JPSS STAR Science Team Annual Meeting

VIIRS EDR Imagery

Don Hillger, and Curtis Seaman, PhDs
EDR Imagery Team Product Lead
(Tom Kopp, Cal/Val Lead)
(Ryan Williams, JAM)
And the rest of the EDR Imagery Team!

12-16 May 2014

Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- S-NPP Algorithms Evaluation:
  - Algorithm Description, Validation Approach and Datasets, Performance *vs.* Requirements, Risks/Issues/Challenges, Quality Monitoring, Recommendations
- Future Plans
  - Plan for JPSS-1 Algorithm Updates and Validation Strategies, Schedule and Milestones
- Summary

EDR Imagery Cal/Val Team

- **NESDIS/StAR** (D. Hillger, D. Molenar, D. Lindsey, T. Schmit – GOES liaison)
- **CIRA/CSU** (C. Seaman, S. Miller, S. Kidder, S. Finley, R. Brummer)
- **CIMSS/SSEC** (T. Jasmin, T. Rink, W. Straka) **McIDAS-V**
- **Aerospace** (T. Kopp, J. Feeley)
- Stellar Solutions (R. Williams)
- **NOAA/NGDC** (C. Elvidge)
- **NRL** (J. Hawkins, K. Richardson, J. Solbrig)
- AFWA (J. Cetola)
- Northrop Grumman (K. Hutchison, R. Mahoney, C. Liang)
- NASA (W. Thomas, P. Meade)
- NOAA/OSPO (A. Irving)
- NASA/SPoRT (G. Jedlovec, M. Smith)

S-NPP/JPSS data sources

- **GRAVITE[1]** (Wash DC, ~7-hour delay)
- **NOAA CLASS[2]** (Asheville, ~7-hour delay) – not actively used
- **Atmosphere PEATE[3]** (Wisconsin, ~7-hour delay)
  - ADDE server for McIDAS
  - FTP and HTML
- **Direct Readout** (Wisconsin, ~0.5-hour delay, only over North America, when the satellite is with sight of Madison)
  - ADDE server for McIDAS
  - FTP
- **AFWA IDPS[4]** (Omaha, near real-time)

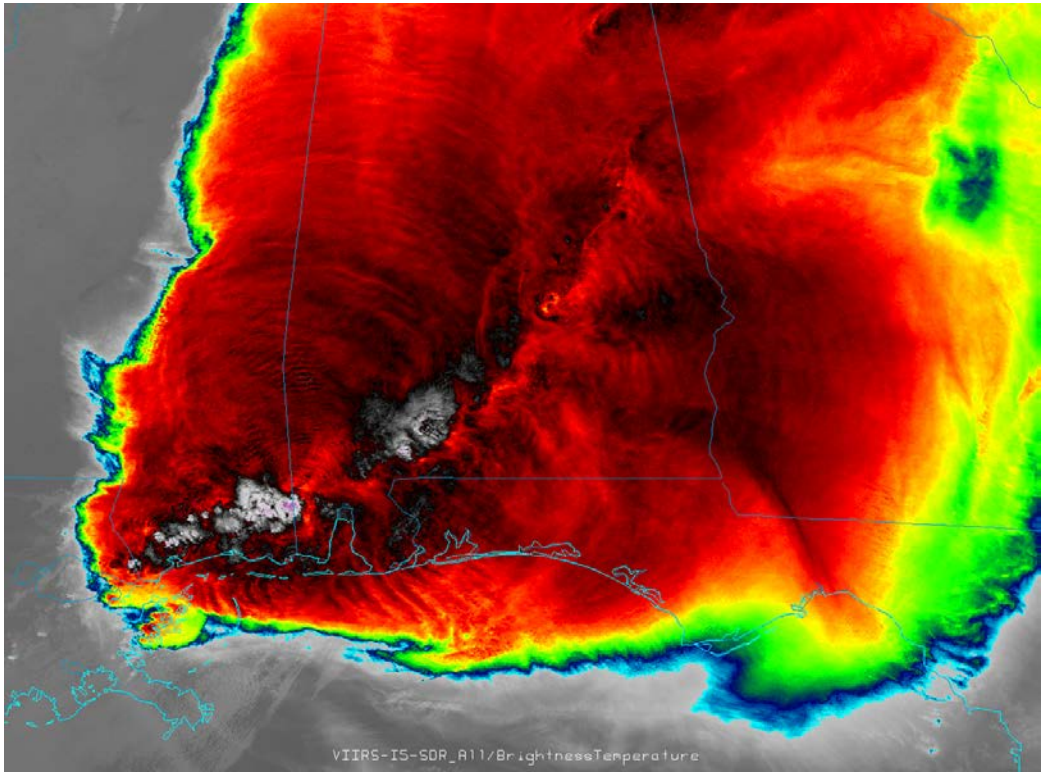
[1]Government Resource for Algorithm Verification, Independent Test, and Evaluation
[2]Comprehensive Large Array-data Stewardship System
[3]Product Evaluation and Algorithm Test Elements
[4]*Air Force Weather Agency* Interface Data Processing Segment

VIIRS Bands Created as EDR Imagery

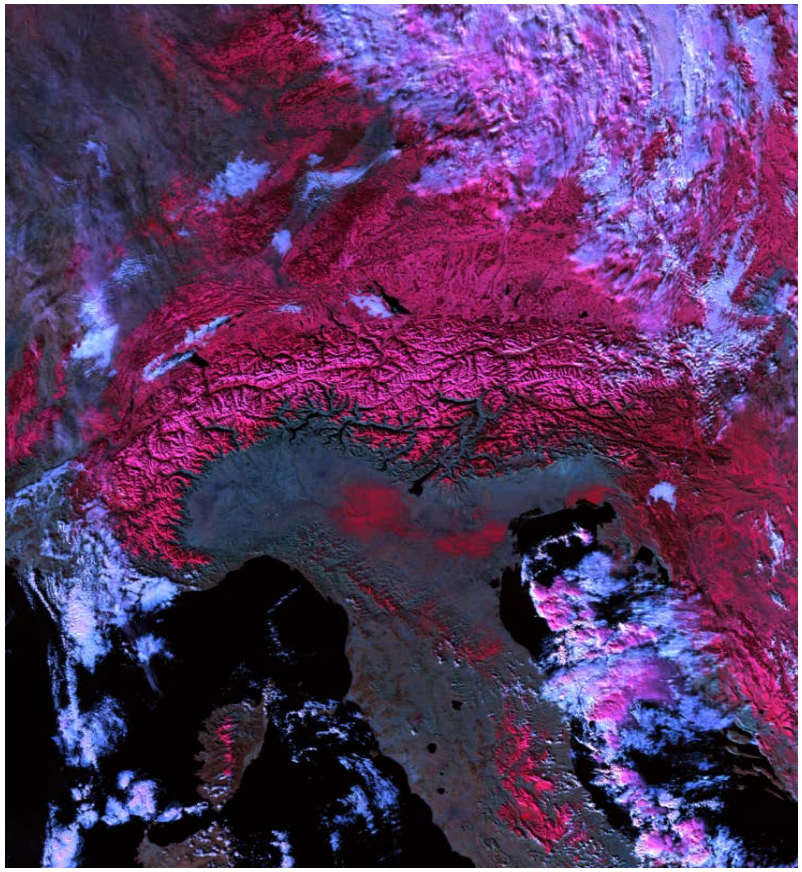
Bands in bold and highlighted in grey are available as Imagery EDRs.

