Use of VIIRS data in CHMI (Czech Hydrometeorological Institute)

Martin Setvák

CHMI Satellite Department
E-mail: martin.setvak@chmi.cz
CHMI website: www.chmi.cz
Personal website: www.setvak.cz

VIIRS User Meeting, 29 – 30 June 2022 (NOAA virtual meeting)

Use of VIIRS data in Czech Hydrometeorological Institute

(national hydro-meteorological service of the Czech Republic)

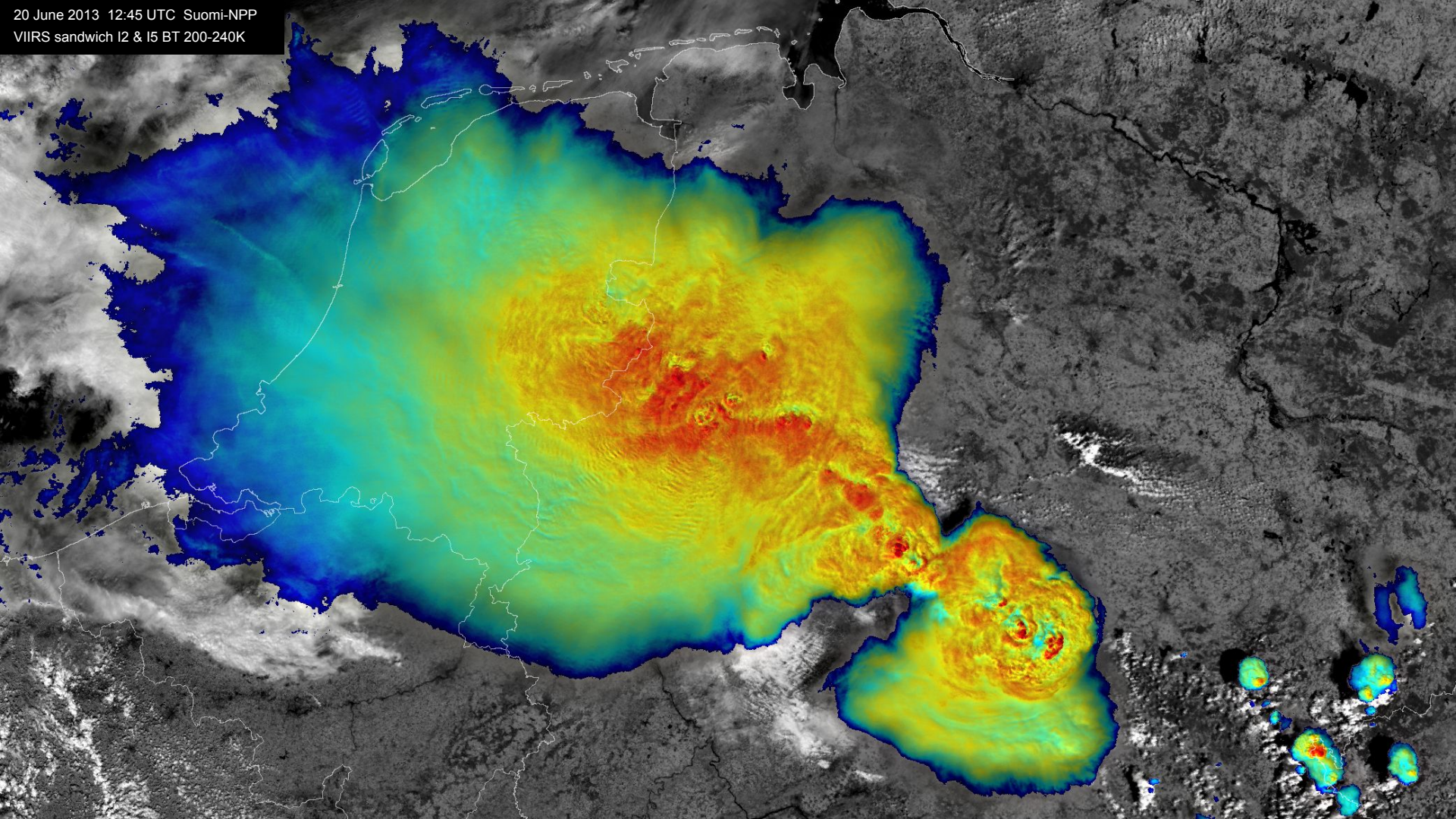
- namely for various case studies, research, education and training, ...
- development or testing of new image products
- preparations for MTG FCI and EPS-SG METimage, familiarization with upcoming new bands

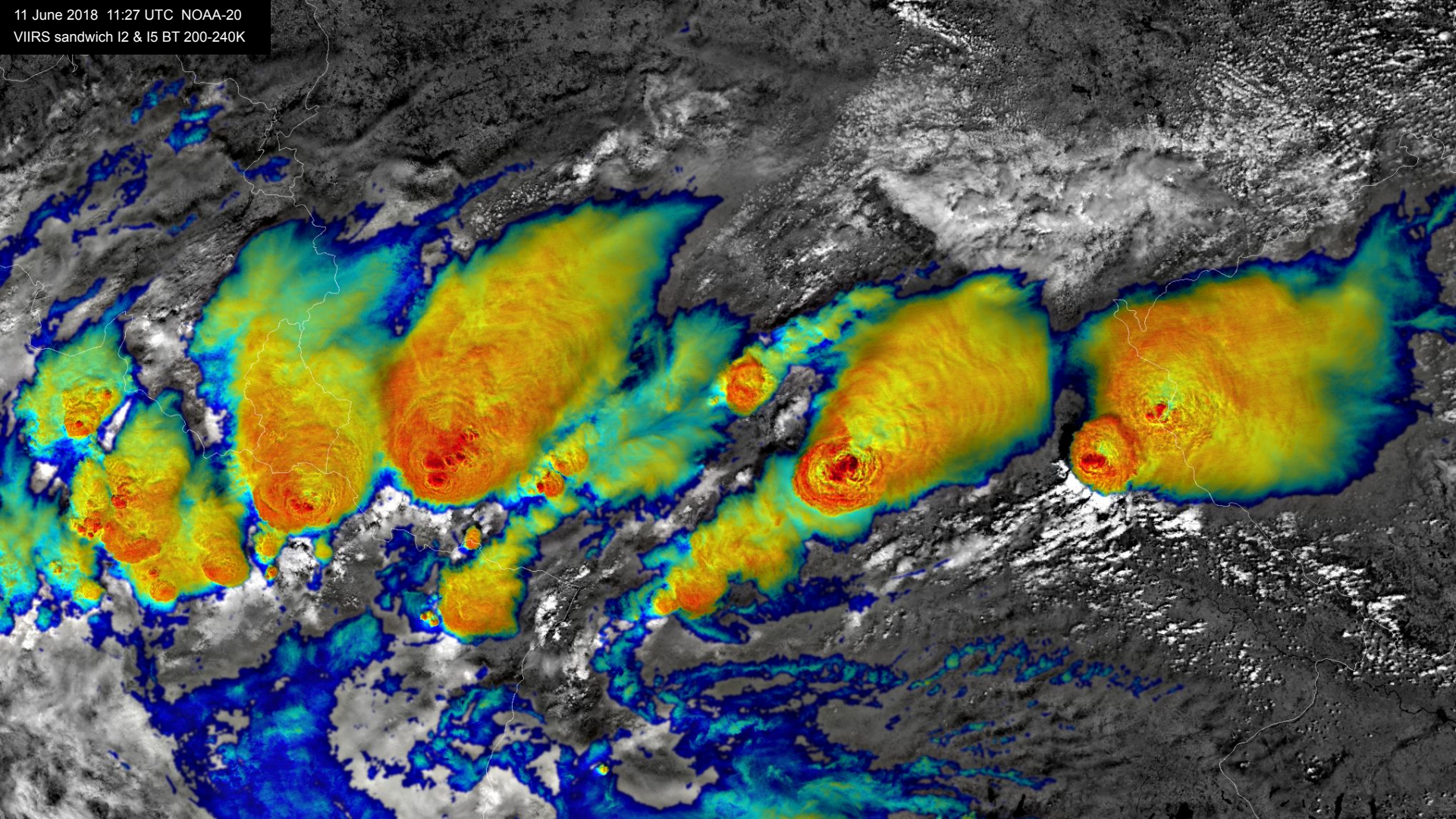
- NOT used operationally (so far, should change soon)

OBSERVATIONS OF TOPS OF CONVECTIVE STORMS

- main benefit – details of storm tops at very high spatial resolution (VIIRS I-bands @ 375 m), high resolution not limited to visible bands only (such as for MODIS or new GEO instruments)
- main drawback – timing of satellite overpasses: too early afternoon for observations of mature convective storms, “good” cases captured by S-NPP or NOAA-20 are rather exception

- used broadly within the EUMETSAT’s Convection Working Group (CWG) and Expert Forum for Preparing MTG Meteorological Applications and Training activities and case studies


20 June 2013 12:45 UTC Suomi-NPP
VIIRS sandwich I2 & I5 BT 200-240K

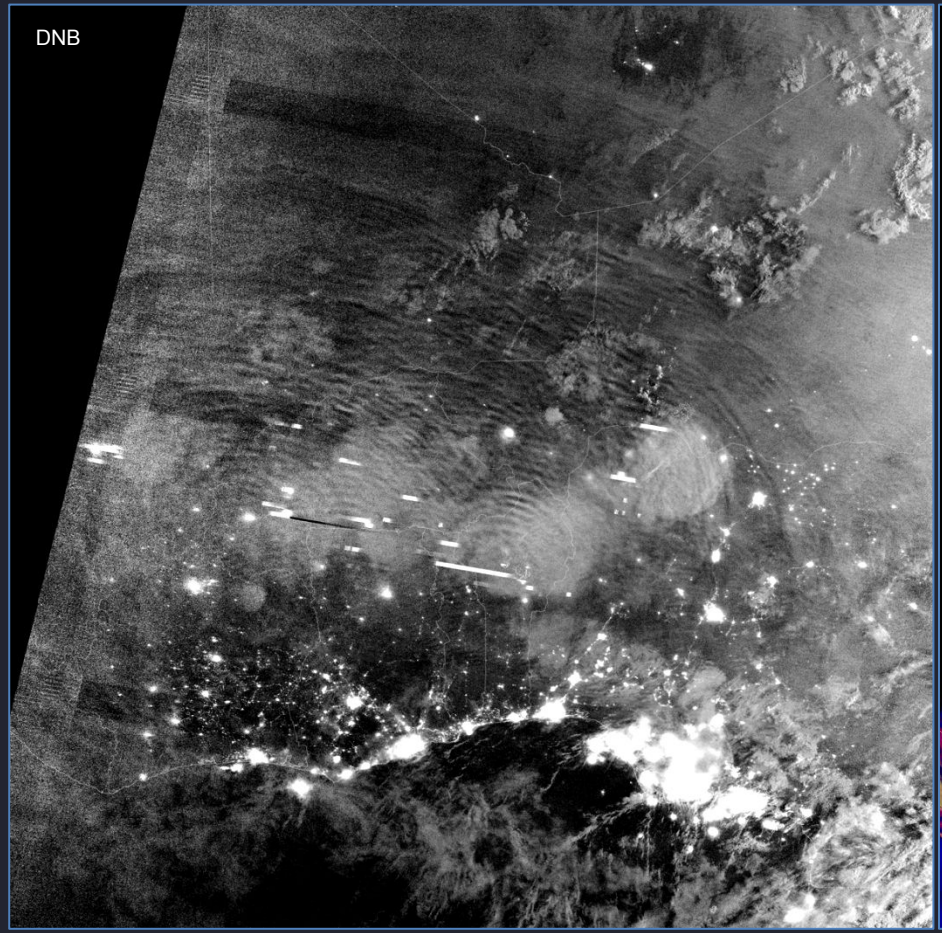

11 June 2018 11:27 UTC NOAA-20
VIIRS sandwich I2 & I5 BT 200-240K

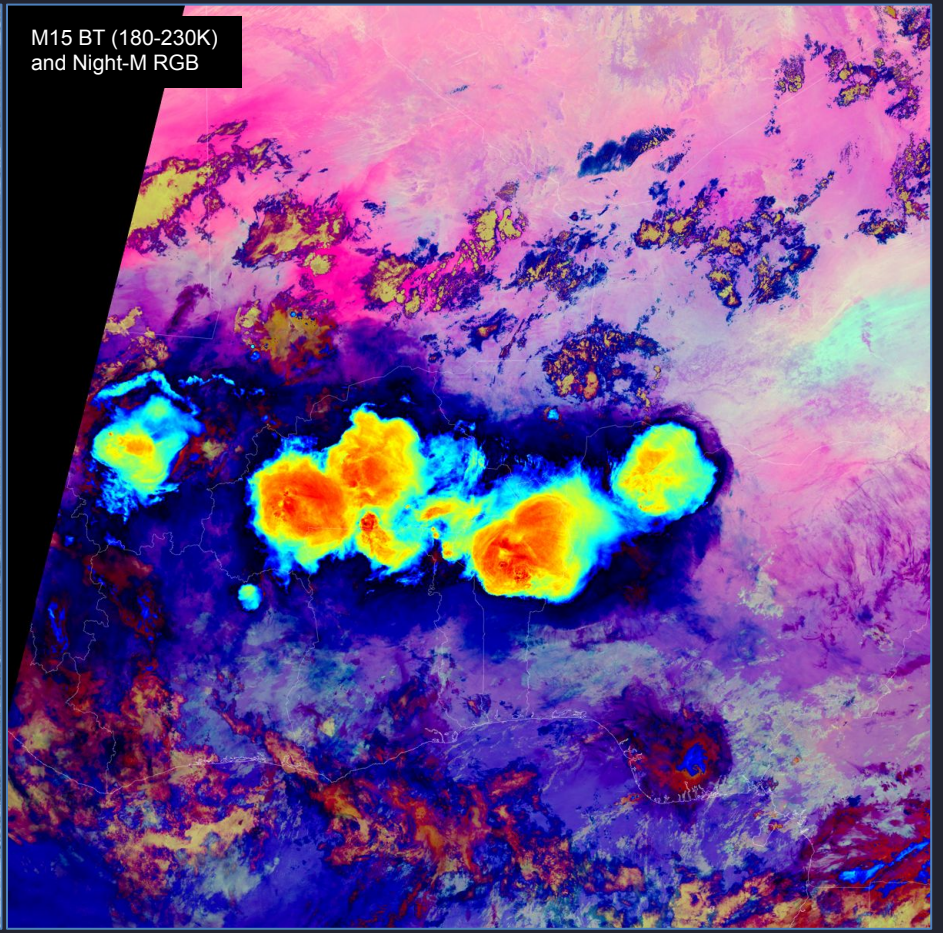
DAY/NIGHT BAND OBSERVATIONS OF GRAVITY WAVES IN NIGHTGLOW GENERATED BY CONVECTIVE STORMS

- gravity waves observed in nightglow (nocturnal airglow) – several trigger mechanisms (deep convection, jet streams, volcanic eruptions, orography, ...), near mesopause levels (about 85 – 100 km)
- documentary study of global occurrence of (pseudo-concentric) gravity waves generated by convective storms; comparison with gravity waves observed in the AIRS 4.3 μm CO_2 absorption bands, at upper stratosphere levels (~ 40 km)
- case studies, education, ...

