

Above-anvil cirrus plumes detection in the 1.38 micron band

Martin Setvák

CHMI Satellite Department

E-mail: martin.setvak@chmi.cz

CHMI website: www.chmi.cz

Personal website: www.setvak.cz

EUMETSAT CWG workshop, 6 – 8 April 2021 (remote)

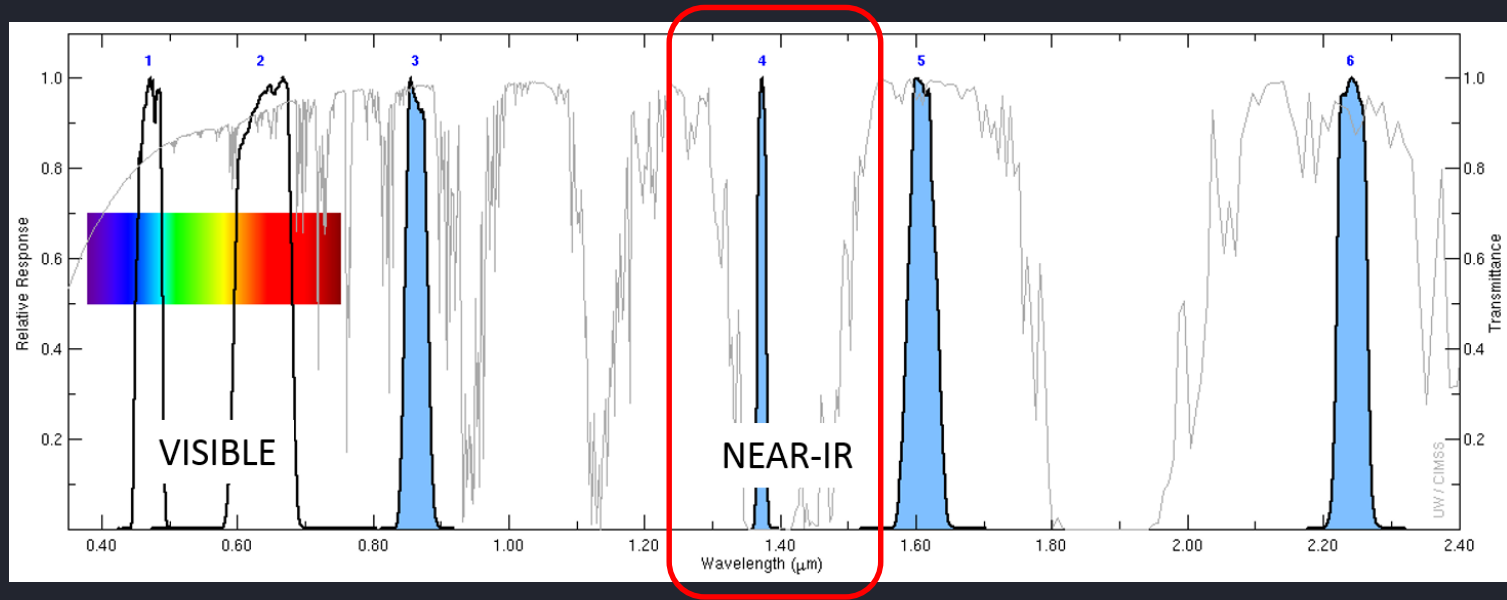
Topics of the study:

- familiarization with the 1.38 μm band properties
- visualization of the 1.38 μm band data, image enhancement options
(more details on this topic in my MTG 3T [workshop presentation](#))
- applicability of this band to storm-top observations:
 - above-anvil cirrus plumes – their structure and extent beyond the regular anvil periphery (???)
 - storm anvil details and extent, detection of thinnest parts of these, comparison to other thin cirrus detection options
 - storm tops in Cloud type RGB

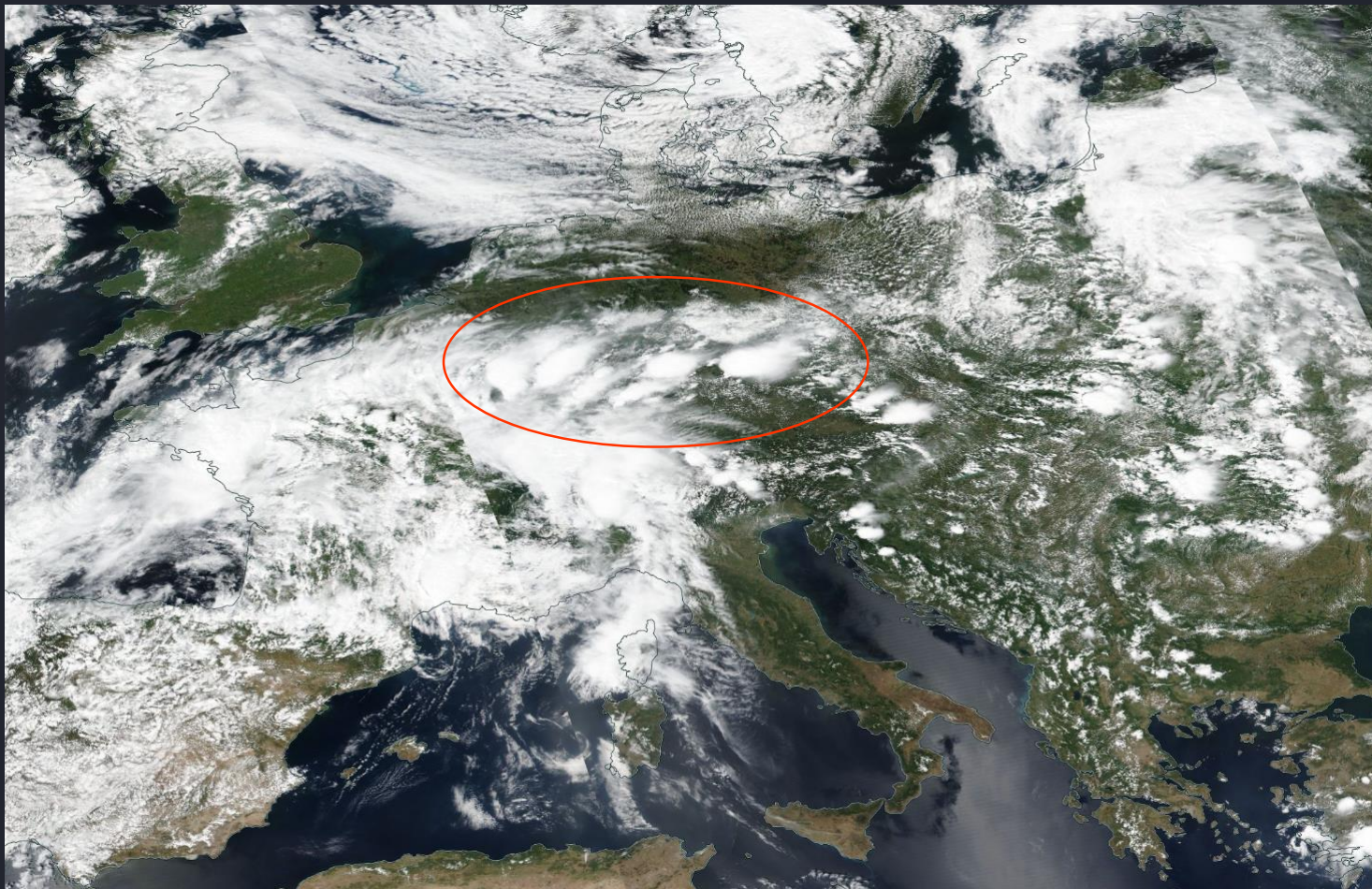
1.38 μm spectral band:

- strong attenuation by tropospheric moisture >>> thin cirrus detection, high clouds discrimination
- used either as stand-alone black & white images, or included as red component in the Cloud Type RGB
- presently available:
 - MODIS instrument on Terra and Aqua
 - VIIRS instrument of NPP and JPSS satellites (NOAA-20 and on),
 - ABI instrument of GOES-R series satellites (GOES 16 and on),
 - AGRI (FY-4A series), AMI (GEO-Kompsat-2A)
 - **not included on AHI (Himawari 8/9)**
- future availability:
 - MTG-I FCI
 - EPS-SG METImage

1.38 μm spectral band:

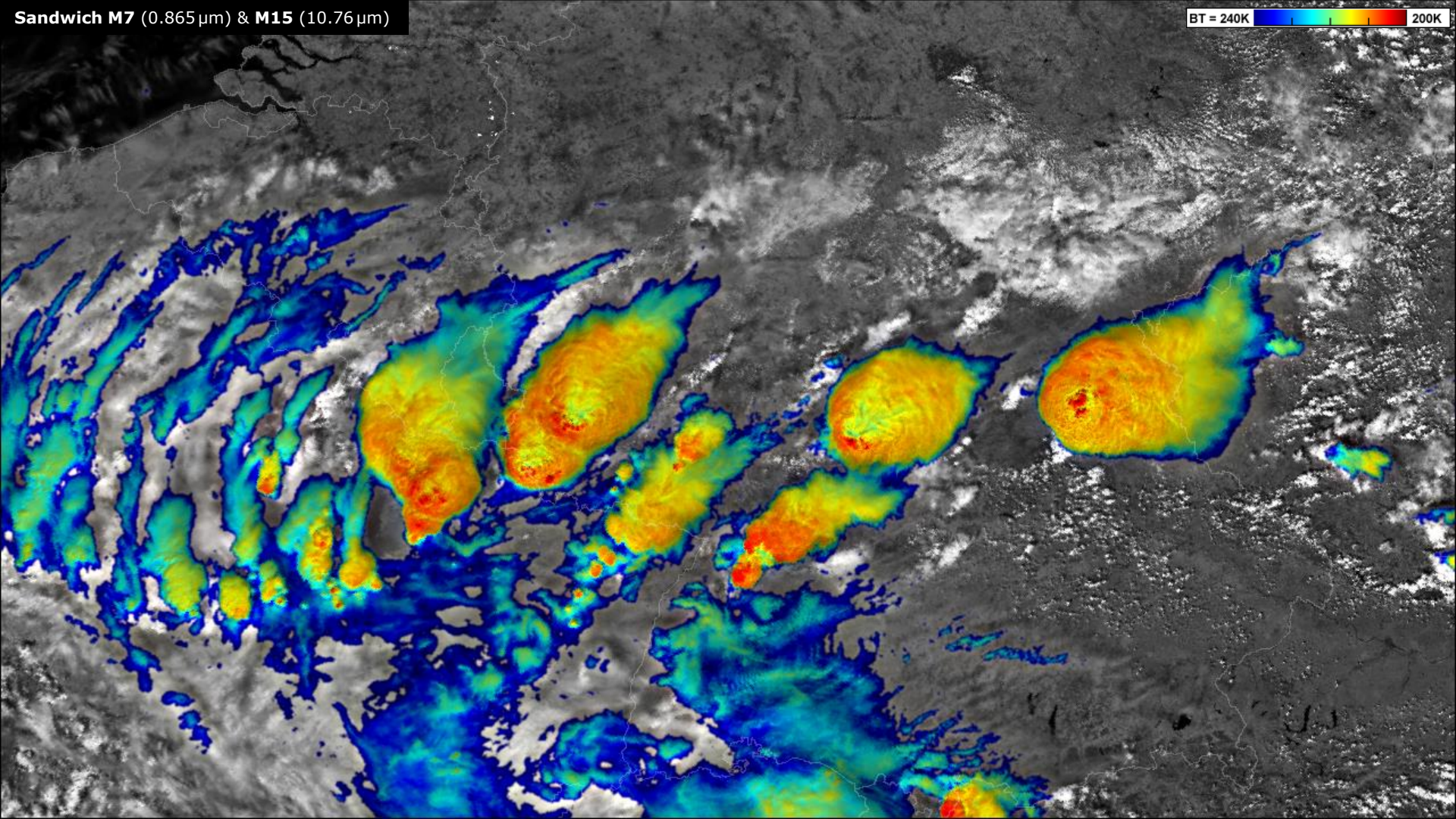


Source: Schmit, T. J., S. S. Lindstrom, J. J. Gerth, M. M. Gunshor, 2018: Applications of the 16 spectral bands on the Advanced Baseline Imager (ABI). J. Operational Meteor., 6 (4), 33-46, doi: <https://doi.org/10.15191/nwajom.2018.0604>

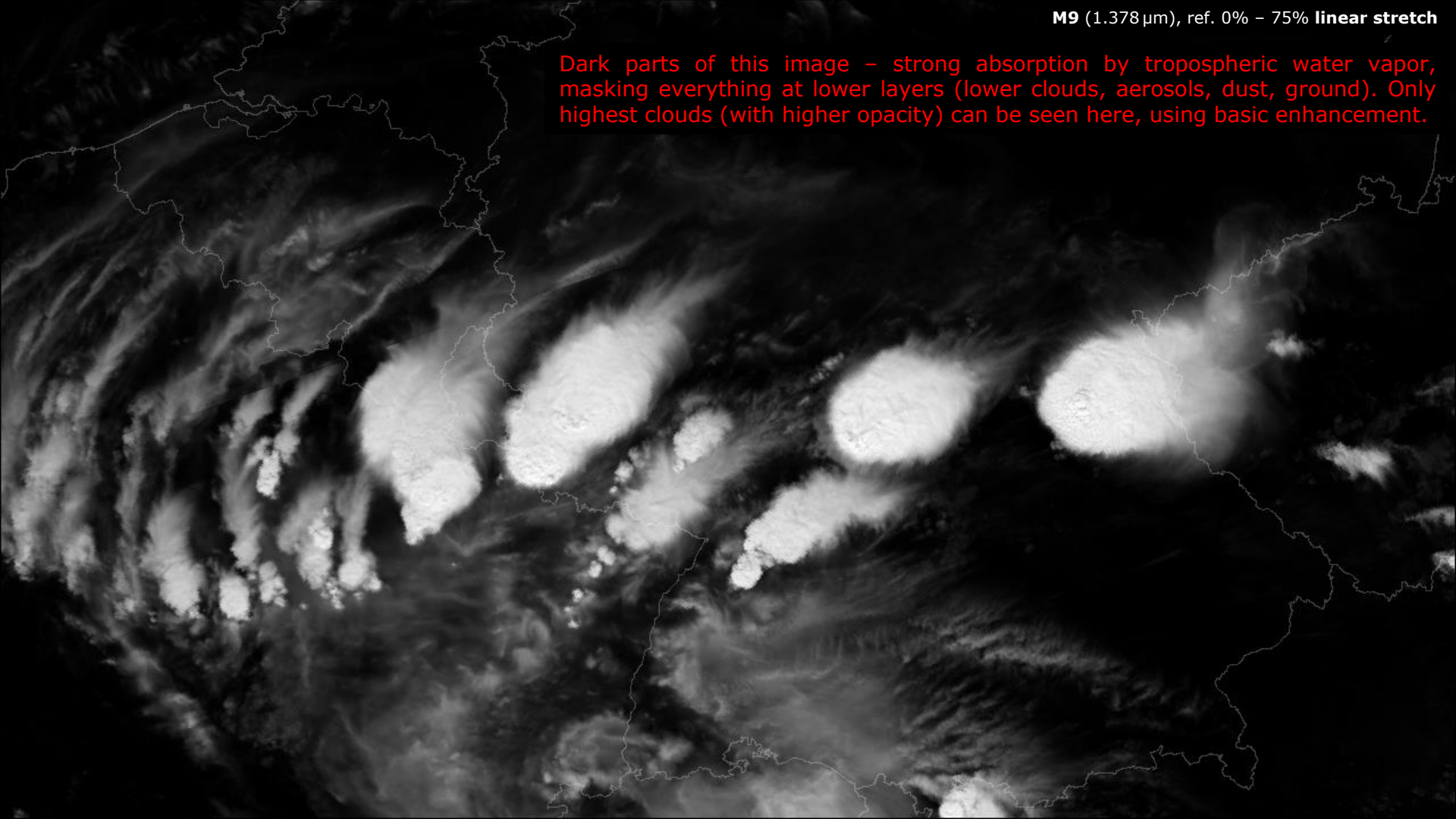


Sandwich M7 (0.865 μm) & M15 (10.76 μm)

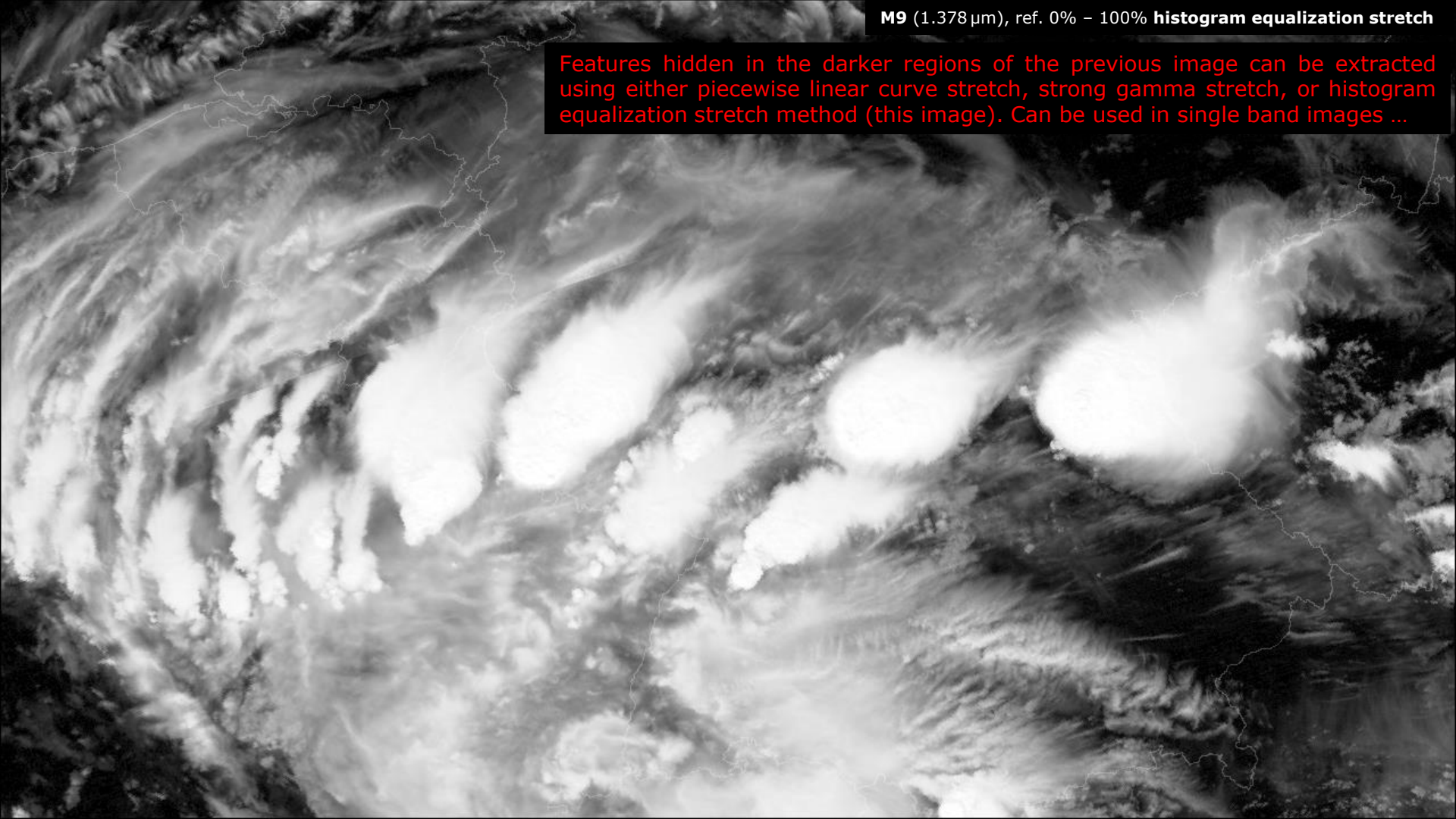
BT = 240K 200K

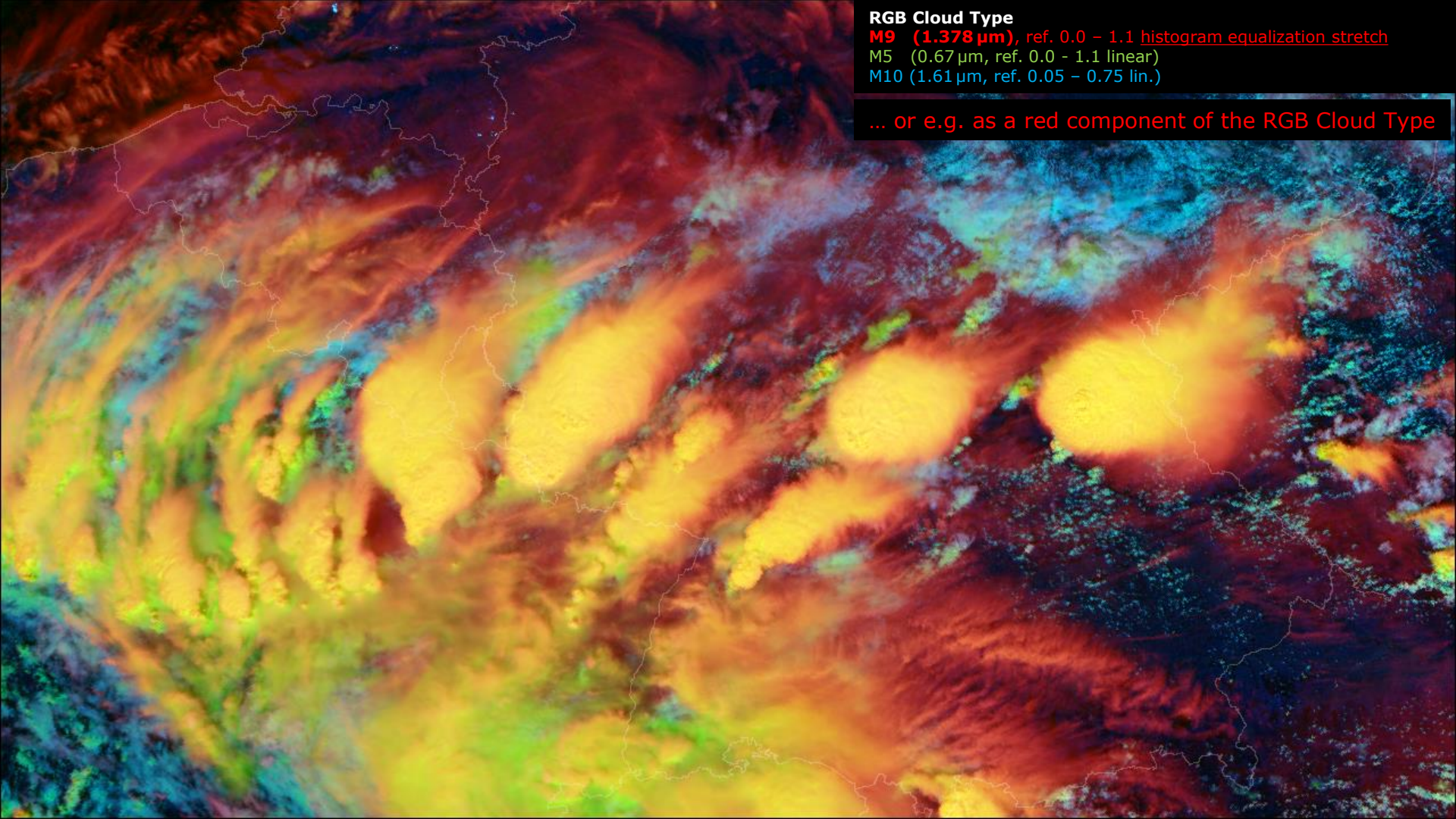


Dark parts of this image – strong absorption by tropospheric water vapor, masking everything at lower layers (lower clouds, aerosols, dust, ground). Only highest clouds (with higher opacity) can be seen here, using basic enhancement.



Features hidden in the darker regions of the previous image can be extracted using either piecewise linear curve stretch, strong gamma stretch, or histogram equalization stretch method (this image). Can be used in single band images ...





RGB Cloud Type

M9 (**1.378 μm**), ref. 0.0 - 1.1 [histogram equalization stretch](#)

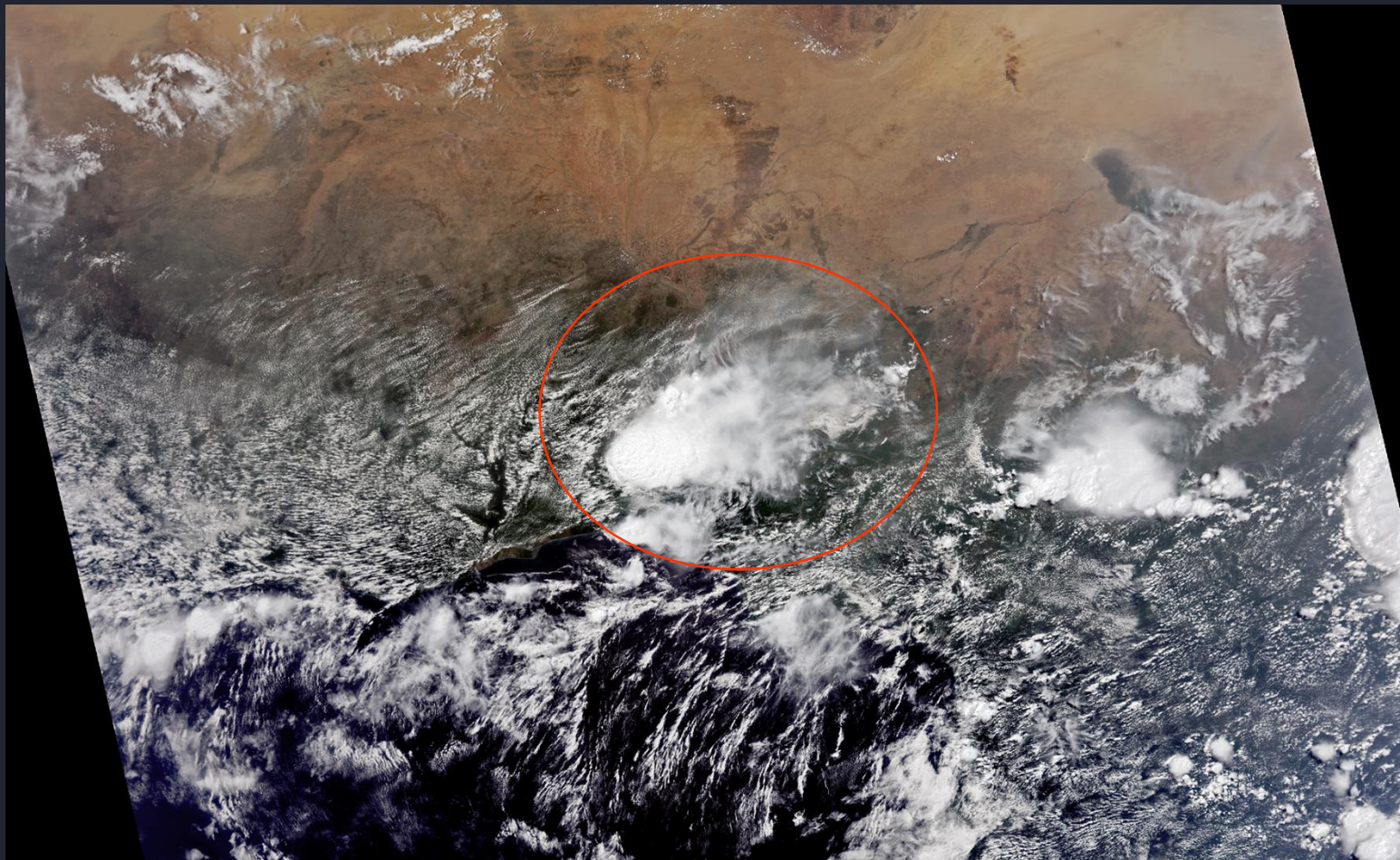
M5 (**0.67 μm** , ref. 0.0 - 1.1 linear)

M10 (**1.61 μm** , ref. 0.05 - 0.75 lin.)

