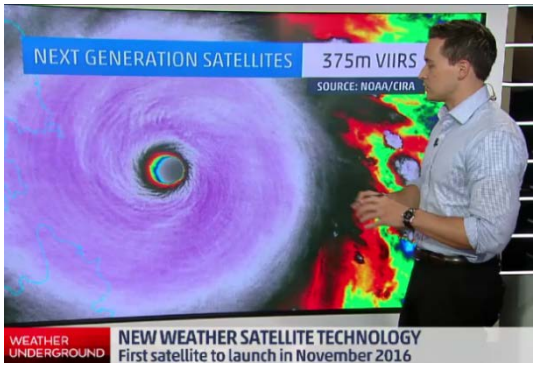
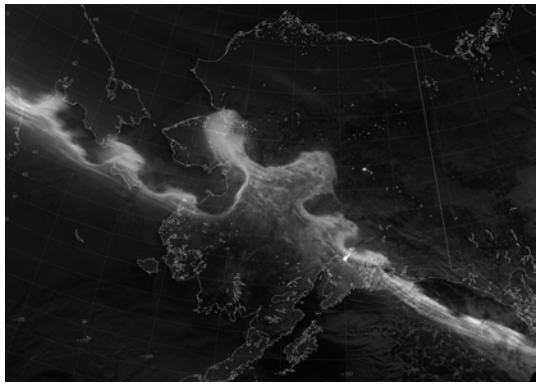
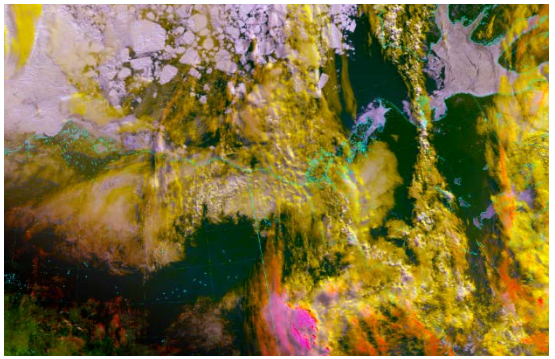
VIIRS Imagery Applications at CIRA







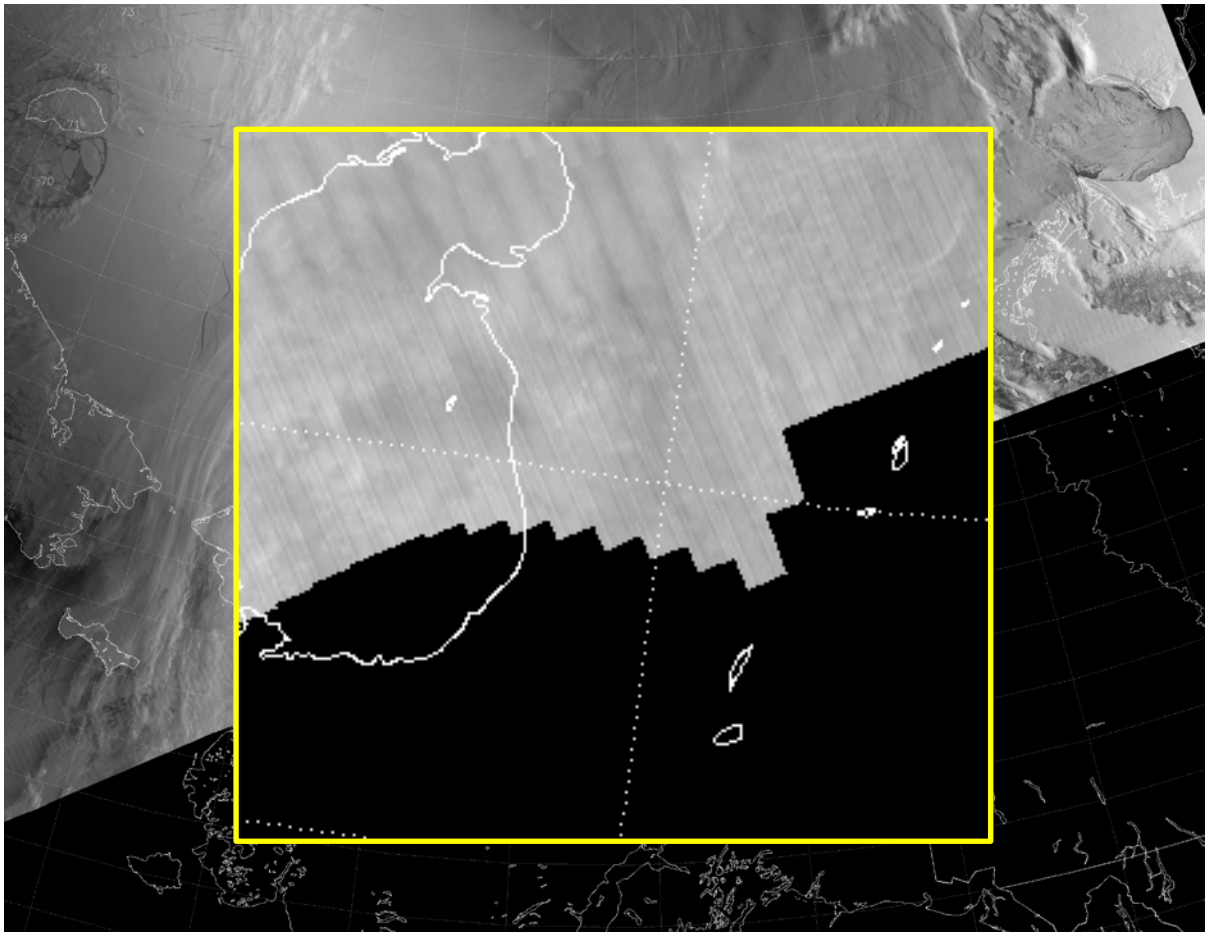
Curtis Seaman, Steve Miller, Jorel Torres

Colorado State University/CIRA

Don Hillger, Dan Lindsey

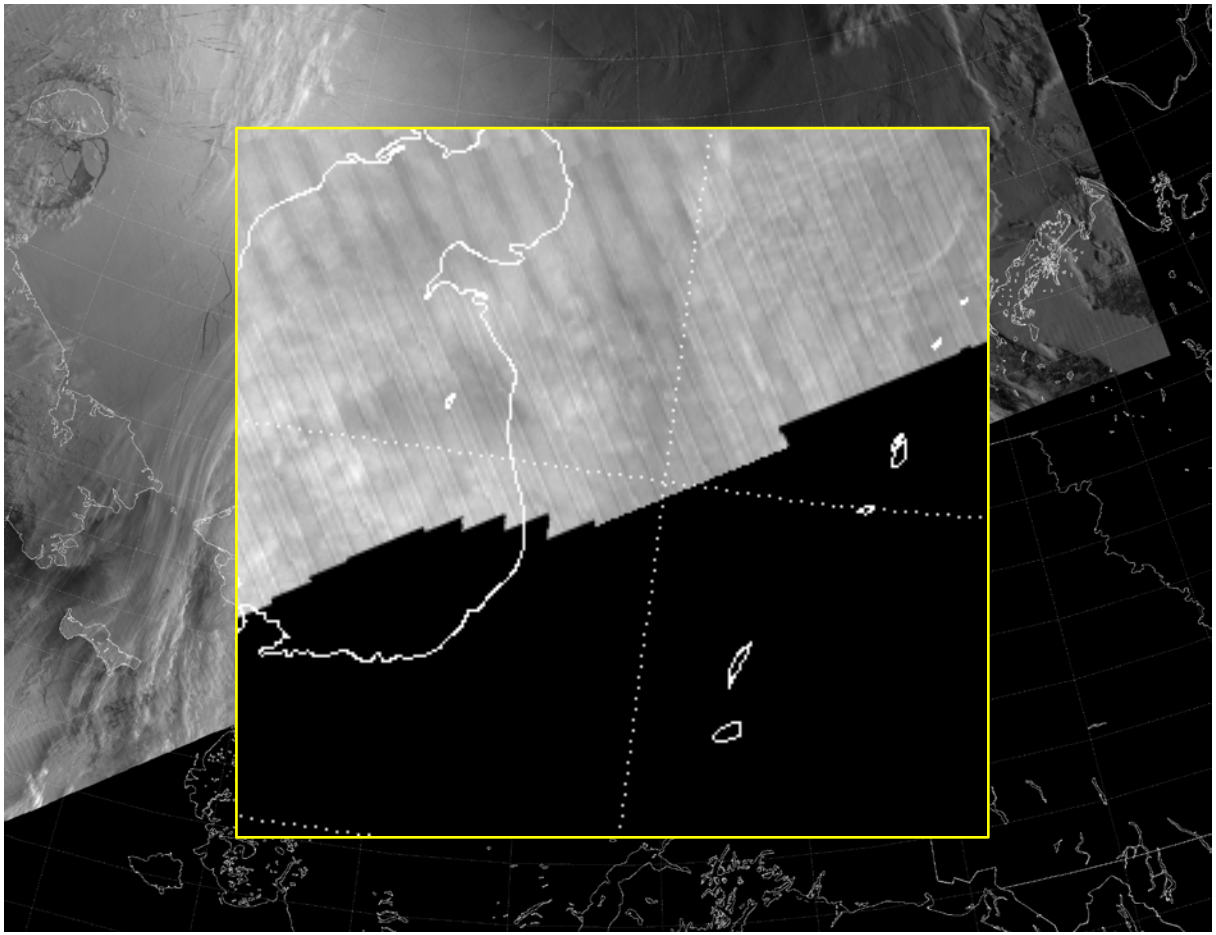
NOAA/NESDIS/Satellite Applications and Research

