EDR Imagery Overview

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And the rest of the **VIIRS EDR Imagery Team**!

StAR JPSS (2nd) Annual Science Meeting
24-28 August 2015

Outline

- **VIIRS Imagery Overview**
  - Imagery Cal/Val Team Members
  - Imagery Product Overview
  - JPSS-1 Readiness
  - Summary and Path Forward

VIIRS EDR Imagery

VIIRS EDR Imagery consists of:

- **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, creating an image product that removes the large radiance contrast in **DNB** from day to night.

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)

EDR Imagery Cal/Val Team Members

PI	Organization	Team Members	Roles and Responsibilities
D. Hillger	**StAR/RAMMB**	D. Lindsey, D. Molenar	Imagery product lead
T. Kopp	**Aerospace**		Cal/Val Lead, VIIRS heritage
S. Miller	**CIRA/RAMMB**	C. Seaman, S. Kidder, S. Finley	Imagery cal/val , VIIRS online, end user support, (social) media interactions
D. Santek	**CIMSS/SSEC**	T. Jasmin, T. Rink, W. Straka III	McIDAS-V McIDAS-X
J. Solbrig	**NRL – Monterrey**	K. Richardson, A. Kuciauskas	NexSat, VIIRS web
C. Elvidge	**NGDC (NCEI – Boulder)**	K. Baugh	DNB
JAM	NASA DPE	B. Thomas	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

EDR Imagery Product Overview

- EDR Imagery is a **Priority 1** VIIRS product
  - Certain EDR Imagery bands are **Key Performance Parameters (KPPs)**
    - **I1, I4, I5, M13, M14, M15** (6 original L1RD KPPs)
    - **DNB/NCC and I3 (2 more)** are being considered for KPP status.
  - The number of KPP bands (**6**), the number of bands created as Imagery from the operational system (**12**), and the total number of bands (**22**), do not match, because no tall VIIRS bands are EDRs!
- 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 most non-Direct Broadcast imagery
  - LTM (Long Term Monitoring)
  - Several websites for the Imagery
  - Engaging users as validation

Table 1
Required Imagery EDR Products

Key Performance Parameters (KPPs) – 6 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
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

Table 2
Other IDPS-generated Imagery EDRs

Other Priority 1 (non-KPP) EDRs – 6 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
Short Wave IR (SWIR)	**I3**	1.58 – 1.64	0.4/0.8
NCC	**DNB**	0.5 – 0.9	0.8
Visual	M1	0.402 – 0.422	0.8/1.6
Visual	M4	0.545 – 0.565	0.8/1.6
SWIR	M9	1.371 – 1.386	0.8/1.6

JPSS-1 Cal/Val Plan

- Validation levels:
  - Beta
  - Provisional
  - Validated
- L + 85 days (for validation)
- “Minimum Mission Success”
  - Checkout not only in **Alaska**, but **worldwide** in lieu of equivalent high latitude examples.

JPSS-1 Cal/Val Plan

- What does VIIRS EDR Imagery Cal/Val entail?
  - SDR Cal/Val for radiances/reflectances
  - EDR Validation by **Imagery users**
- JPSS-1 Image Cal/Val Plan
  - Quantitative at SDR level
  - **Qualitative validation** of Imagery
- Preparations for JPSS-1 VIIRS Imagery
  - **DNB** changes due to increased pixel aggregation at edge of scan
  - No changes to **NCC** software/product expected
  - This will be tested using simulated data for JPSS-1

Table 3
Imagery Product Requirements (from L1RD)

Attribute	Threshold	Objective
1. The Imagery EDR shall be delivered under all weather conditions, including any rain rate		
a. Horizontal Spatial Resolution for visible and IR Imagery bands		
1. Nadir	0.4 km	0.1 km
1. Edge of Swath	0.8 km	0.1 km
1. Night-time visual, Nadir	2.6 km	0.65 km
a. Horizontal Spatial Resolution for moderate resolution bands		
1. Nadir	0.8 km	NS
1. Edge of Swath	1.6 km	NS
a. Mapping Uncertainty		
1. Nadir	1 km	NS
1. Edge of Swath	3 km	0.5 km
1. Night-time visual, Nadir	TBS	1 km
a. Refresh for Visible and IR bands	At least 90% coverage of the globe every 12 hours	NS

These requirements are <u>validated by SDR and geo-location teams</u>

Imagery Product Requirements (from Imagery Cal/Val Plan)

There is a single component of the VIIRS Imagery product that is considered a **Key Performance Parameter (KPP).** 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"

There are no requirements that specifically address the quality of the Imagery products. Nevertheless **the end users are a critical aspect of any Imagery**, and is therefore an important consideration in the Cal/Val process.

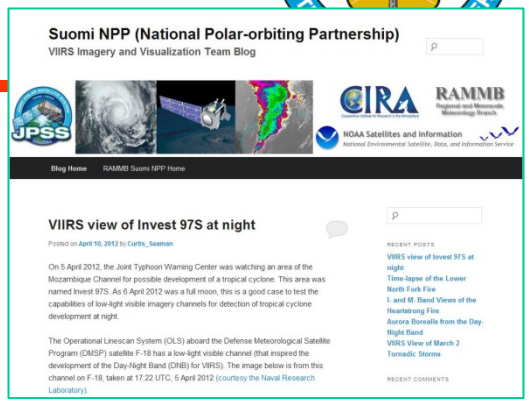
Ultimately, it is the **(Alaska) user** that decides if the quality of the Imagery is acceptable, and as such including the **users** in the Validation process for Imagery is a key consideration in the strategy.

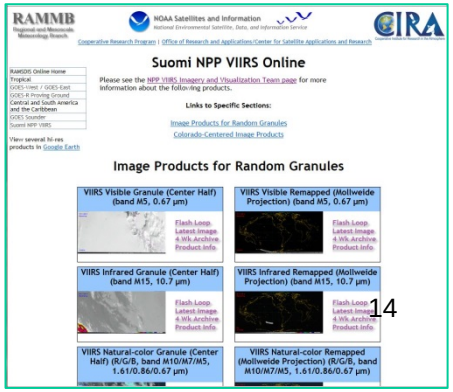
JPSS-1 Cal/Val Plan

- Quantitative:
  - Mainly accomplished at the SDR level
  - VIIRS radiances/reflectances mapped from SDR to EDR using Ground Track Mercator (GTM) software
  - Exception is NCC pseudo-albedos (individually-scaled DNB multi-gain pixels across an image)
- Qualitative:
  - Depends on **user** acceptance of VIIRS Imagery (especially Alaska)
  - **Feedback from users** on imagery issues/artifacts (including noise and striping)
  - **Ability of users to discern/discriminate atmosphere, cloud, and land features** (volcanic ash, ice edges, and fires/smoke)