VIIRS Band	Central Wavelength (µm)	Wavelength Range (µm)	Band Explanation	Spatial Resolution (m) @ nadir
M1	**0.412**	**0.402 - 0.422**	**Visible**	**750 m**
M2	0.445	0.436 - 0.454		
M3	0.488	0.478 - 0.488		
M4	**0.555**	**0.545 - 0.565**		
M5	0.672	0.662 - 0.682		
M6	0.746	0.739 - 0.754	**Near IR**	
M7	0.865	0.846 - 0.885		
M8	1.240	1.23 - 1.25	**Shortwave IR**	
M9	**1.378**	**1.371 - 1.386**		
M10	1.61	1.58 - 1.64		
M11	2.25	2.23 - 2.28		
M12	3.7	3.61 - 3.79	**Medium-wave IR**	
M13	4.05	3.97 - 4.13		
M14	**8.55**	**8.4 - 8.7**	**Longwave IR**	
M15	**10.763**	**10.26 - 11.26**		
M16	**12.013**	**11.54 - 12.49**		
DNB (NCC)	**0.7**	**0.5 - 0.9**	**Visible**	**750 m across full scan**
I1	**0.64**	**0.6 - 0.68**	**Visible**	**375 m**
I2	**0.865**	**0.85 - 0.88**	**Near IR**	
I3	**1.61**	**1.58 - 1.64**	**Shortwave IR**	
I4	**3.74**	**3.55 - 3.93**	**Medium-wave IR**	
I5	**11.45**	**10.5 - 12.4**	**Longwave IR**	

Suomi NPP VIIRS Imagery examples



High-resolution color-enhanced infrared of cloud tops. Image courtesy of Dan Lindsey.

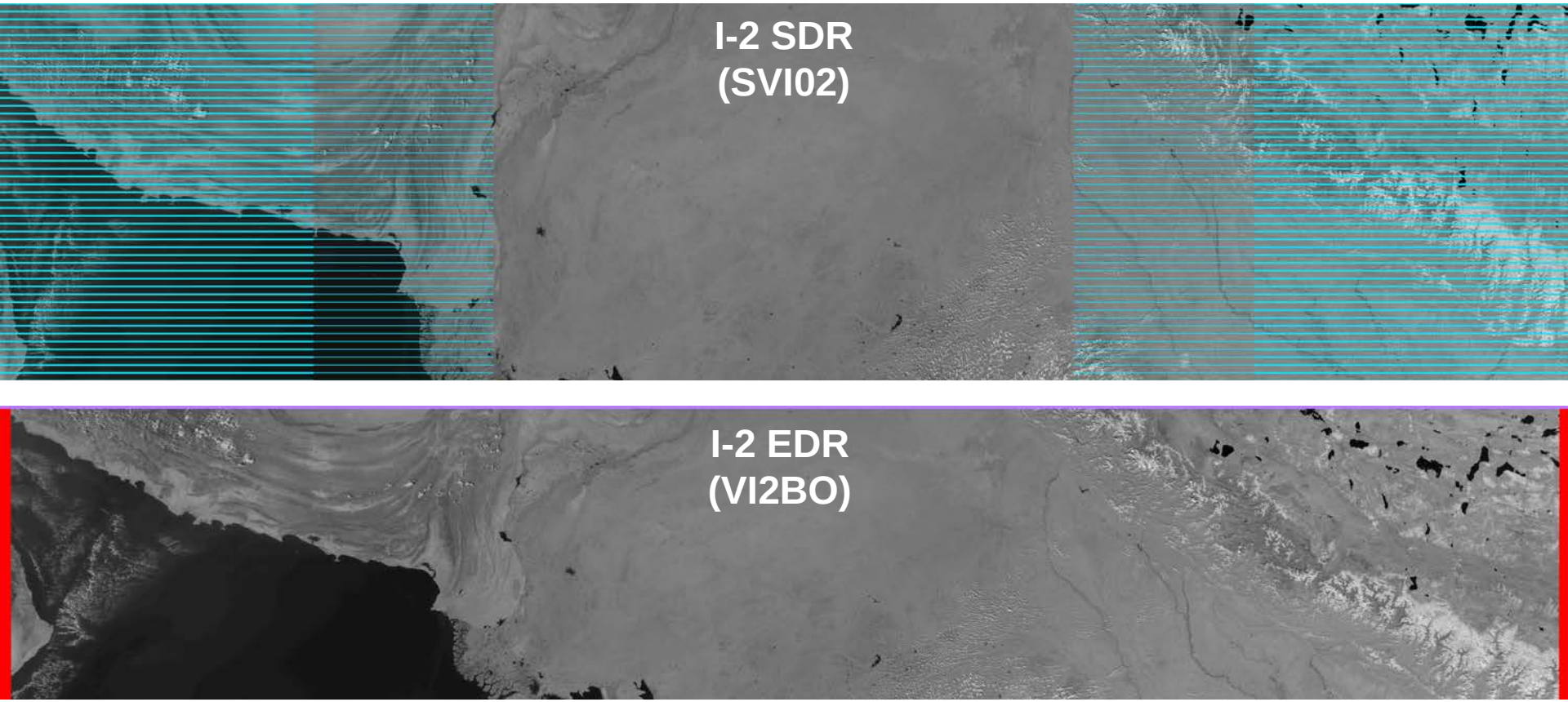


3-color image combination of visible and IR bands over northern Italy. Image courtesy of Curtis Seaman.

VIIRS EDR Imagery Basics

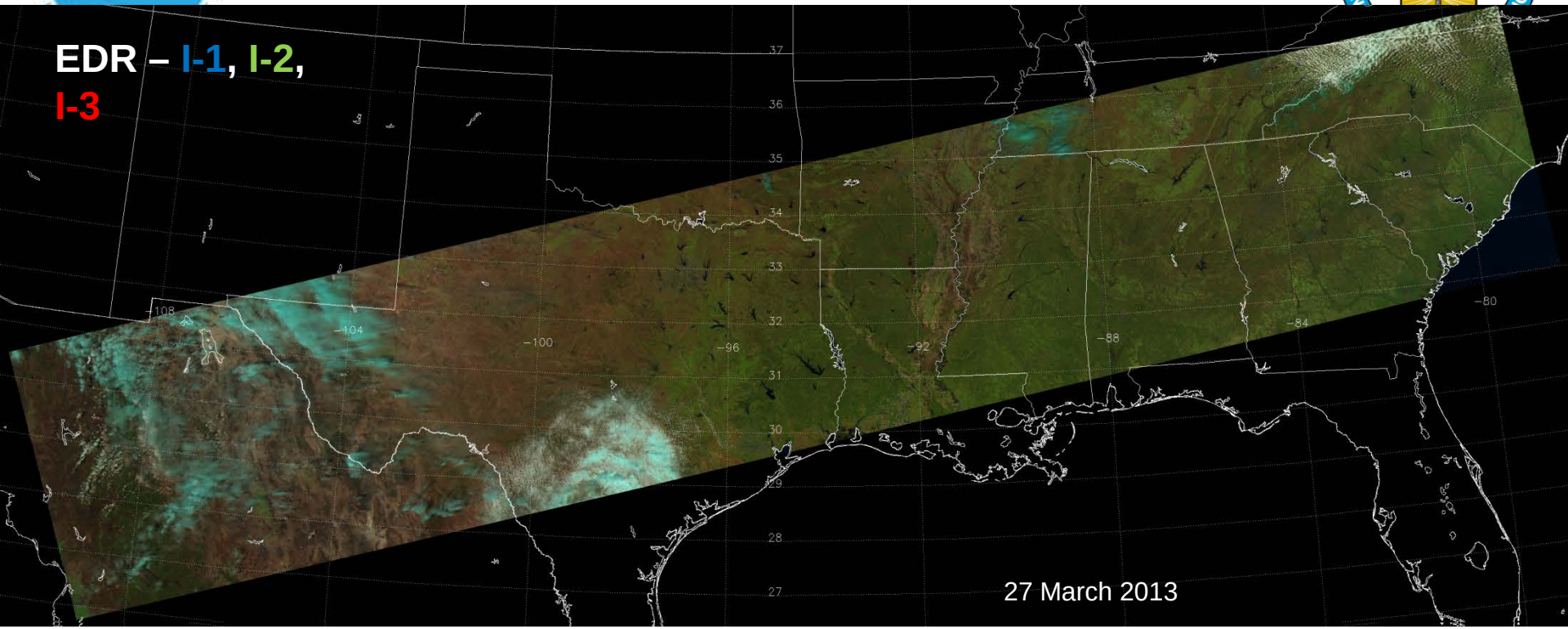
- The **Imagery EDR** is the projection of SDRs onto a **Ground Track Mercator (GTM)** layout (remapped)
  - For the non-DNB/NCC bands: the radiances/reflectances are the same
  - For the **DNB SDR: the Near Constant Contrast (NCC) EDR** Imagery product has additional calculations involved
- Advantages of Imagery EDRs:
  - Bowtie-deletions eliminated
  - Overlapping pixels eliminated
- Current EDR Imagery:
  - 5 I-bands (all of them)
  - 6 of the 16 M-bands (default set, leaving 10 M-bands behind!)

