Storms of 11 July 2016

11:00 – 17:00 UTC

Meteosat-9 (MSG-2) SEVIRI RSS data

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Prepared for purposes of the **Baltic+2017** course,
organized by the Lithuanian Hydrometeorological Service (LHMS),
in cooperation with EUMETSAT

The following PPT sequence shows evolution of convective storms (some of them severe) in the area of north-east Poland, Lithuania, Kaliningrad region of Russia, and north-west part of Belarus, as captured by the Meteosat-9 (MSG-2) satellite on 11 July 2016 between 11:00 – 17:00 UTC, in RSS (Rapid Scan Service) mode.

This PowerPoint/PDF document shows full evolution of these storms, at 5-minute intervals, with comments at the bottom of selected slides, addressing some of the most interesting or important storm-top features or evolution stages of these storms. To see all the fine details of the storm tops, it is highly recommended to follow this material on larger screens or monitors.

For basic understanding of what you can see in these images in various bands or image products, as well as associated image loops (movie files), please read first a tutorial Basics of operational monitoring and nowcasting of convective storms using satellite imagery.

After reading the tutorial above, proceed next with this PPT/PDF material, and afterwards view the evolution of these storms in various image product loops, linked on the next slide (and repeated at the end of this PPT presentation). Or even better, you can view the movie files first, next read this PPT/PDF material, and afterwards return to the movie files again, to check your progress in understanding of what you can see in those movie files, your interpretation of these. Enjoy!

Stand-alone (single bands or image products) animations:

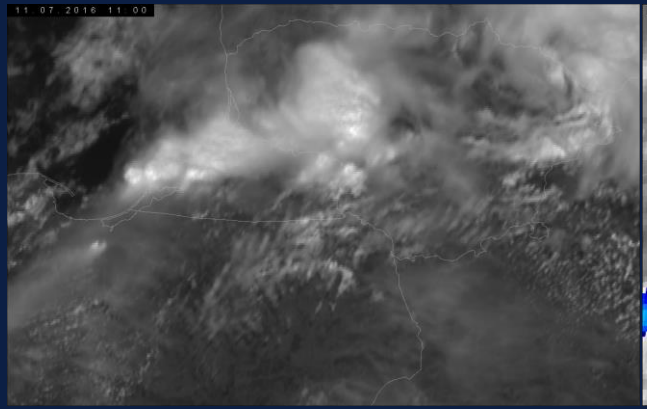
- HRV band [Local or Vimeo]
- Color-enhanced IR10.8 band (BT 203-243K) [Local or Vimeo]
- Near-IR 1.6 µm band [Local or Vimeo]
- IR 3.9 µm band (displayed as "radiance image") [Local or Vimeo]

- (Convective) Storm RGB image product [Local or Vimeo]

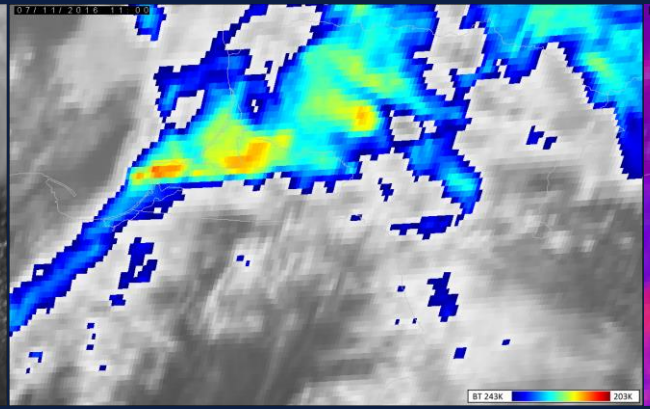
- Sandwich image product of bands HRV and color-enhanced IR10.8 [Local or Vimeo]
- Sandwich image product of band HRV and Storm-RGB image [Local or Vimeo]

Please note that the “local” links above are valid only if you have the original movie files stored locally in a /movies subfolder.

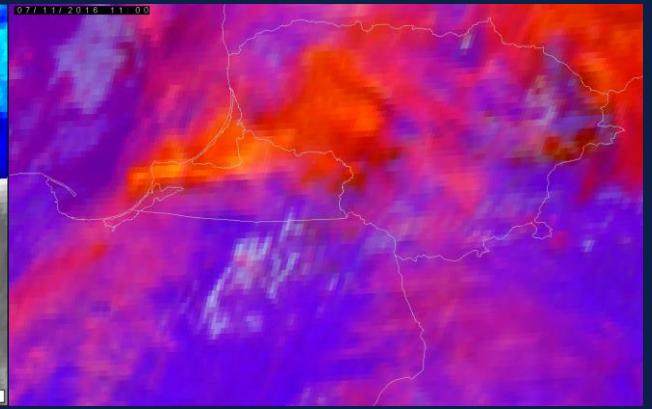
The NIR 1.6 µm band has not been included into the mosaics which follow namely due to the limited space of the slides. Also, since the band contains information which is very close to the IR3.9 band, and, as the IR3.9 band informs about the storm-top microphysics even somewhat better (being more "sensitive" to the uppermost cloud-top layers only) than the NIR 1.6 µm band, the more useful of these two bands is definitely the IR3.9 µm band.



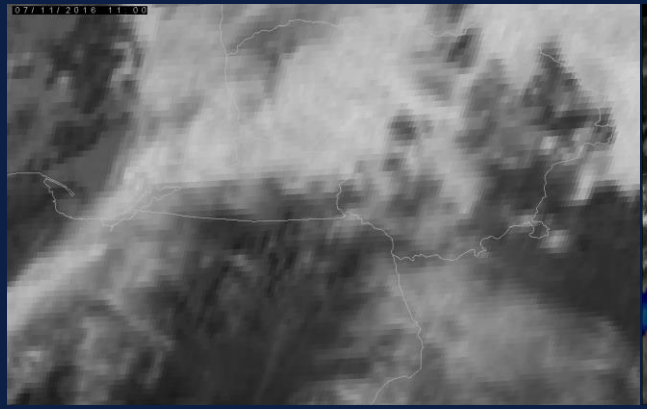
HRV band



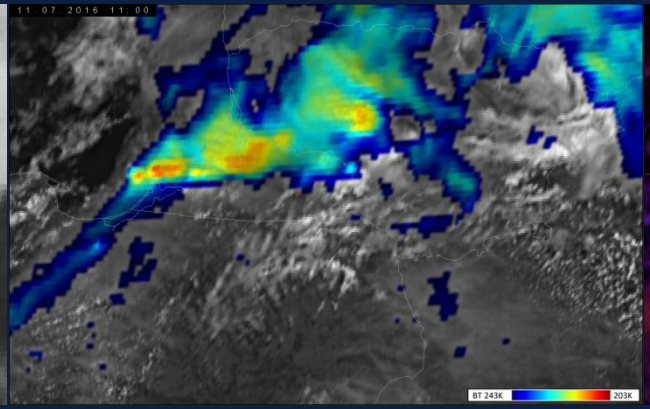
IR 10.8 BT (203-243K) color-enhanced image



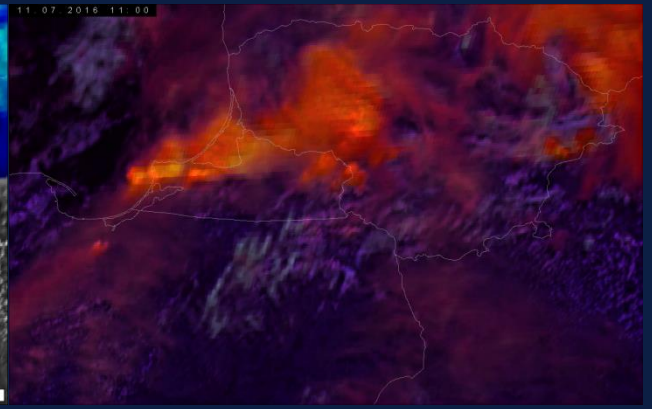
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

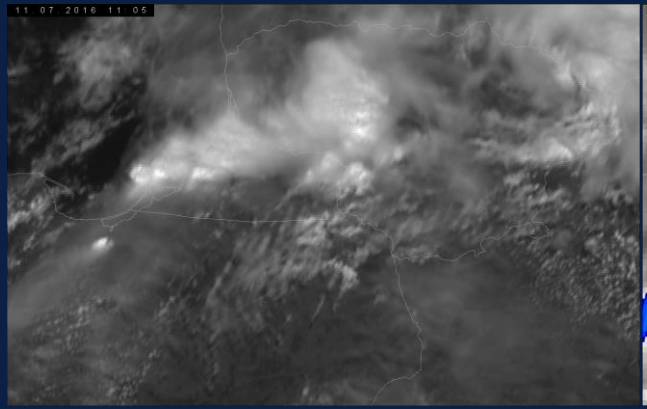


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

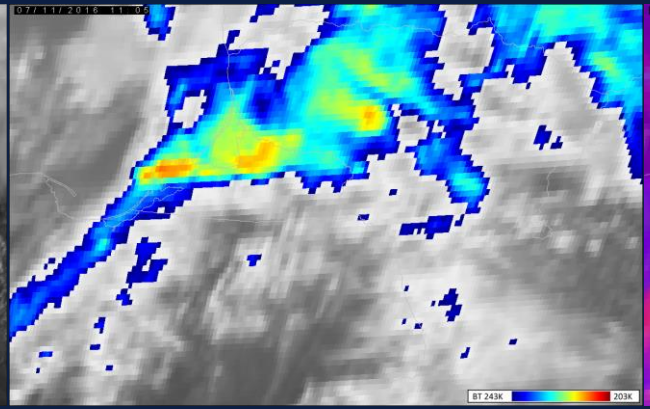


sandwich product – HRV band and Convective storms RGB image

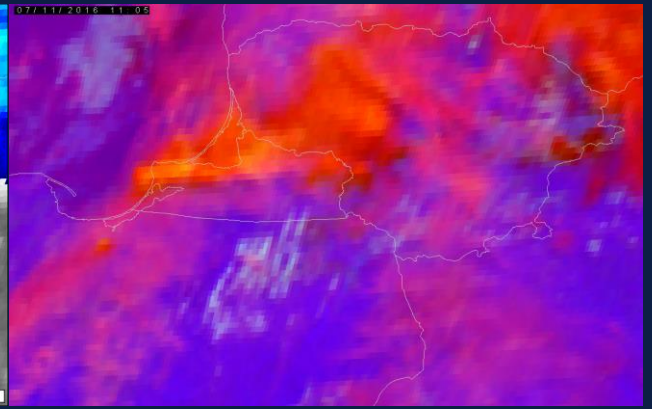
Throughout this presentation, the individual storms or their cloud-top features are usually labeled in one or two images of the mosaic only, typically in the sandwich products – where the individual features are pronounced best. You can compare the visibility of those features with the other bands or Storm RGB product, to evaluate the usefulness ("added value") of the sandwich products against the other images.



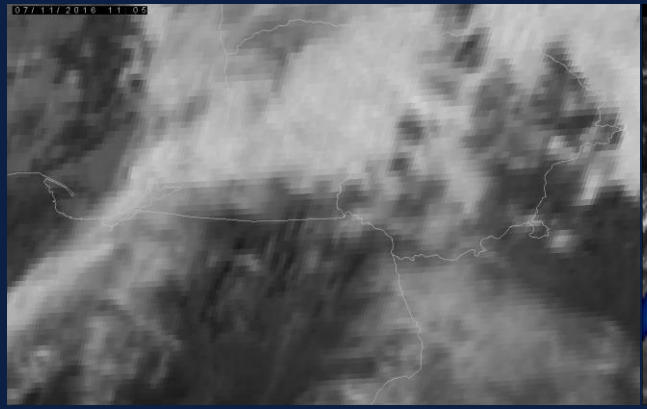
HRV band



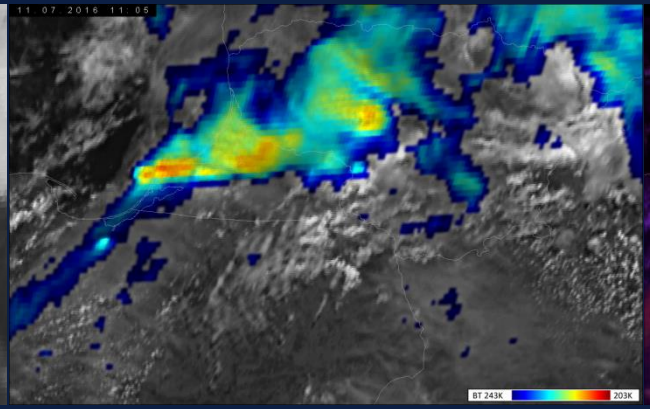
IR 10.8 BT (203-243K) color-enhanced image



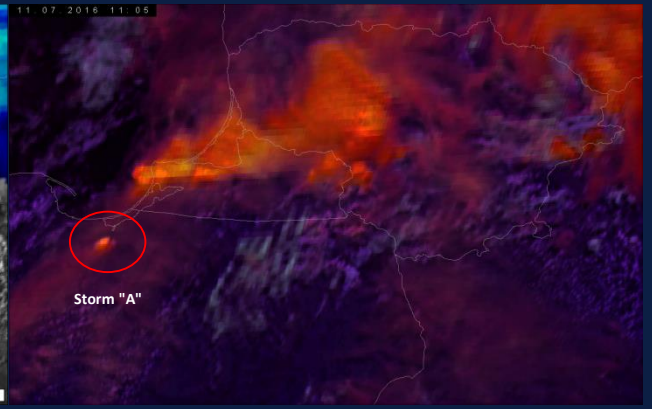
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

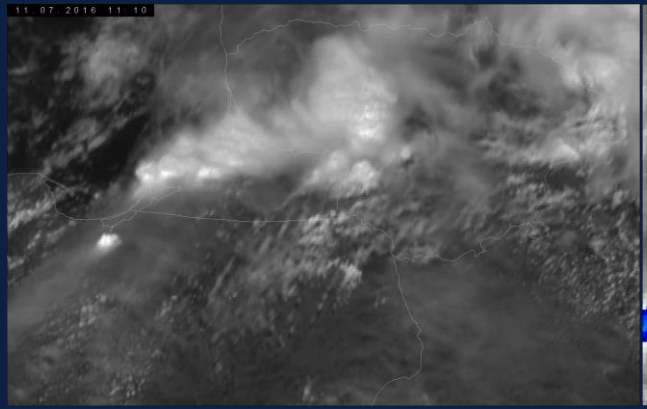


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

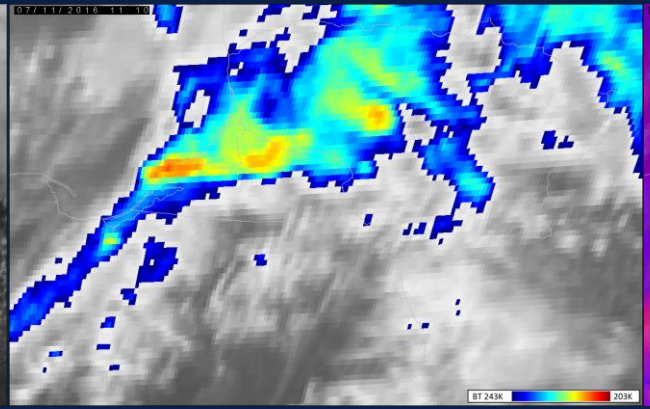


sandwich product – HRV band and Convective storms RGB image

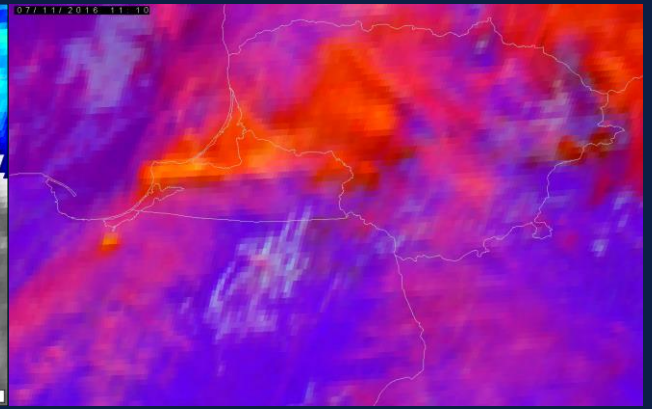
In the next slides pay attention namely to this storm. During its evolution, this storm exhibits most of the features known to be typical for severe convective storms – increased cloud-top reflectivity in the 1.6 µm and 3.9 µm bands (being well pronounced also in the Storm-RGB images and corresponding sandwich product), distinct cold-U shape, long-lived above-anvil ice plume, and overshooting tops. Namely by its microphysics the storm is much different from all the other storms in the area, and thus is the "best candidate" for a severe storm. Further on, this storm is referenced as storm "A".



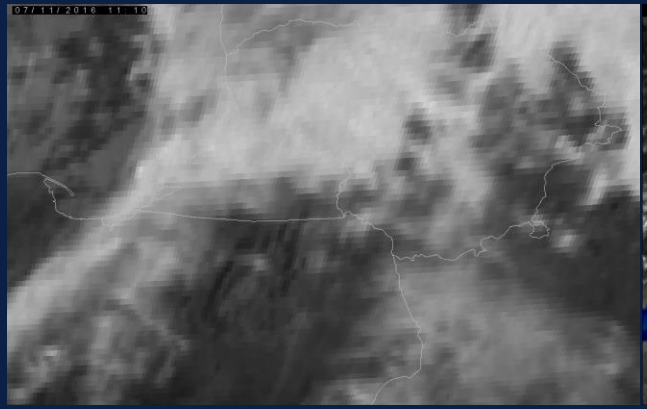
HRV band



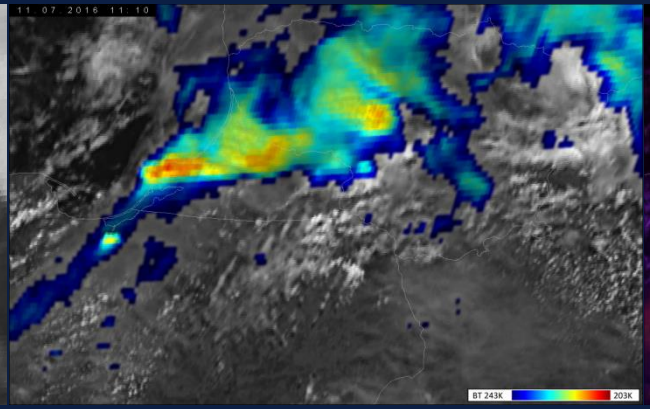
IR 10.8 BT (203-243K) color-enhanced image



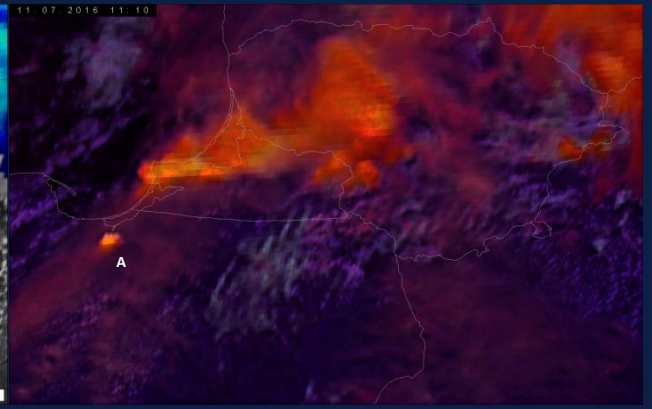
Convective storms RGB image product



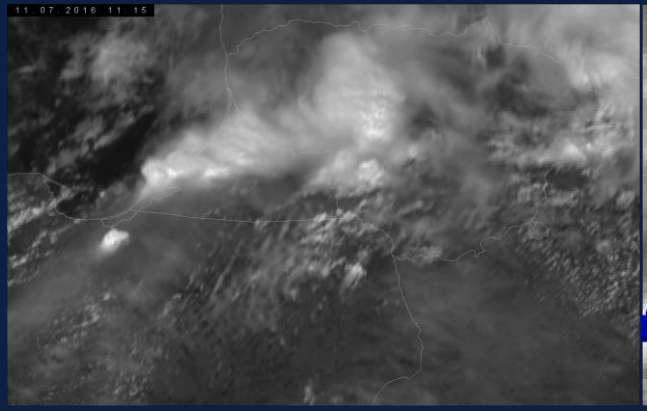
IR 3.9 band (displayed as radiance image)



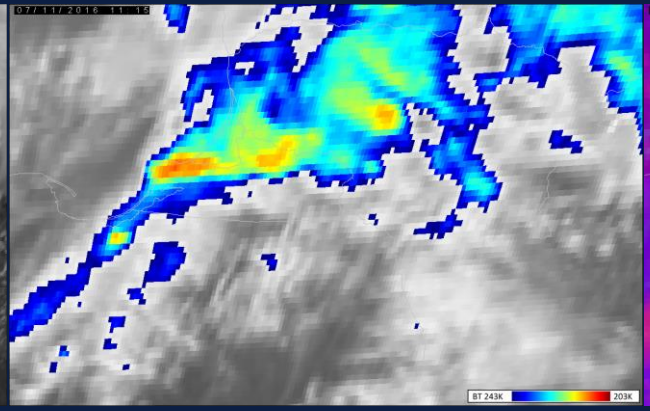
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



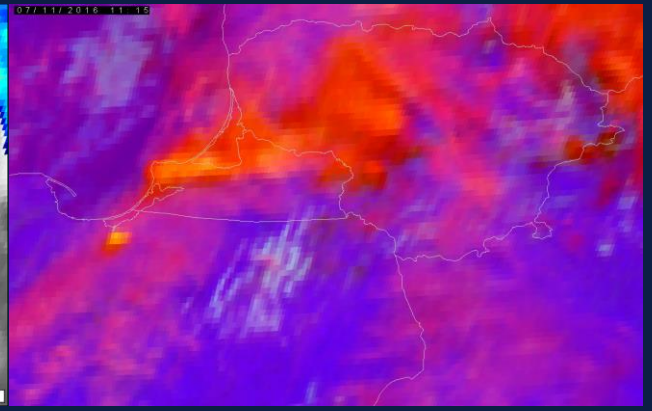
sandwich product – HRV band and Convective storms RGB image



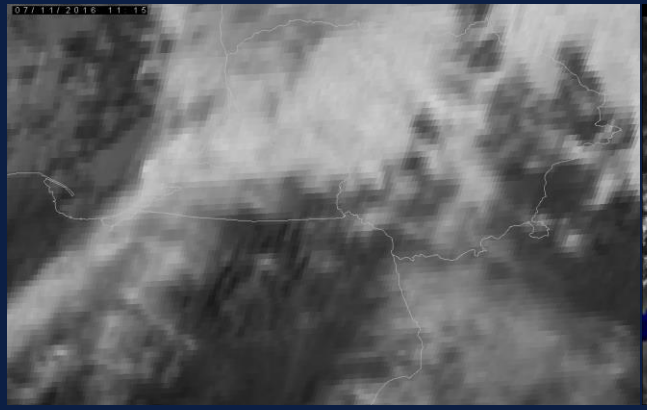
HRV band



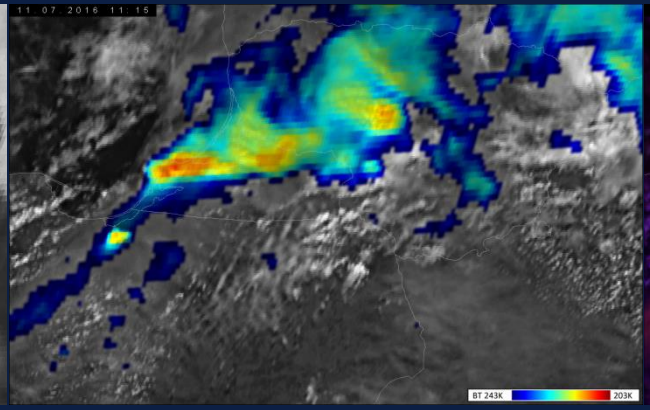
IR 10.8 BT (203-243K) color-enhanced image



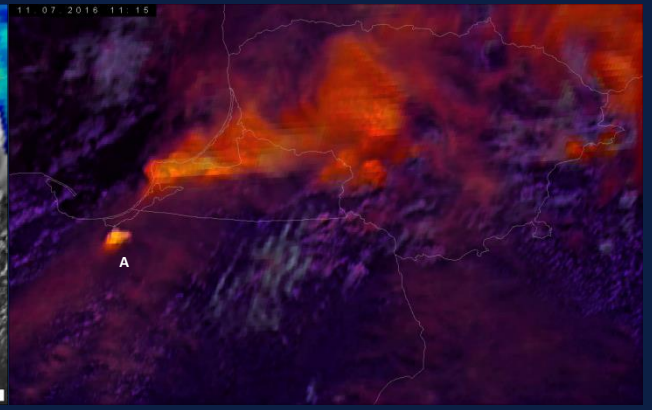
Convective storms RGB image product



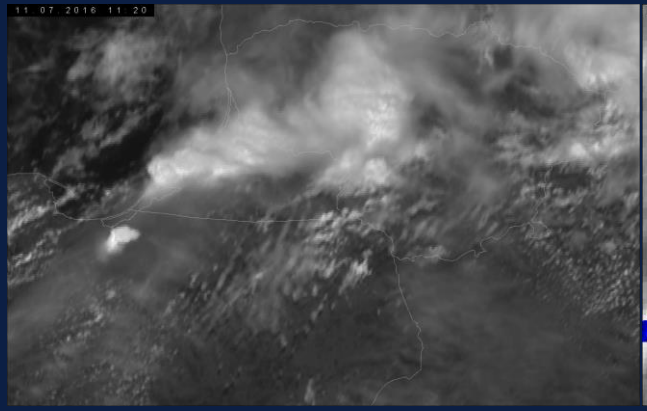
IR 3.9 band (displayed as radiance image)



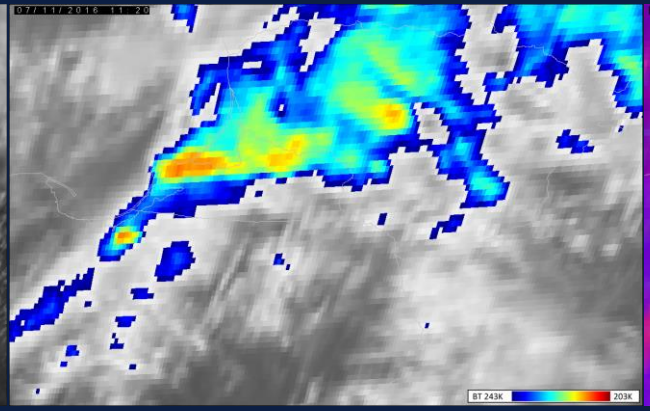
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



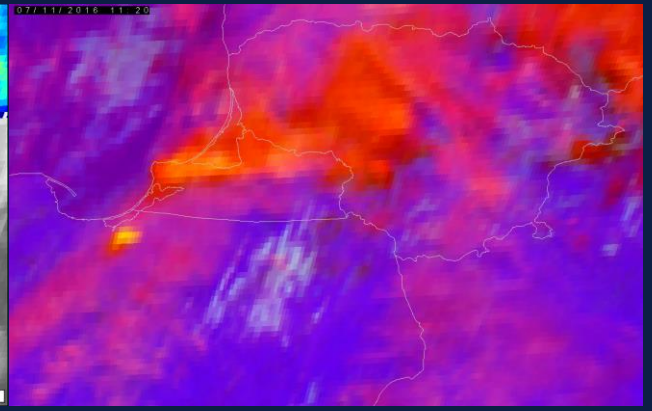
sandwich product – HRV band and Convective storms RGB image



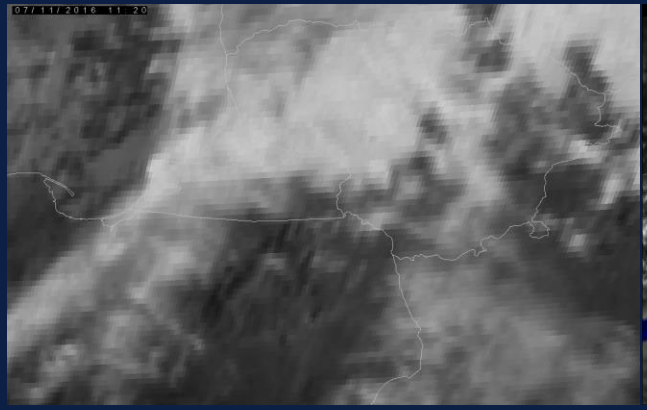
HRV band



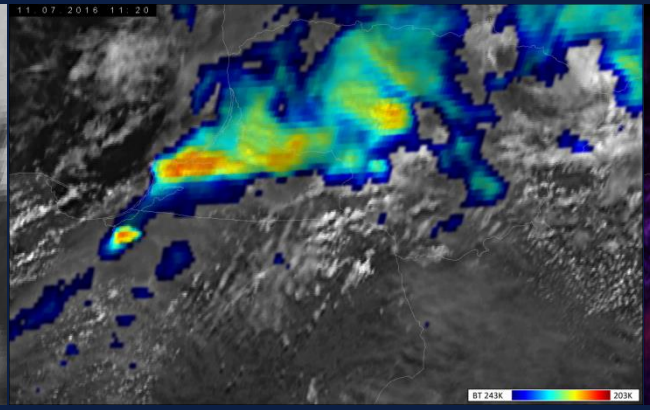
IR 10.8 BT (203-243K) color-enhanced image



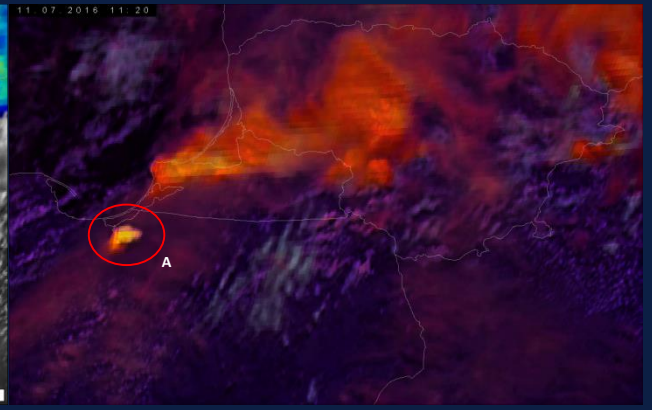
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

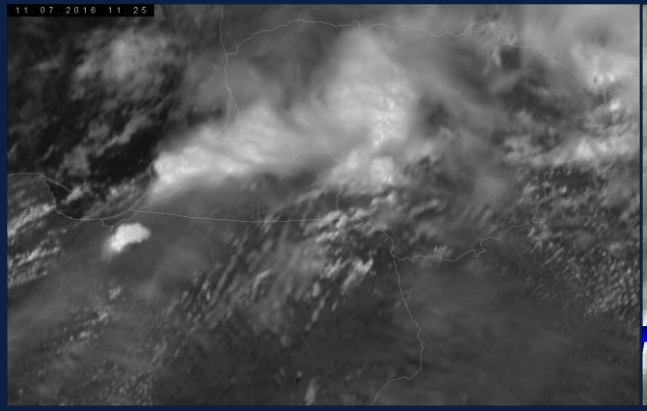


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

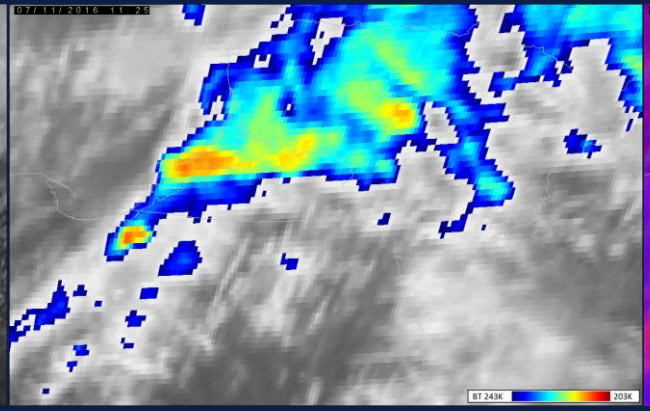


sandwich product – HRV band and Convective storms RGB image

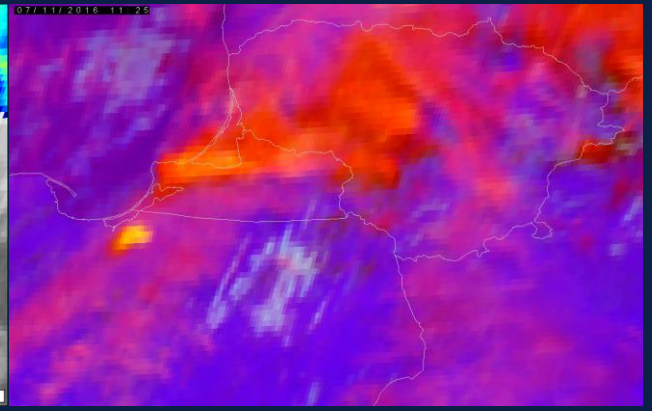
From now on, the cloud-top reflectivity (expressed in the Storm-RGB or in this sandwich product by strong yellow component) of the storm A increases strongly, being present till about 14:00 UTC. By then, the overall cloud-top reflectivity of the storm A weakens, an is replaced by a high-reflectivity above-anvil ice plume . Also notice that the increased cloud-top reflectivity is not yet visible in the stand-alone 3.9 µm band, being partially masked by the thin cirrus around or above the storm.



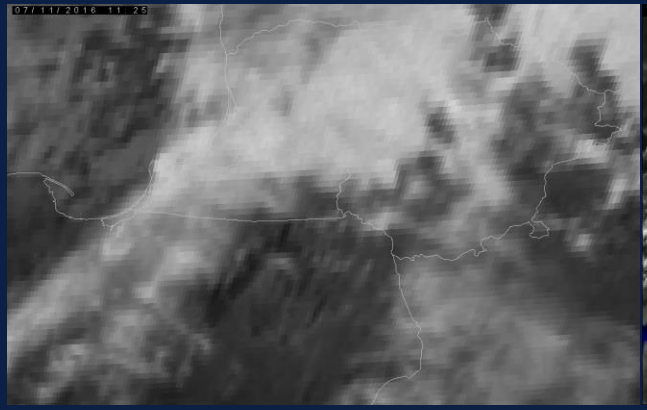
HRV band



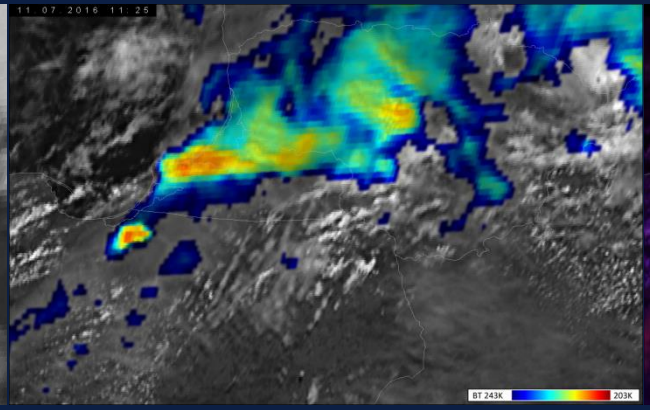
IR 10.8 BT (203-243K) color-enhanced image



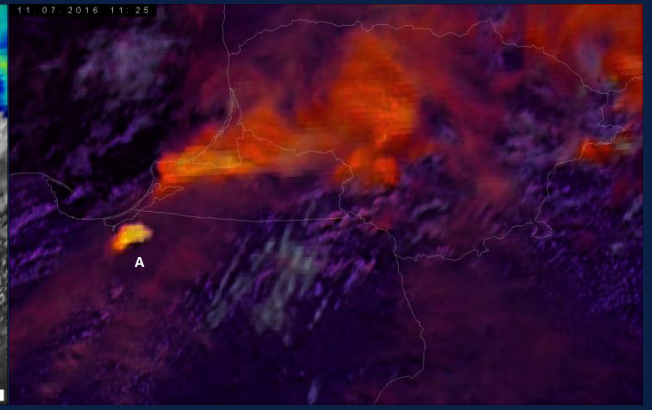
Convective storms RGB image product



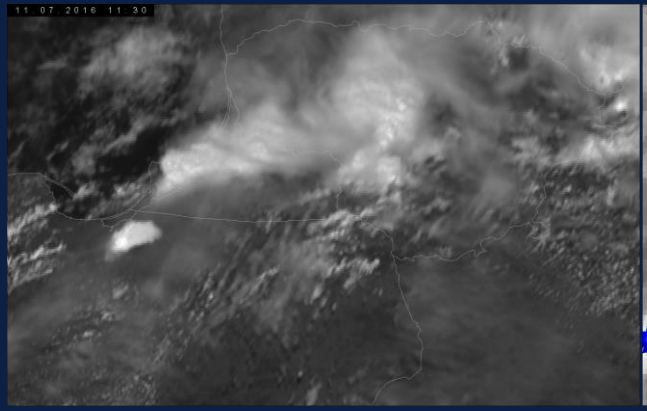
IR 3.9 band (displayed as radiance image)



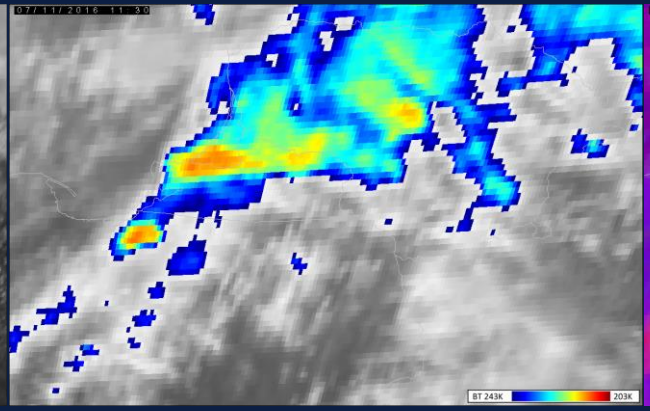
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



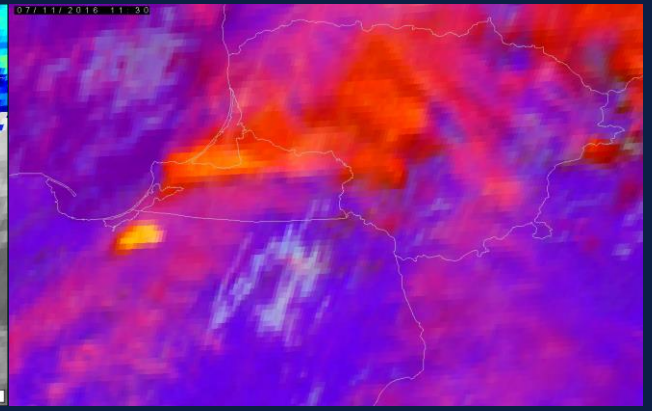
sandwich product – HRV band and Convective storms RGB image



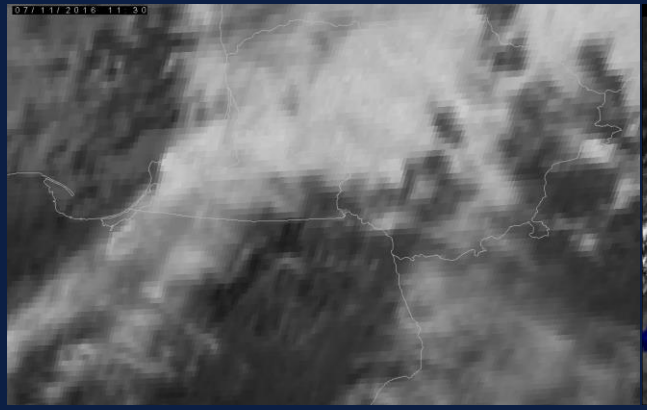
HRV band



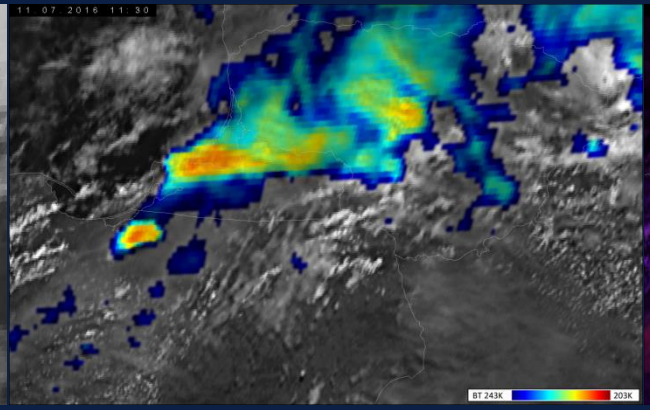
IR 10.8 BT (203-243K) color-enhanced image



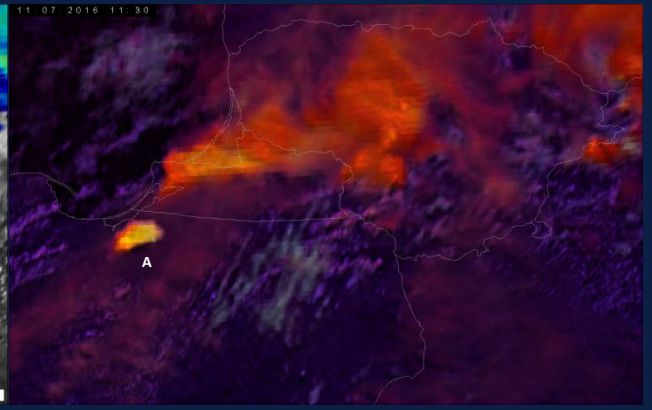
Convective storms RGB image product



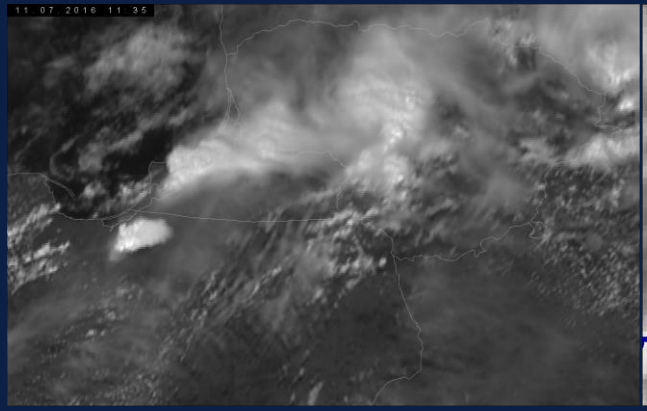
IR 3.9 band (displayed as radiance image)



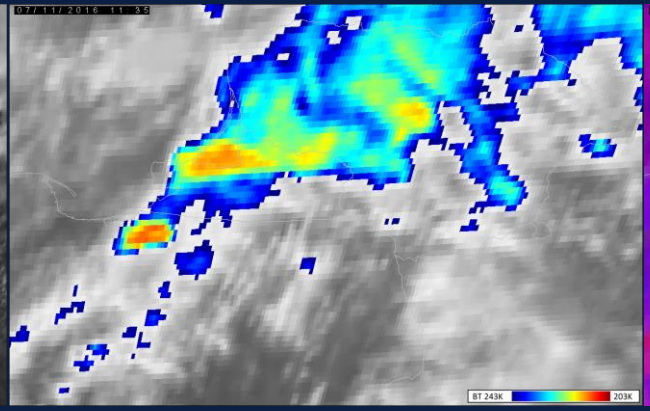
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



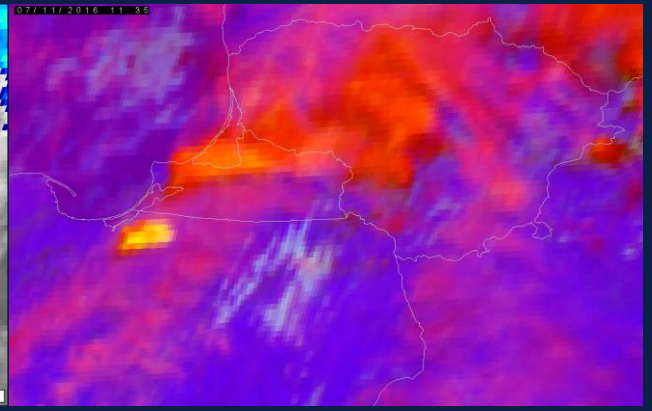
sandwich product – HRV band and Convective storms RGB image



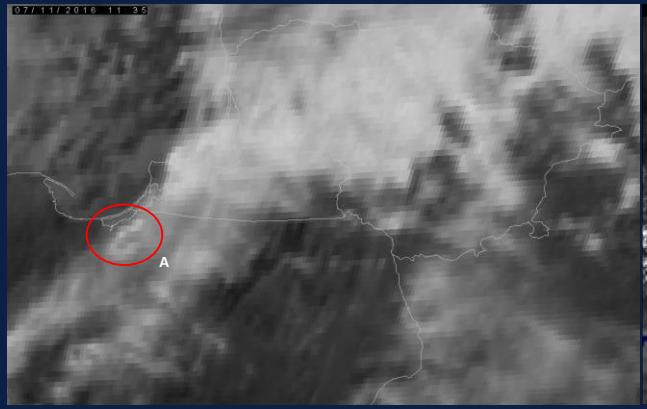
HRV band



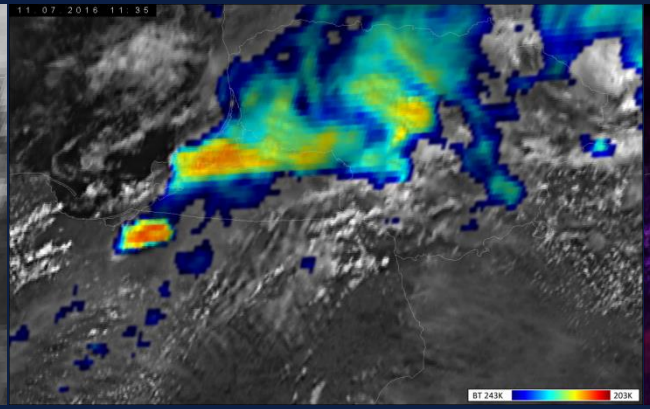
IR 10.8 BT (203-243K) color-enhanced image



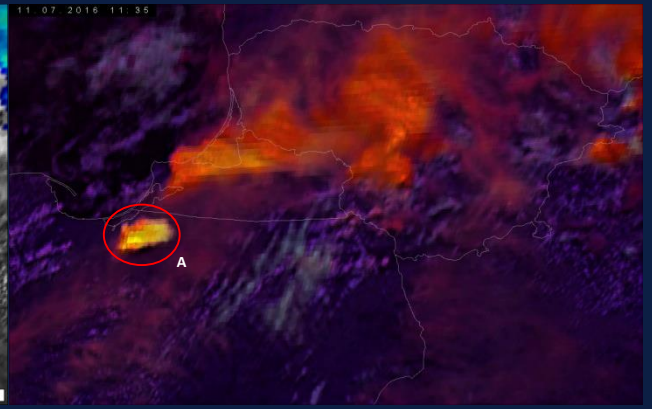
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

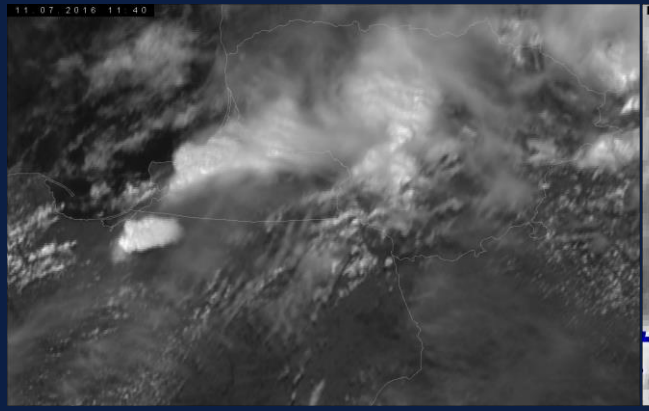


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

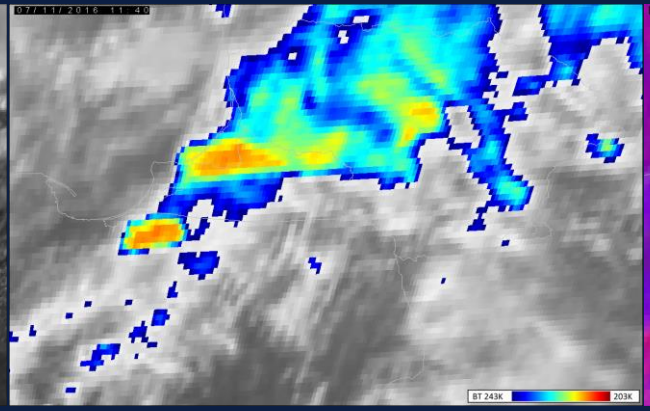


sandwich product – HRV band and Convective storms RGB image

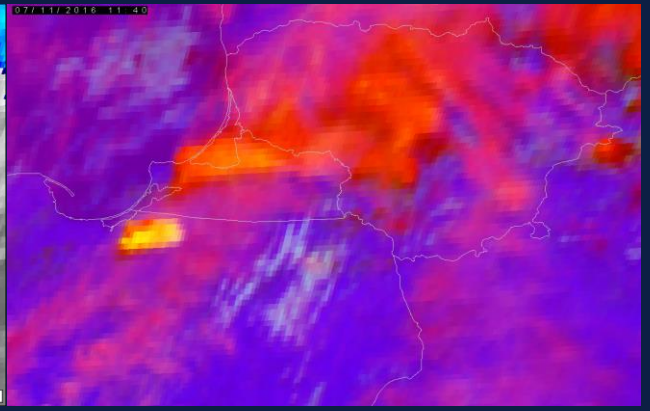
Here the cloud-top reflectivity of the storm A increases sufficiently, to be detected also in the 3.9 µm band images. This might indicate further strengthening of the storm updrafts. At this time, in the IR10.8 band the storm does not indicate anything interesting yet.