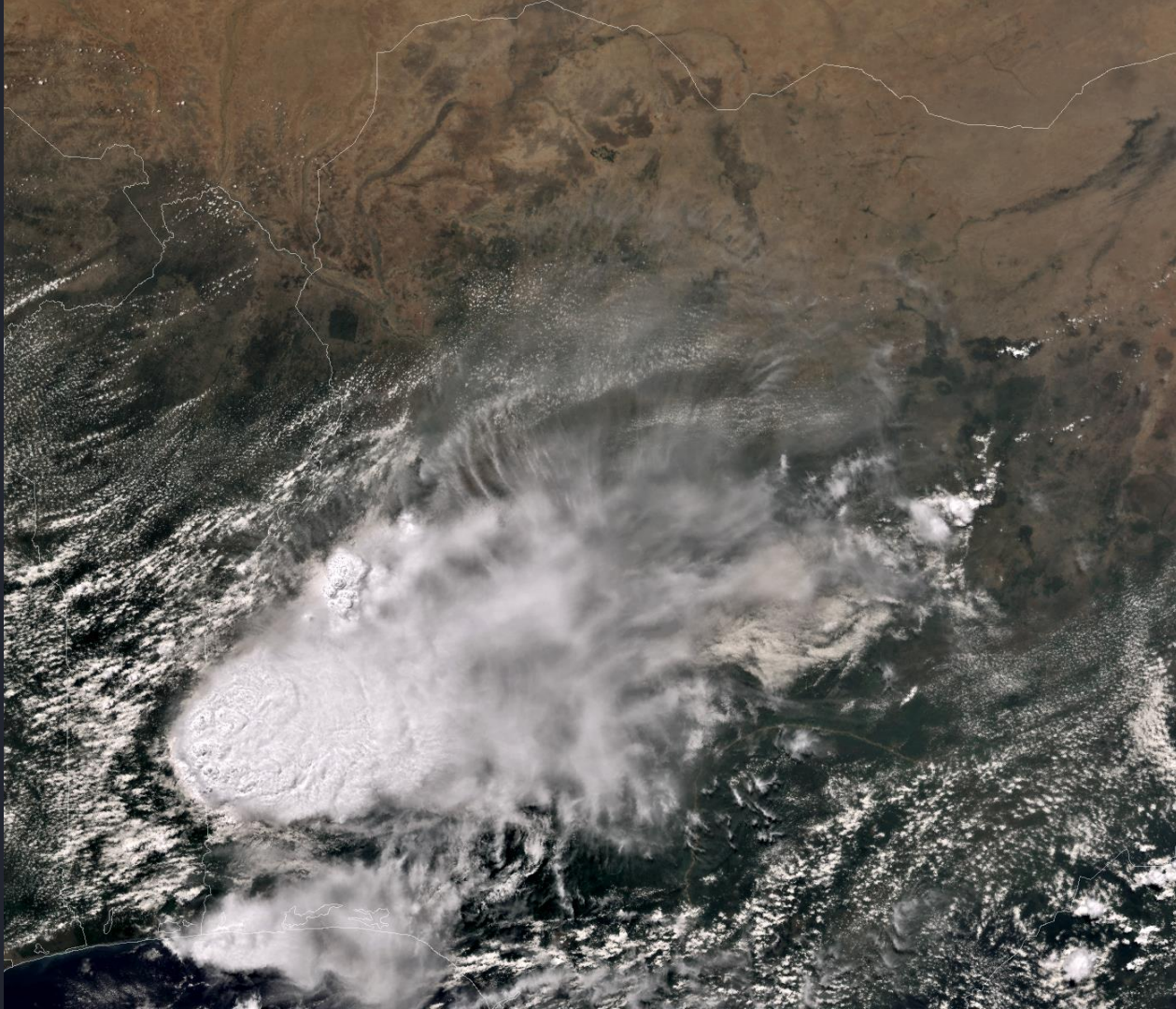
... or e.g. as a red component of the RGB Cloud Type

08 June 2013 13:00 UTC, VIIRS S-NPP, central Africa (Benin, Nigeria)

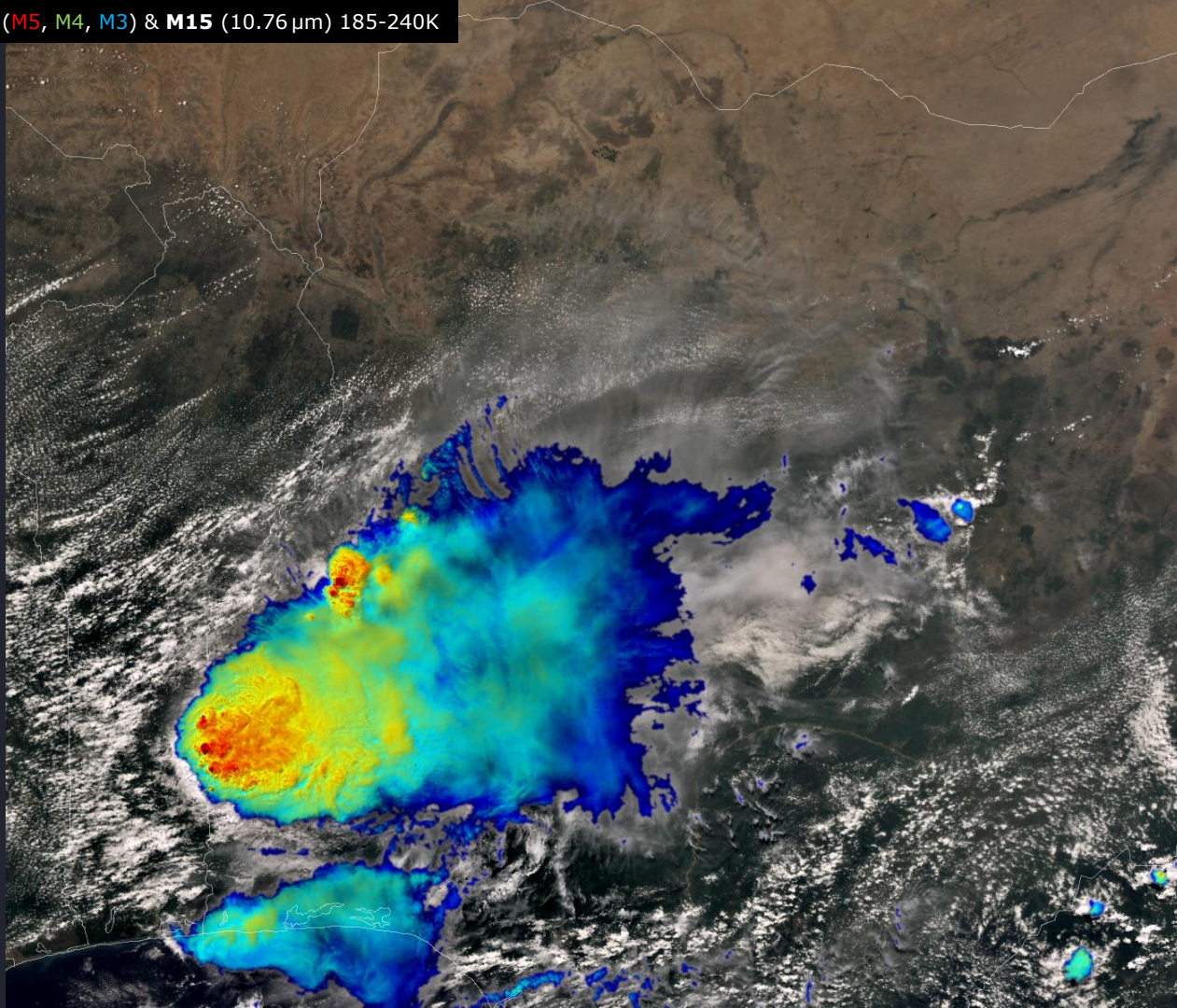
data source: NOAA CLASS, proc. MS (ENVI)



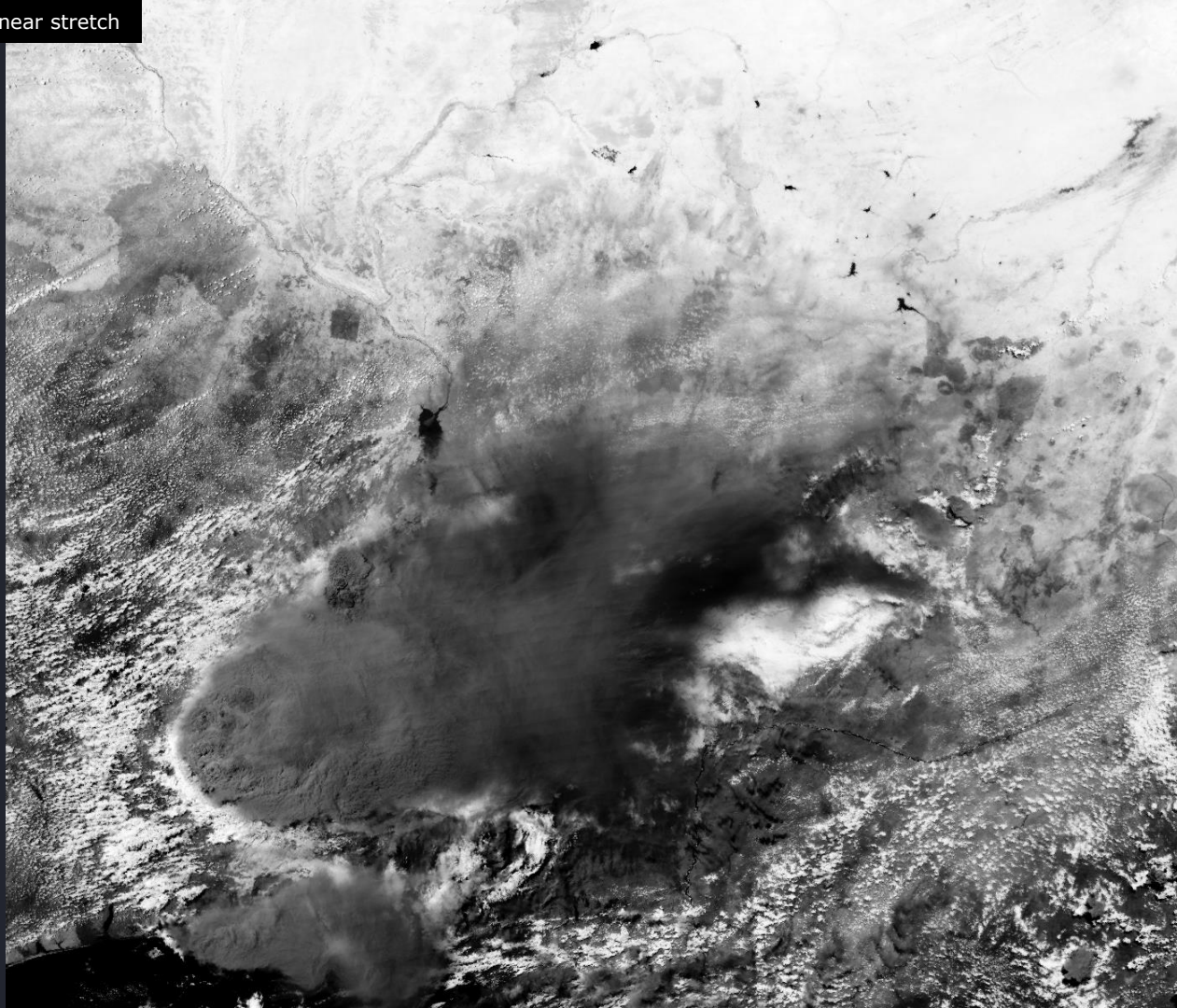
RGB True Color
M5 (0.672 μm)
M4 (0.555 μm)
M3 (0.488 μm)



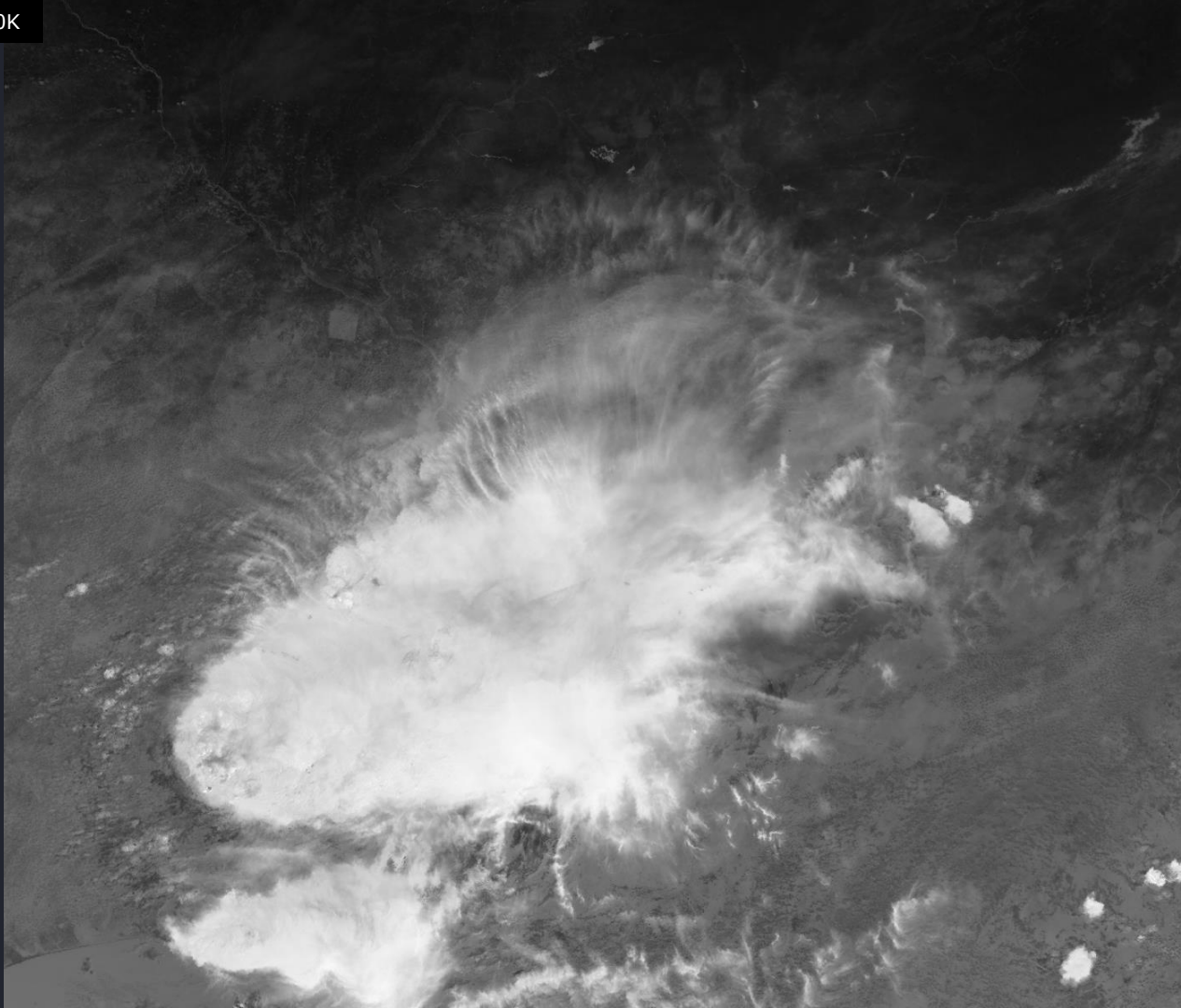
Sandwich RGB TrueColor (M5, M4, M3) & M15 (10.76 μm) 185-240K



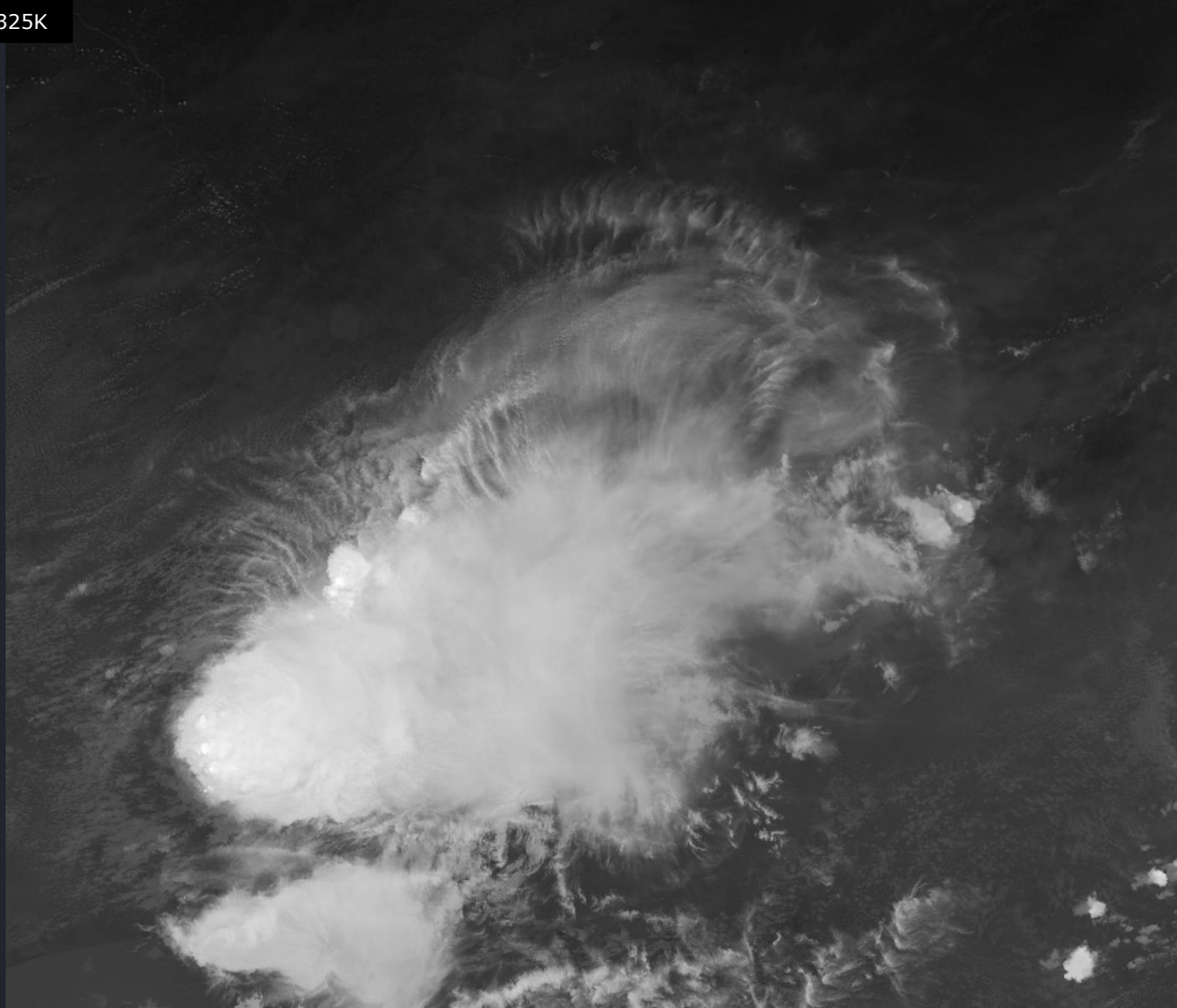
M10 (1.61 μm), piecewise linear stretch



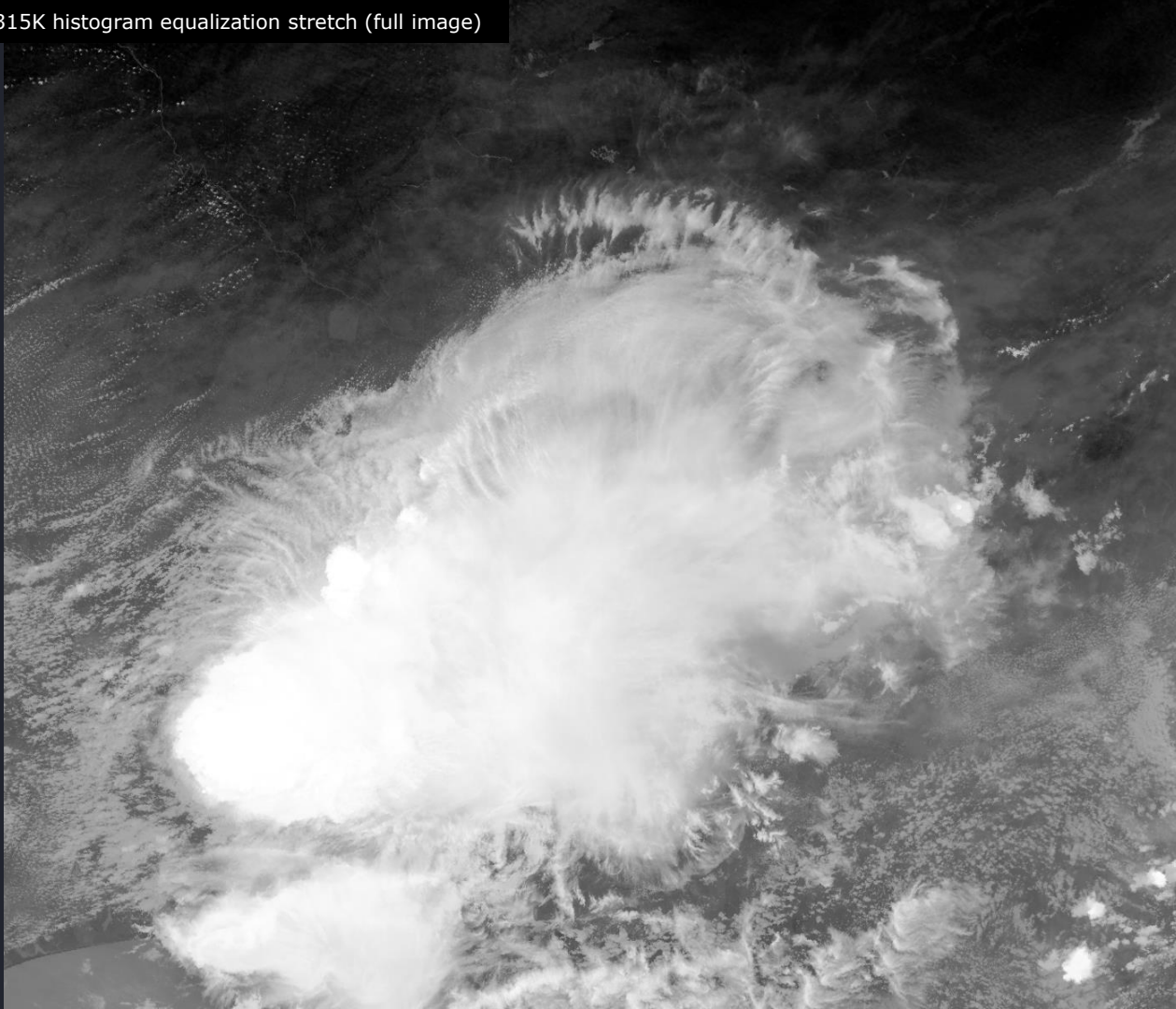
M12 (3.7 μm), BT 255 – 340K



M15 (10.76 μm), BT 185 - 325K



M15 (10.76 μm), BT 190 – 315K histogram equalization stretch (full image)



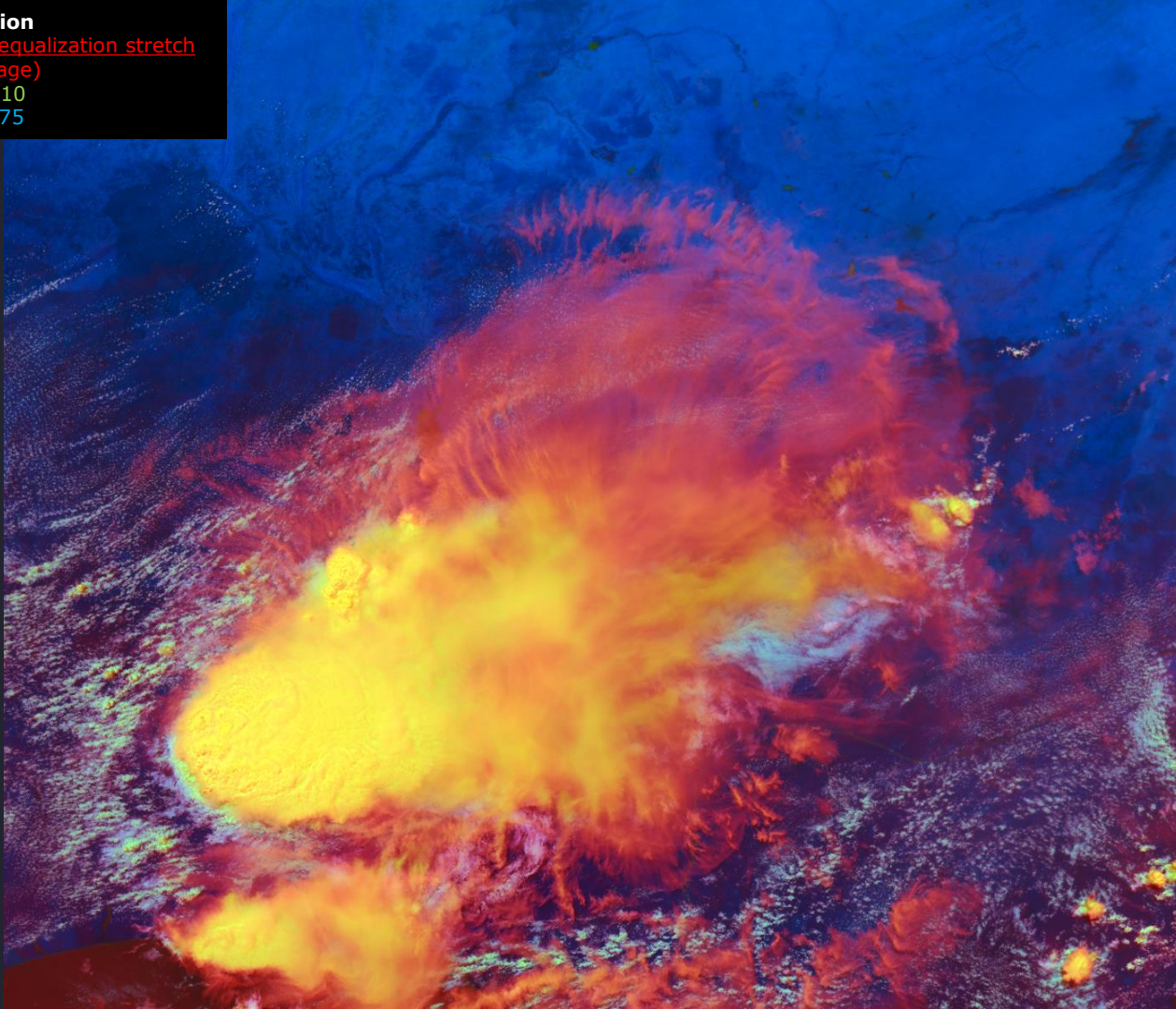
RGB Cloud Phase Distinction

M15 (10.76 μm), [histogram equalization stretch](#)