- main drawback – limited to moonless nights
- possible improvement for consideration – two DNB bands: one in visible range (0.5 – 0.7 μm), another in near-IR range (0.7 – 1.0 μm), or inclusion of sodium filter to suppress city lights (however already somewhat problematic due to ongoing shift from sodium to broadband LED illumination)

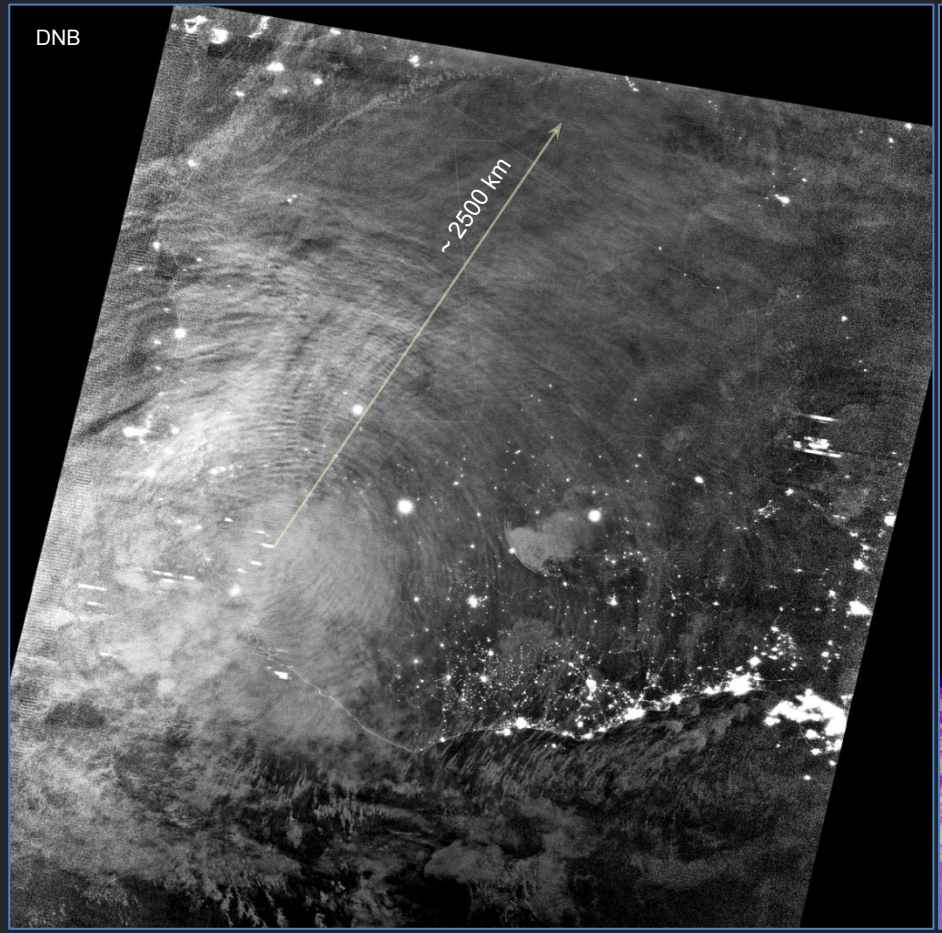
2015-06-11 01:15 UTC S-NPP VIIRS

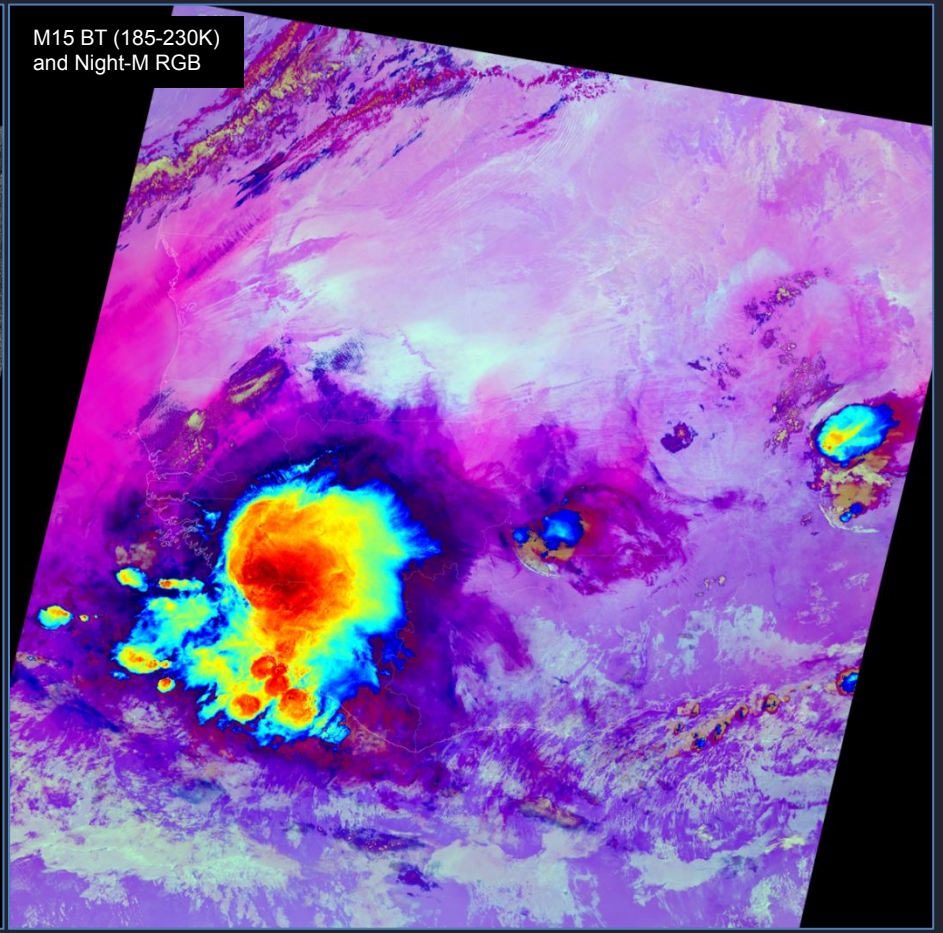




A complex of concentric gravity waves, generated by several storms in the area of Sahel, several sources of the gravity waves, overlapping each other, spreading mainly north.

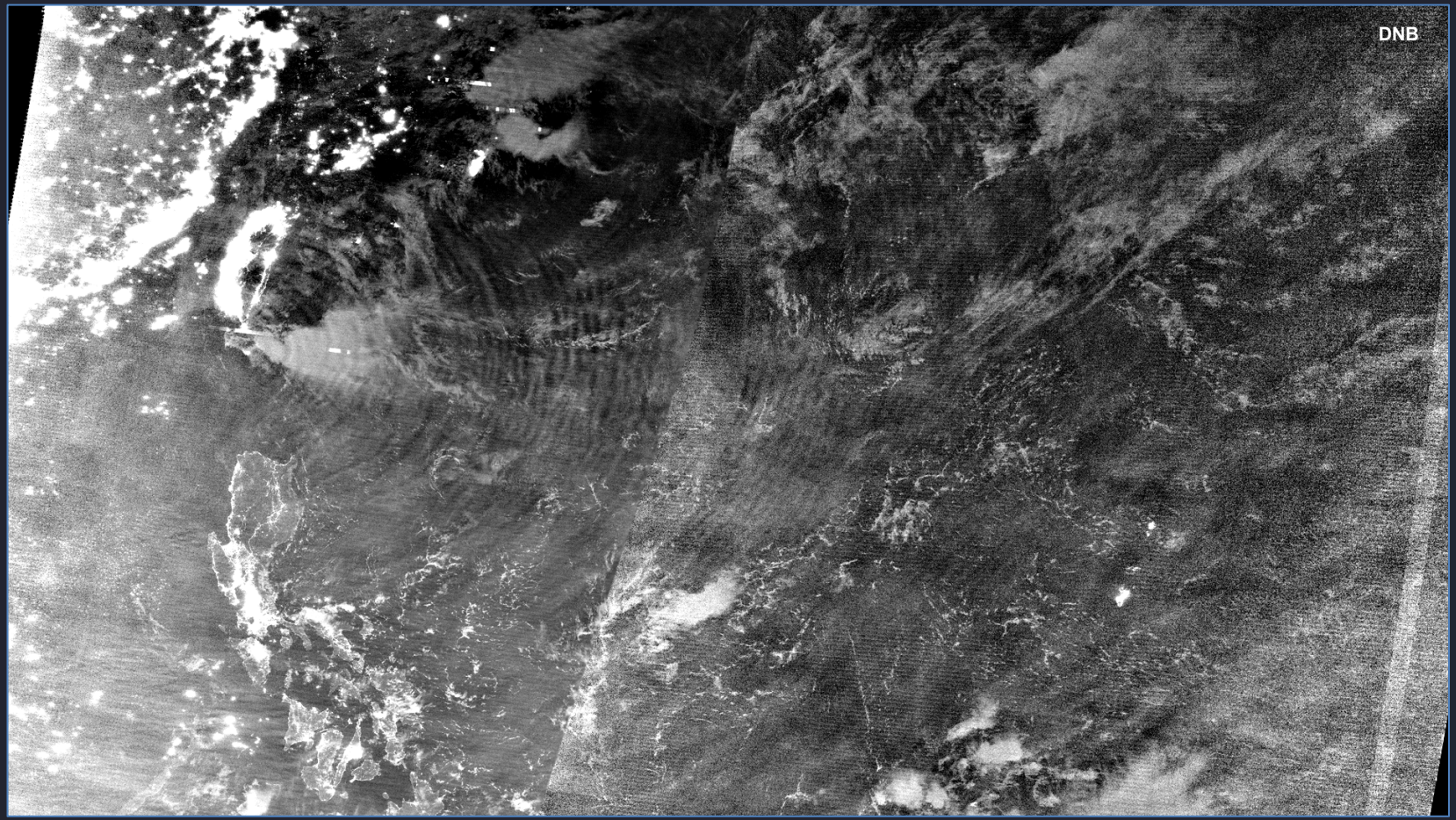
2015-06-14 02:00 UTC S-NPP VIIRS





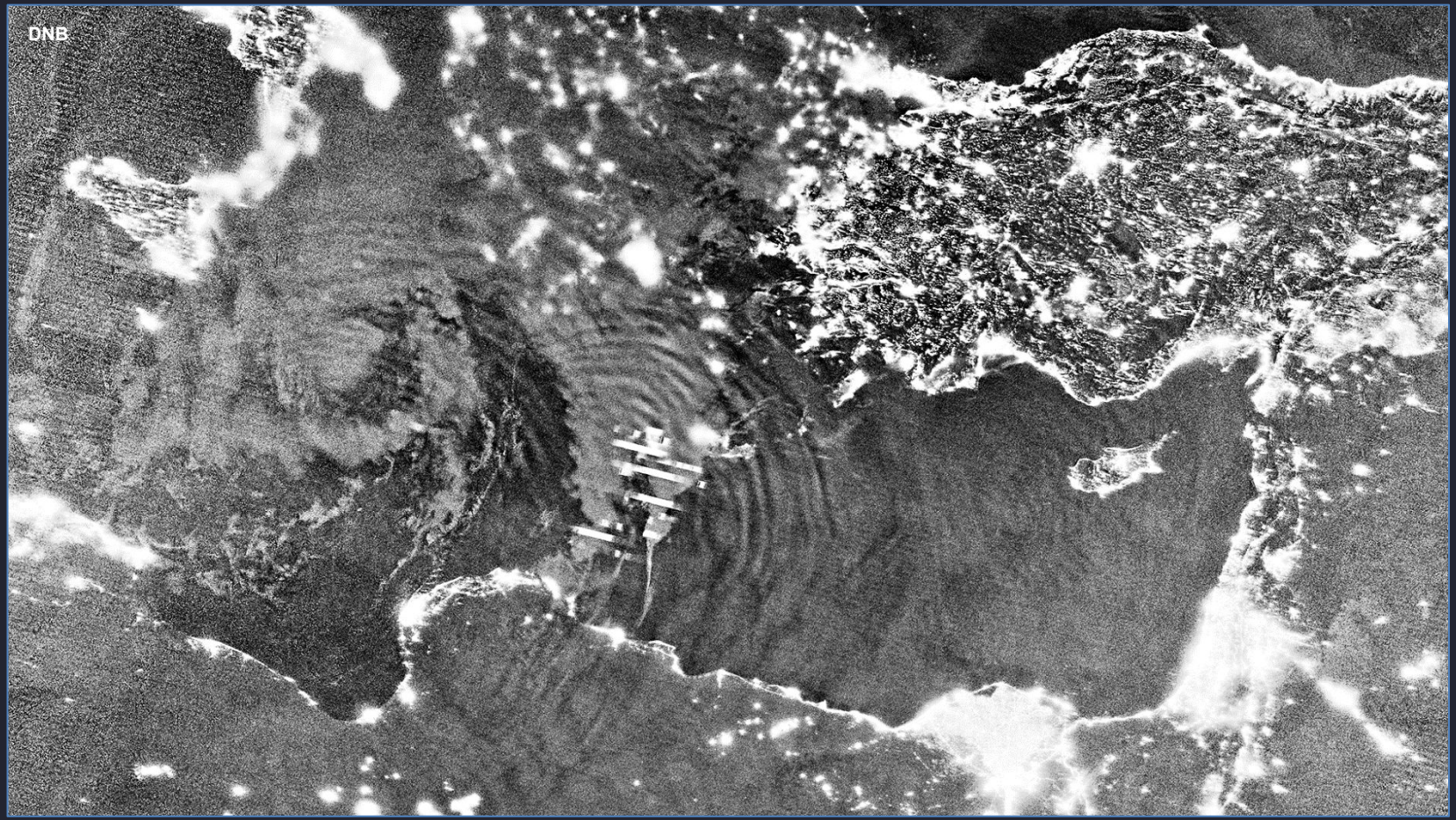
Concentric gravity waves, generated by large storms above west Africa, spreading about 2500 km northward, but to much shorter distance southward.

2018-04-11 16:15 UTC S-NPP (east) and 17:05 UTC NOAA-20 (west), VIIRS DNB



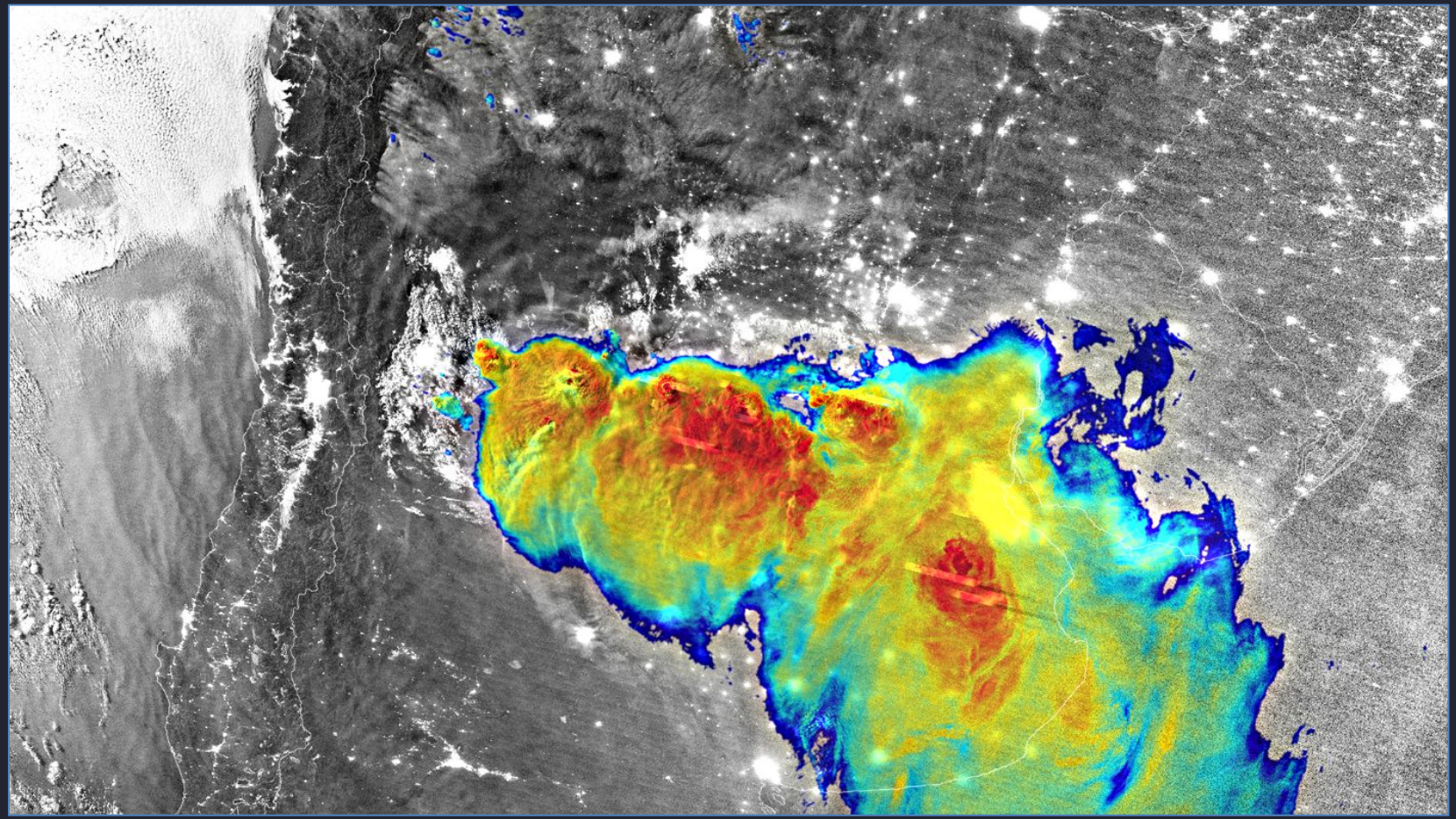
Pseudo-concentric gravity waves, generated by long-lived convective storms east of Taiwan, spreading about 3000 km east

2021-10-15 00:00 UTC S-NPP VIIRS



Pseudo-concentric gravity waves generated by convective storms above eastern Mediterranean Sea

2016-03-18 05:18 UTC S-NPP VIIRS



Gravity waves generated by convective storms above Argentina, visible despite illumination by Moon (~ 6° above horizon, 5 days before full moon).
Sandwich product of DNB and M15 (190-240K). More on this case in Smith et al, 2020, doi 10.1029/2020JD033381

PREPARATIONS FOR MTG FCI:
PIXEL SIZE (RESOLUTION) SIMULATIONS

- details of tops of convective storms – detection and properties of overshooting tops, cloud-top microphysics, cloud-top gravity waves, AACP details, ...
- fire detection, thin fog detection, ...

