VIIRS EDR IMAGERY OVERVIEW

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VIIRS EDR Imagery Team
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Outline

VIIRS Imagery Overview

- Cal/Val Team Members
- Sensor/Algorithm (GTM EDRs)
- S-NPP Product(s) / Examples
- JPSS-1 Readiness (no earlier than 16 March 2017 launch)
- Summary and Path Forward

Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
D. Hillger	**StAR/RAMMB**	D. Lindsey, D. Molenar	Imagery product lead, weekly reports, **social media interactions**, data infrastructure
T. Kopp	**Aerospace**		Cal/Val Lead, VIIRS heritage
S. Miller	**CIRA/RAMMB**	C. Seaman, S. Kidder, S. Finley, G. Chirokova, J. Torres, L. Grasso	Imagery cal/val , VIIRS online, end user support (including tropical cyclones), VIIRS training
D. Santek	**CIMSS/SSEC**	T. Jasmin, T. Rink, W. Straka III	McIDAS-V (display tools) McIDAS-X
K. Richardson	**NRL – Monterrey**	A. Kuciauskas	NexSat, VIIRS web
C. Elvidge	**NCEI – Boulder**	K. Baugh	DNB
JAM	NASA DPE	R. Marley	Algorithm testing
	Noblis	G. Mineart	Requirements
	Raytheon	K. Ahmad, W. Ibrahim	Operations
AIT	StAR	M. Tsidulko	Integration
Alaska users	GINA, NWS	E. Stevens, others	End users, analysis and forecasting

VIIRS EDR Imagery

- **VIIRS Imagery** remapped to the **Ground Track Mercator (GTM**) grid, eliminating overlapping pixels and bowtie deletions.
  - **NCC Imagery** is a pseudo-albedo derived from the DNB by normalizing the large radiance contrast in **DNB** from day to night (7 orders of magnitude)

Characteristic	SDR	EDR
Visible and IR bands	Radiances and/or reflectances	Radiances and/or reflectances (**same** as SDR)
Geo-spatial mapping	**Satellite projection** • Cross-track scans • Bowtie (on spacecraft) deletions • Overlapping pixels	**Ground Track Mercator (GTM)** projection: • Rectangular grid • No imagery gaps • No pixel overlap
Day/night imagery	**DNB (radiances)**	**NCC (pseudo-albedos)**

VIIRS EDR Imagery

- EDR Imagery is a **Priority 1** VIIRS product
  - Certain EDR Imagery bands are **Key Performance Parameters (KPPs)**
    - **I1, I4, I5, M14, M15, M16** (6 original L1RD KPPs)
    - **DNB/NCC and I3** are now also KPP bands (new in 2015)
  - The KPP itself reads as follows:
    - VIIRS Imagery EDR for bands I1, I4, I5, M14, M15, and M16 **for latitudes greater than 60 N in the Alaskan region**

- S-NPP Cal/Val Status
  - Imagery has been Validated since early 2014 (about 2 years after first light VIIRS imagery)
  - Remaining Imagery issues are minor, except for long data latency for some (non-Direct Broadcast) imagery (to be resolved with Block 2.0; and with 2 readout sites with maximum of ½ orbit latency)
  - Several websites for the Imagery (including LTM (Long Term Monitoring)
  - Engaging users for validation and feedback
  - NESDIS Social Media highly receptive of VIIRS Imagery

Table 1: Required Imagery EDR Products

Key Performance Parameters (KPPs) – 8 bands

Imagery EDR Product	VIIRS Band	Wavelength (µm)	Spatial Resolution Nadir/Edge-of-Scan (km)
Daytime Visible	**I1**	0.60 – 0.68	0.4/0.8
Short Wave IR (SWIR)	**I3**	1.58 – 1.64	0.4/0.8
Mid-Wave IR (MWIR)	**I4**	3.55 – 3.93	0.4/0.8
Long-Wave IR (LWIR)	**I5**	10.5 – 12.4	0.4/0.8
LWIR	**M14**	8.4 – 8.7	0.8/1.6
LWIR	**M15**	10.263 – 11.263	0.8/1.6
LWIR	**M16**	11.538 – 12.488	0.8/1.6
NCC	**DNB**	0.5 – 0.9	0.8

Table 2: Other IDPS-generated Imagery EDRs

Other Priority 1 (non-KPP) EDRs – 4 more bands

Imagery EDR Product	VIIRS Band	Wavelength (µm)	Spatial Resolution Nadir/Edge-of-Scan (km)
Near Infrared (NIR)	**I2**	0.846 – 0.885	0.4/0.8
Visible	**M1**	0.402 – 0.422	0.8/1.6
Visible	**M4**	0.545 – 0.565	0.8/1.6
SWIR	**M9**	1.371 – 1.386	0.8/1.6

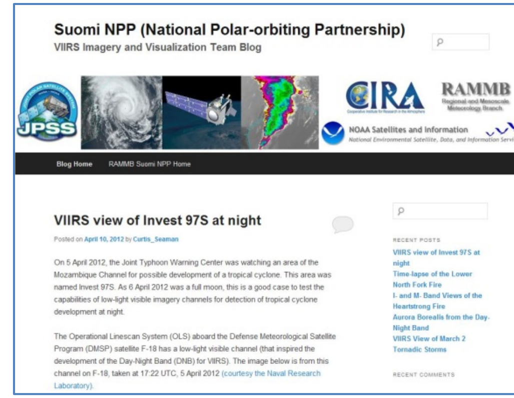
KPPs	EDRs	Total VIIRS bands
8	12	22

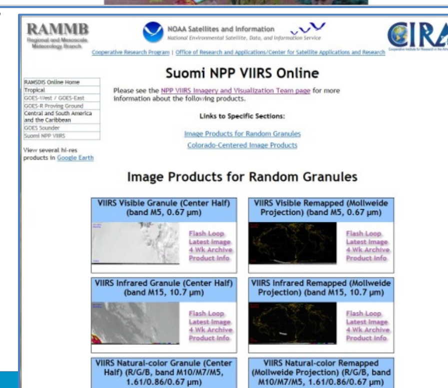
VIIRS Imagery outreach at RAMMB/CIRA and others

- VIIRS Imagery and image products outreach:
  - **VIIRS Imagery and Visualization Team Blog** (http://rammb.cira.colostate.edu/projects/npp/blog/)
  - **Seeing the Light: VIIRS in the Arctic** (http://rammb.cira.colostate.edu/projects/alaska/blog/)
  - **Suomi NPP VIIRS Online (including direct-broadcast imagery)** (http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp)

- **NRL-Monterey** uses of VIIRS:
  - **NexSat** http://www.nrlmry.navy.mil/NEXSAT.html
  - **VIIRS** http://www.nrlmry.navy.mil/VIIRS.html
- **NEIC-Boulder Earth Observation Group (EOG):**
  - **VIIRS** http://ngdc.noaa.gov/eog/viirs.html

- **StAR JPSS VIIRS "Image of the Month"**
  - http://www.star.nesdis.noaa.gov/jpss/
- **StAR ICVS Long Term Monitoring:**
  - http://www.star.nesdis.noaa.gov/icvs/status_NPP_VIIRS.php (select "EDR Imagery Over Alaska")





VIIRS Imagery & Visualization

The Great Flood of 2015

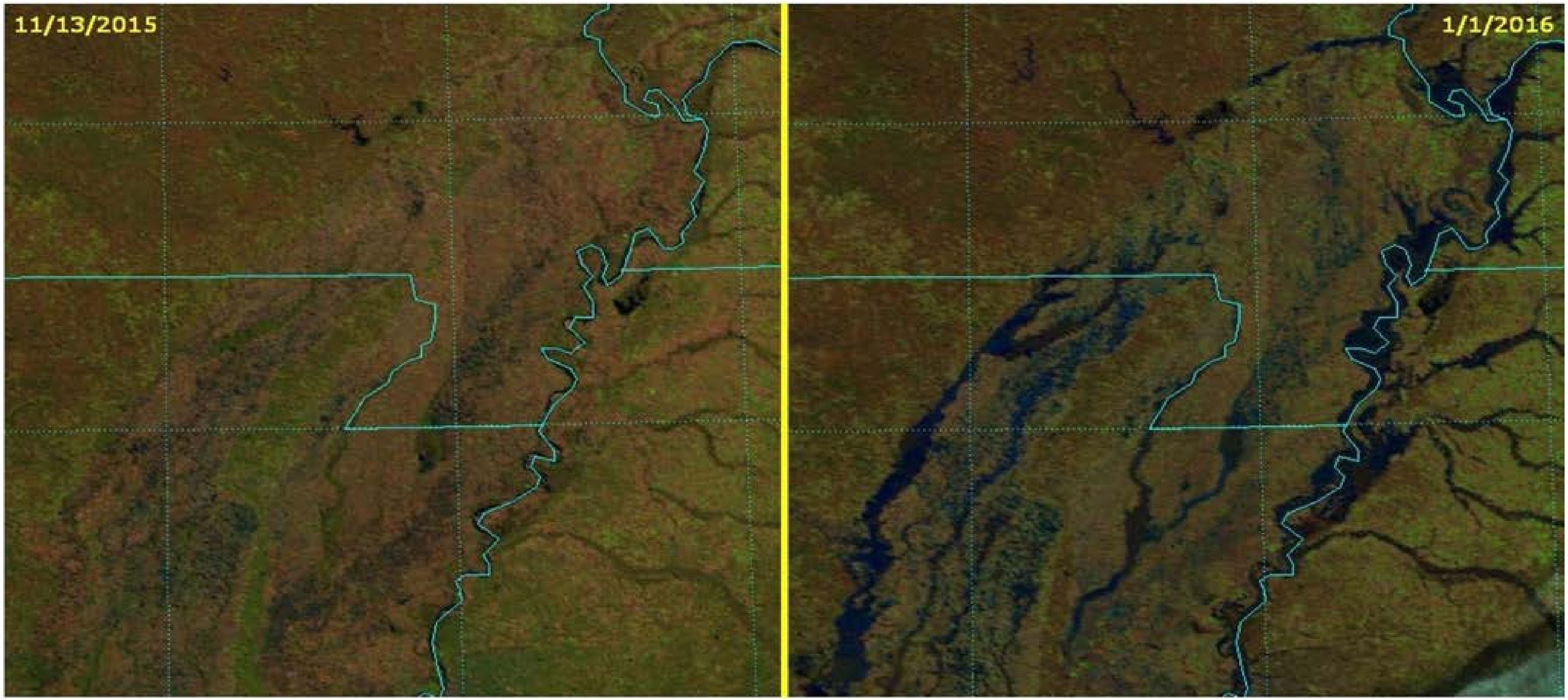


Figure JPSS-2. VIIRS Natural Color RGB composite imagery from Nov. 13, 2015 (left) and Jan. 1,2016 (right) reveals the extent of the flooding in the Midwest due to heavy rains that occurred between the Christmas and New Year's holidays. The VIIRS Imagery and Visualization Team Blog updated their post that discusses the flood event, causing the Mississippi River to reach its highest crest since the Great Flood of 1993. St. Louis, MO received 3 month's worth of precipitation in a three day period from December 26-28, 2015. **Images like these have been shared on social media**. Additional images and discussion are available at: **http://rammb.cira.colostate.edu/projects/npp/blog/index.php/uncategorized/the-great-flood-of-2015/**.

VIIRS Image of the Month – Cloudsnow Day

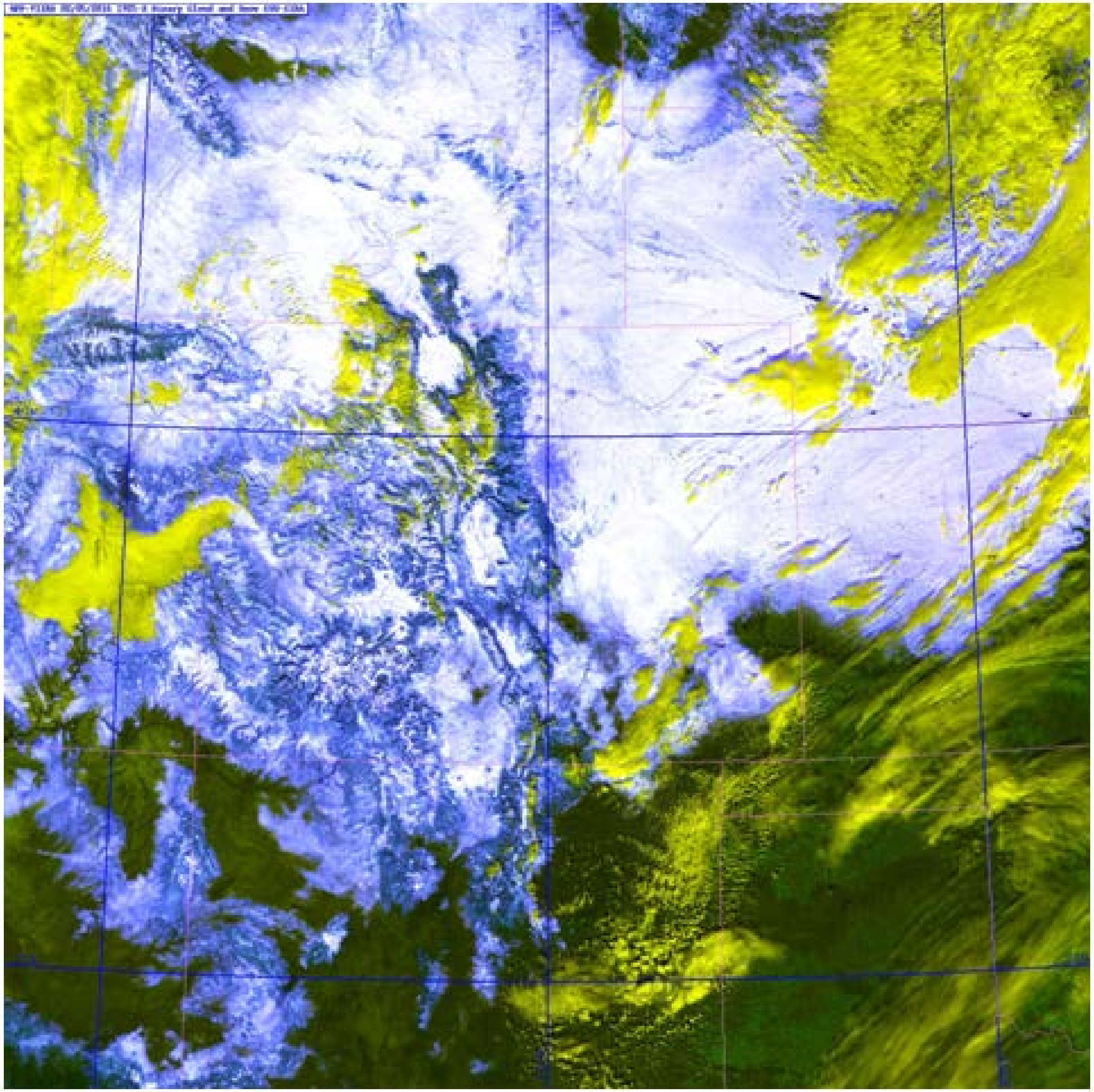


Figure JPSS-11. The image was taken @ 1925Z on 5 February 2016, a few days after a snowstorm that came through the state of Colorado, 1-2 February 2016. The image shows the state of Colorado and its neighboring states, where it discriminates and highlights the differences between snow on the ground (white) from the low-to-high level clouds (yellow). On this particular day, there were not many clouds hovering over the state. Additionally, one can see that almost the entire state of Colorado, from the Rocky Mountains to the eastern High Plains, are covered in snow. The snowstorm brought 12-18 inches (30-50 cm) of snowfall (i.e., snow depth) and approximately 1-2 inches (25-50 mm) of snow-water equivalent (a.k.a. SWE, the amount of liquid water contained within the snowpack) to the front range and Denver Metropolitan areas.

VIIRS Image of the Month - View of Cool Airmass

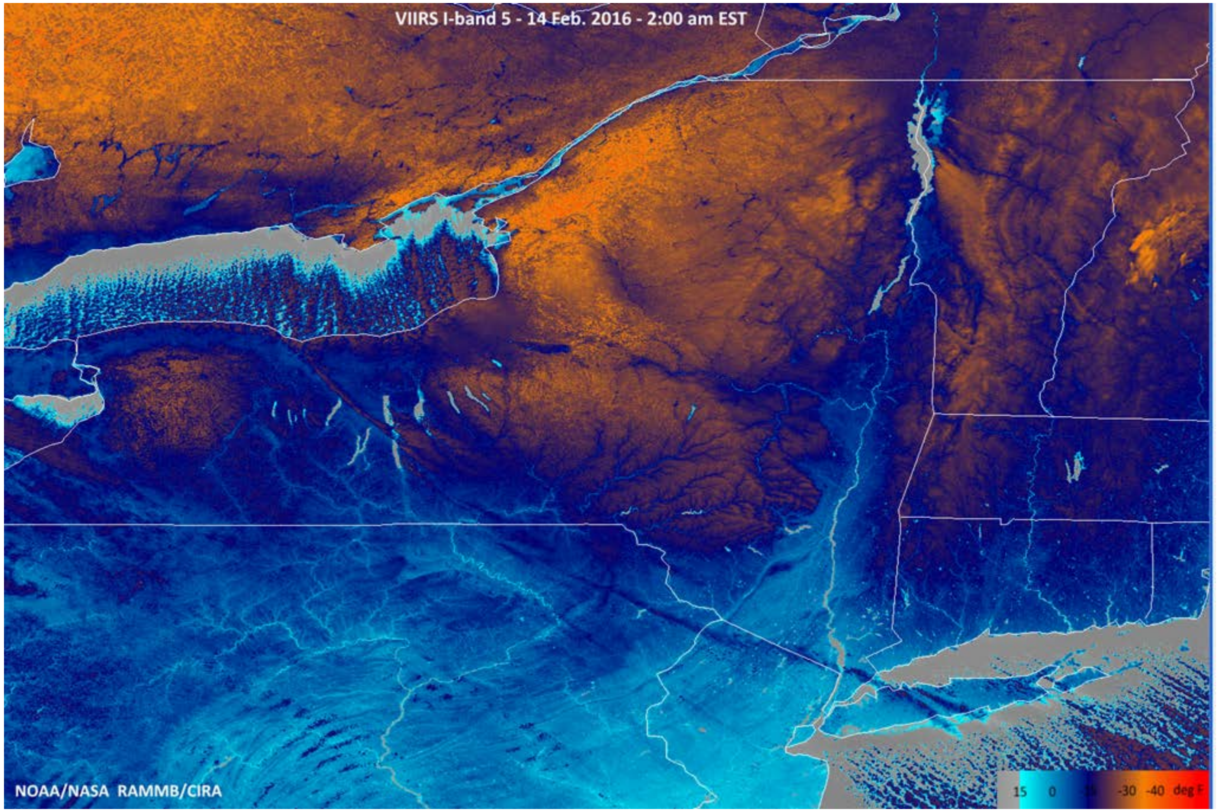


Figure JPSS-10. A bitterly cold airmass dropped over the northeast U.S. on Valentine's Day (Feb. 14, 2016), resulting in many daily record cold temperatures, including in Albany, Watertown, and Syracuse, New York. It was also the coldest temperatures observed in several decades in a number of locations. NPP's nighttime pass at 2 am EST allowed for an impressive VIIRS I-band 5 image over a region that was largely cloud-free. Its high resolution (375 m) captured sharp horizontal gradients in brightness temperature, largely tied to terrain features such as ridges and valleys. The coldest pixel in this scene (in the U.S.) was -49.4 C in a river valley northeast of Watertown, NY. It should be noted that these brightness temperatures are not the "shelter temperatures" that are used for surface temperature observations.

VIIRS Image of the Month – Saharan Dust

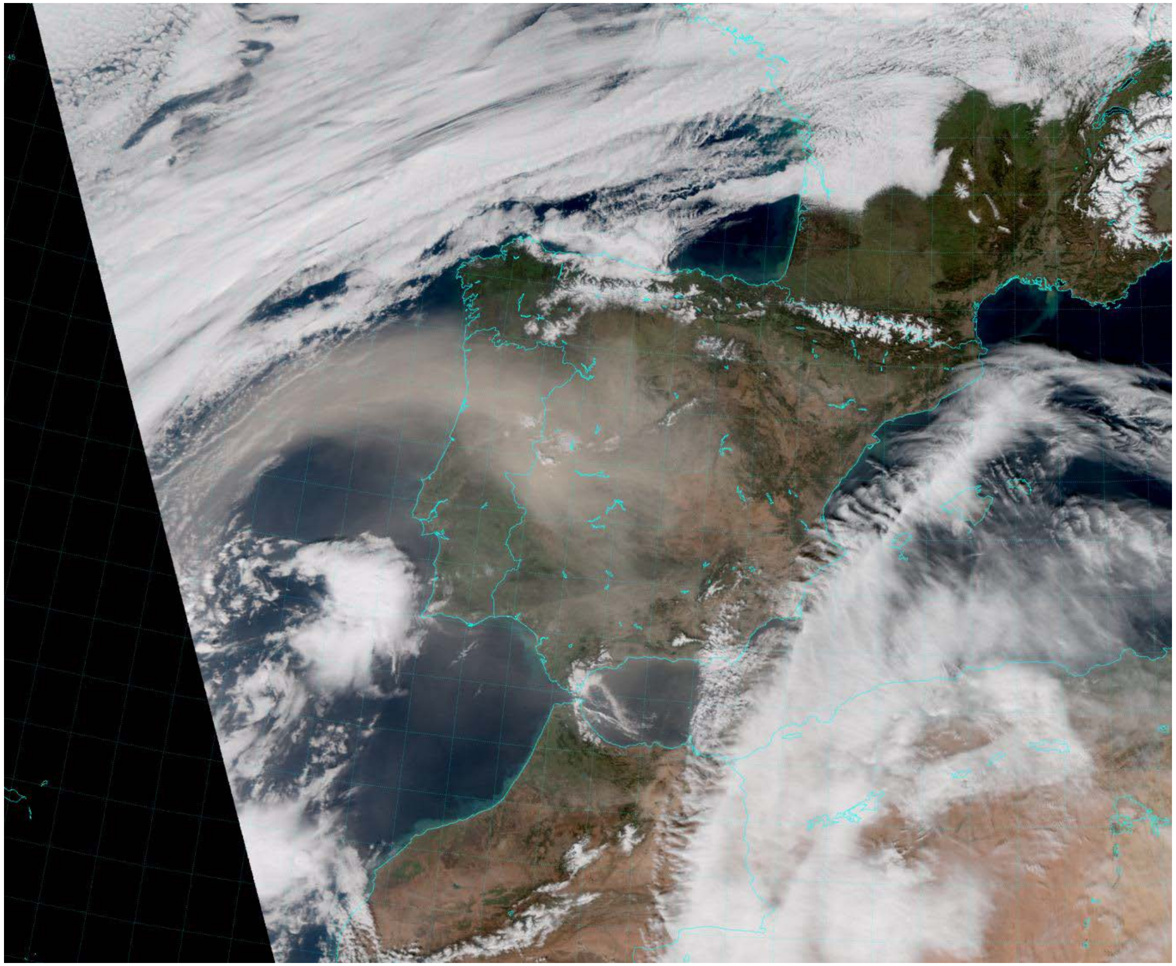


Figure JPSS-1. VIIRS True Color RGB composite image of Saharan dust outbreak over Spain and Portugal (12:40 UTC 21 February 2016).

Image of the Month – Fort McMurray Wildfires

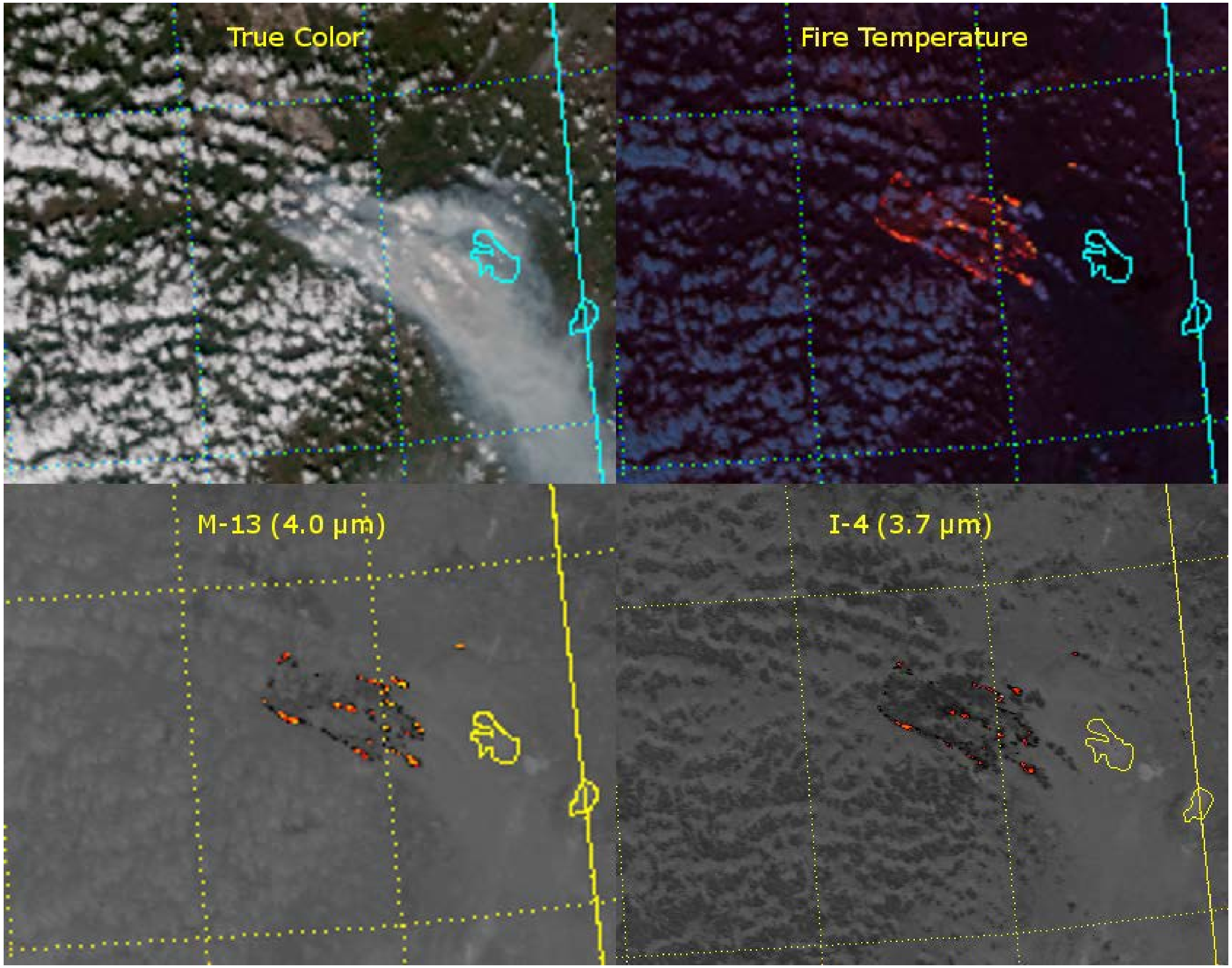
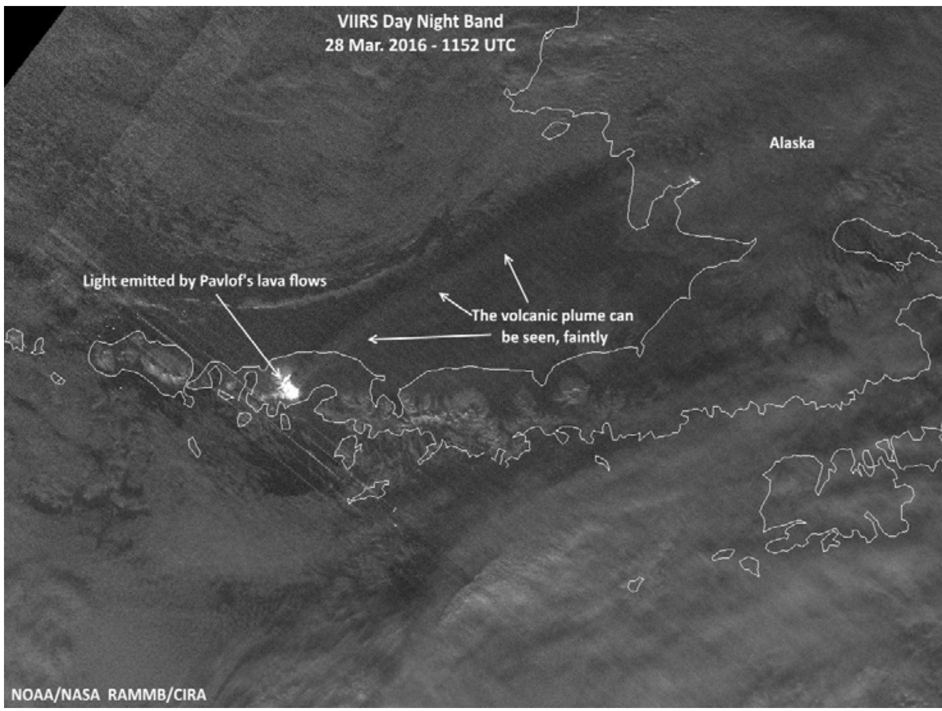


Figure JPSS-1. Imagery from May 5, 2016 centered over the Fort McMurray fires: True-color/red-green-blue (RG) (top left); Fire-temperature RGB (top right); M13 single-band infrared (IR, 4.0 µm, bottom left); and I4 (3.7 µm, bottom right).(Courtesy Curtis Seaman (Cooperative Institute for Research in the Atmosphere (CIRA and Dan Lindsey (STAR).

Image of the Month – Pavlof Eruption

Pavlof Eruption

A number of VIIRS **images** were **provided by RAMMB/CIRA** to NESDIS, which were in turn shared with the media. Some of these were picked up by various media outlets, including http://www.wired.com/2016/03/pavlofs-unexpected-eruption-alaska-spews-ash-20000-feet-high/ and http://fox2now.com/2016/03/28/volcano-erupts-in-southwest-alaska-sends-ash-20000-feet/.



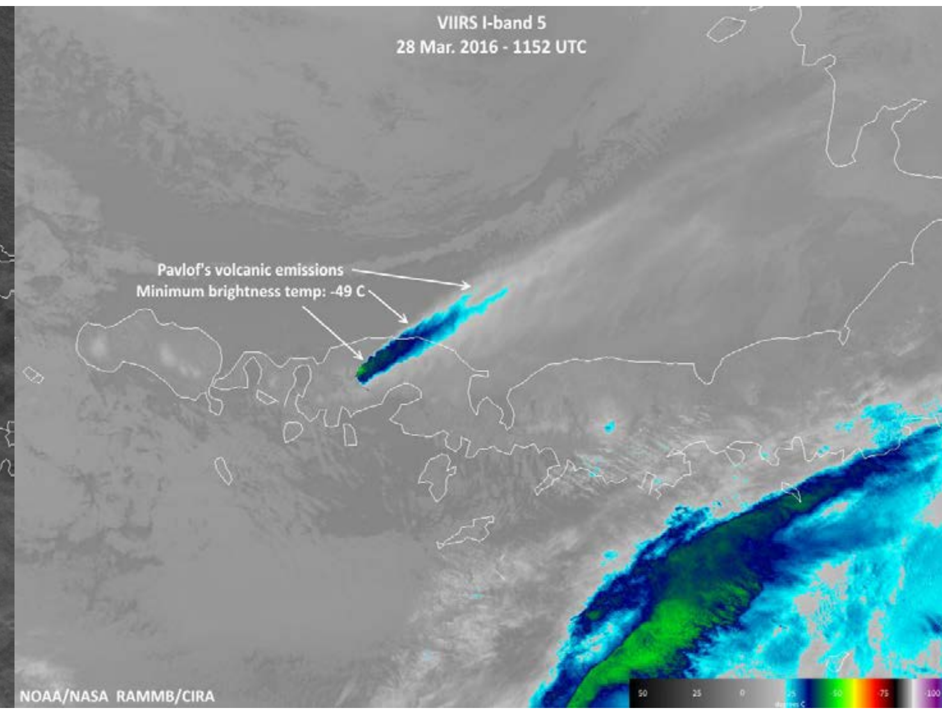


Figure JPSS-1. VIIRS Day/Night Band (DNB) from 1152 March 28, 2016 of recent Pavlof eruption in the Alaska Peninsula.

Figure JPSS-2. Same as Figure JPSS-1, but VIIRS color-enhanced I5 (11.45 µm) band.

Image of the Month – Pavlof Eruption

Figure JPSS-31. Suomi NPP VIIRS image from about 1:30 AM local time (~9 hours after the initial eruption of Pavlof on March 27, 2016). Information from Suomi NPP's Day/Night Band sensor (measuring reflected moonlight off snow, clouds, and ash) has been blended with other measurements that are sensitive to the temperature and composition of water/ice clouds and volcanic ash. With each unique observation playing its part, the low water clouds and snow cover are shown in yellow, higher/thicker ice clouds in shades of blue, and the heart of Pavlof's ash plume streaming to the northeast depicted in red/orange. For reference, the coastal boundaries are drawn in purple. (Steve Miller, CIRA)

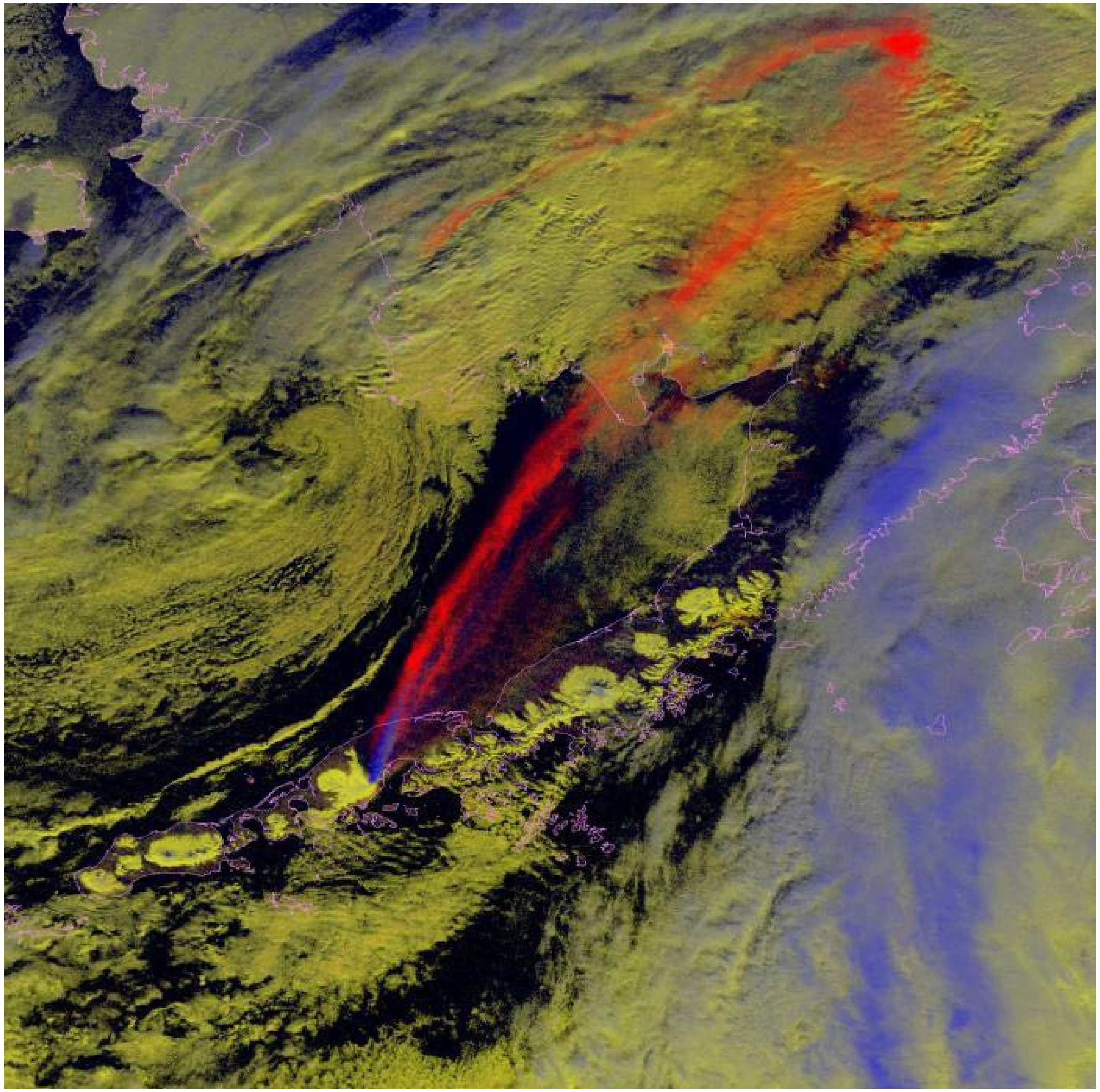


Image of the Month – Tropical Cyclone Fantala

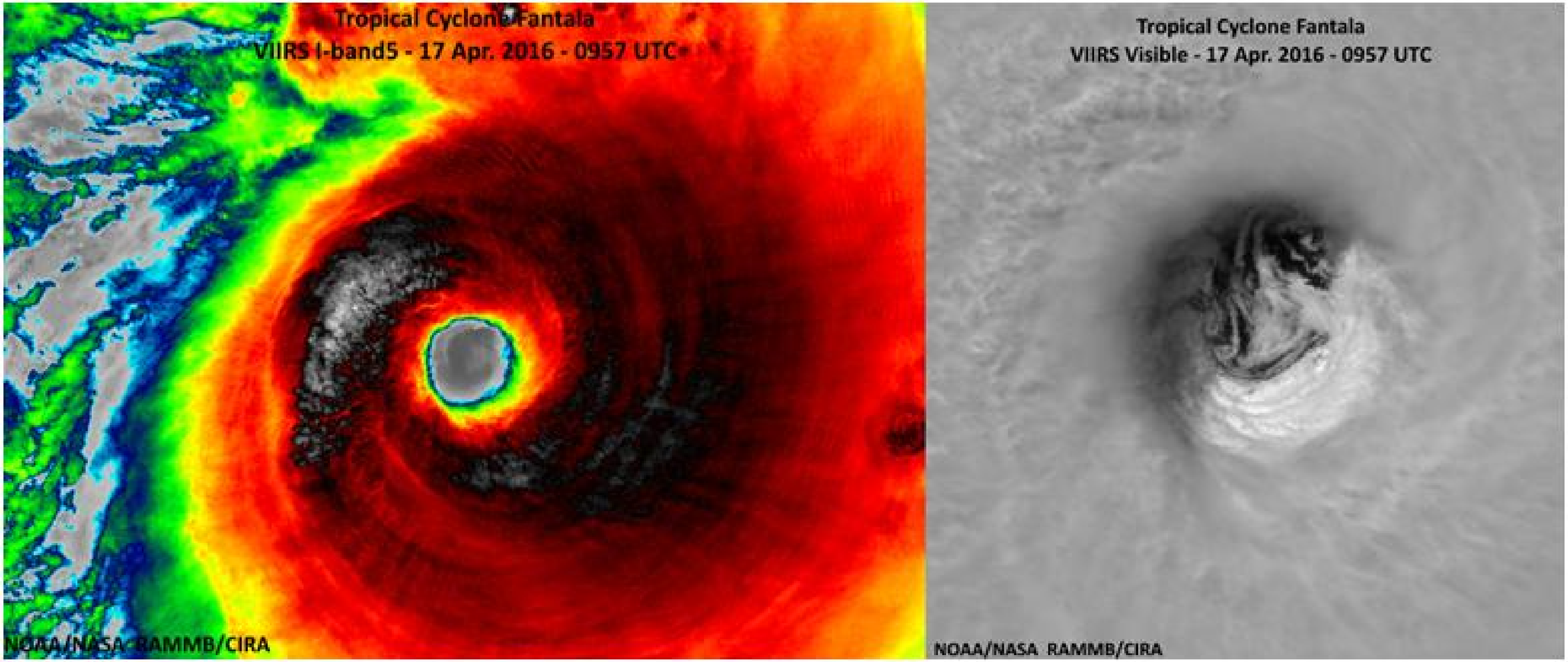


Figure JPSS-31. RAMMB/CIRA personnel provided another 'Image of the Month', this time of Tropical Cyclone Fantala, which achieved a Category 5 intensity of 150 knots on 17 April as it passed north of the island of Madagascar in the southwestern Indian Ocean. It was the most powerful storm in the Indian Ocean on record. The daytime infrared and visible images from the VIIRS 375-m I-bands show a very well-organized storm with a warm eye, symmetric cold central dense overcast, and evidence for mesovortices in the low-level clouds inside the eye. (D. Lindsey, StAR)

Image of the Month – Fires & Smokes

Fires and Smoke in VIIRS Imagery: The image is a result of Principal Component Analysis of VIIRS M-band Imagery. Selected components were combined in this three-color/RGB image, showing the fires and smoke affecting eastern Colorado, western Kansas and Nebraska on 16 June 2016 at *1954 UTC*, in otherwise clear conditions. Normally, smoke is seen best in forward scattering (morning imagery for GOES-West, or evening imagery for GOES-East), with very little signal in backscatter with an overhead sun (as in this ~11 am local VIIRS image). However, this product relies heavily on the VIIRS visible/reflective bands (M1-M5) where scattering increases at shorter wavelengths. Band combinations reveal the smoke, which is an otherwise subtle signal in any single-band image.

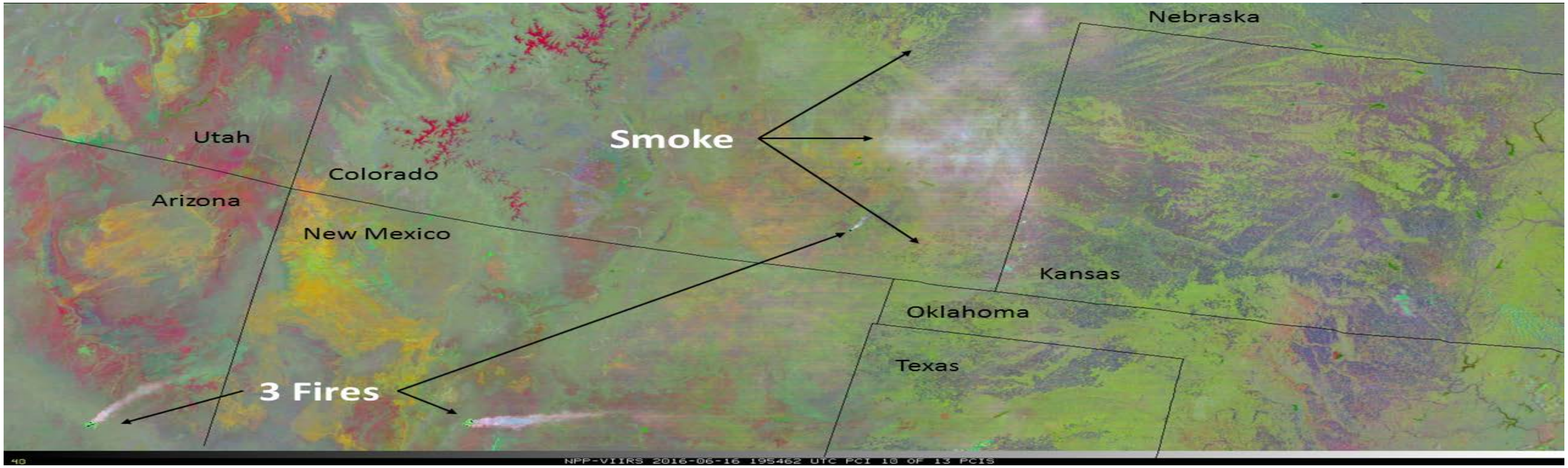
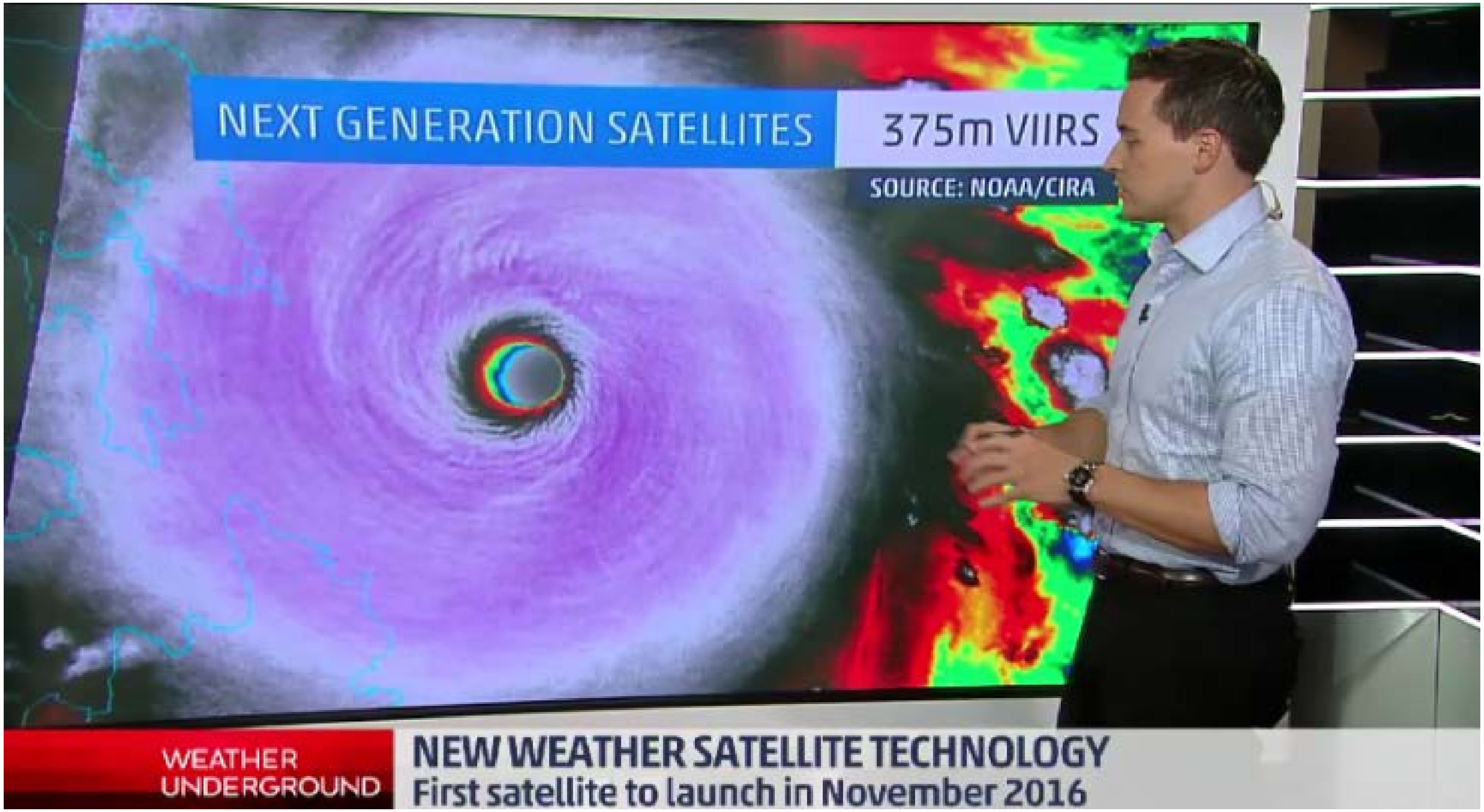


Figure JPSS-1. *False three-color image of fires & smoke from 16 June 2016 at 1954 UTC. The two main fires in Arizona and New Mexico, as well as a smaller fine in southeastern Colorado, caused a smoke layer over eastern Colorado. This product is a result of Principal Component Analysis of the VIIRS M-band imagery, with the main signal coming from the visible/reflective bands M1-M5.*

VIIRS on Social Media!



The Weather Channel aired a segment on 16 June 2016 about observing hurricanes and typhoons with future satellites, including GOES-R and Suomi NPP/JPSS. RAMMB/CIRA provided some VIIRS and Himawari AHI imagery that was used in the segment.

DNB Imagery with Moon Phase/Illumination

Here are the links to the CONUS and Alaska loops for the DNB Moon imagery. For the Alaska loop you may need to zoom out when displaying the sequence.

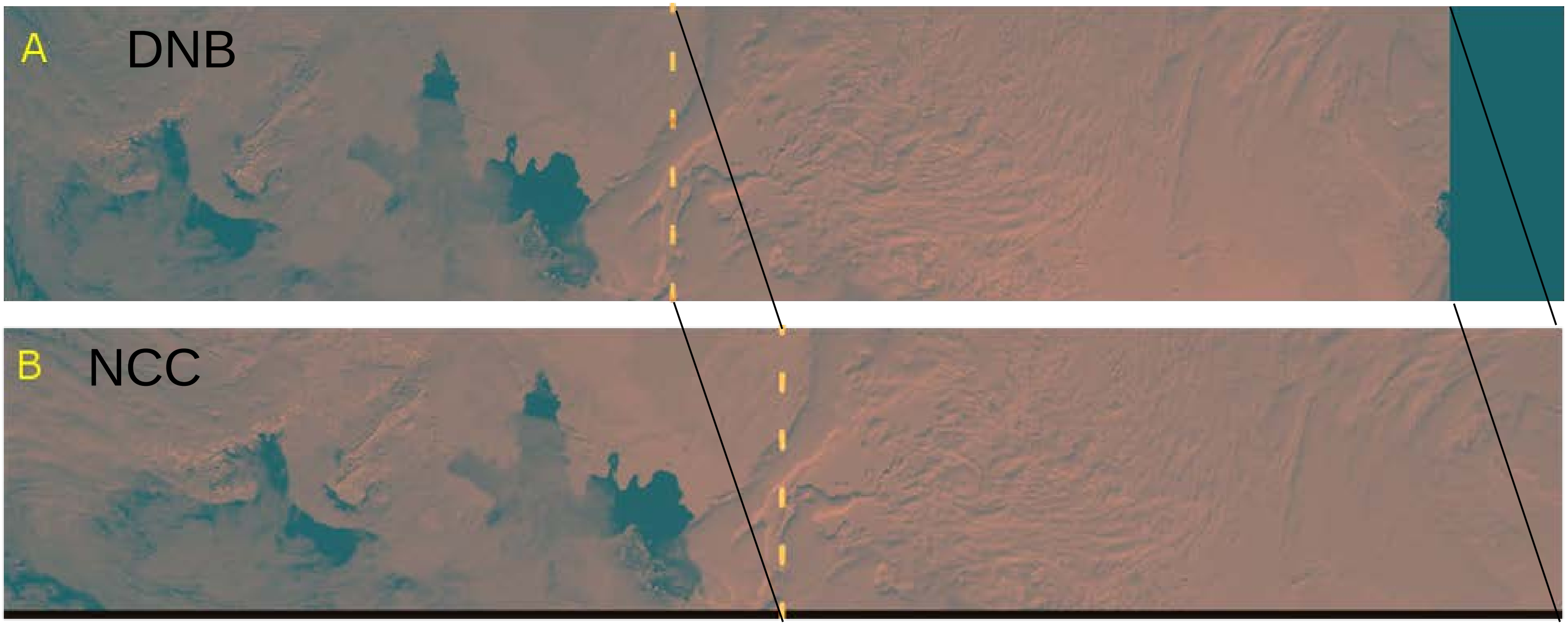
http://rammb.cira.colostate.edu/templates/loop_directory.asp?data_folder=visitview/custom/DNB_images/Moon_Phases_DNB

http://rammb.cira.colostate.edu/templates/loop_directory.asp?data_folder=visitview/custom/DNB_images/Moon_Phases_DNB/Alaska/

JPSS-1 Cal/Val Plan

- JPSS-1 Image Cal/Val Plan
  - **Quantitative calibration** (radiances/reflectances) at SDR level
  - **Qualitative validation** of Imagery by end users
- Preparations for JPSS-1 VIIRS Imagery
  - **DNB** changes due to increased pixel aggregation at edge of scan and extended swath width
    - This was tested using simulated data for JPSS-1
    - No changes to **NCC** software/product needed

Simulation of increased aggregation at edge of swath and extended granule and offset of nadir for JPSS-1 DNB



A) DNB from S-NPP used to display how DNB will look from JPSS-1, with the **blue area on the right filled with extended scene imagery (currently missing in this simulation)**
B) The DNB remapped into the GTM mapping used for NCC, showing that the **NCC shifts the DNB imagery to the right, placing nadir at the center and ignoring the extended scene data on the right**. In each image, the dashed line shows the approximate location of nadir.

EDR Imagery Team J1 L+90 actions

From EDR Imagery (KPP)

- There is only one LUT that may require adjustment, but it is a long-term need and it would NOT require an update in the first 90 days
- NCC Imagery is dependent on the stray light and other DNB fixes from the VIIRS SDR Team.
- Need to visualize the Imagery as soon as possible, given we have to reach validation by L+90 days
  - Download Imagery and create image products as soon as possible.
  - Provide Imagery to, and seek feedback from users, particularly NWS/AWIPS and Alaska.

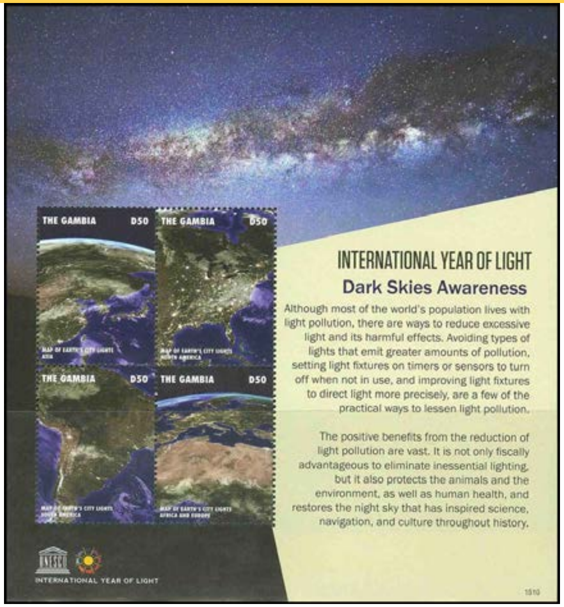
NCC Terrain Correction (TC) geo-locations needed!

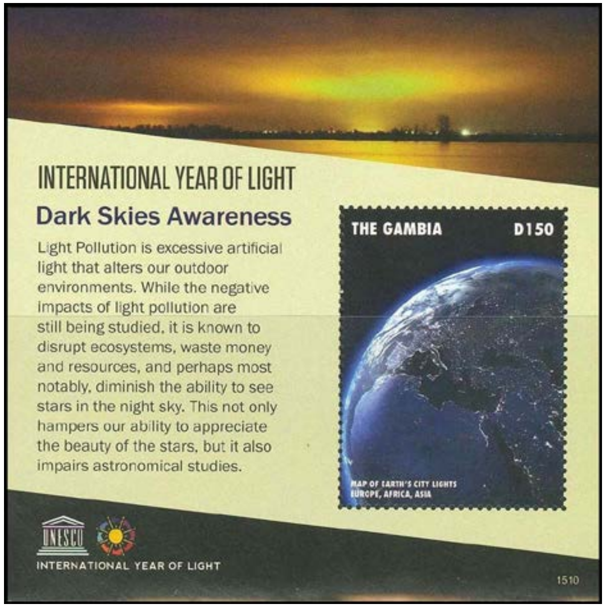
- With **NCC Imagery now available to NWS users** via AWIPS, the JPSS Satellite Liaison has put together NCC loops for user familiarization and training
- These loops reveal an issue with NCC Imagery: that **light sources move from image to image** (**by several kilometers**, unlike similar TC DNB loops)
  - This is likely due to the fact that for Imagery EDRs (NCC, etc.) are based on ellipsoid geo-locations
  - **SDRs have both ellipsoid and terrain-corrected geo-locations**
- **The VIIRS Team and the EDR Imagery Team both supported TC geo-locations for DNB (SDR) in 2011/2012**
  - Now it's time to **add TC geo-locations, or replace the ellipsoid geo-locations**
  - This will require some effort to prove there's a need for a change, document user support for the change, and take this issue thru the review boards and LORWG
- Example for Colorado fires, 9-12 July 2016
  - http://rammb.cira.colostate.edu/templates/loop_directory.asp?data_folder=visitview%2Fcustom%2FFires_07_12_16%2F
- Example from the Sand Fire in Southern California, 22-25 July 2016
  - http://rammb.cira.colostate.edu/templates/loop_directory.asp?data_folder=visitview/custom/Sand_Fire_CA_July_2016/

Summary & Path Forward

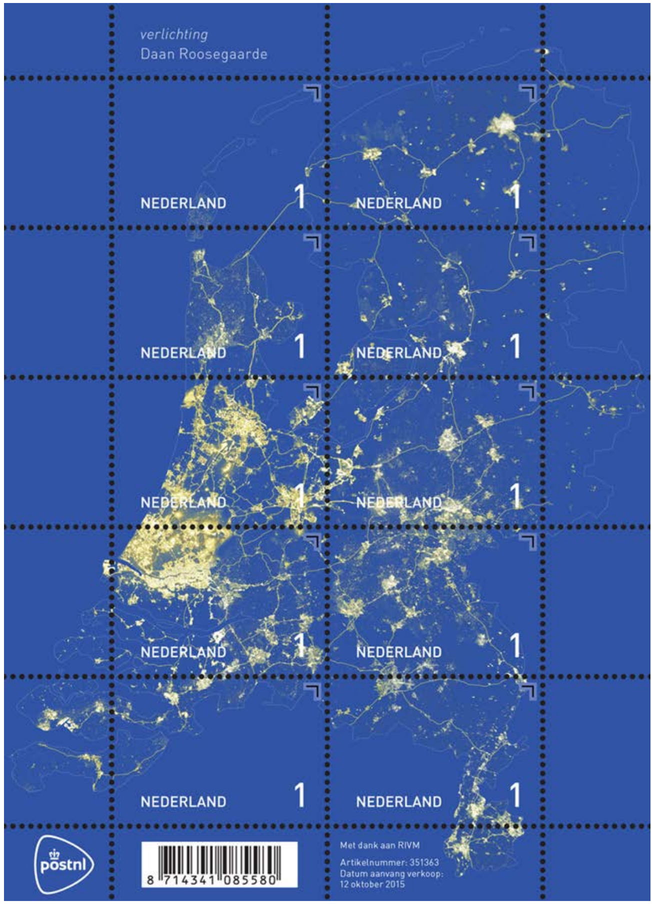
- VIIRS Imagery is **excellent**:
  - Visible/IR are **especially high quality** (and best spatial resolution among operational satellites)
  - **DNB/NCC is the innovative product** from VIIRS that is not available from any geostationary satellite/orbit (or will be for many years!)
  - **Interactions with users vital for Validation** (particularly Alaska and other NWS users)
  - **Social Media outlets** highly receptive of VIIRS Imagery. Good publicity for NOAA/NESDIS and JPSS/VIIRS
- Path Forward
  - **S-NPP and forward: NCC Terrain Corrected geo-locations needed (examples presented, with shifts of several kilometer at higher elevations)**
  - **J1: New DNB aggregation modes** for end of swath pixels on JPSS-1, resulting in extended swath and offset of nadir
    - NCC algorithm/product was tested using simulated DNB from VIIRS SDR Team.
  - **J2 and Beyond**
    - VIIRS has a **potential underlap problem in the footprint** which will lead to a footprint gap between VIIRS scans (detector 1 in one scan and 16 in the next scan) especially at nadir and near the equator
    - Recommend changes to VIIRS (a **water vapor band has been proposed**)

And finally! Postage stamps featuring VIIRS





Netherlands 2015
DNB city lights



Gambia 2015
DNB and true-color VIIRS

USA 2016
True-color VIIRS

Nighttime VIIRS Processing at NOAA/NCEI/EOG

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Earth Observation Group (EOG)
CIRES - University of Colorado, USA
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Chris Elvidge - NOAA NCEI, USA
Mikhail Zhizhin - CIRES - University of Colorado, USA
Feng Chi Hsu - CIRES - University of Colorado, USA
Tilottama Ghosh – CIRES – University of Colorado, USA

EOG Nighttime VIIRS Product Lines

Earth Observation Group Nighttime VIIRS Product Generation System

GRAVITE
~2 hour latency

DNB and I bands
Data volume = 250GB/day

VIIRS Boat Detection (VBD)

- Detects offshore DNB spikes
- Four hour latency

Output csv and kmz posted at NCEI web site
http://www.ngdc.noaa.gov/eog/viirs/download_total_boat.html

Email alert service for detections in Marine Protected Areas, fishery closures and restricted waters.

US Ground Stations
~30 minute latency

DNB and M bands
Data volume = 25GB/day

- VIIRS NightFire (VNF)
- Geolocated DNB mosaics
- for North America with ~1hr latency

Output VNF csv and kmz files and DNB geotiffs posted at NCEI web site.
http://www.ngdc.noaa.gov/eog/index.html

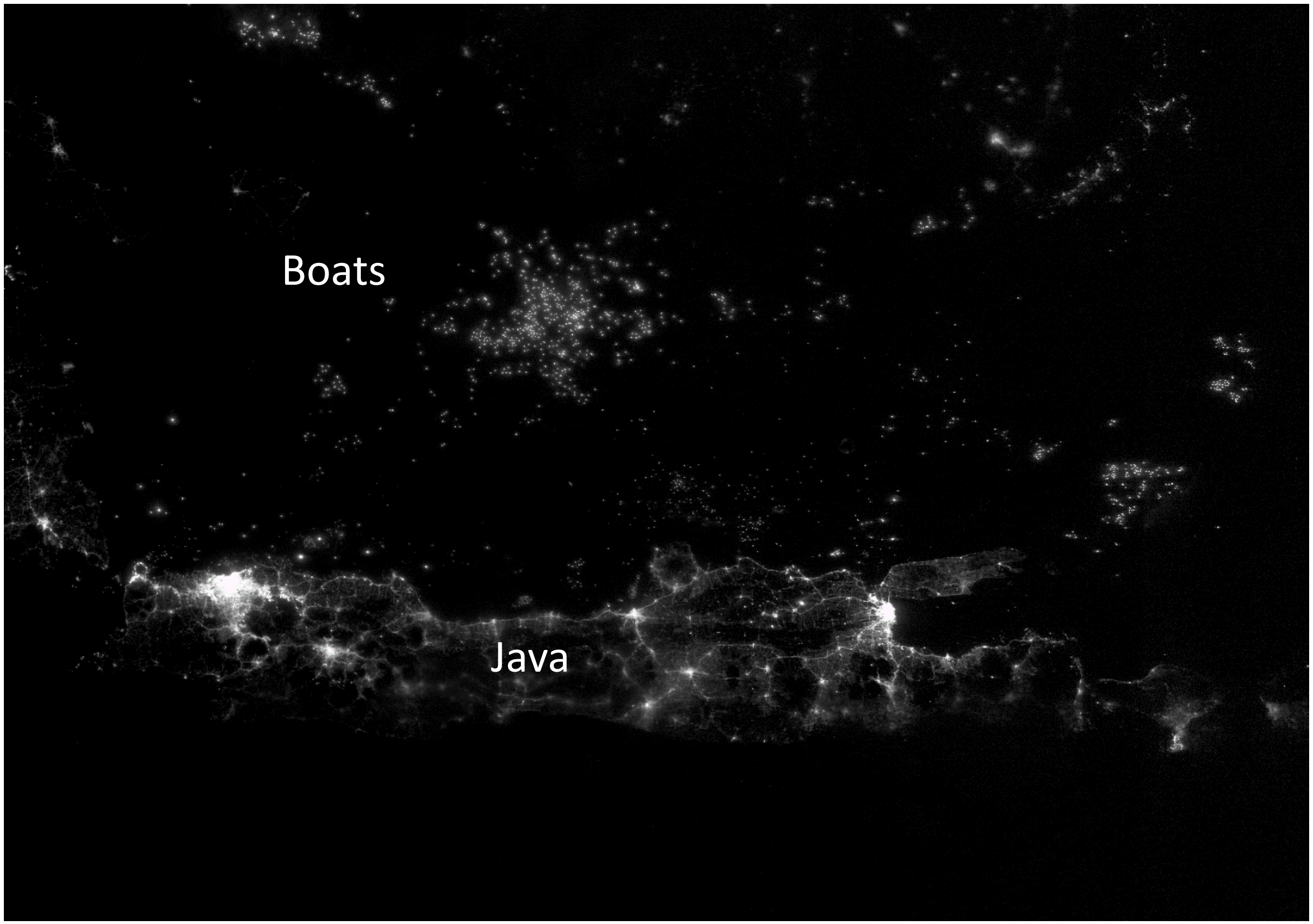
CLASS
~7 hour latency

DNB and M bands
Viirs Cloud Mask
Data volume = 100GB/day

- Nightly global VIIRS NightFire (VNF)
- Monthly DNB cloud-free composites
- Geoloated DNB nightly mosaics

Output VNF csv and kmz files and DNB geotiffs posted at NCEI web site.
http://www.ngdc.noaa.gov/eog/viirs/download_ut_mos.html
http://www.ngdc.noaa.gov/eog/viirs/download_monthly.html
http://www.ngdc.noaa.gov/eog/viirs/download_viirs_fire.html

VIIRS Boat Detection (VBD) Product



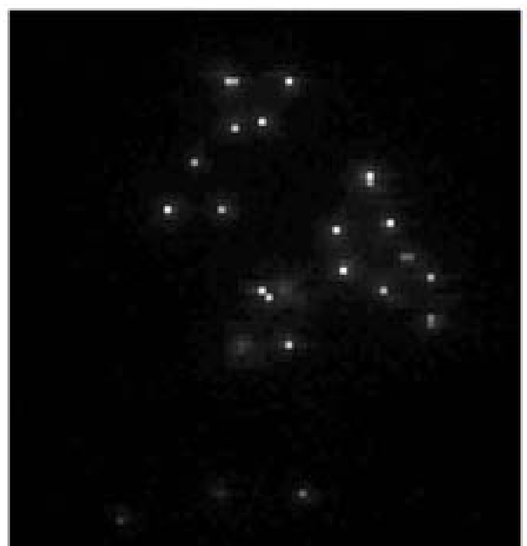
Java Sea, Indonesia September 28, 2014

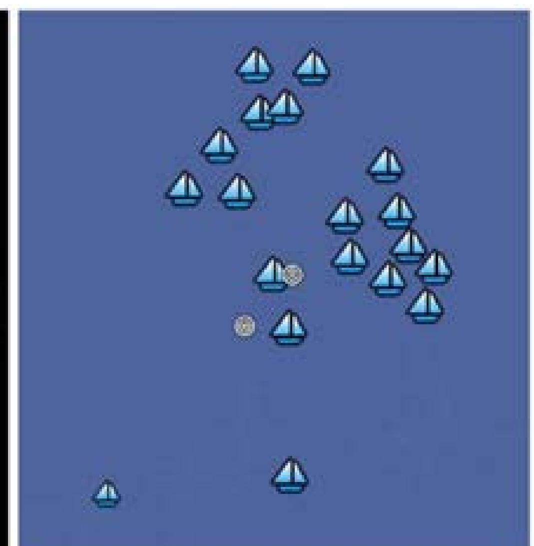
- The Visible Infrared Imaging Radiometer suite has a unique capability to detect lights at the earth's surface. This includes heavily lit boats.
- NCEI has been working on algorithms for reporting boat detections since September 2014.
- Supported by the JPSS program office and USAID.
- Files available by 06:00 local time.

VIIRS Boat Detection (VBD) Product

VIIRS day/night band (DNB) nighttime image data

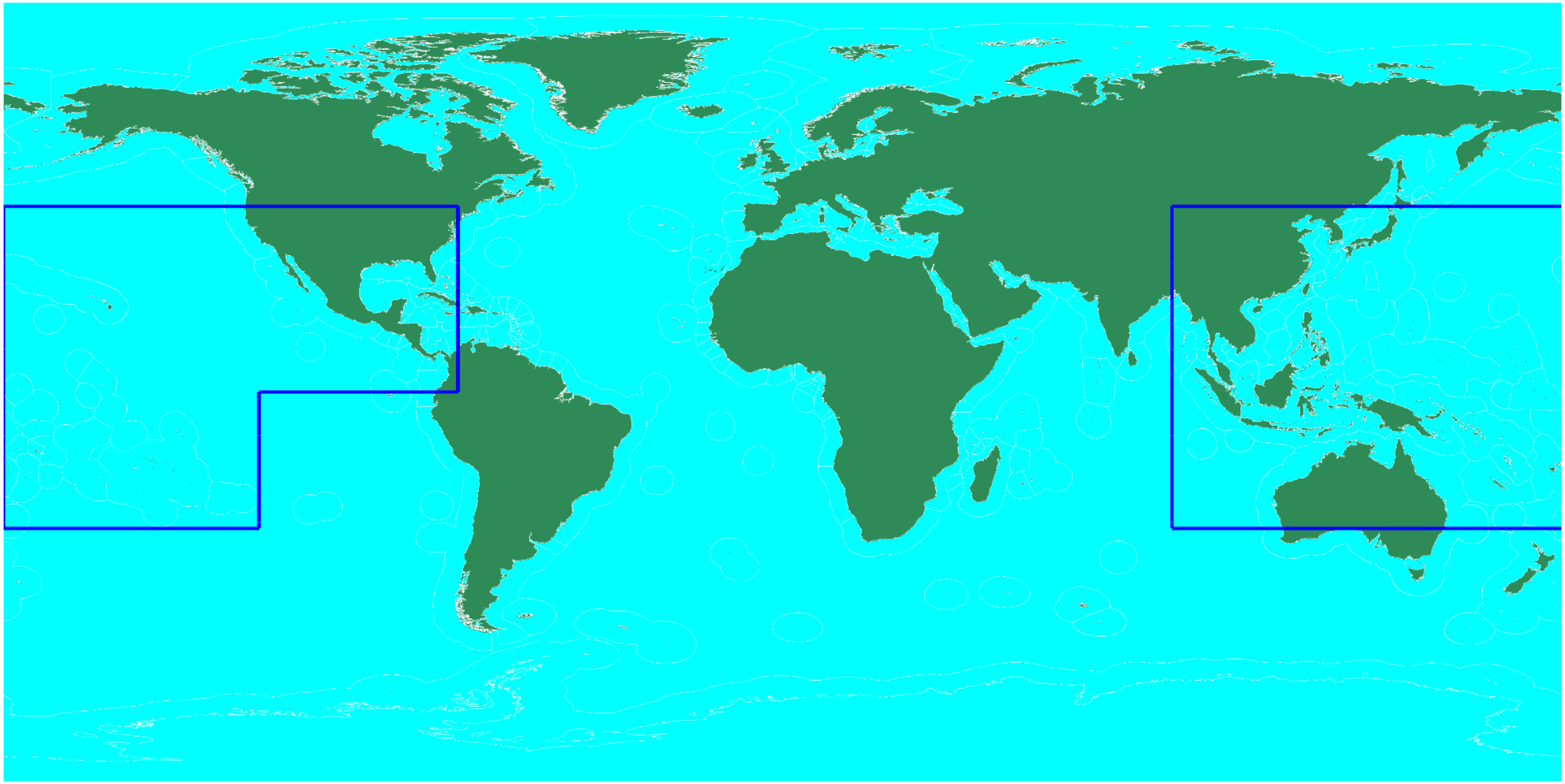
Boat detection data (points)





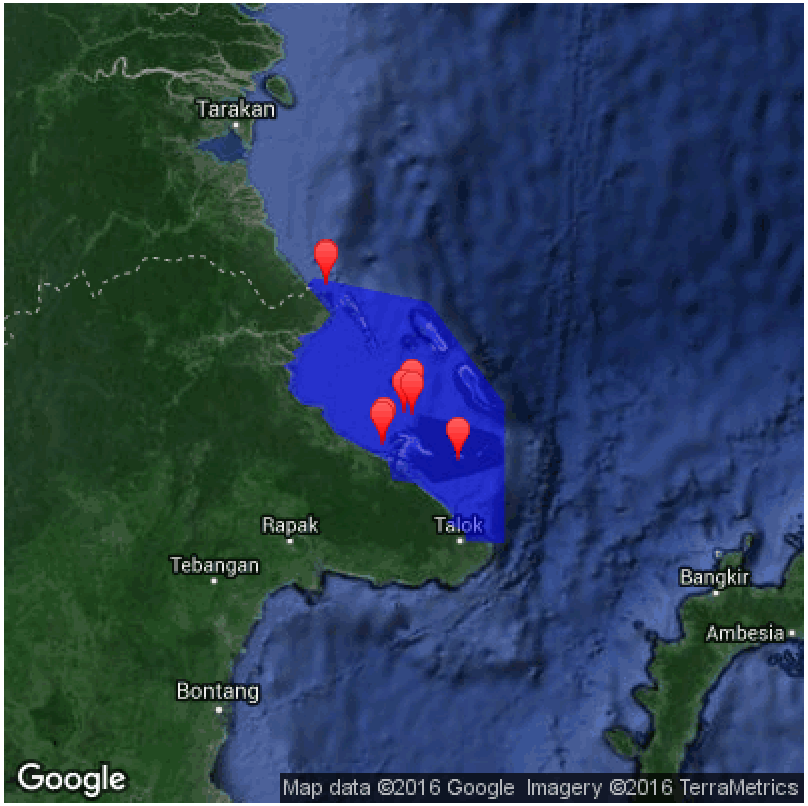
VBD algorithms run on DNB/I5 SDR files, output points, vast data volume reduction

Current VBD Processing Area



VBD alert service example for an Indonesian MPA

Derawan Marine Conservation Area



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2 / 8
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Longitude: 118.069122
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Quality flag= 1 (Strong)

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3 / 8
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Longitude: 118.382790
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Quality flag= 1 (Strong)

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4 / 8
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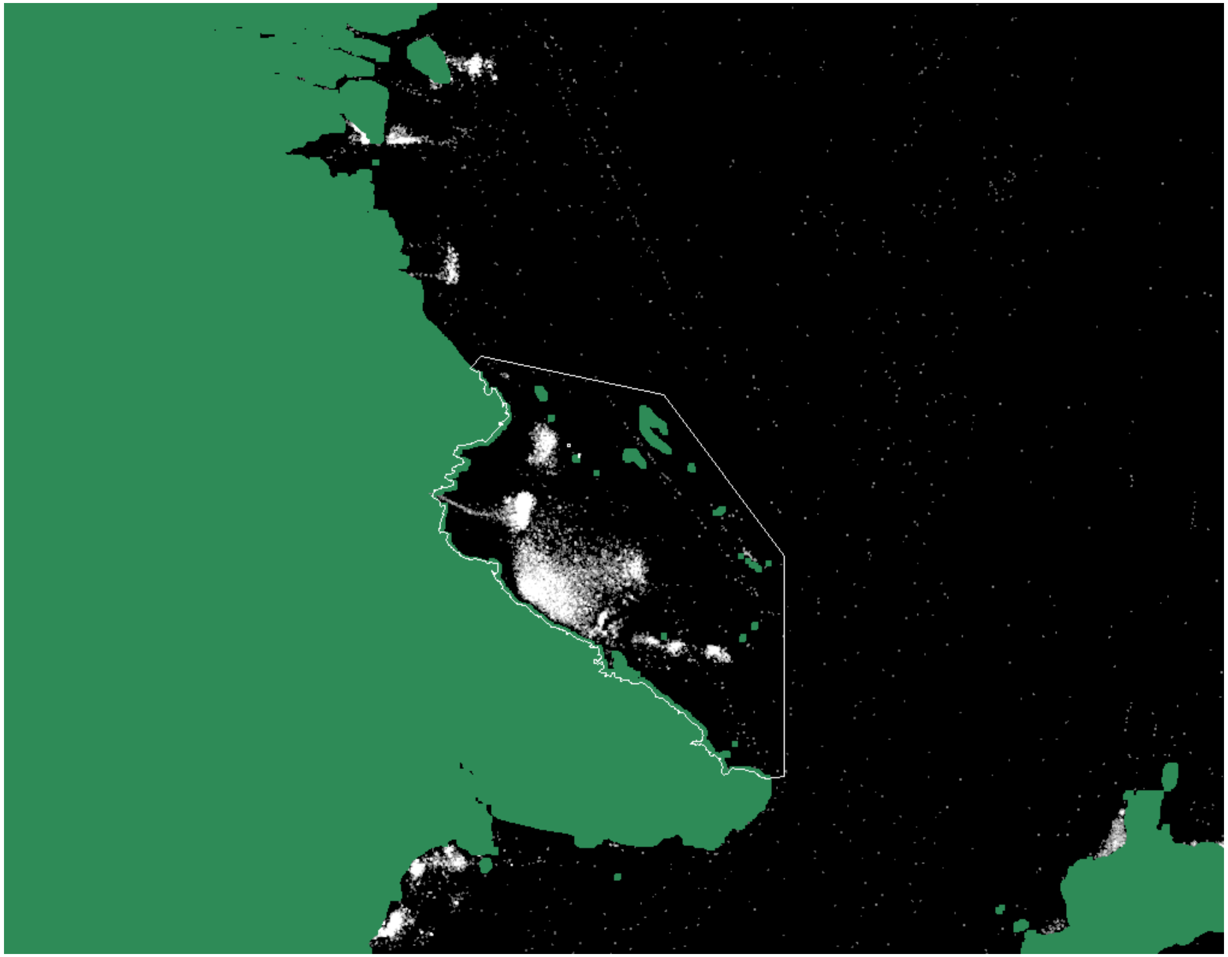
Color: red
Quality flag= 2 (Medium)

+===
7 / 8
UTC_Time: 2016-06-13 18:09:35
Local_Time: 2016-06-14 02:09:35
Latitude: 1.742041
Longitude: 118.541756
Color: red
Quality flag= 2 (Medium)

+===
1 / 8
UTC_Time: 2016-06-13 18:09:40
Local_Time: 2016-06-14 02:09:40
Latitude: 1.476586
Longitude: 118.796684
Color: red
Quality flag= 1 (Strong)

Annual VBD summary grids reveal spatial patterns of fishing boat activity



Derawan Marine Conservation Area

25 Countries Show Clusters of VIIRS Boat Detections

- **Asia:** Russia, Japan, Korea, China, China Taipei, Vietnam, Cambodia, Thailand, Myanmar, Malaysia, Indonesia, Philippines, India

- **Oceania:** Australia, New Zealand, Papua New Guinea

- **Europe, Middle East and Africa:** Egypt, United Arab Emirates, Iran, Oman, South Africa, Malta

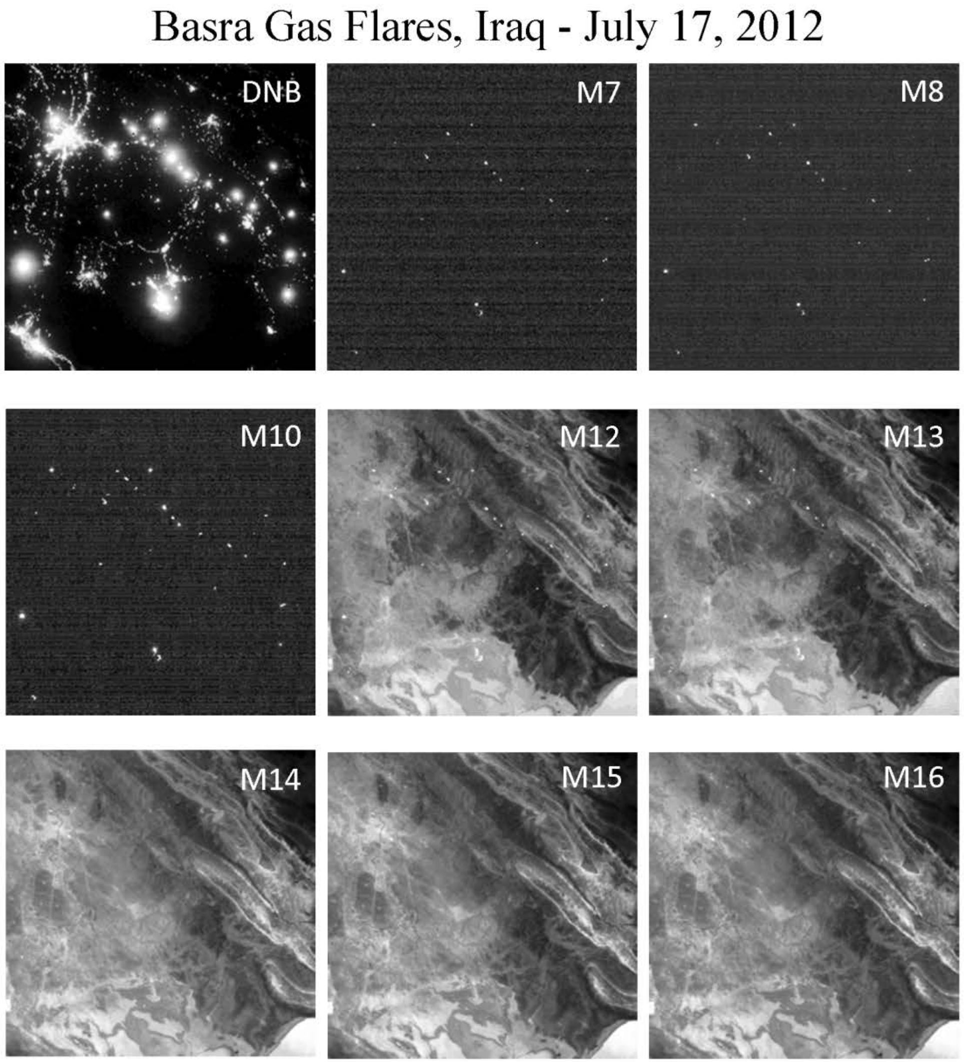
- **Americas:** Argentina, Peru, Ecuador

Current VBD Products/Services

- Nightly VBD files for Asia and Pacific available at: http://www.ngdc.noaa.gov/eog/viirs/download_boat.html
- Country level products are running for: Indonesia, Philippines, Thailand-Cambodia, Vietnam, Fiji, Papua New Guinea, Guam.
- Email alert services for:
  - 86 MPAs in Indonesia
  - Four seasonal fishery closures in the Philippines
  - Restricted municipal waters (out 15 km from shore) in the Philippines. Commercial fishing boats are banned from this zone.

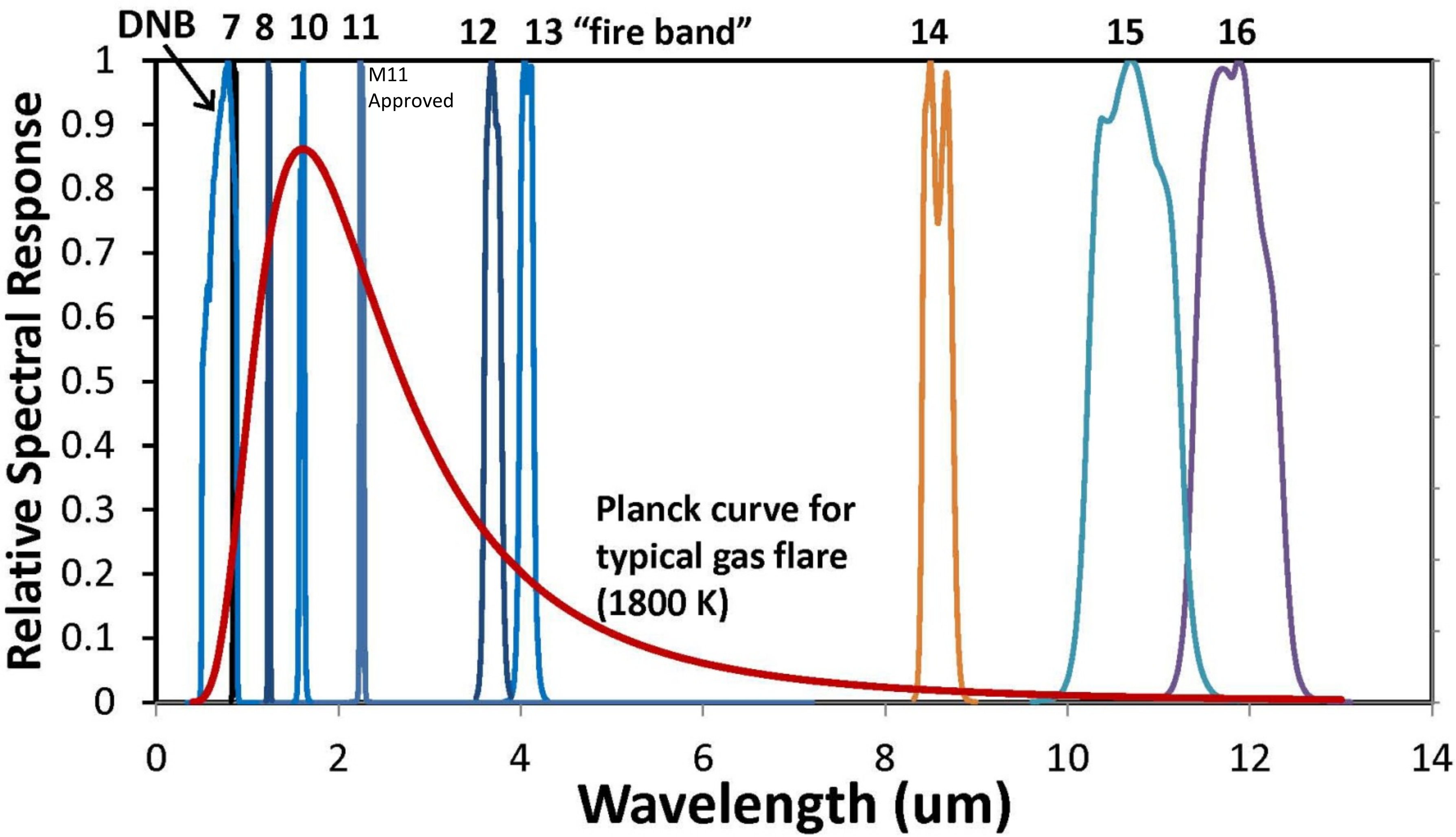
VIIRS Nightfire (VNF)

- A multispectral "fire product" developed by the NOAA Earth Observation Group.
- Makes use of two near infrared (NIR), a short-wave infrared (SWIR), two mid-wave and three long-wave infrared bands.
- The NIR and SWIR bands were designed for daytime imaging of reflected sunlight. IR emitters can be readily identified at night in these spectral bands.
- Daily files are in csv and kmz formats available at: http://ngdc.noaa.gov/eog/viirs/download_viirs_fire.html
- Publications: http://www.mdpi.com/2072-4292/5/9/4423 http://www.mdpi.com/1996-1073/9/1/14



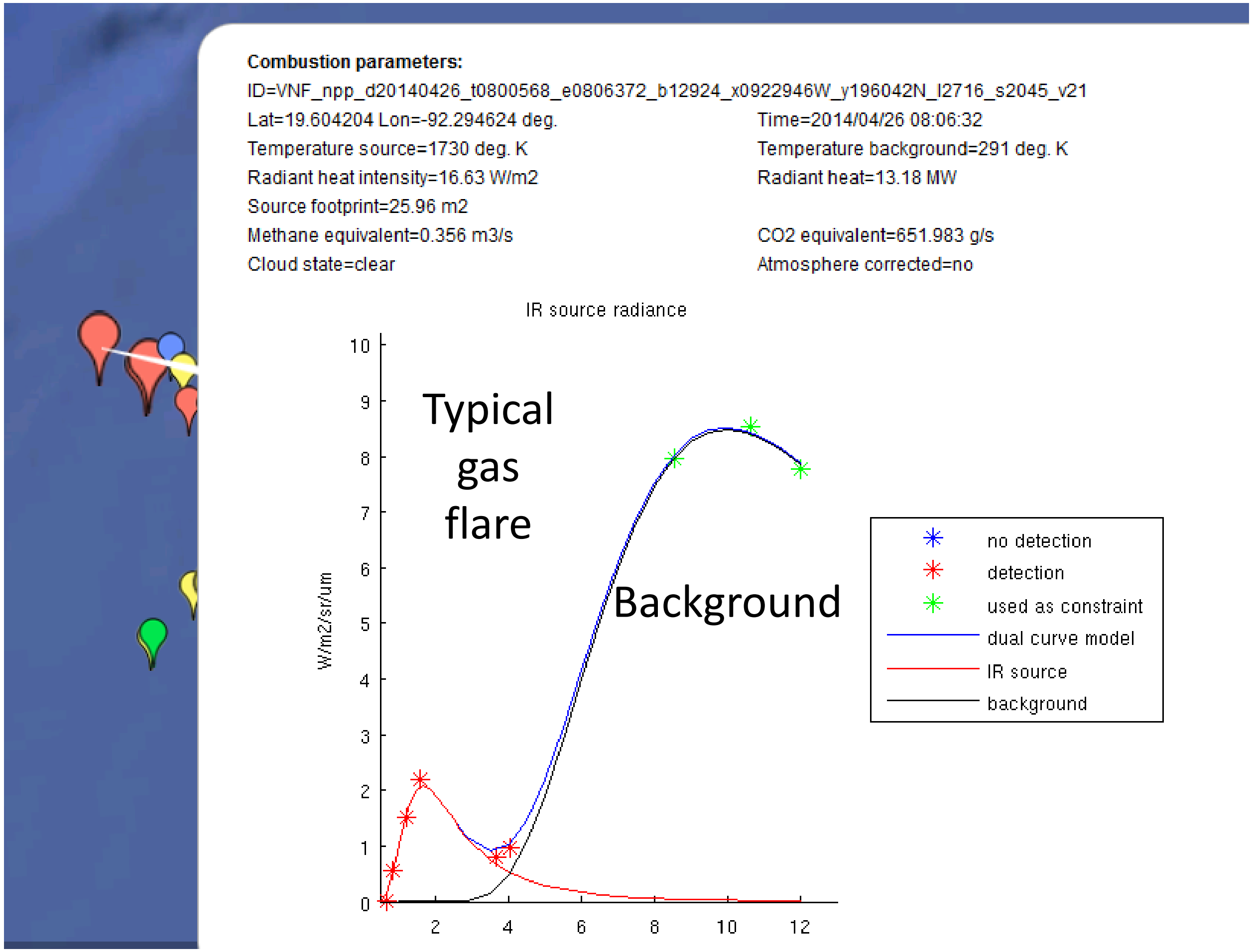
Gas flares are readily detected in the VIIRS M10 spectral band

VIIRS Nightfire (VNF): A global multispectral fire product
Nine channels of data are collected at night



Nighttime collection of channel 11 is expected to start in 2016

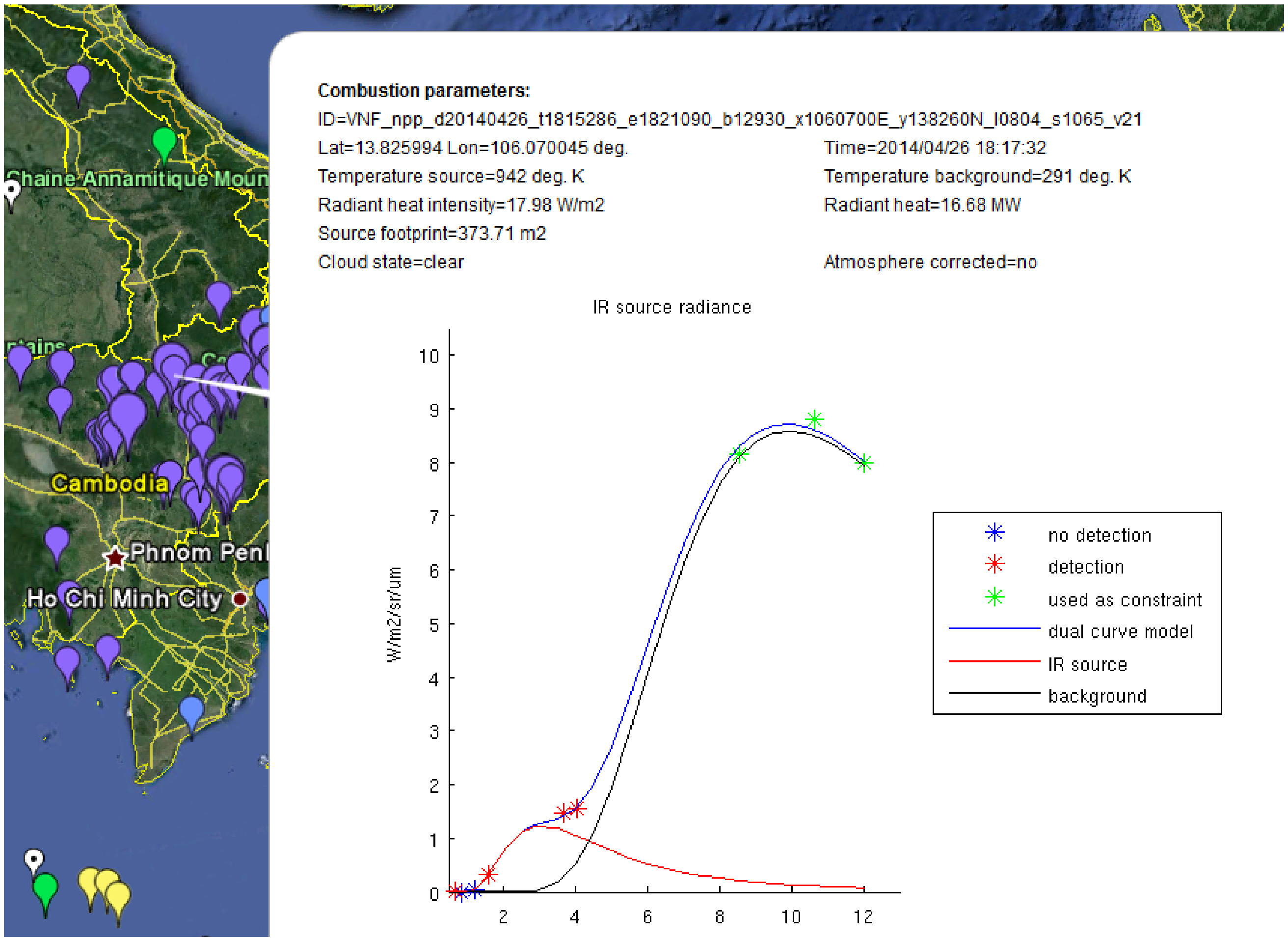
VNF Gas Flare Detection



Planck curve fitting is used to estimate temperature, source size and radiant heat.

Daily files are in csv and kmz formats

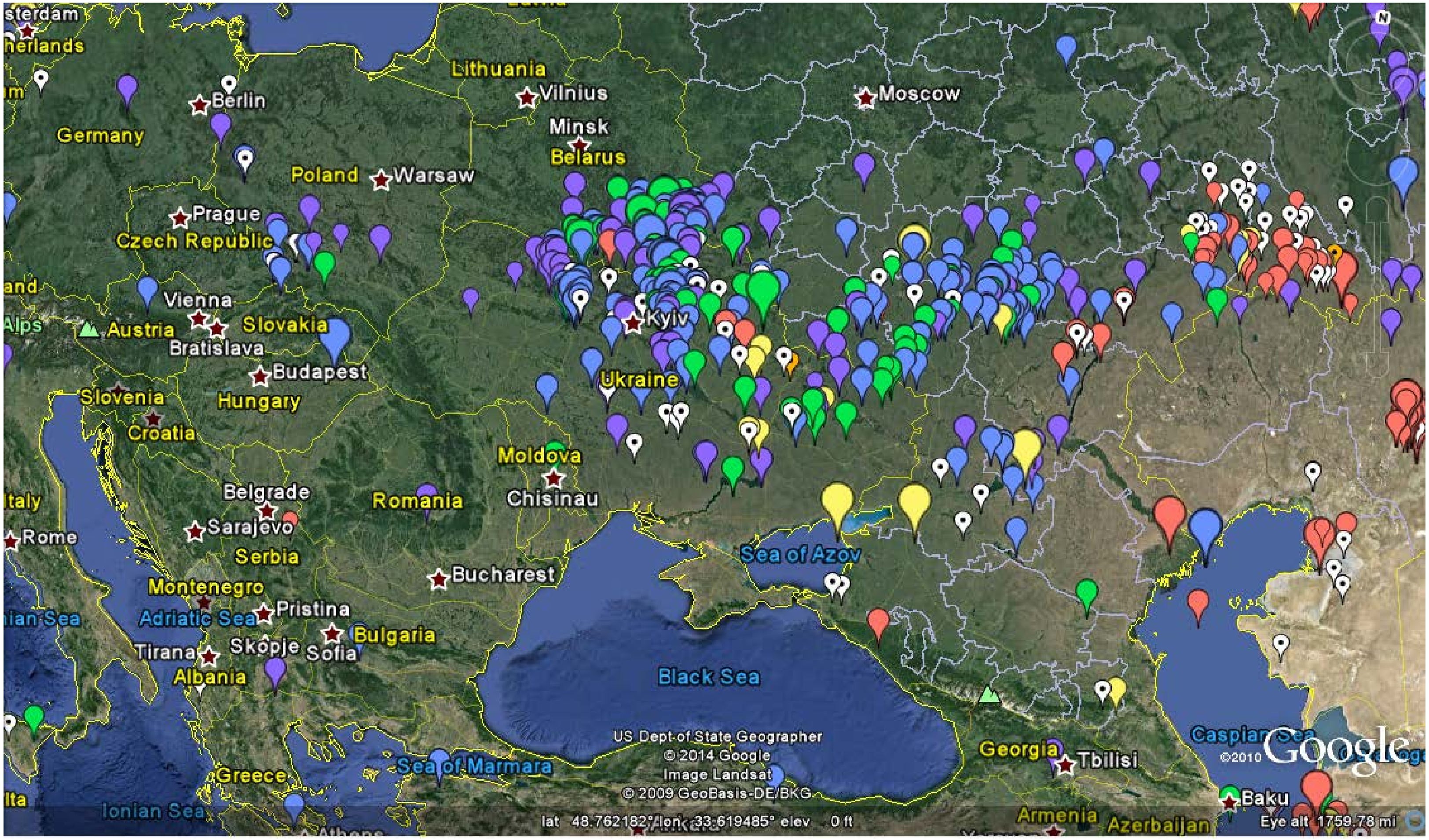
VNF Biomass Burning Detection



Lower temperature than gas flaring. Often these have larger source size than gas flares.

Daily VNF data are available at:

http://ngdc.noaa.gov/eog/viirs/download_viirs_fire.html



Current global processing typically runs with a nine hour delay. This will reduce to a 4 hour latency when M-bands are available through GRAVITE.

Nighttime Lights Composites

- A nighttime lights composite is made to serve as a baseline of persistent light sources.
- Composites are made as an average of the highest quality nighttime lights imagery over desired time period – usually monthly or annually.
- “Stable Lights” composites have ephemeral light sources and non-light (background) areas are removed from a composite.
- EOG group is producing current monthly cloud-free/no-moon DNB nighttime lights composites and is doing algorithm development to turn these in to Stable Lights composites.

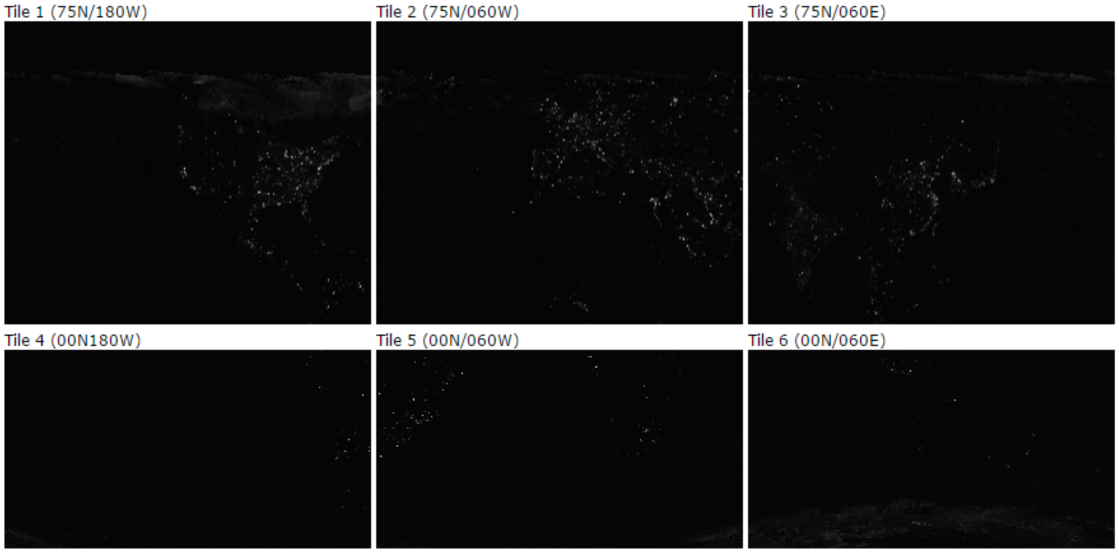
Nighttime Lights Composites
What goes in?

- Only the “highest quality” nighttime data gets averaged into a composite
- Currently this is defined as DNB data that is:
  - Cloud-free (using the VIIRS cloud-mask (VCM) product)
  - Nighttime with solar zenith angles greater than 101
  - Not affected by moonlight (lunar illuminance < 0.0005 lux)
  - Middle of swath (DNB has increased noise at edge of scan)
  - Free of lights from lightning
  - Free of “lights” from South Atlantic Anomaly

Nighttime Lights Composites
(Monthly DNB Products)

Index thumbnails for nighttime light image tiles

Showing thumbnails of May 2014



Last Update: 09/24/2015/15:54:01

Expand All | Contract All

- 2015/July
- 2015/June
- 2015/May
- 2015/April
- 2015/March
- 2015/February
- 2015/January
- 2014/December
- 2014/November
- 2014/October

- Monthly DNB nighttime lights composites are available online
- Globe is cut into 6 tiles to reduce individual file sizes
- These products still contain ephemeral lights and non-lights (background).

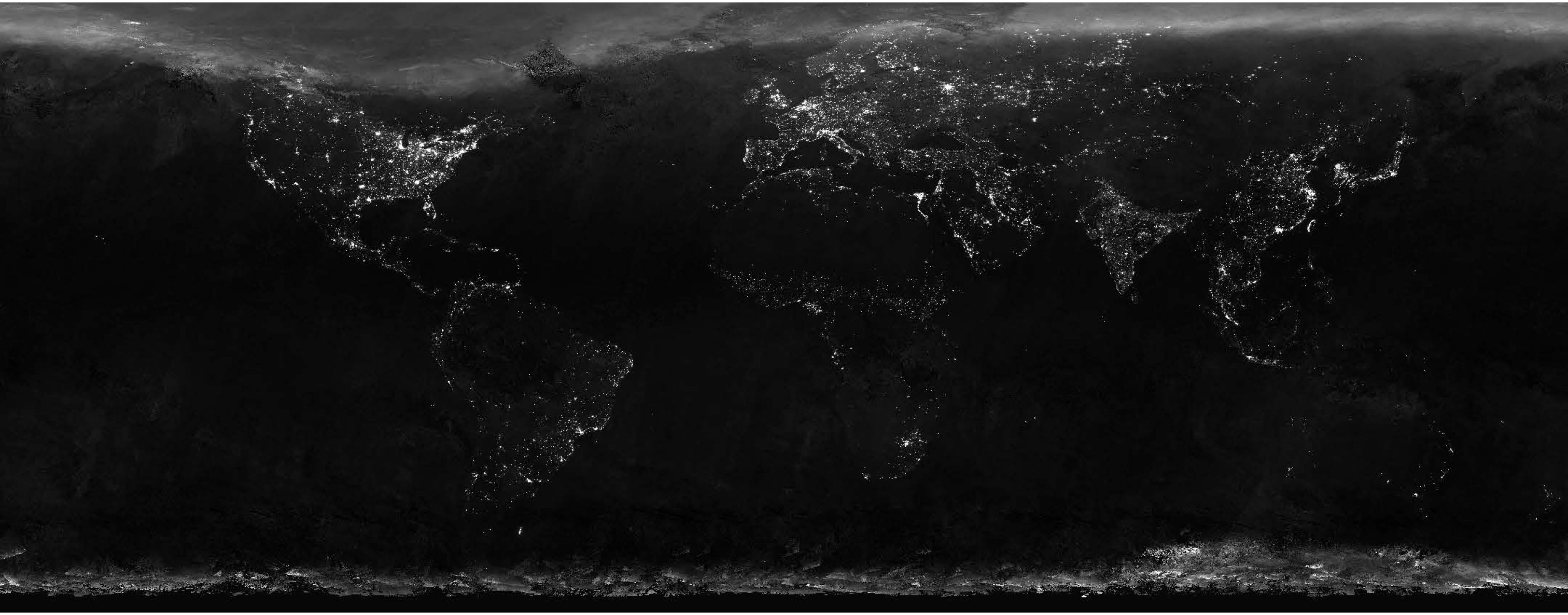
http://www.ngdc.noaa.gov/eog/viirs/download_monthly.html

VIIRS Nighttime Lights Composite – 2015/01

Excluding Stray Light Corrected Areas

VIIRS Nighttime Lights Composite – 2015/01

Including Stray Light Corrected Areas



Questions?

Backup Slides

Superlights

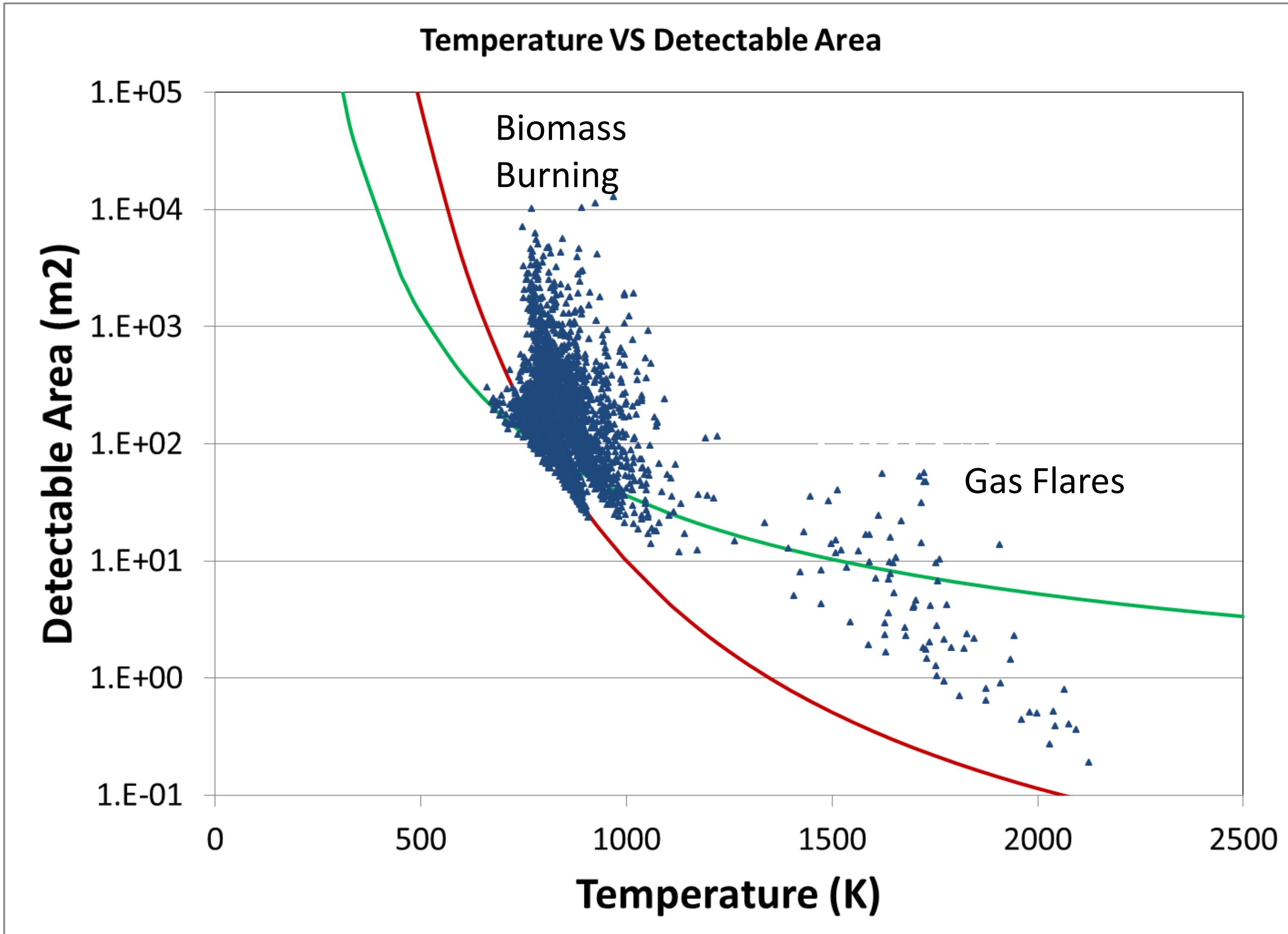
Boats operating with large number of bare high intensity lights

Superlights
Strings of 1500 Watt metal halide bulbs

30-80 bulbs are common - 45,000 to 120,000 Watts of bare bulbs on individual boats!

Detection Limits

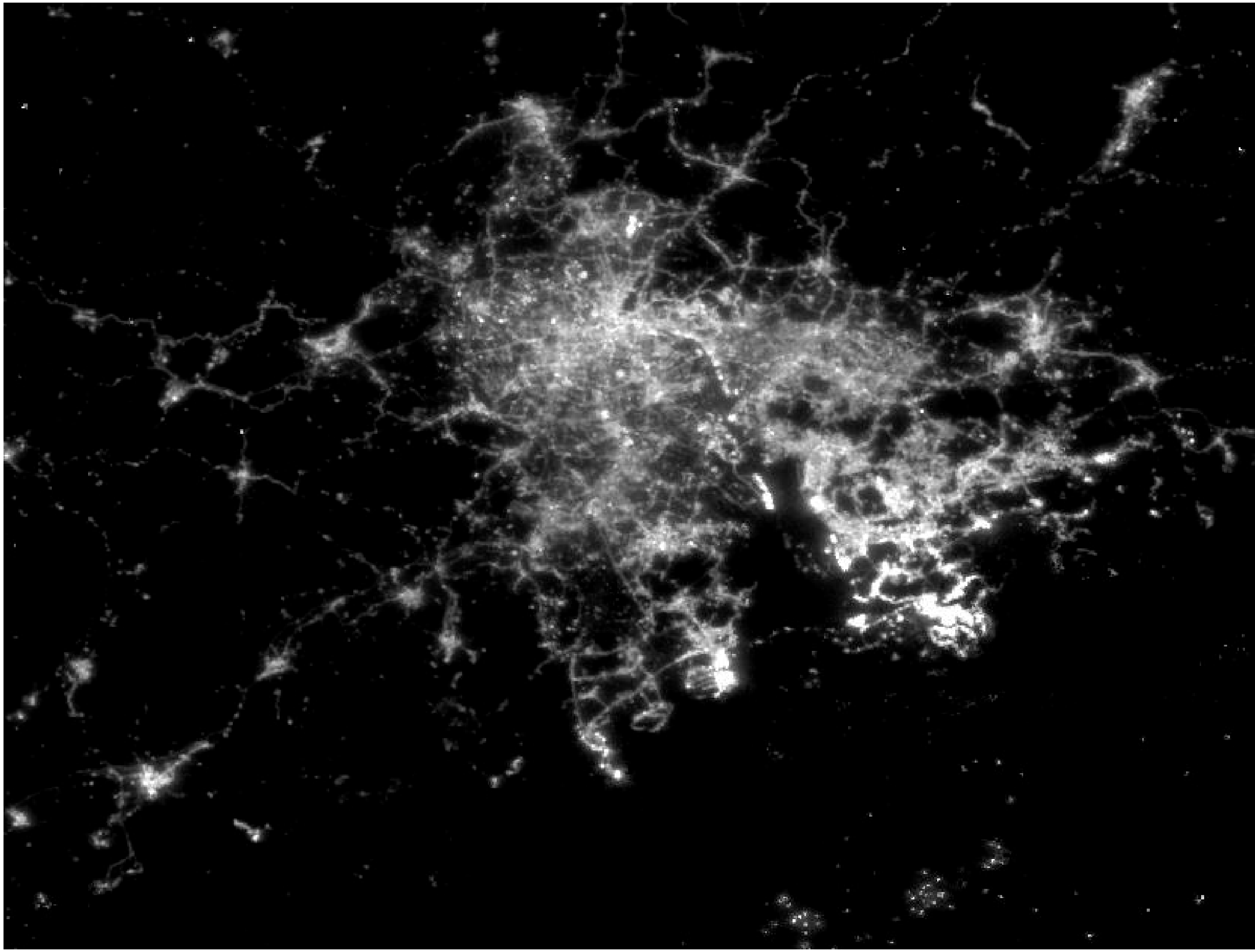
At 1800 K flares as small as 0.25 m^2 are detectable



VIIRS Nighttime Lights Composite

October 2014

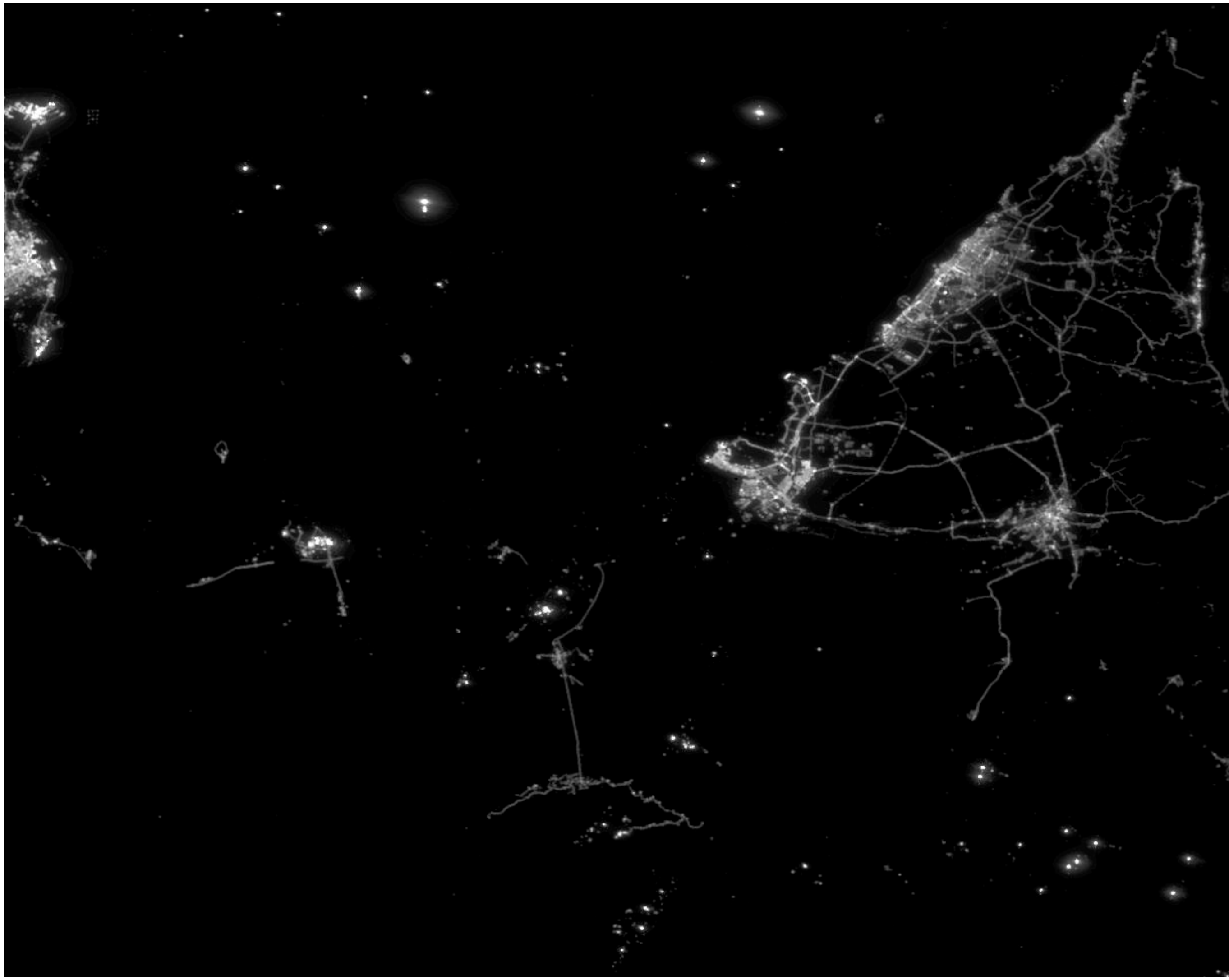
Hong Kong



VIIRS Nighttime Lights Composite

October 2014

United Arab Emirates



VIIRS Nighttime Lights Composite

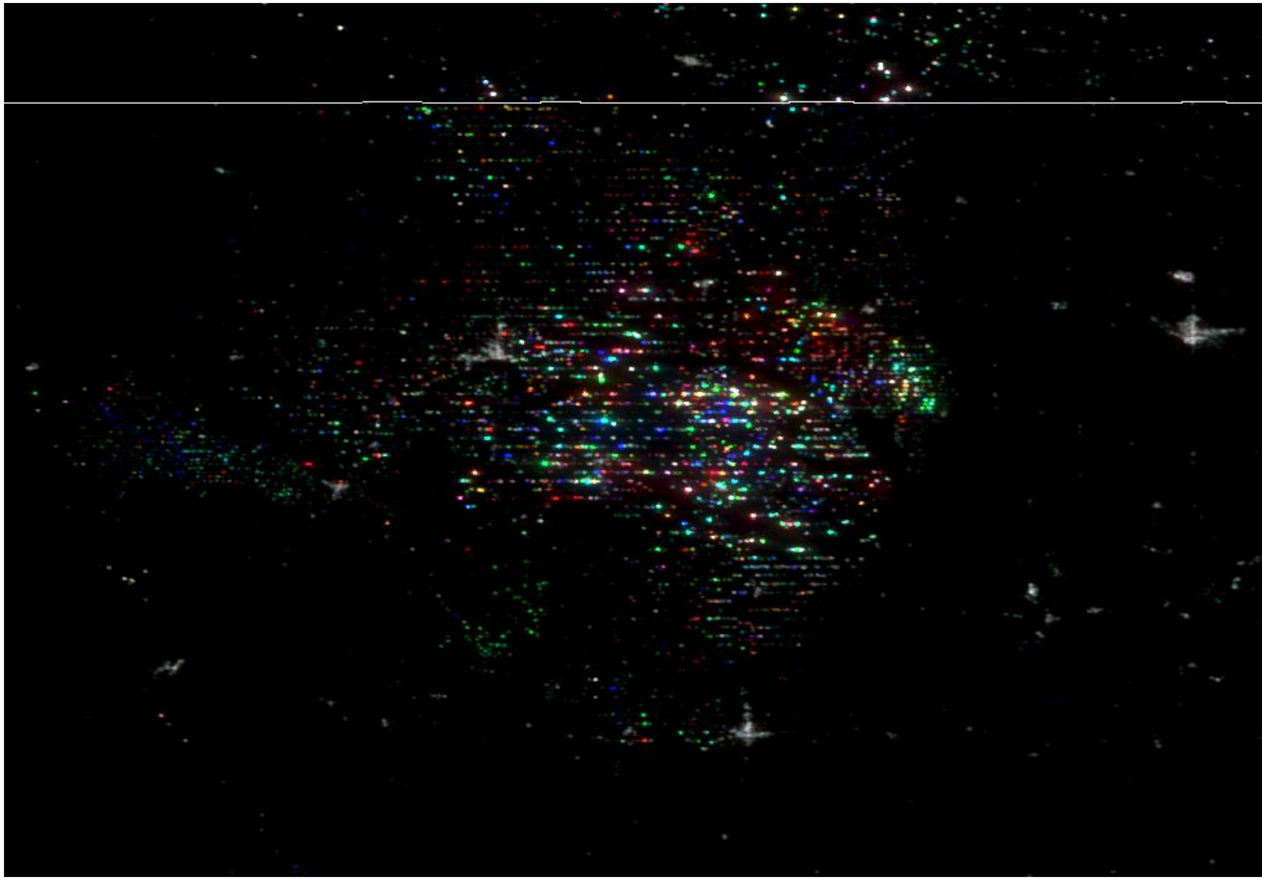
October 2014

Nile Delta (right)
Los Angeles->San Diego (below)

Temporal Change in VIIRS Nighttime Lights Composites

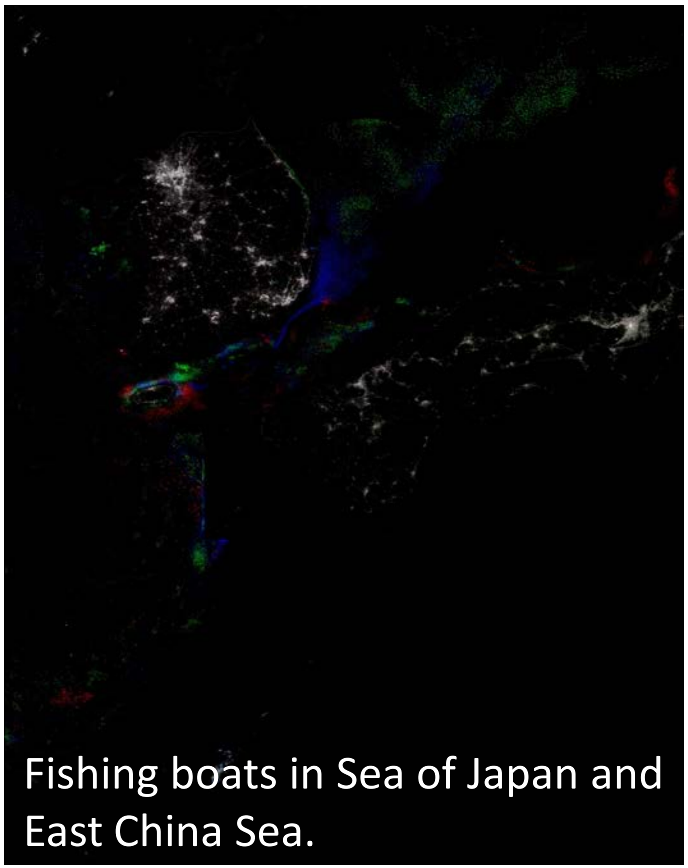
Red = May 2014, Green = September 2014, Blue = October 2014

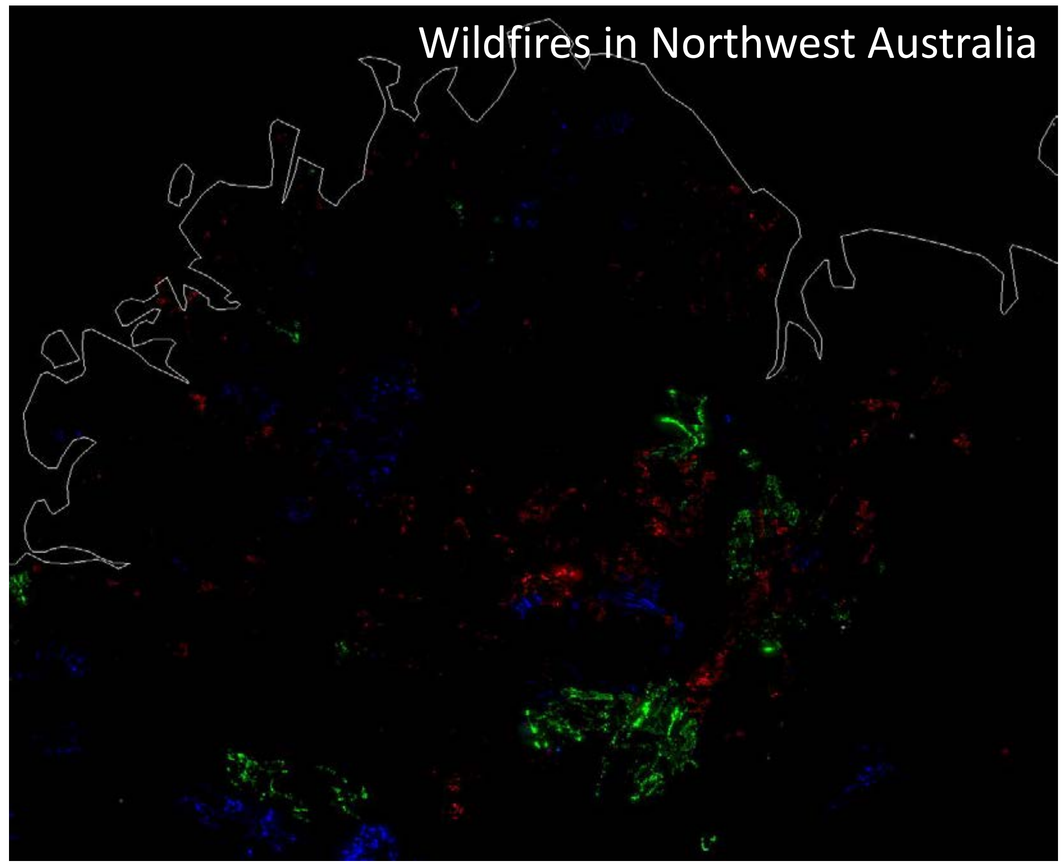
Bakken gas flares in North Dakota, USA, are a mix of permanent and ephemeral sites.



Temporal Change in VIIRS Nighttime Lights Composites

Red = May 2014, Green = September 2014, Blue = October 2014

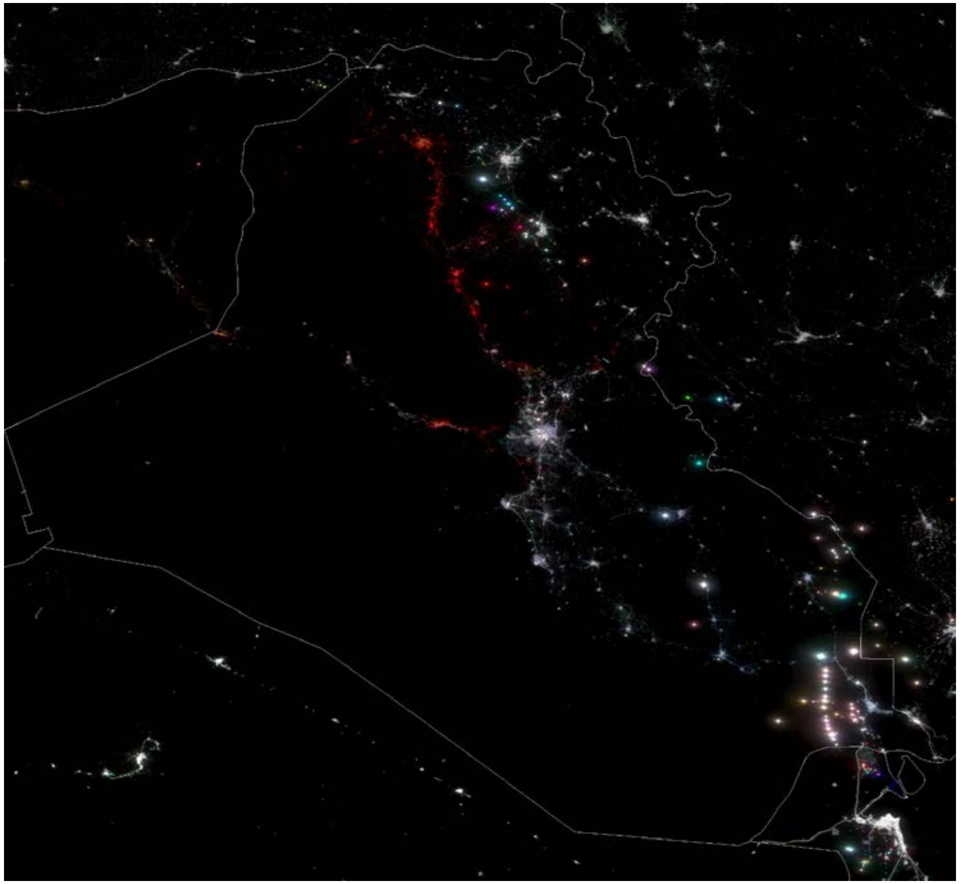




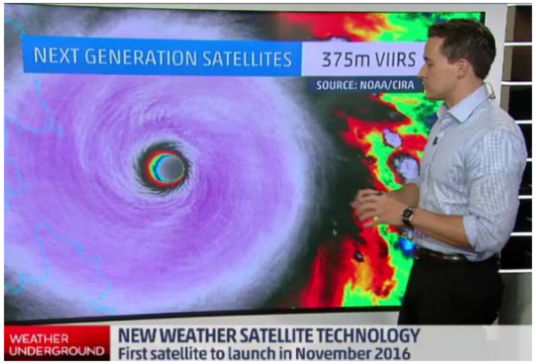
Temporal Change in VIIRS Nighttime Lights Composites

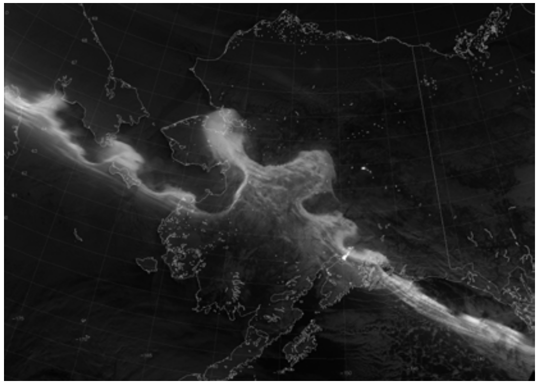
Red = May 2014, Green = September 2014, Blue = October 2014

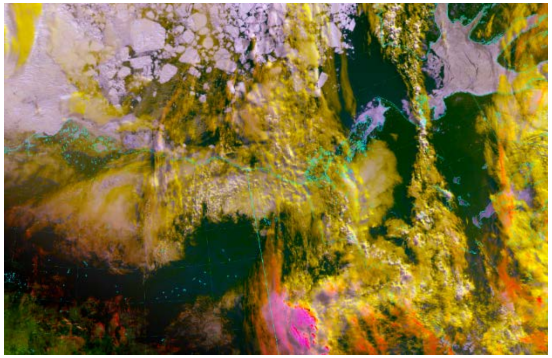
Lights in northern Iraq are present in May 2014, and have been greatly reduced in the September and October 2014 composites.



