CZECH HYDROMETEOROLOGICAL INSTITUTE

SATELLITE MONITORING OF THE CONVECTIVE STORMS

FORECASTERS’ POINT OF VIEW

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Reading, 13 June 2017

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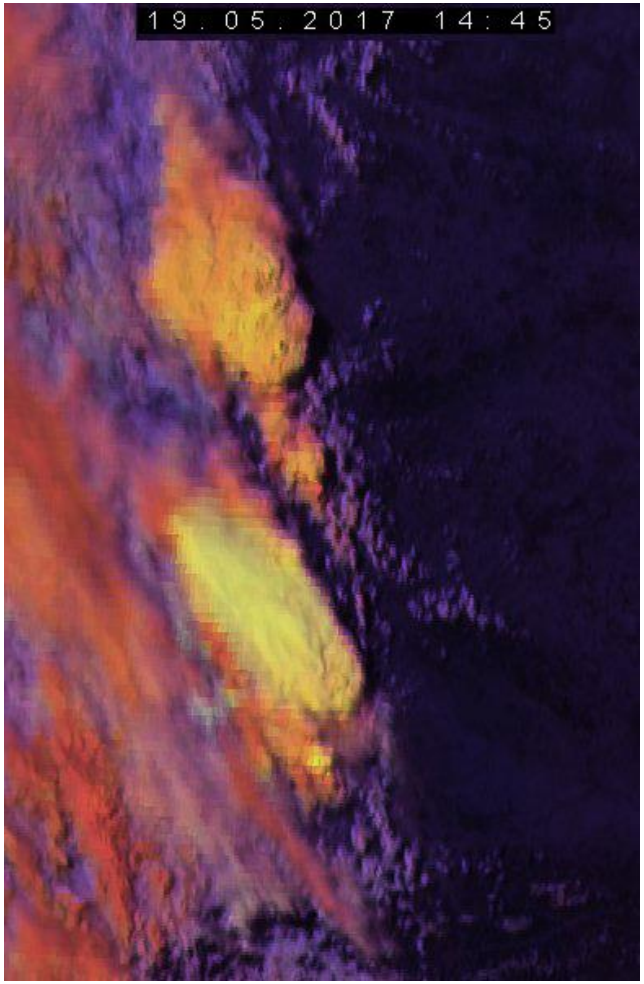
OBJECTIVES OF PRESENTATION



- storm forecasting
  - from long-range forecast to nowcasting
- storm monitoring
  - satellites and geometry
  - storm appearance
- data visualization
  - IR-BT, RGB, sandwich

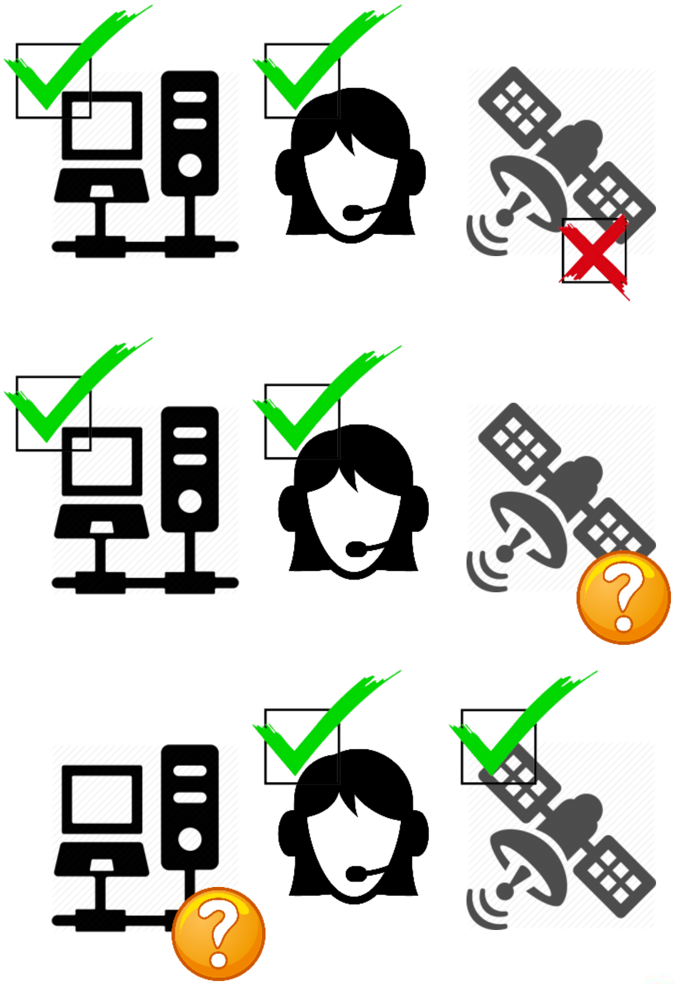
FORECASTER’S POINT OF VIEW

- **convective storms** are challenging
  - where and when will storm evolve ?
  - how dangerous will it be ?
  - how long will it last ?

- **satellite data** are crucial
  - information every 5 min
  - helpful products
  - years of experience

STORM FORECASTING

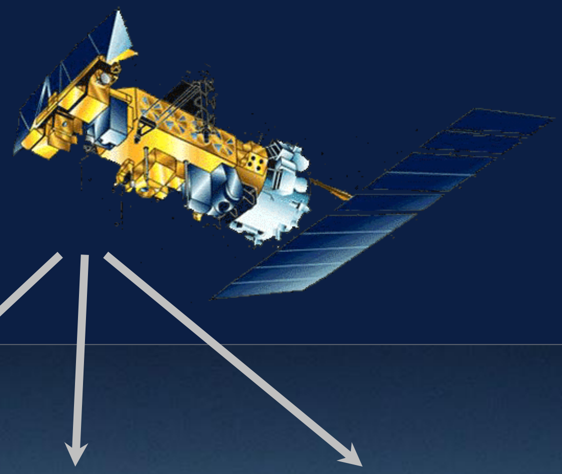
- **long-range forecast**
  - up to 10 days
  - ensembles, probability
- **short-range forecast**
  - today and tomorrow
  - synoptic analysis
- **nowcasting**
  - now or several hours
  - observations, monitoring



STORM MONITORING

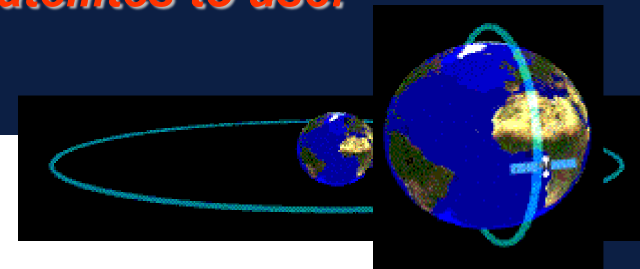
- operational weather satellites (overview)
- basic appearance on satellite images
- visualization techniques
    - cloud-top brightness temperature
        - cold-U and cold ring features, overshooting tops
    - cloud-top reflectivity in 3.5 – 4 μm
        - small ice particles, above-anvil (ice) plumes
    - RGB and Sandwich products

