



VIIRS EDR IMAGERY OVERVIEW

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VIIRS EDR Imagery Team
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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 <ul style="list-style-type: none"> • Cross-track scans • Bowtie (on spacecraft) deletions • Overlapping pixels 	Ground Track Mercator (GTM) projection: <ul style="list-style-type: none"> • 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

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

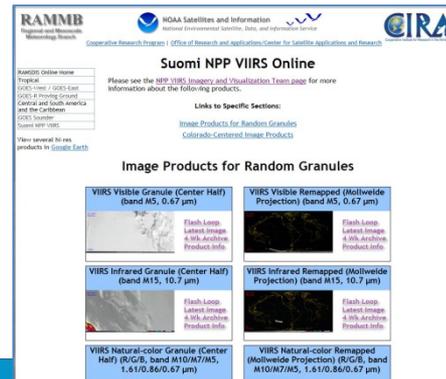
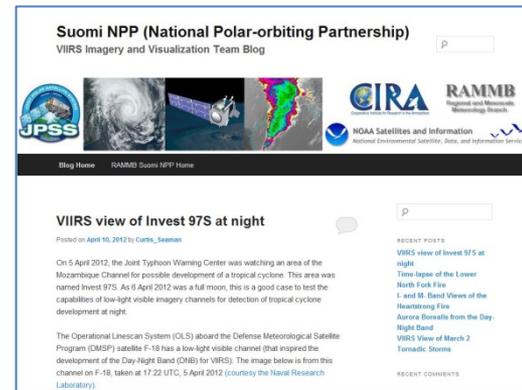
KPPs	EDRs	Total VIIRS bands
8	12	22

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

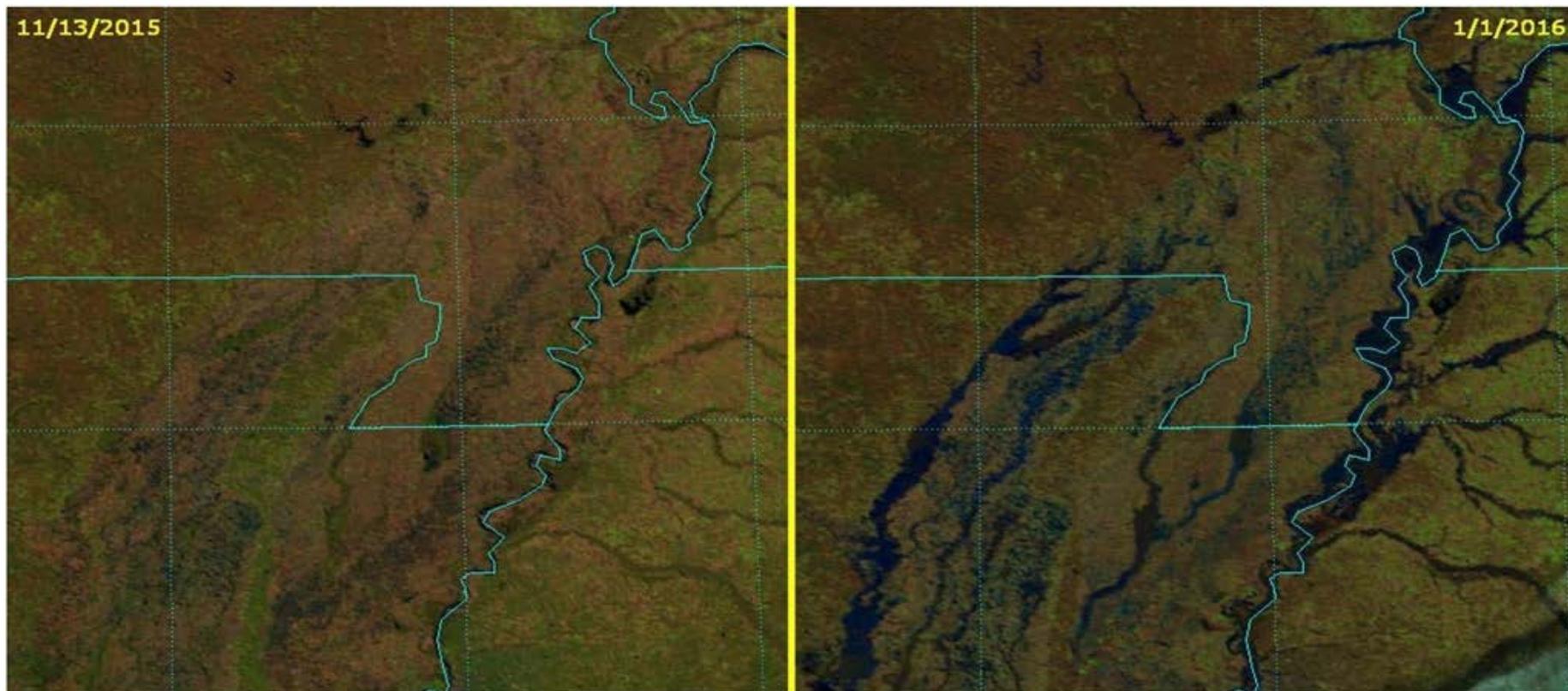


Figure JPSS-2. VIIRS Natural Color RGB composite imagery from Nov. 13, 2015 (left) and Jan. 1, 2016 (right) reveals the extent of the flooding in the Midwest due to heavy rains that occurred between the Christmas and New Year's holidays. The VIIRS Imagery and Visualization Team Blog updated their post 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