VIIRS Imagery Applications at CIRA

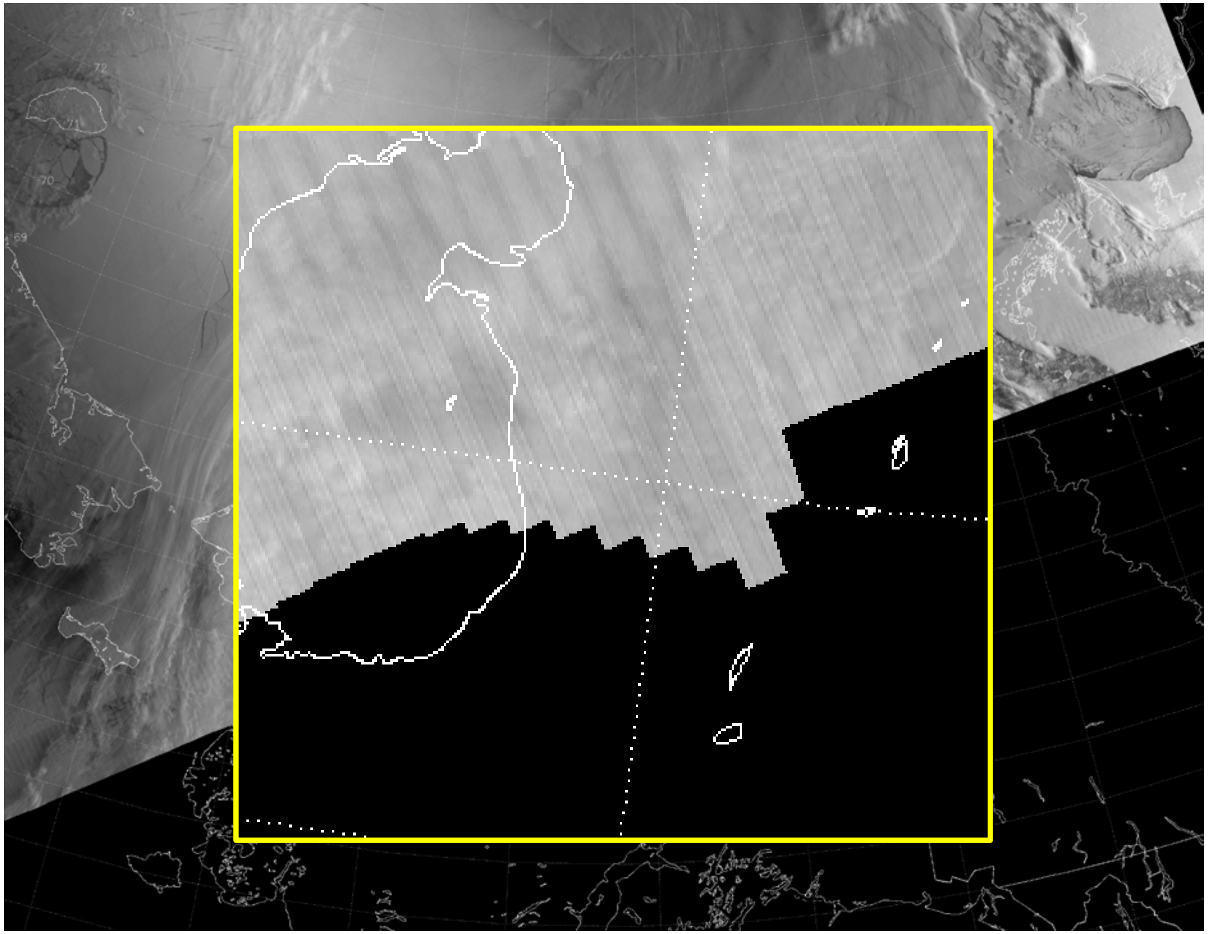






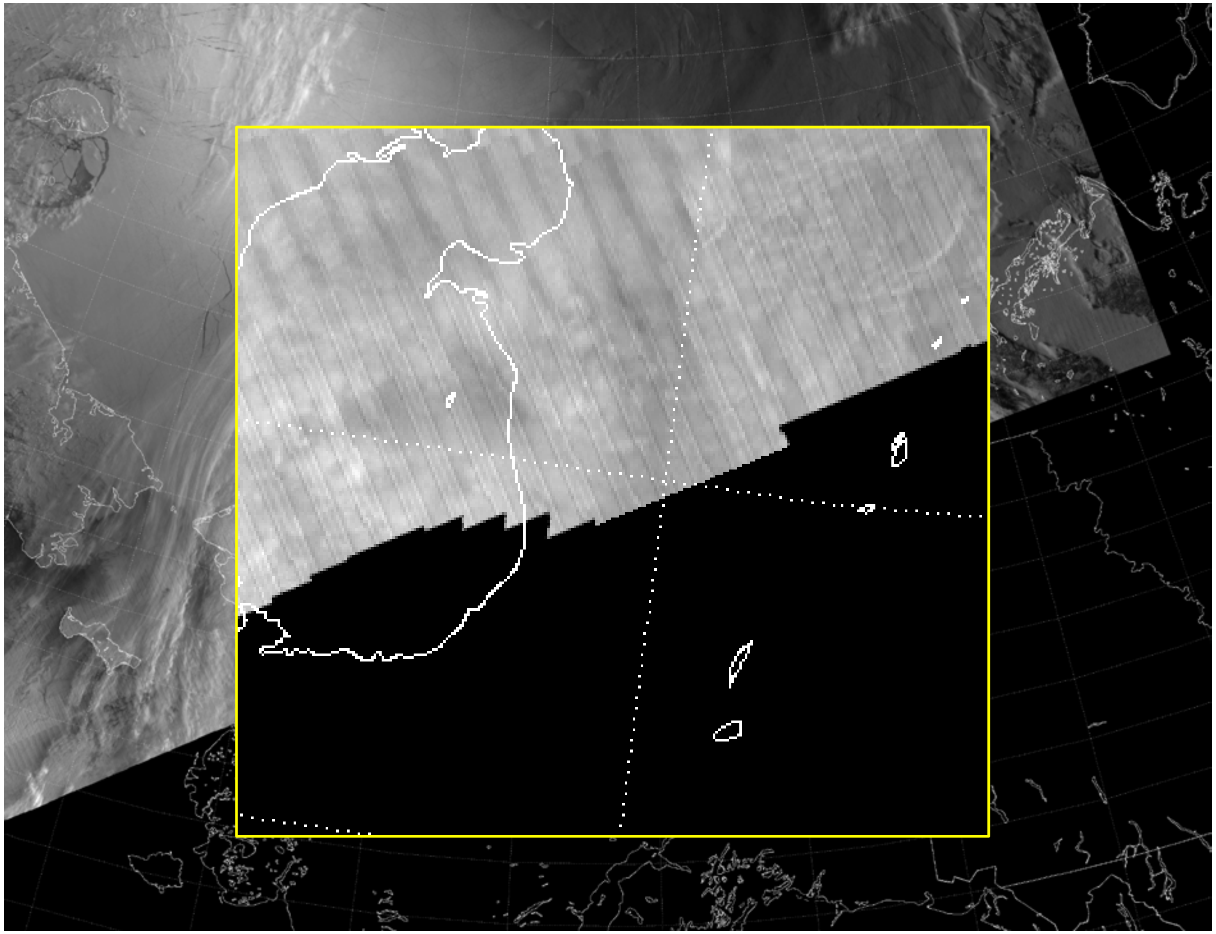
Curtis Seaman, Steve Miller, Jorel Torres
Colorado State University/CIRA
Don Hillger, Dan Lindsey
NOAA/NESDIS/Satellite Applications and Research

Monitoring Artifacts



Attitude error (~16:04 UTC 25 March 2016) causes shift in several scans relative to nominal swath
DNB image shown here (similar for all SDRs)

Monitoring Artifacts

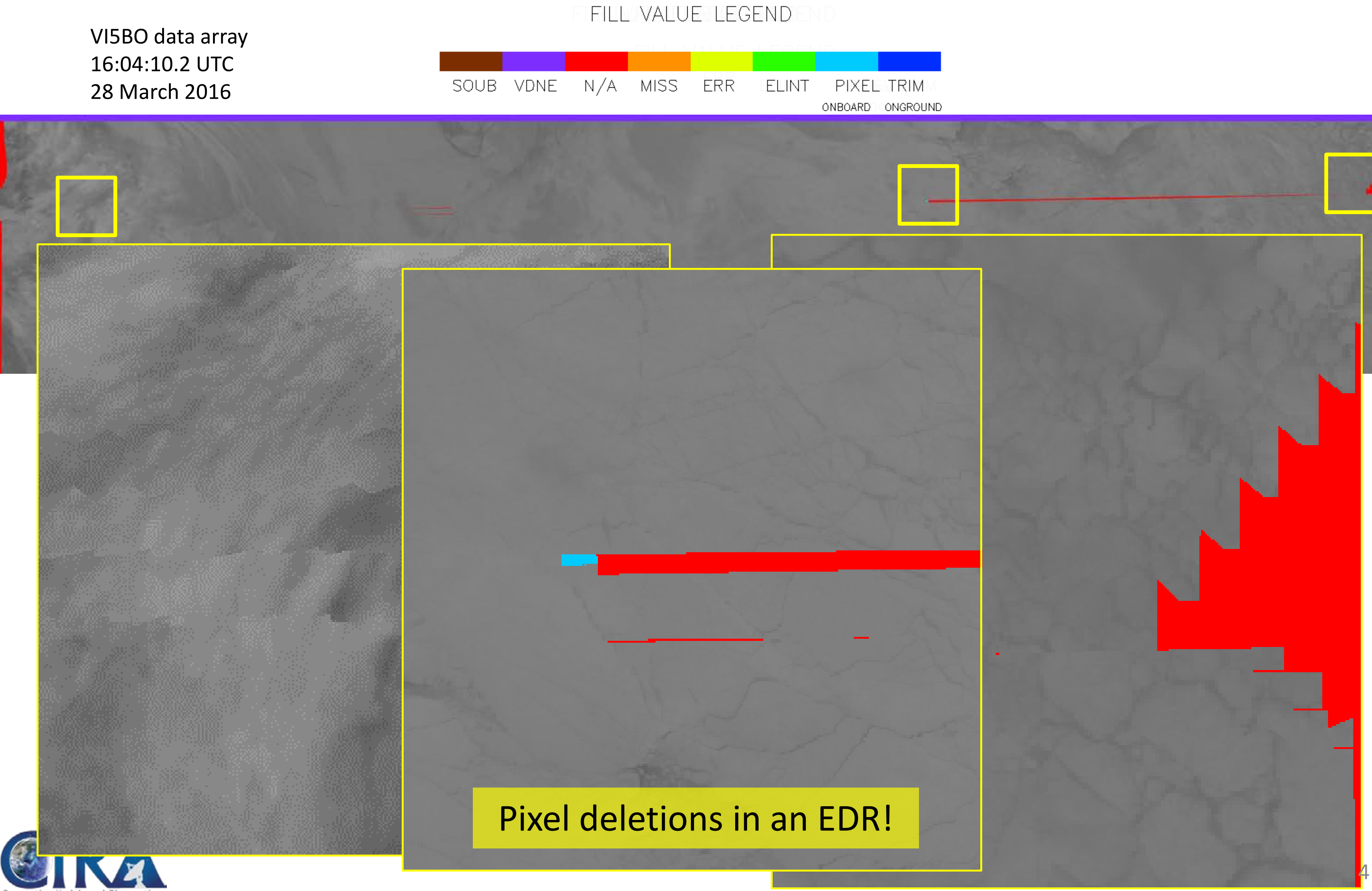


This error is not as noticeable in the EDRs (NCC shown here) because the scan edges fall outside the pre-defined Ground Track Mercator (GTM) grid. But, it does introduce other errors…

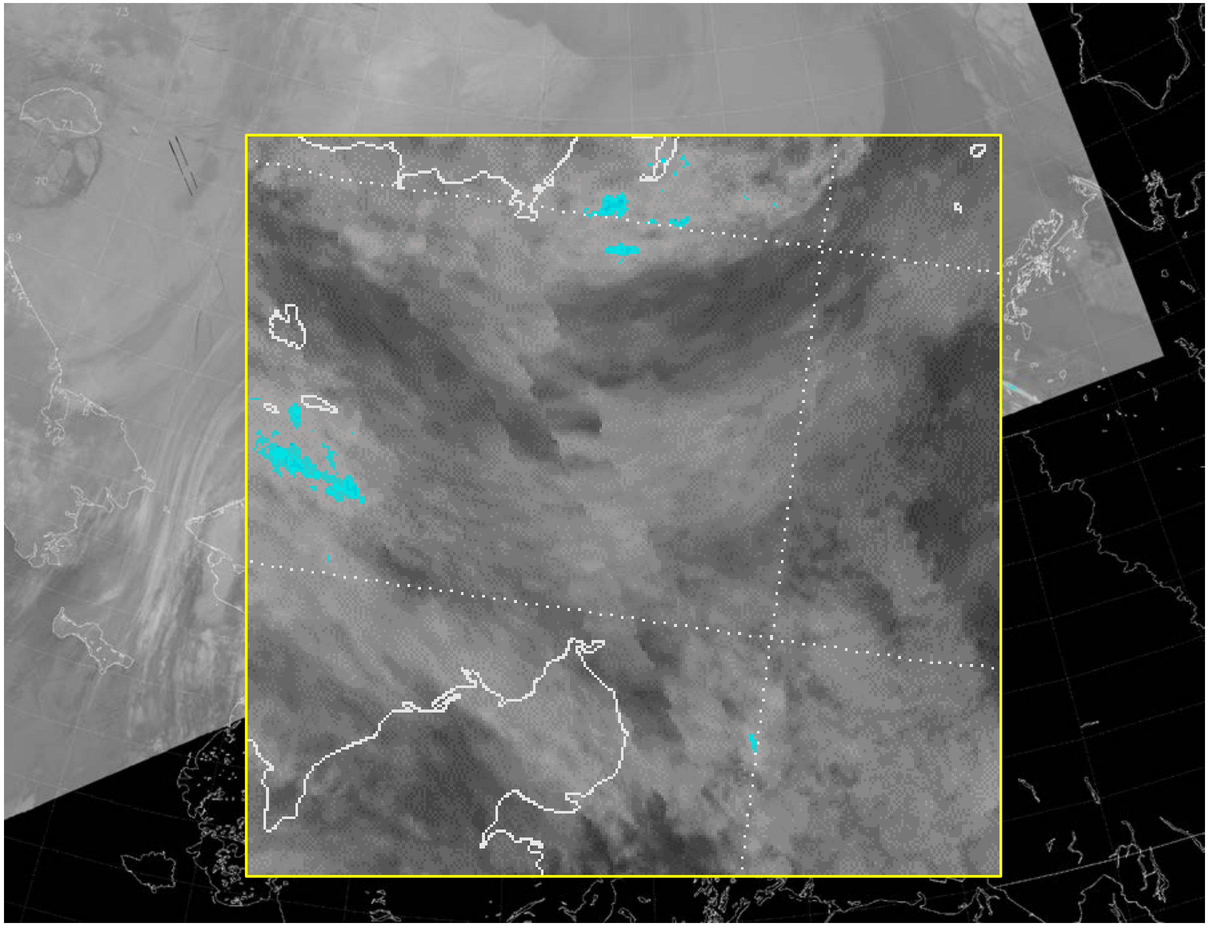
Monitoring Artifacts

Artifacts in the EDR due to attitude error

VI5BO data array
16:04:10.2 UTC
28 March 2016



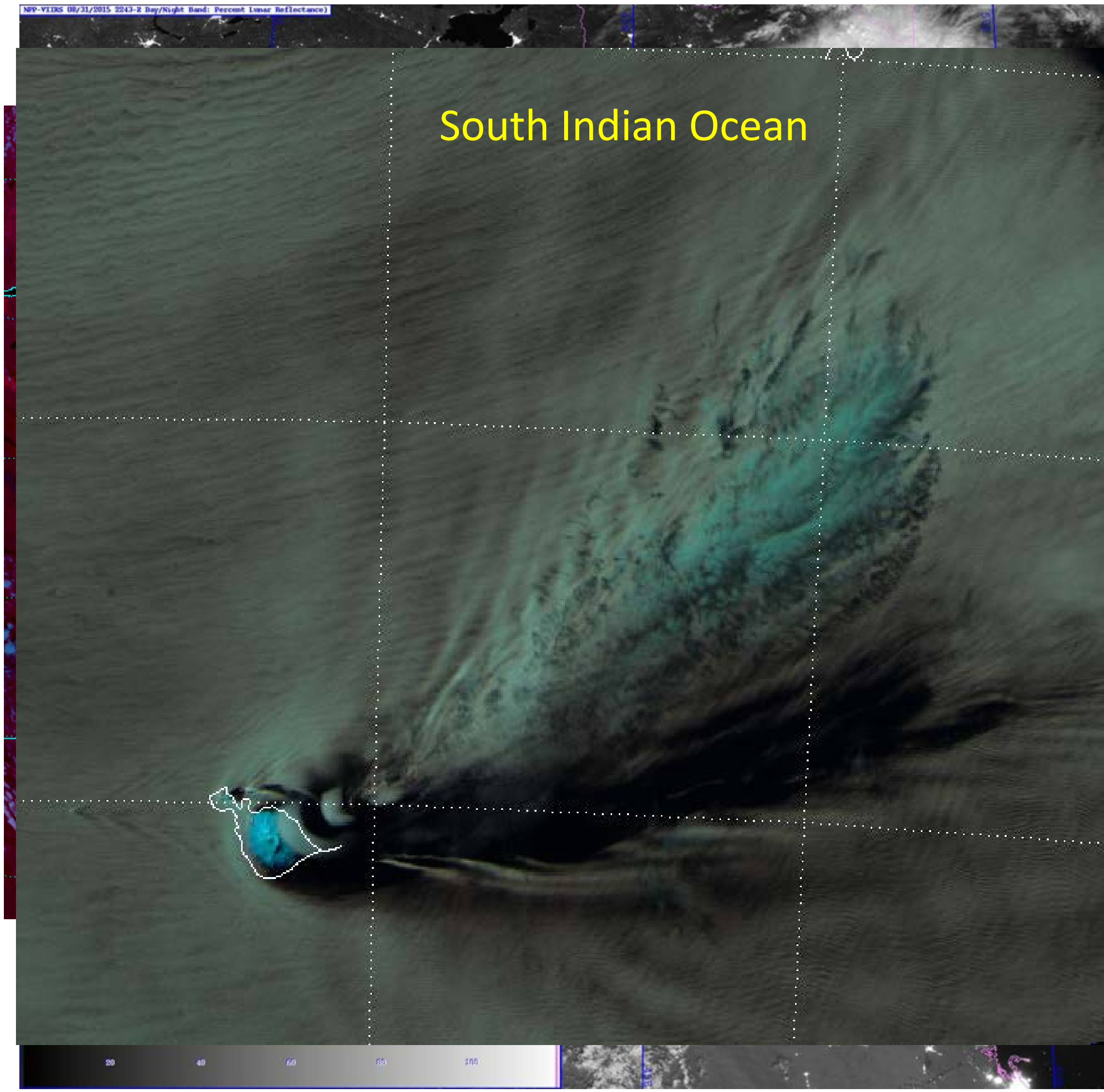
Monitoring Artifacts



Discontinuities between scans still appear in EDR when mapped to Earth; due to attitude error
I-5 EDR shown here

Demonstrating VIIRS: The VIIRS Imagery Team Blog

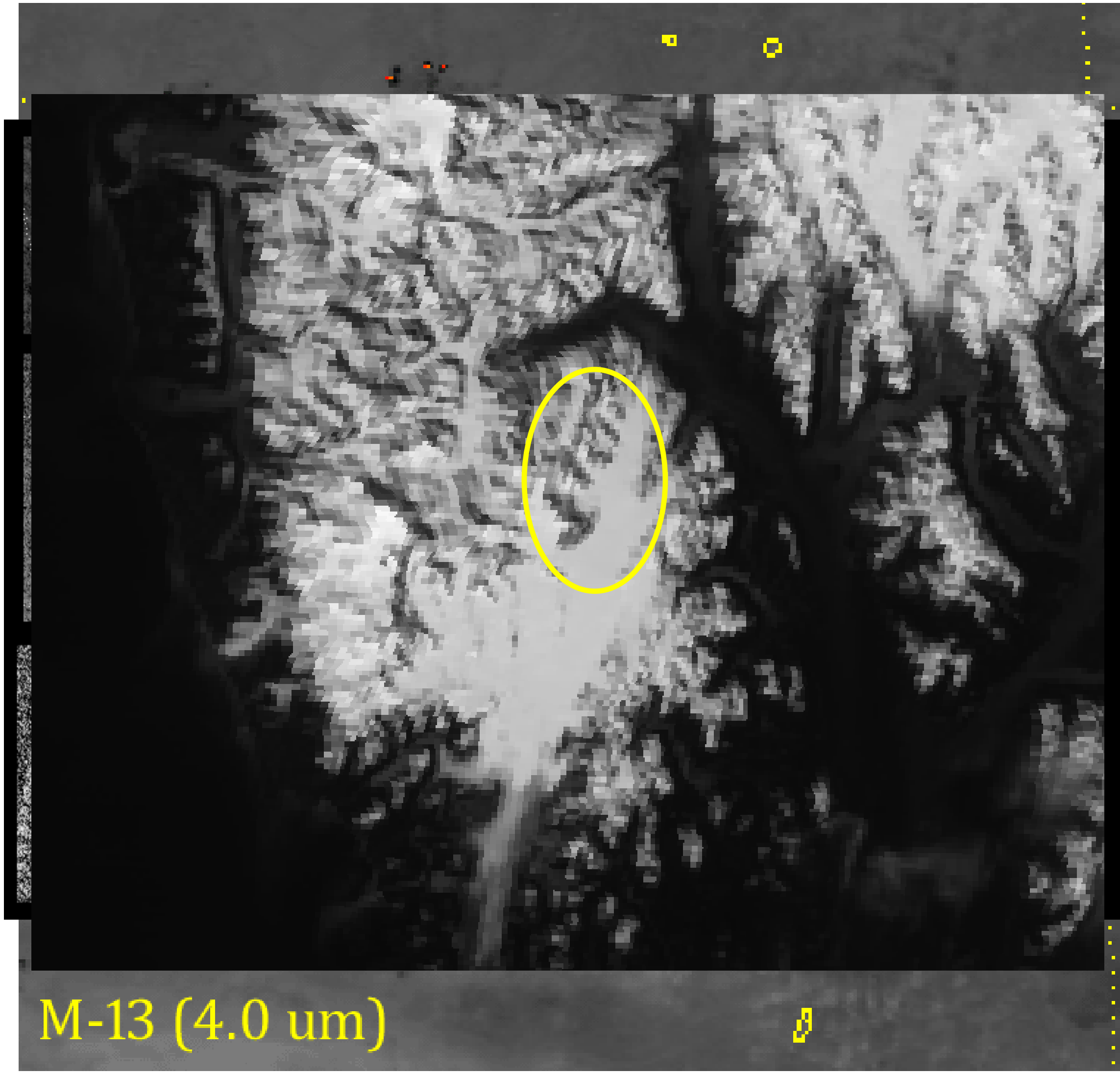
- Self-nominated "Best Blog in the World" demonstrates the wide-ranging application of VIIRS imagery
- Natural Color RGB shows extensive river flooding in Western Russia (April 2013)
- True Color RGB shows "super-smog" over India (Nov-Dec 2015)
- Fire Temperature RGB shows massive fires over Northwest Territories, Canada (July 2014)
- Day/Night Band detects dust storm over Iraq (August 2015)
- Heard Island as seen by VIIRS Natural Color (27 October 2012)



http://rammb.cira.colostate.edu/projects/npp/blog/

Demonstrating VIIRS at high-latitudes: "Seeing the Light" Blog

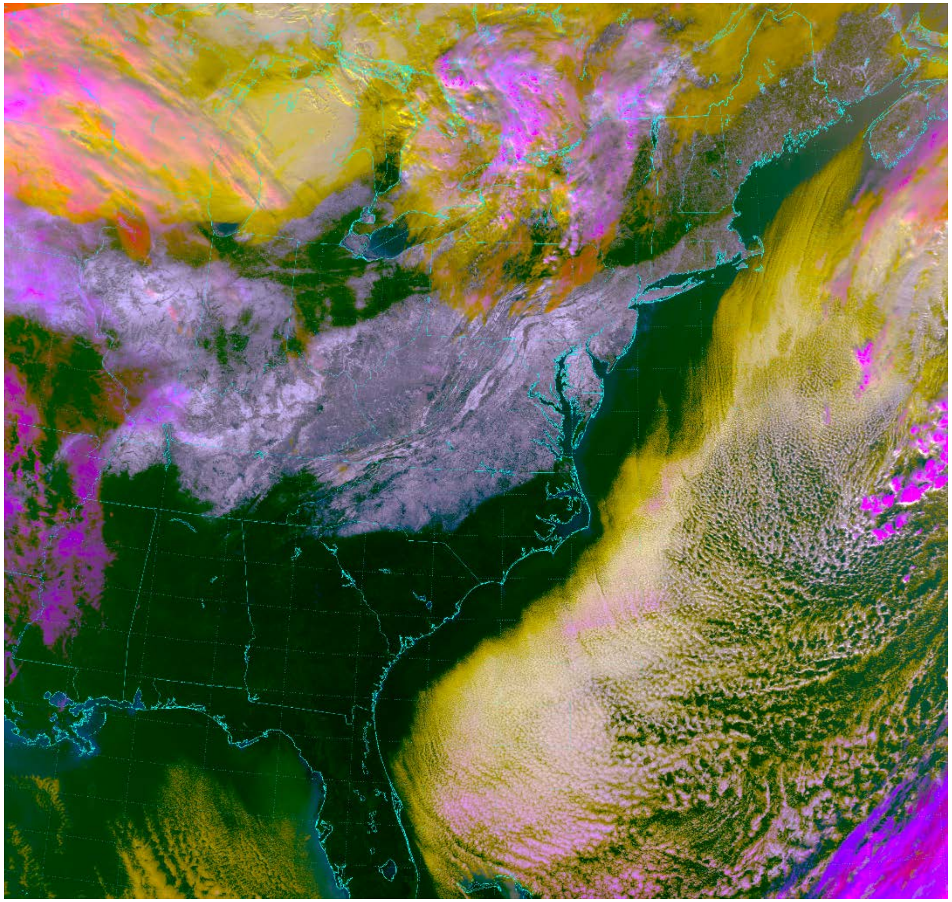
- The "Seeing the Light: VIIRS in the Arctic" blog is geared toward high-latitude users of satellite imagery
- Day/Night Band for ship tracking; "50 Years of Victory" carries the Olympic torch to the North Pole
- Day/Night Band for ice monitoring; N-ICE field experiment (Jan-Feb 2015)
- Demonstrating VIIRS for fires in Alaska (June 2015)
- Optical ghosts caused by lower orbiting satellites seen by the Day/Night Band (4 May 2016)
- Massive landslide in Glacier Bay National Park, Alaska seen by VIIRS (June 2016)



http://rammb.cira.colostate.edu/projects/alaska/blog/

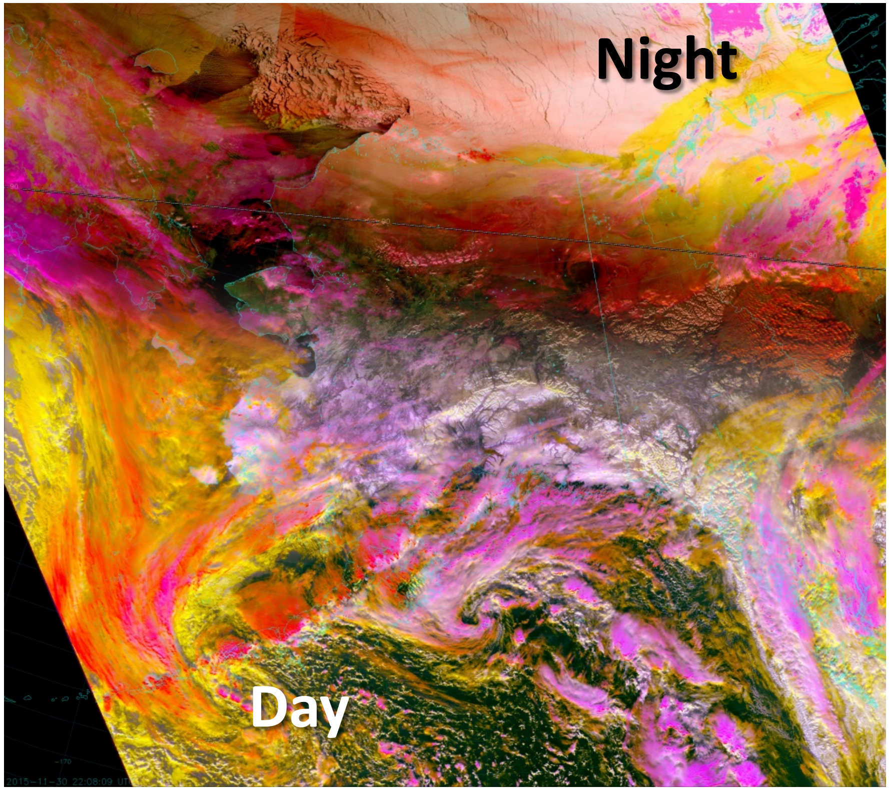
The Great Blizzard of ‘16

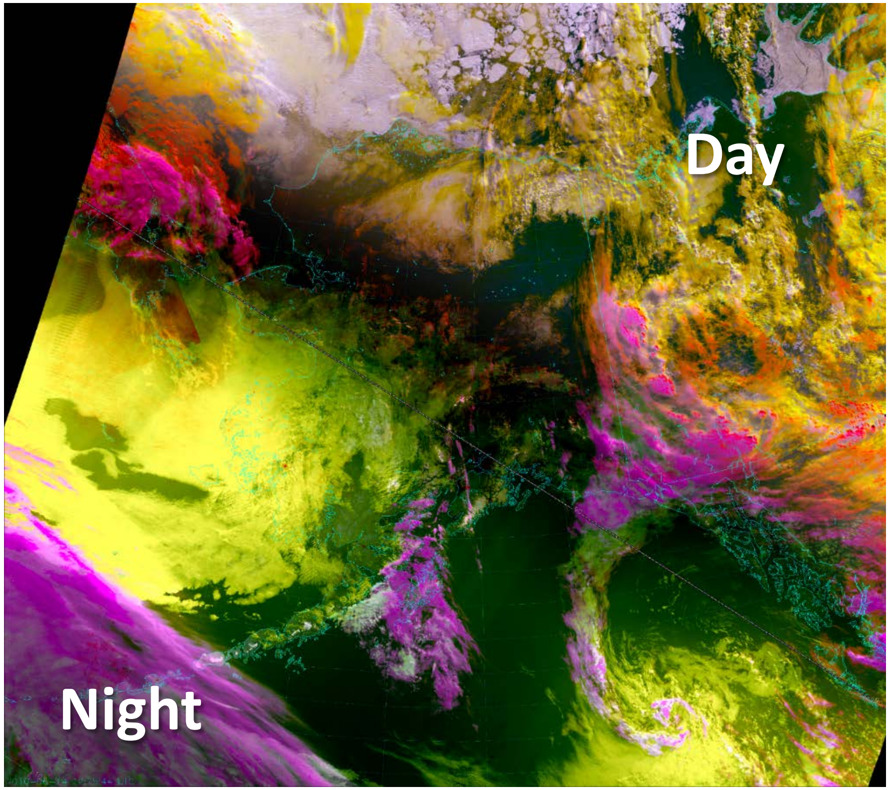
- Can you tell what is cloud and what is snow in the True Color RGB (M-3, M-4, M-5)?
- EUMETSAT Natural Color RGB (M-5, M-7, M-10) discriminates low clouds from snow and ice
- Variation of EUMETSAT Snow RGB (M-11, M-10, M-7) highlights snow in pink/red
- Snow RGB from Météo France produced upon request from UK Met Office (M-7 through M-11)
- CIRA’s Snow/Cloud Discriminator (uses up to 11 bands) keeps snow white and highlights low, mid and high clouds



18:12 UTC 24 January 2016

Day/Night Snow/Cloud Discriminator





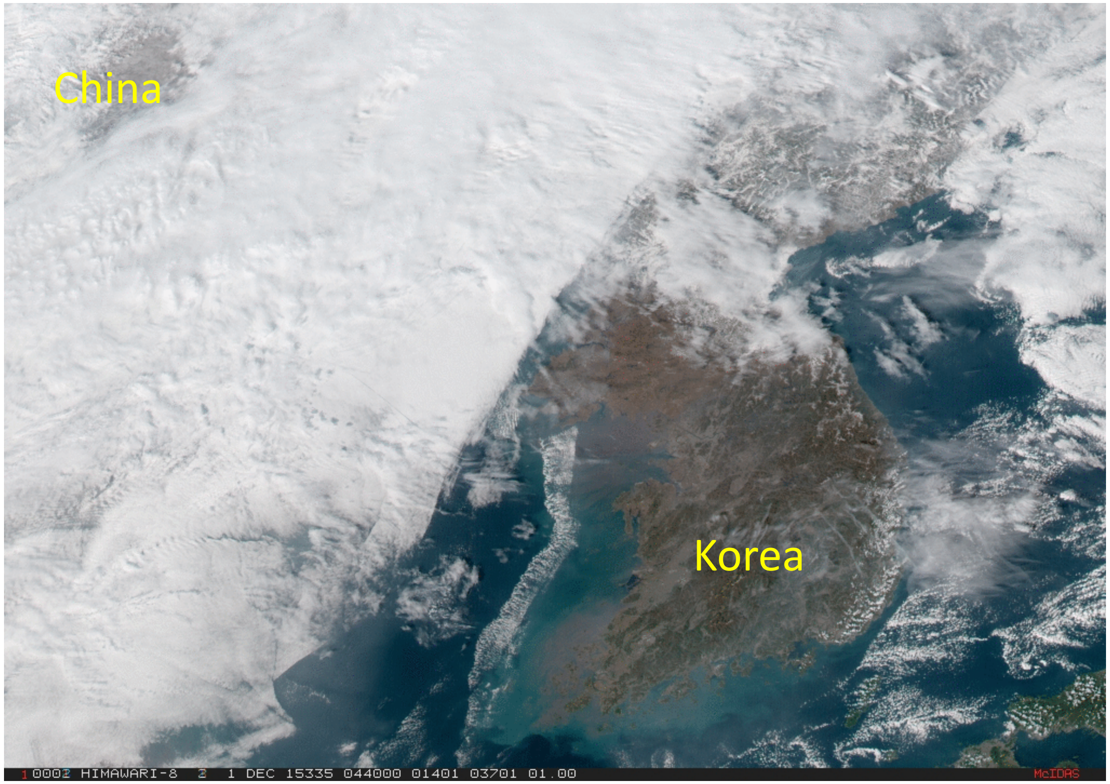
- We continue to develop the Nighttime Snow/Cloud Discriminator product using the Day/Night Band to aid snow/ice discrimination on those long Arctic winter nights

- Blending this product with the Daytime Snow/Cloud Discriminator allows for snow/ice discrimination around-the-clock and across the terminator, extending its use

CIRA
Connecting Models and Observations

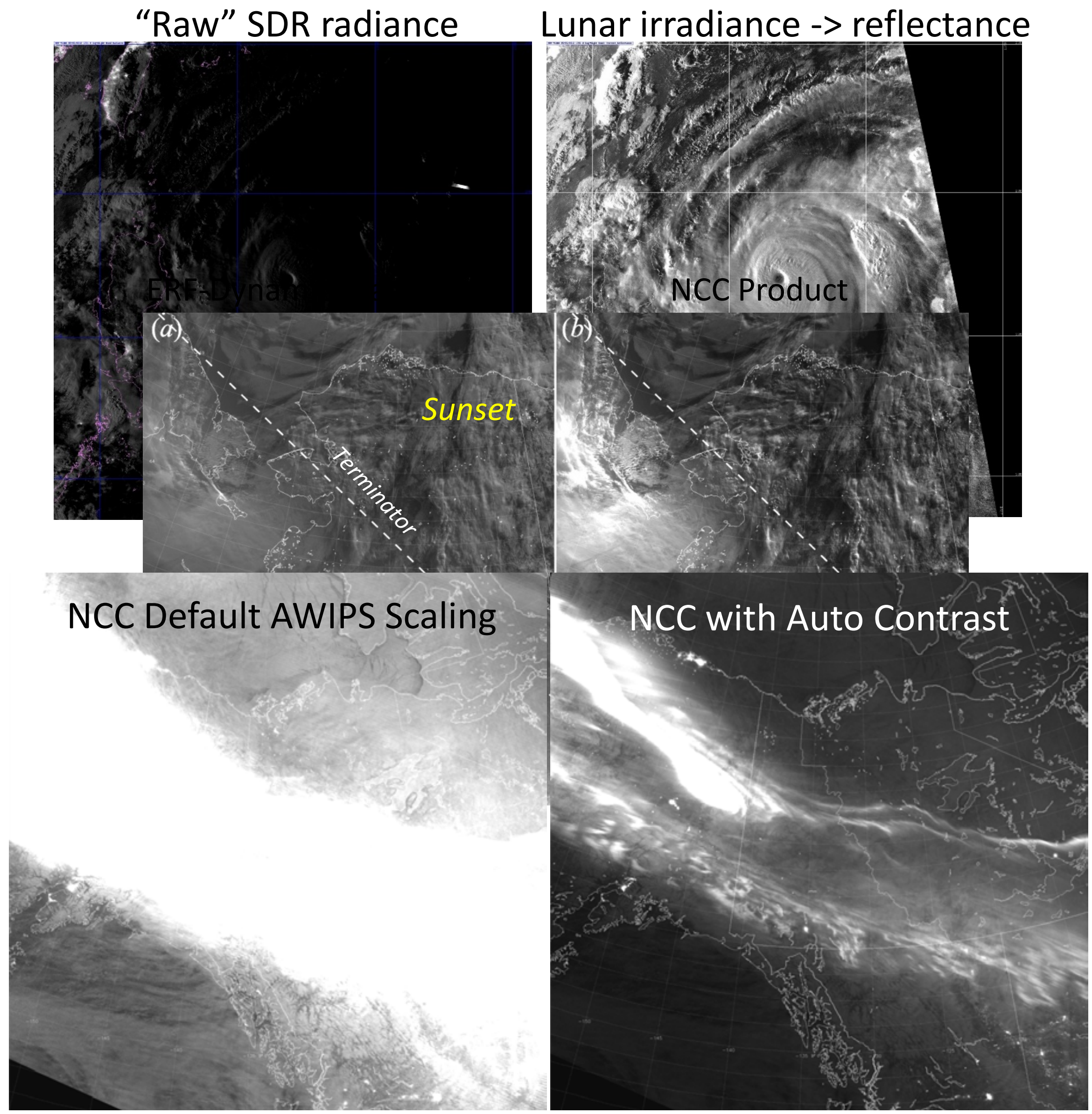
Geocolor using the Day/Night Band

- CIRA's Geocolor product combines True Color imagery during the day with a low cloud/fog product at night
- The high-resolution City Lights Mask (Chris Elvidge/Kim Baugh, NCEI) now replaces the old OLS artificial lights mask to improve the appearance at night
- Example of a combined polar-geo product that is popular with forecasters

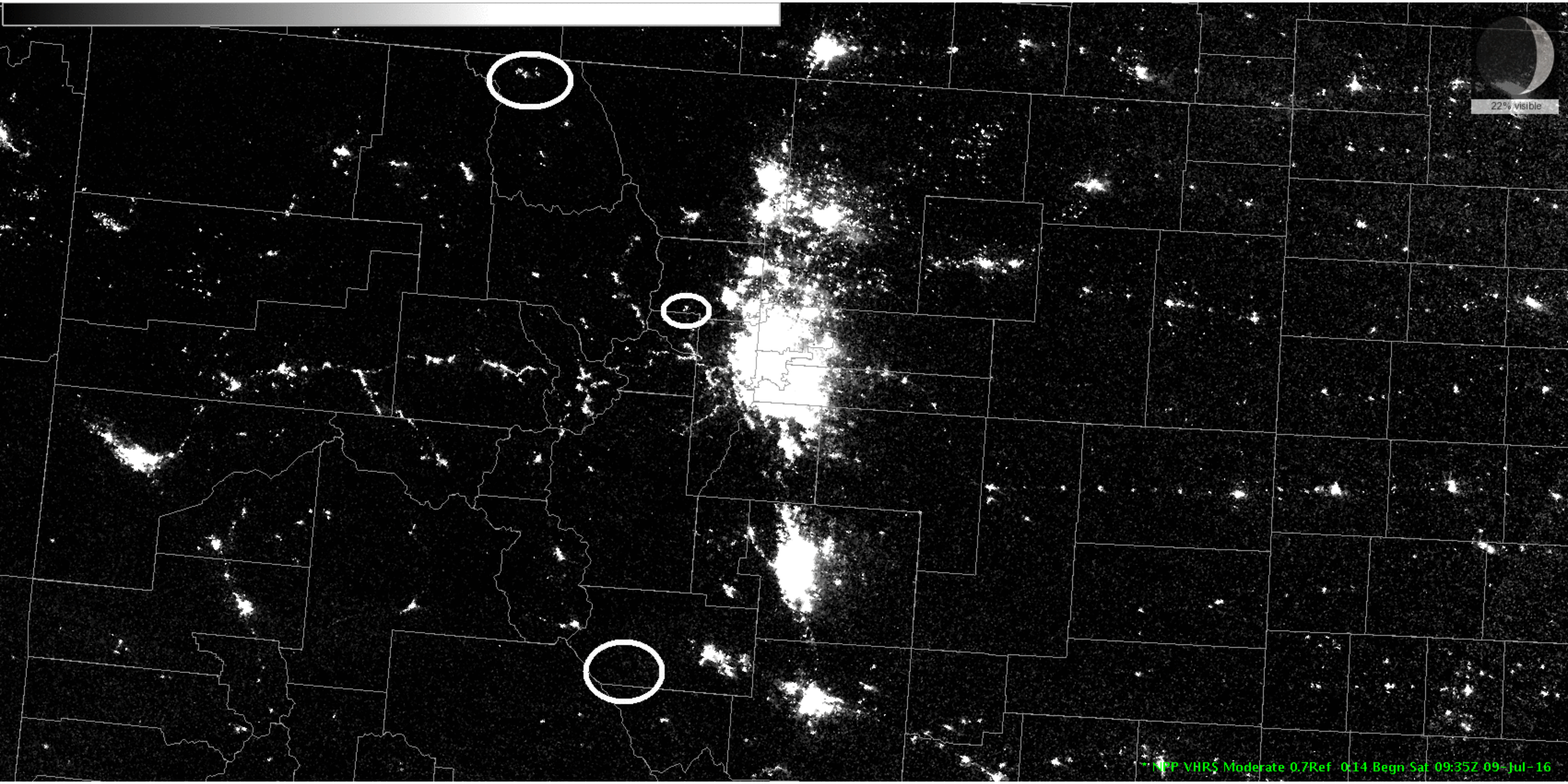


Improving DNB/NCC Display

- The DNB is sensitive to radiance values spanning 8 orders-of-magnitude, which makes display of the imagery difficult
- Lunar irradiance modeling (*Miller et al. 2012*) provides quantitative reflectance calculations useful for nighttime cloud property retrievals (*Walther et al. 2013*) and improving imagery when moonlight is available
- "*ERF*-Dynamic Scaling" algorithm (*Seaman and Miller 2015*) provides nearly-constant contrast imagery from DNB SDRs day and night around the globe
  - Now implemented in CSPP and available in Alaska WFOs
- "Auto Contrast" for the Near Constant Contrast (NCC) EDR and DNB imagery not yet implemented in AWIPS due to coding freeze



NCC in AWIPS - Fires

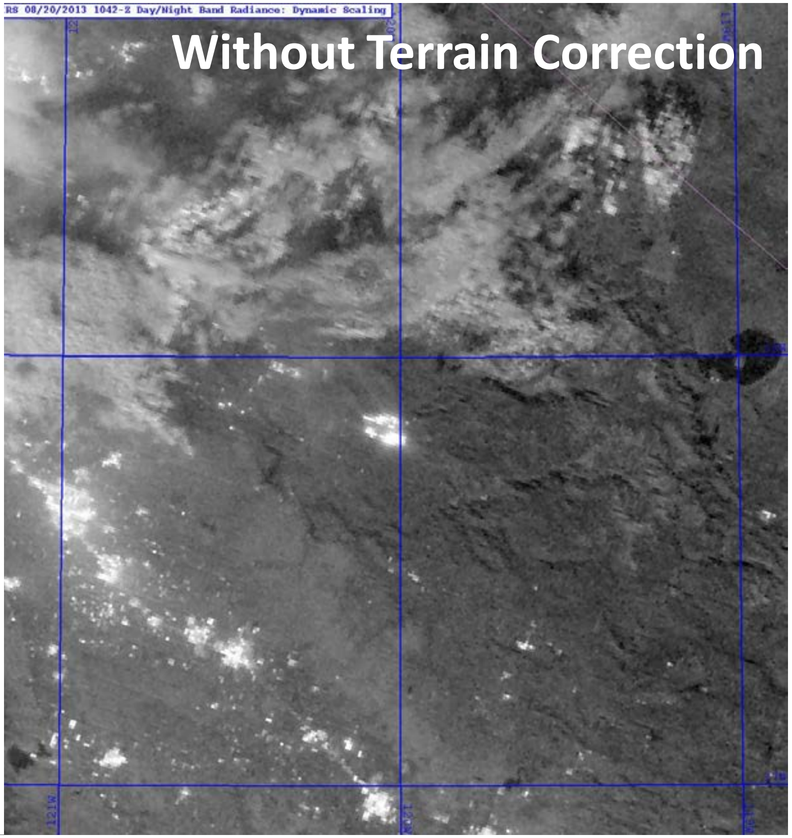


Do the fires move? Or does the ground move?

Fires in the DNB SDR

DNB images of the Rim Fire (2013) in California suffer the same problem as the current NCC EDR. This is due to a lack of terrain-correction.

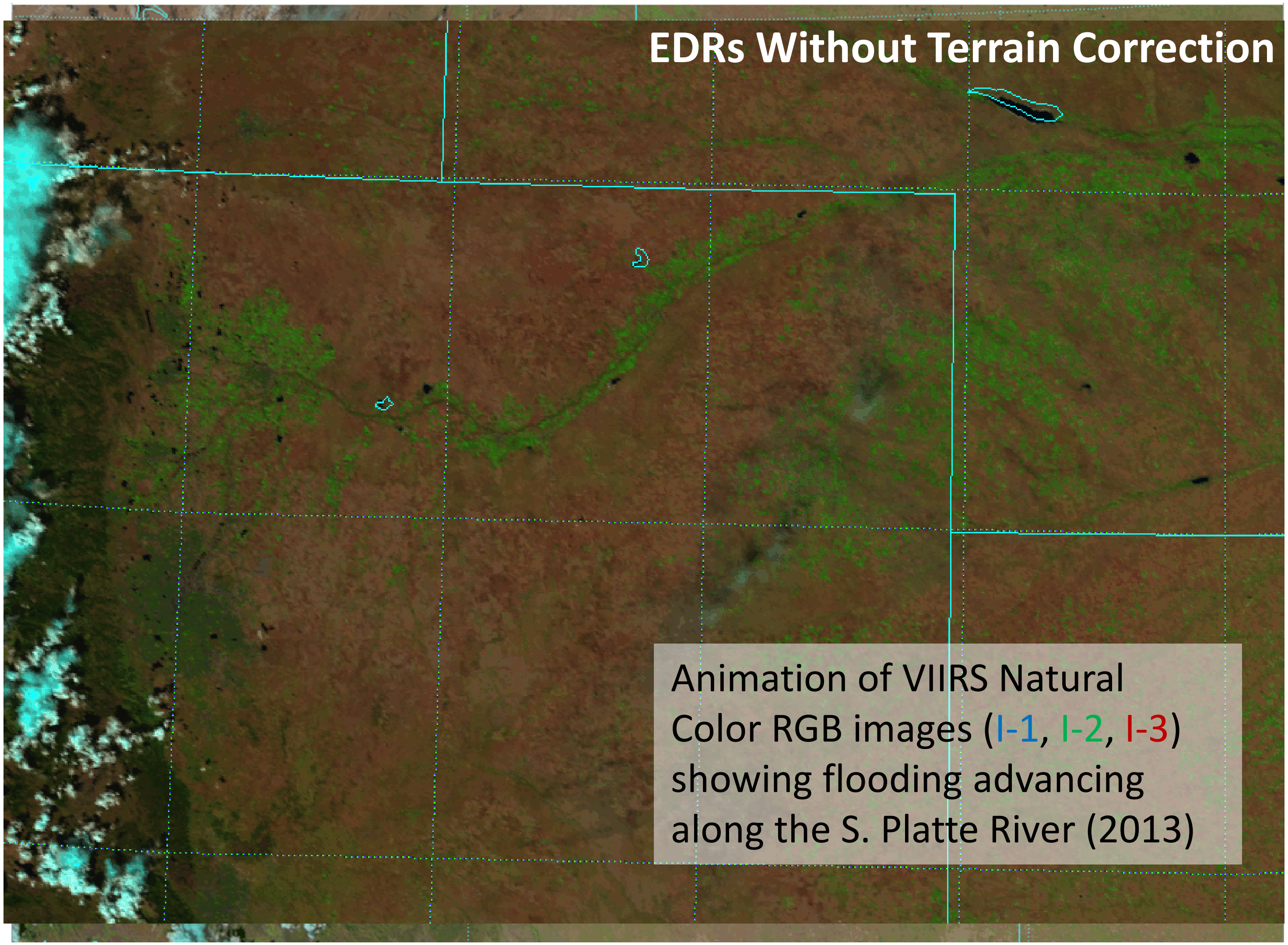
Terrain-correction was added to GDNBO files beginning in May 2014.



Do the fires move? Or does the ground move?

Answer: Both! The NCC EDR is not terrain corrected. This makes the ground appear to move, and impacts the apparent motion of the fires.

Flooding – with and without Terrain Correction

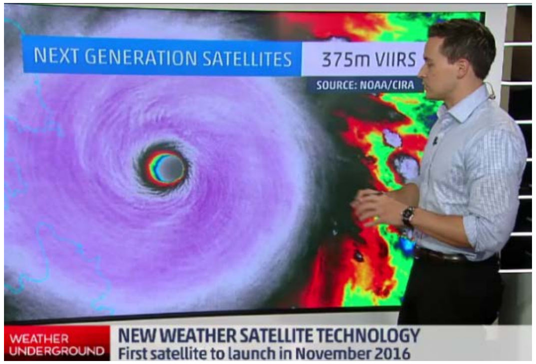


The River Ice and Flooding Product (Sanmei Li, GMU) would not be very useful if it was made with the EDRs!

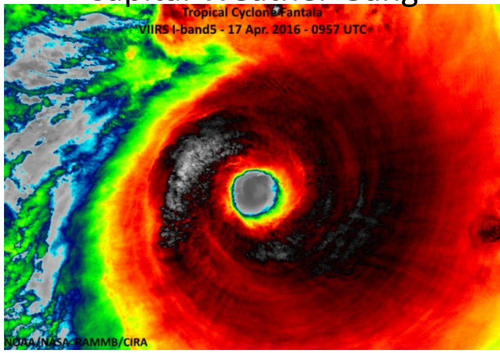
Connecting Models and Observations

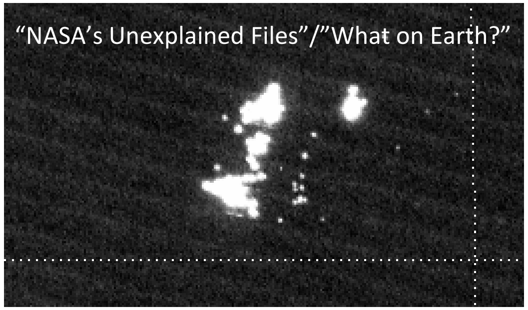
Spreading the Word

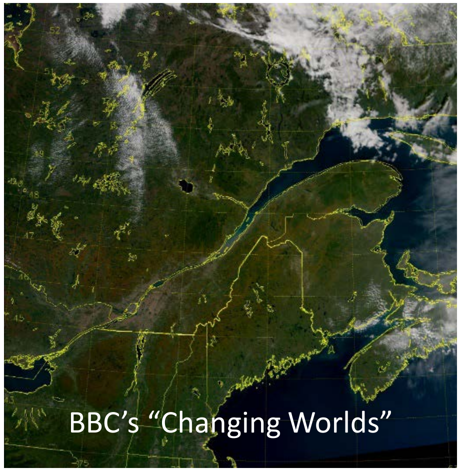
- CIRA VIIRS images have been delivered to a variety of standard media and social media outlets
  - The Weather Channel
  - CNN
  - BBC
  - WagTV (producer of shows for Discovery and Science Channel)
  - Washington Post/ Capital Weather Gang
  - @NOAASatellites on Twitter
  - And many more…

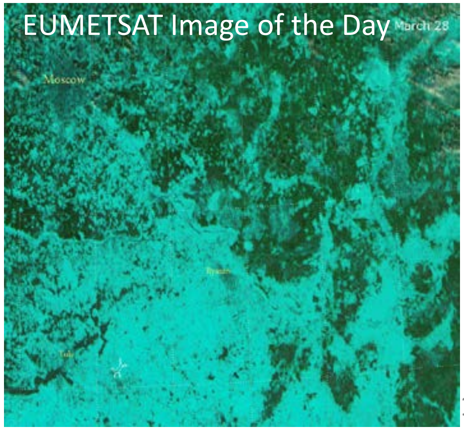


Capital Weather Gang




“NASA’s Unexplained Files”/”What on Earth?”


BBC’s “Changing Worlds”


EUMETSAT Image of the Day

For the User Community

- Imagery EDR User's Guide for all users
  - Guide to using VIIRS EDRs and differences with SDRs
- Quick Guides for forecasters
  - NCC in AWIPS
  - Contributed to several GINA Quick Guides
  - More to come!

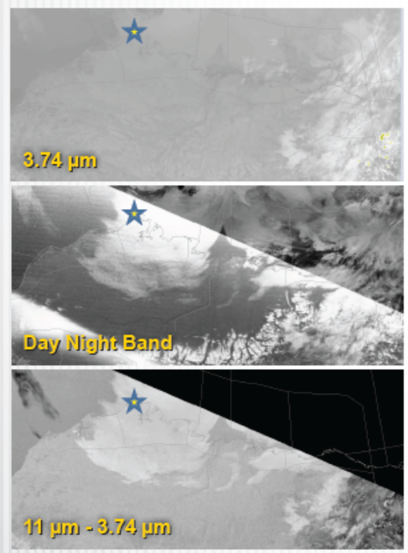
GINA ALASKA DIRECT BROADCAST QUICK GUIDES
The 3.74 µm "Fog and Fire" Band

OVERVIEW

The 3.74 µm channel is in the mid-wave portion of the infrared spectrum and has utility in identifying areas of fog and low stratus when combined with longwave infrared imagery and also in identifying wildfires when used as a stand-alone image.

FINDING FOG WITH THE 3.74 µm CHANNEL

The three images below are from a VIIRS pass at 1128Z on September 3, 2015, over Alaska's North Slope; a star has been placed over Barrow for reference. At 1127Z WSO Barrow took a SPECI observation indicating a ceiling of 300 ft vertical visibility and ¾ mile visibility in mist. The stand-alone 3.74 µm image at top does not offer enough contrast or detail to allow an accurate analysis of the stratus and fog. The low clouds appear much more distinct in the Day Night Band image at middle. Note the sharp line running across the Day Night Band from the upper left to the middle right of the image—the area northeast of this line is illuminated by daylight, and consequently a different processing scheme must be used in that area. At bottom is the traditional "fog product" highlighting the difference in brightness temperatures between the 11 µm longwave IR and the 3.74 µm channel, and here the low clouds and fog are easier to identify.



The channel differencing approach (bottom image) works because liquid water cloud droplets, even super-cooled droplets, exhibit different emissivity at 11 µm and 3.74 µm. Areas with large differences in brightness temperature in this product are thus assumed to be covered by low stratus or fog.

Weaknesses of the channel differencing product include vulnerability to blockage by higher clouds above the stratus and fog, as well as a restriction to the hours of darkness. Note how the fog product at bottom includes no data over the area covered by sunshine in the Day Night Band. The 3.74 µm channel, while still being in the infrared, is of a short enough wavelength that any sunshine reflecting off of clouds overwhelms the emissivity signal at 3.74 µm, with the result that the channel differencing is overly noisy and unusable during daylight hours.

ADDITIONAL REFERENCES

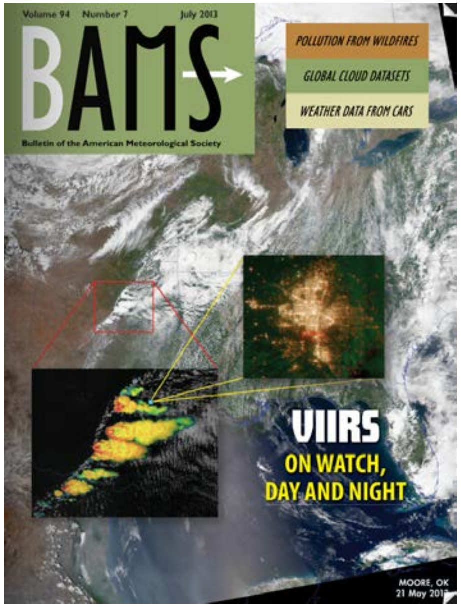
- Blog entry from CIRA about 3.74 µm and other wavelengths used to detect fires in Alaska: http://rammb.cira.colostate.edu/projects/alaska/ blog/index.php/uncategorized/the-land-of-10000-fires/
- Quick guides to channels on the GOES-R Advanced Baseline Imager (ABI). ABI Band 7 is centered at 3.9 µm http://www.goes-r.gov/education/ABI-bands-quick-info.html
- Eric Stevens: eric@gina.alaska.edu | Carl Dierking: cfdierking@alaska.edu | GINA Staff: www.gina.alaska.edu/people

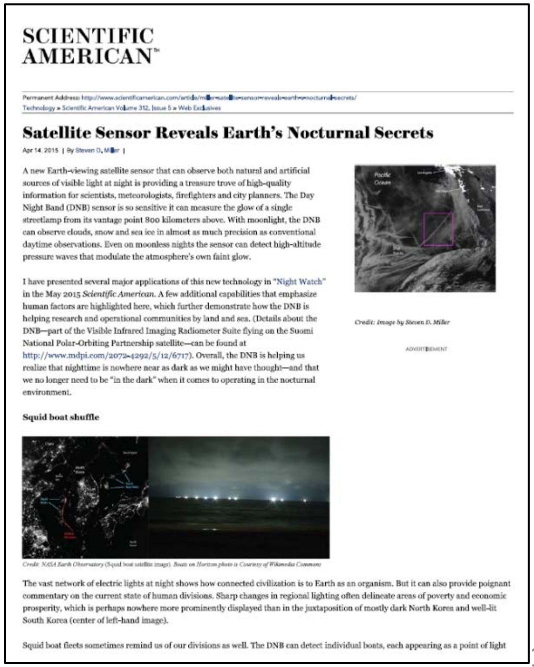
Summary

- Many active projects at CIRA utilize VIIRS
  - Imagery EDR Team efforts
    - Blogs
    - Near-real time imagery
    - Education and Outreach
  - Multi-spectral applications
    - Demonstrating GOES-R capabilities
    - Geocolor using DNB
    - Fire Temperature RGB, Snow/Cloud Discriminator, etc.
  - Day/Night Band applications
  - JPSS Satellite Liaison (see Jorel Torres' presentation)
    - Training (User's Guide, Quick Guides, etc.)
  - Tropical Cyclone research (see Galina Chirokova's presentation)

- Monitoring imagery is ongoing
  - Artifacts inherited from the SDRs are rare

- For the future:
  - Day/Night Band on JPSS-1 will have artifacts
  - Terrain correction for the EDR geolocation
  - Make EDRs from all 16 M-bands
  - Make M-band EDRs more readily available





SCIENTIFIC AMERICAN™

Permanent Address: http://www.scientificamerican.com/article/miller-satellite-sensor-reveals-earth-s-nocturnal-secrets/
Technology » Scientific American Volume 312, Issue 5 » Web Exclusives

Satellite Sensor Reveals Earth's Nocturnal Secrets

Apr 14, 2015 | By Steven D. Miller |

A new Earth-viewing satellite sensor that can observe both natural and artificial sources of visible light at night is providing a treasure trove of high-quality information for scientists, meteorologists, firefighters and city planners. The Day Night Band (DNB) sensor is so sensitive it can measure the glow of a single streetlamp from its vantage point 800 kilometers above. With moonlight, the DNB can observe clouds, snow and sea ice in almost as much precision as conventional daytime observations. Even on moonless nights the sensor can detect high-altitude pressure waves that modulate the atmosphere's own faint glow.

Credit: Image by Steven D. Miller

ADVERTISEMENT

I have presented several major applications of this new technology in "Night Watch" in the May 2015 *Scientific American*. A few additional capabilities that emphasize human factors are highlighted here, which further demonstrate how the DNB is helping research and operational communities by land and sea. (Details about the DNB—part of the Visible Infrared Imaging Radiometer Suite flying on the Suomi National Polar-Orbiting Partnership satellite—can be found at http://www.mdpi.com/2072-4292/5/12/6717). Overall, the DNB is helping us realize that nighttime is nowhere near as dark as we might have thought—and that we no longer need to be "in the dark" when it comes to operating in the nocturnal environment.

Squid boat shuffle

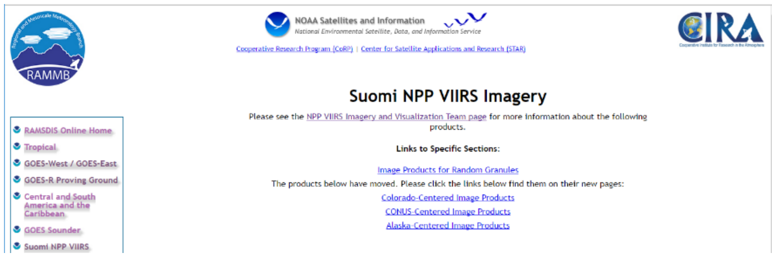
Credit: NASA Earth Observatory (Squid boat satellite image). Boats on Horizon photo is Courtesy of Wikimedia Commons

The vast network of electric lights at night shows how connected civilization is to Earth as an organism. But it can also provide poignant commentary on the current state of human divisions. Sharp changes in regional lighting often delineate areas of poverty and economic prosperity, which is perhaps nowhere more prominently displayed than in the juxtaposition of mostly dark North Korea and well-lit South Korea (center of left-hand image).

Squid boat fleets sometimes remind us of our divisions as well. The DNB can detect individual boats, each appearing as a point of light

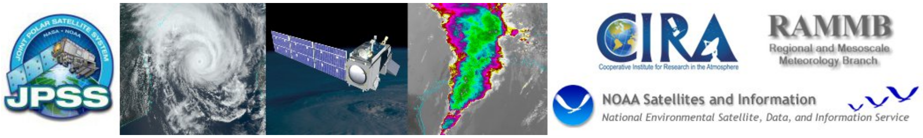
Resources

Near-realtime imagery products:



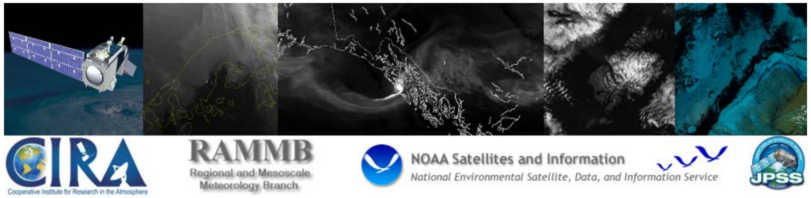
http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp

JPSS Imagery and Visualization Team blog:



http://rammb.cira.colostate.edu/projects/npp/blog/

High-latitude applications of VIIRS Imagery:



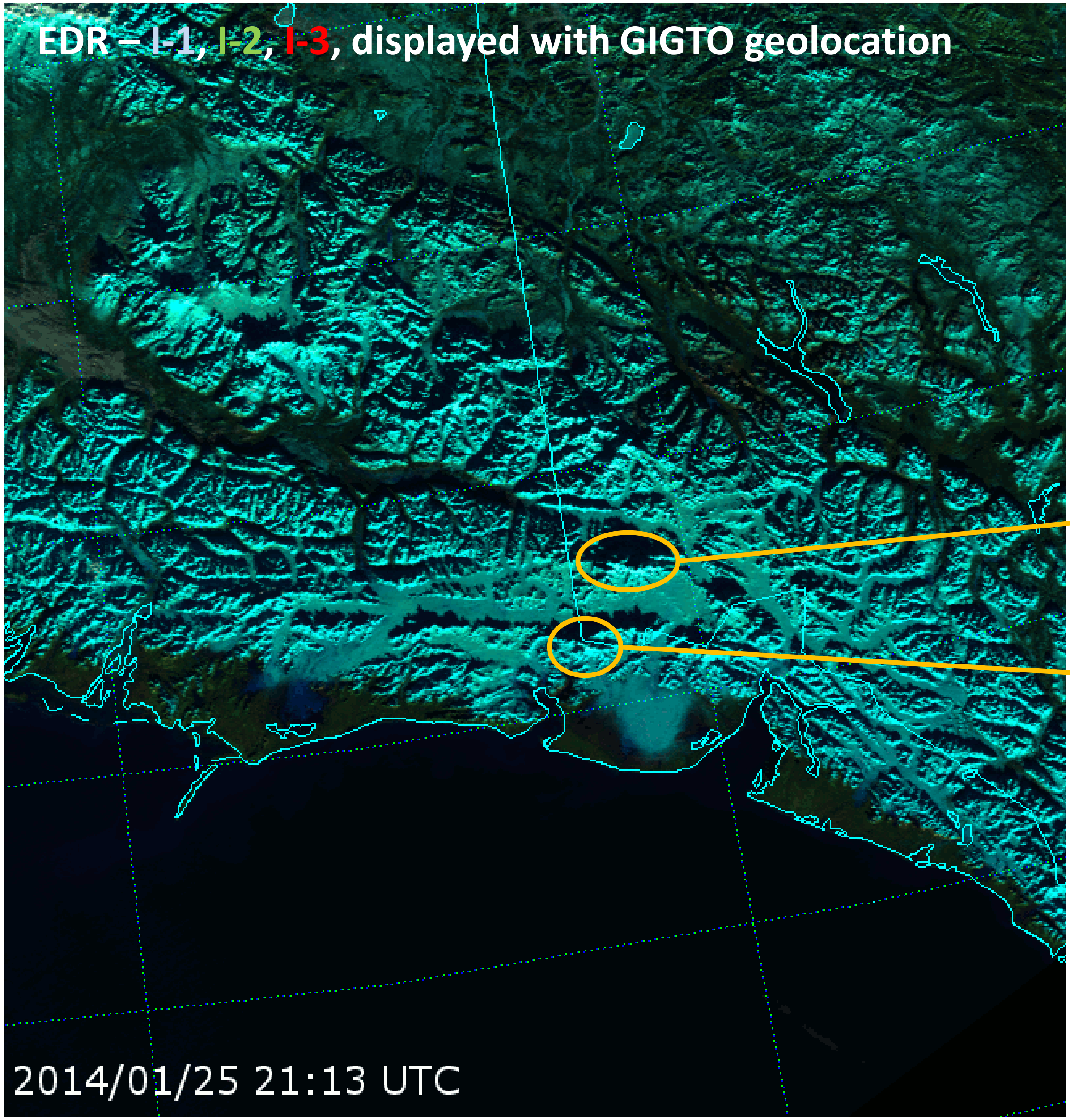
http://rammb.cira.colostate.edu/projects/alaska/blog/

VISIT Training Blog:

http://rammb.cira.colostate.edu/training/visit/blog/

CIRA
Connecting Models and Observations

EDRs are **not** Terrain Corrected!

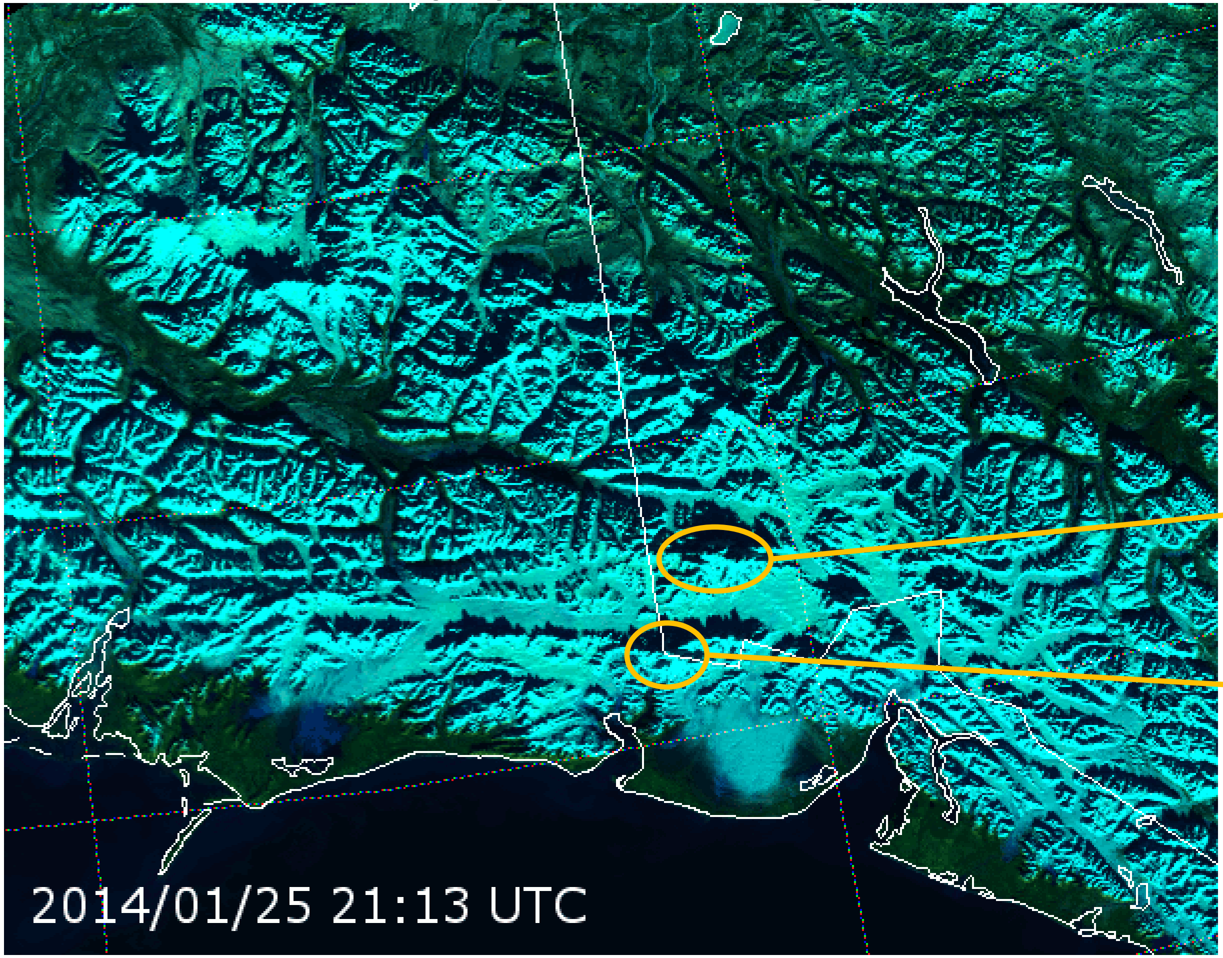


Mt. Logan
(6050 m MSL)

Mt. St. Elias
(5489 m MSL)

Terrain Correction Works!

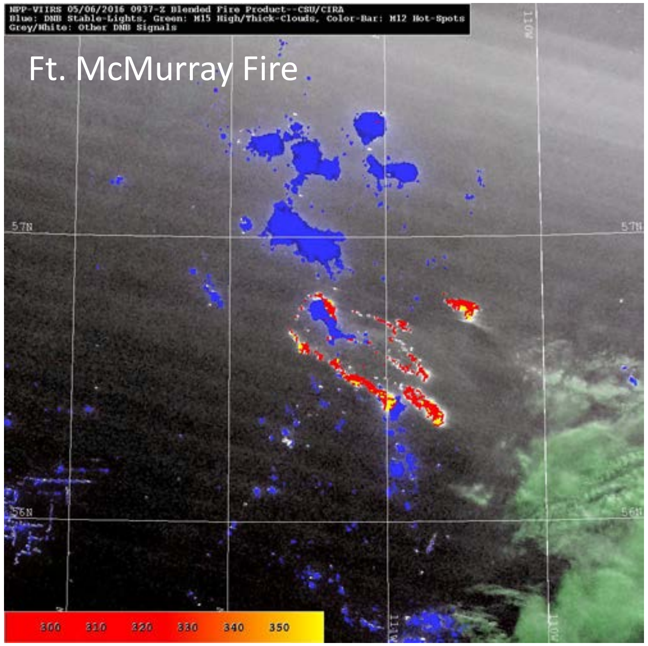
SDR – I-1, I-2, I-3, displayed with GITCO geolocation



Mt. Logan (6050 m MSL)

Mt. St. Elias (5489 m MSL)

Other DNB Multi-spectral Applications



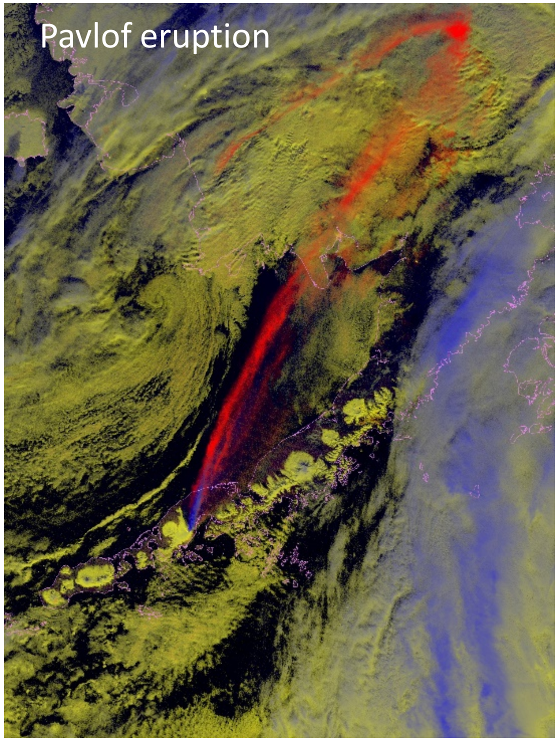
09:37 UTC 6 May 2016

- Through the use of a City Lights Mask (Chris Elvidge/Kim Baugh, NCEI) we can better quantify where fires were detected by the Day/Night Band in the Ft. McMurray Fire

- A hot spot mask applied to M-13 shows where the Day/Night Band detected light emissions from fires that were difficult to detect in M-13

- The eruption of the Pavlof volcano in Alaska was seen by M-13

- An RGB composite using the Day/Night Band better highlights the ash plume



13:25 UTC 28 March 2016

TROPICAL CYCLONE USES OF VIIRS

Galina Chirokova[1], John Knaff[2], Dan Lindsey[2], Robert DeMaria[1], Mark DeMaria[3], and Jack Beven[3]

(1) CIRA, Colorado State University, Fort Collins, CO

(2) NOAA/NESDIS/StAR, Fort Collins, CO

(3) NOAA/NWS/National Hurricane Center, Miami, FL

STAR JPSS
2016 Annual Science Team Meeting
8-12 August 2016
College Park, MD

VIIRS DATA FOR TROPICAL CYCLONE FORECASTING

- VIIRS data have multiple applications for TC analysis and forecasting and can be critical for operational forecasters.
- Important features:
  1. Day Night Band: **visible-like imagery at nighttime**
  2. IR, VIS: **very high resolution** of I-bands, including IR window band (I05, 11.45 μm, 375 m resolution)
  3. 3040 km swath width: **no gaps between the consecutive orbits**, even at the equator

CIRA TROPICAL CYCLONES NEAR REAL TIME STORM-CENTERED VIIRS IMAGERY

An experimental near real-time application displaying storm-relative VIIRS DNB, visible, and IR imagery in the vicinity of TCs has been developed and is available on RAMMB- CIRA's TC Real Time page: http://rammb.cira.colostate.edu/products/tc_realtime/

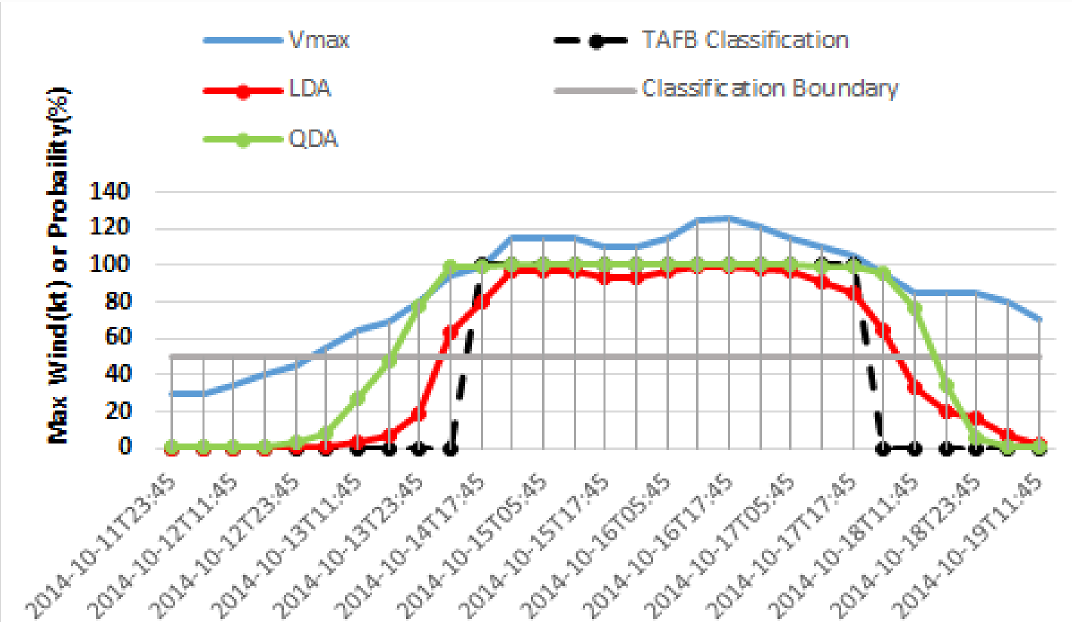
- 3 VIIRS products available online:
  1. **Alternating DNB (at night) and VIS (during day)** [2 hr latency]
  2. **DNB imagery** during both day and night [1.5 hr latency]
  3. **High-resolution IR window band** (I05, 11.45μm, 375 m resolution) [2 hr latency]

- Product description: http://rammb.cira.colostate.edu/products/tc_realtime/about.asp

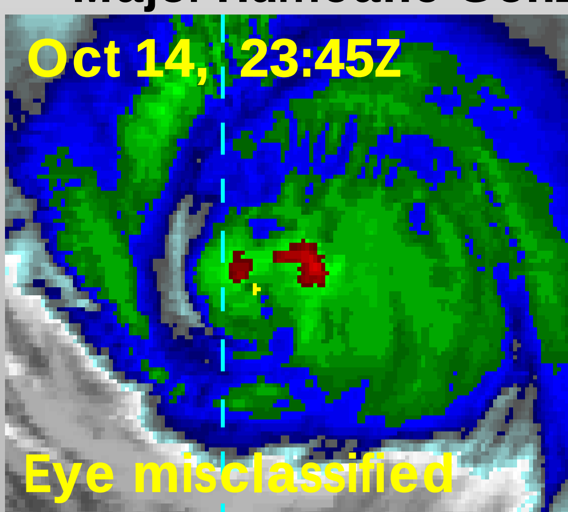
TC USE OF HIGH-RESOLUTION IR WINDOW AND VISIBLE CHANNELS

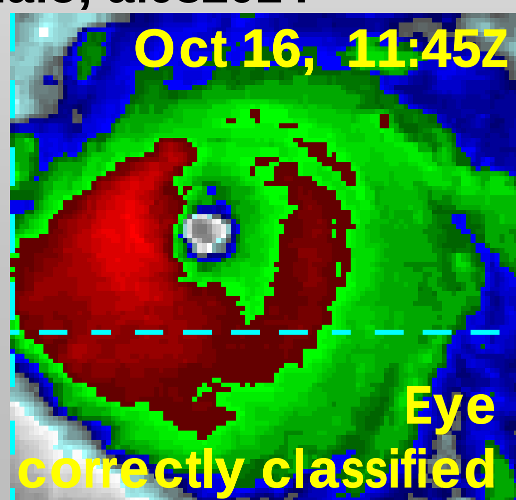
- High-resolution window **IR I05** band:
  - 11.45 μm, 375 m resolution
- High-resolution **VIS I01** band:
  - 0.64 μm, 375 m resolution
- Use in the **algorithm for automated eye-detection**
- Provide **detail about the eye-structure** not visible on GOES imagery

AUTOMATED OBJECTIVE EYE-DETECTION



Major Hurricane Gonzalo, al082014

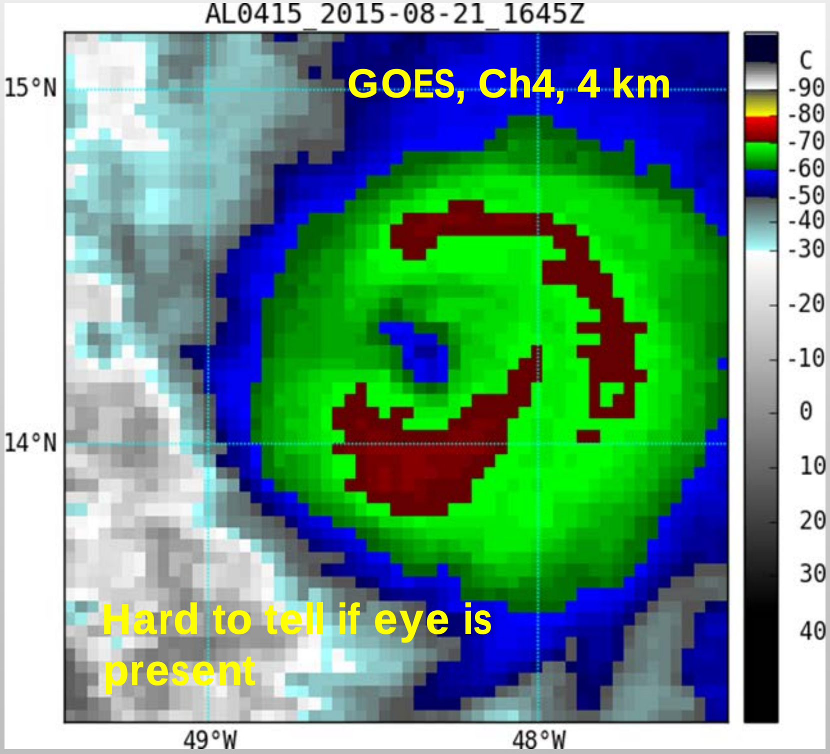


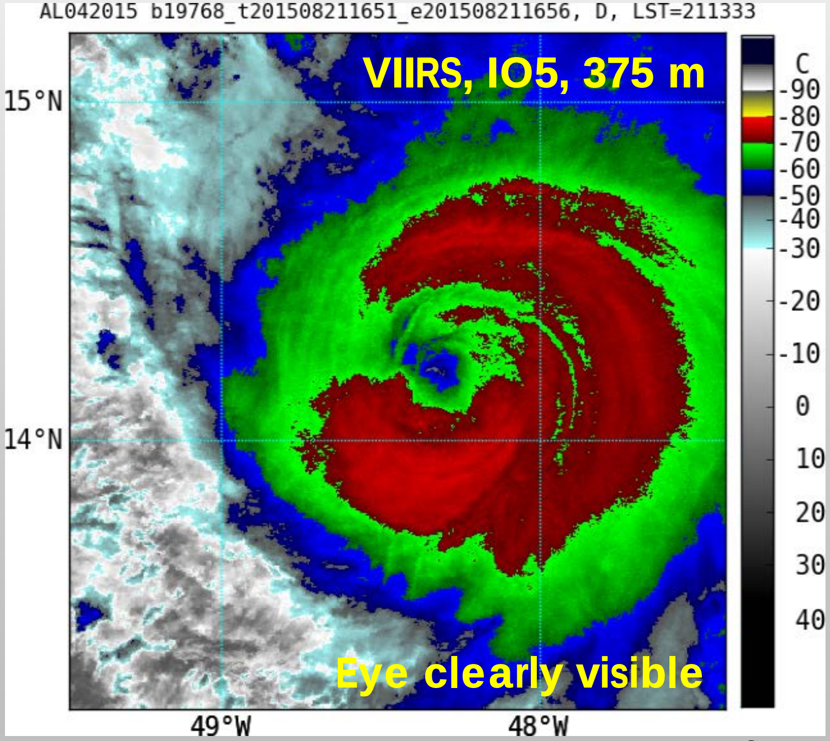


- The hybrid (IR+ Best Track) **automated objective eye-detection algorithm correctly classifies about 90% of the cases**
- Best performance: when storm is either weak (no-eye) or strong (eye already formed)
- Worst performance: when eye is about to form or just formed. That time is also challenging for human observer
- The probabilistic version of the **algorithm could be used as:**
  - ***standalone application***
  - ***input to the Rapid Intensification Index (RII)***
  - ***to forecast eye formation***

AUTOMATED OBJECTIVE EYE-DETECTION

- Further algorithm improvement: use VIIRS high-resolution data for borderline cases
- Example: hurricane Danny, al04 2015 had a very small eye that is visible on VIIRS imagery but hard to detect on GOES

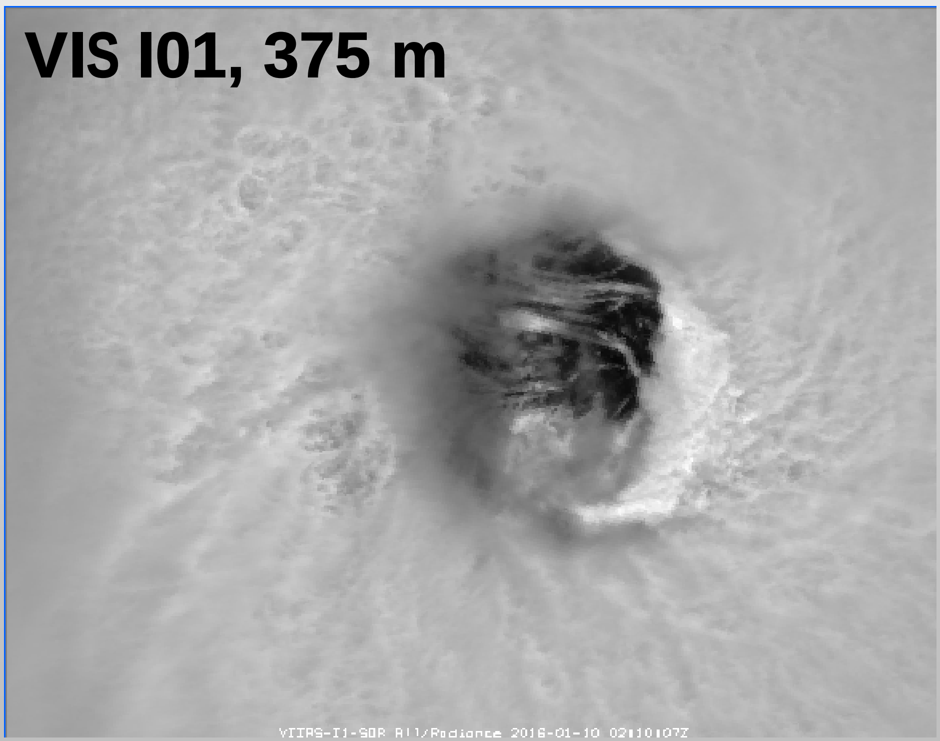




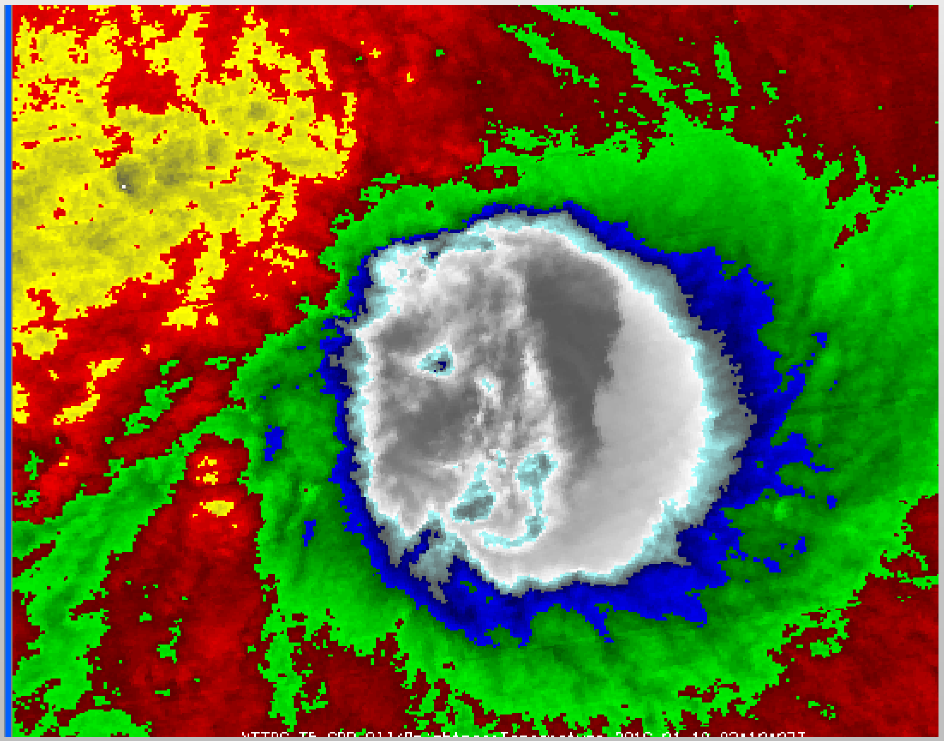
al042015 Major Hurricane DANNY

VIEWING THE EYE STRUCTURE

- The fine structure of the eye , such as mesovortices and the sape of the eye-wall are clearly resolved by I05 but not necessary seen in the GOES imagery
- The details about the eye-structure might be useful for determining the storm intensity



IR Window I05, 375 m



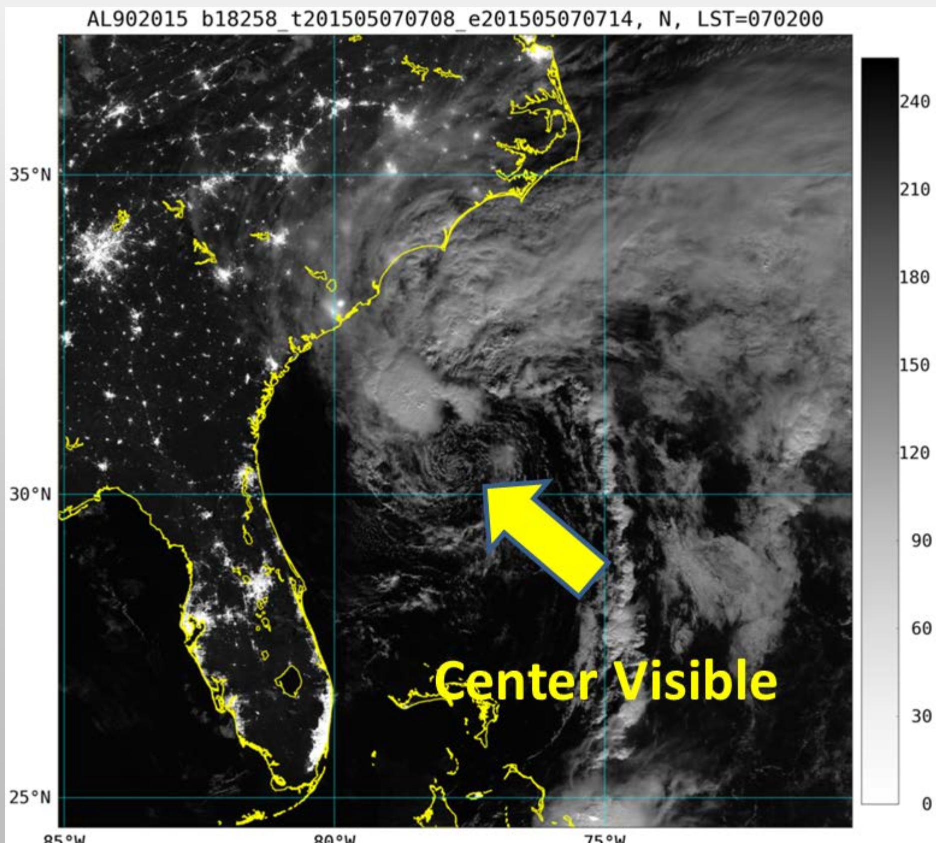
sh062016 TC Ula 10/01/2016 02:03UTC

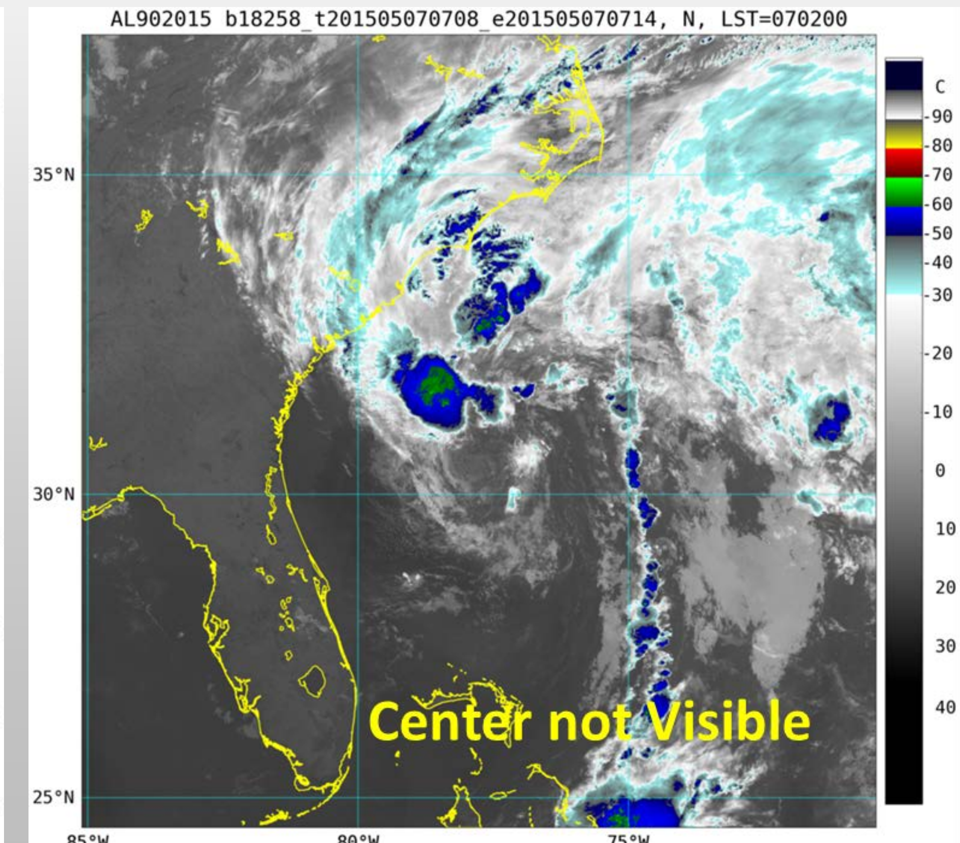
TC USE OF DAY-NIGH BAND (DNB) CHANNEL

- DNB imagery **primary use**
  - **determine the presence of the eye** in cases when the eye is small or is obscured by thin cirrus and not obvious in infrared (IR) imagery
  - **perform center-fixing** and **has been used by forecast centers** to refine nighttime storm center locations
- DNB imagery **can also be used to**
  - **detect night-glow waves** that occur in the stratosphere and not seen in other imagery
  - **detect instantaneous lightning**: lightning location could be an indication of intensifying or weakening storm
- The DNB's nighttime capabilities are **especially important for**
  - **weaker TCs:** are less organized, have multiple circulation centers, and are generally more difficult to locate
  - **sheared TCs:** the low-level circulation center is exposed and/or elongated and is hard to determine from the IR imagery or animations of IR imagery

VIIRS DNB CENTER FIXING

- Low level circulation center visible only on DNB image
- Hard to see the center location from the IR image alone





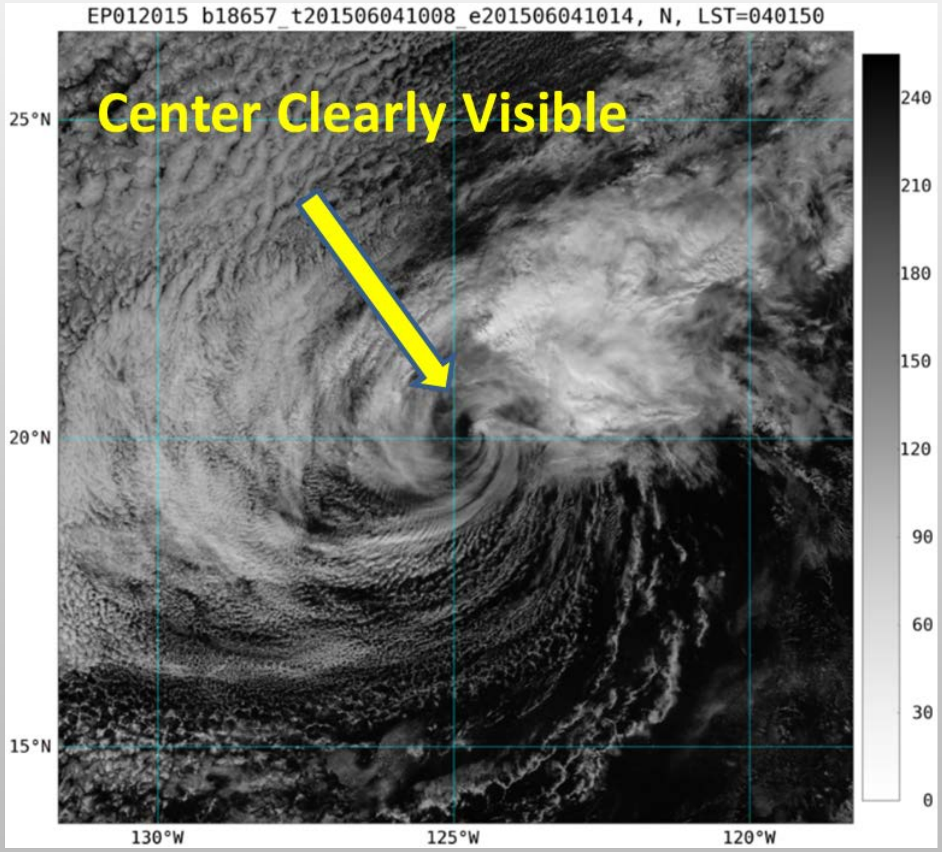
Invest al902015 (right before becoming Tropical Storm ANA)

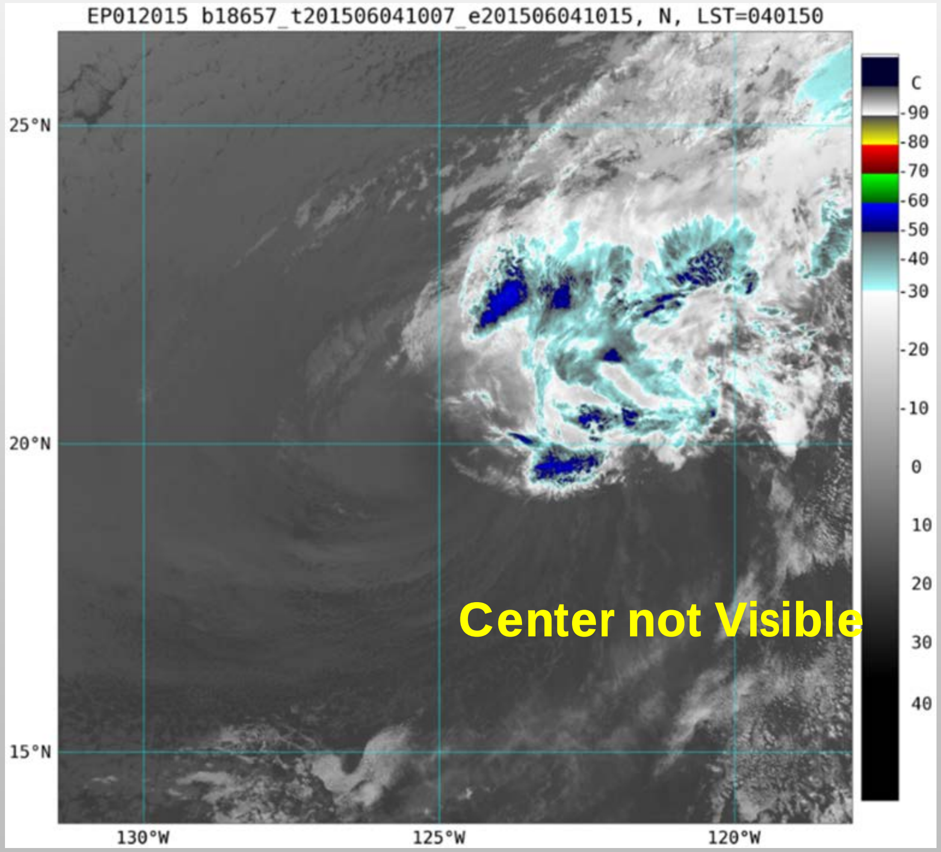
COMMENTS ON CENTER FIXING

- The center is typically the **starting point for intensity estimation**
- Location is **important for warnings** and the running of guidance
- Weaker storms often have **multiple centers**
- Storm **symmetry is often poor in weaker systems** making center fixing challenging
- Sheared tropical cyclones have **displaced centers** which are difficult to find at night

VIIRS DNB CENTER FIXING

- Low level circulation center visible only on DNB image
- Hard to see the center location from the IR image alone

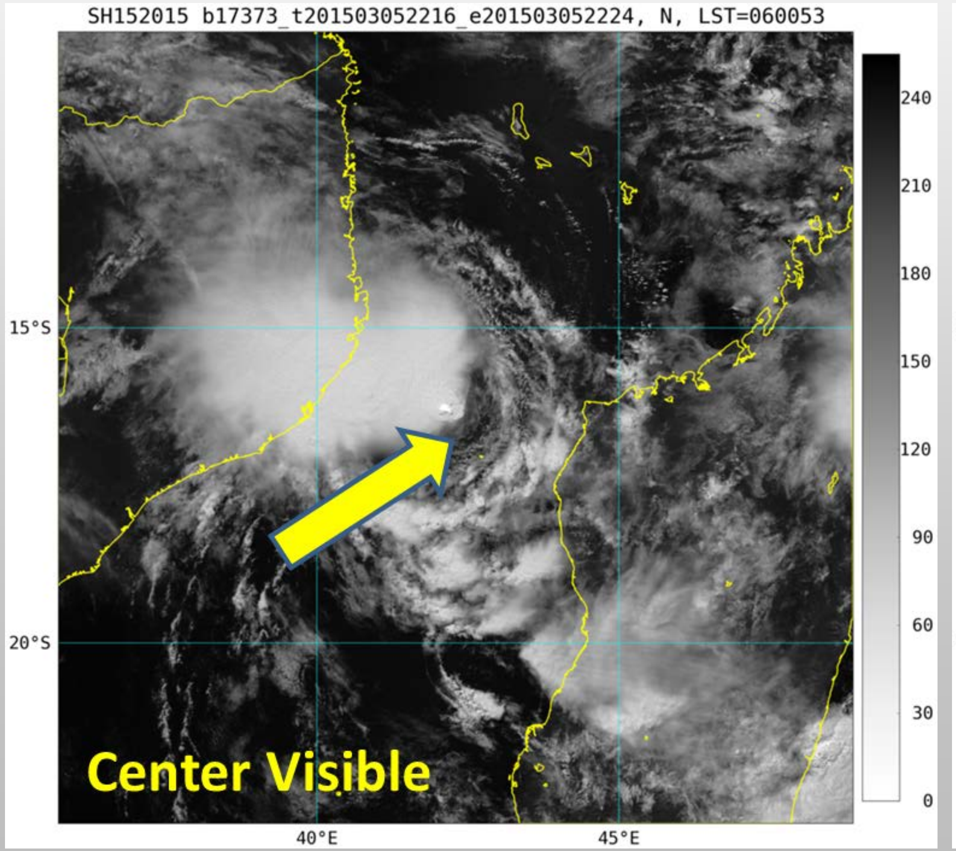


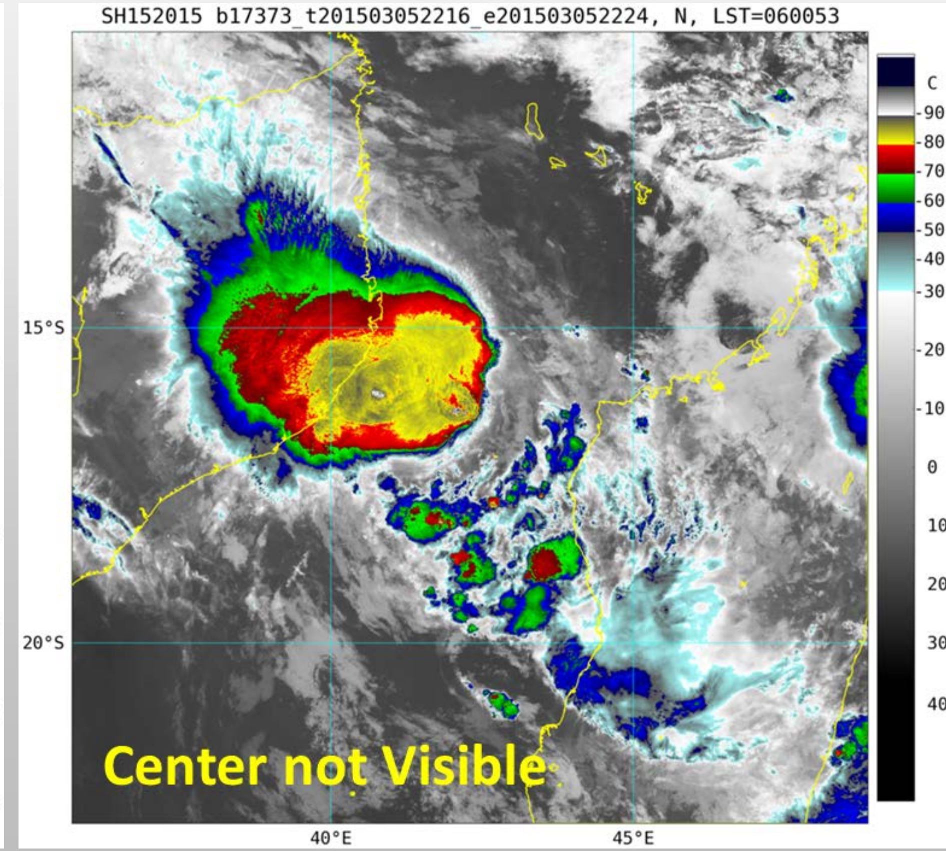


ep012015 Major Hurricane ANDRES

VIIRS DNB CENTER FIXING

- Low level circulation center visible only on DNB image
- Hard to see the center location from the IR image alone

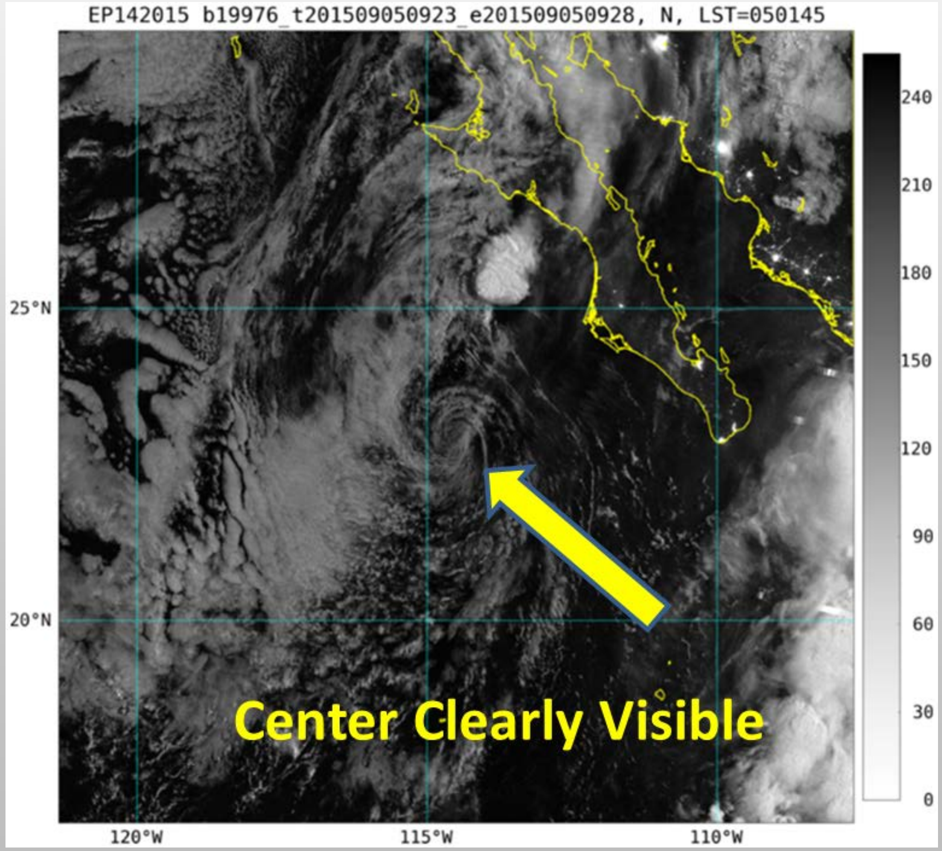


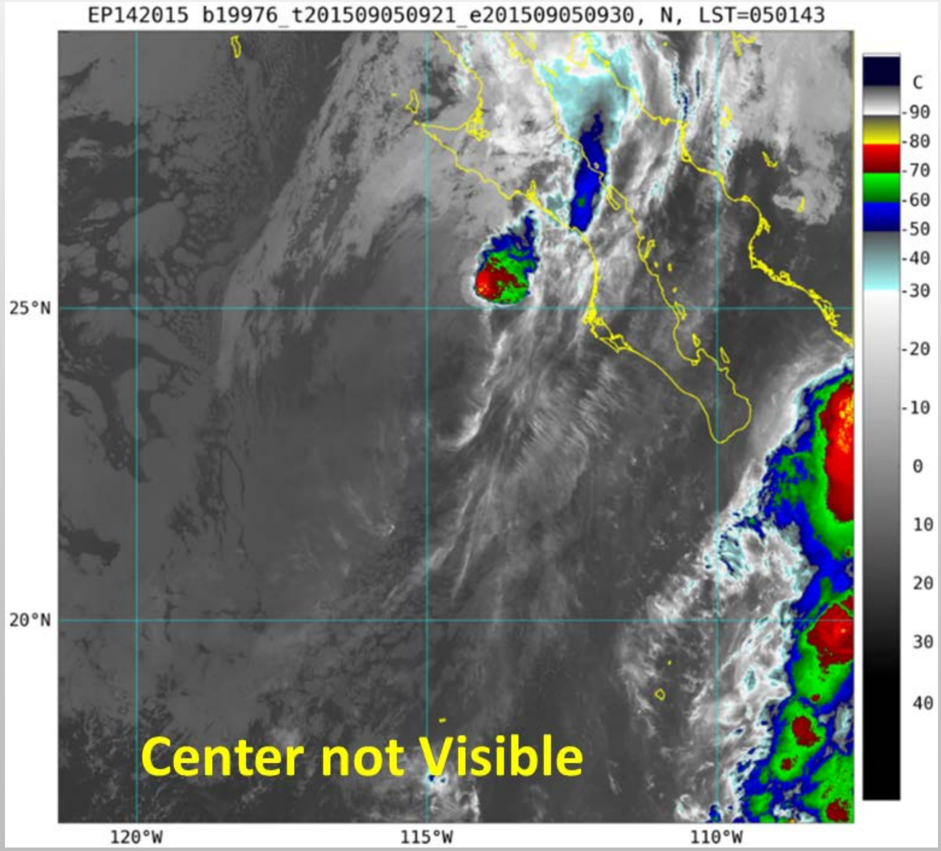


sh152015 Tropical Cyclone FIFTEEN

VIIRS DNB CENTER FIXING

- Low level circulation center visible only on DNB image
- Hard to see the center location from the IR image alone

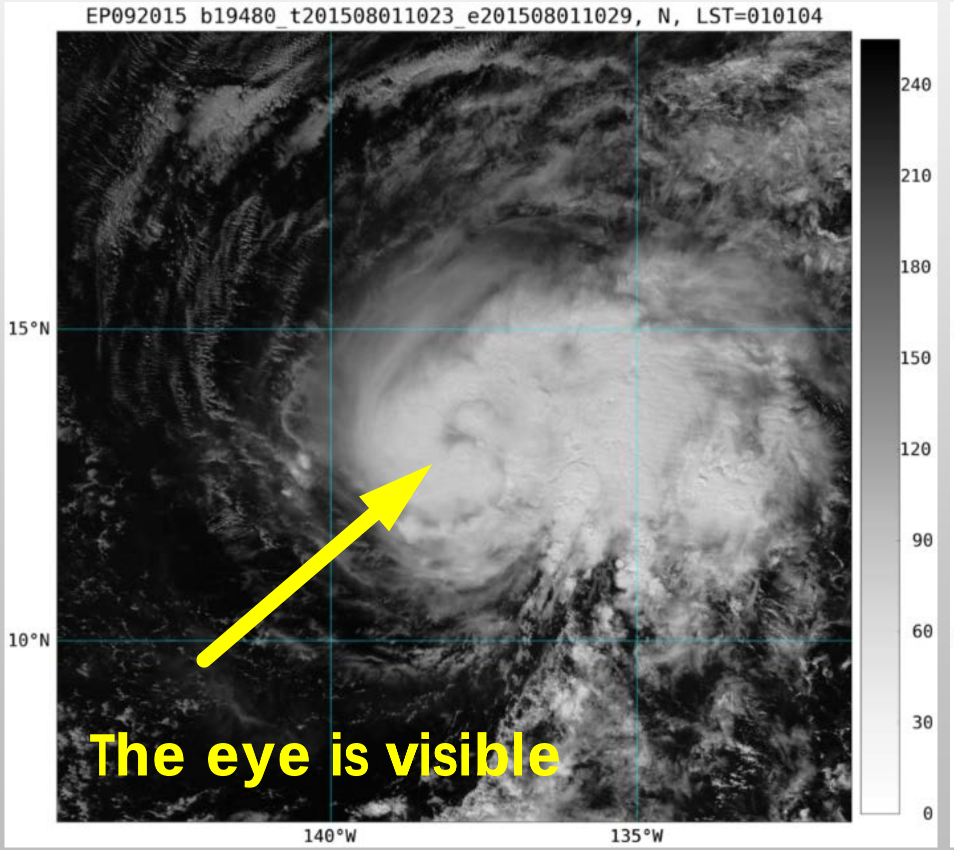


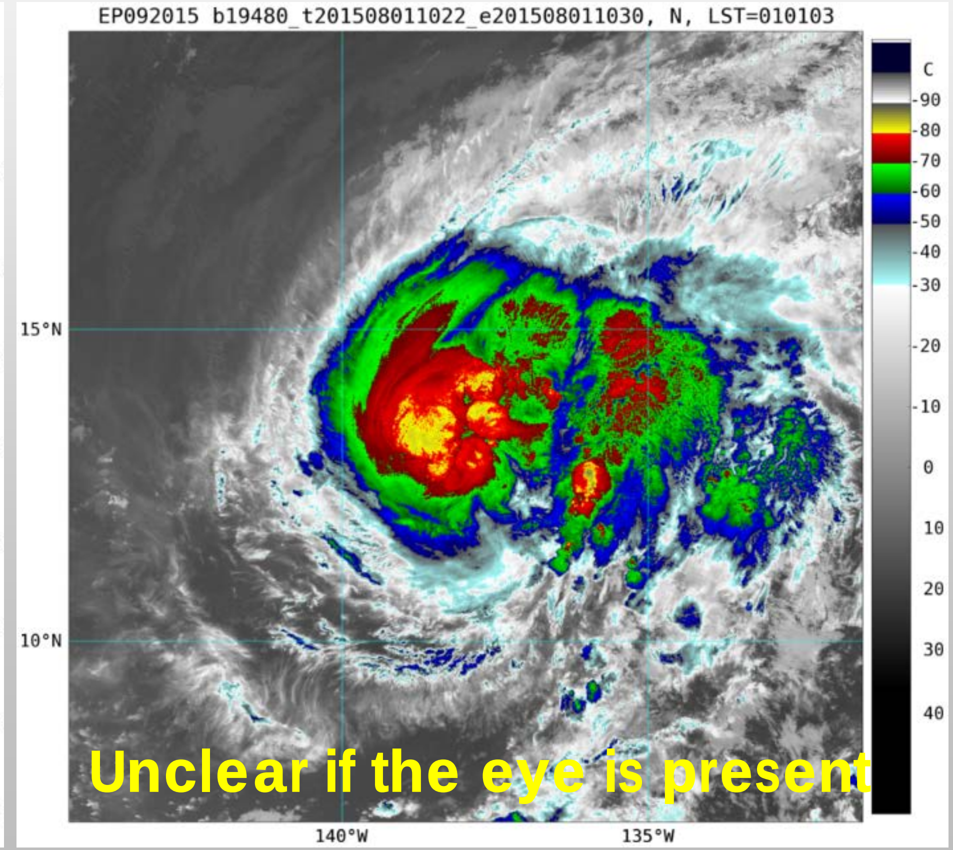


ep142015 Tropical Storm KEVIN

VIIRS DNB EYE-DETECTION

- Eye is clearly visible on DNB image
- Eye presence is not obvious from the IR image

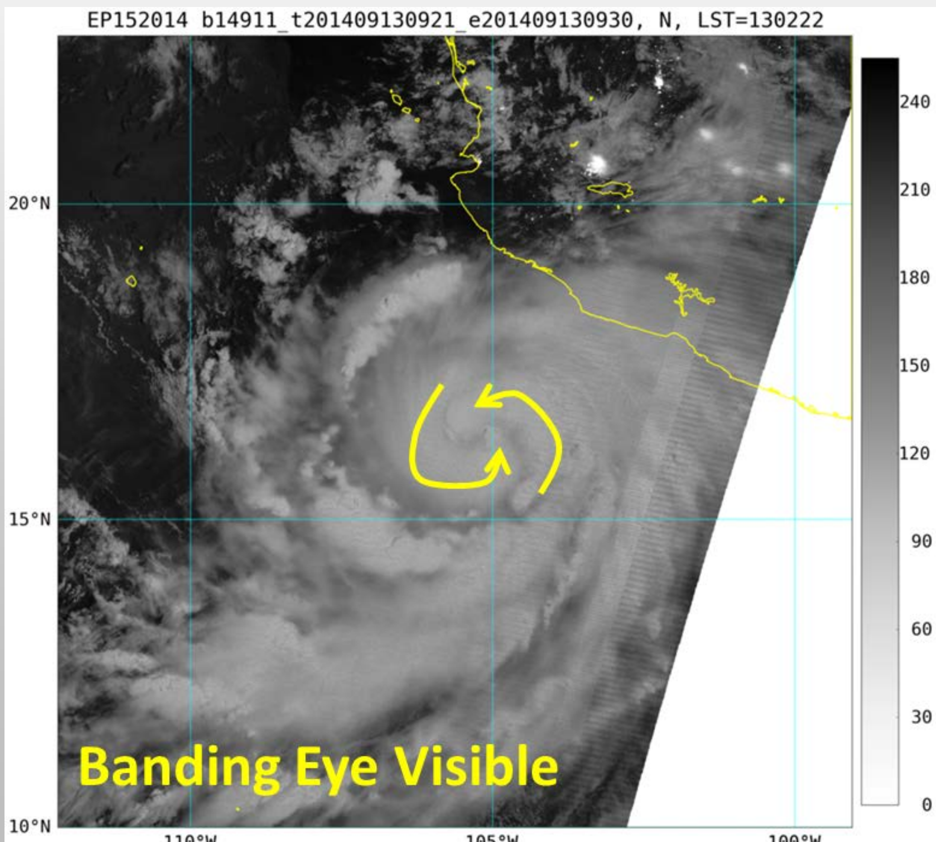


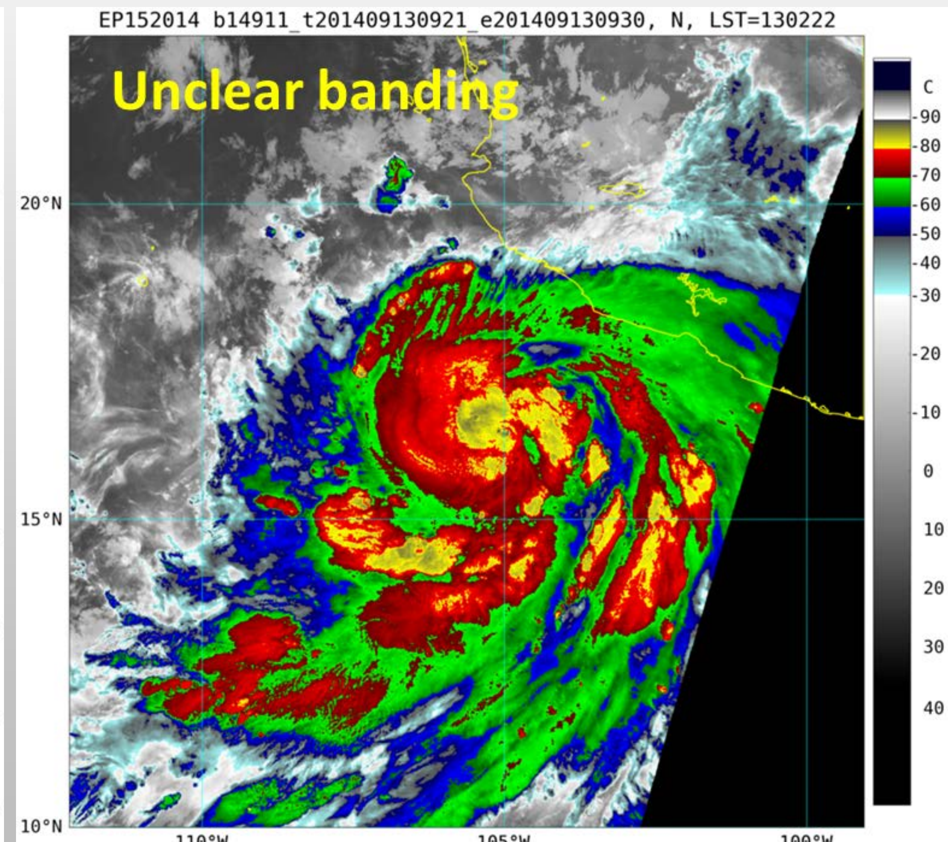


ep150915 Hurricane GUILLERMO

VIIRS DNB EYE-DETECTION

- **Banding eye** is an indication of the intensifying storm
- Banding eye apparent in the night-time DNB image
- No banding indicated in the IR image alone

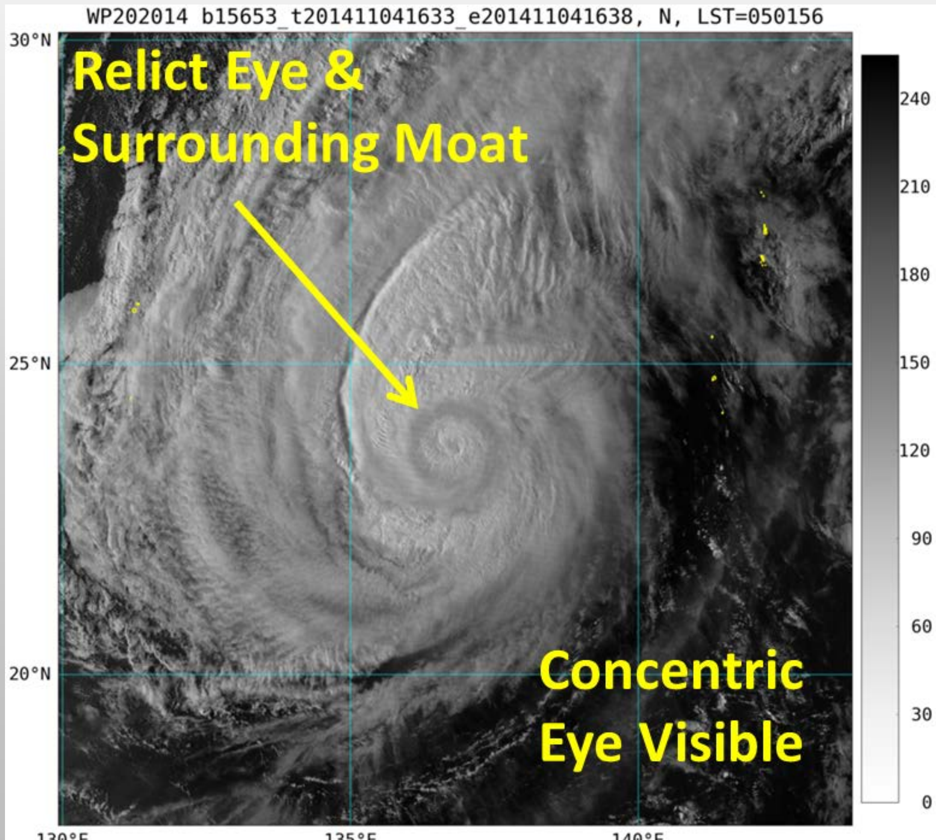


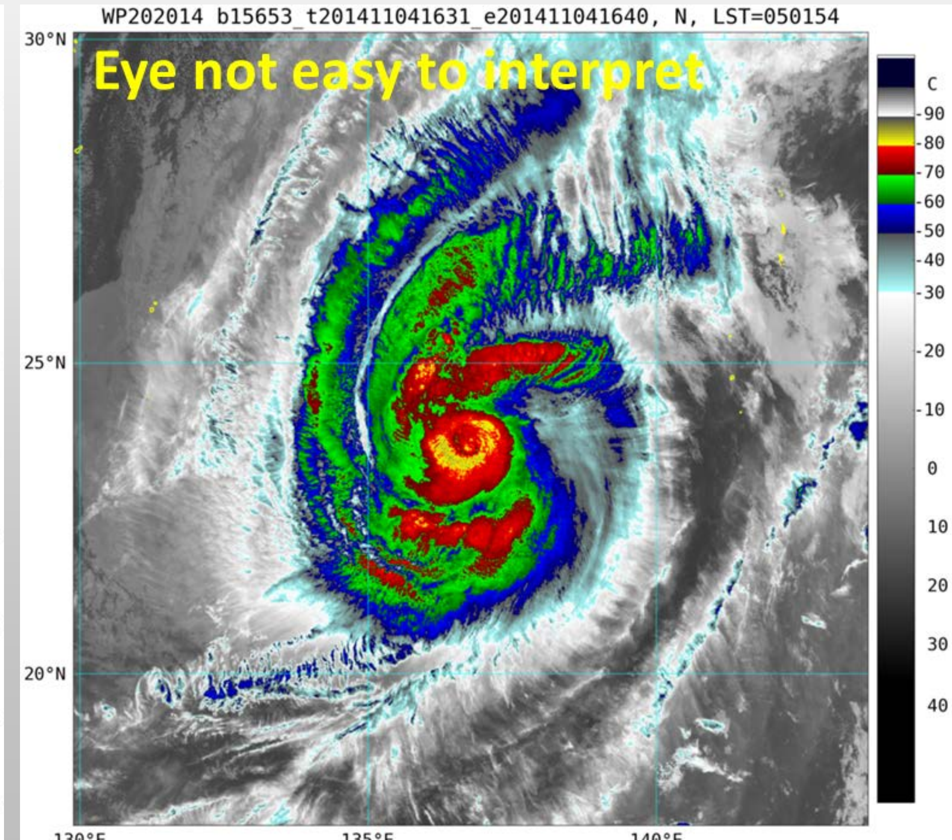


ep152014 Major Hurricane ODILE

VIIRS DNB EYE-DETECTION

- **Concentric eye** is a sign of the secondary eyewall formation; it likely indicates the storm will not be intensifying in the short-term (12 hours)
- Concentric eye is evident in night-time DNB image
- The concentric nature of the eye is more difficult to infer in the IR

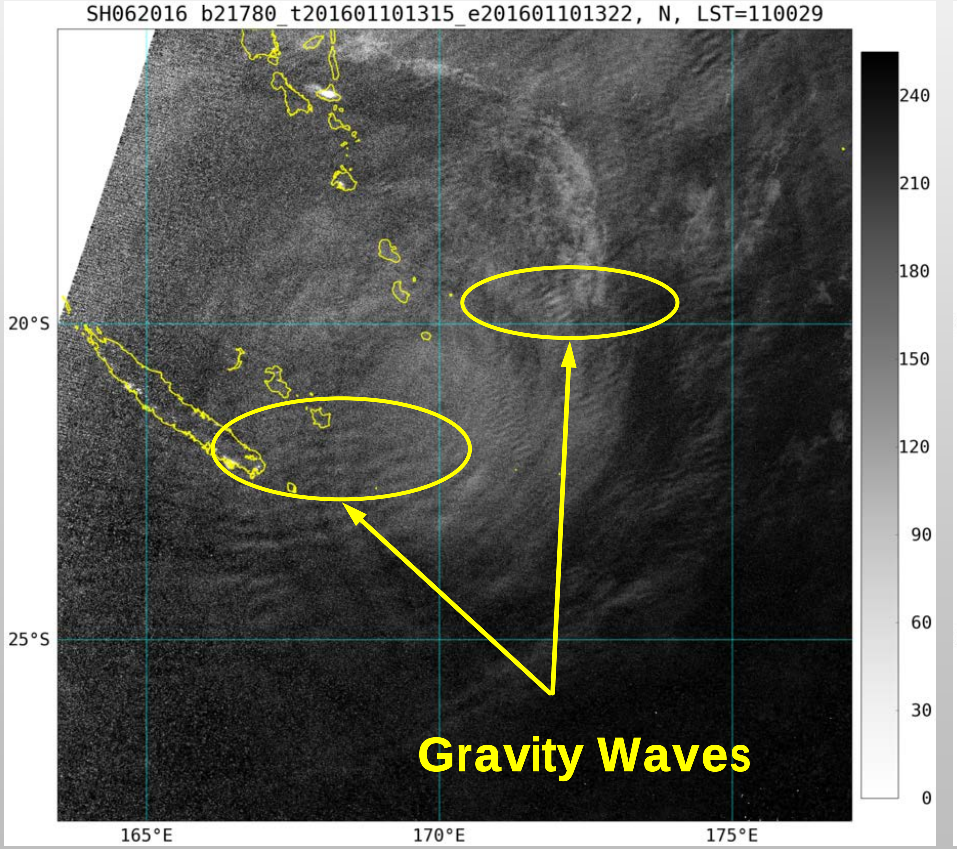


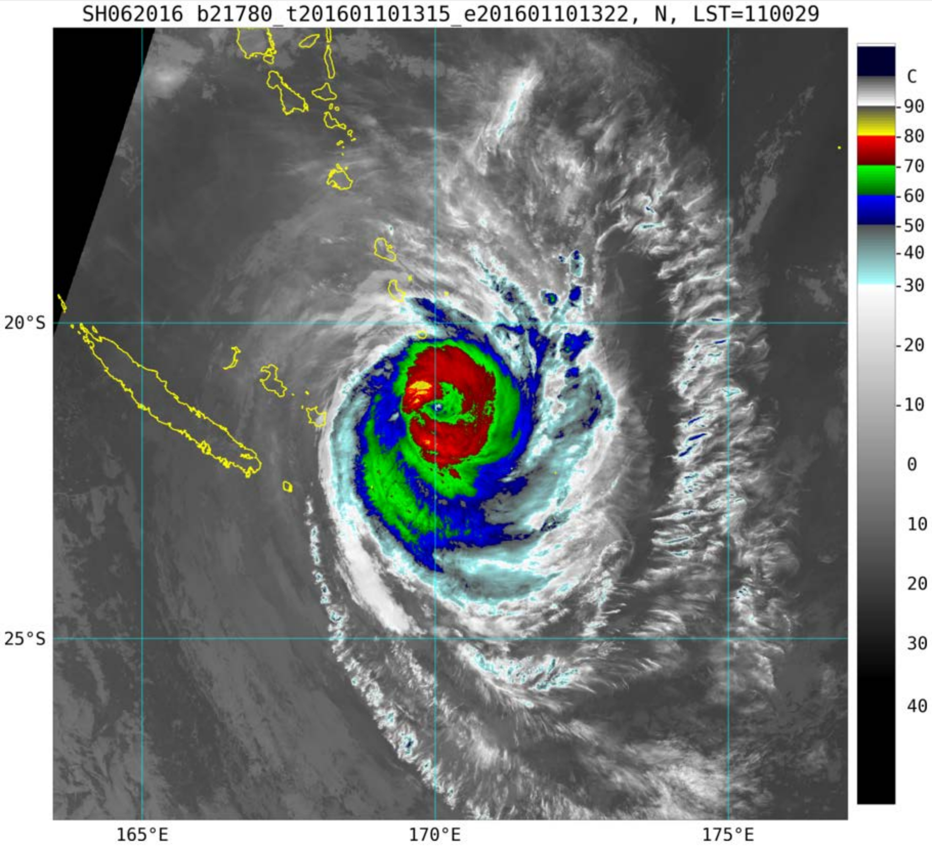


wp092014 Typhoon RAMMASUN

NIGHTGLOW WAVES

- Gravity waves observed in nightglow on DNB images (Yue et al. 2014)





sh212014 Tropical Cyclone HELLEN

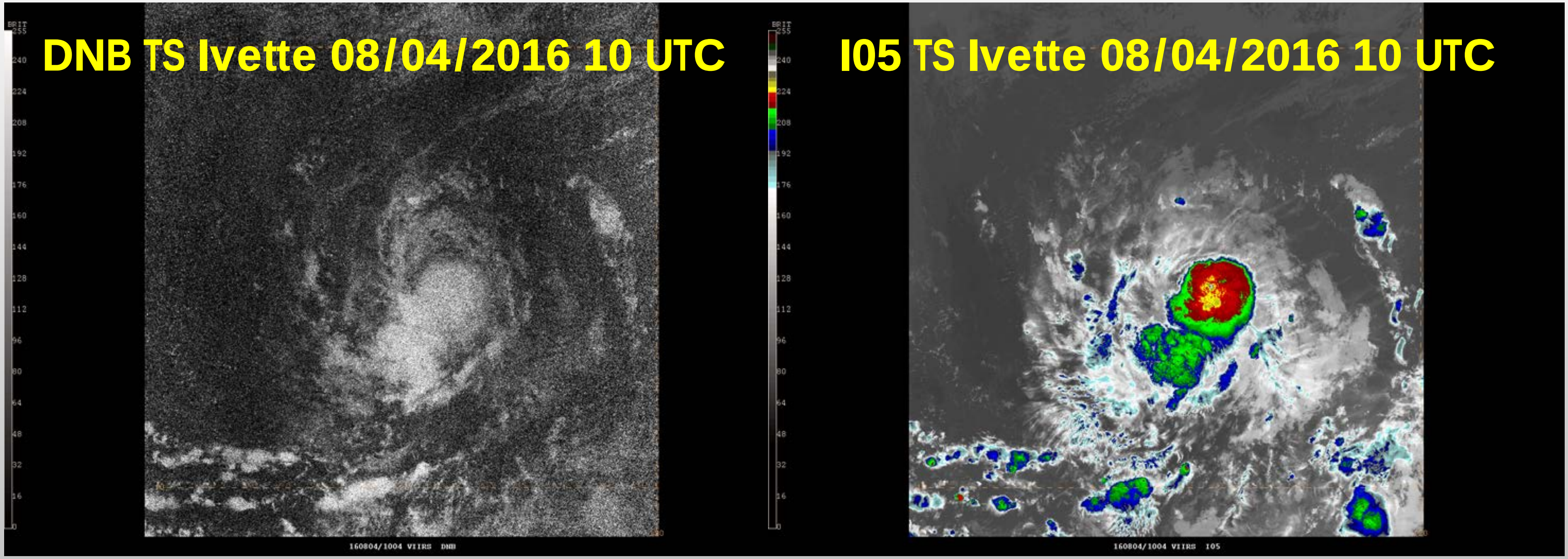
CIRA TC-CENTERED NEAR REAL TIME DNB AND IR IMAGERY AT THE NATIONAL HURRICANE CENTER (NHC)

- CIRA's storm-centered VIIRS imagery has been utilized in the NHC Proving Ground since 2015 and has shown utility for TC analysis
- **In August, 2016 CIRA started providing the NAWIPS version of the storm centered imagery to NHC via LDM in near-real time**
- **Two products are being sent to NHC in near-real time**:
  1. **DNB imagery during both day and night** [1.5 hr latency]
  2. **VIIRS high-resolution IR windows band** (I05, 11.45μm, 375 m resolution) [2 hr latency]
- **Working on** producing the same imagery **using direct broadcast data** to reduce latency

CIRA TC-CENTERED NEAR REAL TIME DNB AND IR IMAGERY AT THE NATIONAL HURRICANE CENTER (NHC)

- Use **existing LDM feed** to send data
- Imagery created specifically for **display in NAWIPS**
- **DNB scaling is tuned to the storm area**
- Can **combine** together **different data sources** (2 DB sites, or DB + high-latency data) to create full storm image
- Small **data storage requirements:** NHC can keep a longer history of real time data on line and **save the data for each storm for post-season analysis** for the tropical cyclone reports
- Forecasters **can readily get information about when the data is available for each storm**. That proved to be very helpful on the 1st week of August when there were storms in both Atlantic and East Pacific

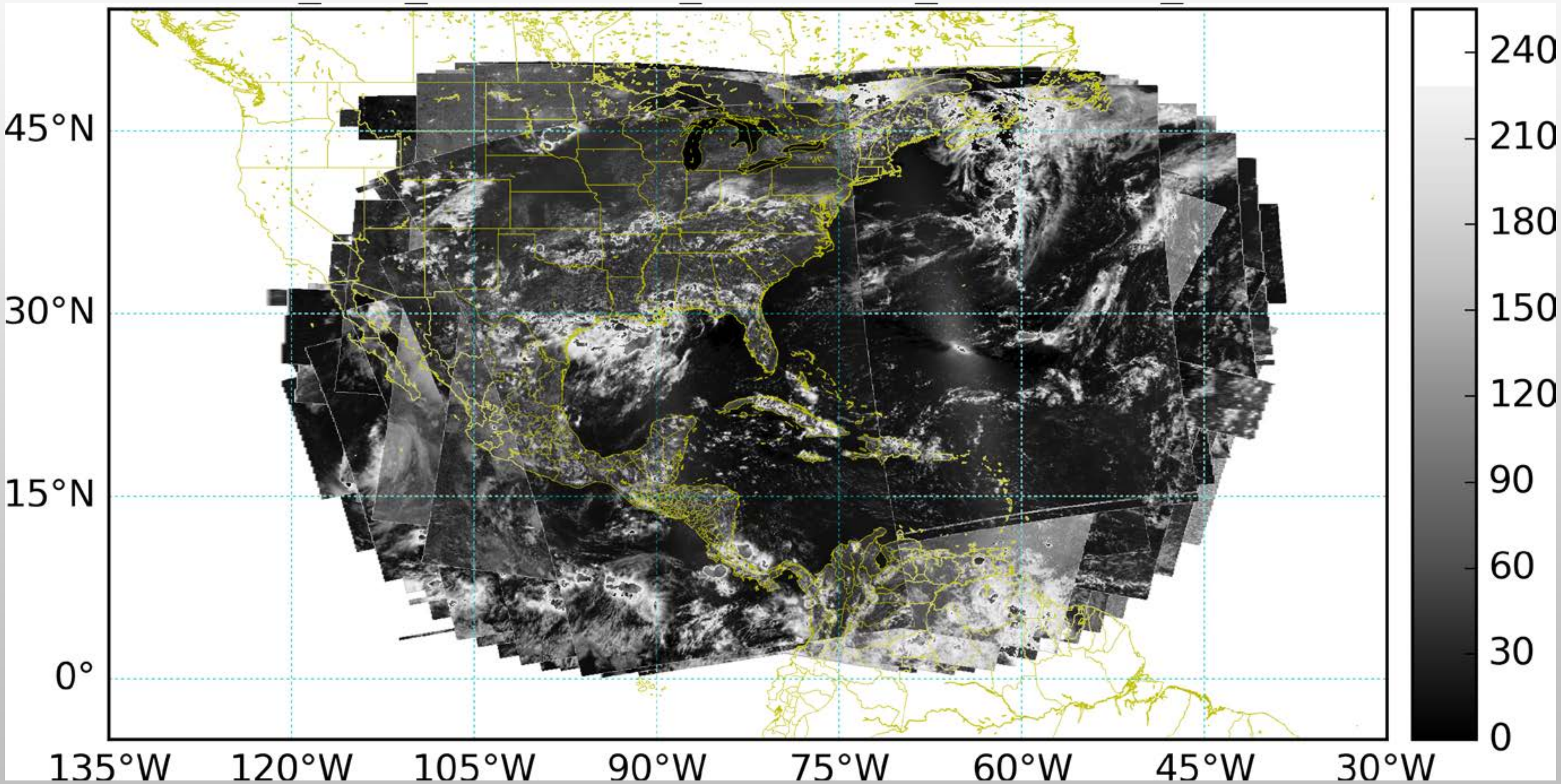
CIRA TC-CENTERED NEAR REAL TIME DNB AND I05 IMAGERY AT THE NATIONAL HURRICANE CENTER NAWIPS SYSTEM



- DNB and I05 images of the tropical storm Ivette, ep102016 displayed on NAWIPS at NHC on August 4th, 2016

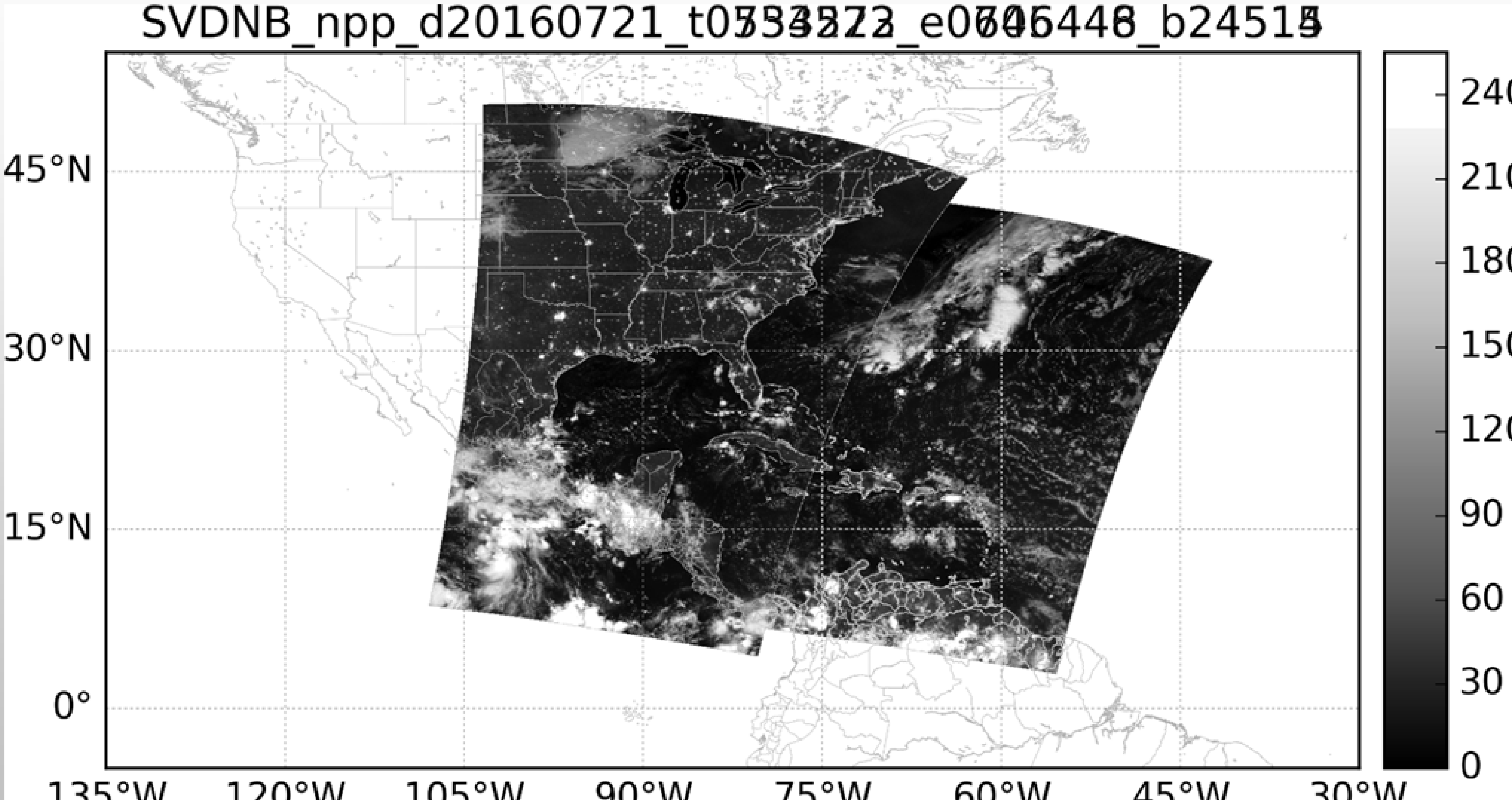
DELIVERING AOML DIRECT BROADCAST DATA TO NHC

- DNB data from the AOML DB ground station
- Combined coverage from July 11 to July 26, 2016



Expected total latency for storm-centered imagery: 25 – 35 minutes

DELIVERING AOML DIRECT BROADCAST DATA TO NHC



➢ **Nigh-time total coverage on July 21, 2016**

SUMMARY

- **VIIRS DNB and high-resolution VIS and IR window channels show a number of features that are important for TC analysis and forecasting and cannot be seen on other imagery**
- The **most important** applications are :
  - **Center - fixing**
  - **Eye - detection**
- **CIRA storm - centered TC imagery** has proven useful for NHC and is currently **delivered to NHC via LDM** in NAWIPS-ready format
- **CIRA is working on providing the same imagery to NHC from direct broadcast sites** to reduce latency

CIRA AND VISIT RESOURCES FOR VIIRS IMAGERY

VISIT:

- VIIRS Satellite Imagery in AWIPS.
  http://rammb.cira.colostate.edu/training/visit/training_sessions/viirs_satellite_imagery_in_awips/
- VIIRS Imagery Interpretation of Super Typhoon Vongfong
  http://rammb.cira.colostate.edu/training/visit/training_sessions/viirs_imagery_interpretation_of_super_typhoon_vongfong
- Use of VIIRS imagery for Tropical Cyclone Forecasting
  http://rammb.cira.colostate.edu/training/visit/training_sessions/use_of_viirs_imagery_for_tropical_cyclone_forecasting/

CIRA:

- Suomi NPP (National Polar-orbiting Partnership) VIIRS Imagery and Visualization Team

  http://rammb.cira.colostate.edu/projects/npp

JPSS Training

BY JOREL TORRES[1]

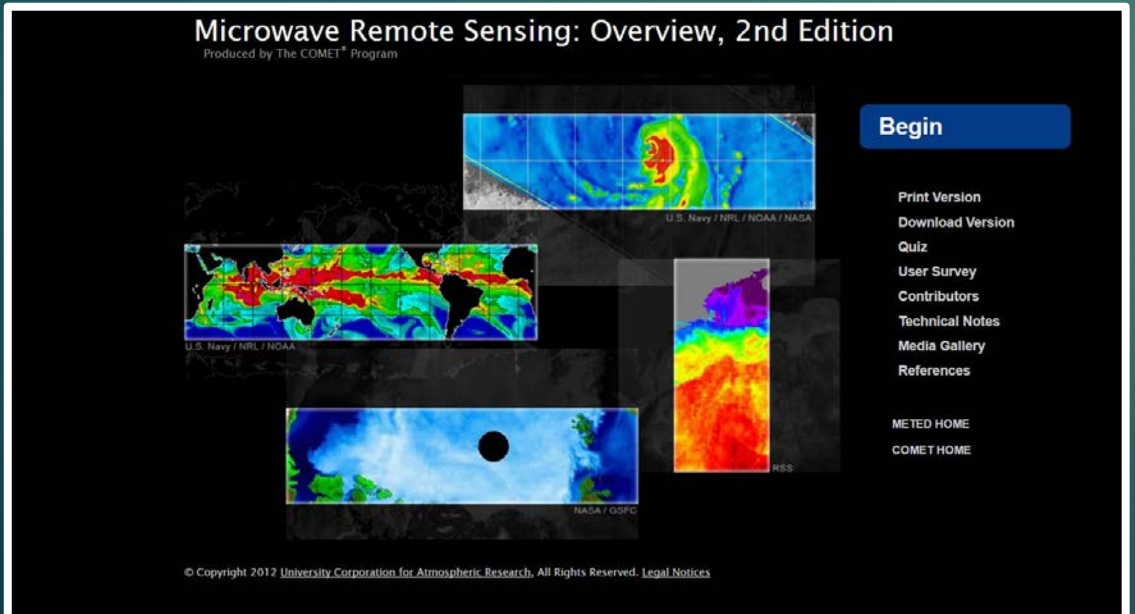
JPSS SATELLITE LIAISON

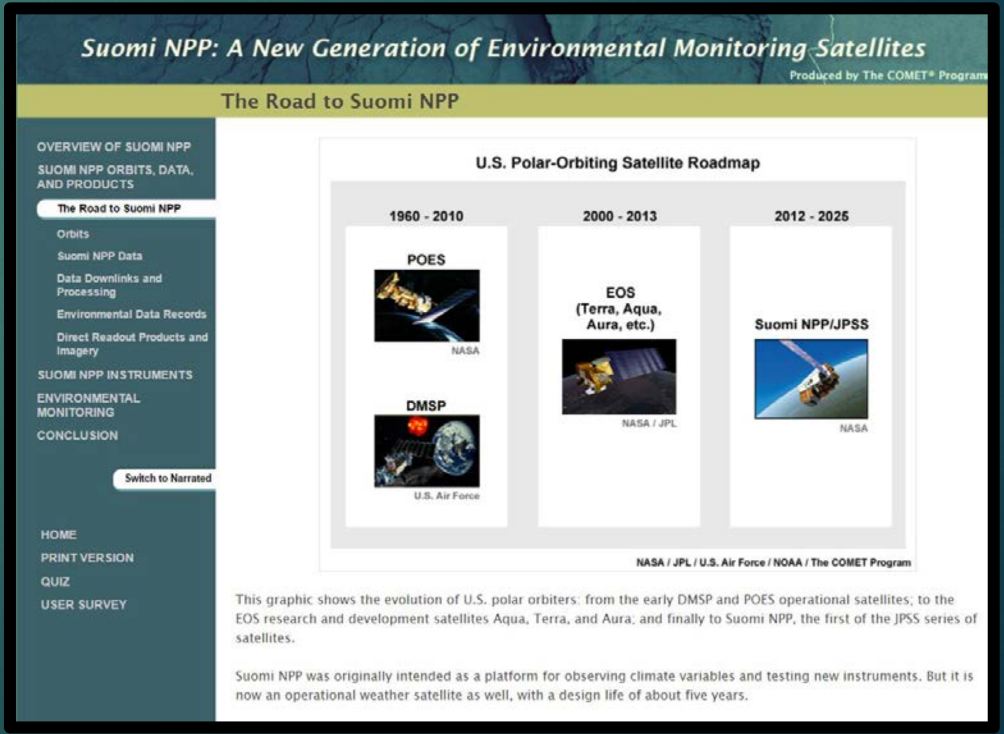
2016 STAR JPSS ANNUAL SCIENCE TEAM MEETING, 8-12 AUGUST 2016

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE (CIRA)[1]

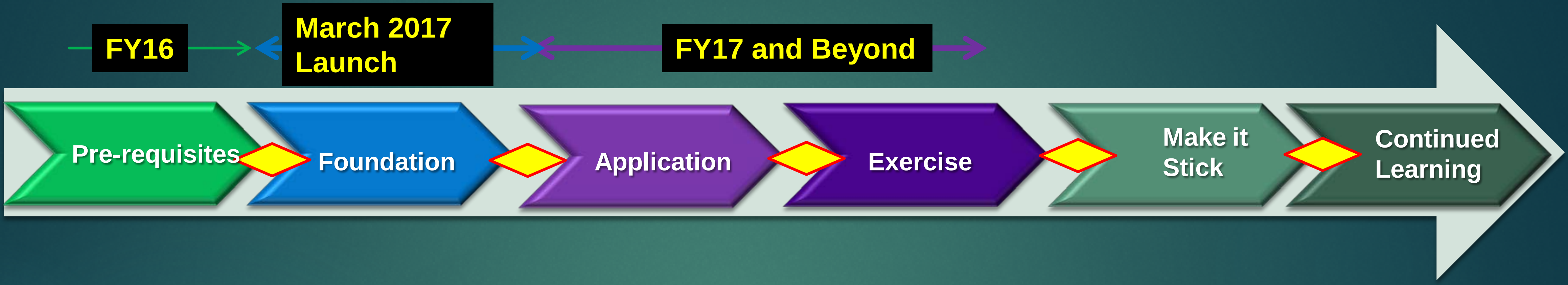
The Need for JPSS Training

- Suomi-NPP (VIIRS) was launched in October 2011 and JPSS-1 that will be launched in March 2017.
- Beneficial for NWS forecasters to utilize satellite data in their forecasts and daily operations. Key for forecasters to understand how JPSS satellite products add observational value to the forecast process.
- Awareness of Existing Training





NWS Training Guidance adapted for JPSS



- Basic Remote Sensing
- Characteristics of Satellites

- NWS-Specific development
- AVHRR vs JPSS
- Leo vs Geo
- Strengths & Weaknesses

- Forecast/ warning process
- Phenomena based
- Baseline products
- Service areas
- 10-15 minute mini-modules
- Quick Guides

- Simulations
- Local training initiatives
- “As it occurs” training
- Evolve initial satellite concept of operations

- Reference materials in AWIPS
- Repeat…practice
- Blogs
- Seasonal readiness
- Peer-to-peer sharing
- Storm-of-the month webinars
- Demonstrated performance
- O2R
- Optimize implementations for operations
- Update for evolving science
- Put in IDSS and WRN context

Slide from Office of the Chief Learning Officer (OCLO)

Future JPSS Training…

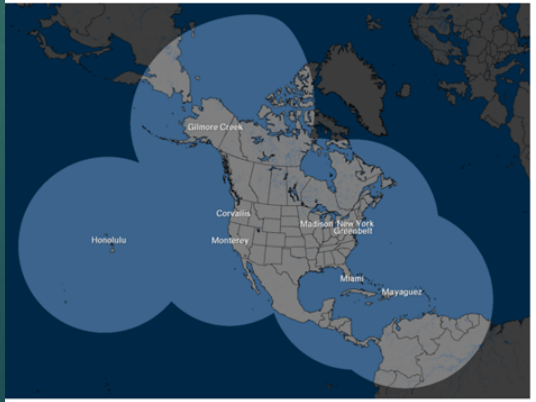
- JPSS-Formal Training Plan
  for NWS operational meteorologists
- First Draft: January 2016

  by Bill Ward and Jordan Gerth
- Combines foundational material and applications with focus on specialized/regional utilities.
- Ensure user awareness of the value of polar-orbiting satellites.

Plan for a Formal Training Program
on the
Joint Polar Satellite System (JPSS) and Global Change Observation Mission (GCOM)
for
National Weather Service Operational Meteorologists

Bill Ward and Jordan Gerth
January 2016

Preface
National Weather Service (NWS) operational meteorologists have long had access to imagery from geostationary weather satellites, and routinely use the imagery as part of their weather analysis and forecast responsibilities. A formal training program has been established to prepare forecasters for the Geostationary Operational Environmental Satellite R-Series (GOES-R) so that the NWS field offices and national centers are ready to employ the improved capabilities on “day one”. This document establishes a complementary program for the Joint Polar Satellite System (JPSS), with the first satellite of the JPSS series launching within months of GOES-R. In some ways, the need for formal training is more pressing for JPSS because the predecessor Suomi National Polar-orbiting Partnership (NPP) satellite is already operational, and providing imagery and products that will continue in the JPSS era with little change in characteristic or quality. Unlike GOES, JPSS and other polar-orbiting satellites, such as the Japan Aerospace Exploration Agency (JAXA) Global Change Observation Mission (GCOM), host instruments for remote sensing in the microwave portion of the electromagnetic spectrum. Furthermore, NOAA has made an investment in L/X-band tracking antennas to receive the direct broadcast of NPP, JPSS, and GCOM imagery, with a number of antennas outside of the contiguous United States to support space-based observations in otherwise data sparse areas. While these antennas collect data for numerical weather prediction (NWP), this imagery and derived products are also starting to find users in nearby NWS field offices.

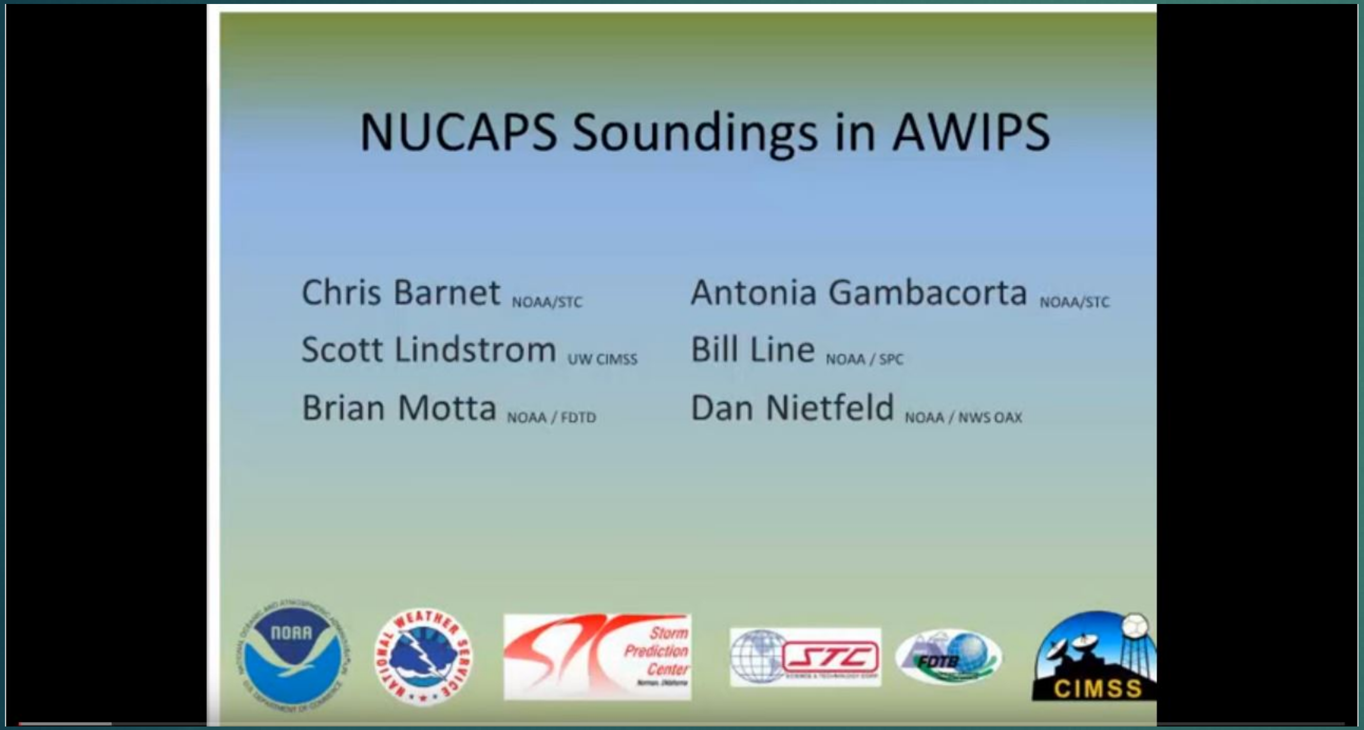


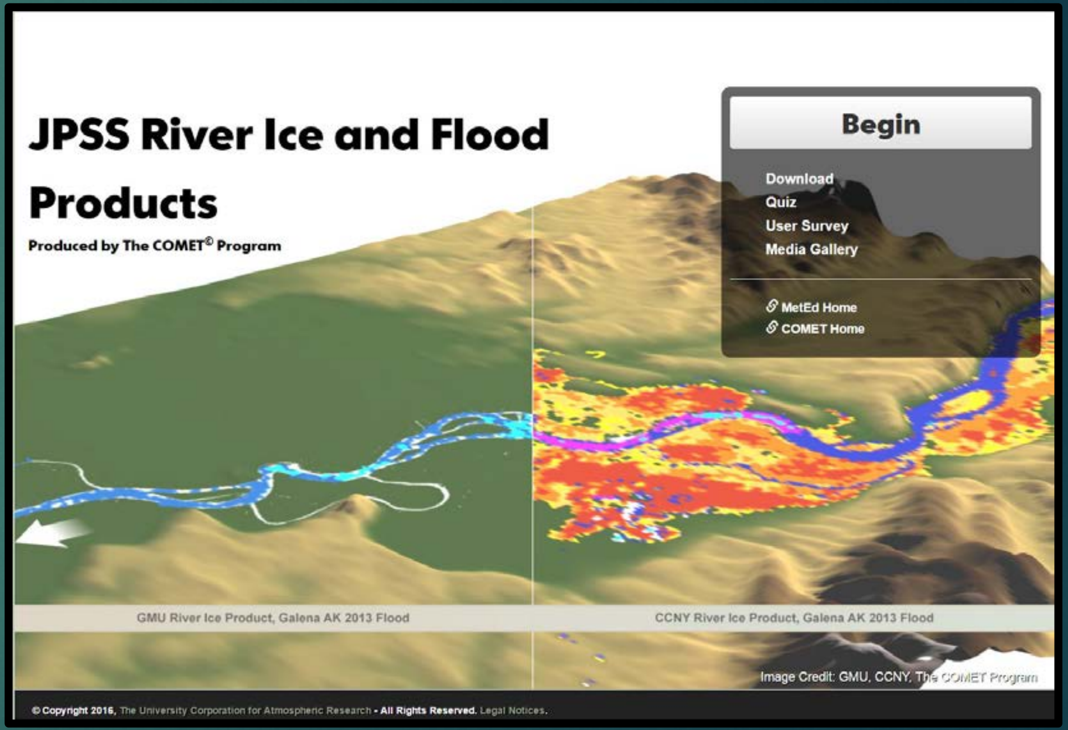
Left: The map shows locations of NOAA-supported L/X-band antennas. The planned Guam antenna is not included. Image source: University of Wisconsin Space Science and Engineering Center (SSEC) Data Center

JPSS Training Overview

Foundational Satellite Training Topic	Run Time	Material to be covered	Existing Training Resources
Introduction to Microwave Remote Sensing, sounders, review of imager.	1 hour and 20 minutes	Comparing microwave bands to infrared bands. Basics of emissivity. Active verse passive remote sensing.	Training developed from COMET, CIRA, CIMSS, GINA, NASA-SPoRT
Introducing Suomi-NPP, JPSS, GCOM	1 hour and 20 minutes	Introduction of satellites, their relative orbits, instrumentation on-board satellites and existing channels.	Training developed from COMET, CIRA, CIMSS, GINA, NASA-SPoRT
Basic Forecast Applications	1 hour and 20 minutes	DNB, NCC, NUCAPS. Uses of imagery. How polar orbiting satellites inform NWP.	Training developed from COMET, CIRA, CIMSS, GINA, NASA-SPoRT

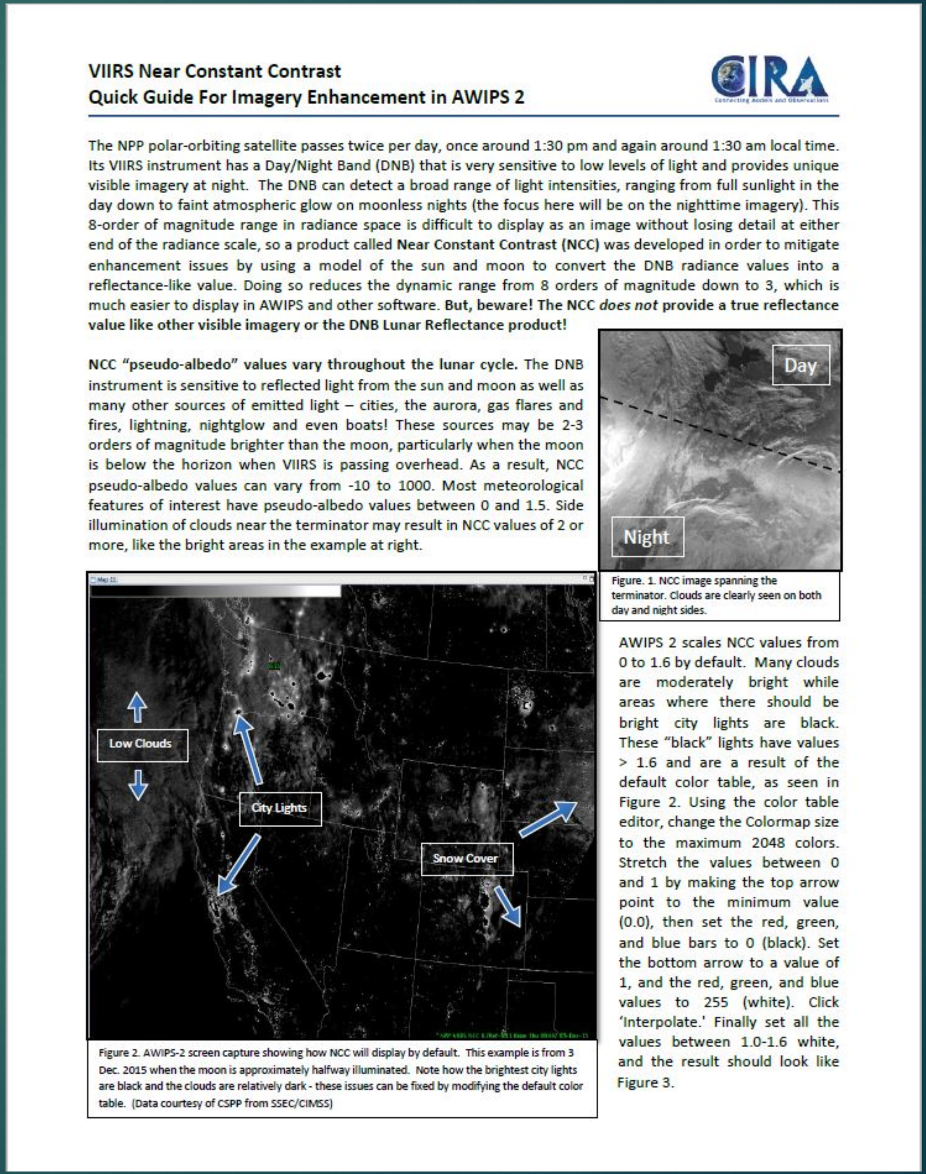
Product Applications for JPSS





Training embedded into AWIPS-II

- ‘Integrated Quick Guides in AWIPS-II’
- Collaboration with NASA SPoRT
- Put in existing quick guides or new quick guides.
- Link to [Quick Guide for Imagery Enhancement in AWIPS-II]().



VIIRS Near Constant Contrast
Quick Guide For Imagery Enhancement in AWIPS 2

The NPP polar-orbiting satellite passes twice per day, once around 1:30 pm and again around 1:30 am local time. Its VIIRS instrument has a Day/Night Band (DNB) that is very sensitive to low levels of light and provides unique visible imagery at night. The DNB can detect a broad range of light intensities, ranging from full sunlight in the day down to faint atmospheric glow on moonless nights (the focus here will be on the nighttime imagery). This 8-order of magnitude range in radiance space is difficult to display as an image without losing detail at either end of the radiance scale, so a product called **Near Constant Contrast (NCC)** was developed in order to mitigate enhancement issues by using a model of the sun and moon to convert the DNB radiance values into a reflectance-like value. Doing so reduces the dynamic range from 8 orders of magnitude down to 3, which is much easier to display in AWIPS and other software. **But, beware! The NCC *does not* provide a true reflectance value like other visible imagery or the DNB Lunar Reflectance product!**

NCC “pseudo-albedo” values vary throughout the lunar cycle. The DNB instrument is sensitive to reflected light from the sun and moon as well as many other sources of emitted light – cities, the aurora, gas flares and fires, lightning, nightglow and even boats! These sources may be 2-3 orders of magnitude brighter than the moon, particularly when the moon is below the horizon when VIIRS is passing overhead. As a result, NCC pseudo-albedo values can vary from -10 to 1000. Most meteorological features of interest have pseudo-albedo values between 0 and 1.5. Side illumination of clouds near the terminator may result in NCC values of 2 or more, like the bright areas in the example at right.

Day
Night

Figure. 1. NCC image spanning the terminator. Clouds are clearly seen on both day and night sides.

