Provisional Maturity Science Review For NOAA-21 VIIRS Imagery

Presented by Bill Line
Date: 03/30/2023

VIIRS Imagery Cal/Val Team (1 slide)

Algorithm Cal/Val Team Members

Name	Organization	Major Task
Bill Line	NESDIS/StAR	Imagery Product Lead
Curtis Seaman	CIRA	Imagery/DNB expert
Steven Miller	CIRA	Imagery/DNB expert
William Straka III	CIMSS/SSEC	Imagery/DNB expert
Don Hillger	CIRA	Imagery expert
Jack Dostalek	CIRA	Imagery expert
Steve Finley	CIRA	IT/data expert
Kumar Gampa	CIRA	Programming expert
Cindy Combs	CIRA	Programming expert
Jorel Torres	CIRA	JPSS Liaison / trainer
CIMSS McIDAS Team	CIMSS	McIDAS X/V Development for VIIRS
Many Users		Imagery Feedback

Product Overview/Requirements (2 slides)

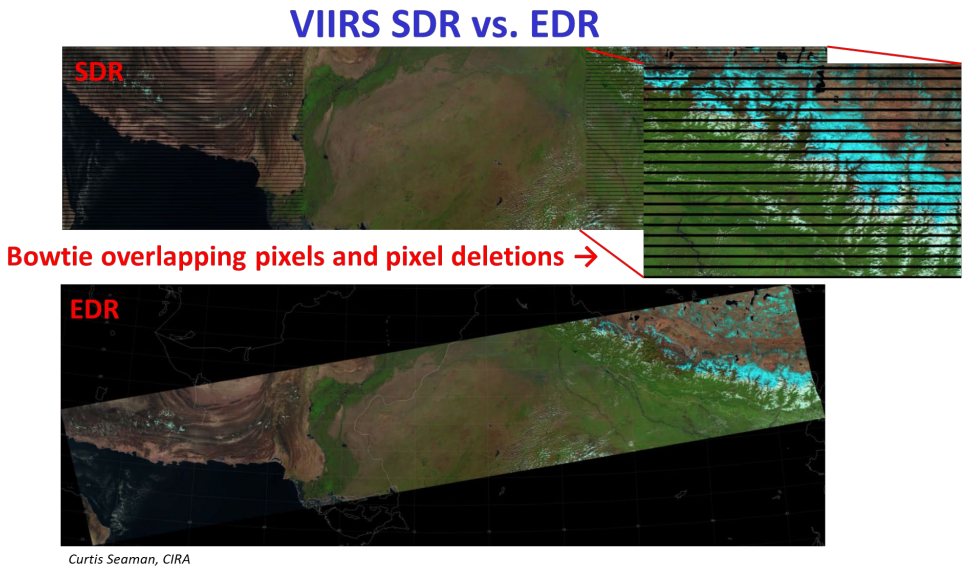
The **VIIRS Imagery EDR** product consists of:

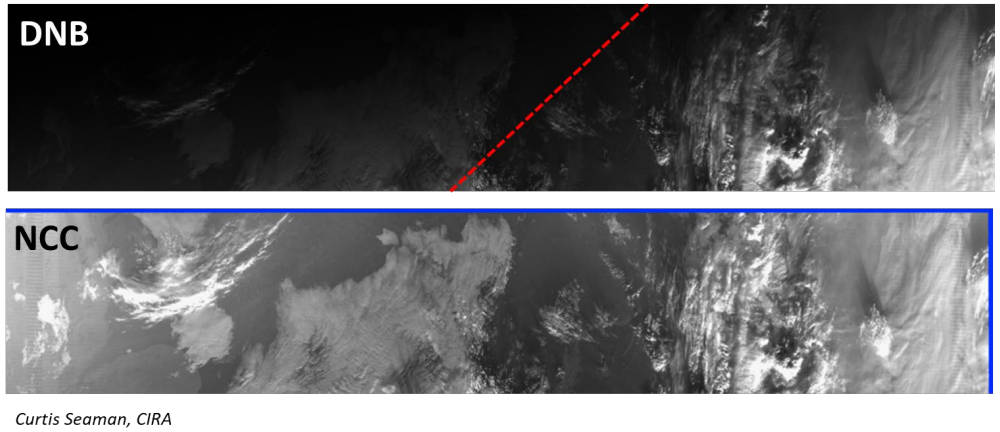
- **16 M-Bands (750 m) and 5 I-Bands (375 m)**
  - Visible and IR radiances/reflectances remapped to the Ground Track Mercator (GTM) grid, eliminating overlapping pixels and bowtie deletions seen in SDR granules.
- **NCC Imagery**
  - The goal of the NCC EDR is to reduce the dynamic range of DNB radiance values (which span 7 orders of magnitude between day and night) by converting it to a quantity with reduced dynamic range (i.e. reflectance) to create images with nearly constant contrast across a given scene.
  - Remapped to GTM

VIIRS Imagery as a **Key Performance Parameter (KPP)** reads as follows:

- VIIRS Imagery EDR for (8) bands I1, I3, I4, I5, M14, M15, M16, and NCC for latitudes greater than 60°N in the Alaskan region
- 87-Minute data latency

* There are no (quantitative) requirements that address the quality of the Imagery products, so imagery is assessed qualitatively. The Imagery user helps to decide if the Image quality is acceptable. Therefore, including the users in the Cal/Val process for Imagery is a significant task/consideration.

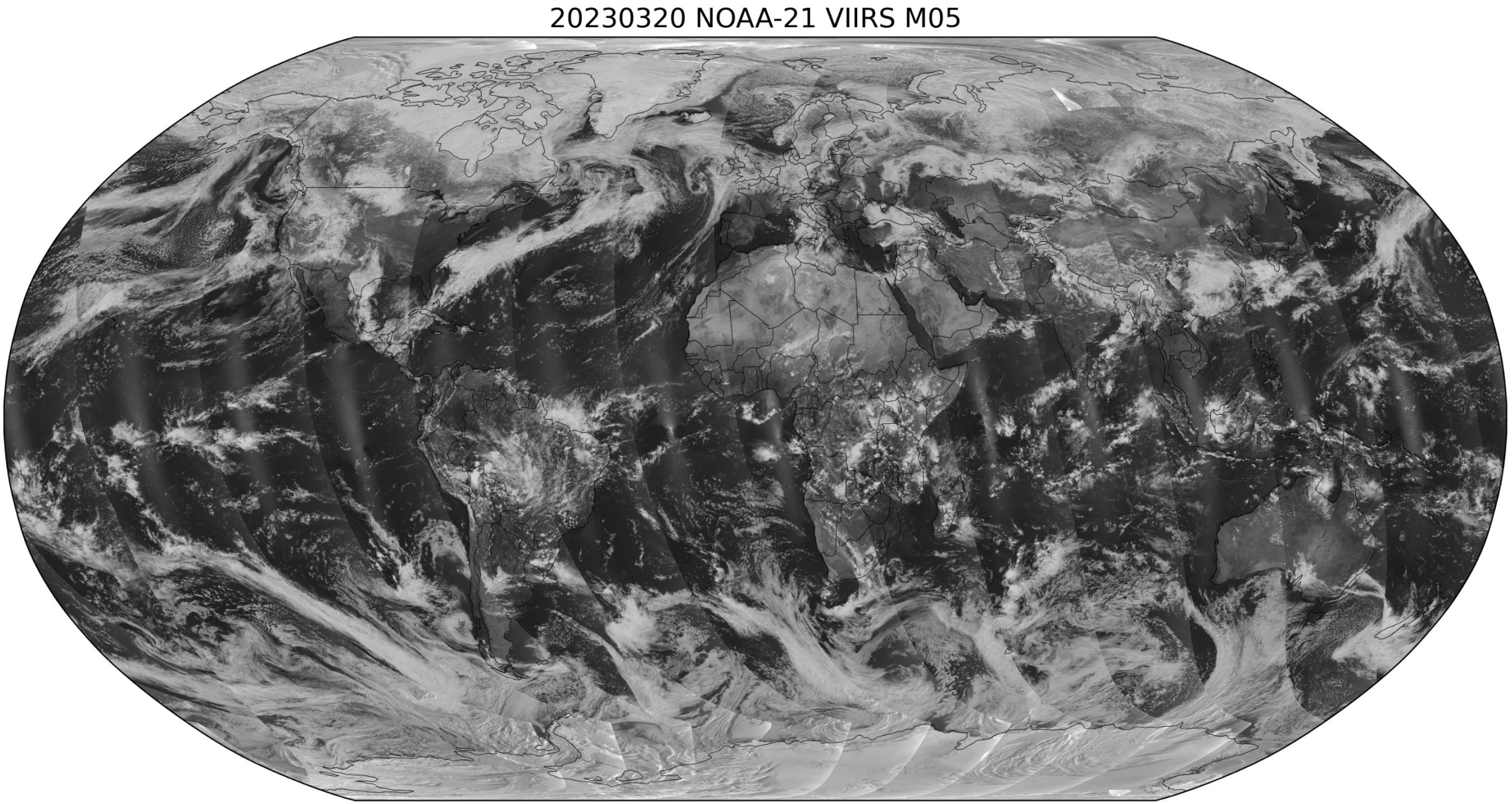




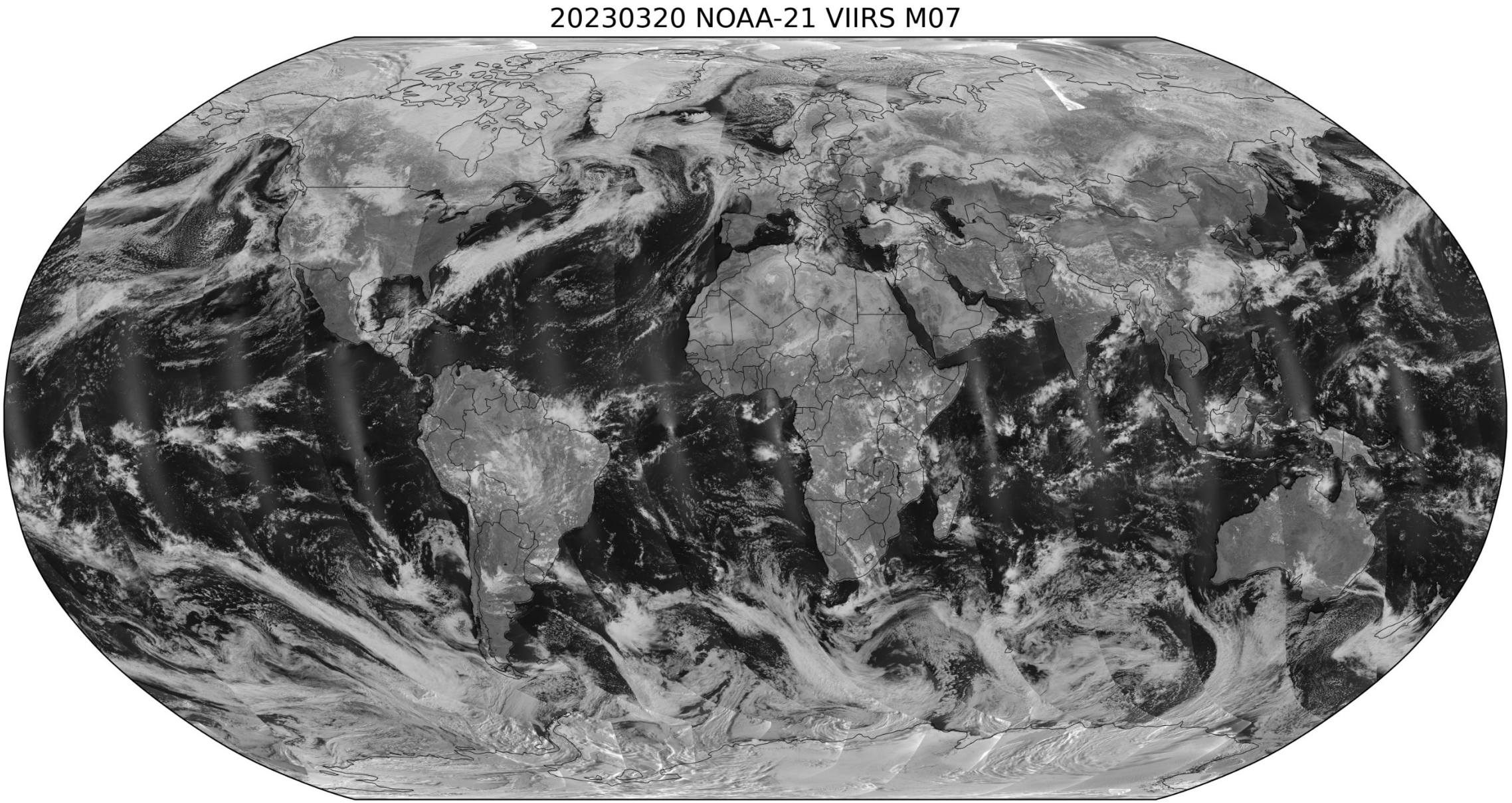
Imagery EDR Performance Evaluation

- Validation data sets (type, periods, coverage)
  - Time Period of Evaluation 3/13 – 3/29
  - All bands for EDR Imagery (KPPs and non-KPPs)
  - A variety of scenes
    - Ocean, Land, Coast, Ice, Deep Convection, Wildfires, Day/Night
- Validation strategies / methods
  - Qualitative Analysis of Imagery
  - Comparison with NPP and NOAA-20
- Validation results
  - Since Beta, have reviewed additional scenes, made more comparisons
  - Results continue to be very positive. Imagery looks great, is usable, and compares well with S-NPP and NOAA-20
  - Of note (details on following slides):
    - NCC (and DNB): Abrupt brightness transition across northern/southern terminators
      - Stray Light, “darkness”, negative pixels
      - SDR team presented upcoming calibration updates
      - LUTS implemented today 3/30, Initial analysis of NCC imagery is very positive!
    - Very Minor Striping in Some Channels
      - Less so than at Beta review
    - Infrequent M9 Pixel Saturation
      - Less so than at Beta review
- Long term monitoring readiness
  - Numerous display capabilities for real-time and archived datasets
    - CIRA Polar Slider, McIDAS-X/V, AWIPS-II, IDL, Python
  - Data collection
    - GRAVITE, DB via GINA and SSEC, CLASS

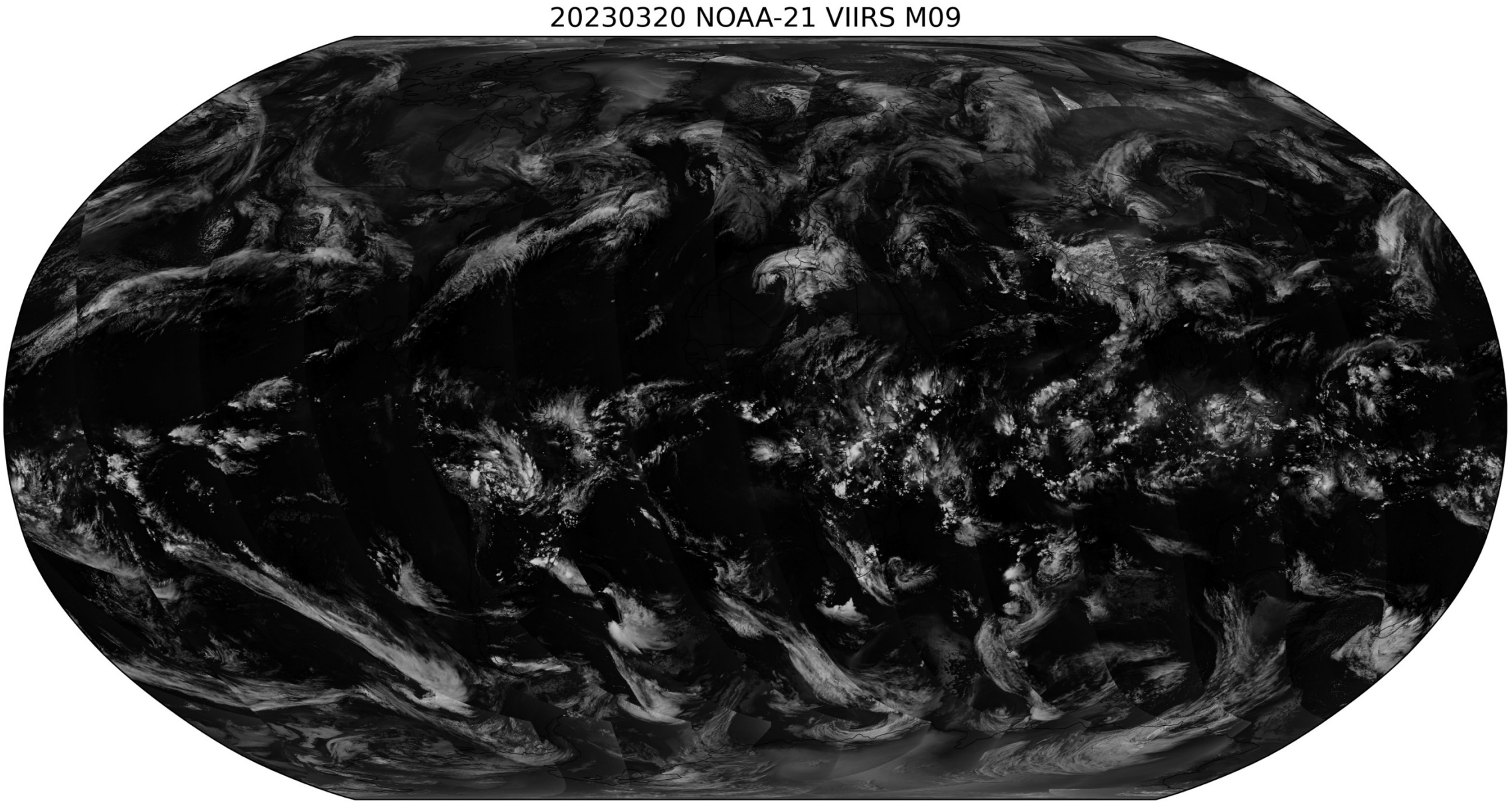
20 Mar 2023 NOAA-21 VIIRS M5 Imagery Global Composite



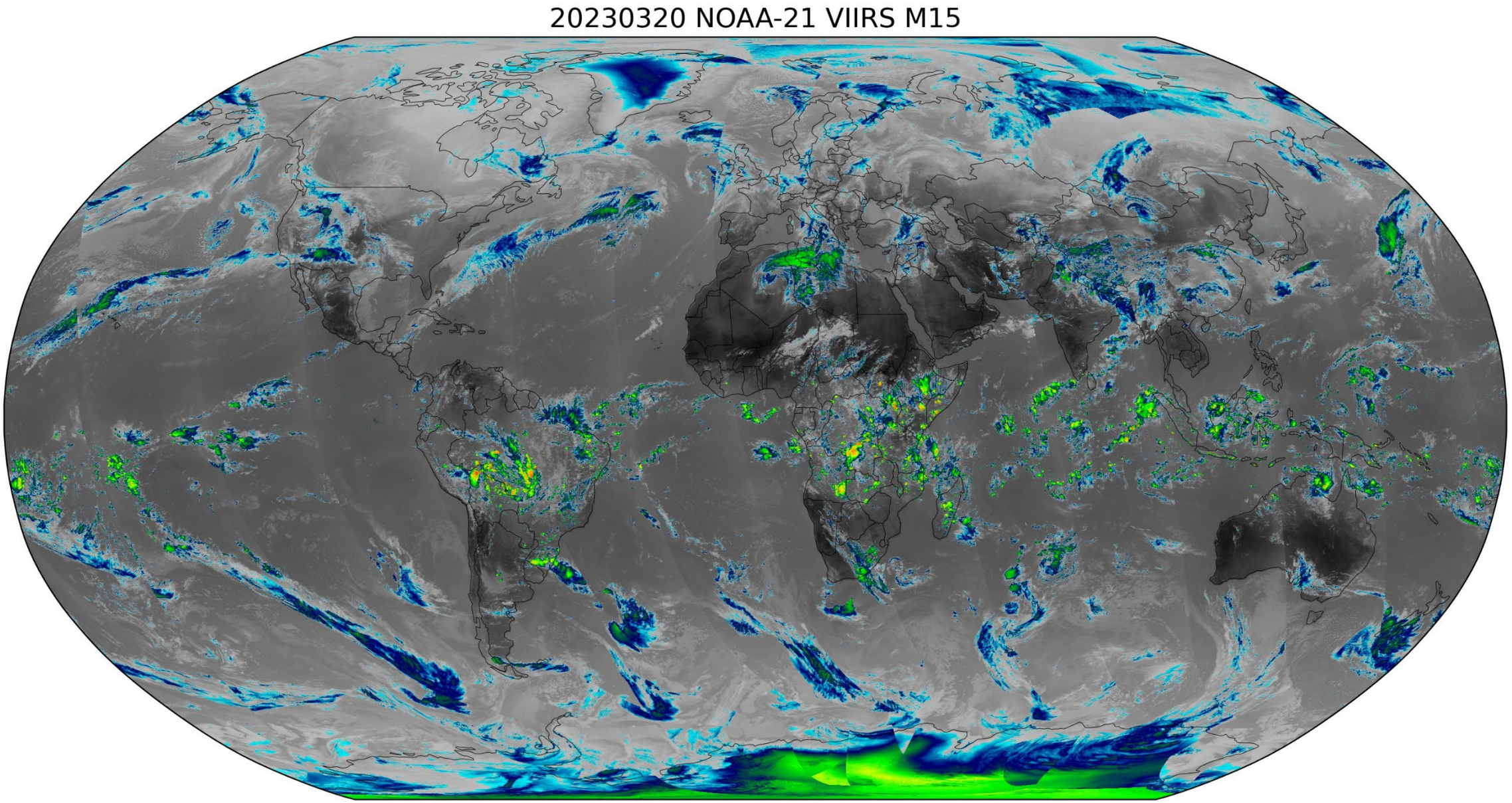
20 Mar 2023 NOAA-21 VIIRS M7 Imagery Global Composite



20 Mar 2023 NOAA-21 VIIRS M9 Imagery Global Composite



20 Mar 2023 NOAA-21 VIIRS M15 Imagery Global Composite



VIIRS All Channel Comparison – Alaska Day (3/24/2023)

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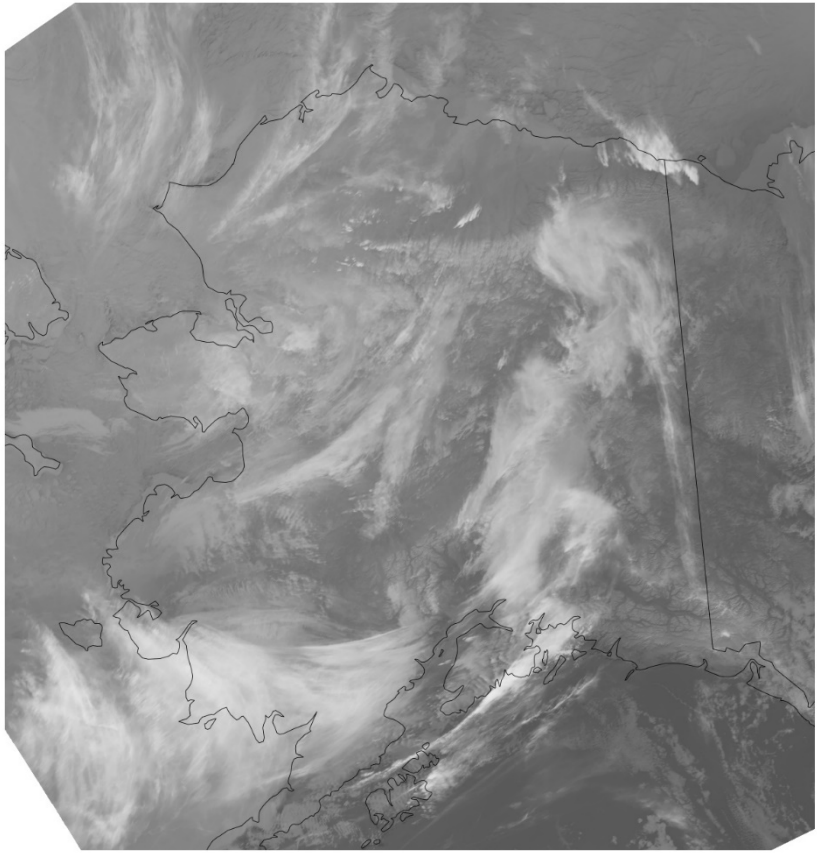

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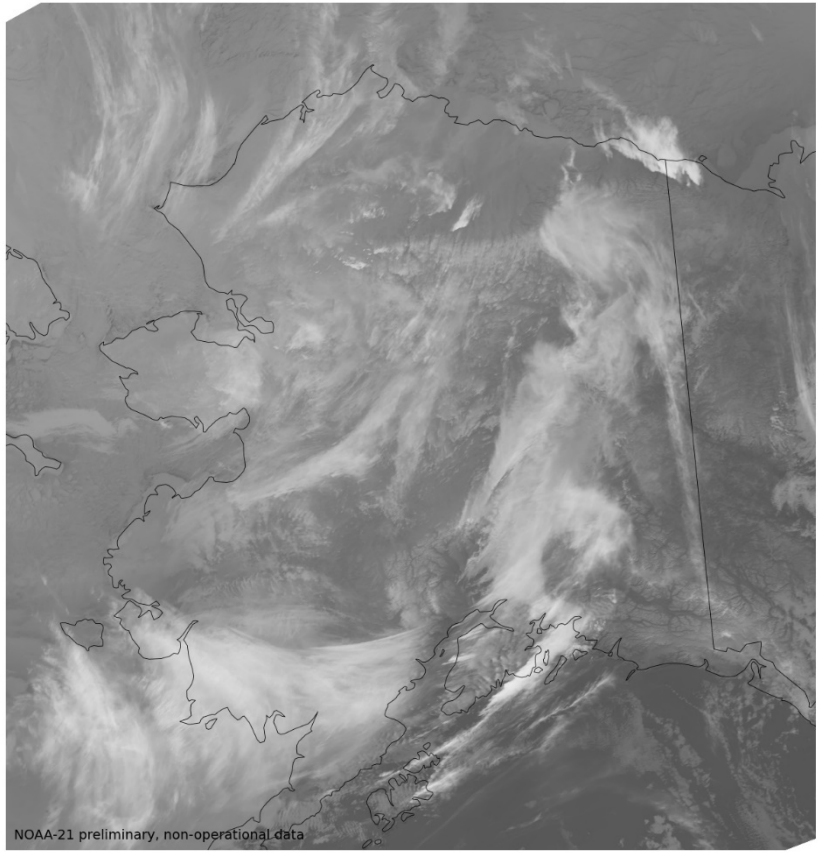

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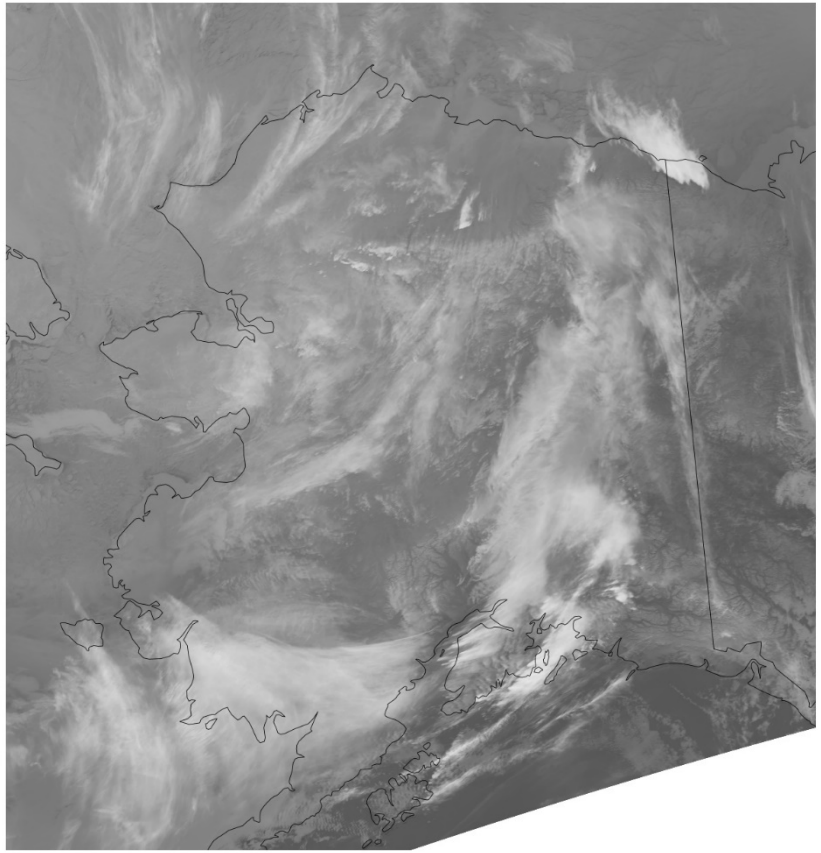

VIIRS All Channel Comparison – Alaska Night (3/24/2023)

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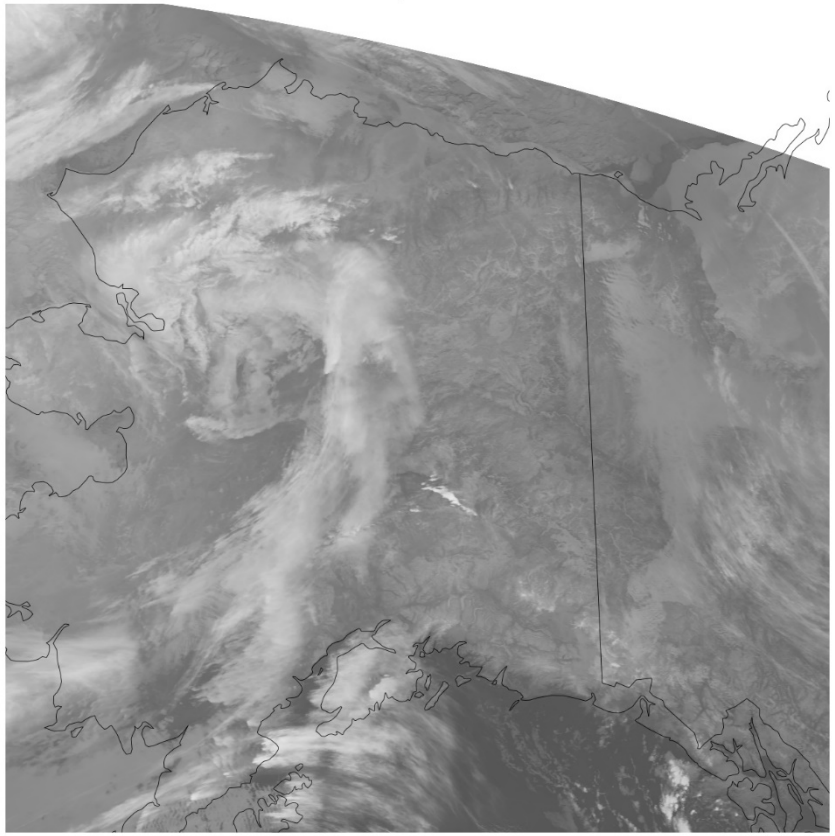

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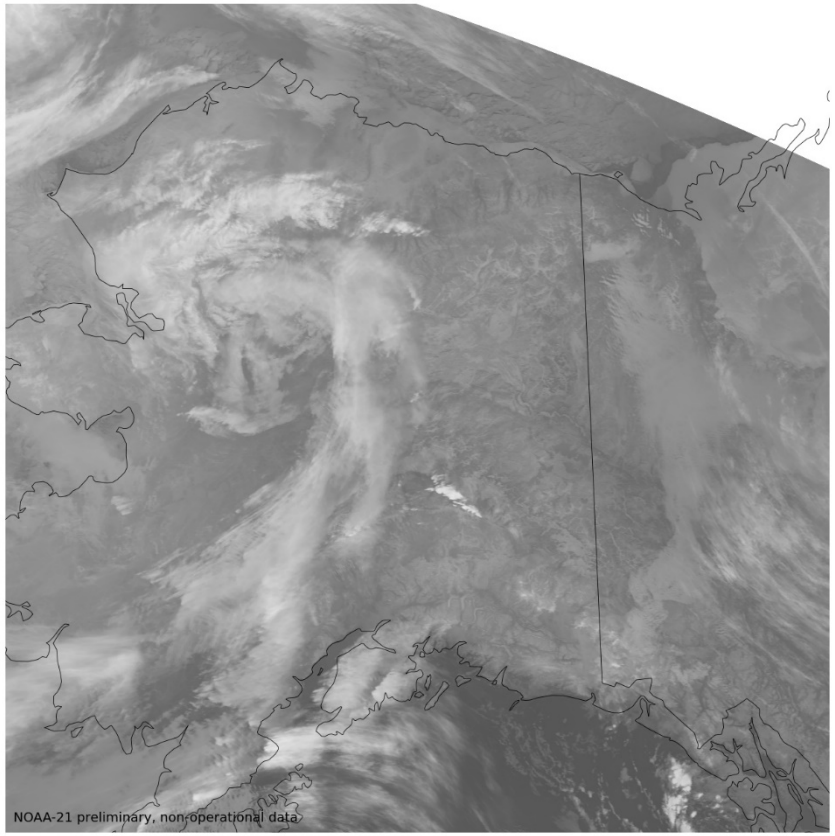

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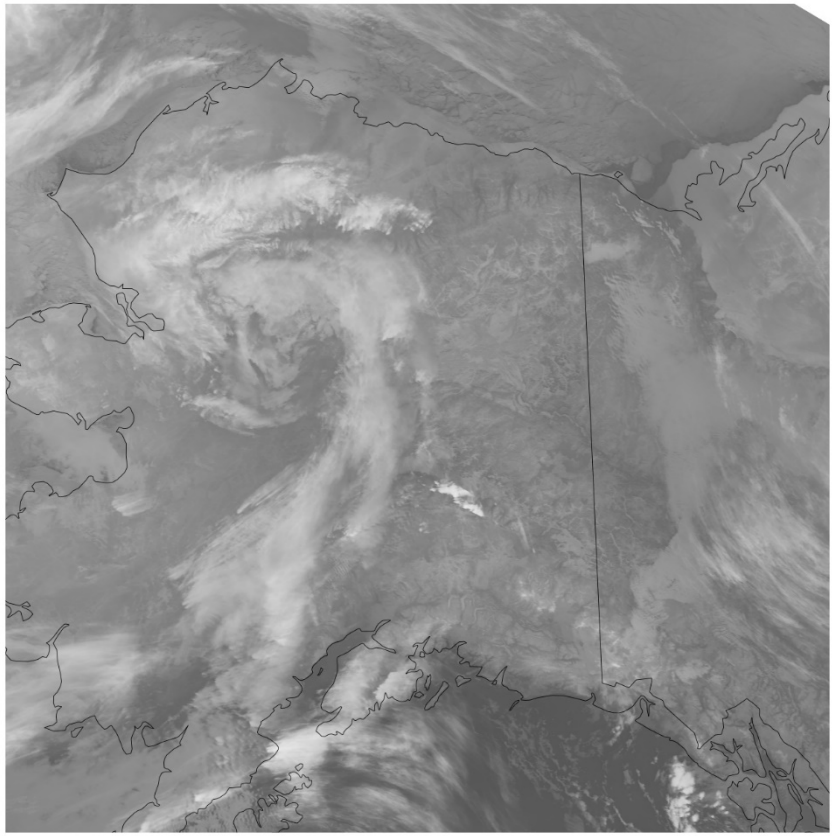

NOAA-21 VIIRS All Channels – TC Herman/Convection Day (3/30/2023)

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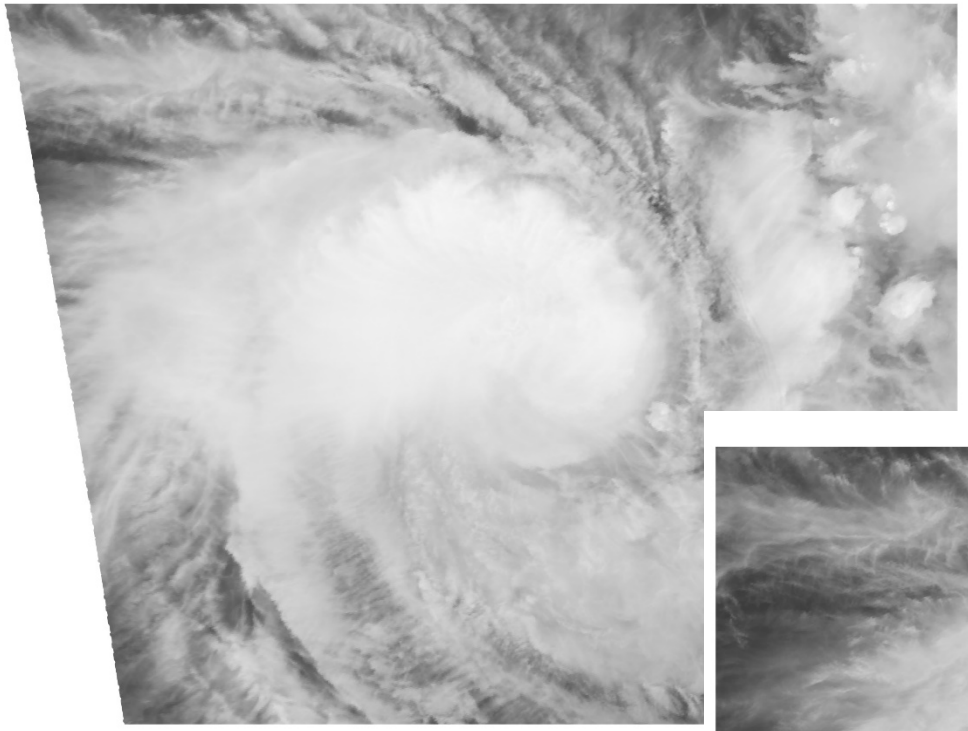

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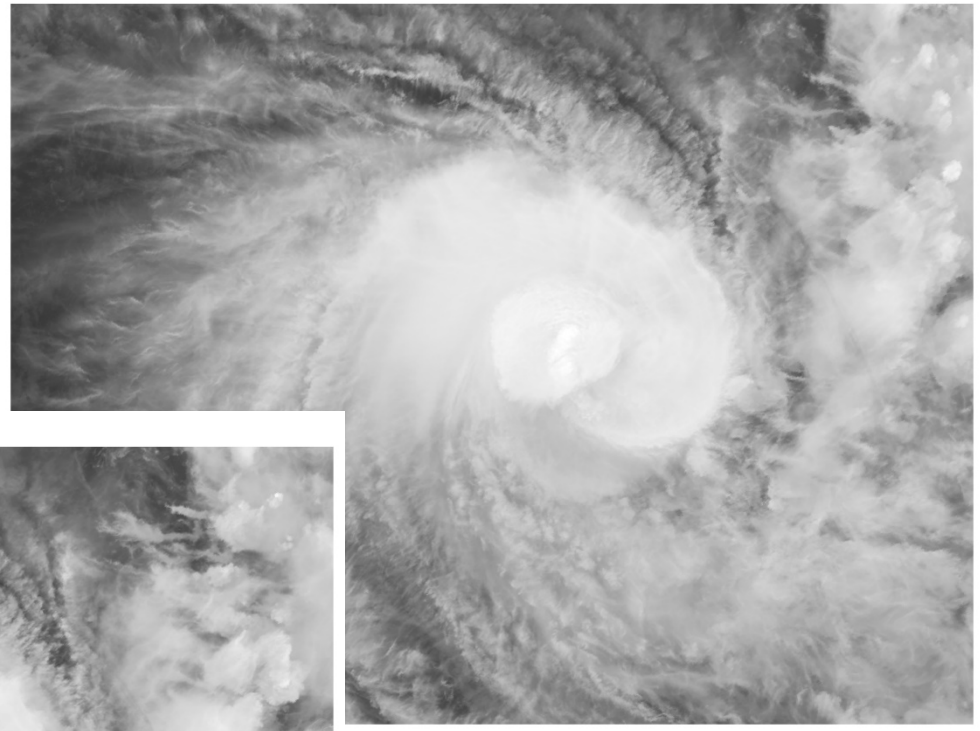

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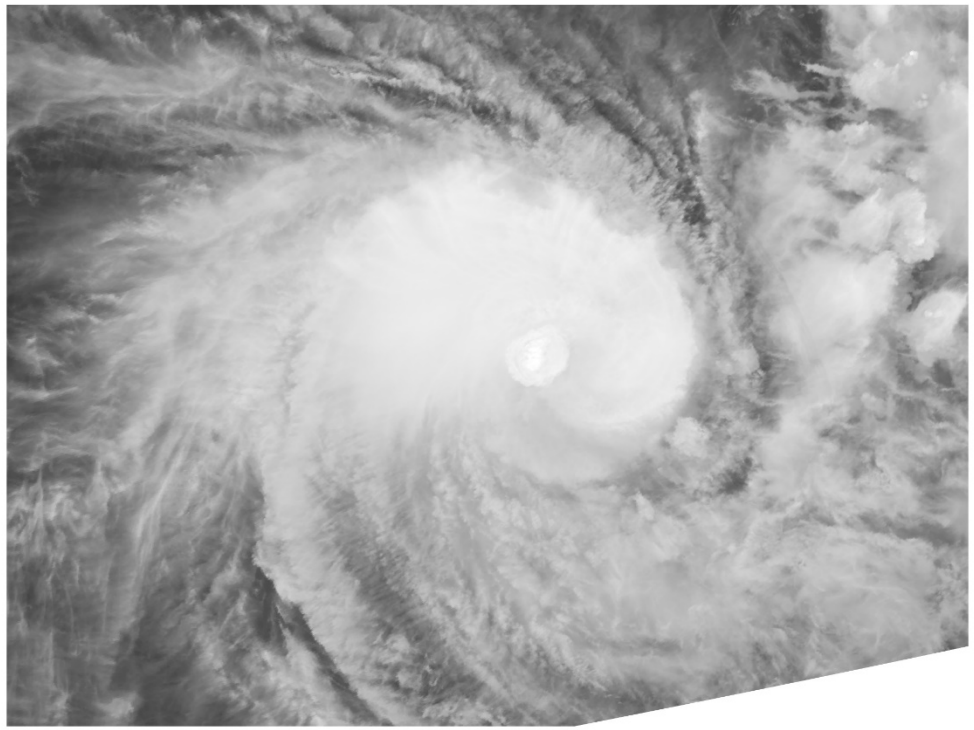

VIIRS M8 Comparison – TC Herman/Convection Day (3/30/2023)

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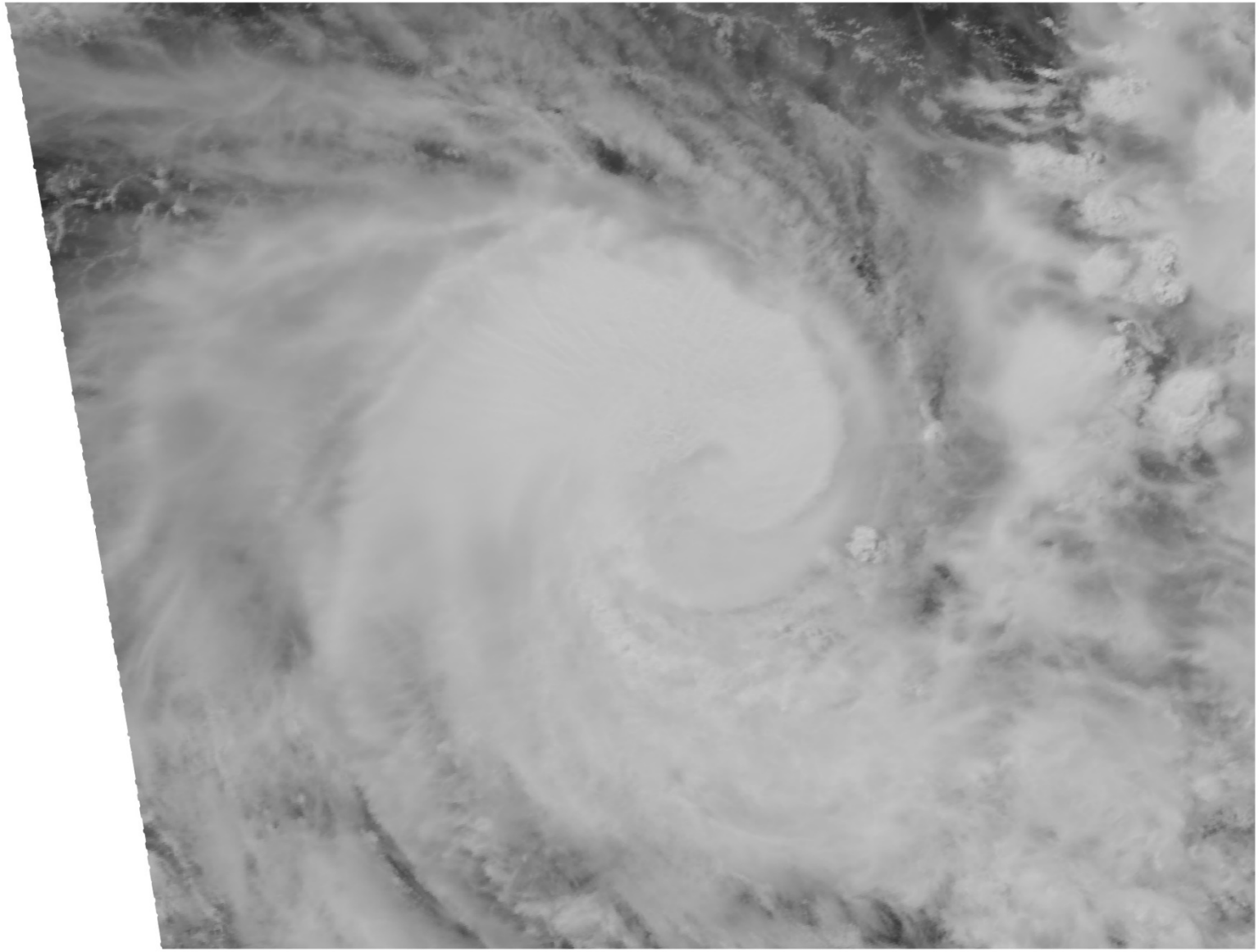

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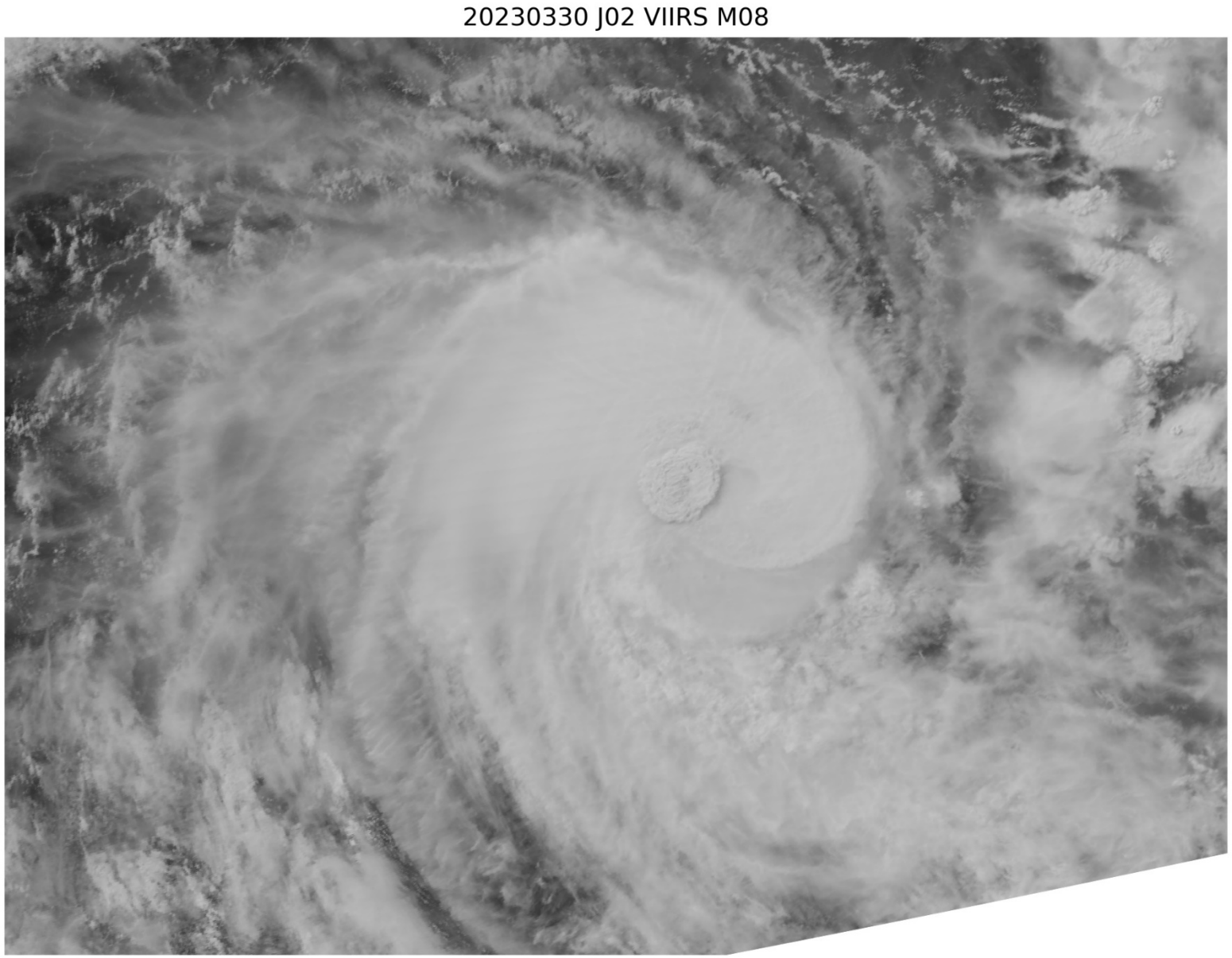

