Assessment of the Suomi NPP VIIRS Aerosol Products for Provisional/Beta Maturity Level

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VIIRS Aerosol Cal/Val Team

Name	Organization	Major Task
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Ashley N. Griffin	PRAXIS, INC/NASA	JAM
Brent Holben	NASA/GSFC	AERONET observations for validation work
Robert Holz	UW/CIMSS	Product validation and science team support
Nai-Yung C. Hsu	NASA/GSFC	Deep-blue algorithm development
Ho-Chun Huang	UMD/CICS	SM algorithm development and validation
Jingfeng Huang	UMD/CICS	AOT Algorithm development and product validation
Edward J. Hyer	NRL	Product validation, assimilation activities
John M. Jackson	NGAS	VIIRS cal/val activities, liaison to SDR team
Shobha Kondragunta	NOAA/NESDIS	Co-lead
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Hongqing Liu	IMSG/NOAA	Visualization, algorithm development, validation
Min M. Oo	UW/CIMSS	Cal/Val with collocated MODIS data
Lorraine A. Remer	UMBC	Algorithm development, ATBD, liason to VCM team
Andrew M. Sayer	NASA/GESTAR	Deep-blue algorithm development
Hai Zhang	IMSG/NOAA	Algorithm coding, validation within IDEA

Criteria for Provisional Maturity Status

- Product quality may not be optimal
  - Product accuracy is determined for a broader (but still limited) set of conditions.
  - No requirement to demonstrate compliance with specifications.
- Incremental product improvements still occurring
  - DR history and future planned efforts will be shown
- General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing
- Users are urged to consult the EDR product status document prior to use of the data in publications
- Ready for operational evaluation

Overview of Data Products

Parameter Name	Units	Horizontal Cell Size (HCS) at Nadir	Comments
Aerosol Optical Thickness (AOT)	Dimensionless	6 km (EDR) 0.75 km (IP)	Retrieved globally during daylight except areas of clouds and bright surfaces. Reported at eleven wavelengths ranging from 0.412-2.25 µm.
Aerosol Particle Size Parameter (APSP) [Ångström Exponent, AE]	Dimensionless	6 km (EDR) 0.75 km (IP)	Reported as Ångström Exponent calculated from optical depths at pairs of wavelengths. Only proxy, not a true measure of size.
Suspended Matter (SM)	Dimensionless (except, smoke concentration in µg/m^3)	0.75 km	Type of aerosol (ash, dust, smoke, sea salt, unknown, none) for moderate to heavy aerosol loading, for AOT larger than threshold.

Work planned before Provisional

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

Outline:

- Objectives and methods for Provisional
- Data and Time period used
- Reduction of high bias over land
- Evaluation with AERONET
  - PGE Matchup
  - MAPSS-like matchup
  - MAN matchup
- Evaluation with MODIS
- Planned improvements
  - Improving surface reflectance band ratios in over-land retrieval

AEROSOL OPTICAL THICKNESS (AOT)

Data Quality Assessment Objectives and Methods for Provisional

- **Objectives:**
  - Establish how well VIIRS AOTs match **AErosol RObotic NETwork (AERONET)** observations and retrievals.
  - Establish how well VIIRS AOTs match **Moderate Resolution Imaging Spectroradiometer (MODIS)** retrievals.
- **Methods:**
  - Comparison with ground measurements
    - AOT at stationary sites
    - AOT from ships
  - Comparison with other satellite-derived AOT:
    - collocated (paired) data
    - non-collocated (unpaired) data

Data used in evaluation

Data used in AOT evaluation

- **Ground measurements**
  - AERONET aerosol data (land and coast) http://aeronet.gsfc.nasa.gov/
  - MAN data (deep ocean cruise data) http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html
- **Satellite-derived aerosol data**
  - VIIRS EDR and IP products http://peate.ssec.wisc.edu/
  - MODIS Aqua aerosol products http://ladsweb.nascom.nasa.gov/
  - MISR aerosol product http://eosweb.larc.nasa.gov/

  Note: MODIS and MISR are not truth and do not exactly match AERONET; nevertheless they represent the current state of the art.

Time periods used in maturity status evaluation

Year	2012								2013		
Month	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Beta											
Provisional											

- **Changes in algorithm dictated 2-3 time intervals to be used in the analysis for Provisional**
  - *Processing error (more on slide "Critical DRs", DR4962)*
    - introduced on Oct 15, 2012, 15:19 GMT
    - corrected on Nov 27, 2012, 14:58 GMT
  - *Processing coefficient update (see next slides)*
    - intended to reduce high AOT bias over land
    - introduced on Jan 22, 2013, 17:28 GMT
- Land: **May-Sep 2012, Dec 2012-Jan 2013, Feb-Mar 2013**
- Ocean: **May-Sep 2012, Dec 2012-Mar 2013**

AEROSOL OPTICAL THICKNESS (AOT)

REDUCTION OF HIGH BIAS OVER LAND

Reduction of high AOT bias over land

- The (current) VIIRS algorithm over land assumes a constant ratio between the surface reflectance in specific bands.
- The significant positive AOT bias over land, reported during the Beta maturity review, was attributed to the surface reflectance band ratios used (pre-launch values)
  - The pre-launch surface reflectance band ratios used in the land inversion were computed using MODIS / AERONET match-up data
  - Originally computed for use in the MOD09 MODIS Surface Reflectance product and adopted by the VIIRS Aerosol algorithm
- The **surface reflectance band ratios (BR)** were recomputed using VIIRS / AERONET match-up data
  - Jun-Sep 2012; ~60,000 match-ups over 99 globally distributed sites
  - DR4989, operational as of January 22, 2013, 17:28 GMT

Wavelength (μm)	Ratio	Pre-launch	Updated
0.412 (M1)	M1/M5	0.3905	0.513
0.445 (M2)	M2/M5	0.475	0.531
0.488 (M3)	M3/M5	0.578	0.645
0.672 (M5)	M5/M5	1.000	1.000
2.250 (M11)	M11/M5	2.000	1.788

← Mx/M5 surface reflectance band ratios, x=1, 2, 3, 5, 11

Evaluation of updated BR using VIIRS / AERONET (PGE) match-up data (1)

- **Time period:**
  - May, 2012 through September, 2012.
  - Reprocessing of VIIRS aerosol retrievals was done on the ADL using the updated band ratios (BR).
- **Match-up and Quality control criteria applied:**

  Truth data source
  - AERONET level 1.5 ***inversion*** product
  - Match-up time window is **+/- one hour**
  - If two observations within the time window are available they are averaged

  VIIRS Aerosol EDR & IP
  - High quality retrievals used
  - **EDR area is 5x5 HCS** around AERONET site
  - **IP area is 51x51 HCS** around AERONET site

  Area Match-up
  - Require 25% of retrievals in area to be high quality
  - Use average value of all high quality pixel

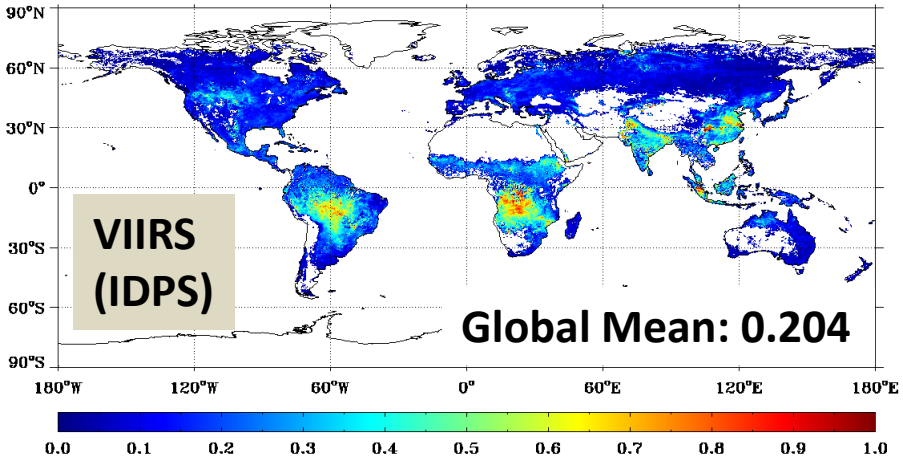
Evaluation of updated BR using VIIRS / AERONET (PGE) match-up data (2)

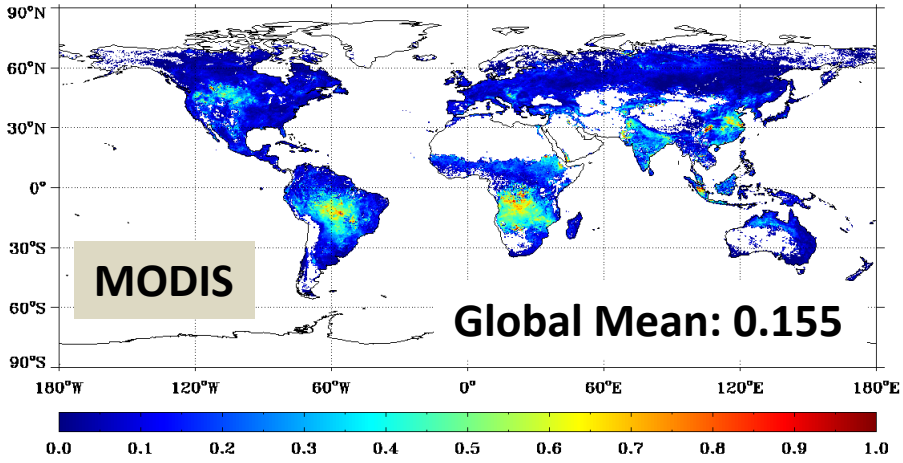
AOT at 550 nm	May, 2012 - September, 2012 (Original Ratios)				May, 2012 - September, 2012 (Updated Ratios)			
	Number of Match-ups	Bias	Std	R2	Number of Match-ups	Bias	Std	R2
Land AOT EDR	1010	0.042	0.110	0.559	**862**	**-0.011**	**0.095**	**0.564**
Land AOT IP	833	0.077	0.125	0.508	**645**	**0.018**	**0.099**	**0.574**

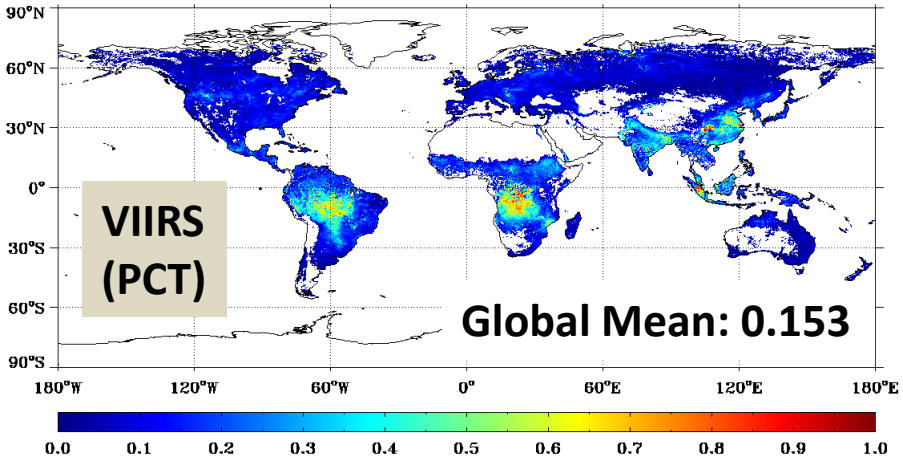
- VIIRS AOT data reprocessed using updated surface reflectance band ratios (BR) for May, 2012 – September, 2012 were used.
- Test results show the **updated surface reflectance ratios over land** lead to
  - **a significant reduction in VIIRS-AERONET AOT bias,**
  - **a moderate improvement in AOT Std,**
  - **a reduction in the number of match-up passing QC.**
- Bias (VIIRS-AERONET) and Std of AOT IP are somewhat larger than bias and Std of AOT EDR.

Evaluation of updated BR using non-collocated Global Data over Land (1)

- Demonstration of the effect of surface band ratio (BR, **PCT**) update on a global scale.
  - **VIIRS AOT retrievals for Sep 2012 were re-processed with updated BR.**
- Best quality EDRs are gridded to 0.25° regular grid.
- **Only common grids are used**
- Monthly averages (arithmetic average of daily data) are plotted.

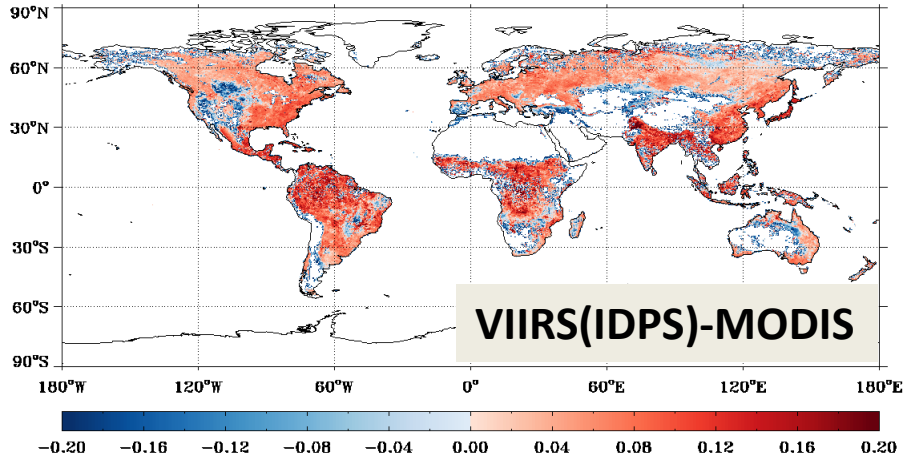




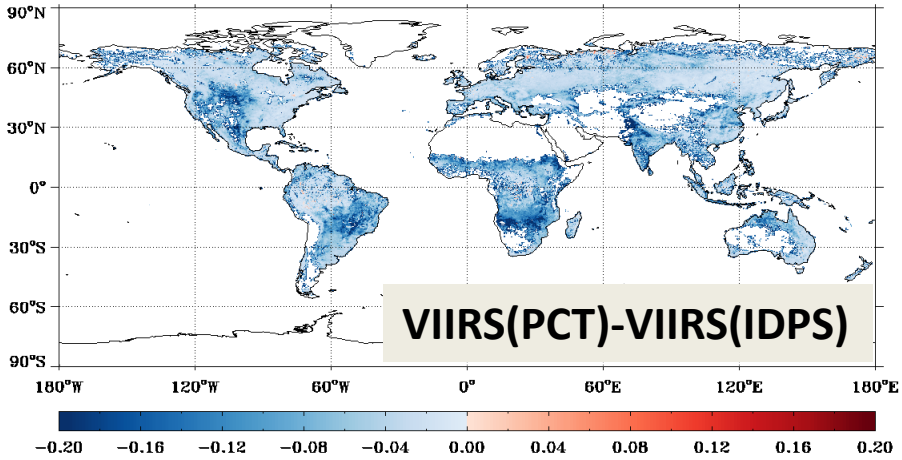


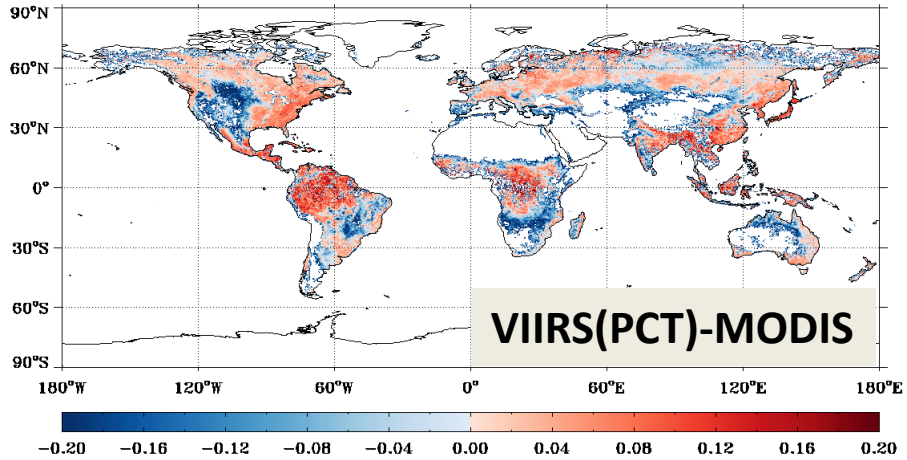
Evaluation of updated BR using non-collocated Global Data over Land (2)

VIIRS-MODIS difference



VIIRS(PCT)-VIIRS(IDPS) difference





Monthly mean AOT for Sep 2012

	IDPS-MODIS	PCT-MODIS
Bias	0.050	-0.002
StdDev	0.084	0.098
MinErr	-2.291	-2.570
MaxErr	1.146	1.112

Large positive bias in IDPS has been reduced in PCT, but magnitude of negative bias has increased.

AEROSOL OPTICAL THICKNESS (AOT)
COMPARISON WITH AERONET

Evaluation using PGE Match-up Data

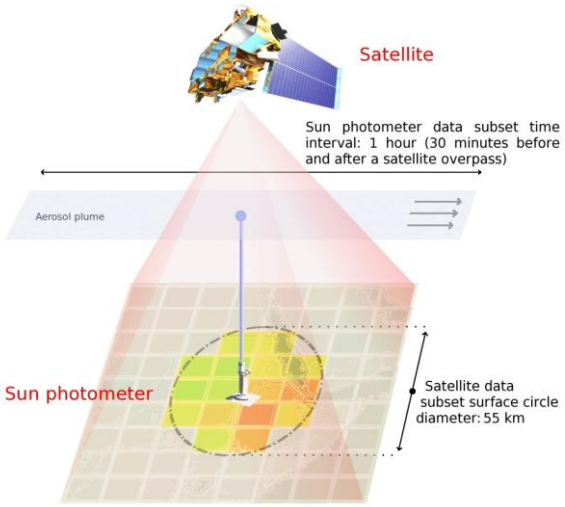
AOT (550 nm)	May 2012 - Sep 2012				Jan 2013 - Mar 2013			
AOT EDR	**#**	**Bias**	**Std**	**R2**	**#**	**Bias**	**Std**	**R2**
Land	862	-0.011	0.095	0.564	1561	-0.024	0.117	0.783
Ocean	208	0.016	0.051	0.901	554	0.015	0.076	0.746
AOT IP	**#**	**Bias**	**Std**	**R2**	**#**	**Bias**	**Std**	**R2**
Land	645	0.018	0.099	0.574	821	-0.003	0.124	0.802
Ocean	181	0.019	0.050	0.890	262	0.016	0.054	0.808

- PGE match-up data are used; **inversion data** from globally distributed AERONET sites (described on slide 13)
- **Over-land aerosol retrievals used updated land BR**; updated BRs do not affect ocean retrievals
- Bias (EDR) **over land** is about -0.01 and -0.02 for these time periods.
- Performance **over ocean** continues to be good for the period extended from one month in Beta (May 2012); EDR and IP AOT are less than ~0.02 higher than AERONET with about half the Std than that over land.

Evaluation using MAPSS-like matchups

- In addition to the PGE Match-up Data, another set of match-ups are also used in the evaluation.
- This set has been prepared following the **Multi-sensor Aerosol Products Sampling System (MAPSS)** protocol.

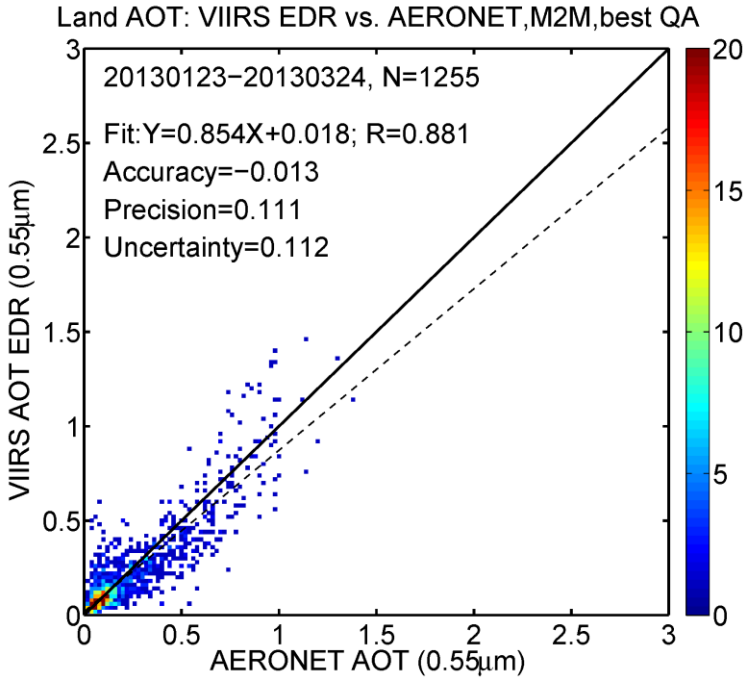
  http://disc.sci.gsfc.nasa.gov/aerosols/services/mapss/mapssdoc.html#description

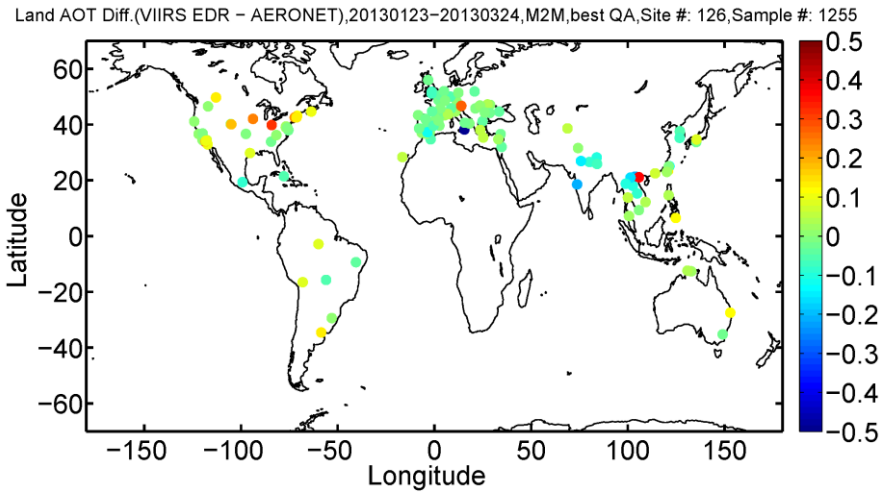


- **Matchup and Quality control criteria for MAPSS-like data:**
  - AERONET L1.5 **Direct Sun retrievals** from max 444 sites (includes DISCOVER_AQ sites) are averaged within **±30 minutes** of VIIRS overpass time.
  - Best quality VIIRS AOTs (QF=0 for IP; QF=3 for EDR) within a radius of **27.5 km** from the AERONET site are averaged.
  - A minimum of **five best quality VIIRS AOT** retrievals (EDR, IP) and **two AERONET observations** must be available within the spatial and temporal constraints.
  - AERONET AOT data, if observed at wavelengths other than 550 nm, are interpolated to 550 nm using AOT at 440 nm and 670nm.