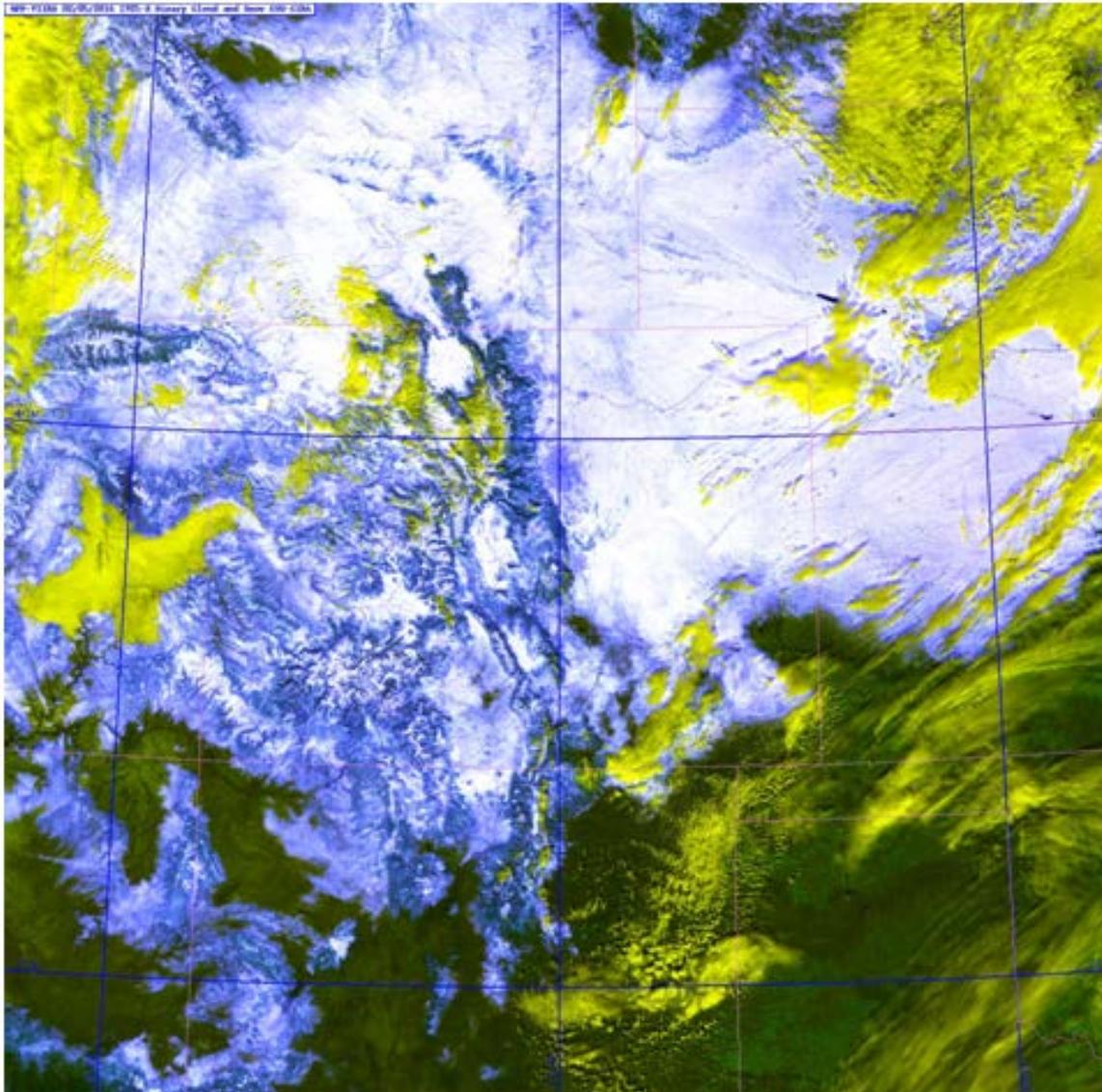


Figure JPSS-11. The image was taken @ 1925Z on 5 February 2016, a few days after a snowstorm that came through the state of Colorado, 1-2 February 2016. The image shows the state of Colorado and its neighboring states, where it discriminates and highlights the differences between snow on the ground (white) 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