VIIRS M8 Comparison – TC Herman/Convection Day (3/30/2023)

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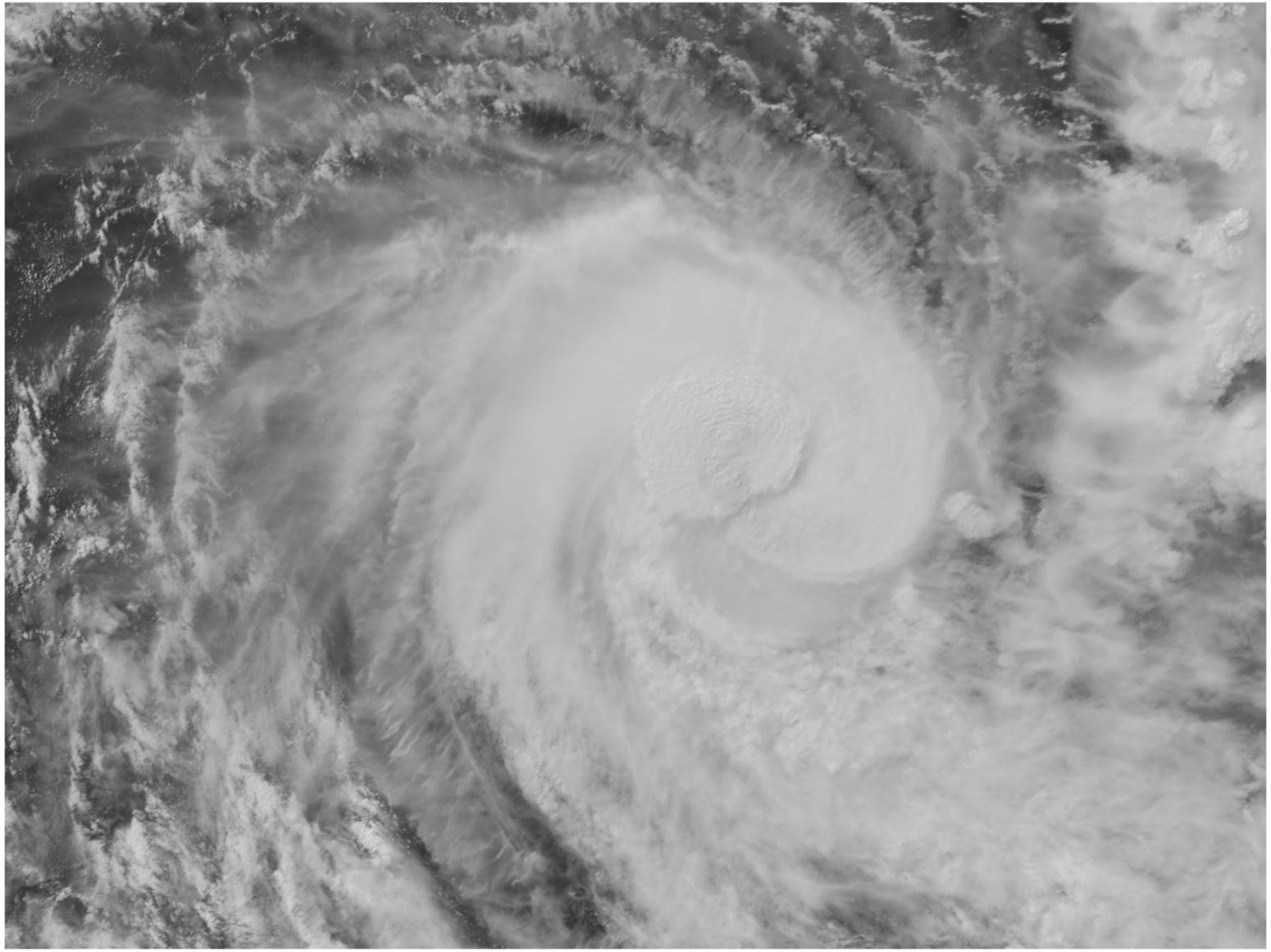

VIIRS All Channel Comparison – Convection Night (3/29/2023)

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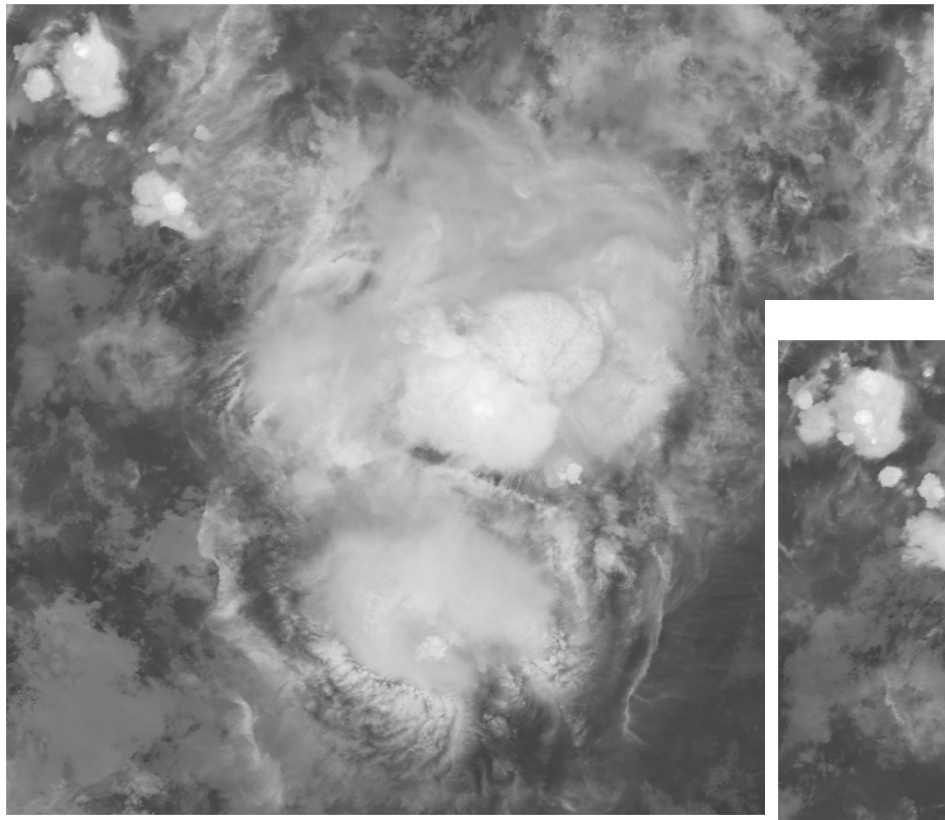

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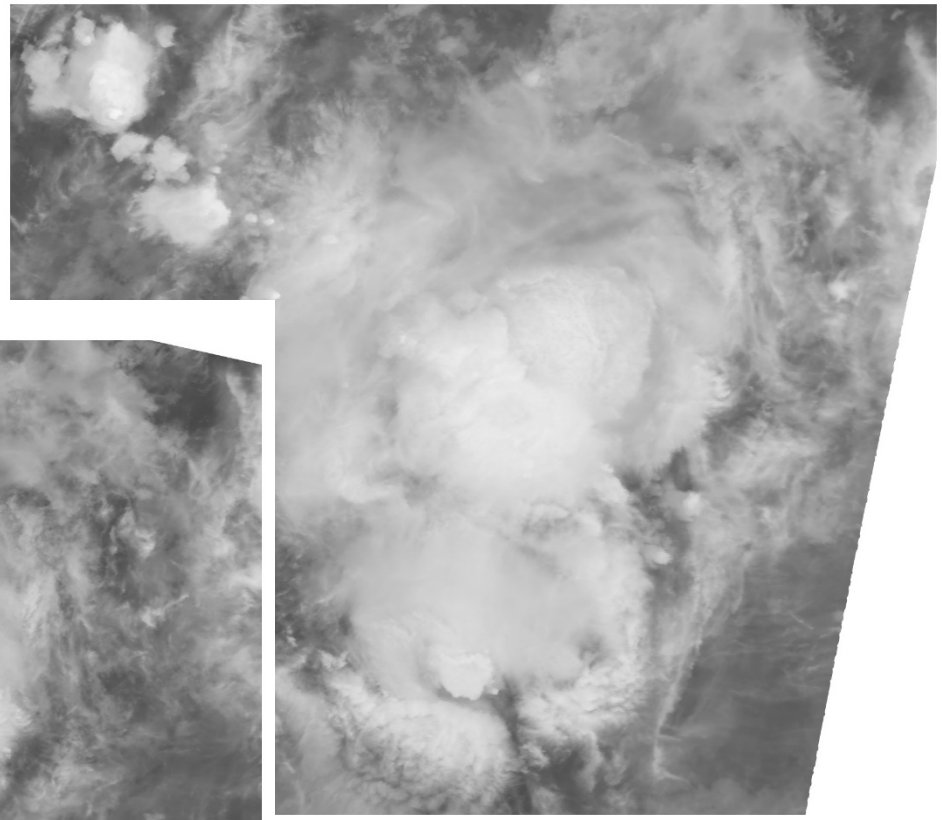

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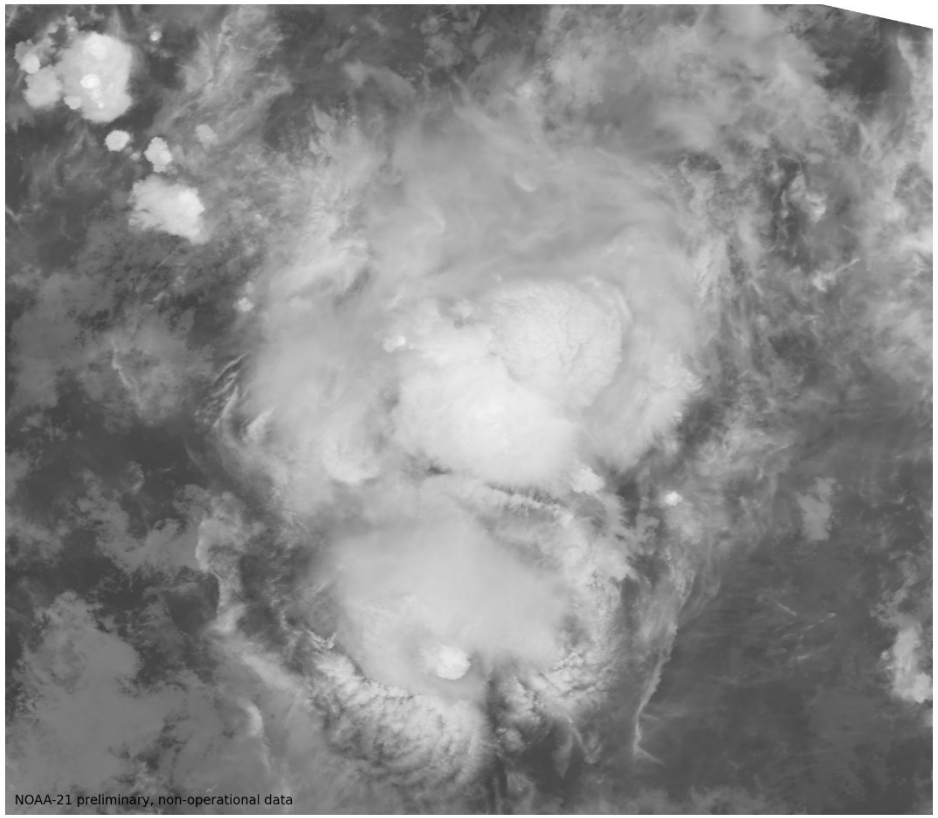
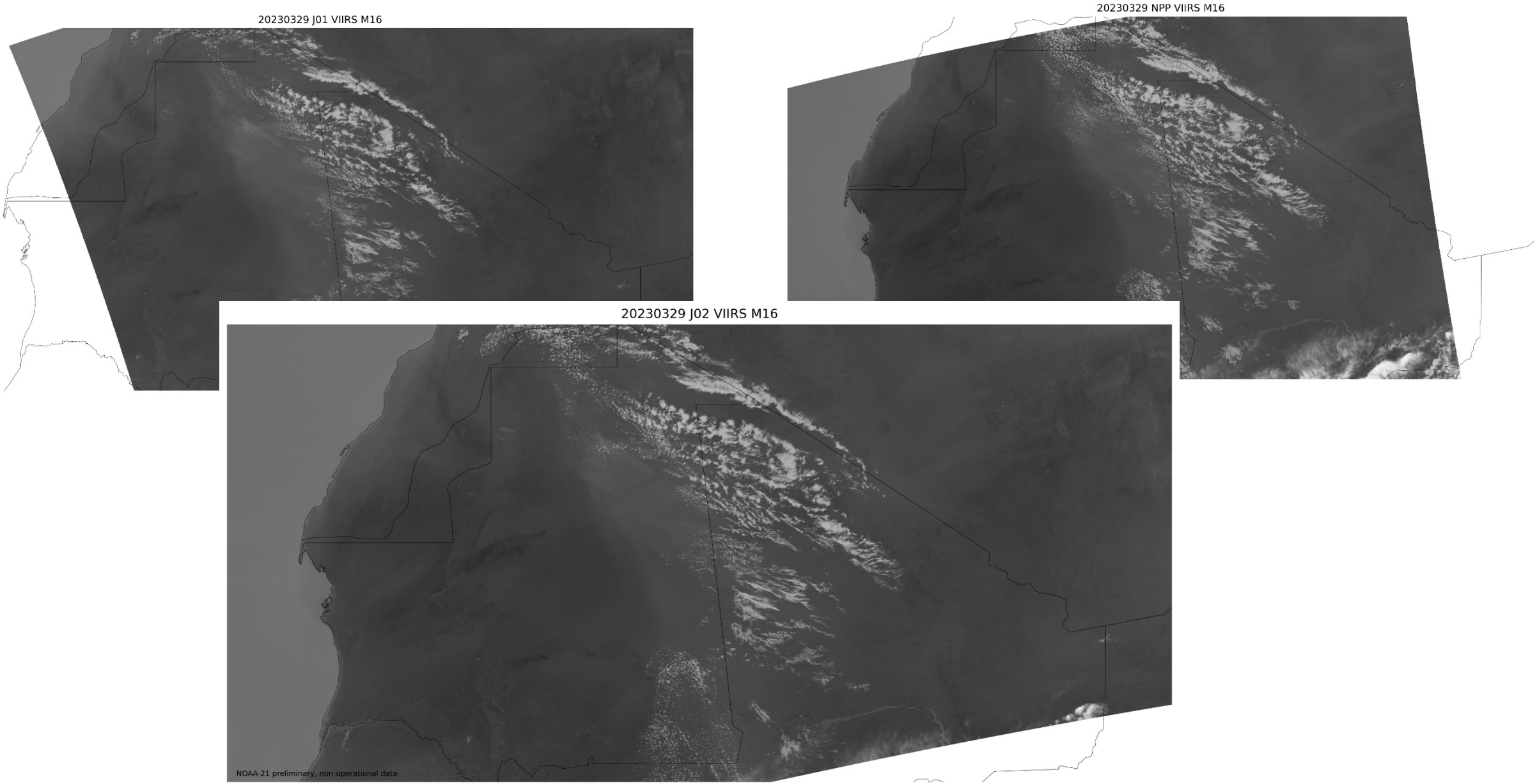


VIIRS All Channel Comparison – Africa Day (3/29/2023)



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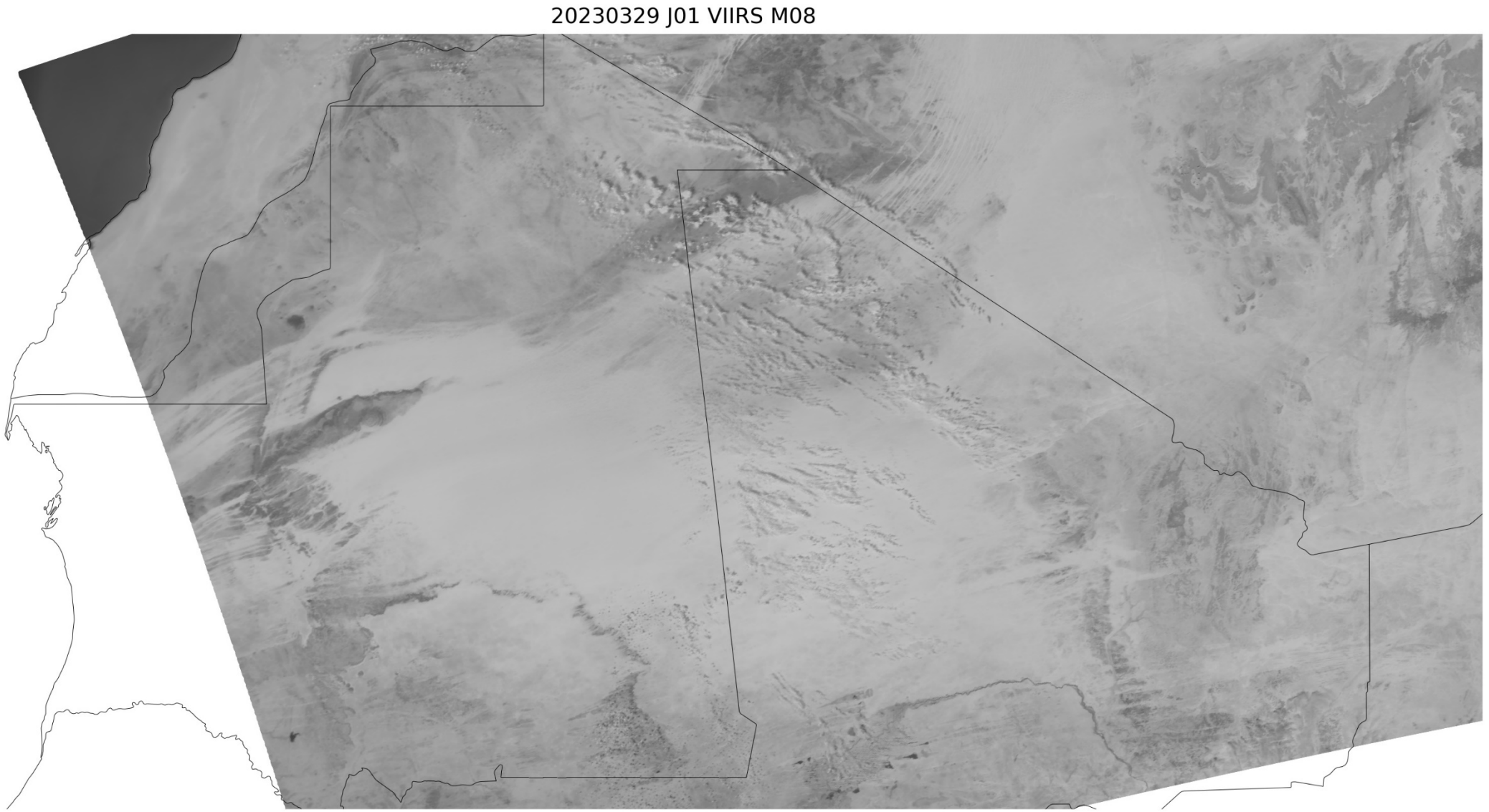

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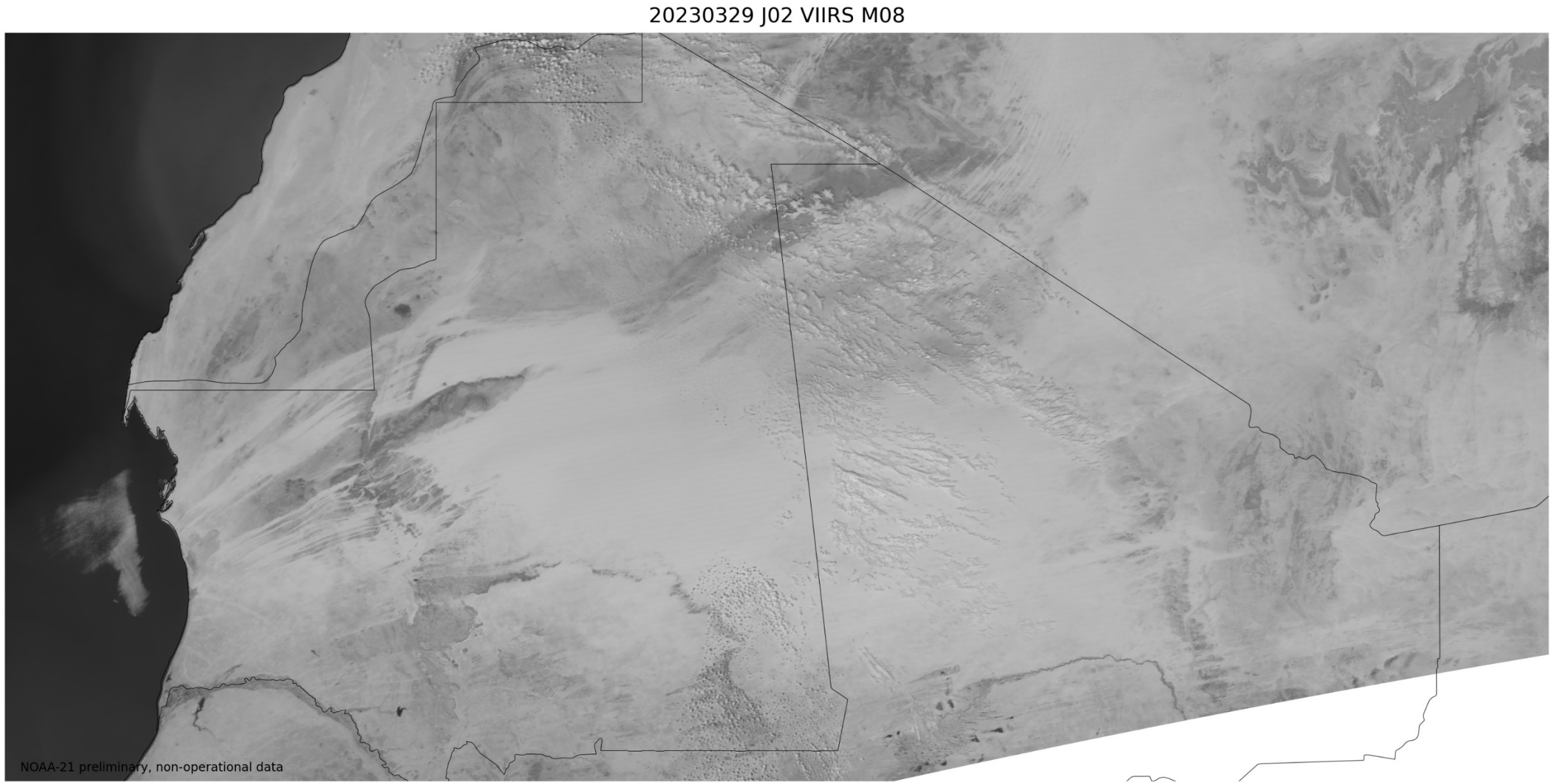
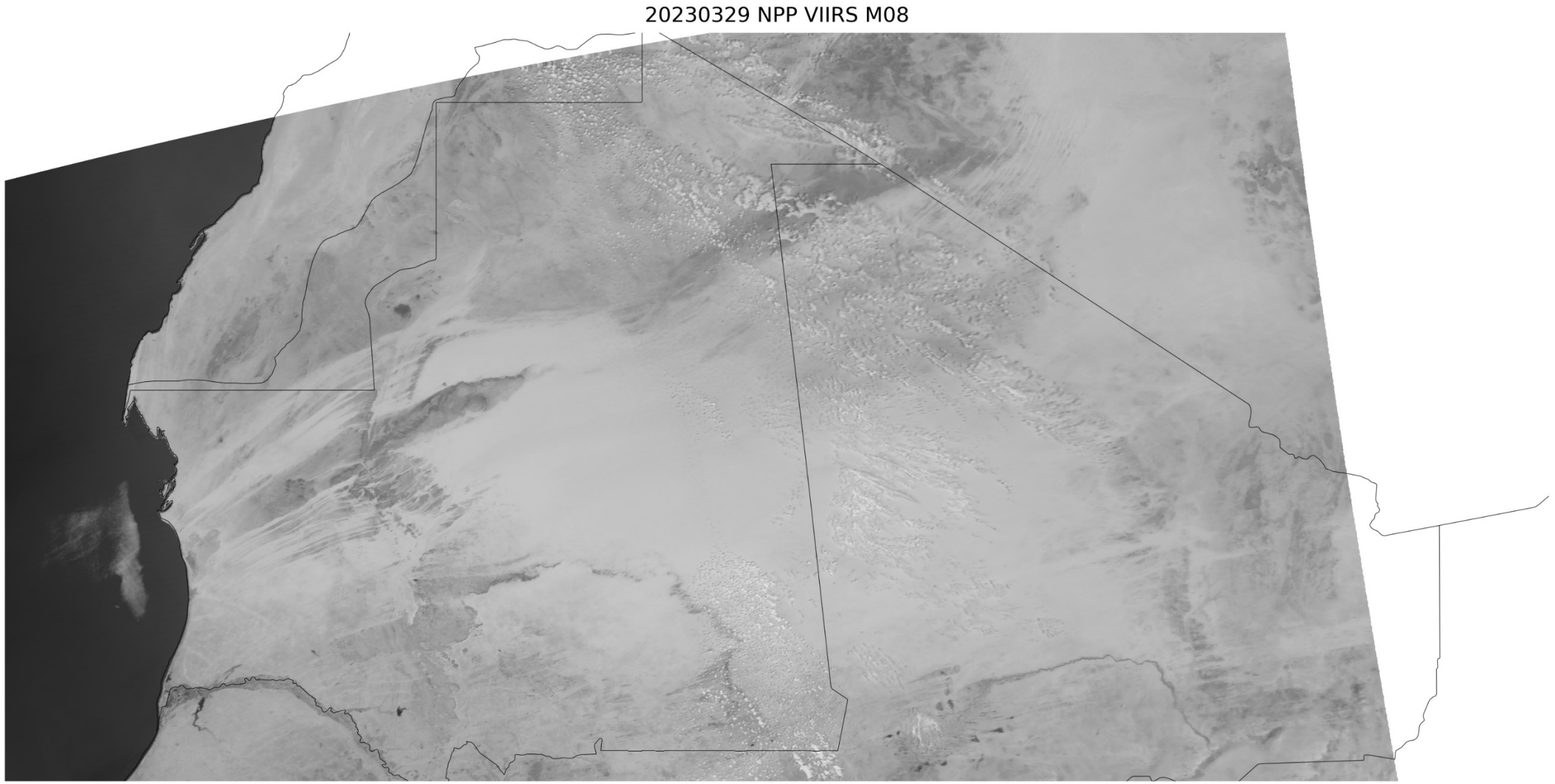


VIIRS M8 Comparison – Africa Day (3/29/2023)



VIIRS All Channel Comparison – Greenland Day (3/29/2023)

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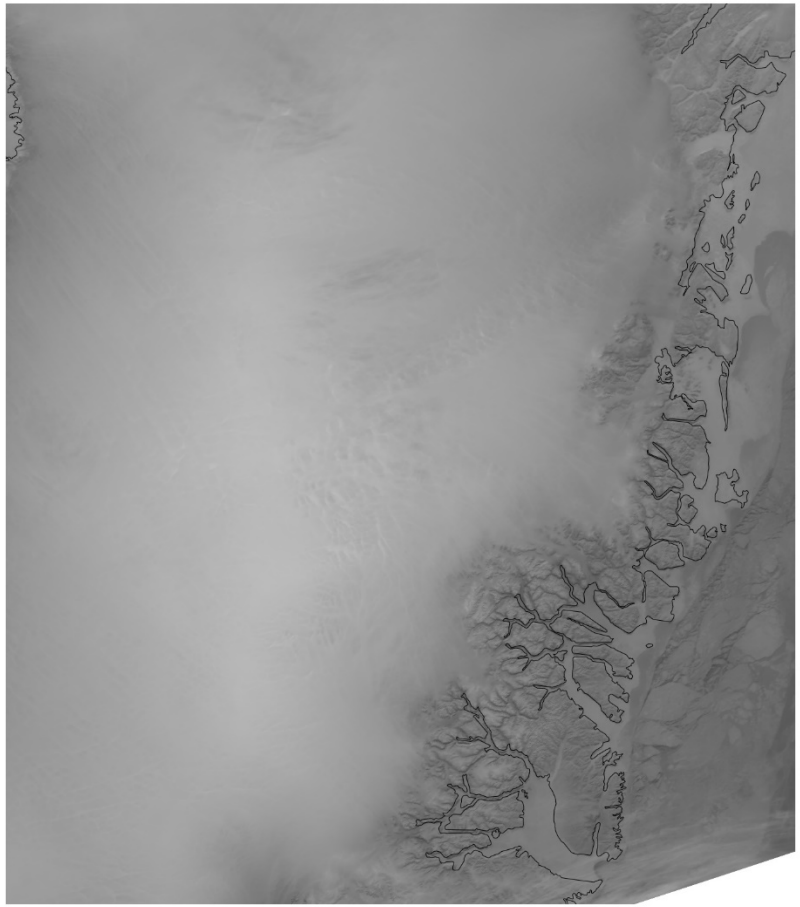

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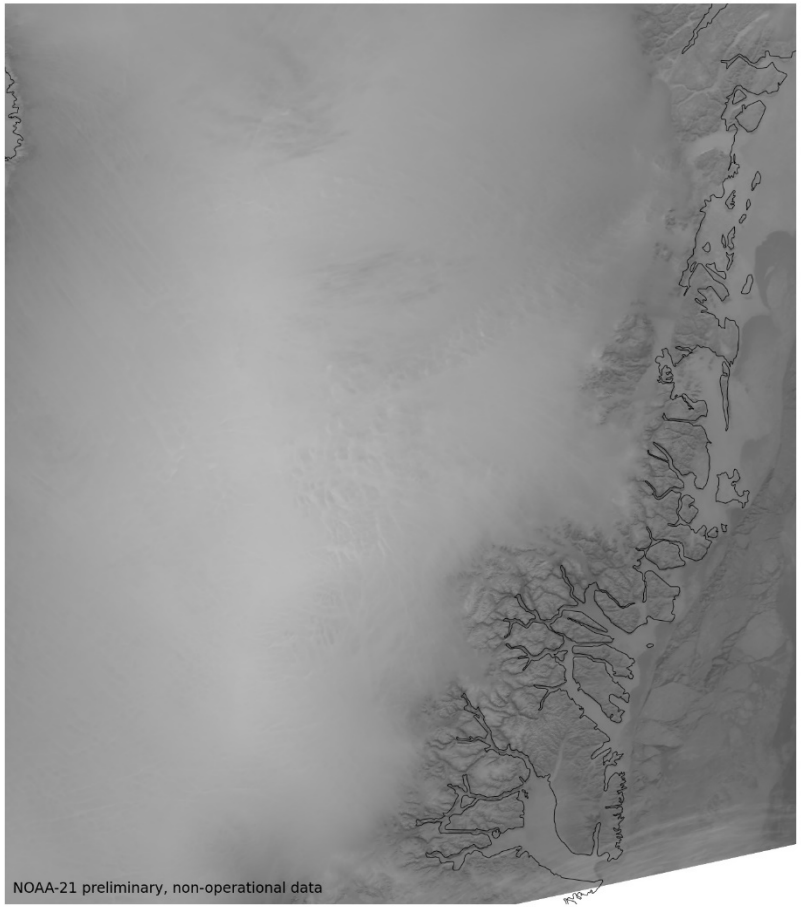
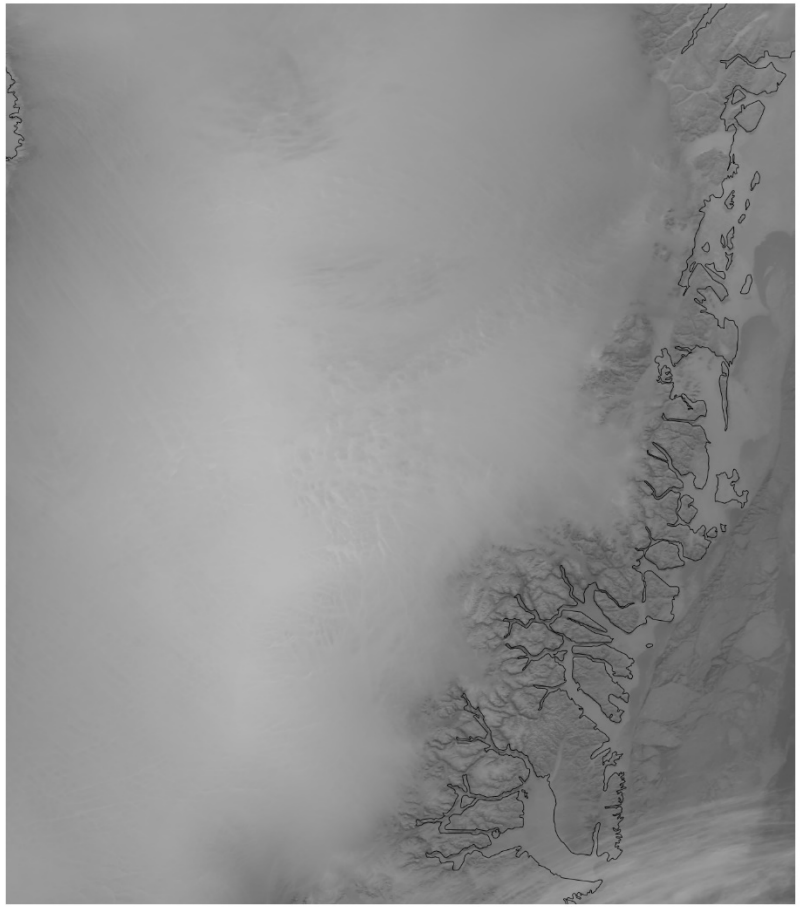
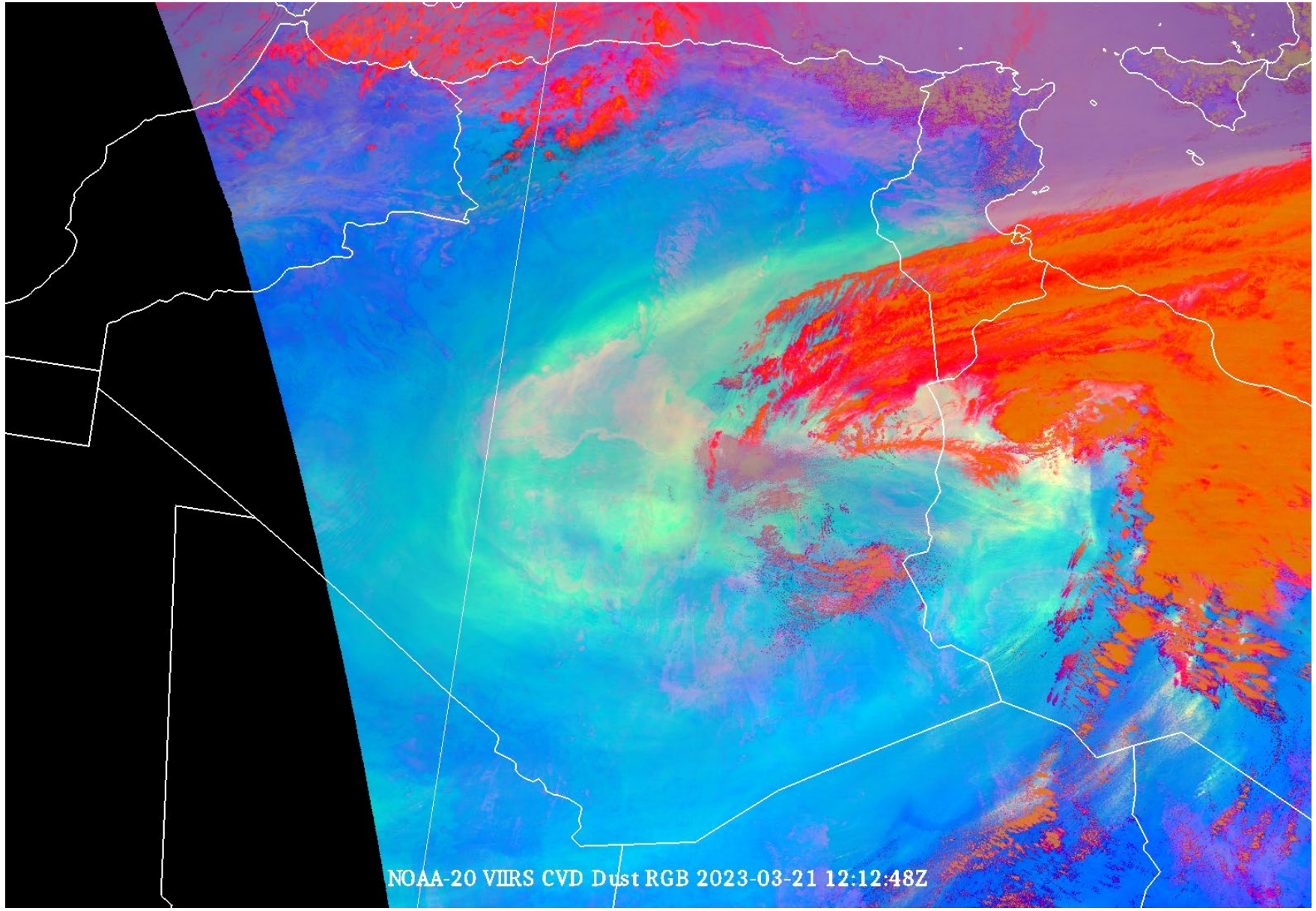


20230329 NPP VIIRS M16



VIIRS Dust RGB Comparison - Northern Africa (3/21/2023)

Africa Blowing Dust
20230321
NOAA-20
Dust CVD RGB
(M15-M14, M16-M15, M15)



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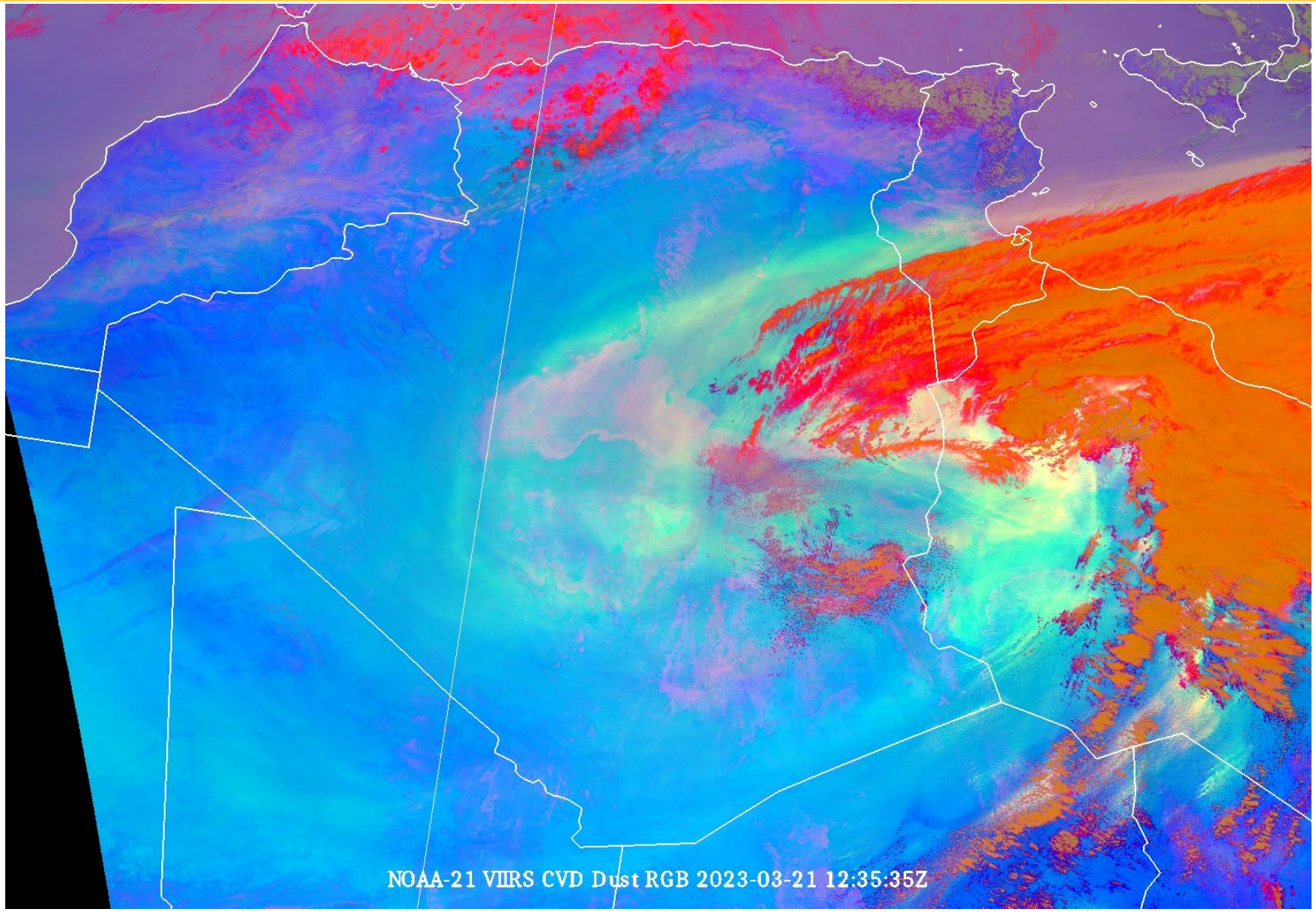

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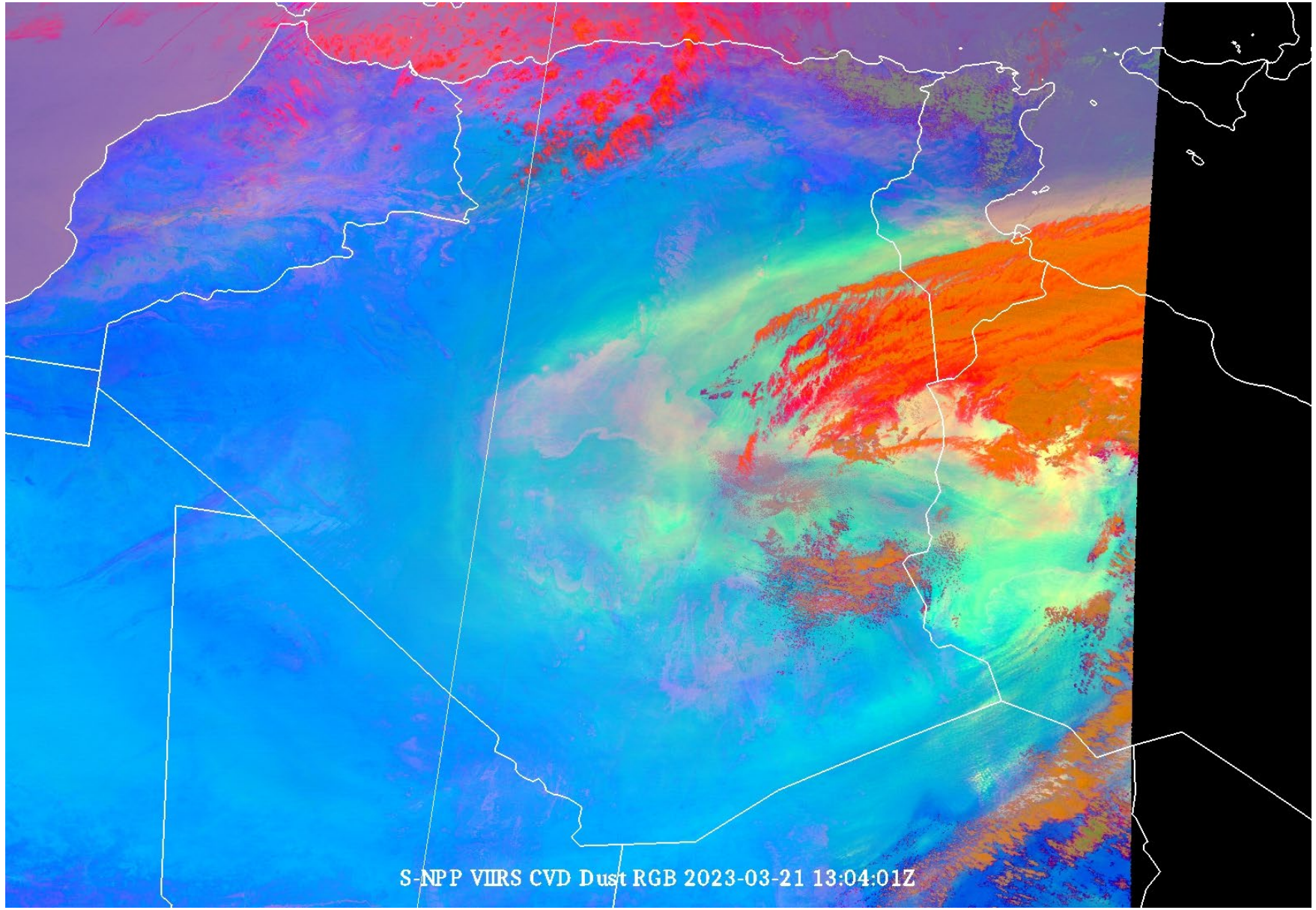
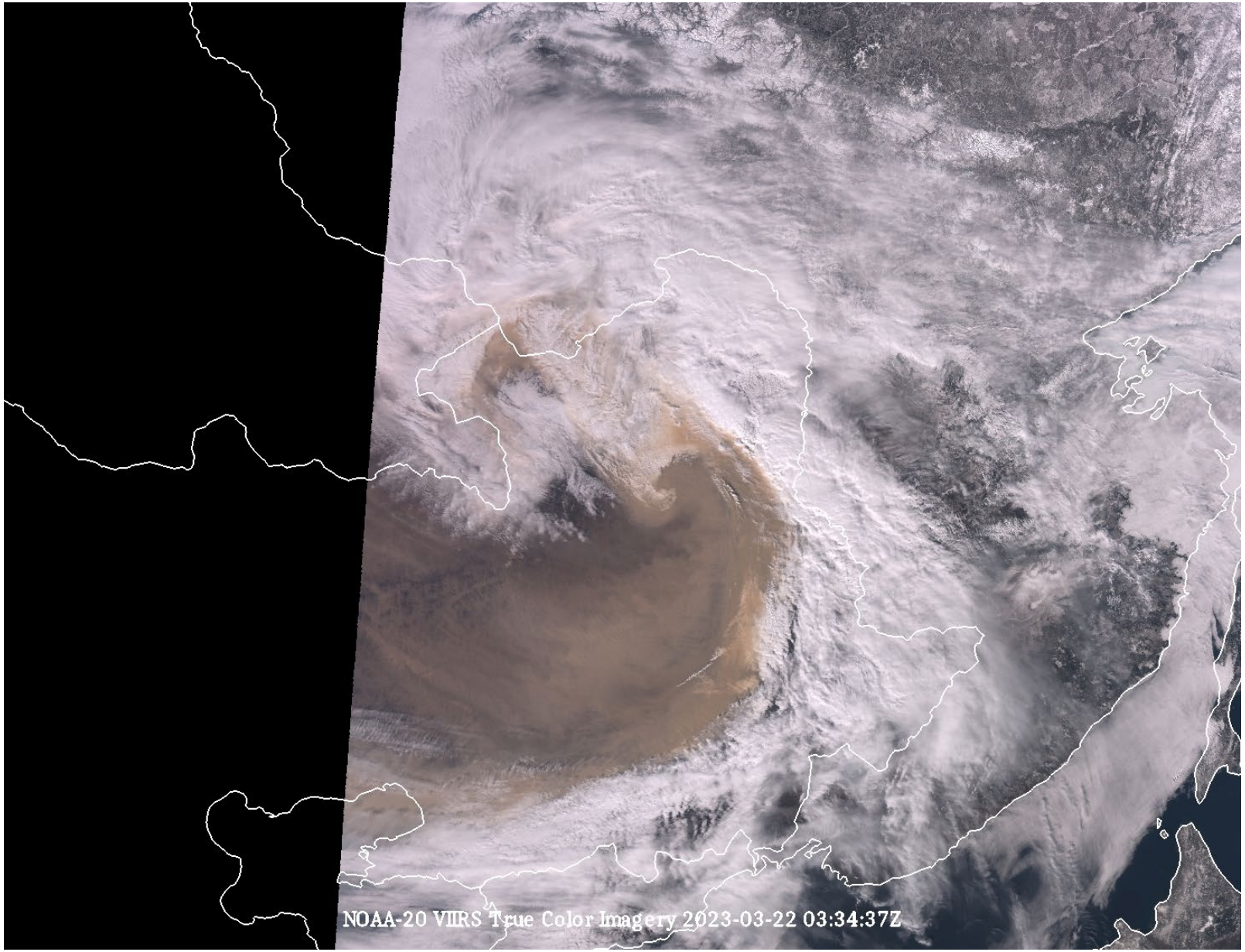
20230321
S-NPP
Dust CVD RGB
(M15-M14, M16-M15, M15)



VIIRS True Color RGB Comparison - Northeast China (3/22/2023)

