# GOES-R Program Overview

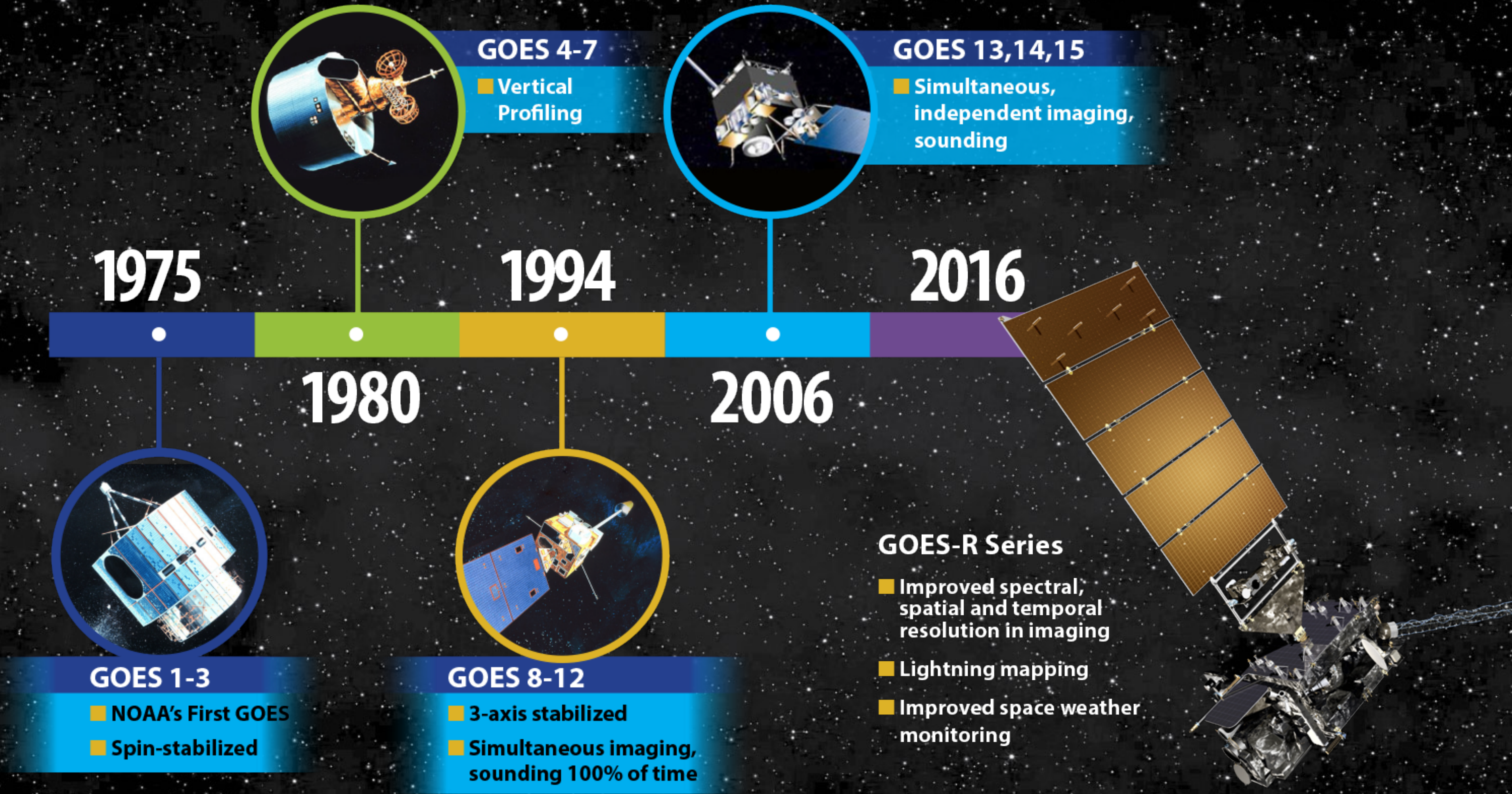

## Dan Lindsey

NESDIS Senior Scientific Adviser
to the GOES-R Program

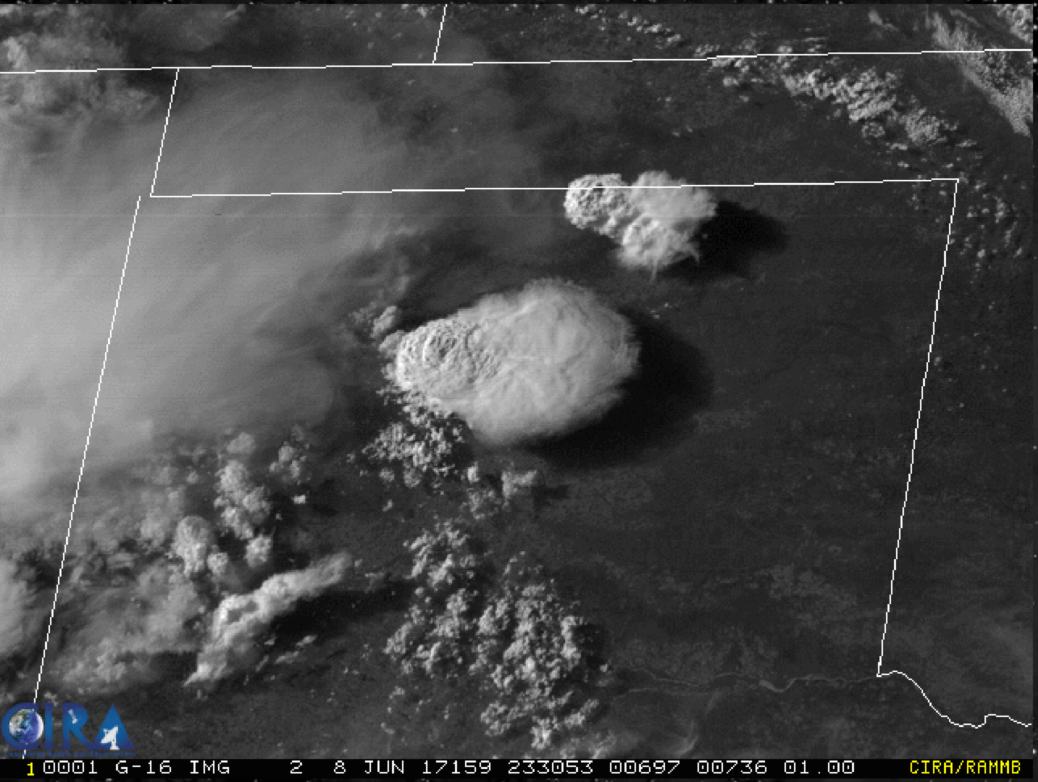

AQPG Workshop
College Park, MD

26 September 2018

# A History of GOES Weather Satellites



# GOES-16 Update

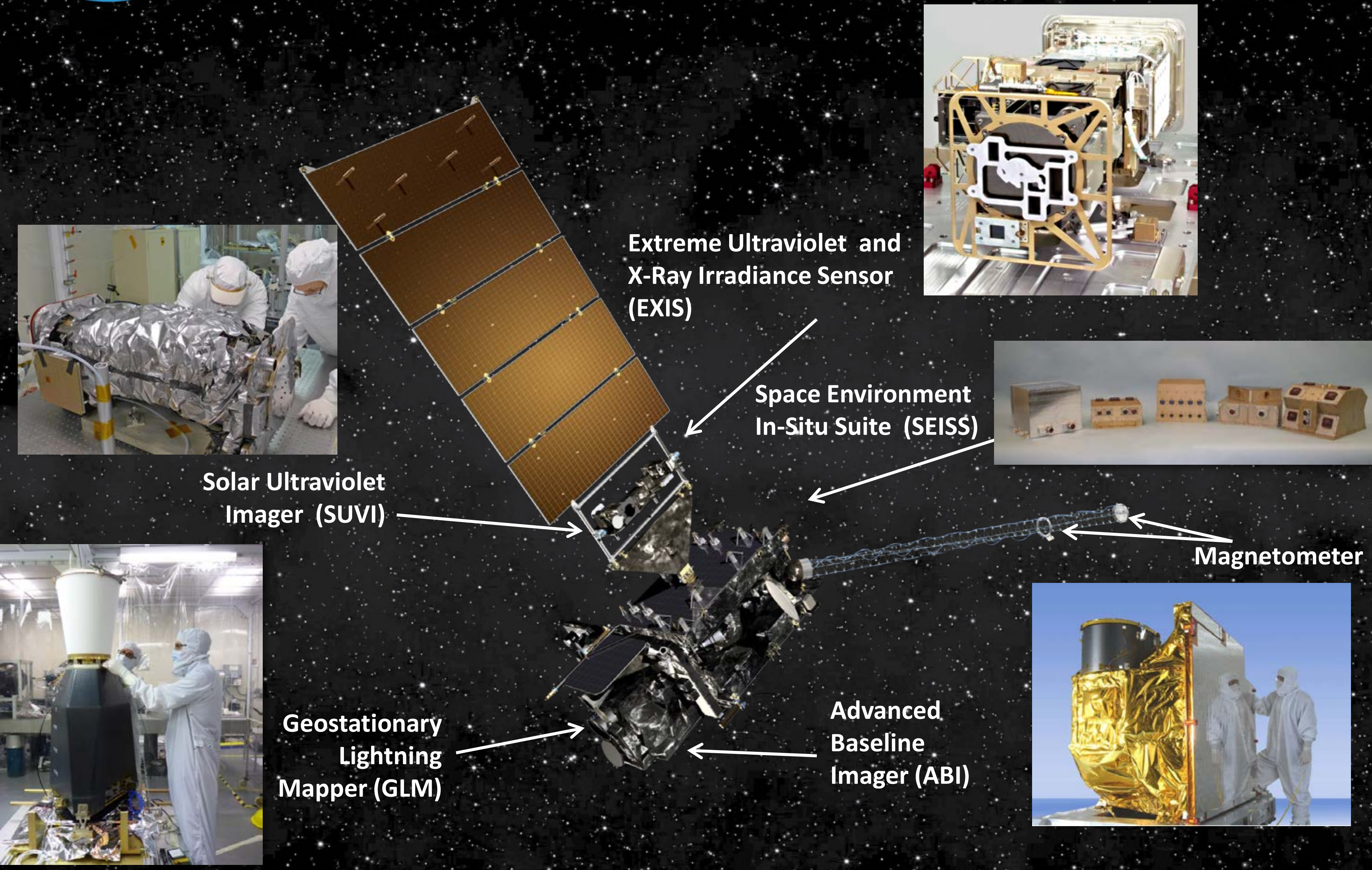



- Became operational as GOES-East on December 18, 2017
- Continuing data product validation
  - 8 of 10 L1b data products achieved provisional status
  - 17 of 24 ABI L2 products achieved provisional
- New products in development
  - Sea & lake ice concentration, thickness, motion
  - Aerosol particle size
  - Blended Sea Surface Temperature
- Plan to switch ABI scan mode to 10 minute full disk mode after testing on GOES-17