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

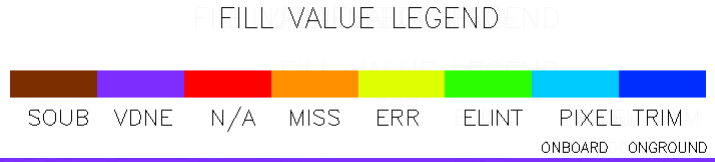


This error is not as noticeable in the EDRs (NCC shown here) because the scan edges fall outside the pre-defined Ground Track Mercator (GTM) grid. But, it does introduce other errors…

Monitoring Artifacts

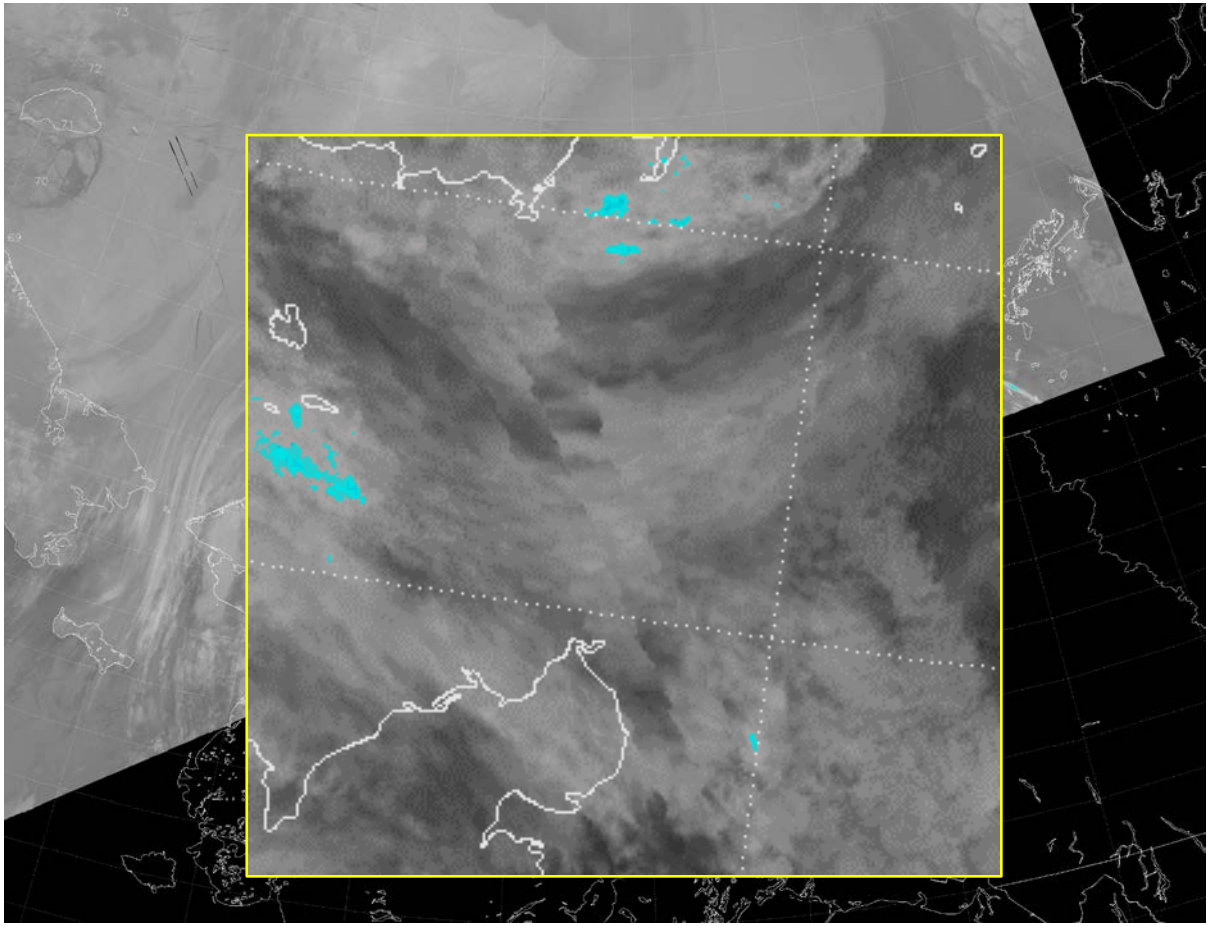
Artifacts in the EDR due to attitude error

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



Pixel deletions in an EDR!