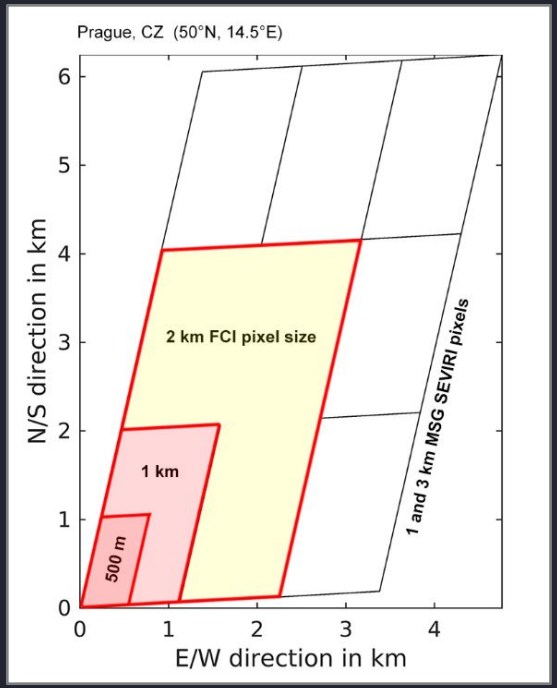
more e.g. here: https://www.setvak.cz/presentations/2019-11-12_Setvak_MTGUP_MTG-FCI_pixel-size-simulations.pptx

MTG-I Flexible Combined Imager (FCI)

	band name (label)	central wavelength	pixel resolution (size) at nadir
*	VIS 0.4	0.444 µm	1 km
*	VIS 0.5	0.510 µm	1 km
	VIS 0.6	0.640 µm	**1 km NR / 0.5 km HR RSS**
	VIS 0.8	0.865 µm	1 km
*	VIS 0.9	0.914 µm	1 km
*	NIR 1.3	1.380 µm	1 km
	NIR 1.6	1.610 µm	1 km
*	NIR 2.2	2.250 µm	**1 km NR / 0.5 km HR RSS**
	IR 3.8	3.800 µm	**2 km NR / 1.0 km HR RSS**
	WV 6.3	6.300 µm	2 km
	WV 7.3	7.350 µm	2 km
	IR 8.7	8.700 µm	2 km
	IR 9.7 (O3)	9.660 µm	2 km
	IR 10.5	10.50 µm	**2 km NR / 1.0 km HR RSS**
	IR 12.3	12.30 µm	2 km
	IR 13.3 (CO2)	13.30 µm	2 km

* new bands, not available on SEVIRI

10 min FDS NR / 2.5 min RSS HR



FDS = Full Disk Service
RSS = Rapid Scan Service

NR = Normal Resolution bands
HR = High Resolution bands

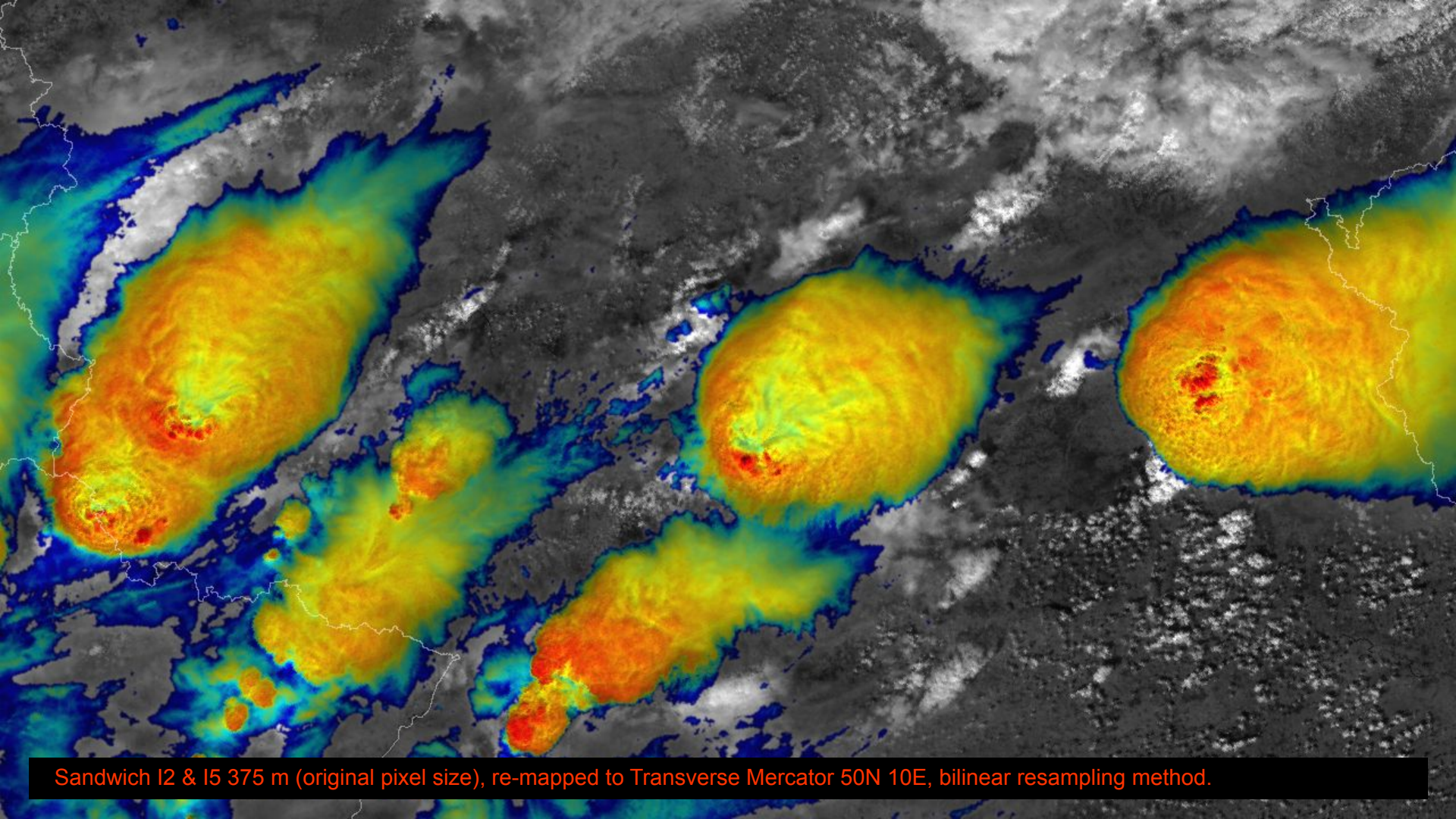
11 June 2018, 11:37 UTC, S-NPP VIIRS, I-bands (375 m)

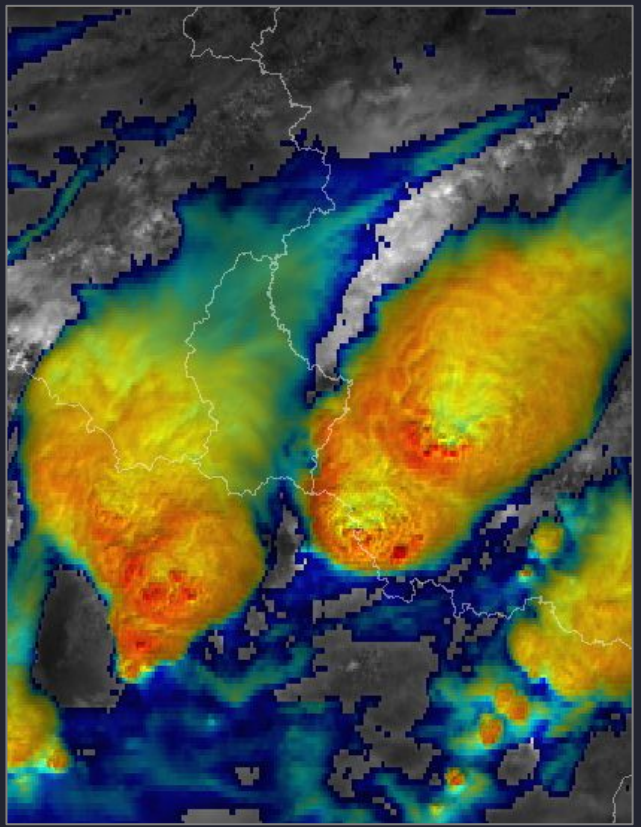
Convective storms above western and central Europe

Source data: S-NPP, VIIRS bands I2 0.862 μm and I5 11.45 μm (375m, SDR), 11:37 UTC,

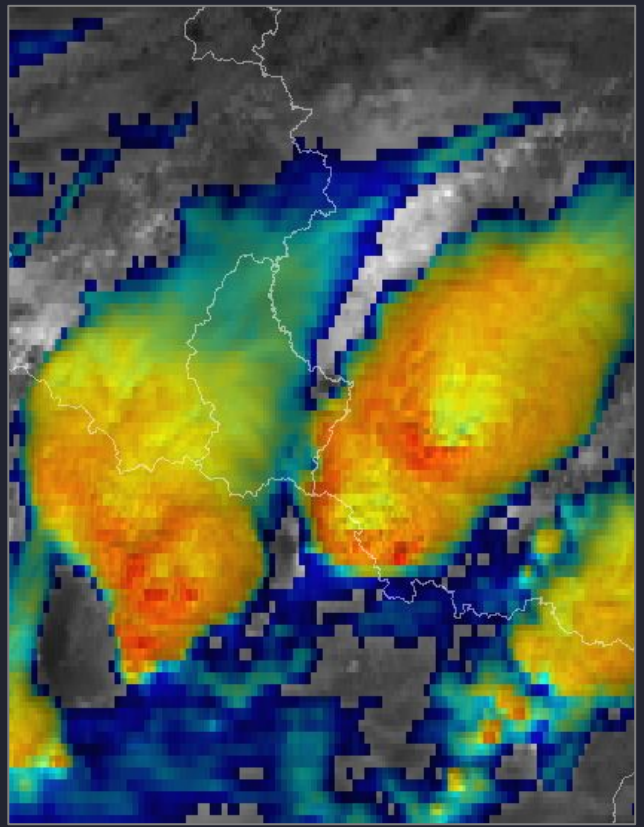
processed in ENVI, using its bilinear interpolation for initial remapping of VIIRS data, and pixel aggregate and nearest neighbor resampling methods for simulations of lower pixel resolution,

simulations of MTG FCI VIS 0.6 (0.640 μm) 0.5 km HR / 1 km NR, and IR10.5 (10.50 μm) 1 km HR / 2 km NR bands, assuming position of the satellite at 9.5 E (RSS satellite).

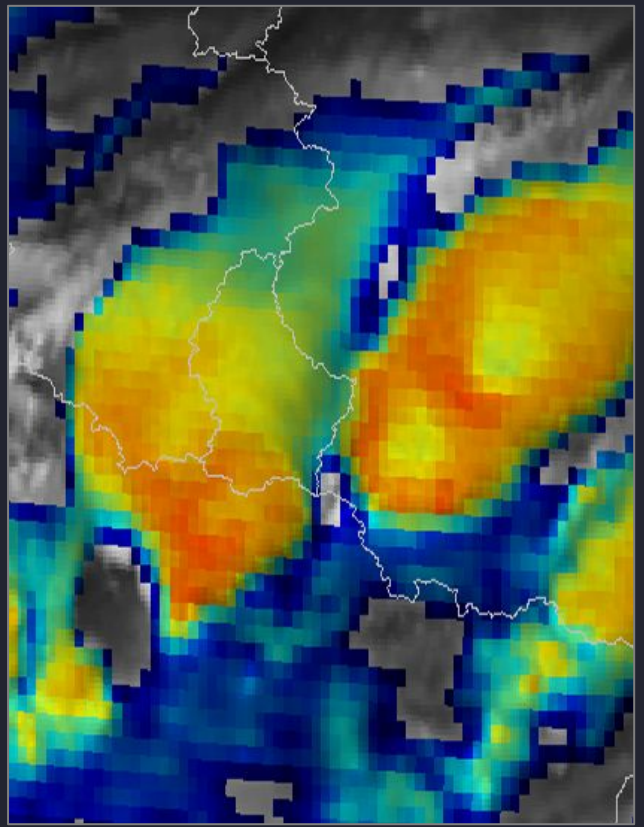

Sandwich I2 & I5 375 m (original pixel size), re-mapped to Transverse Mercator 50N 10E, bilinear resampling method.