# GOES-S Launch – March 1, 2018

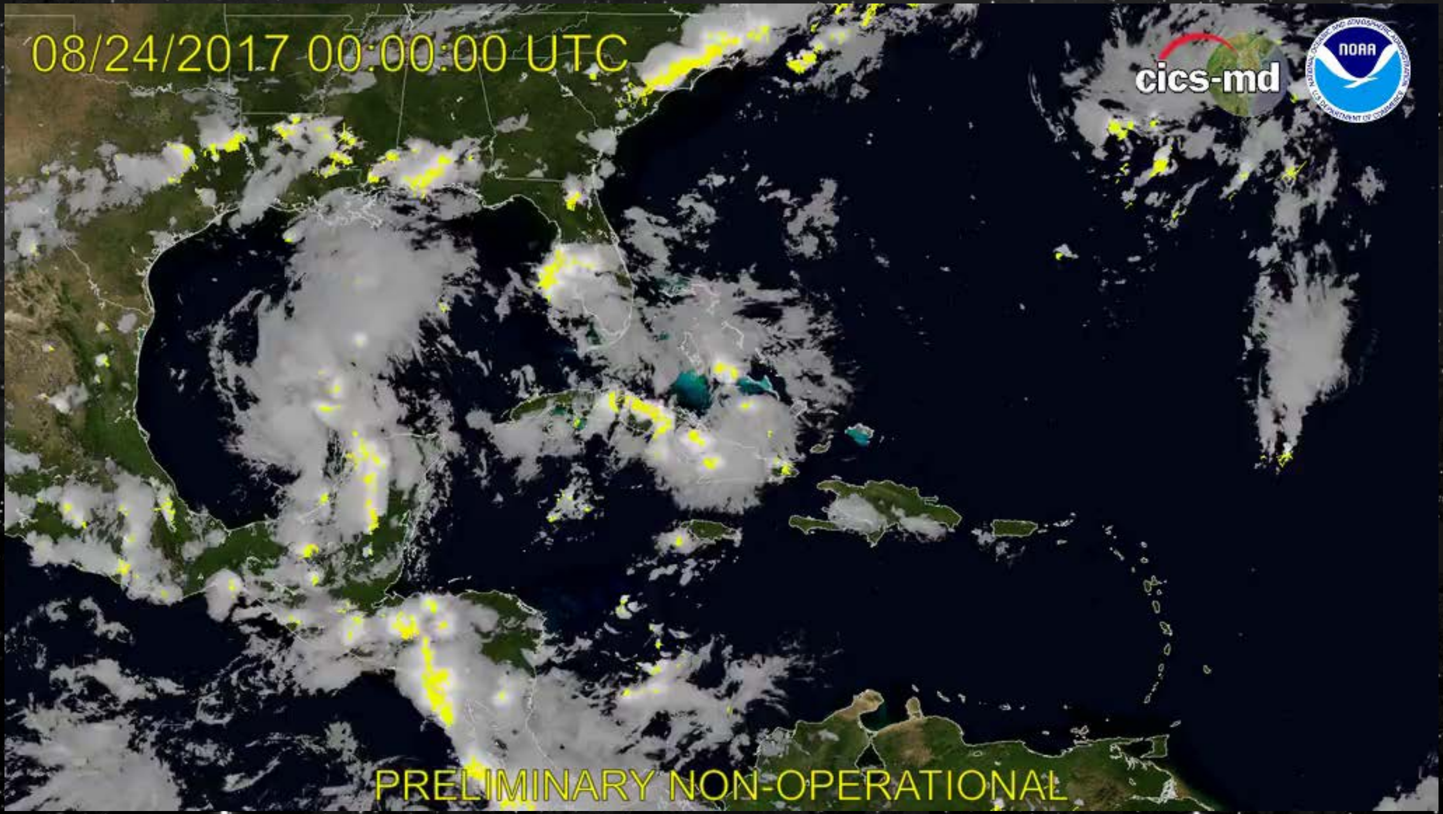
- GOES-S was successfully launched on March 1, 2018, from Kennedy Space Center
- Reached geostationary orbit on March 12 and was renamed GOES-17
- Undergoing checkout from 89.5 W longitude until late October
- Will be moved to 137 W in Oct/Nov and later will become the operational GOES-W
- The ABI cooling system is not working properly, resulting in seasonal IR data issues; Tim's talk provide details

# GOES-R Series Spacecraft



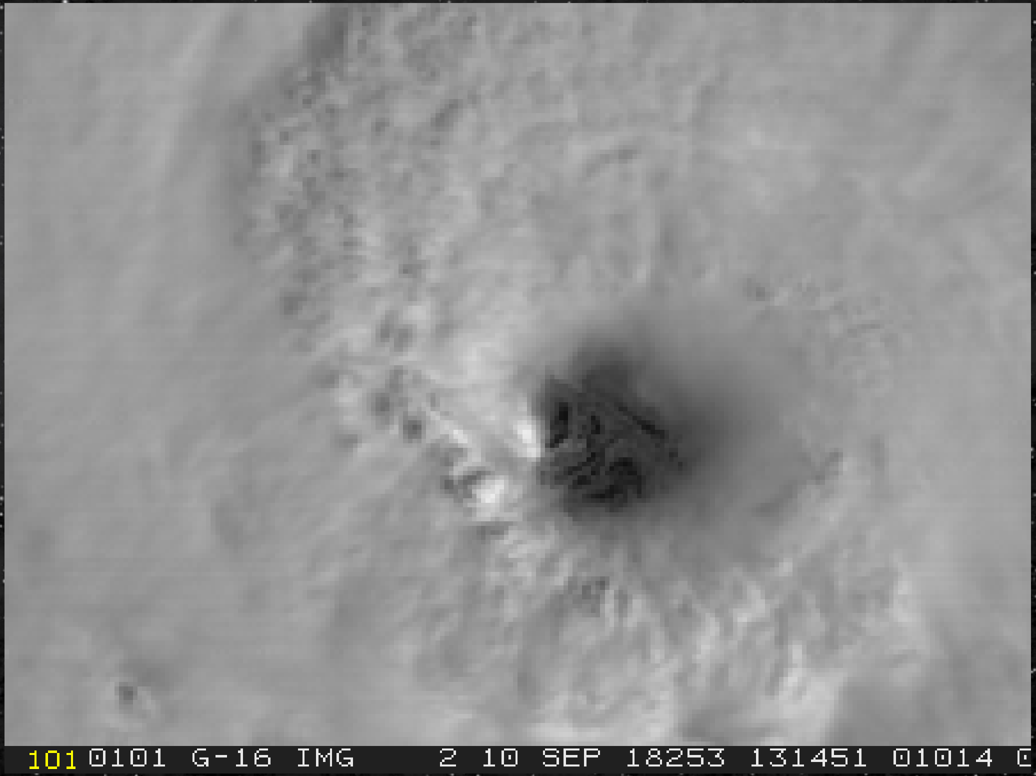
# Geostationary Lightning Mapper (GLM)

- First operational lightning mapper flown in geostationary orbit
- Detects total lightning activity across the Western Hemisphere: in-cloud, cloud-to-cloud, and cloud-to-ground
- Can lead to improved forecaster situational awareness and confidence resulting in more accurate and timely severe storm warnings



# Advanced Baseline Imager (ABI)

- Primary instrument on GOES-R series
- Spatial Resolution: 500-m to 2-km, depending on the channel
- Temporal: Scans the Full Disk every 15 minutes, and can scan smaller sectors (a few U.S. states) every 30 seconds!
- Spectral: 16 total bands
- These improvements are a factor of 3 increase in spectral, a factor of 4 increase in spatial, and a factor of 5 increase in temporal resolutions compared to current GOES




30-sec visible imagery of Hurricane Florence

# Aerosol Detection with the ABI

| Band | Channel (µm) | Function | GOES-15 |
|---|---|---|---|
| 1 | 0.47 | Blue | |
| 2 | 0.64 | Red | Yes (0.63µm) |
| 3 | 0.86 | Green (Veggie) | |
| 4 | 1.38 | Cirrus | |
| 5 | 1.61 | Snow/Ice | |
| 6 | 2.25 | Cloud Particle Size | |
| 7 | 3.90 | Shortwave Window | Yes |
| 8 | 6.18 | Upper-Level Water Vapor | Yes (6.48µm) |
| 9 | 6.95 | Mid-Level Water Vapor | |
| 10 | 7.34 | Lower-Level Water Vapor | |
| 11 | 8.50 | Cloud Top Phase | |
| 12 | 9.61 | Ozone | |
| 13 | 10.35 | Clean IR Longwave Window | |
| 14 | 11.20 | IR Longwave Window | Yes (10.7µm) |
| 15 | 12.30 | Dirty Longwave Window | |
| 16 | 13.30 | $CO_2$ Longwave Infrared | Yes |

1. Channel 1 Visible

Some aerosol particles effectively scatter visible wavelength radiation, particularly in the blue portion of the spectrum. Especially smoke, and the scattering is more in the forward direction.

This means smoke is easiest to detect when the sun-aerosol-satellite orientation is ideal, i.e., near sunrise and sunset

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2. True Color Imagery

We don't have a green band, but CIRA has developed a way to approximate the green component using info from the Himawari AHI

True color imagery allows for easily distinguishing aerosols by color, i.e., brown dust, blueish smoke, gray volcanic ash, etc.

More on this later

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3. Infrared Techniques

The split window difference (Window IR minus Dirty Window) can effectively isolate blowing dust and volcanic ash

Either the 10.35 or 11.2 µm can be used as the Window IR in the difference, but any thresholds will need to be adjusted accordingly

Generally speaking, negative brightness temperatures of 10.35 – 12.3 µm means blowing dust or volcanic ash

# Aerosol Detection with the ABI

| Band | Channel (µm) | Function | GOES-15 |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
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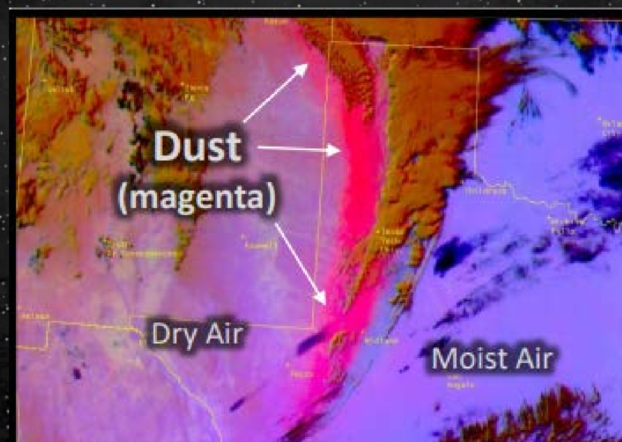
4. Infrared Techniques - RGB

The EUMETSAT Dust RGB

## Dust RGB Recipe

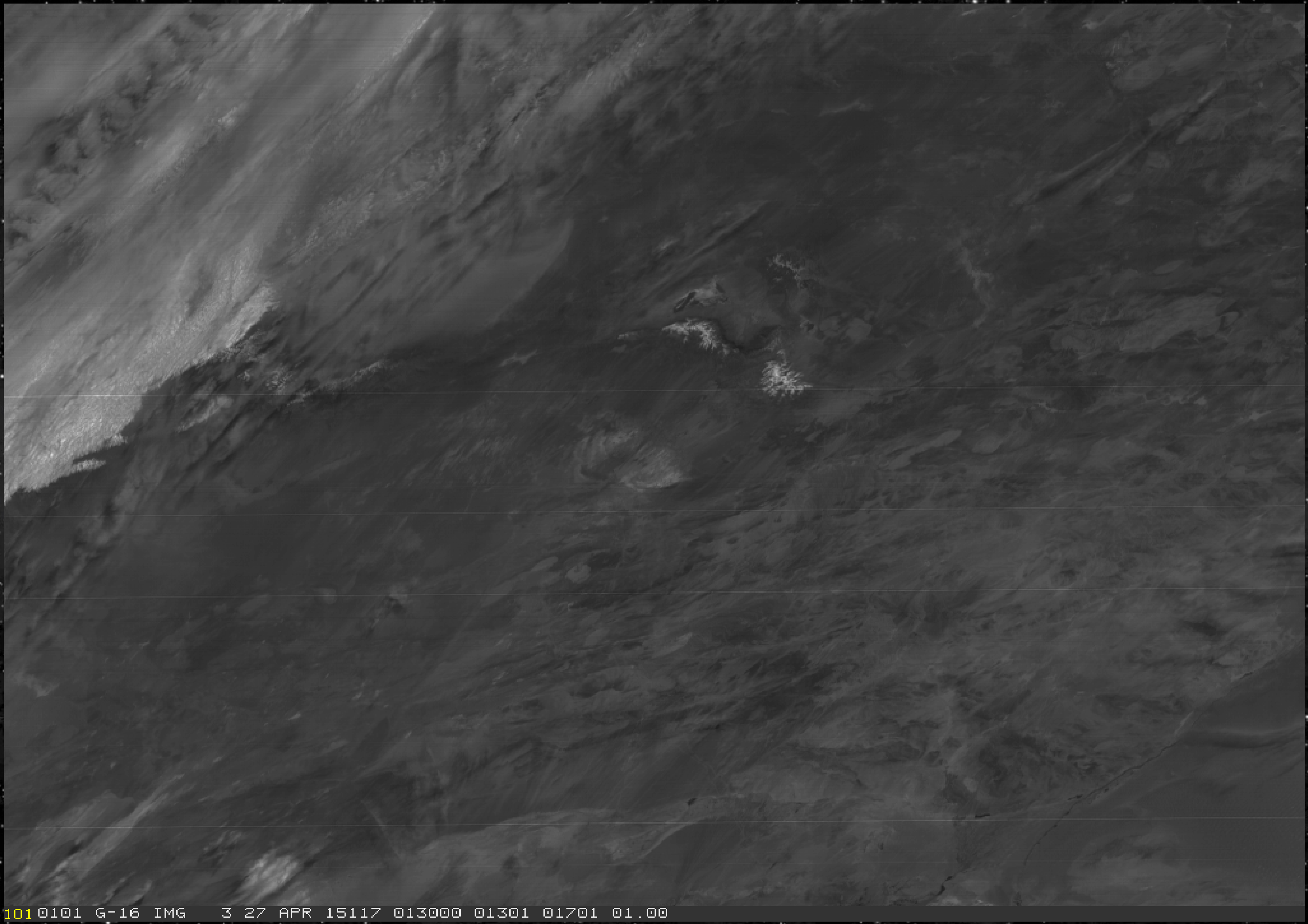
| Color | Band / Band Diff. (µm) | Min – Max Gamma | Physically Relates to… | Small contribution to pixel indicates… | Large Contribution to pixel indicates… |
|---|---|---|---|---|---|
| Red | 12.3-10.3 | -6.7 to 2.6 C 1 | Optical depth / cloud thickness | Thin clouds | Thick clouds or dust |
| Green | 11.2-8.4 | -0.5 to 20.0 C 2.5 | Particle phase | Ice and particles of uniform shape (dust) | Water particles or thin cirrus over deserts |
| Blue | 10.3 | -11.95 to 15.55 C 1 | Surface temperature | Cold surface | Warm surface |



