Assessment of the Suomi NPP VIIRS Aerosol EDRs for Beta Maturity Level

Prepared by
VIIRS Aerosol Calibration/Validation Team

VIIRS Aerosol EDRs

- Aerosol Optical Thickness (AOT) referred to as τ
- Aerosol Particle Size Parameter (APSP) referred to as Angstrom Exponent
- Suspended Matter (SM)

Assessment Basis

- Data from May 2 to June 2, 2012
- Qualitative and quantitative analysis of comparisons with:
  - Satellite-derived (MODIS and CALIPSO) aerosol products
  - Ground-based (AERONET) aerosol data

Beta Maturity Definition

- Early release product
- Minimally validated
- May still contain significant errors
- Versioning not established until a baseline is determined
- Available to allow users to gain familiarity with data formats and parameters
- Product is not appropriate as the basis for quantitative scientific publications, studies or applications

Executive Summary
Findings and Recommendations

- VIIRS aerosol EDRs at Beta level:
  - AOT
  - APSP (with the caveat that APSP over land has no quantitative value)
- VIIRS aerosol EDR NOT at Beta :
  - SM
- The statements reflect the status as of July 2012 when the assessment was completed.
- Recommended starting date for EDRs qualifying for Beta level is May 2, 2012.

Executive Summary: Specific Problems

- Overall significant high bias in AOT over land, away from deserts.
- Artificially high AOT and APSP in the snow melt region.
- Low bias in AOT over ocean in dust outflow regions.
- Proportion of AOT attributed to small particles is too high over ocean.
- Currently no skill in retrieving APSP over land.
- Omnipresent volcanic ash in Suspended Matter and not enough dust.
- Improper ingest of NAAPS model data in low quality IP products (will be fixed in MX6.2; does not impact EDR).
- Missing EDRs in bowtie deletion region.
- Internal fire test fails to find any fires, even when large fires are known to be active. Several other internal tests (e.g., bright pixel flag) need further evaluation to determine performance.
- Angstrom exponent out of range flag only at extreme high latitudes, which seems unlikely.
- Snow and ice is present in strange places.
- Bad SDR flag is too omnipresent.
- In heavy dust/smoke plume regions, AOT could be flagged as out of range.

Executive Summary: Work before Provisional Stage

- Collocations against AERONET/MAN data over ocean,
- Determine reasons for high AOT bias over land, and for high APSP bias over ocean,
- Determine whether there is possibility for any skill in Angstrom Exponent over land,
- Continue investigations beyond this one month of analysis,
- Tune threshold to improve detection of dust over water,
- Lower AOT threshold from 1.0 to 0.5 to type SM,
- Implement subpixel snow/ice mask similar to MODIS to avoid issues with spring thaw,
- Evaluate and improve internal tests to flag bright pixels, ephemeral water, fires, etc.

Data Quality Assessment Objectives

- **Overall questions:**
  - Which products and fields have value and are ready for Beta?
  - Can specific code changes and/or paths of analysis that can make significant improvements to the Beta product before the products are advanced to the next stage be suggested?
- **AOT and ASPS questions:**
  - How well do these products match collocated Moderate Resolution Imaging Spectroradiometer (MODIS) retrievals?
  - How well do these products match collocated AErosol RObotic NETwork (AERONET) observations and retrievals?
  - How well do these products represent the global aerosol system during the period of analysis, without benefit of MODIS or AERONET's collocations to choose conditions?
  - Do Quality Flags matter and how much?
  - Is there a measurable accuracy difference between IP and EDR products?
  - Can we find trends and associations that suggest a path towards improving the VIIRS retrieval?
- **SM questions:**
  - Does the global distribution of suspended matter match our expectations based on EOS-era satellite retrievals and model results?
  - How does the suspended matter product compare with Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) designations of smoke and dust aerosol?

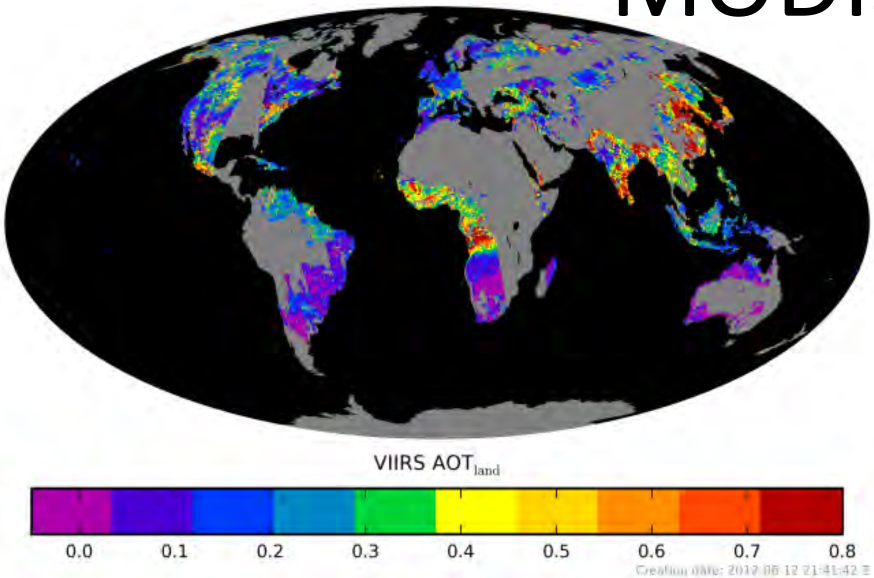
RESULTS

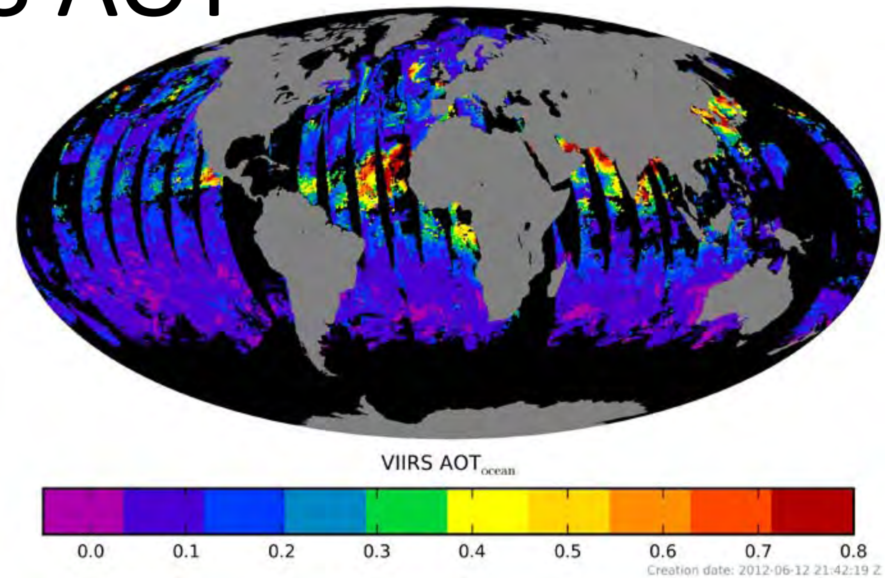
AOT – COLLOCATION OF VIIRS WITH MODIS

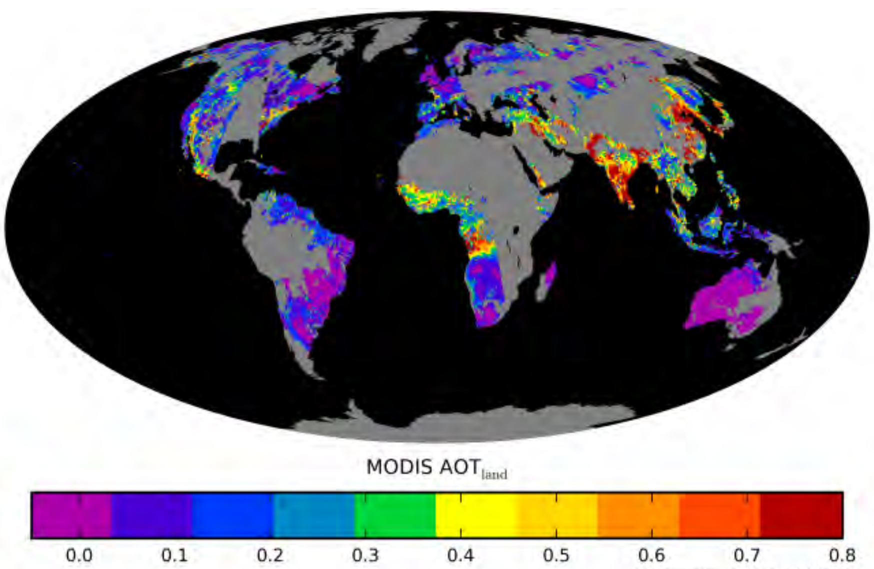
Global Maps of Collocated VIIRS and MODIS AOT

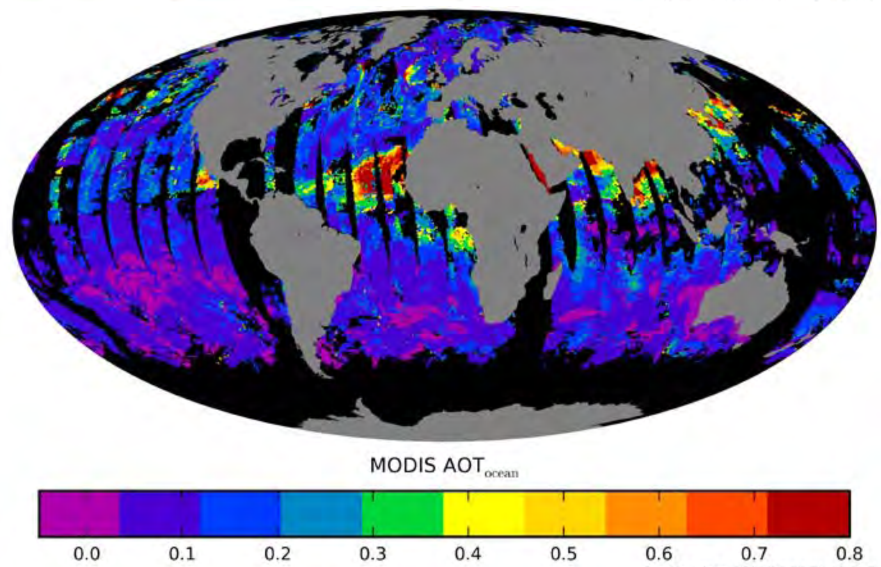
Land

Ocean







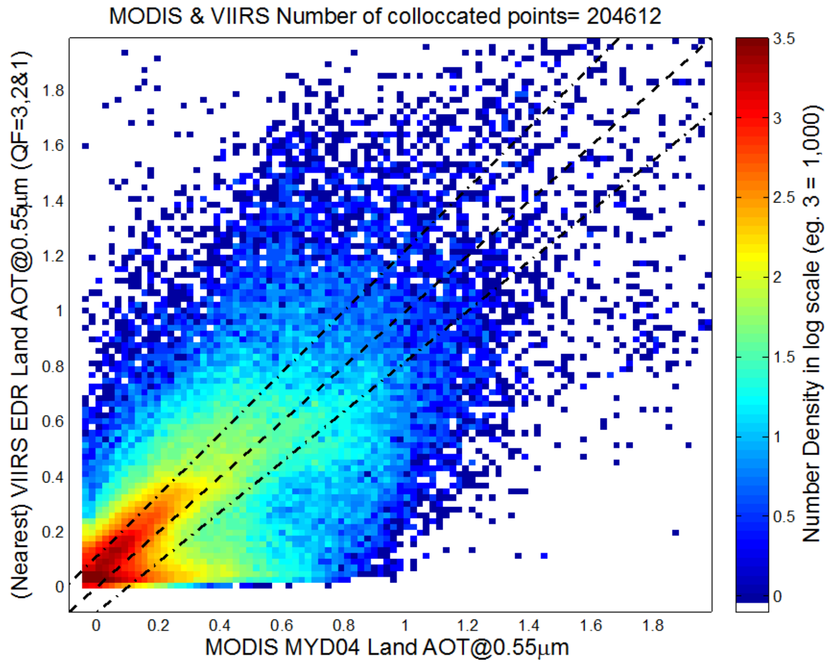


LAND

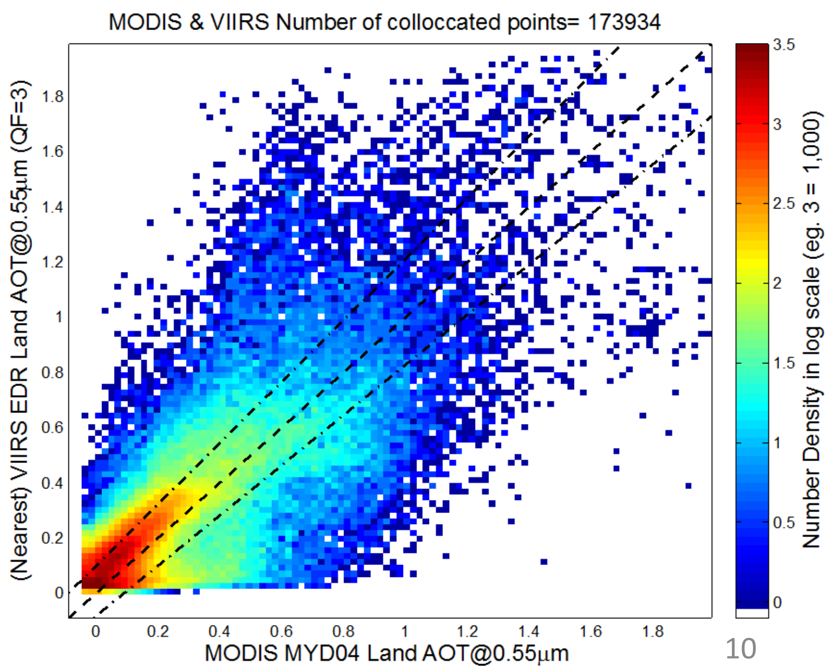
Collocation Criteria

- VIIRs and MODIS AOTs collocated within 5 minutes;
- Best quality MODIS AOT data over land (QF=3) and zero cloud fraction;
- VIIRS AOT from nearest pixel falling within MODIS 10 km.

Mean AOT Bias
(VIIRS – MODIS)
0.0310

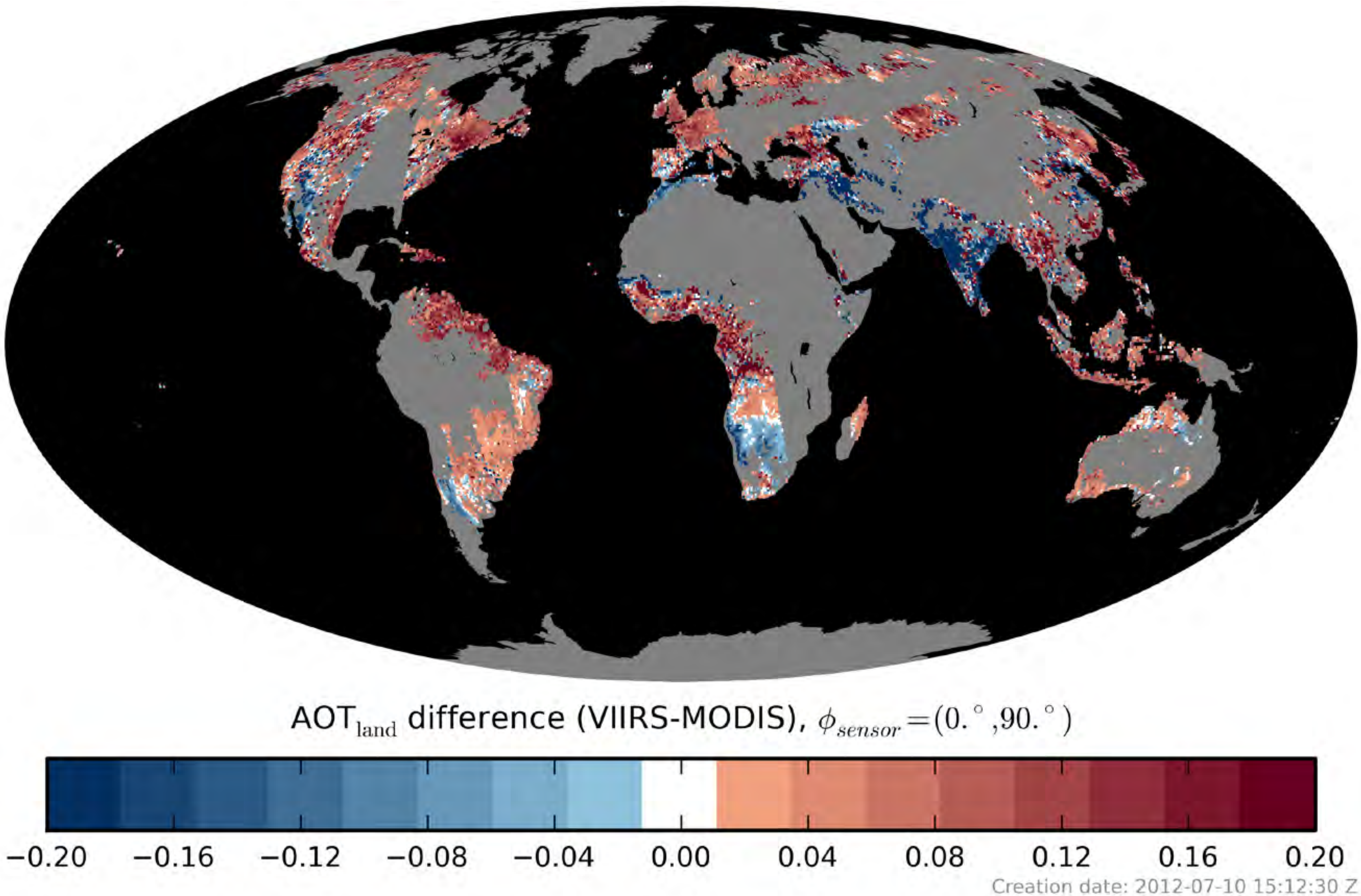


Mean AOT Bias
(VIIRS – MODIS)
0.0465



Top right: VIIRS AOT is “all quality” (QF=1,2,3)
Bottom right: VIIRS AOT is “best quality” (QF=3)