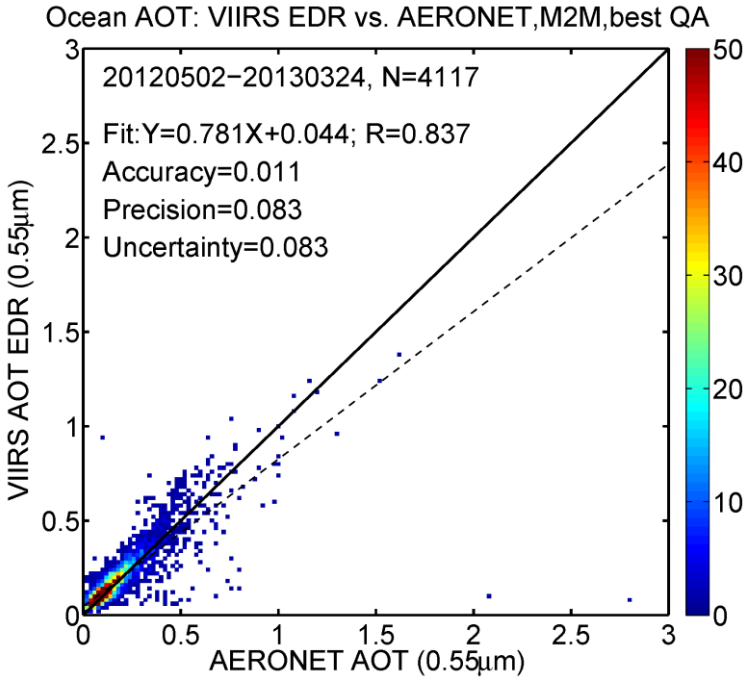
VIIRS AOT EDR vs. AERONET AOT

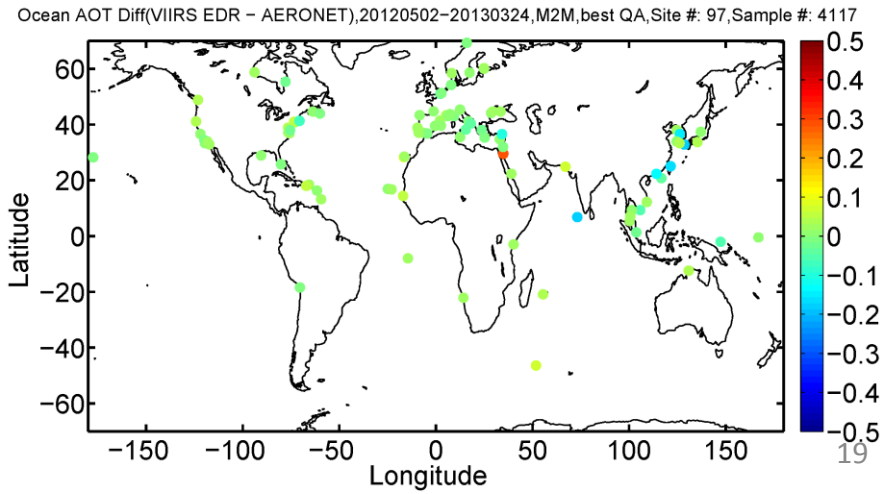
Land (Feb-Mar, 2013)





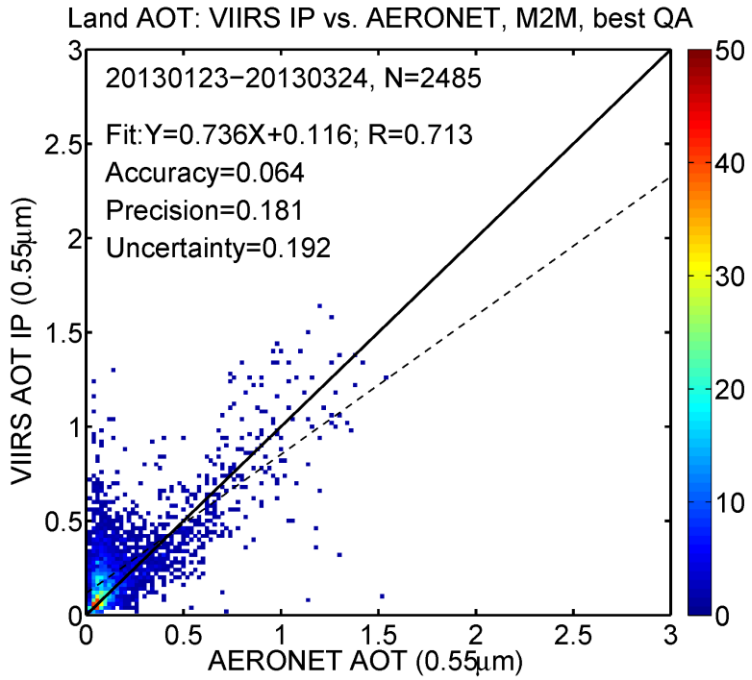
Ocean (May 2012-Mar 2013)

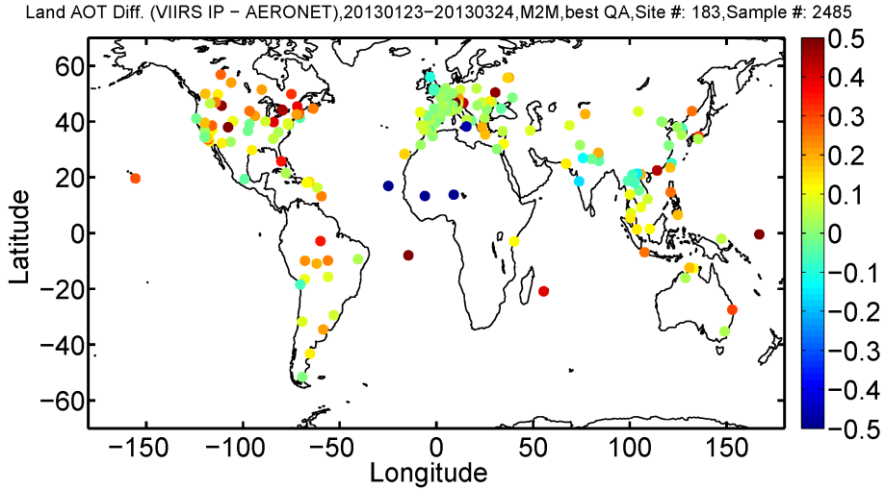




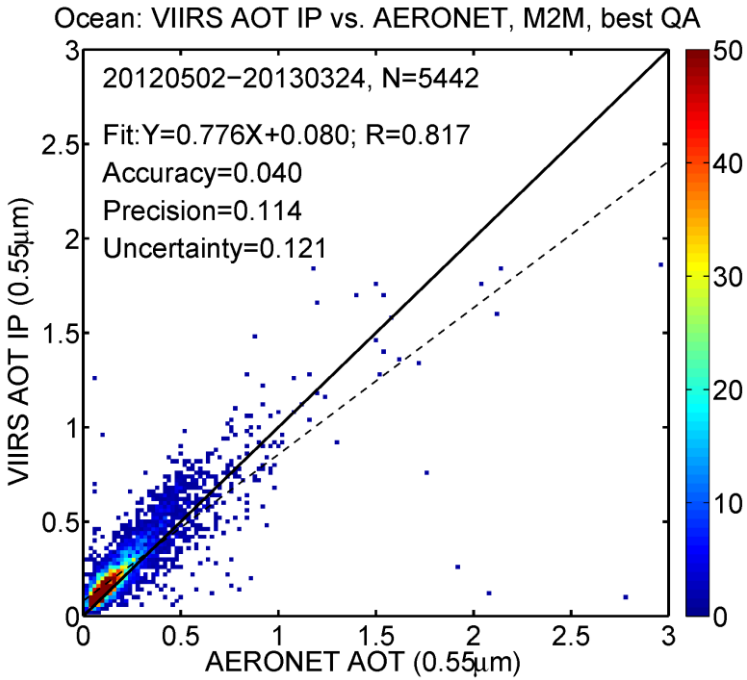
VIIRS AOT IP vs. AERONET AOT

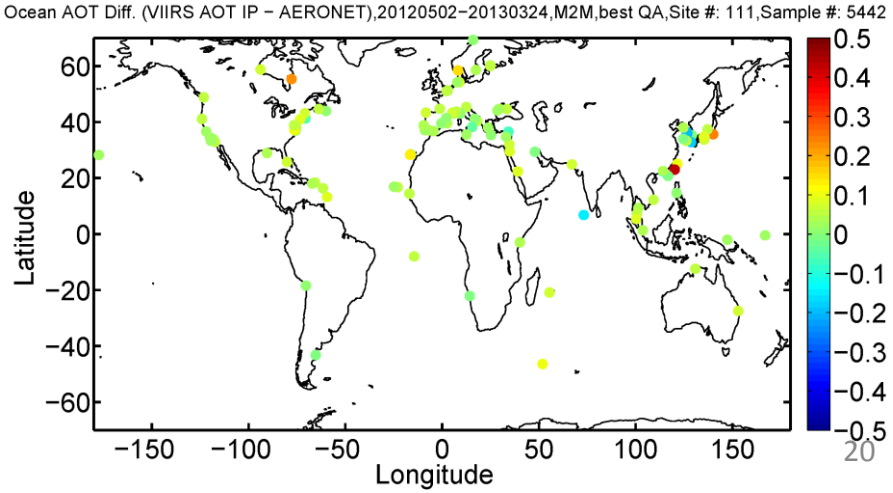
Land (Feb-Mar, 2013)





Ocean (May 2012-Mar 2013)





Satellite-derived AOT vs. AERONET AOT

VIIRS, MODIS (Aqua&Terra), MISR AOT EDR

EDR	VIIRS	MYD04	MOD04	MISR	VIIRS	MYD04	MOD04	MISR
AOT (550 nm)	LAND				OCEAN			
Sample Size	**1255**	1026	1269	718	**4117**	4742	4495	91
Accuracy	**-0.013**	-0.014	-0.043	-0.009	**0.011**	0.006	0.010	0.038
Precision	**0.111**	0.143	0.140	0.133	**0.083**	0.117	0.087	0.059
Uncertainty	**0.112**	0.144	0.146	0.134	**0.083**	0.117	0.087	0.071
Cor Coef	**0.881**	0.858	0.887	0.845	**0.837**	0.795	0.871	0.957

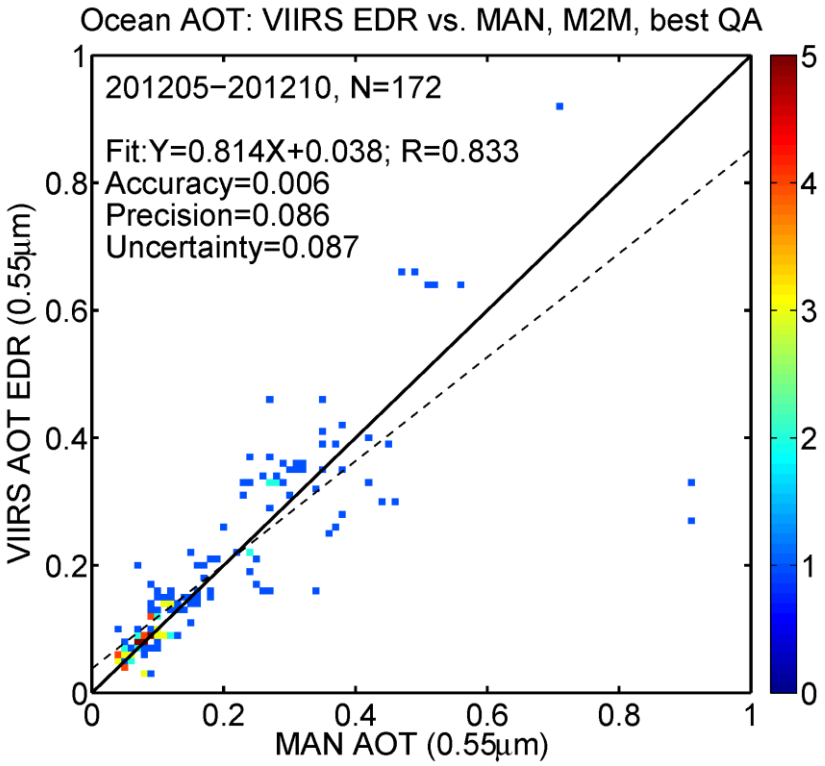
- **VIIRS, MODIS (Aqua and Terra), and MISR AOTs are compared to AERONET AOT.**
- Time periods:
  - *Land*: 01/23/2013-03/24/2013 [~2 months]
  - *Ocean*: 05/02/2012-03/24/2013 (10/15/2012-11/27/2012 excluded) [~9 months]
  - MISR data period is 05/20/2012-11/30/2012
- **In terms of "global" average AOT, the VIIRS aerosol algorithm performance is comparable to those of other algorithms/sensors.**
  - Regionally, significant differences may exist

Comparison of AOT with MAN (1)

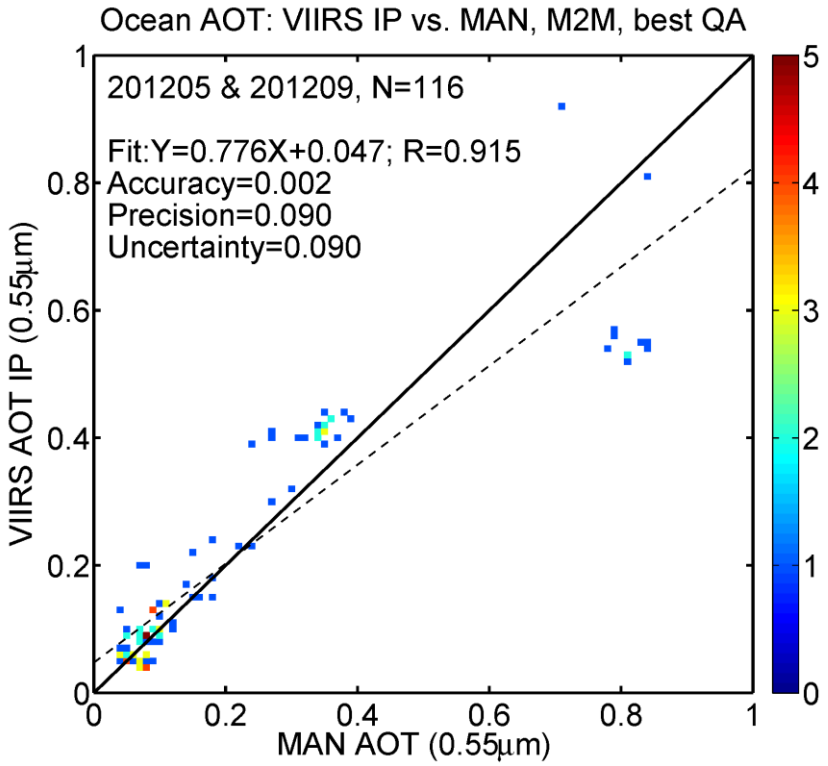
- **Maritime Aerosol Network (MAN)** – cruise based aerosol measurements
  - MAN level 2 (L2) series average data are used.
- ***Period for EDR:* 2 May – Oct 15, 2012 (~5 months)**
  - 10/16-11/27, 2012 excluded (bad VIIRS data)
  - Dec 2012 excluded (most ships at same location or only occasional measurements)
  - MAN L2 data are not yet available for 2013
- ***Period for IP:* May 2012 and Sep 2012 (2 months)**
- **Match-up procedure:**
  - Best quality VIIRS EDR (QF=3) and IP (QF=0) AOTs.
  - MAN's observation time and location are used as reference
  - Box Mean Comparison - Selected VIIRS IPs/EDRs are
    - within ± 30 minutes of MAN observation time,
    - within 0.5°x 0.5° box centered on MAN location.

Comparison of AOT with MAN (2)

EDR



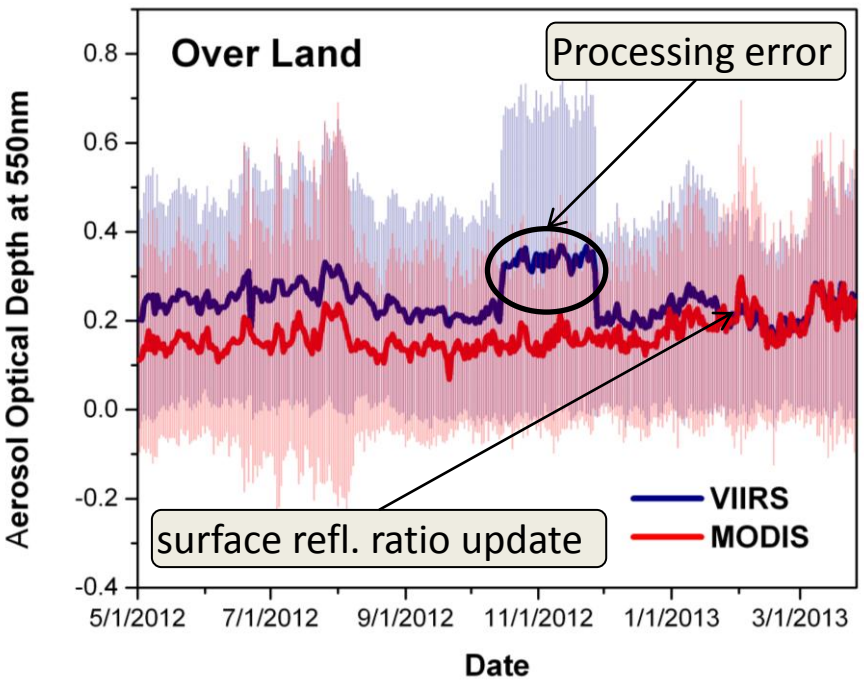
IP

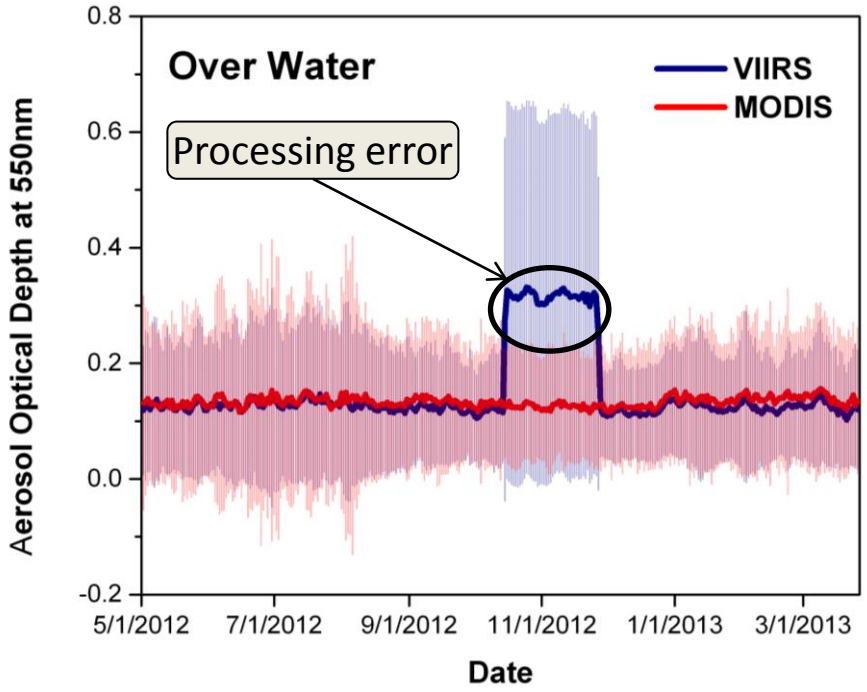


- Some outliers, but excellent agreement overall for both EDR and IP.

AEROSOL OPTICAL THICKNESS (AOT)
COMPARISON WITH MODIS

VIIRS vs. MODIS global mean AOT





- Time series of global mean AOTs
  - Time period: **05/02/2012 – 03/26/2013**
  - VIIRS high quality EDR
  - MODIS (Aqua) “very good” quality retrievals over land and “top-3 quality” over water.
  - Non-collocated data.
- VIIRS follows changes in global mean MODIS AOT even before the surface reflectance ratio update.

Collocated VIIRS and MODIS AOT

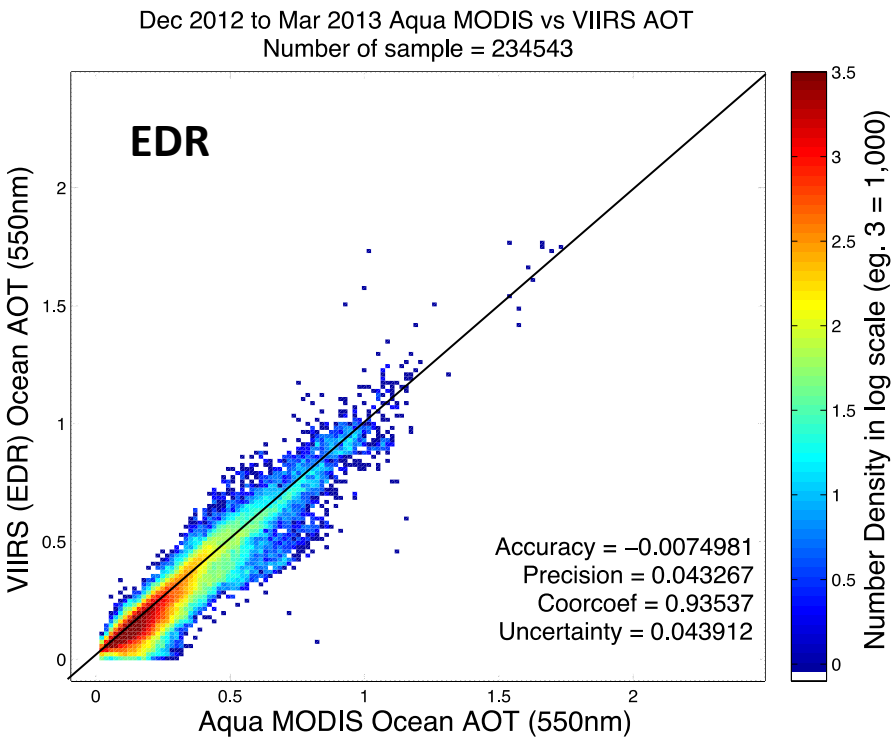
Collocation method:

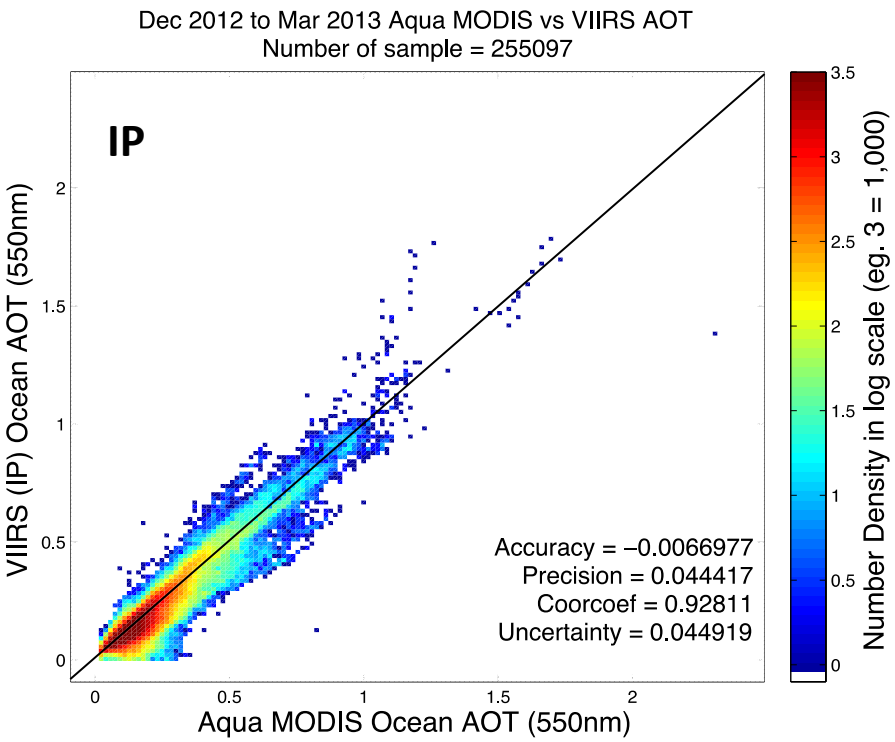
- *Time*: MODIS (L2) and VIIRS (IP/EDR) AOT are matched up in time within 5 minutes
- *Space*: VIIRS AOT from nearest pixel falling within MODIS 10 km.
- Both MODIS over Land and over Ocean AOTs are filtered with MODIS Could Fraction = 0 (from aerosol cloud mask)
- MODIS AOT is filtered with Best Quality Assurance Land and Ocean Flag
- VIIRS AOT is filtered with High Quality flag (QF=3 for EDR and QF=0 for IP)

Time periods used:

- Dec 2012 – Mar 2013: *Ocean only*
- Feb-Mar 2013: *Land and Ocean*

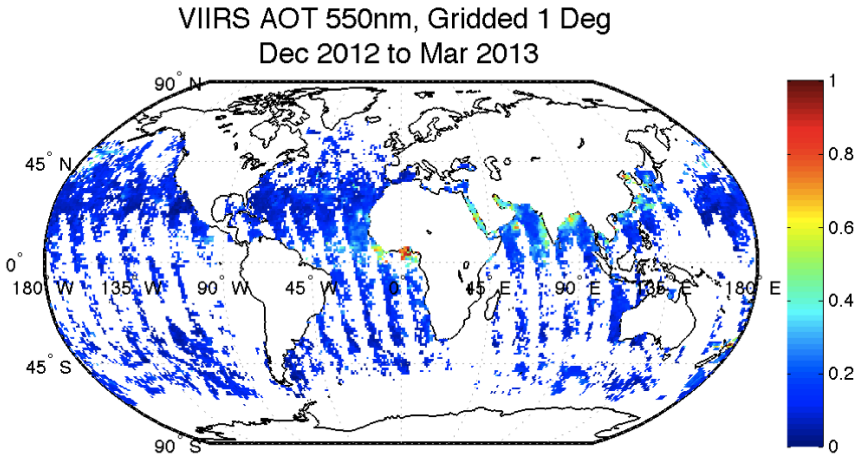
VIIRS AOT vs. MODIS/Aqua Over Ocean (Dec 2012 to Mar 2013)

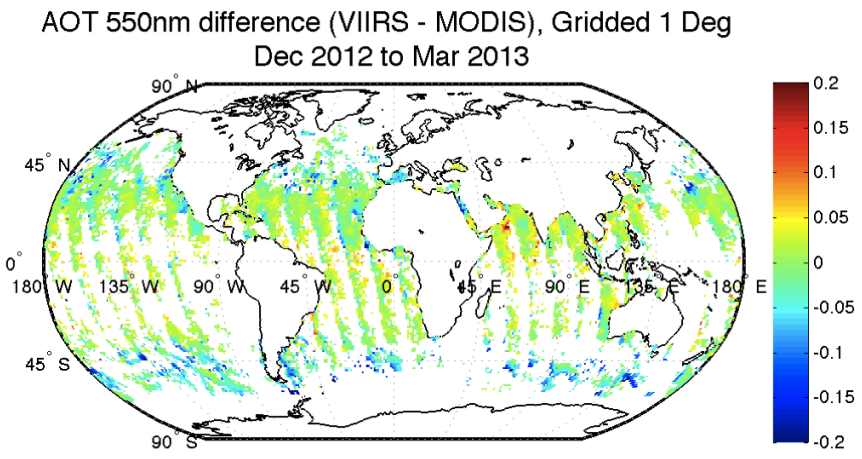


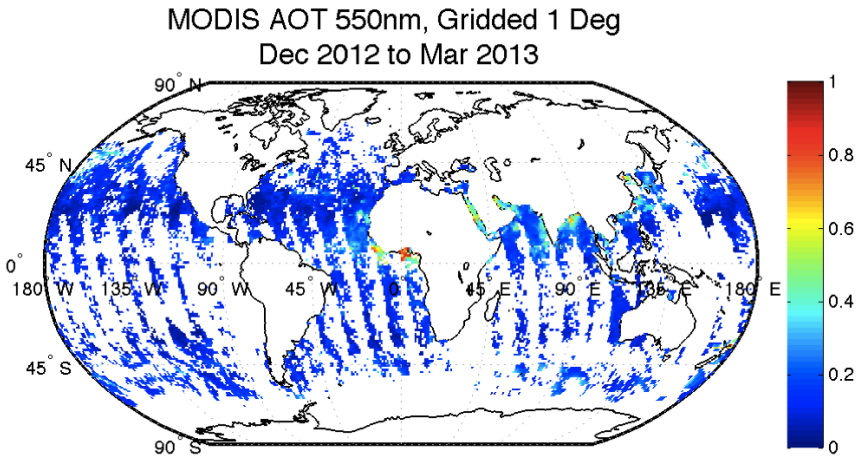


- Collocated MODIS and VIIRS data are used.
- Over ocean, accuracy (bias) and precision (STD) of VIIRS AOT EDR with respect to MODIS AOT are small, about -0.007 and 0.04, respectively.
- Bias and STD of bias of AOT IP are comparable to corresponding EDR values.