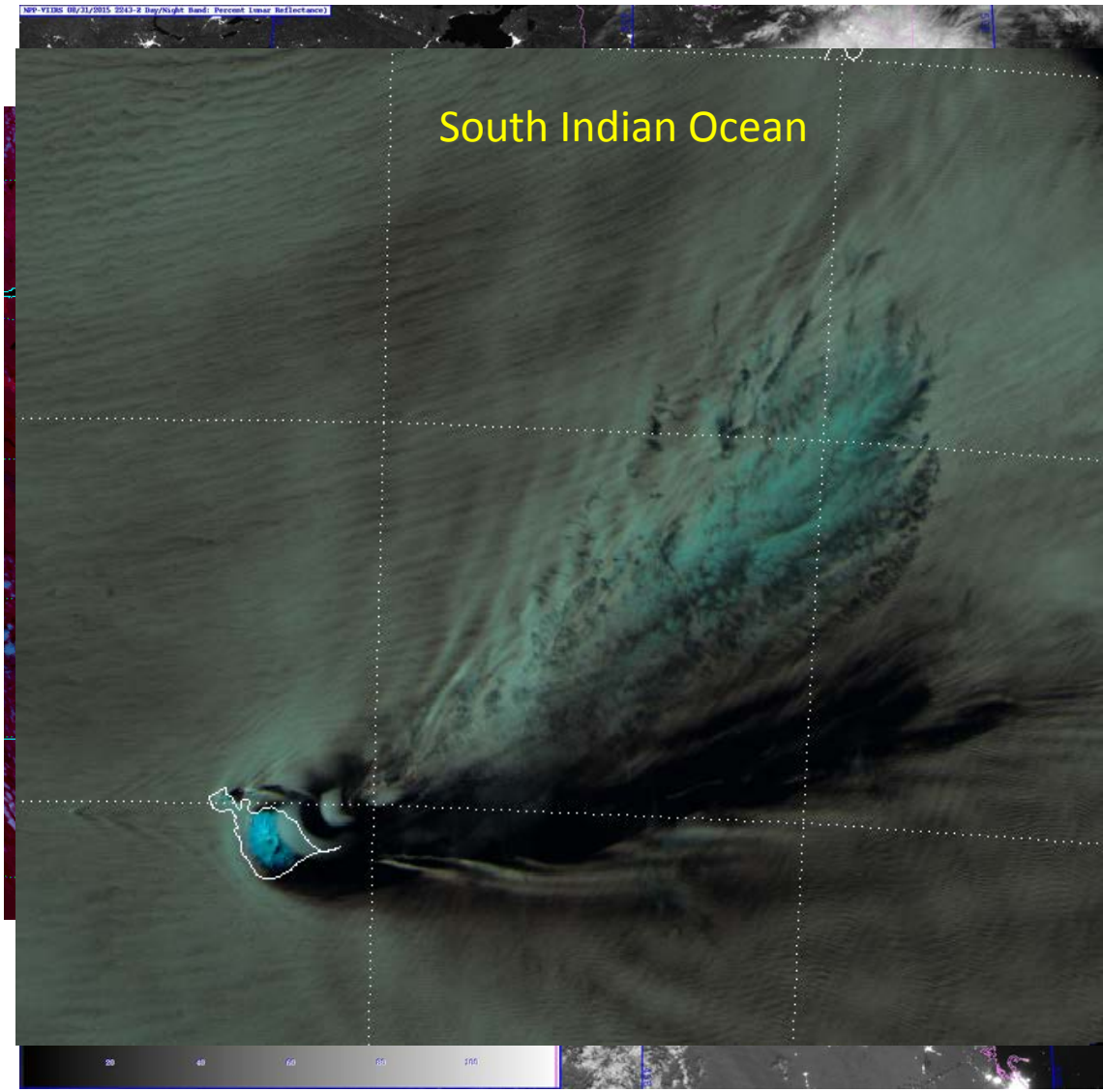
Monitoring Artifacts



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

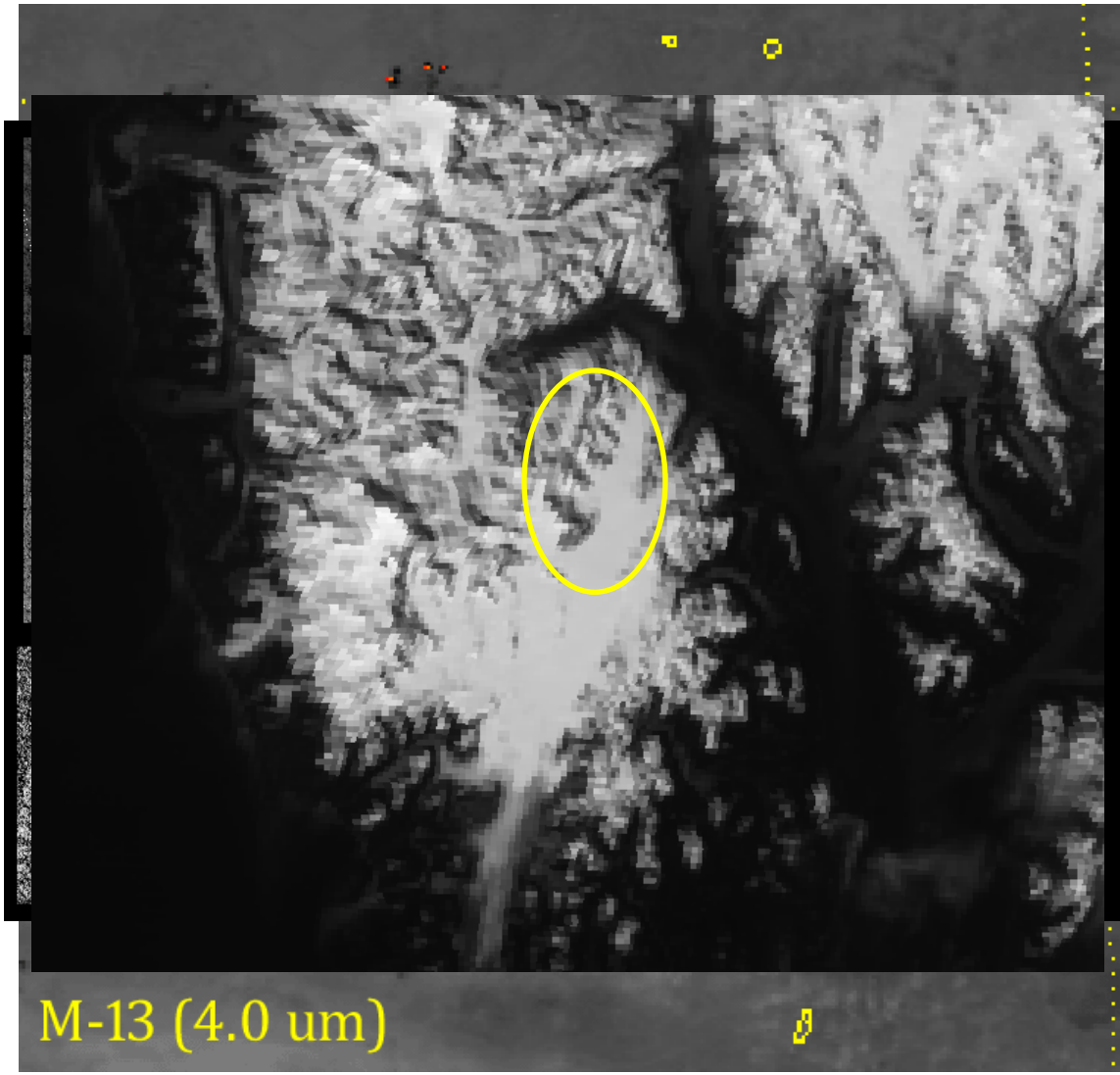
- Self-nominated "Best Blog in the World" demonstrates the wide-ranging application of VIIRS imagery
- Natural Color RGB shows extensive river flooding in Western Russia (April 2013)
- True Color RGB shows "super-smog" over India (Nov-Dec 2015)
- Fire Temperature RGB shows massive fires over Northwest 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

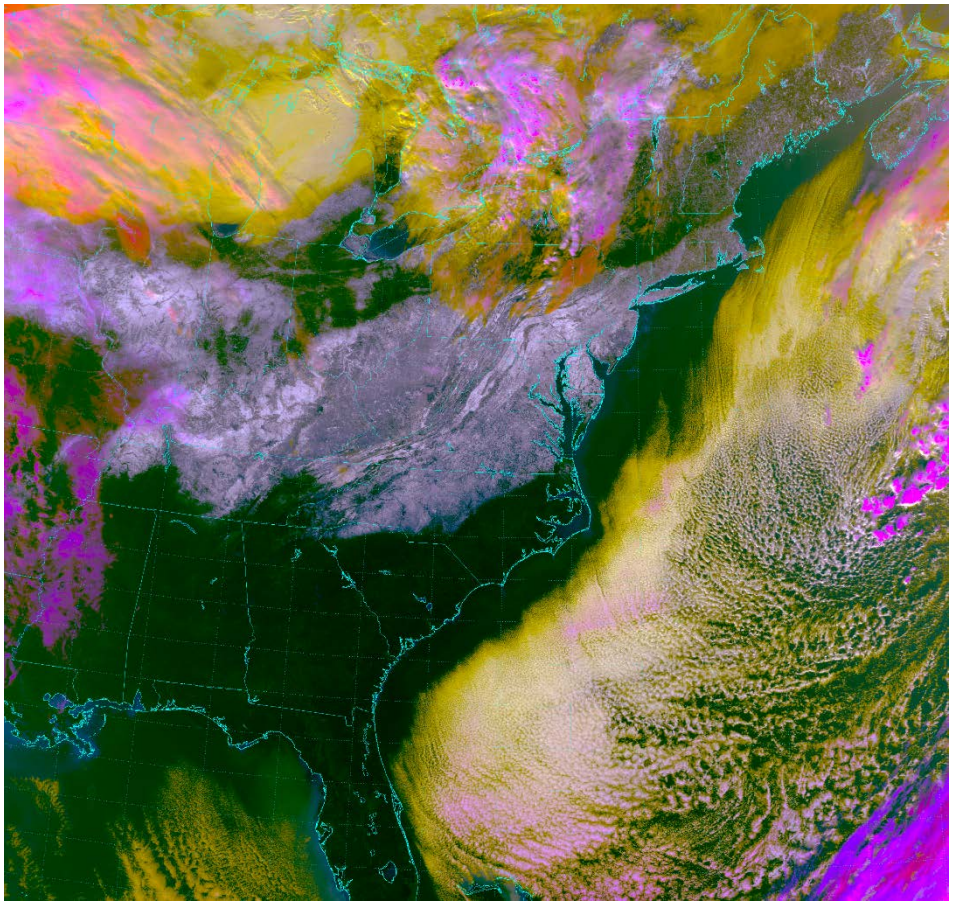
- The "Seeing the Light: VIIRS in the Arctic" blog is geared toward high-latitude users of satellite imagery
- Day/Night Band for ship tracking; "50 Years of Victory" carries the Olympic torch to the North Pole
- Day/Night Band for ice monitoring; N-ICE field experiment (Jan-Feb 2015)
- Demonstrating 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/