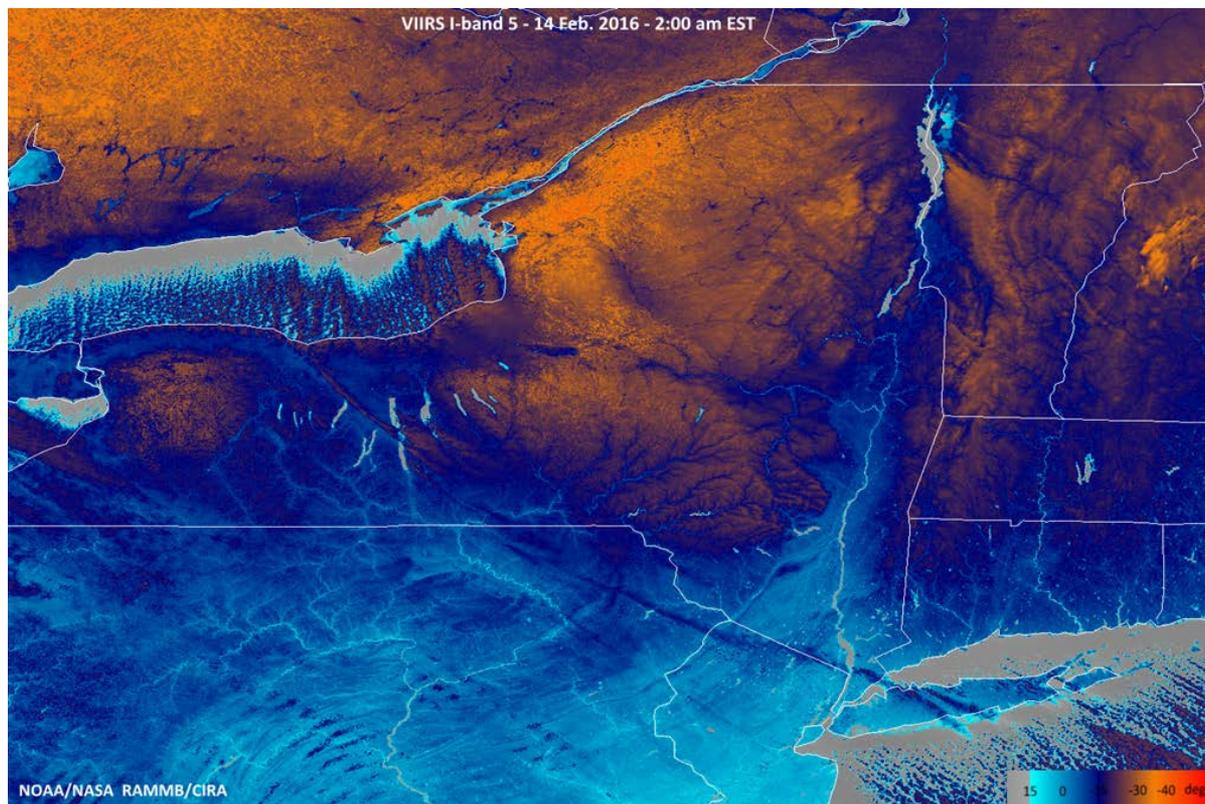


Figure JPSS-10. A bitterly cold airmass dropped over the northeast U.S. on Valentine's Day (Feb. 14, 2016), resulting in many daily record cold temperatures, including in Albany, Watertown, and Syracuse, New York. It was also the coldest temperatures observed in several decades in a number of locations. 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

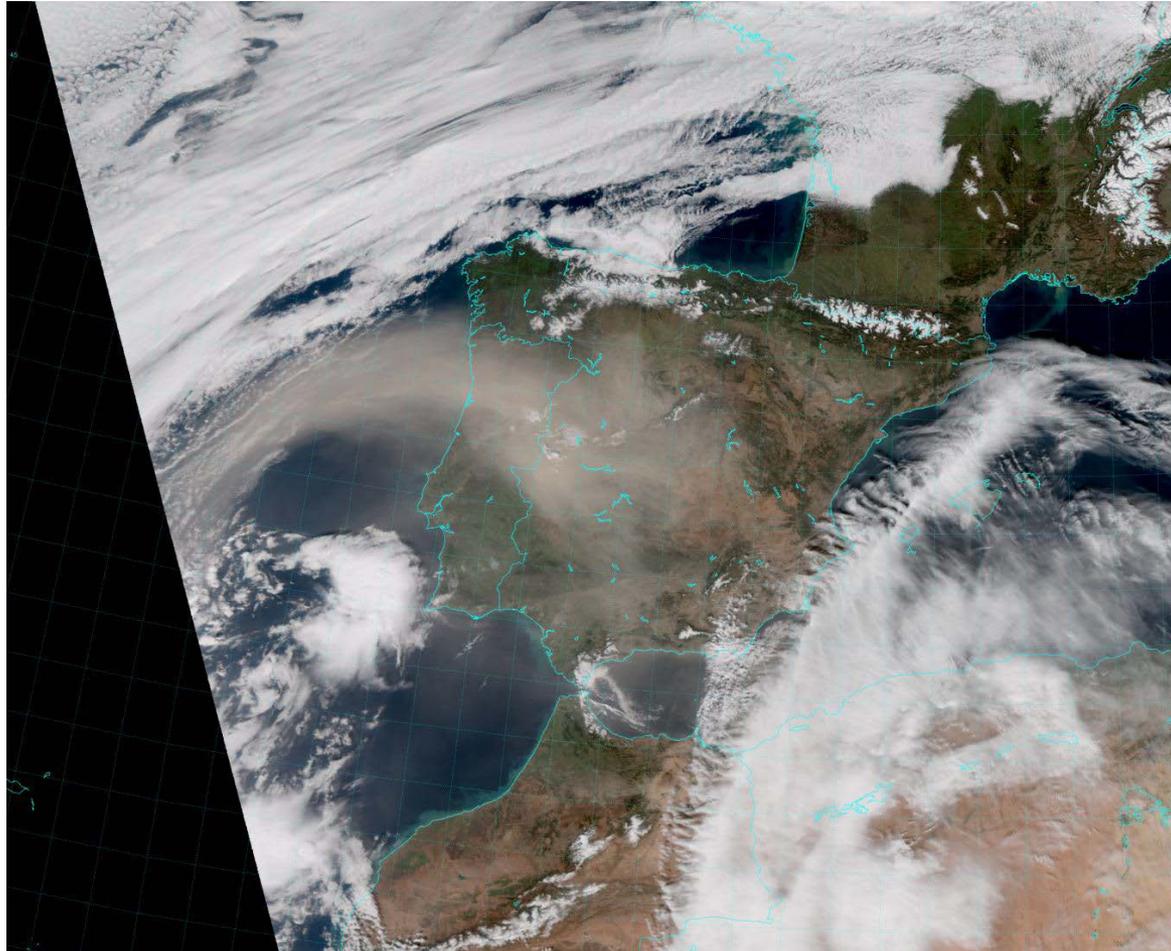


Figure JPSS-1. VIIRS True Color RGB composite image of Saharan dust outbreak over Spain and Portugal (12:40 UTC 21 February 2016).