Global VIIRS – MODIS AOT Over Land

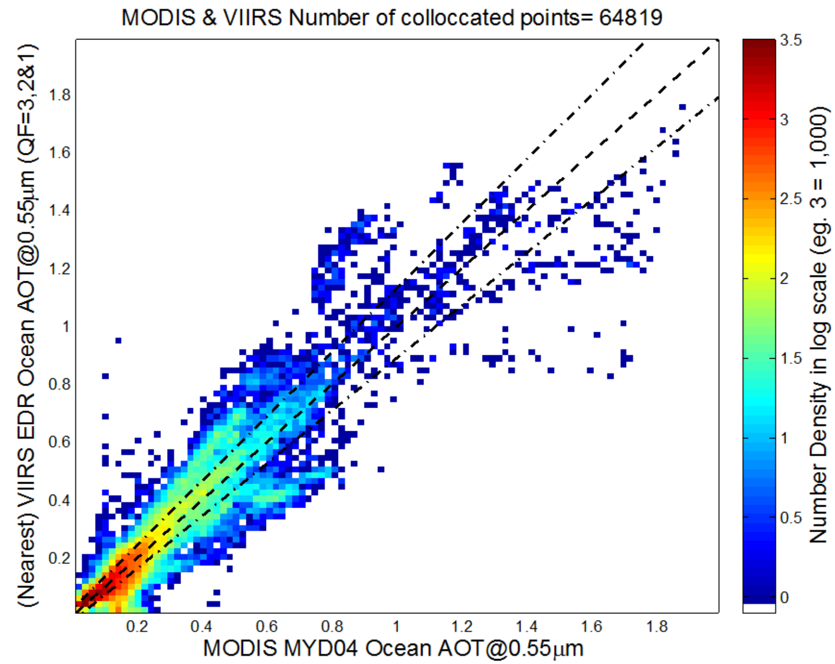


OCEAN

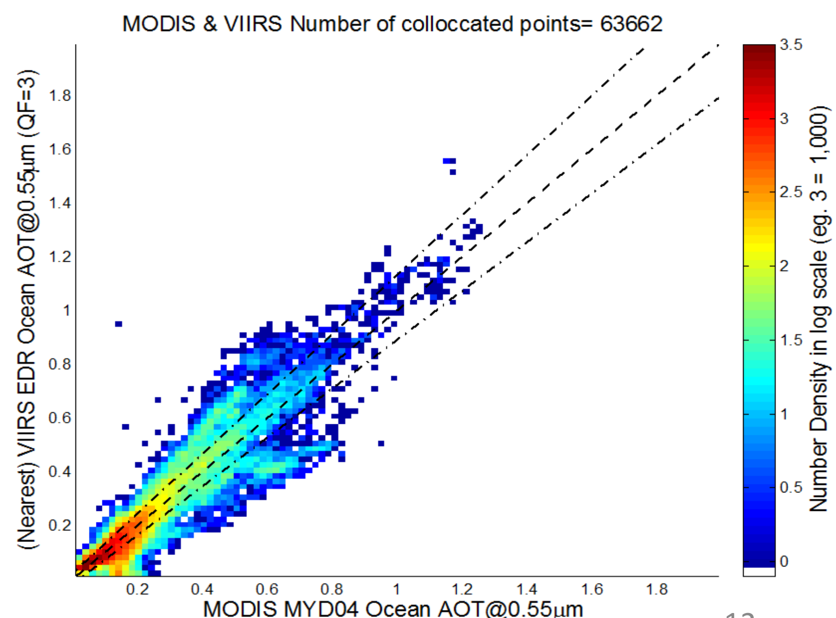
Collocation Criteria

- VIIRs and MODIS AOTs collocated within 5 minutes;
- Best quality MODIS AOT data over ocean (QF=3) and zero cloud fraction;
- VIIRS AOT from nearest pixel falling within MODIS 10 km.

Mean AOT Bias
(VIIRS – MODIS)
-0.0014

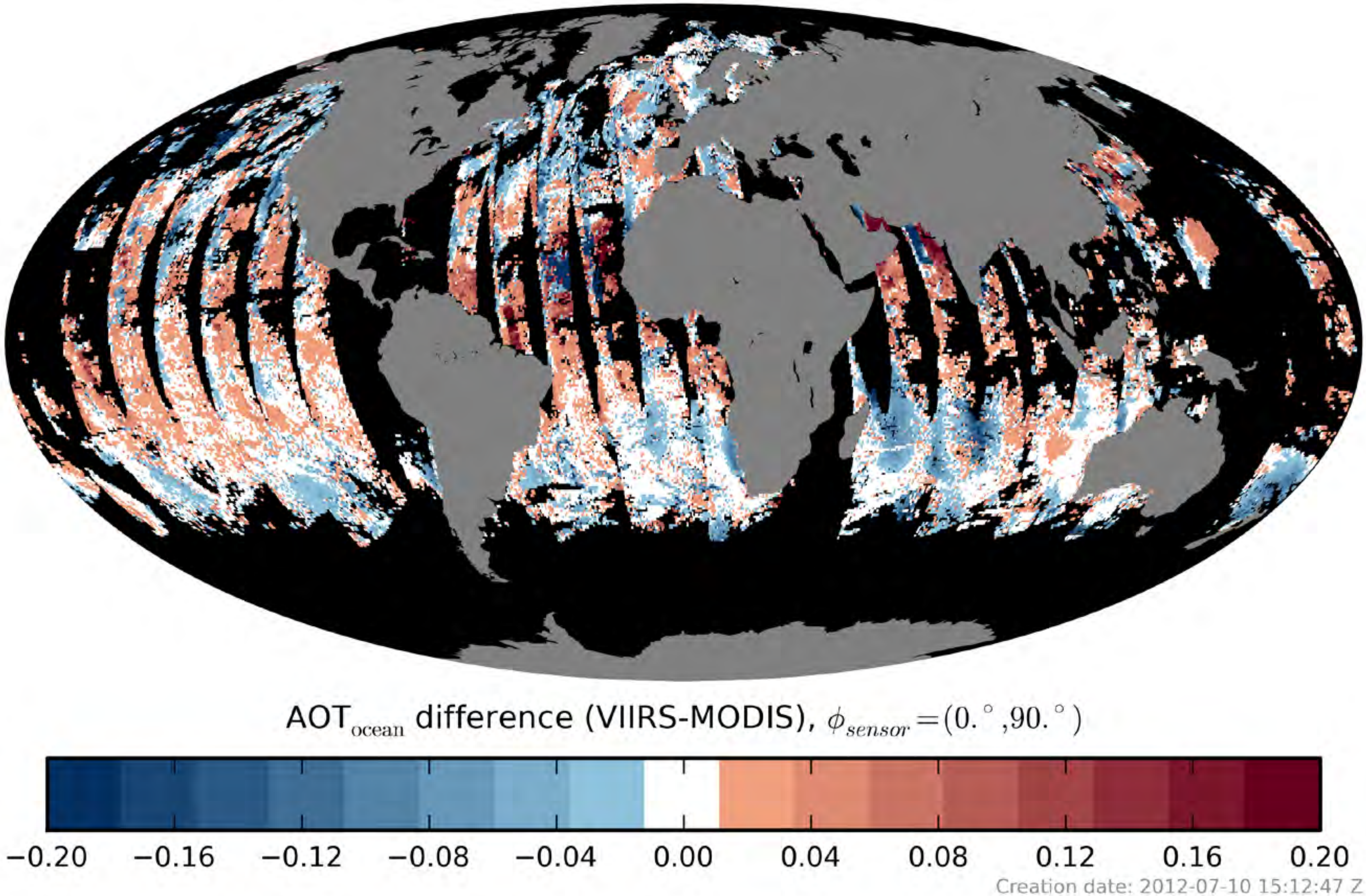


Mean AOT Bias
(VIIRS – MODIS)
-0.0017

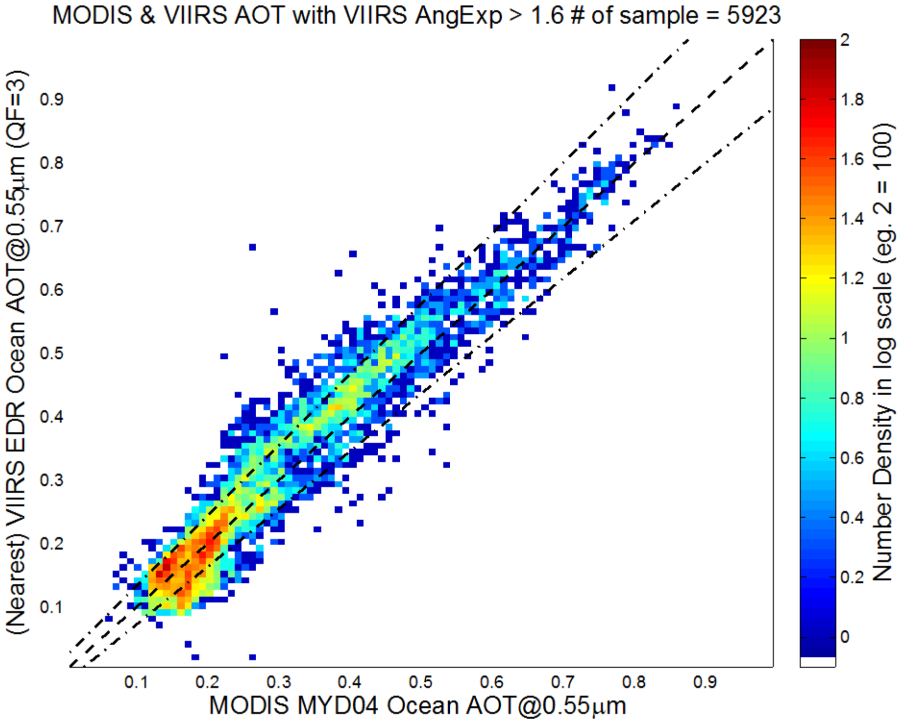


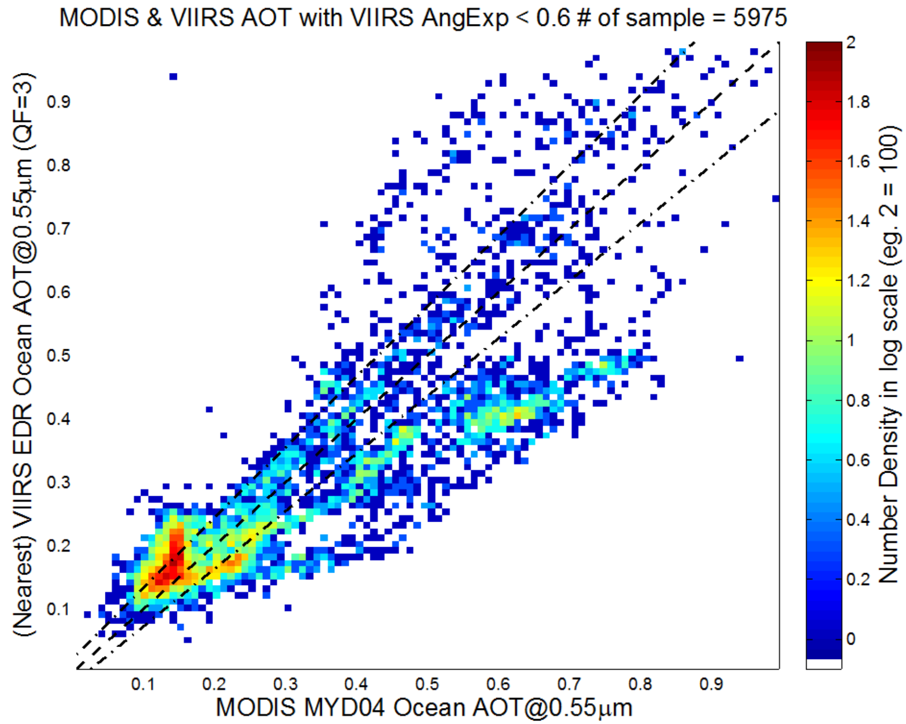
Top right: VIIRS AOT is "all quality" (QF=1,2,3)
Bottom right: VIIRS AOT is "best quality" (QF=3)

Global VIIRS – MODIS AOT over Ocean



MODIS vs. VIIRS AOT over Ocean





Fine Mode Aerosols/Smaller Particles (Angstrom Exponent > 1.6)

Coarse Mode Aerosols/Large Particles (Angstrom Exponent < 0.6)

When MODIS vs. VIIRS AOT over ocean are screened for Angstrom Exponent , VIIRS AOT agrees better with MODIS for smaller particles than for larger particles. This suggests there could be issues with VIIRS AOT retrievals for dust or cloud contamination in MODIS AOT

Summary of Results from Collocated VIIRS vs. MODIS Comparisons

- VIIRS AOT EDR is ready for Beta status
- AOT is characterized in its relationship to MODIS, which is itself a validated product.
- Use of high quality VIIRS AOT EDR (Quality Flag = 3) is highly recommended.
- Ocean VIIRS AOT matches MODIS much better for fine mode dominated aerosol, than for coarse mode. This could be due to cloud contamination in MODIS AOT or errors in VIIRS AOT for dust aerosols.
- All accuracies are based on 1 month of analysis and will change after a full annual cycle is analyzed.

