VIIRS aerosol algorithm and products.

Report to AEROCOM, September 2013.

Lorraine A. Remer
JCET UMBC

Suomi-NPP satellite launched 28 October 2011

VIIRS: Visible-Infrared Imager/Radiometer Suite

CrIS: Cross-track Infrared Sounder

CERES: Cloud and Earth Radiant Energy System

ATMS: Advance Technology Microwave Sounder

OMPS: Ozone Mapping and Profiler Suite

VIIRS: Visible-Infrared Imager/Radiometer Suite

CrIS: Cross-track Infrared Sounder HIRS

CERES: Cloud and Earth Radiant Energy System CERES

ATMS: Advance Technology Microwave Sounder AMSU

OMPS: Ozone Mapping and Profiler Suite OMI

VIIRS: Visible-Infrared Imager/Radiometer Suite MODIS/AVHRR/ SeaWIFS

CrIS: Cross-track Infrared Sounder HIRS

CERES: Cloud and Earth Radiant Energy System CERES

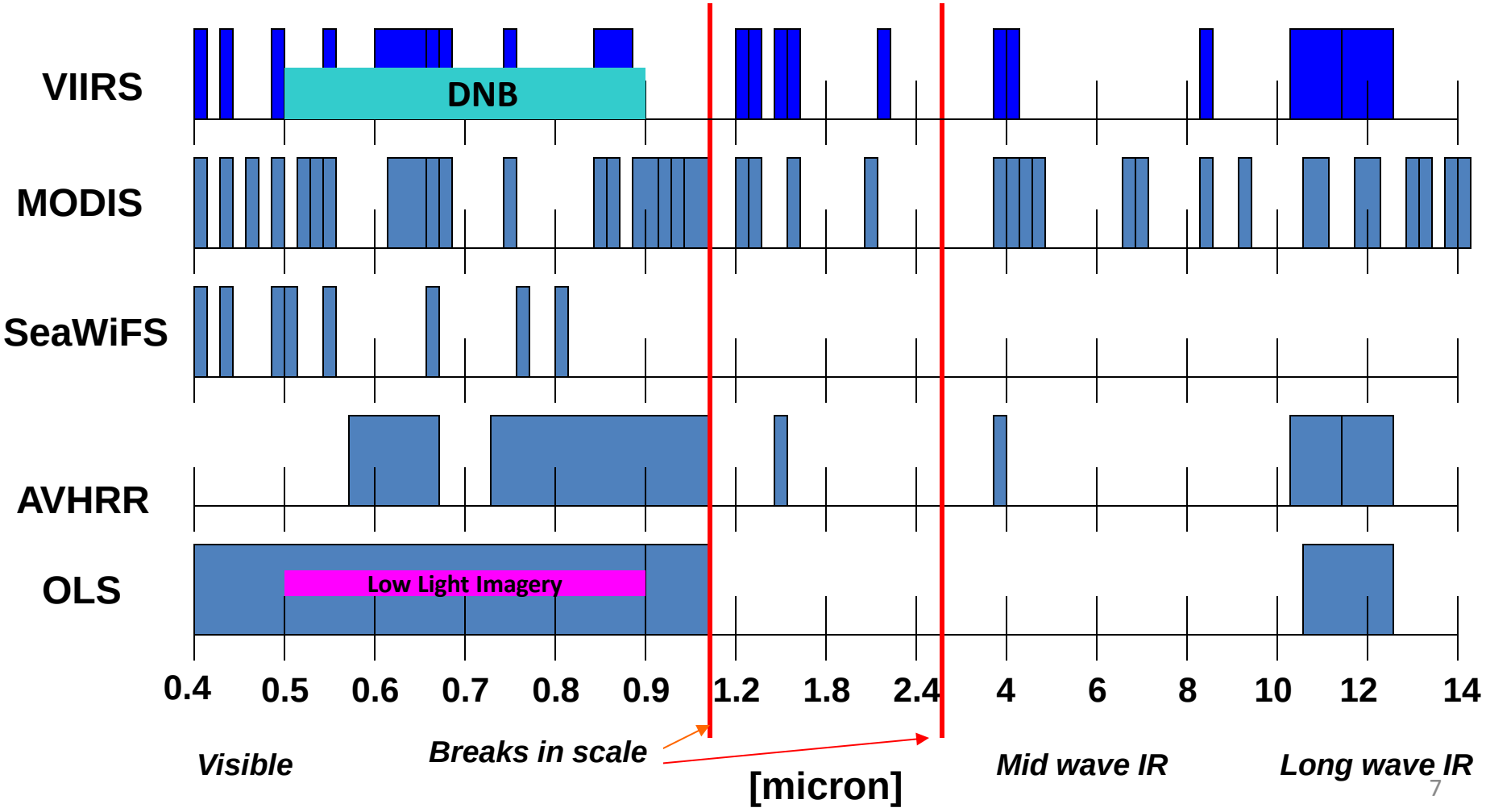
ATMS: Advance Technology Microwave Sounder AMSU

OMPS: Ozone Mapping and Profiler Suite OMI

Name	Organization	Major Task
Kurt F. Brueske	IIS/Raytheon	Code testing support within IDPS
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
Istvan Laszlo	NOAA/NESDIS	Co-lead
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

Heritage Capabilities

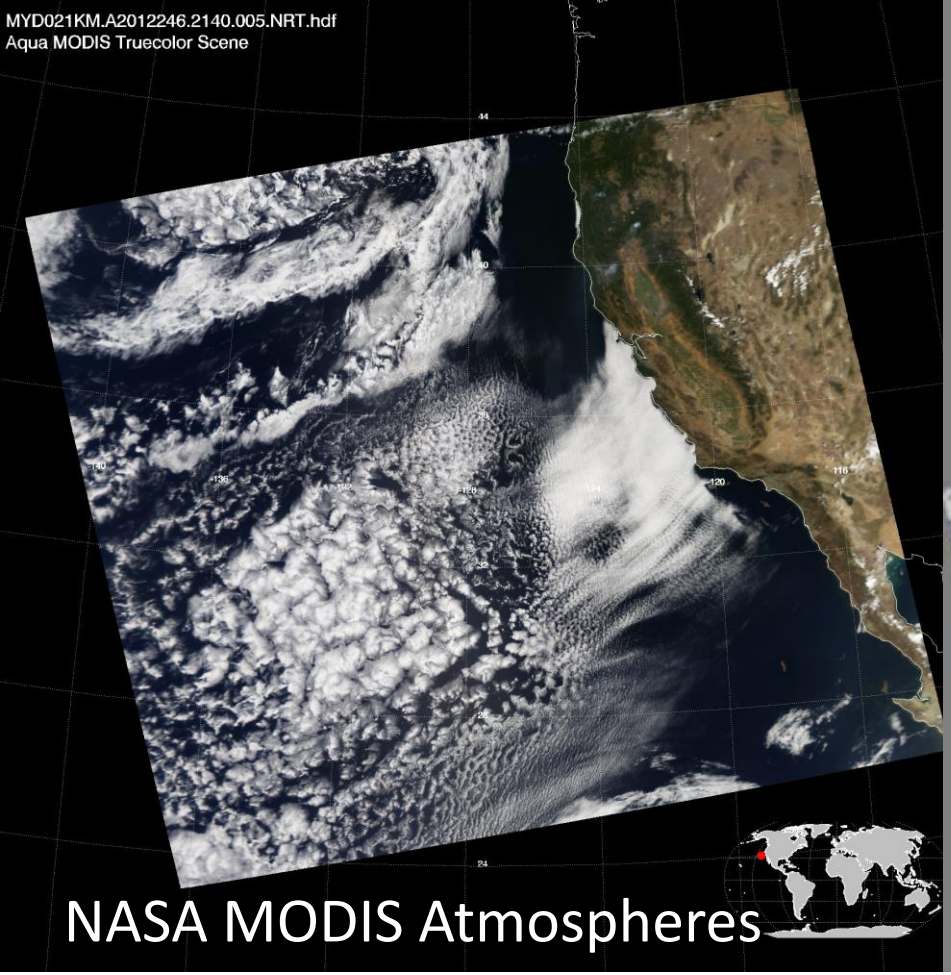
From Ed Hyer, NRL



Credit: Northrup Grumman & Raytheon

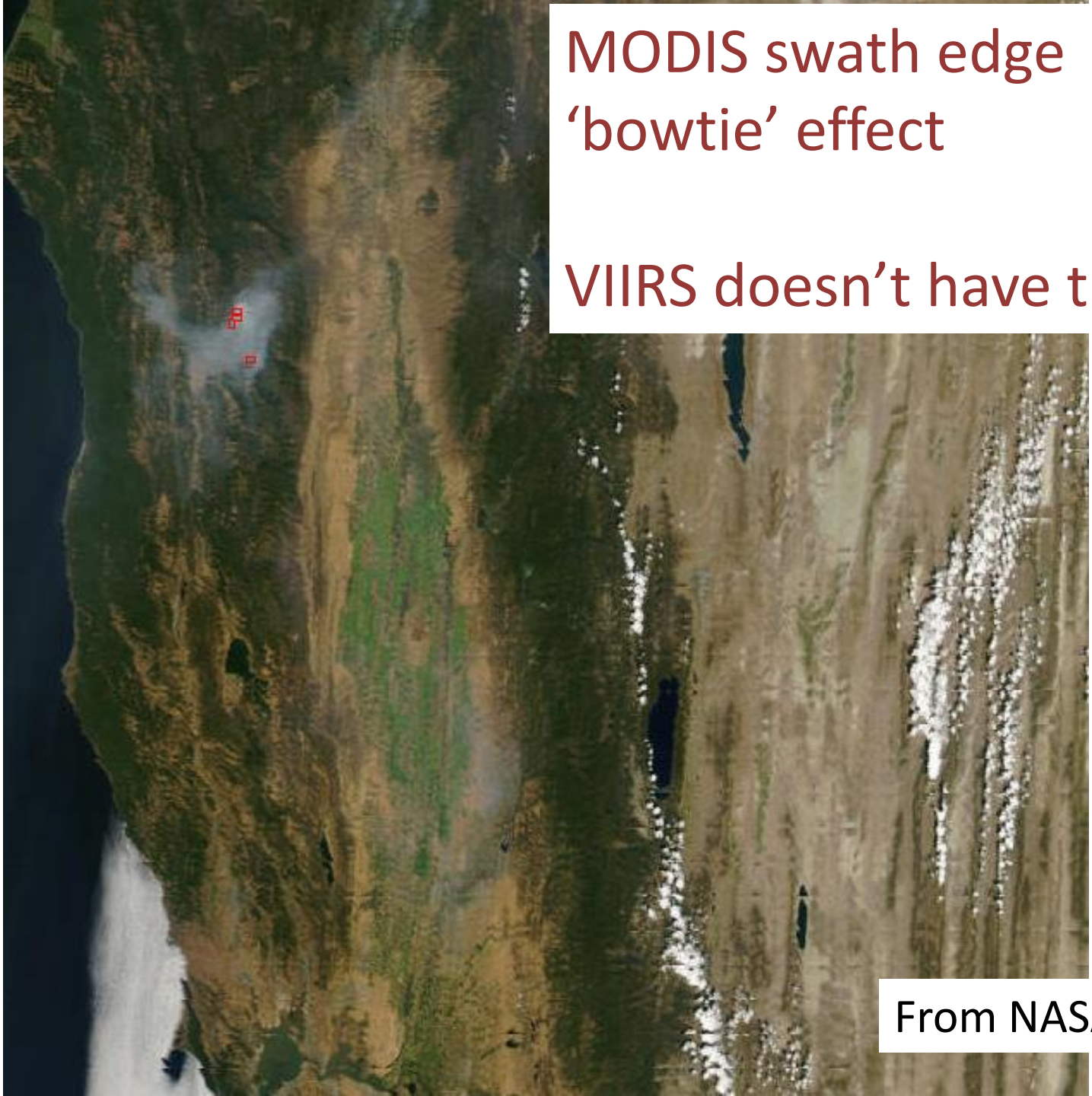
VIIRS is a multiwavelength imager, like MODIS with similar wavelength bands in the aerosol range

	MODIS	VIIRS
Orbit altitude	690 km	824 km
Equator crossing time	13:30 LT	13:30 LT
Granule size	5 minutes	86 seconds
swath	2330 km	3000 km
Pixel nadir	0.5 km	0.75 km
Pixel edge	2 km	1.5 km



MODIS
0.66 – 0.55 – 0.47 µm
2 Sep 2012
21:40 UTC

VIIRS
0.67 – 0.55 – 0.49 µm
2 Sep 2012
20:24:27.8 UTC



MODIS swath edge ‘bowtie’ effect

VIIRS doesn’t have this

From NASA LANCE

	MODIS	VIIRS
Product resolution nadir	10 km and 3 km	6 km and 0.75 km
Product resolution edge	40 km and 12 km	12 km and 1.5 km
Products land	AOT	AOT, (suspended matter)
Products ocean	AOT, fine mode fraction	AOT, Angstrom exponent, (suspended matter)

Suspended matter is a *qualitative* index designating aerosol type.