Image of the Month – Fort McMurray Wildfires

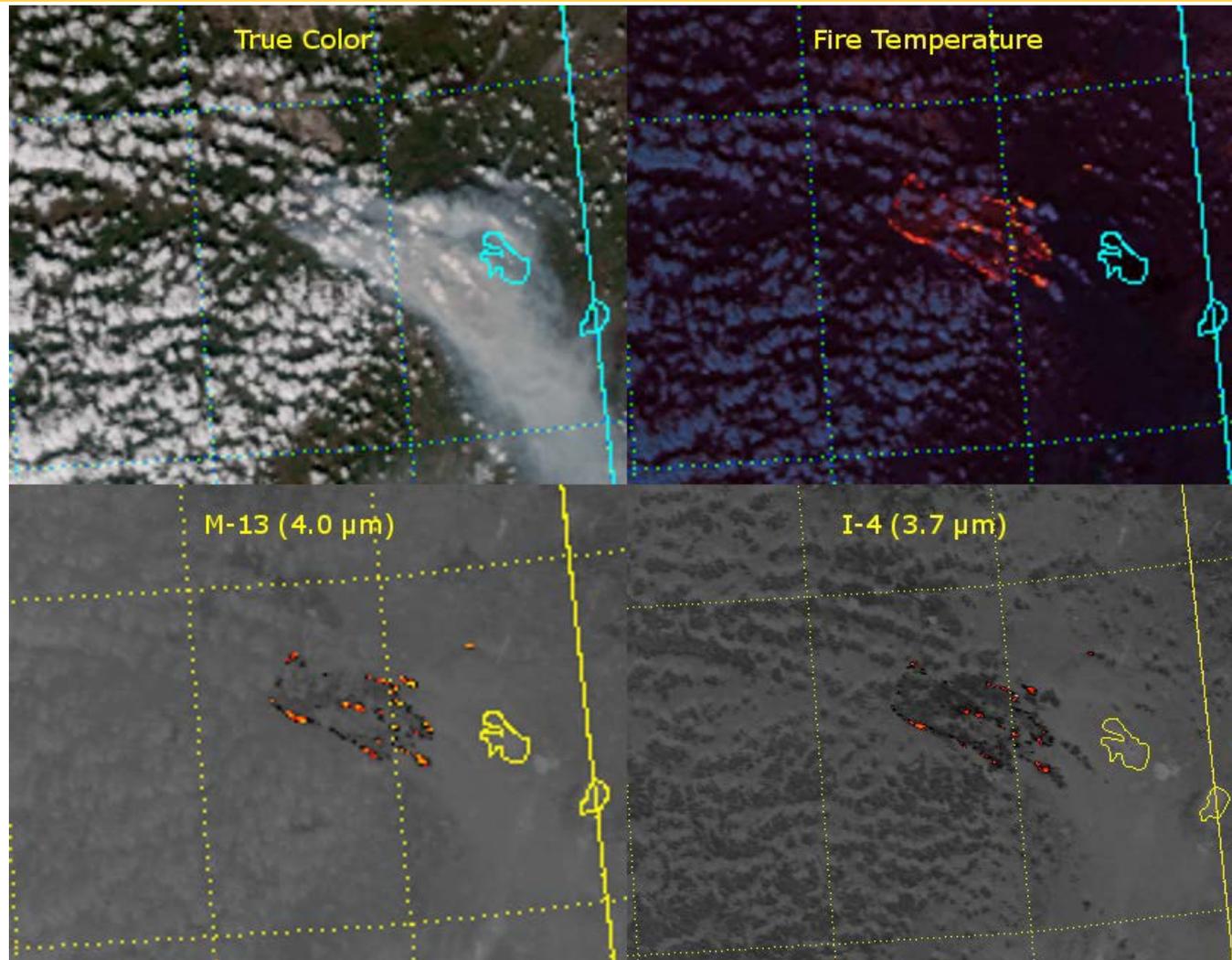


Figure JPSS-1. Imagery from May 5, 2016 centered over the Fort McMurray fires: True-color/red-green-blue (RG) (top left); Fire-temperature RGB (top right); M13 single-band infrared (IR, 4.0 μm , bottom left); and I4 (3.7 μm , bottom right). (Courtesy Curtis Seaman (Cooperative Institute for Research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

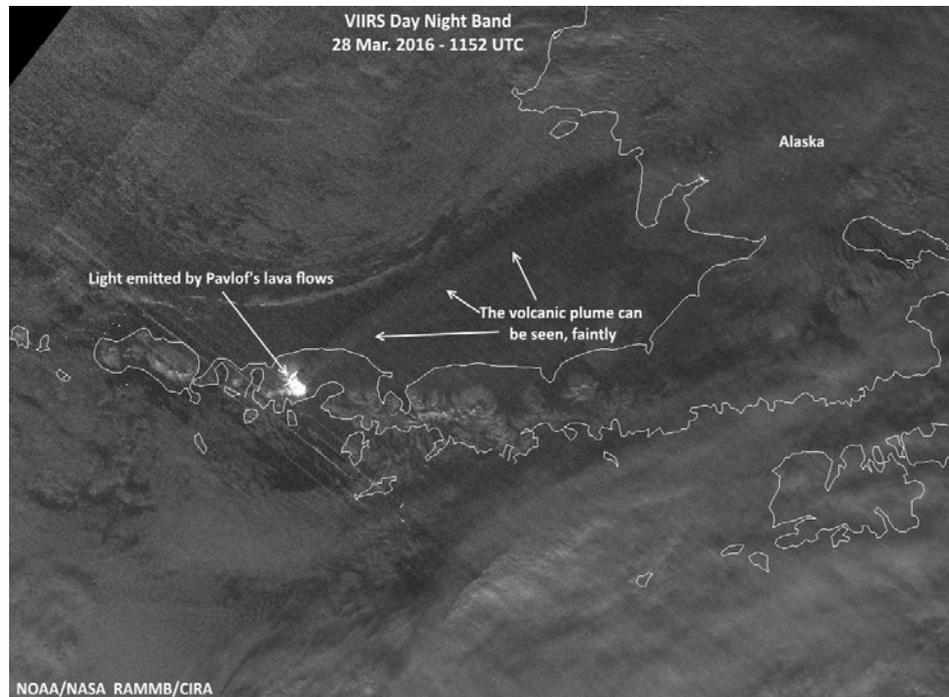


Figure JPSS-1. VIIRS Day/Night Band (DNB) from 1152 March 28, 2016 of recent Pavlof eruption in the Alaska Peninsula.