SDRs and EDRs: What's the difference?

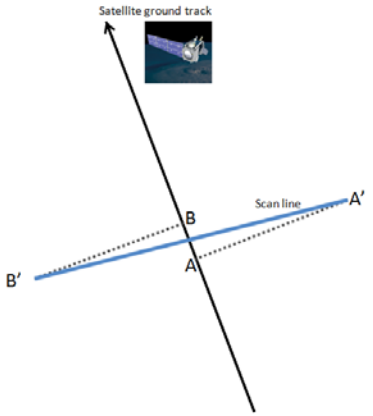


Unmapped SDR and EDR granules from 08:14 UTC 24 October 2013

SDRs and EDRs: Apparent Rotation

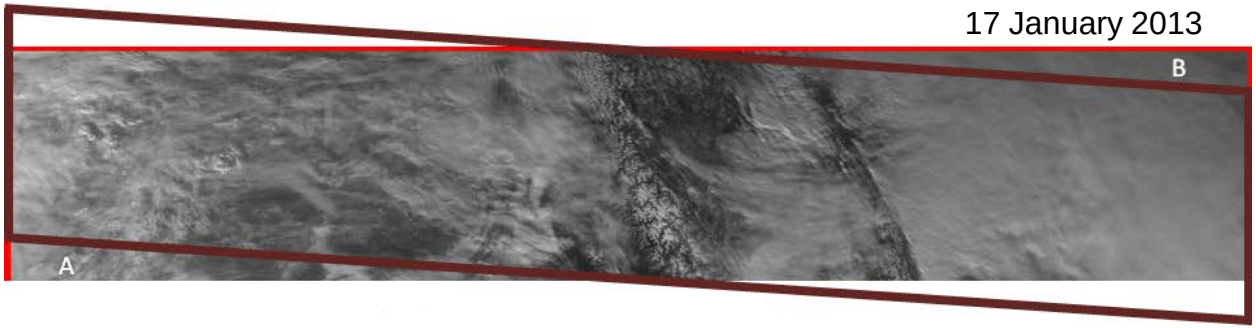


Scan lines in SDR data are not orthogonal to the satellite ground track, due to the constant motion of the satellite. Mapping the data to the Ground Track Mercator (GTM) grid restores orthogonality. This is the cause of the apparent rotation between SDRs and EDRs.



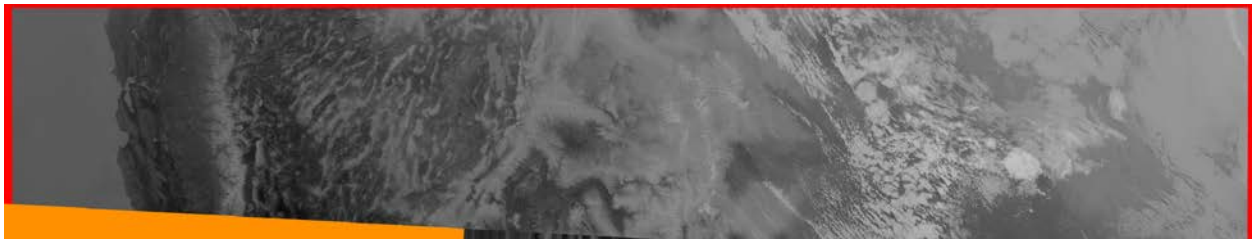
The Case of the Missing Triangles

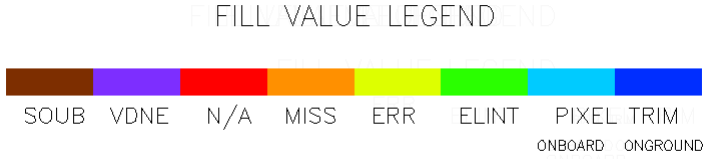
17 January 2013



The brown outline shows where a SDR granule matches up with a given EDR granule. It takes three SDR granules to produce one EDR granule. If an SDR granule is missing when the EDR is created, you get a “missing triangle”…

24 February 2012





Unique features of VIIRS, as compared with its predecessors

- **Finer spatial resolution** for all bands (down to 375 m)
- **Finer spatial resolution at swath edge in particular**
- **Wider (3000 km) swath**, leaving no gaps between adjacent orbits
- **DNB / NCC enables visible light imagery under all natural and artificial illumination conditions**

NCC (EDR) vs. DNB (SDR)