It has no MODIS heritage, and is currently under development with no access to users.

EDR is Environmental Data Record
(Think Level 2 data product)

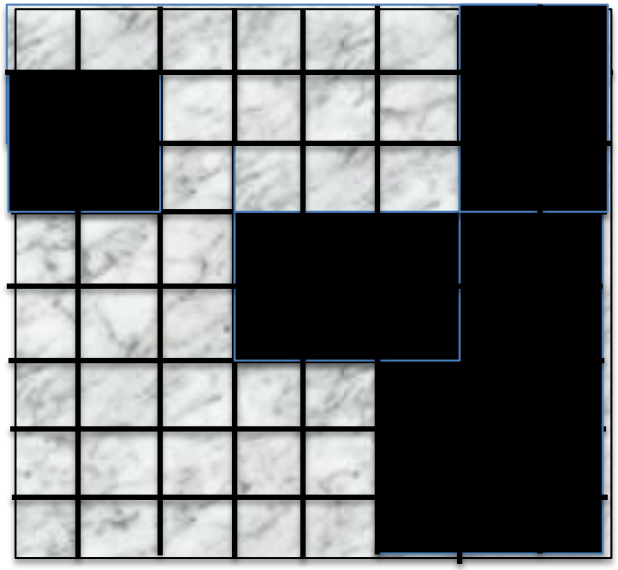
SDR is Sensor Data Record
(Think Level 1b)

IP is Intermediate Product
(No MODIS counterpart).

IP AOT is at 0.75 km nadir, no aggregation

EDR is the aggregation of 8x8 IP retrievals

IP product



35 individual 0.75 km AOT retrievals

EDR product

1 value of AOT to represent the entire box

IP product

EDR product

EDR product is aggregated from IP product, using complex decision tree involving QA. Not from original radiances

Ocean algorithm differences from MODIS

No 550 nm channel in the retrieval

Dynamic glint mask

Variable wind speed

But otherwise every inch a Tanré ocean retrieval, just like MODIS

Land algorithm differences from MODIS

VIIRS retrieval is NOT a Kaufman retrieval, and NOT a Levy retrieval

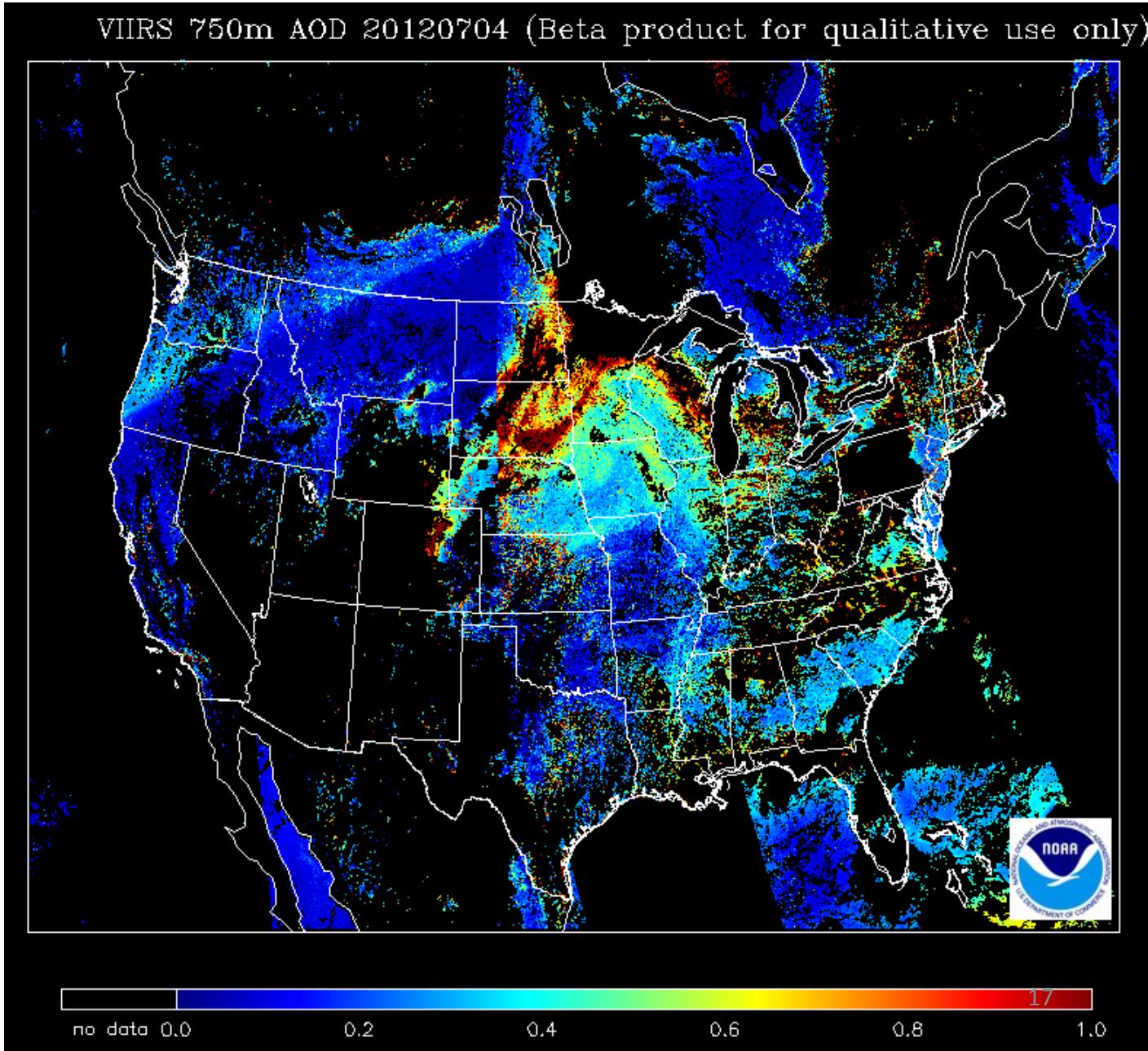
VIIRS: 0.412 µm, 0.444 µm, 0.486 µm, 0.672µm, 2.257 µm
MODIS: 0.466 µm, 0.665 µm, 2.13 µm

VIIRS: Chooses from 5 discrete aerosol models
MODIS: mixes two assigned models

VIIRS: does atmospheric correction and solves for $\rho_{surf}(\lambda)$
MODIS: that's crazy!

VIIRS: fits to expected spectral shape of ρ_{surf}
MODIS: assumes spectral shape and fits to ρ_{TOA}

