Suomi NPP VIIRS Near Constant Contrast (NCC) Imagery EDR Review - Provisional

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and the
EDR Imagery and Visualization Team

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VIIRS EDR Imagery (and Visualization) Team

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- CIRA/CSU (C. Seaman, S. Miller, S. Kidder, S. Finley, R. Brummer)
- CIMSS/SSEC (T. Jasmin, T. Rink, W. Straka)
- Aerospace (T. Kopp, J. Feeley)
- NOAA/NGDC (C. Elvidge)
- NRL (J. Hawkins, K. Richardson, J. Solbrig, T. Lee)
- AFWA (J. Cetola)
- Northrop Grumman (C. Liang, S. Weiss, R. Mahoney)
- NASA (R. Williams, W. Thomas)
- NOAA/OSPO (S. Qiu)
- COAST/Raytheon (B. Johnson)
- NASA/SPoRT (G. Jedlovec, M. Smith)
- StAR (V. Mikles, M. Tsidulko)

VIIRS Environmental Data Record (EDR)s

VIIRS Band	Central Wavelength (µm)	Bandwidth (µm)	Wavelength Range (µm)	Band Explanation	Spatial Resolution (m) @ nadir
M1	0.412	0.02	0.402 - 0.422	Visible	750 m
M2	0.445	0.018	0.436 - 0.454		
M3	0.488	0.02	0.478 - 0.488		
M4	0.555	0.02	0.545 - 0.565		
M5 (B)	0.672	0.02	0.662 - 0.682		
M6	0.746	0.015	0.739 - 0.754	Near IR	
M7 (G)	0.865	0.039	0.846 - 0.885		
M8	1.240	0.020	1.23 - 1.25	Shortwave IR	
M9	1.378	0.015	1.371 - 1.386		
M10 (R)	1.61	0.06	1.58 - 1.64		
M11	2.25	0.05	2.23 - 2.28		
M12	3.7	0.18	3.61 - 3.79	Medium-wave IR	
M13	4.05	0.155	3.97 - 4.13		
M14	8.55	0.3	8.4 - 8.7	Longwave IR	
M15	10.763	1.0	10.26 - 11.26		
M16	12.013	0.95	11.54 - 12.49		
DNB	0.7	0.4	0.5 - 0.9	Visible	750 m across full scan
I1 (B)	0.64	0.08	0.6 - 0.68	Visible	375 m
I2 (G)	0.865	0.039	0.85 - 0.88	Near IR	
I3 (R)	1.61	0.06	1.58 - 1.64	Shortwave IR	
I4	3.74	0.38	3.55 - 3.93	Medium-wave IR	
I5	11.45	1.9	10.5 - 12.4	Longwave IR	

Notes:

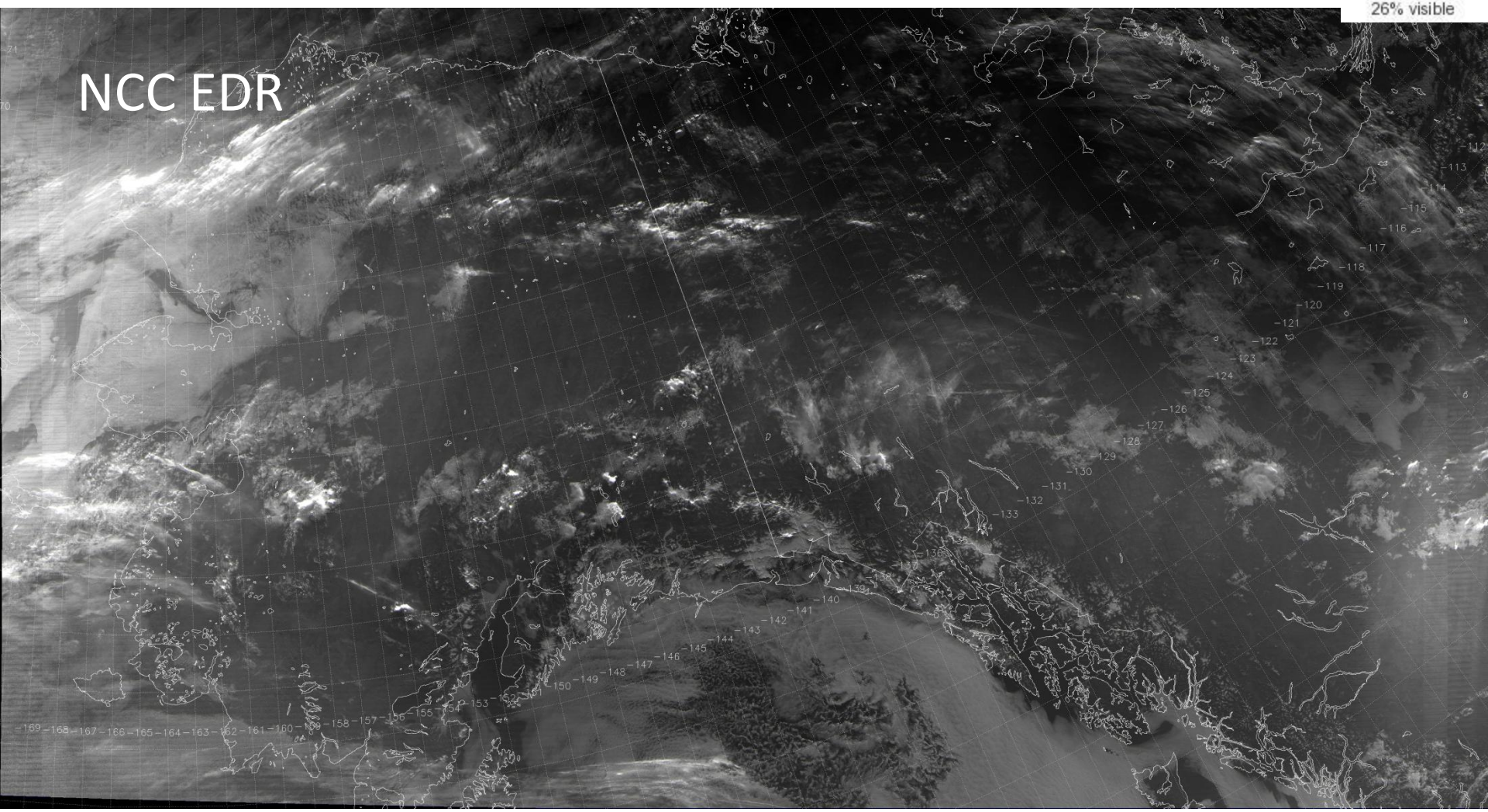
M-bands highlighted in pale yellow are available as EDRs, in addition to SDRs.