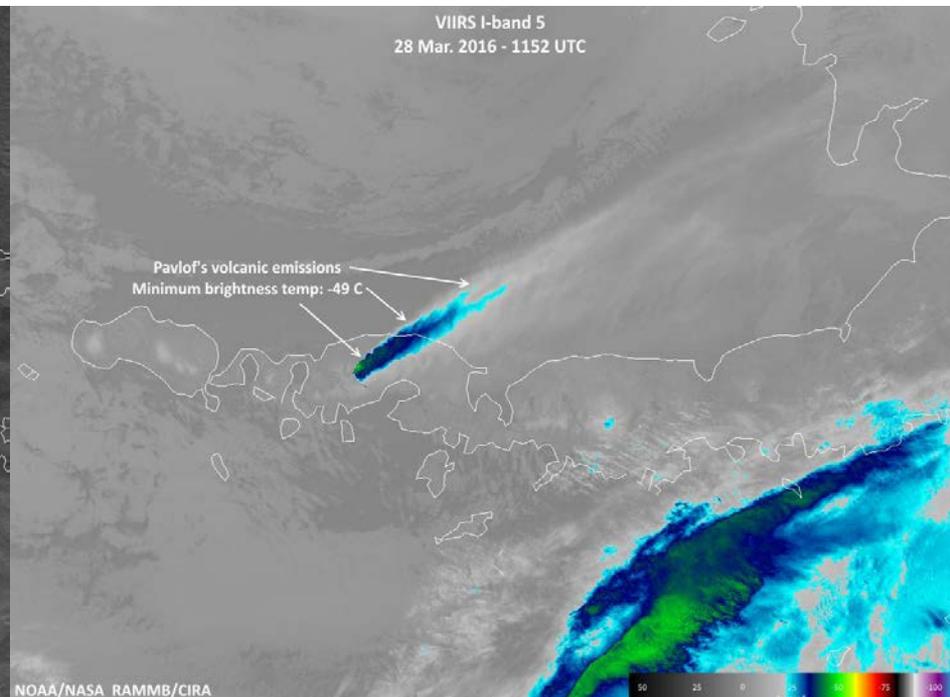


Figure JPSS-2. Same as Figure JPSS-1, but VIIRS color-enhanced I5 (11.45 μm) band.

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)