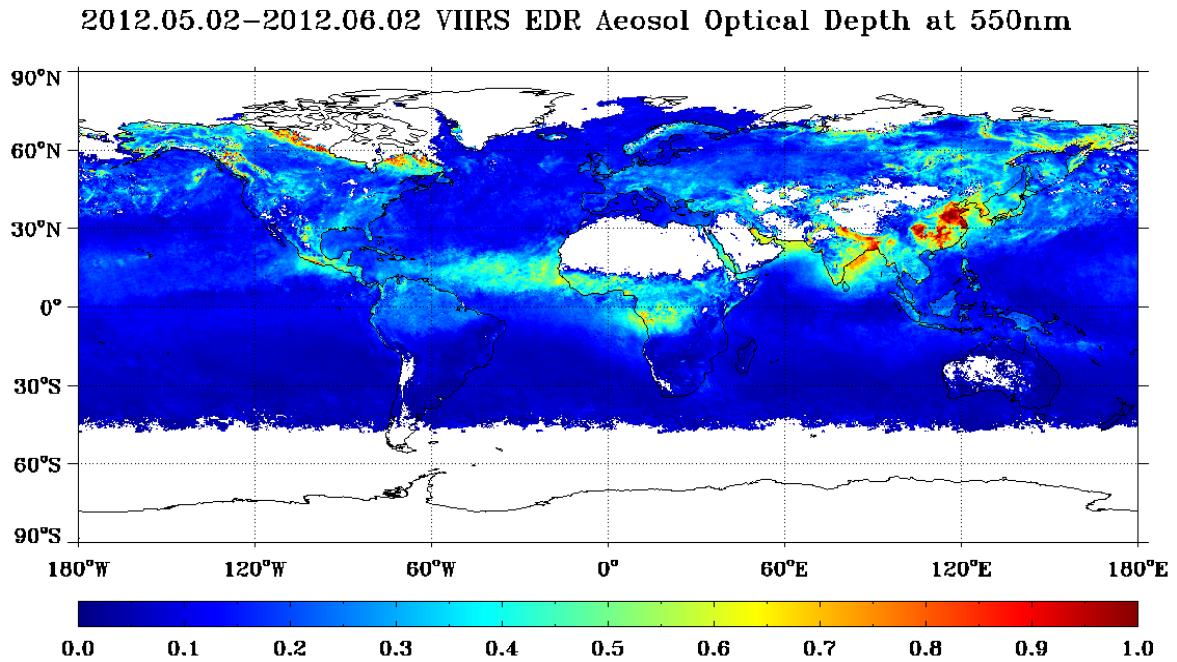
Statistics of VIIRS vs. MODIS AOT where $\Delta\tau = \tau_{VIIRS} - \tau_{MODIS}$

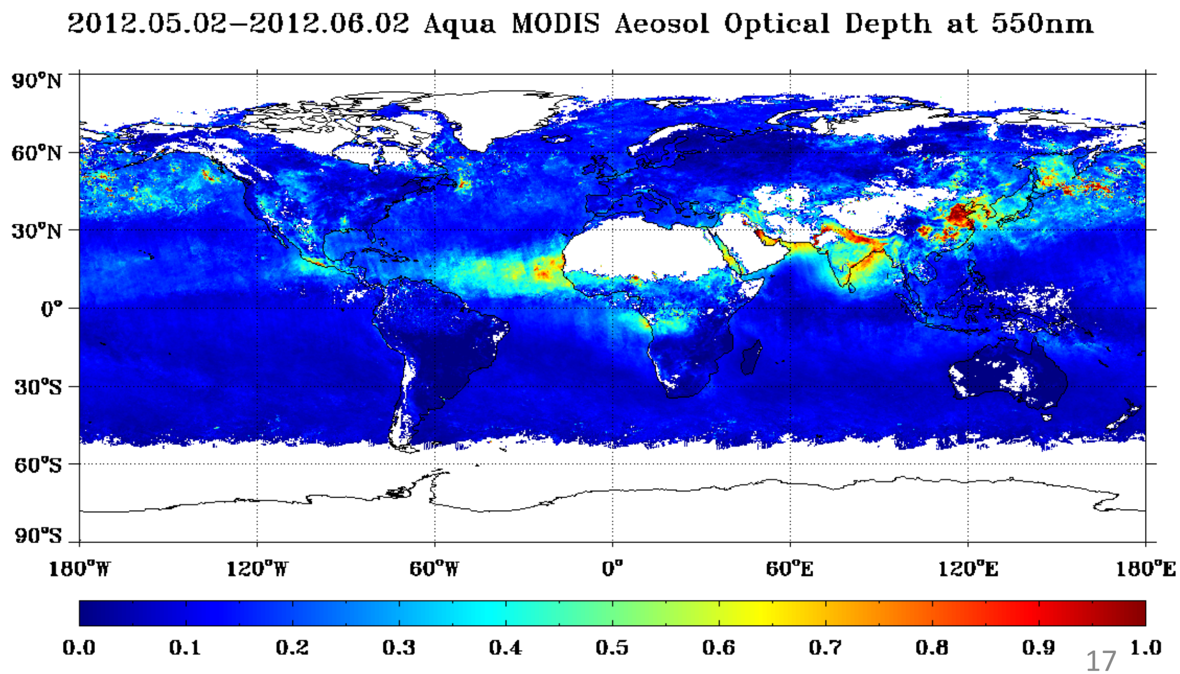
	EDR AOT land	EDR AOT ocean
All QF	STD($\Delta\tau$) = 0.1657 Mean($\Delta\tau$) = 0.0310 R = 0.752 τ_{VIIRS} = 0.7468 τ_{MODIS} +0.0724	STD($\Delta\tau$) = 0.0609 Mean($\Delta\tau$) = -0.0014 R = 0.9367 τ_{VIIRS} = 0.9812 τ_{MODIS} +0.0017
QF>0	STD($\Delta\tau$) = 0.1662 Mean($\Delta\tau$) = 0.0296 R = 0.7518 τ_{VIIRS} = 0.7458 τ_{MODIS} +0.0705	STD($\Delta\tau$) = 0.0627 Mean($\Delta\tau$) = -0.0009 R = 0.9369 τ_{VIIRS} = 0.9897 τ_{MODIS} +0.0008
QF > 1	STD($\Delta\tau$) = 0.1629 Mean($\Delta\tau$) = 0.0301 R = 0.7626 τ_{VIIRS} = 0.742 τ_{MODIS} +0.0734	STD($\Delta\tau$) = 0.0619 Mean($\Delta\tau$) = -0.001 R = 0.9377 τ_{VIIRS} = 0.988 τ_{MODIS} + 0.001
QF = 3	STD($\Delta\tau$) = 0.1445 Mean($\Delta\tau$) = 0.0405 R = 0.8024 τ_{VIIRS} = 0.7974 τ_{MODIS} +0.0719	STD($\Delta\tau$) = 0.0561 Mean($\Delta\tau$) = -0.0017 R = 0.9349 τ_{VIIRS} = 0.9968 τ_{MODIS} -0.0012

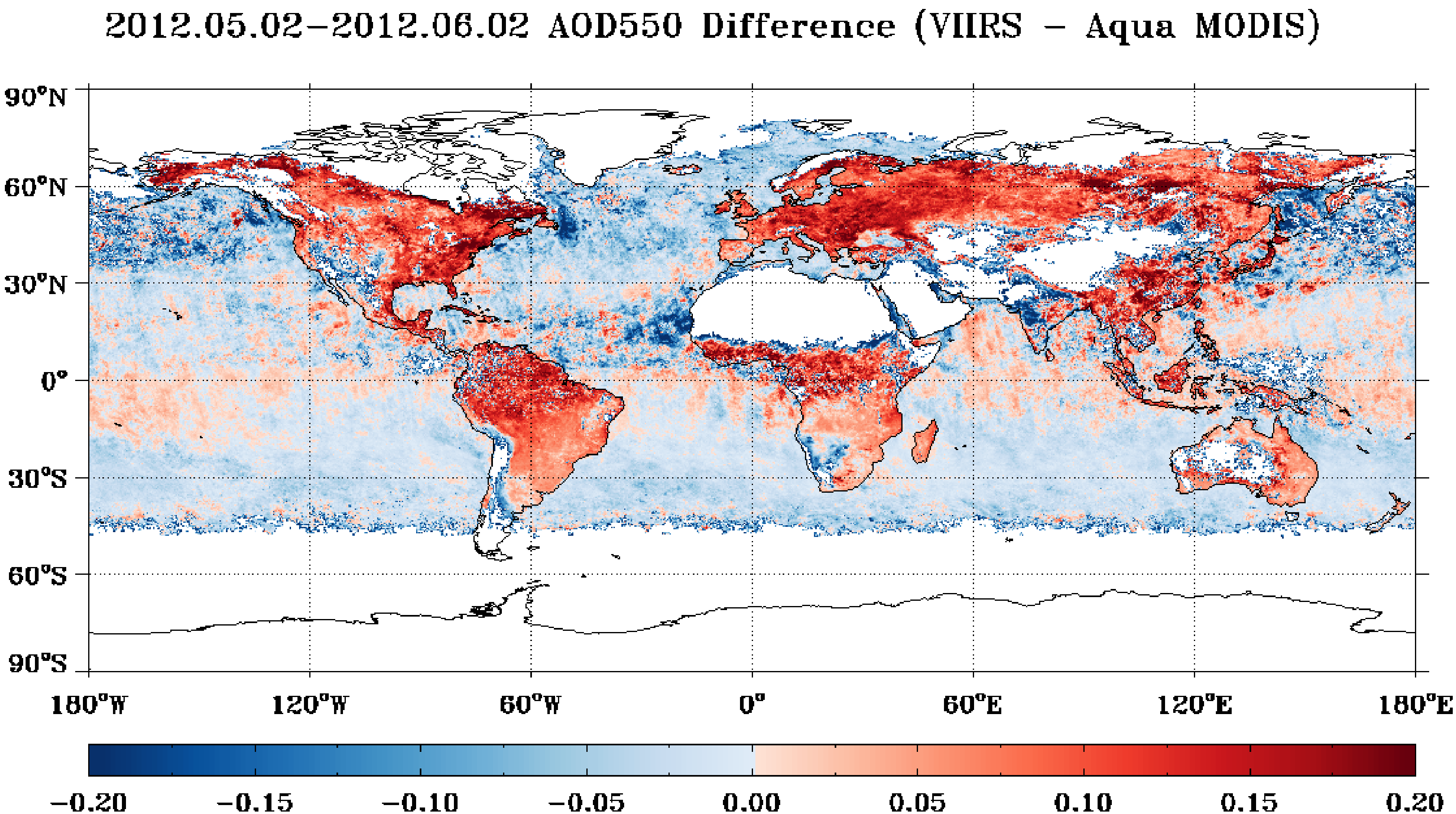
τ: optical thickness (AOT); R: correlation coefficient

Global Maps of VIIRS and MODIS AOT with No Collocation

- Best quality VIIRS AOT and Collection 5.1 Aqua MODIS AOT (best quality over land and all quality over ocean) were mapped into 0.25^{o} x 0.25^{o} grids;
- Spatial patterns and monthly statistics are computed and compared



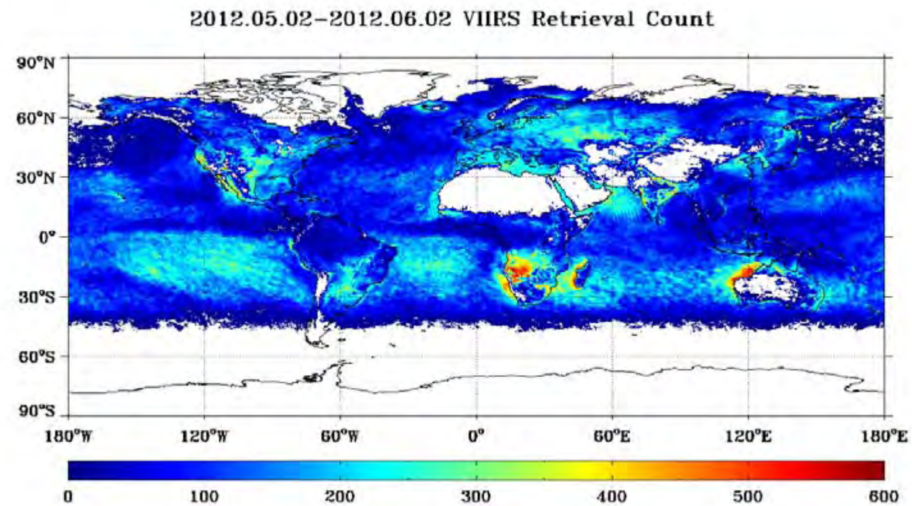


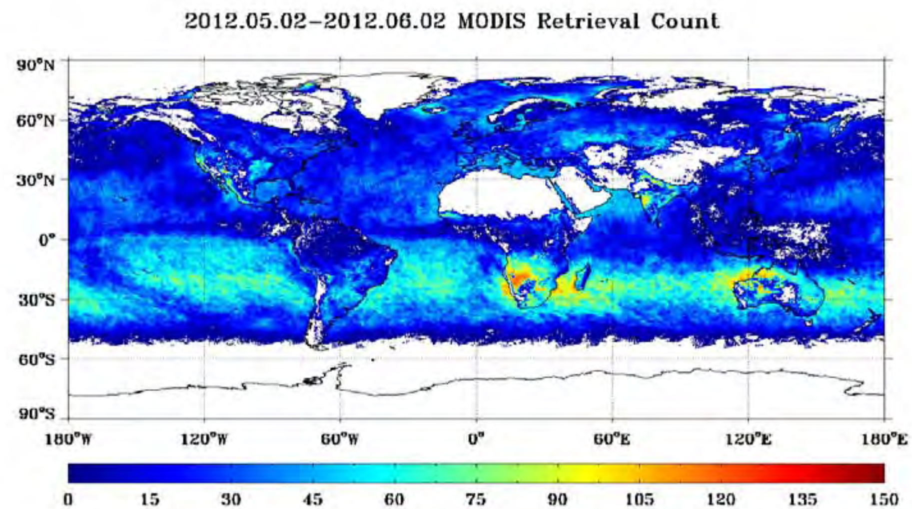


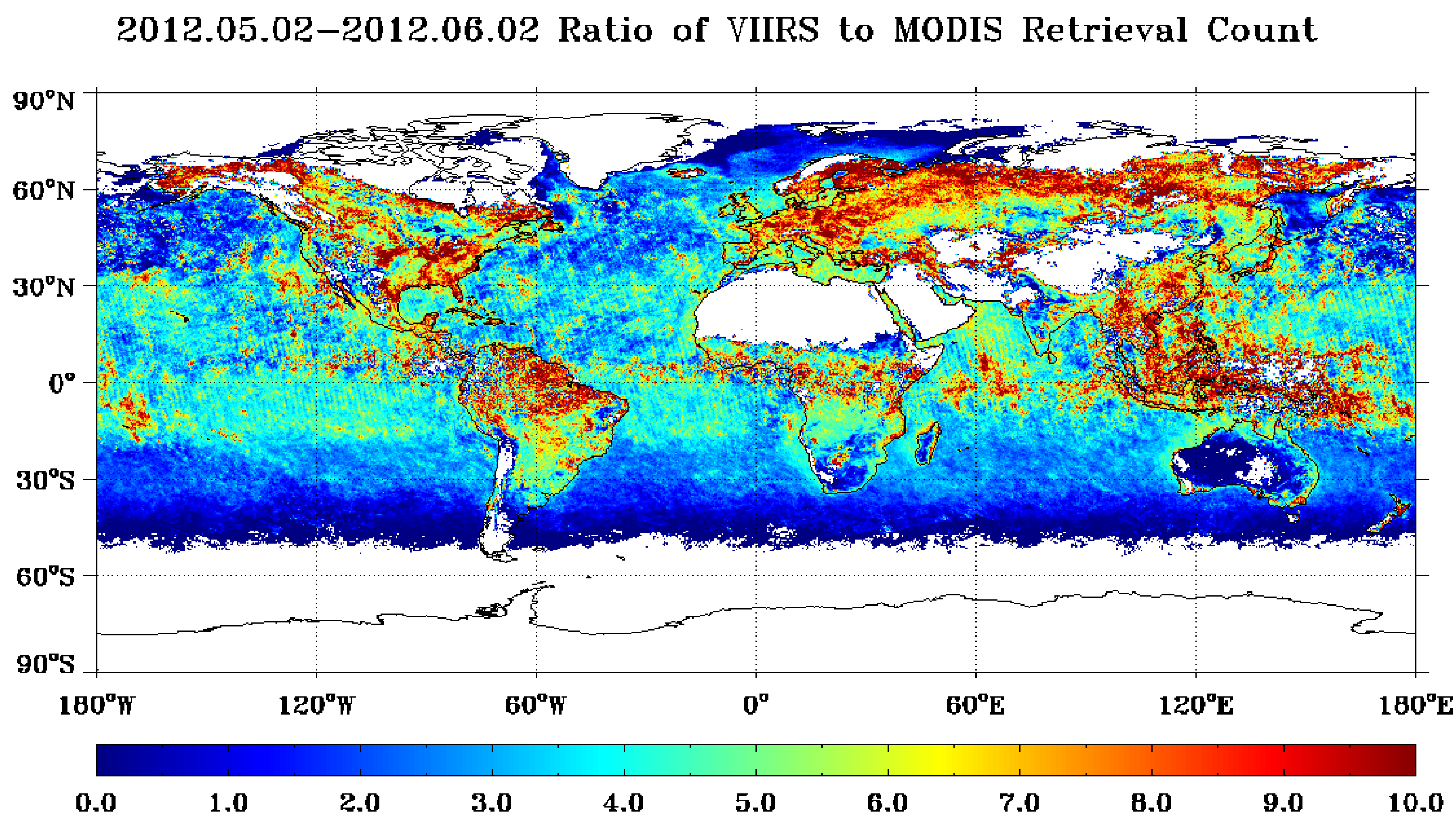
Spatial patterns of differences between VIIRS and MODIS AOT (without collocation) are similar to those with collocation (shown in slides 11 and 13). VIIRS AOT has a positive bias over land and negative bias over ocean

Global Maps of VIIRS and MODIS AOT Retrieval Count with No Collocation

- More retrievals from VIIRS compared to MODIS:
  - Finer spatial resolution
  - Wider swath
- Mean VIIRS to MODIS Retrieval count ratio:
  - Over ocean: 3.2
  - Over land: 5.5
- Correlation between spatial patterns of AOT difference (slide 18) and retrieval count difference (slide 20).

