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 (12 October 2017 launch)
- Summary and Path Forward

Cal/Val Team Members

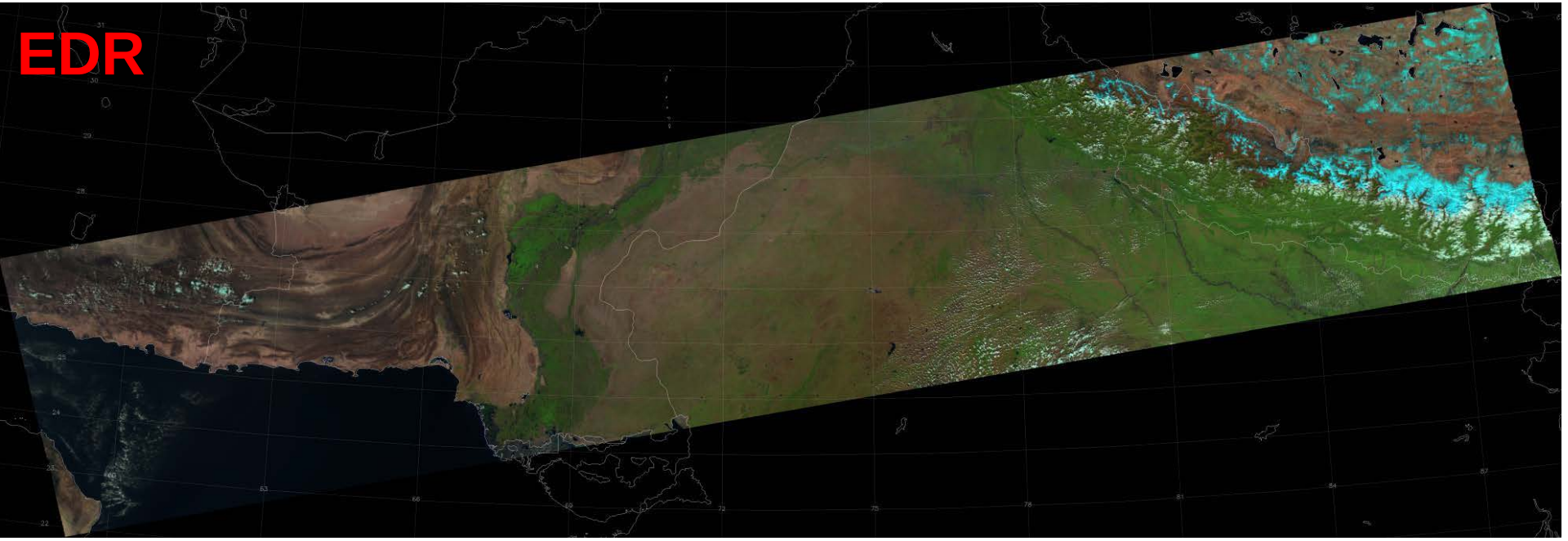
PI	Organization	Team Members	Roles and Responsibilities
D. Hillger	**StAR/RAMMB**	D. Lindsey, D. Molenar	Imagery Product Lead, weekly reports, **social media interactions**, data infrastructure
T. Kopp	**Aerospace**		Cal/Val Lead, VIIRS heritage
S. Miller	**CIRA/RAMMB**	C. Seaman, S. Finley, G. Chirokova, J. Torres, L. Grasso, G. Chirokova	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	W. Ibrahim, K. Ahmad	Operations
AIT	StAR	M. Tsidulko	Integration
Alaska users	GINA, NWS	E. Stevens, M. Kreller, 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**)

