

Comparison of MTG FCI and MSG SEVIRI imagery, with focus on convective storms

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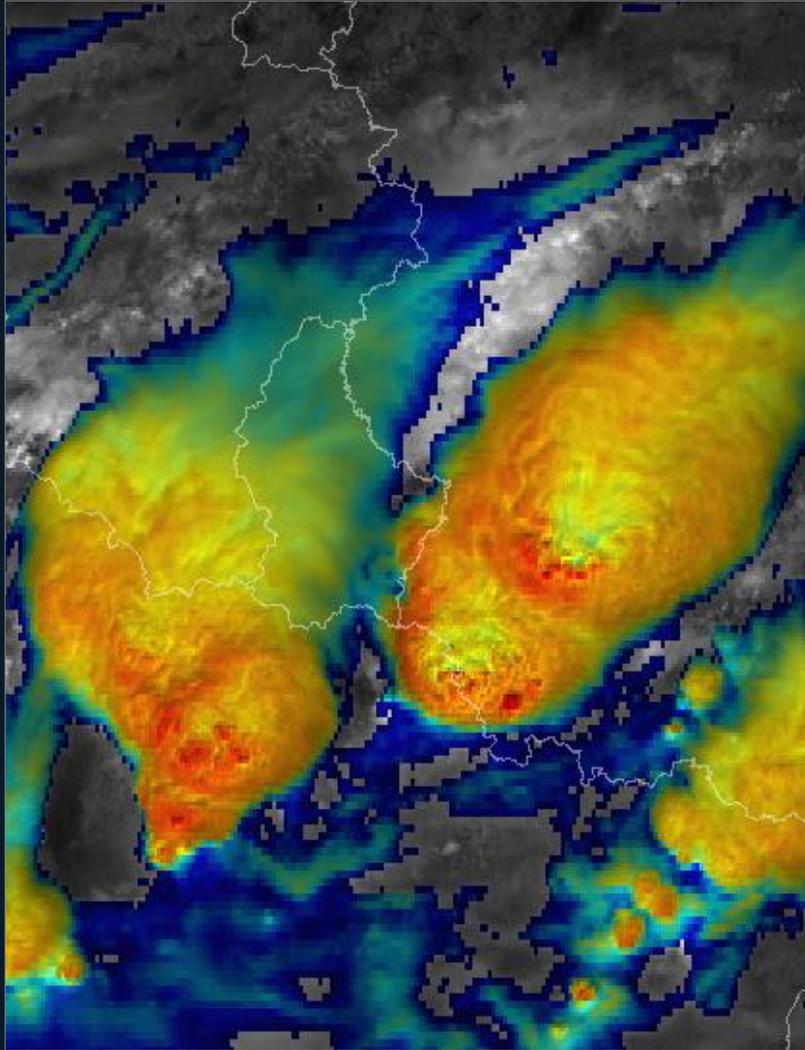
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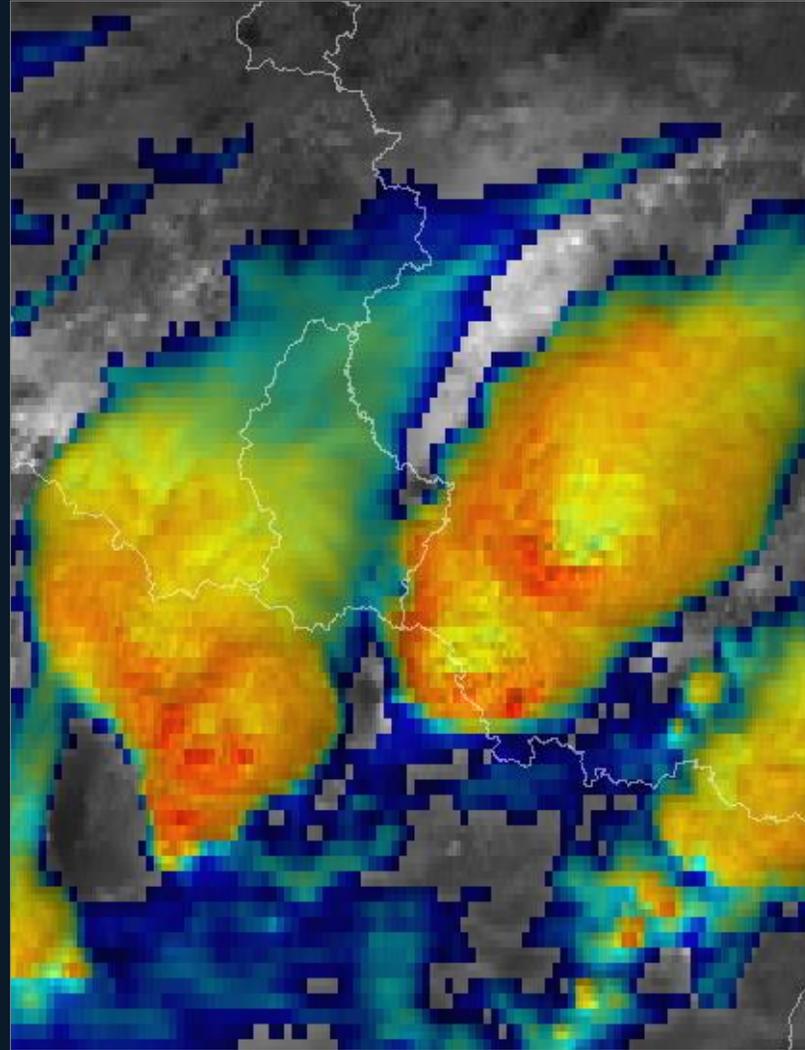
EUMETSAT

EUMETSAT Meteorological Satellite Conference 2023, Malmö, Sweden, 11-15 September 2023

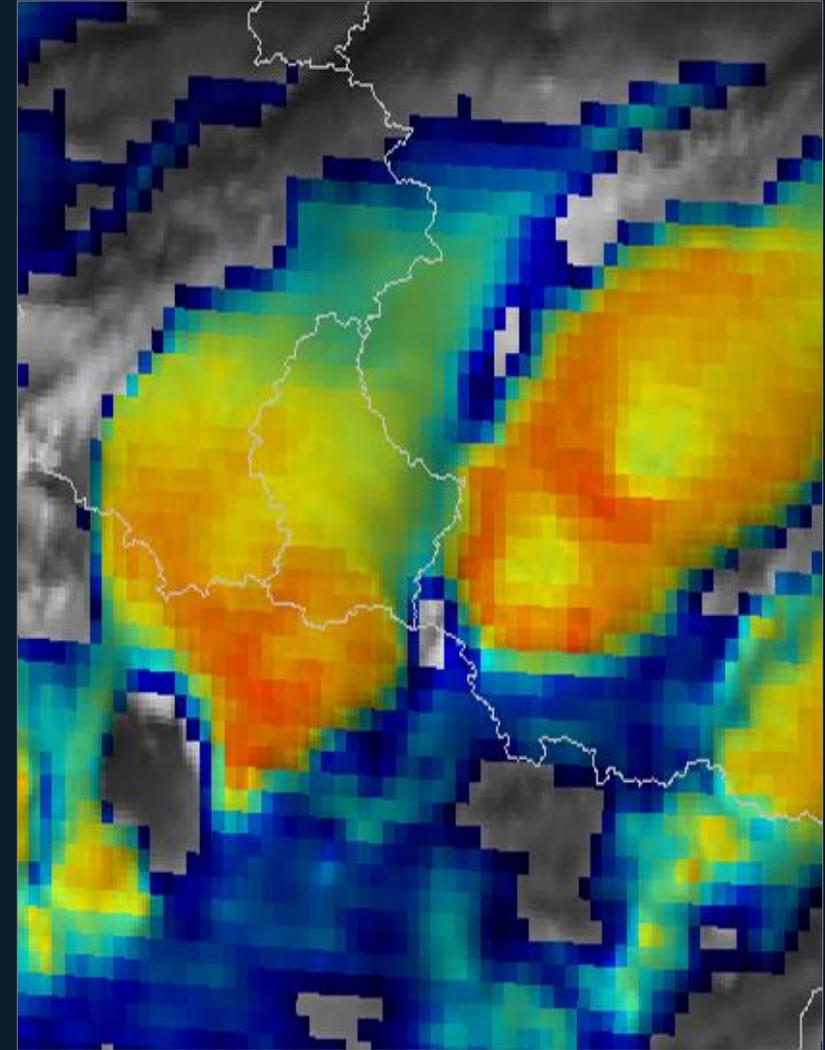
2019 – FCI data simulations, based on VIIRS data (11 June 2018, 11:37 UTC, 375m SDR L1b data),
focused on anticipated pixel resolution and its impacts ... promising expectations



simulated FCI HR sandwich, 0.5x1 / 1x2 km



simulated FCI NR sandwich, 1x2 / 2x4 km



real MSG RSS data, sandwich HRV & IR10.8

Four years later, first FCI L1C commissioning test data – what is the reality? How close are we from those expectations?

FCI Data source:

- **26/06/2023 20:00 UTC to 28/06/2023 10:00 UTC** (40 hours) – FCI L1C Commissioning Data for SAFs package, prepared by EUMETSAT to support SAF FCI L1C format testing and software development, and also kindly provided for this presentation
- **19/07/2023 11:40, 12:10 a 13:00 UTC** (severe storms over north Italy, Slovenia and Croatia)
- MTG-I1 satellite located at 3.4 W, FCI commissioning data processed by IDPF-I v5.1.A patch#4

Other data:

- SEVIRI HRIT data and imagery: EUMETSAT and CHMI archives
- VIIRS L1B data – NOAA CLASS archive

Data processing and visualization:

- PyTroll / Satpy, version 0.41.1 (FCI L1C commissioning data)
- IDL ENVI (VIIRS L1B data, and visualization of ENVI-formatted FCI and SEVIRI data)
- Adobe Photoshop – final image manipulation

Known data limitations (affecting to a certain degree some of the images shown in this presentation):

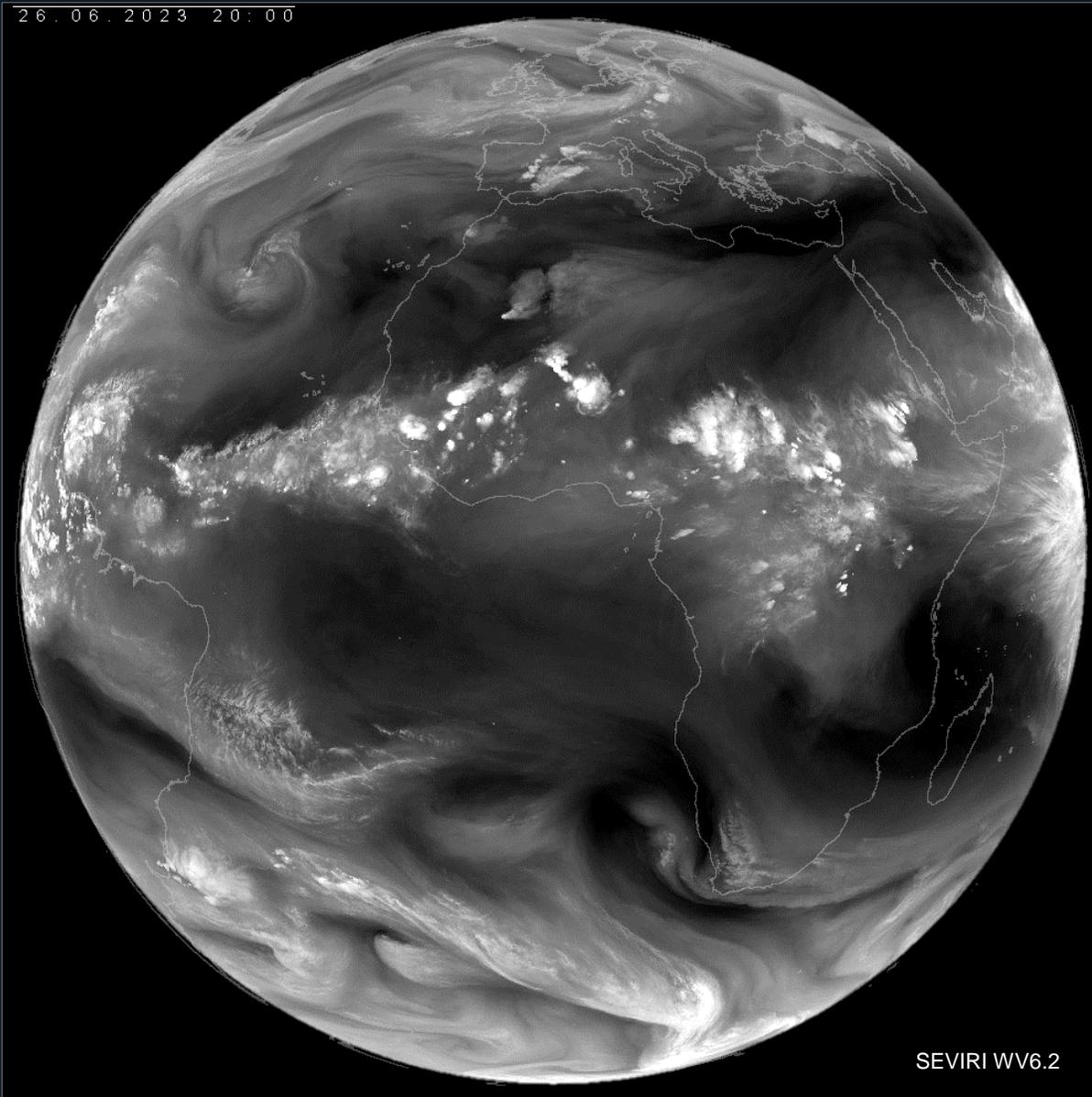
(source: MTGTD-488 FCI L1C Commissioning Data for SAFs - Package Description, DOC EUM/MTG/TEN/23/1369228)

- **Stripes in IR channels:** Stripes can be observed in IR channels (e.g. 3.8 and 13.3, but not only limited to them) due to gain and offset inhomogeneity along the detector array. The anomaly is under investigation and seems not to be related to any hardware failure.
- **Overall Radiometric Calibration:** Data are relying on the on-ground calibration and are pending the full in-orbit radiometric calibration. Not all the radiometric corrections have been enabled yet. Preliminary analysis showed the limitation of such dataset in terms of radiometric accuracy. Stripes in the infrared domain have been observed and are currently under investigation.

Other issues (personal communication):

- The NIR 1.3 is affected by the Earth straylight (ESL), resulting from the fact that the ESL correction algorithms are not active yet. Impacts stand-alone NIR 1.3 images and RGB Cloud Type.

SEVIRI preview of the entire period, covered by the FCI dataset (26 June 2023 20:00 UTC – 28 June 2023 10:00 UTC)



No larger or longer-lived storms at higher latitudes ...



... focus on storms at western Sahel region

- 20230628 01:50 UTC (FCI, SEVIRI, VIIRS) – night case
- 20230627 1400 UTC (FCI, SEVIRI, VIIRS) – daytime case

Advantage of this area selection: close vicinity to the MTG-I1 sub-satellite point, thus highest available pixel resolution and almost no geometric distortion. The MTG FCI and MSG SEVIRI images shown next are displayed in the original satellite projection, to avoid any possible re-mapping artifacts.

The two terms above have been selected as these are also well covered by overpasses of the VIIRS-equipped satellites (S-NPP, NOAA-20 and NOAA-21).

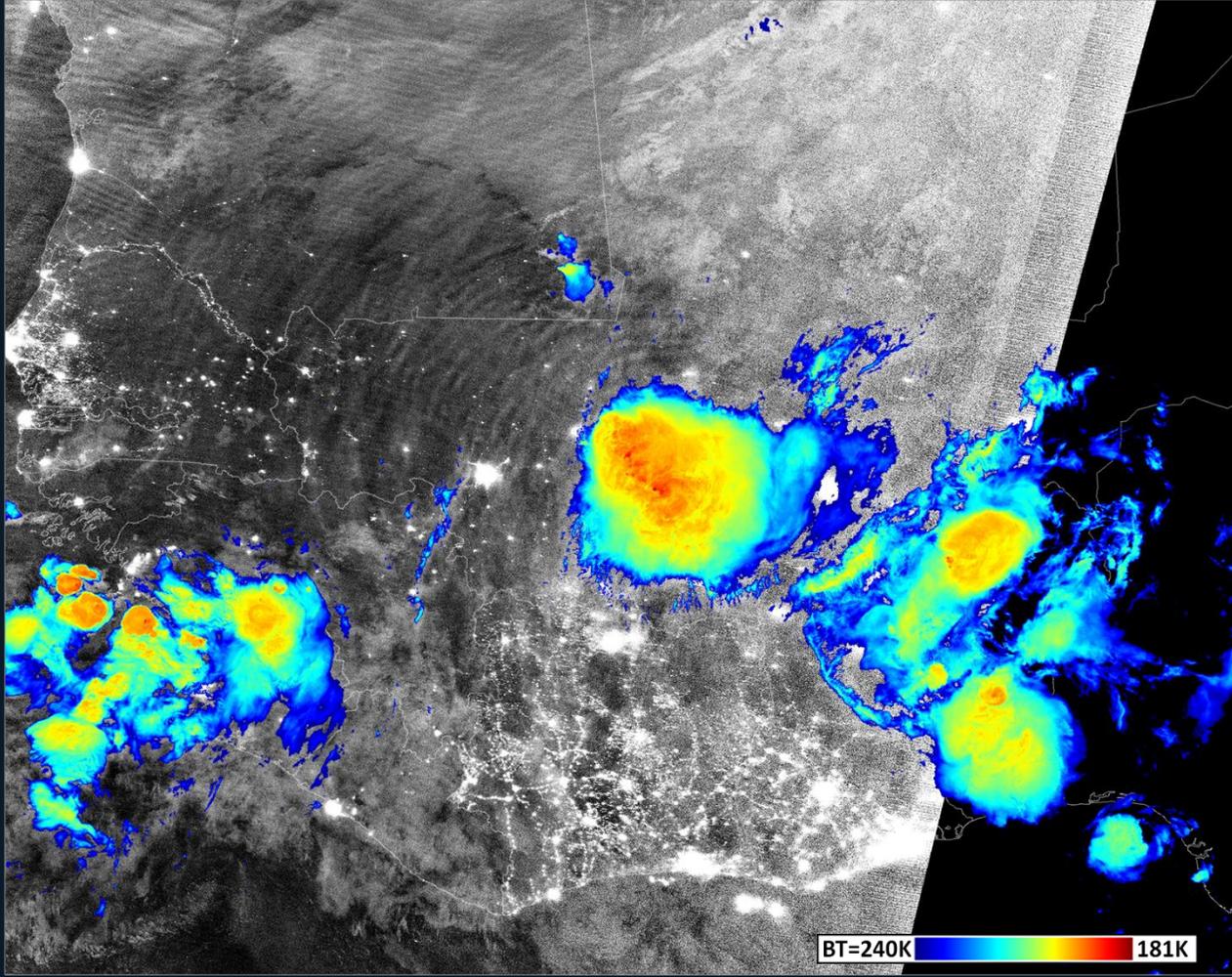
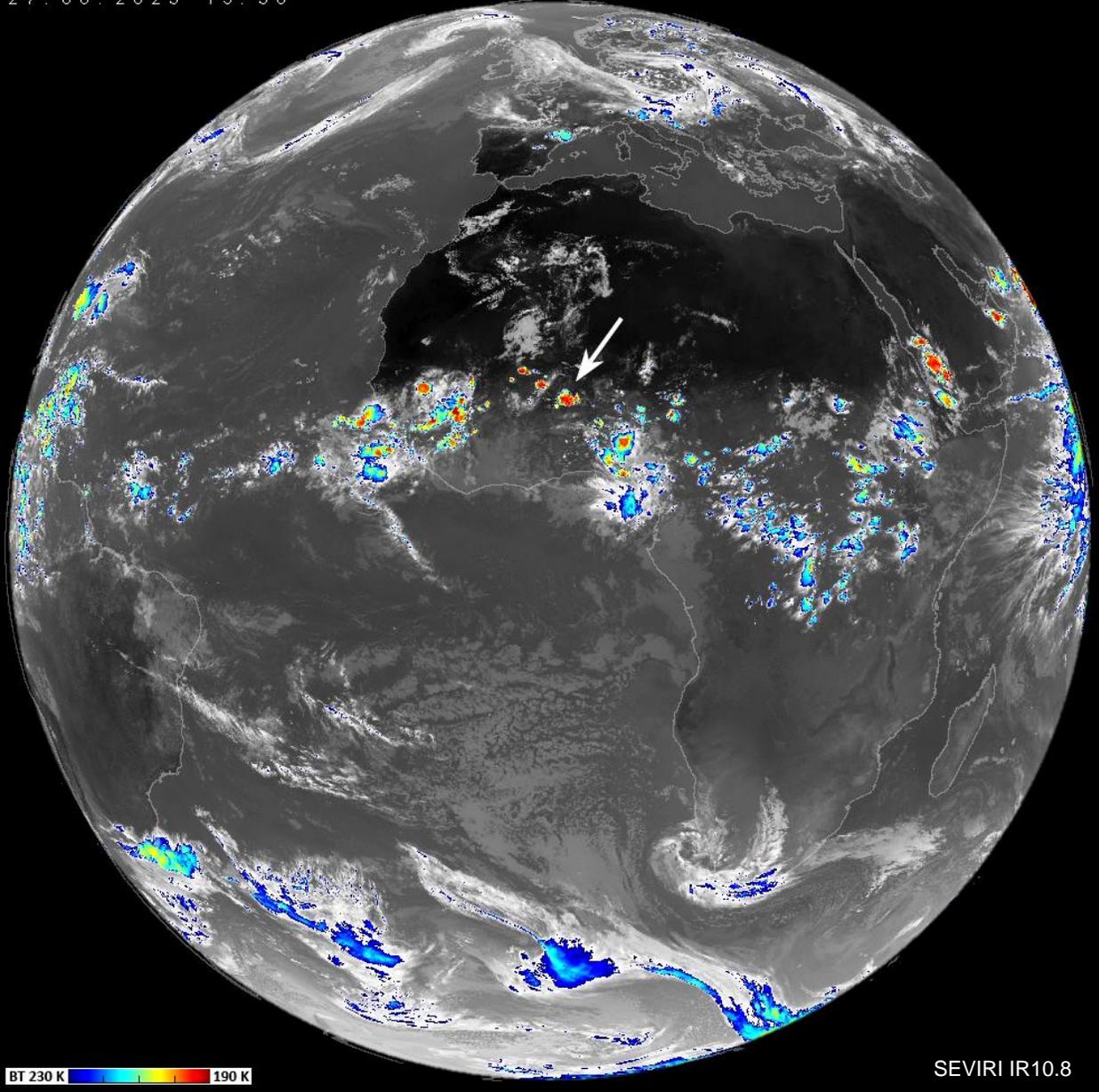
Case #1 – 2023/06/28, storms at night, above Mali and Burkina-Faso region

MTG-I1	... scan time ~ 01:56 UTC
Meteosat-10 (MSG3)	... scan time ~ 01:53 UTC
NOAA-20 (JPSS-1)	... scan time ~ 01:55 UTC

Note: the small scan time differences may reflect storm tops evolution, therefore some of the differences between the three satellites/instruments can account to this factor, and not only to the pixel resolution. Also, certain differences between spectral range of some of the bands of these three instruments result in differences between some of the images and RGB products. This comment is valid also to the other two cases.

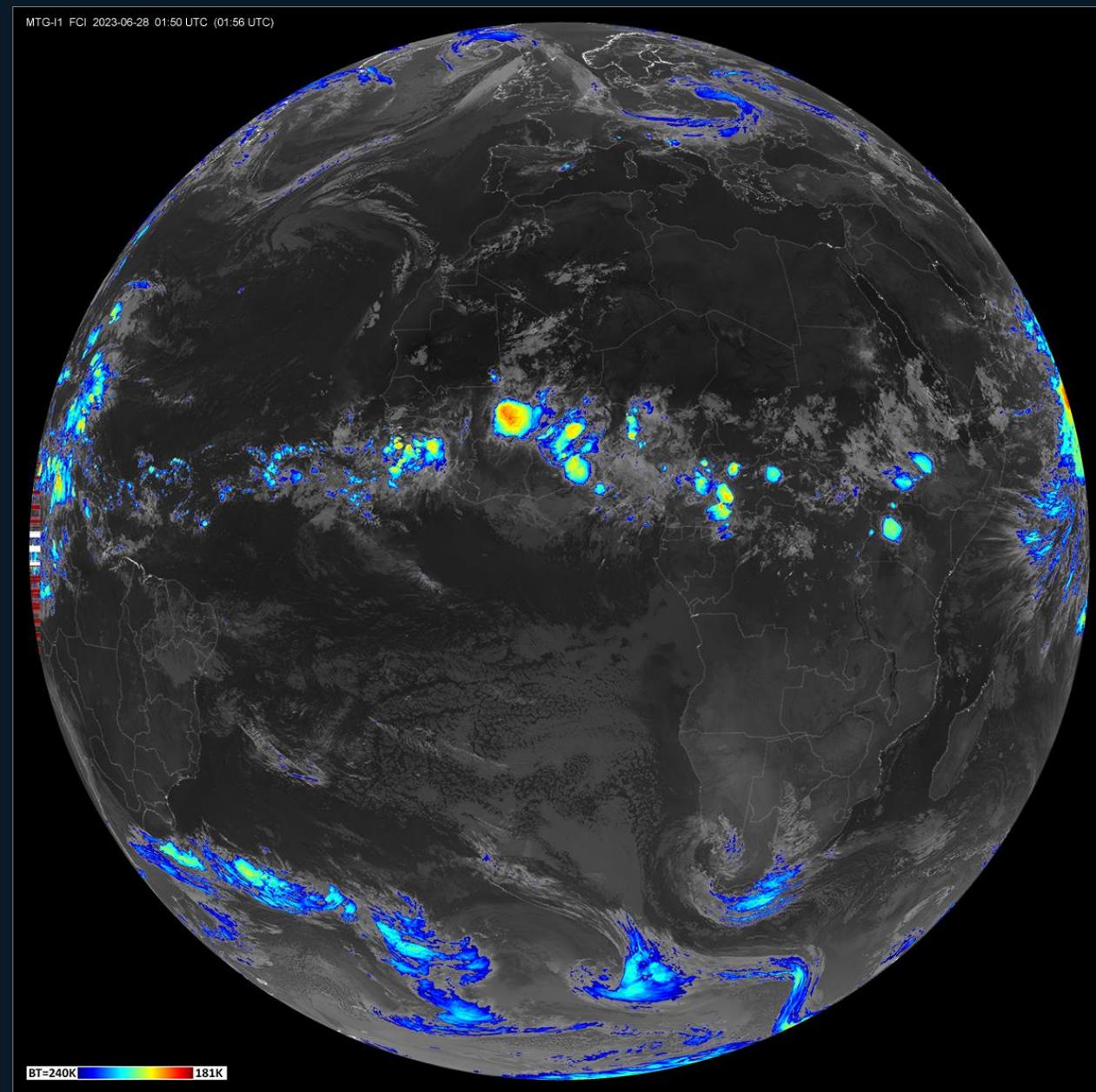
Evolution of storms above west Sahel region, shown in detail in next slides (27 June 2023 15:30 UTC – 28 June 2023 06:00 UTC)

27.06.2023 15:30

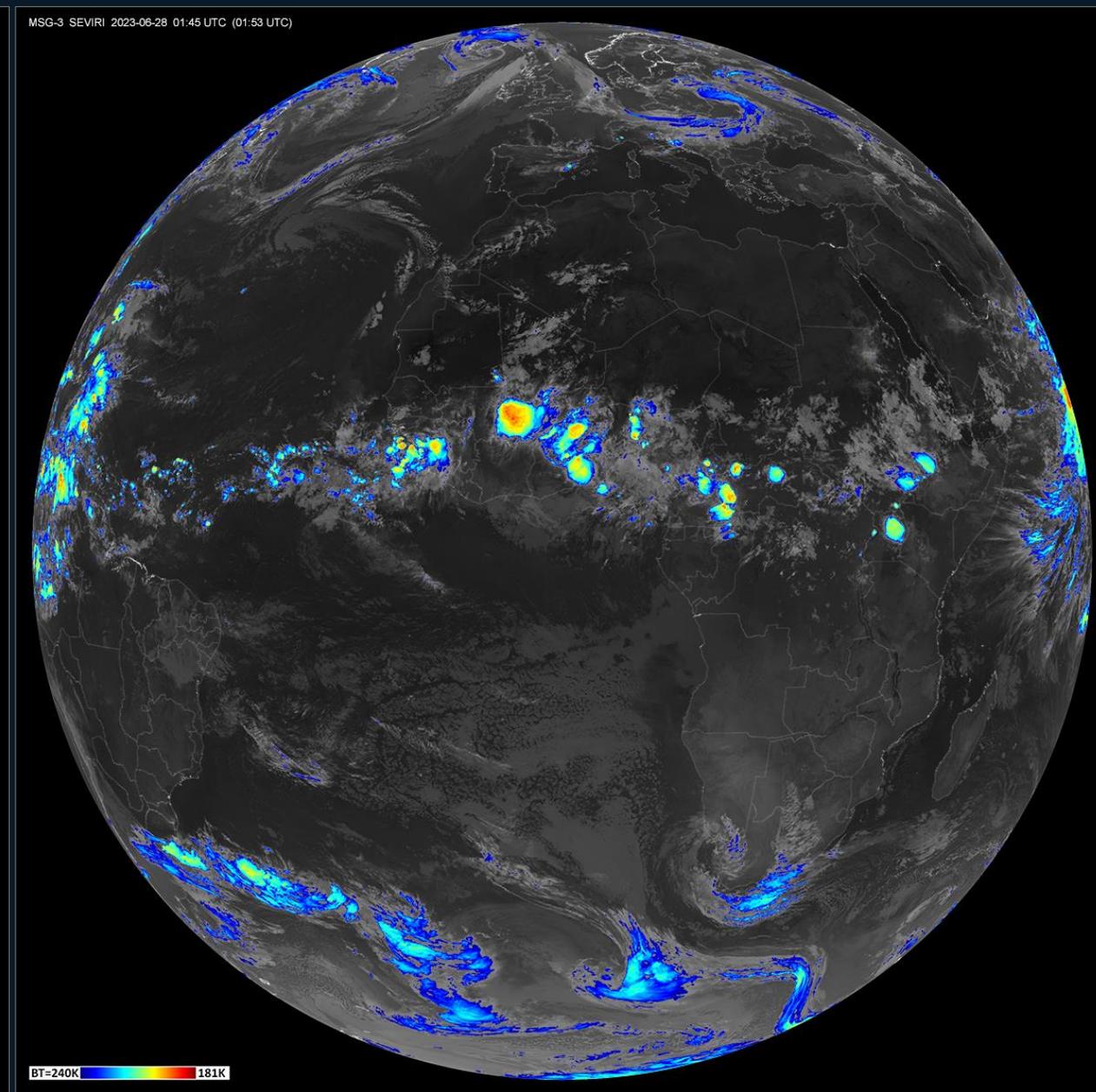


VIIRS M15 (10.76 μm) BT 181-240K blue-red enh., 01:55 UTC, NOAA-20
VIIRS Day/Night Band, 02:20 UTC, NOAA-21 (gravity waves in nightglow)

FCI band IR10.5 (HR) 180-310K (in grey scale) and 181-240K blue-red scale

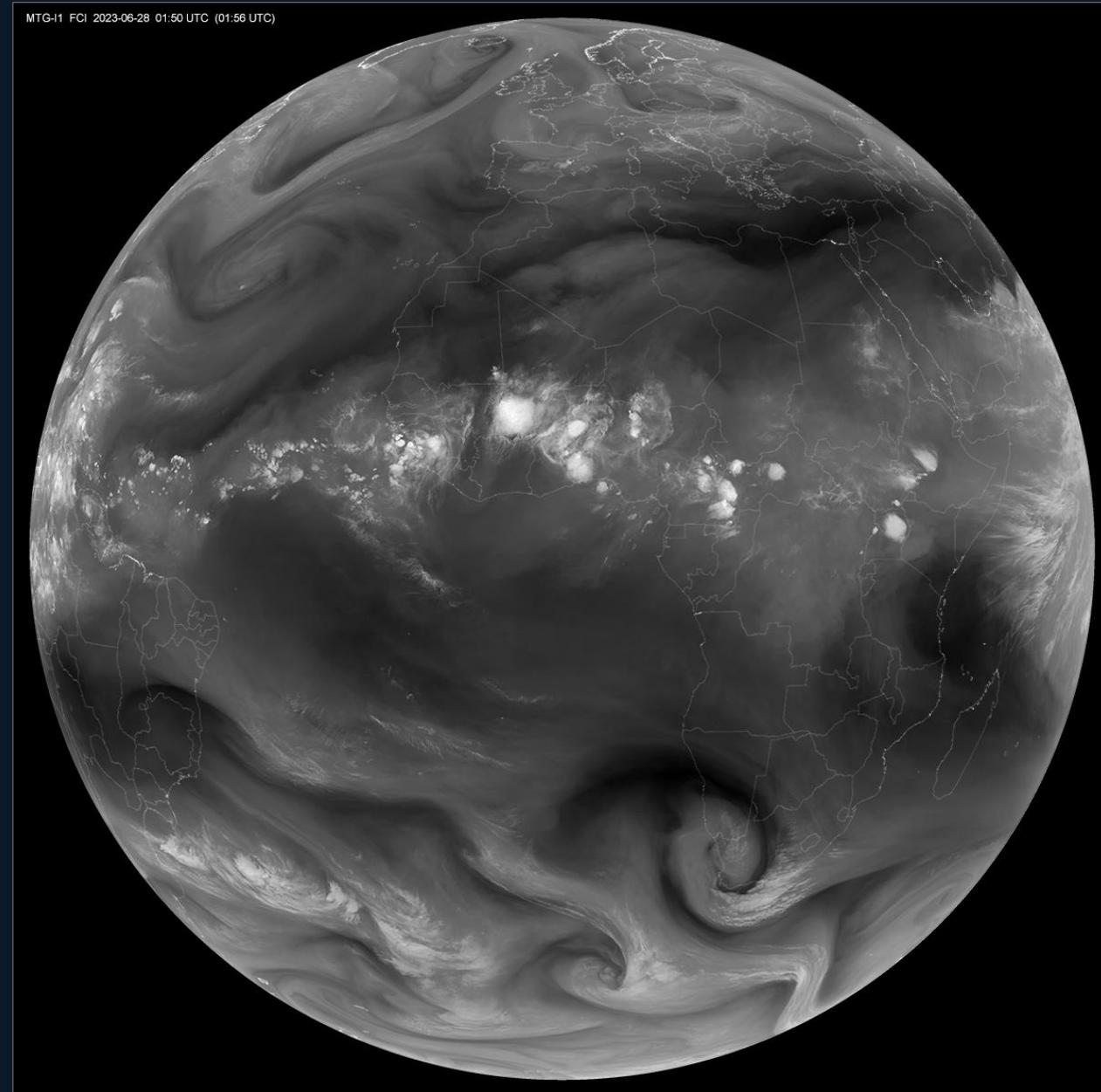


SEVIRI band IR10.8 180-310K (in grey scale) and 181-240K blue-red scale

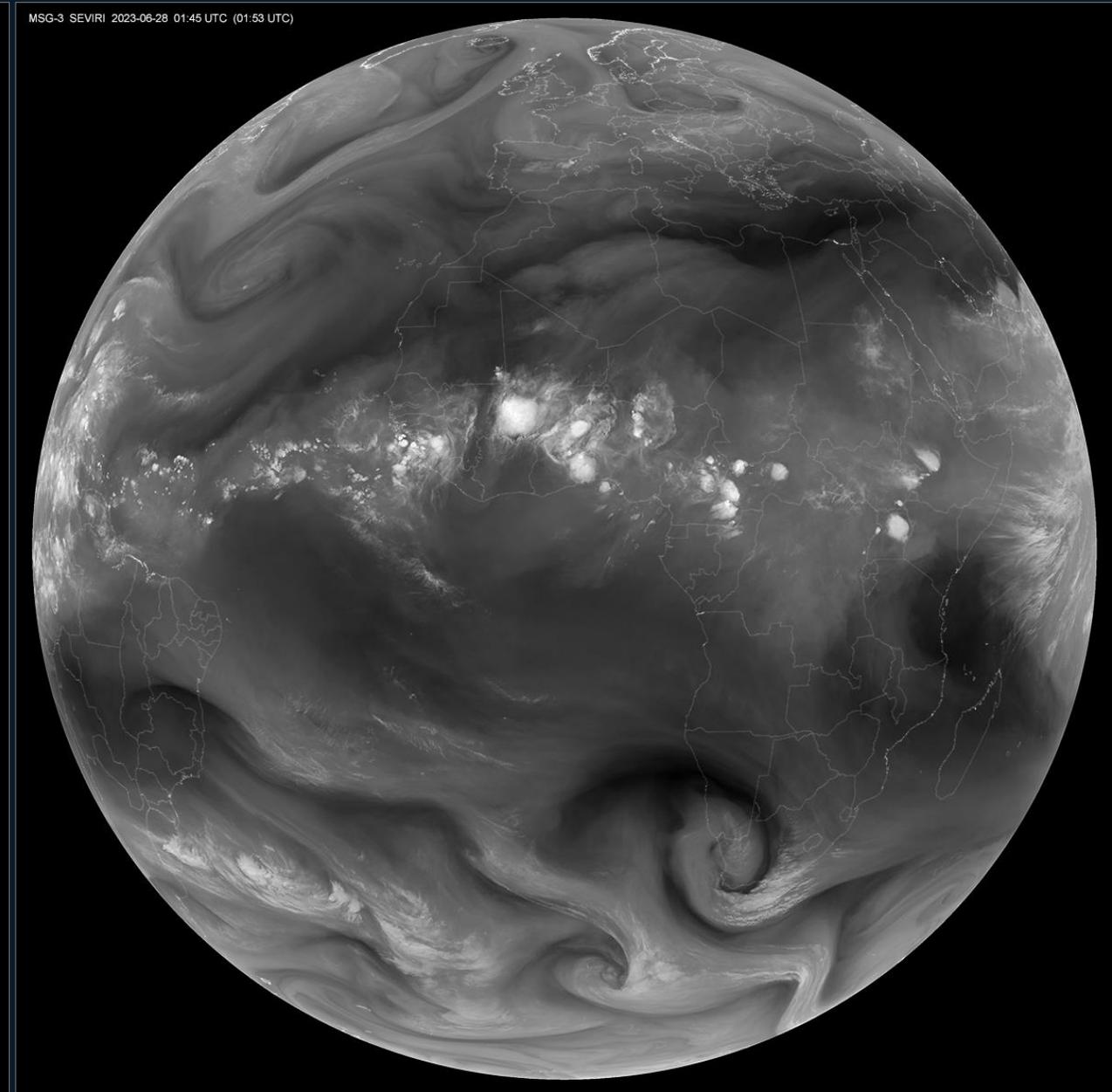


On this global scale, no differences due to pixel resolution can be seen (as expected).