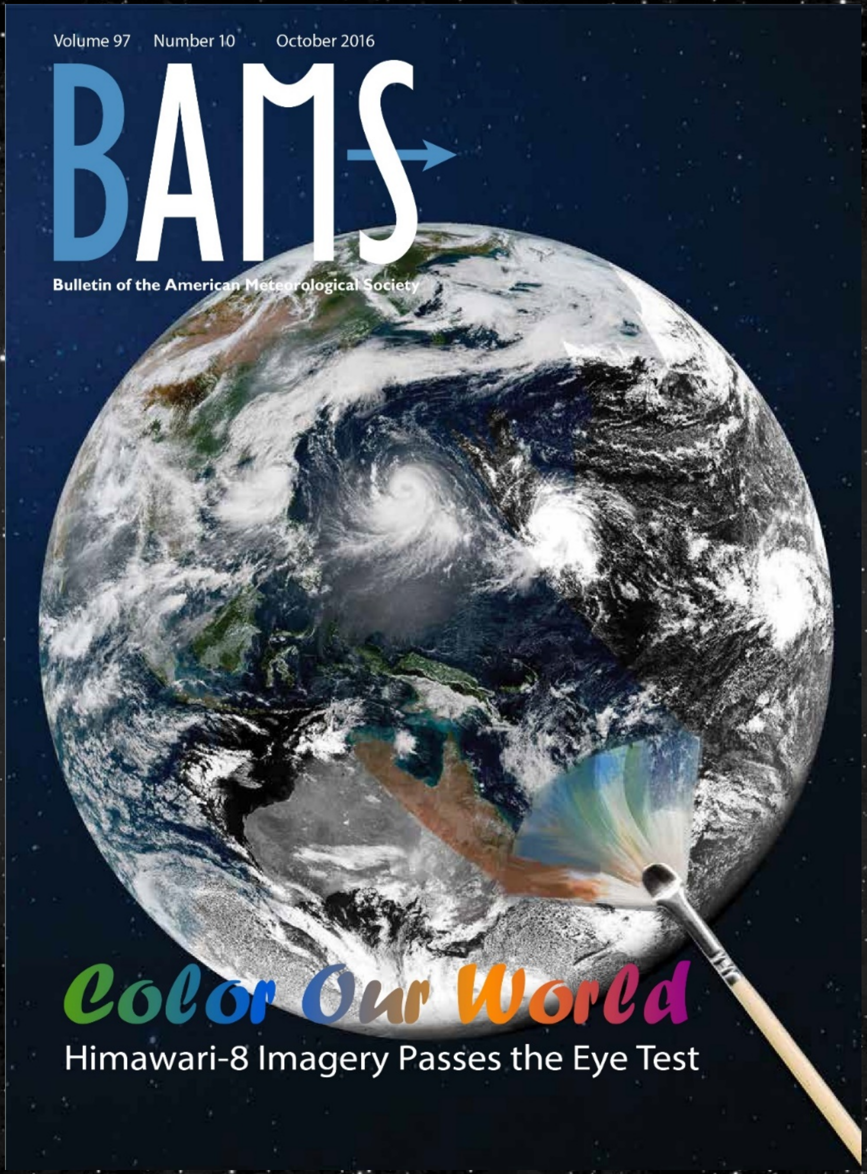

*Dust RGB from GOES-16 ABI at 2302 UTC, 23 March 2017*

# Blowing Dust – western China

## Himawari AHI Band 3 (red) Visible



# True Color Imagery from Geostationary Orbit

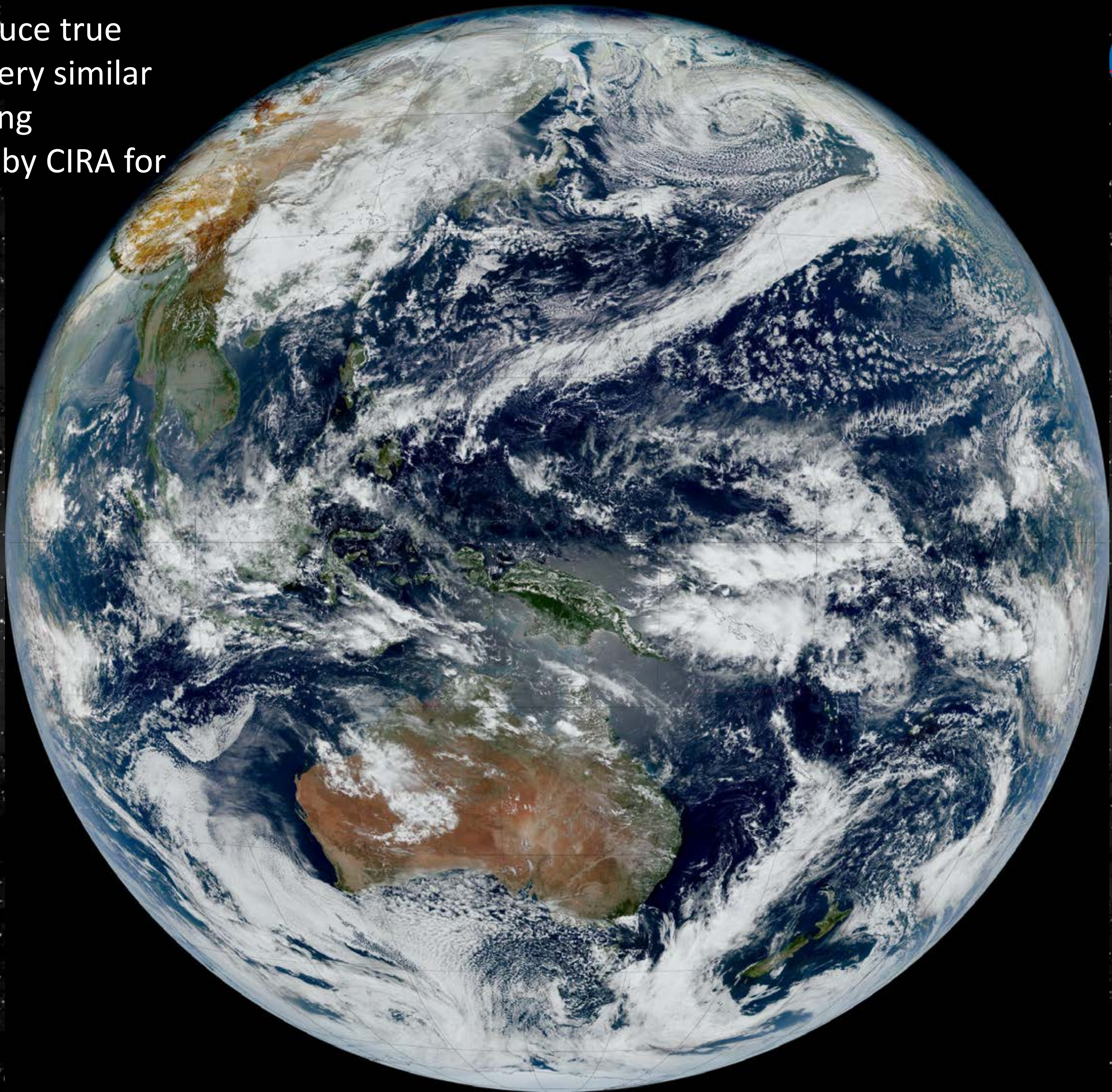


# Channels for ABI, AHI, and others

| Approx. Central Wavelength (µm) | Band Explanation | GOES-R ABI | Himawari AHI | GK-2 AMI | MTG FCI | FY-4 AGRI |
|---|---|---|---|---|---|---|
| | | Central Wavelength (µm) [Band Number] | | | | |
| 0.47 | Visible/reflective | 0.47 [1] | 0.47 [1] | 0.46 [1] | 0.44 [1] | 0.47 [1] |
| 0.51 | | None | 0.51 [2] | 0.51 [2] | 0.51 [2] | None |
| 0.64 | | 0.64 [2] | 0.64 [3] | 0.64 [3] | 0.64 [3] | 0.65 [2] |
| 0.865 | Reflective | 0.865 [3] | 0.86 [4] | 0.86 [4] | 0.865 [4] | 0.825 [3] |
| 0.91 | | None | None | None | 0.914 [5] | None |
| 1.378 | Cirrus | 1.378 [4] | None | 1.38 [5] | 1.38 [6] | 1.375 [4] |
| 1.61 | Snow/Ice | 1.61 [5] | 1.61 [5] | 1.61 [6] | 1.61 [7] | 1.61 [5] |
| 2.25 | Particle size | 2.25 [6] | 2.25 [6] | None | 2.25 [8] | 2.25 [6] |
| 3.90 | Shortwave IR | 3.90 [7] | 3.9 [7] | 3.85 [7] | 3.8 [9] | 3.75[2] [7,8] |
| 6.19 | Water vapor | 6.19 [8] | 6.2 [8] | 6.24 [8] | 6.3 [10] | 6.25 [9] |
| 6.95 | | 6.95 [9] | 6.9 [9] | 6.95 [9] | None | 7.1 [10] |
| 7.34 | | 7.34 [10] | 7.3 [10] | 7.35 [10] | 7.35 [11] | None |
| 8.5 | Water vapor, $SO_2$ | 8.5 [11] | 8.6 [11] | 8.6 [11] | 8.7 [12] | 8.5 [11] |
| 9.61 | Ozone | 9.61 [12] | 9.6 [12] | 9.63 [12] | 9.66 [13] | None |
| 10.35 | Longwave IR | 10.4 [13] | 10.4 [13] | 10.43 [13] | 10.5 [14] | 10.7 [12] |
| 11.2 | | 11.2 [14] | 11.2 [14] | 11.2 [14] | None | None |
| 12.3 | | 12.3 [15] | 12.3 [15] | 12.3 [15] | 12.3 [15] | 12.0 [13] |
| 13.3 | | 13.3 [16] | 13.3 [16] | 13.3 [16] | 13.3 [16] | 13.5 [14] |

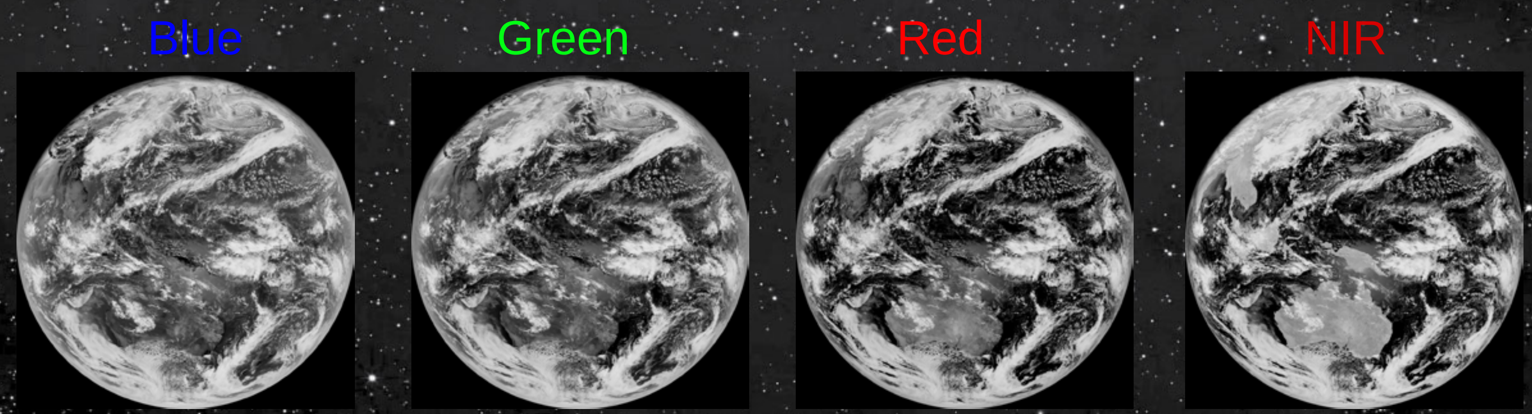
**True-color component bands are highlighted in red, green, and blue.**

Goal: produce true color imagery similar to that being generated by CIRA for Himawari