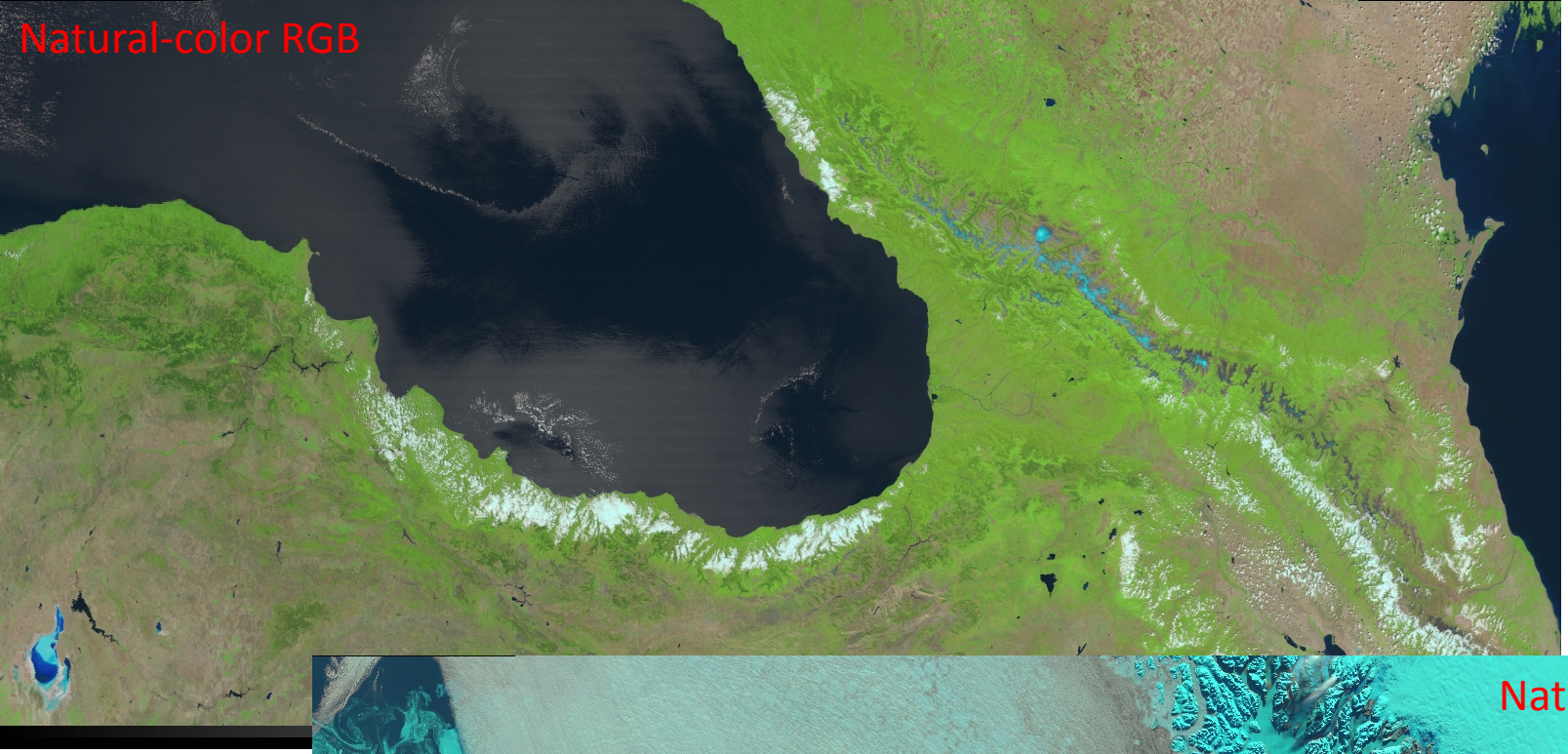
VIIRS Imagery outreach at RAMMB/CIRA and others

- 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)



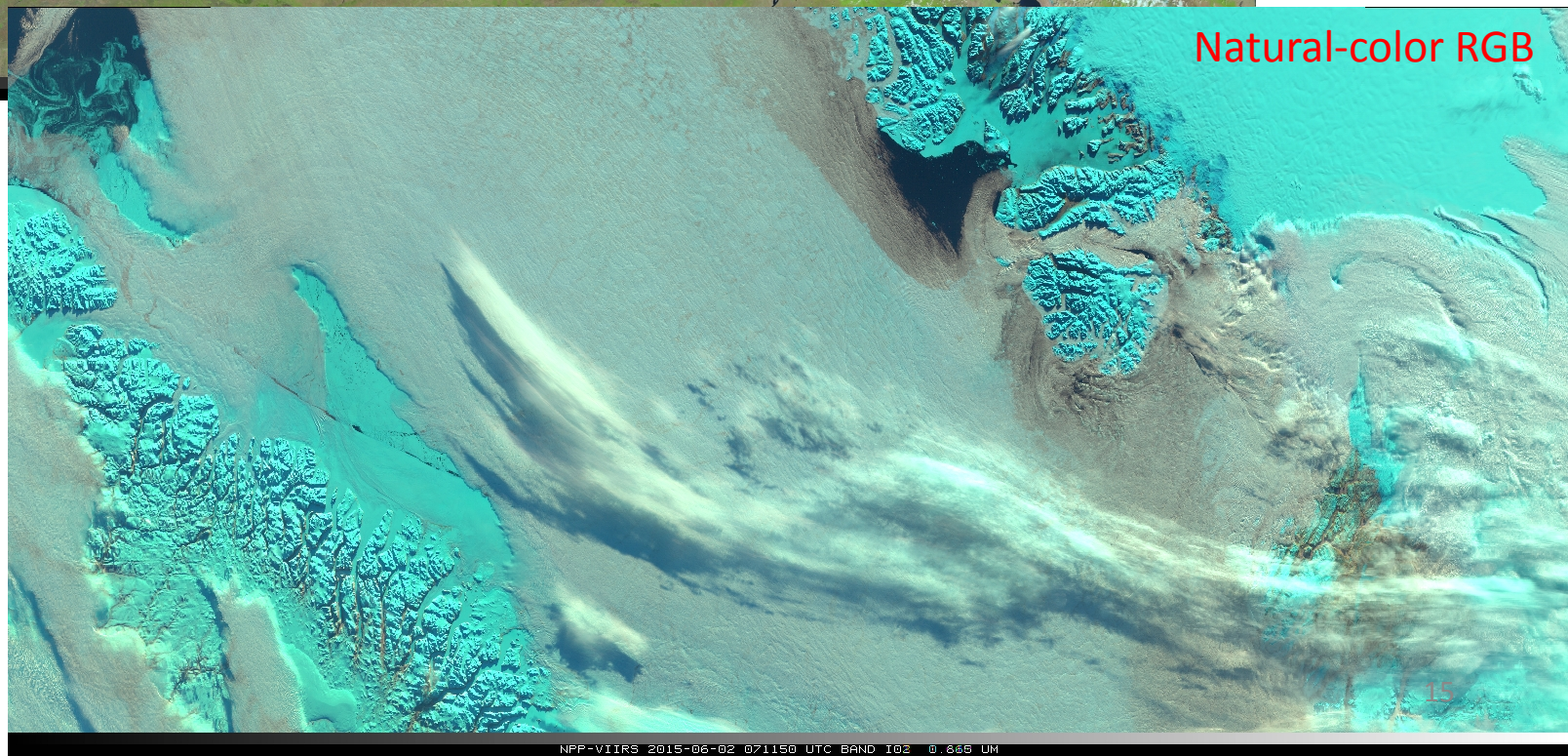


- **NRL-Monterey** uses of VIIRS:
  - **NexSat** http://www.nrlmry.navy.mil/NEXSAT.html
  - **VIIRS Cal/Val** http://www.nrlmry.navy.mil/VIIRS.html
- **NGDC Earth Observation Group (EOG):**
  - **VIIRS** http://ngdc.noaa.gov/eog/viirs.html