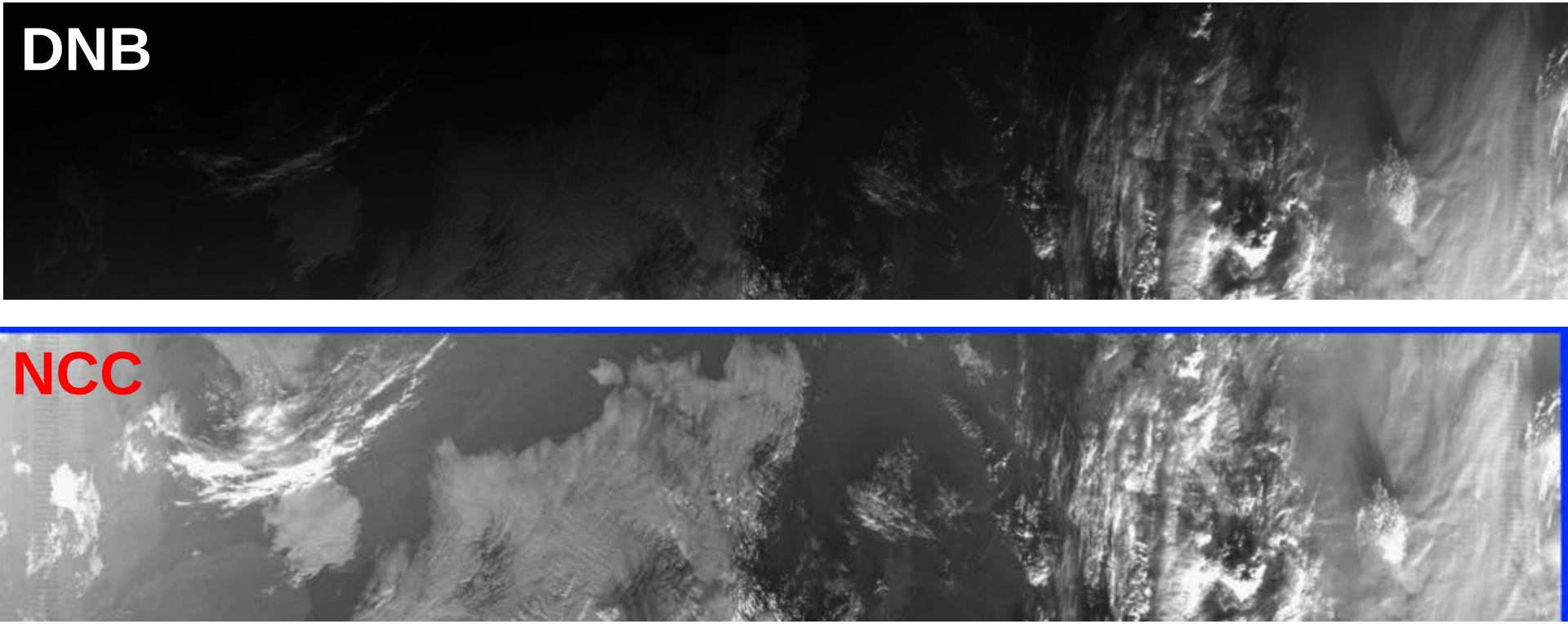
VIIRS SDR vs. EDR



Near Constant Contrast (NCC) vs. Day-Night Band (DNB)

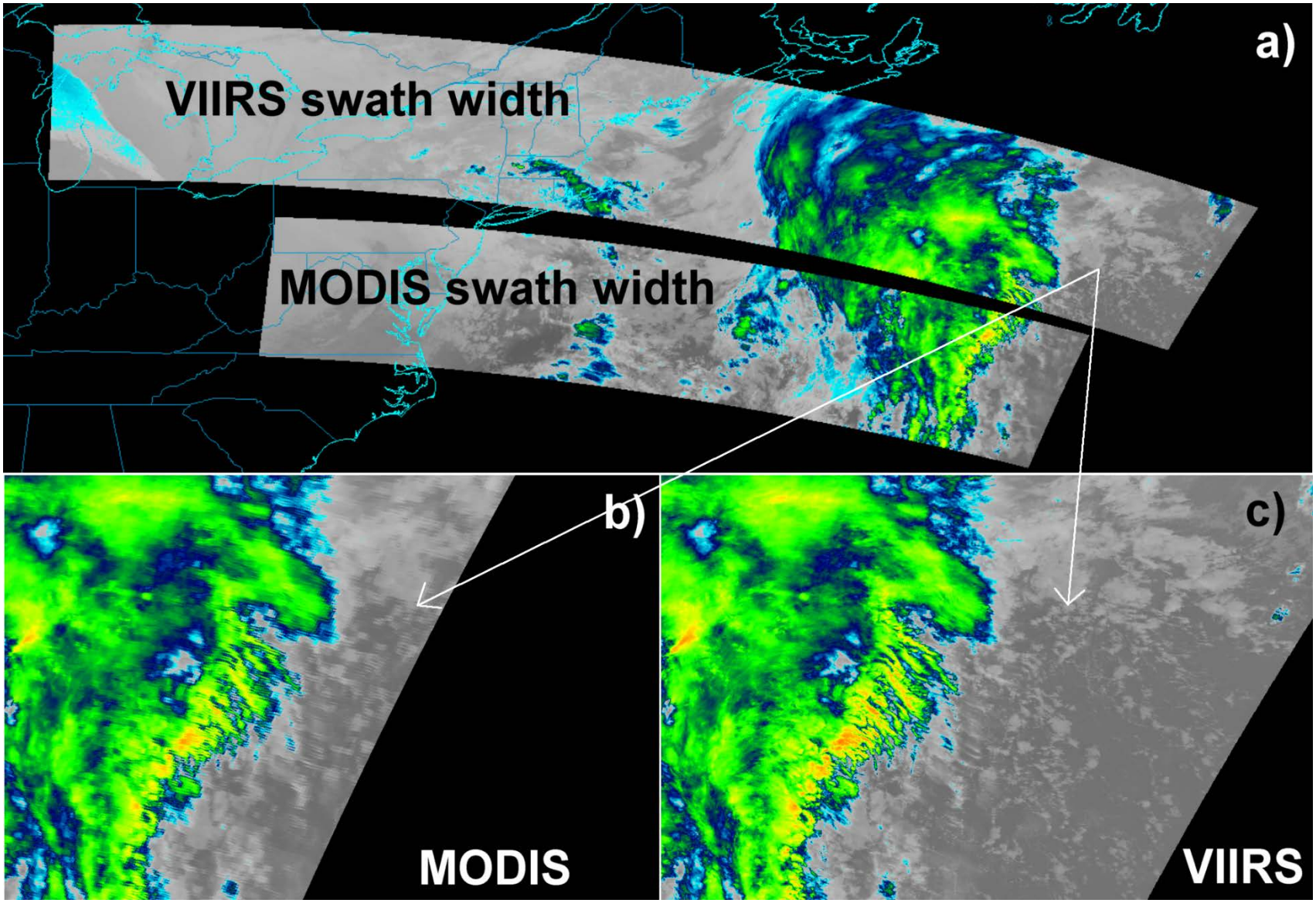
Example of NCC vs. DNB for a day/night terminator (non-lunar) case.