BT 205 - 305K inv. (full image)

M5 (0.67 μm), ref. 0.0 - 1.10

M10 (1.61 μm), ref. 0.0 - 0.75

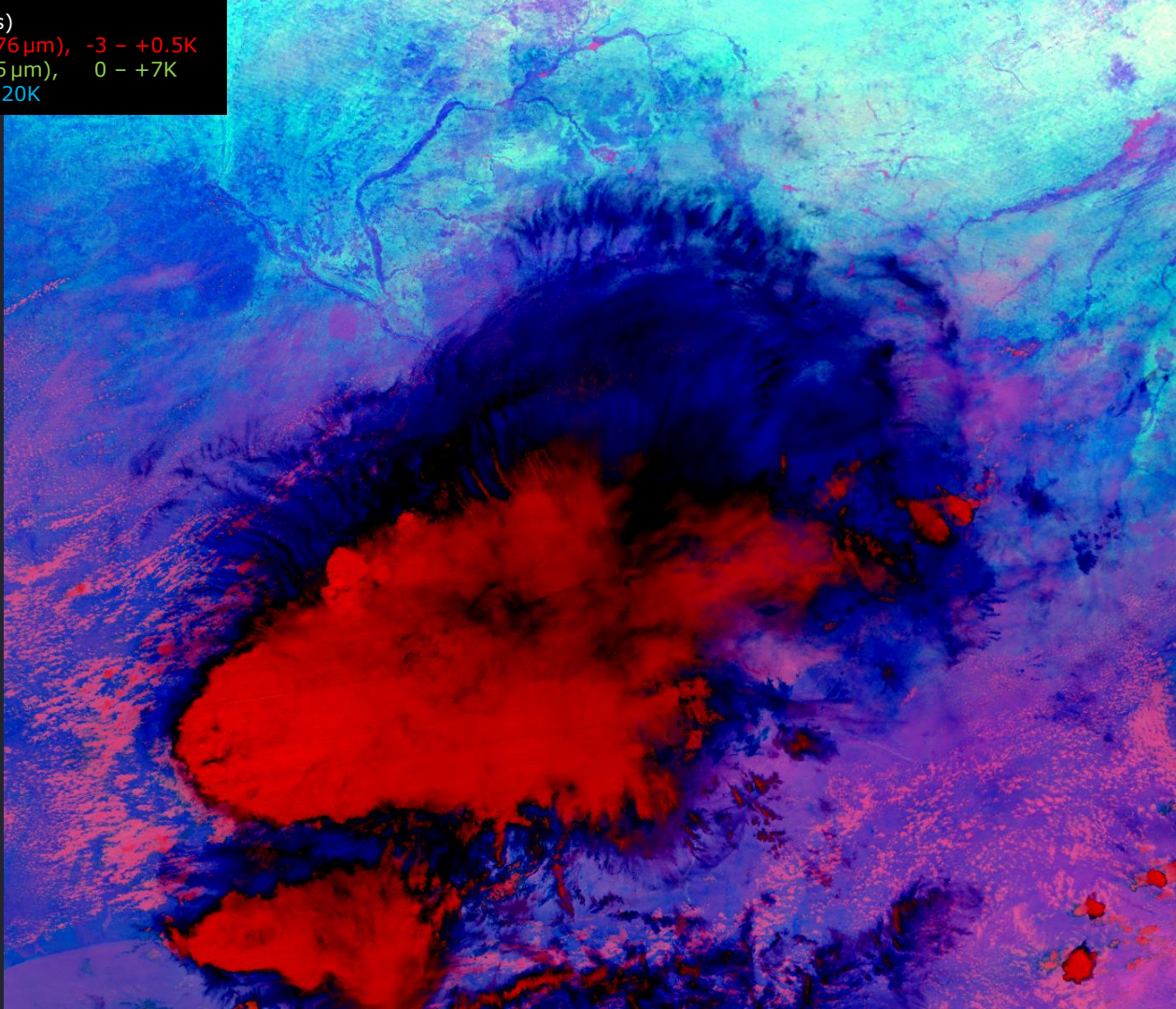


RGB 24M (24h Microphysics)

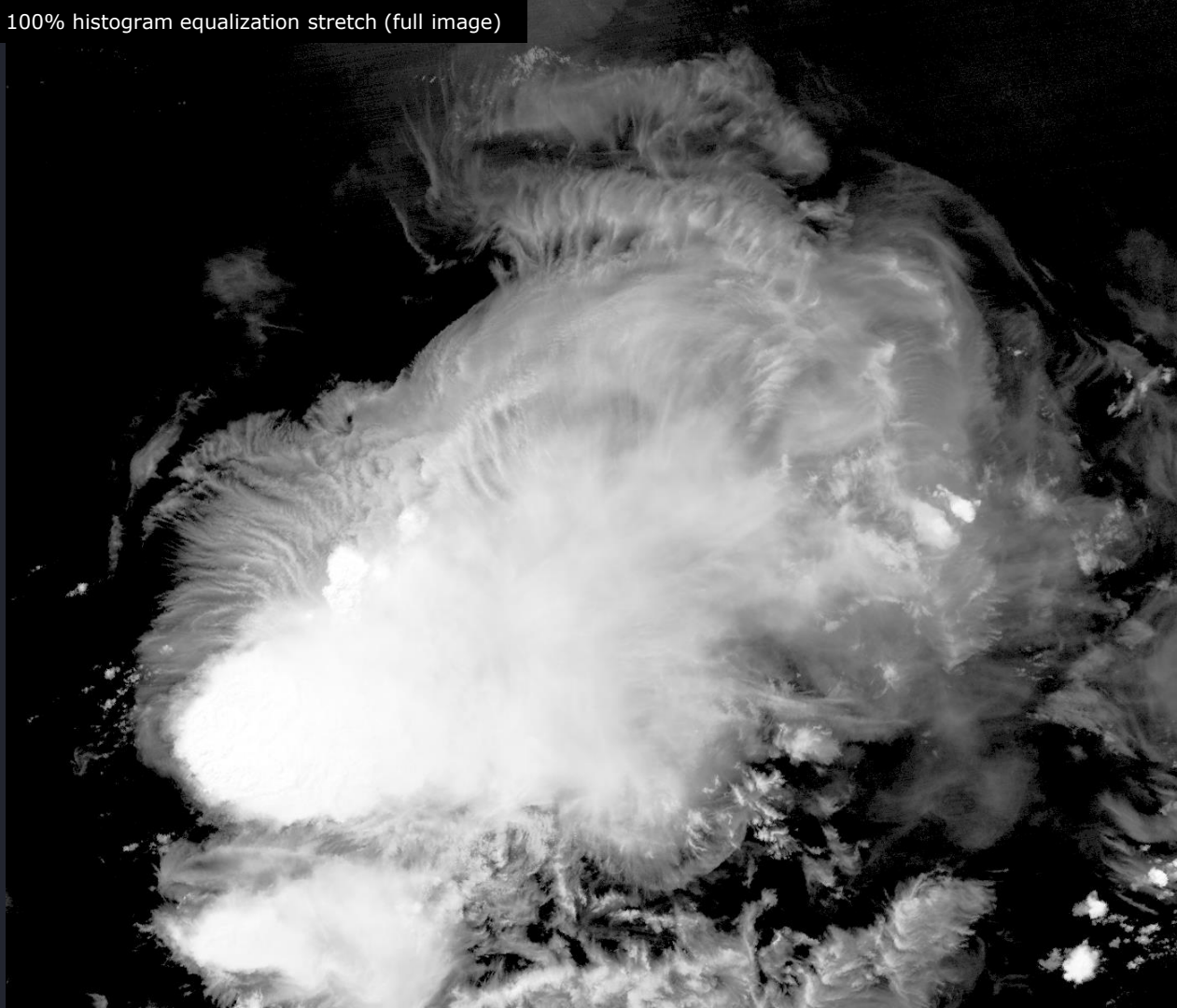
M16 (12.01 μm) - M15 (10.76 μm), -3 - +0.5K

M15 (10.76 μm) - M14 (8.55 μm), 0 - +7K

M15 (10.76 μm), BT 240 - 320K



M9 (1.378 μm), ref. 0.2% – 100% histogram equalization stretch (full image)

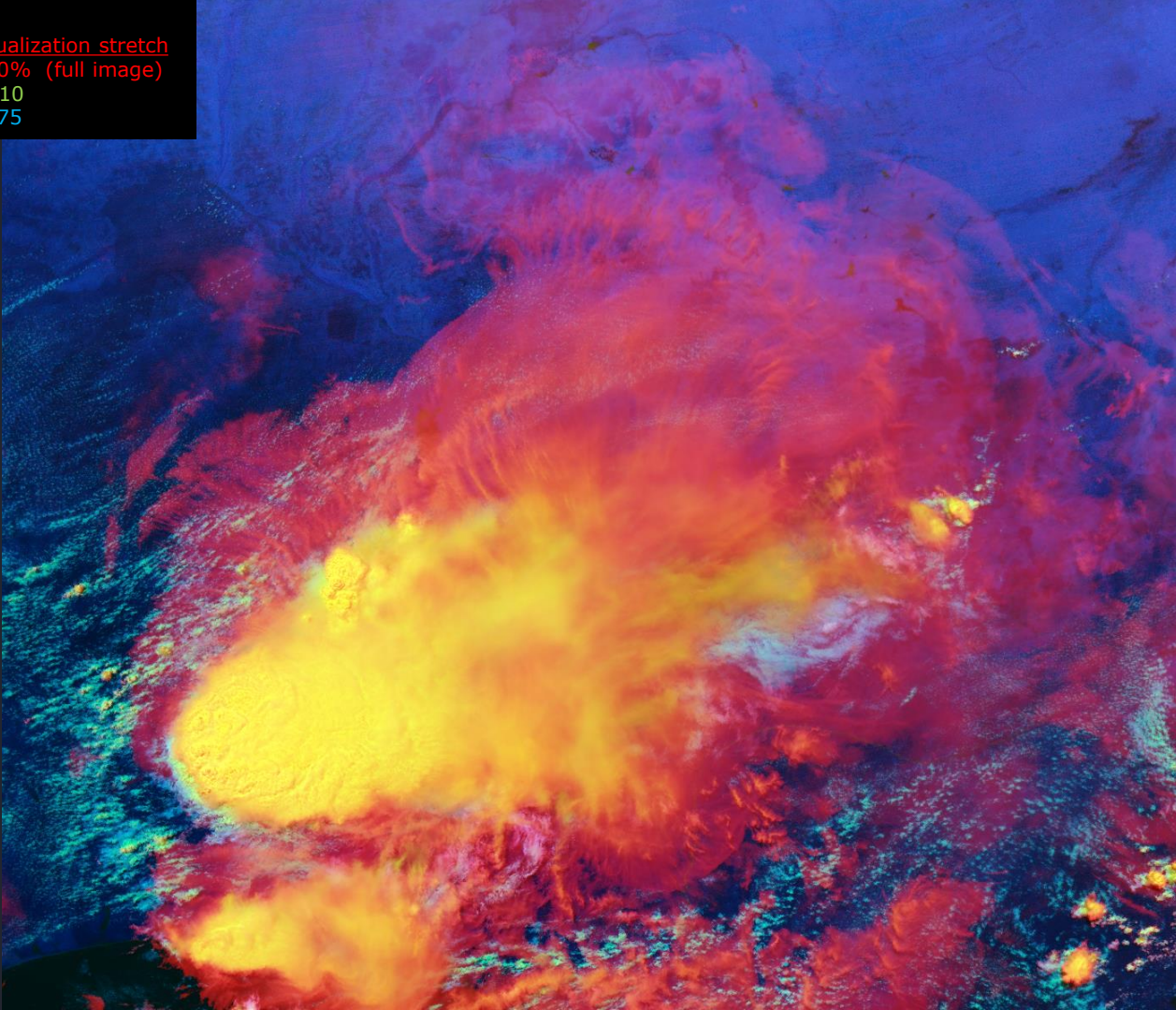


RGB Cloud Type

M9 (1.38 μm), histogram equalization stretch
reflectivity range 0.0% - 100% (full image)

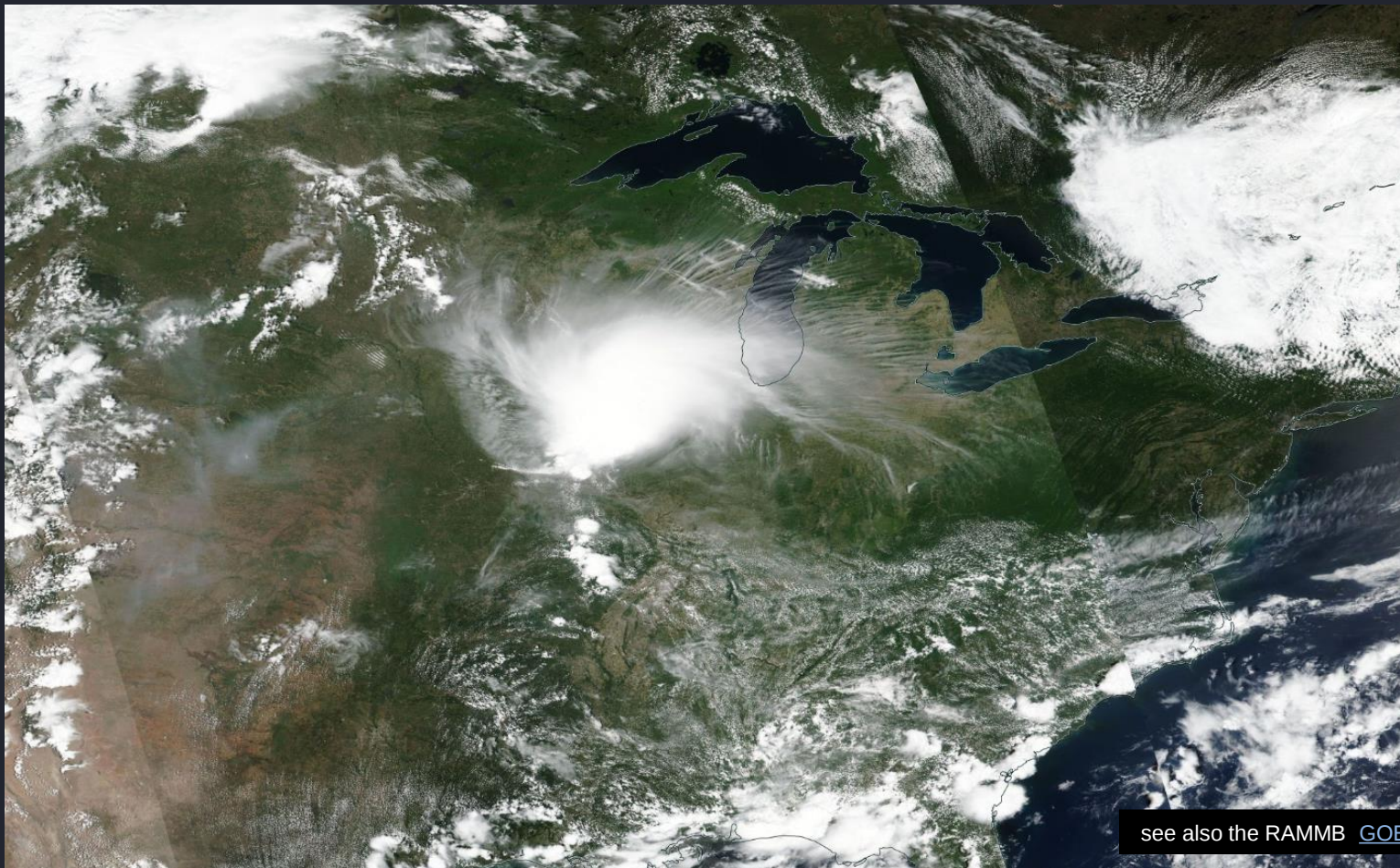
M5 (0.67 μm), ref. 0.0 - 1.10

M10 (1.61 μm), ref. 0.0 - 0.75



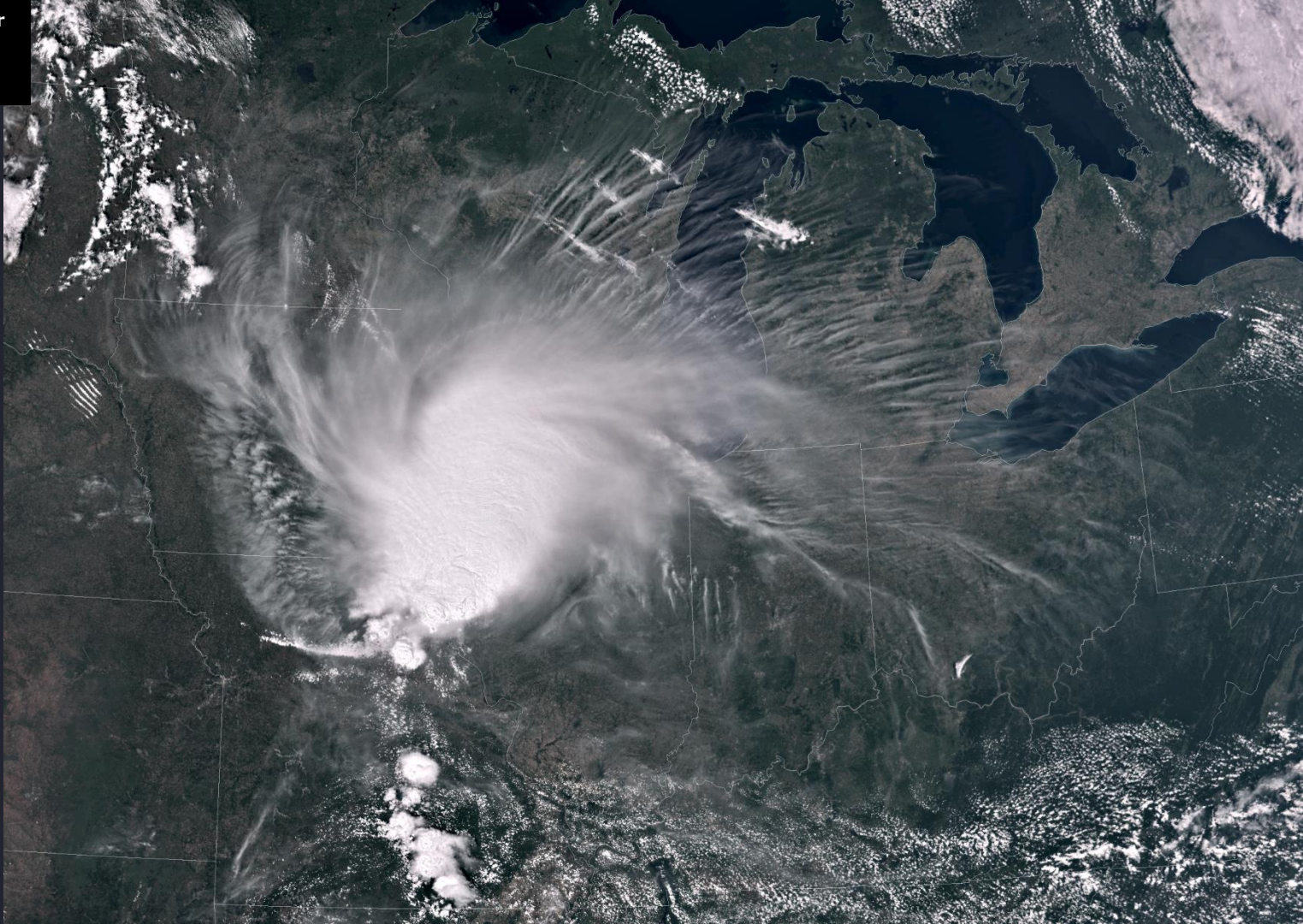
14 June 2018 19:05 UTC, VIIRS S-NPP, U.S.A. (WI, IA, MO, IL)

image source: [NASA EOSDIS Worldview](#)

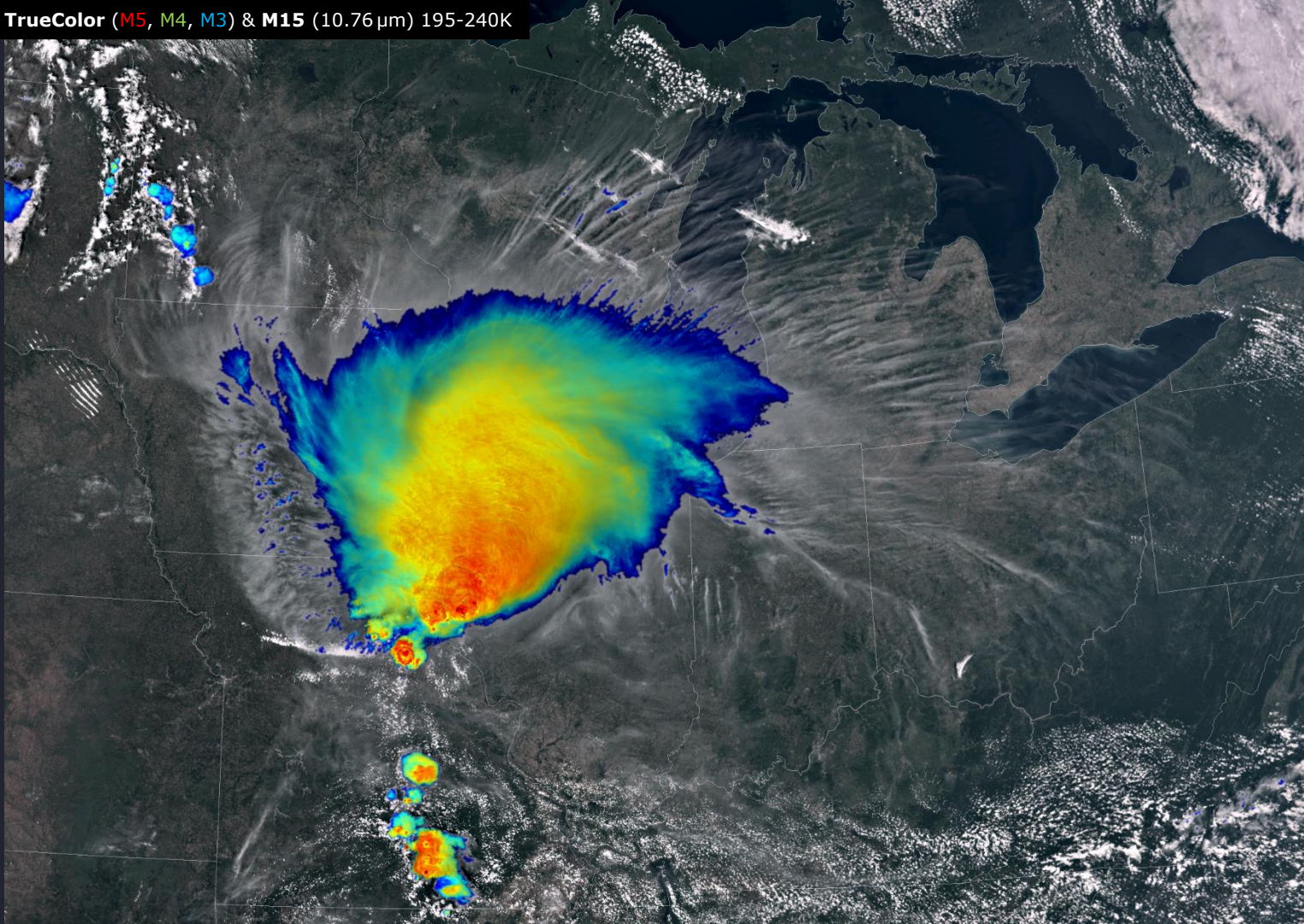


see also the RAMMB [GOES-16 loop](#)

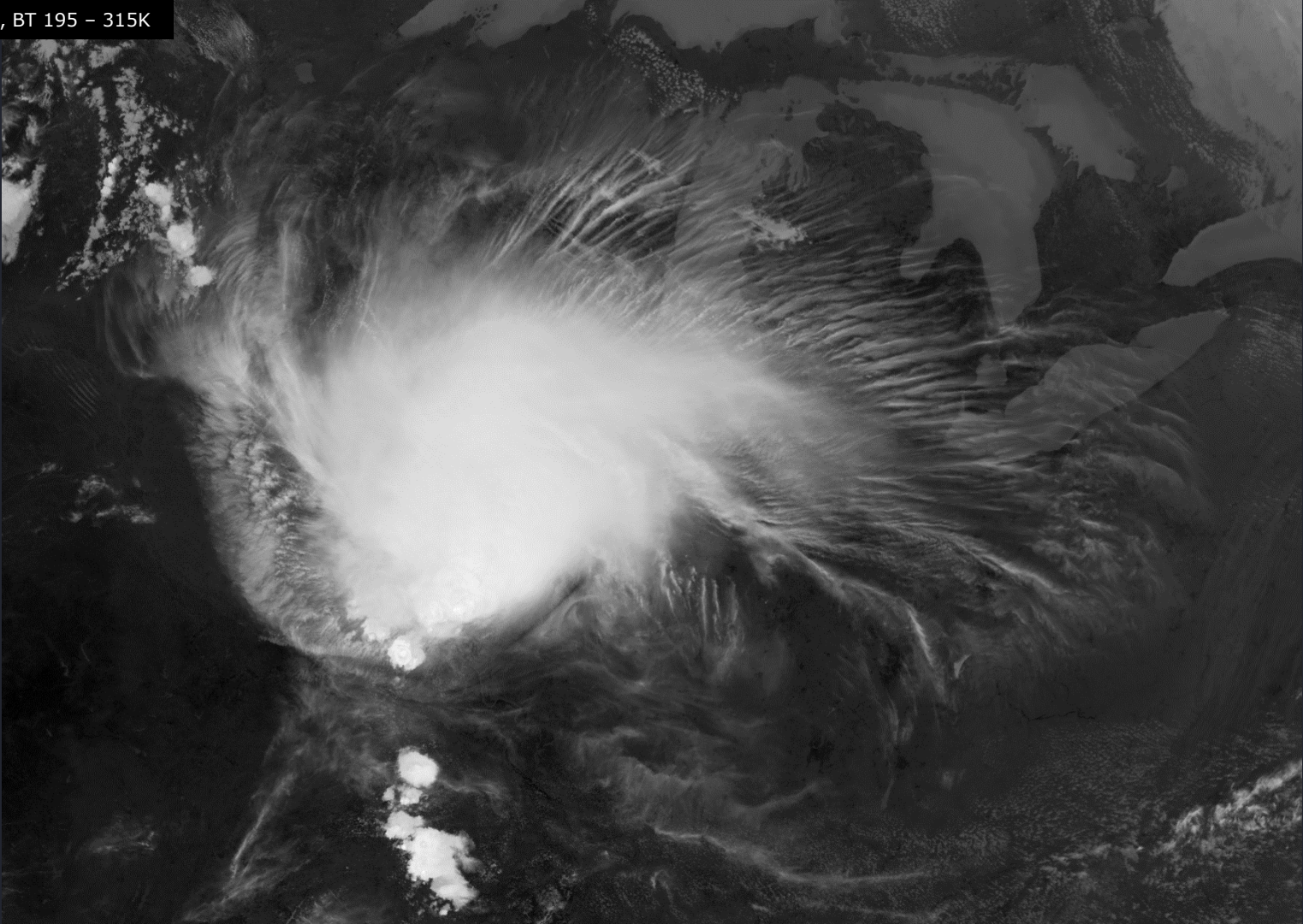
RGB True Color
M5 (0.672 μm)
M4 (0.555 μm)
M3 (0.488 μm)