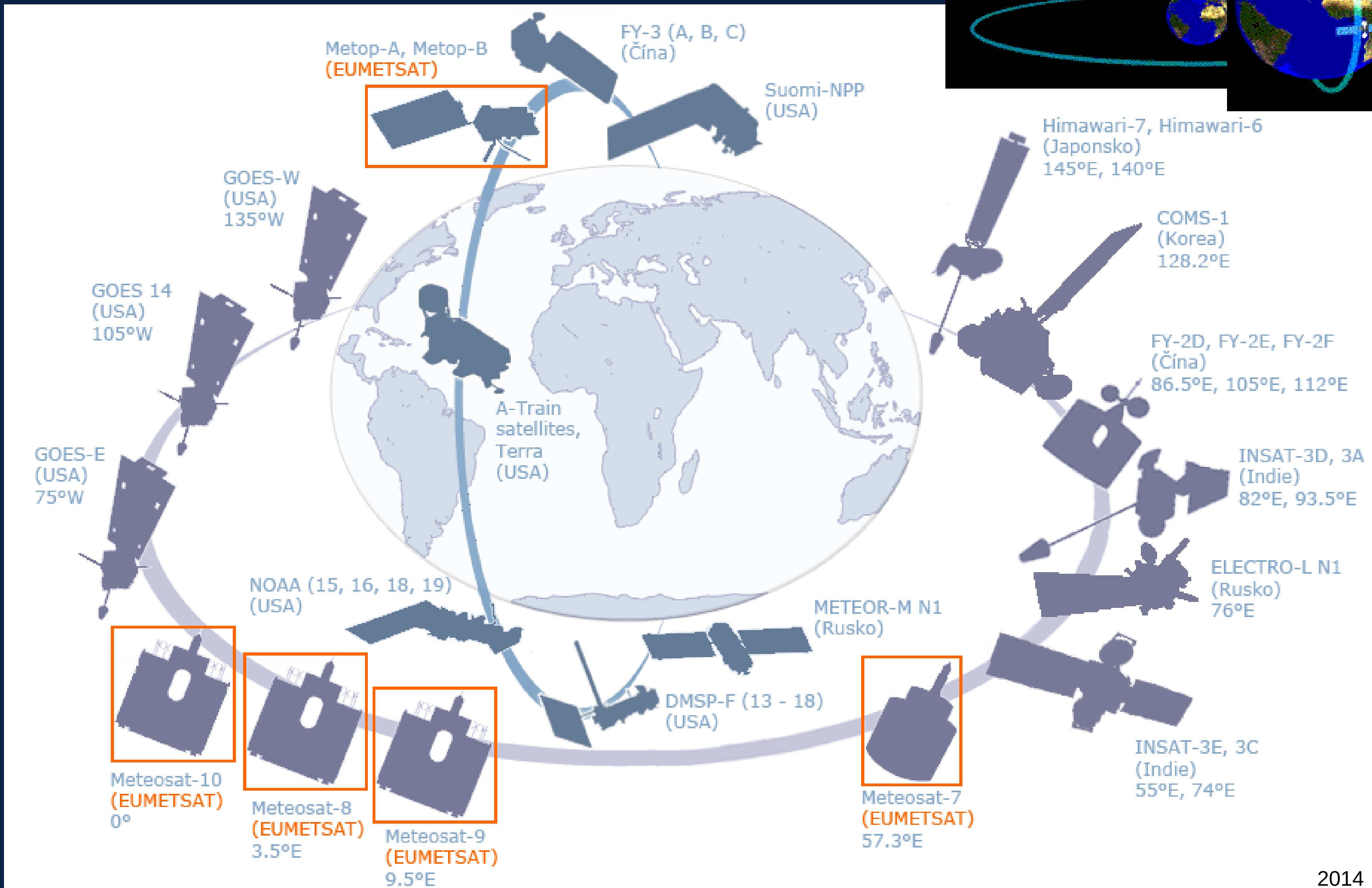
Storms from above …

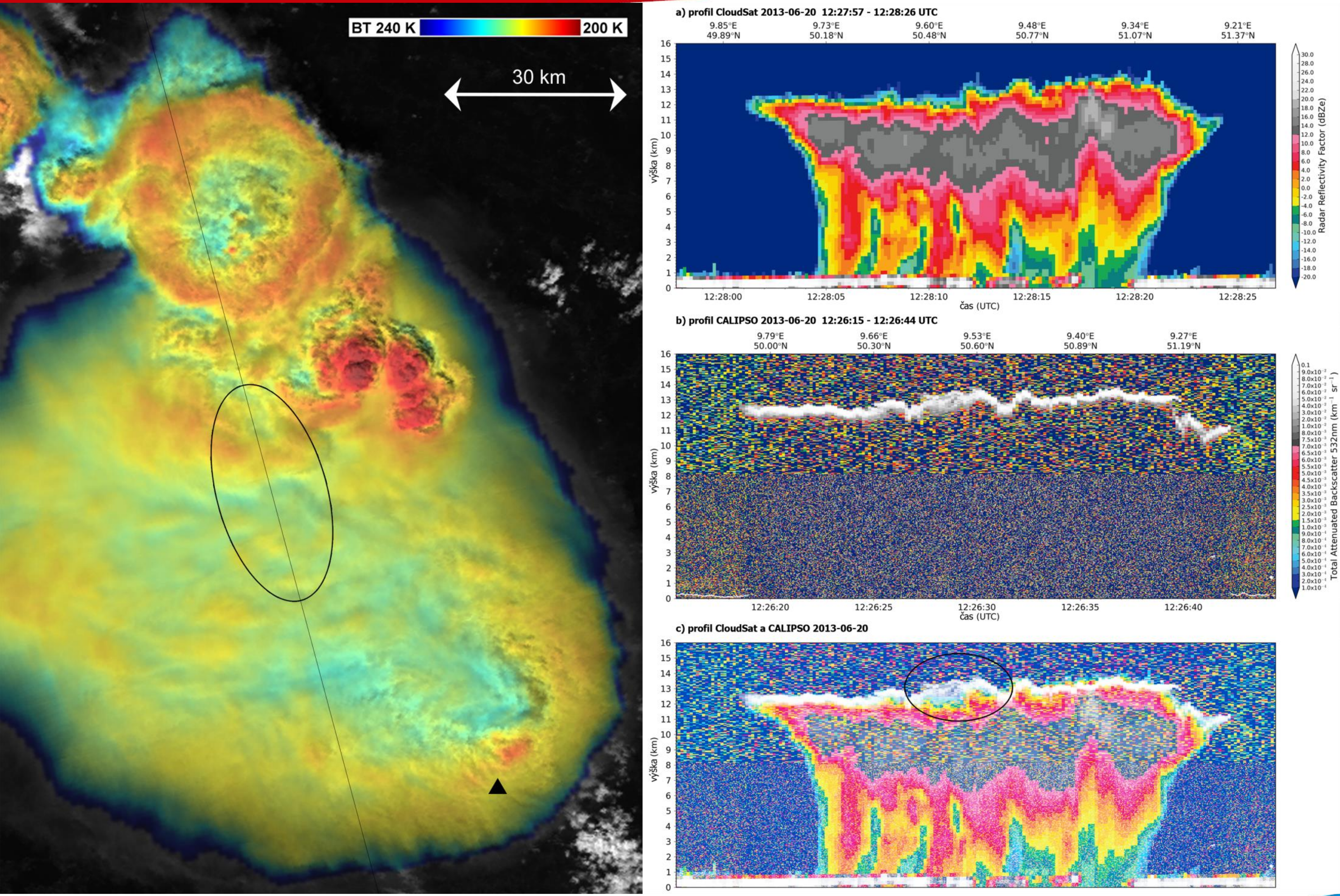


Satellites with <u>passive</u> radiometers can monitor the cloud tops only, they do not see inside the storms, or even under them! Thus, these satellites can't provide us with a direct information about the weather conditions under the storms, such information has to be inferred (derived) from the satellite data indirectly, utilizing conceptual models of convective storms.