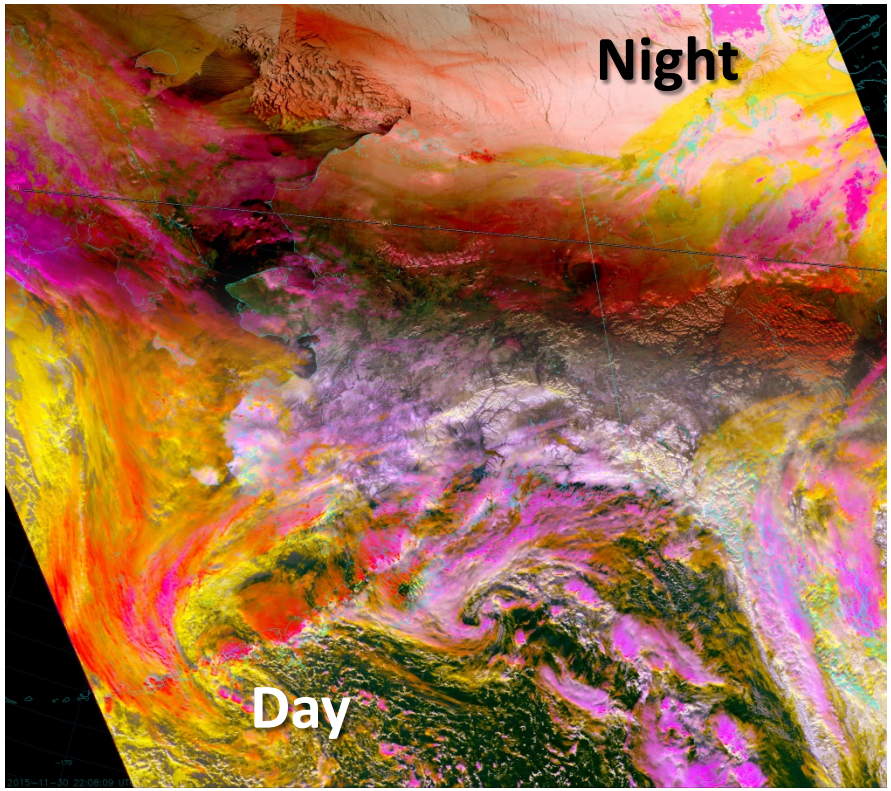
The Great Blizzard of ‘16

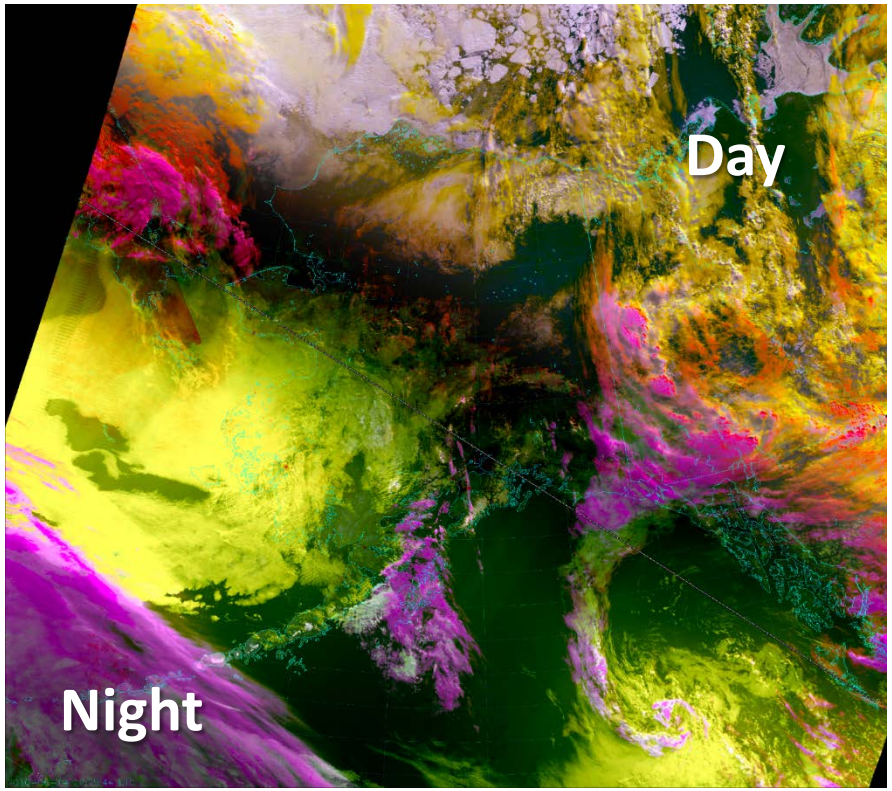
- Can you tell what is cloud and what is snow in the True Color RGB (M-3, M-4, M-5)?
- EUMETSAT Natural Color RGB (M-5, M-7, M-10) discriminates low clouds from snow and ice
- Variation of EUMETSAT Snow RGB (M-11, M-10, M-7) highlights snow in pink/red
- Snow RGB from Météo France produced upon request 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

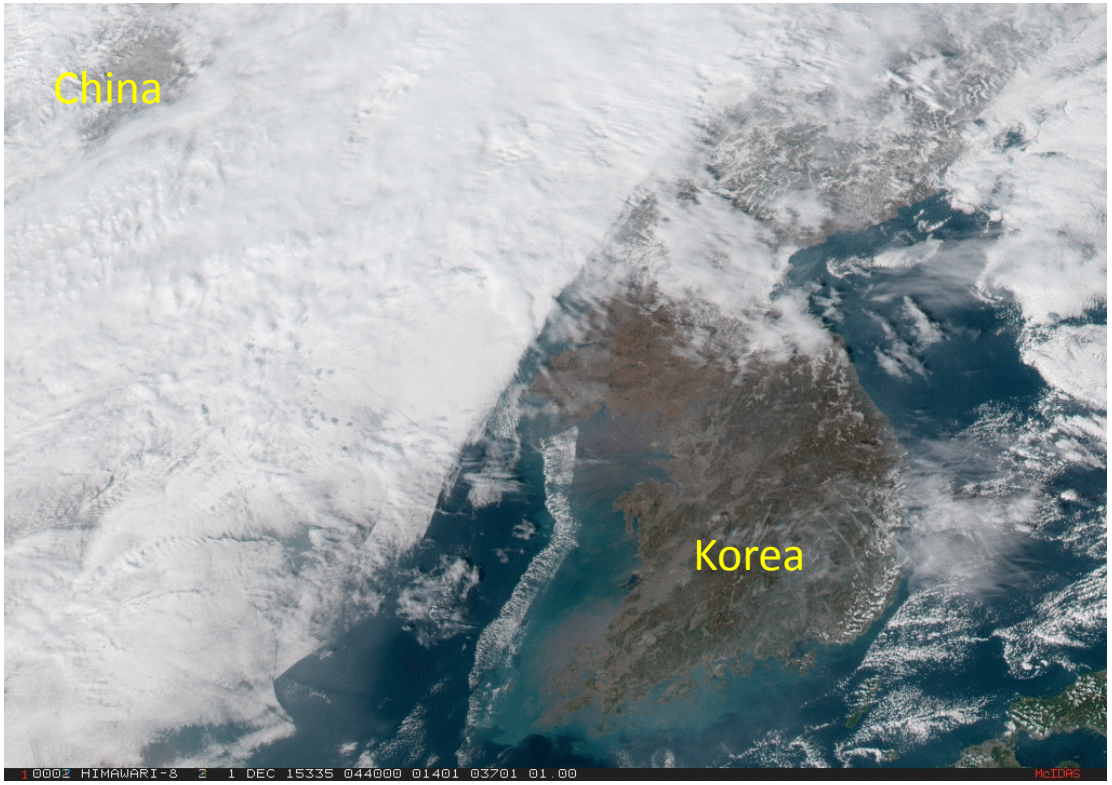
- Blending this product with the Daytime Snow/Cloud Discriminator allows for snow/ice discrimination around-the-clock and across the terminator, extending its use