NCC extends constant contrast into the twilight portion of the granule swath.



Curtis Seaman, CIRA

Better spatial resolution at swath edge



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 definition** reads as follows:
    - **For latitudes greater than 60 deg N in the Alaska Region, VIIRS Imagery EDRs** at 0.64 µm (I1), 1.61 µm (I3), 3.74 µm (I4), 11.45 µm (I5), 8.55 µm (M14), 10.763 µm (M15), 12.03 µm (M16), and the 0.7 µm Near-Constant Contrast (NCC) EDR
- **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) granules** (to be minimized with 2 readout sites, resulting in **maximum of ½ orbit latency**)
  - Several **websites** for the Imagery (including **LTM (Long Term Monitoring)**
  - **Engaging users** for validation and feedback (utilizing JPSS liaisons)
  - 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

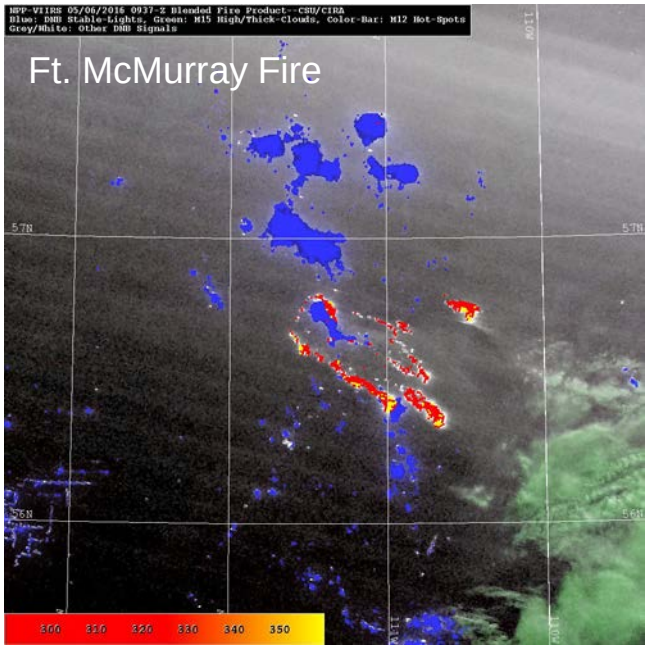
Table 2: Other IDPS-generated Imagery EDRs

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

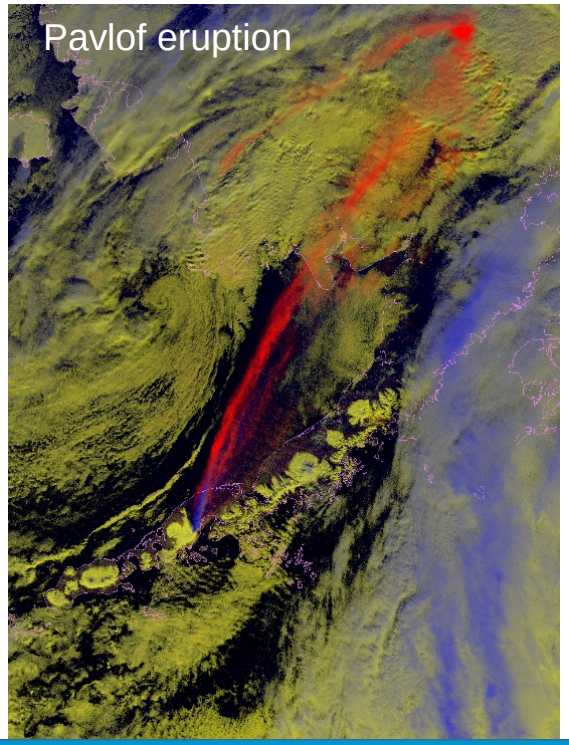
Multi-spectral Applications (with DNB)