FCI band WV6.3 195-260K



SEVIRI band WV6.2 195-260K



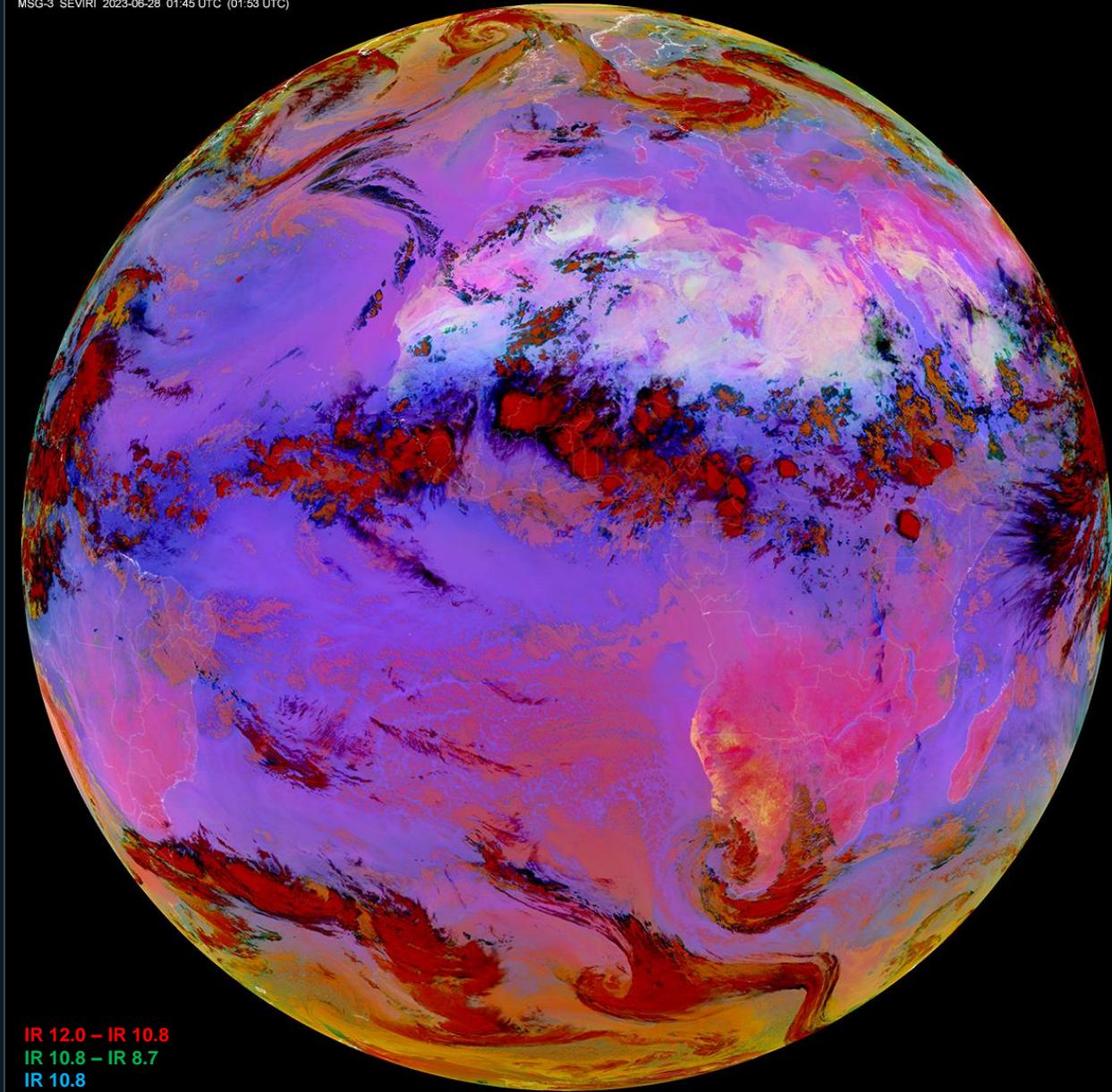
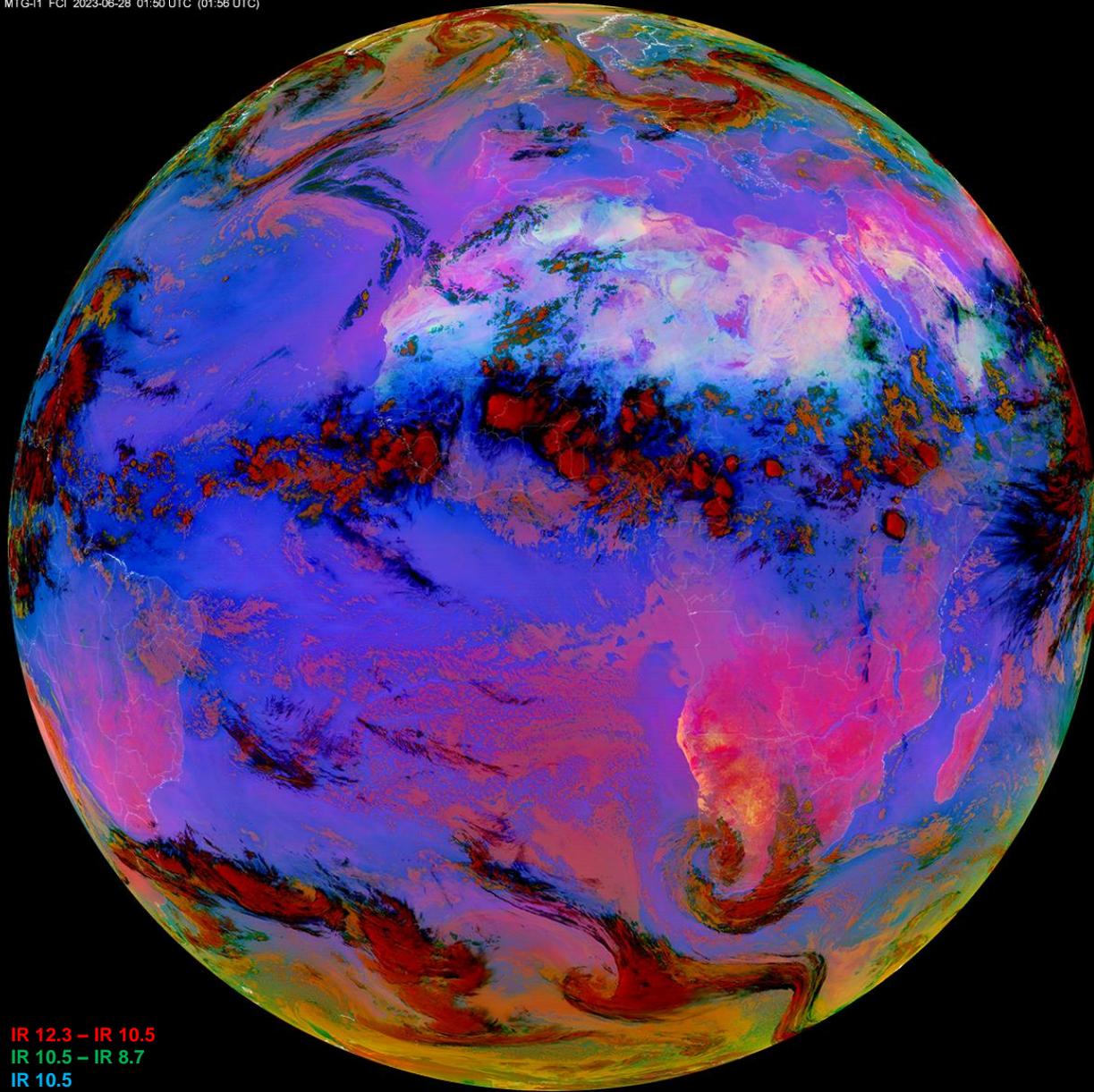
On this global scale, no distinct differences between these.

FCI Dust RGB

SEVIRI Dust RGB

MTG-I1 FCI 2023-06-28 01:50 UTC (01:56 UTC)

MSG-3 SEVIRI 2023-06-28 01:45 UTC (01:53 UTC)



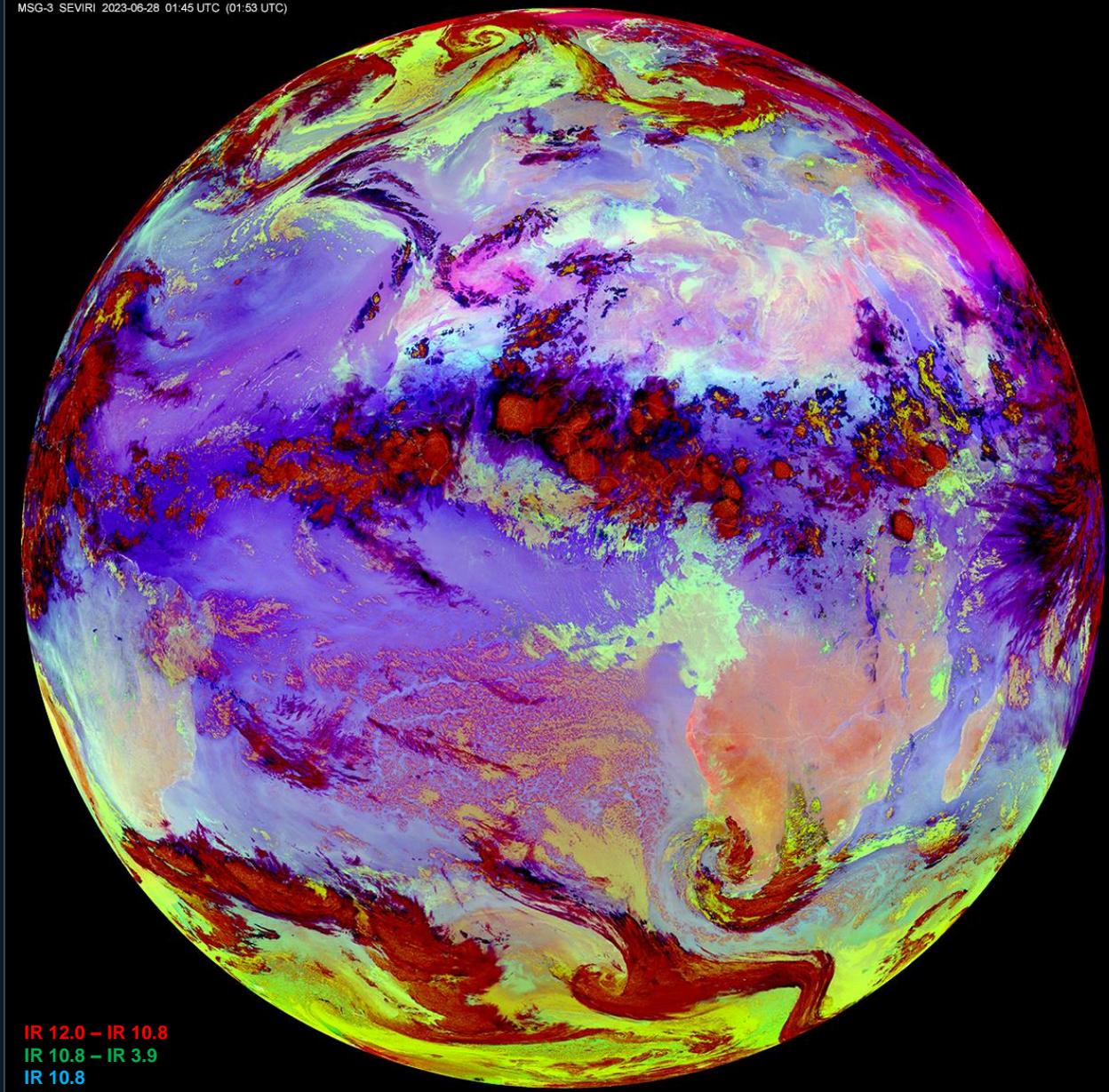
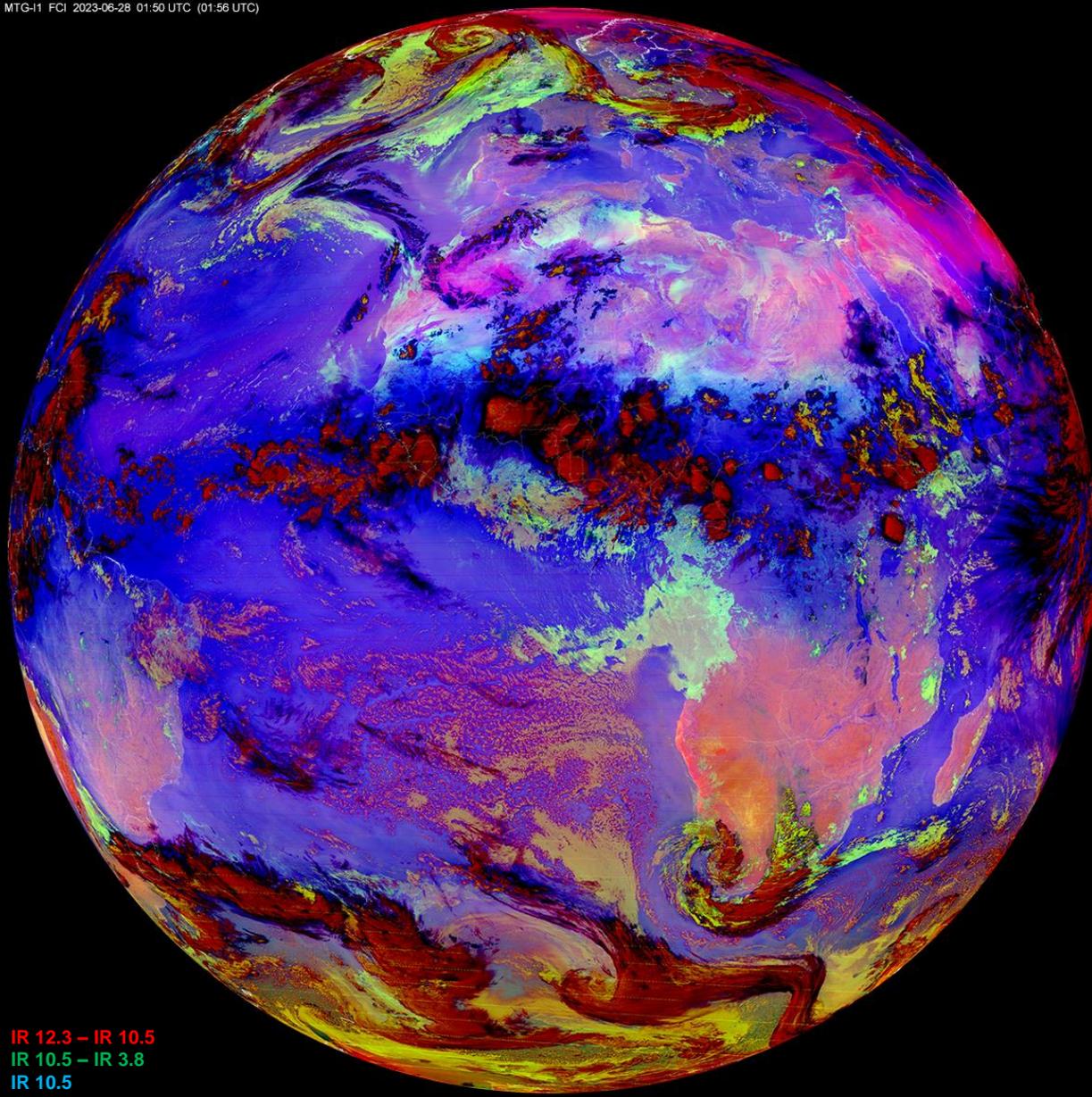
Same settings of these, FCI slightly different colors (higher contrast), most likely due to certain differences in spectral range of the used bands.

FCI Night-M RGB

SEVIRI Night-M RGB

MTG-I1 FCI 2023-06-28 01:50 UTC (01:56 UTC)

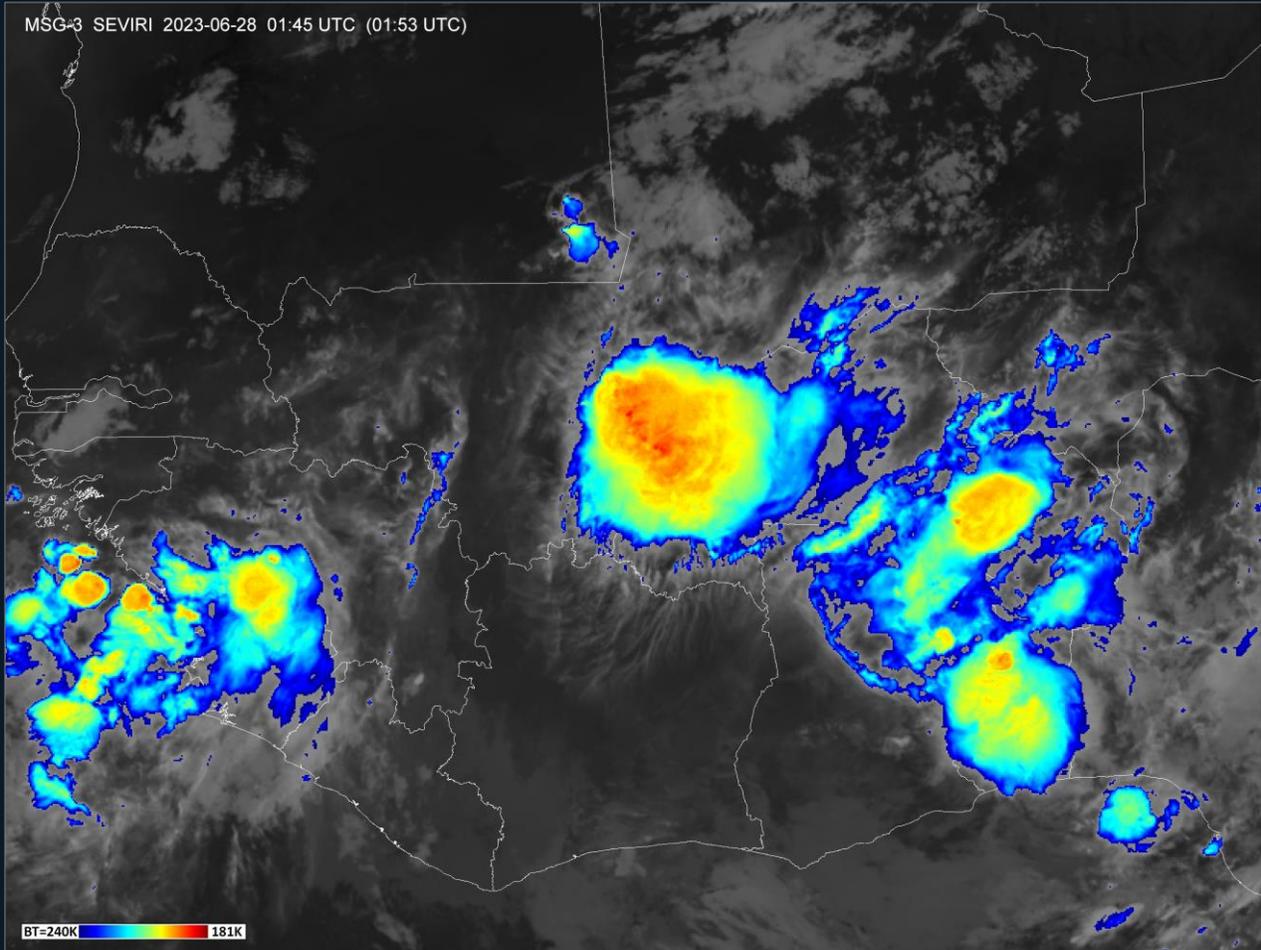
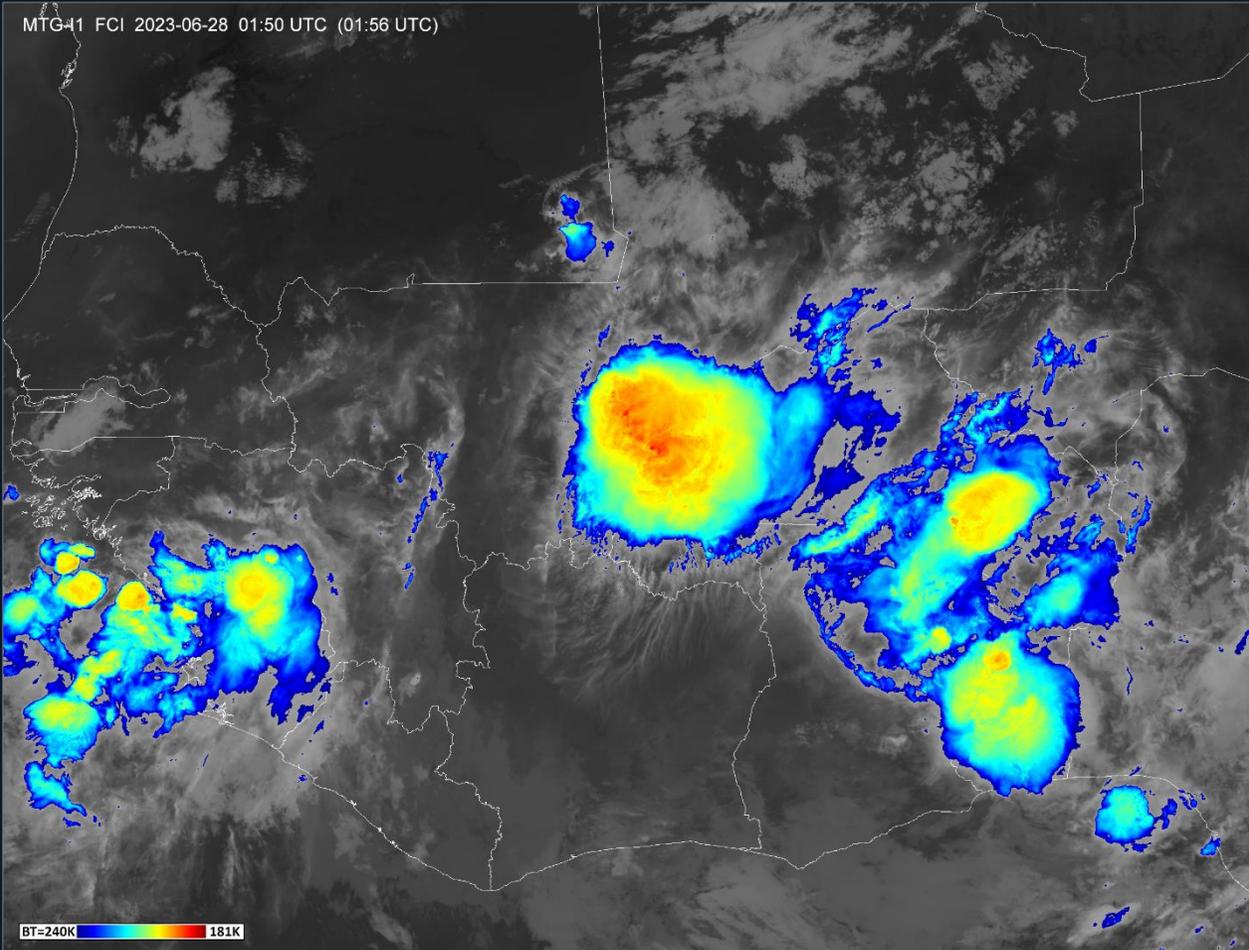
MSG-3 SEVIRI 2023-06-28 01:45 UTC (01:53 UTC)



Differences between these namely due to different spectral range of the IR 3.8 and 3.9 μm bands.

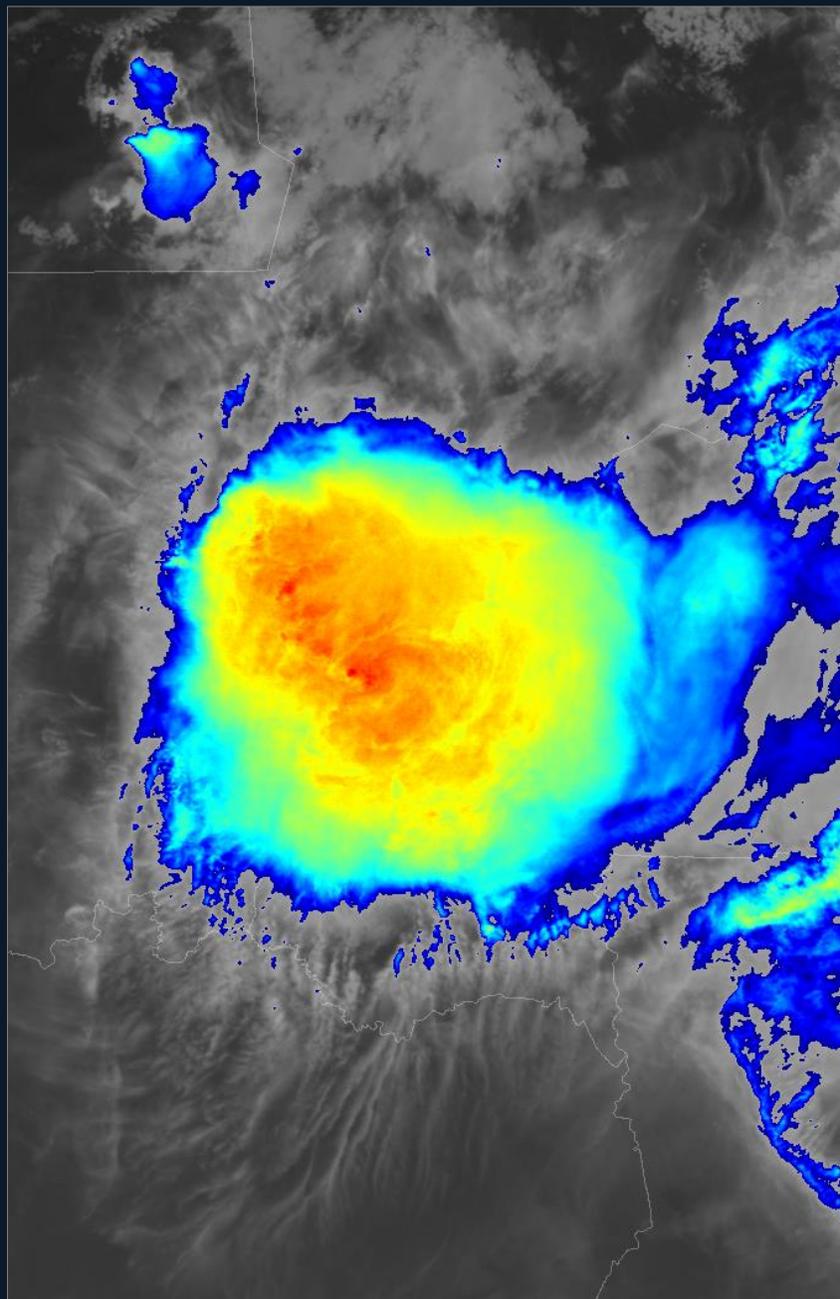
FCI band IR10.5 (HR) 180-310K (in grey scale) and 181-240K blue-red scale

SEVIRI band IR10.8 180-310K (in grey scale) and 181-240K blue-red scale

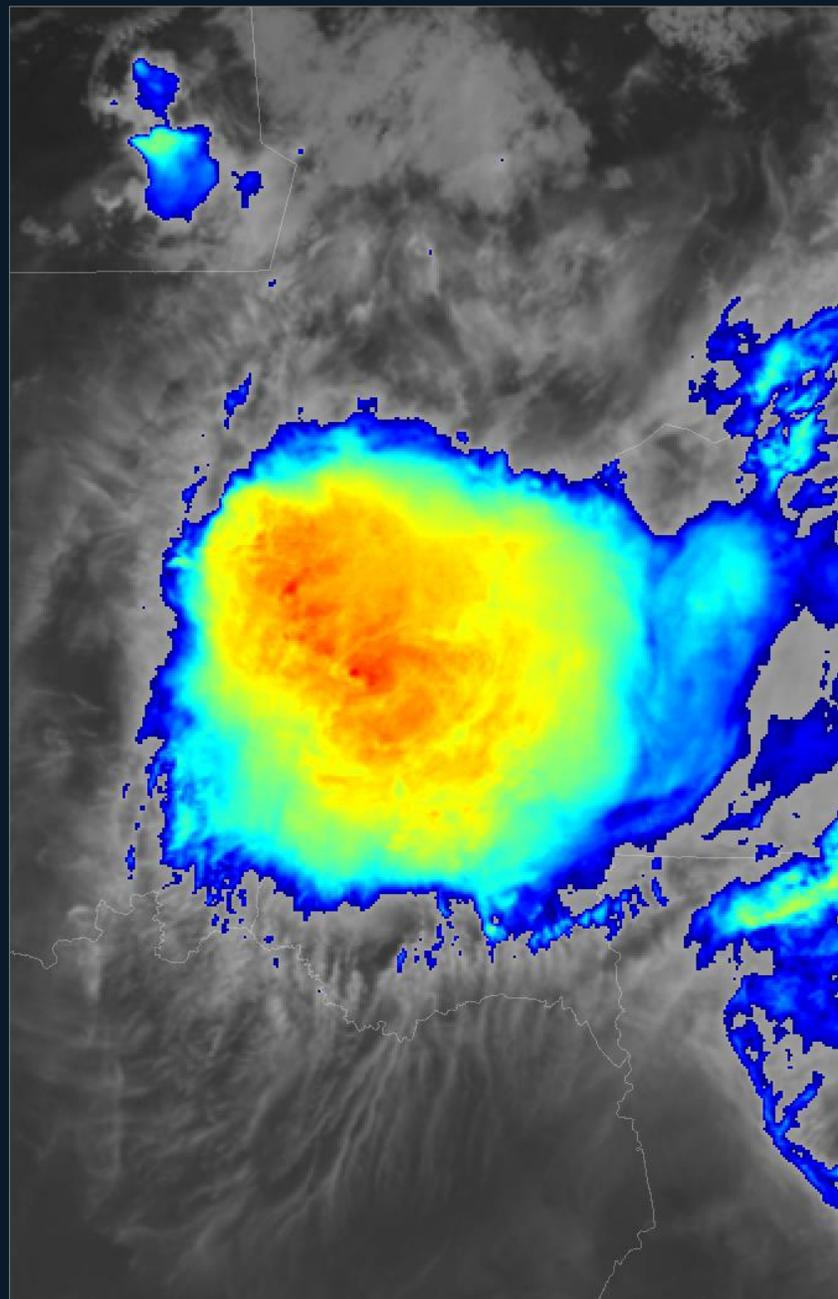


In this "regional scale" images, the SEVIRI image appears slightly more blurred as compared to the FCI one. This difference can be seen much better in detailed view (next slides) ...

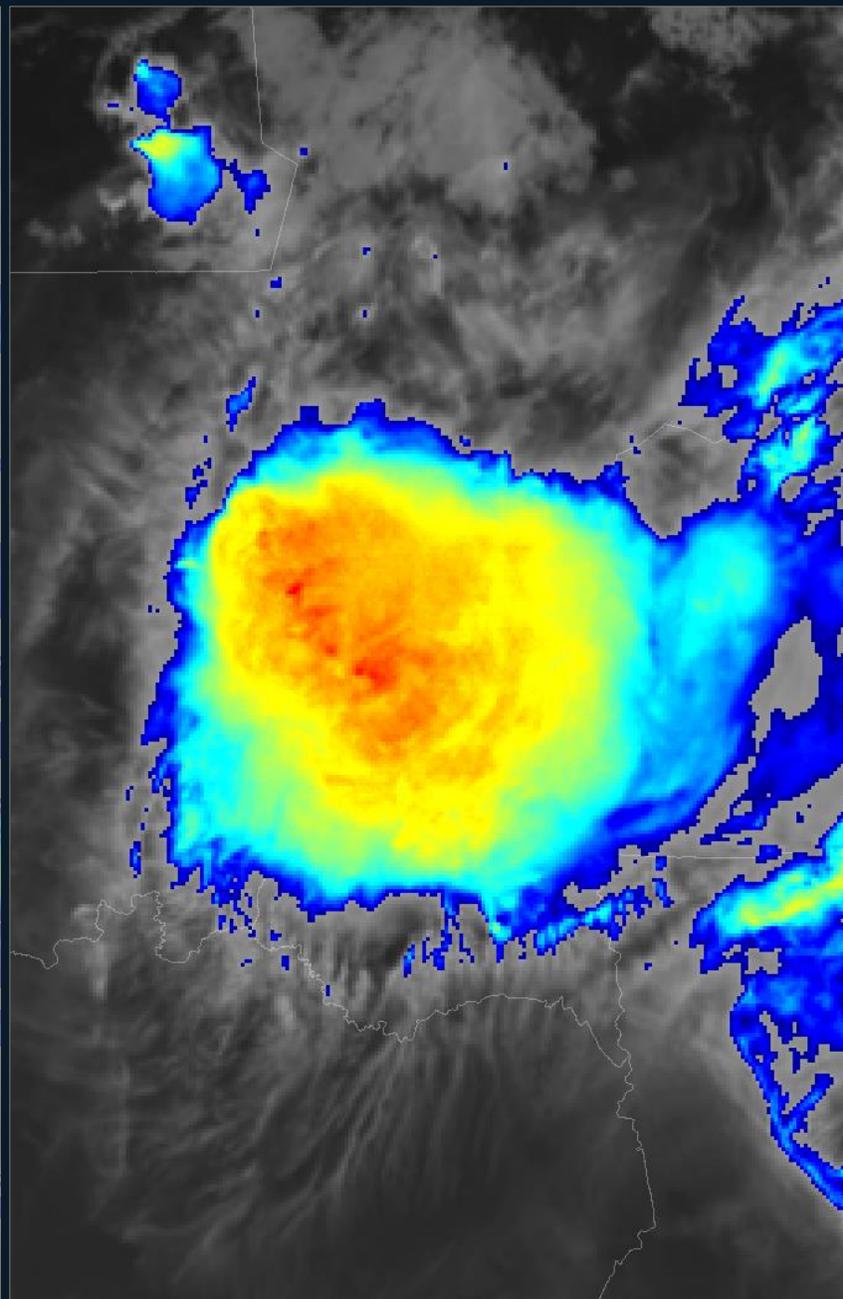
FCI IR10.5 (HR – 1 km)



FCI IR10.5 (NR – 2 km)



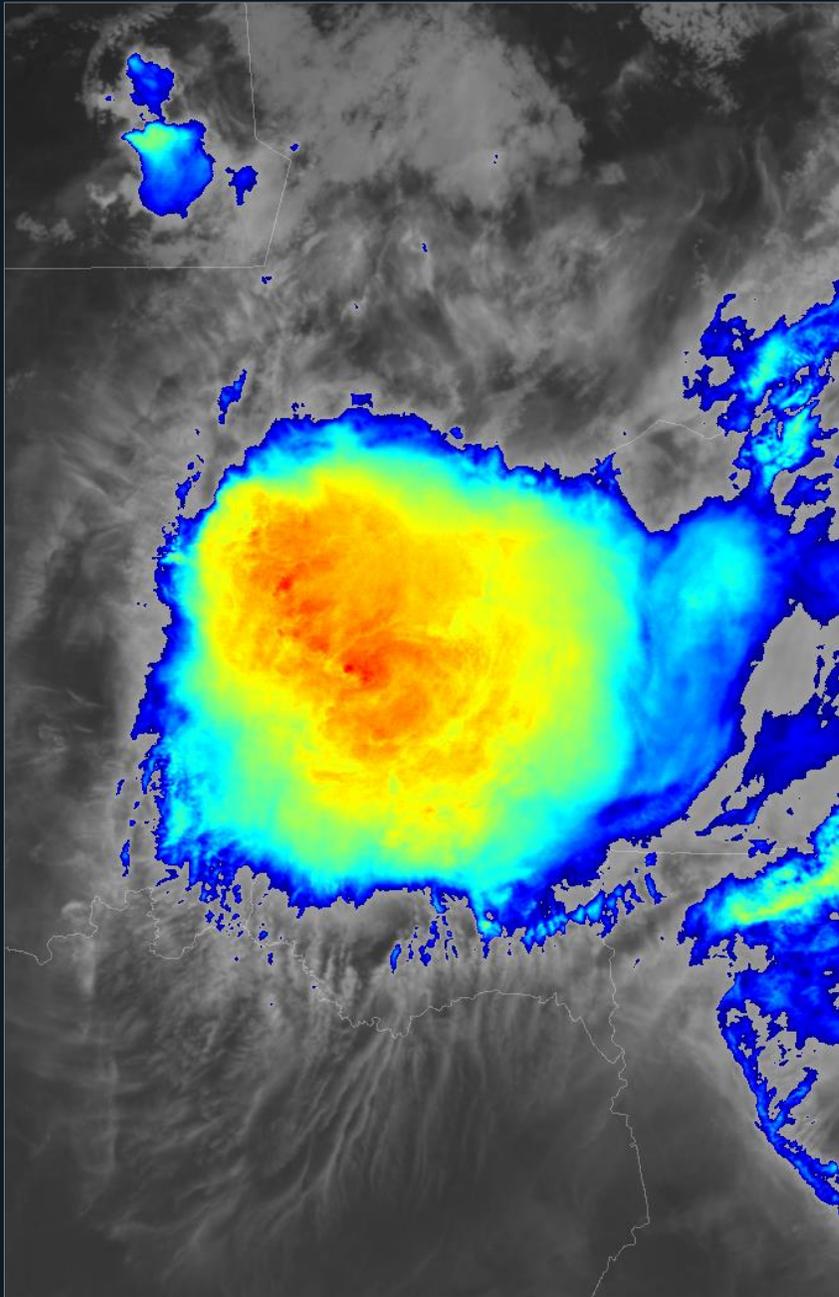
SEVIRI IR10.8 (3 km)