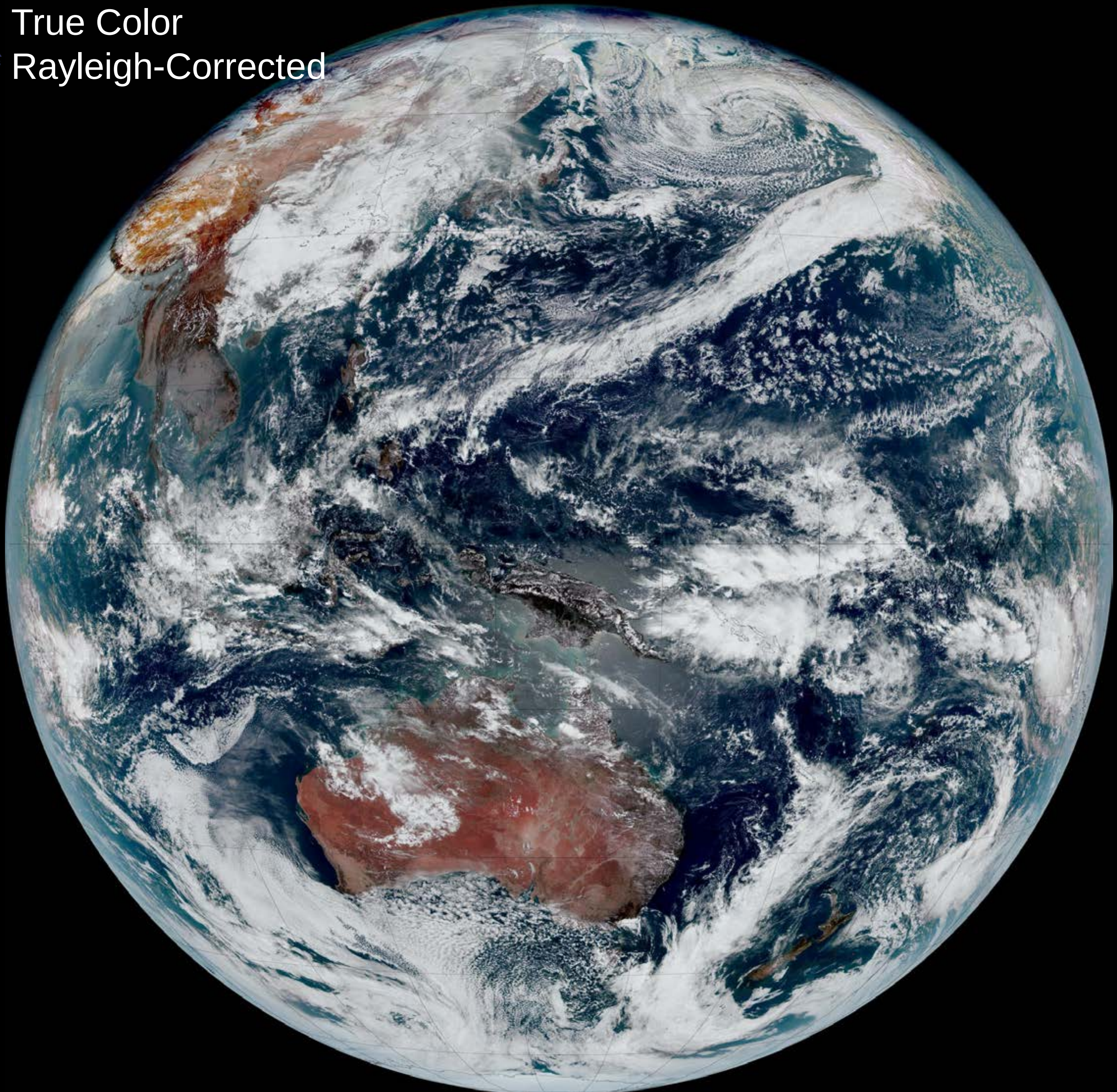
# Step 1: Rayleigh Corrections

- Molecular scatter of sunlight by the gaseous atmosphere is significant, particularly in the blue-band
- Adapted atmospheric correction software, applied previously to SeaWiFS/MODIS/VIIRS sensors, to AHI bands
- Corrections are a function of solar & satellite geometry




→ *These atmospheric corrections are a critical step in attaining high-quality true color imagery*

True Color
Rayleigh-Corrected



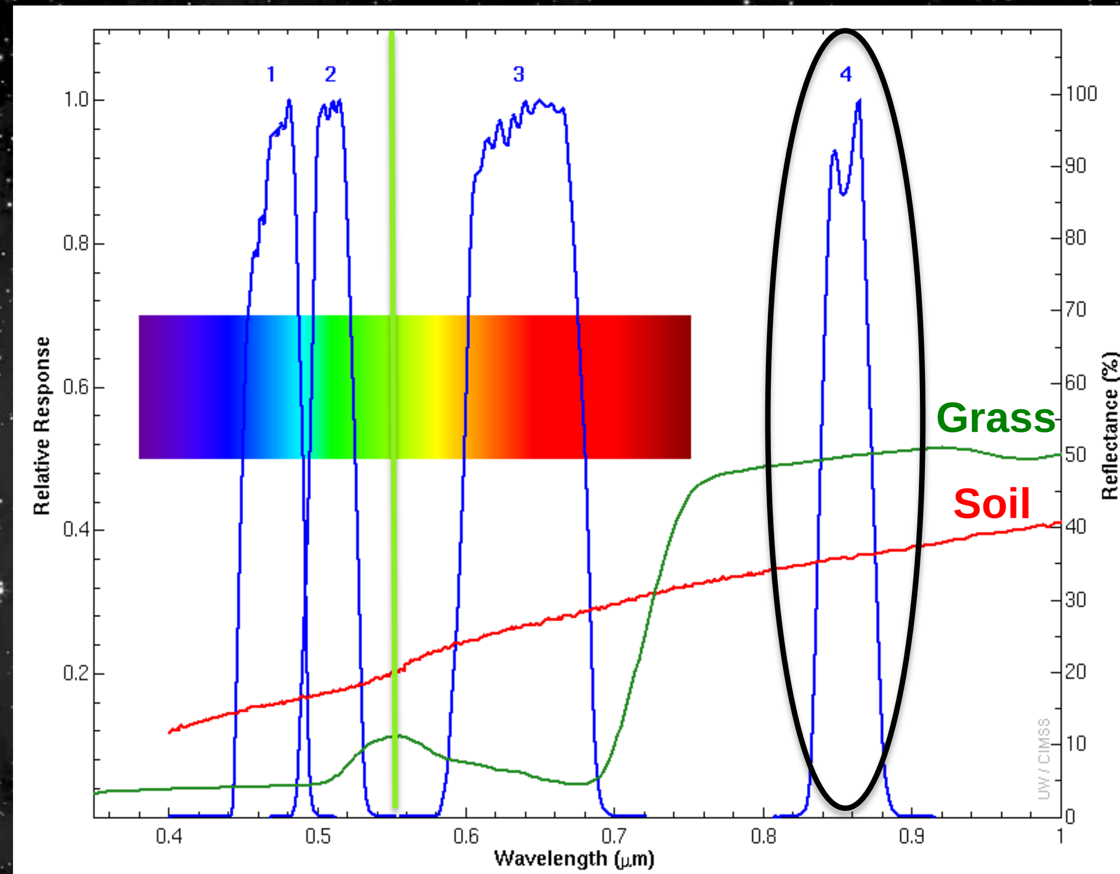
# Step 2: Fix the lack of Green

- Blend 510 nm green band with vegetation-sensitive 856 nm band to produce a 'hybrid green' band ($G_H$):

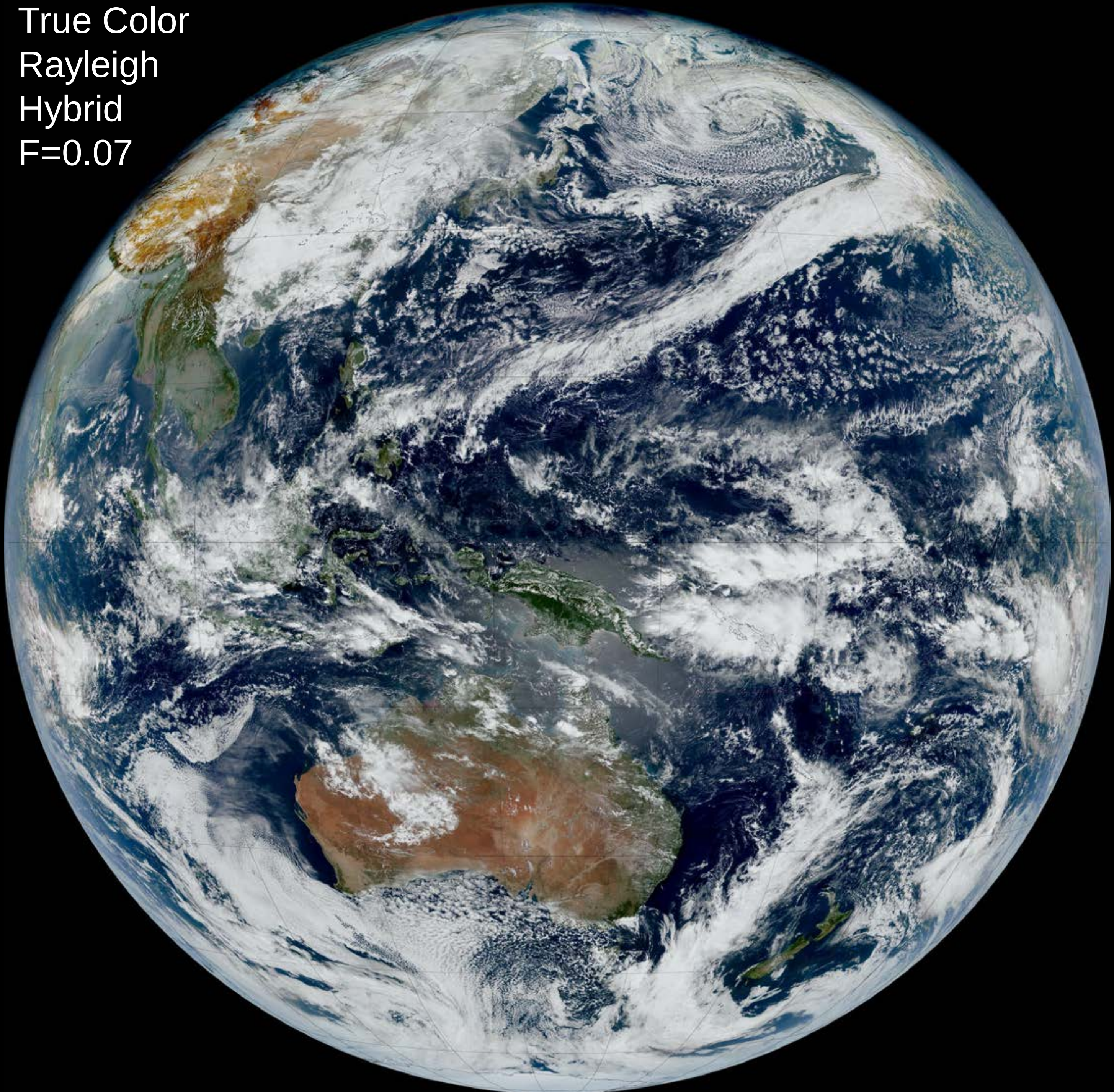
$$G_H = (1-F) * R\_510 + F * R\_856$$

F F ~ 0.07 (experimental)

- Provides enhancement to green vegetation and to mineral soils (e.g., deserts).
- Minimal impact to other features of the scene (clouds, ocean, and shallow-water coloration)




→AHI Band 4 (856 nm) provides a 'boost' to the 510 nm vegetation and soil reflectan


True Color
Rayleigh
Hybrid
F=0.07

# Step 3: Simulate the Green Component

- Take advantage of the fact that Himawari has bands in the red, blue, nearIR, *and* green portions of the spectrum
- We build a 3-dimensional lookup table where the inputs are AHI 0.46 µm, 0.64 µm, and 0.86 µm reflectance, and the output is 0.51 µm (green)
- Example: this point