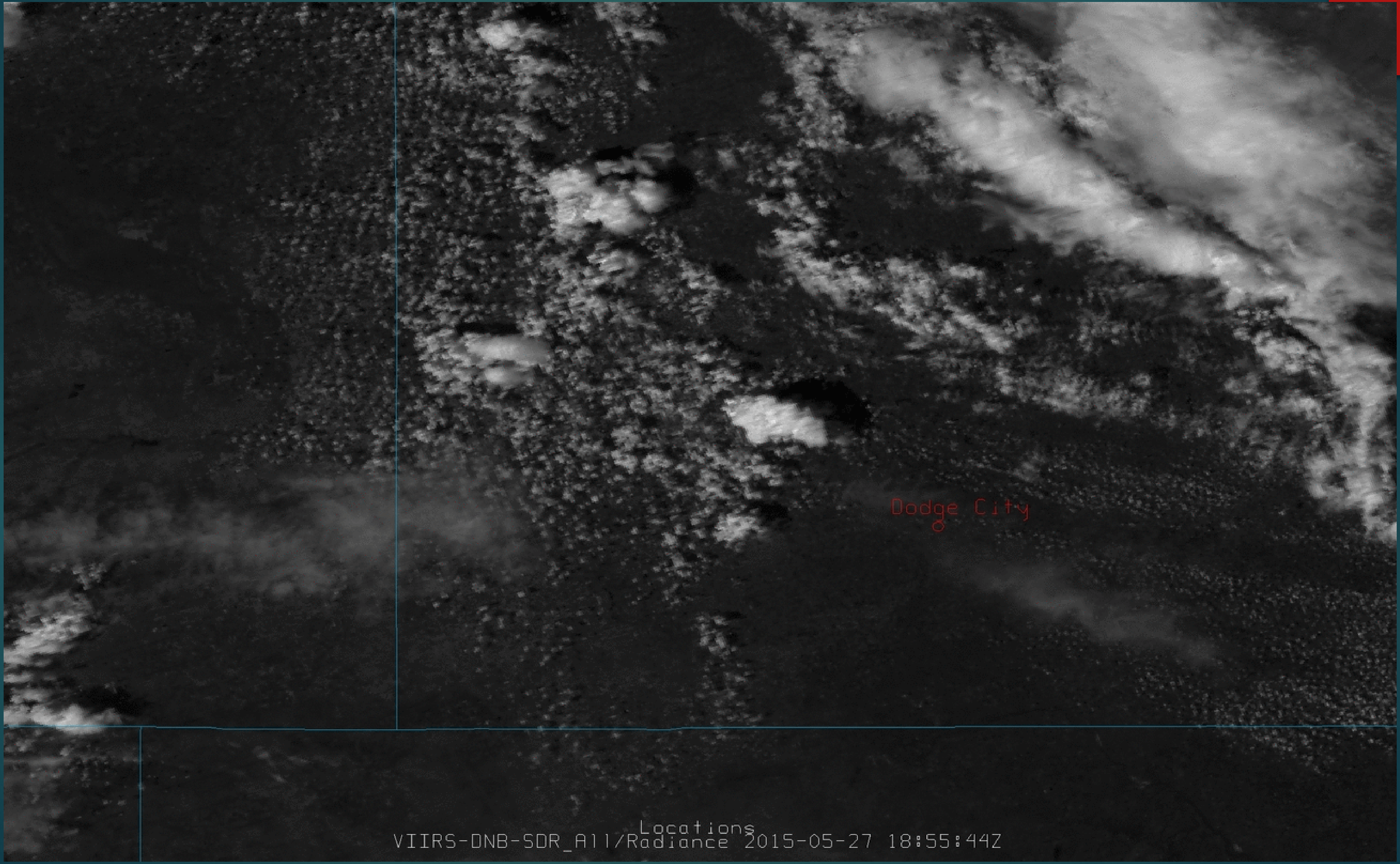
Low Clouds
City Lights
Snow Cover

Figure 2. AWIPS-2 screen capture showing how NCC will display by default. This example is from 3 Dec. 2015 when the moon is approximately halfway illuminated. Note how the brightest city lights are black and the clouds are relatively dark - these issues can be fixed by modifying the default color table. (Data courtesy of CSPP from SSEC/CIMSS)

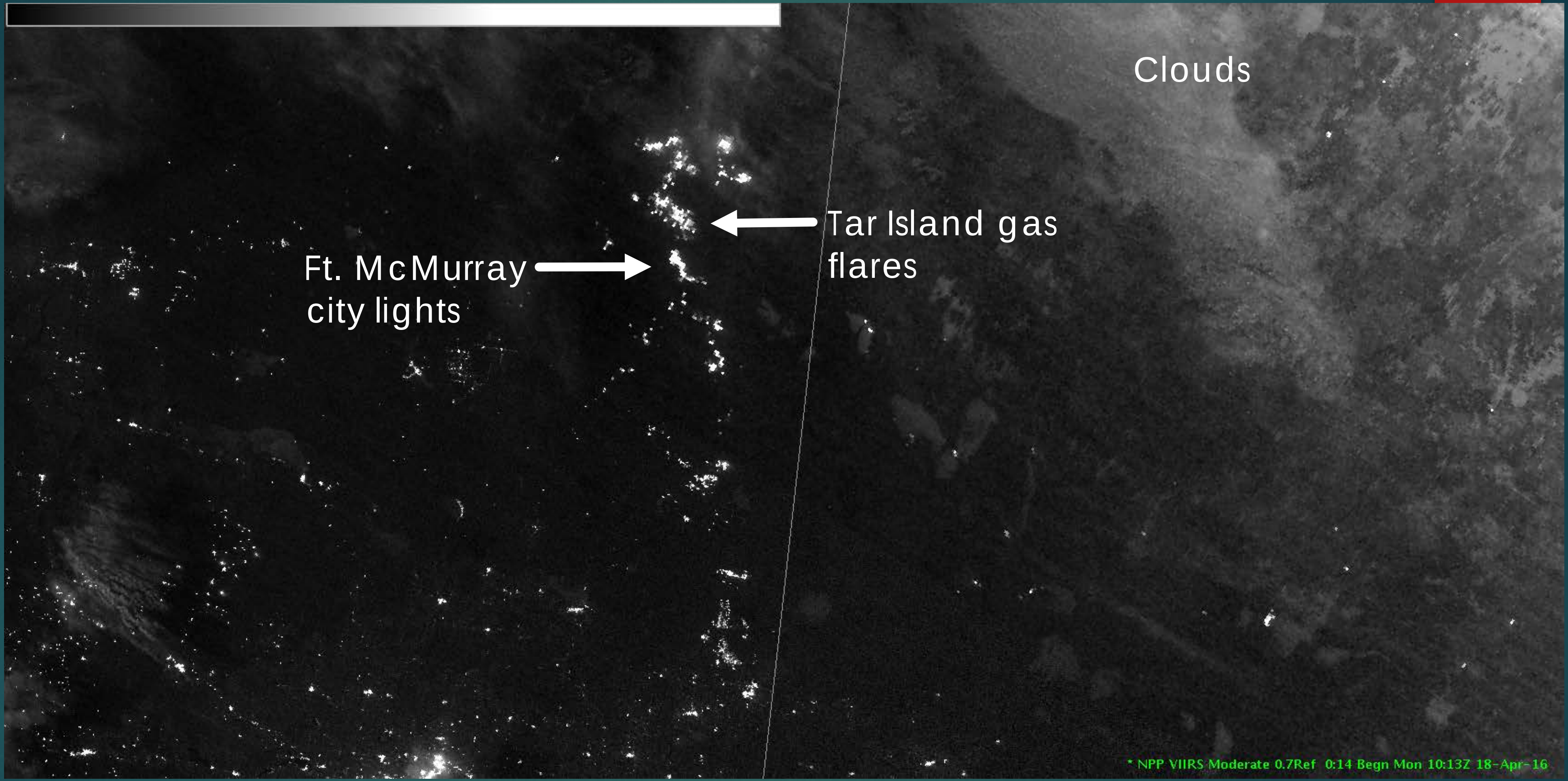
AWIPS 2 scales NCC values from 0 to 1.6 by default. Many clouds are moderately bright while areas where there should be bright city lights are black. These “black” lights have values > 1.6 and are a result of the default color table, as seen in Figure 2. Using the color table editor, change the Colormap size to the maximum 2048 colors. Stretch the values between 0 and 1 by making the top arrow point to the minimum value (0.0), then set the red, green, and blue bars to 0 (black). Set the bottom arrow to a value of 1, and the red, green, and blue values to 255 (white). Click ‘Interpolate.’ Finally set all the values between 1.0-1.6 white, and the result should look like Figure 3.

Training Examples

27 May 2015 @ 2032Z, Dodge City, KS Outbreak



NCC Imagery - Before the fire

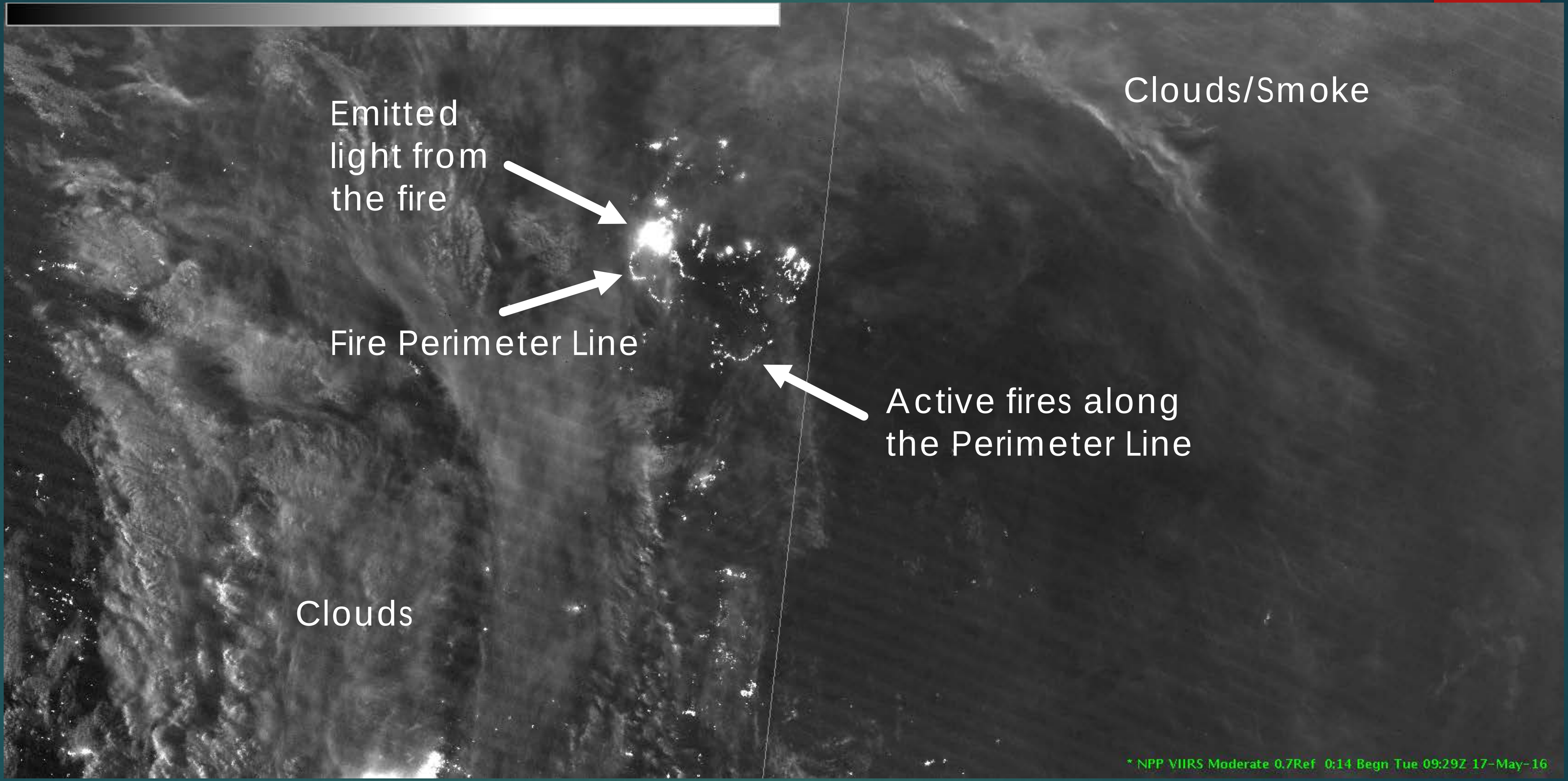


Alberta, Canada

Saskatchewan, Canada

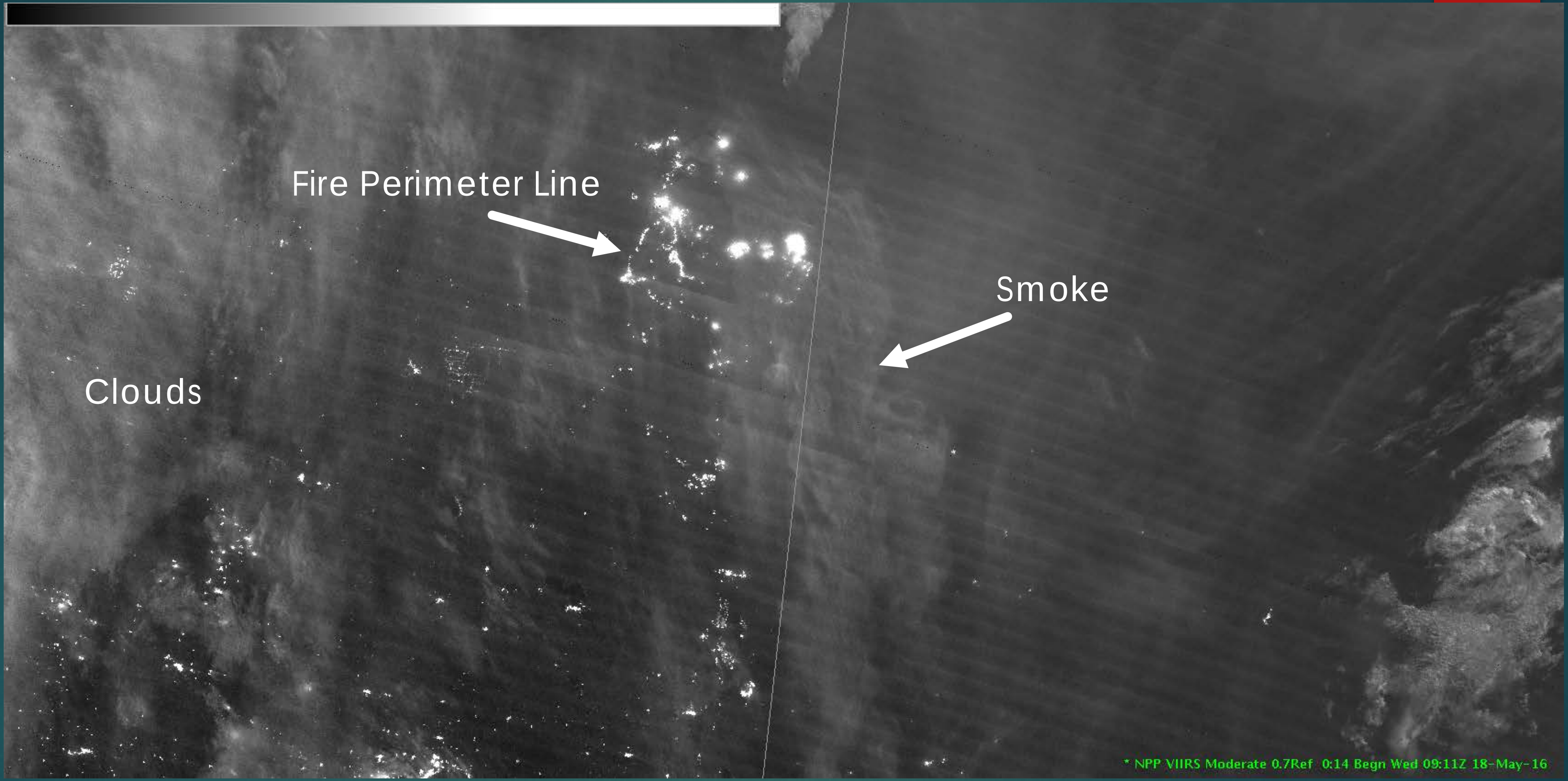
Border between Canadian Provinces

NCC imagery of Ft. McMurray wildfire – 17 May at 0930 UTC

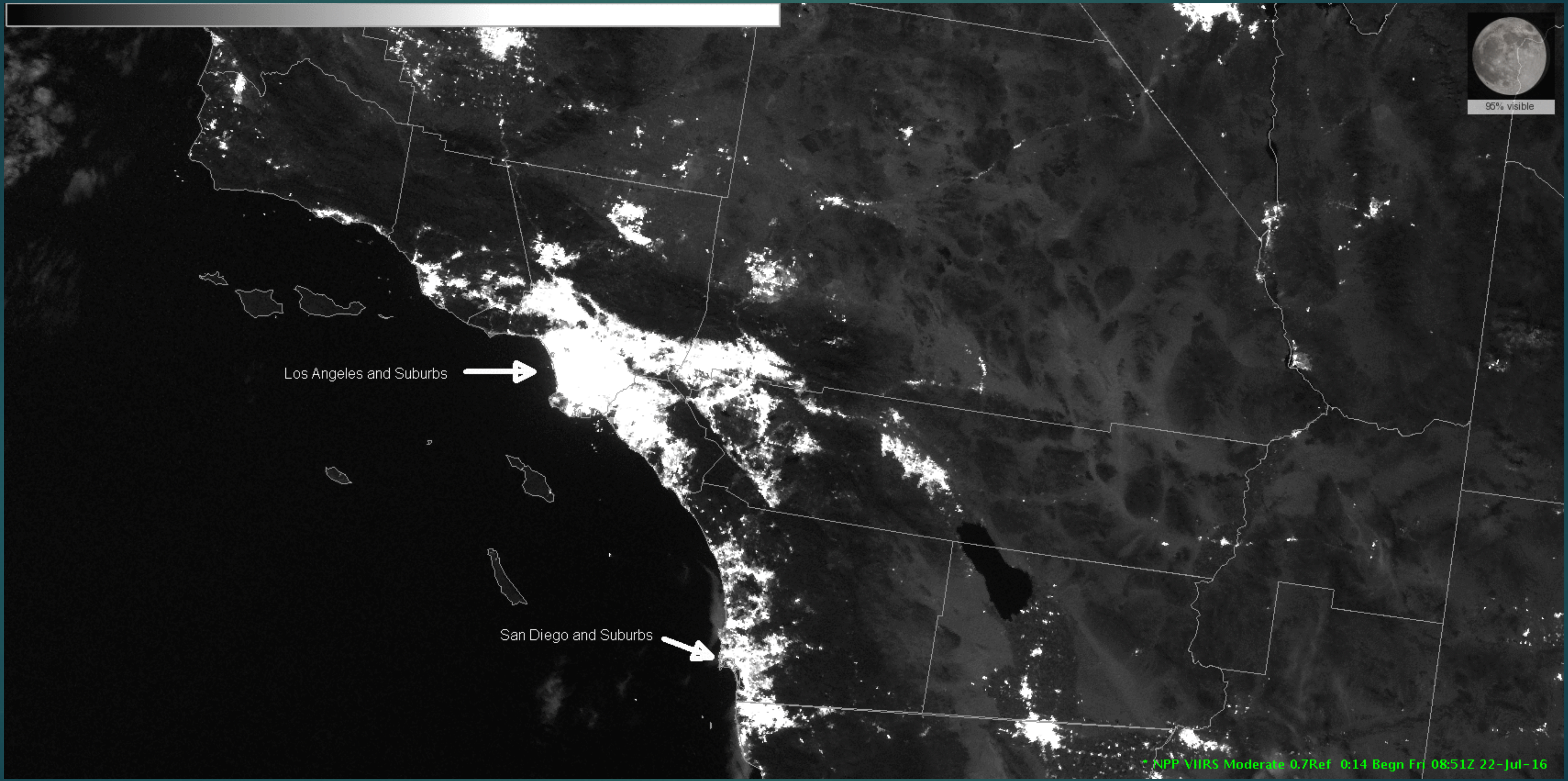


Switch back and forth between the previous slide and this one to see the "new" light sources – these are from actively burning areas

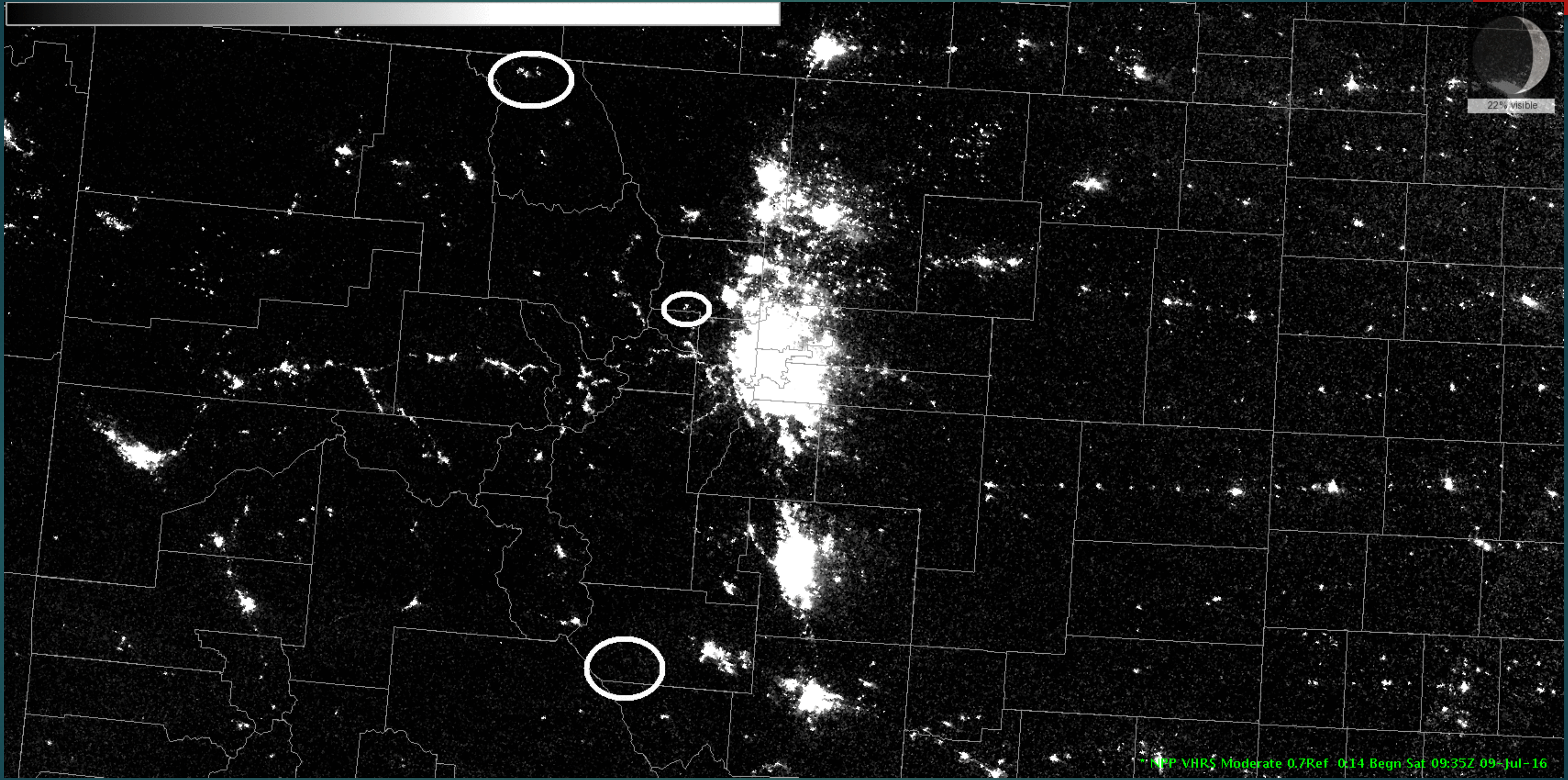
NCC IMAGERY OF FT. MCMURRAY WILDFIRE – 18 MAY AT 0915 UTC



NCC: SAND FIRE, CALIFORNIA

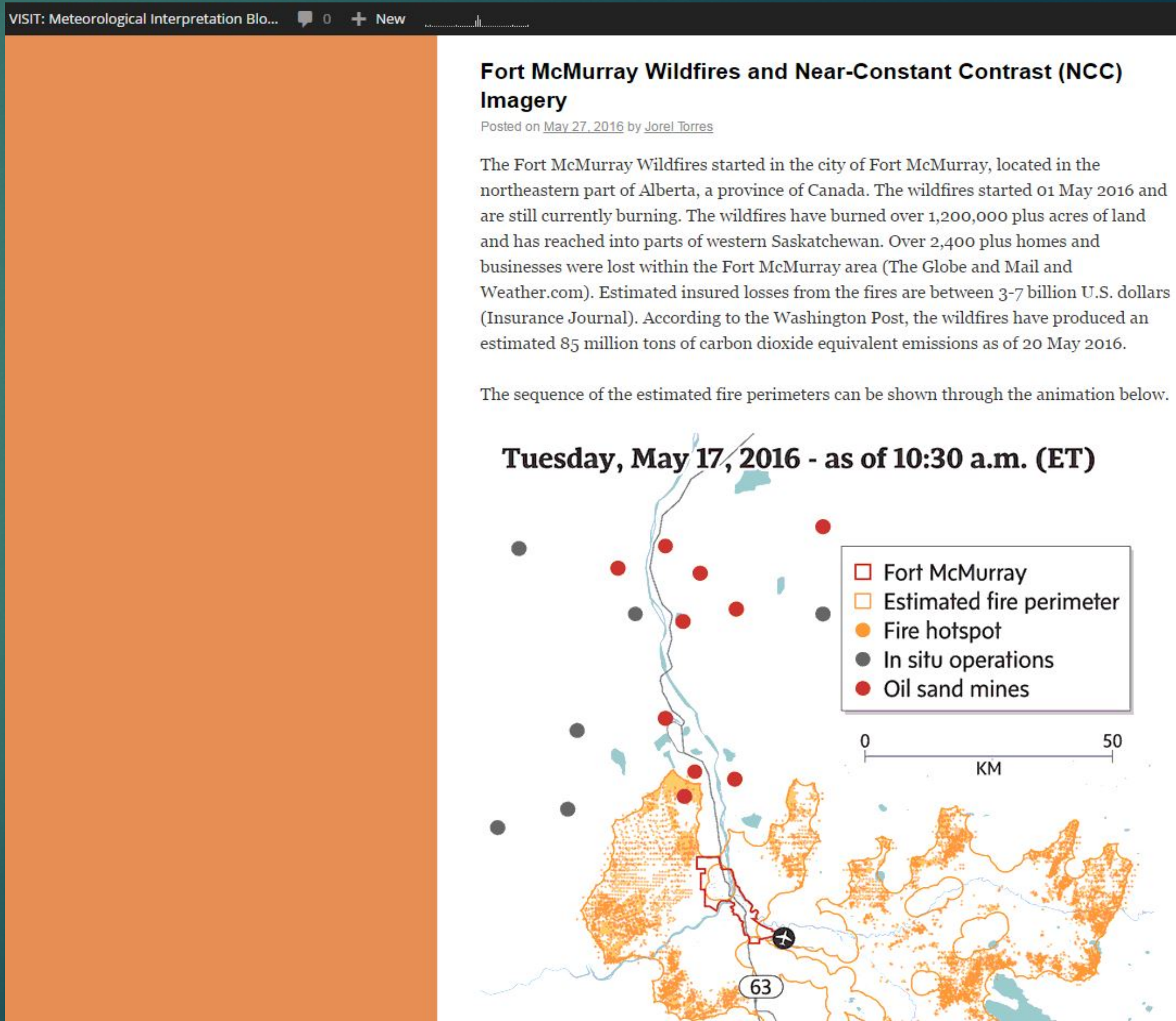


NCC: COLORADO FIRES



Virtual Institute for Satellite Integration Training (VISIT) Blogs

- http://rammb.cira.colostate.edu/training/visit/
- New VISIT Blogs:
  - NCC Imagery, Colorado Fires in July
  - 19 June 2016-Present: Beaver Creek Fire, Jackson County, Colorado
  - NUCAPS, Part One: Introduction
  - NUCAPS, Part Two: Field Campaign and Observations
  - Fort McMurray Wildfires and Near-Constant Contrast (NCC) Imagery
  - Synthetic Imagery from the NAM Alaska Nest 4 km


VISIT: Meteorological Interpretation Blo... 0 New

Fort McMurray Wildfires and Near-Constant Contrast (NCC) Imagery

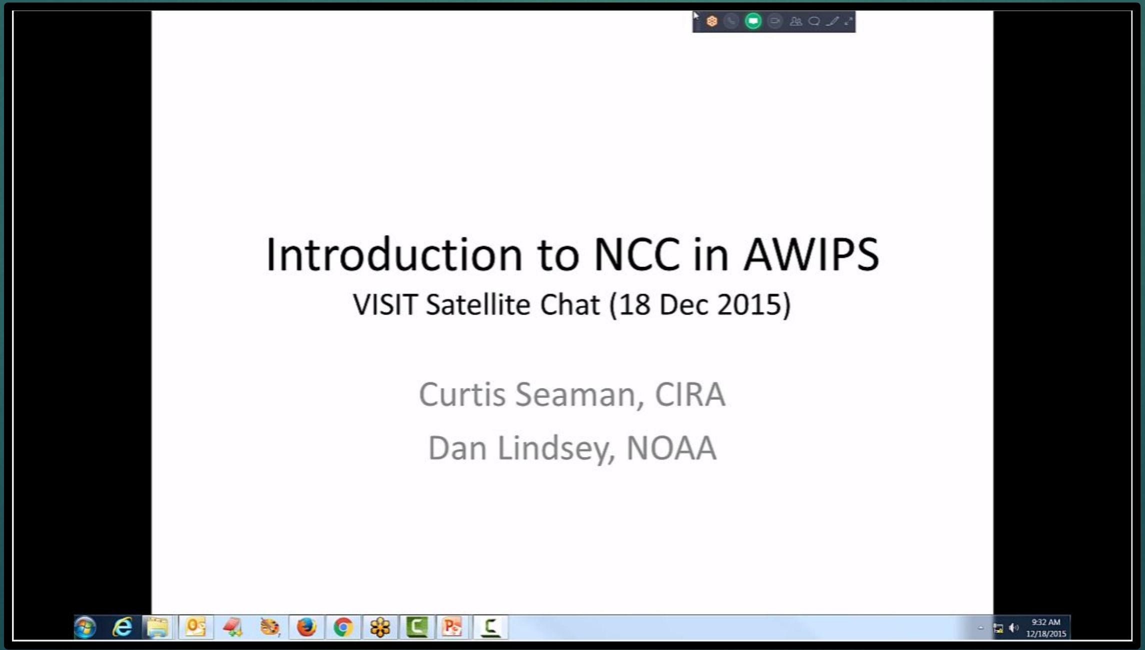
Posted on May 27, 2016 by Jorel Torres

The Fort McMurray Wildfires started in the city of Fort McMurray, located in the northeastern part of Alberta, a province of Canada. The wildfires started 01 May 2016 and are still currently burning. The wildfires have burned over 1,200,000 plus acres of land and has reached into parts of western Saskatchewan. Over 2,400 plus homes and businesses were lost within the Fort McMurray area (The Globe and Mail and Weather.com). Estimated insured losses from the fires are between 3-7 billion U.S. dollars (Insurance Journal). According to the Washington Post, the wildfires have produced an estimated 85 million tons of carbon dioxide equivalent emissions as of 20 May 2016.

The sequence of the estimated fire perimeters can be shown through the animation below.

Future Goals

- Quick Guides of individual bands, JPSS products in AWIPS-II.
- Expand on existing training and start JPSS training.
- Highlight Uniqueness of JPSS Products.
- Interact with the STAT team and other trainers in Boulder (early September).
- Get ready for JPSS-1 launch.



Questions???

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NRL-MRY SNPP Satellite Product Support

Kim Richardson[1], Richard Bankert[1], Steve Miller[2], Arunas Kuciauskas[1], Mindy Surratt[1]

1 Naval Research Laboratory

2 CIRA

Current Satellite Suite

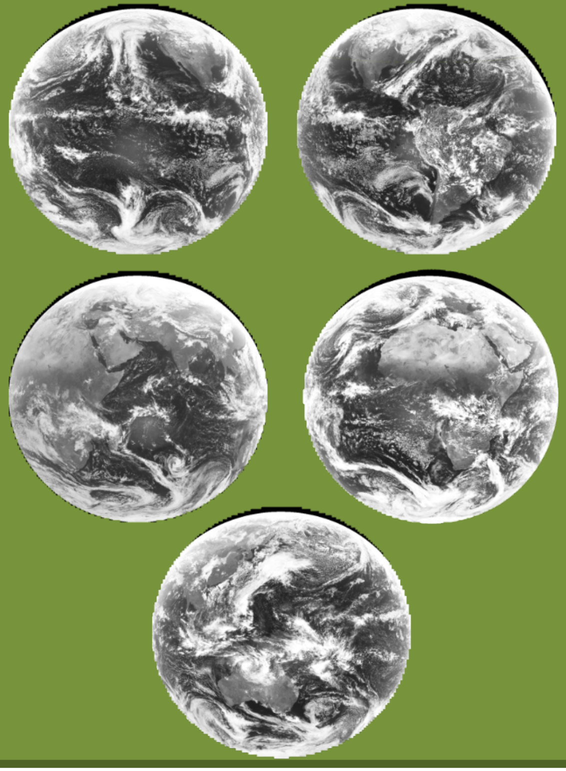
Sensor Suite: Total Sensors: 39

Polar Orbiting Sensors: 34

IR/Vis Imagers:	NOAA	- AVHRR (4)
	METOP	- AVHRR (2)
	DMSP	- OLS (4)
	NASA	- MODIS (2)
	NOAA	- VIIRS
Microwave Imagers:	DMSP	- SSM/I , SSMIS (3)
	NASA	- AMSR2, GMI
	NRL	- WindSat
Micro Sounders:	NOAA	- AMSU (2), MHS (2), ATMS
	METOP	- AMSU (2)
Microwave Radar:	NASA	- GPM, CloudSat
	Foreign	- ASCAT (2), ScatSat

Collaborations: FNMOC, 557WW, NASA, NOAA, CIRA

Geo Sensors: 5



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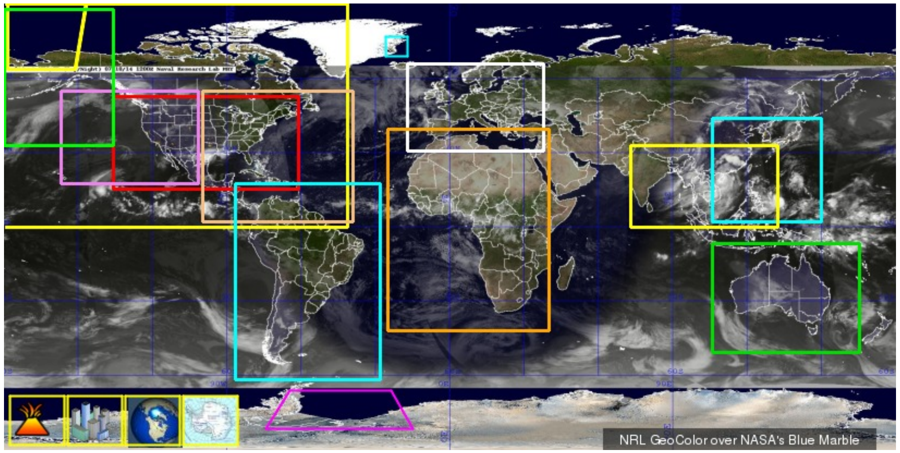
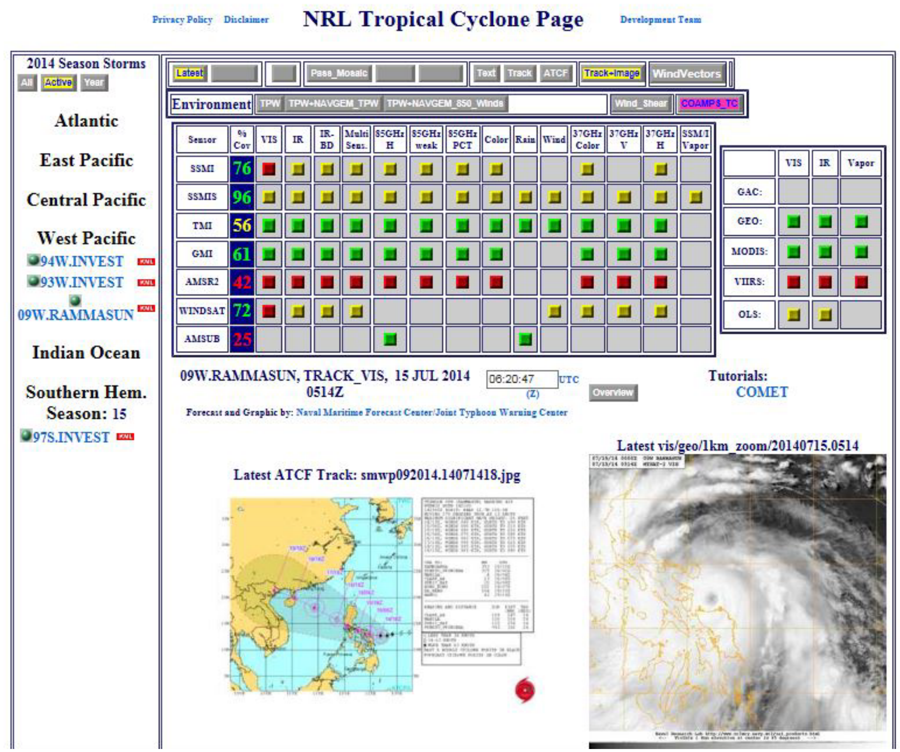
Satellite Meteorological Applications

NexSat



- Over 100k images per day
- 3M+ kml per day
- Digital data products including rain rates, cloud types, etc.
- Used by NWS, NHC, JTWC, etc.

TCWeb



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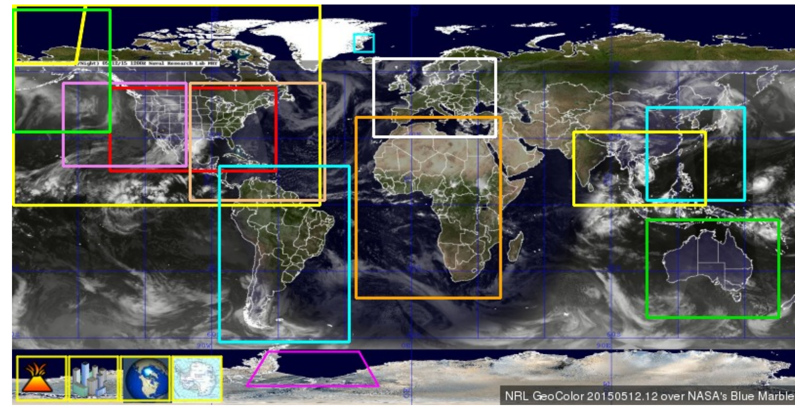
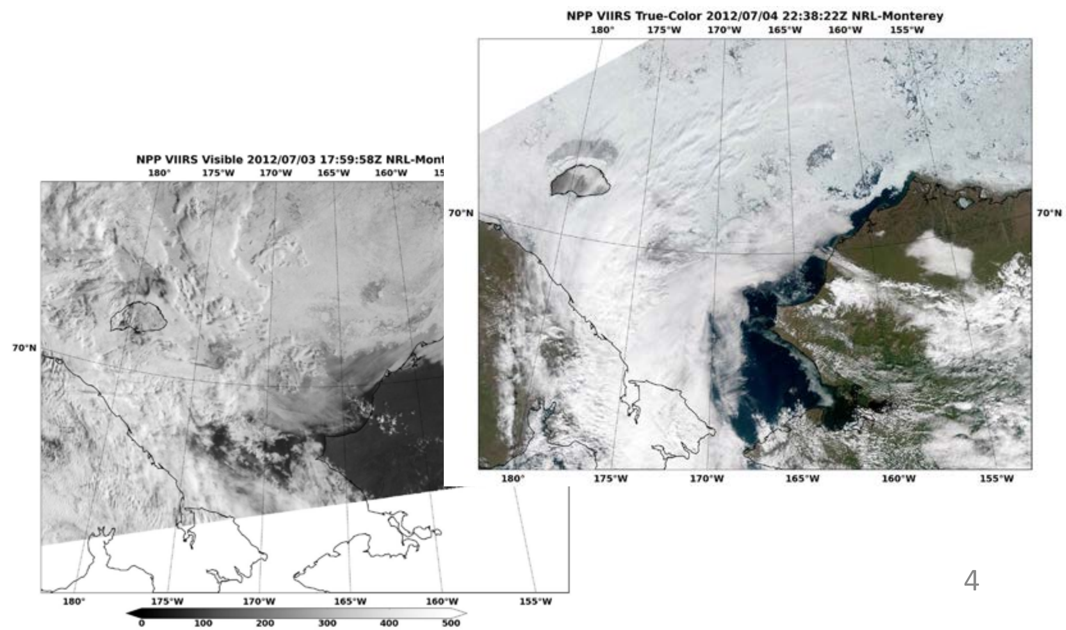
Current IR/Vis Arctic Imagery Support

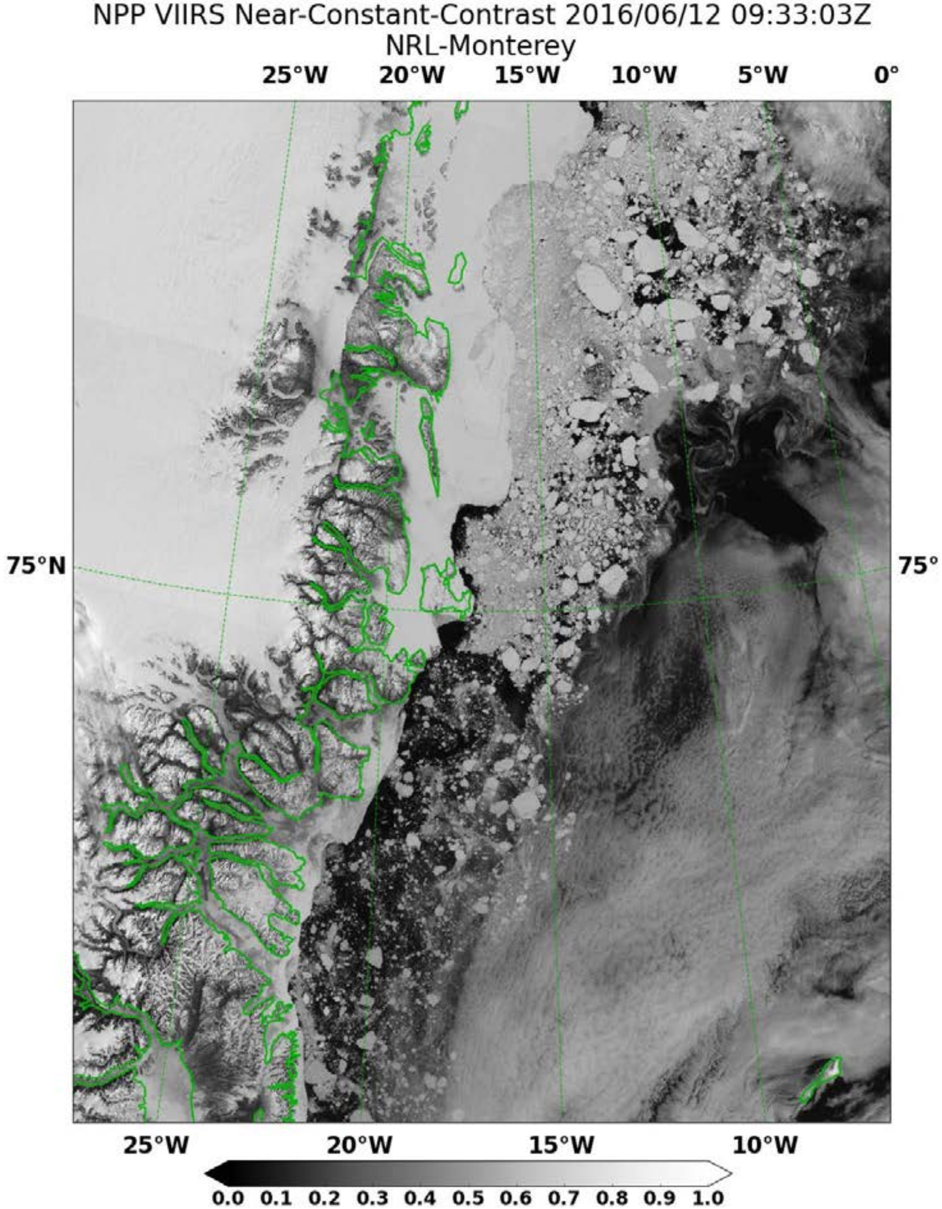
- Imagery available in 1-3 hours.
- Currently includes VIIRS, MODIS, and AVHRR data for six Antarctic and five Arctic sectors.



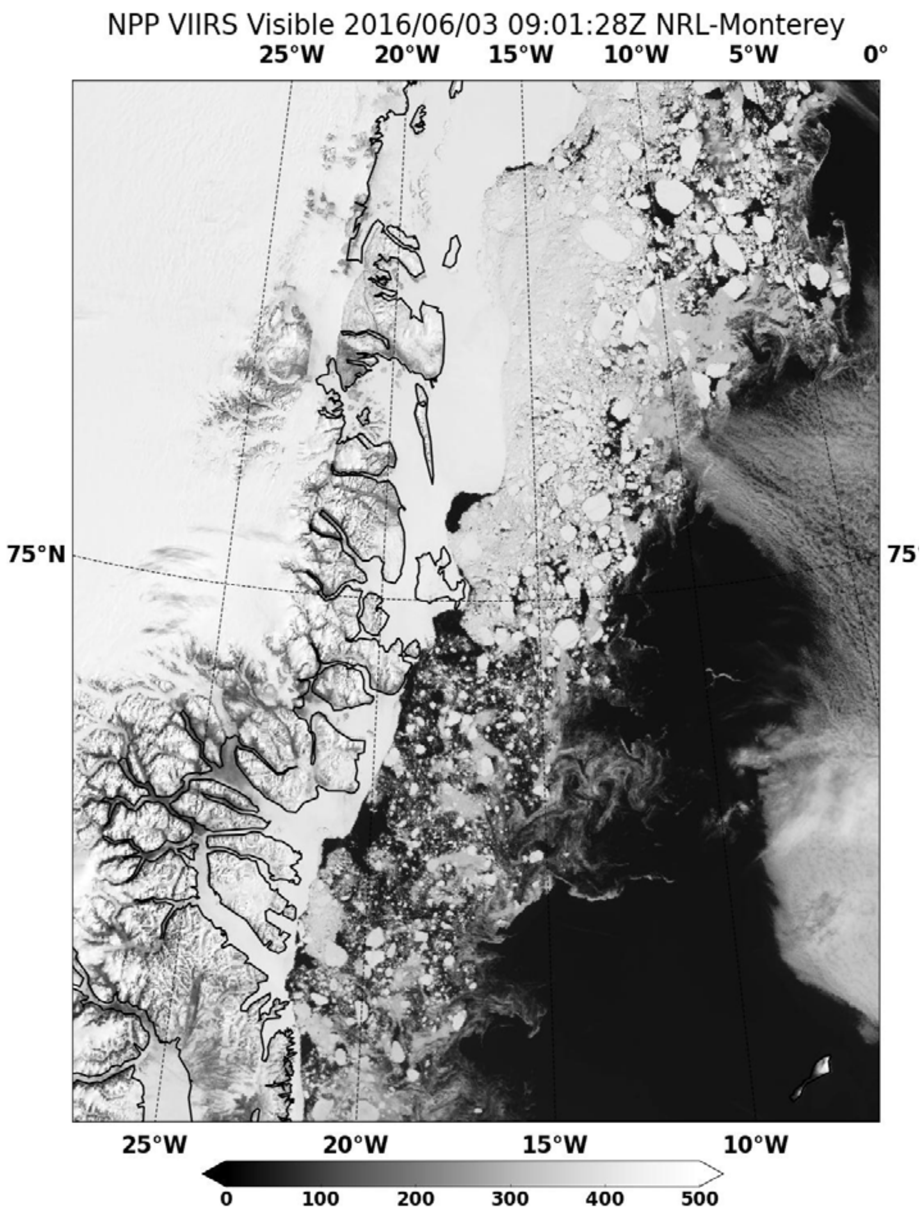
- Products include:
  - Visible
  - Infrared
  - True-Color
  - Day/Night Band
  - IR/Vis RGB

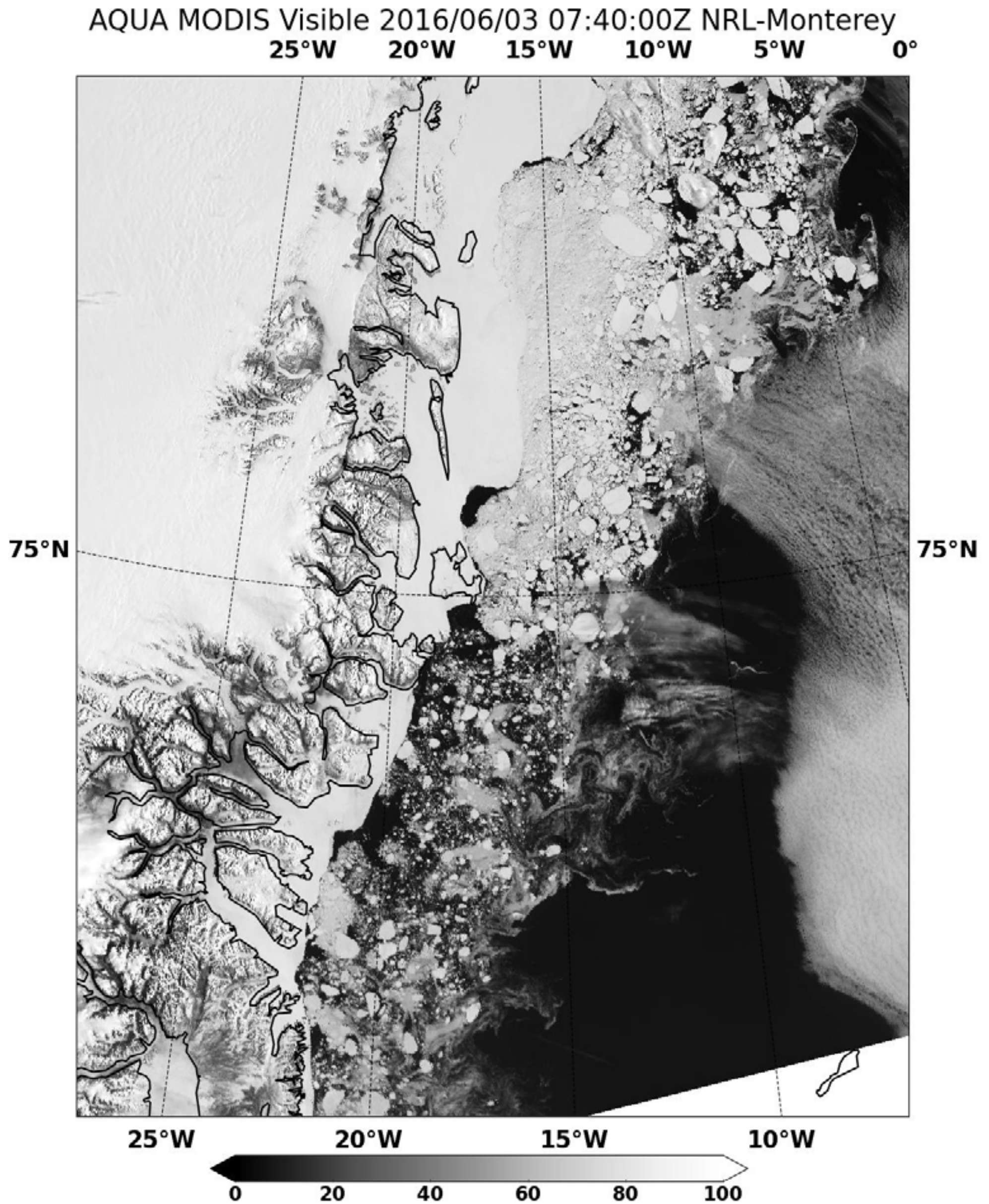


Arctic Imagery Support

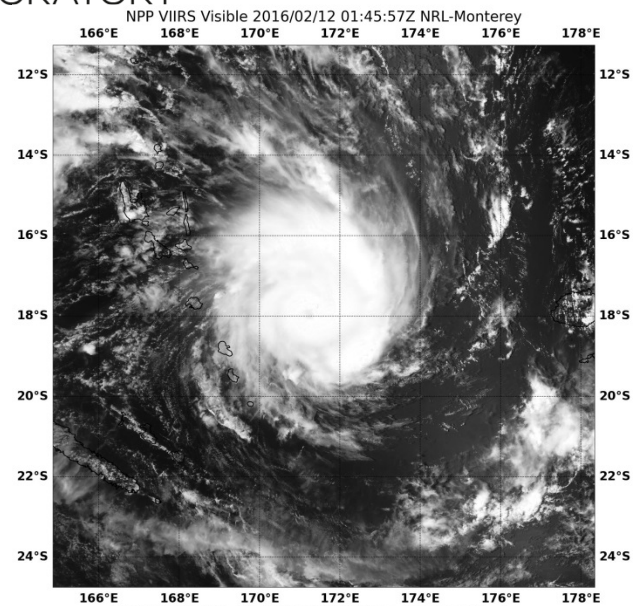


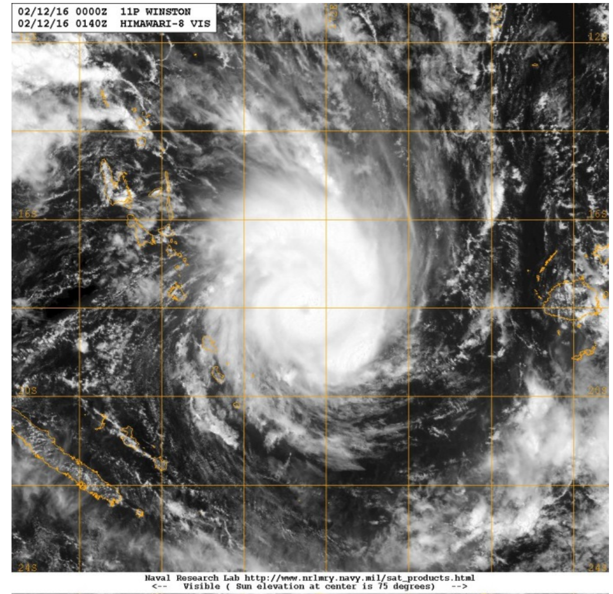
Arctic Imagery Support

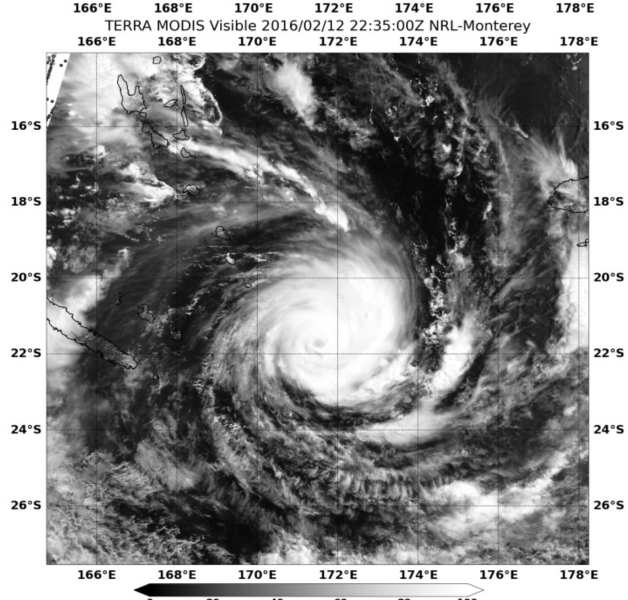


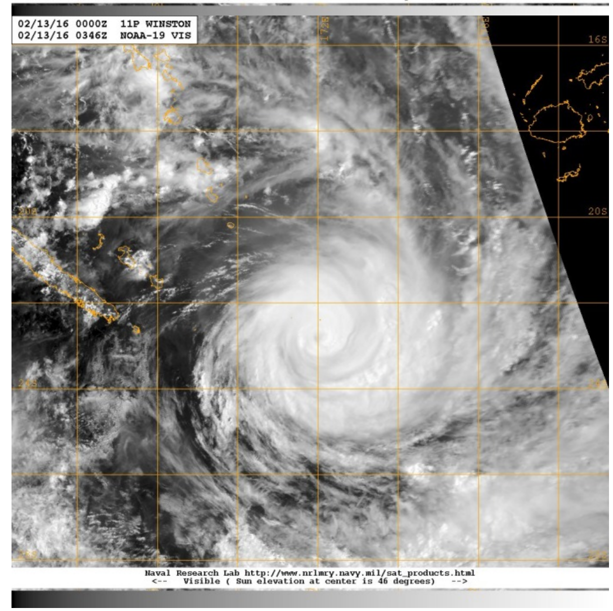


Tropical cyclone support









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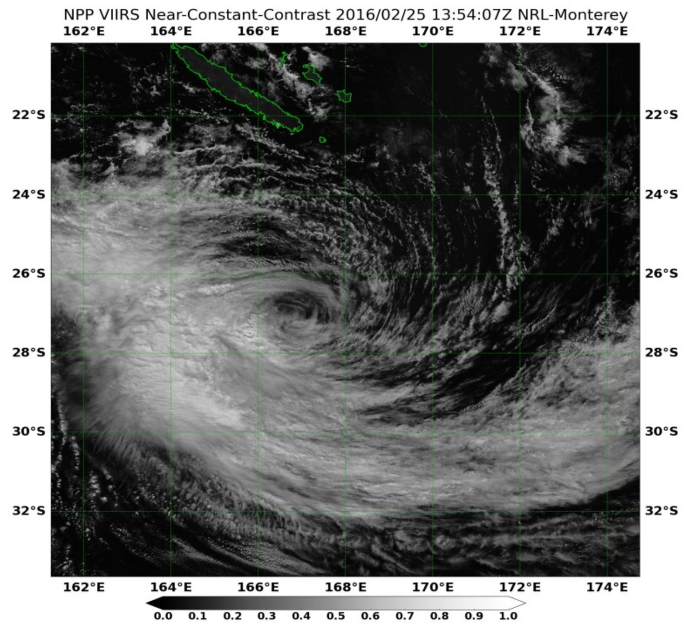
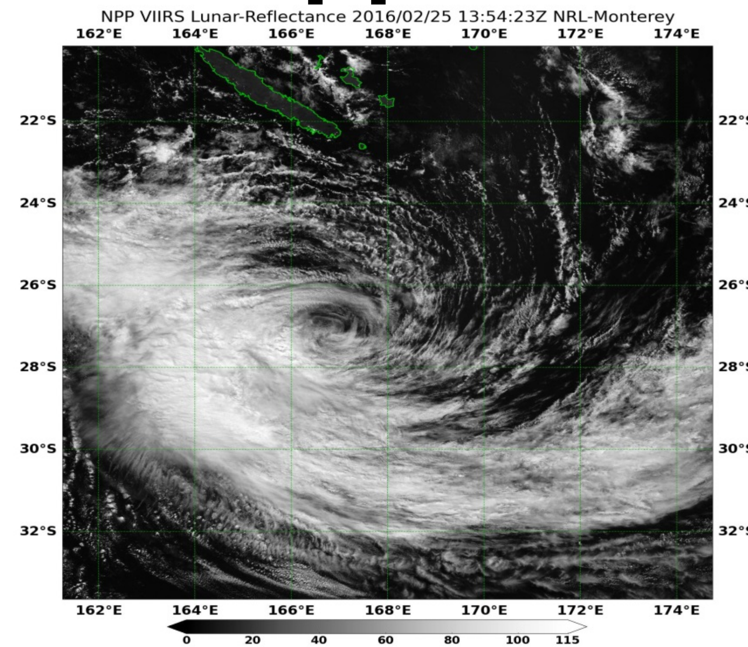
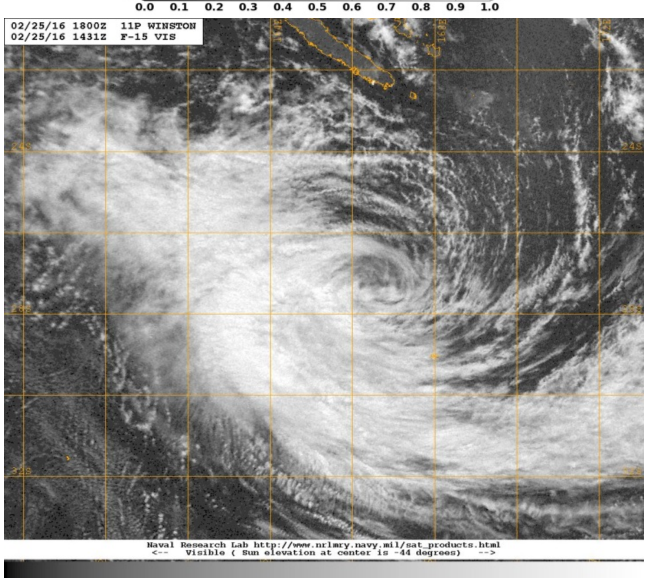
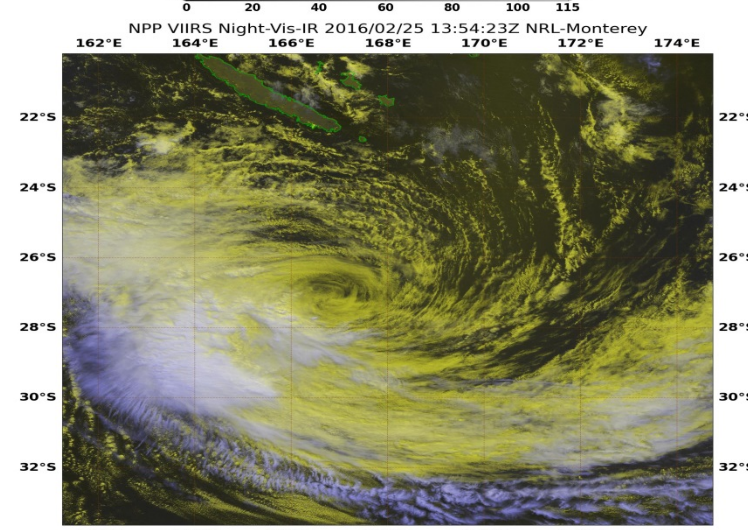
Tropical cyclone support

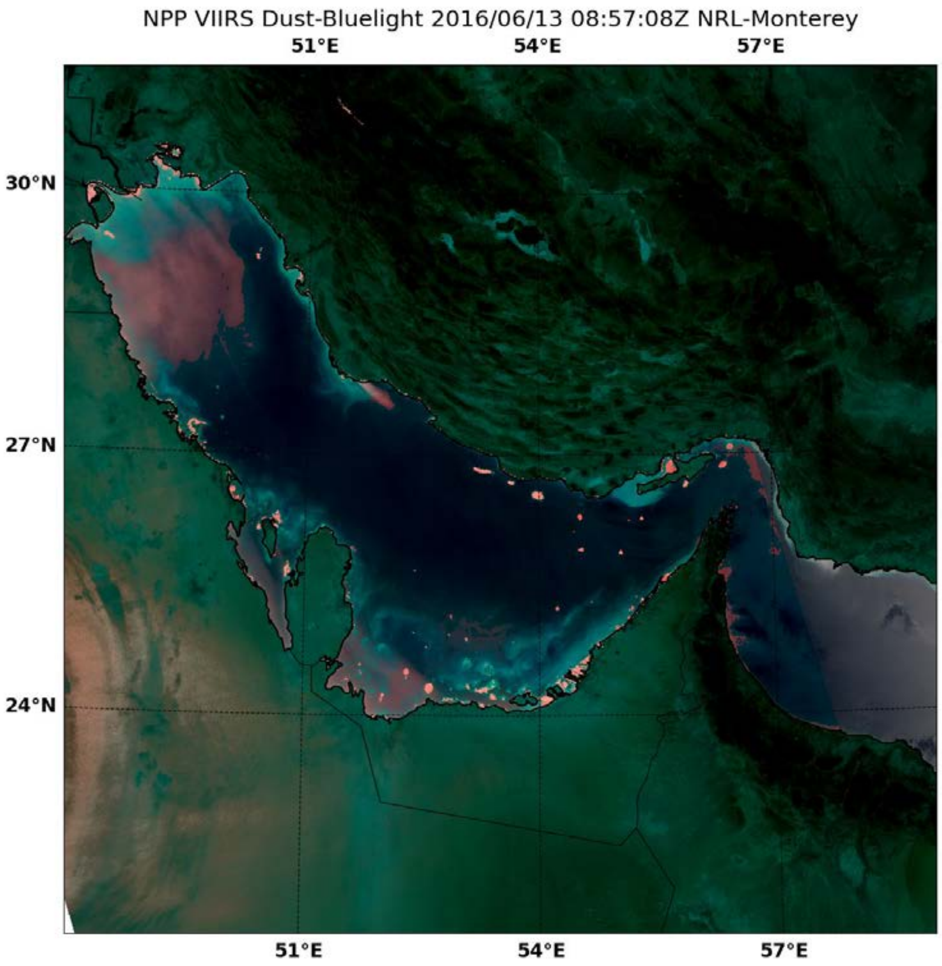


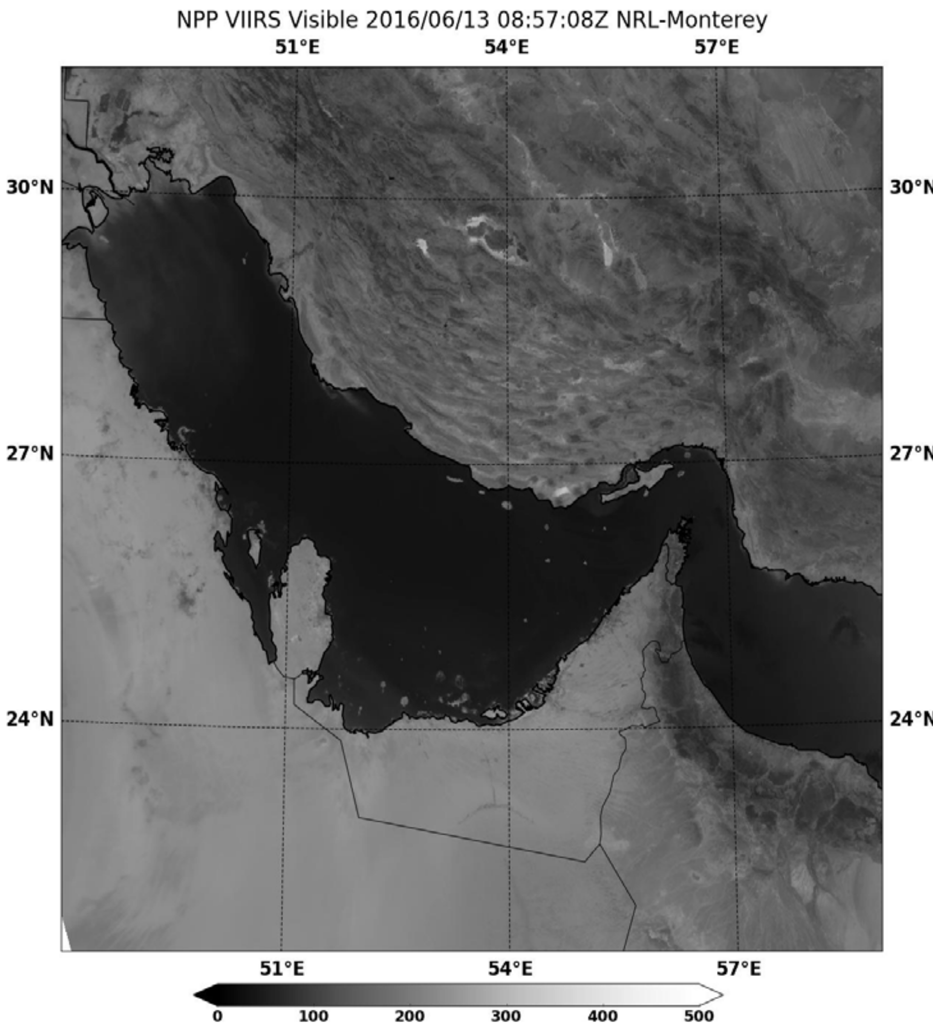






Dust product support





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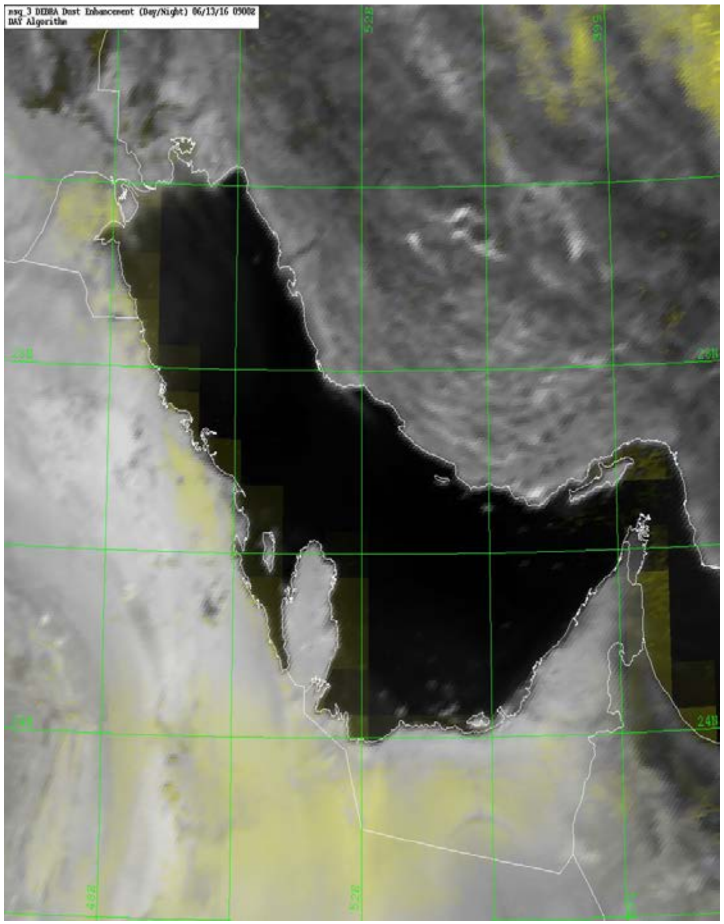
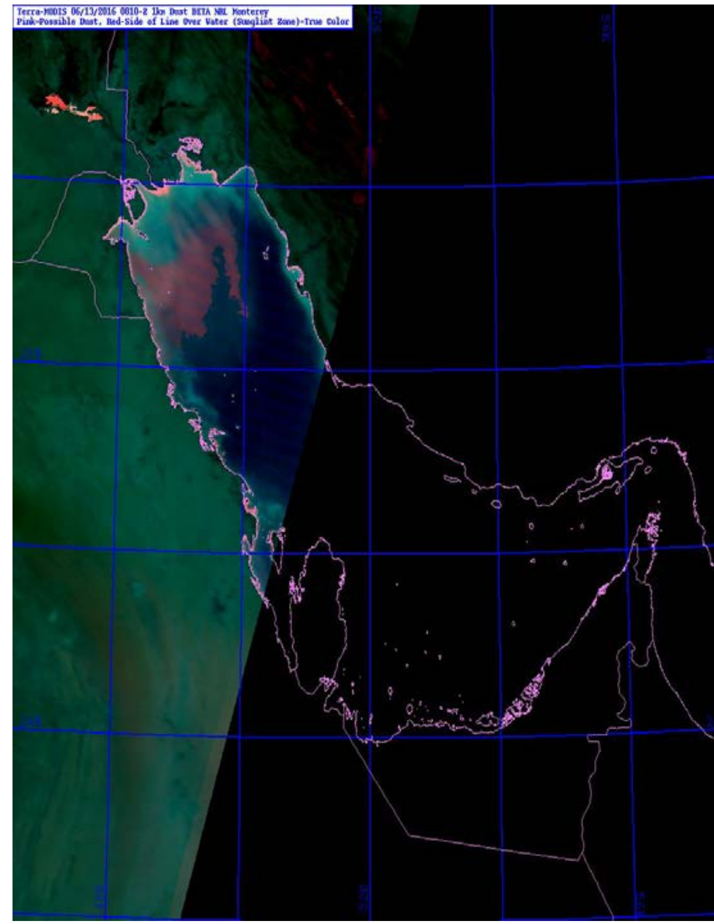
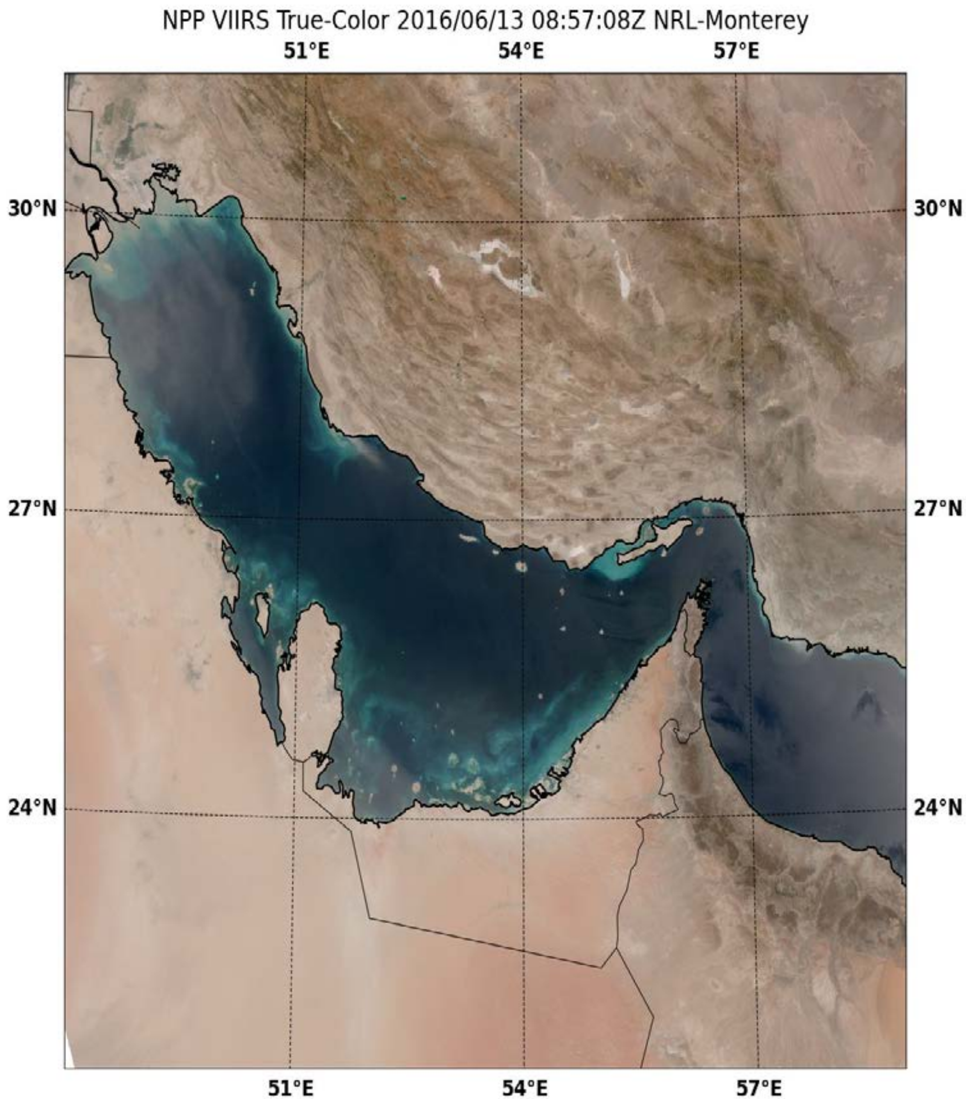
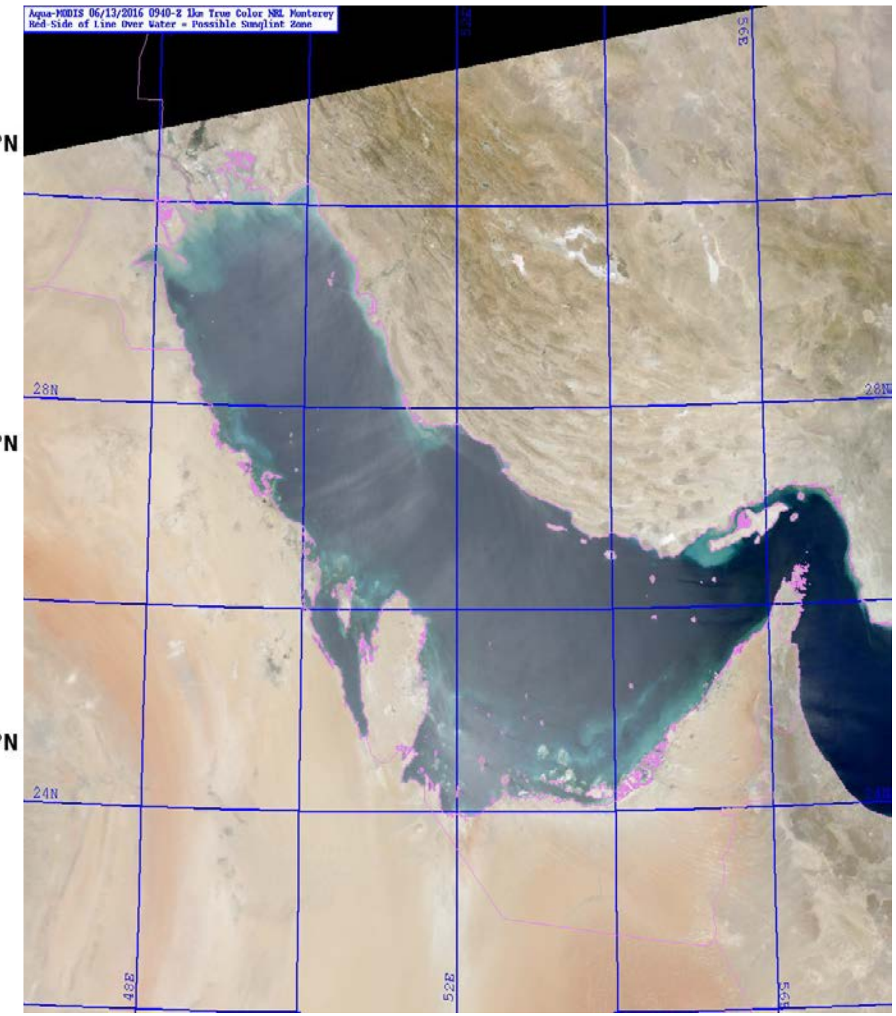
Dust product support





Dust product support



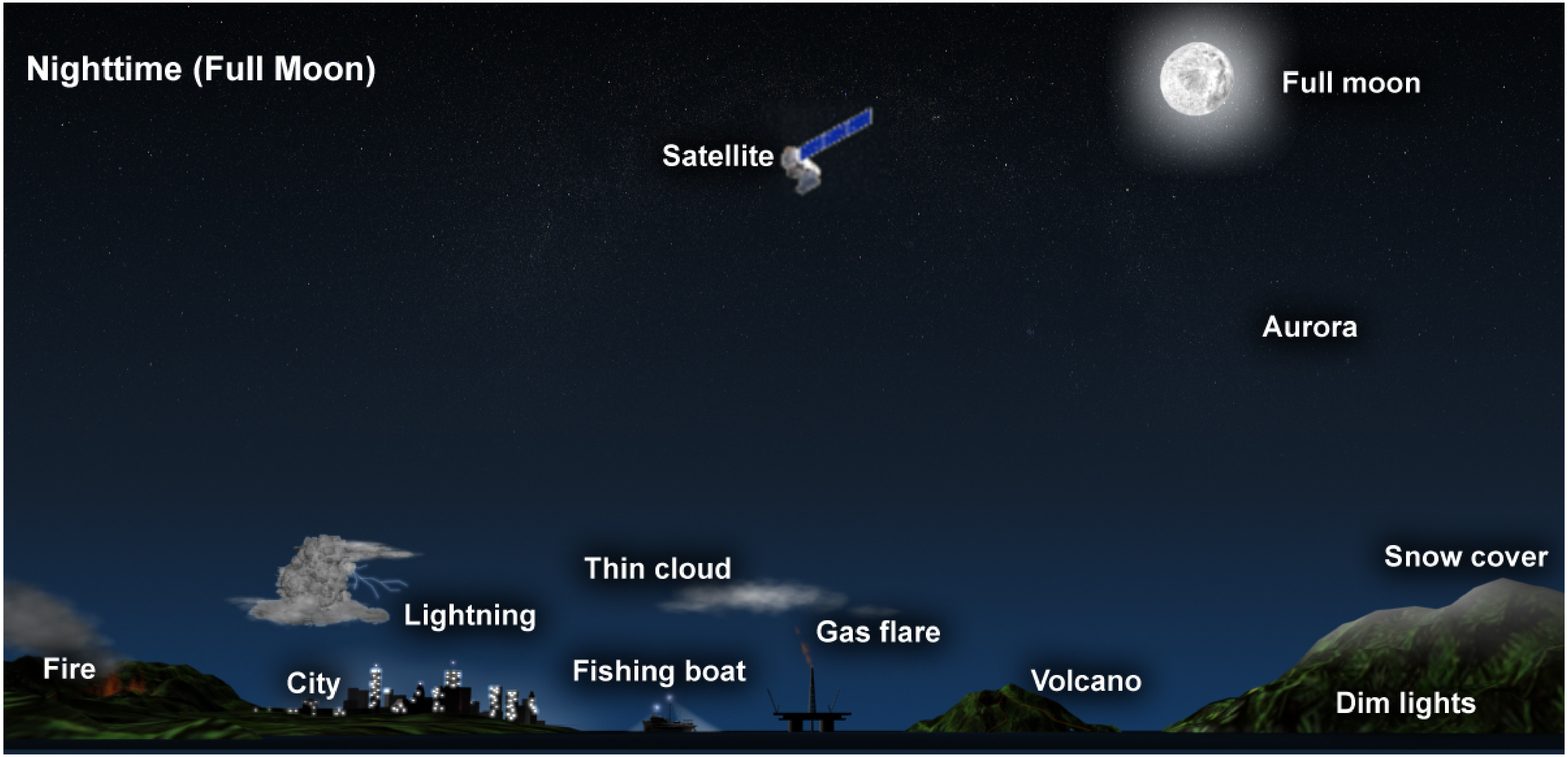


Nighttime Imaging

Day/Night Band

Broadband NIR/Vis channel with high gain

Successor to DMSP Night-Visible channel

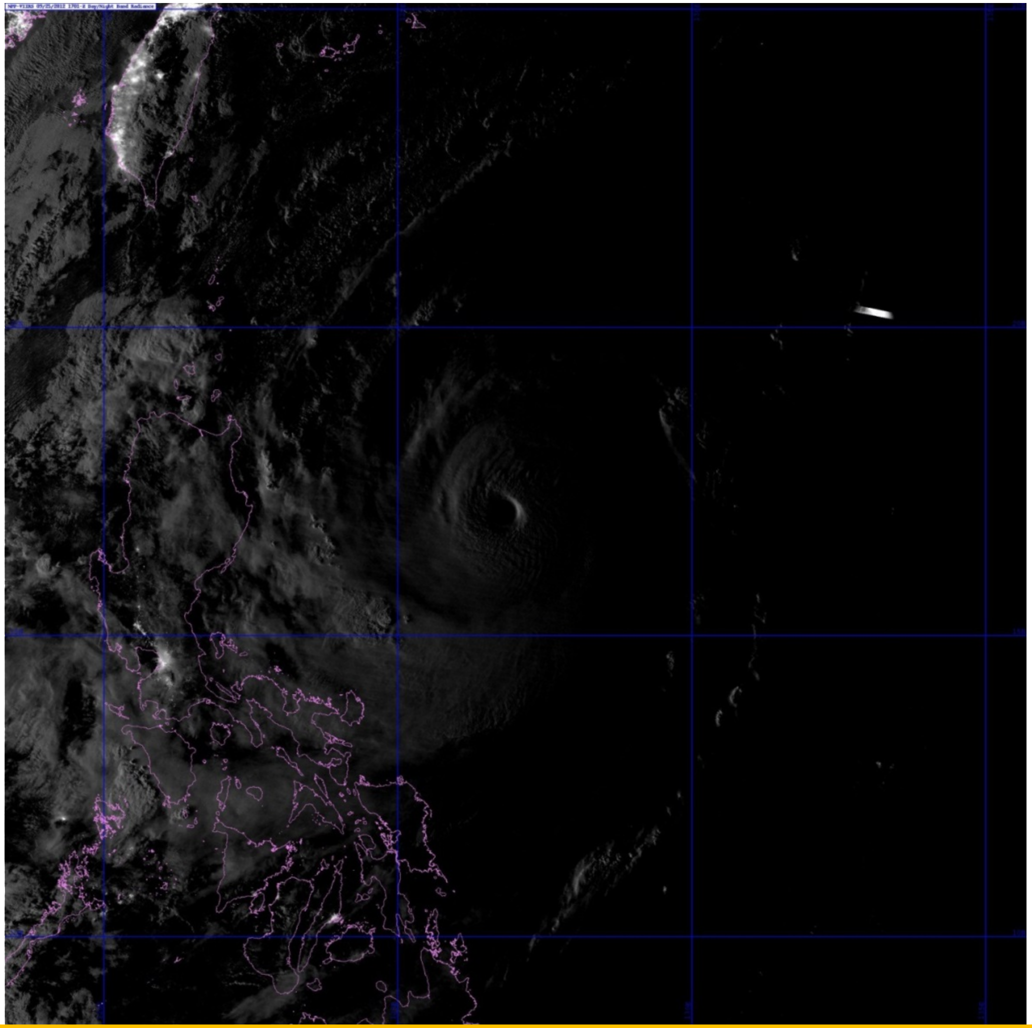


Lunar Model Impact

Lunar model is used to produce a form of near constant contrast (NCC) imagery.

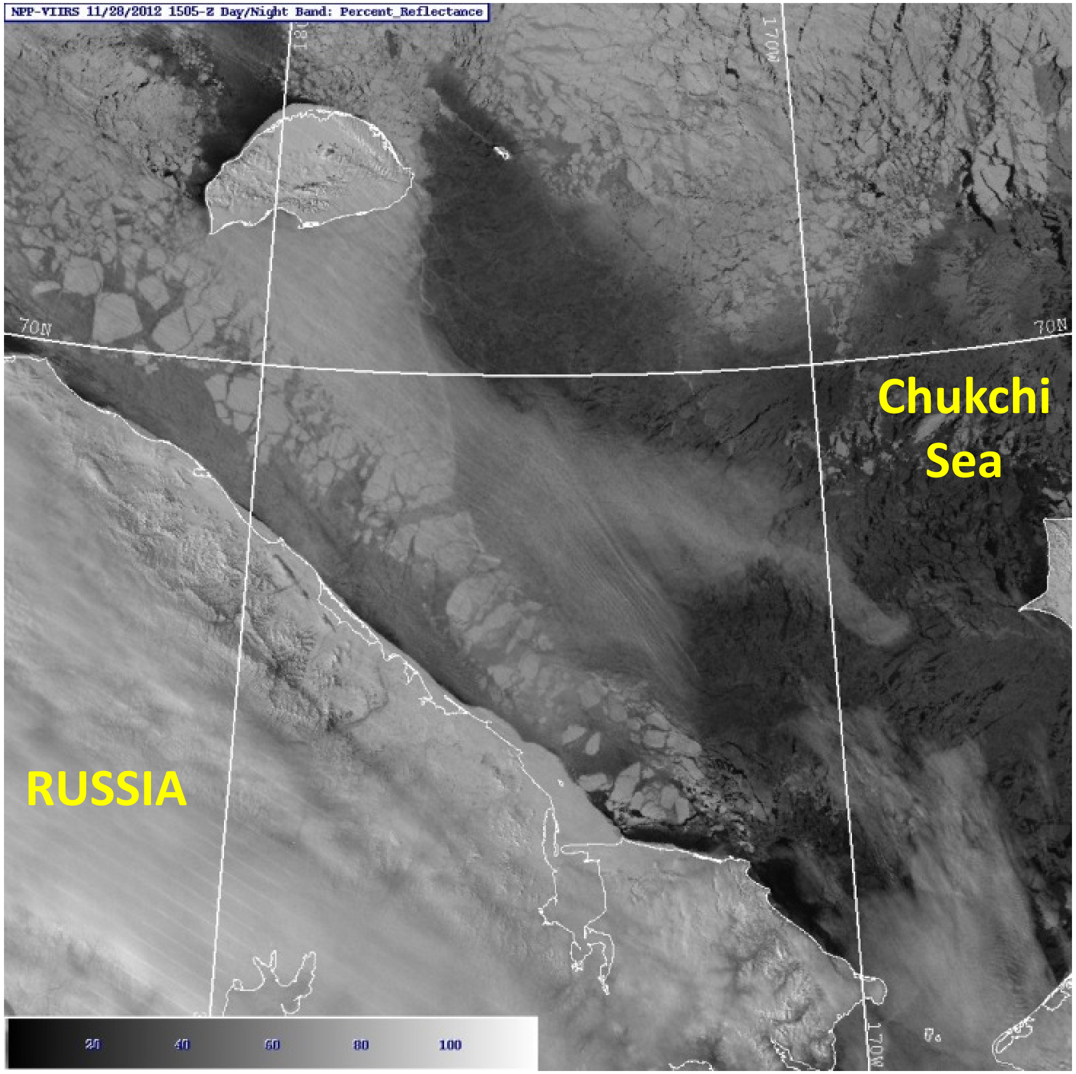
Not applicable to the day/night terminator where solar signal is present.

Moon phase: 80%



Quantitative visible reflectance values: many applications

DNB Sees through Thin Clouds

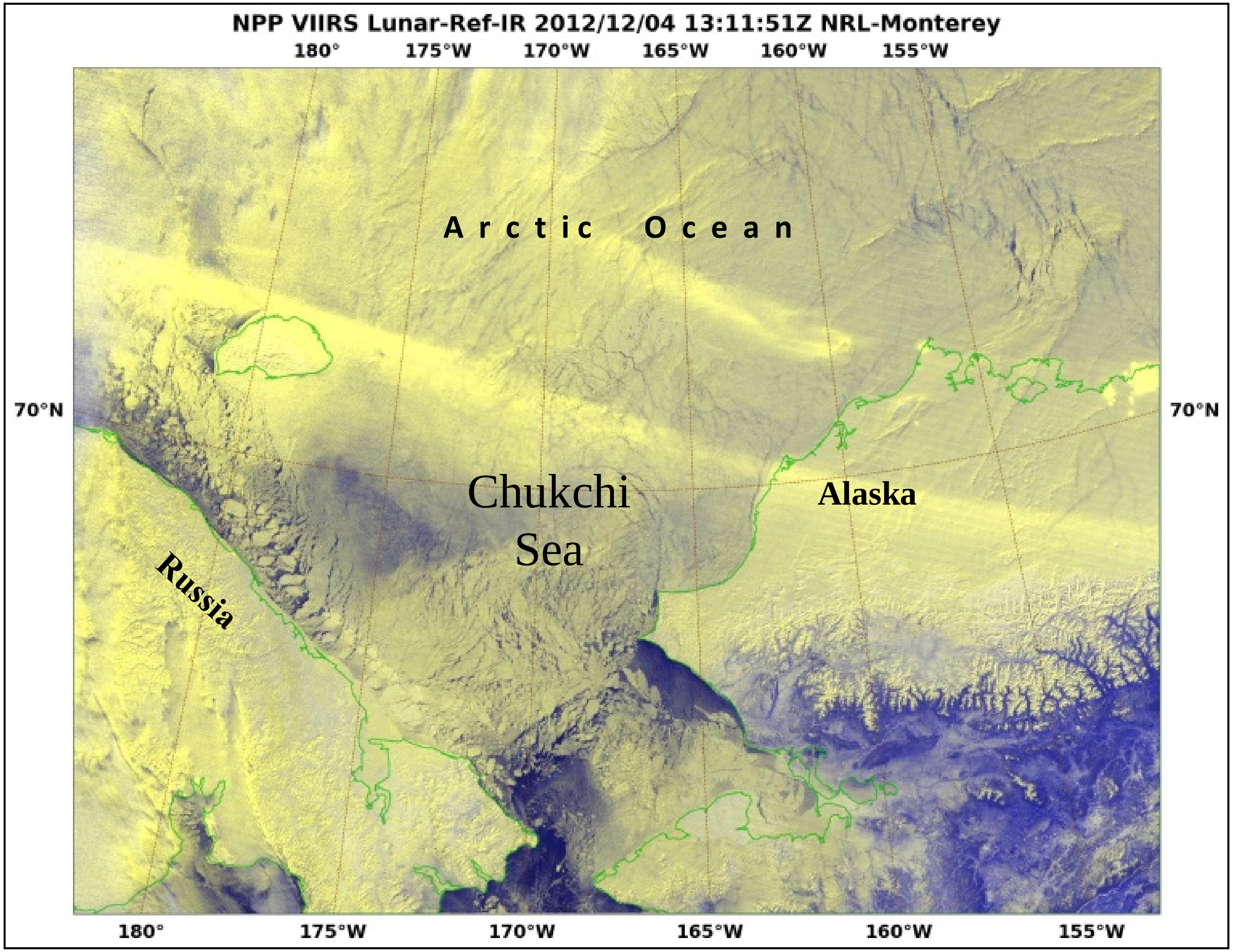


The Northern Passage

Lunar illumination passes through thin cirrus and reflects off sea ice below

Nighttime Sea Ice Monitoring

11/27 – 12/04, Lunar cycle > 3/4



Summary

- NRL Monterey currently provides IR/Vis imagery in multiple global regions from multiple sensors.
- Can create new areas of interest in minutes for support purposes.
- Able to provide imagery in near real-time (1-3 hours).
- DNB may provides useful new information in many support product regions.

Questions

CIMSS support of Imagery EDR team

William Straka III[1]

Tommy Jasmin[1], Bob Carp[1], Dan Lindsey[2], Steve Miller[3], Don Hillger[2]

[1]Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, University of Wisconsin-Madison
[2]NOAA, RAMMB
[3]Cooperative Institute for Research in the Atmosphere, Colorado State University

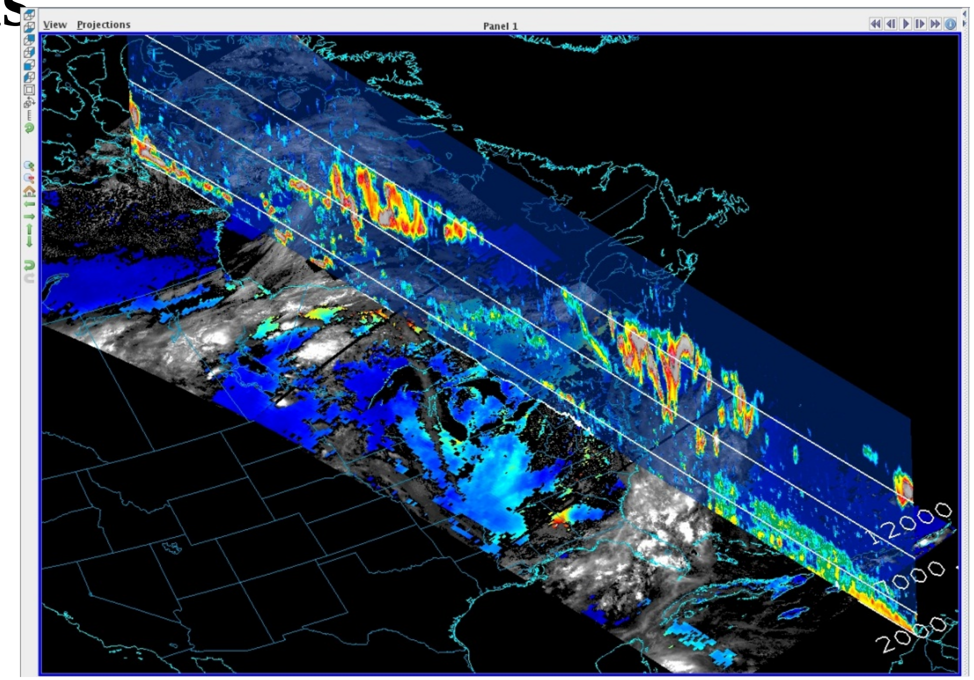
Outline

- Overview of McIDAS-V
- Examples
- McIDAS-V summary
- Other work

What is McIDAS-V

McIDAS-X → VisAD + IDV + HYDRA =

- Integration of Geophysical Data
- Remote and Local Data Access
- Powerful Analysis Tools
- 3D Visualization
- Ease of Re-projection



Key Aspects of McIDAS-V

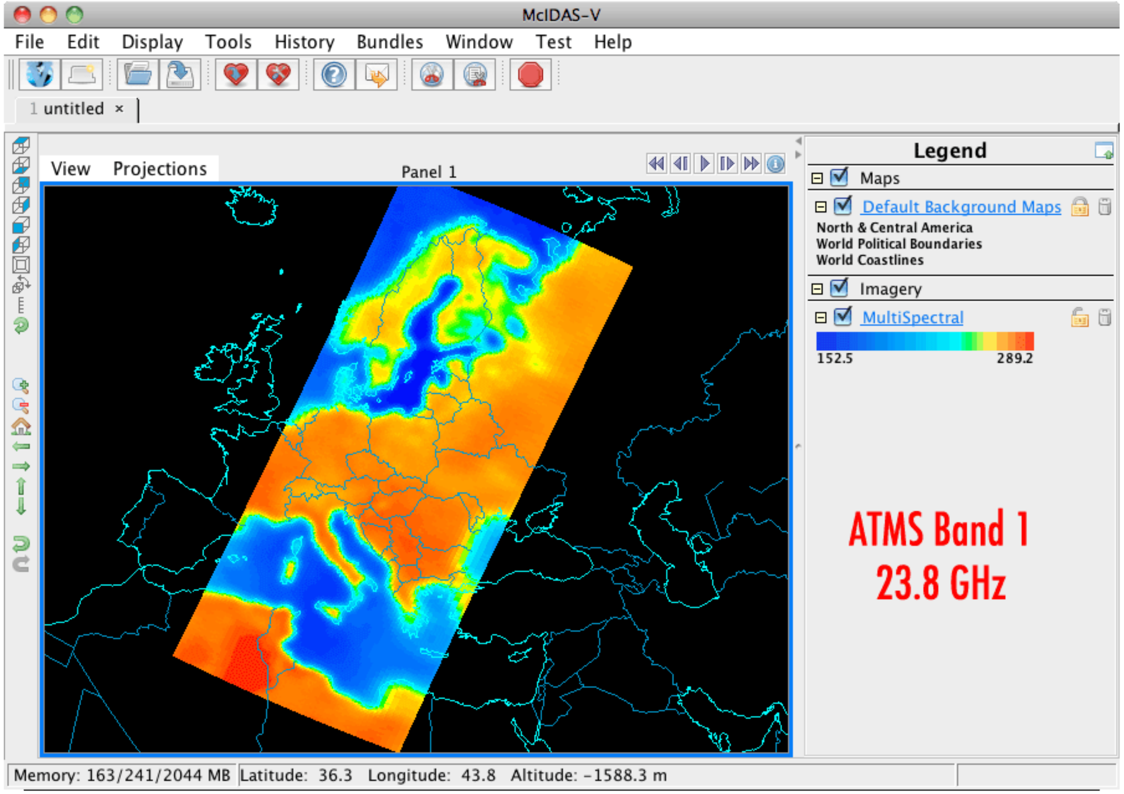
- Built on top an extensible framework for adapting new sources of data (format and type, local or remote), user interface components and for creating novel displays and analysis techniques
- Developed in the Java programming language – object oriented, write once run anywhere, very portable
- Persistence mechanism (bundles) for saving and sharing interesting displays/analysis with other McIDAS-V users
- Python based user defined computation
- Open source, freely available, community driven software
- Is able to easily load and manipulate Suomi NPP (Block 1 and 2) and JPSS-1 simulated Block 2 data without any special readers

Suomi NPP

- S-NPP observes the Earth's surface twice every 24-hour day, once in daylight and once at night.
- It has 5 instruments which retrieve data regarding the atmosphere, land and ocean
  - VIIRS
  - CERES
  - CrIS
  - ATMS
  - OMPS

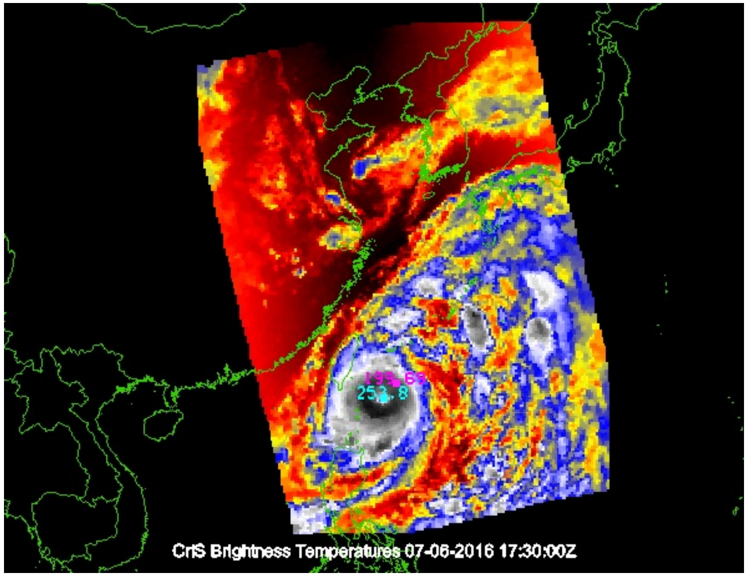
Advanced Technology Microwave Sounder (ATMS)

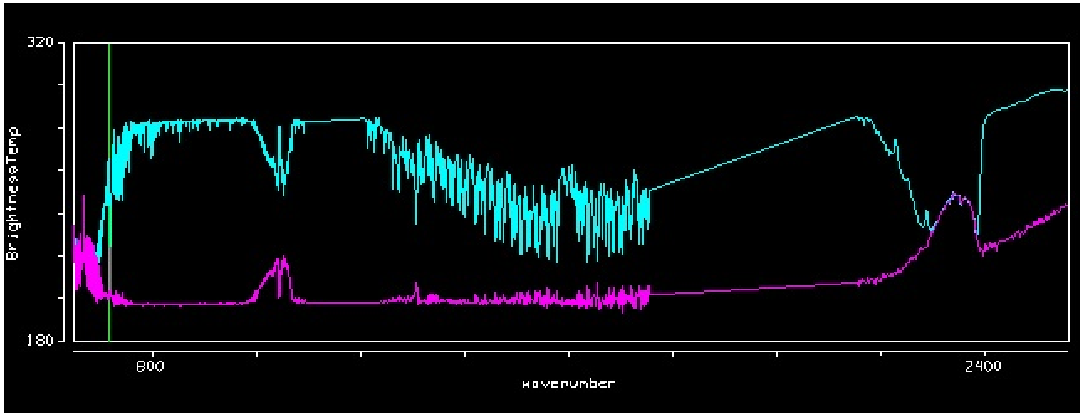
- 22 microwave channels, combining all the channels of the preceding AMSU-A1, AMSU-A2, and AMSU-B sensors into a single package
- Provides sounding observations needed to retrieve profiles of atmospheric temperature and moisture for forecasting models and continuity for climate monitoring purposes.



Cross-track Infrared Sounder (CrIS)

- 1,305 infrared spectral channels
- Designed to provide high vertical resolution information on the atmosphere's structure of temperature and water vapor.





Visible Infrared Imaging Radiometer Suite (VIIRS)

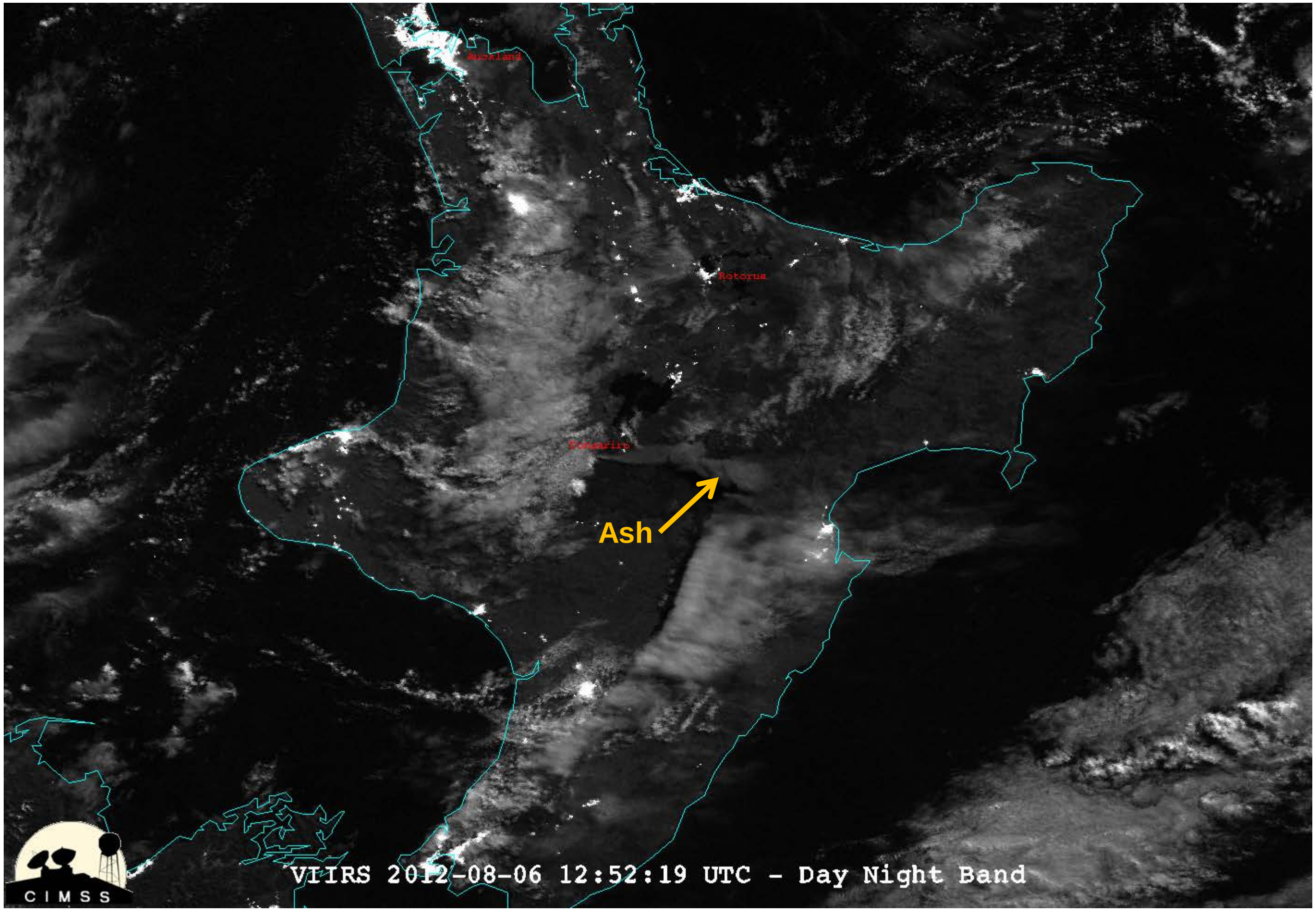
- Has 22 channels at three different resolutions
  - 16 Moderate Band (M-Band) channels (~750 m at nadir)
  - 5 high resolution (I-Band) channels (~375 m at nadir)
  - Day Night Band (~750 m at nadir)
- M and I band data encompass data from 412 nm to 12 µm
- Used to produce Level 2 products

Day Night Band

- The DNB measures visible radiances from both the Earth and atmosphere
- Wavelength of 0.7 μm, 742m x 742m pixel size
- Receives visible data from via reflection and emission sources (natural and anthropogenic)
- Stray light fix implemented August 21, 2013

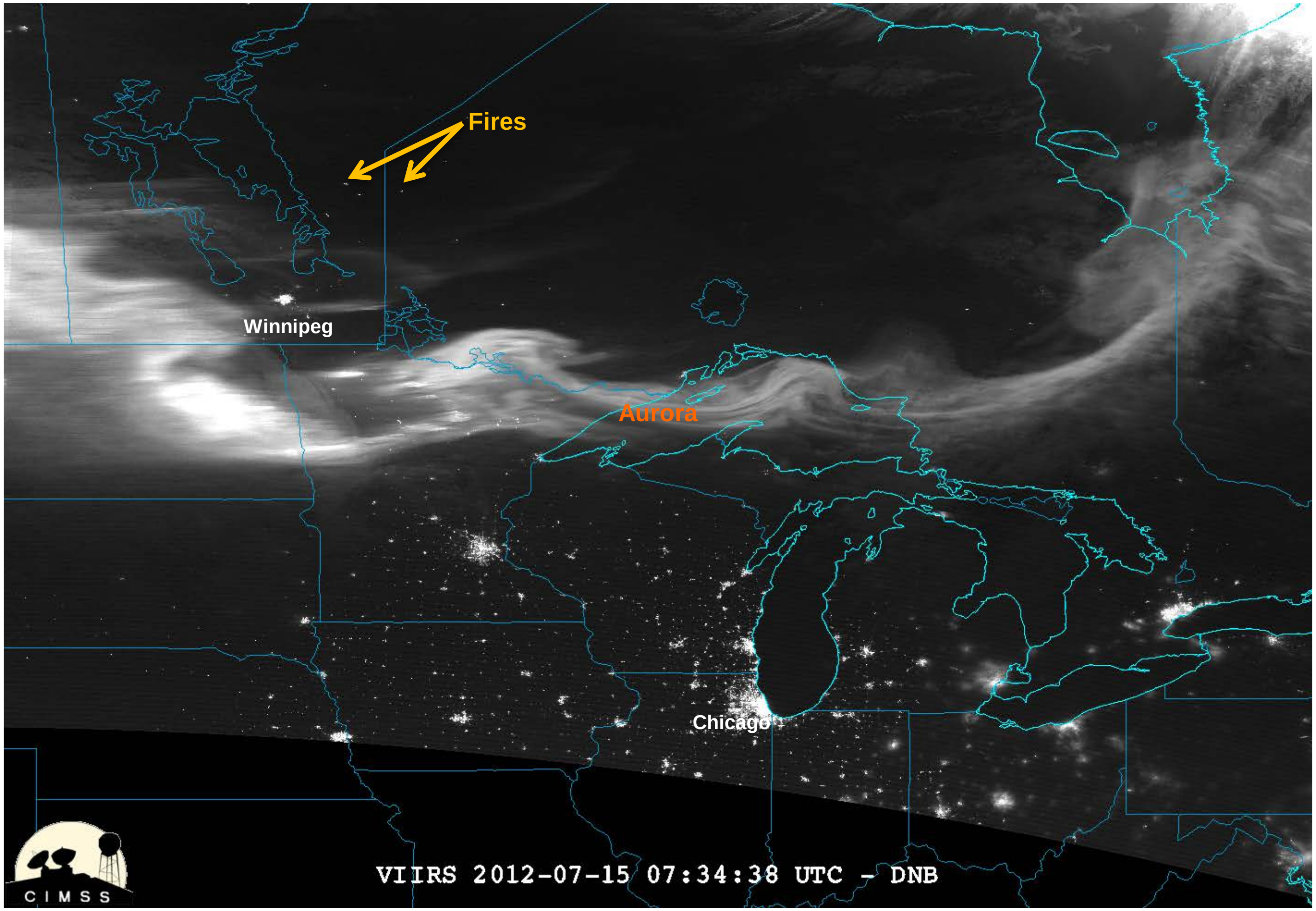
Figure 1 from Lee et al (2005)

Tongariro (New Zealand)
August 6, 2012 – 1252Z

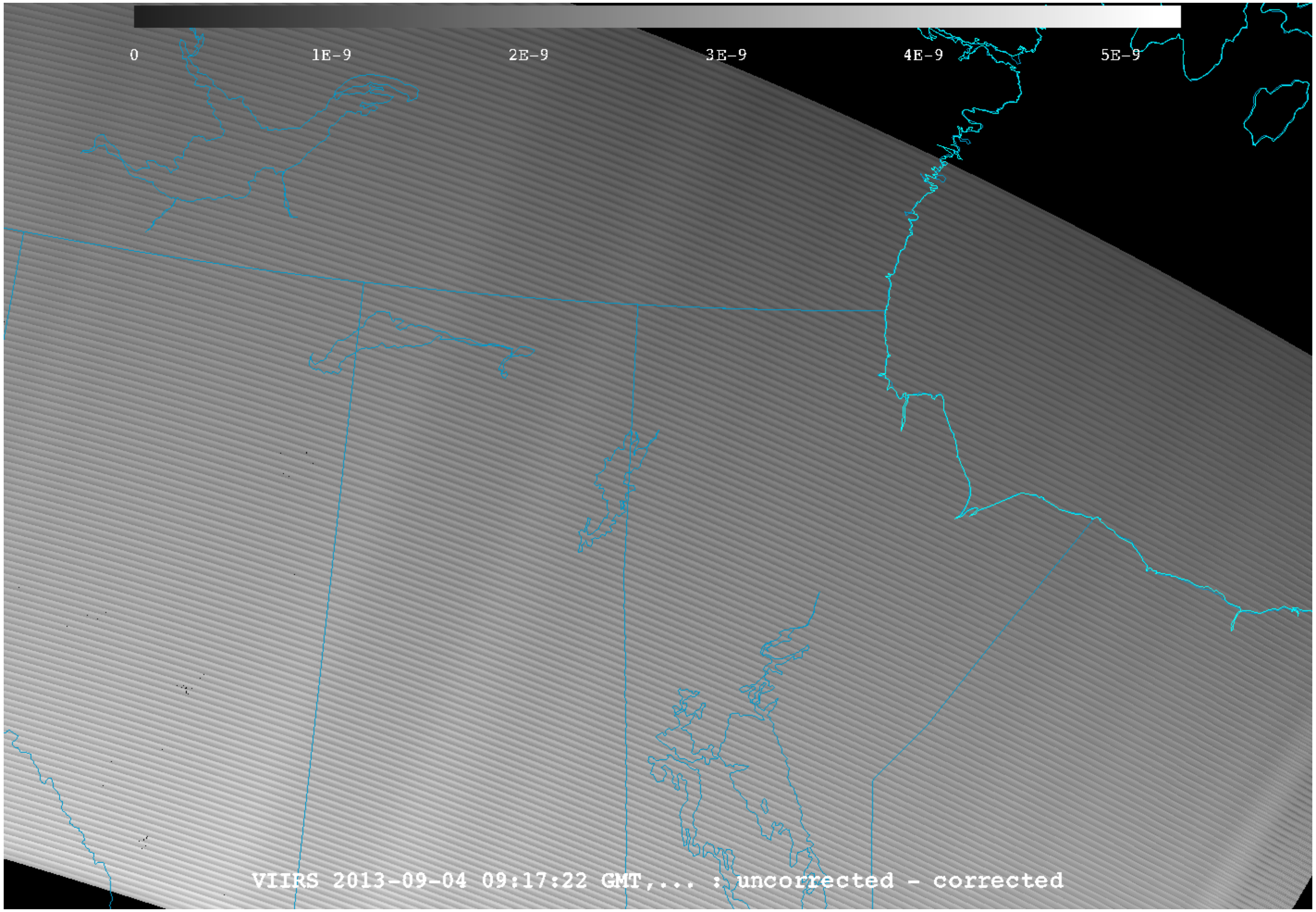


NASA Image of the Day
http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=78791

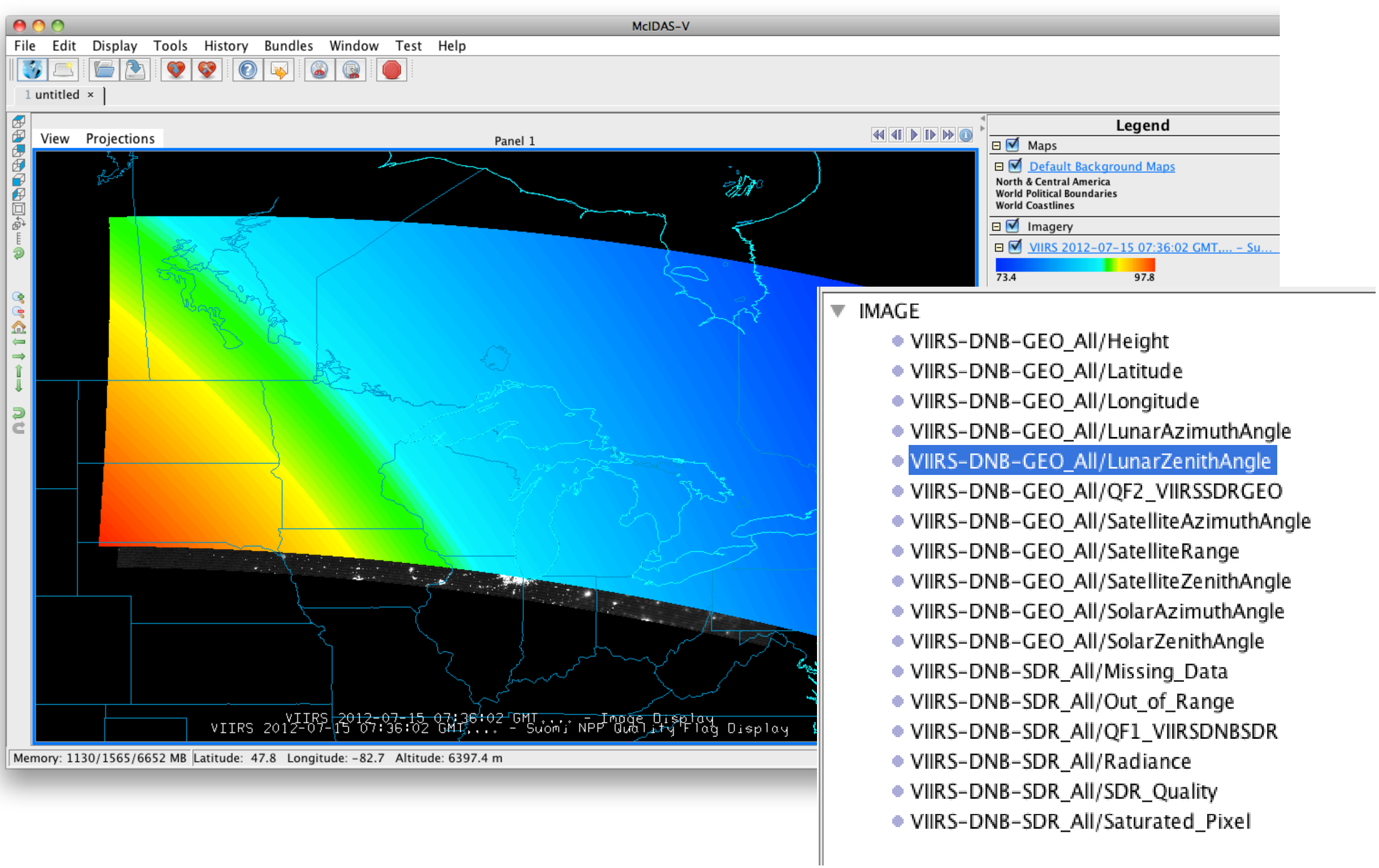
VIIRS (11, 3.9μm and DNB) 0733Z, July 15, 2012



VIIRS Channel Differencing
DNB Stray light example



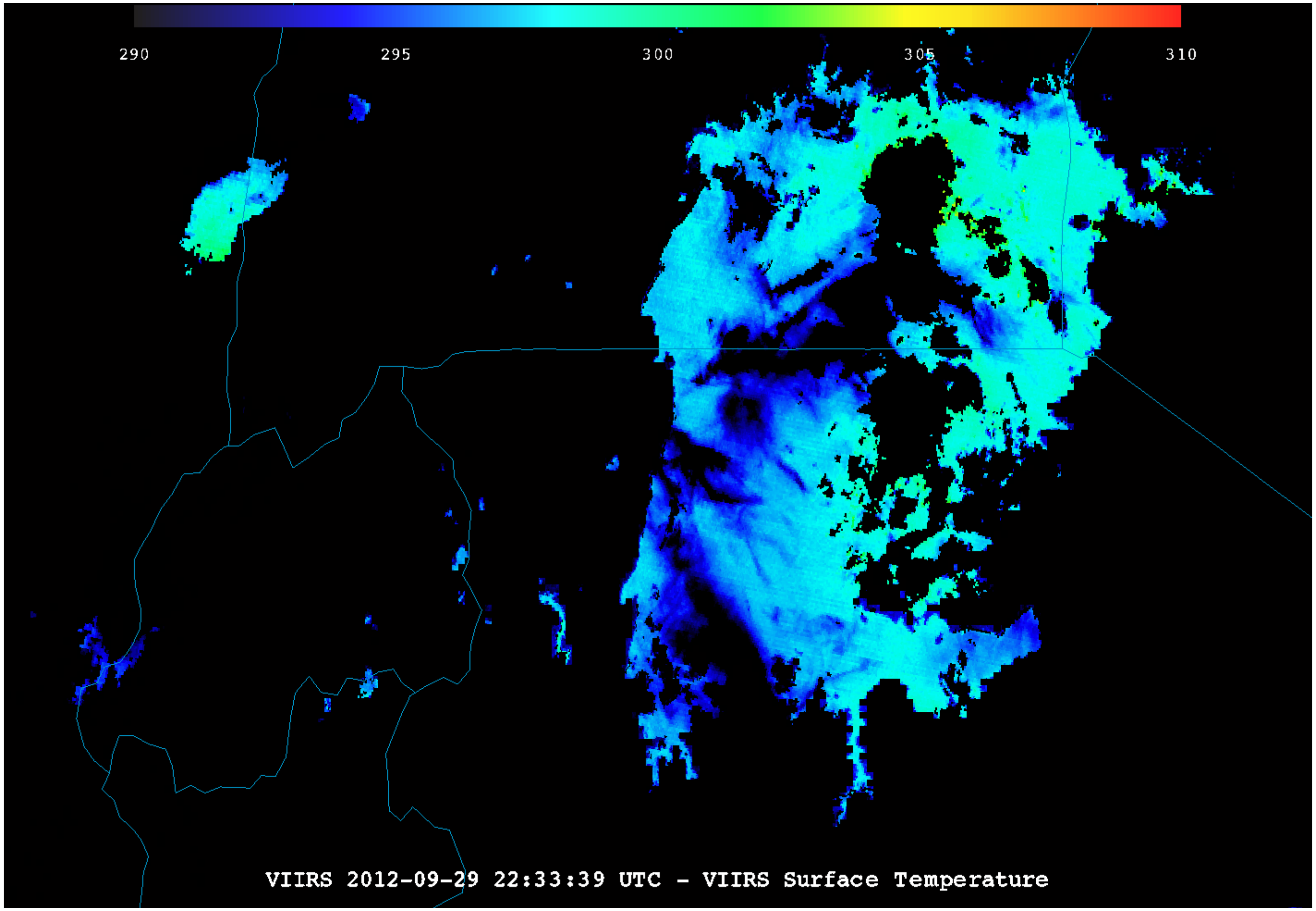
VIIRS SDR Ancillary data



Visible Infrared Imaging Radiometer Suite (VIIRS) EDR

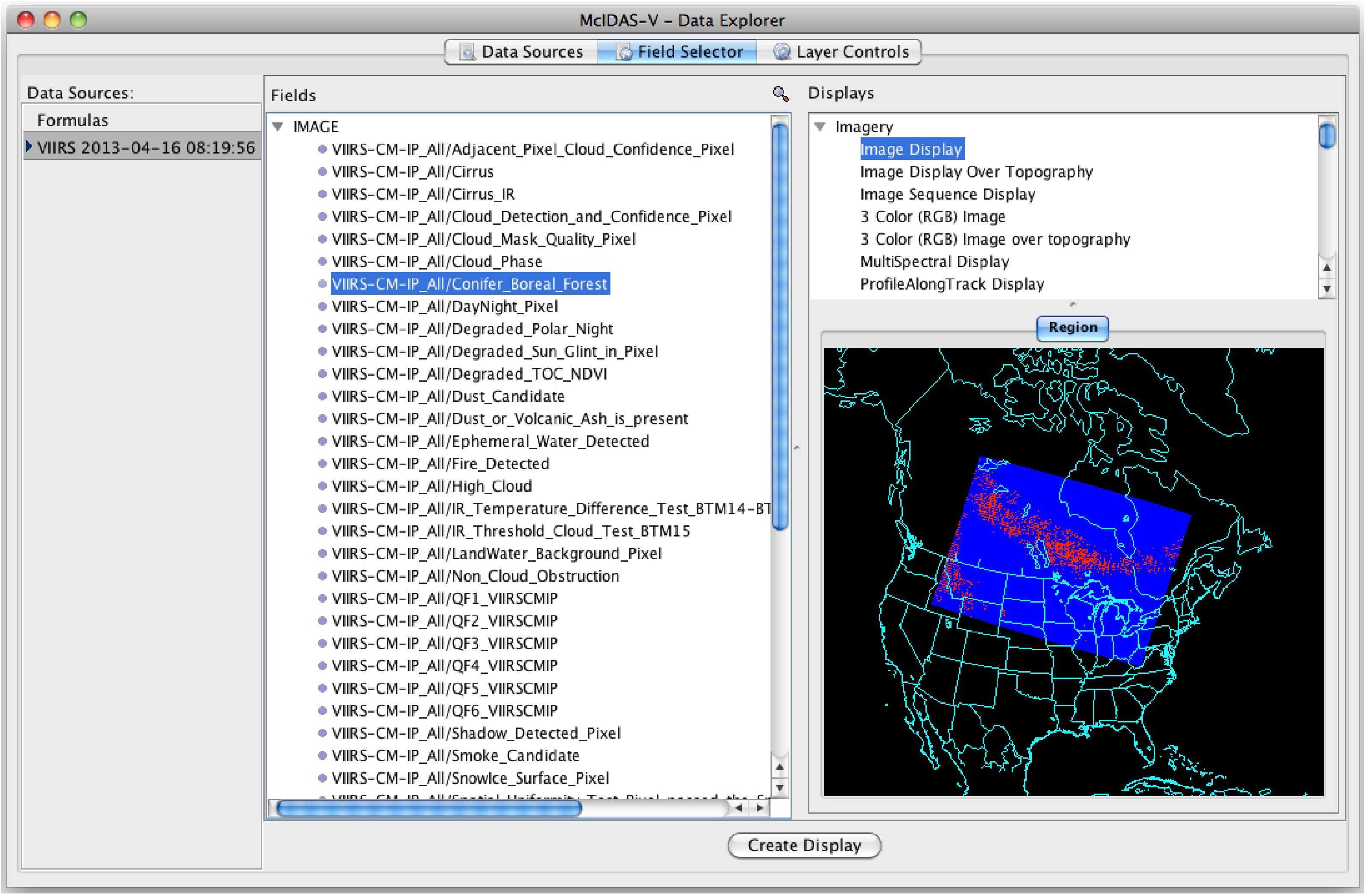
- There are a series of 20 Environmental Data Records (EDRs) produced from VIIRS
- McIDAS-V has been able to successfully ingest all EDRs including NDE Enterprise output
- McIDAS-V can unpack and display bit level data.
  – Ex. Displaying VCM test results

VIIRS DNB and Surface temperature EDR 2236Z, 09/29/2012

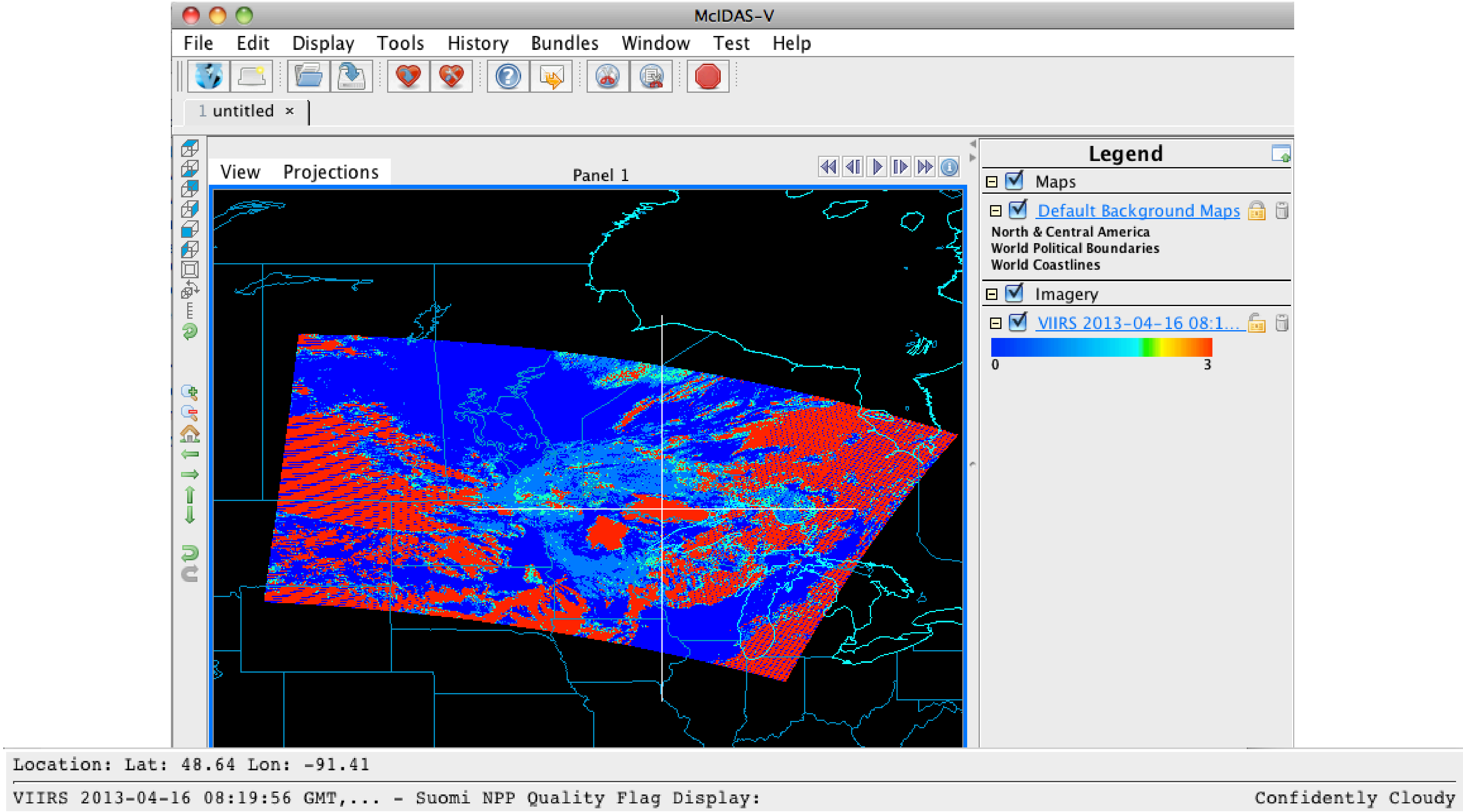


★ Lake Victoria

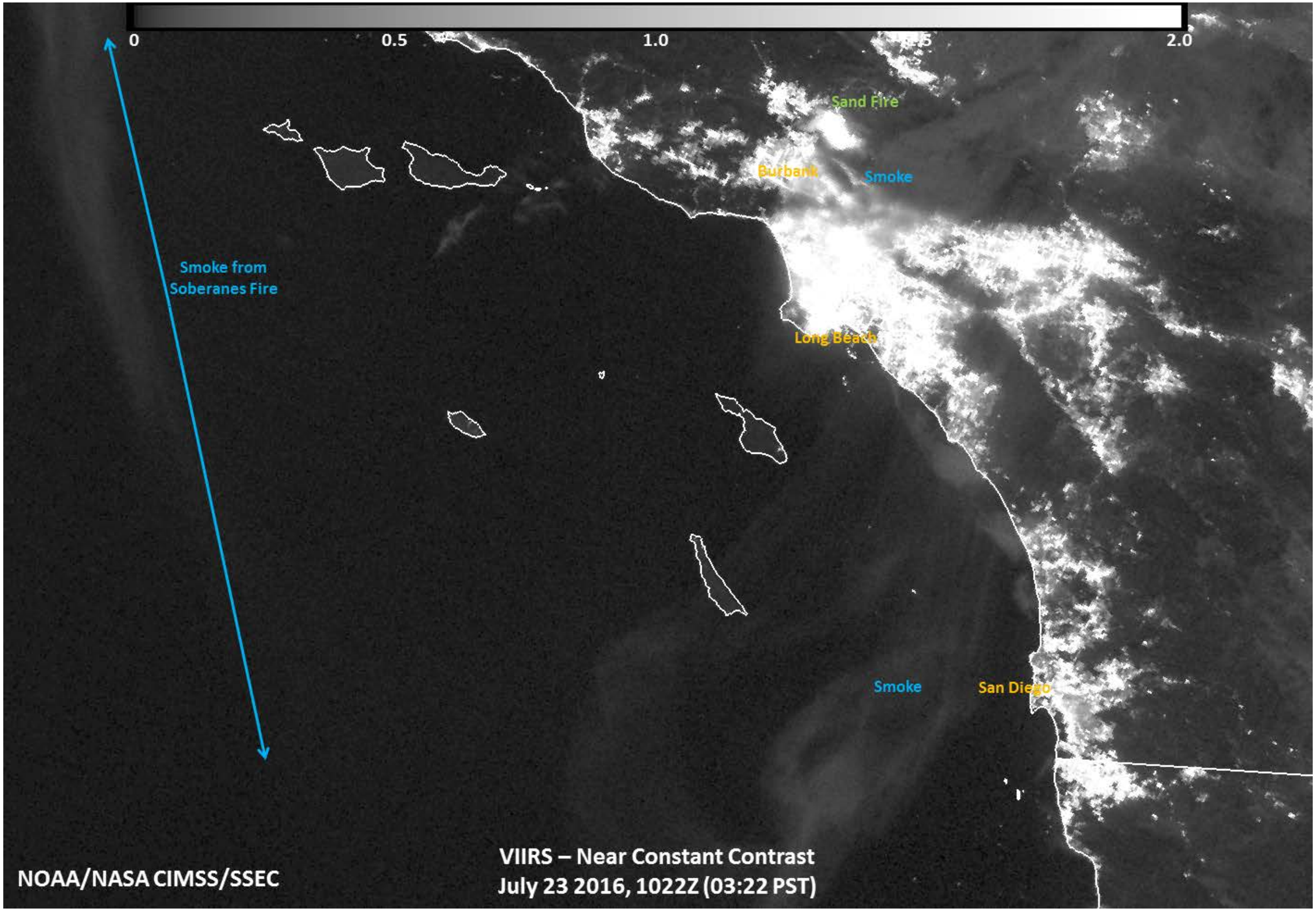
Product EDR Variable selection



Product EDR Data Probe

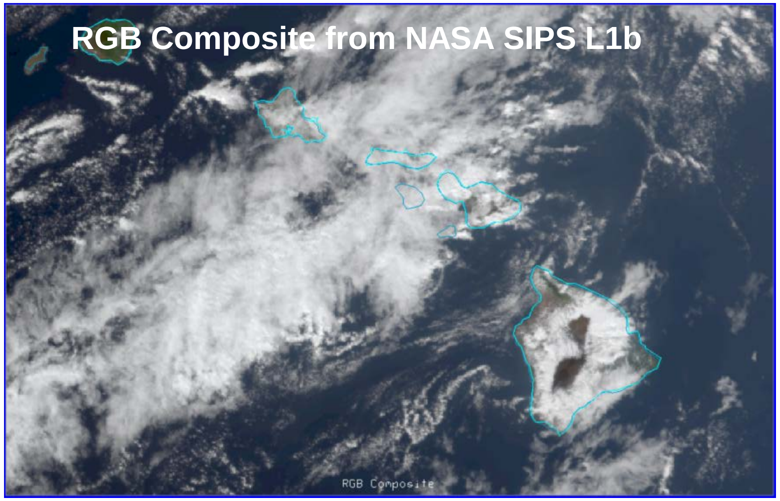


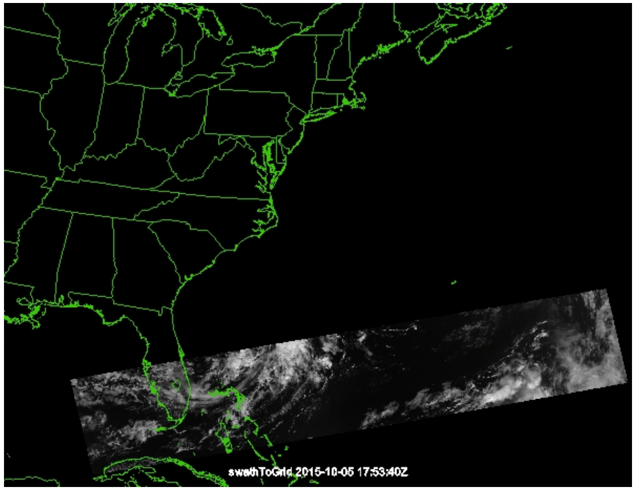
Imagery EDR example



S-NPP specific McIDAS-V 1.6 Updates

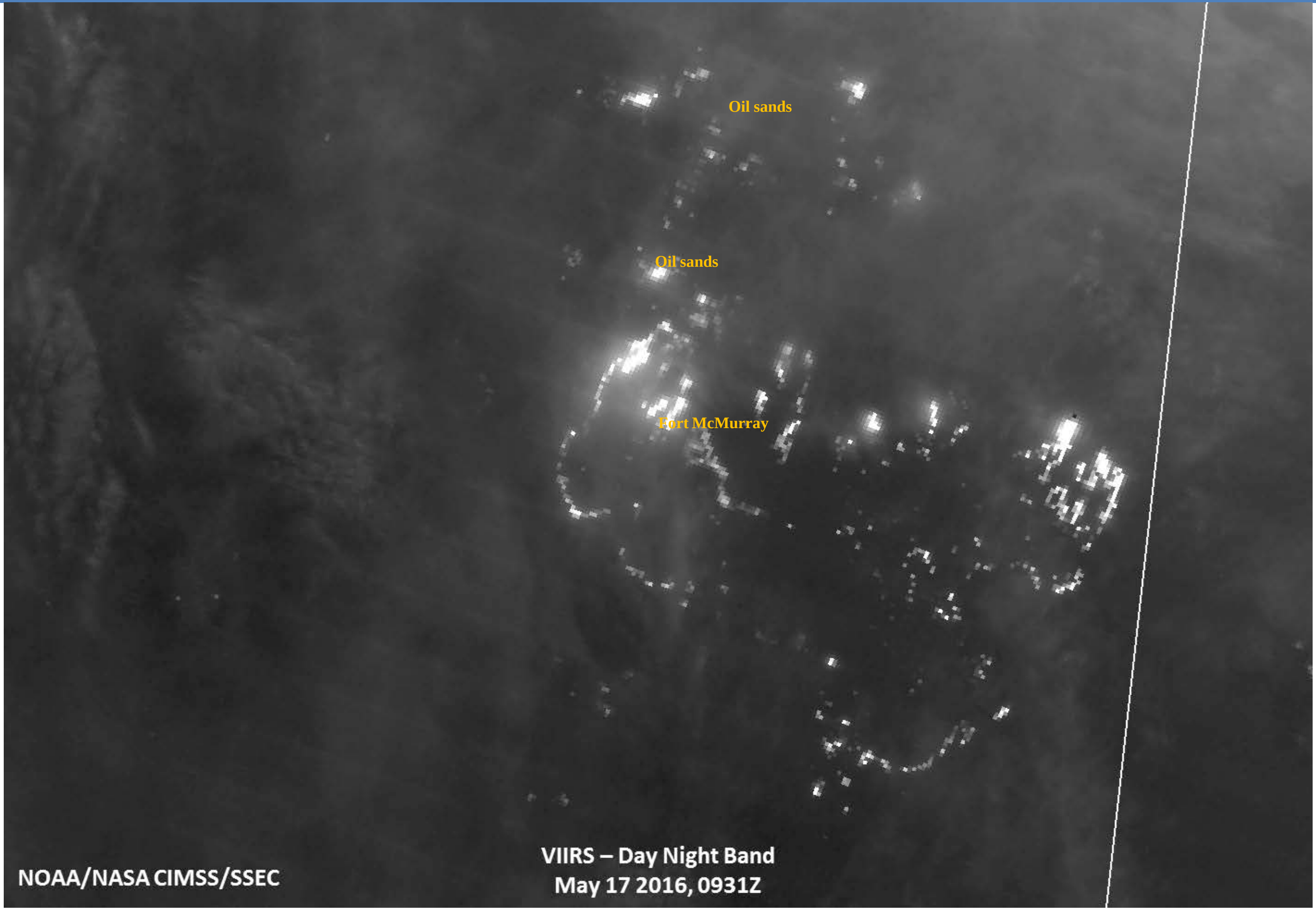
- Expanded granule concatenation for SDRs and EDRs
- Support for both NASA and NOAA L1b formats
  - Needed due to the move of the APEATE to NASA SIPS



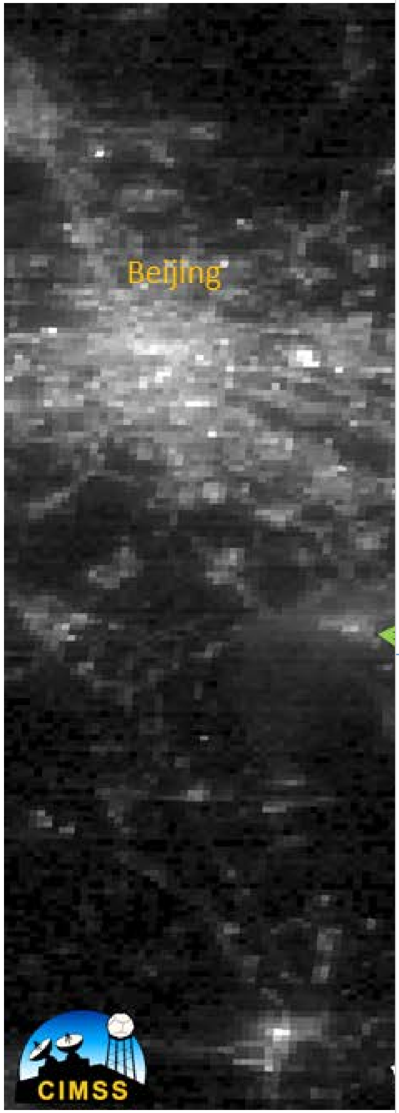


OTHER CIMSS SDR/EDR SUPPORT

Disaster monitoring
Fires and Smoke support



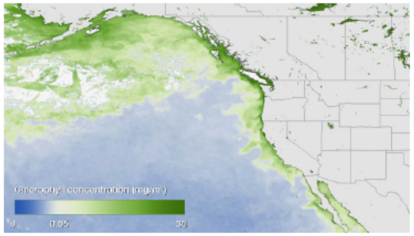
Disaster monitoring
Tianjin, China Port explosion



National Environmental Satellite, Data, and Information Service (NESDIS)
August 2015 Newsletter

Operations – West Coast Algal Blooms

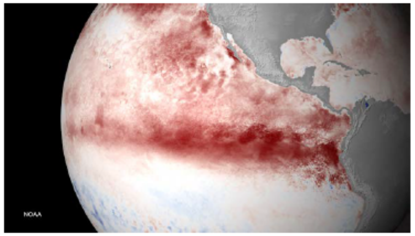
Harmful Algal Bloom is One for the Record Books



Coinciding with above average sea surface temperatures, a record breaking algal bloom continues to expand across the North Pacific, reaching as far north as the Aleutian islands and as far south as southern California. Average chlorophyll concentrations were determined using data from the Visible Infrared Imaging Radiometer Suite (VIIRS) on board the NOAA/NASA Suomi NPP satellite. The darkest green areas have the highest surface chlorophyll concentrations and the largest amounts of phytoplankton, including both toxic and harmless species. With its large size, the bloom has had a large impact on marine life. Fishery closures have occurred in Washington, Oregon, and California, due to extremely high levels of an algal toxin called domoic acid produced by *Pseudo-nitzschia* phytoplankton.

Spotlight – Pacific Ocean Temperatures

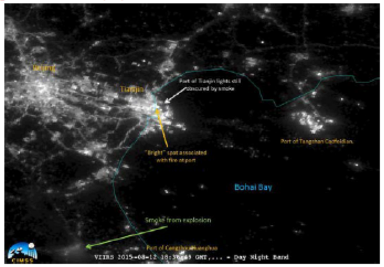
El Niño Predicted to Continue Through Spring 2016



NOAA's National Weather Service released an updated forecast on August 13, predicting a greater than 90% chance that El Niño will continue through the Northern Hemisphere winter, and around an 85% chance that it will last into early spring 2016. The above image displays the weekly sea surface temperature departure from the 1981-2010 average, from the week of August 10. Rising sea surface temperatures in the equatorial Pacific indicate that this year's El Niño could be the strongest ever recorded. Temperature and precipitation impacts from El Niño are expected to increase into the late fall and winter. El Niño will likely contribute to a below normal Atlantic hurricane season and above-normal central and eastern Pacific hurricane season.

Image of the Month

Explosion in Tianjin, China



The Suomi NPP satellite flew over Tianjin, China about 80 minutes after a major explosion on August 12. The day/night band of the VIIRS instrument captured images that show the thick smoke from the fire, the Port of Tianjin lights obscured by smoke, and bright spots associated with the fire. The above image was produced by the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin, Madison.

Message from Dr. Stephen Volz

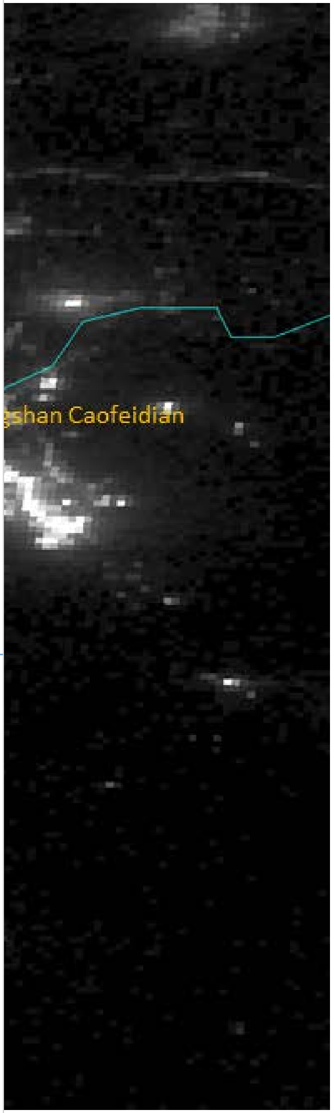
Assistant Administrator for NESDIS

This month marks the 10th anniversary of Hurricane Katrina, which made landfall on August 29, 2005, and was the costliest and third deadliest hurricane ever. To commemorate that event, on July 28, I joined NOAA Administrator Dr. Kathryn Sullivan and Assistant Administrators from NOAA's other line offices for a special briefing to mark a decade of science progress since the 2005 Atlantic hurricane season, which remains the most active on record. If you missed this special event, the audio file and presentation is available here.

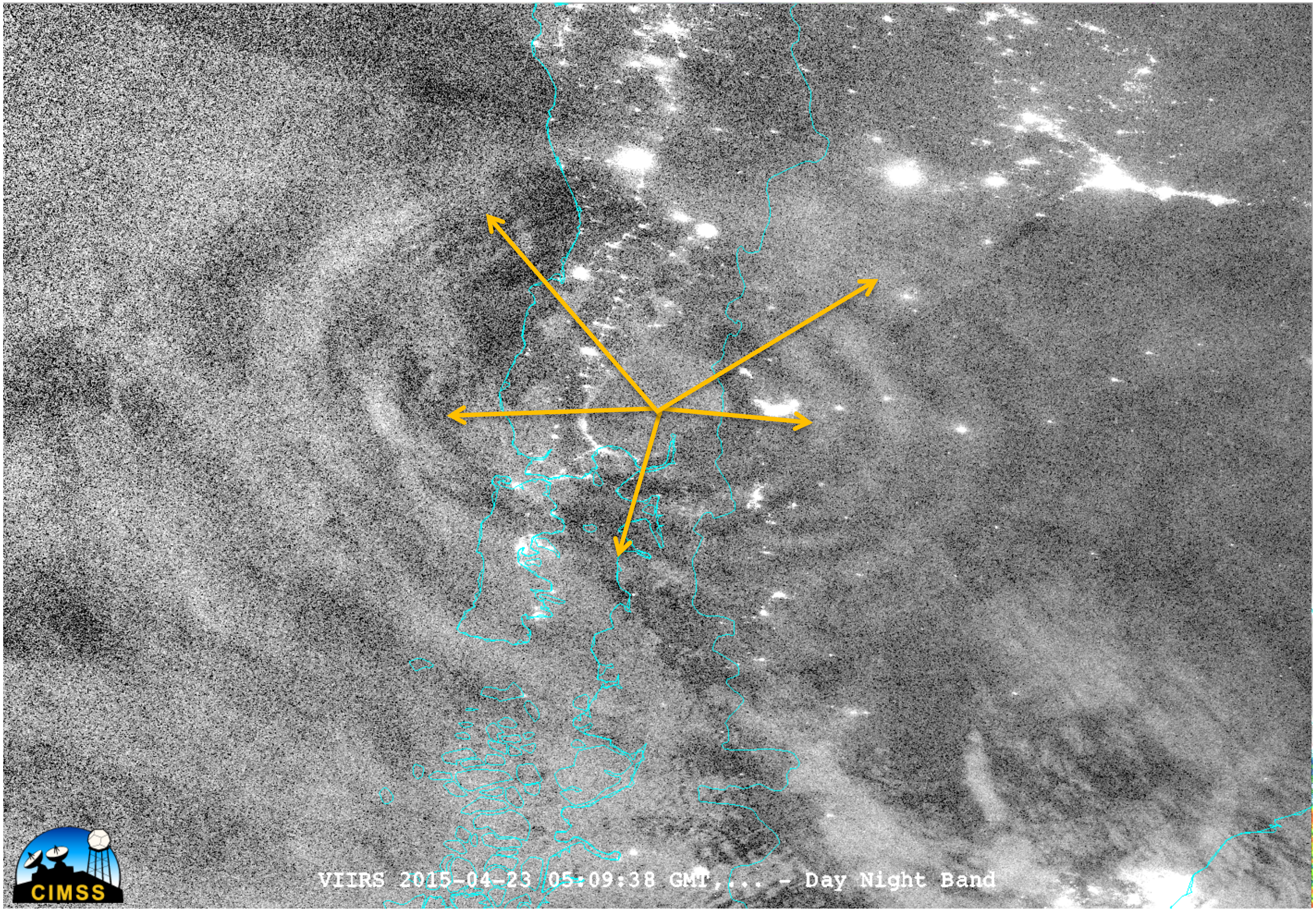
Nominations are now being accepted for the NOAA-David Johnson Award. This award, presented by the National Space Club, is given to young professionals who have developed an innovative application of Earth observation satellite data that can be used for operational purposes to assess and/or predict atmospheric, oceanic, or terrestrial conditions. Please encourage gifted scientists to apply by the October 2 deadline.

I hope that you have had an enjoyable August recess and I welcome you back to D.C. Please contact Sierra Jones (sierra.jones@noaa.gov) if you have any questions regarding NOAA's satellite and information services.

www.nesdis.noaa.gov



Mesospheric Gravity Wave monitoring



Mesospheric Gravity Wave monitoring

- Comparisons of DNB observations with ground based observations
  - Palomar Observatory
  - Amateur airglow photography (US and China)
  - Ground based low-light cameras (US and China)

Texas Thunderstorm

Other activities

- Observations of other interesting phenomena
  - Unexplained streaking in DNB
  - Aurora
  - search for marine bioluminescent sources in Southwest Asia and Indonesia
- Participation in ongoing Cal/Val Team discussions, TIMs, and support studies concerning DNB data quality on J1 and beyond.

Cloud Session Introduction

Andrew Heidinger
NOAA/NESDIS/STAR
Cloud Team Lead

Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
Andrew Heidinger	NOAA/NESDIS/STAR	Yue Li, Denis Botambekov and Tom Kopp (AERO)	Cloud Mask, Cloud Height and CCL
Michael Pavolonis	NOAA/NESDIS/STAR	Corey Calvert (CIMSS)	Cloud Phase/Type
Steve Miller	CIRA	Dan Lindsey, Yoo-Jeong Noh, Curtis Seaman, John Forsythe	Cloud Base and CCL
Andi Walther	CIMSS	Sam Tushaus	Daytime Optical Properties, Precipitation (RR)
Pat Heck/ Pat Minnis	NASA LaRC		Nighttime Optical Properties
Mike Foster	CIMSS	Denis Botambekov, Jay Hoffman	Long-term Monitoring / Reprocessing
Bob Holz	SSEC	Greg Quinn	Validation Tools
Ping Yang	Texas A&M		Cloud particle scattering models.
William Straka and Ruiyue Chen	ASSIST		Algorithm implementation into SAPF and verification of implementation

Cloud Product Enterprise Status

- All algorithms updated in April 2016.

- ASSIST provided multiple days of global output. Report generated.

- Algorithms and ATBD updates delivered to ASSIST on August, 2016 for January 2017 update.