All three images: same black and white (180-310K) and blue-red color scale (181-240K) enhancements

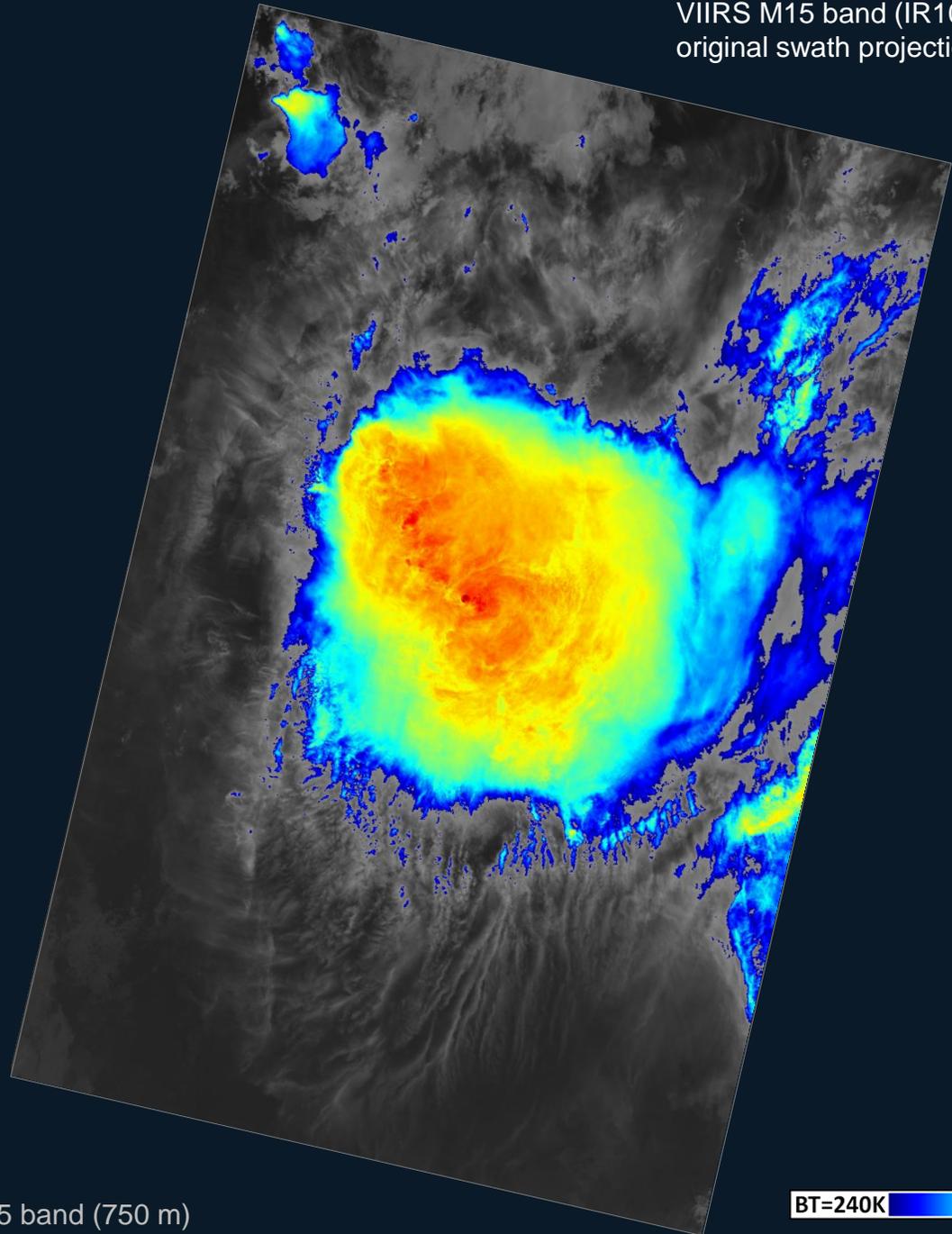


FCI IR10.5 (HR – 1 km)



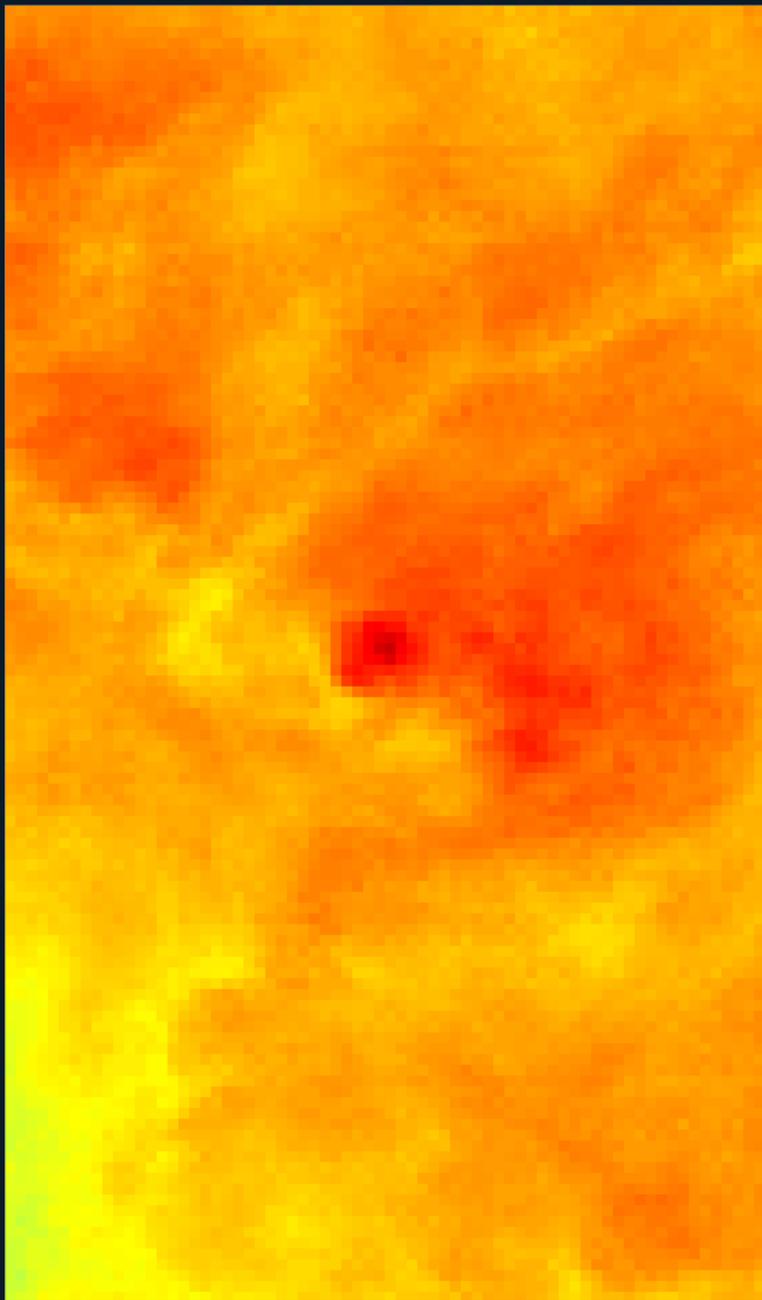
FCI IR10.5 HR (1 km) resolution already very close to VIIRS M15 band (750 m)

VIIRS M15 band (IR10.76), 750 m original swath projection (no resampling)

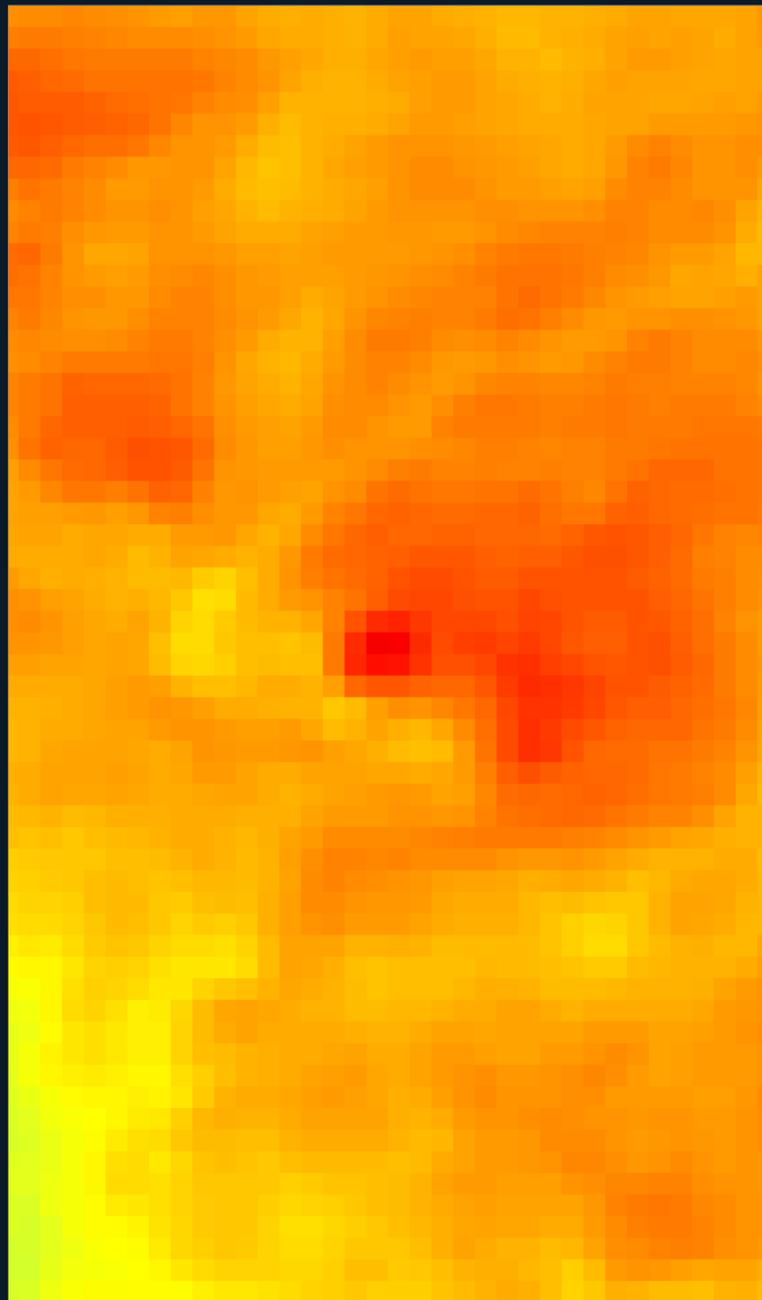


BT=240K  181K

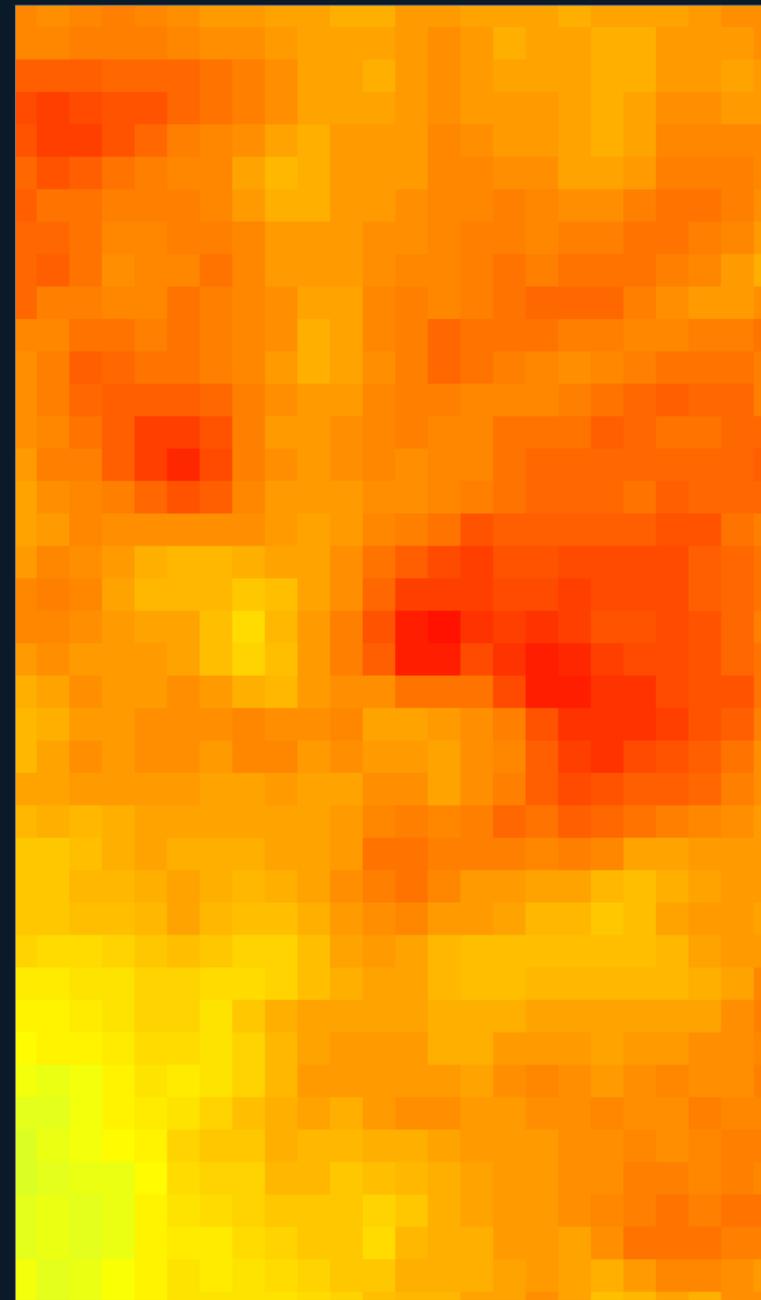
FCI IR10.5 HR – 1 km, BT(min) = 185.3 K



FCI IR10.5 NR – 2 km, BT(min) = 187.5 K



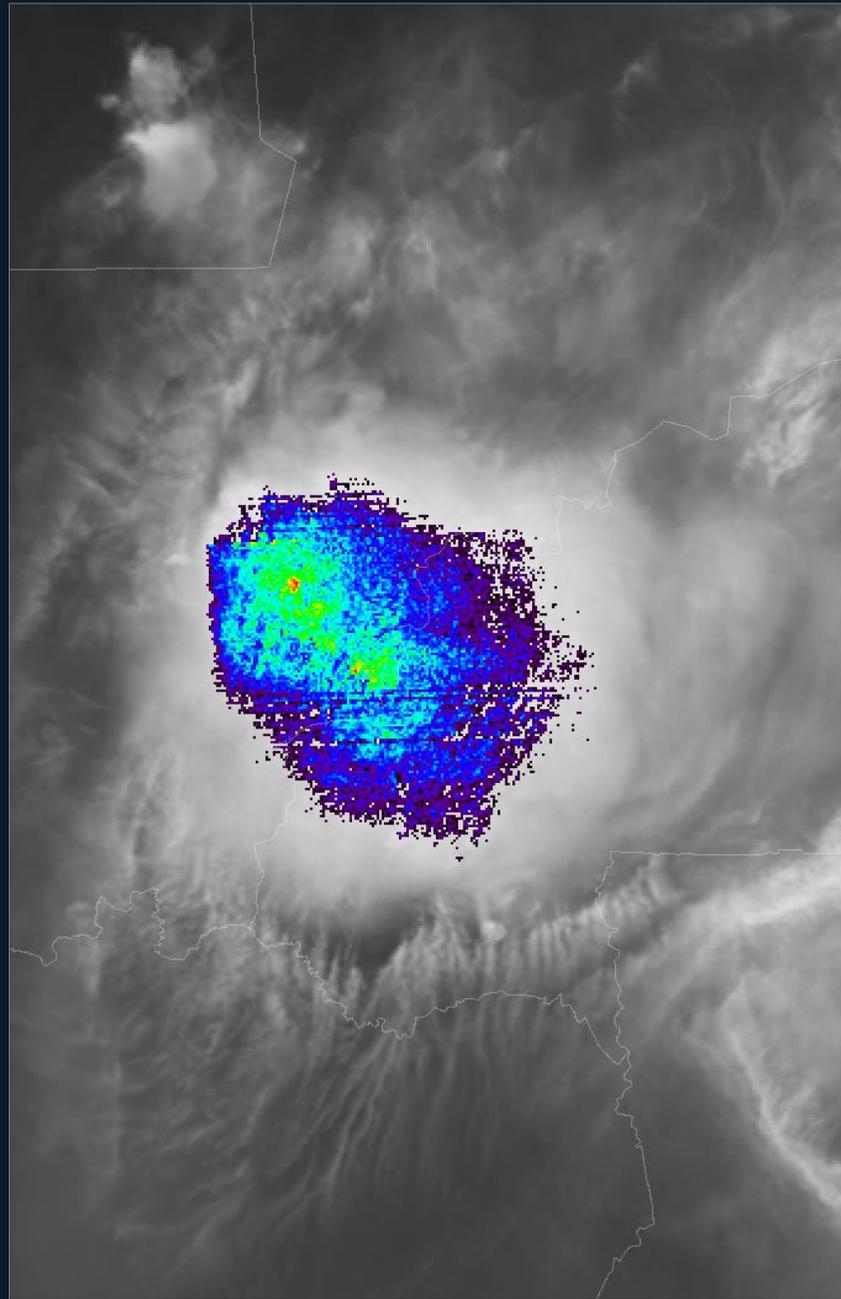
SEVIRI IR10.8 – 3 km, BT(min) = 189.1 K



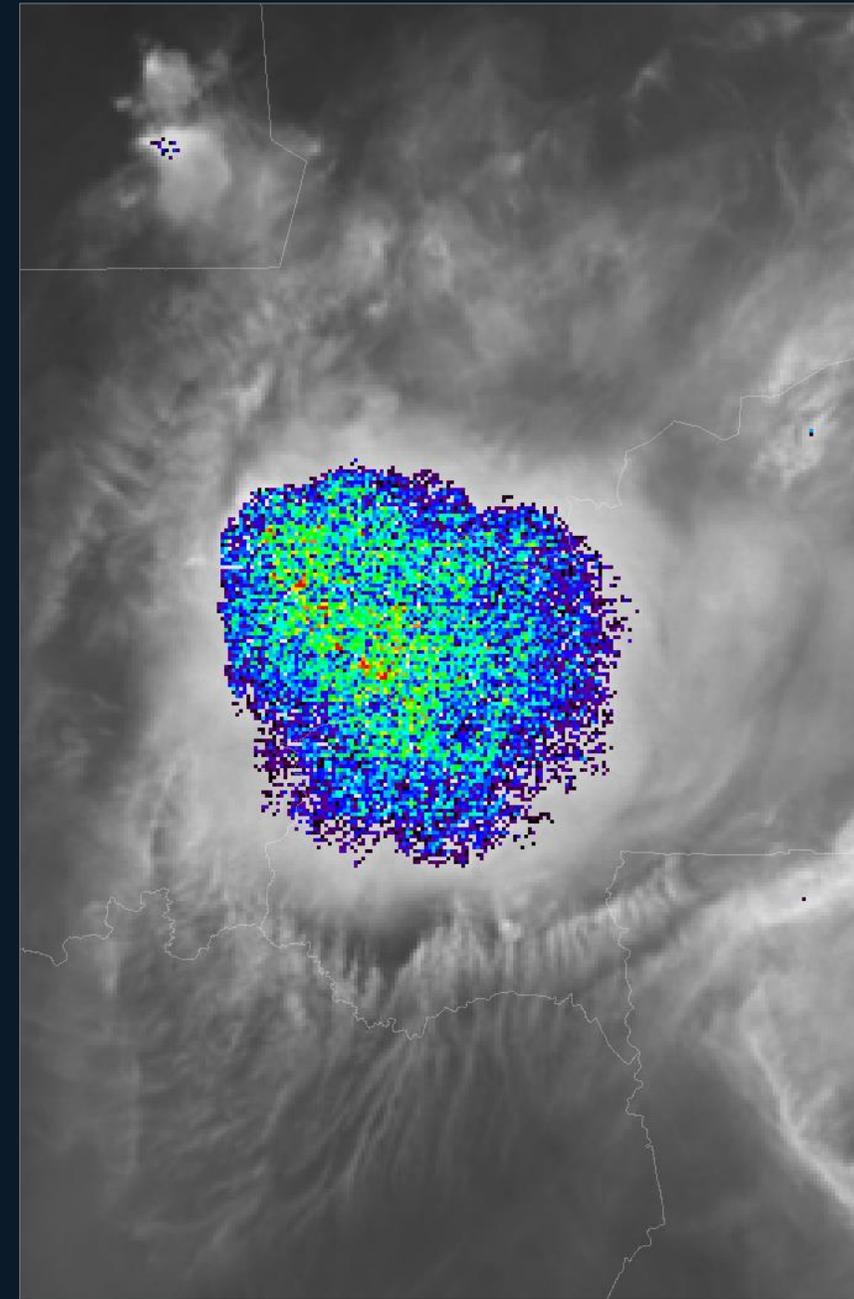
Pixel peeping level – all the same blue-red (181-240K) enhancement.



FCI BTD WV6.3 – IR10.5 (NR, 2 km)



SEVIRI BTD WV6.2 – IR10.8 (3 km)



BTD = 0  3.4K

Positive BTD (Brightness Temperature Difference) of water vapor and IR window bands interpreted (among other) as indication of warmer moisture above storm tops.

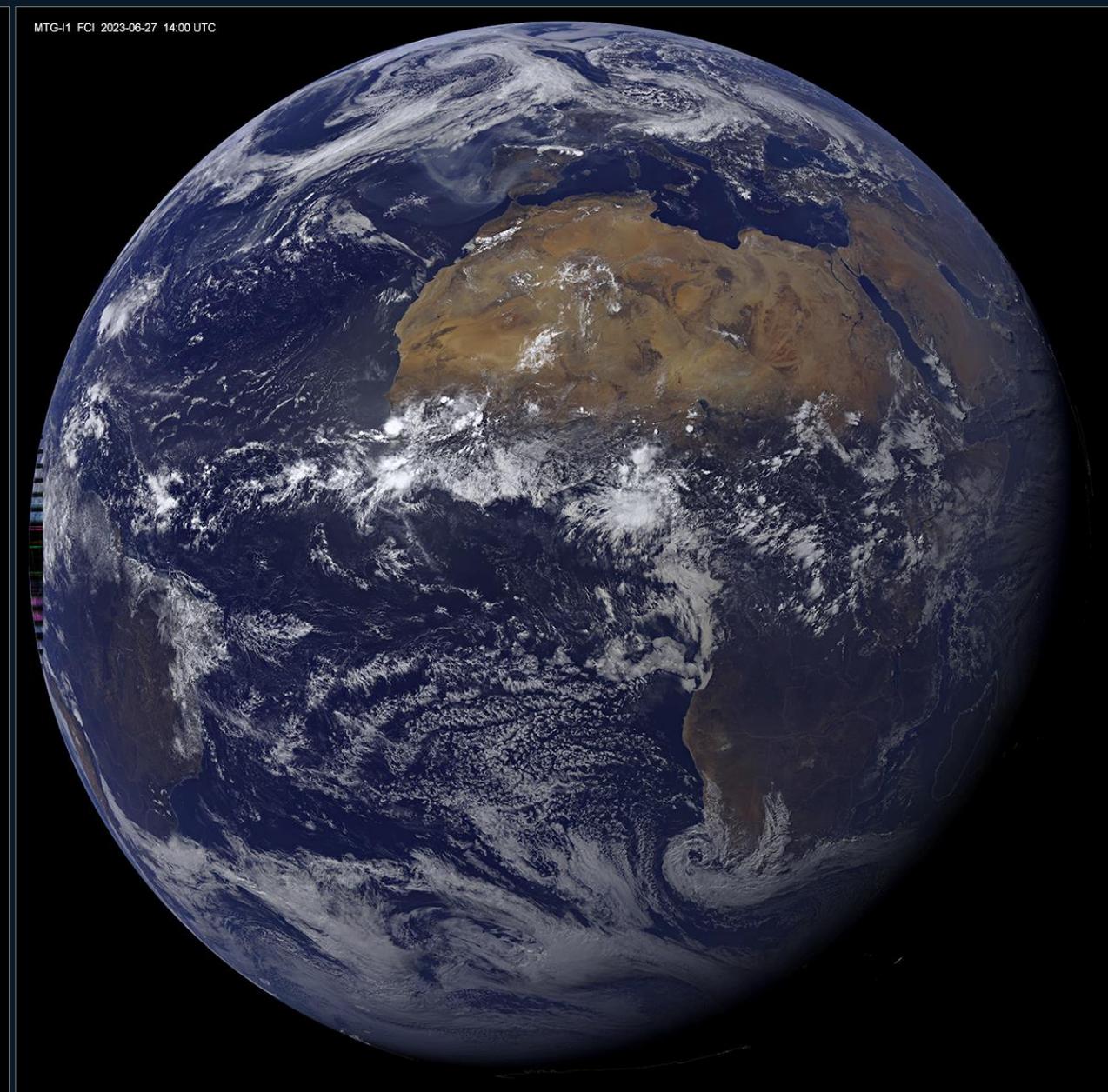
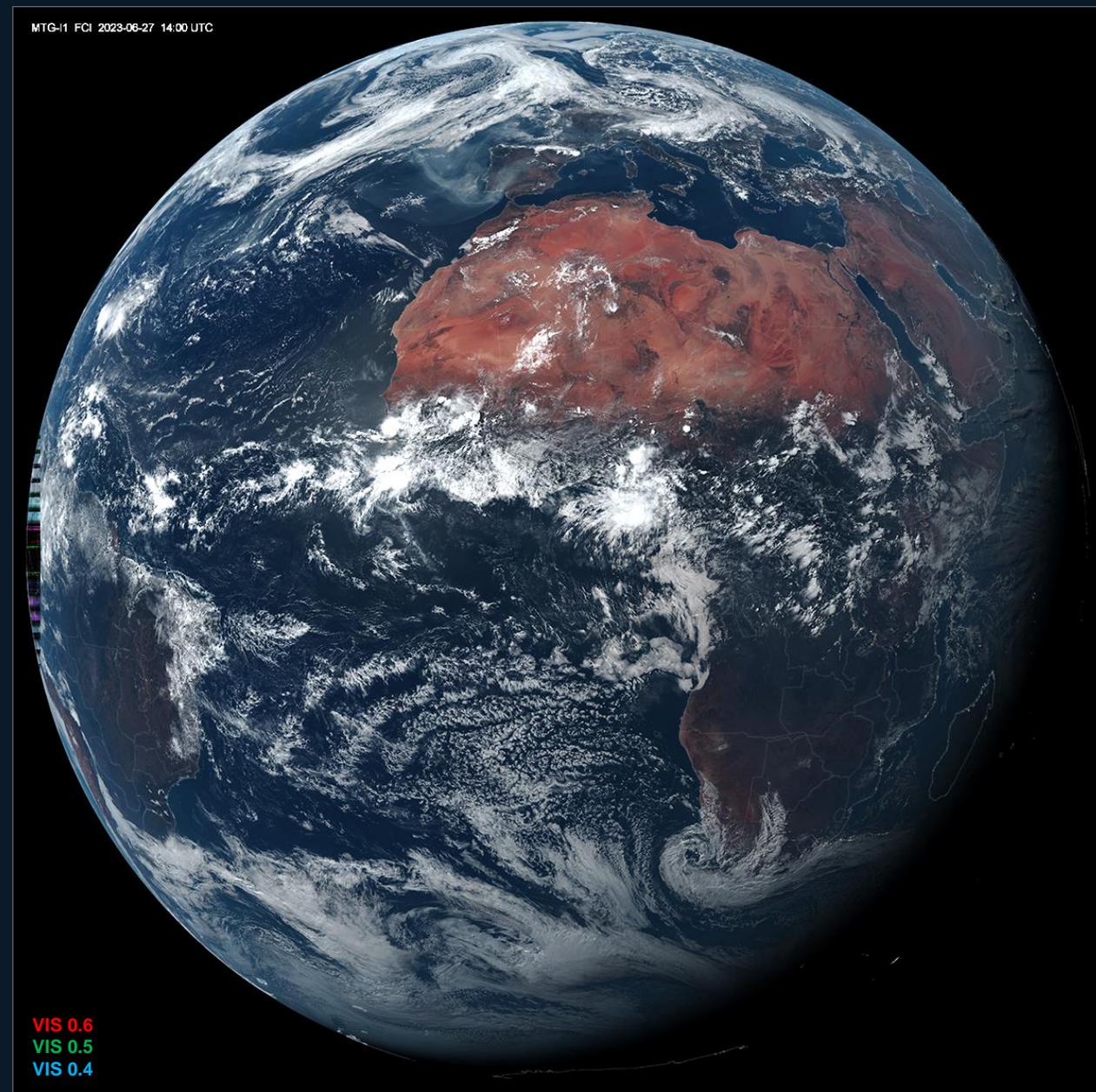
Case #2 – 2023/06/27, daytime storms above westernmost parts of Sahel

MTG-I1	... scan time ~ 14:06 UTC
Meteosat-10 (MSG3)	... scan time ~ 14:08 UTC
Suomi-NPP	... scan time ~ 14:12 UTC

Note: the small scan time differences may reflect storm tops evolution, therefore some of the differences between the three satellites/instruments can account to this factor, and not only to the pixel resolution. Also, certain differences between spectral range of some of the bands of these three instruments result in small differences between some of the images and RGB products.

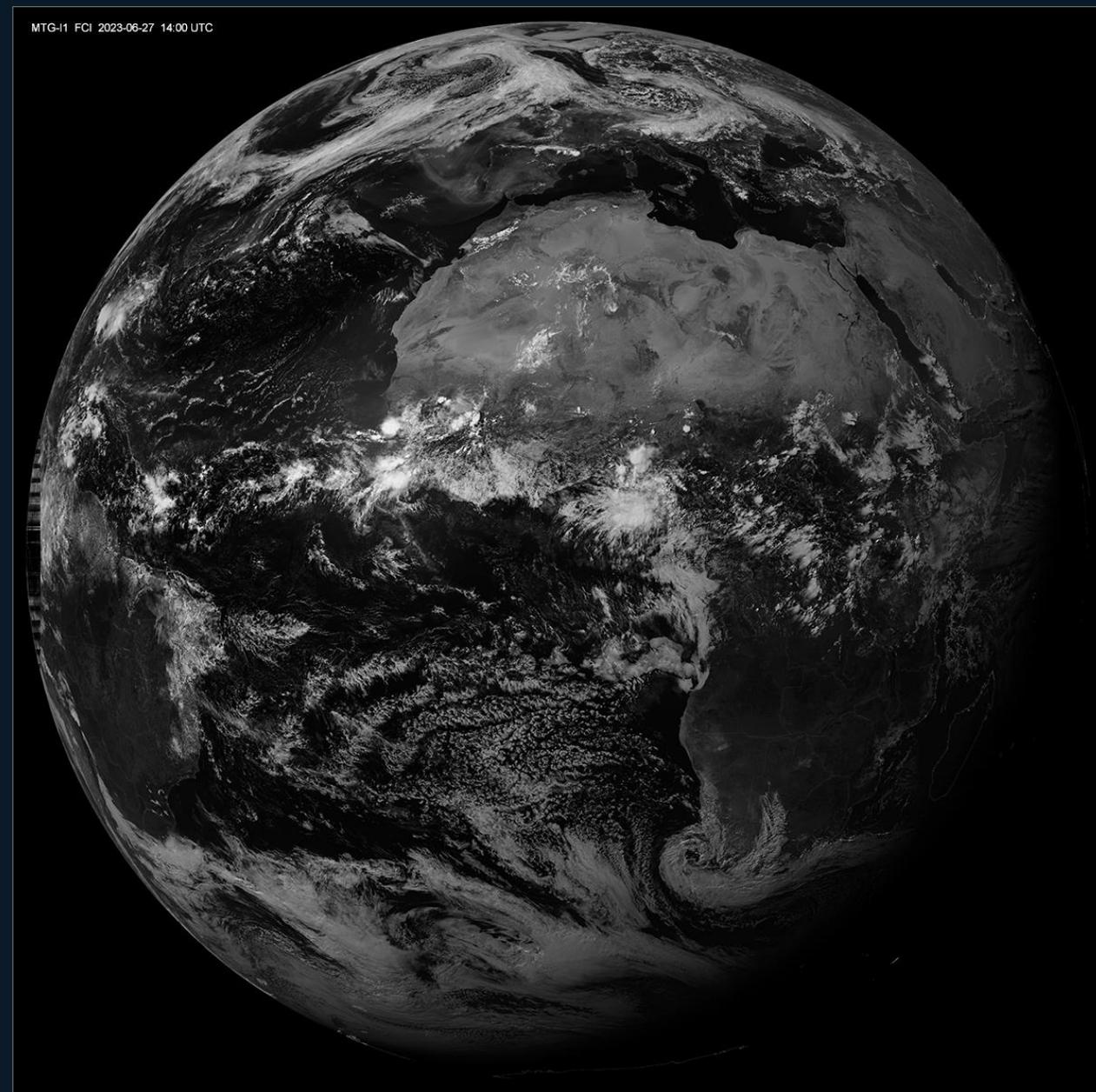
FCI True Color RGB (FCI bands VIS0.6, VIS0.5, VIS0.4)

... and the same image after additional hue and levels adjustment in Photoshop

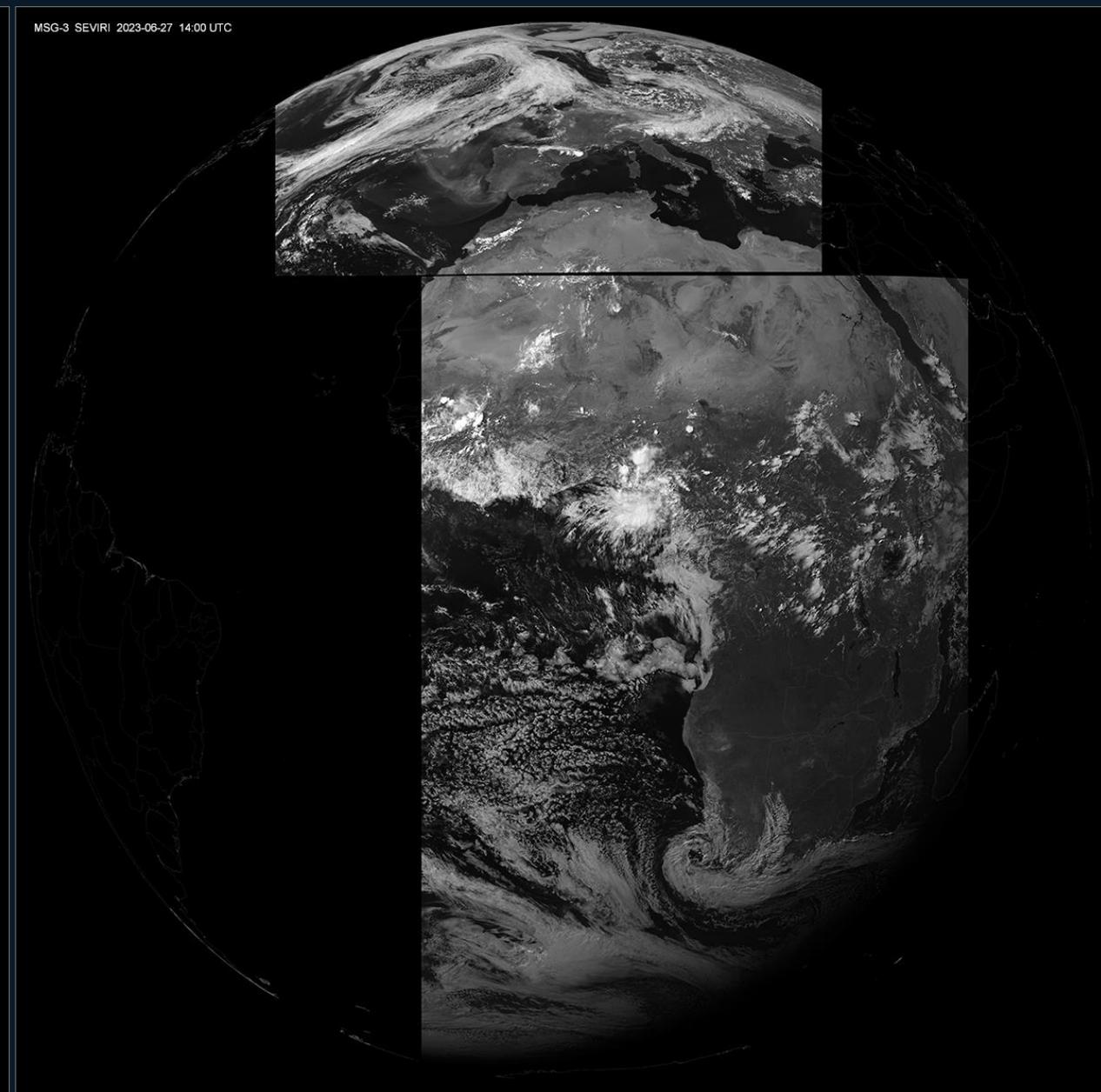


Rayleigh scattering and green band corrections NOT applied here yet.

