JPSS DPA Program Planning Meeting
Aerosol EDR Team

Istvan Laszlo & Shobha Kondragunta

Aerosol EDR Leads

September 21, 2012

Overview of Data Products

VIIRS aerosol EDRs

Parameter Name	Units	Horizontal Cell Size	Comments
Aerosol Optical Thickness (AOT)	Dimensionless	6 km (Nadir)	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 Wavelength Exponent	6 km (Nadir)	Ångström Wavelength Exponent calculated from optical depths at pairs of wavelengths.
Suspended Matter (SM)		0.75 km (Nadir)	Flags (ash, dust, smoke, sea salt, unknown, none) indicating presence of suspended matter in a pixel.

Team Members' Roles & Responsibilities

EDR	Name	Organization	Funding Agency	Task
Lead	Istvan Laszlo	NOAA/NESDIS/STAR	NJO	Co-lead aerosol EDR Team
Lead	Shobha Kondragunta	NOAA/NESDIS/STAR	NJO	Co-lead aerosol EDR team
Member	Lorraine Remer	UMBC	NJO	AOT Algorithm development, user workshops, and proving ground activities
Member	Hongqing Liu	Riverside Technology Incorporated	NJO	Data visualization, AOT algorithm development, and AOT product validation
Member	Jingfeng Huang	UMD-CICS	NJO	AOT Algorithm development and product validation
Member	Heather Cronk	Integrity Applications Incorporated	NJO	Data management and user interaction, VCM liaison
Member	Ho-Chun Huang	UMD-CICS	NJO	Suspended Matter algorithm development and AOT product validation
Member	New hire	STAR scitech II	NJO	Maintain different versions of algorithm code(s)

Team Members' Roles & Responsibilities (cont.)

EDR	Name	Organization	Funding Agency	Task
Member	Bob Holz and Min Oo	UW-Madison	NJO	Product validation and science team support
Member	Edward Hyer	NRL	NJO	Product validation and assimilation activities
Member	Christina Hsu and Andrew Sayer	NASA	NJO and NASA through NPP science team	Deep blue AOT algorithm development
Member	Robert Levy, Leigh Munchak, Shana Mattoo	SSAI at NASA	NASA through NPP science team	Algorithm and product evaluation
Member	Brent Holben	NASA	NJO	AERONET observations for validation work
Member	Sid Jackson	NGAS	NJO	Support VIIRS cal/val team activities and a liaison to SDR team

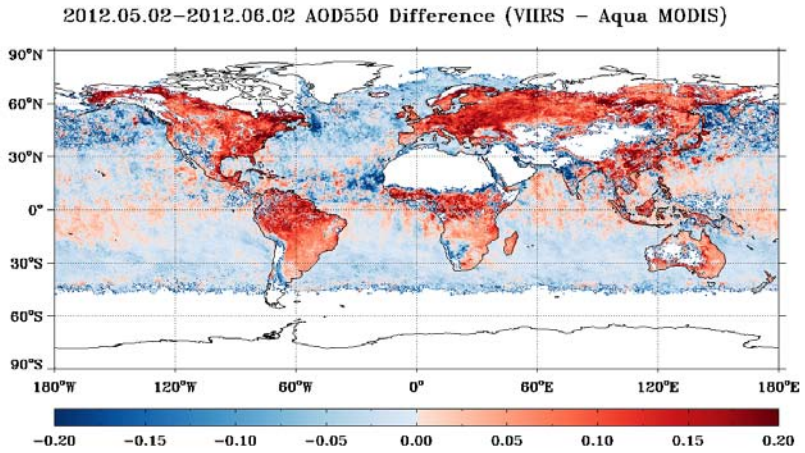
External

FY-12 Accomplishments (Summary)

- Understanding/testing VIIRS aerosol algorithm
  - Submitting and responding to DRs
  - Test runs of various versions of ADL
    - Some investigative runs (see Scientific Advancements)
- Beta submission – FY12 milestone
  - AOT and APSP EDRs are at Beta Maturity
  - SM is not at Beta Maturity
- Update ATBD – FY12 milestone
  - A substantial re-write of the ATBD is underway. Draft version of the completely revised description of the over-land aerosol retrieval has been distributed to team members for review.
  - Ongoing work to check for consistency between ATBD and operational code.
- Develop validation tools – FY12 milestone
  - SM validation tool that relies on CALIPSO data
  - AOT validation tools that rely on AERONET and MODIS data
- Submitted/investigated 10 DRs

Validaiton of Suomi NPP VIIRS Aerosol Products

- VIIRS aerosol EDRs
  - Aerosol Optical Thickness (AOT)
  - Aerosol Particle Size Parameter (APSP)
  - Suspended Matter (SM)
- Aerosol EDR Assessment Basis to demonstrate "Beta Maturity" level:
  - Data from May 2 to June 2, 2012
  - Qualitative and quantitative analysis of comparisons with other satellite (MODIS and CALIPSO) and ground-based (AERONET) aerosol data



Spatial patterns of mean difference between VIIRS and MODIS AOT showing VIIRS is biased high over land and biased low over ocean.

Recommendation of VIIRS Aerosol Cal/Val Team

- VIIRS aerosol EDRs at beta level
  - AOT (land and ocean)
  - APSP (land and ocean)
- VIIRS aerosol EDRs NOT at beta level
  - SM

Sponsored by JPSS Project Office

Error bounds for AOT defined by one standard deviation (68% of Retrievals)

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

Courtesy of S. Kondragunta and I. Laszlo (STAR) and NPP VIIRS Aerosol Cal/Val Team

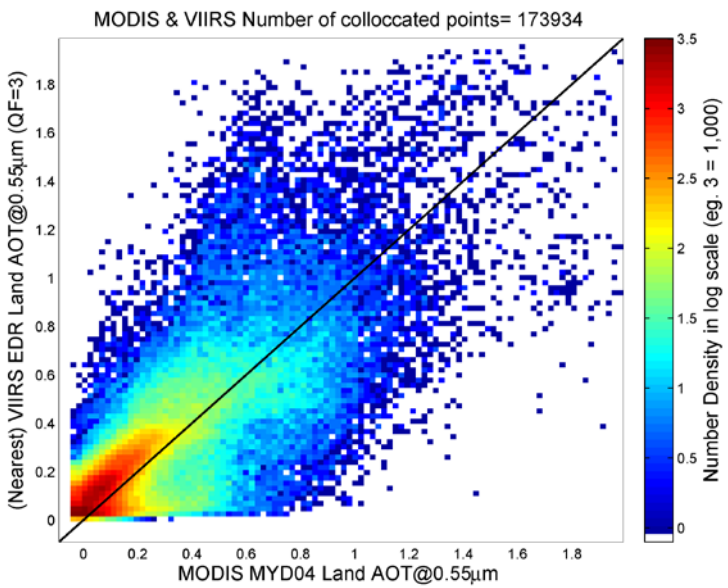
Significance: Preparing users for VIIRS aerosol products by conducting preliminary validation and showing what products are at beta maturity level.