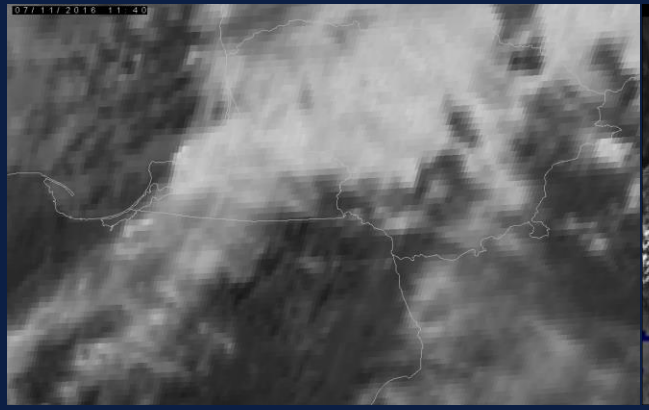
HRV band



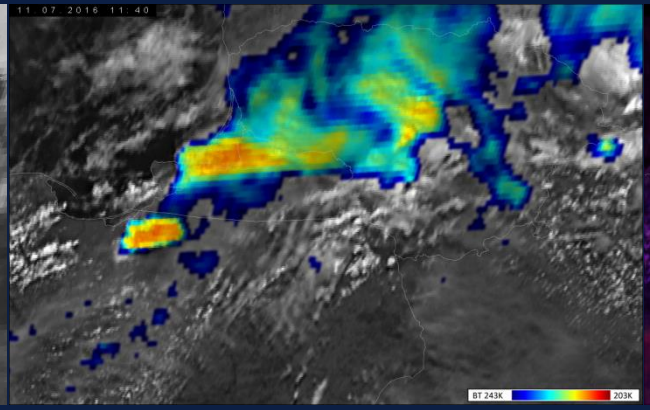
IR 10.8 BT (203-243K) color-enhanced image



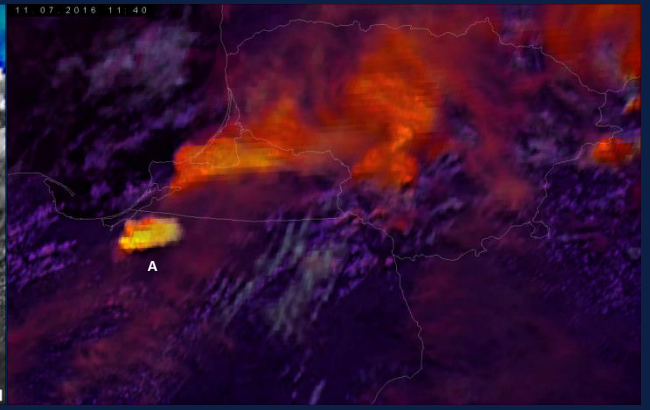
Convective storms RGB image product



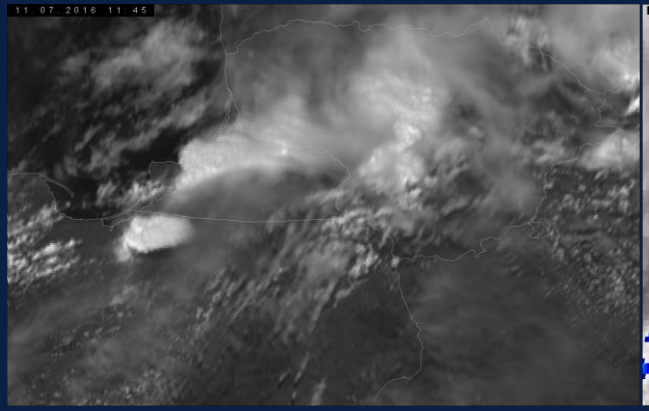
IR 3.9 band (displayed as radiance image)



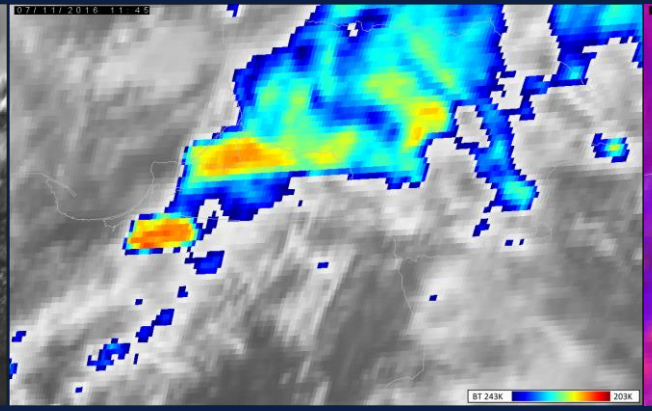
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



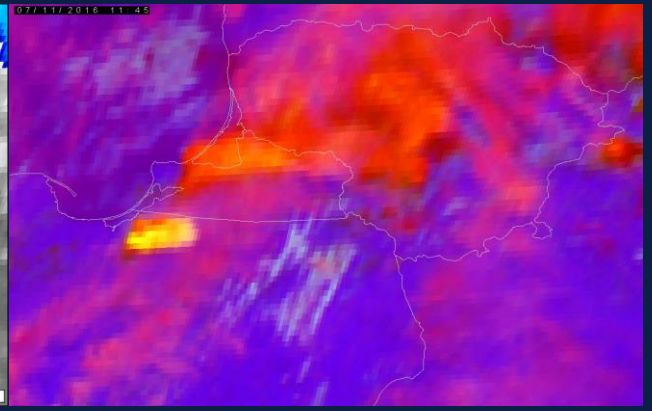
sandwich product – HRV band and Convective storms RGB image



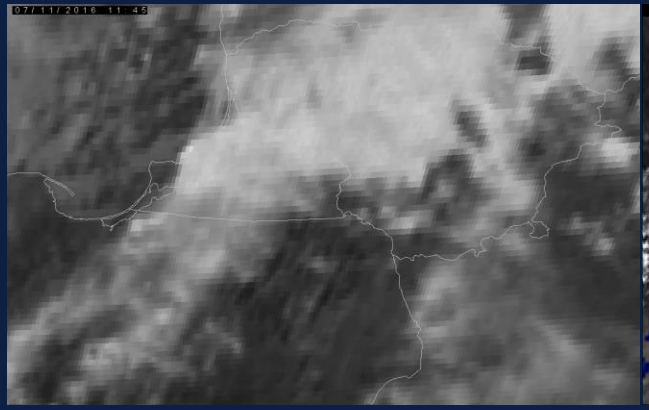
HRV band



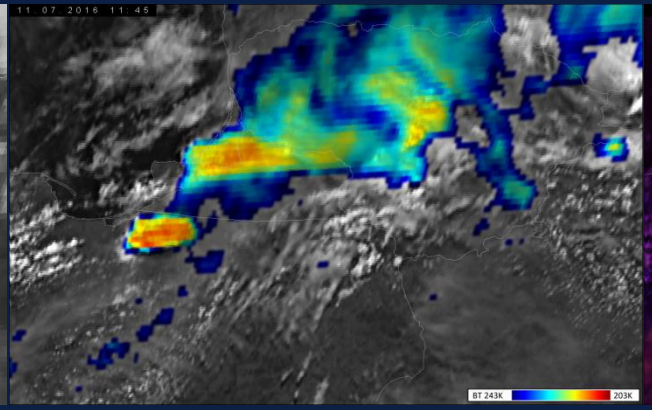
IR 10.8 BT (203-243K) color-enhanced image



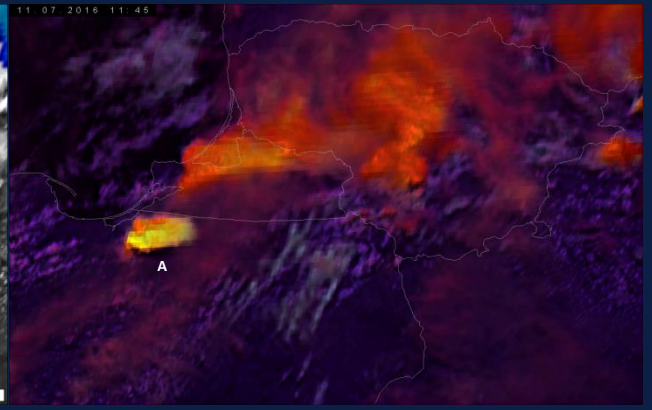
Convective storms RGB image product



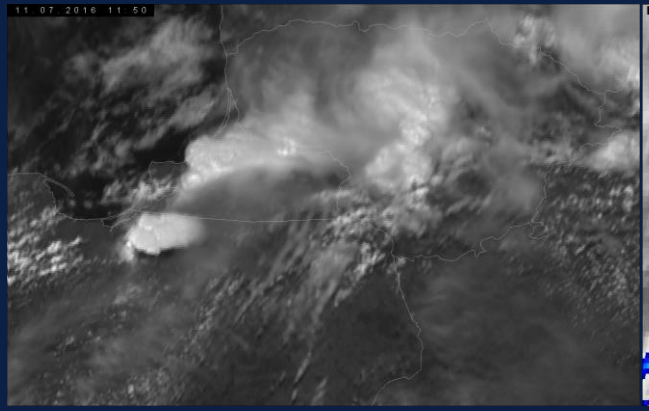
IR 3.9 band (displayed as radiance image)



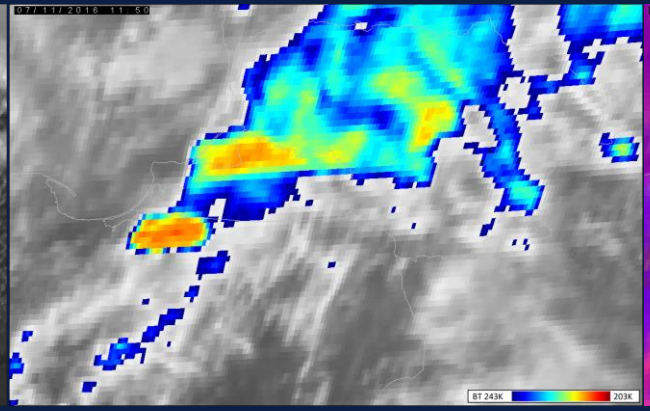
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



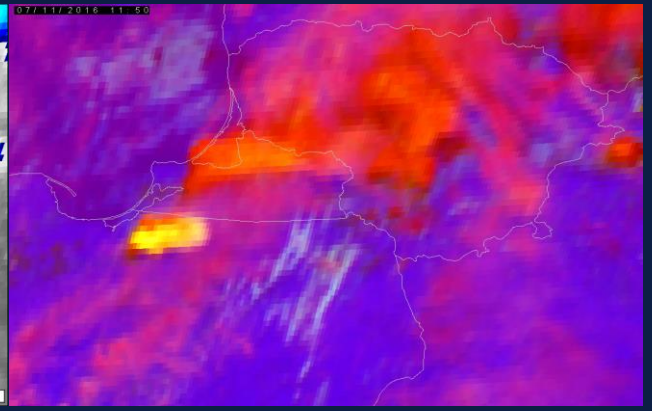
sandwich product – HRV band and Convective storms RGB image



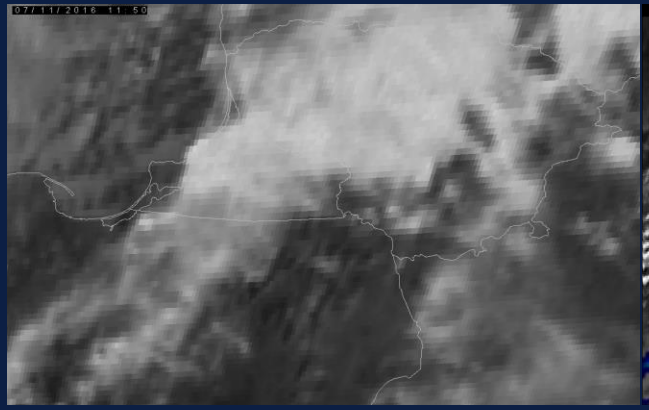
HRV band



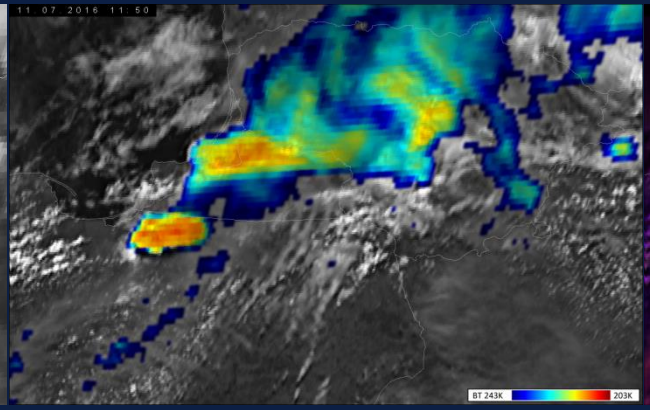
IR 10.8 BT (203-243K) color-enhanced image



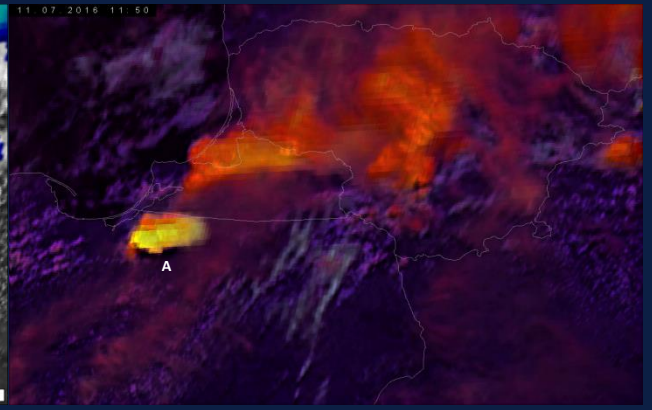
Convective storms RGB image product



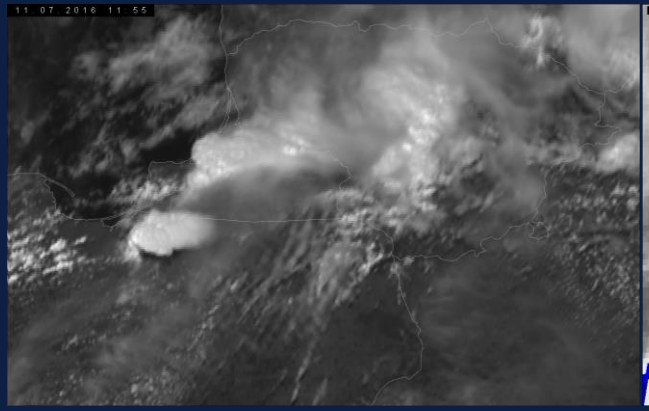
IR 3.9 band (displayed as radiance image)



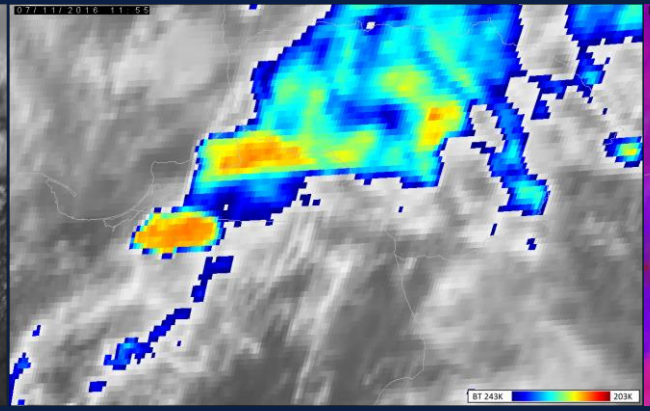
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



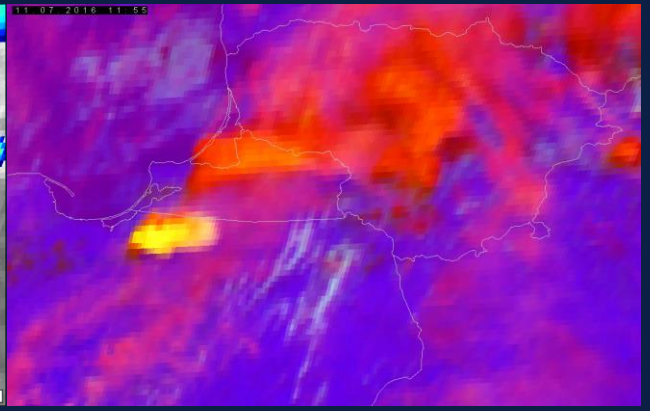
sandwich product – HRV band and Convective storms RGB image



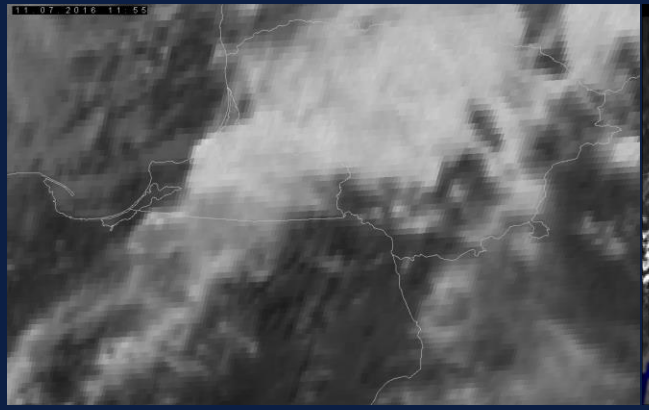
HRV band



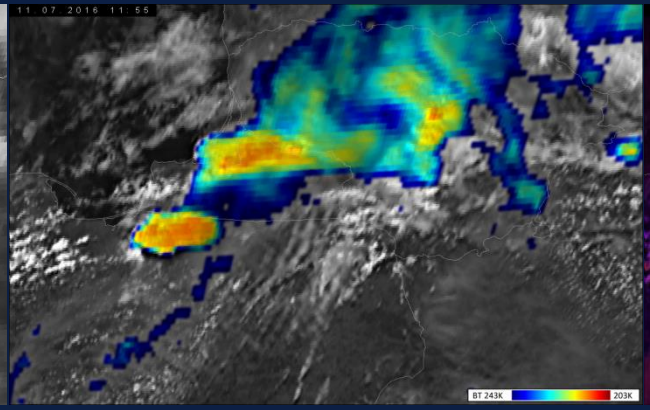
IR 10.8 BT (203-243K) color-enhanced image



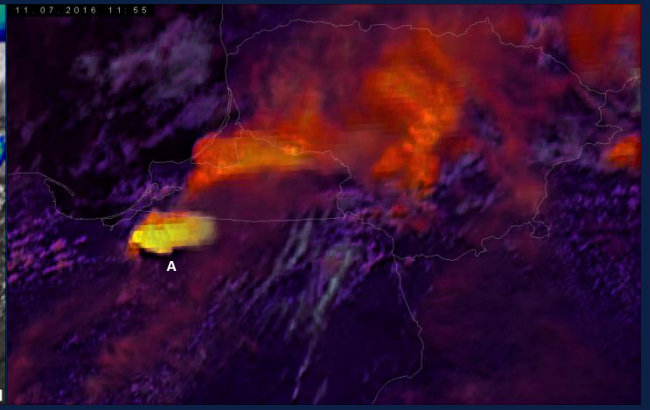
Convective storms RGB image product



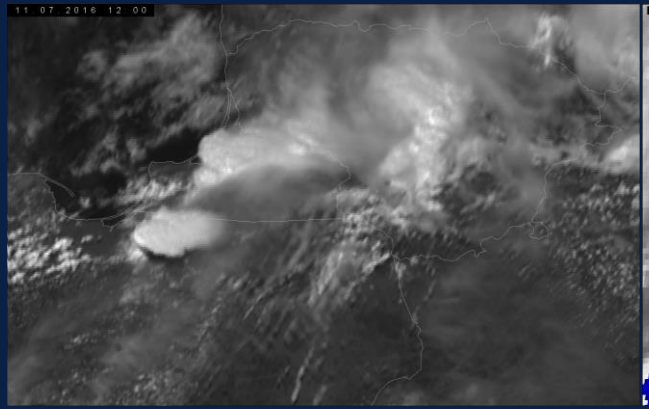
IR 3.9 band (displayed as radiance image)



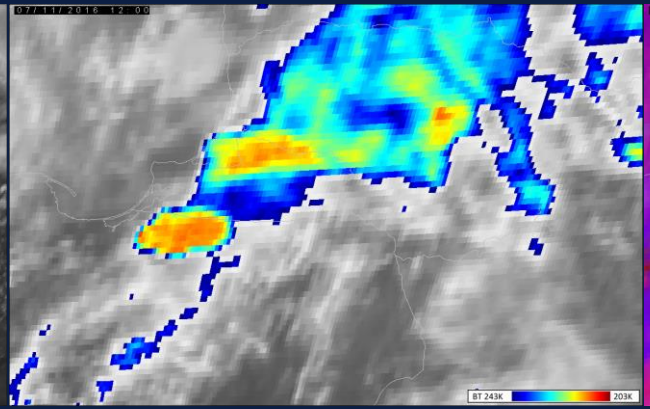
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



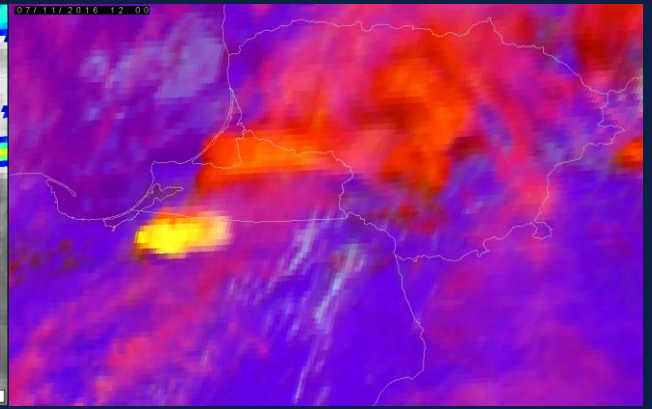
sandwich product – HRV band and Convective storms RGB image



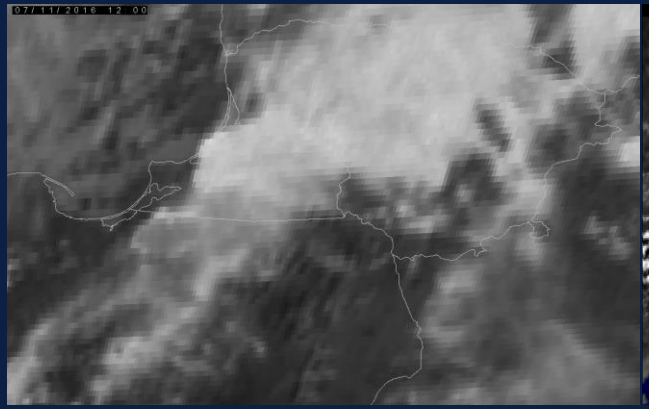
HRV band



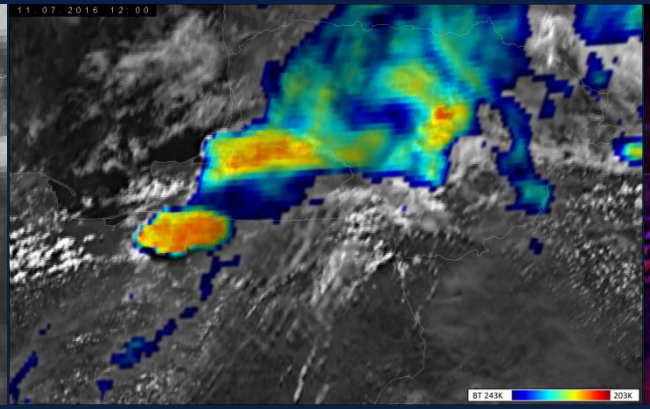
IR 10.8 BT (203-243K) color-enhanced image



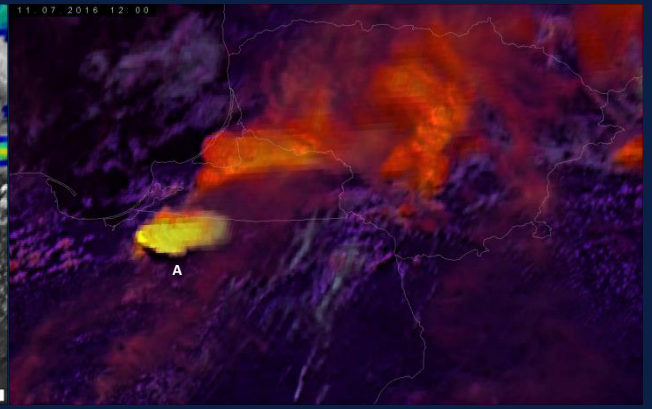
Convective storms RGB image product



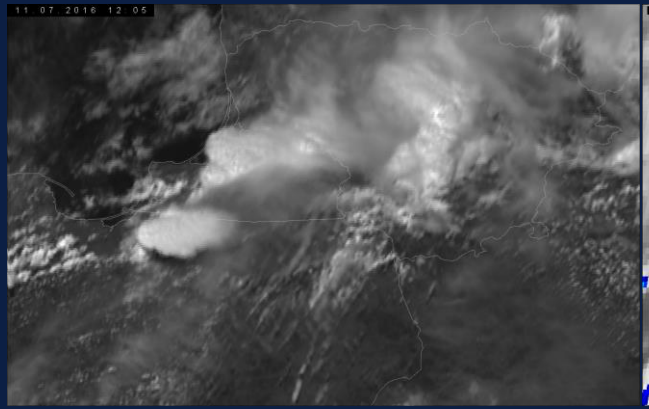
IR 3.9 band (displayed as radiance image)



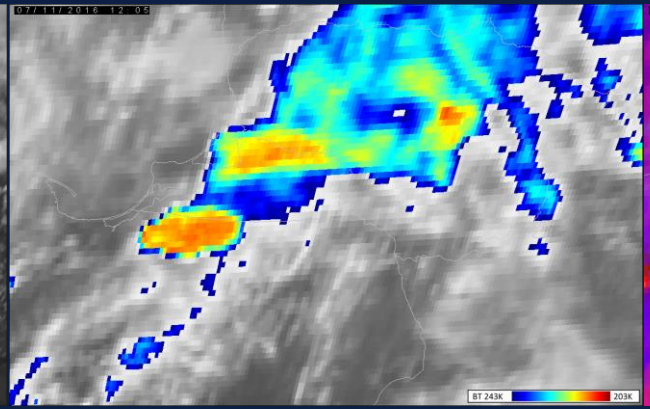
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



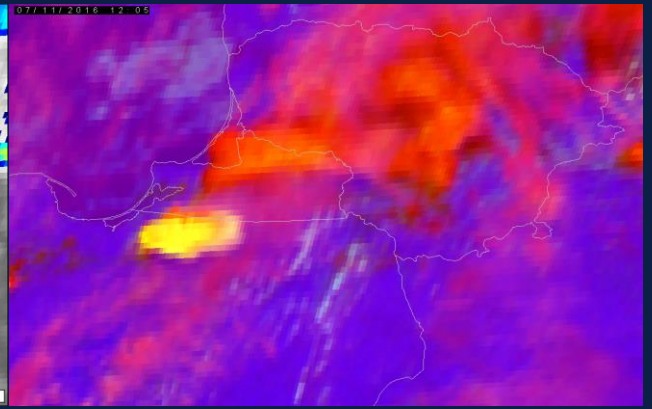
sandwich product – HRV band and Convective storms RGB image



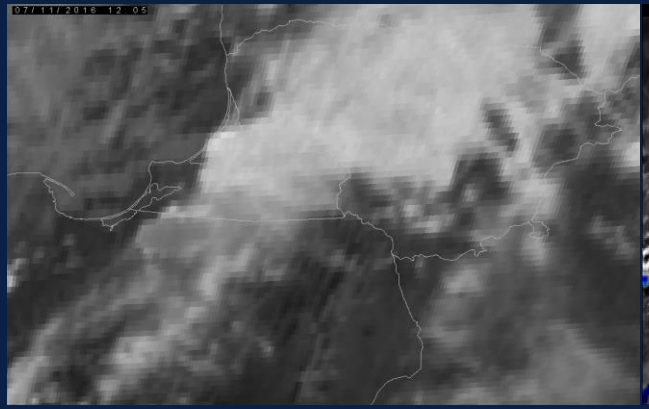
HRV band



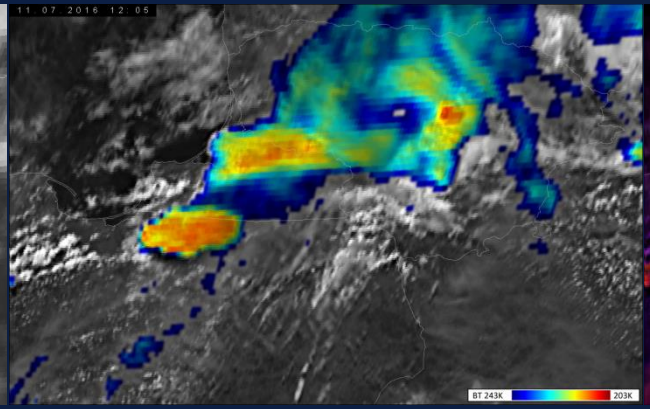
IR 10.8 BT (203-243K) color-enhanced image



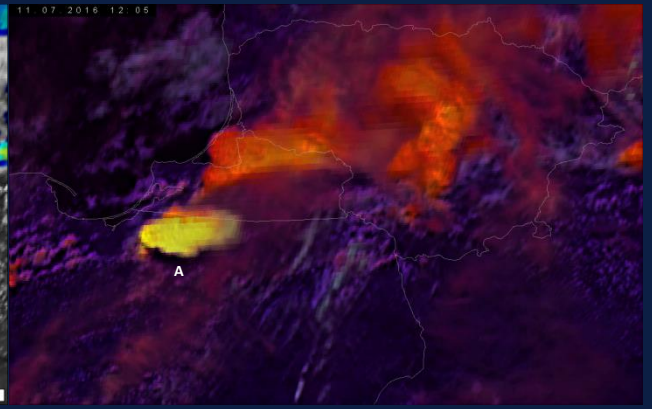
Convective storms RGB image product



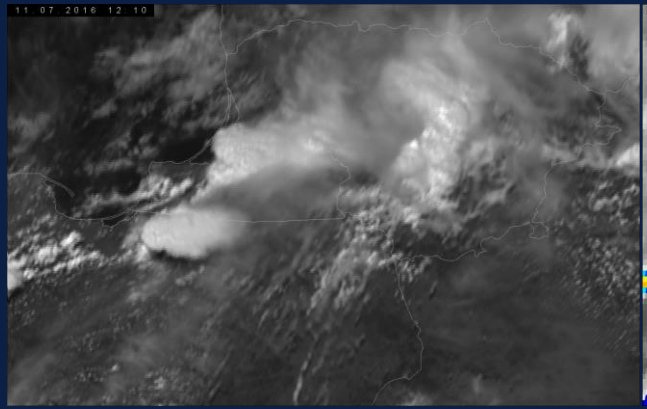
IR 3.9 band (displayed as radiance image)



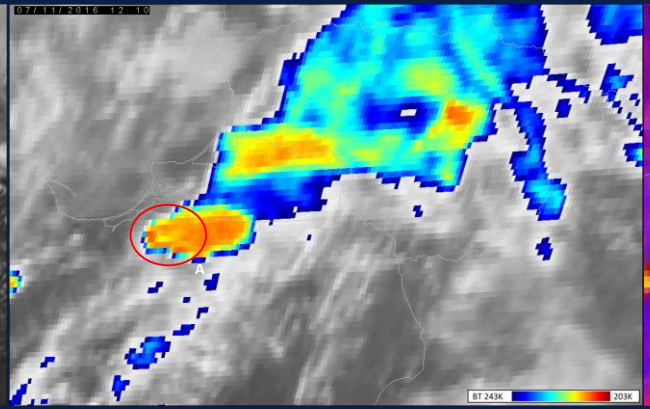
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



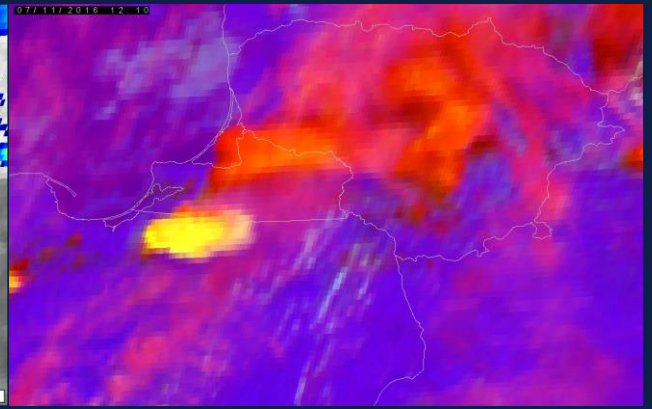
sandwich product – HRV band and Convective storms RGB image



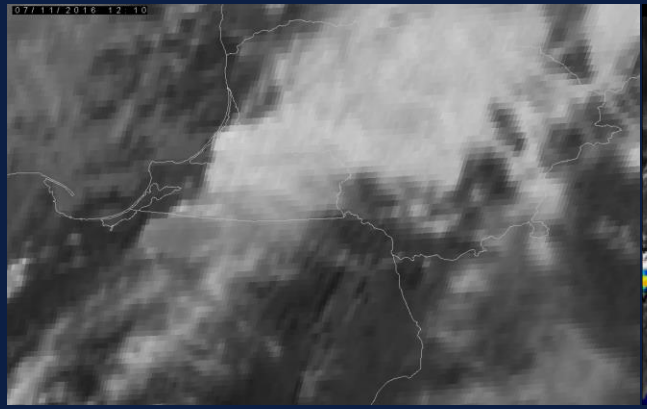
HRV band



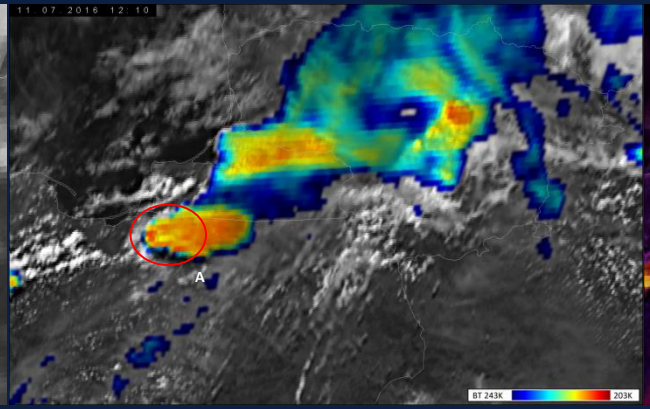
IR 10.8 BT (203-243K) color-enhanced image



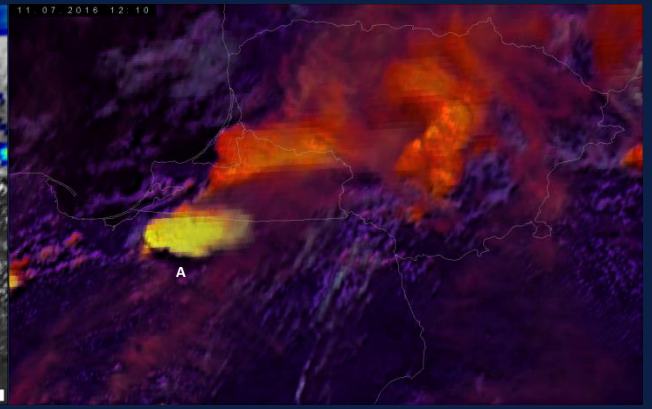
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

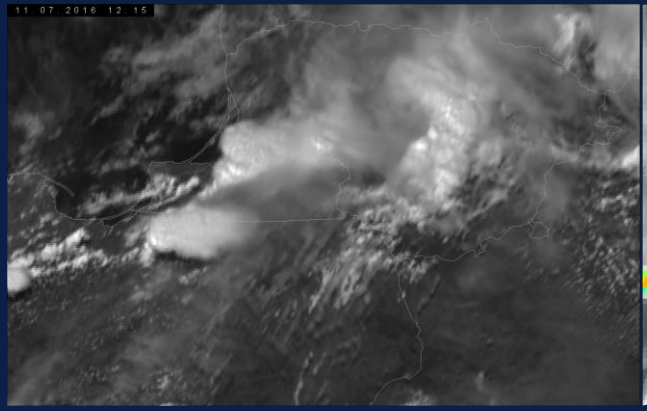


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

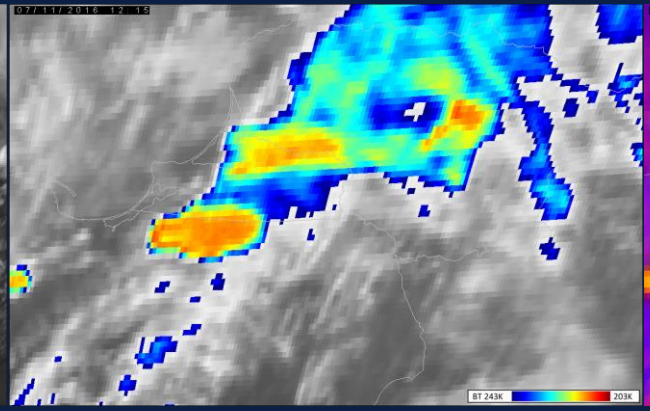


sandwich product – HRV band and Convective storms RGB image

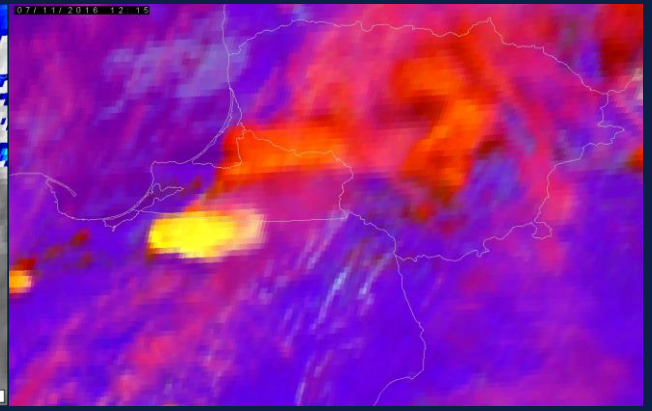
From here on, the storm A begins to exhibit (in the IR10.8 band and corresponding sandwich product) an embedded warm area downwind of the cold overshooting tops, present in the westernmost part of the storm. Till about 12:35 this warm spot is rather weak, in some of the slides it resembles a warm plume (namely in the sandwich of HRV and IR10.8 bands).



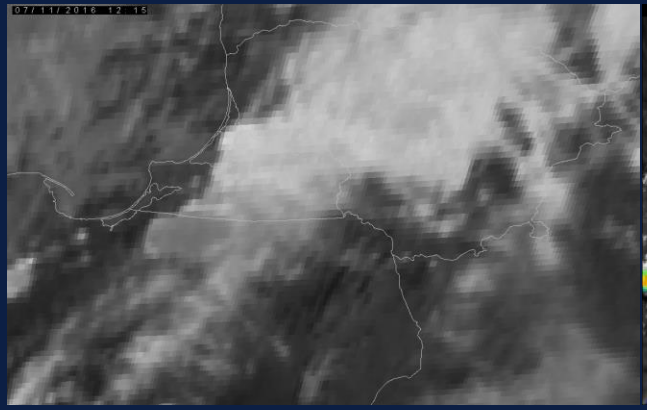
HRV band



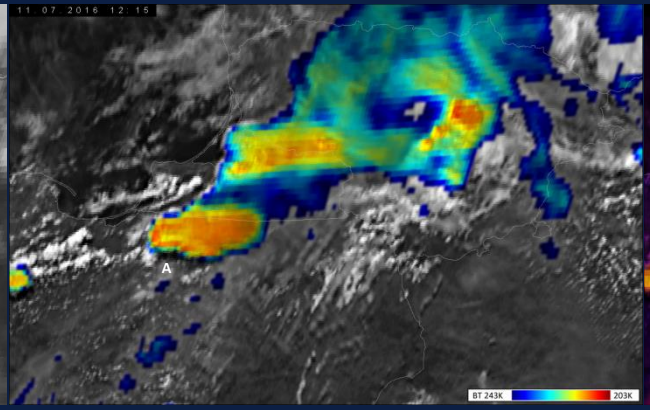
IR 10.8 BT (203-243K) color-enhanced image



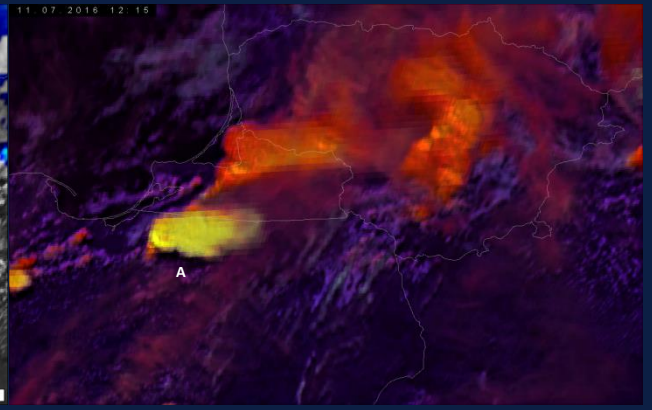
Convective storms RGB image product



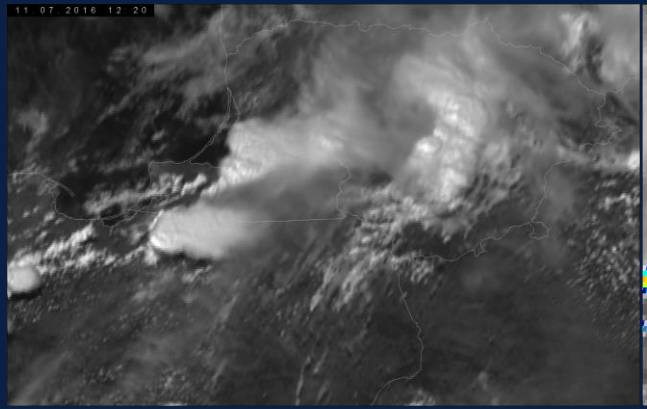
IR 3.9 band (displayed as radiance image)



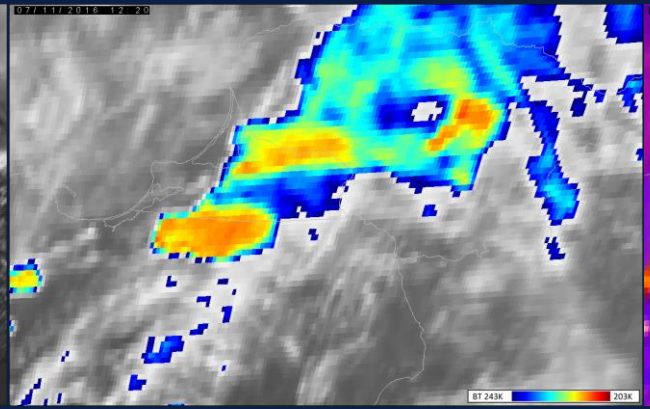
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



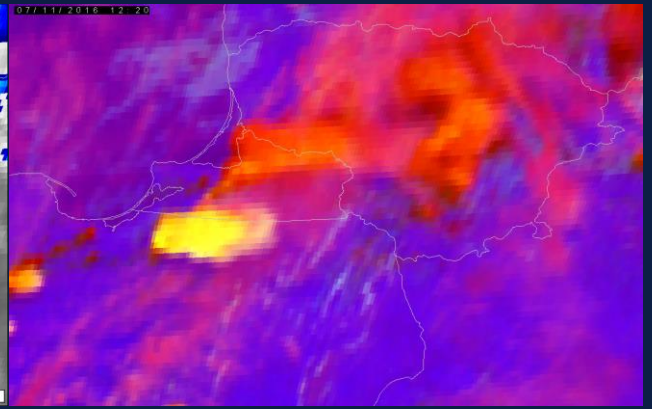
sandwich product – HRV band and Convective storms RGB image



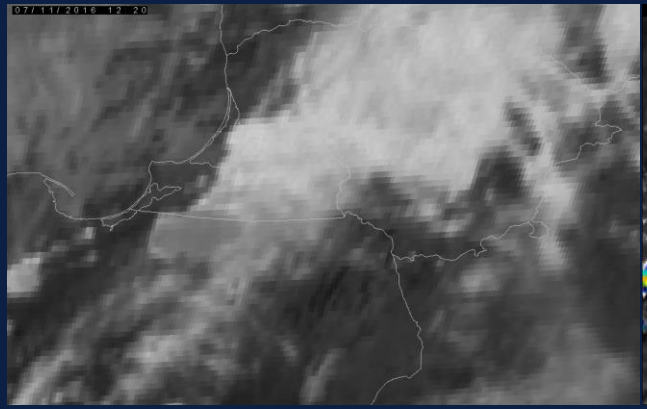
HRV band



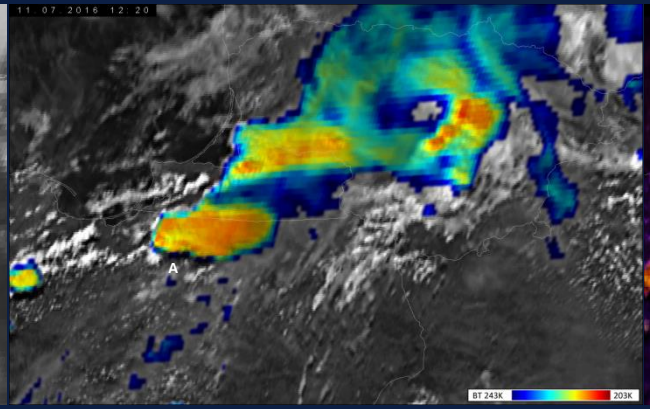
IR 10.8 BT (203-243K) color-enhanced image



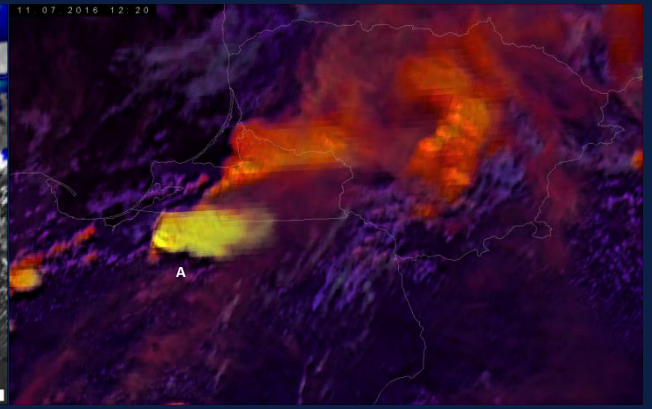
Convective storms RGB image product



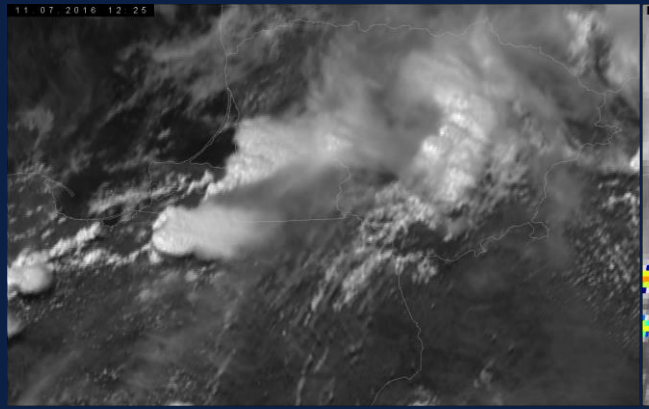
IR 3.9 band (displayed as radiance image)



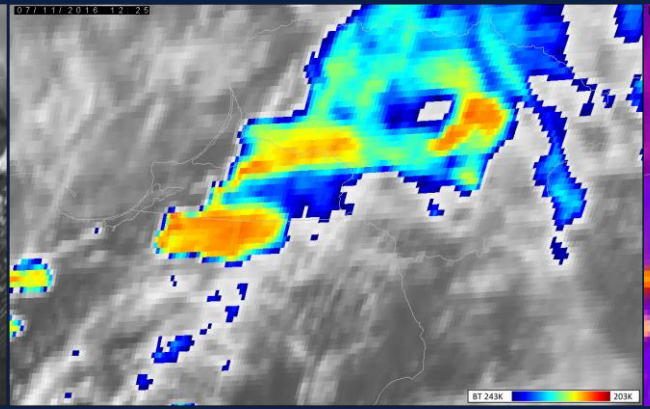
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



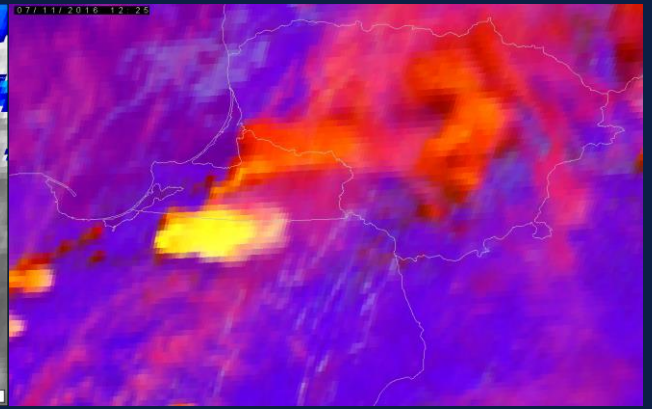
sandwich product – HRV band and Convective storms RGB image



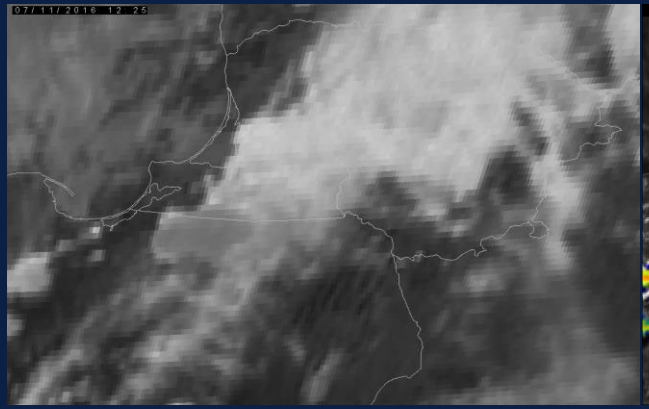
HRV band



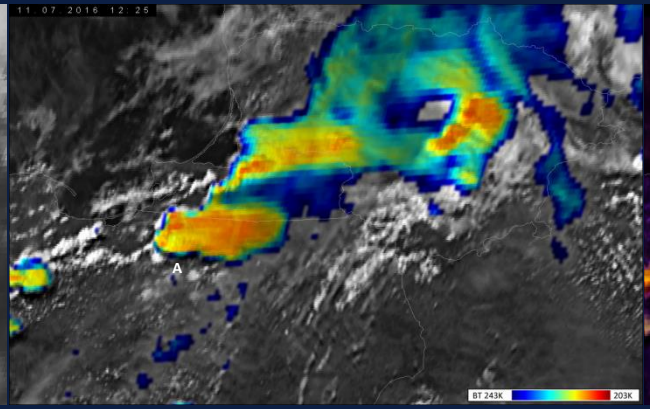
IR 10.8 BT (203-243K) color-enhanced image