Maps of collocated gridded VIIRS and MODIS/Aqua AOT over ocean (Dec 2012-Mar 2013)

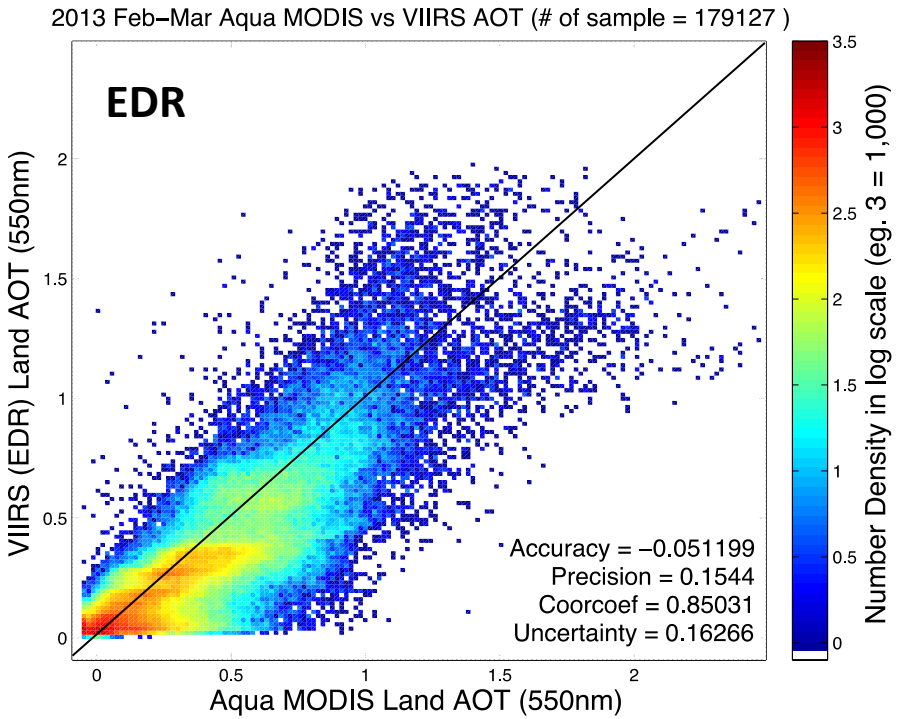


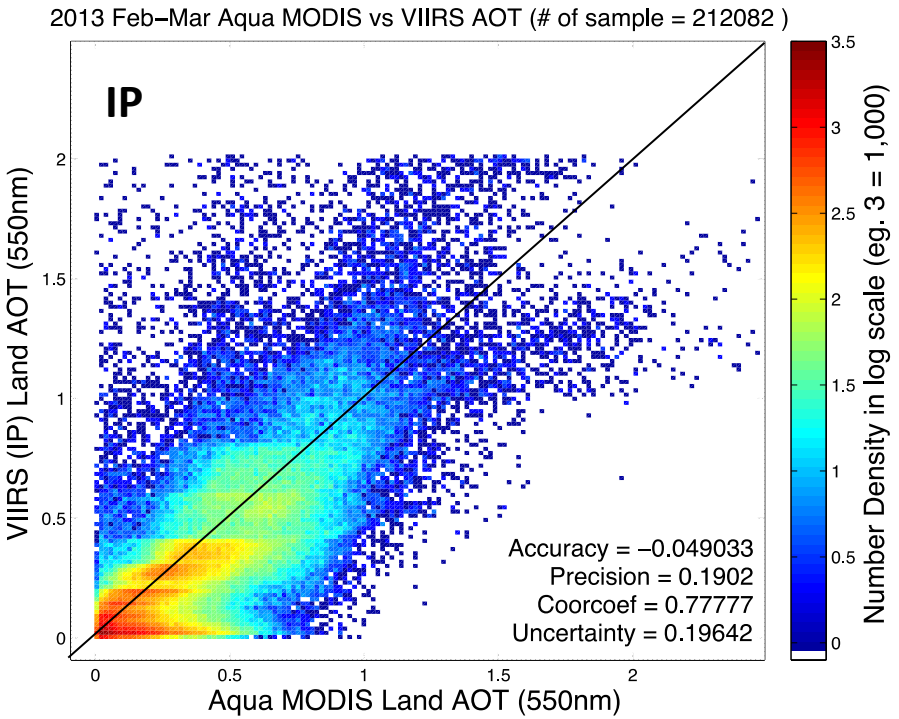




- AOT EDR mapped to 1-degree grids.
- Over ocean, spatial distribution of VIIRS and MODIS/Aqua AOT are similar
  - with somewhat smaller VIIRS AOT at high latitude oceans, and
  - somewhat higher VIIRS AOT at tropical latitudes.

VIIRS AOT vs. MODIS/Aqua over Land (Feb-Mar 2013)

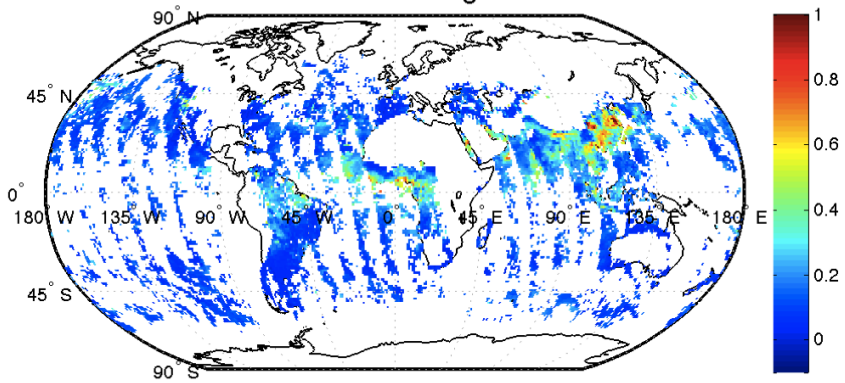




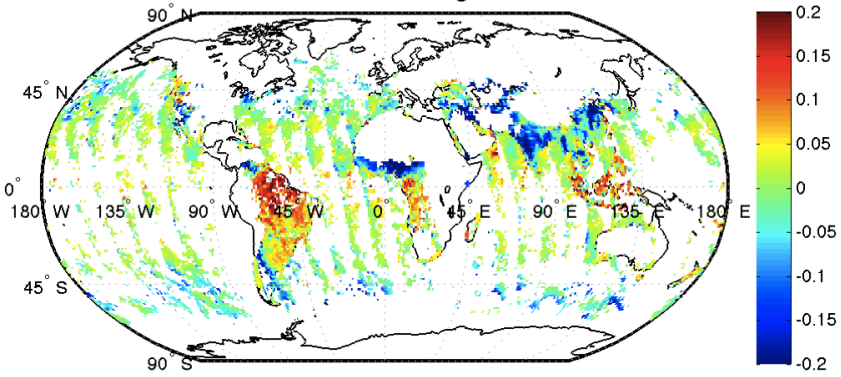
- Collocated MODIS and VIIRS data are used.
- Over land, bias (accuracy) and STD (precision) of VIIRS AOT EDR with respect to MODIS AOT are larger than those over ocean, about -0.05 and 0.15, respectively.
- Bias of VIIRS AOT EDR and IP are comparable.
- STD of bias of AOT IP is larger than that of AOT EDR, 0.19 vs. 0.15 (this is expected).

Maps of collocated gridded VIIRS and MODIS/Aqua AOT over land and ocean (Feb-Mar 2013)

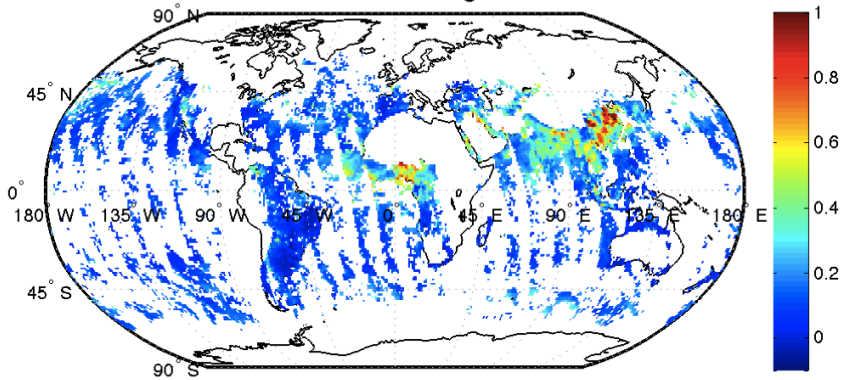
2013 Feb-Mar, VIIRS AOT 550nm
Gridded 1 Deg



2013 Feb-Mar, AOT 550nm difference (VIIRS - MODIS)
Gridded 1 Deg



2013 Feb-Mar, MODIS AOT 550nm
Gridded 1 Deg



- AOT EDR mapped to 1-degree grids.
- Over land, relative to MODIS, VIIRS AOT is still biased high in some places (e.g., Brazil) , while it is biased low at other places (e.g., India).
  - **constant BR is not sufficient!**
- Over ocean, conclusion is the same as for the Dec 2012 – Mar 2013 period (slide 30).

AEROSOL OPTICAL THICKNESS (AOT)
PLANNED IMPROVEMENTS

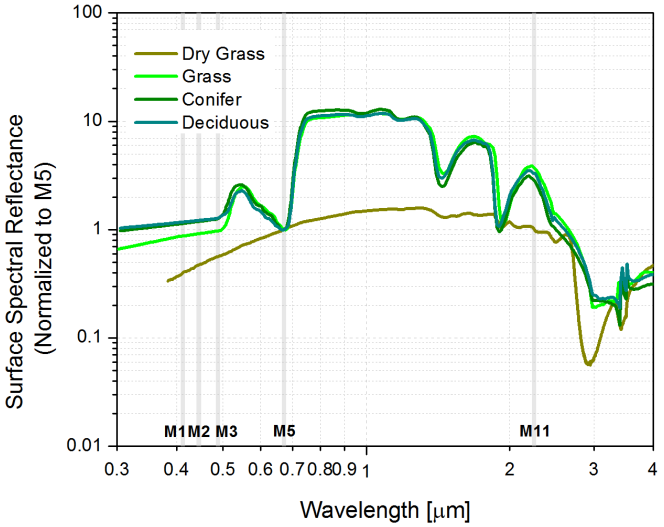
NDVI-dependent surface reflectance ratio (1)

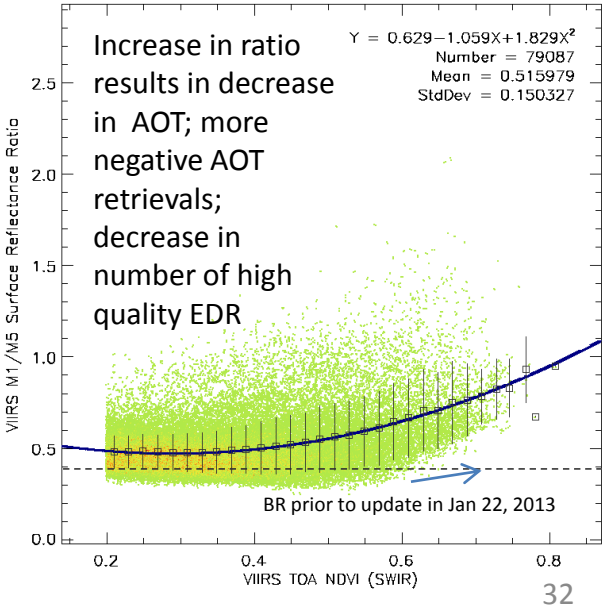
- Surface reflectance band ratios (BR) are expected to depend on geographical location and state of vegetation (season).
- Proposed surface reflectance band ratios are function of top-of-atmosphere SWIR NDVI (proxy of surface type)

  NDVI_SWIR = (M8-M11)/(M8+M11)
- **Method:**
  - Retrieved land surface reflectance in VIIRS bands M1, M2, M3, M5 and M11 for five aerosol models (dust, high/low absorbing smoke, clean/polluted urban) using operational VIIRS lookup tables and atmospheric correction routines in VIIRS over-land aerosol retrieval and AERONET AOT. (MAY-OCT 2012)
  - Mean of the surface reflectances obtained for the five aerosol models with low AOT (<= 0.1) is used in determining BR.

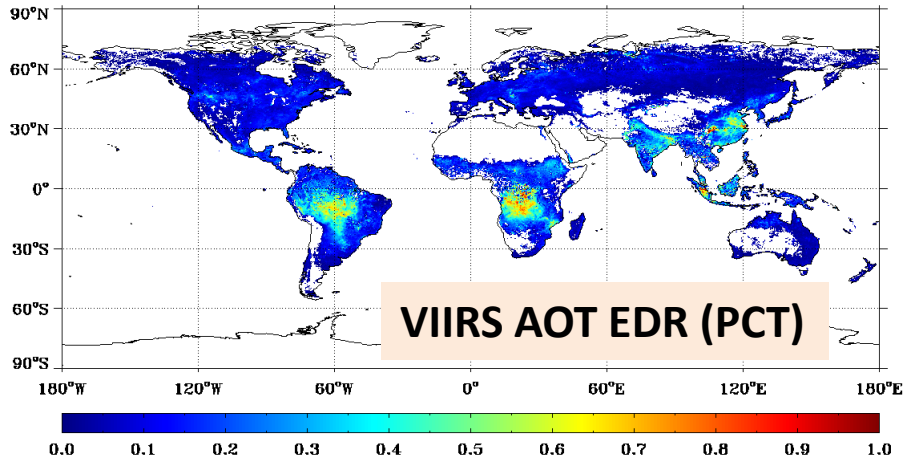
	PCT*	NDVI-dependent BR
M1/M5	0.513	0.629-1.059*NDVI+1.829*NDVI^2
M2/M5	0.531	0.662-0.711*NDVI+1.146*NDVI^2
M3/M5	0.645	0.741-0.653*NDVI+1.076*NDVI^2
M11/M5	1.788	1.117+0.286*NDVI+1.1698*NDVI^2

*PCT: constant BR current as of Jan 23, 2013

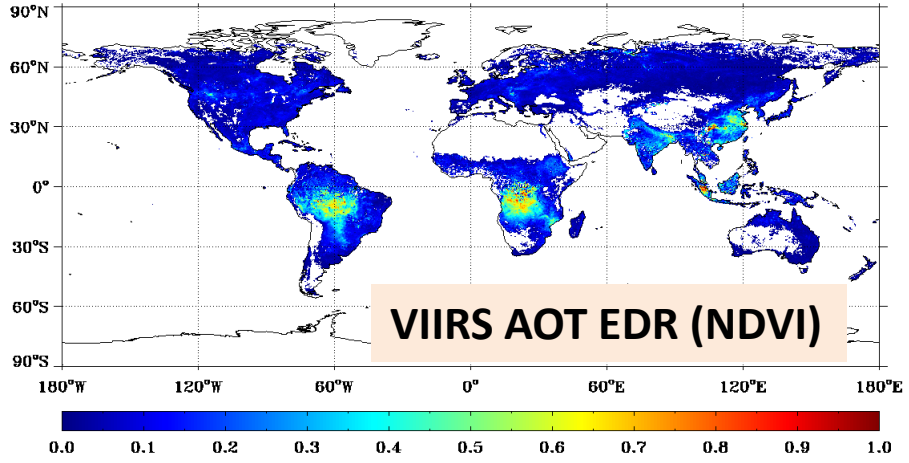




NDVI-dependent surface reflectance ratio (2)



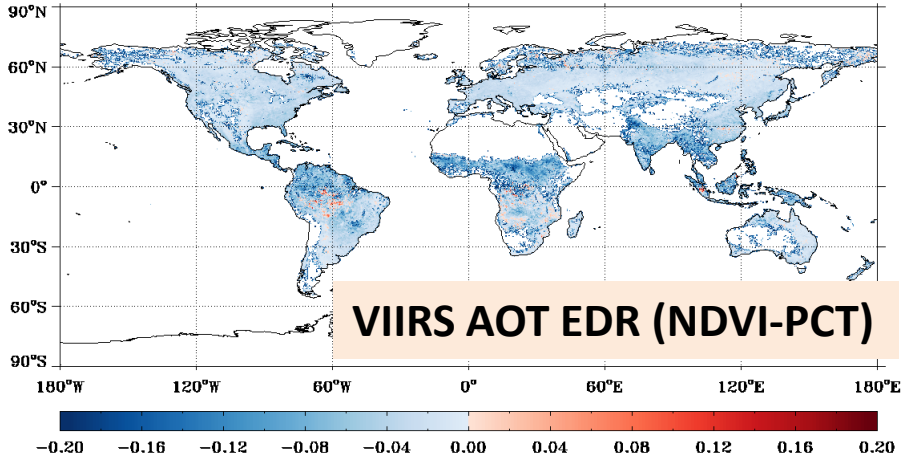
VIIRS AOT EDR (PCT)



VIIRS AOT EDR (NDVI)

	IDPS-MODIS	PCT-MODIS	NDVI-MODIS
Bias	0.050	-0.002	-0.029
StdDev	0.084	0.098	0.098
MinErr	-2.291	-2.570	-2.598
MaxErr	1.146	1.112	1.143

VIIRS(NDVI)-VIIRS(PCT) difference

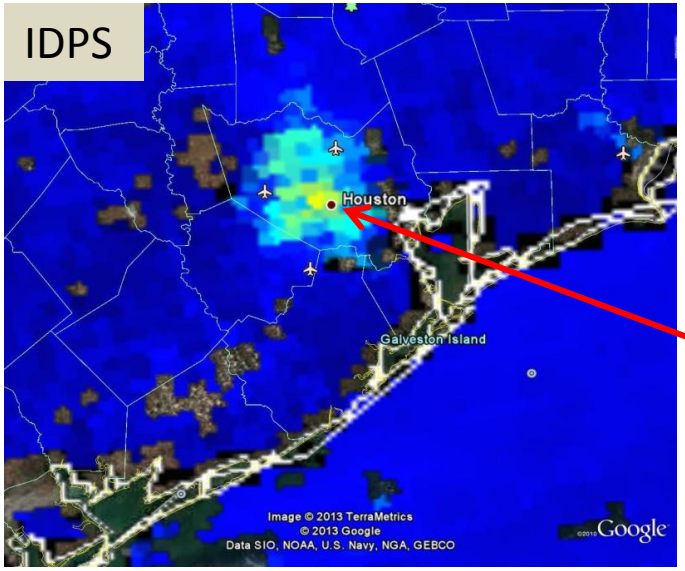


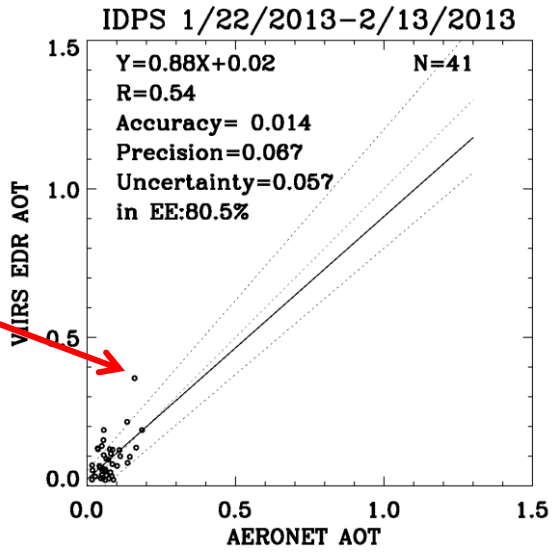
VIIRS AOT EDR (NDVI-PCT)

Monthly mean AOT retrieved over land for **September 2012.**

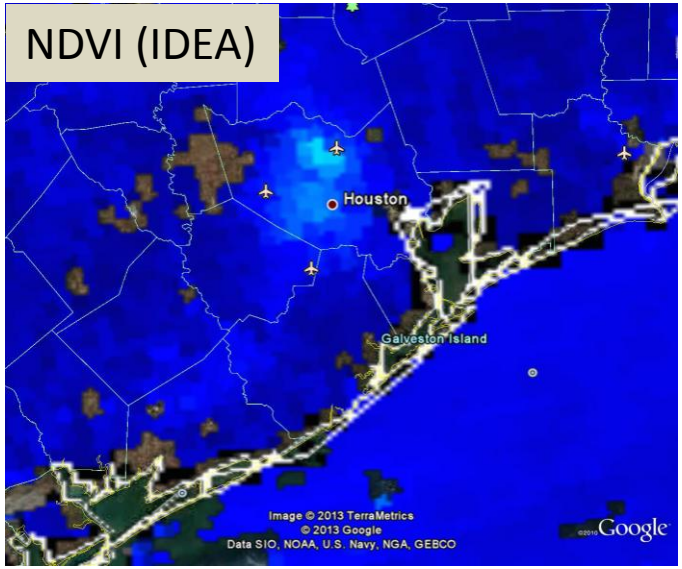
IDPS: original constant BR; **PCT**: updated constant BR; **NDVI**: NDVI-dependent BR

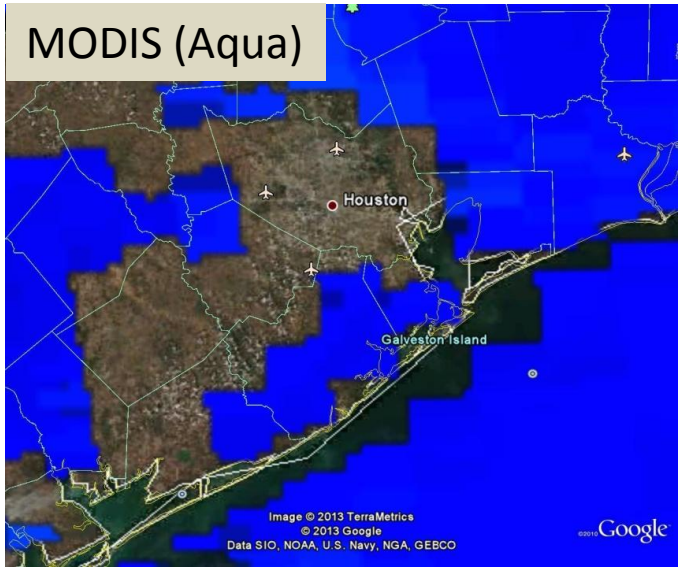
NDVI-dependent surface reflectance ratio (3)





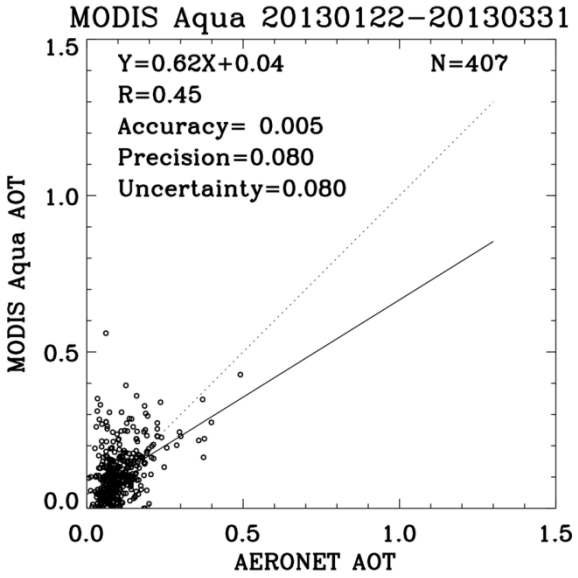
NDVI-dependent BRs have been implemented in VIIRS aerosol algorithm driven by direct broadcast VIIRS data in the **Infusing satellite Data into Environmental Applications (IDEA) over CONUS.**

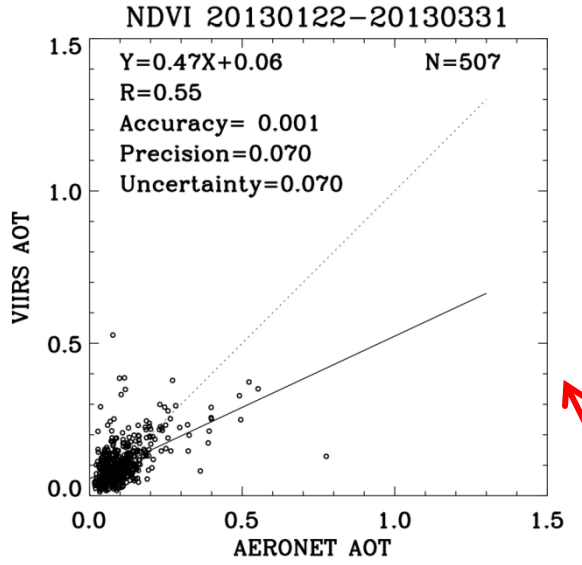




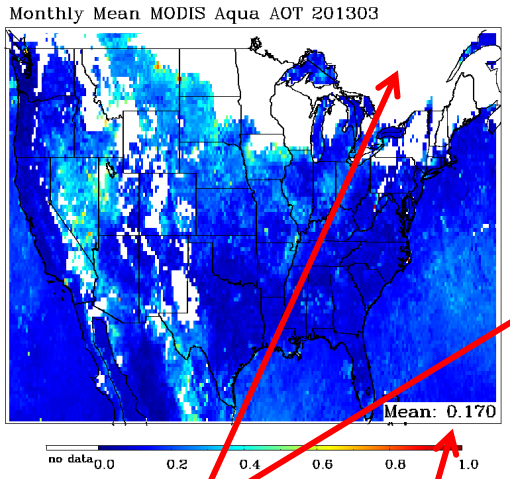
- NDVI-dependent BRs reduce AOT in Houston area 1/22/2013, and
- eliminate VIIRS outlier in scatterplot for 1/22-2/13, 2013.
- MODIS makes no retrieval in this area

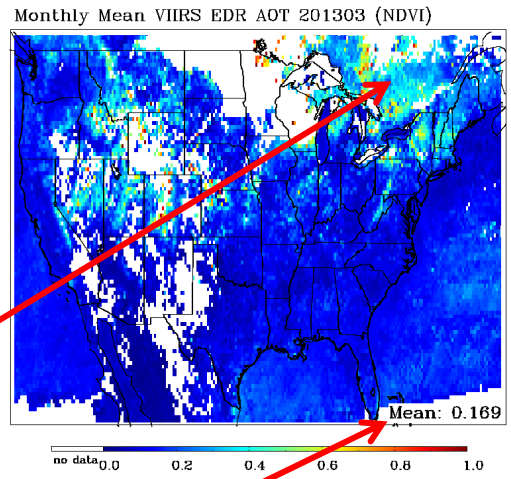
NDVI-dependent surface reflectance ratio (4)

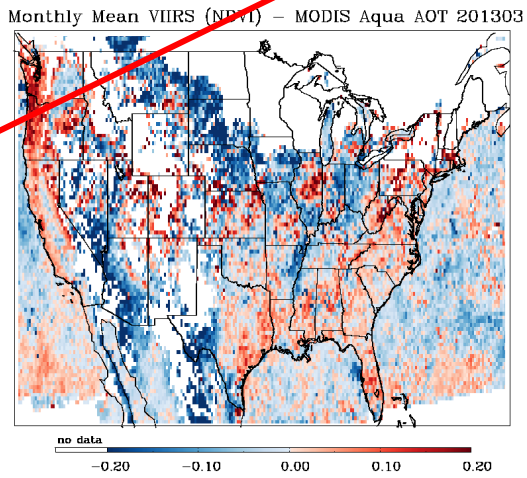




Monthly mean AOT data on 0.25x0.25 degree grids for March 2013.