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



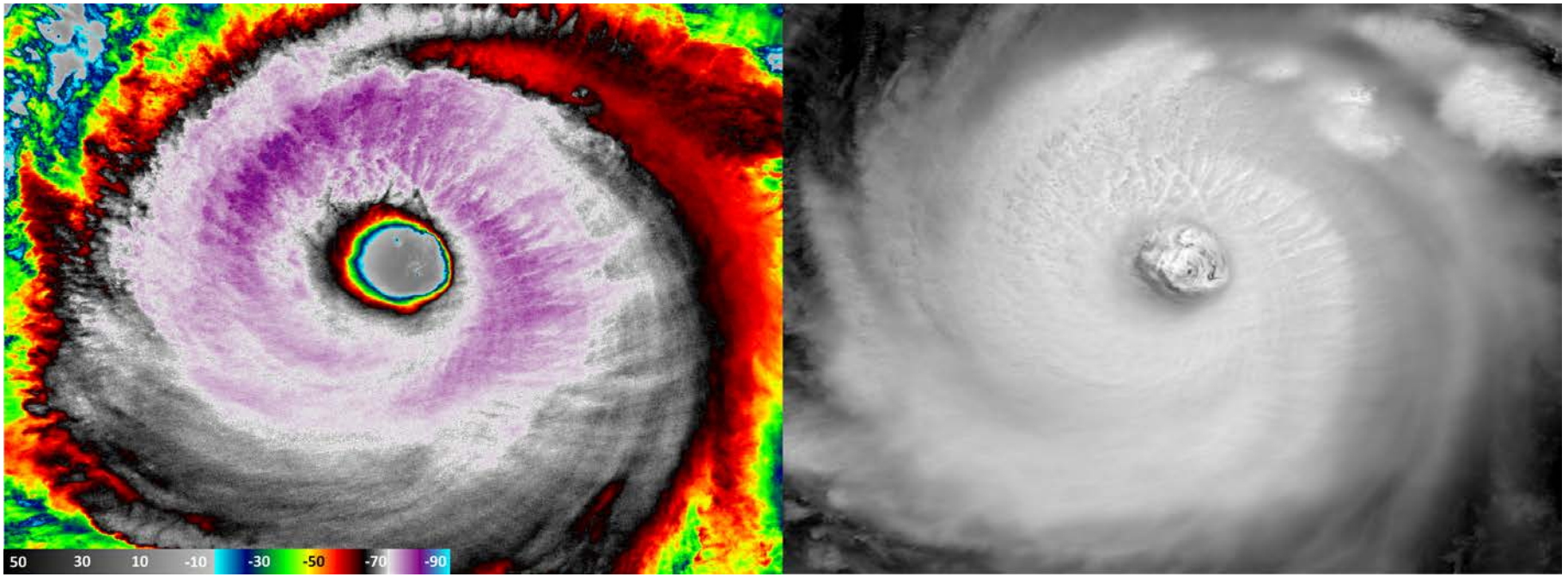
13:25 UTC 28 March 2016

- 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

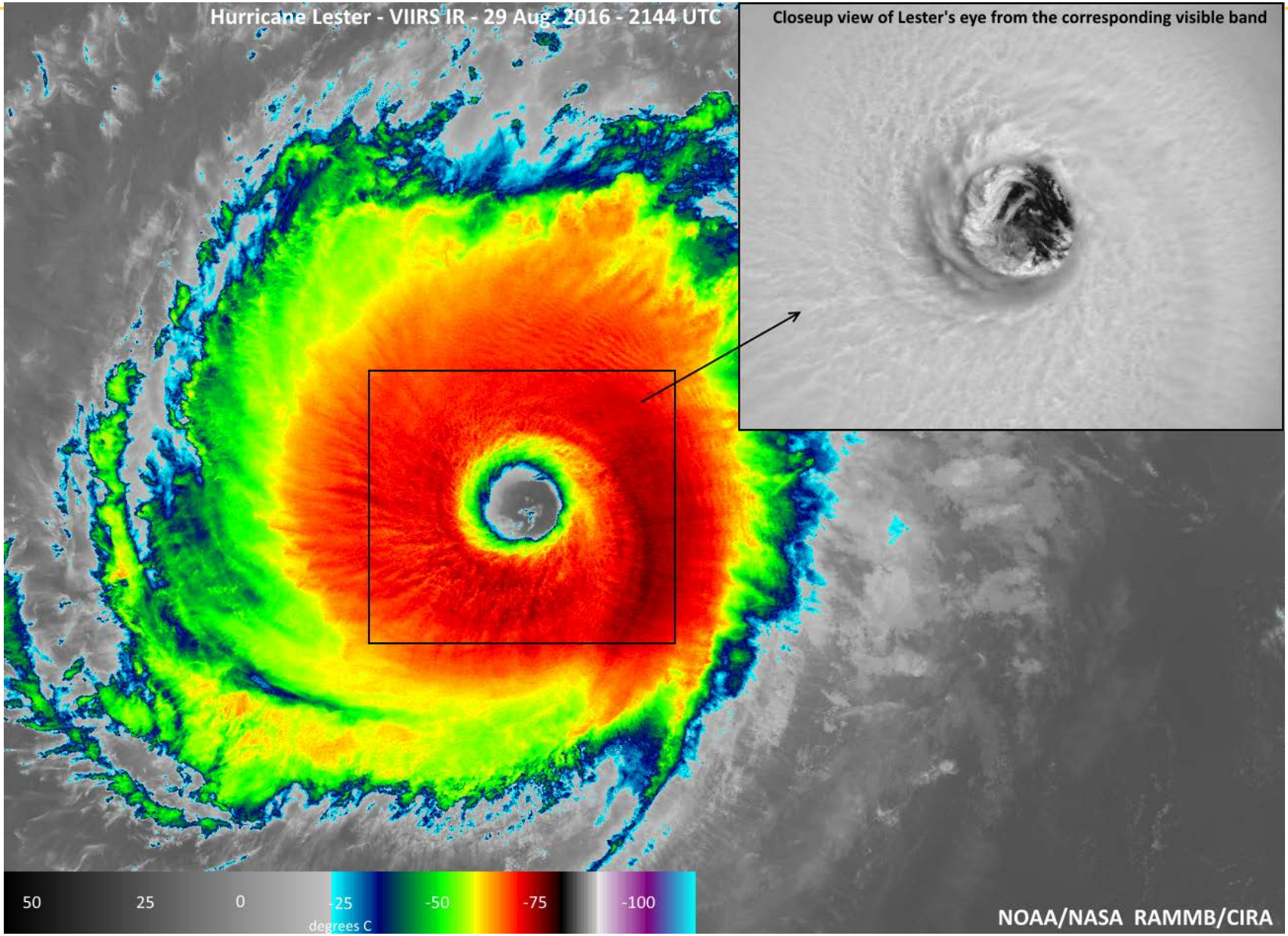
Courtesy: Curtis Seaman

Image of the Month – Super Typhoon Noru 2017



Suomi NPP passed over Super Typhoon Noru at 0310 UTC on 31 July 2017 as it churned in the west Pacific Ocean. The image on the left is a VIIRS I-band-5 IR image and the one on the right is I-band-1 Visible. At the time of these images, the storm was estimated to have maximum