True-color component bands are highlighted in red, green, and blue.

Natural-color component bands are noted with R, G, and B.

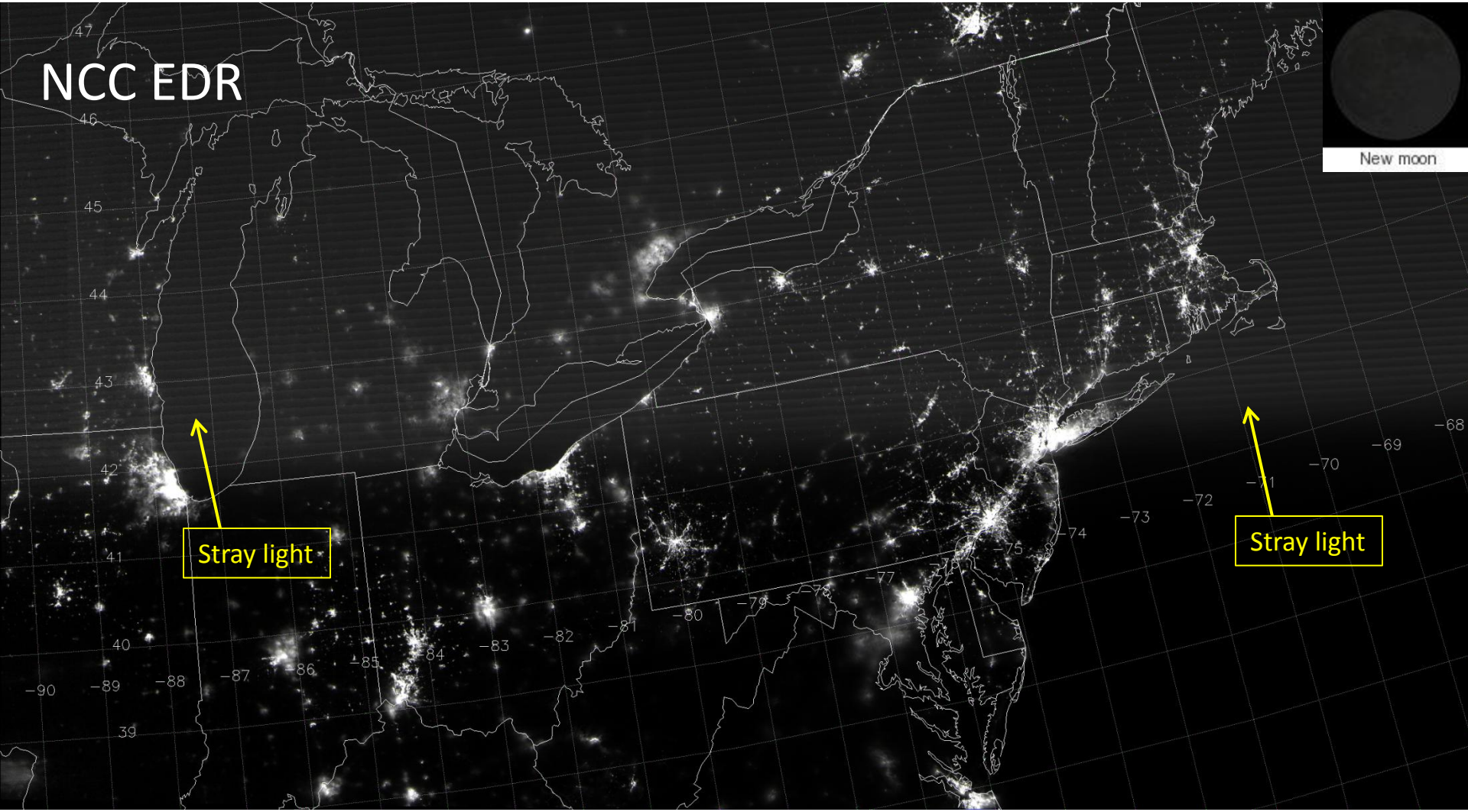
M6 on Suomi NPP has a high radiance fold-over issue with many saturated pixels.