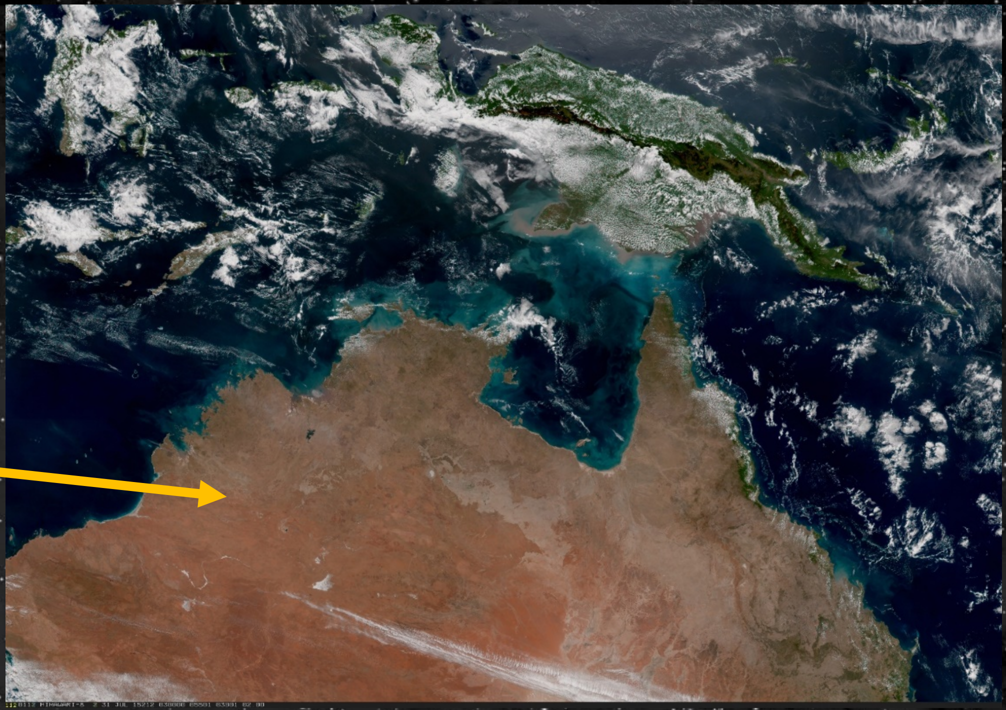
  may have reflectance values of

  Blue: 0.17

  Red: 0.64

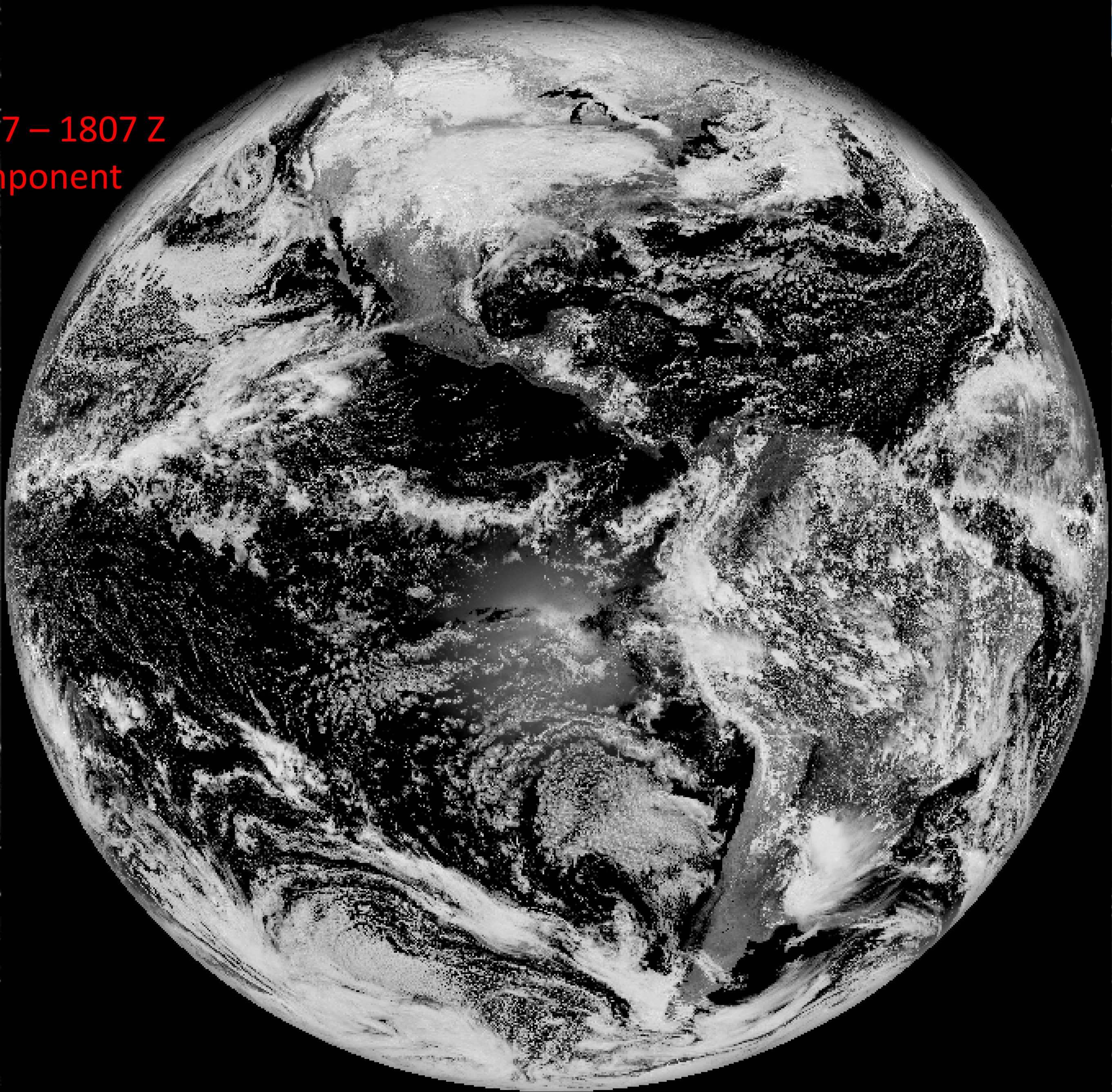
  nearIR: 0.15

  and its corresponding green 0.51 µm reflectance may be: 0.32.
- The table entry (0.17,0.64,0.15) gets populated as 0.32.
- Continue this process for a large number of observations at multiple times of day, times of year, and for multiple surface types.

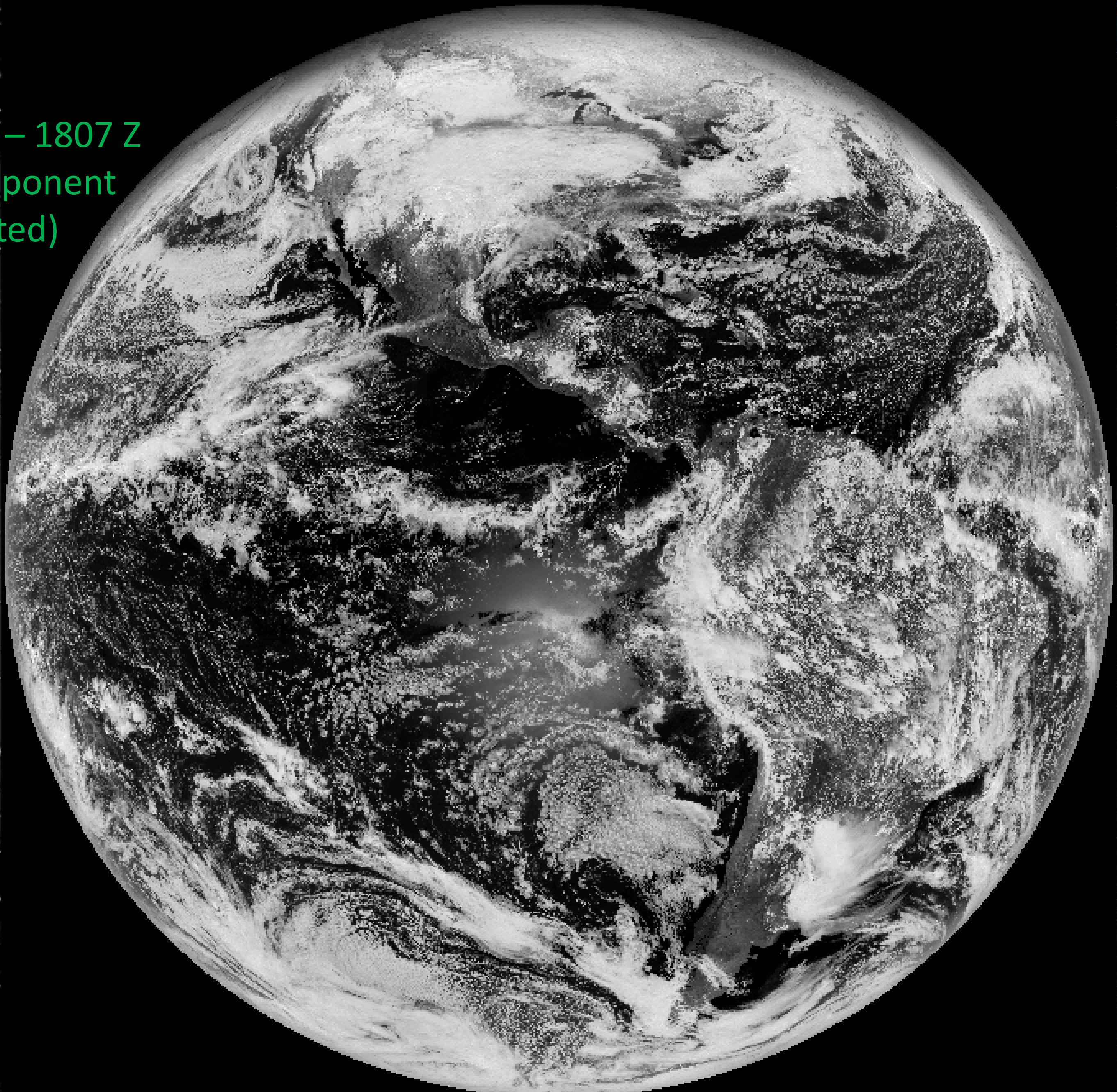


- Now with GOES-16, for every pixel we get the Rayleigh-corrected red, blue, and nearIR reflectance, then consult the lookup table to get the corresponding green value.