China Blowing Dust
20230322
NOAA-20
True Color RGB
(M5, M4, M3)



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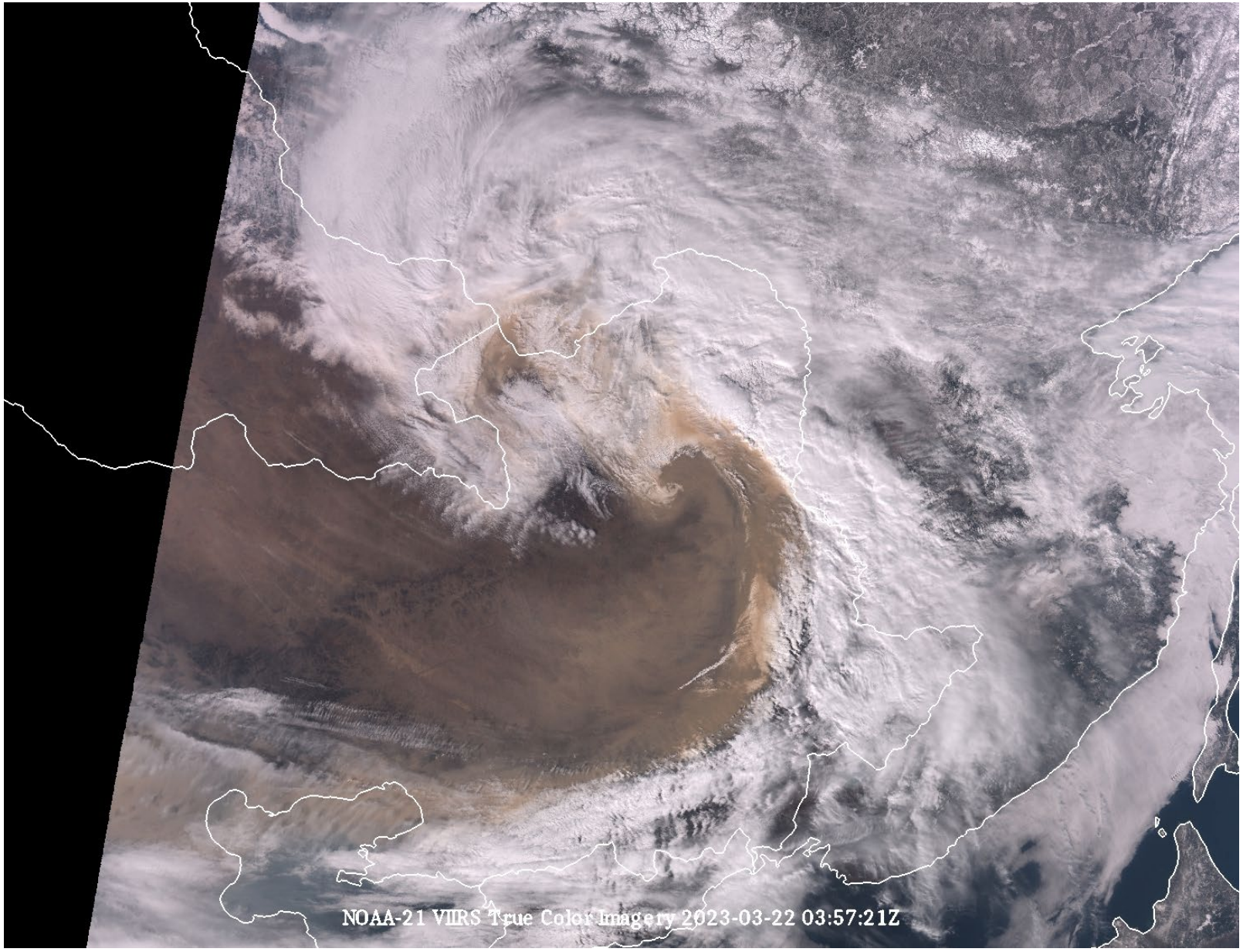
NOAA-21
True Color RGB
(M5, M4, M3)



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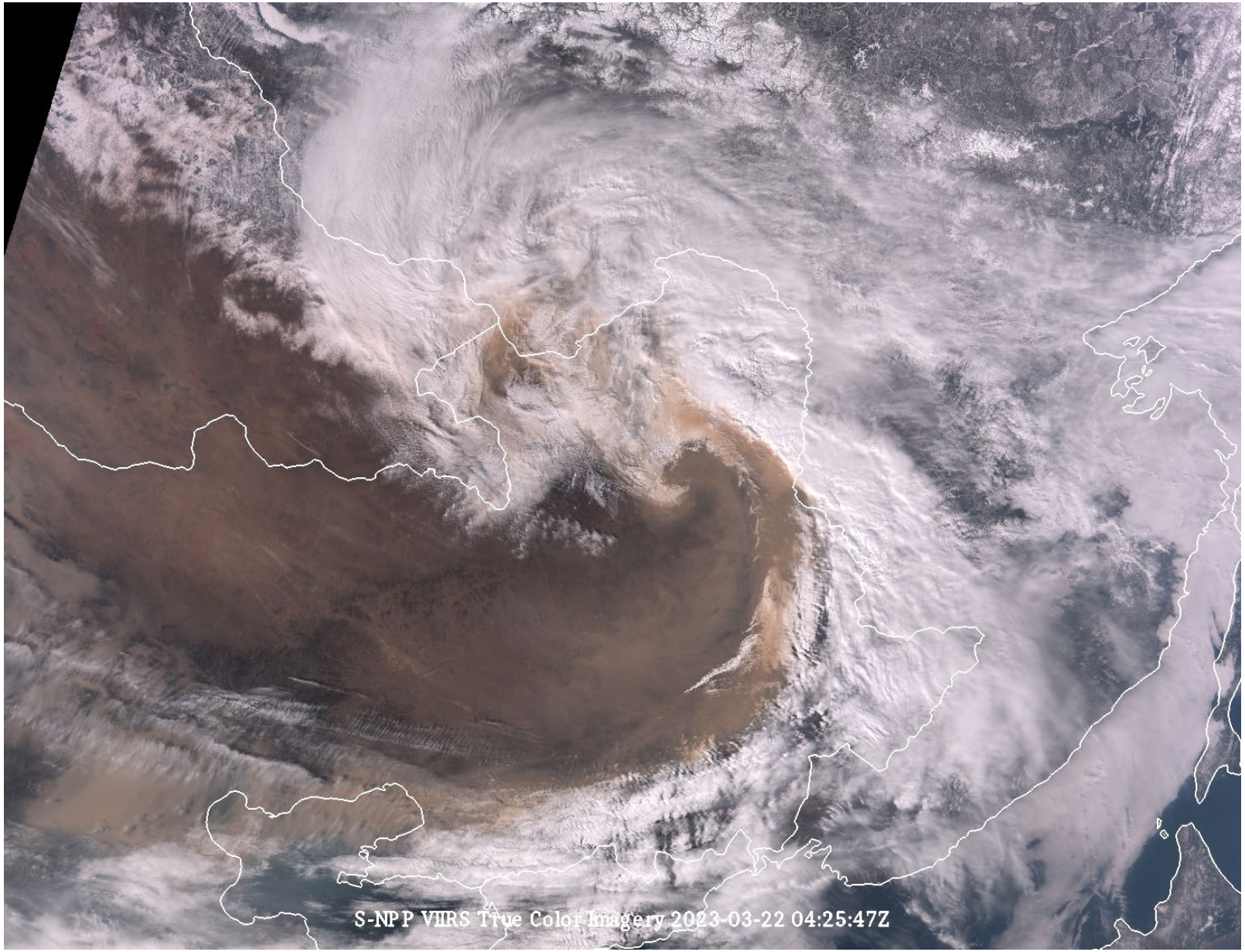
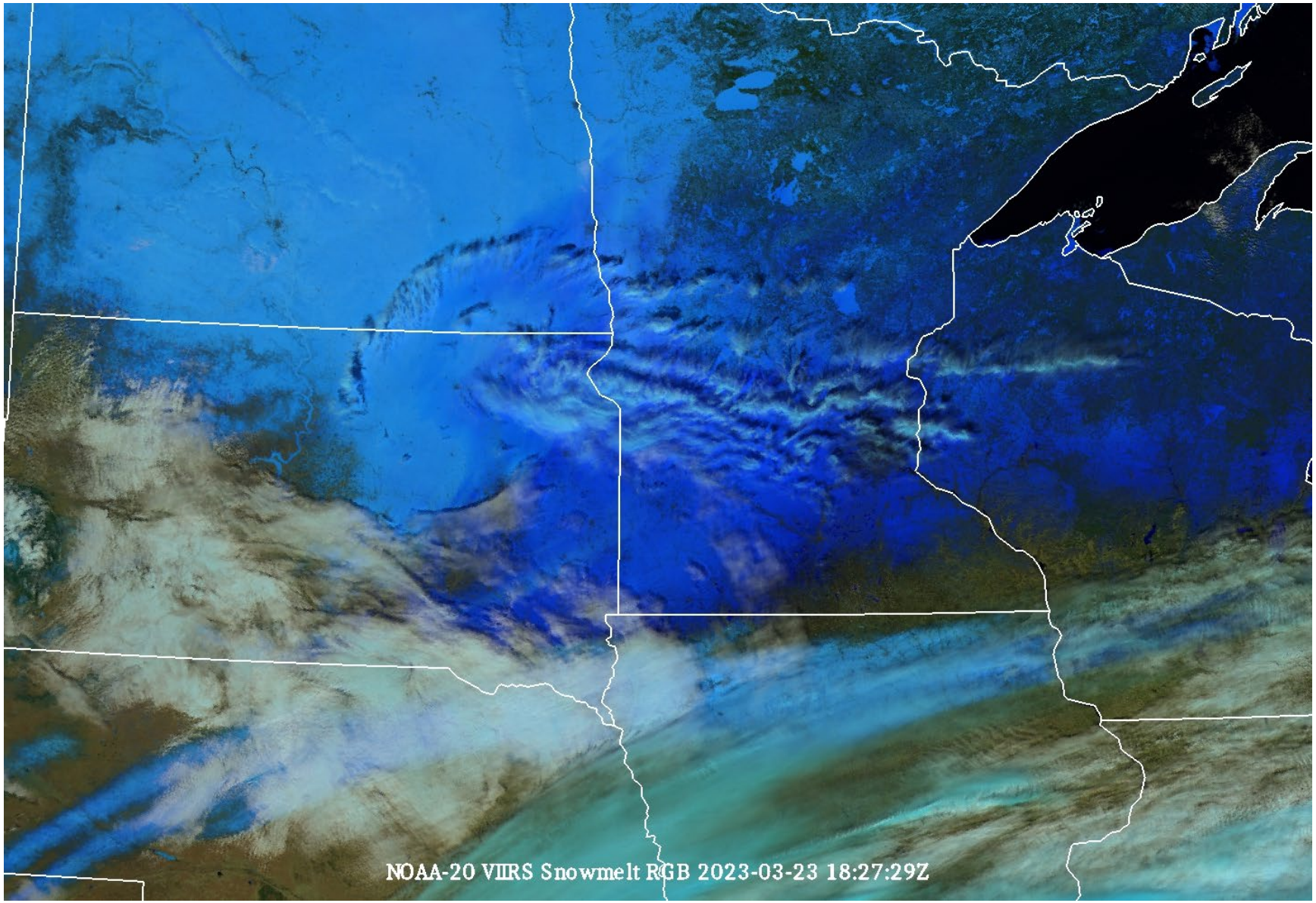
20230322
S-NPP
True Color RGB
(M5, M4, M3)



VIIRS Snowmelt RGB Comparison – Midwest US (3/23/2023)

Midwest US Snowpack
20230323
NOAA-20
Snowmelt RGB
(M10, M8, M5)



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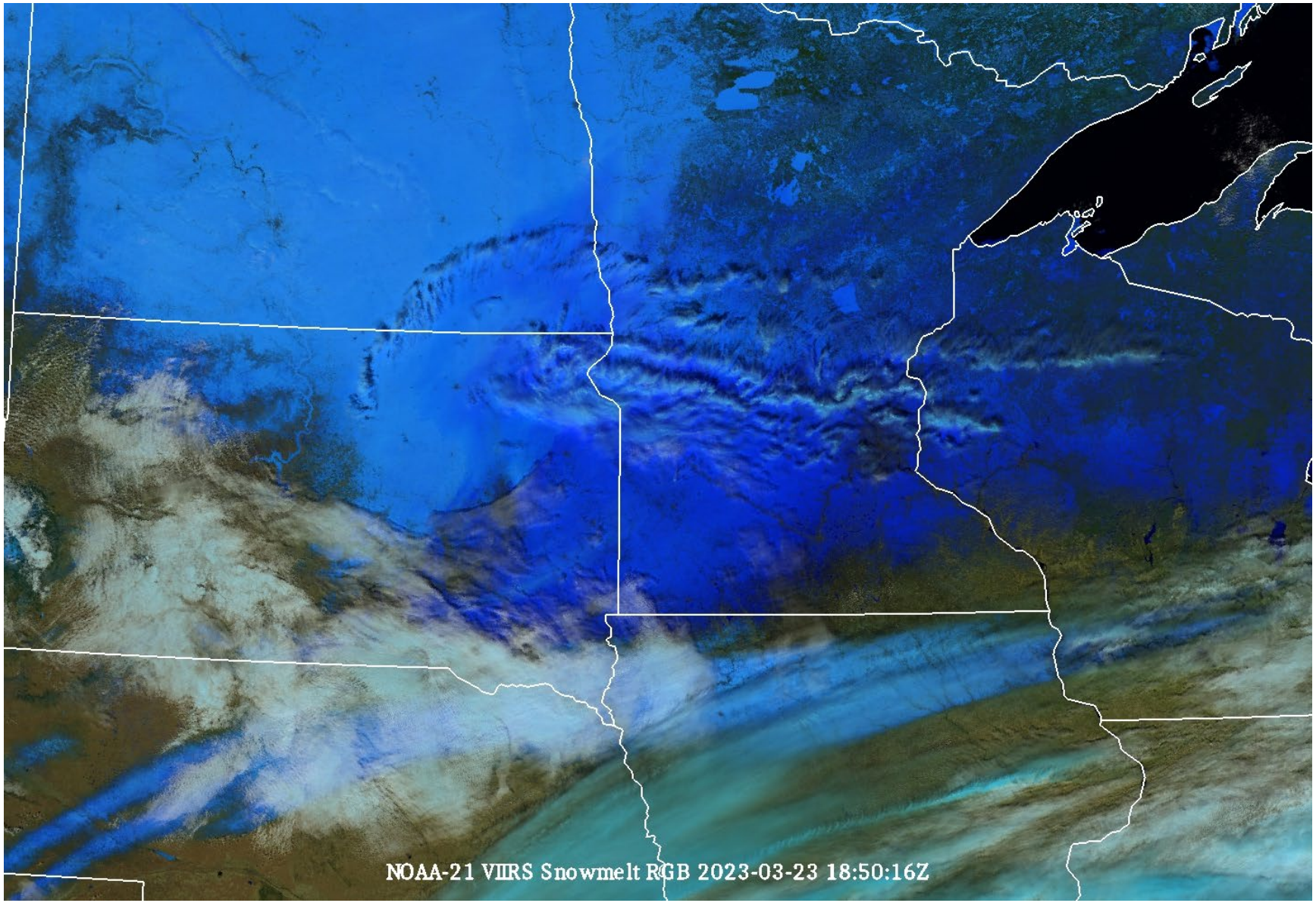
20230323
NOAA-21
Snowmelt RGB
(M10, M8, M5)



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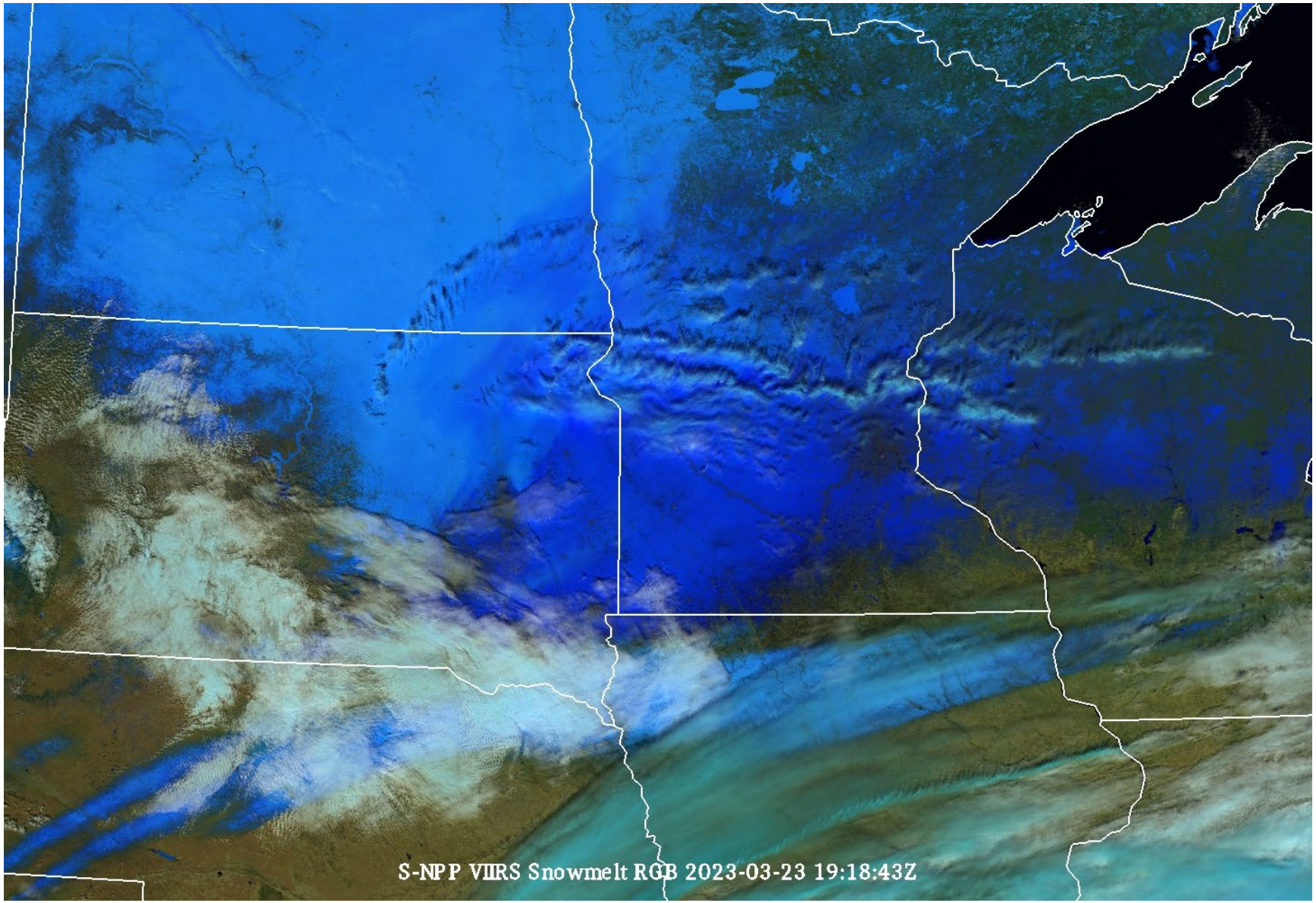
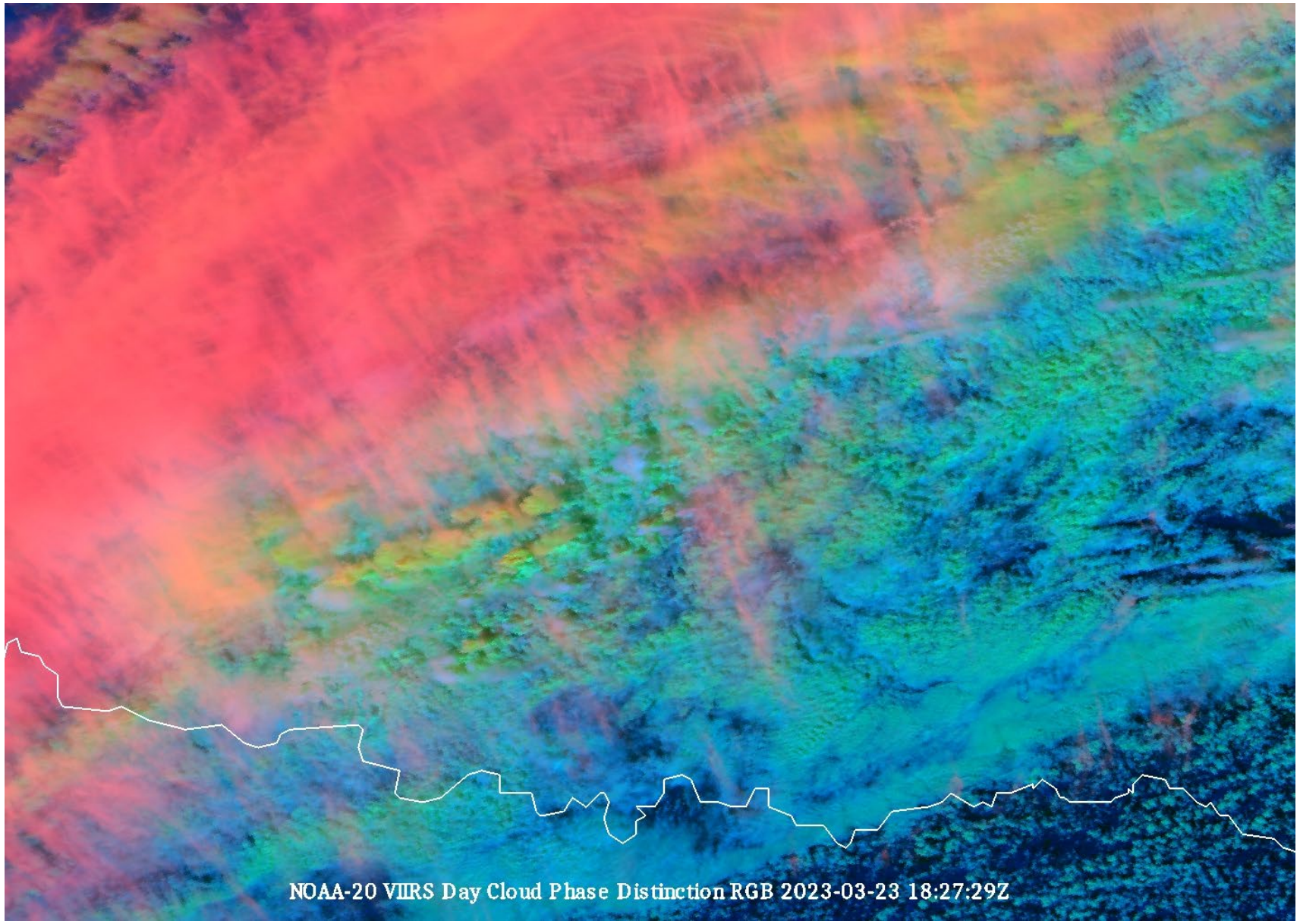
Midwest US Snowpack
20230323
S-NPP
Snowmelt RGB
(M10, M8, M5)



VIIRS Day Cloud Phase Distinction RGB Comparison – Oklahoma (3/23/2023)

Oklahoma Convective Initiation
20230323
NOAA-20
Day Cloud Phase Distinction RGB
(I5, I1, I3)



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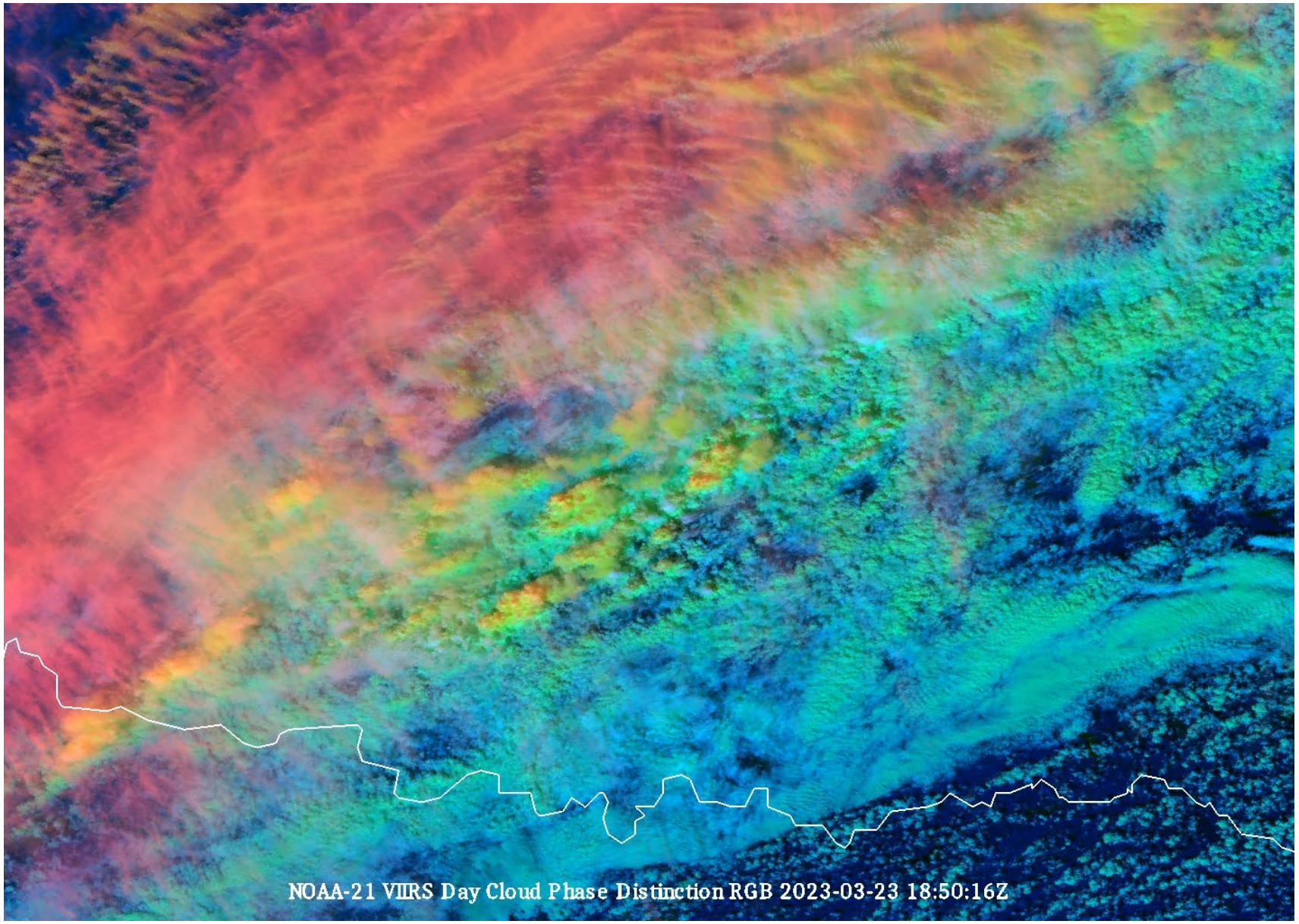
Oklahoma Convective Initiation
20230323
NOAA-21
Day Cloud Phase Distinction RGB
(I5, I1, I3)



VIIRS Day Cloud Phase Distinction RGB Comparison – Oklahoma (3/23/2023)

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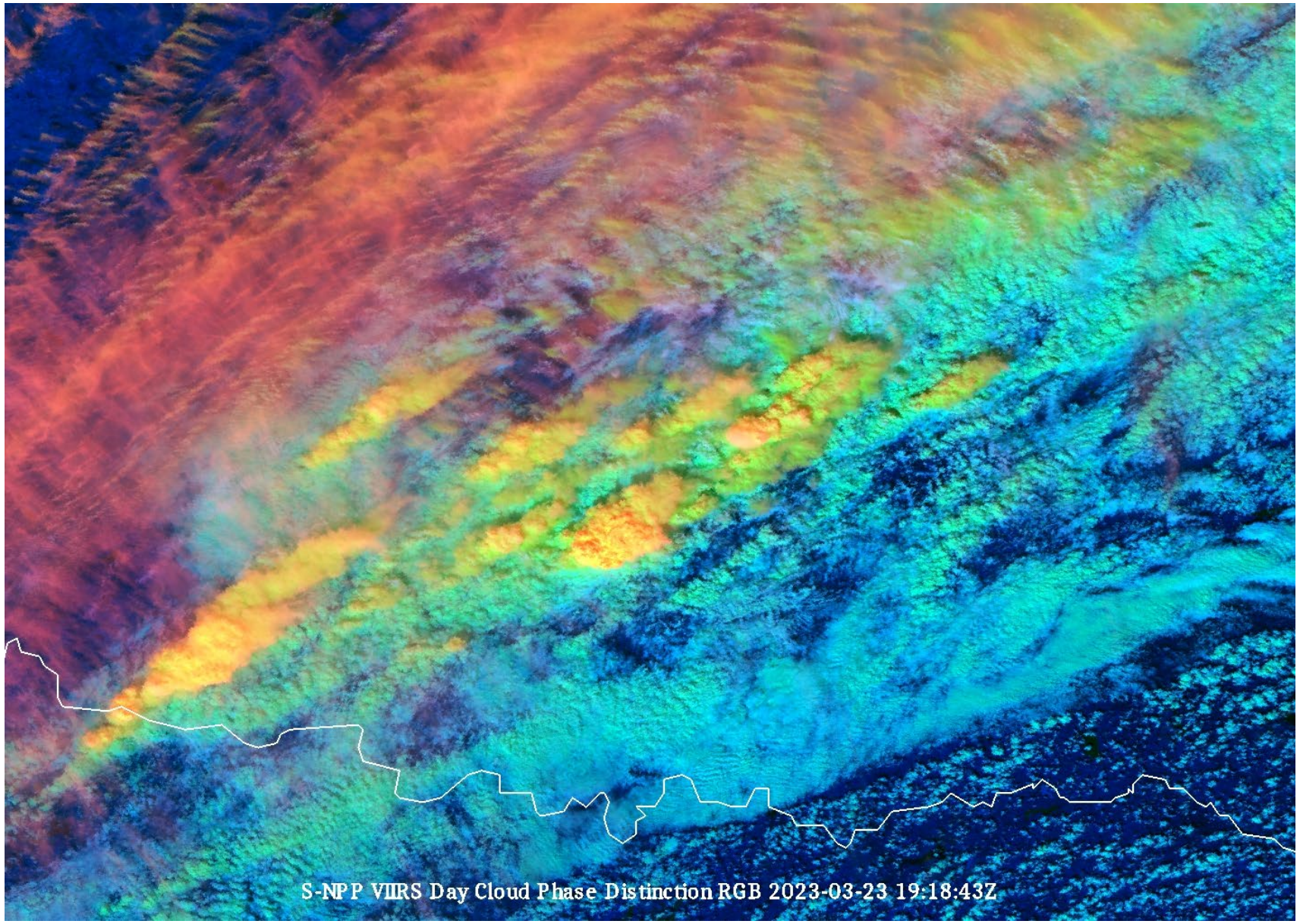
20230323
S-NPP
Day Cloud Phase Distinction RGB
(I5, I1, I3)



VIIRS Fire Temperature RGB Comparison – Australia (3/24/2023)

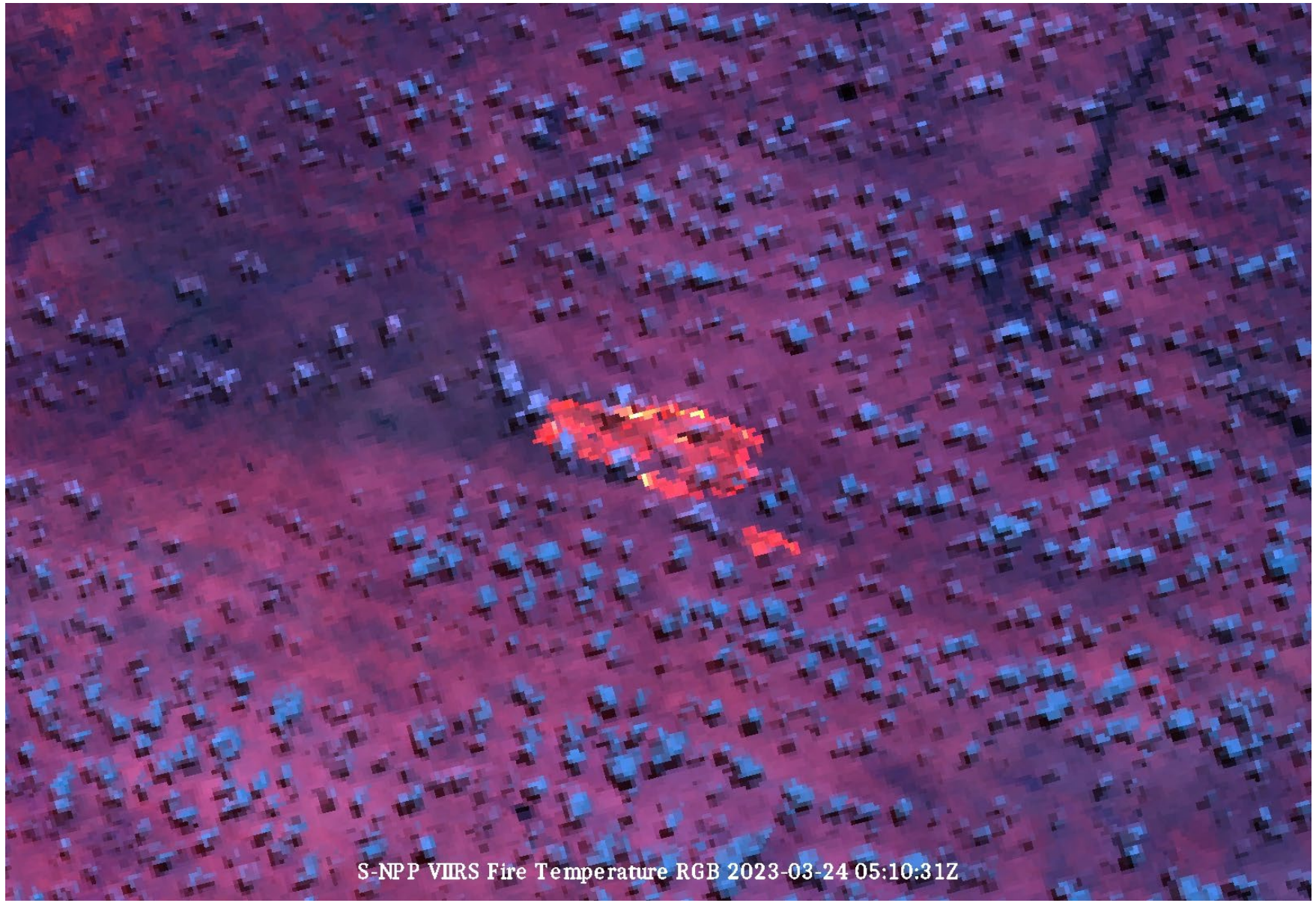
Australia Wildfire
20230324
NOAA-20
Fire Temperature RGB
(M12, M11, M10)

VIIRS Fire Temperature RGB Comparison – Australia (3/24/2023)

Australia Wildfire
20230324
NOAA-21
Fire Temperature RGB
(M12, M11, M10)

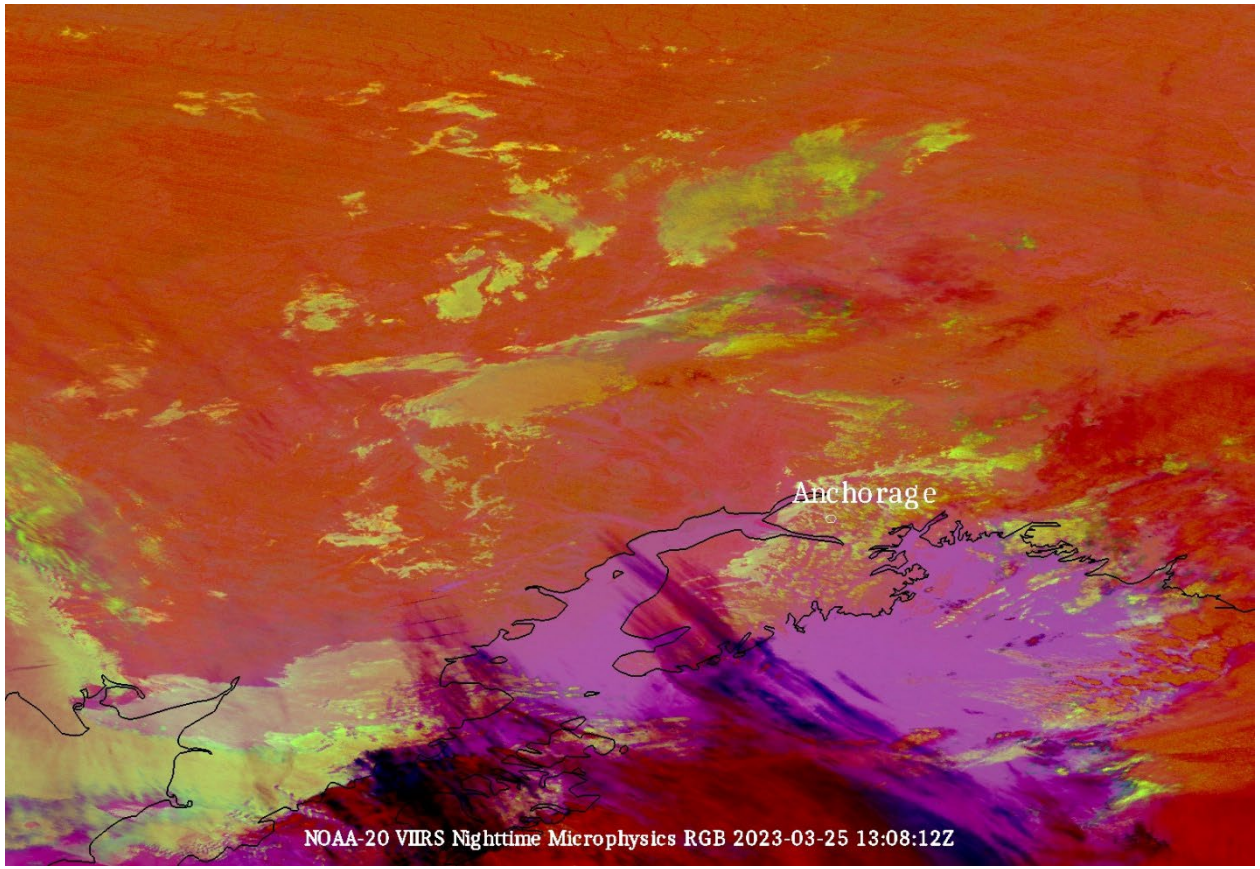
VIIRS Fire Temperature RGB Comparison – Australia (3/24/2023)

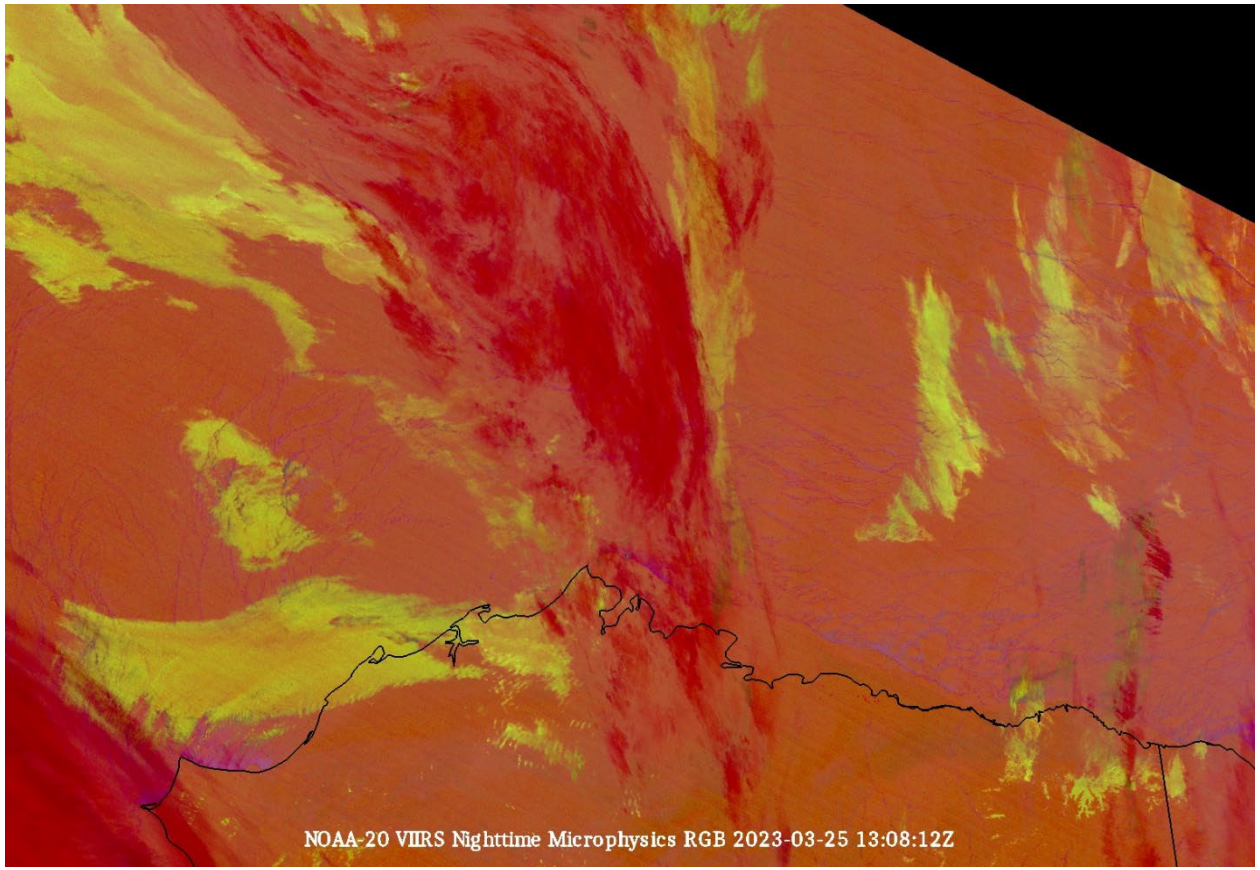
Australia Wildfire
20230324
S-NPP
Fire Temperature RGB
(M12, M11, M10)



VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

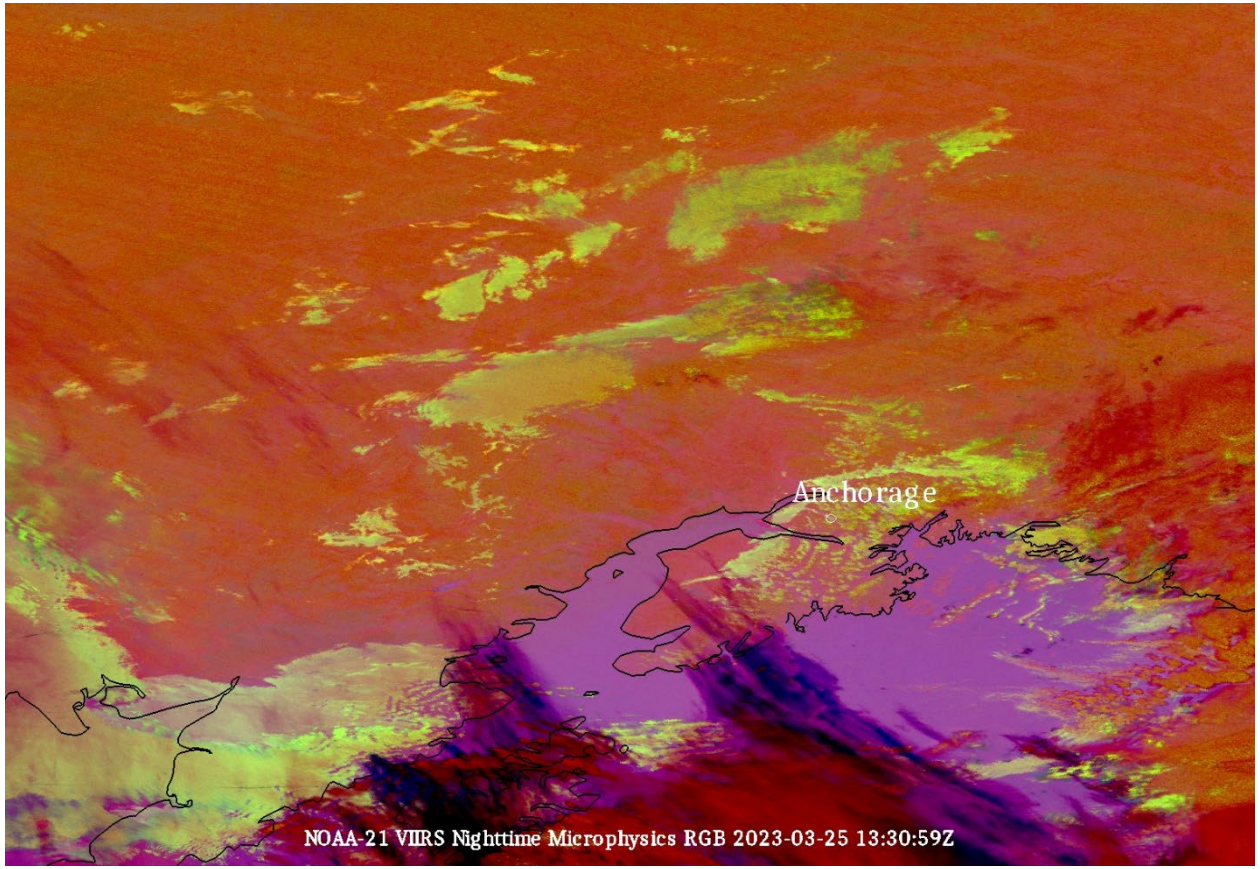
Alaska Nighttime Low Clouds
20230325
NOAA-20
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

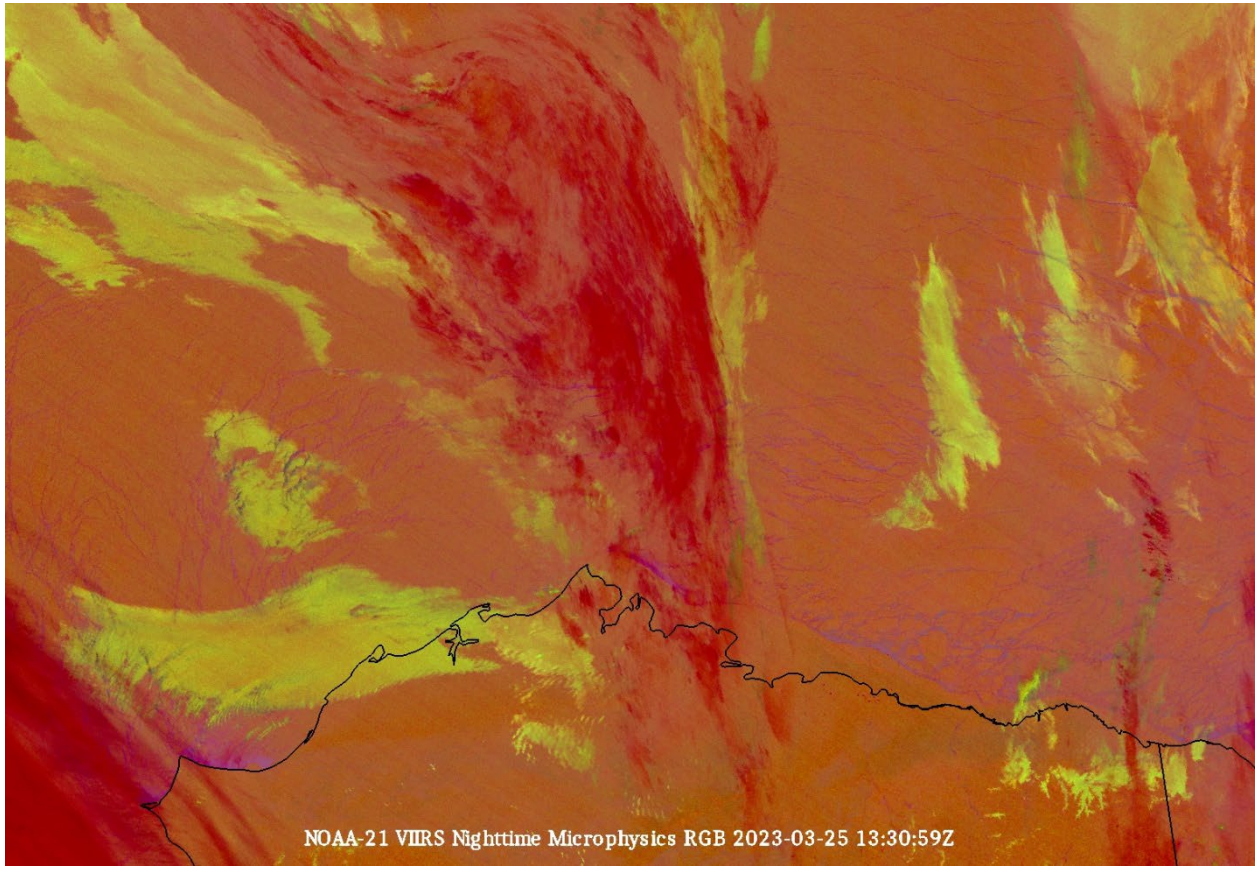




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

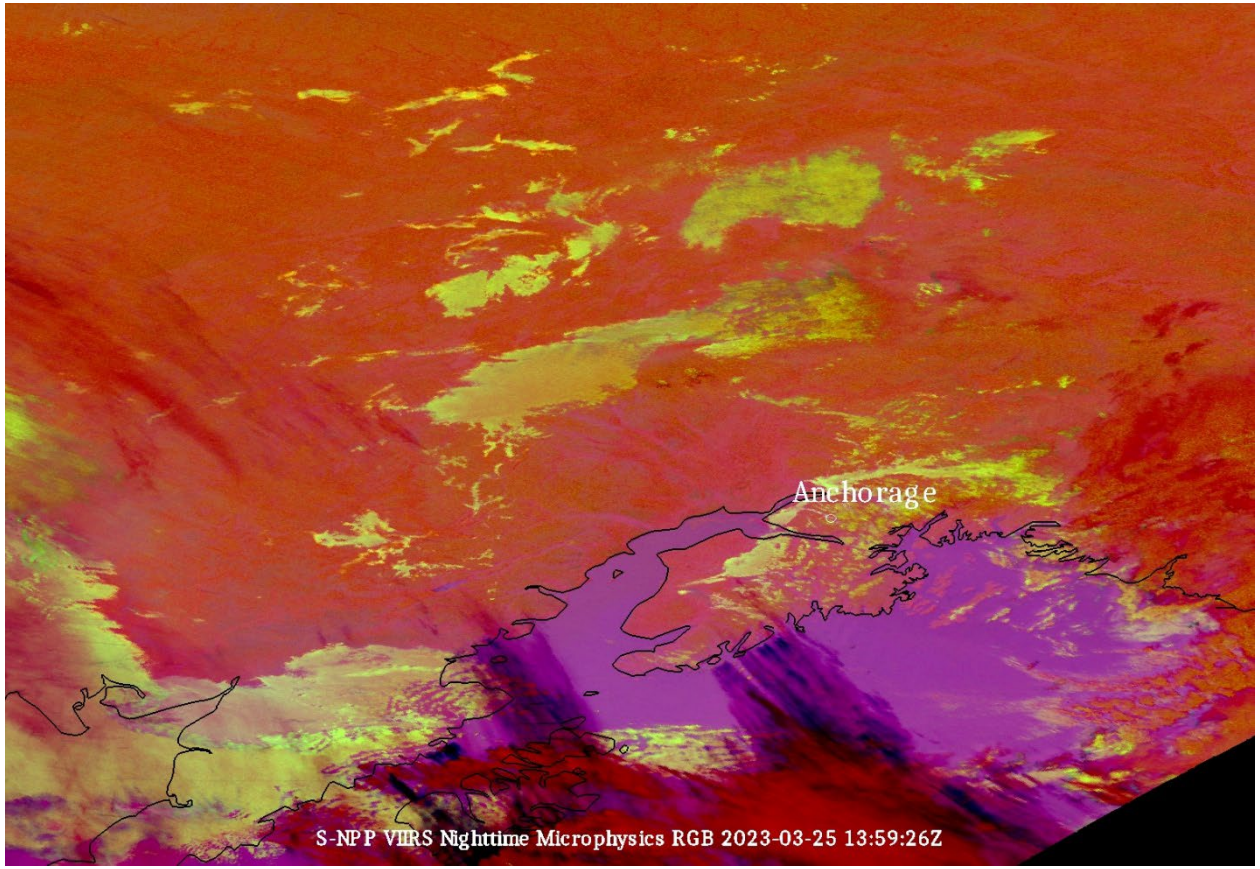
Alaska Nighttime Low Clouds
20230325
NOAA-21
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