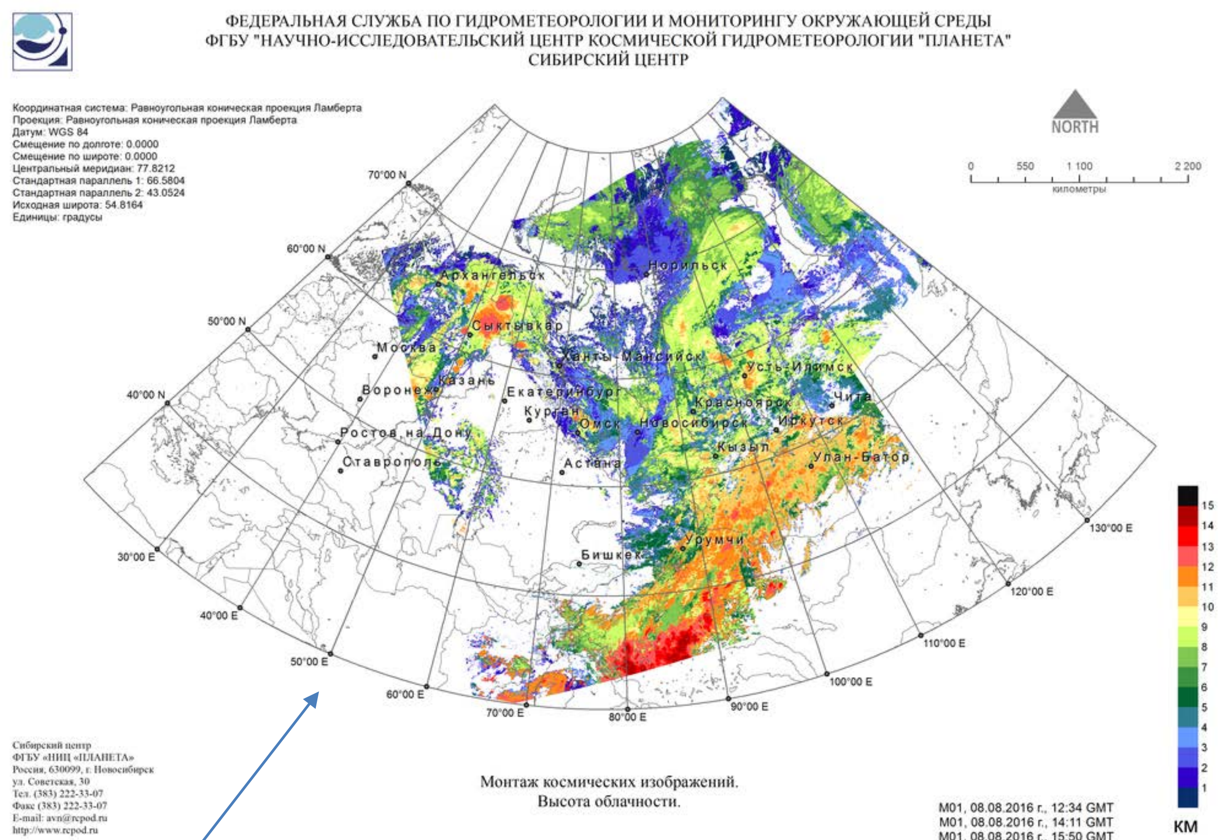
- Updates included
  - ECM
    - includes a thin cirrus flag as requested
    - 3.75 micron test revised and table updated (tbd)

  - ACHA updated with improved
    - microphysical model
    - ocean inversion calculation
    - latitudinal variation in cirrus property first guess

- CSPP Leo / CLAVR-x updated with Enterprise algorithms delivered to ASSIST.
  - International user base is growing steadily

CSPP LEO / CLAVR-x Providing NOAA Enterprise Clouds to DB

- The NOAA Enterprise Cloud Algorithms are distributed through UW/SSEC CSPP LEO.
- CSPP LEO runs NESDIS CLAVR-x.
- Provided good feedback for VIIRS Enterprise cloud products before operational in NDE this fall.
- Roughly 50 downloads
- Active communication with a Russian Remote Sensing Company that sells services to the Russian Weather Agency.
- Goal is to release updates in step with our deliveries to SAPF. (ahead of operations but in-sync with ASSIST)
- CSPP LEO supports VIIRS DNB usage. We hope to transition this to SAPF.

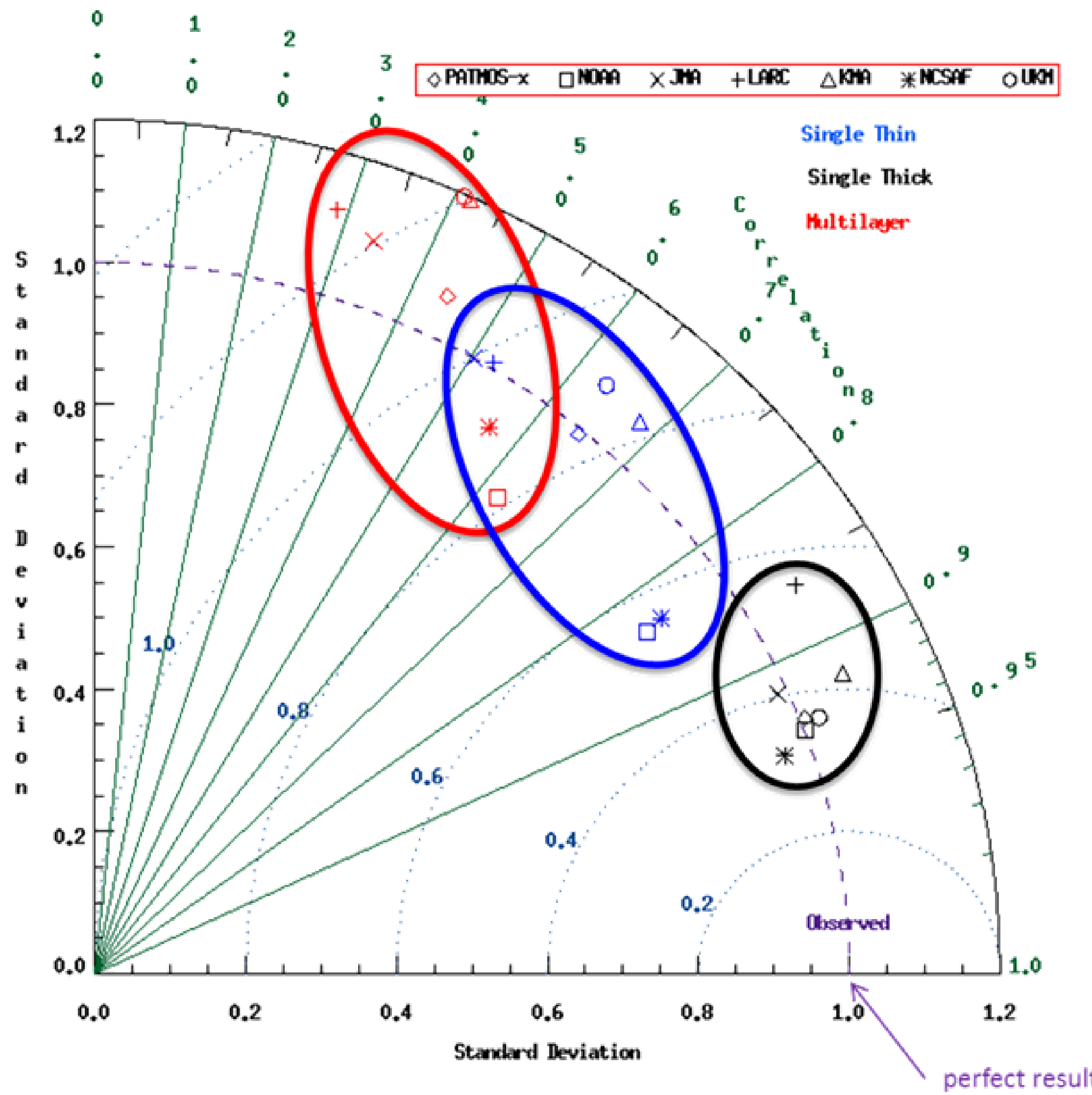


Example CSPP LEO CLAVR-x image provided by Russian CSPP customer

Enterprise Cloud Algorithms Compared to Others

- The Enterprise cloud algorithms generated by the ASSIST were included in a recent algorithm intercomparison conducted by the International Cloud Working Group (ICWG).
- Data was for HIMAWARI/AHI but code was EXACTLY the same as delivered to ASSIST in April 2016.
- The cloud height comparisons are shown here.
- The comparison on the right shows each agency's data compared to NASA/CALIPSO.
- Data labelled NOAA are the Enterprise results (□)
- Data are stratified into single-thick, single thin and multilayer.
- Enterprise does relatively well in all 3 stratifications.
- ICWG is developing an analogous leo analysis for VIIRS.

Taylor Plot of AHI CTH Comparisons



Risk Reduction Status

- With support from JPSS-RR, the ECM is fully capable of using and benefiting from the VIIRS DNB coupled with the CIRA lunar model.
- The lunar analog of the daytime cloud optical and microphysical properties (DCOMP) is also ready for transition (when time is right).
- VIIRS cloud product rain rate also being developed for use in solar or lunar illumination. Provides a complement to the ATMS precip
- RR also funded the fusion of VIIRS and CrIS to provide MODIS-like IR channels. Algorithms being modified to make use of these data.
- An enhanced Cloud Cover Layers (eCCL) from VIIRS is also being developed to meet the requirements from NWS. Fusion of VIIRS and CrIS also helps this.
- It is time to extend the PATMOS-x AVHRR record onto VIIRS. Reprocessing over limited domains has shown this to be feasible. PATMOS-x VIIRS would expose the existing PATMOS-x AVHRR/GOES community to VIIRS. (not a RR proposal)

Current Issues

- ECM Performance in SAPF lags behind the same code implemented in CLAVR-x.
  - ASSIST has found some potential causes.
  - We hope tuning will solve this.
- ECM and other cloud products show “blockiness” due to lack of smoothing of ancillary data.
  - SAPF has the ability but the impact of smoothed NWP ancillary data on all algorithms is being assessed by ASSIST.
- ECM is still not tuned on SAPF output.
  - ASSIST has provided the ability to dump-out all ECM input from the Framework so that Cloud Team may train against it. Until now, we have had to use CLAVR-x.
  - Running the SAPF over the amount of data needed is still a challenge.
- The gfortran 4.4.7 restriction from OSPO limits the implementation of some known improvements into the SAPF.
- The M5 and M7 calibration errors do limit our ability to meet spec in several products.

Introduction to Cloud Talks

1110 - 1130	Impact of VIIRS Enterprise Cloud Products for NWP (Heidinger)
1130 - 1150	The Newly Operational VIIRS Cloud Base and CCL (Noh)
1150 - 1300	Lunch
1350 - 1410	Enterprise Cloud Mask Status (Kopp)
1410 - 1430	JPSS Hydrological Initiative Activities (Forsythe)

Use of VIIRS Cloud Products For NWP

Andrew Heidinger
Yue Li, Steve Wanzong
JPSS Cloud Team

Motivation

There are several ways in which VIIRS Enterprise Cloud Products can influence NWP.

- VIIRS Cloud Heights and Cloud Detections will be used to assist in the identification of clear CrIS pixels.

- VIIRS Cloud Heights are used in the NESDIS Polar Winds Product which is used by NWP.

We placing high priority in characterizing and improving the JPSS Enterprise Cloud Products for these applications.

This talk will demonstrate our work in this area.

VIIRS Cloud Properties for CrIS Cloud Clearing

VIIRS Cloud Products for CrIS Cloud Detection

- Currently, NESDIS creates a BUFR that provide the following information from VIIRS within each CrIS Field of View (FOV)

- The maximum VIIRS Cloud Height
- The cloud fraction from all VIIRS pixels within the CrIS FOV

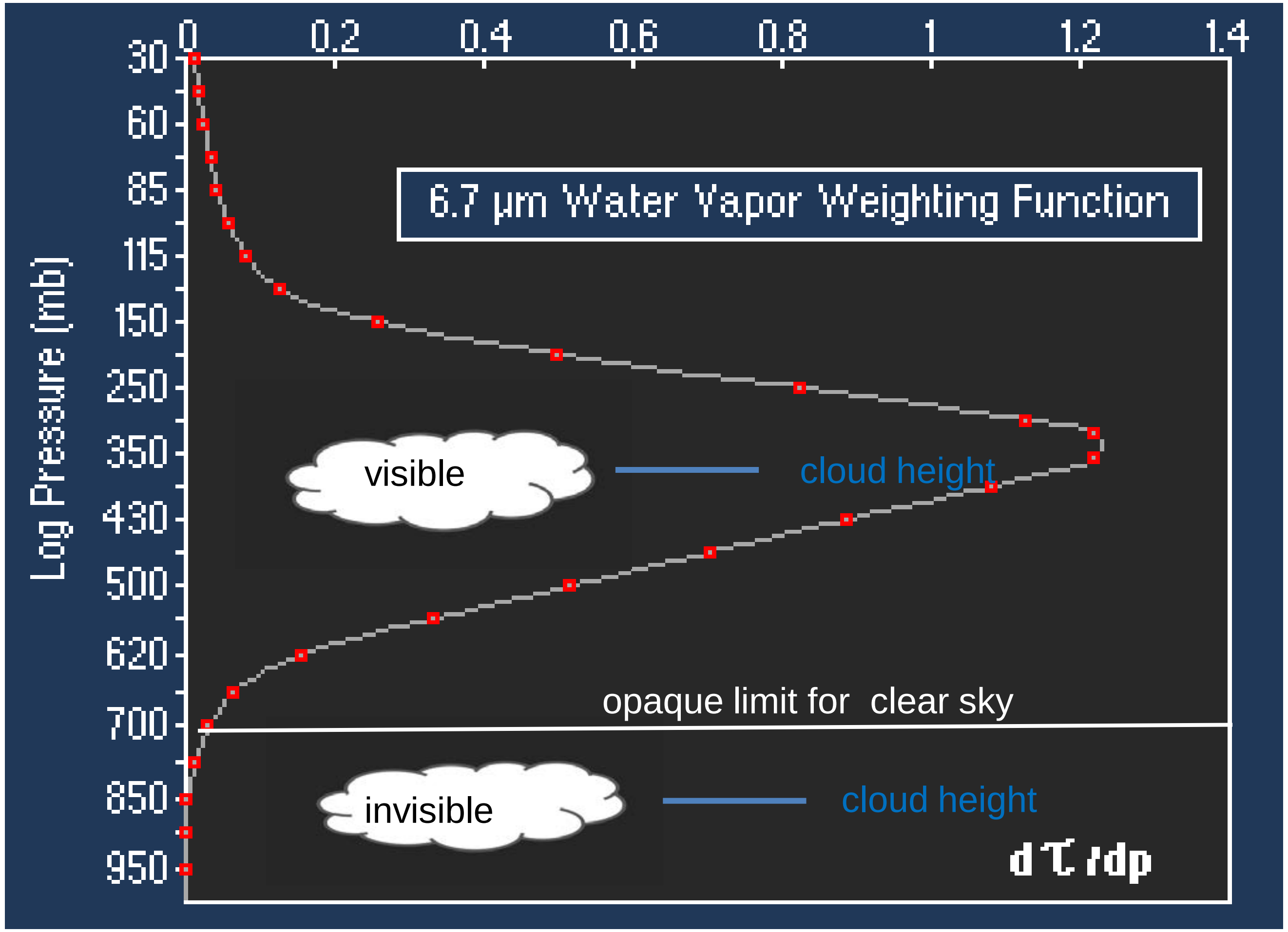
- Starting in November 2016, the NOAA Enterprise products from the ACHA and ECM algorithms will be ingested into that Buffer File.

  - Jim Jung and Andrew Collard are leading the effort to explore how to use this information for improving the detection of clear CrIS field of views.

  - The JPSS cloud team is trying to ensure that VIIRS cloud products are of sufficient accuracy for this application. Here we demonstrate a relevant analysis.

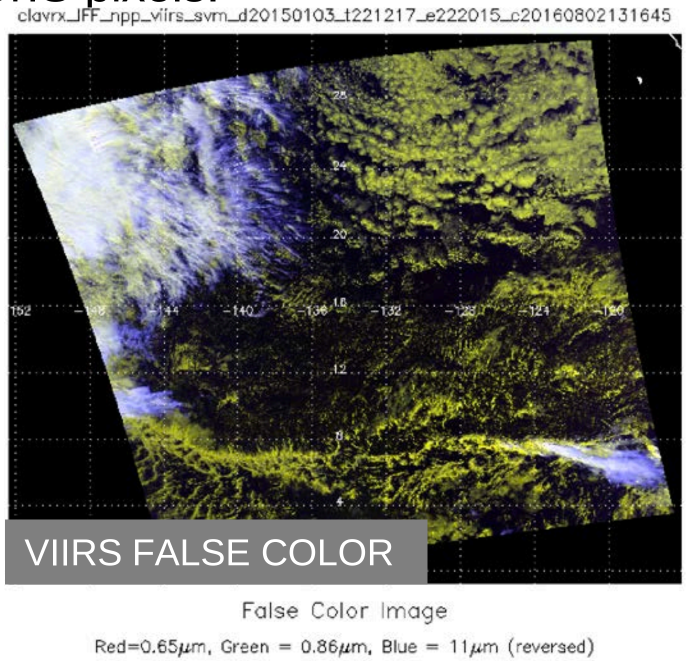
Basic Idea of How VIIRS Cloud Properties Could Be Used.

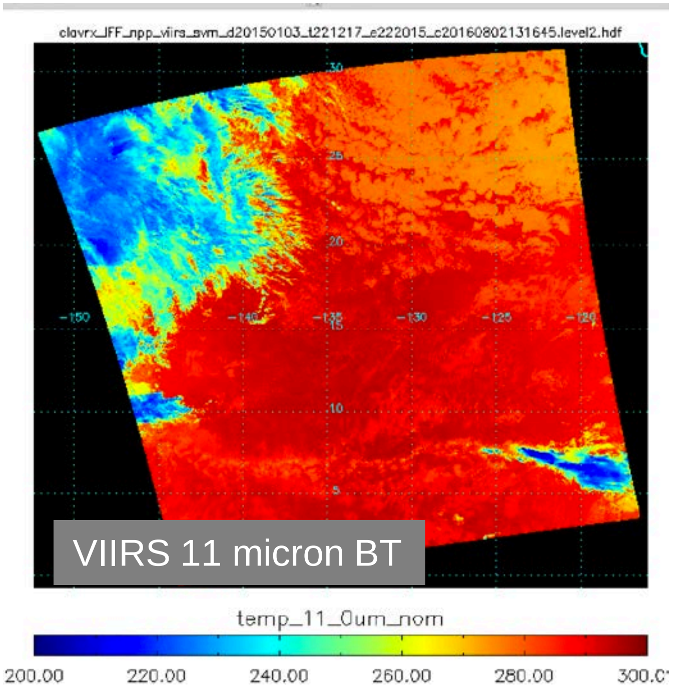
- IR channels in absorbing bands are not influenced by features below the level where their weighting functions approach zero.
- Cloud heights can be used to flag clouds that should be visible or invisible with CrIS observation.
- The maximum cloud height in CrIS FOVs can be used as conservative estimate of cloud vertical extent.
- Actually logic for the use of this information is being developed by Jim Jung and NCEP.
- ***This analysis is just to see if the VIIRS cloud products support this basic approach.***

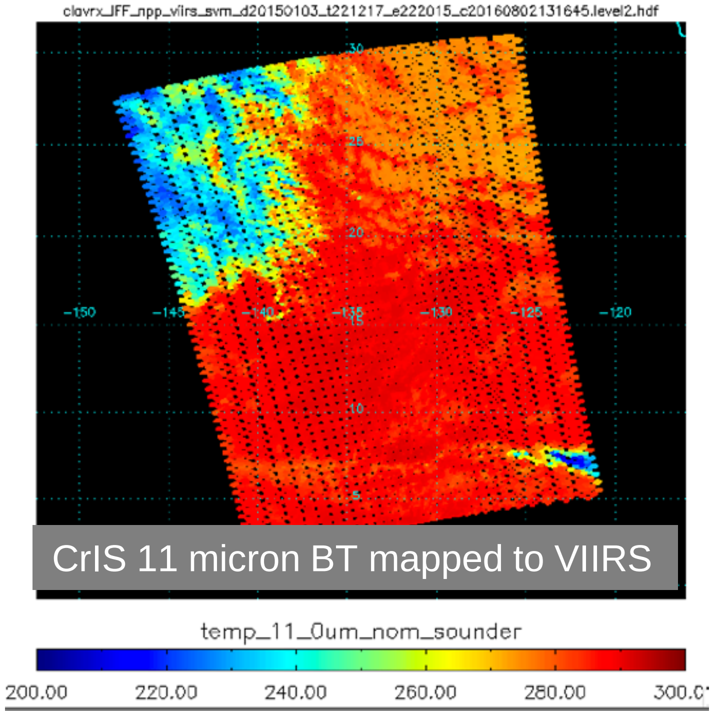


Examples of Using VIIRS Cloud Products for CrIS Cloud Detection

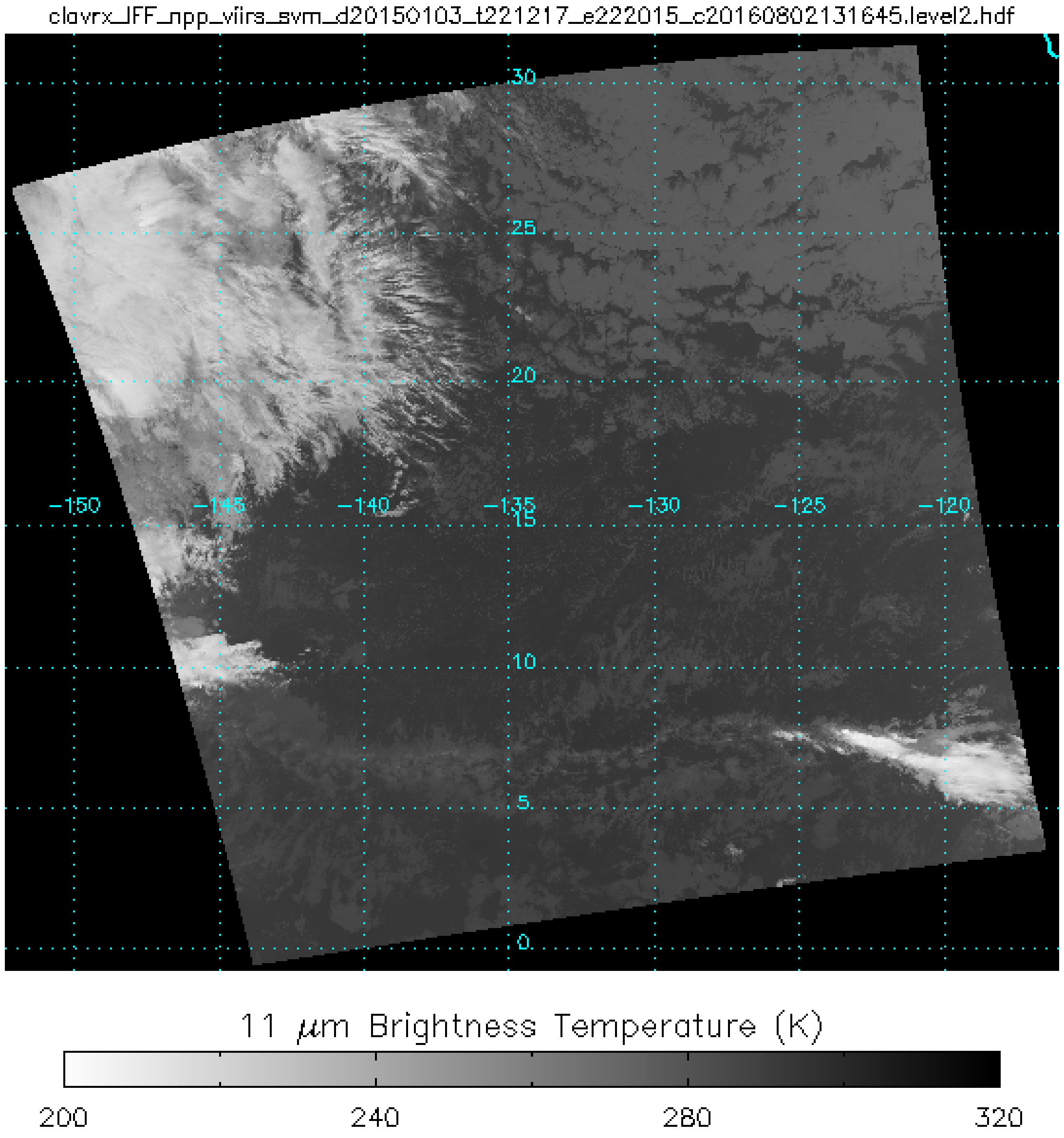
- SSEC has developed tools to map VIIRS into CrIS FOVs and vice versa. These tools create MODIS IR channels from the CrIS spectra.
- We have implemented these tools into CLAVR-x and are expanding the Enterprise Algorithms to use VIIRS and CrIS data (funded by JPSS -RR)
- This gives us the chance to experiment with the use of Enterprise Cloud Properties for detecting clear CrIS pixels.

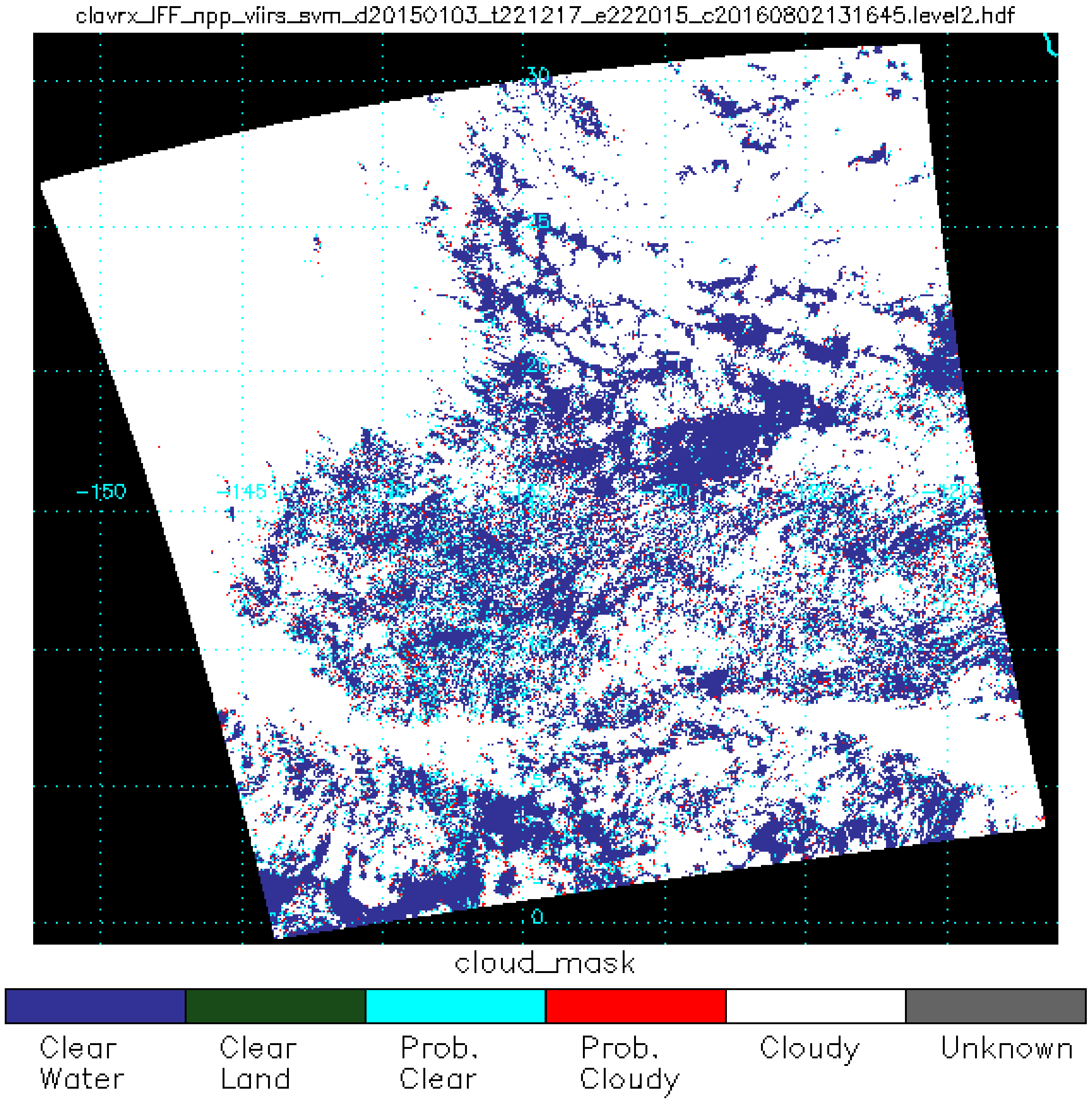




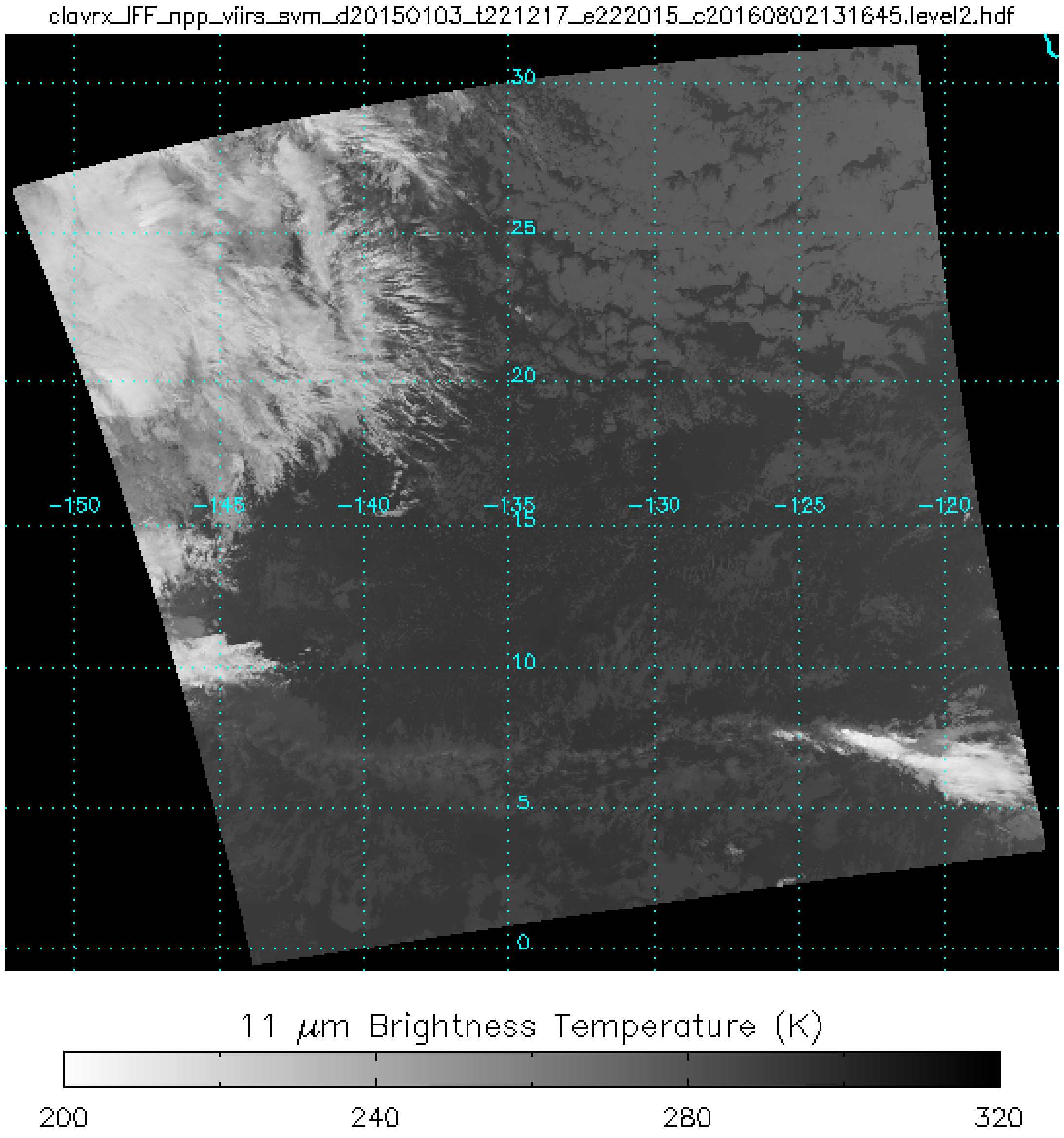


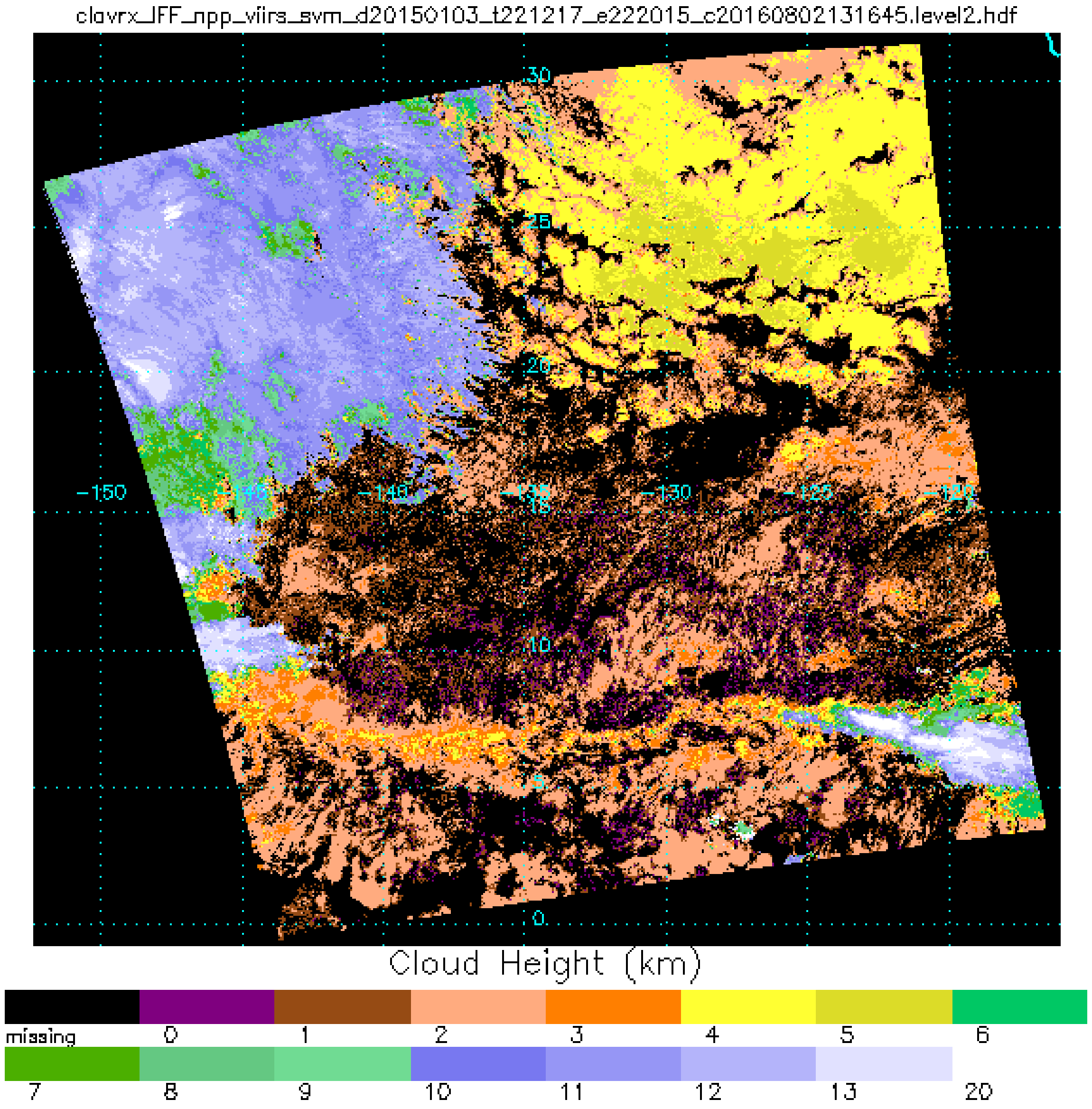
Cloud Mask Result (cloud fraction is mapped into CrIS FOVs.



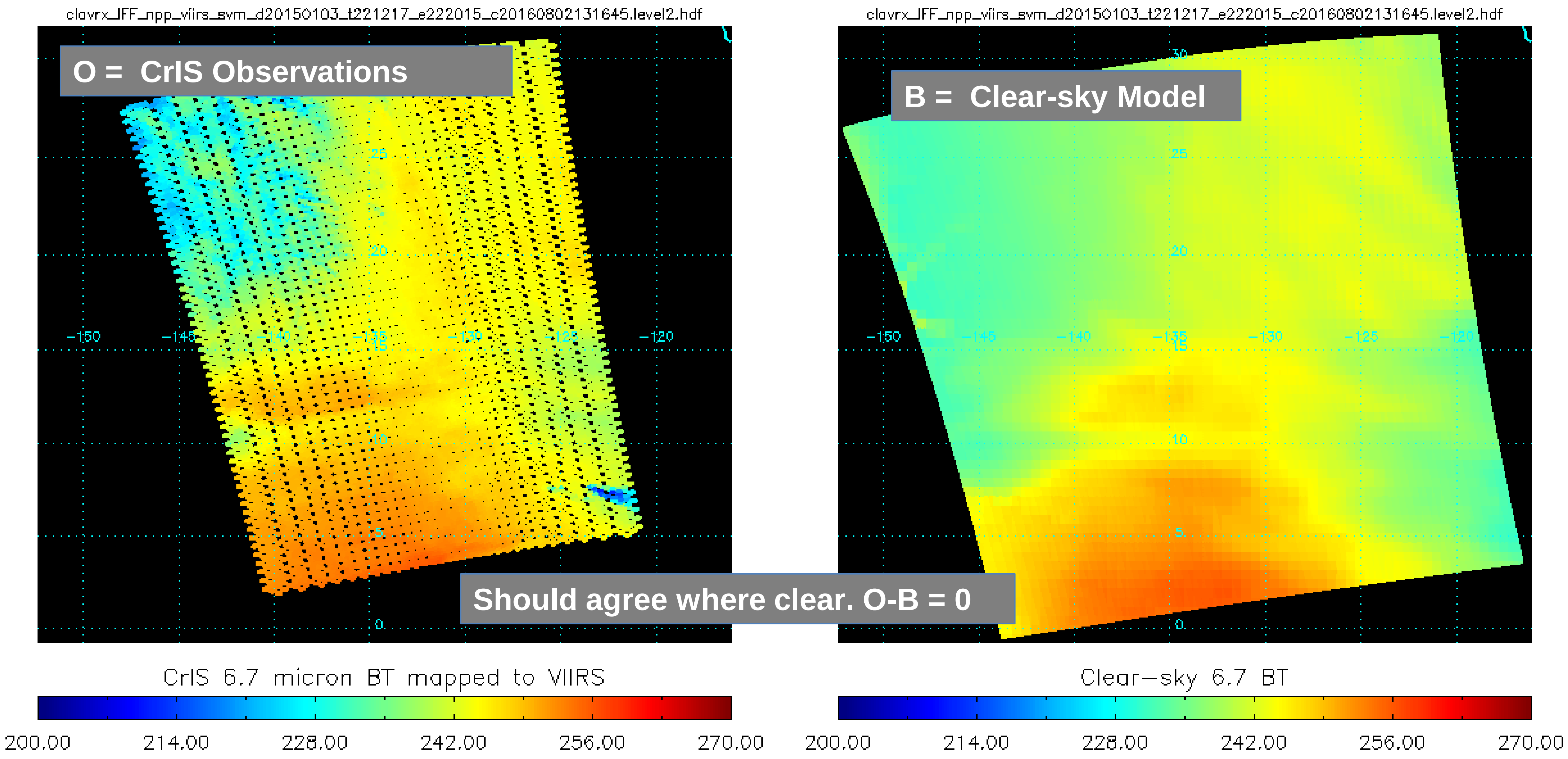


VIIRS Cloud Height (Maximum value in CrIS FOV is used)

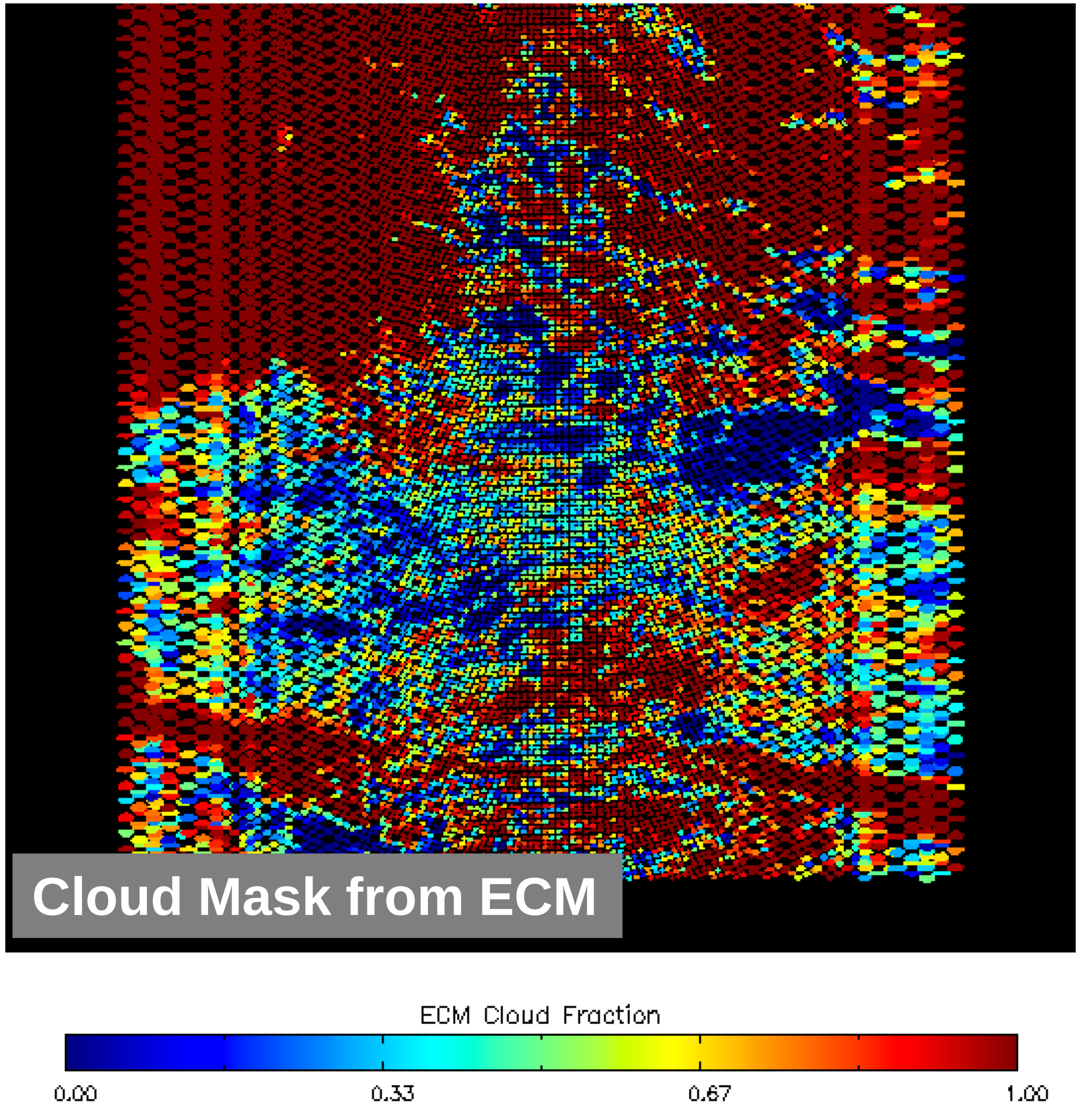


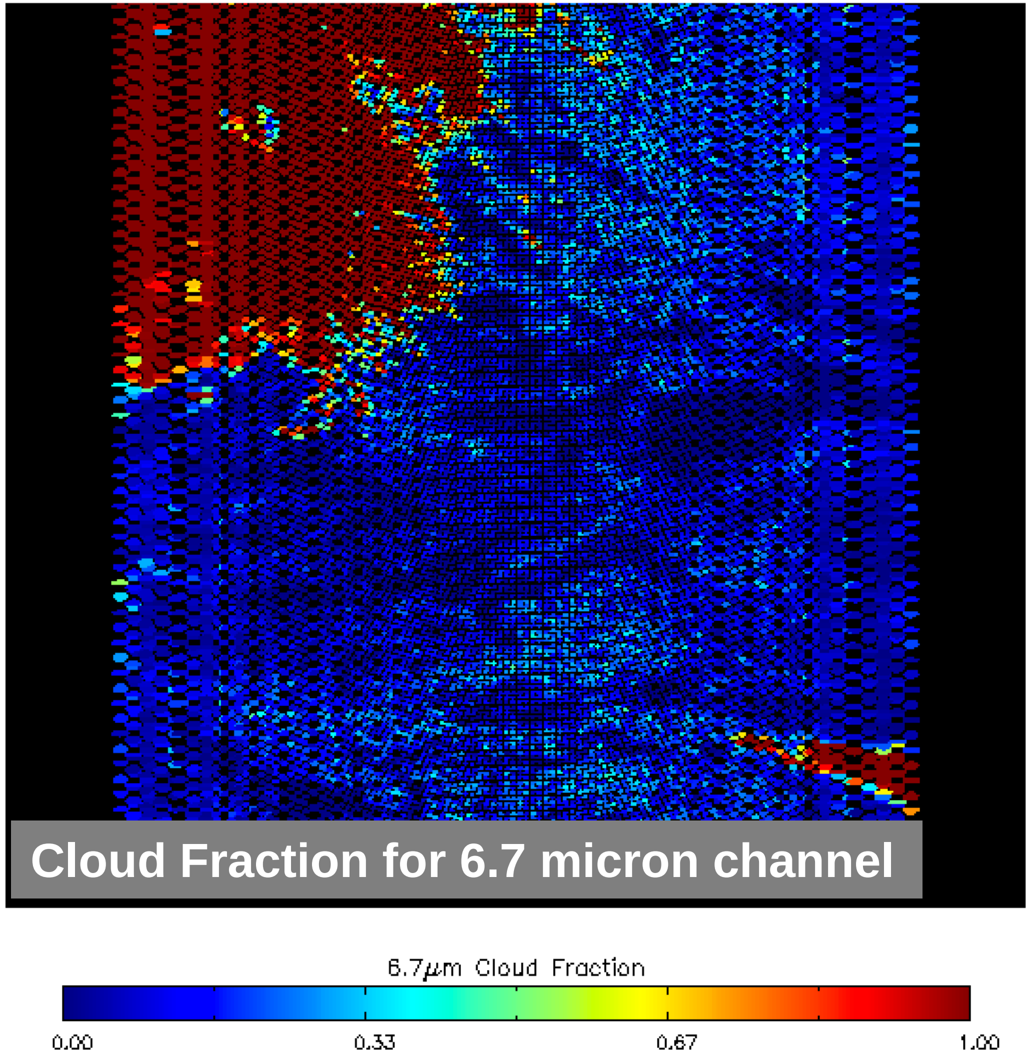


Validating the use of VIIRS Cloud Products for CrIS Cloud Detection



Resulting Cloud Mask for 6.7 micron channel.





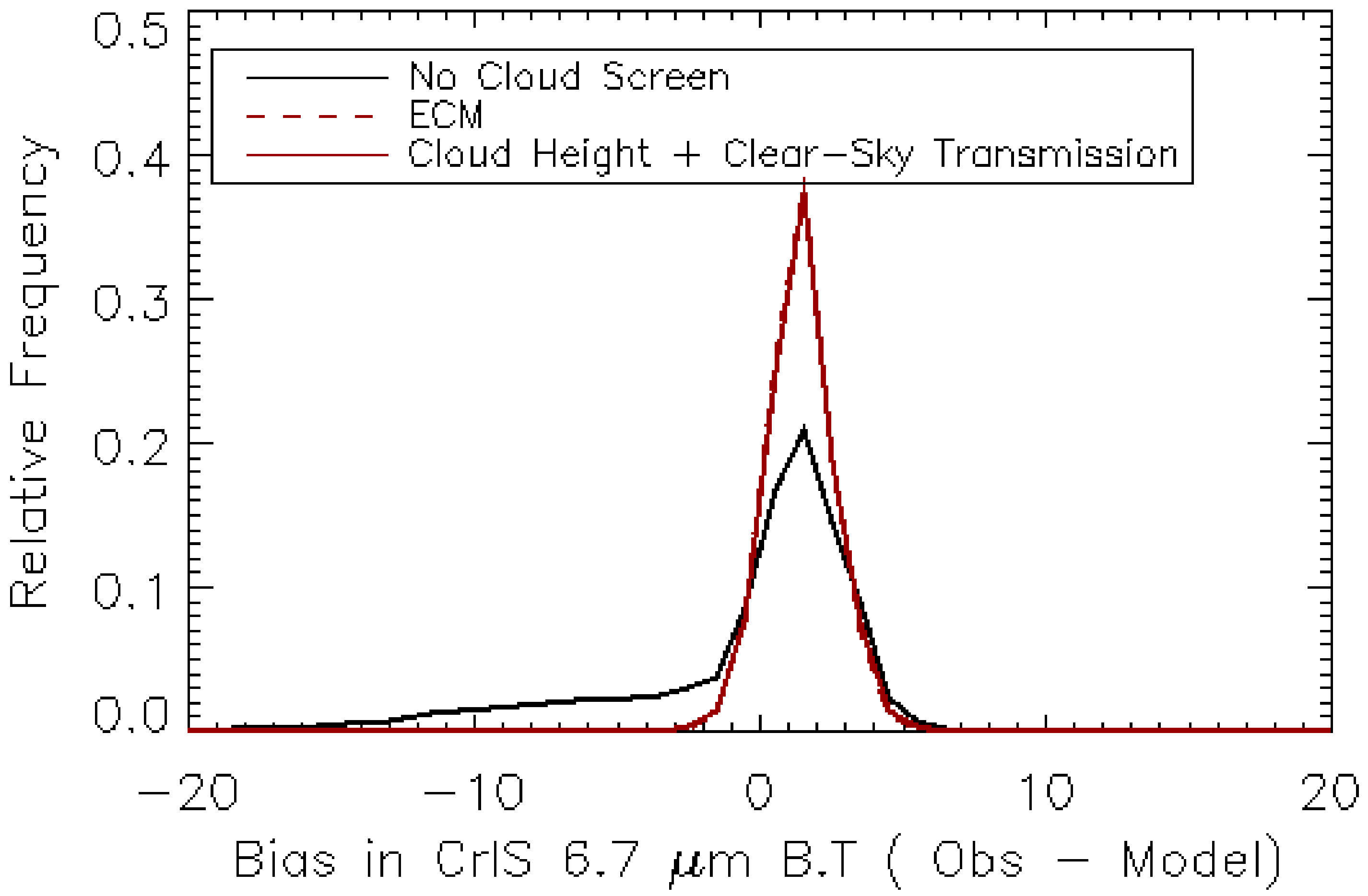
Results

- Our analysis shows that VIIRS cloud heights and cloud fractions are effective cloud screens for CrIS.

- This example shows that cloud heights coupled with the CrIS weighting functions can detect clouds that are invisible and reclassify them as clear.

- The resulting clear distribution matches that from the full cloud mask (ECM) but has many more points due to the recovery of CrIS FOVs with low clouds.

Clear-sky 6.7 radiance distribution using Cloud Height and RTM matches quality of direct use of ECM but provides many more pixels.



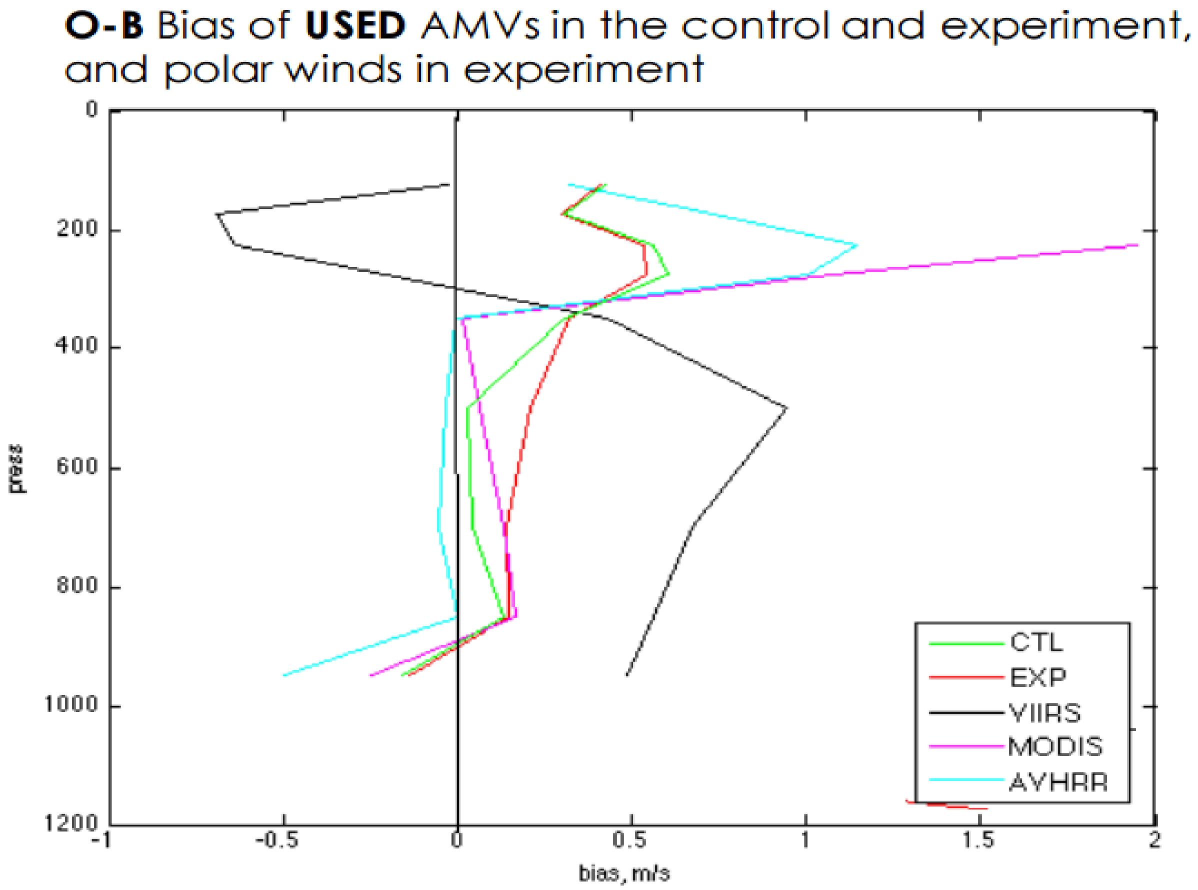
Cloud Heights for Polar Winds

What is Special about the Poles

- Large inversions are common which span from the surface to 2-4 km.
- Water clouds appear at much colder temperatures than at other latitudes and this makes IR cloud phase detection more challenging.
- Cloud detection is also a challenge. Clouds can be warmer than the surface and terminator conditions are prevalent at times.
- RTM accuracy is lower.

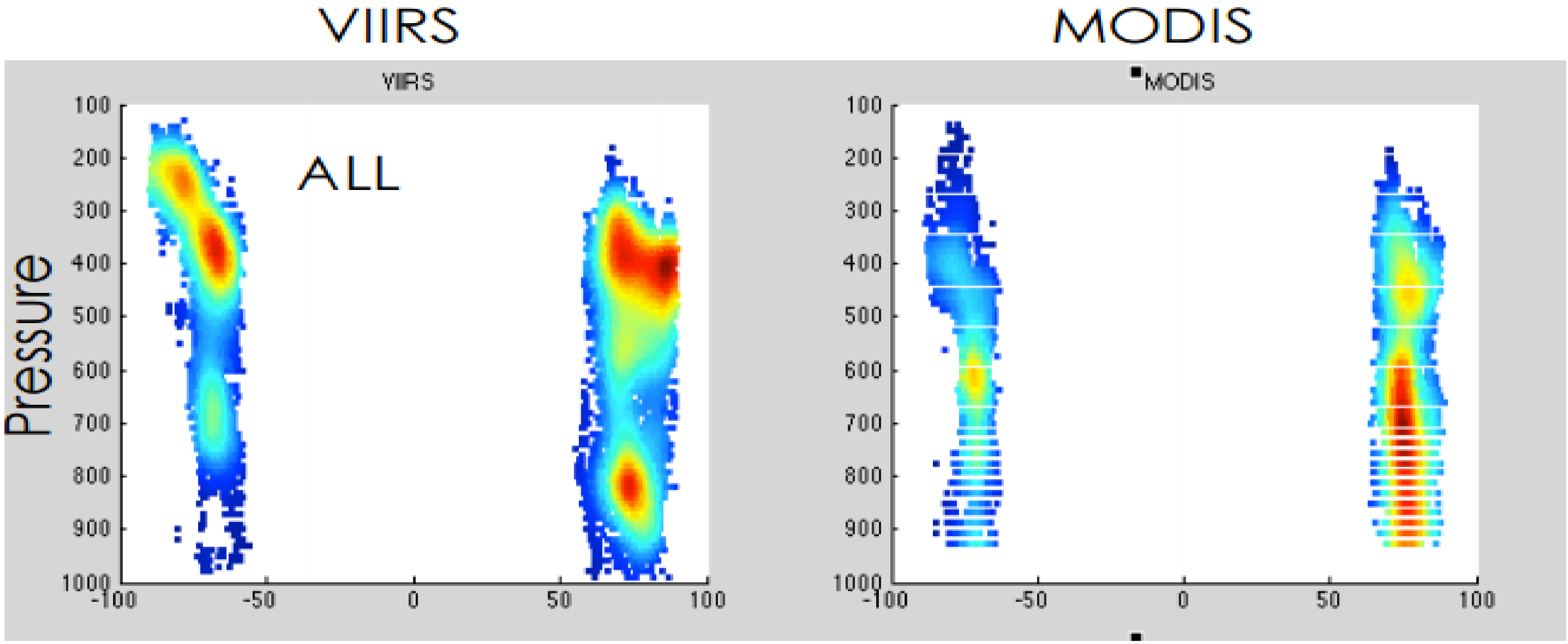
Impact on Polar Winds

- **Iliana Genkova (IMSG/NCEP@CIMSS) has found biases in the VIIRS Polar Winds.**
- **These biases are likely due to biases in the cloud height.**
- **NESDIS Polar Winds code is an older version of the Enterprise Algorithms that uses some aspects of the IDPS products.**
- **MODIS and AVHRR Polar Winds use a heritage system (WINDCO)**



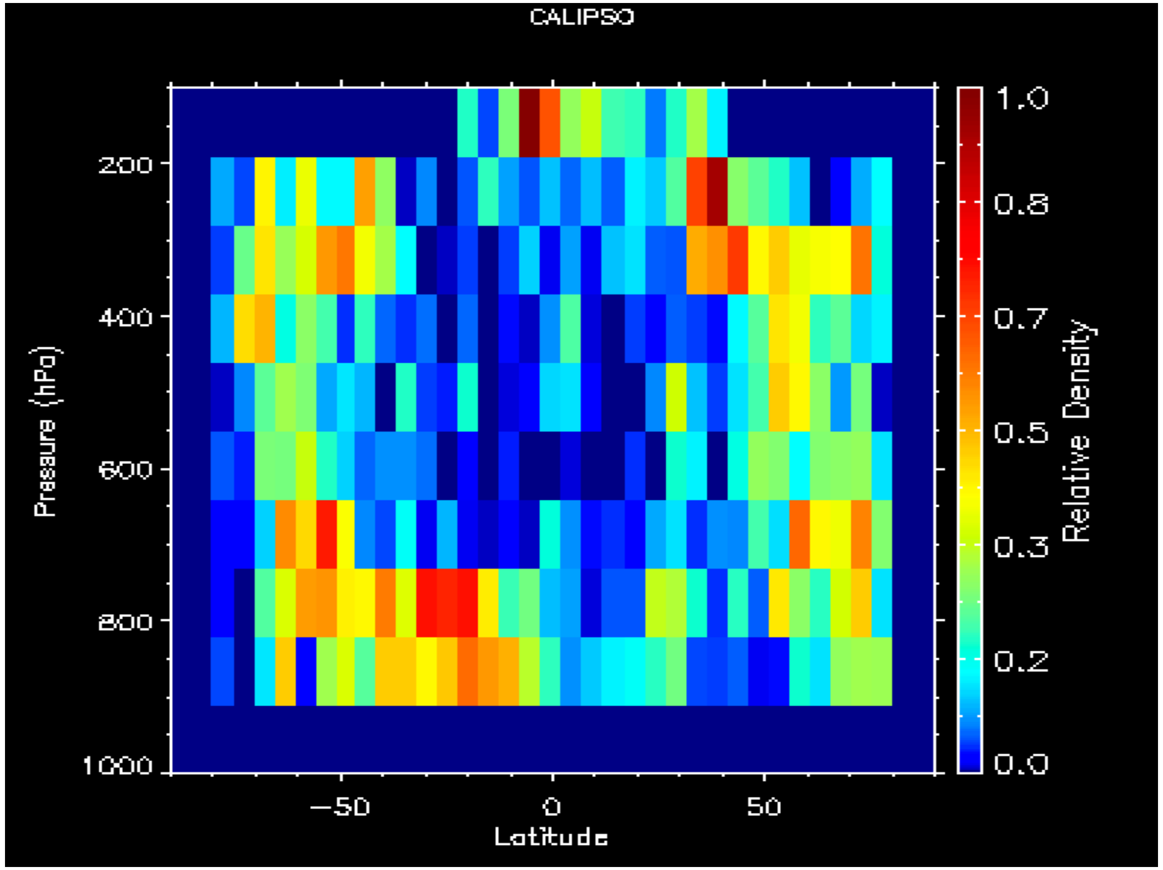
VIIRS Height Issues

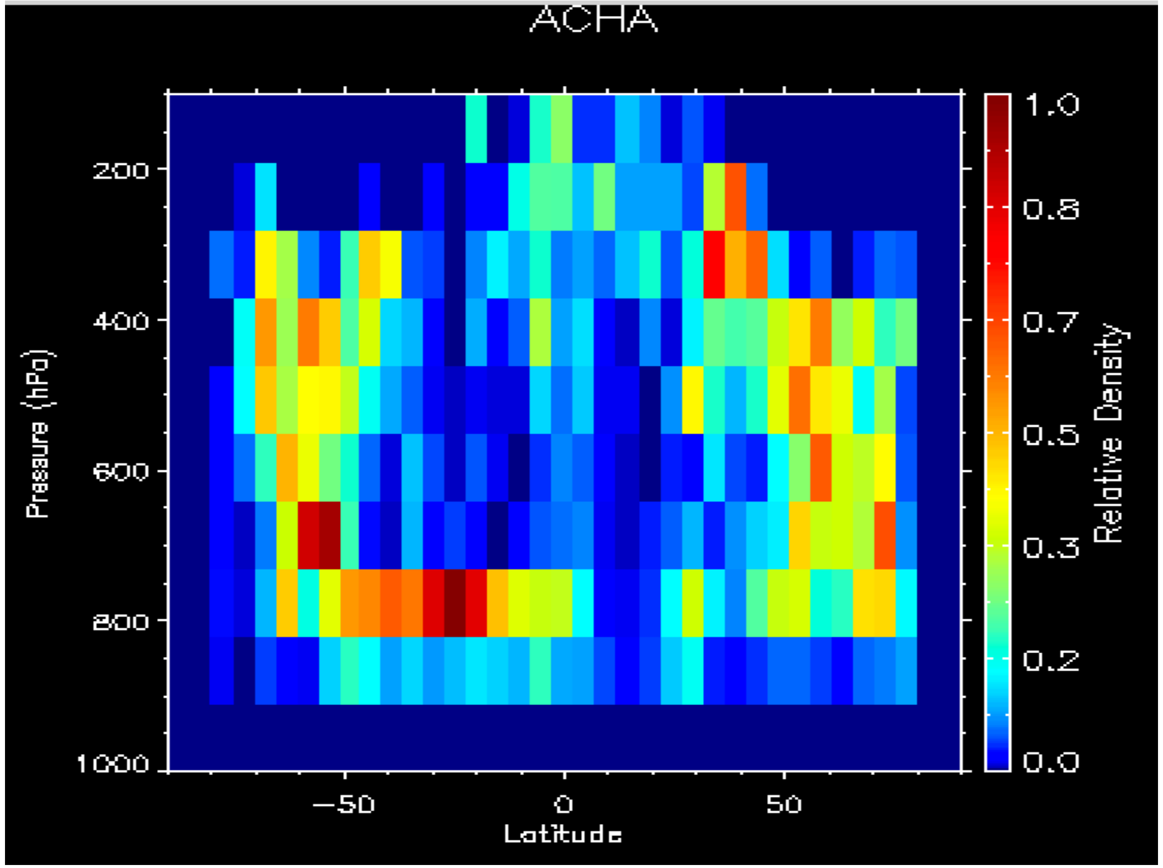
- Analysis by Iliana Genkova (EMC/IMSG) has indicated that the “Enterprise” heights distributions have higher clouds. 2 months of data shown (September and October)
- VIIRS results shows peaks at 300 – 400 hPa
- MODIS results don’t show these peaks.
- Do we see this in the new Enterprise Data?



SAPF Enterprise Cloud Height Results October 2014

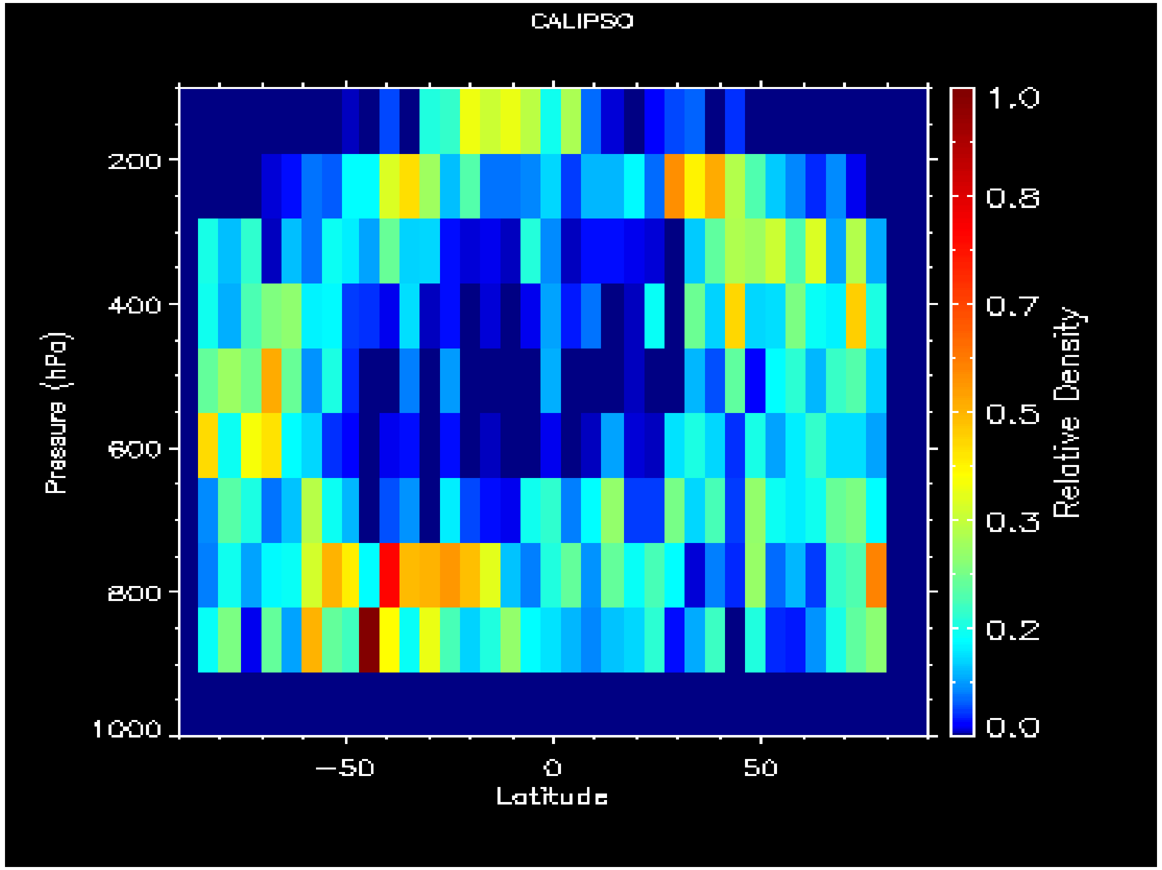
- Comparison of Latitude and Pressure distribution cloud top retrievals for October 2014
- We don't see the over-estimation of Arctic Heights for this day.
- We have limited SAPF output in the September-October period with CALIPSO matches.
- CALIPSO does not observe poleward of 80 degrees.
- CALIPSO = NASA spaceborne lidar
- ACHA = AWG Cloud Height Algorithm

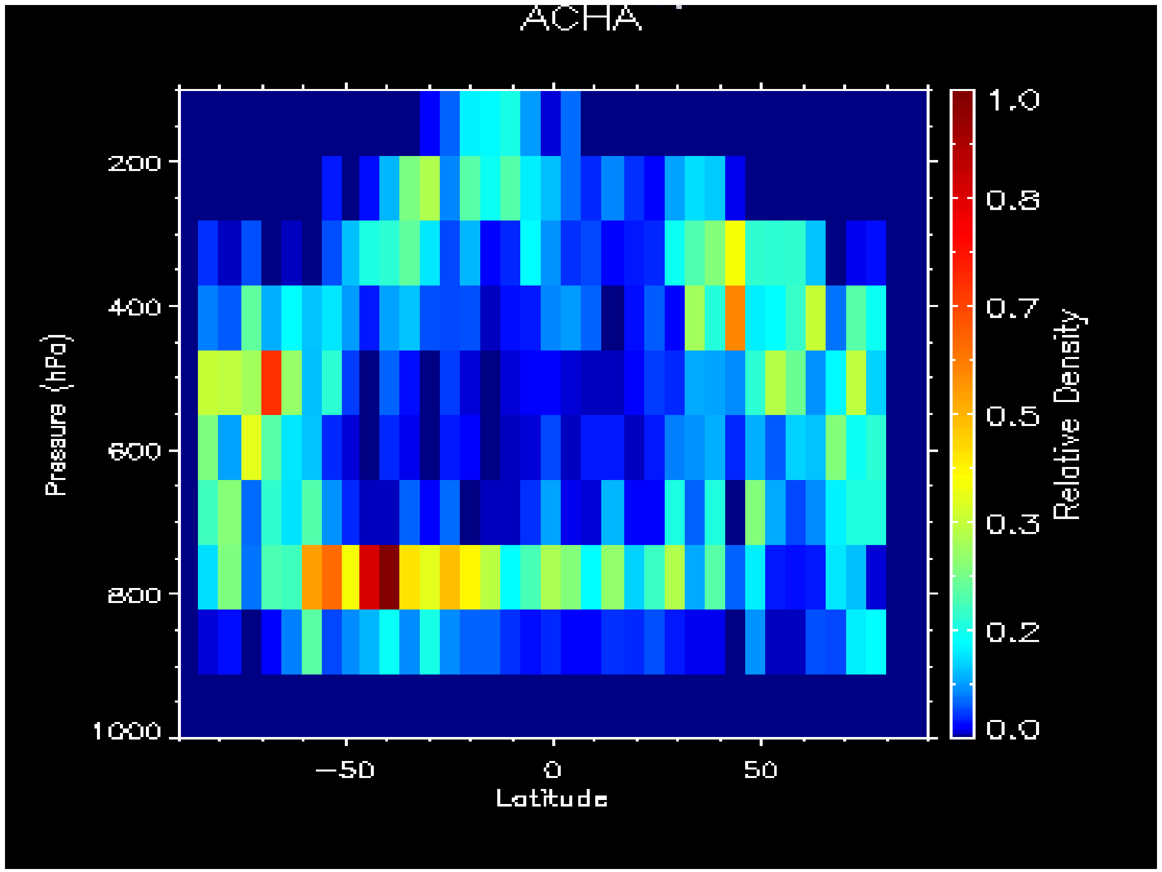




SAPF Enterprise Cloud Height Results January 2015

- Comparison of Latitude and Pressure distribution cloud top retrievals for January 3, 2015





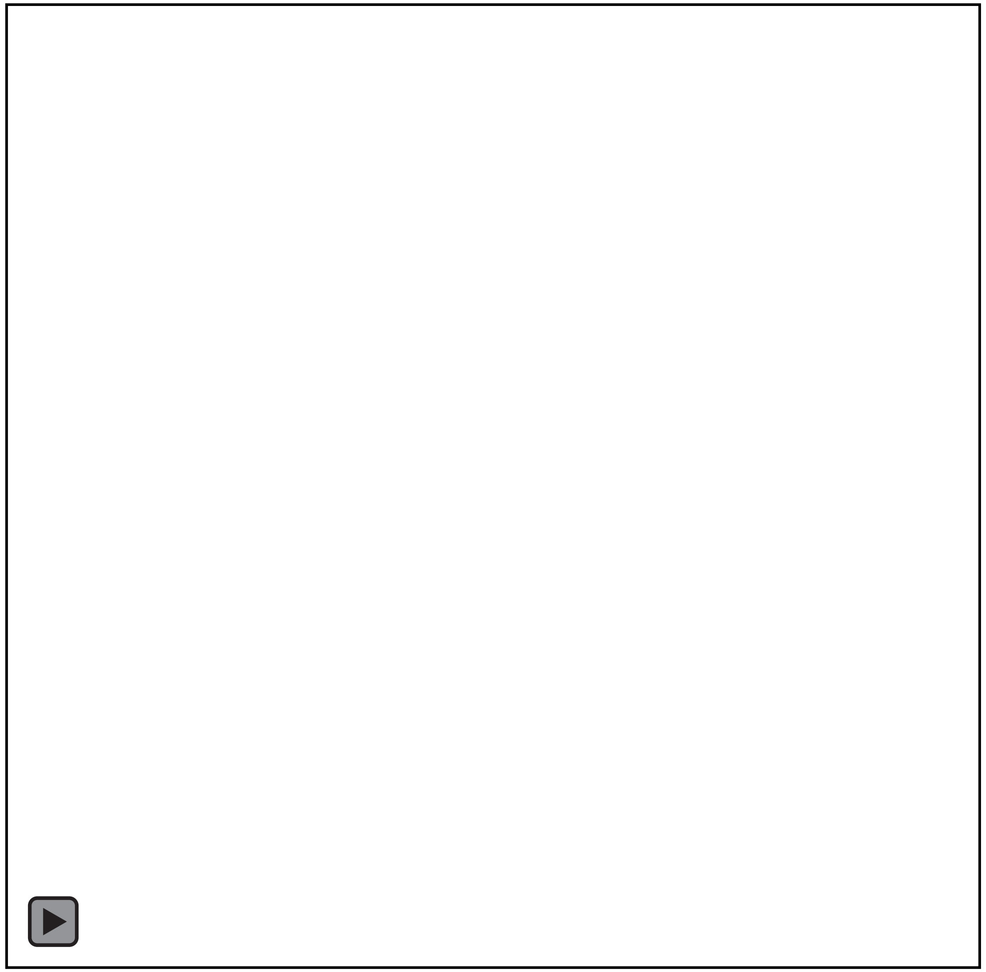
Collaboration with NOAA/CIMSS Polar AMV Team

- GOES-R AMV Software is operational at STAR with VIIRS. MODIS and AVHRR transition is ongoing.
- DB Sites (McMurdo, Sodankyla, Fairbanks, Barrow, and Rothera) continue to use the C version of WINDCO software for AMV production.

- Cloud products are also in demand from the DB sites.

- Collaboration Plan
  – Run CSPP for cloud products at DB sites.
  – Run GOES-R AMV software, using CSPP data as input.
  – Distribute new products to AMV/NWP community.

- Cloud Team will develop test cases to test impacts on Polar Winds for future updates.



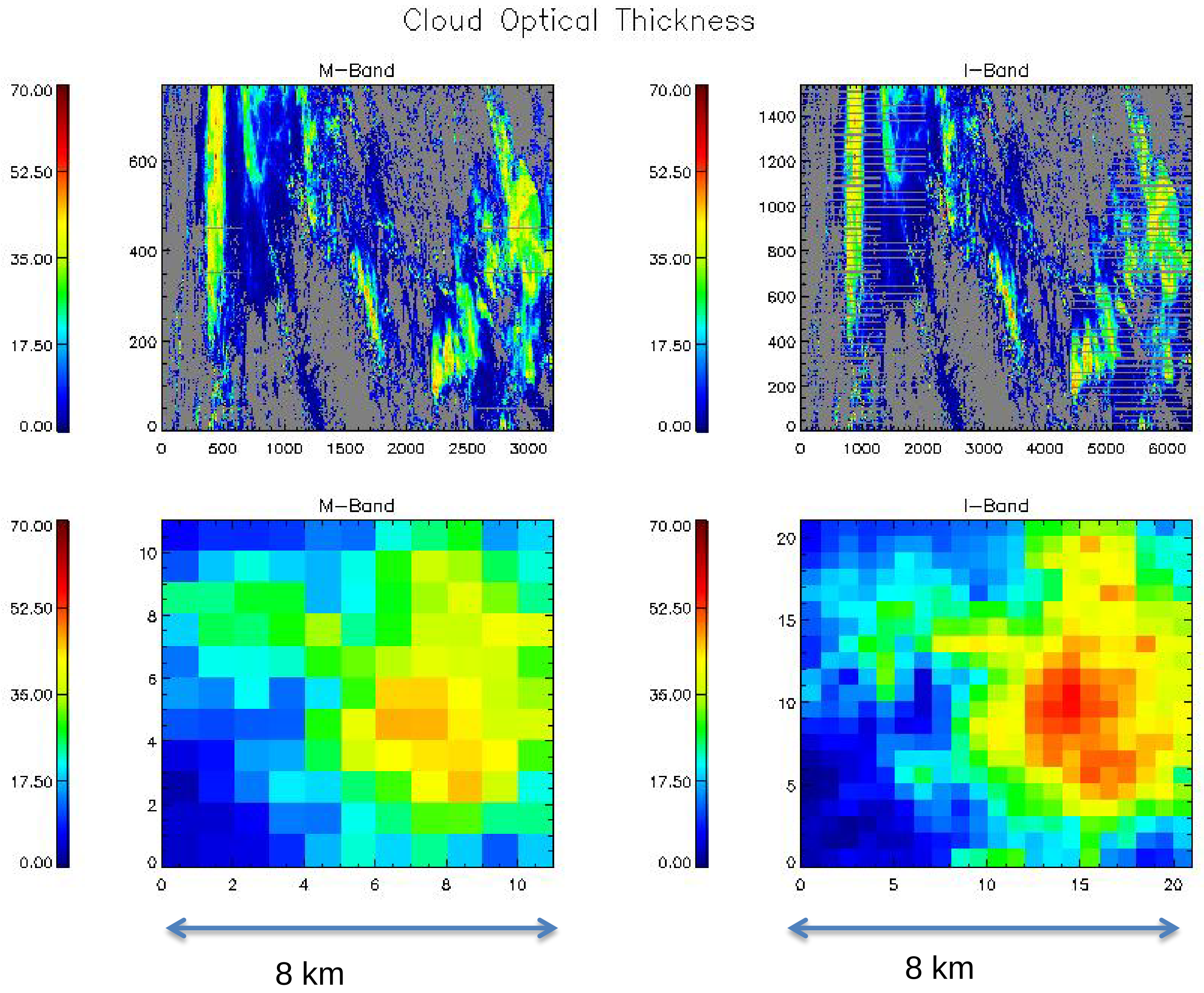
Conclusions

- We are placing a high priority in ensuring Enterprise Cloud Products meet the needs of these two applications.
- We are optimistic that the Enterprise code going operational in the fall does not show the issues seen with the current products
- We will will run our own Polar Winds test cases soon to dig deeper into this.
- We look forward to working with NCEP on the use of VIIRS products mapped into CrIS FOVs.

VIIRS I-Bands – An Area of Growth for Enterprise Cloud Algorithms

- Cloud features can be spatially finer than the VIIRS M-bands.
- The VIIRS I-bands over AVHRR-like capability at 375m.
- Since the Enterprise cloud algorithms are meant to process all data, they function on the VIIRS I-bands.
- CLAVR-x modified to do this but SAPF does already support I-bands.
- Example on right shows an example of DCOMP Cloud Optical Depth.
- Why is this important?

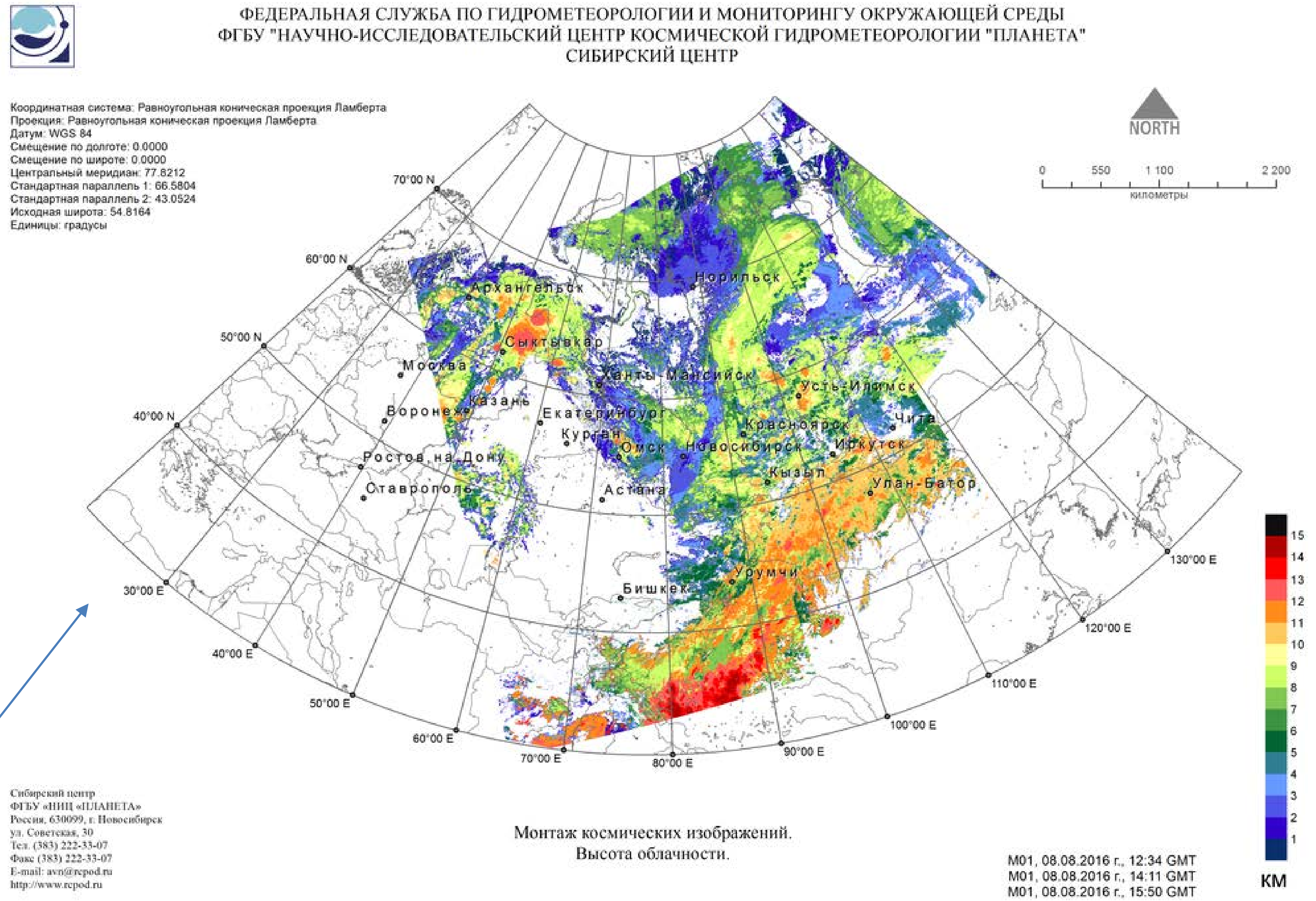
➢ Better resolution of cloud top microphysics in convective storms.
➢ Better characterization of CrIS pixels
➢ Better capture of small scale precip
➢ Better treatment of surface radiation gradients (solar energy).



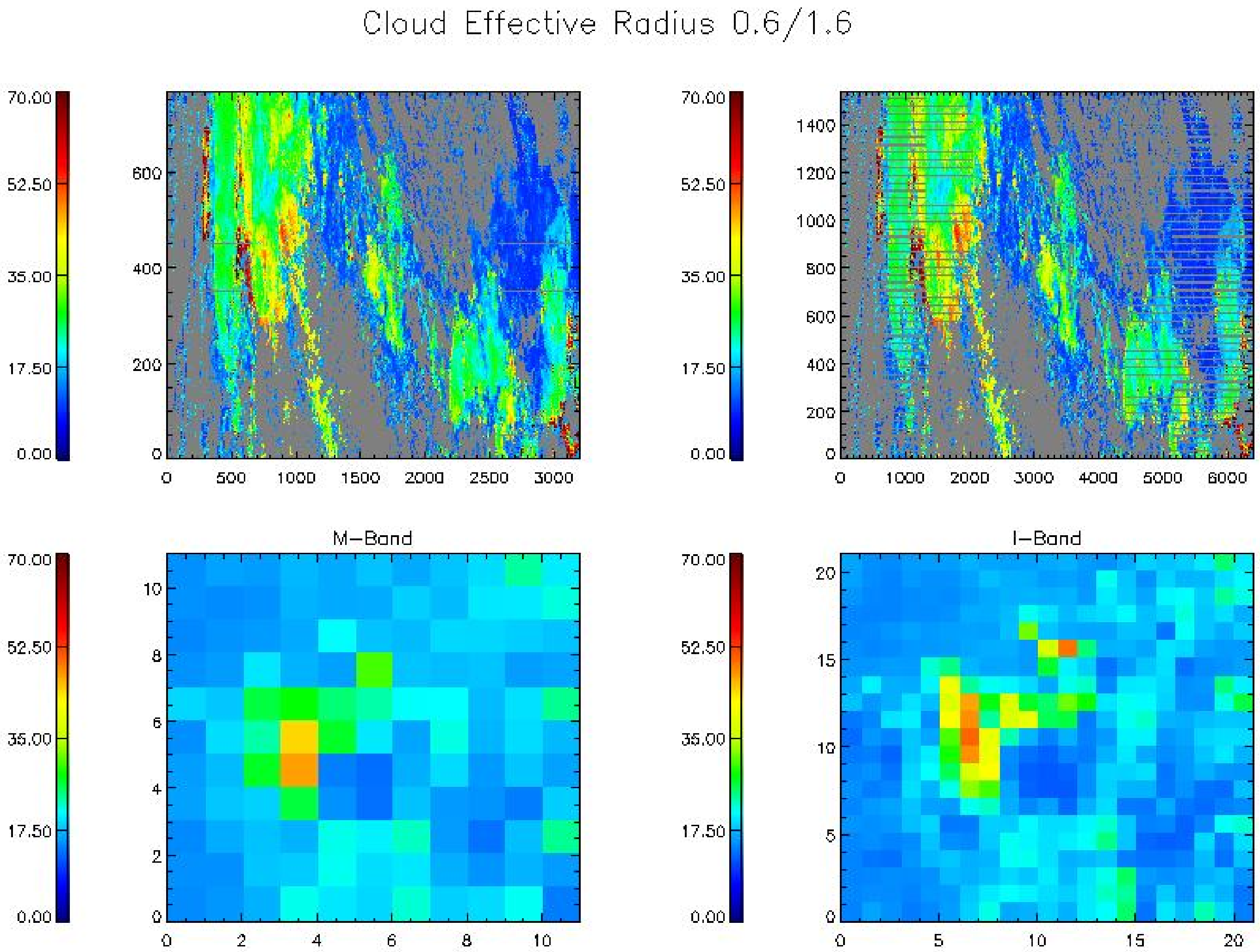
CSPP LEO / CLAVR-x Providing NOAA Enterprise Clouds to DB

- The NOAA Enterprise Cloud Algorithms are distributed through UW/SSEC CSPP LEO.
- CSPP LEO runs NESDIS CLAVR-x.
- Provided good feedback for VIIRS Enterprise cloud products before operational in NDE this fall.
- Roughly 50 downloads
- Active communication with a Russian Remote Sensing Company that sells services to the Russian Weather Agency.
- Goal is to release updates in step with our deliveries to SAPF. (ahead of operations but in-sync with ASSIST)
- CSPP LEO supports VIIRS DNB usage. We hope to transition this to SAPF.

Example CSPP LEO CLAVR-x image provided by Russian CSPP customer



Cloud Effective Radius



THE NEWLY OPERATIONAL VIIRS CLOUD BASE AND CCL (CLOUD COVER/LAYERS)

Yoo-Jeong Noh
(CIRA/Colorado State University)

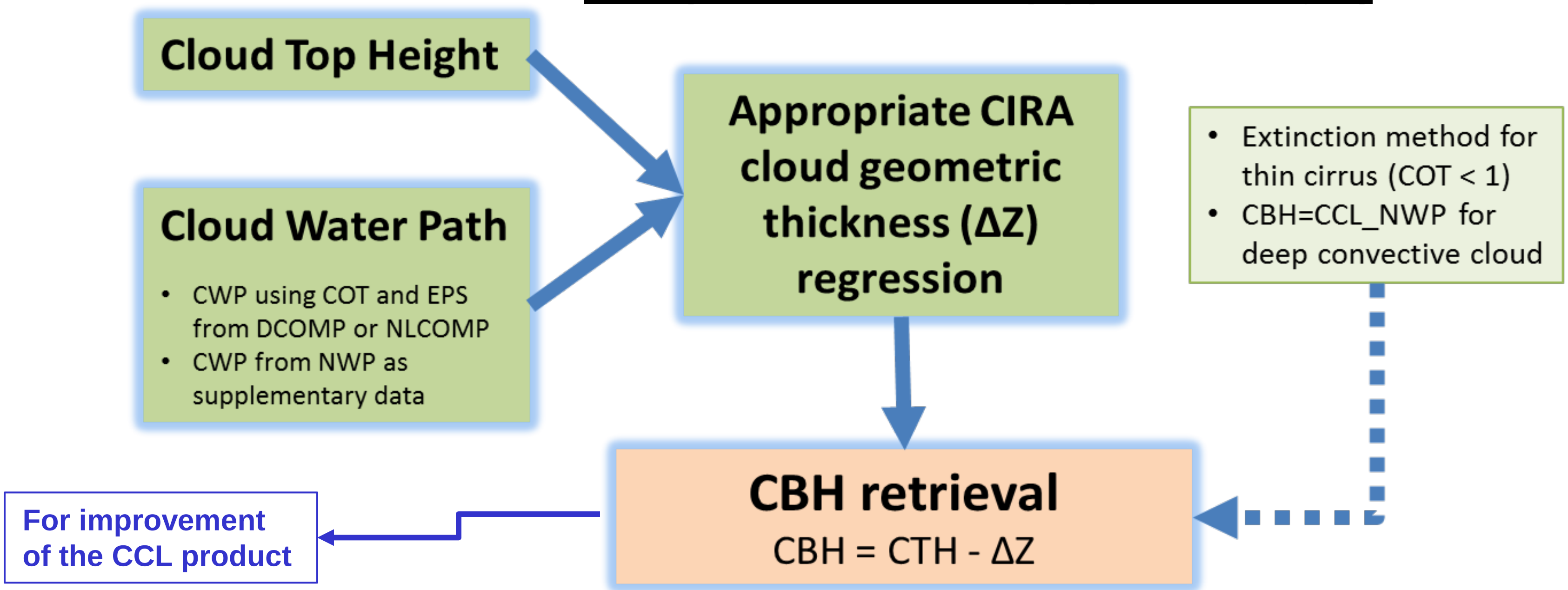
with
Steve Miller, John Forsythe, Curtis Seaman (CIRA)
Dan Lindsey, Andy Heidinger (NOAA/StAR),
and Yue Li (CIMSS)

Introduction

- Knowledge of Cloud Base Height (CBH) is critical to describing cloud radiative feedbacks in numerical models and is of practical significance to aviation communities.
- We developed a new CBH algorithm constrained by Cloud Top Height (CTH) and Cloud Water Path (CWP) using a statistical analysis of A-Train satellite data. It includes an extinction-based method for thin cirrus.
- The cloud base information is a key parameter for an improved Cloud Cover/Layers (CCL) product for lower clouds.
- The CBH product has been applied to Suomi-NPP VIIRS and intensively evaluated against CloudSat data. The results showed the new algorithm yields significantly improved performance over the original VIIRS IDPS CBH algorithm.

Enterprise CBH Algorithm

Enterprise Cloud Base (Uppermost Layer)



- The first version of the CBH algorithm and ATBD was delivered to the STAR Algorithm Implementation Team in February 2016. The CIRA and CIMSS team is now evaluating the operational test output.

✓ Seaman, C. J., Y. J. Noh, S. D. Miller, A. K. Heidinger, and D. T. Lindsey, 2016: Cloud Base Height Estimation from VIIRS. Part I: Operational algorithm validation against CloudSat. *J. Atmos. Ocean. Tech., submitted.*

✓ Noh, Y. J., J. M. Forsythe, S. D. Miller, C. J. Seaman, Y. Li, A. K. Heidinger, D. T. Lindsey, M. Rogers, and P. Partain, 2016: Cloud Base Height Estimation from VIIRS. Part II: Development of a statistical cloud base height retrieval algorithm using A-Train satellite data. *J. Atmos. Ocean. Tech., submitted.*

Product Overview and Status

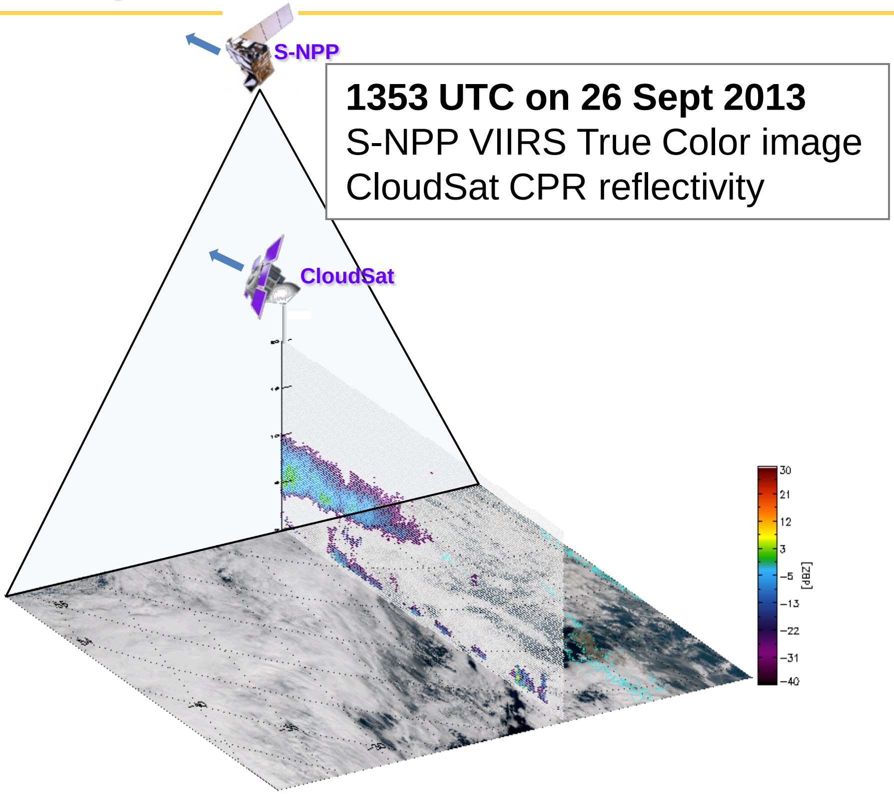
- Performance Summary

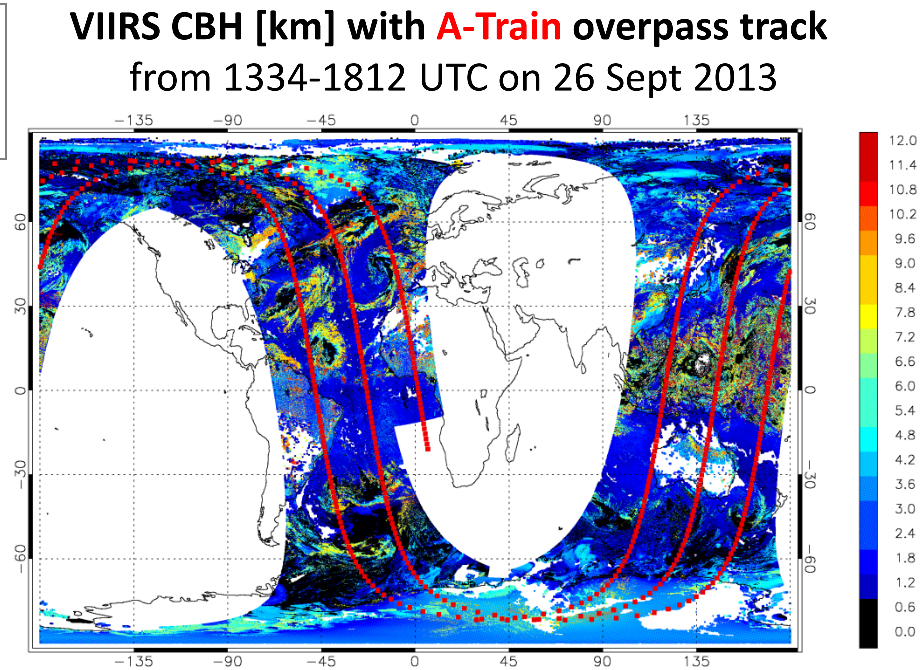
Product	L1RDS Specification	Bias Estimate (mean)	Standard Deviation Estimate
CBH	2 km	0.4 km	1.6 km

(from 5-month matchup comparisons between VIIRS CBH and CloudSat observations)

- The Enterprise CBH algorithm code has been delivered to the STAR Algorithm Implementation Team, now being tested in the operational frame.
- New work in progress
  - ✓ Combine CloudSat and CALIPSO for more robust validation.
  - ✓ Assess the nighttime performance using ground-based measurements.
  - ✓ Improve CCL products using the cloud base information.
  - ✓ Additional algorithm refinements: adopt an adiabatic model for low marine boundary layer clouds.

Matching VIIRS with CloudSat



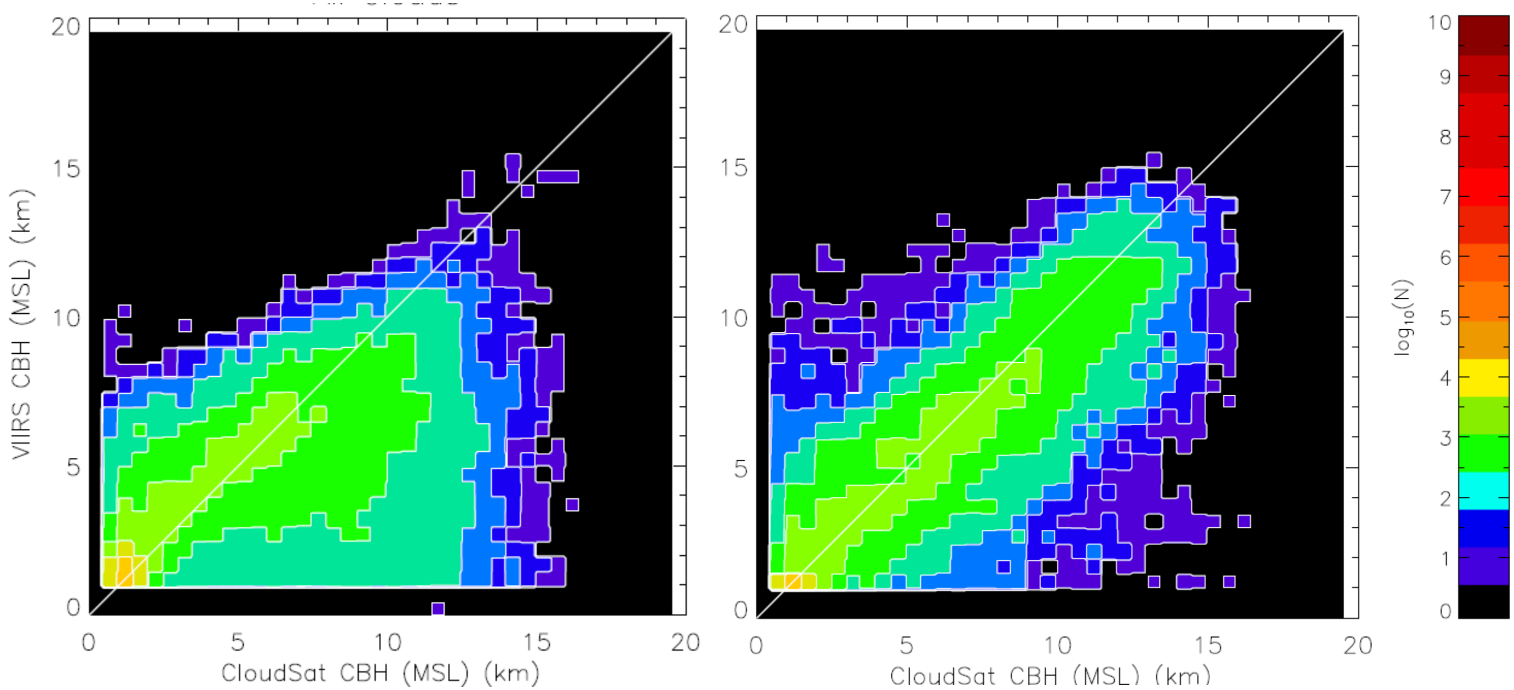


- The CBH product has been applied to Suomi-NPP VIIRS and intensively evaluated against CloudSat data.
- CloudSat-VIIRS overlap for ~4.5 hours every 2-3 days (8-9 matchups per month)
- Due to battery issues, CloudSat only operates on the **daytime** side of the Earth
- Use only the closest VIIRS pixels that overlap CloudSat and have CBH above 1 km

IDPS vs. Enterprise CBH: “Within Spec”

The enterprise CBH performs better.

The original IDPS with CLAVR-x input | **CIRA Statistical Regressions**

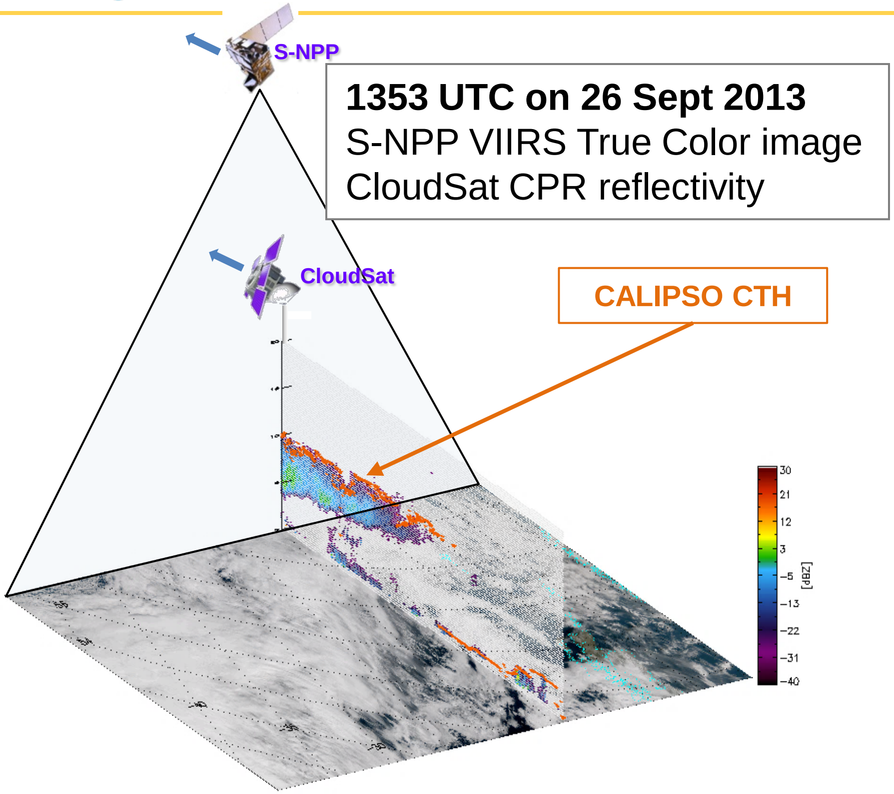


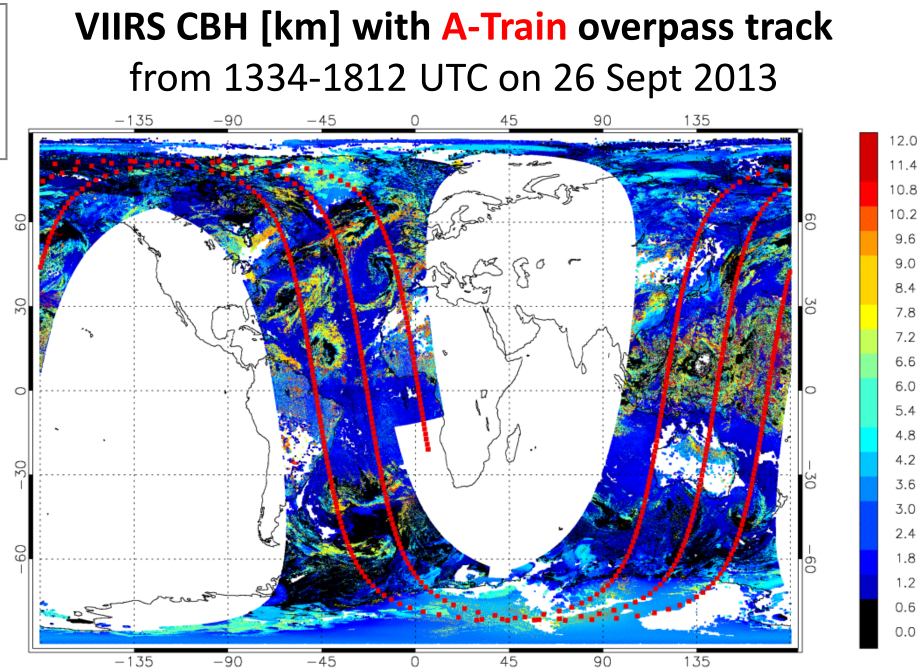
- “**Within Spec**” evaluation for only clouds where the VIIRS CTH retrieval is within the error specifications: CTH within 1 km of CloudSat CTH if COT $\geq$ 1, or within 2 km if COT < 1 (82599 matchup points for Sept-Oct 2013)

CBH [km]	Avg error (bias)	RMSE	Std of error	r^2
IDPS	0.7	2.7	2.6	0.45
Enterprise	0.3	1.8	1.8	0.76

✓ **Much better!**

Matching VIIRS with CloudSat and CALIPSO

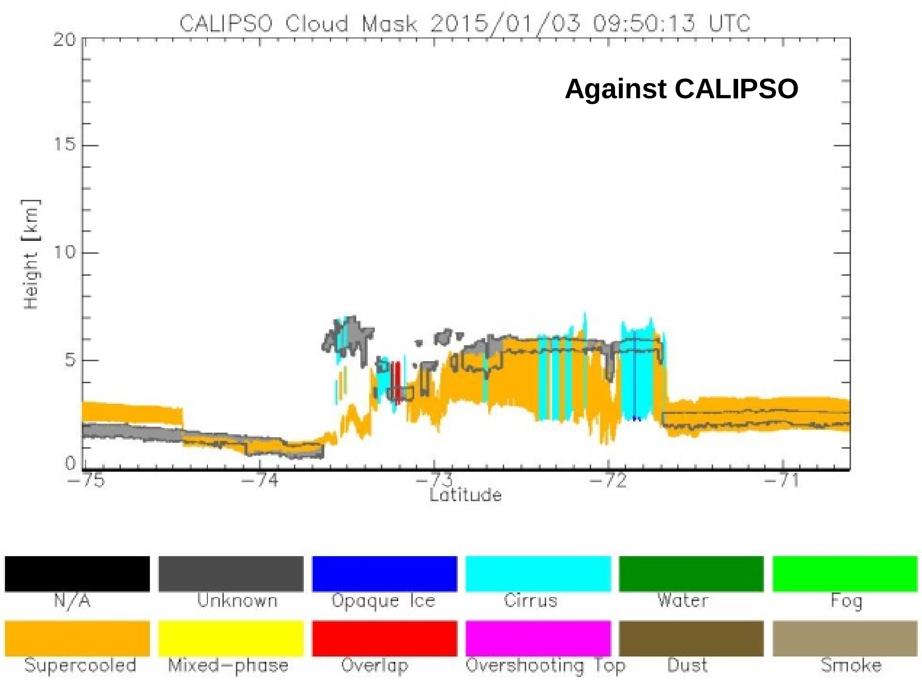


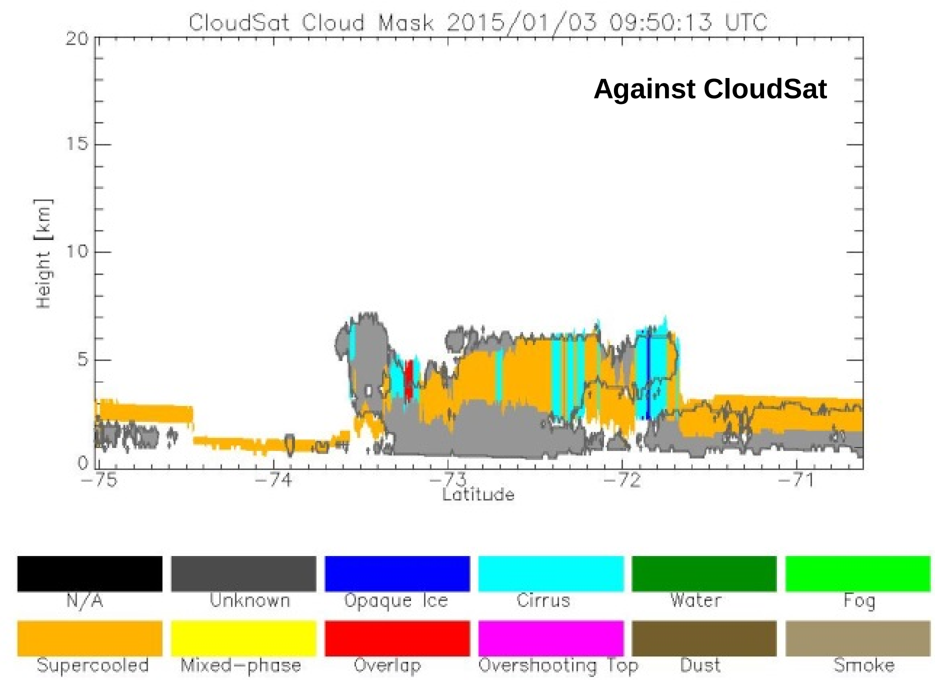


- CALIPSO data is added for validation of optically thin clouds and low water clouds that are often missed by CloudSat.
- The 2B-GEOPROF-LIDAR product is no longer available since the CloudSat battery anomaly in 2011, which made it difficult to maintain tight formation flying of CALIPSO and CloudSat, but they are still within the same orbit.
- CALIPSO Level2 1-km Cloud Layer product used for the matchup.

CBH Validation adding CALIPSO

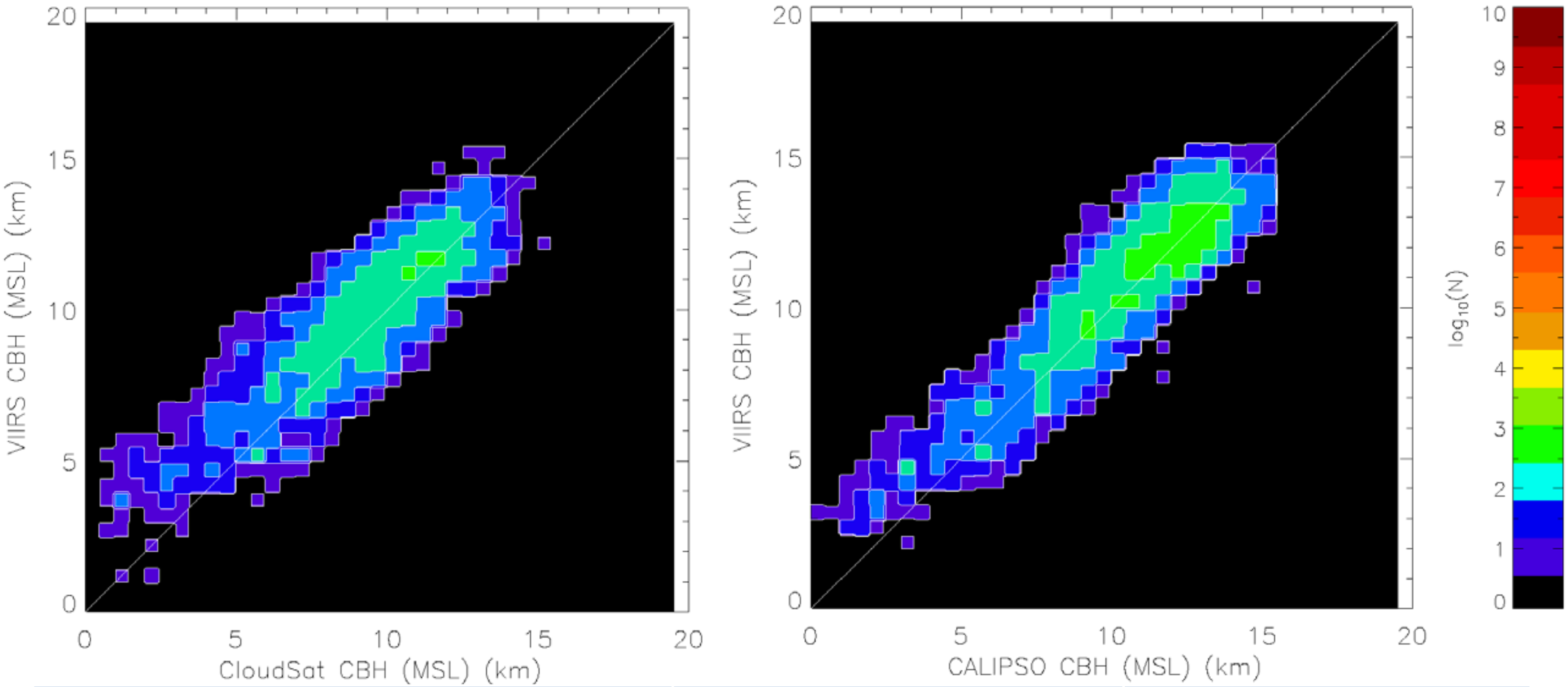
- Topmost layer CBH and CTH data are used for thin clouds (COT<1) and water clouds during Sep-Oct 2013 matchup period.
- **Cloud detection** greatly increases from 5518 to 8738 profiles (within spec) by CALIPSO for thin clouds and from 8730 to 40840 for low water clouds by combining CloudSat/CALIPSO.





Validation of Thin Clouds Using CALIPSO

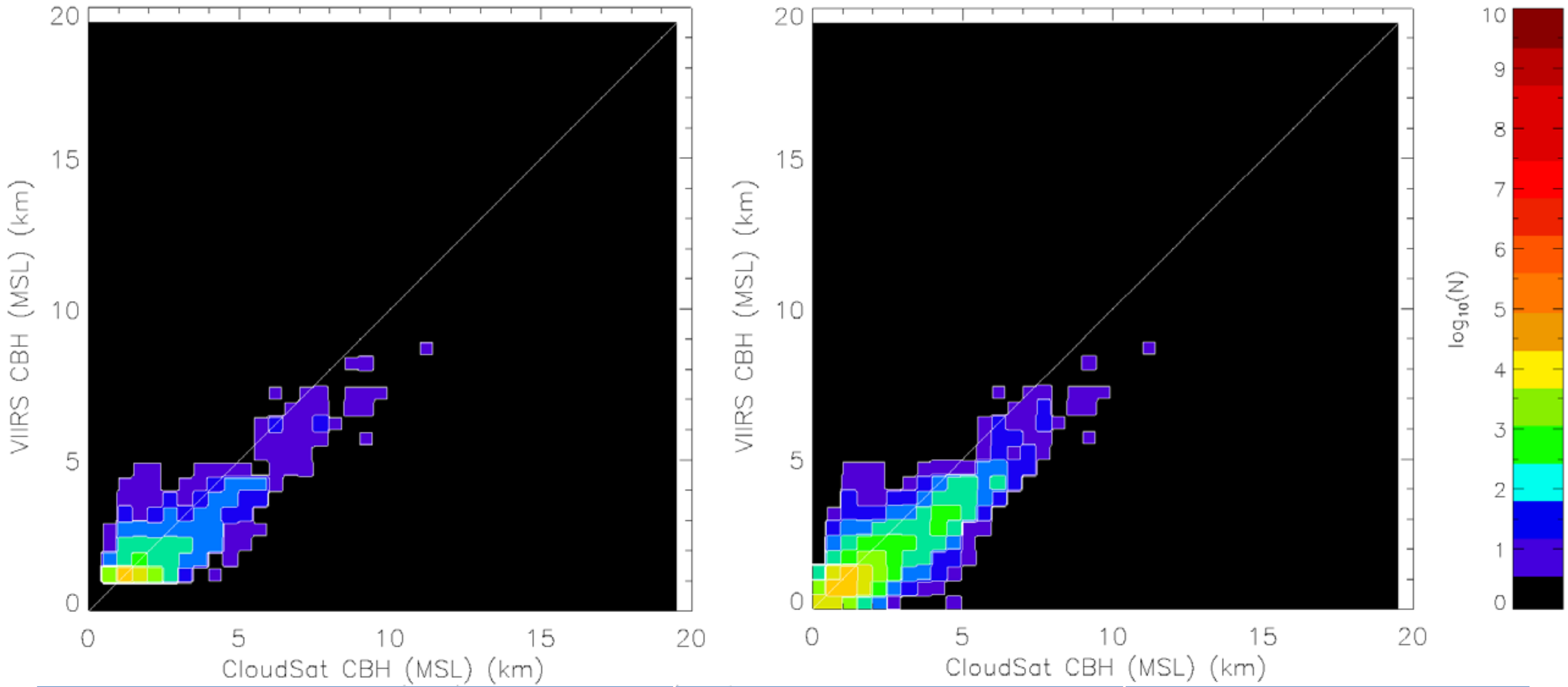
Thin clouds (COT < 1) "within spec" (CTH error < 1 km) using CloudSat (left) and CALIPSO (right)



Errors	CloudSat	CALIPSO
R^2	0.78	0.84
Average error (bias)	-0.5 km	-0.3 km
Standard deviation error	1.2 km	1.0 km
Median error	-0.5 km	-0.2 km
RMSE	1.3 km	1.1 km

Validation of Water Clouds Using CALIPSO/CloudSat

Water clouds "within spec" (CTH error < 1 km) using CloudSat (left) and Combination (right)

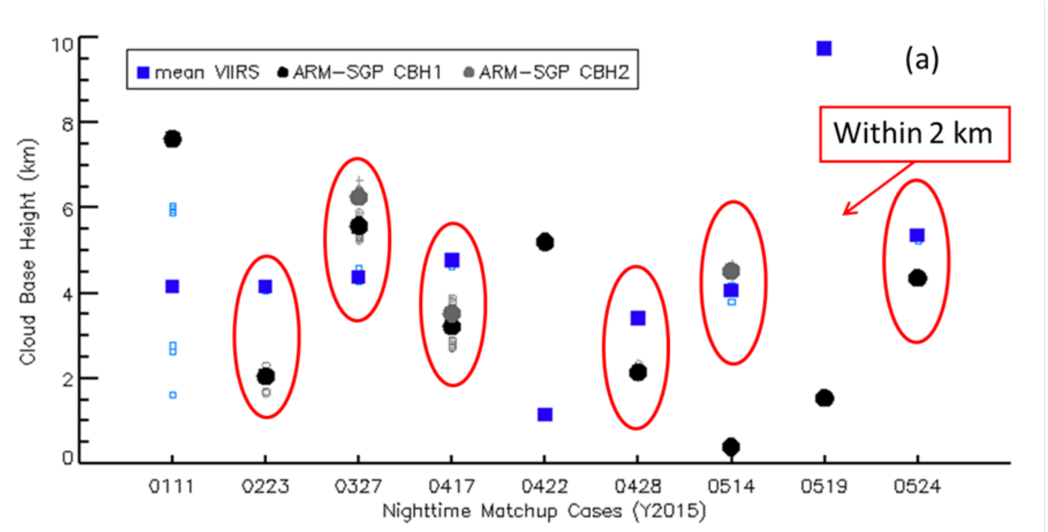


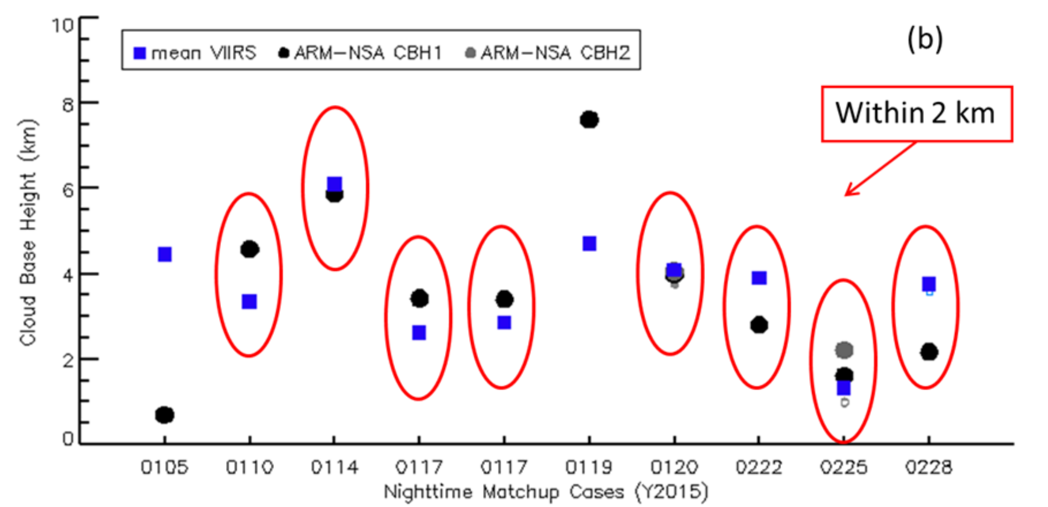
Errors	CloudSat	CloudSat/CALIPSO
R^2	0.80	0.83
Average error (bias)	0.2 km	0.1 km
Standard deviation error	0.4 km	0.4 km
Median error	0.2 km	0.1 km
RMSE	0.5 km	0.4 km

5 times more samples

Nighttime CBH algorithm performance

- CBH is retrieved in both day and **night**.
- Sample evaluations for nighttime CBH performance using ARM ceilometer data from SGP and NSA sites.
  - Blue squares: VIIRS CBHs
  - Black and gray circles: ARM ceilometer CBHs
- CBHs within the 2-km error range are circled in red.

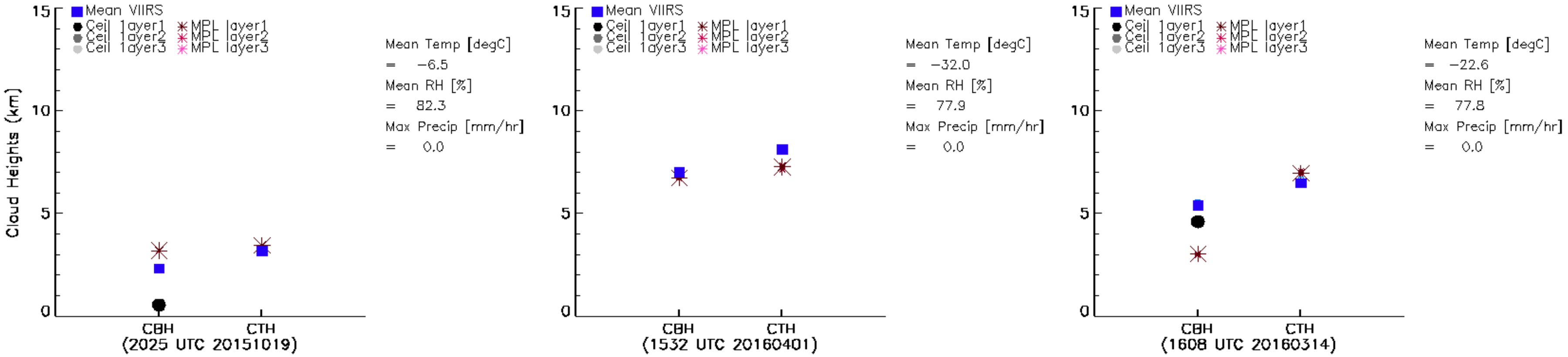




Nighttime CBH algorithm performance

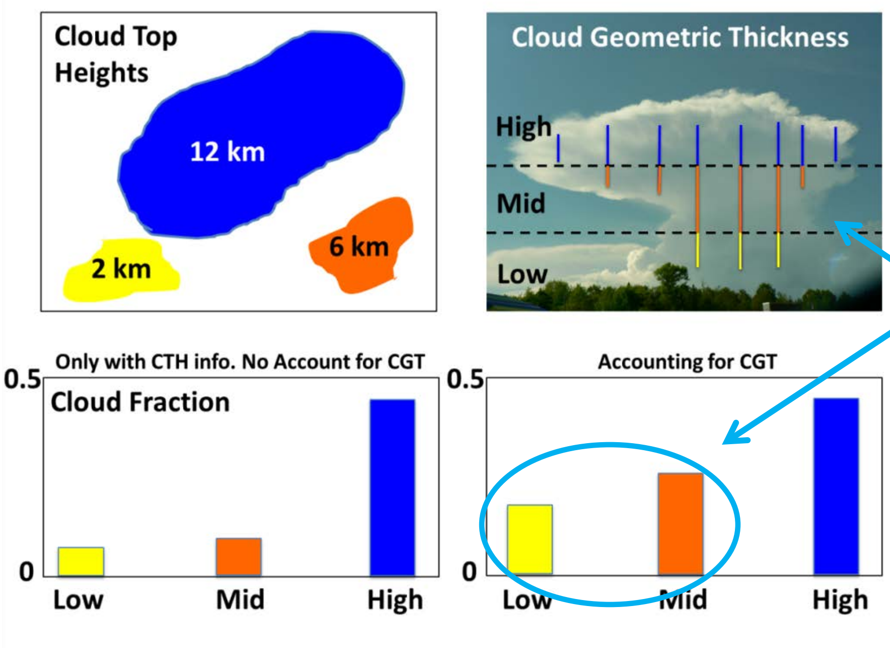
- Validation for an extended period
  - 581 matchups from October 2015 to April 2016
- Ground-based measurements from Ceilometer and Micropulse Lidar at the ARM site on the North Slope of Alaska
- CALIPSO data will be added for multi-layered cloud cases which may have high clouds aloft beyond the ground measurements.

Sample matchup cases from VIIRS-ARM data at night



For Improvement of CCL products

- The cloud base information is used for improvement of CCL products.
- The beta version is tested in the CLAVR-x system. The current CCL algorithm (part of ACHA by Andy Heidinger) is based on cloud top pressures over 3x3 pixels. The high and low layer thresholds are 440 hPa (~6.5 km) and 680 hPa (~3 - 3.5 km).
- The new sub-layer info is obtained by comparing the cloud base data and layer thresholds, and more fractions for lower cloud layers if present.

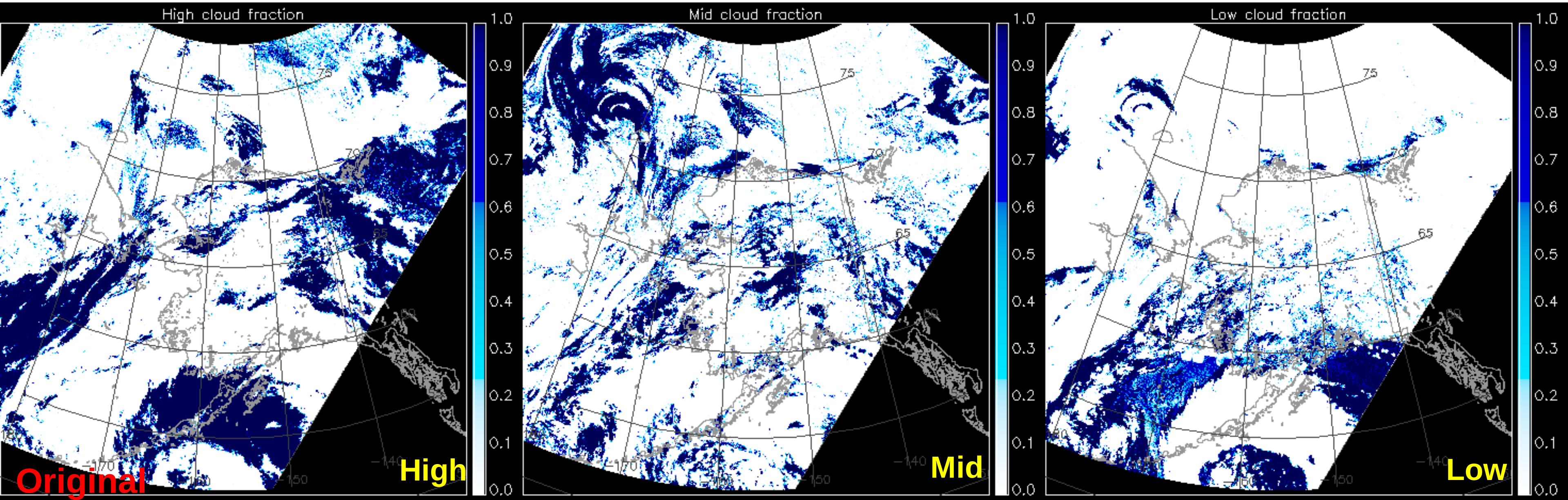


The CBH information can be used to modulate the layered cloud fraction (high/mid/low) by introducing additional cloud coverage at lower (unobserved via satellite) levels of the profile.

Improvement of VIIRS Cloud Cover/Layers

- The new cloud base information is employed to enhance lower cloud layer fractions often missed by the previous CCL retrieval.
- The improved CCL algorithm has been applied to VIIRS.
- Also applicable to geostationary satellite: Himawari-8 AHI for the future GOES-R ABI

S-NPP VIIRS 20160229 (1351-1401 UTC)



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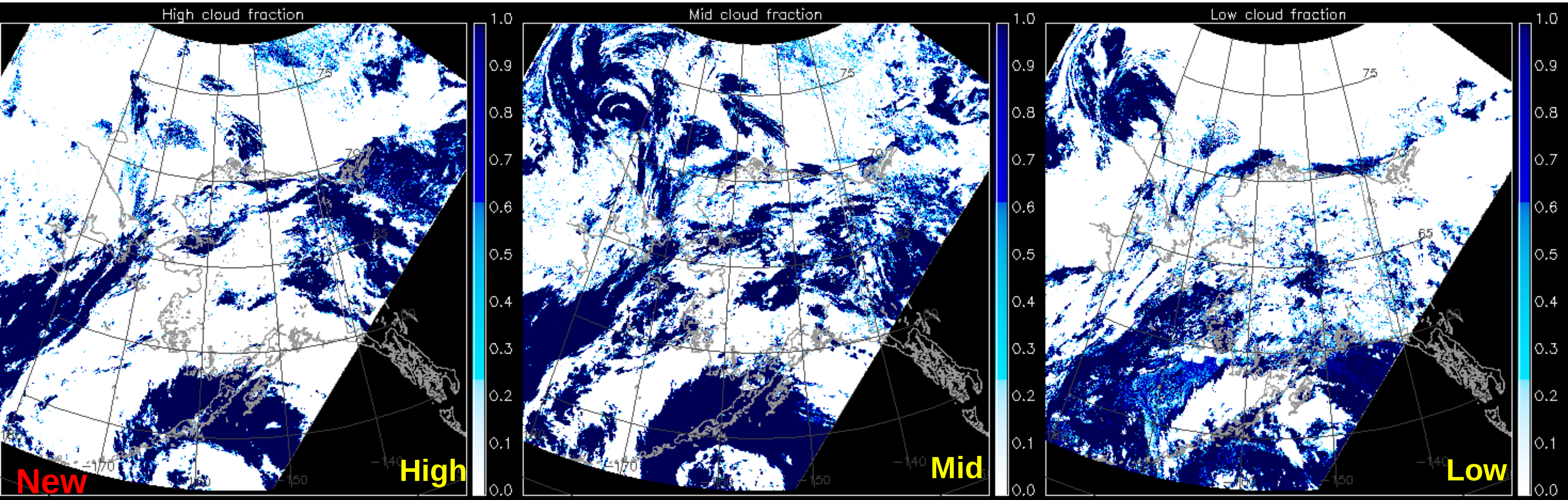
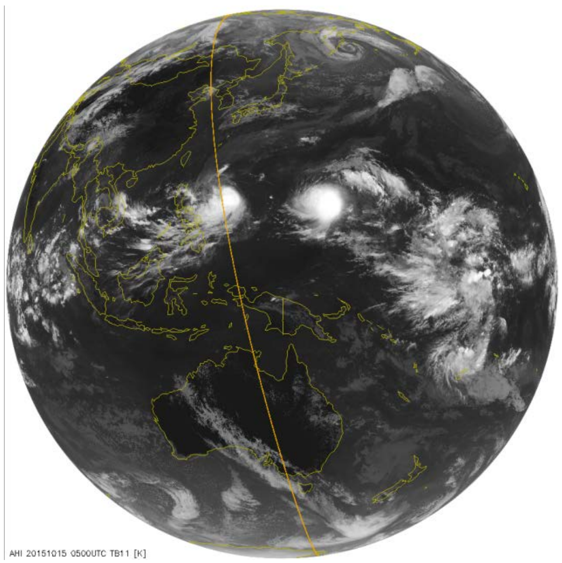
S-NPP VIIRS 20160229 (1351-1401 UTC)



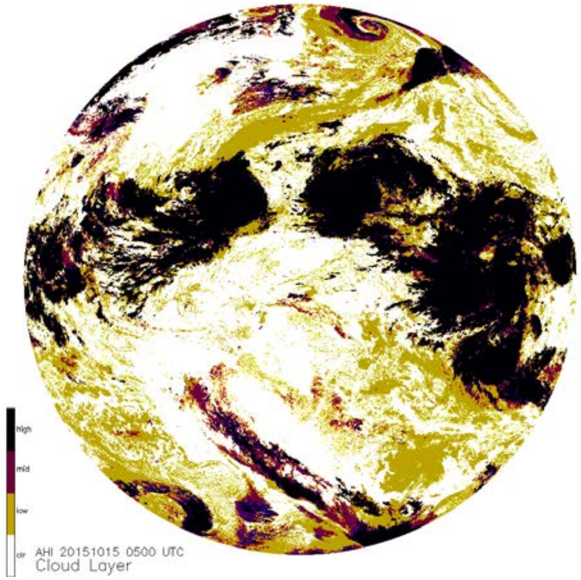
Himawari-8 AHI Cloud Cover/Layers

20151015 (0500 UTC)

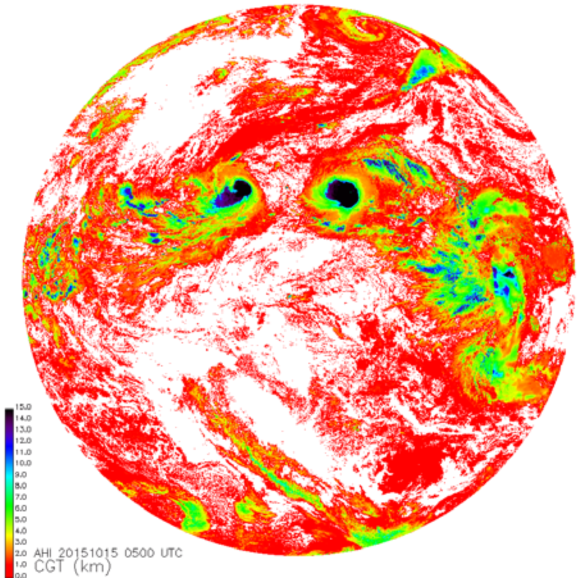
Himawari-8 AHI TB_11 µm



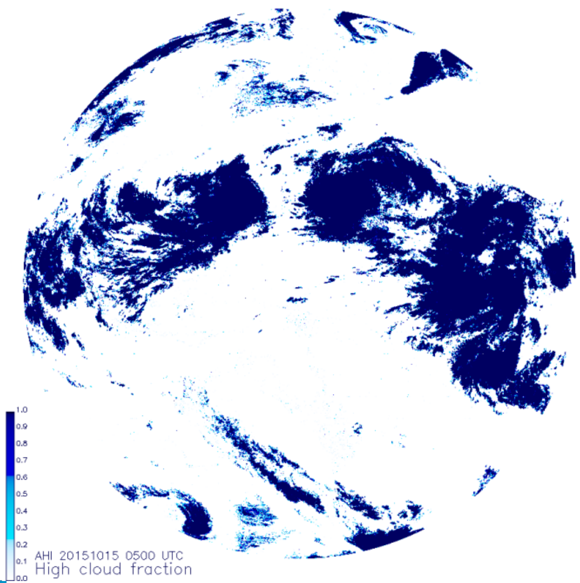
Cloud Layer



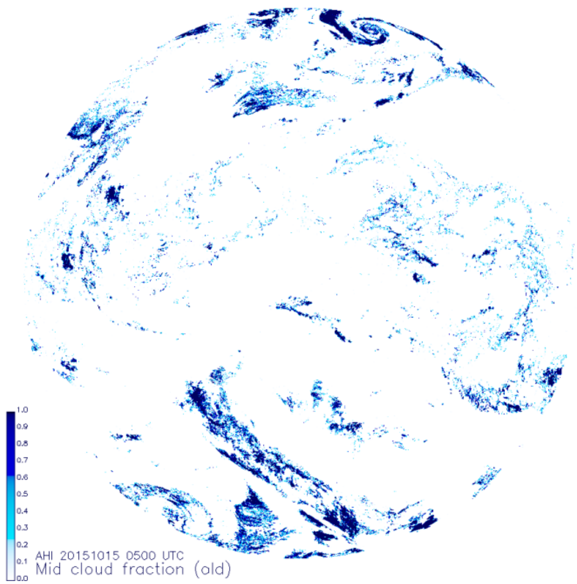
Cloud Geometric Thickness



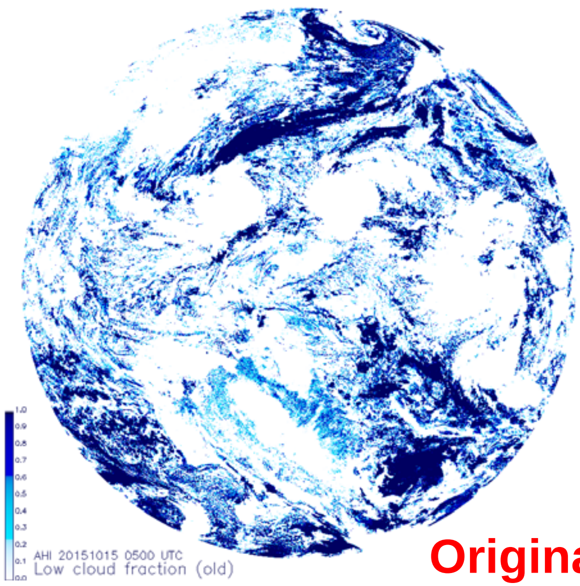
High Cloud Fraction



Mid Cloud Fraction



Low Cloud Fraction

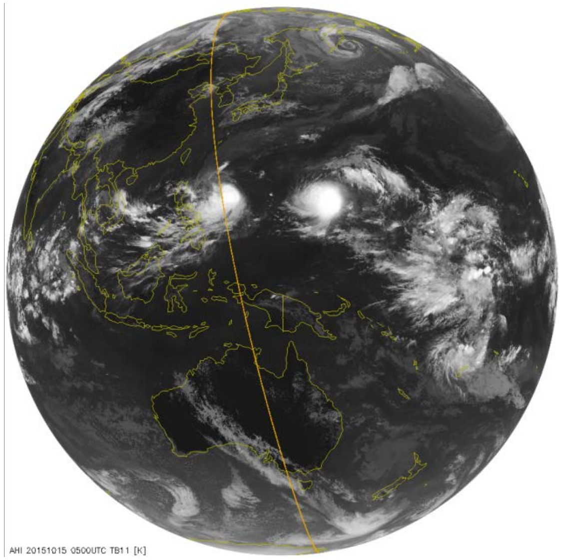


Original

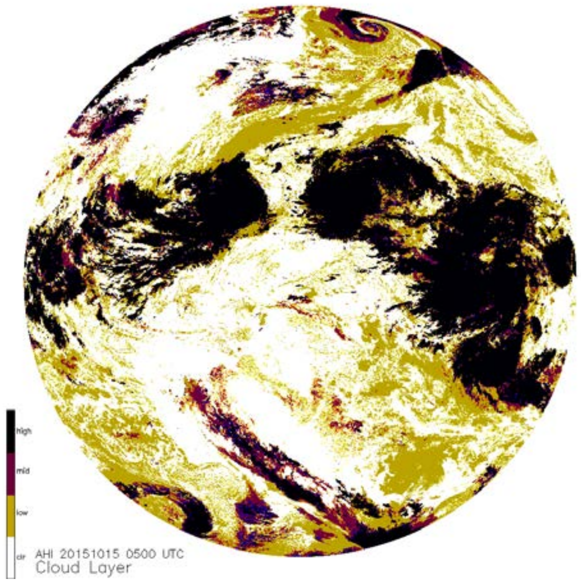
Himawari-8 AHI Cloud Cover/Layers

20151015 (0500 UTC)

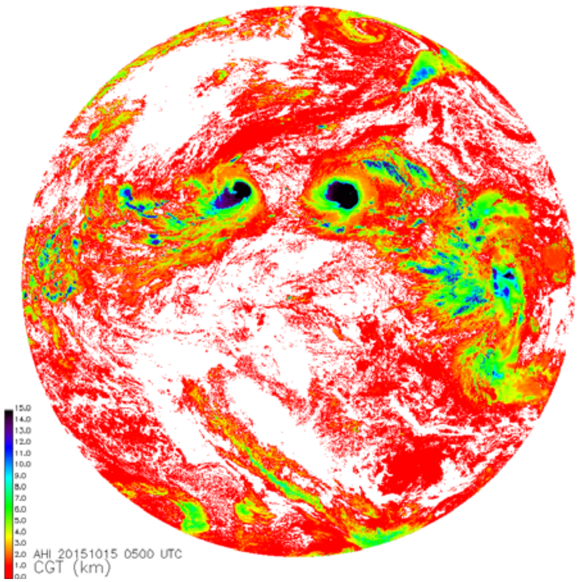
Himawari-8 AHI TB_11 µm



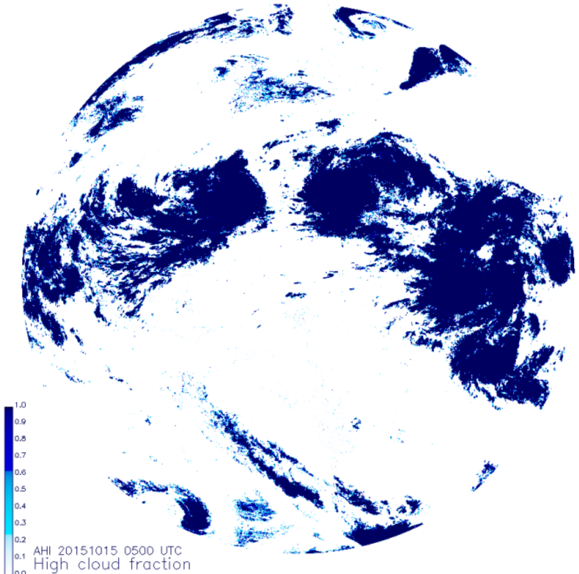
Cloud Layer



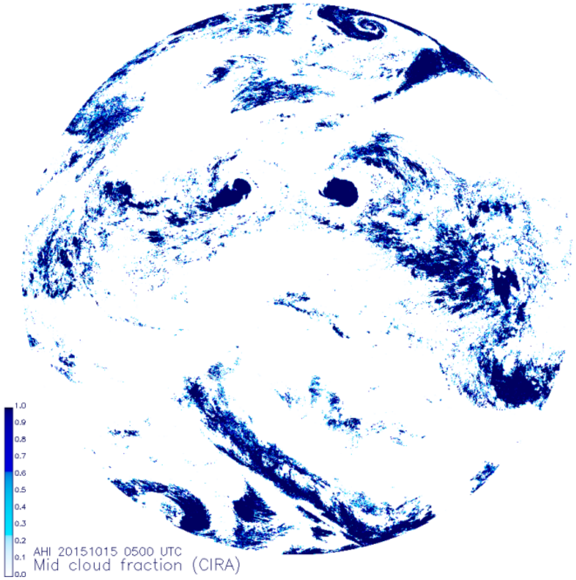
Cloud Geometric Thickness



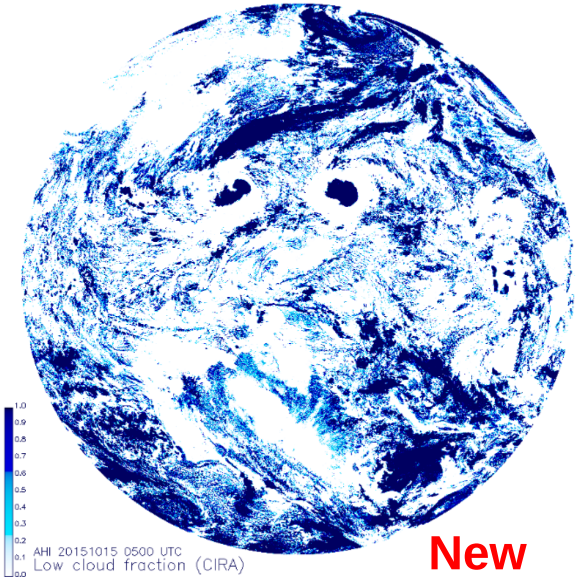
High Cloud Fraction



Mid Cloud Fraction



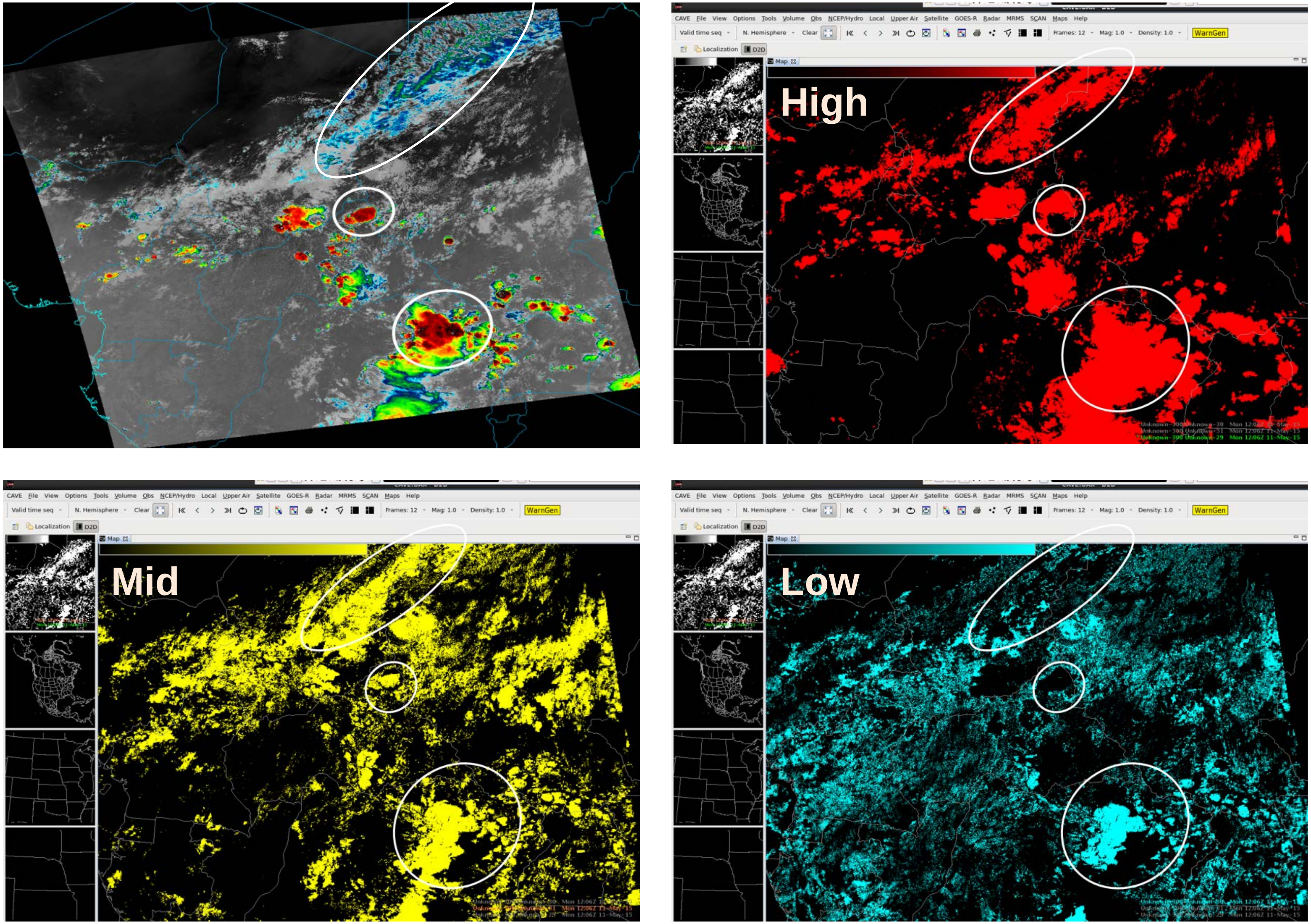
Low Cloud Fraction



New

Sample CCL Display in AWIPS-2

VIIRS I-band 5 (left) and cloud fractions from 11 May 2016 at 1202 UTC over central Africa



Summary & Path Forward

- The Enterprise CBH algorithm (for the uppermost layer) is now operational. The CIRA and CIMSS teams will continue to support the STAR AIT for its correct operation and long-term monitoring within the operational frame.
- Our efforts for validation and are ongoing.
  - Add CALIPSO data for validation and use ground-based measurements (ARM data) for nighttime CBH performance test.
- Improvement of CCL products is in progress.
  - The preliminary results show the additional cloud base information can significantly increase lower cloud fractions which have been overlooked by the original algorithm.
- Major algorithm refinements and tests will be completed before J-1 launch, and validation efforts for optimized performance will continue before/after launch.