At the Day/Night Terminator



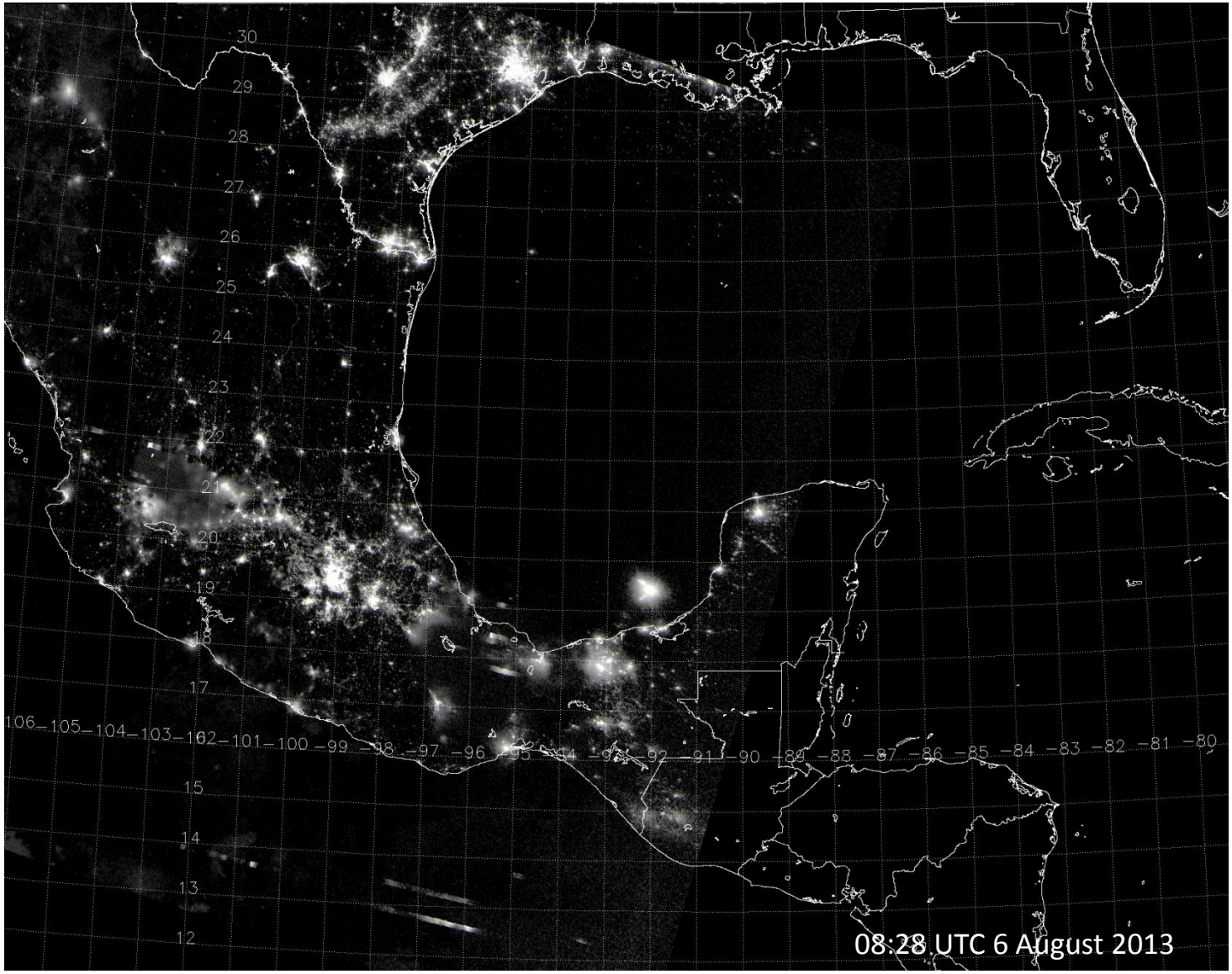
11:53 UTC 31 July 2013

During a New Moon



06:43 UTC 6 August 2013

NCC Over a Full Lunar Cycle



New moon

NPP/JPSS data sources

- **GRAVITE**[1] (Suitland, 7-hour delay)
- **NOAA CLASS**[2] (Asheville, 7-hour delay) – not actively used
- **Atmosphere PEATE**[3] (Wisconsin, 7-hour delay)
  - ADDE server for McIDAS-X
  - FTP and HTML
- **Direct Readout** (Wisconsin, minimal delay, but provides data only over North America, when the satellite is with sight of Madison)
- **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 display tools

- **McIDAS-V** (VIIRS capable) – SSEC/CIMSS/Wisconsin
- **McIDAS-X** (VIIRS capabilities still under development) – SSEC/CIMSS/Wisconsin
- **CSPP (Community Satellite Processing Package)** (CIMSS/Wisconsin) for users of Direct Broadcast VIIRS
- **TeraScan / NexSat** (web display) – NRL
- **IDL**

Suomi NPP Imagery and Visualization Team web page
http://rammb.cira.colostate.edu/projects/npp/

NOAA Satellites and Information
National Environmental Satellite, Data, and Information Service

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

(Last updated: 2013-08-13)

The NESDIS/StAR Imagery and Visualization and Visualization Team is responsible for the checkout of EDR imagery (and data) from the NASA/NOAA **Joint Polar Satellite System (JPSS)** spacecraft, the **Suomi NPP (National Polar-orbiting Partnership).**

Date	Event
28 October 2011 @ 0948 UTC	NPP launch
21 November 2011 @ 1604 UTC	First visible/reflective images
19 January 2012 @ 0620 UTC	First infrared/thermal images
25 January 2012	NPP renamed Suomi NPP

For a roster of VIIRS EDR Imagery Team members, see JPSS_Imagery_and_Visualization_Team.docx.

For a list of VIIRS bands and band information, see VIIRS_bands_and_bandwidths.pdf.

For a spreadsheet of VIIRS EDR maturity levels, see EDR_Imagery_maturity_levels.xlsx.