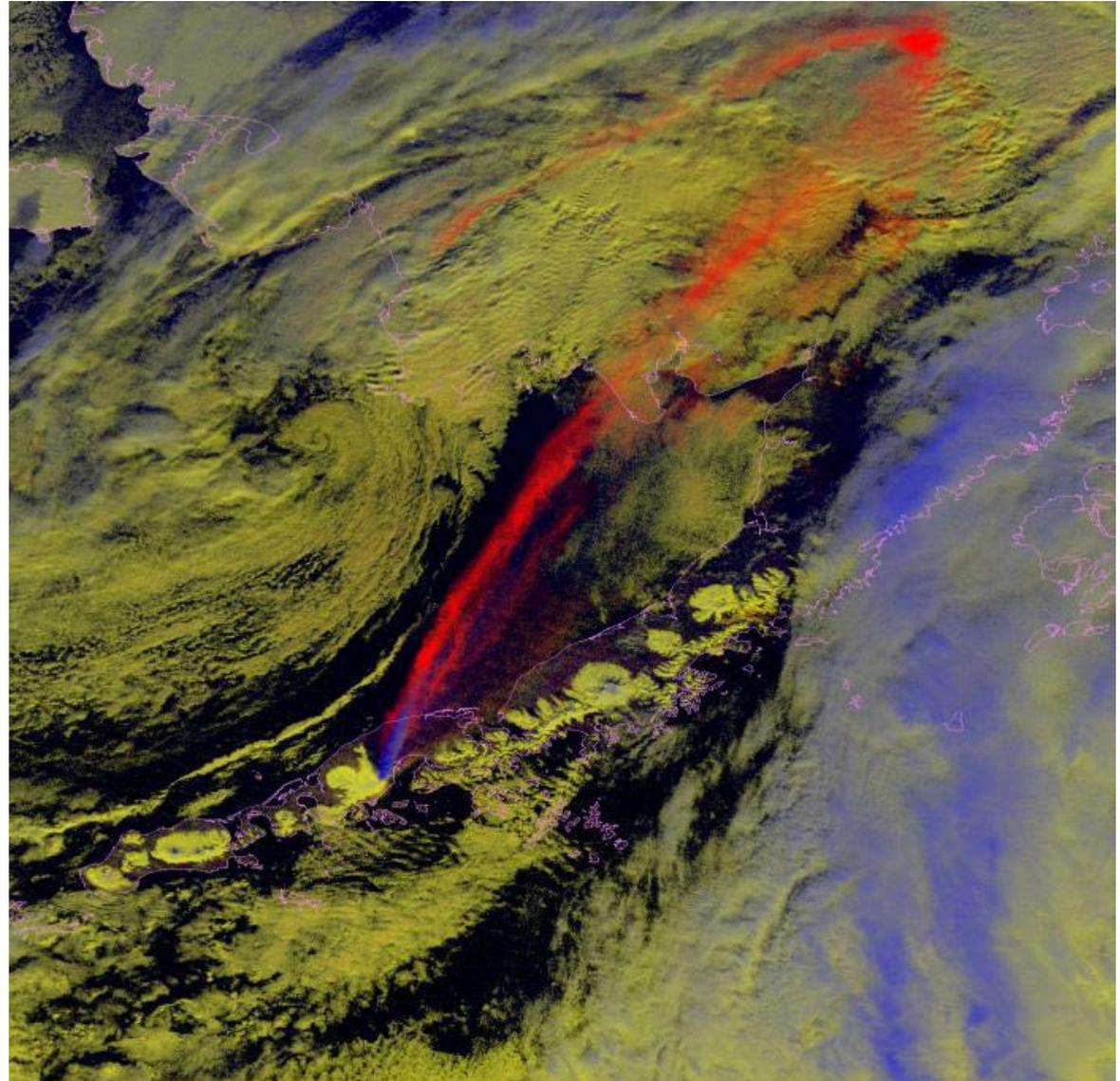


Image of the Month – Tropical Cyclone Fantala

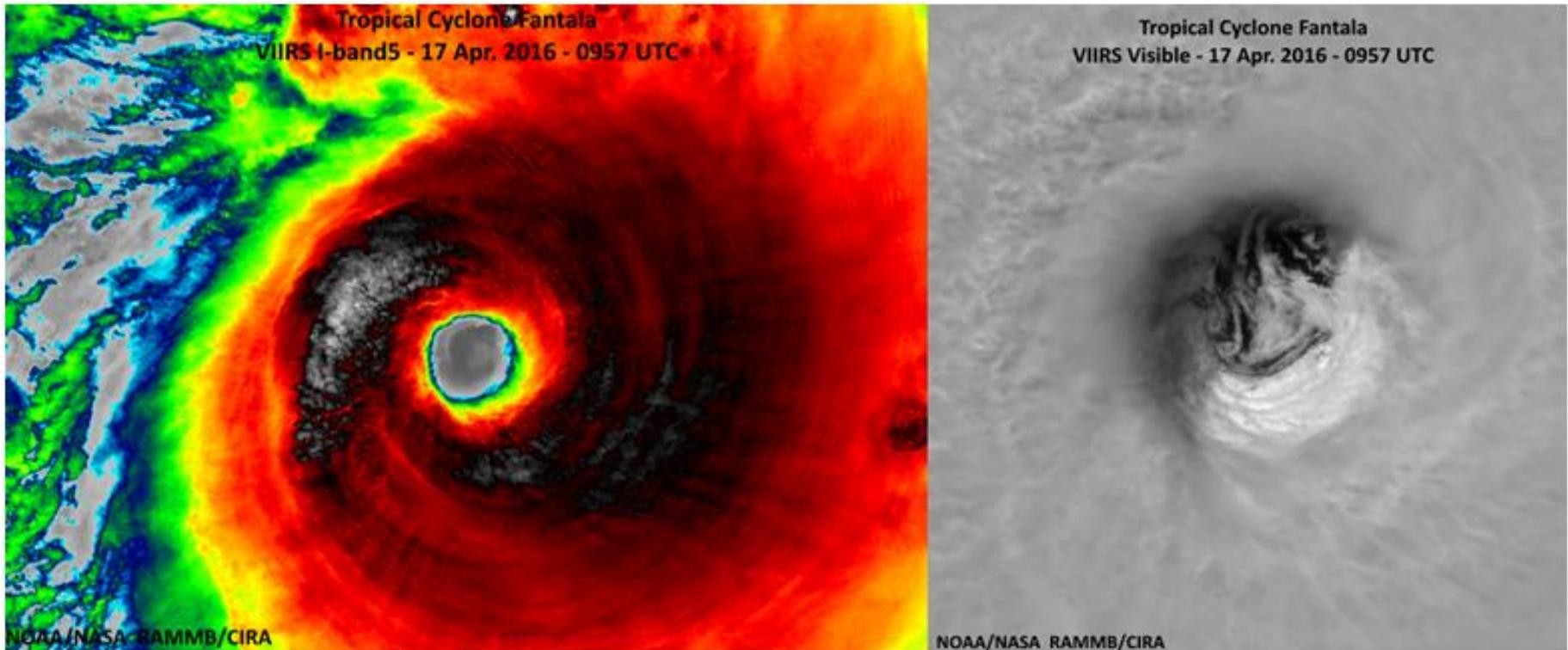


Figure JPSS-31. RAMMB/CIRA personnel provided another ‘Image of the Month’, this time of Tropical Cyclone Fantala, which achieved a Category 5 intensity of 150 knots on 17 April as it passed north of the island of Madagascar in the southwestern Indian Ocean. It was the most powerful storm in the Indian 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.