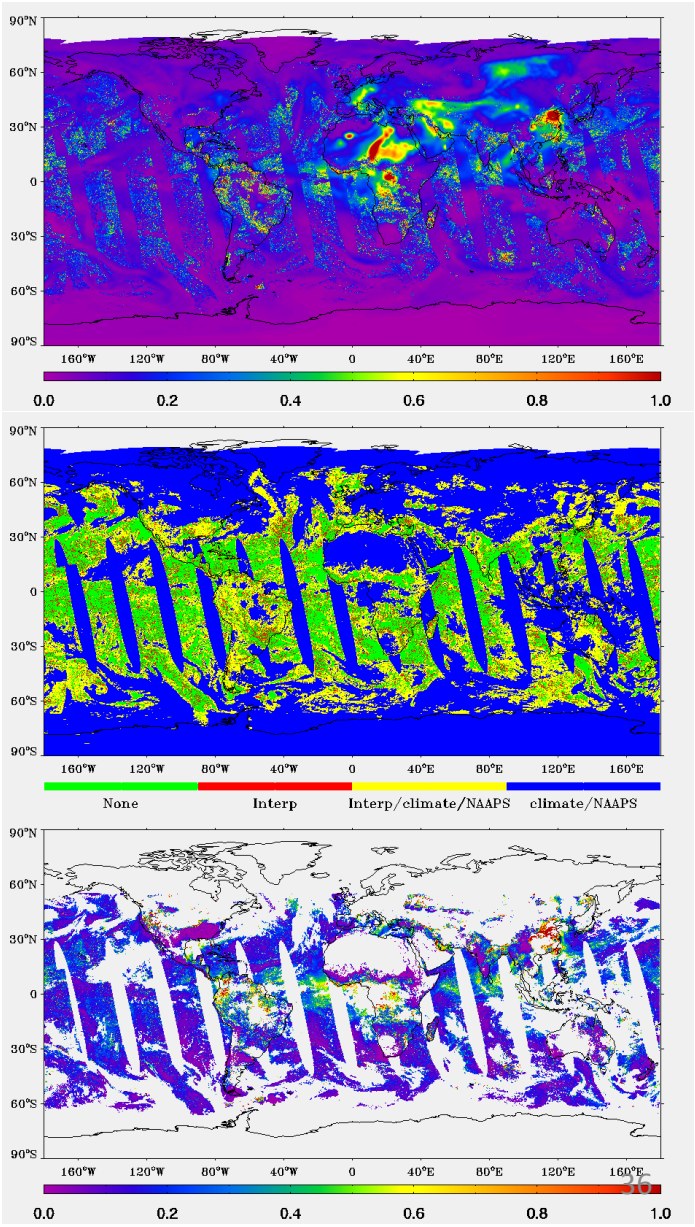


- VIIRS/IDEA retrievals where no MODIS retrievals!
- Similar MODIS and VIIRS/IDEA area (CONUS) averages, but
- substantial regional differences.
- VIIRS outperforms MODIS

Note on AOT IP

- IP AOT product includes AOT from interpolation and NAAPS or climatology.
- The AOT field has sharp gradients (*top*) at the boundaries of VIIRS retrievals and filled data as indicated by Fill Value QF (*middle*).
- Filtering the IP AOT with “High quality” flag recovers the retrieved VIIRS AOT IP (*bottom*).
- Users should be made aware of this.
- Filled data are not included in the evaluation.

Plots are for Feb 24, 2013.



Additional Comments on VIIRS AOT

- VIIRS (unlike MODIS) does not report negative AOT retrievals;
- VIIRS retrieves in places where MODIS does not (internal tests need to be revised/added);
- The internal sea ice test can trigger false detection of sea ice in the tropical Atlantic under heavy dust plumes, thus preventing aerosol retrieval.
- Some VCM data artifacts are present
  - prescribed “no heavy aerosol” flag and higher than expected fraction of heavy aerosol mostly over ocean
  - VCM test for heavy aerosol now includes ‘Probably Cloudy’ pixels. There is evidence of cloud contamination at cloud edges affecting AOT retrievals.

AEROSOL PARTICLE SIZE PARAMETER (APSP)

COMPARISON WITH AERONET

Evaluation of updated BR using VIIRS / AERONET (PGE) match-up data

Angstrom Exponent	May, 2012 - September, 2012 (Original Ratios)				May, 2012 - September, 2012 (Updated Ratios)			
	Number of Match-ups	Bias	Std	R2	Number of Match-ups	Bias	Std	R2
Land AE EDR	358	-0.014	0.550	0.162	**218**	**0.199**	**0.487**	**0.092**
Land AE IP	350	-0.106	0.545	0.081	**208**	**0.163**	**0.455**	**0.104**

- VIIRS aerosol data reprocessing on ADL using the updated band ratios (BR) over land for May, 2012 through September, 2012 were used.
- Test results show the **updated surface reflectance ratios over land** lead to
  - **no improvement in bias and correlation (R2),**
  - **some (marginal) improvement in standard deviation, but not enough to make the product useful,**
  - **reduction in the number of match-up passing QC.**

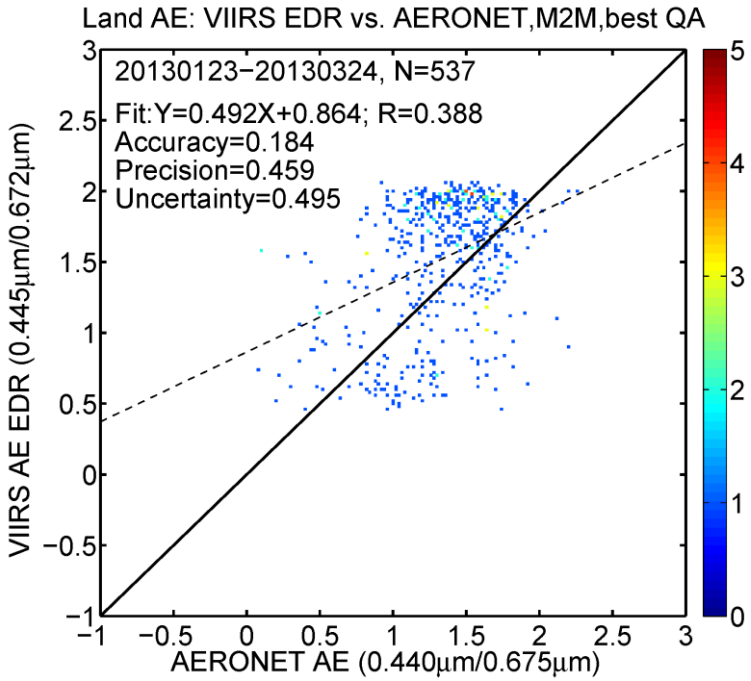
Evaluation of AE using PGE Match-up Data

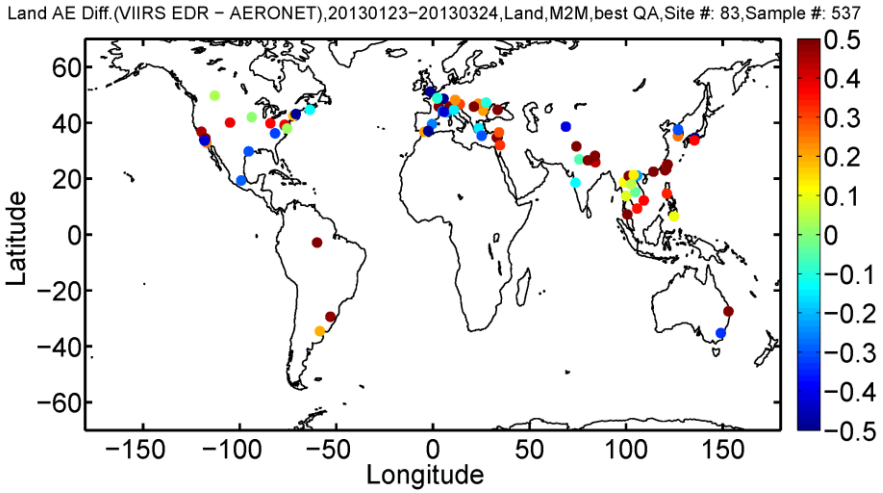
Angstrom Exponent	May 2012 - Sep 2012				Jan 2013 - Mar 2013			
APSP EDR	**#**	**Bias**	**Std**	**R2**	**#**	**Bias**	**Std**	**R2**
Land	218	0.199	0.487	0.092	761	0.238	0.553	0.067
Ocean	99	0.026	0.315	0.697	216	0.082	0.350	0.452
APSP IP	**#**	**Bias**	**Std**	**R2**	**#**	**Bias**	**Std**	**R2**
Land	208	0.163	0.455	0.104	352	0.242	0.451	0.155
Ocean	72	0.025	0.290	0.732	73	0.064	0.381	0.366

- PGE match-up data are used; **inversion data** from globally distributed AERONET sites (described on slide 13).
- **Over-land aerosol retrievals used updated land BR**; updated BRs do not affect ocean retrievals.
- Bias (EDR) **over land** with updated BR is about 0.2; Std is about 0.5, but **correlation is very low** (practically, no correlation)
- **Over ocean**, bias is about 0.03 to 0.08; Std is about 0.3-0.4, and **correlation is higher than that over land**.
- EDR and IP bias and Std are not much different.

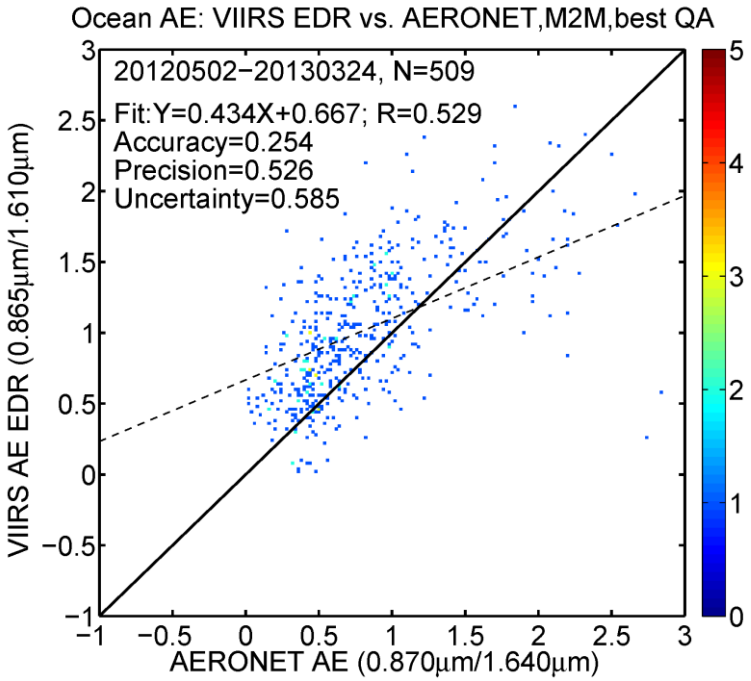
VIIRS APSP (AE) EDR vs. AERONET

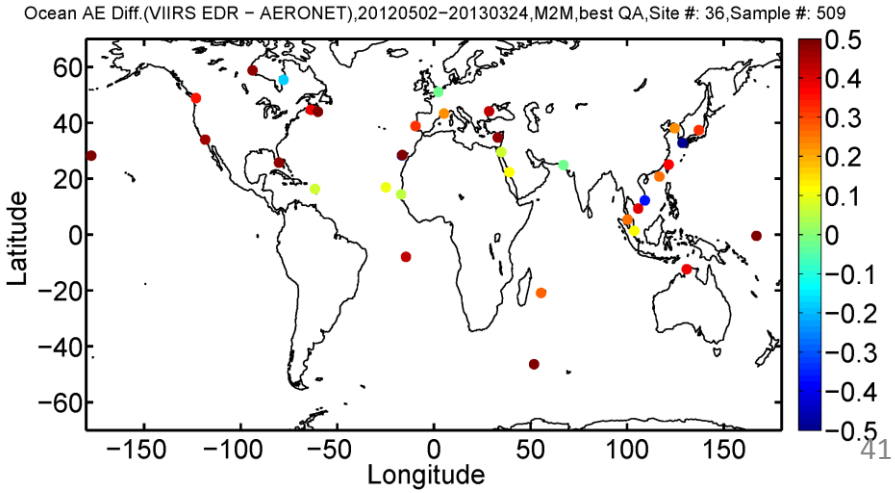
Land (Feb-Mar, 2013)





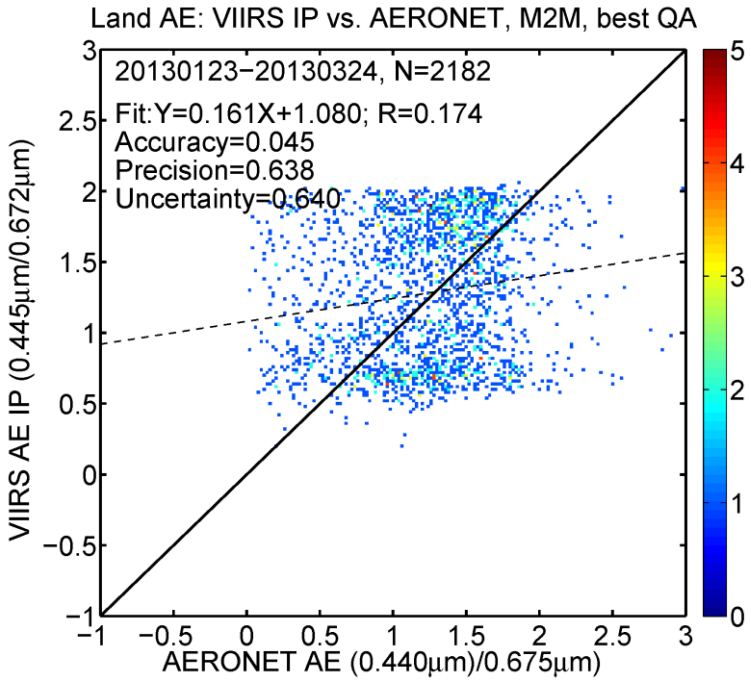
Ocean (May 2012-Mar, 2013)

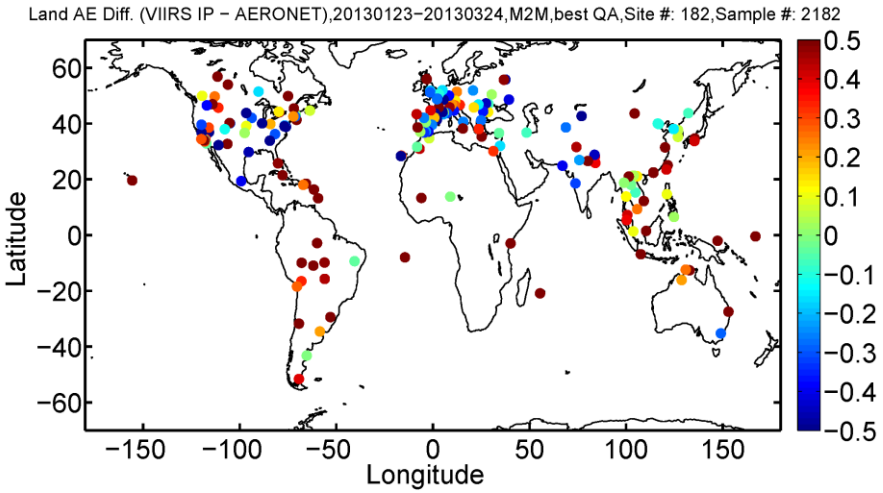




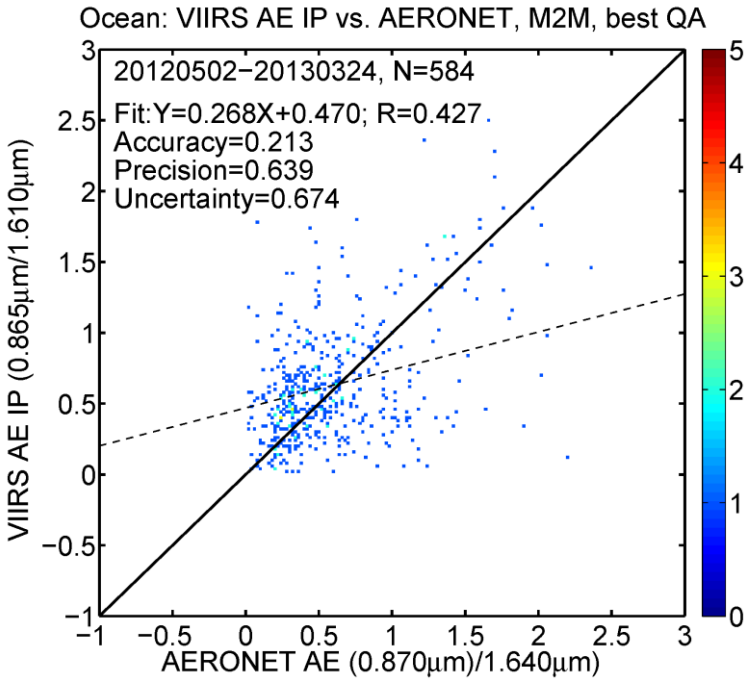
VIIRS APSP (AE) IP vs. AERONET

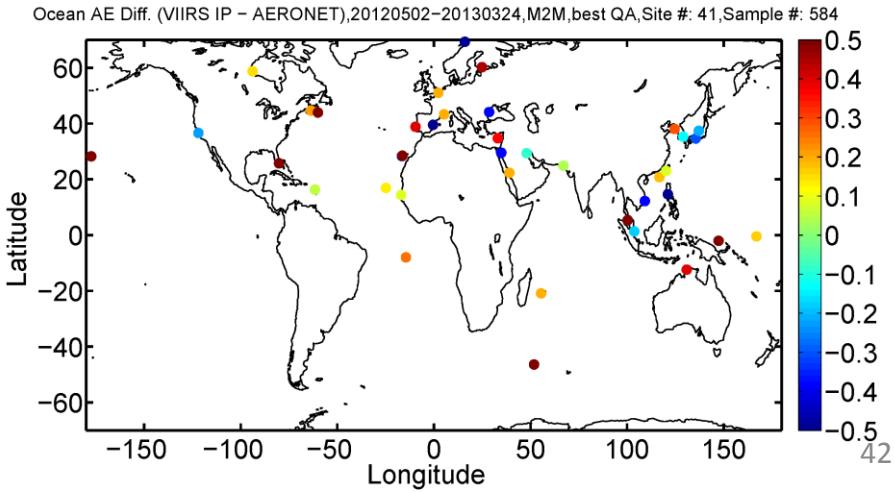
Land (Feb-Mar, 2013)





Ocean (May 2012-Mar, 2013)





Satellite-derived AE vs. AERONET AE

VIIRS APSP EDR , MODIS (Aqua&Terra), MISR AE compared to AERONET AE

EDR	VIIRS	MYD04	MOD04	MISR	VIIRS	MYD04	MOD04	MISR
Angstrom Exp	LAND				OCEAN			
Sample Size	**537**	601	701	718	**509**	787	737	91
Accuracy	**0.184**	-0.272	-0.248	-0.071	**0.254**	-0.128	-0.230	0.153
Precision	**0.459**	0.686	0.675	0.404	**0.526**	0.639	0.726	0.393
Uncertainty	**0.495**	0.738	0.719	0.411	**0.585**	0.652	0.761	0.422
Cor Coef	**0.388**	0.175	0.216	0.611	**0.529**	0.579	0.563	0.714

- Time periods: see slide 22
- **Over land**, VIIRS and MODIS AE performance is inferior to MISR, but *MODIS group does not recommend using their AE*.
- **Over ocean**, VIIRS and MODIS AE performance is comparable; **better correlation with AERONET**; MISR is still the best.

Wavelength pairs (nm)

	VIIRS	AERONET
Land	445/672	440/675
Ocean	865/1610	870/1640
	MODIS	**AERONET**
Land	440/670	440/675
Ocean	550/860	550/870
	MISR	**AERONET**
Land	(1)	440/675
Ocean	(1)	550/870

(1) From fit of AOTs at 446, 558, 672, and 867 nm

AEROSOL PARTICLE SIZE PARAMETER (APSP)

COMPARISON WITH MODIS

Collocated VIIRS and MODIS APSP

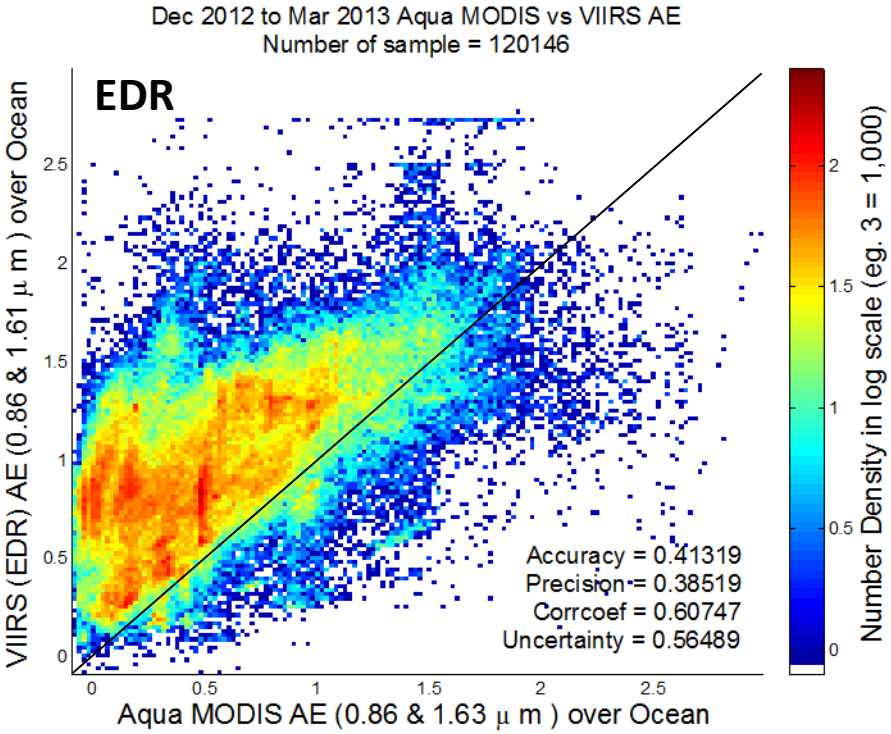
Collocation method:

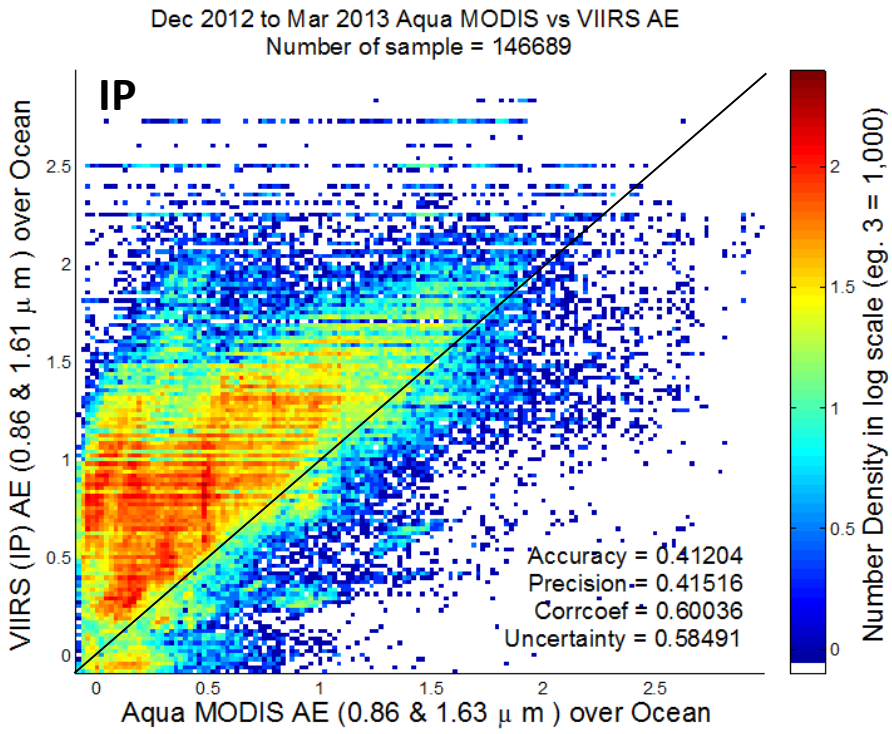
- *Time*: MODIS (L2) and VIIRS (IP/EDR) AOT are matched up in time within 5 minutes
- *Space*: VIIRS AOT from nearest pixel falling within MODIS 10 km.
- **MODIS AEs** are derived from MODIS **AOTs at wavelengths 0.86 and 1.63 µm** filtered with MODIS Could Fraction = 0 (from aerosol cloud mask) and best MODIS AOT Quality Assurance over Ocean
- **VIIRS AEs** are derived from VIIRS **AOTs at wavelengths 0.86 and 1.61 µm** filtered with High Quality flag (QF=3 for EDR and QF=0 for IP)

Time periods used:

- Dec 2012 – Mar 2013: *Ocean only; no MODIS AE over land.*

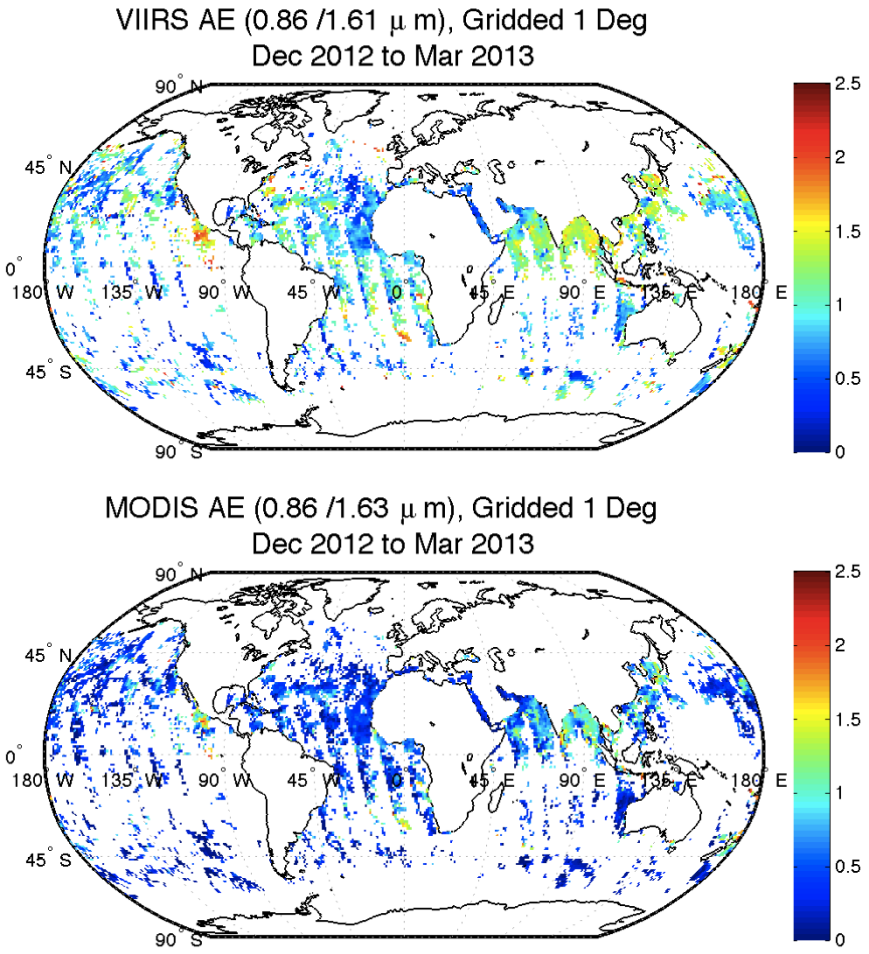
VIIRS vs. MODIS/Aqua AE Over Ocean (Dec 2012 to Mar 2013)





- Collocated VIIRS and MODIS data are used.
- VIIRS AE is biased high (suggesting smaller particles) relative to MODIS AE.
- Standard deviation is somewhat larger for IP than for EDR.