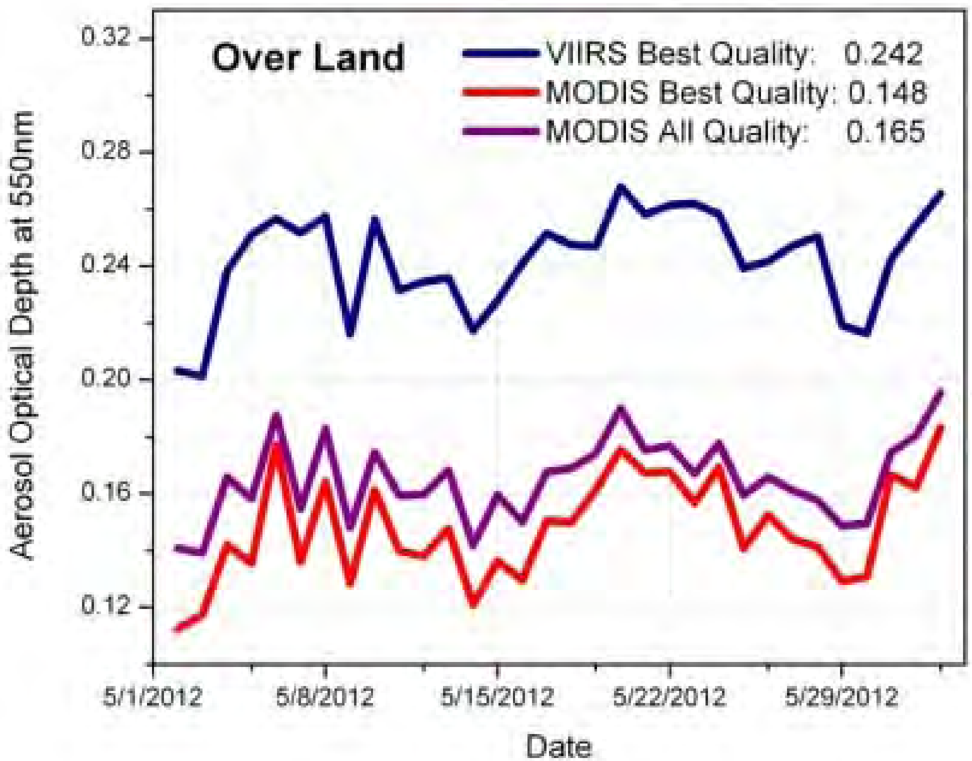


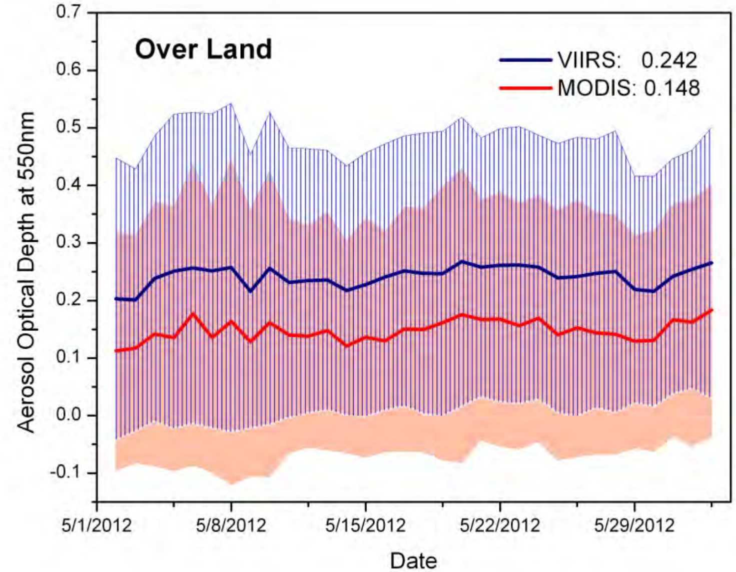


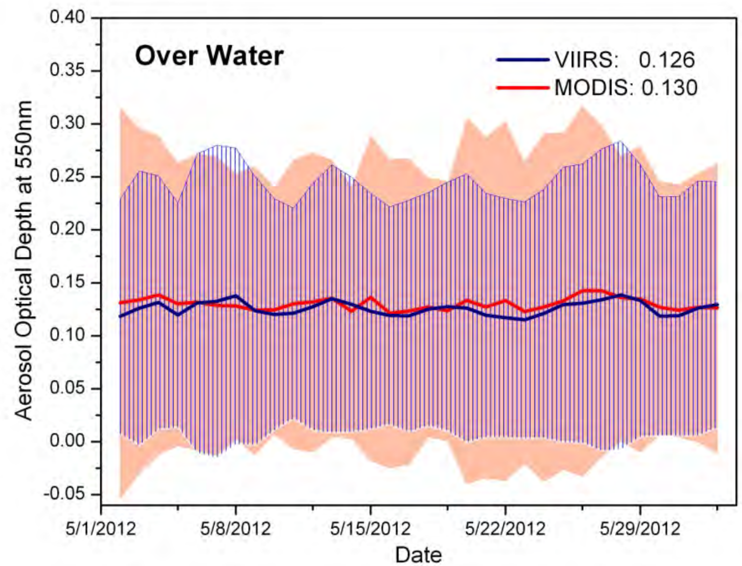


Ratio of number of VIIRS to MODIS retrievals for May 2 to June 2, 2012: VIIRS provides more retrievals than MODIS because of higher spatial resolution and wider swath.

Time Series of Global Mean AOT from VIIRS and MODIS for May 2 to June 2, 2012







VIIRS AOT is systematically higher than MODIS over land even when "all quality" MODIS data are included.

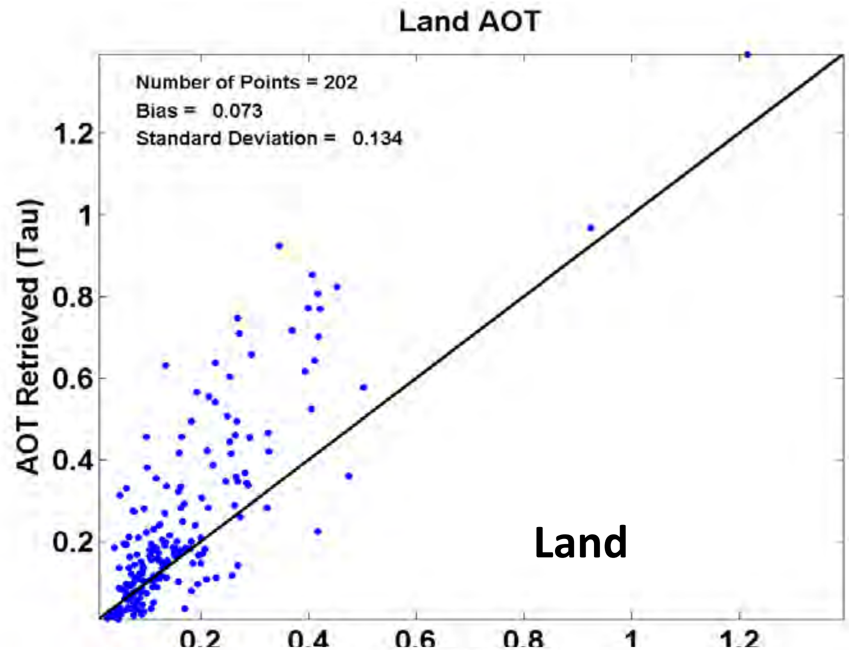
Results

AOT – COLLOCATION WITH AERONET

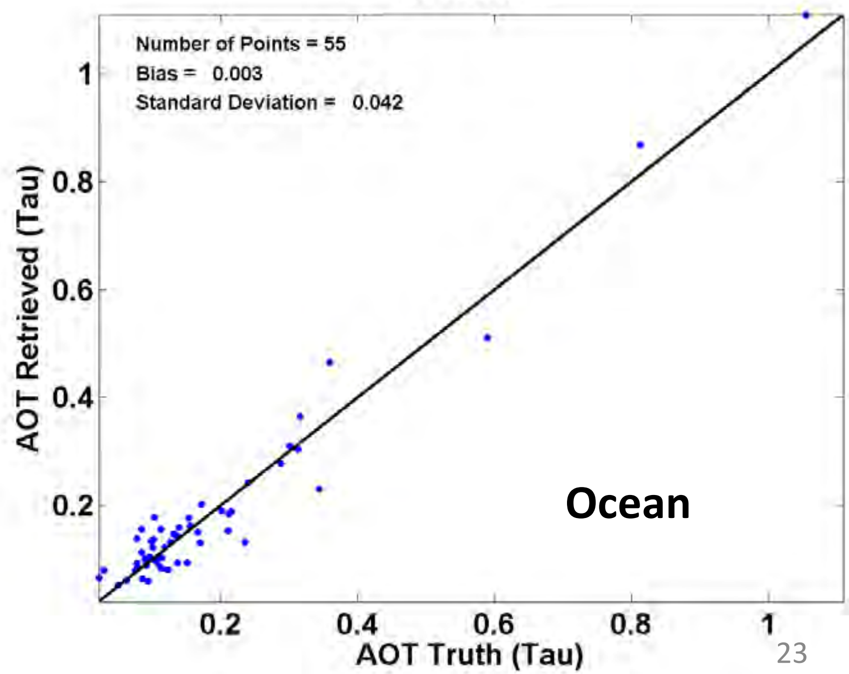
VIIRS vs. AERONET AOT Match-Up Method 1 M2M

- AERONET Level 1.5 (from sky radiance) within ± one hour time window;
- Best quality VIIRS AOT (QF=3) data from a 5 x 5 pixels surrounding the AERONET station are used;
- Mean VIIRS AOT from 5 x 5 pixels with a requirement that a minimum of 25% pixels are of best quality is matched with mean AERONET AOT (M2M).

	Bias	Precision
Land	0.073	0.134
Ocean	0.003	0.042



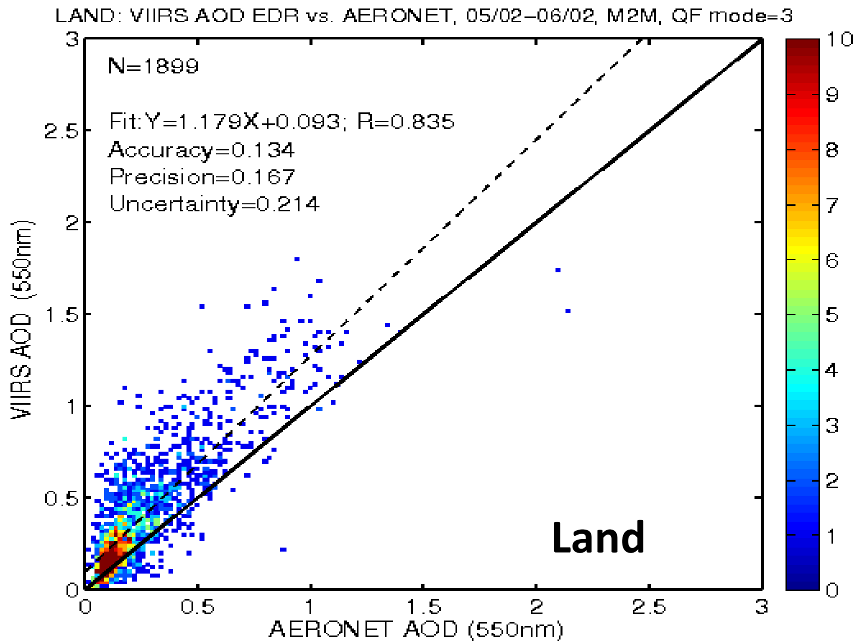
Ocean AOT

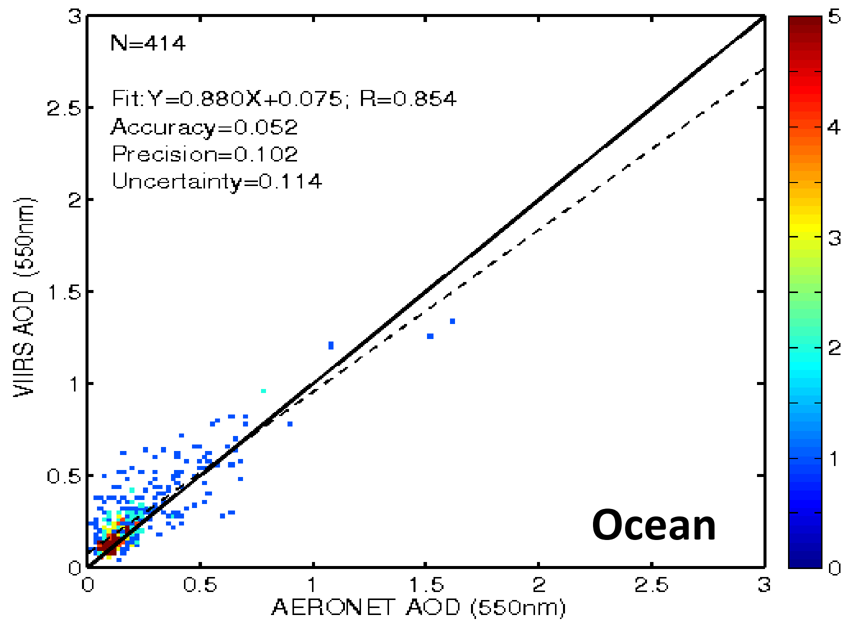


VIIRS vs. AERONET AOT Match-Up Method 2 M2M

- AERONET Level 1.5 (from direct sun retrievals) within ± 30 minute time window. All available measurements are averaged;
- Best quality VIIRS AOT (QF=3) data from pixels within a 27.5 km radius from the center of the AERONET station are used;
- No restriction on the number of samples involved.

	Bias	Precision
Land	0.134	0.167
Ocean	0.052	0.102

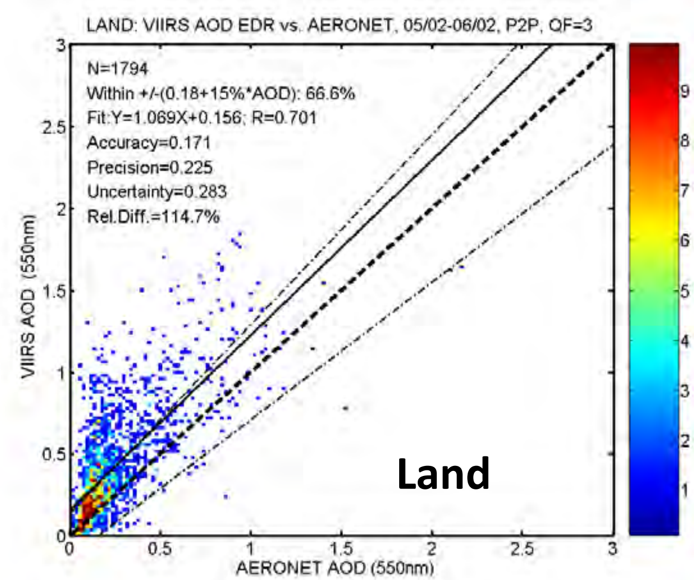


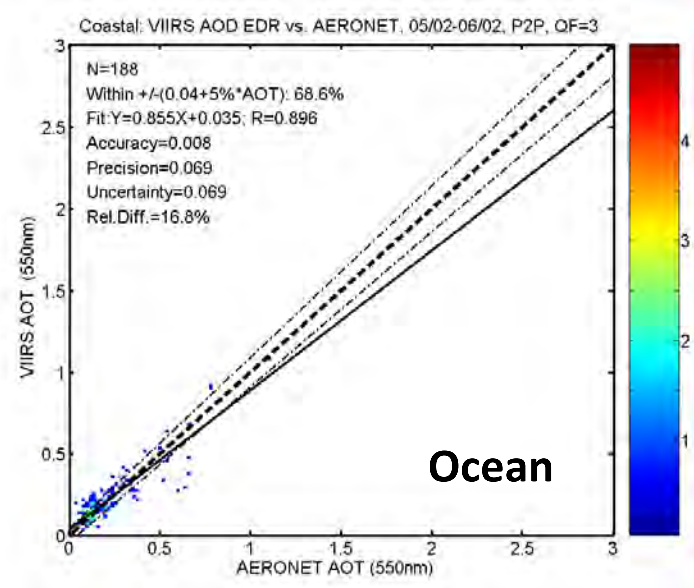


VIIRS vs. AERONET AOT Match-Up Method 2 P2P

- AERONET Level 1.5 (from direct sun retrievals) closest in time to VIIRS overpass time within ± 30 minute time window ;
- Best quality VIIRS AOT (QF=3) data closest to the center of the AERONET station are used;
- Quality of matchup is determined by the quality of VIIRS EDR selected.