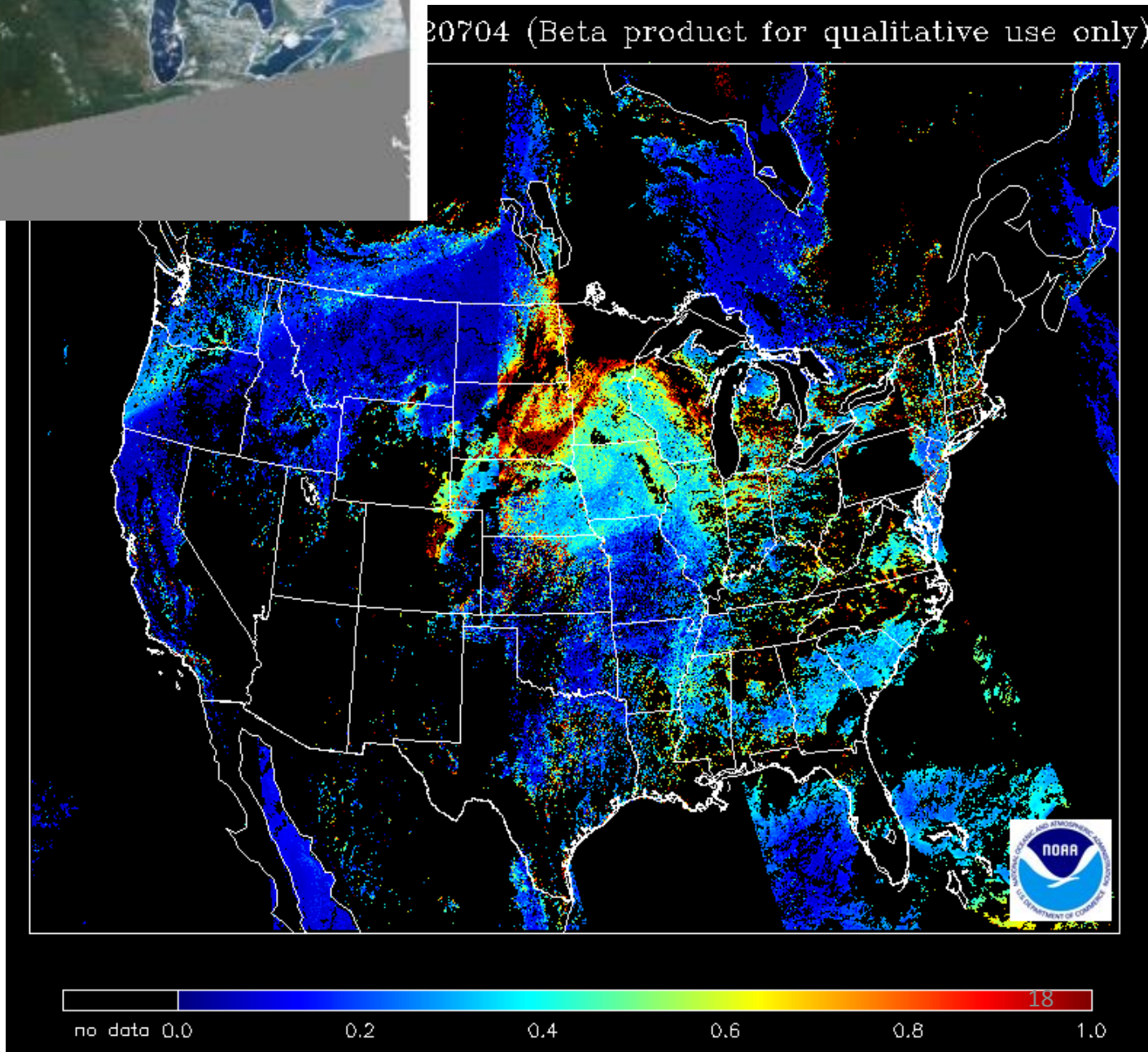
VIIRS AOT 550 nm 4 July 2012 IP 750 m



Kondragunta

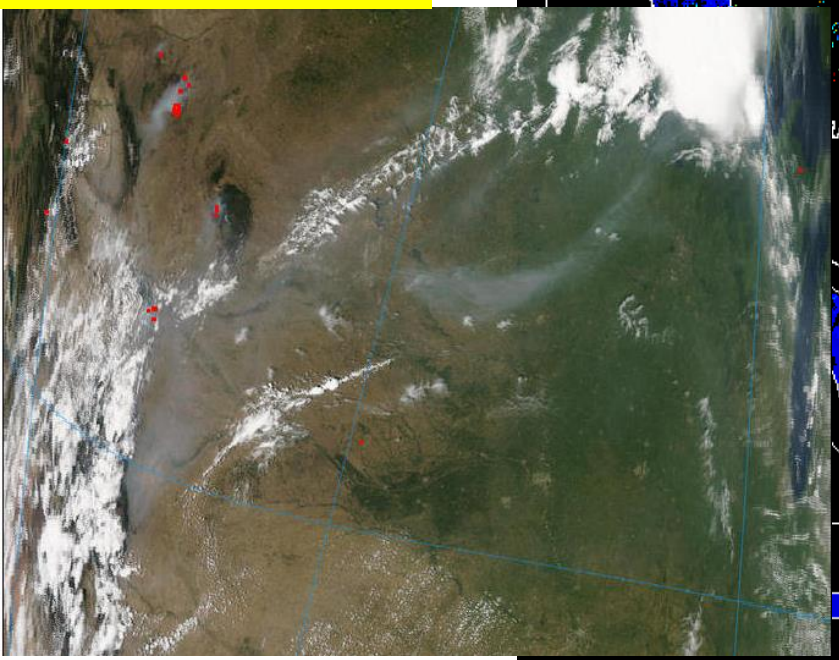
VIIRS AOT 550 nm 4 July 2012

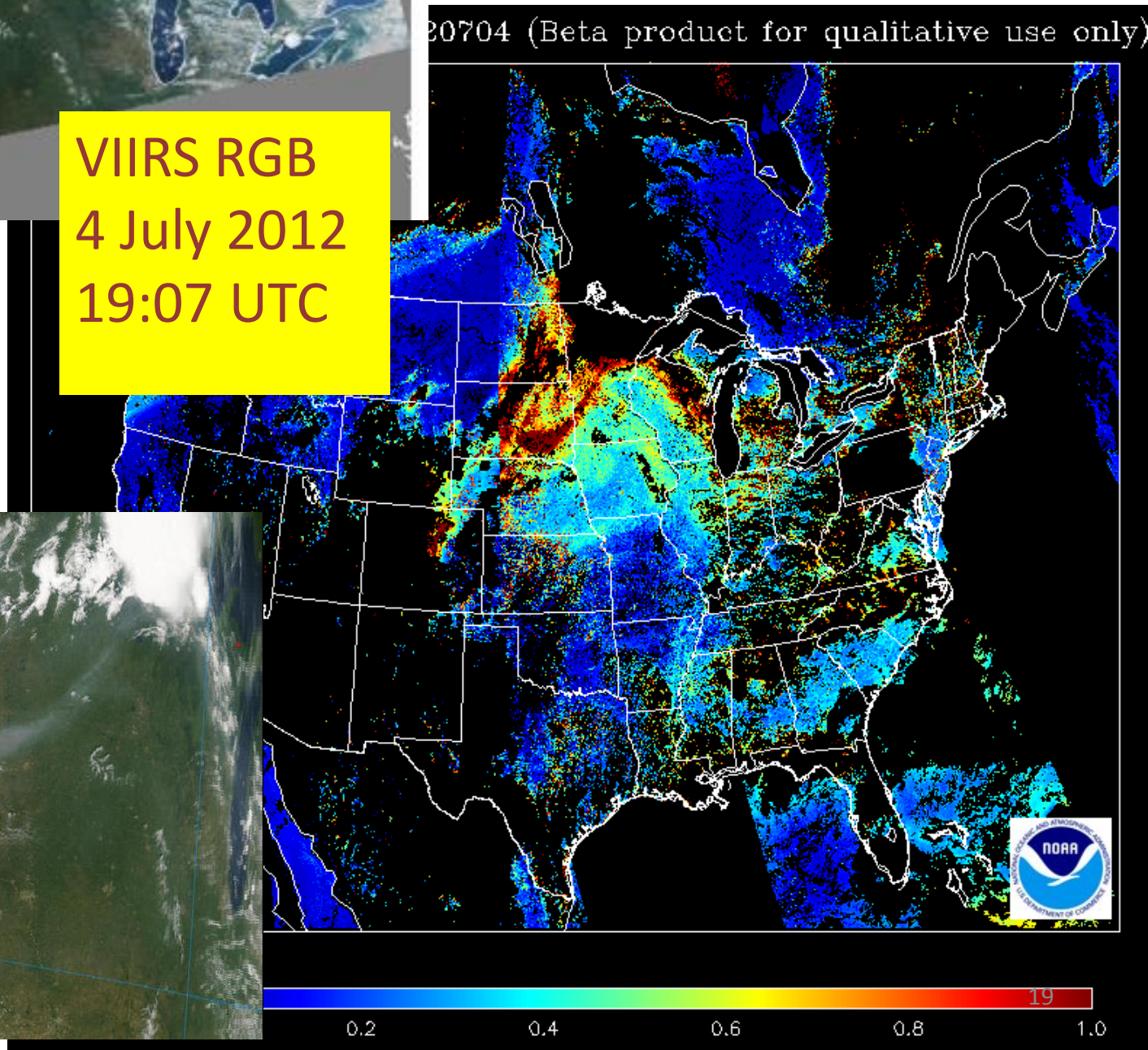
VIIRS RGB
4 July 2012
19:07 UTC

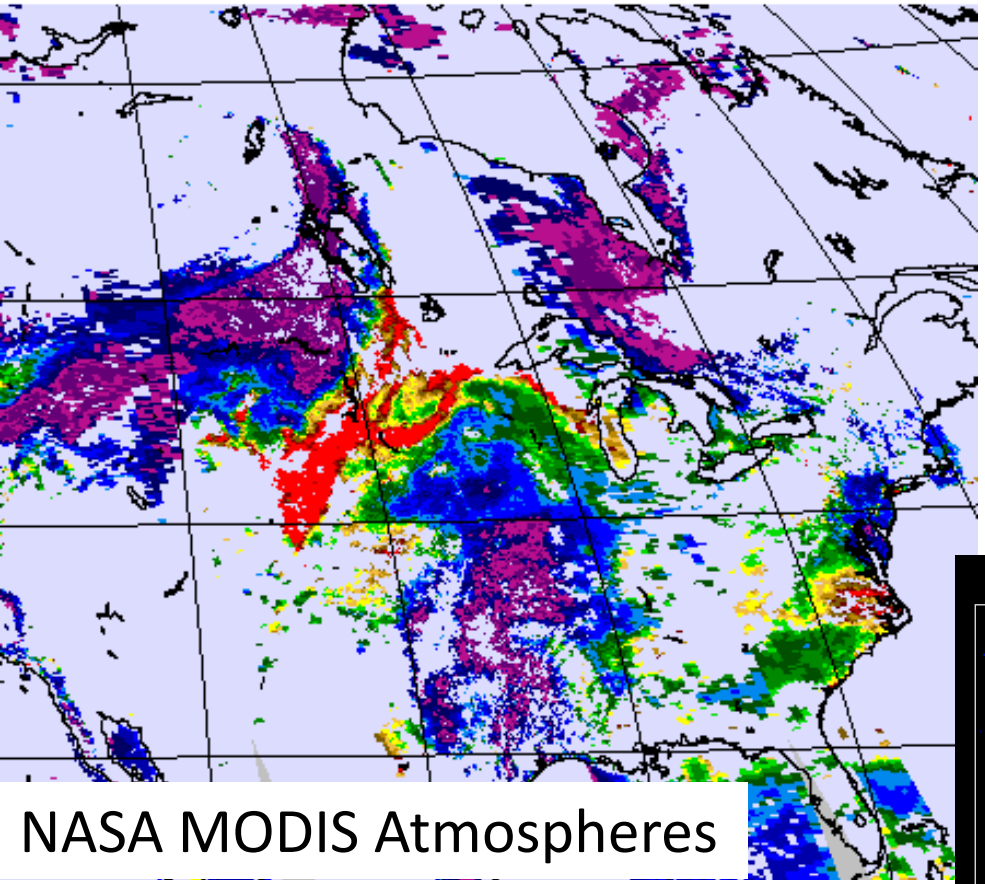


VIIRS RGB
4 July 2012
19:07 UTC

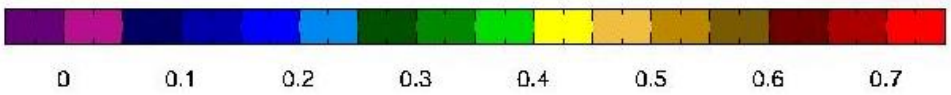
MODIS RGB
4 Jul 2012
19:40 UTC





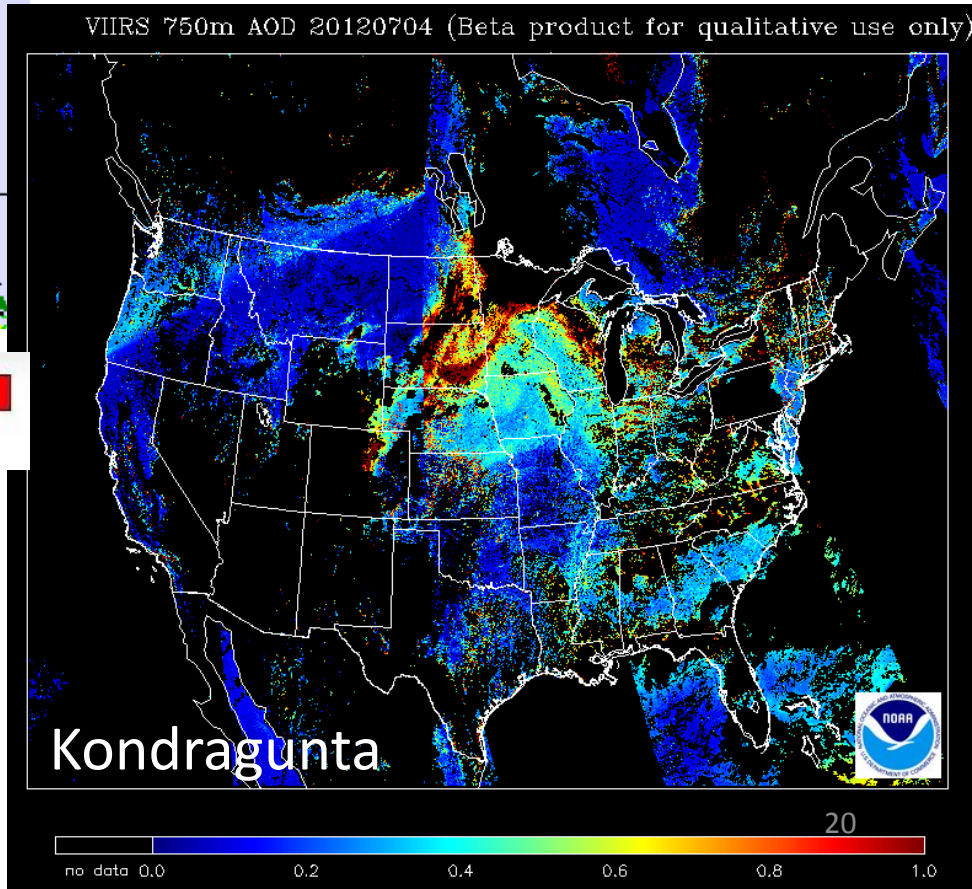


NASA MODIS Atmospheres

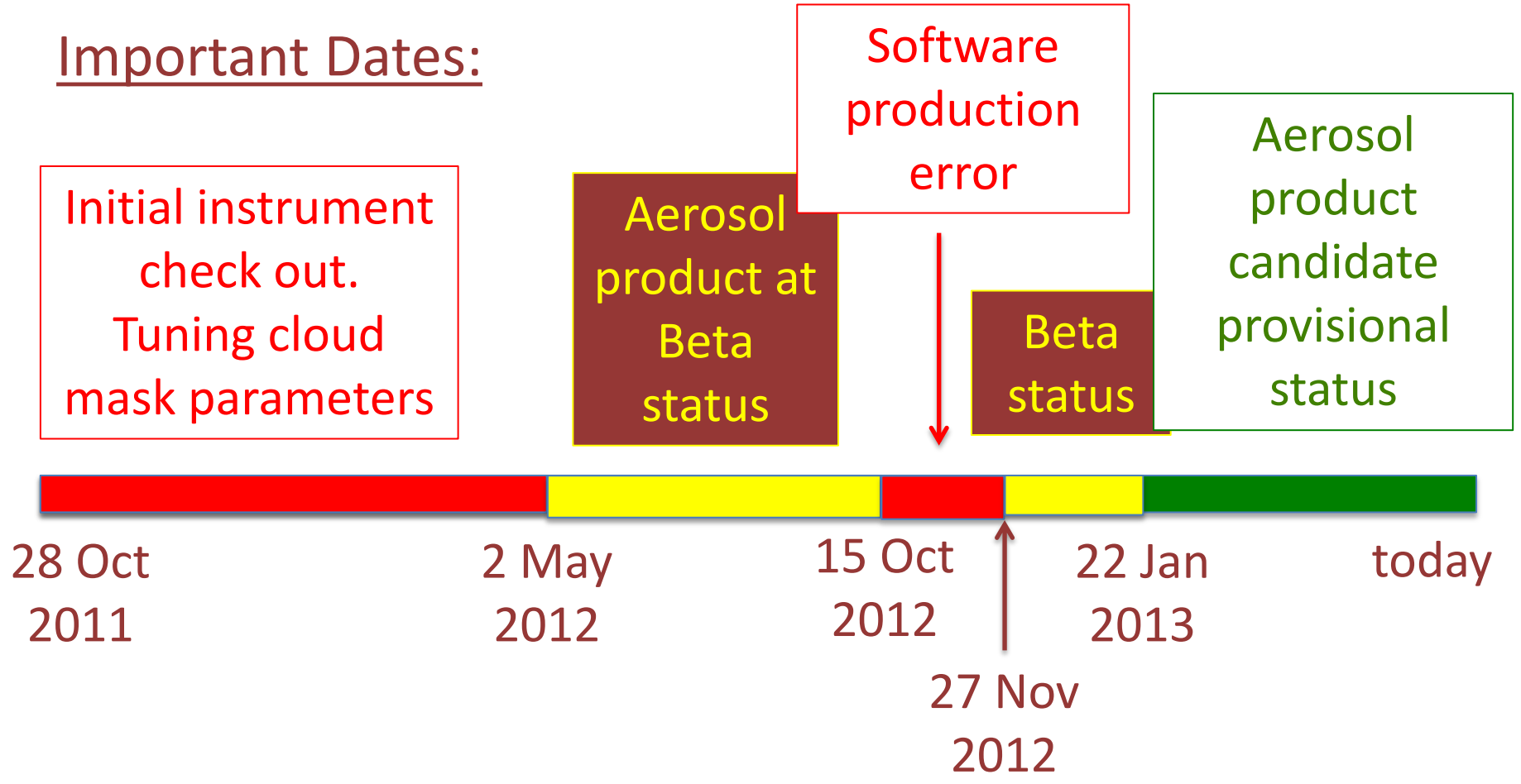


MODIS AOT 550 nm 4 July 2012
Aqua L2 Col51 10 km

VIIRS AOT 550 nm 4 July 2012
IP 750 m



Important Dates:

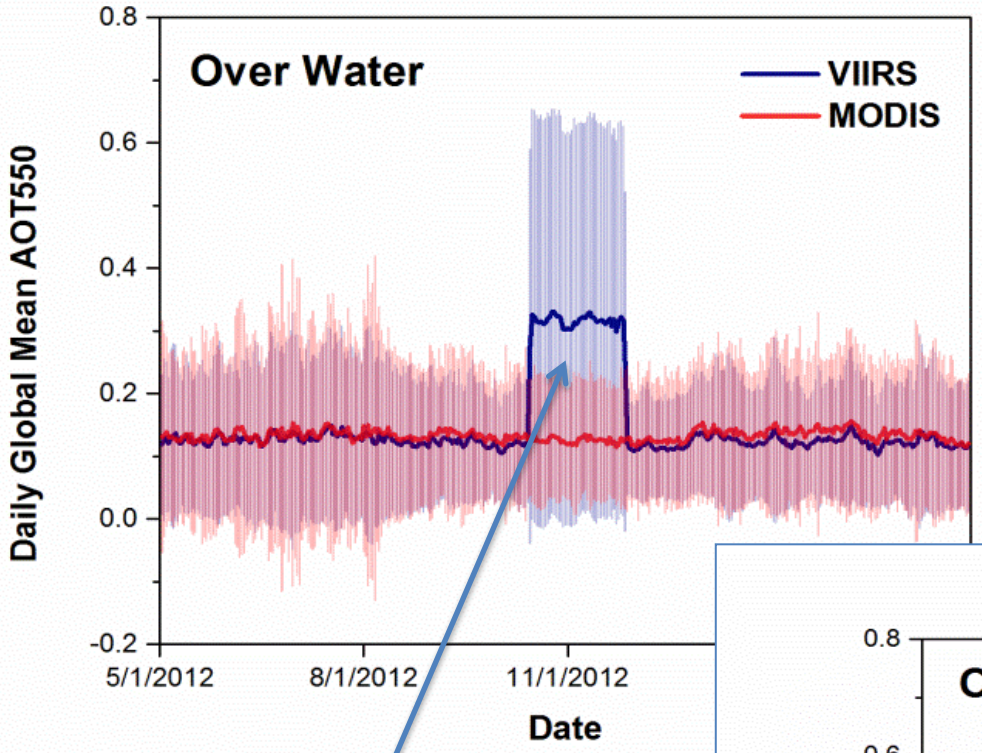


Red periods: DO NOT USE the product.

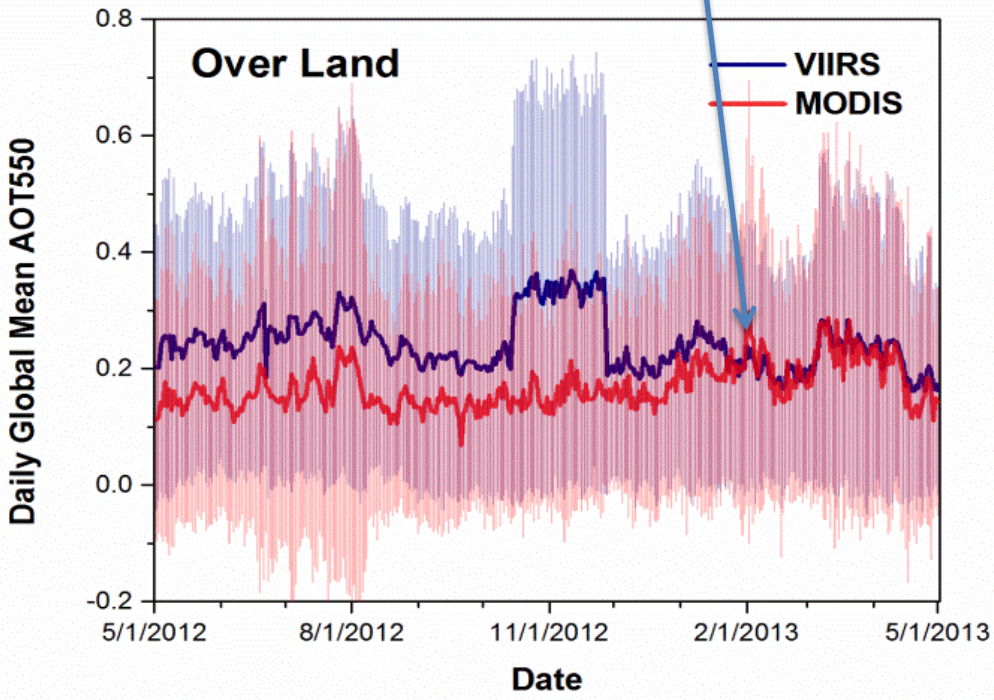
Beta: Use with caution. Known biases. Frequent changes.

Provisional: Improved from Beta. Still under close scrutiny.

Daily global mean AOT550
And standard deviation



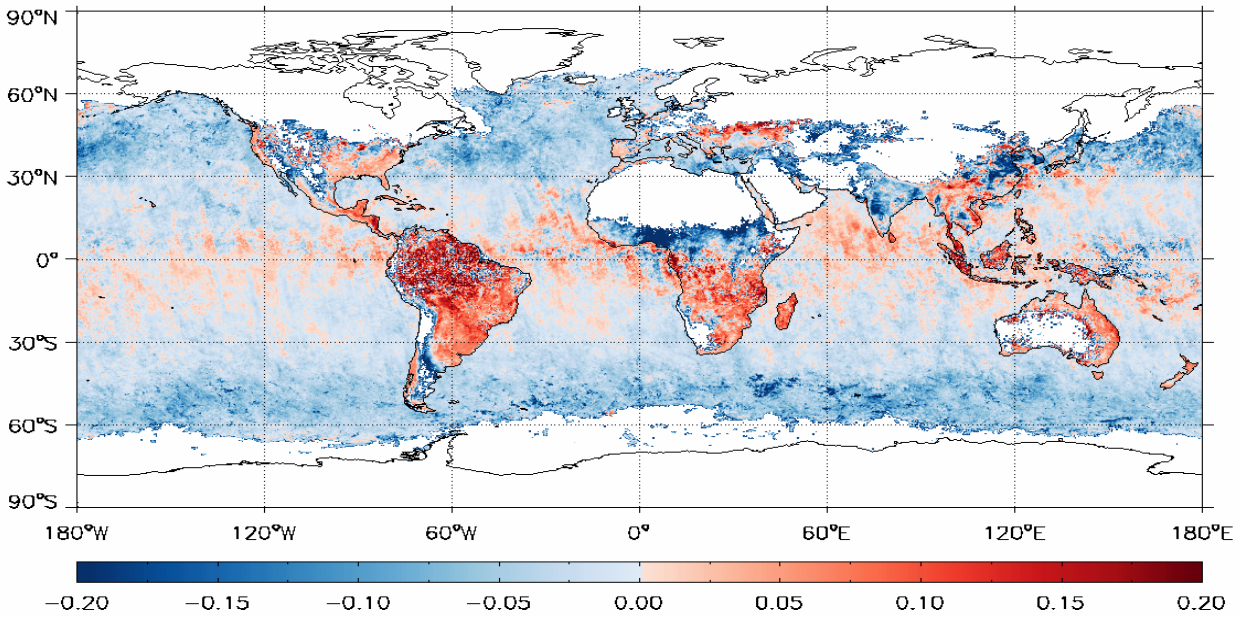
Important algorithm change



Processing error

NOT collocated: both algorithm and sampling differences

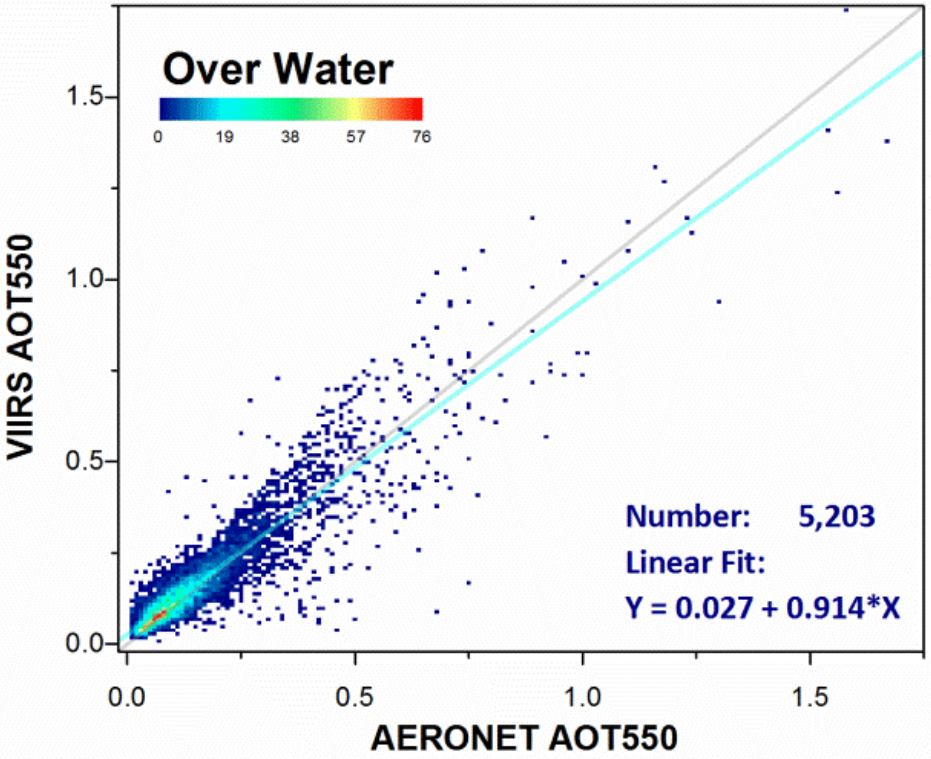
VIIRS AOT550 – MODIS AOT550



-0.20 0.00 0.20

VIIRS team is attacking this problem now
by linking surface assumptions to NDVI_SWIR