Enterprise Cloud Mask (ECM)

STAR / NESDIS / NOAA
andrew.heidinger@noaa.gov
Andrew Heidinger

Thomas Kopp (Aerospace AFB)
Denis Botambekov (CIMSS / UW-Madison)

ECM Format Basics

- The primary output of the ECM is the cloud probability for each VIIRS M-band pixels (CloudProbability in the netCDF file)
- A 4-tier cloud mask with the same categories as with the VCM may be found as well (CloudMask)
- The binary cloud mask, generally not used but required as an output, is found in CloudMaskBinary
- We encourage users to employ cloud probability, as in that form the users may set whatever value they close to determine clear or cloudy conditions
- The breakdown of the individual elements is found in CloudMaskPacked
  - It is not in CloudMaskFlags, there is no use of this for VIIRS based output

Individual ECM Outputs

- The description of the individual bits in the 8 byte CloudMaskPacked output is found in Table 4 of the ECM ATBD
  - For those who have the current version, be aware the Surface Type values given are off by one (Deep Water is 001, Shallow Water 010, etc.)
- Note the original ECM was developed for GOES-R, and hence there are embedded tests that are not applicable to VIIRS
  - BTM11
  - RTCT
  - BTD11_6.7 thermal contrast
  - BTD11_6.7 thermal covariance
  - EMISS4
  - Ref0.63STD
- Each of the other tests are used as described in the ATBD

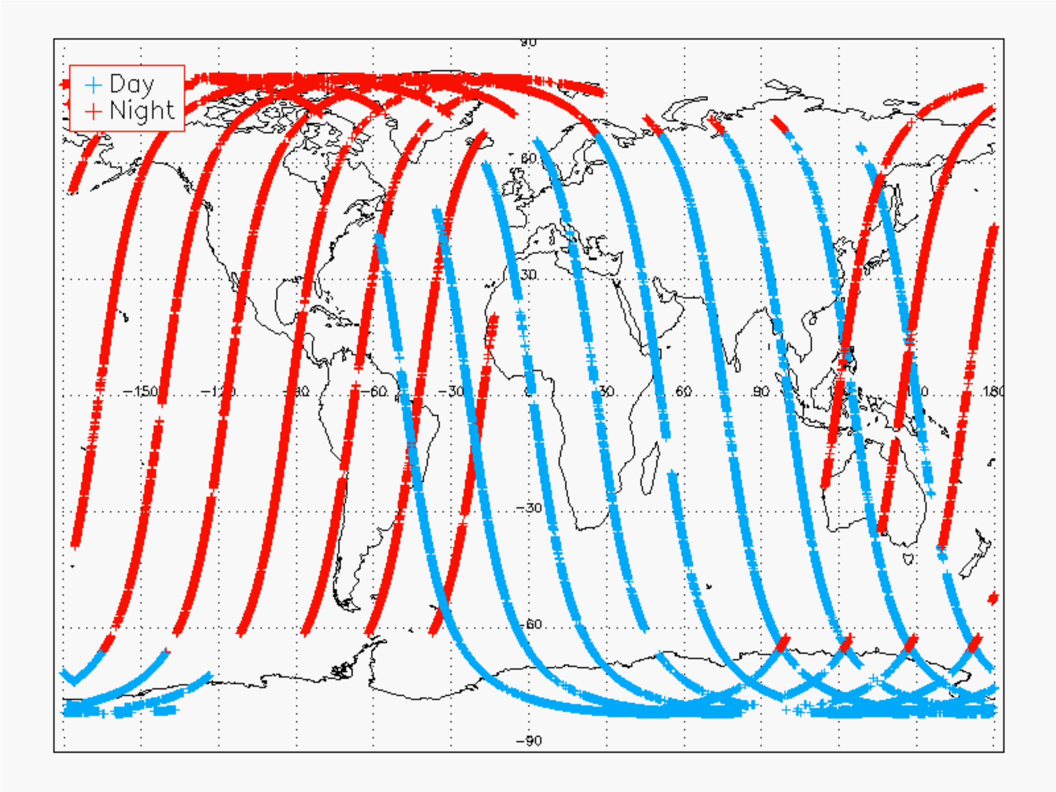
Individual ECM Outputs

- The individual cloud detection tests, contained in bytes 3 through 7, may be 00 (clear), 01 (probably clear), 10 (probably cloudy), or 11 (cloudy)
- The 6 unused cloud detection tests will always contain values of 00
- The remaining tests will contain a climatological value for conditions where they are not executed (e.g. reflective tests at night)
  - Be aware this default value is often one of the probable conditions, and it can vary with surface type
  - The internal logic of the ECM knows when a value is from climatology and when it has been determined by internal logic
  - The thin cirrus bit is a special case and will be described in an update to the ECM ATBD

Notes:

- In this part of analysis VIIRS – CALIOP 1 and 5 km collocation data from January 03, 2015 is used to evaluate the following Cloud Masks performance :
    - CLAVR-x Current Trunk,
    - CLAVR-x Trunk with DNB Off,
    - CLAVR-x AIT Delivery Version,
    - Framework ECM,
    - IDPS VCM.
- Only data with ±0.2 hour (±12 minute) collocation window between VIIRS and CALIOP is used.
- All Cloud Masks are treated as binary.
- Only clear pixels or COD > 1.0 filter is applied.
- Other applied filters are mentioned above each table.

Pixels Used for Evaluation



CALIOP - VIIRS Matchup Pixels Within Maximum
± 0.2 Hour (± 12 Minutes) Time Difference
CALIOP: Clear or COD > 1.0
01/03/2015

VIIRS-CALIOP Stats 1

90N – 90S, Ocean/Land, Day/Night, No Snow/Snow/Ice

Algorithm	Sample Size	Cloud fraction		Pr. Clear	Pr. Cloudy	Probability of		
		CALIOP	VIIRS			Detection	False D.	Miss Cld.
CLAVR-x Trunk	274466	0.673	0.650	0.073	0.070	0.894	0.041	0.064
CLAVR-x No DNB	274466	0.673	0.641	0.083	0.076	0.892	0.038	0.071
CLAVR-x AIT Delivery	274466	0.673	0.634	0.069	0.091	0.896	0.032	0.072
Framework ECM	274060	0.673	0.623	0.076	0.084	0.861	0.044	0.095
VCM IDPS	272416	0.675	0.631	0.070	0.028	0.870	0.043	0.087

60N – 60S, Ocean/Land, Day/Night, No Snow/No Ice

Algorithm	Sample Size	Cloud fraction		Pr. Clear	Pr. Cloudy	Probability of		
		CALIOP	VIIRS			Detection	False D.	Miss Cld.
CLAVR-x Trunk	174618	0.673	0.675	0.028	0.015	0.942	0.030	0.028
CLAVR-x No DNB	174618	0.673	0.658	0.046	0.021	0.938	0.024	0.038
CLAVR-x AIT Delivery	174618	0.673	0.636	0.027	0.046	0.931	0.016	0.053
Framework ECM	174336	0.672	0.629	0.030	0.046	0.887	0.035	0.078
VCM IDPS	172599	0.675	0.654	0.064	0.022	0.938	0.021	0.041

These statistical evaluations are presented to show algorithms' performance over globe and multiple different surface conditions.

VIIRS-CALIOP Stats 2

60N – 60S, Ocean, Day, No Snow/No Ice

Algorithm	Sample Size	Cloud fraction				Probability of		
		CALIOP	VIIRS	Pr. Clear	Pr. Cloudy	Detection	False D.	Miss Cld.
JPSS L1RDS-2457						0.940	0.050	0.010
CLAVR-x Trunk	57693	0.677	0.680	0.013	0.006	0.945	0.029	0.026
CLAVR-x No DNB	57693	0.677	0.680	0.013	0.006	0.945	0.029	0.026
CLAVR-x AIT Delivery	57693	0.677	0.672	0.008	0.008	0.949	0.023	0.028
Framework ECM	57439	0.675	0.669	0.010	0.012	0.905	0.045	0.051
VCM IDPS	56853	0.682	0.680	0.070	0.016	0.944	0.027	0.030

60N – 60S, Ocean, Night, No Snow/No Ice

Algorithm	Sample Size	Cloud fraction				Probability of		
		CALIOP	VIIRS	Pr. Clear	Pr. Cloudy	Detection	False D.	Miss Cld.
JPSS L1RDS-2457						0.850	0.080	0.050
CLAVR-x Trunk	75884	0.739	0.759	0.043	0.022	0.936	0.042	0.022
CLAVR-x No DNB	75884	0.739	0.728	0.067	0.033	0.935	0.027	0.038
CLAVR-x AIT Delivery	75884	0.739	0.684	0.044	0.085	0.916	0.015	0.070
Framework ECM	75868	0.739	0.677	0.043	0.083	0.875	0.032	0.093
VCM IDPS	75010	0.739	0.716	0.074	0.032	0.934	0.022	0.044

Comparison of cloud mask algorithms to JPSS L1RDS requirements (green) over Ocean. Statistics which are not matching requirements in red.

VIIRS-CALIOP Stats 3

60N – 60S, Land, Day, No Snow/No Ice

Algorithm	Sample Size	Cloud fraction				Probability of		
		CALIOP	VIIRS	Pr. Clear	Pr. Cloudy	Detection	False D.	Miss Cld.
JPSS L1RDS-2457						0.900	0.070	0.030
CLAVR-x Trunk	19970	0.377	0.338	0.019	0.009	0.940	0.011	0.050
CLAVR-x No DNB	19970	0.377	0.338	0.019	0.009	0.940	0.011	0.050
CLAVR-x AIT Delivery	19970	0.377	0.351	0.013	0.009	0.950	0.012	0.038
Framework ECM	19958	0.378	0.361	0.030	0.017	0.902	0.041	0.057
VCM IDPS	19804	0.379	0.351	0.033	0.006	0.946	0.013	0.041

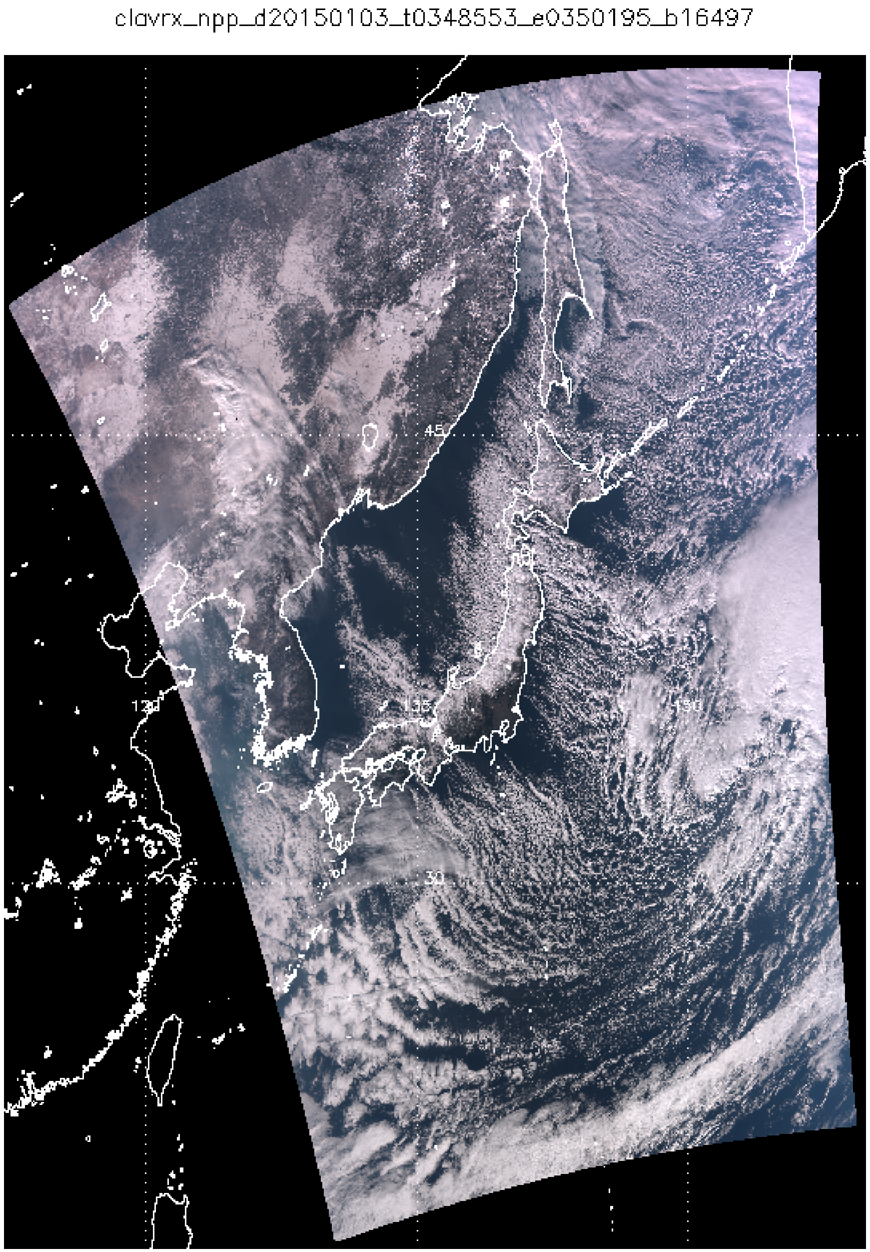
60N – 60S, Land, Night, No Snow/No Ice

Algorithm	Sample Size	Cloud fraction				Probability of		
		CALIOP	VIIRS	Pr. Clear	Pr. Cloudy	Detection	False D.	Miss Cld.
JPSS L1RDS-2457						0.880	0.080	0.050
CLAVR-x Trunk	11099	0.782	0.734	0.028	0.025	0.947	0.003	0.051
CLAVR-x No DNB	11099	0.782	0.685	0.114	0.048	0.901	0.001	0.098
CLAVR-x AIT Delivery	11099	0.782	0.672	0.048	0.052	0.882	0.004	0.114
Framework ECM	11099	0.782	0.600	0.050	0.038	0.812	0.003	0.185
VCM IDPS	11061	0.782	0.688	0.032	0.008	0.904	0.001	0.095

Comparison of cloud mask algorithms to JPSS L1RDS requirements (green) over Land. Statistics which are not matching requirements in red.

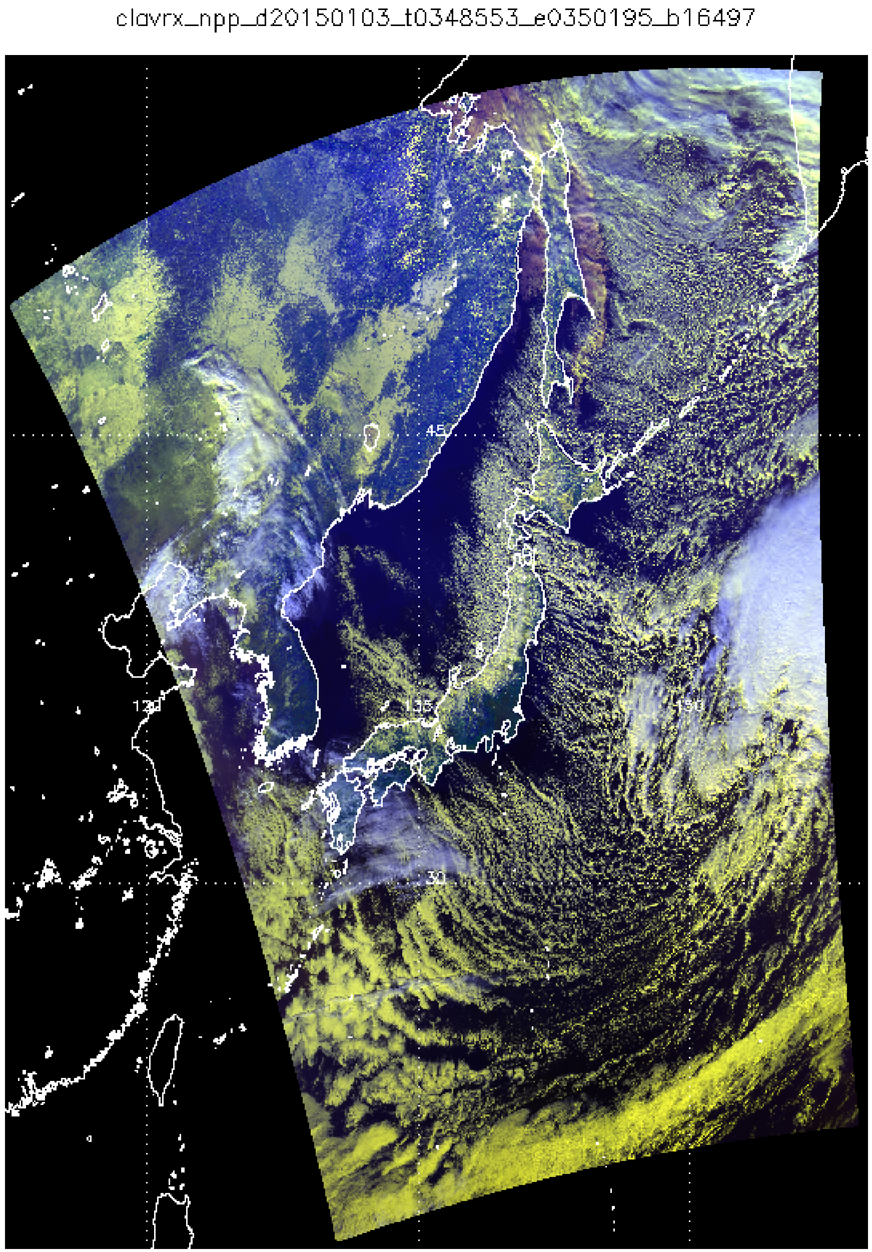
Comparison Example

- ➢This part of analysis is concentrated on 7 daytime granules of VIIRS from 2015-01-03 from 03:40:22 to 03:50:19 UTC over Japan region.
- ➢There are 2 masks:
  - ❖CLAVR-x2AIT is the CLAVR-x Version Delivered to AIT;
  - ❖ECM_AIT is the AIT Framework Output.



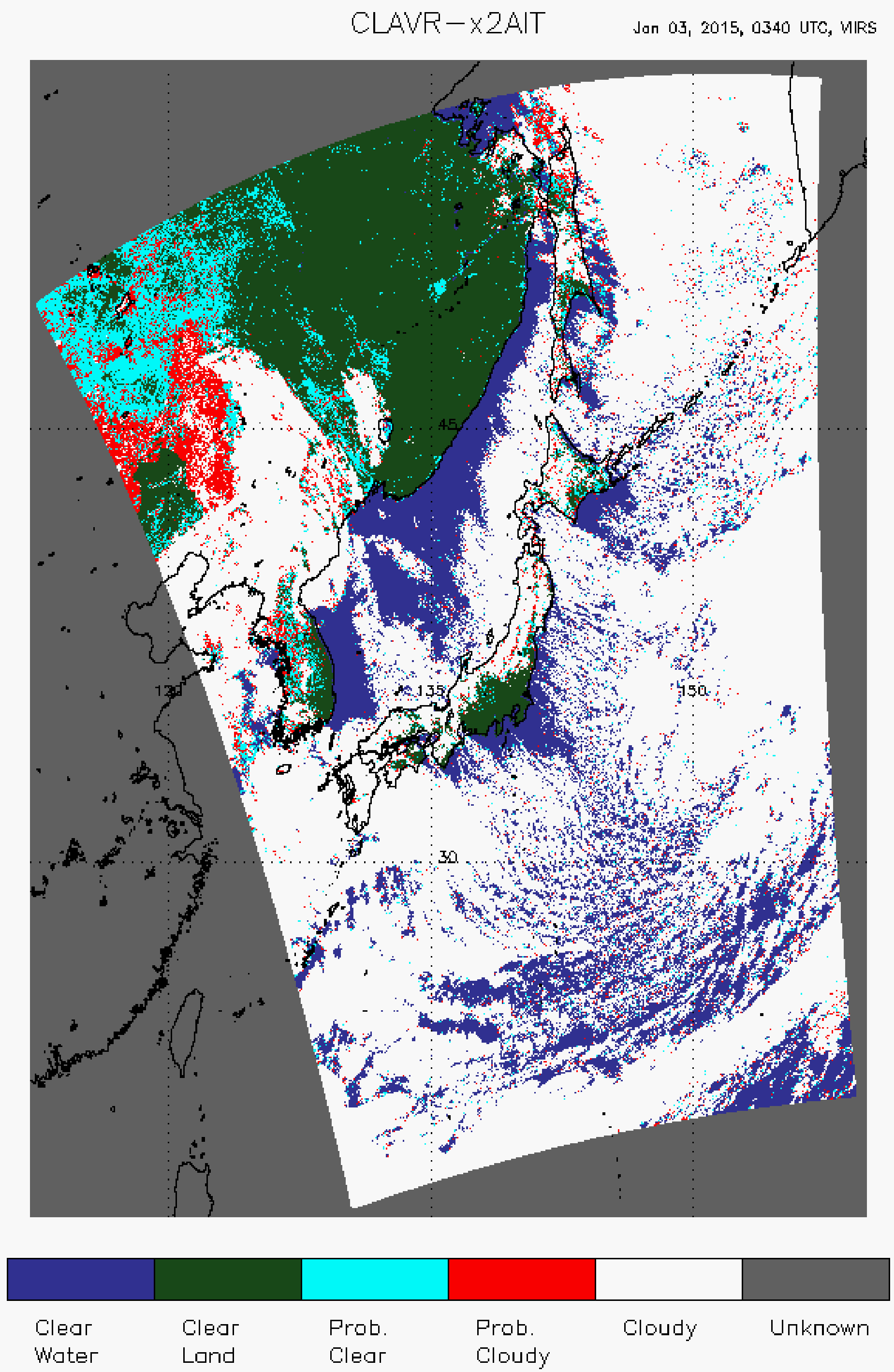
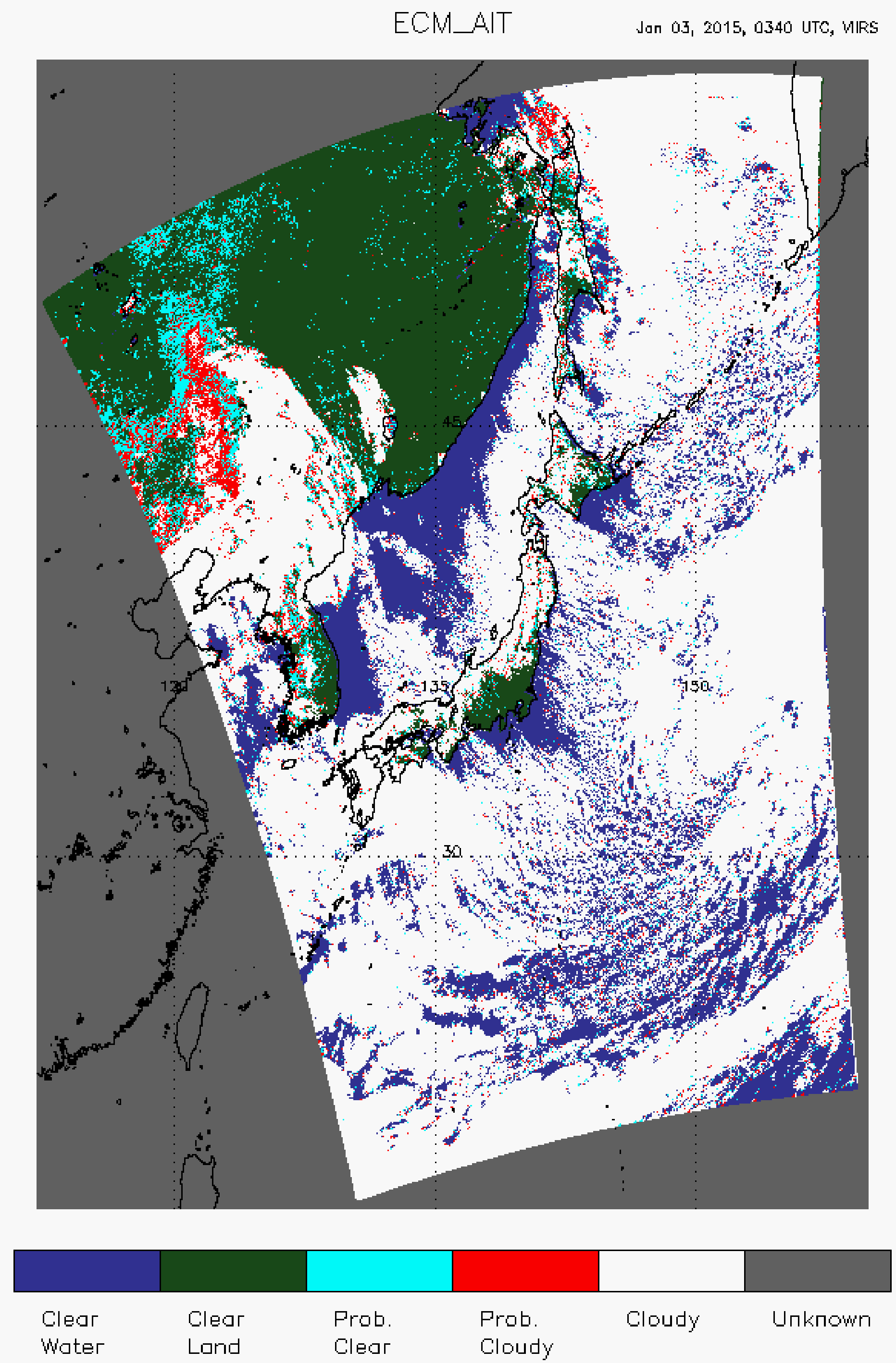
True Color Image

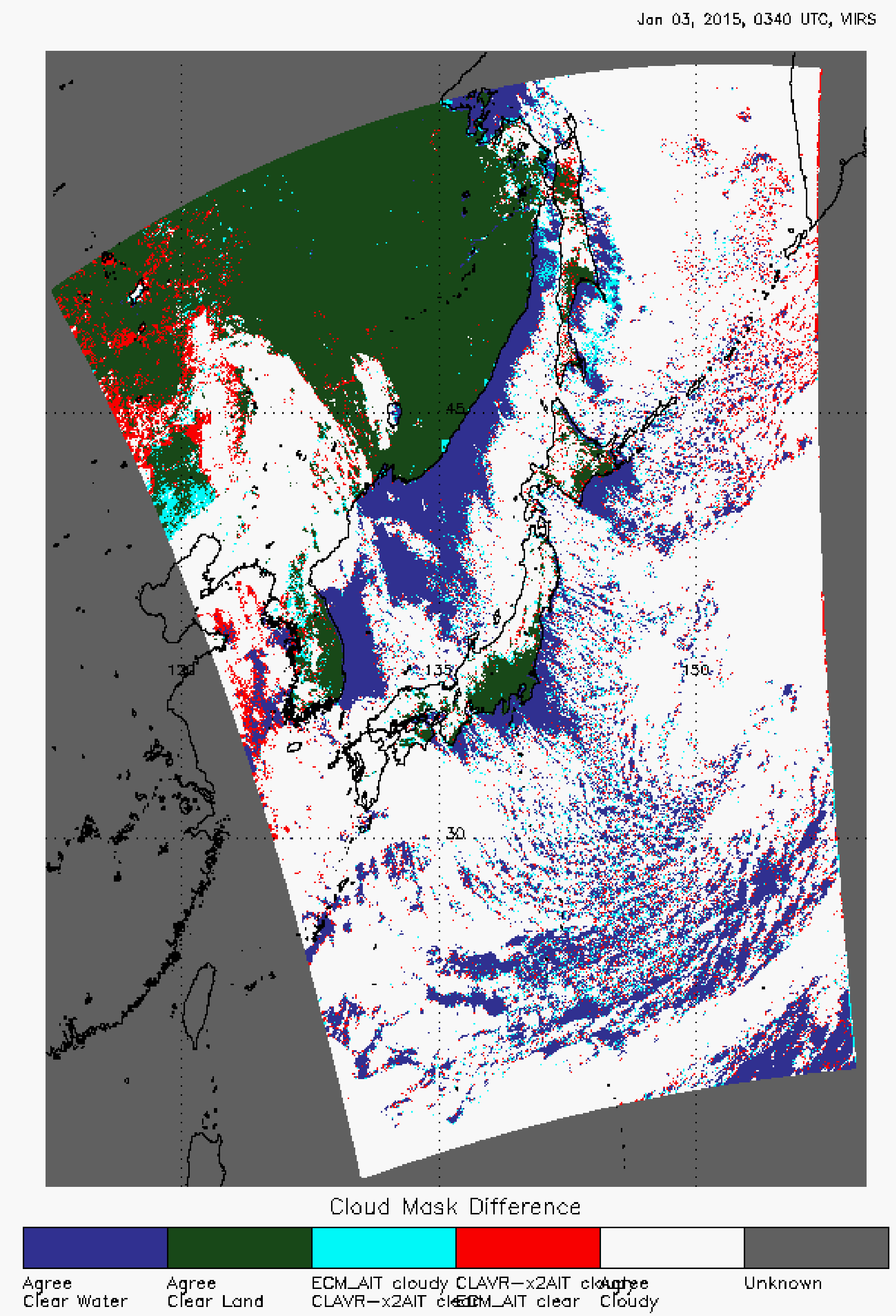
Red=0.65μm, Green = 0.55μm, Blue = 0.48μm

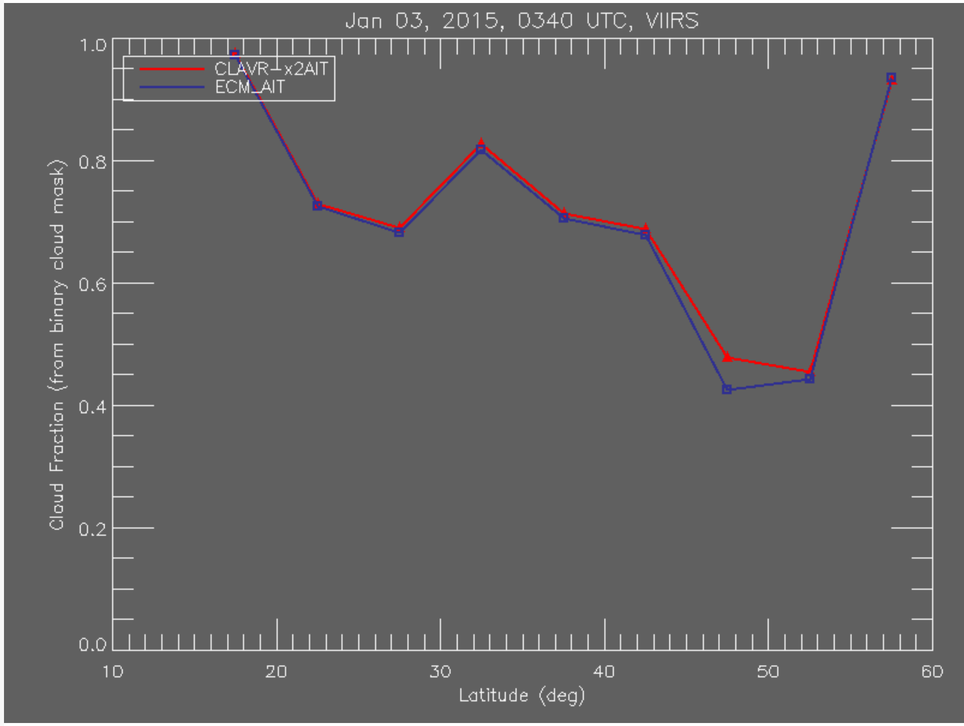


False Color Image

Red=0.65μm, Green = 0.86μm, Blue = 11μm (reversed)


CLAVR-x2AIT
Jan 03, 2015, 0340 UTC, VIIRS
45
30
120
135
150
Clear Water
Clear Land
Prob. Clear
Prob. Cloudy
Cloudy
Unknown

ECM_AIT
Jan 03, 2015, 0340 UTC, VIIRS
45
30
120
135
150
Clear Water
Clear Land
Prob. Clear
Prob. Cloudy
Cloudy
Unknown





CLAVR-x2AIT and ECM_AIT
Zonal Fraction

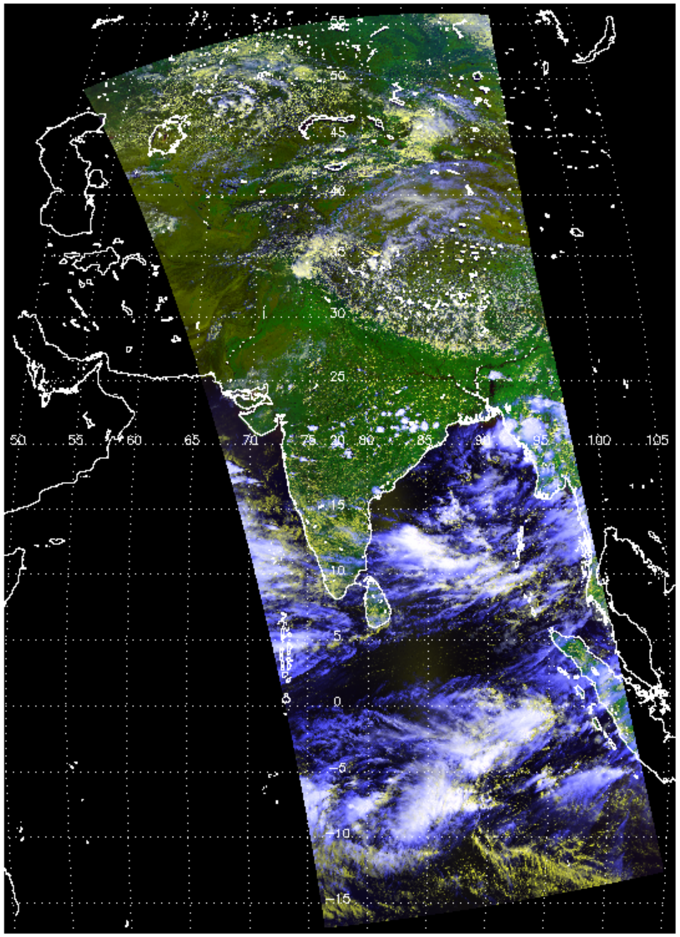
CLAVR-x2AIT and ECM_AIT
Binary Cloud Masks Difference

Thin Cirrus Addition

- ➢Users asked to provide a Thin Cirrus bit in the Packed Bits Structure.
- ➢Logic for Thin Cirrus in the ECM will be similar to that used in the VIIRS Cloud Mask (VCM)
- ➢Thin Cirrus test development is nearly complete and will be part of the August 2016 delivery
- ➢As will be shown, thin cirrus will be yes/no and not the same as the other cloud detection tests

VIIRS Enterprise Cloud Mask (ECM)

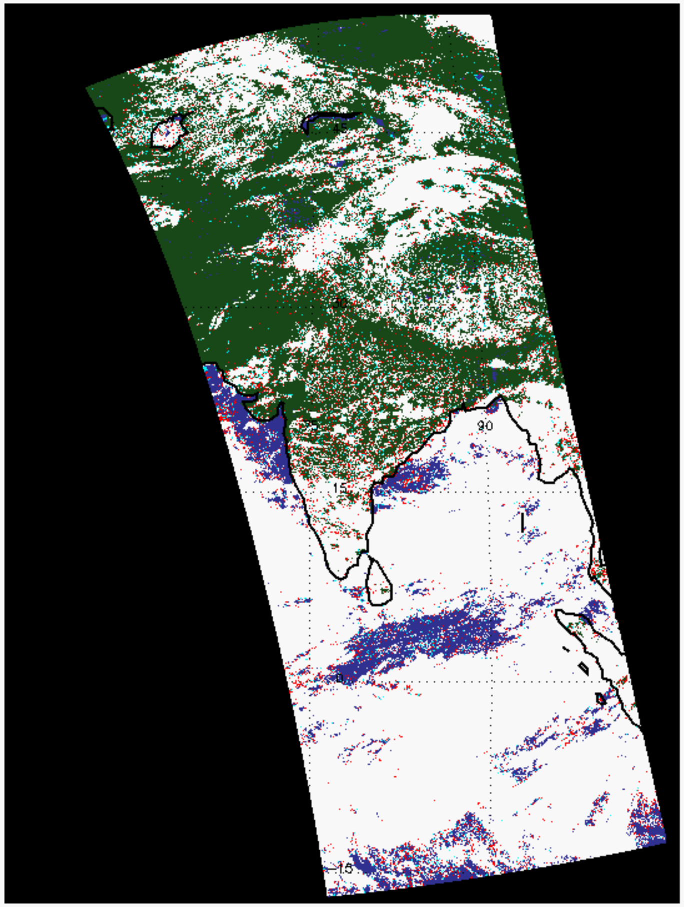
clavrx_npp_d20130913_t0749350_e0750592_b09732



False Color Image

Red=0.65μm, Green = 0.86μm, Blue = 11μm (reversed)

clavrx_npp_d20130913_t0749350_e0750592_b09732.level2.hdf



VIIRS Enterprise Cloud Mask

VIIRS Cloud Mask (VCM)

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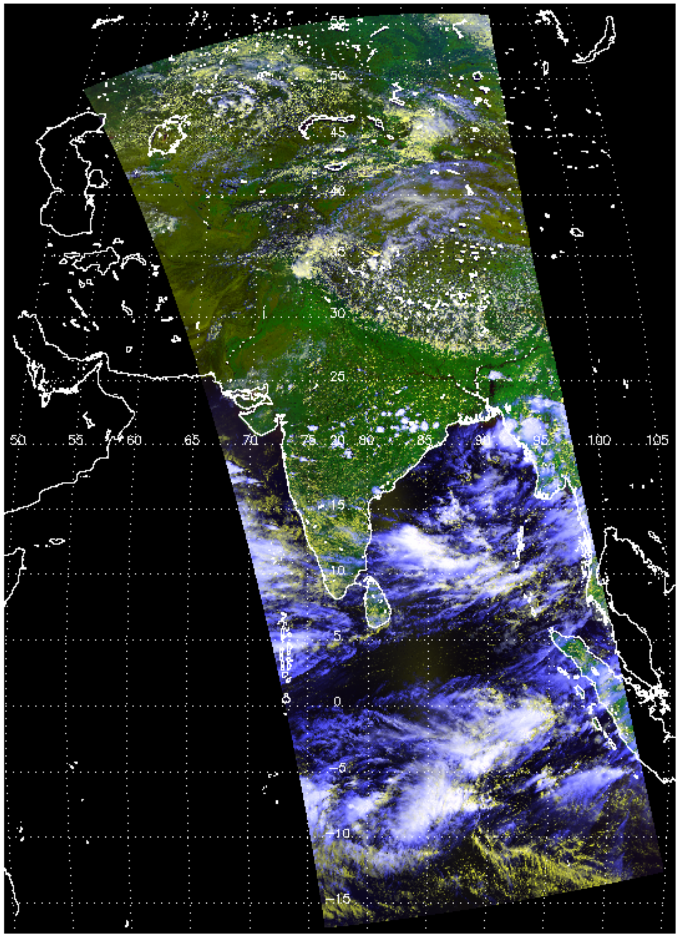
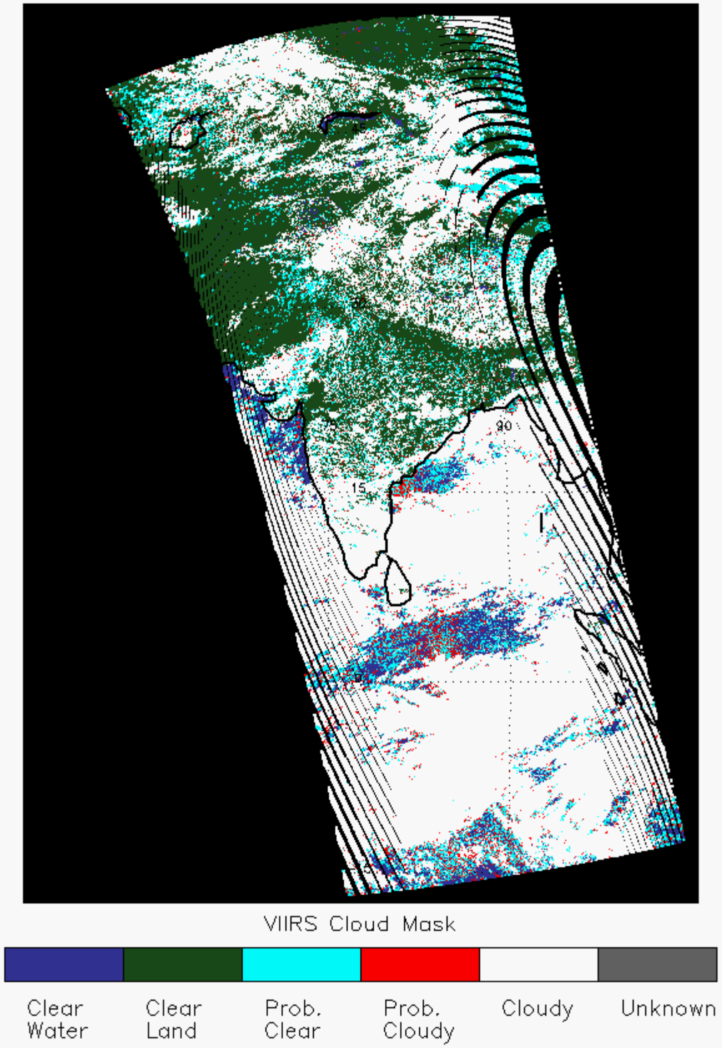


False Color Image

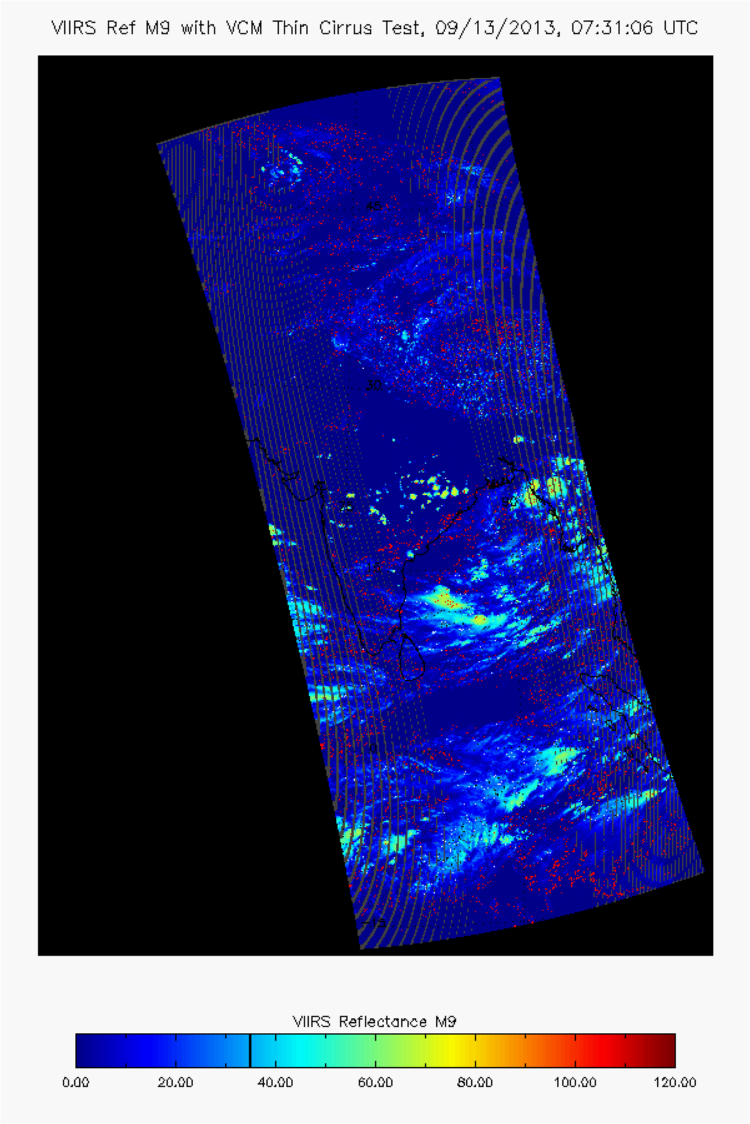
Red=0.65μm, Green = 0.86μm, Blue = 11μm (reversed)

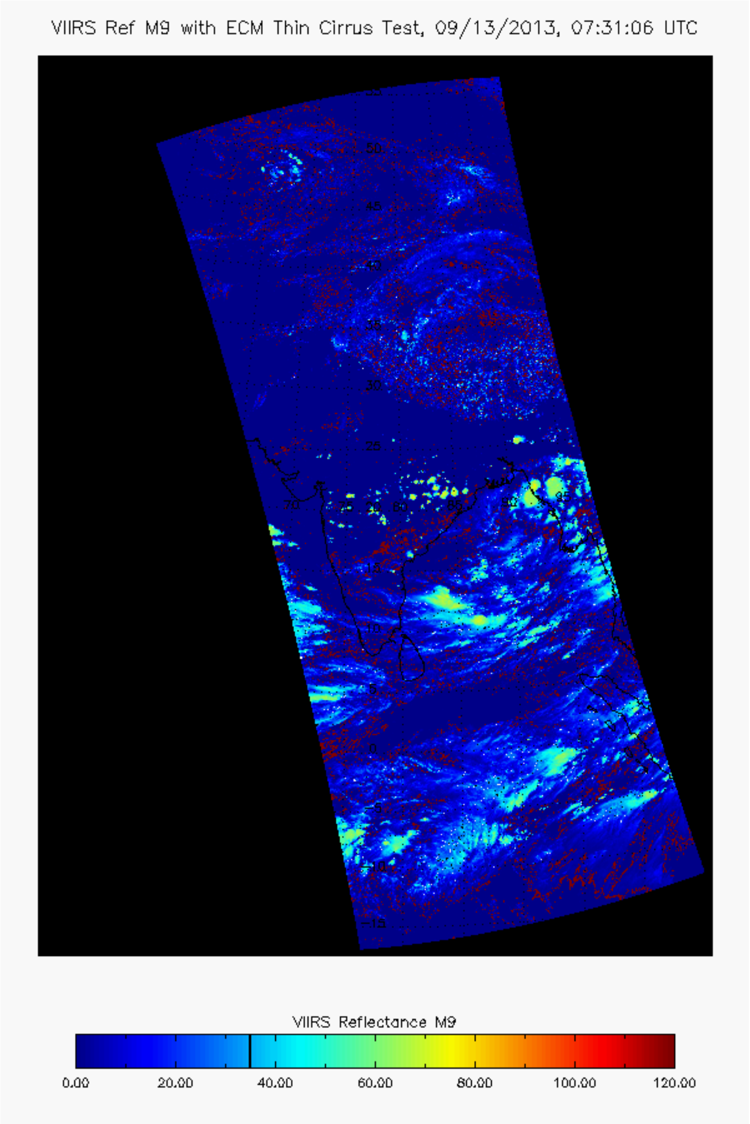
clavrx_npp_d20130913_t0749350_e0750592_b09732.level2.hdf



Thin Cirrus Test

VCM





ECM

ECM Bit Structure

- Proposed Place to Ingest Thin Cirrus Test bit to ECM

Byte	Bit	Flag Description Key	Result
2	0-2	Surface Type Used for Thresholds	001 = Deep Ocean 010 = Shallow Water 011 = Land 100 = Snow 101 = Arctic 110 = Antarctic + Greenland 111 = Desert
	3	Thin Cirrus Test	0 = Clear 1 = Cloudy
	4-5	BT11 – 11 μm Thermal Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy
	6-7	RTCT – Relative Thermal Contrast Test	00 = Clear 01 = Probably Clear 10 = Probably Cloudy 11 = Cloudy

Table 4. Cloud mask tests and flags and their descriptions.
A Naïve Bayesian Cloud Mask Delivered to NOAA Enterprise ATBD.
Version 1.1, June 3rd, 2016.

https://www.dropbox.com/s/otrqhs4lpwu48i4/Cloud_Mask_Enterprise_ATBD_v1.1_2016.docx?dl=0

List of Current Work:

- Investigation of CLAVR-x Cloud Mask and Framework ECM differences.
- Upcoming August, 2016 code and LUTs update.
- Completing Thin Cirrus Test development.
- All tools for Framework ECM are developed and ready to train it against CALIPSO/CALIOP

Summary

- The ECM format is properly described in the ECM ATBD but users should be aware of the role of the individual tests within the ECM structure
- The ECM is ongoing pre-launch validation and known issues are being worked
- Work on the Thin Cirrus Test is nearly complete and will be part of the August 2016 update
- We are always interested in feedback from users

Activities of the Hydrology Initiative of the JPSS PGRR Program

John Forsythe
Cooperative Institute for Research in the Atmosphere
Colorado State University
John.Forsythe@colostate.edu

Initiative Projects/Participants

Group Leader: Ralph Ferraro NOAA/NESDIS/STAR

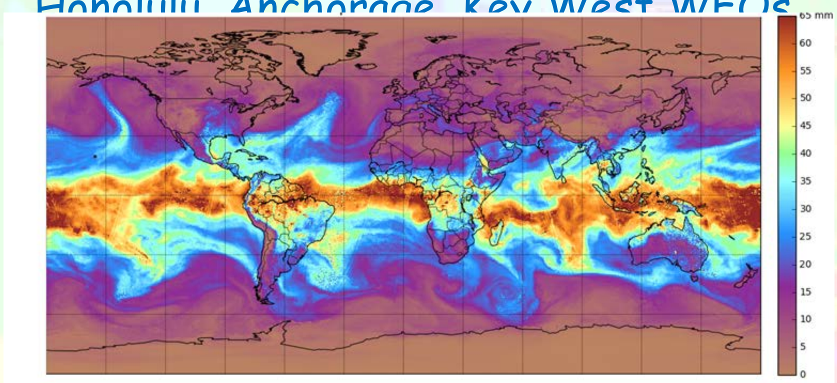
Project PI	Project Title
Dave Gochis *(NCAR)*	Applying Snow Products from S-NPP JPSS and SNODAS to Seasonal Streamflow Forecasting at the NWS National Water Center
Huan Meng *(NESDIS/STAR)*	Continued expansion, enhancement and evolution of the NESDIS snowfall rate product to support weather forecasting
Pingping Xie *(NWS/NCEP)*	Reprocessing of JPSS precipitation and OLR products for improved operational climate applications
Isaac Moradi *(UMD/CICS)*	Extending AMSU/MHS FCDR's and TCDR's to S-NPP ATMS
John Forsythe *(CSU/CIRA)*	Using JPSS Retrievals to Implement a Multisensor, Synoptic, Layered Water Vapor Product for Forecasters
Tony Wimmers *(UW/CIMSS)*	Strengthening TPW visualization in the OCONUS domain with JPSS data products
Tarendra Lakhankar *(CUNY/CREST)*	Validation and Application of JPSS/GCOM-W Soil Moisture Data Product for operational flood monitoring in Puerto Rico
Jerry Zhan *(NESDIS/STAR)*	Enhance Agricultural Drought Monitoring using NPP/JPSS Land EDRs for NIDIS
Andi Walther *(UM/CIMSS)*	Further development of the VIIRS Nighttime Lunar Reflectance-derived Cloud Properties and the Demonstration for their use for Precipitation and Icing Applications

Hydrology Initiative Overview & Objectives

- **Goal(s):**
  - Create a forum for Hydrology-related project teams to interact regularly
  - Coordinate activities of its stakeholder projects to include:
    - Algorithms/techniques/software that is mutually beneficial
    - Link derived products (surface, atmosphere) where possible
    - Develop potential product intercomparisons
    - Engage users, including WFO, National Centers, Proving Grounds, Testbeds
  - Identify newsworthy 'events' to apply project capabilities & evaluate value
  - Develop linkages to other initiatives under JPSS & GOES-R PGRR.
- **Satellite (sensors) used:**
  - Primary - S-NPP (ATMS, VIIRS; CrIS); GCOM (AMSR-2);
  - Secondary - NOAA POES & MetOp (AMSU/MHS; AVHRR); DMSP (SSMIS)
- **We meet "virtually", approximately every 2 months**
  - Held our kick off meeting on July 21, 2015
  - Six meetings since then, most recently June 29, 2016

Examples of NWS User Engagement

- Layer Precipitable Water Vapor (John Forsythe)
  - NESDIS SAB, WPC, NHC, SPC, OPC, + a few WFO's (e.g. Tucson AZ) with data routed via NASA SPoRT
  - Looked at closely during SC floods in Sept. 2015
- TPW Visualizations (Tony Wimmers)
  - Honolulu, Anchorage, Key West WFOs



- Snowfall Rates (Huan Meng)
  - Exploiting Direct Broadcast over CONUS to reduce latency to 30 minutes or less!
  - Product assessment in winter 2015-2016 at six WFOs (via NASA/SPoRT), WPC, SPC, SAB

MESOSCALE PRECIPITATION DISCUSSION 0530
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
1016 AM EDT TUE SEP 29 2015

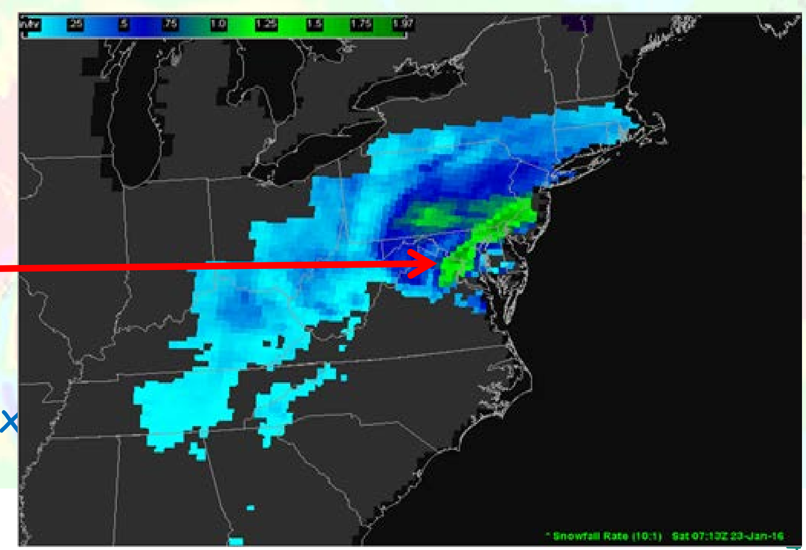
CONCERNING...HEAVY RAINFALL...FLASH FLOODING LIKELY

SUMMARY...A TROPICAL AIRMASS WITH NEAR RECORD PRECIPITABLE WATER WILL RESULT IN A CONTINUED FLOOD AND FLASH FLOOD THREAT INTO THIS AFTERNOON.

...

FORCING FROM THE SHORTWAVE IN GA AND A GENERALLY DIVERGENT PATTERN ALOFT IS HELPING FORCE ASCENT ON THE LARGE SCALE...WITH 20-30 KTS OF LOW LEVEL UPSLOPE FLOW AIDING IN LIFT. LAYERED PRECIPITABLE WATER PRODUCTS SHOW AN IMPRESSIVE COMBINATION OF FACTORS CONTRIBUTING TO THE NEAR RECORD PRECIPITABLE WATER VALUES ACROSS THIS REGION. A CONNECTION TO THE PACIFIC AND TROPICAL STORM MARTY CAN BE SEEN IN THE MID/UPPER LEVELS...WITH A DEEP LAYER CONNECTION TO THE GULF OF MEXICO AND ALSO TROPICAL STORM JOAQUIN IN THE ATLANTIC. THIS IS ALL RESULTING IN A VERY EFFICIENT ATMOSPHERE FOR HEAVY RAIN RATES. THE ONE THING LACKING IS INSTABILITY...BUT AT LEAST SOME DOES EXIST ACROSS THE AREA AS NOTED BY SOME LIGHTNING AND COLDER CLOUD TOPS...

Jan. 16 2016 Snowfall Rate



Examples of NWS User Engagement

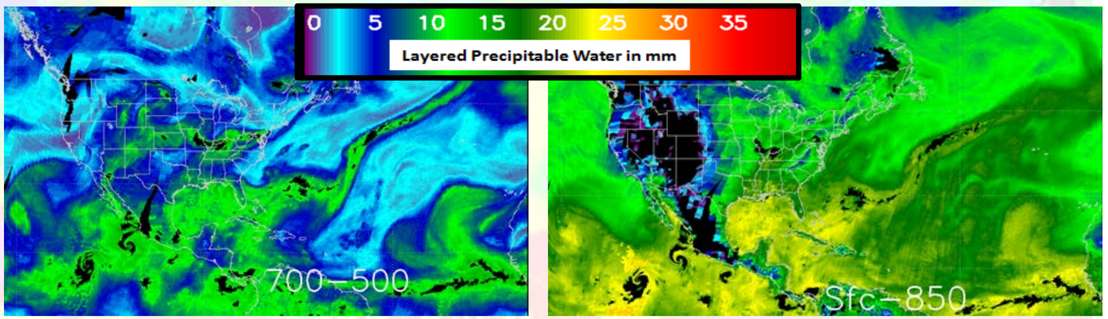
CIRA Layered Precpitable Water frequently mentioned in NHC Tropical Weather Discussions (45 times in July 2016 in Atlantic Discussion) and WPC Mesoscale Precipitation Discussions. Limited distribution to NASA SPoRT partner NWS WFO's.

Environment of tropical waves

TROPICAL WEATHER DISCUSSION
NWS NATIONAL HURRICANE CENTER MIAMI FL
205 PM EDT THU JUN 02 2016

Tropical wave is over the central Caribbean from 15N76W to 03N76W moving W at 20 kt. **The wave is embedded in a high moist environment from the surface to 850 mb as indicated by CIRA LPW imagery .**

(*See related poster by Forsythe et al.)



Area Forecast Discussion
National Weather Service Tucson AZ
154 PM MST THU MAY 12 2016

Moisture surges in SW U.S.

CIRA layered precipitable water estimates show totals up to .8 inches in the central gulf, with contributions from the surface to 850mb layer up from .3 to .5. The bulk (of what is likely a moderate surge) may not make it fully through the northern gulf.

Collaborative Case Studies

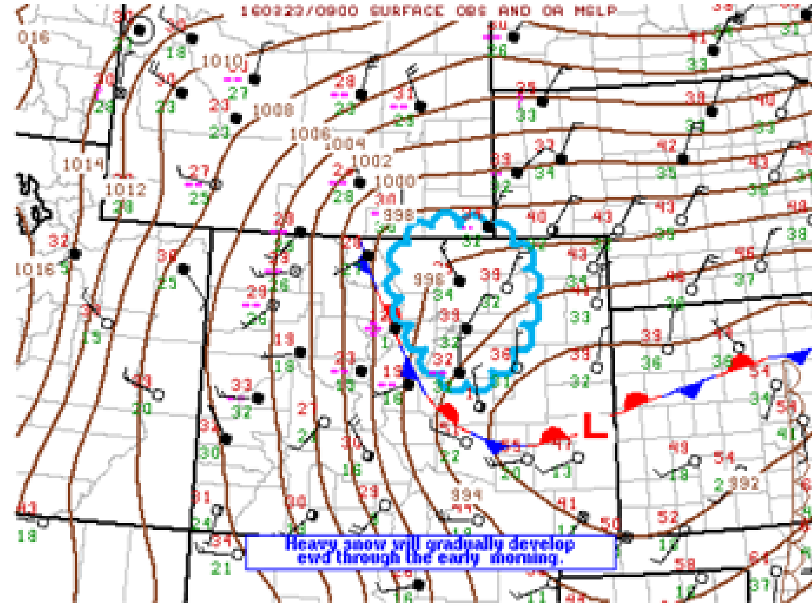
- Hydrology → El Nino of 2015-16 good opportunity to examine various products
  - Note not all of these projects are ripe for this type of study
- CIRA hosting FTP site/data depository
  - Initially start with imagery, but ultimately, data in native resolution with decoders, etc.
- Projects continue to mature, more opportunities to demonstrate the impact on analysis/forecasting/decision making
- Two current case studies:
  - CO Front Range snowstorm – March 23, 2016 (lead J. Forsythe)
  - Houston Texas Area Flooding – Late April 2016 (lead A. Heidinger)

Case 1: March 23-24, 2016 Front Range Blizzard

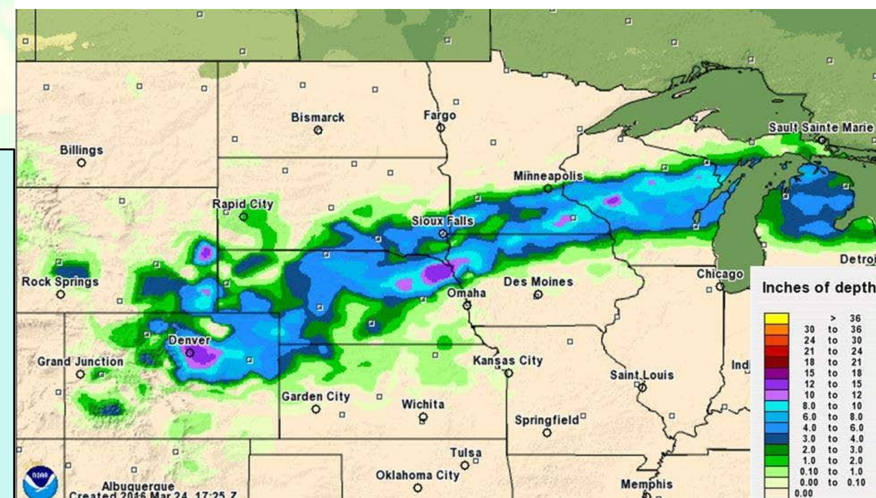
- Interesting synoptic event with very high snowfall rates along Front Range
  - Snowfall rates 2-3"/hr occurred
  - Wetness of snow and strong winds caused extensive power outages

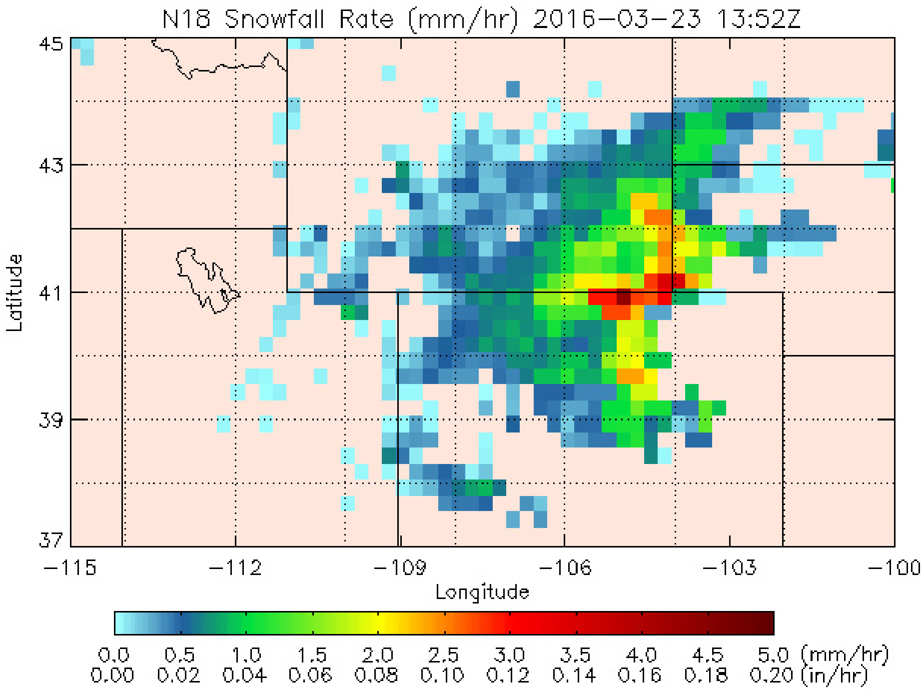
Forecast for Fort Collins for 3/23 morning:
Issued at 4 PM 3/22: Winter Weather Advisory
Issued at 8 PM 3/22: Winter Storm Warning
Issued at 4 AM 3/23: Blizzard Warning

Total: 14" of snow in 7 hours, shut down Fort Collins.
Snowfall rates of 2+" / hour occurred.

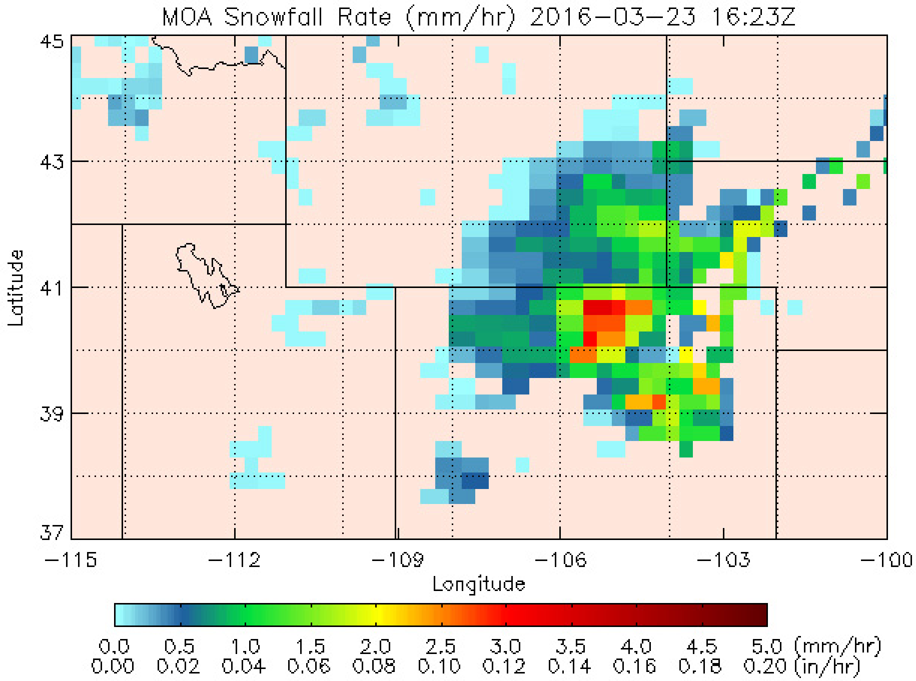


SPC MCD #0250

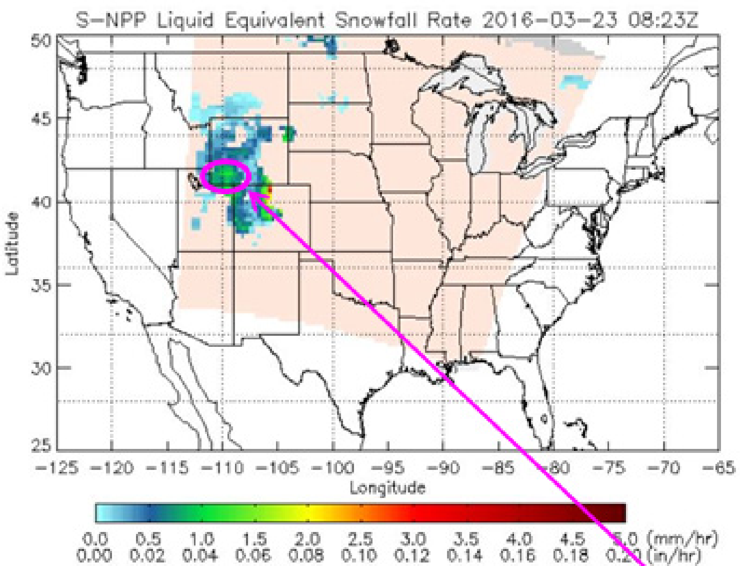


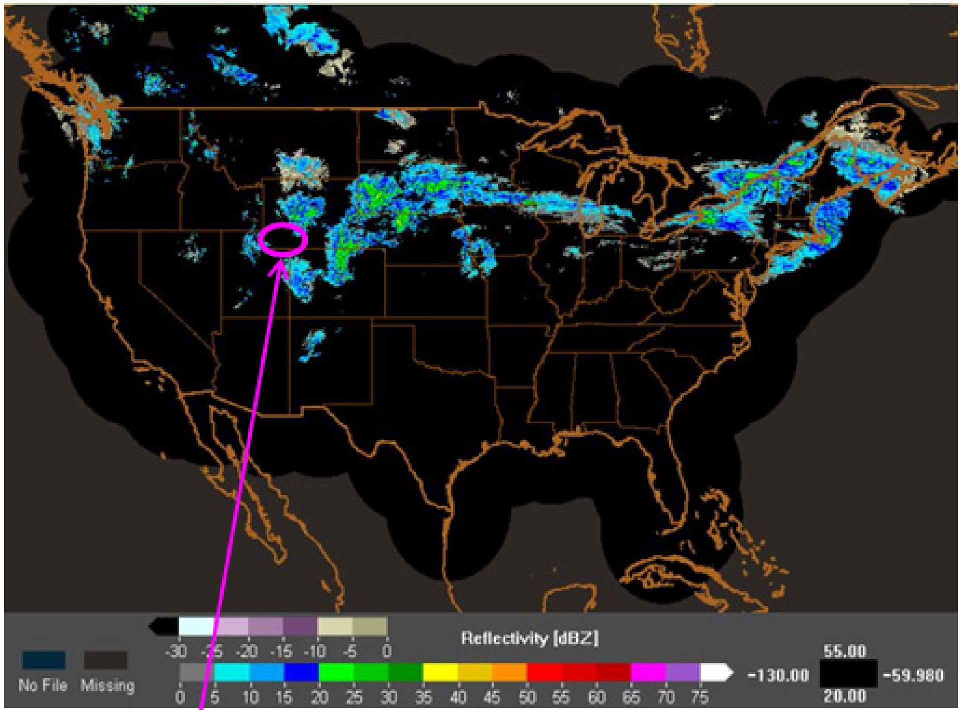


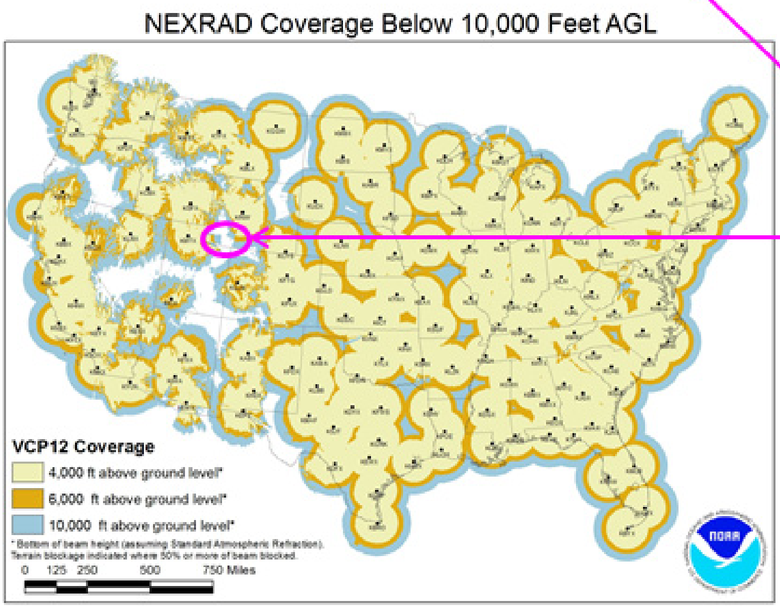
NOAA-18 Liquid Equivalent Snowfall Rate 1345 UTC March 23, 2016 (Blizzard in progress over N. Colorado at this time, 2-3" hour rates reported).



Metop-A Liquid Equivalent Snowfall Rate, 1622 UTC (9:22 AM MST)







Radar gap filled by satellite observation

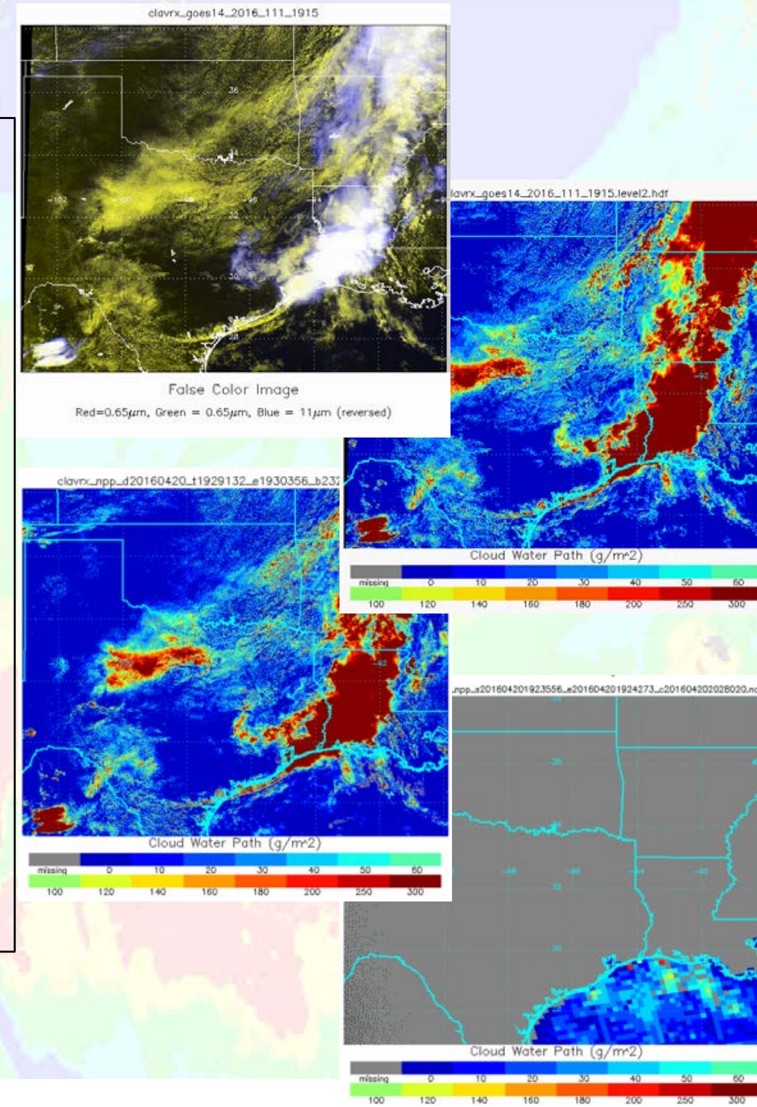
Case 2: Mid-Late April 2016 Texas Flooding

- Up to 17" of rain in Houston area
- Multiple fatalities, damage of ~$5B

Rain rate and water path generated from VIIRS <u>lunar</u> reflectance.
Synergy of GOES-14 1-min data and VIIRS being explored

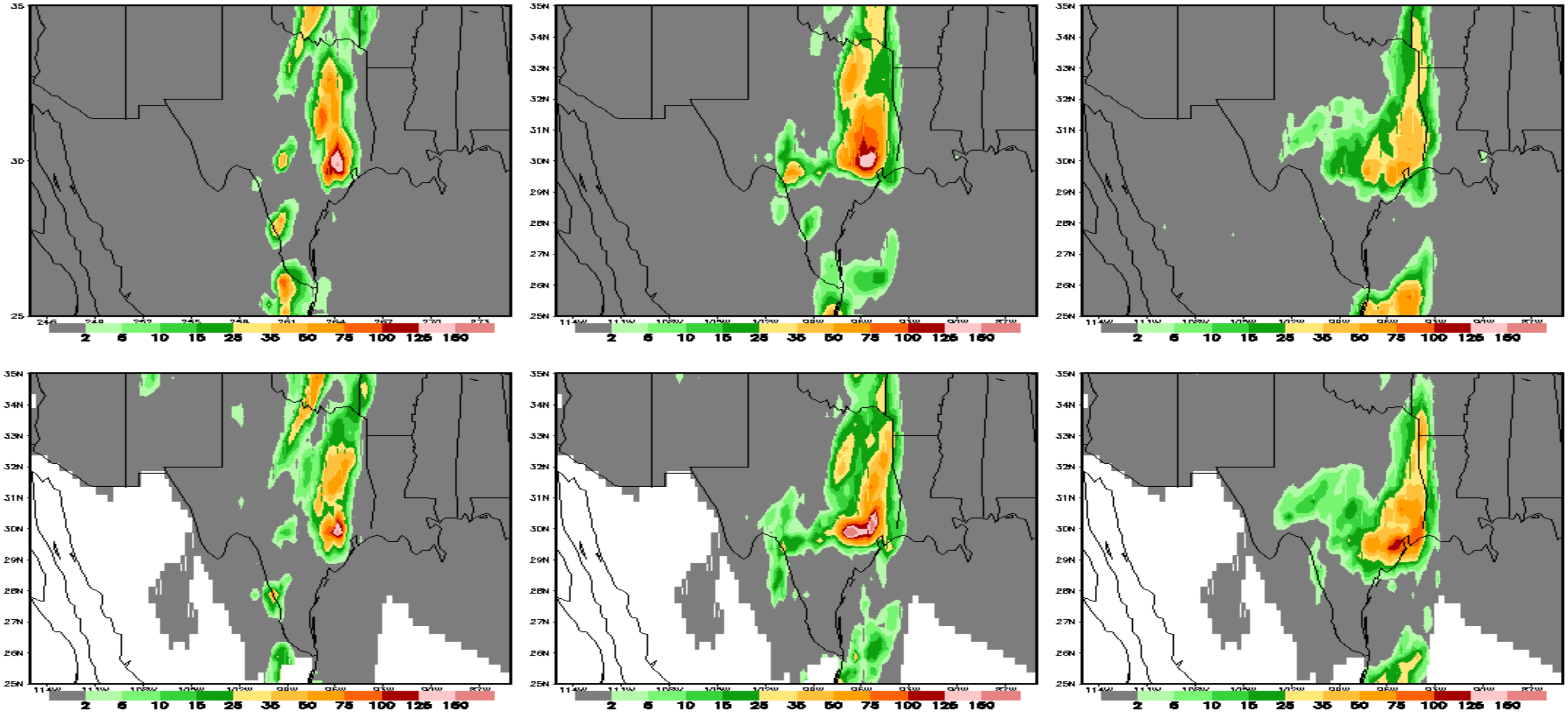
Datasets gathered:

GOES-14
VIIRS
ATMS
RADAR
GCOM-W
LPW
GFS
SCAMPER
GCOM
SMOPS
CMORPH



Texas flooding event 00-18 UTC 18 April 2016

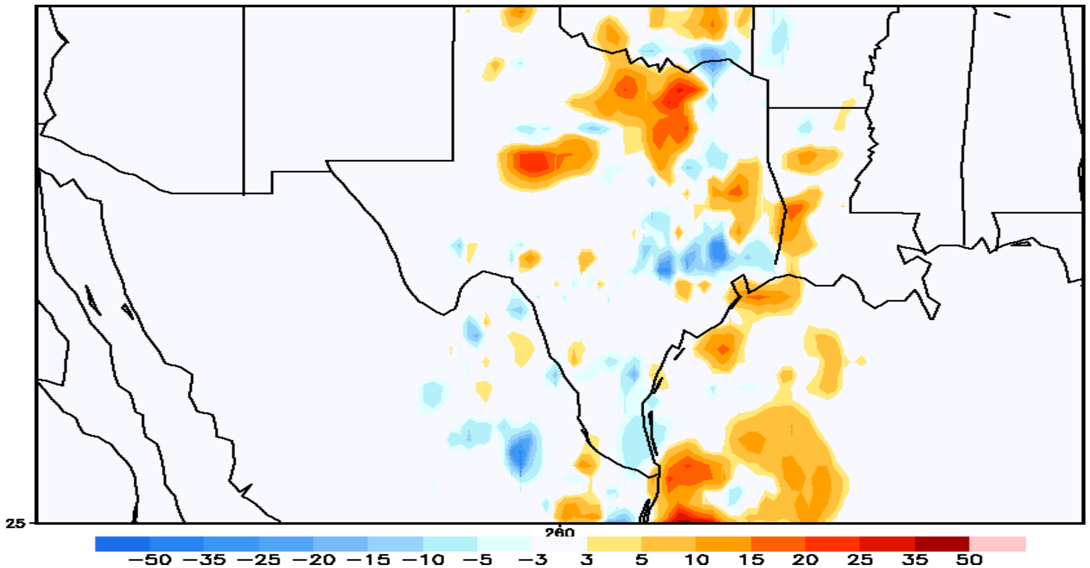
CMORPH with JPSS-ATMS (top) radar (bottom) 6-hour mm total

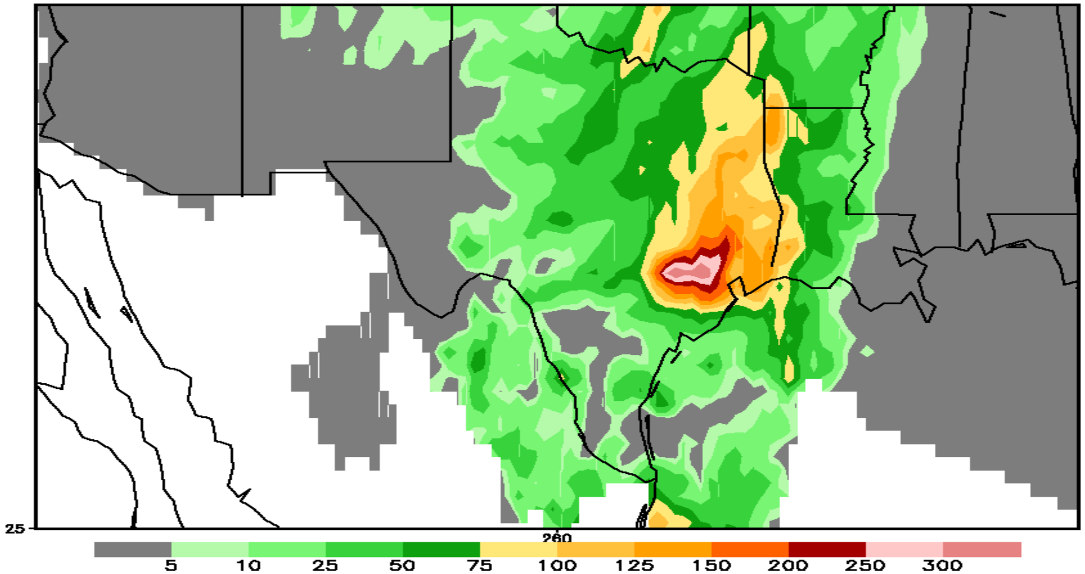


Texas flooding event 18-21 April 2016

With JPSS-ATM –minus w/o JPSS (top) mm

Stage IV radar (bottom) 72-hour mm total





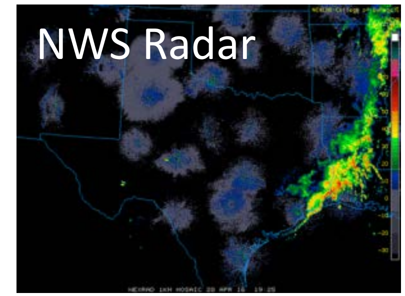
Included in Backup Slides, Summaries of Each Project in the Risk Reduction/Proving Ground – Hydrology Initiative

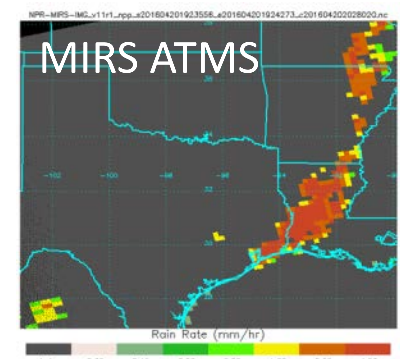
Hydrologic Applications of the VIIRS Cloud Products

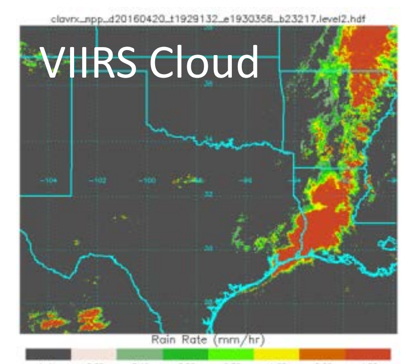
Andi Walther, Andrew Heidinger and Samantha Tushaus

- Objectives
  - Verify the skill in deriving precipitation from VIIRS cloud products and study how they complement other sources (microwave, IR).
  - Explore the accuracy of the cloud water path product from VIIRS and how it can complement that from ATMS (*which lacks coverage over land*)
  - Demonstrate skill with lunar-reflectance to provided unique nighttime ability.
- Primary sensors involved
  - VIIRS including DNB (primary)
  - ATMS (for reference)
- Primary ground data
  - NWS Radar Data
- Targeted end users
  - NWS forecast offices – we think precipitation and water path are better suited for AWIPS displays than the standard cloud optical depth and particle size.

Rain-rates on April 20, 2016 19:30 UTC







Summary and Take Away Points

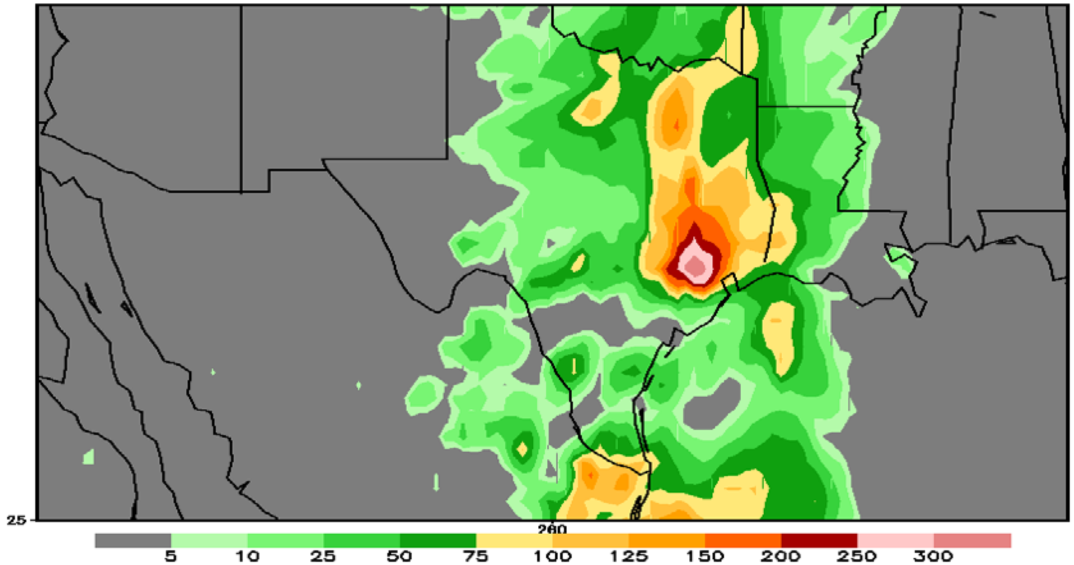
- JPSS is funding a variety of projects related to Hydrology
  - Water vapor, snowfall rates, precipitation, hydrological models, soil moisture, climate data records
  - Some projects are on their second cycle of funding
- Some projects are well engaged with NWS users while others are just starting
  - Engaged with NWSFO's and national centers
  - Have detailed training materials, generally working with NASA/SPoRT and satellite liaisons.
- Some projects are in fact downstream users of some of the hydro. products
- As a way of promoting more end to end use of the products, we are having the PI's collaborate on case studies of interest
  - *If anyone wants to see us focus on a particular case, please let me know!*
  - We plan to develop a publication within 1-year
  - As the case studies mature, we will also engage with other JPSS PGRR initiatives (e.g. NUCAPS)
- Down the road, we hope to engage with similar types of activities under the GOES-R Risk Reduction program

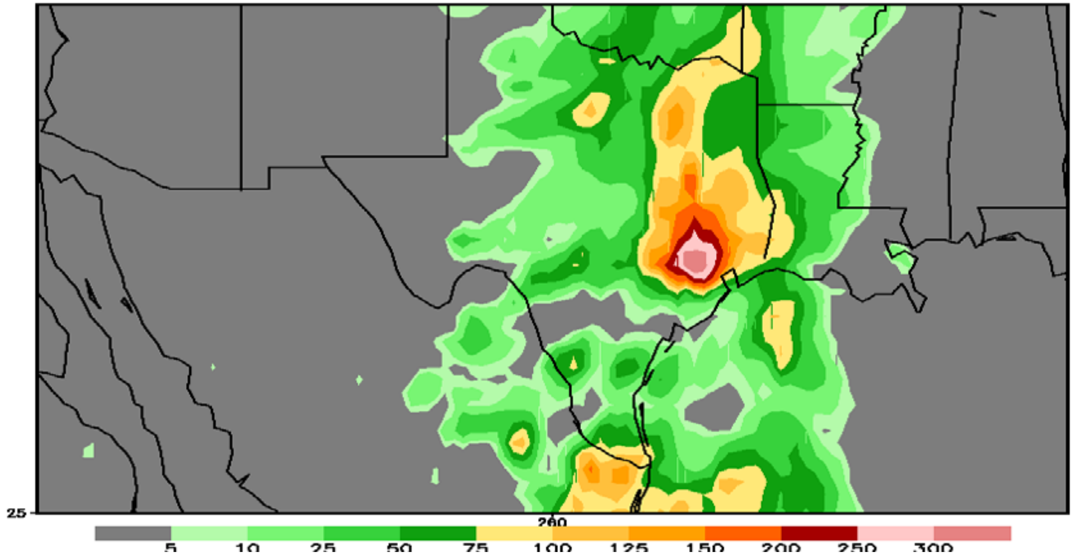
Backup Slides

Hydrology Project Details

Texas flooding event 18-21 April 2016

With/without JPSS-ATM (top/bottom) 72-hour mm totals





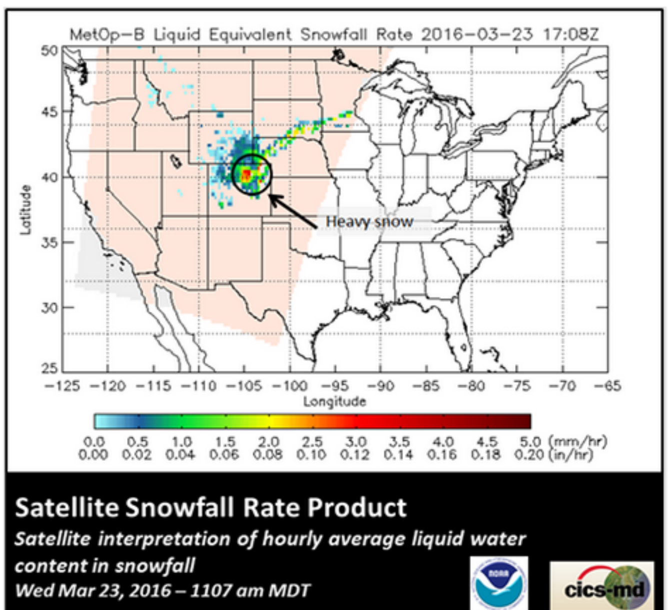
Snowfall Rate Product

Diane Cooper/Sheldon Kusselson

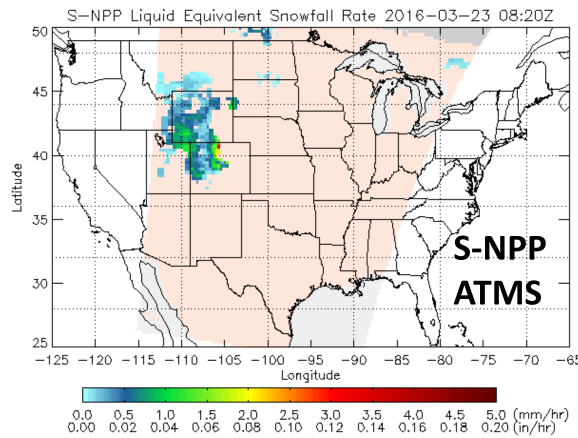
WxIntegrations
March 23 ·

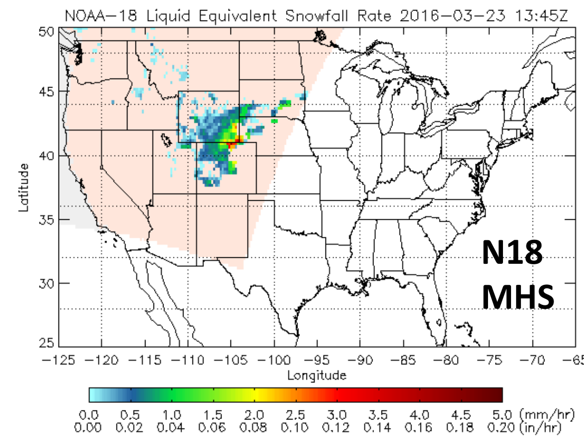
The Colorado Front Range experienced some impressive snowfall rates with the storm this morning. The attached image is the NOAA Satellite Snowfall Rate Product which estimates liquid water content that is in the snow fall. The yellows and brighter reds highlight 0.06 to 0.15 inches of water. Since this was a wet snow, we know the snow ratios were fairly low. Using a ratio of 8 inches of snow to 1 inch of water (8 to 1 ratio) or even a ratio of 10 inches of snow to 1 inch of water (10 to 1 ratio), we can estimate that hourly snowfall rates around 11 am MDT were between 0.5 to 1.5 inches per hour. The snowfall rates were likely heavier in localized areas, but this gives a context of the broader snowfall rates.

While the resolution of the satellite date as is not as fine as radar estimates, it is exceedingly helpful for areas that the radar is blocked such as in hilly or mountainous training or in situations where the radar not seeing the snow.

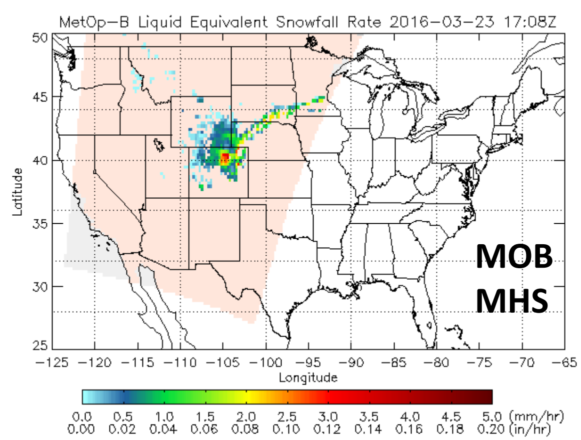


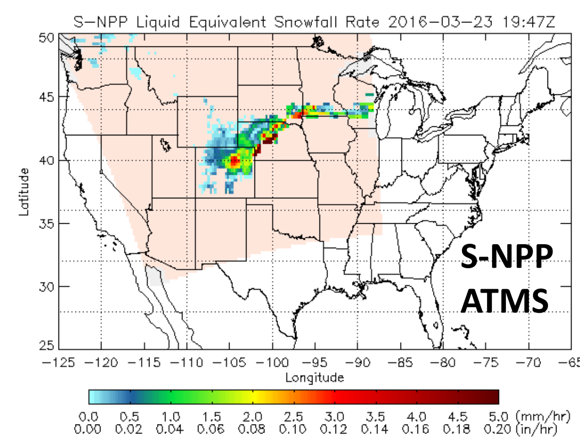
0820 UTC **23 March 2016** **1345 UTC**



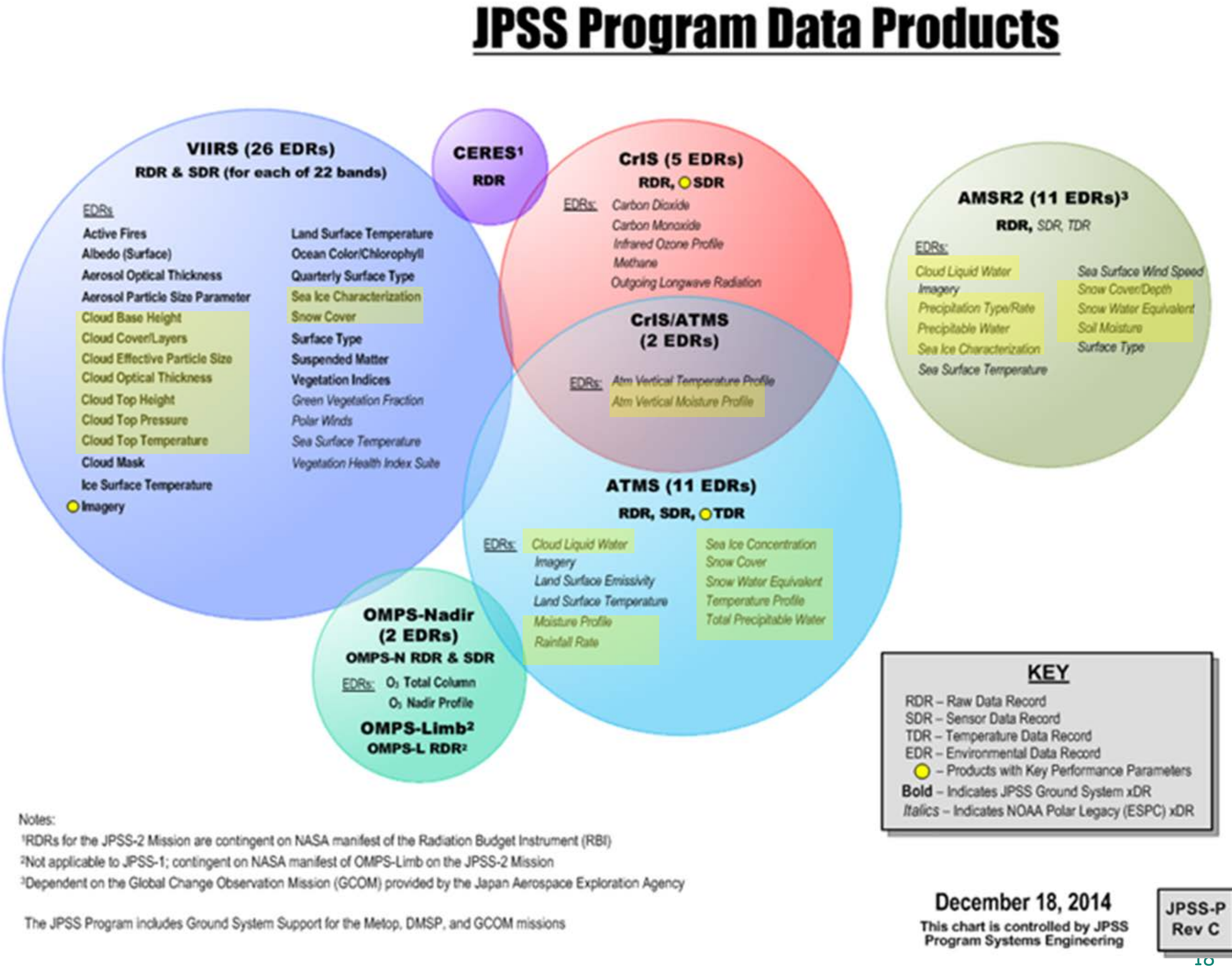


1708 UTC **23 March 2016** **1947 UTC**





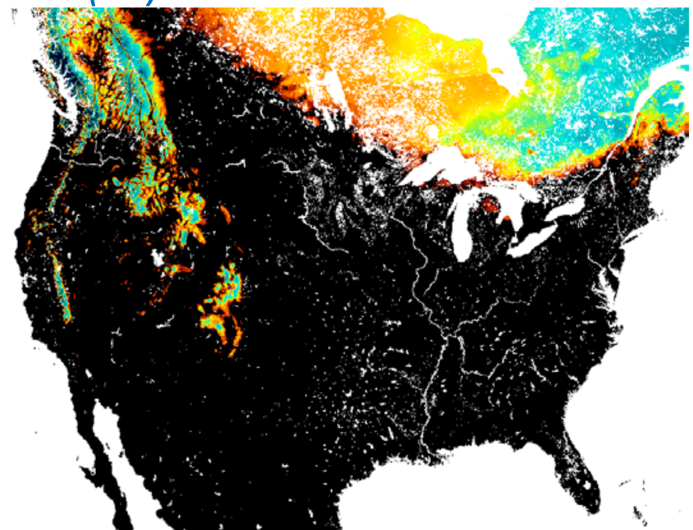
Hydrology – Very Diverse!

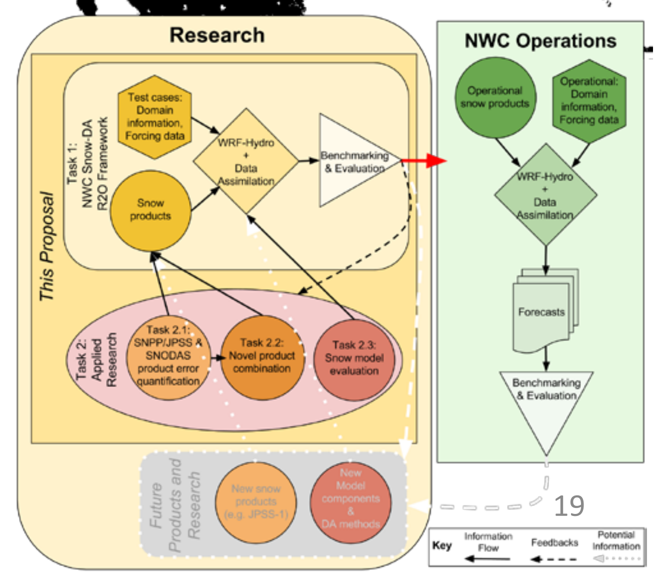


S-NPP/JPSS and SNODAS Applications to the National Water Model

NCAR (Gochis) – NWC (Cosgrove)
NOAA CREST (Romanov) – NCEP (Ek)

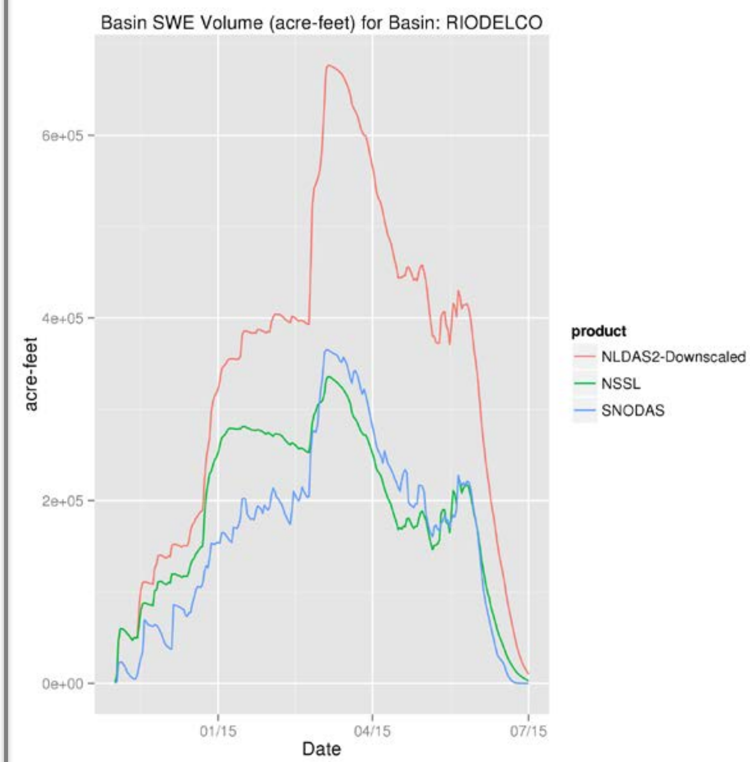
- Objectives
  - Improvement of seasonal streamflow forecasts
    - Assimilation snow observations and SNODAS.
    - Develop error chars of satellite snow obs
    - Combine satellite snow observations
  - Establish and R2O evaluation framework for operational snow products
- Primary sensors involved
  - SNPP satellite:
    - VIIRS snow cover fraction
    - ATMS snow depth and snow water equivalent
  - GCOM-W satellite:
    - AMSR2 snow depth and snow water equivalent
- Primary ground data / ancillary products
  - The SNODAS product & its observations
    - Airborne Gamma
    - Vast point observation data base including SNOTEL, etc.
  - NASA Airborne Snow Observatory
    - LiDAR
    - Hyperspectral (Albedo)
- Targeted end users
  - NWC's National Water Model (NWM)





Project Status/Update

- Accomplishments to date
  - (Not yet funded)
  - Participation in group goals
- Users Engaged to date
  - NWC
  - Colorado Water Conservation Board
  - Colorado Division of Natural Resources
- Near term plans/milestones
  - Compare our forcing product with others in group: development of snow QPE (see figure on right for backgrnd)
  - Establish snow database
- One really interesting result (images on right)

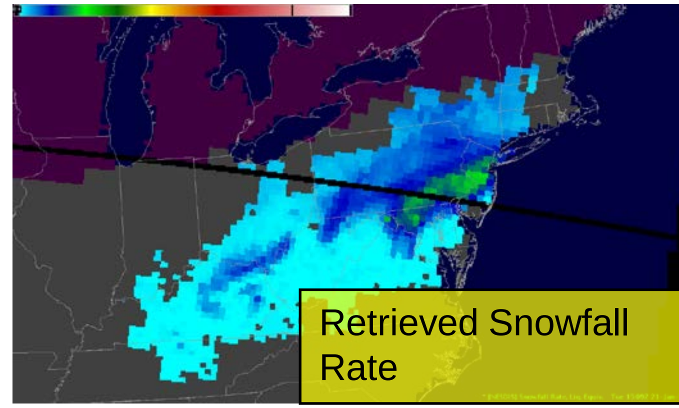


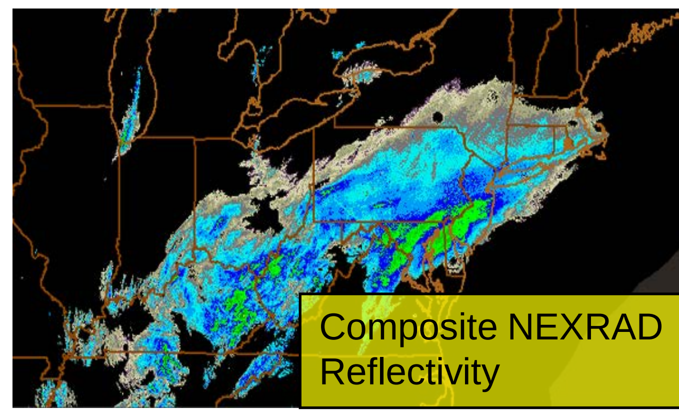
<u>Upper Rio Grande Basin Basin SWE volume uncertainty as a function of forcing product:</u> In-situ-RADAR-based NSSL product improved simulation over NLDAS2 and agreed more with SNODAS.

Continued Expansion, Enhancement and Evolution of the NESDIS Snowfall Rate Product to Support Weather Forecasting

H. Meng, J. Dong, C. Kongoli, R. Ferraro, B. Yan, S. Rudlosky, B. Zavodsky

- Objectives
  - An ATMS snowfall rate (SFR) algorithm was developed previously with the support of JPSS PGRR
  - Improve the SFR algorithm for snowfall associated with low cloud and with dominating emission effect
  - Develop SFR algorithms for SSMIS and GMI sensors
  - Develop prototype over ocean SFR algorithm
- Primary sensors involved
  - ATMS (S-NPP, JPSS)
  - MHS and AMSU pair (POES, Metop)
  - SSMIS (DMSP)
  - GMI (NASA GPM)
- Primary ground data
  - NSSL MRMS radar precipitation
  - NCEI QCLCD gauge
- Targeted end users
  - NWS Weather Forecast Offices (WFOs)
  - National Centers (WPC, SPC)
  - Hydrology community (CMORPH, NWC)

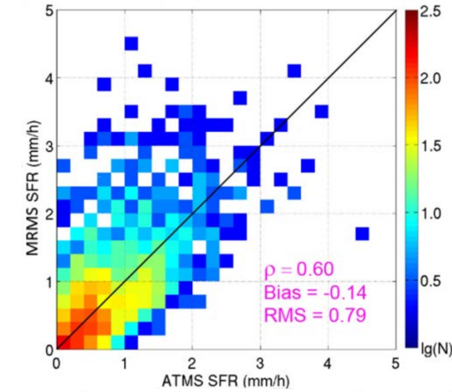


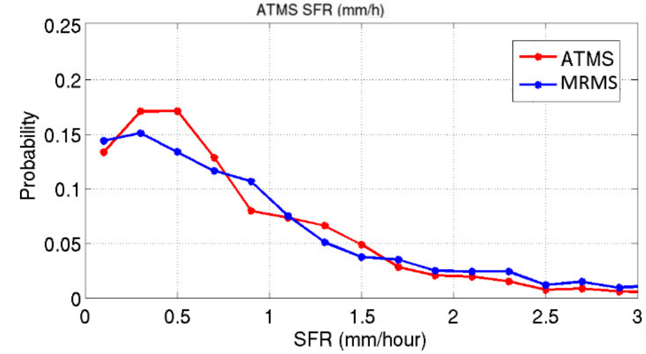


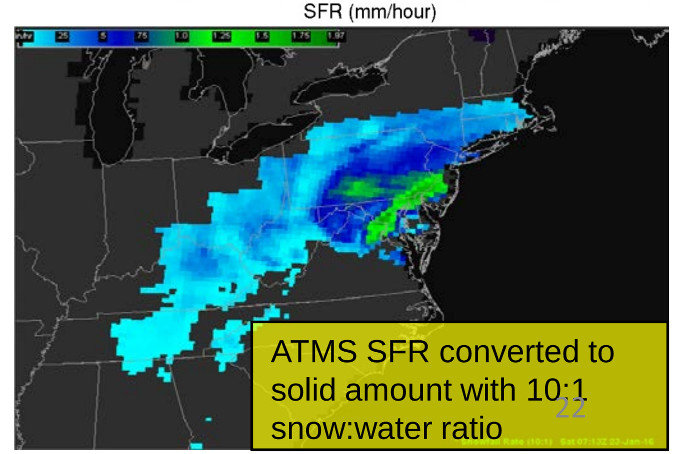
Project Status/Update

- Accomplishments to date
  - Developed a new framework for snowfall detection that can significantly improve probability of detection
  - Completed formulation to incorporate cloud liquid water in the forward radiative transfer model; coding is close to completion
- Users Engaged to date
  - Product assessment in winter 2015-2016 at six WFOs, WPC, SPC, SAB
  - NCEP/CPC, NWC
- Near term plans/milestones
  - Complete development of shallow snowfall detection algorithm
  - Calibrate snowfall rate algorithm after RTM coding is complete
  - Start development of SSMIS snowfall detection algorithm
- One really interesting result (images on right)
  - SFR performed well for the 2016 East Coast Blizzard

ATMS SFR from the East Coast Blizzard Jan 22-23, 2016



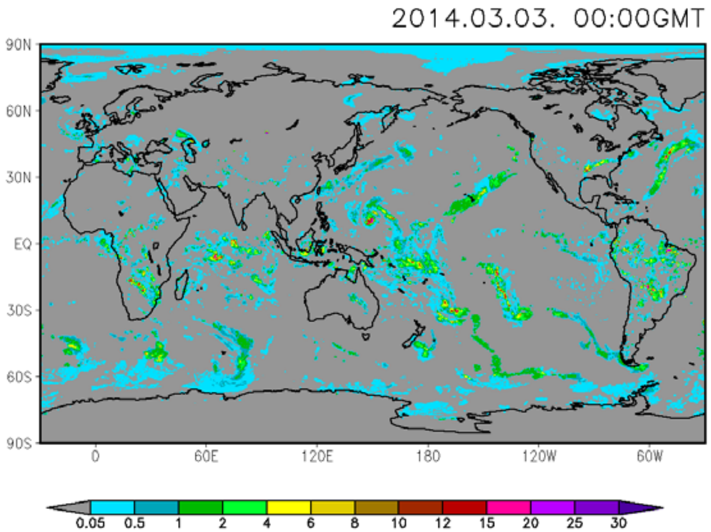




Infusing JPSS PMW Retrievals to CMORPH Precipitation Estimates for Improved Weather, Climate, and Water Applications

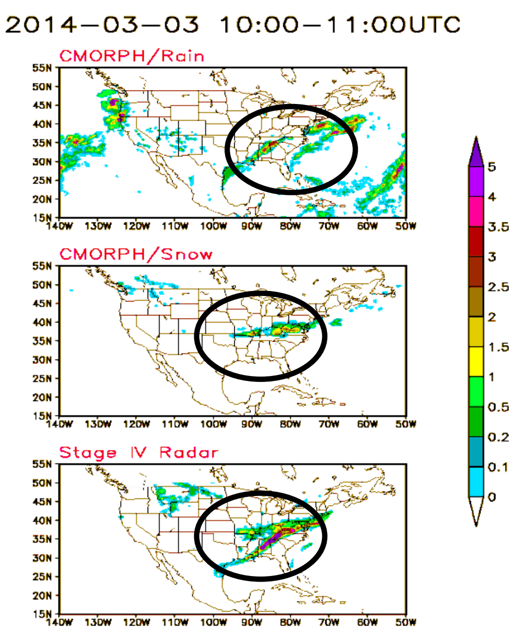
P. Xie, R. Joyce, S. Wu and collaborators

- Objectives
  - *To improve CMORPH integrated precipitation estimates through infusing retrievals from JPSS sensors*
    - Pole-to-pole coverage
    - Snowfall rate representation
    - Improved accuracy / reduced latency
- Primary sensors involved
  - *ATMS, VIIRS*
- Primary ground data
  - Gauge measurements of precipitation
- Targeted end users
  - *NHC, WPC, EMC, CPC and field offices*
  - National / international centers, research institutes, universities, governments, private industries (>100s)



Project Status/Update

- Accomplishments to date
  - Component techniques developed; Test system established
- Users Engaged to date
  - We have been communicating with our users in several key areas (CPC, EMC, NHC, et al) with regard to their users requirements
- Near term plans/milestones
  - Real-time production of the pole-to-pole CMORPH (this coming summer)
  - *Reprocessing the new CMORPH for the JPSS era (?)*
- One really interesting result (images on right)
  - Improved capacity in detecting snowfall rate (left figure) and quantification for storm rainfall (right figure)



CMORPH w/o SFR retrievals

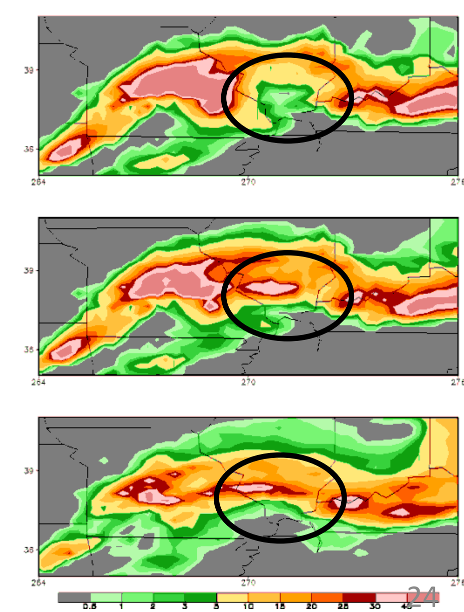
CMORPH with SFR retrievals

Stage IV Radar Est

CMORPH w/o SNPP

CMORPH with SNPP

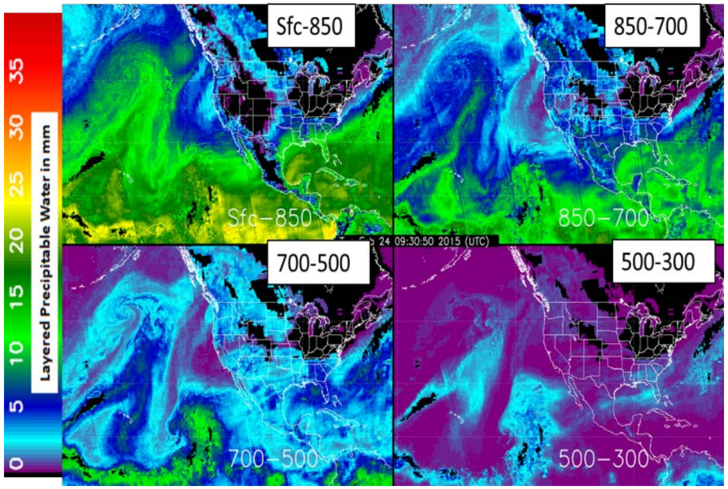
Stage IV Radar Est



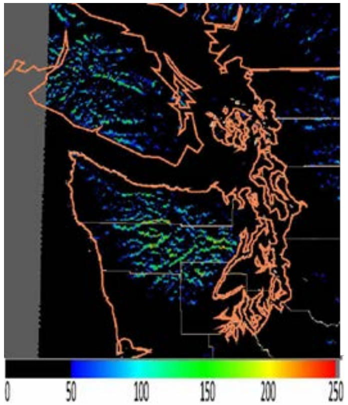
Using JPSS Retrievals to Implement a Multisensor, Synoptic, Layered Water Vapor Product for Forecasters

John Forsythe, Andy Jones, Stan Kidder, Dan Bikos, Ed Szoke
Cooperative Institute for Research in Atmosphere (CIRA),Colorado State University

- Objectives
  - Blend multiple polar soundings of layer precipitable water (LPW) and advect through time to benefit forecasters
  - Update the orographic rain index (ORI)
  - Obtain feedback and develop training materials
- Primary sensors involved
  - S-NPP (ATMS), DMSP F18/~~19~~ (SSMIS), NOAA-18/19 (AMSU-A/MHS), Metop-A/B 9(MHS); all via NOAA MiRS retrieval system.
  - NASA Aqua (AIRS); NUCAPS products
- Primary ground data
  - Radiosondes
  - GFS 0-6 hour forecasts
- Targeted end users
  - National centers (WPC, NHC, SPC, OPC, AWC)



Example of 4-layer blended LPW product produced in near-realtime at CIRA at 0900 UTC 24 February 2015.



ORI product at 00 UTC 14 Feb. 2010. Units are mm * m/s.

Project Status/Update

- Accomplishments to date
  - Product served in near-realtime to national centers.
  - S-NPP MiRS V11 (high resolution (~15 km)) retrievals now included in product
- Users Engaged to date
  - WPC, NHC, SPC, OPC, + WFO's (e.g. Tucson AZ) with data routed via NASA SPoRT
- Near term plans/milestones
  - Develop the advection component by combining GFS winds with the layered water vapor
  - Continue to receive forecaster feedback
- One really interesting result (images on right)
  - Played a key role in understanding the many sources of moisture for record flooding in South Carolina in late September. 12 SOO's briefed via VISIT chat.

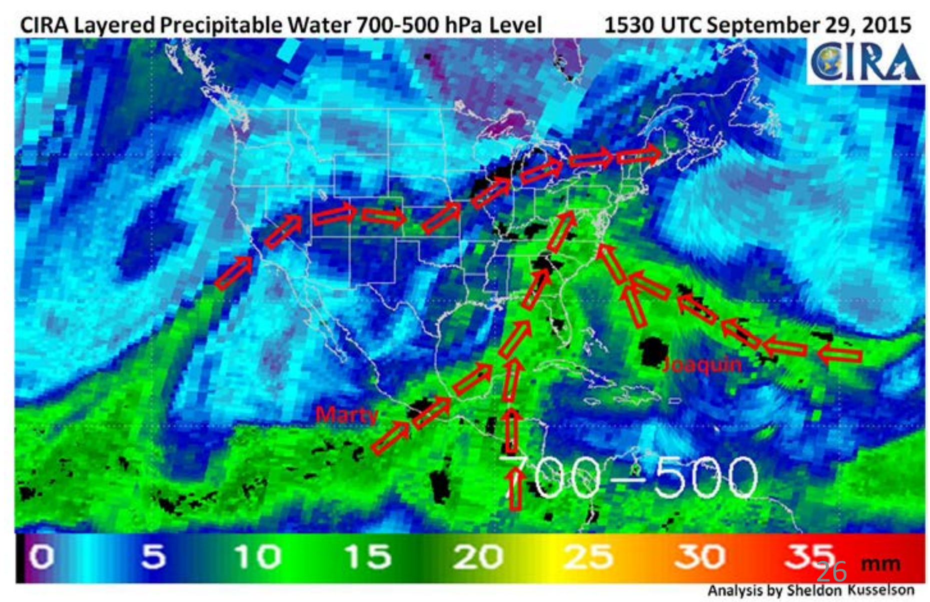
MESOSCALE PRECIPITATION DISCUSSION 0530
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
1016 AM EDT TUE SEP 29 2015

CONCERNING...HEAVY RAINFALL...FLASH FLOODING LIKELY

SUMMARY...A TROPICAL AIRMASS WITH NEAR RECORD PRECIPITABLE WATER WILL RESULT IN A CONTINUED FLOOD AND FLASH FLOOD THREAT INTO THIS AFTERNOON.

...

FORCING FROM THE SHORTWAVE IN GA AND A GENERALLY DIVERGENT PATTERN ALOFT IS HELPING FORCE ASCENT ON THE LARGE SCALE...WITH 20-30 KTS OF LOW LEVEL UPSLOPE FLOW AIDING IN LIFT. LAYERED PRECIPITABLE WATER PRODUCTS SHOW AN IMPRESSIVE COMBINATION OF FACTORS CONTRIBUTING TO THE NEAR RECORD PRECIPITABLE WATER VALUES ACROSS THIS REGION. A CONNECTION TO THE PACIFIC AND TROPICAL STORM MARTY CAN BE SEEN IN THE MID/UPPER LEVELS...WITH A DEEP LAYER CONNECTION TO THE GULF OF MEXICO AND ALSO TROPICAL STORM JOAQUIN IN THE ATLANTIC. THIS IS ALL RESULTING IN A VERY EFFICIENT ATMOSPHERE FOR HEAVY RAIN RATES. THE ONE THING LACKING IS INSTABILITY...BUT AT LEAST SOME DOES EXIST ACROSS THE AREA AS NOTED BY SOME LIGHTNING AND COLDER CLOUD TOPS...



Strengthening TPW visualization in the OCONUS domain with JPSS data products

Tony Wimmers, Chris Velden, Jordan Gerth, Bill Ward, Carven Scott, Kennard Kasper, Xiwu Zhan

- Objectives

  1) Add SNPP ATMS and AMSU/MHS to the hourly, morphed-composite MIMIC-TPW product and ready the system for JPSS

  2) Streamline the algorithm and extend the product domain to 70°N-70°S

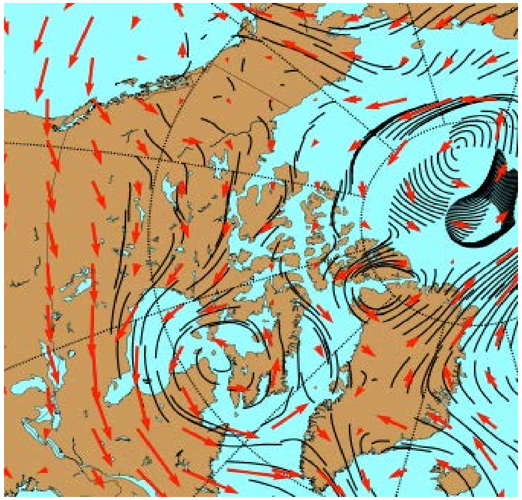
  3) Direct all development toward a future merger with the Blended TPW product

- Primary sensors involved
  - SNPP ATMS, AMSU/MHS, SSMIS

- Targeted end users

  1) Operational NWS forecasters in the OCONUS domain

  2) Tropical weather and tropical cyclone forecasters (NHC, JTWC) and global partners

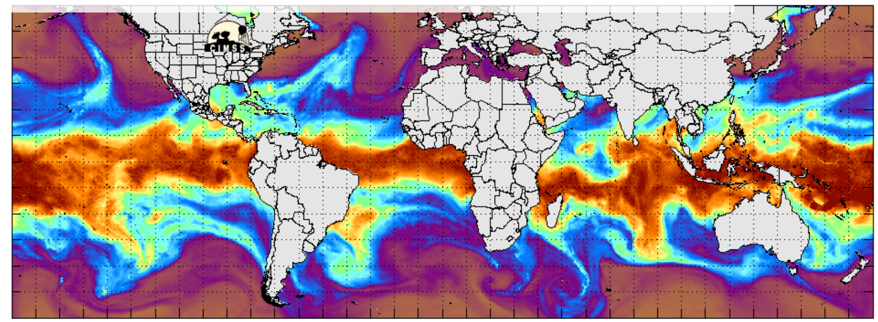


Example of improved data advection scheme
Red: GFS surface winds,
Black: 10-hour Runge-Kutta trajectories used for image morphing of TPW

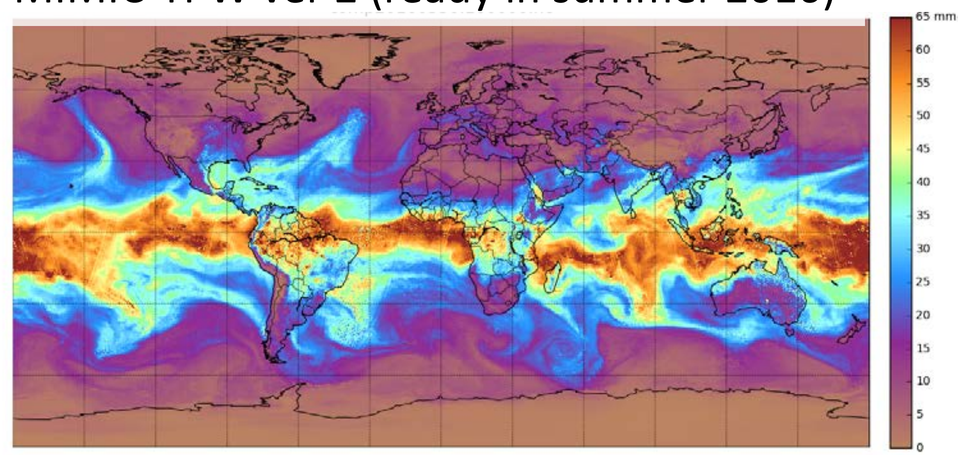
Project Status/Update

- Accomplishments to date
  - 1) Rewrote the algorithm for full portability (Python language, DDS input, NetCDF/AWIPS output)
  - 2) Producing full-globe retrievals (beyond original proposal of 70°N-70°S over water)
  - 3) New algorithm has improved accuracy and 10x improvement in speed
- Users Engaged to date
  - Honolulu, Anchorage, Key West WFOs
- Near term plans/milestones
  - 1) Bring MIMIC-TPW ver 2 online in real-time
  - 2) Engage users with in-person consultation and online materials
- One really interesting result (images on right)
  - Using MIRS ver11.2 retrieval of TPW provides a composite with good intercalibration, 3x higher resolution than MIRS ver9, and no gaps in data.

MIMIC-TPW ver 1 (existing product)



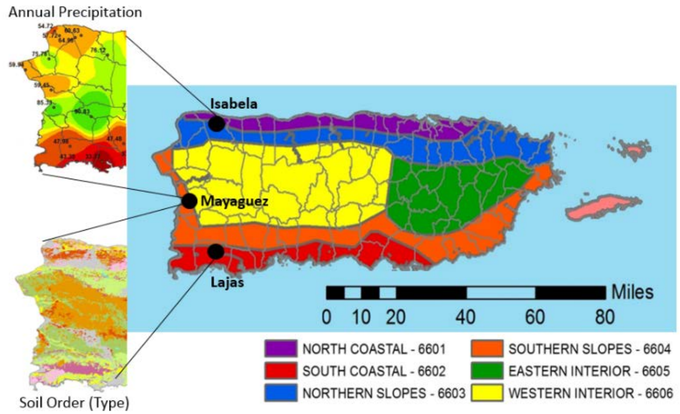
MIMIC-TPW ver 2 (ready in summer 2016)

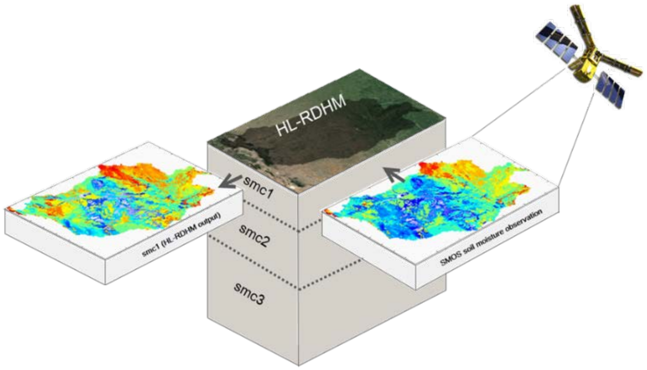


Validation and Application of JPSS/GCOM-W Soil Moisture Data Product for operational flood monitoring in Puerto Rico

Tarendra Lakhankar, Jonathan Munoz, Reza Khanbilvardi, and Nir Krakauer
Xiwu Zhan, Jorge Rivera-Santos, and Reggina Cabrera (Collaborators)

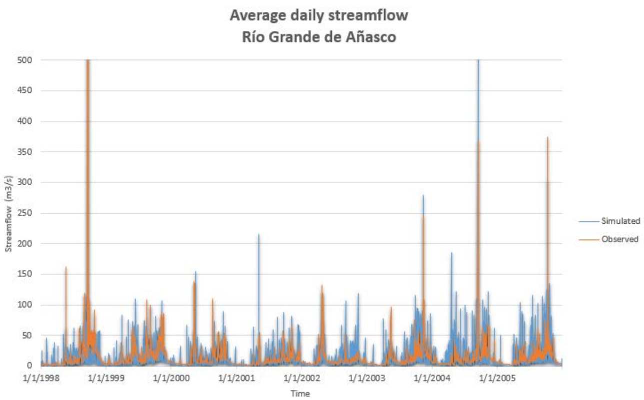
- Objectives
  - Validation of GCOM-W Soil Moisture Data Product using field measurements
  - Field Experiment using L-band Radiometer for GCOM-W soil moisture
  - Development of framework for GCOM-W soil moisture in Flash Flood Guidance System in Puerto Rico
- Primary sensors involved
  - GCOM-W1/AMSR2
  - SMOS and SMAP
- Primary ground data
  - L-Band dual polarized microwave radiometer
  - Soil moisture, vegetation and ancillary data
- Targeted end users
  - WFO/NWS (San Juan)
  - NESDIS/STAR (Cal/Val)





Project Status/Update

- Accomplishments to date
  - Soil moisture field experiment carried out during Feb 2016 at Western part of Puerto Rico
  - Data acquisition and processing of GCOM-W, SMOS, and SMAP microwave sensors and in-situ soil moisture and ancillary data
- Users Engaged to date
  - NWS/WFO San Juan
  - NESDIS/STAR
- Near term plans/milestones
  - Cross-comparison and validation of GCOM-W1/AMSR2, SMOS, and SMAP soil moisture data using in-situ soil moisture data in Puerto Rico
  - Identification of framework for GCOM-W1/AMSR2 soil moisture in Flash Flood Guidance System in Puerto Rico
  - Second round of field experiment for quantification of the effect of land cover heterogeneity in summer 2016
- One really interesting result (images on right)
  - None

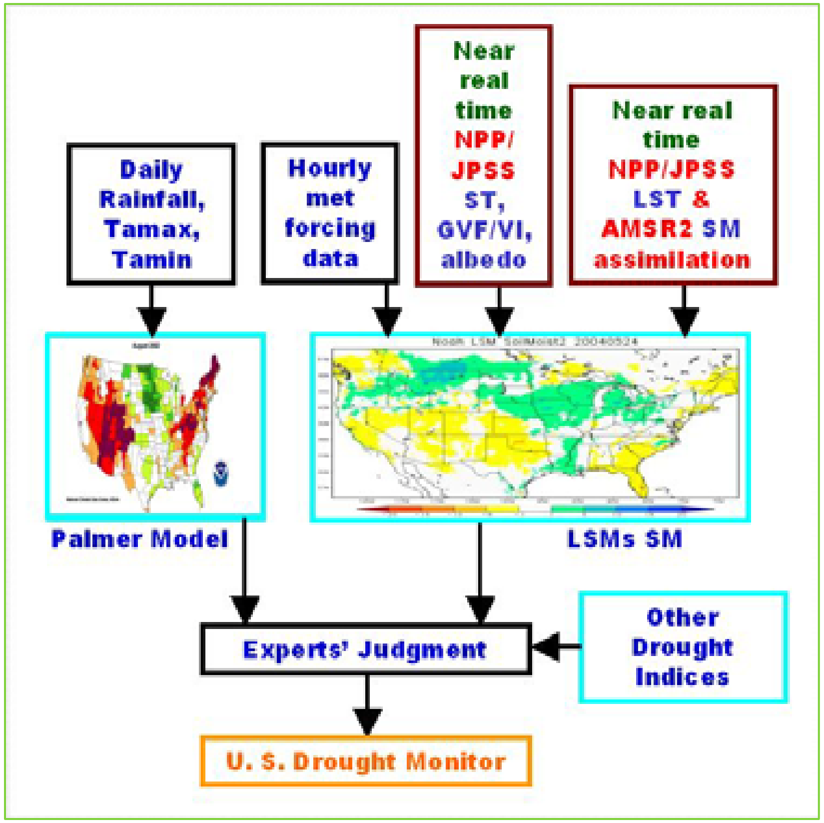


Simulation of streamflow using a conceptual empirical model for the Río Grande de Añasco watershed, PR

Enhance Agricultural Drought Monitoring Using SNPP/JPSS Land EDRs for NIDIS

X. Zhan, C. Hain, J. Yin, J. Liu, L. Fang, M. Ek, J. Huang, M. Anderson, M. Svoboda

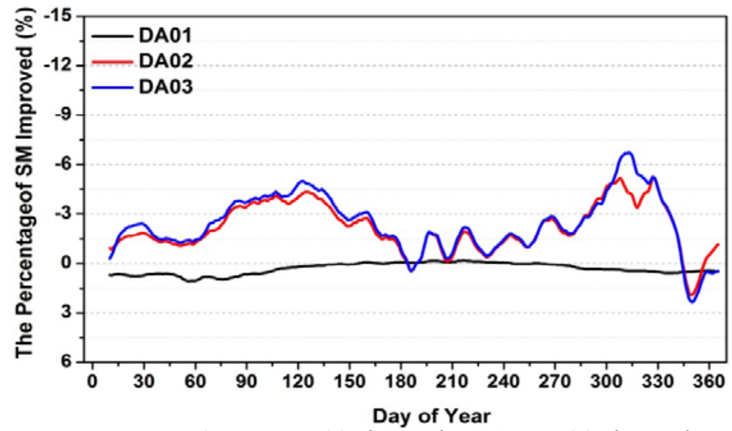
- Objectives
  - Improve current US and global drought monitoring via using near real time SNPP/JPSS land data products
- Primary sensors involved
  - S-NPP/VIIRS
  - GCOM-W1/AMSR2
- Primary ground data
  - Palmer Drought Severity Index
  - In situ soil moisture measurements from USDA SCAN/NOAA CRN ground networks
- Targeted end users
  - NIDIS of USDA, NOAA and USGS
  - NWS-NCEP



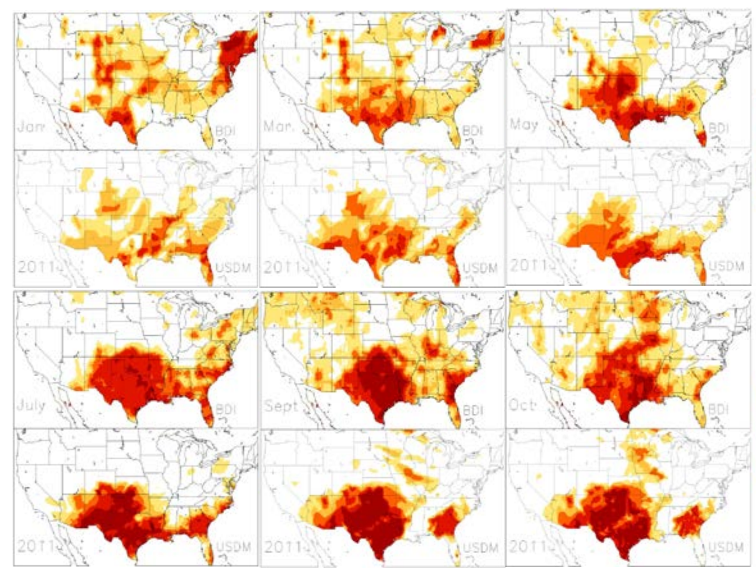
Data flow of Weekly US Drought Monitor (USDM) Generation

Project Status/Update

- Accomplishments to date
  – The most recent surface type data improves Noah model soil moisture simulations
  – Results indicated that NRT JPSS/GCOM land data of GVF and SM may improve Noah model soil moisture estimates and in turn enhances drought monitoring
  – Blending various soil moisture estimates or satellite retrievals generates better drought index (BDI)
  – Four refereed journal papers appeared and two more will be forthcoming
- Users Engaged to date
  – NCEP EMC/CPC drought related research/operations
  – NIDIS of USDA, NOAA and USGS
- Near term plans/milestones
  – Give a talk to national NLDAS monthly telecon on results from this project before project ends in May 2016
  – Further validate the BDI for longer time periods (e.g. 1980-current year) and submit two more journal papers
- One really interesting result (images on right)
  – BDI compared with US drought Monitor (see lower right comparing images)



Near real time weekly (DA02) and monthly (DA03) GVF data improved Noah LSM soil moisture simulations while NRT albedo (DA01) did not for 2012 data.



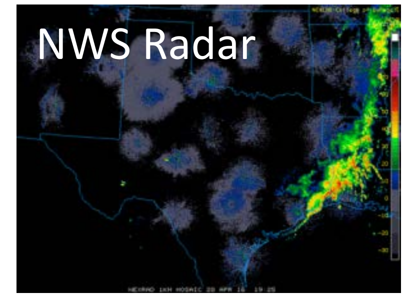
Blended Drought Index (BDI) Compared with USDM

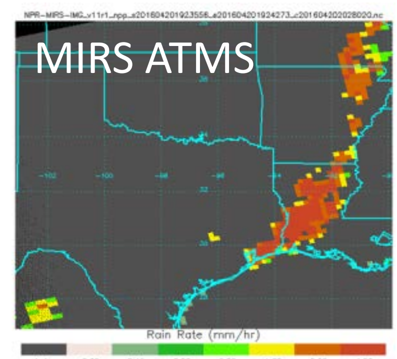
Hydrologic Applications of the VIIRS Cloud Products

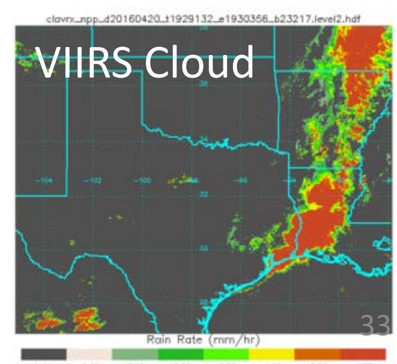
Andi Walther, Andrew Heidinger and Samantha Tushaus

- Objectives
  - Verify the skill in deriving precipitation from VIIRS cloud products and study how they complement other sources (microwave, IR).
  - Explore the accuracy of the cloud water path product from VIIRS and how it can complement that from ATMS (*which lacks coverage over land*)
  - Demonstrate skill with lunar-reflectance to provided unique nighttime ability.
- Primary sensors involved
  - VIIRS including DNB (primary)
  - ATMS (for reference)
- Primary ground data
  - NWS Radar Data
- Targeted end users
  - NWS forecast offices – we think precipitation and water path are better suited for AWIPS displays than the standard cloud optical depth and particle size.

Rain-rates on April 20, 2016 19:30 UTC



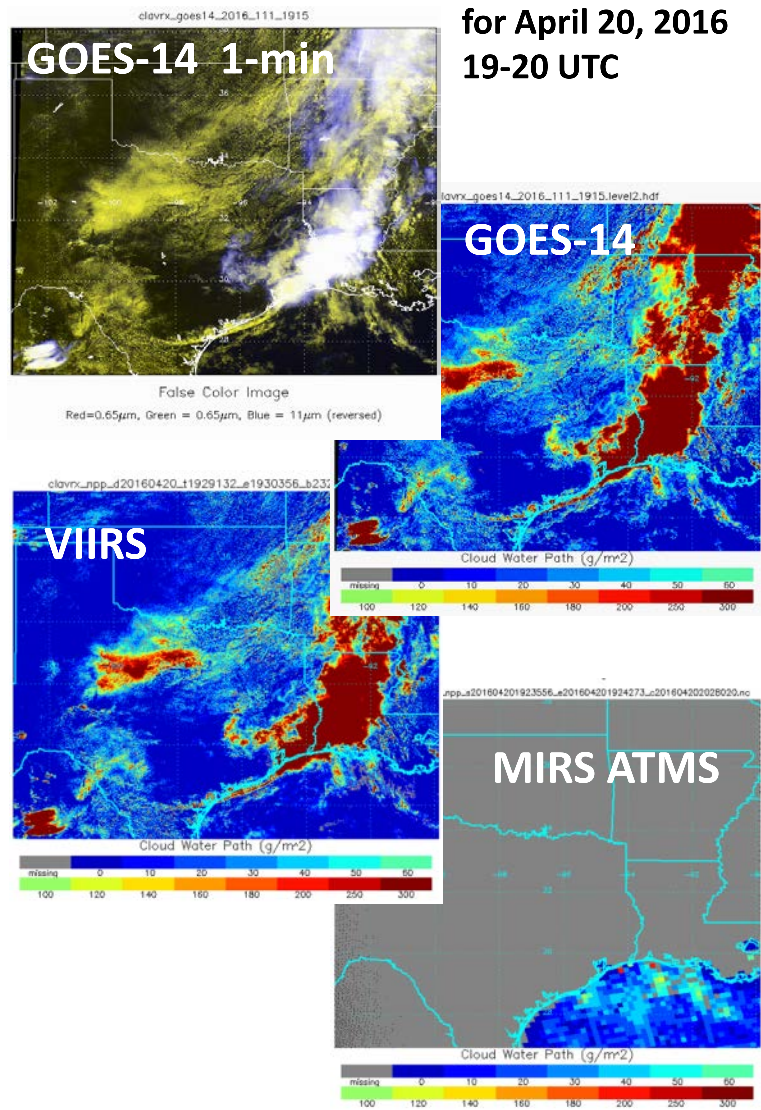




Project Status/Update

- Accomplishments to date
  - The KNMI (Dutch Met Agency's) cloud product precipitation implemented on VIIRS in CLAVR-x.
  - Rain rate and water path generated from VIIRS Lunar reflectance.
  - Generated data for 2 JPSS Hydro test cases
- Users Engaged to date
  - None yet, cloud-derived hydro products are still being tested.
- Near term plans/milestones
  - Analyze April 20,2016 case (Houston Floods)
  - Explore remaining issues with VIIRS lunar products.
- One really interesting result (images on right)
  - April 20, 2016 had GOES-14 1-minute data.
  - We are exploring the synergy of the high temporal GOES and high spatial VIIRS for this significant hydrological event.

Cloud Water Path for April 20, 2016 19-20 UTC



Case 1: Atmospheric River, California, January 5 2016

MESOSCALE PRECIPITATION DISCUSSION 0001
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
544 AM EST TUE JAN 05 2016

AREAS AFFECTED...CENTRAL CA COAST...SRN CA

CONCERNING...HEAVY RAINFALL...FLASH FLOODING POSSIBLE

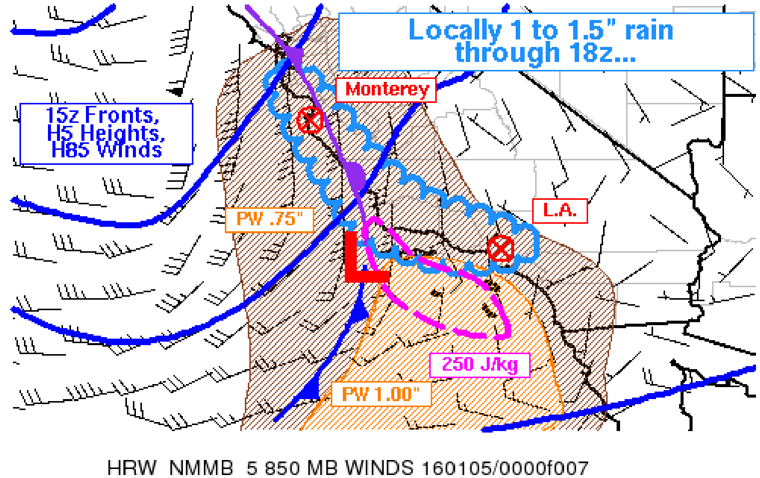
VALID 051043Z - 051643Z

SUMMARY...RAIN RATES WILL INCREASE ALONG THE CENTRAL AND SOUTHERN CALIFORNIA COAST EARLY THIS MORNING...AND HEAVIER RAIN WILL BEGIN TO SPREAD INTO THE L.A. BASIN AROUND 15Z. FLASH FLOODING IS POSSIBLE.

DISCUSSION...STRONG ASCENT WILL ACCOMPANY AN OCCLUDED FRONT COMING ONSHORE ALONG THE LENGTH OF THE CA COAST...AND ASSOCIATED POSITIVE TILT UPPER TROUGH...WITH LATER EMPHASIS FOR HEIGHT FALLS IN THE BASE OF THE TROUGH ALONG THE SOUTHERN CALIFORNIA COAST. ALTHOUGH LIGHTNING HAD NOT BEEN DETECTED AS OF 1030Z...RADAR AND SATELLITE PRESENTATION WAS IMPRESSIVE NEAR AND OFFSHORE OF MONTEREY...WHERE CLOUD TOPS HAD COOLED TO -40C...AND CONVECTIVE RADAR ELEMENTS WERE TRACKABLE...NOT SIMPLY HIGH REFLECTIVITY DUE TO BRIGHT BANDING. SURFACE OBSERVATIONS HAD BEGUN TO SAMPLE HEAVY RAIN AND ACCUMULATIONS EXCEEDING A HALF INCH PER HOUR IN THE BAY AREA.

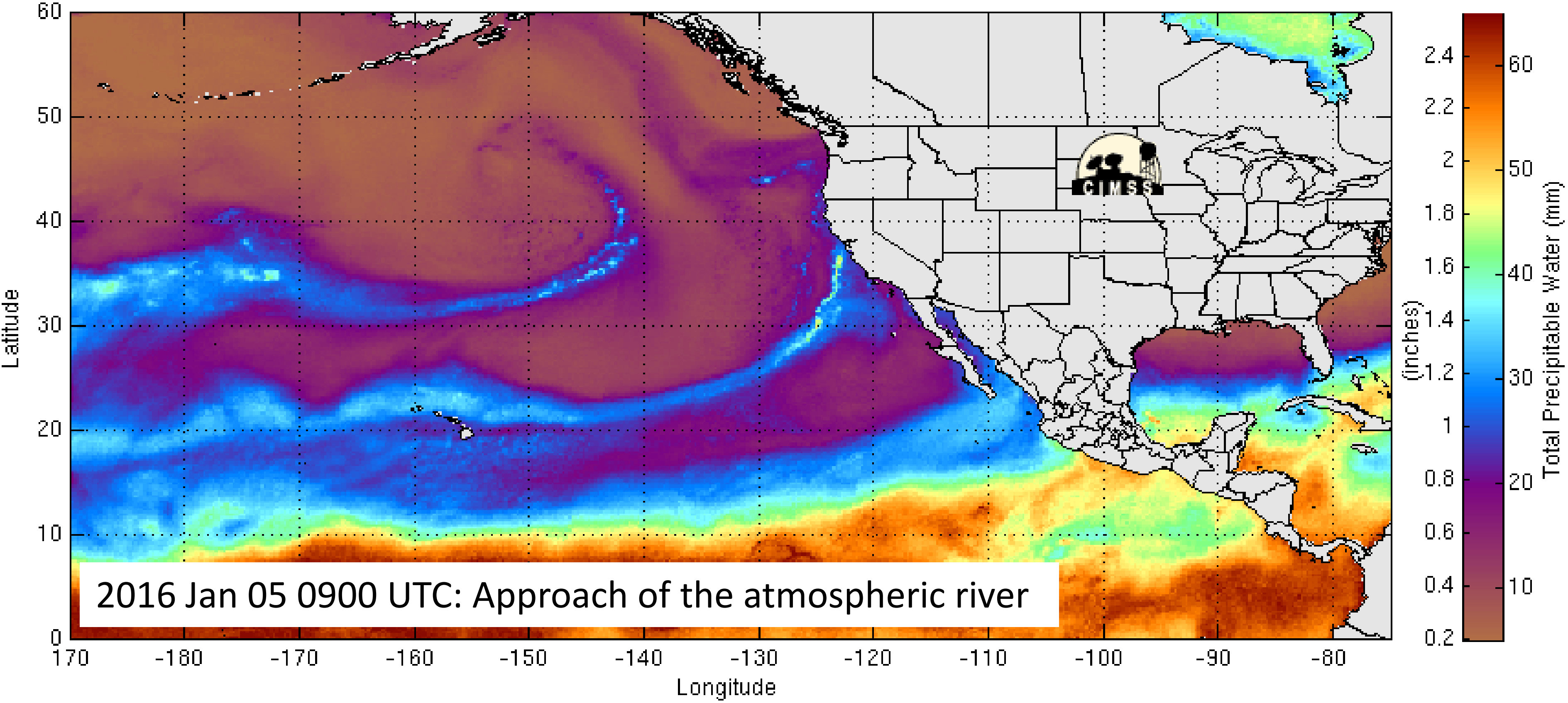
A FRONTAL PRECIPITATION BAND WILL PROGRESS STEADILY EASTWARD...WITH THE BACK EDGE COMING SOUTH ALONG THE COAST THIS MORNING. EXPECTATIONS PER THE HIGH RESOLUTION MODELS ARE FAIRLY UNIFORM...WITH AREAL AVERAGE 0.50 TO 1.0 INCHES OF RAIN THROUGH 18Z...BUT LOCALLY GREATER THAN 1.5. TOTALS MAY BE ESPECIALLY ENHANCED IN THE SOUTHWARD FACING MOUNTAINS OF SOUTHERN CALIFORNIA...OWING TO S/SW LOW LEVEL FLOW...LONGER DURATION OF BROAD HEIGHT FALLS...AND PROXIMITY TO GREATER PW VALUES NEAR 1.00 INCH ALONG WITH ENOUGH INSTABILITY FOR THE HRRR TO PICK UP ON 250 J/KG. **THE HEAVIER RAIN RATES SHOULD REACH LOS ANGELES BY 15-17Z...AND THE EVENT IS EXPECTED TO CONTINUE INTO THE AFTERNOON FROM THERE SOUTHWARD...WITH MAXIMUM HOURLY RATES APPROACHING 0.75 INCHES. THIS WOULD BE VERY CLOSE TO FLASH FLOOD GUIDANCE VALUES...AND WOULD BE MORE THAN ENOUGH TO CAUSE FLASH FLOODING IN THE MORE SUSCEPTIBLE BURN SCAR AREAS.**

BURKE
ATTN...WFO...HNX...LOX...MTR...SGX.