	Bias	Precision
Land	0.171	0.255
Ocean	0.008	0.069

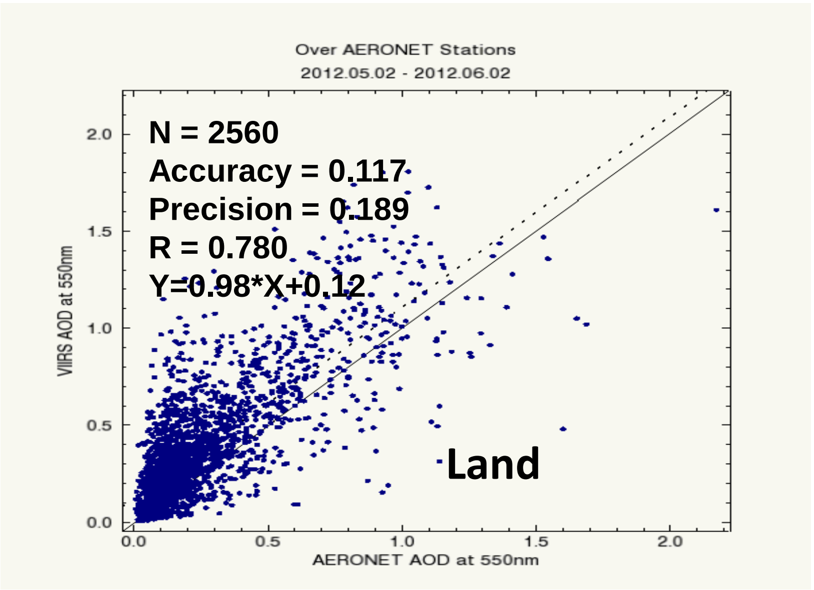


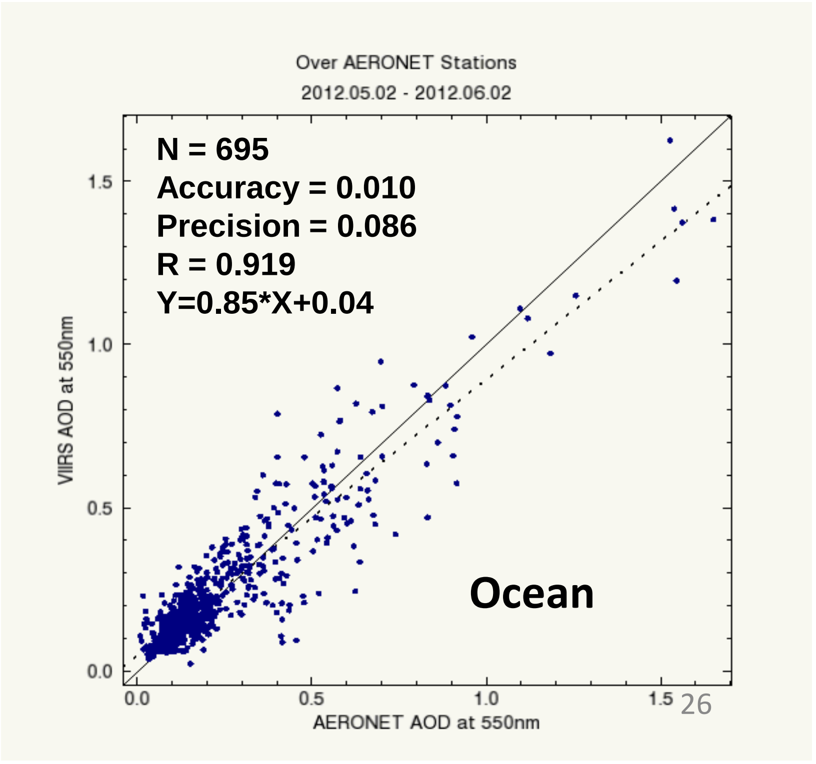


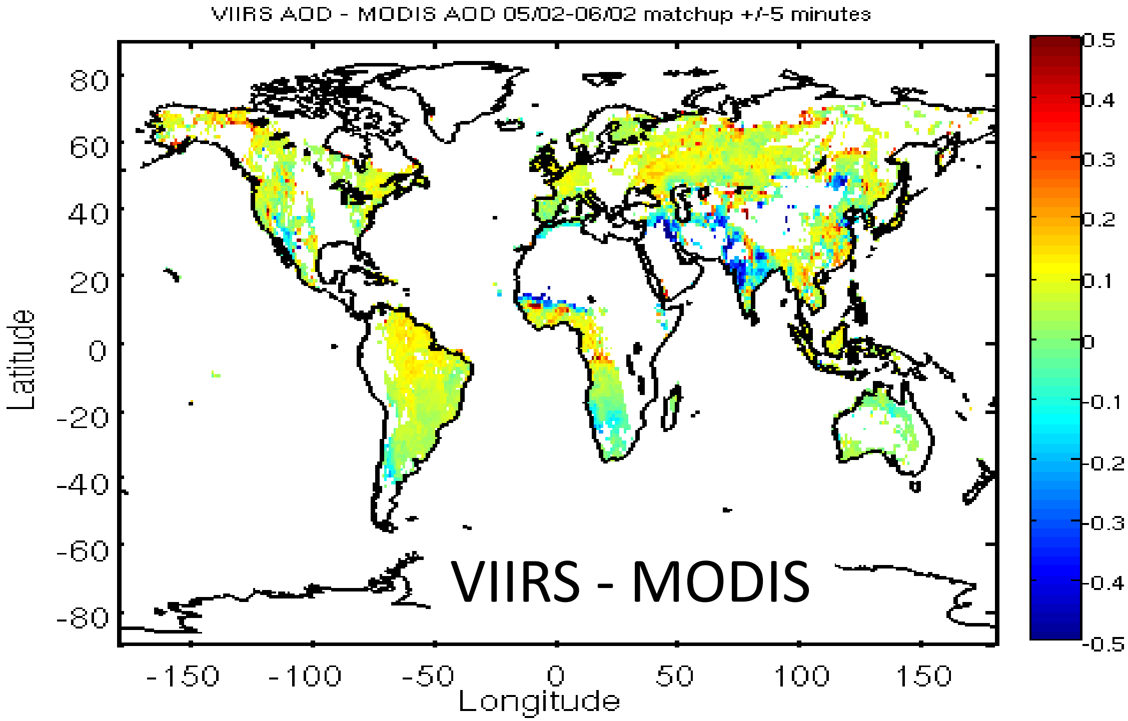
VIIRS vs. AERONET AOT Match-Up Method 3 M2M

- AERONET Level 1.5 (from direct sun retrievals) within ± 30 minute time window;
- Best quality VIIRS AOT (QF=3) data from a 5 x 5 pixels surrounding the AERONET station are used;
- No restriction on the number of samples involved.

	Bias	Precision
Land	0.117	0.189
Ocean	0.010	0.086

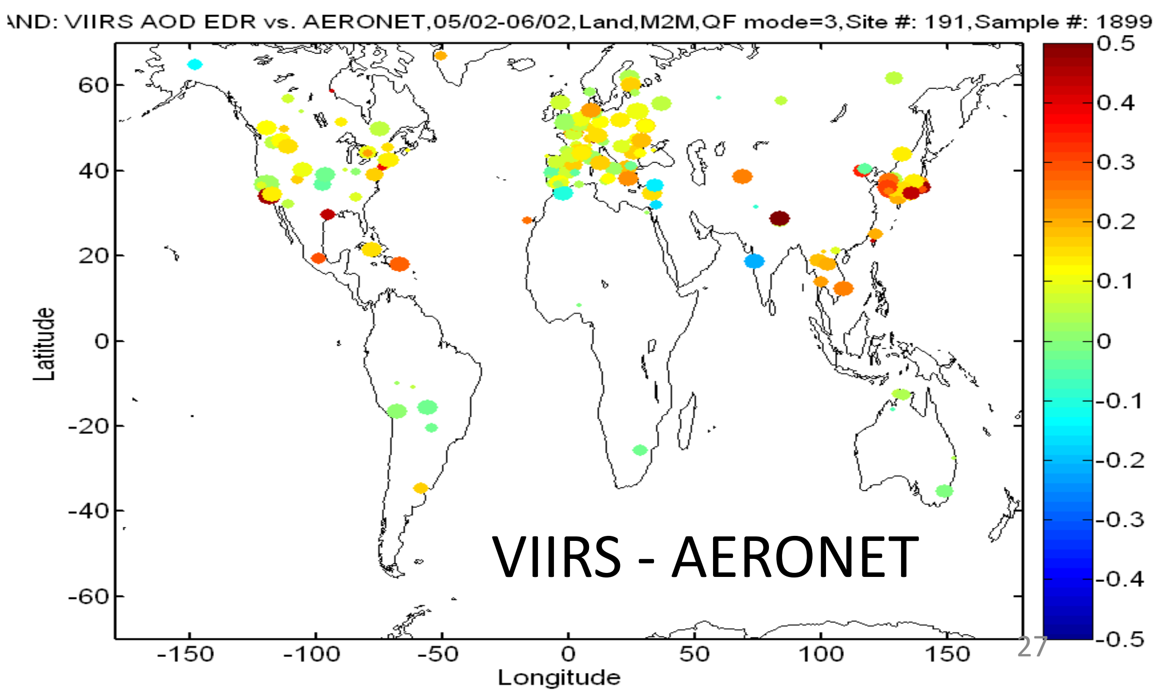






Spatial Patterns of VIIRS vs. MODIS (top left) and VIIRS vs. AERONET (bottom right)

Both collocations show that VIIRS AOT is biased high over land, specifically pacific north west, eastern Europe, Japan. However, over South America, VIIRS retrievals are not biased high.



Summary of Results from Collocated VIIRS vs. AERONET Comparisons

- **Land:**
  - There are sufficient collocations with AERONET over land to further evaluate VIIRS over land accuracy.
  - VIIRS AOT is biased high (~0.07 to 0.17).
- **Ocean:**
  - VIIRS vs. AERONET comparisons at coastal and island stations are problematic because VIIRS spatial averages around the AERONET station contain both land and ocean pixels and the exact point match-up is likely land, not ocean. Also there are insufficient collocations to draw strong conclusions.
  - Despite problems, it is clear that collocations with AERONET over ocean show negligible bias (~0 to 0.06).

AOT	P/M	N	Slope	Offset	Corr. Coef.	Rel. Diff. (%)	Accuracy	Precision	Uncertainty
					Land				
Matchup Method 1	P2P	156					0.153	0.235	
	M2M	202					0.073	0.134	
Matchup Method 2	P2P	1794	1.069	0.156	0.701	114.7	0.171	0.225	0.283
	M2M	1899	1.179	0.093	0.835	78.9	0.134	0.167	0.214
Matchup Method 3	M2M	2560	0.98	0.12	0.780		0.117	0.189	0.222
					Ocean				
Matchup Method 1	P2P	17					-0.003	0.062	
	M2M	55					0.003	0.042	
Matchup Method 2	M2M	414	0.880	0.075	0.854	63.7	0.052	0.102	0.114
Matchup Method 3	M2M	695	0.85	0.04	0.919		0.010	0.086	0.087

Error bounds Defined by One Standard Deviation (66% of Retrievals)

	Land	Ocean
AERONET	±0.13 ± 15%	±0.04 ± 5%
MODIS	±0.09 ± 10%	±0.02 ± 10%

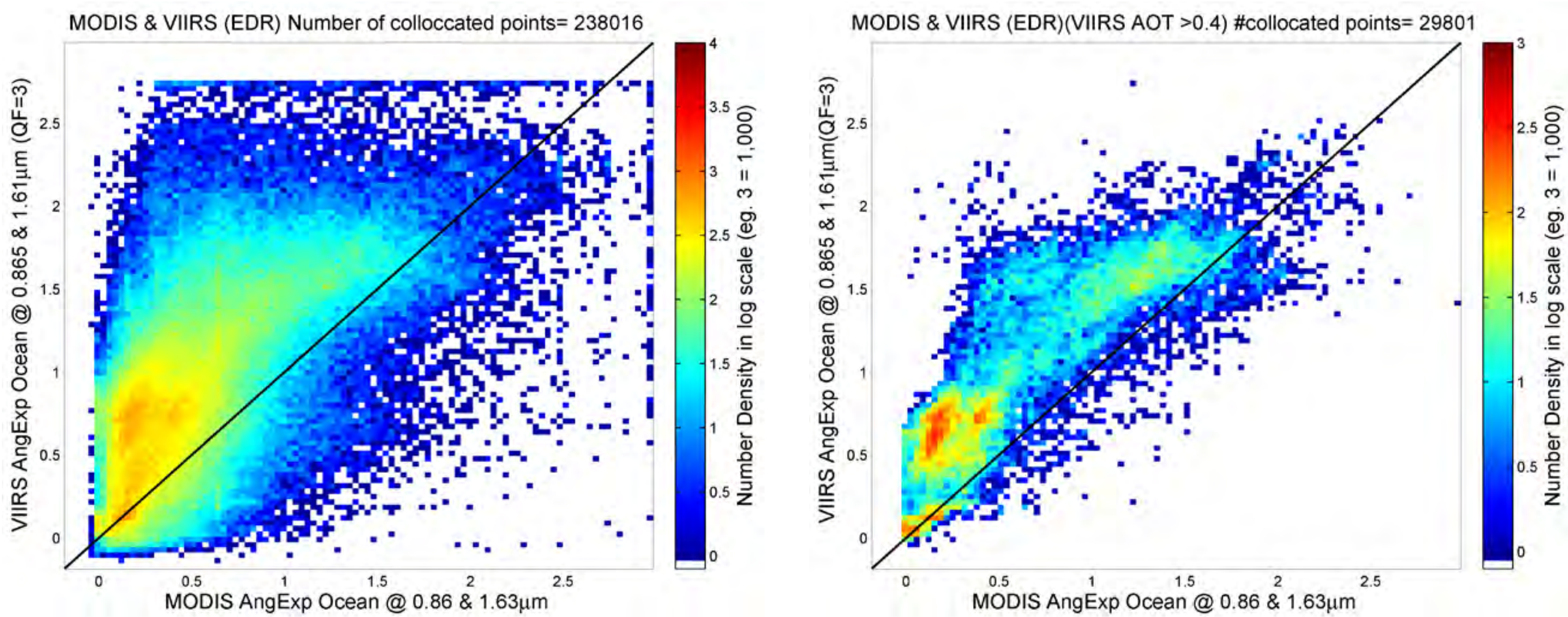
Over land: VIIRS matches MODIS better than VIIRS matches AERONET. Note that MODIS is not truth and does not exactly match AERONET

Over ocean: VIIRS matches MODIS and AERONET

Results

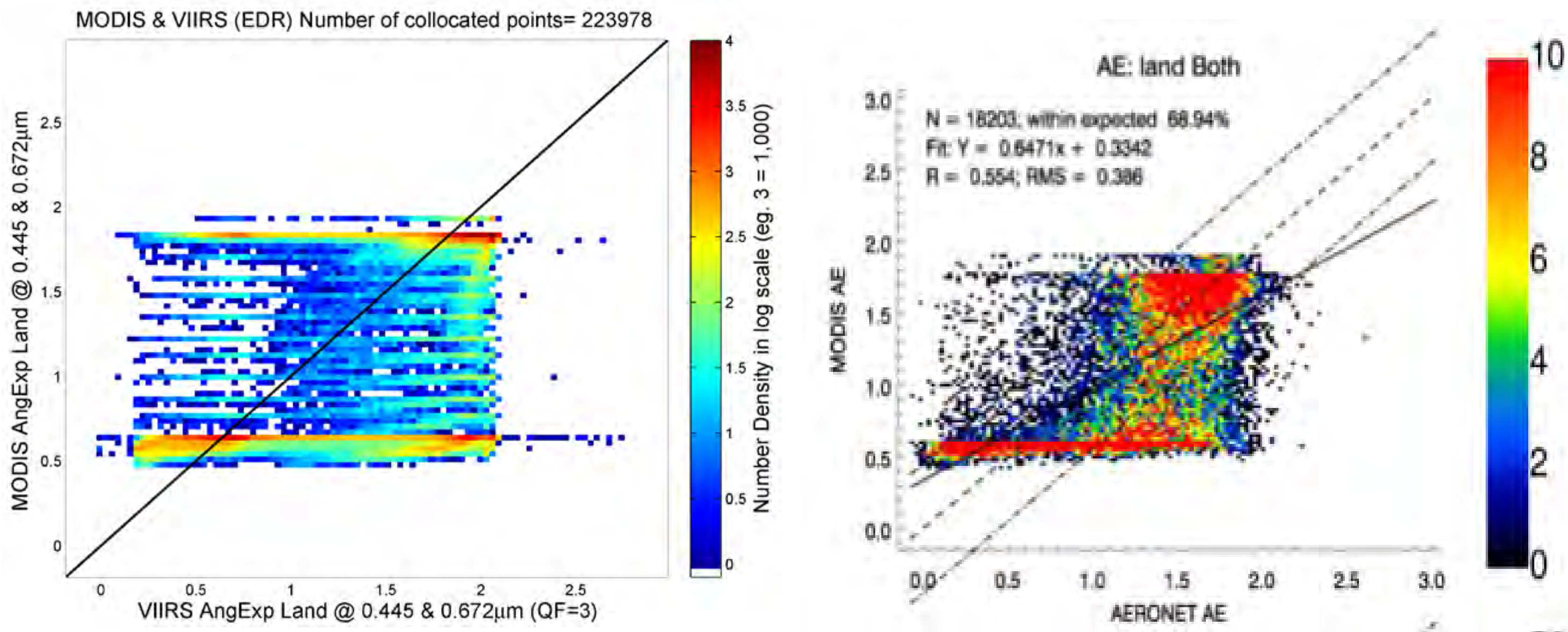
AEROSOL PARTICLE SIZE PARAMETER – COLLOCATION WITH MODIS

VIIRS vs. MODIS Angstrom Exponent (AE) over Ocean



- VIIRS AE determined from AOT 0.865 µm and 1.61 µm.
- MODIS AE determined from AOT at 0.860 µm and 1.63 µm.
- Best quality VIIRS and MODIS AE data used.
- Left figure is for data with no screening based on AOT whereas right figure is AE with AOT greater than 0.4.