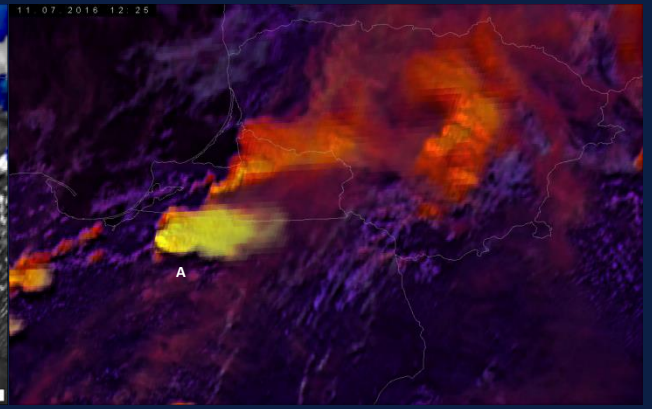
Convective storms RGB image product



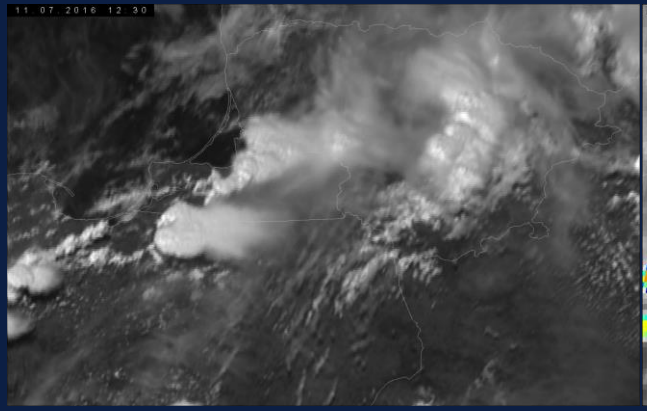
IR 3.9 band (displayed as radiance image)



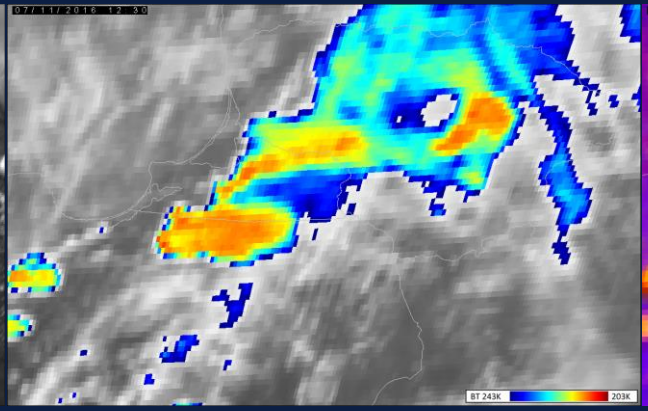
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



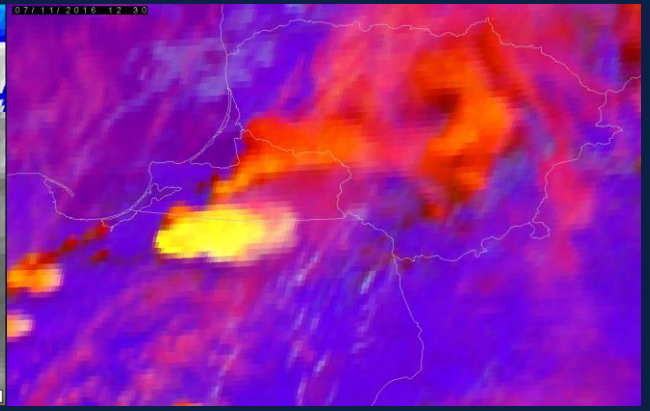
sandwich product – HRV band and Convective storms RGB image



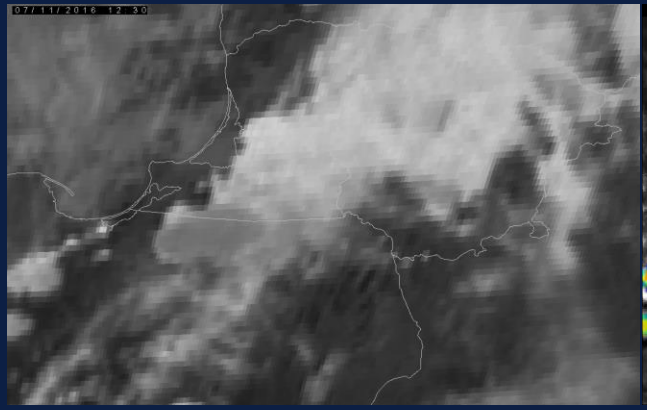
HRV band



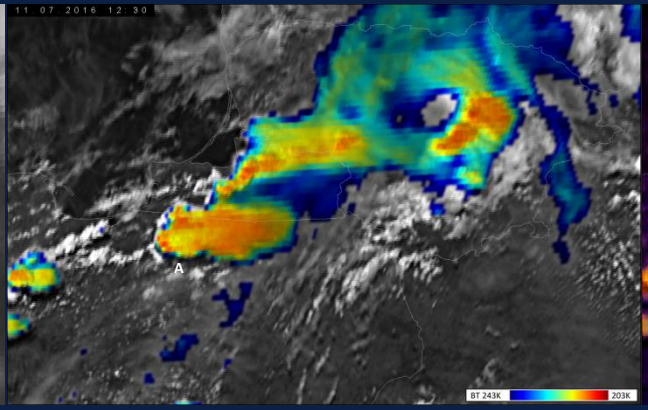
IR 10.8 BT (203-243K) color-enhanced image



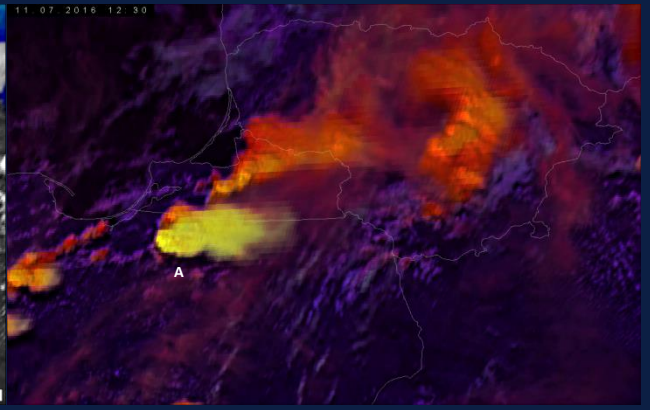
Convective storms RGB image product



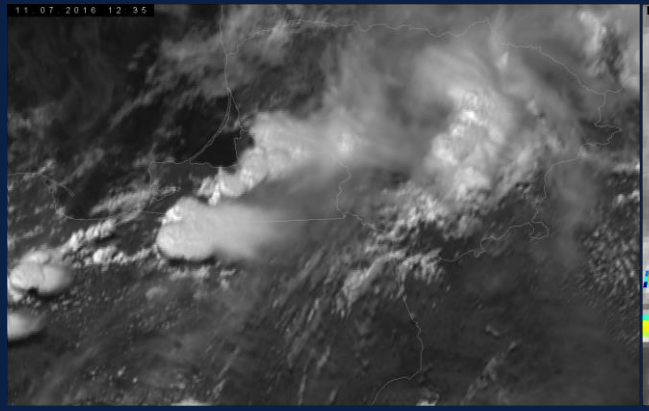
IR 3.9 band (displayed as radiance image)



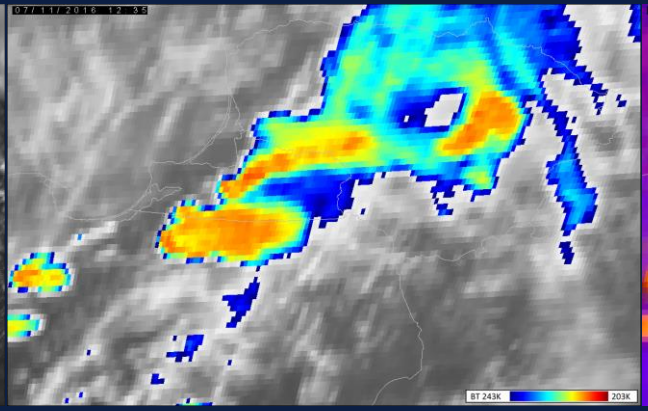
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



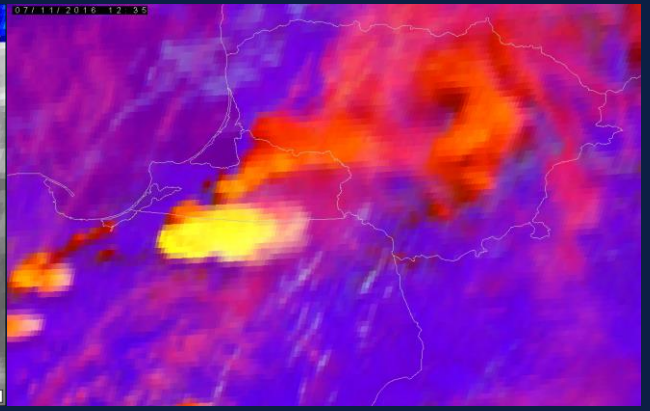
sandwich product – HRV band and Convective storms RGB image



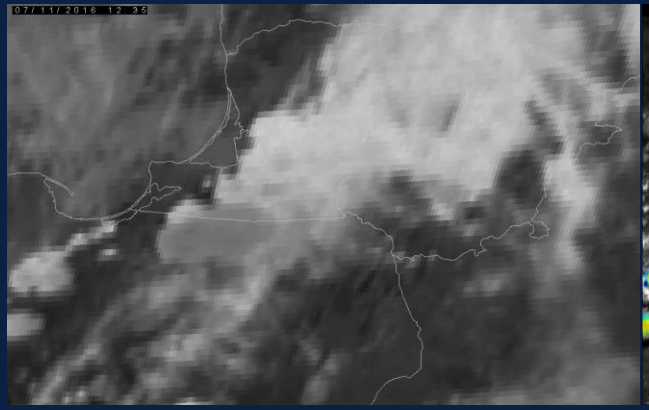
HRV band



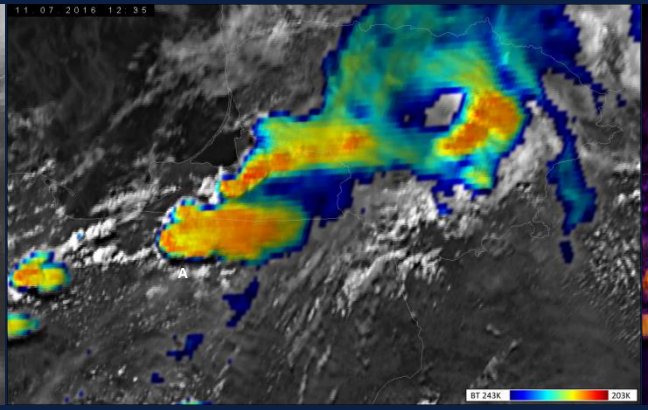
IR 10.8 BT (203-243K) color-enhanced image



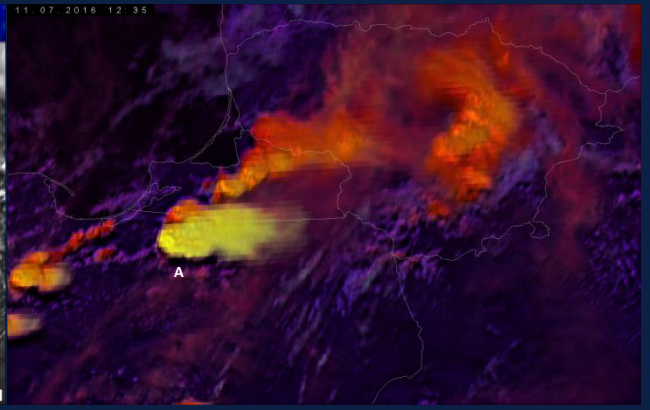
Convective storms RGB image product



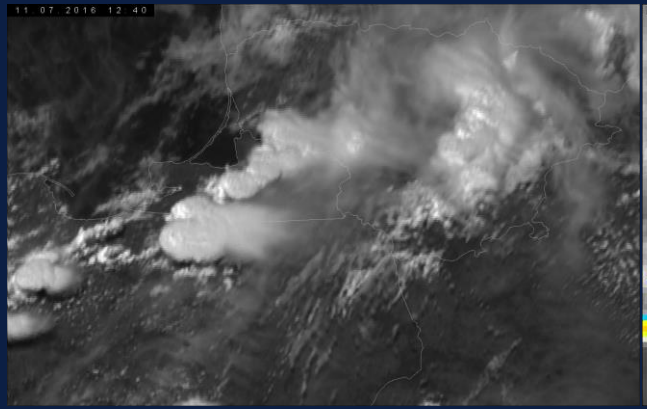
IR 3.9 band (displayed as radiance image)



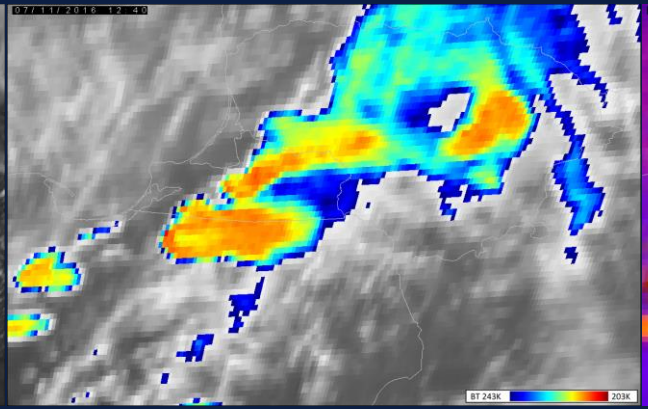
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



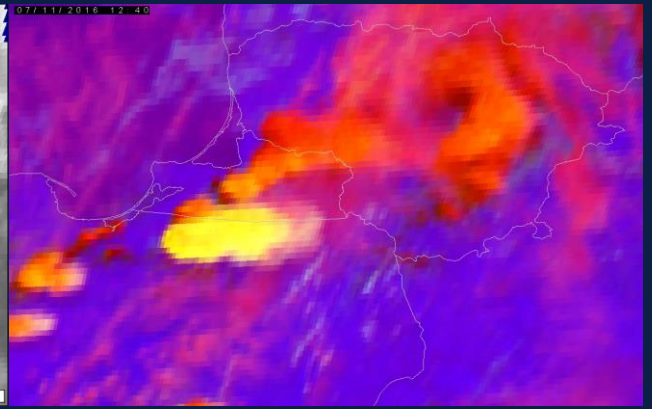
sandwich product – HRV band and Convective storms RGB image



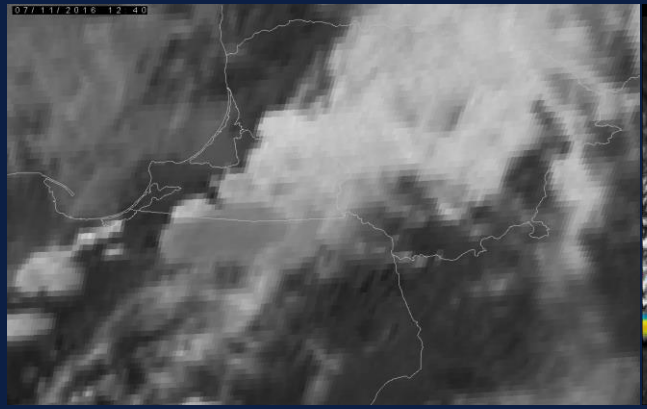
HRV band



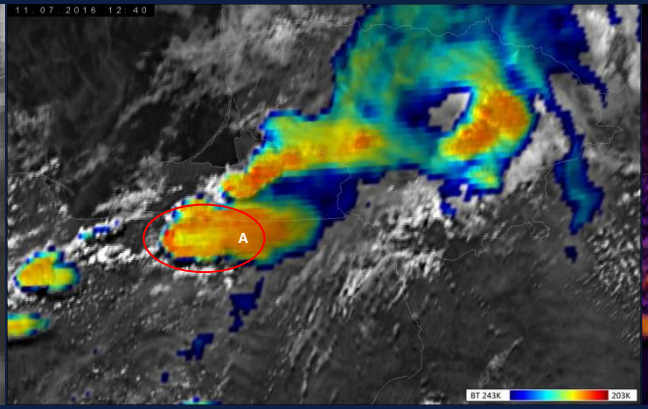
IR 10.8 BT (203-243K) color-enhanced image



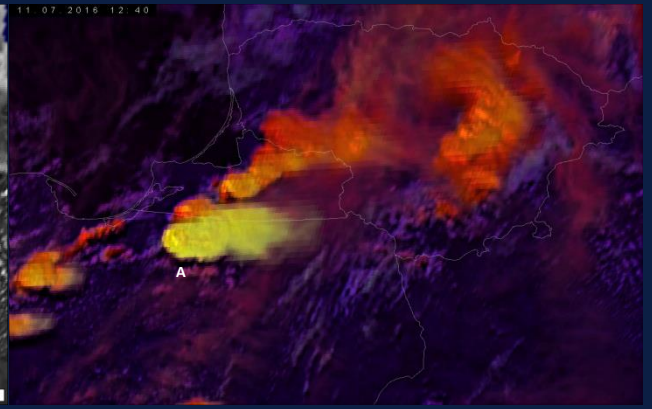
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

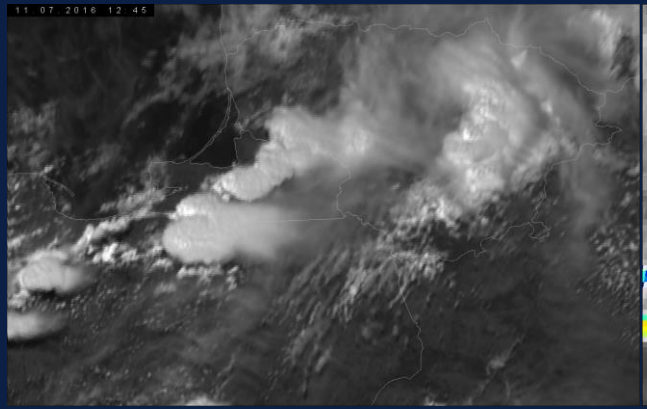


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

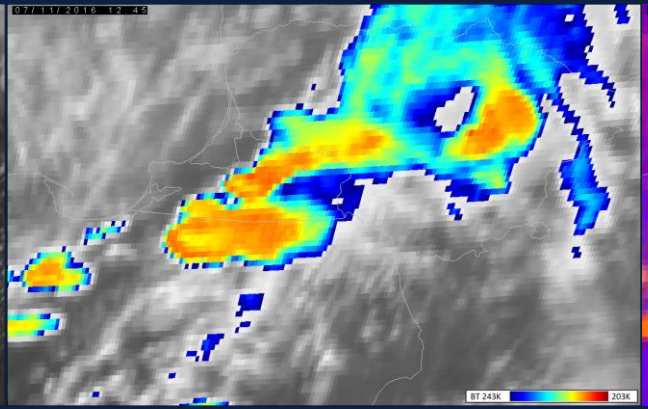


sandwich product – HRV band and Convective storms RGB image

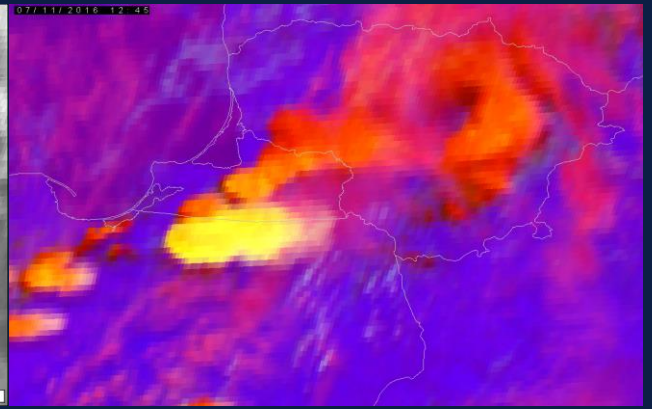
From here on, the embedded warm area downwind of the overshooting tops increases in size, and the whole storm gains an appearance of a typical "cold-U shaped" storm. The 3.9 µm cloud-top reflectivity of the storm is still very high, there are distinct overshooting tops ... so from now-on the storm definitely has all the indicators of potentially high severity. Don't forget that all of the storm tops and their various features appear shifted by about 25-35 km north - northeast from their real location due to the parallax effect.



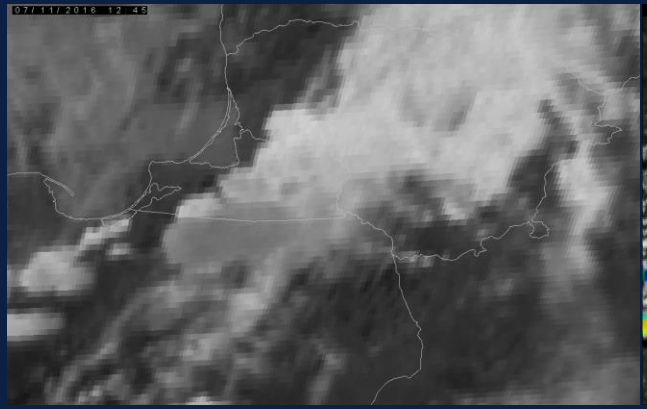
HRV band



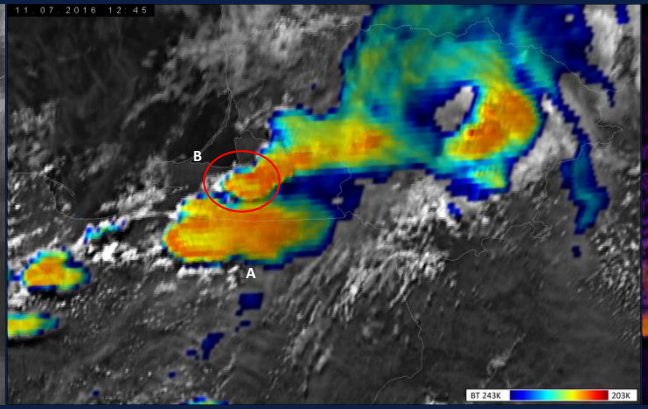
IR 10.8 BT (203-243K) color-enhanced image



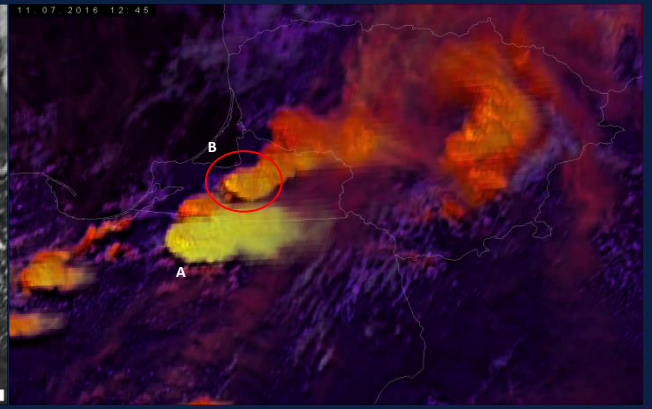
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

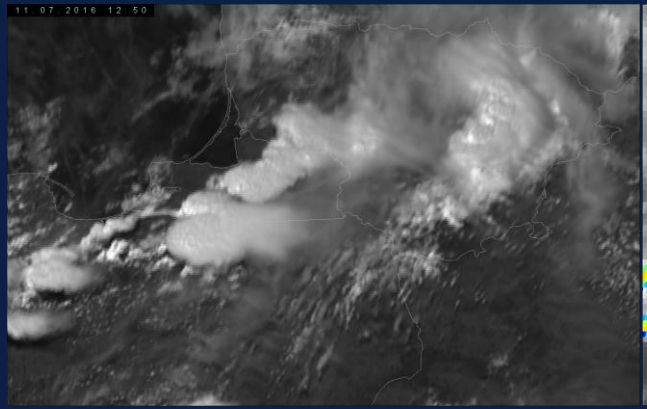


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

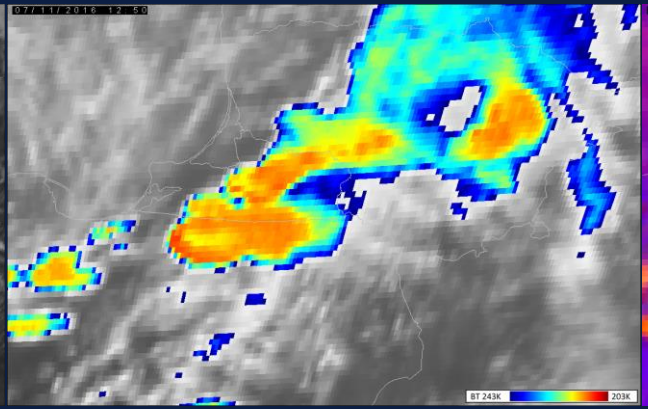


sandwich product – HRV band and Convective storms RGB image

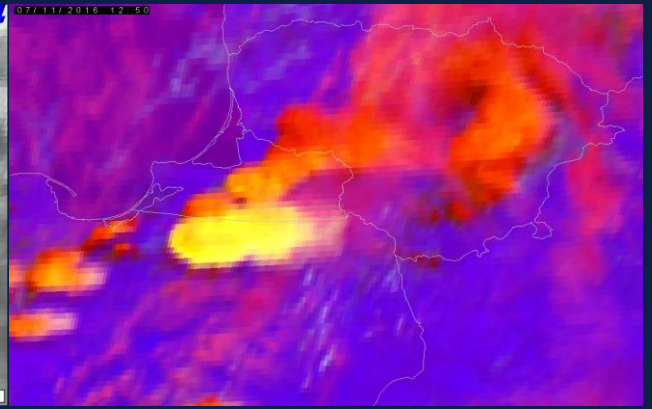
At this point, another potentially interesting storm (labeled as storm "B") begins to evolve NE of the storm A. The storm B has formed within a pre-existing line of weaker storms (probably a convergence line), but from these MSG images it is impossible to decide if storm A and its outflow had any influence on the storm B (its formation and strength) or not. However, at this stage the storm B doesn't appear interesting yet ... its time will only come.



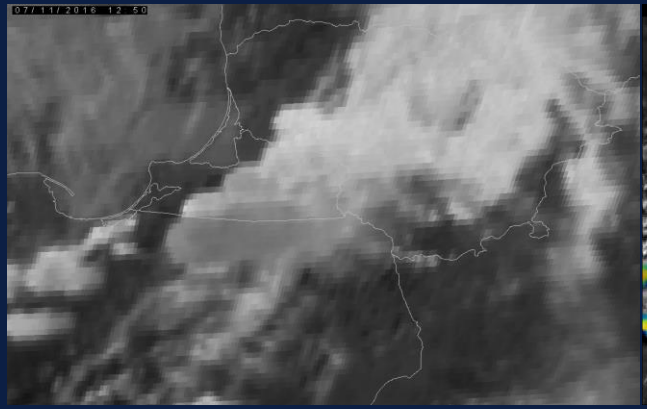
HRV band



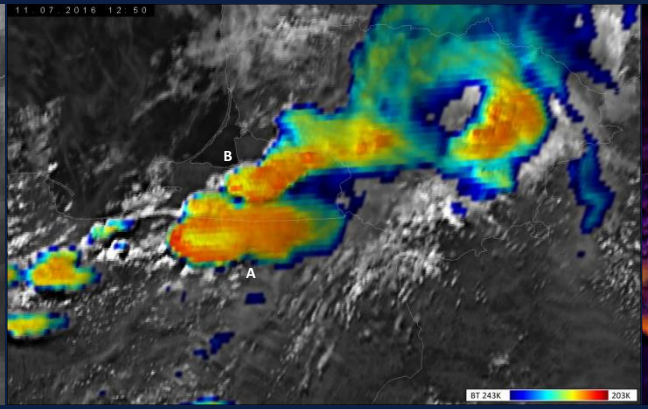
IR 10.8 BT (203-243K) color-enhanced image



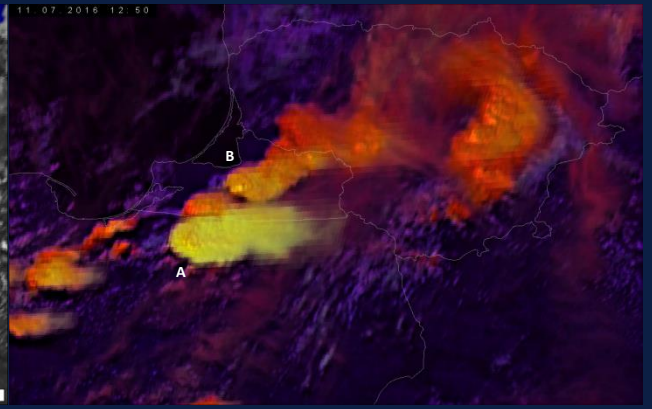
Convective storms RGB image product



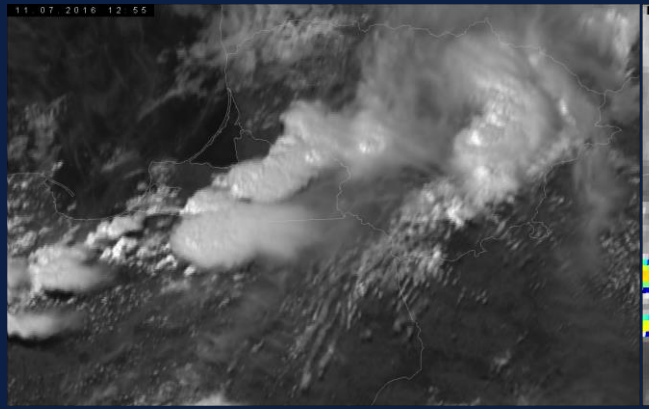
IR 3.9 band (displayed as radiance image)



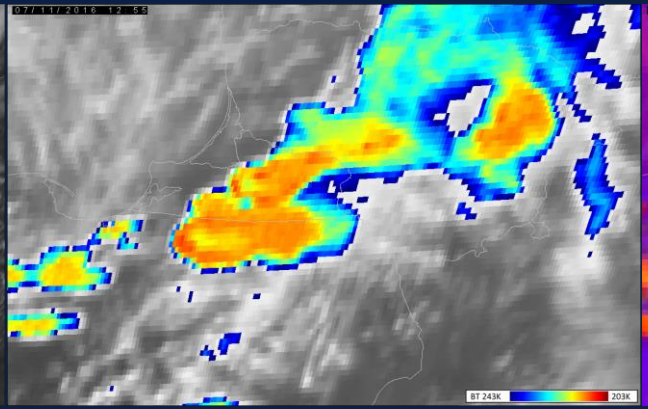
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



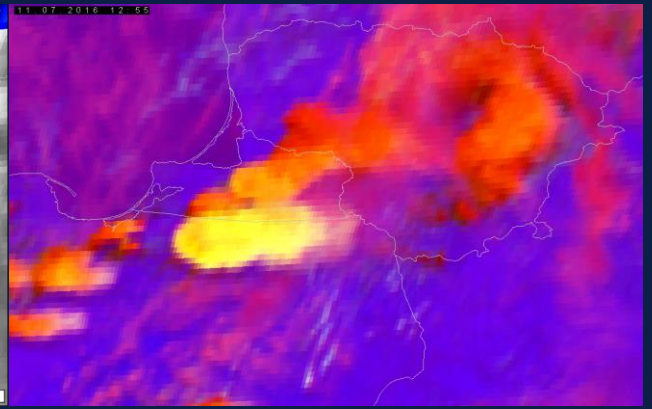
sandwich product – HRV band and Convective storms RGB image



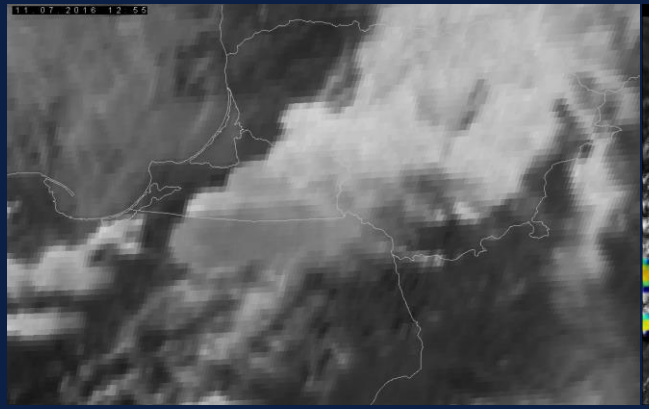
HRV band



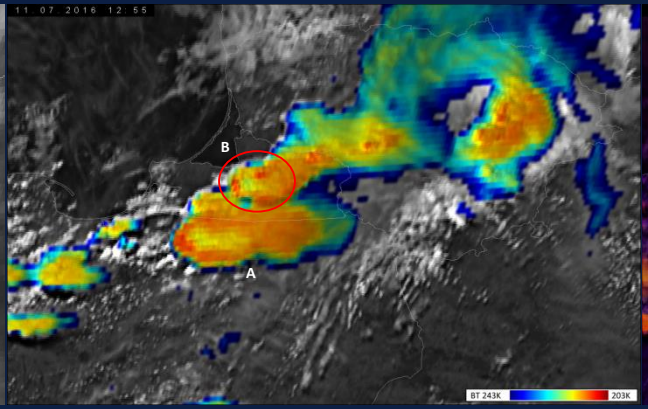
IR 10.8 BT (203-243K) color-enhanced image



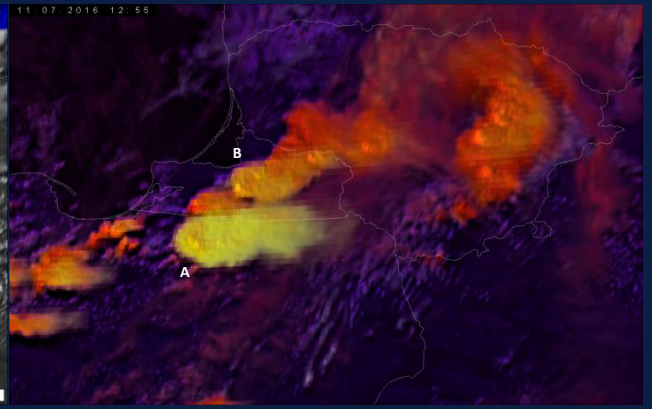
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

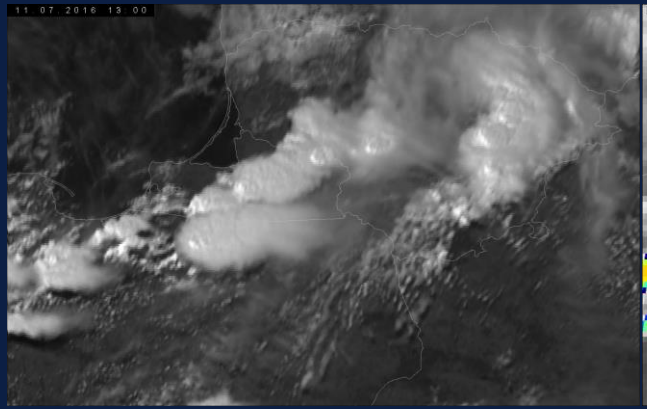


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

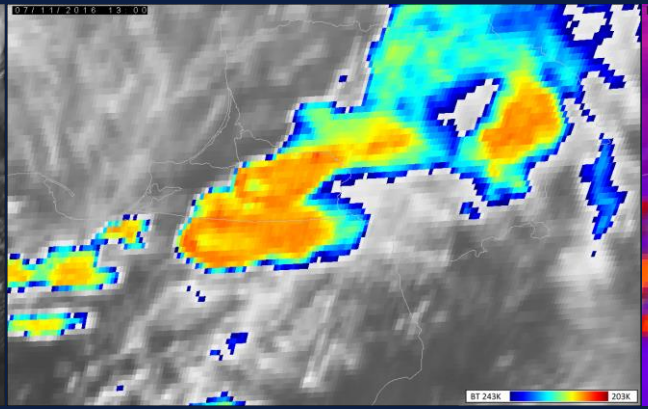


sandwich product – HRV band and Convective storms RGB image

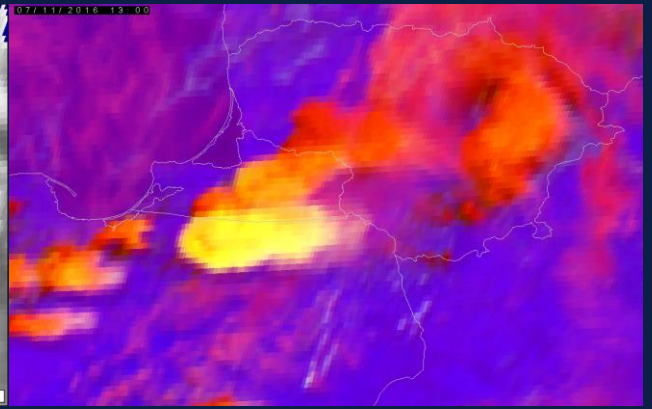
Here the storm B begins to form a distinct embedded warm area, downwind (east) of cold overshooting tops. This warm area strengthens and increases its horizontal extend (size) with time (next several slides), and ultimately – around 13:05 – forms a distinct cold-U feature, similar to that of the storm A. Its cloud-top reflectivity in microphysical bands or in the Storm-RGB product (and corresponding sandwich product) is slightly higher than that of the other storms in the area, but still much weaker than cloud-top reflectivity of the storm A.



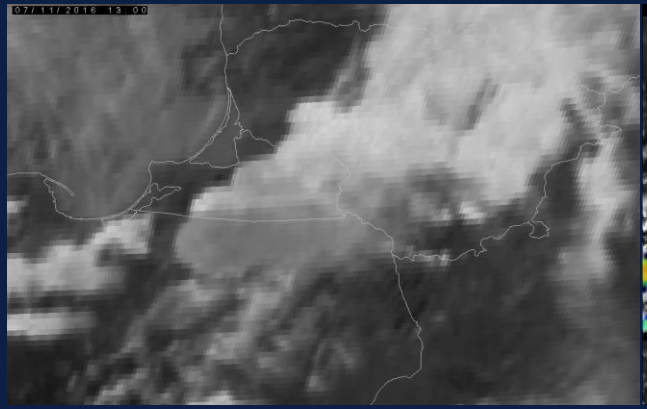
HRV band



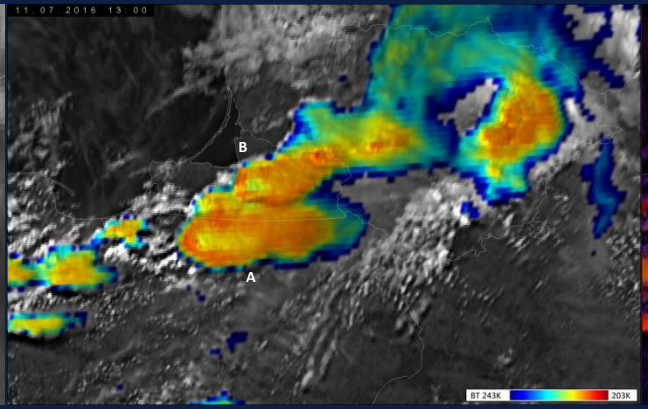
IR 10.8 BT (203-243K) color-enhanced image



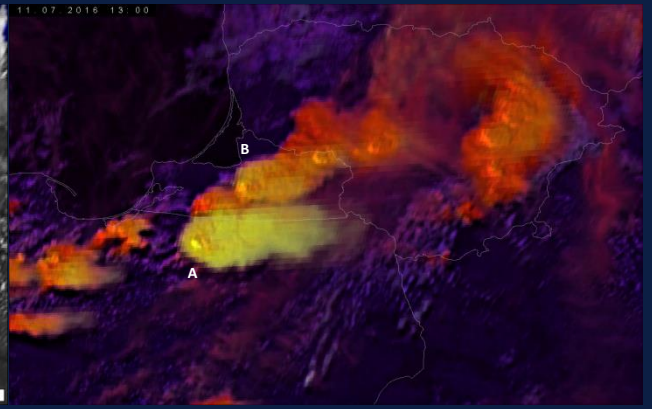
Convective storms RGB image product



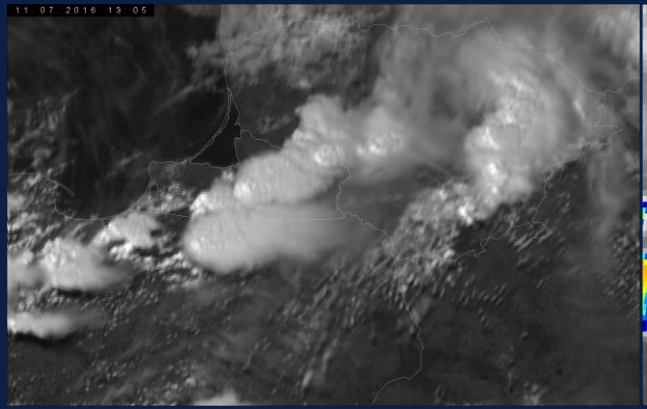
IR 3.9 band (displayed as radiance image)



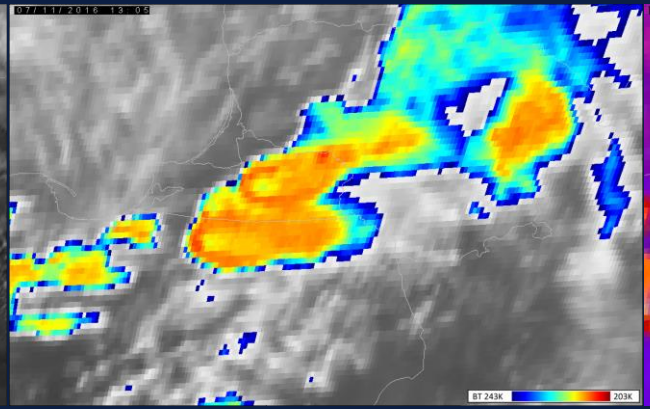
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



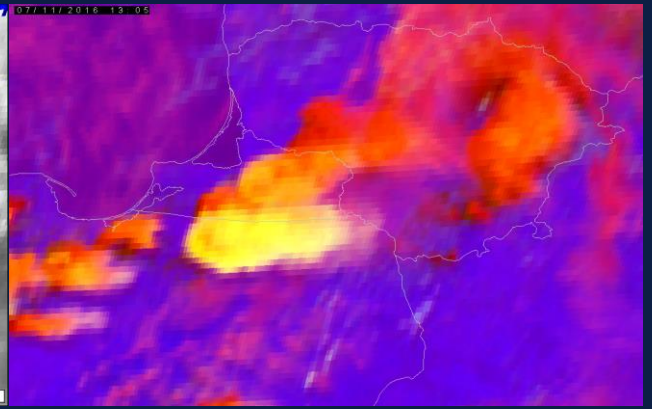
sandwich product – HRV band and Convective storms RGB image



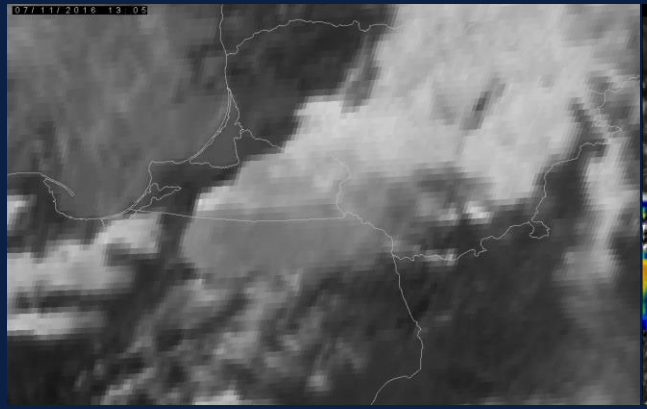
HRV band



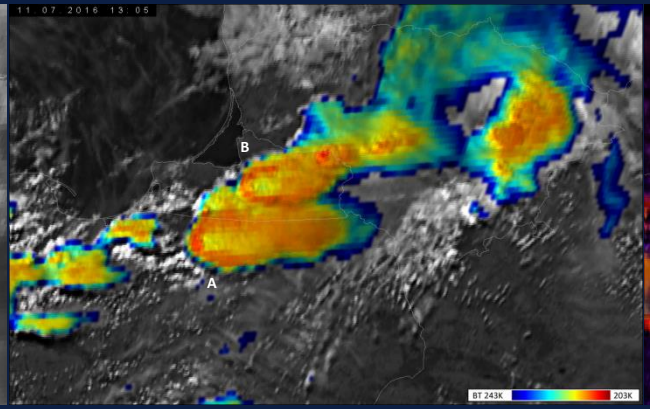
IR 10.8 BT (203-243K) color-enhanced image



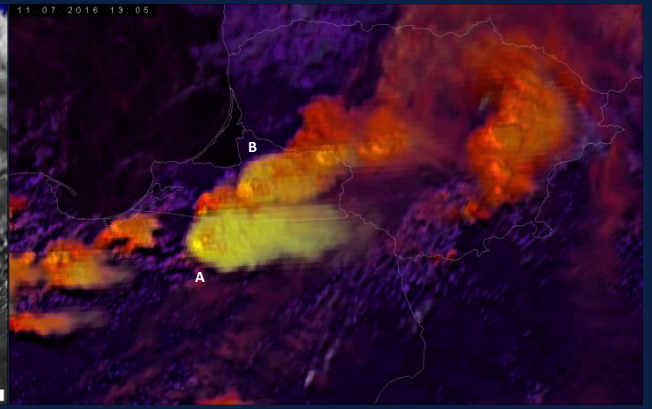
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

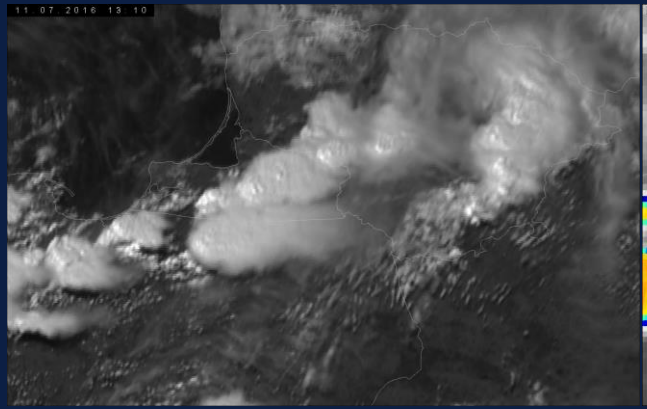


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

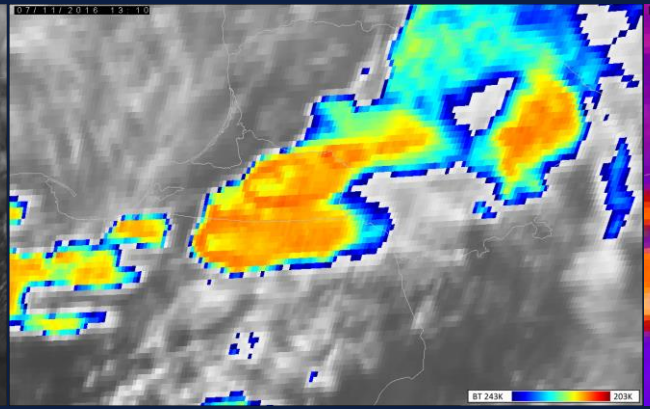


sandwich product – HRV band and Convective storms RGB image

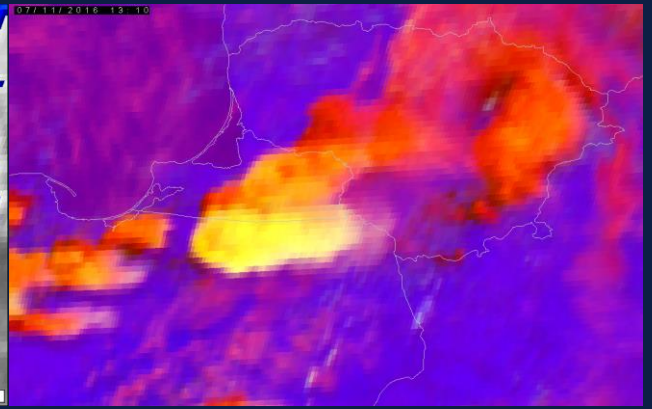
From now-on, the two storms (A and B) appear very similar in the IR10.8 band, both of them exhibit a very well pronounced cold-U feature, and both of them are accompanied by active overshooting tops, The only difference between them is the cloud-top reflectivity, with reflectivity of the storm A being significantly higher than that of storm B. This difference remains preserved throughout the whole lifetime of these two storms. High 1.6 and 3.9 µm cloud-top reflectivity typically means strong updrafts, thus higher potential of the storm to produce severe weather.