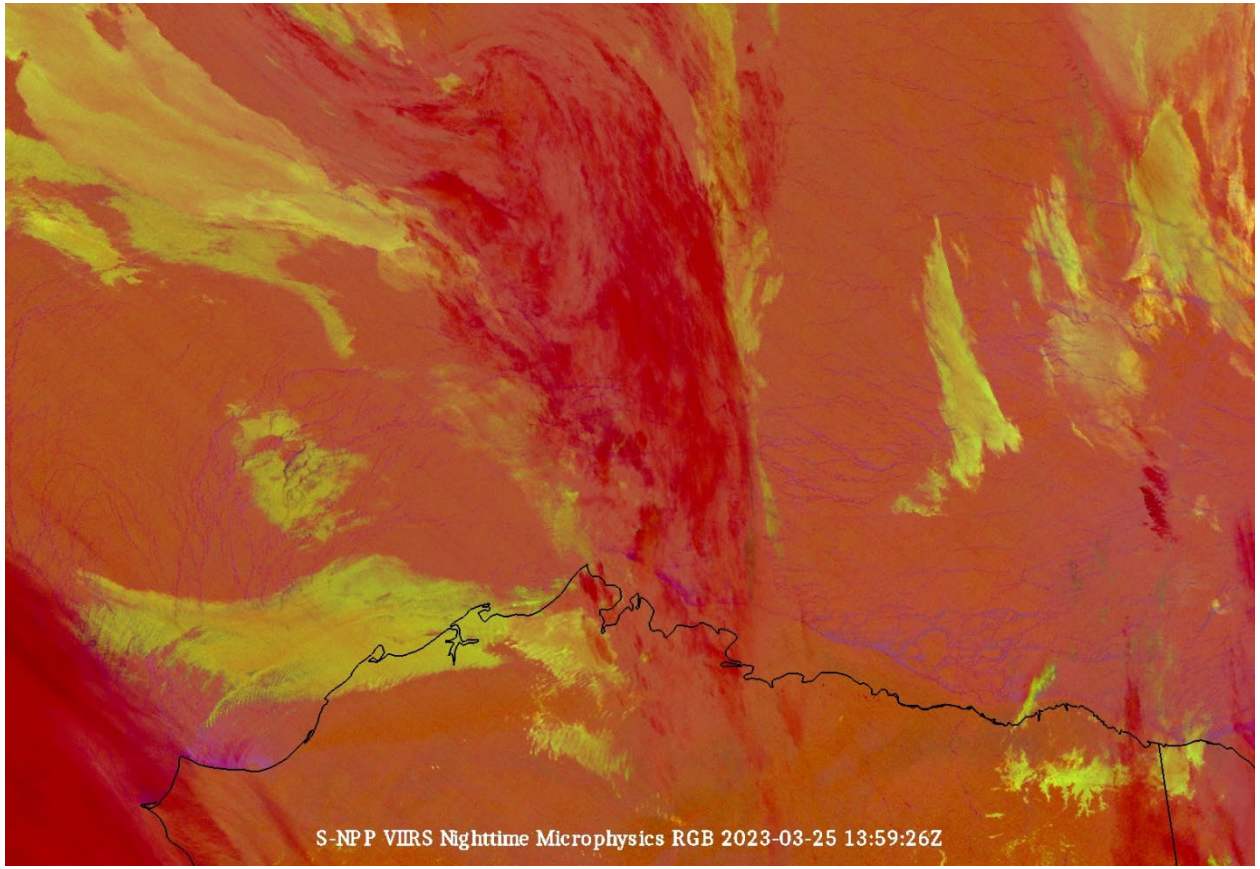




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

Alaska Nighttime Low Clouds
20230325
S-NPP
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

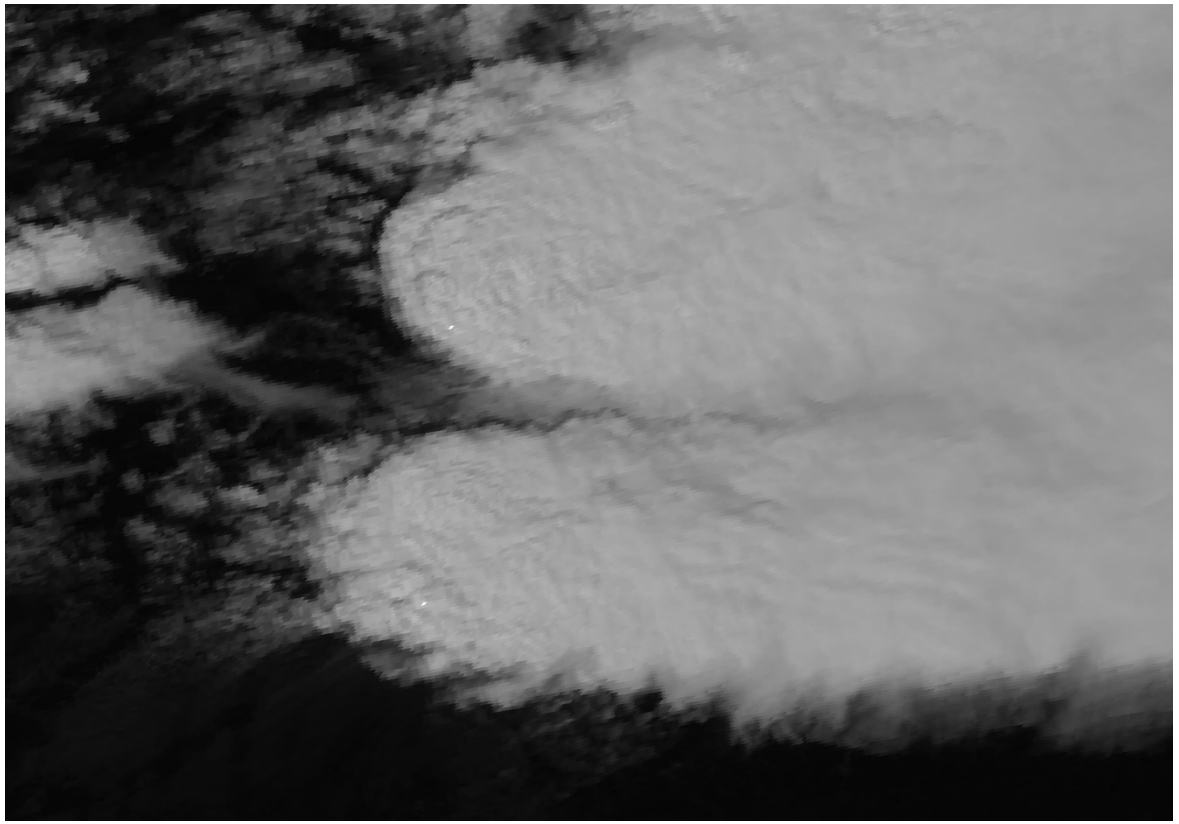




M9 Saturated Pixels

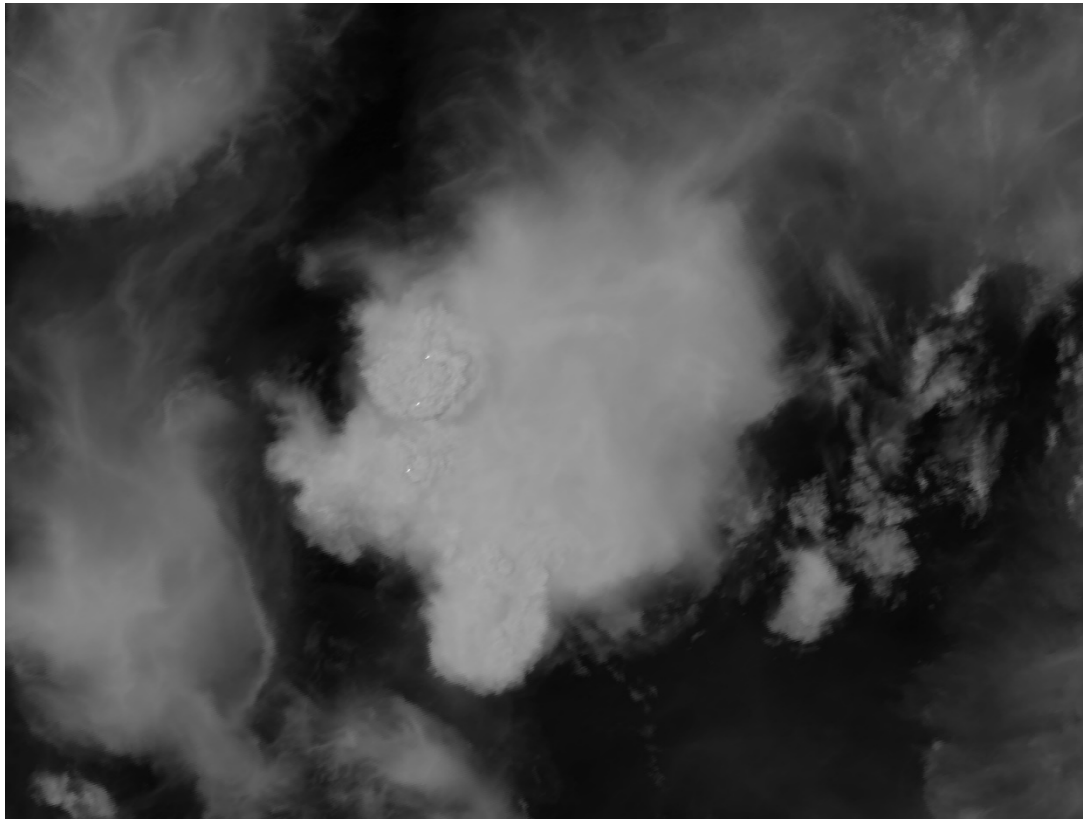
Noted in Beta Review
Infrequently observed in Deep Convection, even less abundant now than in February

20230326 J02 VIIRS M09



Southeast US
20230326
NOAA-21
Band M09

20230326 J02 VIIRS M09

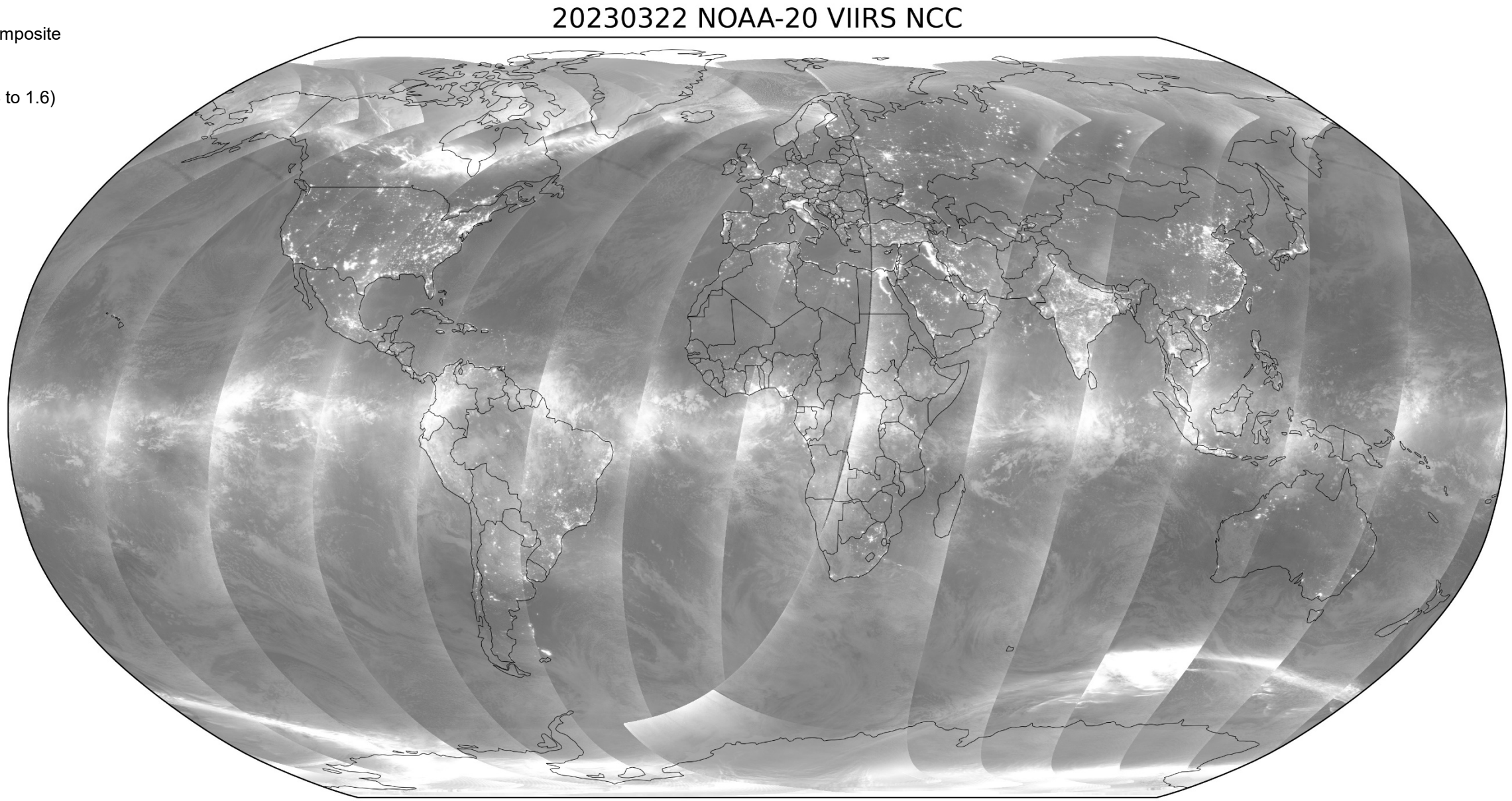


Atlantic Ocean (near Africa)
20230326
NOAA-21
Band M09

DNB/NCC Analysis

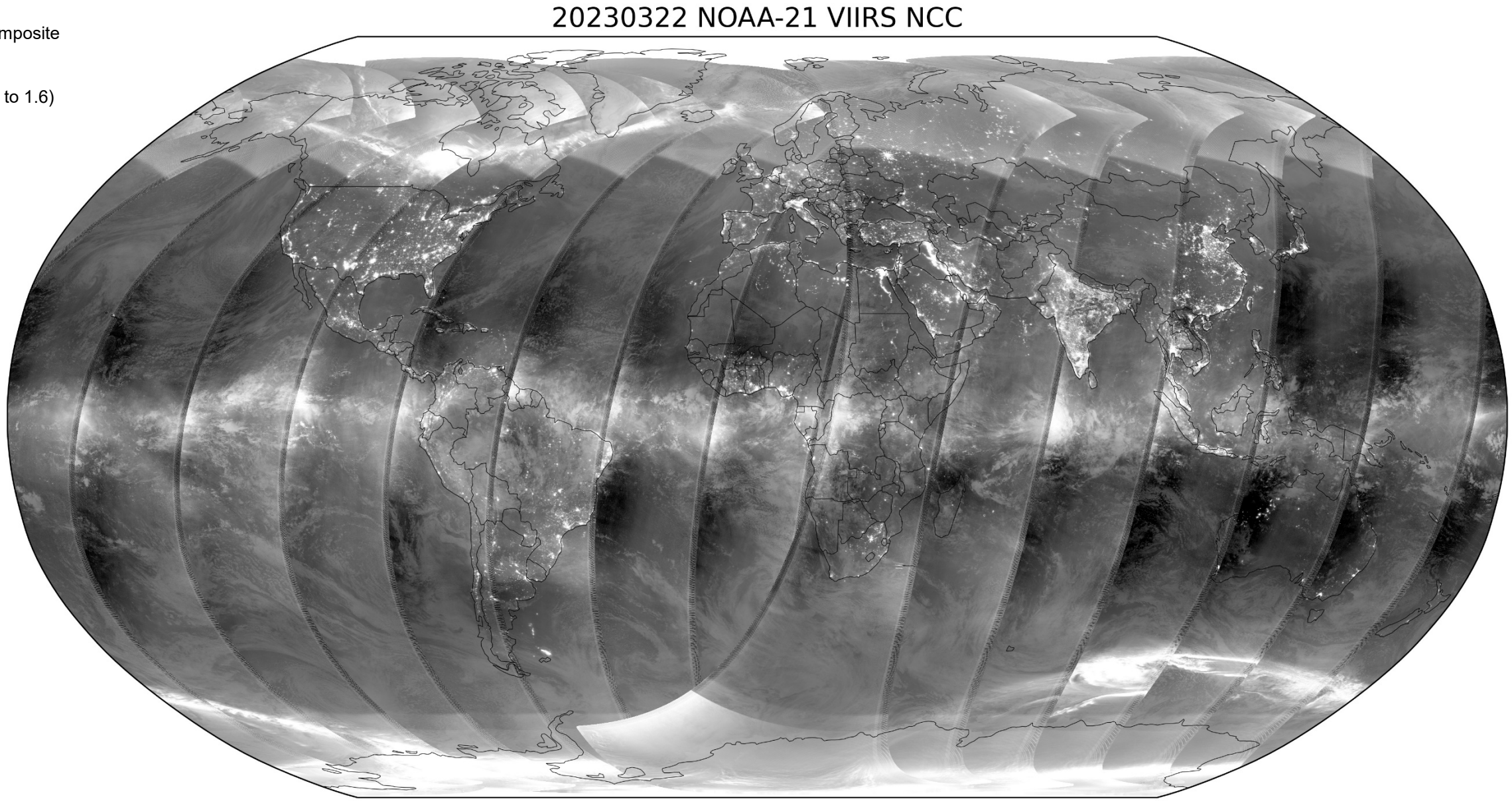
20 Mar 2023 NOAA-20 VIIRS NCC Imagery Global Composite

Global Composite
20230322
NOAA-20
NCC (-0.4 to 1.6)



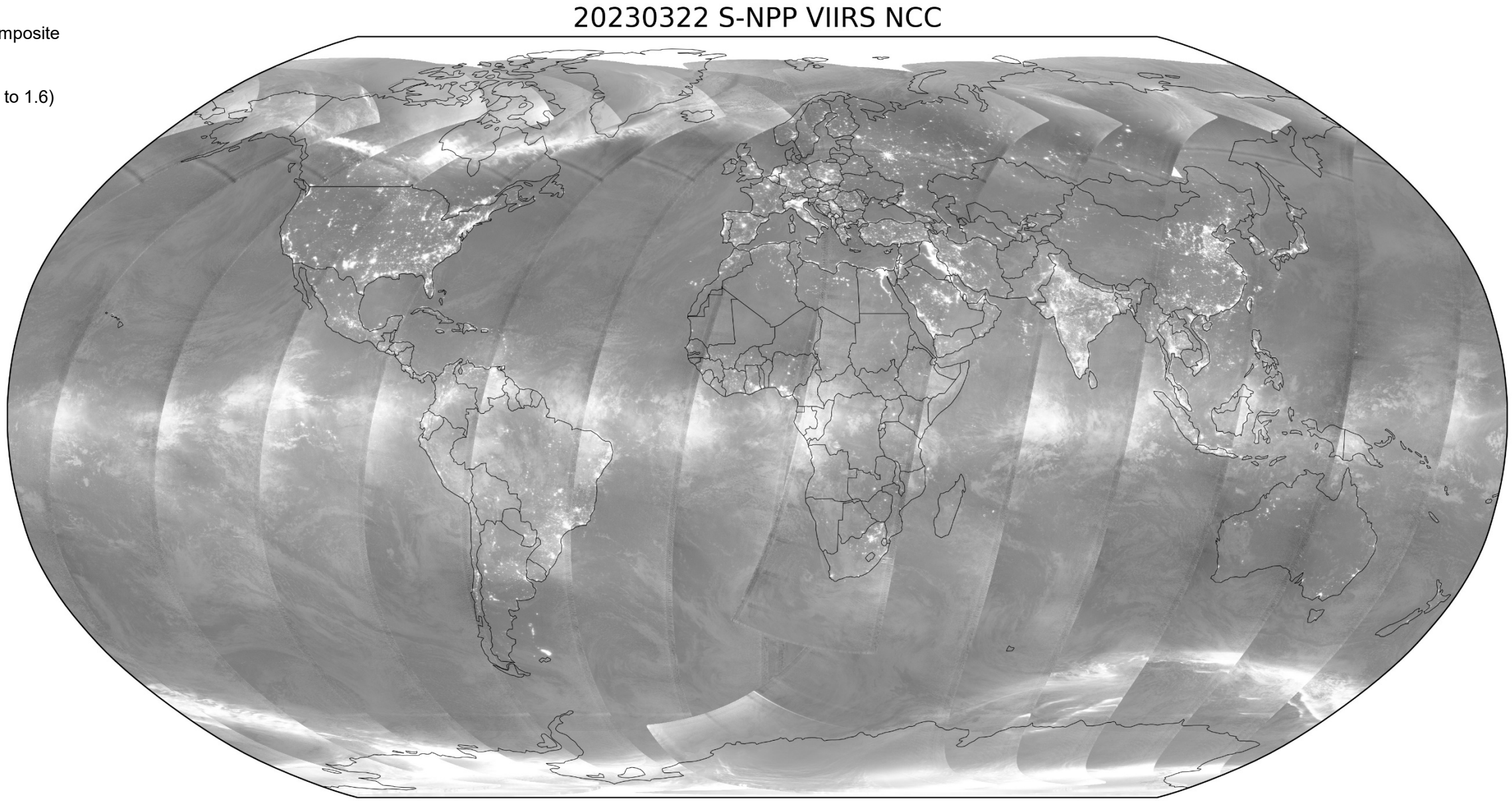
20 Mar 2023 NOAA-21 VIIRS NCC Imagery Global Composite

Global Composite
20230322
NOAA-21
NCC (-0.4 to 1.6)



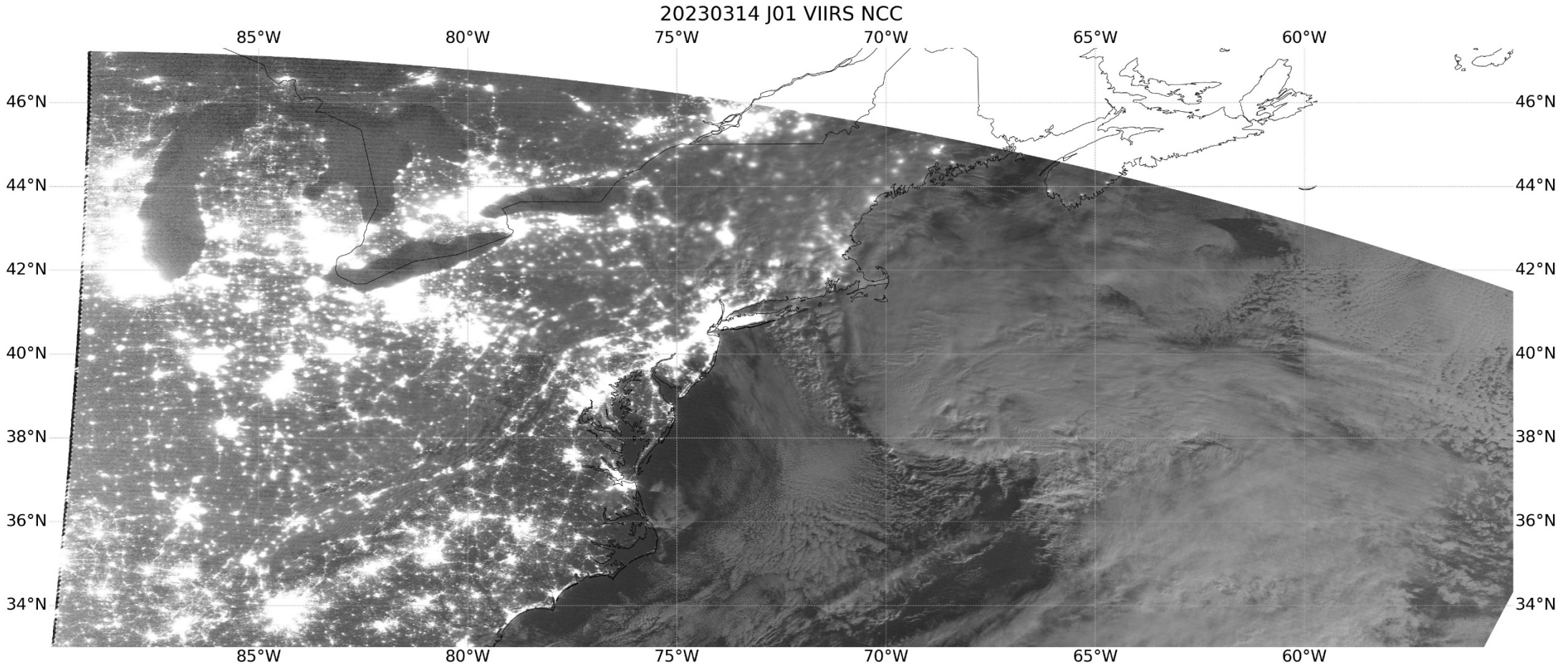
20 Mar 2023 S-NPP VIIRS NCC Imagery Global Composite

Global Composite
20230322
S-NPP
NCC (-0.4 to 1.6)



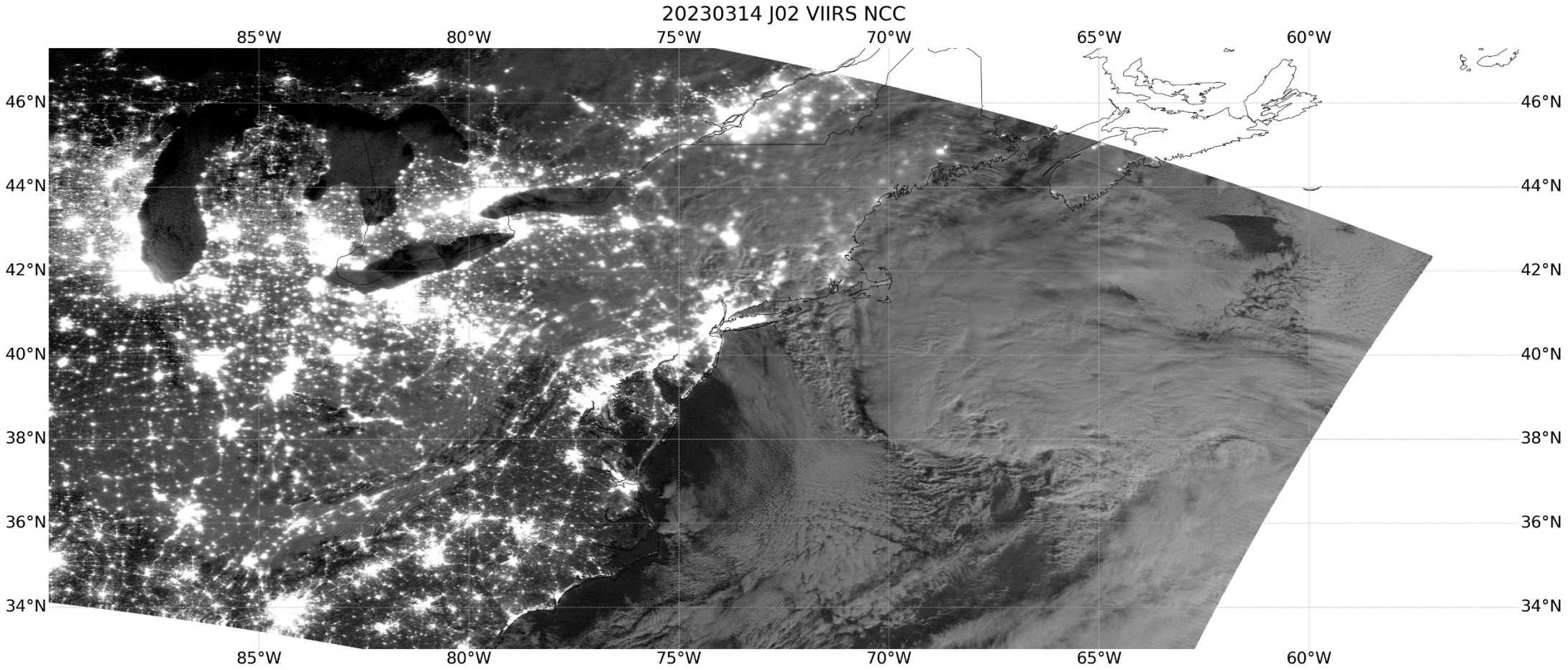
NCC Over US East Coast

US East Coast
20230314 (Night)
NOAA-20
NCC



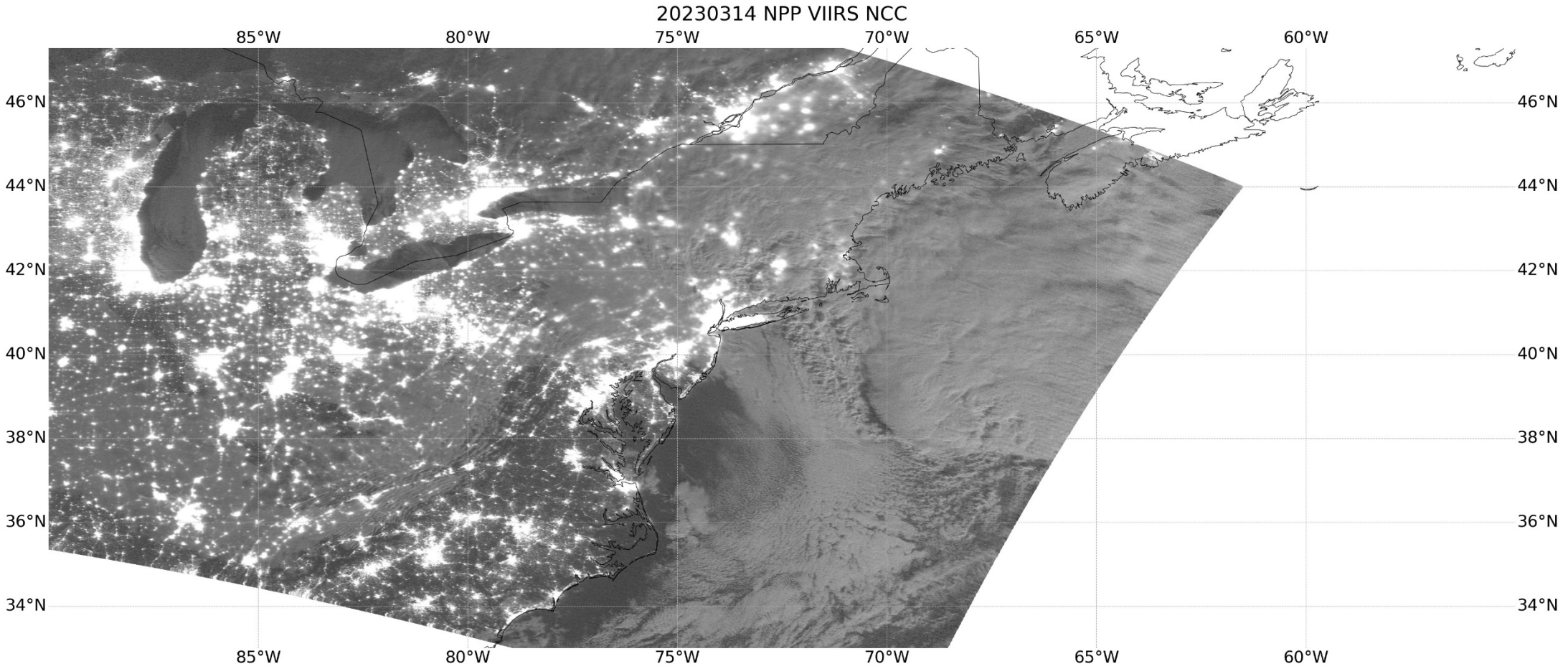
NCC Over US East Coast

US East Coast
20230314 (Night)
NOAA-21
NCC



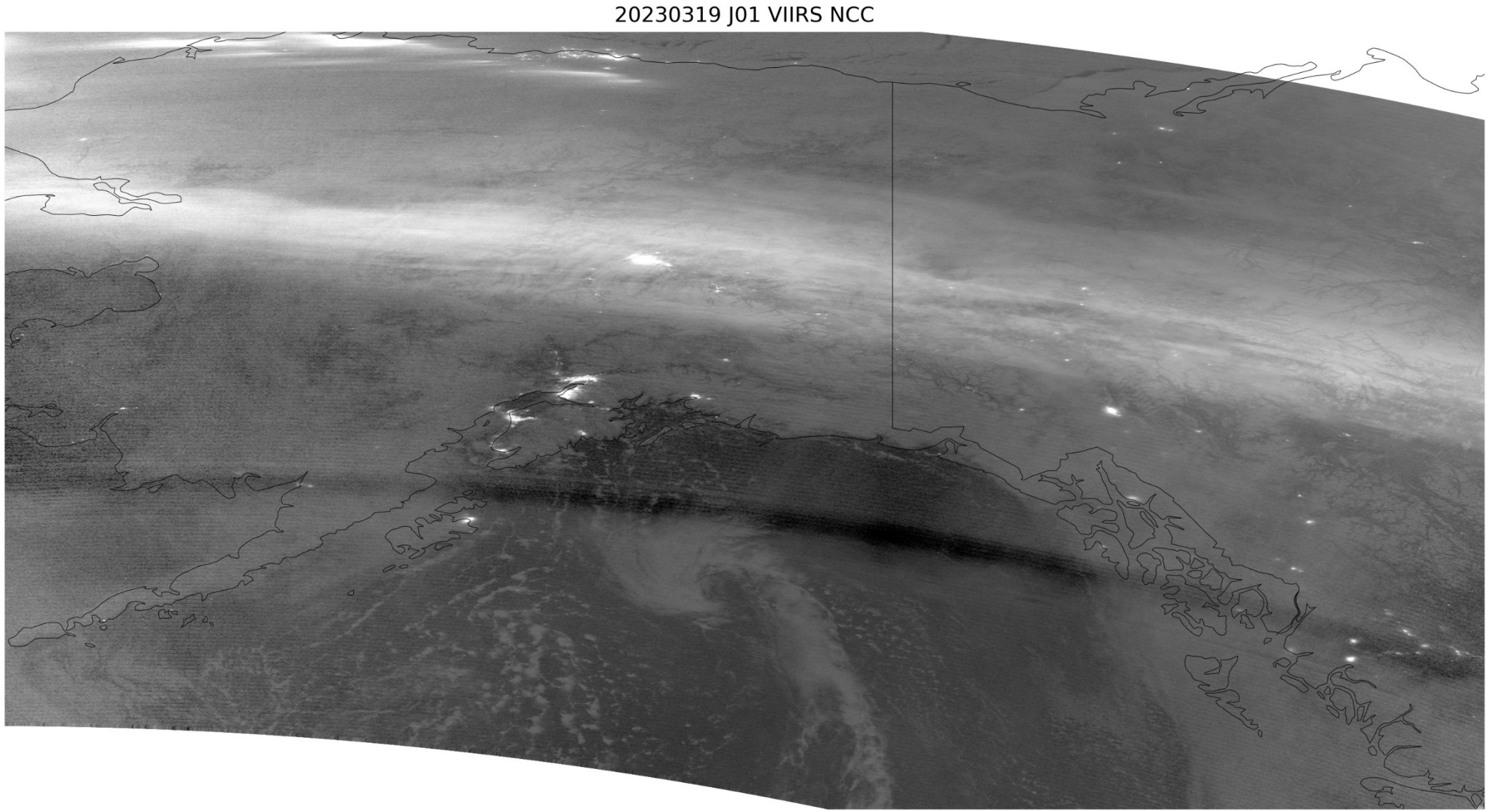
NCC Over US East Coast

US East Coast
20230314 (Night)
S-NPP
NCC



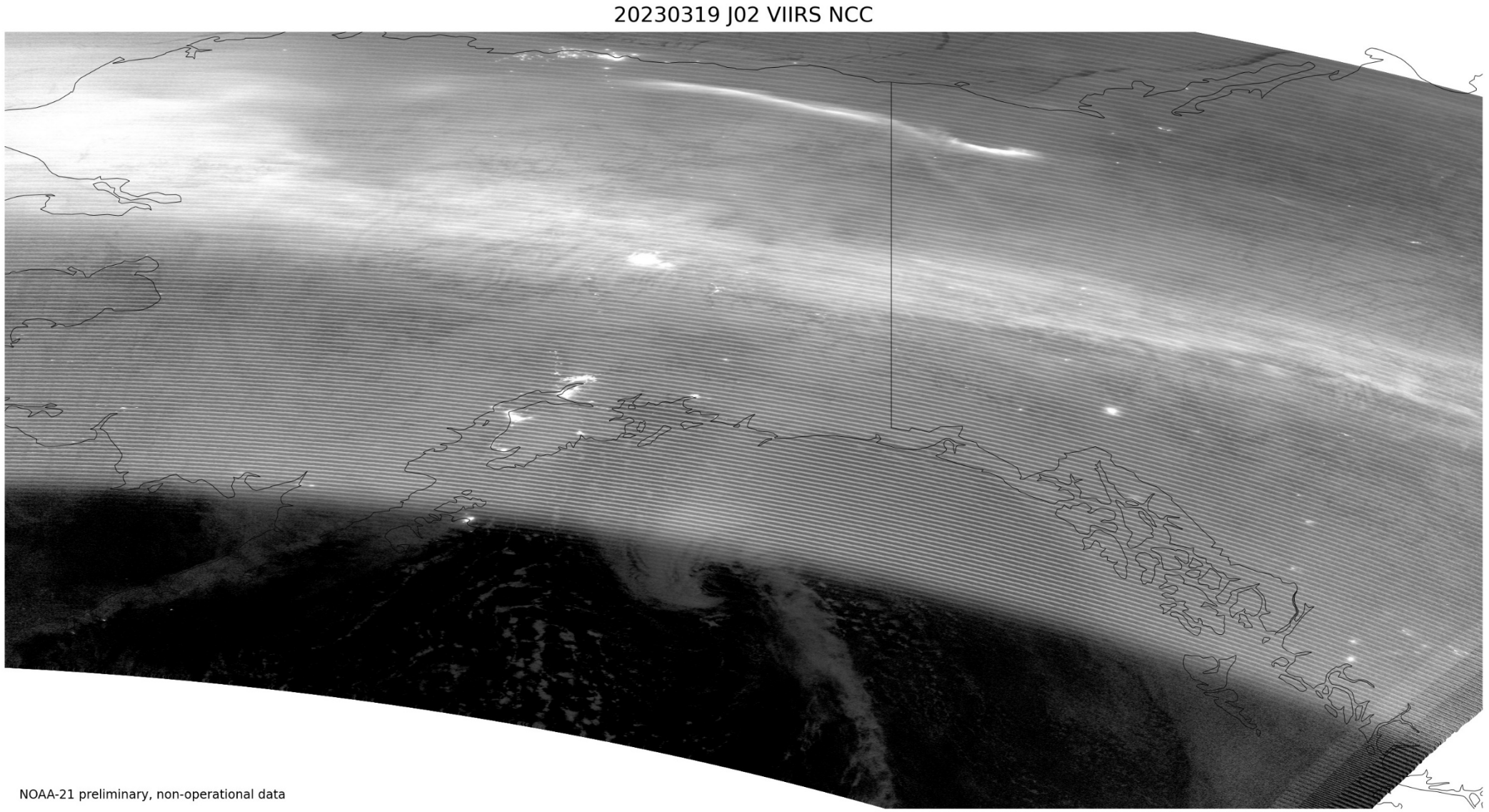
NCC Over Alaska

Alaska
20230319 (Night)
NOAA-20
NCC (0 to 1.6)



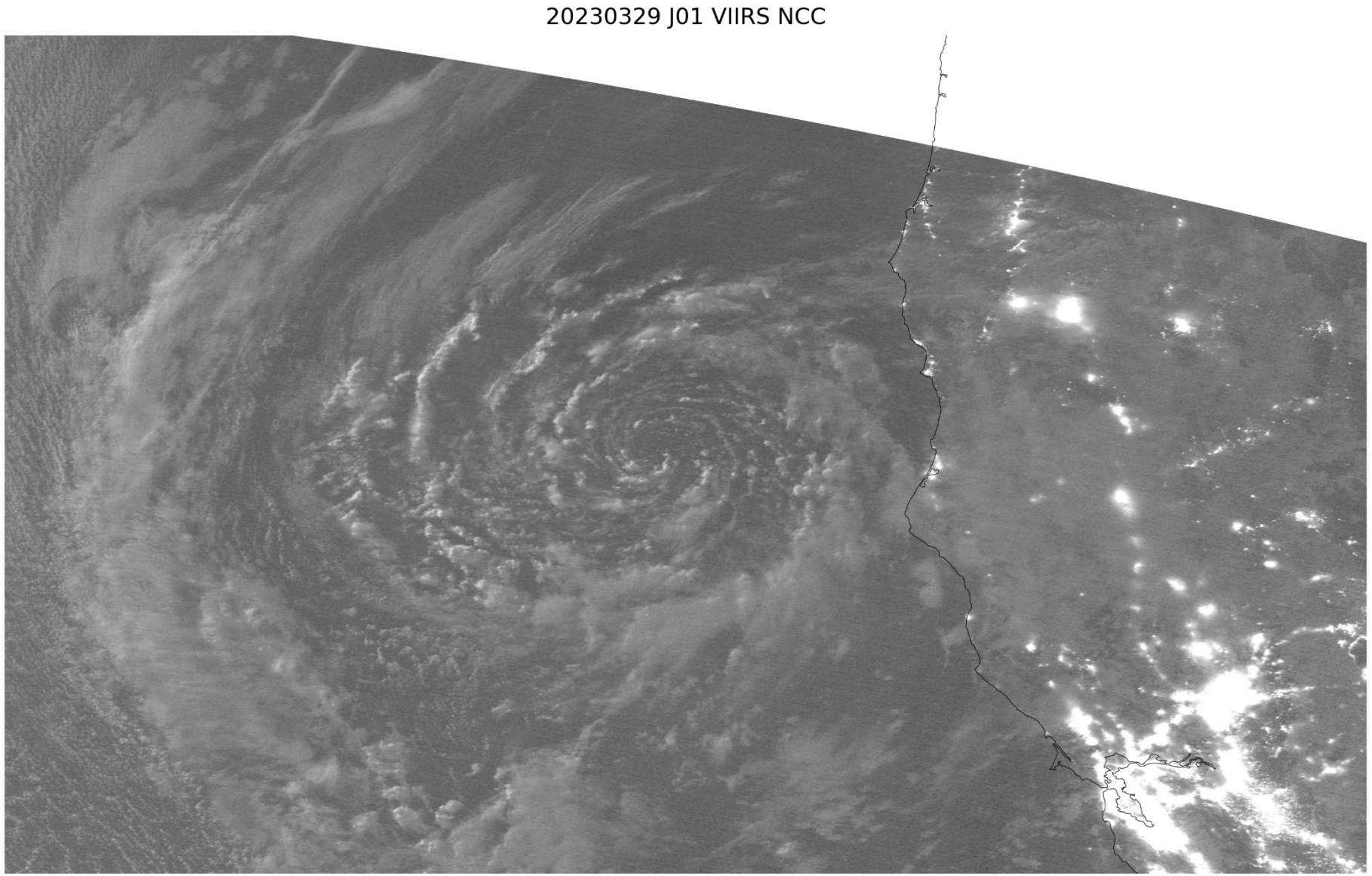
NCC Over Alaska

Alaska
20230319 (Night)
NOAA-21
NCC (0 to 1.6)



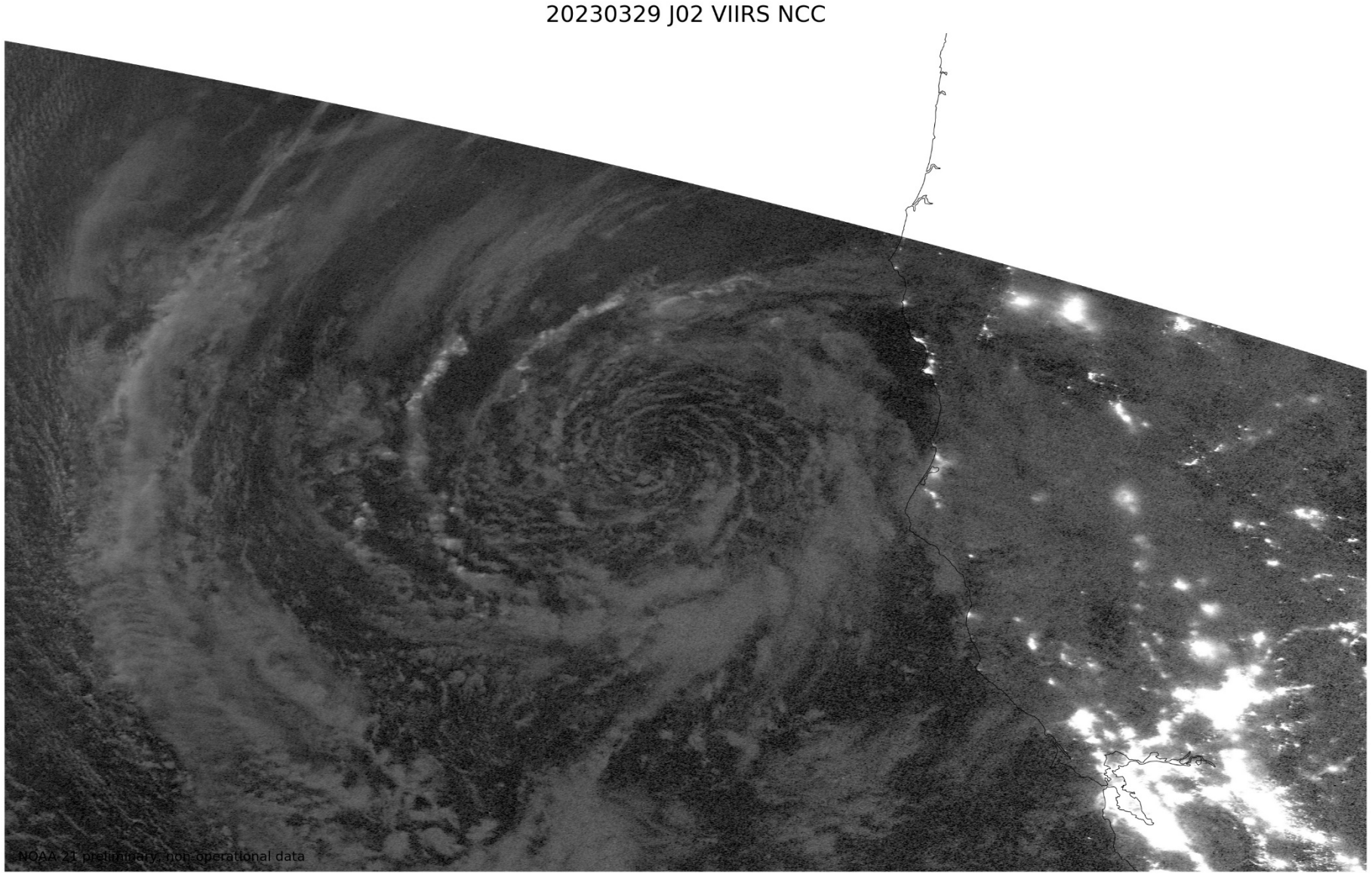
NCC over West Coast Cyclone

California Coast
20230329 (Night)
NOAA-20
NCC (-0.1 to 1.2)