Maps of collocated gridded VIIRS and MODIS/Aqua AE over ocean (Dec 2012-Mar 2013)



- AE EDR mapped to 1-degree grids.
- Similar spatial pattern:
  - larger values over the Bay of Bengal, South China Sea, west of the southern tip of Africa, south-west of Mexico City.
- But overall, VIIRS AE tends to be higher than MODIS AE

AOT and APSP recommendation

- The statements below reflect the status as of April 2013 when the assessment was completed.
- **VIIRS AOT is at Provisional maturity level.**
- **APSP remains at Beta maturity level.**
- Recommended **starting (effectivity) date** for **AOT** qualifying **for Provisional level is Jan 23, 2013**.

SUSPENDED MATTER (SM)

SM User Requirement and Current Operational Capabilities at NOAA

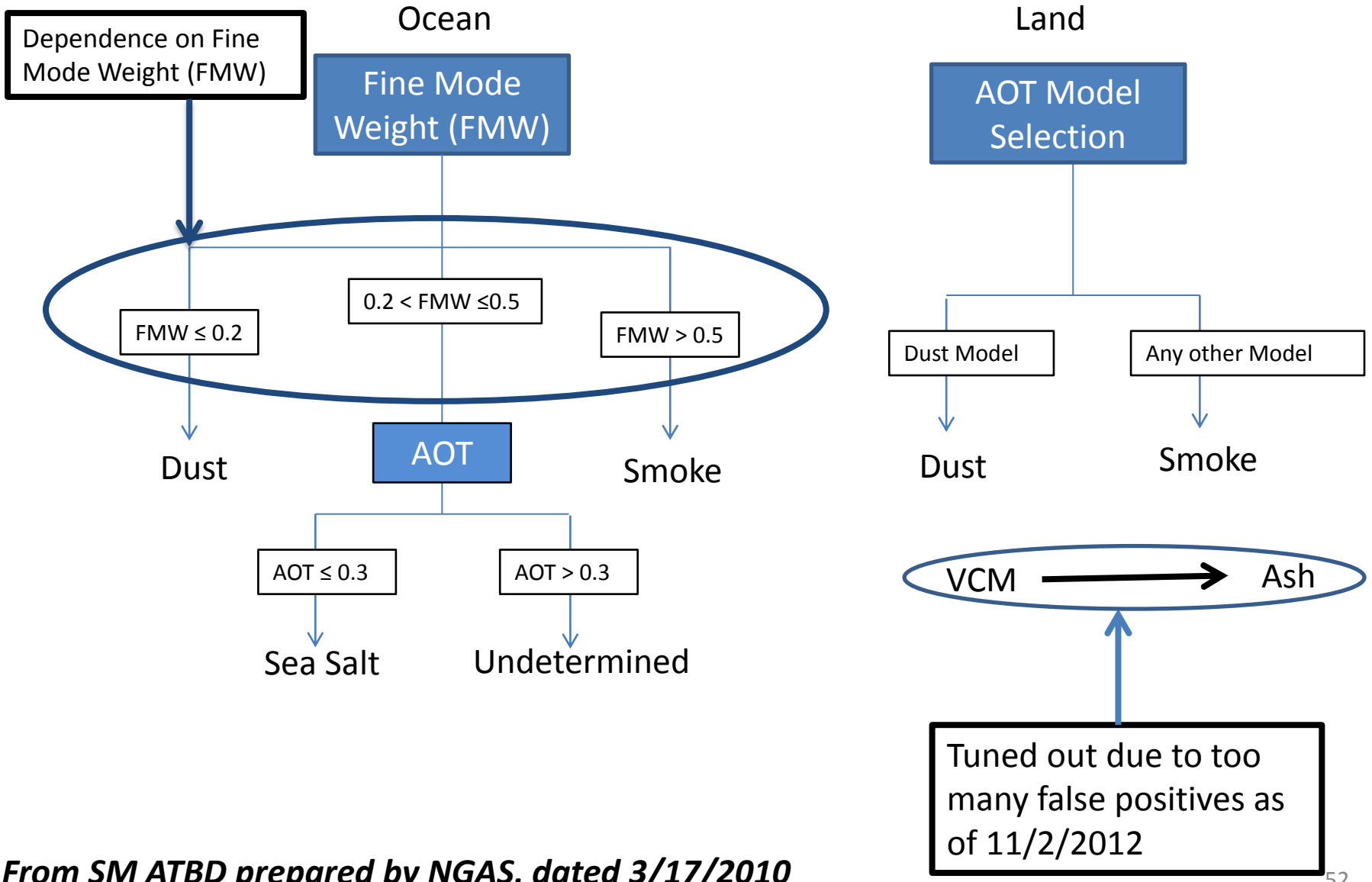
Product	Sensor	Accuracy	User	Application
Dust flag	Aqua MODIS	80% correct classification	NWS/NCEP	Tag MODIS dark target AOT and deep blue AOD as "dust AOT" to verify NWS operational dust forecasts
			NWS field offices (e.g., NWS Alaska)	Dust event monitoring and forecasting
			EPA	Provide waivers to states for exceptional events rule
Smoke flag*	GOES Imager	80% correct classification	NWS/NCEP	Tag GOES AOT as "smoke AOT" to verify NWS operational smoke forecasts
			NWS field offices (e.g., NWS Alaska)	Smoke event monitoring and forecasting
			EPA	Provide waivers to states for exceptional events rule

* STAR also generates smoke detection from Aqua and Terra MODIS but the product is a research version. NWS preferred a GOES product because forecasts can be verified on an hourly basis.

L1RD Supplement Requirements

Product	Threshold	Objective	Notes
SM	Dust, smoke, volcanic ash	Dust, smoke, volcanic ash, sea salt	
Smoke plume	0 to 150 µg/m^3	0 to 200 µg/m^3	
Accuracy			
SM	80%		
Smoke	70%		
Dust	80%		
Ash	60%		Dust can be mis-identified as ash
Mixed Aerosol		80%	Report not only dominant aerosol but other aerosol components as well

SM Algorithm Overview



From SM ATBD prepared by NGAS, dated 3/17/2010

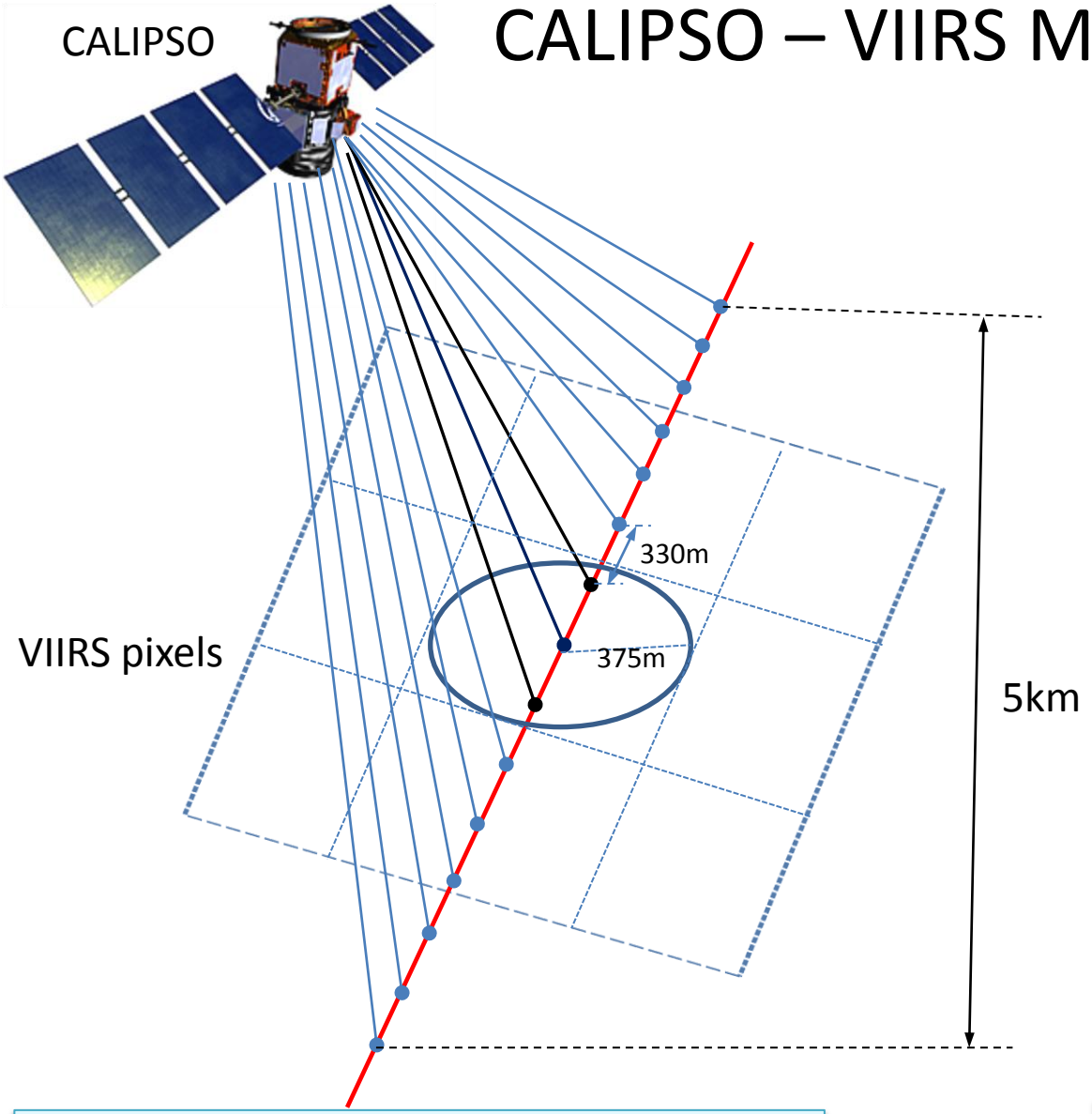
Heavy Aerosol Flag vs. SM

- VCM attempts to identify the presence of heavy aerosol flag for scenes that are classified as “confidently/probably cloudy” and passes that information to aerosol algorithm.
  - Aerosol algorithm uses it to *reset* “confidently/probably cloudy” pixels as clear sky to attempt AOT/Angstrom Exponent/SM retrieval.
  - If heavy aerosols (dust and smoke) are indeed present, AOT up to 2.0 is retrieved. AOTs higher than 2.0 are flagged as “out of range”.
  - If the pixels are indeed cloudy, AOTs will be high and likely out of range as well.
- With the recent inclusion of “probably cloudy” into heavy aerosol logic (*implementation date June 27, 2013*), cloud edges are being falsely identified as heavy aerosols.
  - This will have an implication for global mean values, especially over Ocean.
- SM algorithm does not rely on heavy aerosol information from VCM except for “volcanic ash”.
  - But, VCM tuned out all volcanic ash testing as of November 2, 2012

SM Product Validation

- Qualitative comparison of monthly global maps of VIIRS SM (dominant aerosol type), dust fraction, and smoke fraction to CALIPSO product (http://cain.larc.nasa.gov/)
  - CALIPSO: 5° x 5°
    - Coarser grid for CALIPSO is used to obtain a good sample size.
  - VIIRS: 0.25° x 0.25°
- Direct matchups of CALIPSO and VIIRS SM to compute accuracy, probability of detection, and false alarm ratio.
  - 31 individual cases (granules) covering both land and water. Most of the matchups are for dust; for smoke no good matchups were obtained in the time period (August 2012 and January - February 2013) we looked at.

CALIPSO – VIIRS Matchups

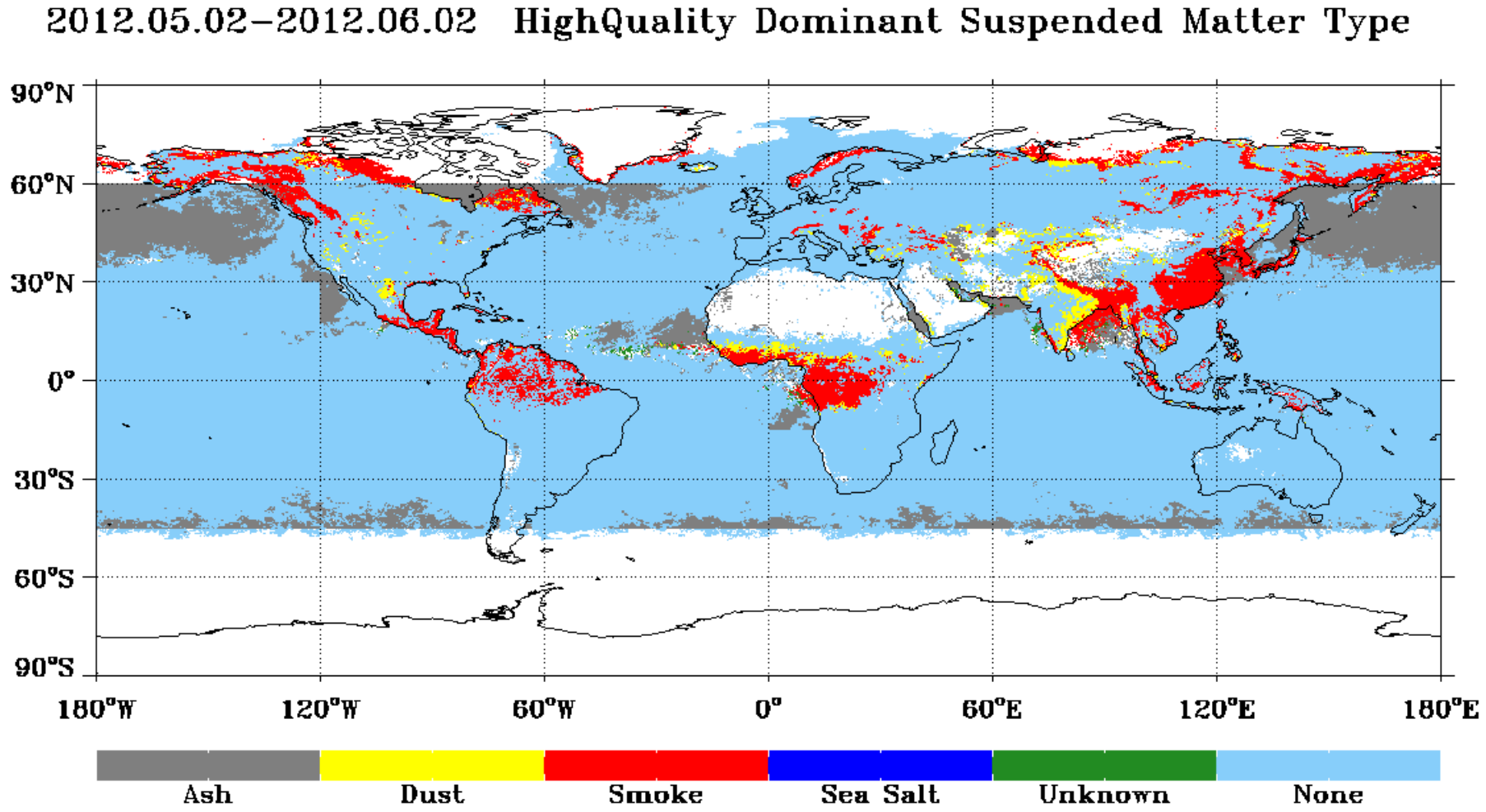


- Time difference: ±2 minutes
- Spatially , VIIRS pixels within ± 375m of the middle CALIPSO profile was selected.
- Middle three profiles are used to determine aerosol type in the column
  - All three profiles need to be cloud-free;
  - Dominant aerosol type is determined through the calculation of dust (or smoke) fraction (i.e., no of dust (or smoke) layers divided by the no. of aerosol layers from surface to 12km.
- VIIRS SM data are filtered for high quality.

True Positive (TP): VIIRS and CALIPSO say dust
True Negative(TN): VIIRS and CALIPSO say no dust
False Negative(FN): VIIRS says no dust but CALIPSO says dust
False Positive(FP): VIIRS says dust when CALIPSO says no dust

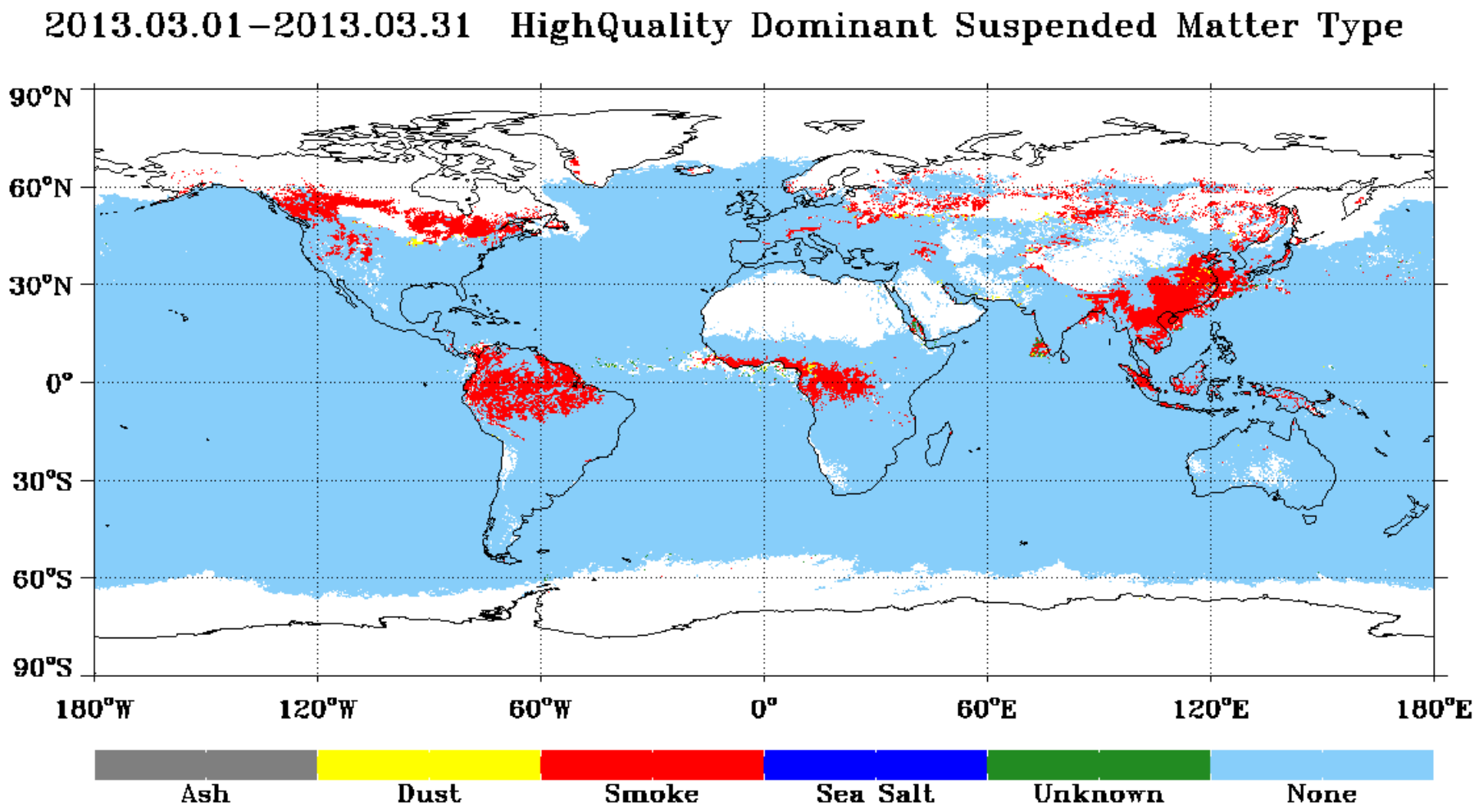
POD = TP/(TP+FN)
Accuracy = (TP+TN)/(TP+TN+FP+FN)
FAR = FP/(FP+TP)

From Beta Maturity Report: Global Map of Dominant Suspended Matter Type



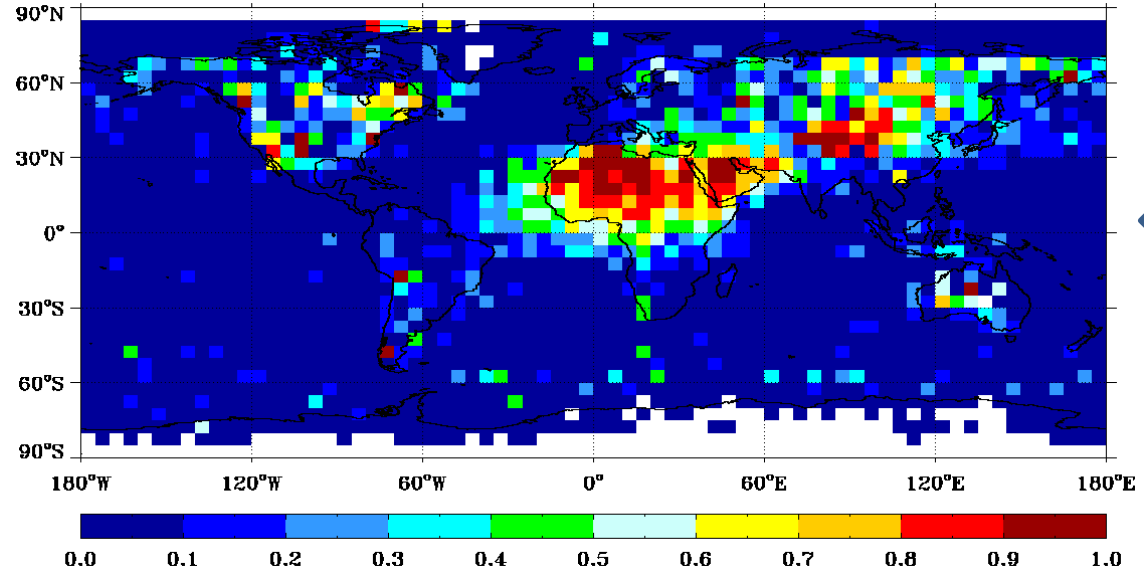
- Too much smoke over land.
- Too much volcanic ash, especially in regions where volcanic ash is not expected to be present.
- Missing dust over near dust sources and dust outflow regions (e.g., off of African coast).

March 2013 (After PCT Update) : Global Map of Dominant Suspended Matter Type



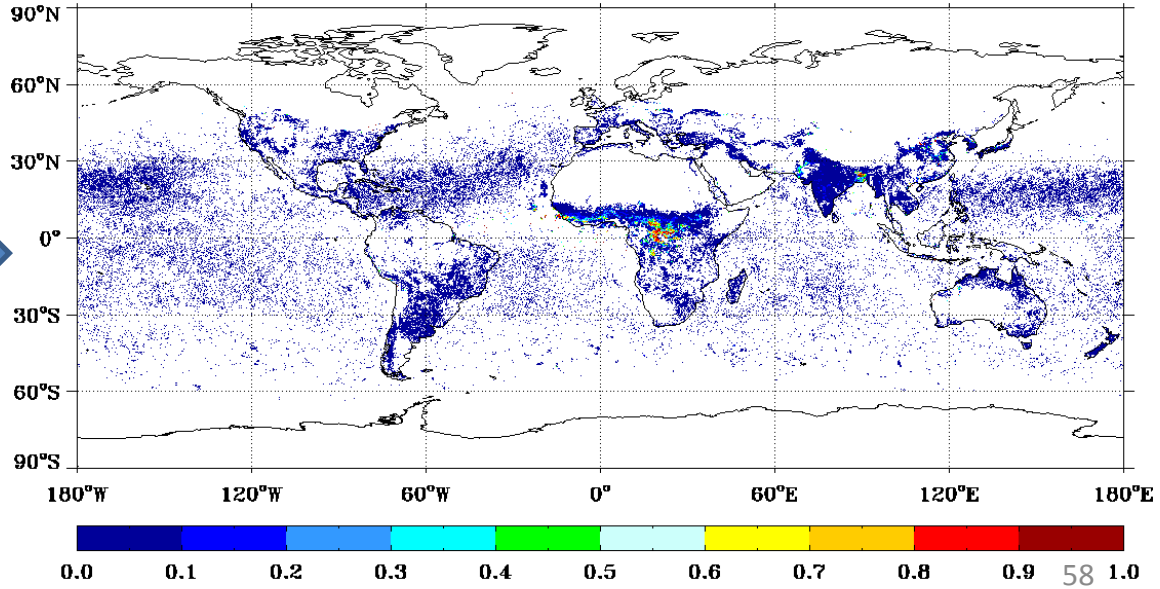
- No volcanic ash because VCM tuned out the tests. Impact: if there is a volcanic eruption, VIIRS will not be able to provide volcanic ash information although the eruption will show up in the AOT product.
- Too much smoke over land.
- Missing dust over near dust sources and dust outflow regions (e.g., off of African coast).