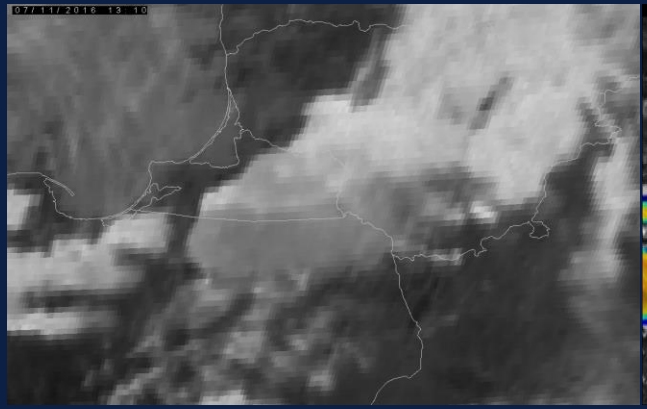
HRV band



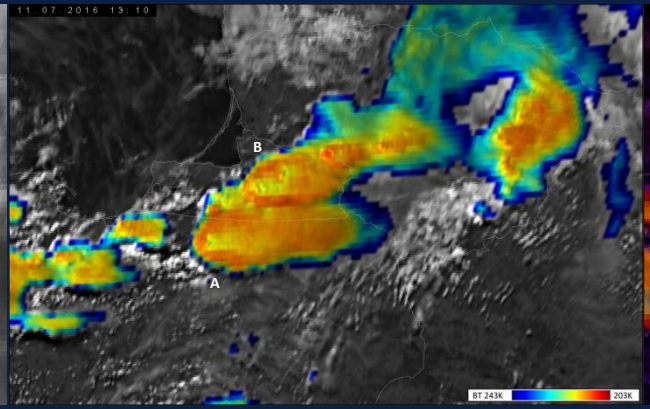
IR 10.8 BT (203-243K) color-enhanced image



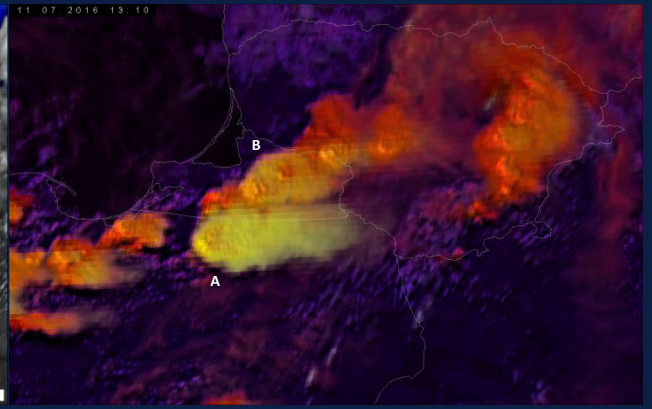
Convective storms RGB image product



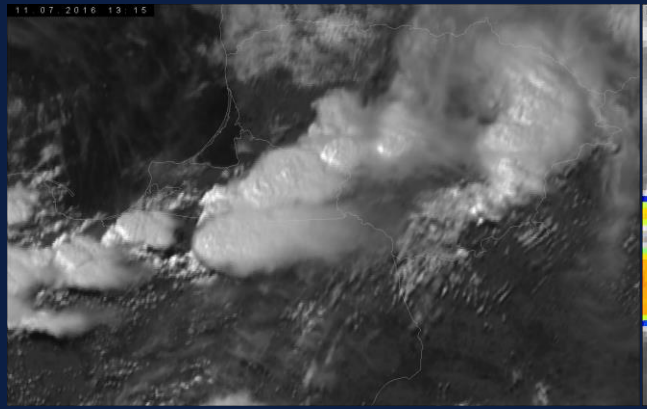
IR 3.9 band (displayed as radiance image)



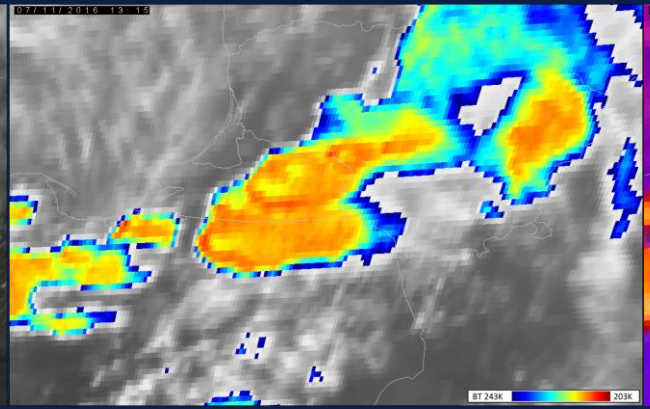
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



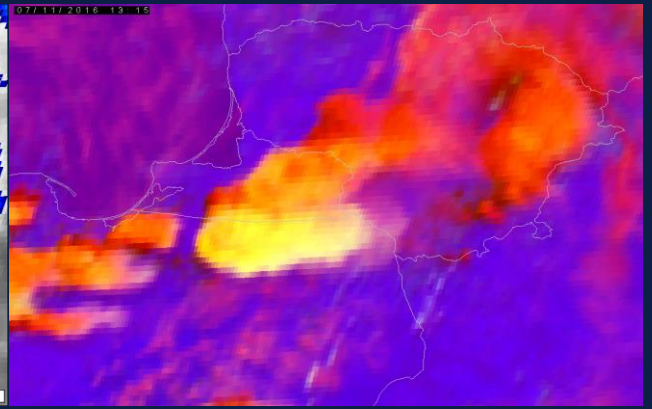
sandwich product – HRV band and Convective storms RGB image



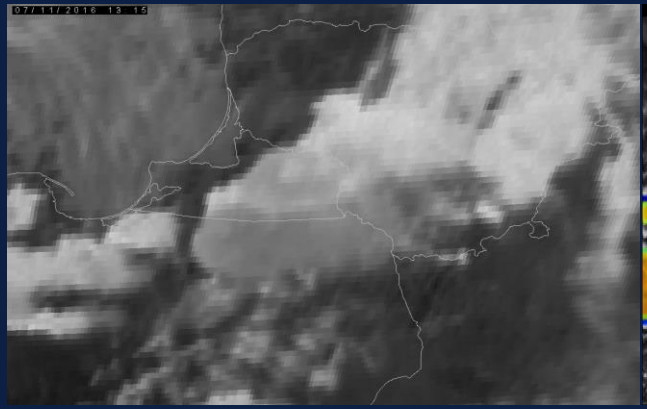
HRV band



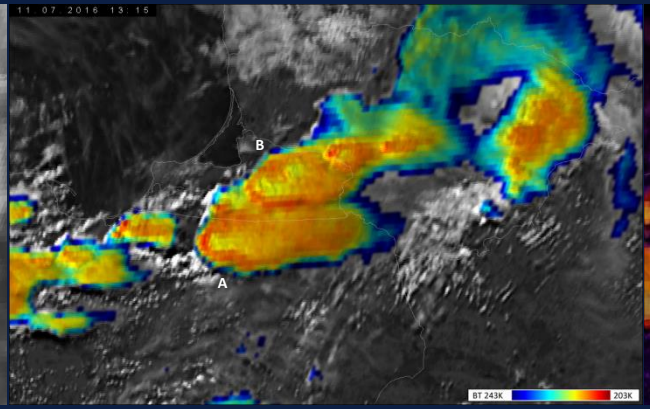
IR 10.8 BT (203-243K) color-enhanced image



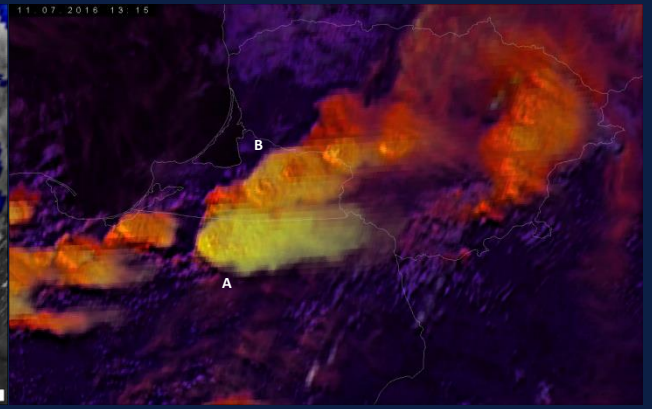
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

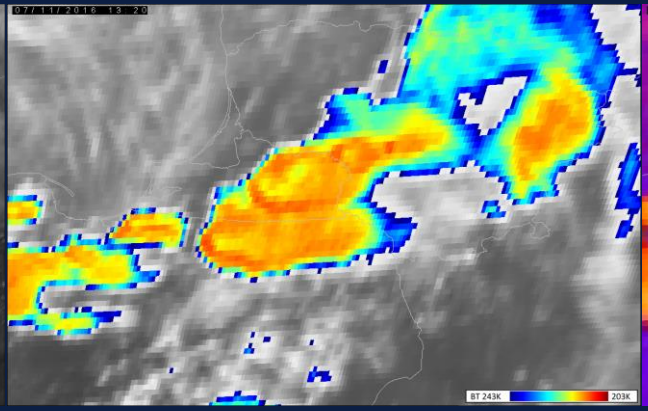


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

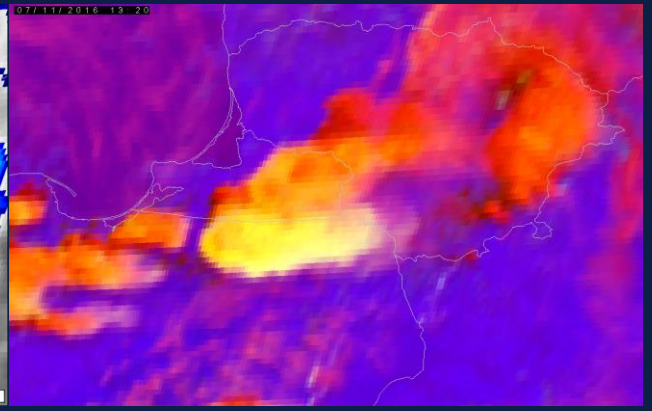


sandwich product – HRV band and Convective storms RGB image

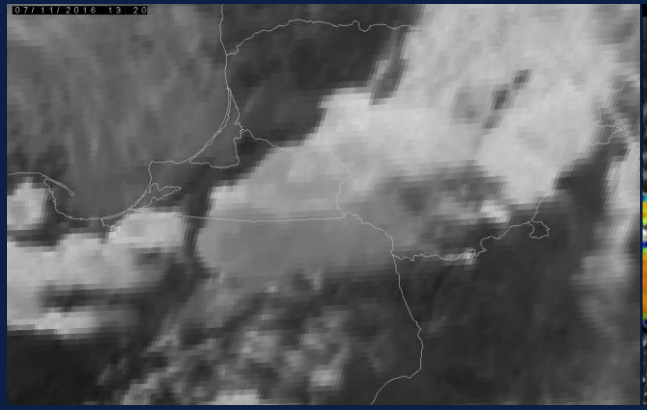
HRV band



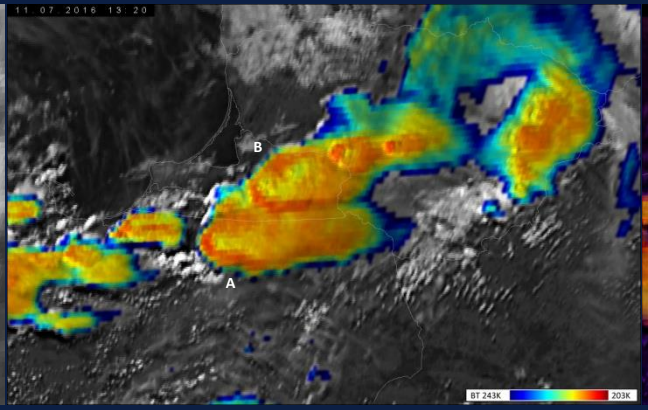
IR 10.8 BT (203-243K) color-enhanced image



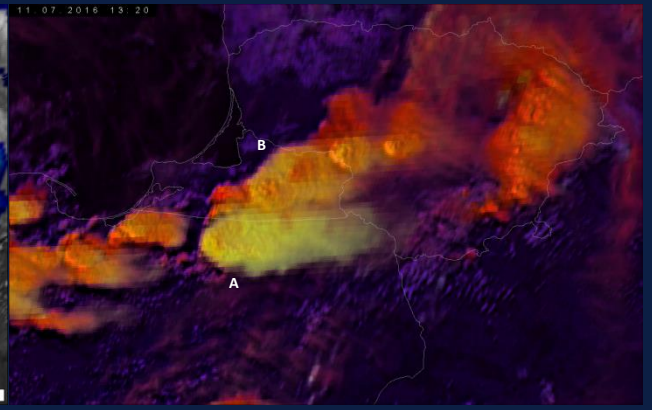
Convective storms RGB image product



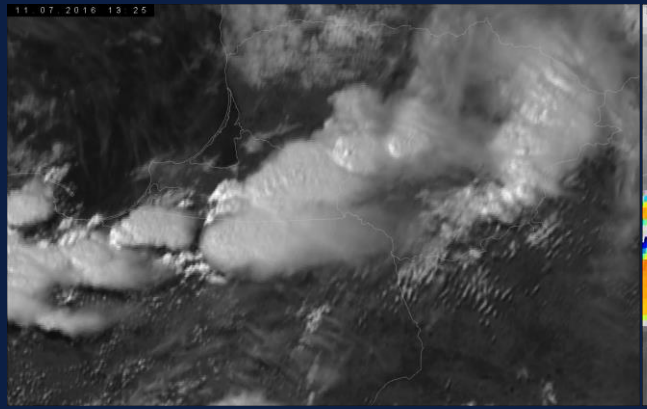
IR 3.9 band (displayed as radiance image)



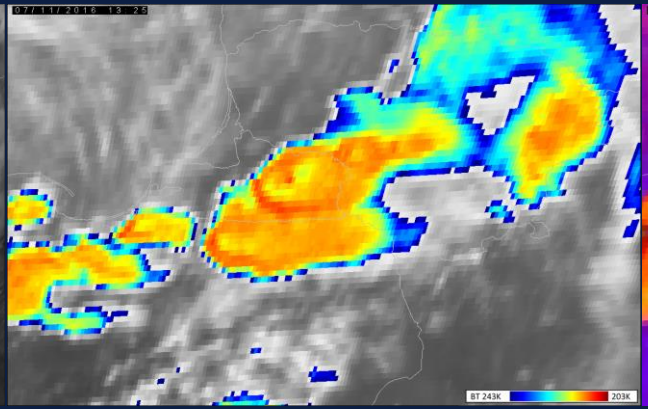
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



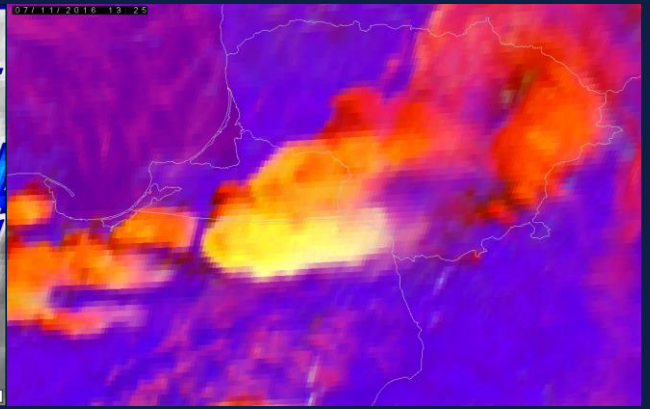
sandwich product – HRV band and Convective storms RGB image



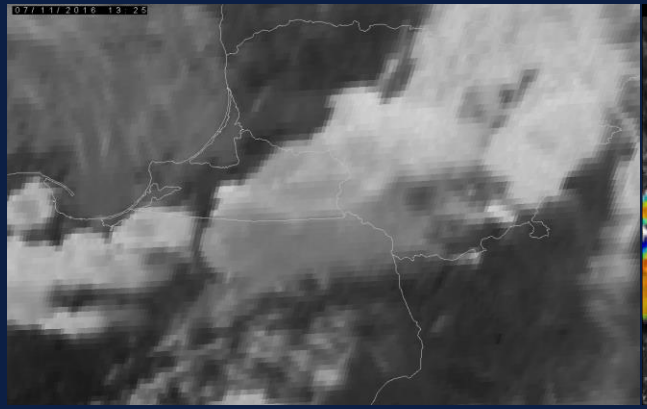
HRV band



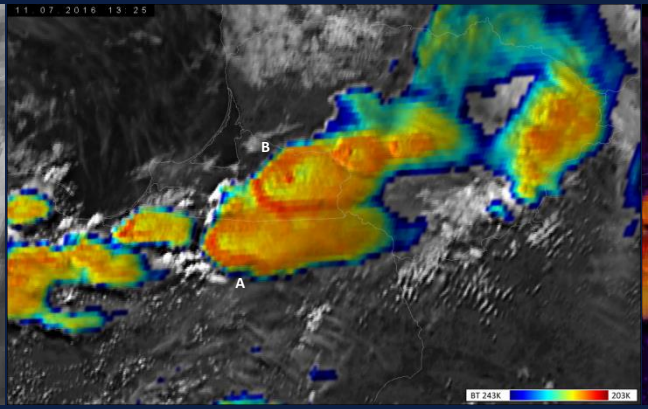
IR 10.8 BT (203-243K) color-enhanced image



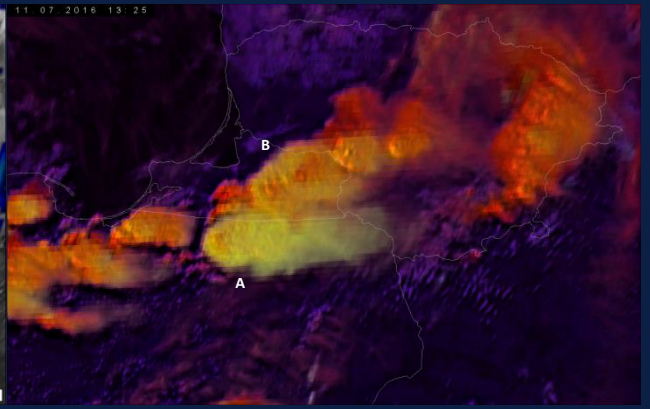
Convective storms RGB image product



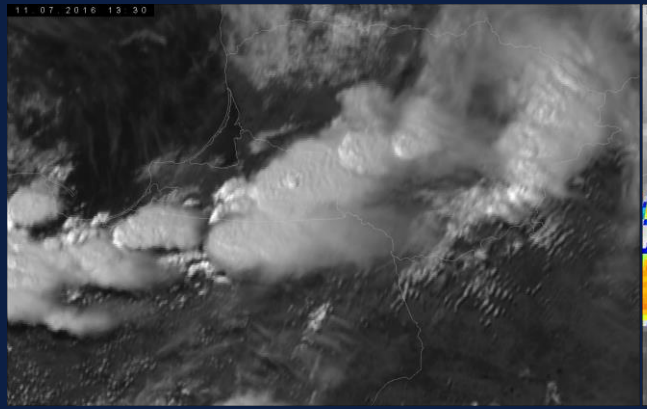
IR 3.9 band (displayed as radiance image)



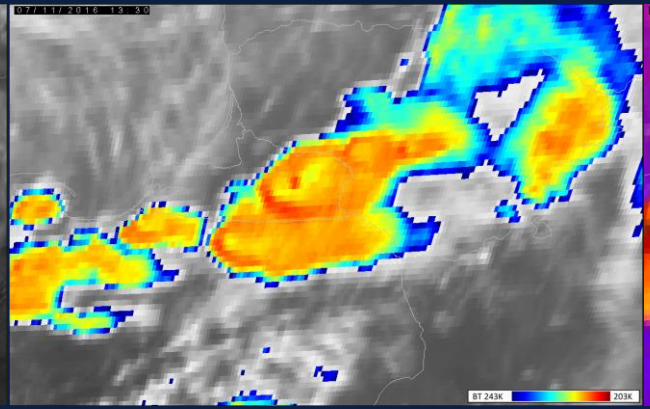
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



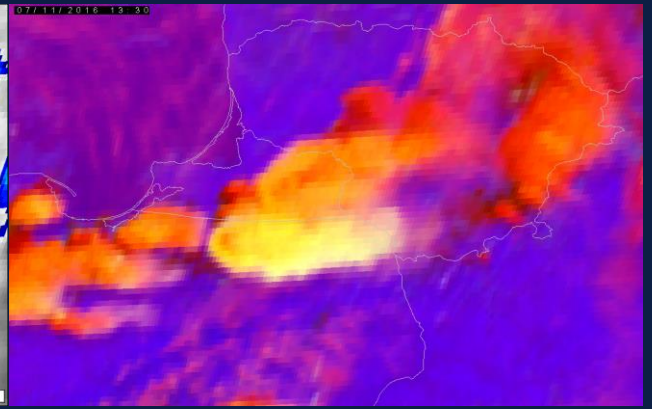
sandwich product – HRV band and Convective storms RGB image



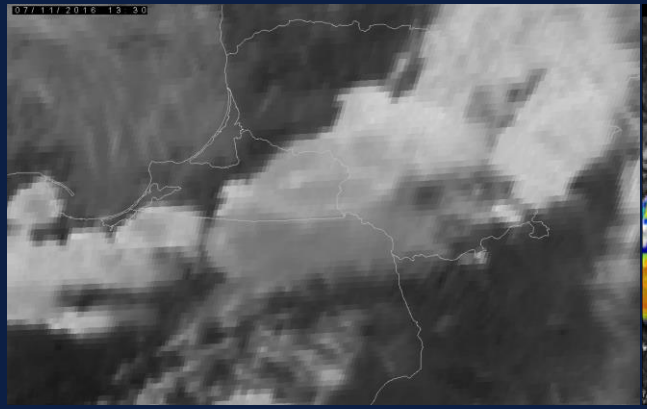
HRV band



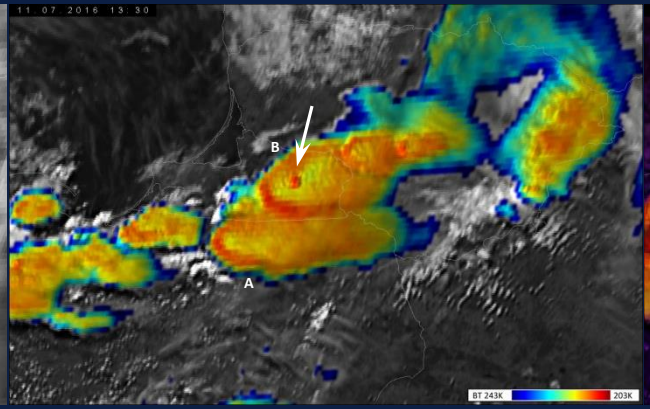
IR 10.8 BT (203-243K) color-enhanced image



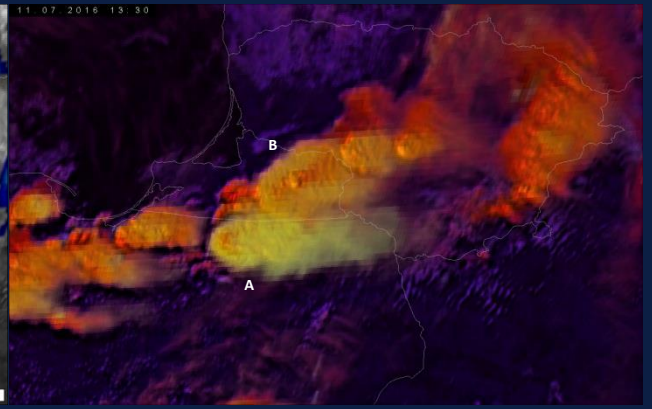
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

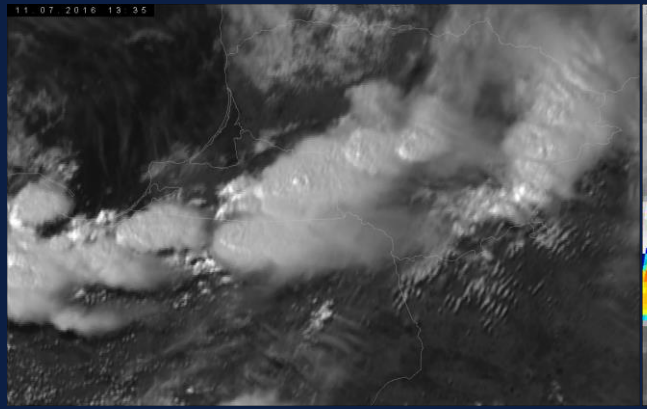


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

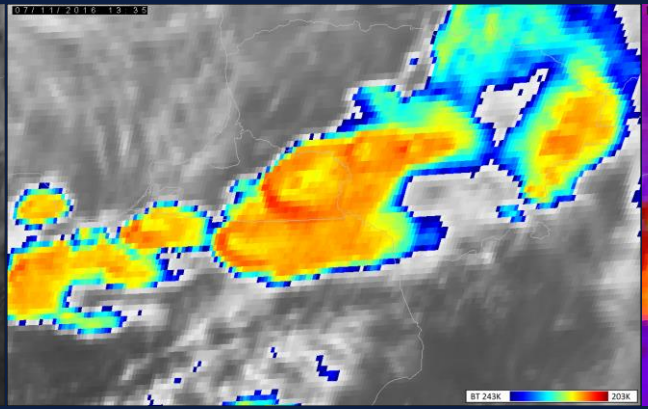


sandwich product – HRV band and Convective storms RGB image

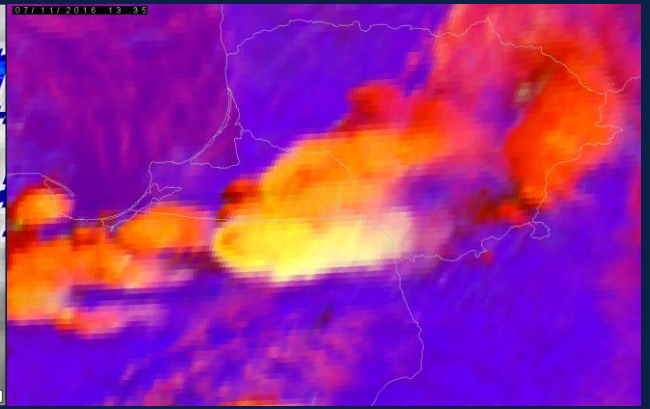
At this time, storm B generates a very well pronounced overshooting top (OT, arrowed). First trace of the OT is visible already on previous slide, and on the next slide it is gone. Typically, such well-developed OTs manifest a strong surge in the updraft intensity, and thus is likely to be followed shortly by a strong downdraft (downburst or microburst). However, note that the 3.9 μm reflectivity of this OT is very low, indicating a presence of normal, larger ice particles. Also the location of this OT is rather atypical, usually these are located near the apex of the cold-U. Thus, its significance is somewhat uncertain ...



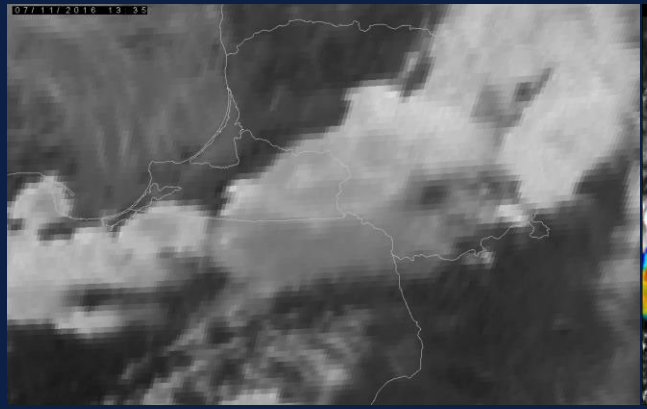
HRV band



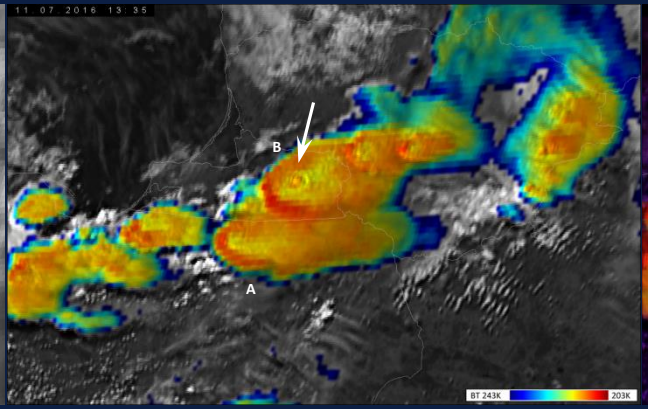
IR 10.8 BT (203-243K) color-enhanced image



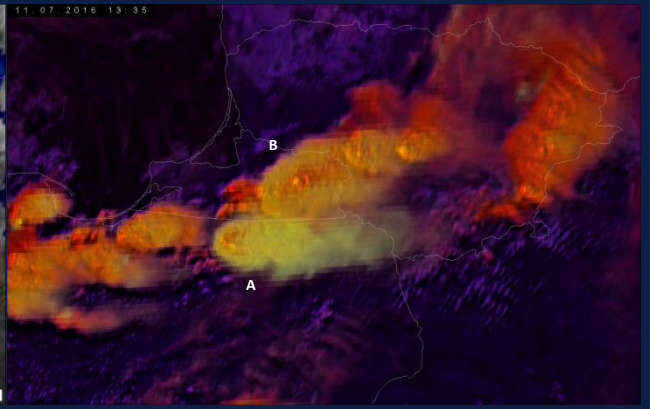
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

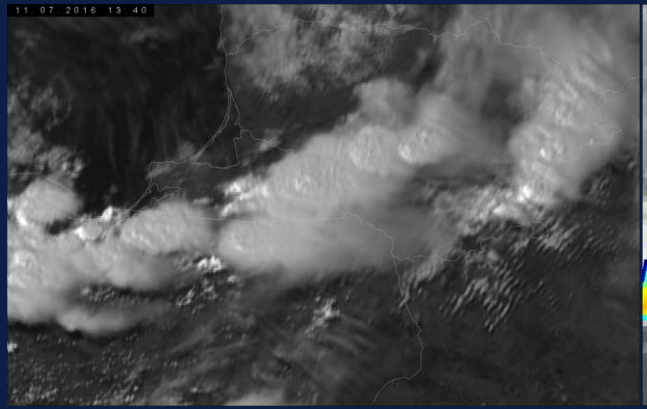


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

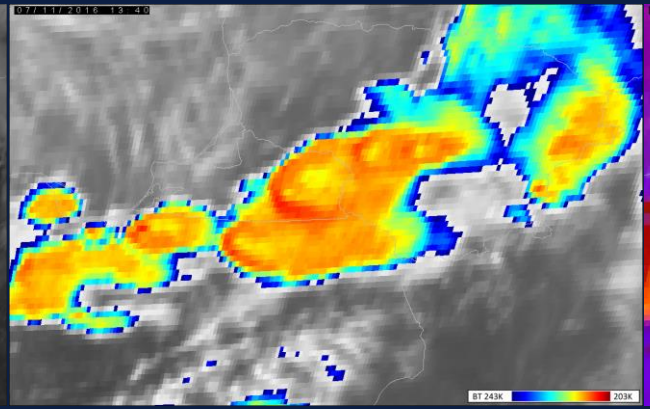


sandwich product – HRV band and Convective storms RGB image

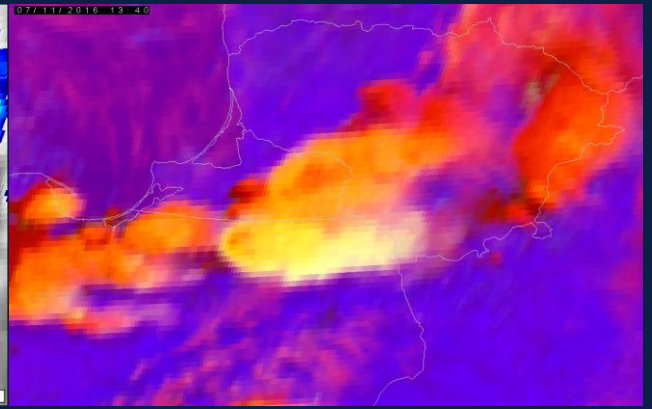
Here the OT from previous slide has already collapsed, and a small gravity wave expands eastward.



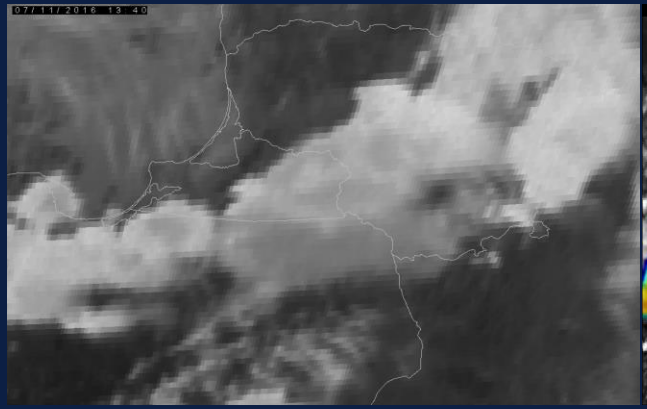
HRV band



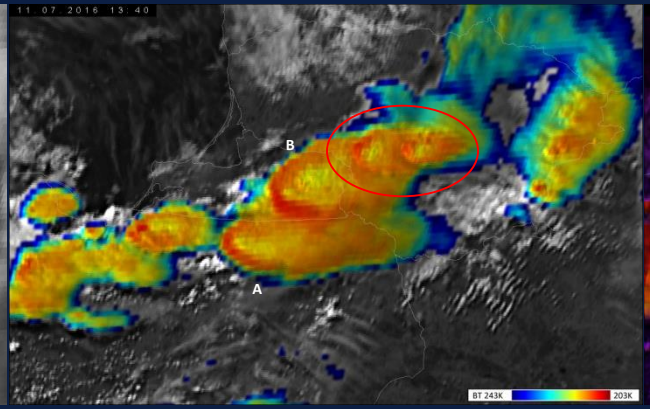
IR 10.8 BT (203-243K) color-enhanced image



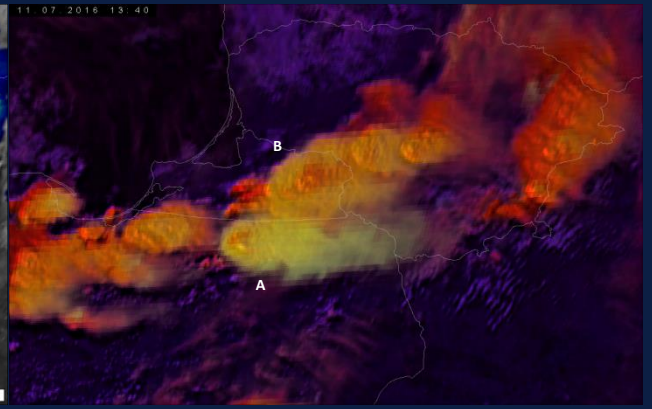
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

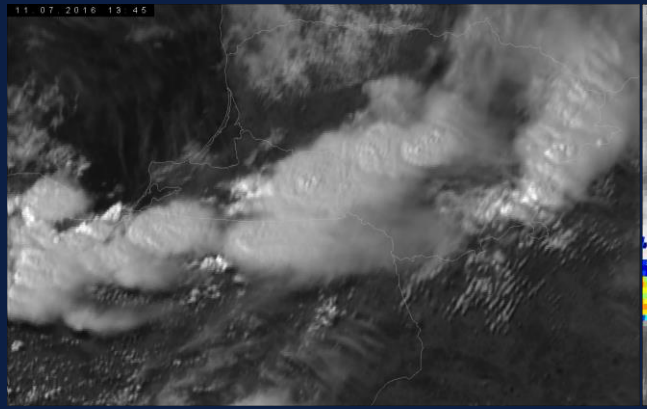


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

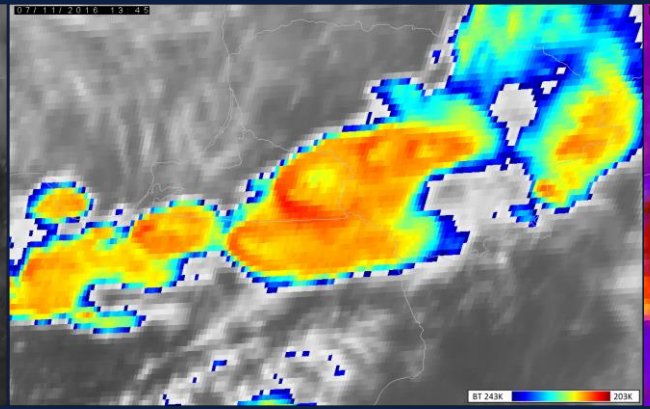


sandwich product – HRV band and Convective storms RGB image

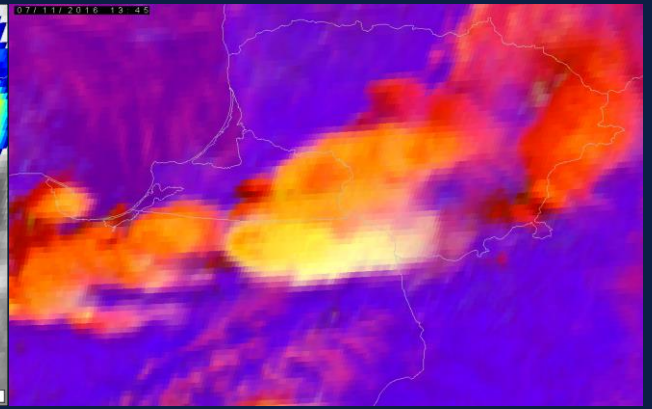
Notice here another two smaller storms east of the storm B, both with cold rings forming atop of these. They never reached the stage of cold-U, but the cold ring feature was present there for almost 1 hour (for the eastern storm).



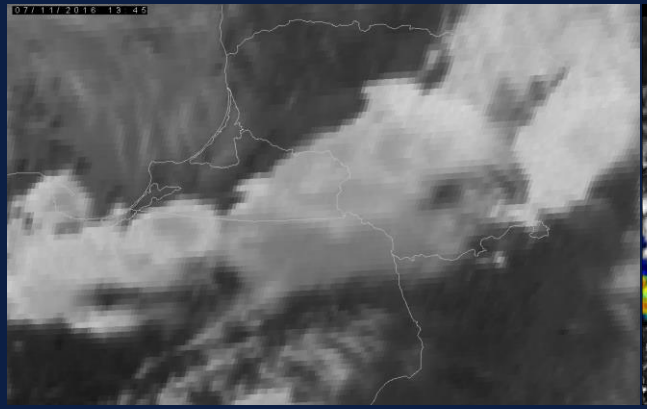
HRV band



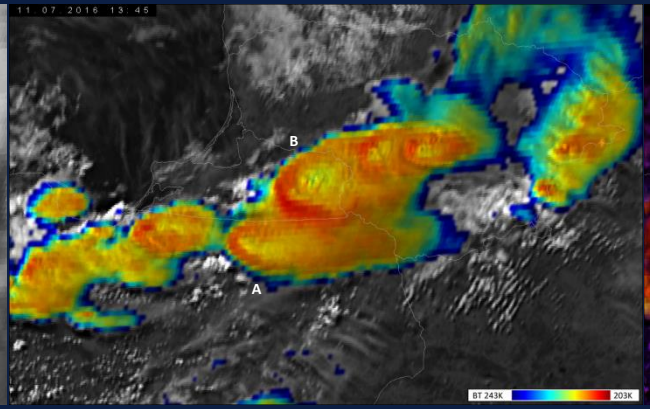
IR 10.8 BT (203-243K) color-enhanced image



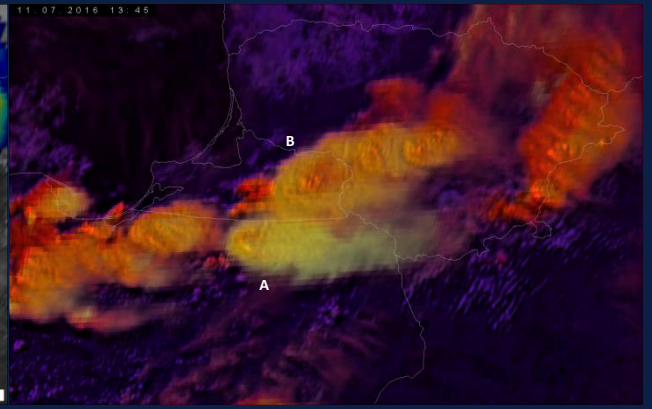
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

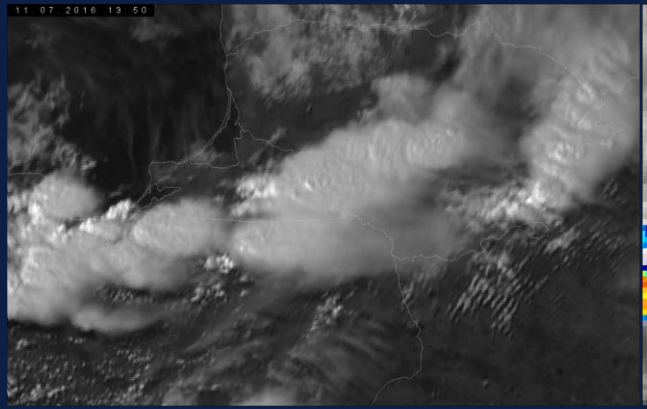


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

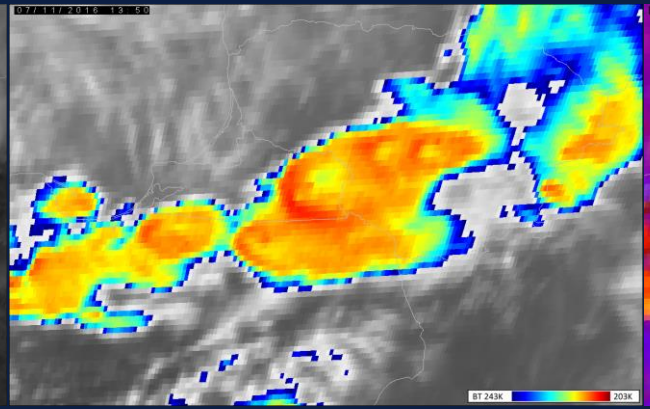


sandwich product – HRV band and Convective storms RGB image

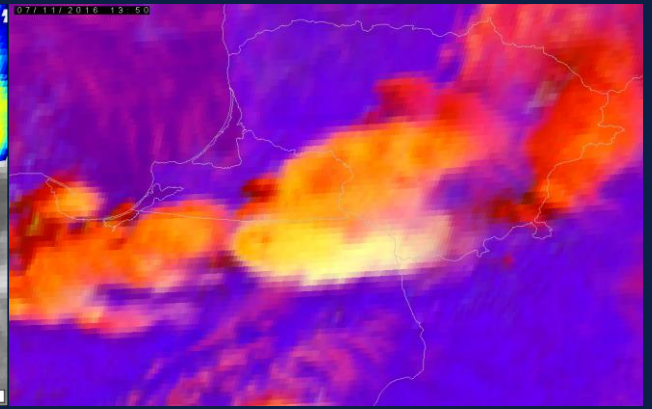
Warm area inside the top of storm A gradually modifies its shape, beginning to resemble a warmer, above-anvil ice plume. The plume becomes well visible in next slides, namely in both sandwich products.



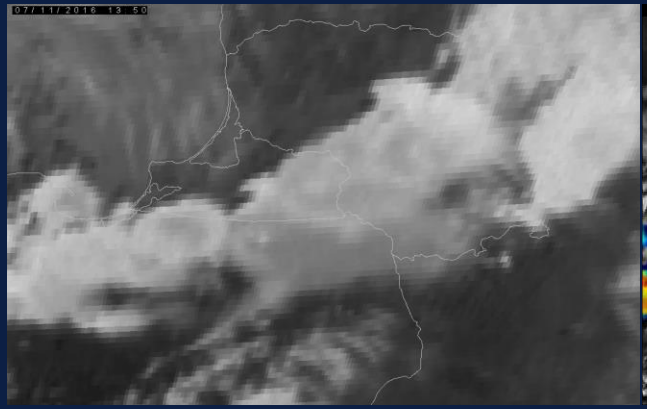
HRV band



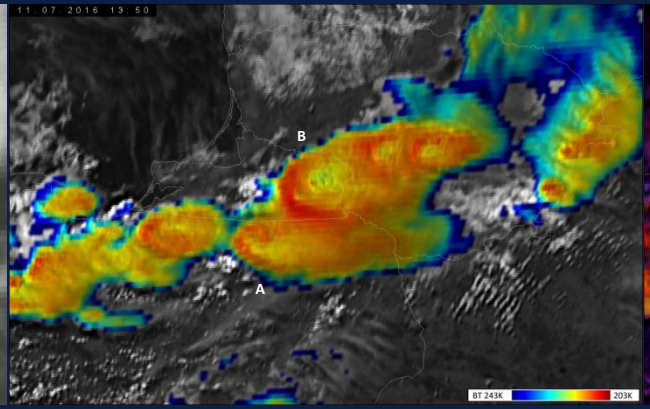
IR 10.8 BT (203-243K) color-enhanced image



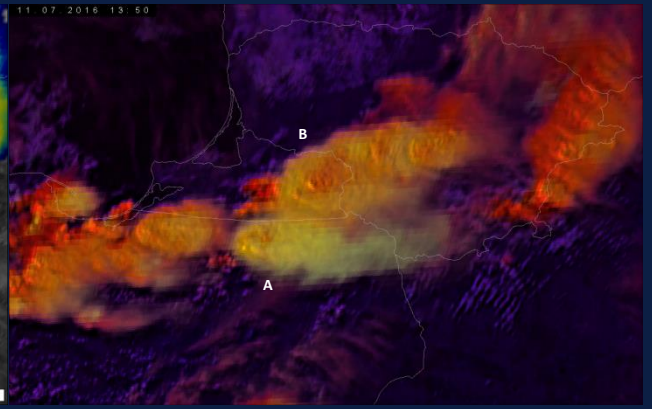
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

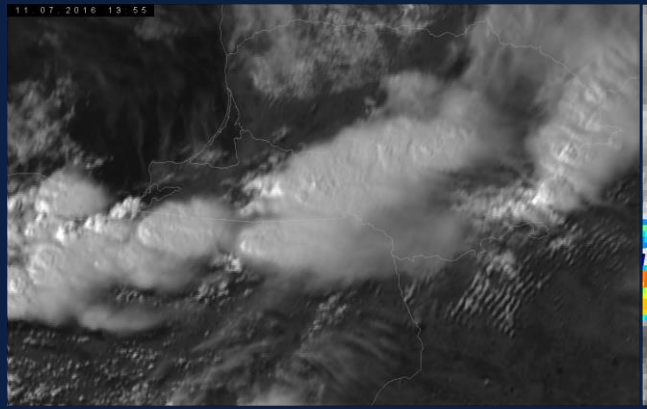


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

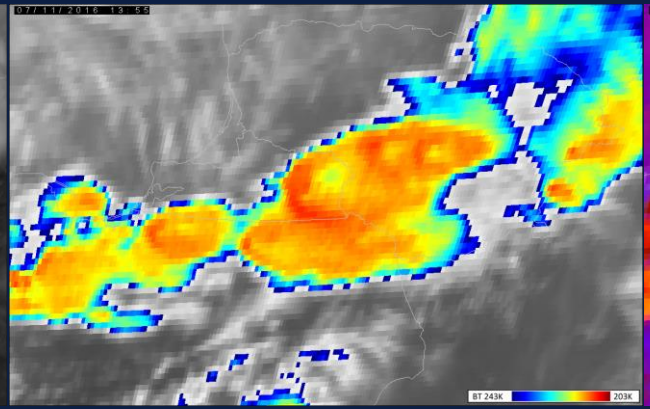


sandwich product – HRV band and Convective storms RGB image

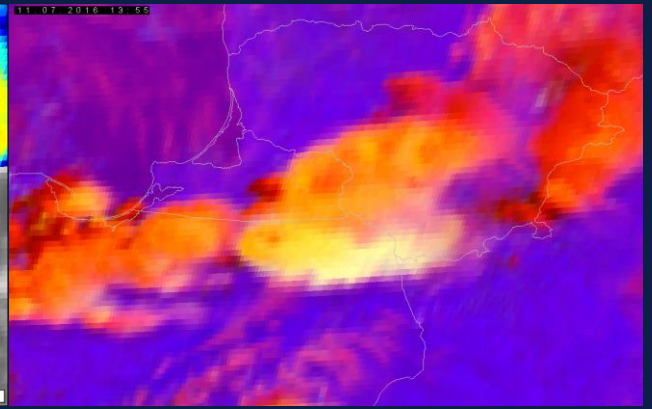
The storm A is beginning to weaken here, in 20 minutes it will be almost gone. The storm B still maintains its distinct cold-U shape, lasting for about one more hour.