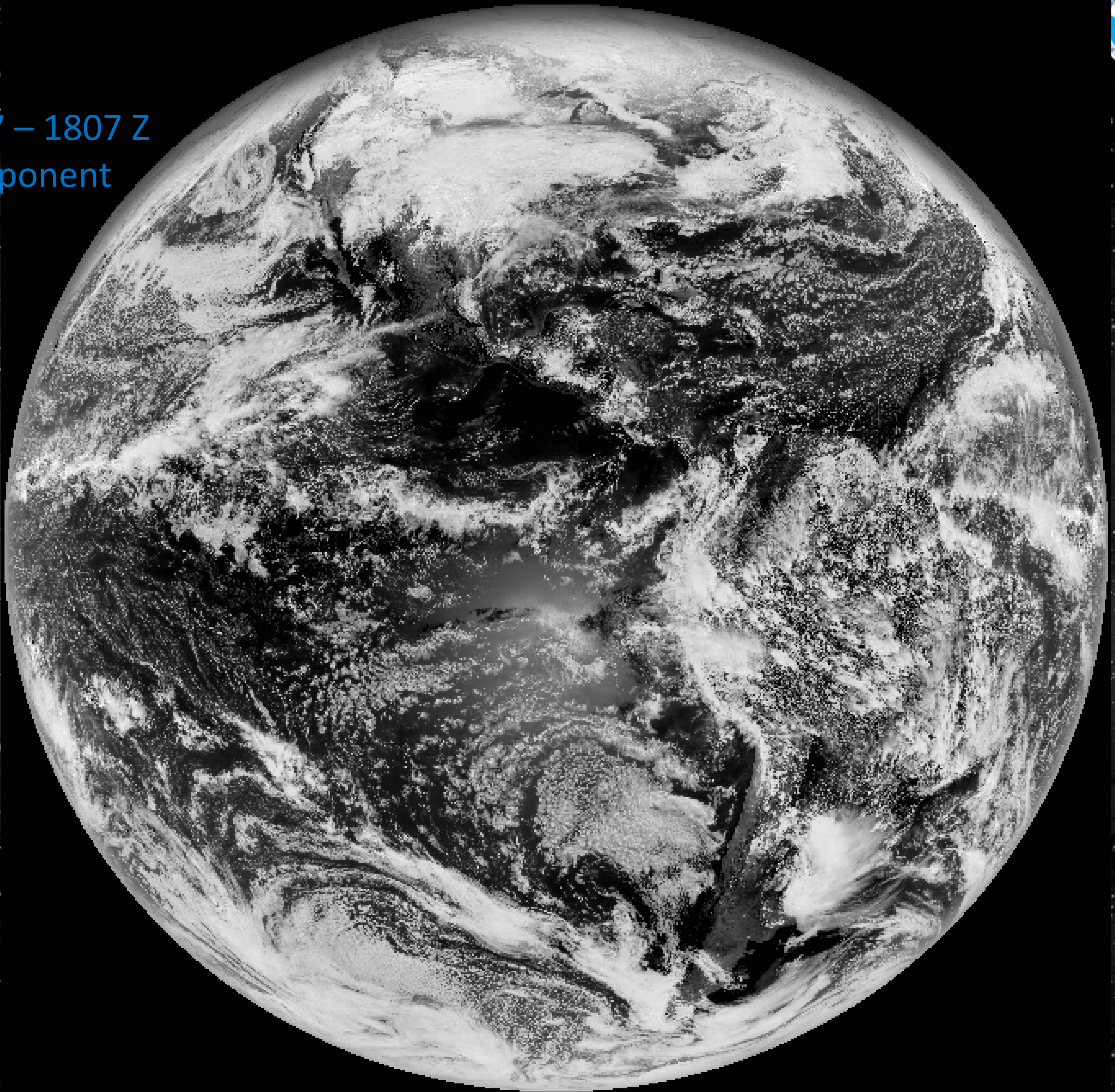
15 Jan. 2017 – 1807 Z
Red Component



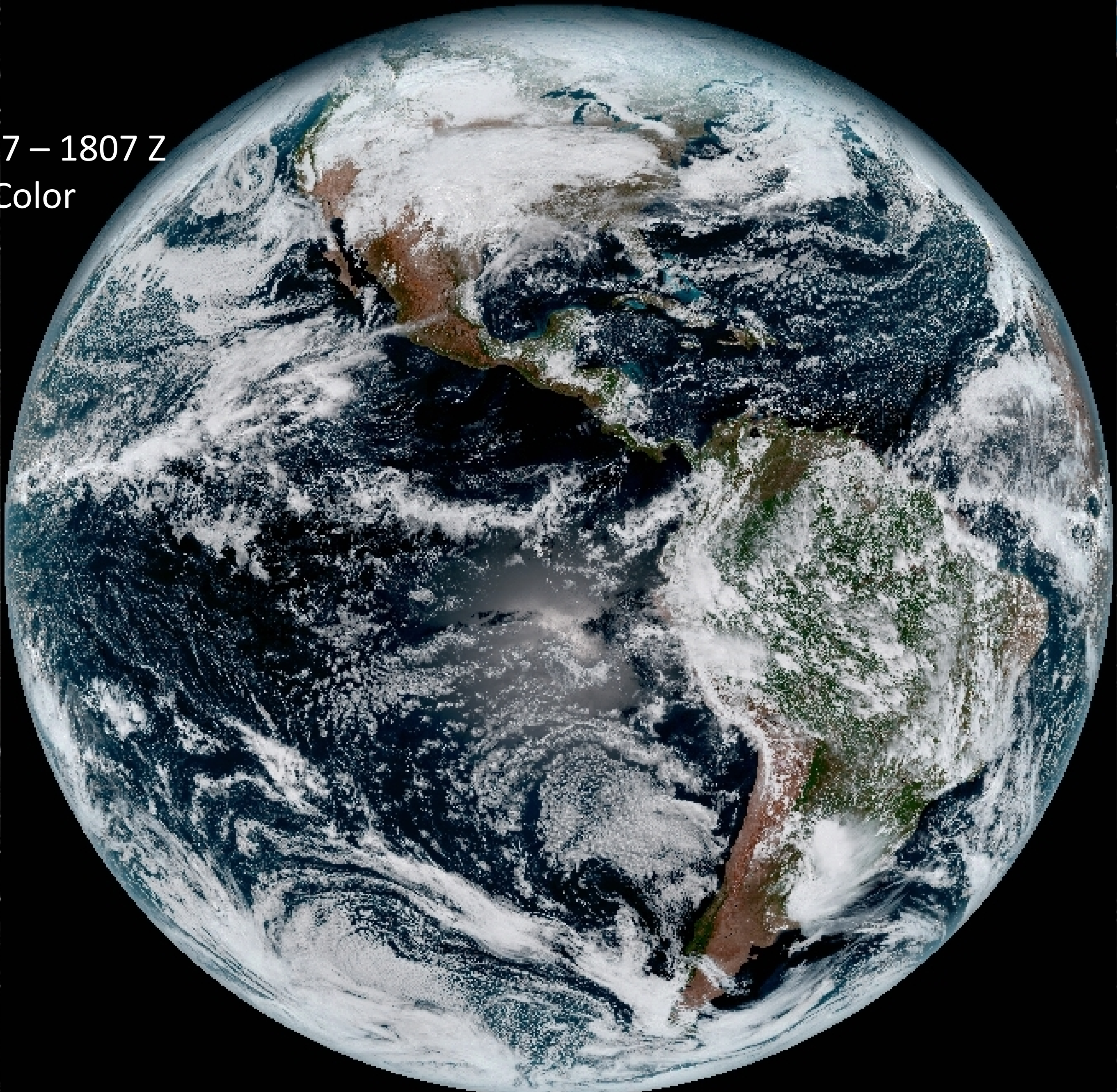
15 Jan. 2017 – 1807 Z
Green Component
(simulated)