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

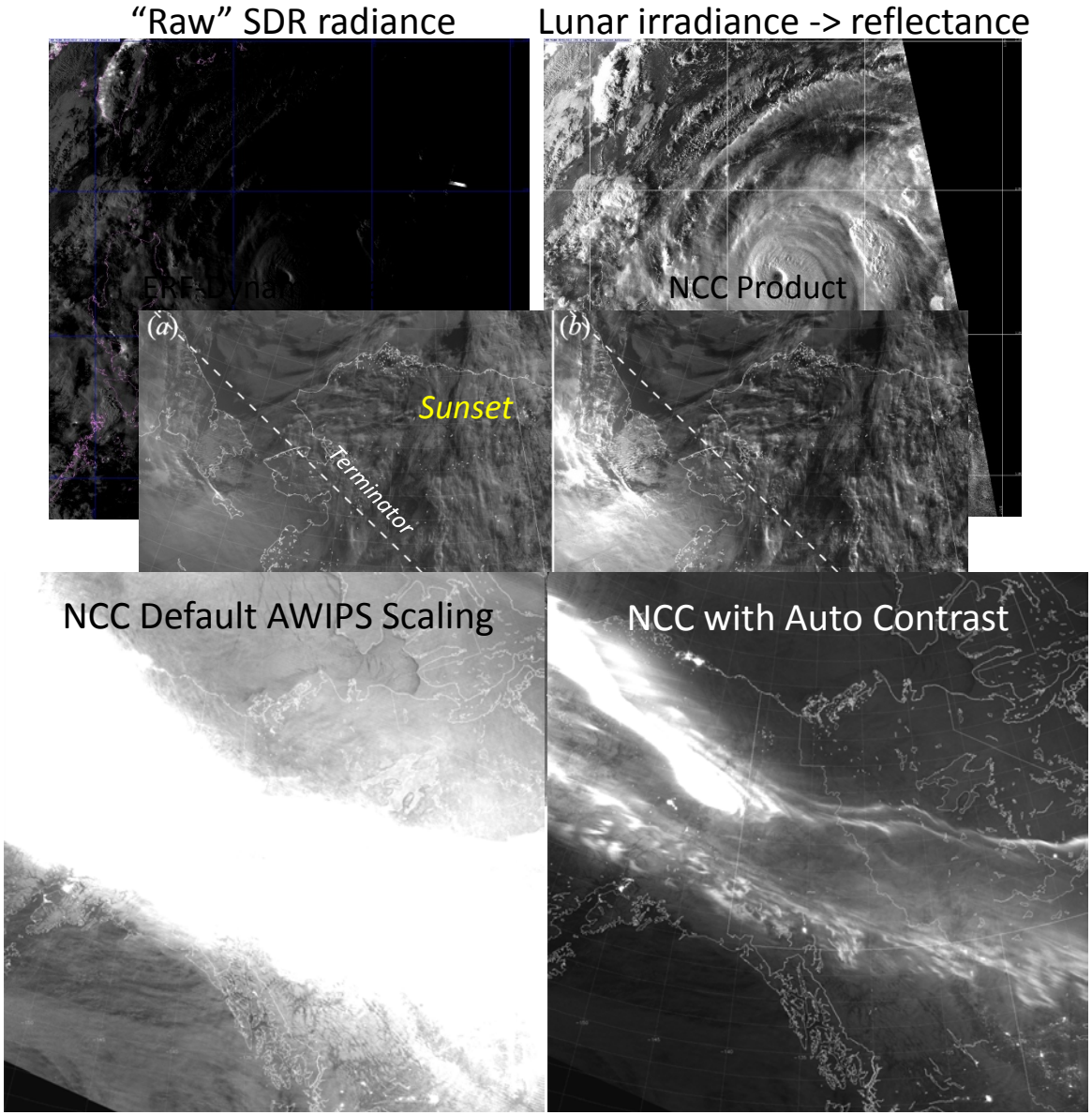
- The high-resolution City Lights Mask (Chris Elvidge/Kim Baugh, NCEI) now replaces the old OLS artificial lights mask to improve the appearance at night

- Example of a combined polar-geo product that is popular with forecasters

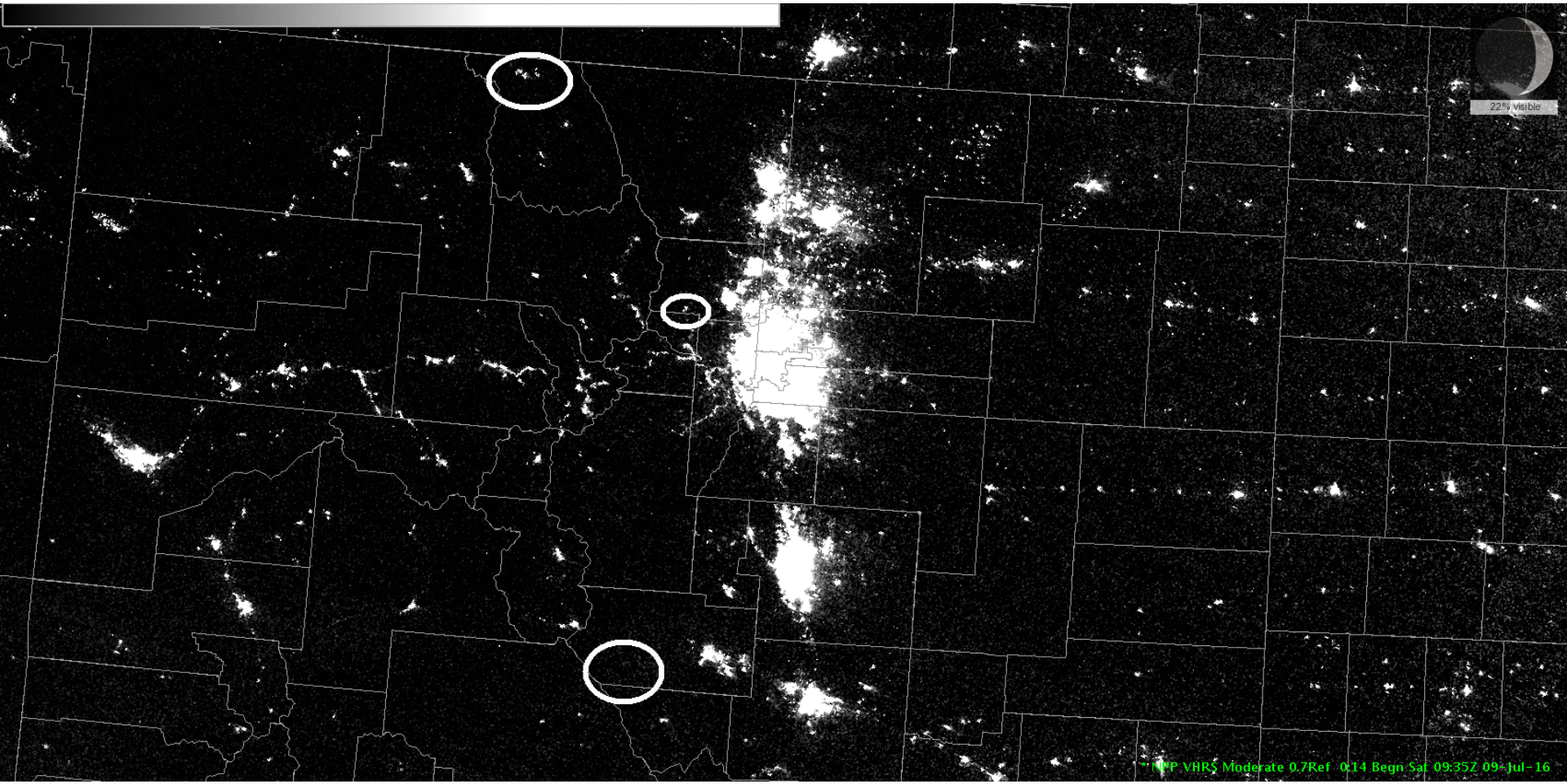


Improving DNB/NCC Display

- 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

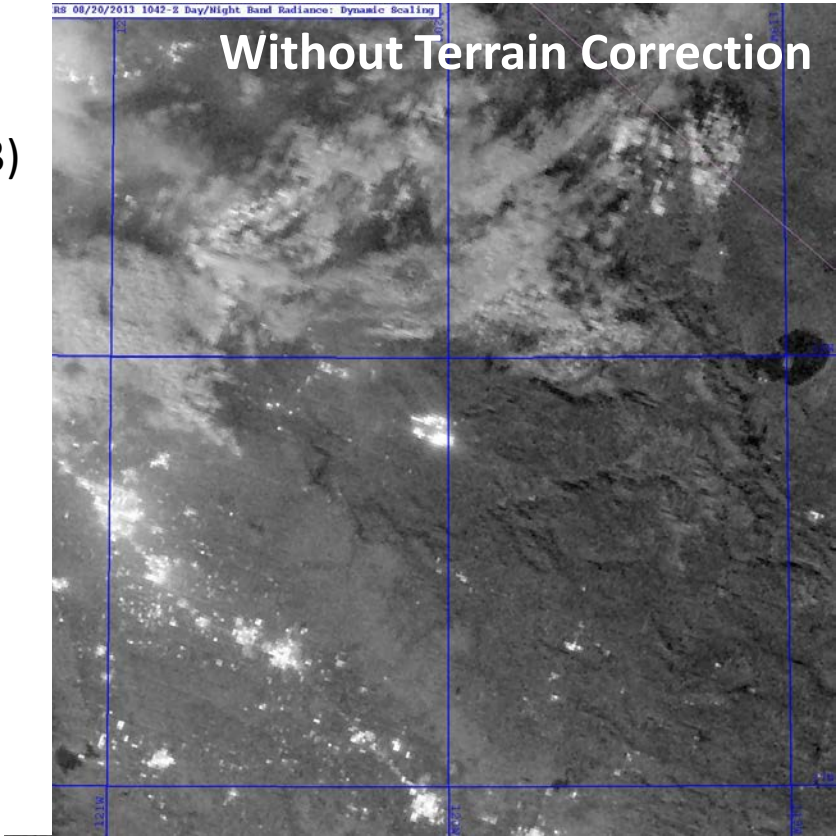


Do the fires move? Or does the ground move?