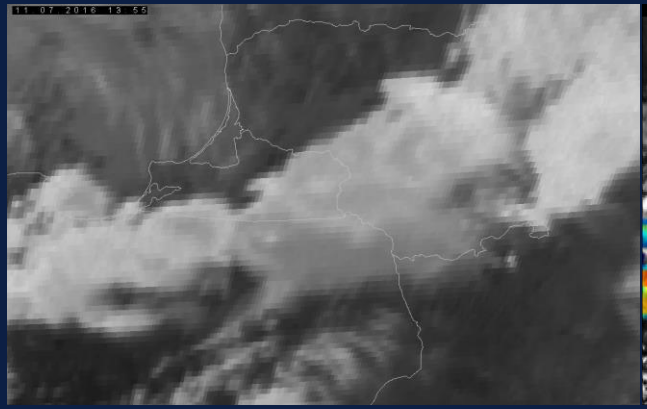
HRV band



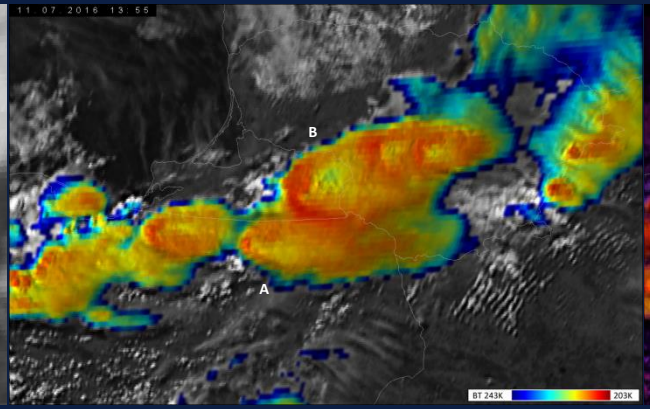
IR 10.8 BT (203-243K) color-enhanced image



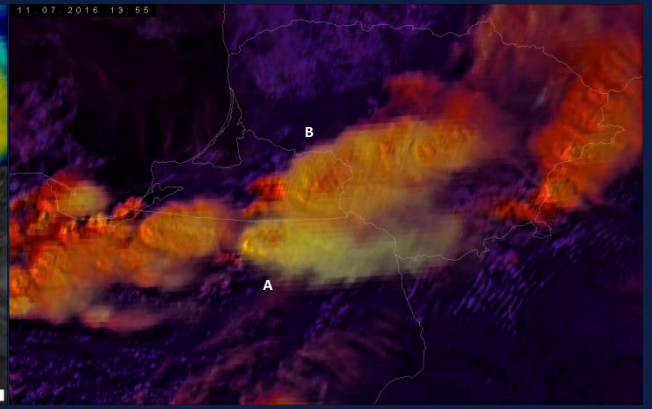
Convective storms RGB image product



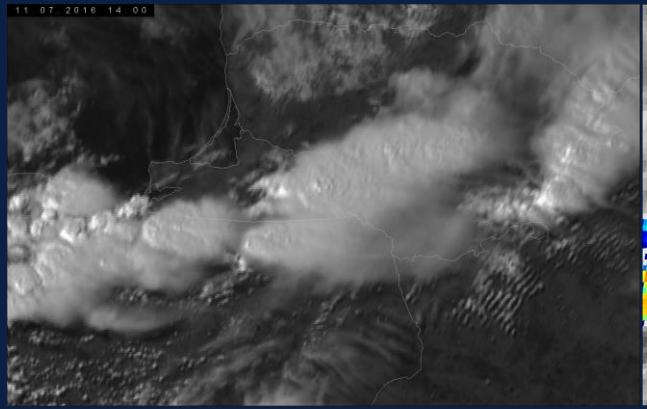
IR 3.9 band (displayed as radiance image)



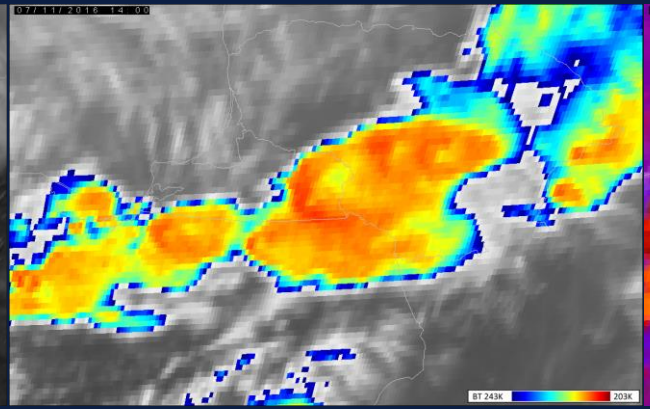
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



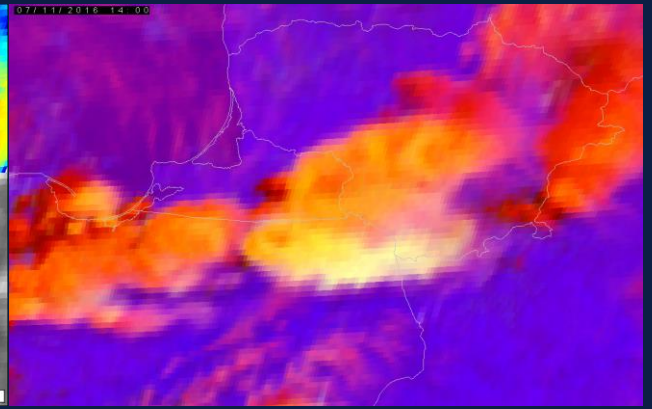
sandwich product – HRV band and Convective storms RGB image



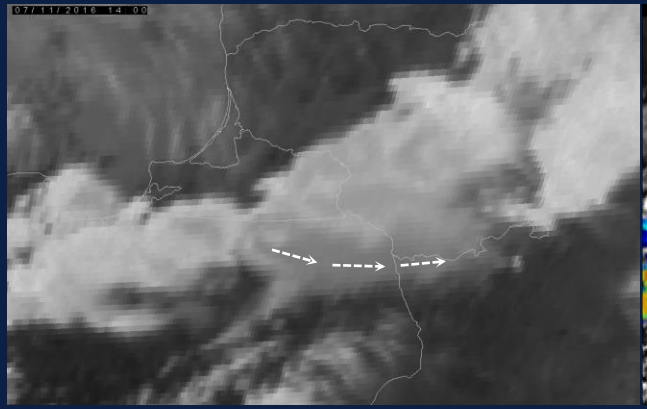
HRV band



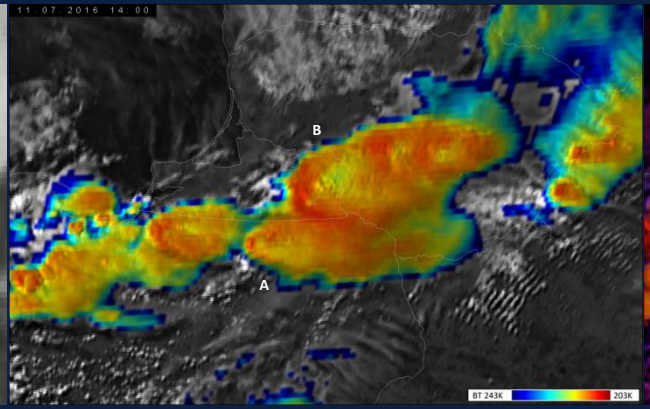
IR 10.8 BT (203-243K) color-enhanced image



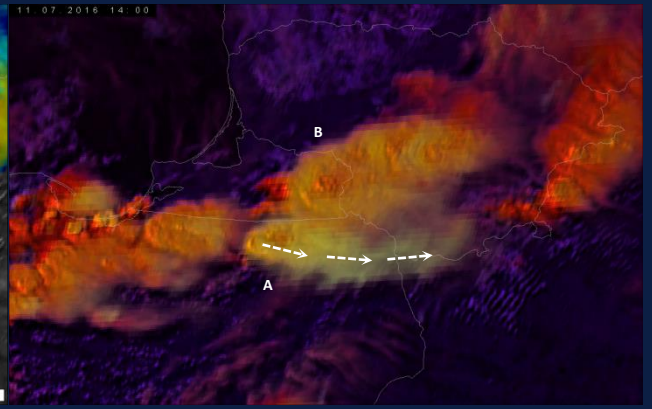
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

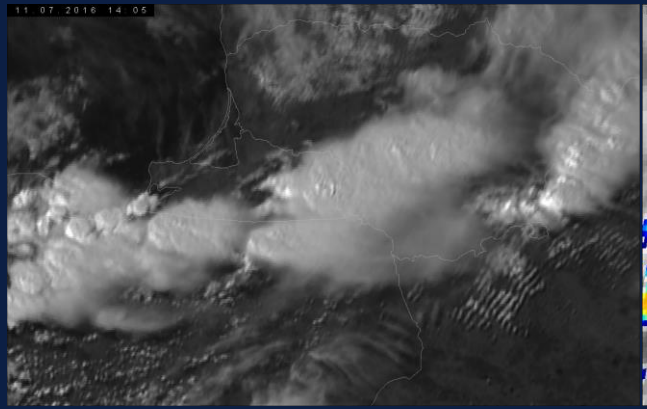


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

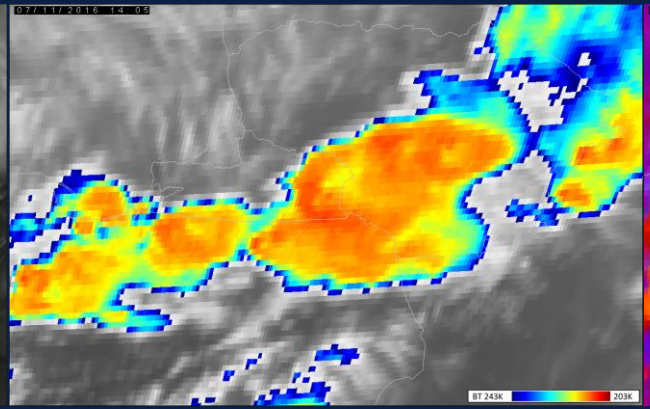


sandwich product – HRV band and Convective storms RGB image

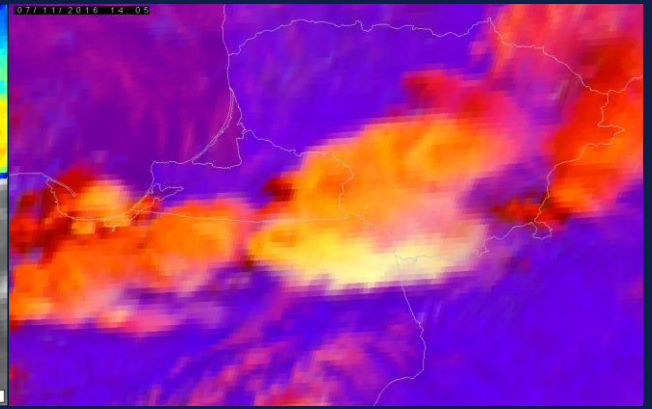
Arrows indicate location and direction of the above-anvil ice plume, generated by storm A and its successor, storm "C" (two slides ahead). The plume itself can be followed almost till the end of the sequence.



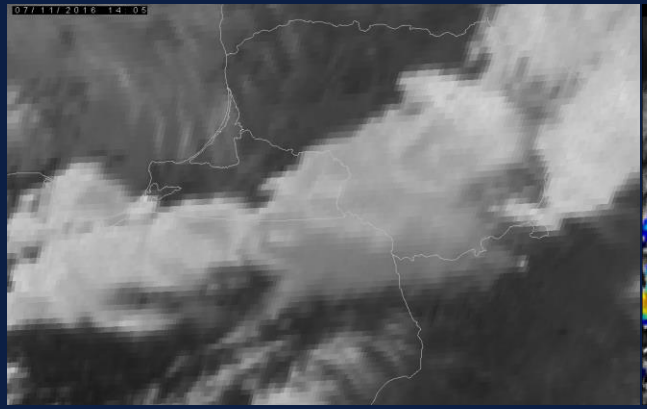
HRV band



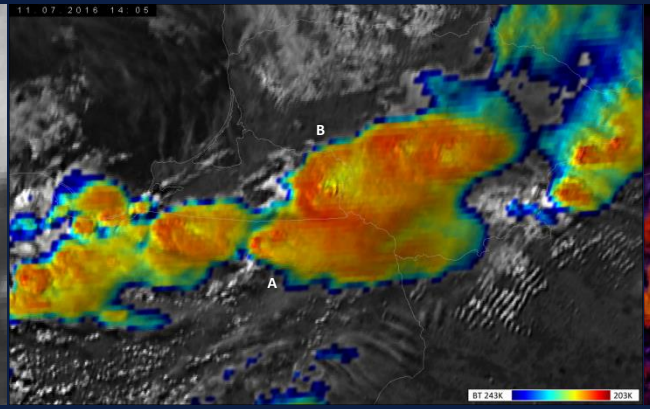
IR 10.8 BT (203-243K) color-enhanced image



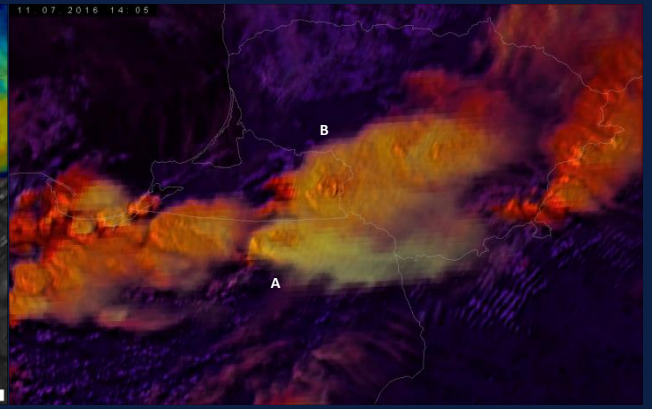
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

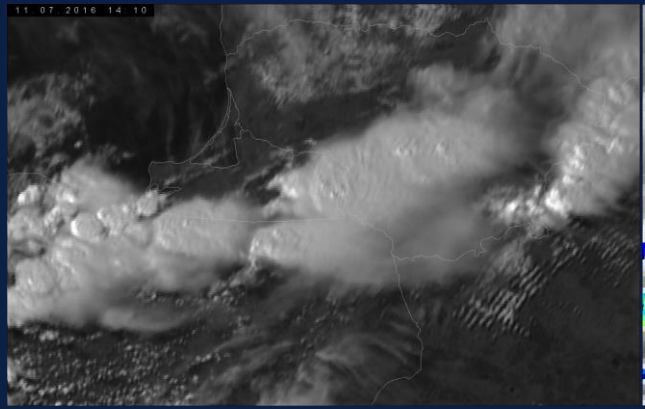


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

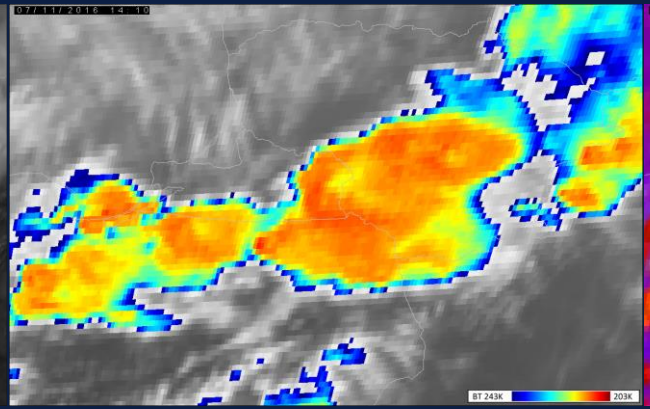


sandwich product – HRV band and Convective storms RGB image

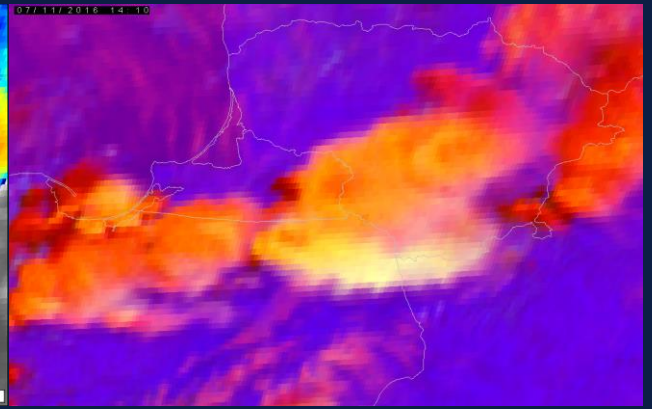
Here the storm A is almost gone. Interestingly, though, the plume which can be best seen in the Storm-RGB sandwich, seems to survive this episode, and the new storm ("C" in the next slide) continues to "feed" the plume (next slides) instead.



HRV band

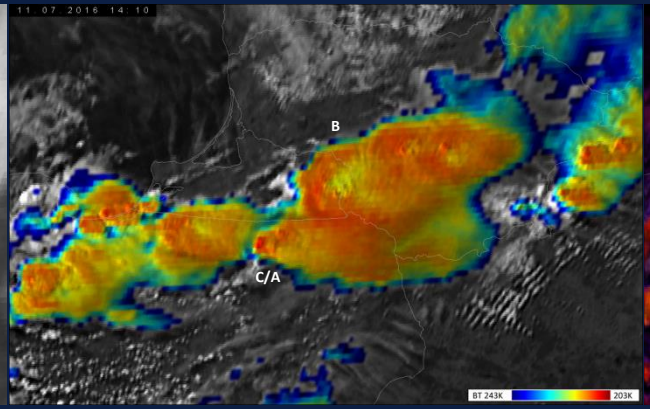


IR 10.8 BT (203-243K) color-enhanced image

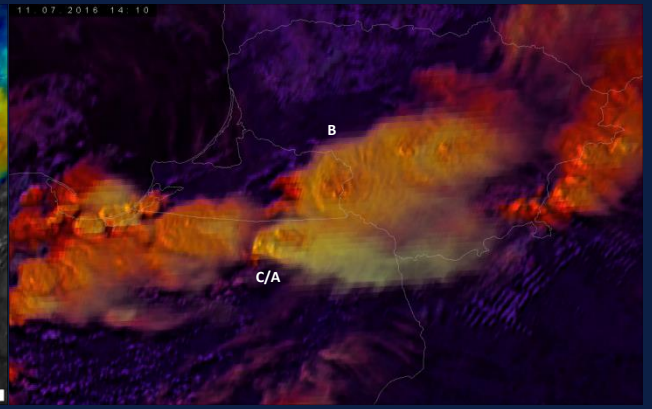


Convective storms RGB image product

IR 3.9 band (displayed as radiance image)

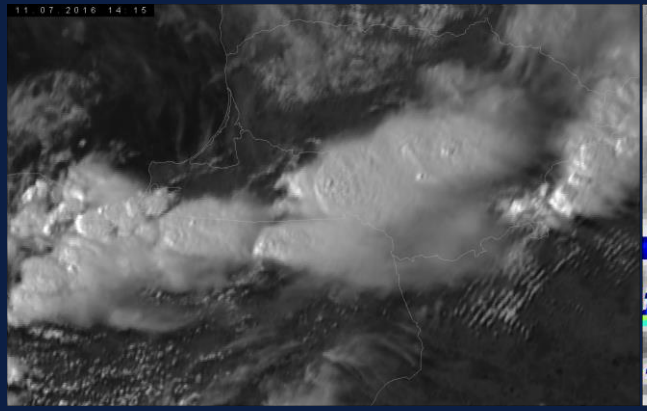


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

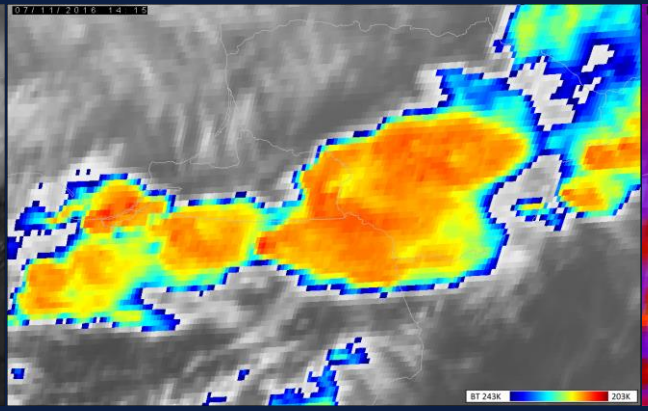


sandwich product – HRV band and Convective storms RGB image

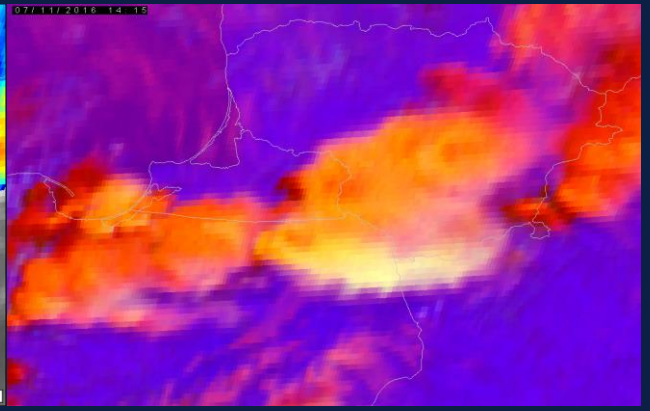
At the location of the dissipated storm A, a new cell begins to evolve, first as a strong, cold overshooting top (namely at next slide), and further evolves into a distinct cold-ring shaped storm. From next slide this new storm (or storm cell) is labeled as storm "C".



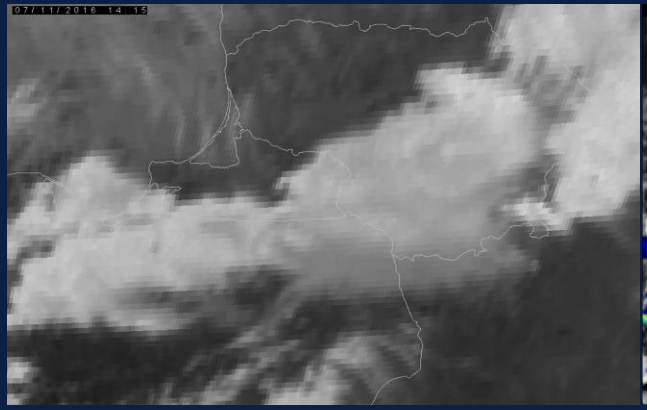
HRV band



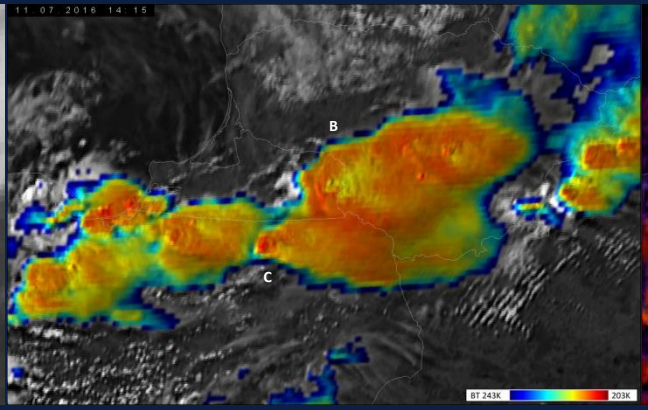
IR 10.8 BT (203-243K) color-enhanced image



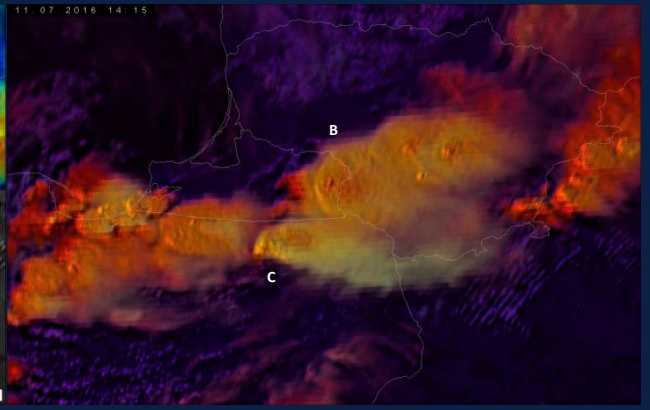
Convective storms RGB image product



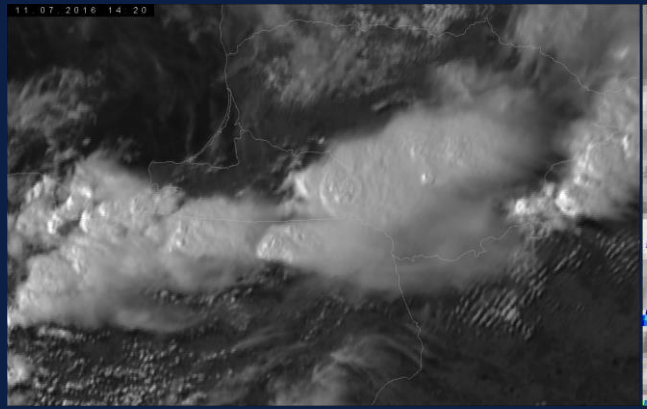
IR 3.9 band (displayed as radiance image)



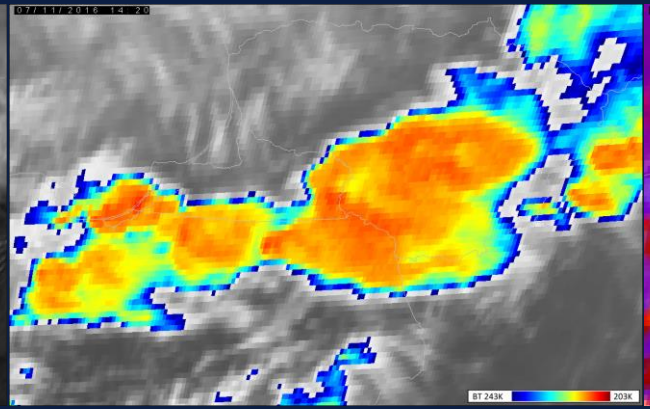
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



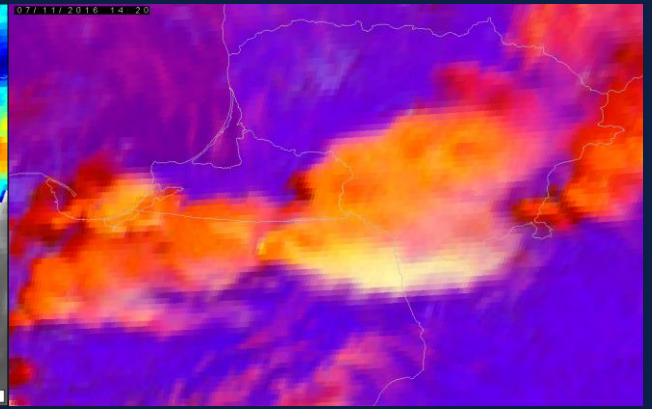
sandwich product – HRV band and Convective storms RGB image



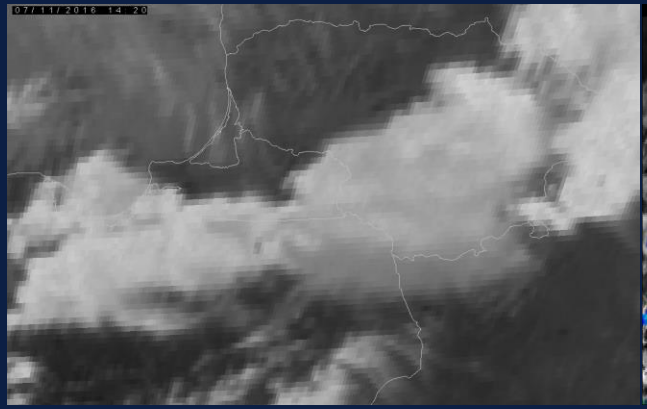
HRV band



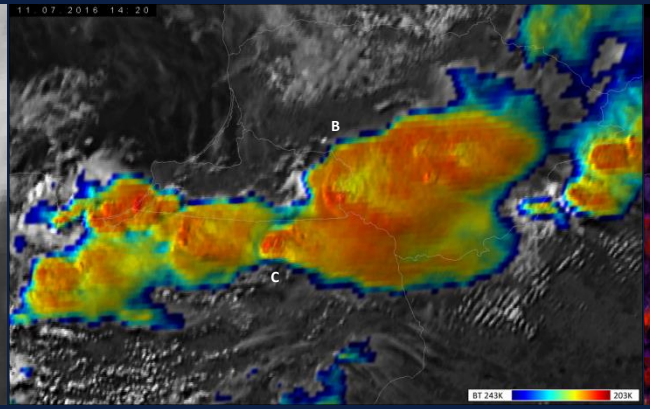
IR 10.8 BT (203-243K) color-enhanced image



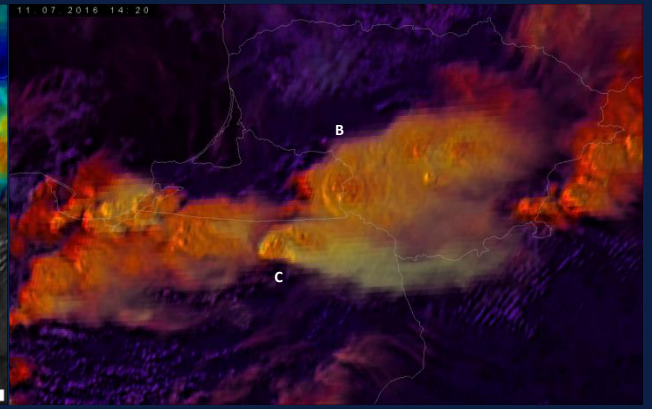
Convective storms RGB image product



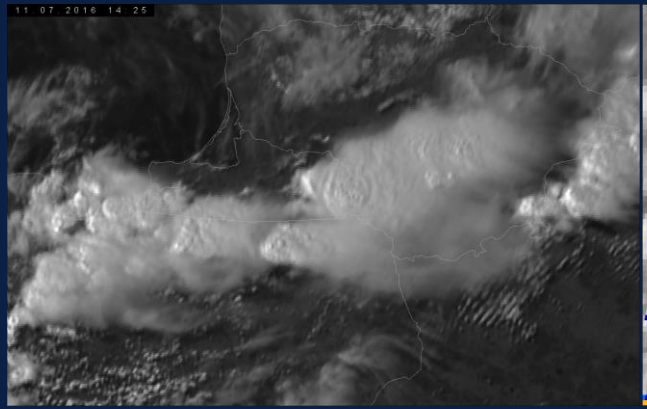
IR 3.9 band (displayed as radiance image)



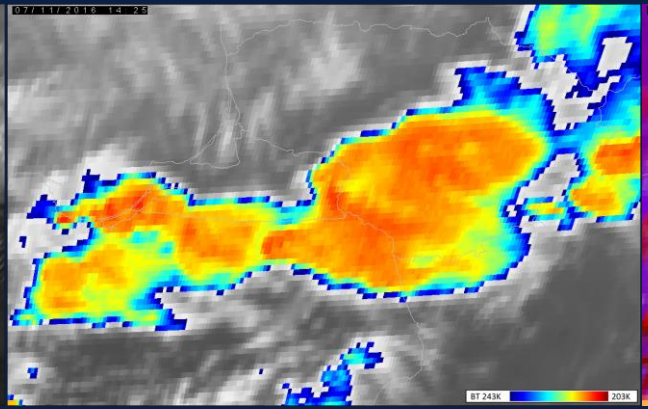
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



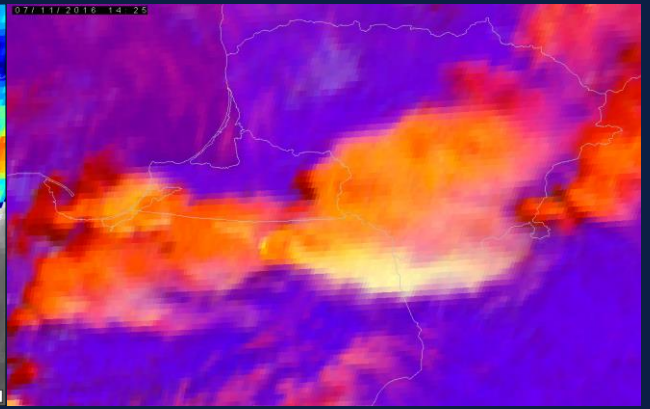
sandwich product – HRV band and Convective storms RGB image



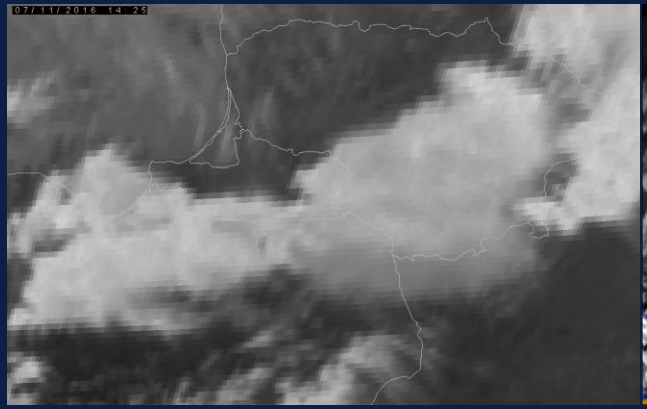
HRV band



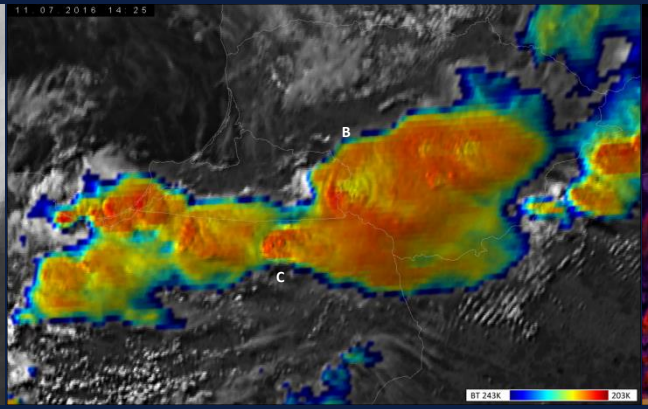
IR 10.8 BT (203-243K) color-enhanced image



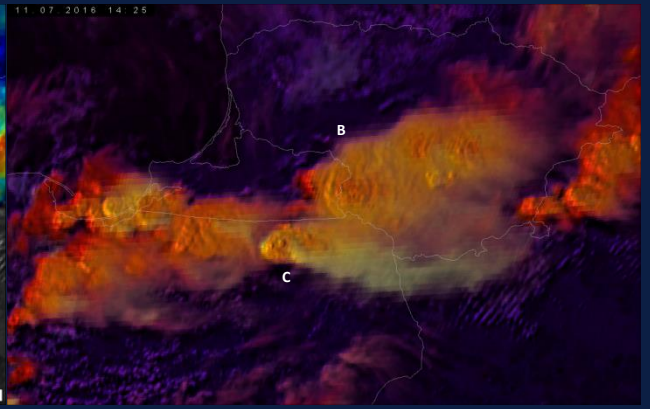
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

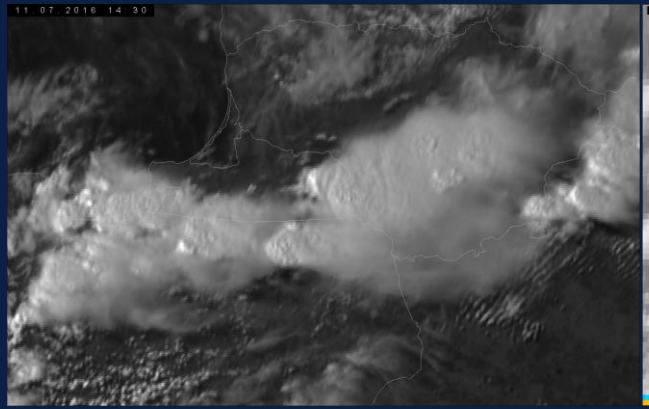


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

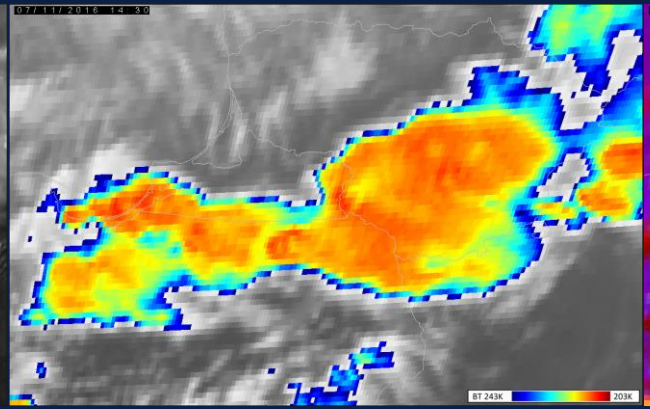


sandwich product – HRV band and Convective storms RGB image

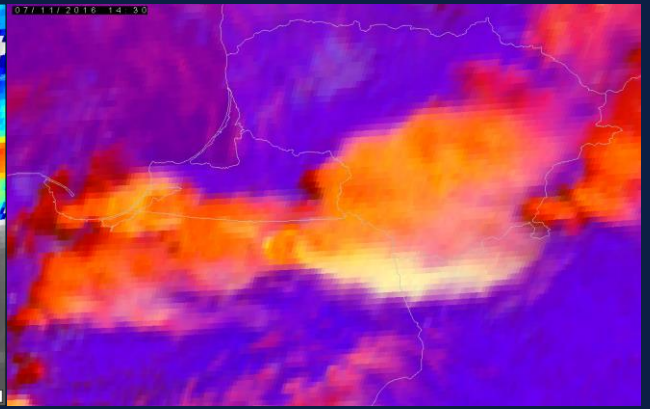
Here the new storm cell C begins to grow, taking on an appearance of well-pronounced cold-ring later on (next slides). The storm C also continues feeding the higher reflectivity plume, spreading eastward.



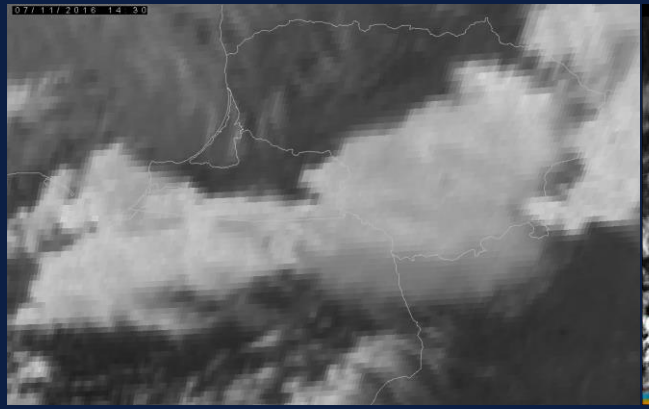
HRV band



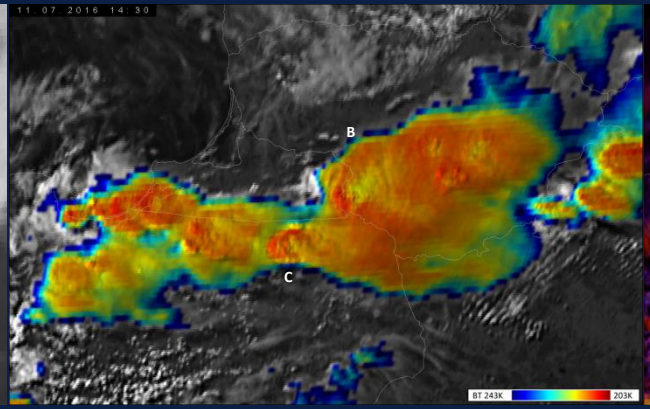
IR 10.8 BT (203-243K) color-enhanced image



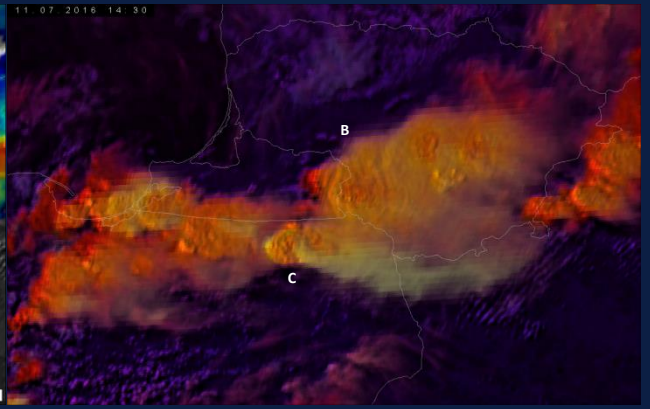
Convective storms RGB image product



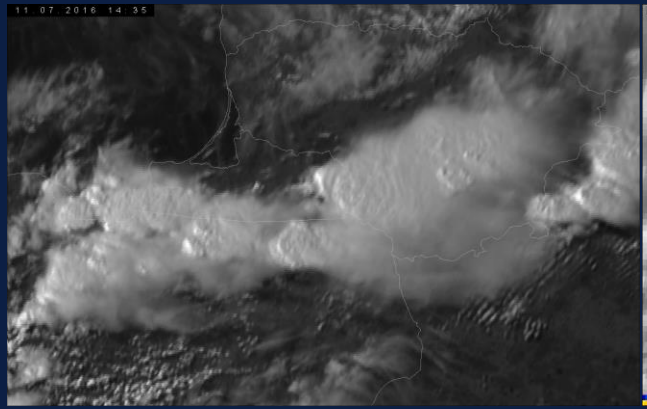
IR 3.9 band (displayed as radiance image)



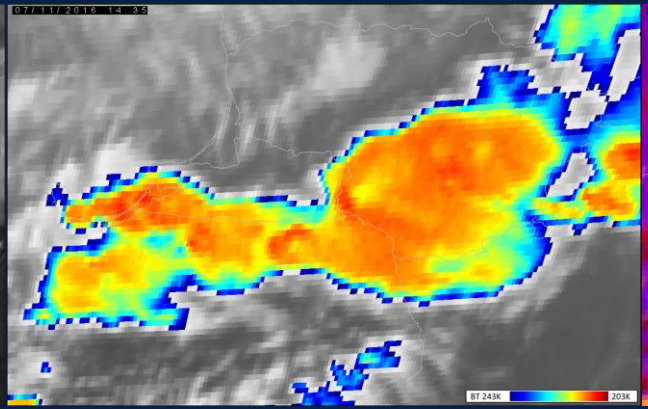
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



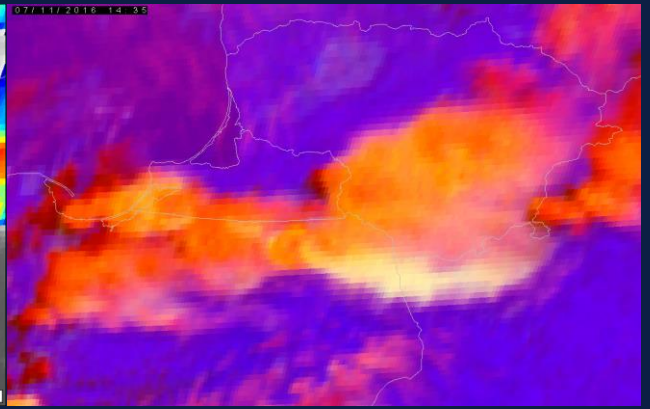
sandwich product – HRV band and Convective storms RGB image



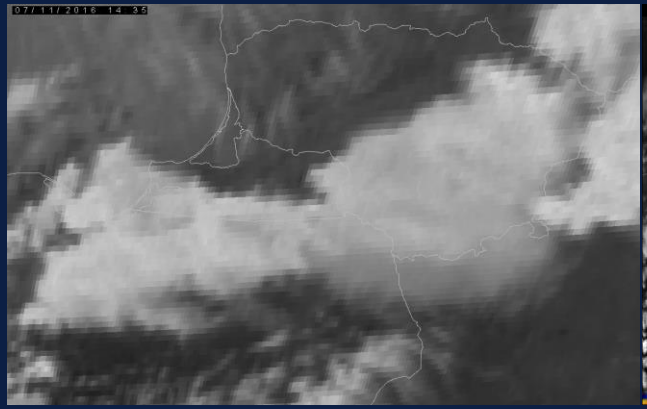
HRV band



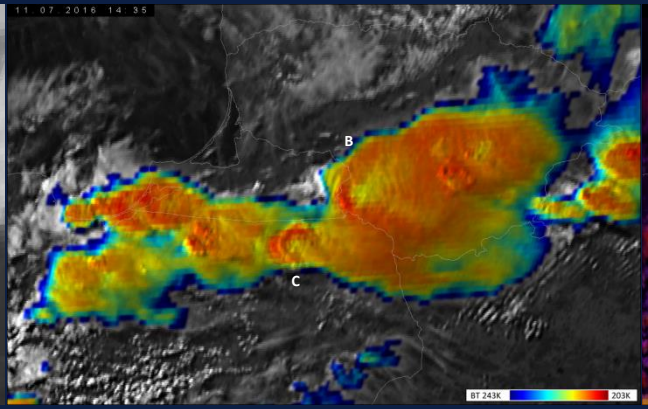
IR 10.8 BT (203-243K) color-enhanced image



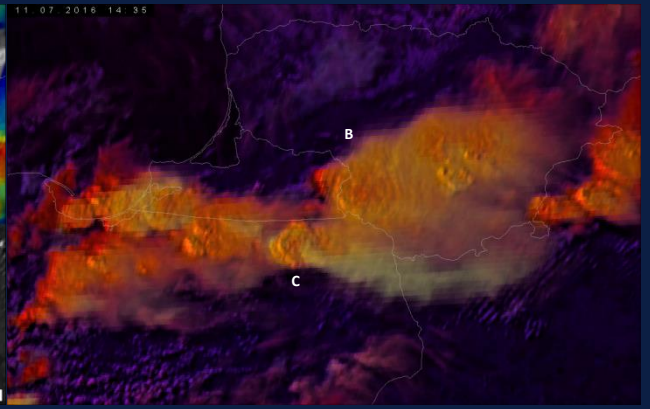
Convective storms RGB image product



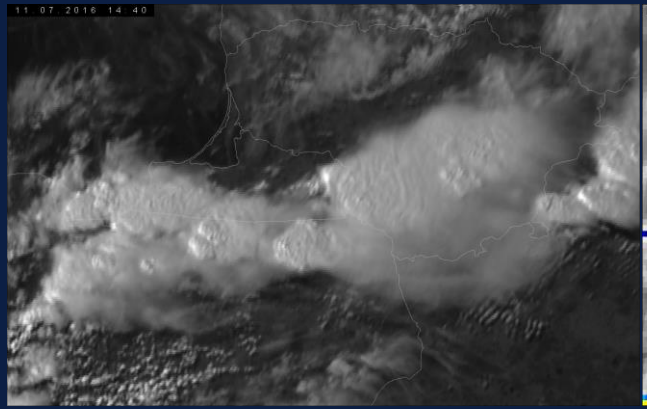
IR 3.9 band (displayed as radiance image)



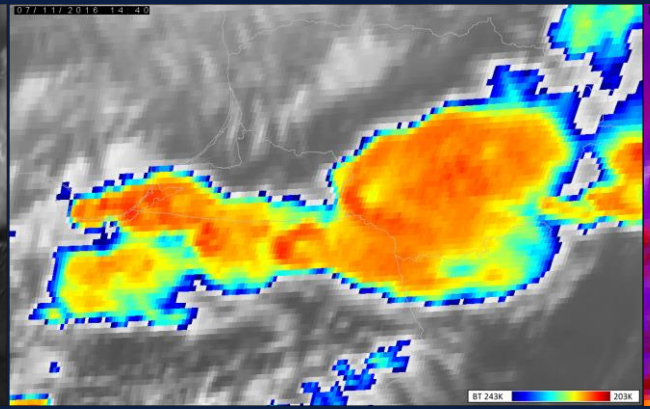
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



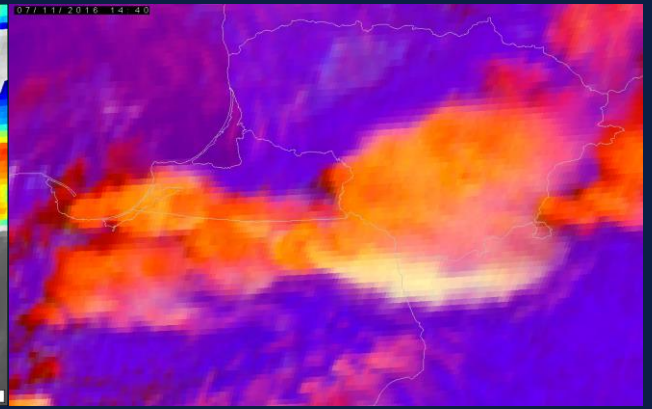
sandwich product – HRV band and Convective storms RGB image



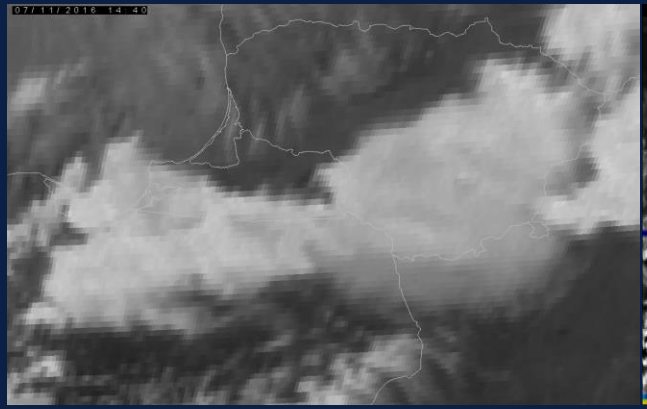
HRV band



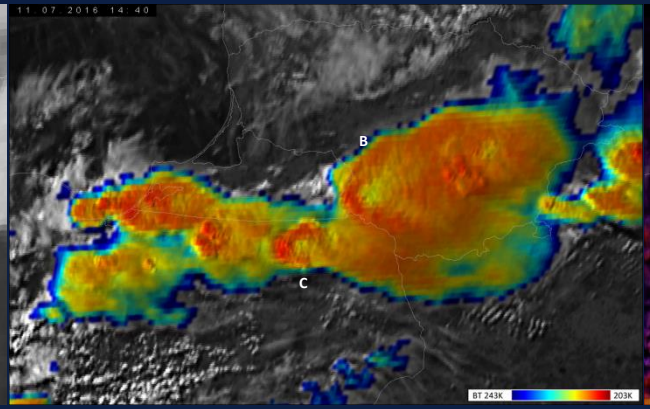
IR 10.8 BT (203-243K) color-enhanced image



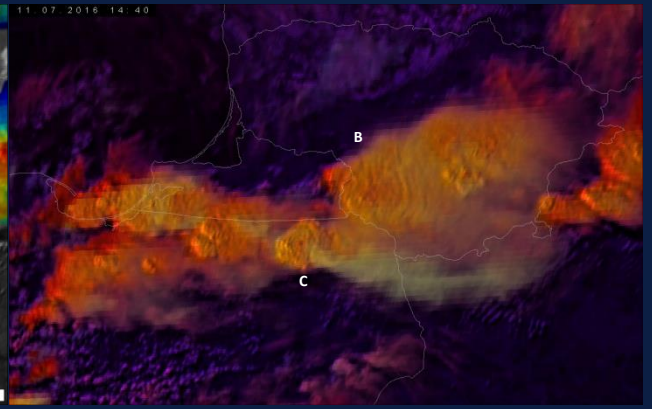
Convective storms RGB image product



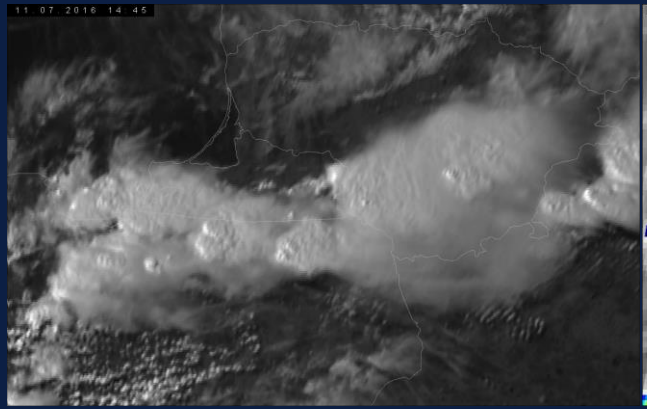
IR 3.9 band (displayed as radiance image)



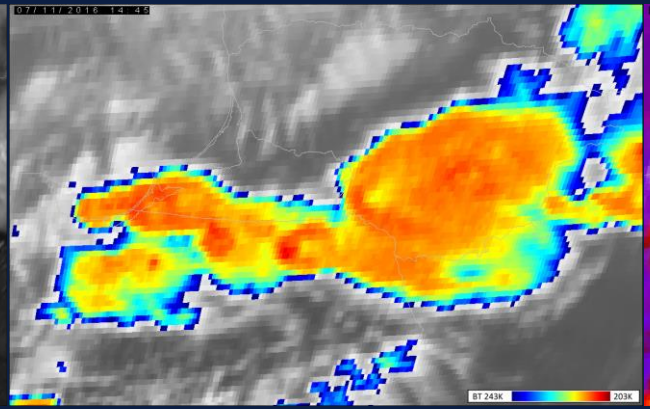
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



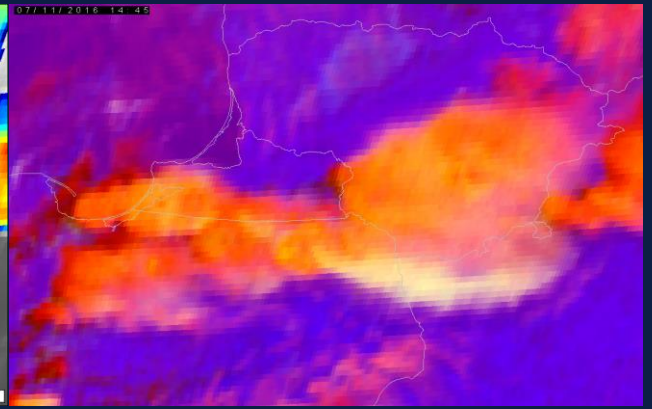
sandwich product – HRV band and Convective storms RGB image



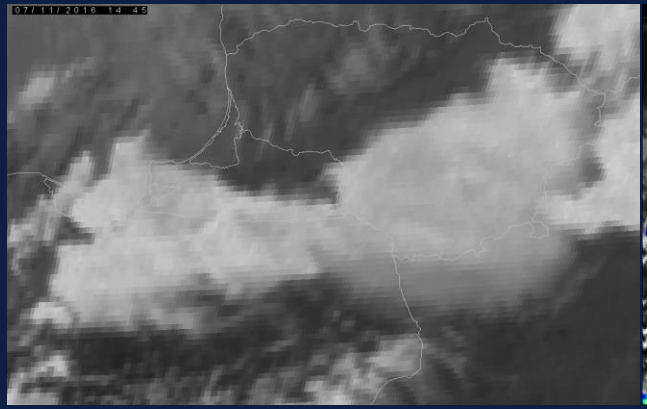
HRV band



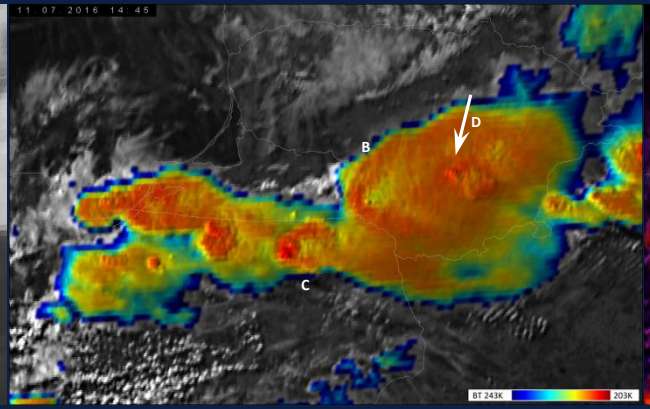
IR 10.8 BT (203-243K) color-enhanced image



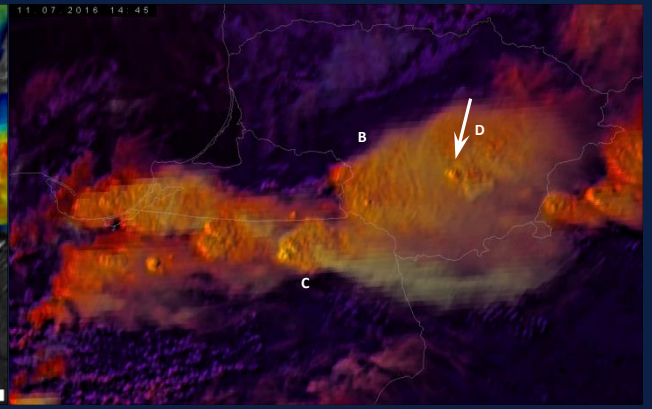
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

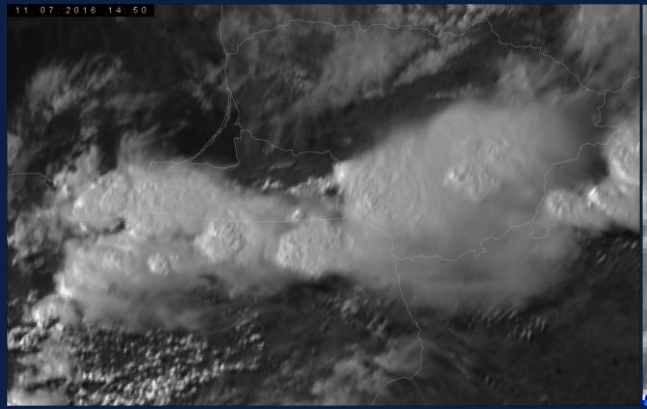


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

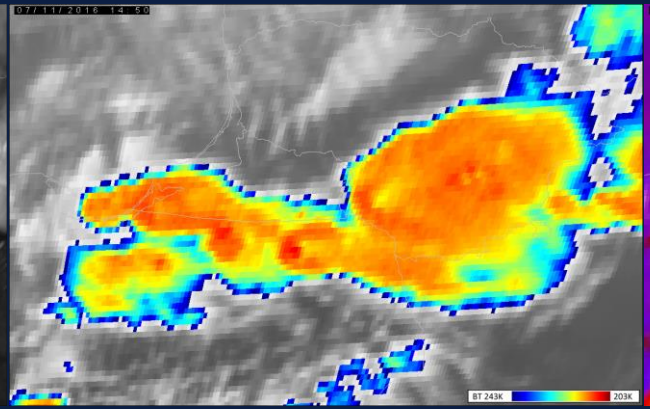


sandwich product – HRV band and Convective storms RGB image

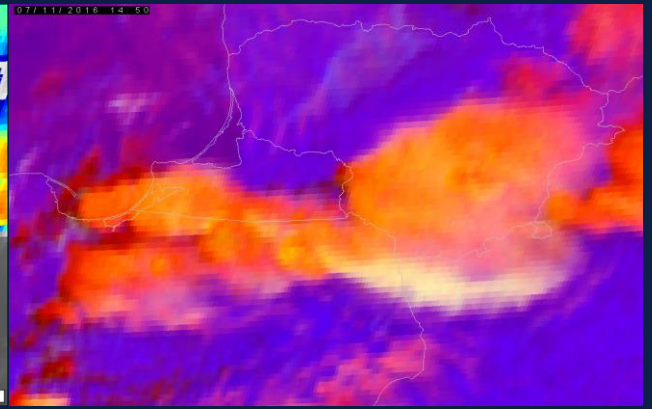
Downwind (east) of core of the storm B, within its anvil, a stronger overshooting top (OT) pops up in an area of previously weaker OT activity. Later on (several next slides) this OT transforms itself into a smaller, shorter-lived cold ring, but it never reaches the magnitude of the storms A, B and C, and dissipates by about 15:25.