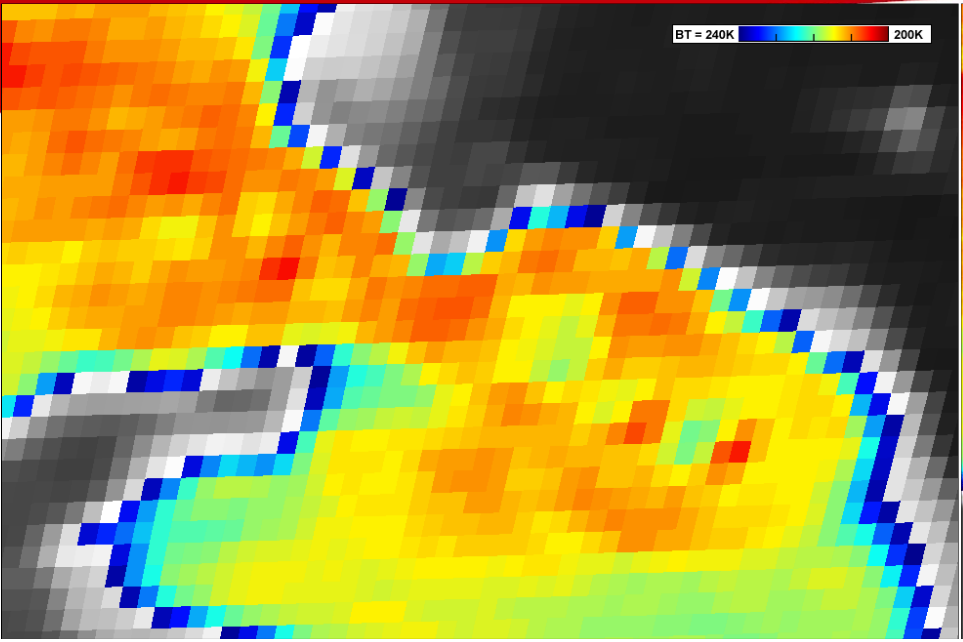
Storms from above … which operational weather satellites to use: geostationary (GEO) or low-Earth orbit (LEO) ones?



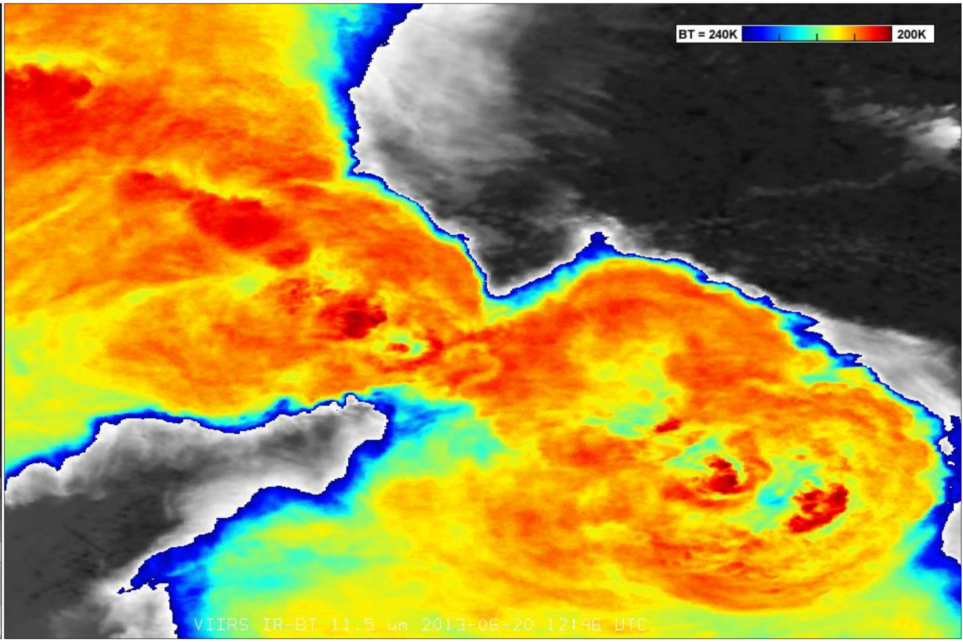




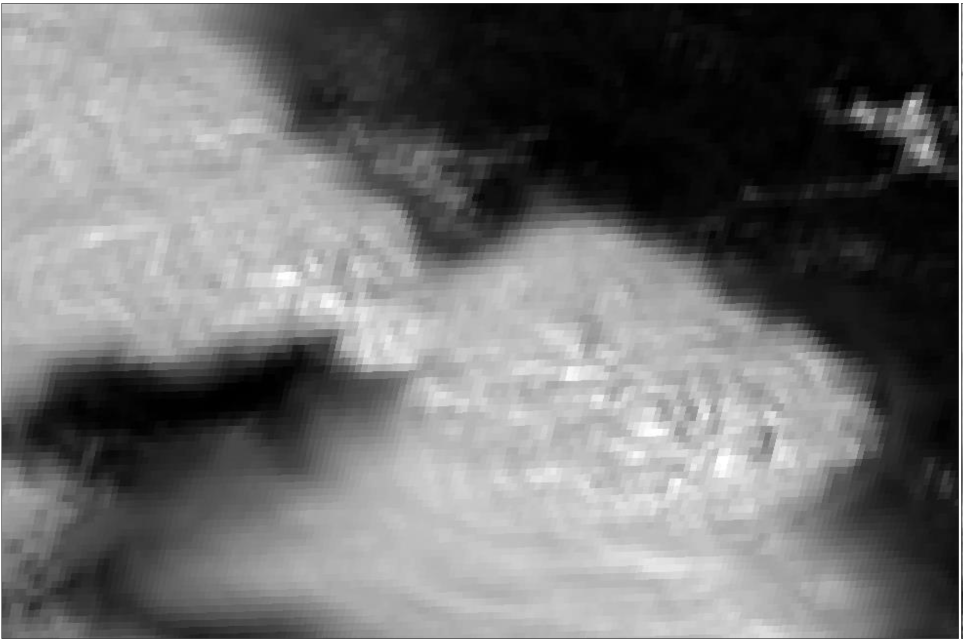
Aqua/MODIS 2013-06-20 12:25 UTC; hail occurrence at 12:26 UTC



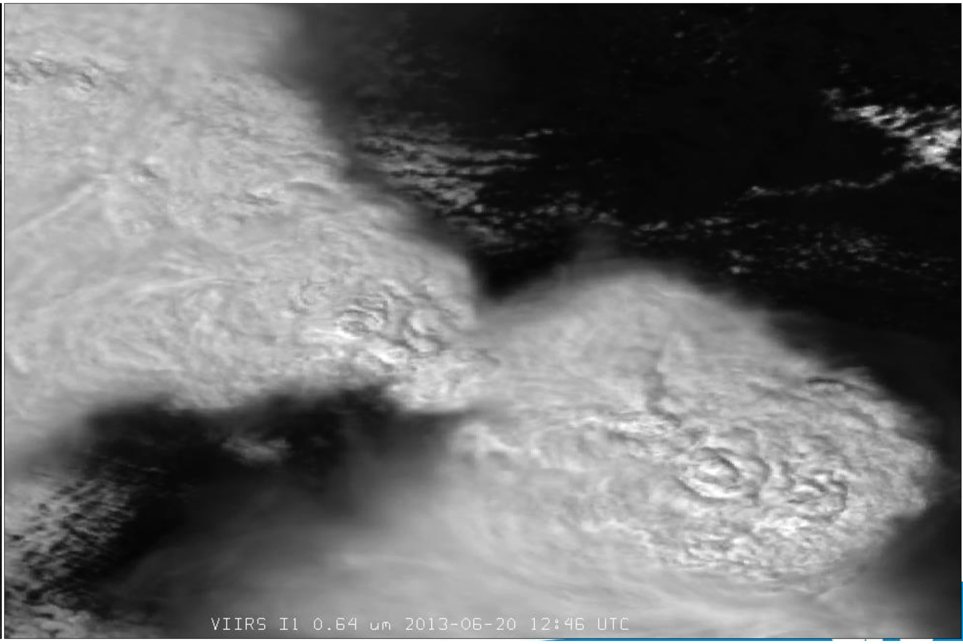
2016-06-20 12:45 UTC MSG/SEVIRI (3 km) IR10.8