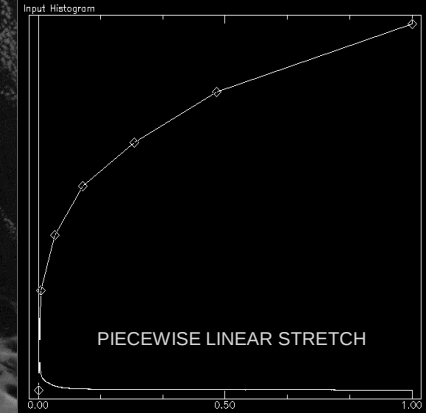
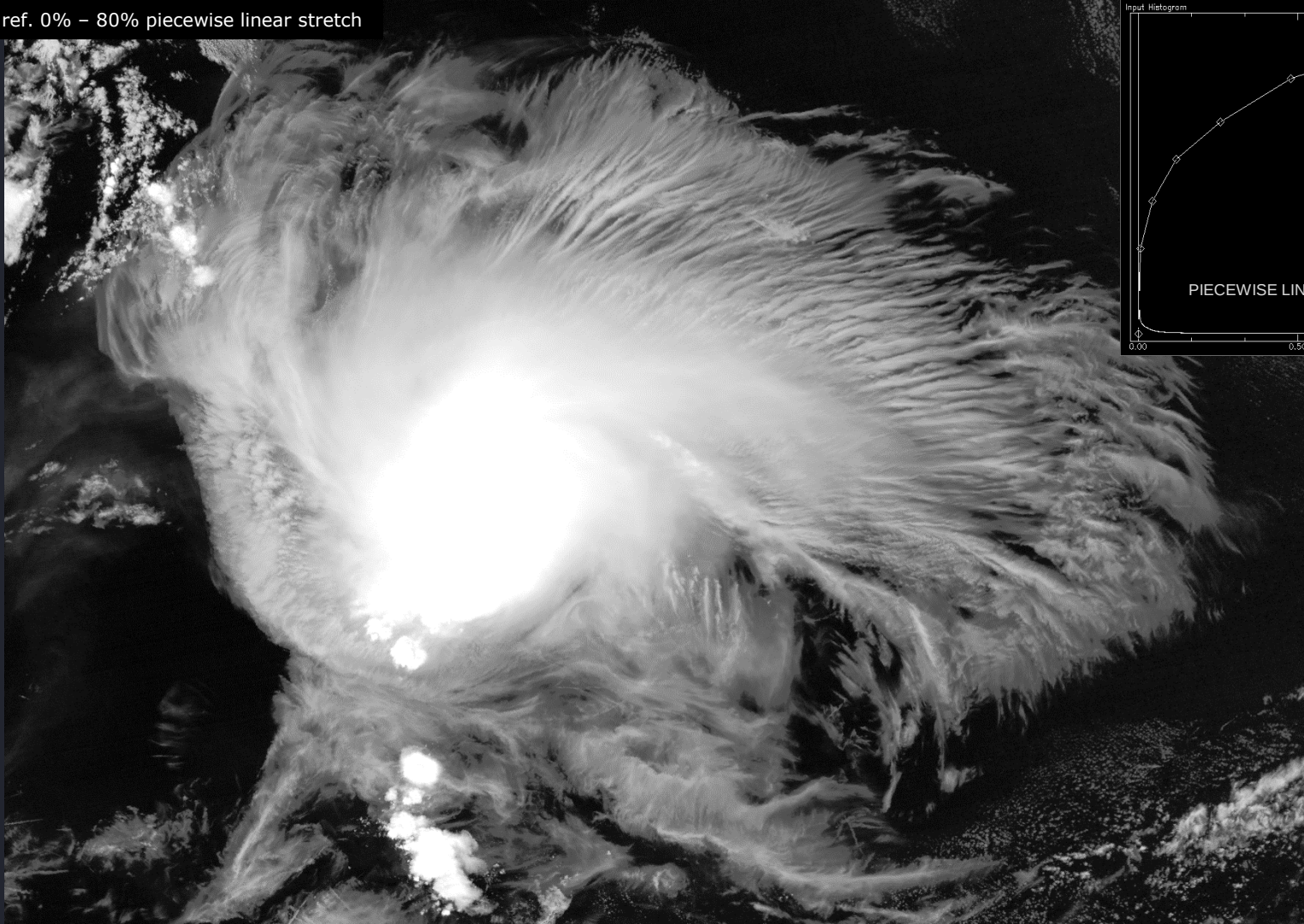
Sandwich RGB TrueColor (M5, M4, M3) & M15 (10.76 μm) 195-240K



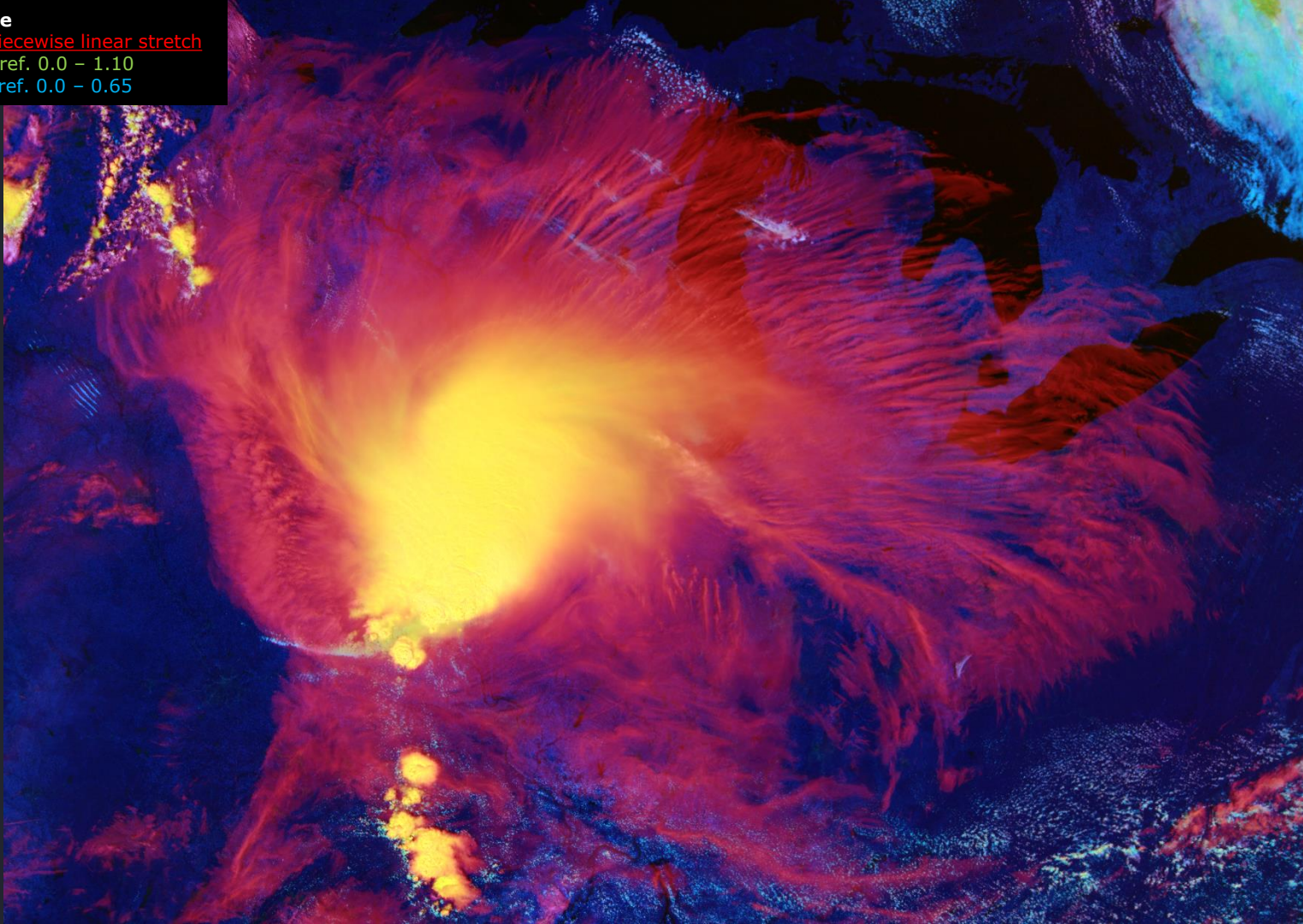
M15 (10.76 μm), BT 195 - 315K



M9 (1.378 μm), ref. 0% – 80% piecewise linear stretch



RGB Cloud Type
M9 (1.38 μm), piecewise linear stretch
M5 (0.67 μm), ref. 0.0 - 1.10
M10 (1.61 μm), ref. 0.0 - 0.65

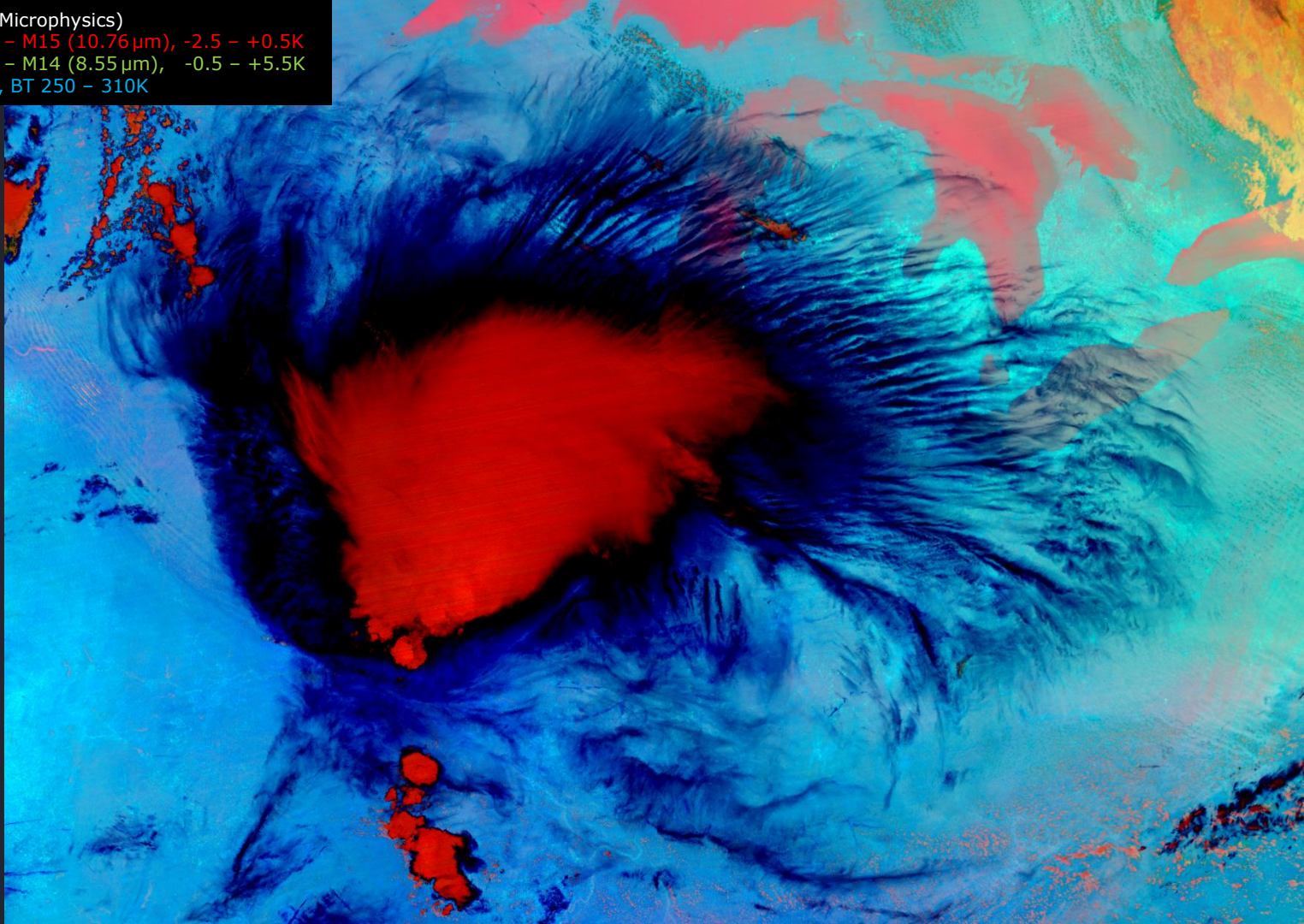


RGB 24M (24h Microphysics)

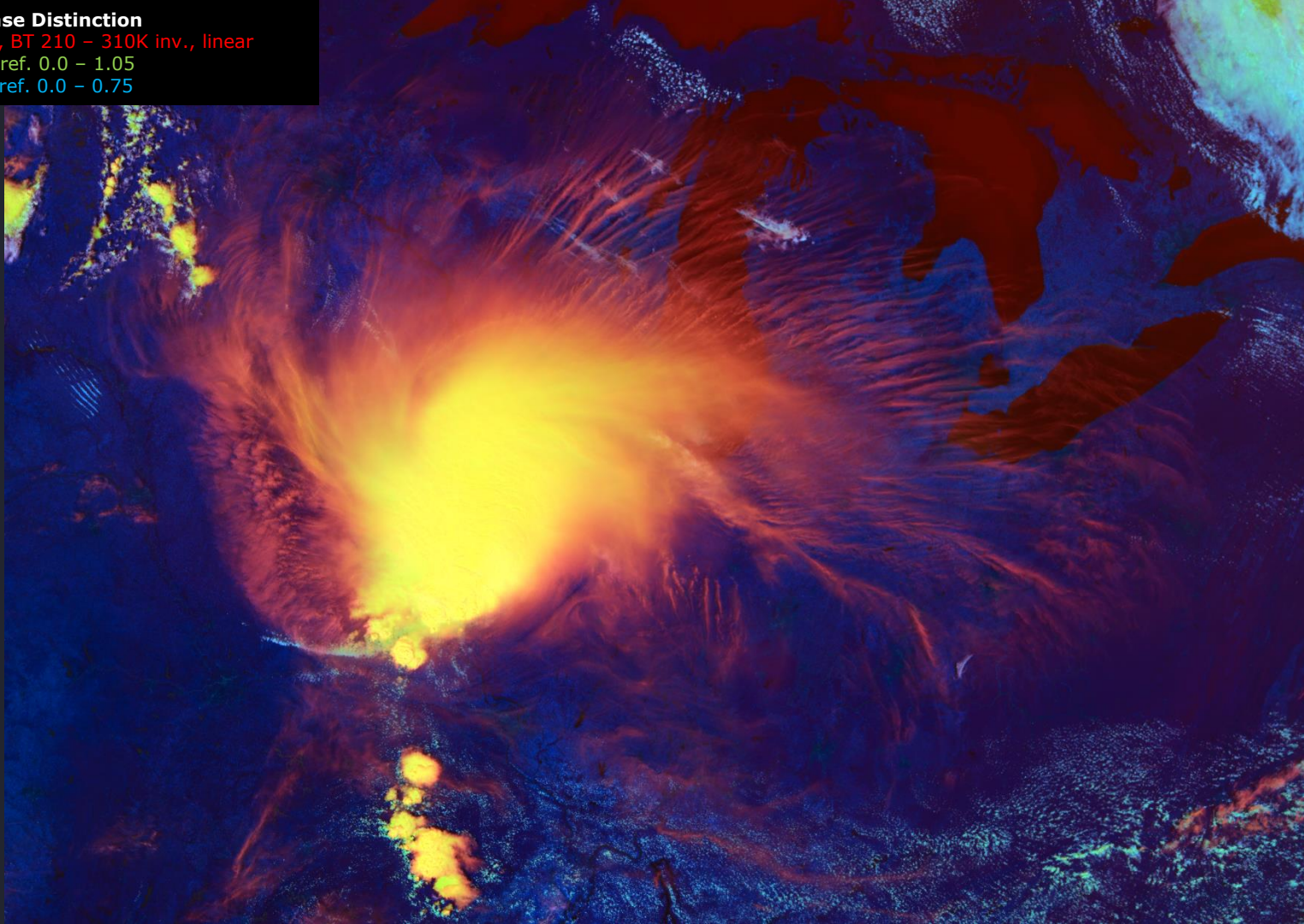
M16 (12.01 μm) - M15 (10.76 μm), -2.5 - +0.5K

M15 (10.76 μm) - M14 (8.55 μm), -0.5 - +5.5K

M15 (10.76 μm), BT 250 - 310K



RGB Cloud Phase Distinction
M15 (10.76 μm), BT 210 - 310K inv., linear
M5 (0.67 μm), ref. 0.0 - 1.05
M10 (1.61 μm), ref. 0.0 - 0.75



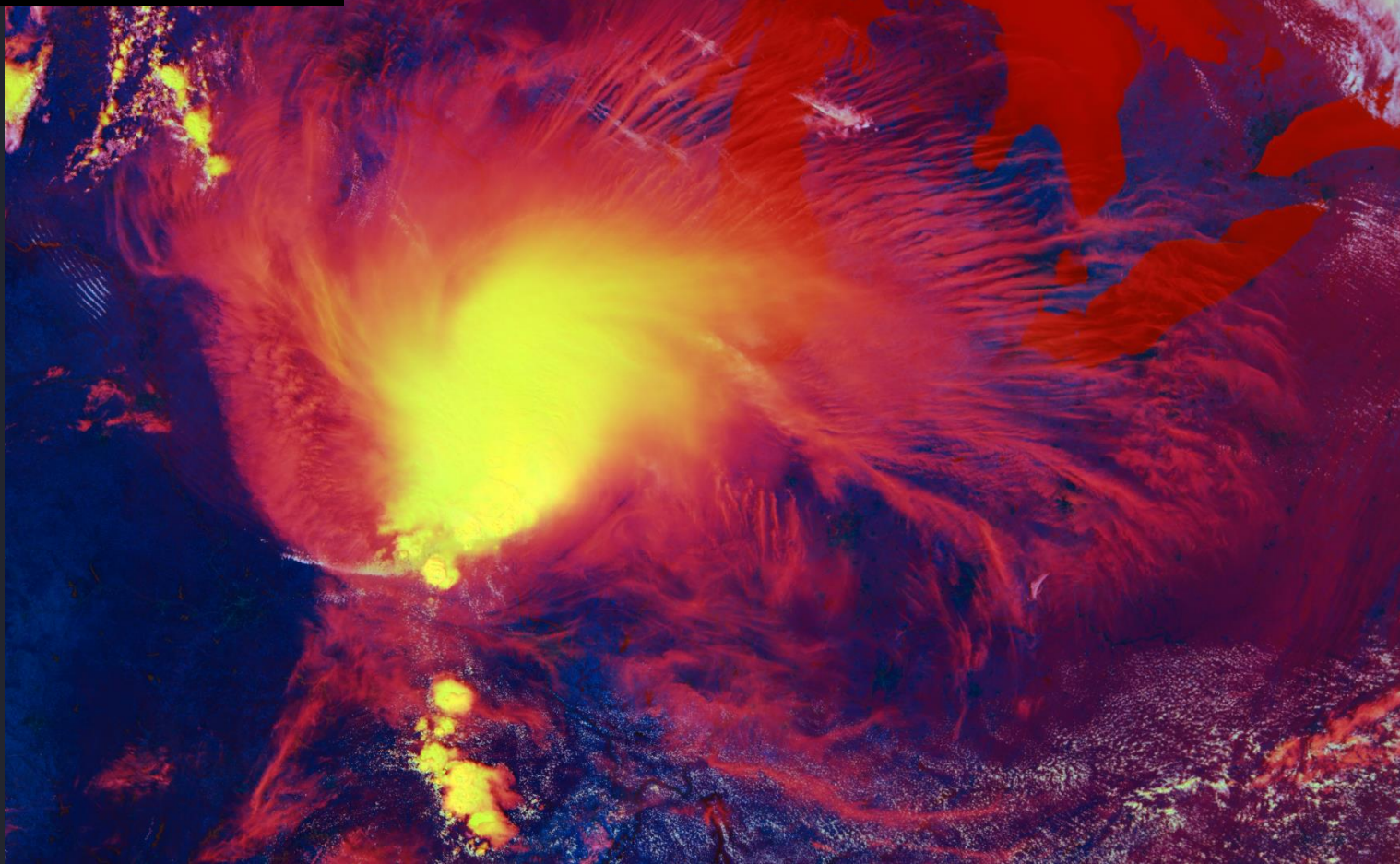
RGB Cloud Phase Distinction

M15 (10.76 μm), [histogram equalization stretch](#)

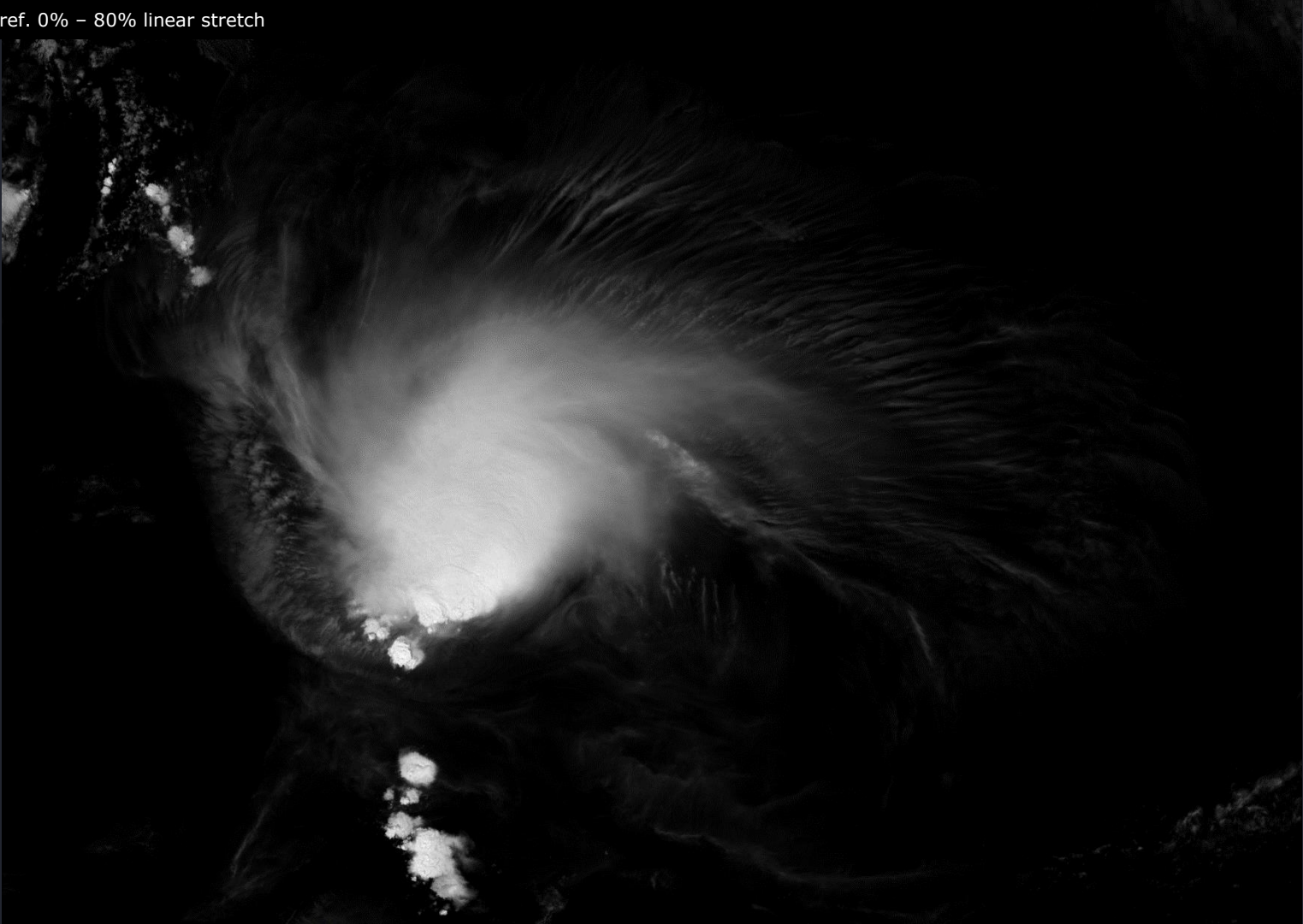
BT 210 - 310K inv. (image subset)