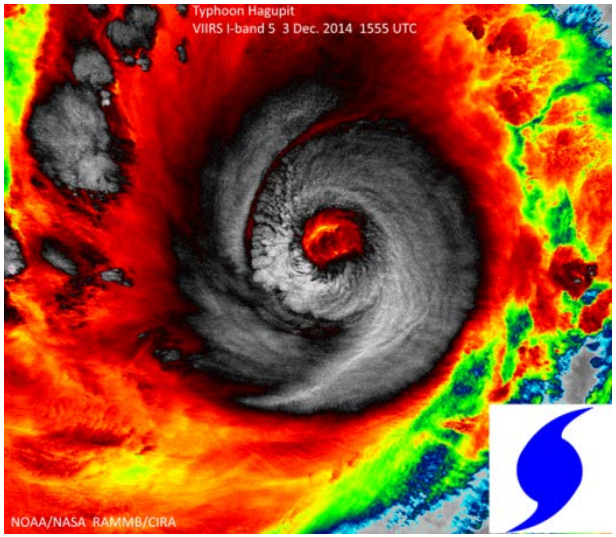
VIIRS Online realtime Imagery validation

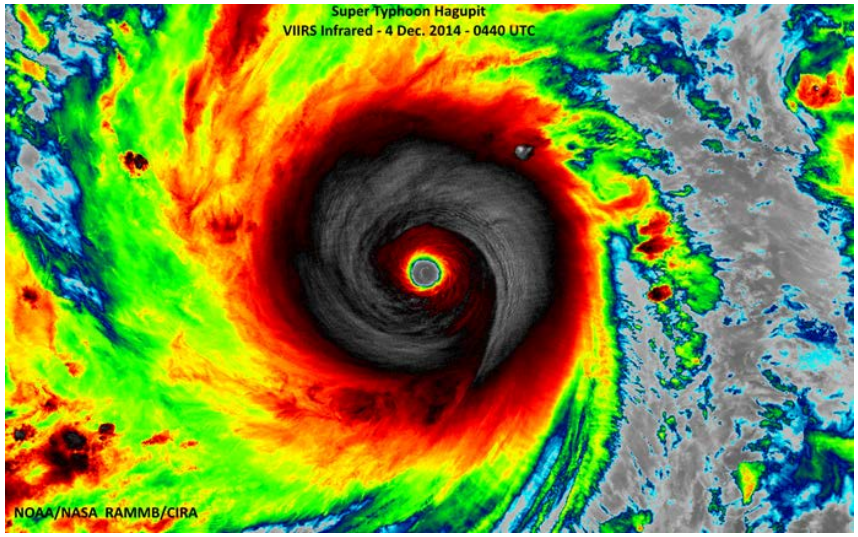
VIIRS natural-color (RGB) images showing vegetation/ land (above) and snow/cloud discrimination (below)

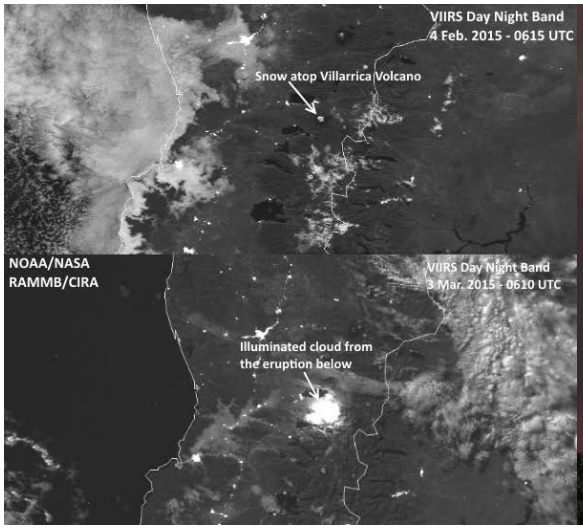


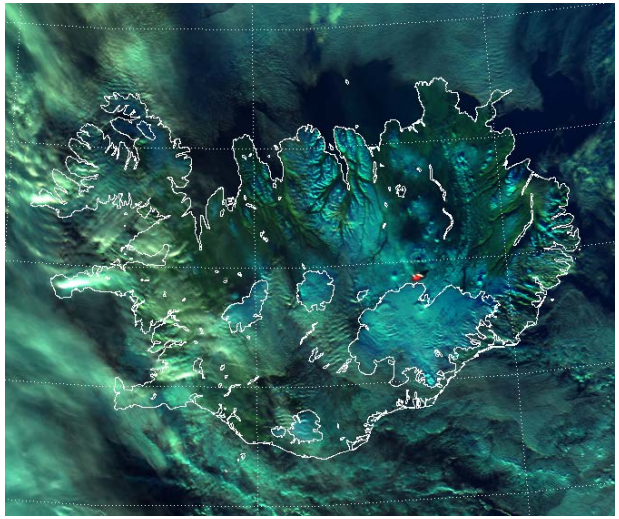
VIIRS Imagery (Visible/IR and DNB)

Various VIIRS Imagery examples, depicting details in cloud formations or on the ground which are not seen with other instrumentation. **Many examples used by Social Media.**