sustained winds of 130 knots, a category 4 storm on the Saffir-Simpson scale. (D. Lindsey, StAR)

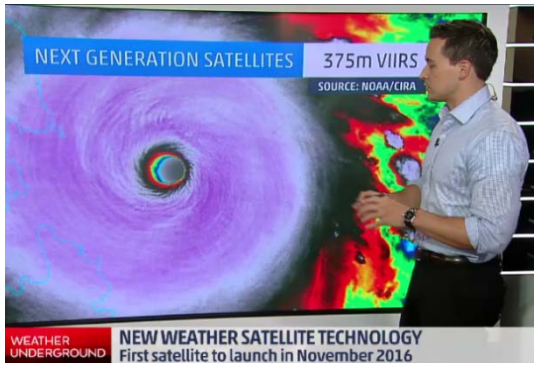
Hurricane Lester 2016



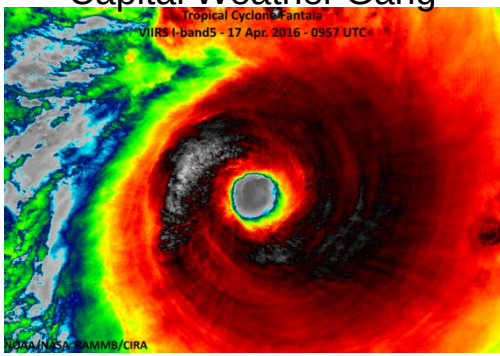
Spreading the Word

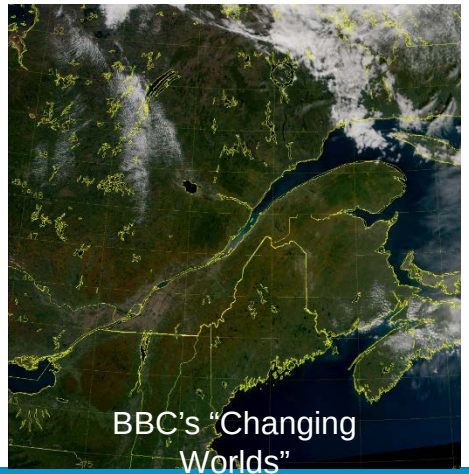
- CIRA VIIRS images have been delivered to a variety of **standard media and social media outlets**
  - The Weather Channel
  - CNN
  - BBC
  - WagTV (producer of shows for *Discovery* and *Science Channel*)
  - *Washington Post*/ Capital Weather Gang
  - @NOAASatellites on Twitter
  - And many more…