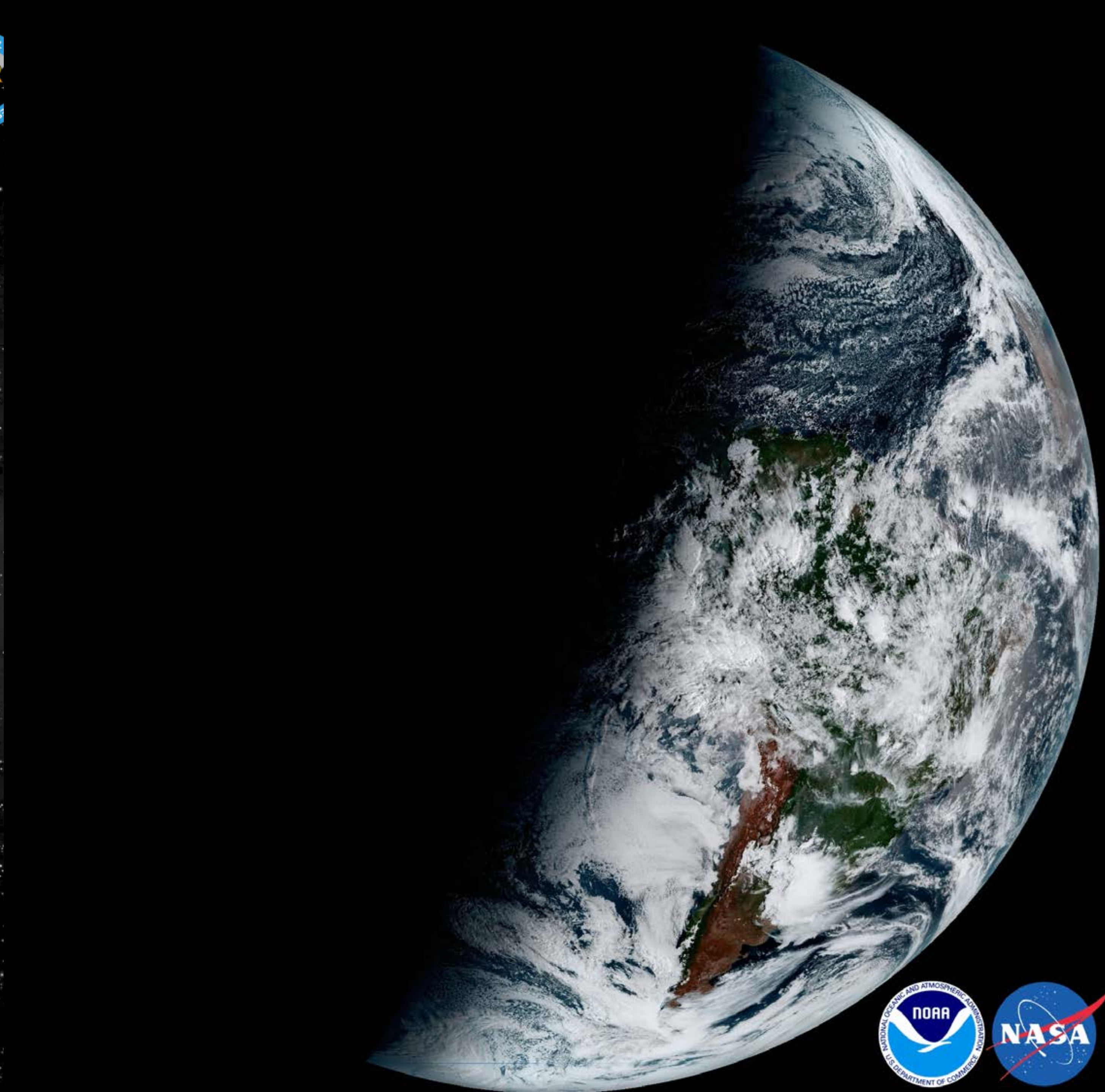


15 Jan. 2017 – 1807 Z
Blue Component

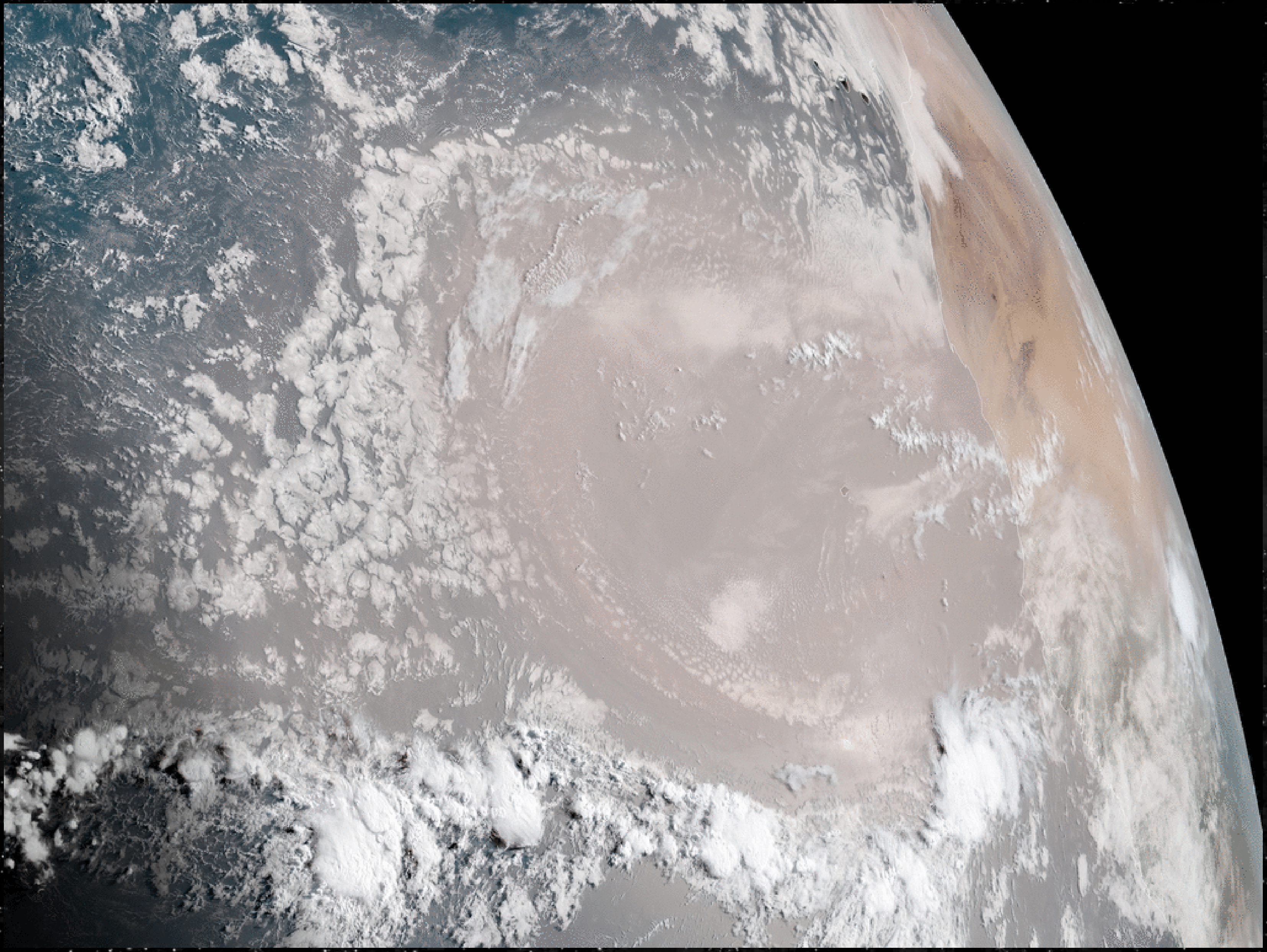


15 Jan. 2017 – 1807 Z
True Color

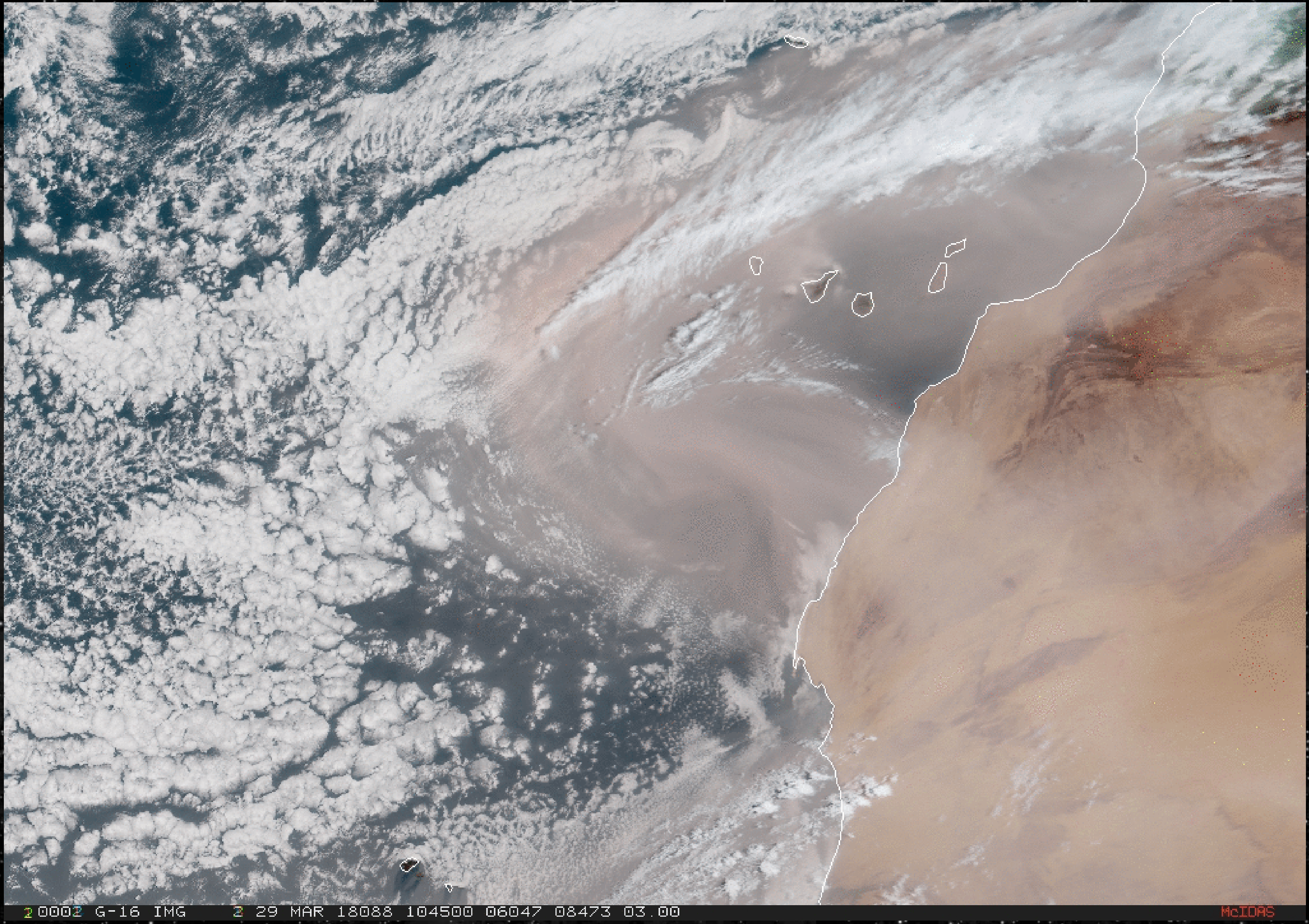




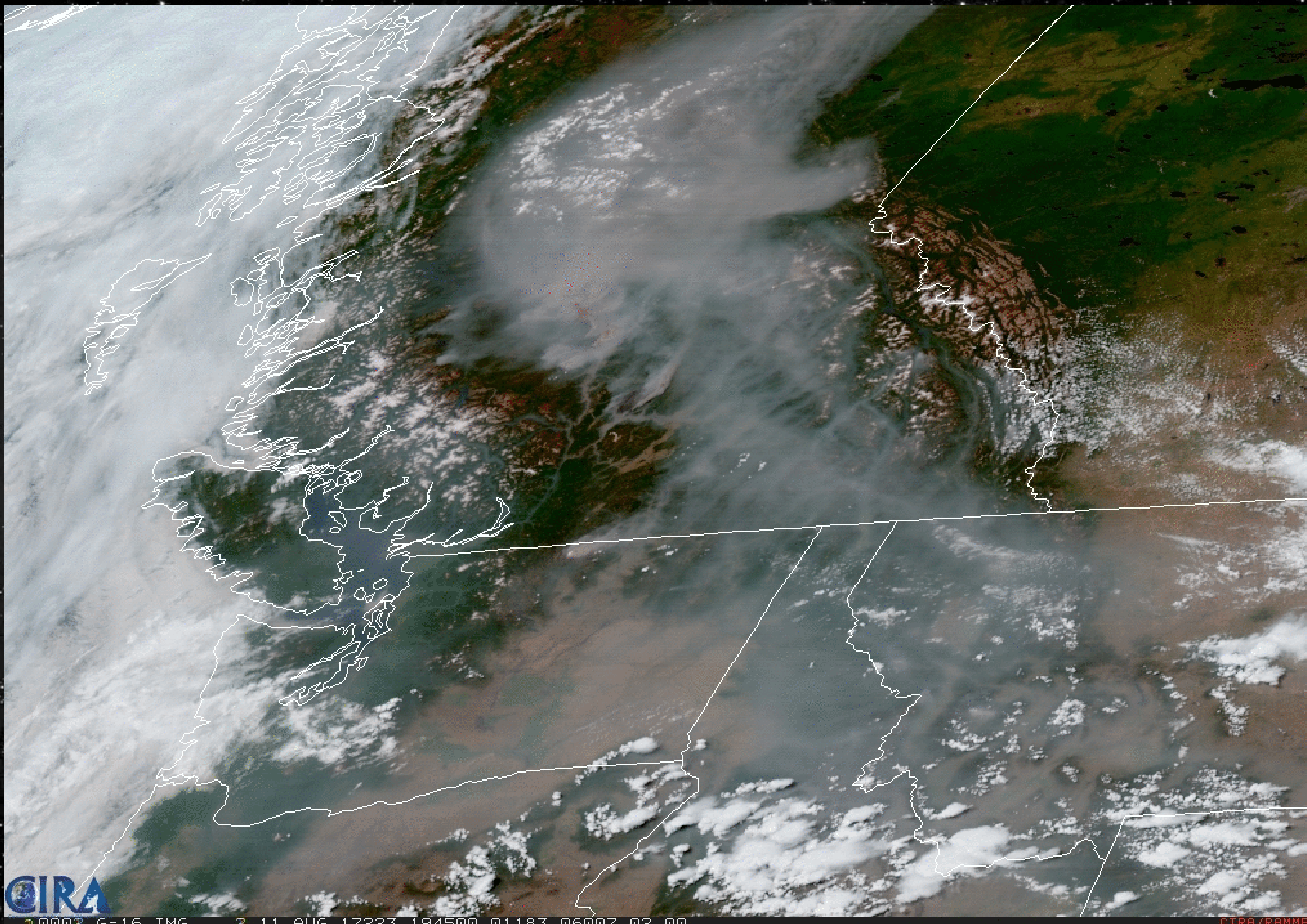
# Saharan Dust – 1 Aug. 2018



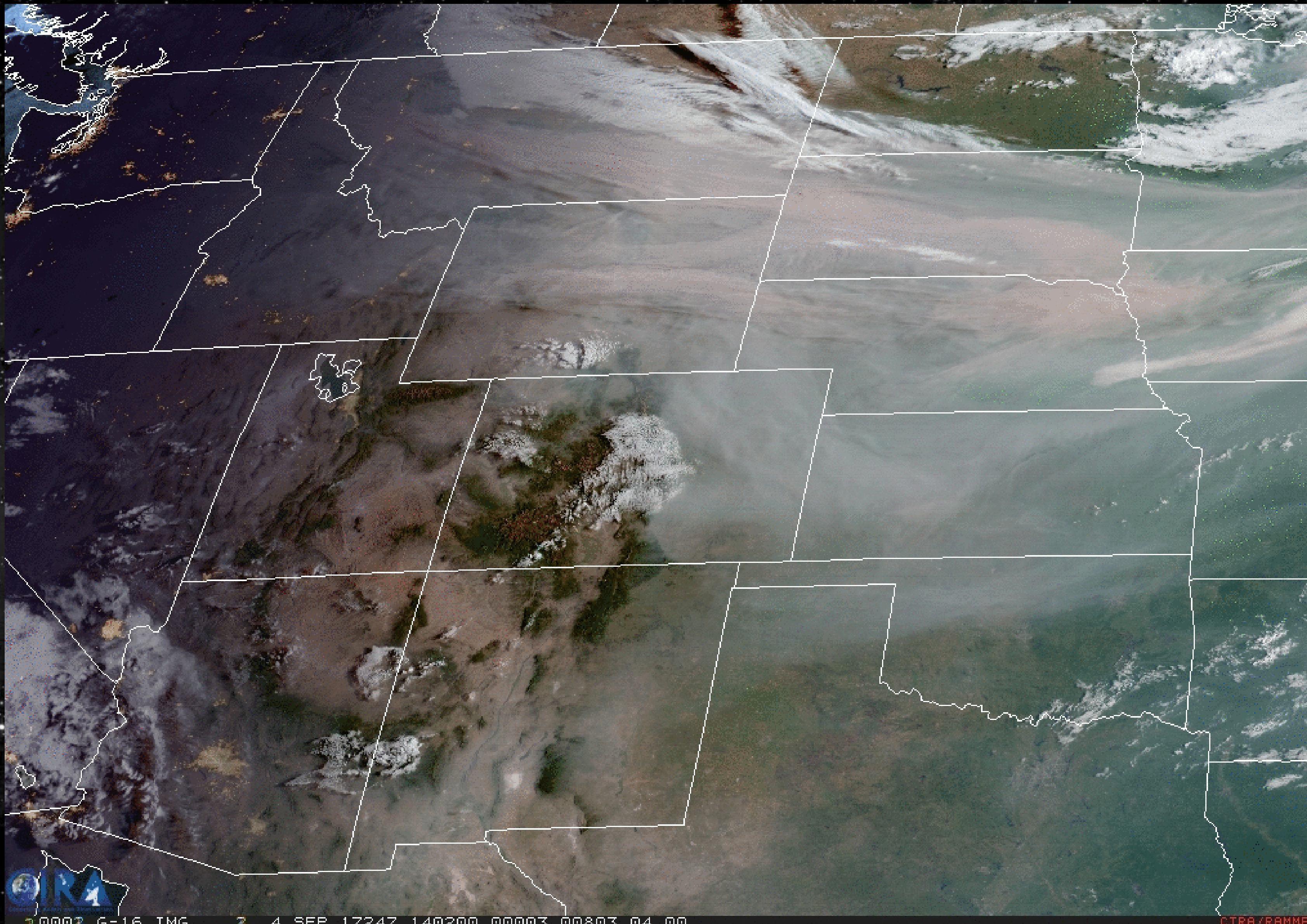
# Saharan Dust – 29 March 2018



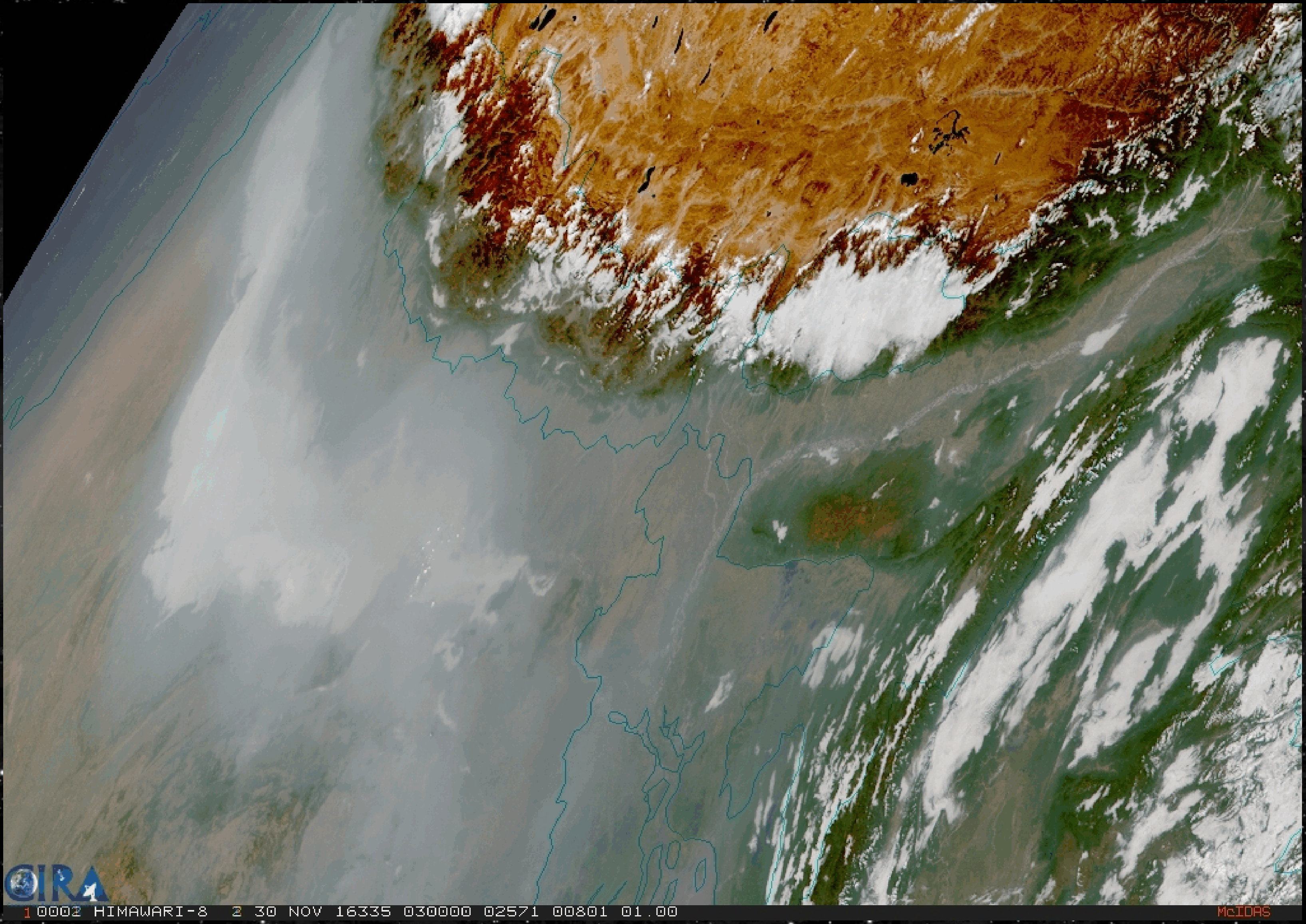
# Smoke – 11 August 2017



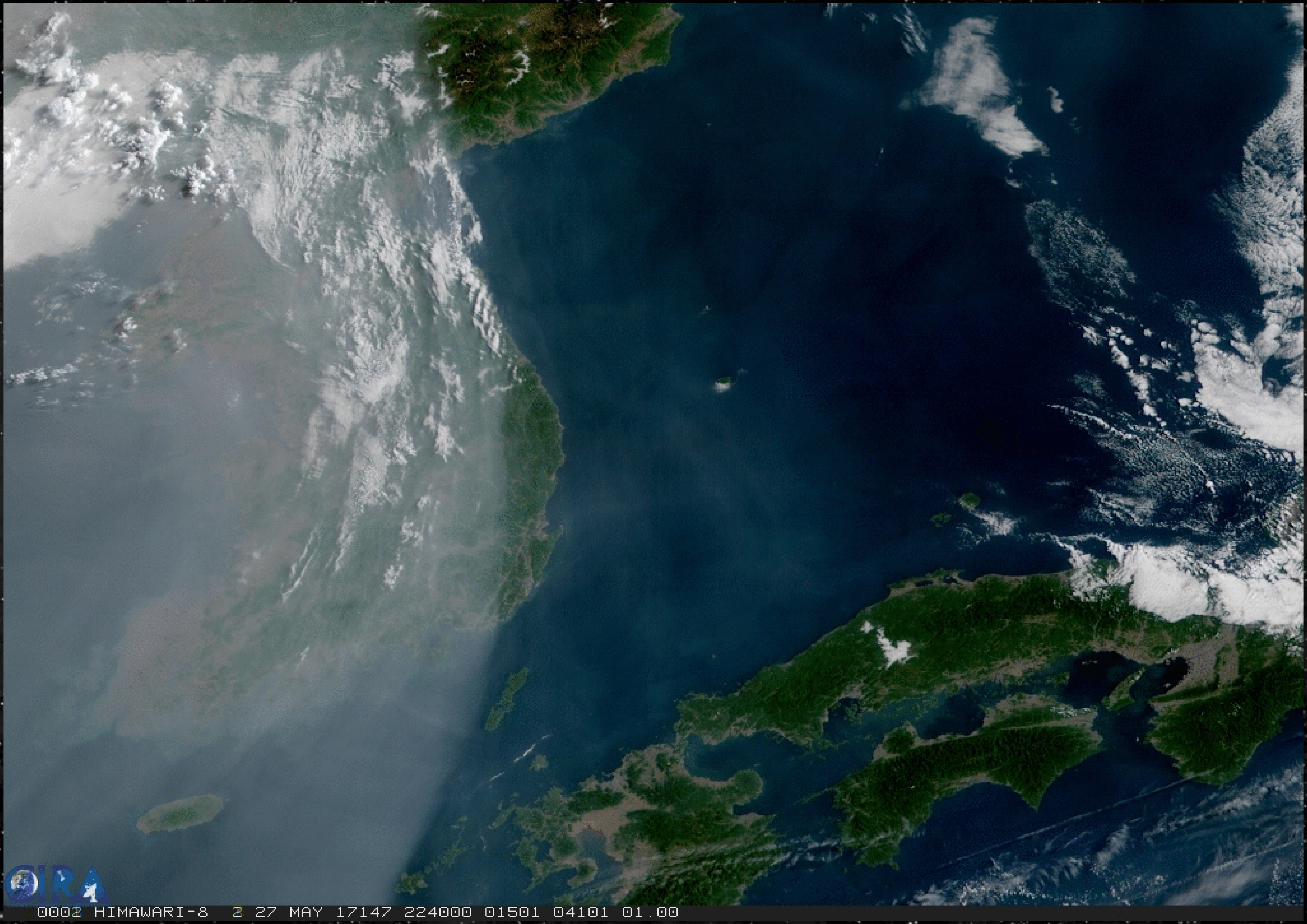
# Smoke – 4 September 2017



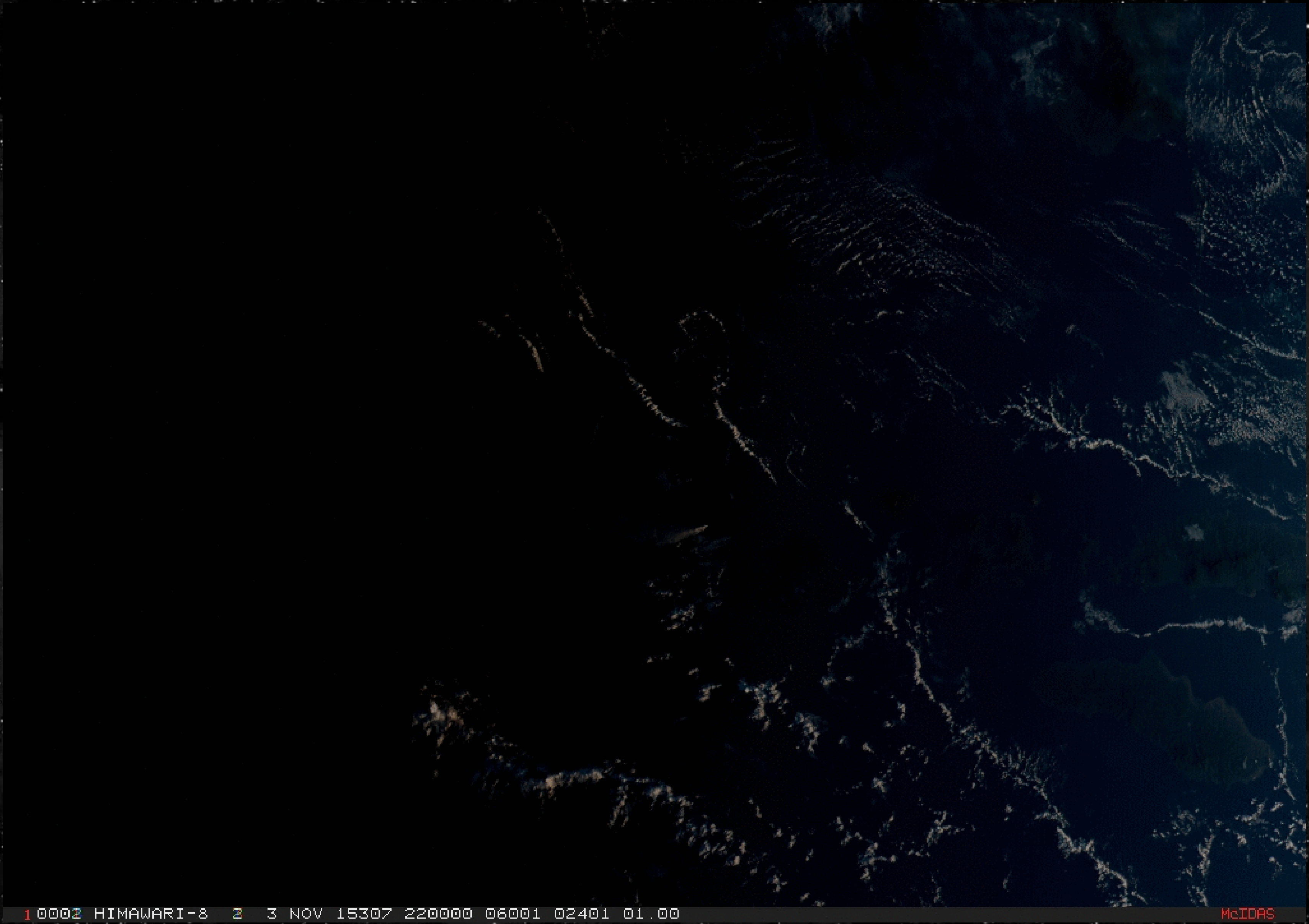