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.

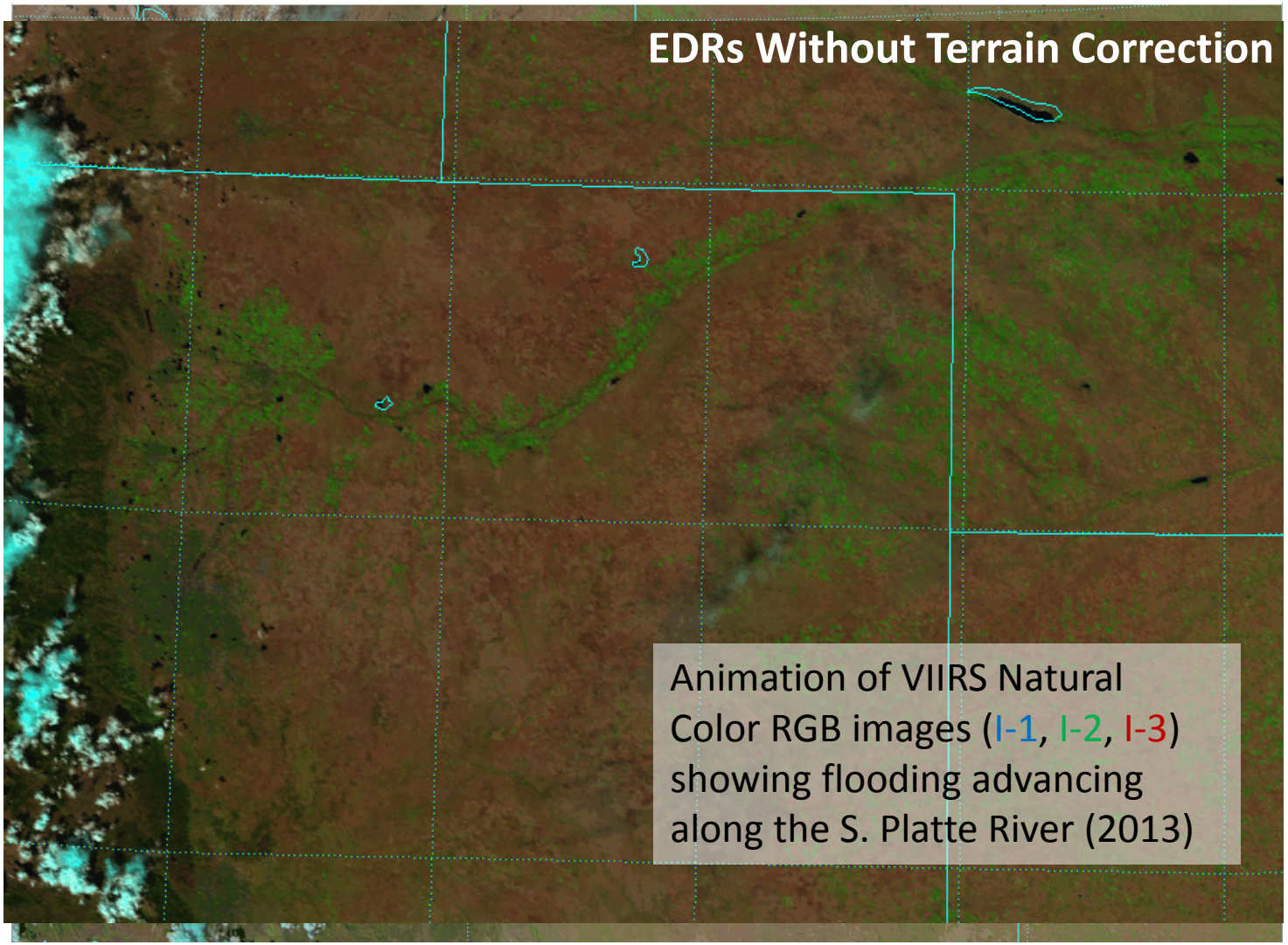
Terrain-correction was added to GDNBO files beginning in May 2014.



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.

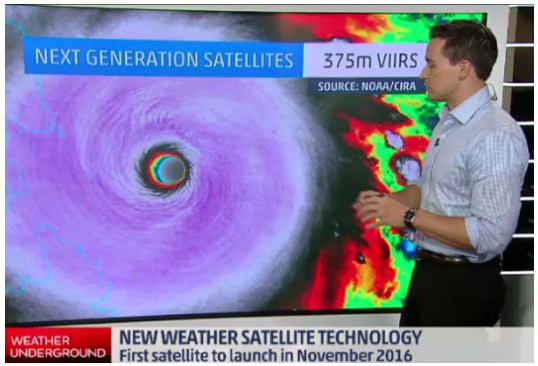
Flooding – with and without Terrain Correction



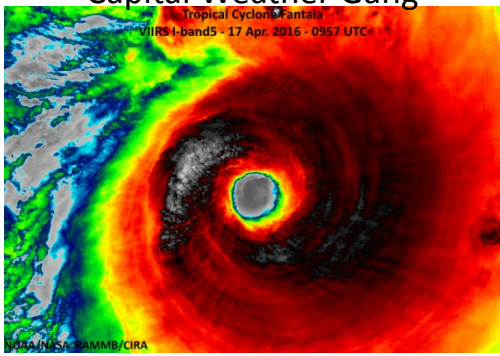
The River Ice and Flooding Product (Sanmei Li, GMU) would not be very useful if it was made with the EDRs!

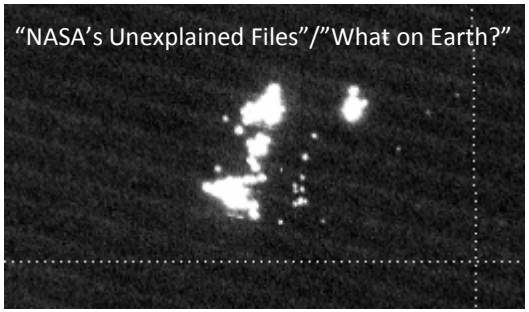
Spreading the Word

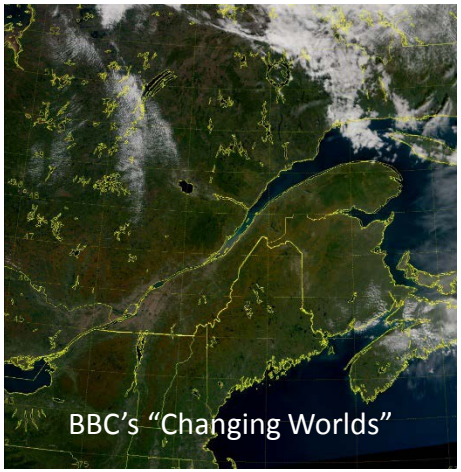
- CIRA VIIRS images have been delivered to a variety of standard media and social media outlets
  - The Weather Channel
  - CNN
  - BBC
  - WagTV (producer of shows for Discovery and Science Channel)
  - Washington Post/ Capital Weather Gang
  - @NOAASatellites on Twitter
  - And many more…