February 2013



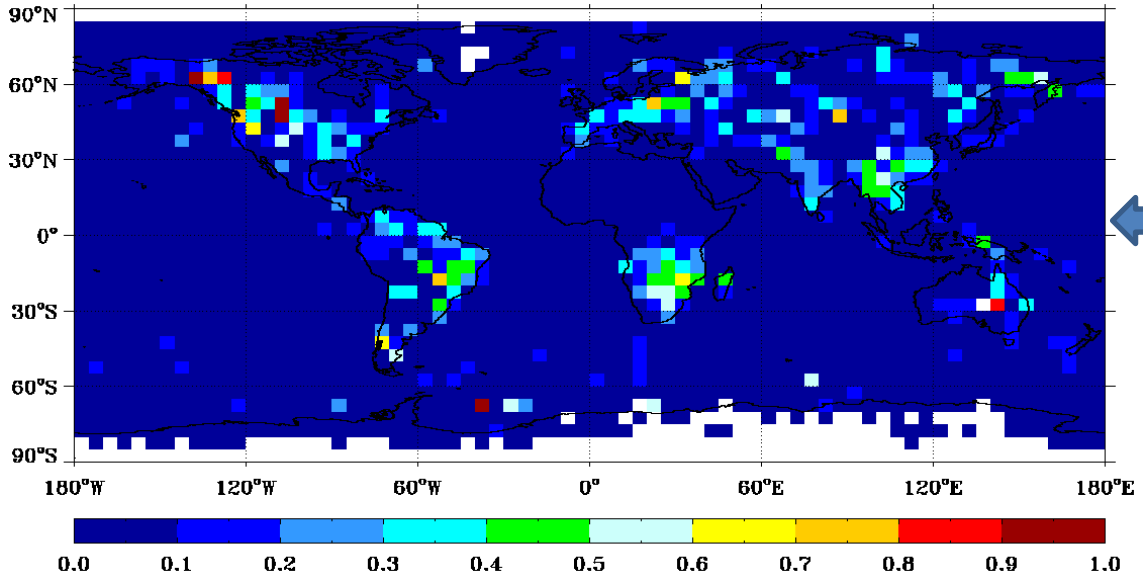
CALIPSO "Dust Fraction" at 5° x 5°

VIIRS "Dust Fraction" at 0.25° x 0.25°



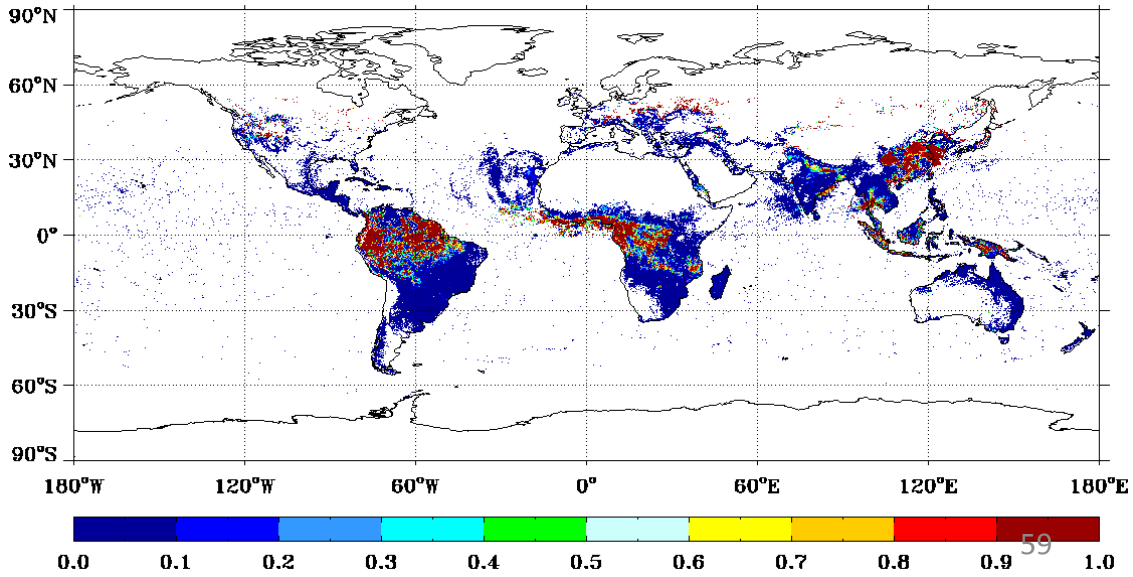
VIIRS global dust distribution not consistent with CALIPSO

February 2013



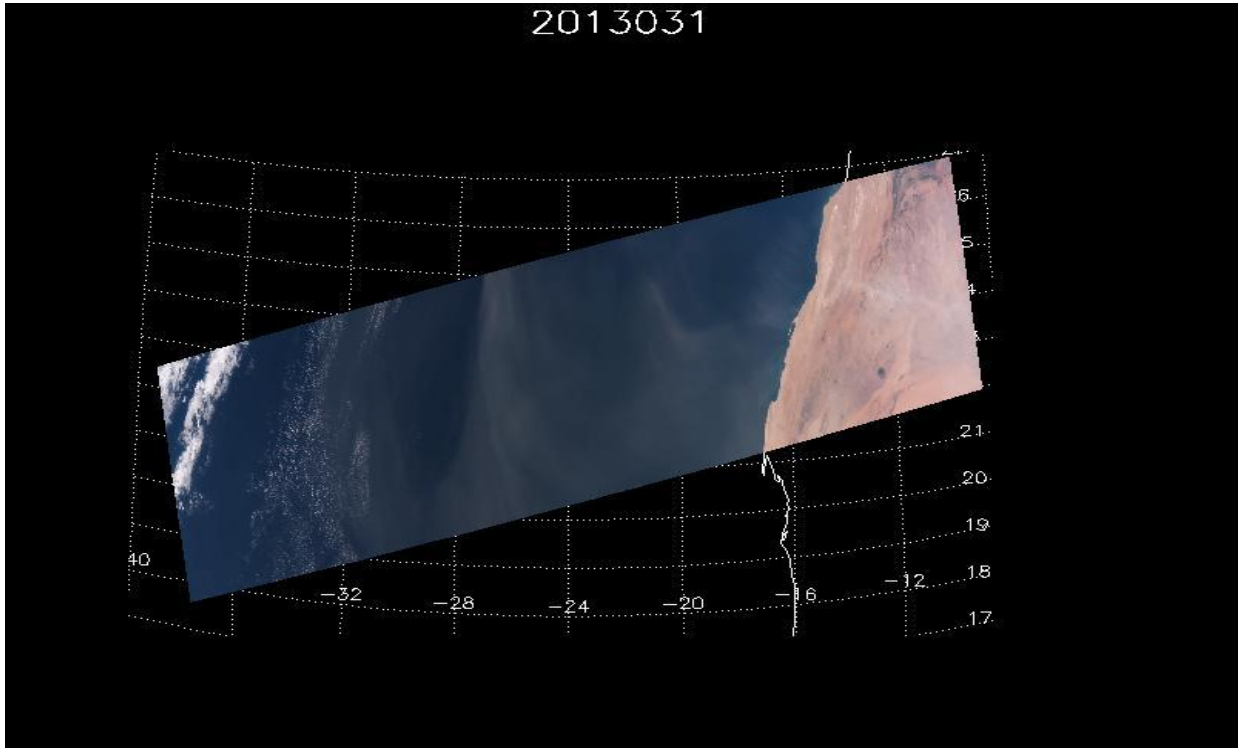
CALIPSO "Smoke Fraction" at 5° x 5°

VIIRS "Smoke Fraction" at 0.25° x 0.25°



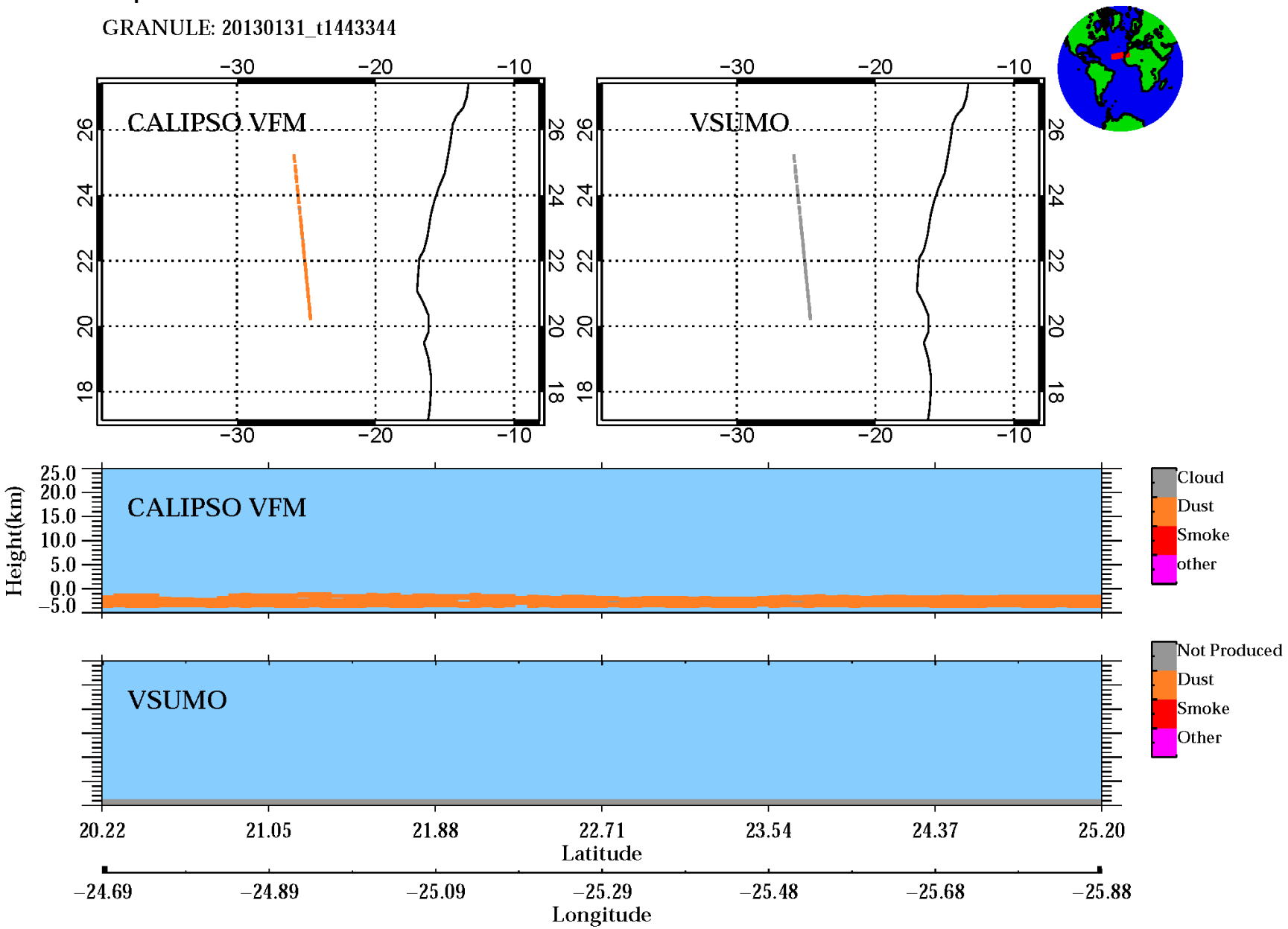
VIIRS global smoke distribution not consistent with CALIPSO but very consistent with seasonal global biomass burning shown in Zhang et al., 2012

VIIRS – CALIPSO SM Matchups



VIIRS RGB January 31, 2013 showing a dust plume over the Atlantic. Next slide shows VIIRS SM matchup with CALIPSO for this granule.

VIIRS SM product



VIIRS vs. CALIPSO SM Matchups

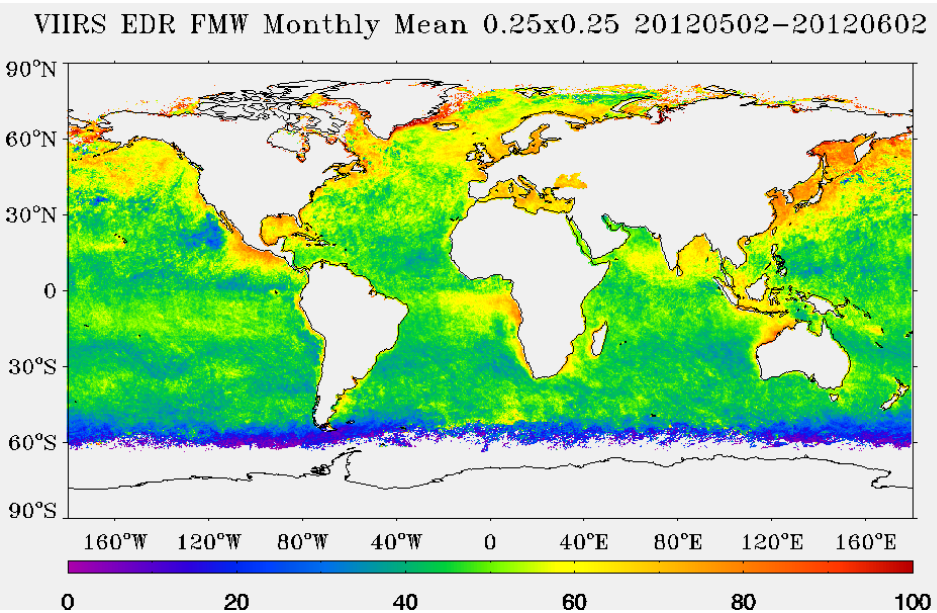
Land	Granule		Accuracy	POD	FAR
d20120801_t1332529					
		VSUMO	24.3	0.0	N/A
d20130108_t1010226					
		VSUMO	0.0	0.0	N/A
d20130115_t1122460					
		VSUMO	16.7	0.0	N/A
d20130222_t1110420					
		VSUMO	16.7	0.0	N/A

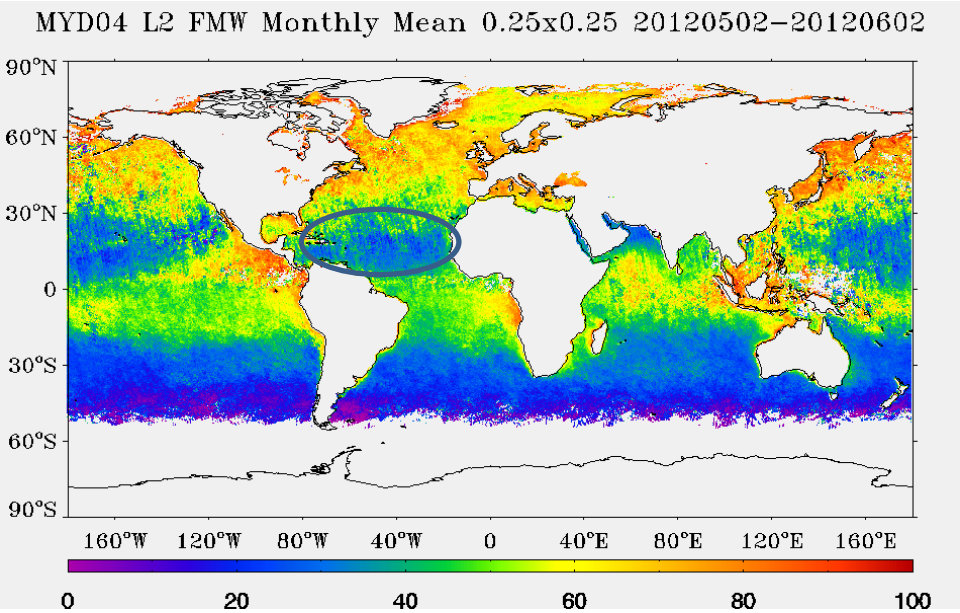
Water	Granule		Accuracy	POD	FAR
d20120801_t1324204					
		VSUMO	80.4	0.0	N/A
d20130108_t1511560					
		VSUMO	6.9	0.0	N/A
d20130131_t1443344					
		VSUMO	2.3	0.0	N/A
d20130131_t1444598					
		VSUMO	13.1	0.0	N/A
d20130222_t1110420					
		VSUMO	45.0	0.7	14.3

SM Algorithm Approach Issues

- Attempts to determine SM based on Fine Mode Weight (FMW) over Ocean:
  - Single thresholds (e.g., 20% for dust), although based on AERONET volume size distribution analysis, for different aerosol types are not valid because changes in plume characteristics change FMW;
  - Analysis of FMW from MODIS data (Yu et al., JGR, 2009) shows that values have seasonal and regional dependencies;
  - The operational (IDPS) version of Look-up-Table (LUT) for over Ocean aerosol retrieval used aerosol optical properties (models) different from MODIS Collection 5.
- Attempts to determine SM based on land aerosol model over Land:
  - Uncertain and depends on the way residuals are calculated.
- High quality SM detection for AOTs > 0.5 and typing only for AOTs > 1.0

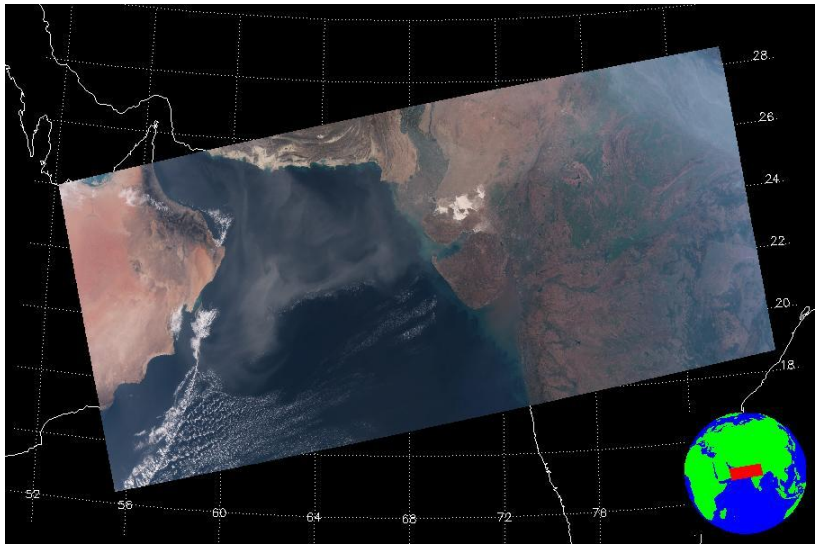
Analysis of VIIRS FMW

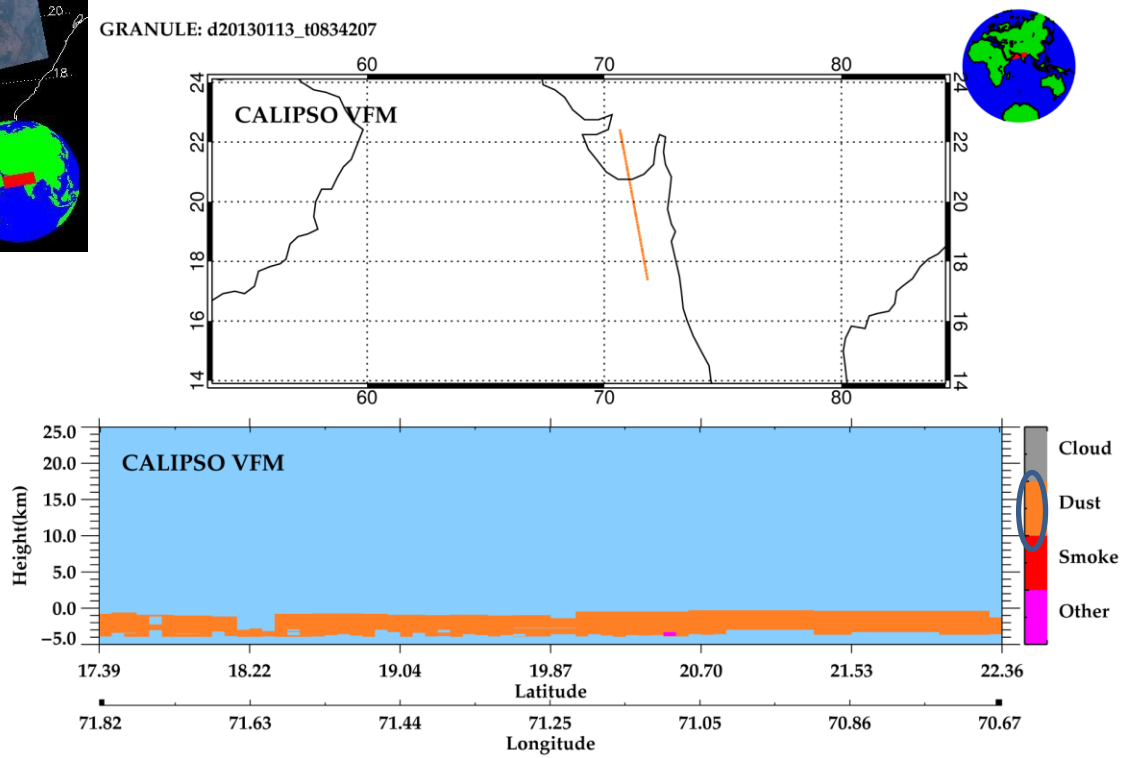




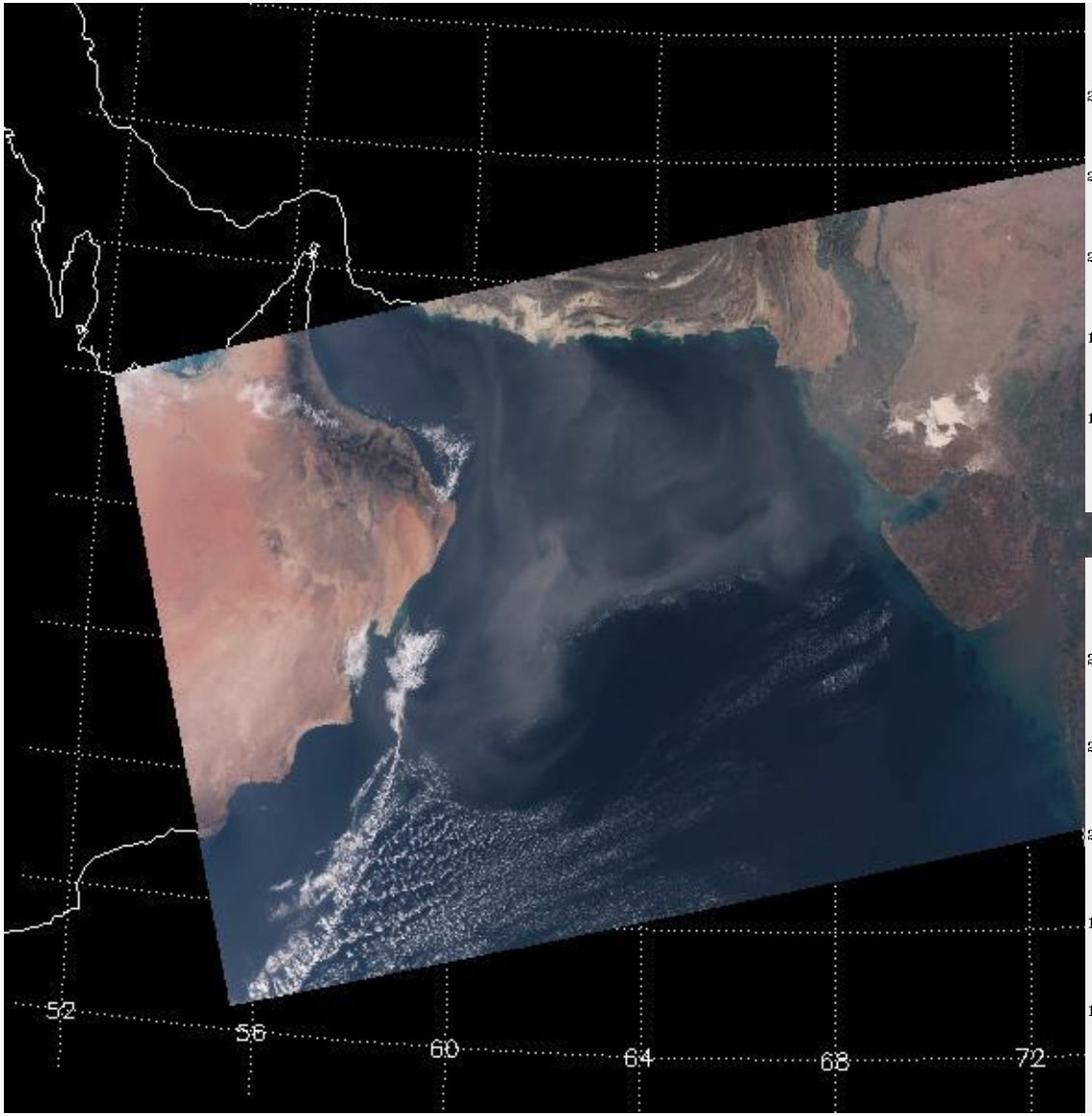
MODIS shows lower FMW near the dust source regions. This feature is missing in VIIRS due to which SM algorithm misses dust detection.

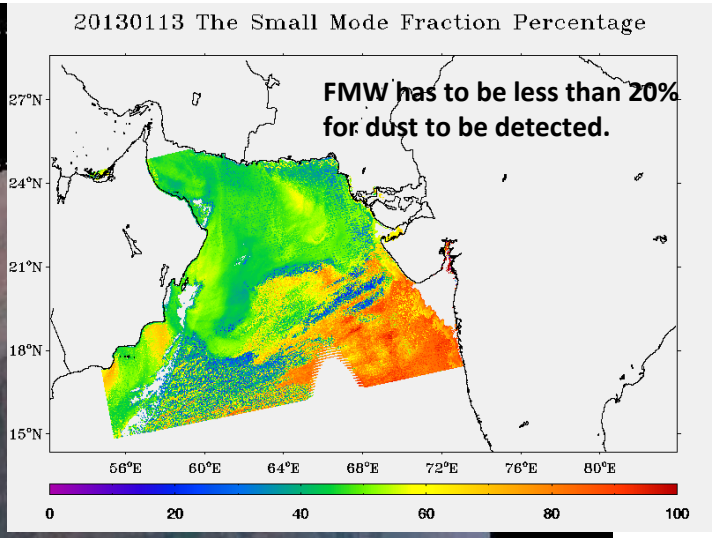
Analysis of January 13, 2013 Dust Case

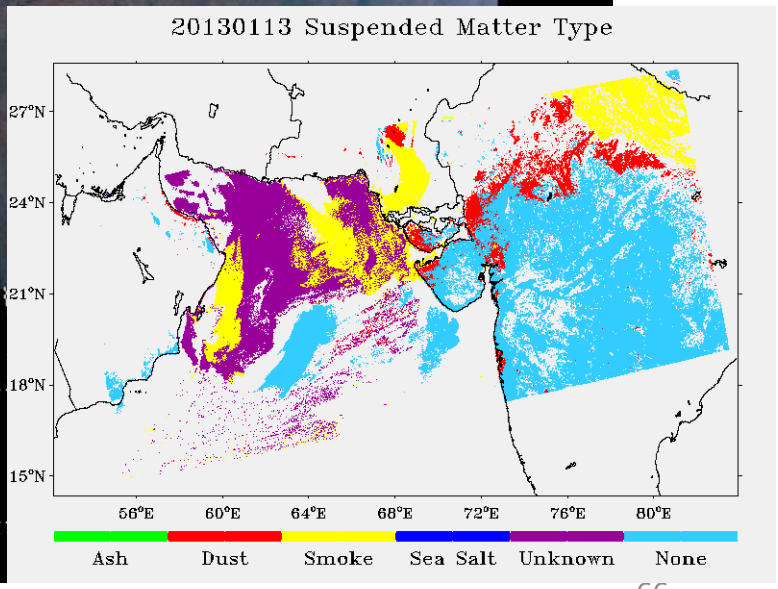




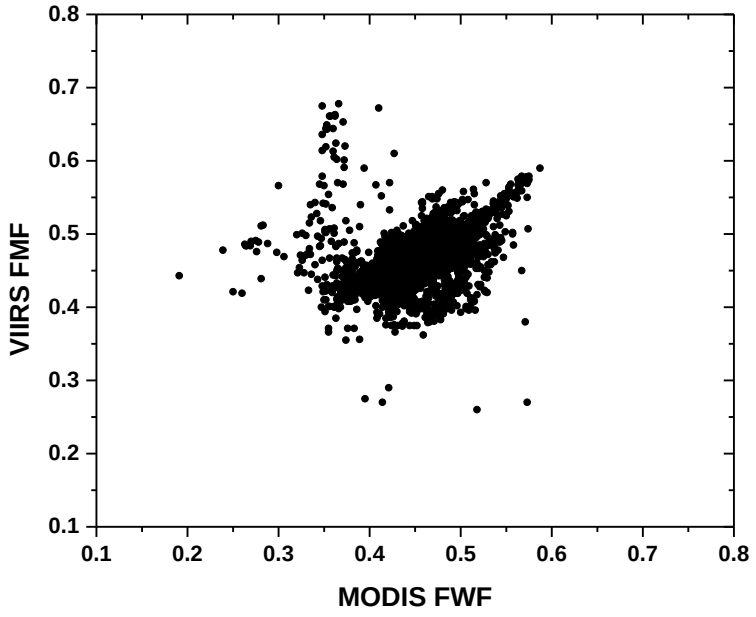
Analysis of VIIRS FMW (cont.)