2016-06-20 12:46 UTC Suomi-NPP/VIIRS (375 m) I5 band



2016-06-20 12:45 UTC MSG/SEVIRI (1 km) HRV



2016-06-20 12:46 UTC Suomi-NPP/VIIRS (375 m) I1 band

BASIC APPEARANCE OF STORMS

- size and shape of convective storms affected by:

  internal storm dynamics – storm updrafts (strength, duration), storm splitting (supercells)

  interaction with other storm cells – merging of anvils

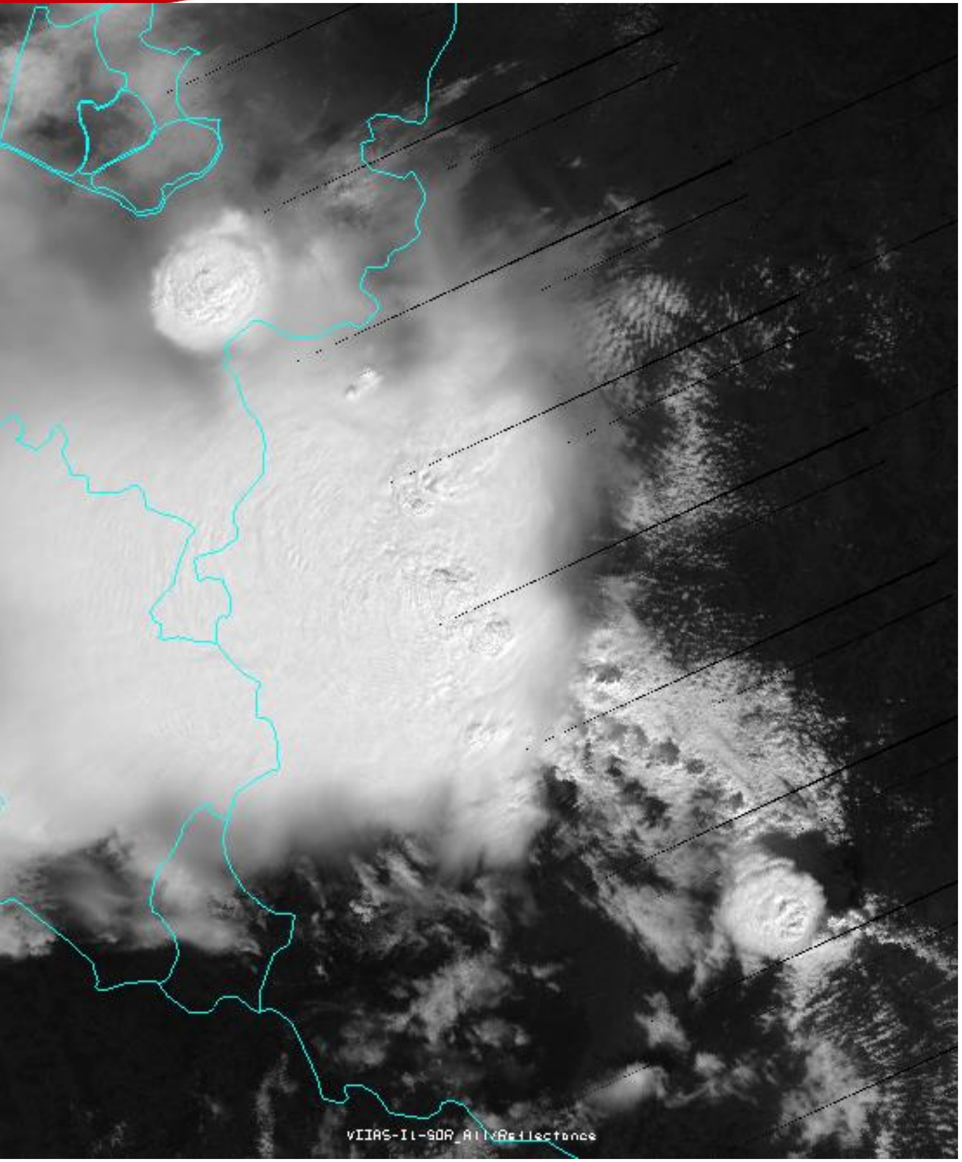
  interaction with environment – wind shear,

  storm relative winds, moisture

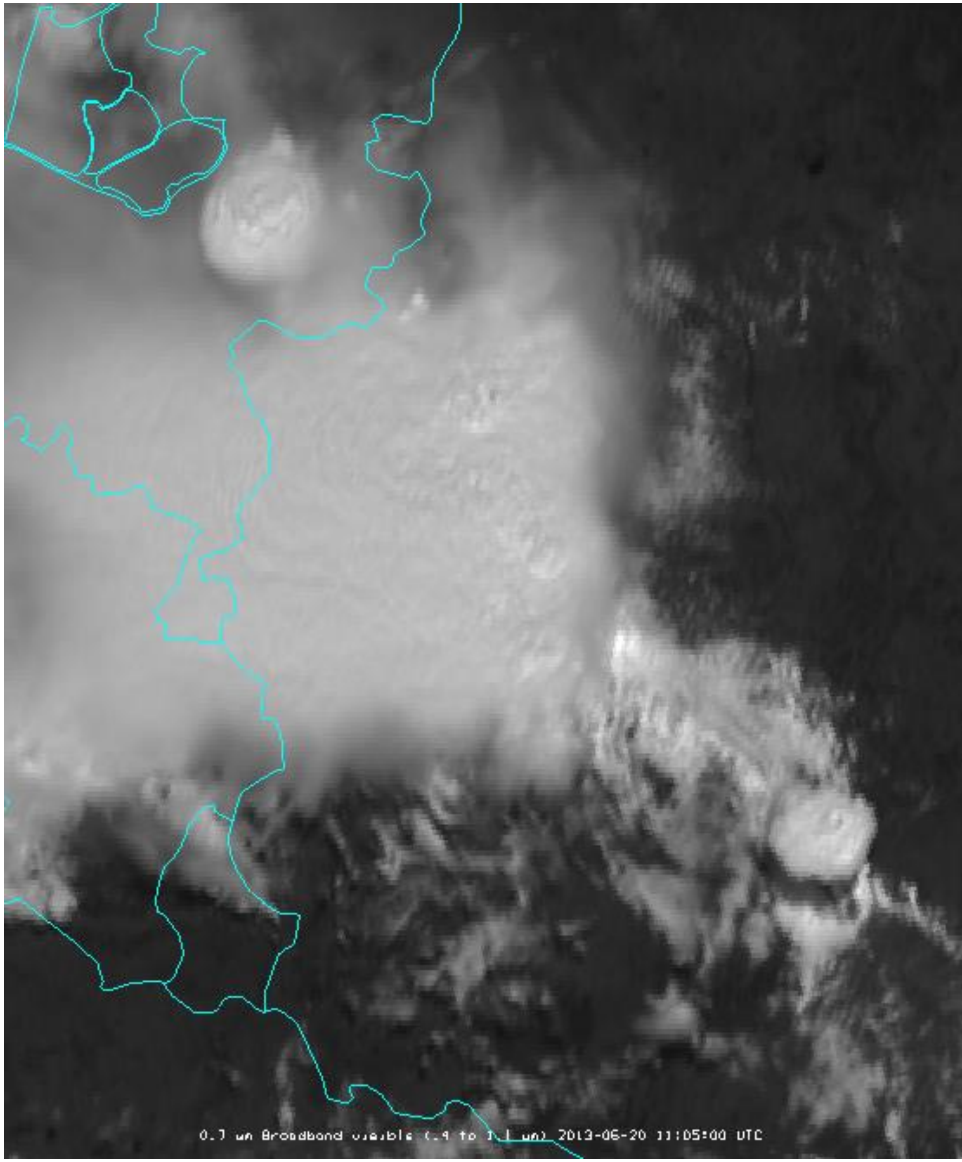
  viewing geometry – scan conditions: nadir vs low angle