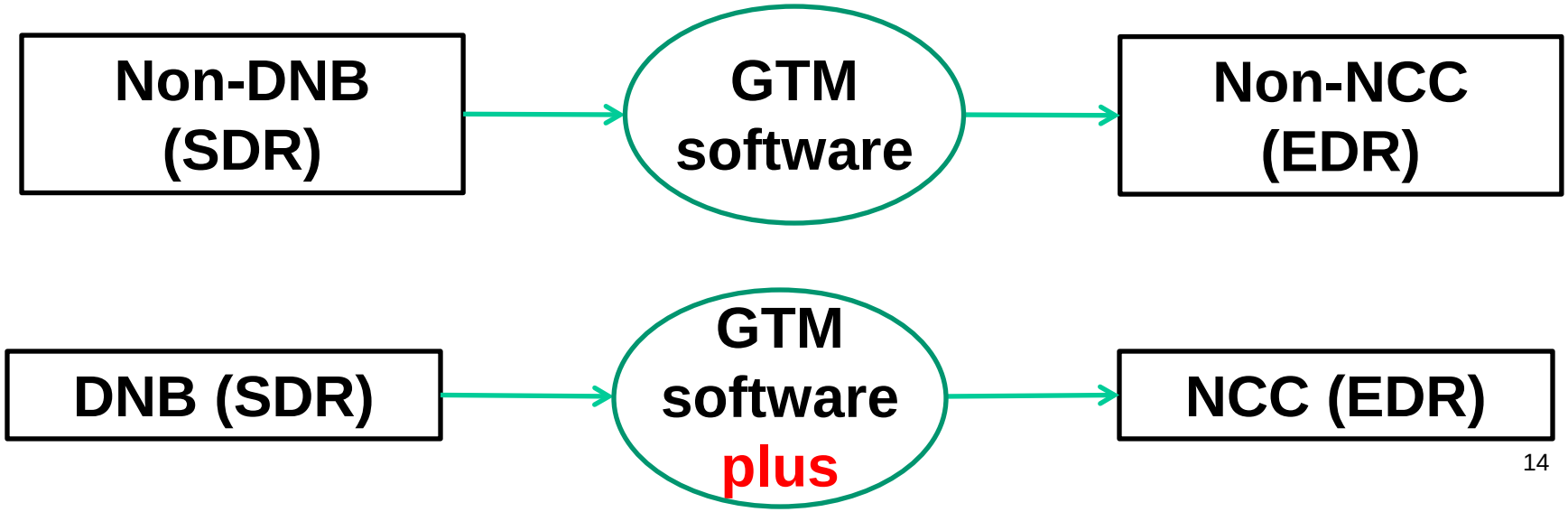
- **What are the differences?**

Product	xDR	Units	Mapping
DNB	SDR	Radiances	Raw
NCC	EDR	Pseudo-albedos	GTM

- **Which is better?**
- **Answer: Depends on the usage!**

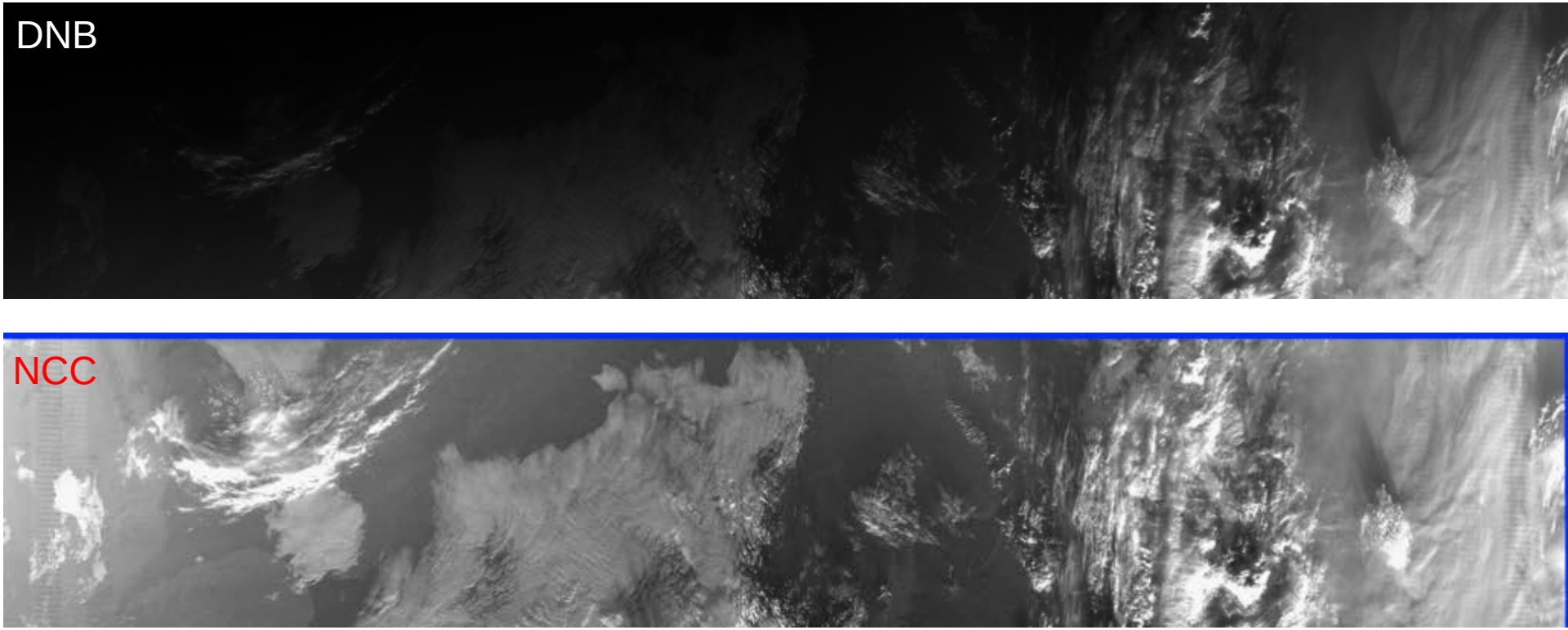
Sensor Data Record (SDR) to Environmental Data Record (EDR)

- **Ground Track Mercator (GTM)** remapping software.
  - GTM is a **remapping** of the data, but the **same radiances/reflectances** for Non-NCC bands only.
- For **NCC Imagery** there is **additional radiance processing**



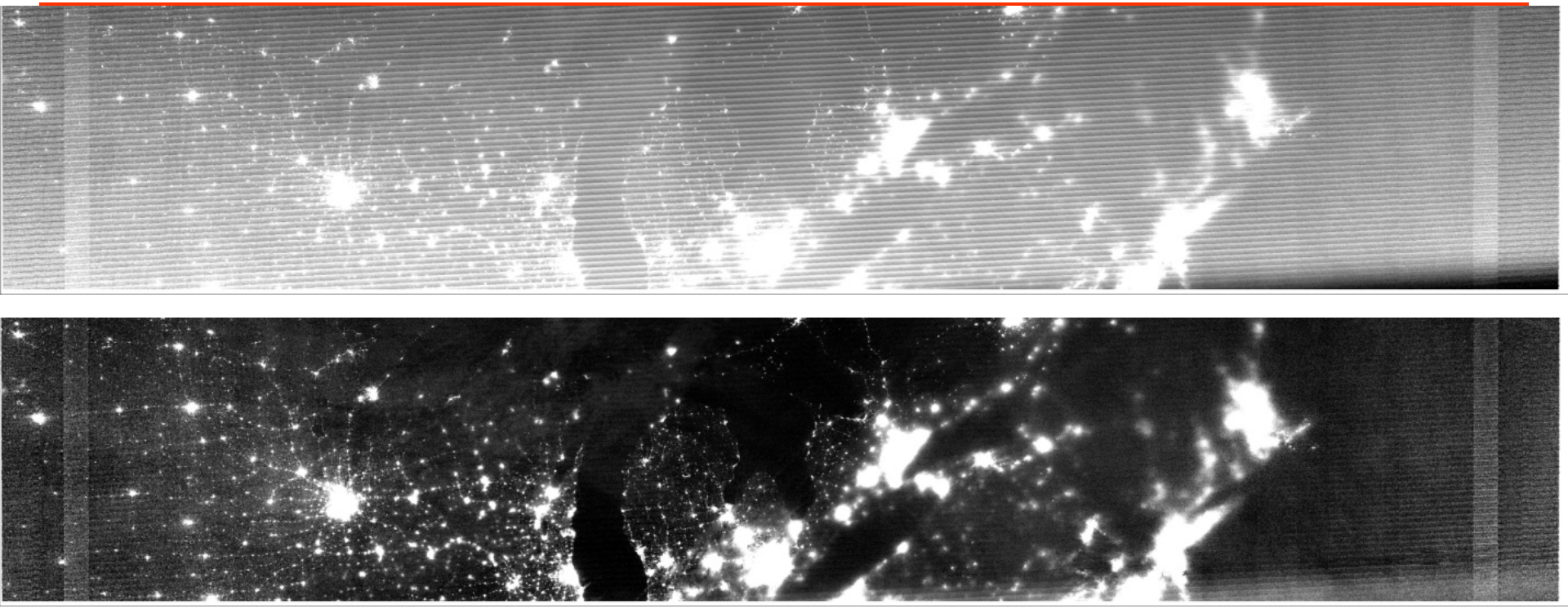
Near Constant Contrast (NCC) Product

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



Cross-terminator DNB SDR (top) versus NCC Imagery EDR (bottom)

Stray light in NCC Imagery before (top) versus NCC after removal (bottom)



Artifacts in the DNB SDR are inherited by the NCC Imagery EDR. Before August 2013 the most significant of these was a stray light issue with the DNB on the dark side of the terminator. The DNB SDR algorithm was adjusted to correct for this error in August 2013. The impact on the NCC Imagery EDR was profound. The removal of the stray light is evident in the bottom image, taken from the granule over the upper Midwest of the United States on 9 August 2013. As a reference, Lake Michigan may be seen in the middle of the granule