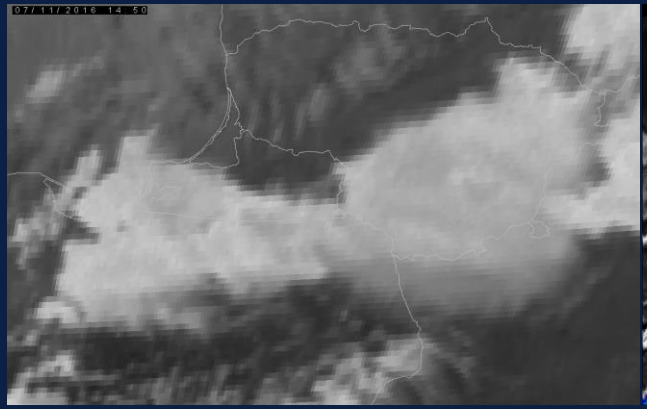
HRV band



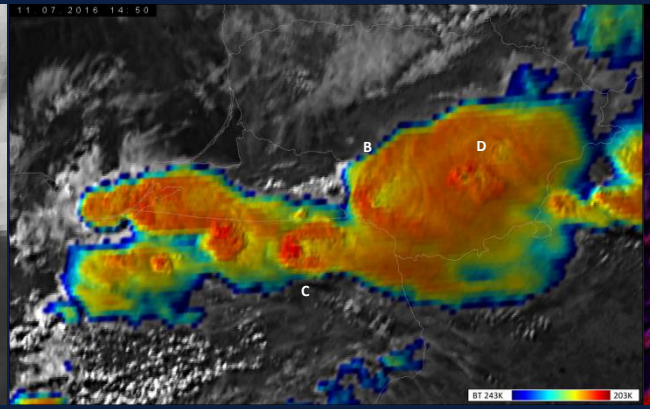
IR 10.8 BT (203-243K) color-enhanced image



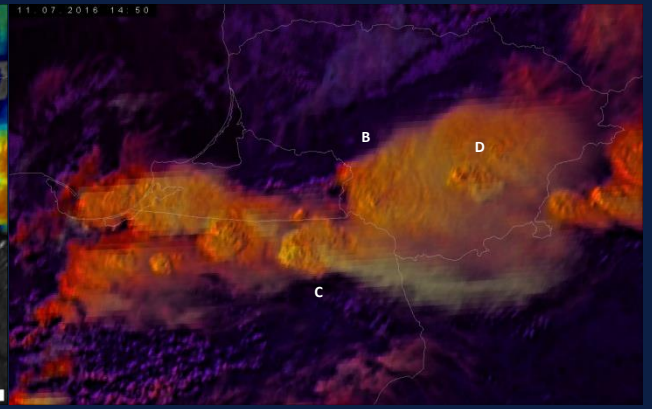
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

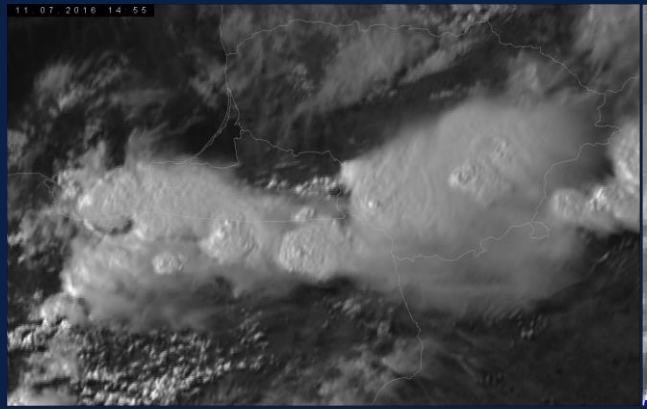


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

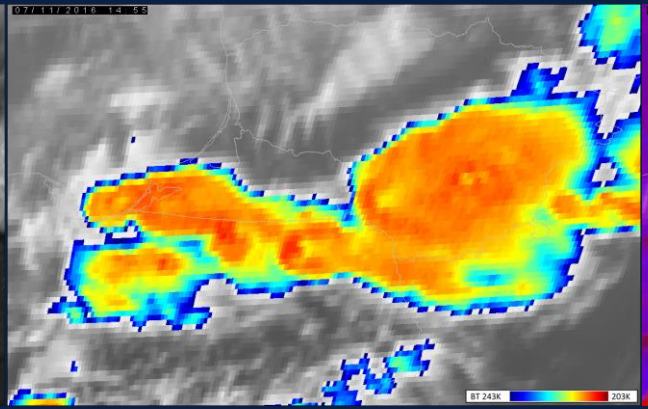


sandwich product – HRV band and Convective storms RGB image

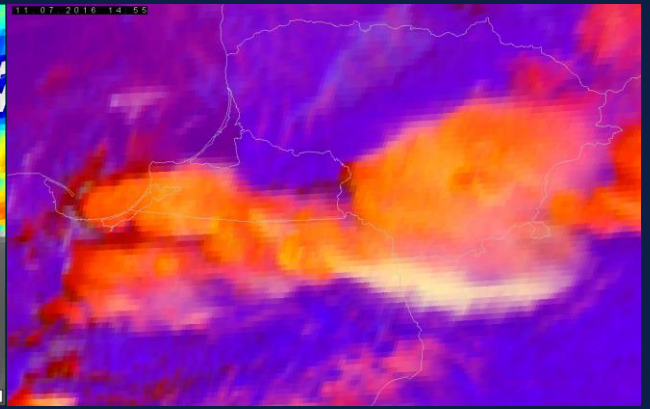
The higher reflectivity above-anvil ice plume of the storm C seems to loose its connection with the core of the storm, and begins to drift slowly away, eastward. This might indicate some changes of internal storm C dynamics, despite the fact that the storm top begins to form a distinct, long-lived cold ring.



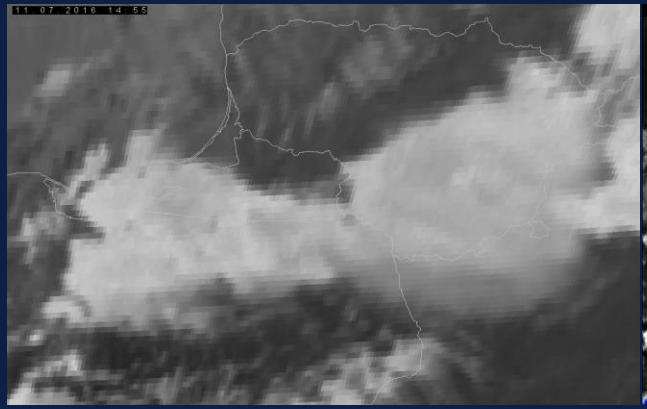
HRV band



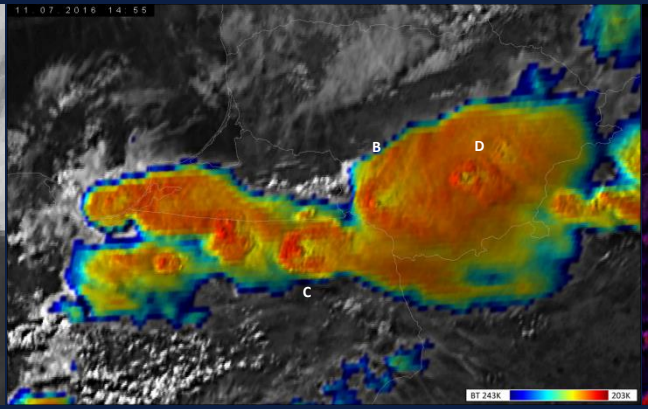
IR 10.8 BT (203-243K) color-enhanced image



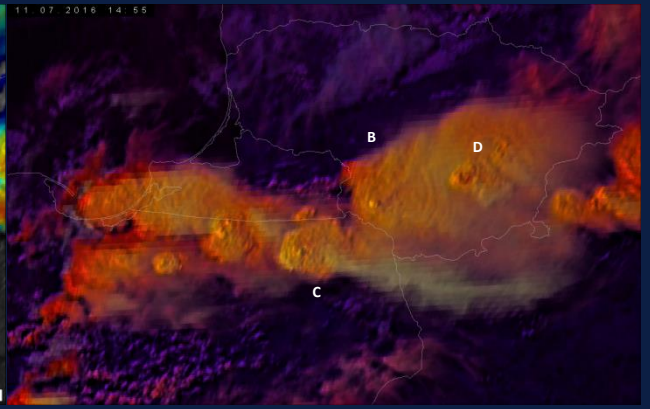
Convective storms RGB image product



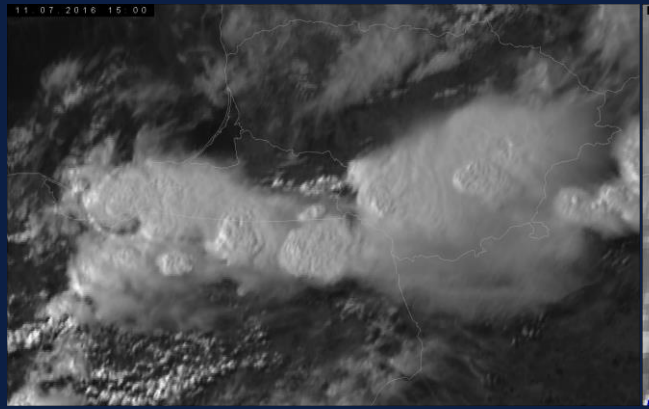
IR 3.9 band (displayed as radiance image)



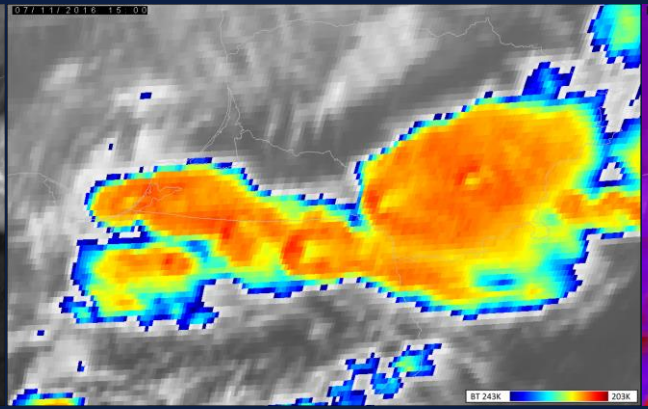
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



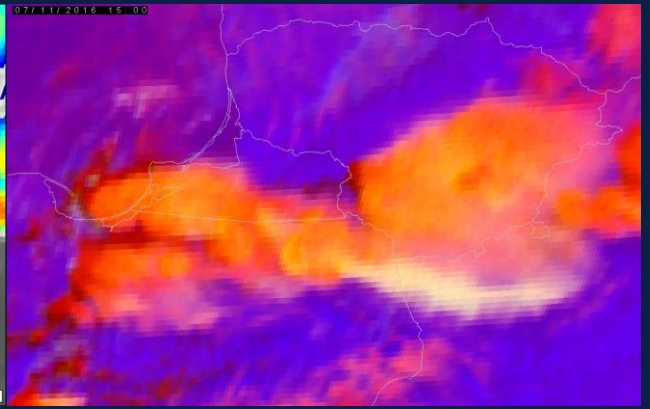
sandwich product – HRV band and Convective storms RGB image



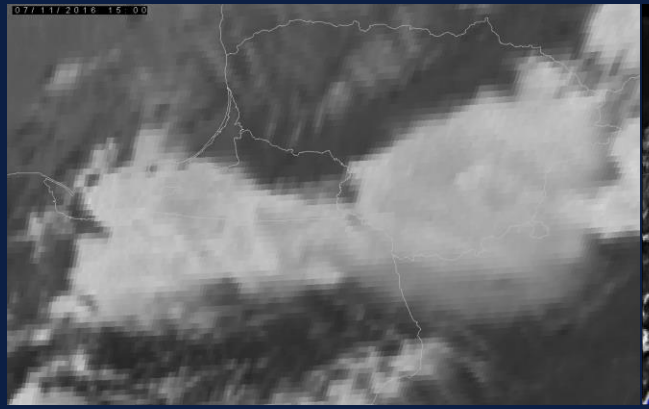
HRV band



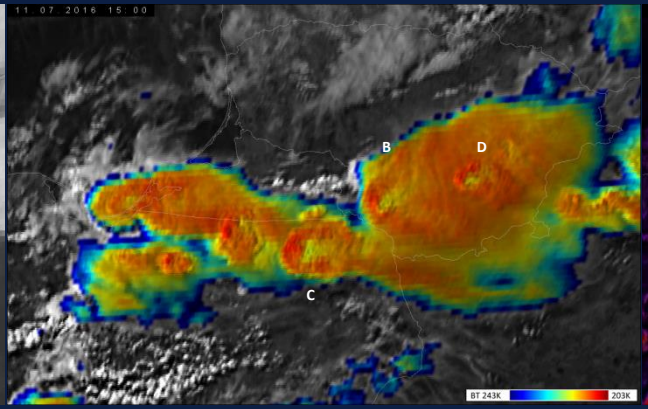
IR 10.8 BT (203-243K) color-enhanced image



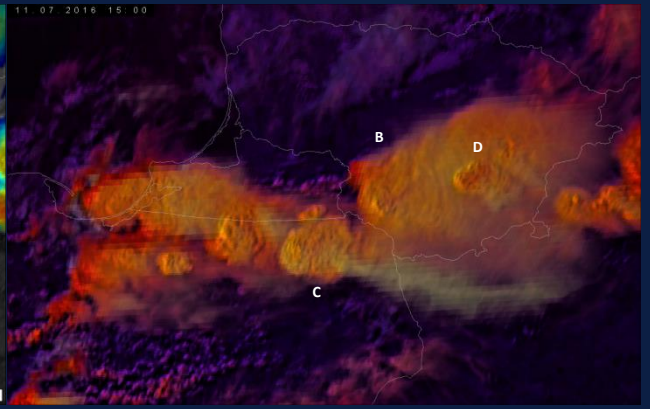
Convective storms RGB image product



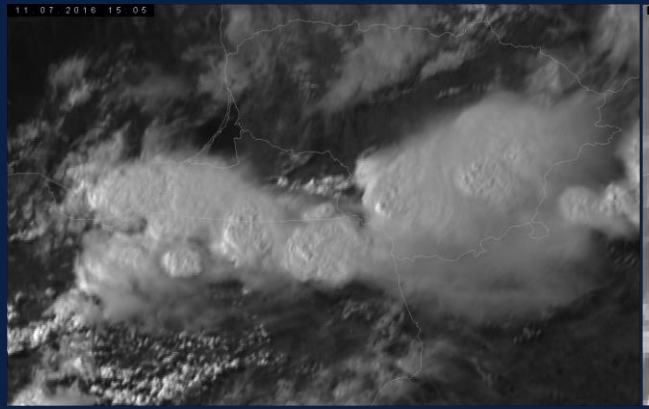
IR 3.9 band (displayed as radiance image)



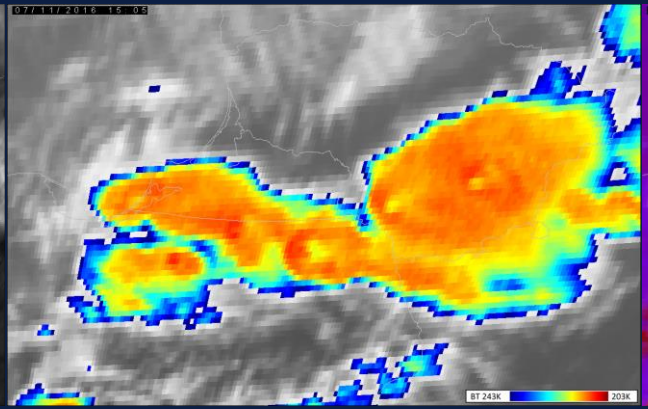
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



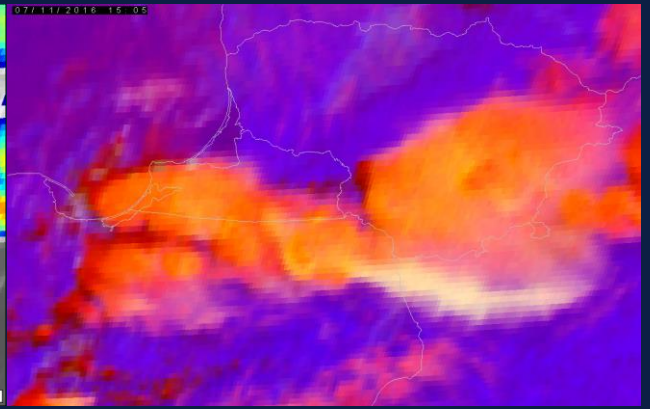
sandwich product – HRV band and Convective storms RGB image



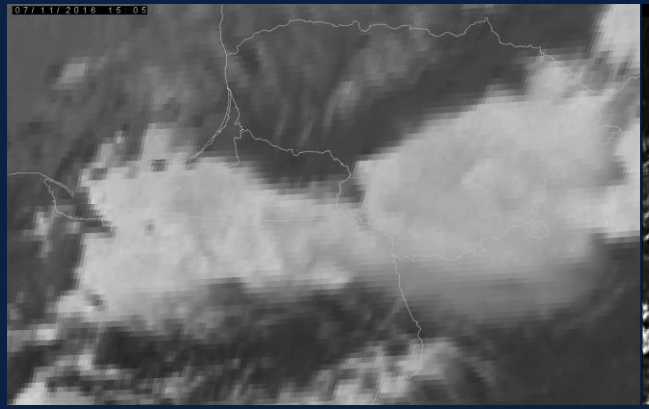
HRV band



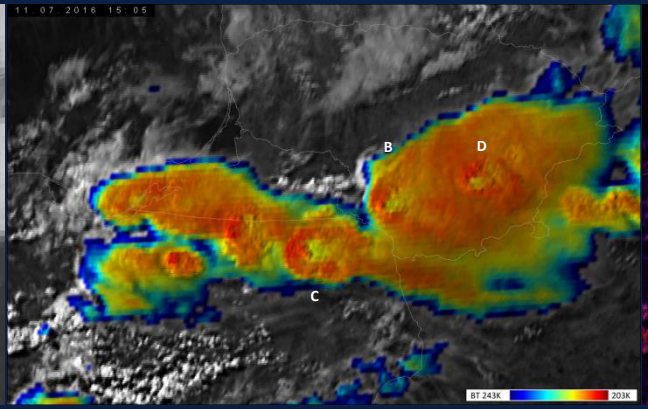
IR 10.8 BT (203-243K) color-enhanced image



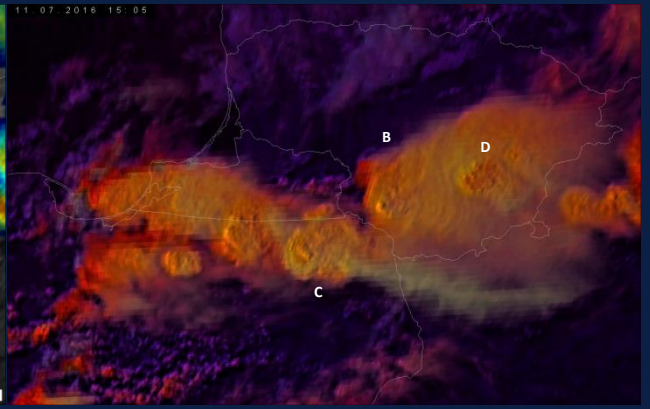
Convective storms RGB image product



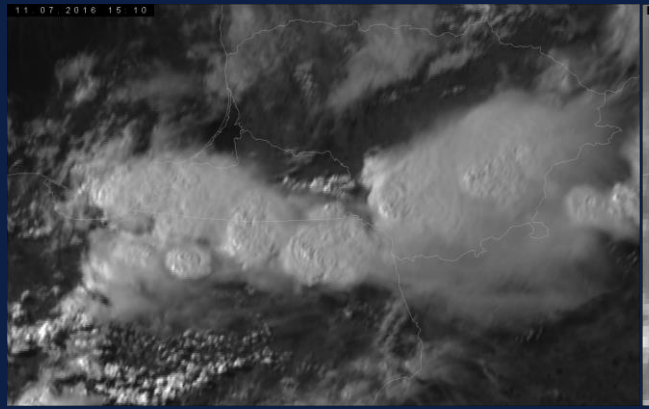
IR 3.9 band (displayed as radiance image)



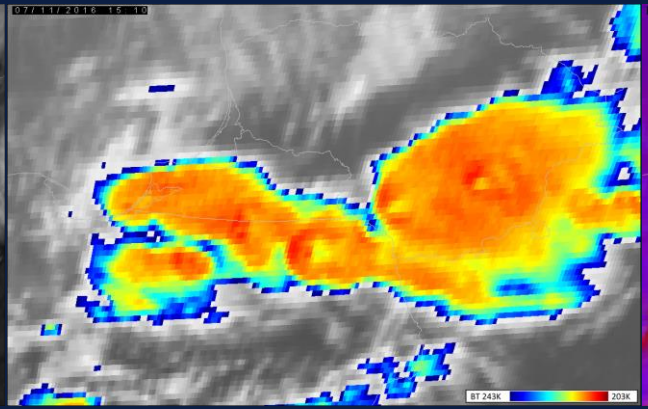
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



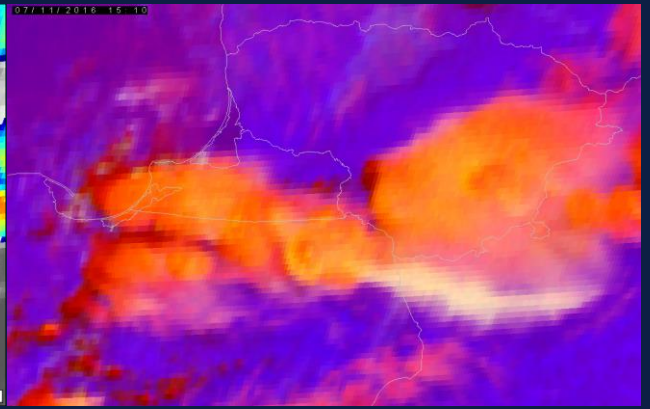
sandwich product – HRV band and Convective storms RGB image



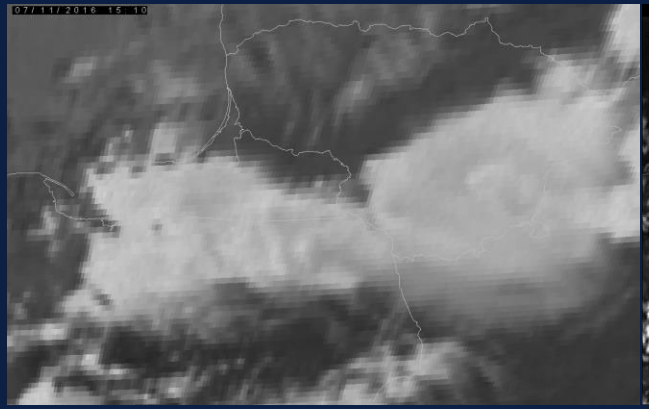
HRV band



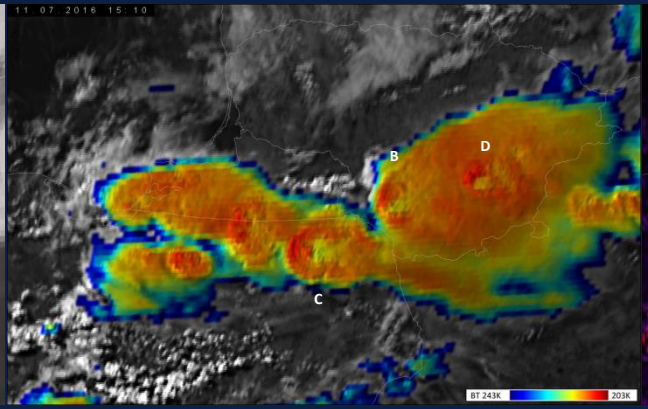
IR 10.8 BT (203-243K) color-enhanced image



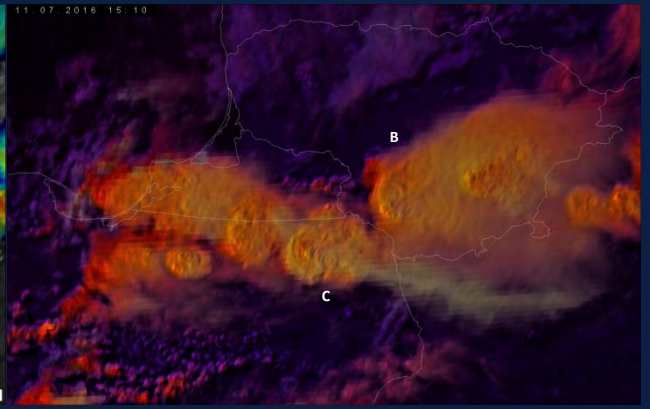
Convective storms RGB image product



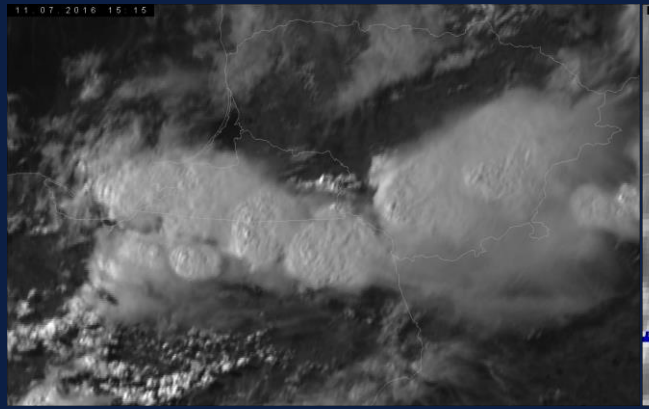
IR 3.9 band (displayed as radiance image)



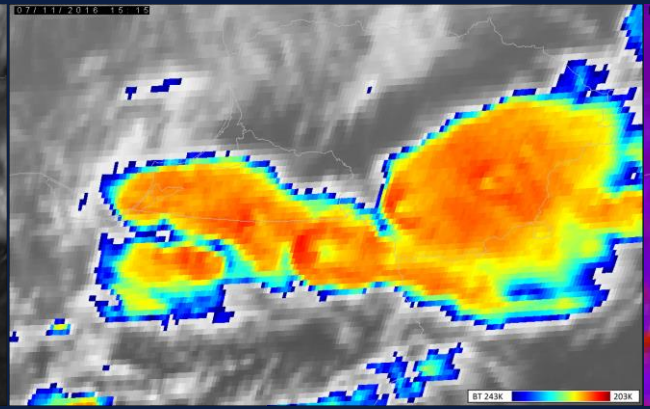
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



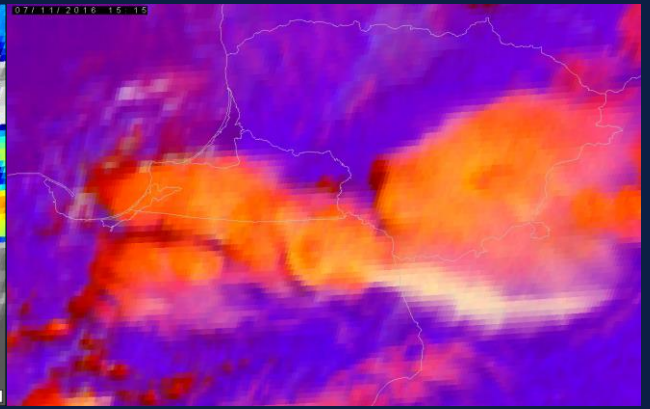
sandwich product – HRV band and Convective storms RGB image



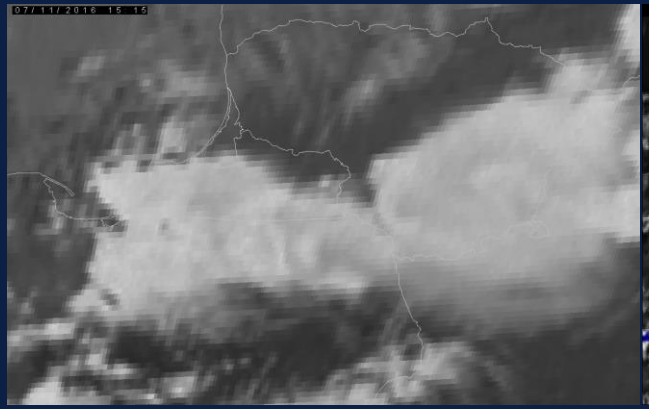
HRV band



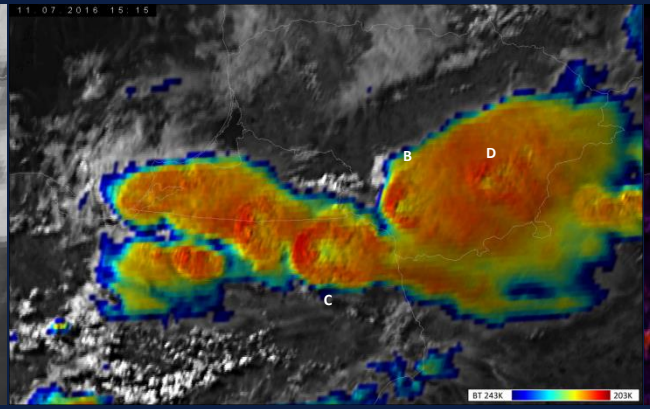
IR 10.8 BT (203-243K) color-enhanced image



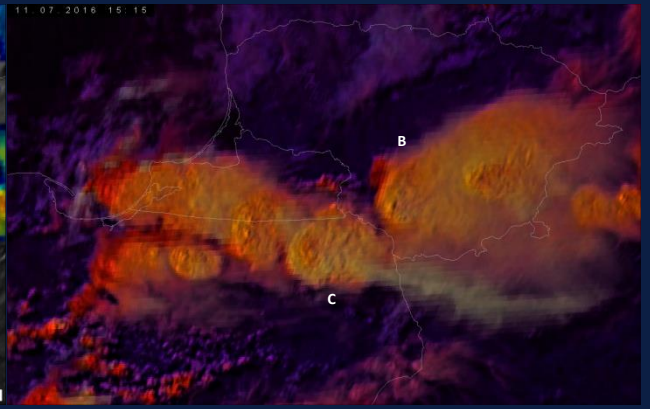
Convective storms RGB image product



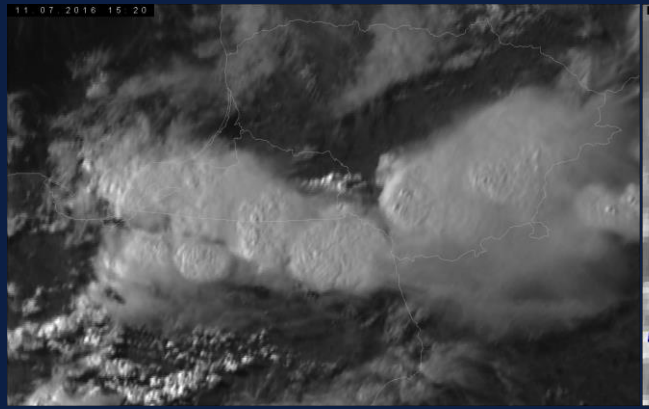
IR 3.9 band (displayed as radiance image)



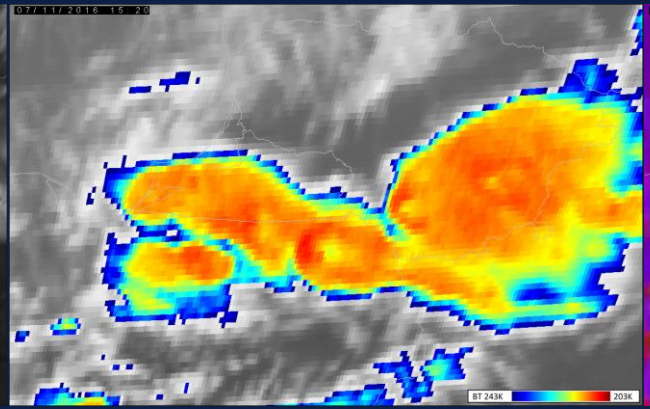
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



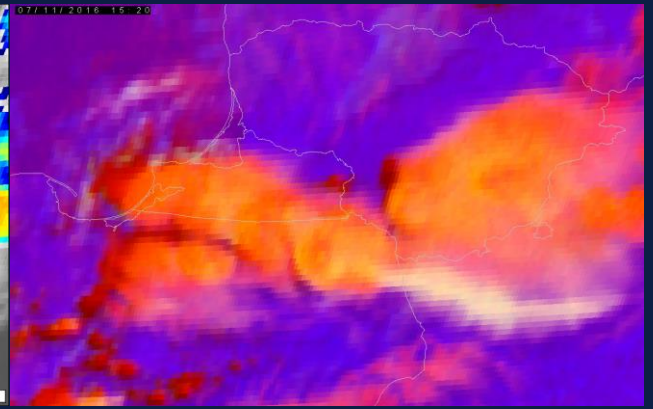
sandwich product – HRV band and Convective storms RGB image



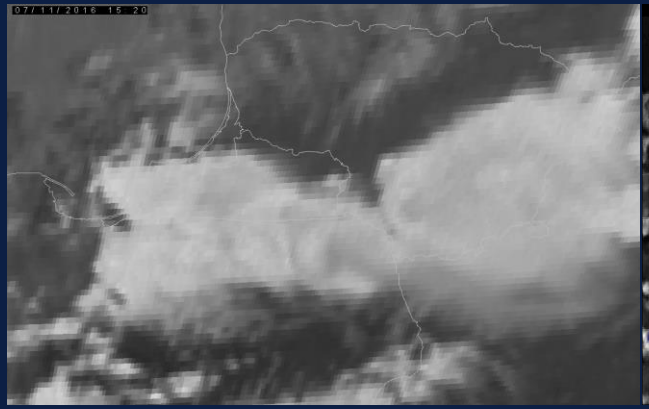
HRV band



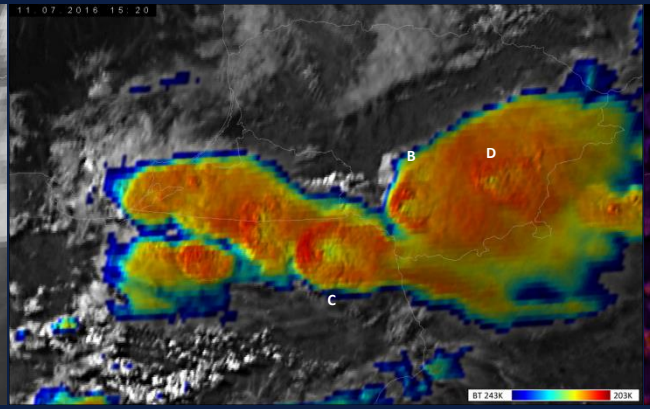
IR 10.8 BT (203-243K) color-enhanced image



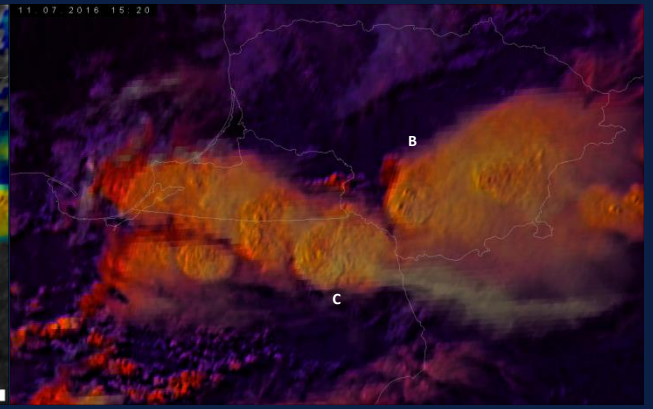
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

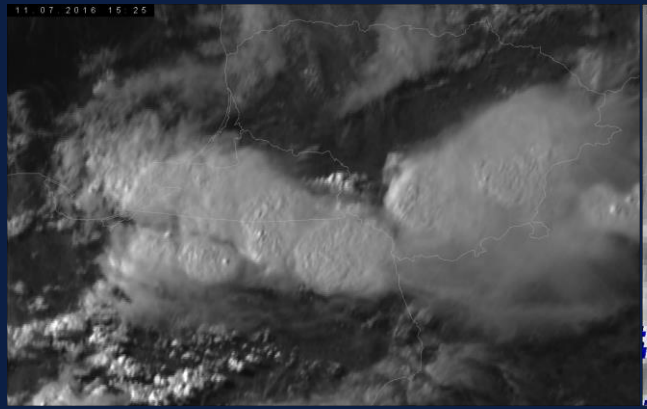


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

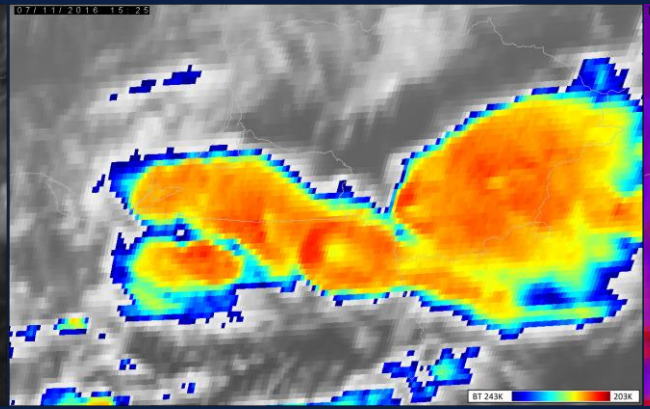


sandwich product – HRV band and Convective storms RGB image

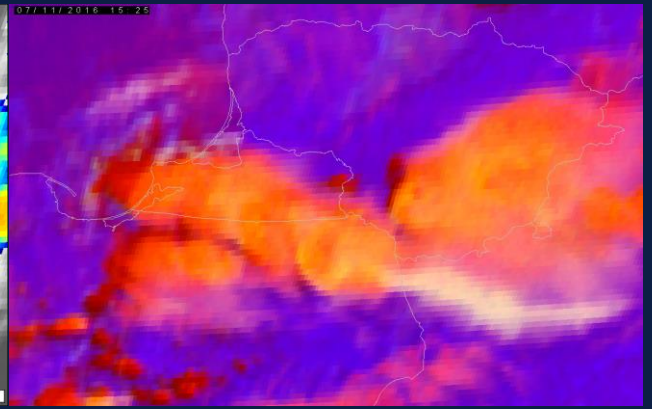
By now, the distinct cold-U shape of storm B and cold ring of storm D begin to weaken. The cold-ring shape of storm C still grows.



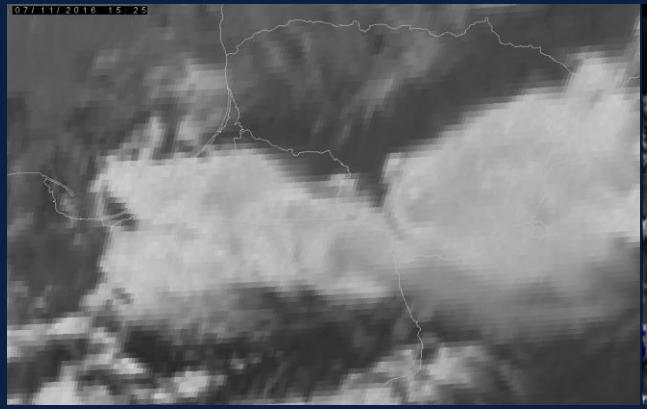
HRV band



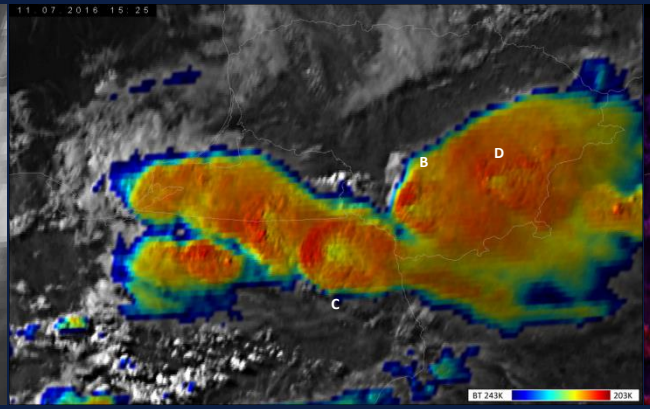
IR 10.8 BT (203-243K) color-enhanced image



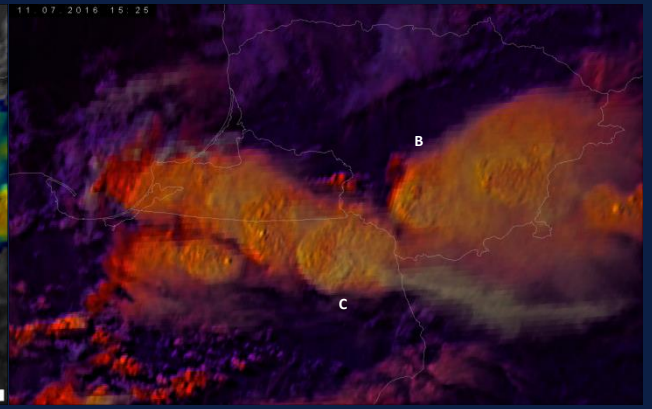
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

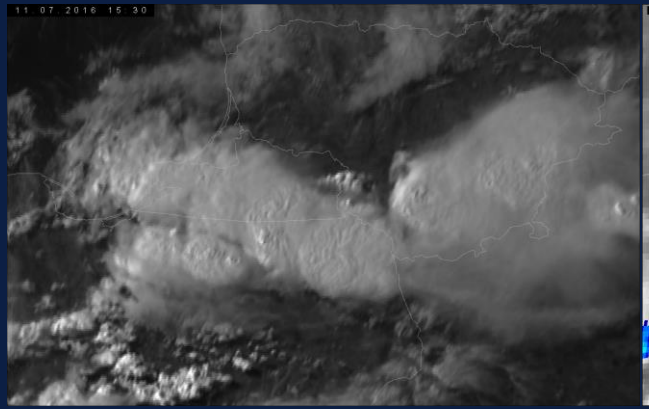


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

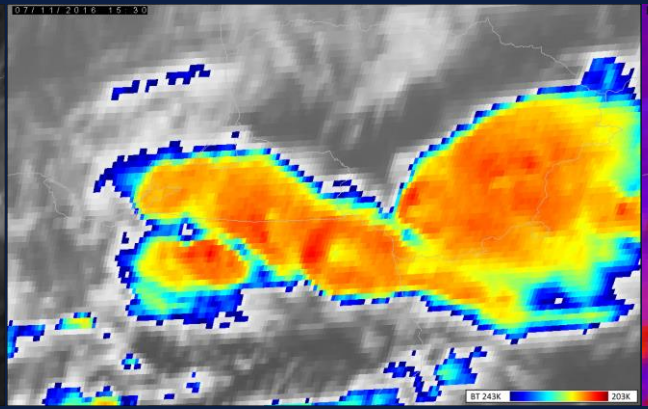


sandwich product – HRV band and Convective storms RGB image

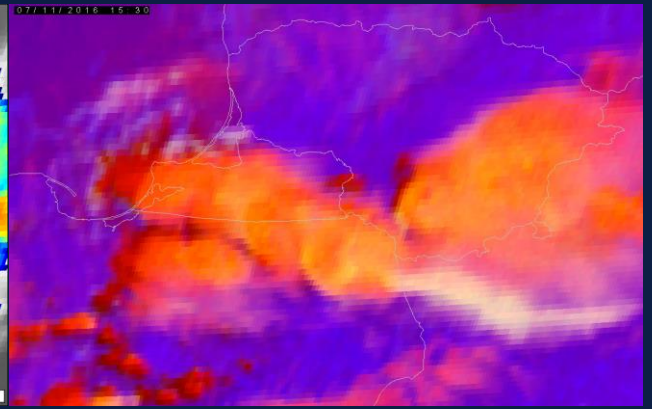
At this point, the cold-U feature of the storm B fades out and disappears. However, the storm itself did not quite die-out, updrafts at north-west part of the former cold-U are still active, the storm strengthens again and keeps active till about 17:30, though without any satellite-based "severity indicators".