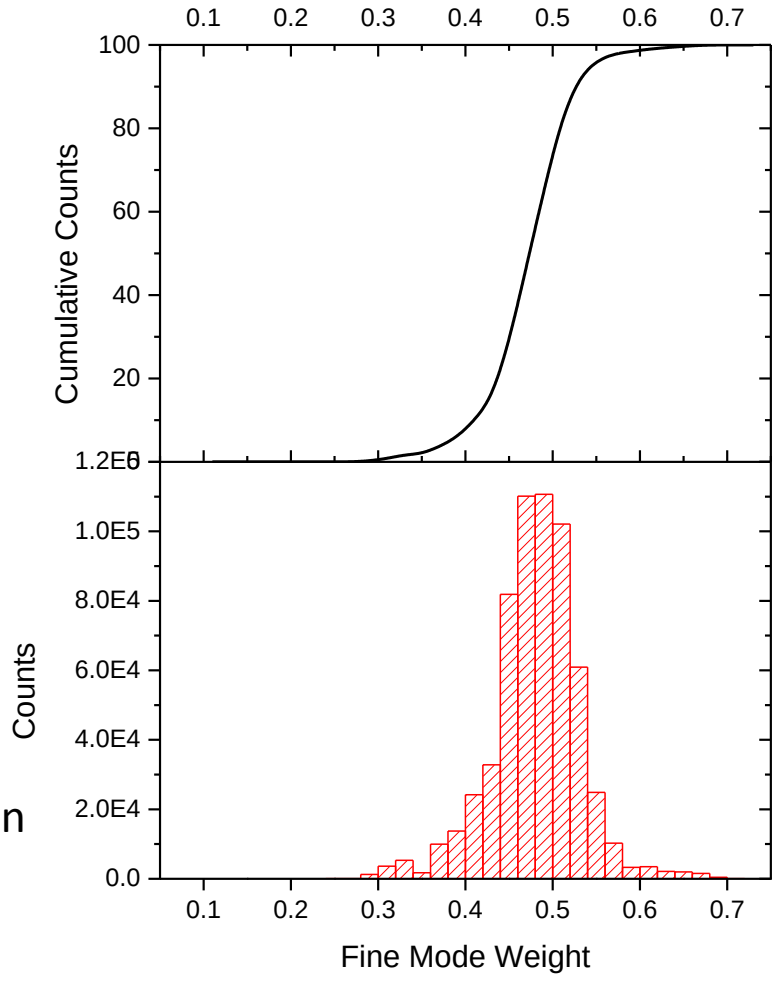






Analysis of VIIRS FMW (cont.)





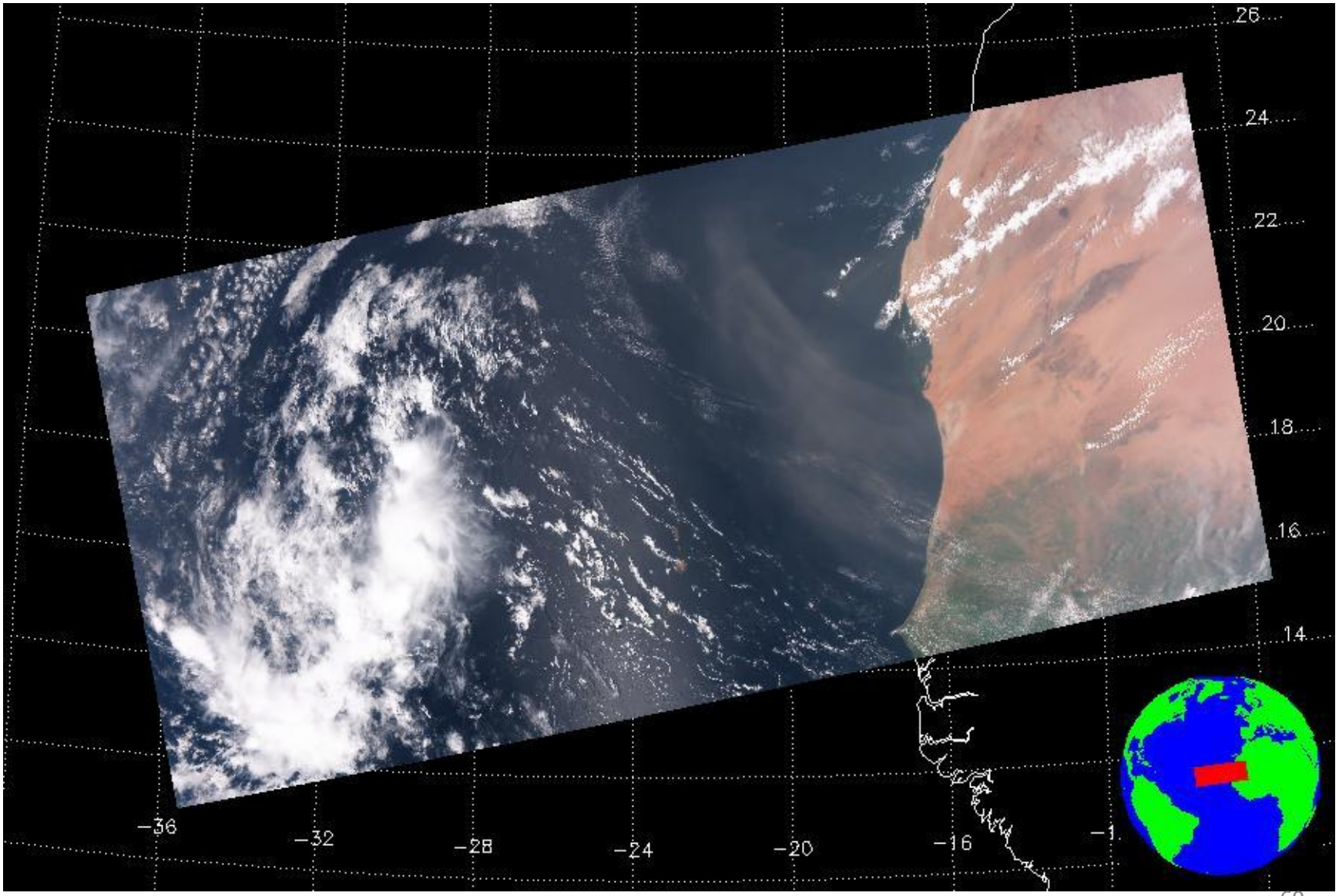
- No single VIIRS dust pixel has FMW less than 20%
- Mean FMW in the dust plume ~50%
- VIIRS FMW correlates well with MODIS but both MODIS and VIIRS show high FMW

Test Changes to SM Algorithm

- Test runs were conducted using the following approaches:
  - **IDPS:** no change operational output
  - **LUT:** using new lookup table calculated with MODIS Collection 5 ocean aerosol models
  - **RES:** using new lookup table; residual computation following MODIS method

- Testing done on the following datasets:
  - 2012.09.09: t1441290, t1442544
  - 2012.09.13: t1506465, t1508119
  - 2013.01.13: t0834207, t0835461
  - September 2012 DOY 259

2012.09.09

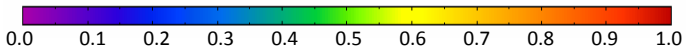


FMW

IDPS

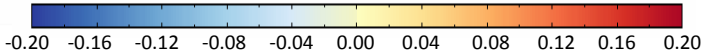
LUT

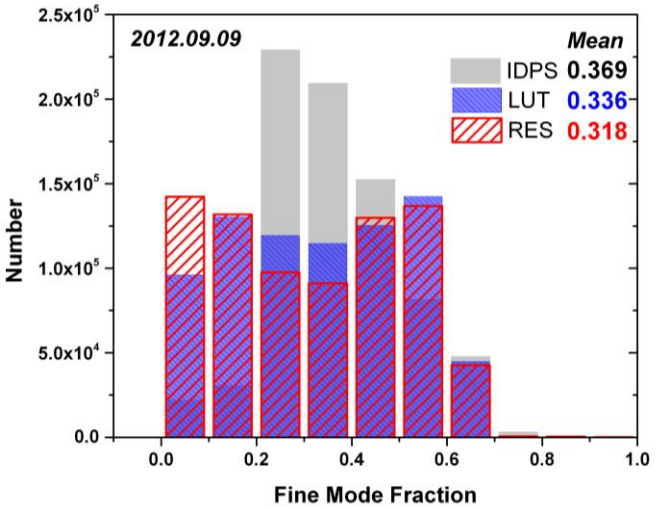
RES



LUT - IDPS

RES - LUT





2012.09.09

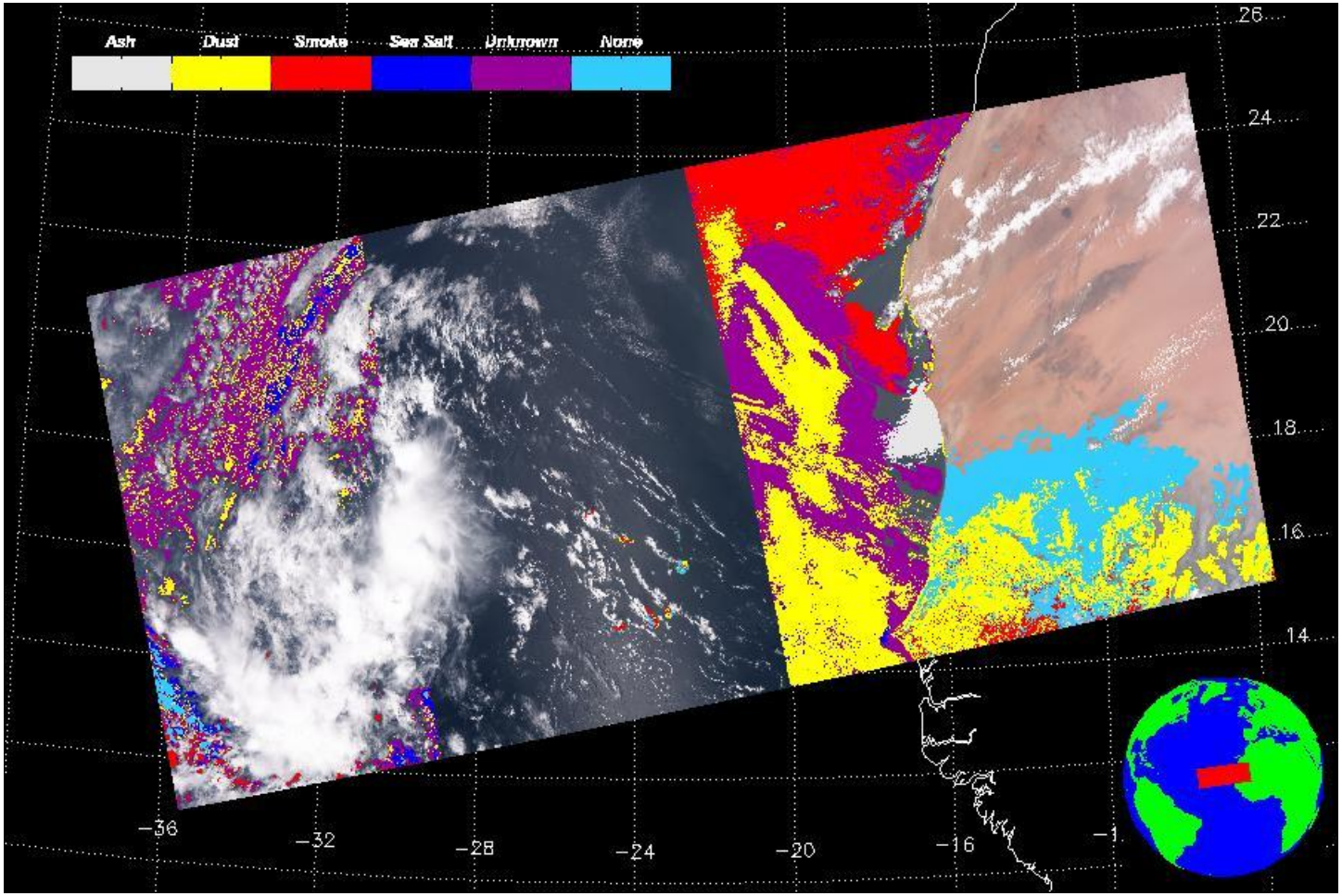
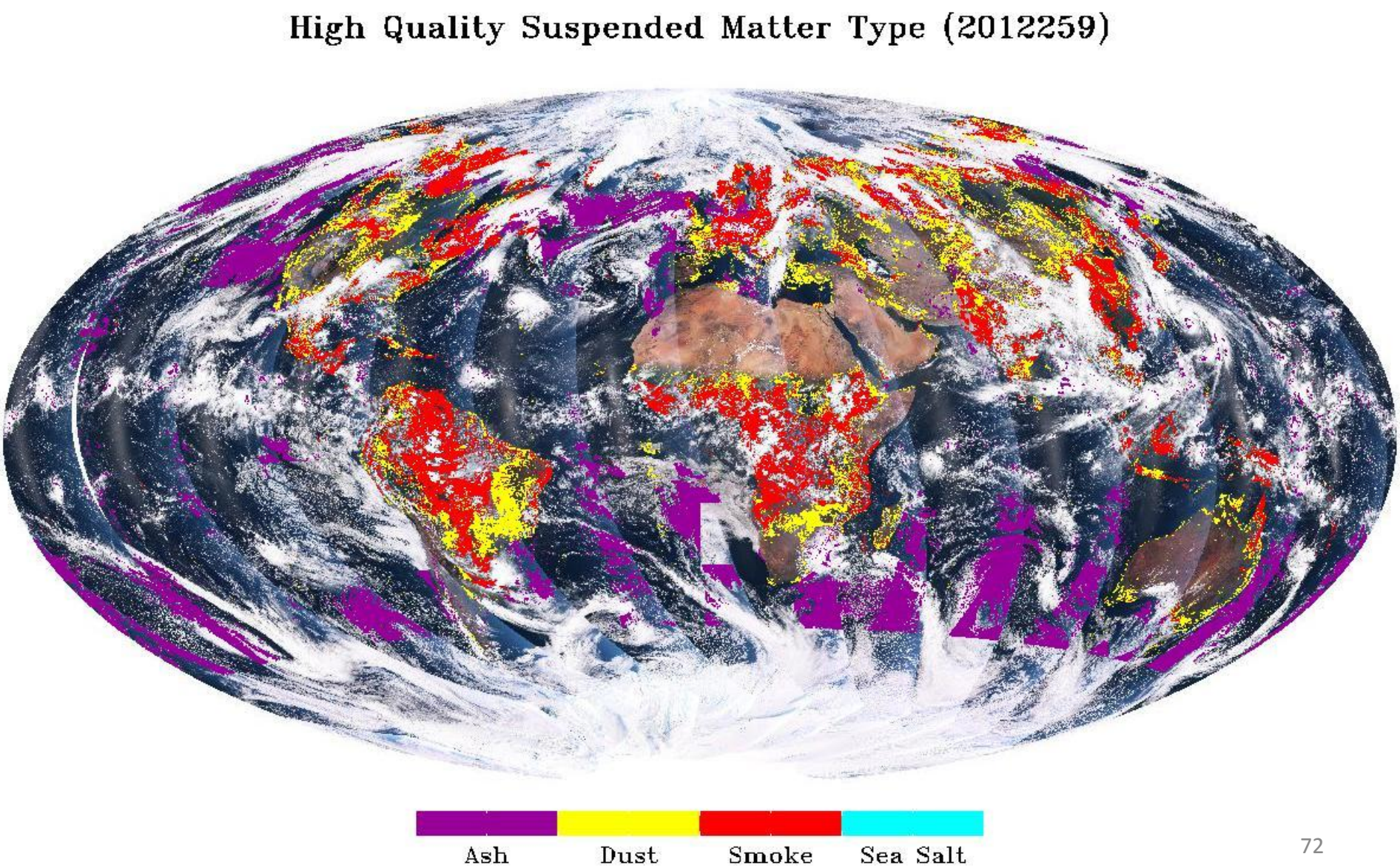


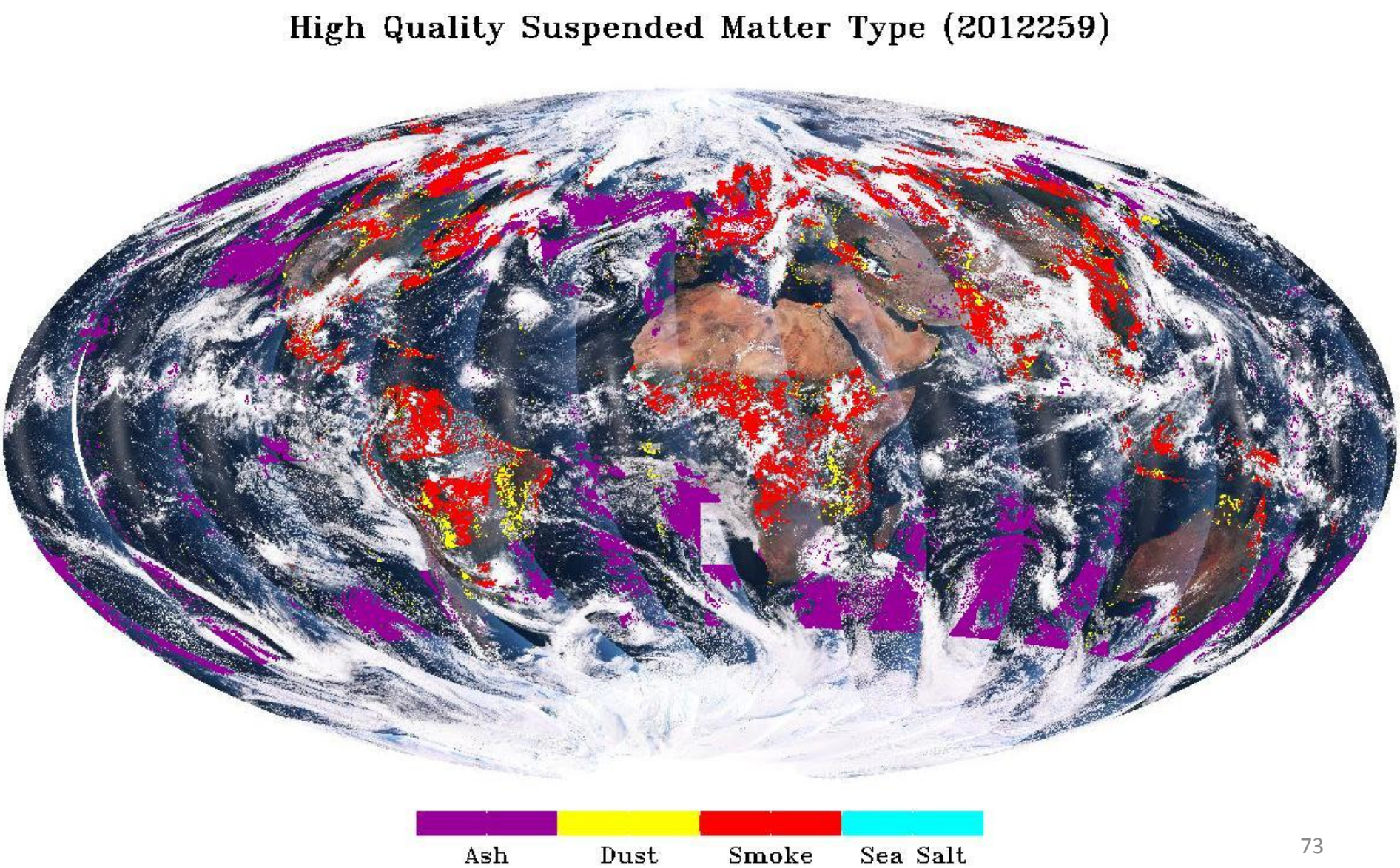
Image 1: IDPS
Image 2: LUT update
Image 3: LUT update + Update to residual calculation

IDPS Product



Reprocessed with STAR Stand Alone Algorithm

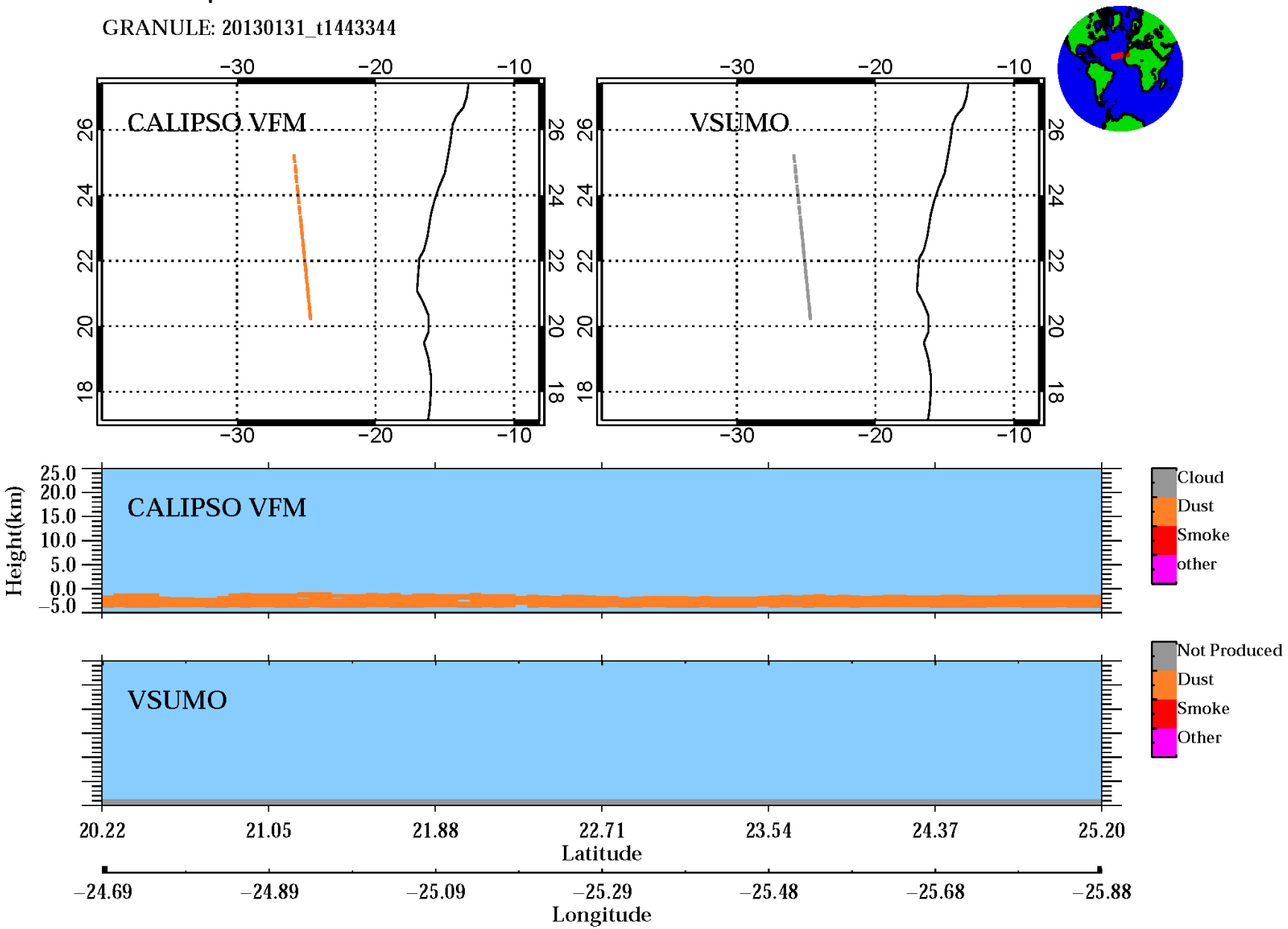
With updated LUT (using MODIS C5 ocean aerosol models) and NDVI-dependent land surface reflectance ratios



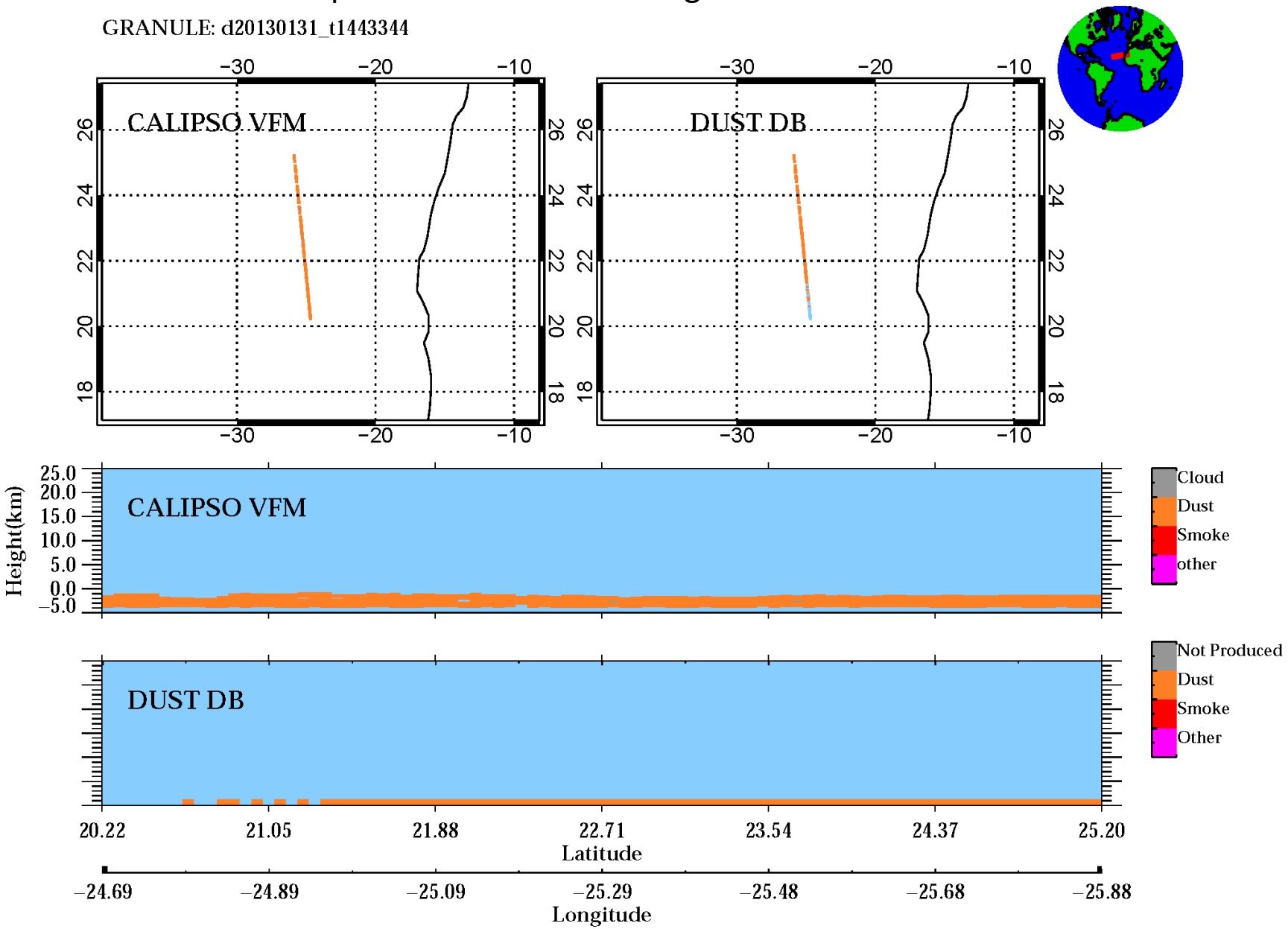
Some Key Remarks on SM

- SM is not a legacy NASA MODIS product
- SM product is very difficult to evaluate and validate
  - Reliance on other satellite (CALIPSO) data. Poor matchups with CALIPSO. Will look into MISR for future work.
  - In situ (IMPROVE network) data are available but with a 1 to 2 yr latency.
  - AERONET Angstrom Exponent based classification can be used but not really "truth" like the AERONET AOT product is.
- VIIRS SM algorithm relies on AOT and other internal parameters (not validated) to identify and type SM
  - Aerosol FMW over ocean
  - Aerosol model over land
- In this review, we showed that VIIRS SM product cannot meet user requirement and alternate algorithms (slide 28) are needed to improve the product performance. The VIIRS SM product is not recommended for use in any applications.