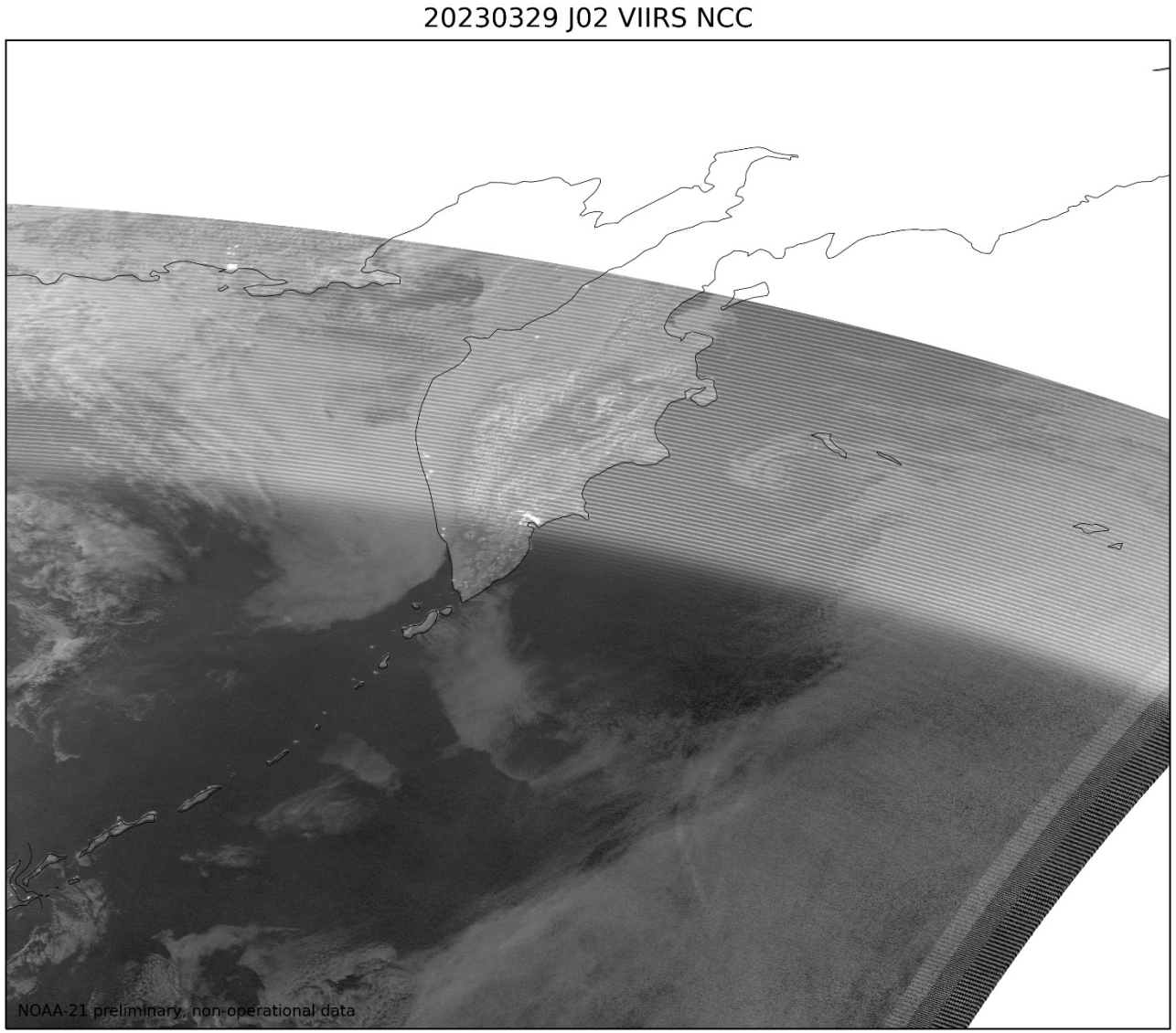
NCC over West Coast Cyclone

California Coast
20230329 (Night)
NOAA-21
NCC (-0.1 to 1.2)



NOAA-21 NCC on 3/29 over East Asia

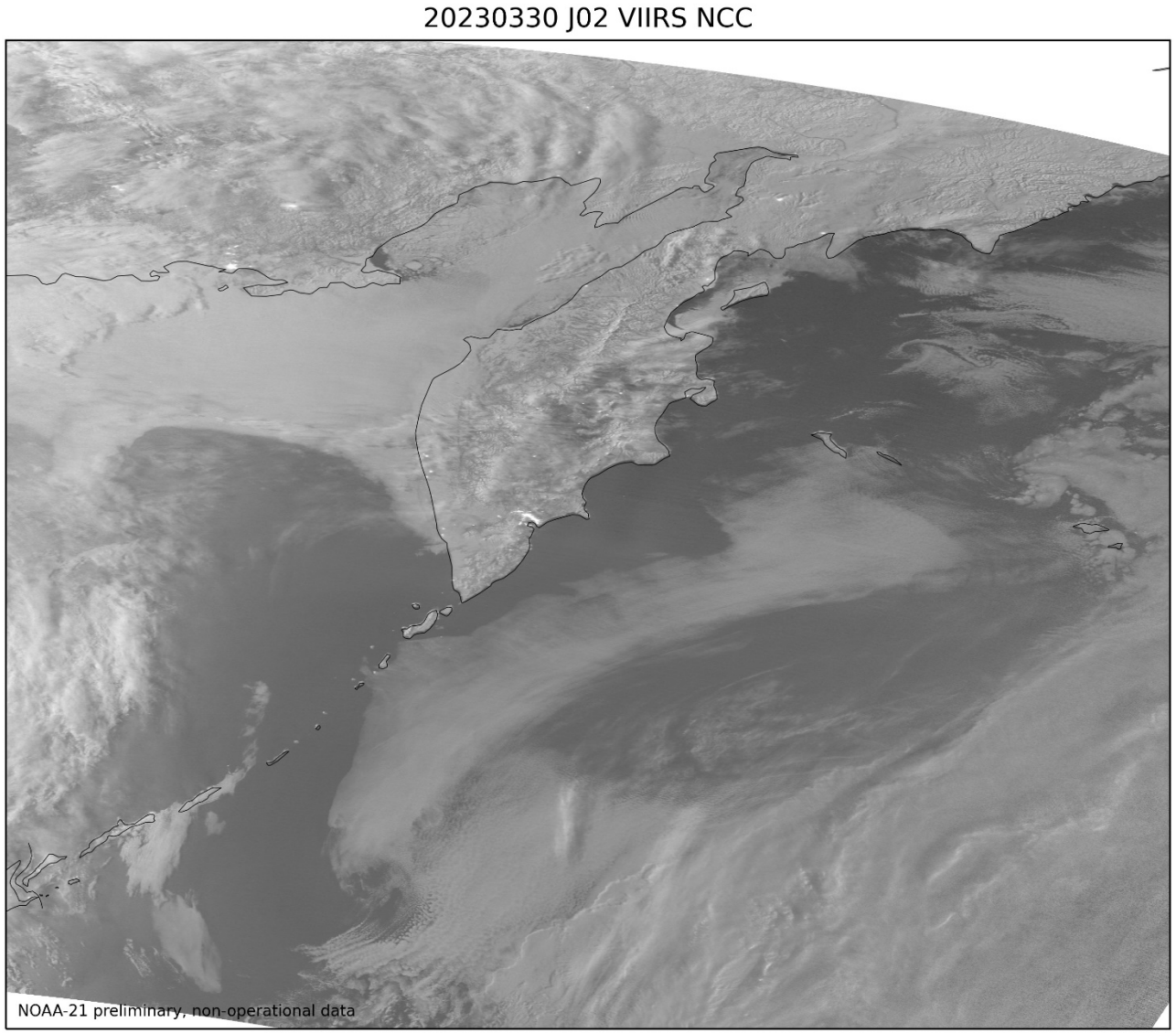
E Asia
20230329 (Night)
NOAA-21
NCC (-0.1 to 1.1)



NOAA-21 NCC on 3/30 over East Asia

E Asia
20230330 (Night)
NOAA-21
NCC (-0.1 to 1.1)

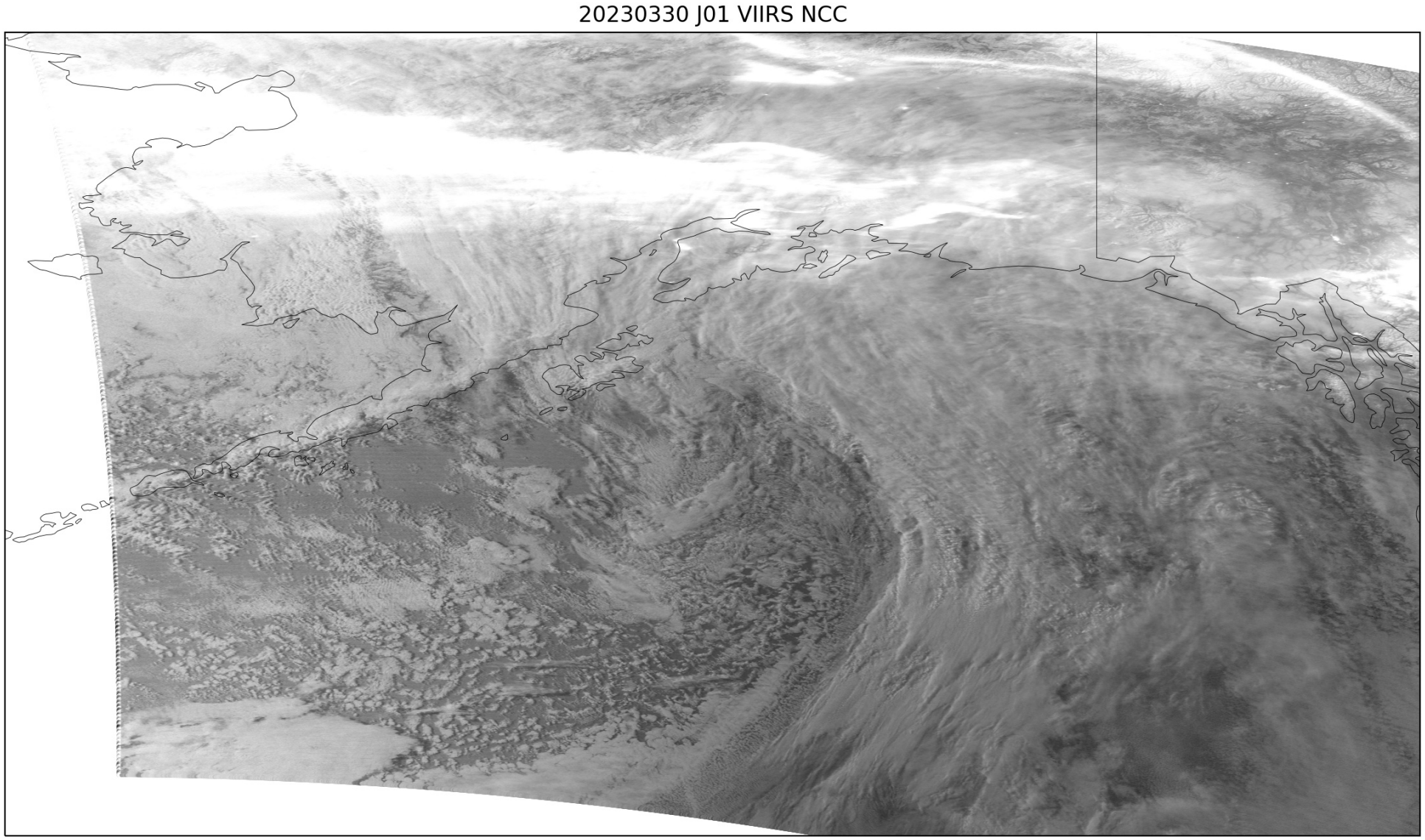
NOAA-21 NCC Imagery looks much better with implementation of DNB LUTs on 3/30



NOAA-21 NCC on 3/30 over Alaska

NOAA-21 NCC Imagery looks much better with implementation of DNB LUTs on 3/30

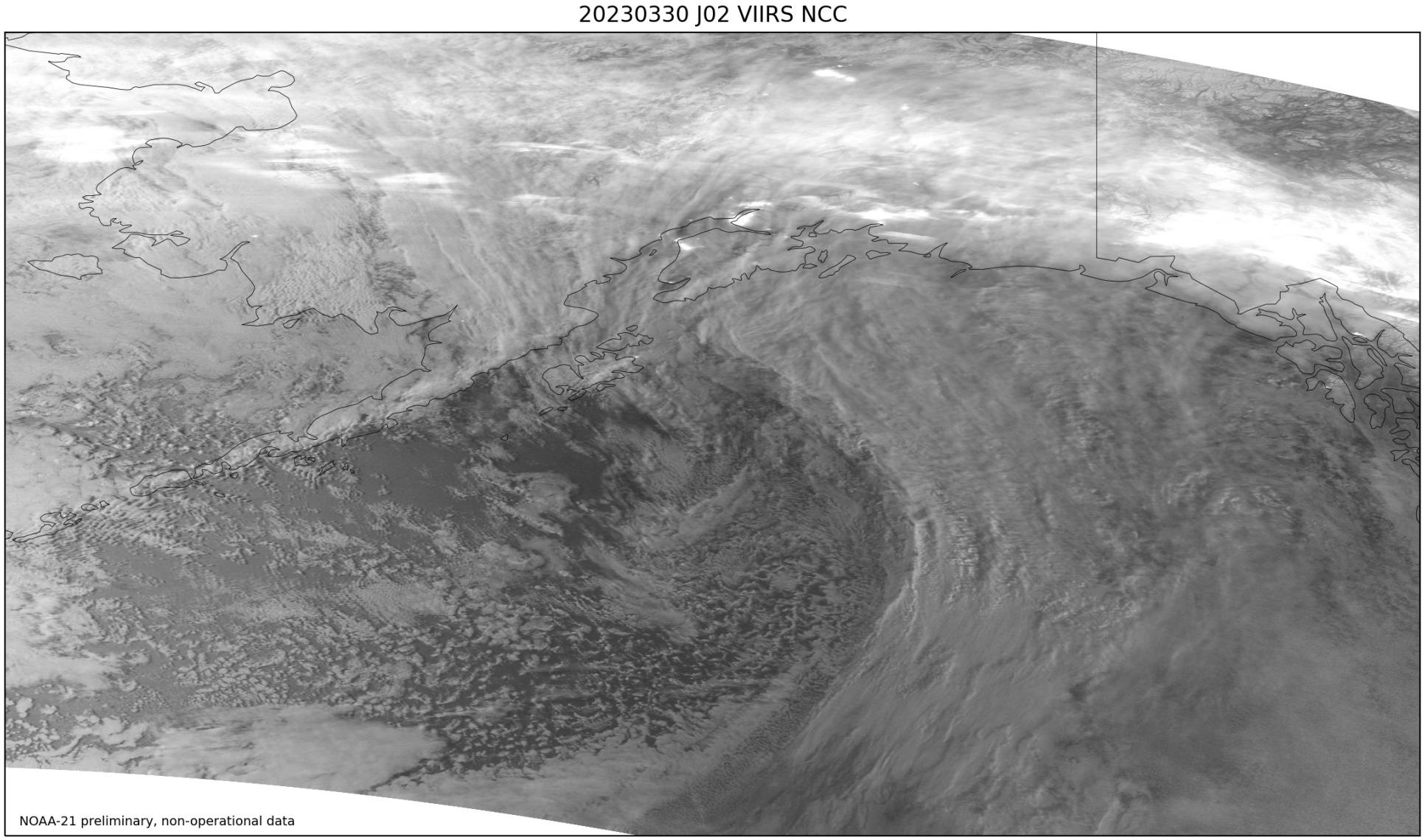
Alaska
20230330 (Night)
NOAA-20
NCC (0 to 1.4)



NOAA-21 NCC on 3/30 over Alaska

NOAA-21 NCC Imagery looks much better with implementation of DNB LUTs on 3/30

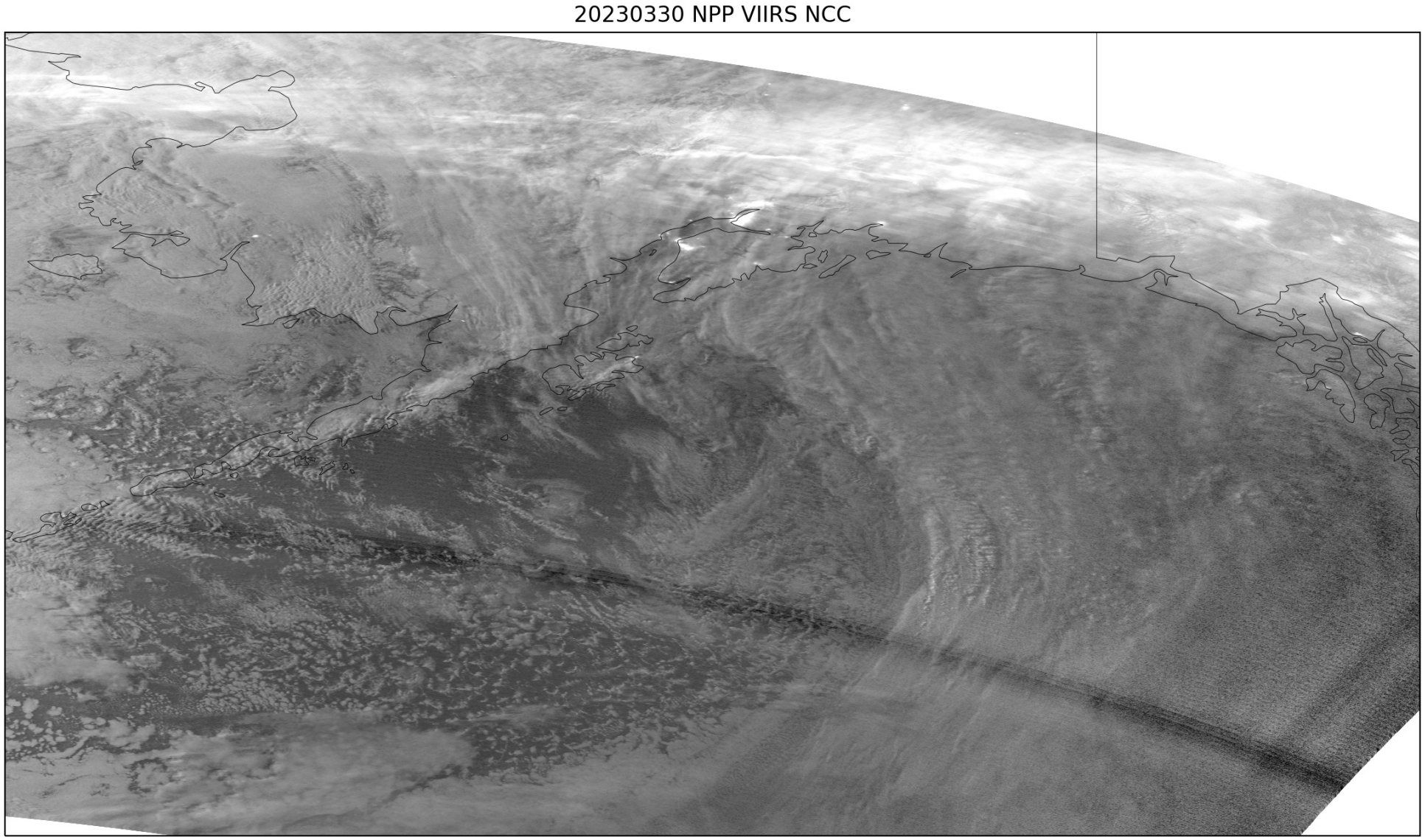
Alaska
20230330 (Night)
NOAA-21
NCC (0 to 1.4)



NOAA-21 NCC on 3/30 over Alaska

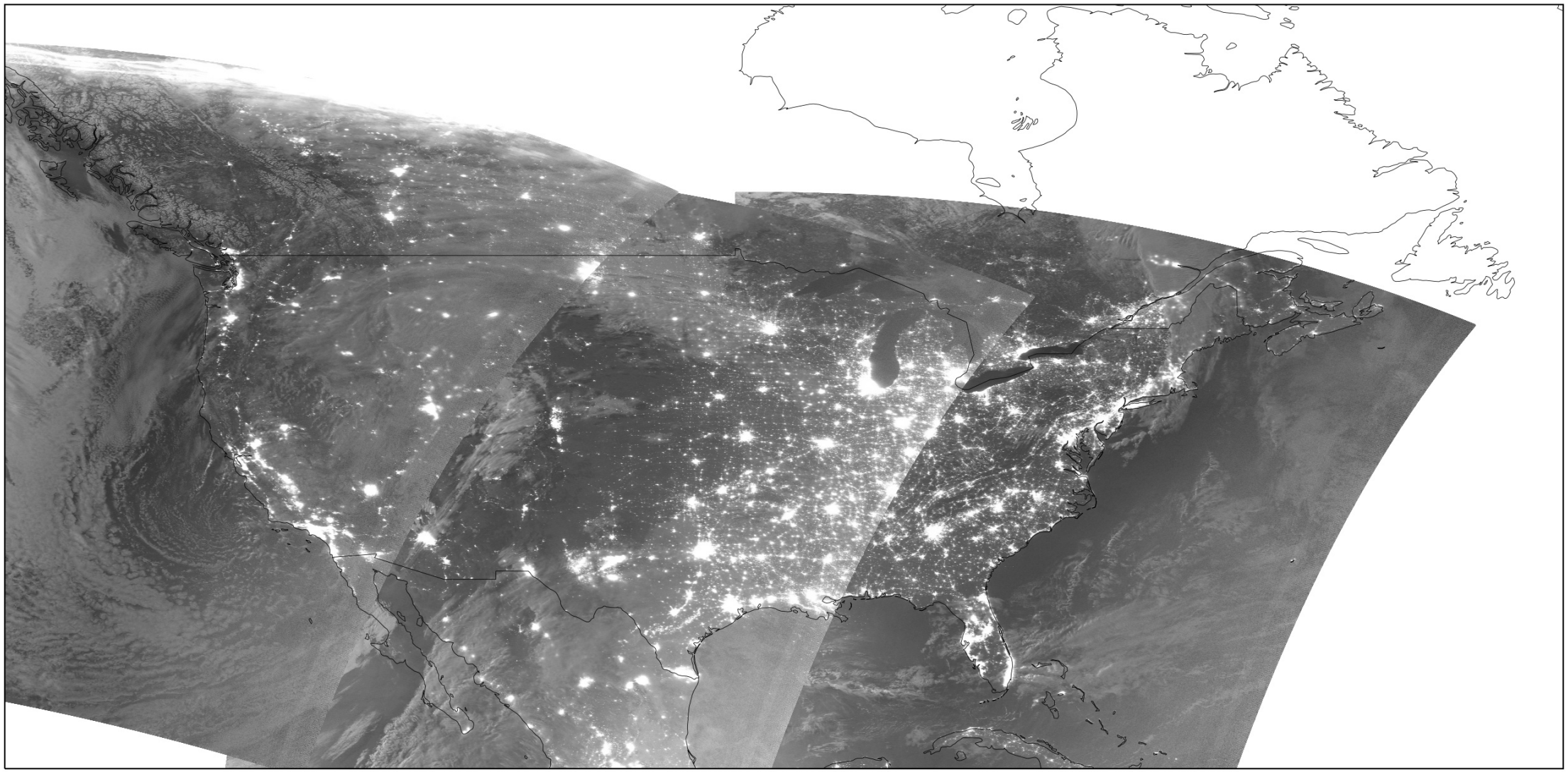
NOAA-21 NCC Imagery looks much better with implementation of DNB LUTs on 3/30

Alaska
20230330 (Night)
S-NPP
NCC (0 to 1.4)



NOAA021 NCC on 3/30 over CONUS

CONUS
20230330 (Night)
NOAA-21
NCC (0 to 1.6)



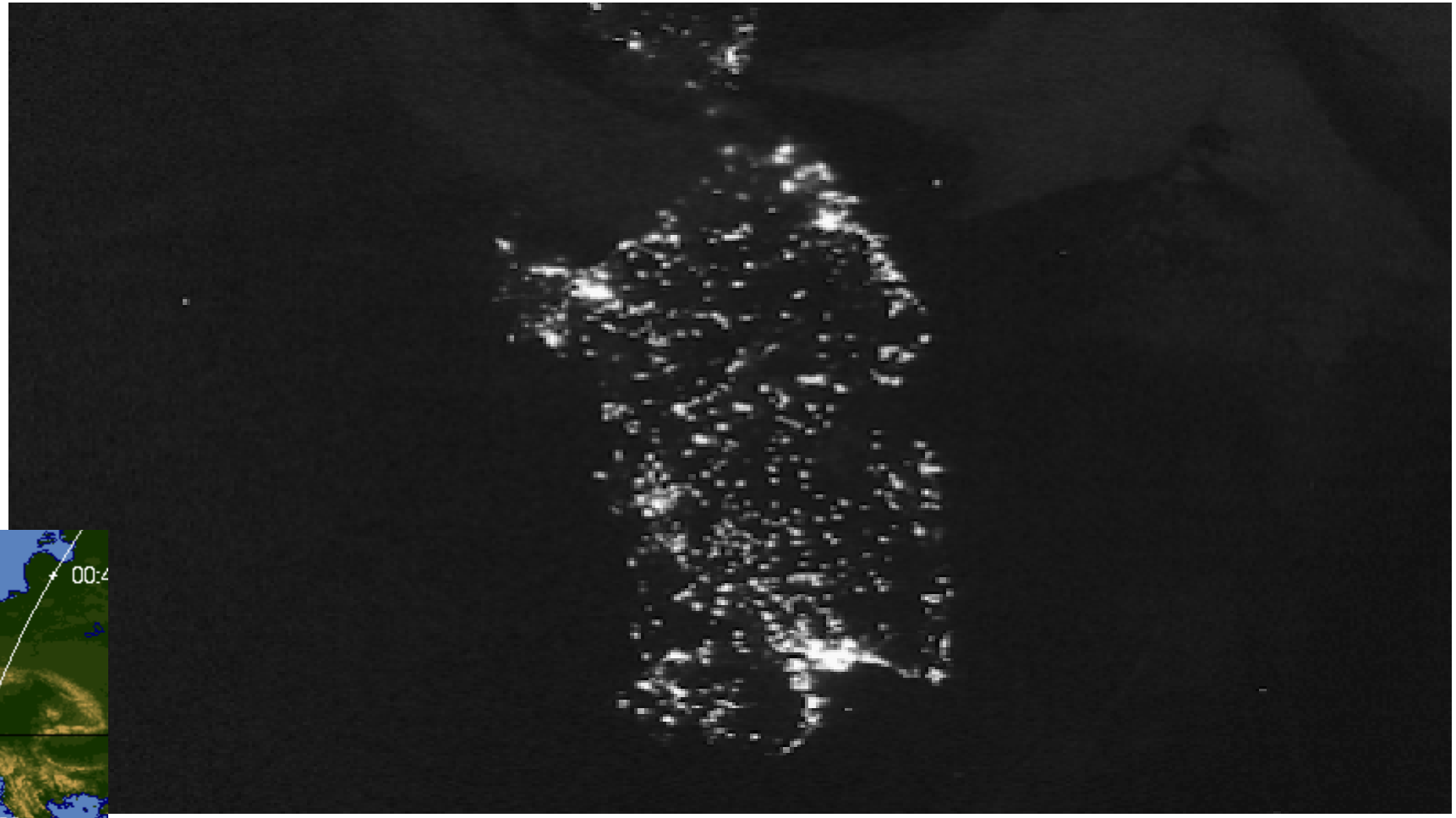
DNB Smearing Investigation

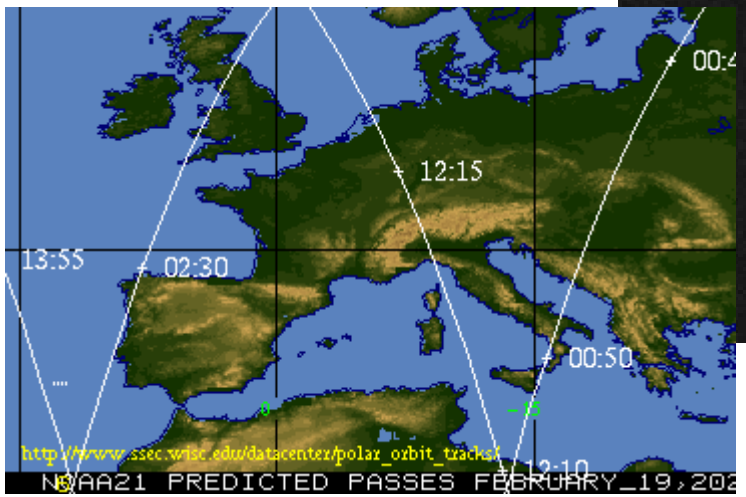
Imagery Team investigations have not revealed obvious along-scan smearing above what is observed in NOAA-20 or S-NPP

20230219

N21 DNB (native projection)

Sardina





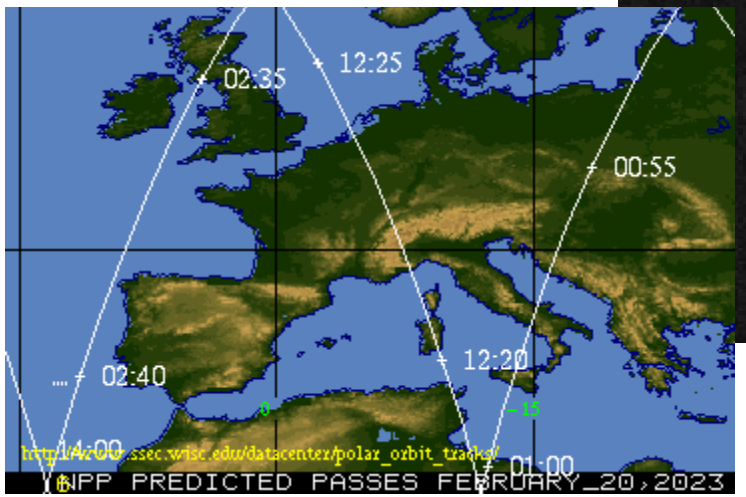
DNB Smearing Investigation

Imagery Team investigations have not revealed obvious along-scan smearing above what is observed in NOAA-20 or S-NPP

20230220

NPP DNB (native projection)

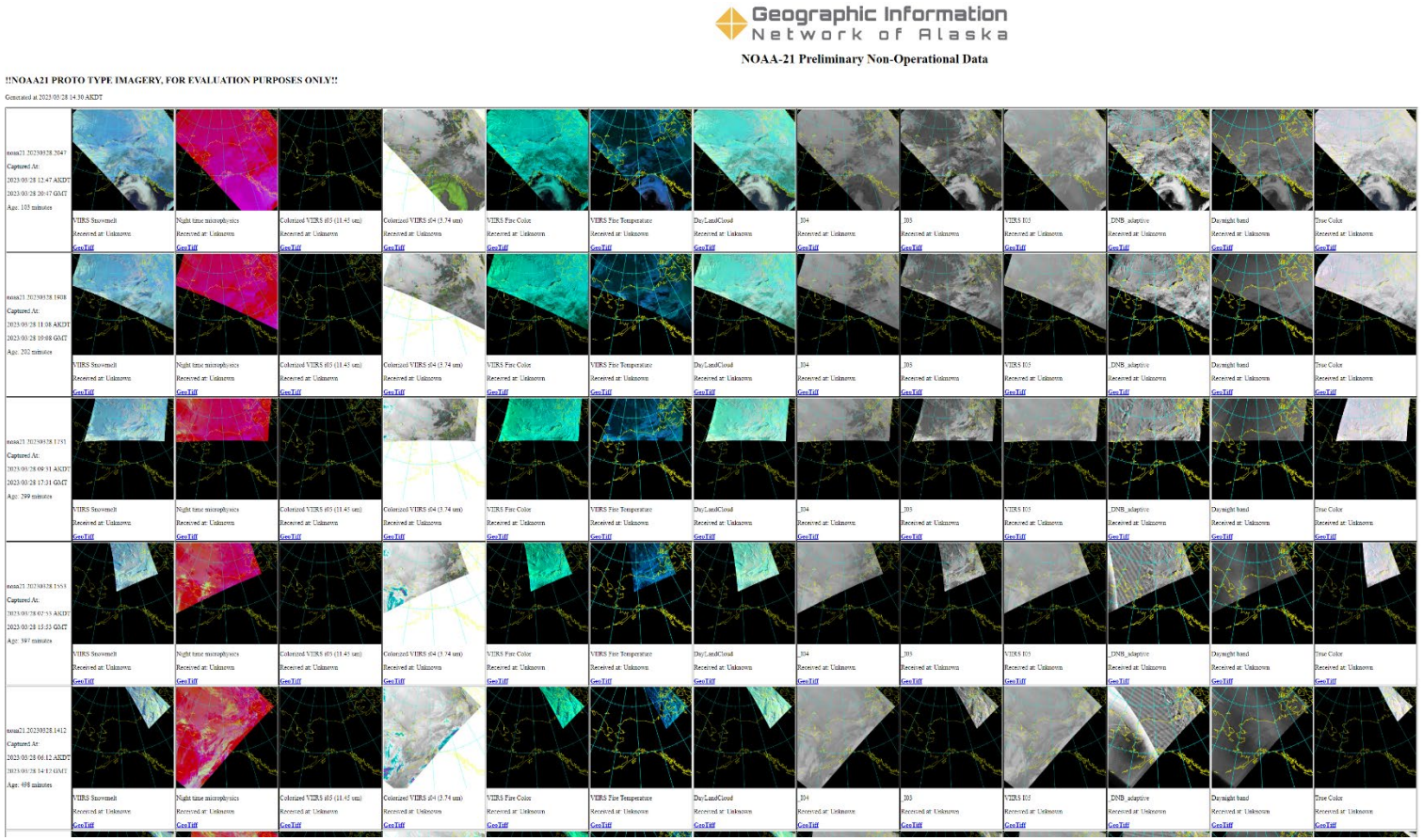
Sardina

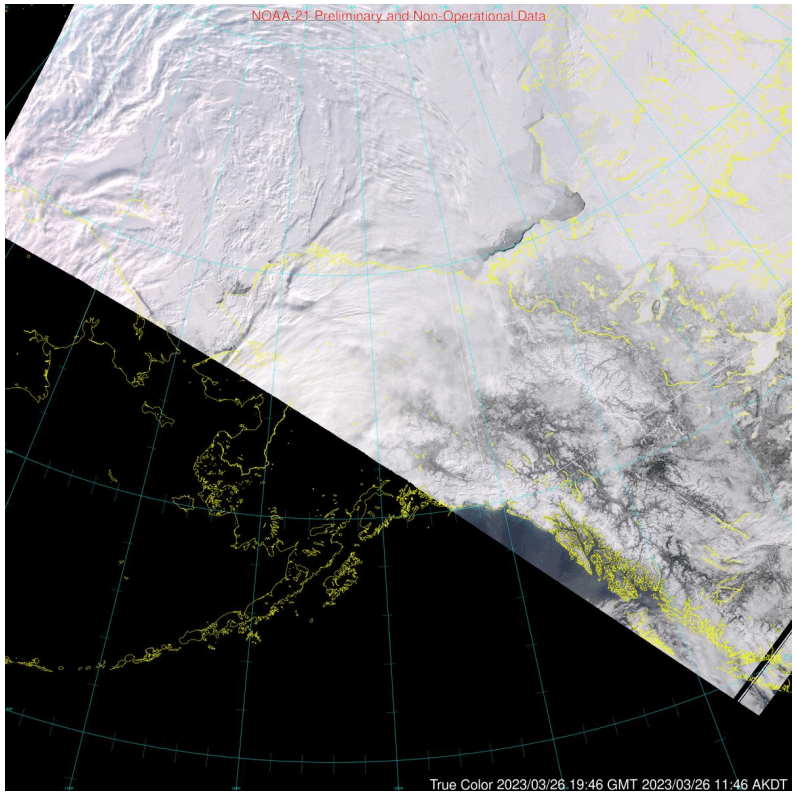


User Feedback - GINA

University of Alaska Geographic Information Network of Alaska (GINA)
Acquiring NOAA-21 VIIRS Imagery via Direct Broadcast and processed with CSPP
Successfully ingesting and displaying Imagery in local AWIPS and generating Images and GeoTIFFs for display on protected page
Feedback:

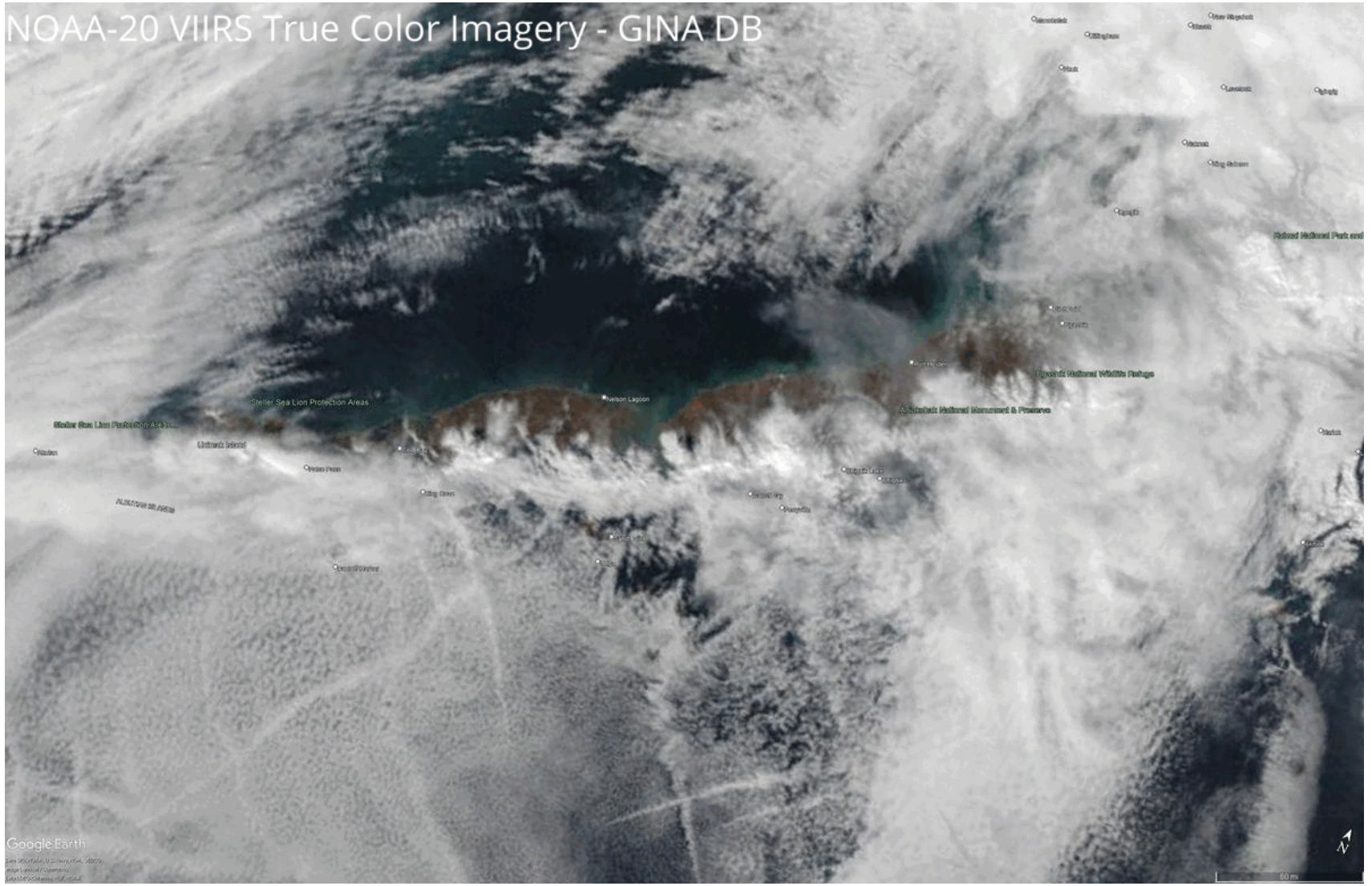
- Continues to be positive, with DNB being the only band with noticeable differences when compared to that from N20 and NPP
- Will be meeting with NWS/AK over the next week to craft a plan forward related to NOAA-21 in NWS/AK
- Imagery still contains slight geoloc errors when compared with NOAA-20 and S-NPP, and operational data
  - CSPP is aware that this geolocation error remains present in, and is unique to, DB data (processed in CSPP)





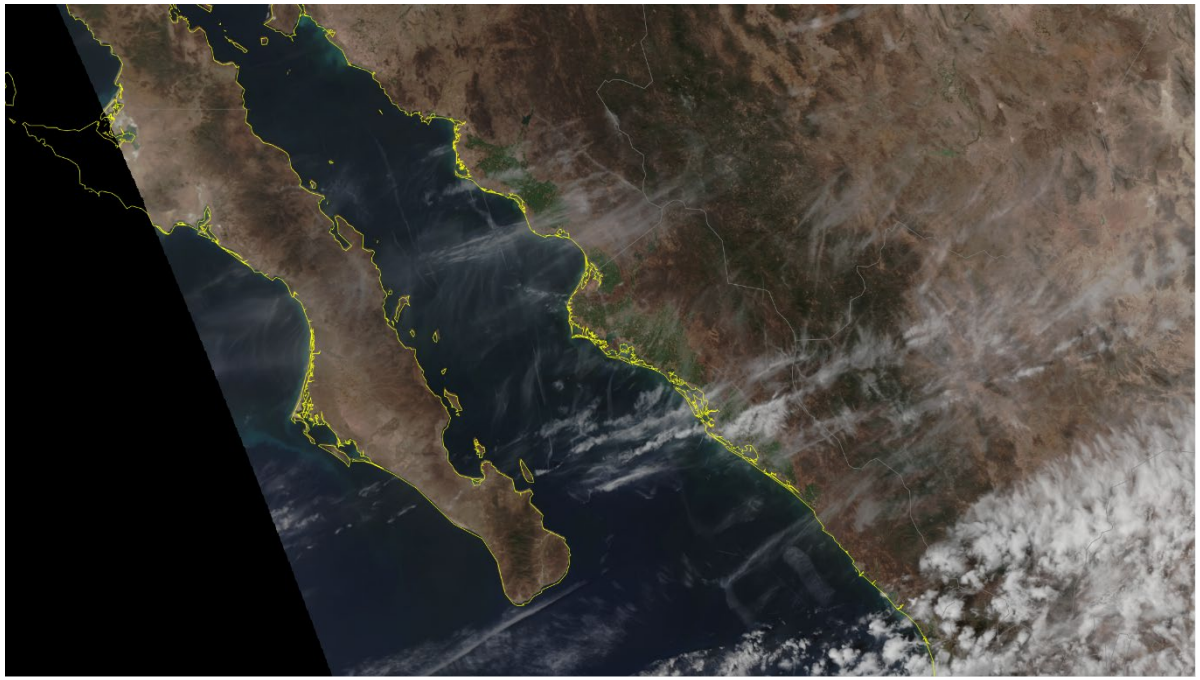
User Feedback - GINA

GINA DB Imagery Geolocation Error Compared to NOAA-20 and S-NPP



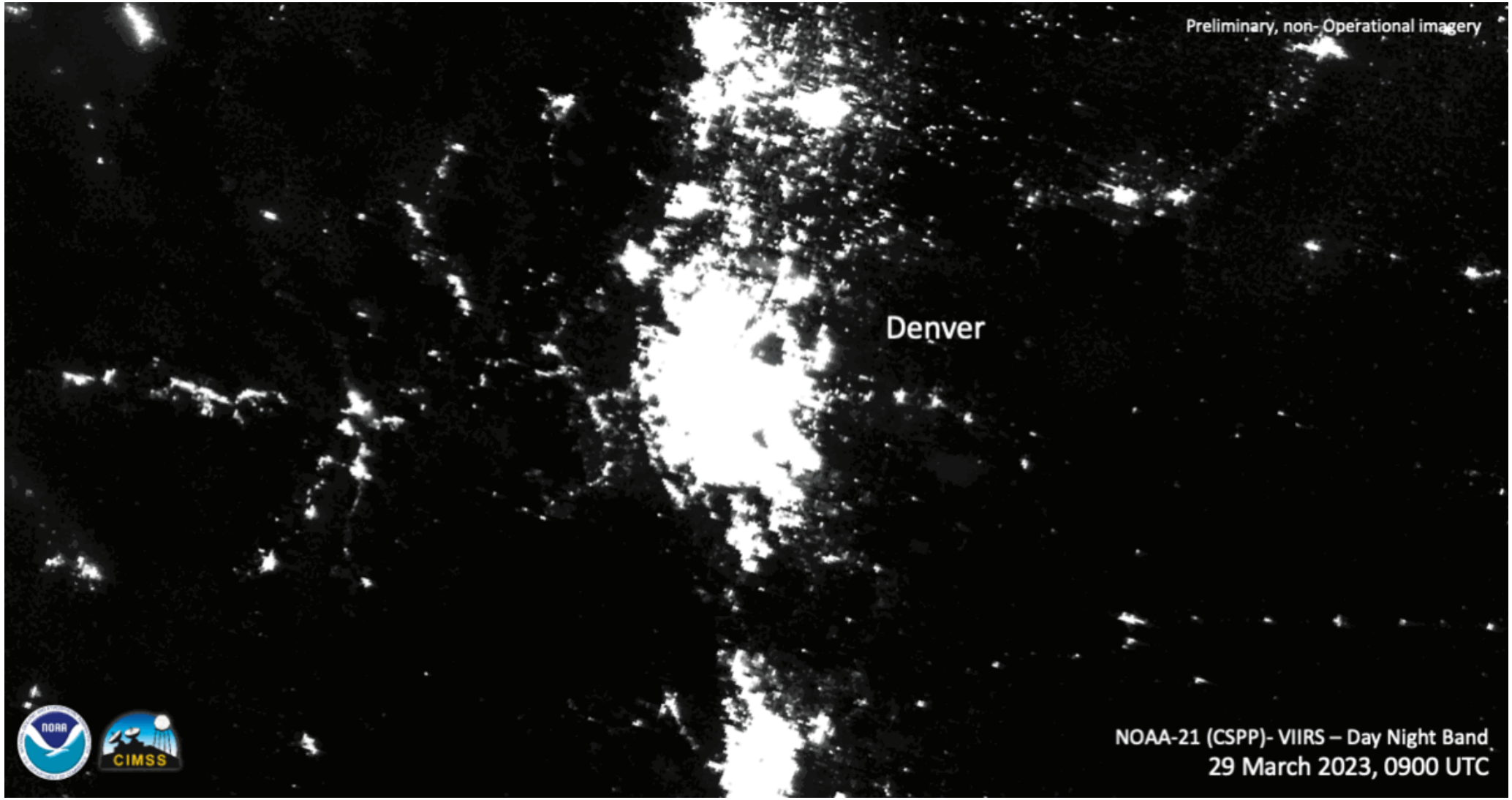
User Feedback - CIMSS

University of Alaska Geographic Information Network of Alaska (GINA)
Acquiring NOAA-21 VIIRS Imagery via Direct Broadcast and processed with CSPP
Successfully creating NOAA-21 VIIRS Imagery from DB
Feedback:
- No significant comments to pass along
- Like GINA, imagery contains slight geoloc errors when compared with NOAA-20 and S-NPP, and operational data
  - CSPP is aware that this geolocation error remains present in, and is unique to, DB data (processed in CSPP)