VIIRS vs. MODIS Angstrom Exponent (AE) over Land



From Levy et al., 2010
doi:10.5194/acp-10-10399-2010

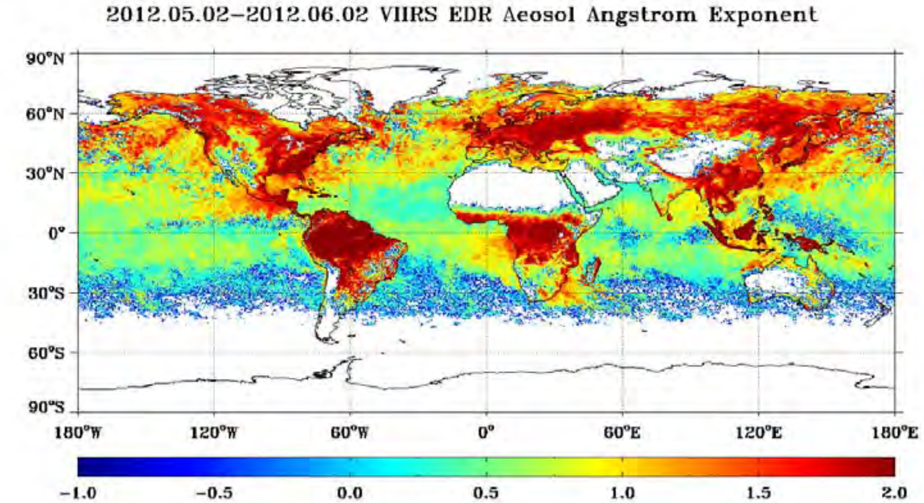
- VIIRS AE determined from AOT 0.445 µm and 0.672 µm.
- MODIS AE determined from AOT at 0.466 µm interpolated to 0.445 µm and 0.672 µm.
- Best quality VIIRS and MODIS AE data used.
- Scatter plots of MODIS vs. VIIRS (left) and MODIS vs. AERONET AE (right).
- Data show no skill to retrieve AE over land.

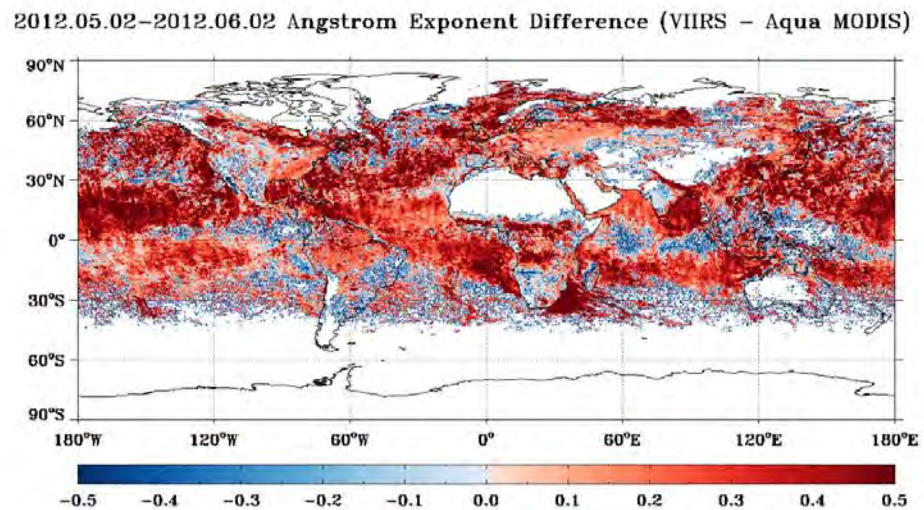
Results

AEROSOL PARTICLE SIZE PARAMETER – NO COLLOCATION WITH MODIS

Global Maps of VIIRS and MODIS Angstrom Exponent with No Collocation

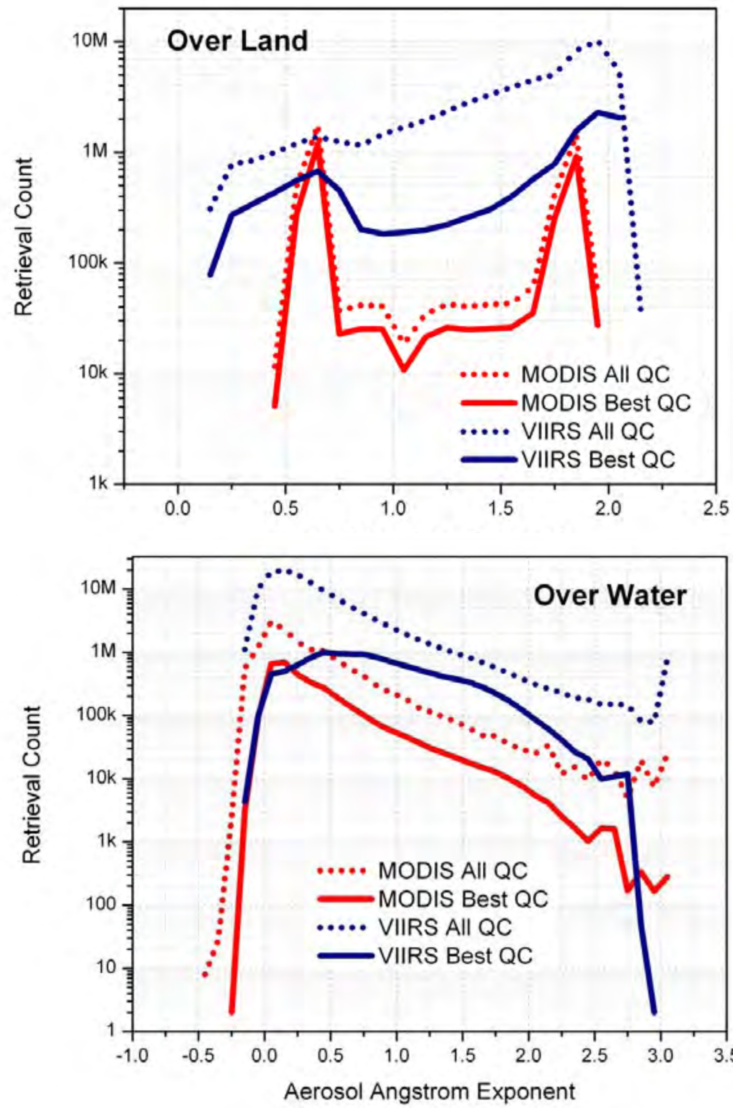
- VIIRS AE (shown in top right figure) is greater than 1.5 over land indicating the presence of small particles;
- VIIRS – MODIS AE (bottom right) shows a positive bias both over land and ocean;
- NASA MODIS team recommends not using AE over land. NPP aerosol cal/val team will do additional analysis to determine if there is any skill. Preliminary analysis for May 2 to June 2, 2012 time period shows no skill over land.
- Caveats: wavelengths used to calculate VIIRS and MODIS AEs are different. VIIRS: 0.45 µm and 0.67 µm; MODIS: 0.47 µm and 0.67 µm.





Histograms of VIIRS and MODIS Angstrom Exponent with No Collocation

- MODIS and VIIRS AEs have similar distribution over water (bottom right);
- MODIS AE shows a binary pattern corresponding to small (large particles) and large (small particles) values.
- VIIRS AE for "best quality" is closer to MODIS than "all quality". Additionally, difference between "all quality" and "best quality" is small for MODIS than for VIIRS
- Caveats: wavelengths used to calculate VIIRS and MODIS AEs are different. VIIRS: 0.45 µm and 0.67 µm; MODIS: 0.47 µm and 0.67 µm.



Summary of Results from Collocated VIIRS and MODIS AE

- Over ocean, QF flags are more important for Angstrom Exponent than for AOT.
- Best quality VIIRS AE has good correlation with MODIS AE over ocean but has a positive high bias.
- If AE retrievals are filtered for AOT greater than 0.4 (like AERONET) then difference between VIIRS and MODIS AE is ±0.5. If AE retrievals are screened for AOT greater than 0.15 not much different than using no AOT screening for AEs.
- Over land, AE is uncorrelated with MODIS, but MODIS is uncorrelated with AERONET. MODIS cannot be used as a standard to evaluate VIIRS for this product.
- Recommend using only “best quality” AE over ocean, and recommend AEs for AOTs greater than 0.4. Do not recommend using AEs over land.

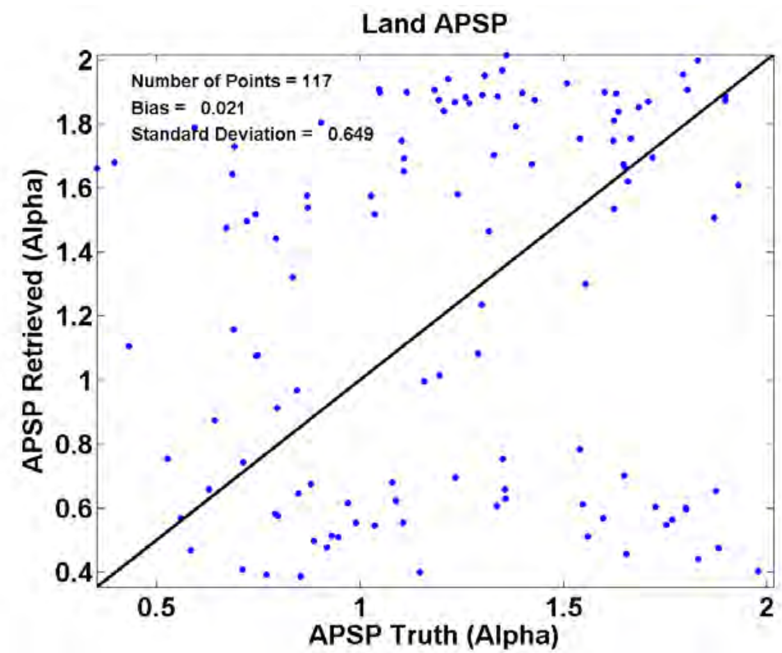
Results

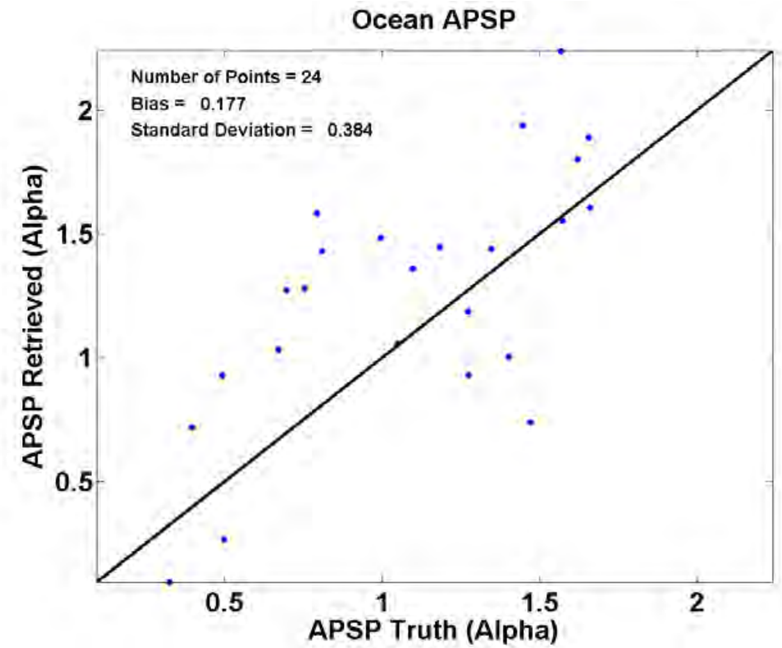
AEROSOL PARTICLE SIZE PARAMETER – COLLOCATION WITH AERONET

VIIRS vs. AERONET Angstrom Exponent (AE) Match-Up Method 1 M2M

- AERONET Level 1.5 (from sky radiance) within ± one hour time window;
- Best quality VIIRS AE (QF=3) data from a 5 x 5 pixels surrounding the AERONET station are used;
- Mean VIIRS AE from 5 x 5 pixels with a requirement that a minimum of 25% pixels are of best quality is matched with mean AERONET AE (M2M).

	Bias	Precision
Land	0.021	0.649
Ocean	0.177	0.384

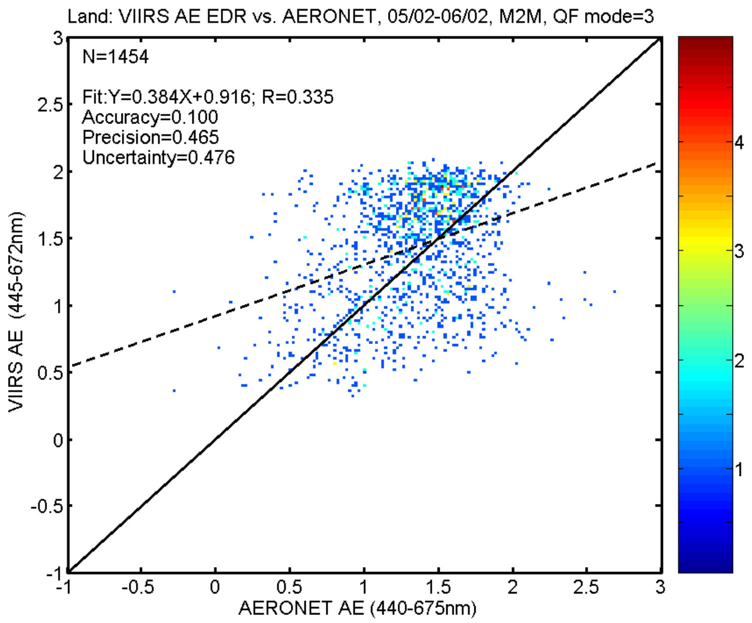


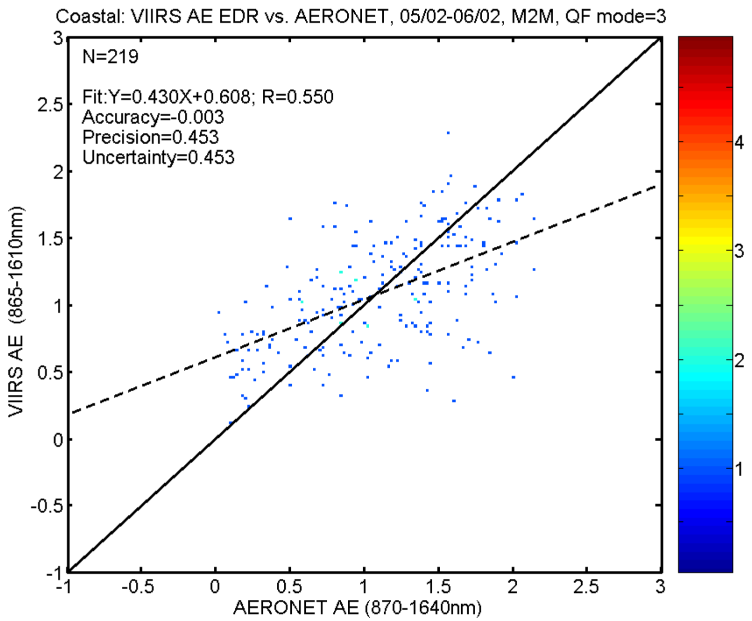


VIIRS vs. AERONET Angstrom Exponent (AE) Match-Up Method 2 M2M

- AERONET Level 1.5 (from direct sun retrievals) within ± 30 minute time window. All available measurements are averaged;
- Best quality VIIRS AE (QF=3) data from pixels within a 27.5 km radius from the center of the AERONET station are used;
- No restriction on the number of samples involved.

	Bias	Precision
Land	0.100	0.465
Ocean	0.003	0.453





Summary of Results from Collocated VIIRS and AERONET AE

- Insufficient collocations over ocean to give firm support to MODIS collocation analysis. Although suggestion is in the same direction, VIIRS will be biased high against AERONET, as it is against MODIS.
- Over land, same lack of correlation between VIIRS and AERONET, as between VIIRS and MODIS.