  → parallax shift effect, re-mapping

  » problems with accurate geo-referencing of higher clouds and some of the derived products

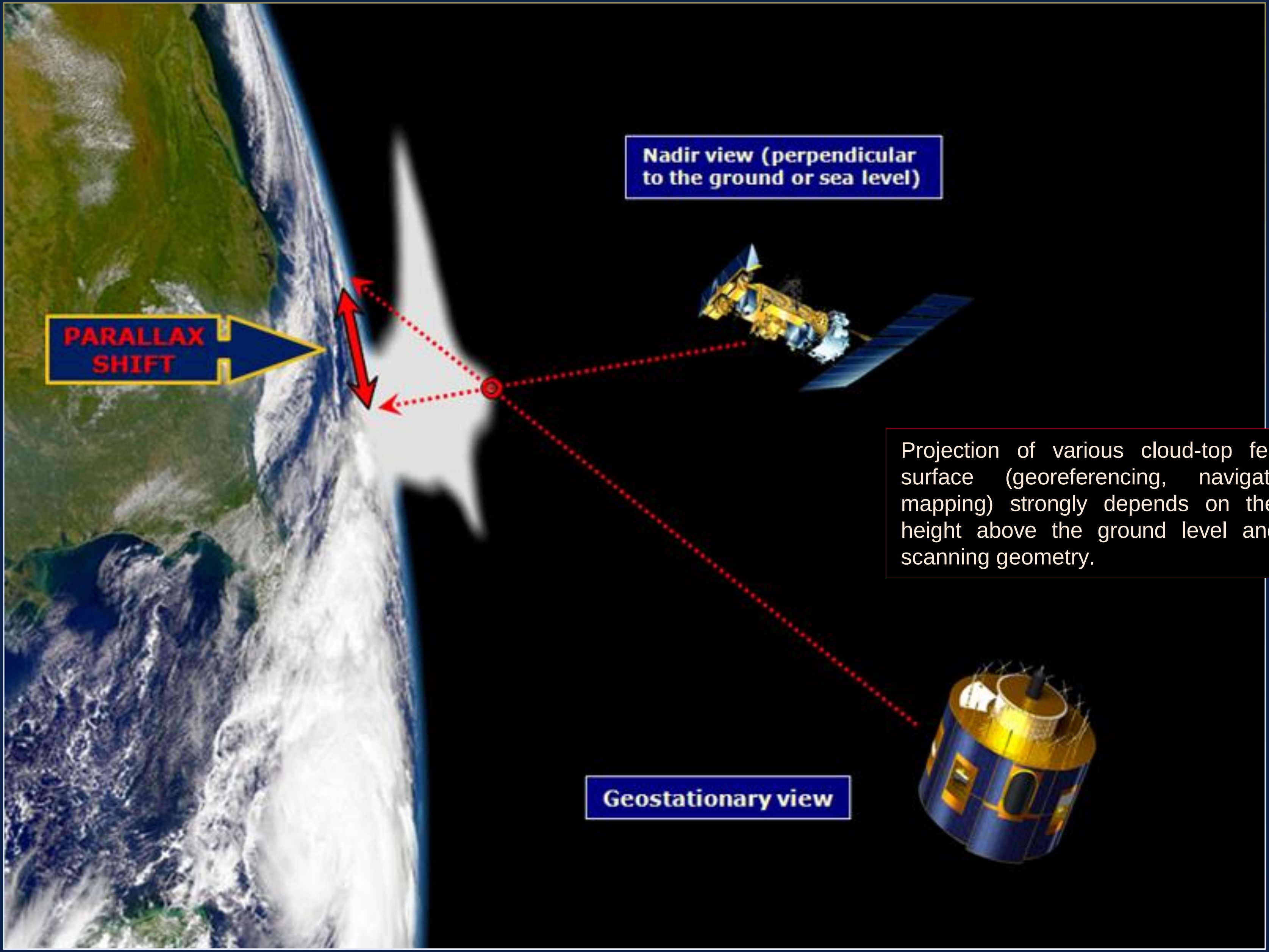


Suomi-NPP/VIIRS band 1 11:05 UTC ~ 375 m



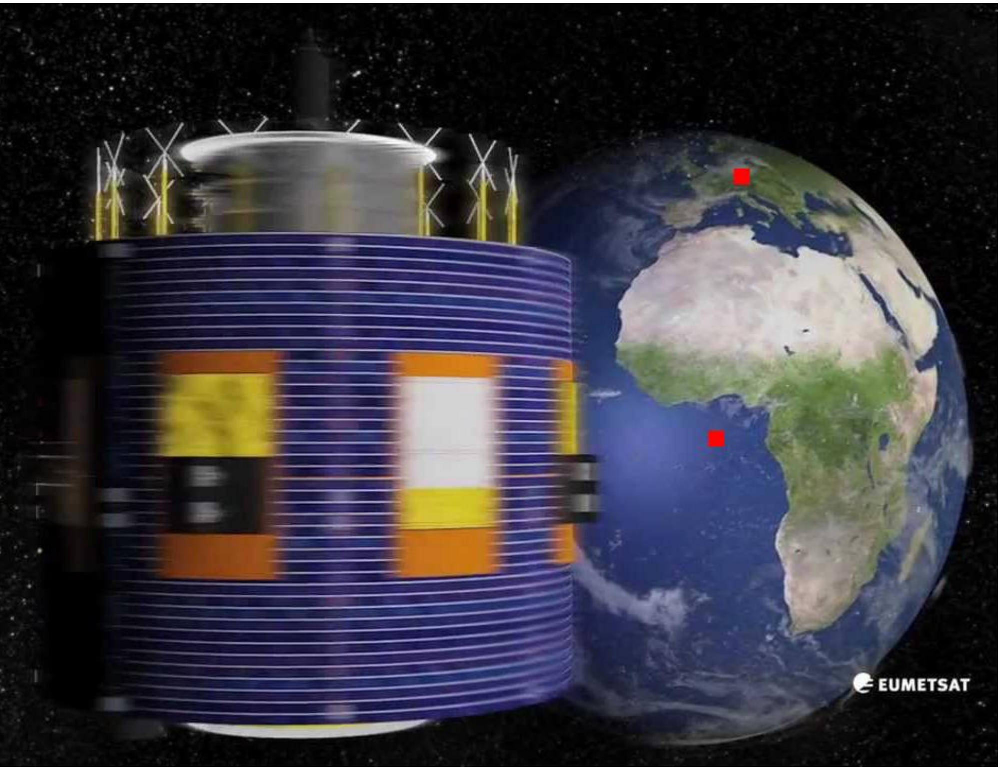
MSG/SEVIRI HRV 11:05 UTC ~ 1 km

Parallax shift in satellite imagery



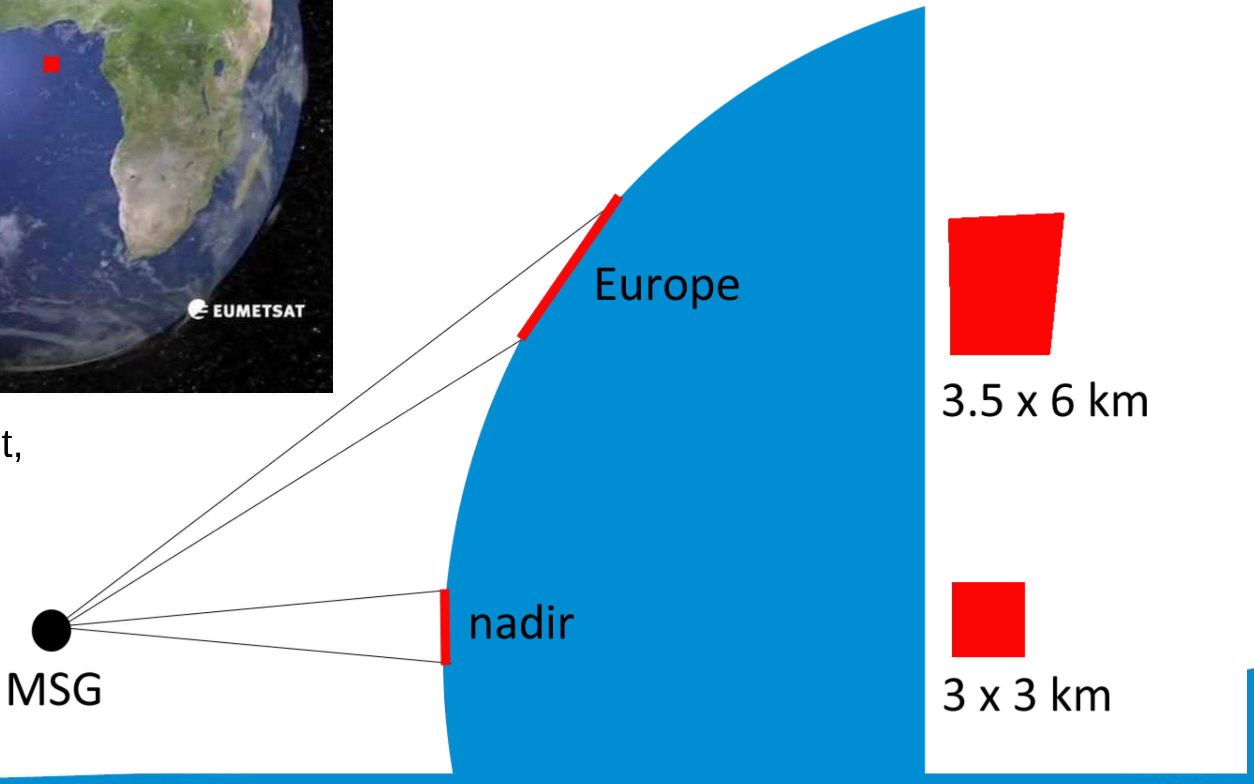