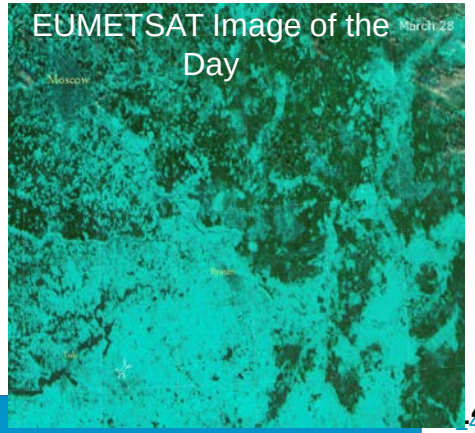
Courtesy: Curtis Seaman



Capital Weather Gang







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!

Courtesy: Curtis Seaman

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.

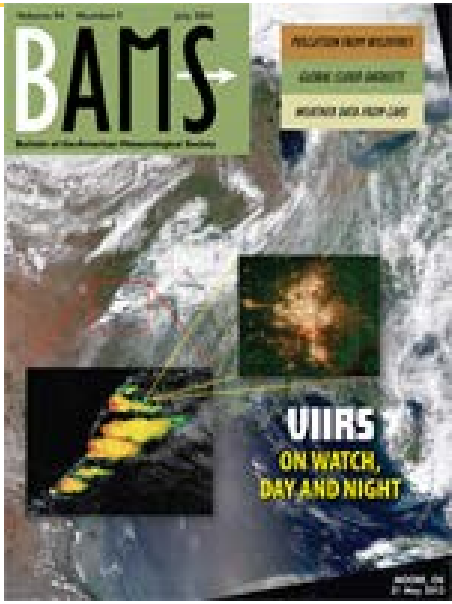
Weaknesses of the channel differencing product include vulnerability to blockage by higher clouds above the stratus and fog, as well as a restriction to the hours of darkness. Note how the fog product at bottom includes no data over the area covered by sunshine in the Day Night Band. The 3.74 µm channel, 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

References

- **Hillger, D.,** T. Kopp, T. Lee, D. Lindsey, C. Seaman, S. Miller, J. Solbrig, S. Kidder, S. Bachmeier, T. Jasmin, and T. Rink, 2013: **First-Light Imagery from Suomi NPP VIIRS, *BAMS*, 94, 1019-1029:** http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-12-00097.1
- **Beginner's Guide to VIIRS Imagery Data:** http://rammb.cira.colostate.edu/projects/npp/Beginner_Guide_to_VIIRS_Imagery_Data.pdf
- **VIIRS Imagery EDR User's Guide:** https://www.star.nesdis.noaa.gov/jpss/documents/UserGuides/VIIRS_Imagery_EDR_Users_Guide_TR_NESDIS_150.pdf



VIIRS Imagery at other sites

- **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")