VIIRS AOT vs. AERONET

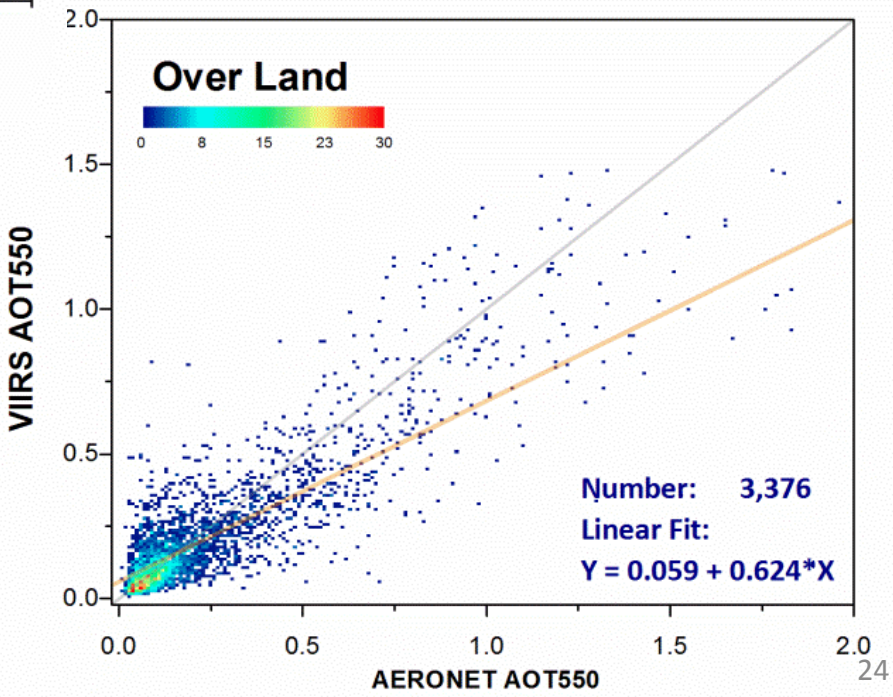


Ocean

VIIRS R=0.91 MODIS R=0.92

65% within expected error

(same as MODIS)



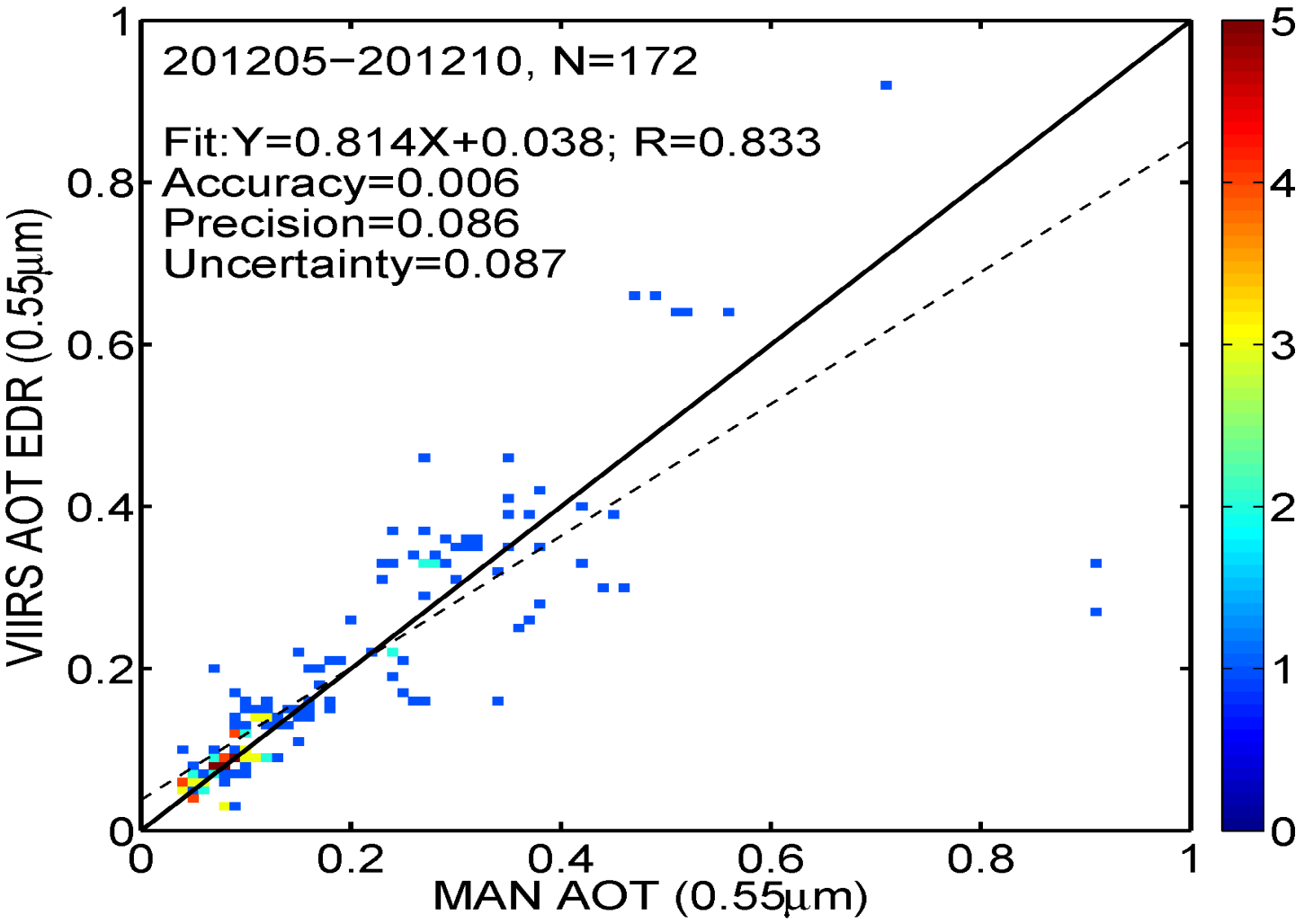
Land

VIIRS R=0.80 MODIS R=0.91

71% within expected error

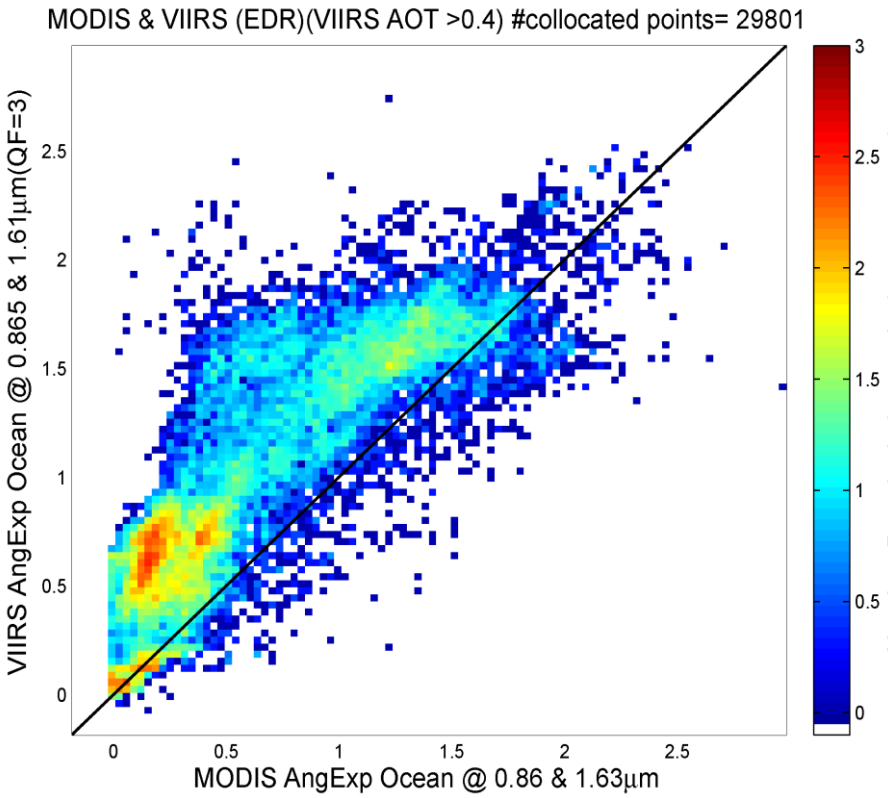
MODIS only 65%

VIIRS vs. MAN

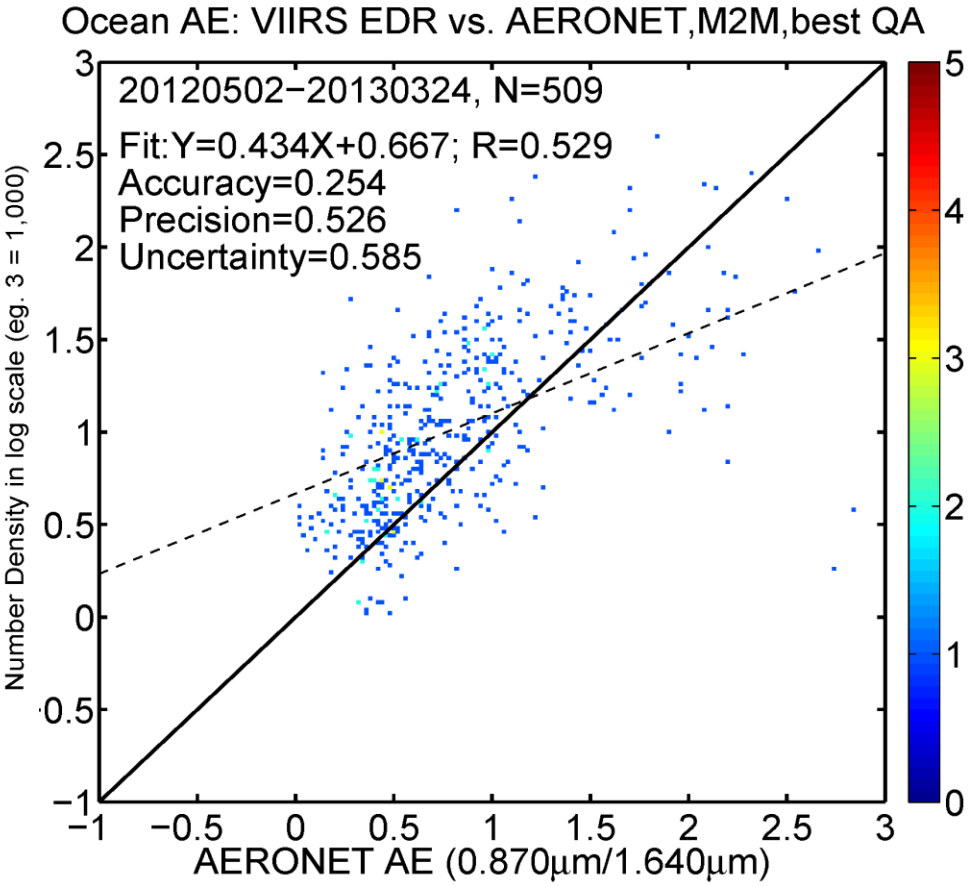

201205−201210, N=172
Fit:Y=0.814X+0.038; R=0.833
Accuracy=0.006
Precision=0.086
Uncertainty=0.087
VIIRS AOT EDR (0.55µm)
MAN AOT (0.55µm)
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5

Angstrom Exponent Over Ocean

VIIRS vs. MODIS (AOT > 0.4)