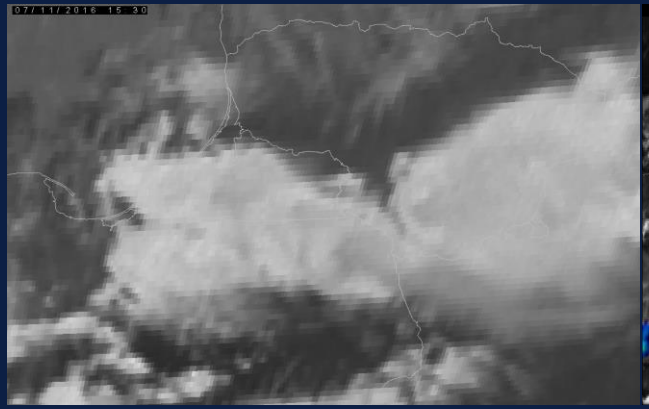
HRV band



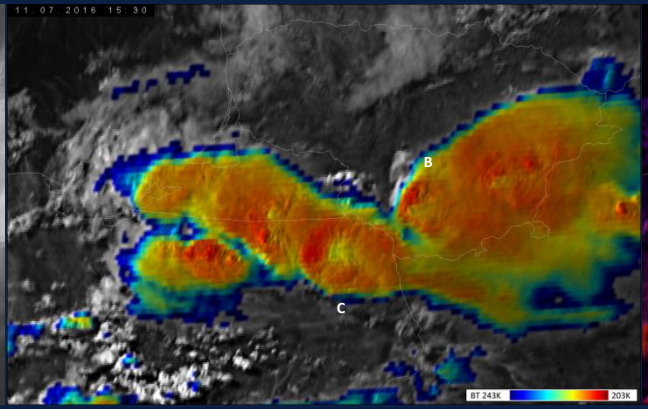
IR 10.8 BT (203-243K) color-enhanced image



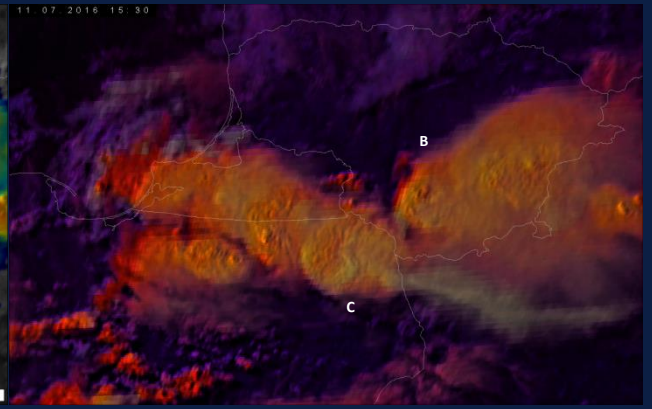
Convective storms RGB image product



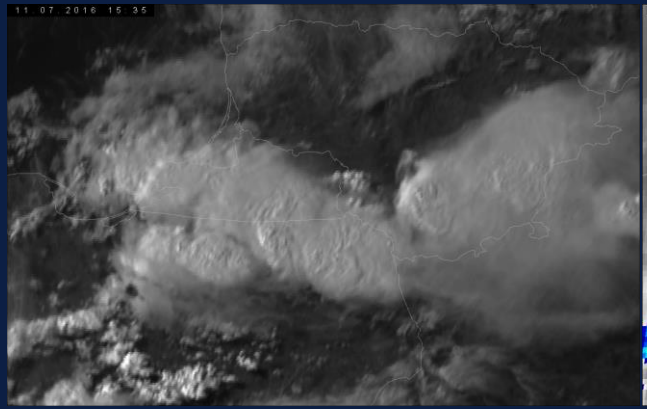
IR 3.9 band (displayed as radiance image)



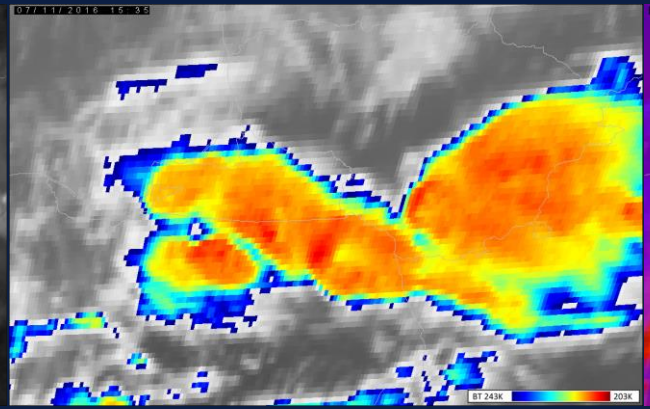
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



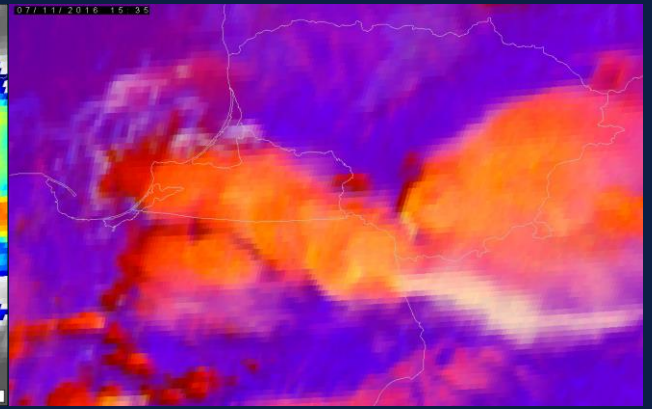
sandwich product – HRV band and Convective storms RGB image



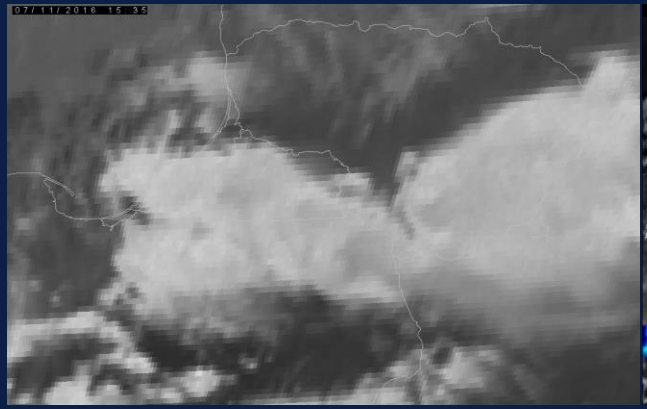
HRV band



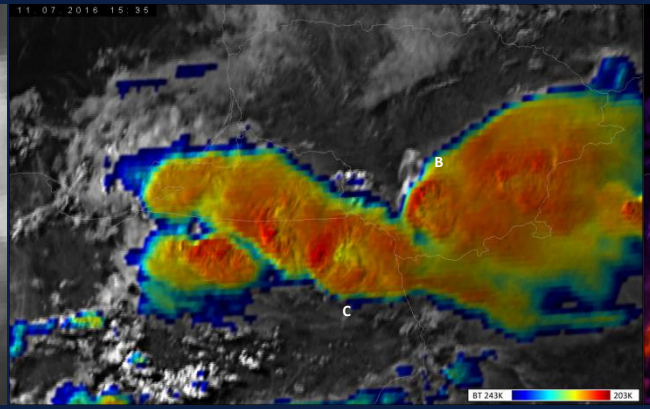
IR 10.8 BT (203-243K) color-enhanced image



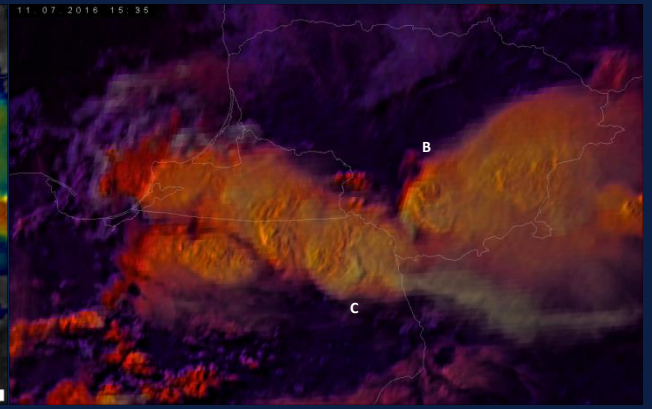
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

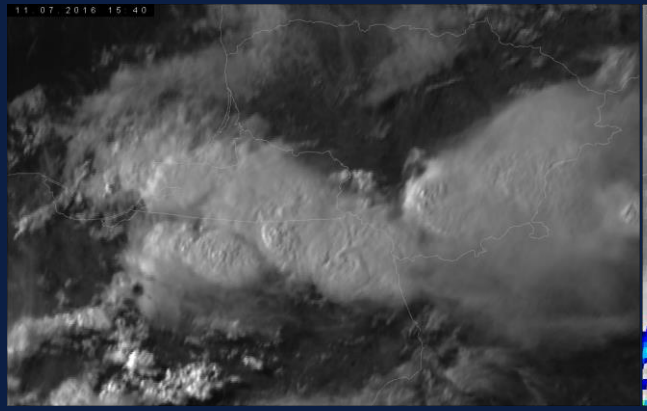


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

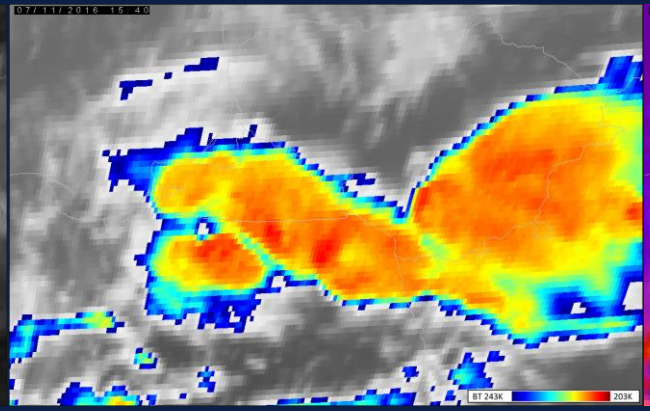


sandwich product – HRV band and Convective storms RGB image

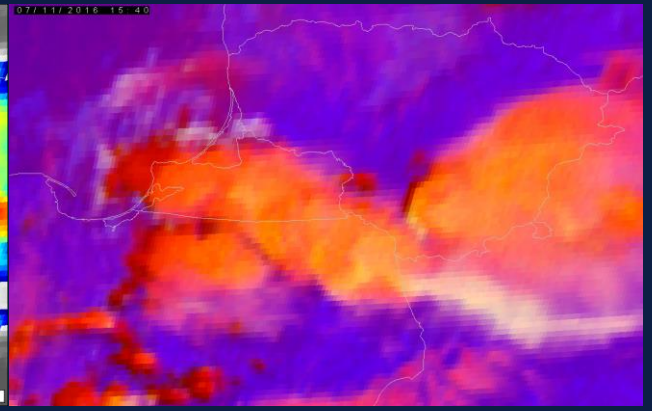
Here (and on the next slide) the cold ring of storm C reaches its maximum extent, afterwards it begins to weaken and diminishes.



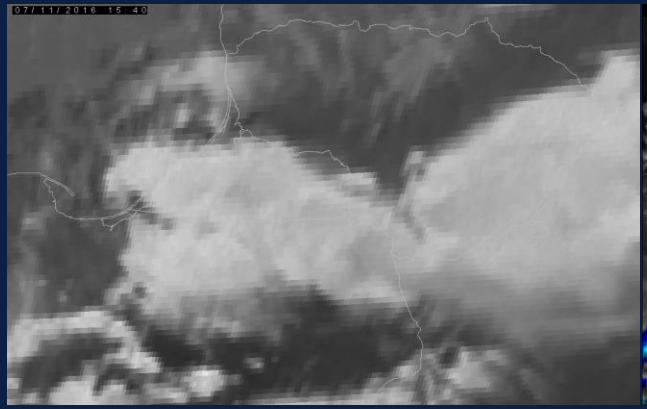
HRV band



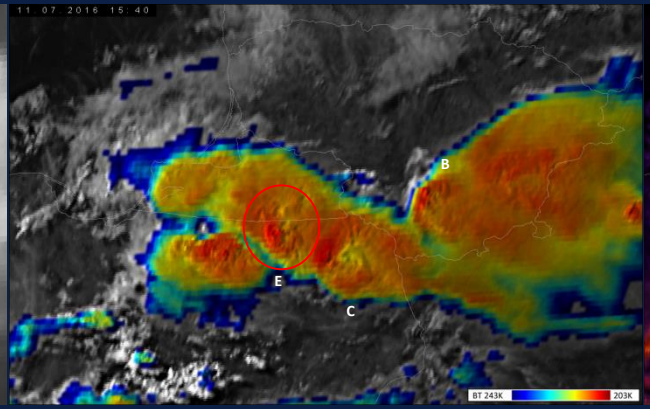
IR 10.8 BT (203-243K) color-enhanced image



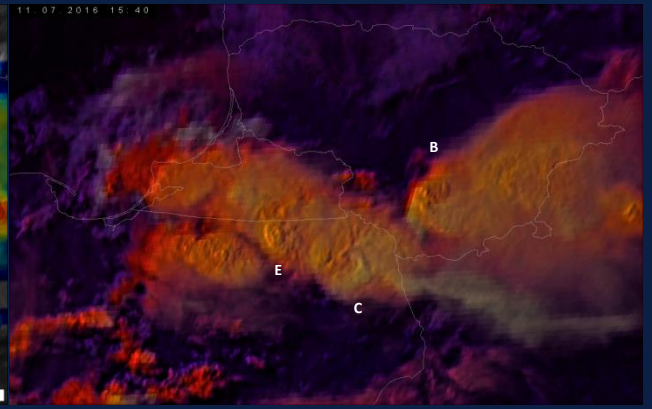
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

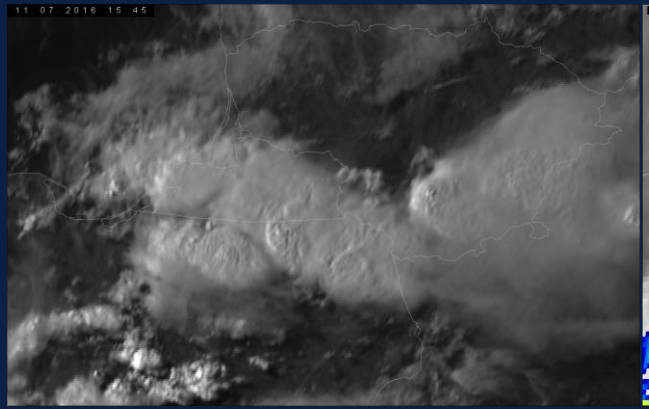


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

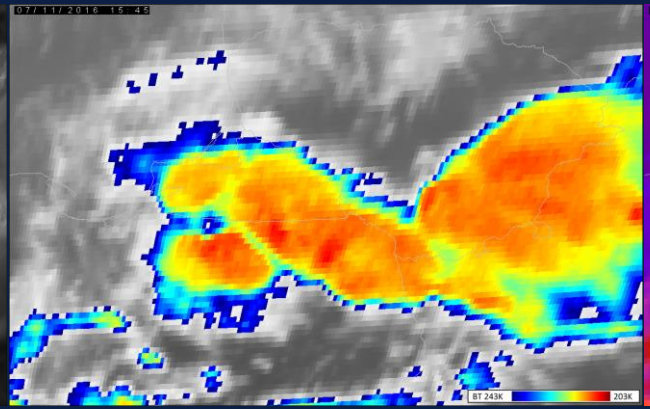


sandwich product – HRV band and Convective storms RGB image

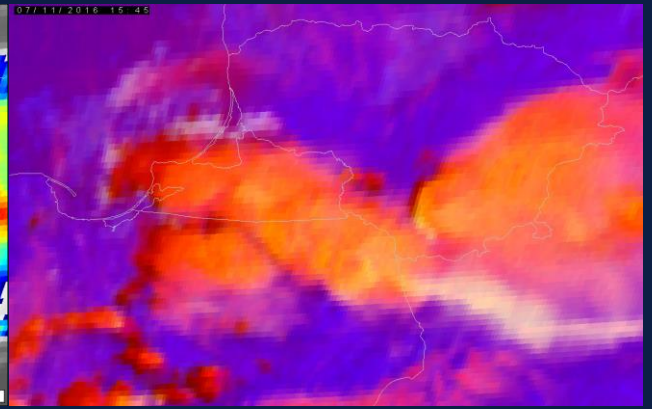
West of the storm C (upwind) a new storm cell (E) begins to strengthen, forming later also a cold-U feature. Might be that this cell was triggered by an outflow from storm C; however this is only a speculation which can't be proved by satellite imagery alone.



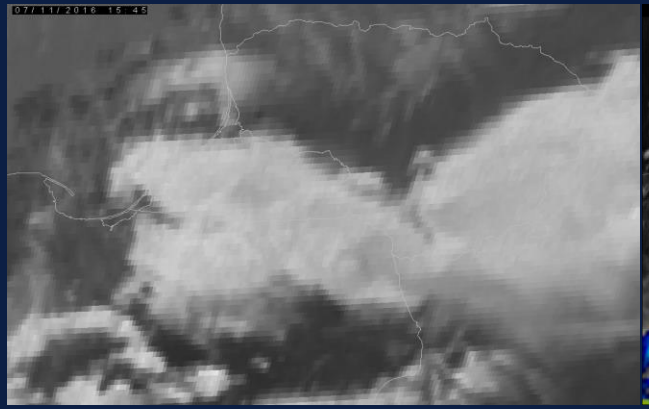
HRV band



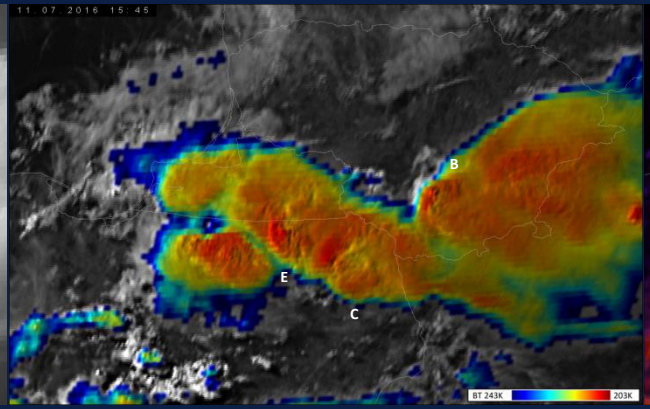
IR 10.8 BT (203-243K) color-enhanced image



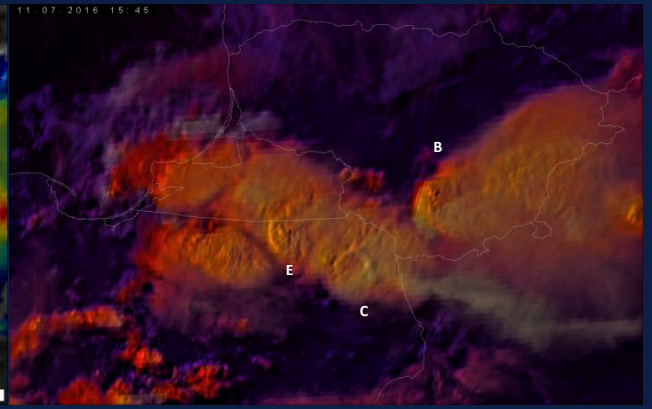
Convective storms RGB image product



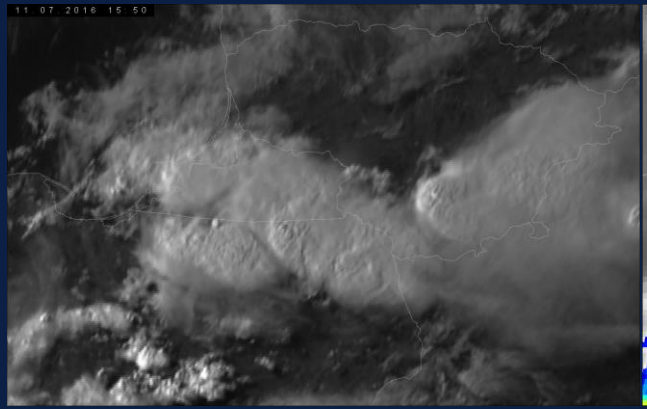
IR 3.9 band (displayed as radiance image)



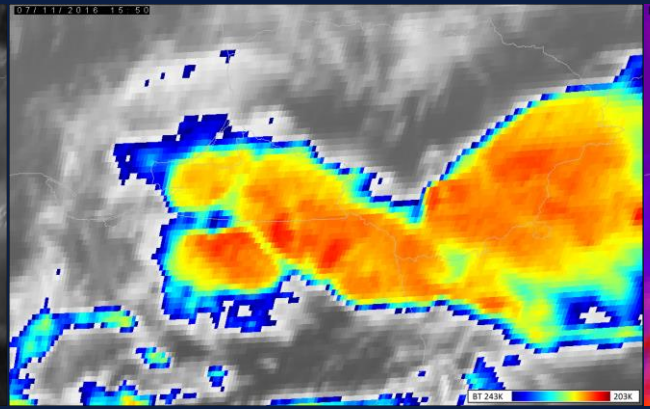
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



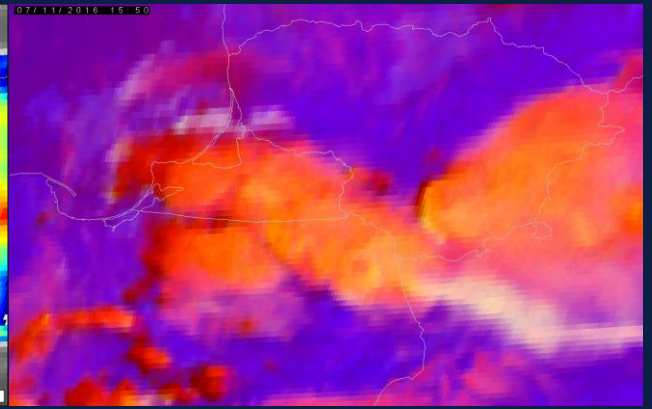
sandwich product – HRV band and Convective storms RGB image



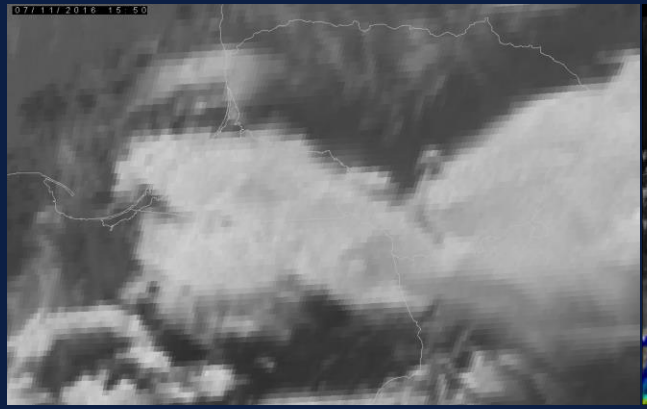
HRV band



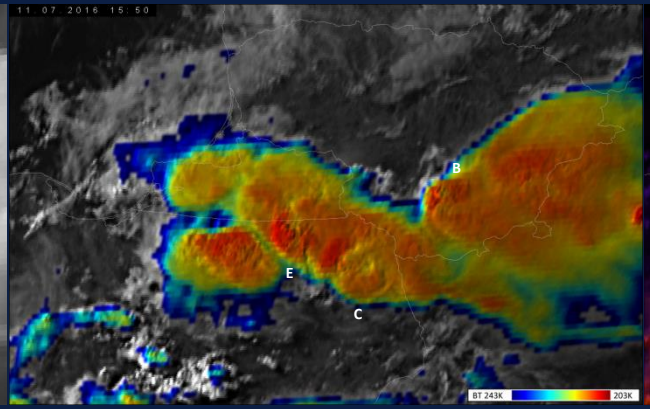
IR 10.8 BT (203-243K) color-enhanced image



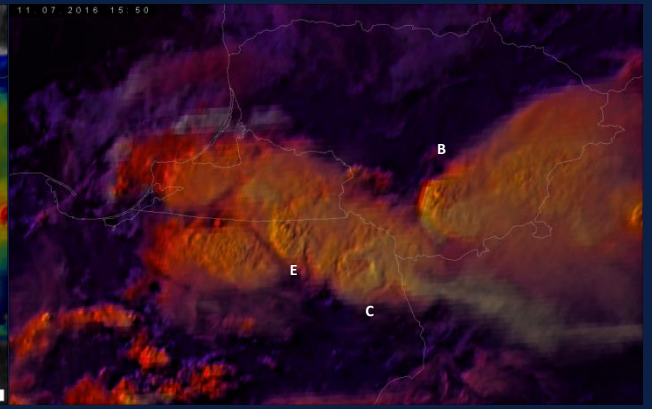
Convective storms RGB image product



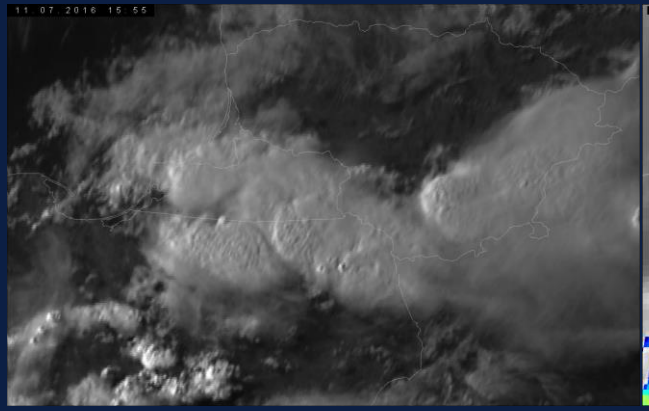
IR 3.9 band (displayed as radiance image)



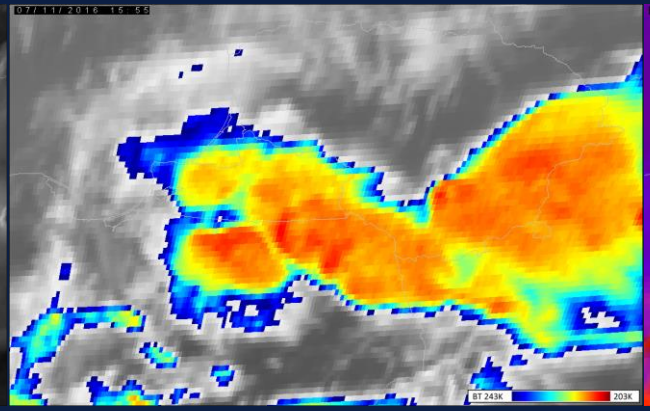
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



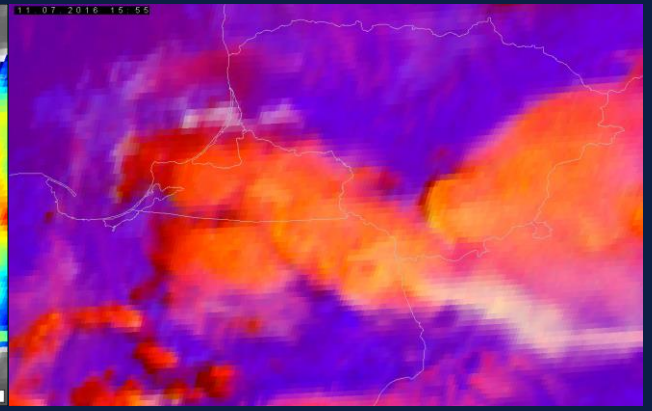
sandwich product – HRV band and Convective storms RGB image



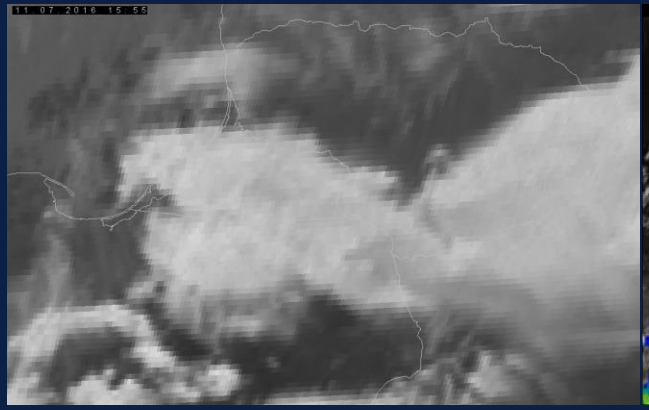
HRV band



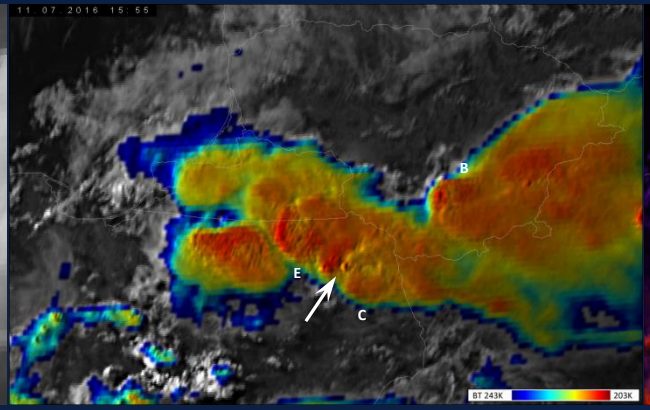
IR 10.8 BT (203-243K) color-enhanced image



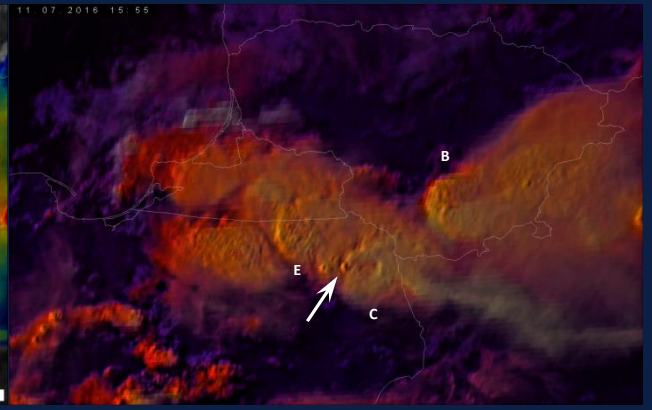
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

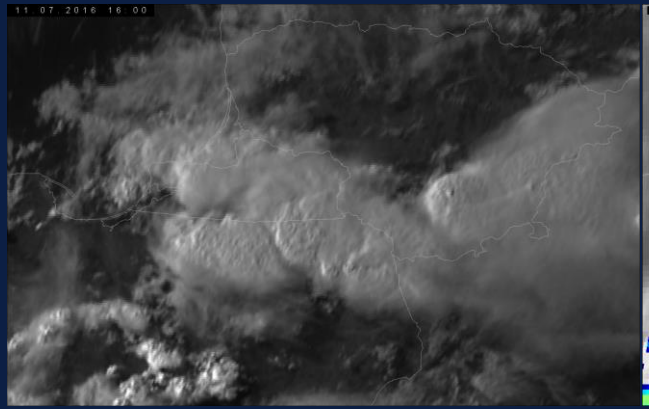


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

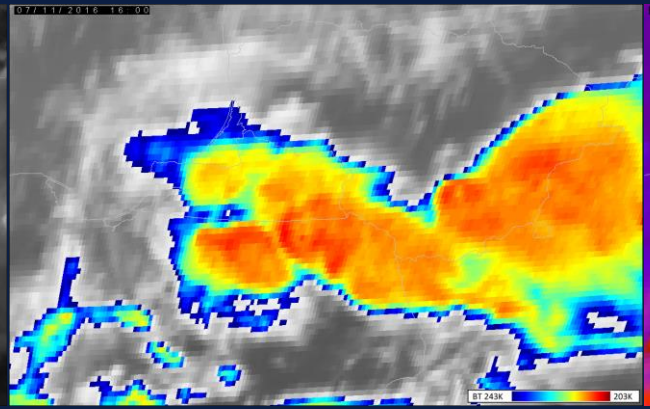


sandwich product – HRV band and Convective storms RGB image

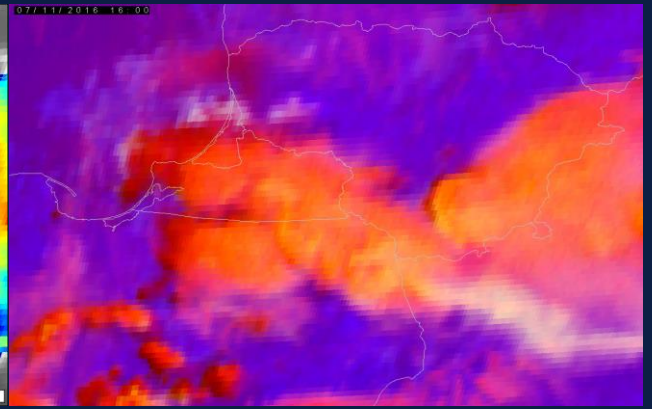
Between storms C and E, two distinct overshooting tops form. While the larger one (closer to storm E) reaches very low temperatures, the smaller of these (closer to storm C) remains relatively warm, but it seems to be generating a plume (arrowed). "Source" of the plume seems to survive for about next 3 slides, even after disappearance of the "feeding" OT.



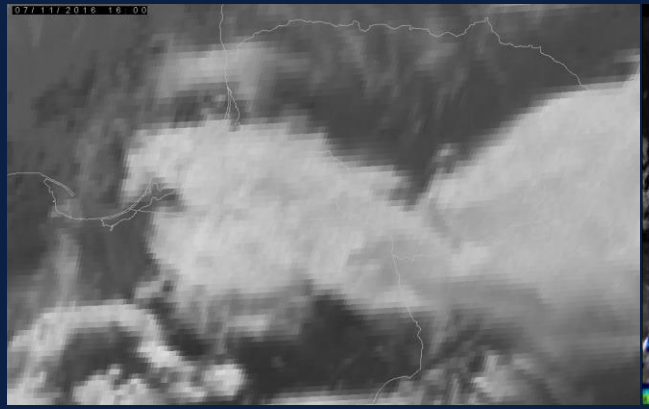
HRV band



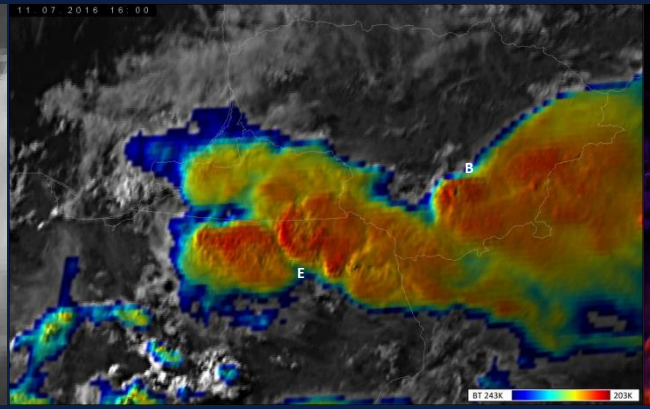
IR 10.8 BT (203-243K) color-enhanced image



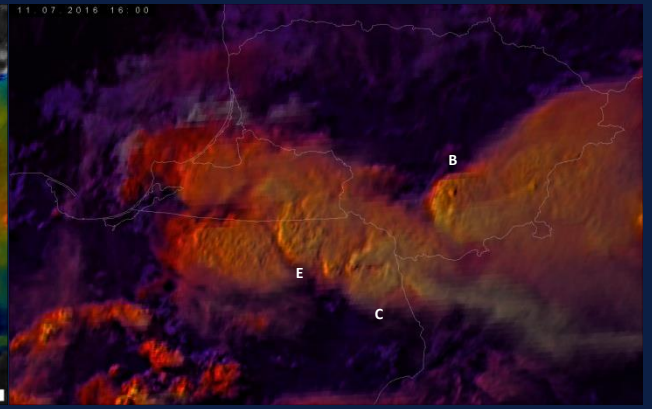
Convective storms RGB image product



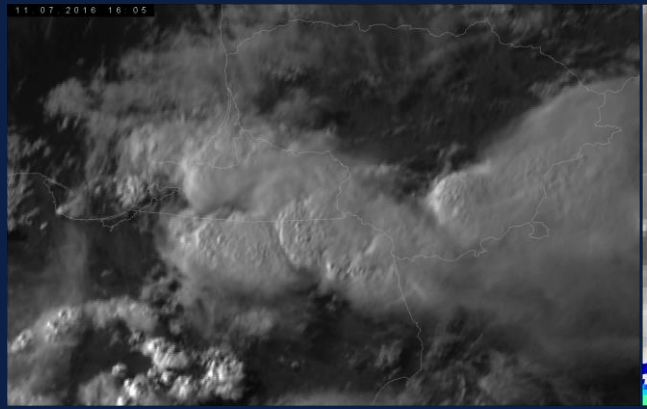
IR 3.9 band (displayed as radiance image)



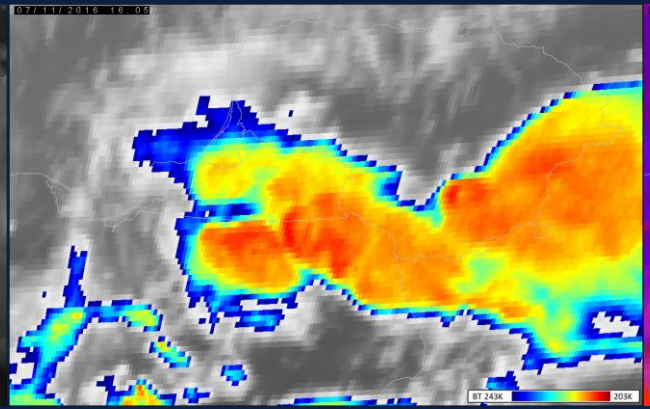
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



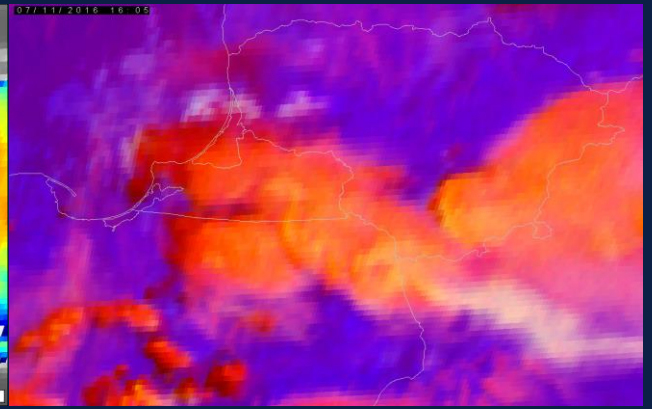
sandwich product – HRV band and Convective storms RGB image



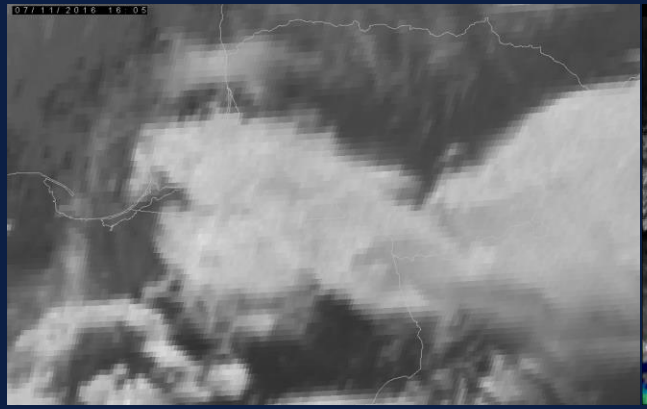
HRV band



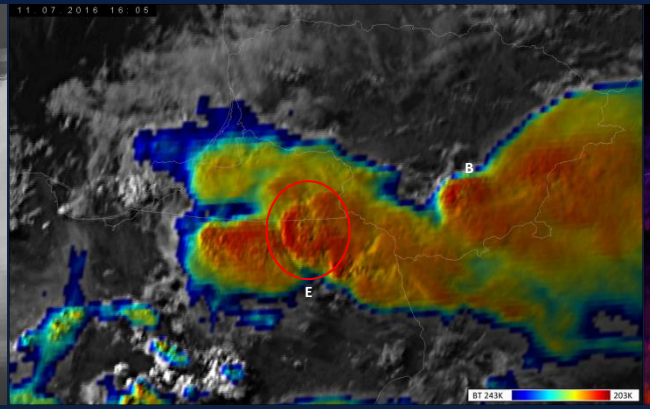
IR 10.8 BT (203-243K) color-enhanced image



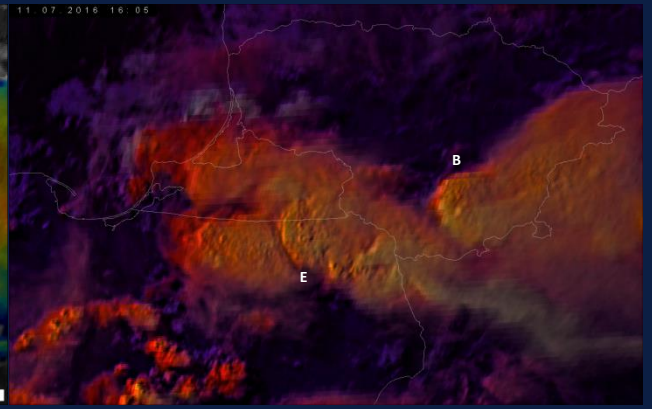
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

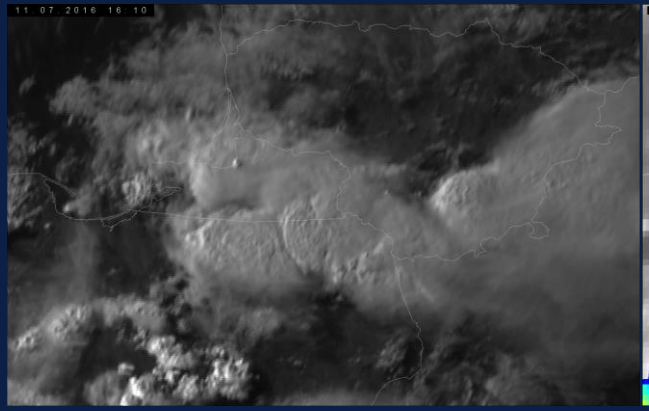


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

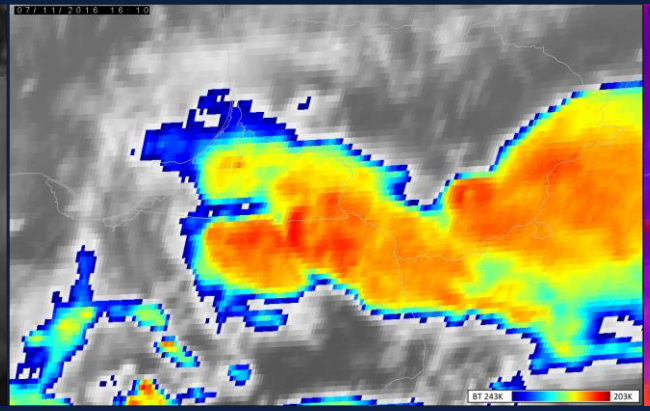


sandwich product – HRV band and Convective storms RGB image

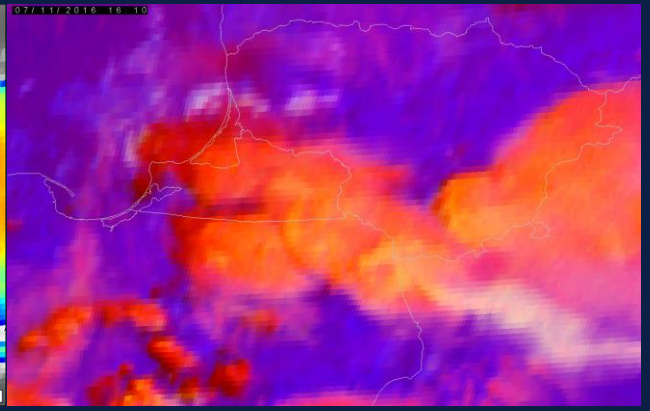
At this stage (and next several slides), the storm E exhibits a feature which is somewhere between a cold ring and cold-U, with OT activity at its southern parts, and even several smaller plumes. However, the cold feature, OTs and small plumes are rather short-lived, so it appears that the storm probably did not reach the intensity of the other storms (A, B and C) discussed before.



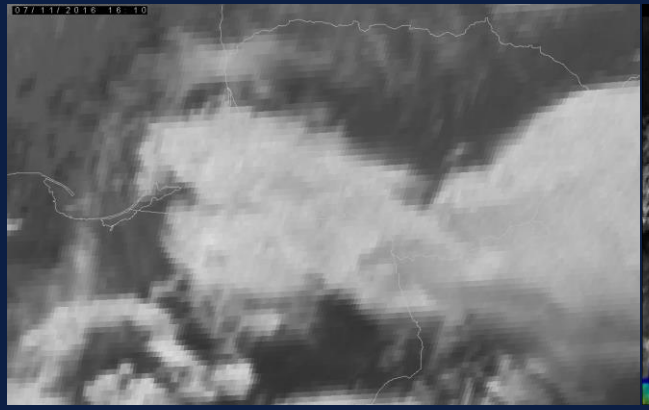
HRV band



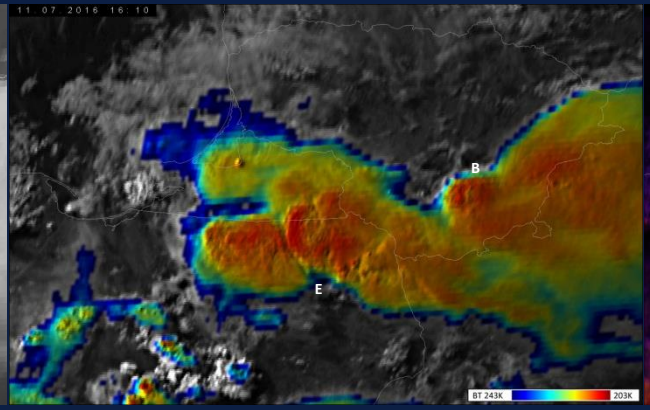
IR 10.8 BT (203-243K) color-enhanced image



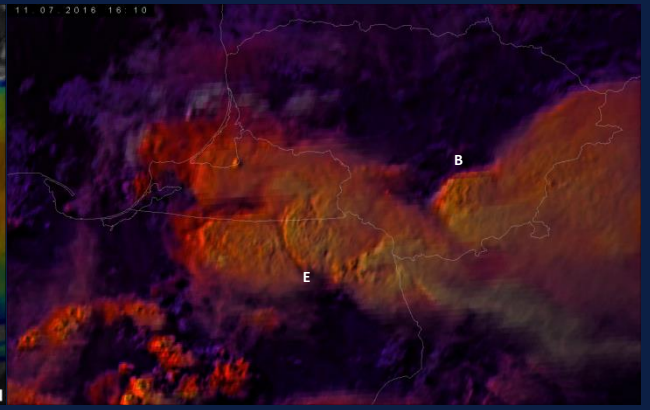
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

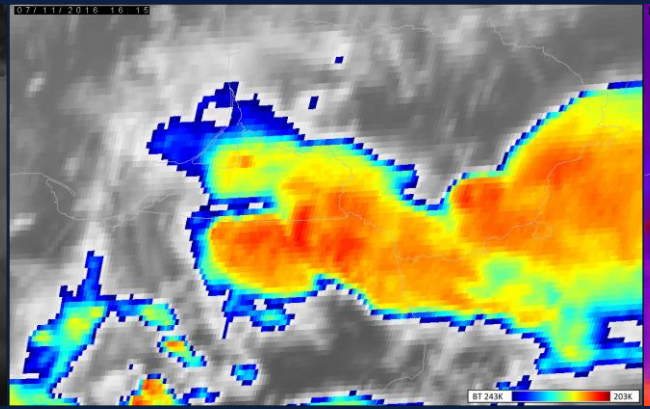


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

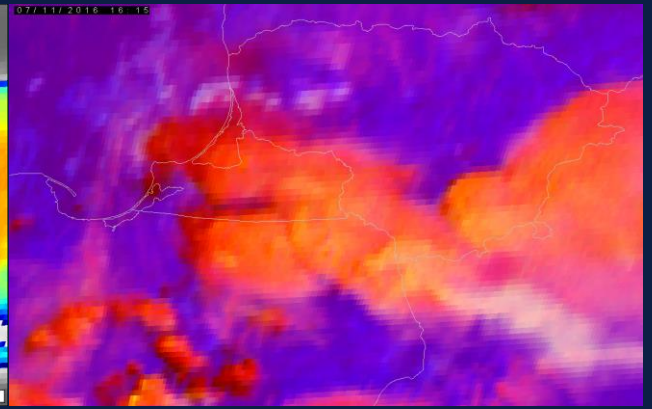


sandwich product – HRV band and Convective storms RGB image

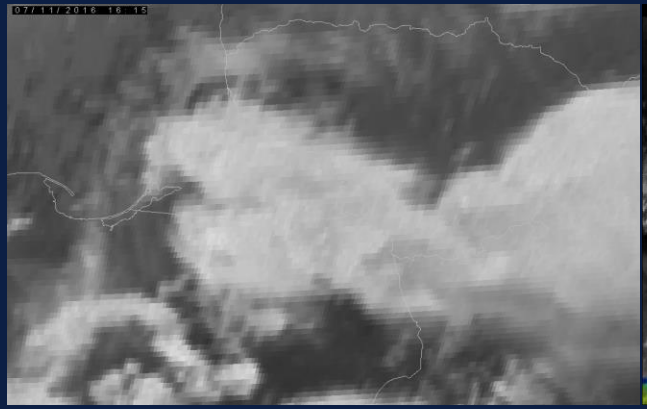
HRV band



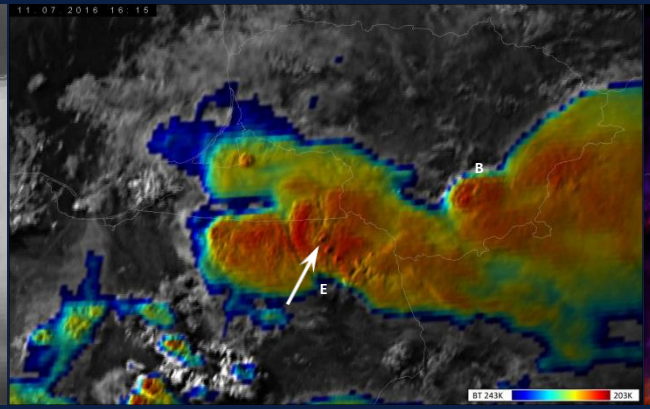
IR 10.8 BT (203-243K) color-enhanced image



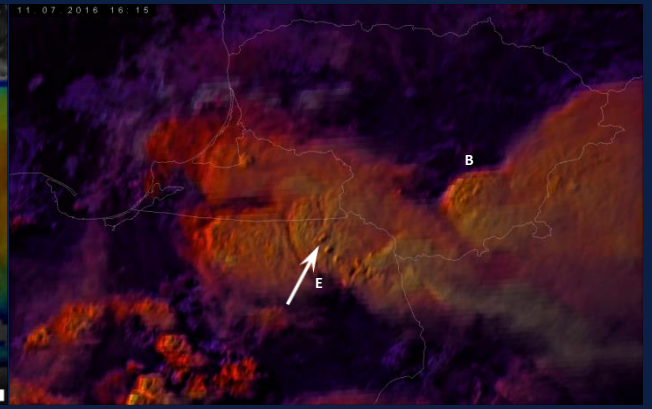
Convective storms RGB image product



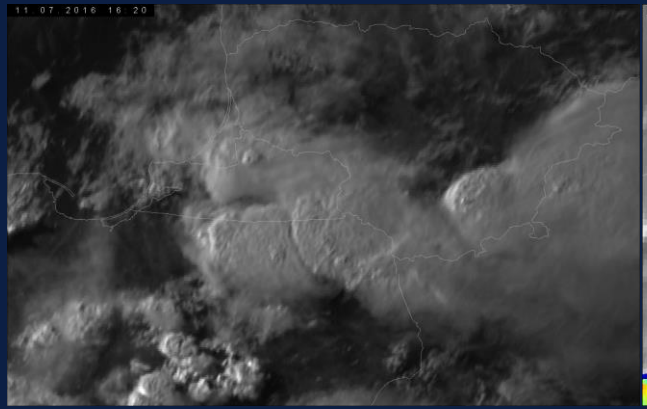
IR 3.9 band (displayed as radiance image)