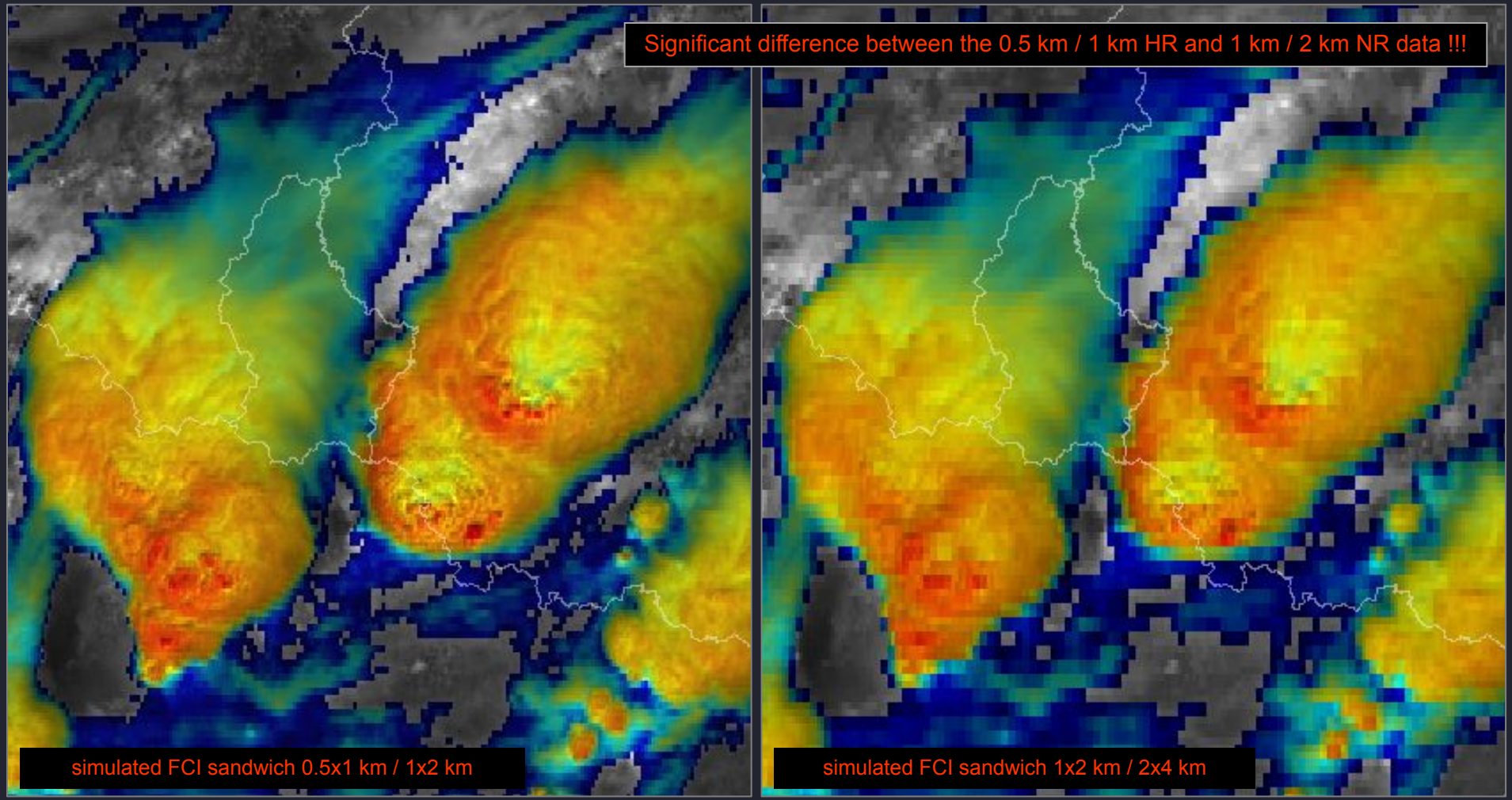
simulated FCI sandwich, 0.5x1 km / 1x2 km



simulated FCI sandwich, 1x2 km / 2x4 km



MSG RSS, sandwich HRV & IR10.8


Significant difference between the 0.5 km / 1 km HR and 1 km / 2 km NR data !!!
simulated FCI sandwich 0.5x1 km / 1x2 km
simulated FCI sandwich 1x2 km / 2x4 km

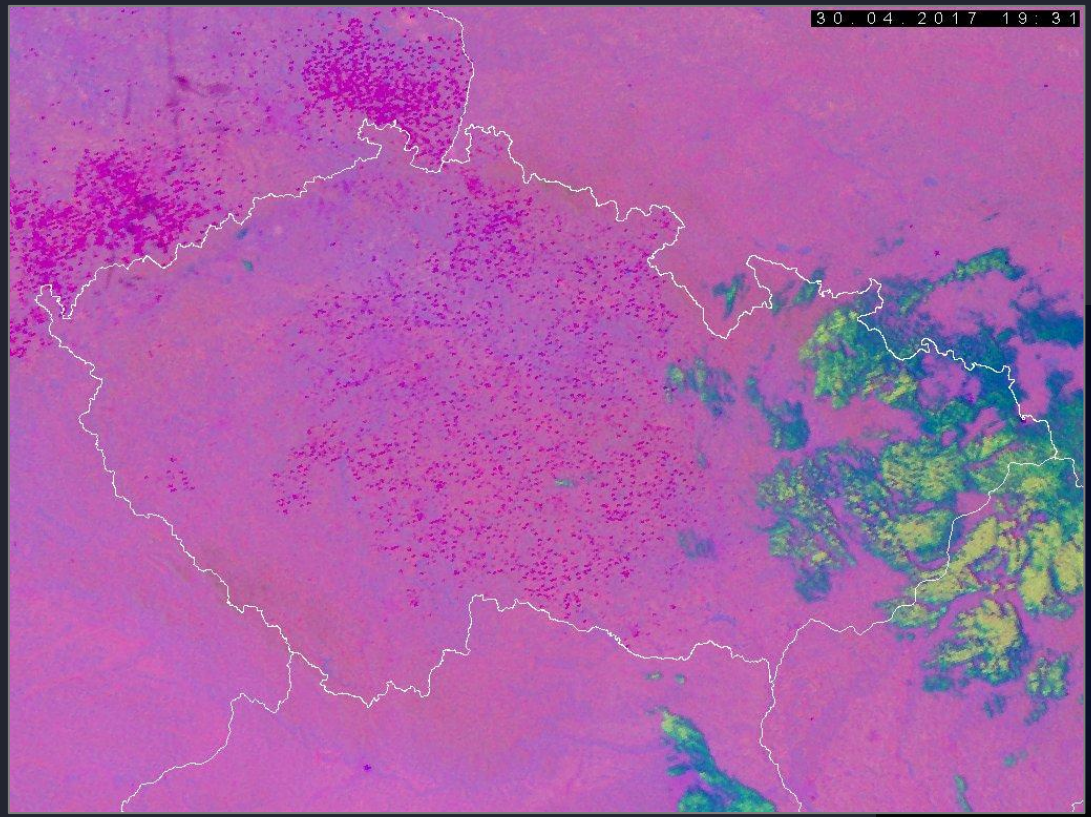
30 April / 01 May 2019, 01:20 UTC, NOAA-20, VIIRS, I-bands (375 m)

Fire detection, central Europe – Beltain (Beltane, Walpurgis) night

Source data: NOAA-20 (JPSS-1), VIIRS bands I4 3.74 µm and I5 11.45 µm (375m, SDR), 01:20 UTC,

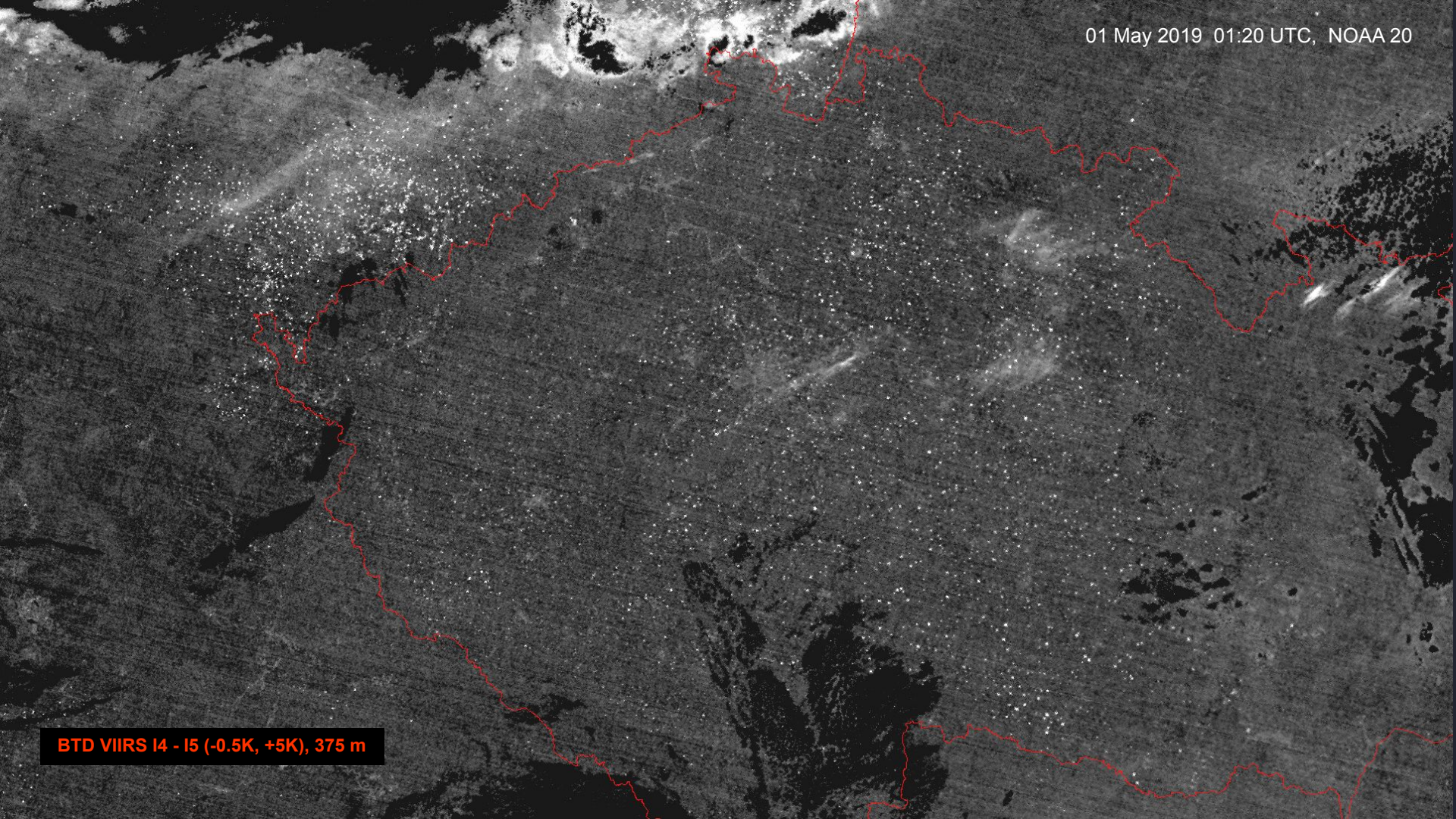
processed in ENVI, using its bilinear interpolation for initial remapping of VIIRS data, and pixel aggregate and nearest neighbor resampling methods for simulations of lower pixel resolution,

simulations of MTG FCI IR 3.8 (3.80 µm) and IR10.5 (10.50 µm) 1 km HR / 2 km NR bands



METOP AVHRR, Night Microphysics RGB

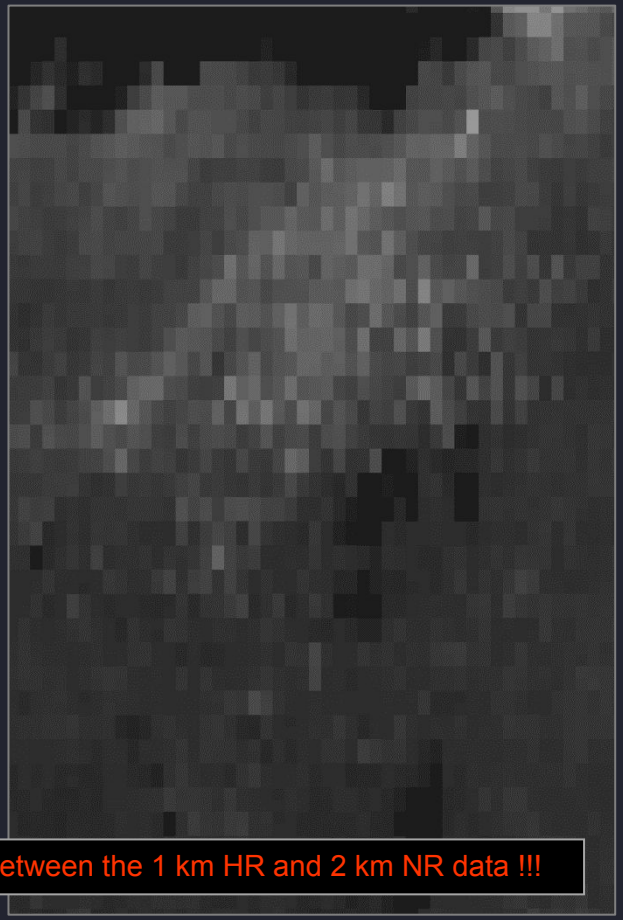
Temperature of bonfire – up to about 1400 K


01 May 2019 01:20 UTC, NOAA 20
BTD VIIRS I4 - I5 (-0.5K, +5K), 375 m

Original satellite projection (VIIRS)

MTG FCI 1 km HR bands

MTG FCI 2 km NR bands



Significant difference between the 1 km HR and 2 km NR data !!!

original 375 m data

simulated pixel size 1 x 2 km

simulated pixel size 2 x 4 km

PREPARATIONS FOR MTG FCI:
FAMILIARIZATION WITH NEW BANDS AND IMAGE PRODUCTS

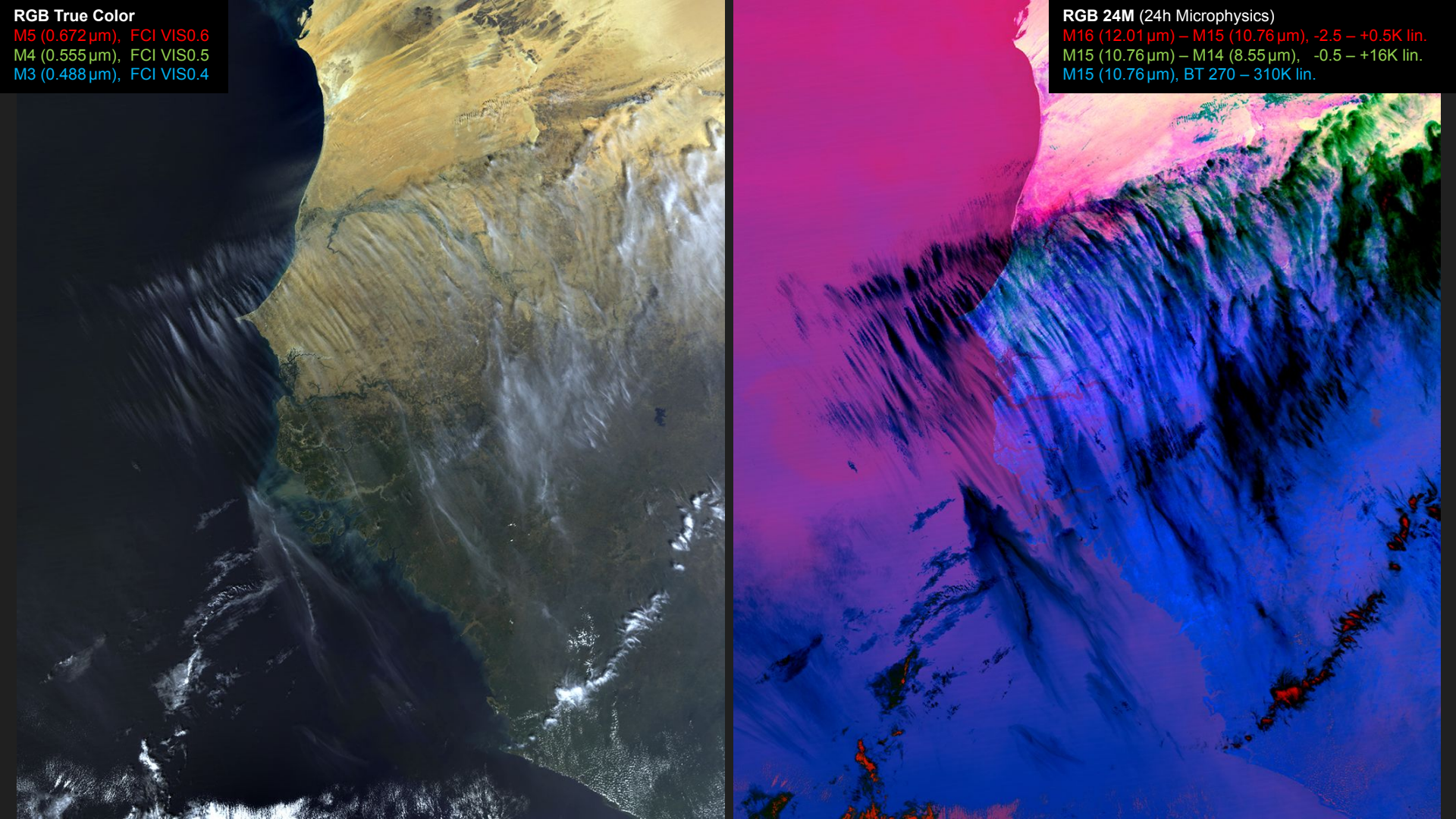
- focus at 1.38 μm band and RGBs using this band
- thin cirrus detection and above anvil cirrus plumes (AACP)
- aerosols and low-level moisture