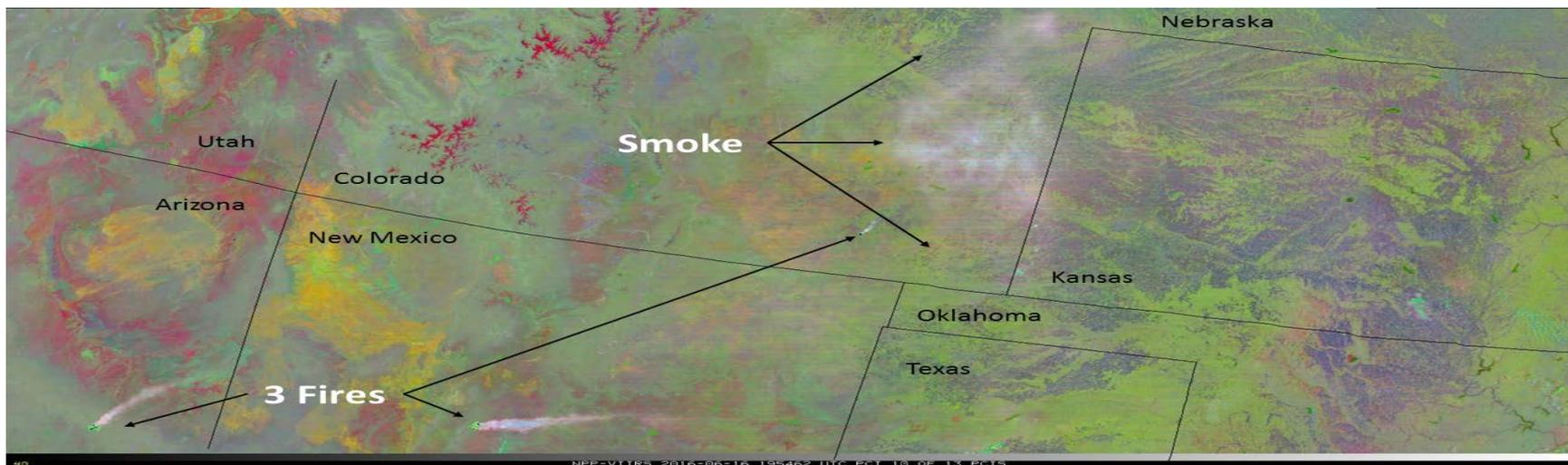
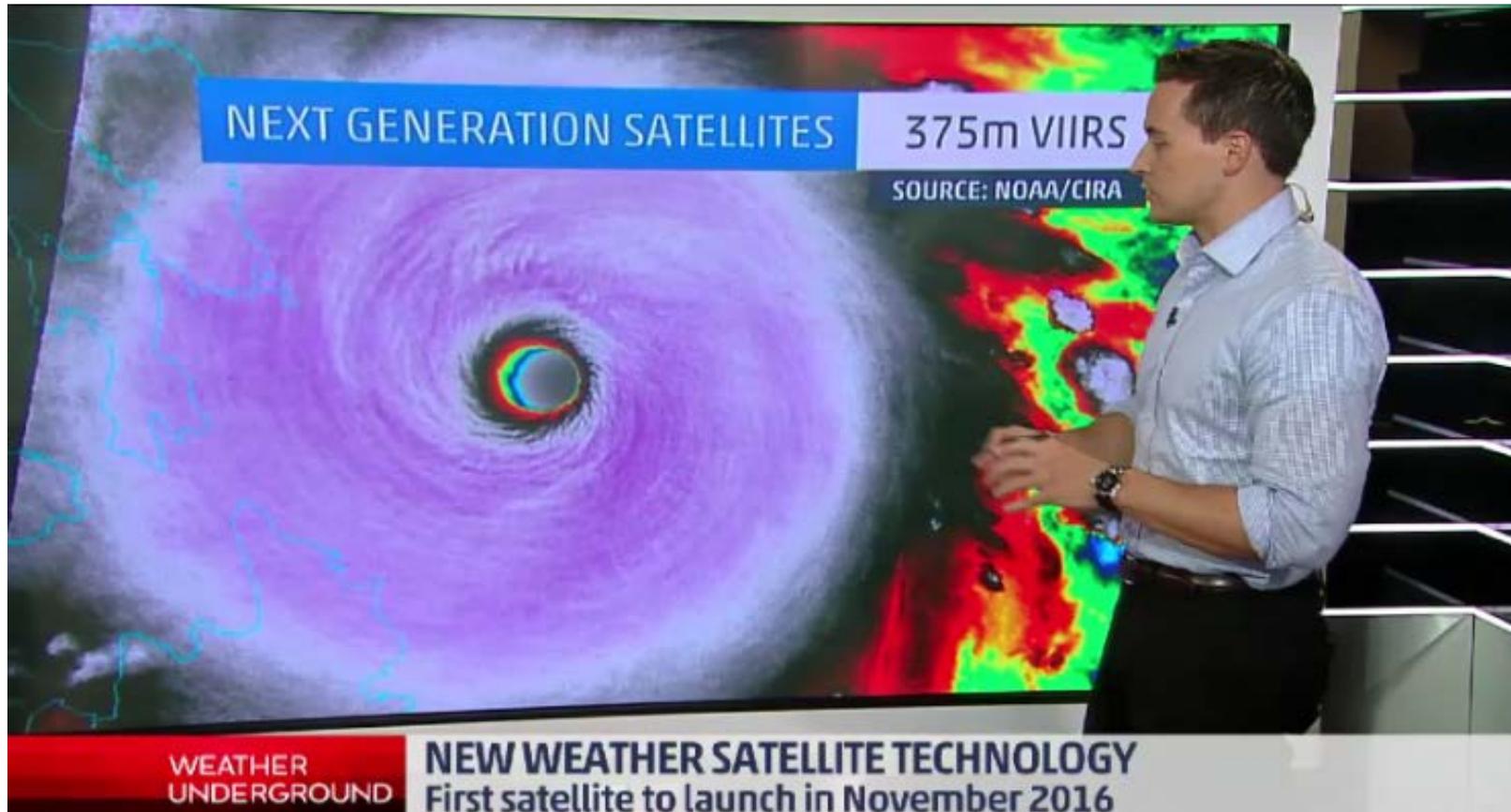


Figure JPSS-1. False three-color image of fires & smoke from 16 June 2016 at 1954 UTC. The two main fires in Arizona and New Mexico, as well as a smaller fire in southeastern Colorado, caused a smoke layer over eastern Colorado. This product is a result of Principal Component Analysis of the VIIRS M-band 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.