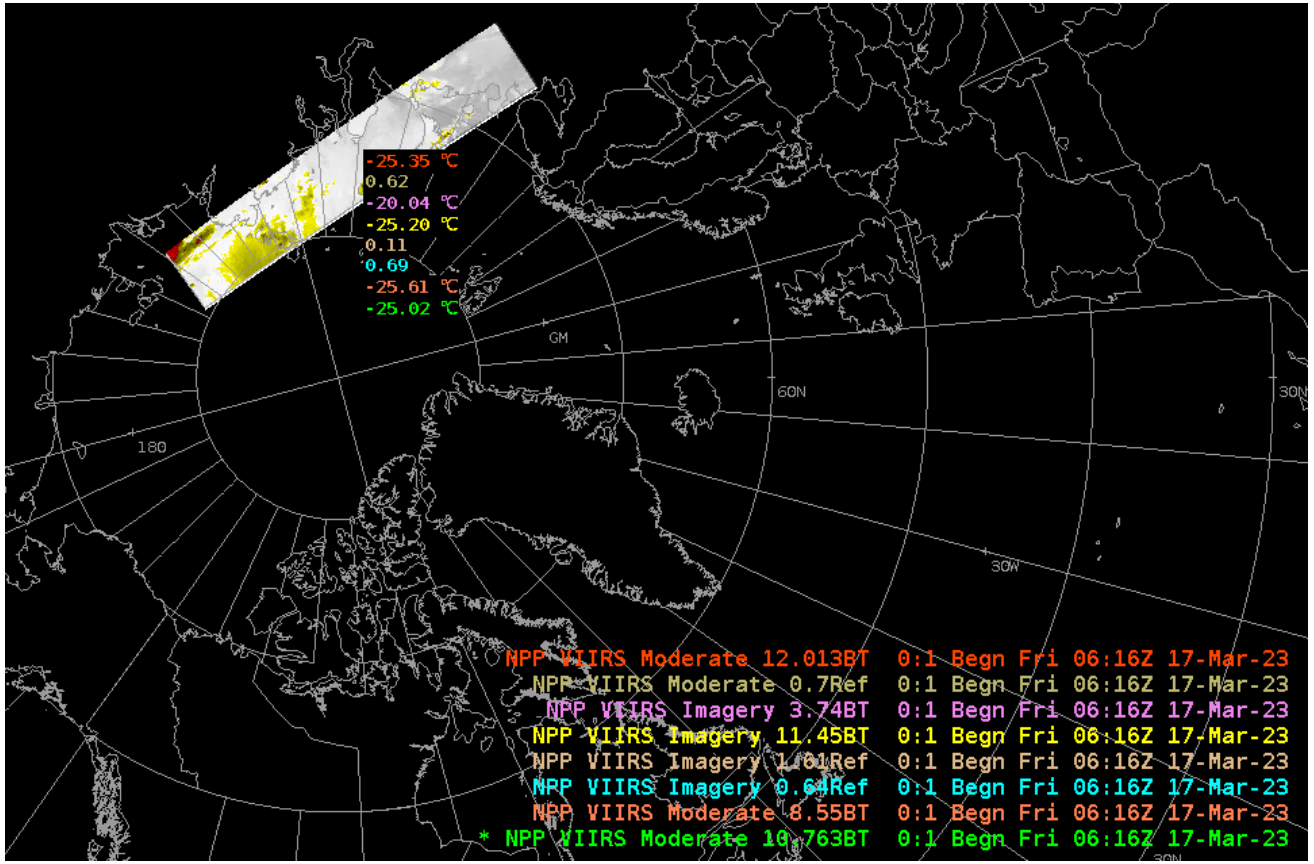
User Feedback - CIMSS

CIMSS DB Imagery Geolocation Error Compared to Operational File



User Feedback - NWS

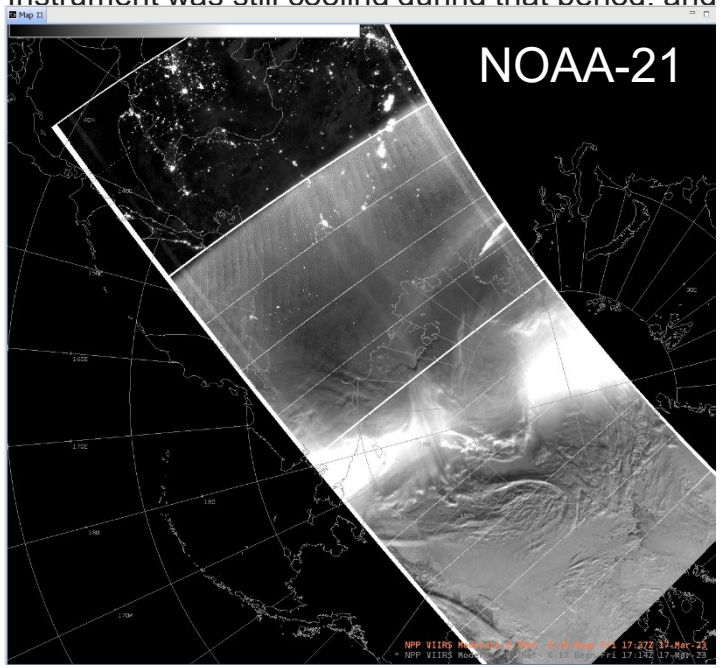
- NCCF tailoring of the Imagery KPP (I1, I3, I4, I5, M14, M15, M16, NCC) files for AWIPS works. AWIPS' EDEX and CAVE correctly handle and display the tailored VIIRS imagery products from NOAA-21, NOAA-20, and S-NPP
- See screenshot below of all 8 NOAA-21 VIIRS Imagery files loaded in AWIPS, with data readout:

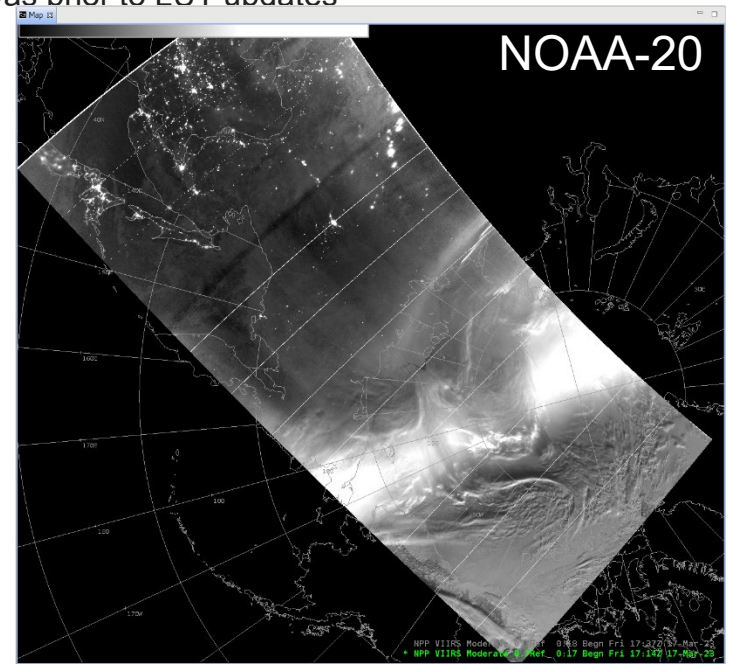


John Evans, TOWR-S

User Feedback - NWS

- NWS concern about present appearance of DNB/NCC. There has been great email correspondence between NWS, VIIRS SDR Team, and Imagery EDR Team about appearance. Most notable:
  - Abrupt brightness transition across northern/southern terminators
    - Stray light zone and dark pixels
    - expected to improve with upcoming LUT updates
  - Edge of granule fill pixels more abundant than with N20 and NPP
    - edge of scan stripes became more obvious right after the on orbit calibration. Expected to be improved with upcoming LUT updates
  - Excessive brightness in NCC during Feb 22-28 period (but not since)
    - Instrument was still cooling during that period, and that was prior to LUT updates





John Evans, TOWR-S

User Feedback - NWS

- Next Steps with NWS (Many thanks to John Evans, TOWR-S, for the details)
  - In the operational AWIPS system, NOAA-21 VIIRS imagery products will replace their S-NPP counterparts: they will reuse the S-NPP WMO headers for routing through the Network Control Facility (NCF) and over the Satellite Broadcast Network (SBN), and for handling in each site's EDEX (ingest / index) system and CAVE (graphical workstation) software.
  - After suitable public notice, NCF will unsubscribe to S-NPP VIIRS imagery products and subscribe to their NOAA-21 counterparts, and end users of the SBN will begin to see NOAA-21 products where they used to see S-NPP products.
  - In the short term, CAVE menu entries will still say "S-NPP..." even though they will correspond to NOAA-21 products; we will inform AWIPS users of this. Then in the summer (exact timeframe TBD) we will make available a new bundle of AWIPS configurations (a "TOWR-S RPM") to update the CAVE menu entries.
  - In addition, the AWIPS NCF will send the 8 Alaska KPPs for NOAA-21 directly to the NWS Alaska Regional HQ. It currently does that for the corresponding channels of S-NPP VIIRS: so because this routing is based on WMO headers, it will begin sending the NOAA-21 KPPs without any reconfiguration.

Check List - Provisional Maturity

Provisional Maturity End State	Assessment
Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from select locations, periods, and associated ground truth or field campaign efforts.	All bands of Imagery EDR have been monitored since Mid-Feb (Cryo-doors open), across a variety of scenes and seasons globally, and compared with Imagery from S-NPP and NOAA-20
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Examples of single band Imagery and Multispectral Imagery products, which are all leveraged by users, have been created, analyzed, and compared with those from S-NPP and NOAA-20
Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.	N/A
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	Yes for all VIS, NIR, and IR bands. NCC will be ready upon operational implementation of DNB LUTs discussed by SDR team.

Documentations (Check List, 1 slide)

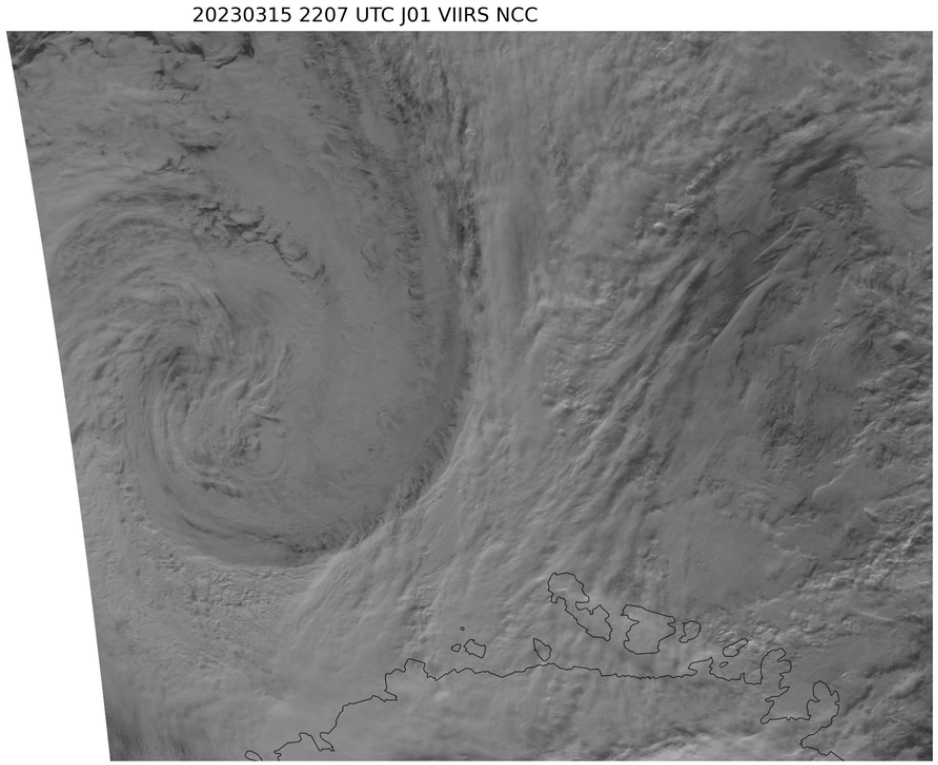
Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes
System Maintenance Manual (for ESPC products)	
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

Conclusion (1 slide)

- Cal/Val results summary:
  - **Team recommends Provisional Maturity for VIIRS EDR Imagery**
  - **Effective: once the latest SDR LUTs are operationalized (Mar 30)**
  - Final thoughts
    - DNB/NCC Appearance – Straylight/striping, darkness/negative values
      - Yields abrupt brightness transition near N/S Terminator
      - Upcoming LUT updates expected to improve imagery appearance
        - » LUTS implemented today 3/30, Initial analysis of NCC imagery is very positive!
    - NCC “Smearing”/Leakage appears to have minimal impact on interpretation of imagery, qualitatively
    - Infrequent M9 Pixel saturation
      - less so than 1 month ago
      - Does not impact qualitative analysis of imagery
    - Very subtle striping noted in some bands over uniform scenes
      - Less so than 1 month ago
      - Does not impact qualitative analysis of imagery

Path Forward (1-2 slides)

- Continued monitoring of imagery, especially post LUT updates
  - Specifically
    - DNB Smearing
    - SWIR band degradation
  - Communicate findings with the VIIRS SDR team
- Continued engagement with users regarding access to imagery, quality of imagery, benefits of 3 VIIRS
  - Including DB Imagery processed in CSPP (geolocation error)
- Display of NOAA-21 Imagery with S-NPP and NOAA-20 on CIRA Polar SLIDER



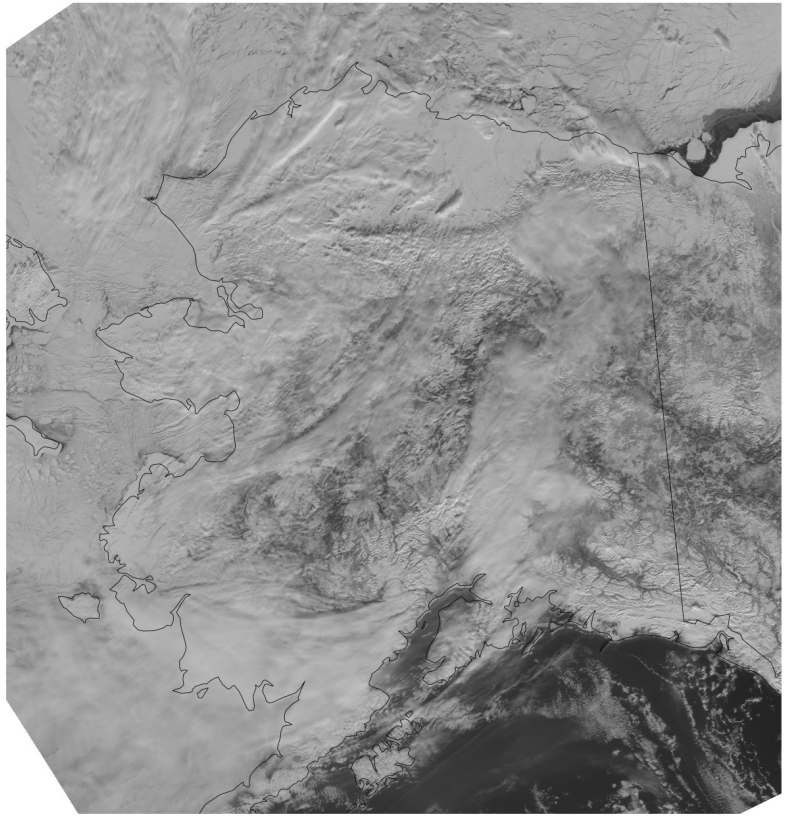
Antarctic Polar Cyclone
20230315-16 (Day – Night)
NOAA-21
NCC (0 to 2.5)

Product Overview/Requirements (2 slides)

Product Requirements from JPSS L1RD

Attribute	Threshold	Objective
1. The Imagery EDR shall be delivered under all weather conditions.		
a. Horizontal Spatial Resolution for Imagery Resolution Bands		
1. Nadir	0.4 km	0.1 km
2. Edge of Swath	0.8 km	0.1 km
b. Horizontal Spatial Resolution for Moderate Resolution Bands (1)		
1. Nadir	0.8 km	NS
2. Edge of Swath	1.6 km	NS
c. Horizontal Spatial Resolution for Imagery derived from the Day-Night Band (DNB)		
1. Nadir	0.8 km	0.65 km
2. Edge of Swath	1.6 km	NS
d. Mapping Uncertainty, 3 Sigma		
1. Nadir	1 km	NS
2. Edge of Swath	3 km	0.5 km
f. Coverage	Global	NS
Notes:		
1. M-Band Imagery requirements are applicable any VIIRS Moderate Resolution band Imagery EDR that is produced by the system		

20230324 J01 VIIRS I1



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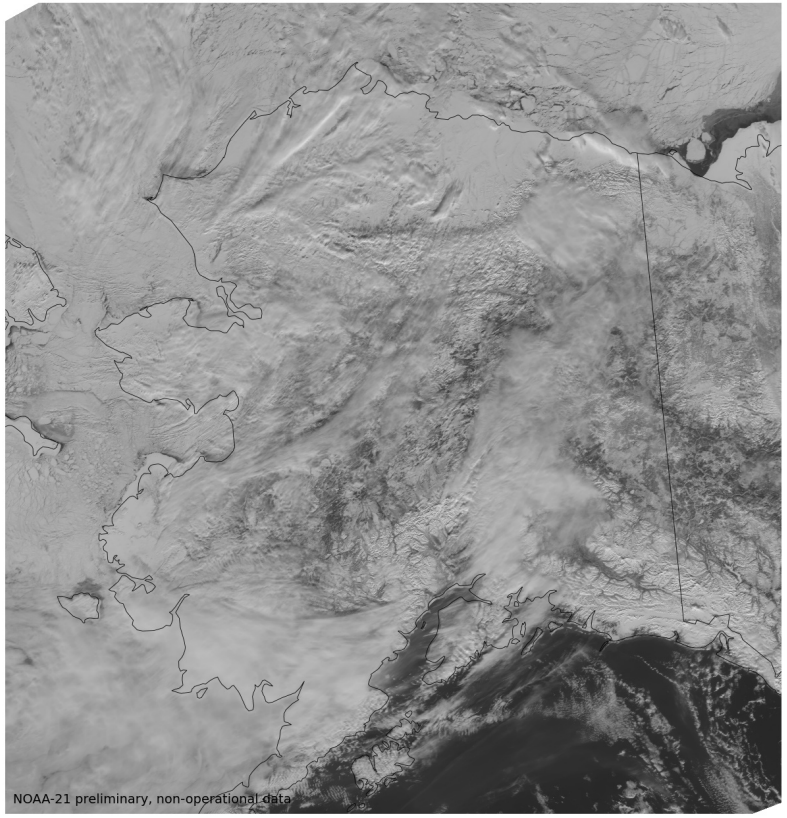
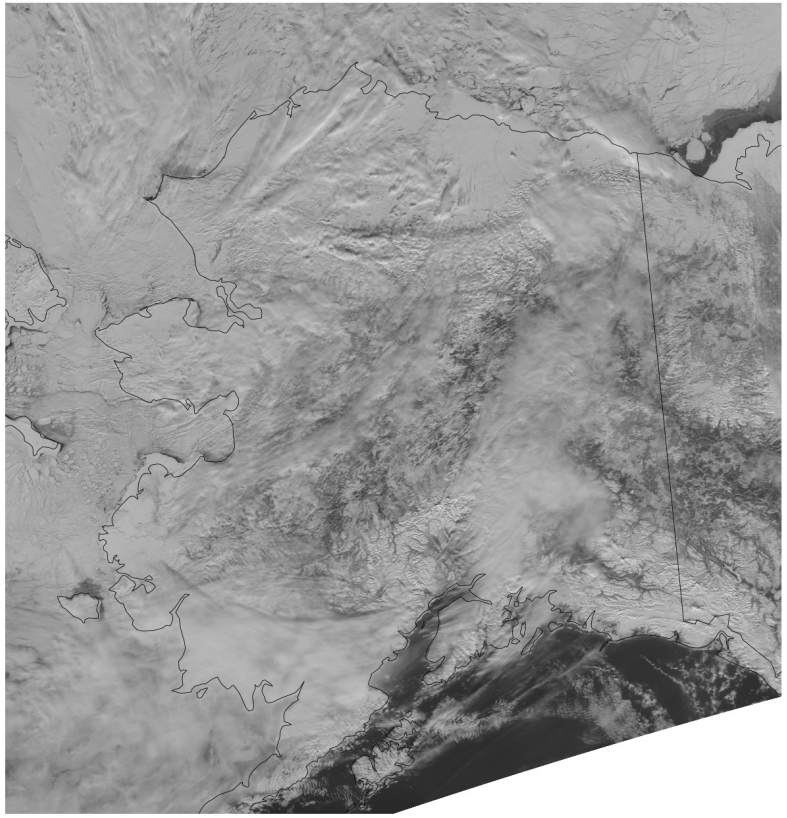


20230324 NPP VIIRS I1



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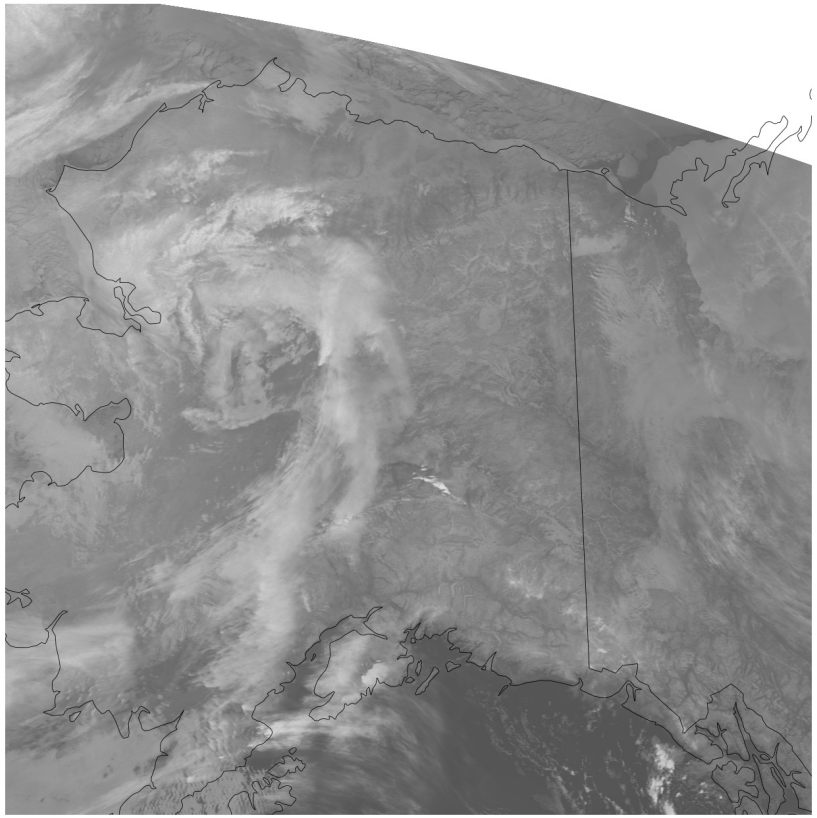

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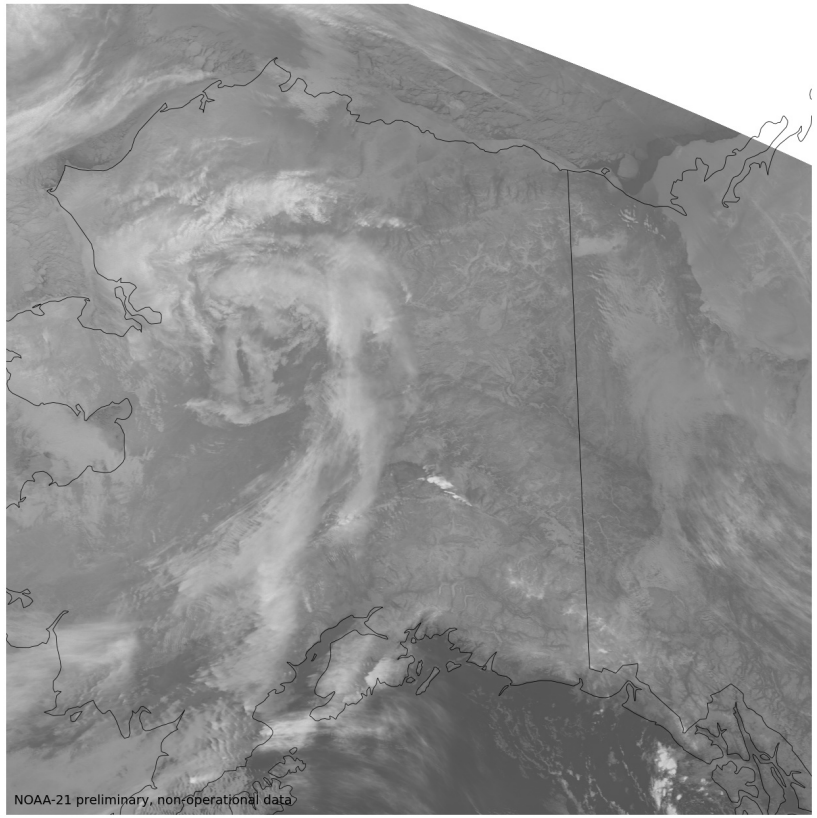
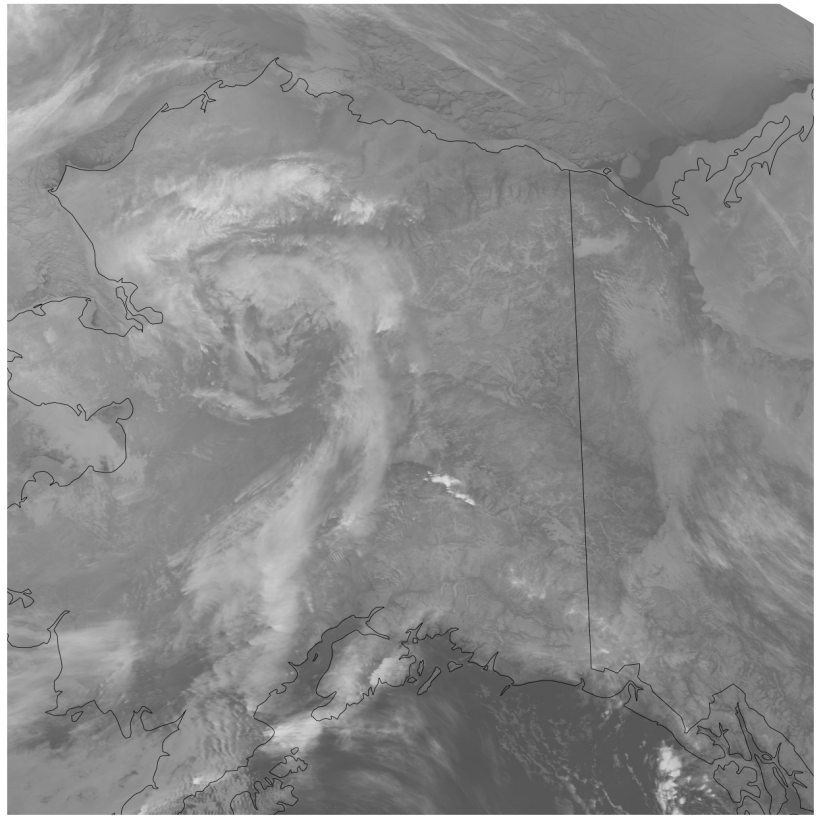
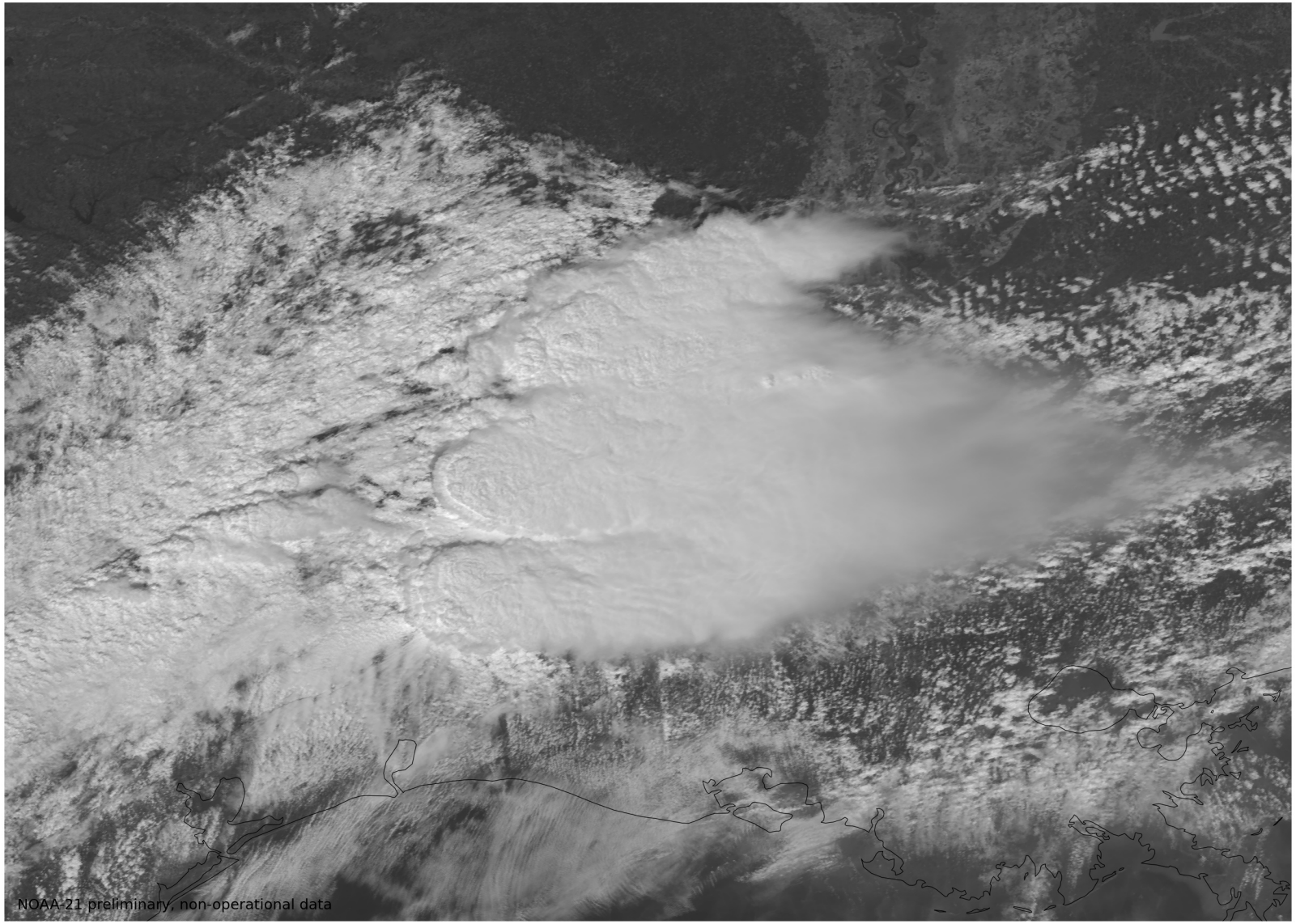


20230324 NPP VIIRS I4

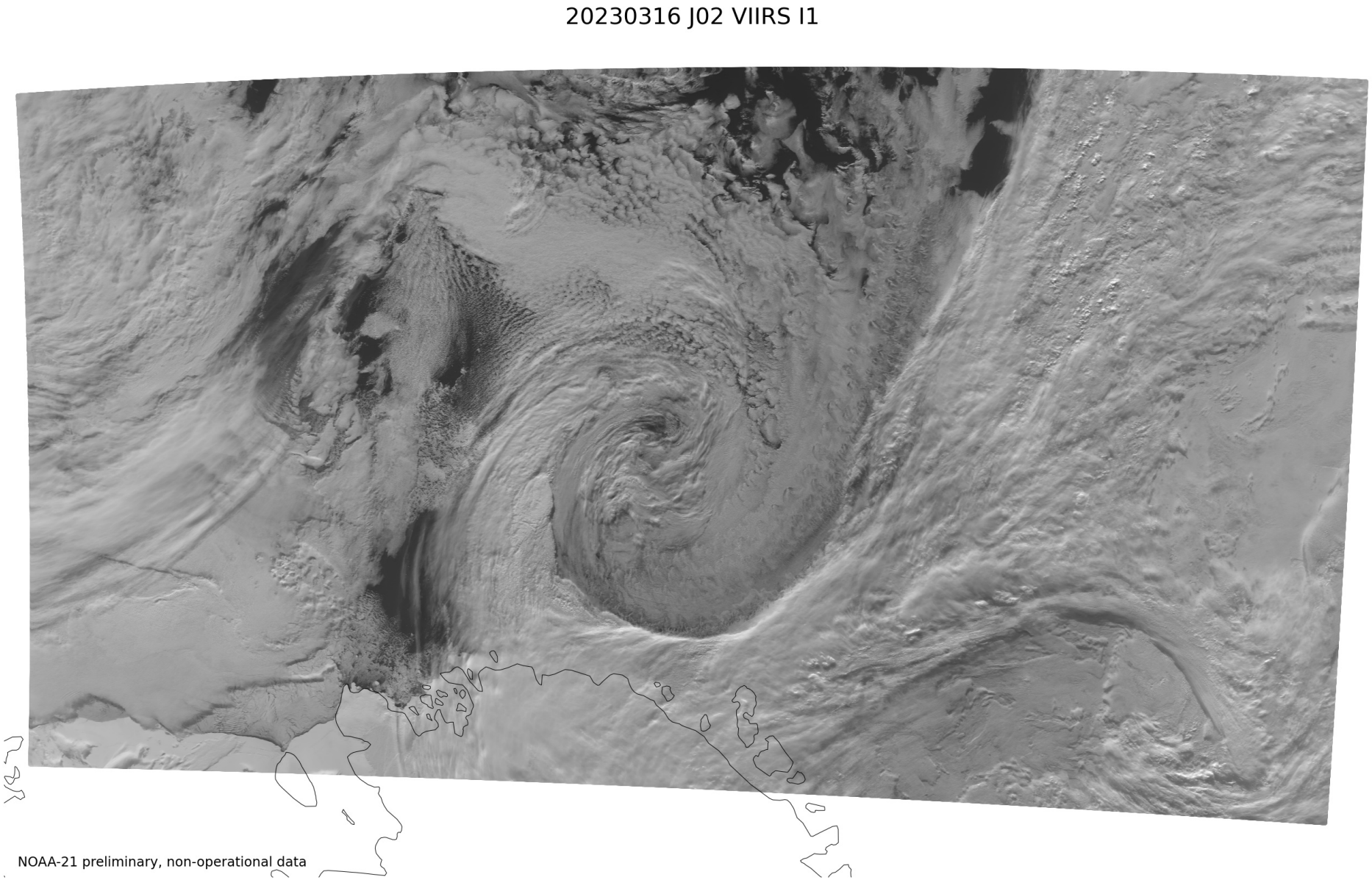


20230326 J02 VIIRS I1



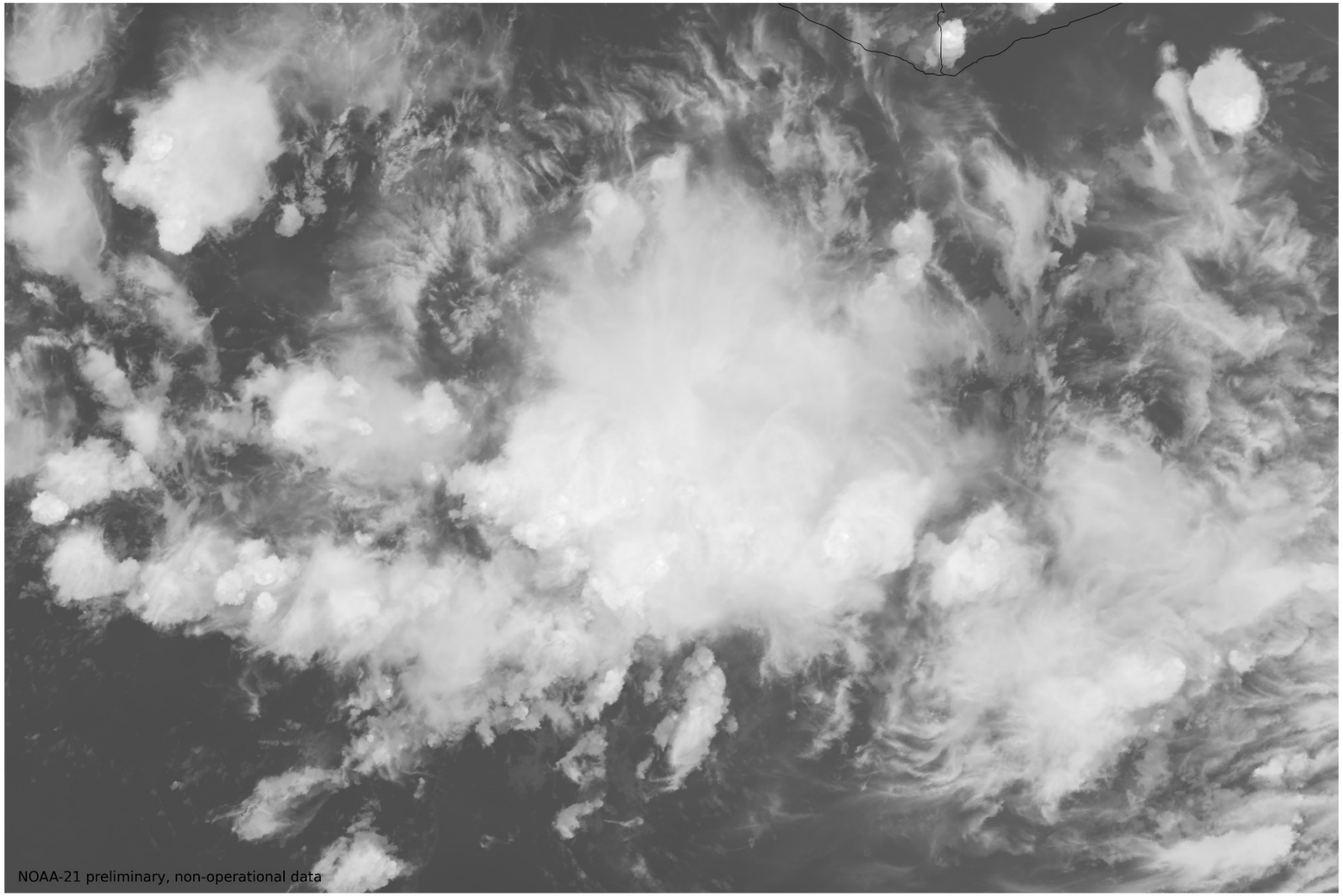
NOAA-21 VIIRS All Channels - Antarctic Polar Cyclone (3/16/2023)

Antarctic Polar Cyclone
20230316 Day
NOAA-21
All 22 Bands



NOAA-21 VIIRS All Channels – Convection Day (3/26/2023)

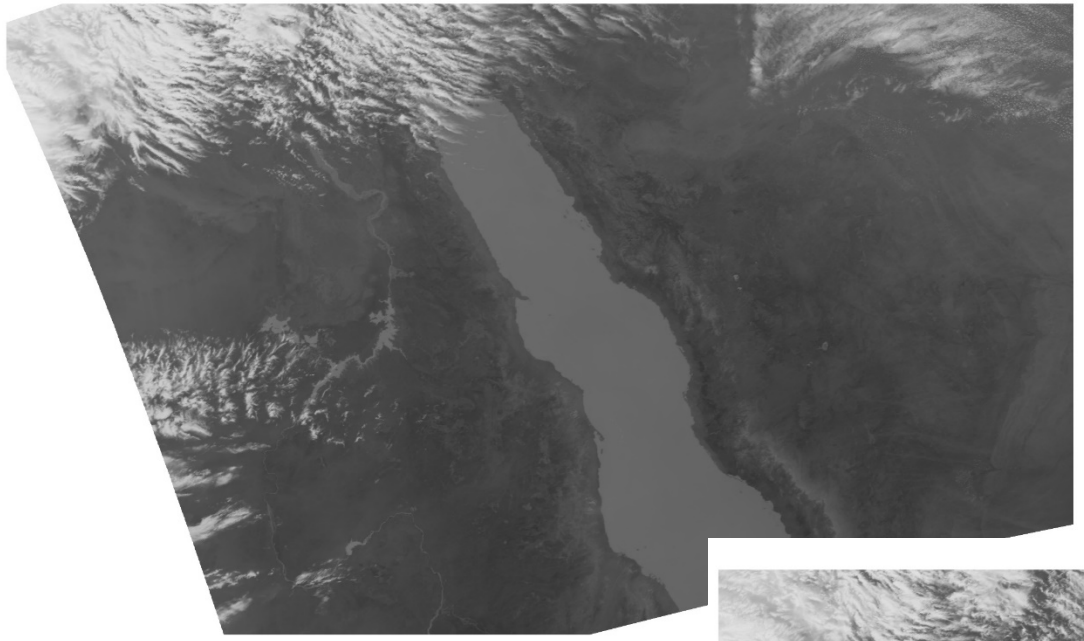
20230326 J02 VIIRS M16



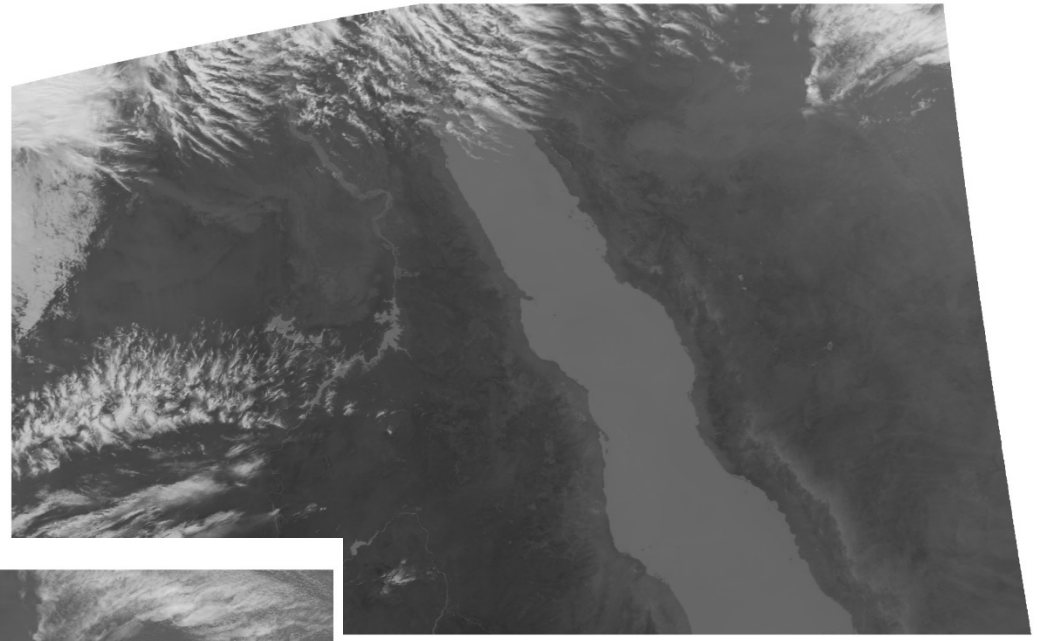
20230326 J02 VIIRS I1

VIIRS All Channel Comparison – Red Sea Day (3/22/2023)

20230322 J01 VIIRS M16



20230322 NPP VIIRS M16



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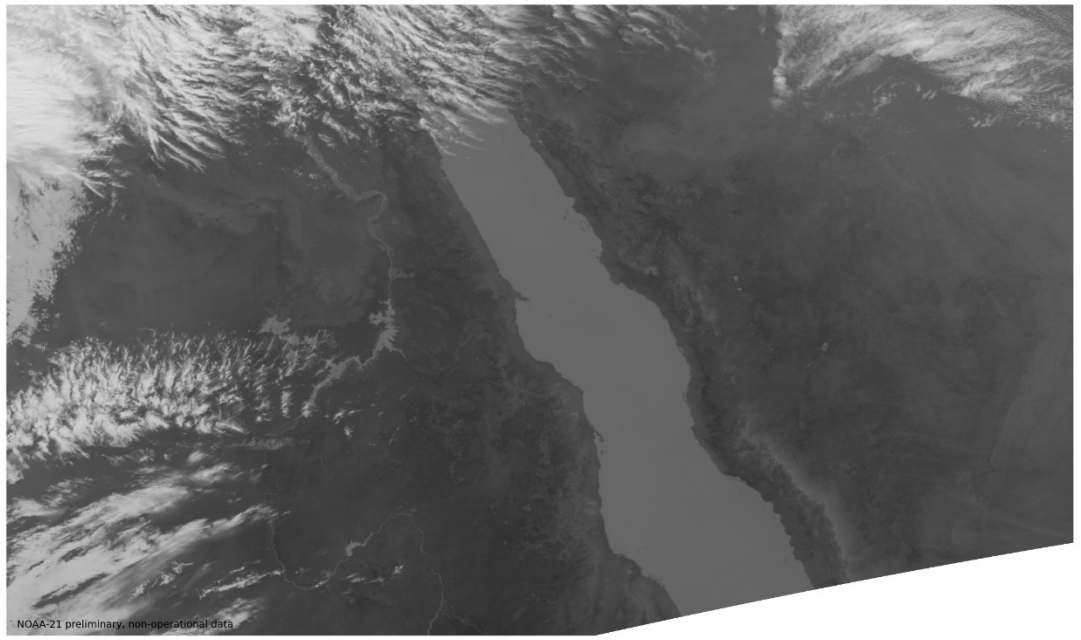
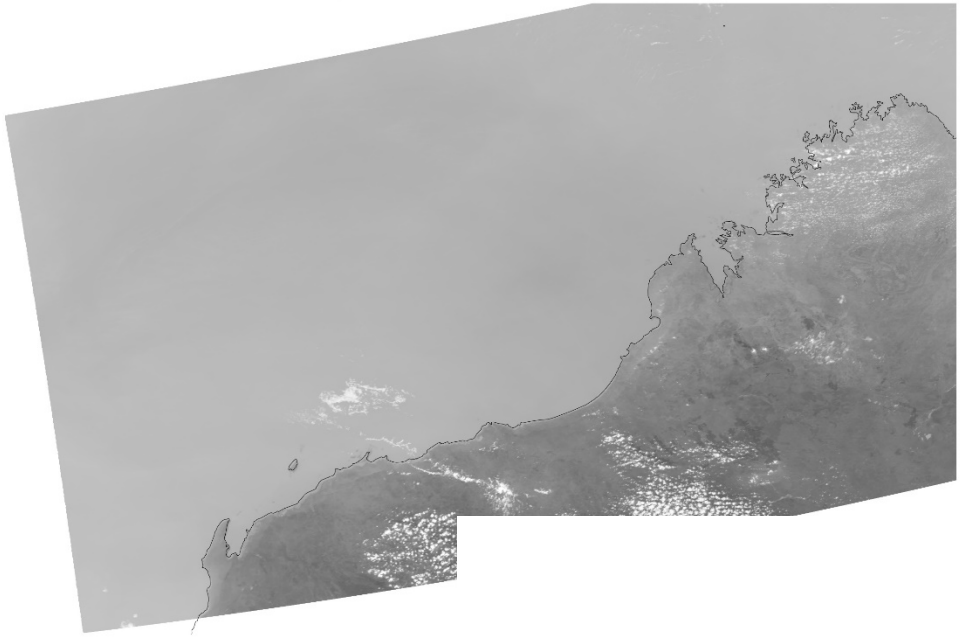


20230316 J01 VIIRS M16



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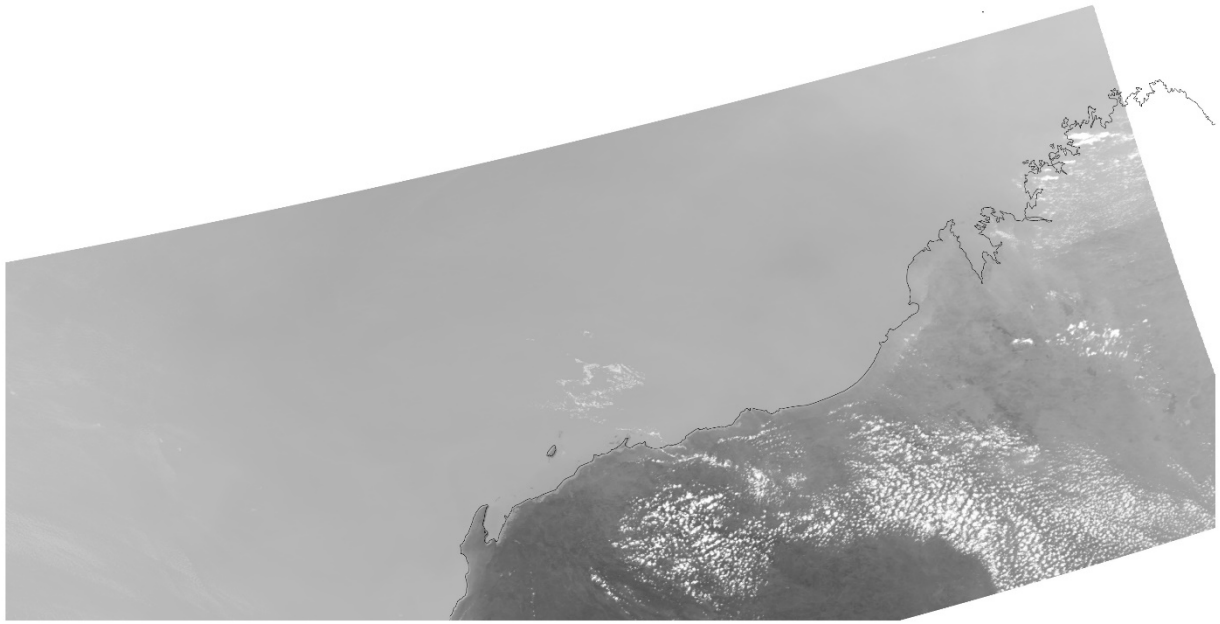