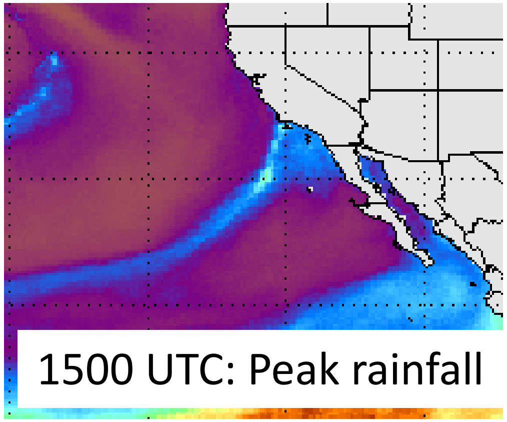


WPC MPD #0001

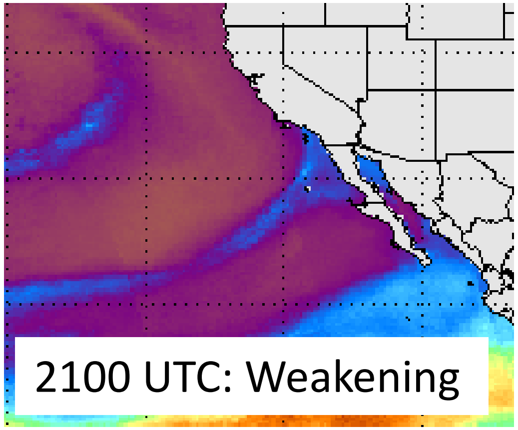
MIMIC TPW



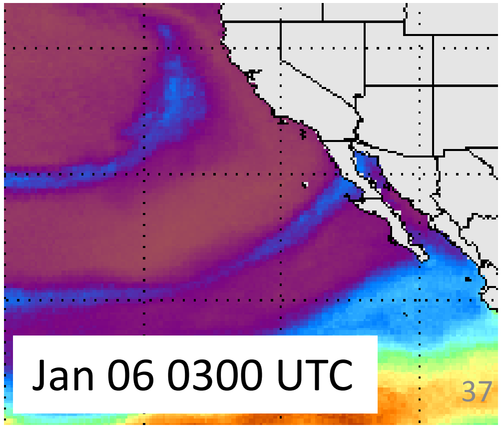
2016 Jan 05 0900 UTC: Approach of the atmospheric river



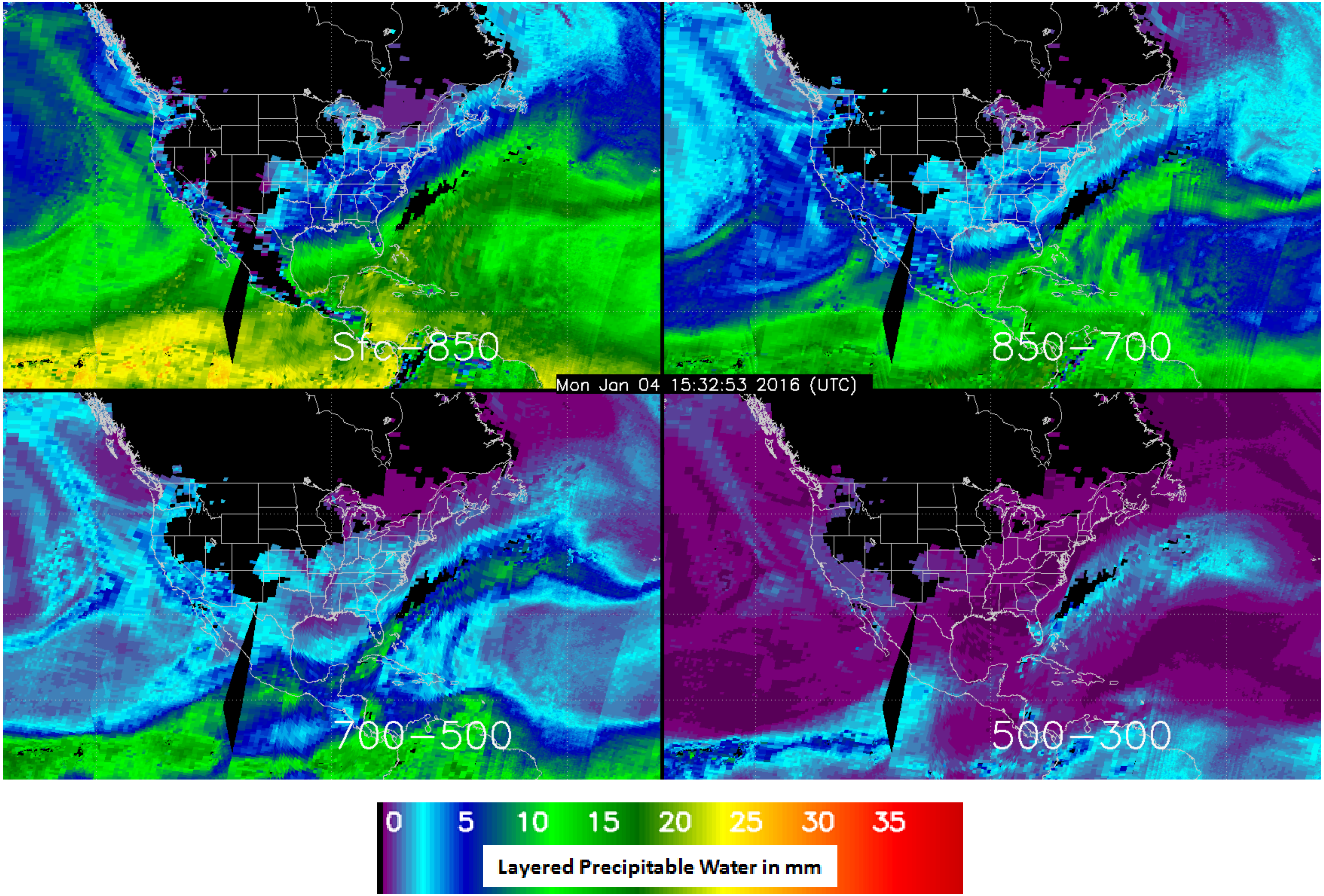
1500 UTC: Peak rainfall



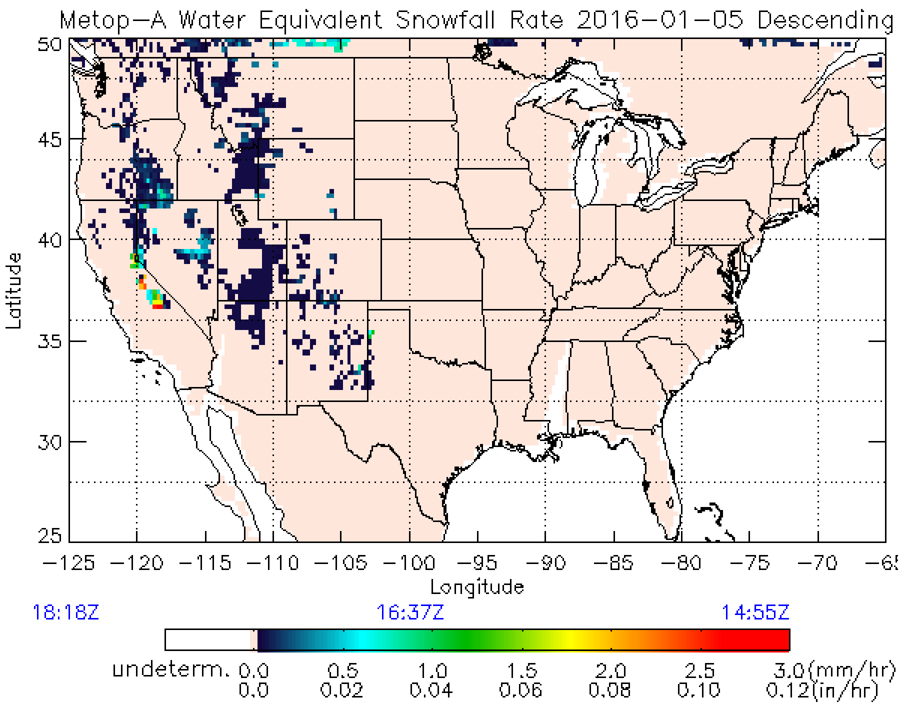
2100 UTC: Weakening

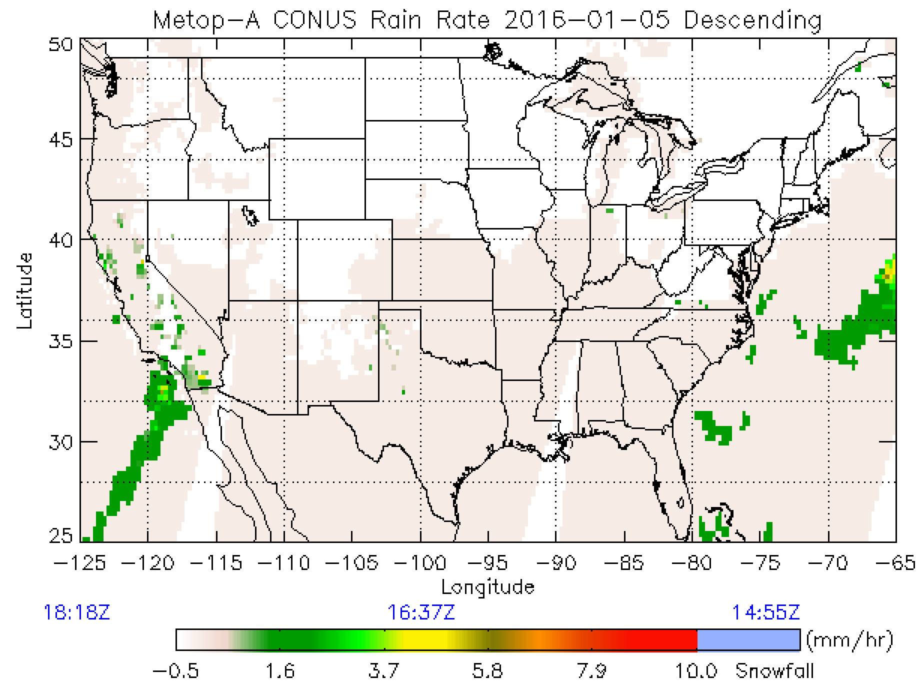


Jan 06 0300 UTC

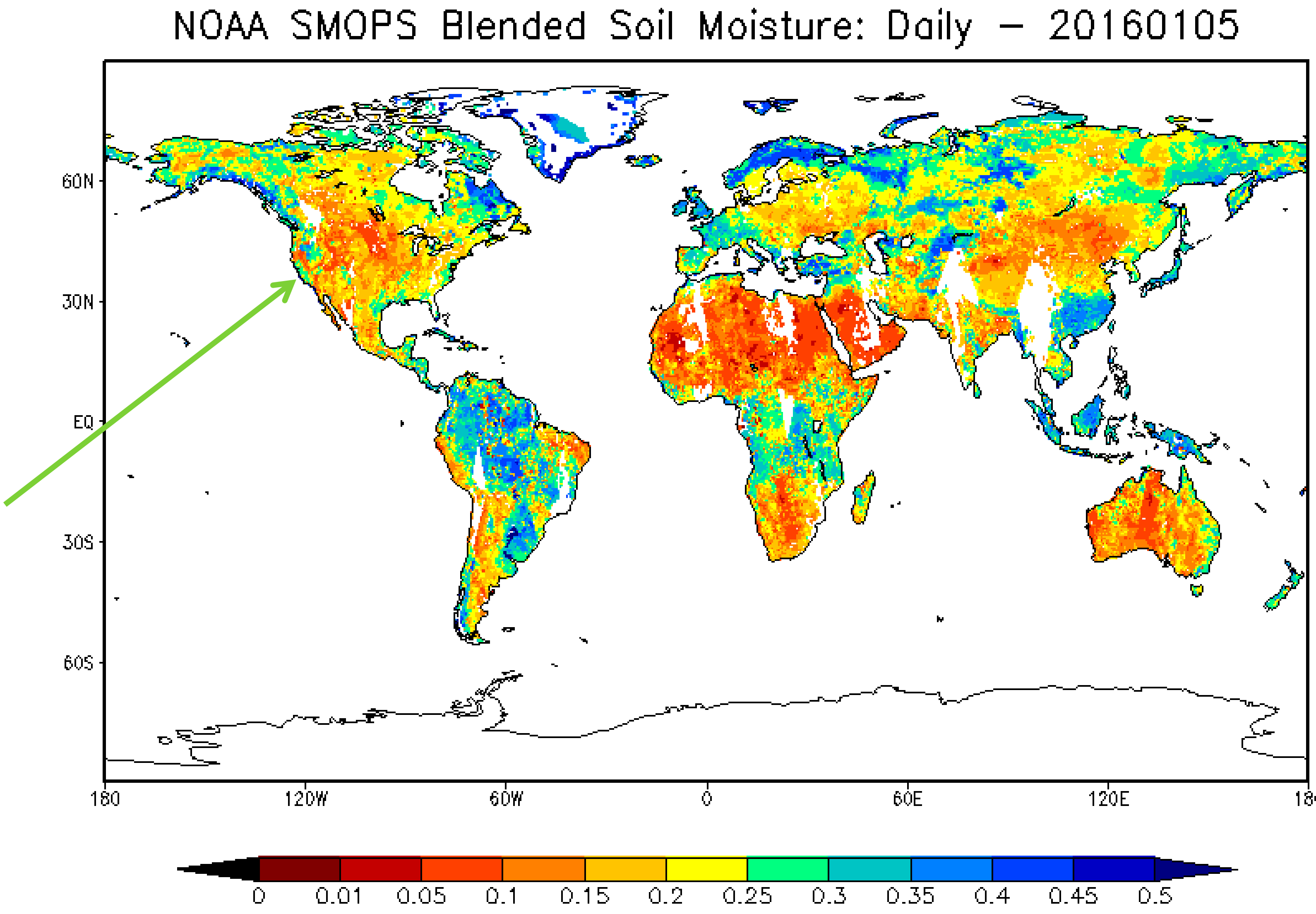


Broad moisture signature at lower layers, small signal above 500 mb





http://www.star.nesdis.noaa.gov/corp/scsb/mspps_backup/sfr_realtime.html

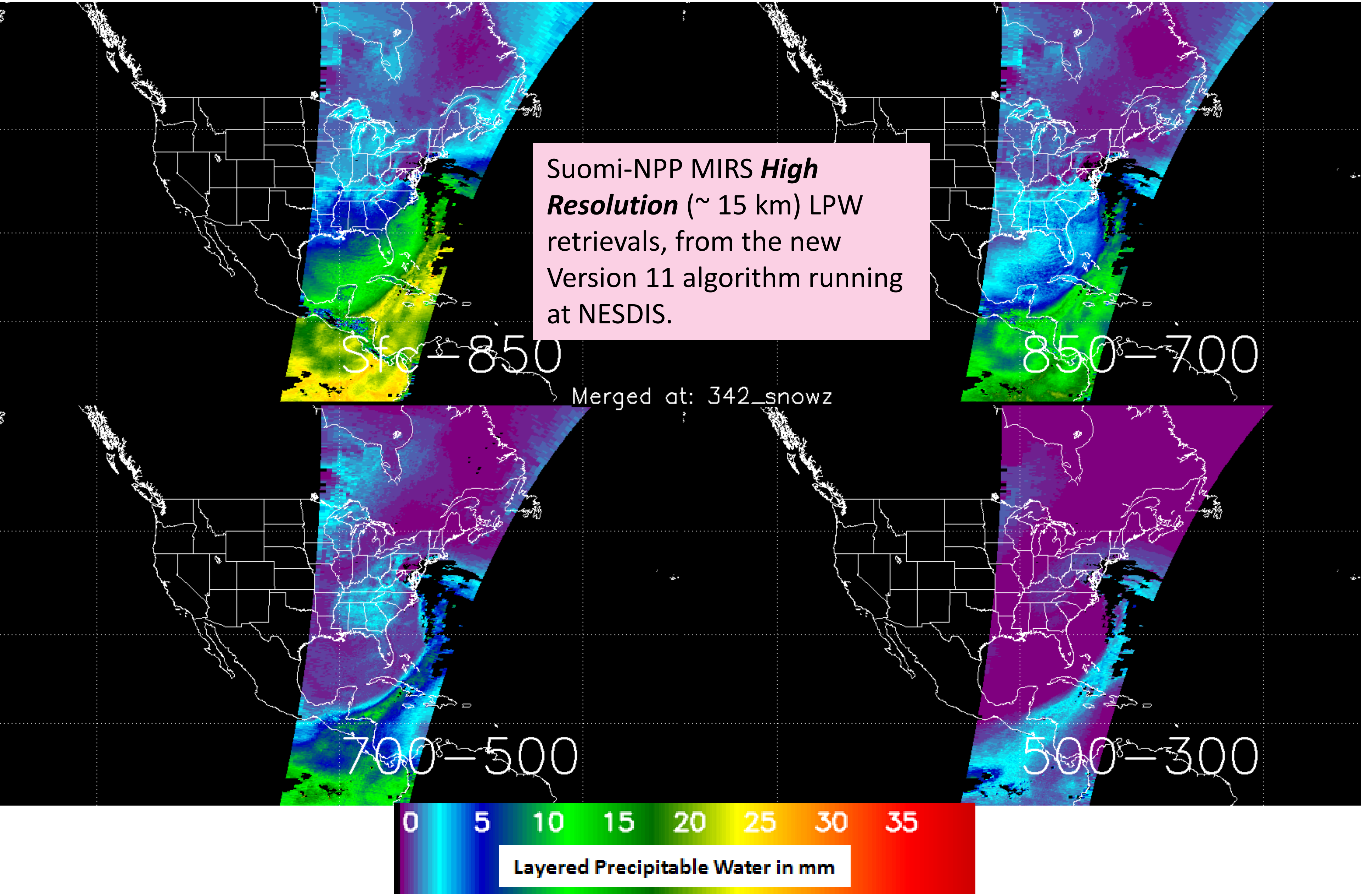

NOAA SMOPS Blended Soil Moisture: Daily - 20160105
60N
30N
EQ
30S
60S
180
120W
60W
0
60E
120E
180
0
0.01
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

Case 2: East Coast Blizzard of 2016. January 22-23 2016

See also:

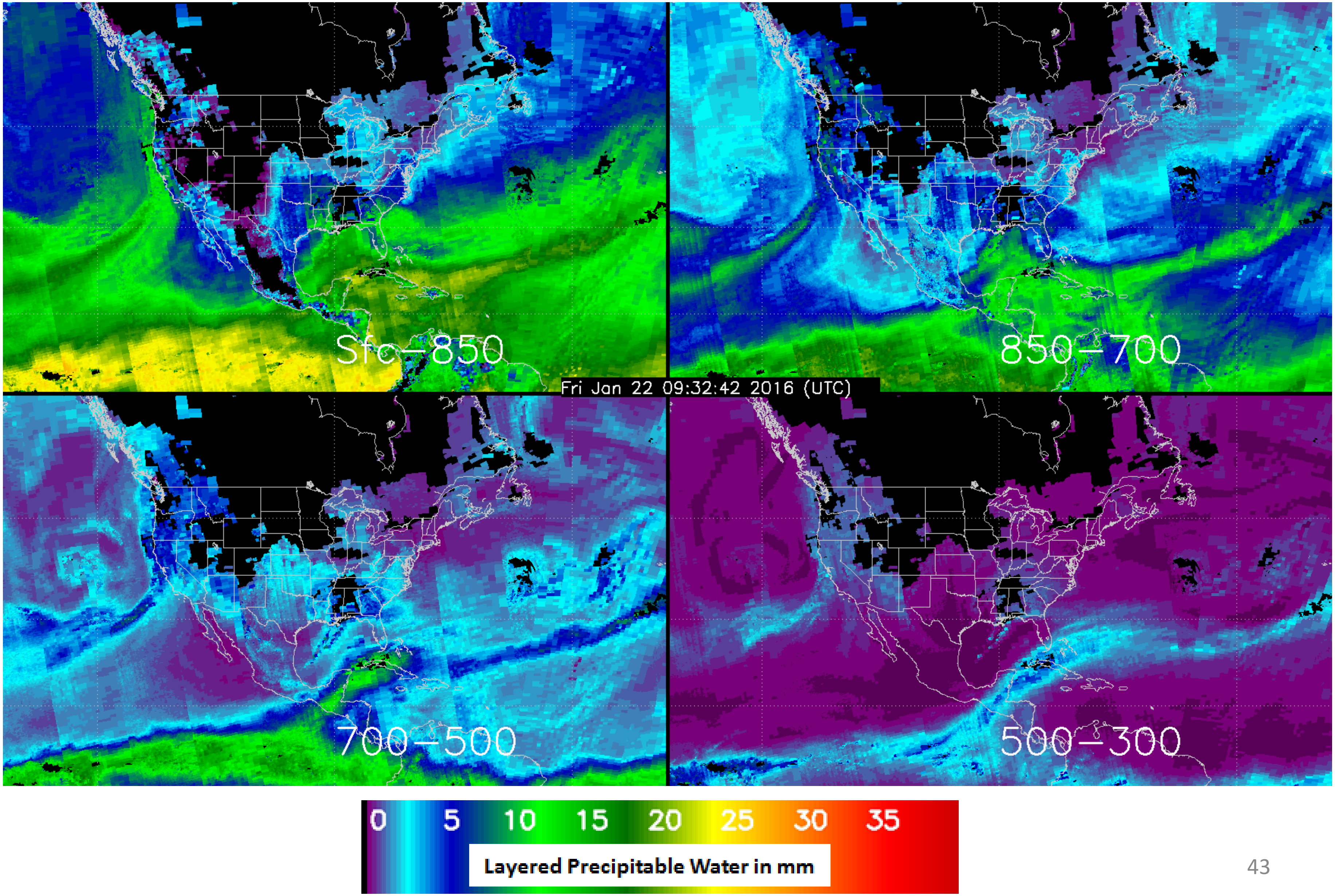
http://www.star.nesdis.noaa.gov/jpss/Blizzard2016.php

East Coast Snowstorm: Layered water vapor: Jan. 23 07 UTC (coastal low was forming at this time)

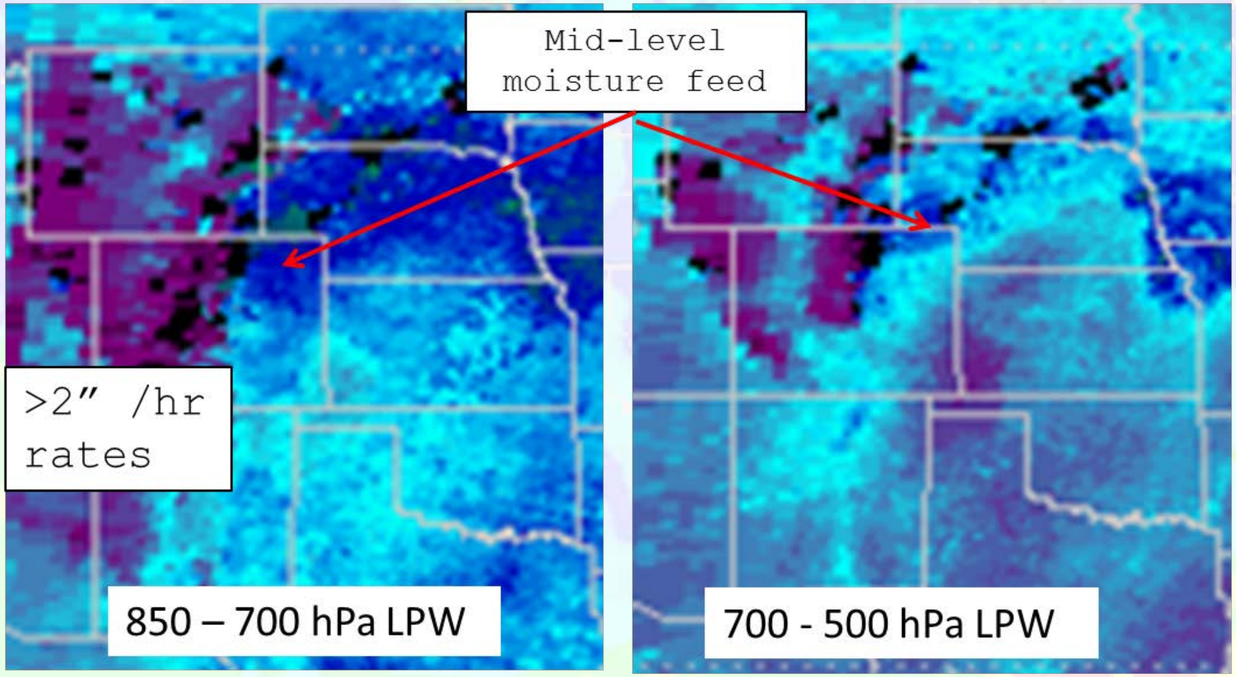


Suomi-NPP MIRS ***High Resolution*** (~ 15 km) LPW retrievals, from the new Version 11 algorithm running at NESDIS.

East Coast Snowstorm: Layered water vapor Jan 22, 09 UTC to Jan. 23 18 UTC (NOAA-18/19; Metop-A, -B, DMSP F18) using MIRS V8 (old version). SNPP to be added soon.



Water Vapor Products



CIRA Blended Layered Precipitable Water Vapor merged at 1200 UTC 23 March 2016 [S-NPP MiRS retrievals shown]

Forecast for Fort Collins for 3/23 morning:
4 PM 3/22: Winter Weather Advisory
8 PM 3/22: Winter Storm Warning
4 AM 3/23: Blizzard Warning
Total: 14″ of snow in 7 hours, shut down city.

HIGHLIGHTS OF AEROSOL CAL/VAL TEAM ACTIVITIES

NOAA/NESDIS/STAR

Istvan Laszlo and Shobha Kondragunta

Aerosol Cal/Val Team

Outline

- Cal/Val Team Members
- Highlights of Activities to Date
- Algorithm Overview
- S-NPP Products
- JPSS-1 Readiness
- Summary and Path Forward

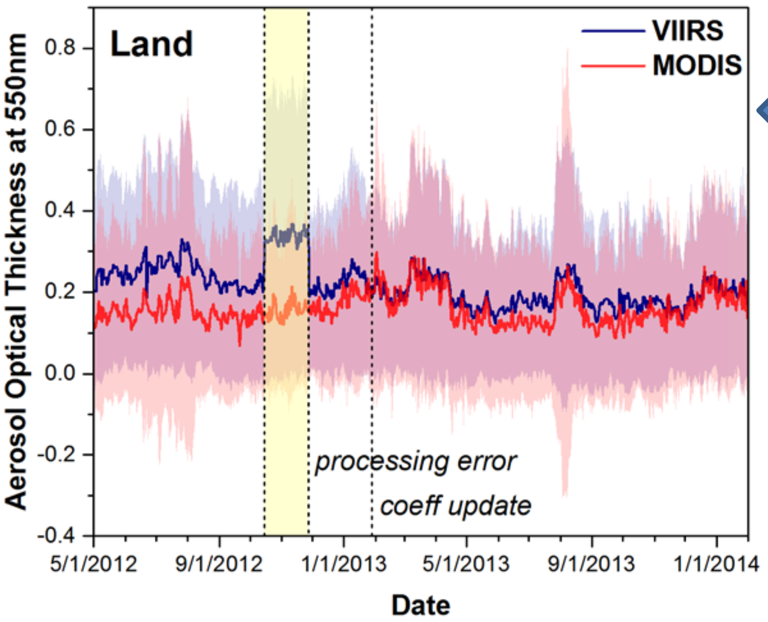
Cal/Val Team Members

Name	Organization	Roles and Responsibilities
Pubu Ciren	IMSG/NOAA	ADP algorithm development/validation
Bigyani Das	IMSG/NOAA	Algorithm integration
Brent Holben	NASA/GSFC	AERONET observations for validation work
Jingfeng Huang	UMD/CICS	AOT product validation
Edward J. Hyer	NRL	Product validation, assimilation activities
Shobha Kondragunta	NOAA/NESDIS	Co-lead
Istvan Laszlo	NOAA/NESDIS	Co-lead
Hongqing Liu	IMSG/NOAA	Visualization, algorithm development, validation
Lorraine A. Remer	UMBC	Documentation and validation
Hai Zhang	IMSG/NOAA	Algorithm coding, validation within IDEA
Stephen Superczynski	IMSG/NOAA	Data management and user outreach

Accomplishments to Date

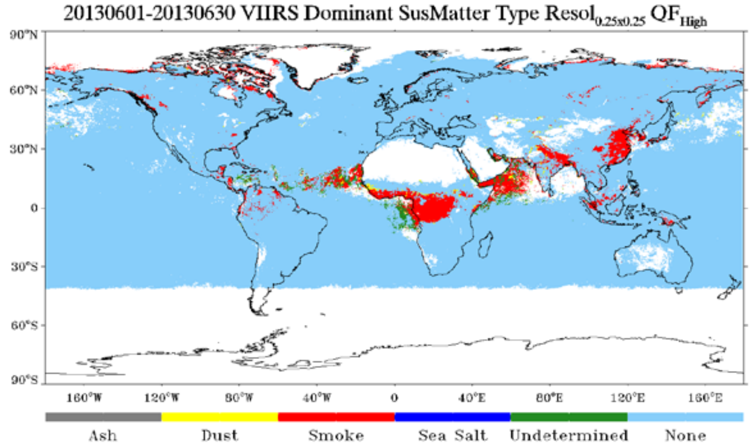
- **Evaluated current operational S-NPP/IDPS aerosol products for maturity levels**
  - Reference data: AERONET, MODIS, MISR, CALIPSO
  - Demonstrated initial AOT retrieval had a large positive bias over land
  - Demonstrated SNPP/IDPS SM product does not meet requirements
- **Evaluated IDPS AOT EDR and IP products with AERONET L2 data**
  - Published results in JGR paper(2016)
- **Developed EPS AOT and AD (formerly SM) algorithms**
  - Designed to work on both VIIRS and ABI (AHI)
  - Improved aerosol detection (AD)
    - Dust detection published in JGR (2014)
  - Improved surface reflectance ratios and high AOT retrieval over land
    - Manuscript in preparation
  - Added AOT retrieval over bright snow/ice-free land
    - Manuscript submitted to JGR (2016)
- **Reprocessed 2015 S-NPP/VIIRS AOD and AD products with EPS algorithms**
- **Provided reprocessed data of AOT and AD to users**

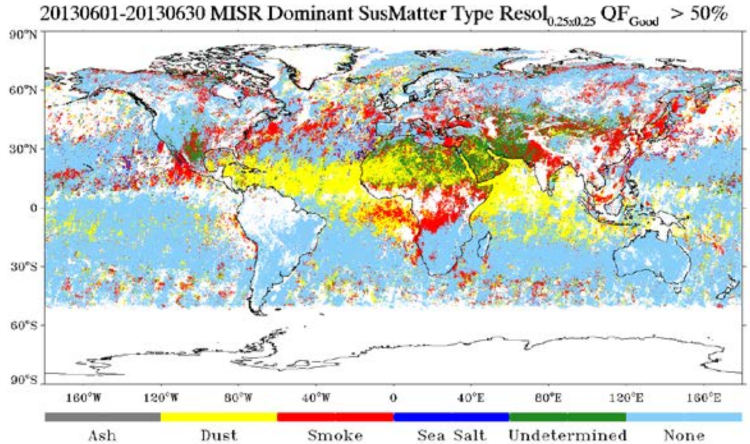
Accomplishments – IDPS Products



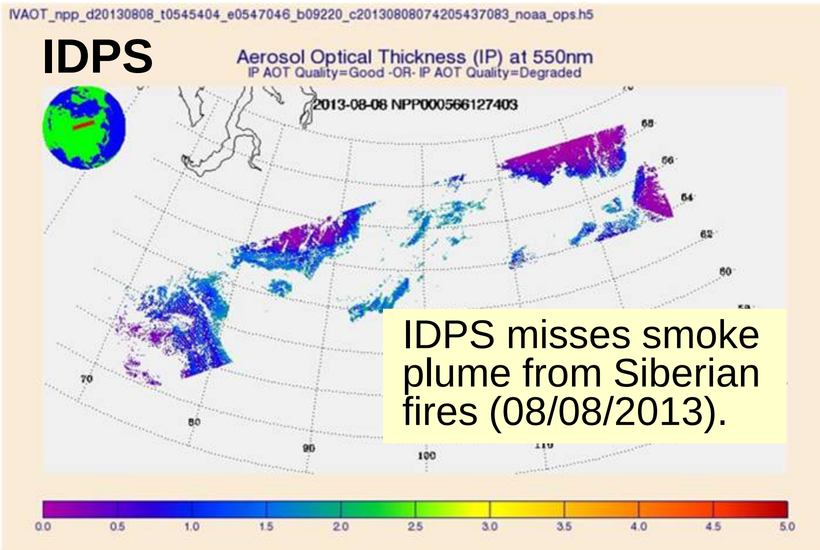
AOT over land has large bias relative to MODIS before revising relevant coefficients

SM product accuracy (20%) (established by comparison to MISR) product does not meet the 80% accuracy requirement

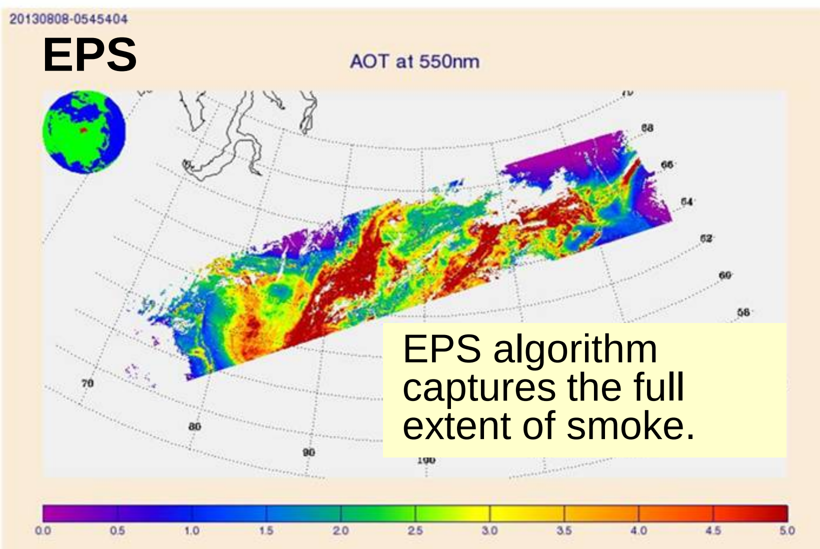




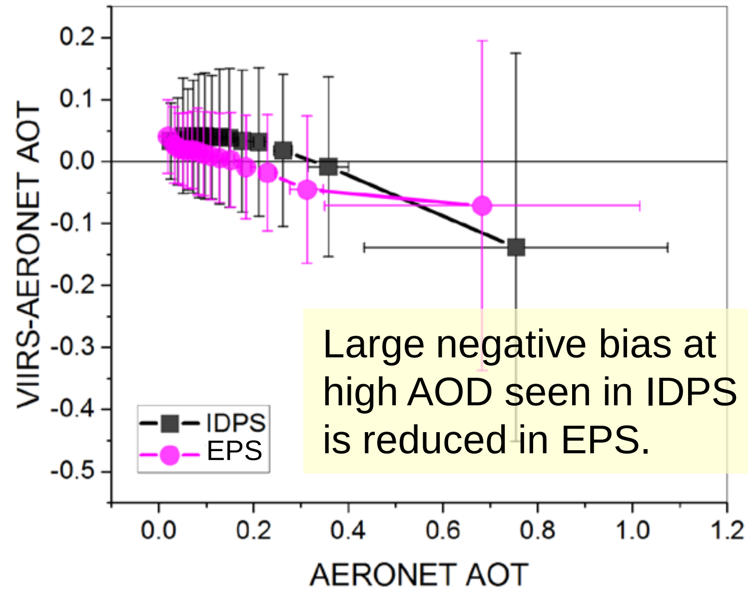
Accomplishments – EPS Products



IDPS misses smoke plume from Siberian fires (08/08/2013).

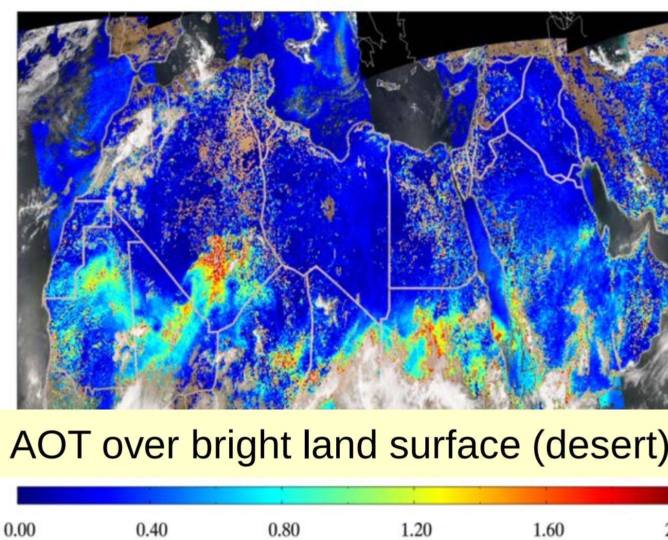


EPS algorithm captures the full extent of smoke.



Large negative bias at high AOD seen in IDPS is reduced in EPS.

VIIRS AOT 20130823



AOT over bright land surface (desert).

EPS AOT, APSP Algorithm Overview

- Designed to work with VIIRS and ABI (AHI) observations
- Separate algorithms over land and water
  - **Water**: MODIS heritage; based on Tanré et al. (1997)
    - Includes large inland water bodies
  - **Land**: separate paths for dark and bright surface
    - Dark surface: combines two "flavors" of the "dark-target" approach
      1. M3/M5 (works better for low AOT)
      2. M3/M11 (works better for high AOT)
    - Bright (snow-free) surface: regional ratios of surface reflectances
      - M3/M5 for North Africa/Arabian Peninsula
      - M1/M5 for the other regions
- Uses SW for AOT, SW+IR for internal test, masks (cloud, snow/ice, etc.), ancillary data (P, TPW, ozone, wind)
- **Output:** AOT at 550 nm and at SW channels (range: -0.05 to 5.0), Ångström exponents over water, aerosol model, fine-mode weight over water, quality flags, diagnostics (residual, AOD for each land aerosol models, surface reflectance, etc.)

EPS AD Algorithm Overview

Input Reflectances:

412, 440, 2250 nm

Internal Tests:

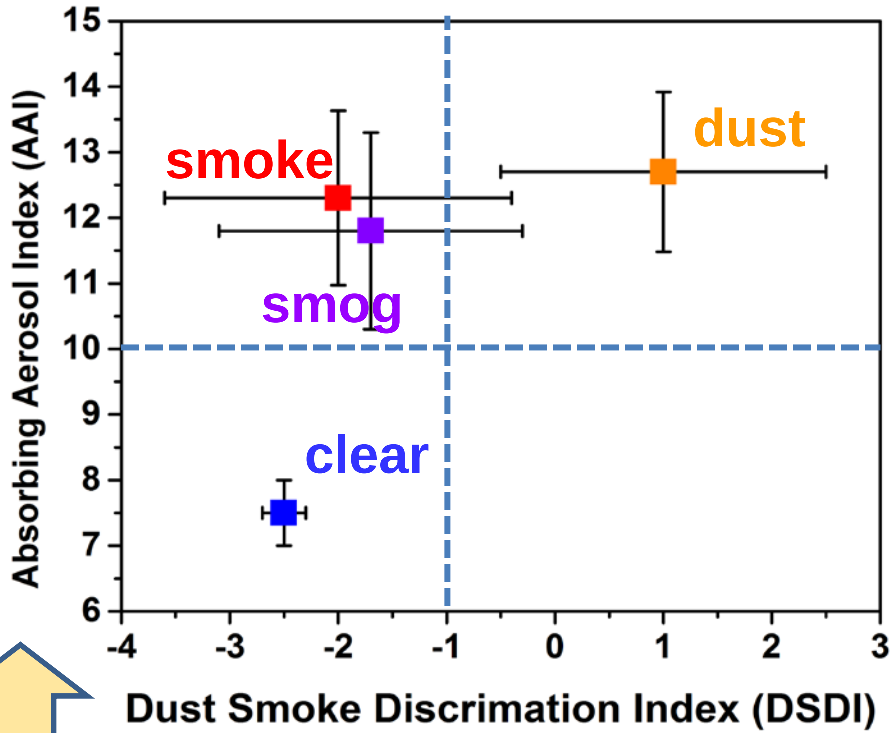
Spatial Variability Test: 412 nm (land); 865 nm (water)

Turbid Water Test: 488 nm, 1.24 µm, 1.61 µm, 2.25 µm

Bright Pixel Test:1.24 µm, 2.25 µm

NDVI Test: 640 nm, 865 nm

Snow Test: 865 nm, 1.24 µm + IR



Absorbing Aerosol Index

$AAI = -100[\log_{10}(R_{412}/R_{440}) - \log_{10}(R^{RAY}_{412}/R^{RAY}_{440})]$

Dust Smoke Discrimination Index

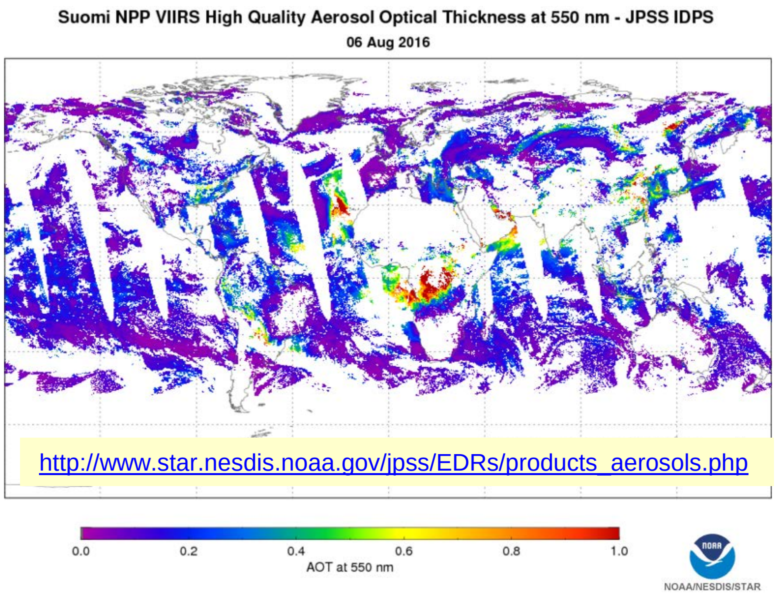
$DSDI = -10[\log_{10}(R_{412}/R_{2250})$

S-NPP AOT Product Overview (1)

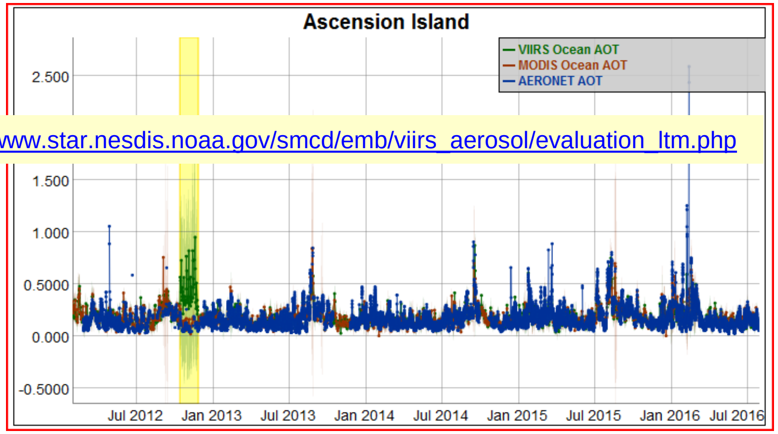
AOT - Land	L1RDS	Performance
AOT550 < 0.1		
Accuracy	0.06	0.03
Precision	0.15	0.07
0.1 ≤ AOT550 ≤ 0.8		
Accuracy	0.05	-0.01
Precision	0.25	0.11
AOT550 > 0.8		
Accuracy	0.20	-0.05
Precision	0.45	0.38

AOT - Water	L1RDS	Performance
AOT550 < 0.3		
Accuracy	0.08	0.03
Precision	0.15	0.04
AOT550 >= 0.3		
Accuracy	0.15	0.01
Precision	0.35	0.11

- Long Term Monitoring (IDPS)



http://www.star.nesdis.noaa.gov/jpss/EDRs/products_aerosols.php

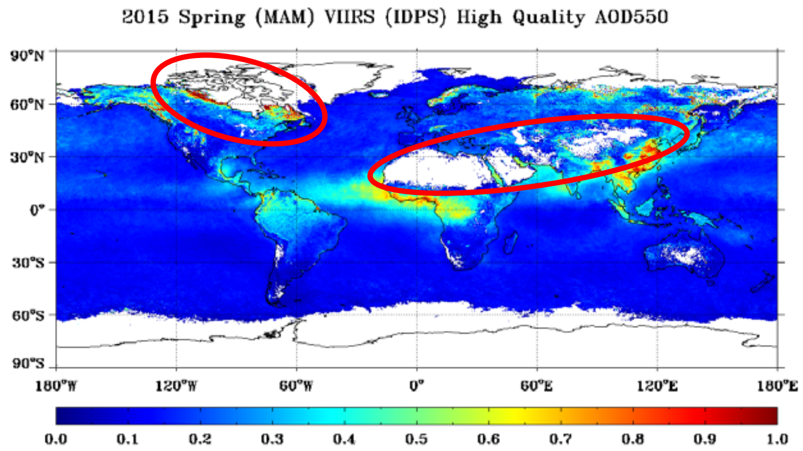


http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/evaluation_ltm.php

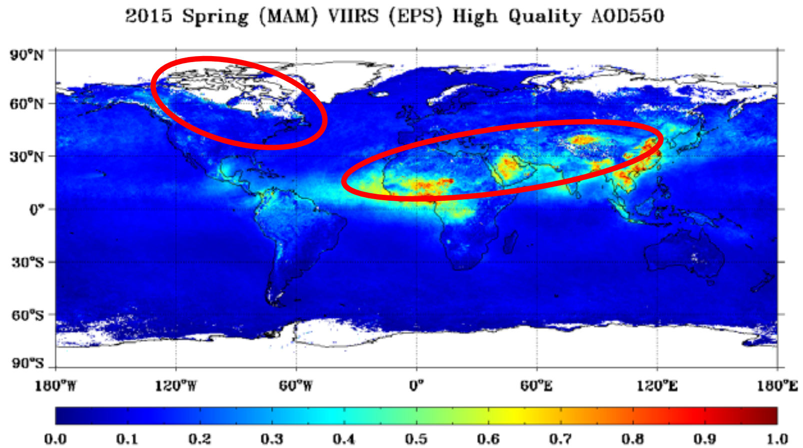
S-NPP AOT Product Overview (2)

- **Enterprise AOT Algorithm Status:**
  - o Algorithm is ready
  - o Scheduled for operational implementation in 2016
- **Reprocessing:**
  - o with EPS algorithm
  - o 2015 completed
  - o Output Data
    - – Pixel-level retrieval and diagnostic outputs in compressed HDF5 format for each granule
    - – Total size 7.7T (about 22G per day)
  - o Provided data to users at
    - – NOAA Earth System Research Laboratory (ESRL)
    - – NOAA Joint Center for Satellite Data Assimilation (JCSDA);
    - – NOAA National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC)
    - – University at Albany, State University of New York
    - – Naval Research Laboratory (NRL)

IDPS



EPS

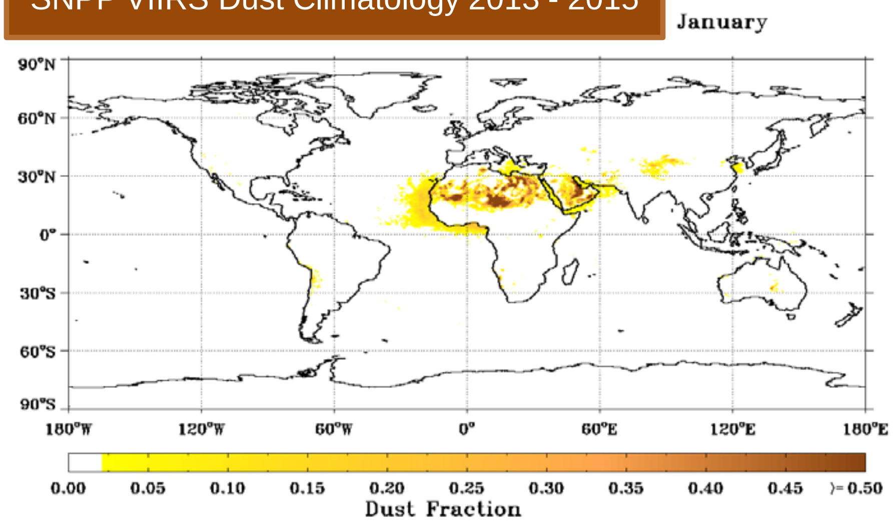


S-NPP AD Product Overview

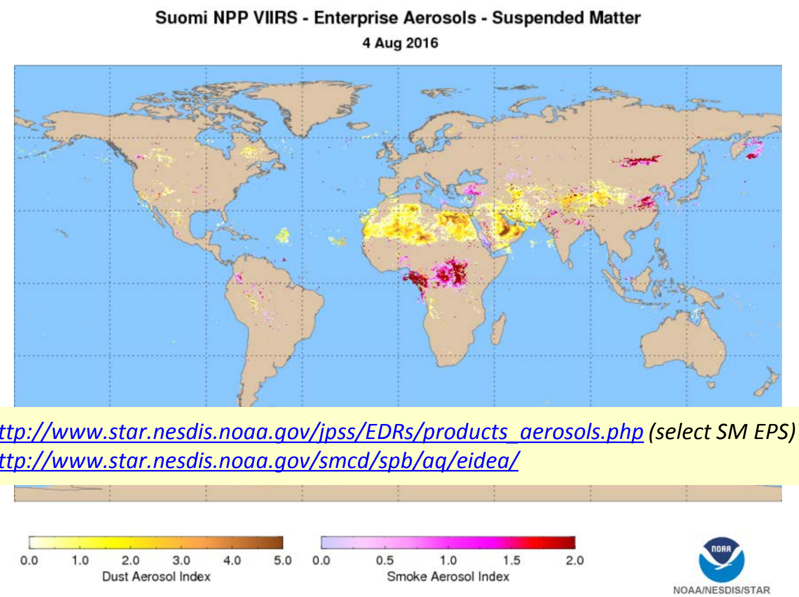
Product	L1RDS	Performance	
		Land	*Water*
Accuracy (%)			
Smoke	70	98	94
Dust	80	84	95
Ash	60		

Both dust and smoke products meet requirements

SNPP VIIRS Dust Climatology 2013 - 2015



- **Long Term Monitoring (EPS)**

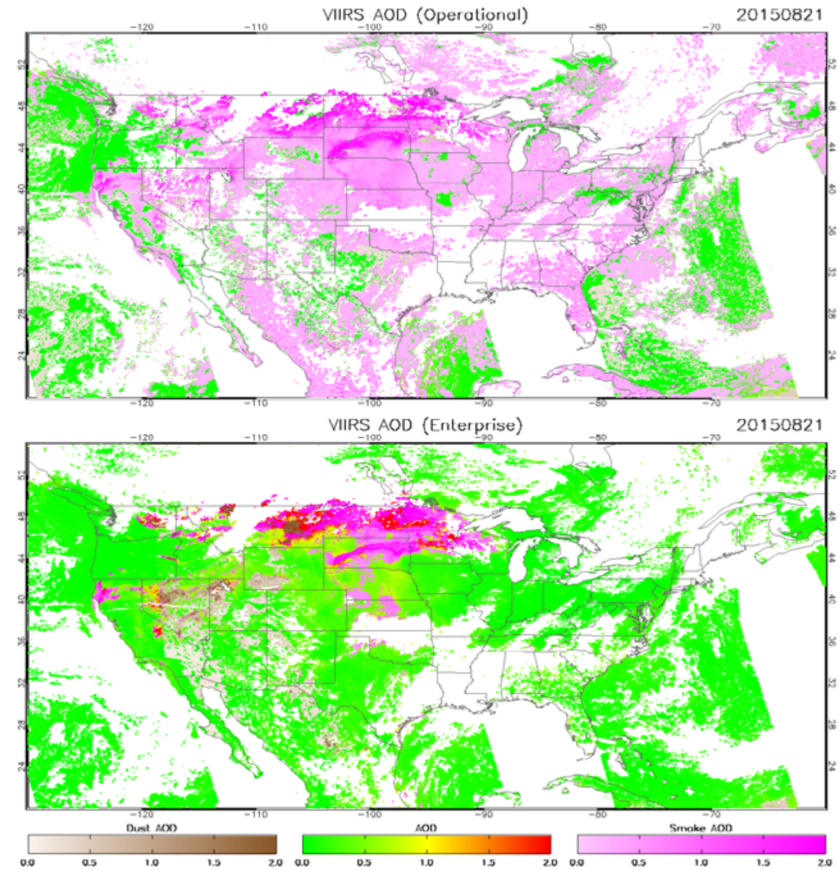


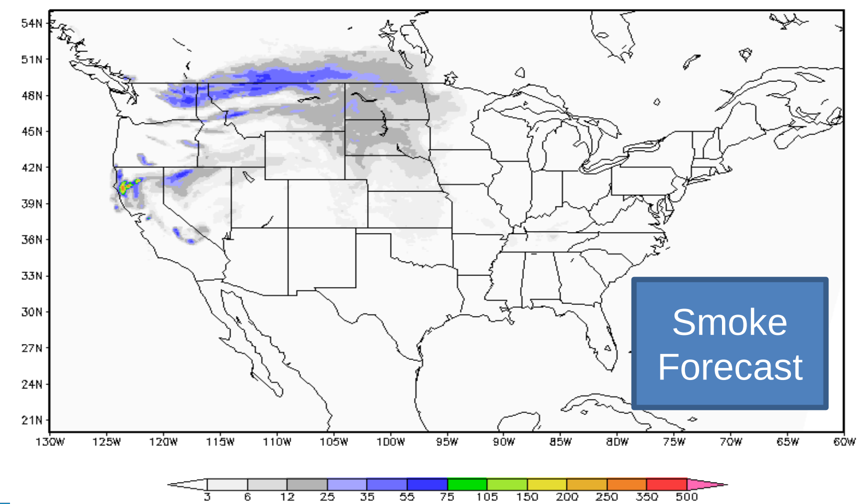
http://www.star.nesdis.noaa.gov/jpss/EDRs/products_aerosols.php (select SM EPS)
http://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/

- **Enterprise AD Algorithm Status:**
  - Algorithm is ready
  - Scheduled for implementation in NDE in summer 2016
- **Reprocessing:**
  - with EPS algorithm
  - 2015 completed; other years ongoing

User Feedback

- **Overall user feedback is positive.**
- ***NRL*:**
  - Data assimilation testing of EPS product is underway. Compared to MODIS it has reduced bias and includes high AOT. "*Much happier with this product*".
- ***NCEP:***
  - EPS AOT and smoke/dust products provide a unique opportunity for direct comparison between observed and modeled smoke and dust concentrations.
  - The high resolution, extension to bright-surface and to higher upper bound in EPS provide better areal coverage for comparison with model output.
- ***OAR:***
  - Implemented assimilation of VIIRS AOT in the Gridpoint Statistical Interpolation (GSI).
  - Developed assimilation of dust and smoke masks and indices to improve assimilation for dust storm and forest fire forecast.
  - Evaluated performance of assimilation of *VIIRS AOT and dust masks* during storms over Southwestern USA and over Northern Africa.
  - Currently evaluating performance of the assimilation of *VIIRS AOT and smoke products* for forecasting of smoke during summer 2016 using WRF-Chem. Upon completion, will consider assimilation of these products in r-t forecasting.



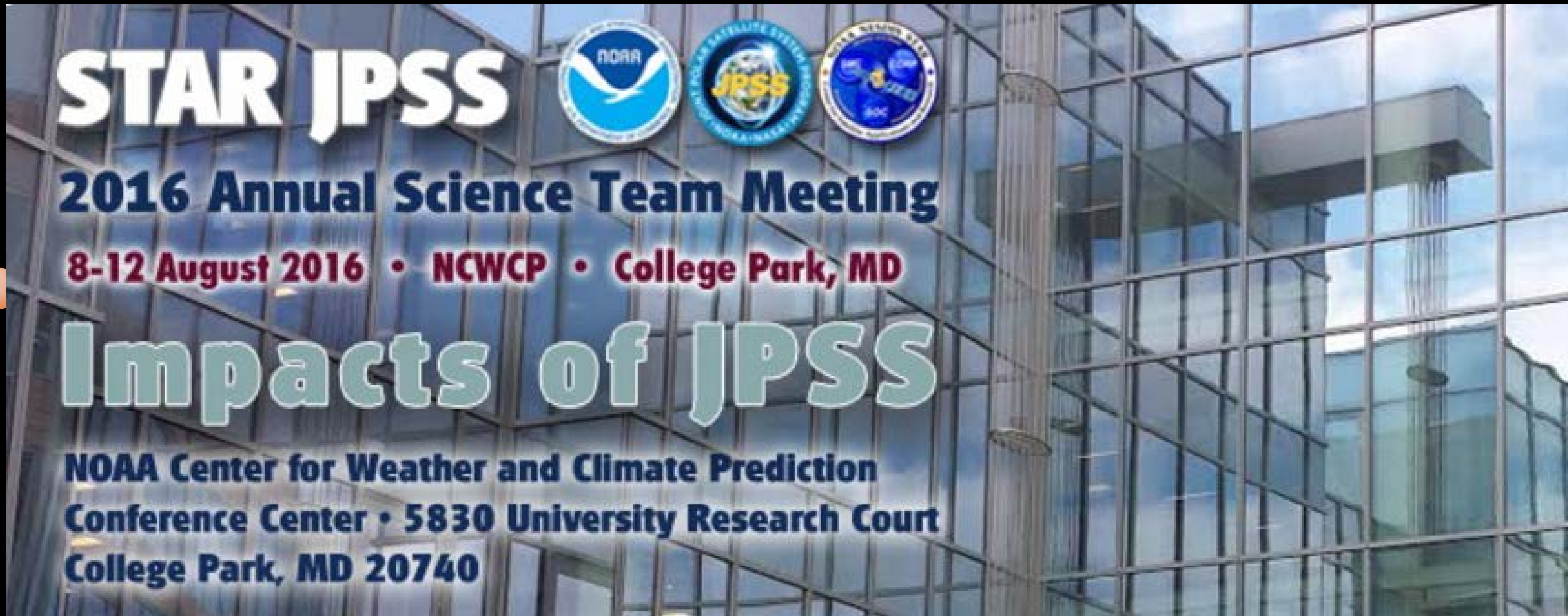


JPSS-1 Readiness

- Algorithm changes from S-NPP to JPSS-1
  - No major changes. Minor changes associated with thresholds for spatial/spectral tests and for surface reflectance ratios are expected and will be implemented.
- Post-Launch Cal/Val Plans
  - Comparisons to SNPP VIIRS, CALIPSO, CATS, MISR
  - Field campaign data as available
  - Beta: L+4m; Provisional: L+12m; Validated: L+16m
- Accomplishments and Highlights Moving Towards J1
  - EPS aerosol algorithms are ready for J1; codes and ATBDs delivered
- Major Risks/Issues/Challenges/ and Mitigation
  - No major risks or issues
- Collaboration with Stake Holders/User Agencies
  - Yearly meetings (e.g., with data assimilation scientists and air-quality forecasters) to provide updates on product status (next is in Sep 2016)

Summary & Path Forward

- EPS AOT and AD algorithms have been developed, tested with S-NPP data, and shown to meet/exceed requirements; algorithm software have been delivered.
- LTM capability has been developed.
- Reprocessing of S-NPP aerosol data with EPS algorithms has started.
- **Algorithm improvements**
  - *ADP*:
    - Account for surface contribution to TOA reflectances in computing absorbing aerosol index.
    - Introduce geometry and location dependent thresholds used in spectral tests.
    - Develop an approach to determine surface smoke and dust concentrations.
  - *AOT*:
    - Update spectral surface reflectance relationships to minimize seasonal and regional biases.
    - Examine causes of systematic error in spectral AOT; apply fix.
- **Path Forward**
  - Participate in J1 readiness reviews
  - Conduct cal/val work
  - Investigate instrument/product anomalies



The EPS Aerosol Optical Depth Algorithm and Product

Hongqing Liu, Hai Zhang
and NOAA STAR Aerosol Cal/Val Team

Features

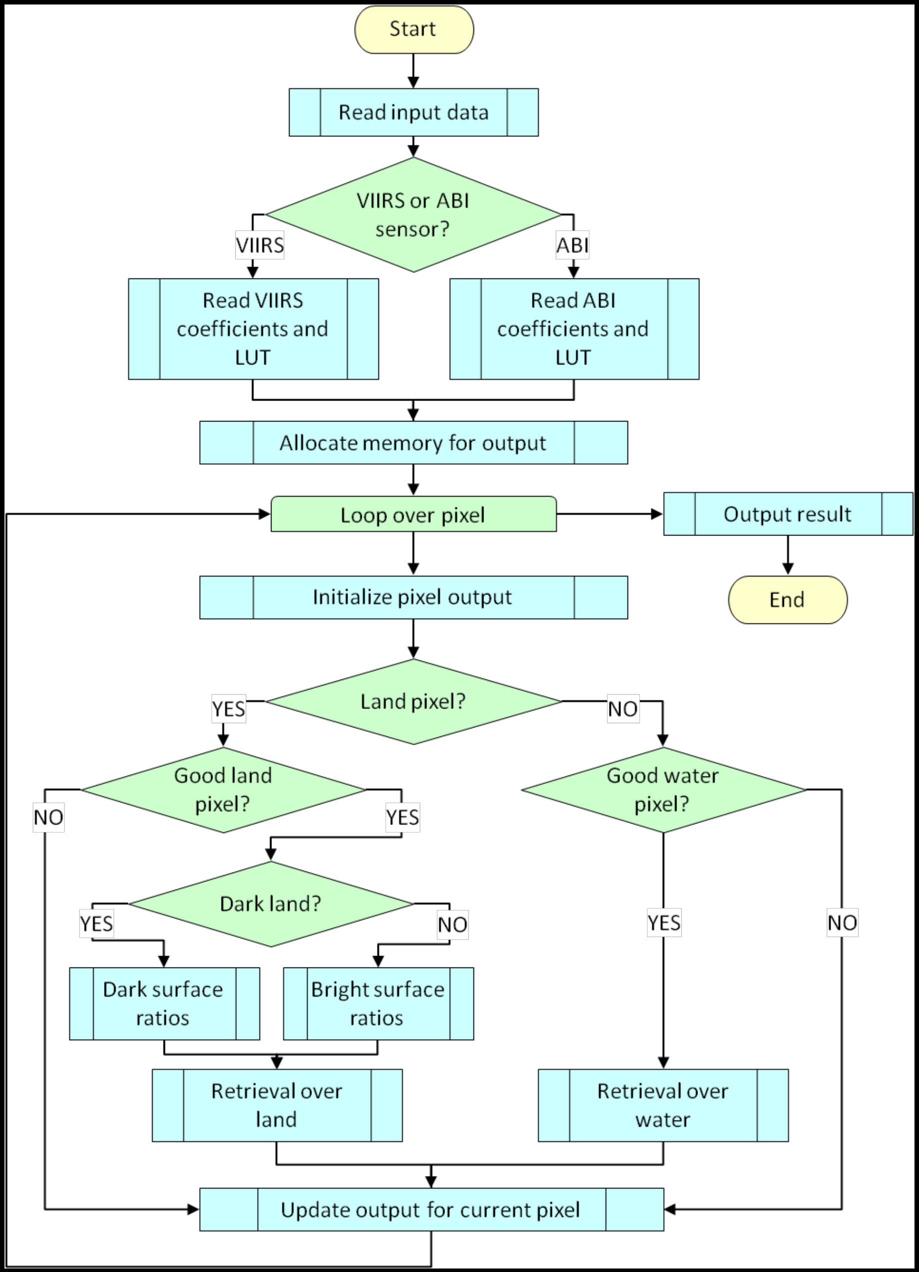
- Approach
  - Multi-spectral aerosol retrieval
- Heritage
  - MODIS and VIIRS
- Retrieval Coverage
  - Daytime cloud and snow/ice-free areas
  - Land: dark and bright
  - Ocean: non-glint deep water
  - AOD at 0.55µm: from -0.05 to 5.0
- Sensors Applied
  - VIIRS and ABI/AHI

Inputs and Outputs

- Inputs
  - Geolocation and geometry
  - SDR
    - SW reflectance
    - Brightness temperature at 11 and 12 µm
  - Cloud masks
    - Cloud confidence
    - Land/water mask
    - Snow/ice mask
    - Fire mask
    - Glint mask
    - Cloud shadow mask
    - Heavy aerosol mask
  - Model data
    - Surface pressure
    - TPW
    - Ozone
    - Wind speed and direction
  - Auxiliary data
    - Lookup tables
    - Coefficients and thresholds
    - Surface spectral reflectance relationship
    - Land cover type

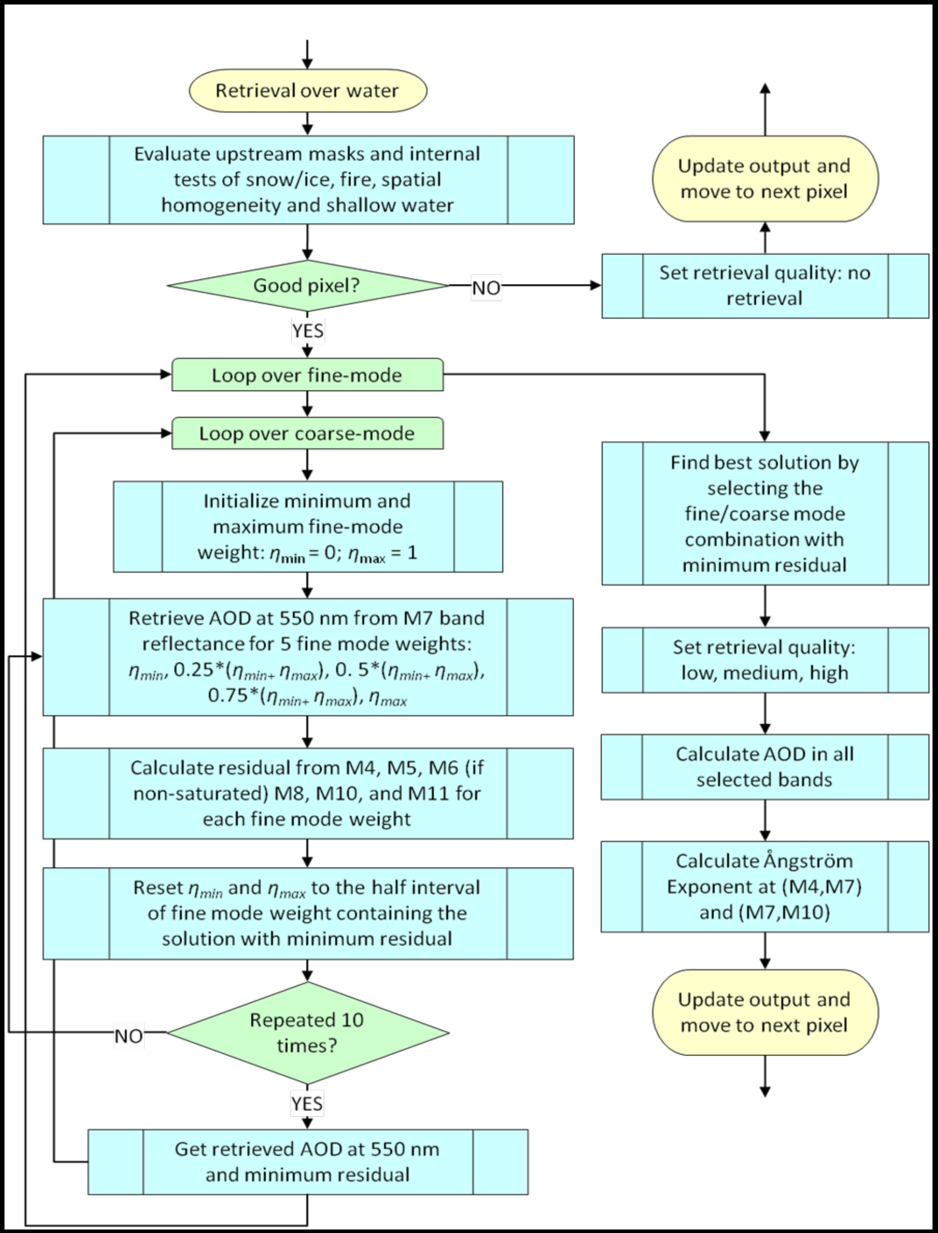
- Outputs
  - AOD550
  - AOD at sensor channels
  - Ångström Exponent over water (M4/M7 and M7/M10)
  - Aerosol model selected
  - Fine mode weight over water
  - Quality flags
    - Overall quality
    - External masks
    - Invalid inputs
    - Internal tests
    - Retrieval paths
    - Retrieval quality
  - Diagnostics
    - Surface reflectance
    - Retrieval residual
    - Spatial inhomogeneity
    - AOD and residual for each land aerosol model

Retrieval Process



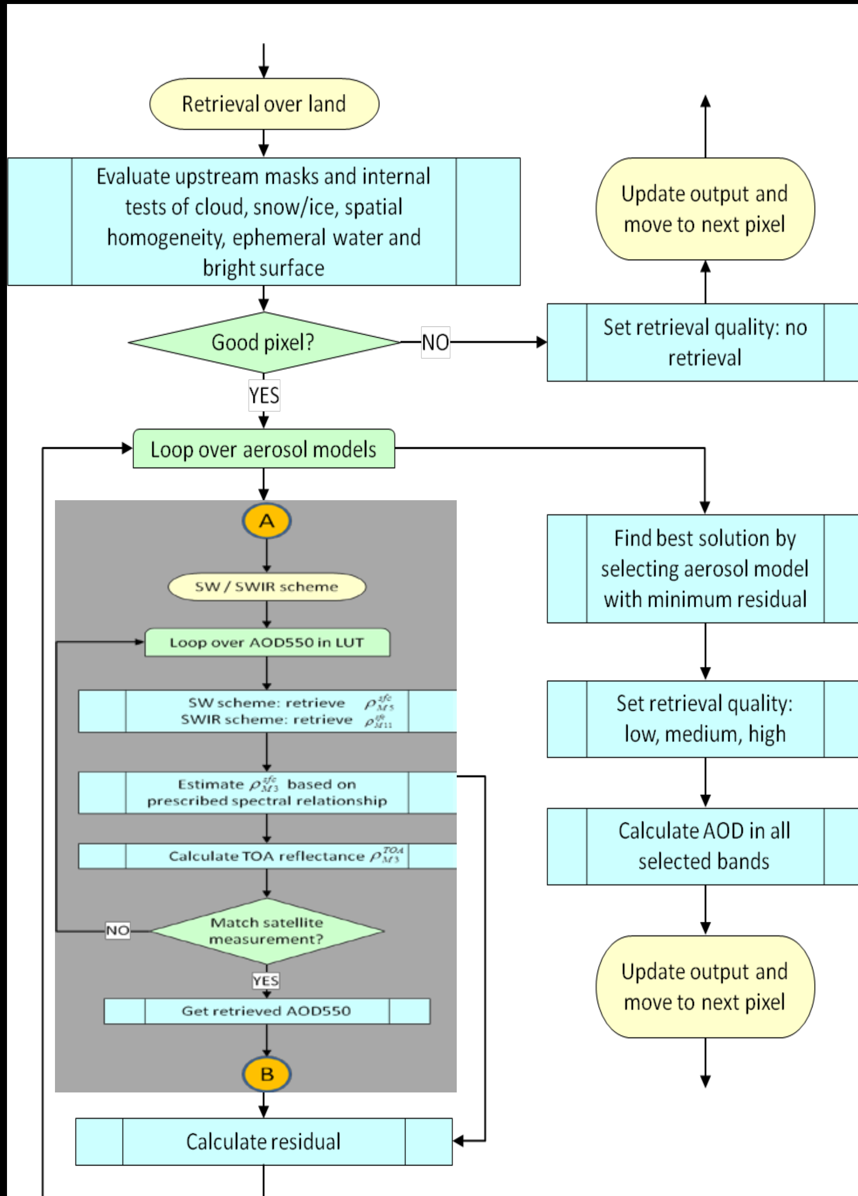
- Inputs
  - Land: M1,2,3,5,11
  - Water: M4,5,6,7,8,10,11
- Lookup tables
  - Pre-calculated with 6SV RTM
- Pixel-level retrieval
- Separate algorithms for land and water
- Separate paths for dark and bright land

Ocean Algorithm



- Linear combination of one (out of four) fine mode and one (out of five) coarse mode
- Bisection (Interval-halving) method used to search for the solution of the AOD550 and fine-mode-weight for a given pair of aerosol modes
  - Matching TOA M7 reflectance
  - Compute residual as the difference between calculated and measured reflectance at other channels
- Find the best solution with minimum residual

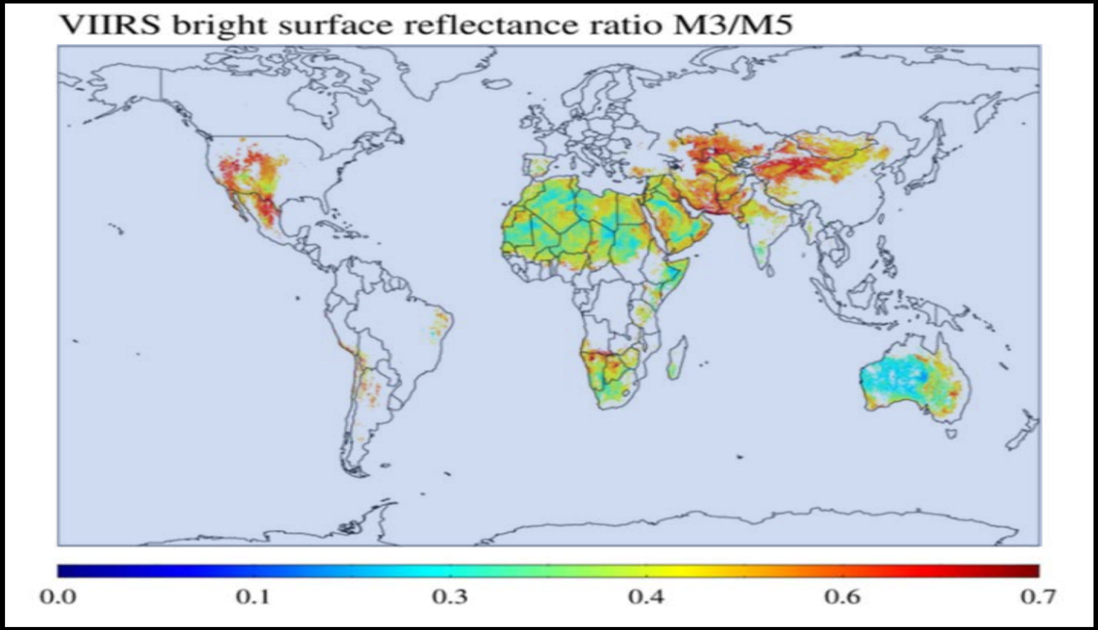
Dark Land Algorithm



- Four candidate aerosol models built in the LUT
  - Dust, generic, urban, smoke
- Spectral surface reflectance relationship
  - Function of scene greenness (NDVI), redness (M4/M5), and geometry
- Hybrid algorithm
  - SW scheme
    - M3 vs. M5
    - Suitable for low AOD cases
  - SWIR scheme
    - M3 vs. M11
    - Suitable for high AOD cases
  - Switch from SW to SWIR scheme if the estimated surface reflectance at M3 is larger than 0.1
- Select aerosol model with minimum residual
  - Residual is computed as the difference between calculated and measured TOA reflectance at M1, M2 and M5(SWIR)/M11(SW)

Bright Land Algorithm

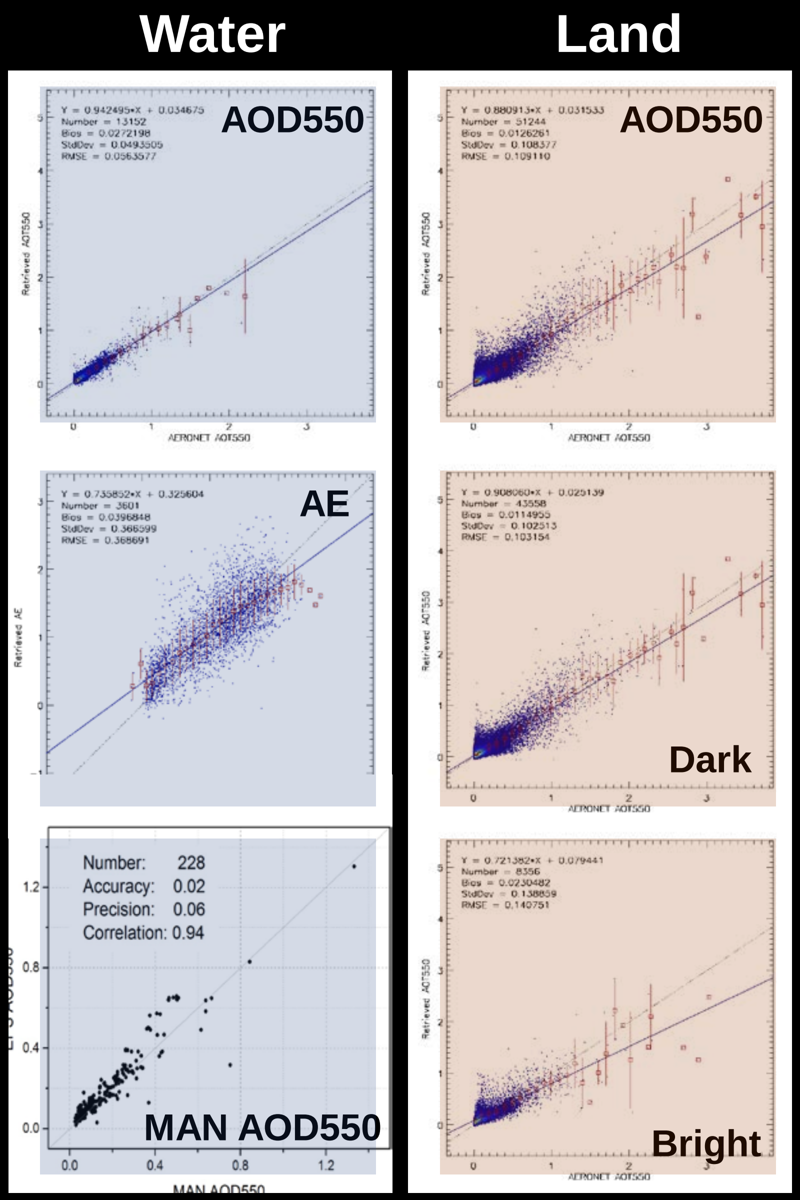
- Applied where M11 TOA reflectance > 0.25
- Spectral surface reflectance ratios are prescribed
  - 0.1° by 0.1° spatial resolution
  - Function of scattering angle for forward/backward reflection



- Two separate domains
  - North Africa and Arabian Peninsula
    - Dust aerosol model
    - Retrieval at M3 channel
  - Other areas
    - Select aerosol model
    - Retrieval at M1 channel

Validation

- Retrieval with VIIRS inputs
  - High quality AOD550
  - High quality AE over water (M4 vs M7)
- Validation against the Level 2.0 AERONET measurements
  - Period of 10/26/2012 – 3/12/2016 for ground measurements
  - Period of year 2015 for the Marine Aerosol Network (MAN) measurements
  - Statistics include accuracy (bias), precision (standard deviation of error) and number of match-ups



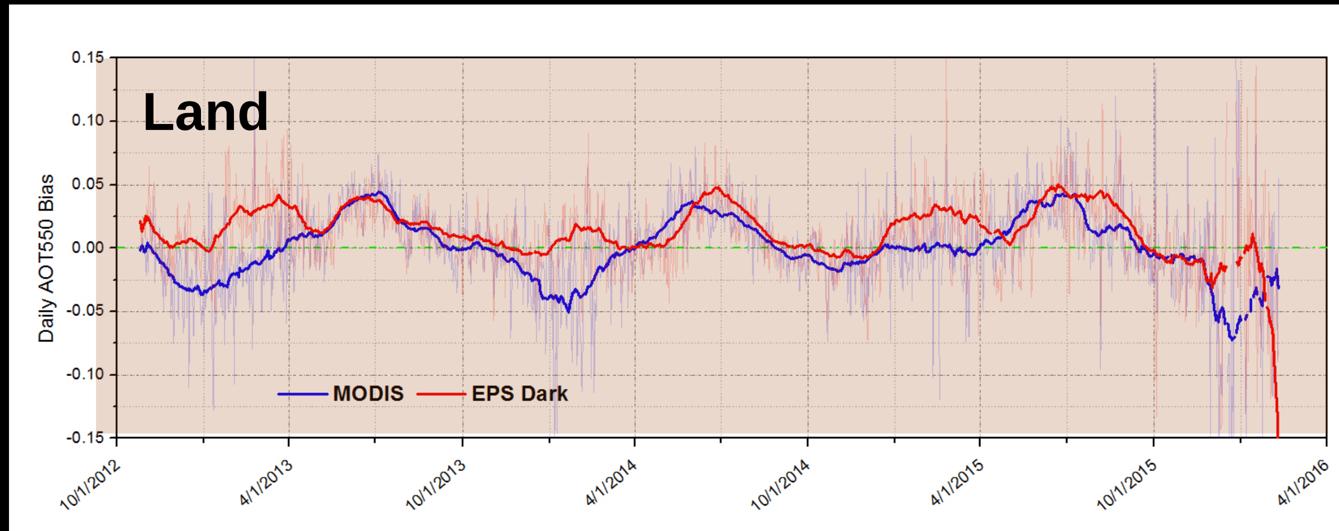
Validation Statistics

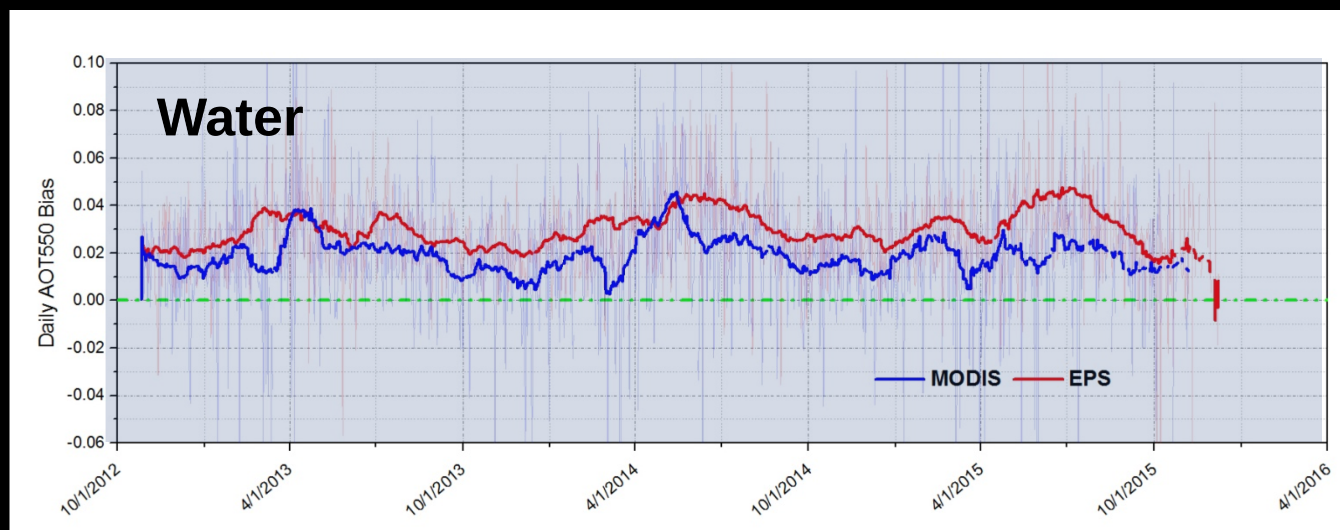
Water	EPS	Requirement
AOD550 < 0.3		
Accuracy	0.029	0.08
Precision	0.038	0.15
Number	12,049	
AOD550 ≥ 0.3		
Accuracy	0.011	0.15
Precision	0.113	0.35
Number	1,103	
All AOD550		
Accuracy	0.027	
Precision	0.049	
Number	13,152	
Ångström Exponent		
Accuracy	0.040	0.3
Precision	0.367	0.6
Number	3,601	

Land	EPS	EPS Dark	EPS Bright	Requir-ement
AOD550 < 0.1				
Accuracy	0.032	0.028	0.069	0.06
Precision	0.069	0.067	0.088	0.15
Number	26,842	24,097	3,393	
0.1 ≤ AOD550 ≤ 0.8				
Accuracy	-0.006	-0.009	-0.002	0.05
Precision	0.114	0.108	0.138	0.25
Number	23,396	18,641	4,785	
AOD550 > 0.8				
Accuracy	-0.048	-0.017	-0.198	0.20
Precision	0.381	0.377	0.367	0.45
Number	1,006	820	178	
All				
Accuracy	0.013	0.012	0.023	
Precision	0.108	0.103	0.139	
Number	51,244	43,558	8,356	

- Retrievals meet the requirement

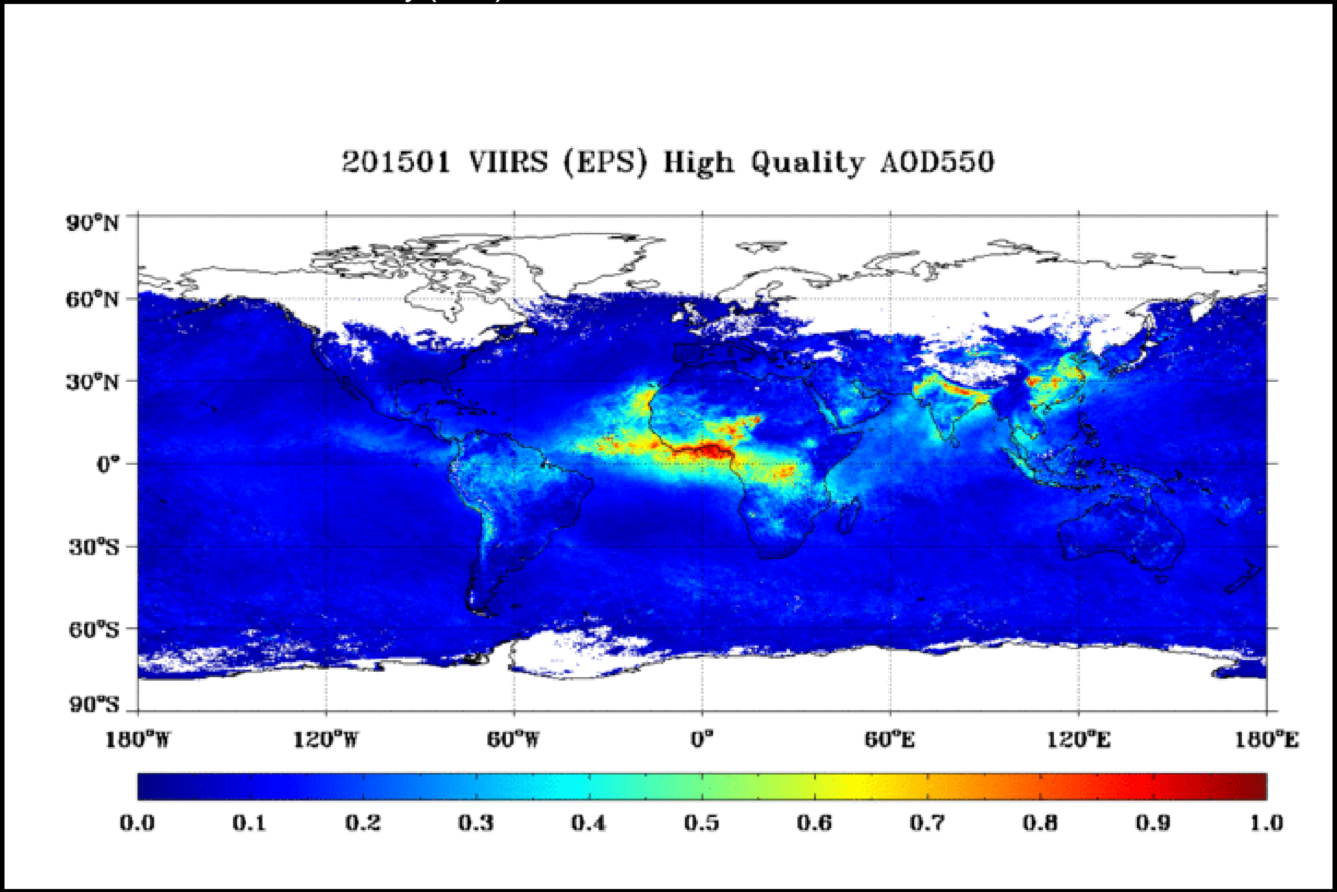
Time Series


Land
Daily AOT550 Bias
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
MODIS
EPS Dark
10/1/2012
4/1/2013
10/1/2013
4/1/2014
10/1/2014
4/1/2015
10/1/2015
4/1/2016

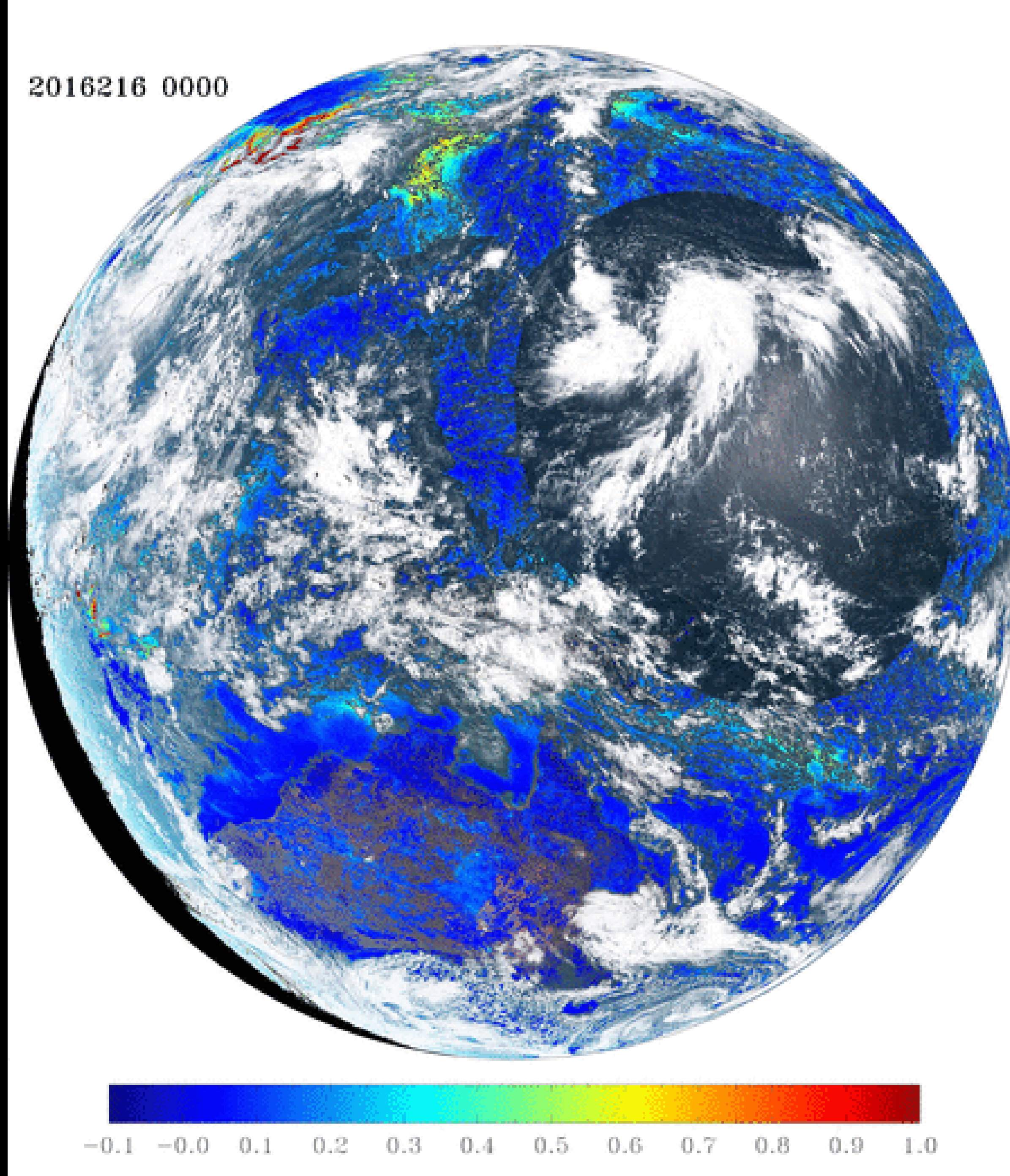

Water
Daily AOT550 Bias
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
MODIS
EPS
10/1/2012
4/1/2013
10/1/2013
4/1/2014
10/1/2014
4/1/2015
10/1/2015
4/1/2016

Reprocess VIIRS Aerosol Retrieval

- Time Period
  - Year 2015
- Output Data
  - Pixel-level retrieval and diagnostic outputs in compressed HDF5 format for each granule
  - Total size 7.7T (about 22G per day)
- Data assimilation applications
  - NOAA Earth System Research Laboratory (ESRL)
  - NOAA Joint Center for Satellite Data Assimilation (JCSDA);
  - NOAA National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC)
  - University at Albany, State University of New York
  - Naval Research Laboratory (NRL)



Retrieval with AHI



Summary

- EPS aerosol algorithm is developed to retrieve aerosol optical depth for both VIIRS and GOES-R ABI data to achieve a cross-platform consistency of NOAA satellite-based aerosol retrievals.
- Evaluation of the algorithm shows the performance meets requirement.
- Global application is performed with VIIRS and AHI data.

The EPS Aerosol Detection Product From Multi-Satellite Sensors

Pubu Ciren[2] and Shobha Kondragunta[1]
[1] NOAA/NESDIS/STAR
[2] IMSG

JPSS Annual Meeting 2016 , College park, MD

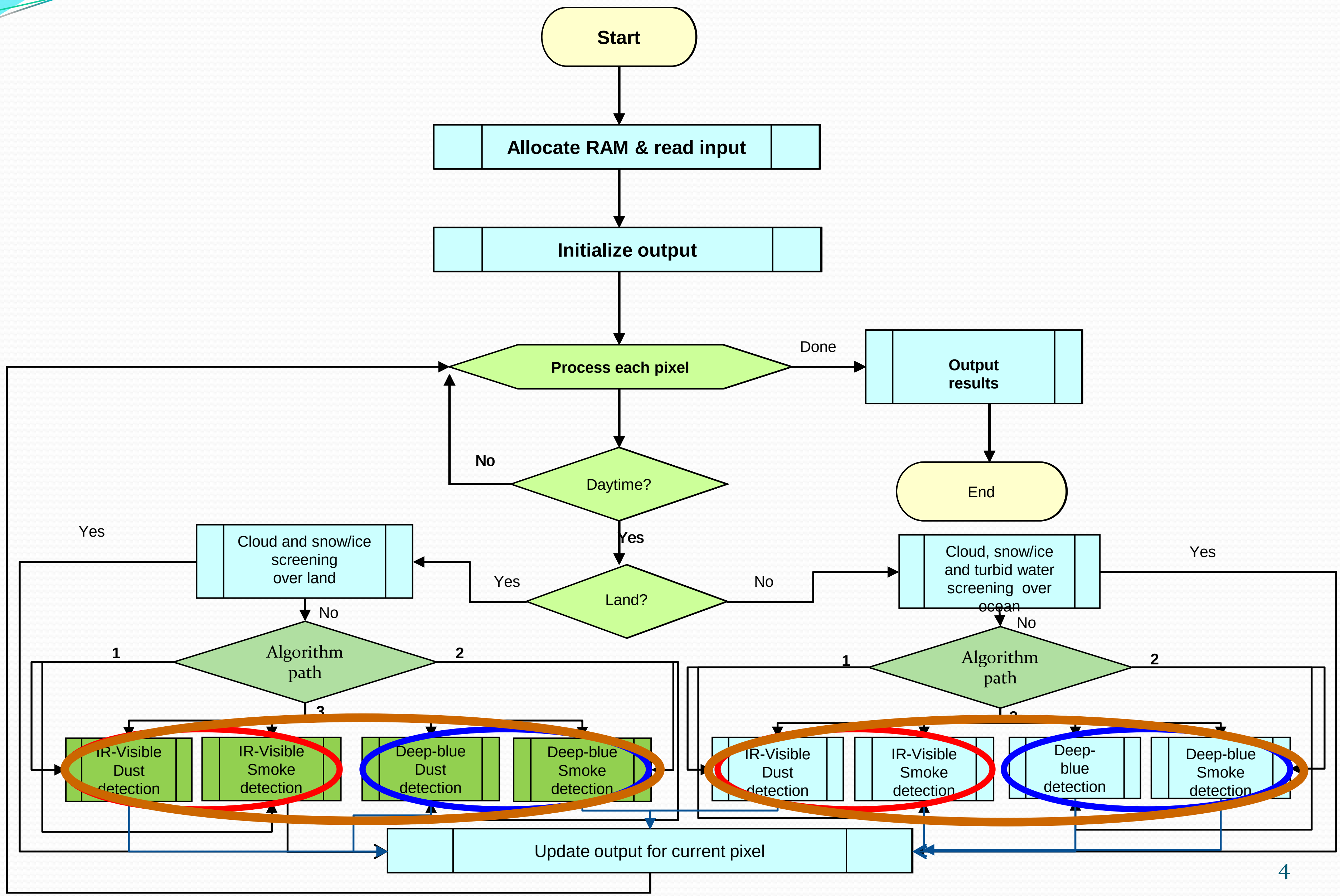
Outline

- Overview of the Enterprise Processing System (EPS) Aerosol Detection Algorithm
- EPS Aerosol Detection Products from Multi-sensors: S-NPP VIIRS, EOS MODIS, Himawari AHI, and future Sensor: TEMPO
- Algorithm improvement
- Summary

What is the EPS Aerosol Detection Algorithm?

- The Enterprise Processing System Aerosol Detection algorithm was designed to have one set of algorithms working on observations from multi-sensors including both GEO and LEO platforms.
- Heritage is the GOES-R AWG and JPSS Risk Reduction aerosol detection algorithms.
- Uniform input and output structure.

EPS Aerosol Detection Algorithm (1)



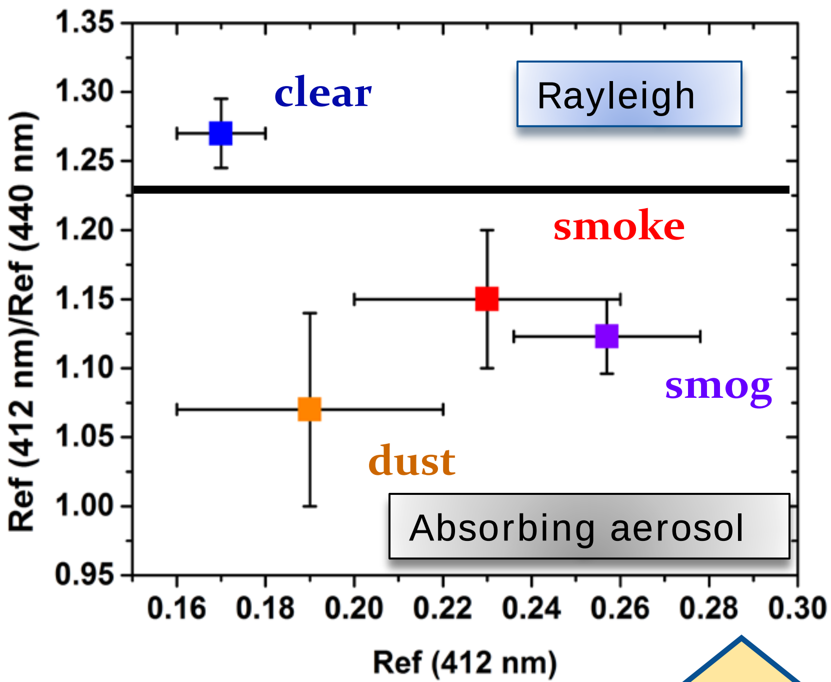
EPS Aerosol Detection Algorithm (2)

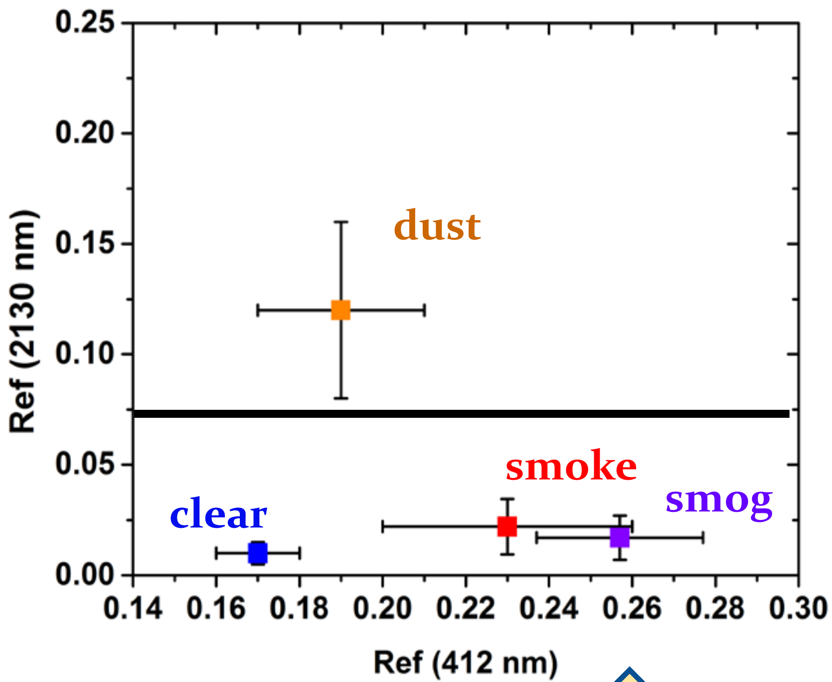
Table 1. Mapping of channels for different sensors to channels used in EPS ADP algorithm

Channel In EPS		Sensors			
		VIIRS	MODIS	ABI	AHI
1	0.412µm	M1	Band 8	X	X
2	0.445 µm	M2	Band 9	X	X
3	0.488 µm	M3	Band 3	Band 1	Band1
4	0.555 µm	M4	Band 4	X	x
5	0.640 µm	M5	Band 1	Band 2	Band3
6	0.746 µm	M6	Band 15	X	X
7	0.865 µm	M7	Band 2	Band 3	Band 4
8	1.24 µm	M8	Band 5	X	X
9	1.38 µm	M9	Band 26	Band 4	X (Band 5)*
10	1.61 µm	M10	Band 6	Band 5	Band 5
11	2.25 µm	M11	Band 7	Band 6	Band 6
12	3.70 µm	M12	Band 20	X(Band 7)*	X(Band 7)*
13	4.05 µm	M13	Band 21	Band 7	Band 7
14	10.7 µm	M15	Band 31	Band 14	Band 14
15	12.01 µm	M16	Band 32	Band 15	Band 15

Green: used by both deep-blue based and IR-visible based detection algorithms
Blue: only used by deep-blue based detection algorithm
Brown: only used by IR-Visible based detection algorithm.
*****: band is missing but using the corresponding band in the parentheses instead.
X: channel is missing, but not needed, and filled with "-999.9"

Aerosol Detection Algorithm (path1)





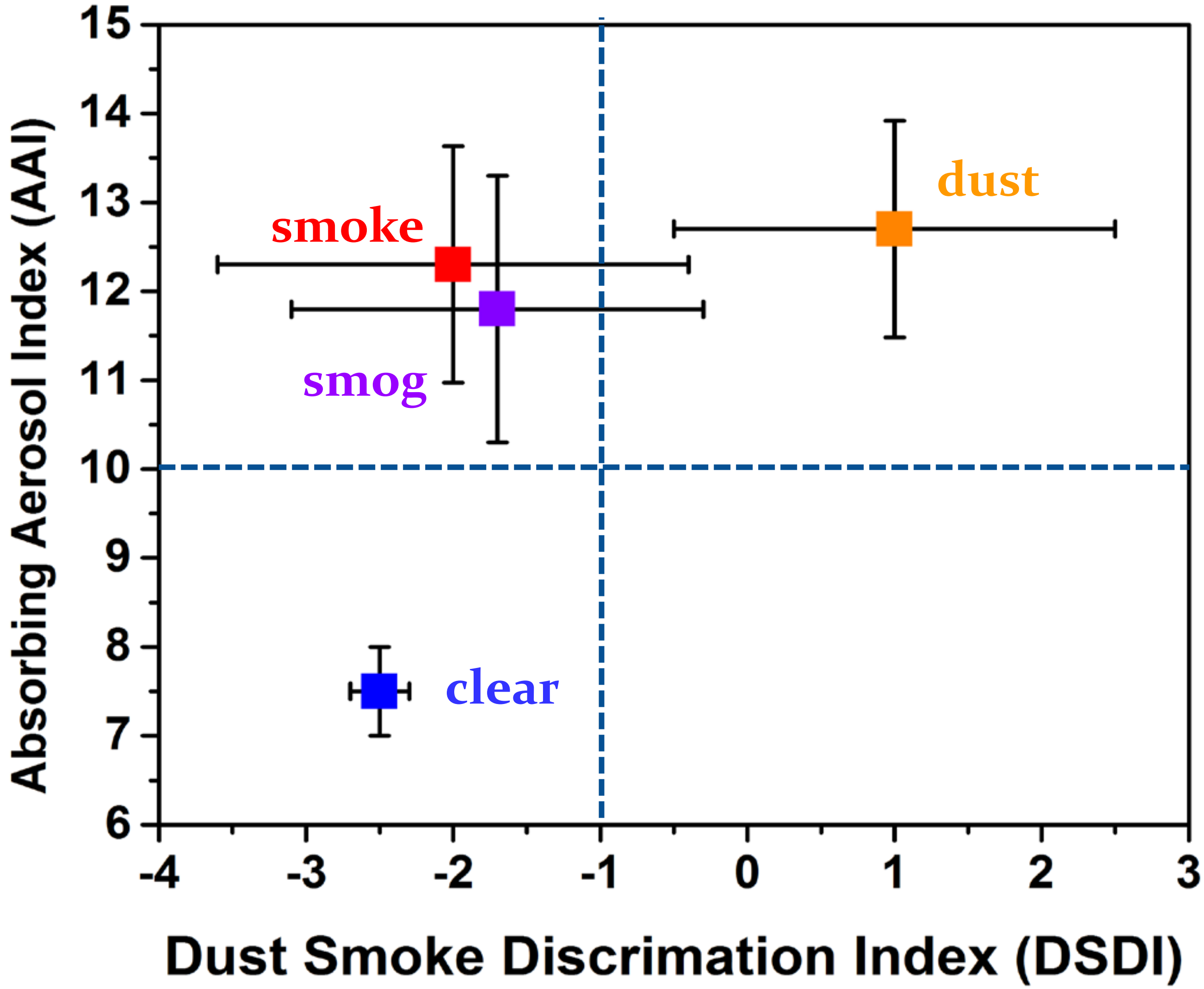
Absorbing Aerosol Index

$AAI = -100[\log_{10}(R_{412}/R_{440}) - \log_{10}(R^{RAY}{}_{412}/R^{RAY}{}_{440})]$

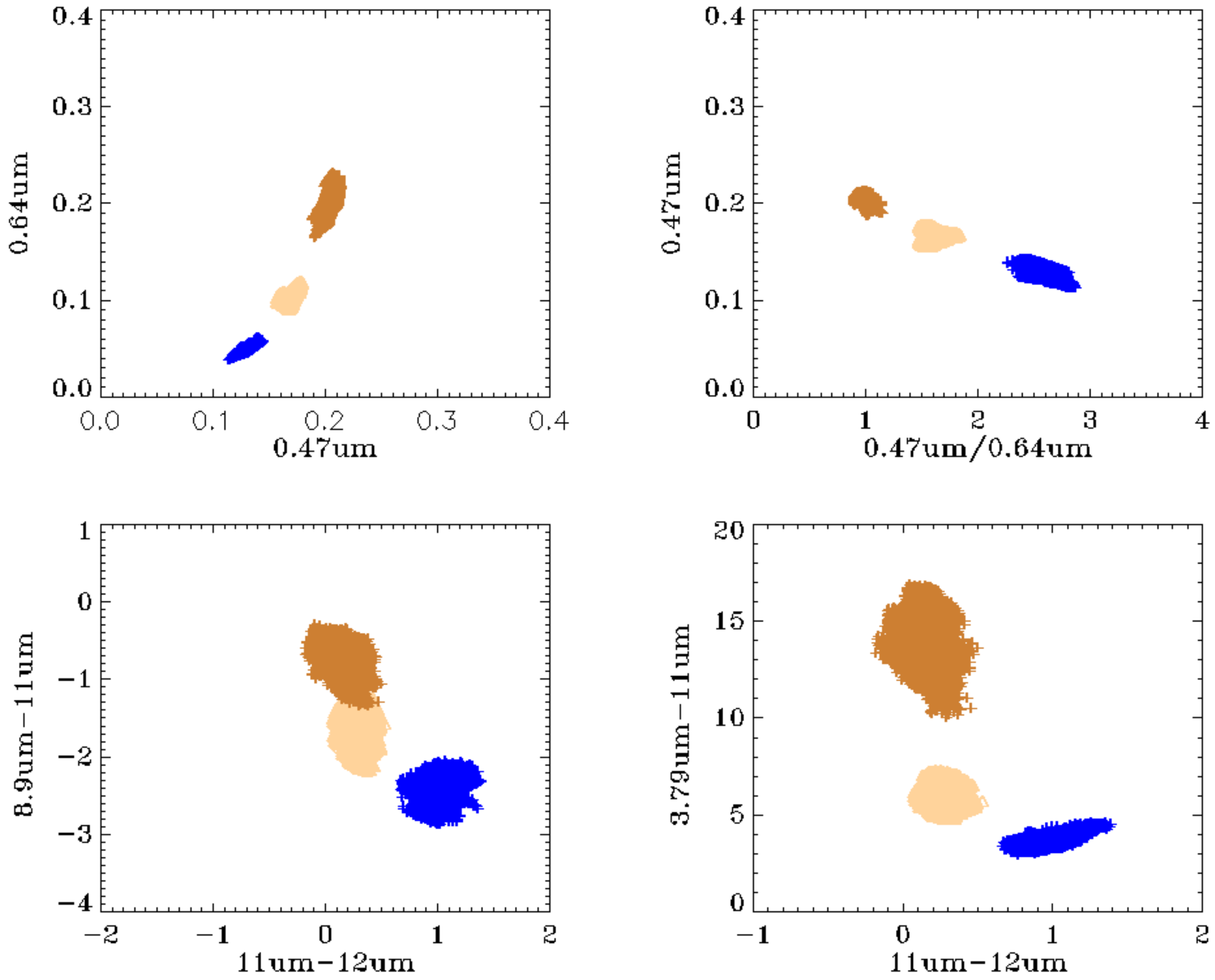
Dust Smoke Discrimination Index

$DSDI = -10[\log_{10}(R_{412}/R_{2250})]$

Aerosol Detection Algorithm (path1)



Aerosol Detection Algorithm (path2)



Clear

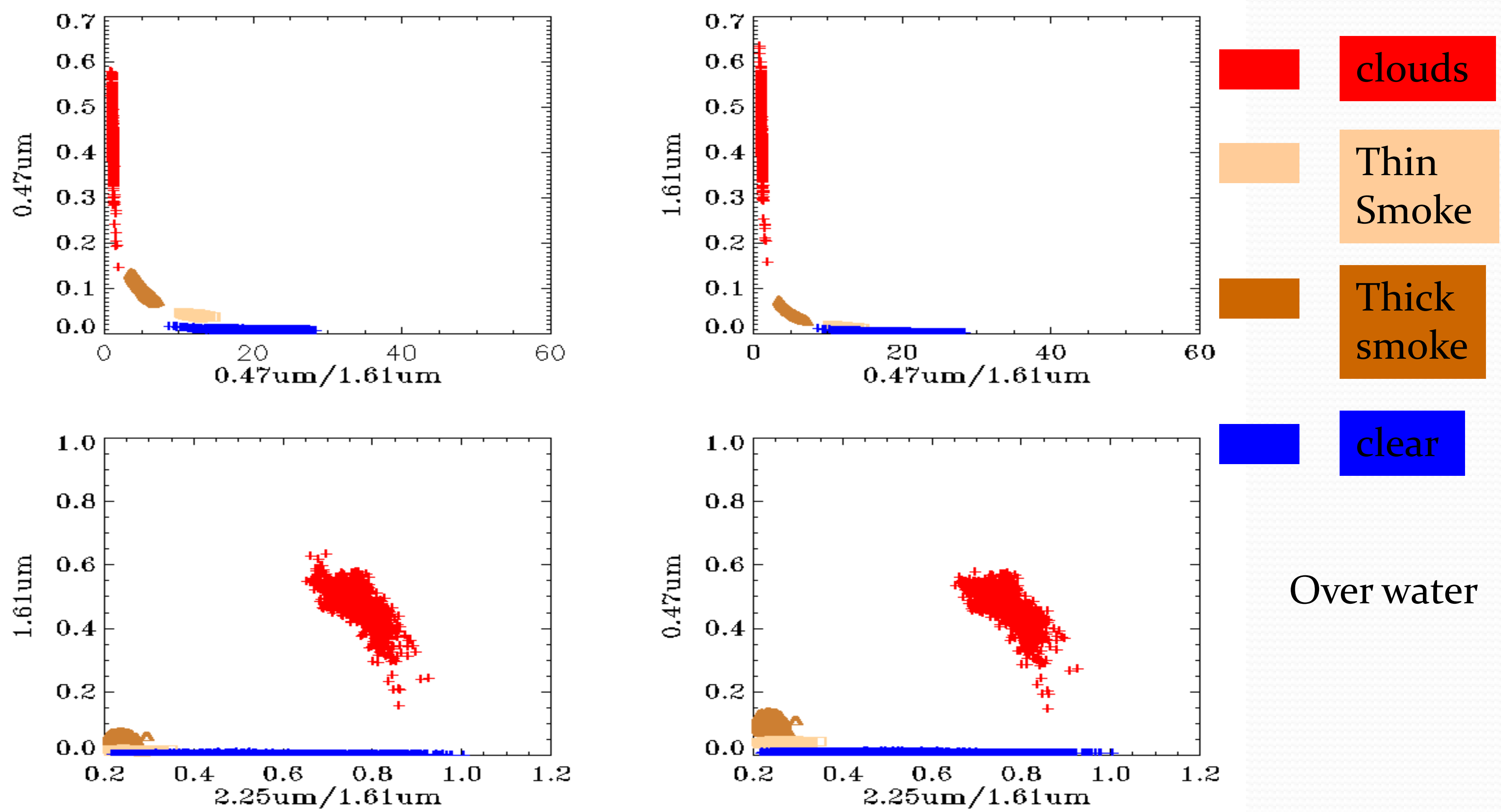
Thin Dust

Thick Dust

Over water

In IR region, dust decreases the brightness temperature difference between 11 and 12 μm, compared to clear sky. In visible region, dust reduces the contrast between two neighboring wavelengths , such as 0.47 μm/0.64 μm.

Aerosol Detection Algorithm (path2)



Weak spectral dependence of reflection from clouds and strong wavelength dependent reflection from smoke allows us to use spectral contrast between two visible wavelengths to separate smoke from clouds; and further separate thick smoke from thin smoke .

Outputs from EPS Aerosol Detection(1)

Output flags from EPS ADP product

Type/Byte		Flag Name	Meaning	
			Value: 0 (default)	1
Integer	1	**Volcanic Ash**	**No**	**yes**
	2	**Cloud**	**No**	**yes**
	3	**Dust**	**No**	**yes**
	4	**Smoke**	**No**	**yes**
	5	**None/Unknown/Clear**	**No**	**yes**
	6	**Snow/ice**	**No**	**yes**

Quality flags from EPS ADP product

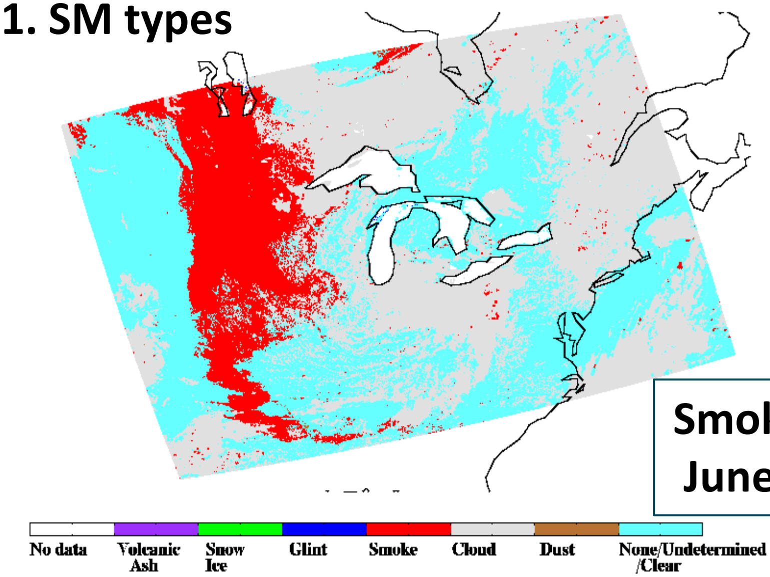
Byte/Bit*		Quality Flag Name	Meaning		
			2bit: 10 (default:00)	01	11
1	0-1	QC_ASH_DETECTION	Low	Medium	High
	2-3	QC_SMOKE_DETECTION	Low	Medium	High
	4-5	QC_DUST_CONFIDENCE	Low	Medium	High
	6-7	QC_NUC_CONFIDENCE	Low	Medium	High

Output from EPS ADP product

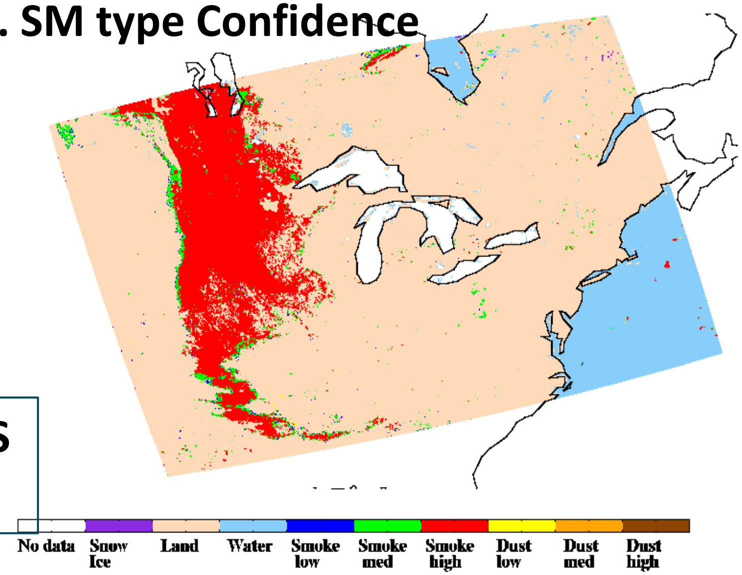
Type	Name	Meaning
Float 32	**Scaled Absorbing Aerosol Index**	**Index scaled by the corresponding threshold to illustrate the intensity of smoke/dust event**
Float 32	**Non-dust aerosol index**	**an index used to separate smoke from dust**

Outputs from EPS Aerosol Detection(2)

1. SM types

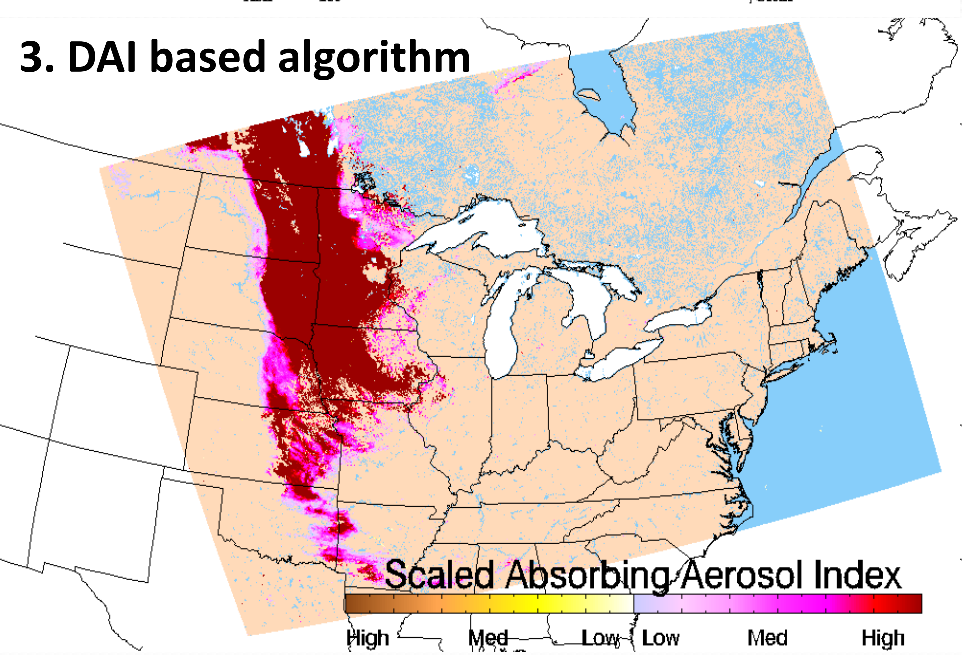


2. SM type Confidence

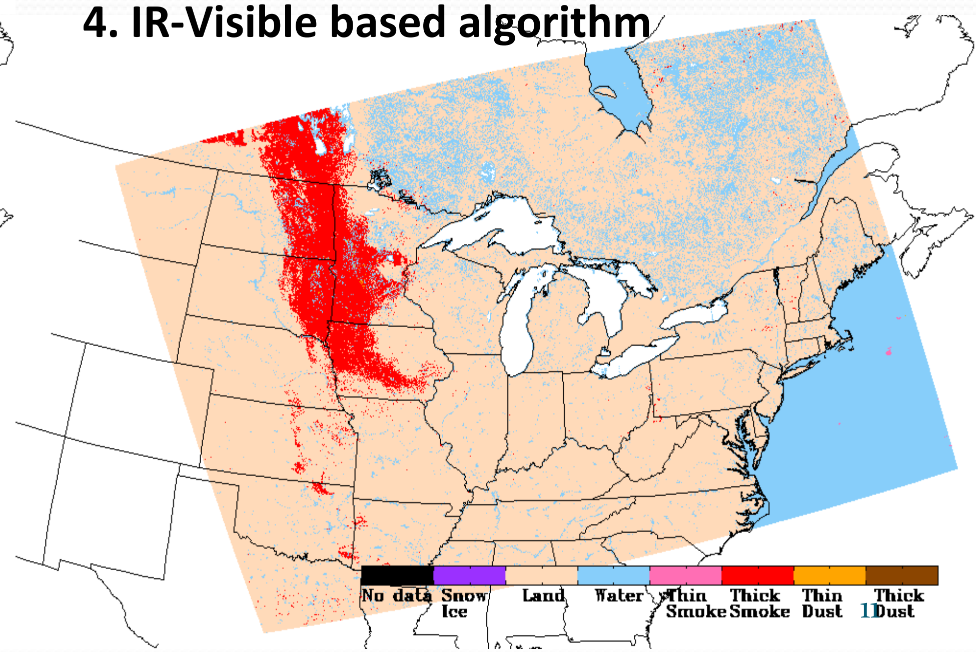


Smoke over U.S
June 29,2015

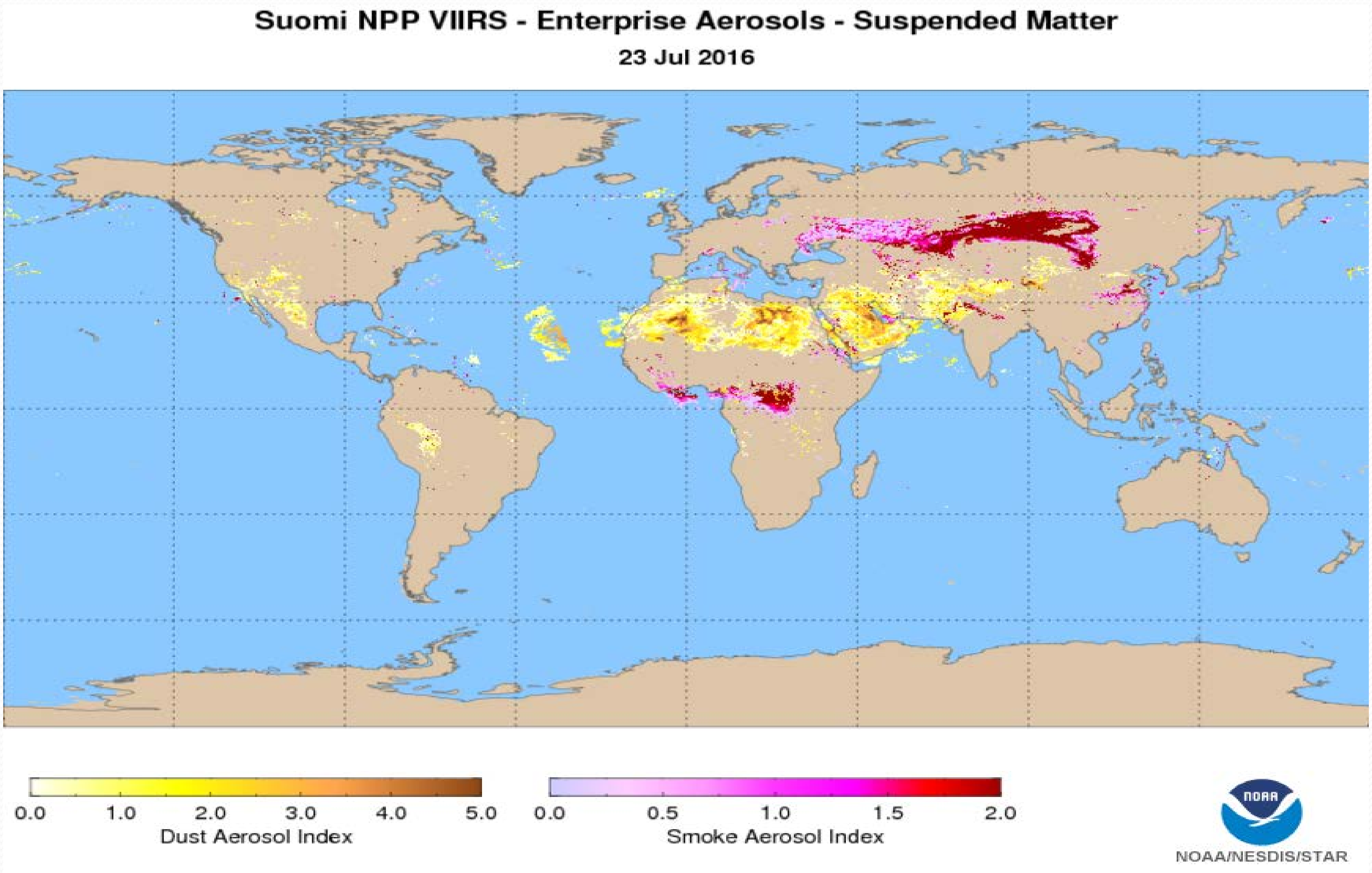
3. DAI based algorithm



4. IR-Visible based algorithm

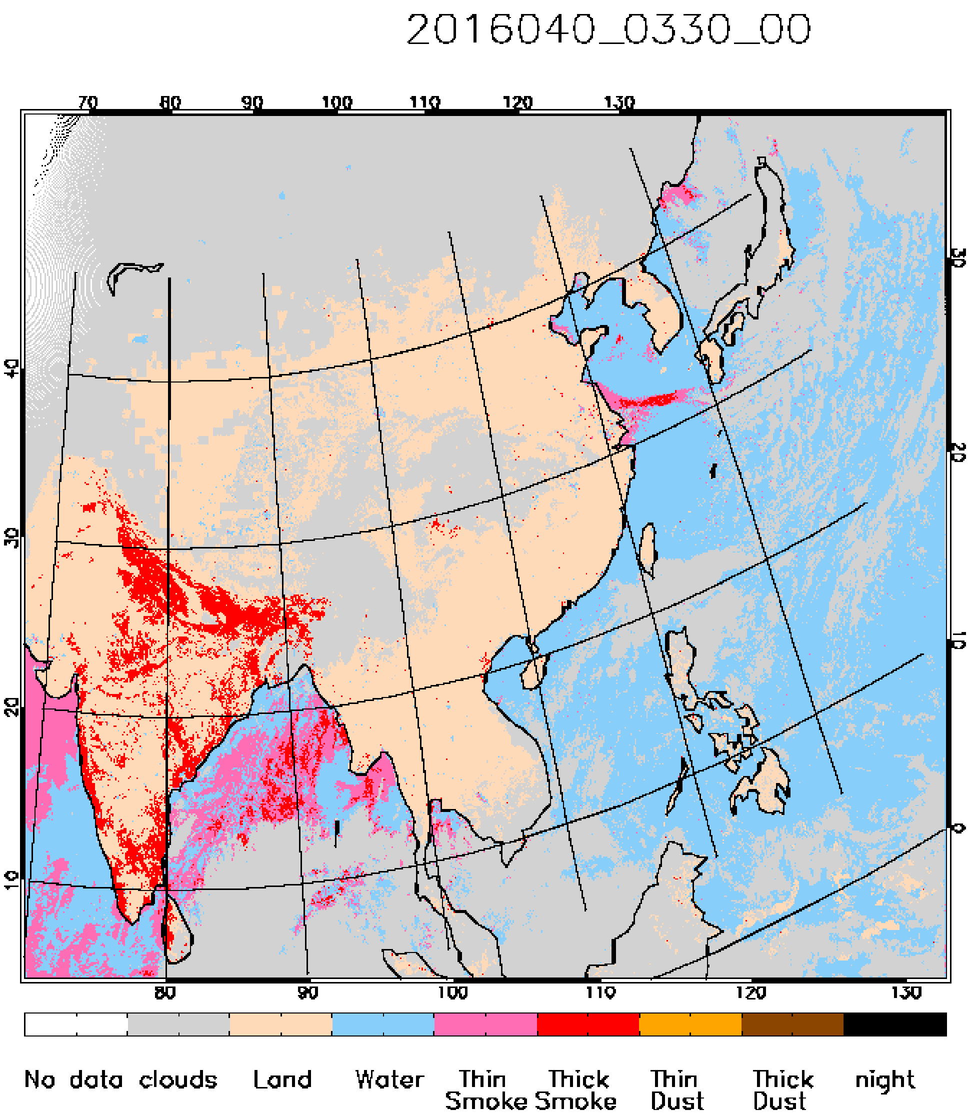


Real-time EPS Aerosol Detection



http://www.star.nesdis.noaa.gov/jpss/EDRs/products_aerosols.php

Enterprise Algorithm Aerosol Detection Product (ADP) generated using AHI for February 9, 2016



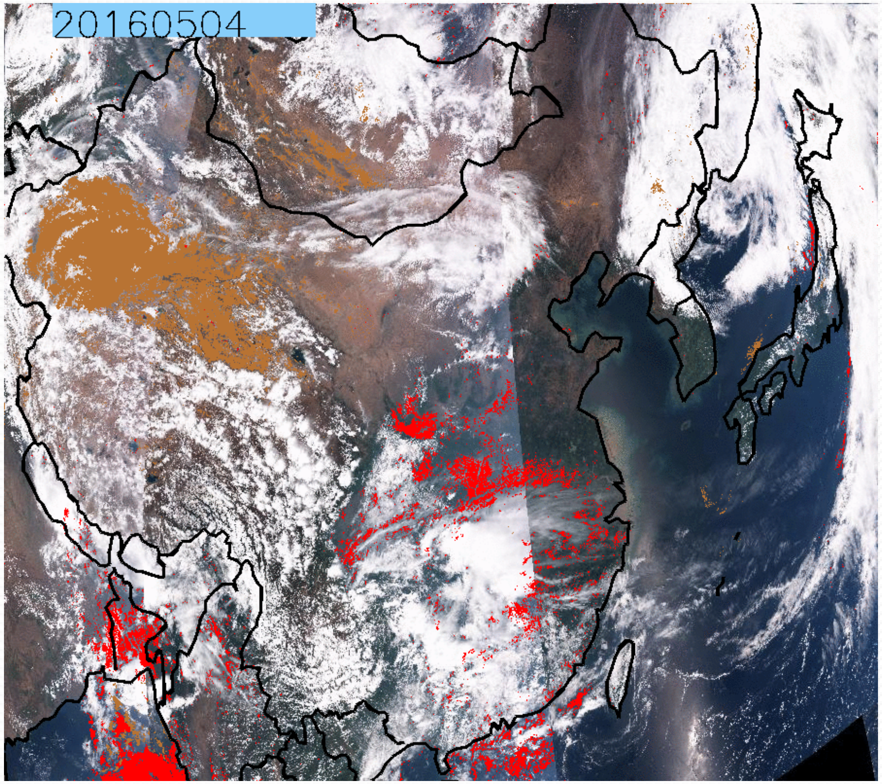
Winter-time smog (mainly sulfate and highly absorbing brown carbon) is a big concern in Asia with high concentrations of aerosols in the boundary layer impacting air quality and visibility.

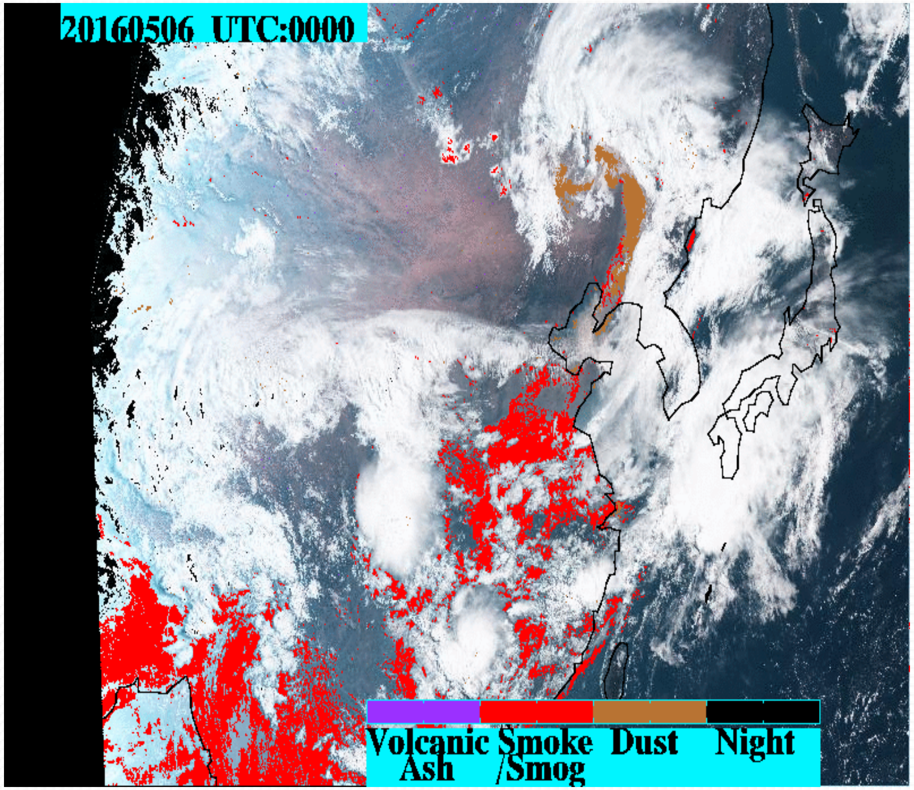
30-minute AHI aerosol imagery loop

Enterprise Aerosol Detection Products: GEO v.s. LEO

SNPP VIIRS

AHI



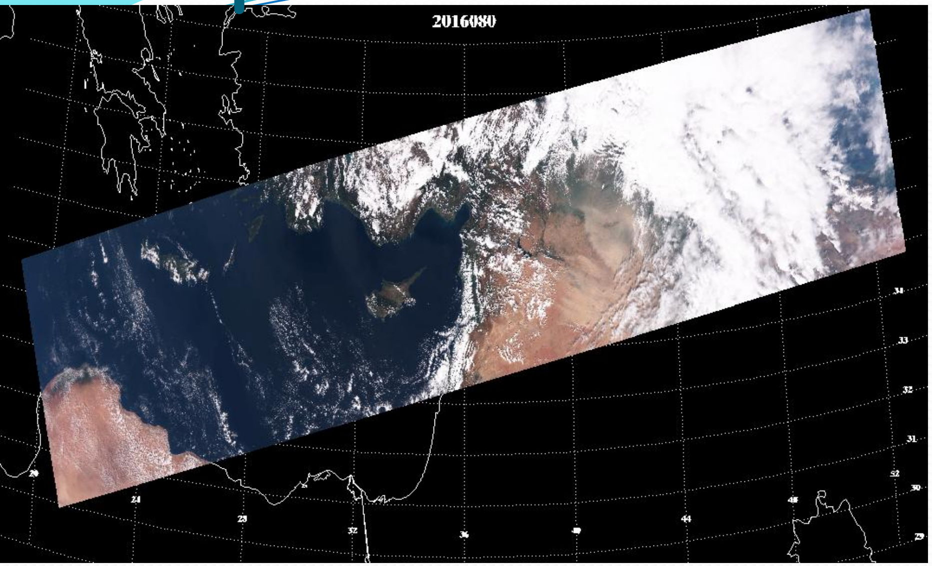


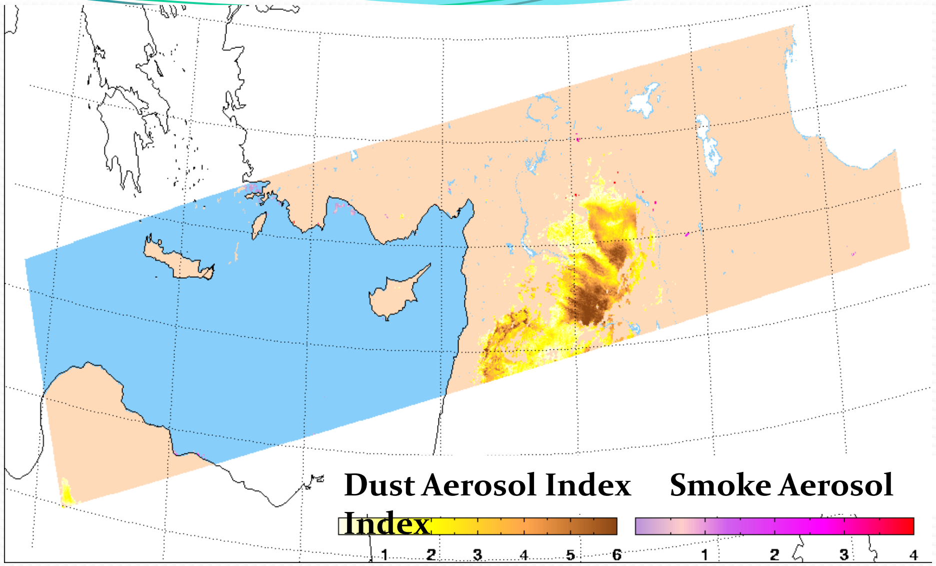
Smoke/Smog

Dust

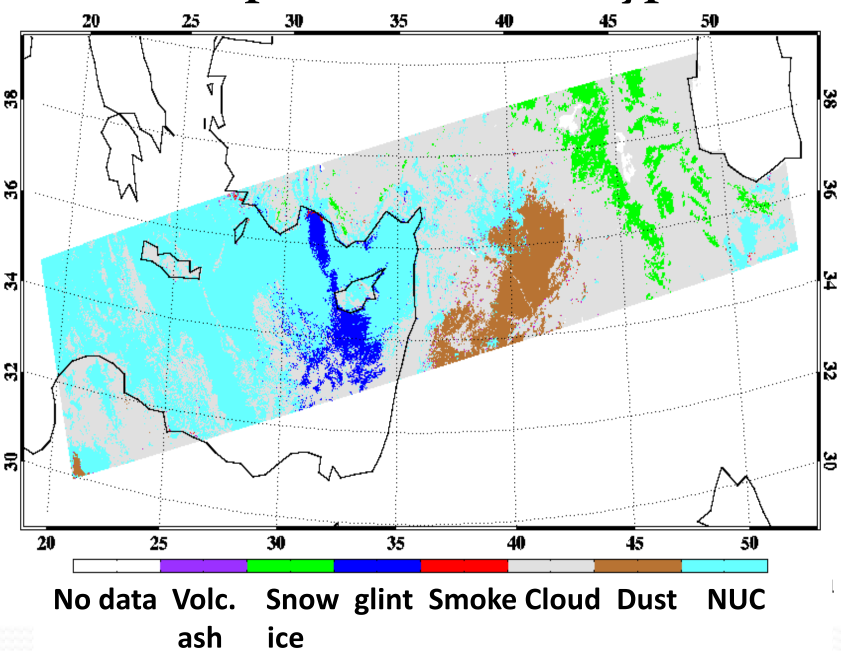
Asian dust captured in EPS ADP from both VIIRS (*left*) and Himawari AHI (*right*).