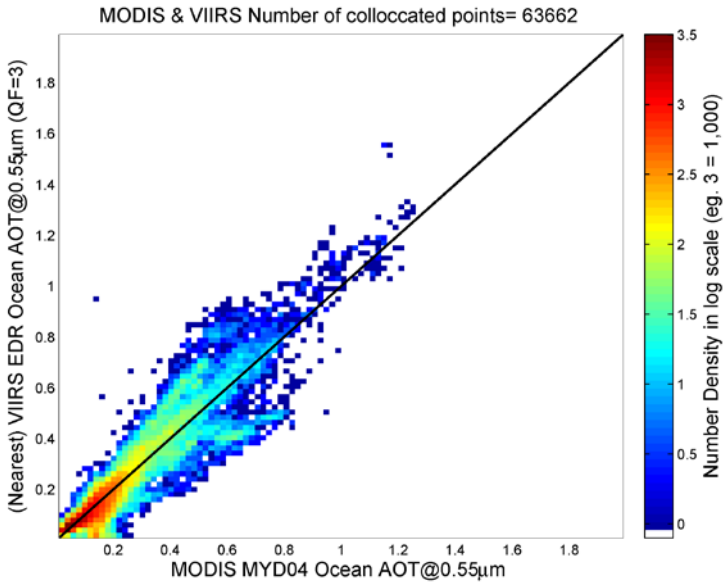
FY-12 Accomplishments

Evaluation with independent Satellite Data

- Initial evaluation of AOT with collocated MODIS data

Land **VIIRS-MODIS AOT difference** Ocean





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

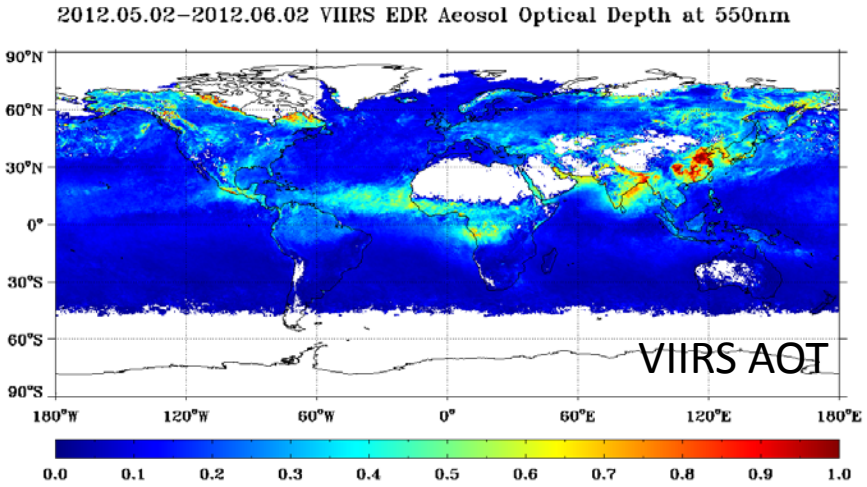
- *Land*: over-estimation on average, large scatter.
- *Ocean*: good agreement on average, reduced scatter.

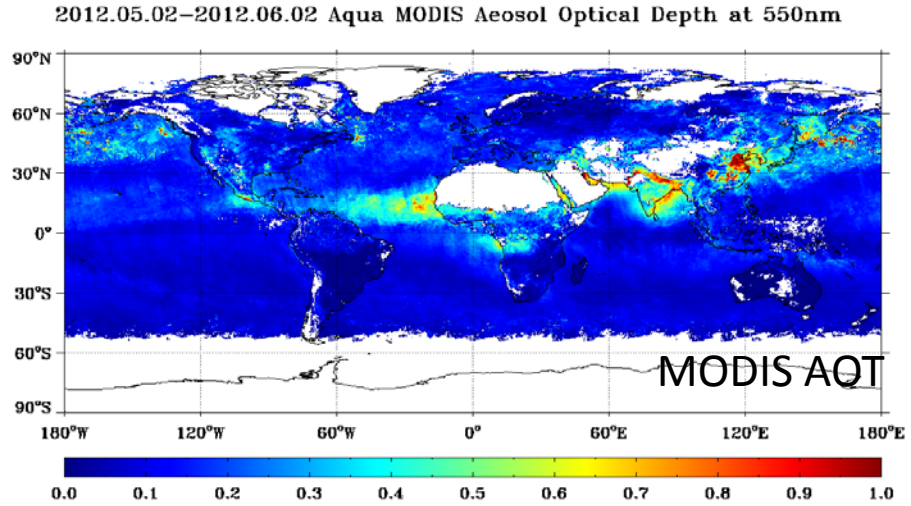
VIIRS land and ocean algorithms are different

FY-12 Accomplishments

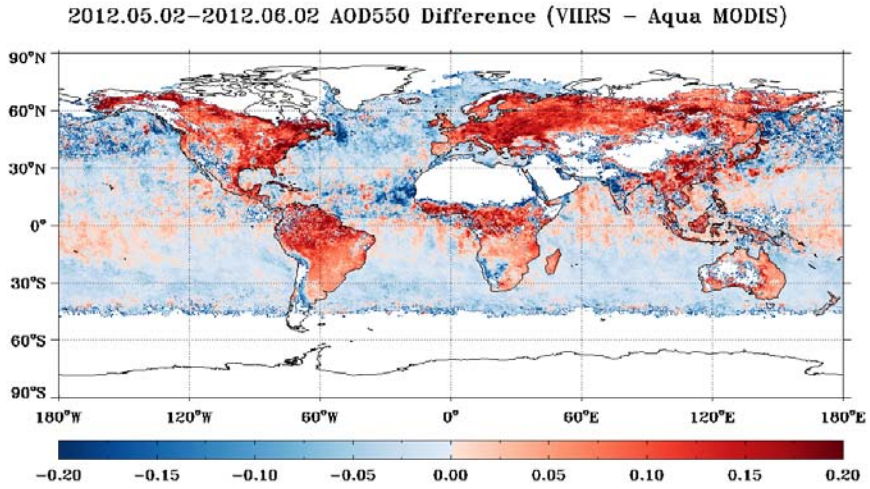
Evaluation of AOT with Independent Satellite Data