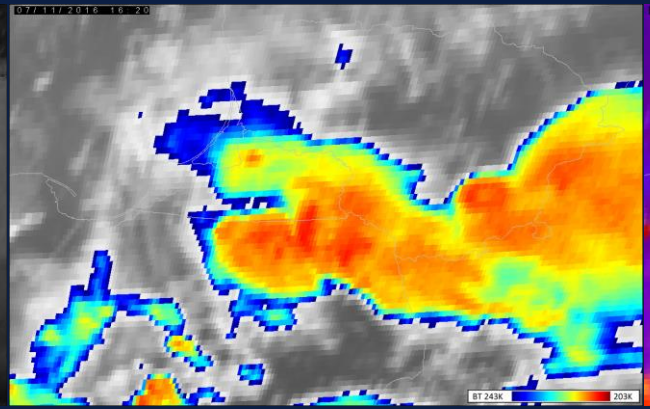
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



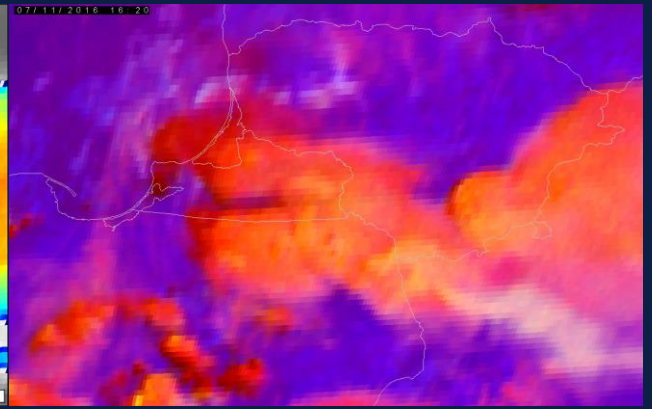
sandwich product – HRV band and Convective storms RGB image



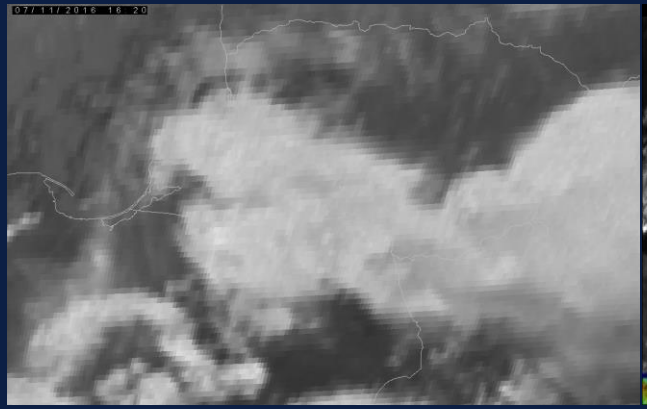
HRV band



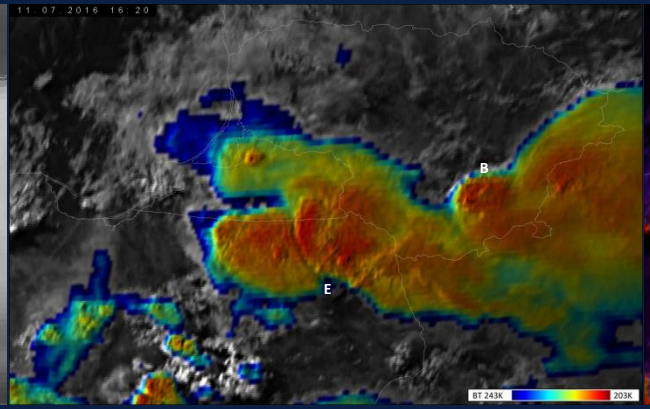
IR 10.8 BT (203-243K) color-enhanced image



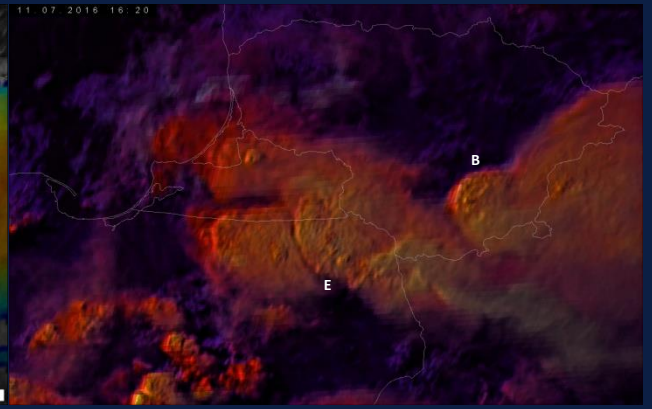
Convective storms RGB image product



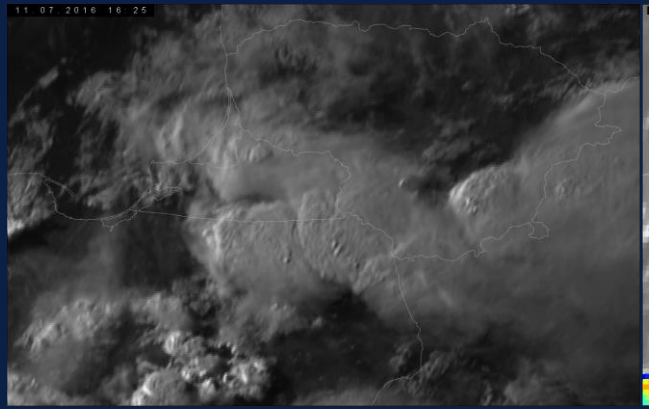
IR 3.9 band (displayed as radiance image)



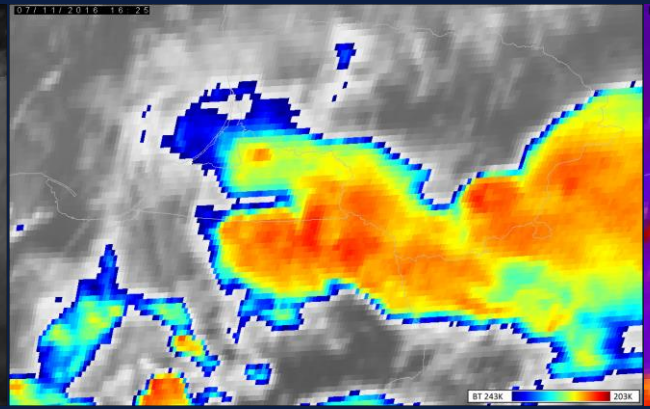
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



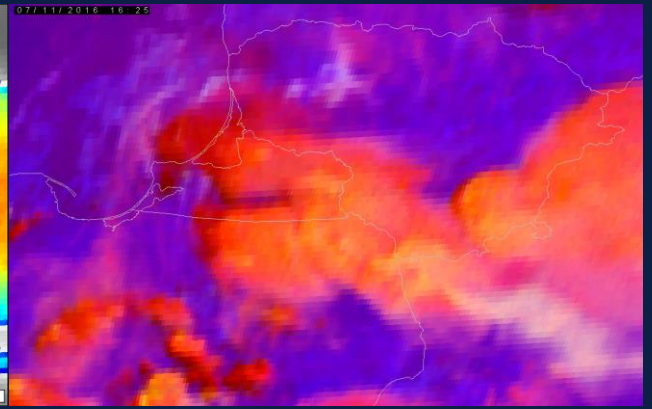
sandwich product – HRV band and Convective storms RGB image



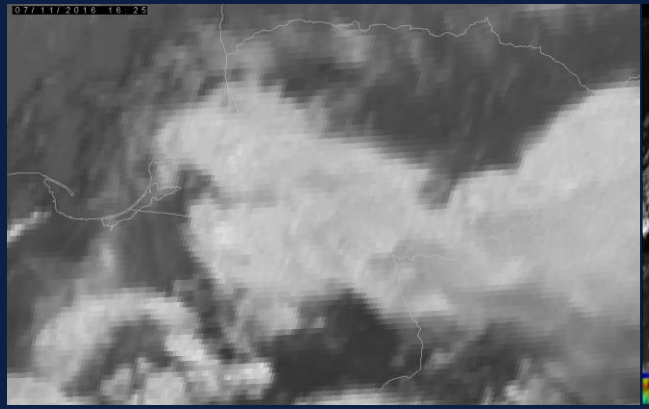
HRV band



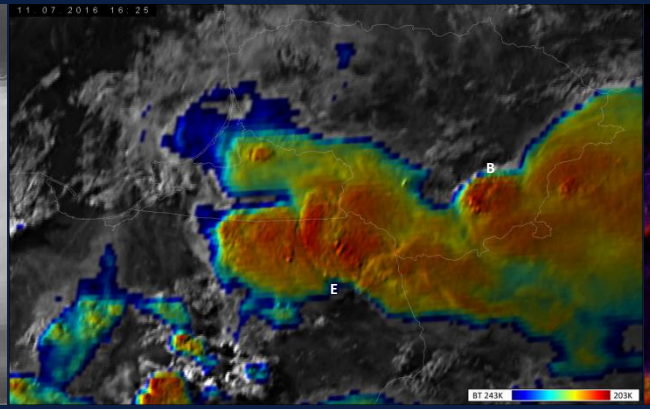
IR 10.8 BT (203-243K) color-enhanced image



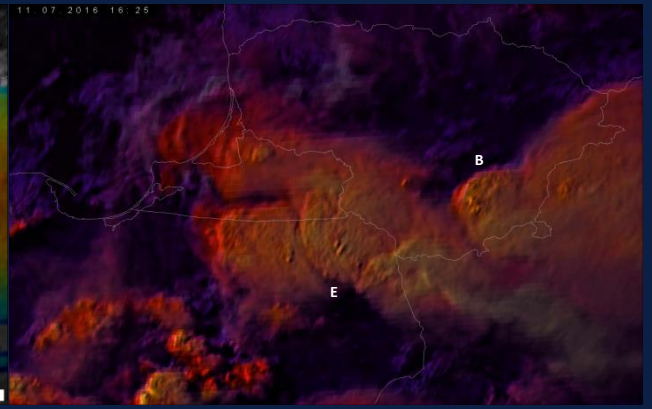
Convective storms RGB image product



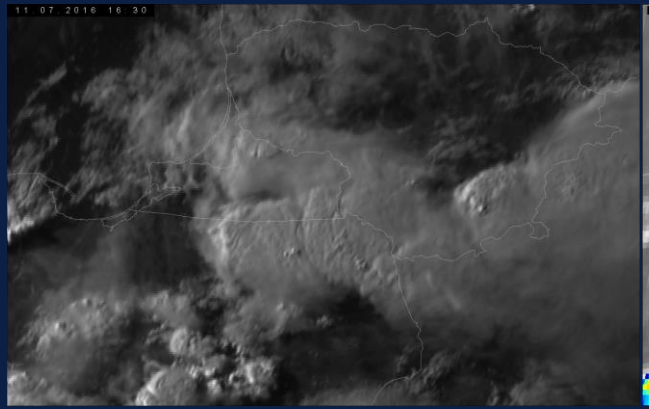
IR 3.9 band (displayed as radiance image)



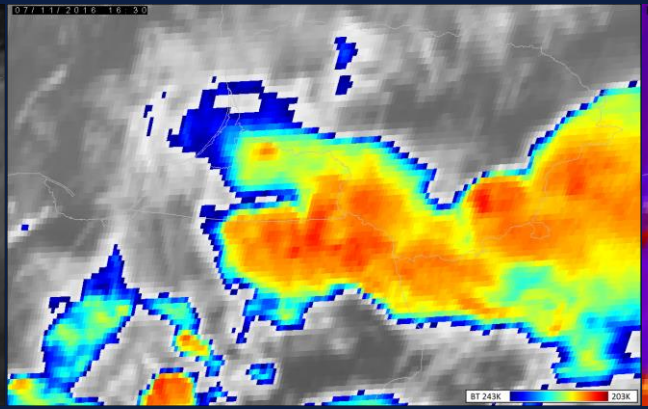
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



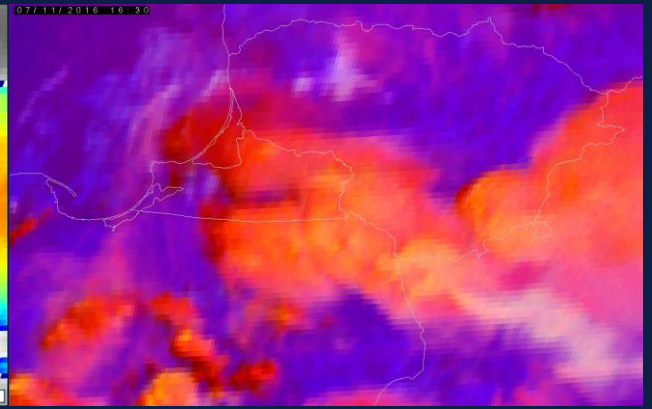
sandwich product – HRV band and Convective storms RGB image



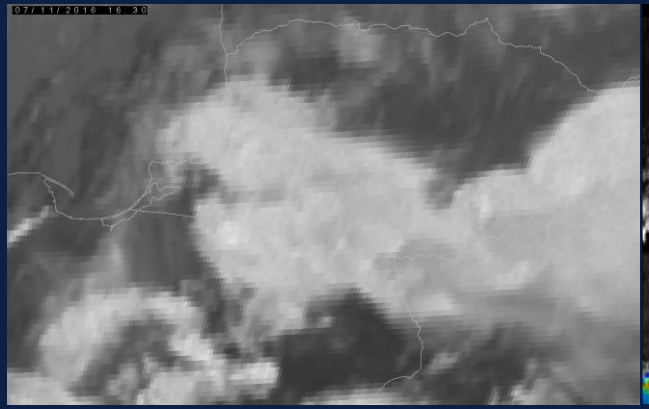
HRV band



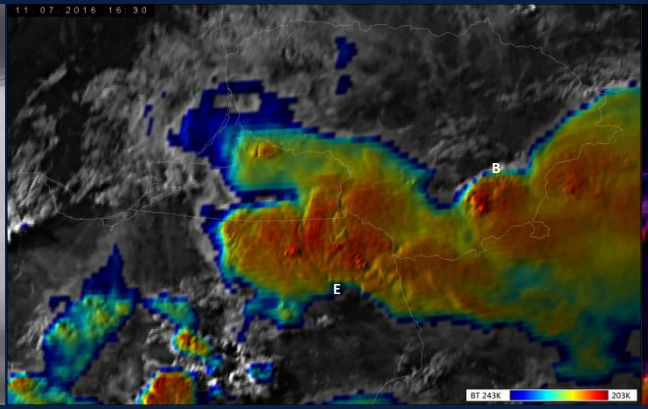
IR 10.8 BT (203-243K) color-enhanced image



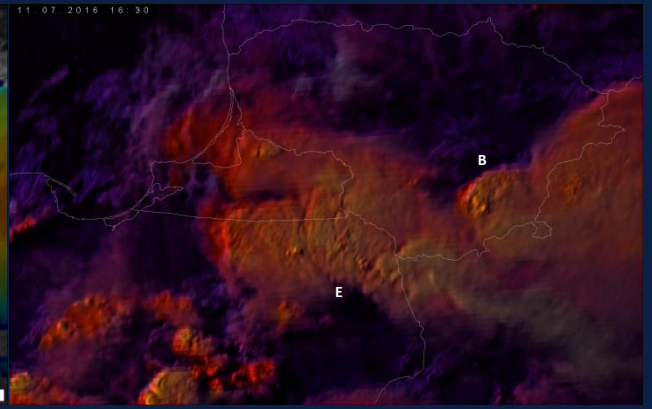
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

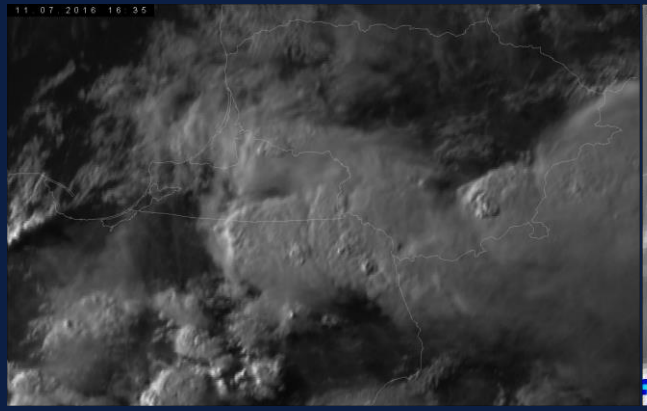


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

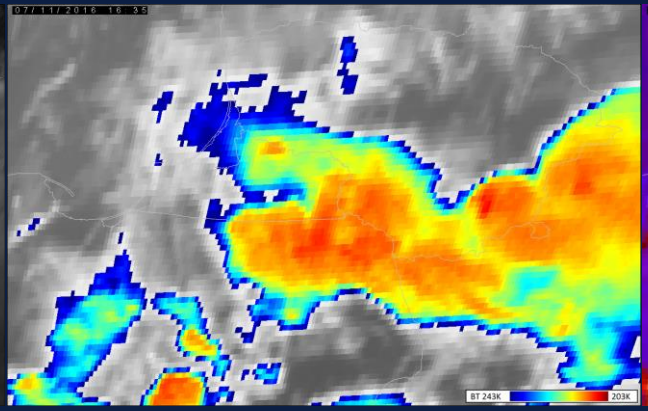


sandwich product – HRV band and Convective storms RGB image

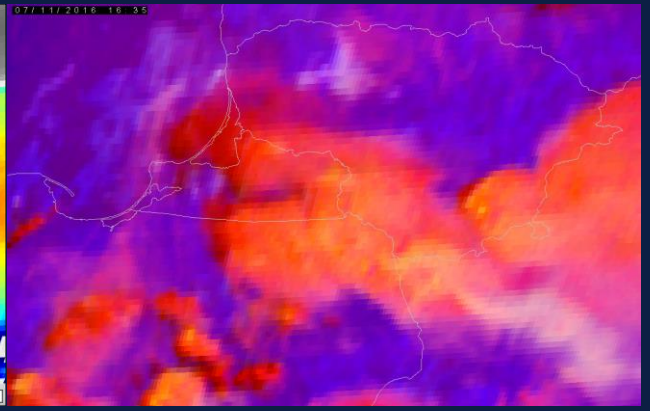
The storm B is still active – we can see several overshooting tops in its core, which we can follow for about next 20 minutes. However, these OTs are just ordinary ones, not differing from those which we can see above some of the other storms in the area.



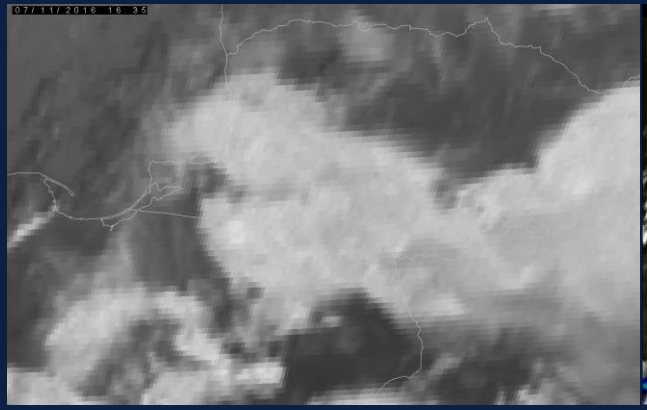
HRV band



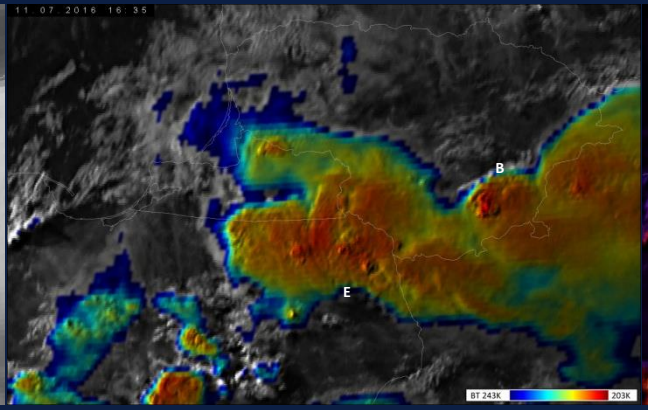
IR 10.8 BT (203-243K) color-enhanced image



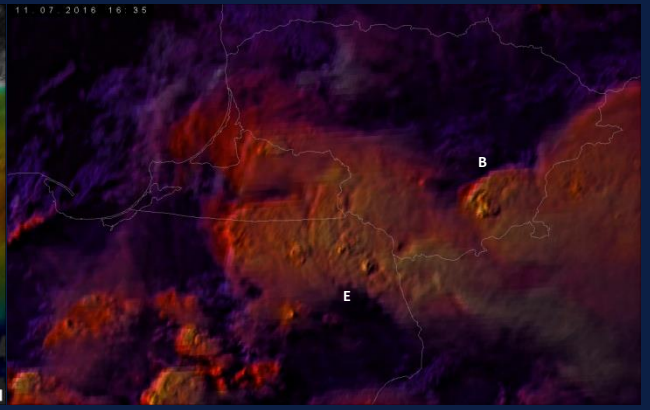
Convective storms RGB image product



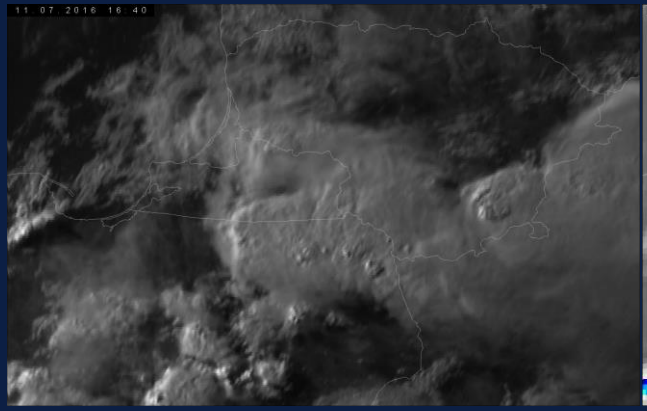
IR 3.9 band (displayed as radiance image)



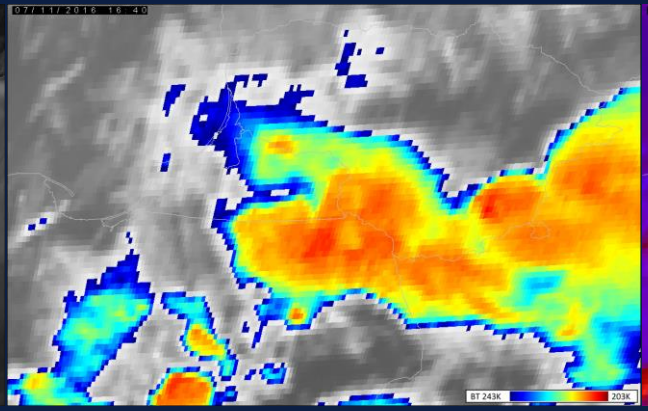
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



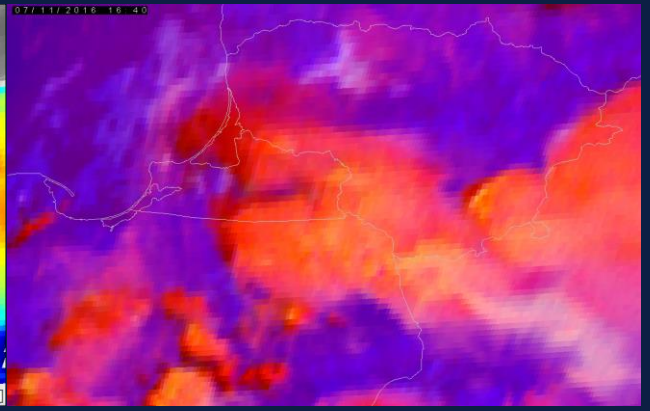
sandwich product – HRV band and Convective storms RGB image



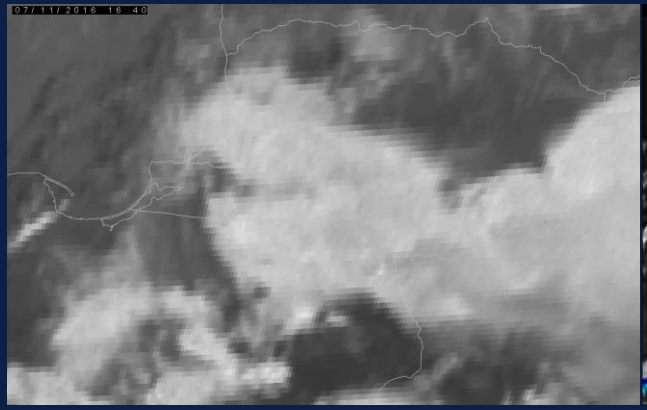
HRV band



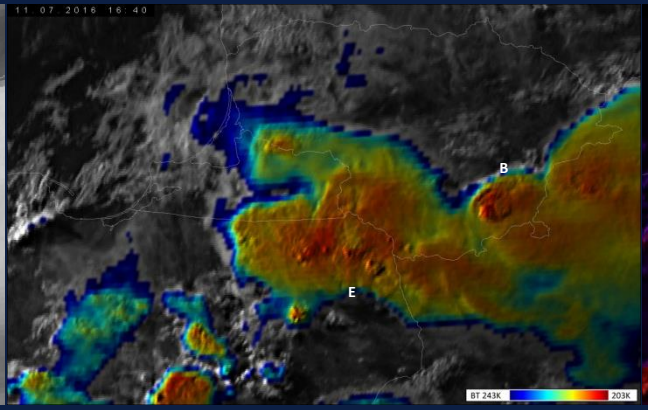
IR 10.8 BT (203-243K) color-enhanced image



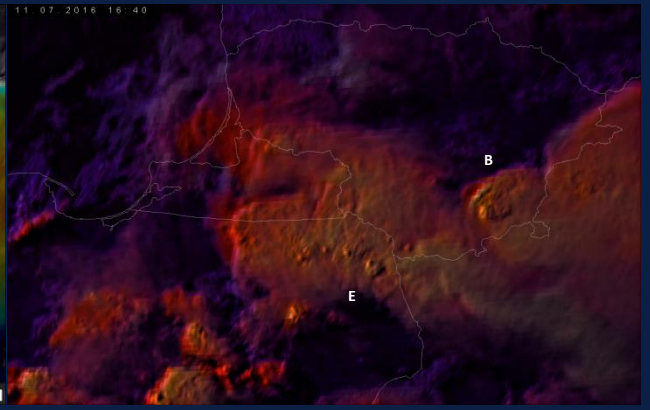
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)

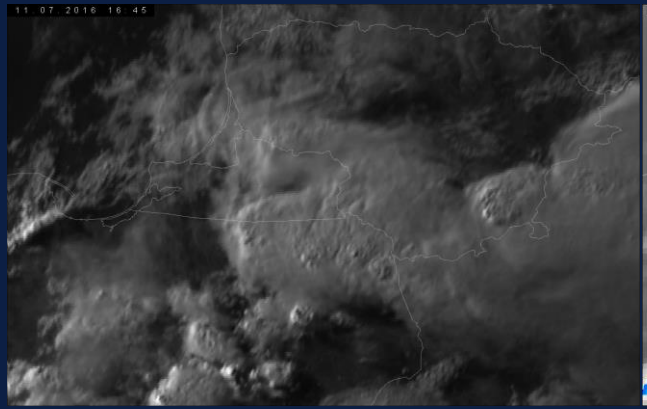


sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image

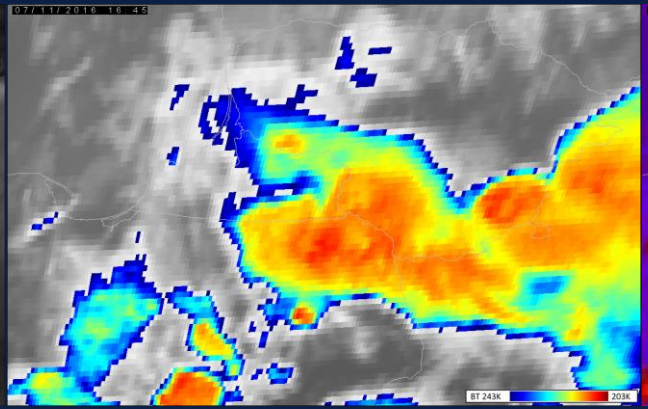


sandwich product – HRV band and Convective storms RGB image

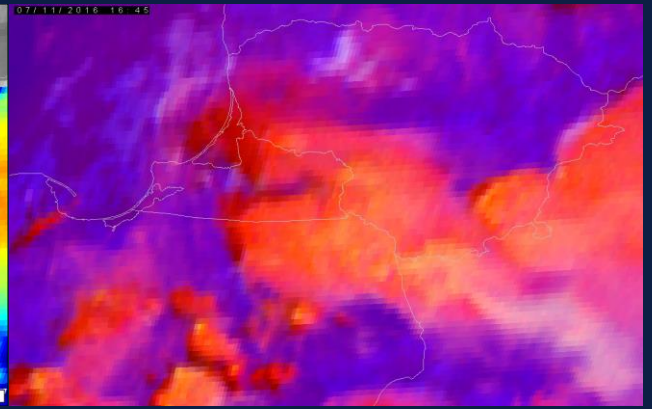
By now, the cold-U atop storm E is almost gone. From now on, the storm E doesn't show anything interesting, only several overshooting tops popping up and disappearing soon after. Storm B still keeps going on ...



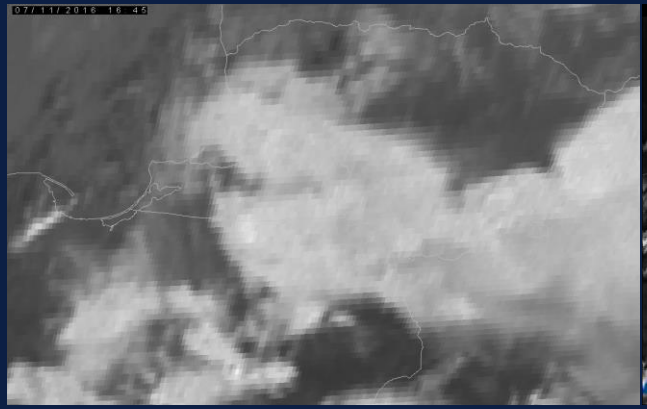
HRV band



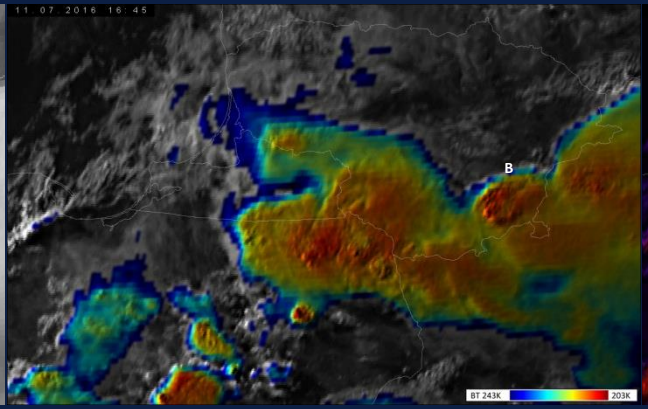
IR 10.8 BT (203-243K) color-enhanced image



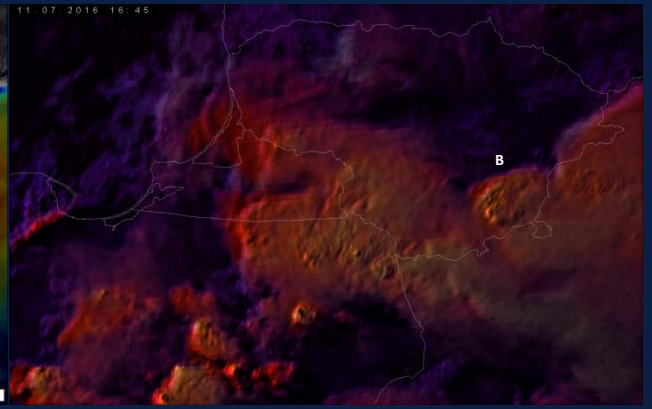
Convective storms RGB image product



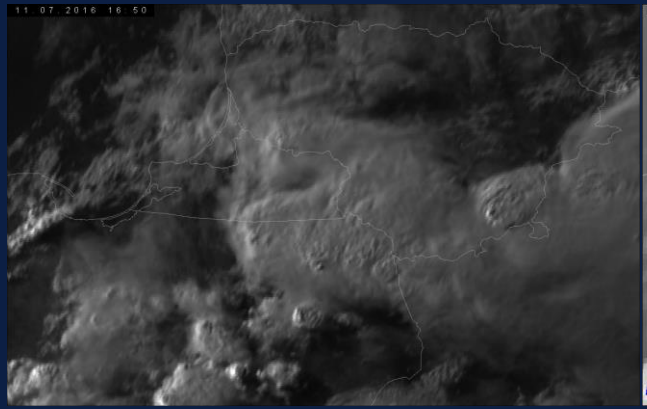
IR 3.9 band (displayed as radiance image)



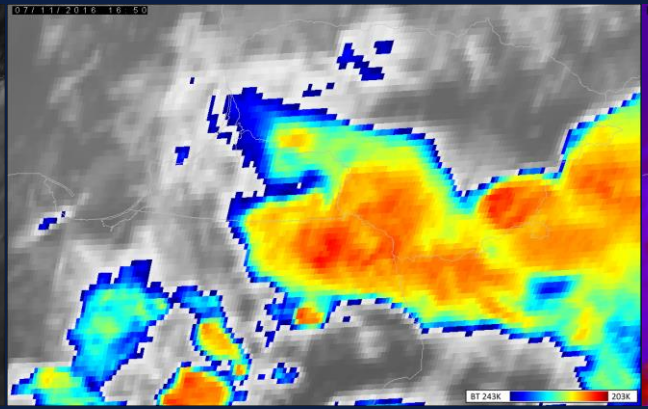
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



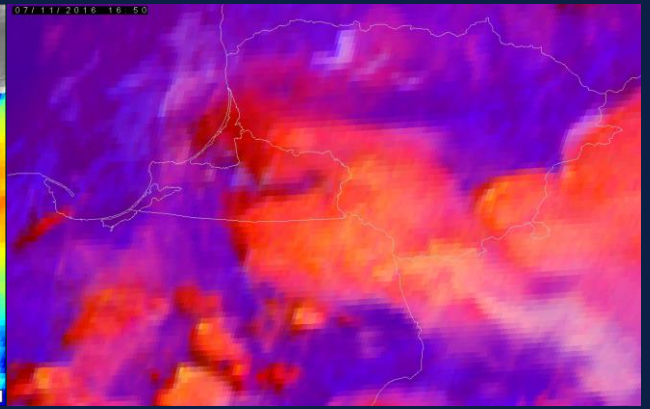
sandwich product – HRV band and Convective storms RGB image



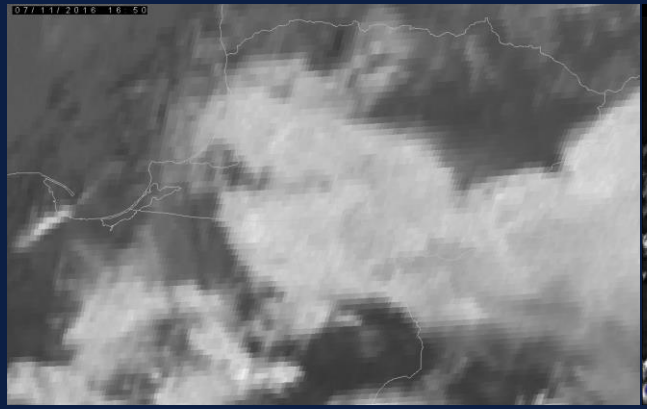
HRV band



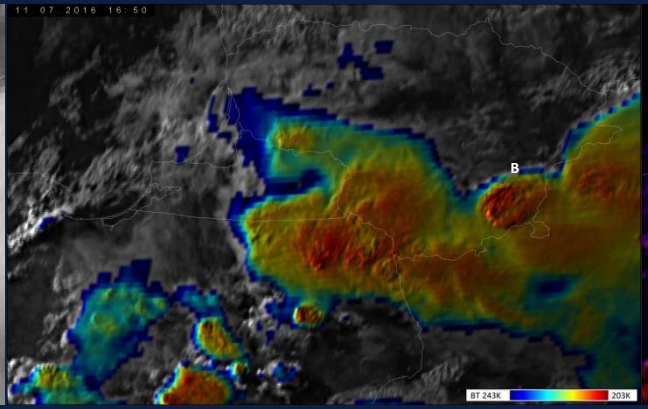
IR 10.8 BT (203-243K) color-enhanced image



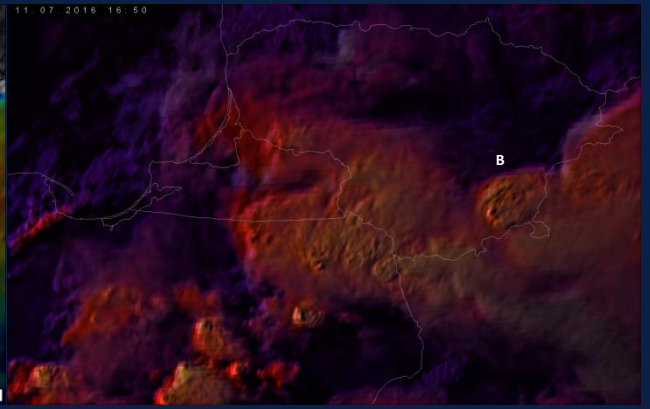
Convective storms RGB image product



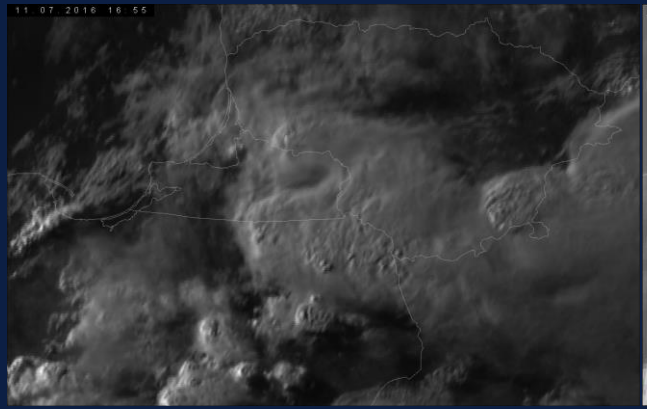
IR 3.9 band (displayed as radiance image)



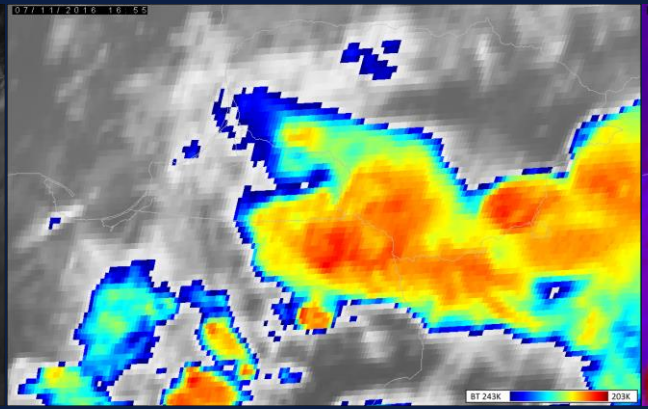
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



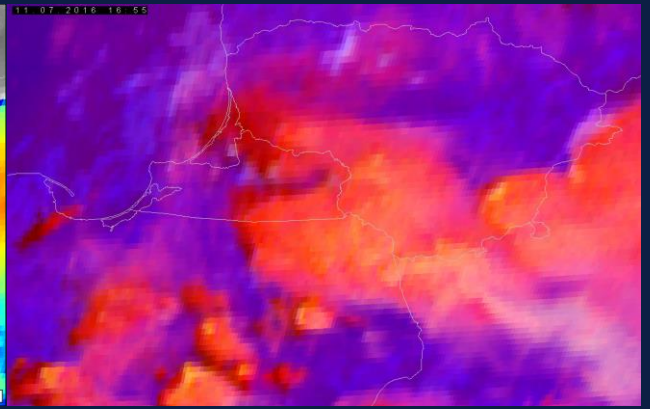
sandwich product – HRV band and Convective storms RGB image



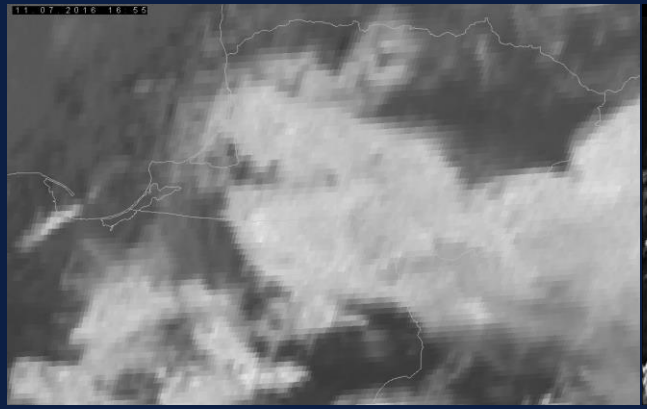
HRV band



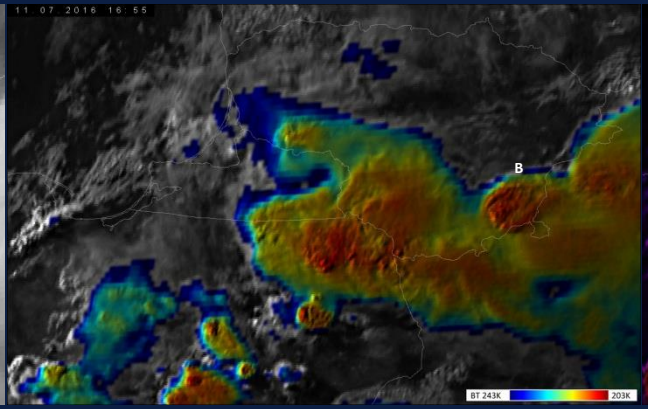
IR 10.8 BT (203-243K) color-enhanced image



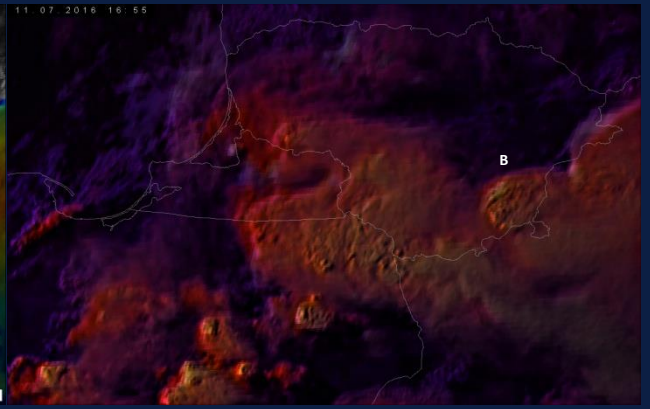
Convective storms RGB image product



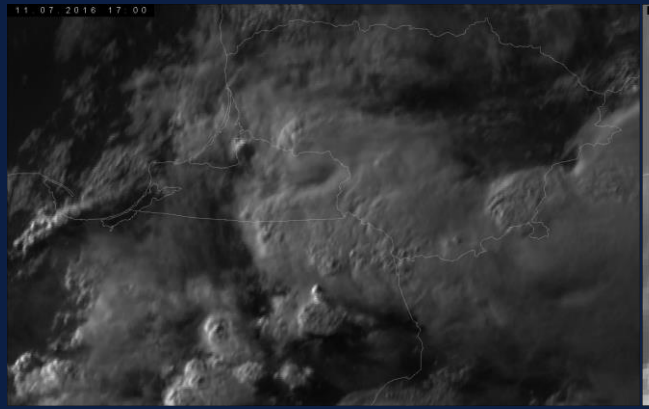
IR 3.9 band (displayed as radiance image)



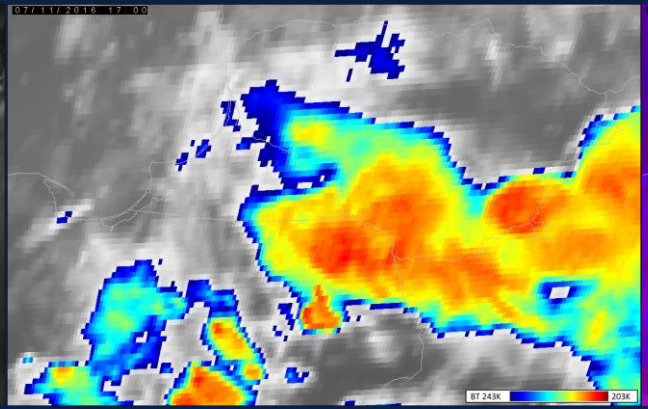
sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



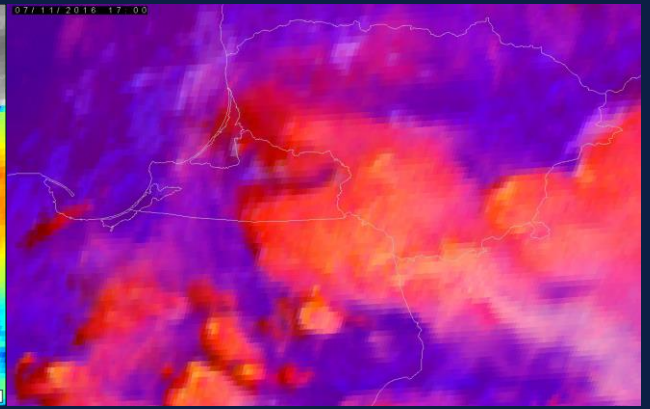
sandwich product – HRV band and Convective storms RGB image



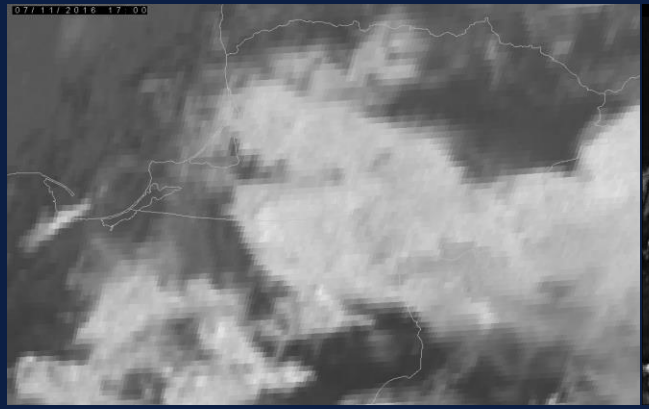
HRV band



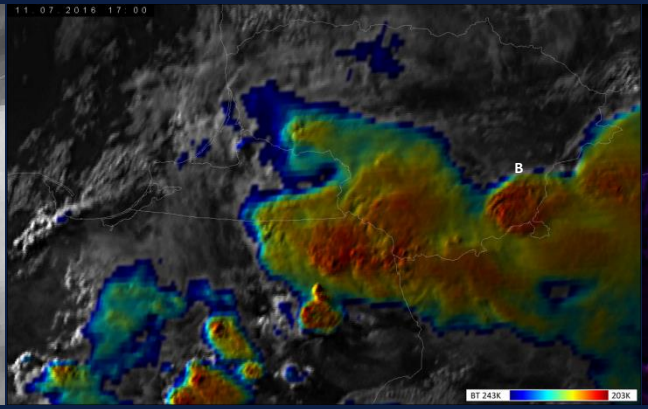
IR 10.8 BT (203-243K) color-enhanced image



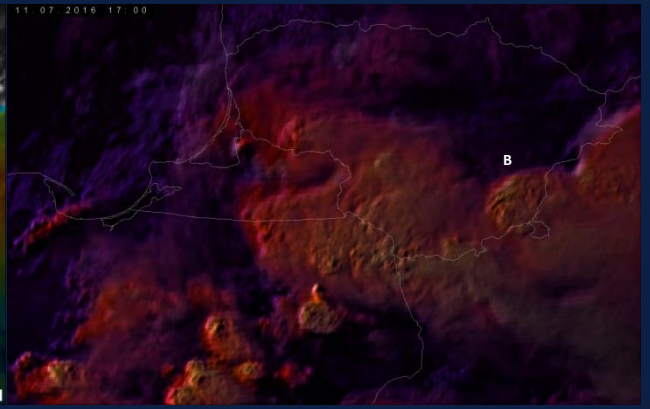
Convective storms RGB image product



IR 3.9 band (displayed as radiance image)



sandwich product – HRV band and color-enhanced IR10.8 (203-243K) image



sandwich product – HRV band and Convective storms RGB image

The storm B begins to weaken now, and disappears in about 20-30 minutes (not shown here). It was the longest-lived storm of the whole series ... And this is also the last image mosaic of this PPT/PDF document, though some new storms evolved in the area later on, after sunset and in the evening hours.

Stand-alone (single bands or image products) animations:

- HRV band [Local or Vimeo]
- Color-enhanced IR10.8 band (BT 203-243K) [Local or Vimeo]
- Near-IR 1.6 µm band [Local or Vimeo]
- IR 3.9 µm band (displayed as "radiance image") [Local or Vimeo]

- (Convective) Storm RGB image product [Local or Vimeo]

- Sandwich image product of bands HRV and color-enhanced IR10.8 [Local or Vimeo]
- Sandwich image product of band HRV and Storm-RGB image [Local or Vimeo]

Please note that the “local” links above are valid only if you have the original movie files stored locally in a /movies subfolder.

I'm pretty sure that I did not cover all of the possibly interesting storm-top features (namely overshooting tops and smaller above-anvil plumes), and ignored some of the other, smaller storms (which might have been severe as well). I just wanted to focus on the "eye-catchers", the most prominent of the storms and their cloud-top features.

Now you can try to evaluate yourself which of these storms and phases of their "life" seem to be the best candidates (from the satellite perspective) for potential severity. Next, you can try to compare your "severity-evaluation" with ground-truth data, observations and damage reports, where available …

Just remember: not every severe storm must appear "interesting" in satellite imagery, and vice versa, not every "great" storm in satellite images must be severe. But they usually are ...

Martin Setvák

Praha, February 2017