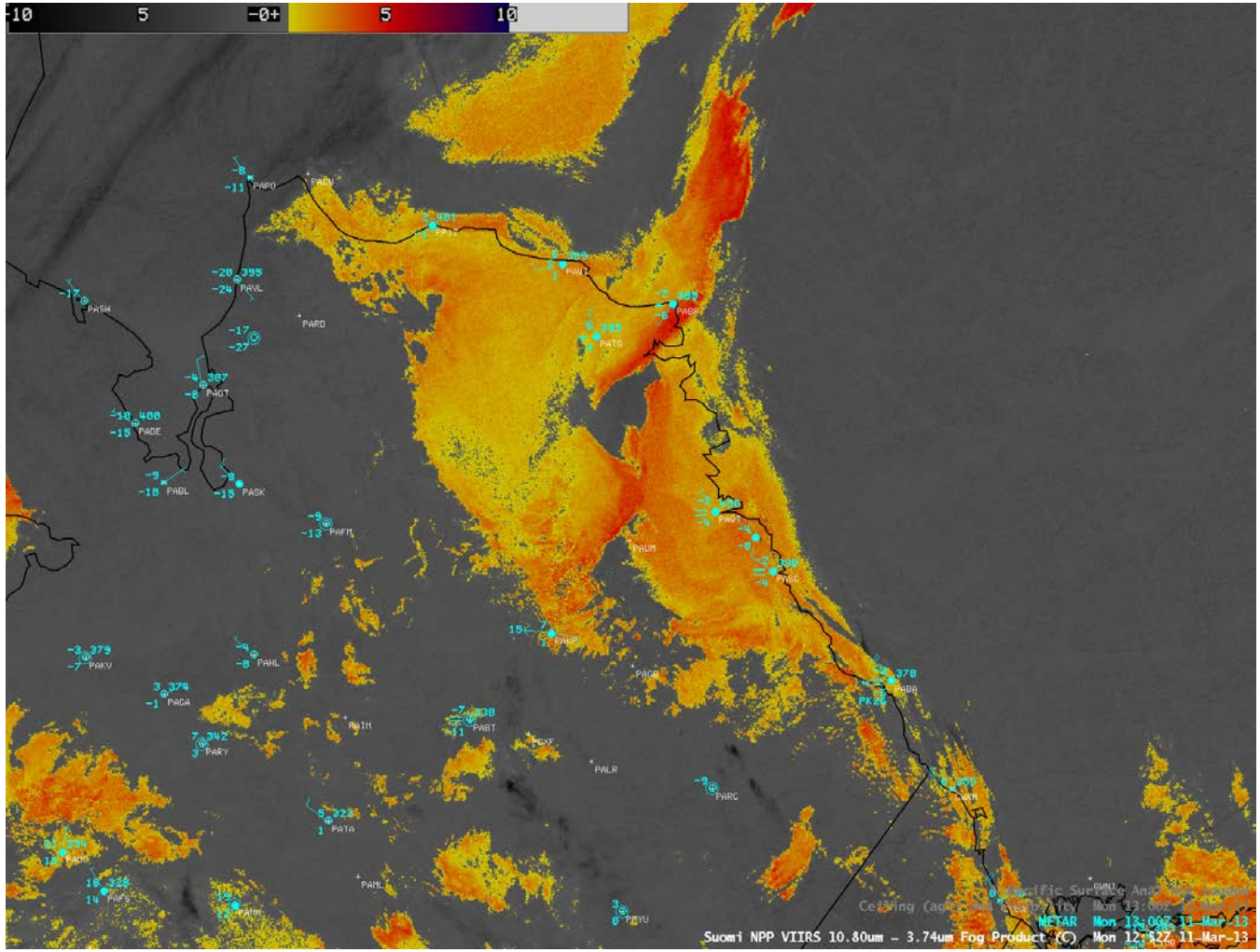




Examples of VIIRS Imagery uses/strengths (2/2)

- Alaska **operational** uses in particular:
  - Alaska fog/low stratus, 11 March 2013
  - Gulf of Alaska complex circulations, 21 Nov 2012
  - Alaska blowing dust, 21 Oct 2012, and 3 Feb 2015
  - Areal extent of smoke in Yukon and Alaska, 26 June 2015
  - Fires and smoke in Alaska, 4 July 2015
  - Aurora across Alaska, 4 July 2015
  - Areal flooding and river-ice breakup (nothing shown here, details in AMS, AGU and OCONUS presentations)
- Worldwide in **operations**
  - Hurricane/TC center at night, 29 July 2013

Fog and stratus deck over the North Slope region of Alaska, 11 March 2013



AWIPS images of the Suomi NPP VIIRS IR brightness temperature difference "fog/stratus product" showed the coverage of the fog and stratus over the area.

Fog and stratus deck over the North Slope region of Alaska, 11 March 2013

The Area Forecast Discussion issued by the National Weather Service forecast office in Fairbanks mentioned the presence of a layer of fog and stratus over parts of the North Slope region of Alaska:

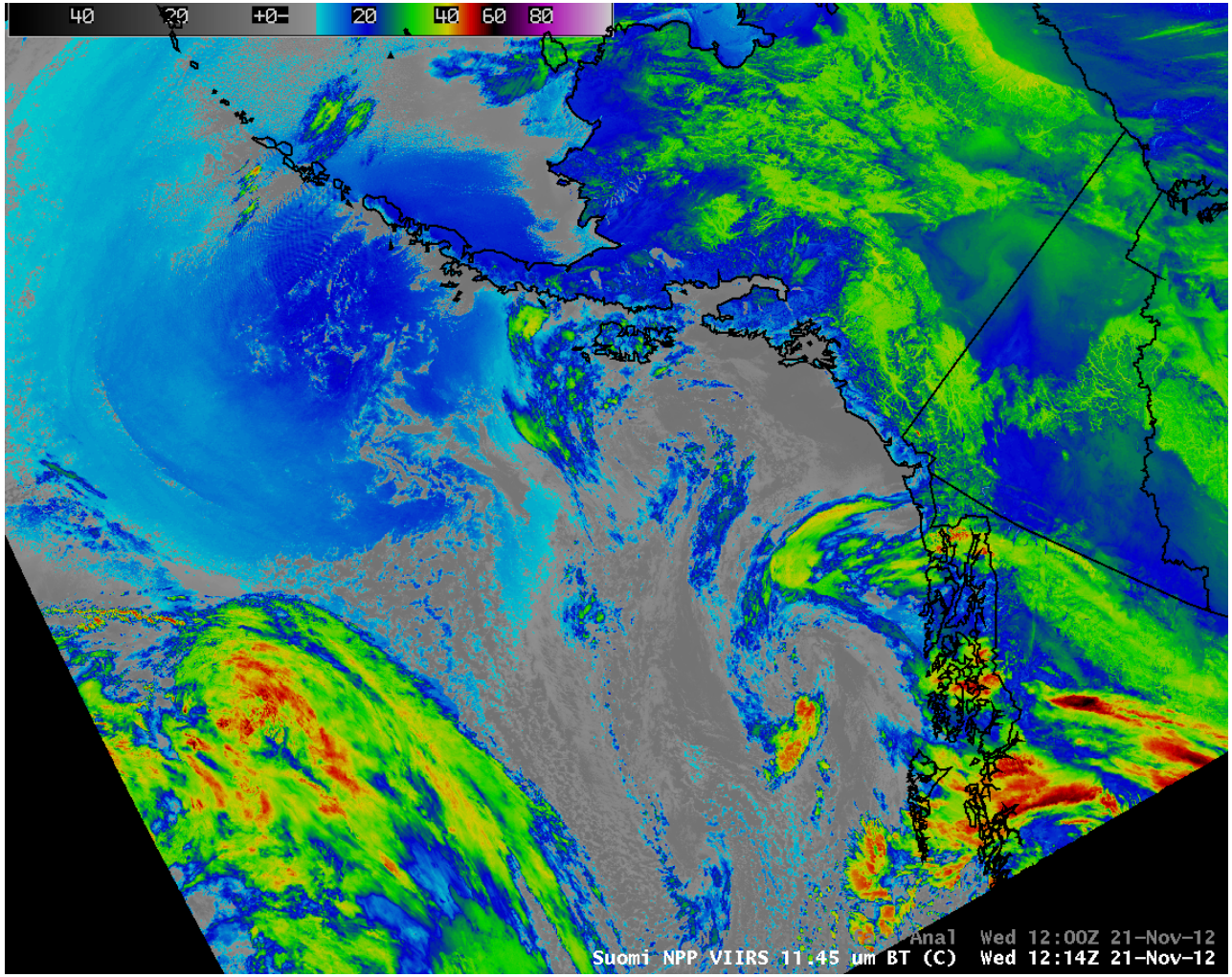
NORTHERN ALASKA **FORECAST DISCUSSION**

NATIONAL WEATHER SERVICE FAIRBANKS AK

1258 PM AKDT MON MAR 11 2013

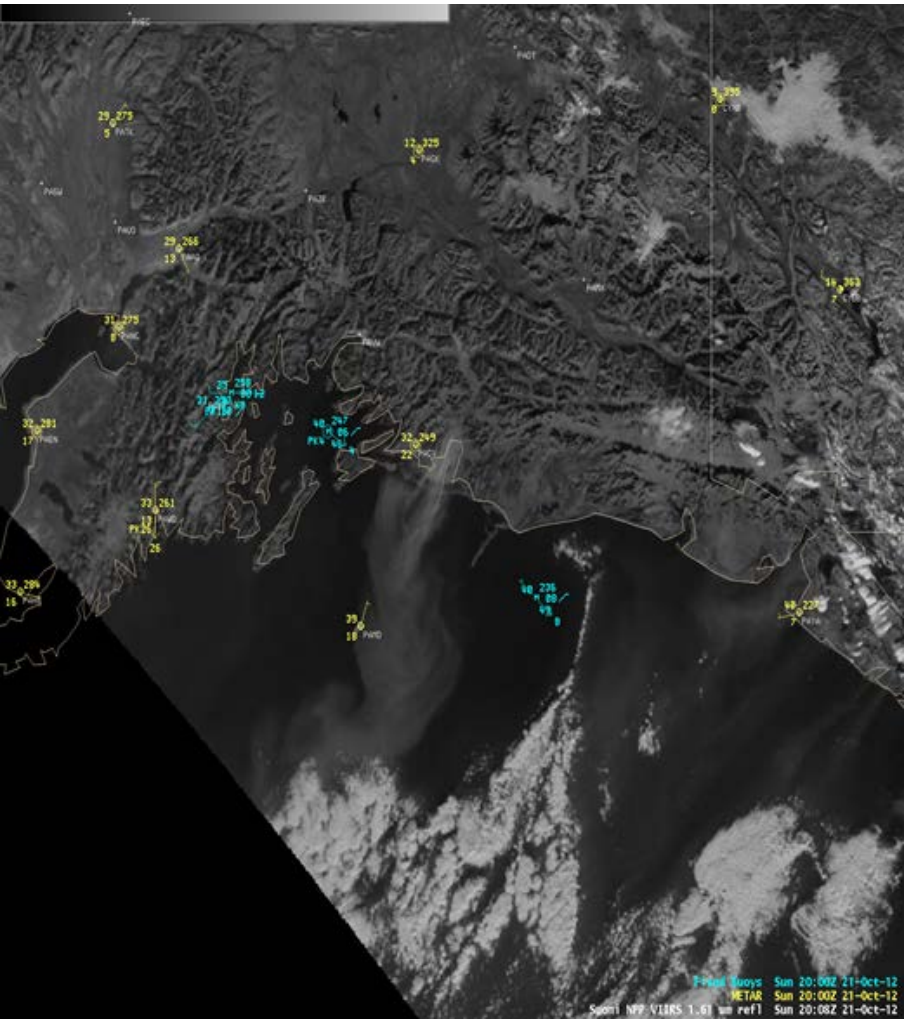
NORTH SLOPE…**THE SUOMI NPP VIIRS SATELLITE FOG PRODUCT WAS INDICATING A DECENT LAYER OF STRATUS ALONG THE NORTH SLOPE.** OBSERVATIONS ACROSS THE AREA GENERALLY INDICATED 1 TO 2 MILES IN VISIBILITY WITH FLURRIES AND FOG. THE IFR CONDITIONS ALIGN VERY WELL WITH THE HIGHER PROBABILITIES OF MODIS IFR PRODUCT. THERE ARE SOME VERY ISOLATED POCKETS OF HIGHER PROBABILITIES OF THE MODIS LIFR CONDITIONS. THESE CONDITIONS SHOULD REMAIN THROUGH TUESDAY EVENING OR WEDNESDAY MORNING AS THE SURFACE HIGH PRESSURE REMAINS WITHIN THE AREA. BY WEDNESDAY MORNING THE SURFACE PRESSURE GRADIENT BEGINS TO TIGHTEN…PROVIDING AN INCREASE IN WINDS AND PERHAPS A BREAK IN SOME OF THE FOG.

Using VIIRS imagery to help diagnose complex Gulf of Alaska circulations, 21 November 2012