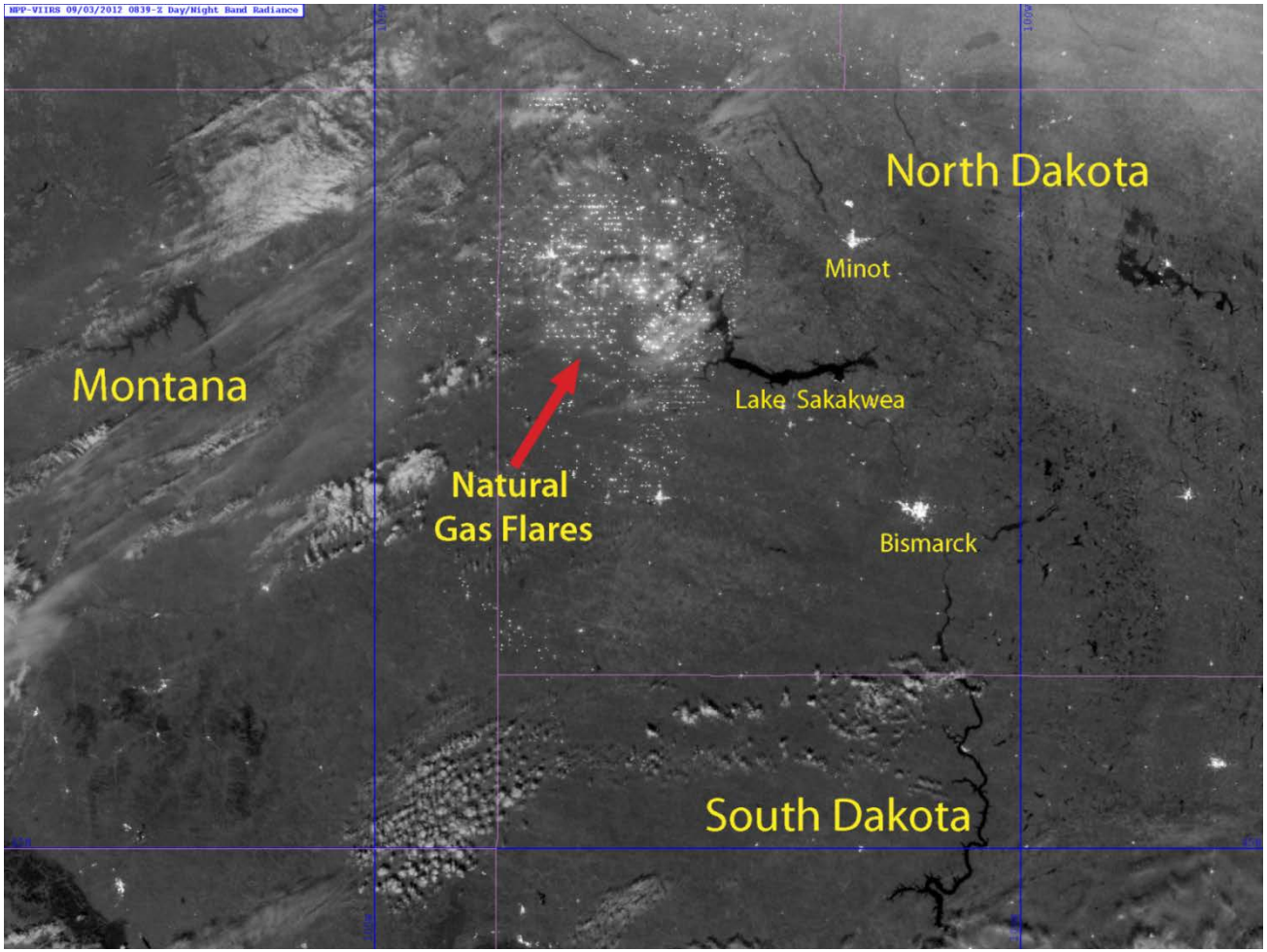
Algorithm Evaluations
(Slide formatted as requested.)

- In the case of IDPS algorithms, we want the algorithm leads to provide 1 of 3 recommendations:

  1. **NPOESS algorithm has evolved into the NOAA-endorsed JPSS algorithm and any needed improvements should continue.**
  2. NPOESS (or evolved) algorithm will not meet requirements or effort is too large, replace with NOAA-endorsed JPSS algorithm
  3. NOAA-endorsed algorithm should be used even if NPOESS (or evolved) algorithm meets performance because of legacy, enterprise, blended products, and other considerations.

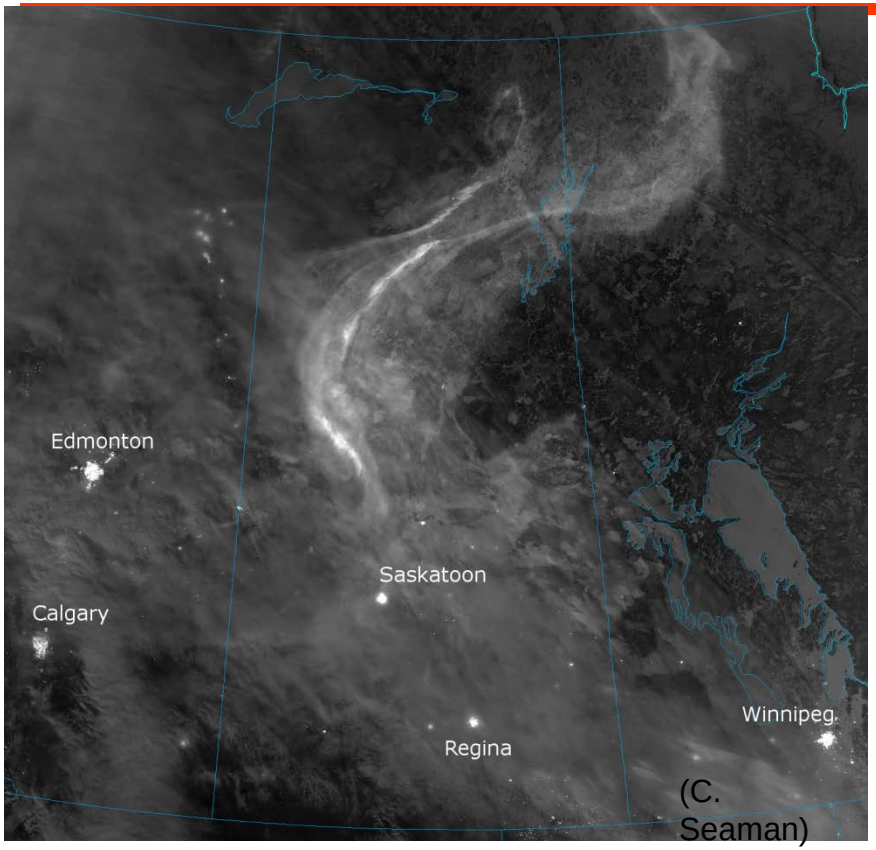
- For 2 or 3, present the alternative algorithm methodology description, algorithm performance against the level 2 supplement specification and any user assessments.