- Initial evaluation of AOT with non-collocated MODIS data





VIIRS-MODIS AOT

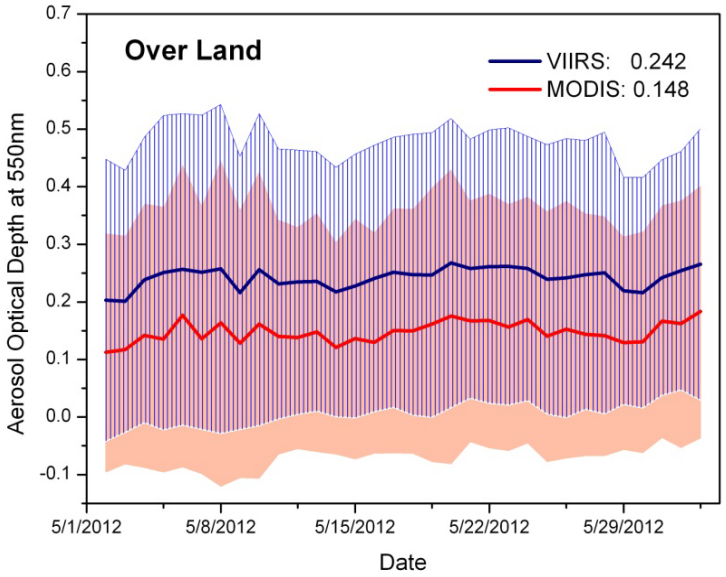


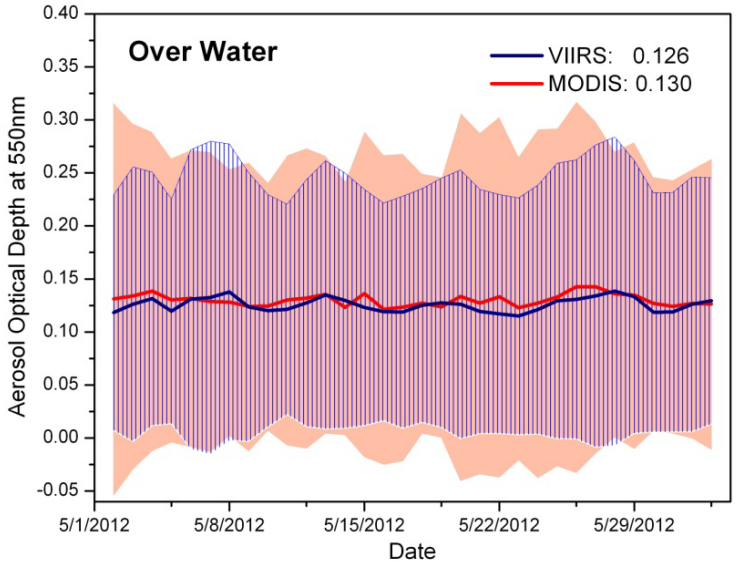
- Best quality VIIRS AOT and Collection 5.1 Aqua MODIS AOT (best quality over land and all quality over ocean) are mapped into 0.25° x 0.25° grids.
- Over-estimation over dark land regions, under-estimation over brighter land and in desert transition regions.
- Smaller negative bias and under-estimation in dust outflow regions over ocean.

FY-12 Accomplishments

Evaluation of AOT with Independent Satellite Data

- Time series of AOT and non-collocated MODIS data

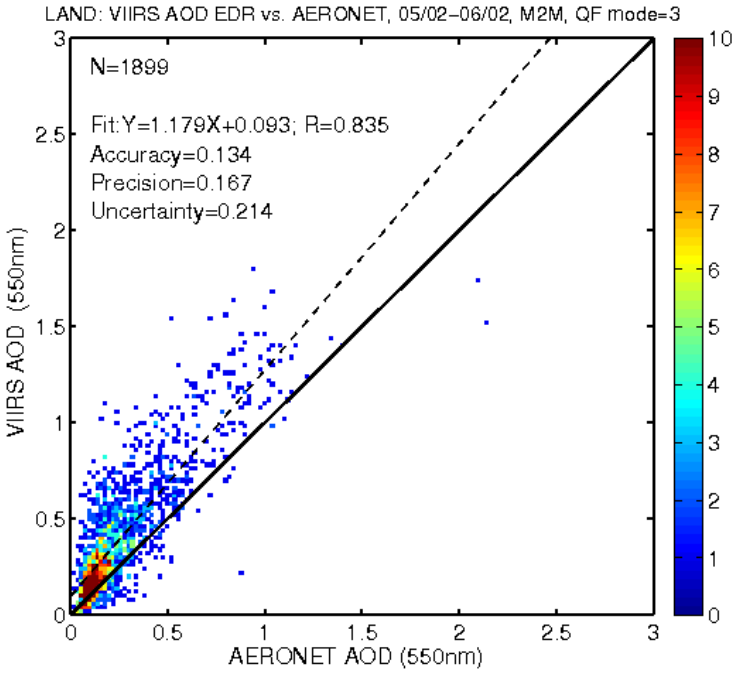


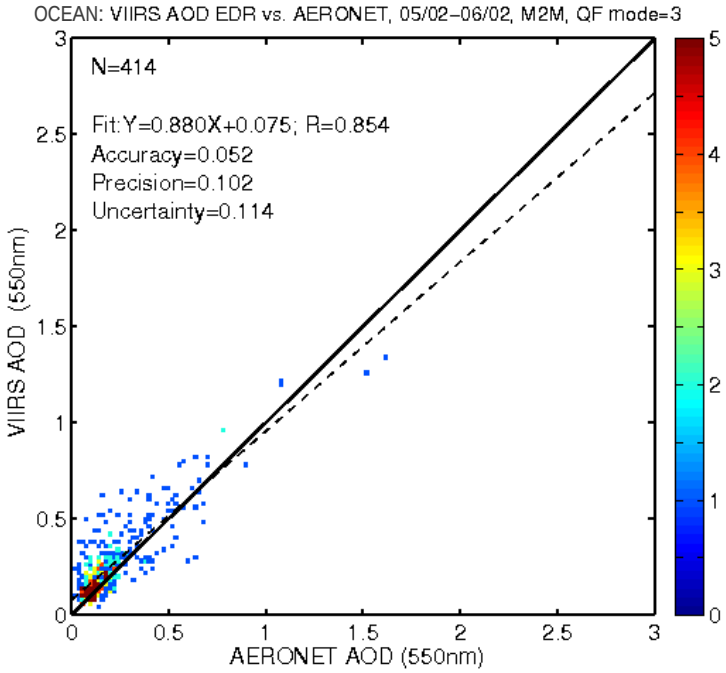


- Over land, VIIRS AOT is systematically higher than MODIS, but VIIRS and MODIS AOT track each other.
- Over ocean, VIIRS AOT is higher on some days and lower on others, but overall VIIRS and MODIS AOT agree rather well; standard deviation of VIIRS AOT on most days is smaller than the of MODIS AOT.

FY-12 Accomplishments

Evaluation of AOT with AERONET





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.

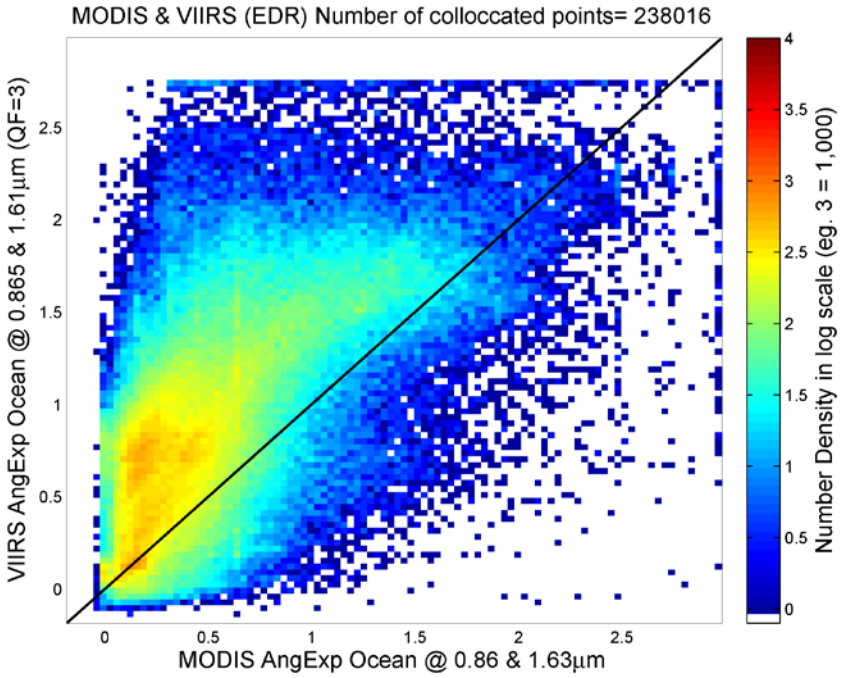
Error bounds Defined by One Standard Deviation (68% of Retrievals)