Suomi NPP VIIRS 11.45 µm IR image with surface analysis

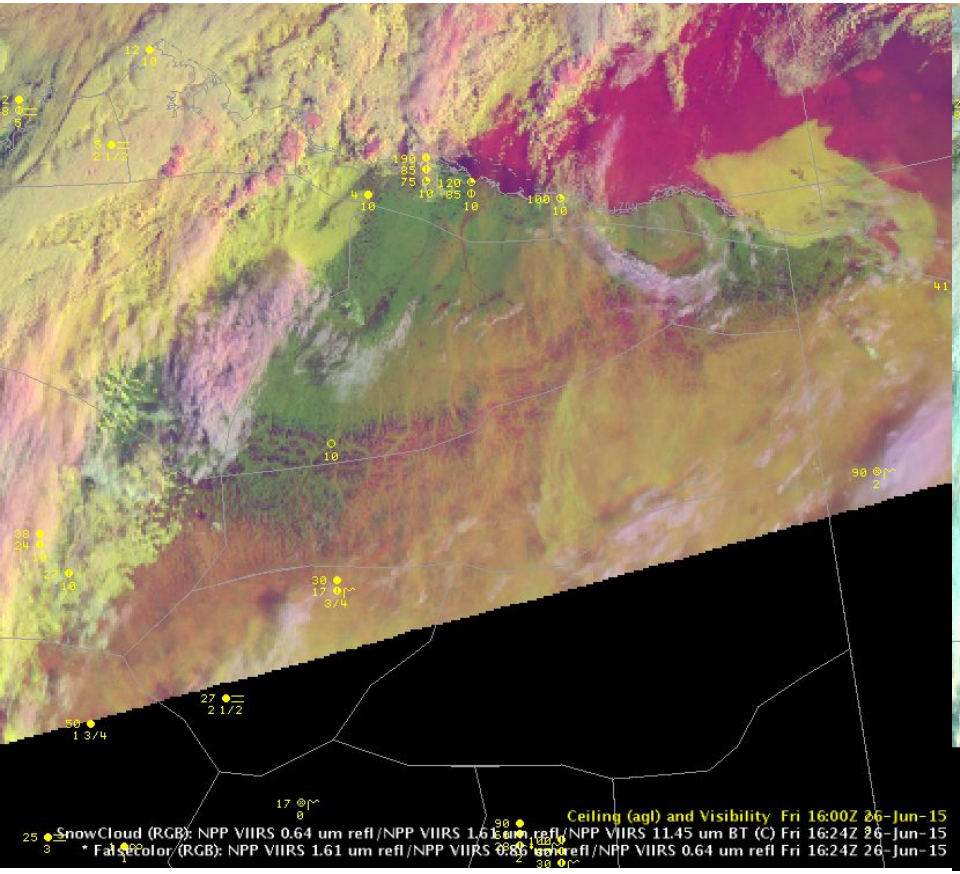
Blowing Dust in Alaska – 21 Oct 2012

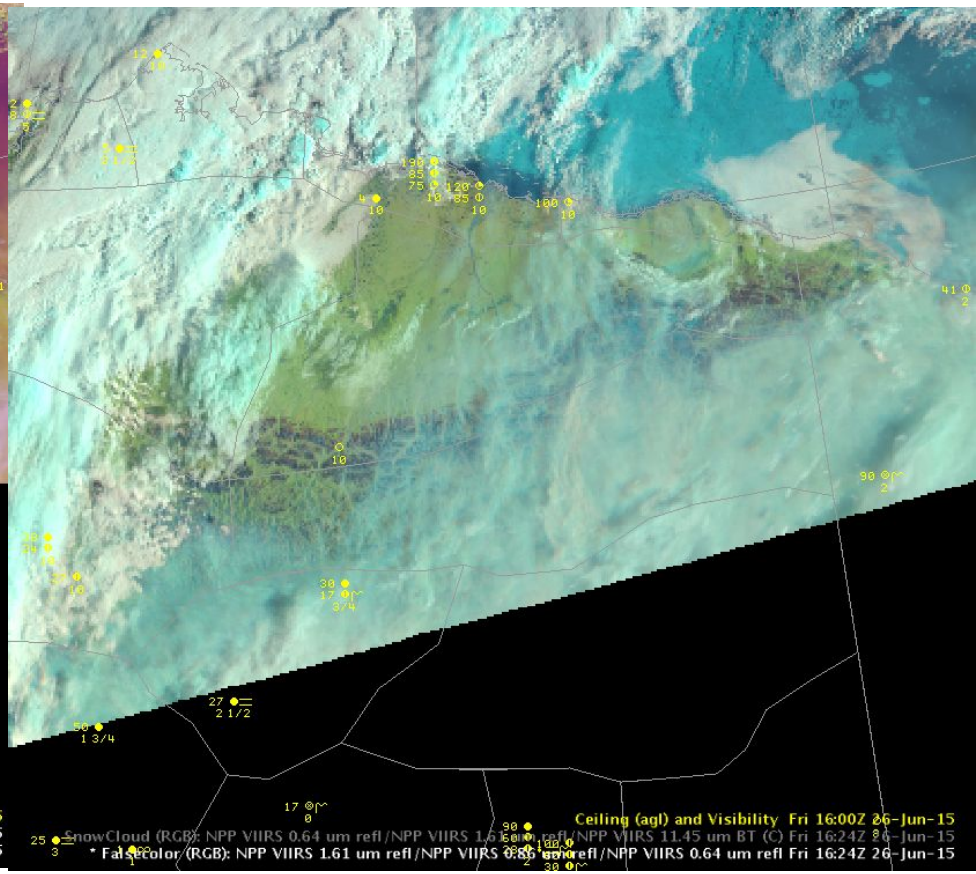


Attached is an **AWIPS screen capture of the VIIRS 1.61 um I3 band showing blowing dust blasting out of the Copper River Delta southward over the Gulf of Alaska on a windy day.** This image courtesy of WFO Anchorage Science Officer Jim Nelson. While the 1.61 um channel seems most commonly to be used by the NWS here as a component of RGBs discriminating snow and ice on the ground from clouds above, it has also gotten some secondary use in identifying blowing glacial silt as a single-channel image during the daytime.

The neat thing about this glacial silt application of the 1.61 um channel is that it allows forecasters to "see" the wind, at least qualitatively. Images like this give forecasters more confidence when including verbiage like "stronger local gusts out of bays and passes" in the marine forecasts for the North Gulf Coast, despite the lack of observations from buoys or ships indicating such winds. Very broadly speaking, in a region suffering from a sparse network of surface-based observations, **satellite products like this help forecasters fill in the gaps and develop their mental model of what is going on.** (Eric Stevens, GINA, Fairbanks)