Projection of various cloud-top features to surface (georeferencing, navigation, re-mapping) strongly depends on their actual height above the ground level and on the scanning geometry.

SPATIAL RESOLUTION



- **the position of the satellite:**

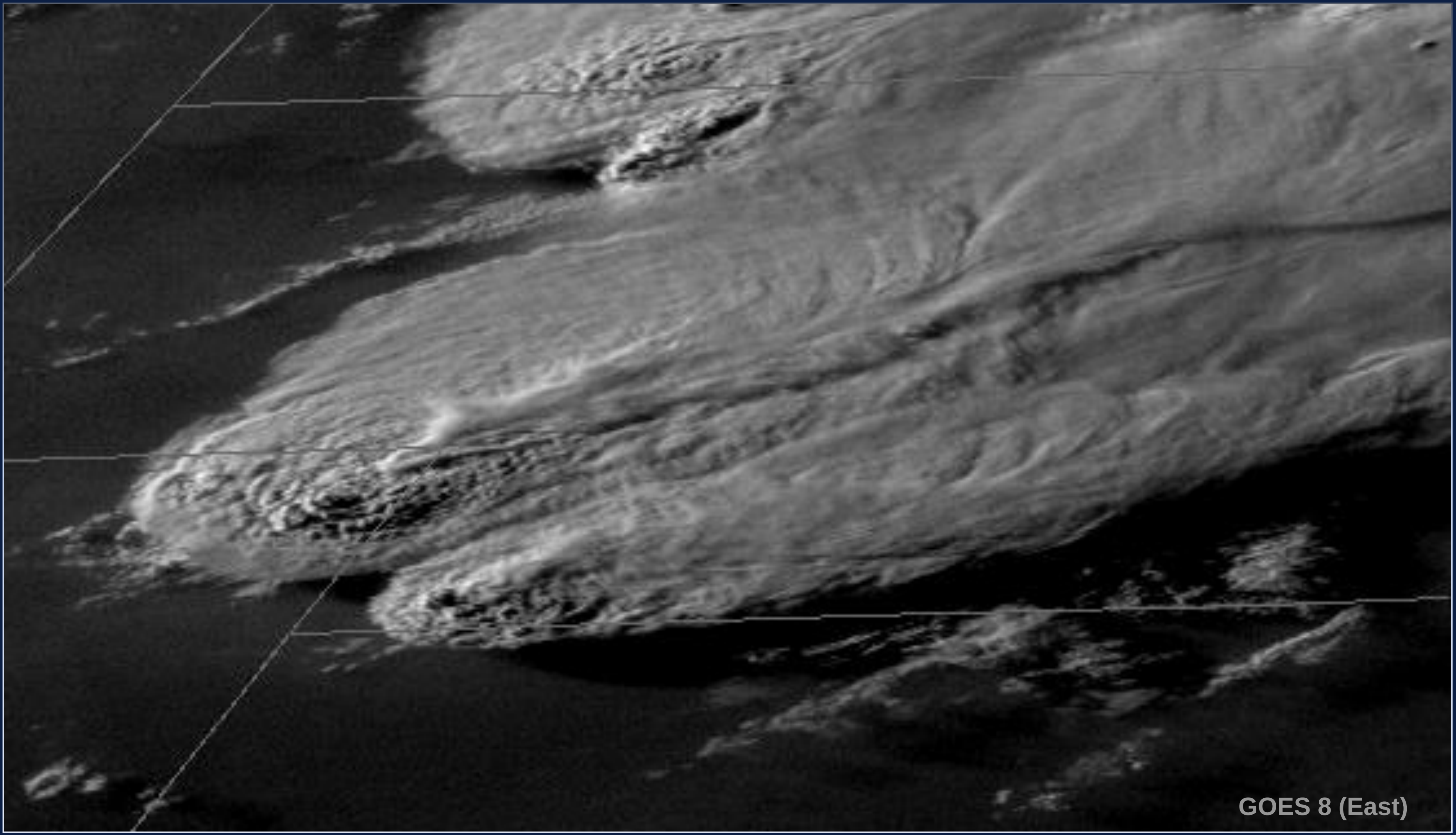
Meteosat-11	3.4° W
Meteosat-10	0°
Meteosat-9	9.5° E
Meteosat-8	41.5° E



The closer to the sub-satellite point, the better is the image quality (lesser distortion, higher image resolution, smaller parallax shift)