M5 (0.67 μm), ref. 0.0 - 1.05

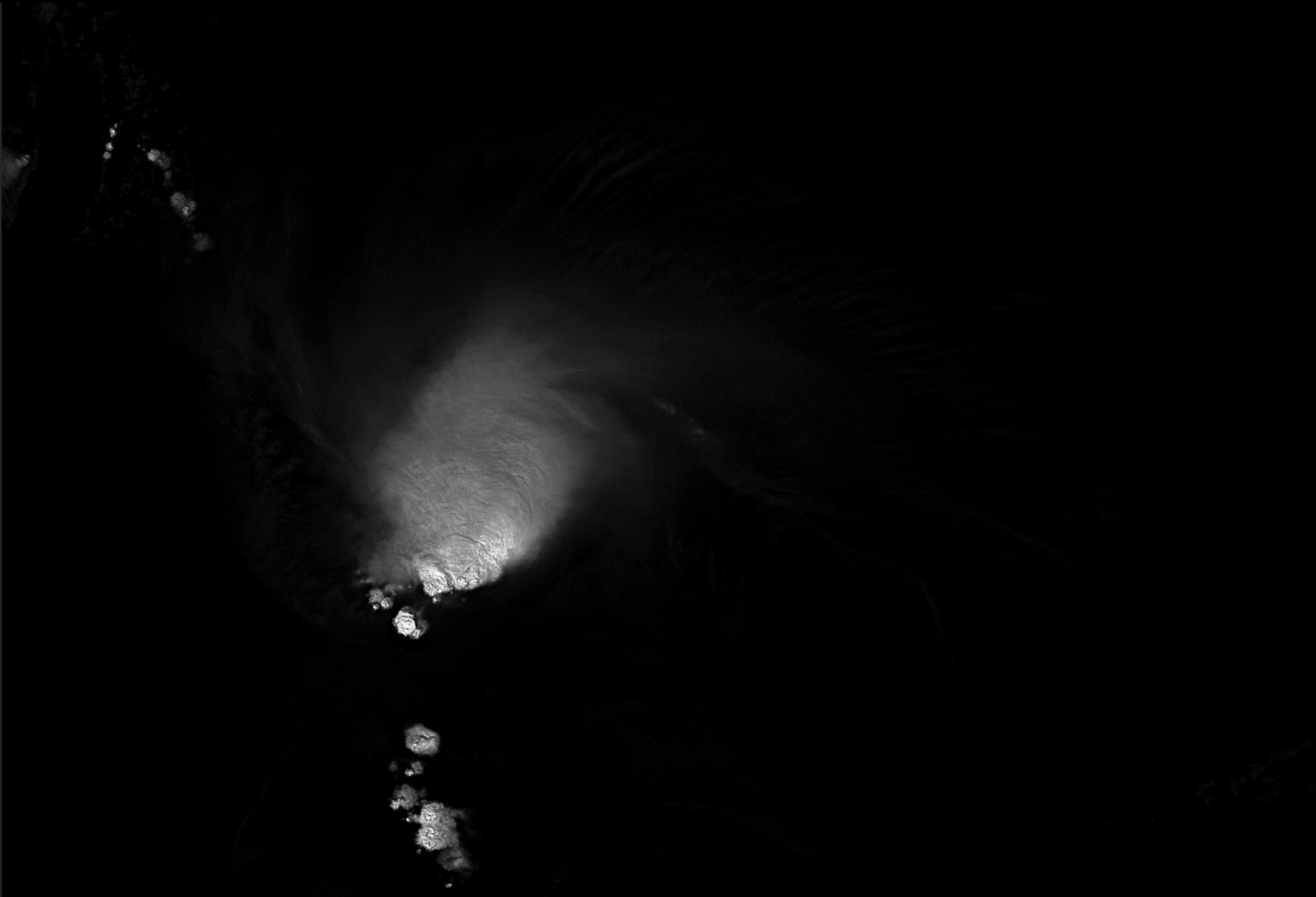
M10 (1.61 μm), ref. 0.0 - 0.75



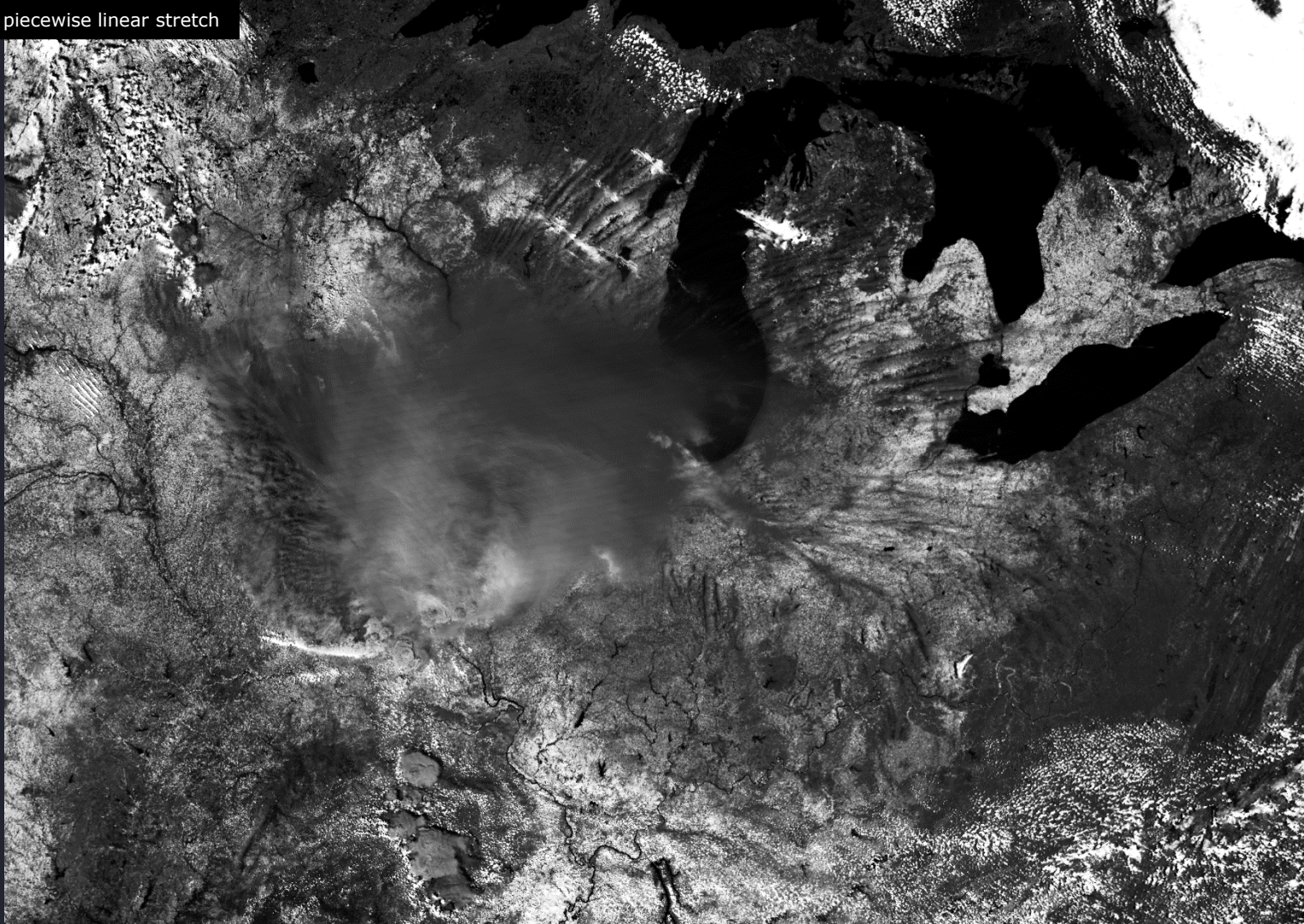
M9 (1.378 μm), ref. 0% – 80% linear stretch



M9 (1.378 μm), ref. 0% – 80% strong piecewise linear stretch



M10 (1.61 μm), piecewise linear stretch

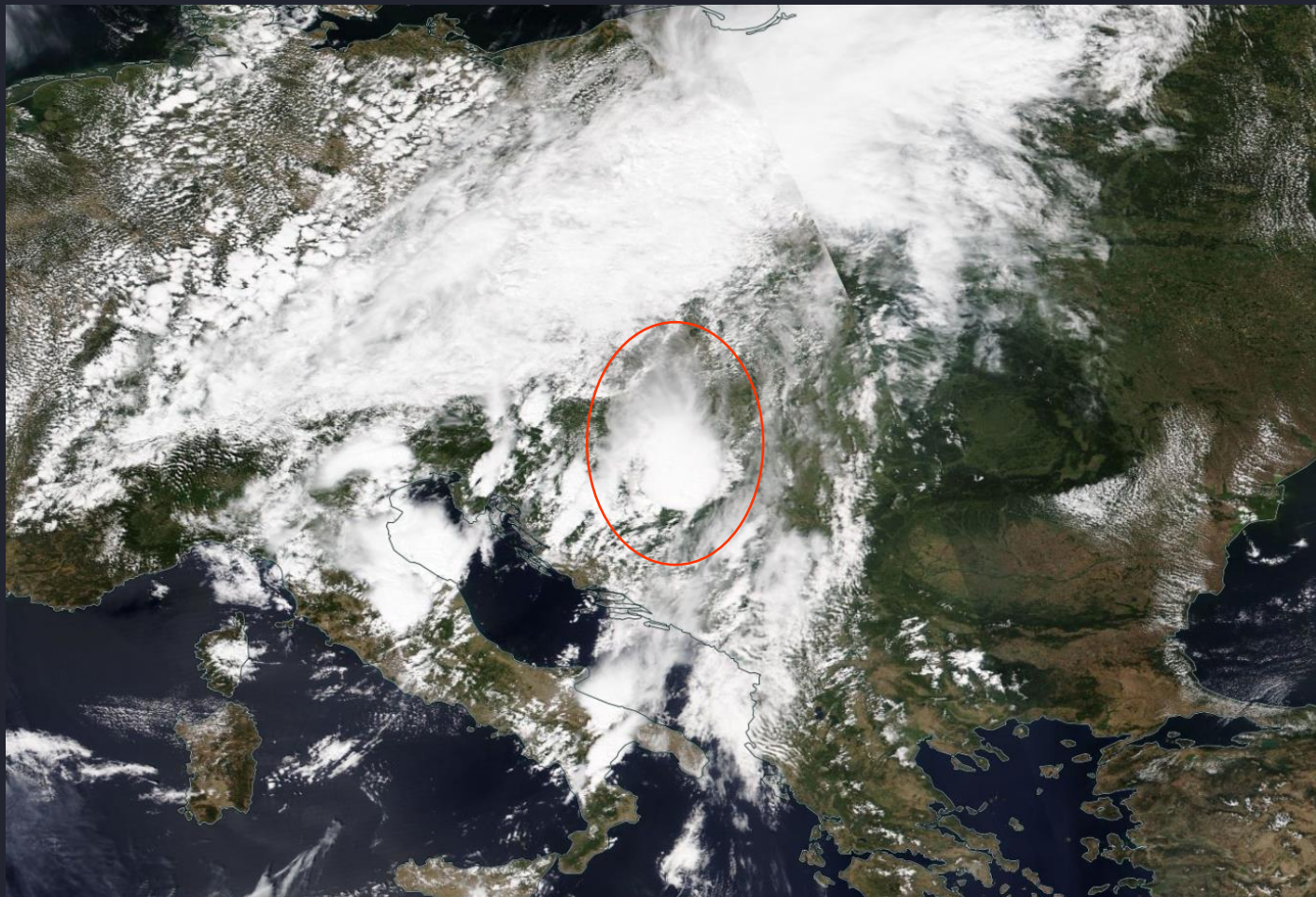


M12 (3.7 μm), BT 255 – 295K



04 August 2020 12:07 UTC, VIIRS NOAA-20, Croatia, Hungary

image source: [NASA EOSDIS Worldview](#)

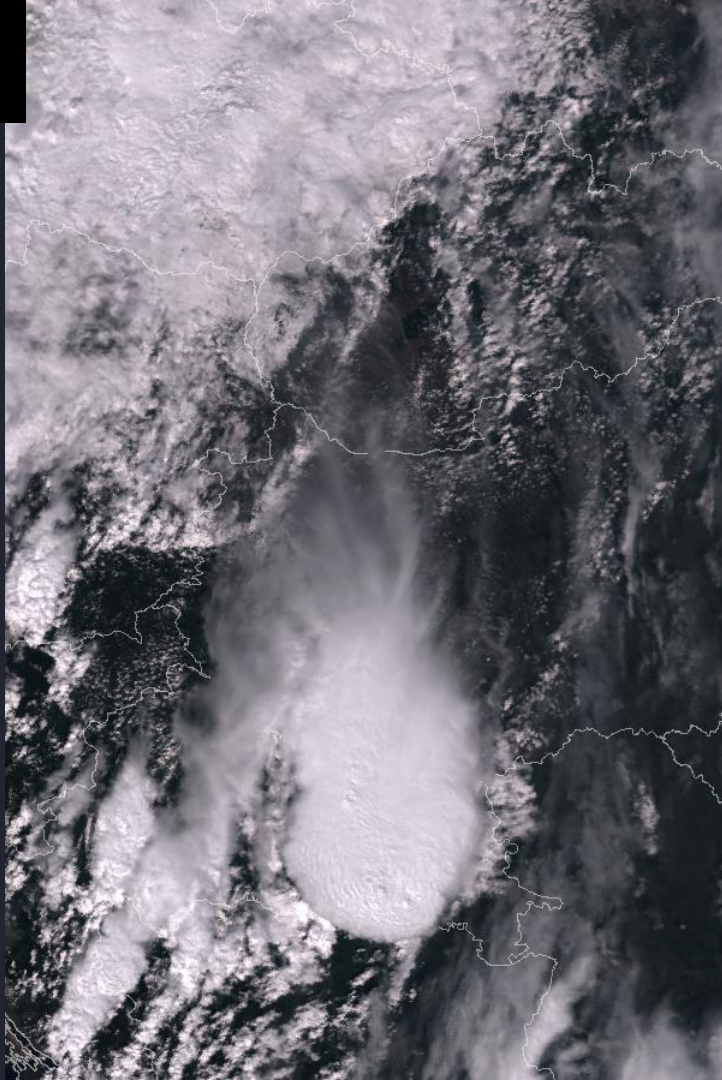


RGB True Color

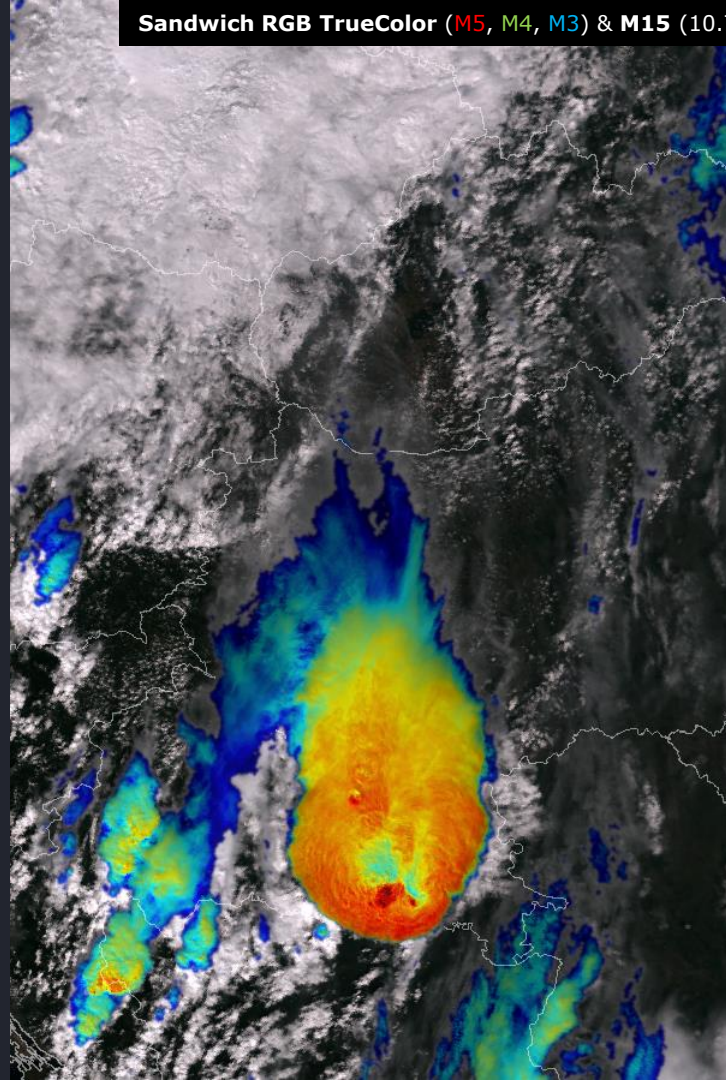
M5 (0.672 μm)

M4 (0.555 μm)

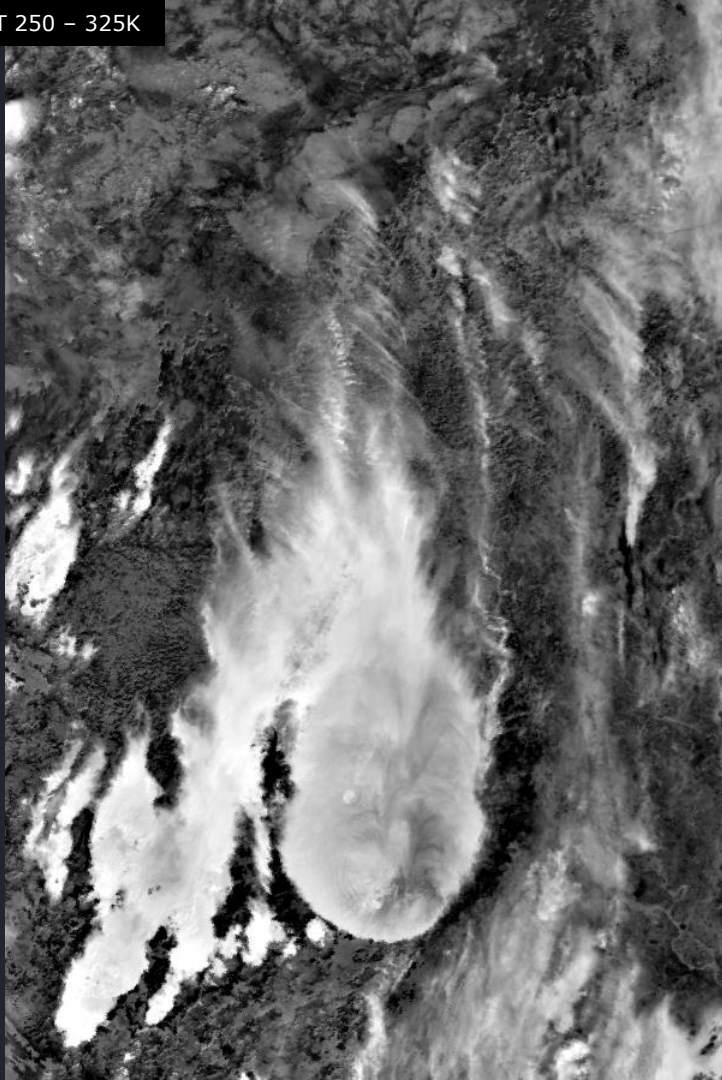
M3 (0.488 μm)



Sandwich RGB TrueColor (M5, M4, M3) & M15 (10.76 μm) 205-240K



M12 ($3.7\text{ }\mu\text{m}$), BT 250 – 325K



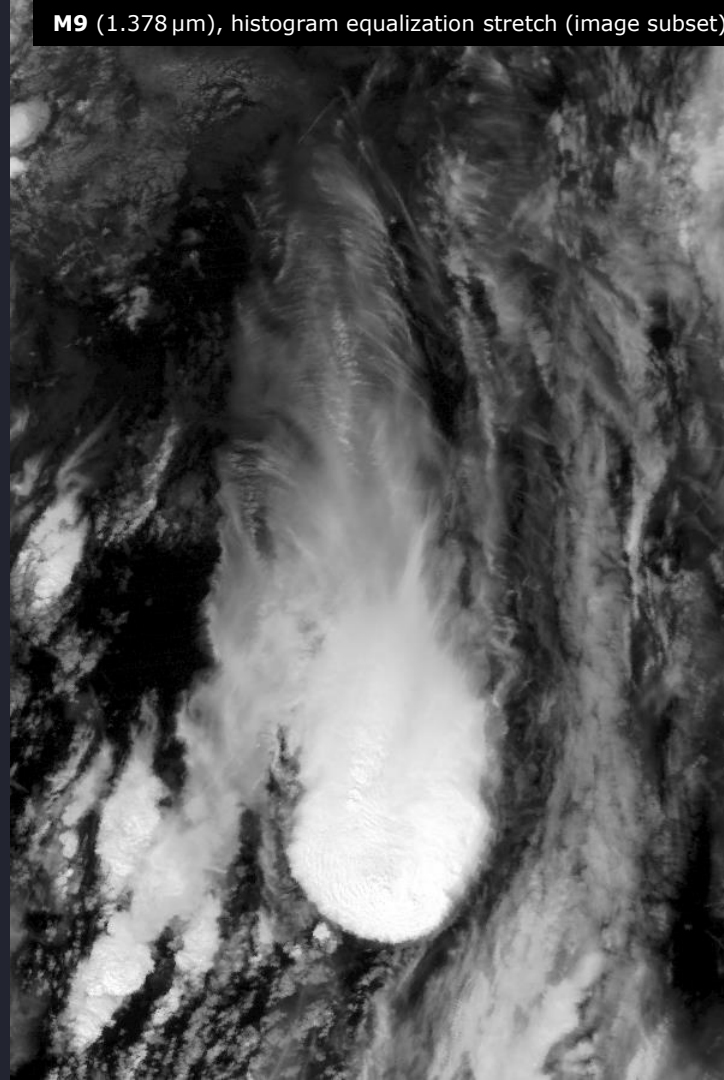
M15 ($10.76\text{ }\mu\text{m}$), BT 205 – 240K



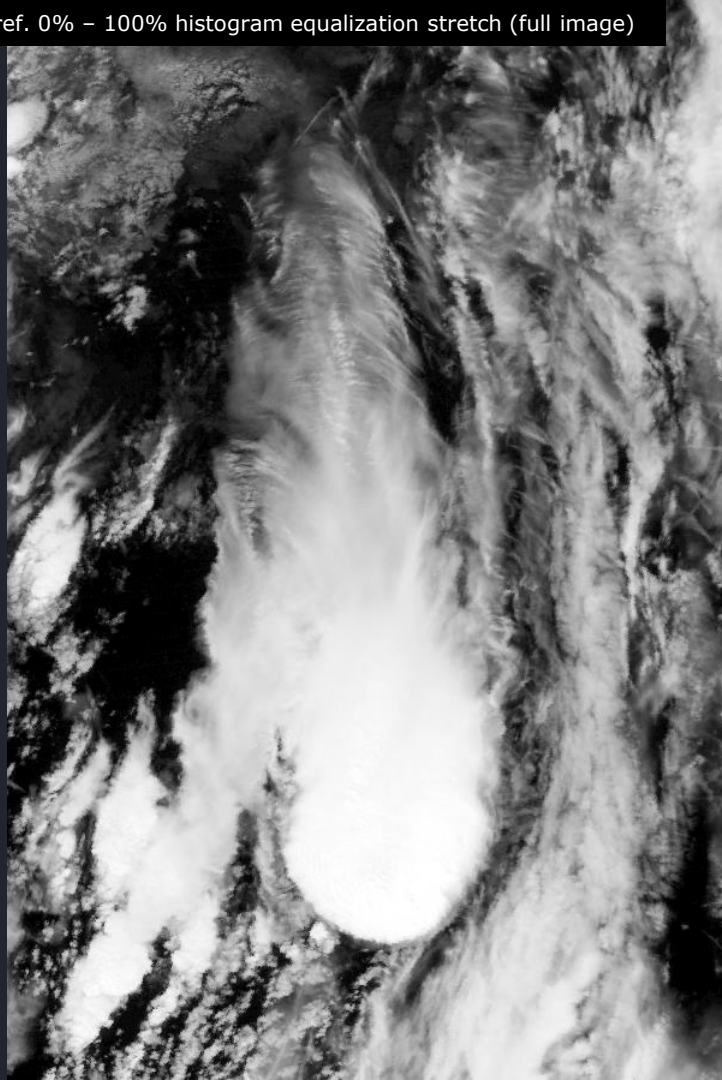
M9 (1.378 μm), ref. 0% – 80% linear stretch



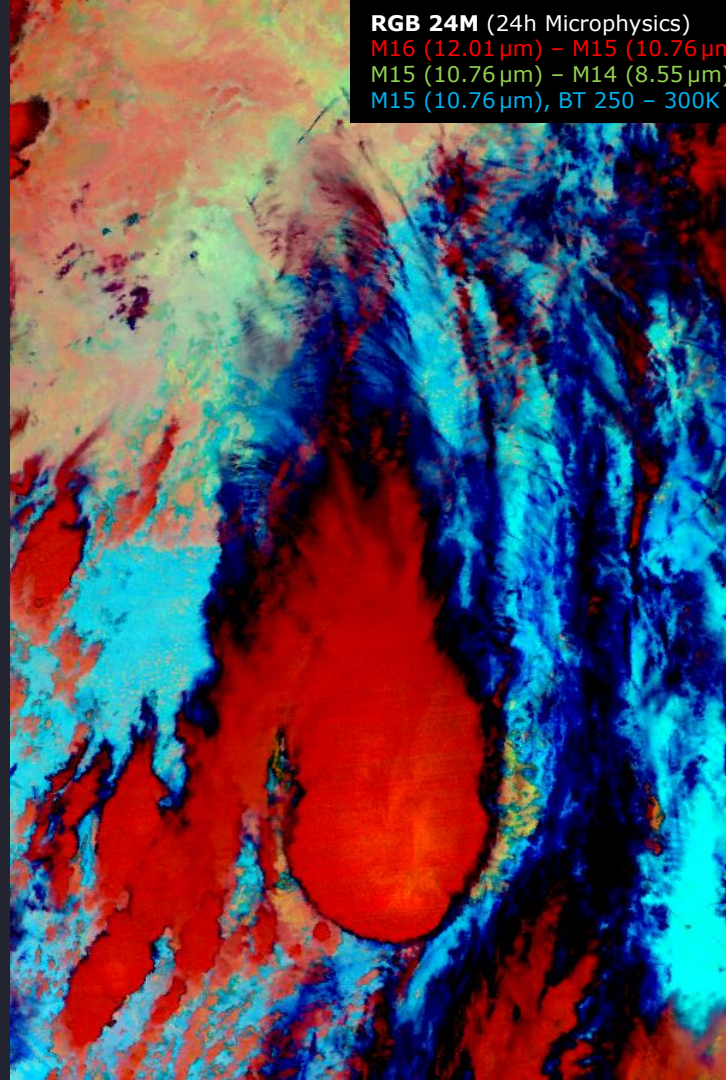
M9 (1.378 μm), histogram equalization stretch (image subset)



M9 (1.378 μm), ref. 0% - 100% histogram equalization stretch (full image)



RGB 24M (24h Microphysics)
M16 (12.01 μm) - M15 (10.76 μm), -2.5 - +0.5K
M15 (10.76 μm) - M14 (8.55 μm), 0 - +4K
M15 (10.76 μm), BT 250 - 300K

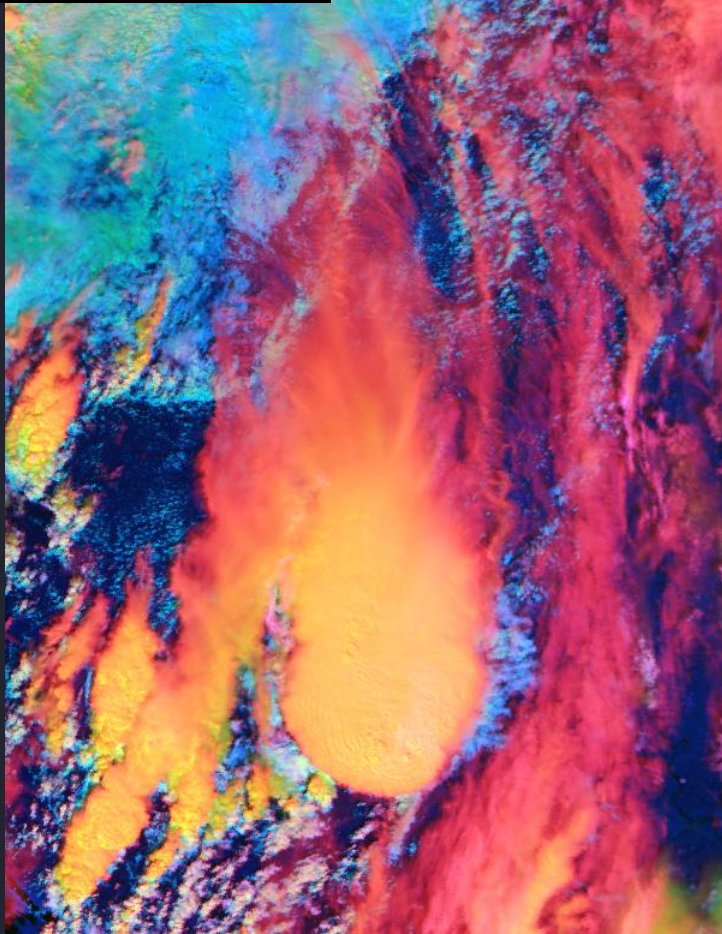


RGB Cloud Type

M9 ($1.38\mu\text{m}$), [histogram equalization stretch](#)
reflectivity range 0.0% - 100% (full image)