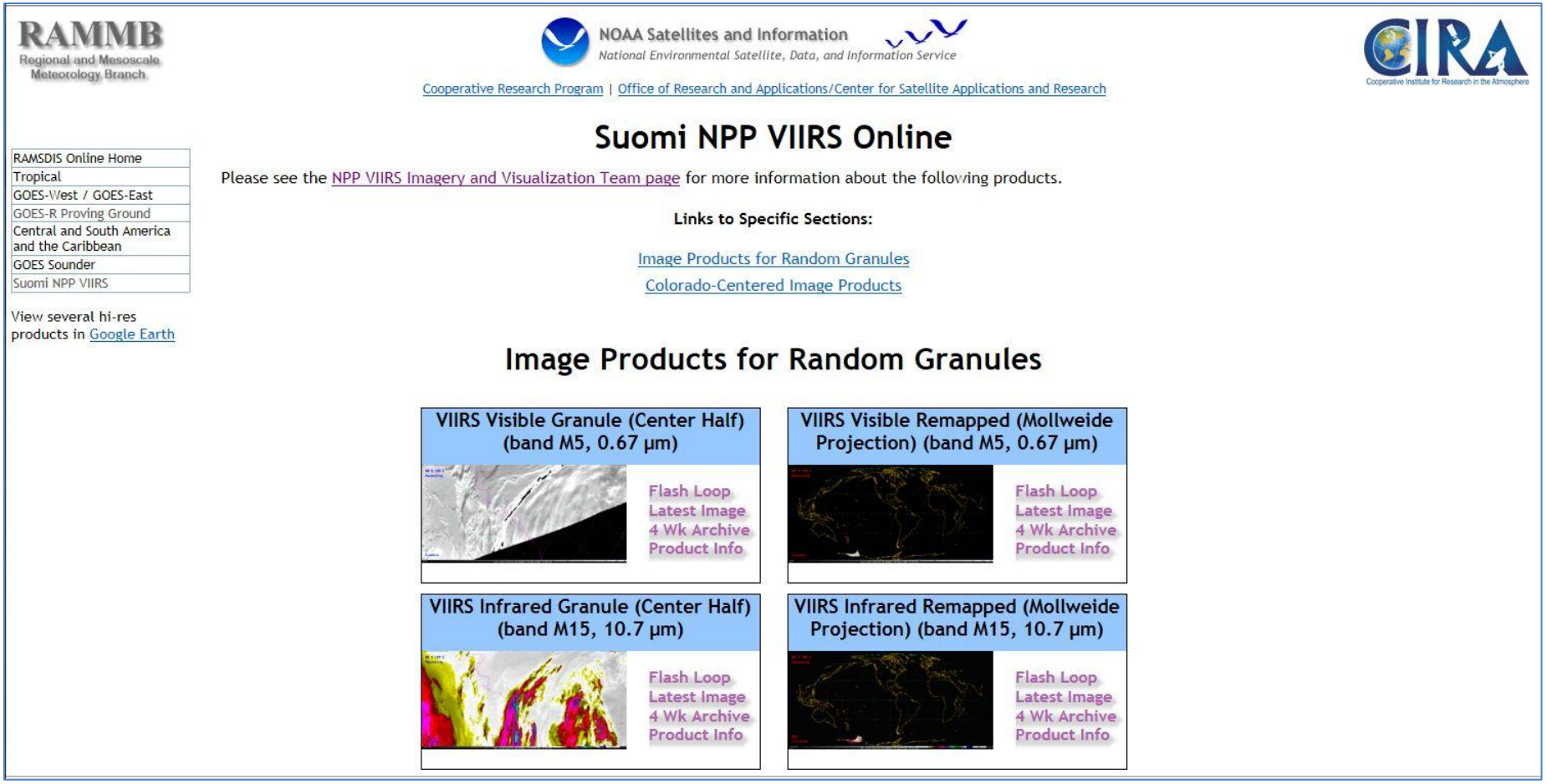
For a beginners guide to VIIRS imagery data, see Beginner_Guide_to_VIIRS_Imagery_Data.pdf. (~1 MB) (Presentation courtesy of C. Seaman, CIRA]

Website	URL
CIRA's **Suomi NPP Blog**	http://rammb.cira.colostate.edu/projects/npp/blog/
CIRA's **Suomi NPP Cal/Val**	http://rammb.cira.colostate.edu/projects/npp/calval/
CIRA's **VIIRS granules online**	http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp
NRL's **VIIRS imagery**	http://www.nrlmry.navy.mil/VIIRS.html
CIMSS' **Satellite Blog for VIIRS**	http://cimss.ssec.wisc.edu/goes/blog/archives/category/viirs
StAR-JPSS **ADP (Algorithm and Data Products)**	http://www.star.nesdis.noaa.gov/jpss/index.php
NOAA **CLASS**	http://www.class.ncdc.noaa.gov/

NPP Orbital Passes	Reverse Chronology of NPP VIIRS Imagery Significant Events (Newest information at the top)	NPP Reference Information/Websites and VIIRS Imagery Documents

Suomi NPP VIIRS Online

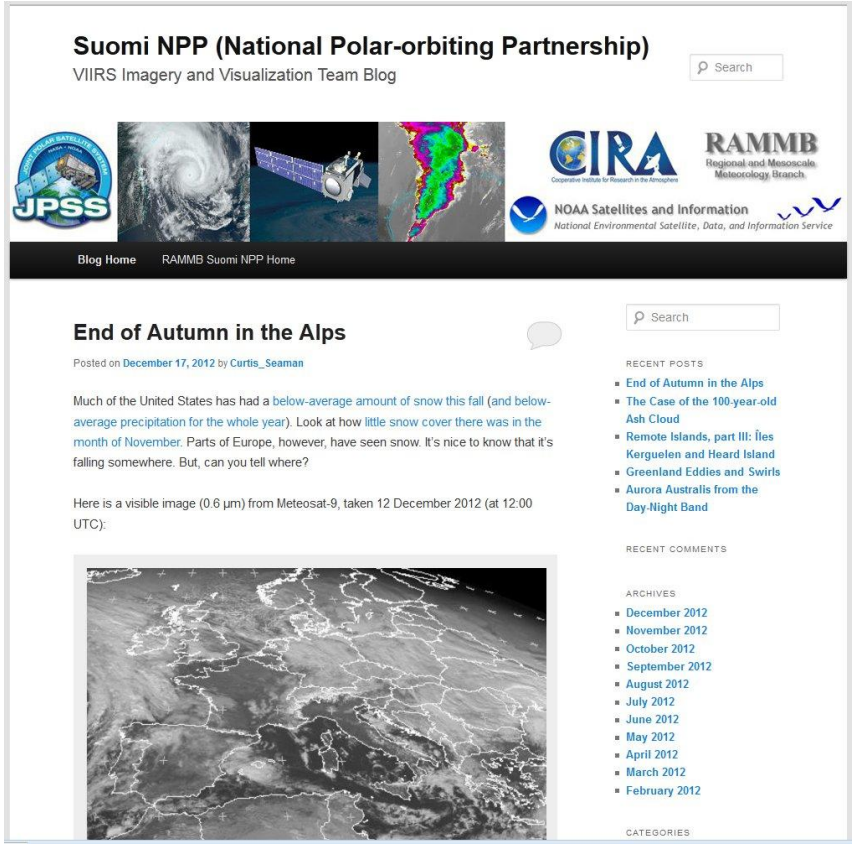
http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp