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

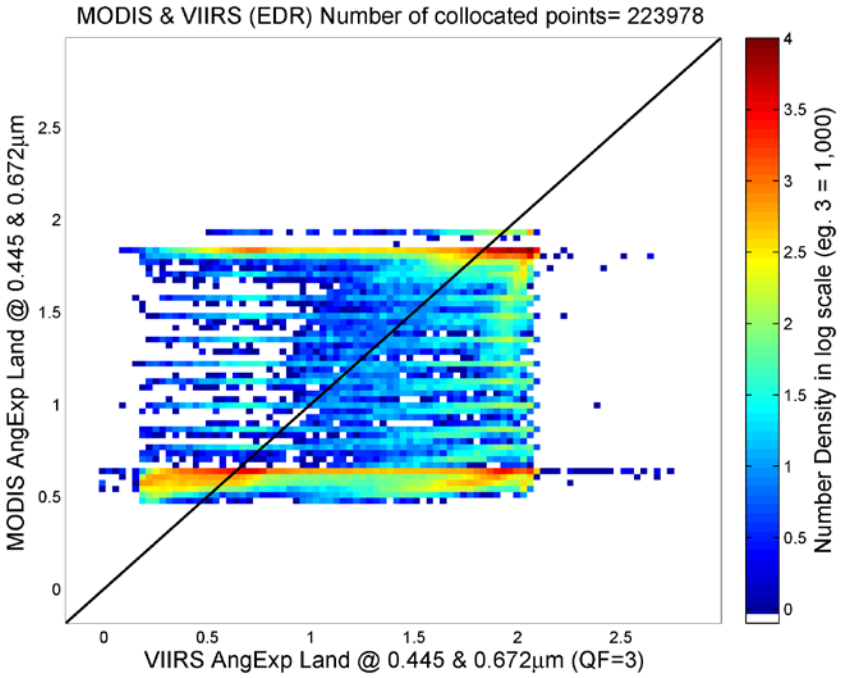
FY-12 Accomplishments

Evaluation of APSP with independent Satellite Data & AERONET

Ocean



Land



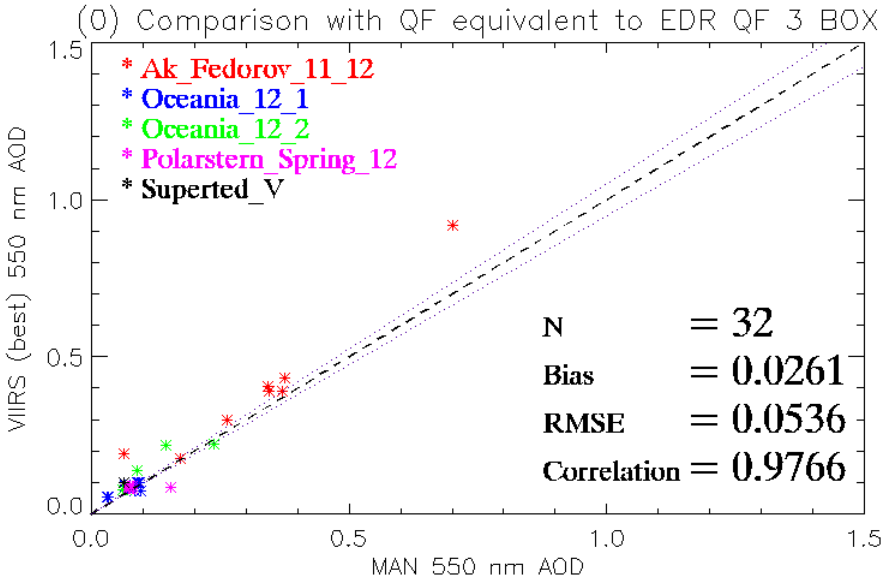
- Best quality VIIRS and MODIS AE data used.
- AE overestimated compared to MODIS over ocean; but, when data are screened for AOT > 0.4, the agreement is better.
- No skill to retrieve AE over land.
- **Same conclusion when compared to AERONET.**

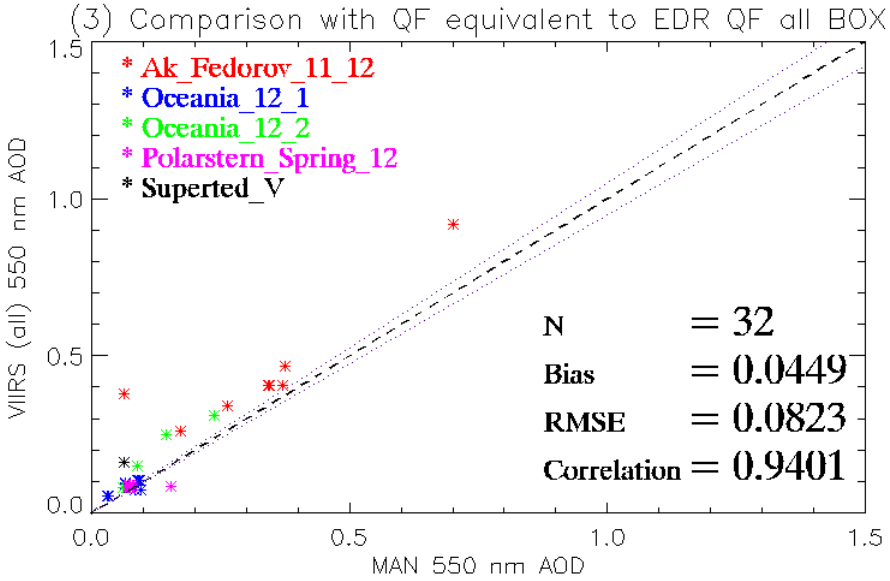
Error bounds Defined by One Standard Deviation (68% of Retrievals)

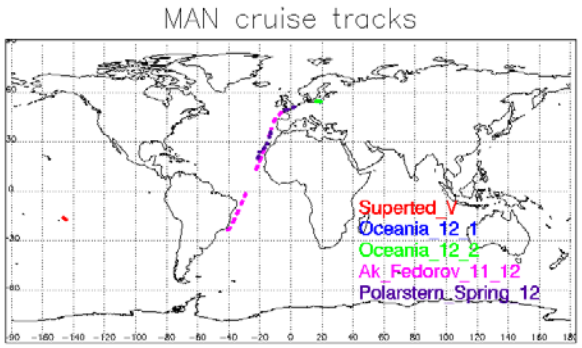
	land	ocean
AERONET	±0.5	±0.5
MODIS		±0.5