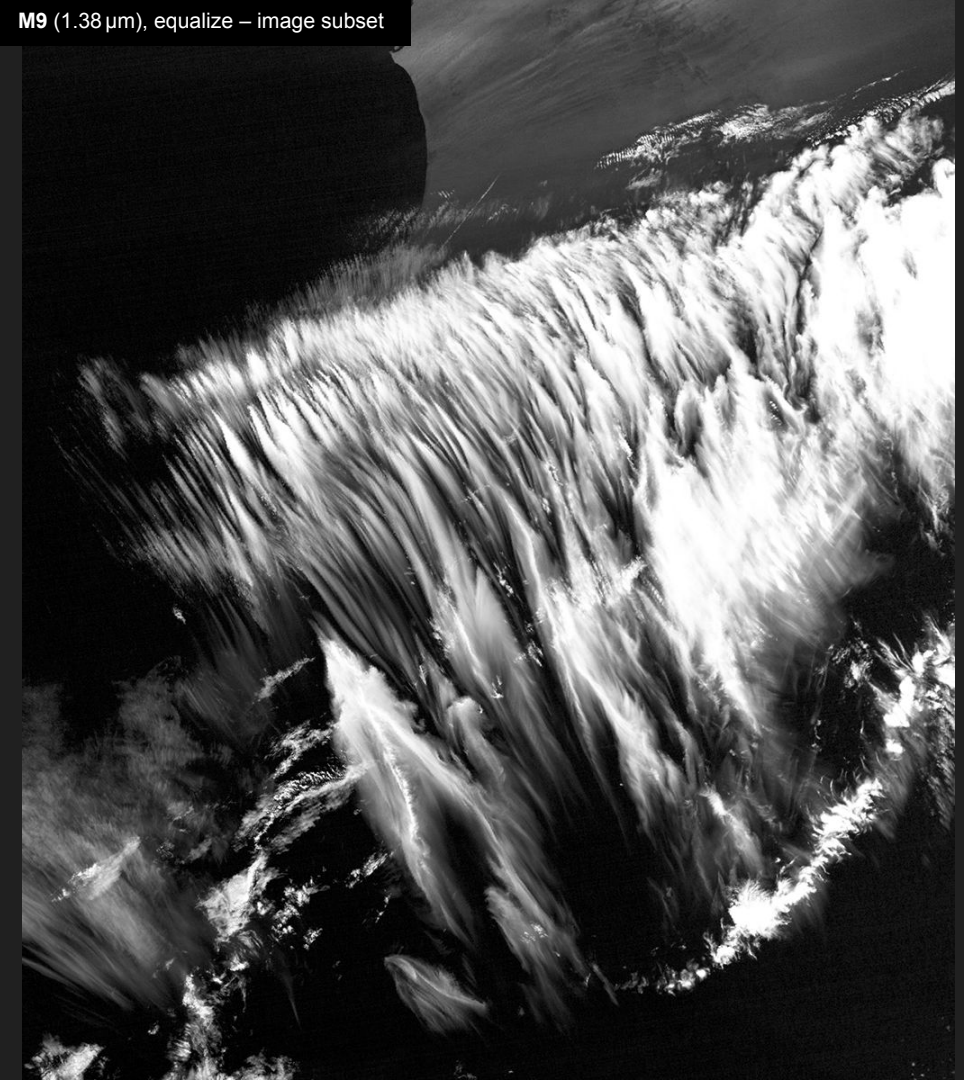
09 January 2020, 14:30 UTC, S-NPP VIIRS, M-bands (750 m)

Thin cirrus clouds, west Africa

single 1.38 μm band and related RGBs

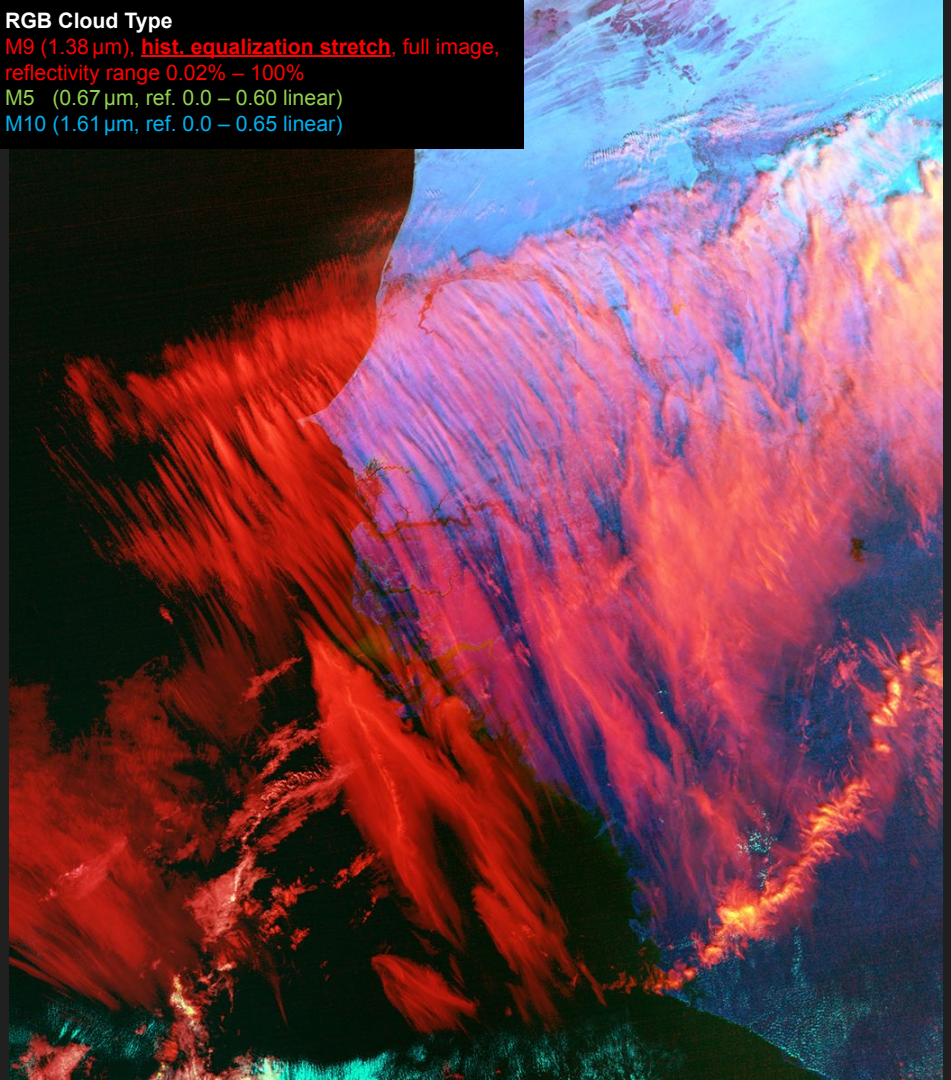
more here: https://www.setvak.cz/presentations/2021-03-08_Setvak_EUM-MTG-3T_workshop.pptx


RGB True Color
M5 (0.672 µm), FCI VIS0.6
M4 (0.555 µm), FCI VIS0.5
M3 (0.488 µm), FCI VIS0.4
RGB 24M (24h Microphysics)
M16 (12.01 µm) – M15 (10.76 µm), -2.5 – +0.5K lin.
M15 (10.76 µm) – M14 (8.55 µm), -0.5 – +16K lin.
M15 (10.76 µm), BT 270 – 310K lin.

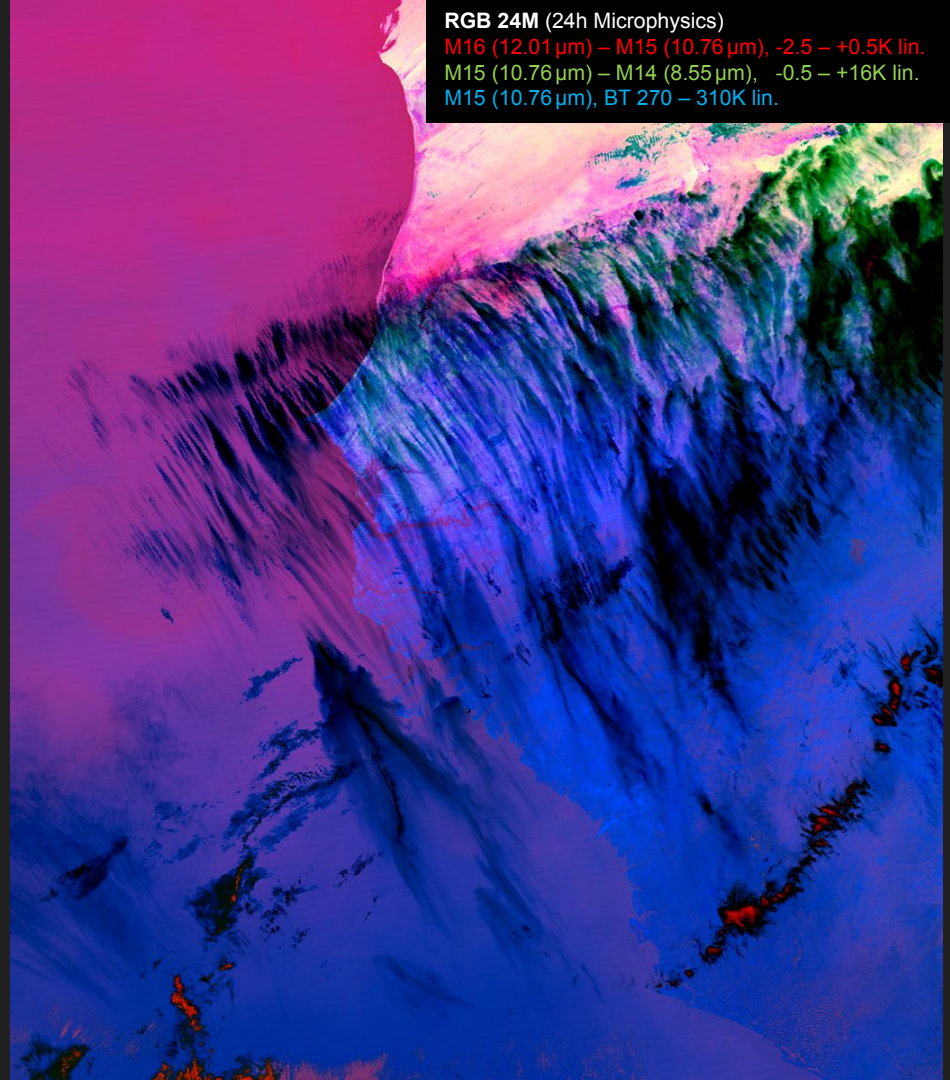

M9 (1.38 µm), equalize – image subset


M9 (1.38 µm), equalize – full image

RGB Cloud Type
M9 (1.38 µm), **hist. equalization stretch**, full image, reflectivity range 0.02% – 100%
M5 (0.67 µm, ref. 0.0 – 0.60 linear)
M10 (1.61 µm, ref. 0.0 – 0.65 linear)



RGB 24M (24h Microphysics)
M16 (12.01 µm) – M15 (10.76 µm), -2.5 – +0.5K lin.
M15 (10.76 µm) – M14 (8.55 µm), -0.5 – +16K lin.
M15 (10.76 µm), BT 270 – 310K lin.



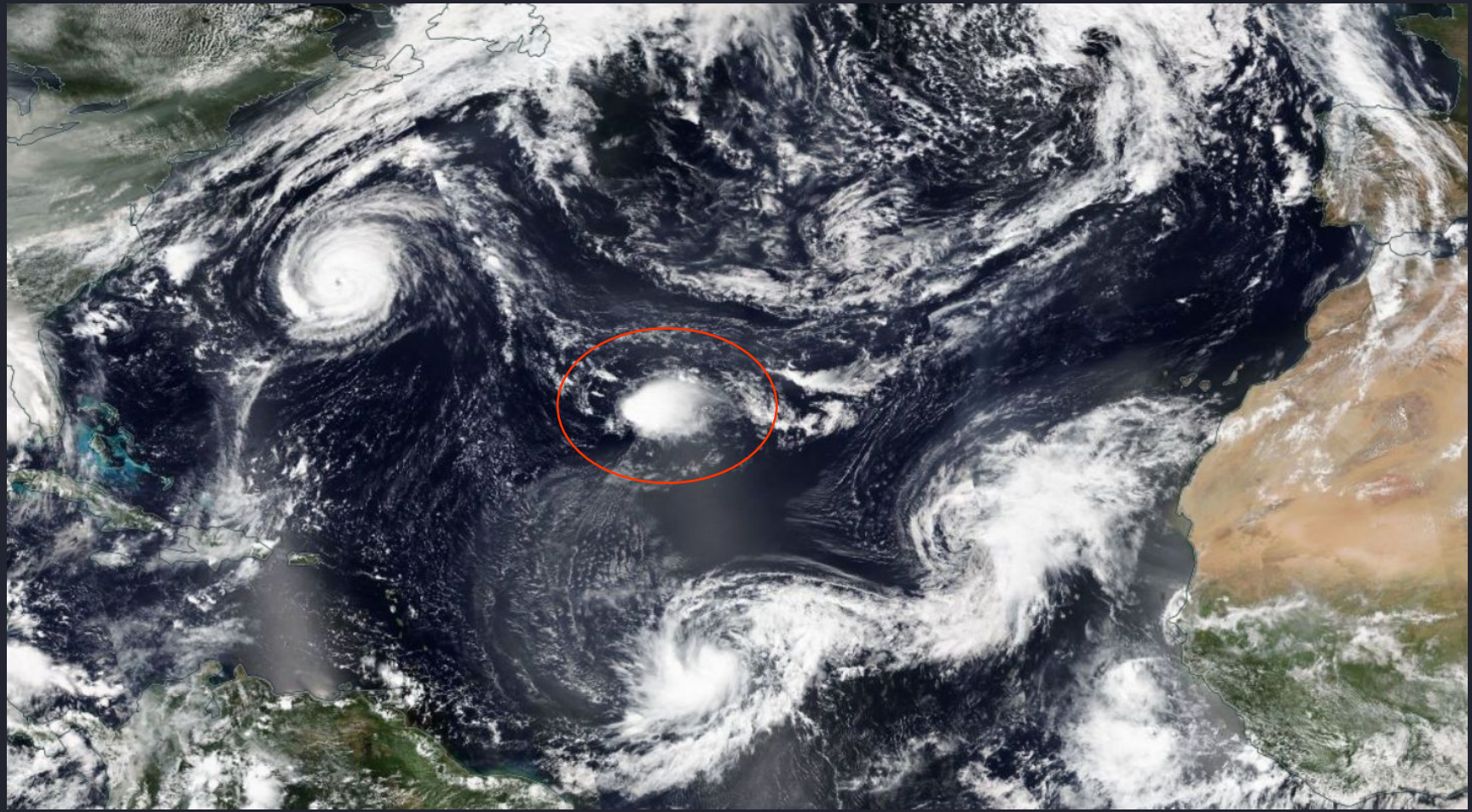
14 September 2020, 15:57 UTC, NOAA-20 VIIRS, M-bands (750 m)