JPSS/Suomi NPP VIIRS Imagery Blog

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

- Blog maintained at CIRA to **highlight capabilities of VIIRS** instrument.
- Designed to provide **education/outreach** of VIIRS imagery applications.
- Blog covers **wide range of topics:** tropical cyclones, severe weather, fire detection, auroras, volcanic eruptions, flooding, snow and ice detection, DNB applications, RGB composites and other interesting high-resolution imagery from VIIRS



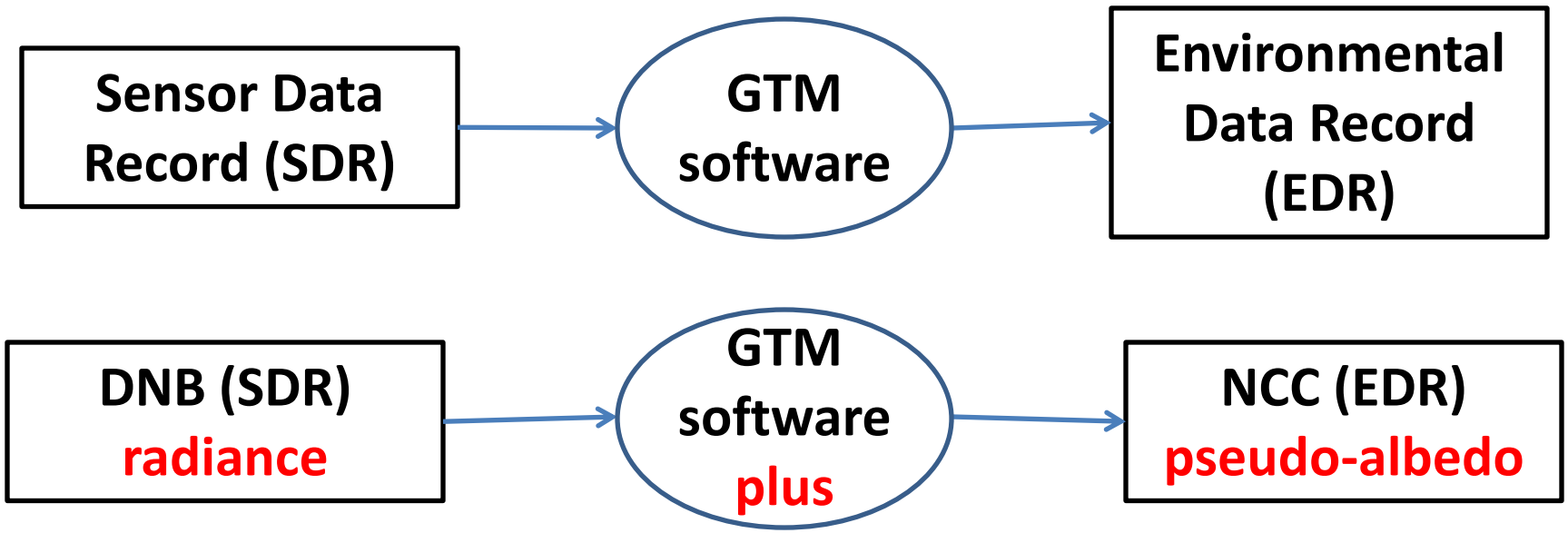
Journal articles from the Imagery Team

- 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.** *Bull. Amer. Meteor. Soc*., 94(7), 1019-1029, plus cover images. doi:10.1175/BAMS-D-12-00097.1

- Hillger, D., C. Seaman, C. Liang, S. Miller, D. Lindsey, and T. Kopp, 2013: **Suomi NPP VIIRS Imagery Calibration and Validation.** Submitted to *Journal of Geophysical Research-Atmospheres (JGR)* for publication in a "Special Issue of AGU *JGR-Atmospheres* on Suomi NPP Cal/Val Science Results". Invited to submit a cover figure.

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/temperatures** for Non-NCC bands only.
- For NCC imagery, which is derived from the Day Night Band (DNB), there is **additional radiance (reflectance) processing**



Near Constant Contrast Process Adjusts for Solar/Lunar Effects

- Process uses large Look-Up Tables, referred to as GVVSSE (pronounced “goosey”) tables, to mitigate variations in the scene caused solely by solar or lunar differences in illumination across the granule
  - These Gain Value Versus Scene Source Elevation tables use curves of solar and lunar radiances based on solar/lunar angles (and for the moon, its phase) to remove variations caused only by sensor/solar/lunar angle variations
  - The greatest impact from these computations is in the terminator region
- These tables only require updating when major characteristics of the DNB are altered (such as stray light, Build 7.2)

NCC Algorithm Itself is a Straightforward Process

- The NCC algorithm first reads in the necessary GVVSSE tables and radiances from the Day Night Band (DNB)
- Using the DNB geolocation, determine the latitude, longitude, solar and lunar viewing angles, sensor viewing angle, and the phase of the moon
  - Each of these is employed within the GVVSSE table
- Compute a **pseudo-albedo** based on the adjustments determined from the LUT
- Map these albedos to the GTM grid

Unique features of VIIRS/NCC, as compared with its predecessors

- The only predecessor to NCC (DNB) is the DMSP Operational Line Scanner (OLS)
- The OLS is an Imager, and not a Radiometer
  - Hence OLS did not provide radiances and was not intended for any quantitative use
- NCC Imagery is able to produce useful imagery at lower lunar reflectances than the OLS
- Because the NCC Imagery is created on the same projection as the M-bands, it is straightforward to use NCC in a multi-spectral image (OLS has only a single IR with its' day-night band)
- Examples follow (used alone, and combined with other VIIRS M band imagery)