AE	P/M	Sample Size N	Slope	Offset	Corr. Coef.	Rel. Diff.	Accuracy	Precision	Uncertainty
Land									
Matchup Method 1	P2P	98					-0.18	0.701	
	M2M	117					0.021	0.649	
Matchup Method 2	P2P	1450	0.367	0.760	0.229	6%	-0.057	0.656	0.659
	M2M	1454	0.384	0.916	0.335	18.8%	0.100	0.465	0.476
Matchup Method 3	M2M	2241	0.35	0.86	0.251		0.042	0.602	0.603
Ocean									
Matchup Method 1	P2P	10					-0.103	0.455	
	M2M	24					0.177	0.384	
Matchup Method 2	P2P	109	0.644	0.308	0.559	7.6%	-0.135	0.505	0.523
	M2M	219	0.43	0.608	0.55	81.9%	-0.003	0.453	0.453
Matchup Method 3	M2M	189	0.25	0.74	0.325		0.086	0.715	0.718

Error bounds Defined by One Standard Deviation (66% of Retrievals)

	land	ocean
AERONET	±0.5	±0.5
MODIS		±0.5

- Land really should not be bound. No correlation.
- AERONET is based on very few points “over ocean”, and is really coastal.
- VIIRS and MODIS AE collocations over ocean for AOTs greater than 0.4; No analysis over land because MODIS does not recommend using its retrievals.

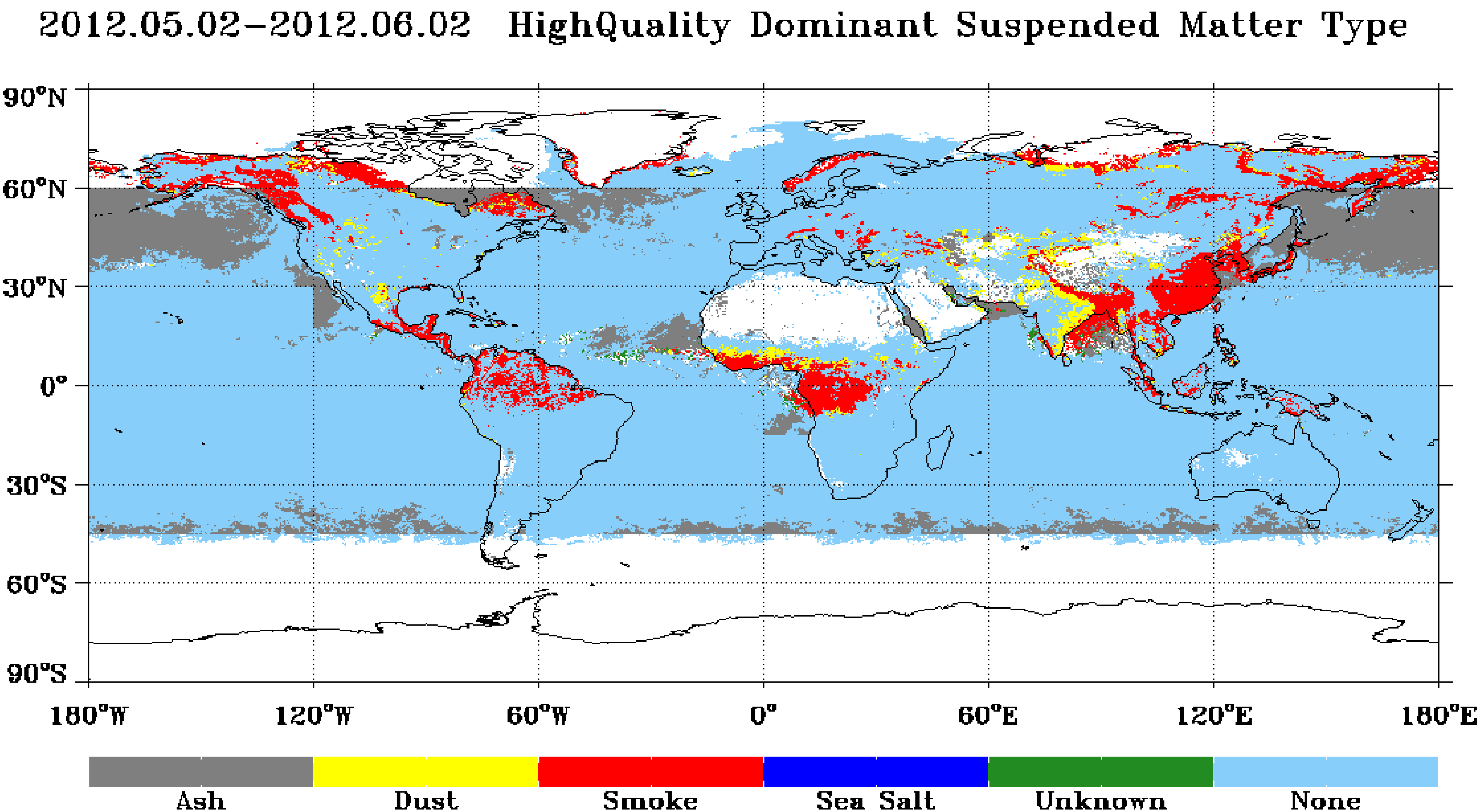
RESULTS

SM – COMPARISONS TO CALIPSO WITHOUT COLLOCATION

SM: VIIRS vs. CALIPSO

- Matchup Criteria
  - VIIRS SM IP (best quality) mapped to 0.25^o x 0.25^o grids
  - VIIRS SM IP mapped (best quality) to 5^o x 5^o grids for comparisons with CALIPSO
  - Dominant aerosol type and fraction for each aerosol type determined

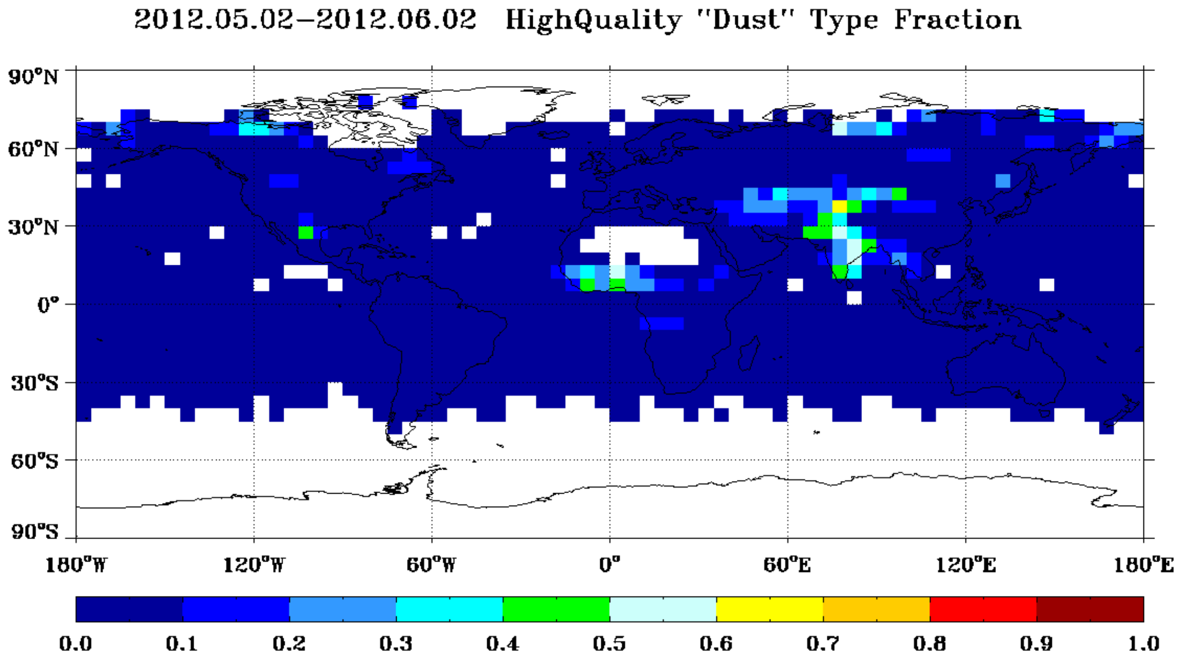
Global Map of Dominant Suspended Matter Type

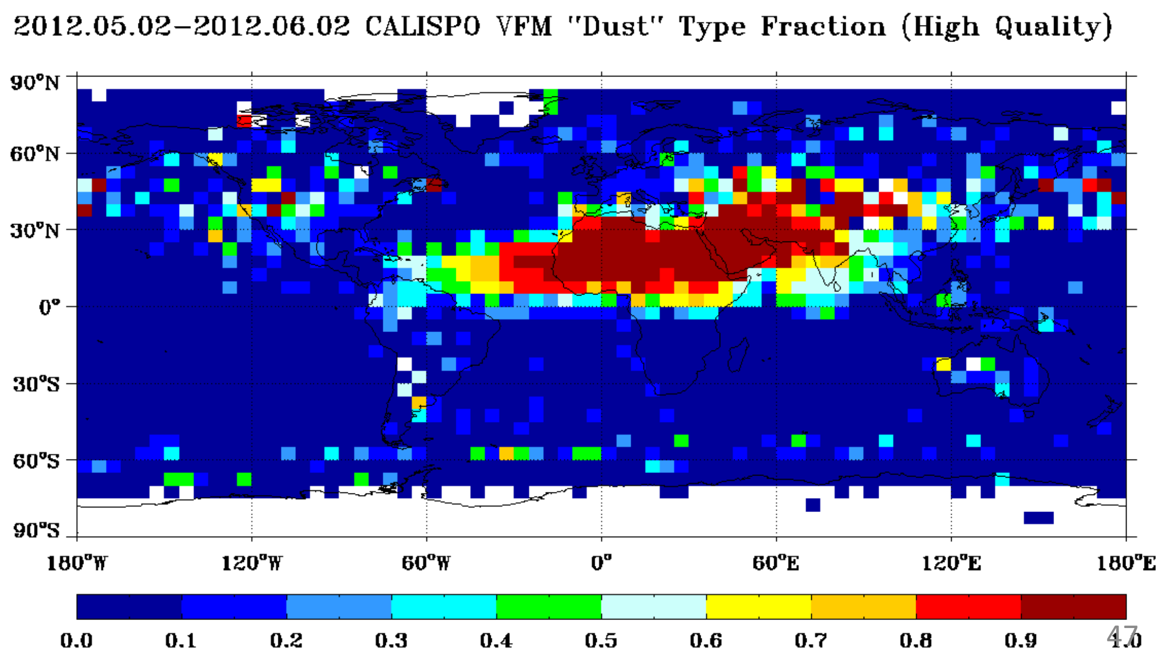


- Too much smoke over land
- Too much volcanic ash, especially in regions where volcanic ash is not expected to be present
- Missing dust over near dust sources and dust outflow regions (e.g., off of African coast)

Dust Fraction:
VIIRS vs. CALIPSO

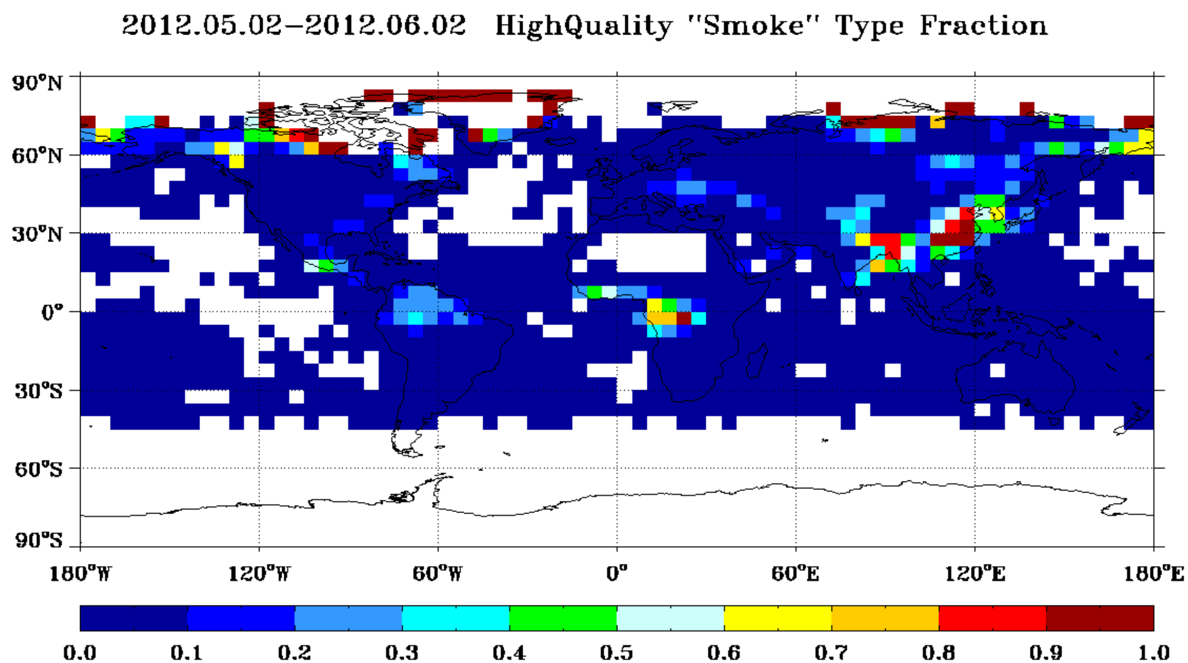
- Missing dust detection in VIIRS SM product even in regions where dust is known to be predominant as seen in CALIPSO;
- Probable causes:
    - Over land: no AOT retrievals over bright surfaces and no SM typing if AOT is less than 1.0
    - Over water: no SM typing if AOT is less than 1.0 and SM typing of dust is tied to fine mode fraction threshold of 20% which needs tuning.

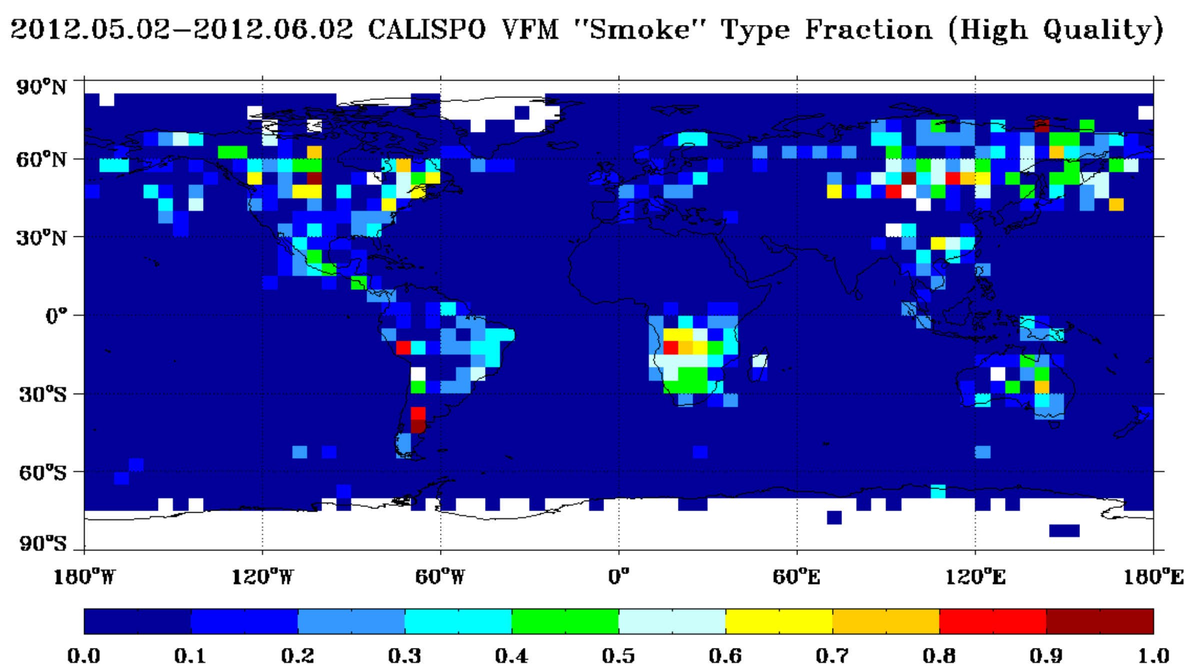




Smoke Fraction: VIIRS vs. CALIPSO

- Patterns of VIIRS smoke do not match with CALIPSO
- All non-dust SM over land is typed as smoke in VIIRS
- VIIRS smoke detected in the northern high latitudes is likely due to artifacts of snow melt falsely detected as aerosols





Summary of Results from VIIRS vs. CALIPSO SM Comparisons

- **Land:**
  - All non-dust aerosols are typed as smoke aerosols. Due to this there is a lot of smoke aerosol type;
  - Snow melt region during Spring thaw is falsely detected as smoke
  - Spatial patterns of smoke aerosol do not match with those observed in CALIPSO
- **Ocean:**
  - A lot of volcanic ash detected over ocean including the dust outflow region in the Atlantic;
  - Spatial patterns of dust aerosol do not match with those observed in CALIPSO;
  - Aerosol type determined based on thresholds of AOT and fine mode fraction. These thresholds need to be tuned to detect dust over ocean.