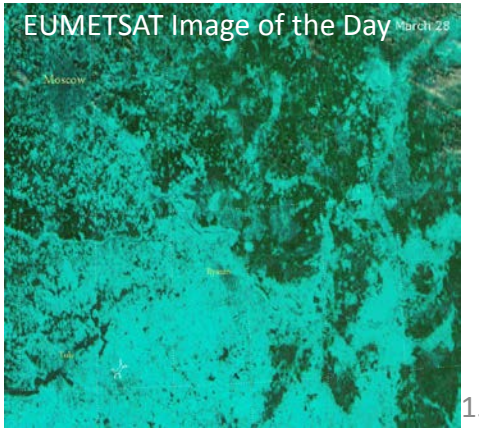


Capital Weather Gang



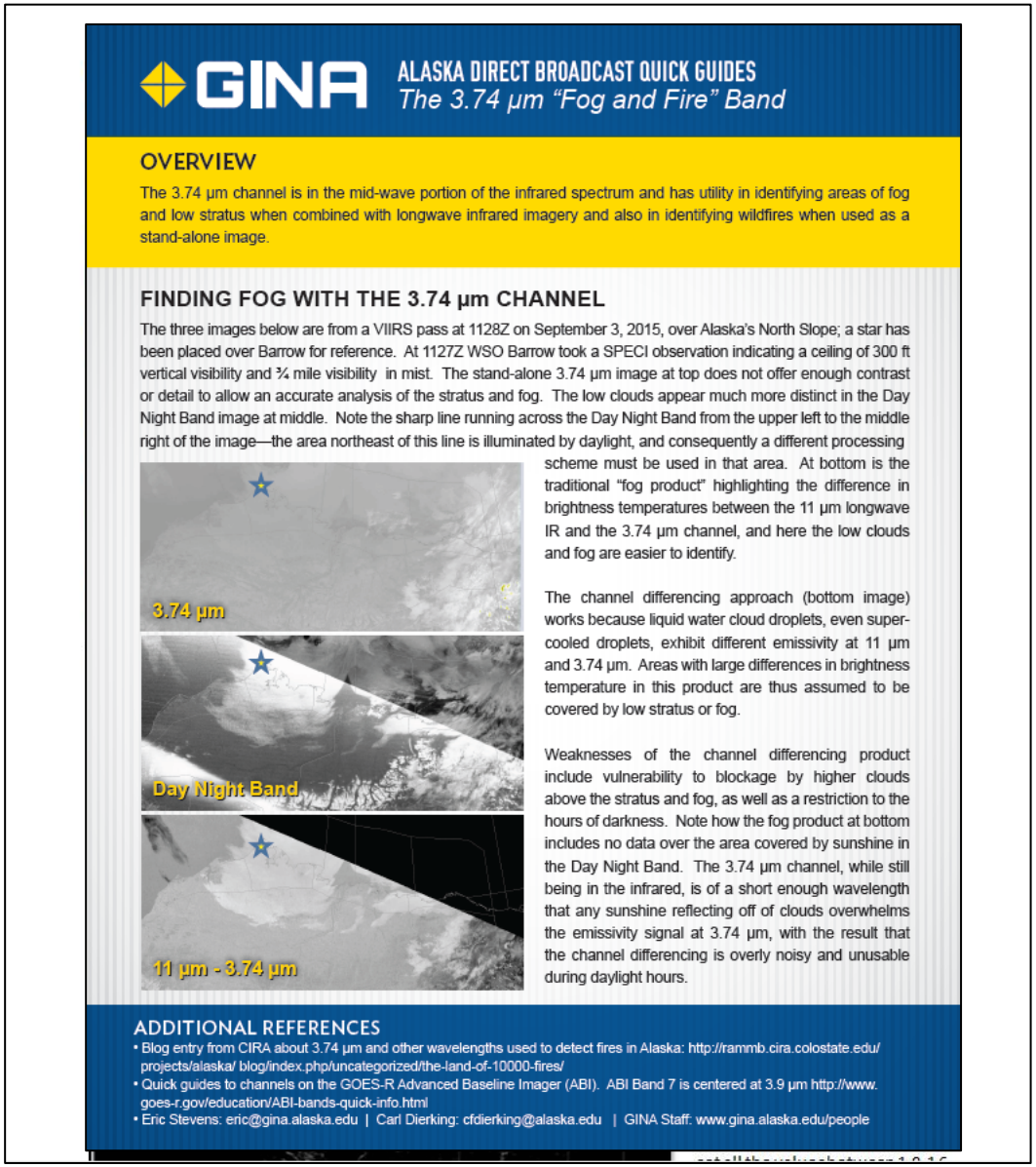






For the User Community

- 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

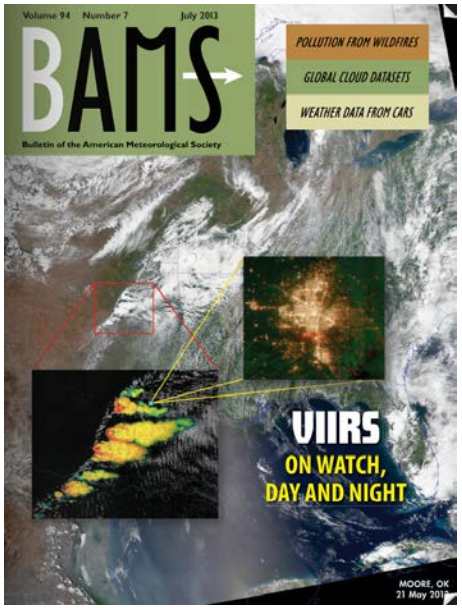
- Blog entry from CIRA about 3.74 µm and other wavelengths used to detect fires in Alaska: http://rammb.cira.colostate.edu/projects/alaska/blog/index.php/uncategorized/the-land-of-10000-fires/
- Quick guides to channels on the GOES-R Advanced Baseline Imager (ABI). ABI Band 7 is centered at 3.9 µm http://www.goes-r.gov/education/ABI-bands-quick-info.html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

Satellite Sensor Reveals Earth's Nocturnal Secrets

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.

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.

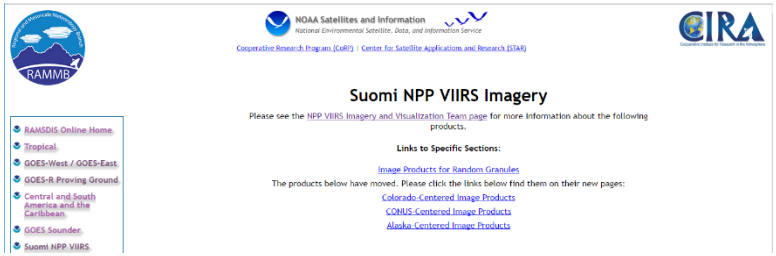
Squid boat shuffle

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 Koren 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

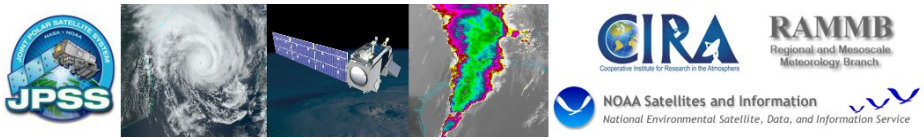
Resources

Near-realtime imagery products:



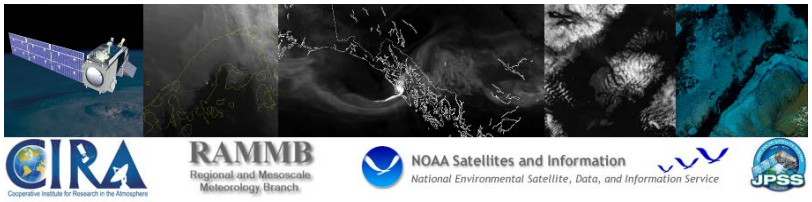
http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp

JPSS Imagery and Visualization Team blog:



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

High-latitude applications of VIIRS Imagery:



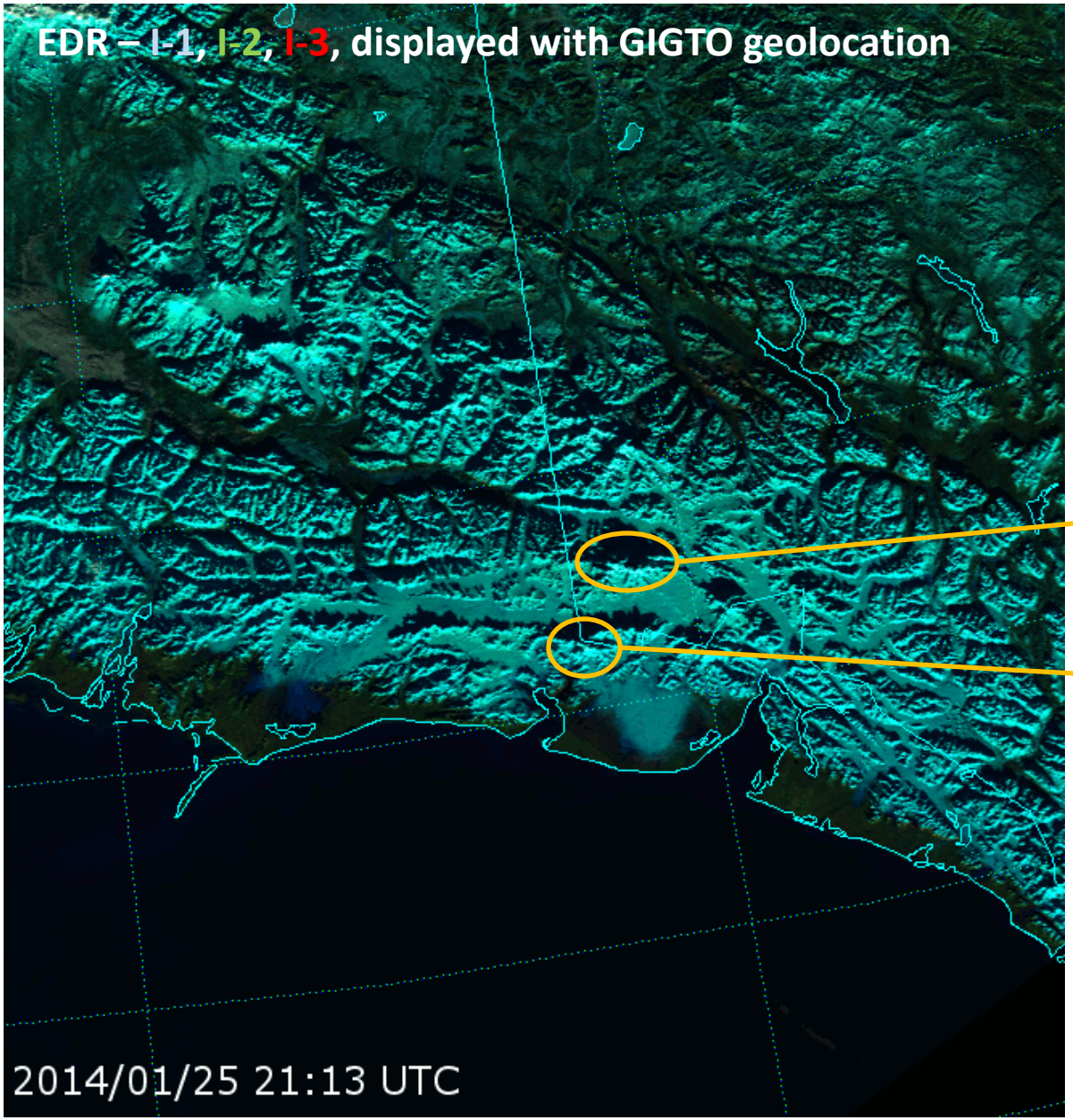
http://rammb.cira.colostate.edu/projects/alaska/blog/