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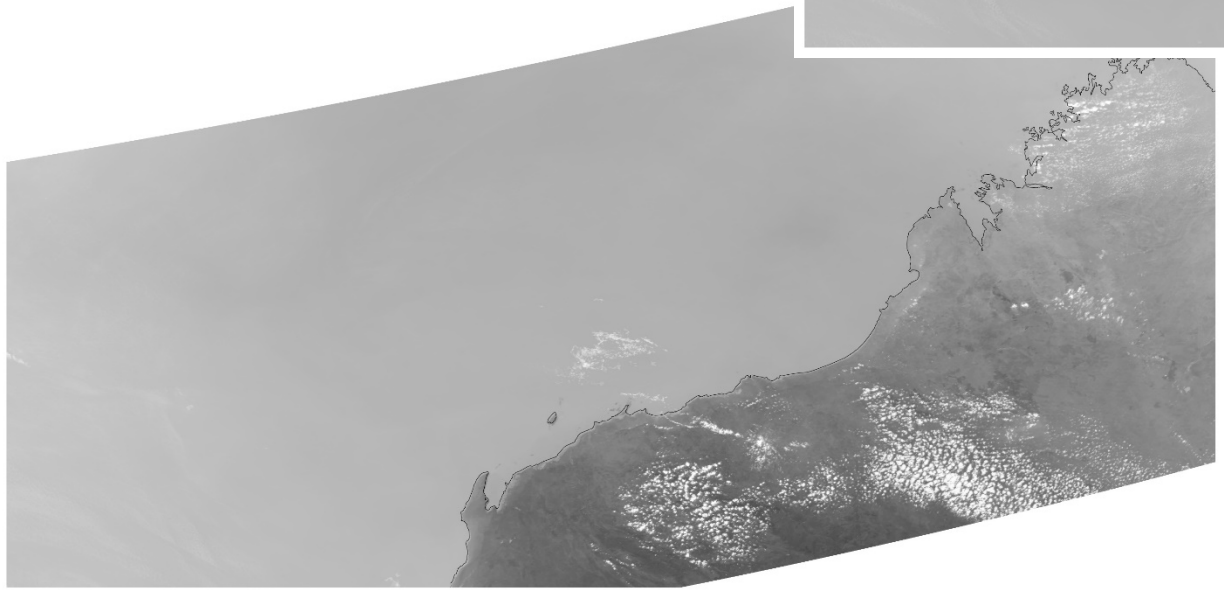
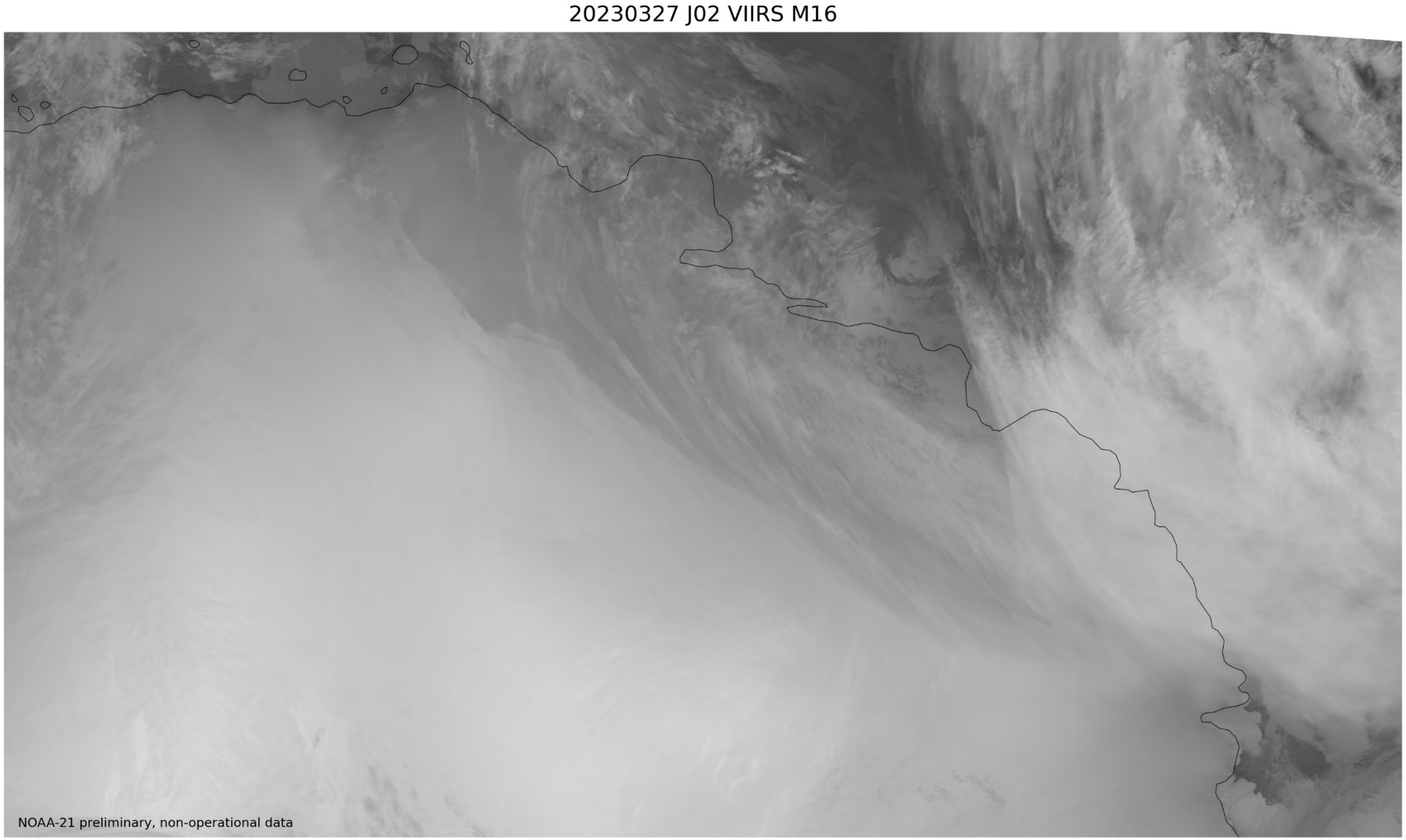
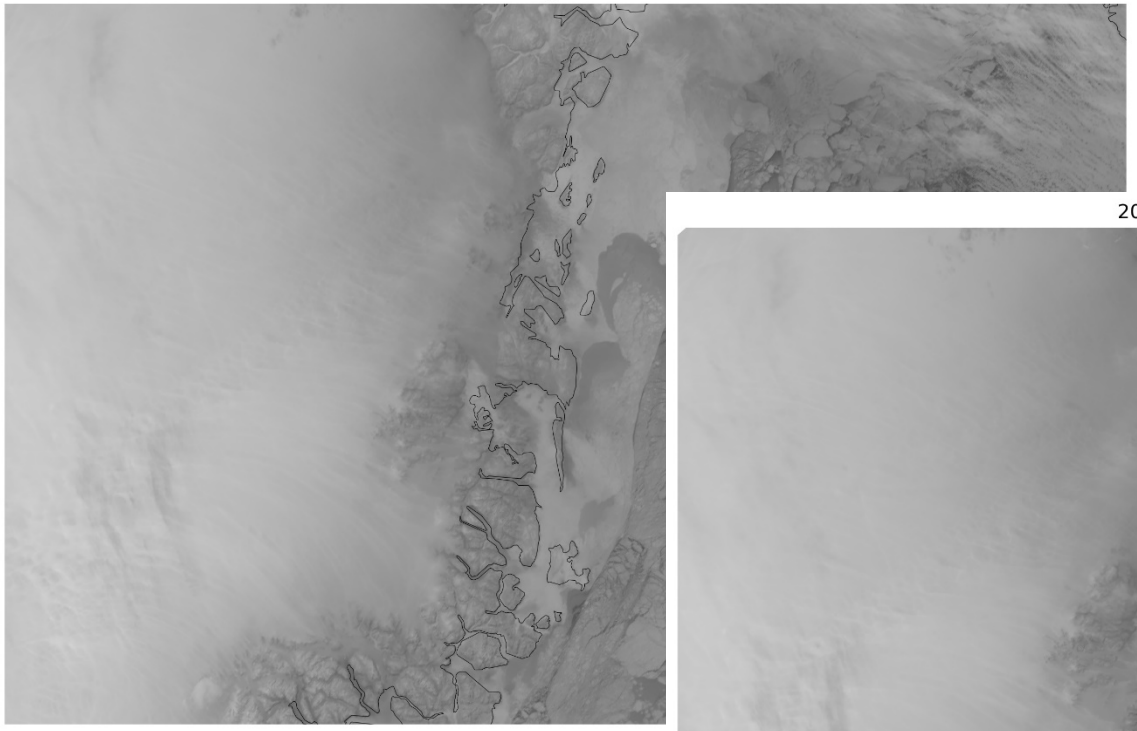


NOAA-21 VIIRS All Channels – Antarctica (3/27/2023)



VIIRS All Channel Comparison – Greenland Day (3/20/2023)

20230320 J01 VIIRS M16



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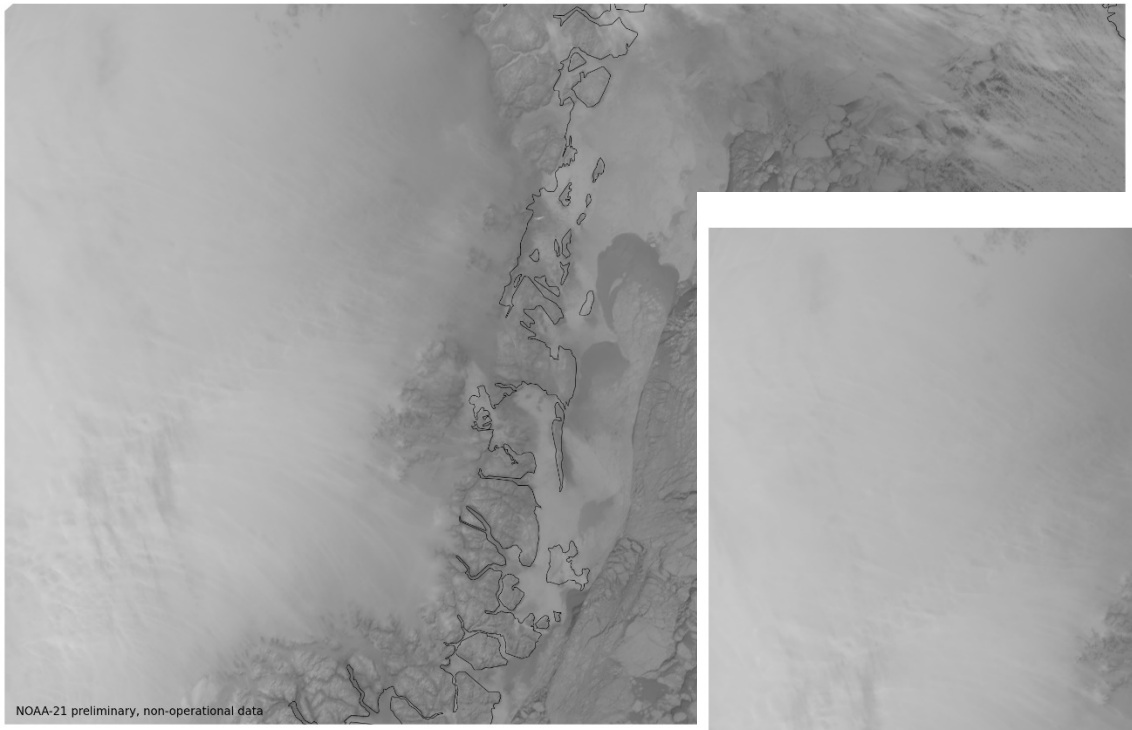

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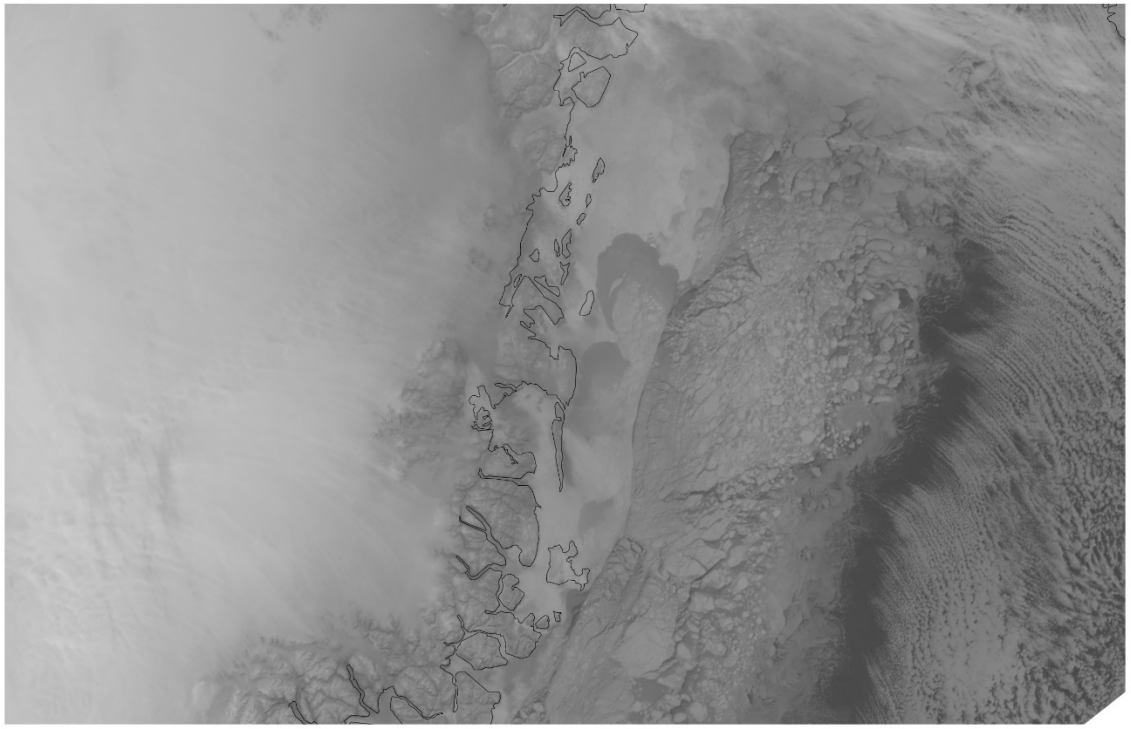
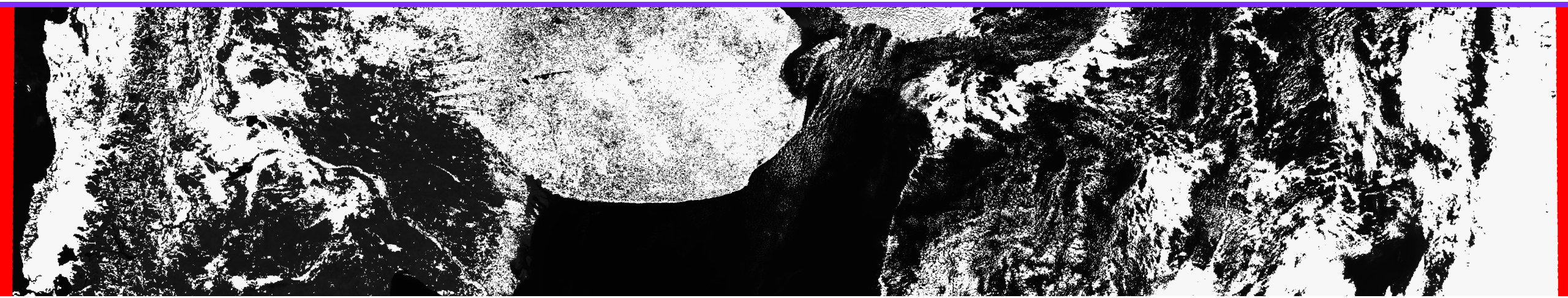


Band M6 Performance

It is our understanding that M6 should saturate over land and clouds. Have noticed scenes such as this where that is not always the case (cloud free, land)

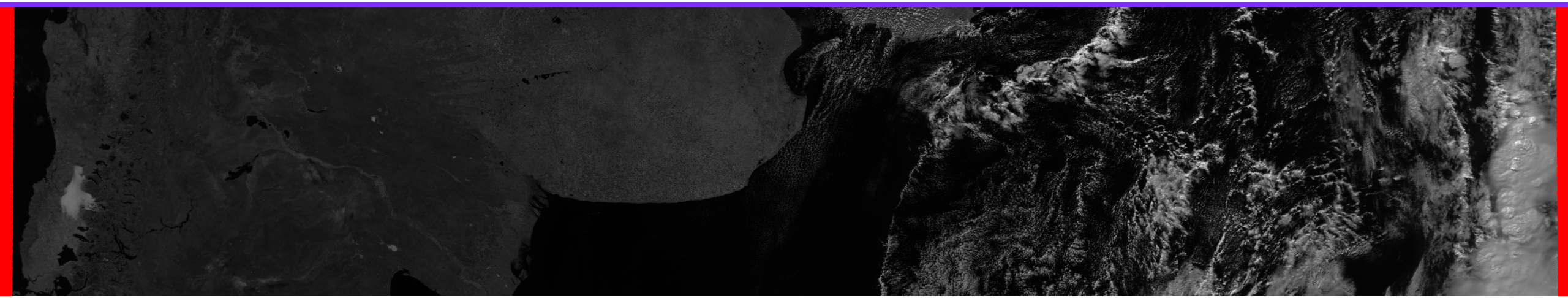
NOAA-21 M6



Band M6 Performance

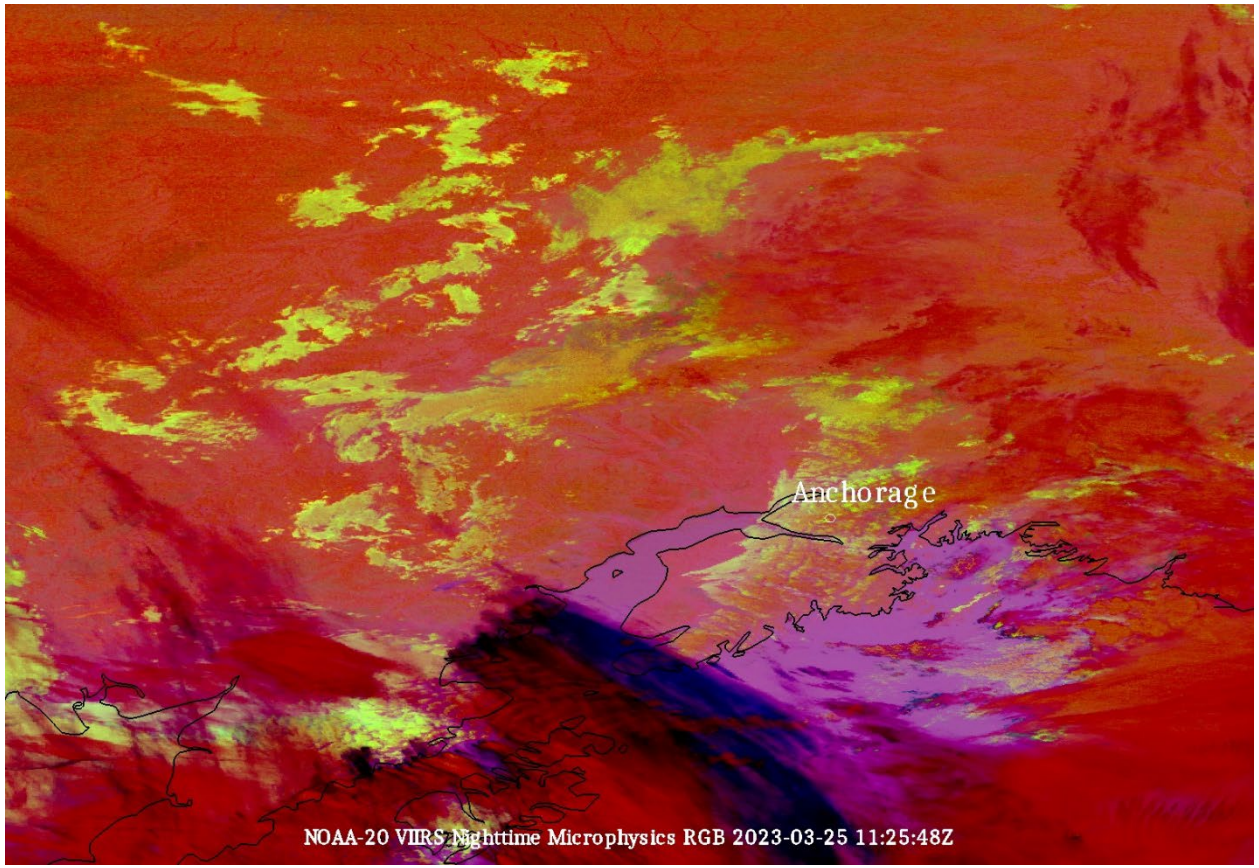
It is our understanding that M6 should saturate over land and clouds. Have noticed scenes such as this where that is not always the case (cloud free, land)

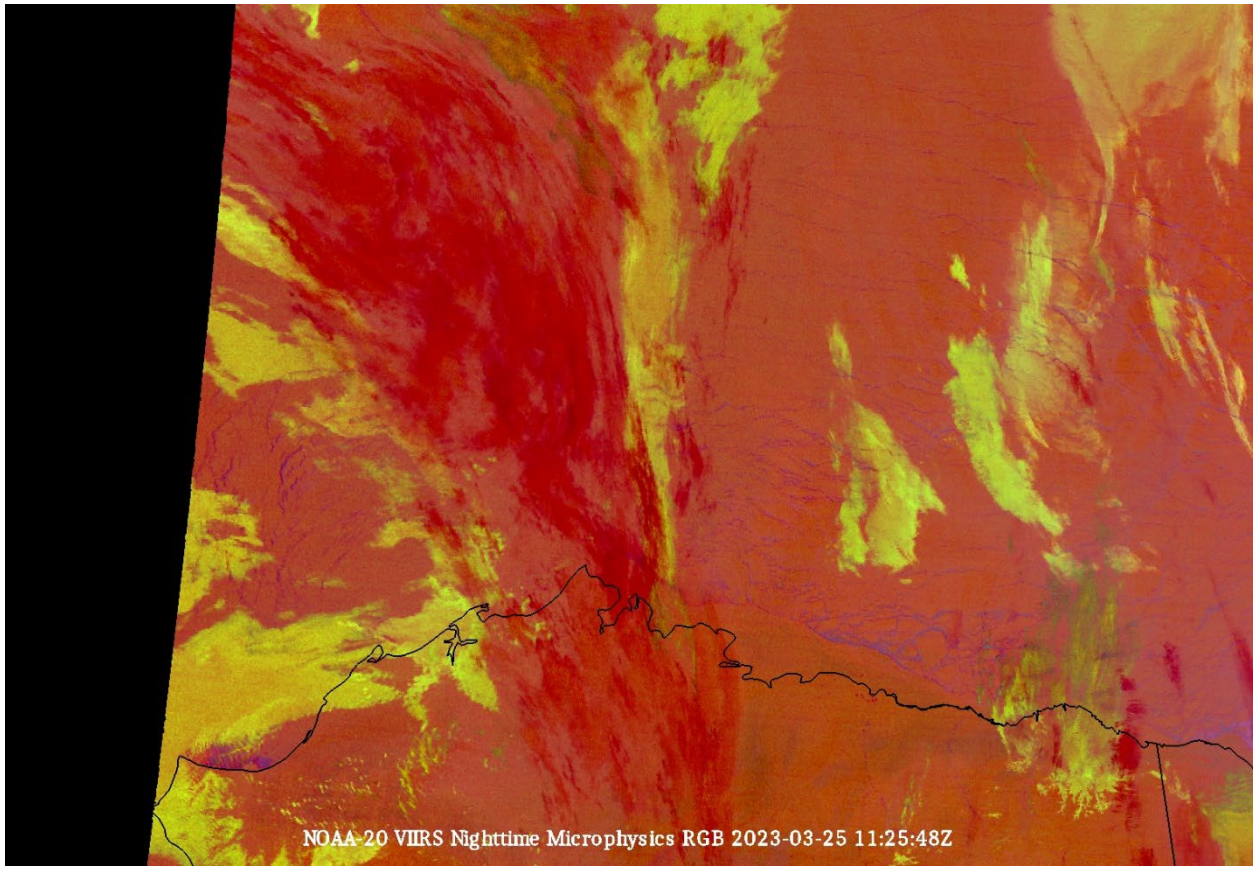
NOAA-21 M7



VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

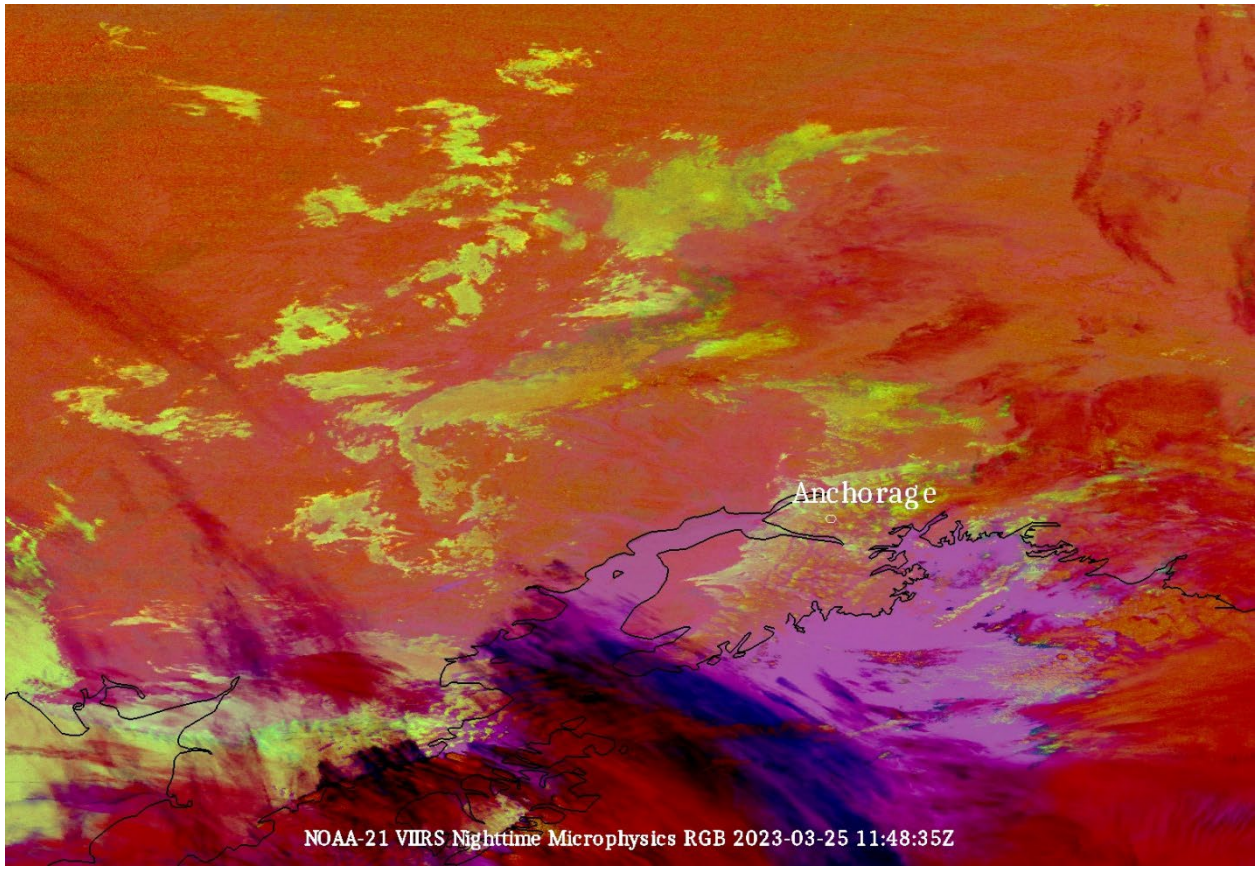
Alaska Nighttime Low Clouds
20230325
NOAA-20
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

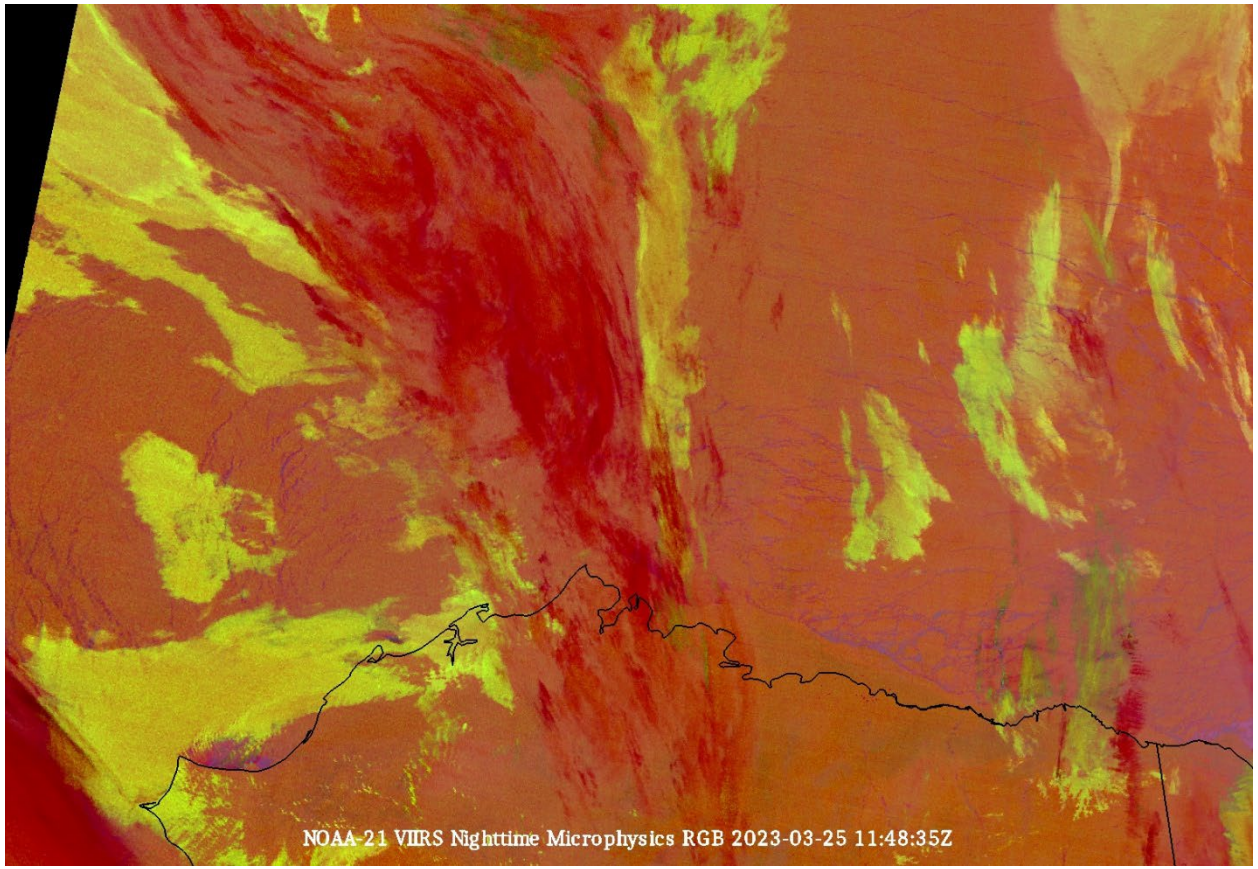




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

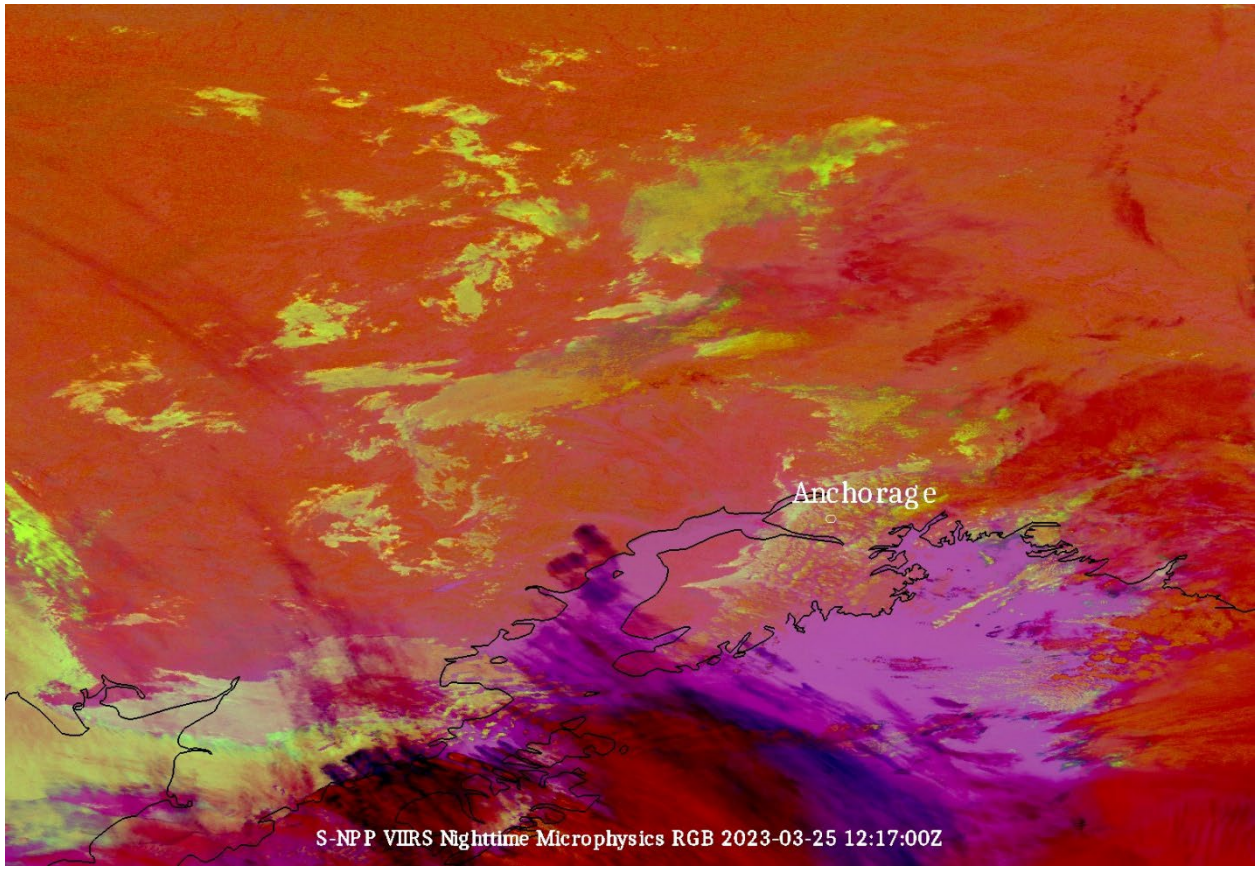
Alaska Nighttime Low Clouds
20230325
NOAA-21
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

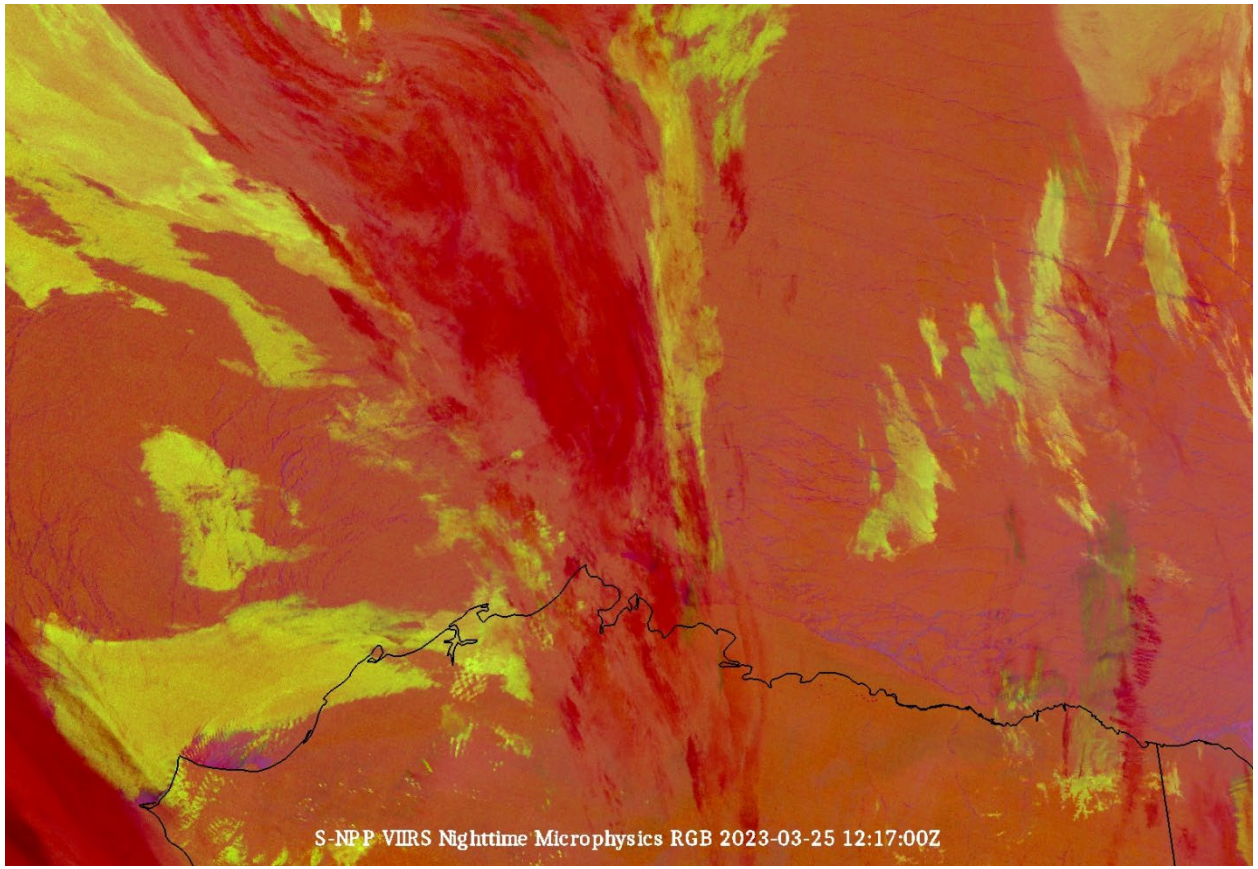




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

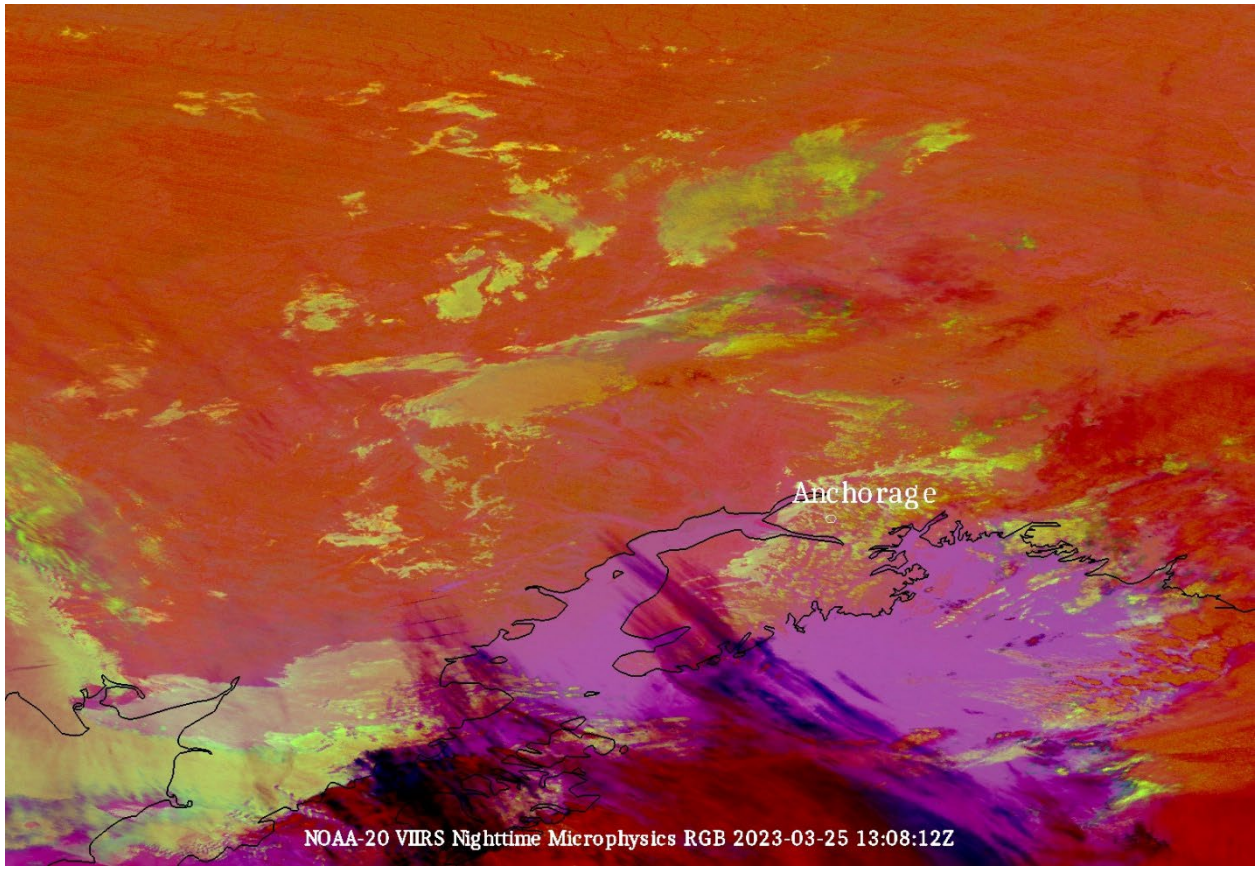
Alaska Nighttime Low Clouds
20230325
S-NPP
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

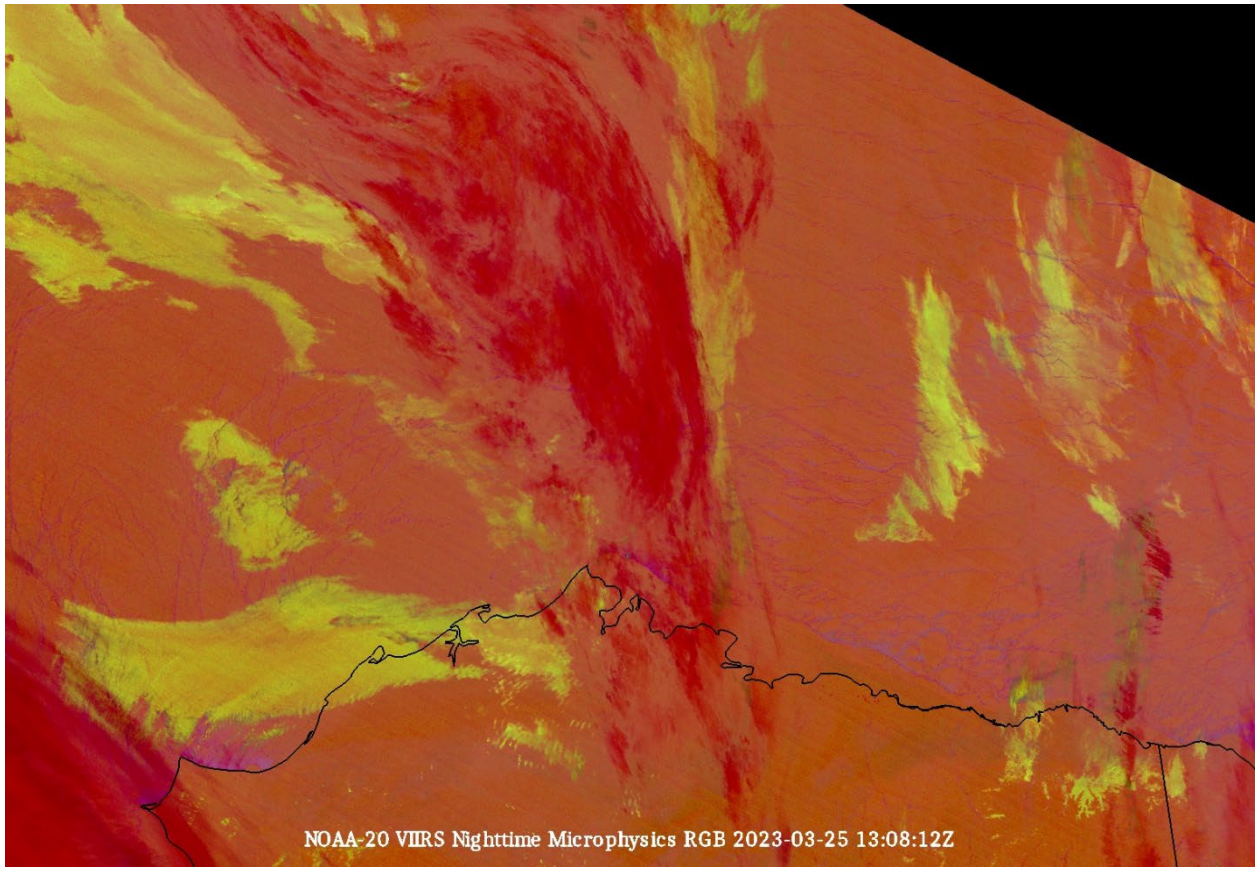




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

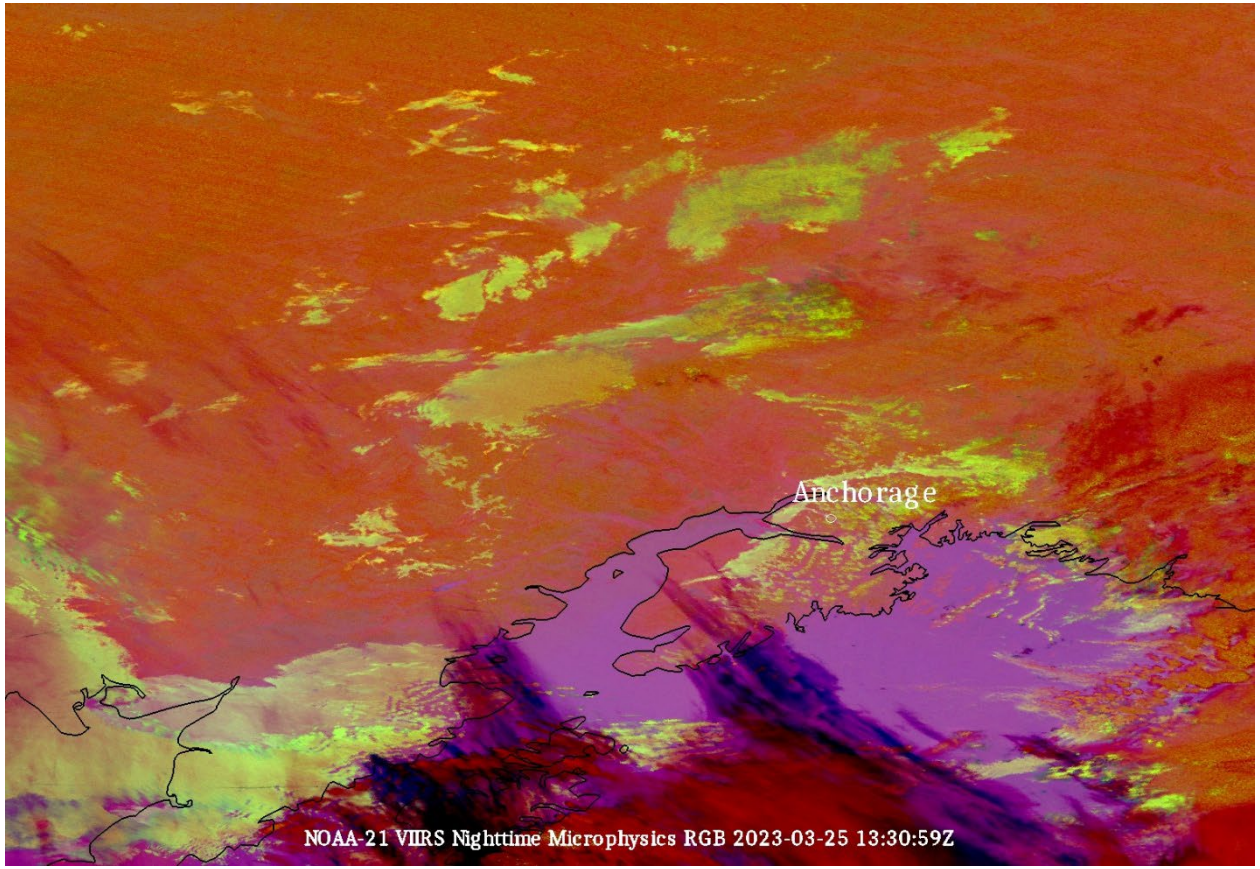
Alaska Nighttime Low Clouds
20230325
NOAA-20
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