Above-anvil (ice) plumes

Nebraska, 22/23May 1996, 0045 UTC



Above-anvil (ice) plumes

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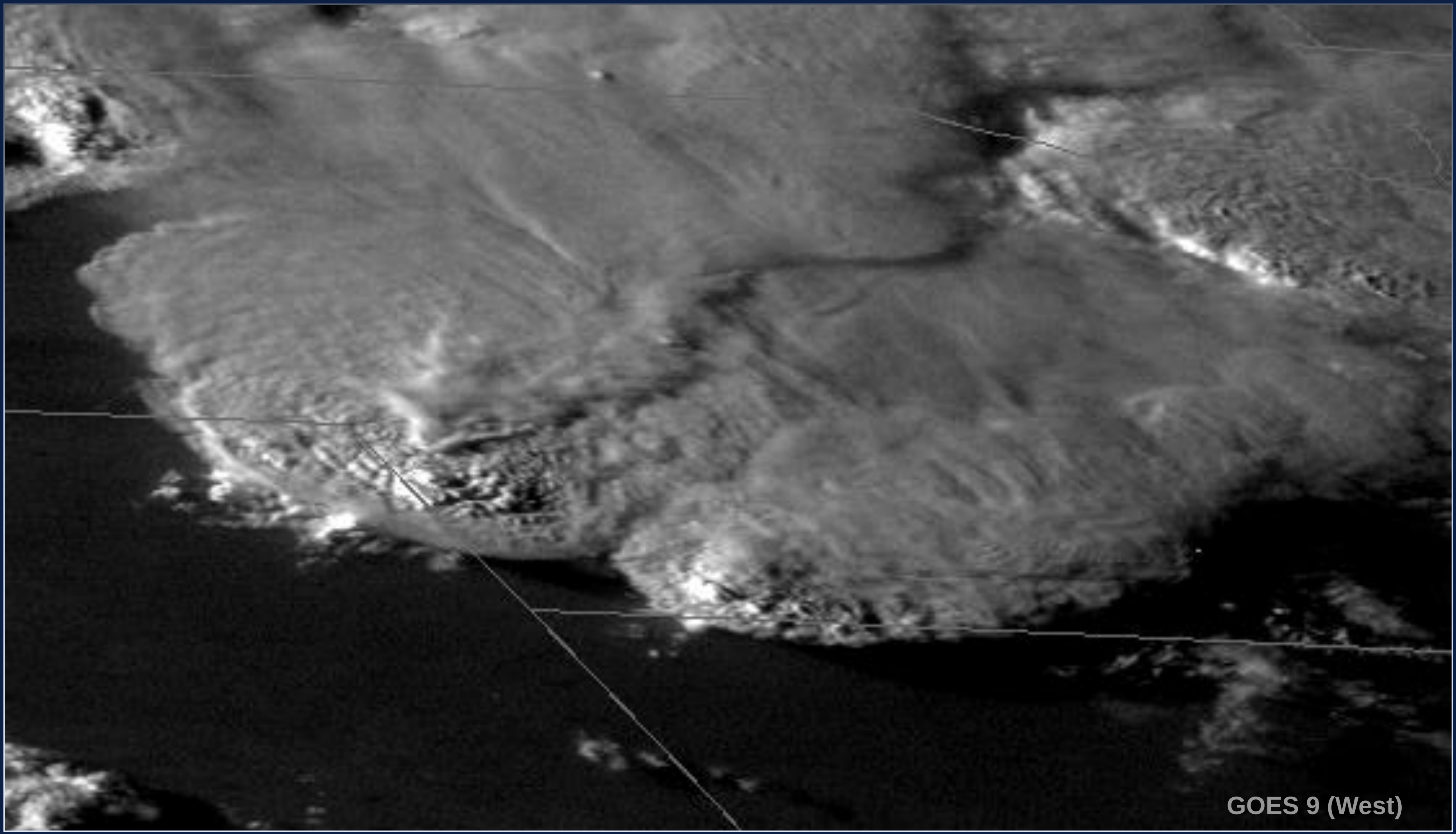
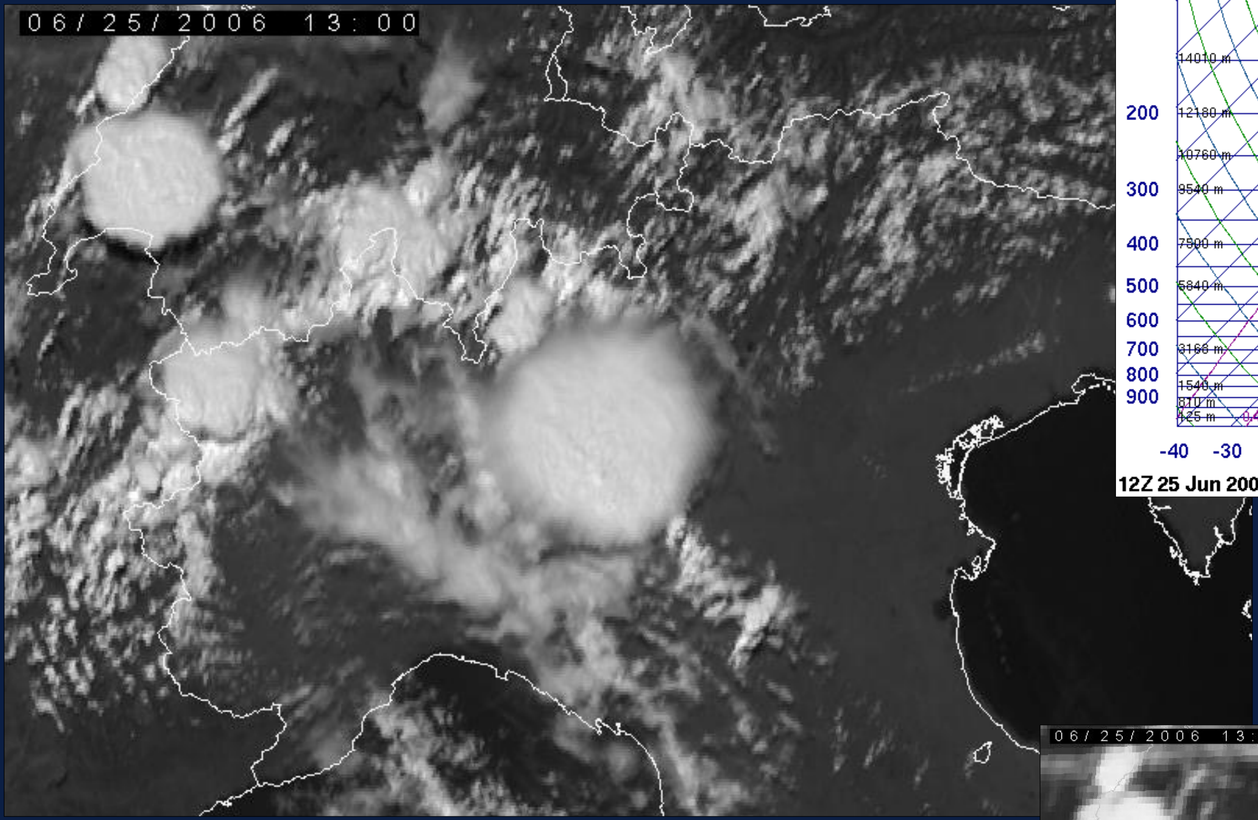
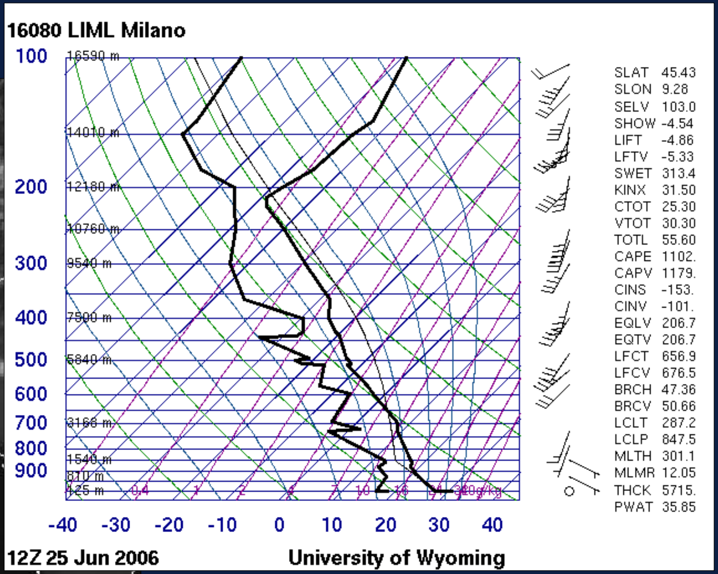
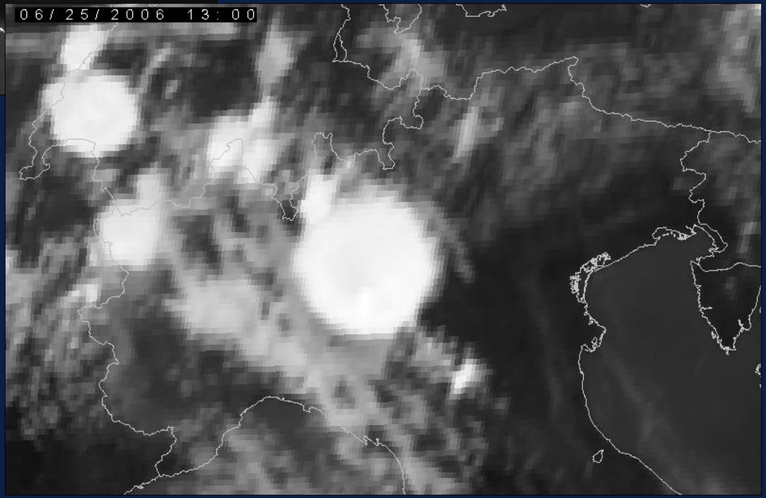