VISIT Training Blog:

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

CIRA
Connecting Models and Observations

EDRs are **not** Terrain Corrected!

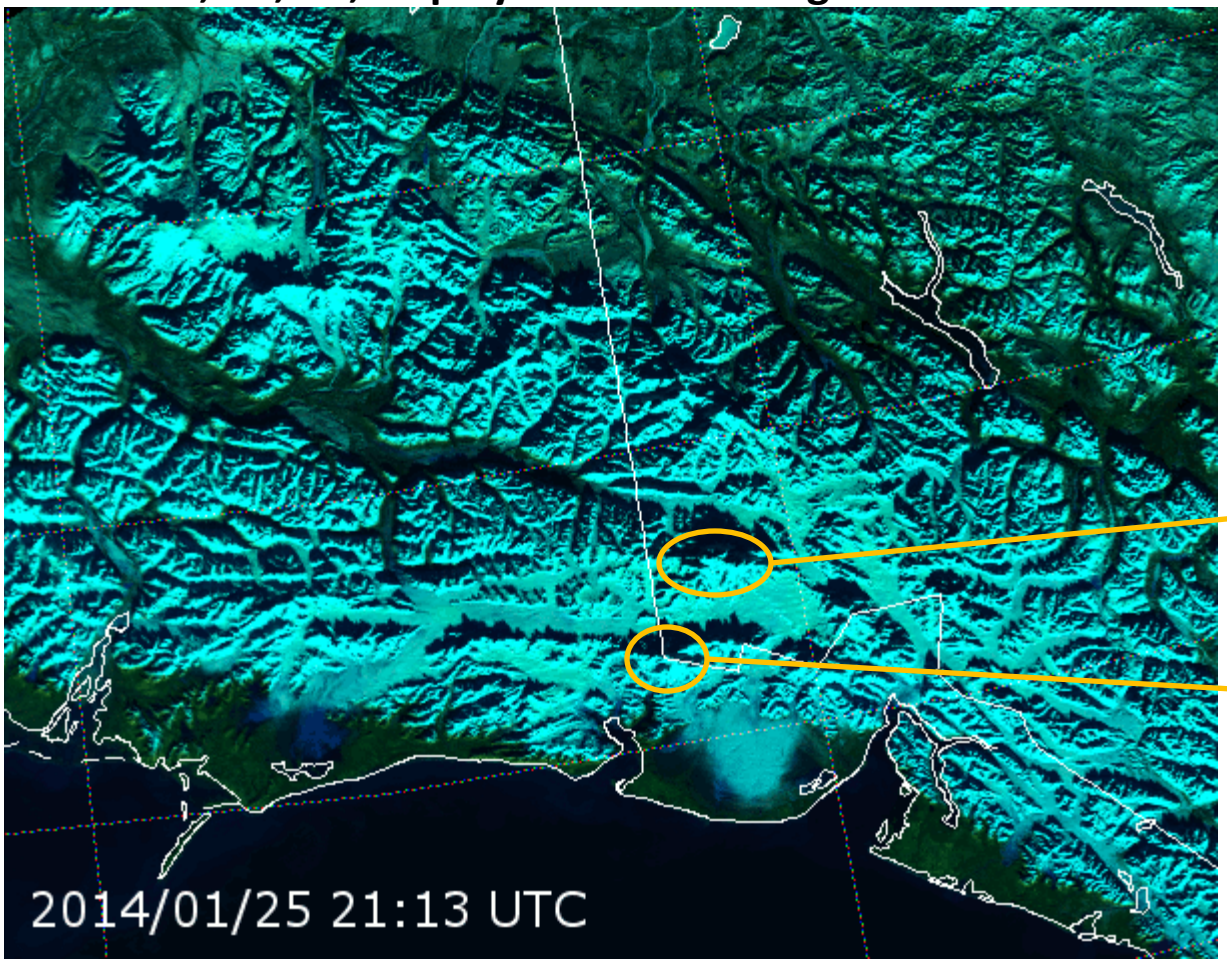


Mt. Logan
(6050 m MSL)

Mt. St. Elias
(5489 m MSL)

Terrain Correction Works!

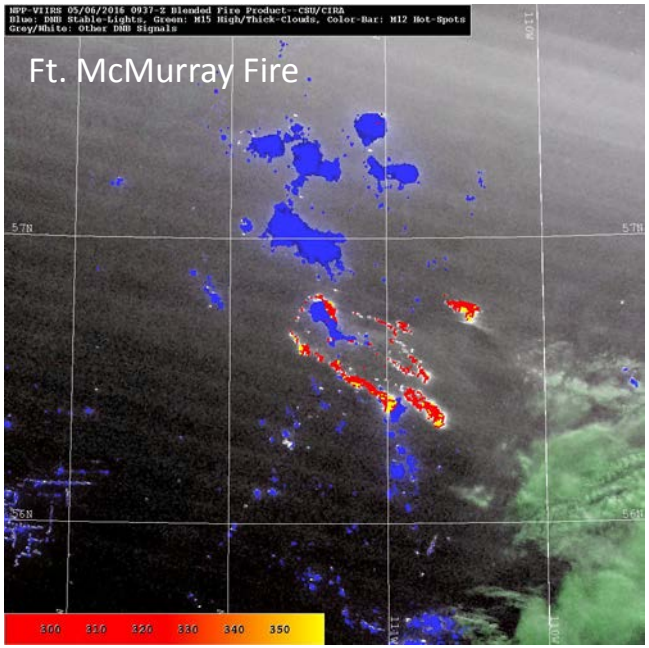
SDR – I-1, I-2, I-3, displayed with GITCO geolocation



Mt. Logan
(6050 m MSL)

Mt. St. Elias
(5489 m MSL)

Other DNB Multi-spectral Applications



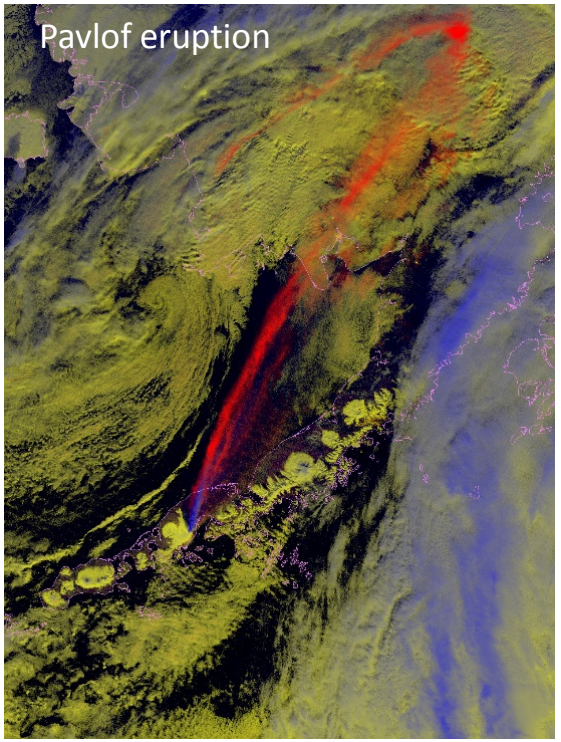
09:37 UTC 6 May 2016

- 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