VIIRS NCC imagery issues so far:

- Many issues were the same as with non-NCC Imagery, and these were covered in the non-NCC provisional brief
  - Server (GRAVITE) issues
  - Missing geo-location values in granules
  - Missing data “triangles” in granules
  - Padding stripes (fill values) from the use of GTM and a constant array size
- Each of these has been resolved
- Non-NCC Imagery EDR was declared provisional in January 2013

VIIRS NCC imagery issues so far:

- NCC had two major issues that delayed movement to provisional, both tied to the lack of NCC Imagery at night outside of the full moon phase
  - The first was an artificial limit discovered in a LUT, that in turn impacted the application of the GVVSSE tables and resulted in unnecessary FILL
    - This was resolved by an adjustment to the GVVSSE tables and a small change to the appropriate LUT that improved results to near the half-moon phase
  - The second issue was related to the inability of the original NCC algorithm to deal with very small radiances as the lunar reflectance decreased
    - This was resolved via a software update implemented with Build 7.1 that allows an increased range of albedo values, which in turn permitted consideration of very small radiances that previously had led to FILL values inside NCC
- Both are now resolved

VIIRS NCC vs. DMSP OLS

OLS

NCC

Stray light suppression

15

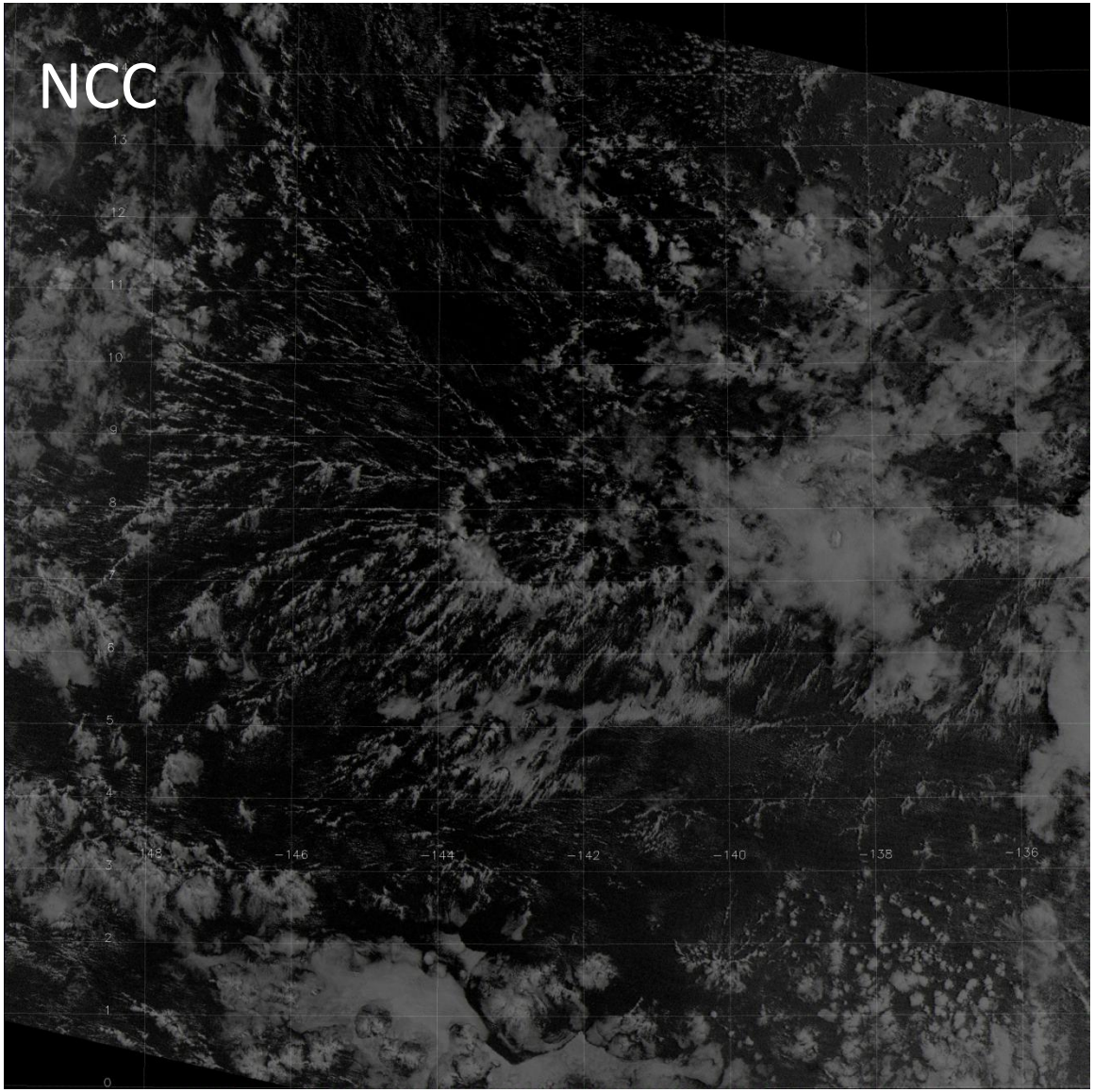
-150

-135

0

12:20 UTC 29 July 2013

10:54 UTC 29 July 2013


NCC
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−148
−146
−144
−142
−140
−138
−136