FCI band VIS0.6 – 0.5 km pixel size



SEVIRI band HRV – 1 km pixel size



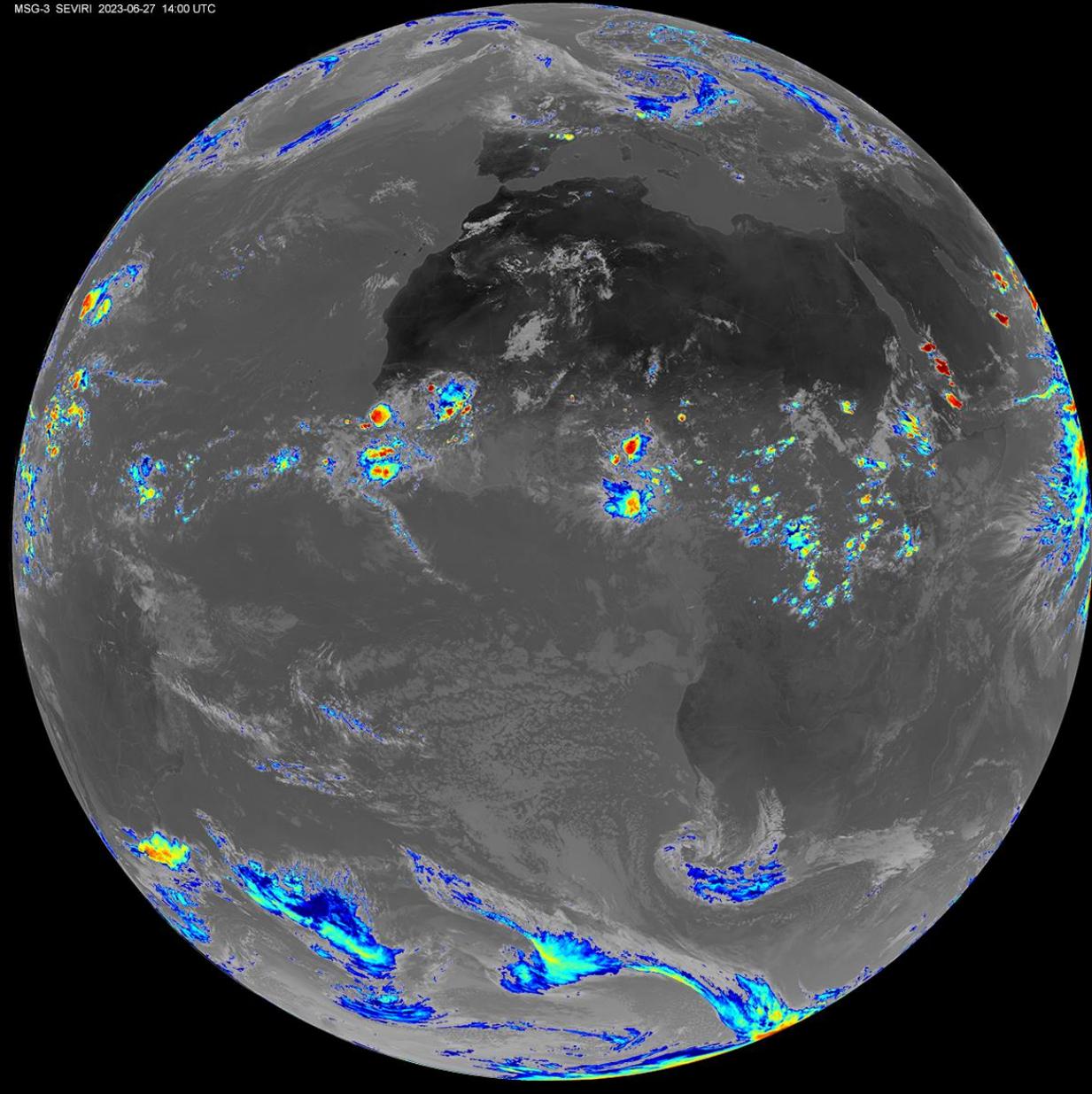
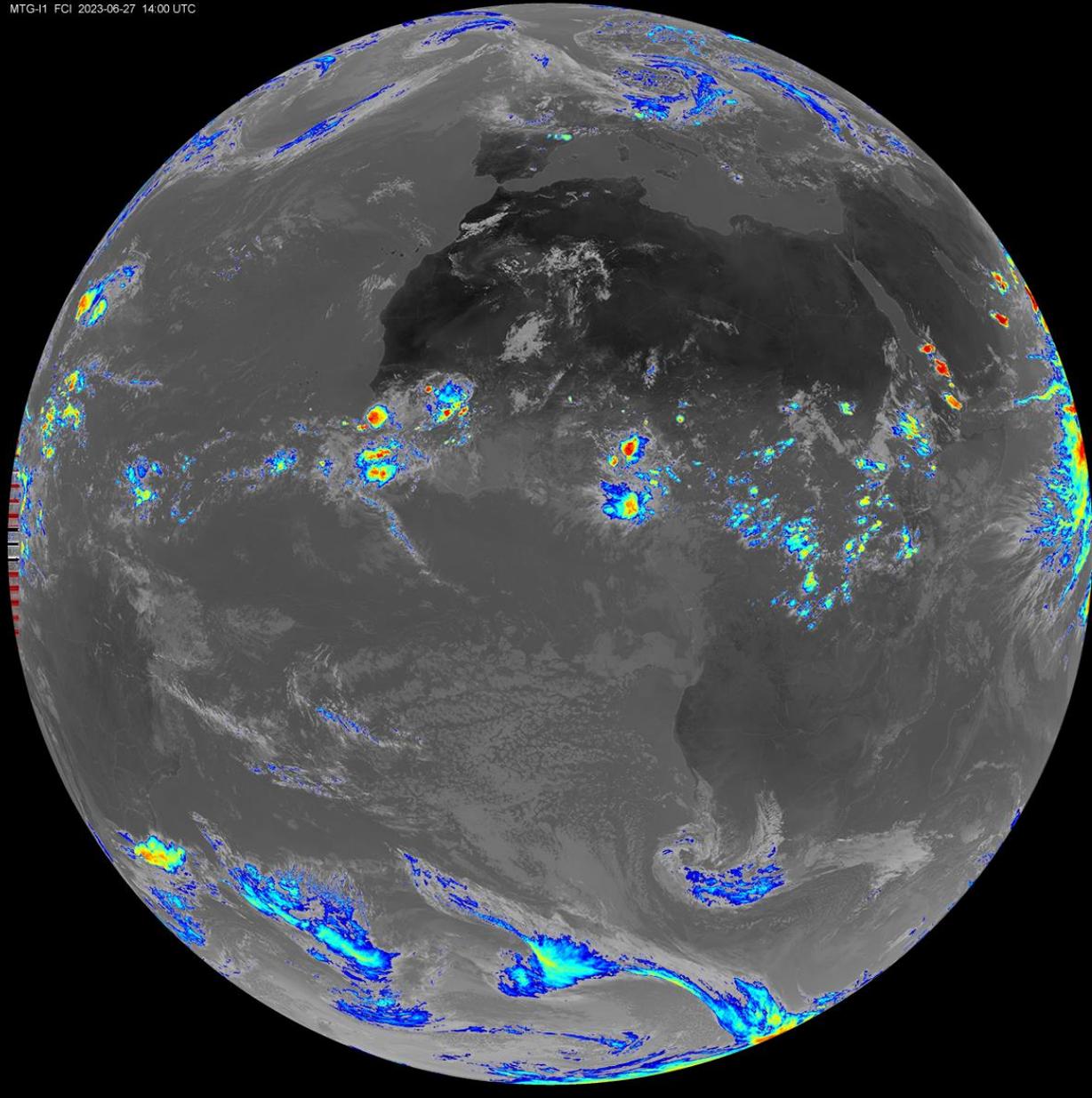
While the SEVIRI 1 km HRV band covers only part of the globe (with shifting position of the two areas throughout the day), the FCI 0.5 km VIS0.6 band covers the entire globe.

FCI band IR 10.5, BT 195-240K

SEVIRI band IR 10.8, BT 195-240K

MTG-H1 FCI 2023-06-27 14:00 UTC

MSG-3 SEVIRI 2023-06-27 14:00 UTC

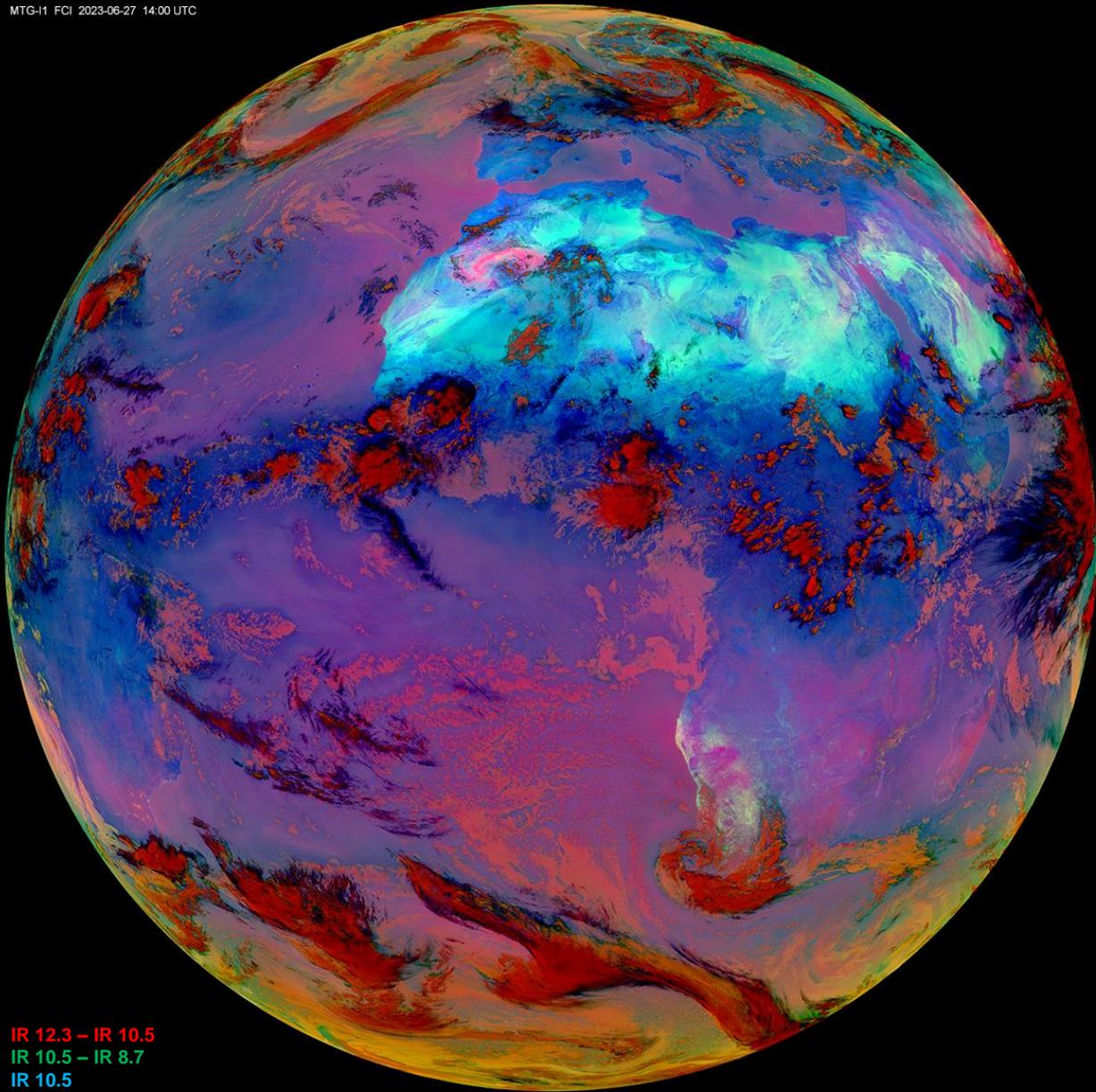


As in the previous case, no distinct differences between these at this scale.

BT 240K  195K

FCI Dust RGB

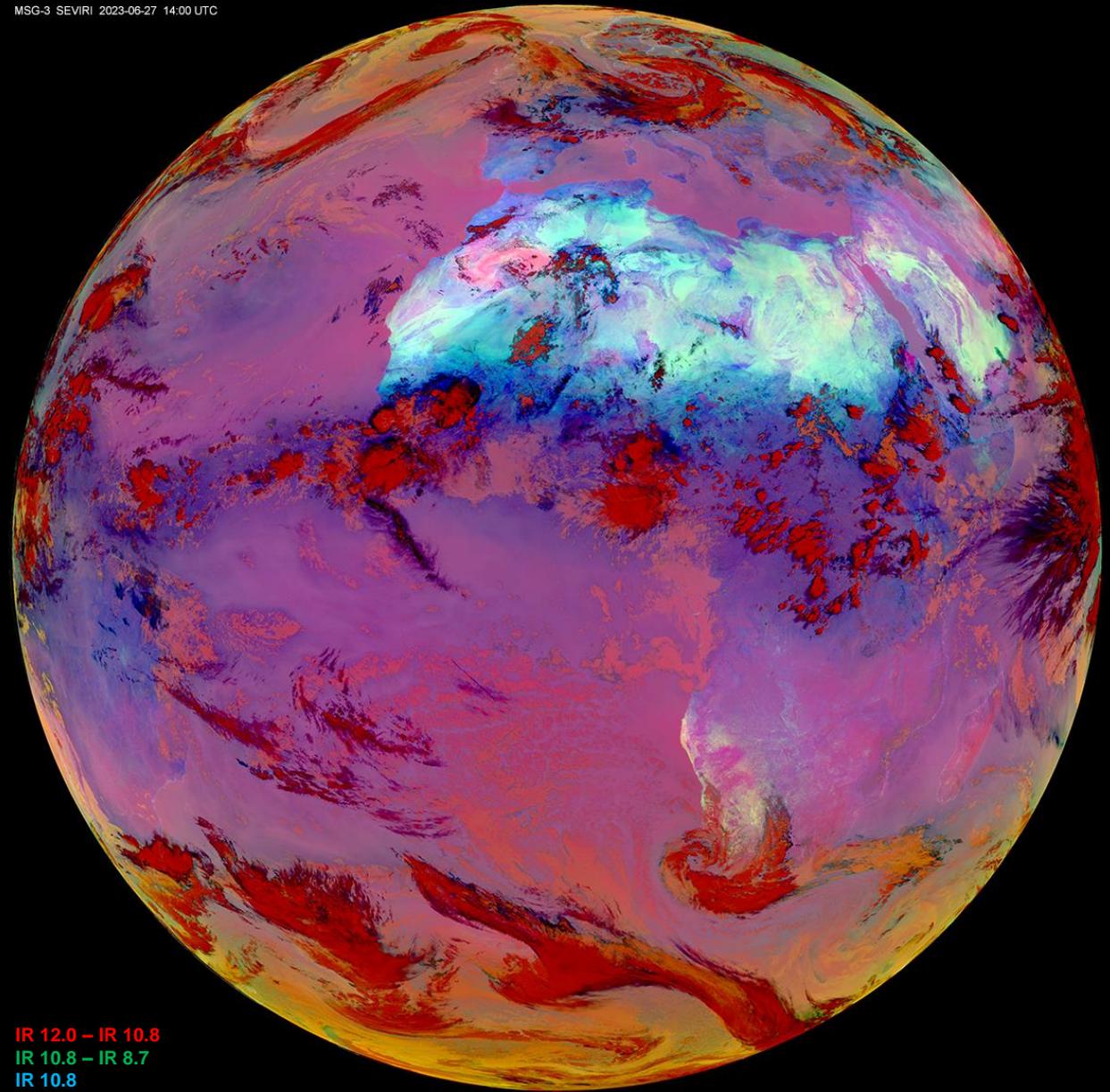
MTG-H1 FCI 2023-06-27 14:00 UTC



IR 12.3 – IR 10.5
IR 10.5 – IR 8.7
IR 10.5

SEVIRI Dust RGB

MSG-3 SEVIRI 2023-06-27 14:00 UTC

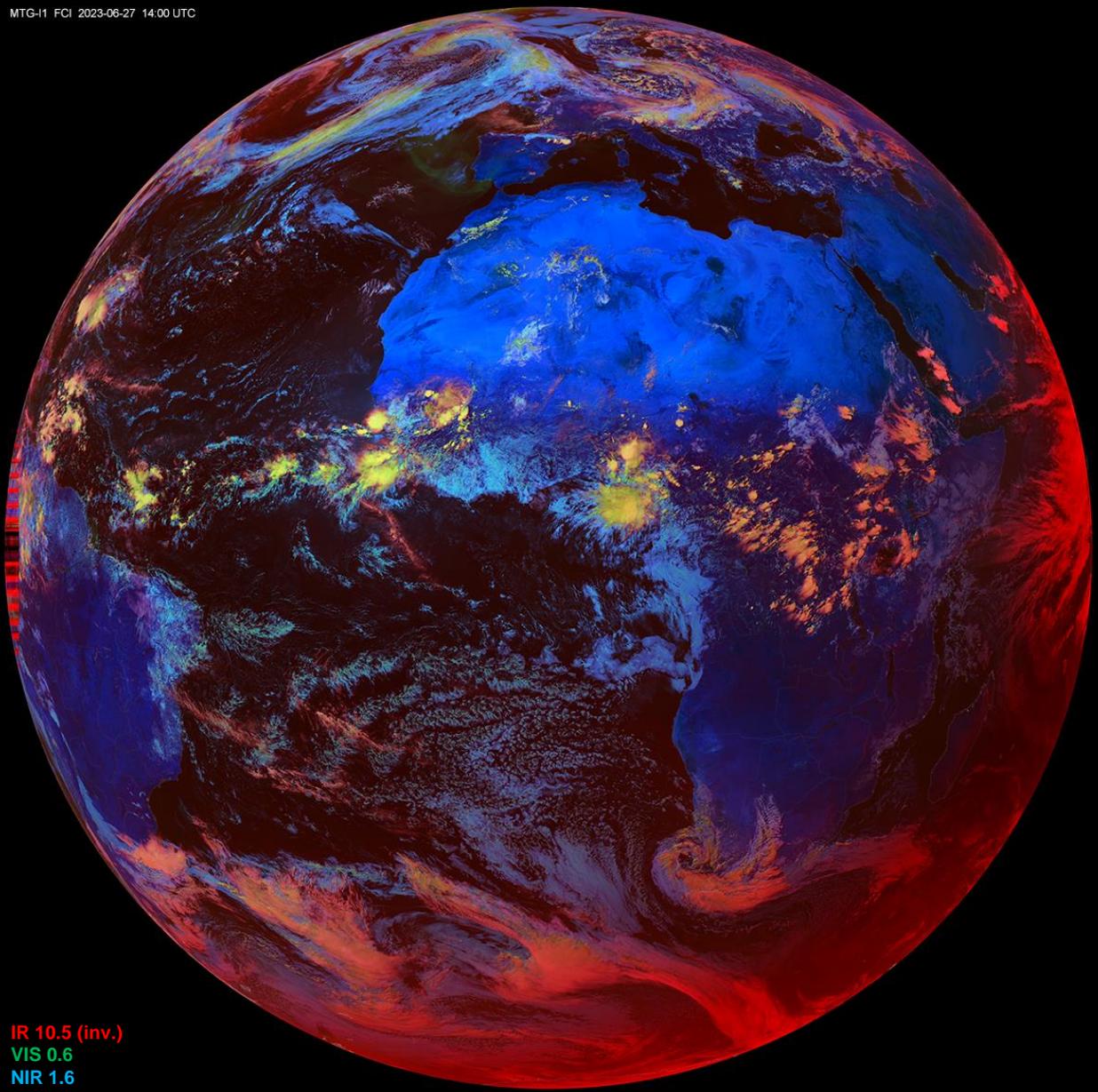


IR 12.0 – IR 10.8
IR 10.8 – IR 8.7
IR 10.8

Same settings of these, FCI slightly different colors (higher contrast), most likely due to certain differences in spectral range of the used bands.

FCI RGB Cloud Phase Distinction

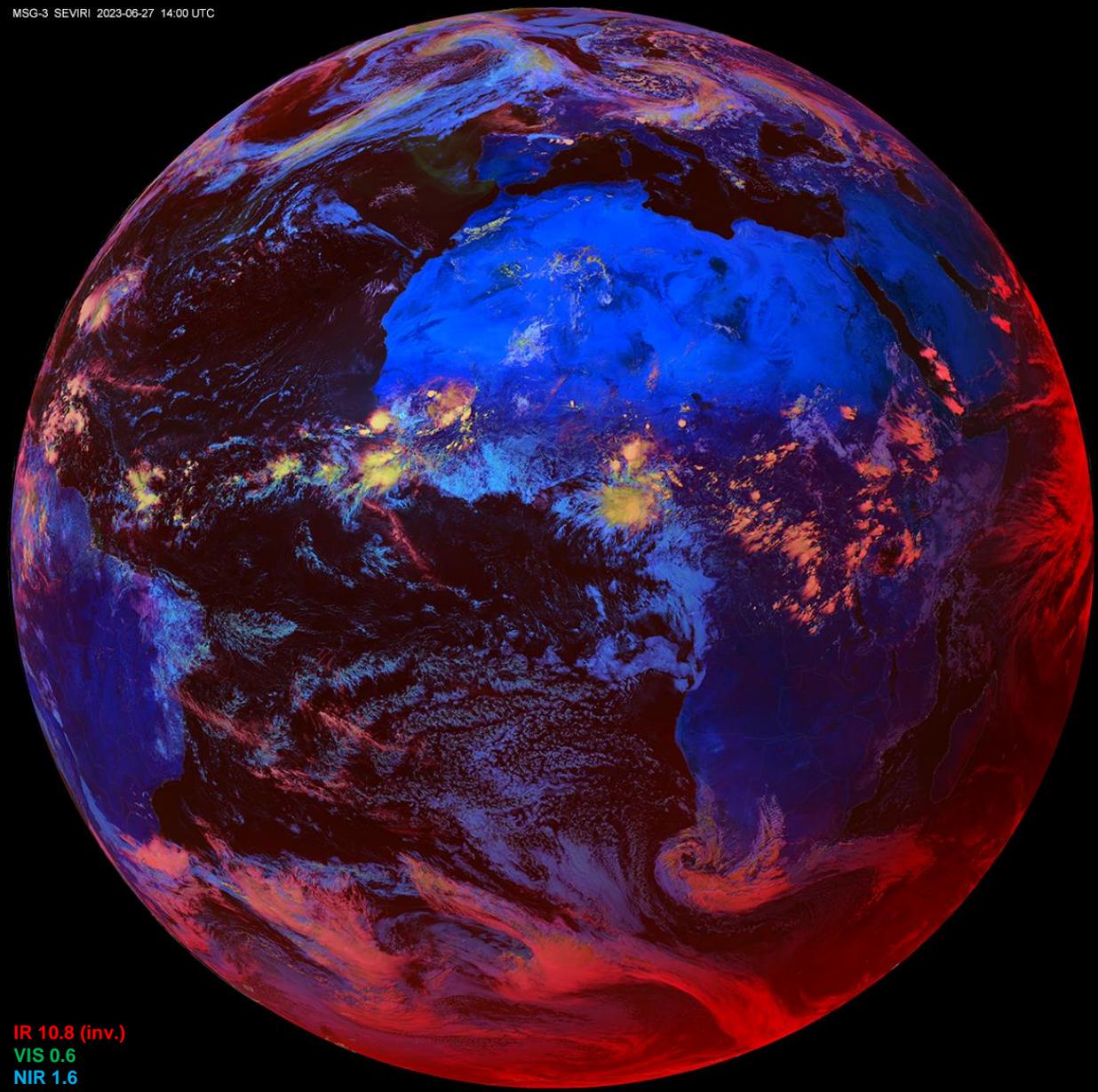
MTG-H1 FCI 2023-06-27 14:00 UTC



IR 10.5 (inv.)
VIS 0.6
NIR 1.6

SEVIRI RGB Cloud Phase Distinction

MSG-3 SEVIRI 2023-06-27 14:00 UTC

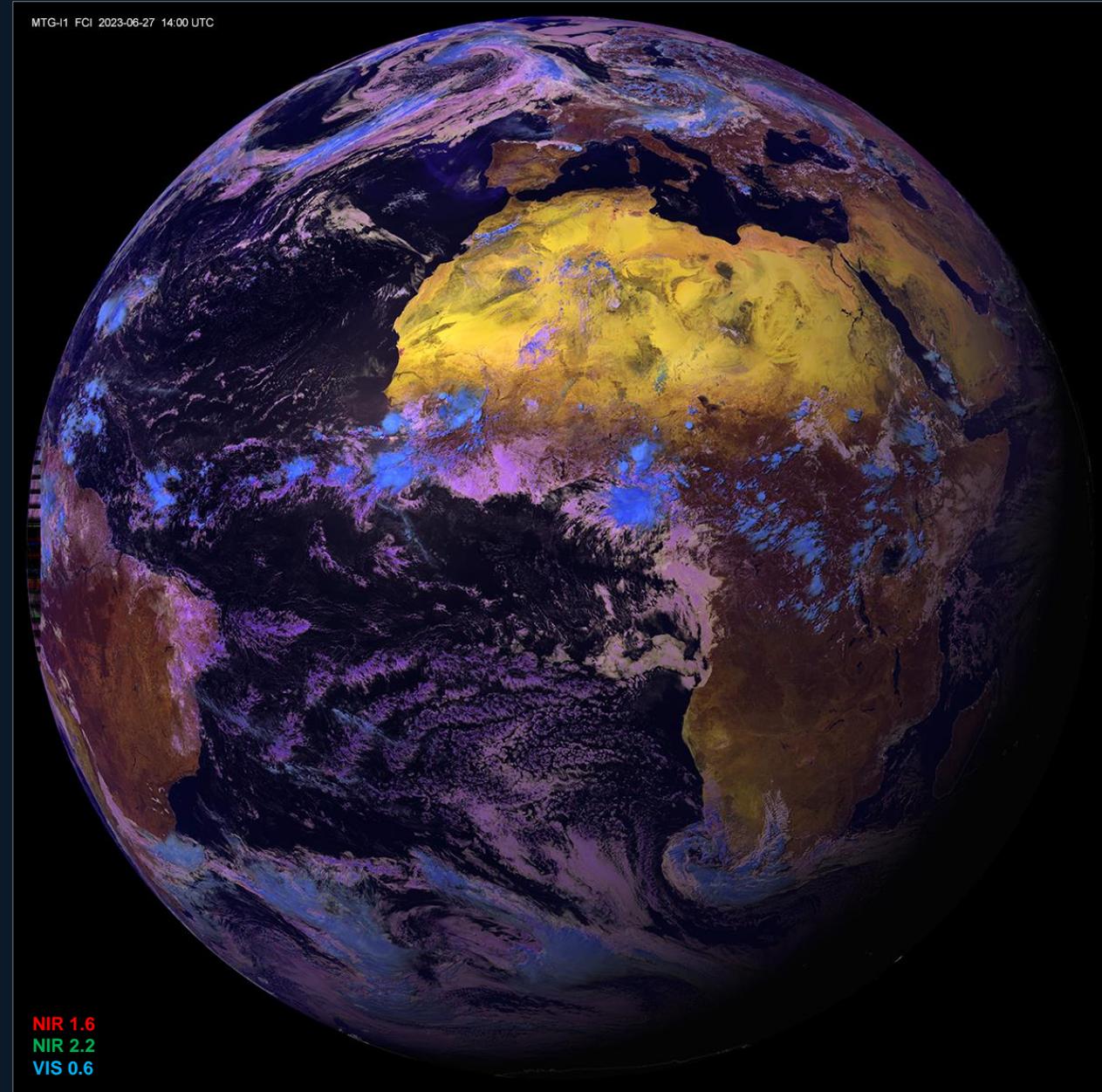


IR 10.8 (inv.)
VIS 0.6
NIR 1.6

Only very small differences in colors, most likely due to slightly different wavelengths of the IR 10.5/10.8 bands (???)

FCI RGB Cloud Phase

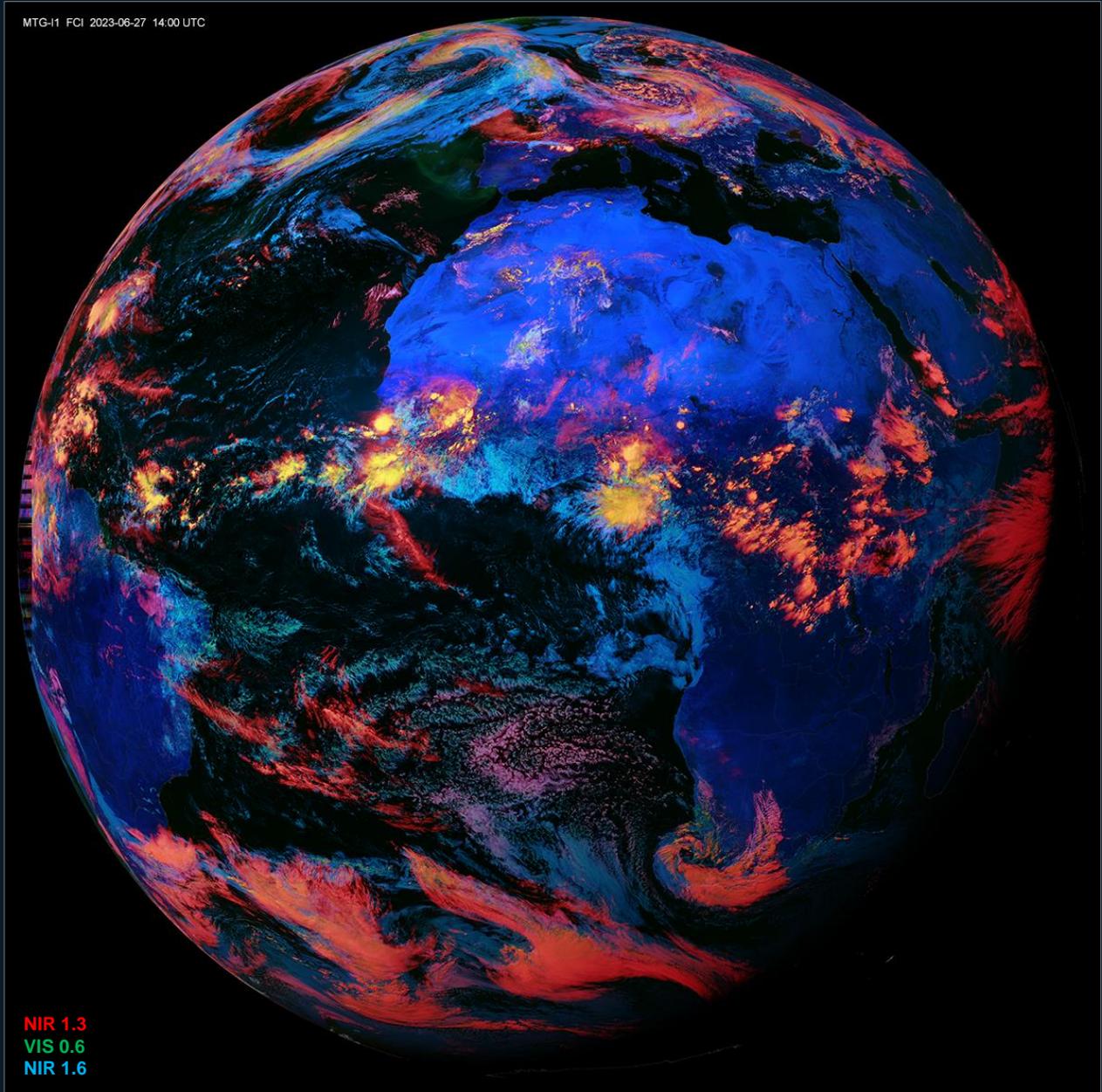
MTG-H1 FCI 2023-06-27 14:00 UTC



NIR 1.6
NIR 2.2
VIS 0.6

FCI RGB Cloud Type

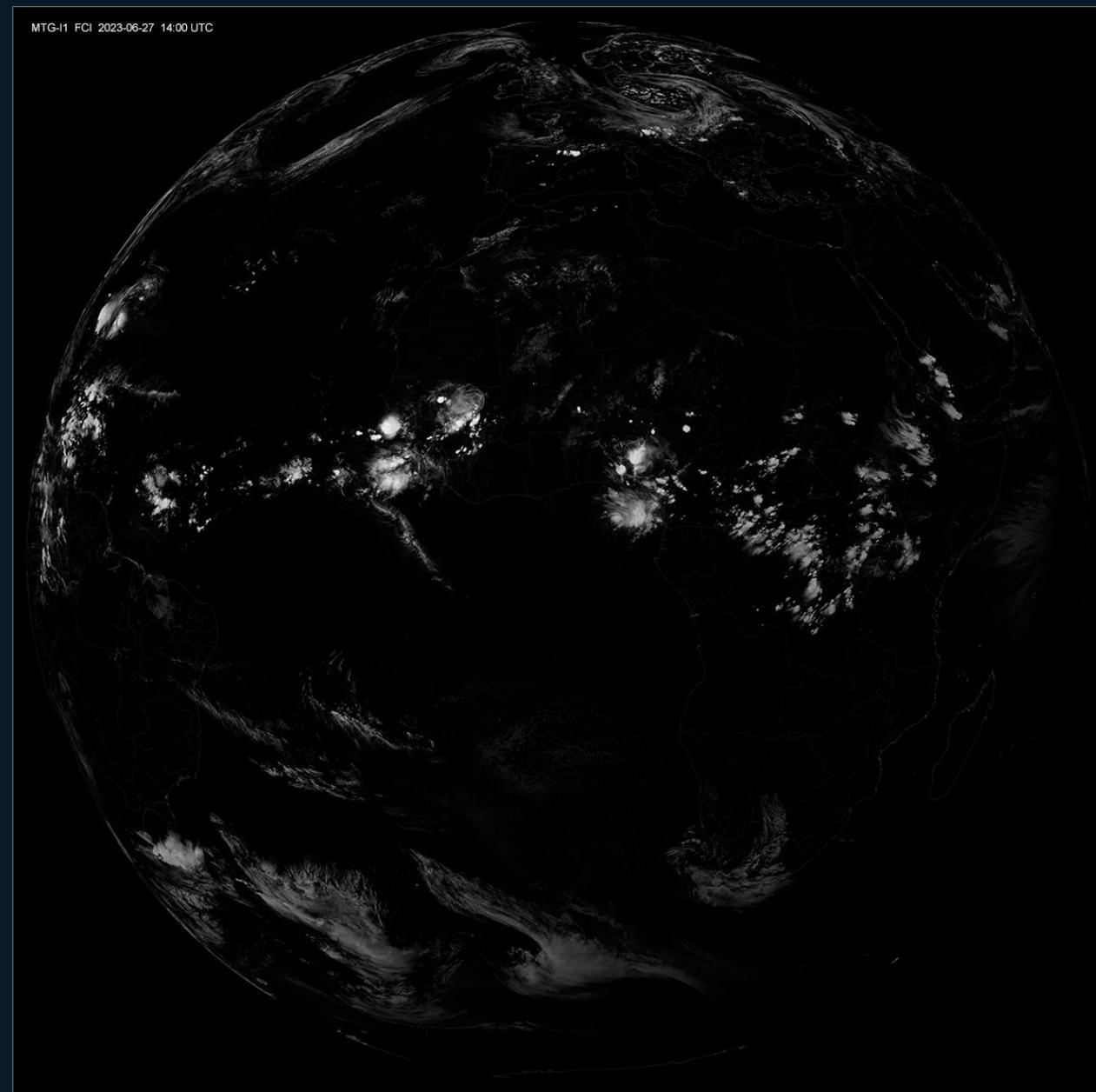
MTG-H1 FCI 2023-06-27 14:00 UTC



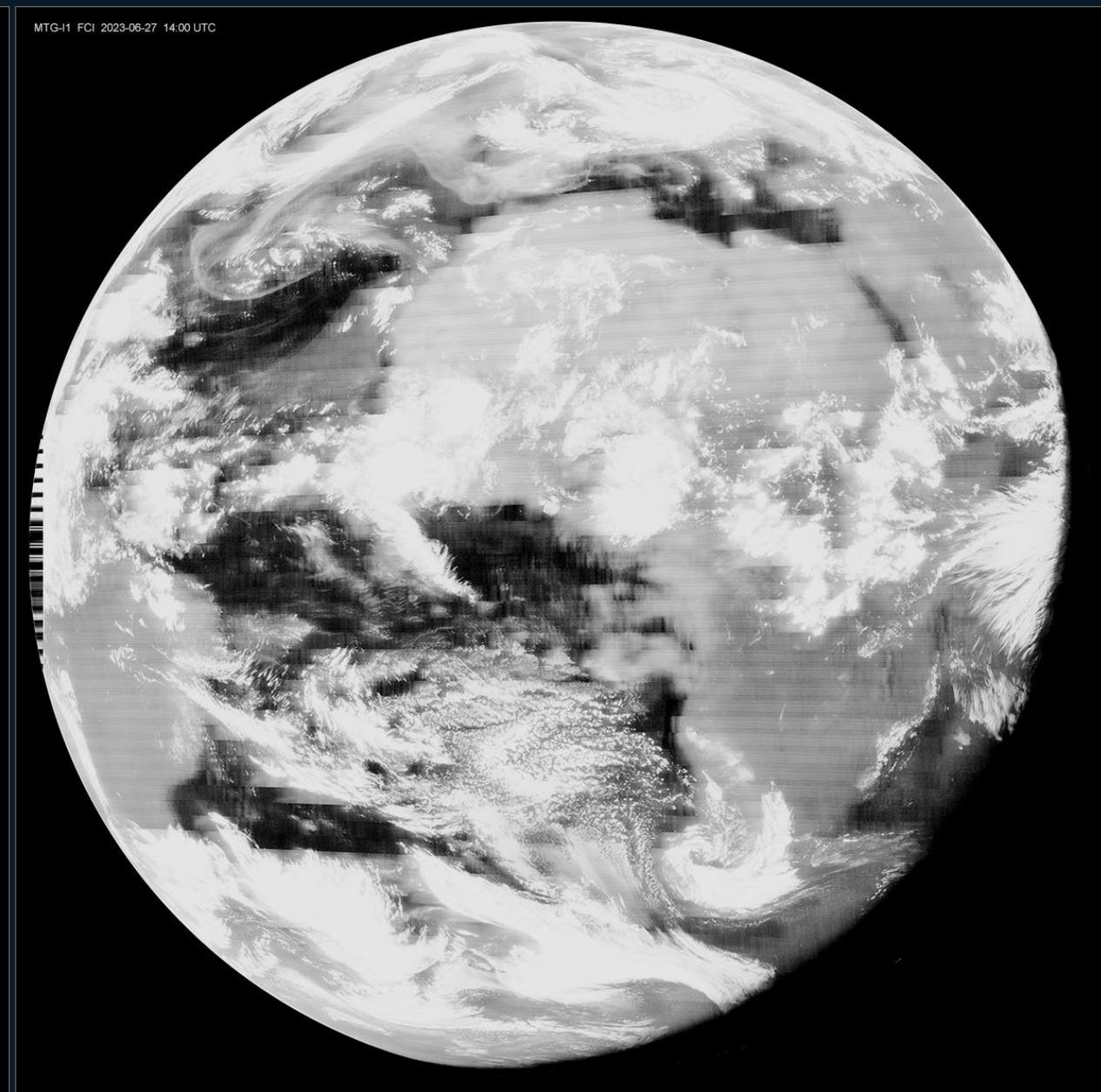
NIR 1.3
VIS 0.6
NIR 1.6

No equivalent products available from MSG SEVIRI

FCI NIR1.3 band, refl. 0 – 60% linear enhancement



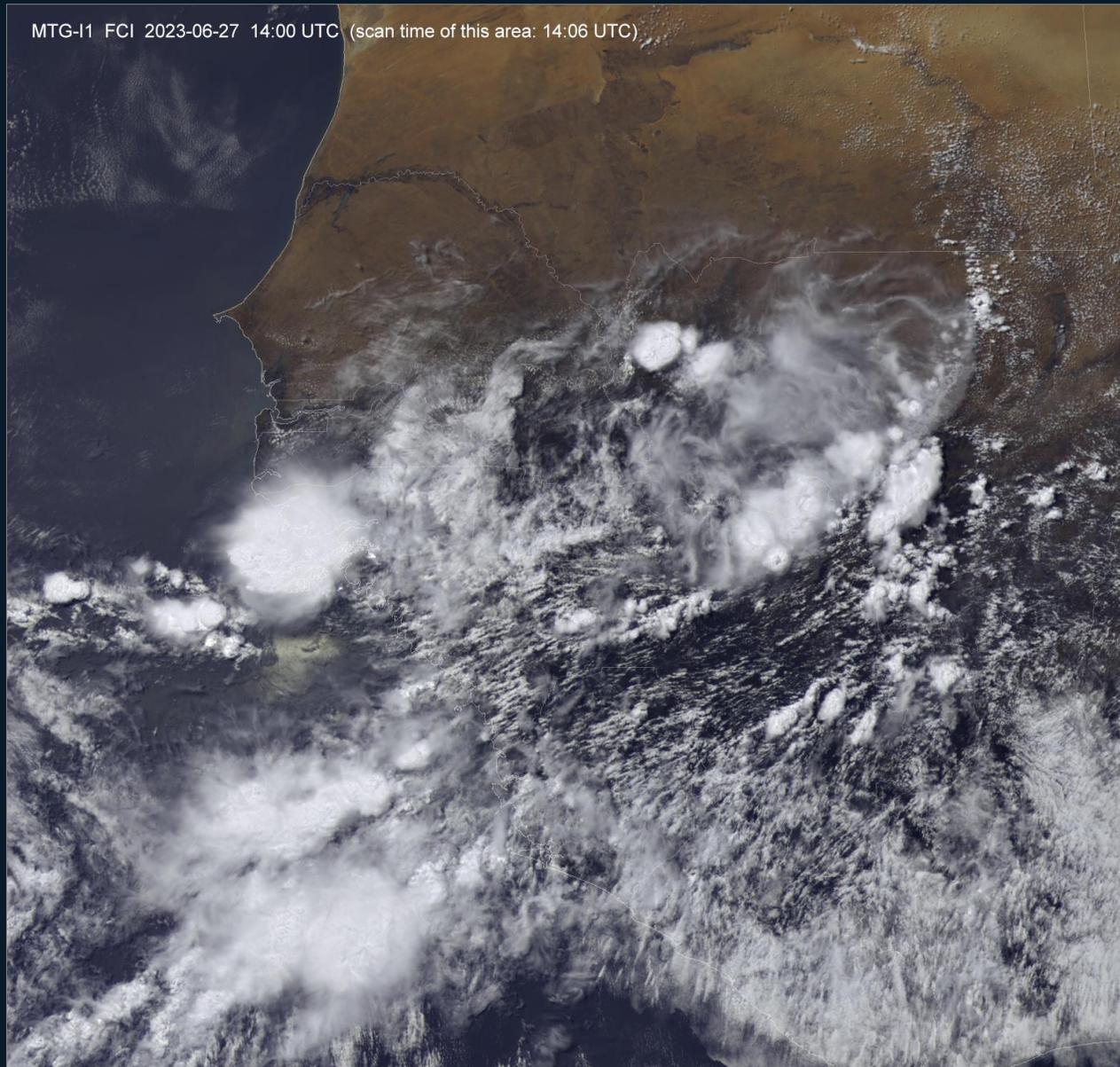
FCI NIR1.3 band, refl. 0 – 70% histogram equalization method (extreme settings)



No Earth Stray Light (ESL) correction applied yet. Despite this, still can be used in RGB Cloud Type product (with delicate fine tuning of the product).