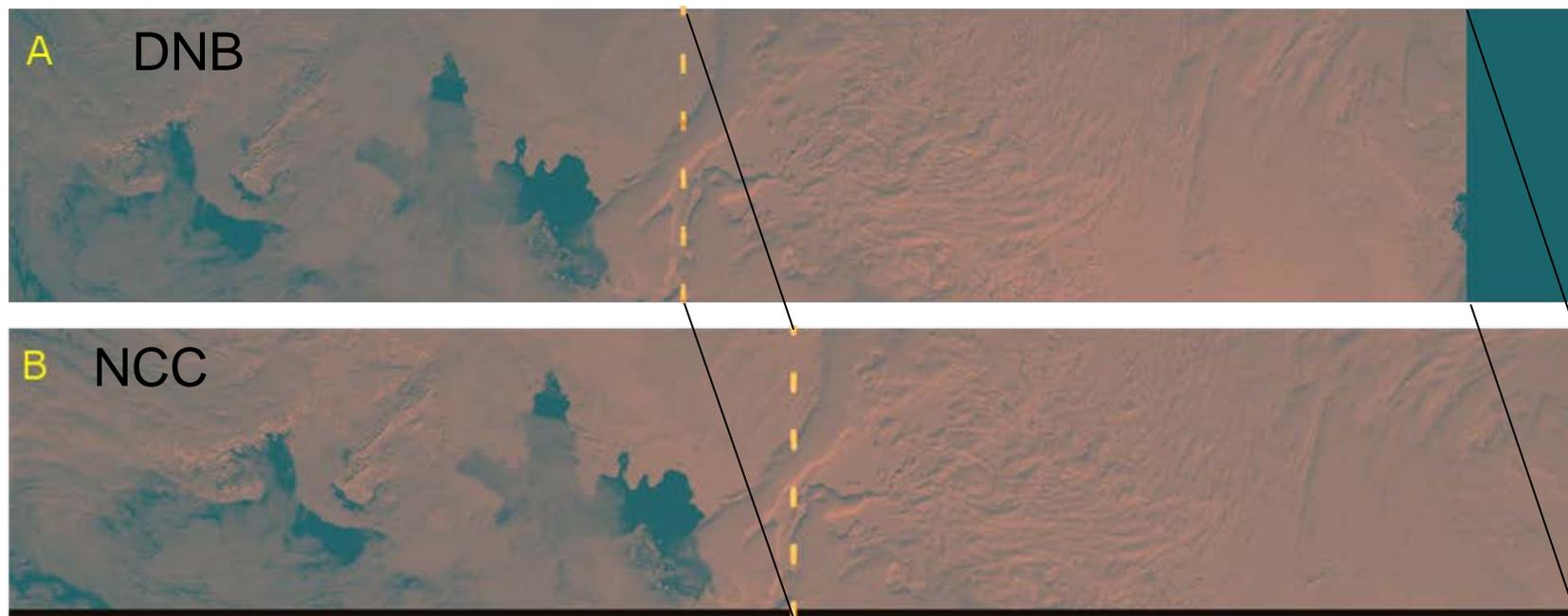
http://rammb.cira.colostate.edu/templates/loop_directory.asp?data_folder=visitview/custom/DNB_images/Moon_Phases_DNB

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.

From EDR Imagery (KPP)

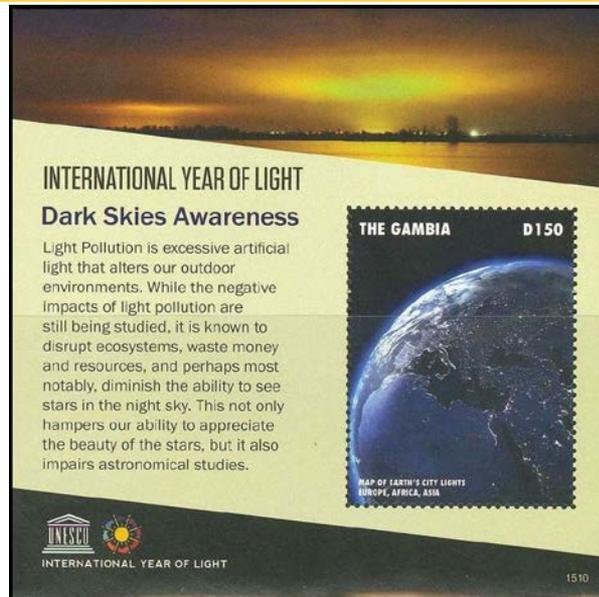
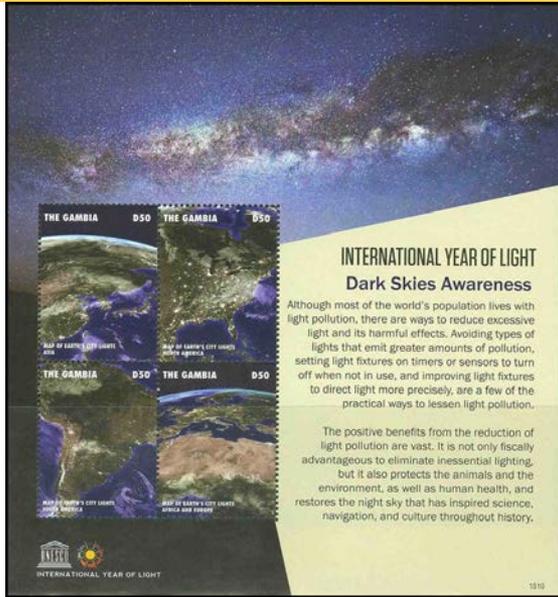
- There is only one LUT that may require adjustment, but it is a long-term need and it would NOT require an update in the first 90 days
- NCC Imagery is dependent on the stray light and other DNB fixes from the VIIRS SDR Team.
- Need to visualize the Imagery as soon as possible, given we have to reach 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.

- 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



Gambia 2015 DNB and true-color VIIRS

USA 2016 True-color VIIRS



Netherlands 2015 DNB city lights