VIIRS NCC vs. DMSP OLS


Full moon

OLS

NCC

Stray light suppression

15

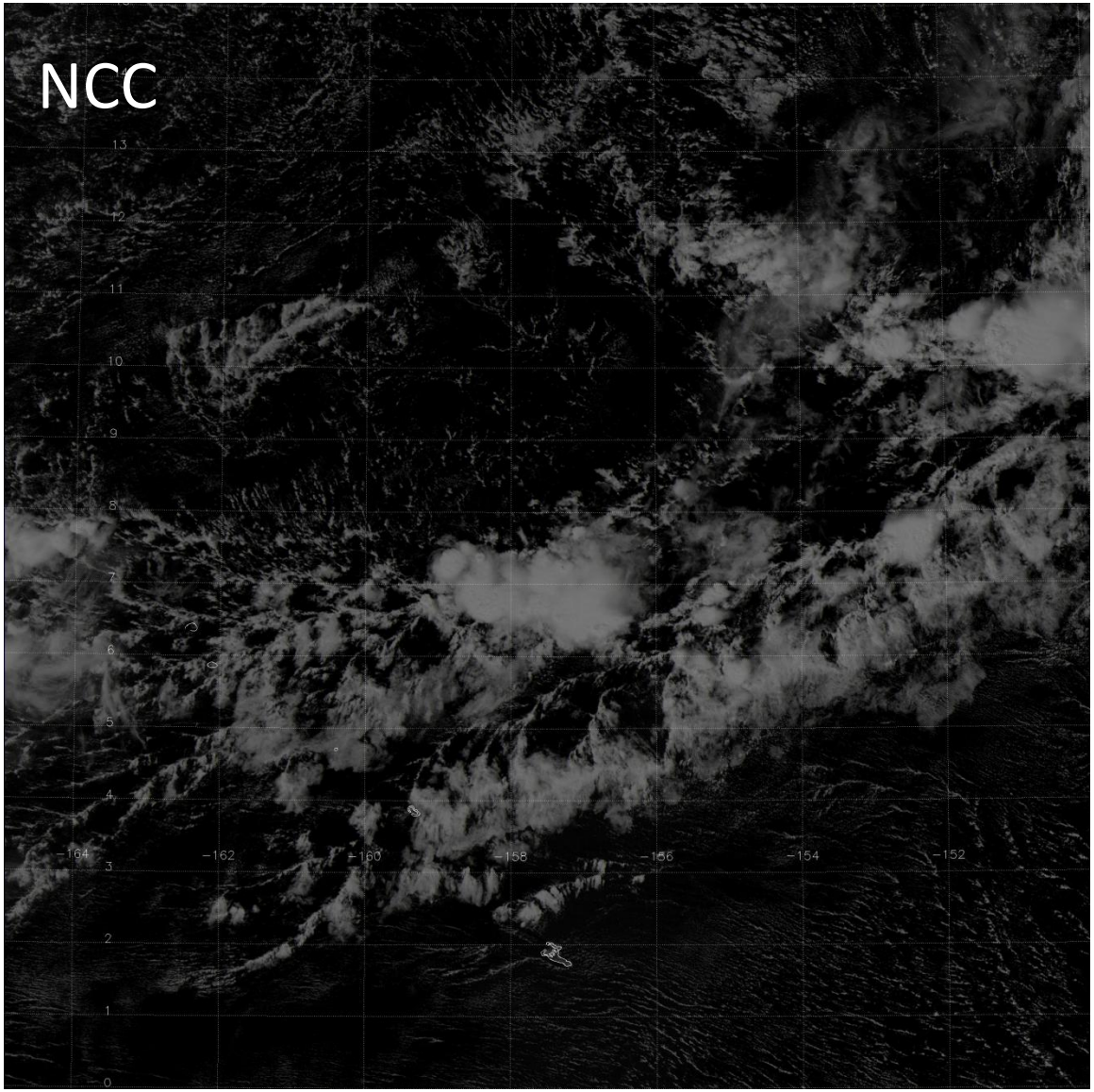
-165

-150

0

14:13 UTC 22 July 2013

11:20 UTC 22 July 2013


NCC
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-164
-162
-160
-158
-156
-154
-152