Mostly cloud-free DNB image over the U.S. Upper Midwest, 3 September 2012 at 0839 UTC

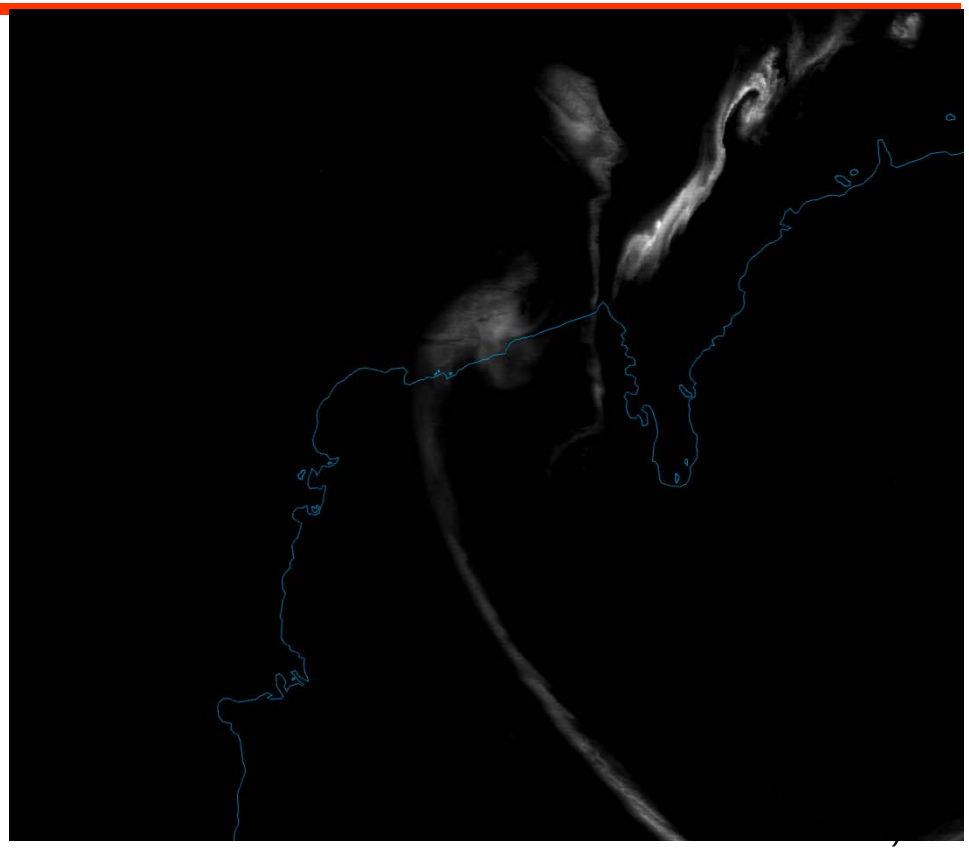


Note the lights from major cities, as well as a large cluster of oil flare signatures in northwestern North Dakota from the recently-developed Bakken formation.

Auroras in the DNB
Images courtesy Curtis Seaman (CIRA)



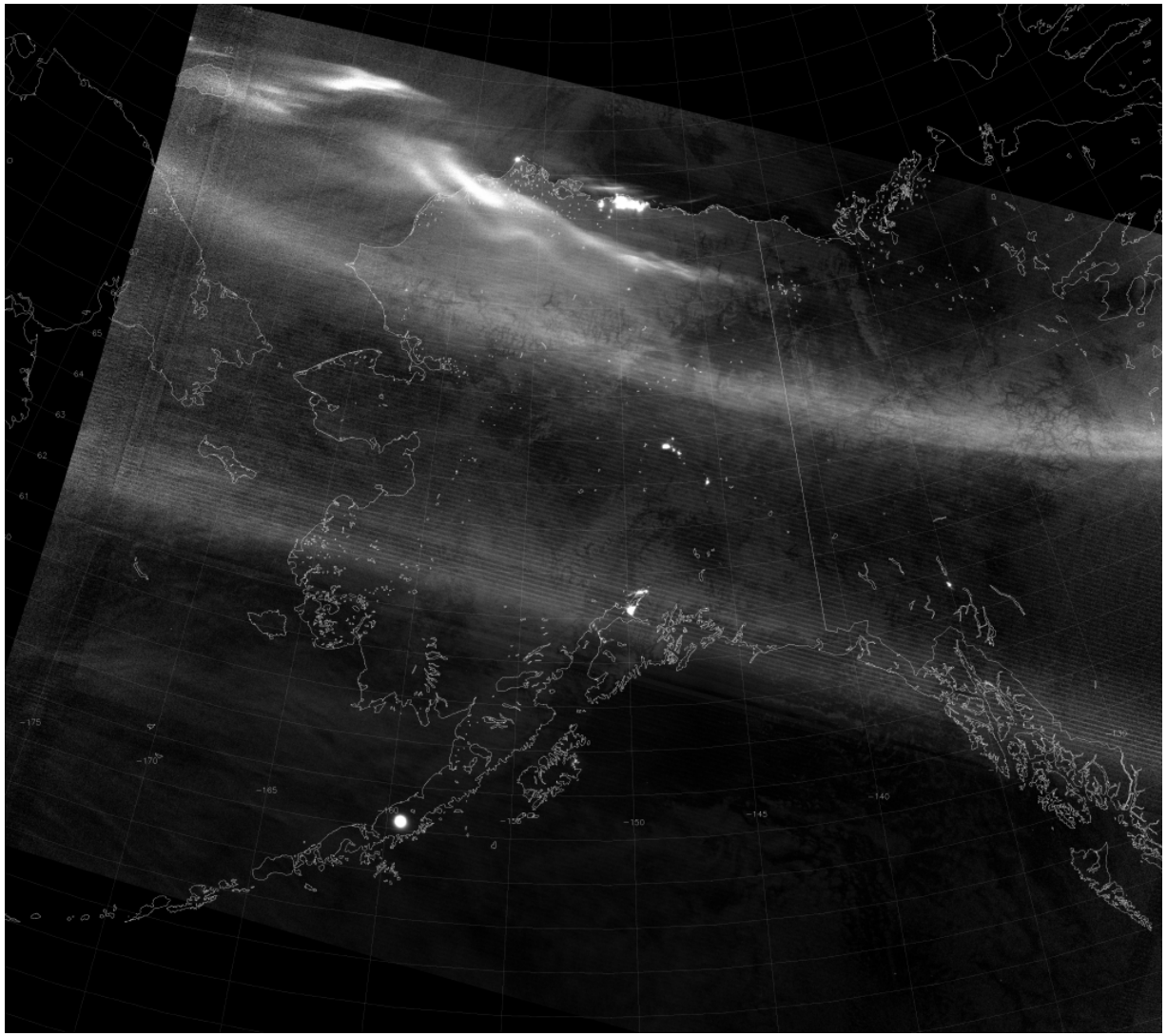
Aurora Borealis over Saskatchewan, Canada on 9 March 2012, visible during a full moon!



Aurora Australis over Antarctica on 15 September 2012, during a new moon.

VIIRS DNB image, 1219 UTC, 7 October 2013.