FCI True Color RGB (FCI bands VIS0.6, VIS0.5, VIS0.4)

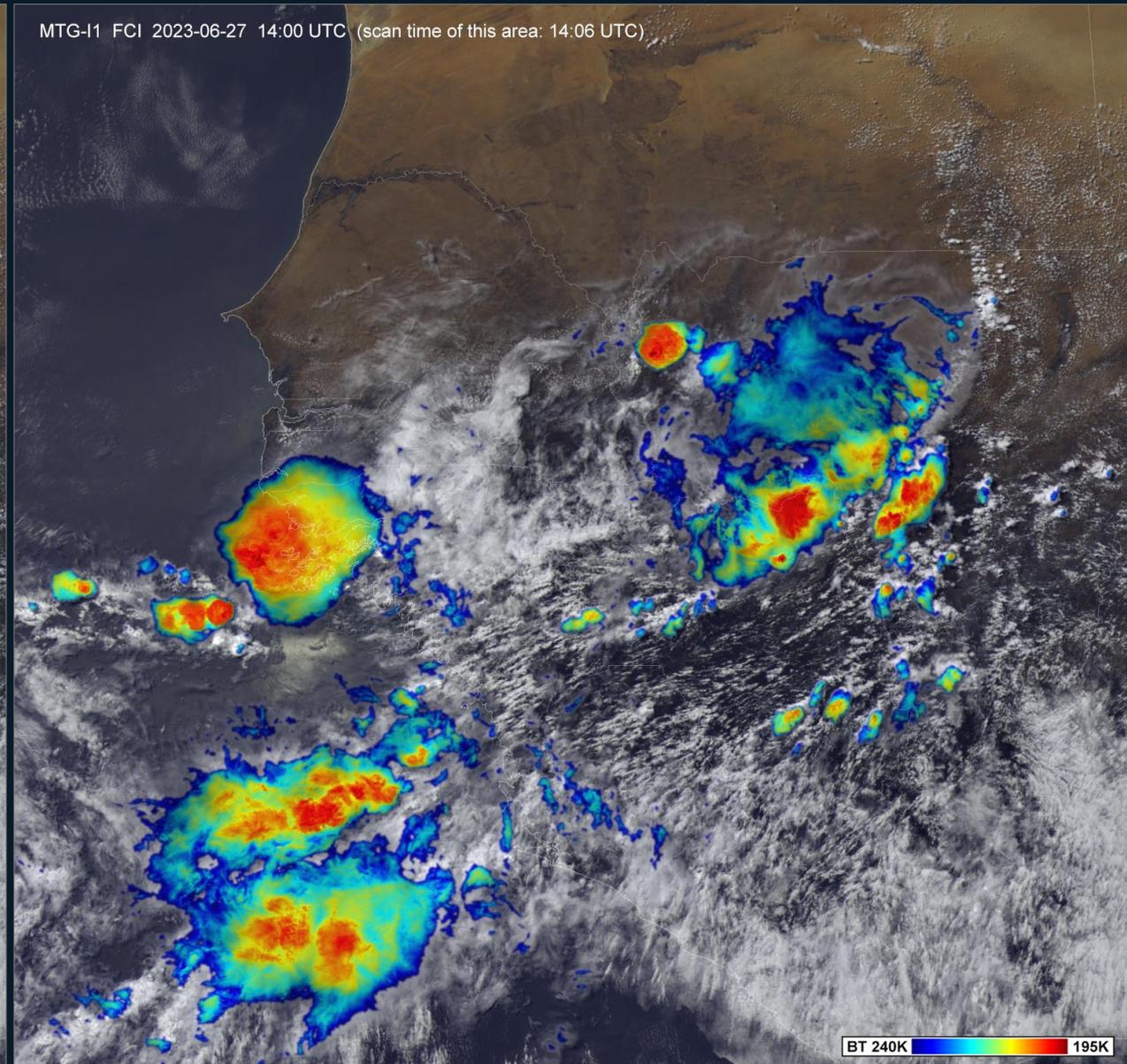
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



VIS 0.6
VIS 0.5
VIS 0.4

FCI sandwich of True Color RGB and IR10.5 BT 195-240K

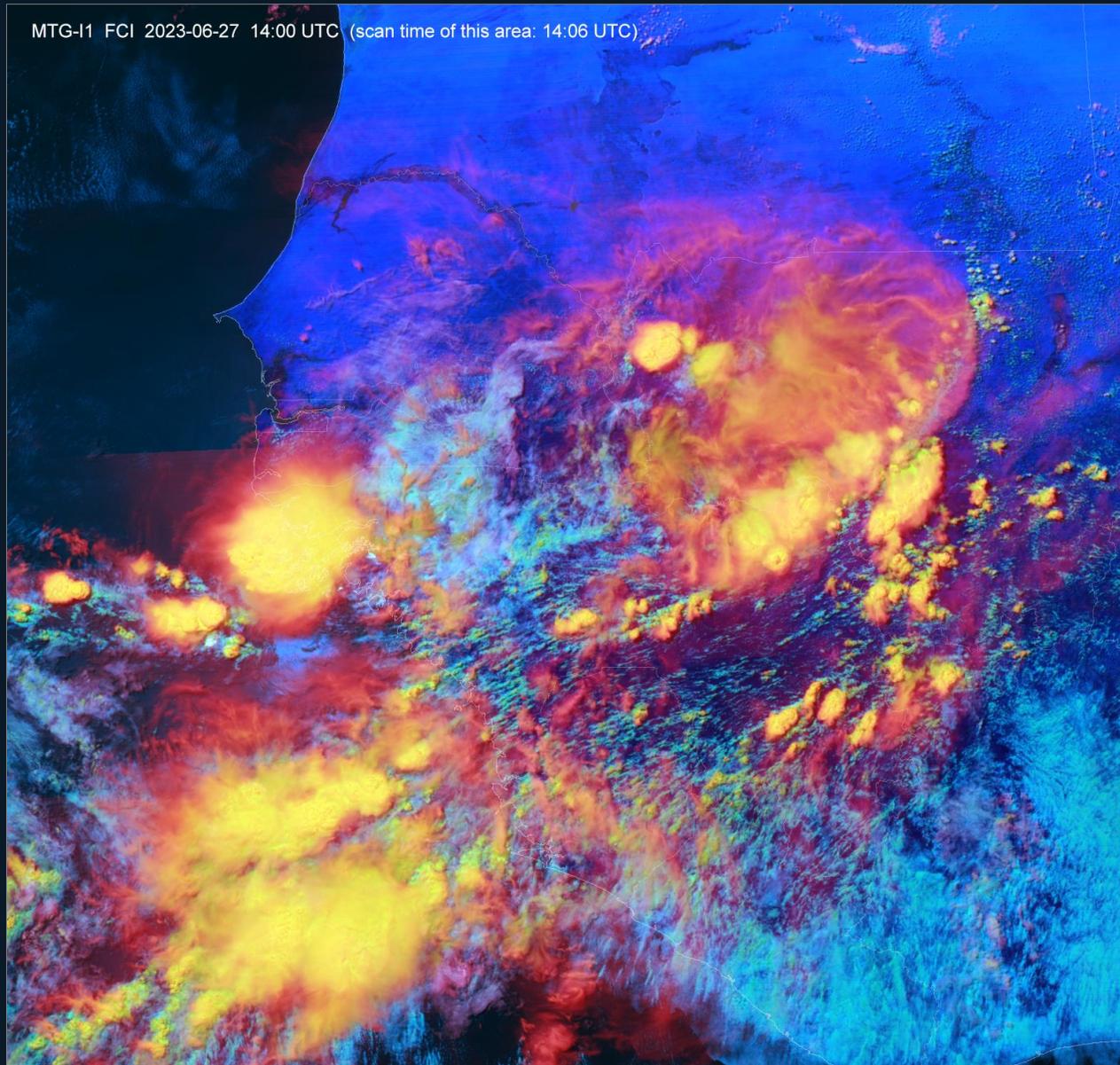
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



BT 240K 195K

FCI Cloud Type RGB

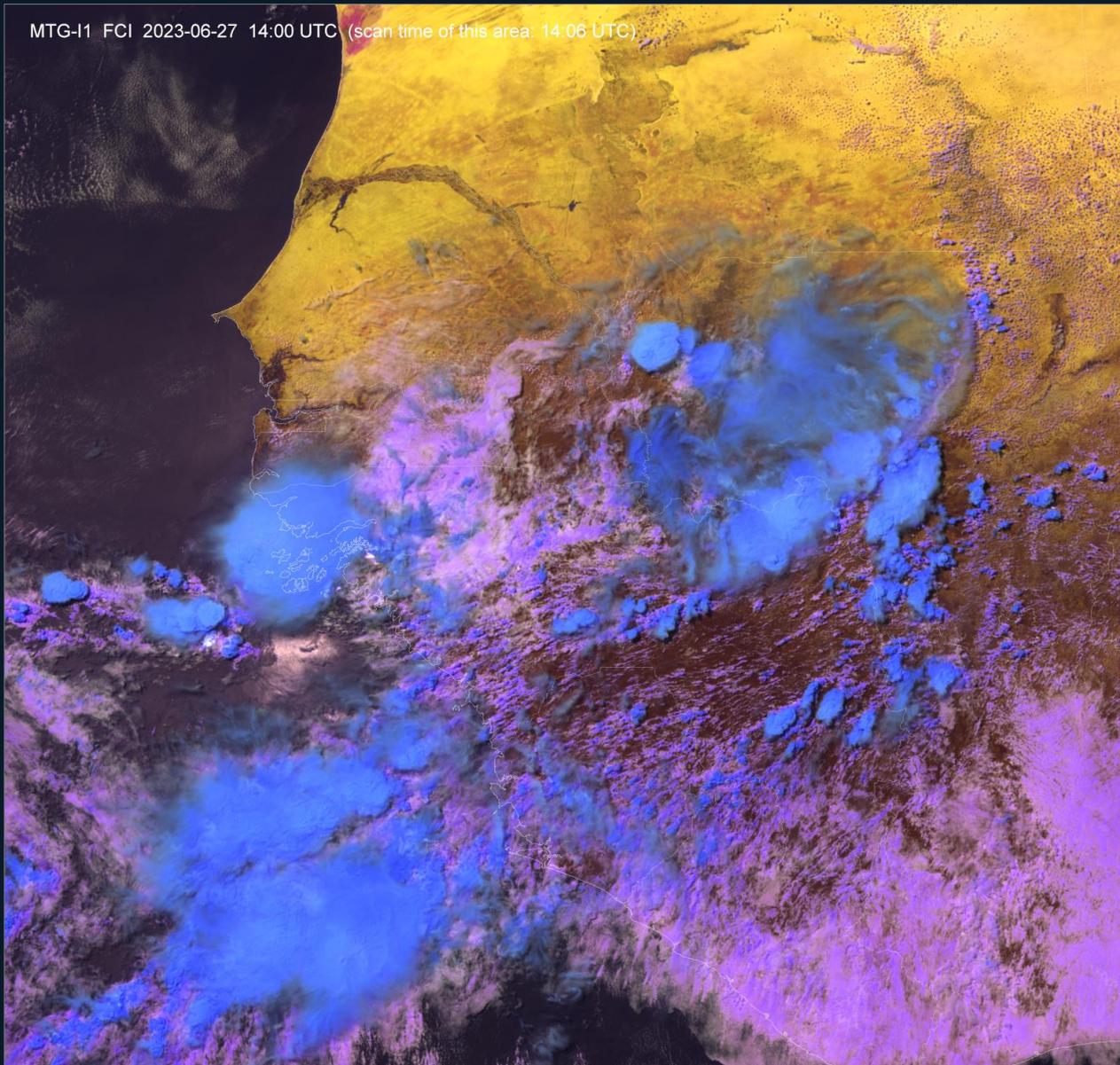
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



NIR 1.3
VIS 0.6
NIR 1.6 No Earth Stray Light (ESL) correction applied yet. After applying the ESL correction, the product should perform even better for thin cirrus detection.

FCI Cloud Phase RGB

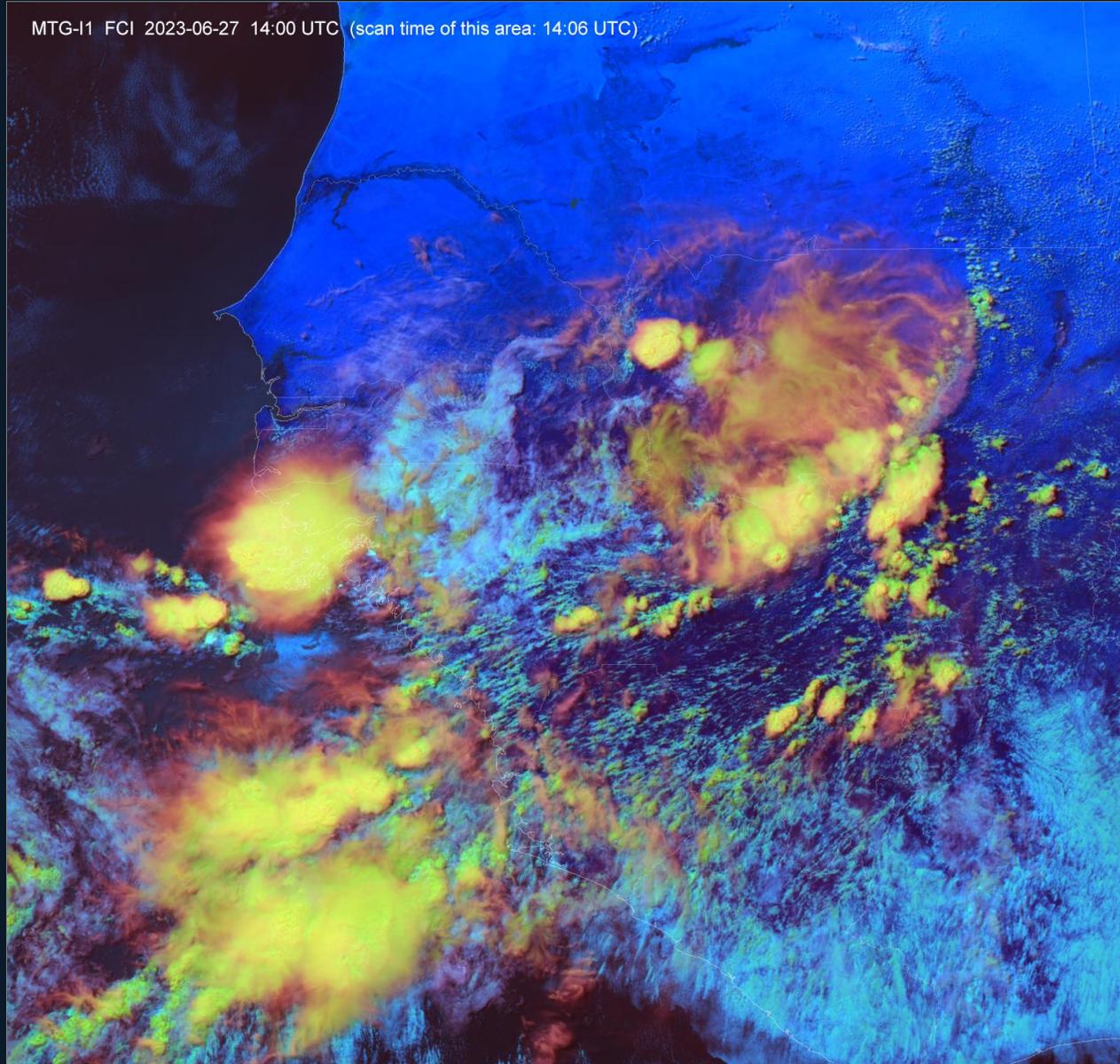
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



NIR 1.6
NIR 2.2
VIS 0.6

FCI Cloud Phase Distinction RGB

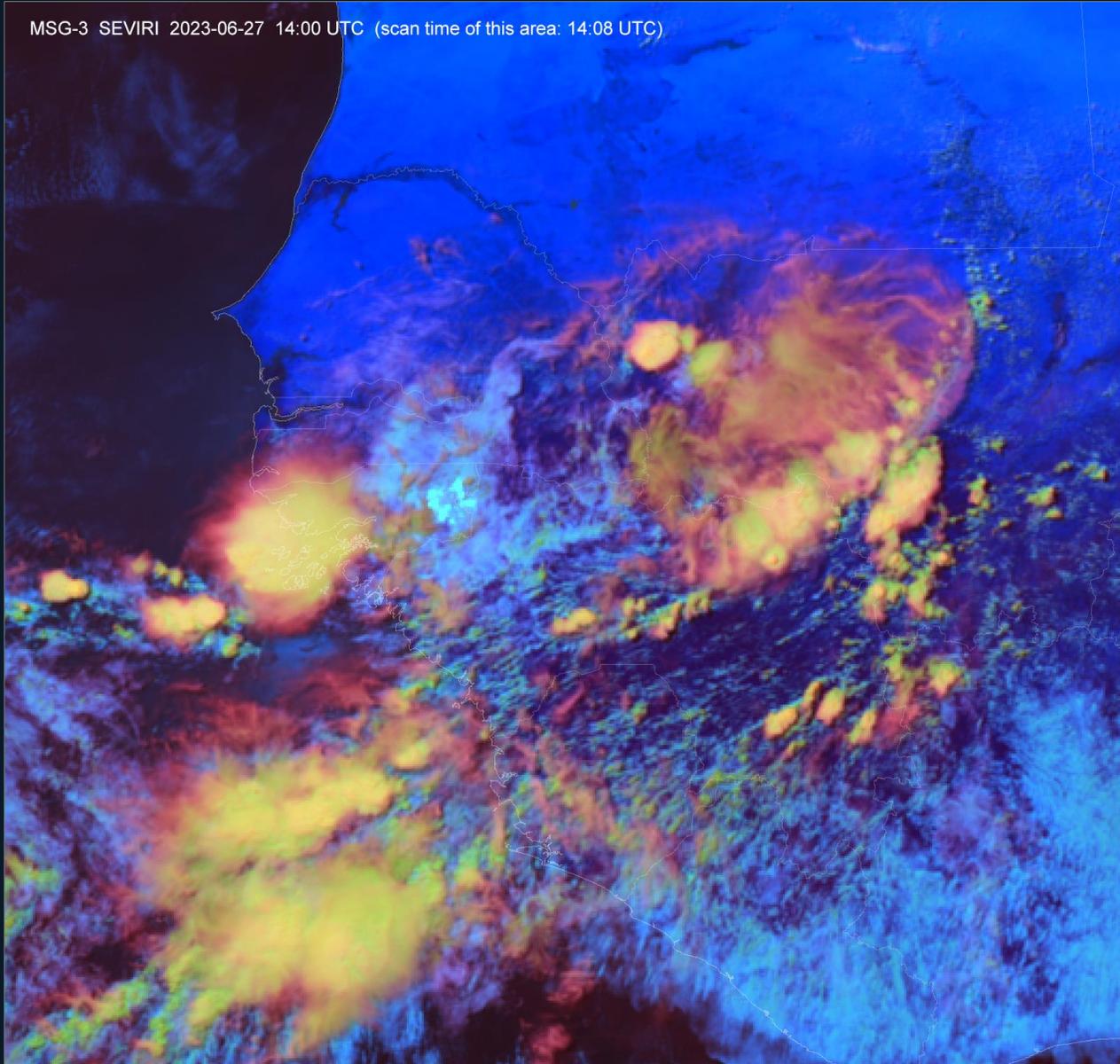
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



IR 10.5 (inv.)
VIS 0.6
NIR 1.6

SEVIRI Cloud Phase Distinction RGB

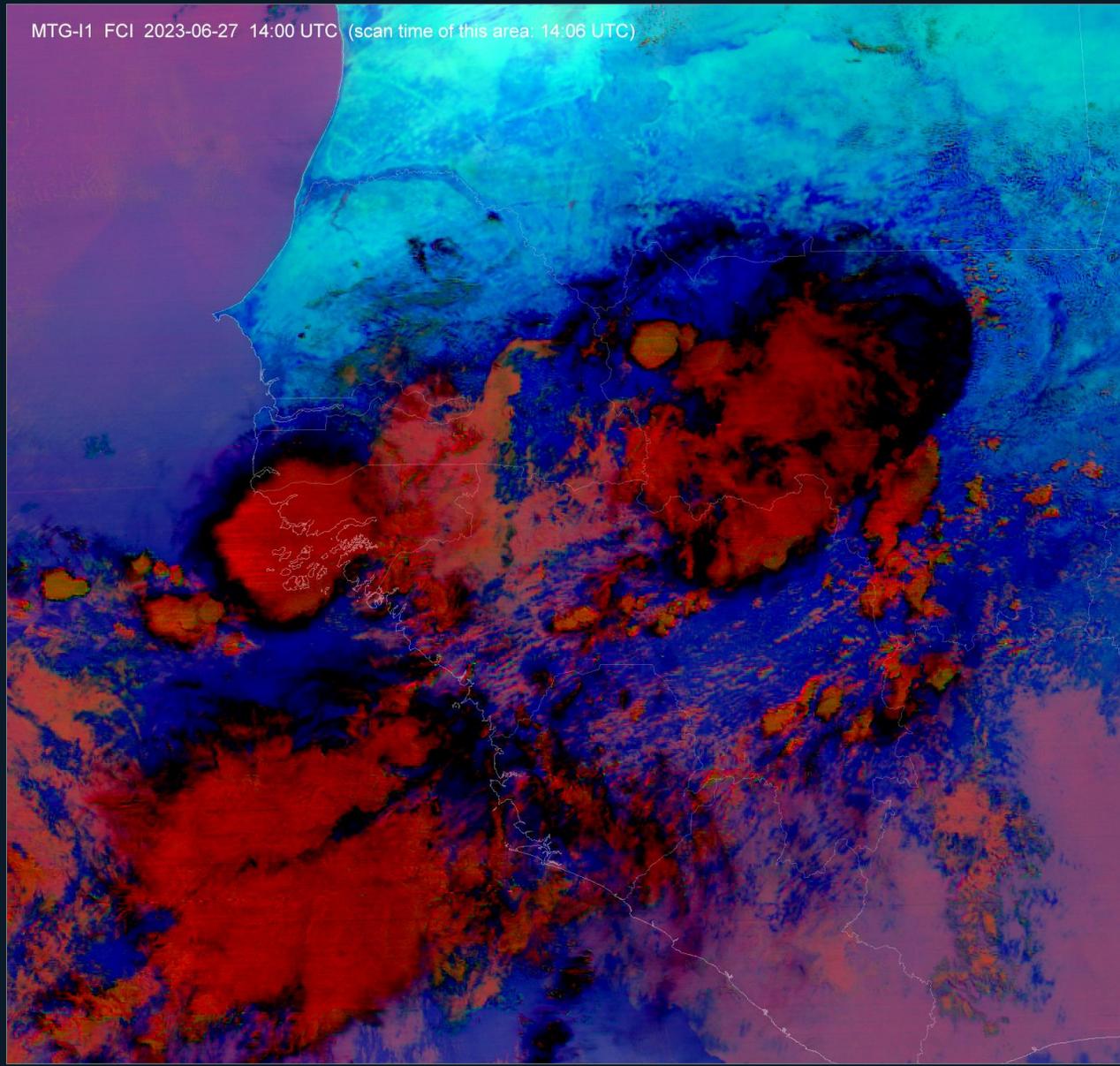
MSG-3 SEVIRI 2023-06-27 14:00 UTC (scan time of this area: 14:08 UTC)



IR 10.8 (inv.)
VIS 0.6
NIR 1.6

FCI Dust RGB

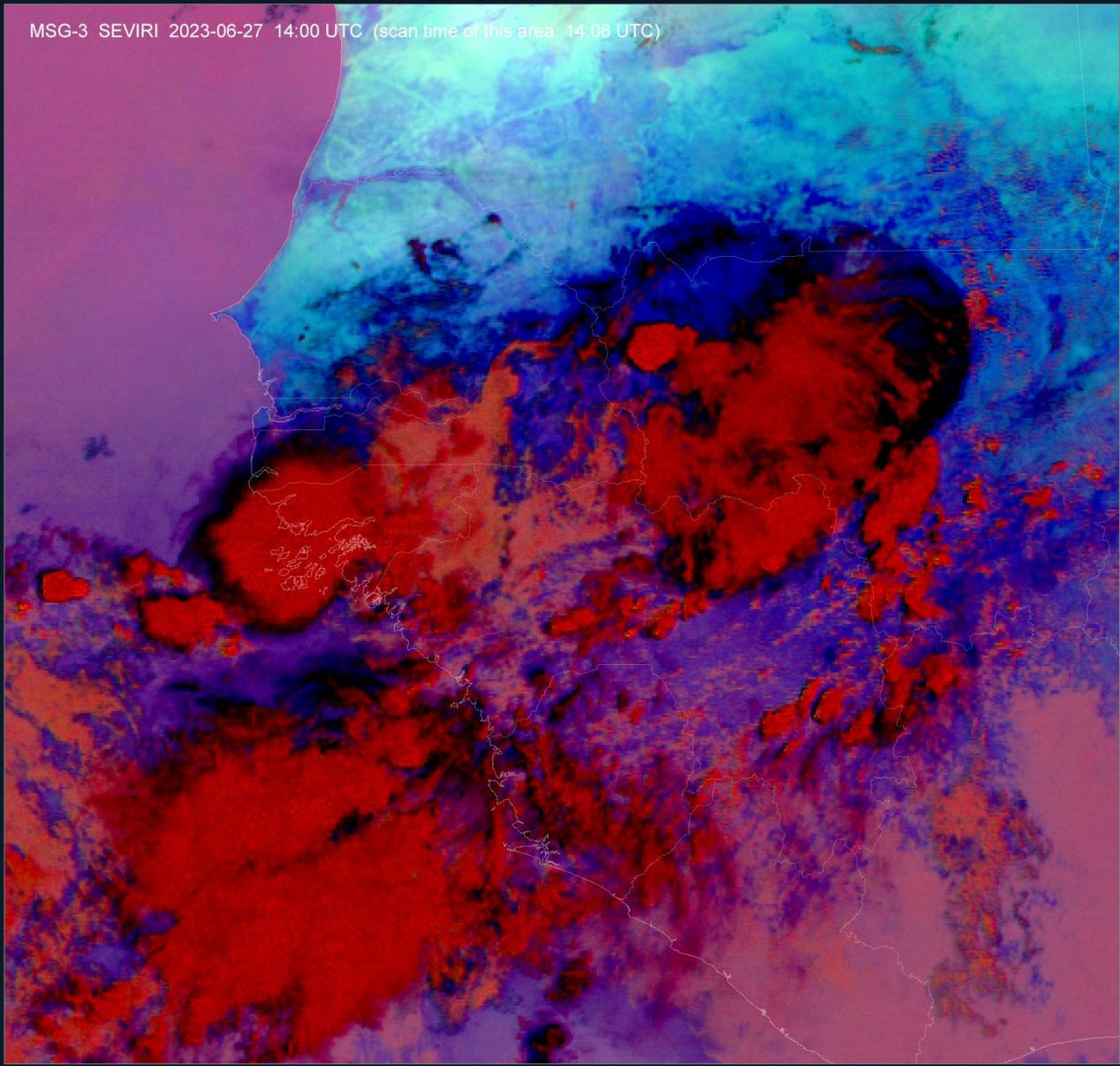
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



IR 12.3 – IR 10.5
IR 10.5 – IR 8.7
IR 10.5

SEVIRI Dust RGB

MSG-3 SEVIRI 2023-06-27 14:00 UTC (scan time of this area: 14:08 UTC)



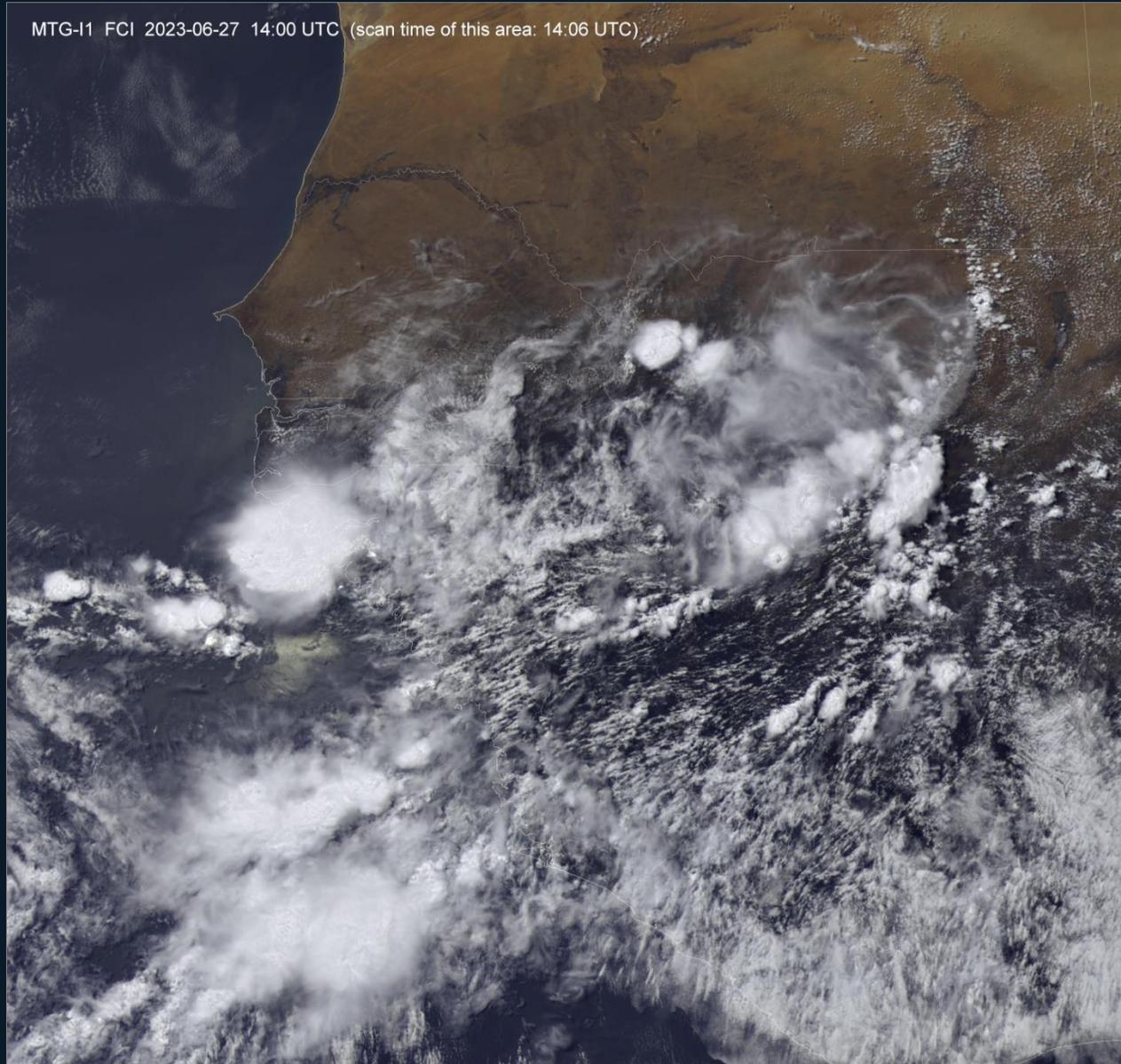
IR 12.0 – IR 10.8
IR 10.8 – IR 8.7
IR 10.8

Comparison of MTG-I1 FCI and Suomi-NPP VIIRS image products

(about 6 minutes difference between these)

FCI True Color RGB (bands VIS0.6, VIS0.5, VIS0.4)