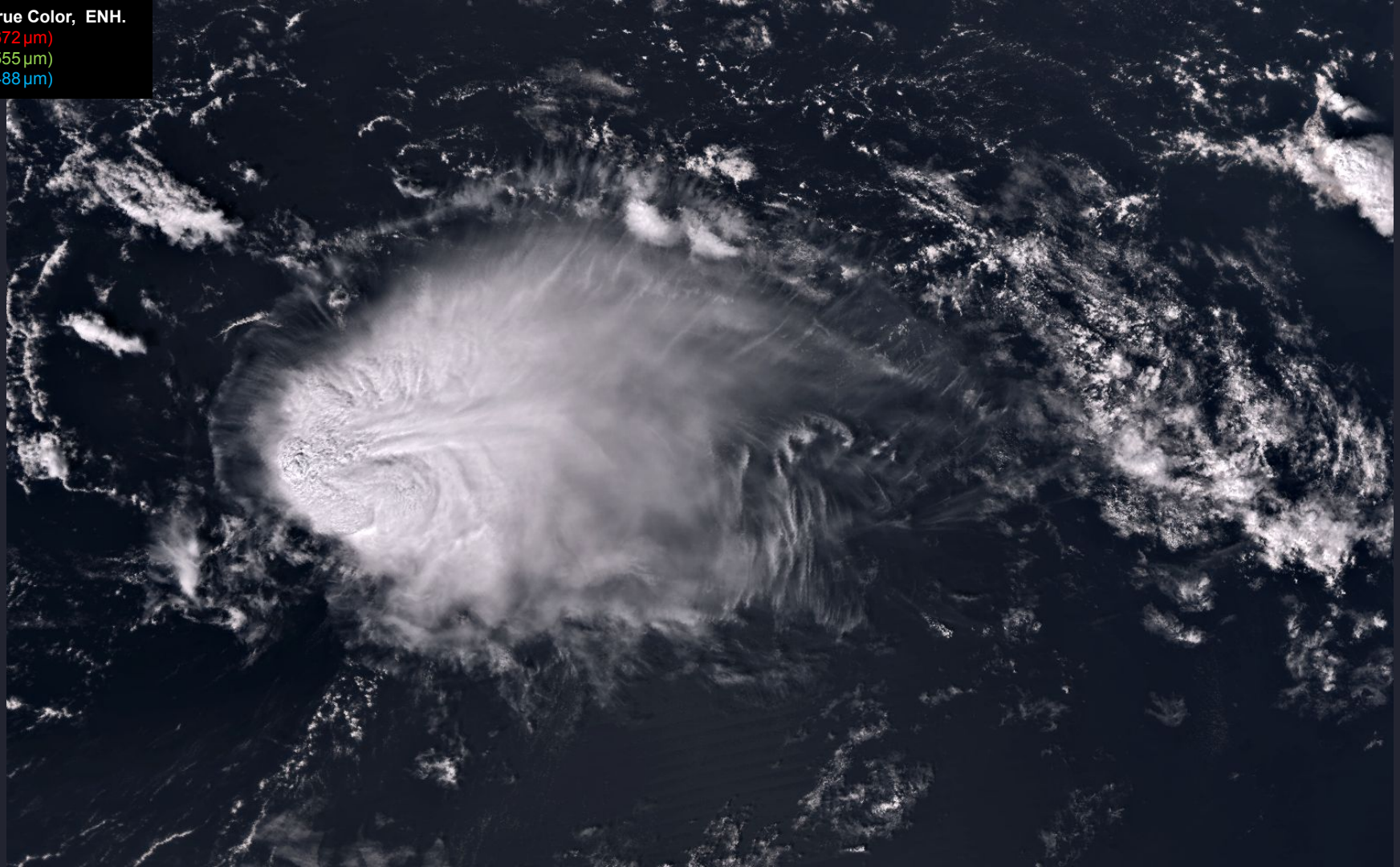
Thin cirrus clouds and above-anvil cirrus plume (AACP), central Atlantic Ocean

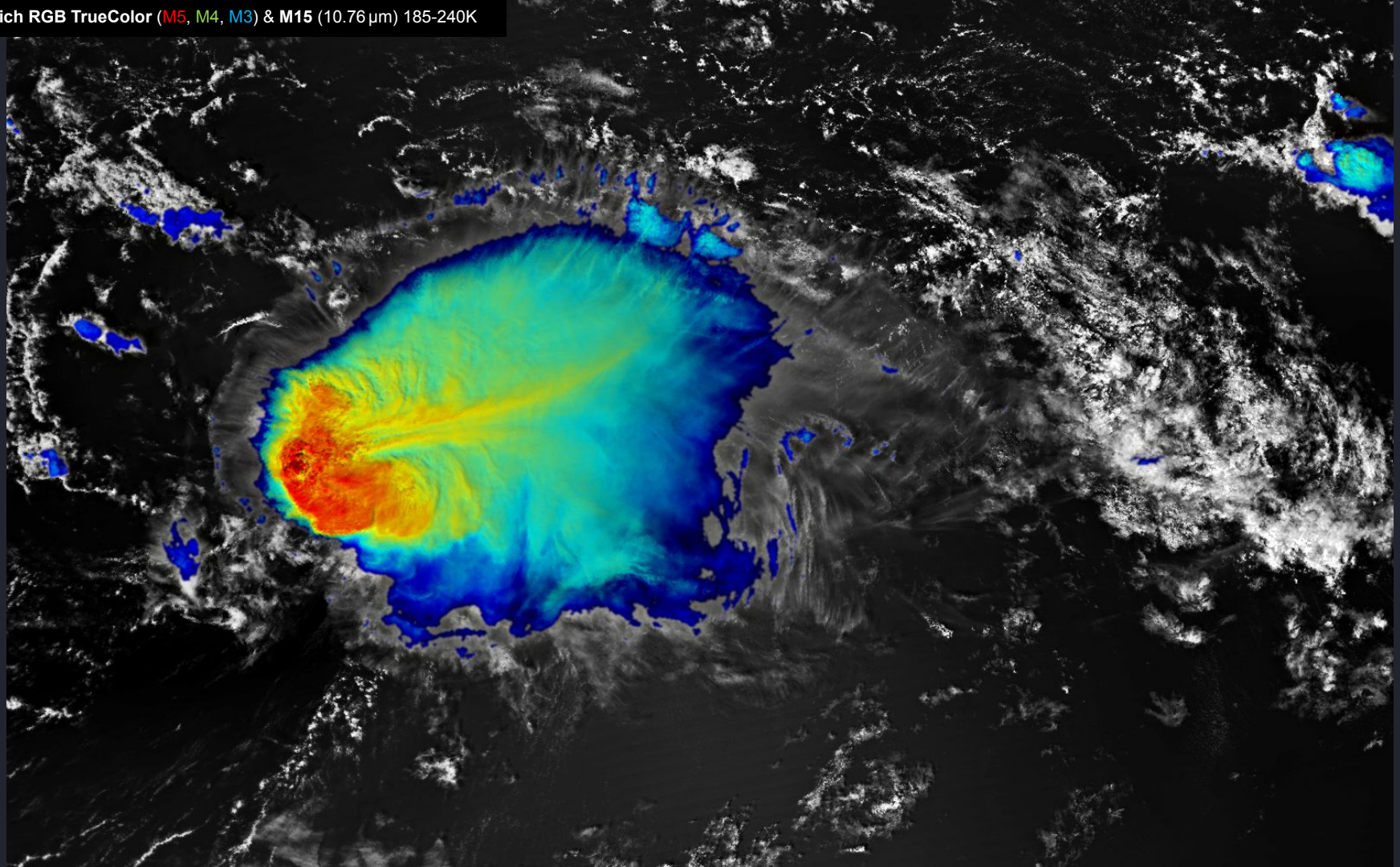
single 1.38 μm band and related RGBs

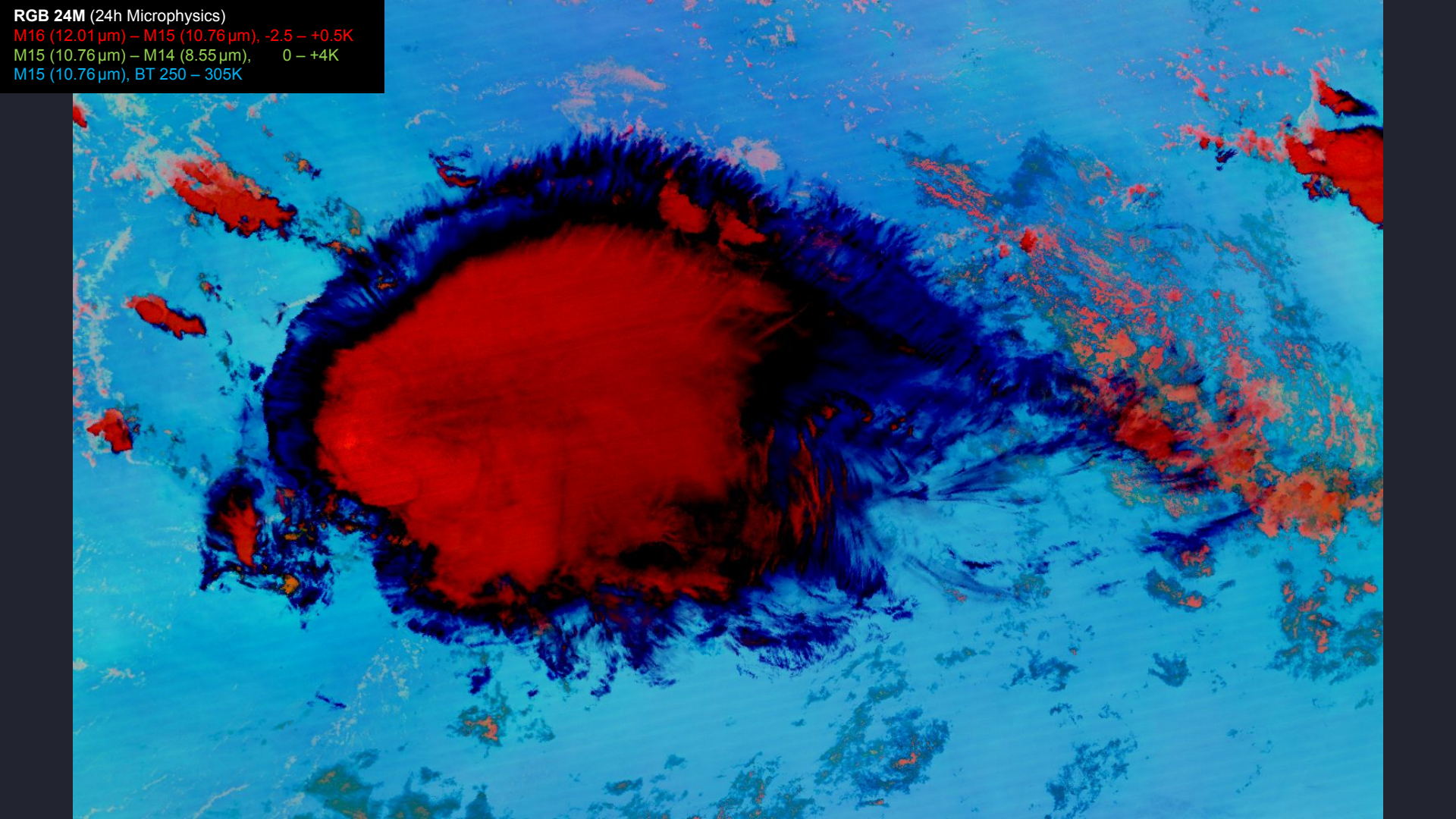
more here: https://www.setvak.cz/presentations/2021-04-05_Setvak_CWG-2021-workshop_longer-version.pptx

image source: NASA EOSDIS Worldview

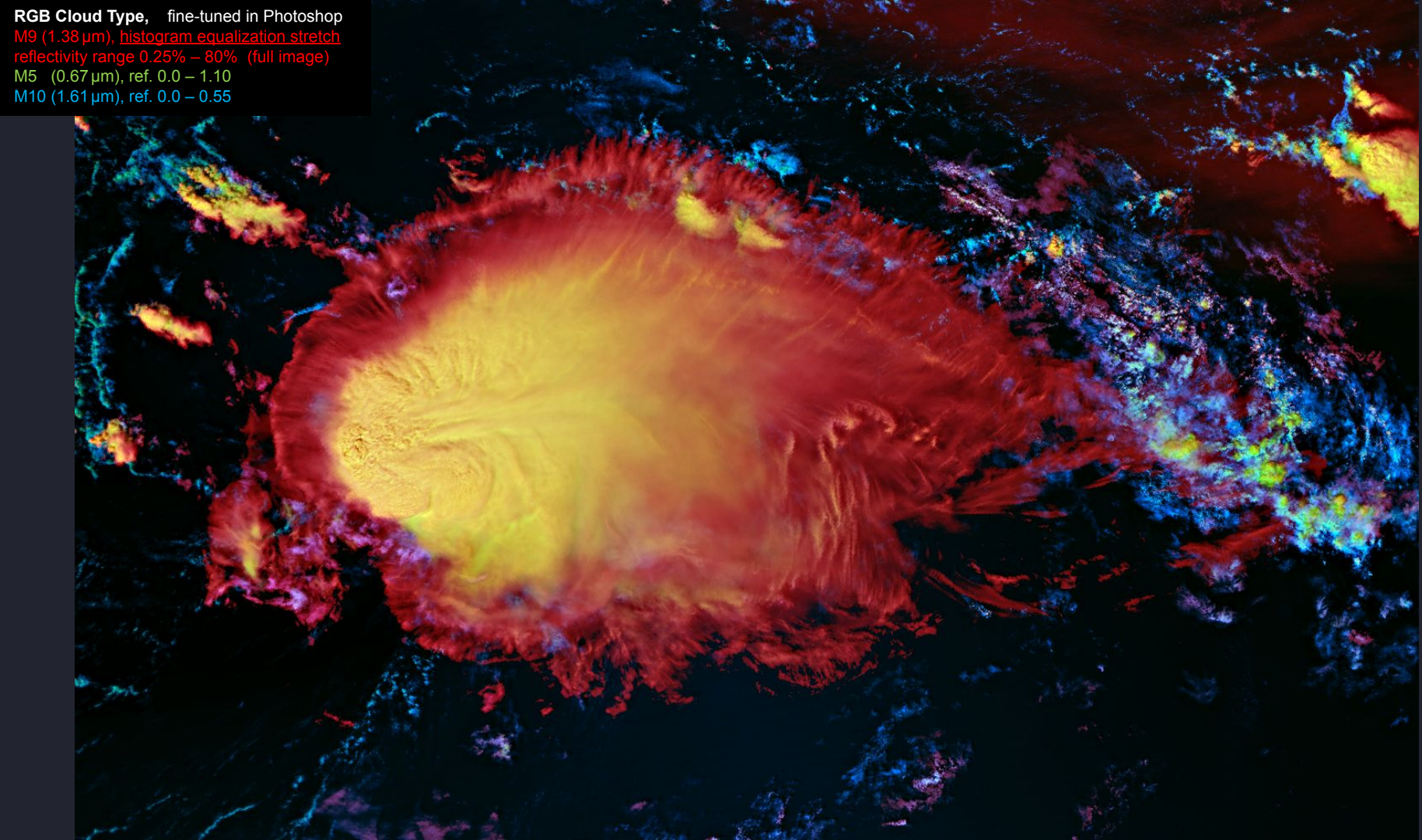



RGB True Color, ENH.
M5 (0.672 µm)
M4 (0.555 µm)
M3 (0.488 µm)


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


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


M9 (1.378 µm), ref. 0% – 80% piecewise linear stretch
Input Histogram
0.00
0.40
0.80


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

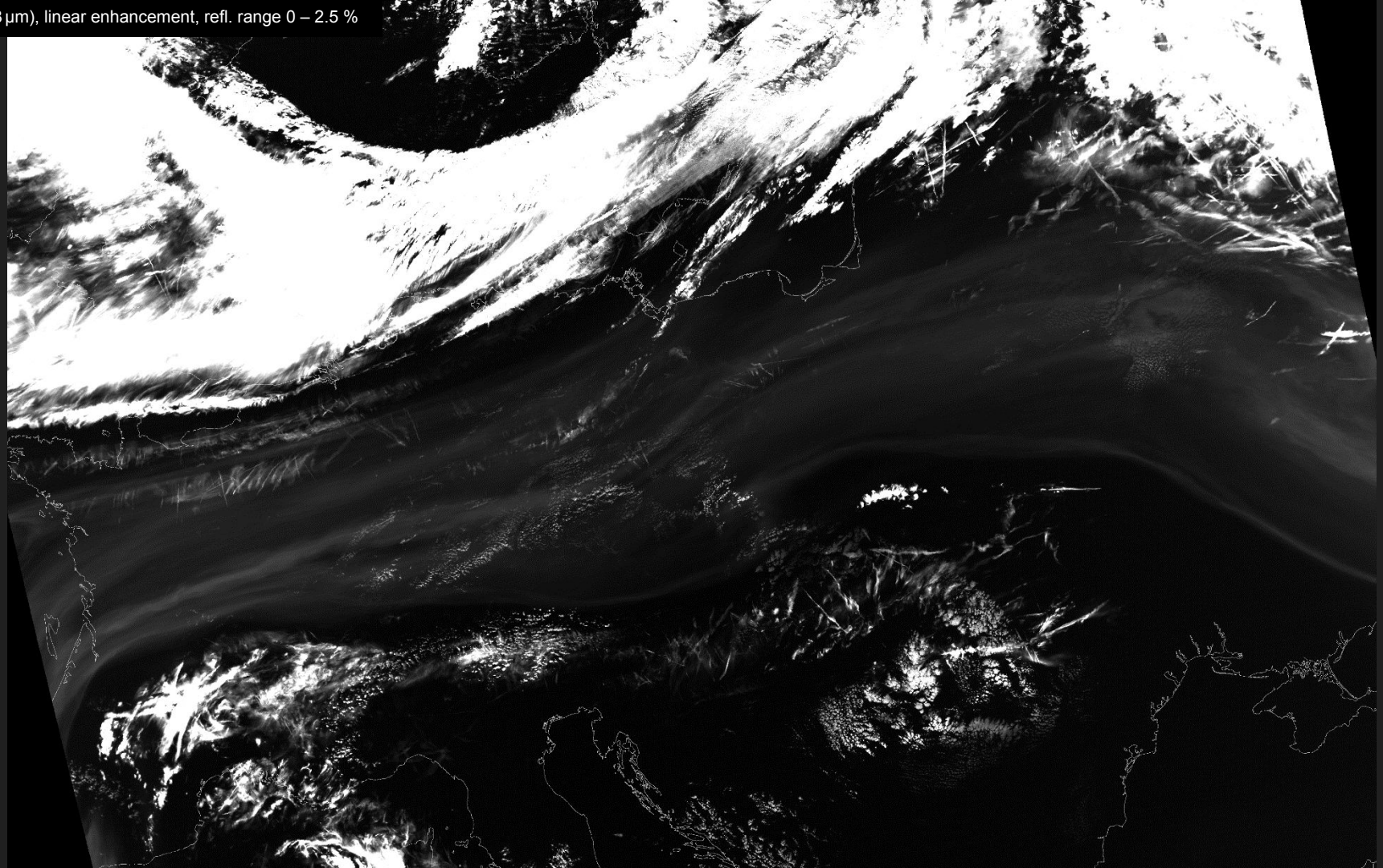
12 September 2020, 11:37 UTC, NOAA-20 VIIRS, M-bands (750 m)