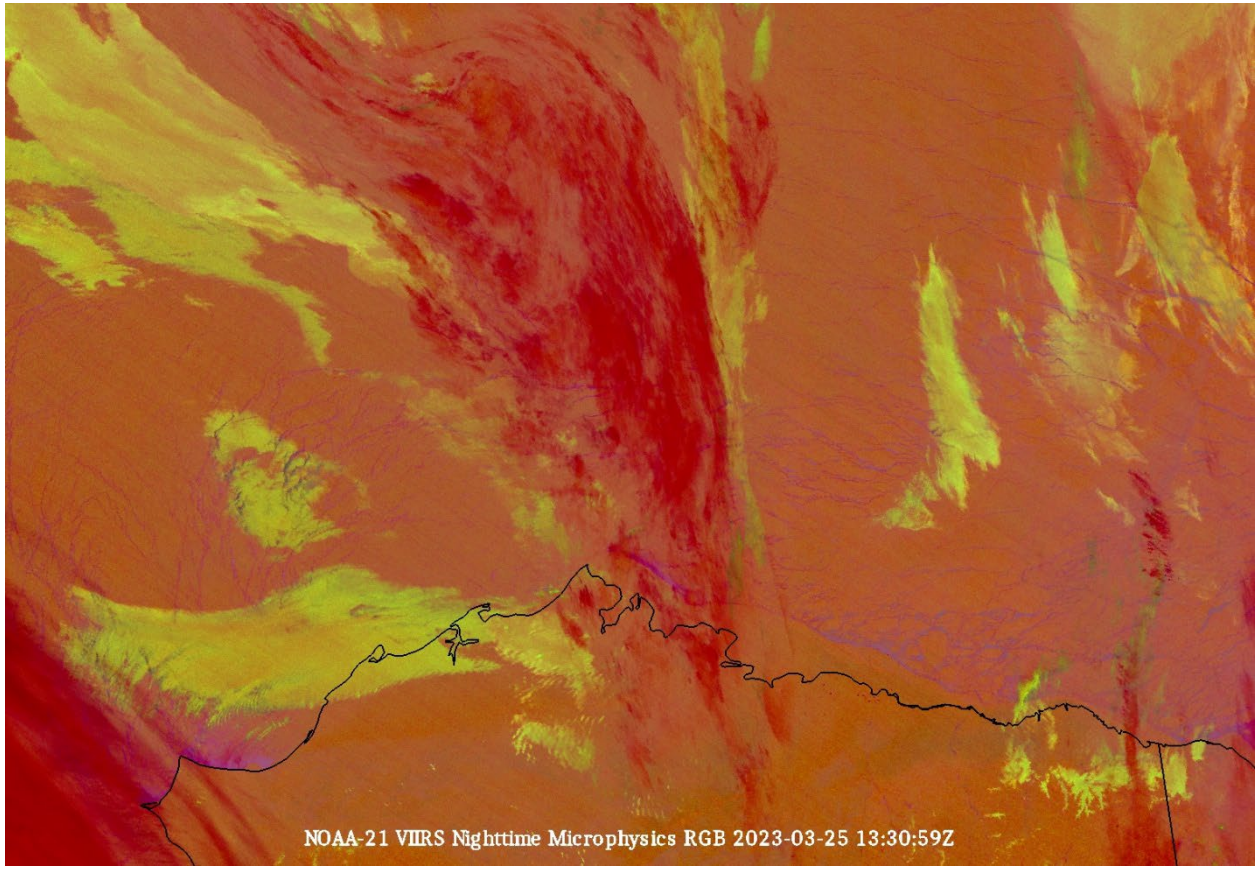




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

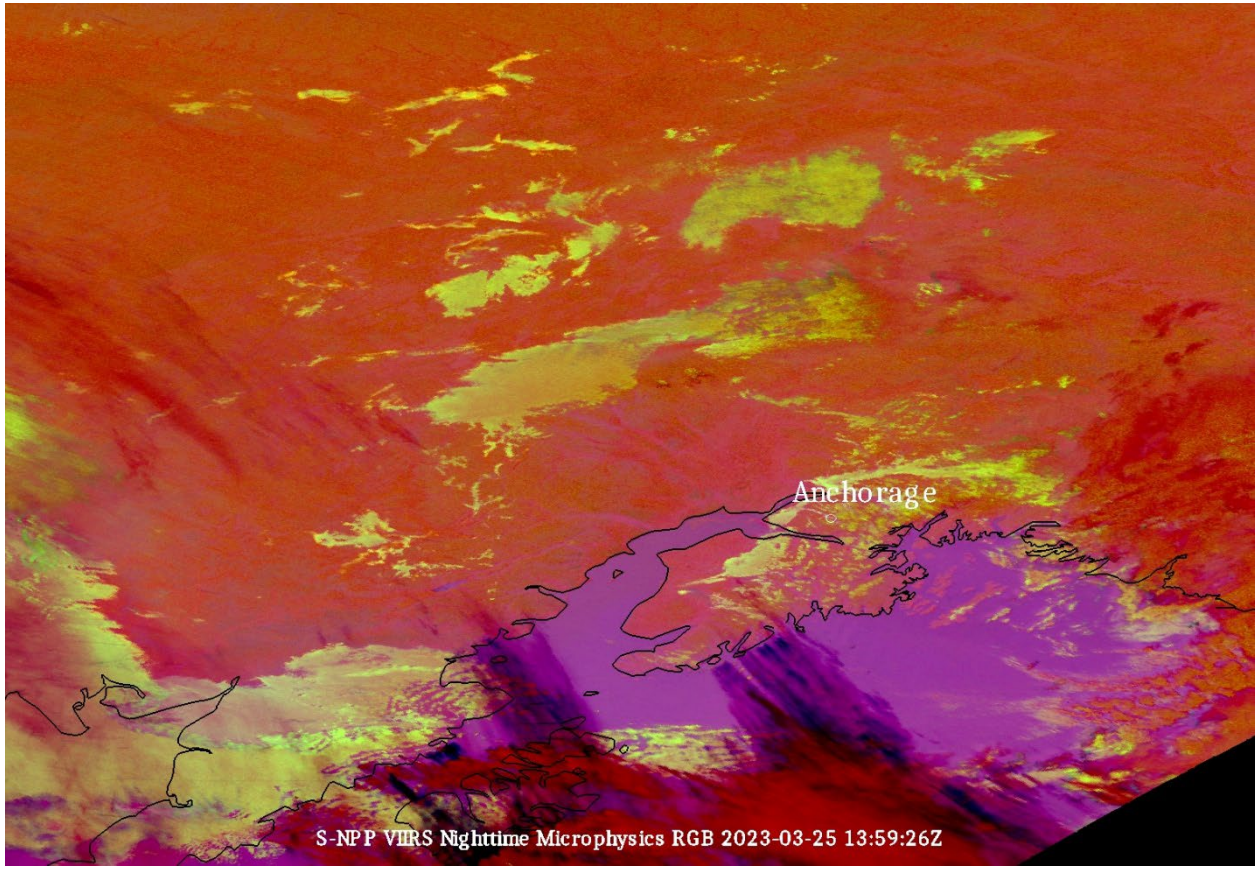
Alaska Nighttime Low Clouds
20230325
NOAA-21
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)

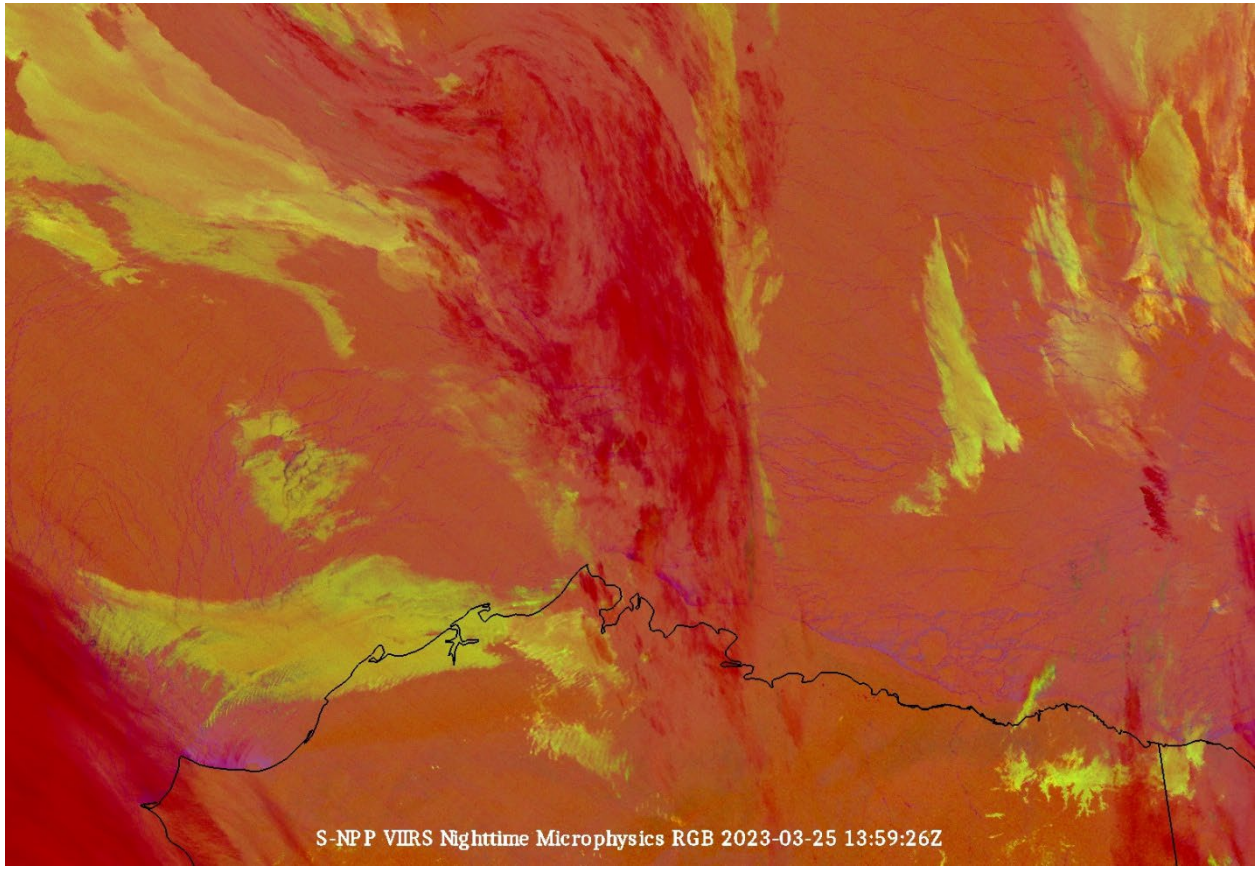




VIIRS Nighttime Microphysics RGB Comparison – Alaska (3/25/2023)

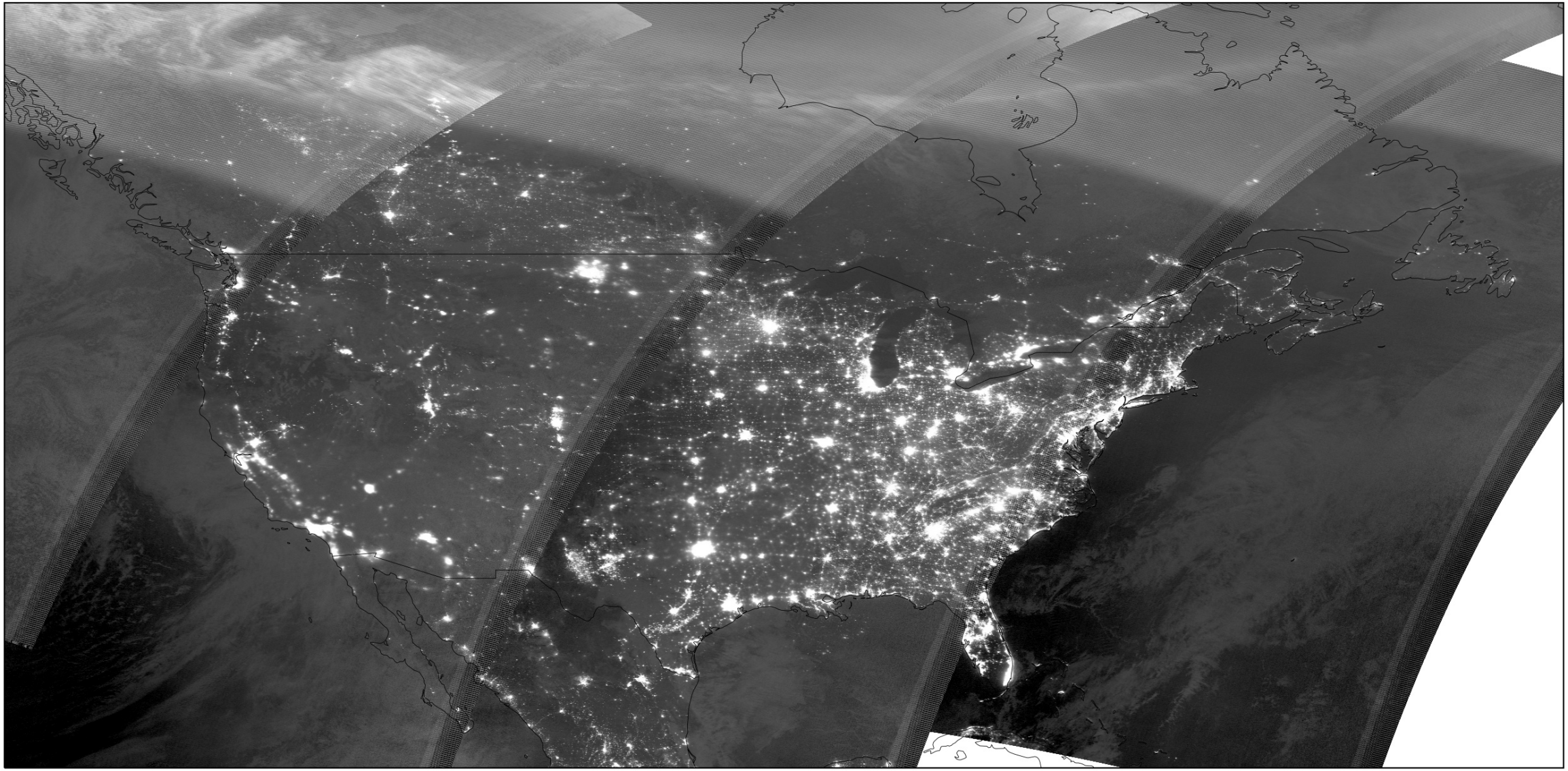
Alaska Nighttime Low Clouds
20230325
S-NPP
Nighttime Microphysics RGB
(M16-M15, M15-M13, M15)





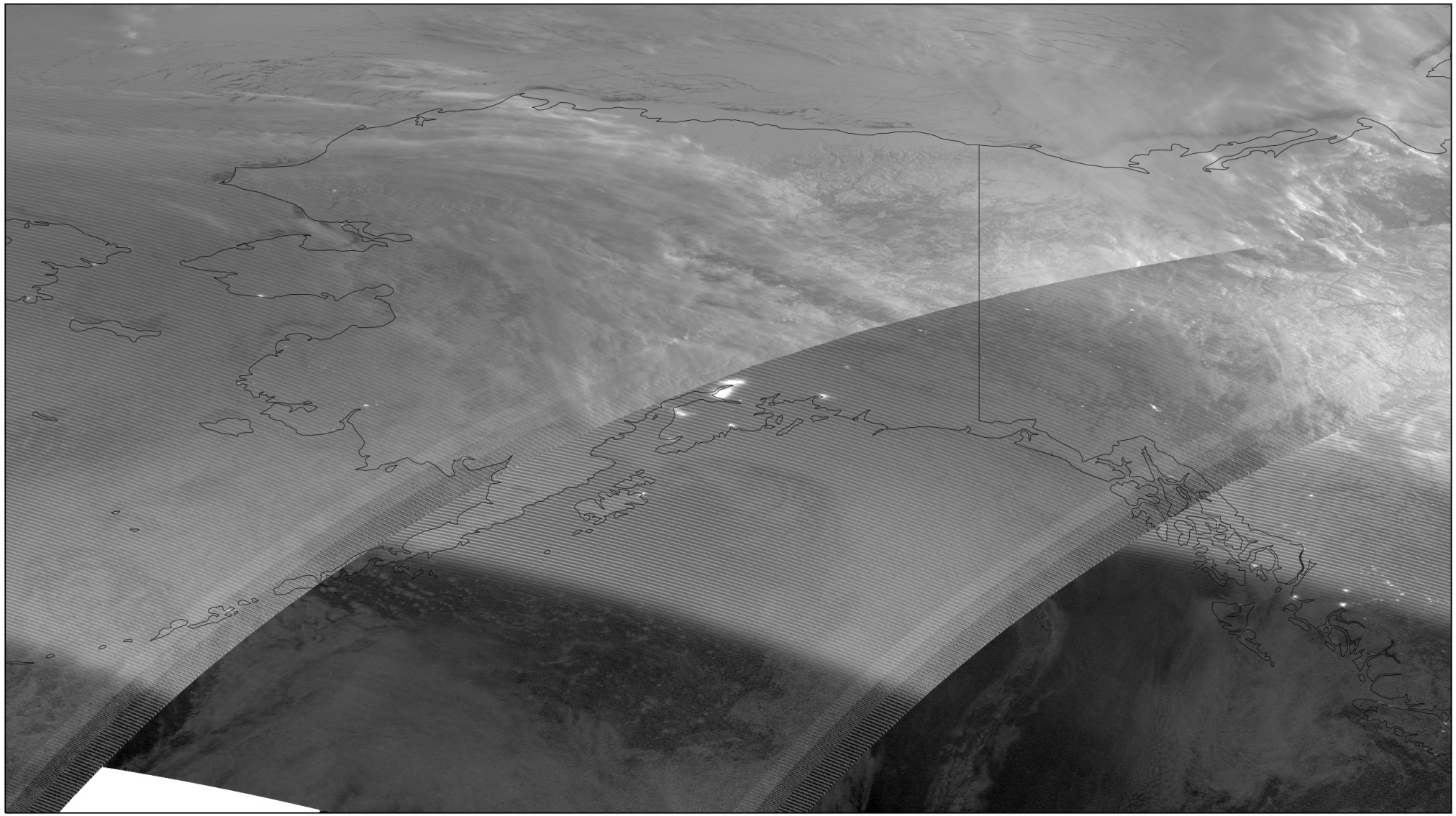
Global Composite
20230322
NOAA-21
NCC (-0.3 to 3)

20230321 NOAA-21 VIIRS NCC



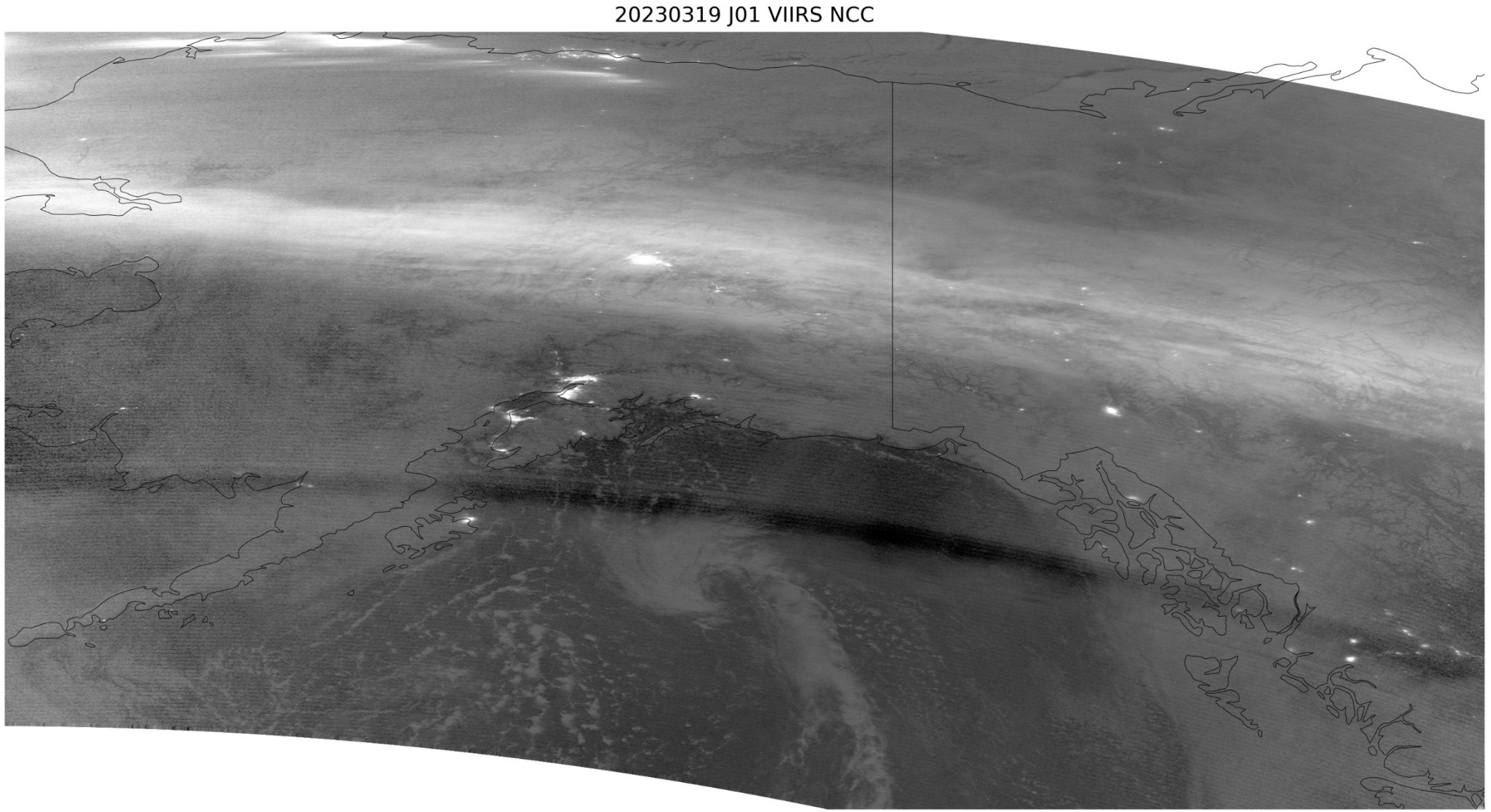
Global Composite
20230322
NOAA-21
NCC (-0.1 to 2)

20230321 NOAA-21 VIIRS NCC



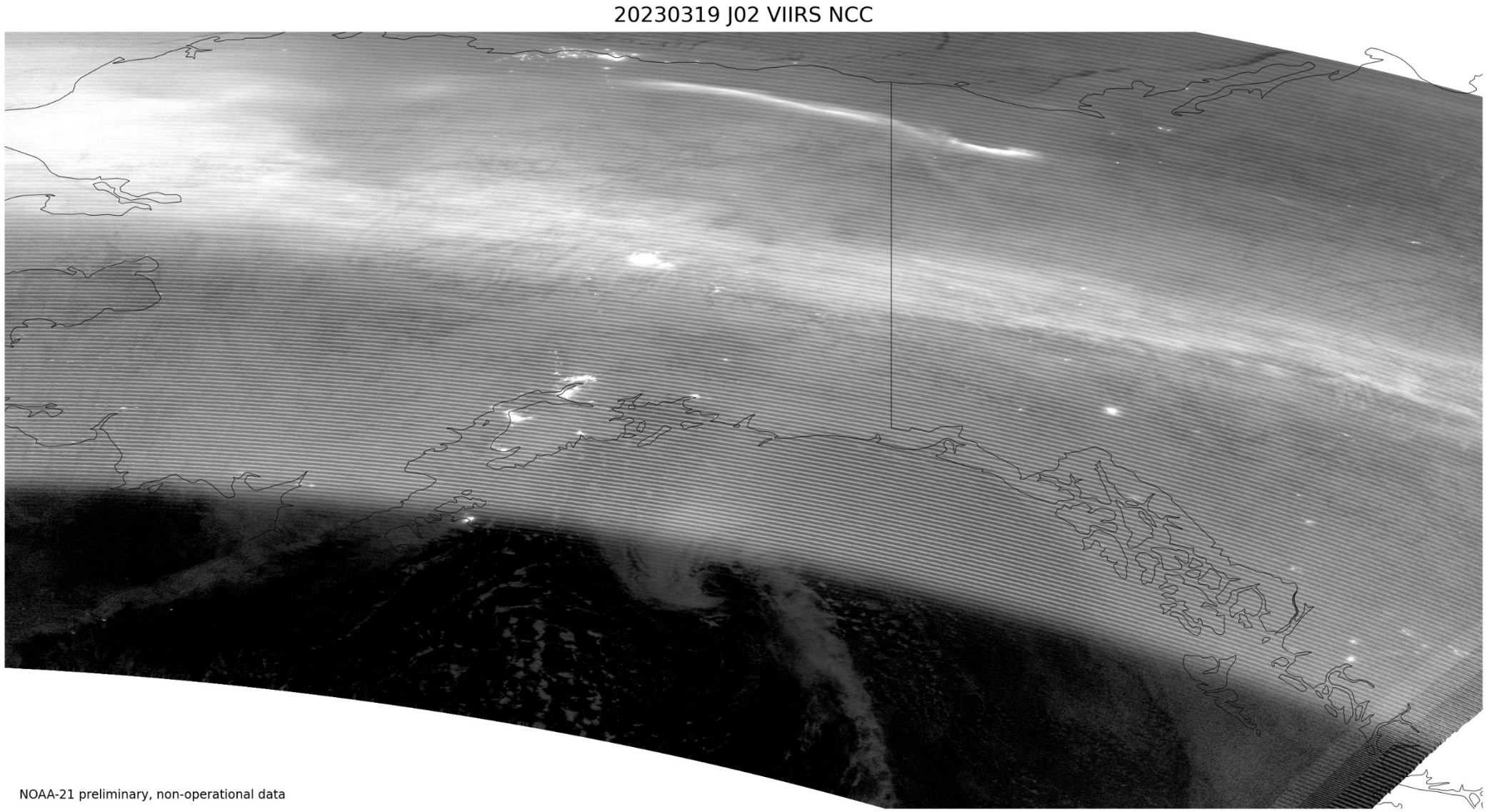
NCC Over Alaska

Alaska
20230319 (Night)
NOAA-20
NCC (0 to 1.6)



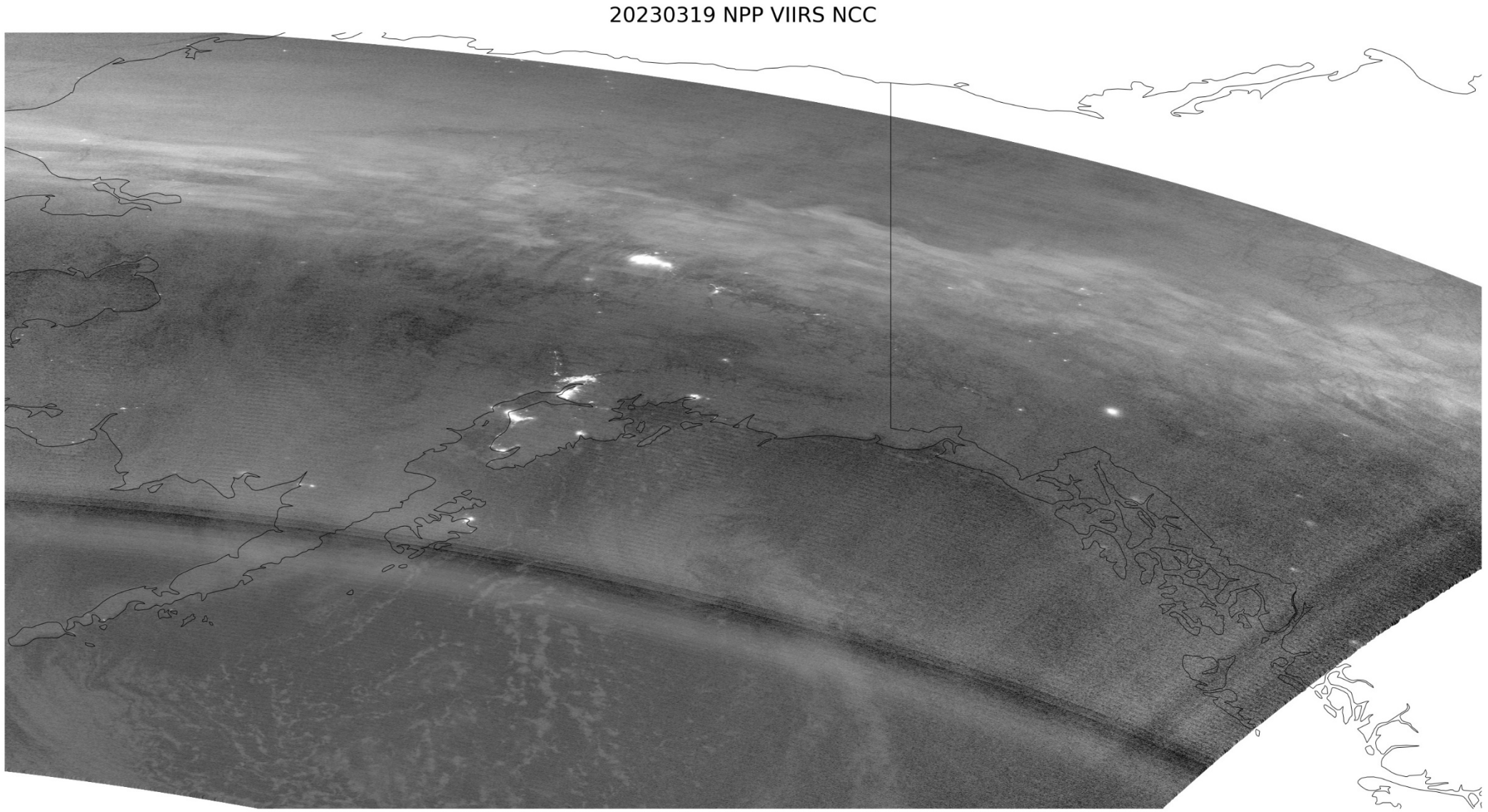
NCC Over Alaska

Alaska
20230319 (Night)
NOAA-21
NCC (0 to 1.6)



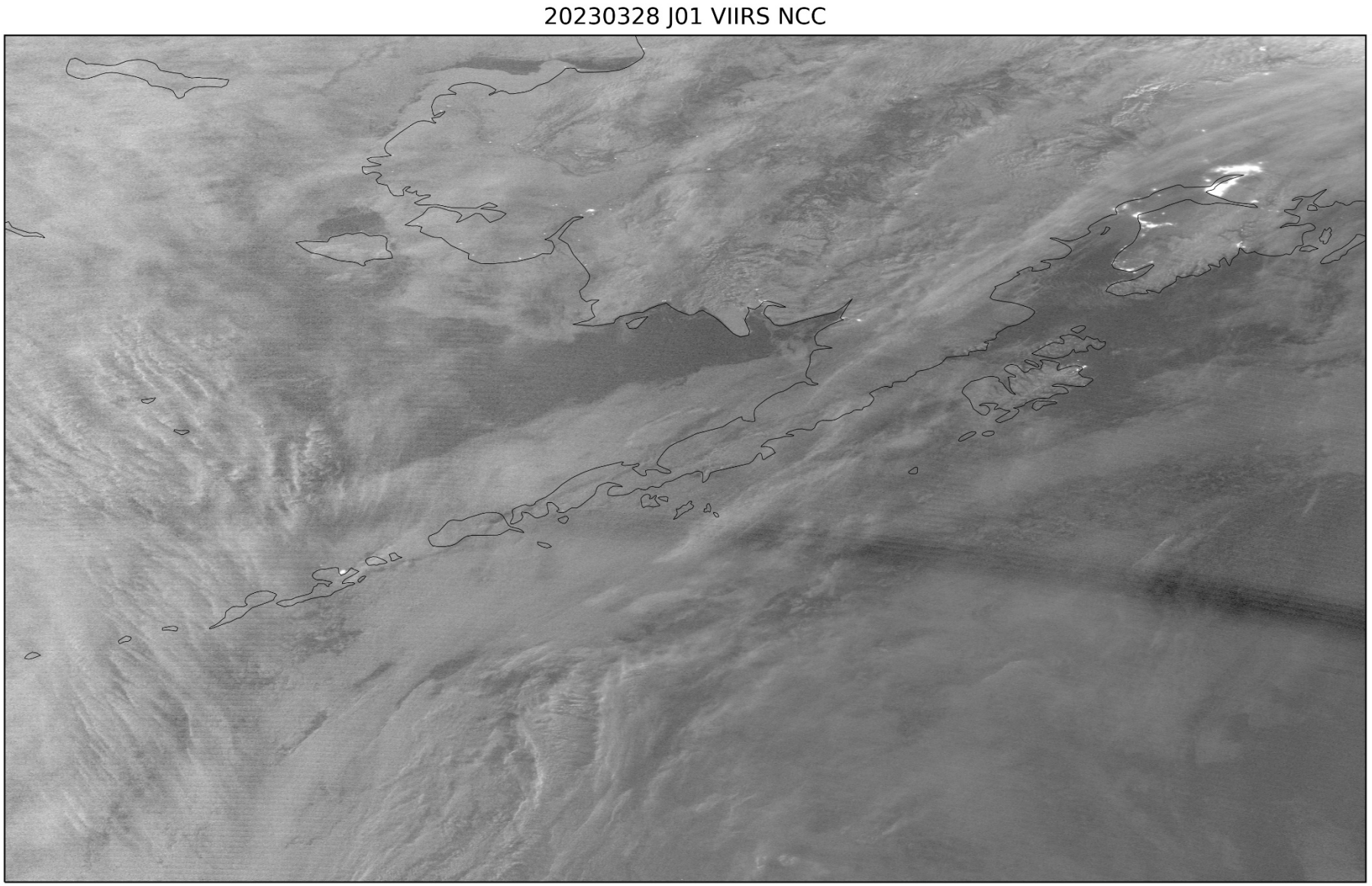
NCC Over Alaska

Alaska
20230319 (Night)
S-NPP
NCC (0 to 1.6)



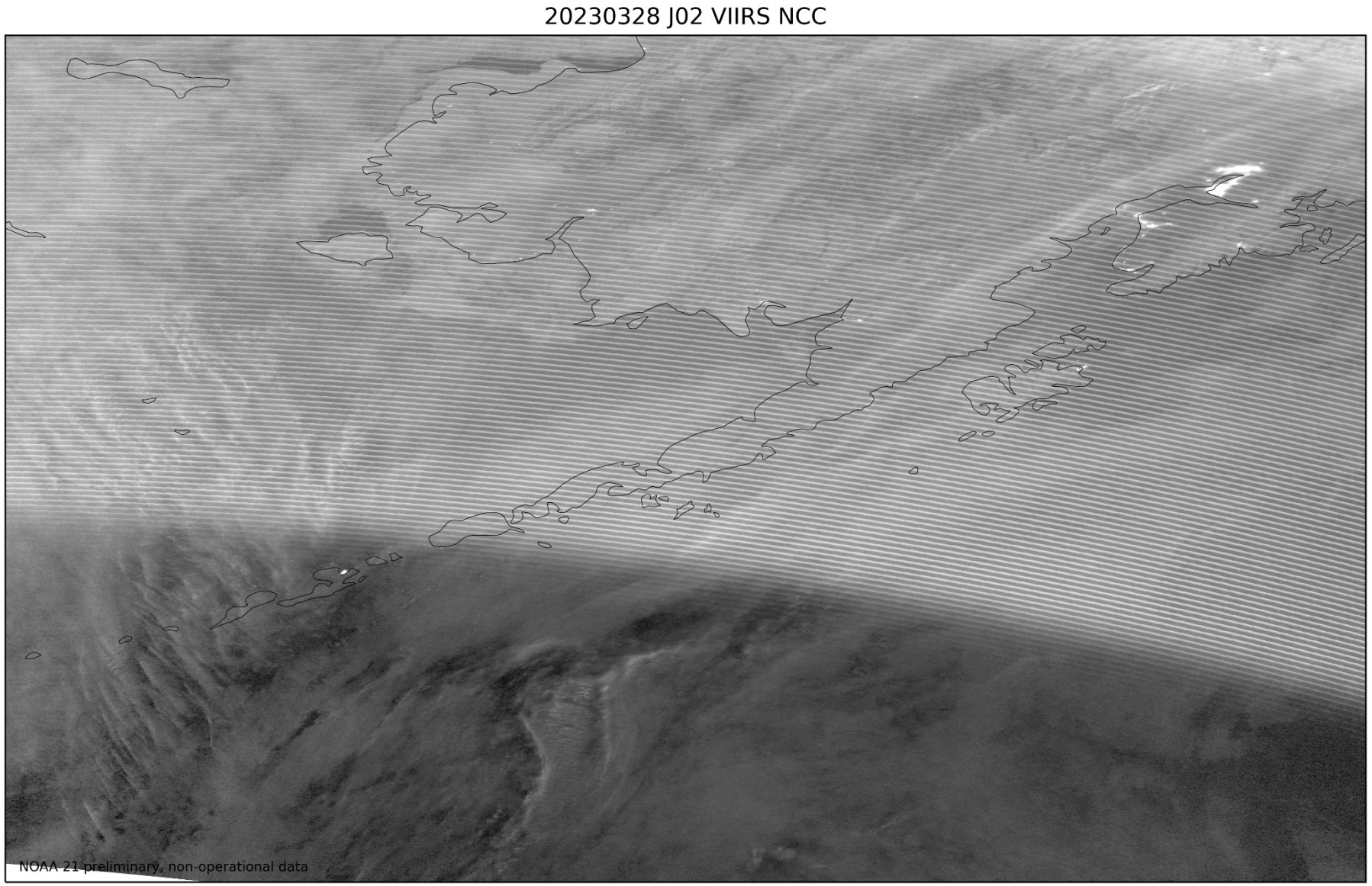
NCC Over Alaska Aleutian Islands

Alaska
20230328 (Night)
NOAA-20
NCC (-0.1 to 1.1)



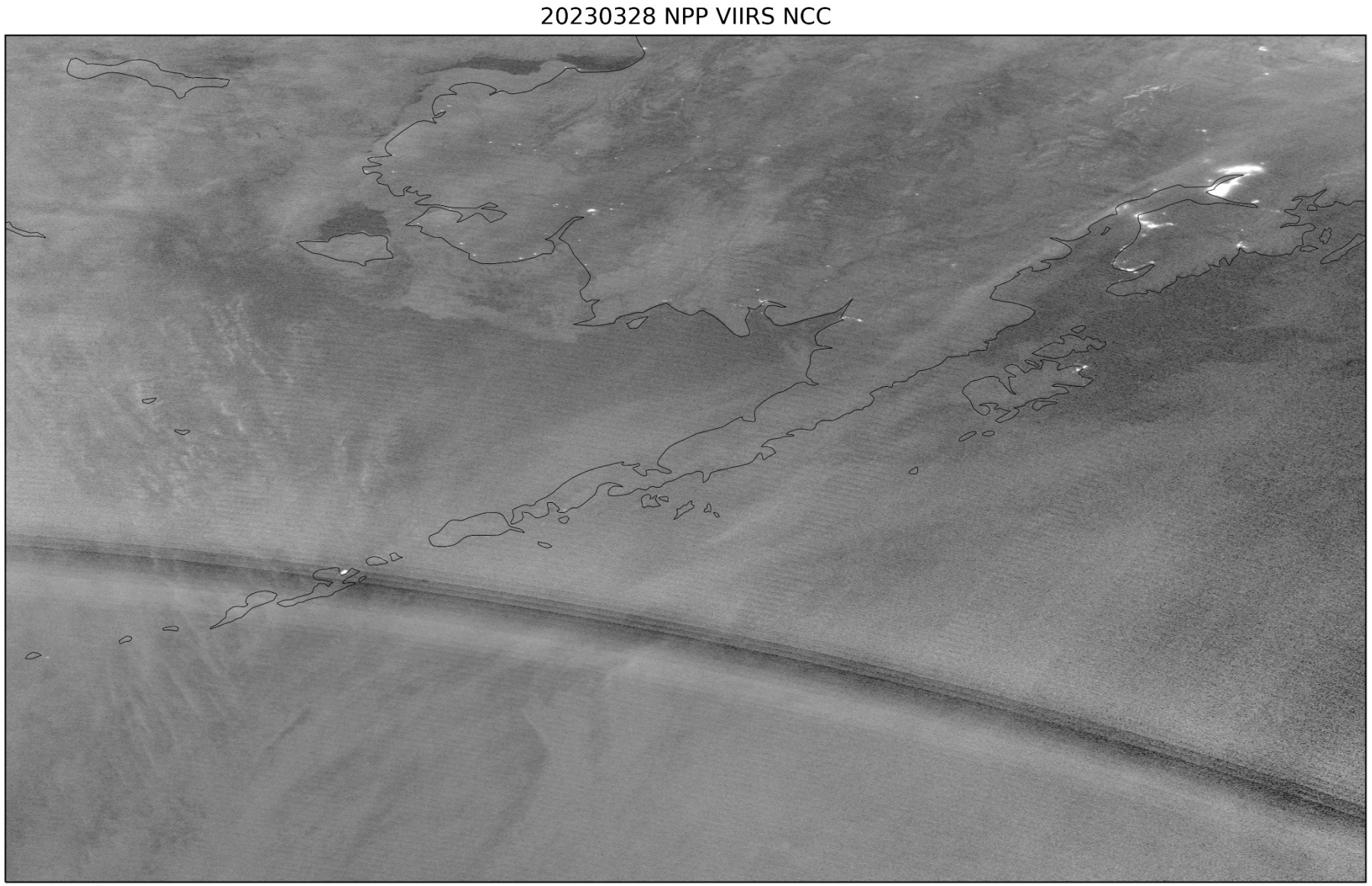
NCC Over Alaska Aleutian Islands

Alaska
20230328 (Night)
NOAA-21
NCC (-0.1 to 1.1)



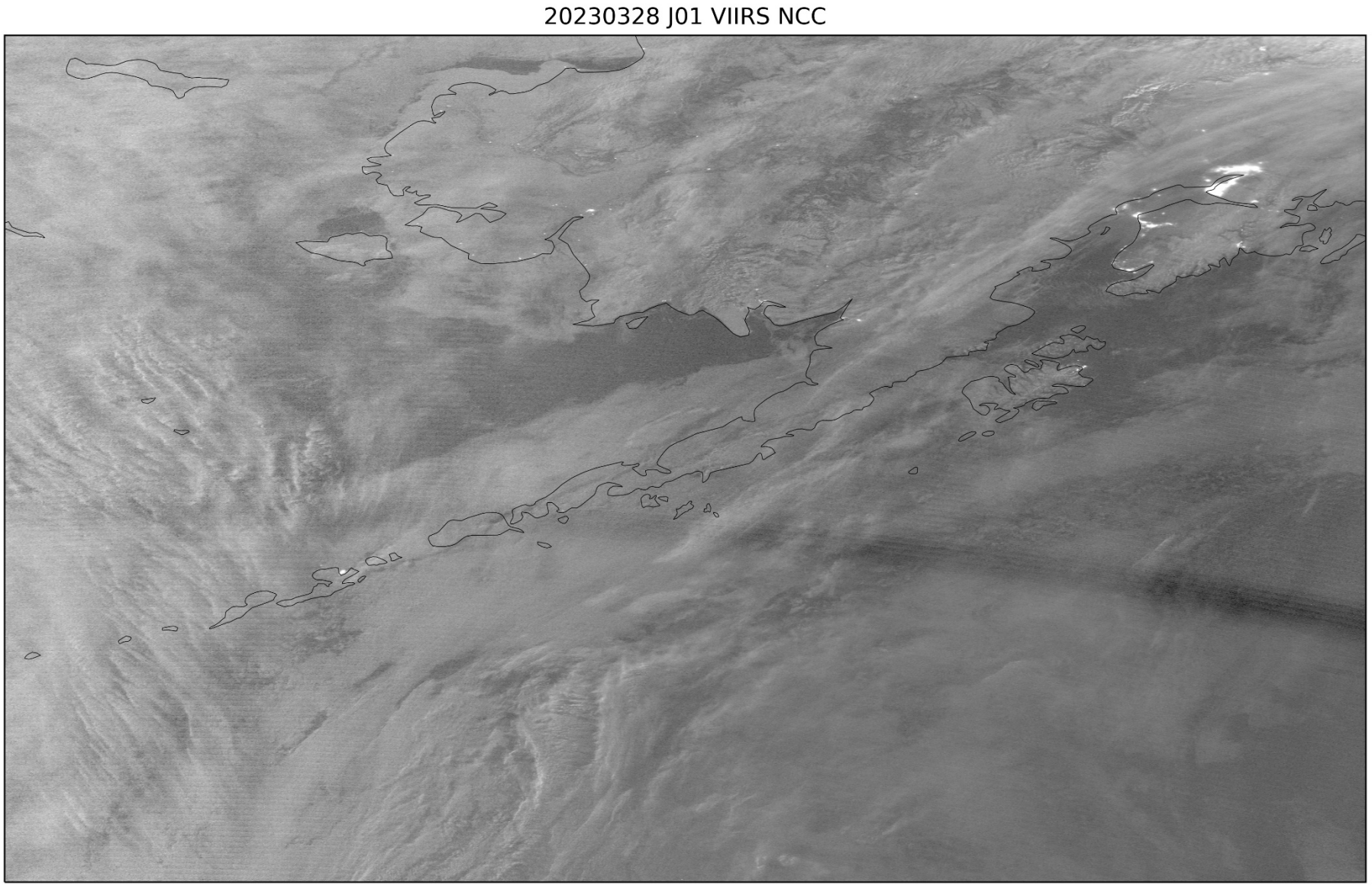
NCC Over Alaska Aleutian Islands

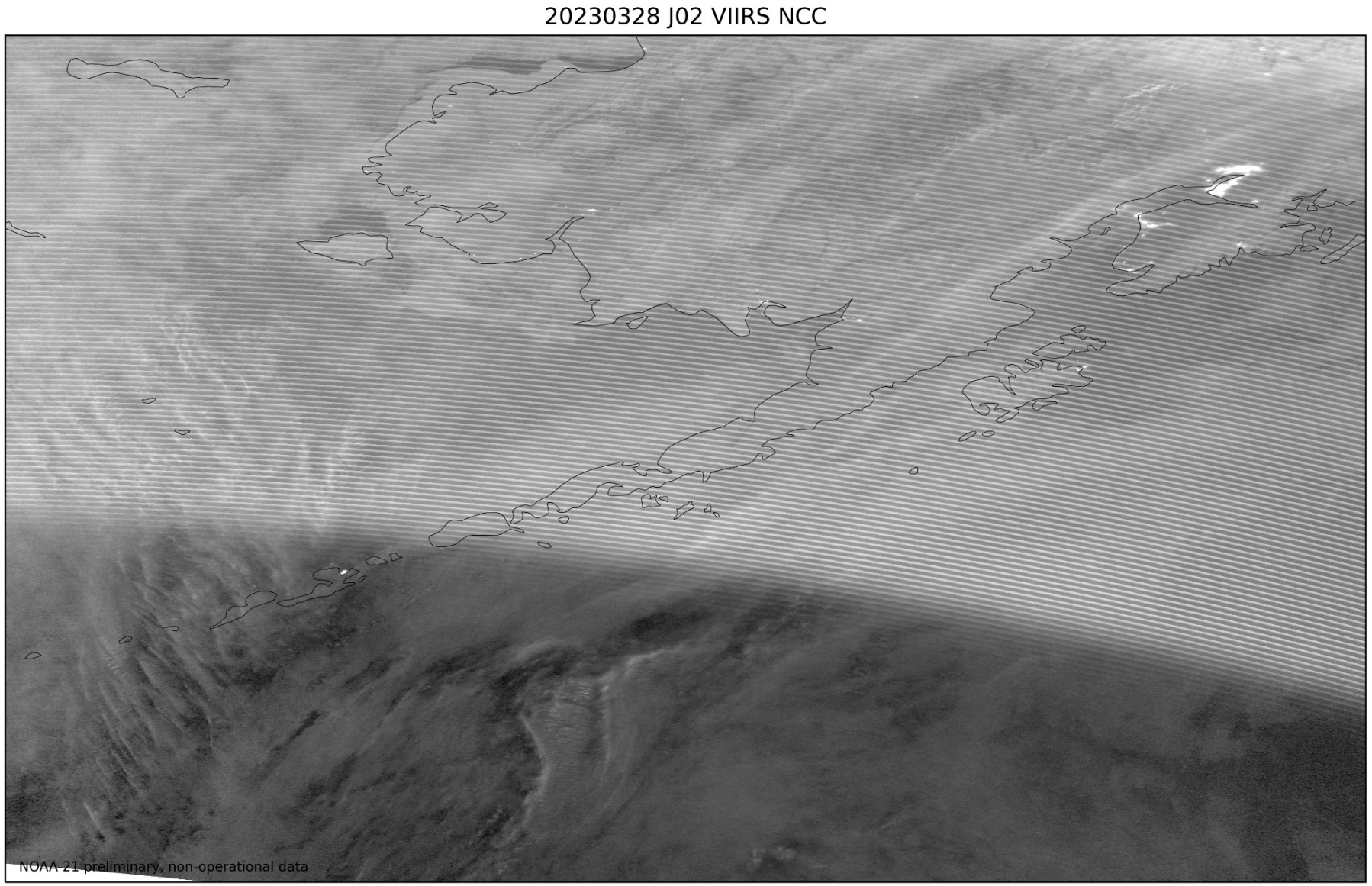
Alaska
20230328 (Night)
S-NPP
NCC (-0.1 to 1.1)



NCC Over Alaska Aleutian Islands

Alaska
20230328 (Night)
NOAA-20
NCC (-0.1 to 1.1)



NCC Over Alaska Aleutian Islands

Alaska
20230328 (Night)
NOAA-21
NCC (-0.1 to 1.1)