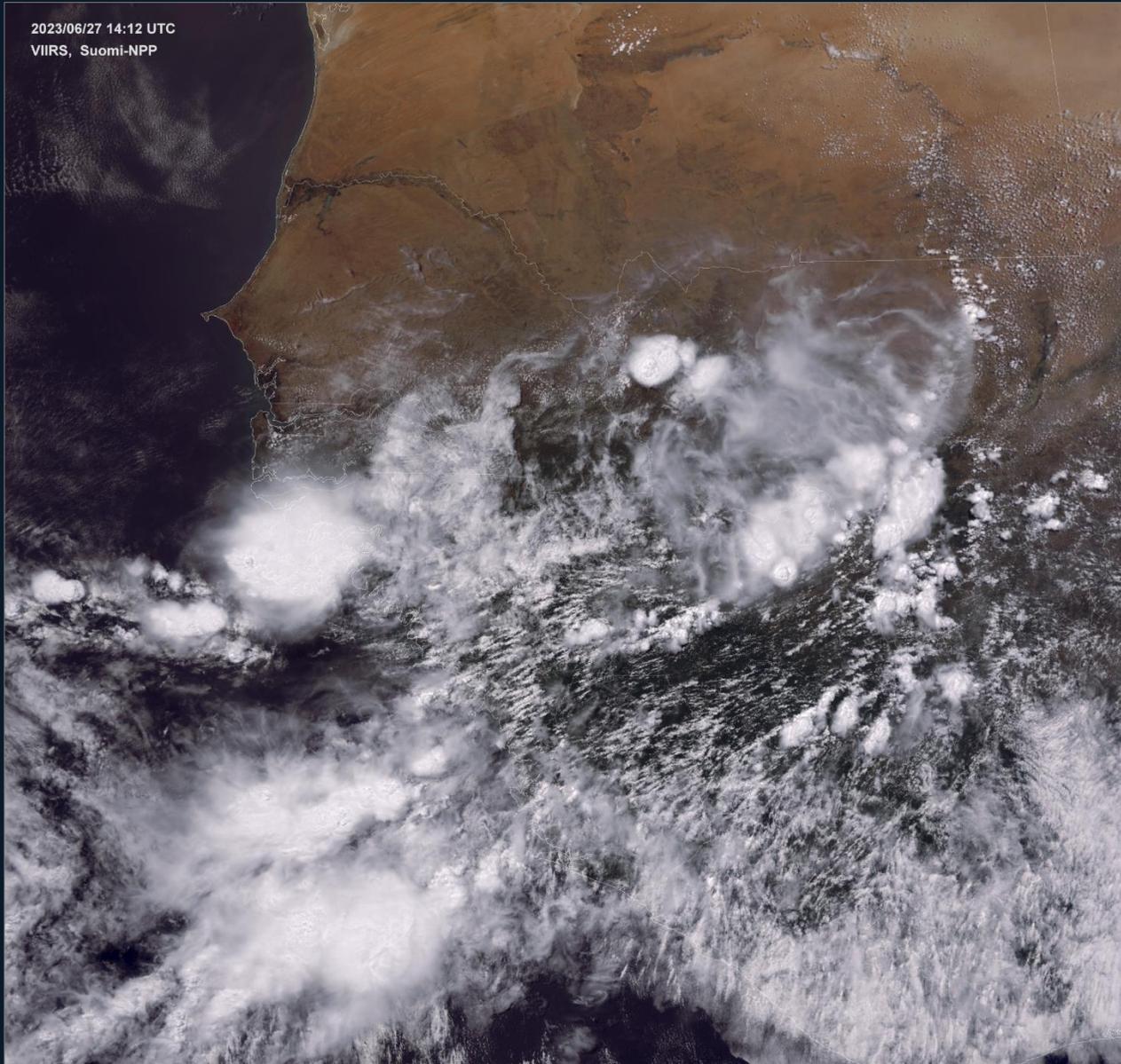
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



VIS 0.6
VIS 0.5
VIS 0.4

VIIRS True Color RGB (bands M05, M04 and M03)

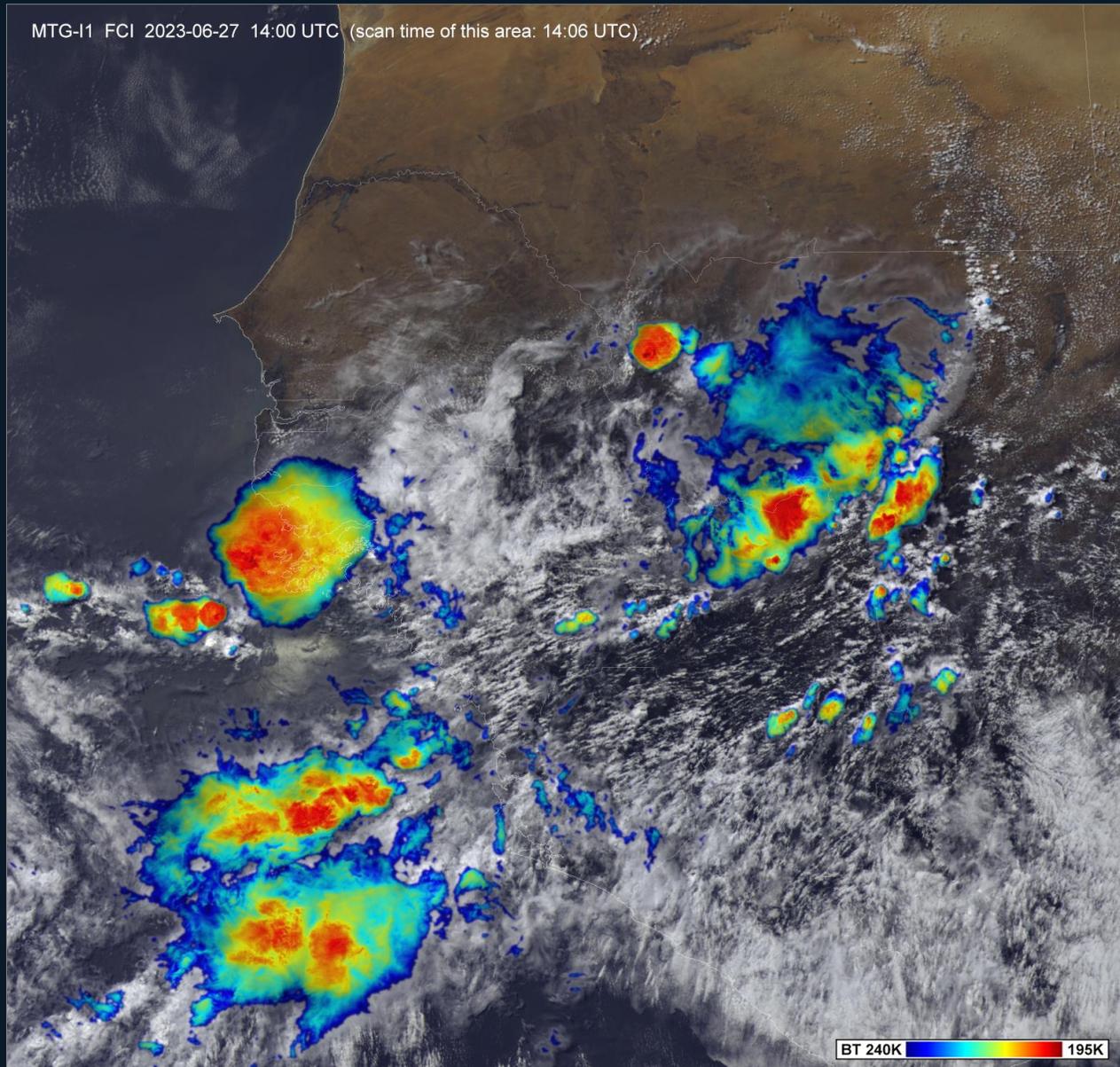
2023/06/27 14:12 UTC
VIIRS, Suomi-NPP



M5 (0.672)
M4 (0.555)
M3 (0.488)

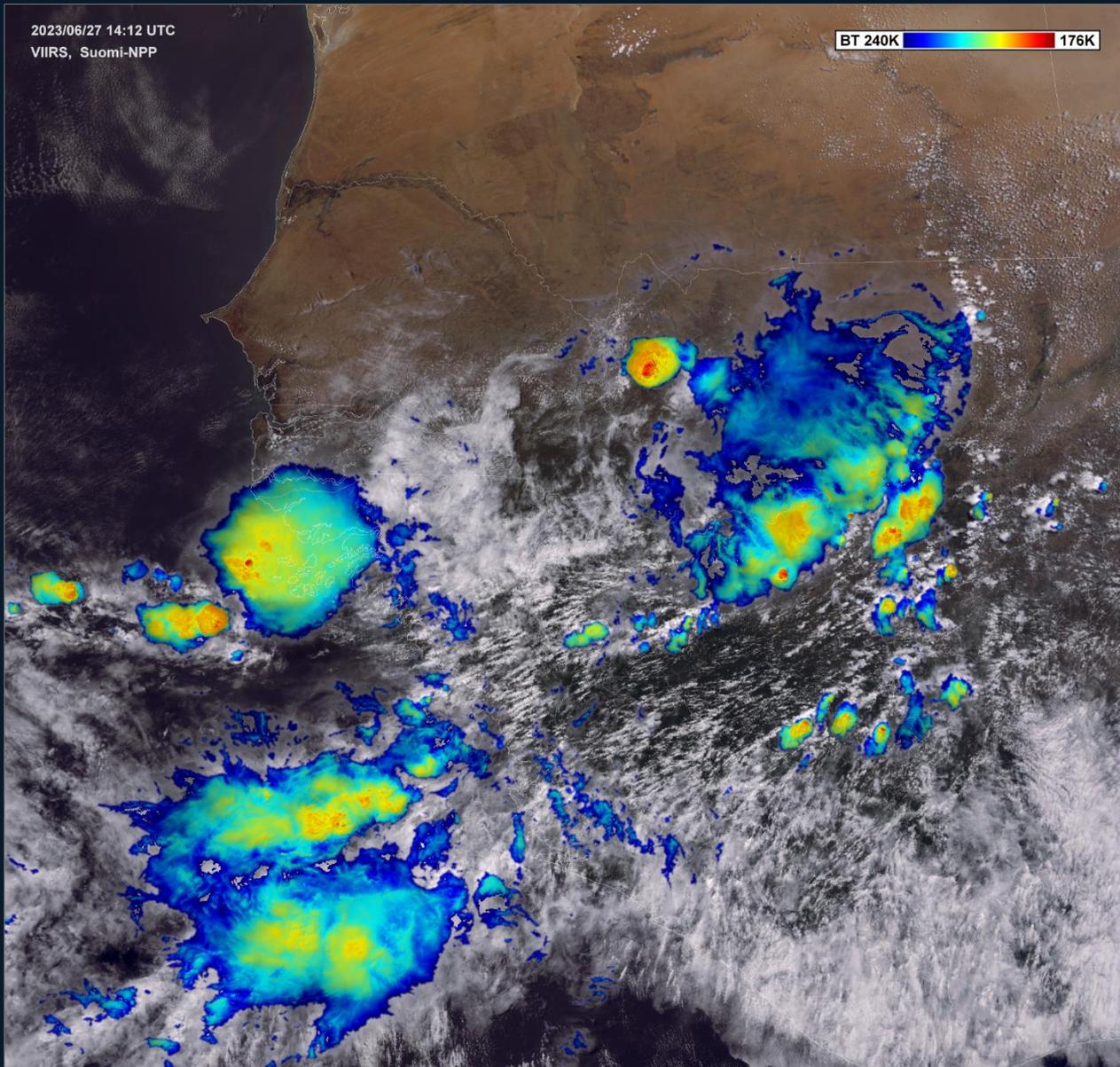
FCI sandwich of True Color RGB and IR10.5 BT 195-240K

MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



VIIRS sandwich of True Color RGB and M15 BT 176-240K

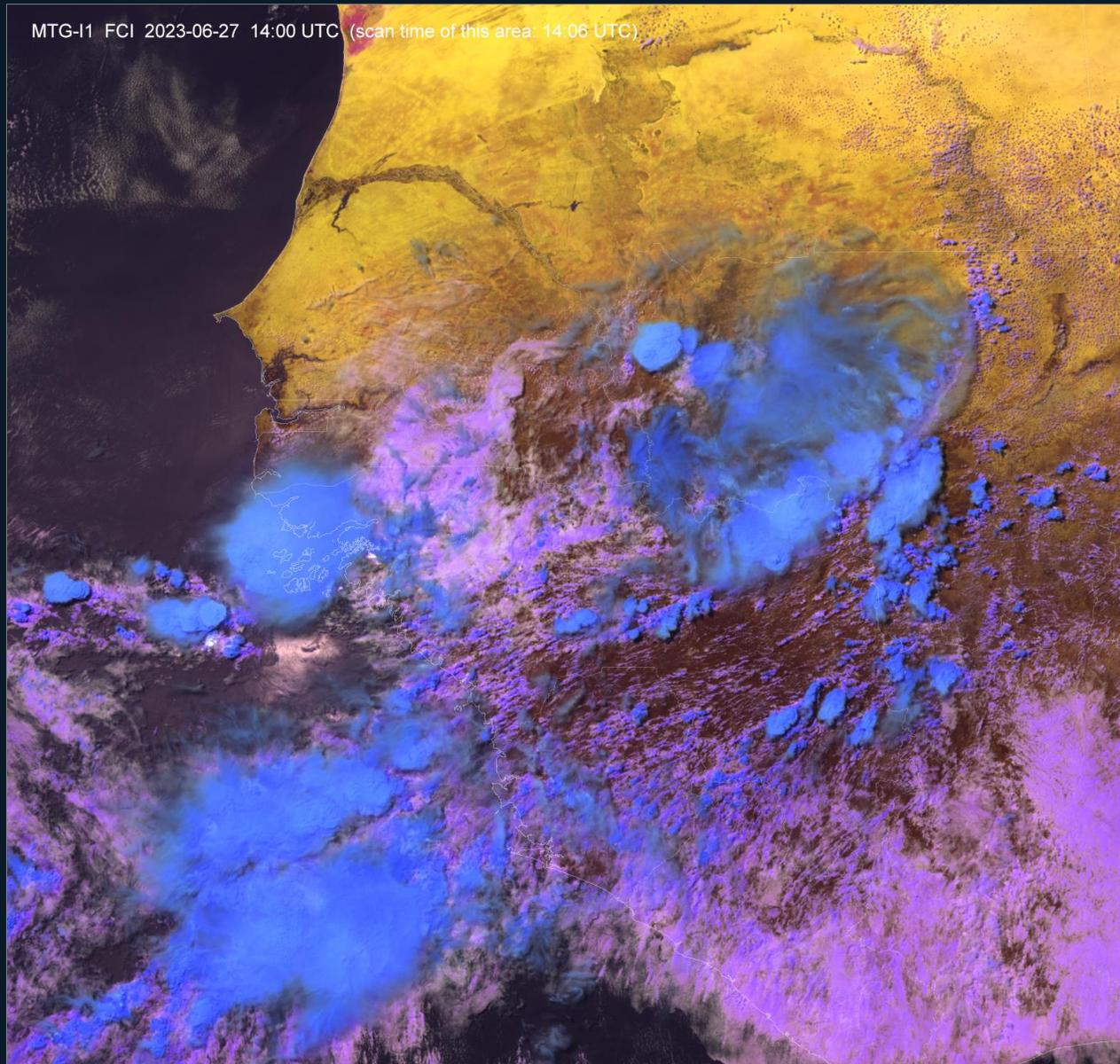
2023/06/27 14:12 UTC
VIIRS, Suomi-NPP



Different range of color enhancement for the two satellites (based on lowest IR brightness temperature).

FCI Cloud Phase RGB

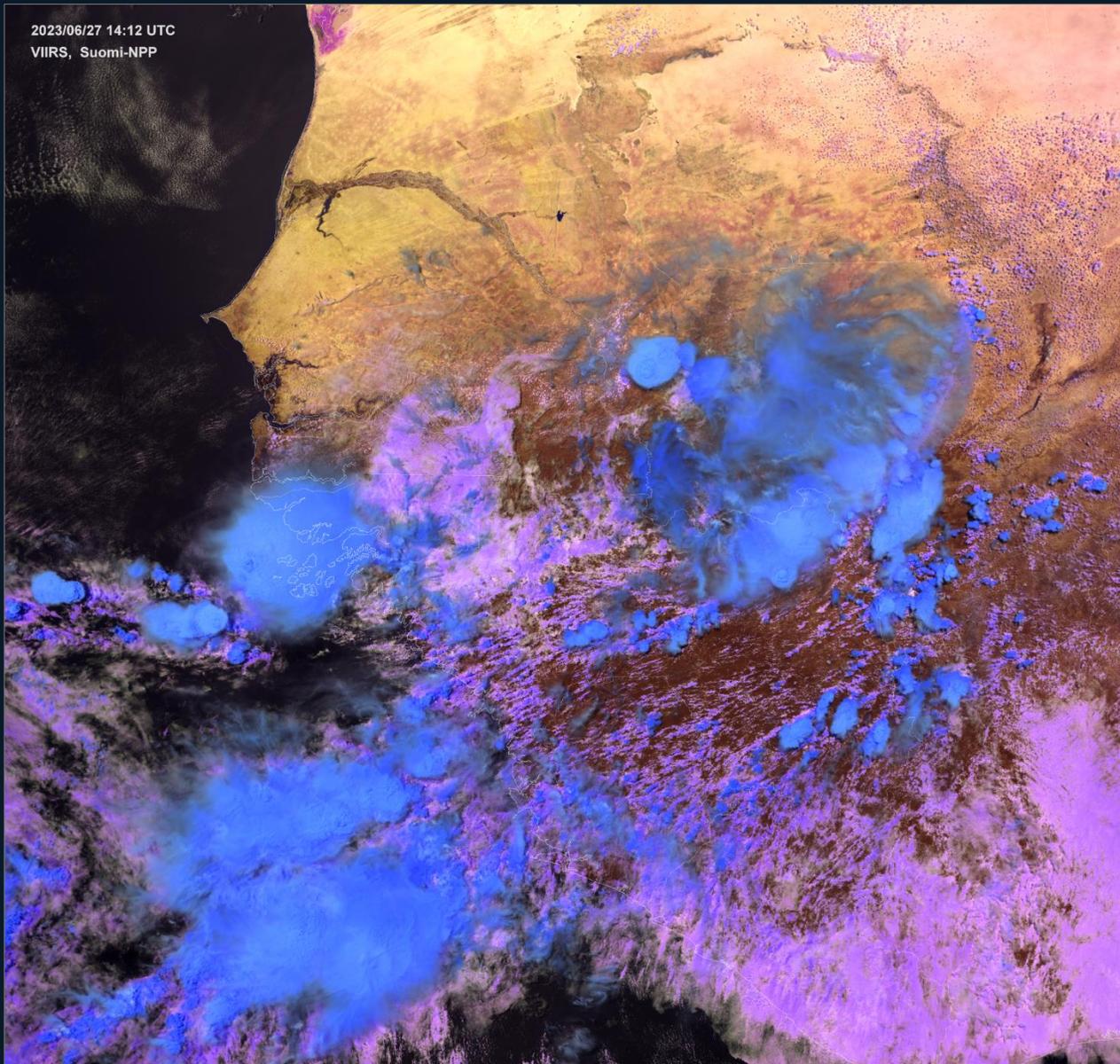
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14.06 UTC)



NIR 1.6
NIR 2.2
VIS 0.6

VIIRS Cloud Phase RGB

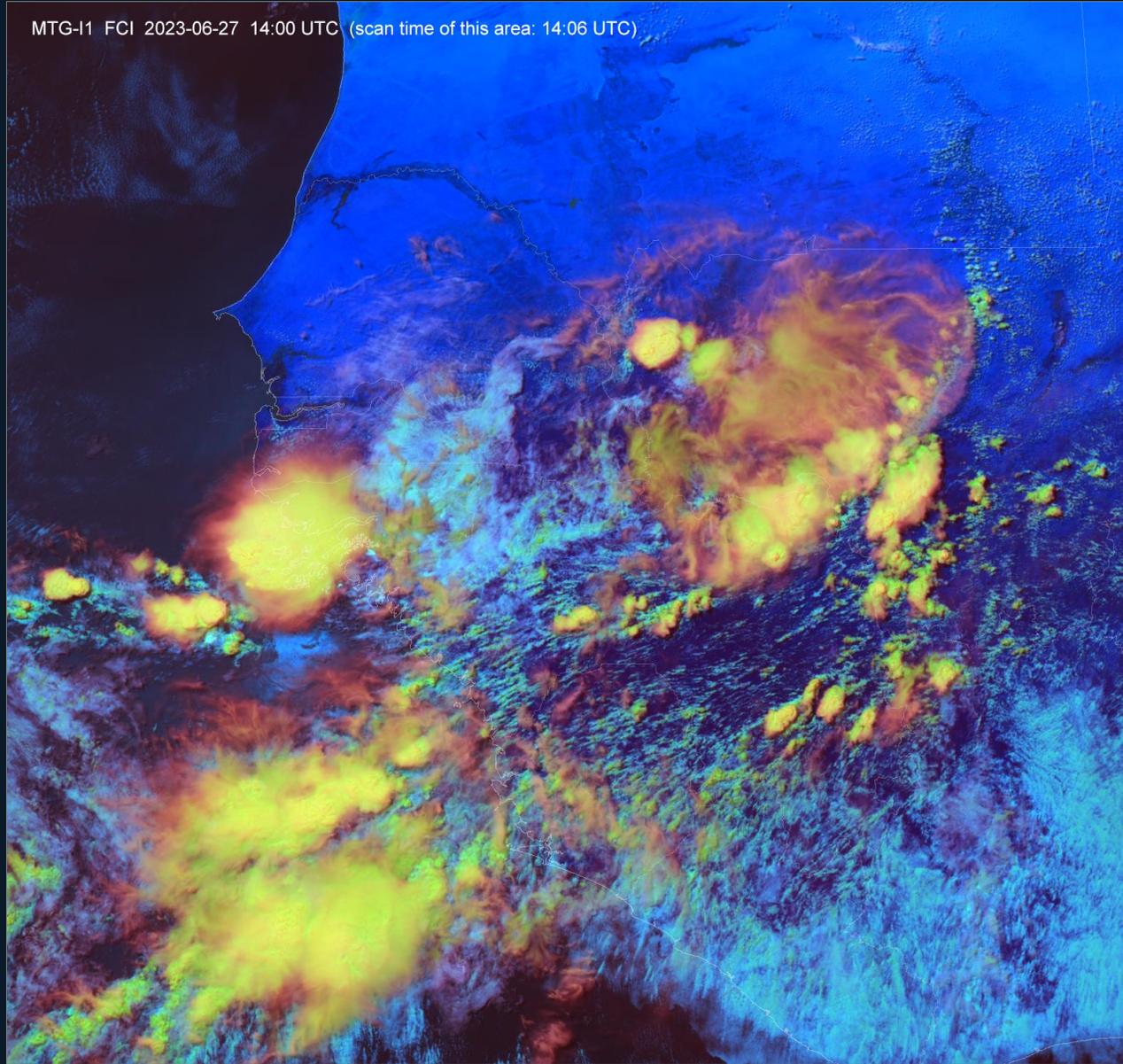
2023/06/27 14:12 UTC
VIIRS, Suomi-NPP



M10 (1.61)
M11 (2.25)
M5 (0.672)

FCI Cloud Phase Distinction RGB

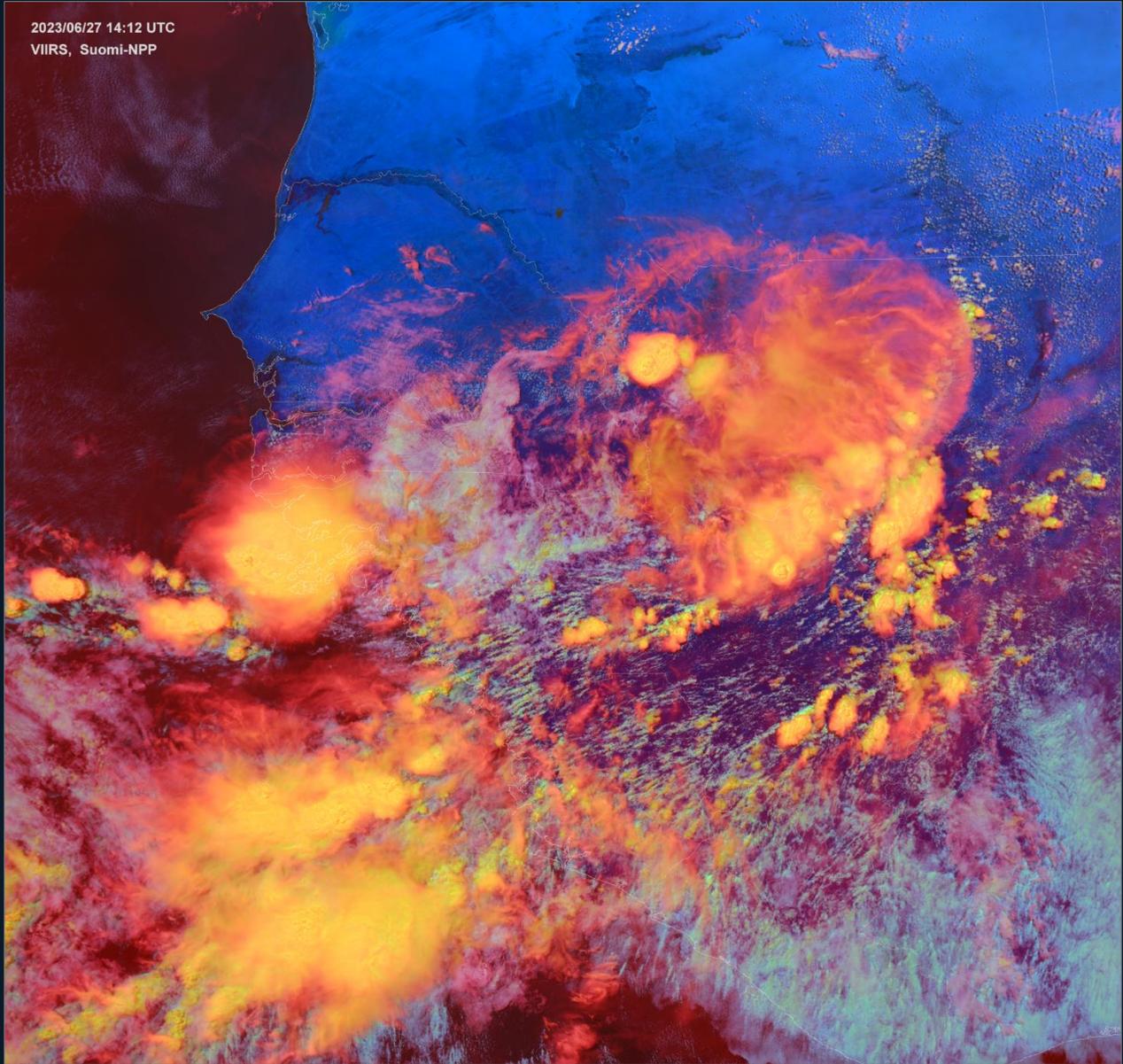
MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



IR 10.5 (inv.)
VIS 0.6
NIR 1.6

VIIRS Cloud Phase Distinction RGB

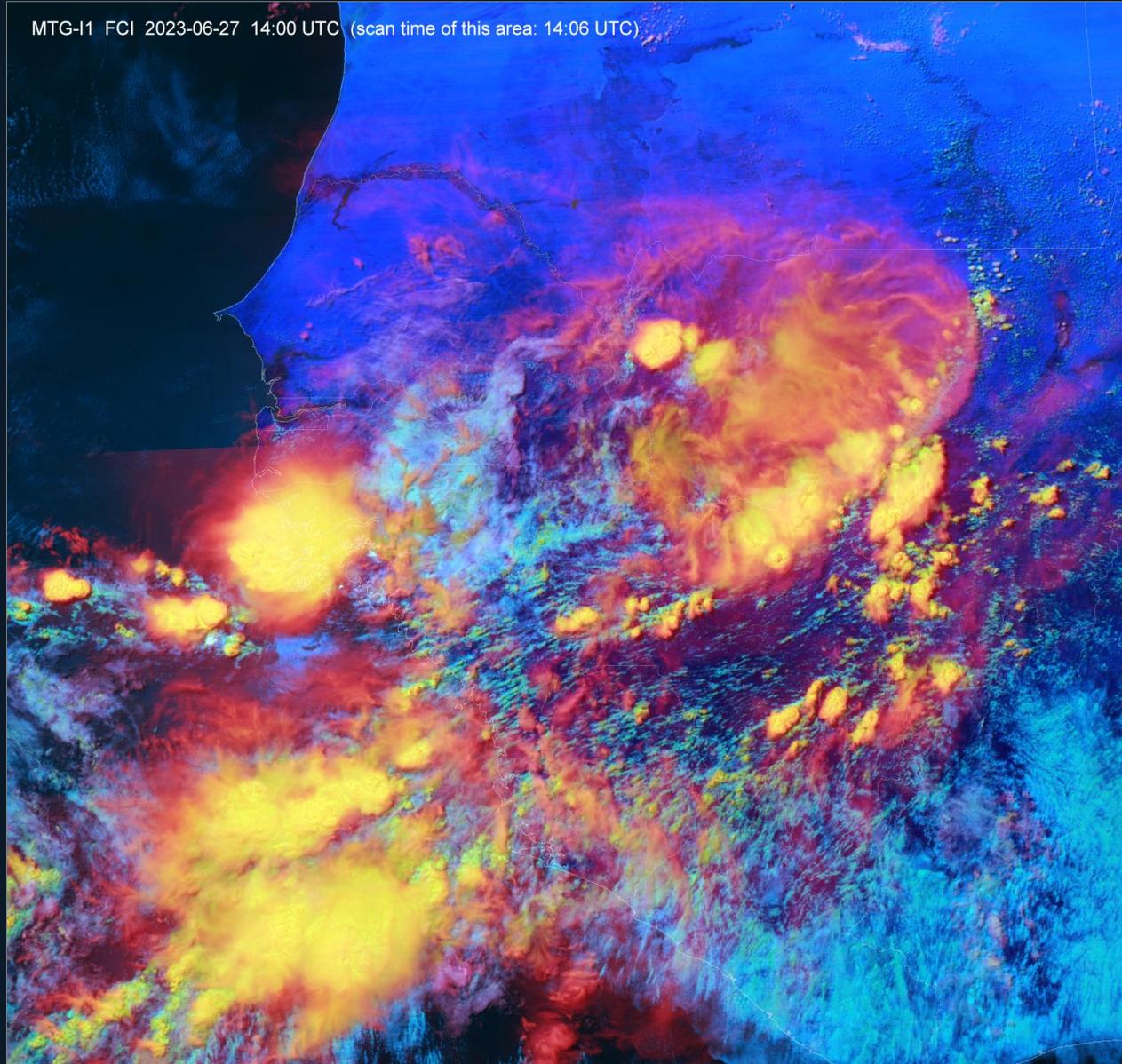
2023/06/27 14:12 UTC
VIIRS, Suomi-NPP



M15 (10.76) (inv.)
M5 (0.672)
M10 (1.61)

FCI Cloud Type RGB

MTG-I1 FCI 2023-06-27 14:00 UTC (scan time of this area: 14:06 UTC)



NIR 1.3
VIS 0.6
NIR 1.6

No Earth Stray Light (ESL) correction applied yet. After applying the ESL correction, the product should perform even better for thin cirrus detection.

VIIRS Cloud Type RGB

2023/06/27 14:12 UTC
VIIRS, Suomi-NPP



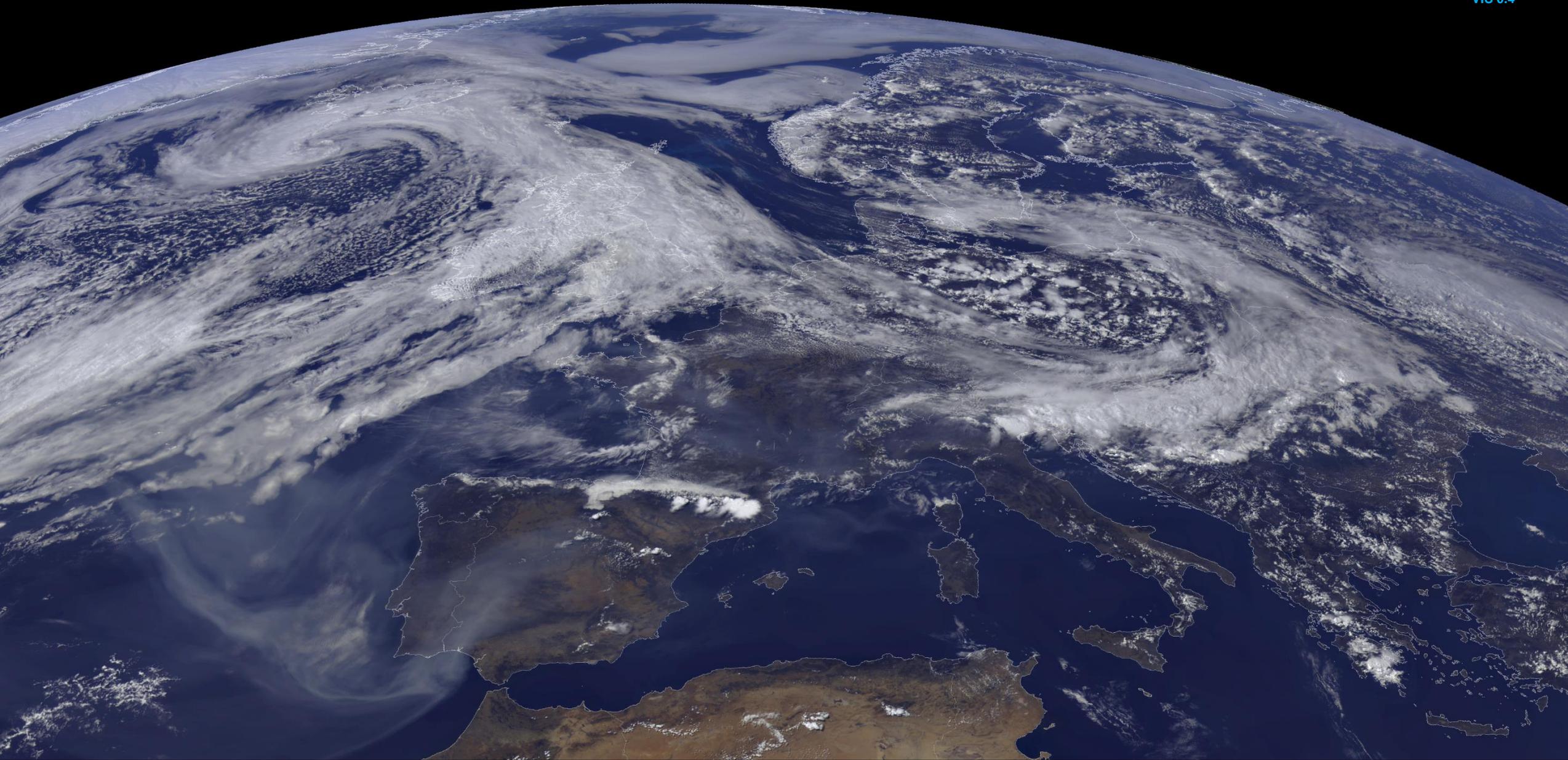
M9 (1.378)
M5 (0.672)
M10 (1.61)

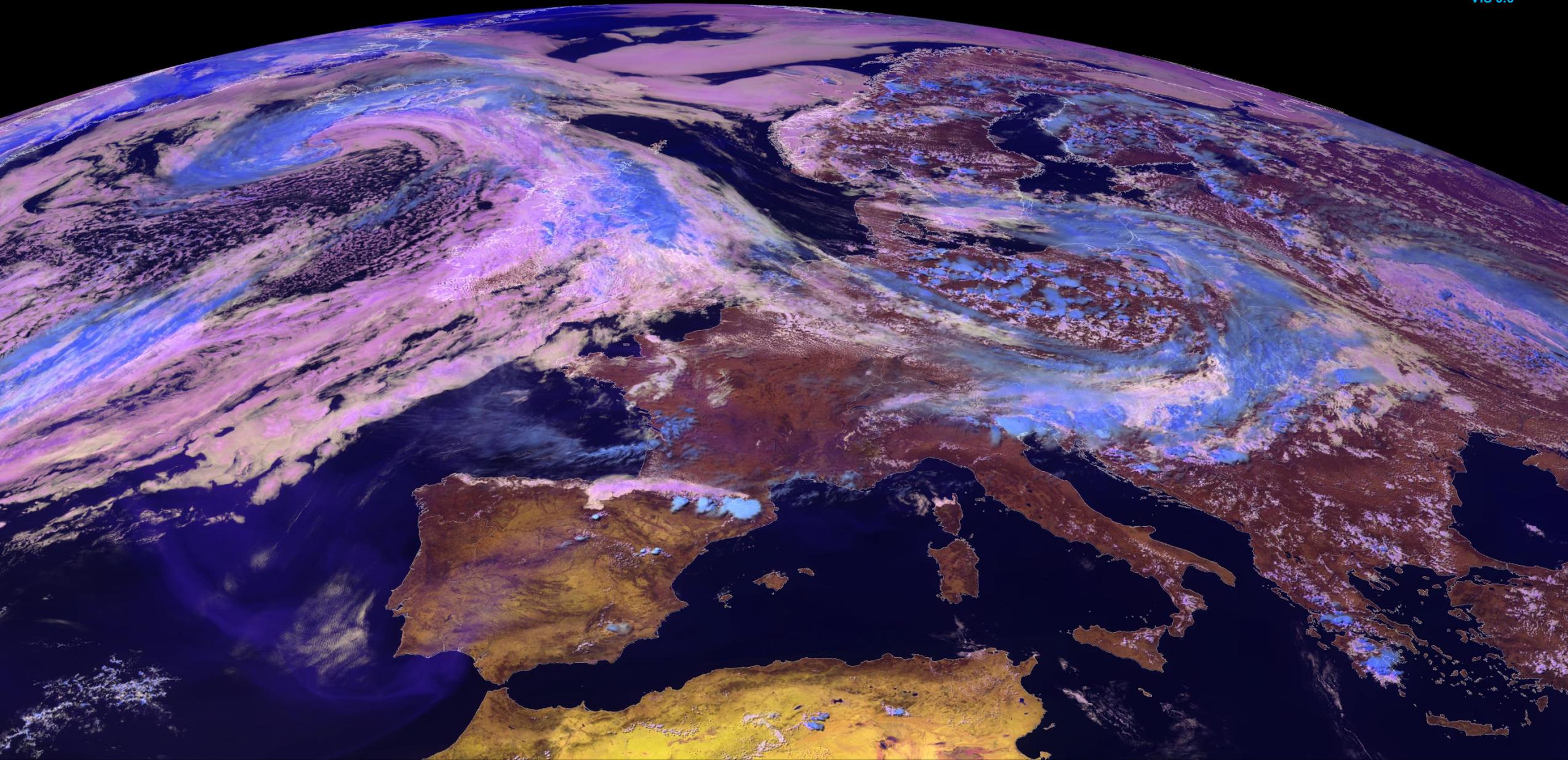
VIIRS M09 band (1.378 μm) is not impacted by stray light, thus performs slightly better in detection of thinnest cirrus clouds.