Enterprise Aerosol Detection Products : DUST

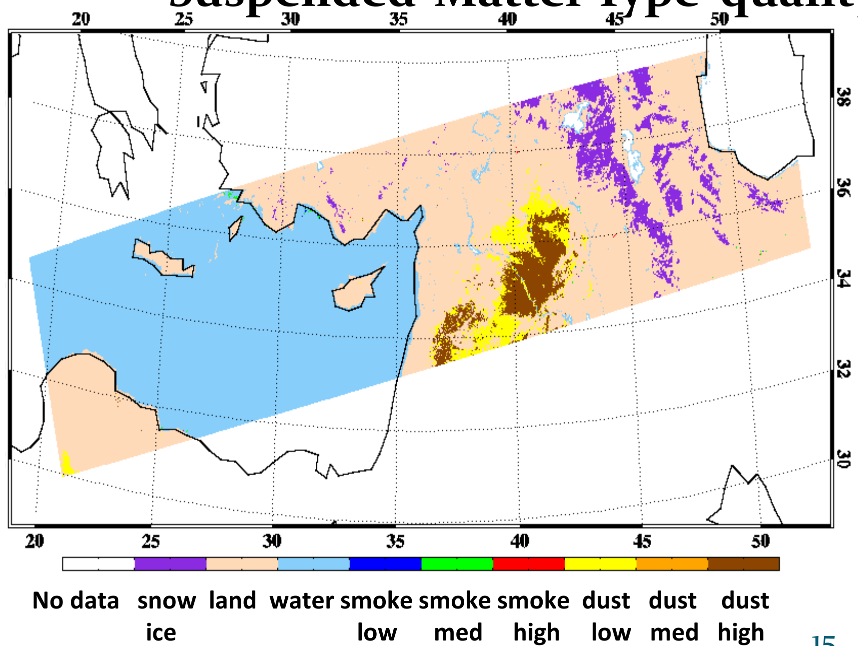




Suspended-Matter Type



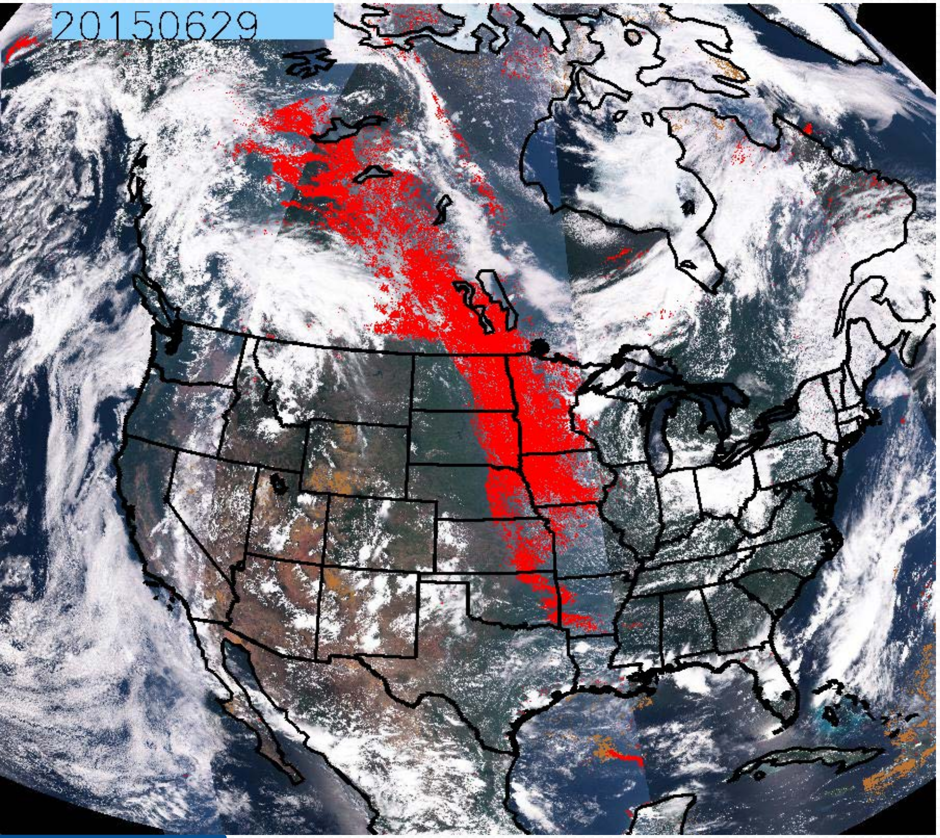
Suspended-Matter Type quality



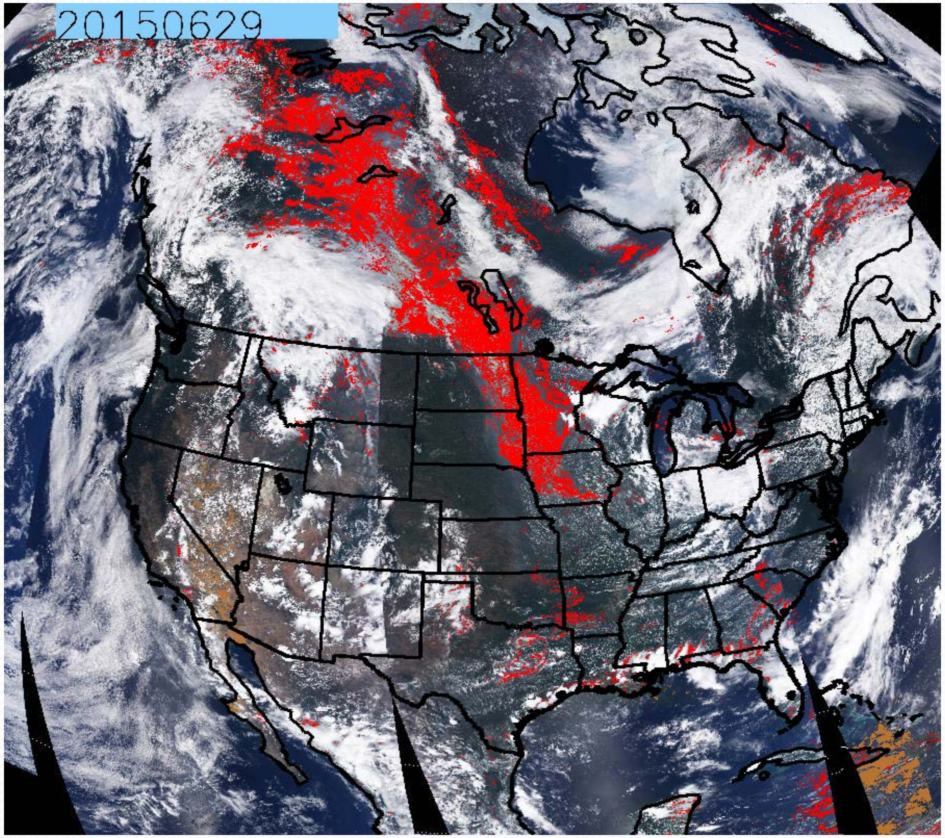
Enterprise Aerosol Detection Products : MODIS

Smoke plume from forest fire originated from Canada on 06/29/2015

S-NPP VIIRS



MODIS Aqua

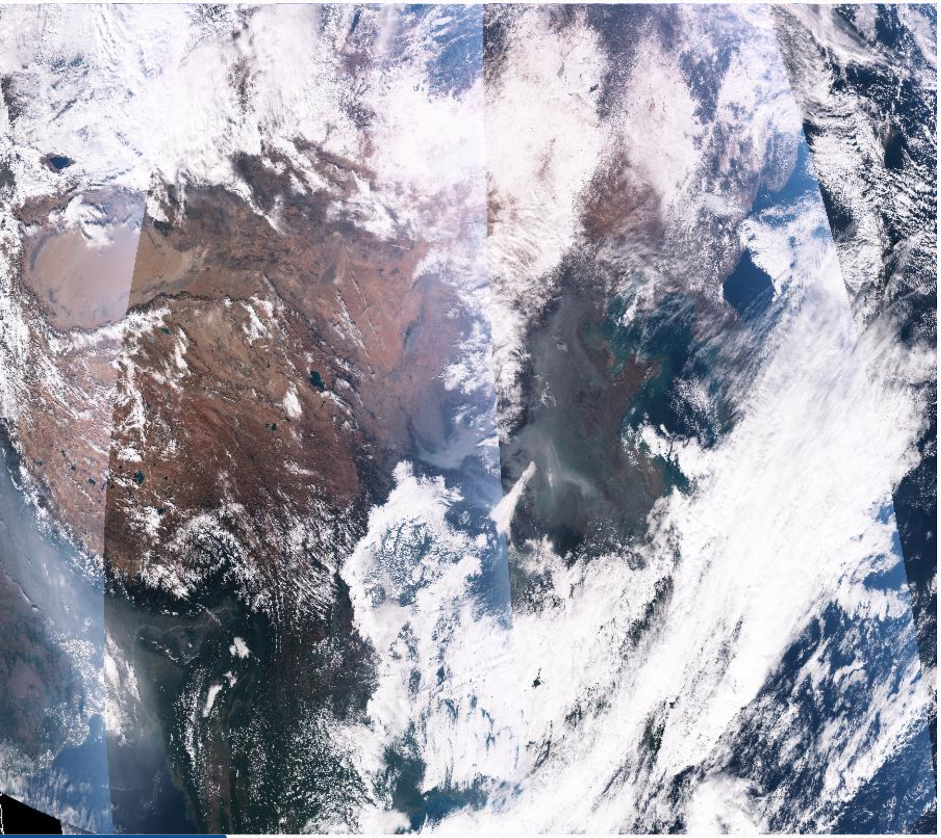


Smoke/Smog

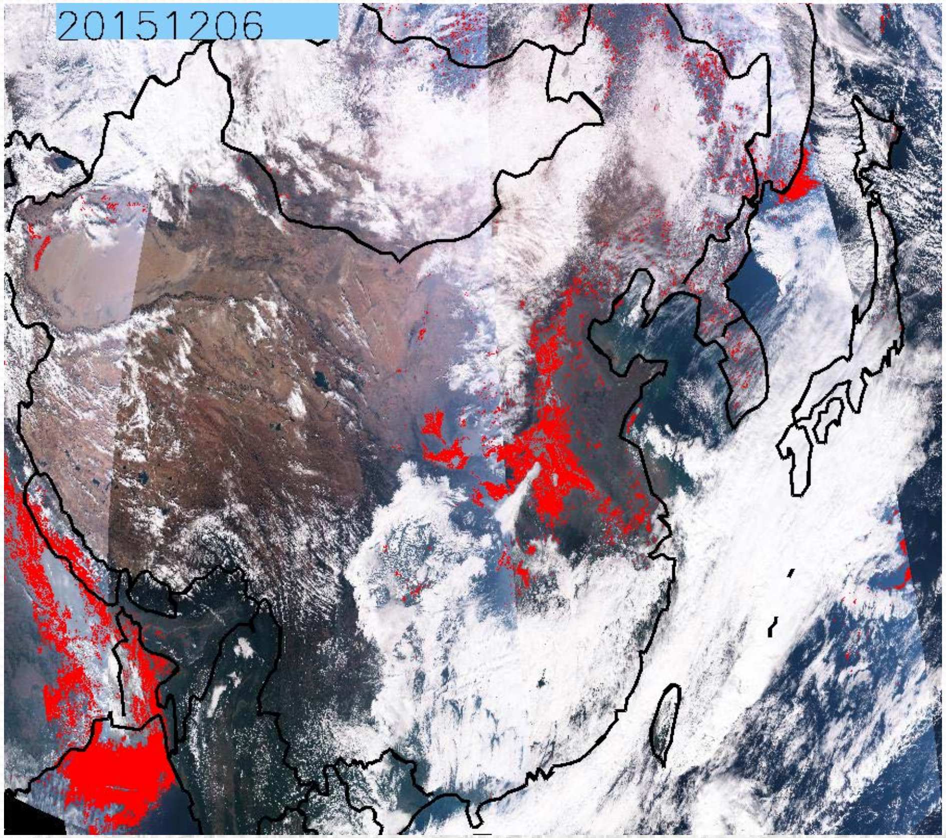
Dust

Enterprise Aerosol Detection Products : Asian Smog

S-NPP VIIRS RGB



EPS ADP on S-NPP VIIRS



Smoke/Smog

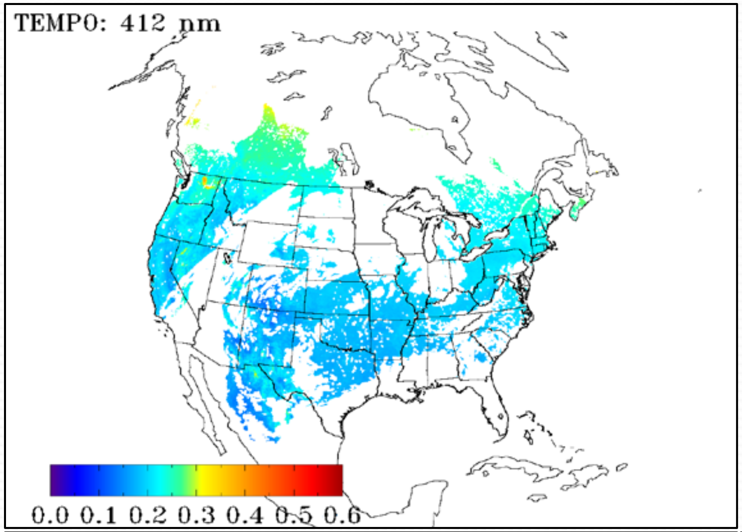
Dust

Asian Smog lingering over China and India on 12/06/2015 detected by EPS ADP

Enterprise Aerosol Detection algorithm applied to future sensor: TEMPO

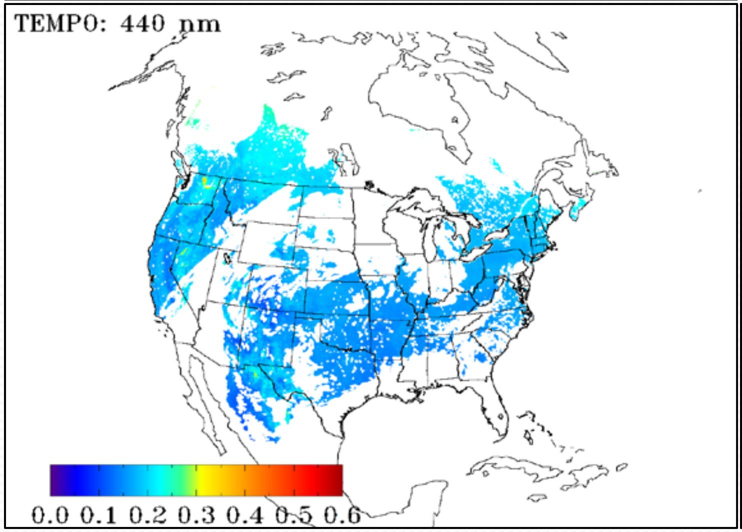
- TEMPO (Tropospheric Emissions: Monitoring of Pollution), a NASA Earth Venture Instrument , is a UV-Visible (290-740nm) spectrometer on GEO orbit.
- First GEO-satellite with measurements in the “deep-blue” spectral region.
- Will be on-orbit about the same time as GOES-R.
- NASA generated synthetic radiances for a smoke case
  - Hourly, 7-km nature run for 22 cases; smoke case for August 7, 2006 used in this study
  - Simulated radiances for GOES-R and TEMPO footprints using VLIDORT
  - Aerosol optical properties from OPAC data base

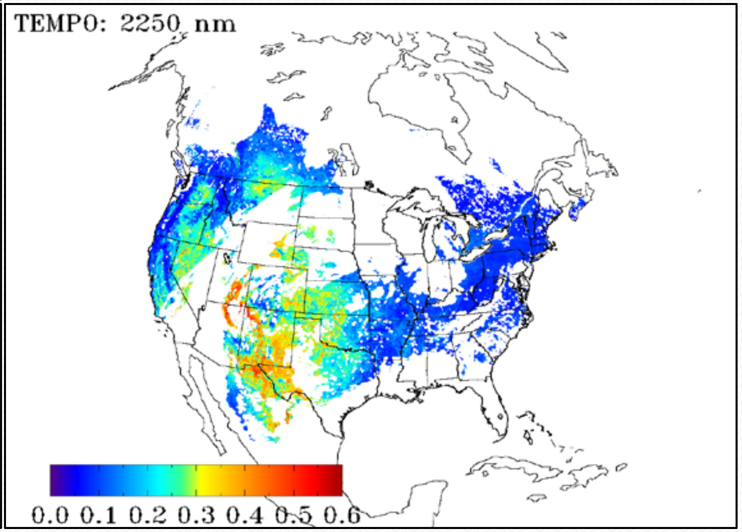
Enterprise Aerosol Detection algorithm applied to future sensor: TEMPO



Exp	412 nm	440 nm	2.25 µm
1	TEMPO	TEMPO	GOES-R
2	TEMPO	TEMPO	TEMPO

Input data for EPS aerosol detection algorithm

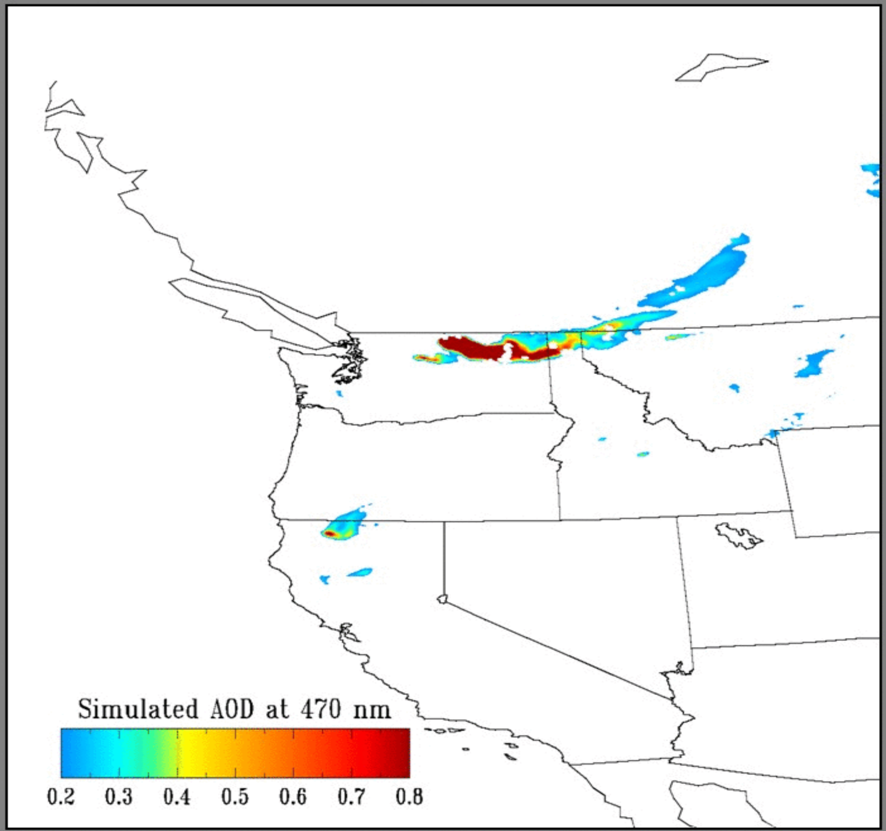


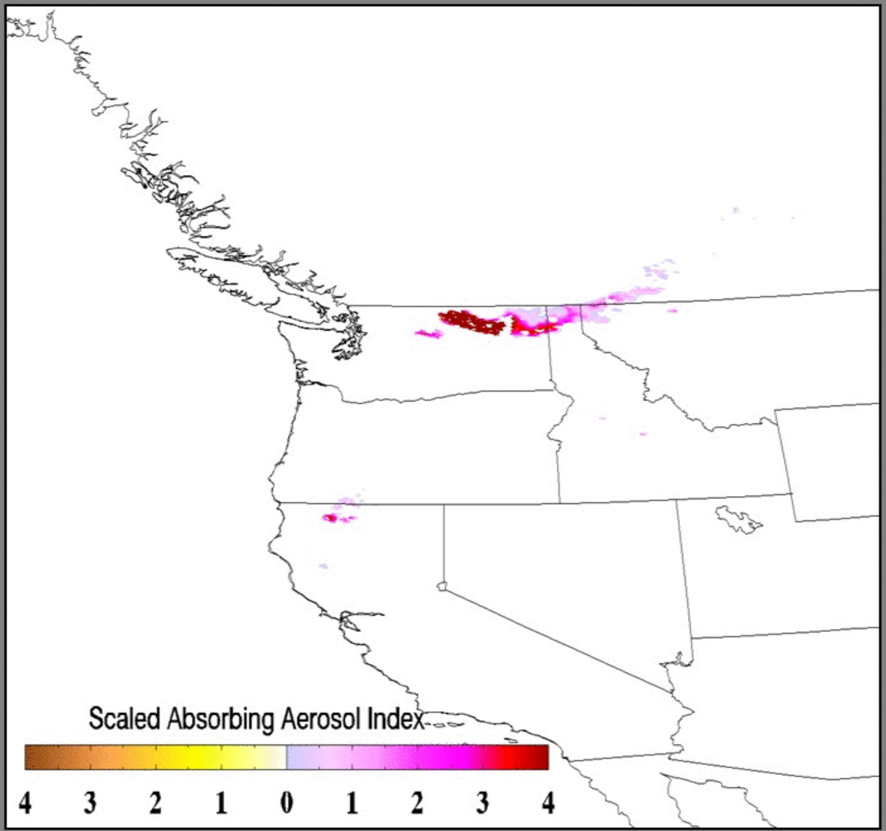


Exp 2

Enterprise Aerosol Detection algorithm applied to future sensor: TEMPO

UTC: 00:00

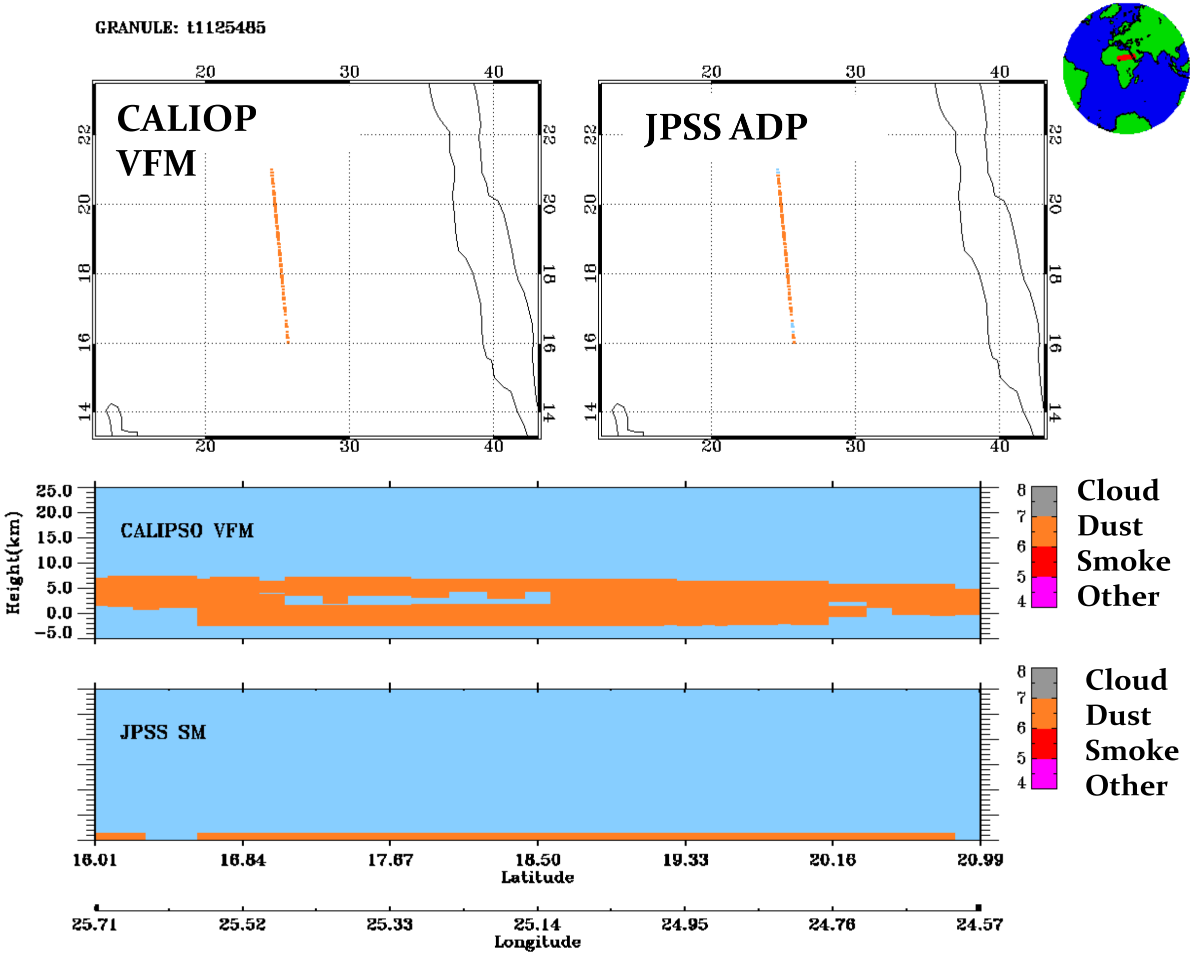




EPS ADP (on VIIRS) vs. CALIPSO

Land	Accuracy (%)	POCD (%)	POFD (%)
DUST	84.4	85.3	3.1
SMOKE	98.4	96.7	34.1

Water	Accuracy (%)	POCD (%)	POFD (%)
DUST	95.4	96.4	3.3
SMOKE	94.0	97.2	45.7



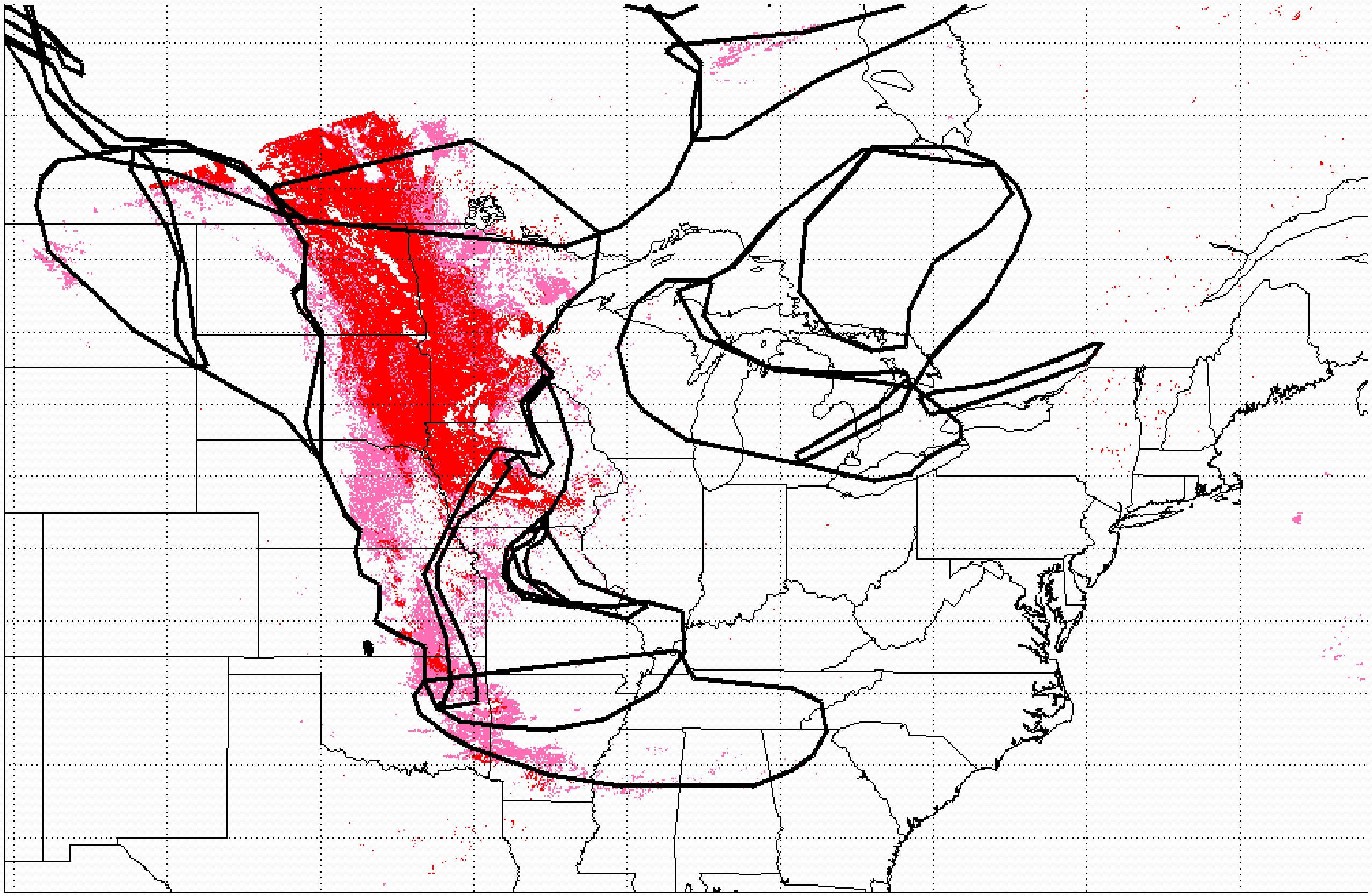
TRUTH DATA

JPSS ADP

	Yes	No
Yes	A	B
No	C	D

POCD = A/(A+C)
POFD = B/(A+B)
Accuracy = (A+D)/(A+B+C+D)

EPS ADP vs. NOAA HMS smoke product

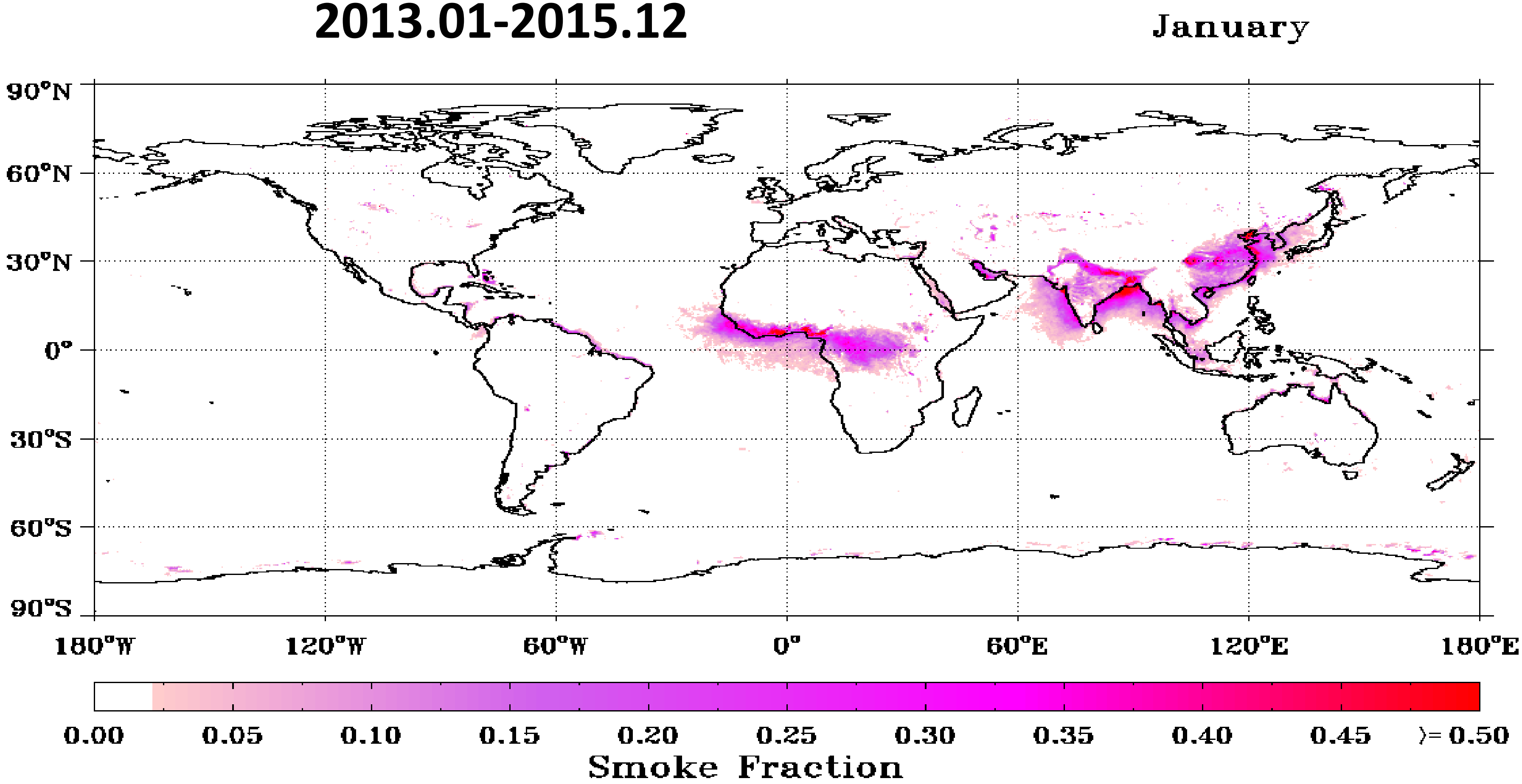


Example of smoke plume on 06/29/2015. Polygons of smoke plume from NOAA HMS (black-thick line) overlap smoke mask from EPS ADP on VIIRS

Global Monthly Smoke Fraction

0.25 x 0.25 degree

2013.01-2015.12

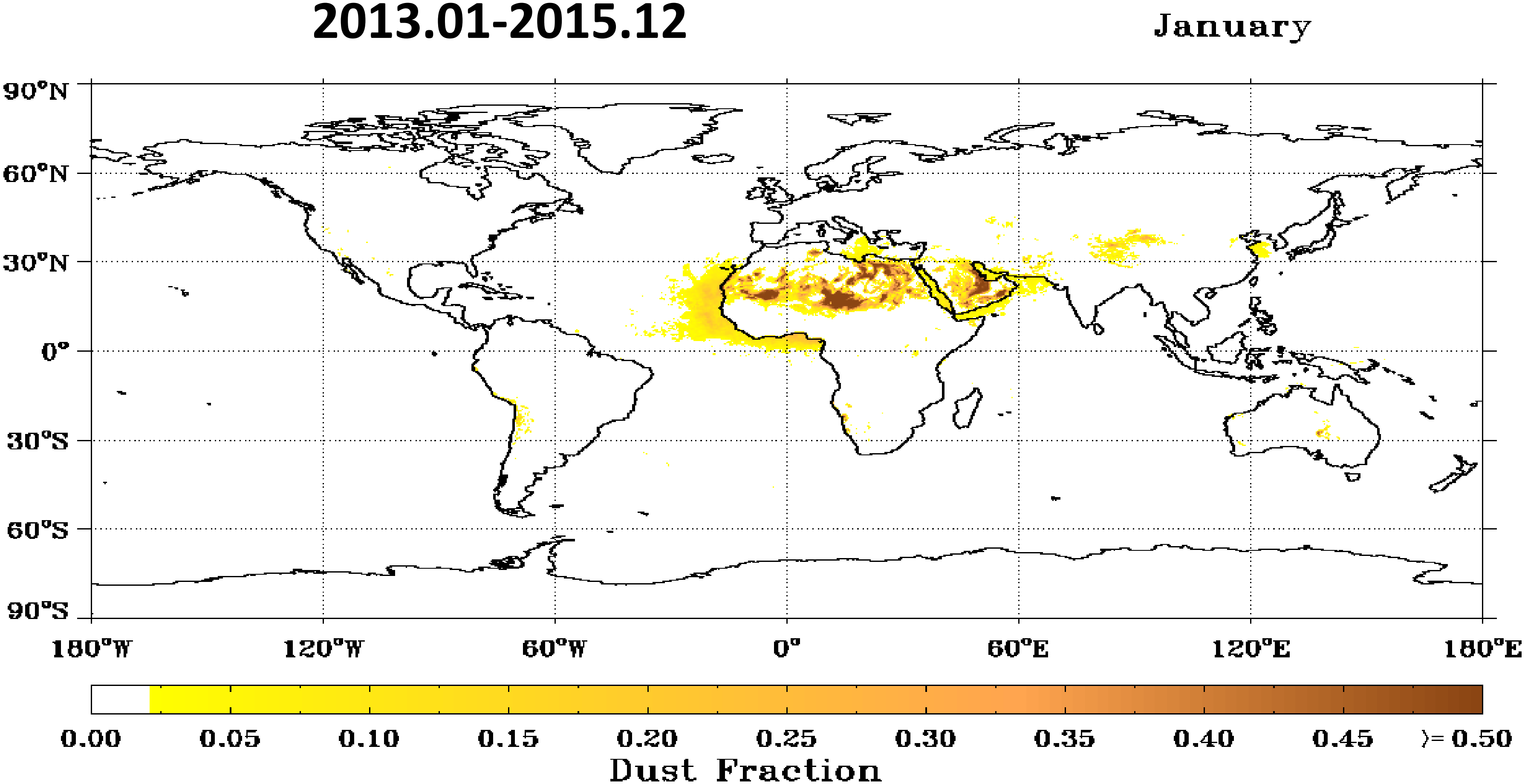


Smoke(dust) fraction is defined as the Number of smoke (dust) detected divided by the total number of detections in each grid.

Global Monthly Dust Fraction

0.25 x 0.25 degree

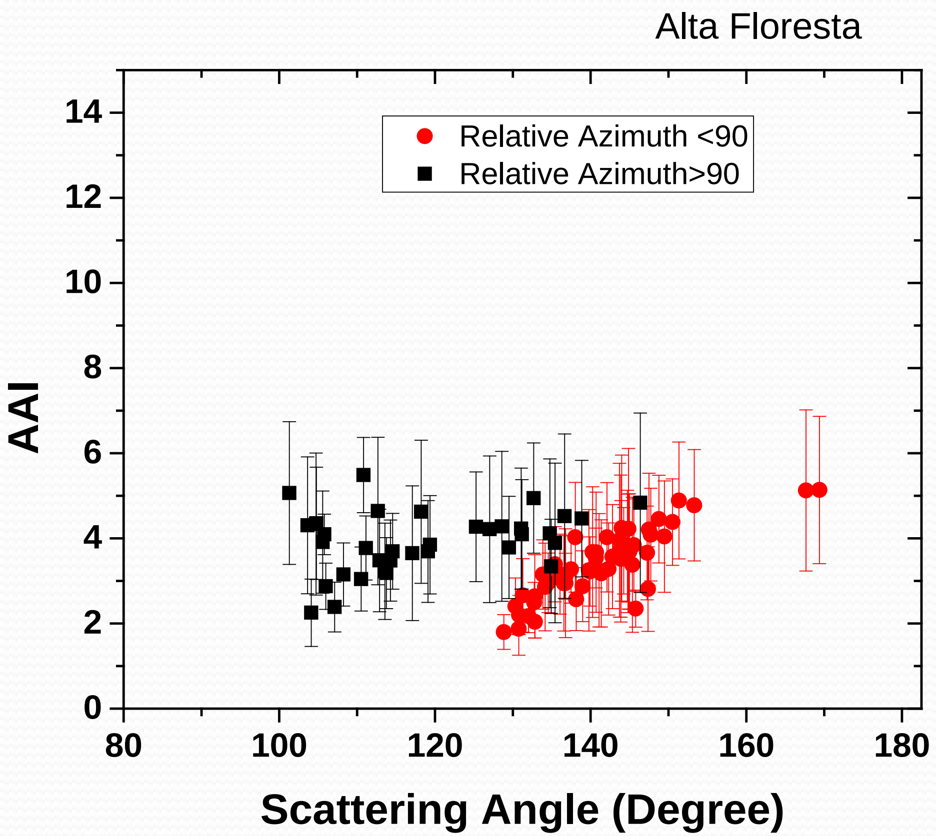
2013.01-2015.12

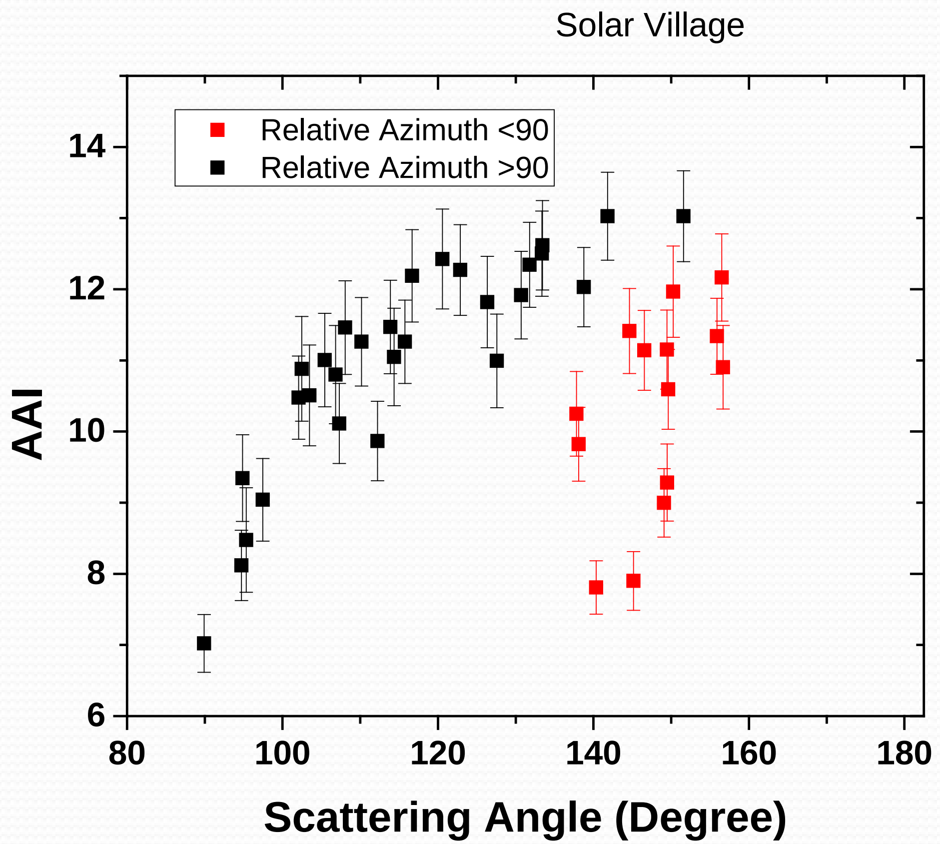


Smoke(dust) fraction is defined as the Number of smoke (dust) detected divided by the total number of detections in each grid.

Algorithm improvements (1)

AOD<0.2, 2012.05 to 2014.05



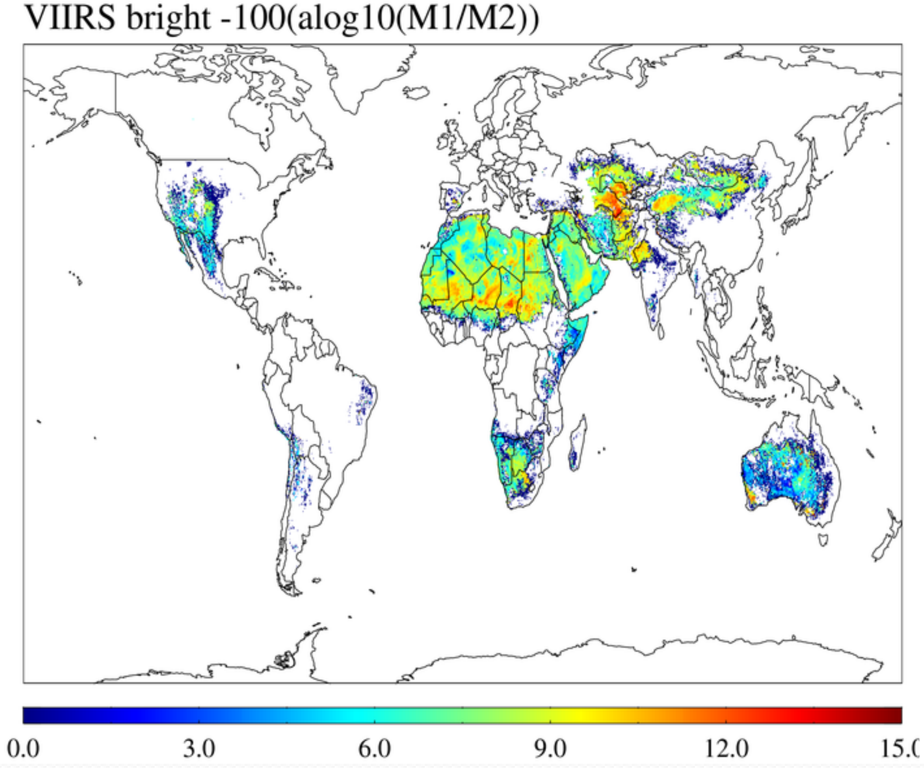


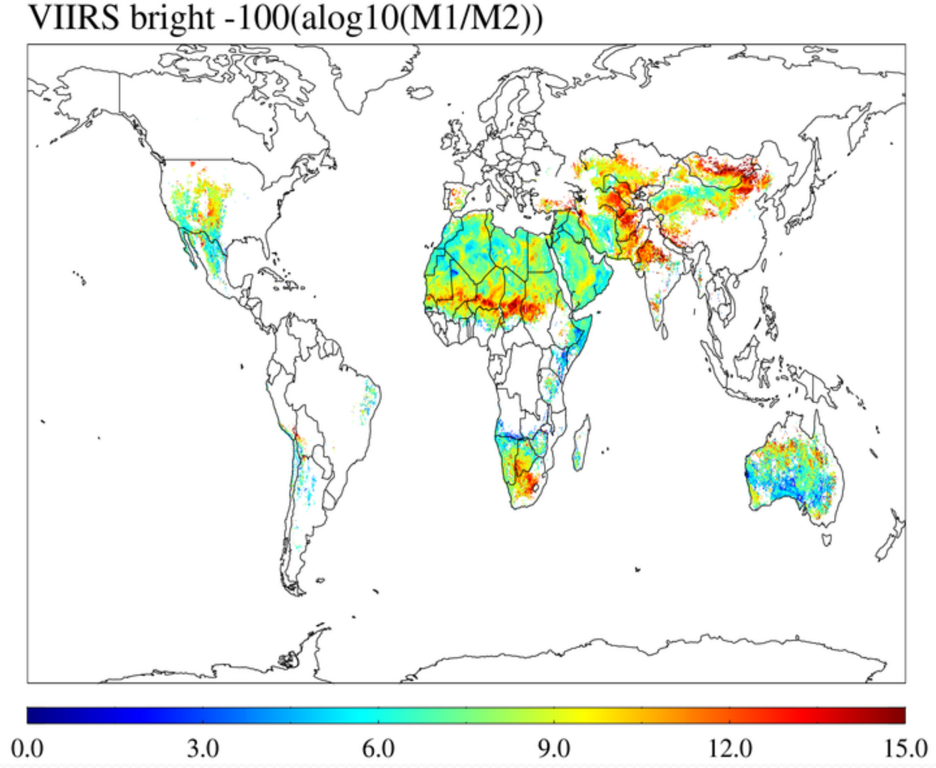
Background AAI is a function for scattering angle and different between backward (Relative azimuth<90) and forward (Relative azimuth>90) direction.

Algorithm improvements (2)

Relative azimuth >90.0 **Relative azimuth <90.0 Bright surface**

Scattering angle=140



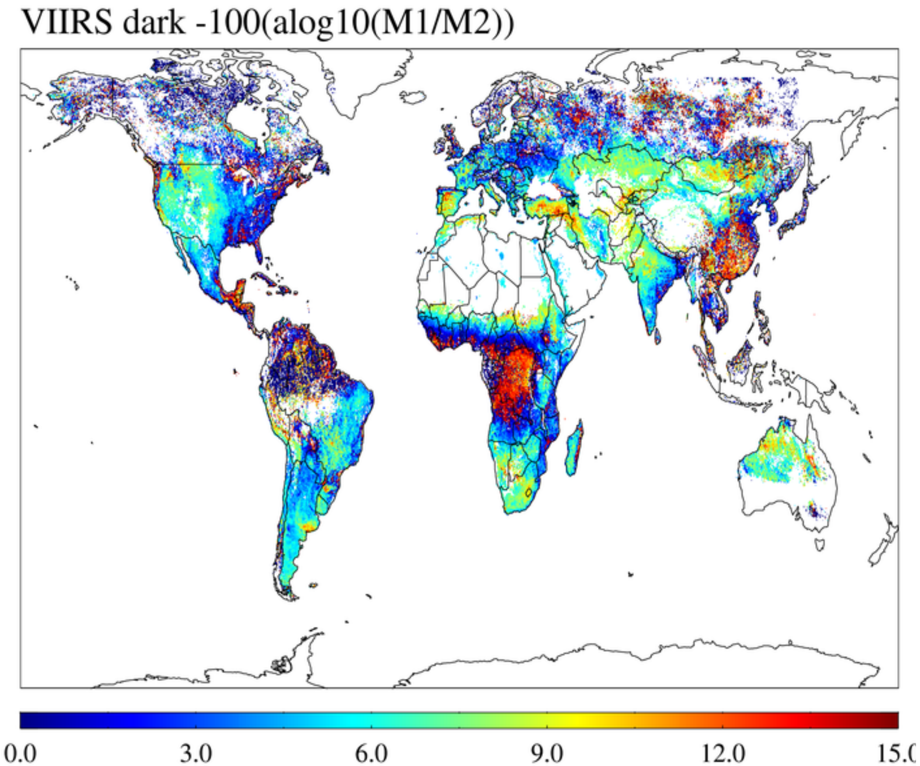


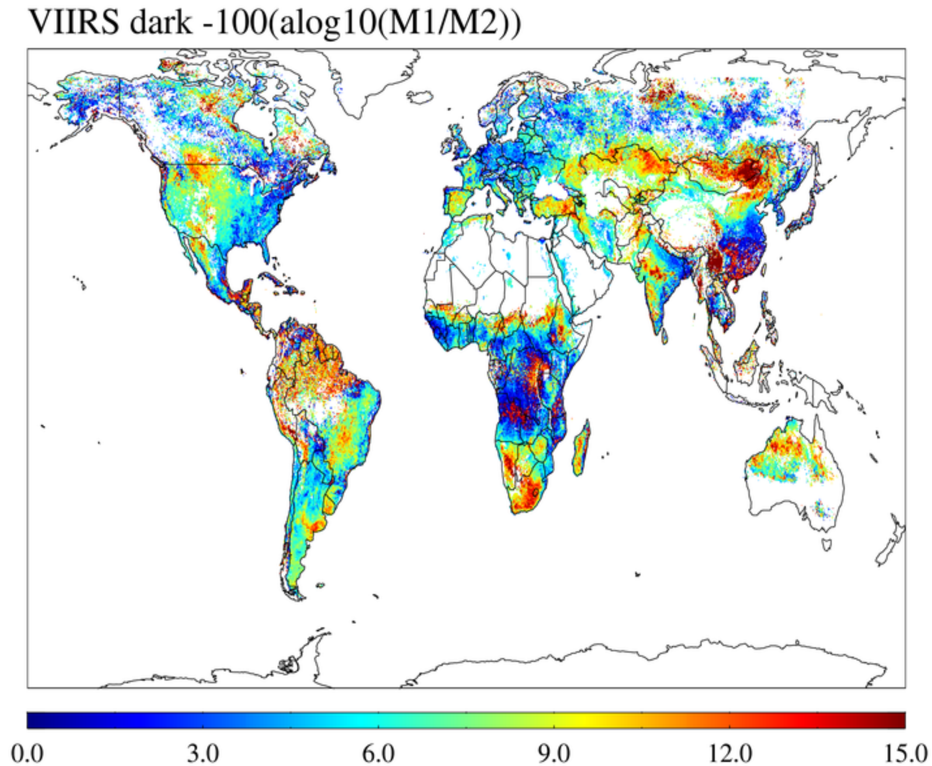
The derived climatology of surface reflectance ratio between M1 and M2, indicates that AAI threshold may vary with geo-location, as a result of surface type changes.

Algorithm improvements (3)

Relative azimuth >90.0 **Relative azimuth <90.0 Dark surface**

Scattering angle=140





The derived climatology of surface reflectance ratio between M1 and M2, indicates that AAI threshold may vary with geo-location, as a result of surface type changes.

Summary

- EPS Aerosol detection algorithm combines IR-visible based and DAI-based algorithms to work on observations from multi-sensors.
- The concept, function and results of EPS ADP algorithm have been demonstrated by applying EPS aerosol detection algorithm to observations from multi-sensors, including MODIS, S-NPP VIIRS, AHI and future sensor (TEMPO)
- Validations against CALIOP VFM product indicated that EPS aerosol detection algorithm meets requirements with an accuracy of around 80%.
- Future improvements on EPS aerosol detection algorithm is undergoing by creating geometry and geo-location dependent thresholds to reduce false alarm rate.

Assessment of Cloud Contamination in VIIRS Aerosol Products

Steve Superczynski

VIIRS Aerosol Team (S. Kondragunta, I. Laszlo, H. Liu, H. Zhang, J. Huang, P. Ciren, L. Remer)

STAR JPSS Annual Meeting
August 8 -12th, 2016
NCWCP - College Park, MD

Overview

- Short description of IDPS Aerosol Optical Depth product and some known issues.
- Data preparation and analysis
- Collocation results and findings
- Selected granule examples
- Summary

VIIRS AOD (IDPS)

- AOD retrieved over dark surfaces at the M-band pixel level (750 m).
- Based on inputs (e.g. VCM) and internal checks, each pixel is assigned 1 of 4 quality flags (good, degraded, excluded, not produced).
- IP AOD is aggregated to EDR product by averaging all good and degraded pixels (‘Top 2’) within 8x8 box.
    - Top 40% and bottom 20% of AOD pixels not included in averaging to further mitigate effects of pixels contaminated by cloud, snow/ice, cloud shadow, etc.
- **Known Issues:**
    - VIIRS AOD has a slight positive bias over land, particularly at the IP level
    - Comparisons with other satellite AOD datasets show some seasonal/regional dependency on both AOD and data coverage.

Analysis

- Datasets:
  - CALIPSO Cloud Layers -1 km, 30m vert.
  - VIIRS Cloud Mask (VCM) – 750 m
  - VIIRS Aerosol Optical Depth – 750 m (IP), 6 km (EDR)
- CALIPSO cloud info used to examine VCM errors and the role they play in AOD retrieval.
  - If the number of cloud layers detected in the CALIPSO profile ≥1 then it is deemed ‘cloudy’.
  - VIIRS 4-tier cloud mask converted to binary mask
    - Probably and Confidently Cloudy -> Cloudy
    - Probably and Confidently Clear -> Clear
  - Observations from CALIPSO and VIIRS must be within 5 minutes and within 750 m of one another to be considered a match.

Results of CALIPSO matchups

Feb '13 - Feb'14		VIIRS	
CALIPSO		Cloudy	Clear
	Cloudy	65079	14482
	Clear	4129	47298
Accuracy: 86%			

- VIIRS exhibits a large number of false-clear (FC) detections, where VCM says 'clear' but CALIPSO says 'cloudy'.
- 23.4% of VIIRS aerosol retrievals could potentially be cloud contaminated. (False Clear/Total Clear)
- 66% of the FC matches were labeled 'confidently clear' by VCM.

FC pixel qualities

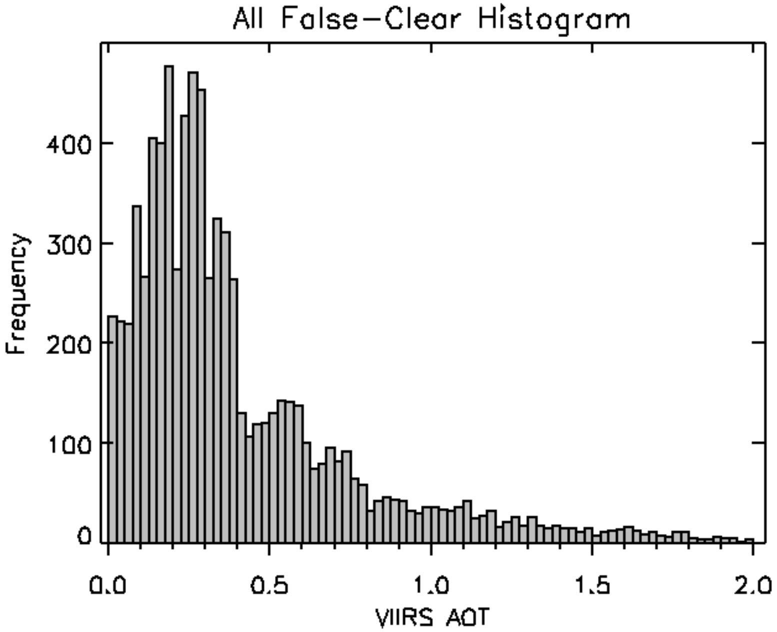
IP Flag	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Total
Good	130	51	122	74	165	215	329	162	51	89	56	152	**1596**
Degraded	388	319	549	362	583	903	1143	410	569	567	298	279	**6370**
Excluded	13	17	104	76	74	112	151	114	232	204	142	261	**1500**
Not Produced	929	846	219	341	316	157	192	66	96	423	835	596	**5016**
TOTAL	1460	1233	994	853	1138	1387	1815	752	948	1283	1331	1288	**14482**

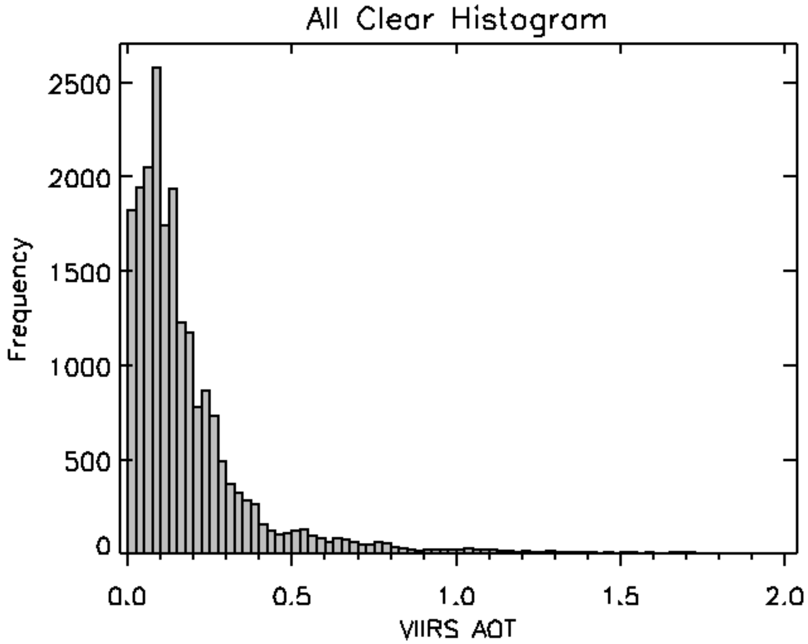
7966

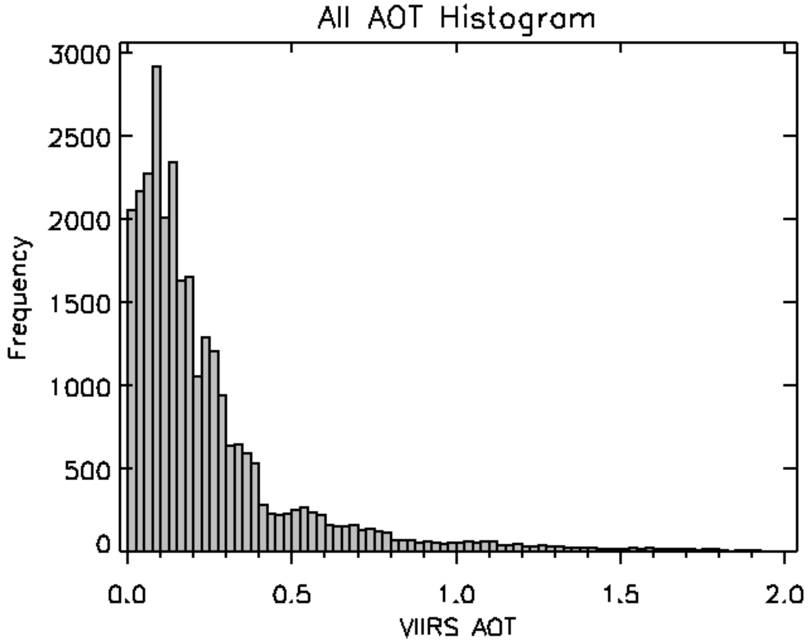
EDR Flag	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Total
High	56	32	55	35	87	130	155	124	34	60	25	56	**849**
Medium	127	128	213	118	205	335	364	134	199	154	86	83	**2146**
Low	56	74	80	76	58	135	121	87	122	110	89	72	**1081**
Not Produced	337	251	68	95	134	35	56	9	29	106	298	158	**1577**
TOTAL	576	485	416	325	484	635	696	354	384	430	498	370	**5653**

2995

AOD distribution







- Small but noticeable increase in high AOD values when comparing FC to clear retrievals.
- Average AOD of FC pixels is about 0.06 higher than remaining pixels

Initial discoveries

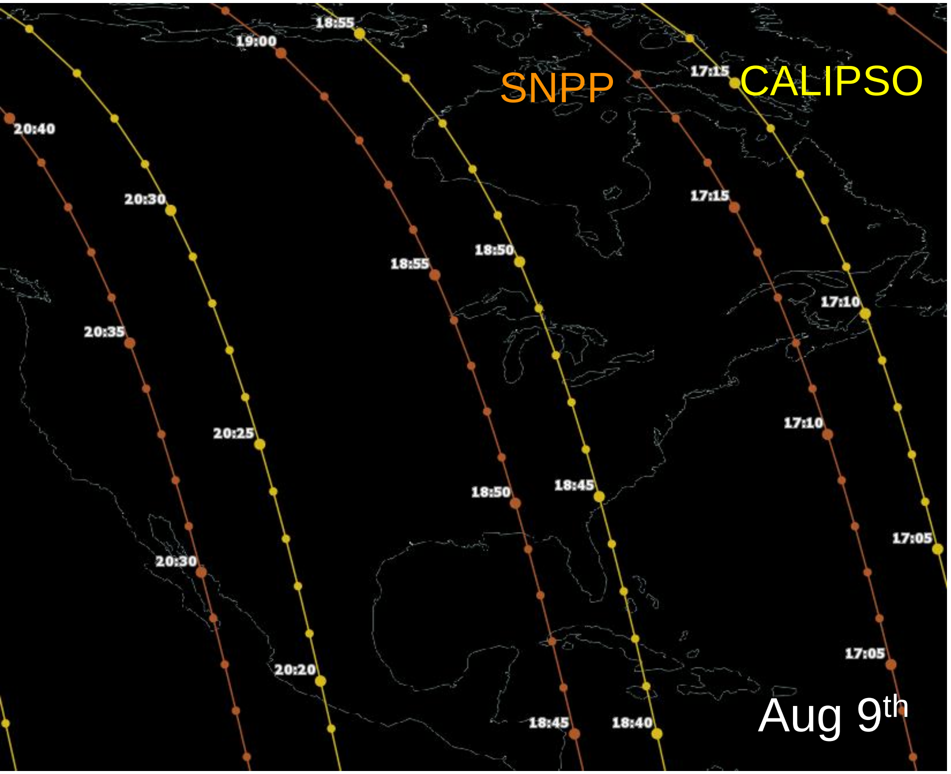
- Higher number of confidently clear pixels are found to be contaminated.
- Factoring in quality level, the number of potentially contaminated pixels is reduced from 14482 to 7966 (45% reduction)
  - Affected EDR pixels similarly decrease by 47%.
  - This means that approximately 12% of aerosol retrievals could still be impacted by clouds.
- The false-clear pixels cause an increase in the number of high-AOD retrievals, and some widening of the AOD distribution at moderate AOD.

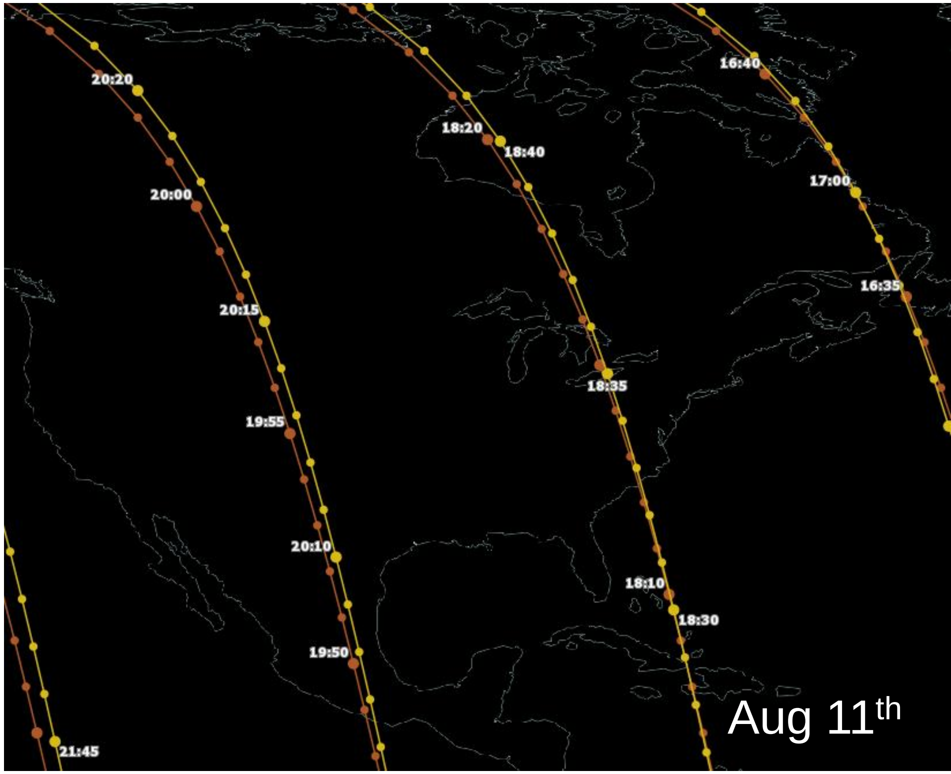
Digging deeper

- Pixel-level quality and internal checks are not the only line of defense.
- Aggregation to the EDR includes further quality checks and filtering to reduce effects from clouds and other adverse retrieval conditions.
  - If number of top 2 IP pixels in 8x8 box > 16, then filtering takes place based on retrieved AOD using 40/20 rule.
  - We can see which pixels are removed when we follow the FC pixels through the aggregation process.
  - Overall 3763 additional FC pixels are discarded (3196 in top 40%, 567 in bottom 20%) – Only benefits EDR however

Potential Collocation Issues

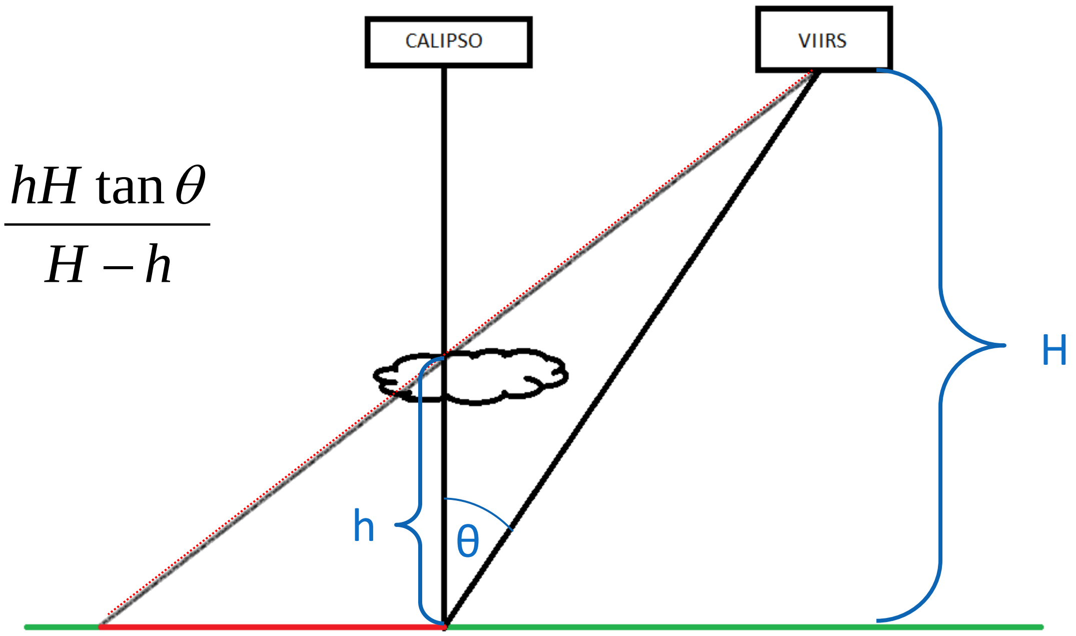
- Satellite orbit differences cause similar overpass times to occur just once every few days.
- VIIRS observations that are matched up with CALIPSO are end up being far from nadir.





Satellite Parallax

$$\text{Offset} = \frac{hH \tan\theta}{H - h}$$



- Calculate offset using cloud top height (*h*) along with altitude (*H*) and viewing angle (θ) of VIIRS (Wang and Huang, 2014)
- The shift in ground location will increase as *h* and θ increase.

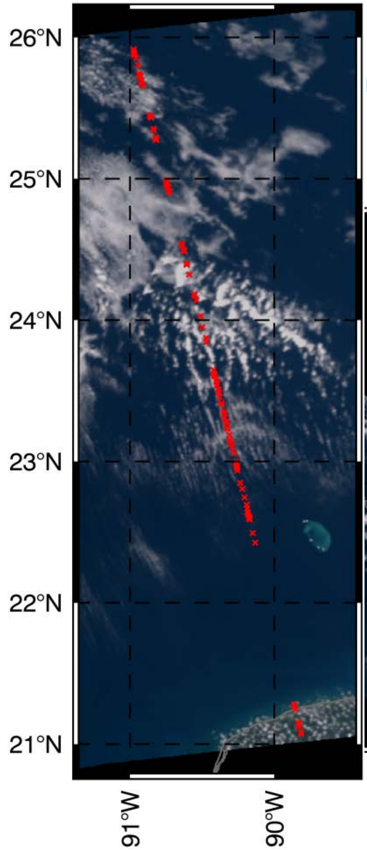
Pixel counts when accounting for parallax

- Allowing for a maximum offset of 0.75 km reduces number of FC pixels by 85-95%.
- Doesn't necessarily mean those pixels with greater offset are not contaminated.
- Ratio of conf. clear to prob. clear pixels now closer to what we expect.

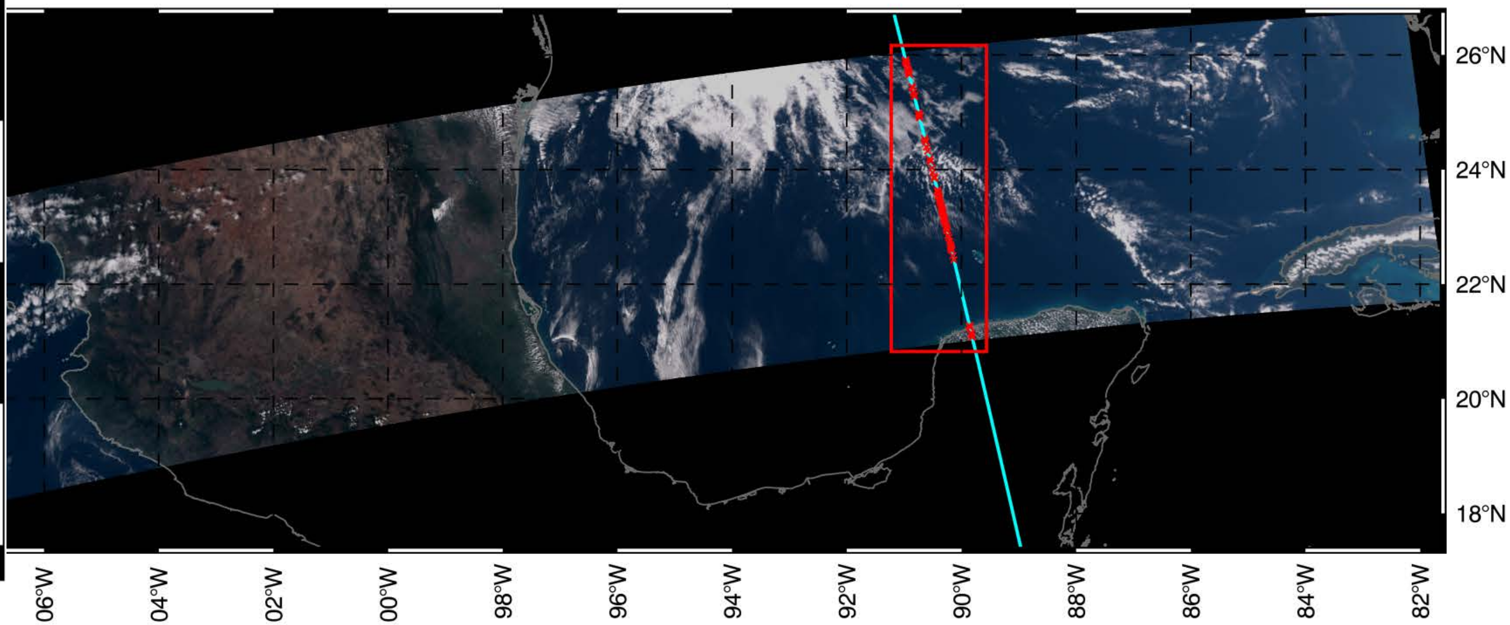
False-Clear parameter	No Parallax check	0.75 km Max Offset
IP-Good	1596	141
IP-Degraded	6370	414
IP-Excluded	1500	36
IP-Not Produced	5016	488
Confidently Clear	9547	508
Probably Clear	4935	573
Top 40%	3196	246
Bottom 20%	567	34
EDR-High	849	139
EDR-Medium	2146	164
EDR-Low	1081	64
EDR-Not Produced	1577	223

Specific cases – Scattered Cloud Field

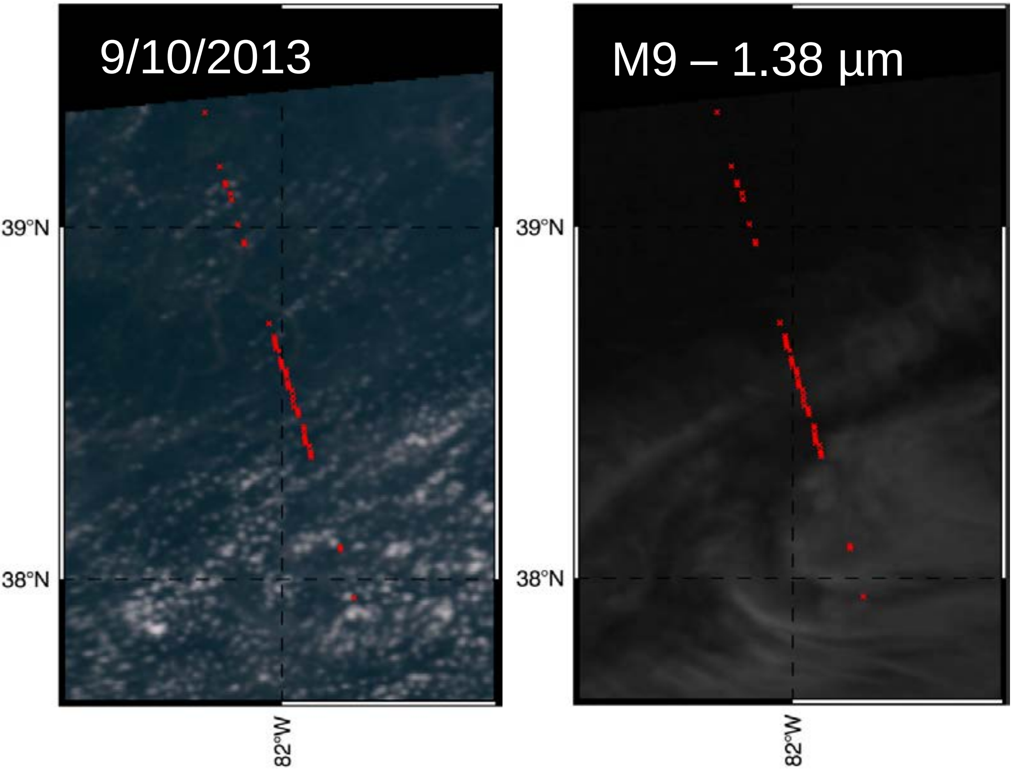
- 94 total FC pixels
  - VCM: 17 conf. clear, 77 prob. Clear
  - 81 of the FC pixels are largely surrounded by cloudy pixels.
  - 47 pixels flagged for cloud shadow

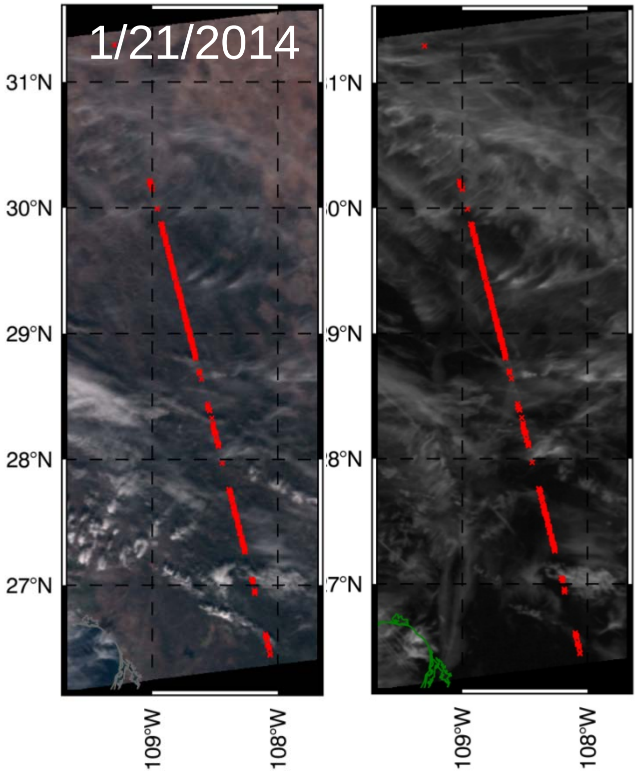


2-6-2013 19:35 UTC



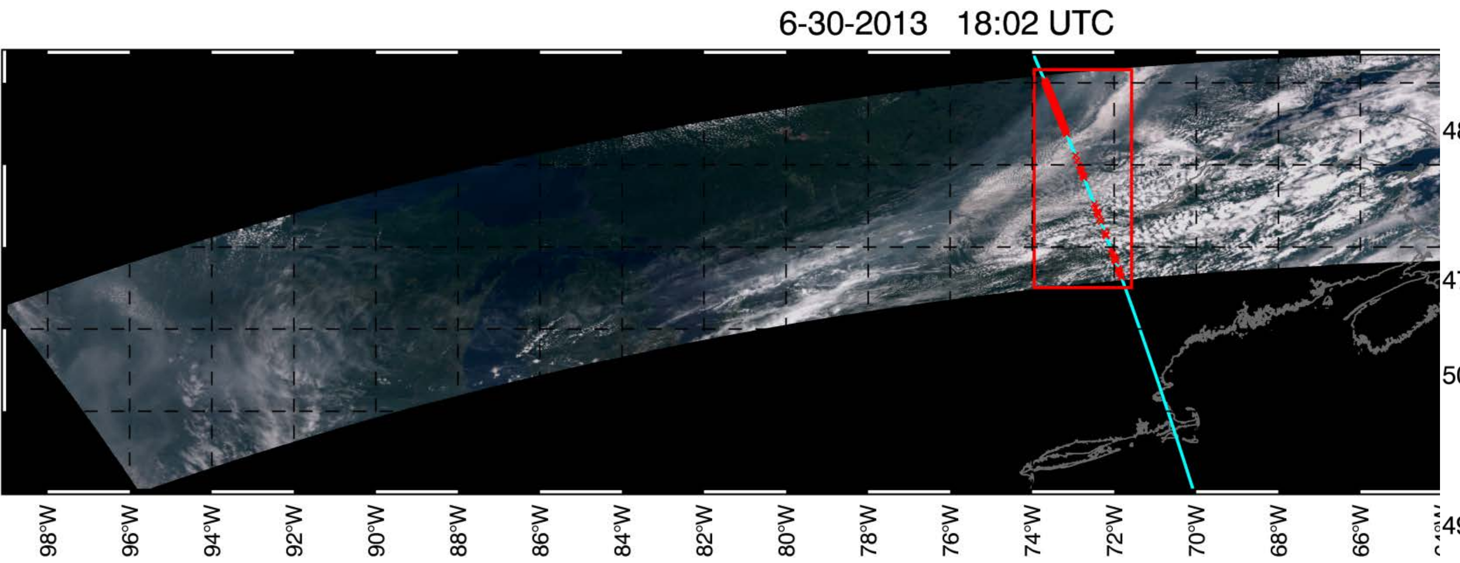
Specific Cases - Cirrus

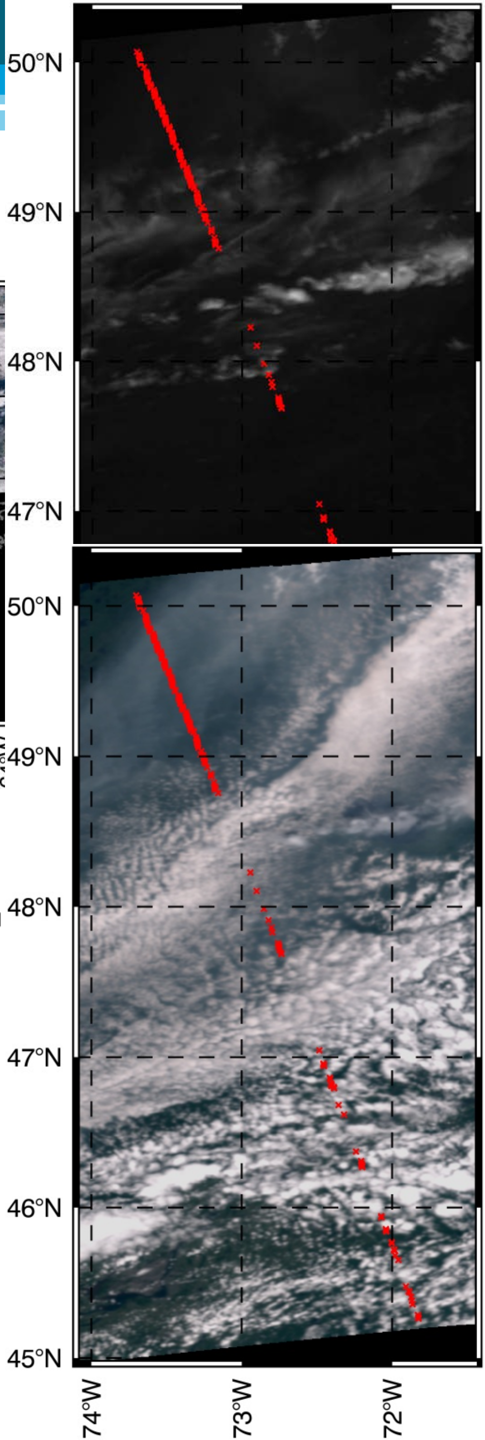


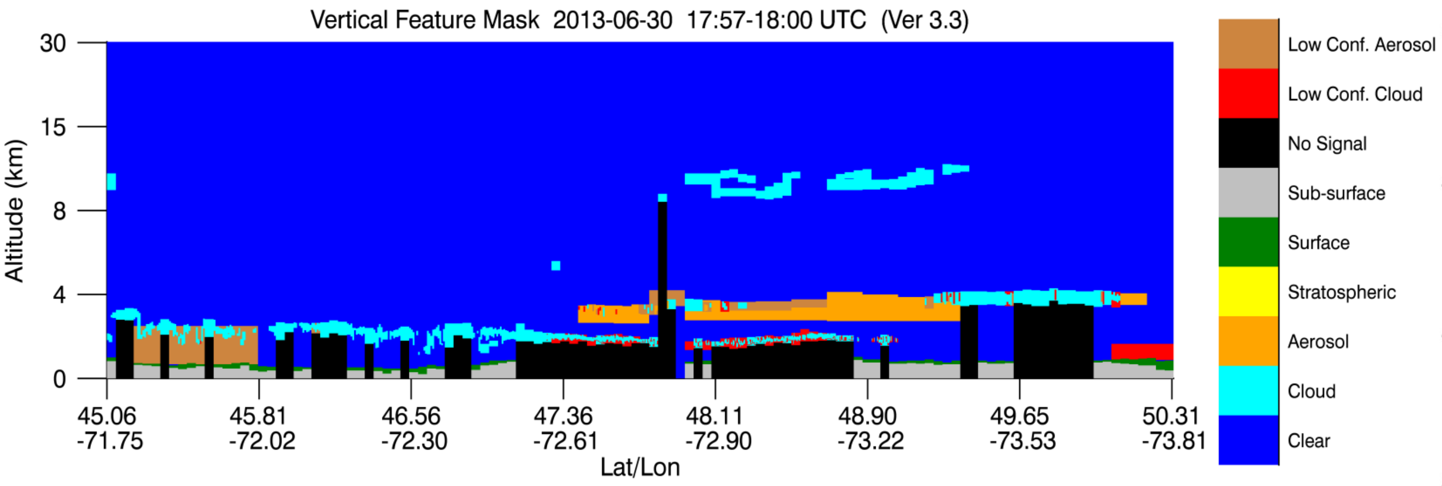


- Most FC pixels and surrounding pixels flagged as ‘clear’.
- Sept. 10: 0 pixels flagged for cirrus; Jan 21: 22 out of 210 flagged for cirrus
- Detection of thin cirrus by VCM or Aerosol alg. may not be able to match higher sensitivity of CALIPSO.

Mixed Aerosol/Clouds







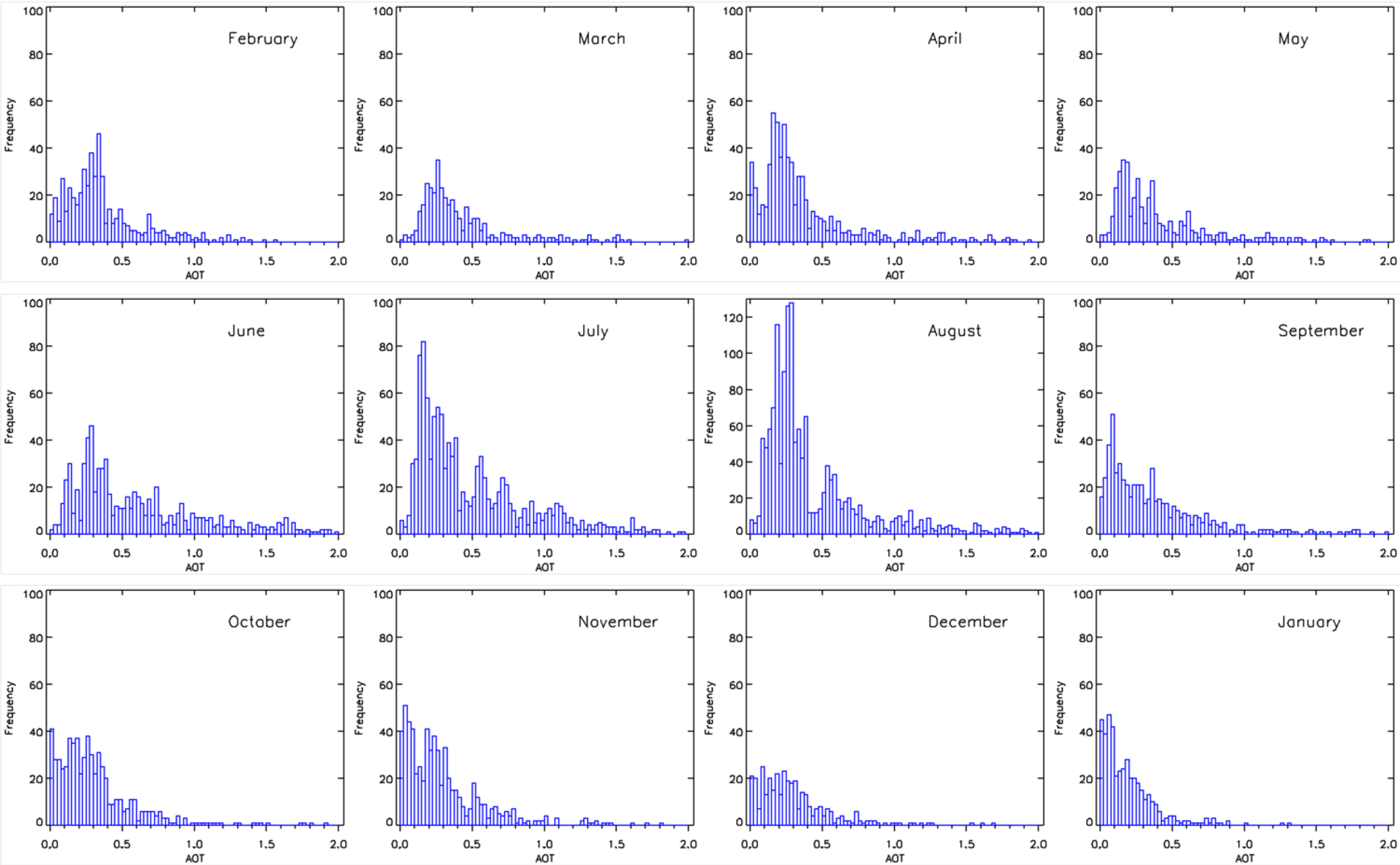
Summary

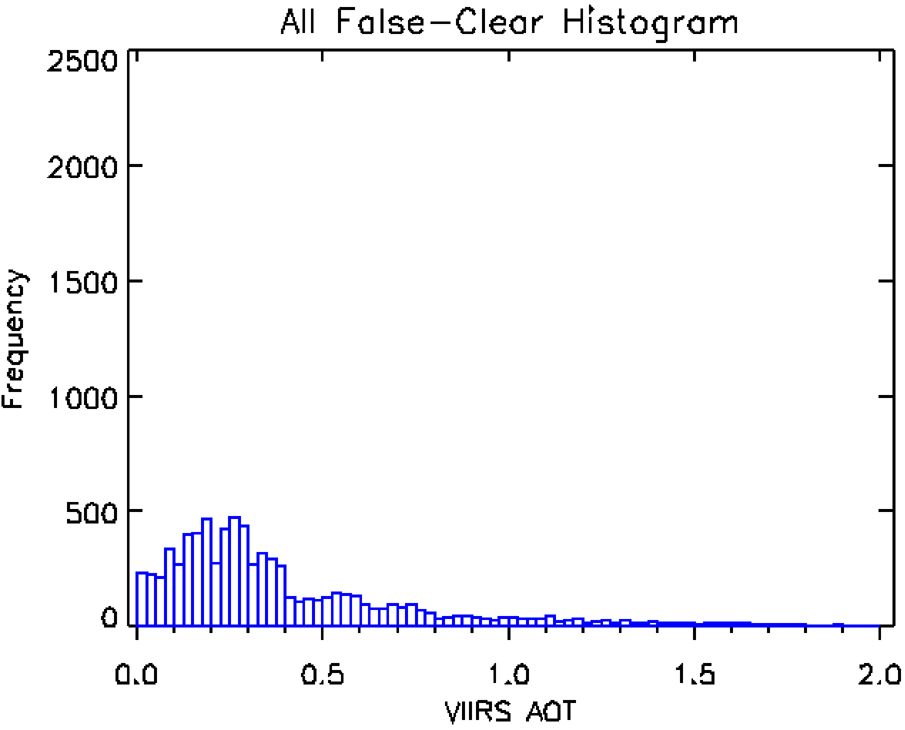
- Based on matchups with CALIPSO, approximately a quarter of VIIRS aerosol retrievals could potentially be cloud contaminated.
- Nearly half (45%) of these FC matchups however are not top-2 quality and therefore are not impacting the EDR product.
- In addition, a large percentage (47%) of FC with top-2 quality are removed during aggregation.
- Taking into account quality designation and aggregation, the maximum cloud contamination would be around 7% for this time period.
- Cirrus clouds and mixed/ambiguous scenes potential contributors to remaining cloud contamination.

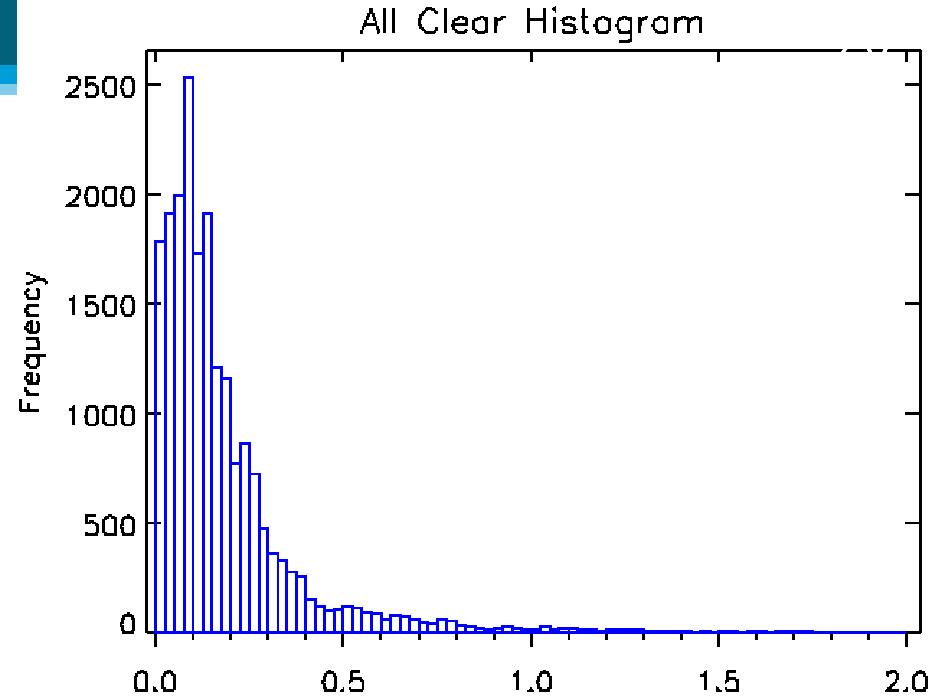
THANK YOU!

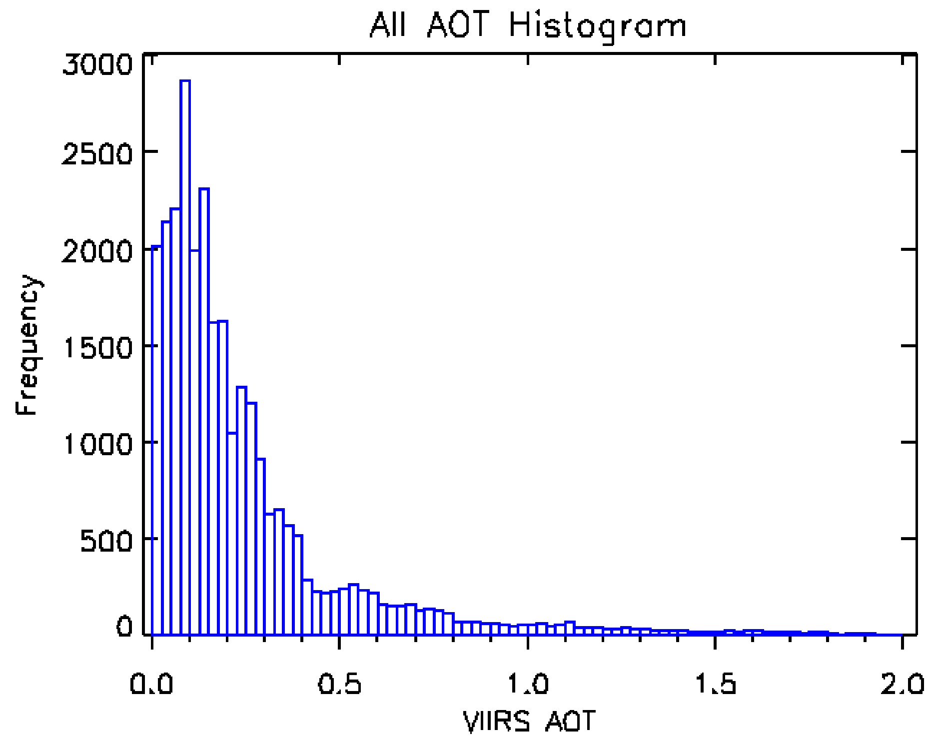
- Questions?

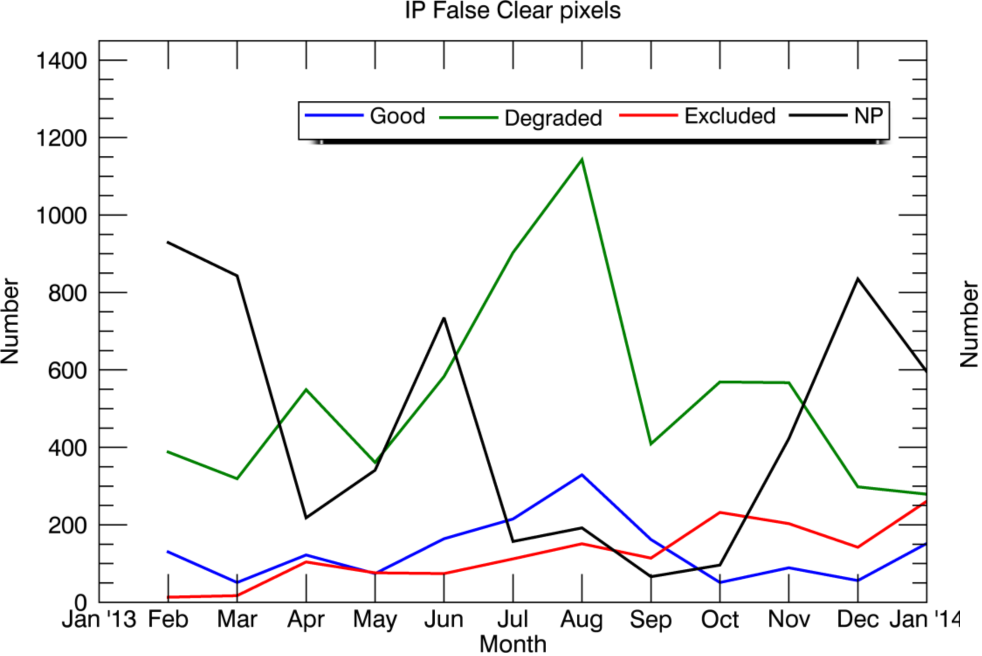
Additional Slides


February
March
April
May
June
July
August
September
October
November
December
January
Frequency
AOT
0,0
0,5
1,0
1,5
2,0
0
20
40
60
80
100
120

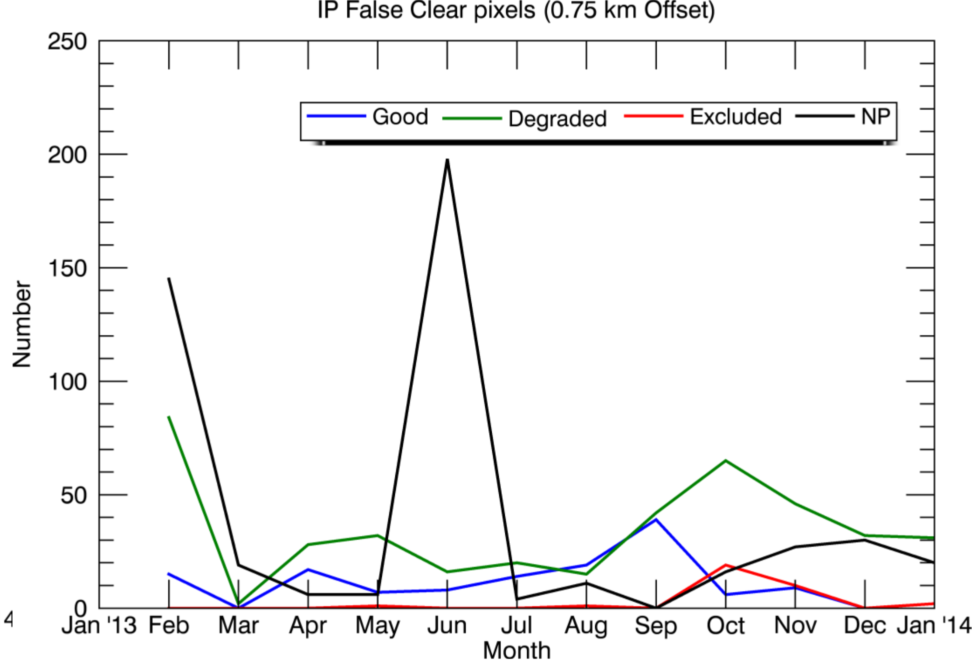

All False-Clear Histogram
Frequency
VIIRS AOT


All Clear Histogram
Frequency

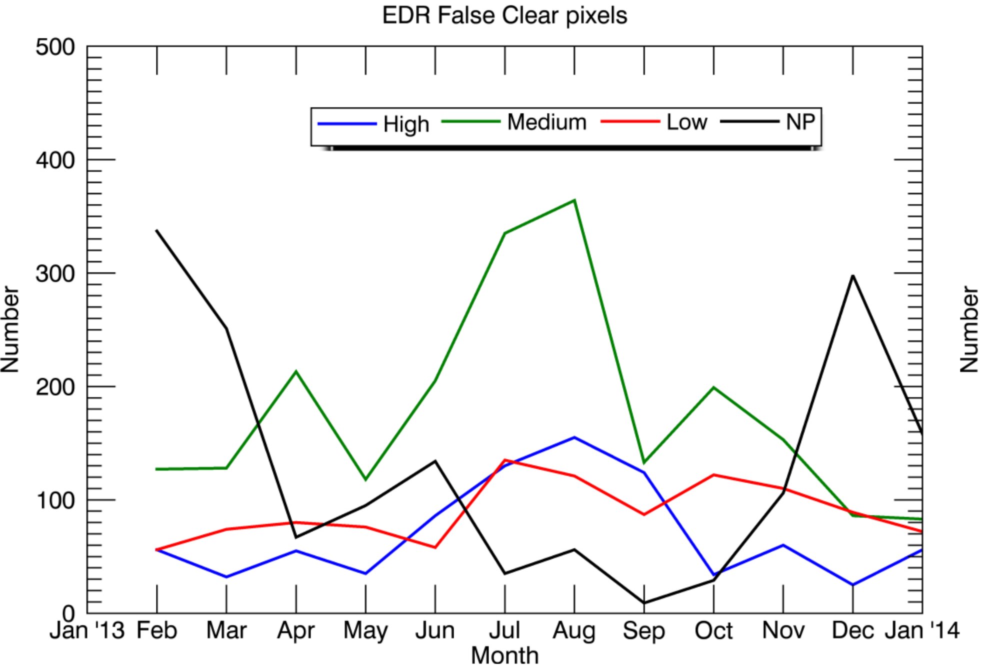

All AOT Histogram
Frequency
VIIRS AOT



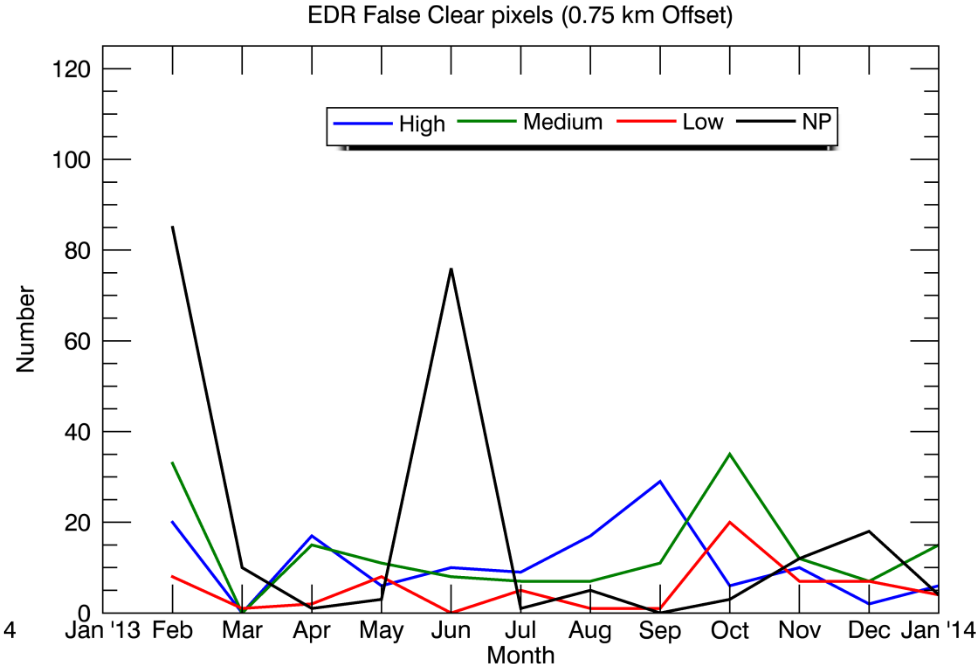
IP False Clear pixels
Good
Degraded
Excluded
NP
Number
Month
Jan '13 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan '14



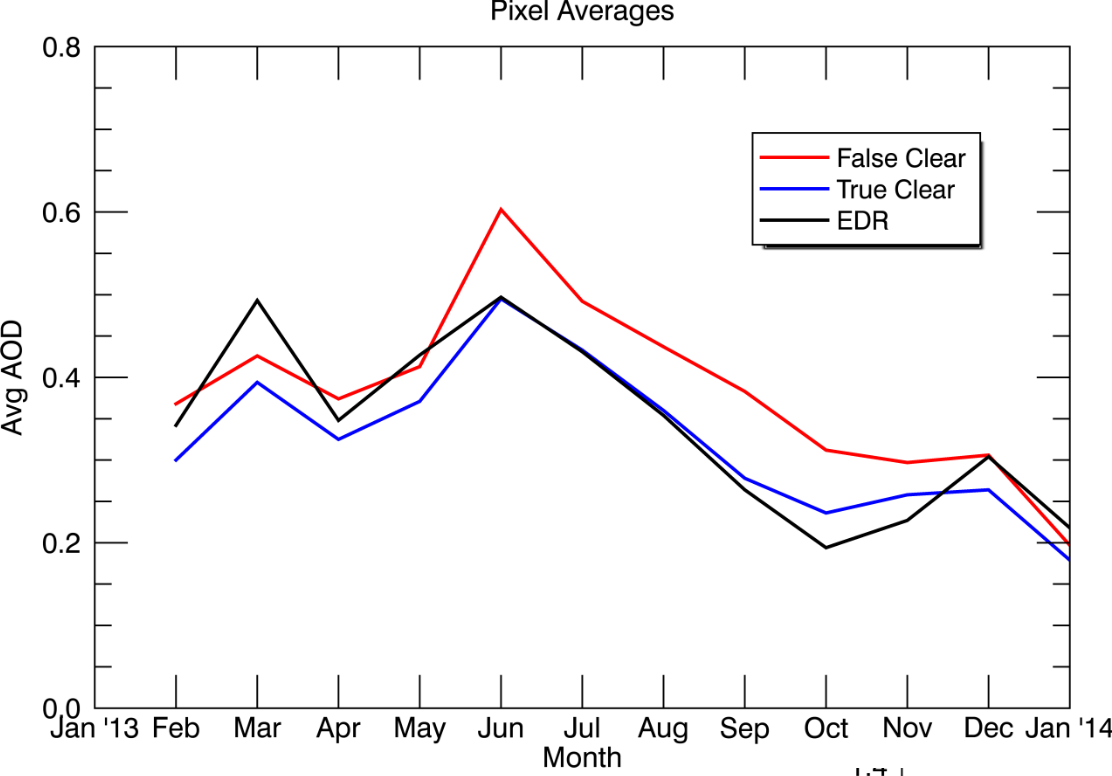
IP False Clear pixels (0.75 km Offset)
Good
Degraded
Excluded
NP
Number
Month
Jan '13 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan '14



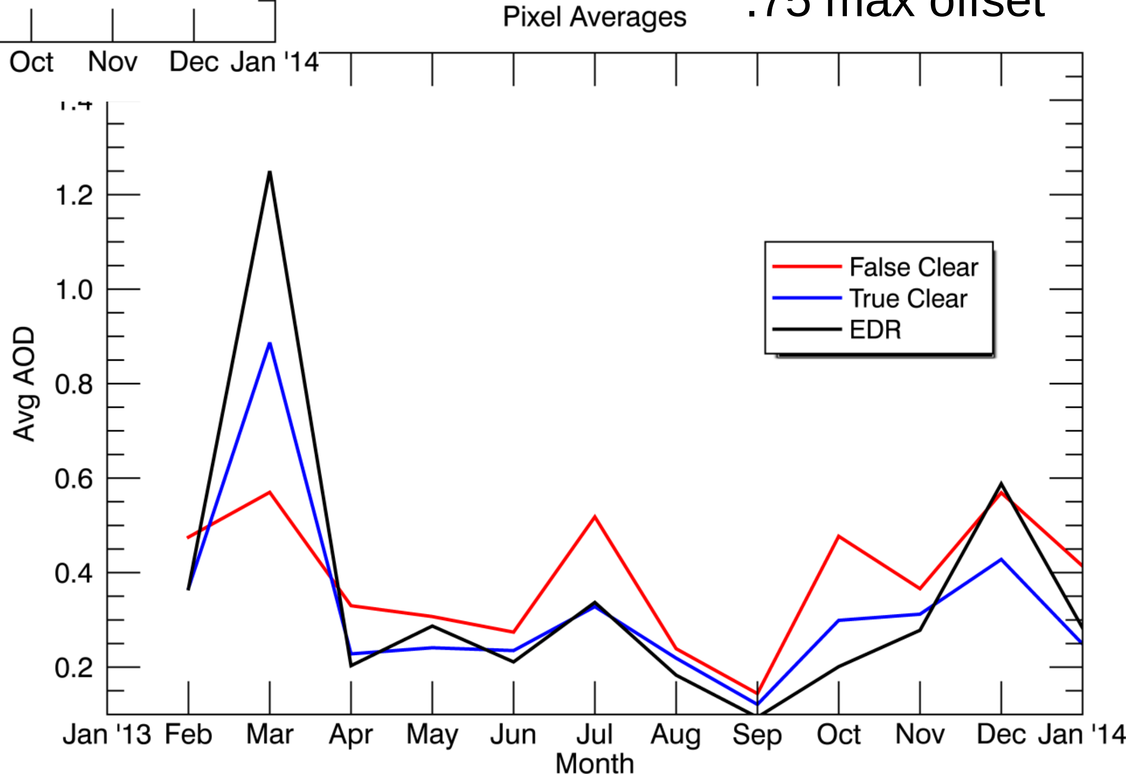
EDR False Clear pixels
High
Medium
Low
NP
Number
Month
Jan '13 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan '14



EDR False Clear pixels (0.75 km Offset)
High
Medium
Low
NP
Number
Month
Jan '13 Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan '14



.75 max offset



Investigating VIIRS aerosol retrievals during the SEAC4RS experiment

Lorraine A. Remer[1]

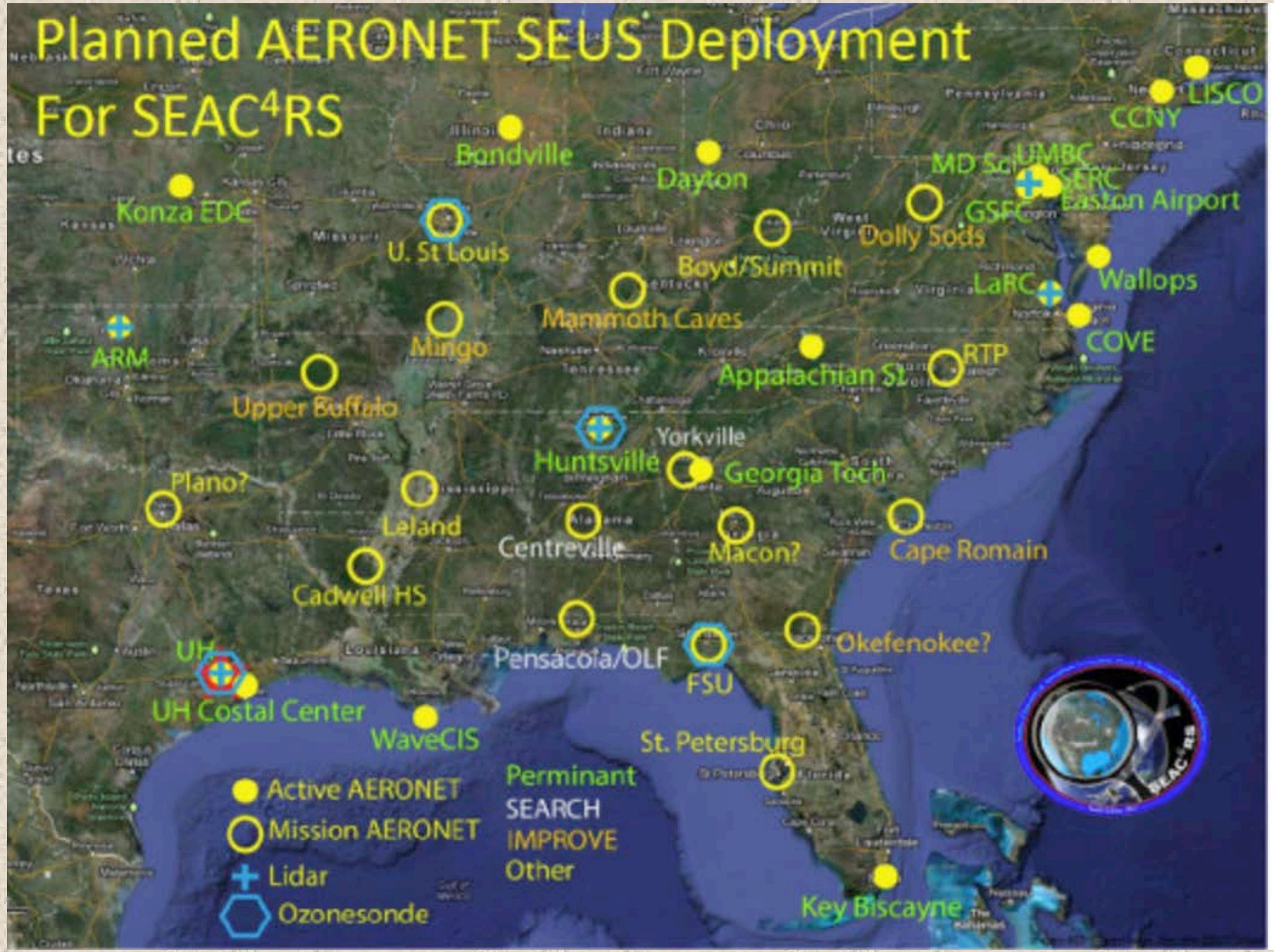
Jingfeng Huang[4], Leigh A. Munchak[3]

F. Daniel Orozco[1,2], W. Reed Espinosa[1,2] and J. Vanderlei Martins[1,2]

[1] JCET UMBC; [2] Dept of Physics, UMBC; [3] SSAI at NASA GSFC; [4] UMD/ESSIC at NOAA/NESDIS/STAR

SEAC4RS across the southeast U.S. (SEUS) Aug/Sep 2013
Aircraft and AERONET

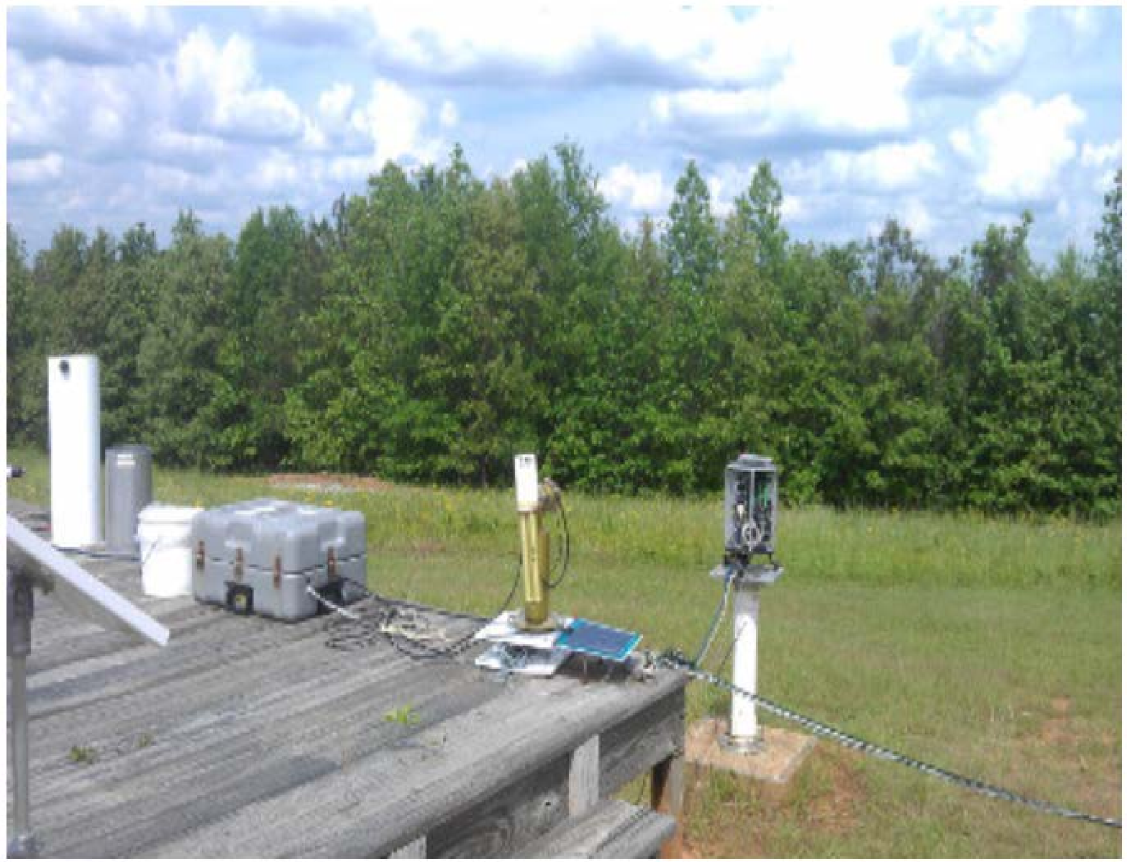
AERONET grid spacing about 400 km



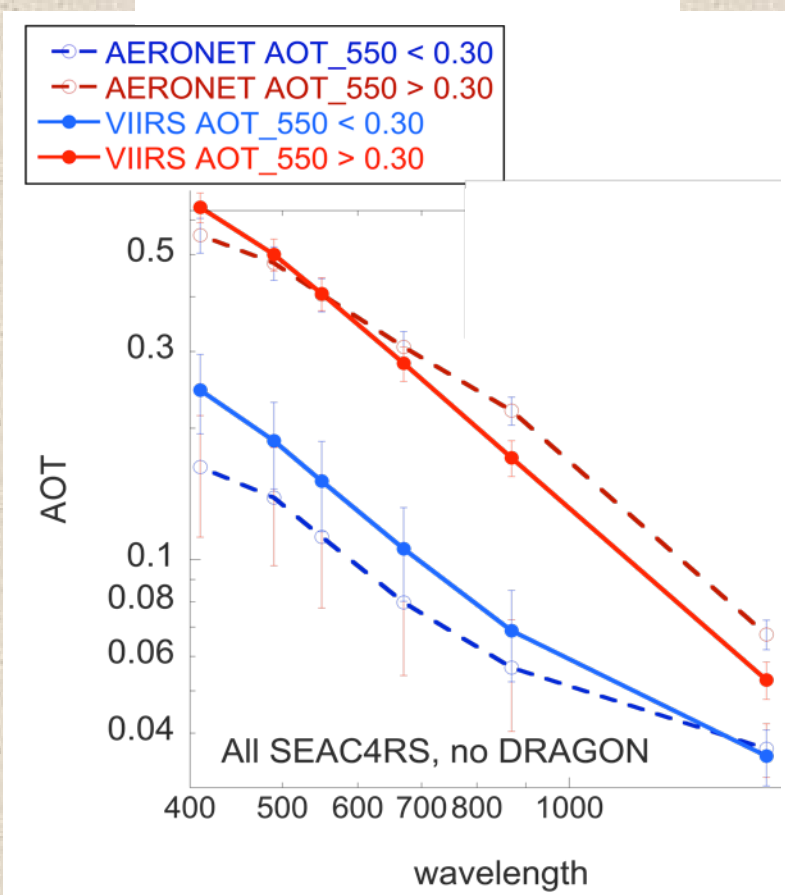
Provided opportunity for deep dive into VIIRS aerosol retrieval

http://aeronet.gsfc.nasa.gov

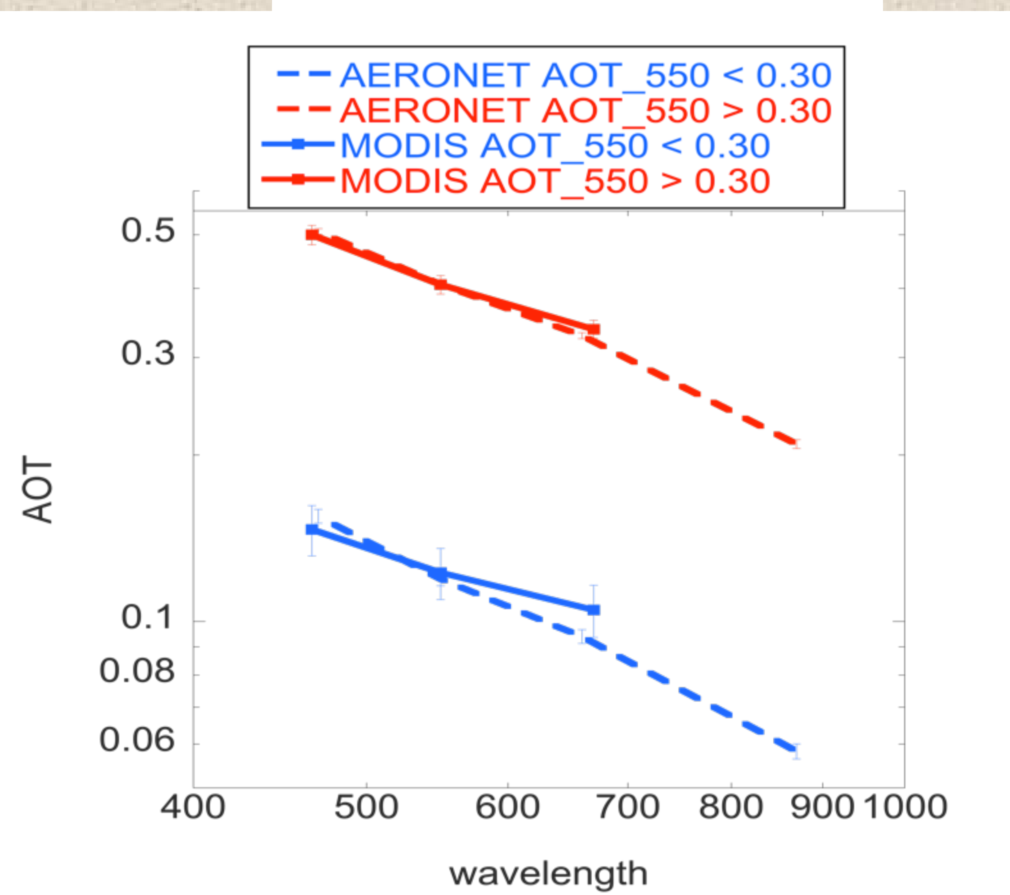
AERONET station at SEARCH_Centreville



VIIRS SEAC4RS

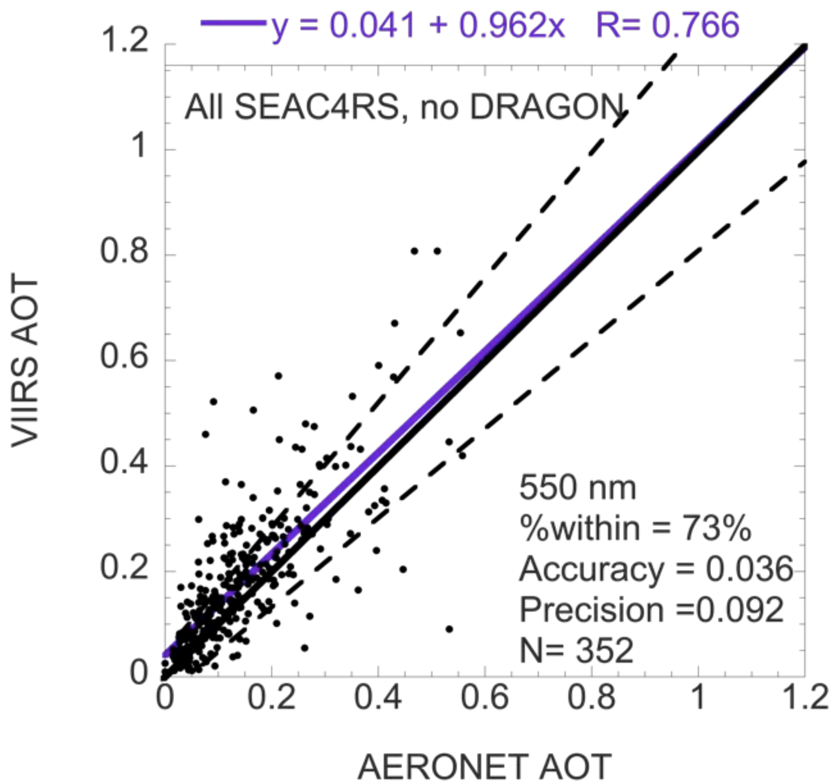


MODIS SEAC4RS

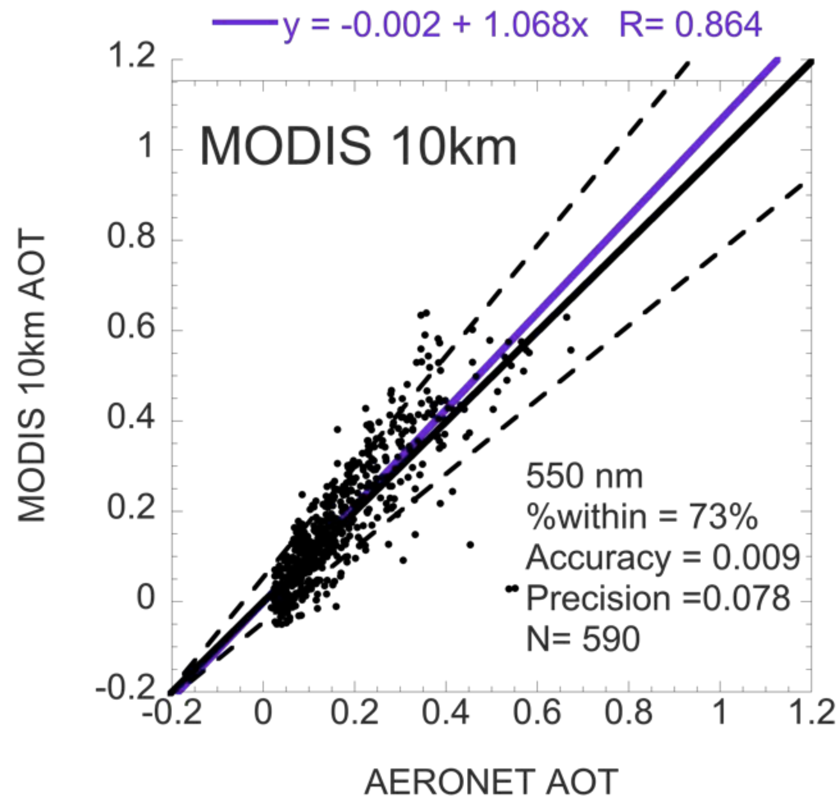


Collocated data set SEUS stations Aug/Sep 2013
VIIRS AOT(λ) collocated with AERONET
MODIS AOT(λ) collocated with AERONET
VIIRS and MODIS not collocated with each other

VIIRS 6km EDR

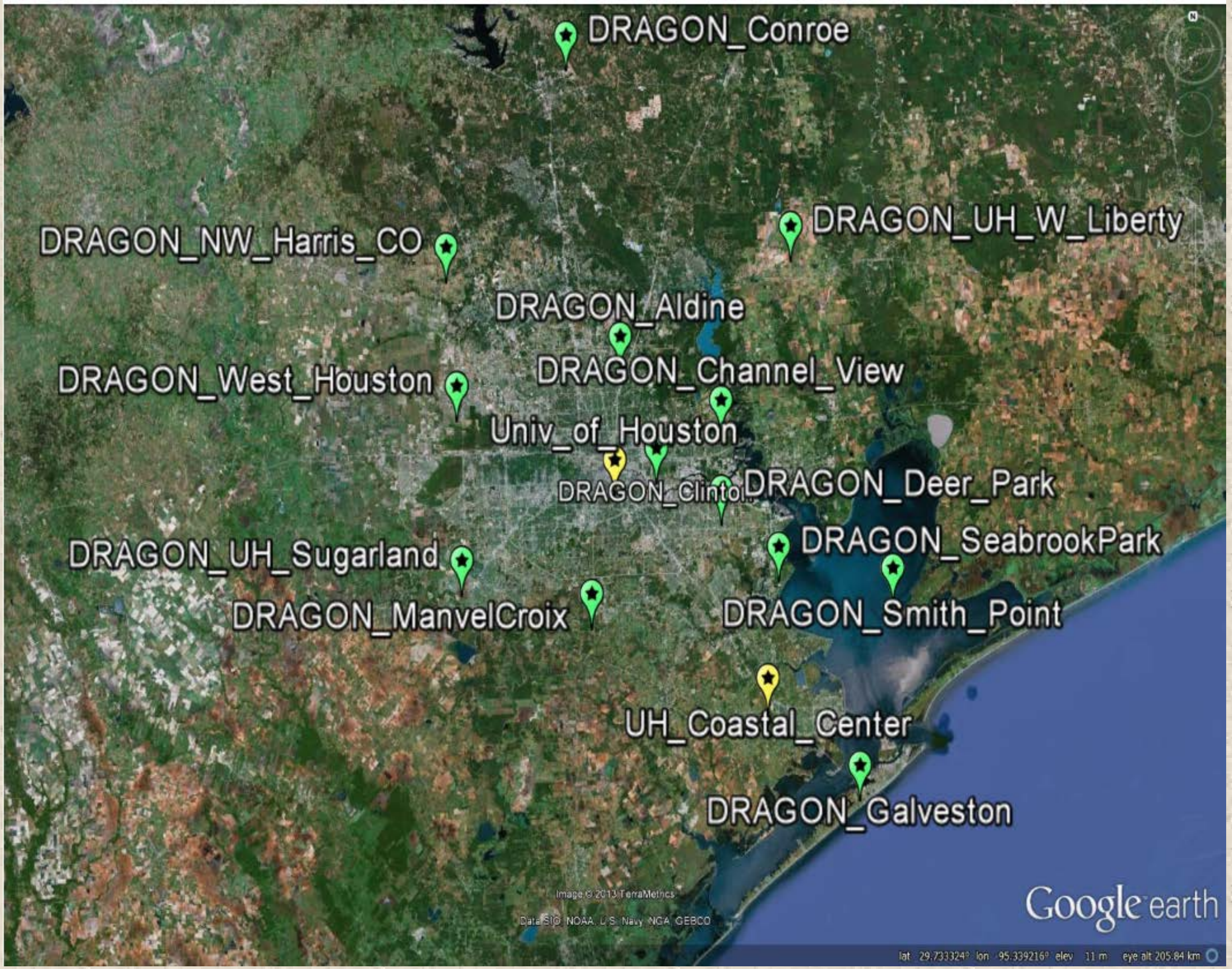


MODIS 10 km



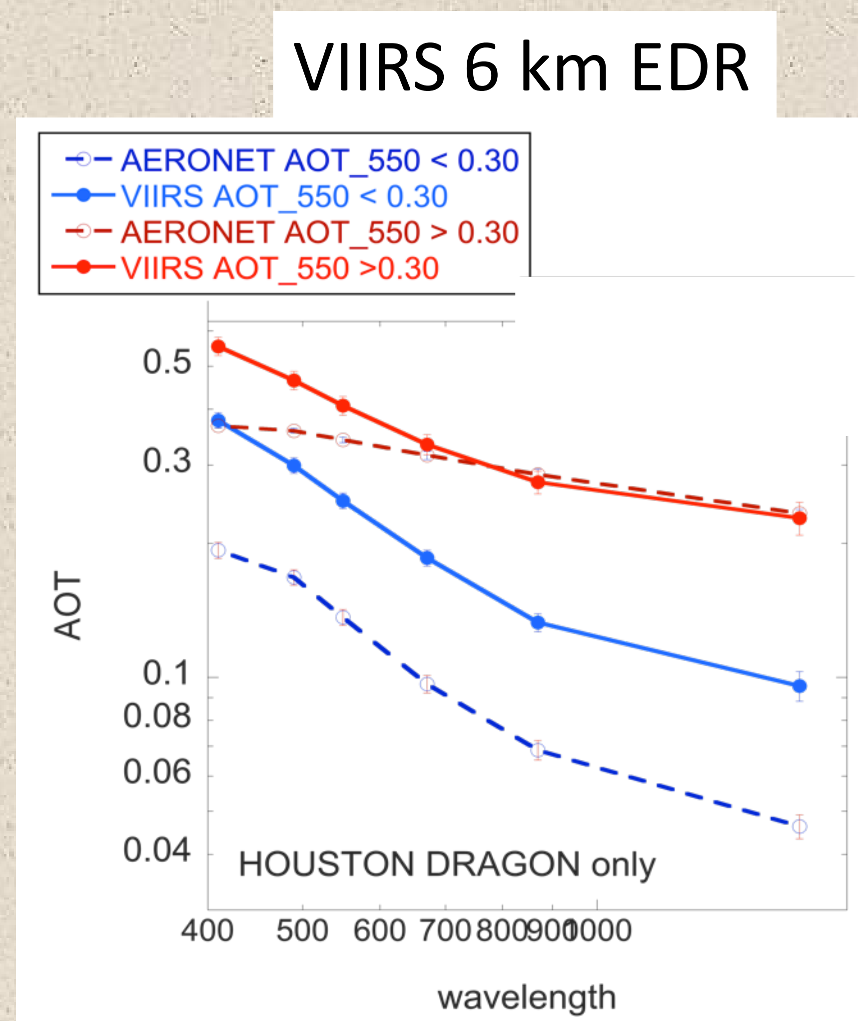
Both products validating very well
MODIS has slightly higher accuracy, better precision and more samples
(MODIS also allows negatives)

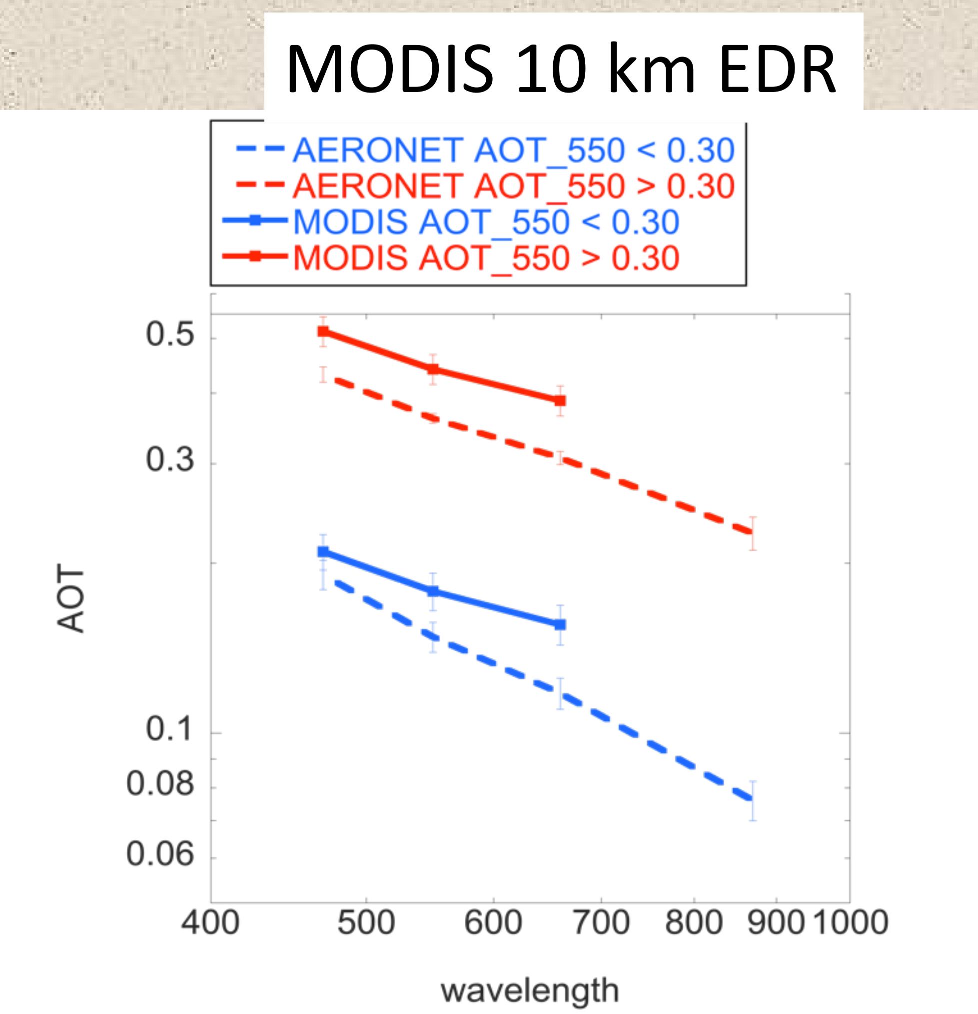
Houston DRAGON network within SEAC4RS AERONET grid spacing about 10 km



AERONET station at the University of Houston

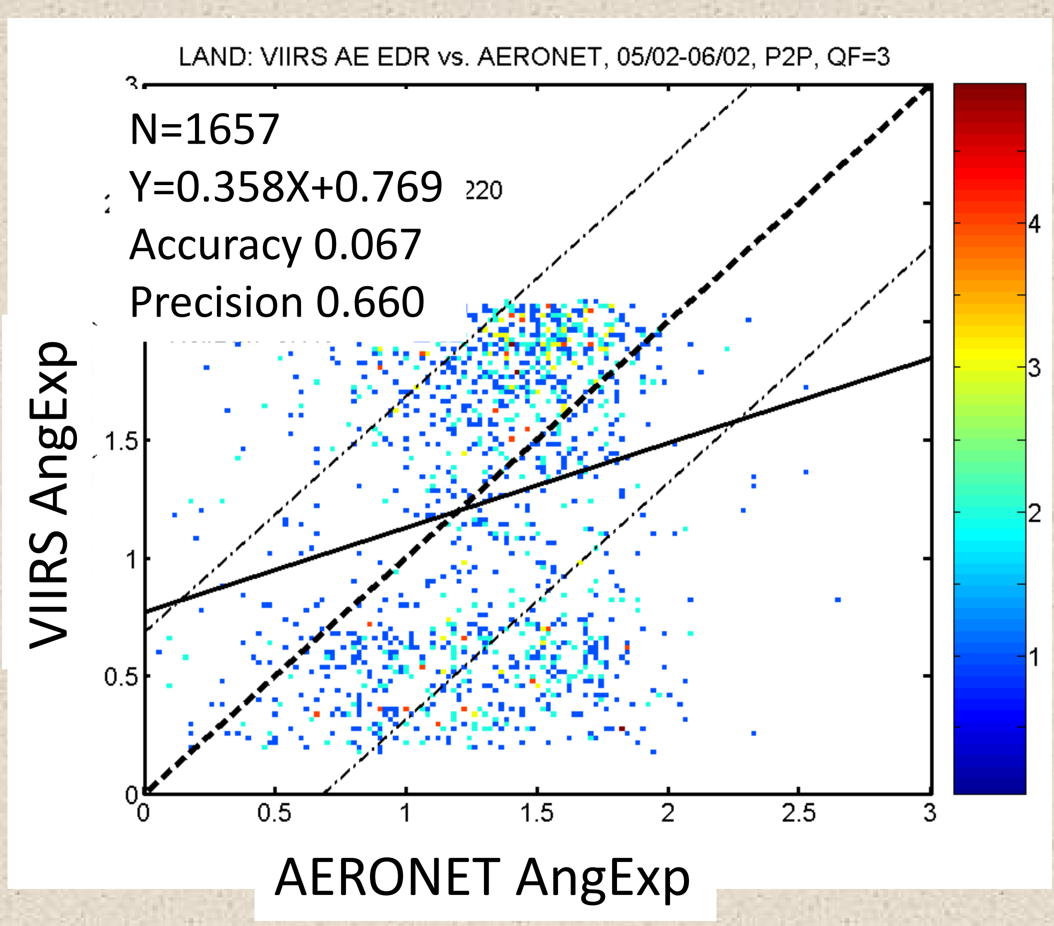
(Note downtown Houston within the collocation circle)





VIIRS and MODIS products are biased high in urban areas
Especially when AOT is low

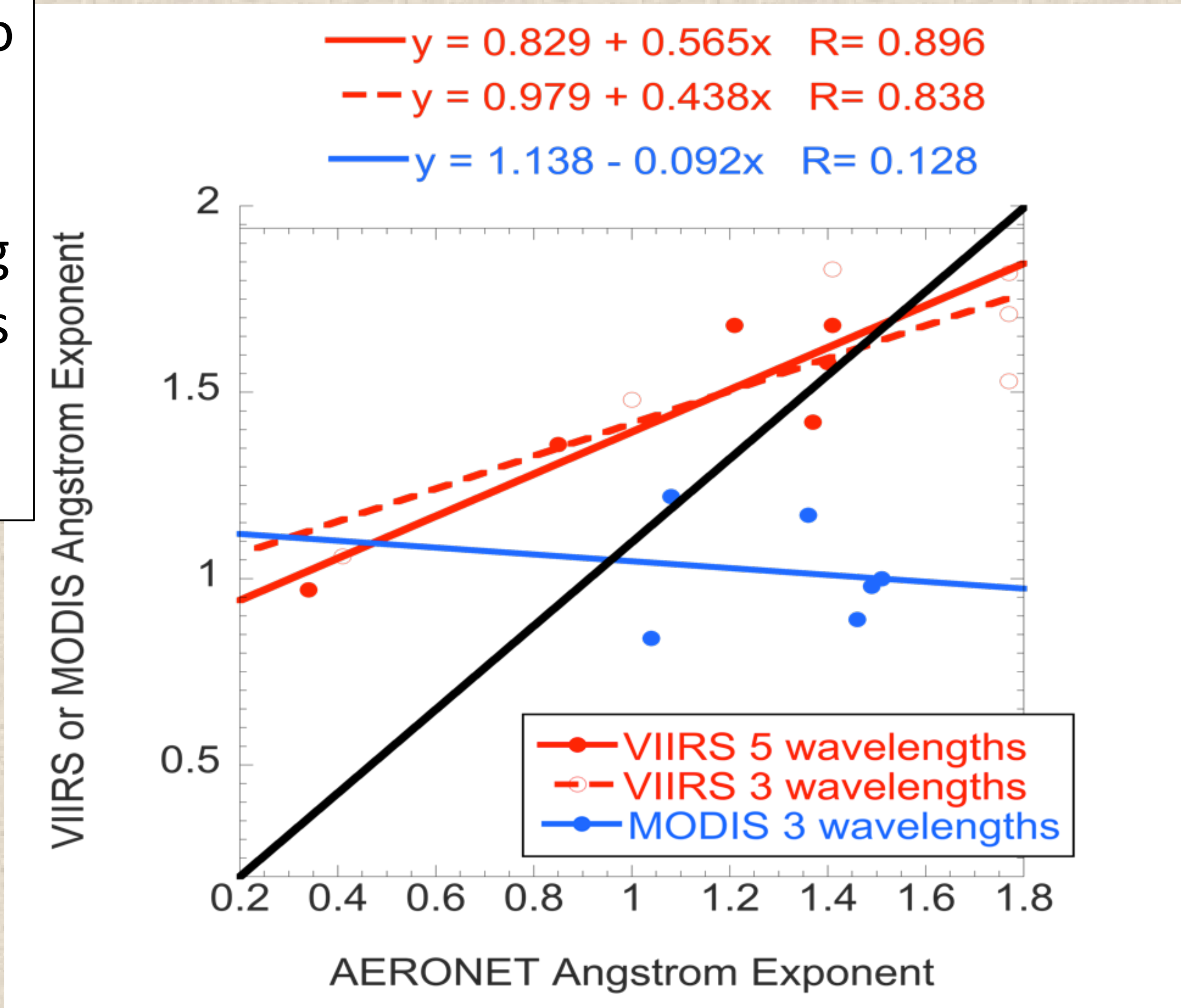
Early validation of Angström Exponent



In first analysis for Beta level validation, it appeared as though VIIRS AngExp over land had little skill

Not surprising because MODIS had no skill over land either

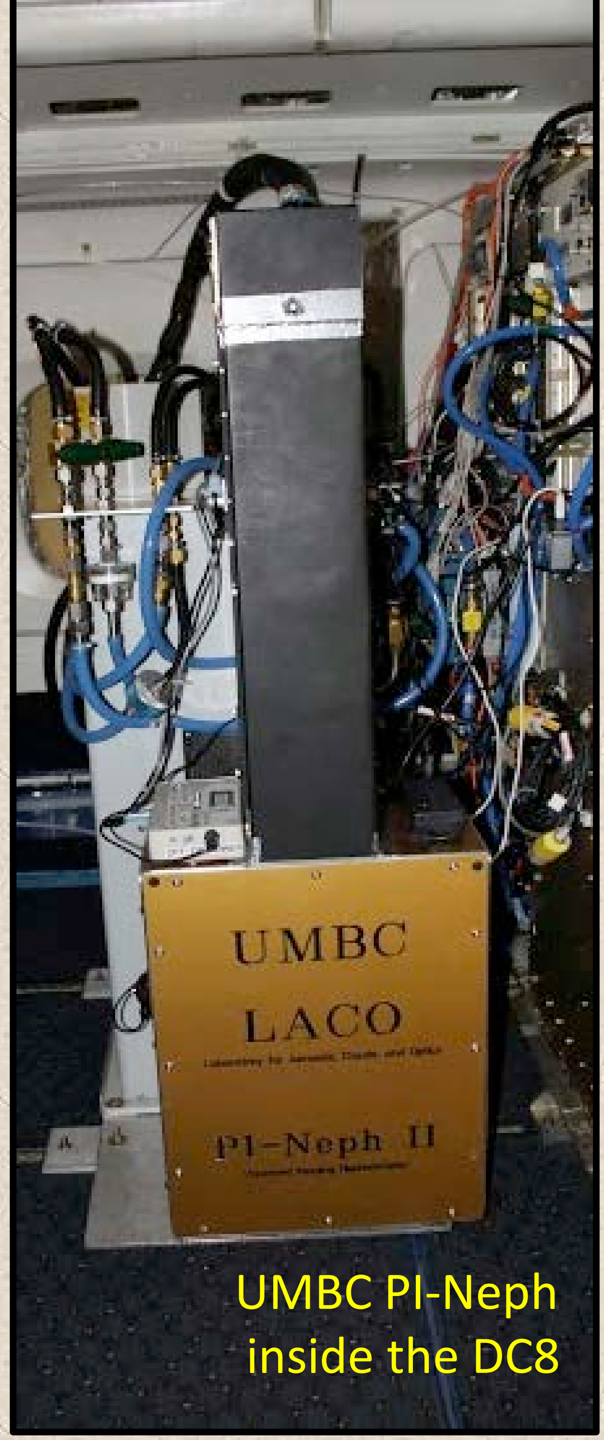
In SEAC4RS,
MODIS definitely has no skill
But VIIRS IDPS product shows skill at producing an AngExp over land, as compared with AERONET



3 different AOT ranges
SEAC4RS and Houston DRAGON
6 points

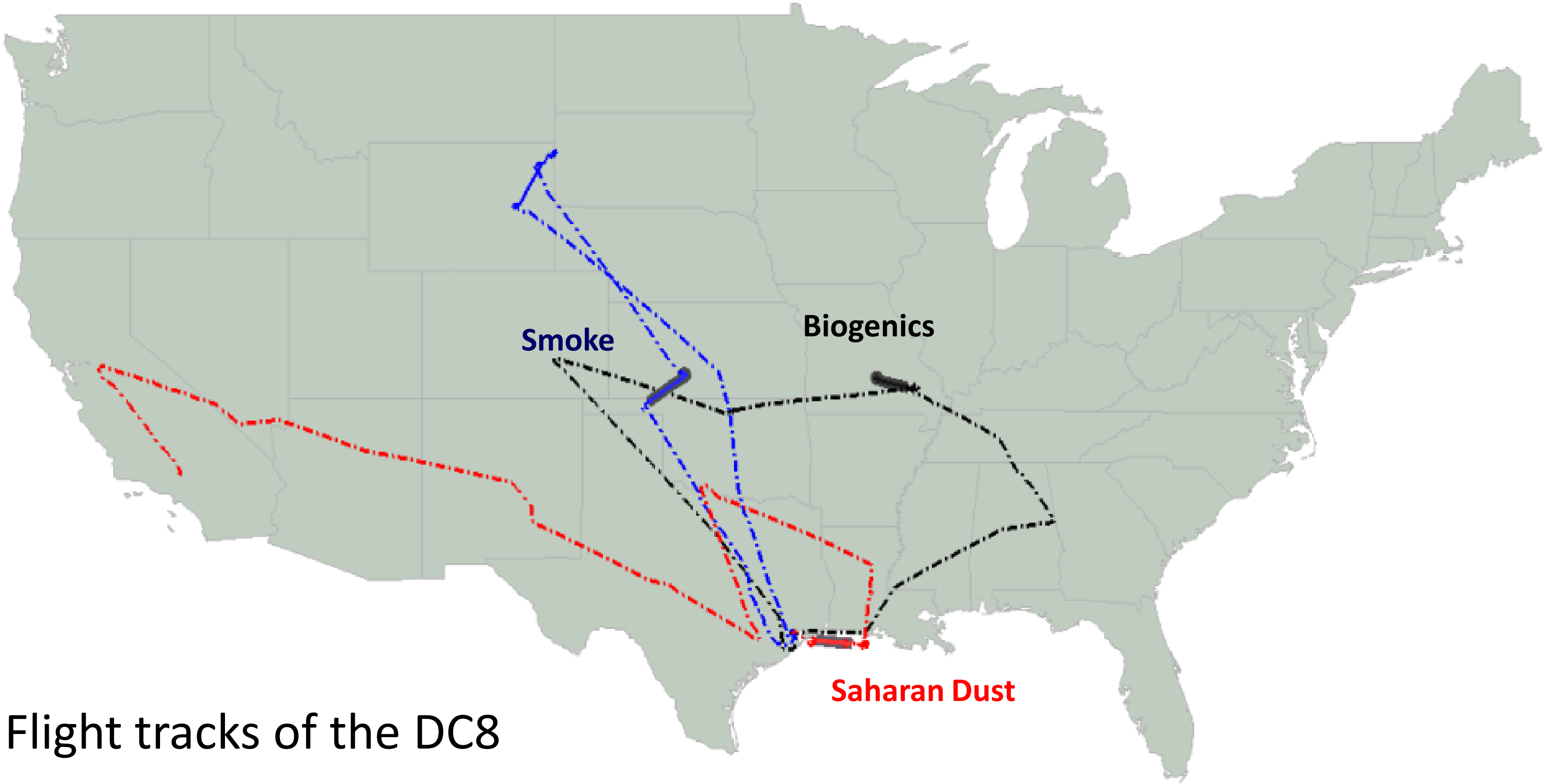

NASA DC8 SEAC4RS Aug/Sep 2013


EARTH SCIENCE
Inlets grabbing air into the DC8


UMBC
LACO
PI-Neph II
UMBC PI-Neph
inside the DC8

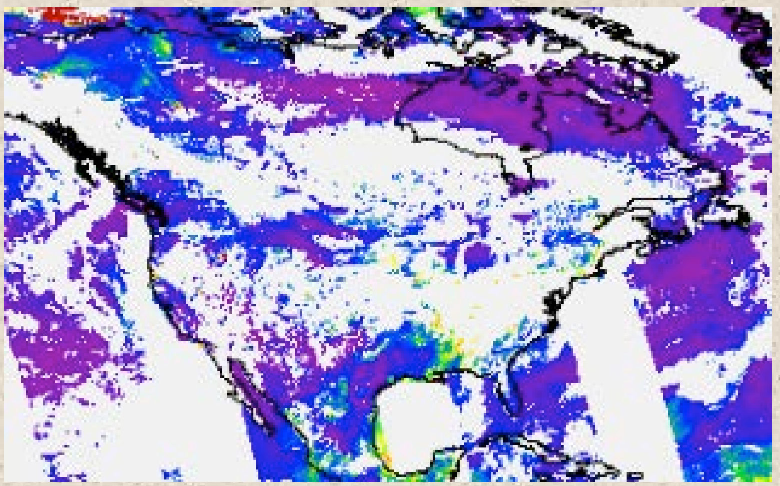
3 case studies from SEAC4RS:

Saharan dust 8 Aug 2013
Aged smoke 19 Aug 2013
Biogenics 19 Sep 2013

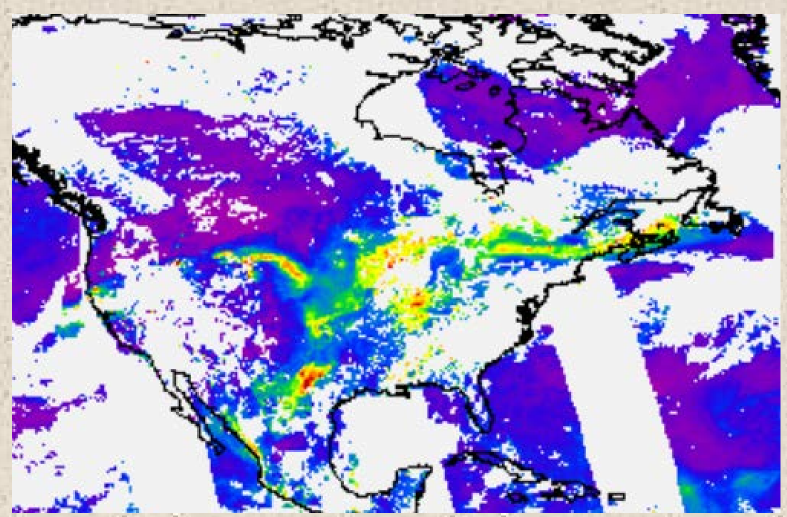


Flight tracks of the DC8

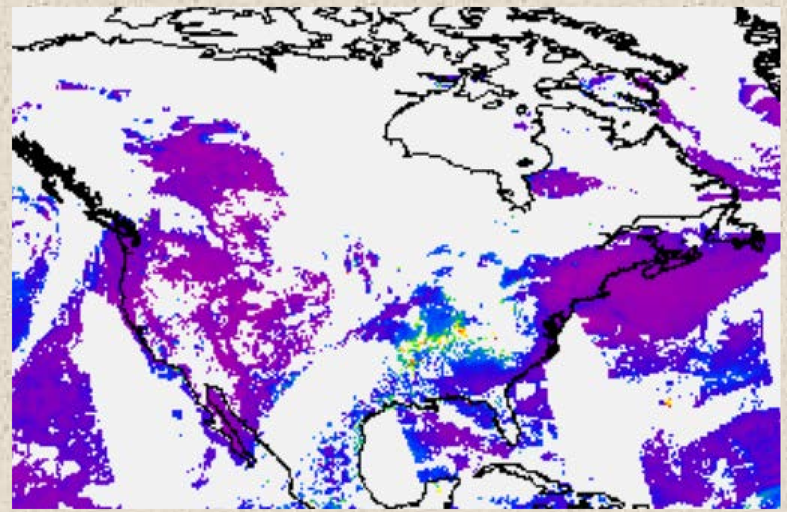
8 Aug 2013 Saharan Dust



19 Aug 2013 Aged Smoke



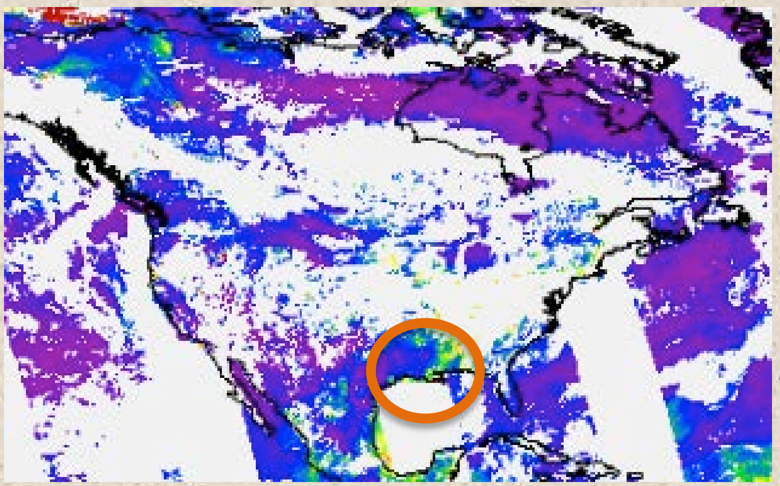
19 Sep 2013 Biogenics



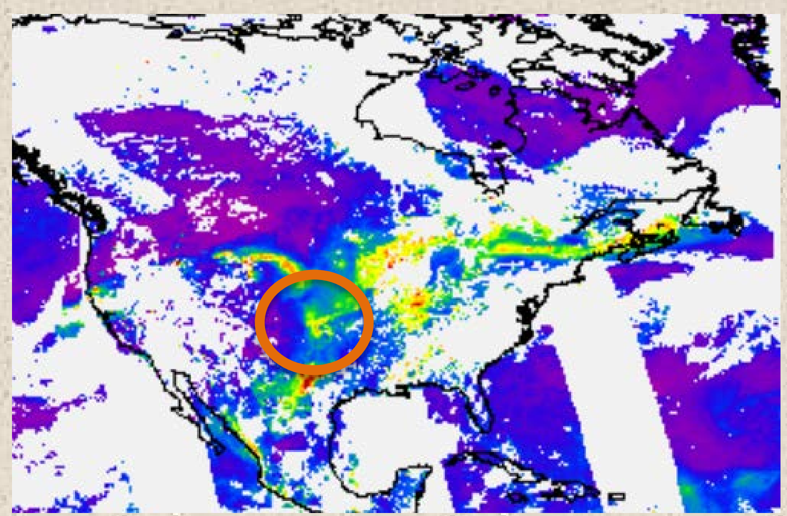
NOAA STAR VIIRS AOT 550 nm
Gridded 0.25^o x 0.25^o
Available as image or data

http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/products_gridded.php

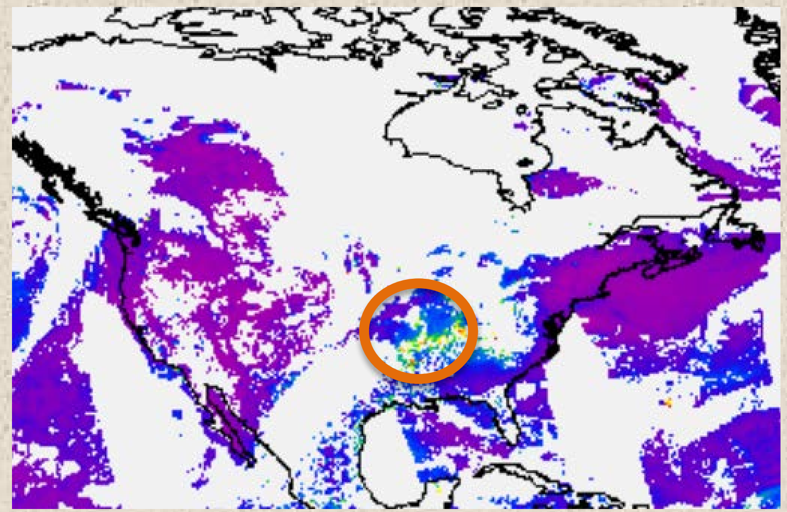
8 Aug 2013 Saharan Dust



19 Aug 2013 Aged Smoke



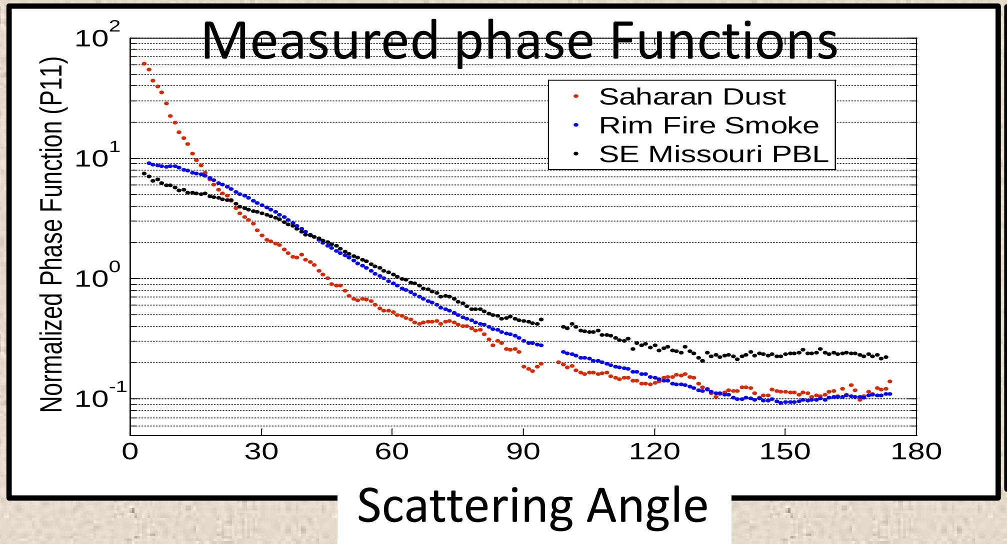
19 Sep 2013 Biogenics

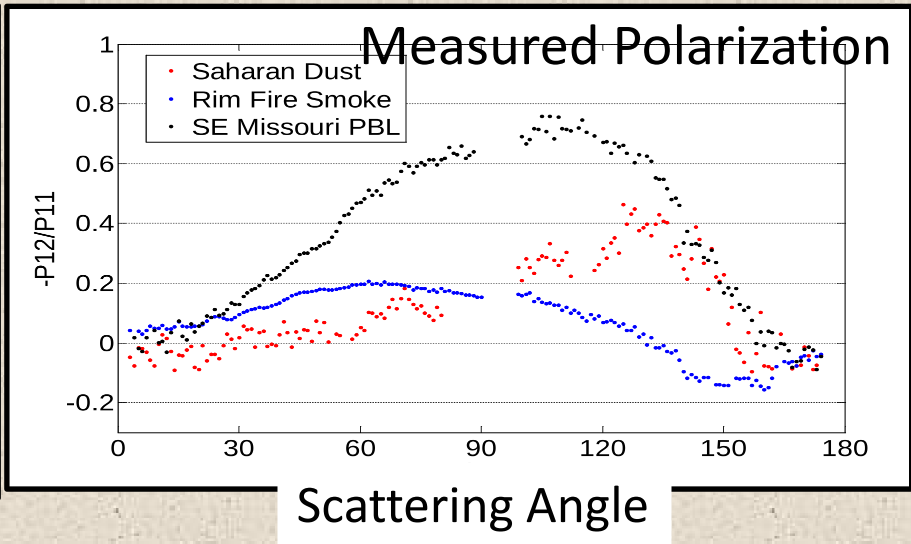


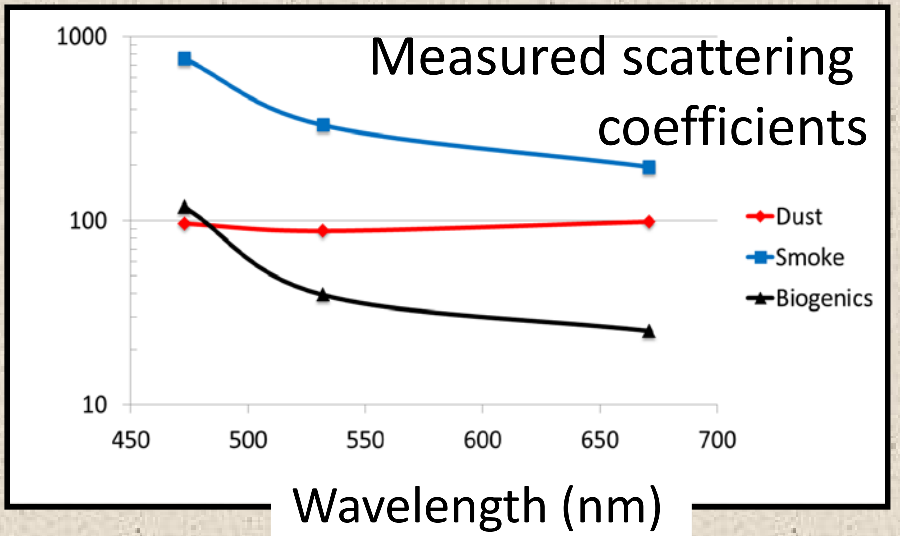
NOAA STAR VIIRS AOT 550 nm
Gridded 0.25° x 0.25°
Available as image or data

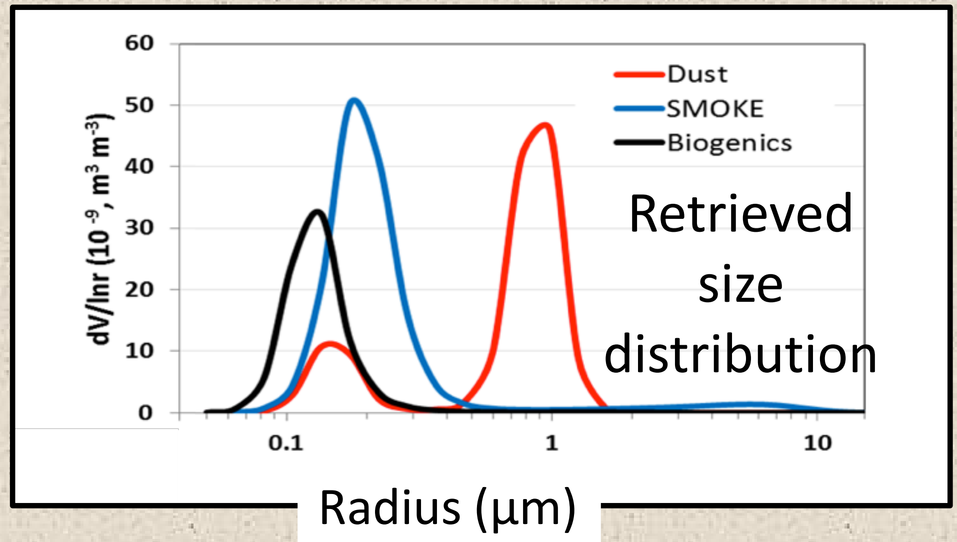
http://www.star.nesdis.noaa.gov/smcd/emb/viirs_aerosol/products_gridded.php

Dubovik GRASP retrieval transforms measurements into retrieved aerosol properties

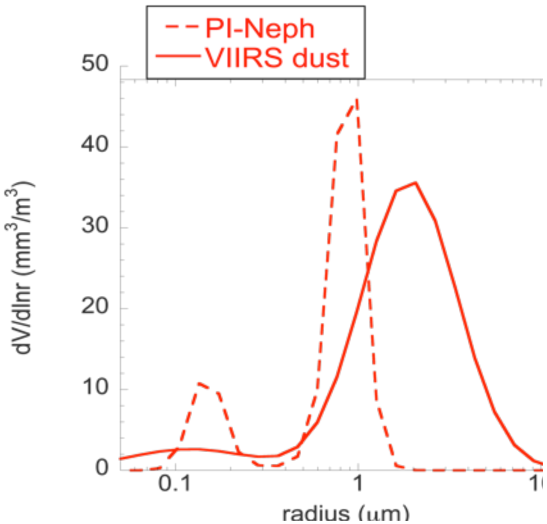




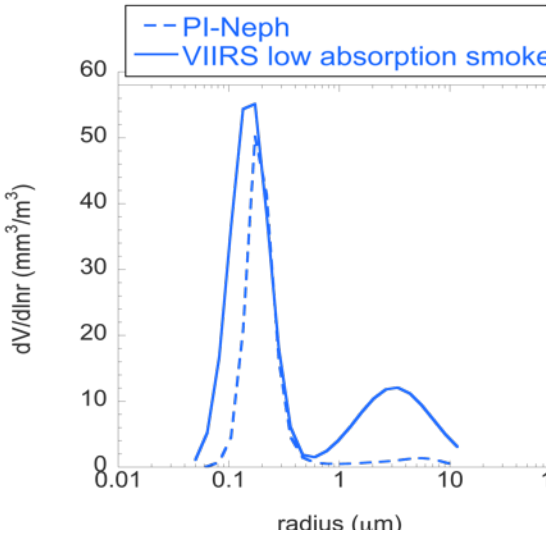




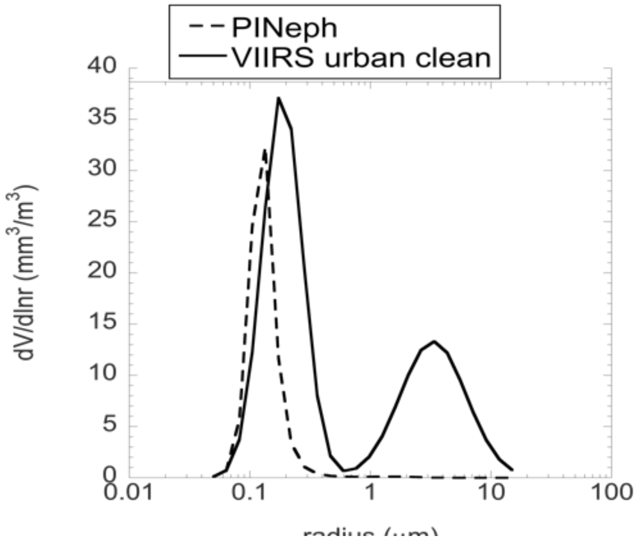
In 3 examples, the VIIRS IDPS algorithm chooses an aerosol model VERY CLOSE to that measured by PI-Neph



08Aug Saharan Dust
VIIRS AOT_550 = 0.40
VIIRS chose Dust model



19Aug Aged Smoke
VIIRS AOT_550 = 0.60
VIIRS chose low abs smoke



19Sep Biogenics
VIIRS AOT_550 =0.40
VIIRS chose low abs urban

Conclusions:

- VIIRS IDPS AOT retrievals at 6 km matched AERONET well over the southeast U.S. during August/September 2013.