VIIRS AOT EDR Quality Flag Summary

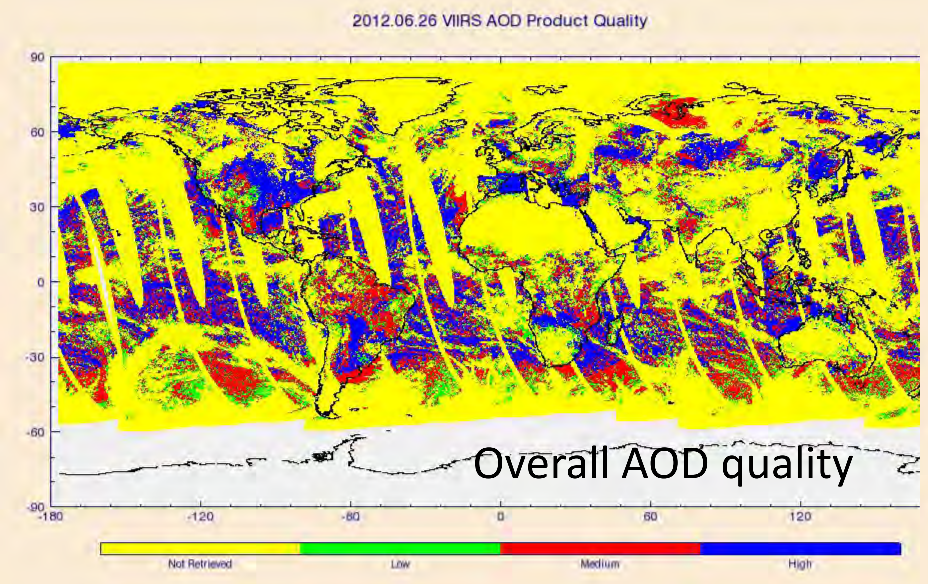
Most EDR QF flags seem to be working and make intuitive sense except:

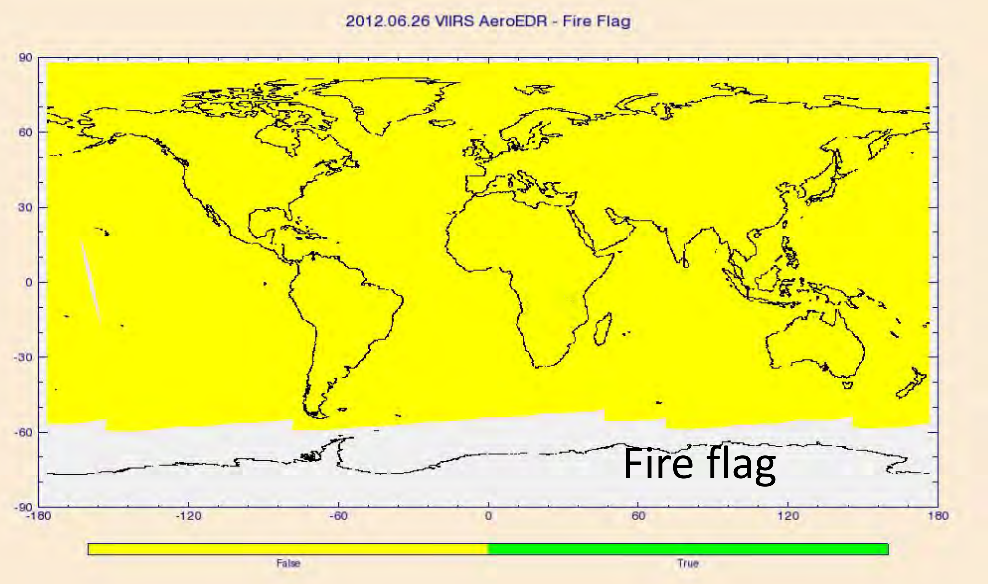
- Internal fire test fails to find any fires, even when large fires are known to be active.
- Angstrom exponent out of range flag only at extreme high latitudes, which seems unlikely.
- Snow and ice in strange places.
- Bad SDR is too omnipresent.

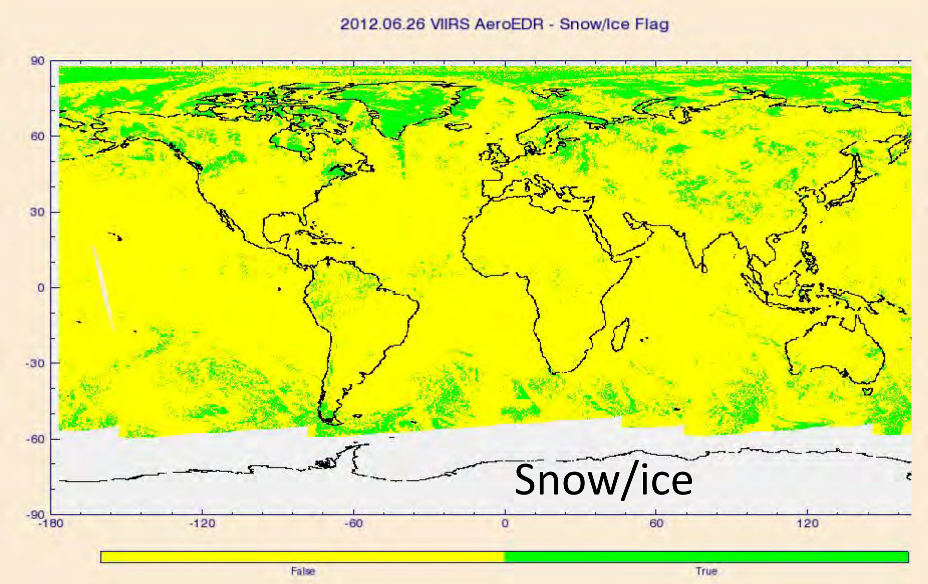
Other flags will require further understanding in order to make use of the information offered:

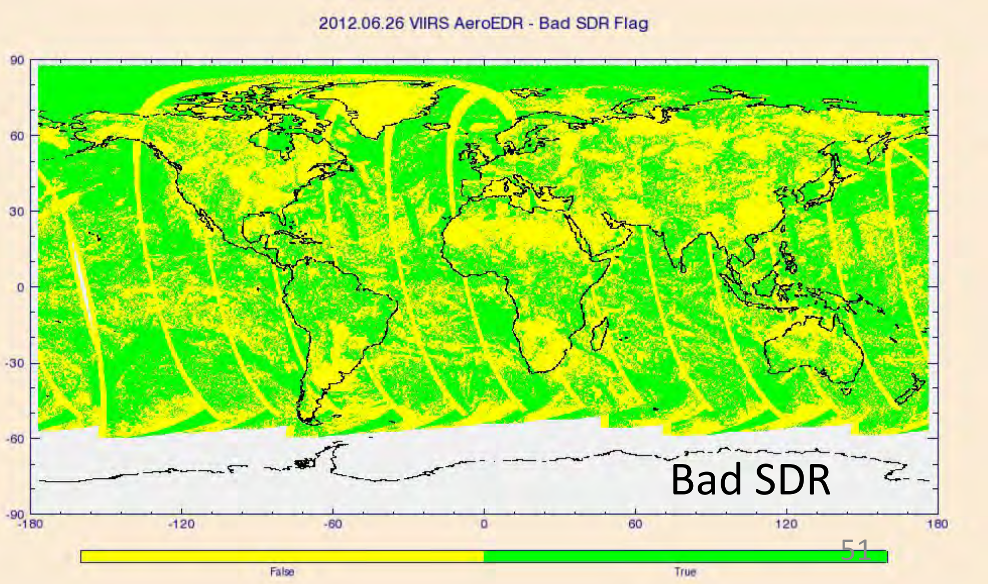
- AOD out of range.
- Cloud contamination, cloud adjacent, cirrus contamination and cloud shadow.

Global Maps of Quality Flags for Jun 26, 2012







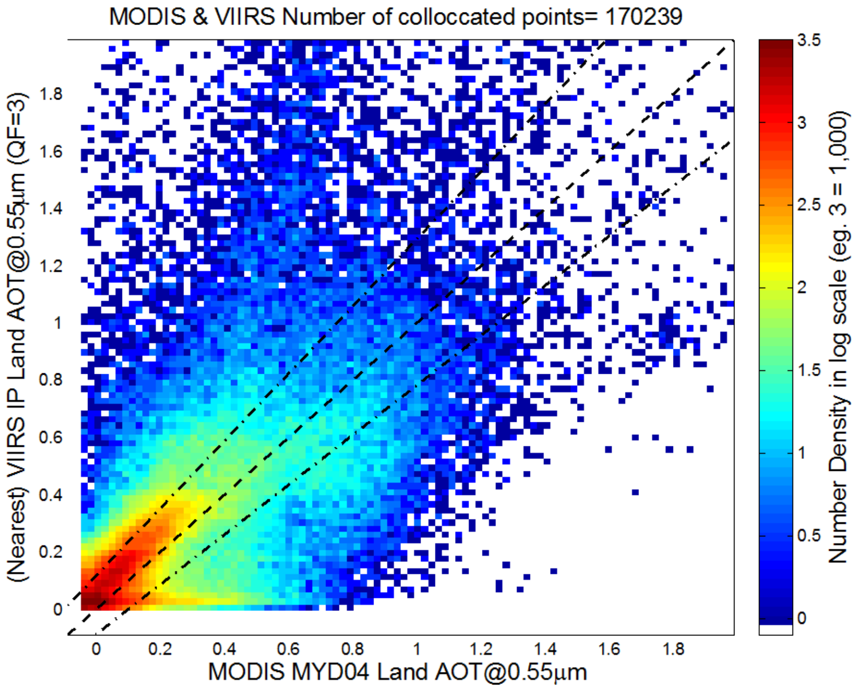


Statement on VIIRS AOT IP

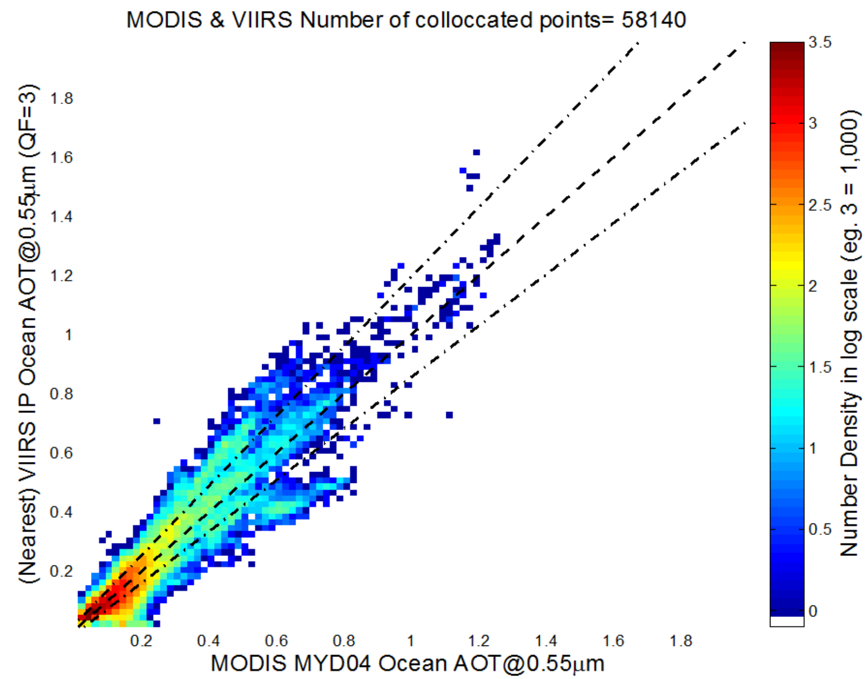
- VIIRS AOT IP (pixel level) is not designated for public release;
- Cal/Val team conducted extensive evaluation of AOT IP by comparing it to AERONET and MODIS AOTs and found that the “best quality” AOT IP is at Beta maturity level;
- User community (e.g., air quality forecasters) are eager to use high resolution AOT products provided product accuracy is high;
- **Cal/Val team is preparing to file a “change request” to make VIIRS AOT IP available for public use.**

IP: VIIRS vs.MODIS

AOT IP over LAND



AOT IP over OCEAN

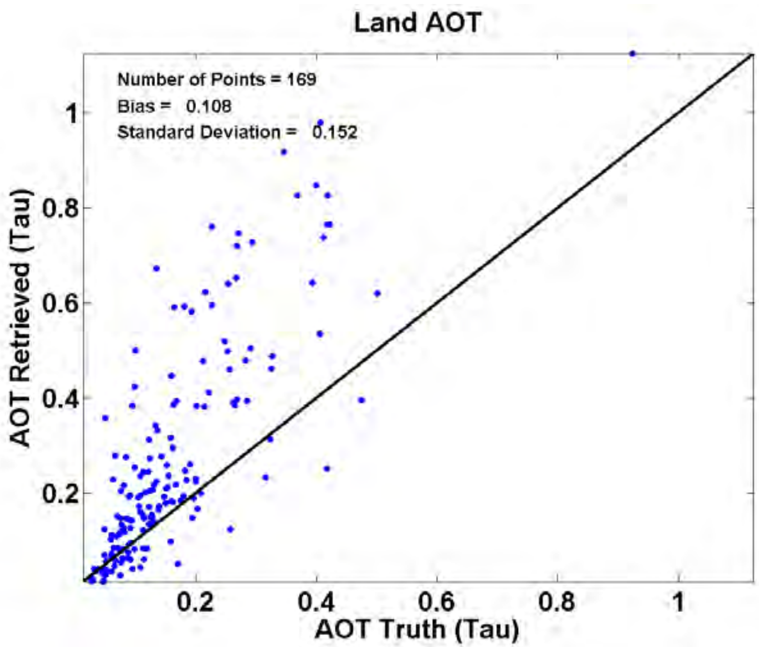


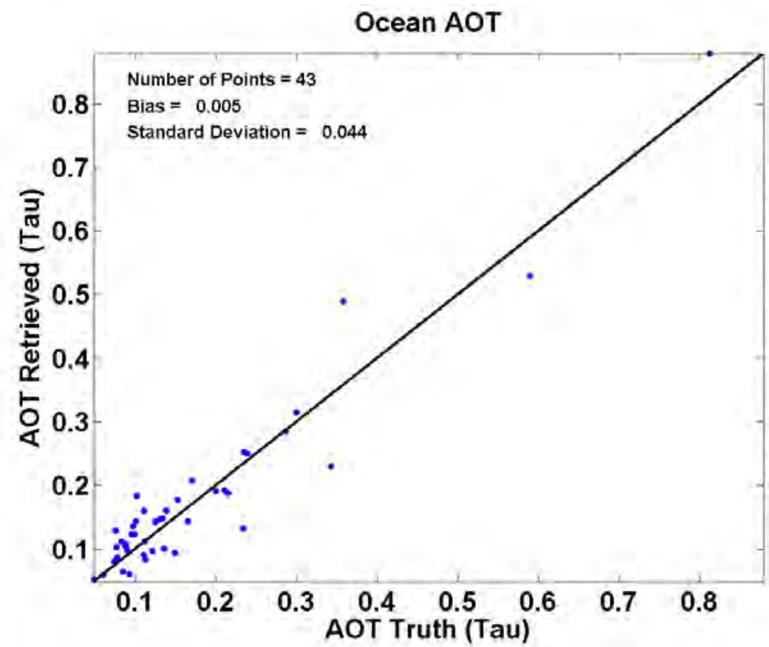
Statistics of VIIRS AOT (IP & EDR) vs. MODIS AOT where $\Delta\tau = \tau_{VIIRS} - \tau_{MODIS}$

QF	IP AOT land	EDR AOT land	IP AOT ocean	EDR AOT ocean
0 (IP) 3 (EDR)	STD($\Delta\tau$) = 0.1949 Mean($\Delta\tau$) = 0.0465 R = 0.7221 $\tau_{VIIRS} = 0.8057\ \tau_{MODIS} + 0.0785$	STD($\Delta\tau$) = 0.1445 Mean($\Delta\tau$) = 0.0405 R= 0.8024 $\tau_{VIIRS} = 0.7974\ \tau_{MODIS} + 0.0719$	STD($\Delta\tau$) = 0.0556 Mean($\Delta\tau$) = 0.0023 R = 0.9345 $\tau_{VIIRS} = 1.0033\ \tau_{MODIS} + 0.0019$	STD($\Delta\tau$) = 0.0561 Mean($\Delta\tau$) = -0.0017 R= 0.9349 $\tau_{VIIRS} = 0.9968\ \tau_{MODIS} - 0.0012$

τ: optical thickness (AOT); R: correlation coefficient

IP: VIIRS vs. AERONET





Statistics of VIIRS AOT (IP & EDR) vs. AERONET AOT

LAND	P/M	N	Accuracy	Precision
Match-up 1; IP	P2P	157	0.204	0.319
	M2M	169	0.108	0.152
Match-up 1; EDR	P2P	156	0.153	0.235
	M2M	202	0.073	0.134

OCEAN	P/M	N	Accuracy	Precision
Match-up 1; IP	P2P	1	-0.003	0.000
	M2M	43	0.005	0.044
Match-up 1; EDR	P2P	17	-0.003	0.062
	M2M	55	0.003	0.042