VIIRS vs. AERONET



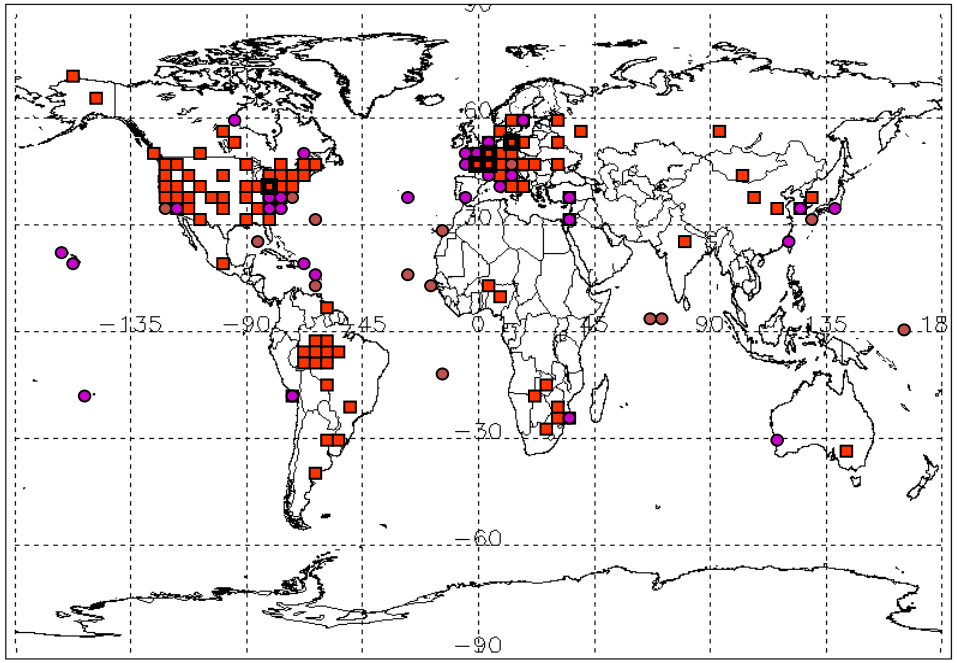
VIIRS aerosol product is quickly progressing to MODIS level of validity

Needs Deep Blue.

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

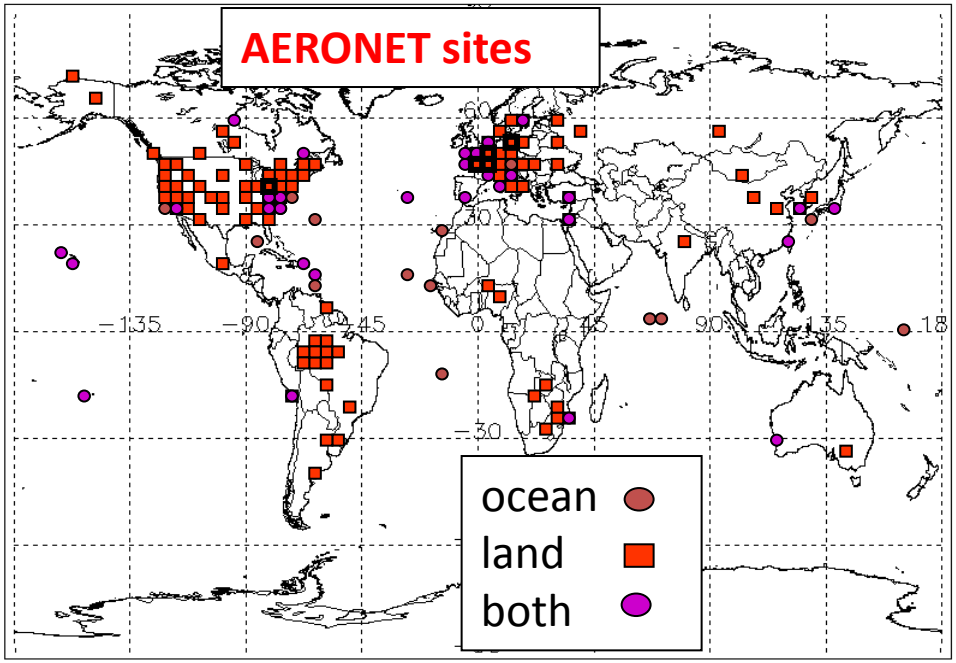
In time AERONET spread out to less desirable surfaces and MODIS retrieval “got worse”

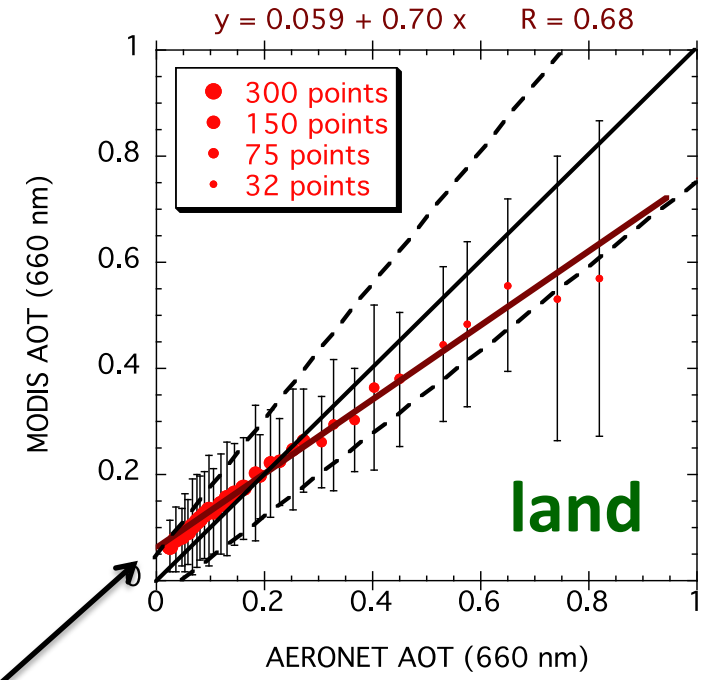
VIIRS is facing a harder “audience”

In perspective

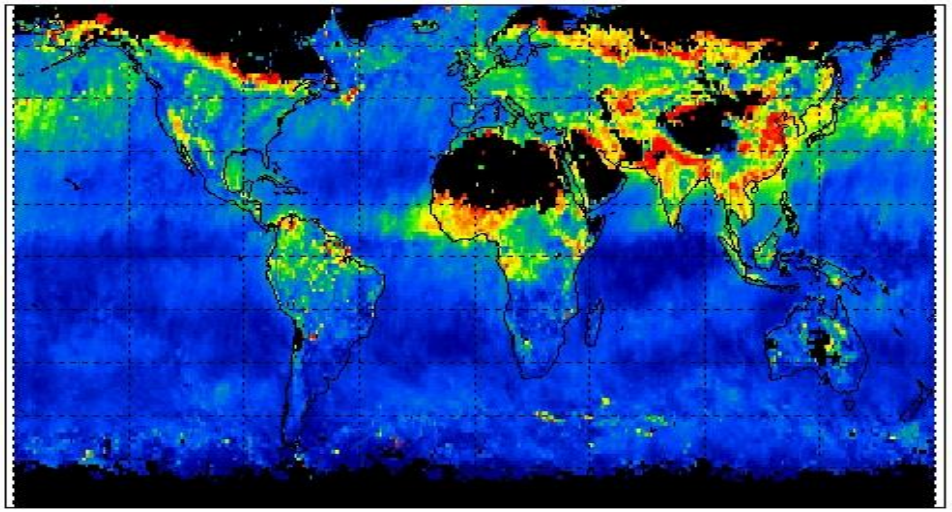
MODIS aerosol validation 2000-2002

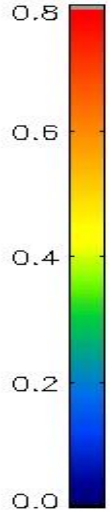
(3 years after Terra launch)





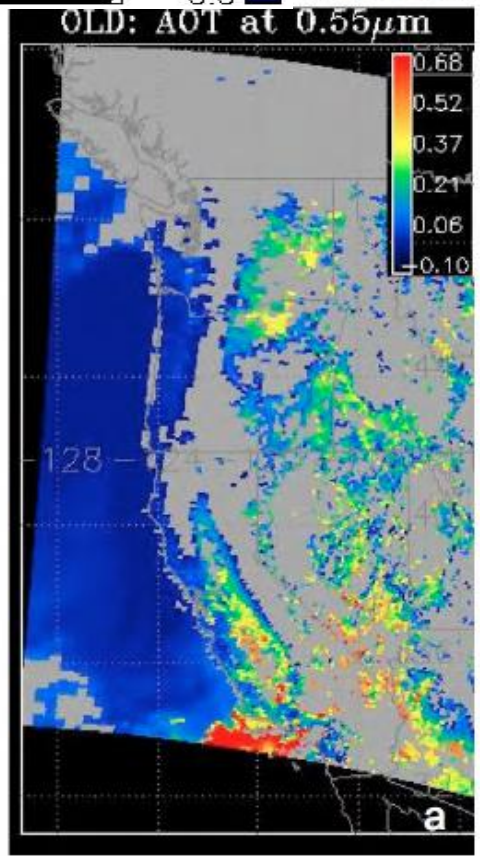
0.06 high bias over land,
against “favorable” AERONET stations.
2 years later this bias was closer to 0.10

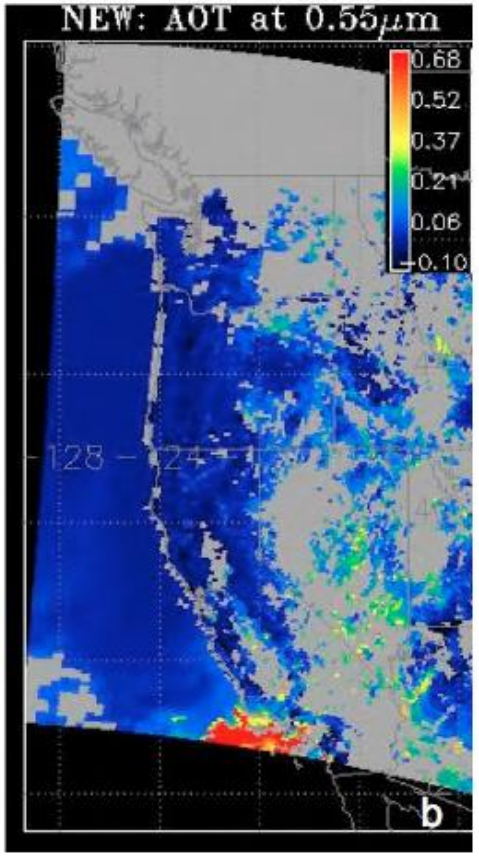




Sep 30, 2003; 17:55 UTC

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 2 years 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 their expectations.

The main obstacle to VIIRS aerosol success will be
data dissemination,
not data quality.