M5 ($0.67\mu\text{m}$), ref. 0.0 - 1.10

M10 ($1.61\mu\text{m}$), ref. 0.0 - 0.75

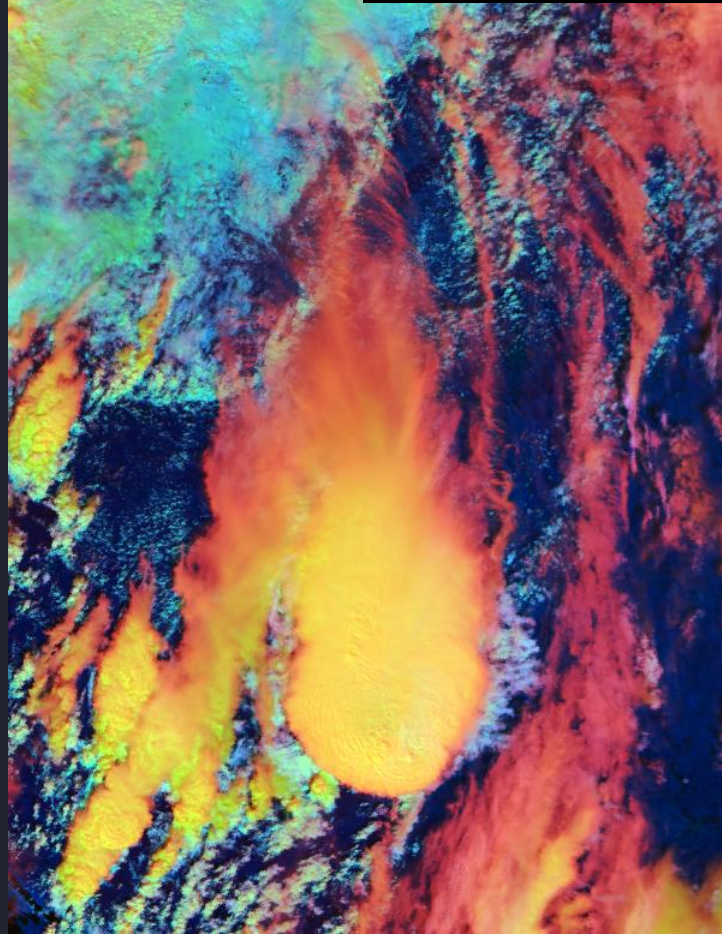


RGB Cloud Phase Distinction

M15 ($10.76\mu\text{m}$), [histogram equalization stretch](#)
BT 205 - 305K inv. (full image)

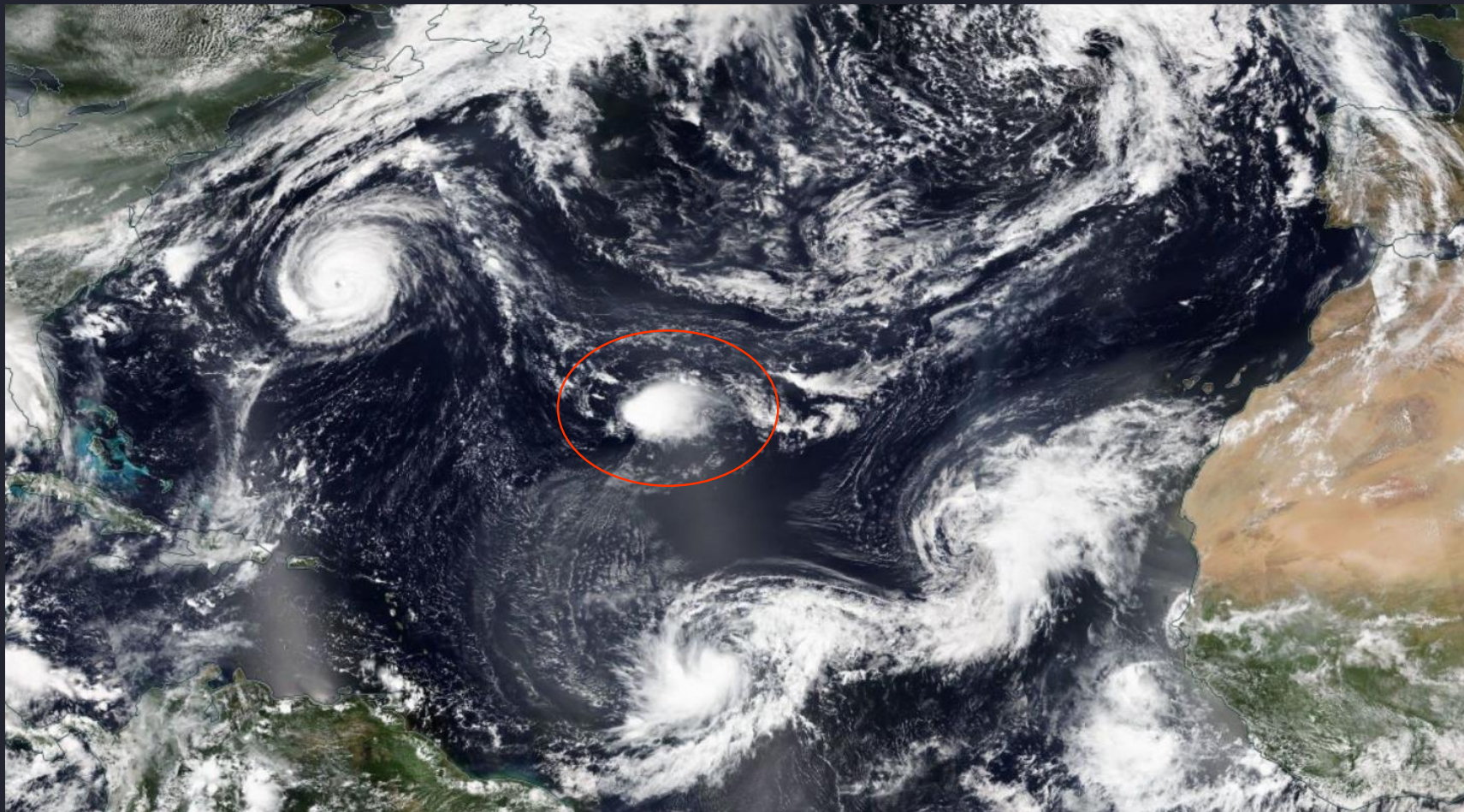
M5 ($0.67\mu\text{m}$), ref. 0.0 - 1.10

M10 ($1.61\mu\text{m}$), ref. 0.0 - 0.75

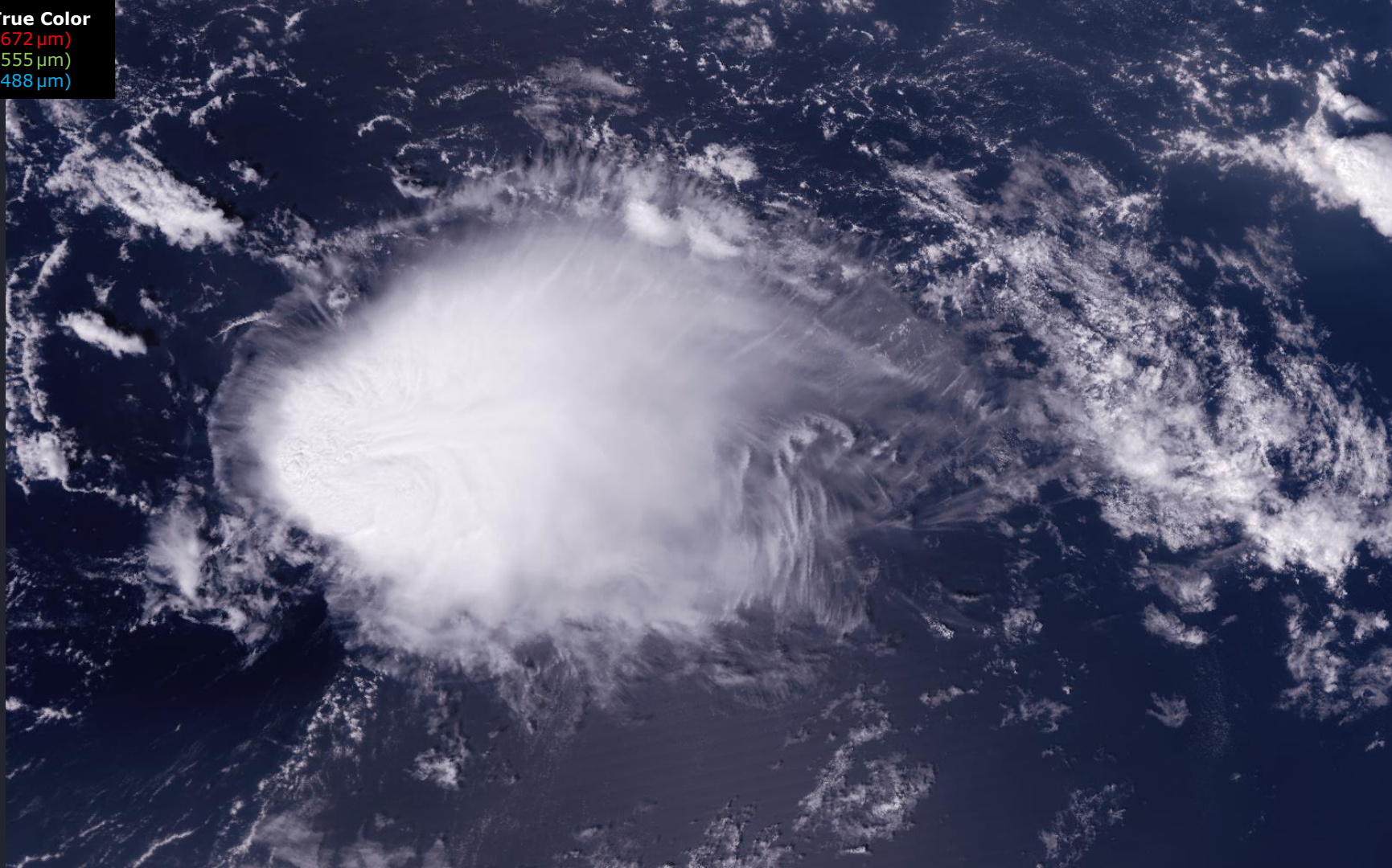


14 September 2020 15:57 UTC, VIIRS NOAA-20, central Atlantic

image source: [NASA EOSDIS Worldview](#)



RGB True Color
M5 (0.672 μm)
M4 (0.555 μm)
M3 (0.488 μm)

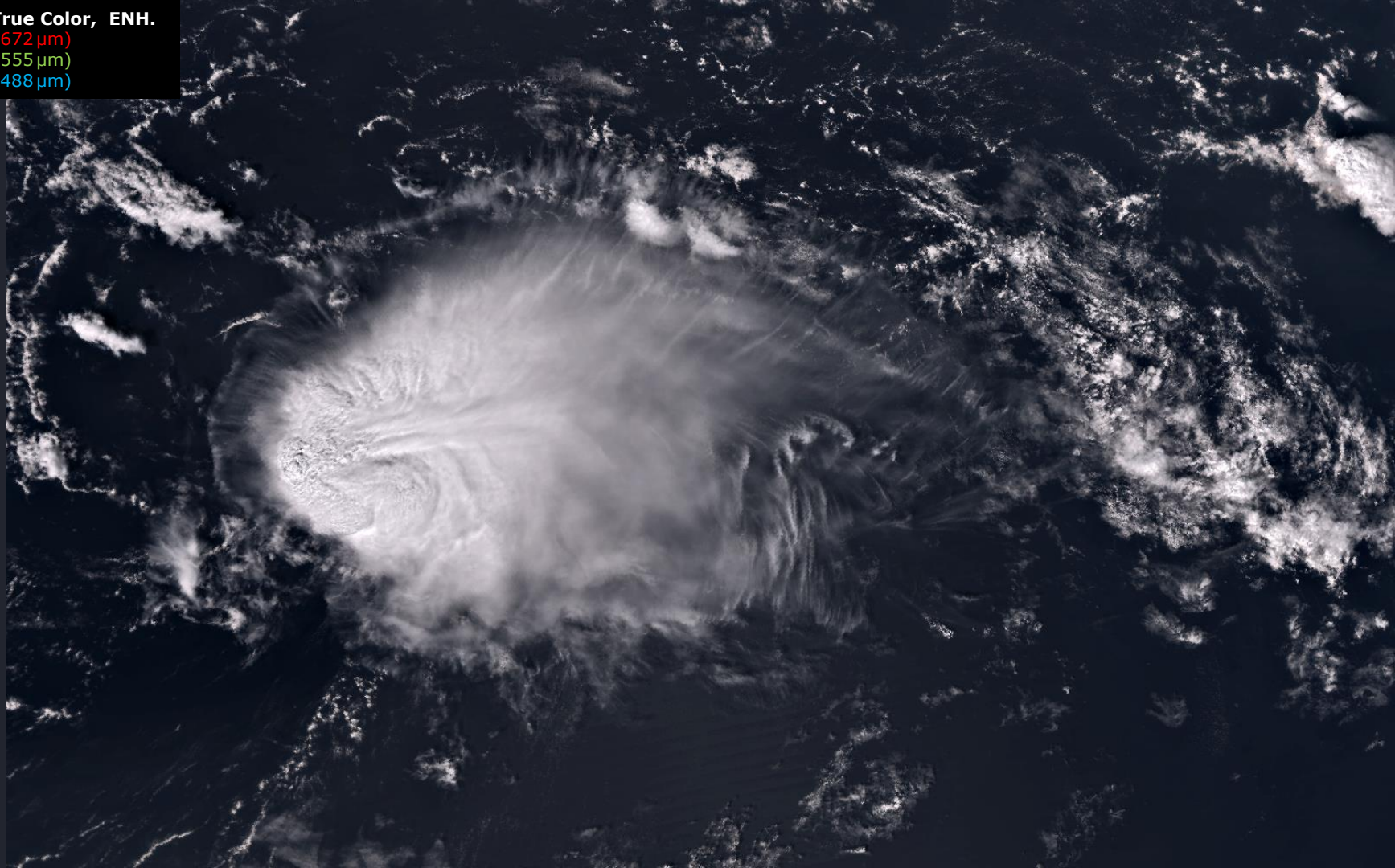


RGB True Color, ENH.

M5 (0.672 μm)

M4 (0.555 μm)

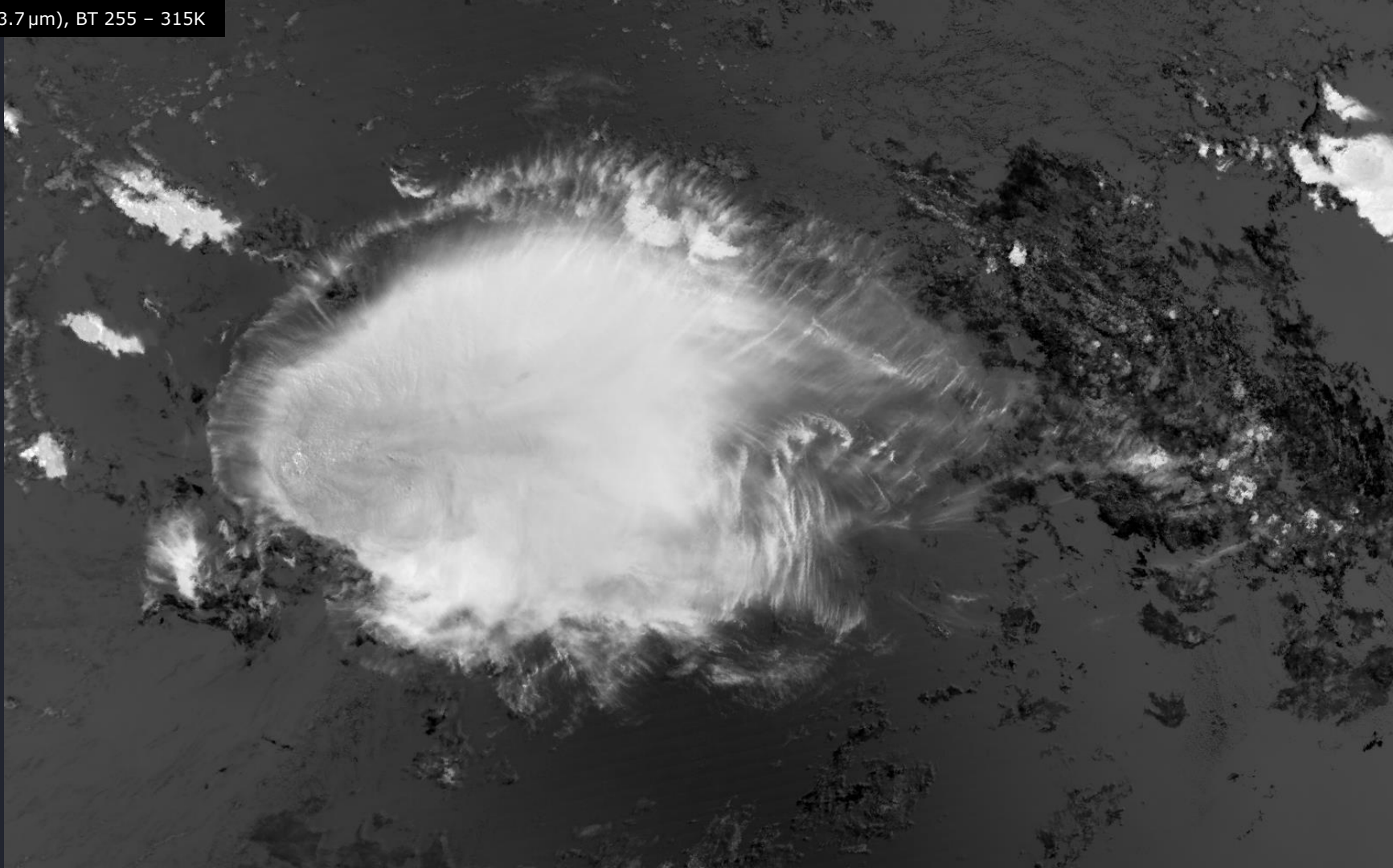
M3 (0.488 μm)



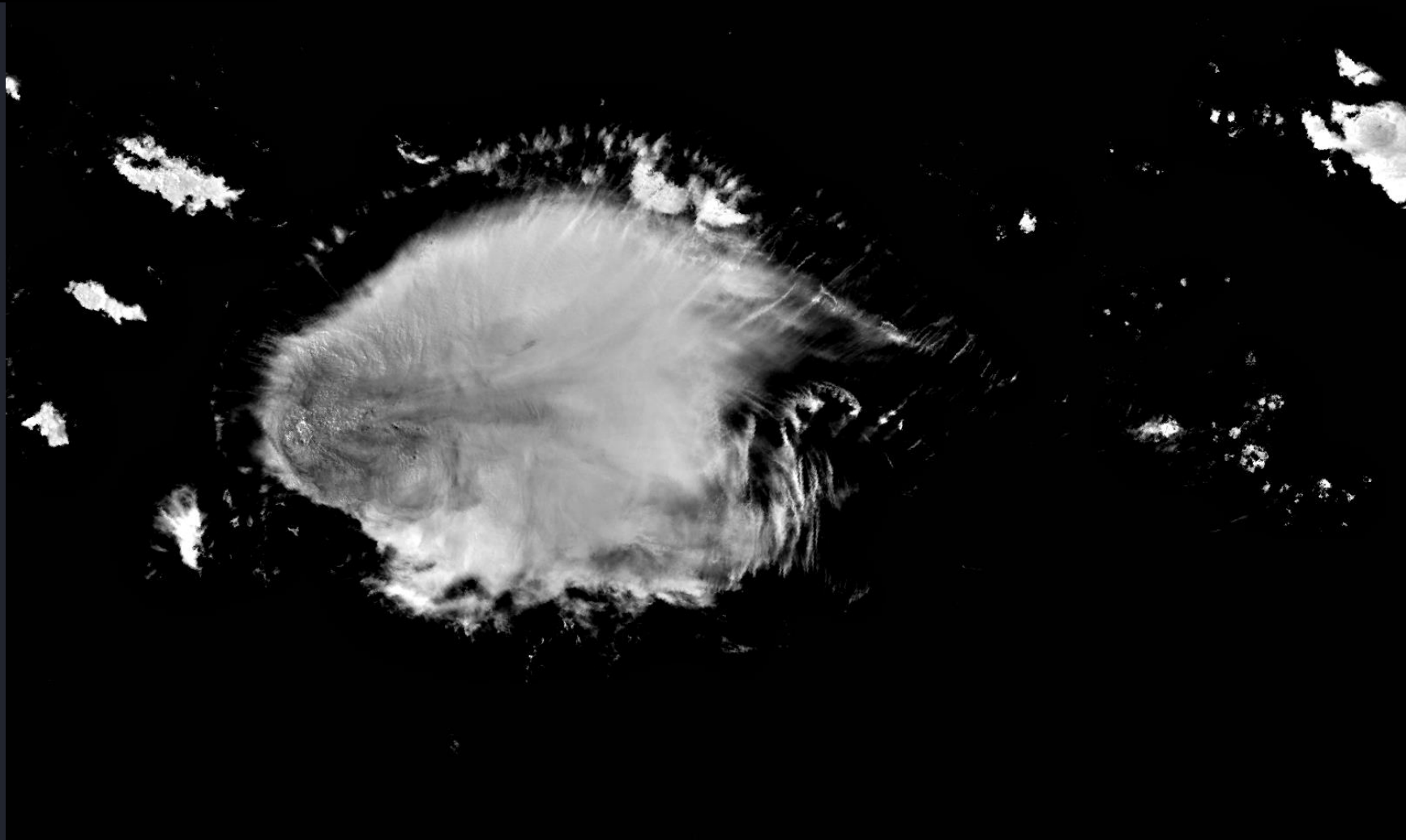
M10 (1.61 μm), ref. 18% – 31%



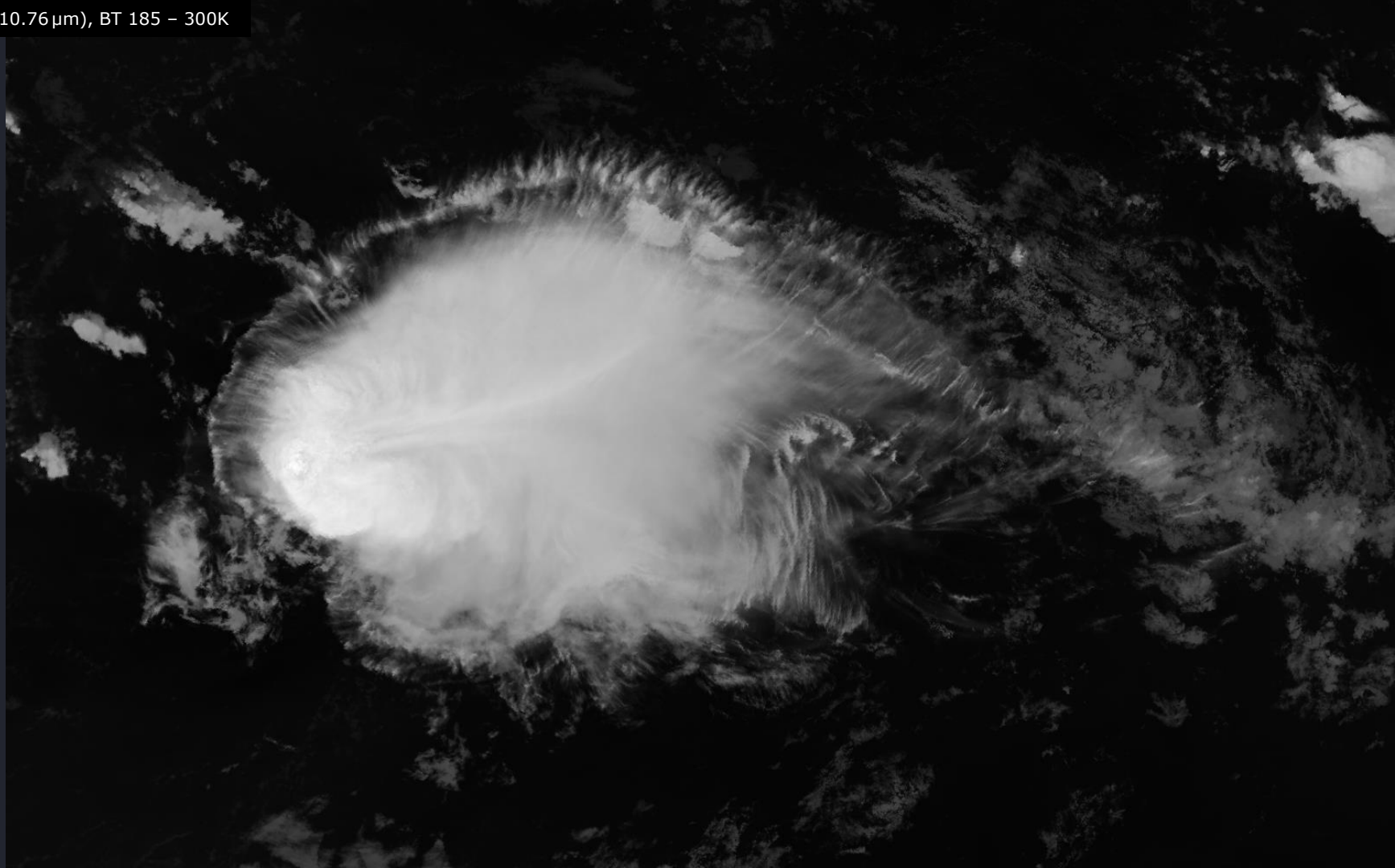
M12 (3.7 μm), BT 255 – 315K



M12 (3.7 μm), BT 255 – 290K enh.