FY-12 Accomplishments

Evaluation of AOT over Ocean using MAN Data



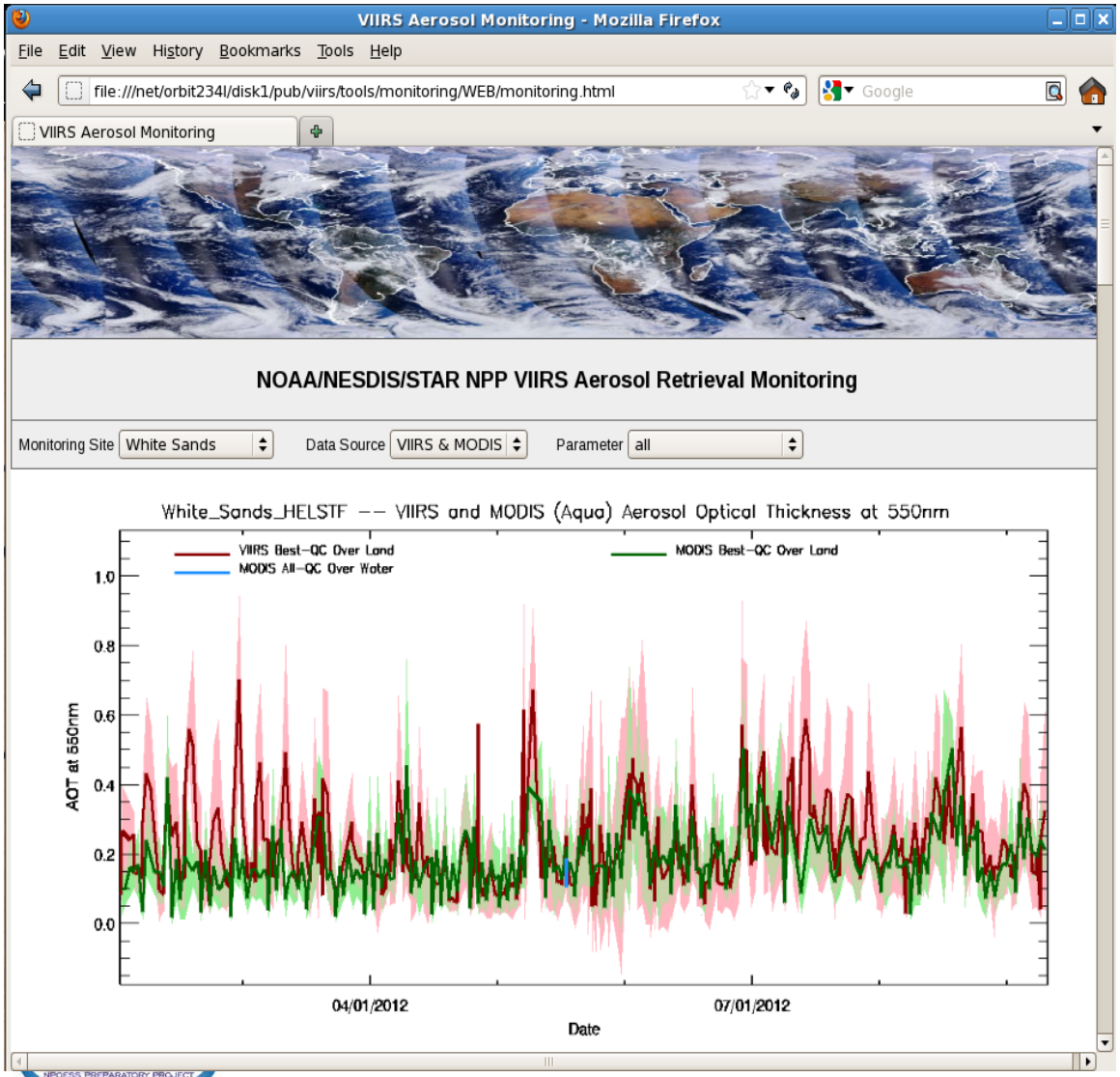




VIIRS vs. MAN AOT Match-Up

- Maritime Aerosol Network (MAN) AOT data from commercial and research cruises used to evaluate VIIRS AOT over Ocean. *Routine AERONET stations are located over islands or near coasts. MAN data offers measurements over open Ocean*.
- Analysis using matchups based on VIIRS AOT in a pixel closest to MAN location shows that VIIRS AOT over Ocean has a very low bias. Analysis using other matchup criteria shows similar results.

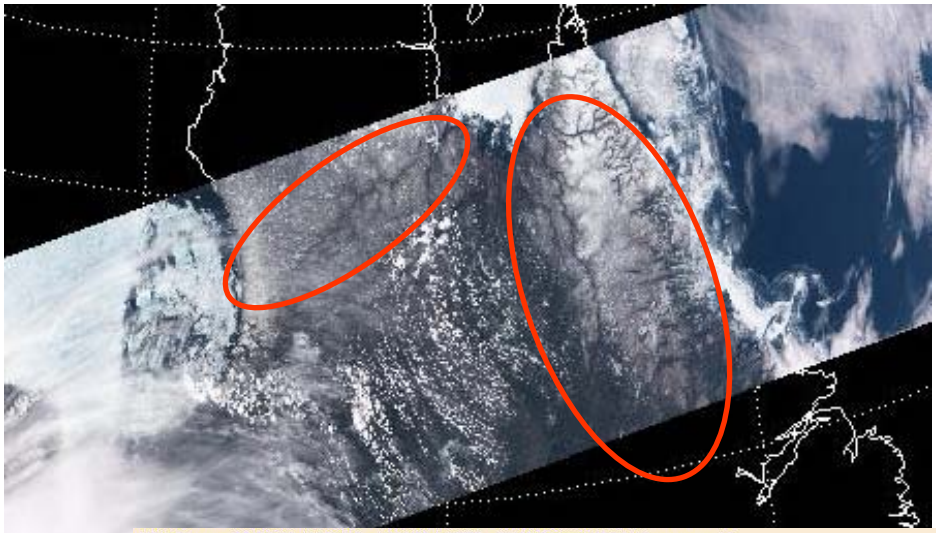
FY-12 Accomplishments
Monitoring Tools

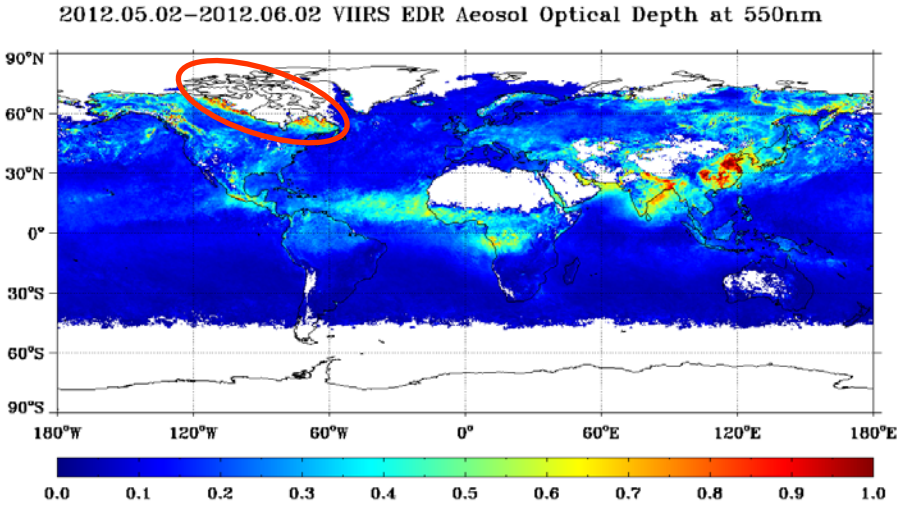


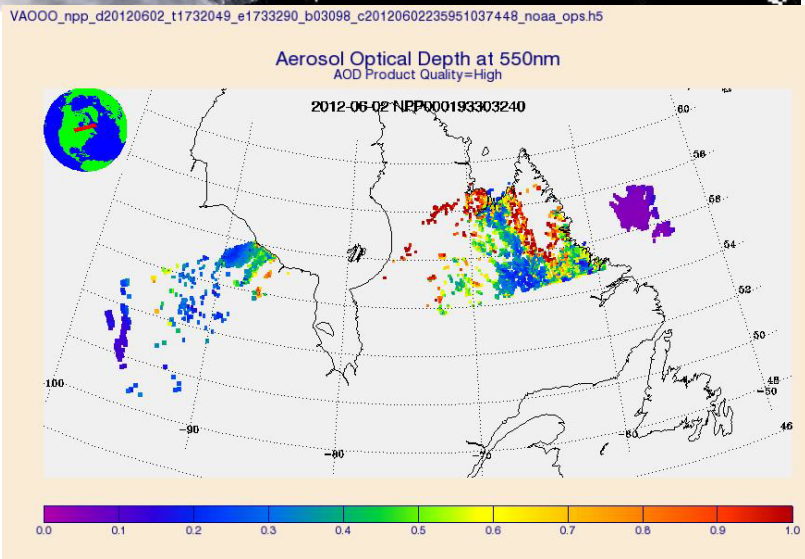
- Trending plots are generated for six different AERONET stations with low cloud cover.
  - Trending plots of AOT, angstrom exponent, reflectance, cloud fraction, and retrieval counts.
  - Trending plots of bias between VIIRS vs. AERONET and VIIRS vs. MODIS AOTs.