Obtaining VIIRS aerosol data and documentation

Data (not SM) are available through CLASS:
http://www.class.noaa.gov

A "back door" for data via the IDEA site:
https://www.star.nesdis.noaa.gov/smcd/spb/aq/index_viirs.php?product_id=4

Another back door to get ***gridded data*** (0.25 degree)
http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/index.php

Users' guide available at:
http://www.star.nesdis.noaa.gov/jpss/ATBD.php#S126472

README file under VIIRS aerosol (AOT) at:
http://www.nsof.class.noaa.gov/saa/products/welcome

Other documents are available at:
http://npp.gsfc.nasa.gov/science/documents.html

In addition…

2 papers in revision for publication in JGR

Jackson et al. To explain the algorithm

Liu et al. To demonstrate preliminary evaluation

From the Users Guide

Data are available through CLASS:

http://www.class.noaa.gov

AEROSOL EDR Product File

VAOOO_npp_d20120626_t1958134_e1959376_b03440_c20120627024612139725_noaa_ops.h5

HDF5 format

GAERO_npp_d20120626_t1958134_e1959376_b03440_c20120627021509002956_noaa_ops.h5

AEROSOL geolocation file

From the Users Guide

Data are available through CLASS:

http://www.class.noaa.gov

AEROSOL EDR Product File

VAOOO_npp_d20120626_t1958134_e1959376_b03440_c20120627024612139725_noaa_ops.h5

HDF5 format

GAERO_npp_d20120626_t1958134_e1959376_b03440_c20120627021509002956_noaa_ops.h5

AEROSOL geolocation file

Back door #1: U.S. real-time imagery/animations

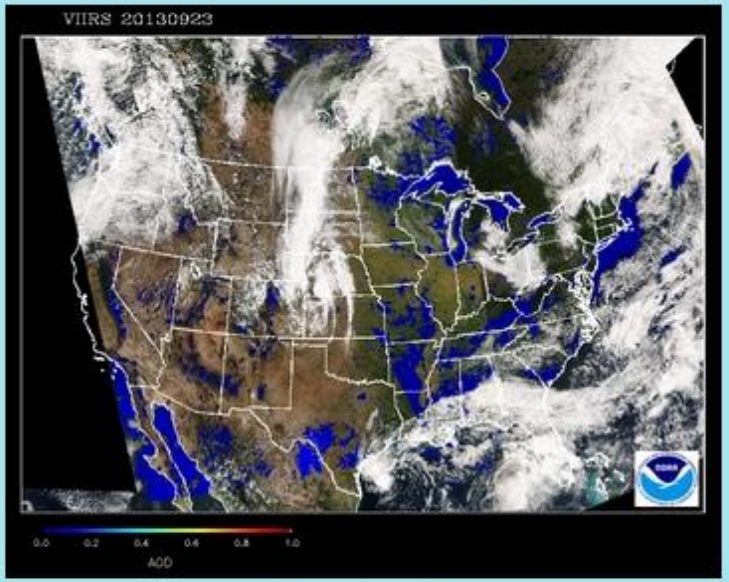
IDEA Infusing satellite Data into Environmental Applications

We value your feedback! Please send any comments, problems and suggestions to the IDEA Team.

MODIS (Terra) | MODIS (Aqua) | GASP | GASP WEST | VIIRS CONUS | VIIRS OCONUS

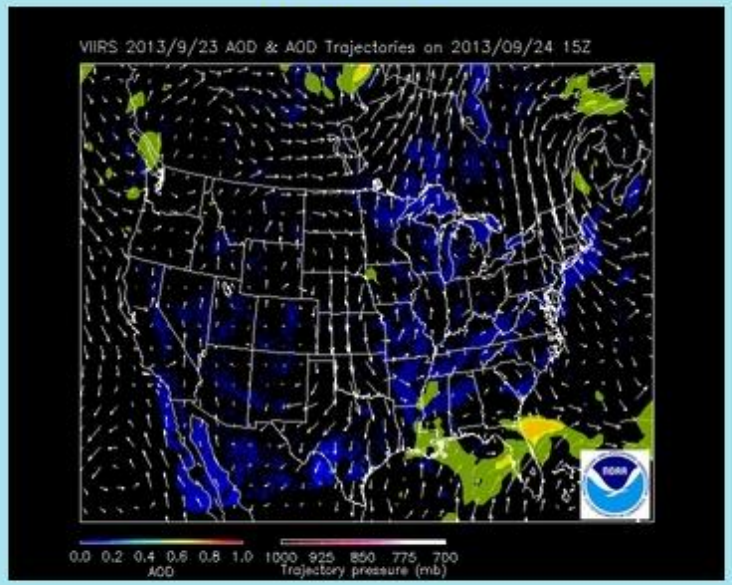
Disclaimer: The version of the VIIRS aerosol algorithm on this site is an enhanced version and is different from the official VIIRS aerosol products available at NOAA CLASS

Regional plots of VIIRS aerosol optical depth (AOD)



Select Region

48-hour aerosol trajectory forecast, with model winds and precipitation



View latest

Back door #2: Global gridded data

Search STAR websites Go

- STAR / SMCD / VIIRS Aerosol Calibration and Validation Home >>
- Products
- Data content and format
- Evaluation
- Documents
- Known Problems
- Team
- Links

Data and images displayed on STAR sites are provided for experimental use only and are not official operational NOAA products. More information>>

STAR / SMCD / VIIRS Aerosol Calibration and Validation

Aerosol from SNPP/VIIRS

The Visible/Infrared Imaging/Radiometer Suite (VIIRS) sensor onboard the Suomi National Polar-orbiting Partnership (SNPP) satellite was launched into Sun-synchronous orbit with a 13:30 Local Time of Ascending Node (LTAN) in October 2011. The raw VIIRS measurements of reflected and thermal radiances are presented as dimensionless "counts" and stored in Raw Data Records (RDRs). The RDRs are processed with calibration and geo-location information, and are presented with engineering units of radiance and quality flags as Sensor Data Records (SDRs). SDRs are used to derive Envoronmental Data Records (EDRs), geophysical parameters, including aerosols. SNPP VIIRS provides a key set of aerosol EDRs based on daily global observations from space. These products are the

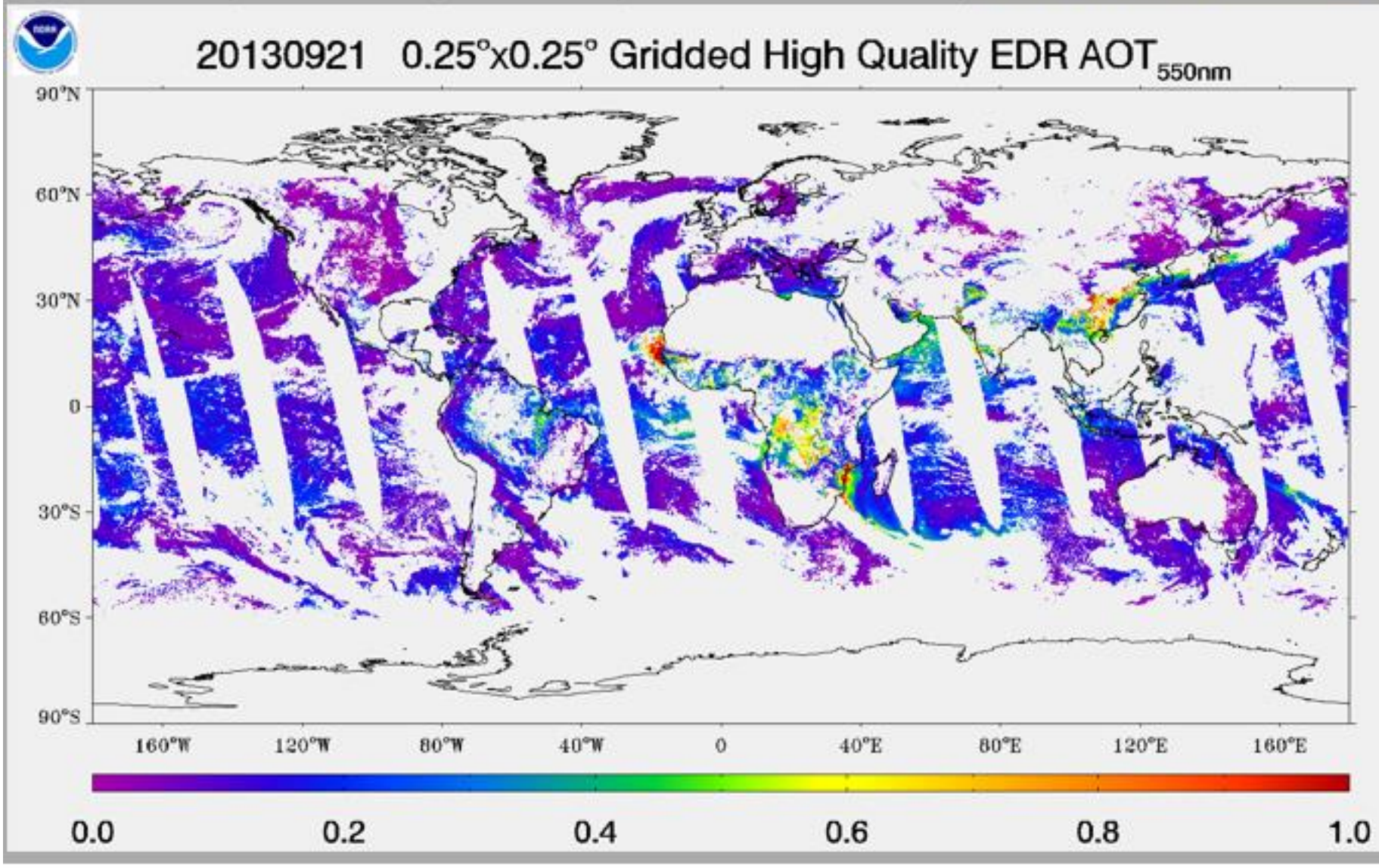
- **Aerosol Optical Thickness (AOT)**, providing a measure of the aerosol content of the atmospheric column,
- **Aerosol Particle Size Parameter (APSP)**, given as the Ångström Exponent (AE), a qualitative measure of particle size with larger AE corresponding to smaller particles, and vice-versa,
- **Suspended Matter (SM)**, indicating the presence of dust, smoke, sea salt, volcanic ash above a threshold amount.

Global gridded aerosol optical thickness

The operational VIIRS 550-nm AOT EDRs at nominal 6-km resolution, and collected during a 24-h period, are gridded on a regular 0.25 x 0.25-degree equal angle (~28x28 km at the equator) grid. Maps of these daily gridded AOTs can be displayed here.

0.25x0.25-degree Gridded Aerosol Optical Thickness at 550 nm

Year: 2013 Month: Sep Day: 21 Display Image Data Access - FTP site



The VIIRS ***sensor*** is sufficient to match MODIS aerosol capabilities,
but is not another MODIS.

The VIIRS aerosol ***algorithms*** are NOT the same as MODIS algorithms.

There is no Deep Blue.

VIIRS AOT product is good and is approaching MODIS accuracies.
It will be VERY GOOD in about a year. Ocean is already very good.

VIIRS Suspended Matter is under development. (Aerosol type)

A back door to obtain GLOBAL GRIDDED (0.25 degree) AOT is available.

No plans for reprocessing and data record is not continuous. Know the time line.

Read the documentation for caveats.

BACK-UP

NOAA HOME WEATHER OCEANS FISHERIES CHARTING SATELLITES CLIMATE RESEARCH COASTS CAREERS

NOAA COMPREHENSIVE LARGE ARRAY-DATA STEWARDSHIP SYSTEM (CLASS)

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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Release Info
- » Version 6.2.4 September 17, 2013

Other Links
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- » NODC
- » NCDC
- » NGDC
- » NESDIS

NEWS

CLASS will be unavailable 9/24/2013 from 1300-1900 UTC (9AM-3PM EDT):
On September 24, 2013, from 1300-1900 UTC (9AM-3PM EDT) CLASS will be conducting a system-wide maintenance, which will require all CLASS web services and subscription services to be off-line during the planned 6 hour maintenance window. However, ftp access to completed orders will still be available to users. If you have any questions, please contact **CLASS Help Desk**

Attention CLASS users (09/10/13):
On September 19, 2013, one of the CLASS sites will change IP addresses for **ftp.class.ncdc.noaa.gov** from **152.53.15.180** to **204.62.251.180**. If you have firewall rules including this IP address, please update them accordingly. If you have questions, please contact **class.help@noaa.gov**

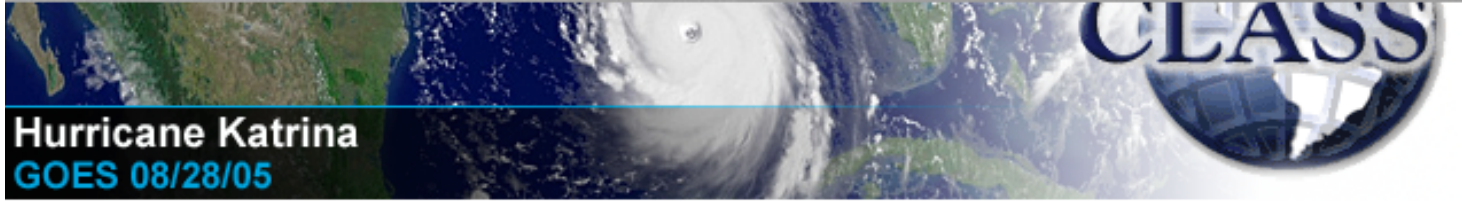
Attention Suomi NPP Users:
The most recent global NPP operational products are now available in daily tar files for quick and easy downloads at: **ftp://ftp-npp.class.ngdc.noaa.gov/**. Please see the **NPP help page** for instructions. Up to the most recent 90 days of data will be available for direct online access.