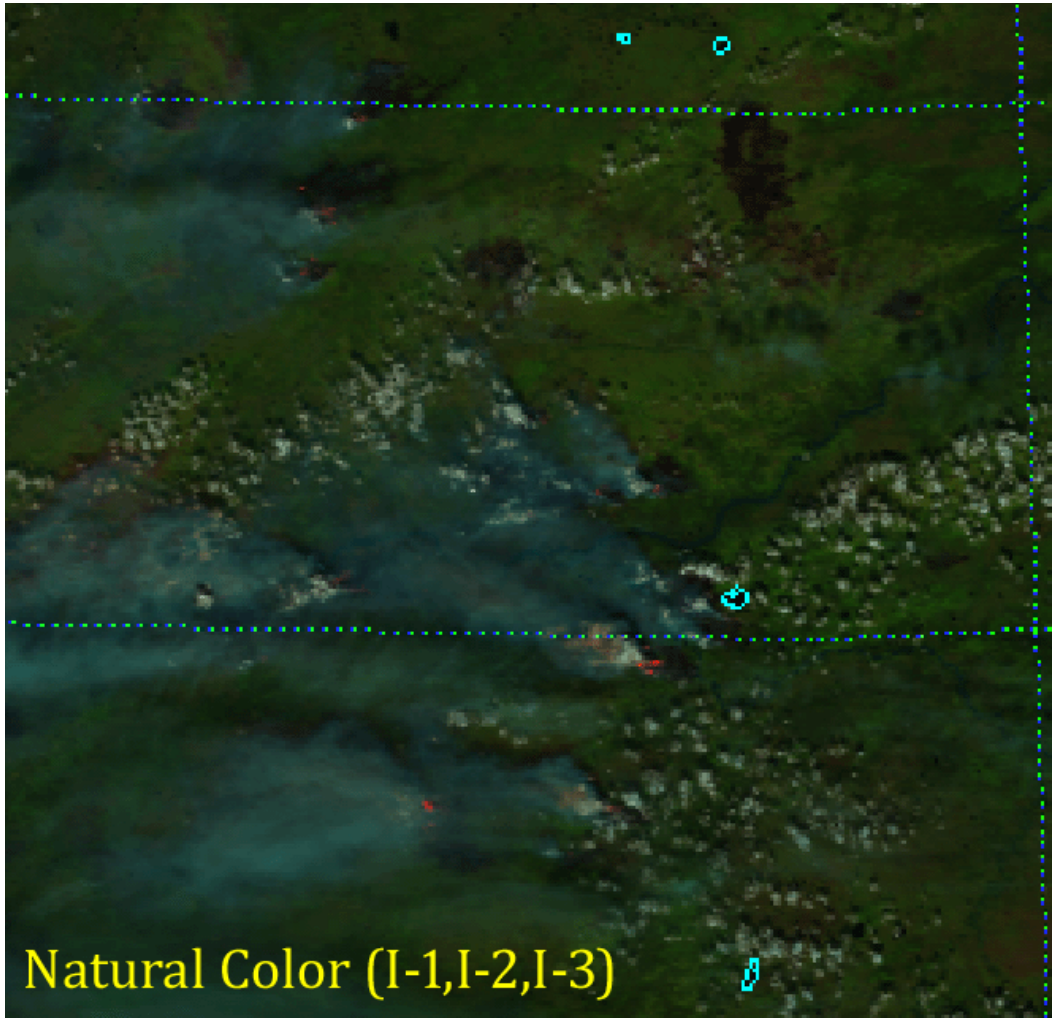
Areal extent of smoke in Yukon Territory and Alaska – 25 June 2015





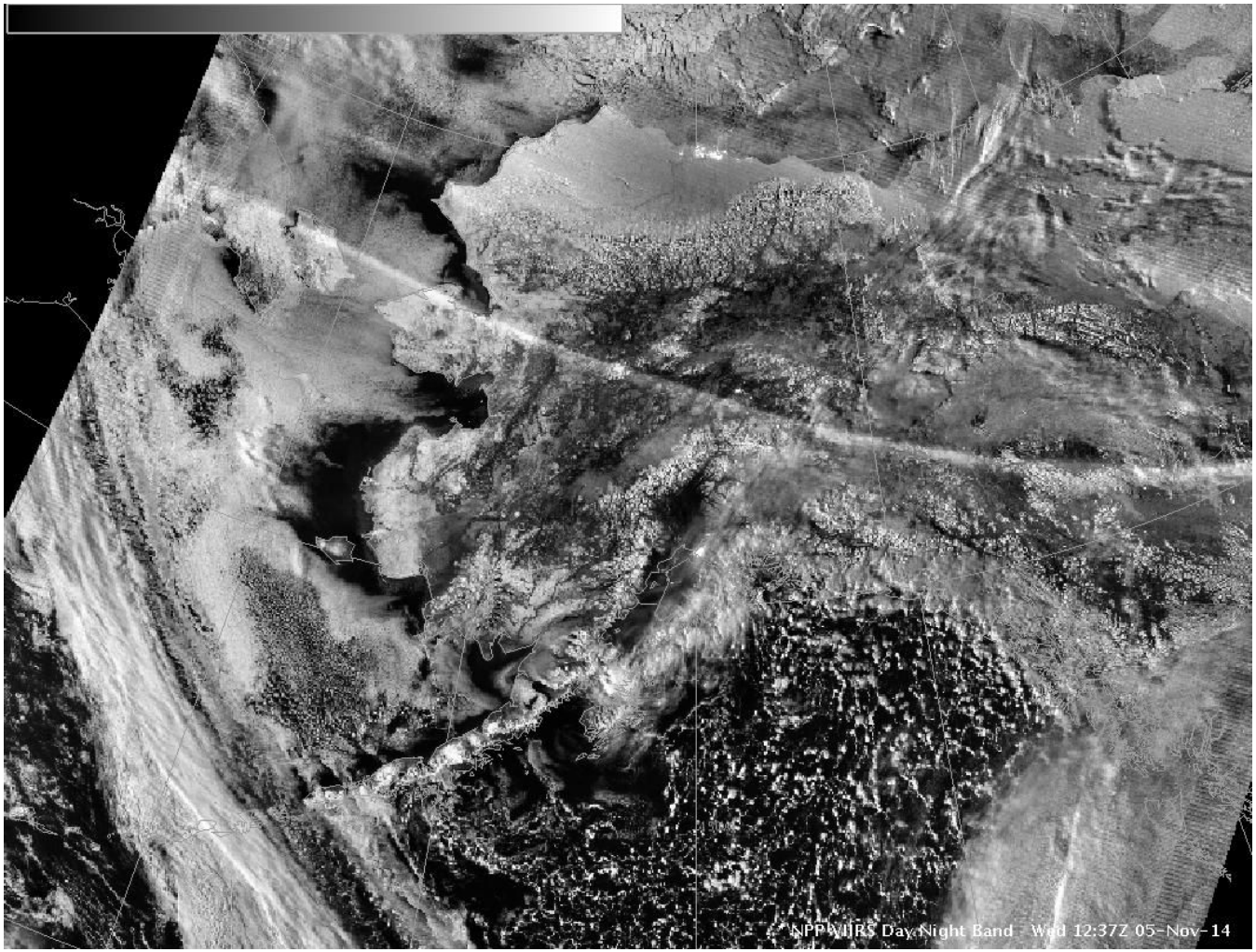
From the morning of 2015 June 26. This was a case where the "**natural color" RGB** and the **"cloudoversnow" RGB** satellite imagery helped the Public forecast. Specifically, to help see the **areal extent of the smoke**. The smoke had spread north into the Yukon Territories and spilled through the Brooks Range. Note the 2SM vis reports being measured at Shingle Point, YK and Old Crow, YK. (Ed Townsend [NWS, AK])