# Pollution – 30 November 2016



# Pollution – 27 May 2017



# Volcanic Ash – 3 November 2015

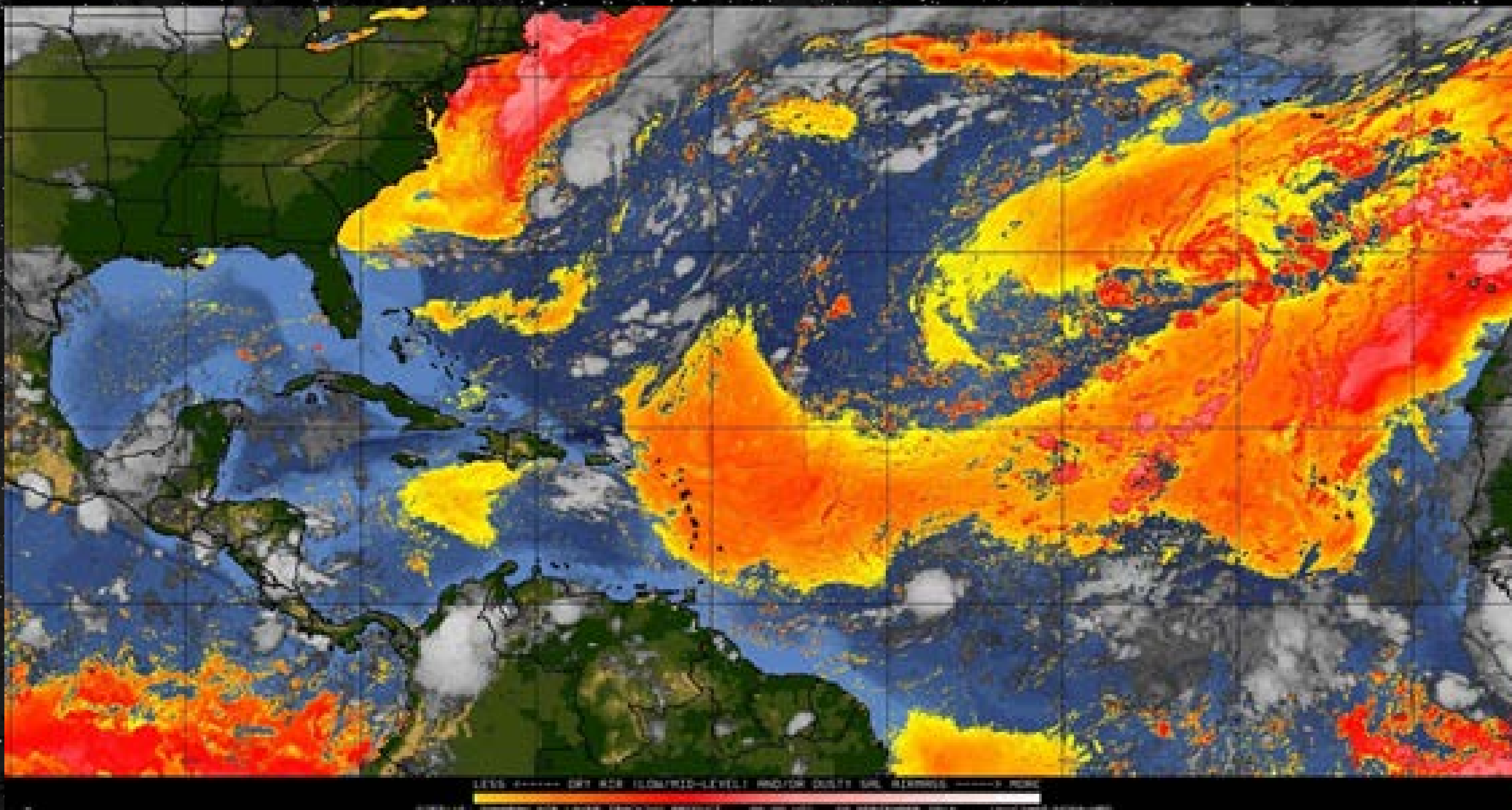


# Michael Folmer Satellite Liaison: 2018 Saharan air layer evaluation

Participants:

- WPC International Desk
- NHC/TAFB
- Key West WFO
- Miami WFO
- Melbourne WFO
- Ruskin WFO
- San Juan WFO
- CIMH Barbados

# September 2017 SAL Outbreak




Courtesy of Scott Lindstrom (CIMSS)
CIMSS Blog: http://cimss.ssec.wisc.edu/goes/blog/archives/29877

# September 2017 SAL Outbreak


Courtesy Ernesto Rodriquez (San Juan NWS)


# Thank you

For more information visit www.goes-r.gov

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