VIIRS IDPS SM product



VIIRS SM based on Deep Blue Dust Detection Algorithm



VIIRS vs. CALIPSO SM Matchups

Land Granule		Accuracy	POD	FAR
d20120801_t1332529				
	VSUMO	24.3	0.0	N/A
d20130108_t1010226				
	VSUMO	0.0	0.0	N/A
d20130115_t1122460				
	VSUMO	16.7	0.0	N/A
d20130222_t1110420				
	VSUMO	16.7	0.0	N/A

Water Granule		Accuracy	POD	FAR
d20120801_t1324204				
	VSUMO	80.4	0.0	N/A
d20130108_t1511560				
	VSUMO	6.9	0.0	N/A
d20130131_t1443344				
	VSUMO	2.3	0.0	N/A
d20130131_t1444598				
	VSUMO	13.1	0.0	N/A
d20130222_t1110420				
	VSUMO	45.0	0.7	14.3

VIIRS vs. CALIPSO SM Matchups

Land	Granule		Accuracy	POD	FAR
d20120801_t1332529		DBDI	78.4	100.0	22.2
		VSUMO	24.3	0.0	N/A
d20130108_t1010226		DBDI	96.7	96.7	0.0
		VSUMO	0.0	0.0	N/A
d20130115_t1122460		DBDI	78.3	84	10.6
		VSUMO	16.7	0.0	N/A
d20130222_t1110420		DBDI	93.3	96.0	4
		VSUMO	16.7	0.0	N/A

Water	Granule		Accuracy	POD	FAR
d20120801_t1324204		DBDI	89.1	44.4	0.0
		VSUMO	80.4	0.0	N/A
d20130108_t1511560		DBDI	93.0	100.0	6.98
		VSUMO	6.9	0.0	N/A
d20130131_t1443344		DBDI	82.7	84.7	2.7
		VSUMO	2.3	0.0	N/A
d20130131_t1444598		DBDI	79.8	82.2	6.3
		VSUMO	13.1	0.0	N/A
d20130222_t1110420		DBDI	90.9	80.0	0
		VSUMO	45.0	0.7	14.3

Conclusions on VIIRS SM

- **The VIIRS SM product is advanced to Beta maturity level, but is not recommended for use at this time.**
  - **Effectivity date: May 2, 2012**
- Both qualitative and quantitative comparisons of VIIRS SM with CALIPSO Vertical Feature Mask show that **SM product should not be used in scientific work or in any applications related to policy and decision support systems.**
- Alternate algorithms exist for SM which show a better accuracy, probability of detection, and false alarm ratio compared to operational (IDPS) VIIRS SM product but they have some limitations as well:
  - More testing and upgrades needed over bright surface

ATBD Update
Critical DRs
Caveats at the time of beta maturity level review
Updates/new caveats
Path Forward

CHALLENGES AND REMAINING ISSUES

ATBD Updates

AOT & APSP

- Update is an almost complete re-write of the **VIIRS Aerosol Optical Thickness (AOT) and Particle Size Parameter Algorithm Theoretical Basis Document (ATBD).**
- Revised theoretical and mathematical description of over-land aerosol retrieval to match algorithm implemented.
- Revision reflects updated surface reflectance band ratios.
- Expanded description of aerosol models used in look-up tables.
- Aggregation of AOT IP into AOT EDR and quality flags are now fully described.
- Updated/expanded the validation section using evaluation of actual VIIRS aerosol retrievals with AERONET and MODIS aerosol data.
- Methodology for NDVI-dependent surface reflectance band ratios, as a potential update for over-land retrieval, is discussed.
- Draft of updated ATBD is available now.
- Updated ATBD will be submitted in upcoming DR for requesting Provisional Maturity.

SM

- No update to SM ATBD.

Critical DRs

ADR Title	Aerosol retrieval anomaly following Mx6.3/6.4 transition		
ADR4962	Submit Date: 2012-10-19	PCR32735	Status: Closed
ADR Description	Following the recent Mx6.3/6.4 transition, VIIRS Aerosol EDR and IP values are showing up even for confidently cloudy areas (as determined by the VCM) where there should not be aerosol retrievals. The VCM input appears to be correct. However, the AOT IP Cloud Confidence Flag reports 'Confidently Clear' where the VCM says "Confidently Cloudy". As a result, aerosol retrievals are performed for much of the cloudy areas leading to increased AOT values.		
Note	Fix was implemented in Mx6.5 on 2012-11-27.		

ADR Title	Update spectral reflectance ratios for land inversion		
ADR4989	Submit Date: 2012-11-27	474-CCR-12-0788	Status: Closed
ADR Description	The pre-launch spectral reflectance ratios used in the land inversion were generated using MODIS /AERONET match-up data. These spectral reflectance ratios have been regenerated using VIIRS / AERONET match-up data. Reprocessing VIIRS data using the updated coefficients shows improvement versus AERONET in-situ measurements of AOT. The operational processing coefficients should be updated to use these new values.		
Note	New PCT of spectral reflectance ratios went into operation on 2013-01-22.		

Other DRs (1)

ADR Title	Aerosol inversion failure for a single pixel should not cause a granule failure		
ADR4889	Submit Date: 2012-09-04	PCR32259	Status: Closed
ADR Description	There are numerous reasons for an individual pixel inversion to fail in the main pixel loop of the VIIRS Aerosol algorithm. Error trapping has been implemented to avoid segmentation faults; however, the logic in the main pixel loop is incorrect and returns PRO_FAIL from the main program under certain error conditions. If an individual pixel inversion fails, that pixels should have all output values set to fill, the overall quality set to not produced and then processing should continue with the next pixel.		
Note	The fix is in Mx7.1 build with TTO 2013-06-27.		

ADR Title	Inconsistent Low Sun Quality Flags between aerosol IP and EDR products		
ADR4975	Submit Date: 2012-10-31	PCR33470	Status: Closed
ADR Description	When the two aerosol EDR low sun quality flags are compared against the aerosol IP day/night quality flag, there are data patches where the quality flags are not set correctly or consistently to the aerosol IP day/night flag. Investigation indicated that such inconsistency is due to the aerosol EDR low sun quality flags are set within the land/ocean aerosol retrieval determination loop. Therefore, for any EDR pixels that are not going to have aerosol retrievals because they are not land or ocean dominated, the corresponding aerosol EDR low sun quality flags will stay as the initial default values that may not be consistent to the aerosol IP day/night quality flag.		
Note	The fix is in Mx7.1 build with TTO 2013-06-27.		

Other DRs (2)

ADR Title	AOT IP does not contain proper fill at night in maneuver		
ADR5016	Submit Date: 2012-12-13	PCR32613	Status: Open
ADR Description	AOT IP has incorrect fill in maneuver at night, but ok in day.RTN PCR Wording: In VIIRS Maneuver PROXY Dataset 4, Granule NPP001212109974, the Aerosol Optical Thickness IP (AOT IP) does not properly contain ELINT fill. This is a night granule and the product seems to contain proper ELINT fill in day granules. This was found in build 7.F.		
Note	The fix is planned for IDPS_NPP_Maint_1.5.8.		

ADR Title	VIIRS Suspended Matter EDR not compliant with EDRPR		
ADR7049	Submit Date: 2013-02-14	PCR33804	Status: Open
ADR Description	Suspended Matter EDR is currently implemented to be fill when the VCM is not Confidently clear or Probably Clear. The EDRPR says: NPP.EDR.9.2 SM product shall be produced only for pixels under Confidently Clear as determined by the VCM. Fill values shall be used otherwise. The (under development) new Level 2 spec also says the same thing. The decision needs to be made now whether the EDRPR is changed (and upcoming Block 2 Level 2 spec as well as Level 3 SRS) or the implementation is changed. The current functionality is non-compliant with the EDRPR and fails current and Block 1.5 IDPS/PRO requirements.		
Note	Aerosol Cal/Val Team recommended to retrieve SM from both Confidently Clear and Probably Clear pixels; that is, the documentation should be changed not the code. The fix is planned for IDPS_NPP_Maint_1.5.8.		

Recent DRs

ADR4991	Update spectral reflectance ratios for land inversion to be a function of SWIR NDVI
ADR4988	Extend reporting range of AOT EDR
ADR4836	Inconsistency in VIIRS IP AOT and EDR AOT Quality Flag (QF) Definitions
ADR4724	Angstrom Exponent Quality Flag (IP) error
ADR4706	Update Aerosol LUT for RSR changes
ADR7113	Aerosol inversion over ocean should not use band M6 when saturation rollover is possible
ADR7115	Calculation of residual for band M7 is not skipped in over-ocean aerosol retrieval

Caveats

- AOT:
  - Recommend using only high quality EDR and IP
  - Accuracy and precision values over land are derived from “only” two months of VIIRS retrievals (Feb-Mar, 2013), which have the updated surface reflectance band ratios implemented
  - Testing and tuning of various internal tests are still ongoing (expected to minimize artifacts associated with snow melt, etc.)
- APSP (AE):
  - Only “best quality” AE with AOT greater than 0.4 over ocean correlates moderately well with ground-based measurements.
  - AE over land is not recommended.
- SM:
  - SM is not recommended for use at this time.

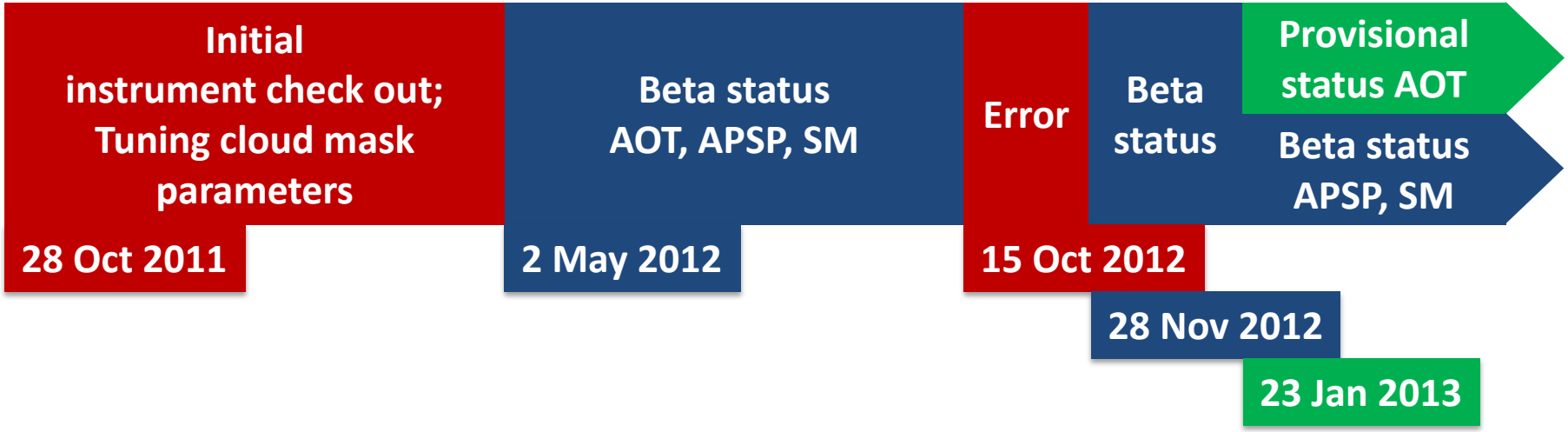
Work planned before Validated 1
(Path forward)

- **AOT and APSP:**
  - Monitor the effect of latest changes to the VCM, and adapt aerosol PCT and code to these changes, if necessary;
  - Investigate options for reducing std in fit of surface reflectance band ratios (may lead to decrease in number of negative AOT retrievals over land);
  - Test NDVI-dependent surface reflectance ratio using a longer time period;
  - Implement NDVI-dependent surface reflectance ratio;
  - Evaluate VIIRS APSP (and MODIS AE) with MAN APSP over open ocean;
  - Test and expand valid range of land and ocean AOT retrievals from 2 to 5 at the high end and from zero to small negatives at the low end;
  - Test the elimination of the internal snow/ice flag over oceans;
  - Evaluate choice of aerosol models, land and ocean, in terms of covering adequate solution space and consequences for retrieving AE;
- **SM**
  - Additional testing with new LUT over ocean retrievals to see if there is any skill. Even so, over land product will continue to be an issue
  - Complete testing of alternate algorithm based on deep blue and mid-IR channels for different scenarios; make it a stand alone SM algorithm for operational implementation, and update SM ATBD

Assessment of Data Quality Threshold Tables

- The current aerosol Data Quality monitoring reports summaries of
  - AOT, APSP, SM and SM typing product quality,
  - AOT, APSP, SM detection and SM typing exclusion.
- The current DQTTs are adequate, no update is necessary for Provisional Maturity.
- DQTTs will be re-evaluated using several months of Provisional aerosol data
  - Updates to DQTT will be implemented if needed at the time of Validated 1 Maturity.

Product Timeline



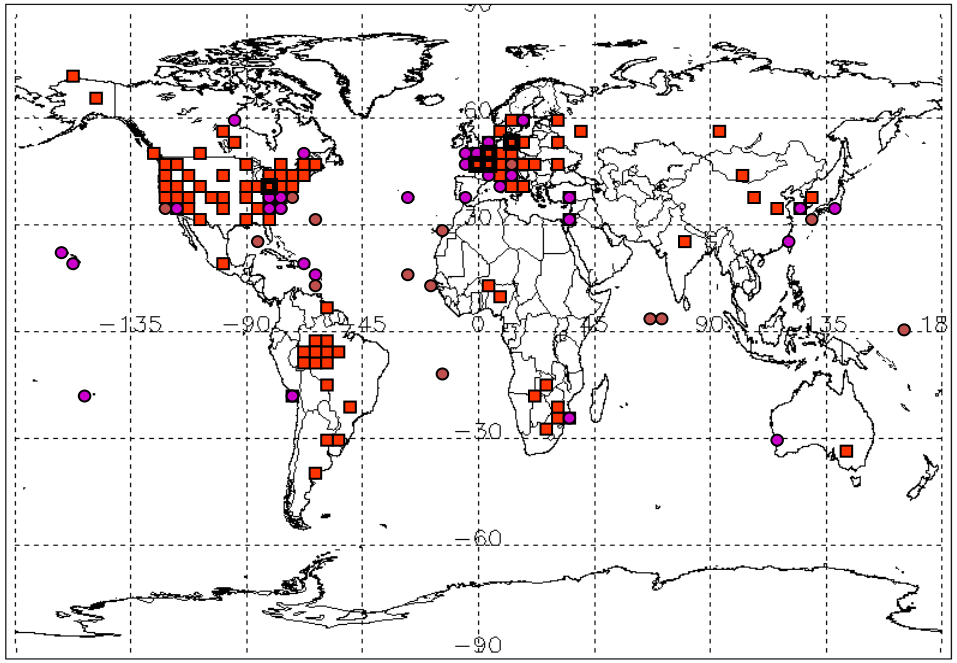
Red periods:	Product is not available to public, or product should not be used.
Blue periods:	Product is available to public, but it should be used with caution, known problems, frequent changes.
Green period:	Product is available to public; users are encouraged to evaluate.

IN PERSPECTIVE - VIIRS VS. MODIS ALGORITHM EVOLUTION

In perspective

VIIRS vs. MODIS algorithm evolution

3 years after Terra launch



Global validation heavily weighted to Eastern U.S. and western Europe, with Amazon also well-represented.

ALL VEGETATED SURFACES

1 year after Suomi-NPP launch

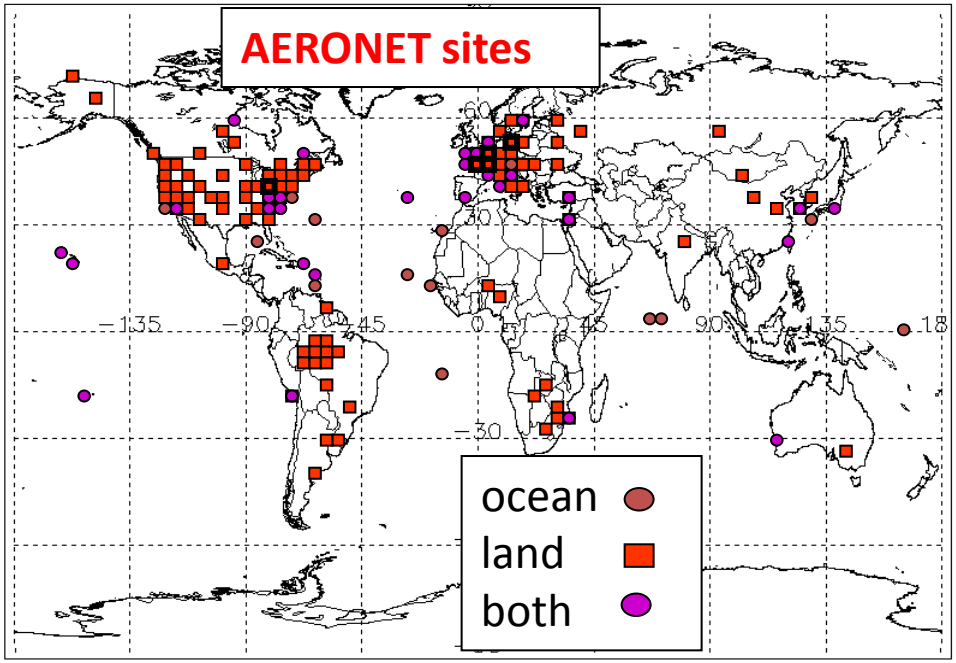
In time AERONET spread out to less desirable surfaces and MODIS retrieval “got worse”

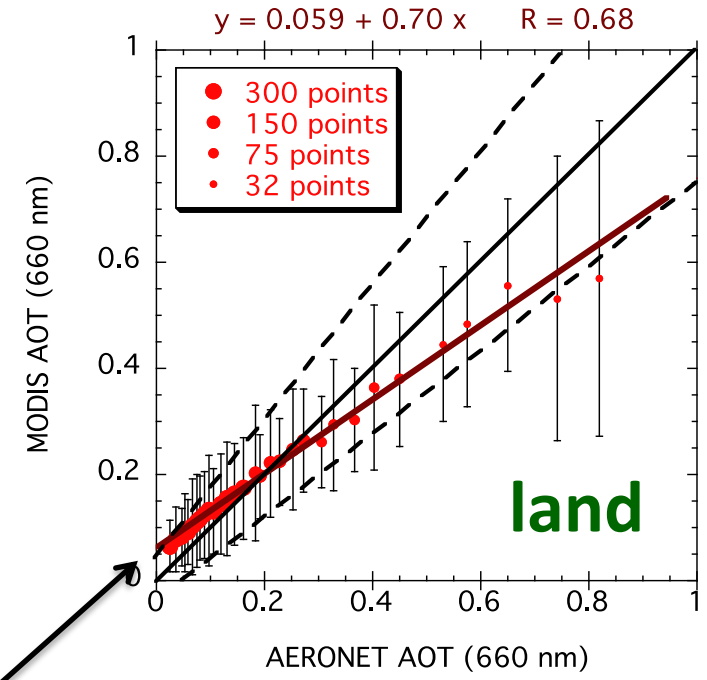
VIIRS is facing a harder “audience”

In perspective

VIIRS vs. MODIS algorithm evolution

MODIS aerosol validation 2000-2002
(3 years after Terra launch)

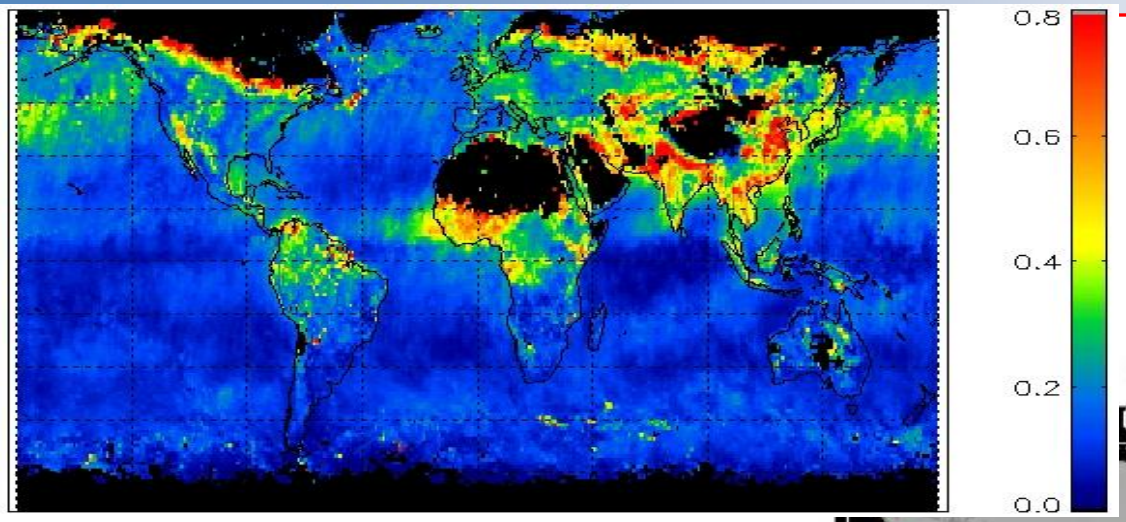




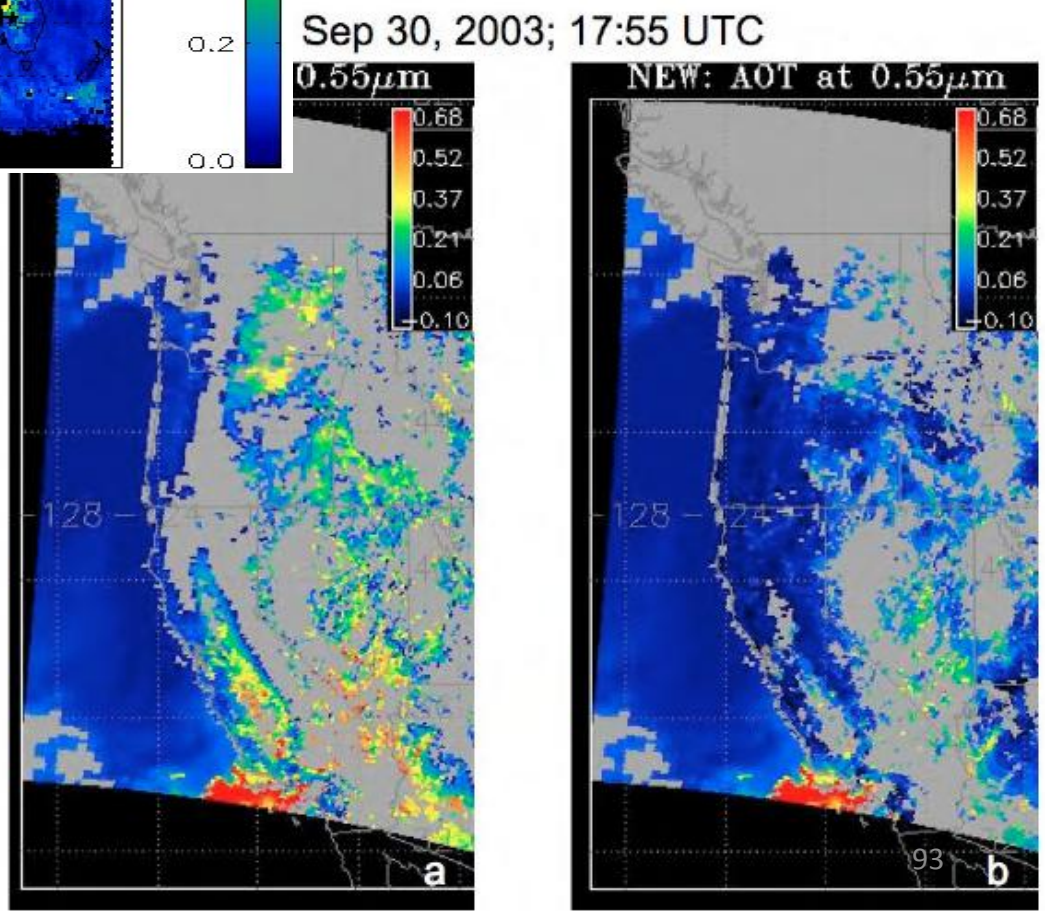
0.06 high bias over land,
against “favorable” AERONET stations.
2 years later this bias was closer to 0.10

In perspective

VIIRS vs. MODIS algorithm evolution



4 years after launch and still plagued by Spring thaw snow melt and artificial AOT of 0.2 to 0.3 over low NDVI areas and places with complex topography, which was finally eliminated in 2006 (6 years after launch)



In perspective

VIIRS vs. MODIS algorithm evolution

It's only been 18 months since launch of VIIRS

- Already VIIRS is producing AOT and AE with accuracy equal to MODIS that took MODIS 4 to 6 years to accomplish!

From the MODIS perspective, VIIRS is advancing at light speed, and people need to be patient with the expectations.