Fires and smoke in Alaska in two VIIRS RGBs – 4 July 2015

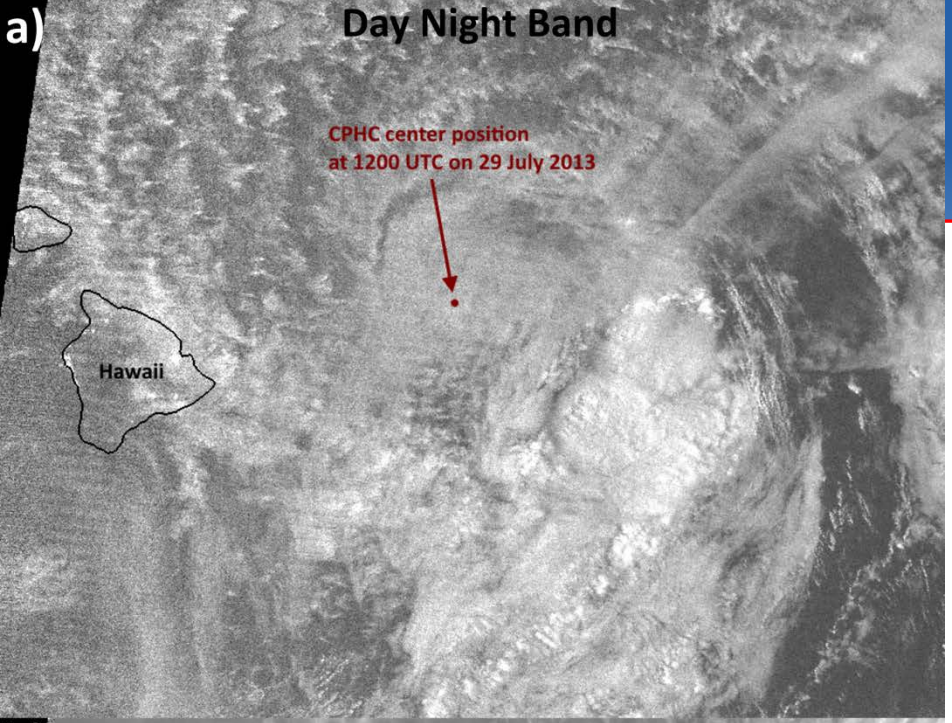


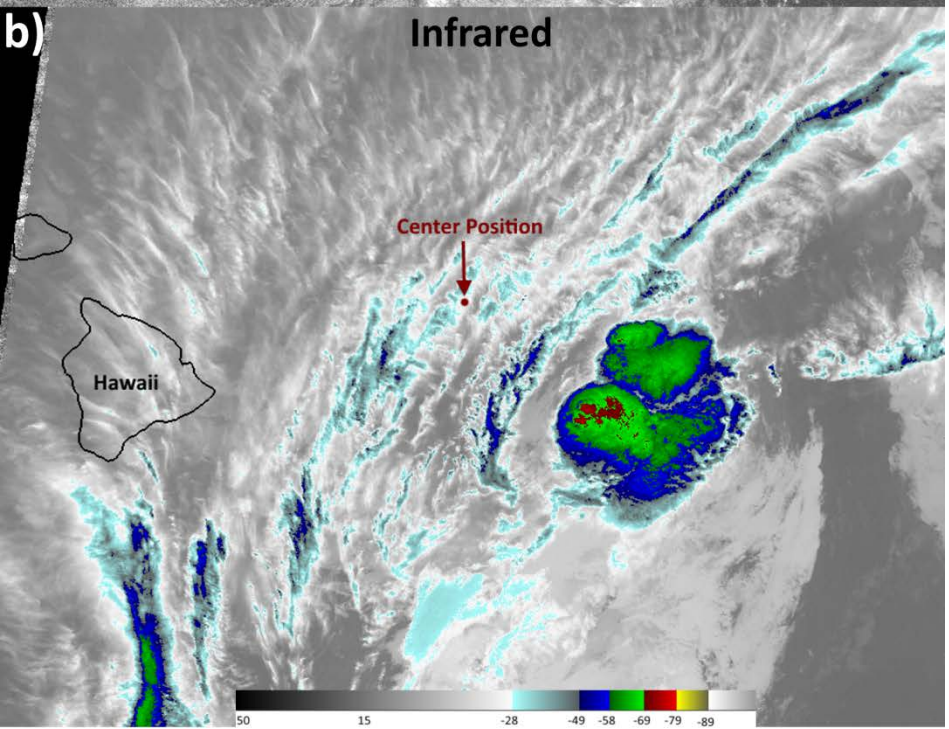
2015 July 4th, screenshots over the AK Central Interior where the **"Natural color" RGB** was useful in delineating smoke and detecting fire 'hot spots'. (Ed Townsend [NWS, AK], C. Seaman [CIRA])

Aurora across Alaska in DNB – 4 July 2015



VIIRS Day/Night in which with a band of Aurora crosses the entire state of Alaska (Ben Bartos, NWS, Fairbanks)





Tropical Cyclone position/center at night with DNB

VIIRS a) Day Night Band and b) I-band 5 showing **Tropical Storm Flossie east of Hawaii** on 29 July 2013 at 1103 UTC. The analyzed position by the Central Pacific Hurricane Center of the center of the storm at 1200 UTC is denoted by a maroon dot in both images. The units of brightness temperature in b) are degrees C.

TC position/center with DNB

The VIIRS Day Night Band can be useful for identifying low cloud features in the presence of higher overlapping clouds. A good example occurred east of Hawaii on 29 July 2013. Tropical Storm Flossie was east of the big island of Hawaii moving generally to the west-northwest.

The Central Pacific Hurricane Center (CPHC) stated in one of their forecast discussions: "THE **CENTER OF FLOSSIE** WAS HIDDEN BY HIGH CLOUDS MOST OF THE NIGHT BEFORE **VIIRS NIGHTTIME VISUAL SATELLITE IMAGERY** REVEALED AN **EXPOSED LOW LEVEL CIRCULATION CENTER FARTHER NORTH THAN EXPECTED**. **WE RE-BESTED THE 0600 UTC POSITION BASED ON THE VISIBLE DATA."** (http://www.prh.noaa.gov/cphc/tcpages/archive/2013/TCDCP1.EP062013.019.1307291511) **Figure a** shows the VIIRS Day Night Band image at 1103 UTC that was being referred to, and **Figure b** shows the corresponding I-band 5 image (11.4 μm infrared). High cirrus clouds with brightness temperatures around -30°C can be see in the infrared image to the northwest of the deepest convection, but in the day night band some low clouds can be seen underneath. CPHC inferred the center of circulation based on the shape of these low level clouds, and their 1200 UTC analysis of the center location is denoted in the figure with a maroon dot. The infrared imagery alone would not have been useful in locating the center.

Summary & Path Forward

- VIIRS Imagery is **excellent**:
  - Visible/IR are especially high quality (and best spatial resolution of operational satellites)
  - DNB/NCC is the innovative product from VIIRS that is not available from any geostationary satellite/orbit.
- Path Forward
  - New **"Image of the Month"**, requested by Lihang for StAR JPSS website.
  - **New DNB aggregation modes** for end of swath pixels on JPSS-1
    - NCC algorithm/product to be tested using simulated DNB from VIIRS SDR Team.
  - **J2 and Beyond**: Recommend changes to bands (suggest water vapor imagery)