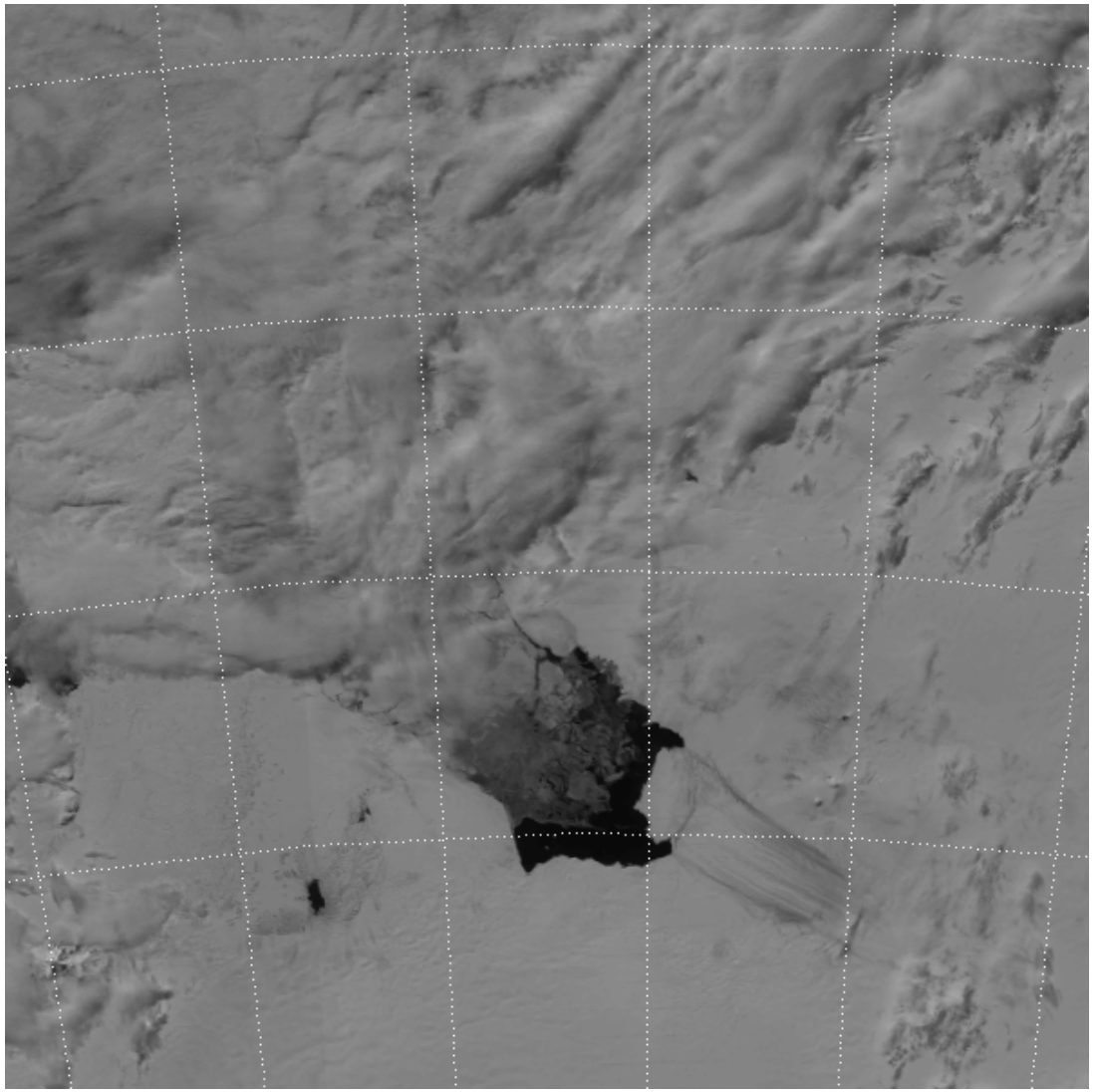
Image courtesy Curtis Seaman (CIRA)



Note Aurora (as well as stray light), Prudhoe Bay lights, and Veniamin of volcano on Aleutian Islands

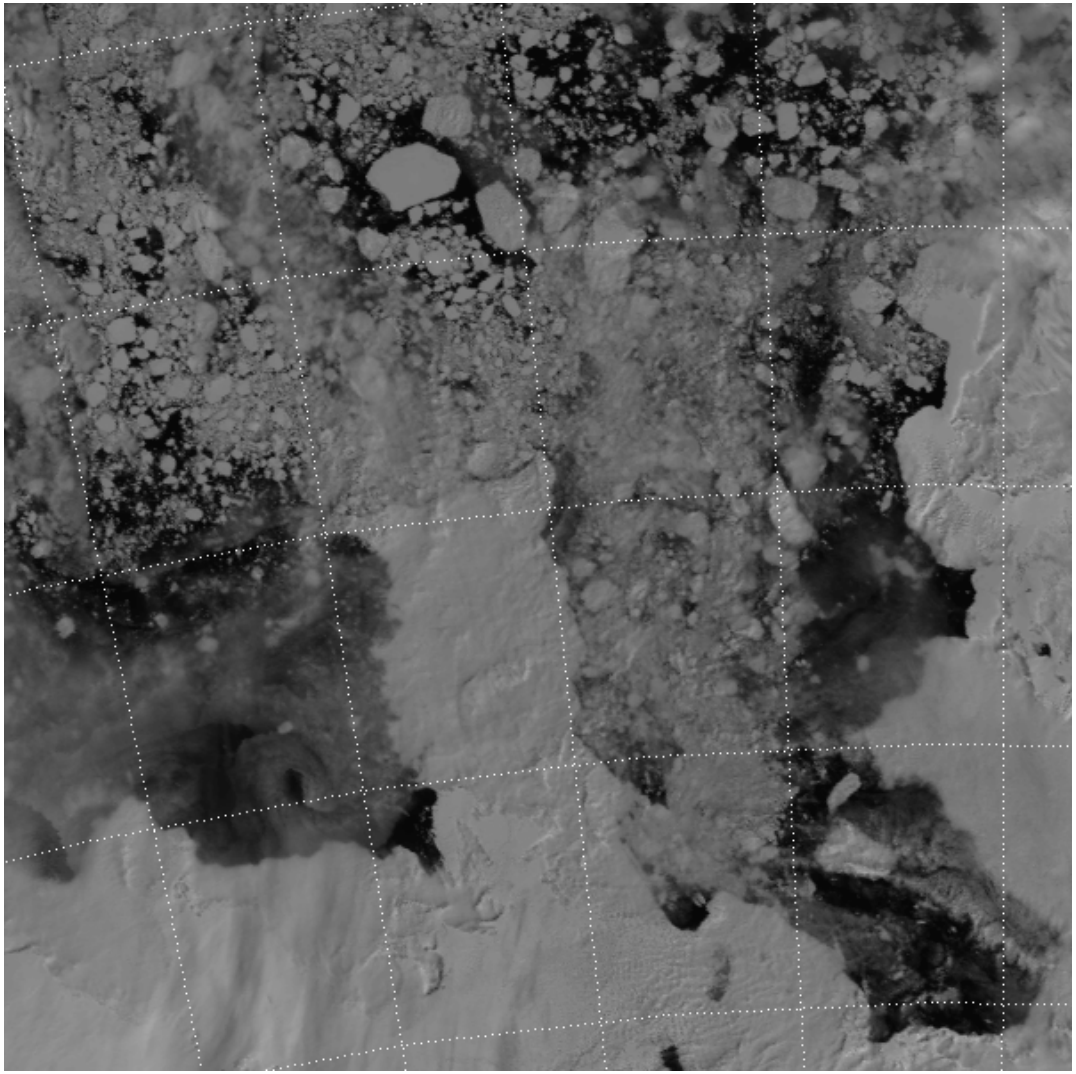
Animation of VIIRS NCC images of the Pine Island Glacier and a huge iceberg breaking away, 7-18 November 2013.

Images courtesy Curtis Seaman (CIRA)