JPSS-1 Cal/Val Plan

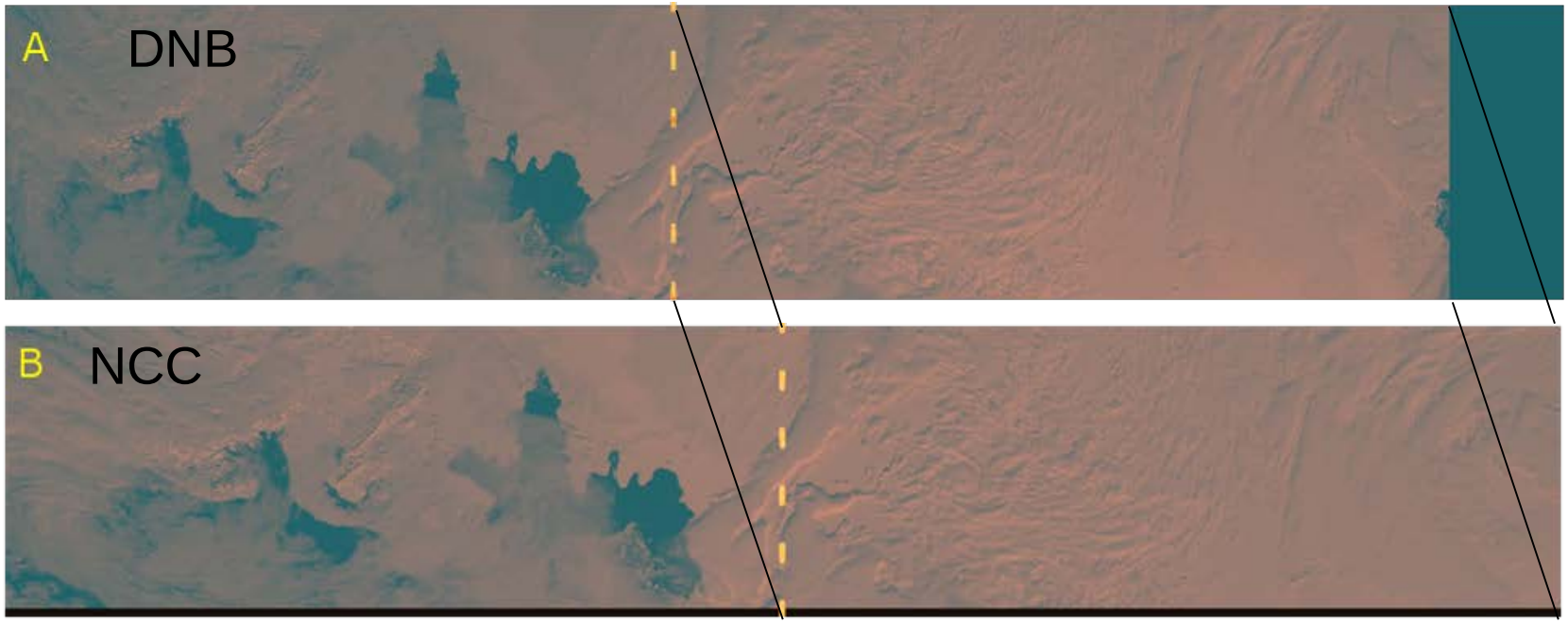
- JPSS-1 Image Cal/Val Plan
  - **Quantitative calibration** (radiances/reflectances) at SDR level
  - **Qualitative validation** of Imagery by end users
- Preparations for JPSS-1 VIIRS Imagery
  - **DNB** changes due to increased pixel aggregation at edge of scan and extended swath width
    - This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

EDR Imagery Team J1 L+90 actions

From EDR Imagery (KPP)

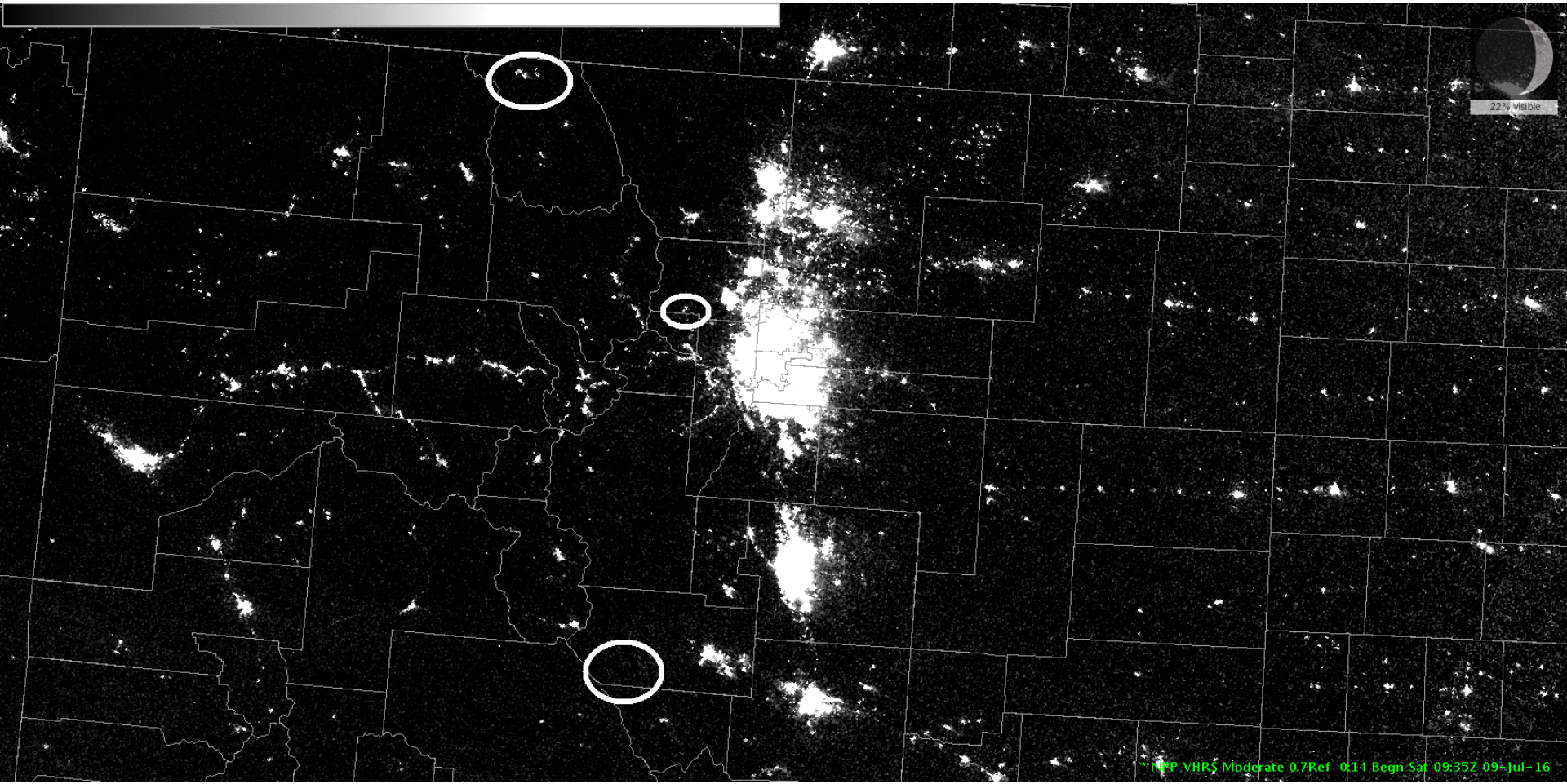
- NCC Imagery is dependent on the **stray light and other DNB fixes from the VIIRS SDR Team**.
- The **NCC LUT that may require adjustment**, but it is a **long-term need** and it would **NOT** require an update in the first 90 days
- Need to **visualize Imagery as soon as possible**, given we have to reach validation by L+90 days
  - Imagery to users
  - Feedback from users
  - Particularly NWS/AWIPS and Alaska
- **Extended granule for DNB** due to increased aggregation of J-1 data at end of swath (see next slide)