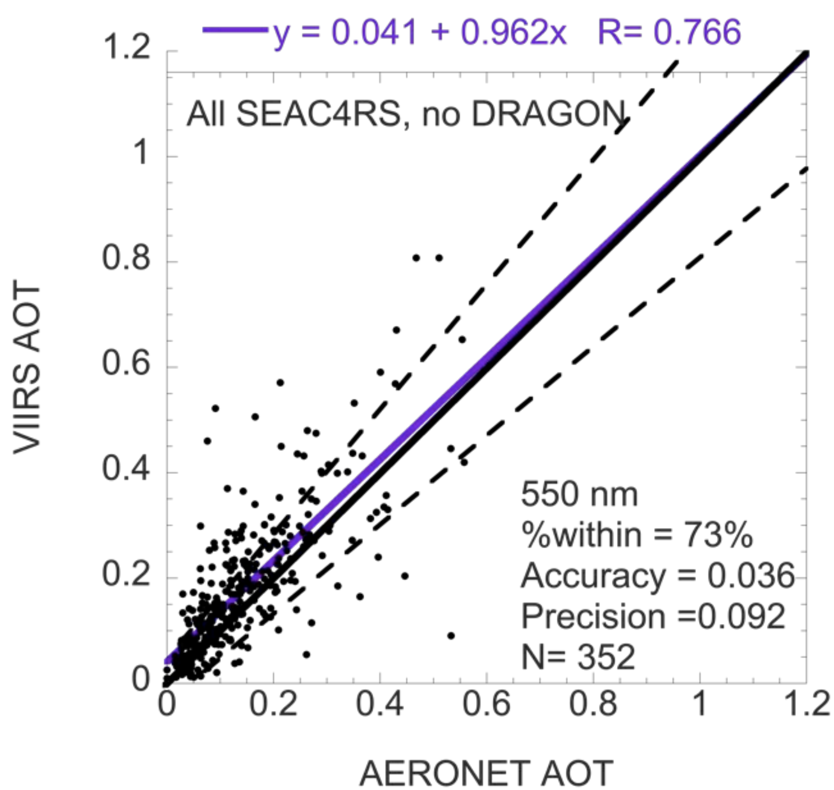
- VIIRS IDPS AOT retrievals are less capable over the urban surface in greater Houston.

- Unlike MODIS, the VIIRS algorithm is showing some skill at deriving *size parameter* over land.

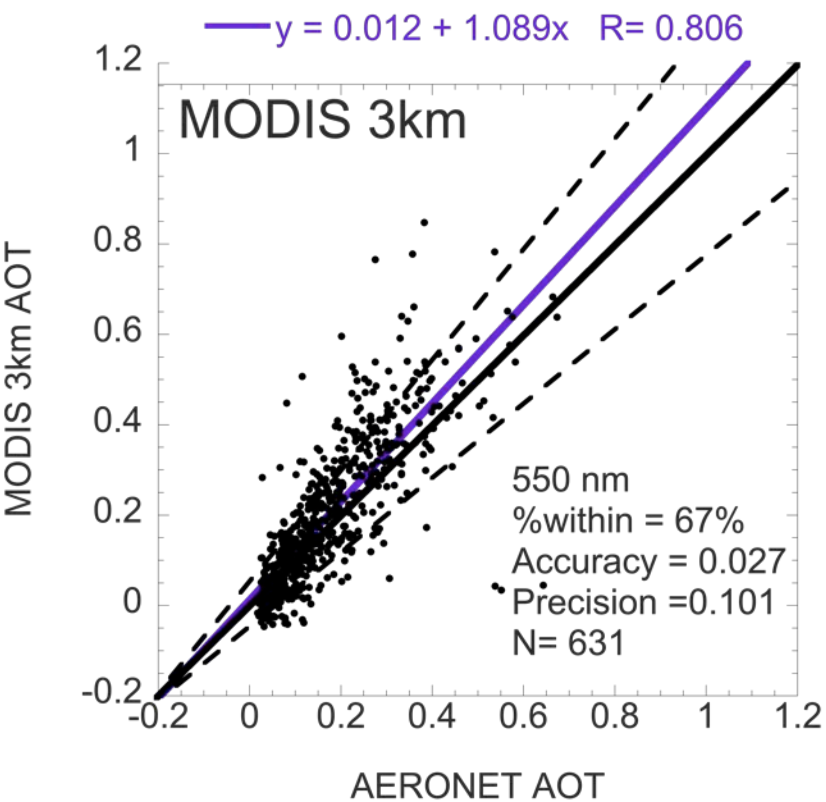
- The VIIRS IDPS algorithm seems to be able to choose the correct aerosol model.

Back up

VIIRS 6km EDR



MODIS 3 km



VIIRS 6 km validation statistics more comparable to MODIS 3 km

U.S. NAVAL RESEARCH LABORATORY

Incorporating NOAA-derived VIIRS AOD into the Navy Aerosol Model to Monitor SAL Events over the North Tropical Atlantic Basin

Arunas Kuciauskas[1], P. Lynch[1], J. Campbell[1], E. Hyer[1], and M. Oyola[2]

1. Naval Research Laboratory, Marine Meteorology Division (NRL-MMD)
2. American Society for Engineering Education, Washington, DC

Focus:

Assist Puerto Rico NWS/Fire Weather Agency in forecasting SAL events beyond 3 days

effort adaptable to downwind regions:
South/Southeast US, Gulf of Mexico, Bahamas, Central America, North and South America

STAR JPSS 2016 Annual Science Team Meeting, 8 – 12 August, College Park, MD

photo courtesy: NOAA

Background & Motivation

NOAA-JPSS Sponsored Project

1. NRL-MMD supporting NWS-Puerto Rico and CIMH (Barbados)

- NexSat and SAL satellite websites
  - near real time state-of-the-art GEO and LEO products
  - Model overlays
- Navy Aerosol Analysis Prediction System (NAAPS)
  - global operational dust model with R&D versatility
- Overall objective for greater Caribbean region
  - supporting general weather, fires, TC's, dust events

2. Current focus related to African dust/Saharan Air Layer (SAL) Events

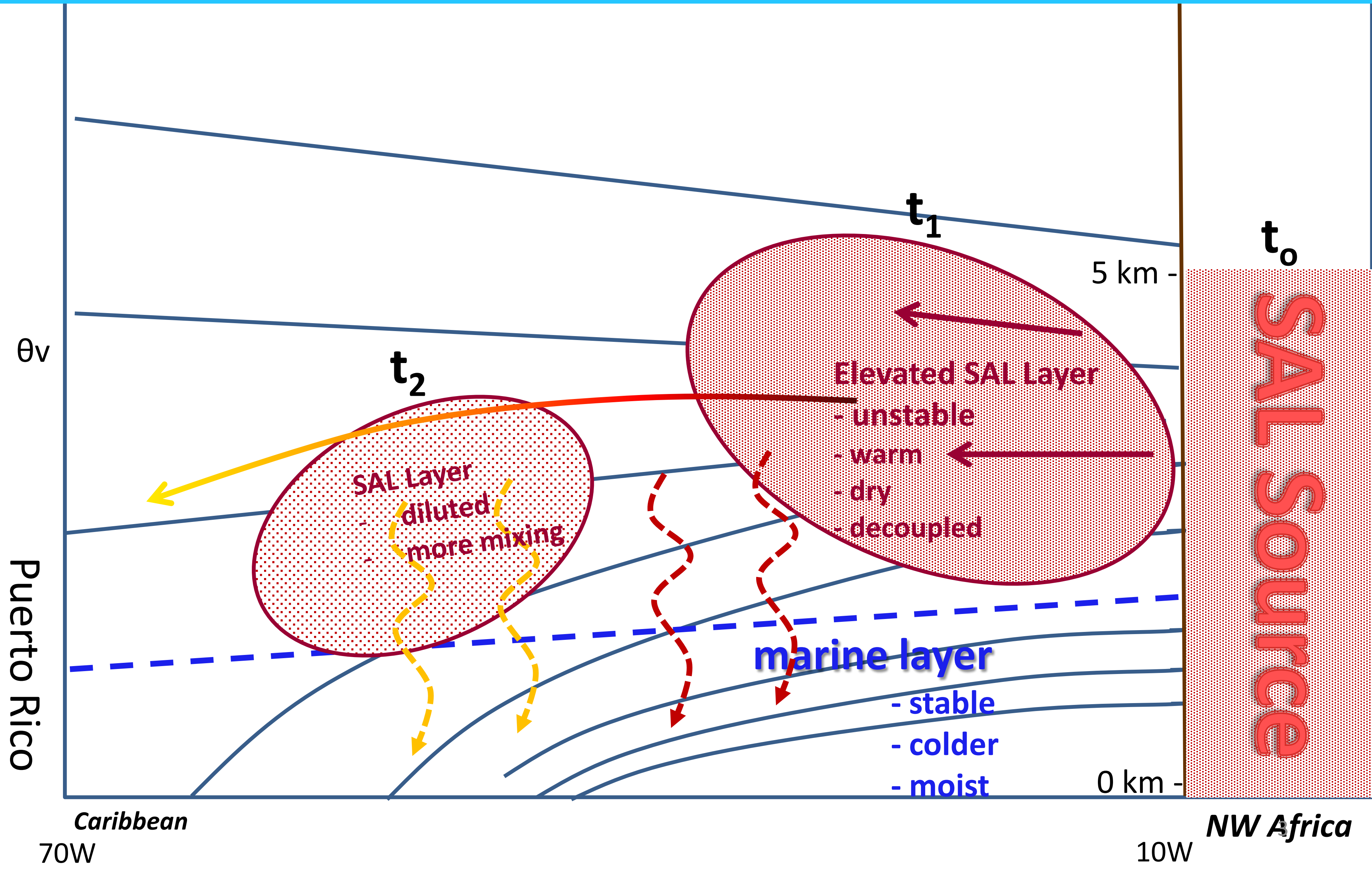
- Improving dust model output via NAAPS – *applying NOAA VIIRS AOD*
- Host additional S.A.L. products through multi-agency/academia collaborations
- Publications, BAMS

3. Integrate SAL monitoring with human health aspects

- Gain better understanding of African dust impacts over greater Caribbean
  - Scientific aspects
  - Human health aspects
- Seeking further partnerships with various local & national agencies

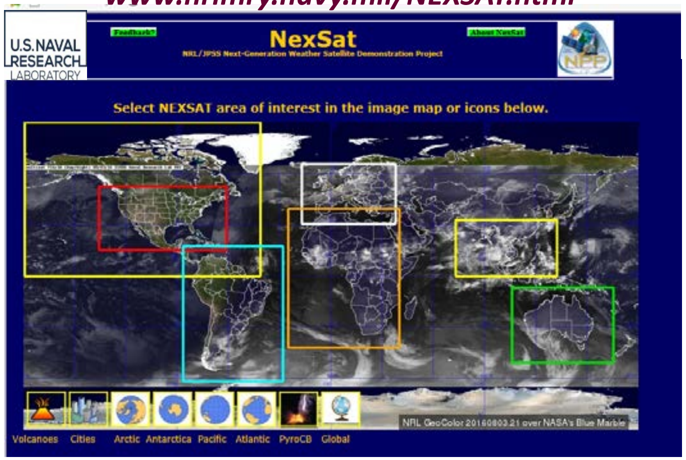
courtesy: Dr. Jeff Masters – Weather Underground

Environment Depicting SAL Propagation Across Tropical Atlantic Basin

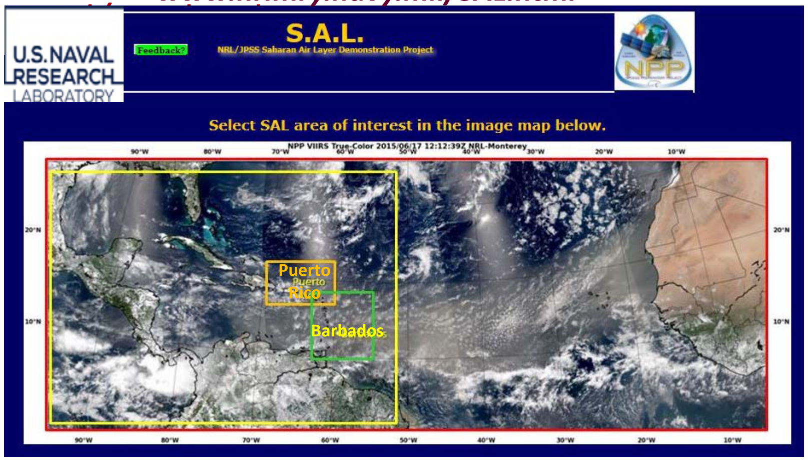


NRL-MMD Websites for SAL Support

www.nrlmry.navy.mil/NEXSAT.html



www.nrlmry.navy.mil/SAL.html



Standard Products
Visible (daytime)
Visible (night time)
Infrared
Water Vapor
True Color
Pseudo/GEO True Color
Rain Rates
Lidar CALIPSO/CALIOP MPLNET
Rain Totals • 3, 6, 12, 24 hours • 2, 3, 4, 5, 6, 7, 10, 12, 14 days
*Winds • Scatterometer (sfc) • GEO ○ low level ○ middle level ○ upper level

Cloud Products
Cloud layers (snow, low-middle, high)
Cirrus cloud detection
Contrail detection
Nocturnal Low CLouds
Convective cloud top height
Cloud properties • effective radius • optical depth • cloud top temperature • cloud top height • cloud type

Environmental Products
Aerosol amounts (optical depth)
Biomass (vegetation type)
Dust detection - MODIS - VIIRS - MSG (DEBRA)
Fire detection (hot spots)
Lightning detection

Models	
Navy global (NAVGEM)	NAAPS dust model
Sea Level Pressure	Total AOD
500 mb Heights	Coarse AOD
sfc, 700 500 300 mb Winds	Fine AOD
1000-500 mb Thickness	Concentration [dust]
Surface Temperature	
Jet Stream	

red products: *deemed important by NWS-PR*

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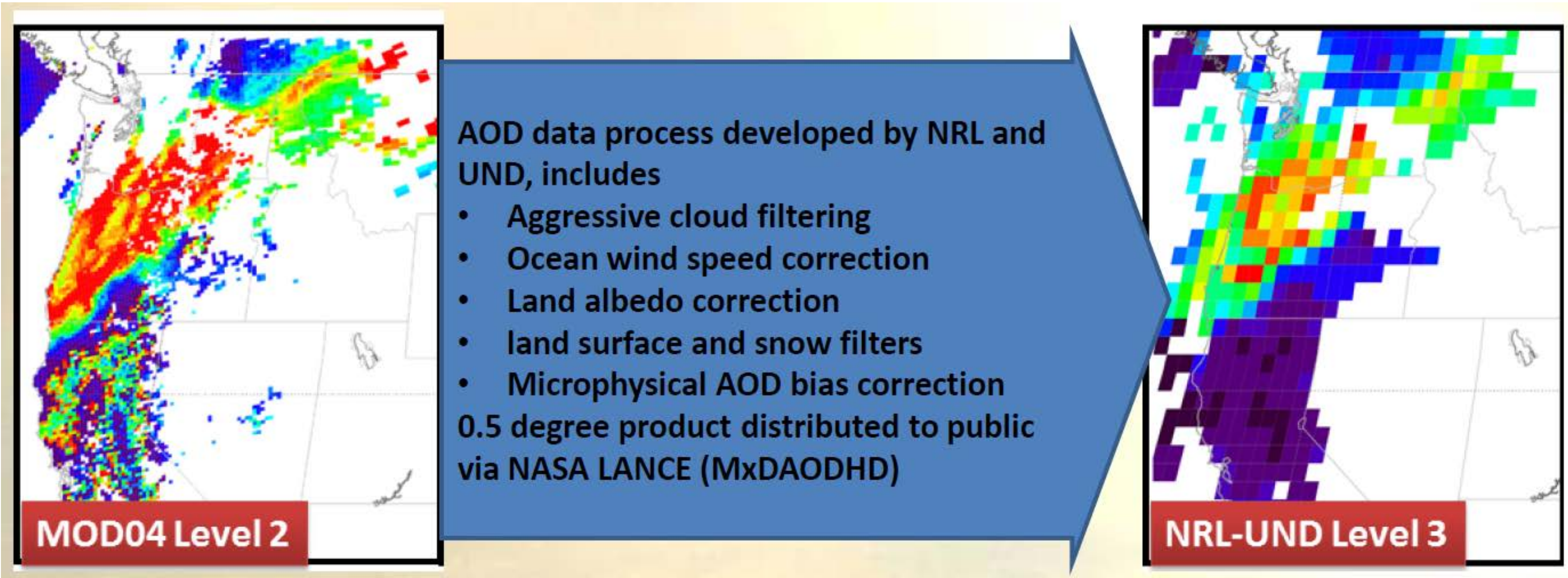
Navy Aerosol Analysis and Prediction System NAAPS

- Produces 6-day forecasts, 4 times daily, 0.3 X 0.3 degree res, 42 vertical levels of:
  - Mass concentrations of sulfate + organic aerosols , biomass burning smoke, dust, sea salt and column total aerosol optical depth (AOD)
- Utilizes Meteorological analysis and forecast fields from the Navy Global Environmental Model (NAVGEM)
- Can be initialized with assimilation of MODIS, VIIRS, AVHRR, MISR, and CALIOP data (current operational model uses MODIS only)
- Dust emission triggered when NAVGEM friction velocity exceeds thresholds (0.6 m/s) & sfc moisture < 0.4
- Valuable resource for air quality & fire hazard prediction throughout Western Atlantic regions
- For this experiment, a research version of the model used identical configurations, initializing using either VIIRS+MODIS or MODIS-only data
- Model validation results use AERONET Level 2.0 data

Ref: http://www.nrlmry.navy.mil/aerosol/

Preparing aerosol data for assimilation in NAAPS: filtering, correction, aggregation



- **Pre-processing of VIIRS IDPS EDR data for NAAPS assimilation** ⟶ **Transition to NOAA Enterprise**
- **"fullQA" uses information packaged with EDR granules to filter data:**
  - **QA = 'Good' (highest EDR QA value)**
  - **Cloud mask, cloud proximity, snow flags, glint flags**
- **Observations aggregated to 1-degree, 6-hour**
  - **Operational NAAPS now 1/3°, 1° used for testing**
- **Two tests run**
  - **Short test: qualitative: 1-30 June 2014 (dust event 23-28 June)**
  - **Long test: quantitative: 2013.01.24.00 to 2014.01.12.00**

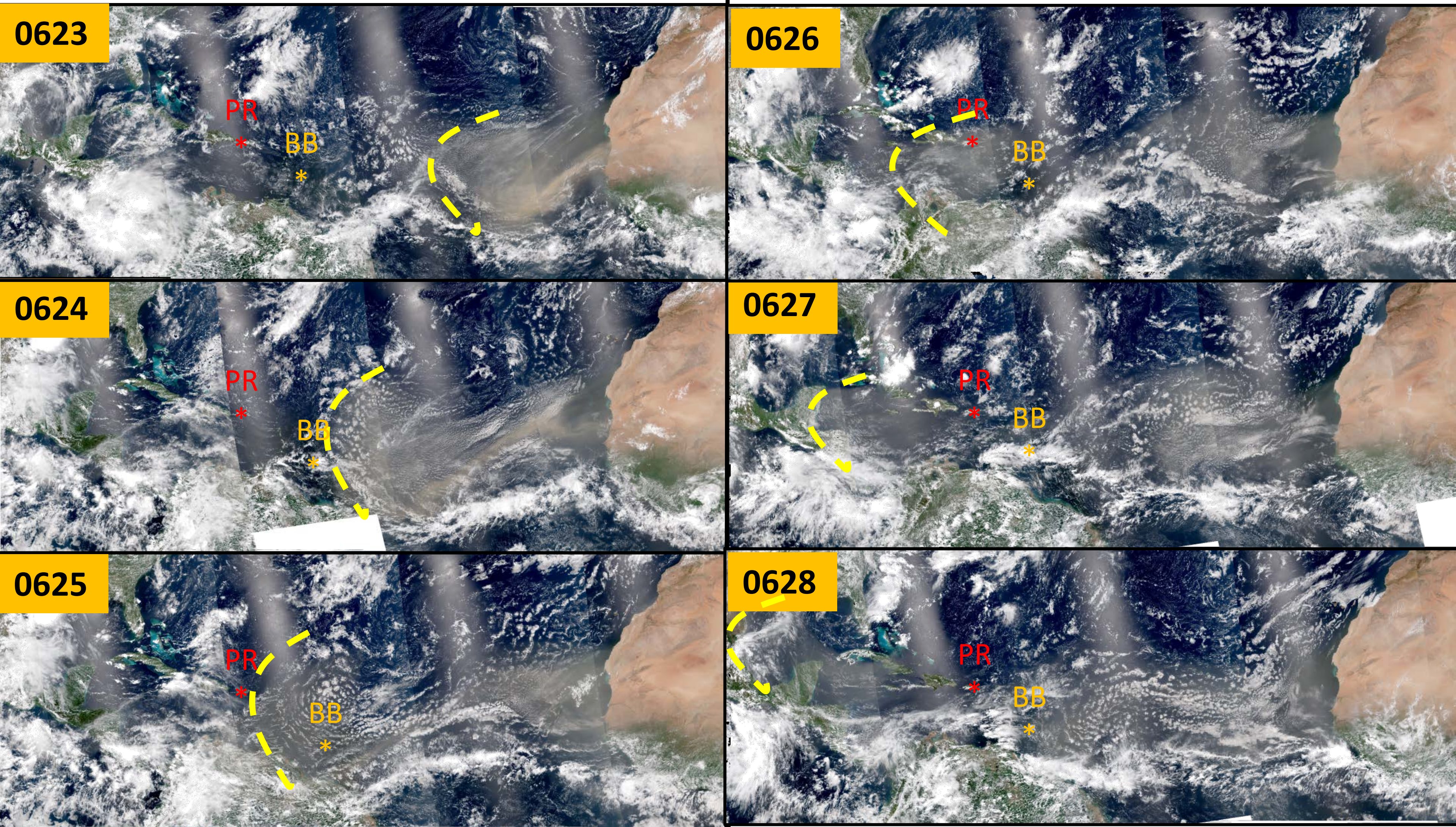
Courtesy: Edward Hyer, NRL

Tracking a *dusty* SAL Event

23 – 28 June, 2014

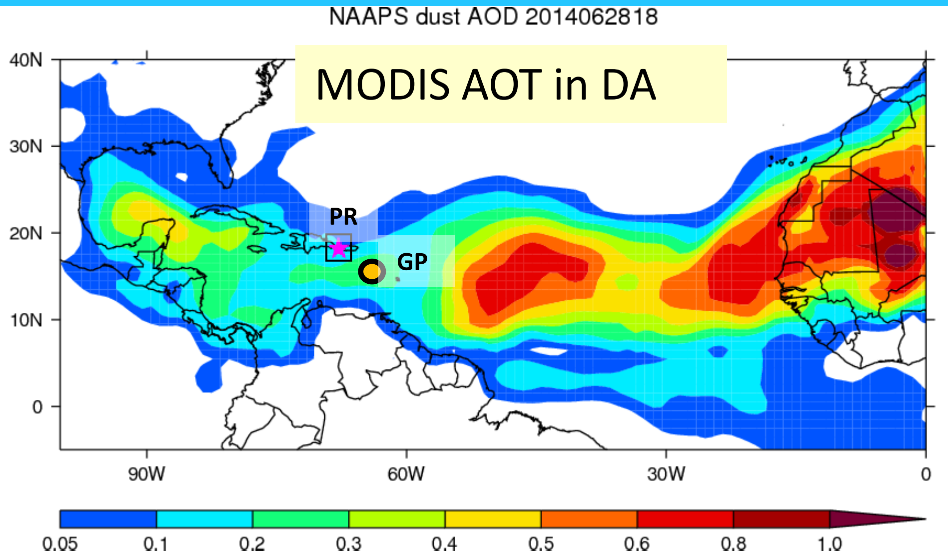
VIIRS True Color imagery

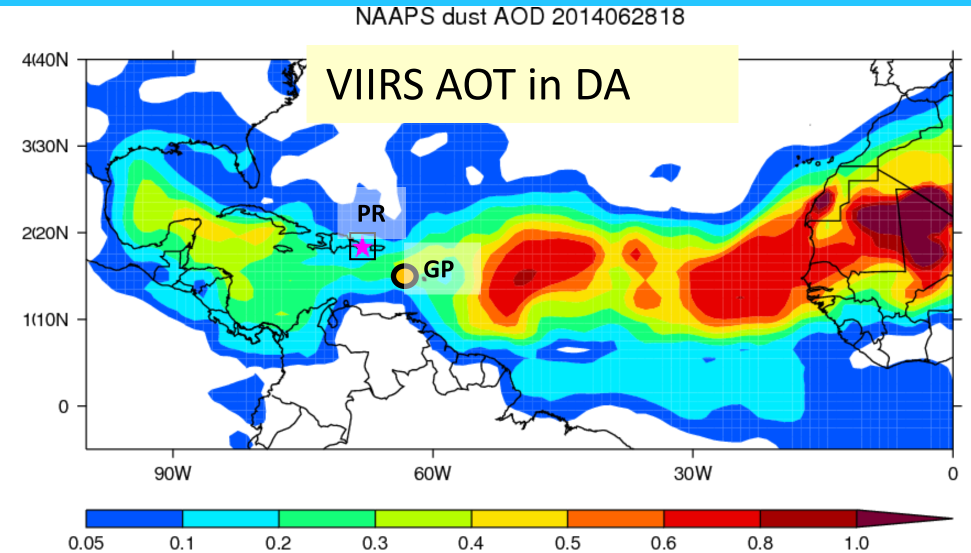
Targeted areas: Puerto Rico (PR) and Barbados (BB)

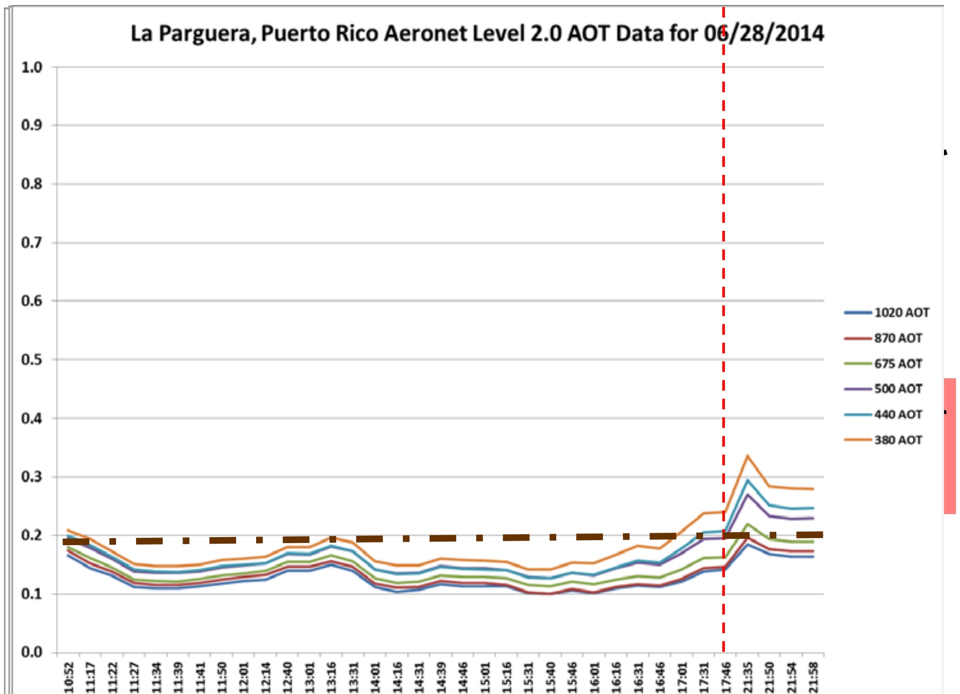


Comparing NAAPS: with MODIS vs VIIRS AOD in DA

pink star = La Paguera, orange dot = Guadaloupe

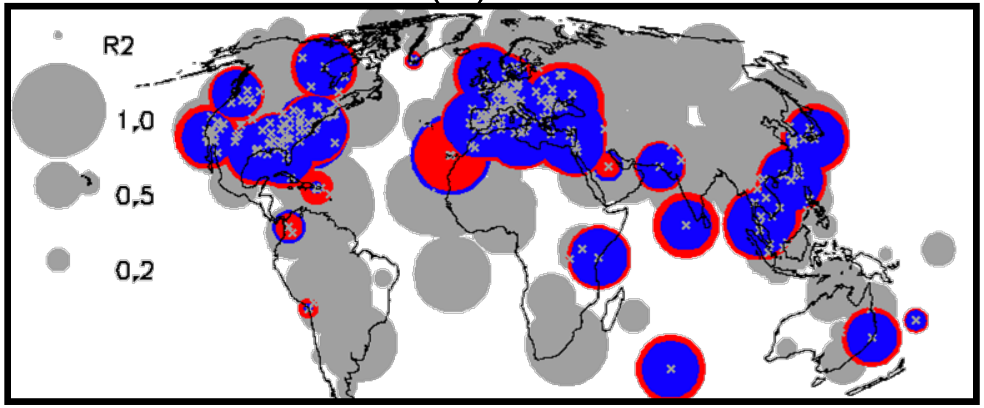




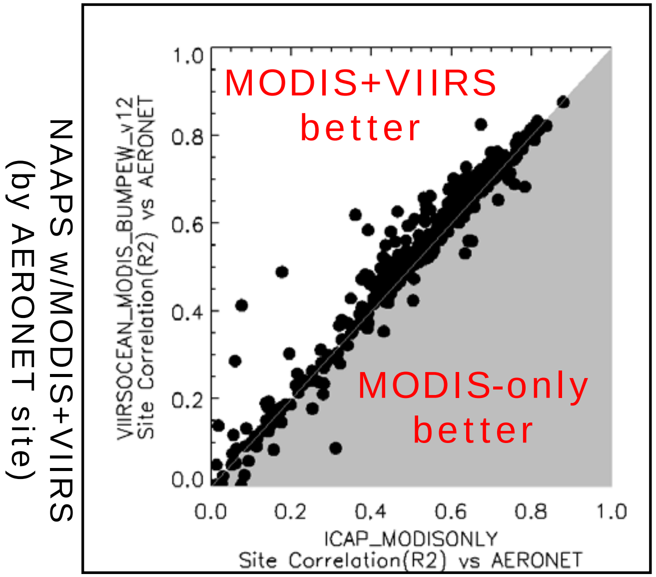


12-month quantitative test: NAAPS runs using MODIS-only (OPS) vs VIIRS+MODIS

AOD Correlation (r^2) at AERONET stations



MODIS+VIIRS MODIS only



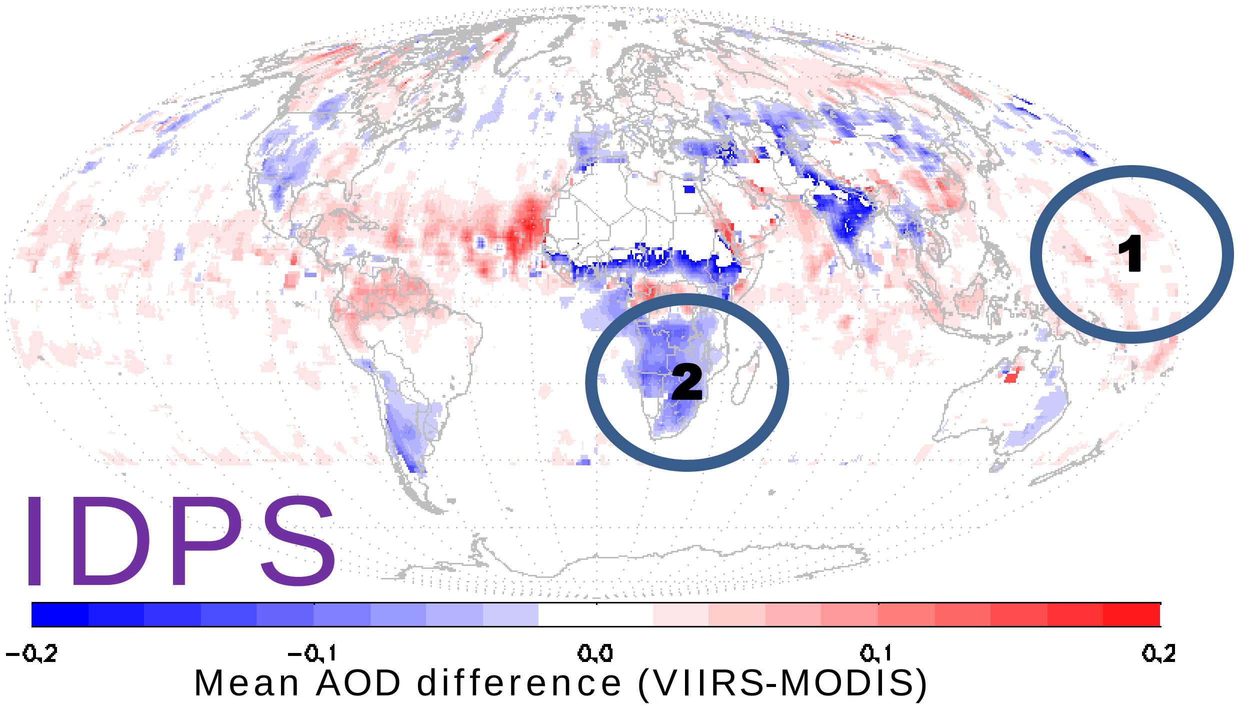
NAAPS w/MODIS (by AERONET site)

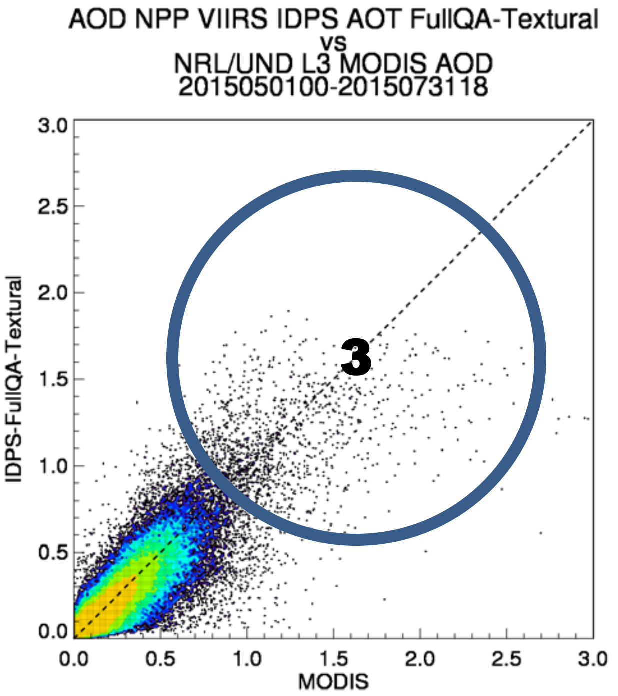
NAAPS AOD analysis results:

- **201302 – 201402 NAAPS analysis (6-hourly data) compared to AERONET L2.0 data**
- **VIIRS+MODIS better than MODIS only**
  - **correlation (r^2) vs AERONET L2.0 increased at 256 of 382 stations**
  - **Slope vs AERONET L2.0 improved at 224 of 382 stations**
  - Colored symbols on map indicate stations where r^2 differed by more than 0.05

Courtesy: Edward Hyer, NRL

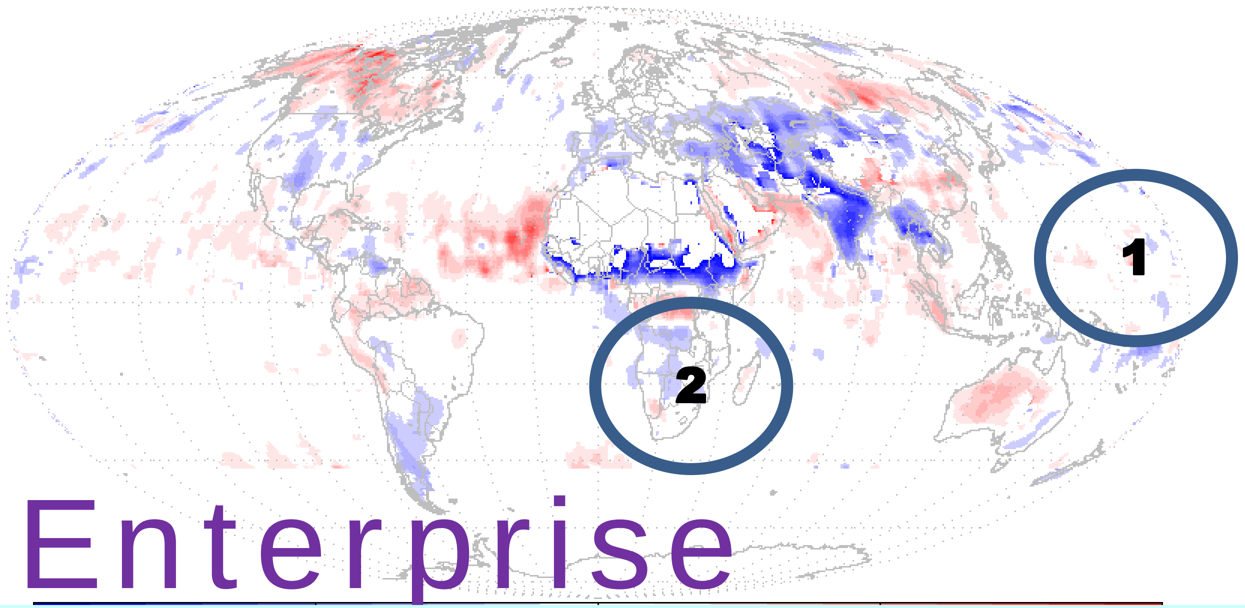
VIIRS AOD data using IDPS

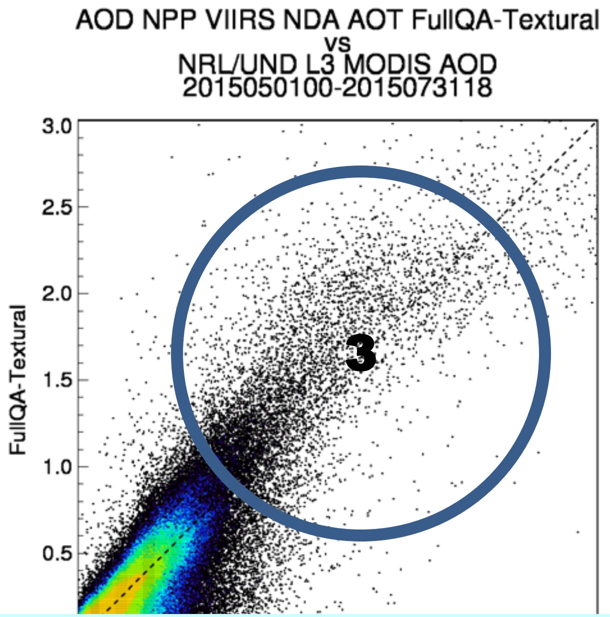




- 3-month comparison to MODIS NRL/UND L3 Data Assimilation product: 201505-201507
- VIIRS data aggregated and filtered ‘FullQA’ + buddy checks and neighborhood tests
- Left: map of AOD differences (paired) (smoothed for plotting)
- Right: scatter-density plot of AOD differences vs MODIS

New VIIRS AOD data using NOAA STAR Enterprise





Enterprise AOD from NOAA STAR

- ***Improves bias correction compared to AERONET***
- ***Allows greater number of dust-related values into NAAPS DA***
- ***DA testing of new Enterprise product is underway at NRL***

U.S. NAVAL RESEARCH LABORATORY

Summary

VIIRS impact on monitoring & predicting SAL events

1. Comparisons of NAAPS DA: MODIS (OPS) vs MODIS+VIIRS AOD

a) VIIRS + MODIS outperforms MODIS-only

b) Improvements seen in case studies and statistical analyses

c) VIIRS has more spatial coverage than MODIS, particularly over the tropics, so more AOT retrievals

d) IDPS VIIRS AOT contains more bias than NOAA STAR Enterprise VIIRS AOT

e) Positive impact to forecasting SAL dust events at NWS, San Juan

  i. VIIRS DA should yield improved forecasts and characteristics of SAL propagation out to 3–6 days

2. Future Efforts

a) Will provide NAAPS with Enterprise VIIRS AOD as DA into NRL-MMD SAL webpage

b) More interaction with forecasters/scientists within greater Caribbean

Web resource: ***http://www.nrlmry.navy.mil/NEXSAT.html & SAL.html***

Assimilation of VIIRS aerosol products to improve NCEP global aerosol predictions

Sarah Lu, Shih-Wei Wei, Sheng-Po Chen (SUNYA)
Shobha Kondragunta, Qiang Zhao (NESDIS/STAR)
Jeff McQueen, Jun Wang, Partha Bhattacharjee (NWS/NCEP)

Outline

1. Scope of global aerosol prediction at NCEP
2. The need for aerosol data assimilation
3. Status update in aerosol data assimilation
4. Conclusions

NCEP global aerosol modeling and assimilation

Long-term goal

- Allow aerosol impacts on weather forecasts and climate predictions to be considered
- Enable NCEP to provide quality atmospheric constituent products serving the stakeholders, e.g., health professionals, policy makers, climate scientists, and solar energy plant managers

Phased implementation for NEMS GFS Aerosol Component (NGAC)

- Phase 1: Dust-only forecasts (operational)
- Phase 2: Multi-species forecasts for dust, sulfate, sea salt, and carbonaceous aerosols using NESDIS's NRT GBBEPx smoke emissions (planned FY16 implementation)
- Phase 3: Multi-species forecasts initialized from aerosol analysis

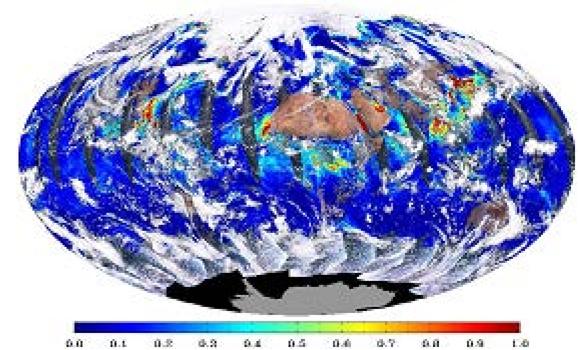
Incremental updates for aerosol data assimilation

- The first phase is based on the GSI framework using VIIRS AOD as input observations and the NGAC output as first guess
- The system will be extended to use multi-sensor and multi-platform aerosol observations and evolve to an ensemble-based system

Using satellite data to improve aerosol forecasting

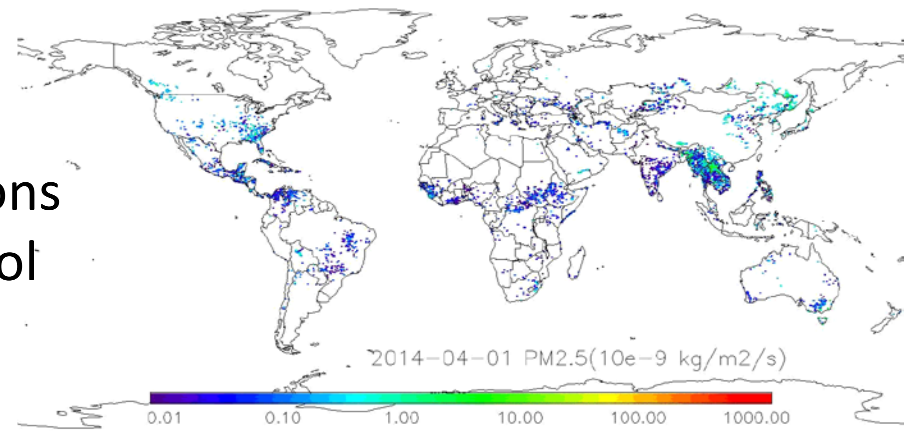
- NCEP's global aerosol forecasting capability has been build upon multi-institute collaboration (NCEP, GSFC, STAR, SUNYA) and leverage the expertise in other modeling centers (ICAP)
- Satellite observations have been used to improve aerosol products
    - Routine monitoring of model performance
    - Near-real-time biomass burning emissions from satellite observations
    - Data assimilation of satellite aerosol observations (in development)

Aerosol observations from VIIRS



From NOAA/NESDIS/STAR website

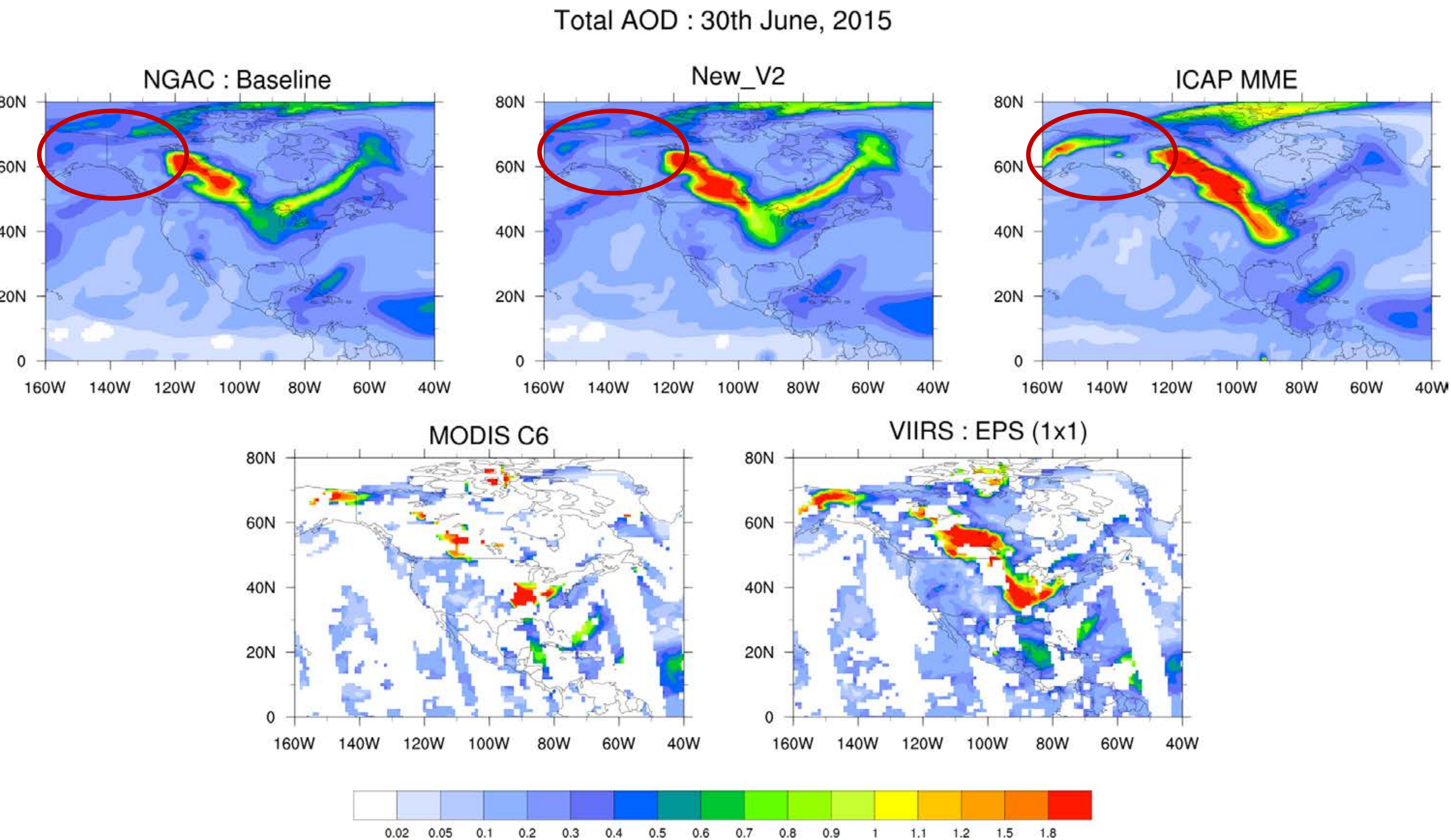
Near-real-time biomass burning emissions from multiple satellites



Outline

1. Scope of global aerosol prediction at NCEP
2. The need for aerosol data assimilation
3. Status update in aerosol data assimilation
4. Conclusions

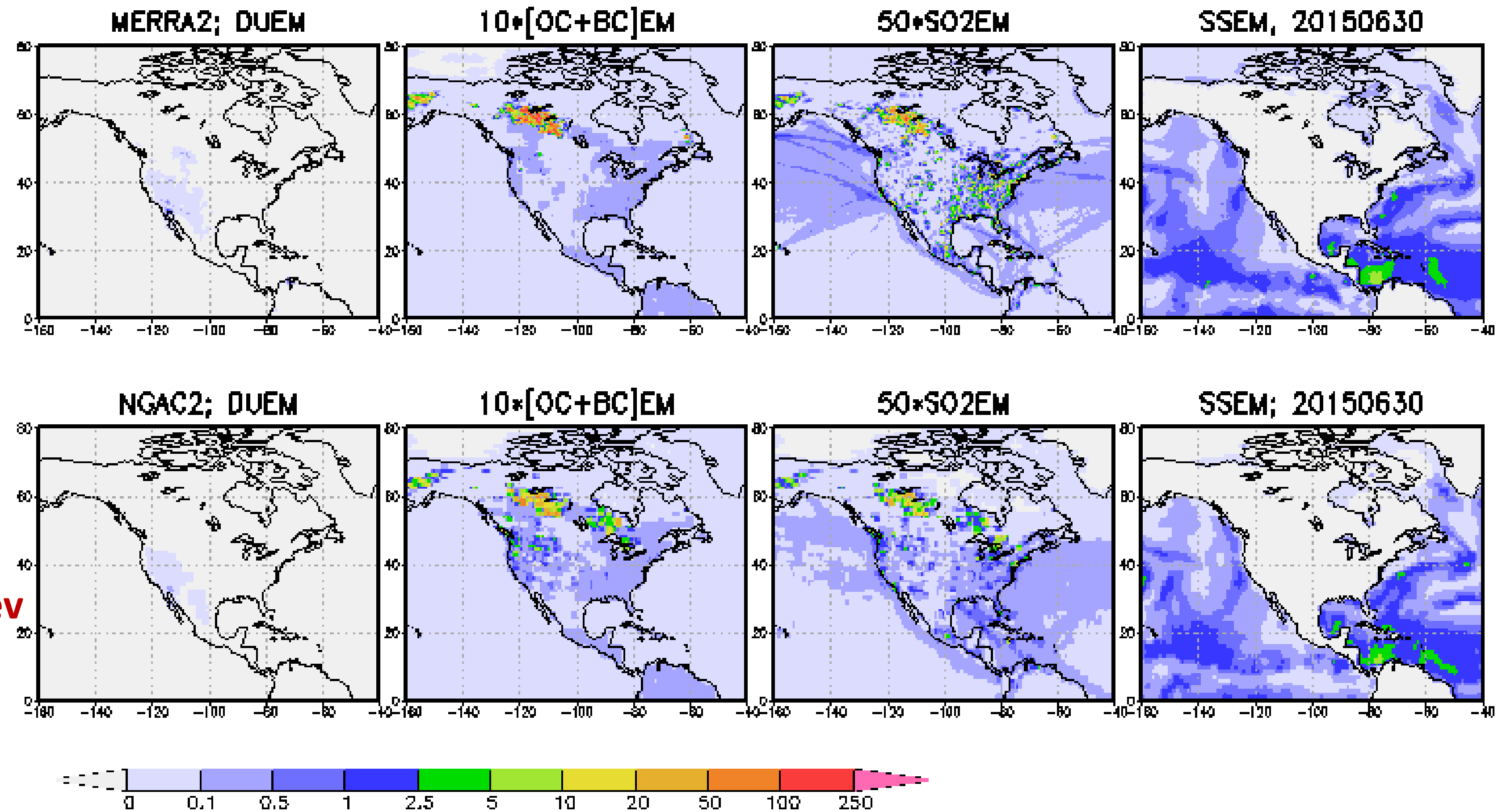
July 2015 case: Lower AOD in NGACv2 than ICAP-MME for the areas affected by Alaska and Africa smoke



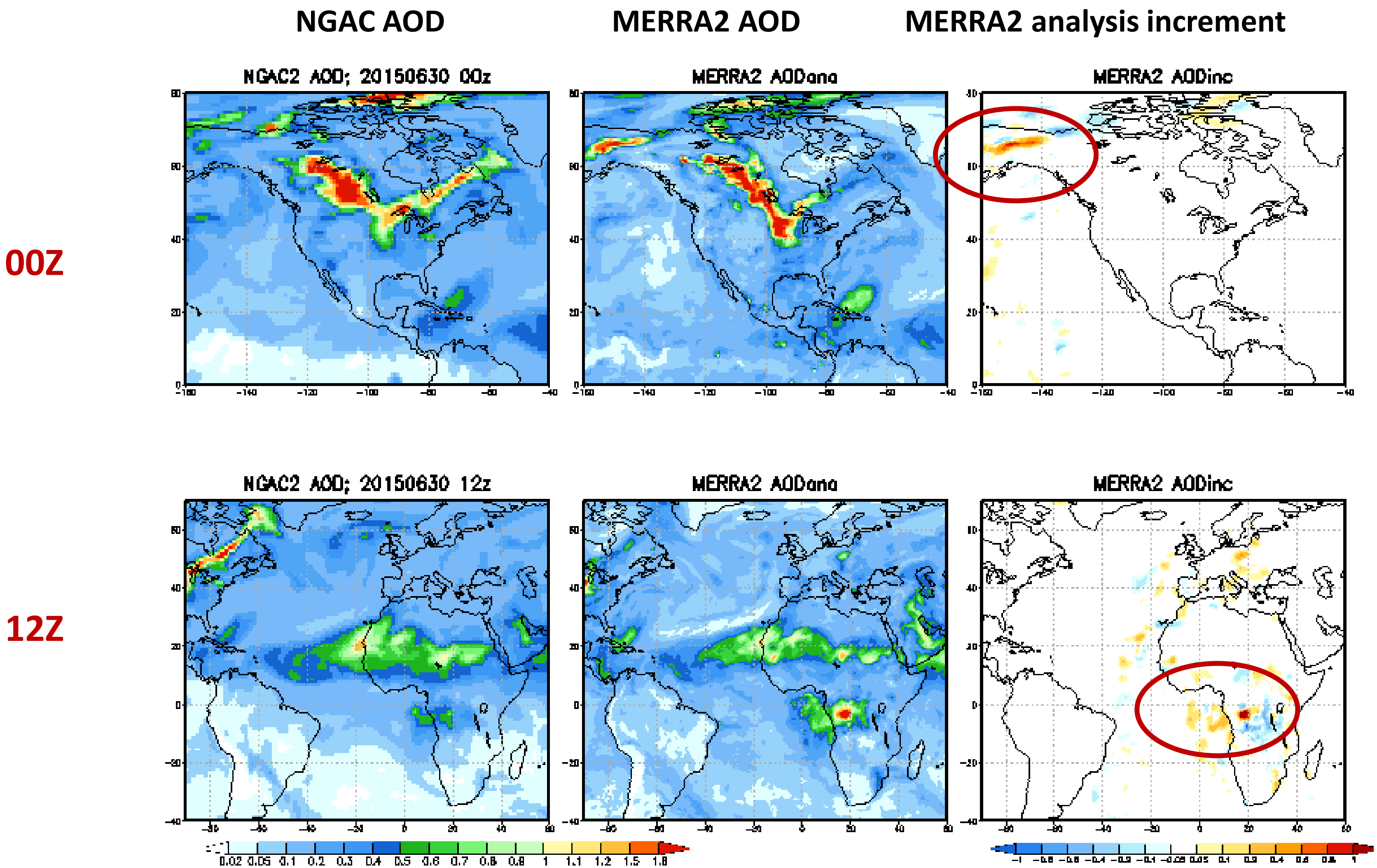
Emissions for DU, OC+BC, SO2, SS for 2015-06-30 12Z

MERRA2

NGACV2_rev



Comparable Alaska smoke emissions in QFED2 (for MERRA2) and GBBEPx (for NGAC v2)



Comparable smoke emissions between QFED2 and GBBEPx

The AODs differences between MERRA2 and NGACv2 are attributed to analysis increment

Outline

1. Scope of global aerosol prediction at NCEP
2. The need for aerosol data assimilation
3. Status update in aerosol data assimilation
4. Conclusions

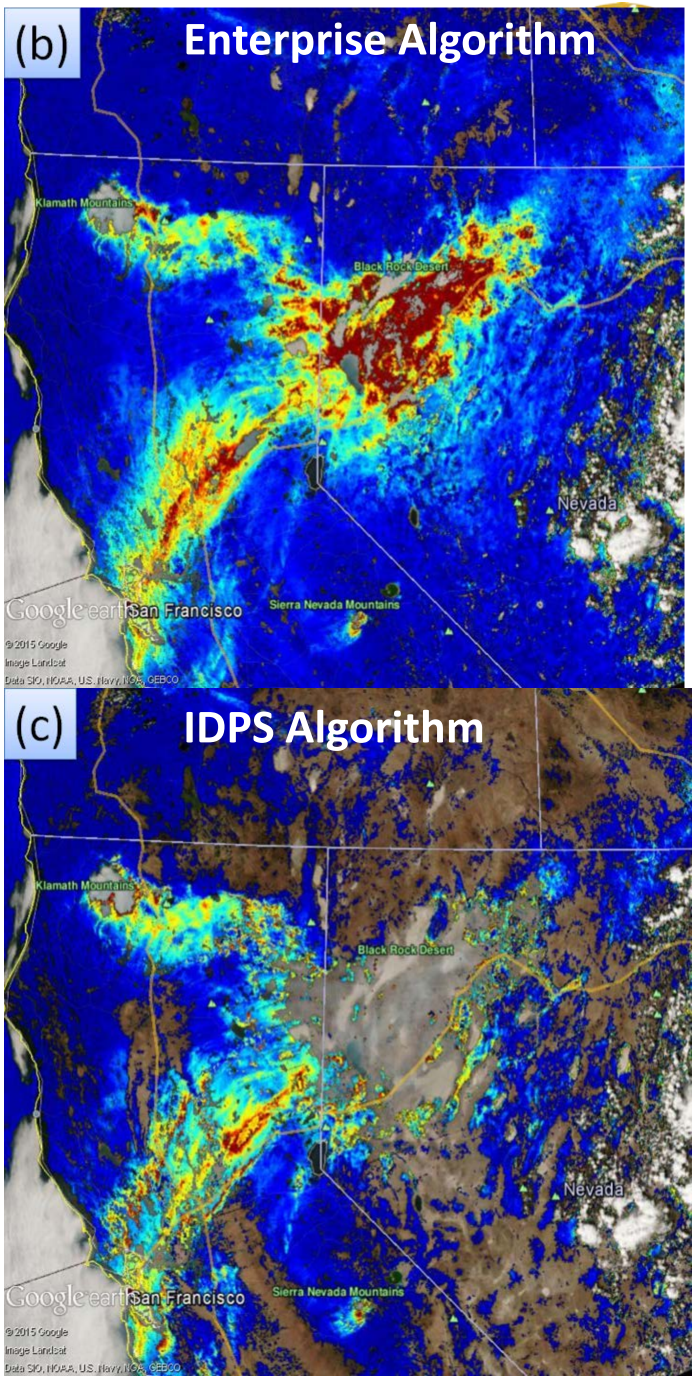
Project Milestones Overview

Task	Description	Milestones/ Deliverables
1. VIIRS quality assurance and bias correction	Conduct VIIRS AOD error analysis and establish VIIRS data screening procedure	DA grade VIIRS AOD products
2. Global aerosol analysis	Develop GSI-based AOD data assimilation system using NCEP's NGAC as first guess and VIIRS AOD as observation input	GSI AOD DA system
3.Benchmark study	Demonstrate the anticipated improvement resulted from AOD DA	Benchmark report

Task 1 VIIRS AOD Quality Assurance and Bias Correction

- VIIRS operational AOD (IDPS version) is well validated and documented. However, the following issues have been documented:
  - Smoke plumes are identified as cirrus cloud
  - Data gaps over bright surfaces
  - Measurement range extends only from 0 to 2 optical depth units

- Enterprise algorithm has been developed to circumvent the deficiencies. This algorithm to be operational in NDE in 2016
  - Testing and evaluation ongoing



Task 1 VIIRS AOD Quality Assurance and Bias Correction –cont'd

- Obtain AOD and dust/smoke mask products from Enterprise algorithms for select case studies and do model comparison studies

- Identify VIIRS AOD data artifacts and sources of errors and develop data screening procedures if needed

Task 2 Technical/Scientific Progress

- With an older version of GSI/CRTM, NCAR and ESRL assimilates MODIS AOD using WRF-CHEM as first guess
- AOD DA code has been committed to the GSI code repository
- We are extending the new GSI option to use NGAC as first guess and VIIRS AOD as observation input.

Task 2 Technical/Scientific Progress –cont'd

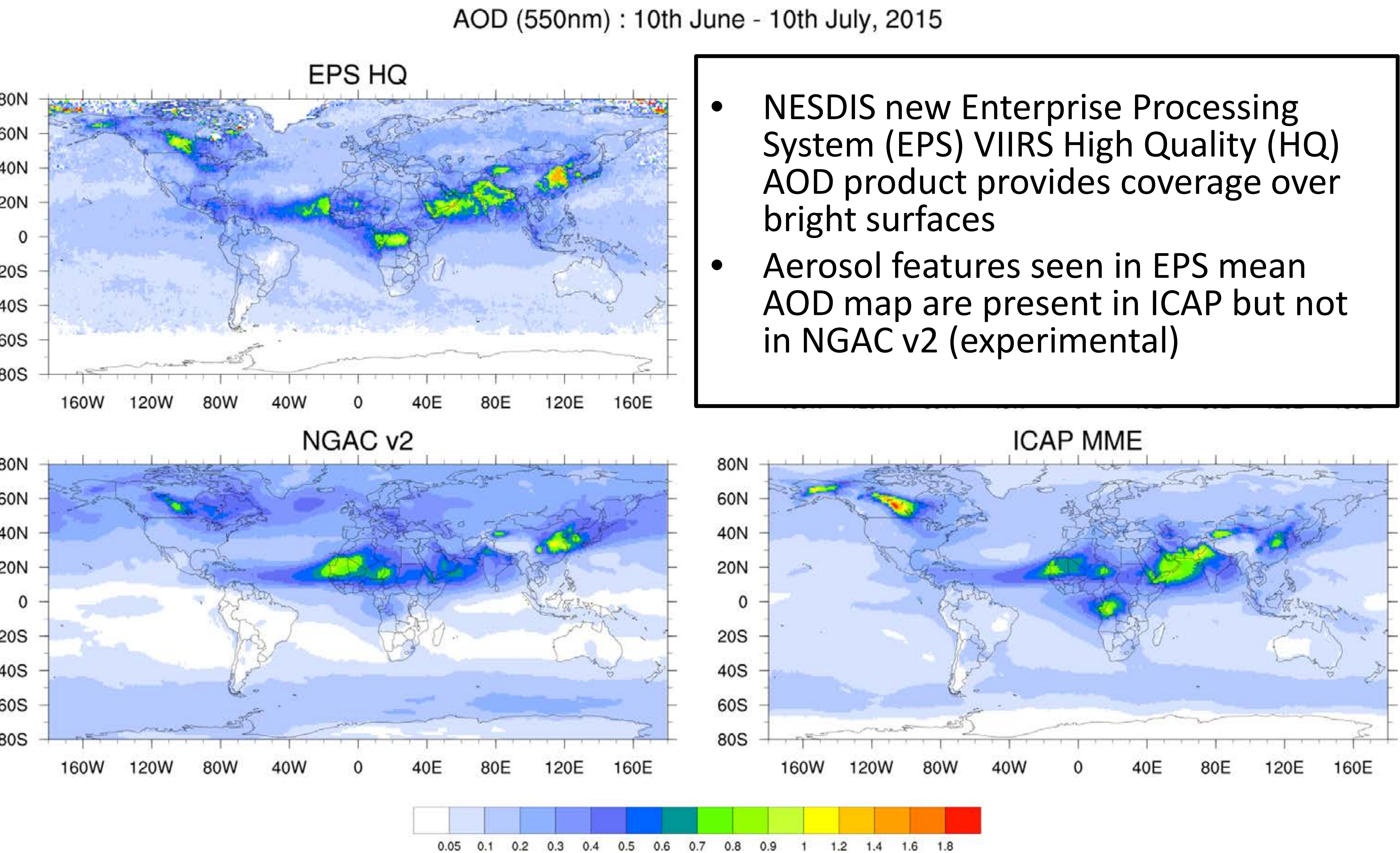
- GOCART interface in GSI:
  - GSI code modified to read in NGAC first guess
- Observation reading interface in GSI:
  - GSI code modified to read VIIRS AOD
  - Observation thinning for VIIRS AOD will be done in reading step.
- Specification of background error
  - Calculated using the NMC method
  - Spatial correlation for GOCART aerosol species
- Specification of observation errors
  - Determined from VIIRS versus AERONET comparisons (VIIRS Cal/Val)
- Observation operator
  - Use JCSDA Community Radiative Transfer Model (CRTM V2.2.3) as observation operator for VIIRS AOD
  - Forward and Jacobian models
- Synergistic activities:
  - VIIRS AOD from Enterprise algorithm has been encoded in BUFR format and dumped to a development database at EMC

Outline

1. Scope of global aerosol prediction at NCEP
2. The need for aerosol data assimilation
3. Status update in aerosol data assimilation
4. Conclusions

Concluding Remarks

- NESDIS new Enterprise Processing System (EPS) VIIRS High Quality (HQ) AOD product provides coverage over bright surfaces
- Aerosol features seen in EPS mean AOD map are present in ICAP but not in NGAC v2 (experimental)



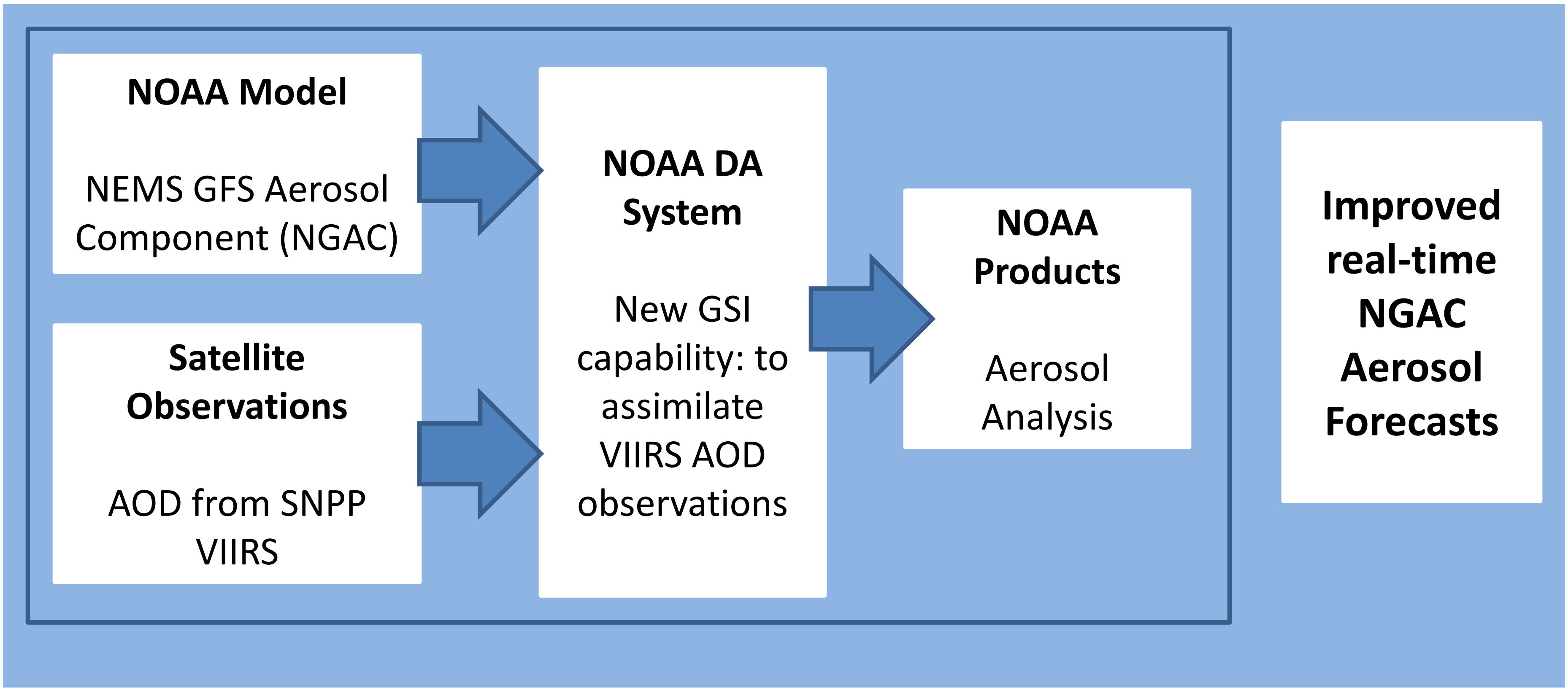
Concluding Remarks

- Ongoing efforts:
  - VIIRS AOD data assimilation using GSI and NGAC
  - The prototype system is being testing and evaluated

- Planned activities
  - Ensemble-based DA (Unified Global Coupled System)
  - Assimilate aerosol observations from multiple platforms

BackUp Slides

Improving NCEP global aerosol forecasts using SNPP VIIRS aerosol products

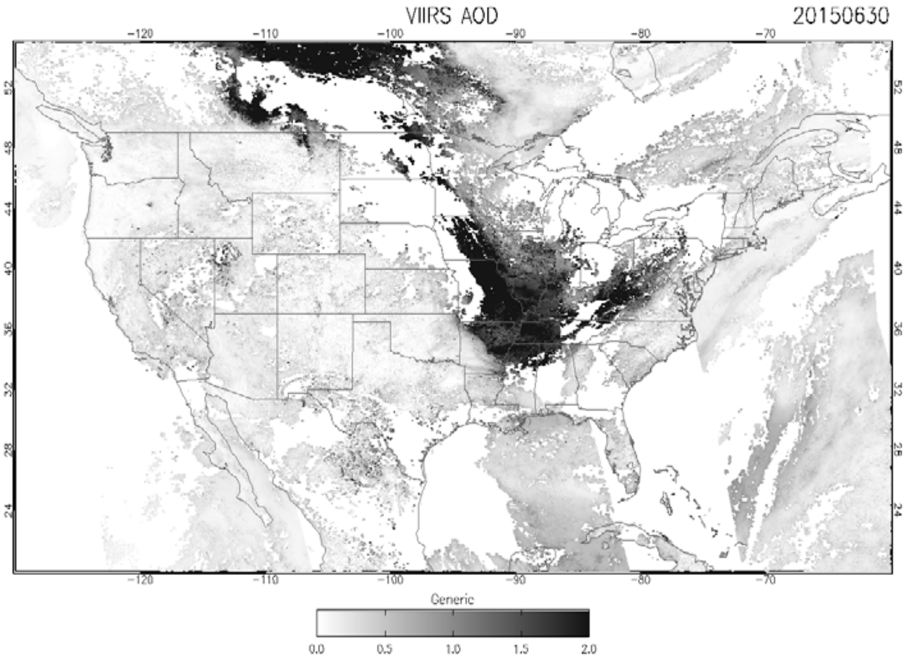


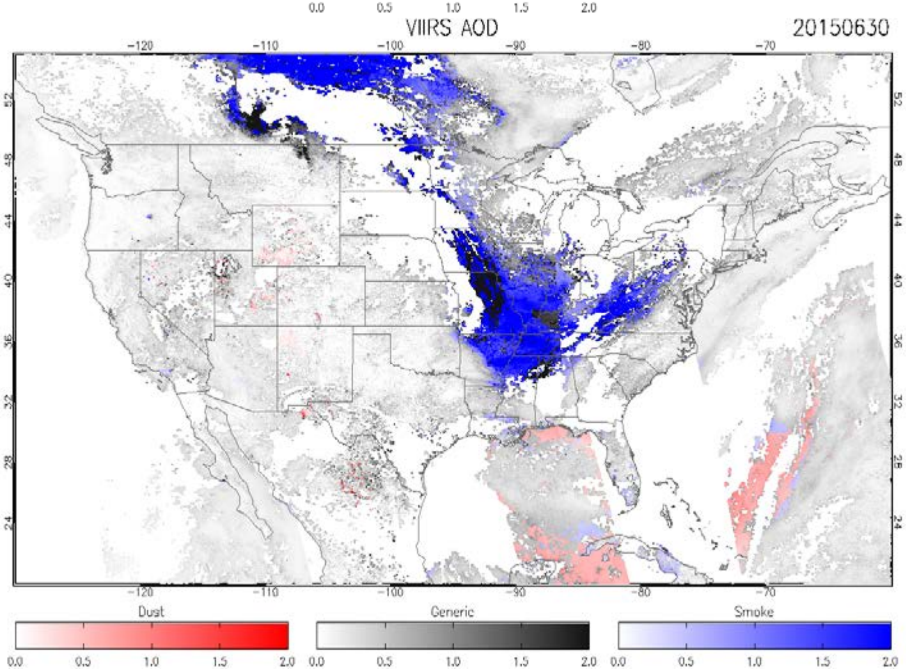
Major Milestones:

- Data assimilation grade VIIRS aerosol products
- Prototype GSI VIIRS AOD assimilation system

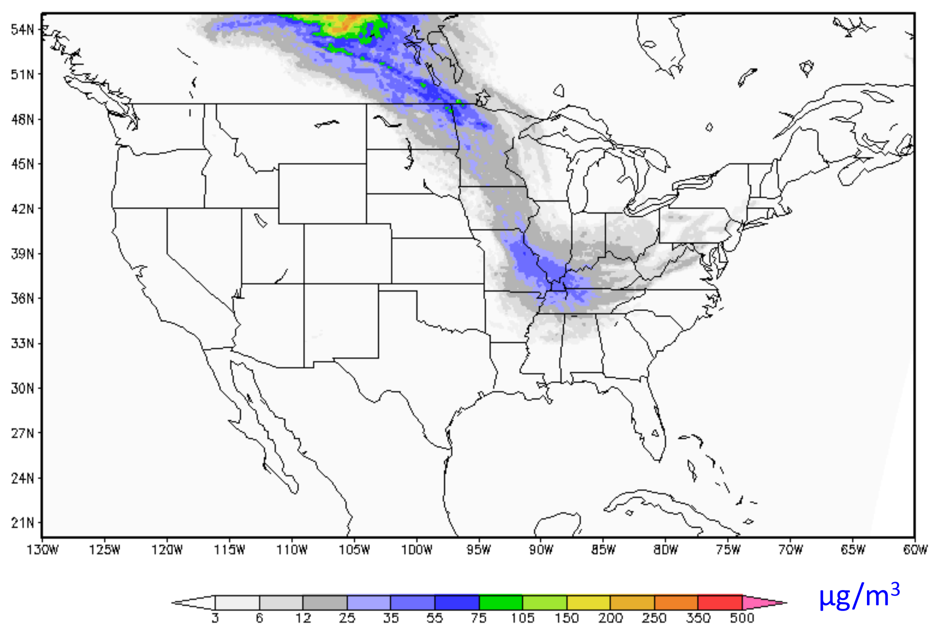
Quick Checkup of VIIRS Aerosol Products

- VIIRS Enterprise Algorithm AOD Product
  - Moderate channel resolution ~750m
  - Daily global coverage with 14-15 orbits
- VIIRS Smoke/Dust Detection Product
  - DAI based algorithm with deep-blue channels
  - Detects dust and smoke plumes
- A few wildfire episodes were selected based on operational HYSPLIT model smoke forecasts
- HYSPLIT smoke forecasts were taken as reference and compared against





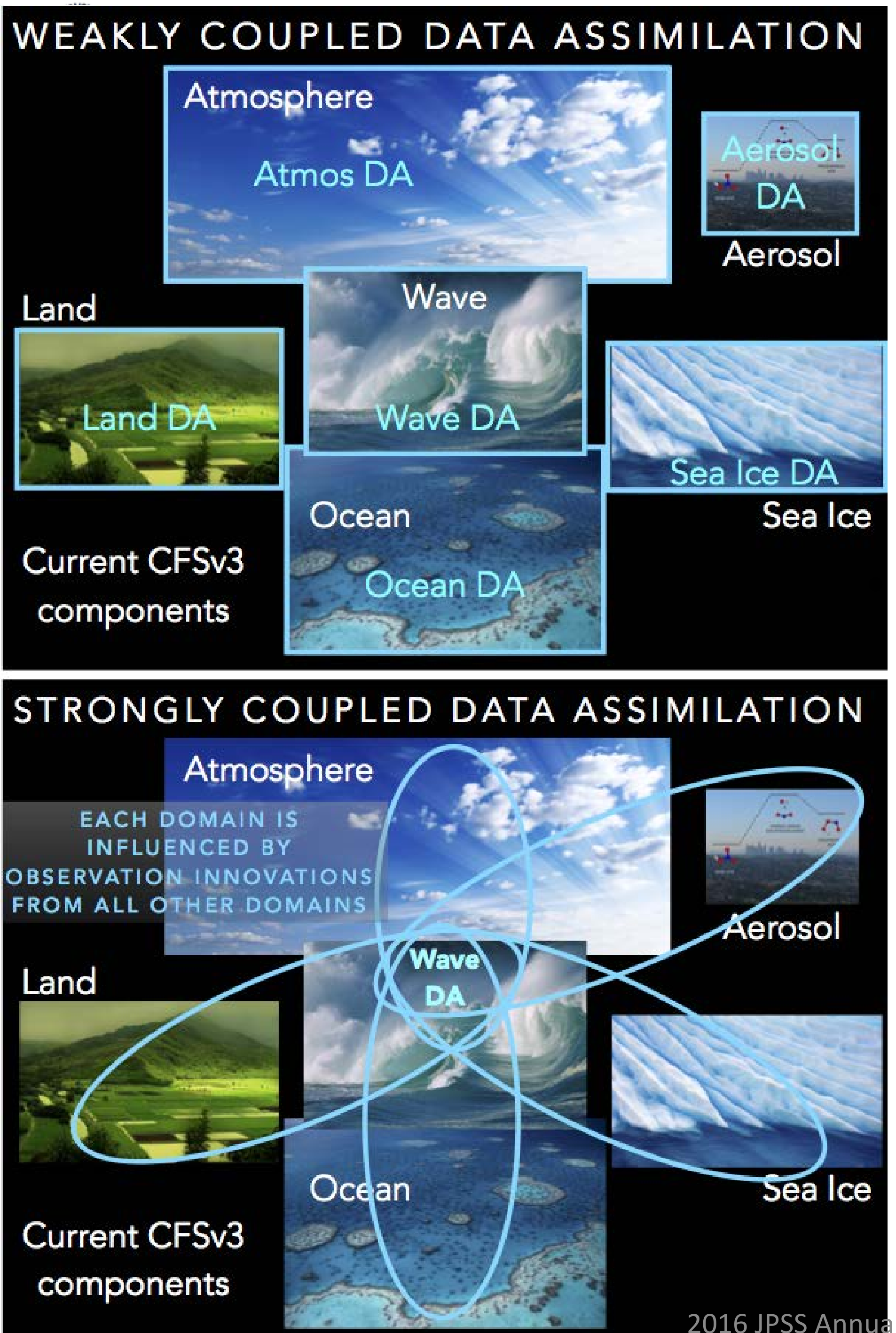
HYSPLIT Column Average Smoke Concentration 2015063018



Unified Global Coupled System (UGCS)

- Efforts are underway at NCEP/EMC to develop a fully-coupled ensemble-based DA system for earth system components, including atmosphere, ocean, land, sea ice, wave, and aerosols.

- The UGCS-aerosol infrastructure will leverage the variational GSI efforts project (e.g., quality assurance and bias-correction of the VIIRS AOD observations; specification of the observation errors; observation operator implemented in the GSI)



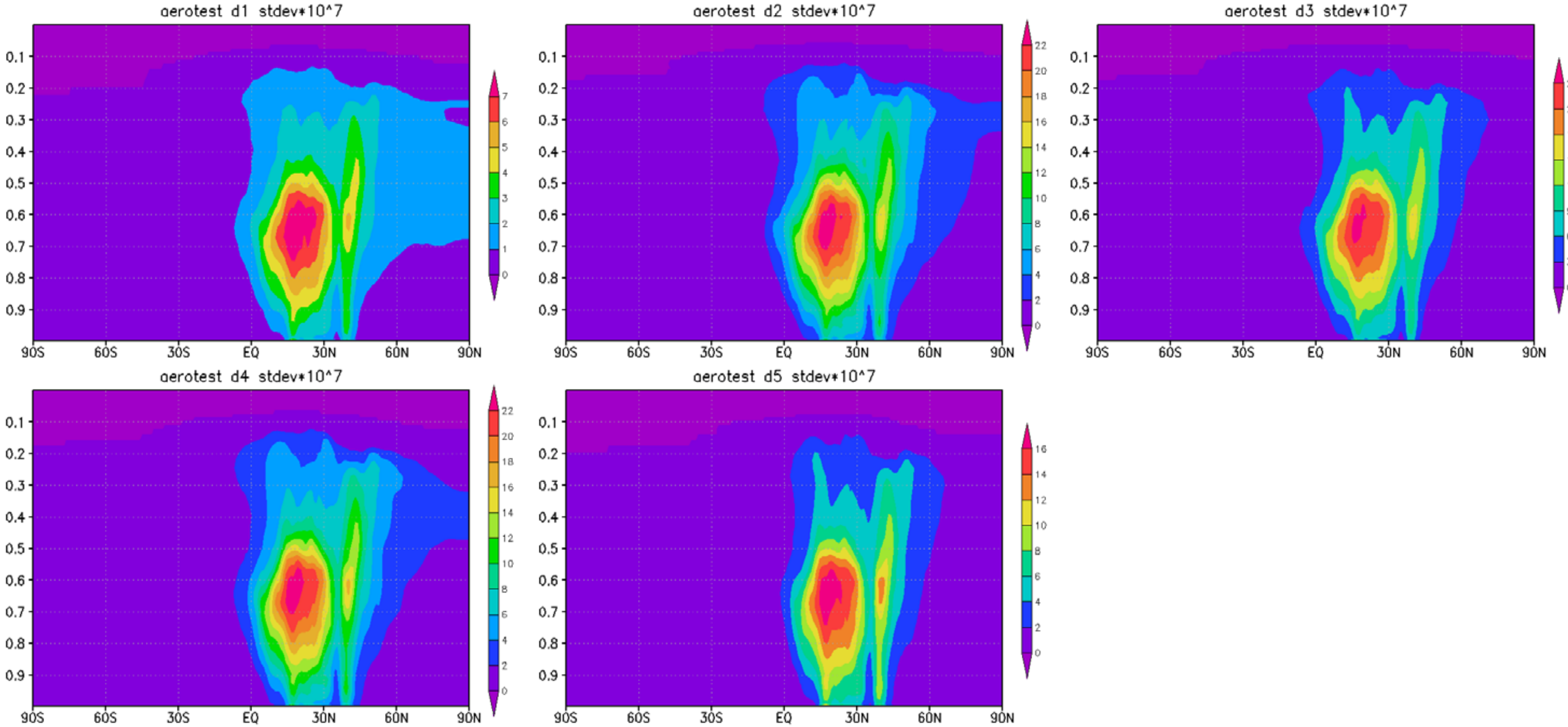
Weak coupling

- Aerosol analysis is combined with the independent analyses from the other system components to produce a coupled forecast.

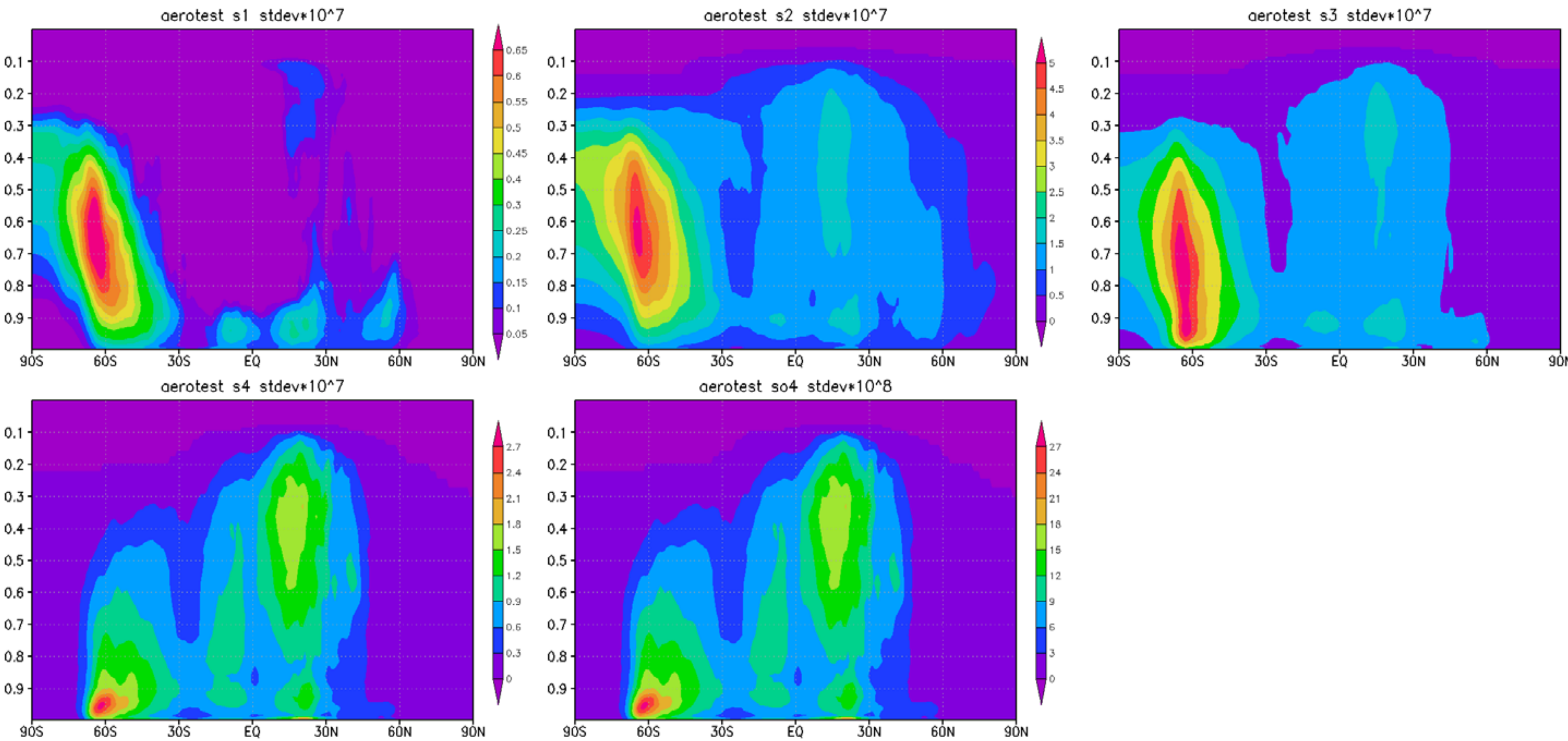
Strong coupling

- Incorporate innovations from other system components
- Iterative testing of the addition of innovations, e.g., sea surface temperature from the ocean component, soil moisture from the land component, and winds from the atmosphere component.)

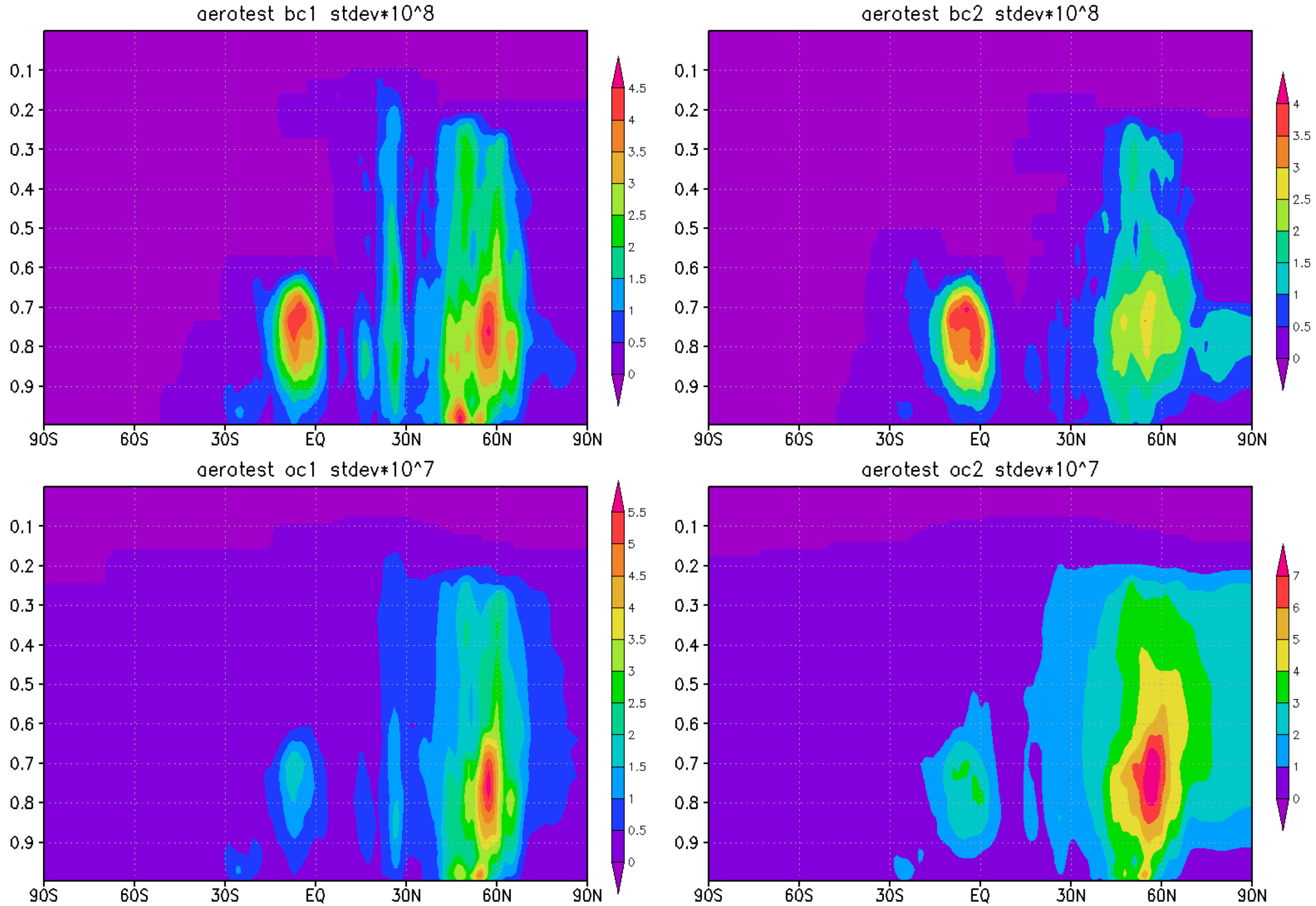
Dust bin 1 to bin 5 standard deviation



Sea salt bin 1 to bin 4 and sulfate standard deviation



OC and BC standard deviation



Assimilation of VIIRS AOD and dust and smoke products for regional forecasting of aerosols

Mariusz Pagowski, Georg Grell [1]
Shobha Kondragunta, Pubu Ciren, Hai Zhang [2]

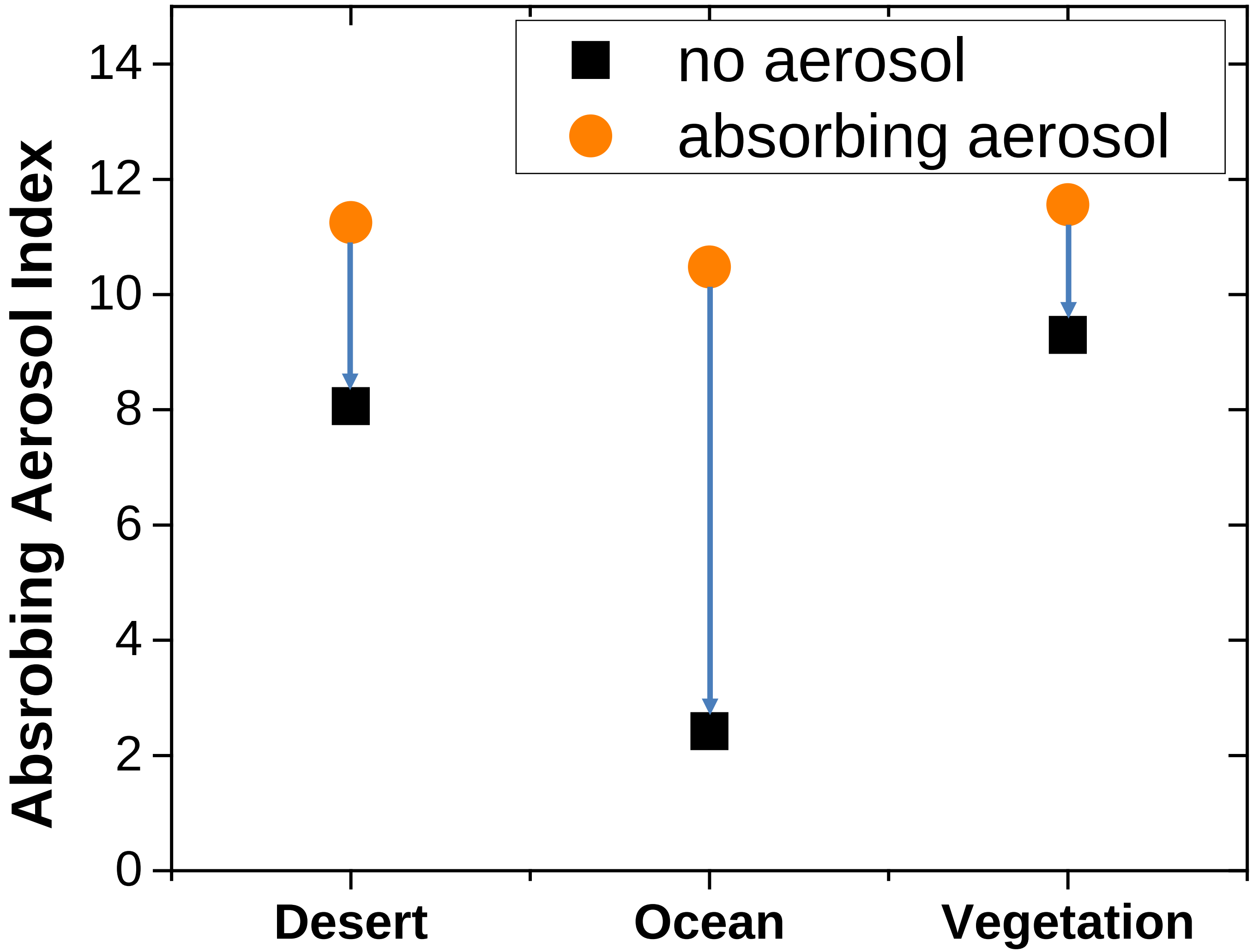
[1] NOAA/ESRL, Boulder, CO, USA
[2] NOAA/NESDIS, College Park, MD, USA

Outline

- Simulations with regional model WRF-Chem of smoke fires over CONUS in July 2016 and a dust storm over Northern Africa/Europe in March 2014 .

- Assimilation of VIIRS Aerosol Optical Depth at 550 nm using 3D-Var algorithm in the Gridpoint Statistical Interpolation (GSI) (assimilation of VIIRS AOD at 550 nm has been implemented in the GSI and submitted for review to be include in the trunk for public distribution)

- In parallel to the above assimilation of VIIRS AOD 550nm combined with smoke and dust masks. VIIRS AOD and masks are obtained daily from NESDIS ftp with minimal delay and are being tested for application for assimilation into RAP-Chem and HRRR-Smoke forecasts.



$$AAI = -100[1og_{10}(R_{412}/R_{440}) - \log_{10}(R'_{412}/R'_{440})]$$

Contrast between 412 and 440 nm for dust in the atmosphere

Contrast between 412 and 440 nm for Rayleigh atmosphere

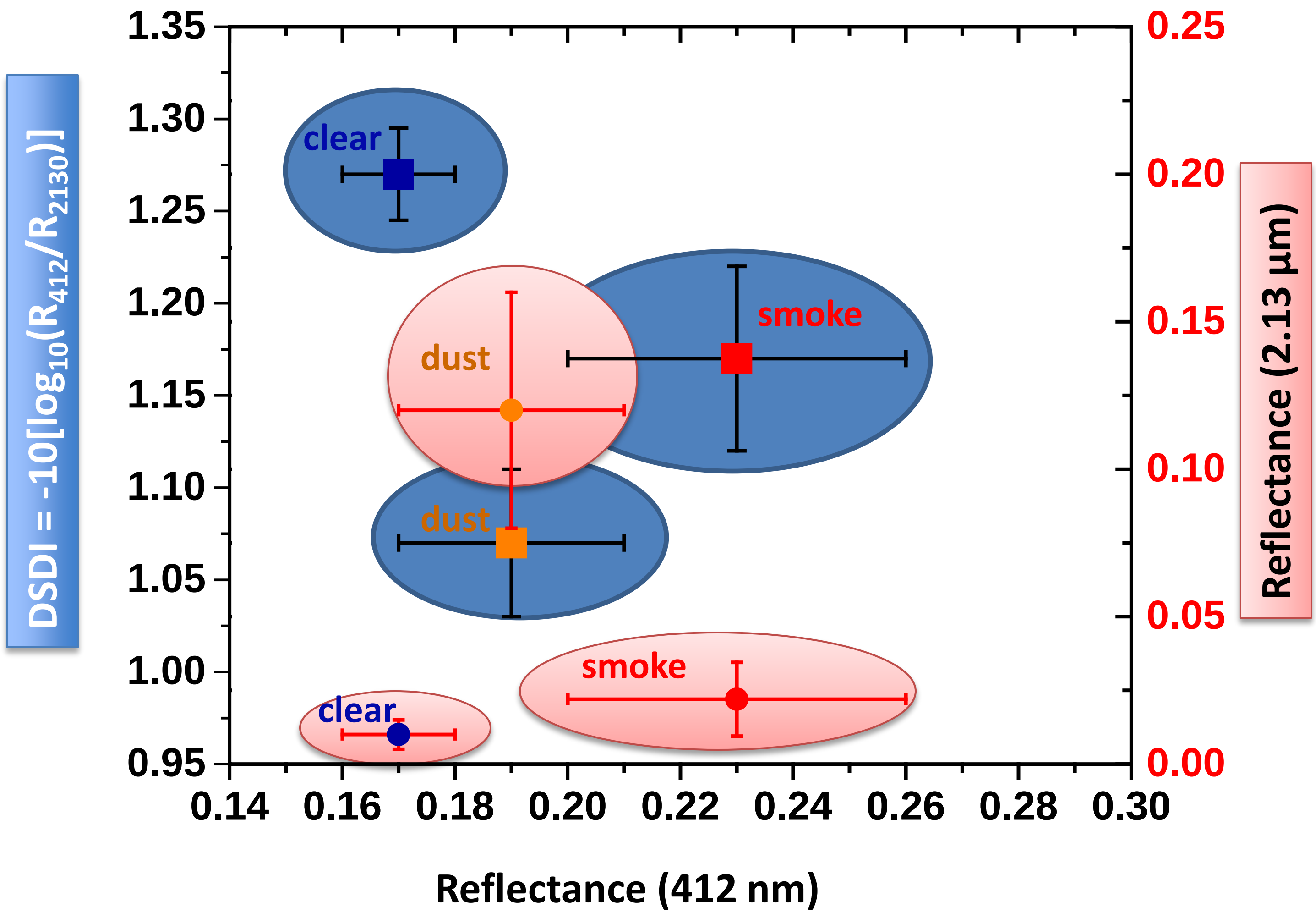
VIIRS dust detection algorithm takes advantage of changes to spectral contrast with and without dust in the atmosphere - *Spectral contrast change provides absorbing aerosol index (AAI).*

Dust Smoke Discrimination Index (DSDI) separates smoke from dust (next slide)

Dust Smoke Discrimination Index (DSDI) separates the absorbing aerosol into dust or smoke

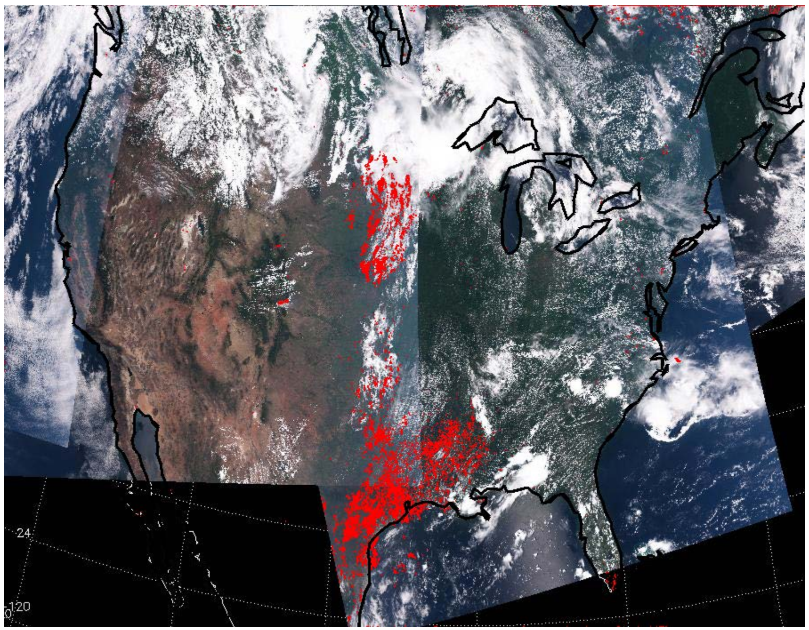
•Contrast between VIIRS-measured reflectance at 412 nm and 2.13 µm for clear sky (Rayleigh atmosphere) is reduced for **smoke** and **dust**.

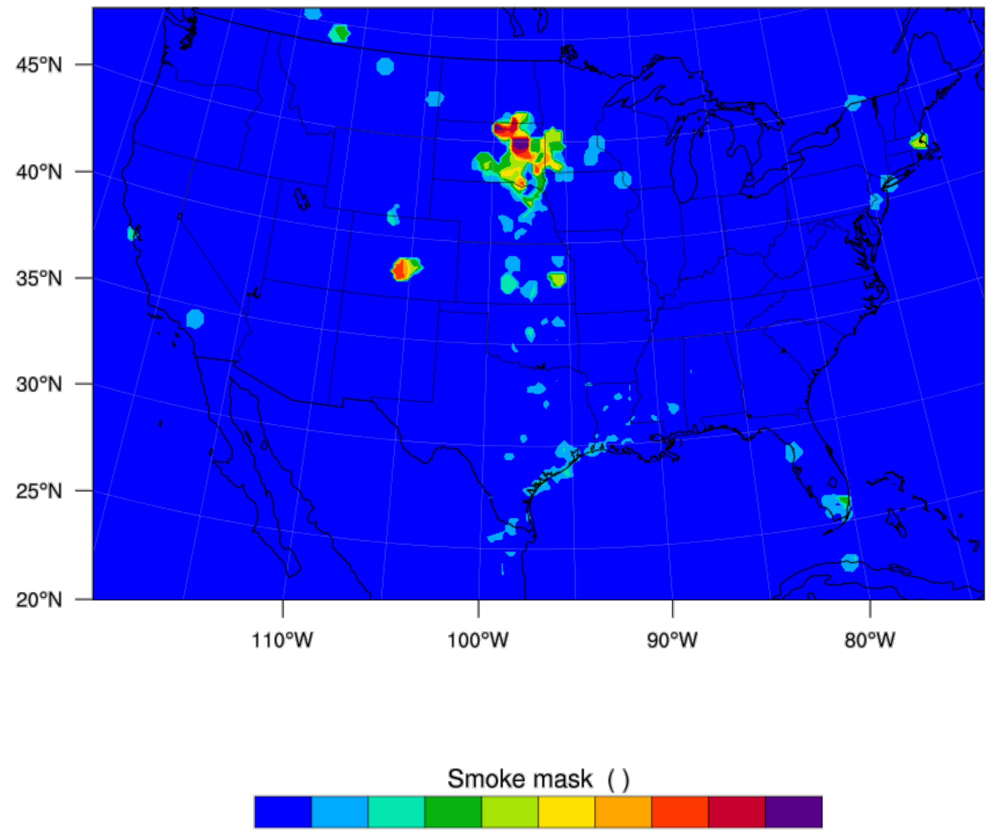
• VIIRS measured reflectance at 2.13 µm is higher for dust (due to scattering) than **smoke** (transparent)



Smoke assimilation

20160711





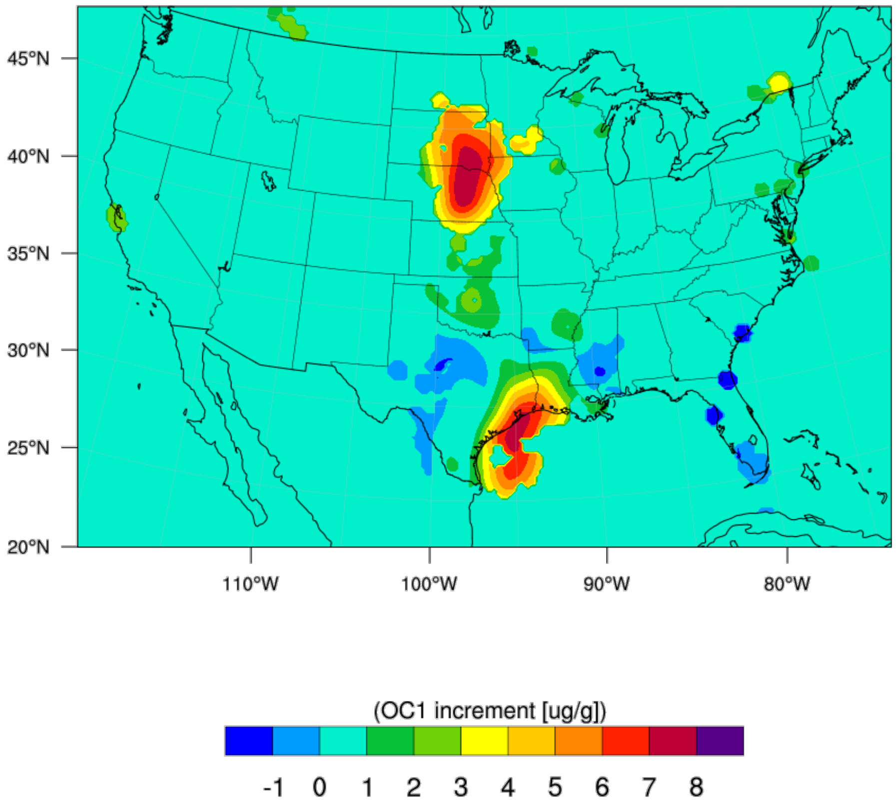
Smoke mask (not AOD i.e. neither intensity nor dust/smoke index); composition of three satellite passes from ~17 UTC to ~21 UTC.

Smoke index interpolated in model space

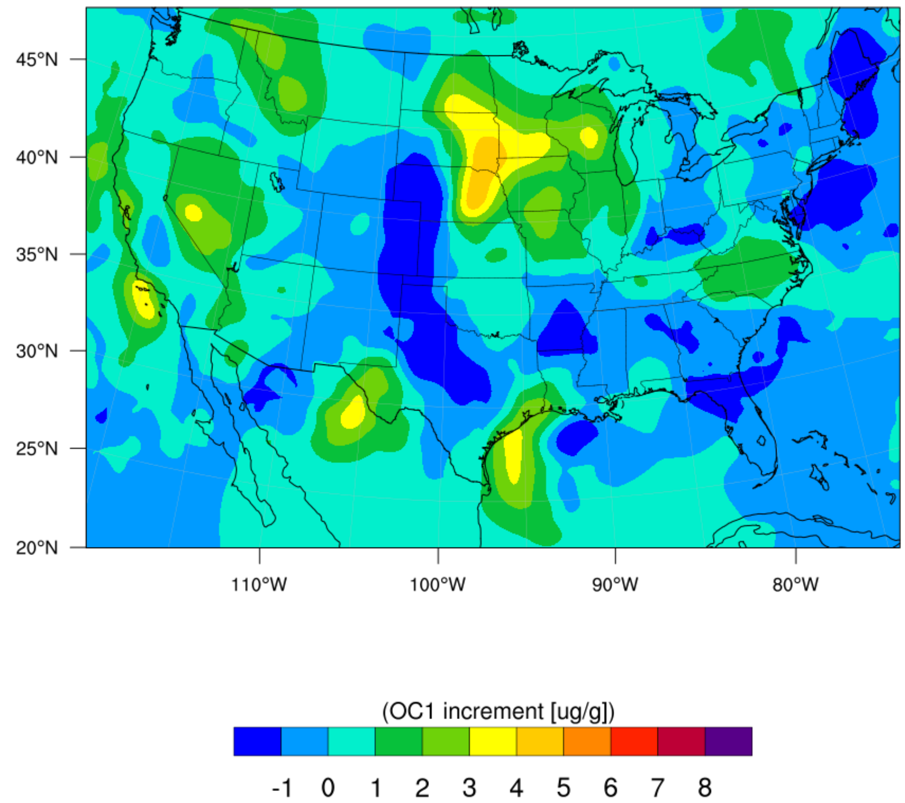
Smoke assimilation

Assimilation of AOD at 550 nm centered at 1800 UTC with 3-hr window.

2016071118

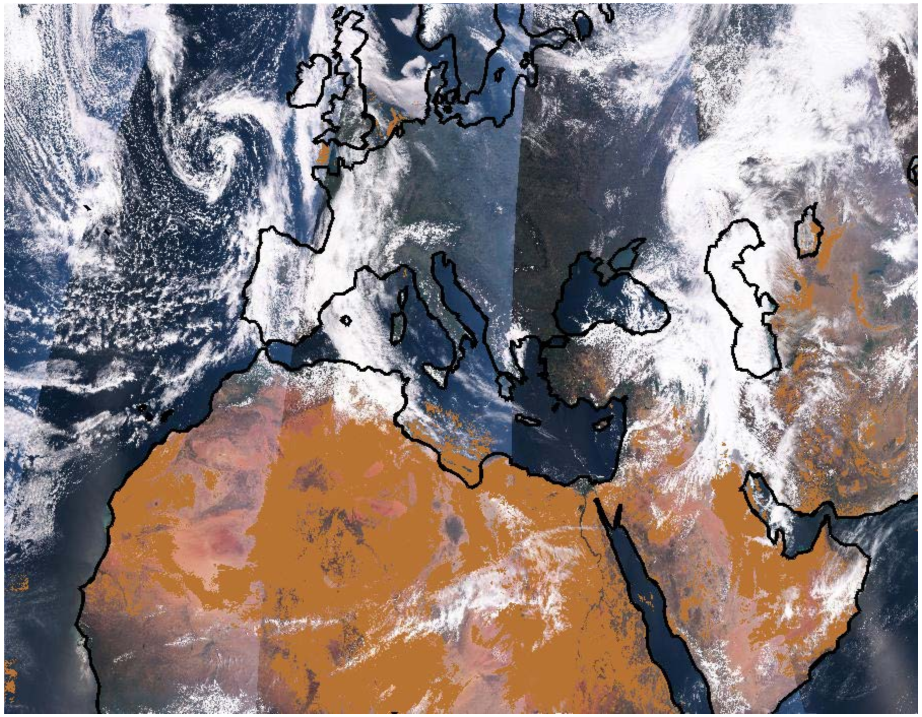


With smoke mask

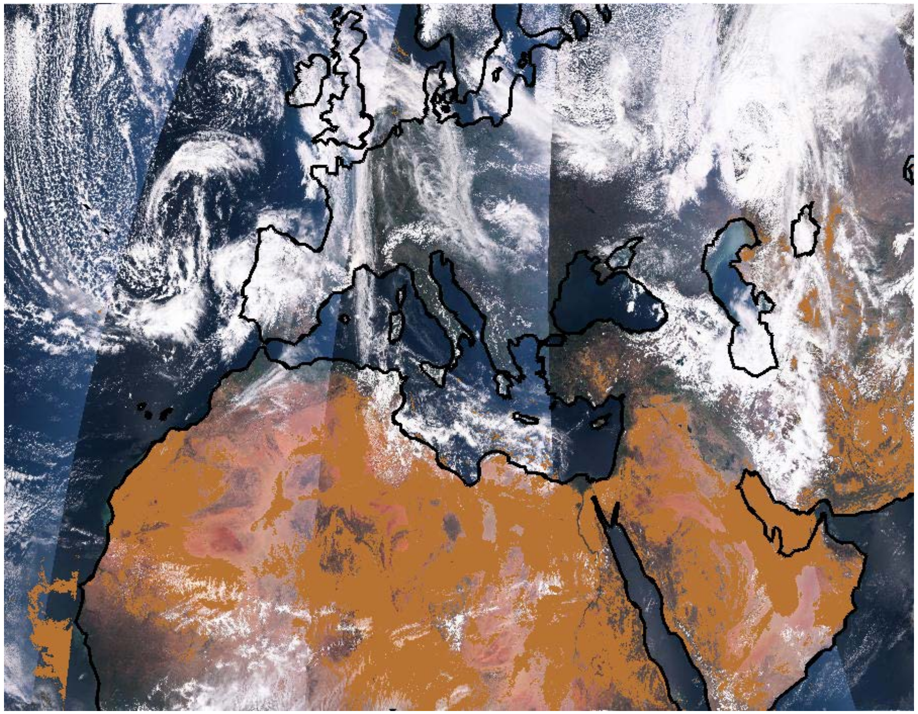


Without smoke mask

Data assimilation



20140330

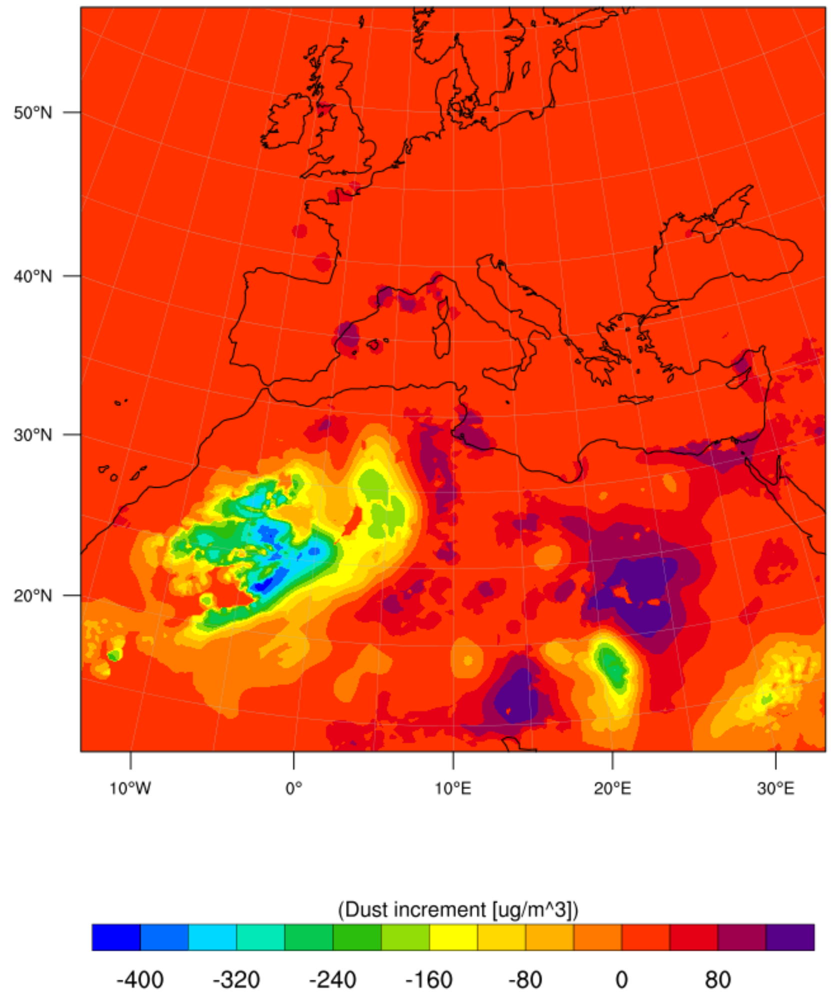


20140331

Dust mask (not AOD i.e. not intensity).
Composition of five satellite passes from ~09 UTC to ~16 UTC.
Assimilation of AOD at 550 nm centered at 1200 UTC with 3-hr window.

Data Assimilation

Increment of total dust at the surface at 2014033012
due to the assimilation of VIIRS AOD at 550 nm with dust mask



Conclusions

- Testing of assimilation of VIIRS AOD 550nm and masks and their influence on aerosols forecasts is underway for possible application in r-t RAP-Chem and HRRR-Smoke.

- We are be developing a chemical global model for NGGPS with VIIRS AOD data assimilation as a component.

- In our opinion AOD assimilation in global domain more impactful because dor regional domains satellite coverage limited and also because of dependence on lateral conditions.

Forecasting the Impact of Smoke from Mt McMurray Fires on U.S. Air Quality using S-NPP VIIRS Aerosol Products

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STAR JPSS Annual Science Team Meeting

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Operational Air Quality Forecasting

- State, local, and tribal agencies issue air quality forecasts to protect the public from the adverse health effects of criteria pollutants
  - 43 states plus Washington, DC
  - O_3, $PM_{2.5}$, PM_{10} most commonly forecasted pollutants
  - Based on EPA's color coded Air Quality Index (AQI)
  - Forecasts typically issued by mid-afternoon (~3 PM) for next day; some agencies do morning updates
  - Forecasts available on state and local websites and EPA's AirNow national website (http://www.airnow.gov/)

Wildfire Smoke is a Problem for $PM_{2.5}$ Forecasts

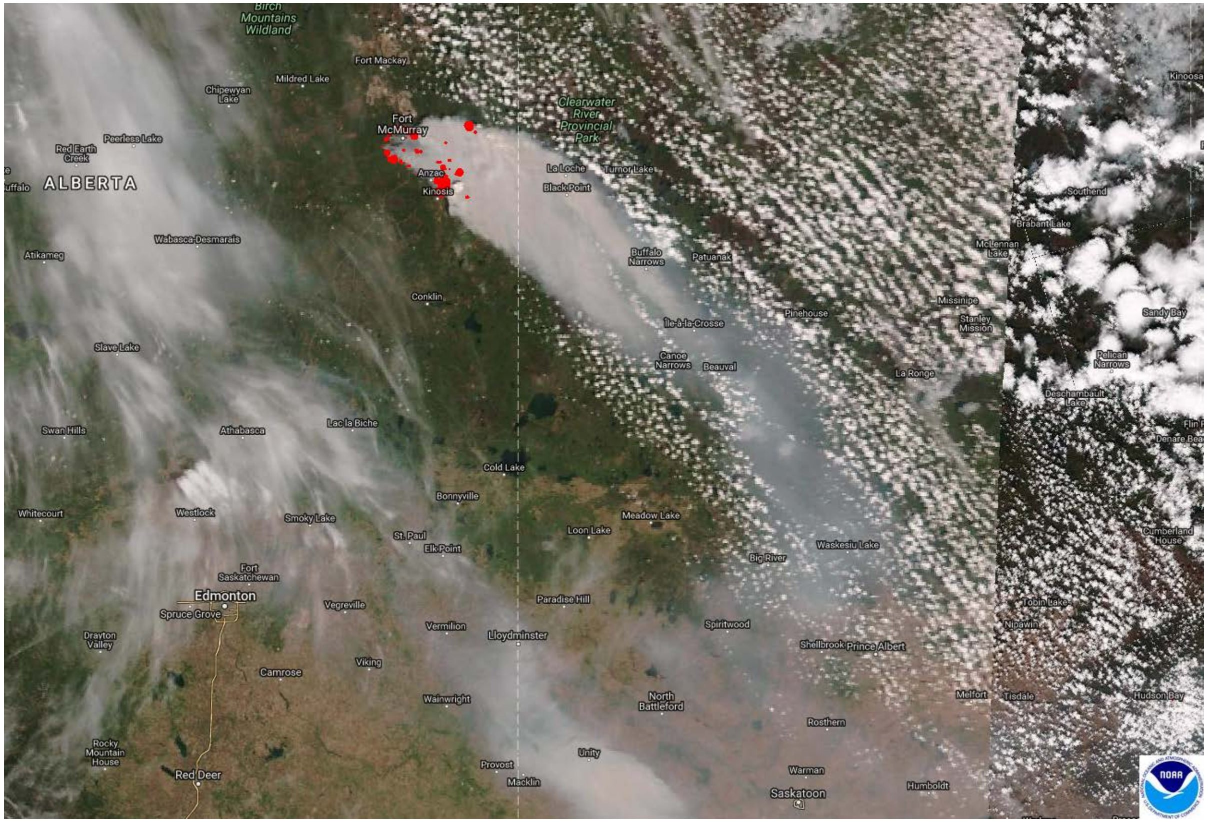
- $PM_{2.5}$ is a mixture of solid and liquid particles with aerodynamic diameters ≤ 2.5 μm
- Smoke from major wildfires can be transported long distances, sometimes 100s of km downwind
- If smoke mixes to surface, it can impact local $PM_{2.5}$ conditions
  - Can cause exceedance of daily National Ambient Air Quality Standard (NAAQS): 35 μg/m^3 (24-hr)
  - Observed Code Orange or higher $PM_{2.5}$ corresponds to exceedance of NAAQS
  - Forecasted Code Orange or higher $PM_{2.5}$: Air Quality Alert (AQA) issued

Very Difficult to Forecast Impacts of Smoke

- Forecasters have variety of tools they use as guidance to prepare $PM_{2.5}$ forecasts, but none are skillful in case of transported smoke
- Climatology: smoke events are rare for most locations
- Persistence: can't account for first day of smoke event (but can be useful for multi-day smoke events)
- Numerical $PM_{2.5}$ models: don't include transported smoke in boundary conditions
- So forecasters turn to satellite aerosol products to track smoke plumes and predict whether smoke will mix to surface

Case Study: Fort McMurray Fire, May 2016

- Ft McMurray fire began May 1, 2016
  - Burned for more than 1 month
  - Consumed > 600,000 hectacres
  - Forced evacuation of > 88,000 residents from city in early May

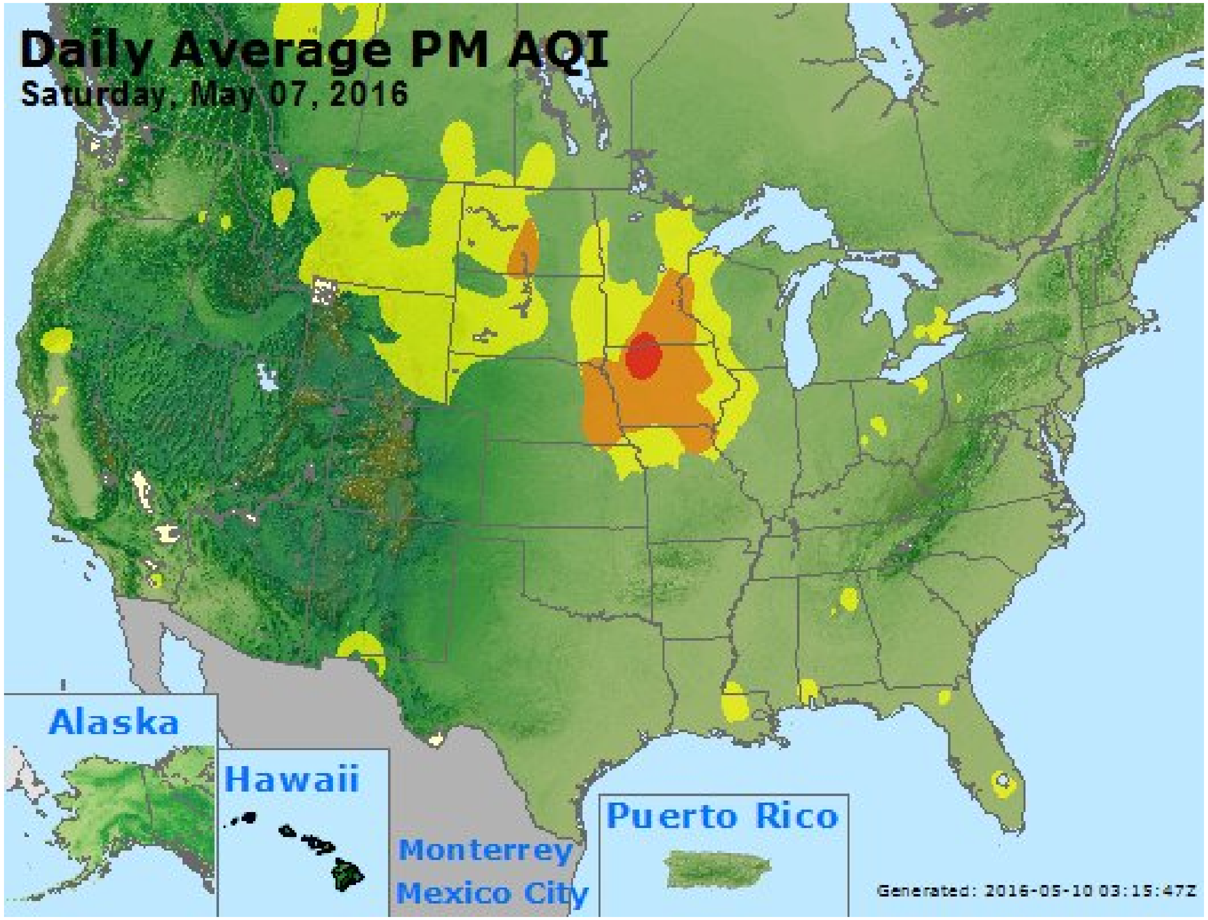


VIIRS RGB and FRP
May 6, 2016

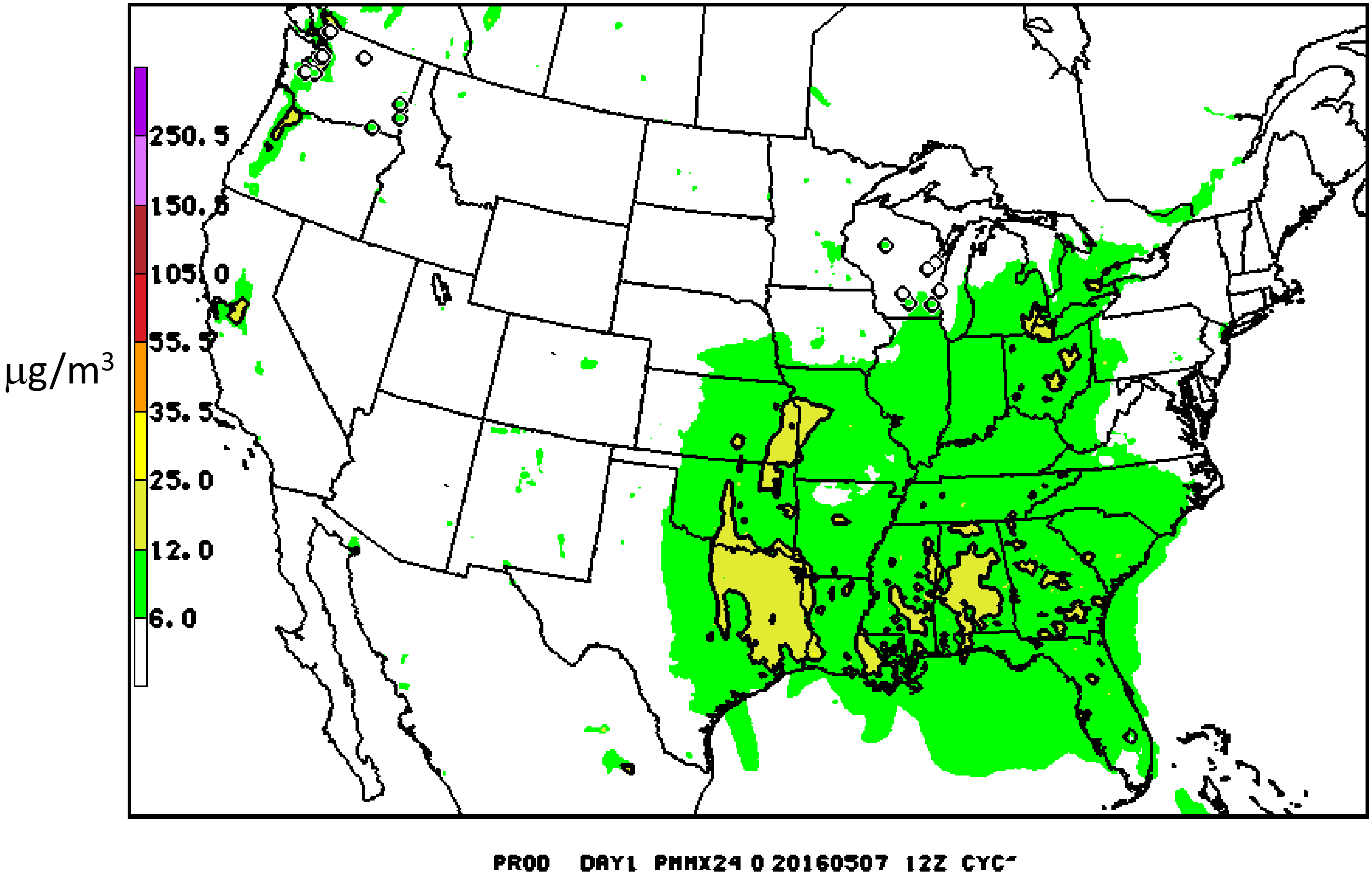
Smoke Transported to Northern Plains, May 7

- Smoke from Ft McMurray fire traveled to N. Plains states and caused widespread exceedances of $PM_{2.5}$ NAAQS on May 7
- Event only lasted one day – $PM_{2.5}$ dropped to Code Yellow on May 8

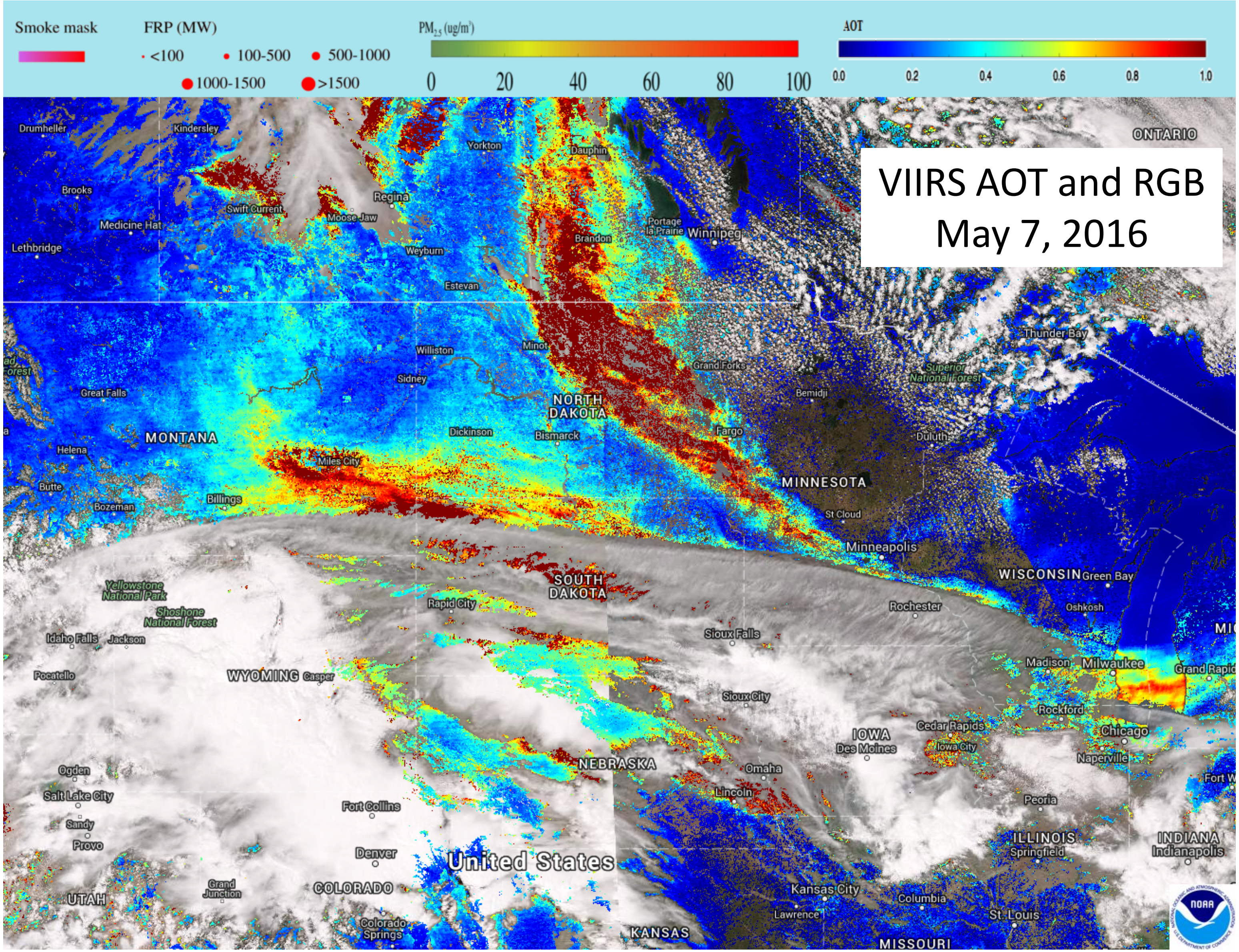
Good	0 to 50
Moderate	51 to 100
Unhealthy for Sensitive Groups	101 to 150
Unhealthy	151 to 200
Very Unhealthy	201 to 300
Hazardous	301 to 500



Operational $PM_{2.5}$ Model Did Not Predict Smoke Impacts

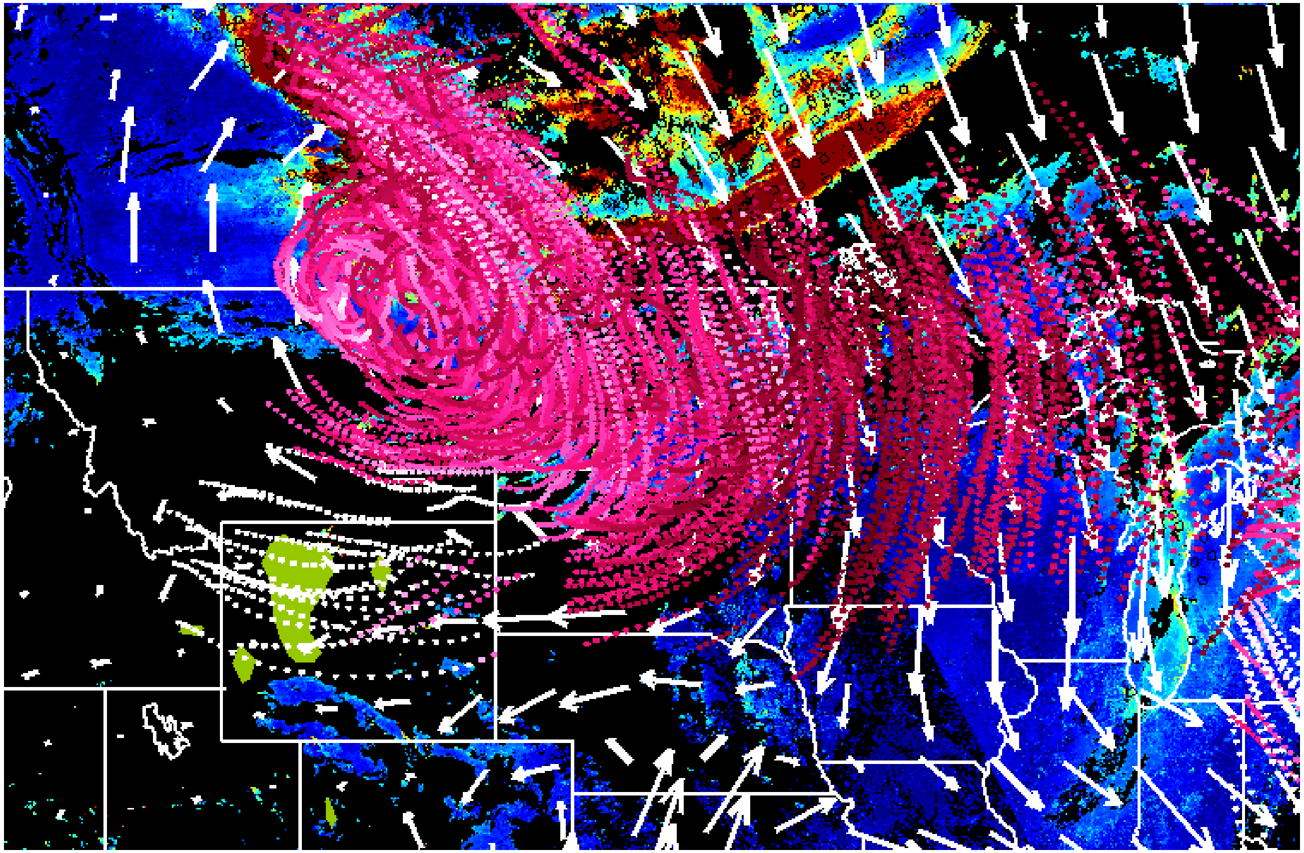


VIIRS Aerosol Products Showed Smoke Transport



Best Forecast Tool is 48-Hr Forward Trajectories

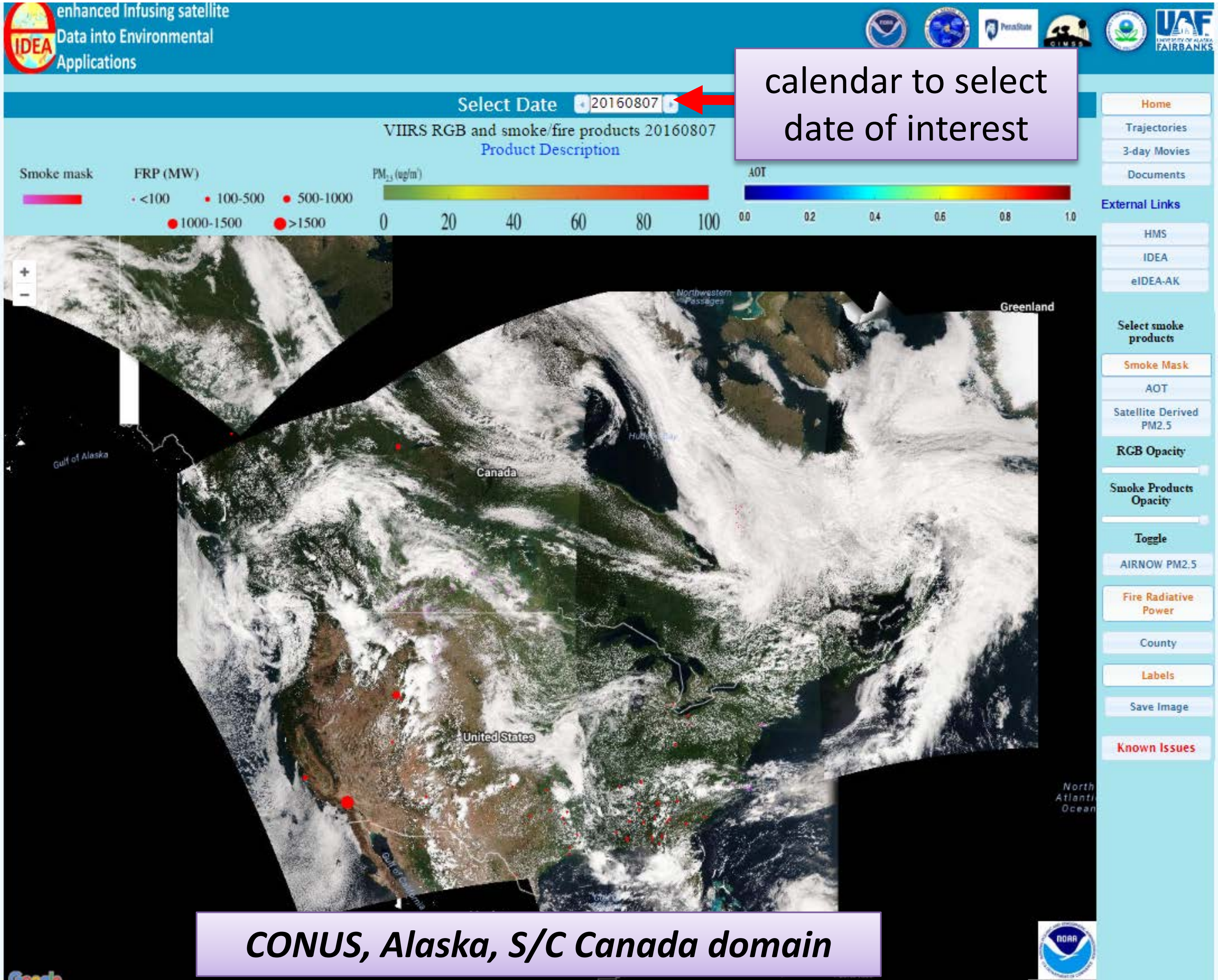
- Static example of 48-hr trajectories initiated at 12 UTC May 6
- Trajectories originated at areas of high observed AOT (> 0.4)
- Magenta/pink lines indicate transport of smoke S/SW into Plains states, remaining near the surface



Trajectory at 15 UTC May 7, 2016

eIDEA: New 1-Stop Fire and Smoke Imagery

http://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/



calendar to select date of interest

animations and external links

main product overlay buttons

CONUS, Alaska, S/C Canada domain

Importance of VIIRS Aerosol Products for Forecasting Impacts of Transported Smoke

- VIIRS RGB and AOD essential for identifying smoke plume transport upwind
  - Gives forecasters a heads-up when smoke may be heading toward forecast area
  - Use in conjunction with surface $PM_{2.5}$ measurements to determine when smoke is impacting surface air quality
- 48-hour aerosol trajectories critical tool for identifying when smoke will reach surface in forecast area
  - No other forecast tools can predict when transported smoke will move into forecast area and mix to surface
- New eIDEA website designed for operational users