Case #2 – 2023/06/27, the same data, crop over Europe

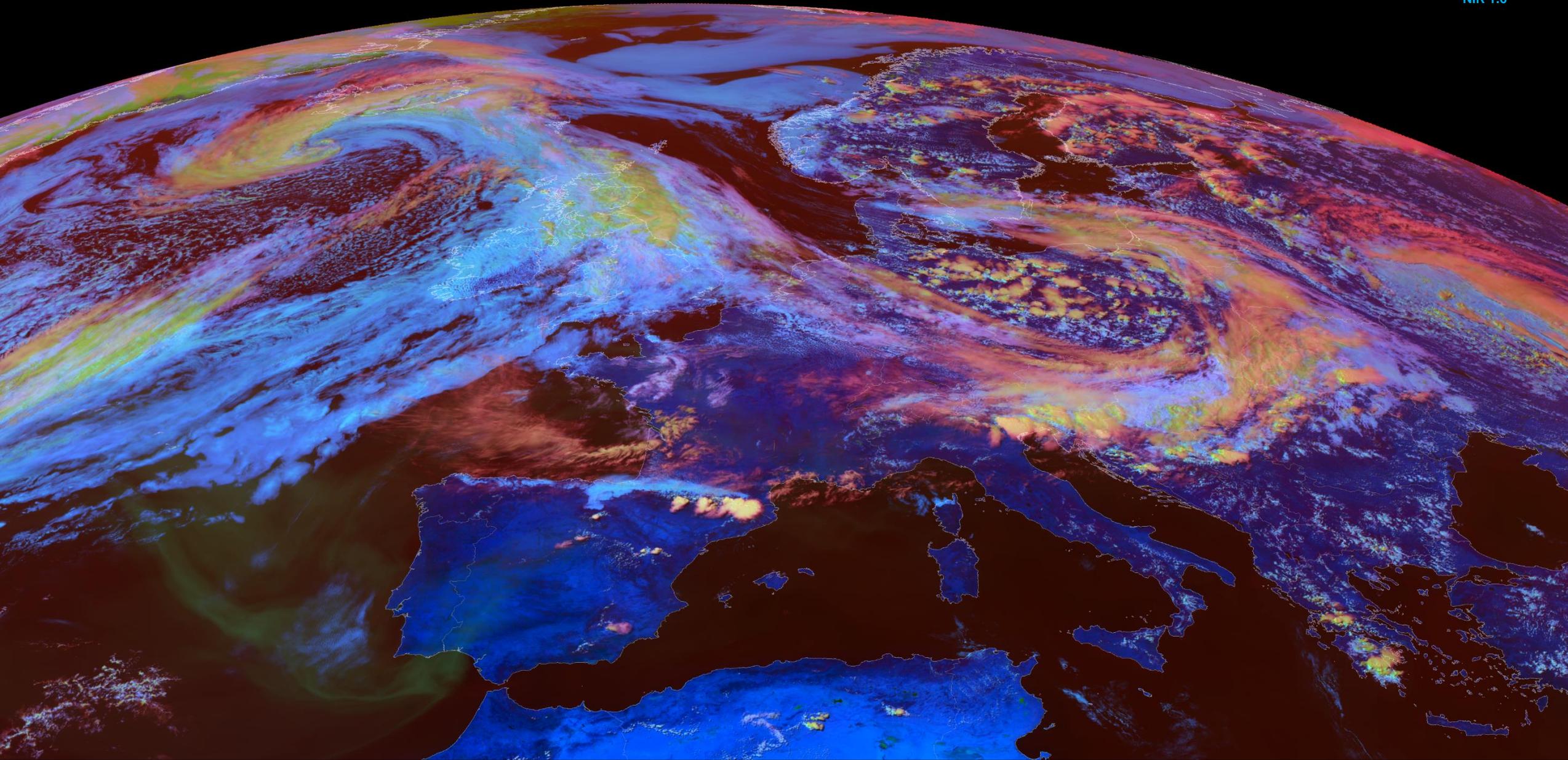
MTG-I1

... scan time ~ 14:08 UTC





Three new RGB products designed for discrimination of high clouds composed of ice – cirrus and cumulonimbus clouds



Three new RGB products designed for discrimination of high clouds composed of ice – cirrus and cumulonimbus clouds



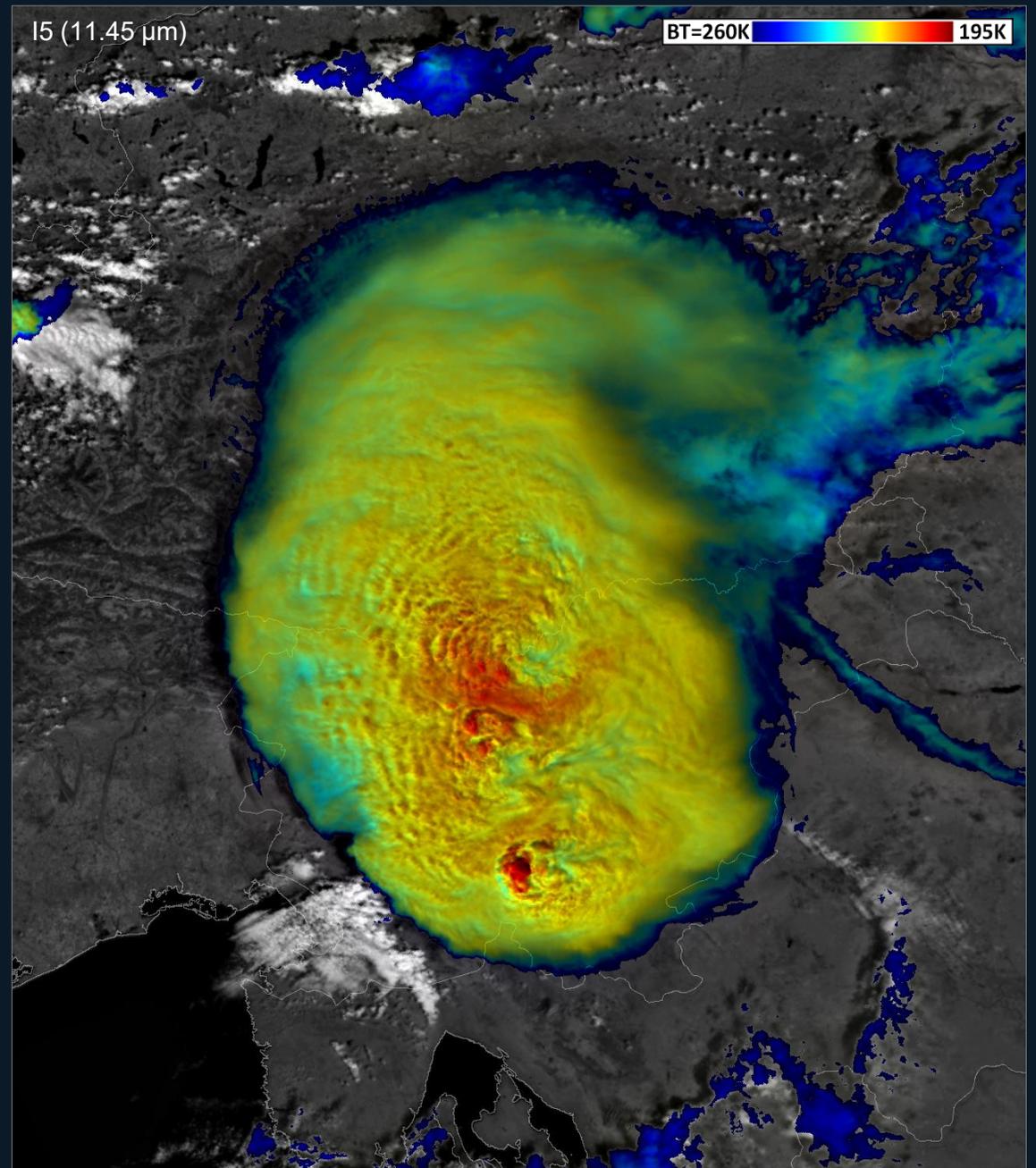
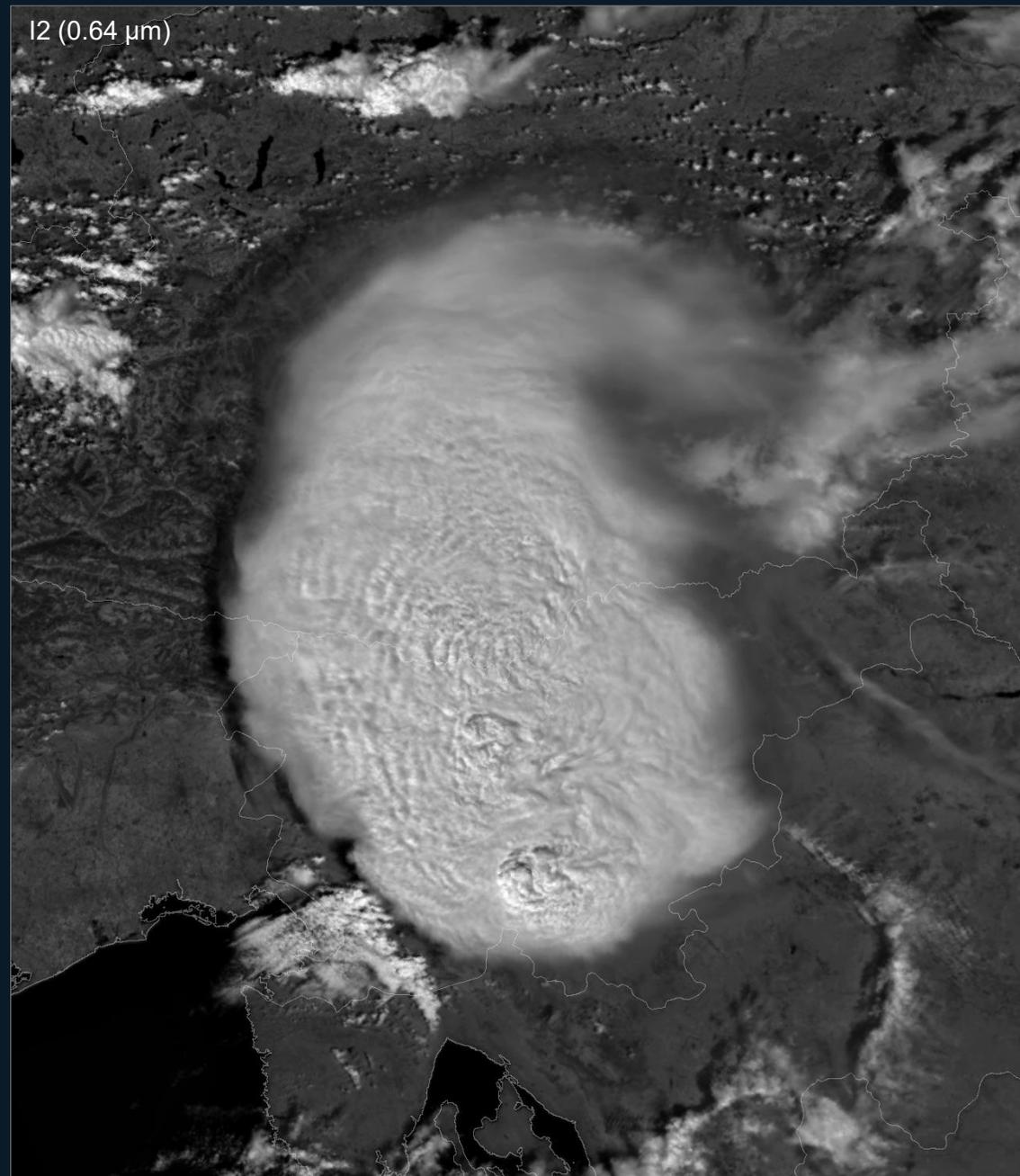
Three new RGB products designed for discrimination of high clouds composed of ice – cirrus and cumulonimbus clouds

Case #3 – 2023/07/19, giant hail producing storms over north Italy, Slovenia and Croatia

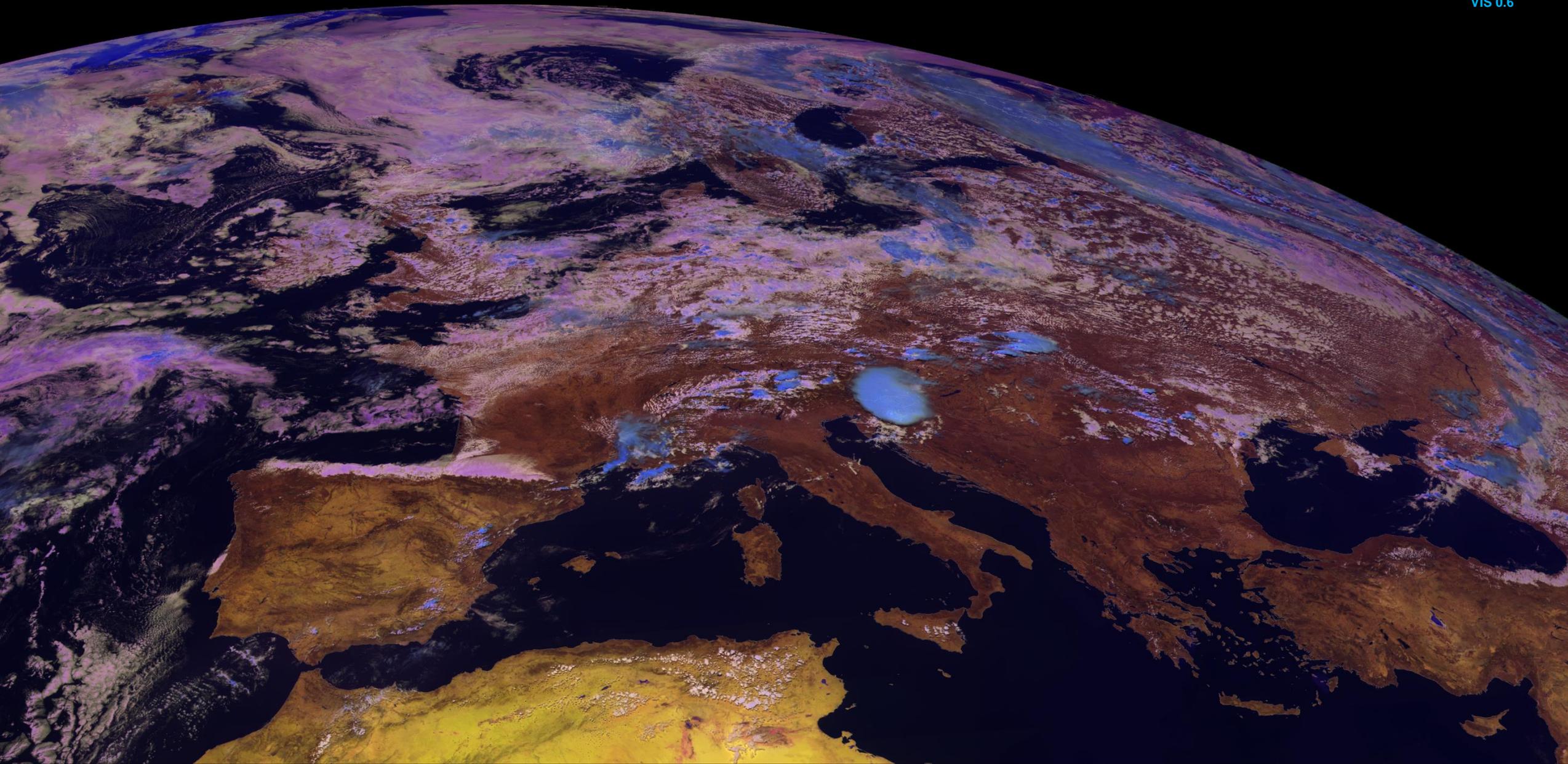
Suomi-NPP	... scan time ~ 12:27 UTC
MTG-I1	... scan time ~ 13:08 UTC
Meteosat-10 (MSG3)	... scan time ~ 13:10 UTC

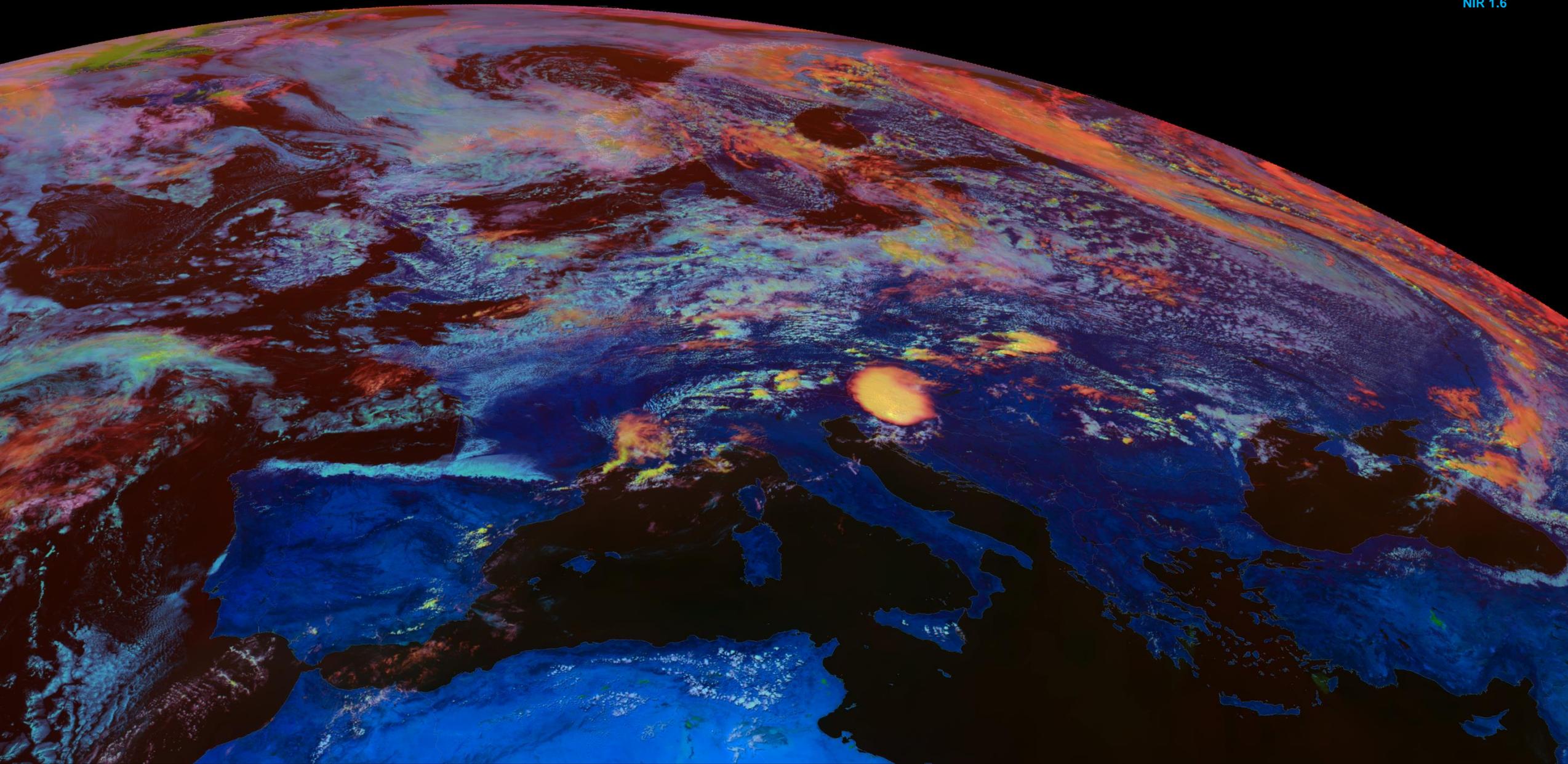
Note: the small scan time differences may reflect rapid evolution of storm tops, namely development of overshooting tops. Therefore some of the differences between MTG-I1 and MSG-3 imagery can account to this factor, and not only to the pixel resolution or slight differences of spectral ranges of some of the bands. In this case, S-NPP preceded the two GEO satellites by about 40 minutes.

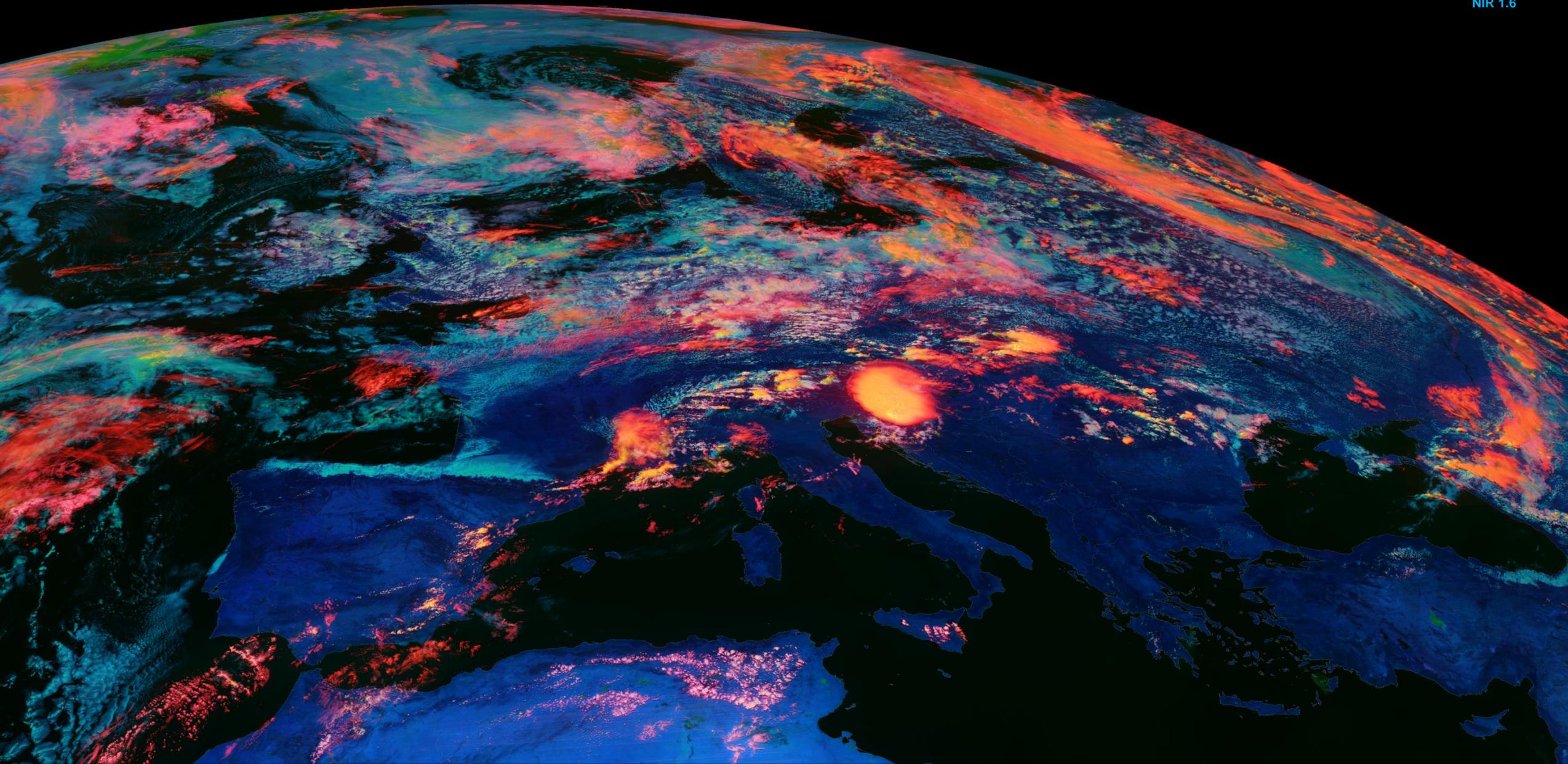
Appearance of the storms in Suomi-NPP VIIRS imagery (375 m I-bands), at 12:27 UTC





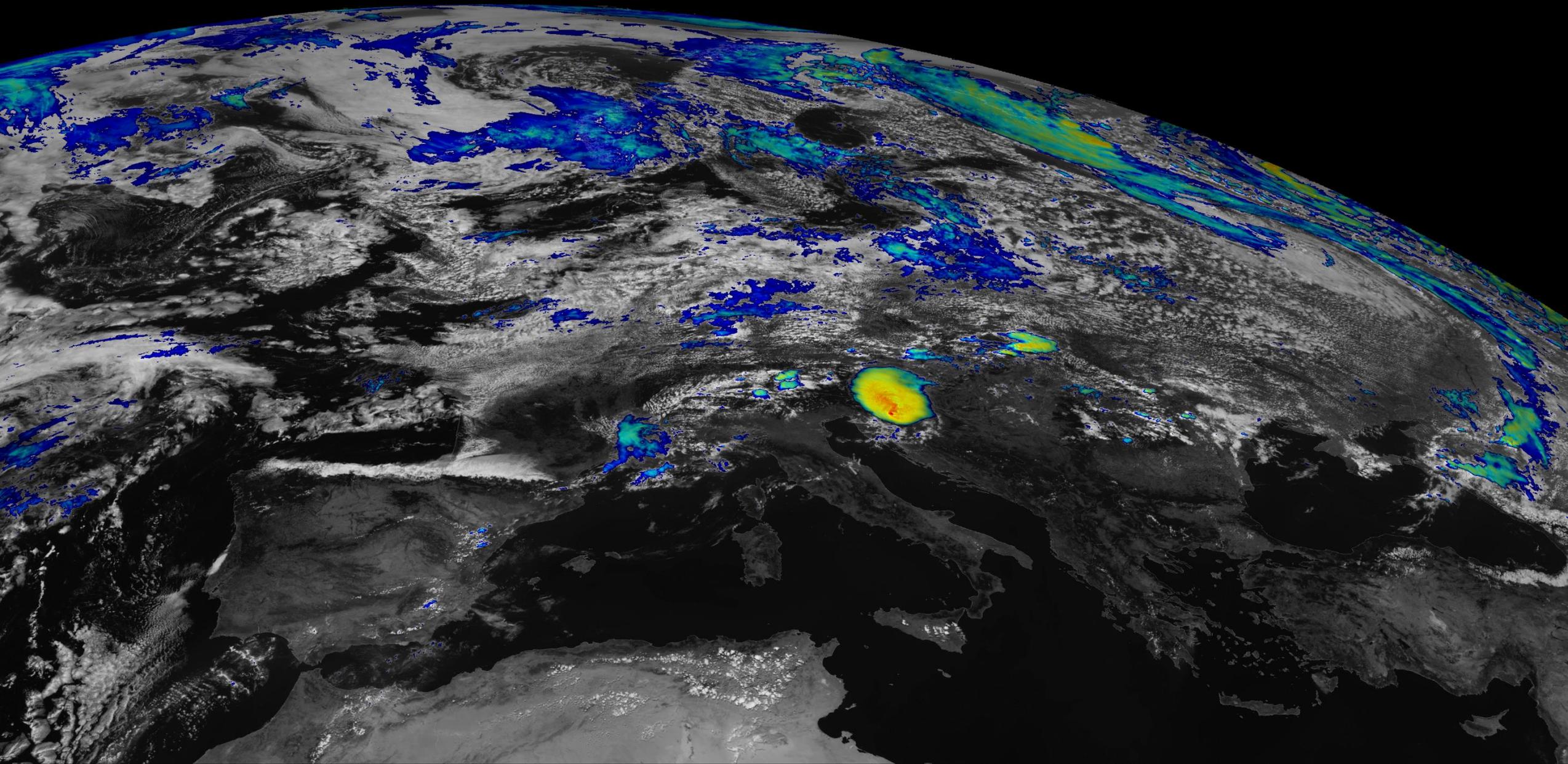






FCI sandwich VIS 0.6 and IR 10.5 BT 200 – 260 K

BT=260K  200K



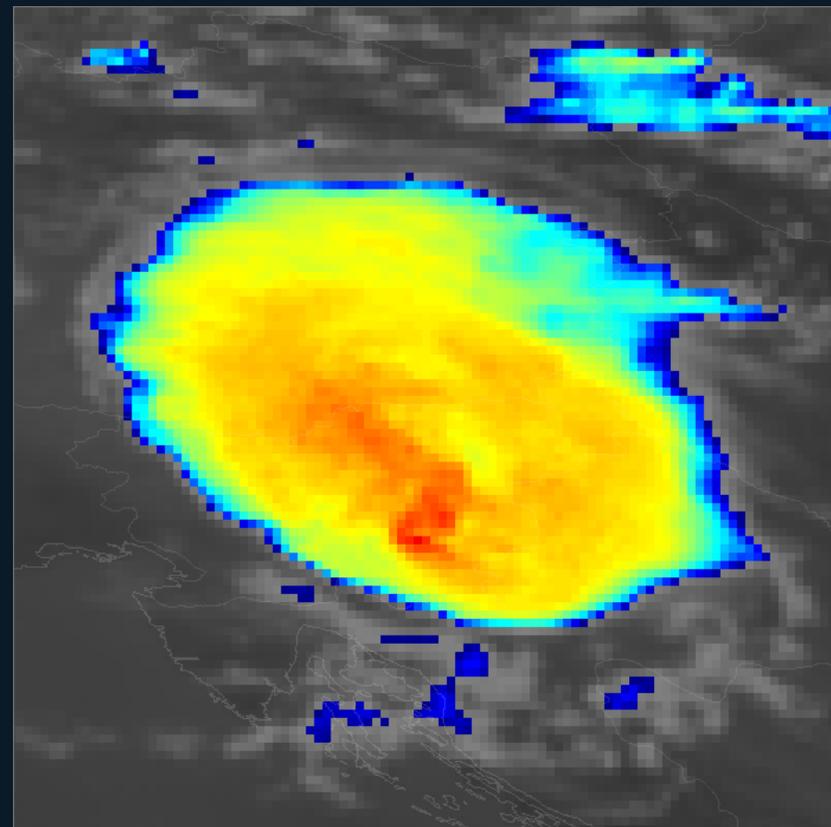
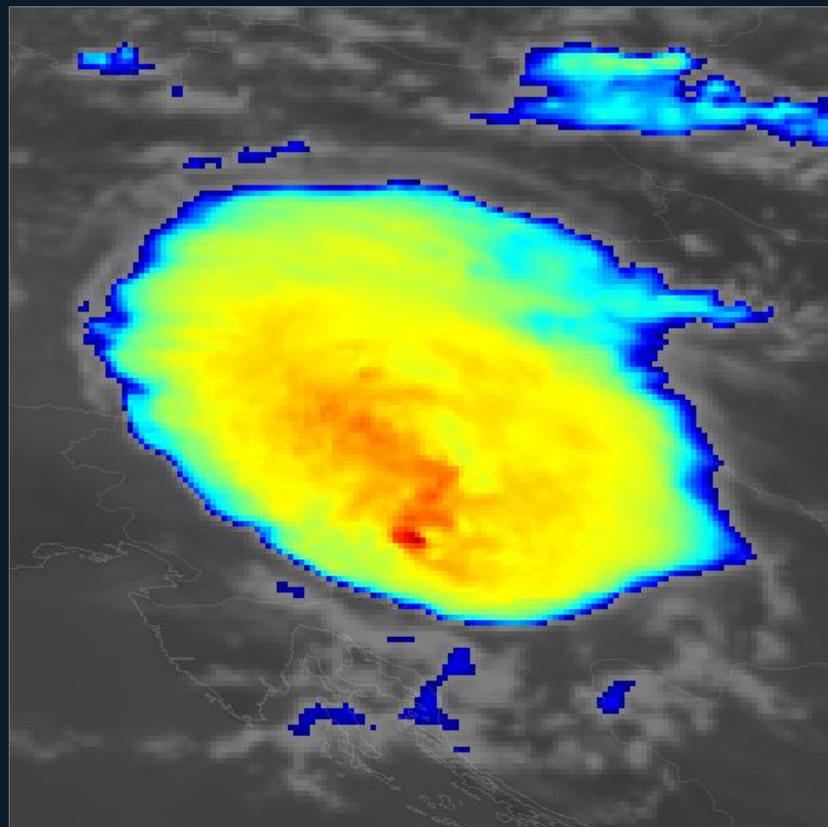
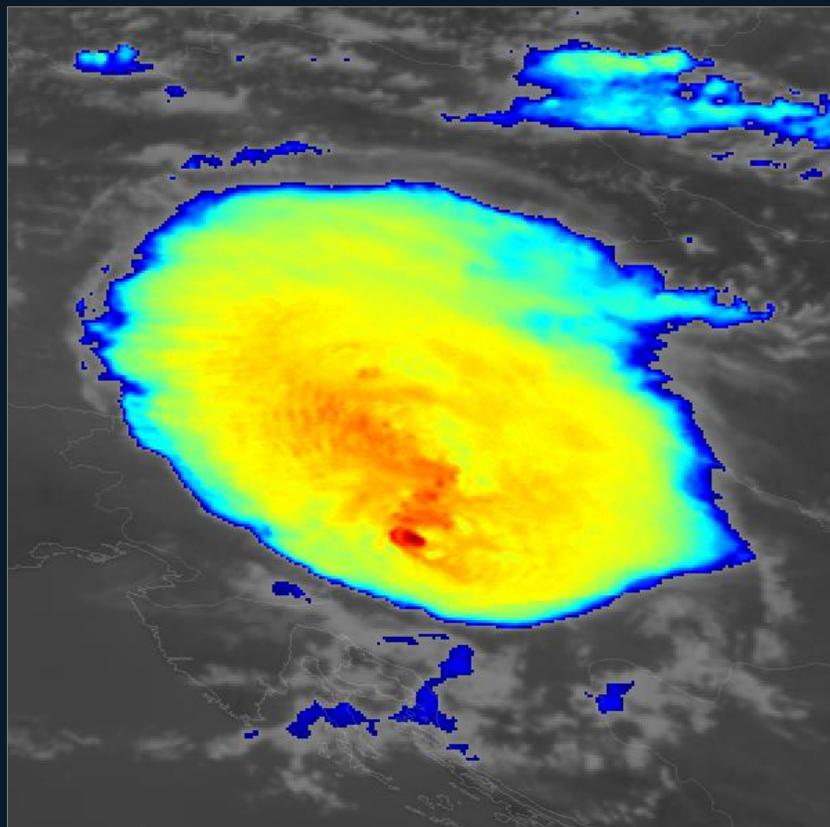
IR bands



FCI HR (1 km) IR 10.5, $BT_{\min} = 201.6$ K

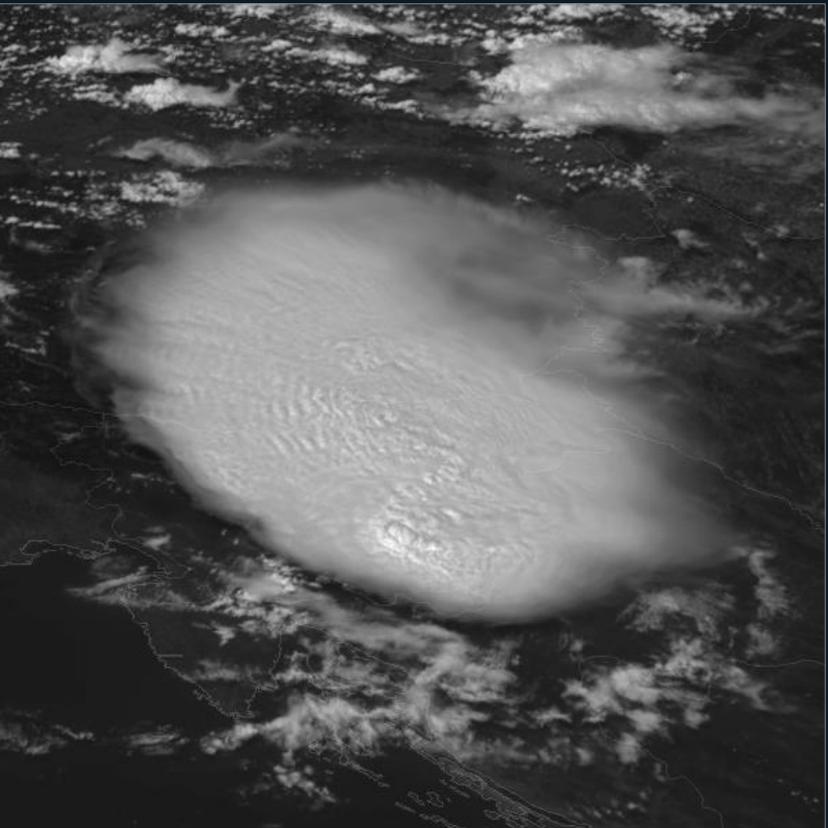
FCI NR (2 km) IR 10.5, $BT_{\min} = 203.0$ K