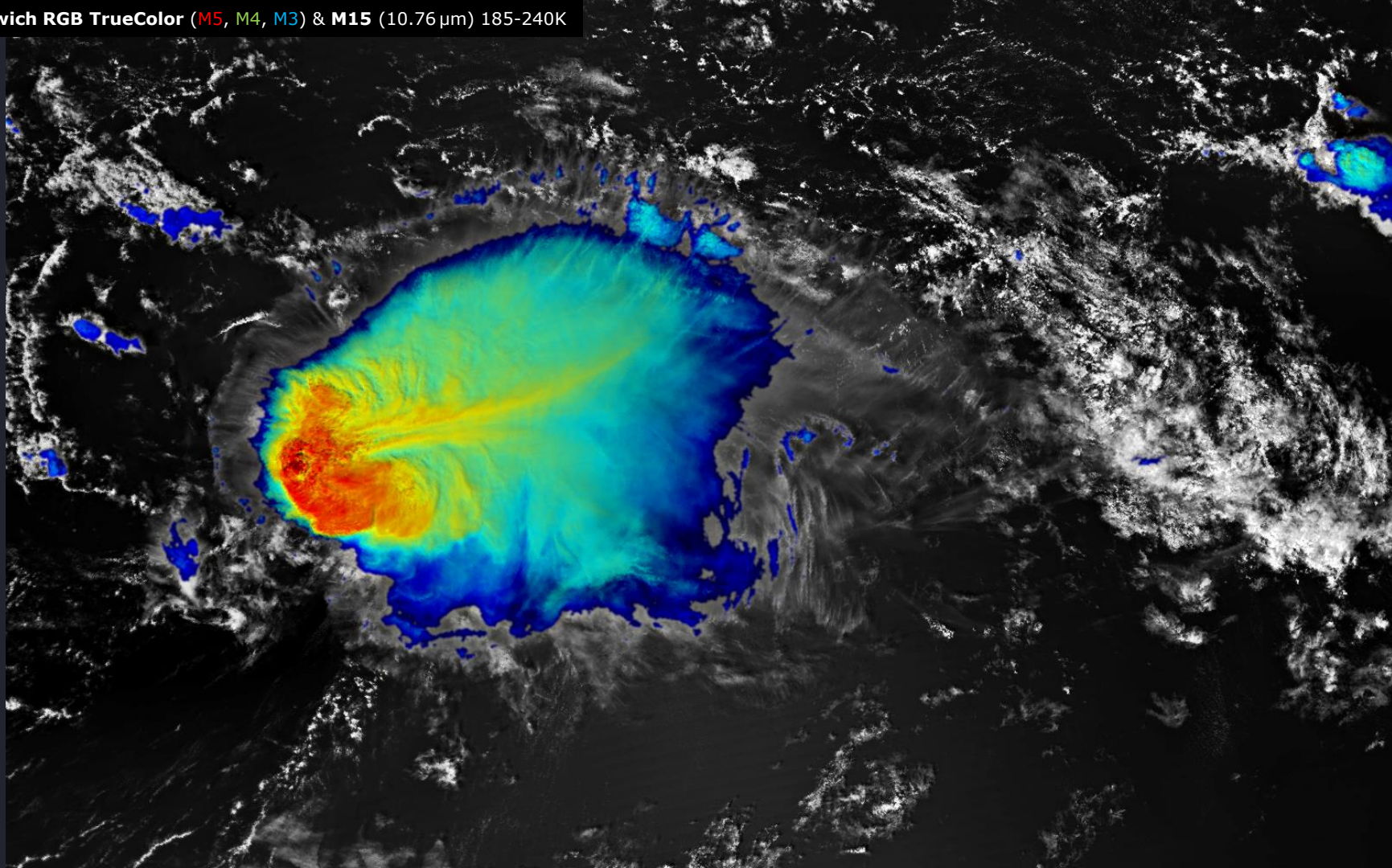
M15 (10.76 μm), BT 185 - 300K



M15 (10.76 μm), BT 185 - 240K



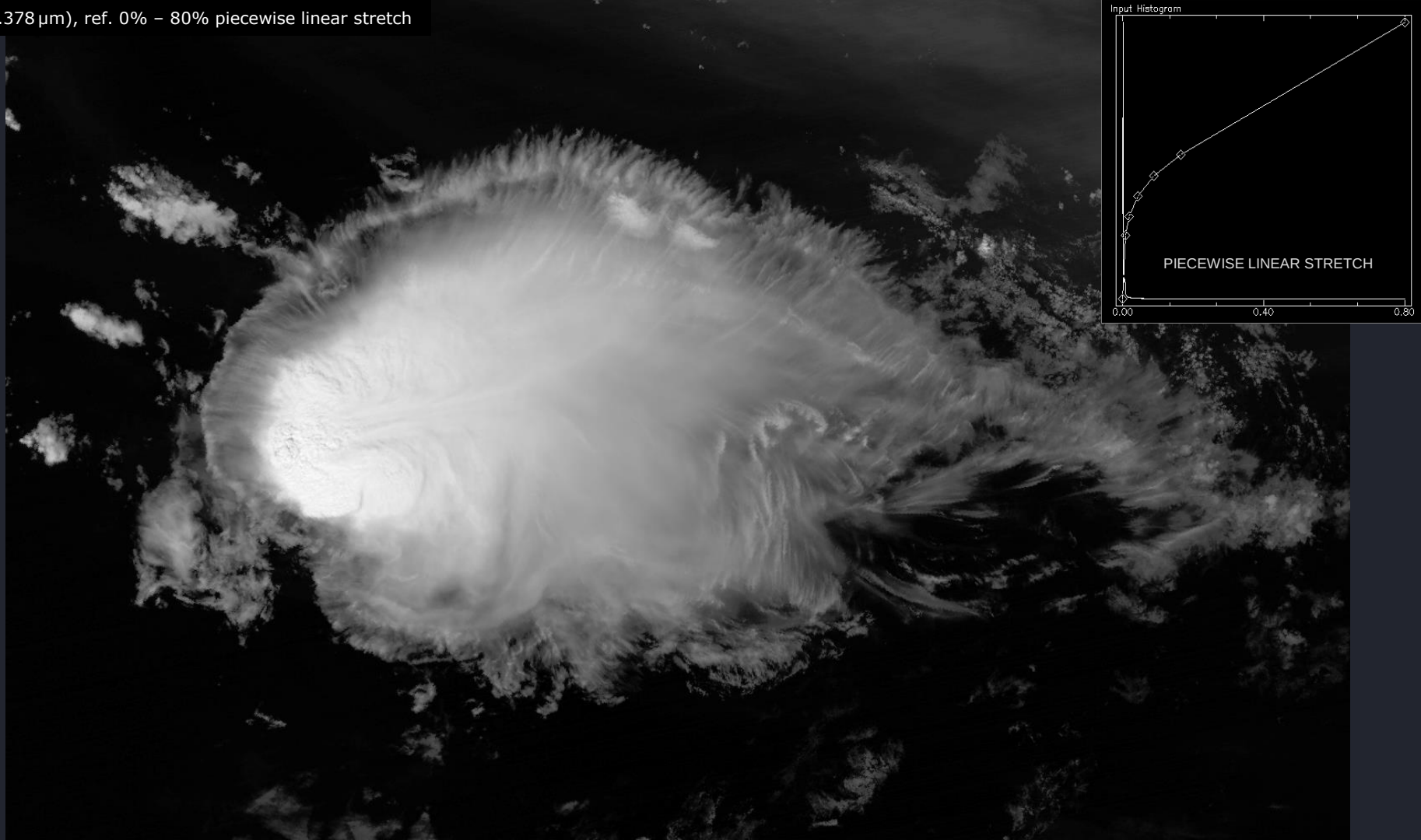
Sandwich RGB TrueColor (M5, M4, M3) & M15 (10.76 μ m) 185-240K



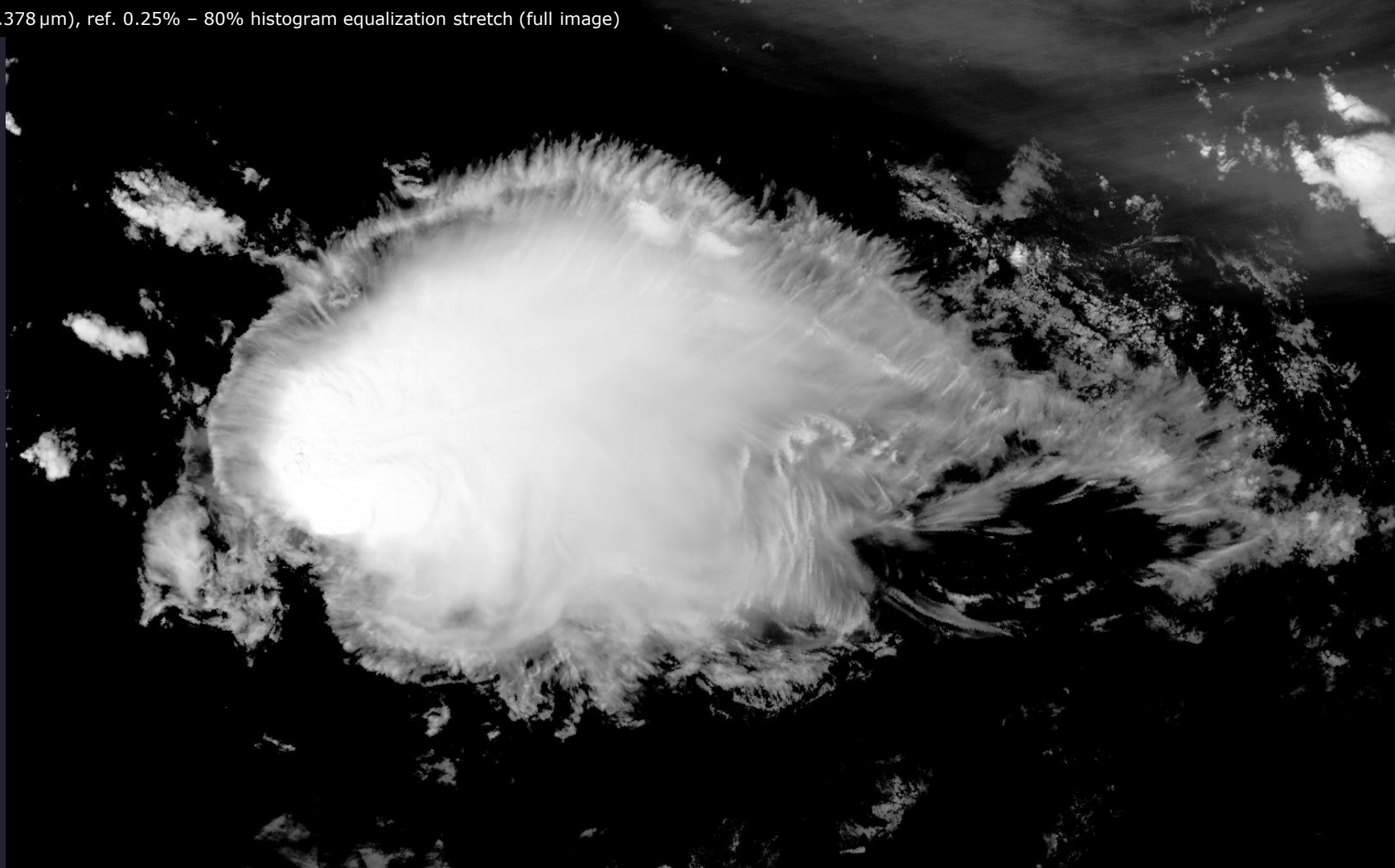
M9 (1.378 μm), ref. 0% – 80% linear stretch



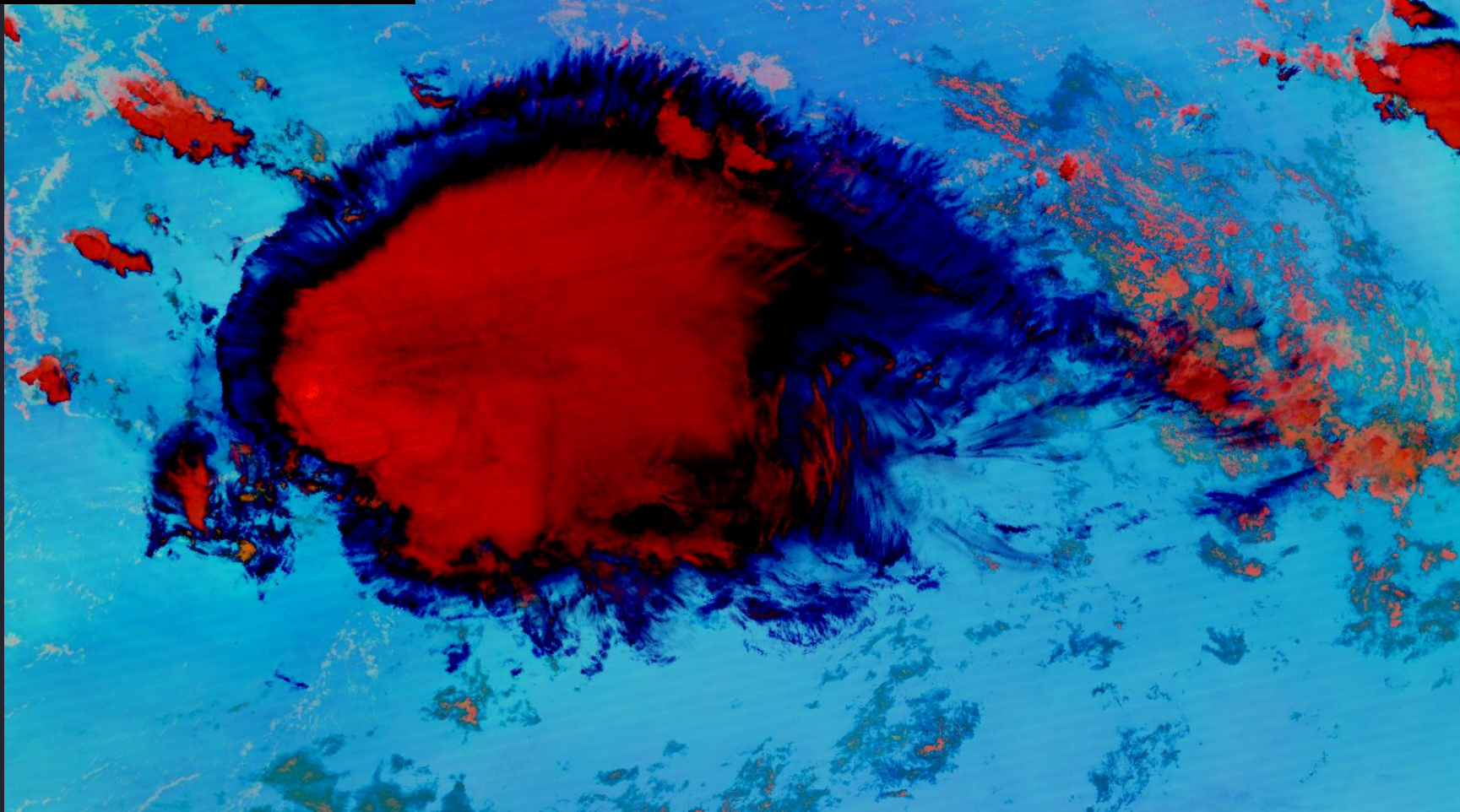
M9 (1.378 μm), ref. 0% – 80% piecewise linear stretch



M9 (1.378 μm), ref. 0.25% – 80% histogram equalization stretch (full image)



RGB 24M (24h Microphysics)
M16 (12.01 μm) - M15 (10.76 μm), -2.5 - +0.5K
M15 (10.76 μm) - M14 (8.55 μm), 0 - +4K
M15 (10.76 μm), BT 250 - 305K



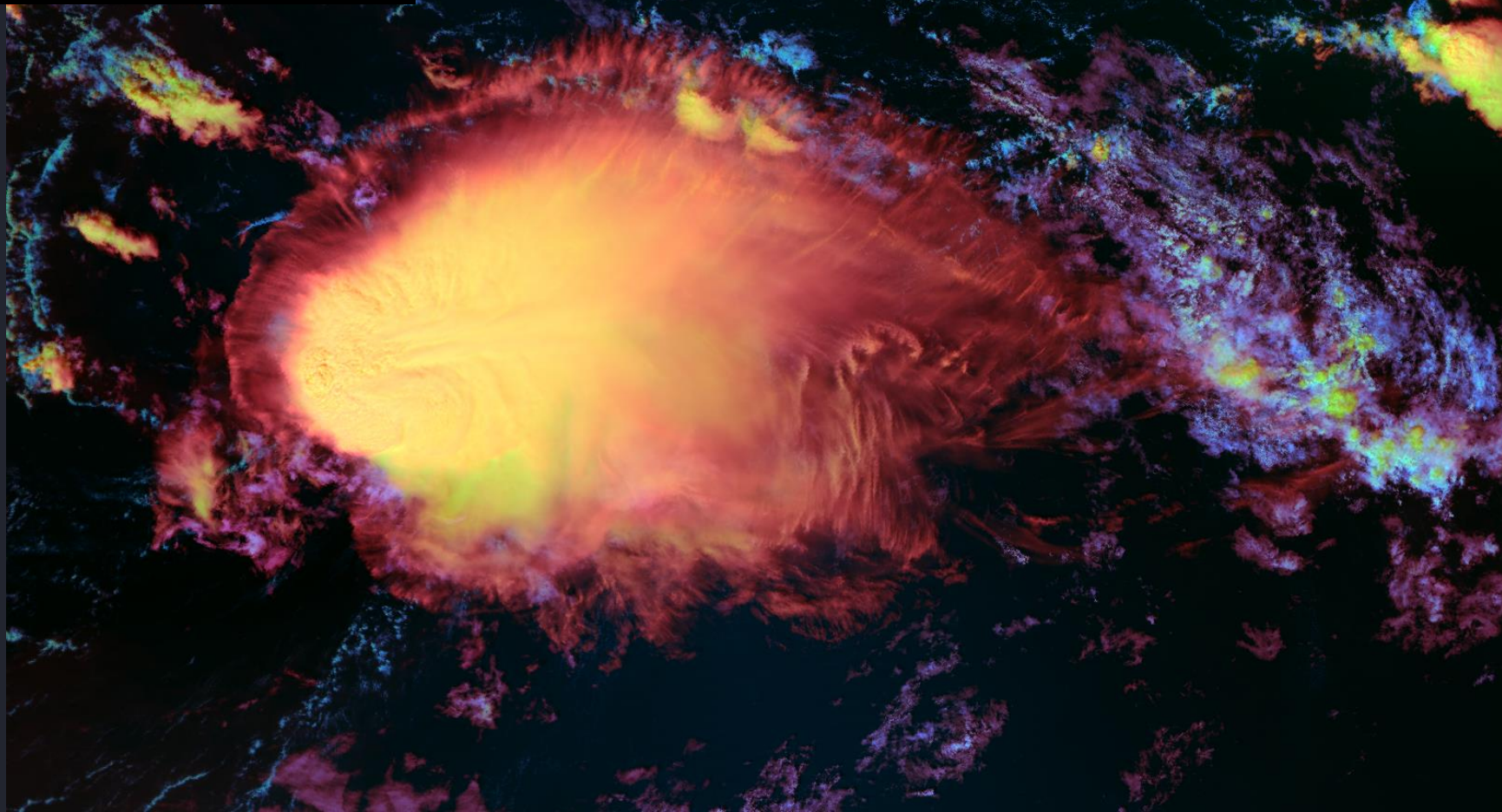
RGB Cloud Phase Distinction

M15 (10.76 μm), [histogram equalization stretch](#)

BT 205 – 293.5K inv. (image subset)

M5 (0.67 μm), ref. 0.0 – 1.10

M10 (1.61 μm), ref. 0.0 – 0.55



RGB Cloud Type

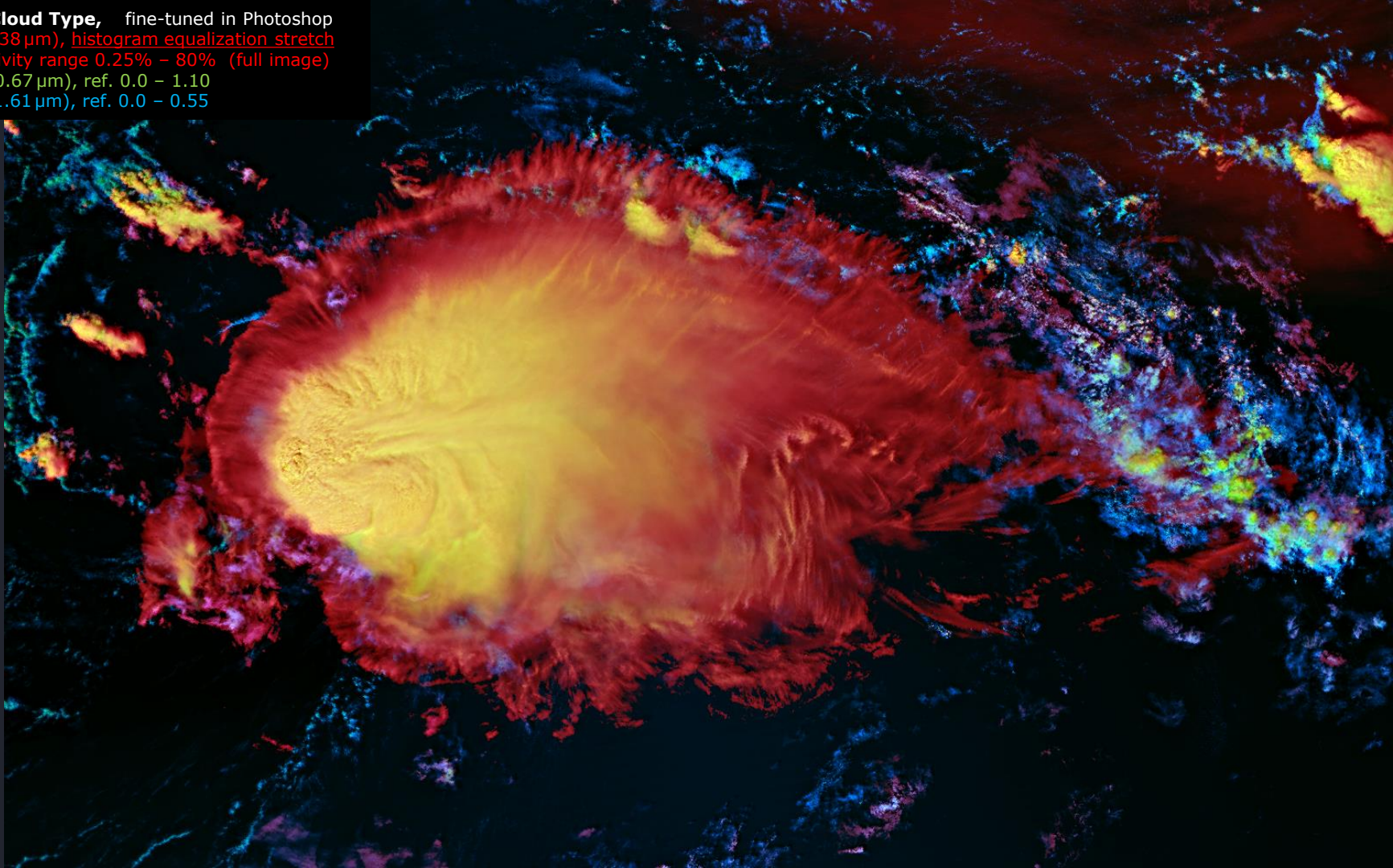
M9 (1.38 μm), histogram equalization stretch
reflectivity range 0.25% - 80% (full image)

M5 (0.67 μm), ref. 0.0 - 1.10

M10 (1.61 μm), ref. 0.0 - 0.55



RGB Cloud Type, fine-tuned in Photoshop
M9 (1.38 μm), histogram equalization stretch
reflectivity range 0.25% - 80% (full image)
M5 (0.67 μm), ref. 0.0 - 1.10
M10 (1.61 μm), ref. 0.0 - 0.55



Brief summary:

- In most cases (including those not shown here), the 1.38 μm band and Cloud Type RGB provide about the same amount of information about thin cirrus as other bands and RGBs. However, to show the full extent of the thinnest cirrus, advanced enhancement methods need to be applied: piecewise linear stretch, histogram equalization stretch, or stronger gamma stretch (not tested yet).
- In some cases, the 1.38 μm band and Cloud Type RGB can show more of the thin cirrus, which escapes other methods (products) ... e.g. above desert areas (?).
- Up to now, no case with a plume extending beyond the regular anvil edge in the 1.38 μm band was found ... an impact of unfavorable timing of the NPP / NOAA-20 passes (shortly after local noon).
- The histogram equalization stretch and piecewise linear stretch can be useful for case studies, but (probably) not for operational use.
- Better option for similar studies – data from ABI, without the timing problem ...

Data:

- Suomi-NPP and NOAA-20 (JPSS-1) VIIRS M-bands, 750m pixel resolution
- cases selection: [NASA EOS Worldview](#)
link preconfigured for S-NPP (available since 24 Nov 2015) and NOAA-20 (since 25 Apr 2020)
- L1B data source: [NOAA CLASS archive](#)
- disadvantage: early afternoon orbit (ECT ~ 13:30 local time, asc.) » only very few mature storms at this time of the day, difficult to find good cases ...
- total of about 40 cases from 2012, 2013, and 2016 – 2021, from these ~ 30 cases processed tentatively, and from these ~ 20 cases processed in detail

Processing:

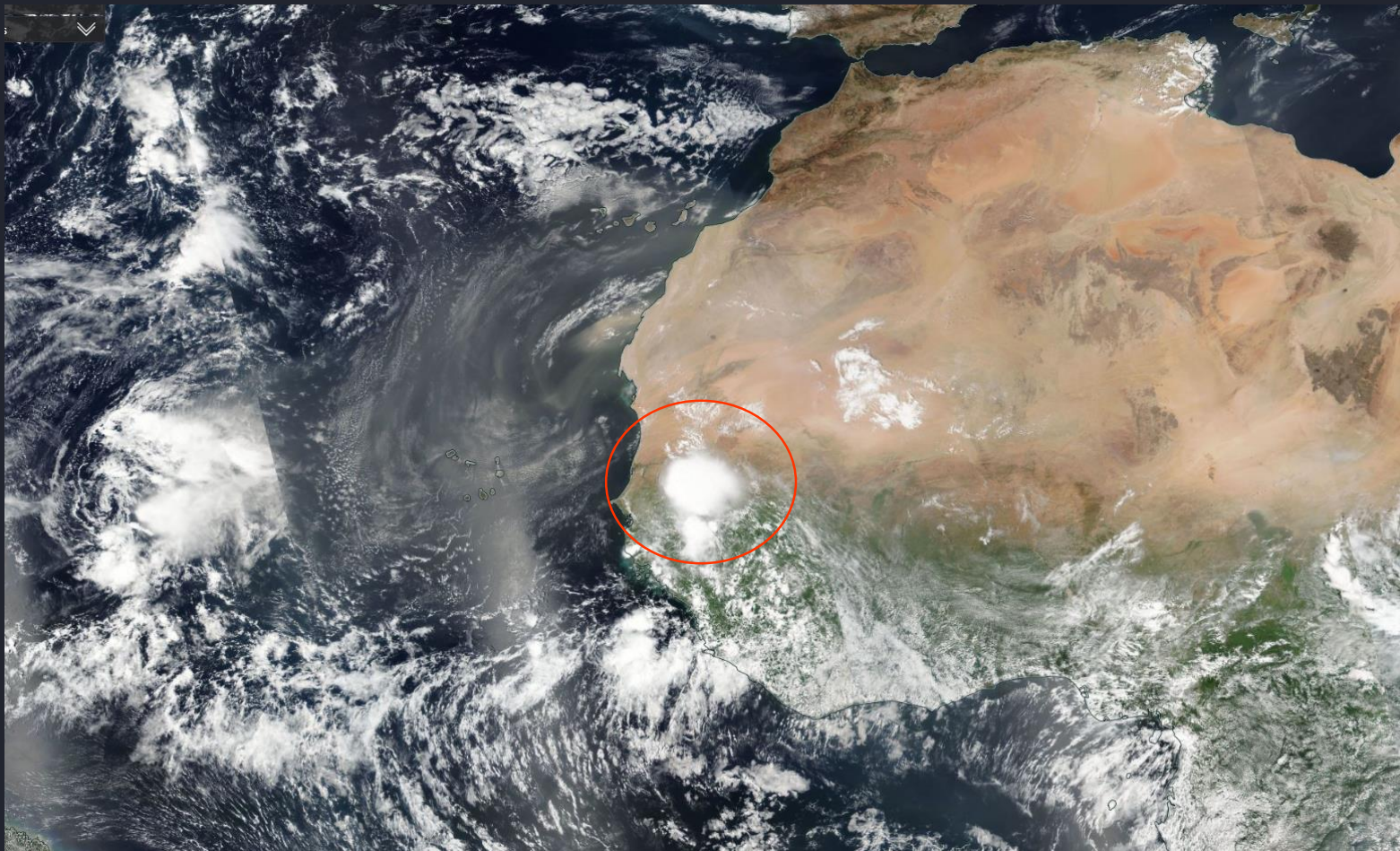
- [ENVI](#) and its [VCTK](#) plugin
- modest fine-tuning of some of the images in [Adobe Photoshop](#)