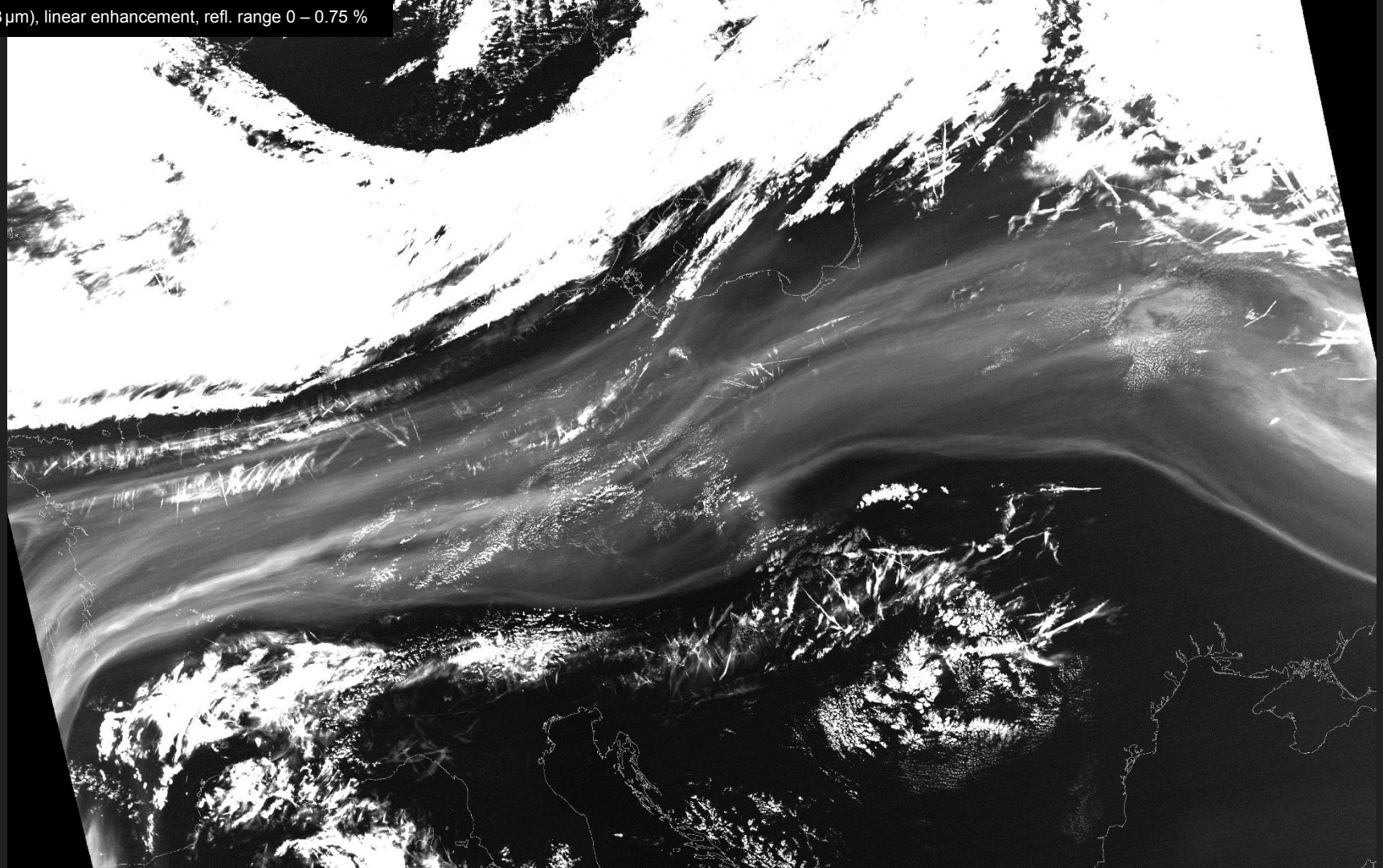
Europe – ash from California fires

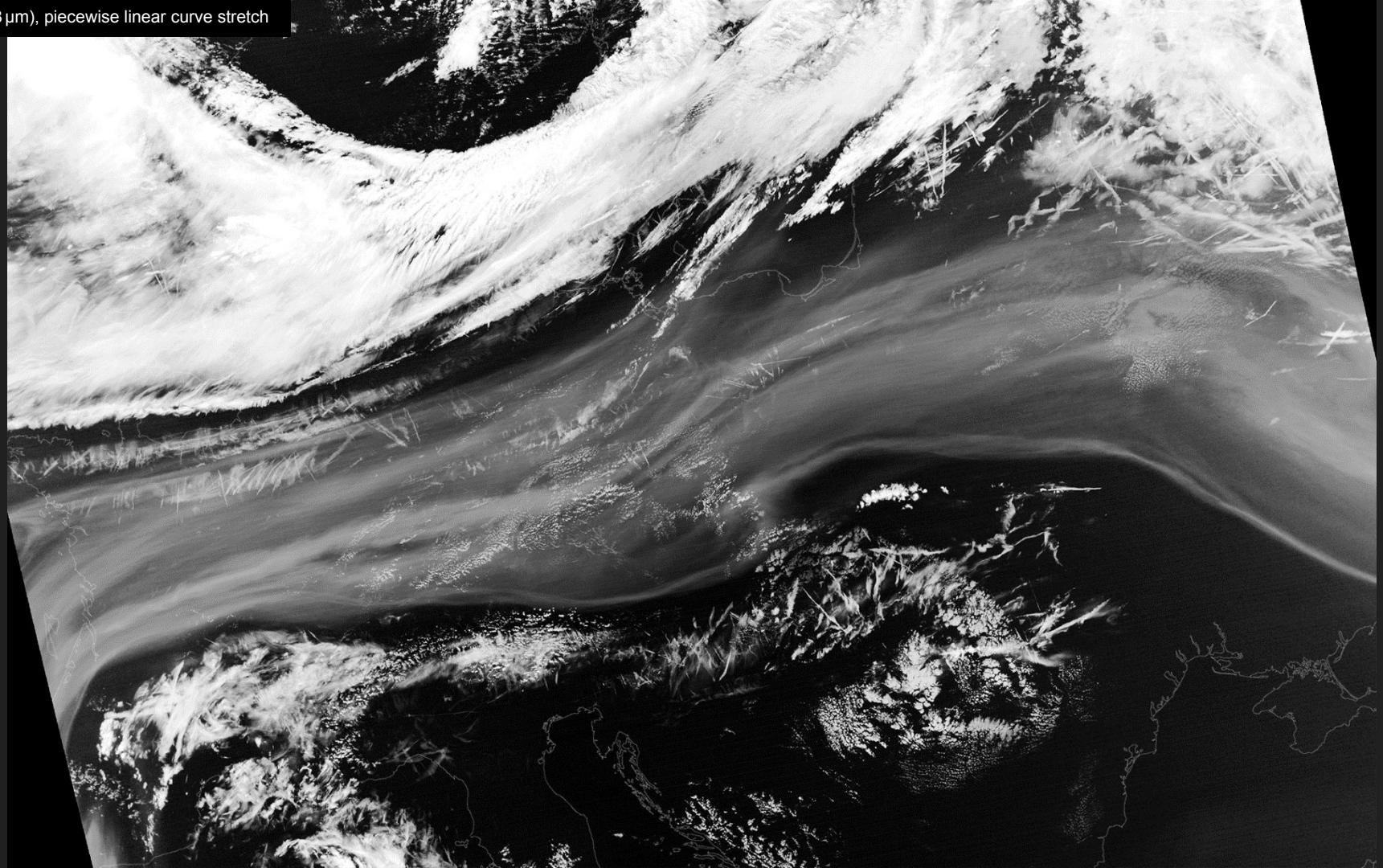
Demonstration of various enhancement methods

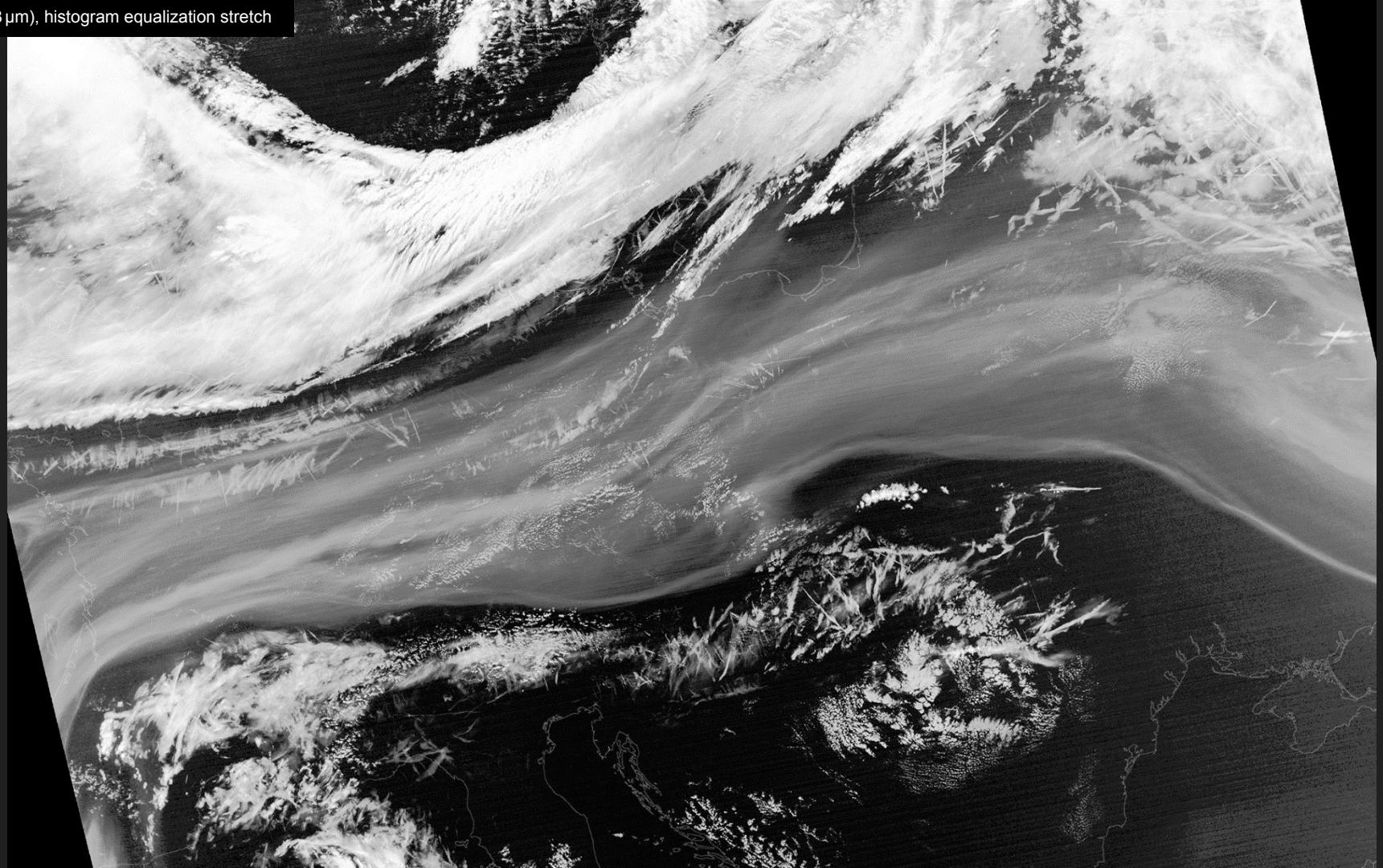
https://www.eumetsat.int/smoke-california-fires-above-europe-seen-noaa-20

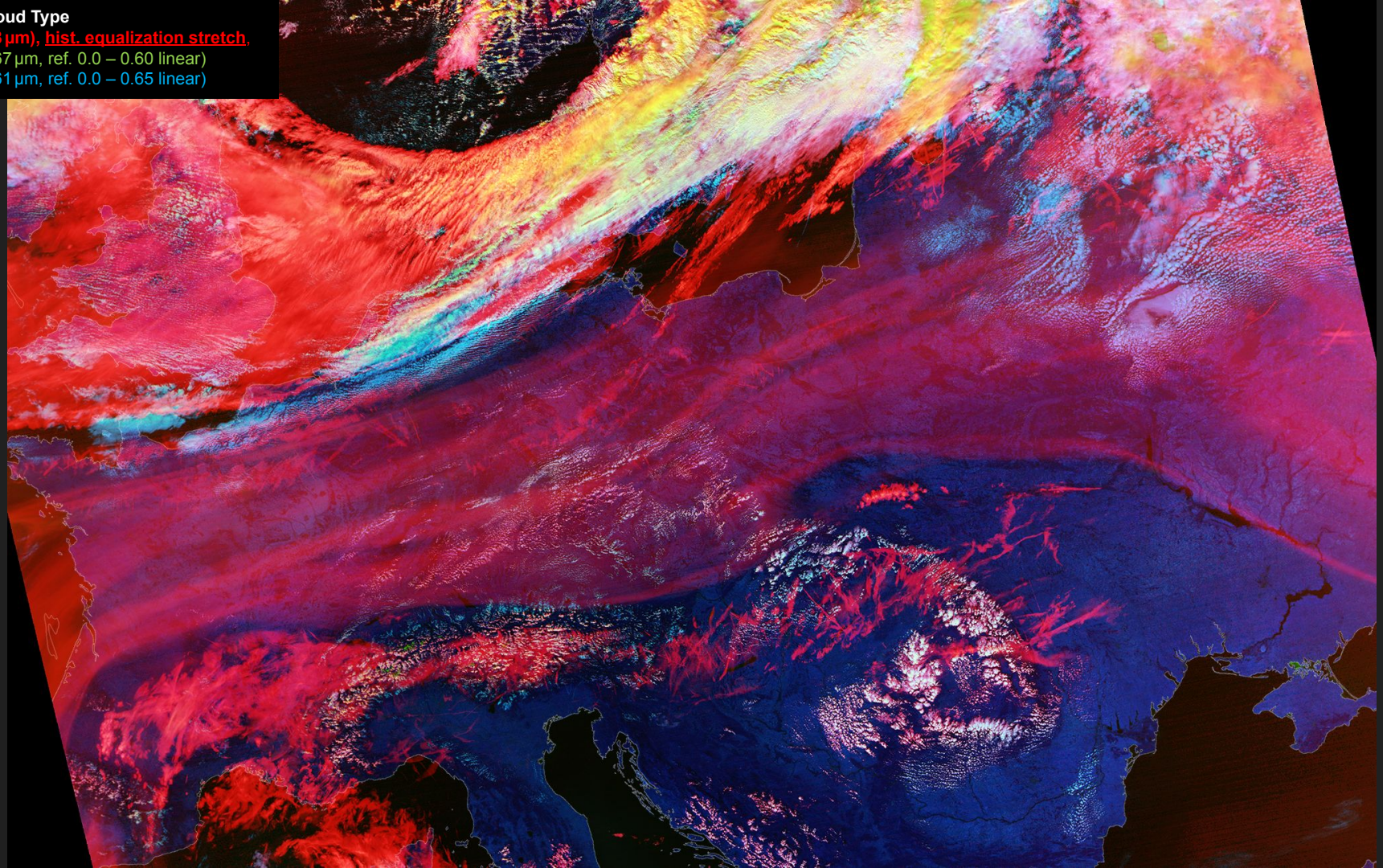

VIIRS RGB 541
M5 (0.672 µm)
M4 (0.555 µm)
M1 (0.412 µm)