SEVIRI (3 km) IR 10.8, $BT_{\min} = 206.8$ K

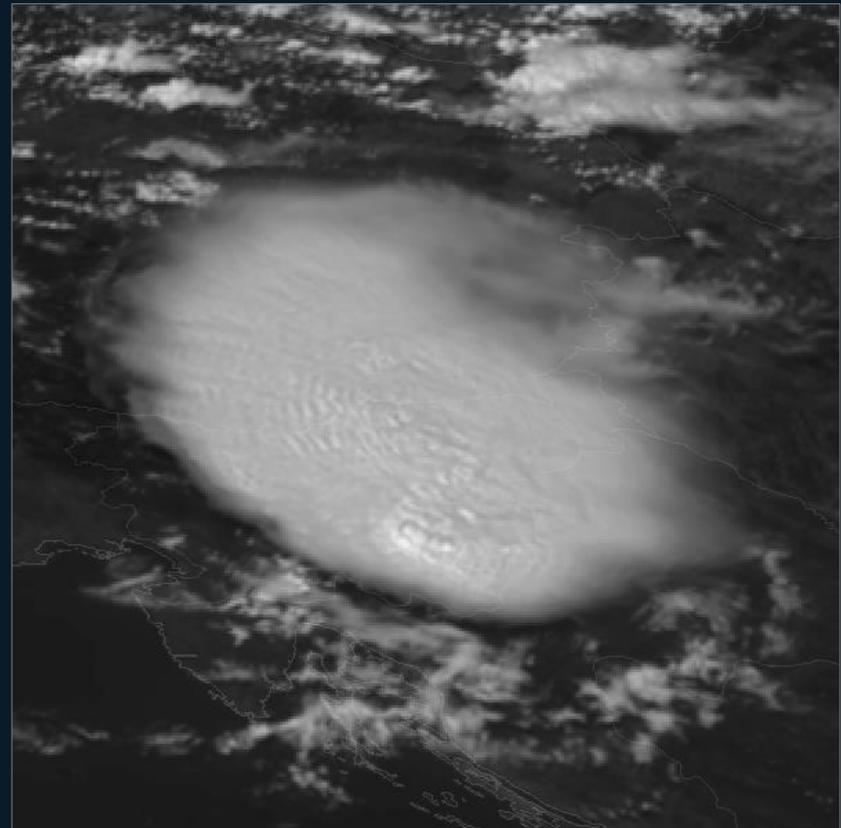


VIS bands

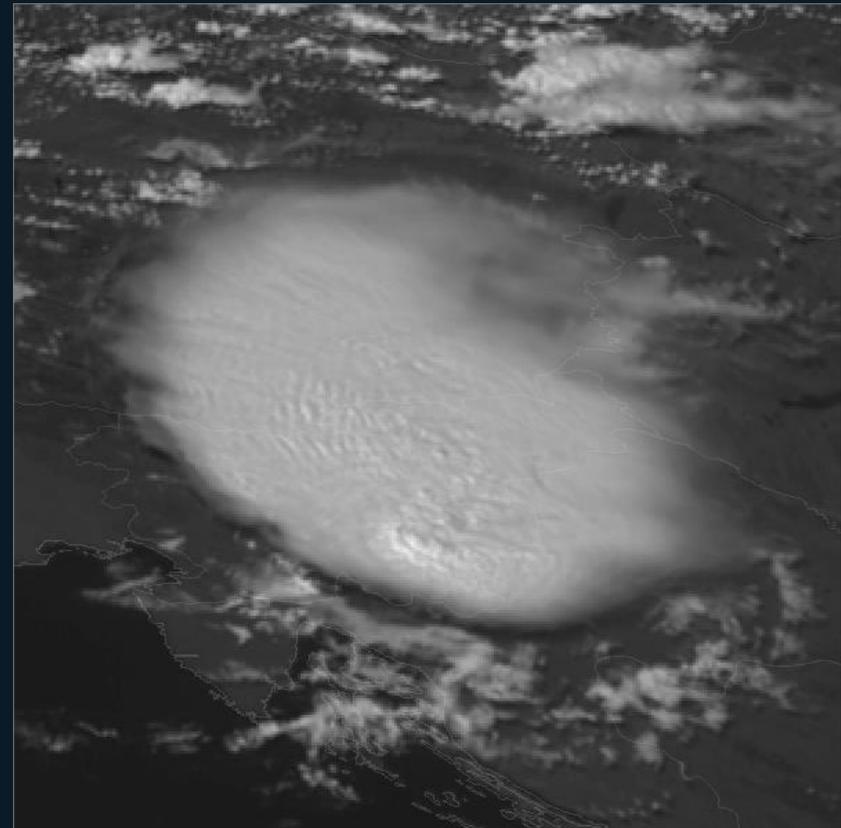
FCI HR (0.5 km) VIS 0.6



FCI NR (1 km) VIS 0.6



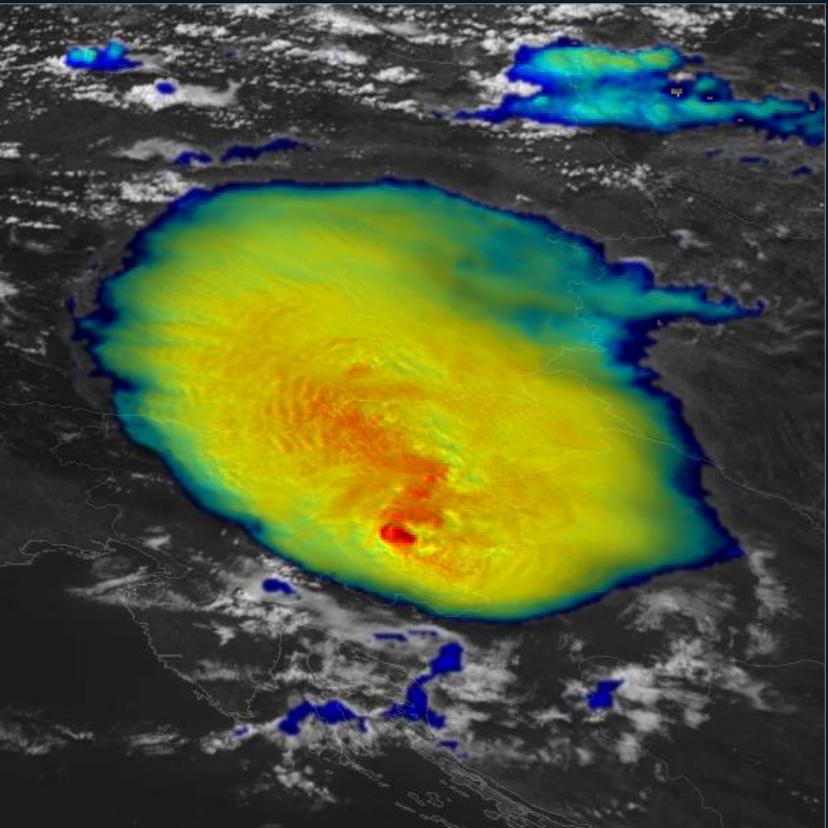
SEVIRI (1 km) HRV



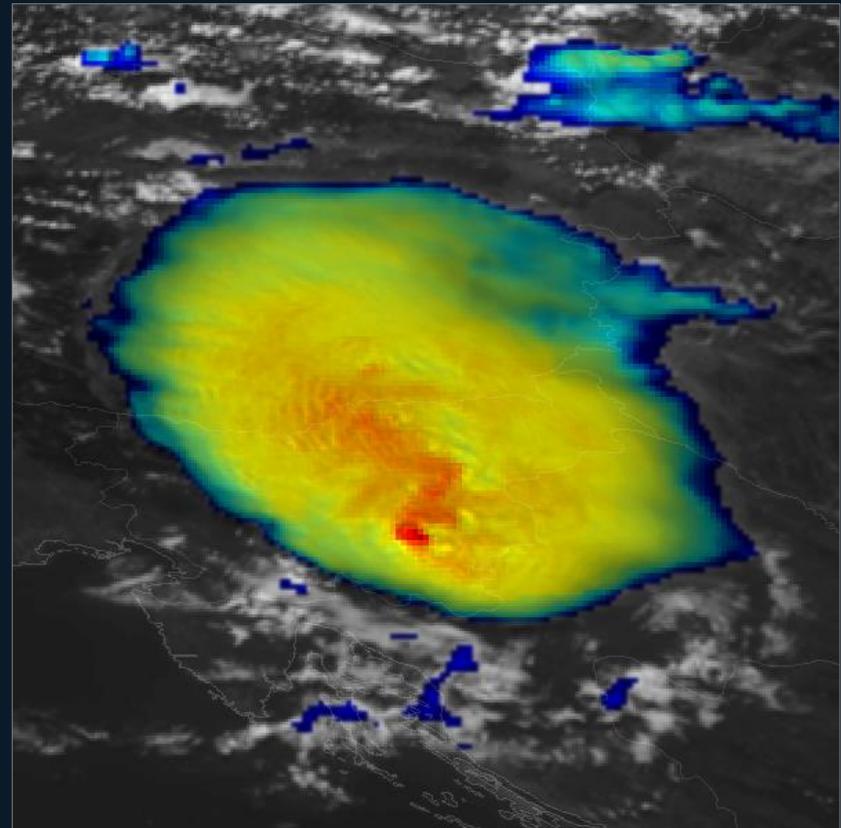
Sandwich product of VIS and IR bands



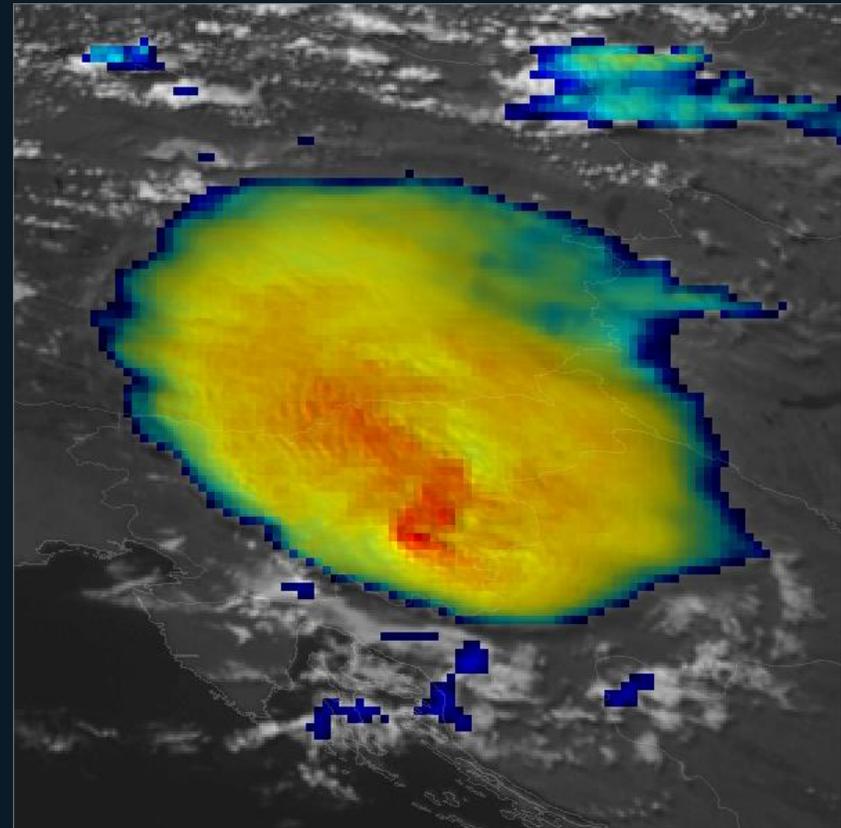
FCI HR sandwich VIS 0.6 (0.5 km) & IR 10.5 (1 km)



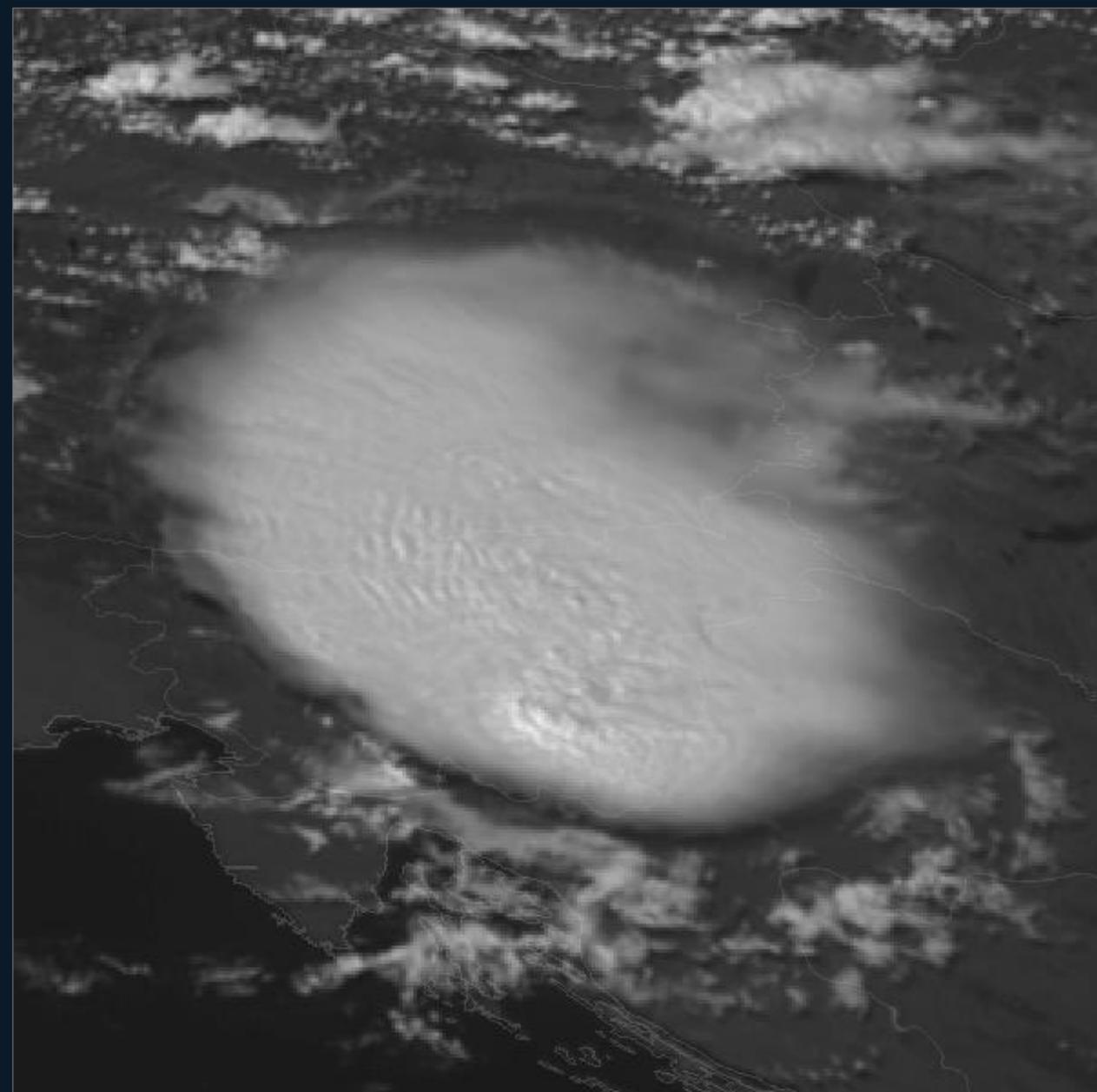
FCI NR sandwich VIS 0.6 (1 km) & IR 10.5 (2 km)



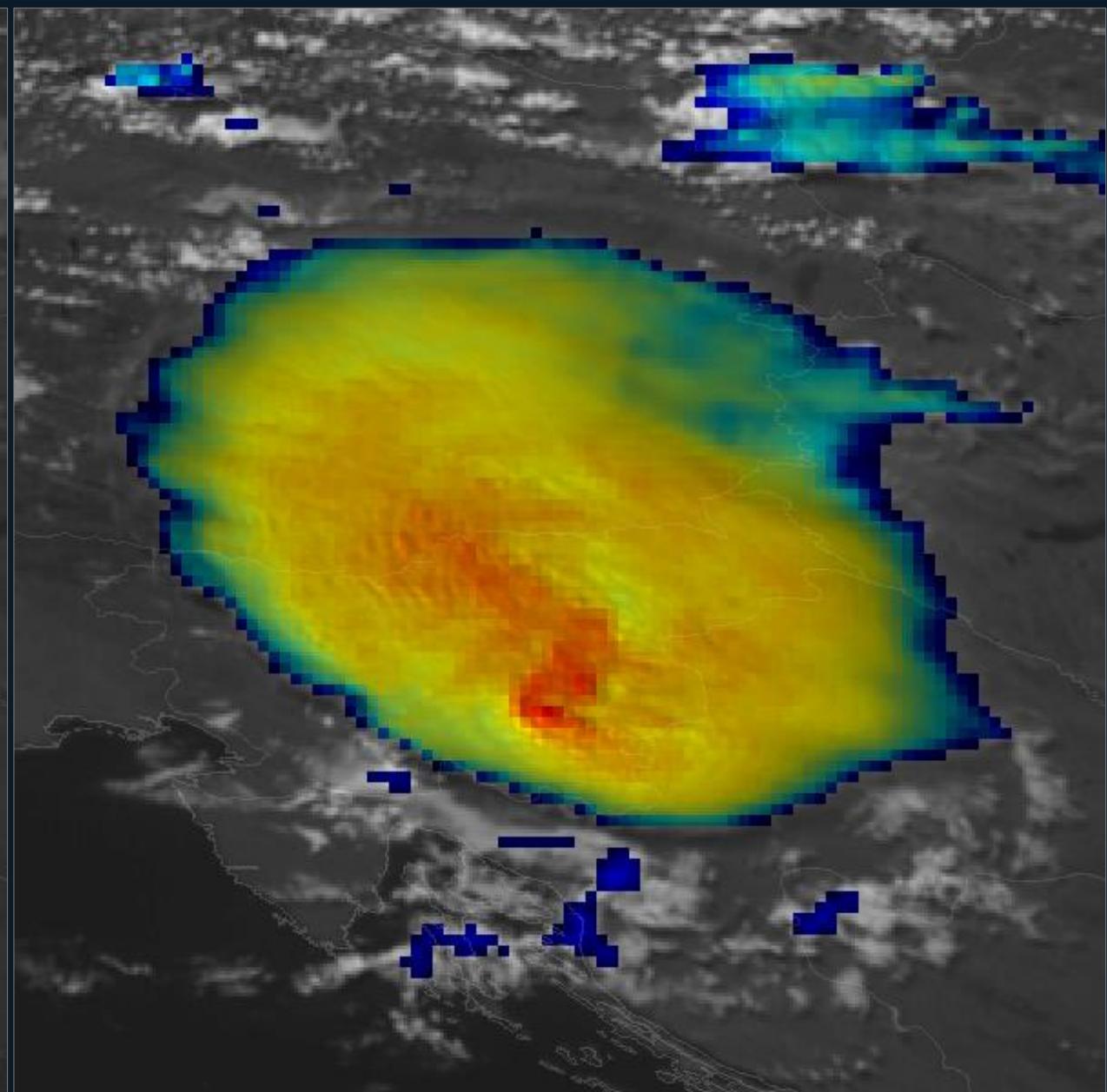
SEVIRI sandwich HRV (1 km) & IR 10.8 (3 km)



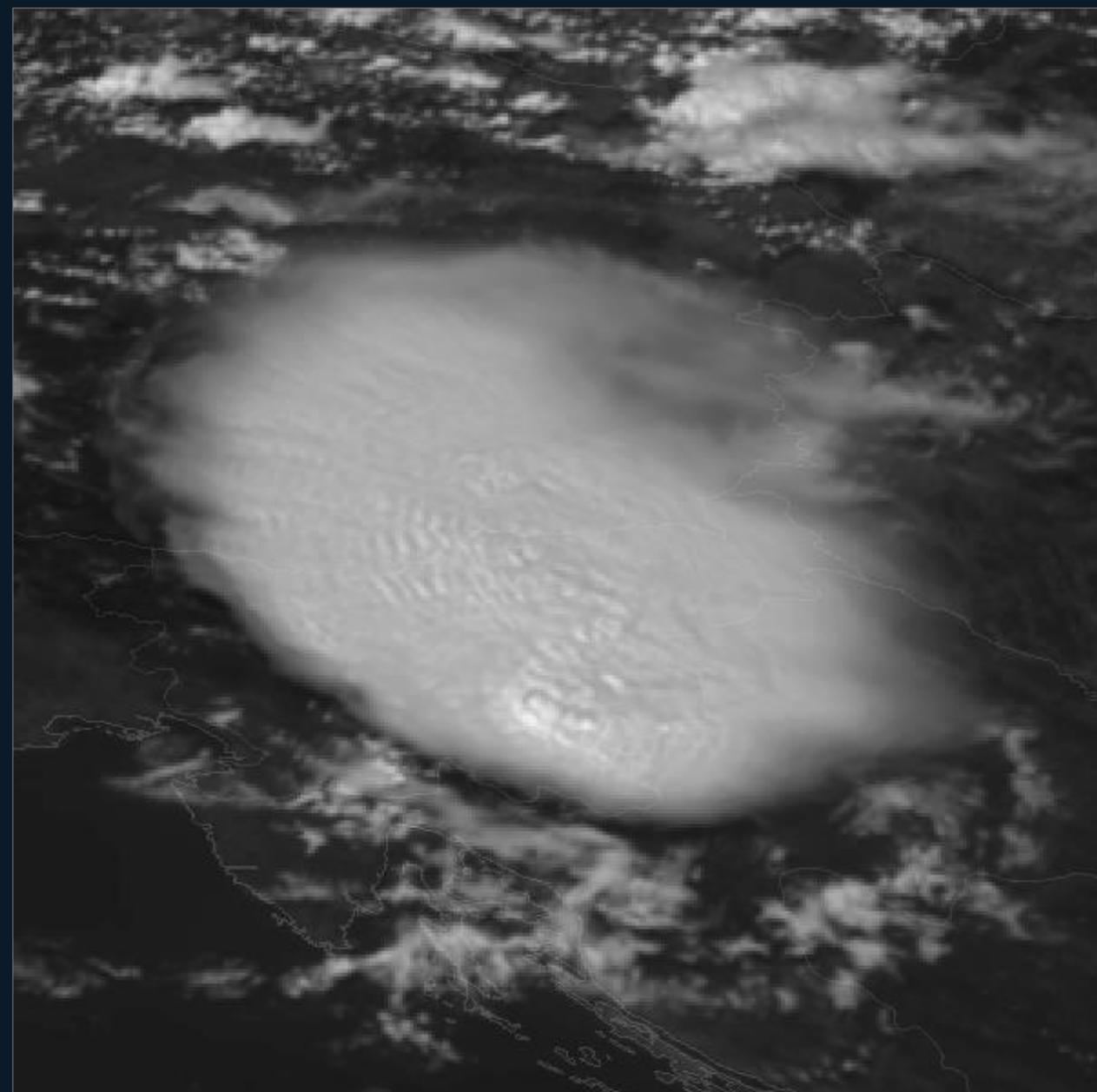
SEVIRI HRV (1 km)



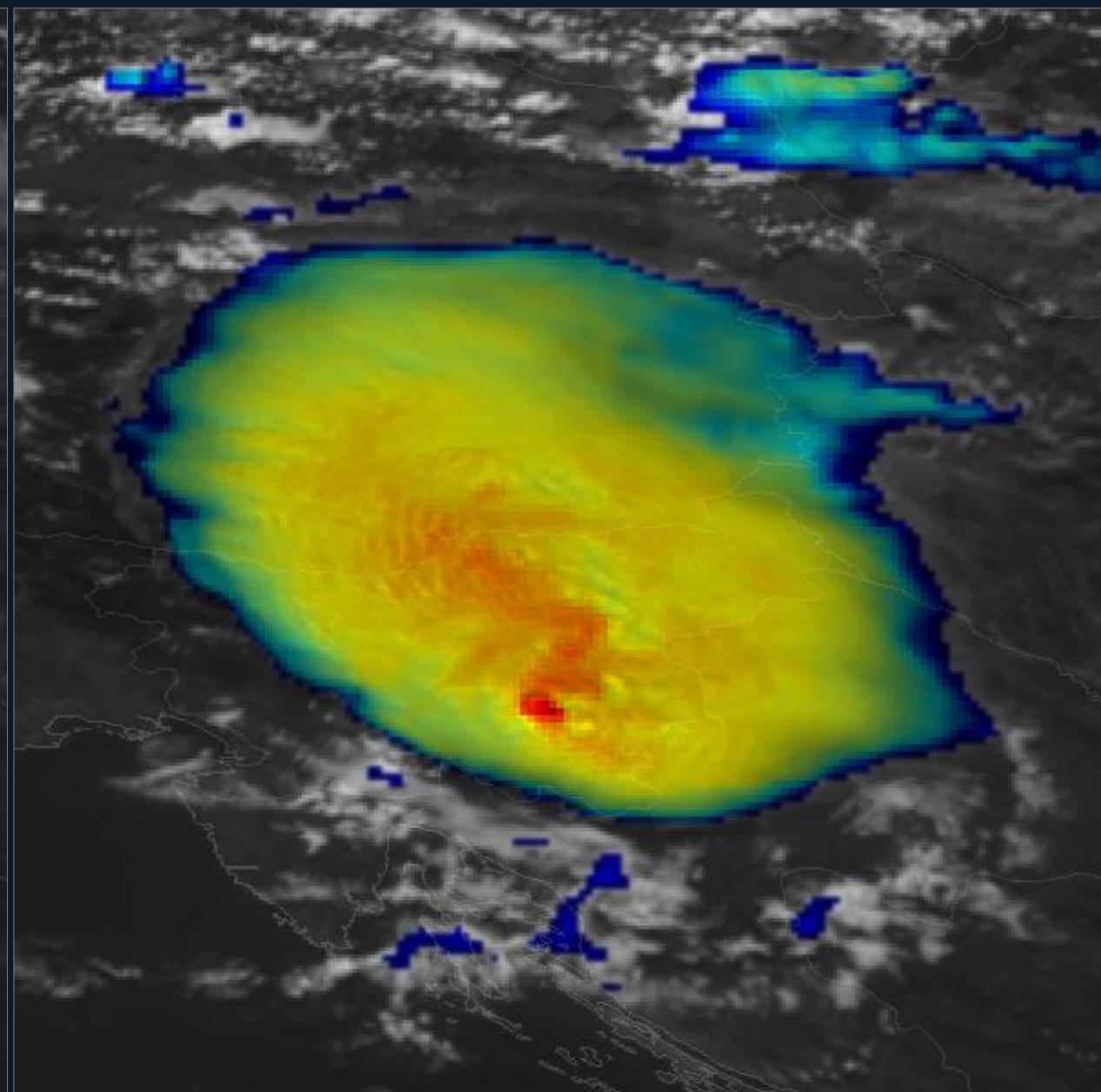
SEVIRI sandwich HRV (1 km) & IR 10.8 (3 km)



FCI NR (1 km) VIS 0.6

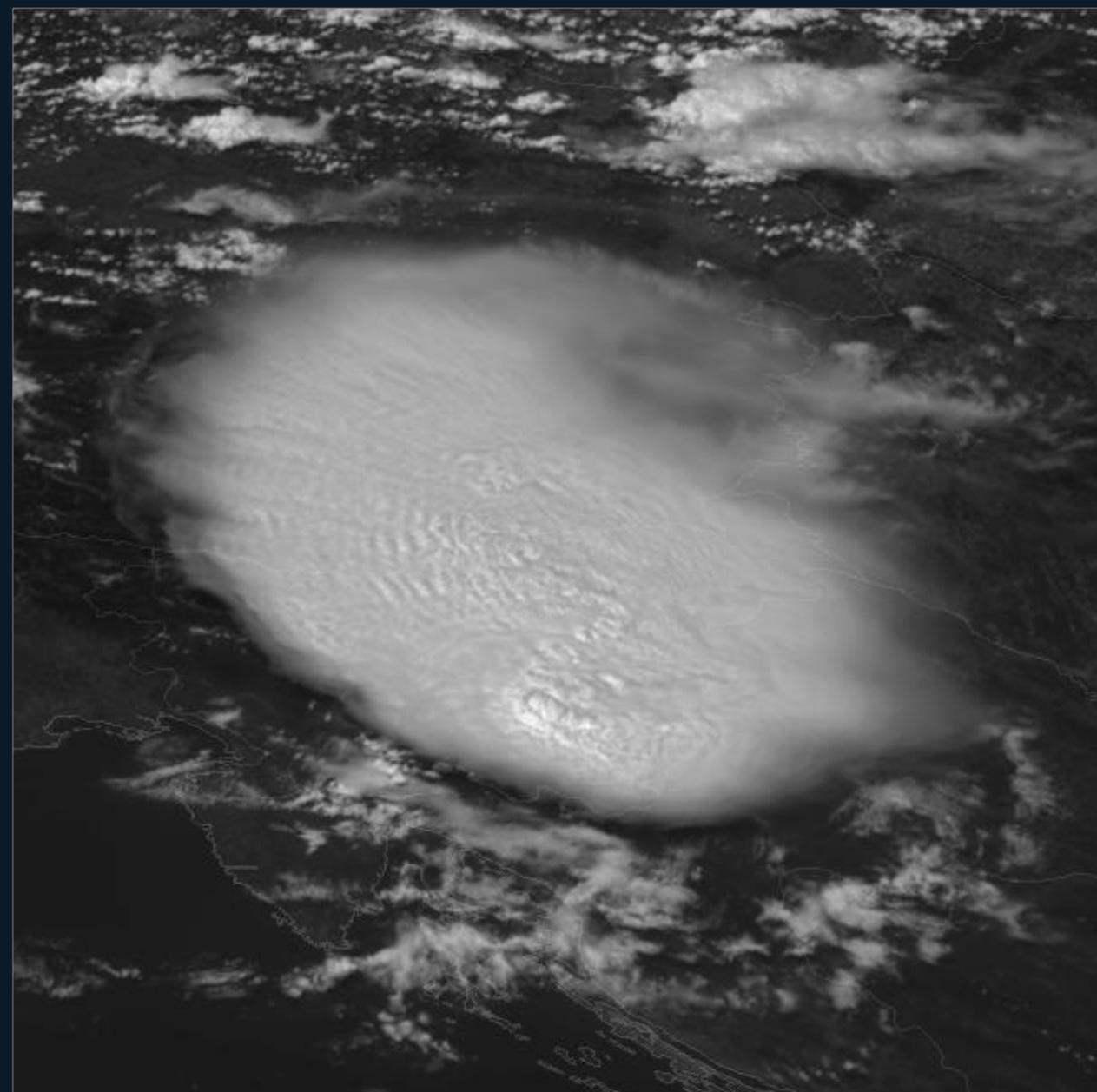


FCI NR sandwich VIS 0.6 (1 km) & IR 10.5 (2 km)

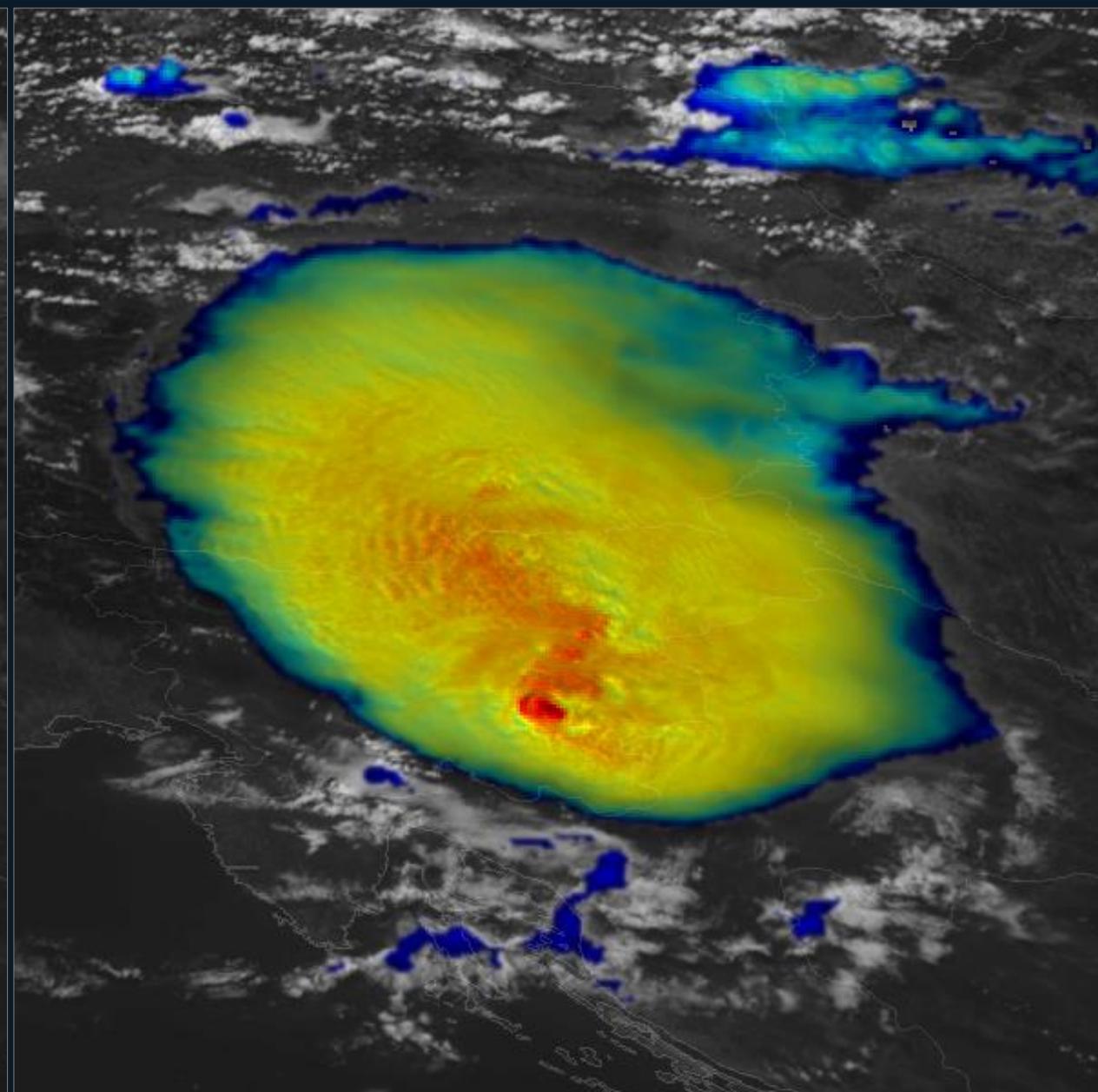


BT=260K  200K

FCI HR (0.5 km) VIS 0.6



FCI HR sandwich VIS 0.6 (0.5 km) & IR 10.5 (1 km)



BT=260K 200K

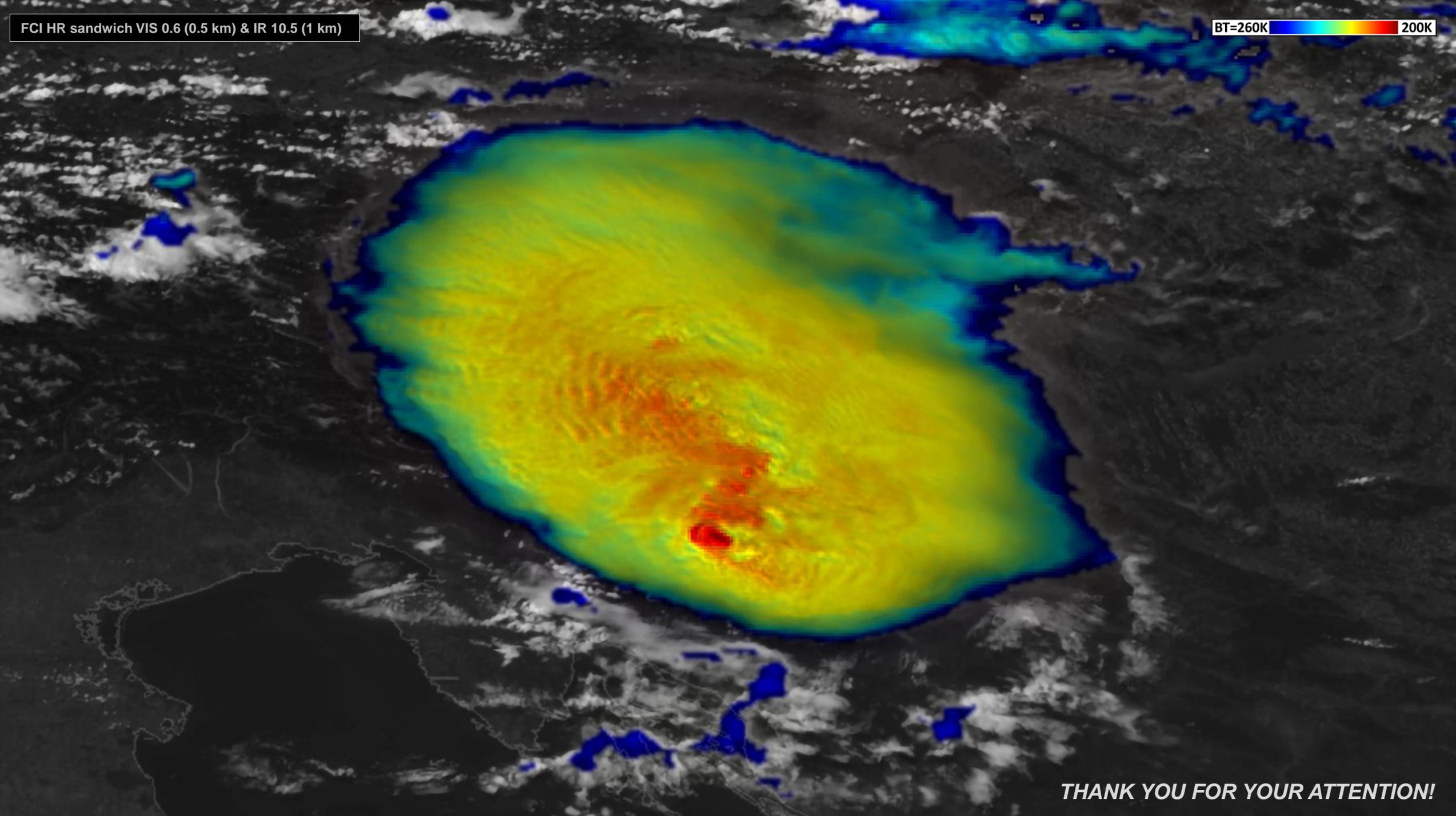
SUMMARY:

- Despite the commissioning status of the data and some issues still to be carried out, the quality of images and derived RGB and sandwich products is excellent, fully meeting the expectations;
- other RGB and sandwich image products will be tested later, after IDPF upgrade to its final operational version;
- FCI image products comparable to those from VIIRS M-bands;
- namely for monitoring and nowcasting of convective storms, the HR data provide much more detailed information about structure of the storm tops, as compared to FCI NR and SEVIRI data.

Big acknowledgements to EUMETSAT for provision of these FCI commissioning data for this presentation!

FCI HR sandwich VIS 0.6 (0.5 km) & IR 10.5 (1 km)

BT=260K 200K



THANK YOU FOR YOUR ATTENTION!