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.

NCC in AWIPS - Fires



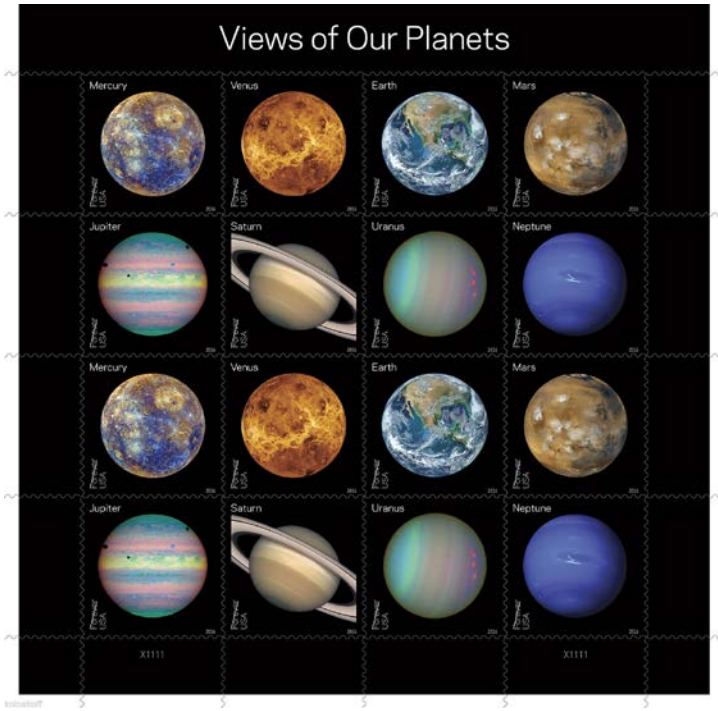
Do the fires move? Or does the ground move?

Terrain Correction needed (and required in Block 3.0) for NCC and other Imagery EDRs! (an ongoing effort)

FY17 Accomplishments and FY18 Plans

- **VIIRS Imagery is Excellent:**
  - Visible/IR are **especially high quality** (and best spatial resolution among operational satellites, at 375 m)
  - **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 with JPSS-1**
  - **NCC Terrain-Corrected Geo-locations needed** (shifts of several kilometers at higher elevations with ellipsoid geo-locations)
  - **New DNB aggregation modes** for end of swath pixels, resulting in extended swath and offset of nadir
  - **Imagery from 2 satellites with 50 minute separation**, to be able to do temporal analysis of imagery features (clouds, fires, smoke, ash, etc.)

VIIRS true-color on US postage stamp 2016



US postage stamp (2016) showing the "Blue Marble" composite image created from VIIRS true-color imagery from 2012.

VIIRS DNB on postage stamp 2016

Netherlands postage stamps (2016) showing the DNB imagery in the background of this souvenir sheet.