Issue: High AOD belt over Canada from VIIRS

Plausible reasons under investigation:
- cloud contamination
- unfavorable surface condition due to snow melting
- smoke plumes from biomass burning



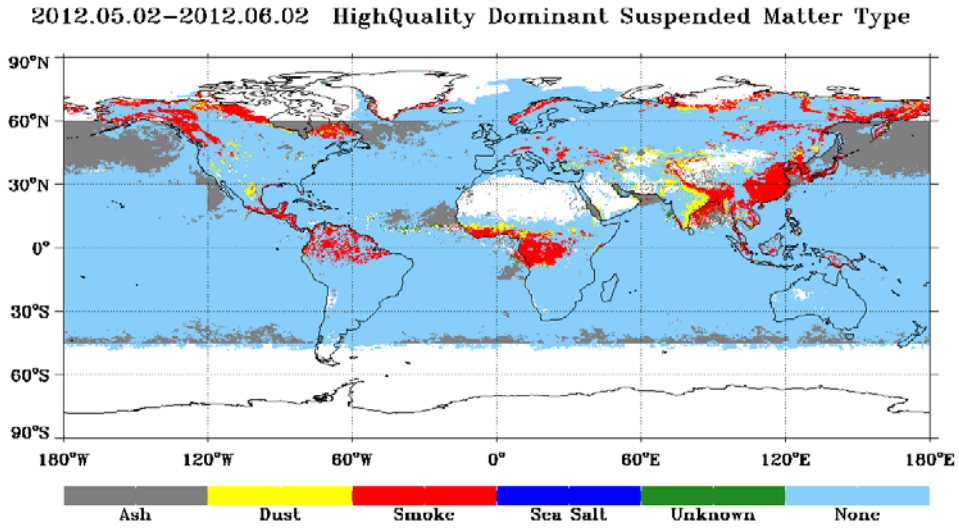




FY-12 Accomplishments

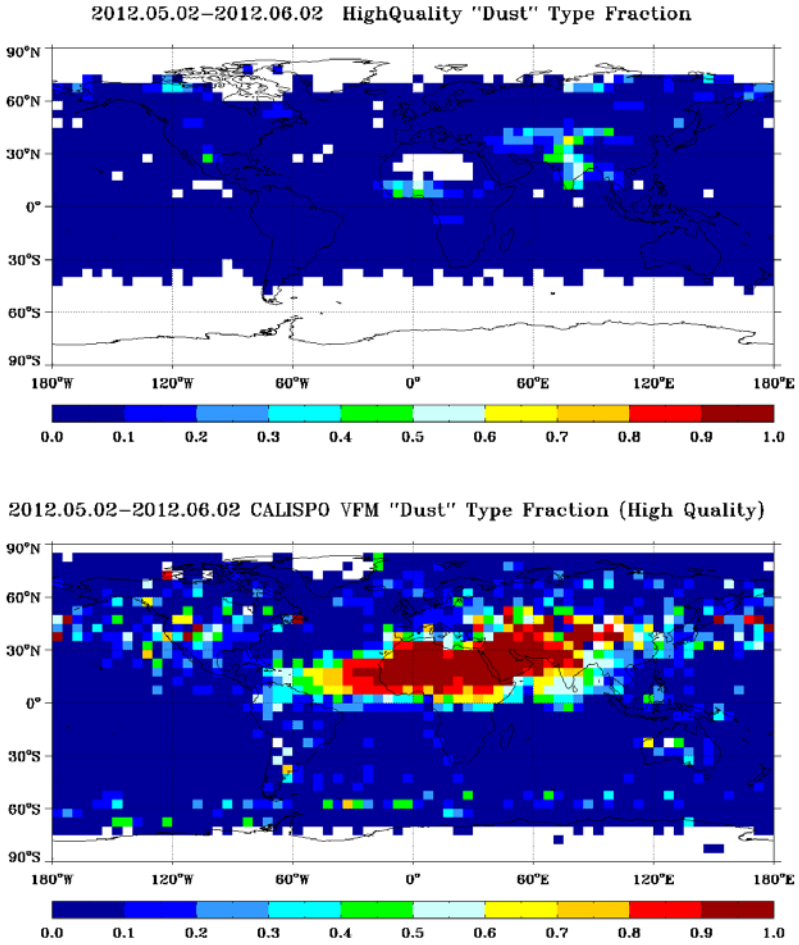
Evaluation of SM

VIIRS dominant SM



- Too much smoke over land
- Too much volcanic ash, especially in regions where volcanic ash is not expected to be present (*VCM turned off volcanic ash tests based on feedback from aerosol team*)
- Missing dust over near dust sources and dust outflow regions (e.g., off of African coast)
- Patterns of VIIRS smoke do not match with CALIPSO (not shown)

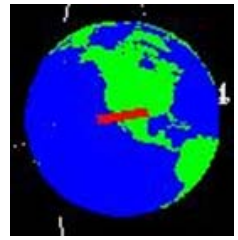
Dust fraction from VIIRS (top) and CALIPSO (bottom)