M9 (1.38 µm), linear enhancement, refl. range 0 – 2.5 %


M9 (1.38 µm), linear enhancement, refl. range 0 – 0.75 %


M9 (1.38 µm), piecewise linear curve stretch


M9 (1.38 µm), histogram equalization stretch

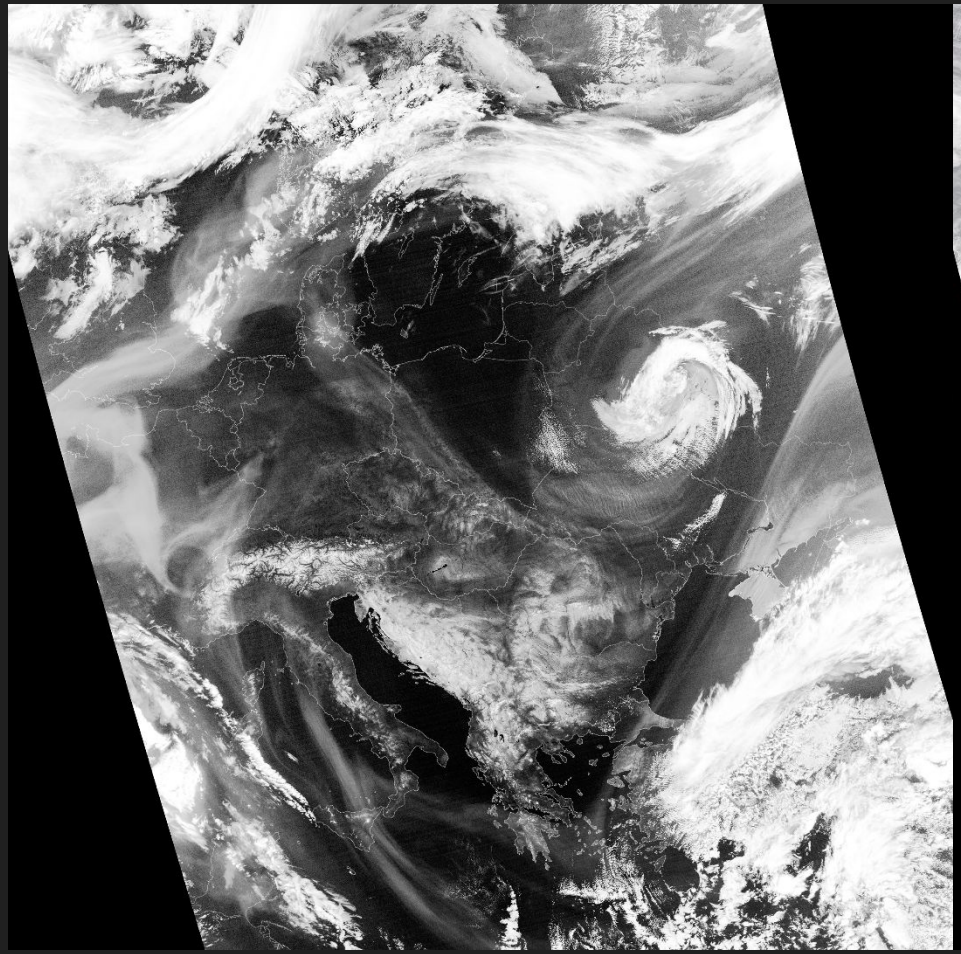

RGB Cloud Type
M9 (1.38 µm), hist. equalization stretch,
M5 (0.67 µm, ref. 0.0 – 0.60 linear)
M10 (1.61 µm, ref. 0.0 – 0.65 linear)

24 March 2022, 11:25 UTC, S-NPP VIIRS, M-bands (750 m)

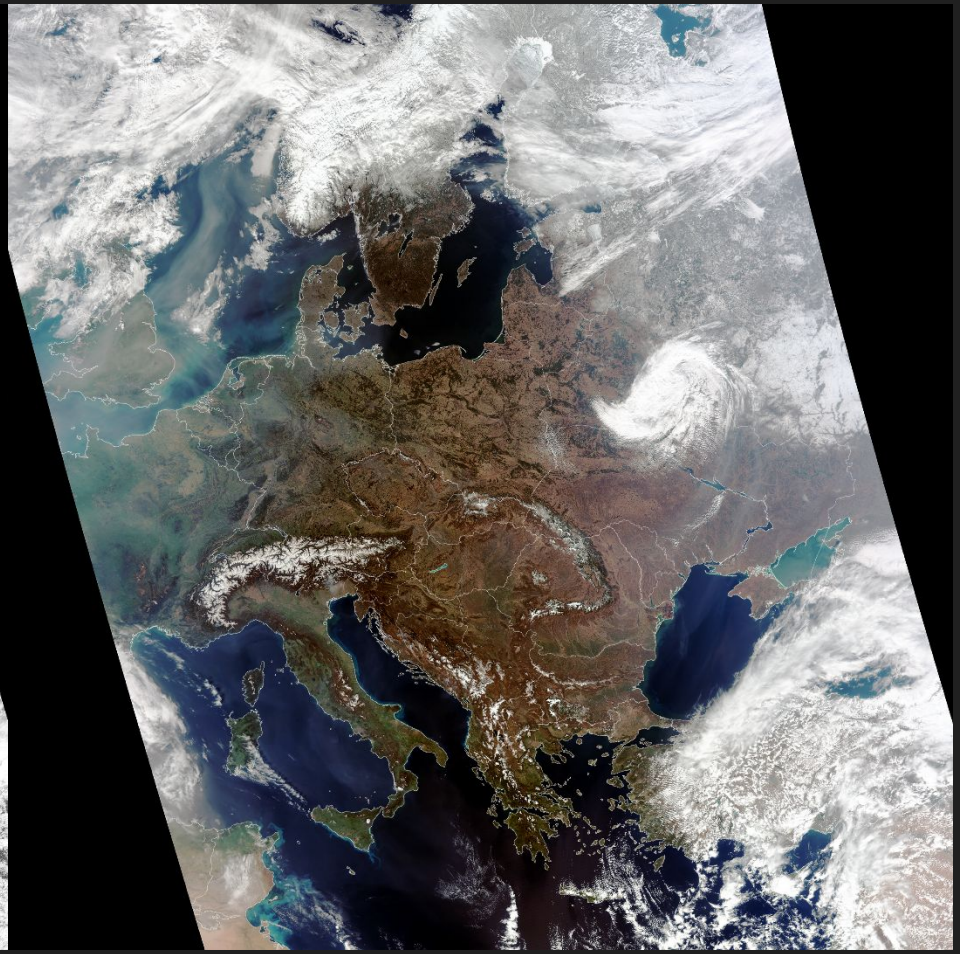
Eastern Europe – low level aerosols/moisture

More details on this and similar cases here:
https://training.tools.eumetsat.int/cwg/res/meeting2022/presentations/16052022/Setvak_1.38um_CWG-2022-Budapest_ver-20220516_final.pptx

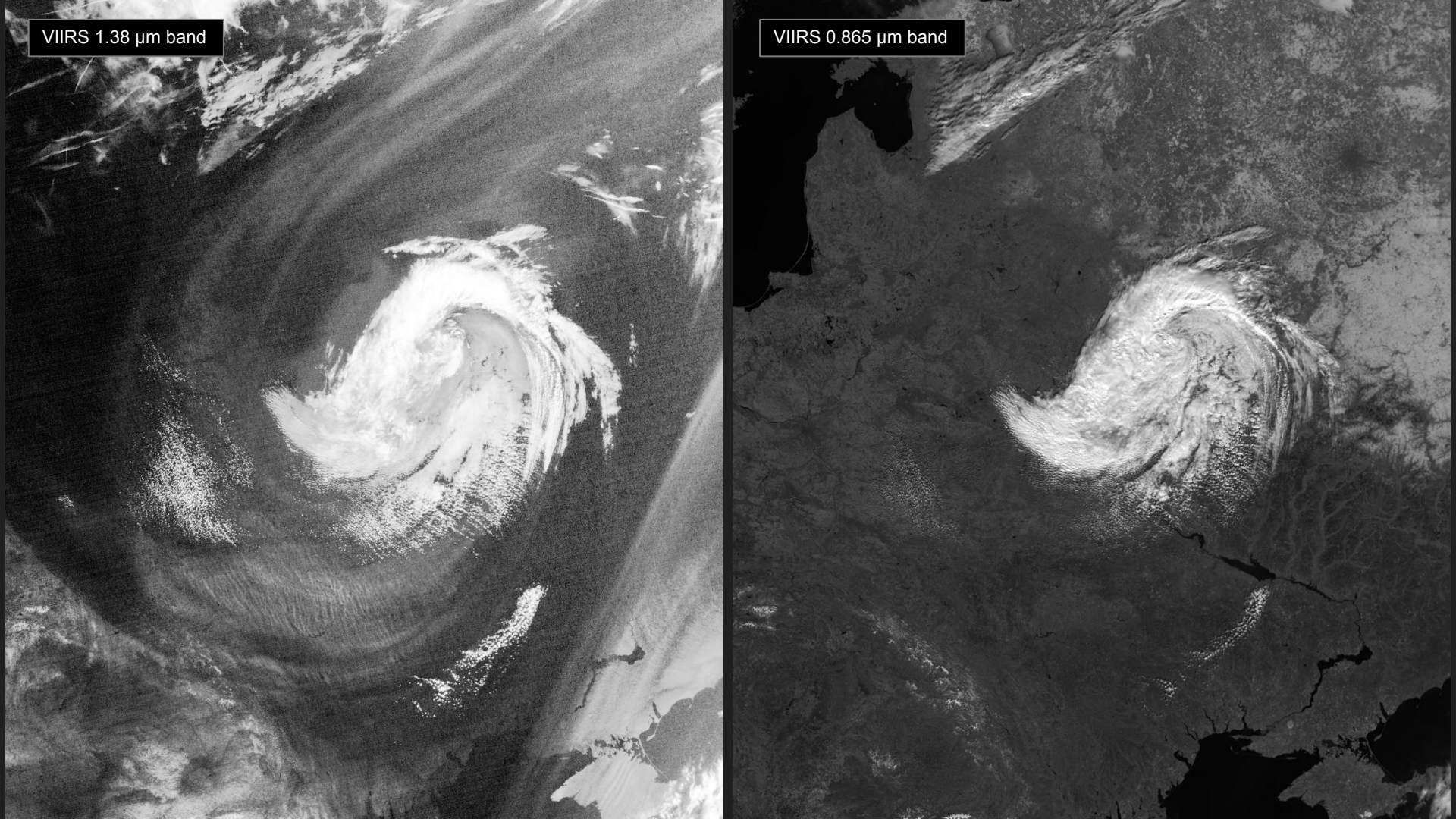
2022-03-24 11:25 UTC NPP

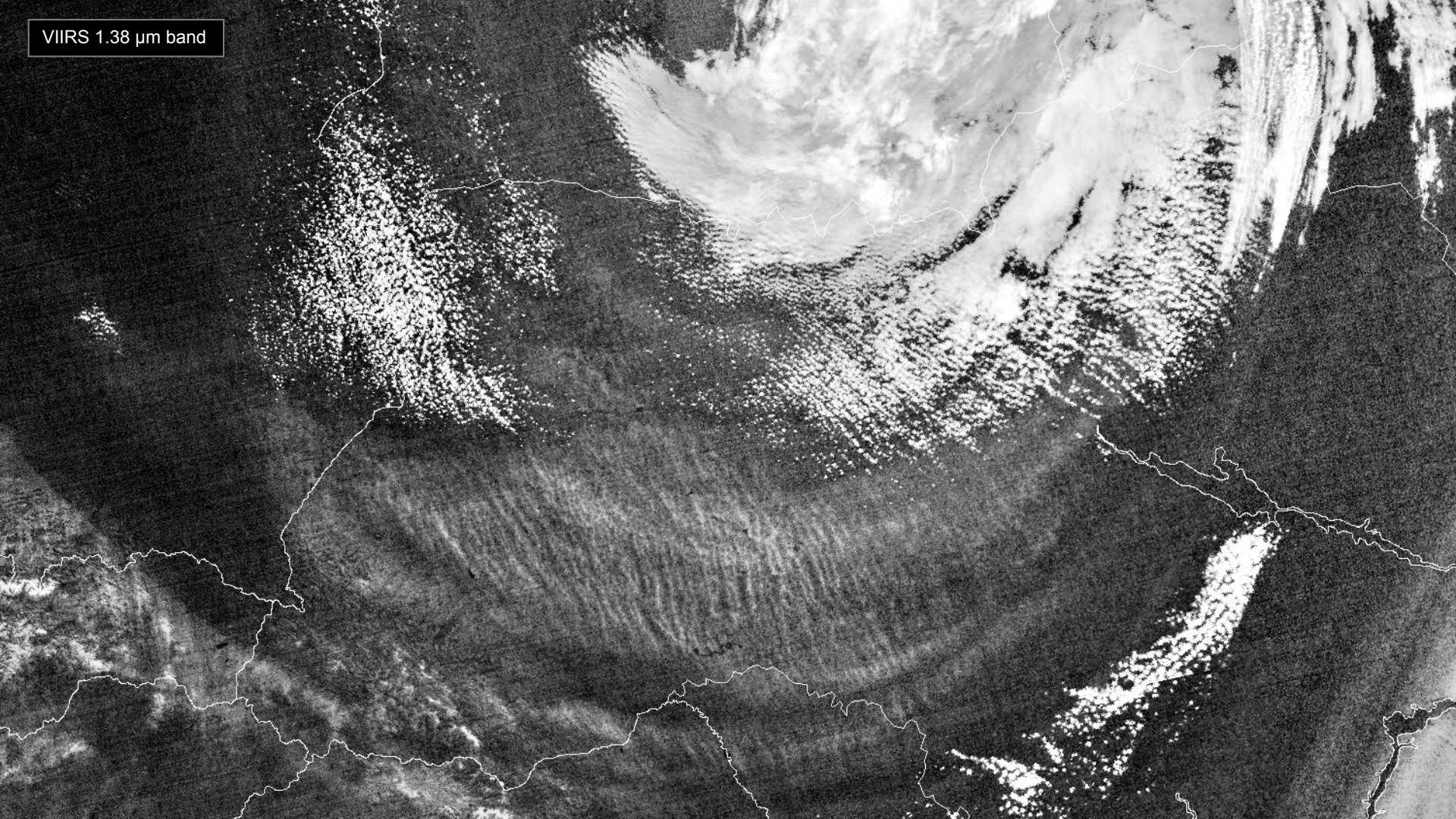


VIIRS 1.38 μm band (M09)



True-color RGB (VIIRS M-bands 5, 4, 3)


VIIRS 1.38 μm band
VIIRS 0.865 μm band


VIIRS 1.38 μm band

SUMMARY AND FINAL COMMENTS

- great instrument for studies benefiting from its high spatial resolution and improved spectral band quality
- availability of the Day/Night Band >>> new perspective for nocturnal observations of Earth and its atmosphere (namely observations of various gravity waves in nightglow)
- very helpful in preparations for MTG FCI

- main drawback: absence of water vapor absorption bands
- significant limitation of its use: too early afternoon orbit for studies of mature convective storms
- question: any chance to shift S-NPP to a later afternoon orbit, after launch of JPSS-2 ???