THE END

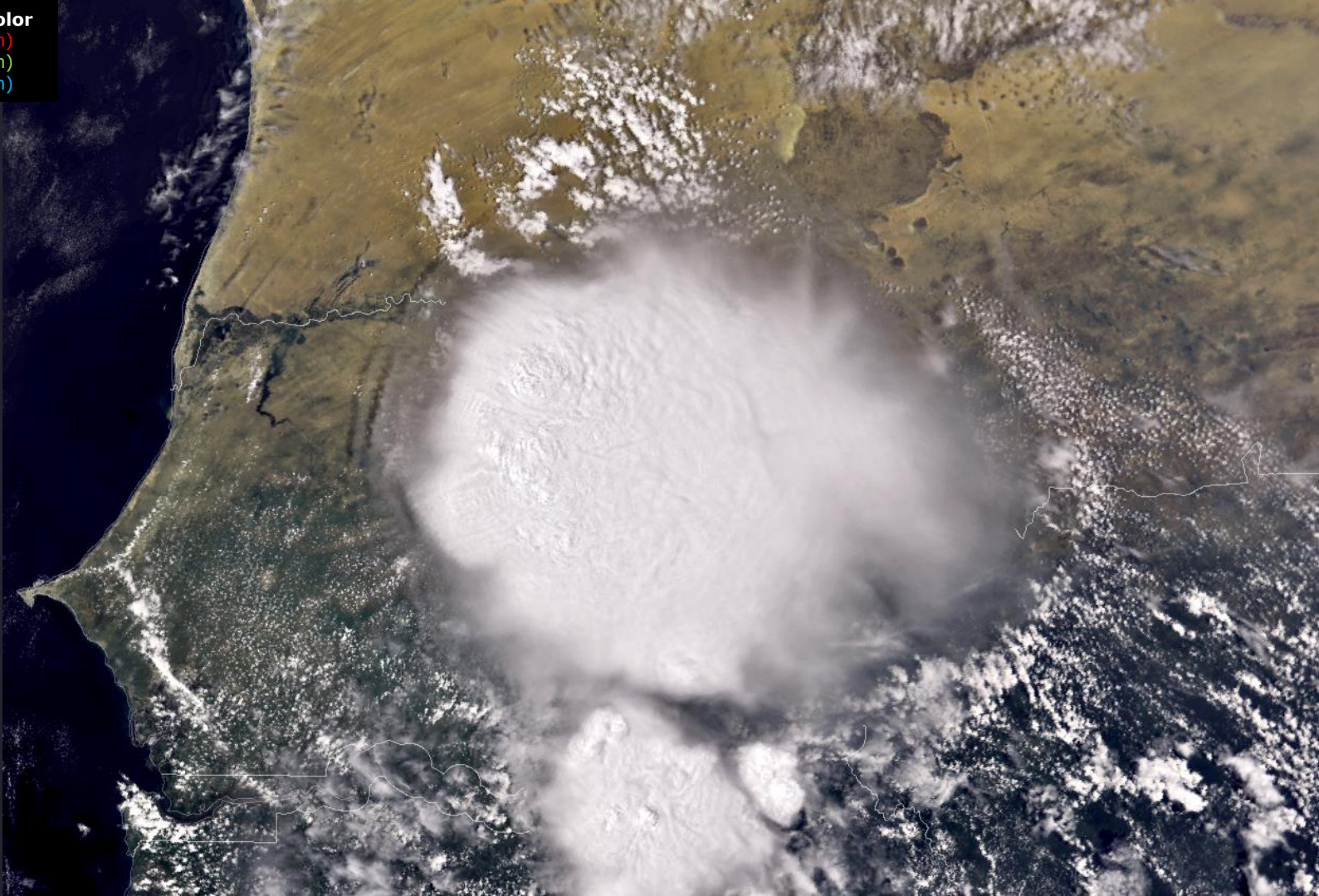
ADDITIONAL SLIDES

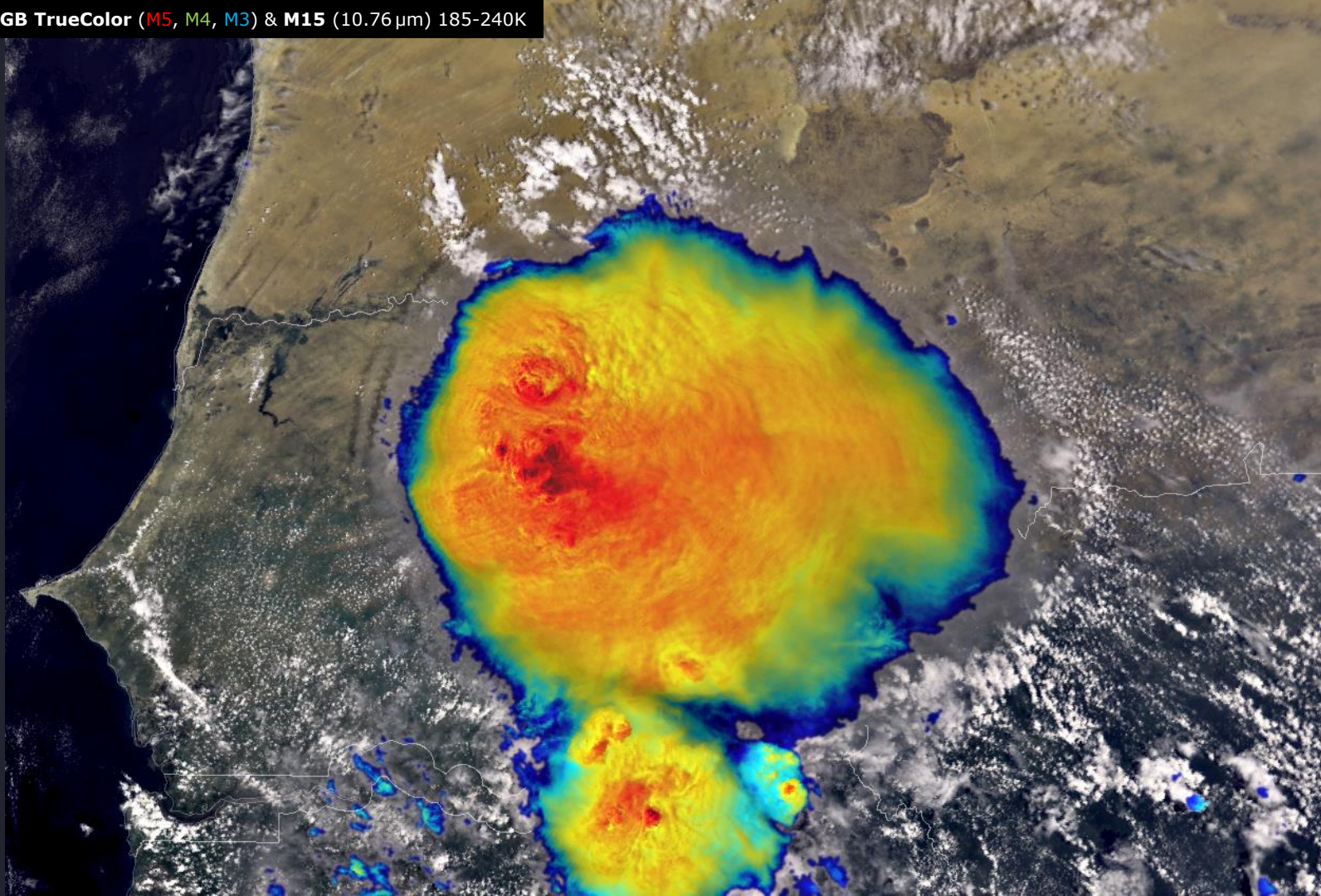
18 September 2018 14:38 UTC, VIIRS S-NPP, west Africa (Senegal)

image source: [NASA EOSDIS Worldview](#)

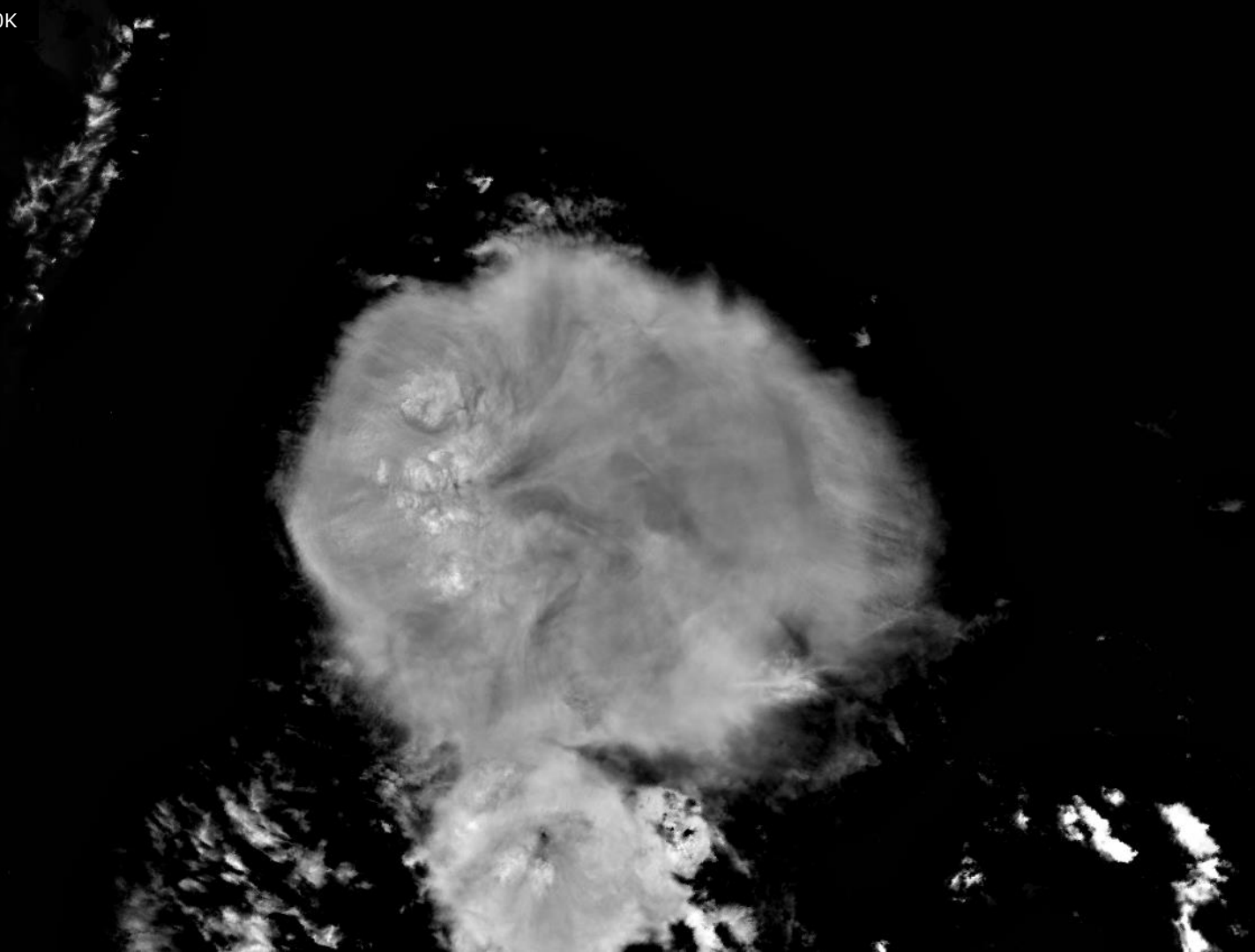


RGB True Color
M5 (0.672 μm)
M4 (0.555 μm)
M3 (0.488 μm)

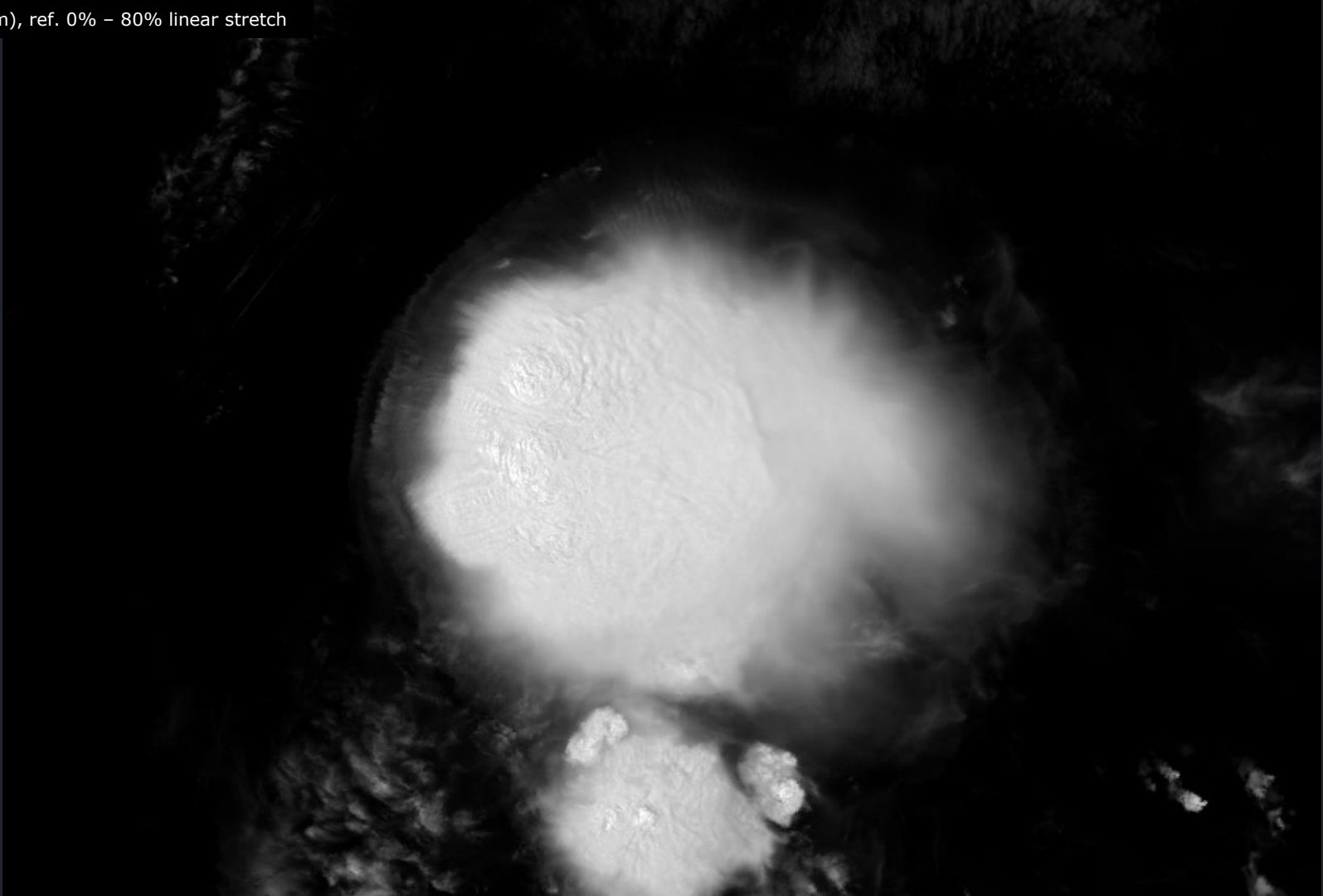




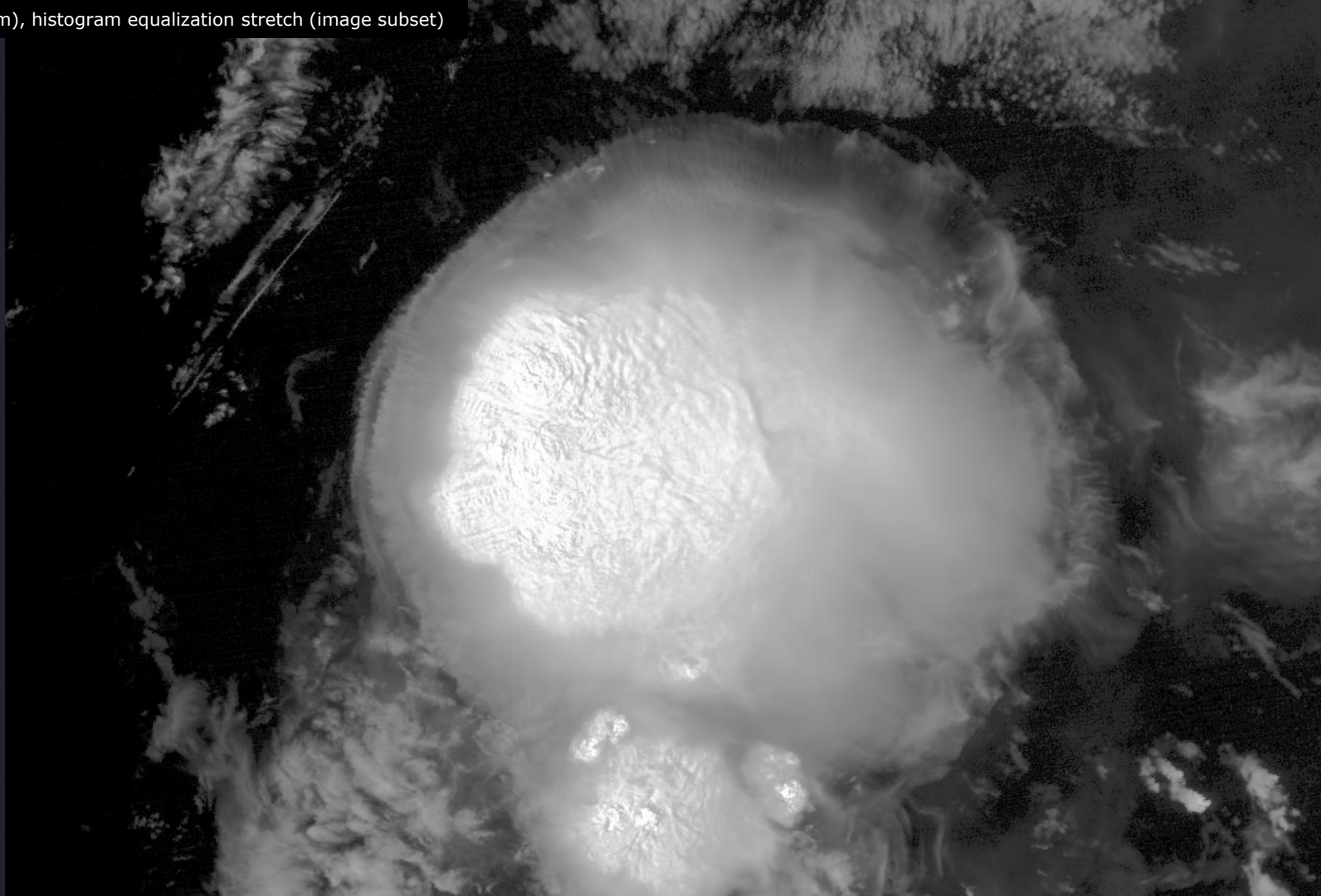
M12 (3.7 μm), BT 255 – 300K



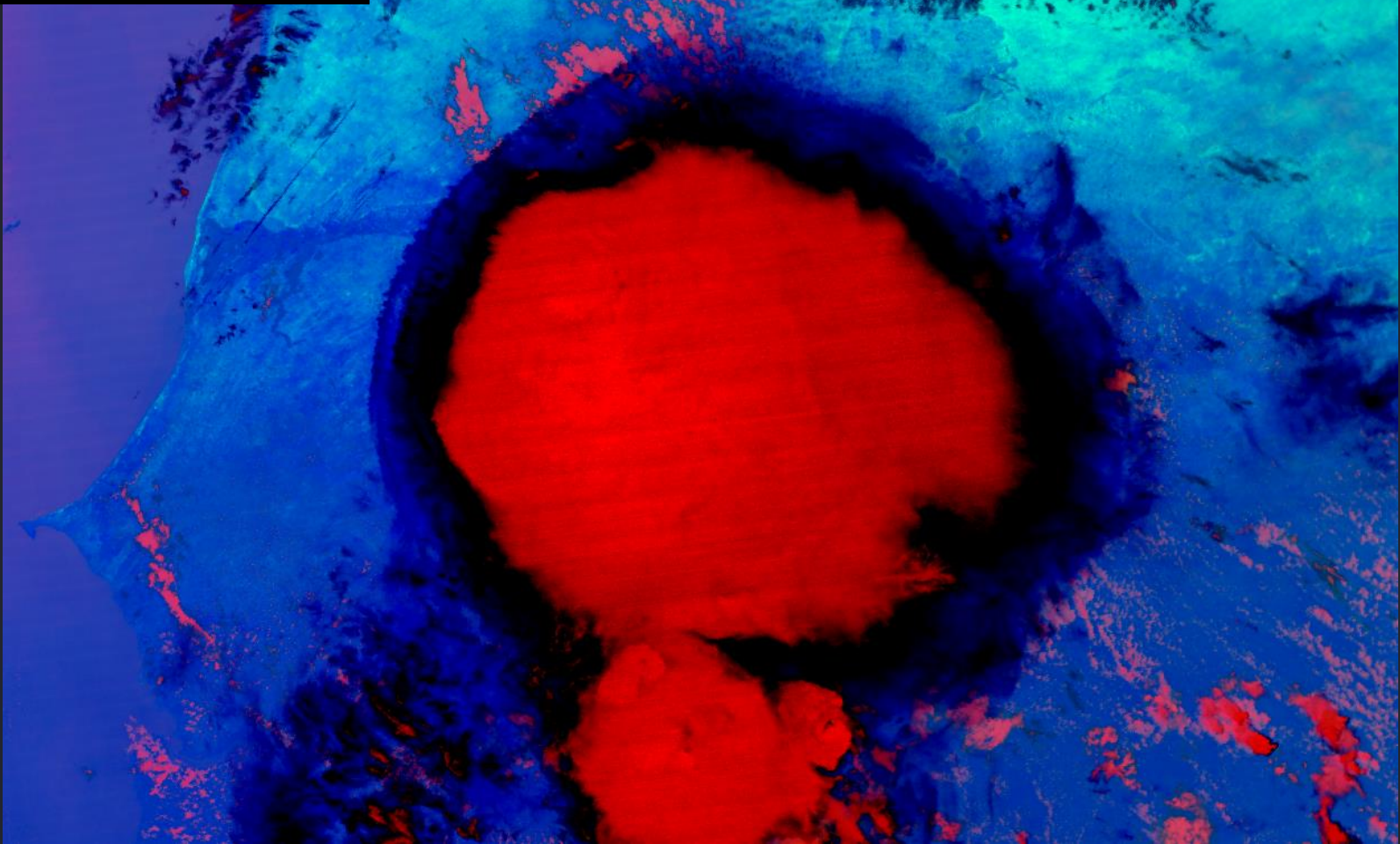
M9 (1.378 μm), ref. 0% – 80% linear stretch



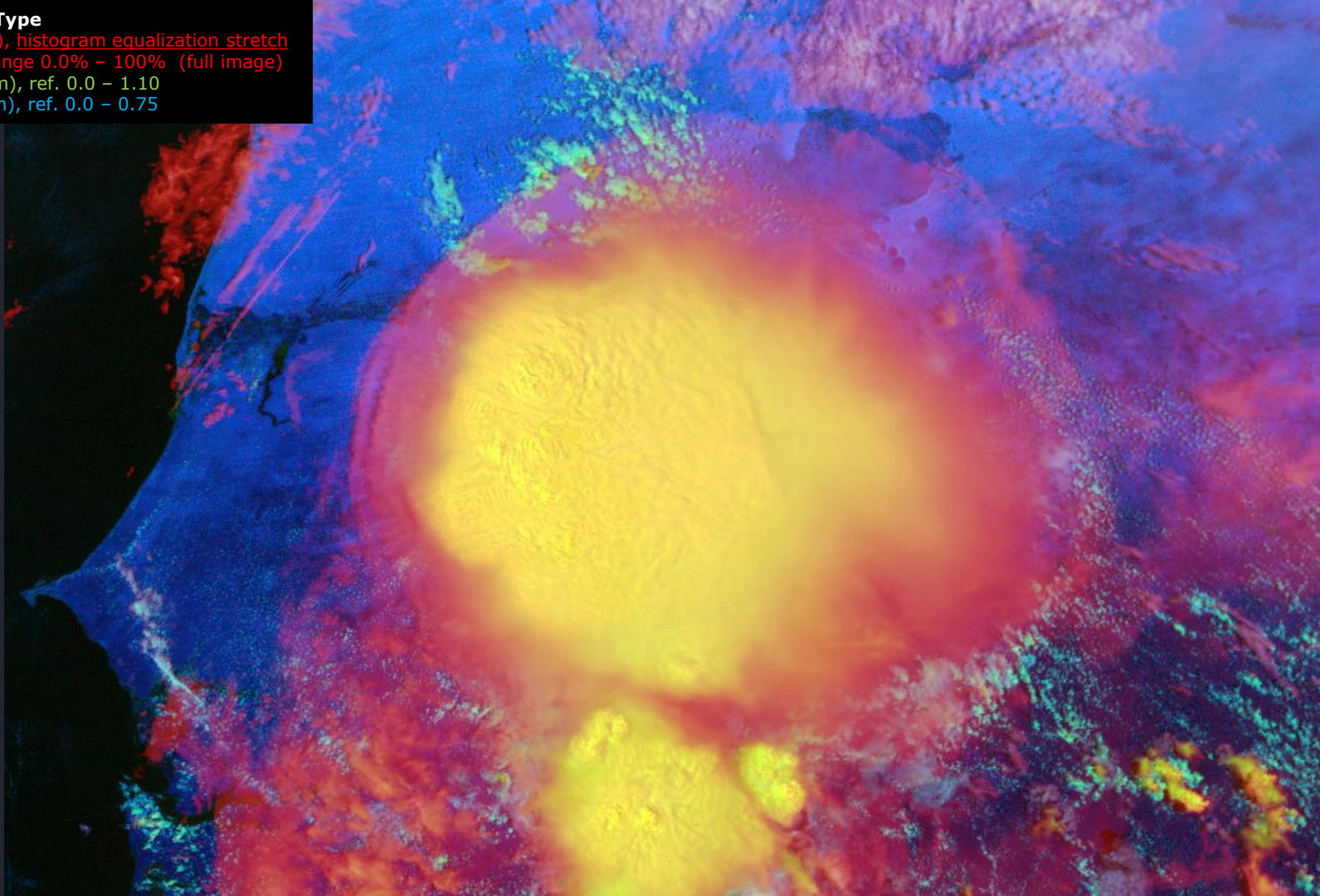
M9 (1.378 μm), histogram equalization stretch (image subset)



RGB 24M (24h Microphysics)
M16 (12.01 μm) - M15 (10.76 μm), -3.0 - +0.5K
M15 (10.76 μm) - M14 (8.55 μm), 0 - +10K
M15 (10.76 μm), BT 240 - 320K



RGB Cloud Type
M9 (1.38 μm), histogram equalization stretch
reflectivity range 0.0% - 100% (full image)
M5 (0.67 μm), ref. 0.0 - 1.10
M10 (1.61 μm), ref. 0.0 - 0.75



RGB Cloud Phase Distinction
M15 (10.76 μm), [histogram equalization stretch](#)
BT 205 – 305K inv. (full image)
M5 (0.67 μm), ref. 0.0 – 1.10
M10 (1.61 μm), ref. 0.0 – 0.75

