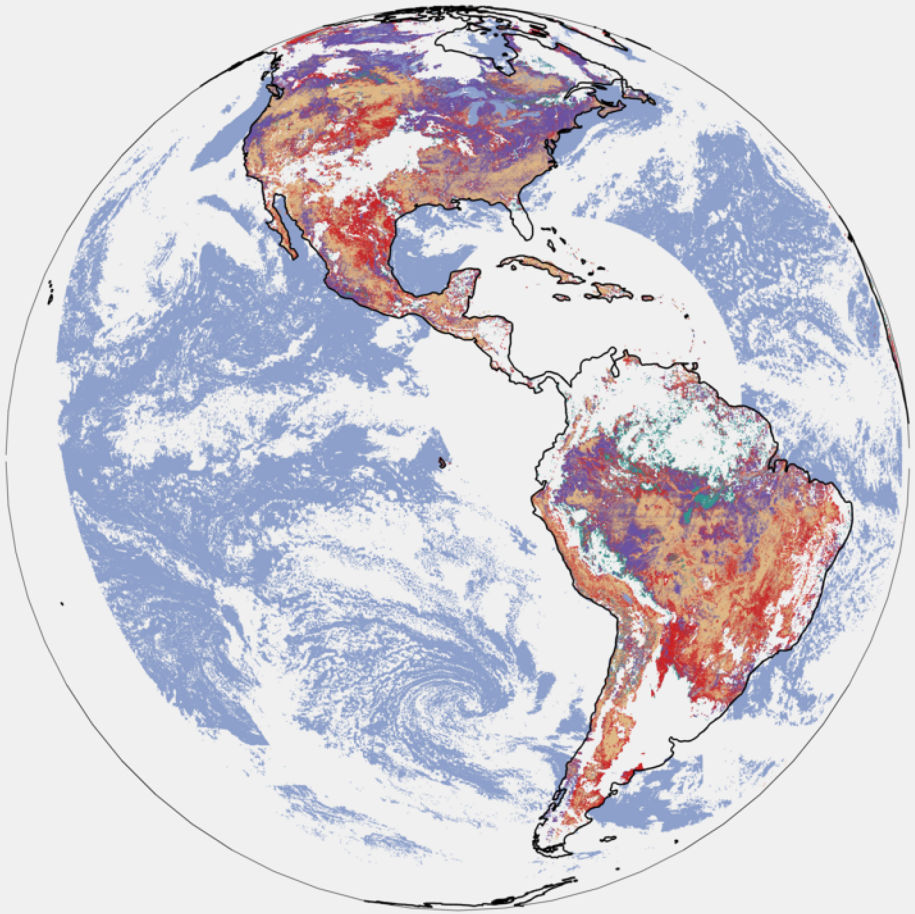
Land Aerosol Model Selection
Unchanged Band 2 Reflectance



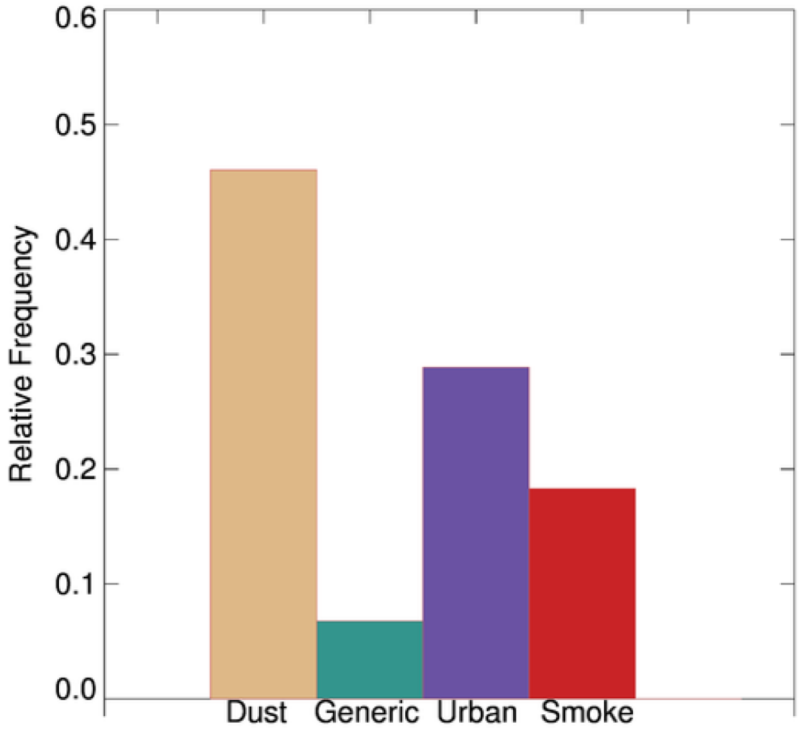
With current ABI Band 2 reflectance



Land Aerosol Model Selection
Reduced Band 2 Reflectance

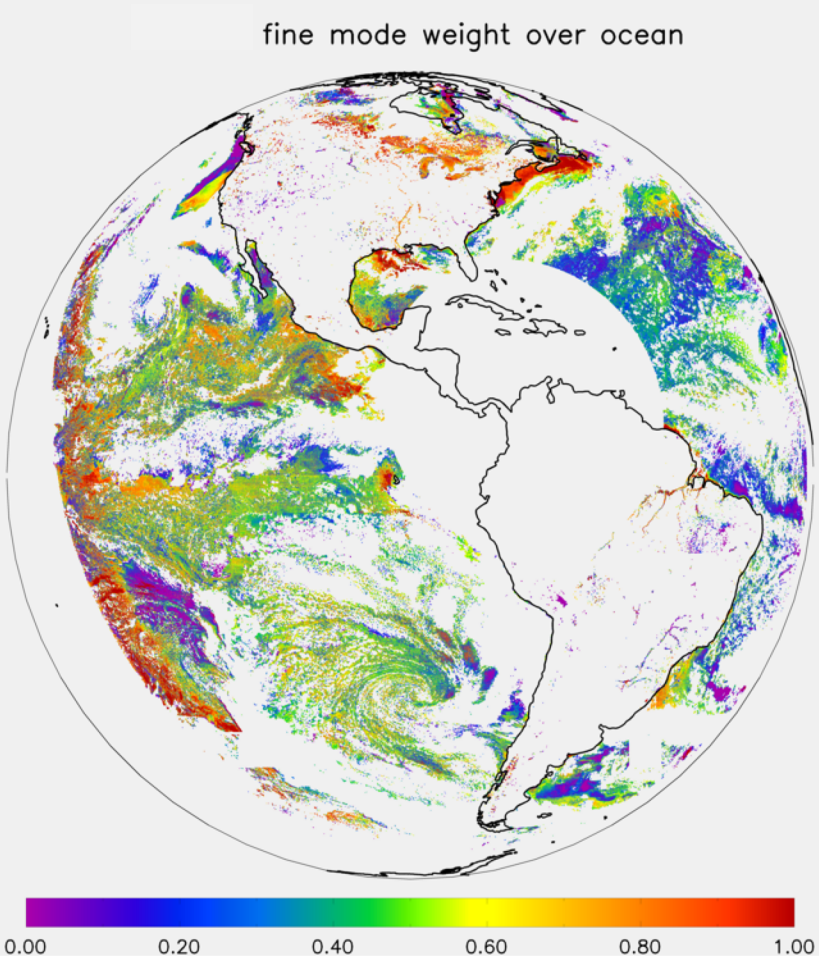


With reduced ABI Band 2 reflectance



Fine Mode Weight

Unchanged Band 2 Reflectance



Reduced Band 2 Reflectance