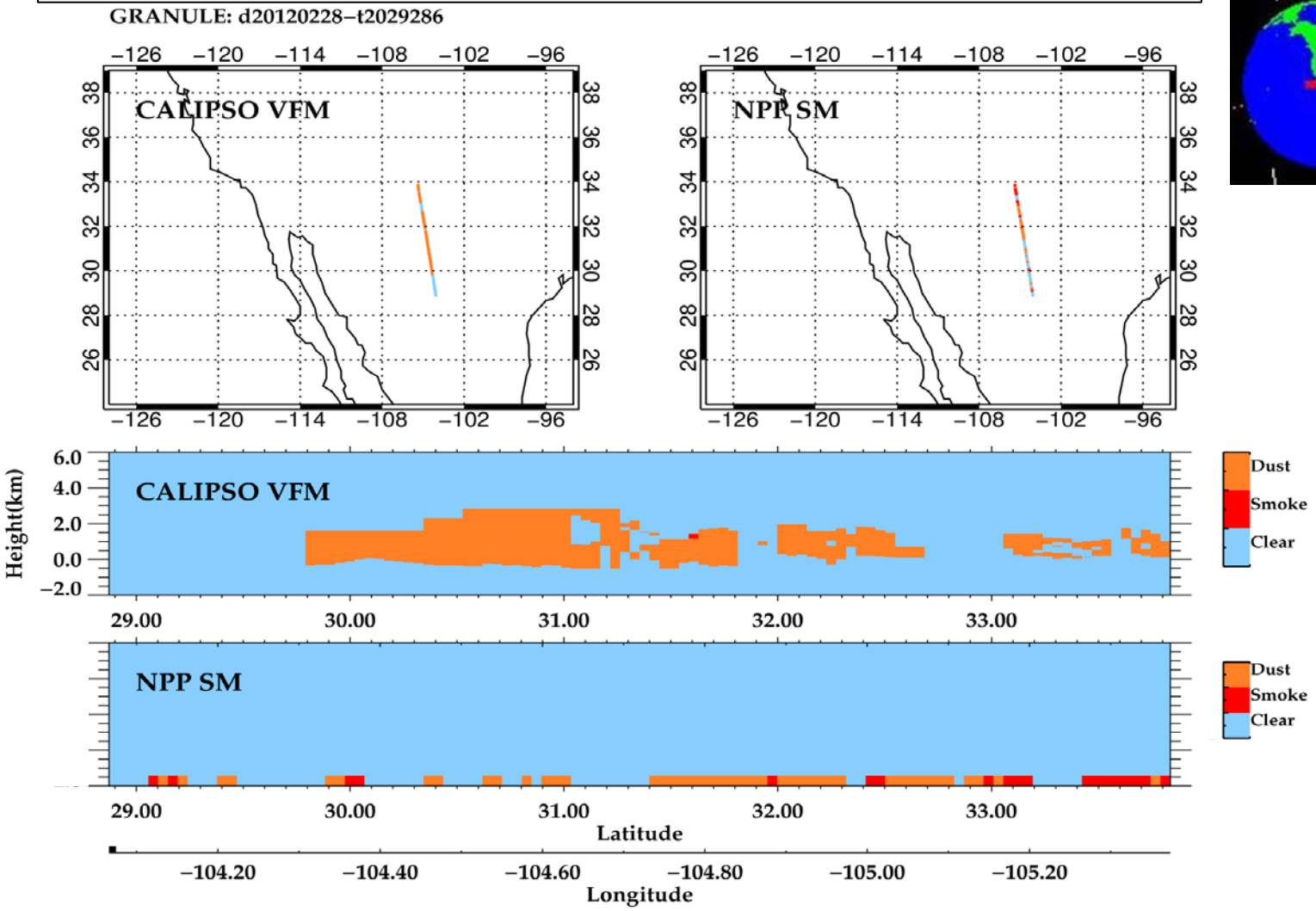


FY-12 Accomplishments

Evaluation of SM

	all data	med-high quality	High quality only
Correct Classification Ratio:	**47 %**	**34%**	**30%**



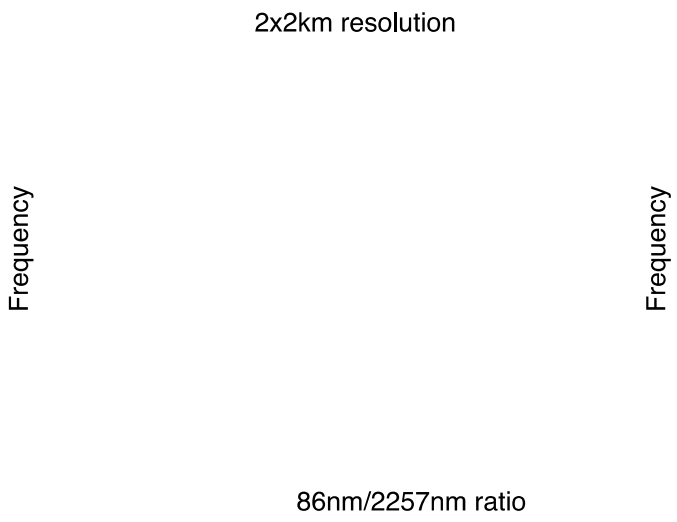


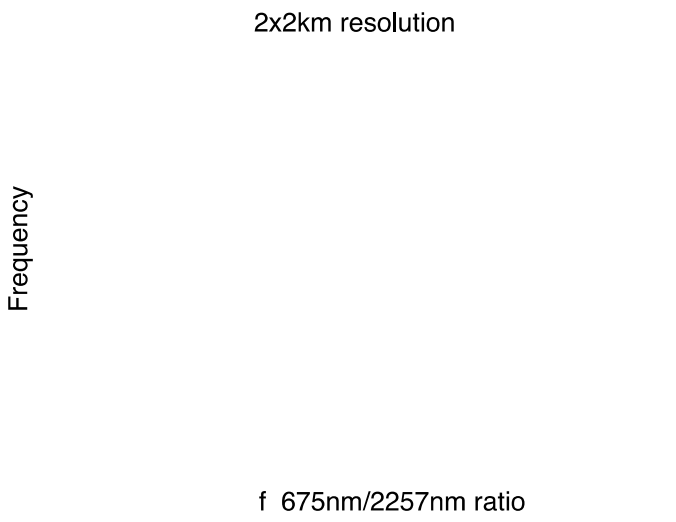
FY12 Accomplishments: DRs

DR number	Short Description
4517	Algorithm crashes when sensor zenith angle > 80 deg during lunar roll maneuver. - OPEN (Permanent fix has been worked out and submitted)
4598	The NAAPS data are transposed in IVAOT – CLOSED (fixed in Mx6.2)
4658	Logic for determining Land / Water / Not Processed path for Aerosol EDR aggregation is incorrect in extended pixel trim region – CLOSED (fixed in Mx6.3)
4697	Incorrect recurrence formula for calculating molecular spherical albedo – CLOSED (fixed in Mx6.2)
4706	Update Aerosol LUT for RSR changes – OPEN (no PCR yet)
4724	The Angstrom Exponent IP Quality Flag is incorrectly set as “High Quality” for bowtie deleted pixels. It should be “Not Produced” - OPEN
4836	Make IP and EDR AOT quality flags consistent - OPEN
4862	Declare aerosol AOT and APSP EDRs beta - CLOSED
4888	Make IP AOT available to user community - OPEN
4889	Current error trapping logic results in failed retrieval for the entire granule when aerosol inversion fails for a single pixel - OPEN

Scientific Advancements

- Spectral Surface Reflectance Ratios used in the operational algorithm are being examined from surface reflectances retrieved from VIIRS TOA reflectance and AERONET AOT:
  - used Land PEATE VIIRS AERONET collocation files
  - 193 AERONET sites, 1 month (MAY) collocation
  - approximately ~ 2900 clear sky conditions
  - analysis suggests a higher M3/M5 ratio of 0.693 instead of current value of 0.578 – expected to lower AOT at most places

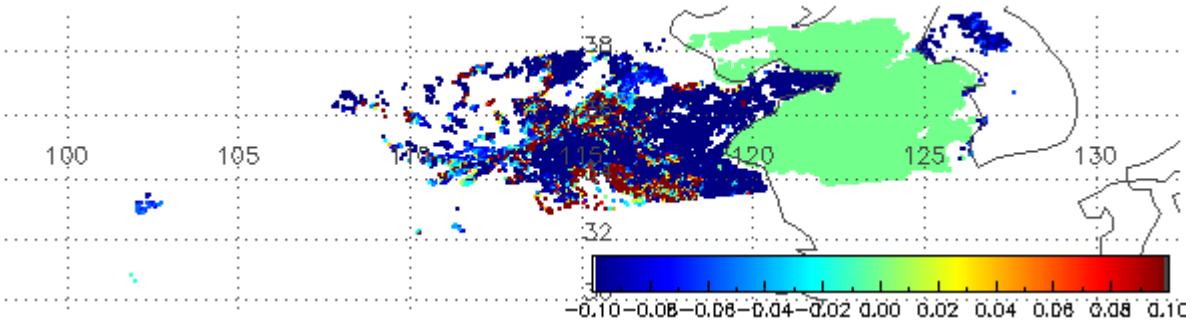




Frequency distribution of M3/M11 (left) and M5/M11 (right) surface reflectances

Scientific Advancements

- High AOT bias over land has been identified
  - Possible dominant cause is identified as inadequate spectral surface reflectance ratios:
    - ADL test runs with adjusted ratios (for testing sensitivity)



Changing the current M3/M5 ratio of 0.578 to 0.678 reduces the AOT over land in most places. May need regional and monthly ratios (or NDVI-dependent), eventually.