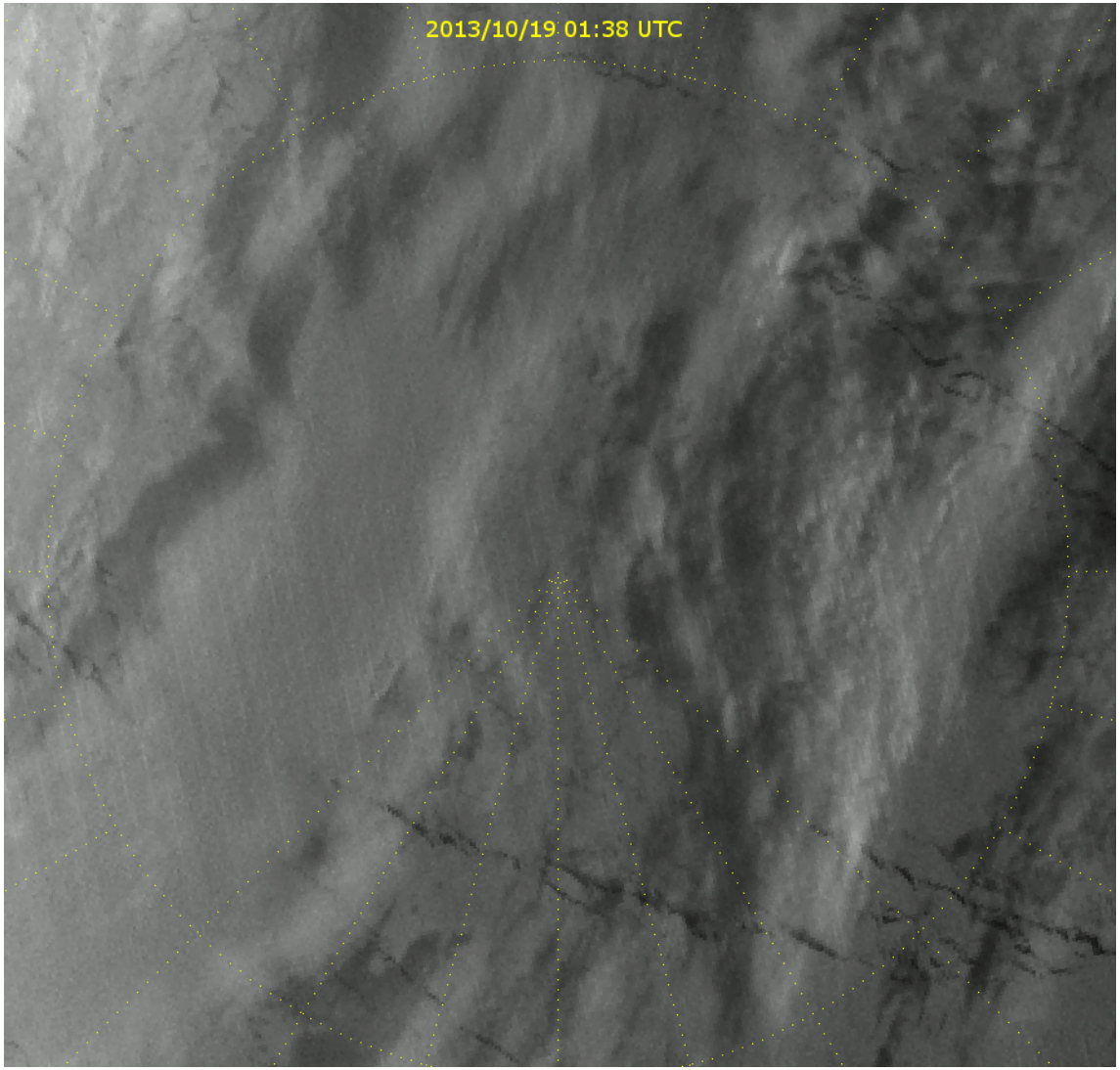
Animation of VIIRS NCC images of icebergs, 20-26 December 2013.

Images courtesy Curtis Seaman (CIRA)



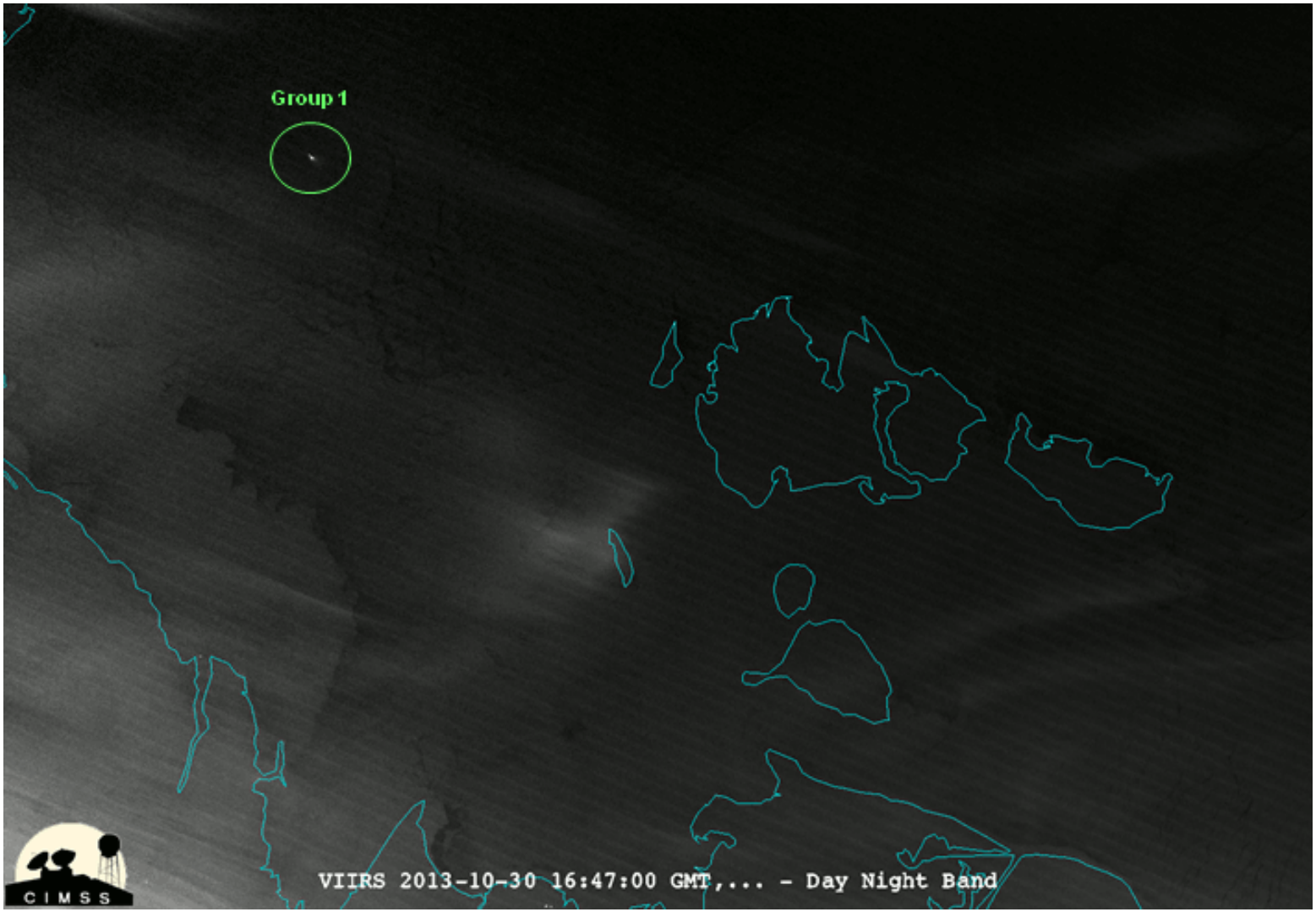
Animation of VIIRS DNB images from 19-20 October 2013. The North Pole is located at the center of the image. Light from the ship carrying the 2014 Winter Olympic torch is visible.

Images courtesy Curtis Seaman (CIRA)



Animation of selected VIIRS DNB images from 30 October to 2 November 2013.

Images courtesy William Straka III (CIMSS)



Future Plans

- **VIIRS EDR Imagery latency** (of 6-7 hours for non-direct broadcast imagery) is a major hindrance for real-time use by analysts and forecasters.
- **Missing M-bands as EDRs** limits many image products, including RGB combinations, one being true-color imagery.
- Remaining relatively-minor NCC Imagery issues continue:
  - **Stray light** will continue with JPSS-1
  - **Crosstalk** issue being studied
- **Involving additional Imagery users** depends on data availability issues, such as lack of bandwidth to carry VIIRS Imagery to AWIPS for example.

Summary

- VIIRS EDR Imagery (including NCC Imagery) has reached the **Validation 3 maturity stage** in April 2014, back dated to August 2013.
- **Feedback** is still requested from users.
- **DNB/NCC** will continue as **unique imagery** on JPSS-1 and JPSS-2!
- Only major concern is **data latency** for non-direct-broadcast users (~6 hours).

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VIIRS Imagery outreach at RAMMB/CIRA

- 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 Cal/Val** http://www.nrlmry.navy.mil/VIIRS.html