SEARCH FOR DATA

- Environmental Data from Polar-orbiting Satellites
- Environmental Data from Geostationary Satellites
- Defense Meteorological Satellite Program (DMSP)
- Suomi National Polar-orbitir Partnership (NPP)
- Sea Surface Temperature da (SST)
- RADARSAT
- Altimetry / Sea Surface Heig Data (JASON-2)
- Global Navigation Satellite Systems (GNSS)
- Other - Miscellaneous products in CLASS

SEARCH COLLECTION METADA

» GO



NEWS

CLASS will be unavailable 9/24/2013 from 1300-1900 UTC (9AM-3PM EDT):

On September 24, 2013, from 1300-1900 UTC (9AM-3PM EDT) CLASS will be conducting a system-wide maintenance, which will require all CLASS web services and subscription services to be off-line during the planned 6 hour maintenance window. However, ftp access to completed orders will still be available to users. If you have any questions, please contact **CLASS Help Desk**

Attention CLASS users (09/10/13):

On September 19, 2013, one of the CLASS sites will change IP addresses for **ftp.class.ncdc.noaa.gov** from **152.53.15.180** to **204.62.251.180**. If you have firewall rules including this IP address, please update them accordingly. If you have questions, please contact **class.help@noaa.gov**

Attention Suomi NPP Users:

The most recent global NPP operational products are now available in daily tar files for quick and easy downloads at: **ftp://ftp-npp.class.ngdc.noaa.gov/**. Please see the **NPP help page** for instructions. Up to the most recent 90 days of data will be available for direct online access.

Attention CORS users (07/2013):

The National Geodetic Survey's CORS data archived at the National Geophysical Data Center has been transitioned into CLASS. The data collections include RINEX since 1994 and raw GPS from selected CORS sites since 2004. The original at-sampling rate was retained except where there was only the 30-second decimated rate data. For more info see the CORS CLASS search page.

Attention Metop users (08/14/2013):

With the exception of GOME Level 2 data, all Metop-B level 1b and 1c satellite data is now available beginning January 15, 2013 (IASI L1c starts on May 16, 2013). Pre-operational data collected prior to those dates remains restricted. Please contact the **CLASS Help Desk** if assistance is needed.

Metop-A Outgoing Longwave Radiation dataset is now available since July 31, 2013.

Suomi NPP data access status (09/06/13):

Below is a list of S-NPP products released to the public and now available through CLASS. The complete list of products along with the begin dates of product availability are located on the **Suomi NPP FAQ** page. The remaining NPP products will be released to the user community over a time frame of several months. Please note that all newly released products are at 'Beta' maturity level as defined in the **Product Maturity Level page**. Details of high priority issues related to the data quality are contained in the Readme files provided by the NPP Project Scientist.

+ Defense Meteorological Satellite Program (DMSP)

− Suomi National Polar-orbitir Partnership (NPP)

- NPP Advanced Technology Microwave Sounder (ATMS)
- NPP Clouds and Earth Radiar Energy System (CERES)
- NPP Cross-track Infrared Sounder combined with the Advanced Technology Microwave Sounder (CRIMSS
- NPP Cross-track Infrared Sounder (CrIS)
- NPP Auxiliary Files (NP_AUX)
- NPP Cal/Val Investigator Containers(NP_CONTR)
- NPP Documentation (NPDOC
- NPP Retained Intermediate Products - Gridded (RIP_GRI
- NPP Mission Notices (NP_MSNNTCE)
- NPP Retained Intermediate Products - Non-Gridded (RIP_NOGRD)
- NPP Official Dynamic Ancillar Data (NP_ODAD)
- NPP Official Static Ancillary Data (NP_OSAD)
- NPP Spacecraft (NP_SPCRFT
- NPP Software Release Pkg (NP_SW)
- NPP Test Data Release Pkg (NP_TD)
- NPP Ozone Mapping and Profiler Suite (OMPS)
- NPP Visible/Infrared Imager/Radiometer Suite (VII

+ Sea Surface Temperature da (SST)

+ RADARSAT

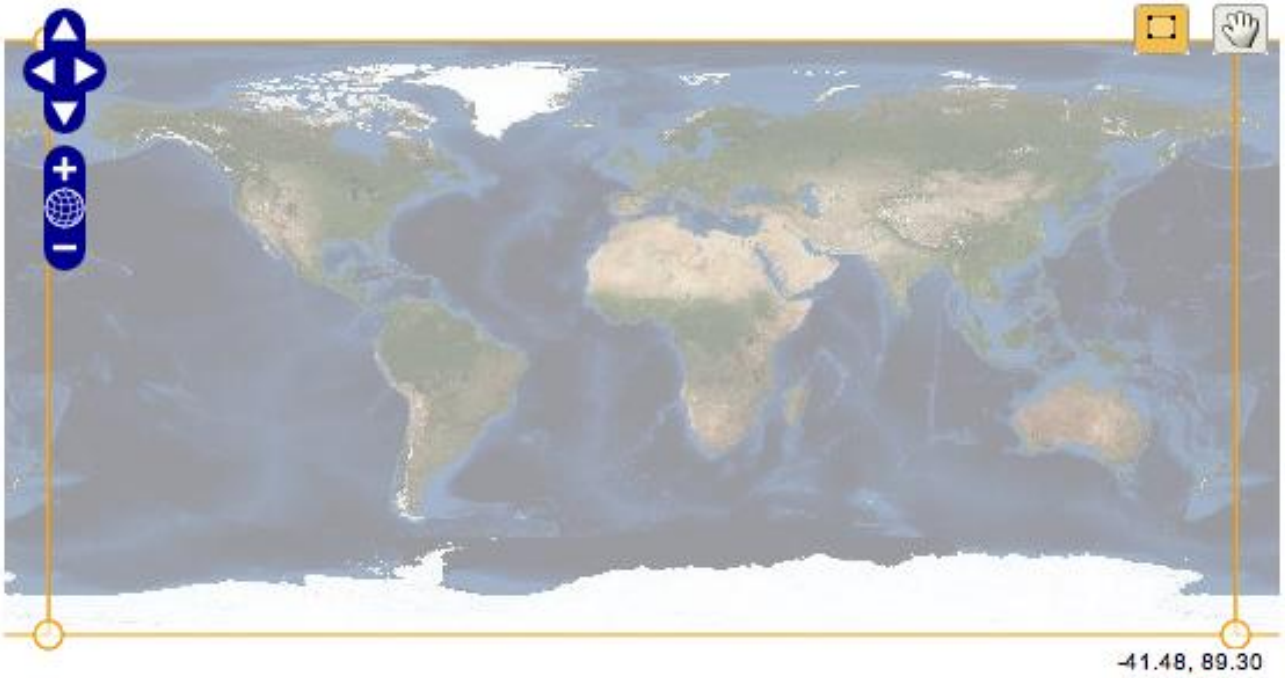
Search - VIIRS

Data Description

Visible/Infrared Imager Radiometer Suite - The Visible/Infrared Imager/Radiometer Suite collects visible/infrared imagery and radiometric data. Data types include atmospheric, clouds, earth radiation budget, clear-air land/water surfaces, sea surface temperature, ocean color, and low light visible imagery. VIIRS contributes to 23 Environmental Data Records (EDRs) and is the primary instrument for 18 EDRs.

Details - Metadata, Documentation

Spatial



90

-180 180

-90

Max Area

Note: XY Plane searches are resized to enforce a minimum lat/lon difference of 0.1 degrees.

Temporal

(maximum range is 366 days)

Start Date (format: YYYY-MM-DD) 2013-09-22

Start Time (UTC) (format: HH:MM:SS) 00:00:00

End Date (format: YYYY-MM-DD) 2013-09-23

End Time (UTC) (format: HH:MM:SS) 23:59:59

Specify the range of the times for: ○ Each Day Or ◉ The Entire Range Of Days

Advanced Search

Datatype

Sensor Data Record

- ☐ VIIRS Day Night Band SDR (public 02/07/2012)
- ☐ VIIRS Imagery Band 01 SDR (public 02/07/2012)
- ☐ VIIRS Imagery Band 02 SDR (public 02/07/2012)
- ☐ VIIRS Imagery Band 03 SDR (public 02/07/2012)
- ☐ VIIRS Imagery Band 04 SDR (public 02/07/2012)
- ☐ VIIRS Imagery Band 05 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 01 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 02 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 03 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 04 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 05 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 06 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 07 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 08 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 09 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 10 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 11 SDR (public 02/07/2012)
- ☐ VIIRS Moderate Resolution Band 12 SDR (public 02/07/2012)

Node

- ○ Ascending
- ○ Descending
- ○ Either

Satellite

NPP

VIIRS Moderate Resolution Band 16 SDR (public 02/07/2012)

Raw Data Record

- VIIRS Diagnostic RDR (none available)
- VIIRS Memory Dump RDR (public 02/07/2012)
- VIIRS Science RDR (public 02/07/2012)
- VIIRS Telemetry Diagnostic RDR (none available)
- VIIRS Telemetry RDR (public 02/07/2012)

Intermediate Product

- VIIRS Cloud Mask Intermediate Product (public 05/02/12)
- VIIRS Quarterly Surface Type IP

Geolocation

- VIIRS Aerosol (aggregated) EDR Ellipsoid Geolocation (public 05/02/2012)
- VIIRS Cloud Aggregated EDR Ellipsoid Geolocation (restricted)
- VIIRS Day Night Band SDR Ellipsoid Geolocation (public 02/07/2012)
- VIIRS Image Bands EDR GTM Geolocation (public 02/07/2012)
- VIIRS Image Bands SDR Ellipsoid Geolocation (public 02/07/2012)
- VIIRS Image Bands SDR Ellipsoid Terrain Corrected Geolocation (public 02/07/2012)
- VIIRS Moderate Bands SDR Geolocation (public 02/07/2012)
- VIIRS Moderate Bands SDR Terrain Corrected Geolocation (public 02/07/2012)
- VIIRS Near Constant Contrast (NCC) EDR Ground Track Mercator (GTM) Geolocation (public 07/18/2012)
- VIIRS Net Heat Flux EDR Geolocation (restricted)

Enviromental Data Record

- VIIRS Aerosol Optical Thickness (AOT) EDR (public 05/02/2012)
- VIIRS Cloud Base Height EDR (public 04/27/2013)
- VIIRS Cloud Cover Layers EDR (public 04/27/2013)
- VIIRS Cloud Effective Particle Size EDR (public 04/27/2013)
- VIIRS Cloud Optical Thickness EDR (public 04/27/2013)
- VIIRS Cloud Top Height EDR (public 04/27/2013)
- VIIRS Cloud Top Pressure EDR (public 04/27/2013)
- VIIRS Cloud Top Temperature EDR (public 04/27/2013)
- VIIRS Ice Surface Temperature EDR (public 03/14/2013)

VIIRS Sea Surface Temperature EDR (public 01/22/2012)
VIIRS Snow Cover/Depth Binary Map EDR (public 03/14/2013)
VIIRS Snow Cover/Depth Snow Fraction EDR (public 03/14/2013)
VIIRS Surface Albedo EDR (restricted)
VIIRS Surface Type EDR (public 01/29/2013)
VIIRS Suspended Matter EDR (public 05/12/2012)
VIIRS Vegetation Index EDR (public 05/02/2012)

Application Related Product

VIIRS Active Fires ARP (public 04/03/2012)

Search — to place small order after reviewing inventory and granule metadata, including browse images when available.

Quick Search & Order — to place large order without reviewing inventory or granule (file) metadata.

Save Criteria | Load Criteria | Dataset Name/Granule ID/Beginning Orbit Number View | Reset