VIIRS NCC vs. DMSP OLS


Full moon

OLS

NCC

45

-165

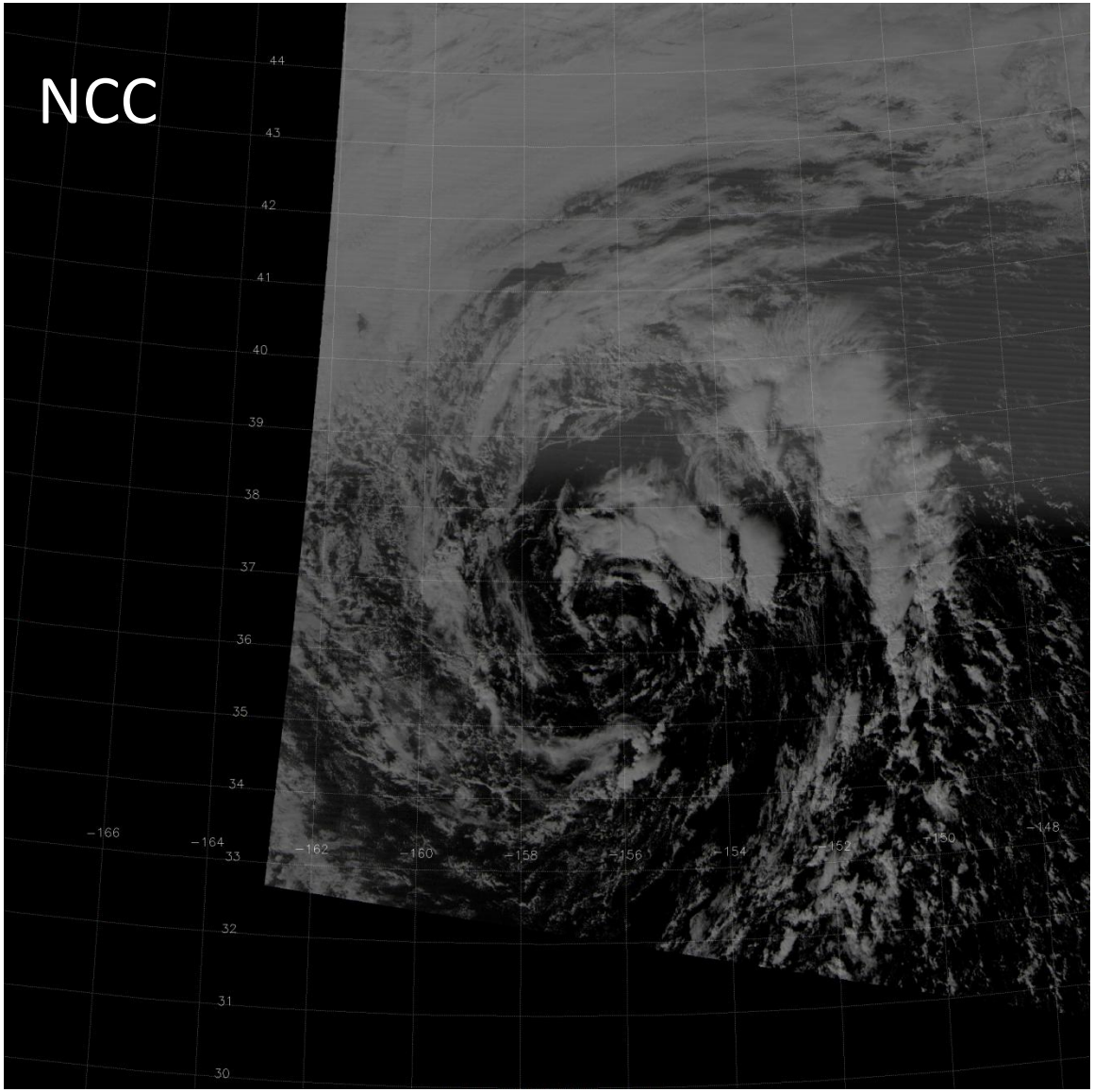
-150

30

Stray light suppression

14:13 UTC 22 July 2013

11:20 UTC 22 July 2013


NCC
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
−166
−164
−162
−160
−158
−156
−154
−152
−150
−148

RGB Composite Using NCC

M-15 EDR, NCC, NCC

06:15 UTC 13 August 2013

EDR Provisional Criteria – Imagery

Provisional Definition	Artifacts (Deliverables)	Imagery EDR
Product quality may not be optimal	**Product accuracy** is determined for a broader (but still limited) set of conditions. No requirement to demonstrate compliance with specifications.	**Clouds and sea ice edge at a minimum, but many others are possible**
Incremental **product improvements** are still occurring	Narrative, listing and discussing **known errors**. All DRs are identified and prioritized (1-5). Provisional readiness will address priorities 1-2. Pathway towards algorithm improvements to meet specifications is demonstrated.	**No known performance issues .** **DRs (mostly resolved for non-NCC imagery)**
Version control is in affect	Description of the development environment, algorithm version (IDPS build number), and LUTs/PCTs versions used to generate the product validation materials. **ATBDs** are accurate, up-to-date and consistent with the product running.	**ATBD is up-to-date, as is all other documentation**
General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing	ADP STAR will request feedback from **appropriate users** for the product. The notification letter will include a Provisional Maturity disclaimer. DPA will send request to Project Science to post Provisional Maturity disclaimer on CLASS. DPA will submit readme document (#3 below) to CLASS.	**Some feedback from users already exists (NRL/McIDAS):** **- Minor near-noise-level striping has been noticed. Multi-spectral analysis is common** **- Comparison to (improvements over) other satellites**
Users are urged to consult the **EDR product status document prior** to use of the data in publications	**Warning of potential non-reproducibility** of results due to continuing calibration and code changes. **Identify known deficiencies** regarding product quality.	**Non-reproducibility is irrelevant, because imagery is not a climate product**
May be replaced in the **archive** when the validated product becomes available	Technical evaluation of limited **data reprocessing** is presented.	**Not directly relevant**
Ready for **operational evaluation**	**Key NOAA and non-NOAA end users** are identified and **feedback requested**	**Users are already involved (as seen by Imagery Team makeup)**

NCC Imagery DRs

- DR 4470 – No NCC imagery for nighttime granules
  - Resolved in Build 7.1, July 10, 2013
- DR 4484 – NCC Imagery needs to match OLS Coverage (useful imagery to near half-moon phase)
  - Resolved in LUT update in November 2012
- DR 4718 – Update GVVSSE LUTs
  - Resolved in LUT update in July 2012
- DR 4902 – Too many FILL values in very dark pixels
  - Resolved in Build 7.1, July 10, 2013
- DR 4867 – Discontinuity at the 105 solar angle
  - Resolved in Build 7.1, July 10, 2013

NCC Imagery DRs

- DR 4653 – Request for all 16 M-bands as Imagery EDRs in S-NPP. This was written in April 2012 when two users disagreed on which 6 bands should be the default bands
- DR 7257 – Written in June 2013, this DR is essentially the same request for JPSS-1, but adds our identification of inconsistent requirements in the various JPSS Level 1 documents
  - The JPSS requirements added specific M-bands not noted in earlier NPOESS specifications, but does not specify the precise number of M-band Imagery EDRs expected

Beta and Provisional ReadMe Caveats

- Imagery **detector-to-detector striping**:
  - Currently significant where stray light exists in the DNB
    - Expected to be sharply mitigated in Build 7.2
  - Striping may also appear depending on the enhancement used on NCC Imagery, especially when the initial radiances are low
- **Data latency**:
  - Not improved yet!
  - Hoping for improvement within NDE
- **Carryovers to Provisional ReadMe**
  - Continue data availability/latency issue

Path Forward to Validation Stage 1

- Continued **feedback from users**:
  - Expand to **additional users**
    - NIC
    - Navy
    - NWS
- Quantitative analysis of EDR imagery **geo-location**, details in discussion with DPA
- Limited quantitative analysis of EDR **striping**, details in discussion with the SDR team and DPA

Summary

- **We've made excellent progress with VIIRS Imagery after 18 months!**
- NCC Imagery now non-FILL even under new moon conditions
- NCC Imagery now exceeds the only similar capability in existence today (DMSP OLS)
- NCC has now reached **provisional status**
  - Date this was achieved is 10 July 2013, with the implementation of Build 7.1