Issues, Challenges, Setbacks

- High AOT bias over land
  - Tune or establish new spectral surface reflectance ratios.
- No skill in retrieving Angstrom Exponent over land
  - Revised LUT and surface reflectance ratios may improve spectral AOT
  - Calculate Angstrom Exponent from “single-channel” AOT
    - aerosol model selected by multichannel-retrieval will not dominate APSP
    - not binary (MODIS) or quintuple (current VIIRS)
  - APSP may not be improved
    - theoretical limitations: not enough independent information to retrieve 3 parameters (surface reflectance, AOT, aerosol model)
- Artificially high AOT and APSP in the snow melt region.
  - Revise spectral thresholds for sub-pixel snow/ice mask tests.

Issues, Challenges, Setbacks

- Low bias in AOT over ocean in dust outflow regions.
  - Revisions to dust aerosol model?
- Proportion of AOT attributed to small particles is unexpectedly too high over ocean.
  - Effects dust detection in SM algorithm. Revising fine mode fraction threshold used could improve dust detection.
- Incorrect SM typing
  - lower AOT threshold from 1.0 to 0.5
  - tune thresholds to improve detection of dust over ocean.
- Internal fire test fails to find any fires, even when large fires are known to be active.
- Snow and ice detected in unlikely places.
  - Will rely on fixes to snow/ice information from VCM
  - Tune internal snow/ice tests
- Running aerosol algorithms in ADL to diagnose issues and test algorithm changes
  - Implementation of new versions of ADL on local system is taking too much time. For example ADL 4.1 is coming out soon and we have not installed ADL4.0 yet.
  - Limited capability for processing large volume of data. *As of this week we developed wrappers based on perl/shell scripts to automate the process and run multiple granules.*
  - Availability of tools required to generate ADL compatible input files (ancillary data). *We are circumventing this by running parts of SDR code to generate ancillary files.*

Changes in Strategy (due to funding constraints)

- Slower pace of algorithm improvements
  - Deep blue AOT algorithm work to begin in FY13 by Christina Hsu. *NWS has a user requirement.*
  - Implementation of deep blue AOT algorithm into IDPS and ADL will require additional support to STAR and NGAS? Path forward not clear.
- Reduced level of new algorithm development
  - New methods recently developed may not be implemented
- Delay in testing and implementing algorithm improvements if/when cal/val team and users find product inaccuracies.

FY-13 Schedule and Milestones

- Documentation of VIIRS aerosol product maturity status as provisional (March 2013)
- Revisions to ATBDs (rev 1: November 2012, rev 2: November 2013)
- Demonstrate the capability for generating/updating LUT (February 2013)
- Updated spectral surface reflectance ratios (November 2012, July 2013)
- Revised thresholds and code for improving SM (June 2013)
- Code implementing updated internal test for snow detection (May 2013)
- Source codes and lookup tables for the Deep Blue algorithm to retrieval aerosol optical thickness over deserts (October 30, 2013)
- ATBD document for VIIRS Deep Blue algorithm (November 30, 2013)
- VIIRS/MODIS and VIIRS CALIOP collocated products (global)
- Reports providing the current assessment of the VIIRS aerosol products based on results from the direct match up processing (March 2013, March 2014)
- Report on feasibility for improved APSP over land (March 2014)
- AERONET level 1.5 (real-time) data set for validation purposes (continuous)
- User workshop (September 2013)
- Quarterly reports

Path Forward (FY-13 thru FY-17)

(assume "FYxx" runs from April 1, 20xx to March 31, 20xx+1)

	Suomi NPP	JPSS J1
FY13	• Version 2 of ATBD • Updated surface reflectance ratios and revisions to snow internal test implemented • Revised thresholds for SM implemented • AERONET level 1.5 (real-time) data set for validation • Provisional Maturity level reached • User workshop	JPSS Risk Reduction Projects: •Test GOES-R ABI algorithms on VIIRS data • Adapt MODIS deep blue dust index algorithm for VIIRS
FY14	• First version of Deep-Blue algorithm implemented/tested • Stage 1 Validation level reached • Version 3 of ATBD • Stage 2 Validation level reached	• Hold algorithm preliminary design reviews • Define validation plan
FY15	• Stage 3 Validation level reached • Version 4 of ATBD	• Hold algorithm critical design reviews • Begin transitioning to JPSS • Redefine aerosol EDR (APSP) if needed • Generate LUTs for J1 VIIRS sensor
FY16	• Long-term validation of VIIRS aerosol data record	• J1 launch • Beta maturity status
FY17		• Aerosol EDR evaluation: provisional maturity status

Summary

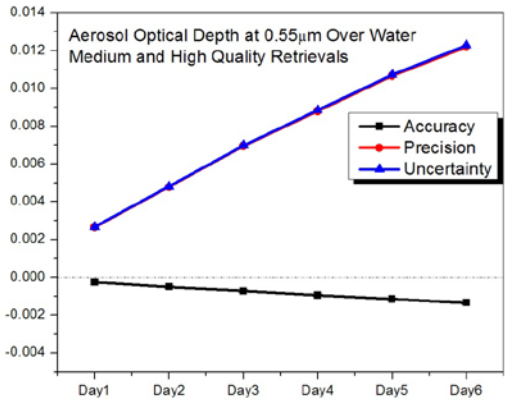
- AOT and APSP EDRs reached beta maturity.
- SM did not reach beta maturity.
- Large positive bias in AOT over land for which potential fixes are under investigation.
- SM algorithm needs substantial revisions to various spectral threshold tests to improve aerosol typing.
- Successful demonstration of the ability to test algorithm changes in ADL.
- Engaging users for VIIRS product applications
  - User's manual reviewed by EPA's Remote Sensing Information Gateway (RSIG) team. Suggested revisions will be implemented.
  - Case studies using VIIRS data are being developed for the 3rd GOES-R proving ground workshop for focus group to be held at UMBC on November 1, 2012.

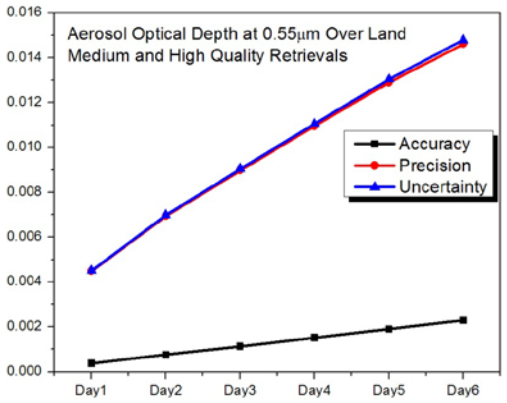
BACKUP

FY-12 Accomplishments

VIIRS Degradation Impact Study

- Impact of VIIRS Vis/NIR band degradation on aerosol EDRs (AOT and particle size) was estimated by considering the change in SNR and weekly drift (~ -1% in M7) in gain.
  - VIIRS Aerosol algorithm is not sensitive to the predicted decrease in SNR.
  - Currently estimated **weekly drift should not prevent the VIIRS Aerosol AOT and APSP Products from meeting the requirements overall.** A daily gain update is also preferred in order to avoid weekly jumps.
  - Due to changes in spectral transmission RSRs and LUTs (VIIRS Aerosol Atmosphere LUT and Aerosol Sunglint LUT) should be regenerated now and when the gain has stabilized in order to eliminate LUT errors and to ensure a stable long term operational product.





Evolution of AOT changes during six days

- Increasing negative/positive bias over water/land.
- Standard deviation and RMS increase as the gain decreases.
- **Changed precision and uncertainty still meet requirements.** (Requirements fall out of scale of figures and therefore not plotted.)