Impact of the wind shear – weak shear

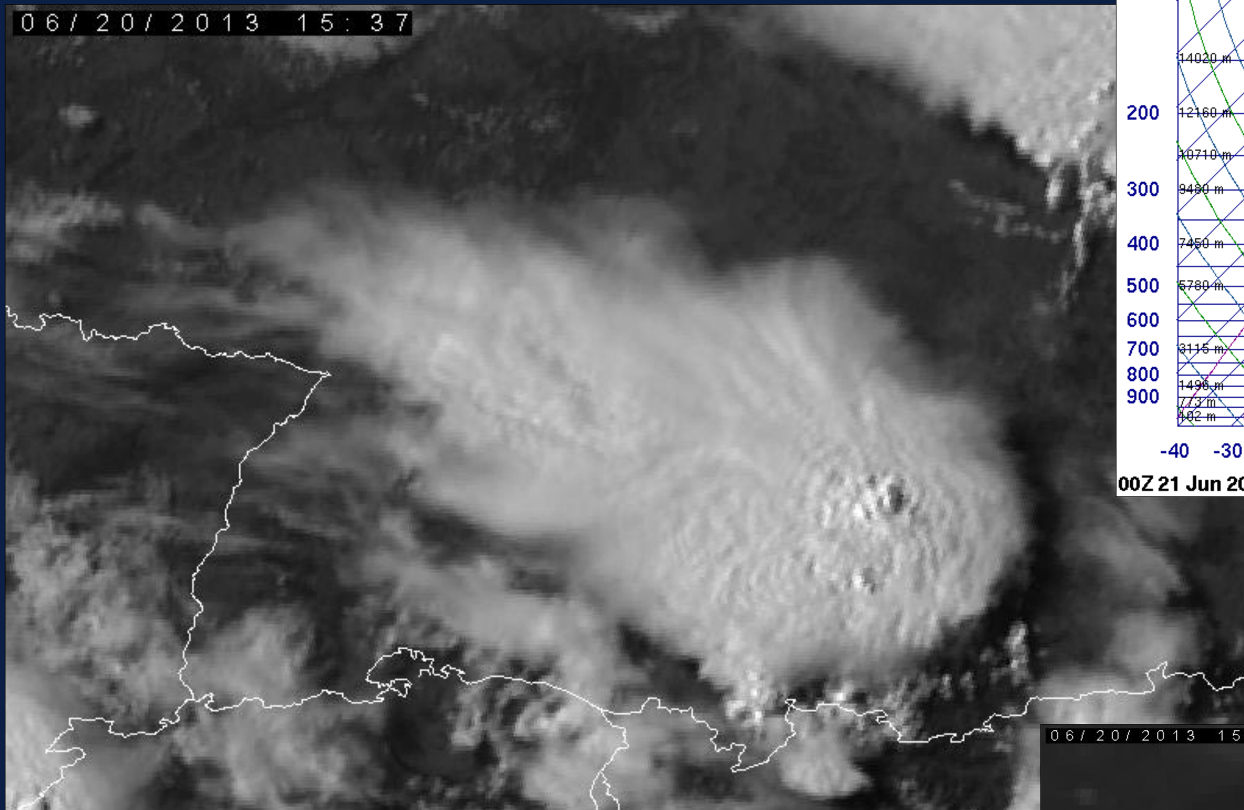


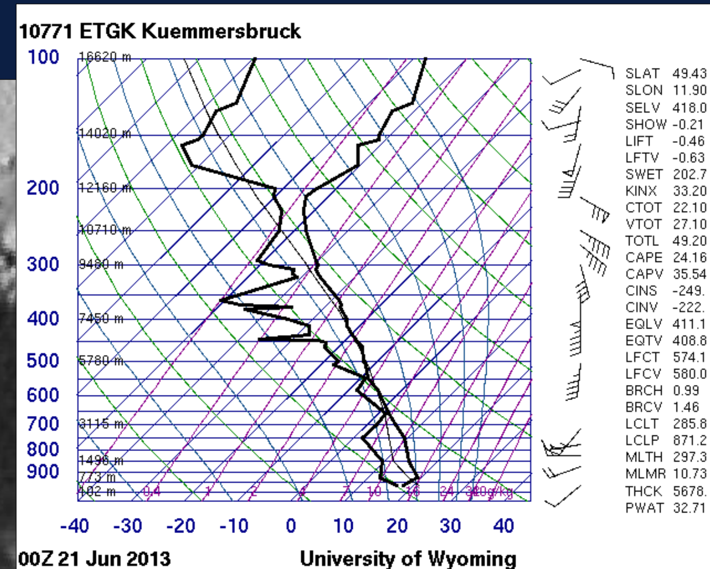


2006-06-25 13:00, Meteosat-8, north Italy

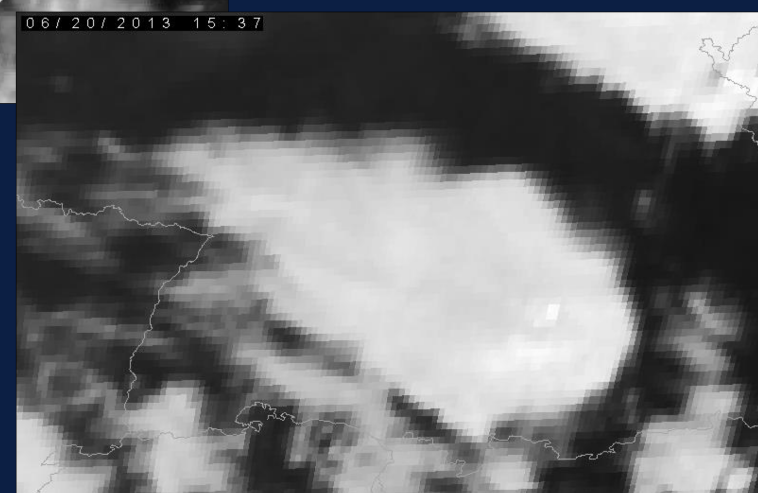


Impact of the wind shear – strong shear





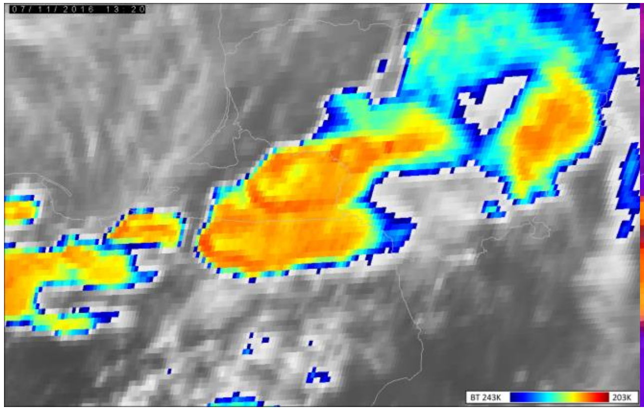
2013-06-20 15:37, Meteosat-8, south Germany



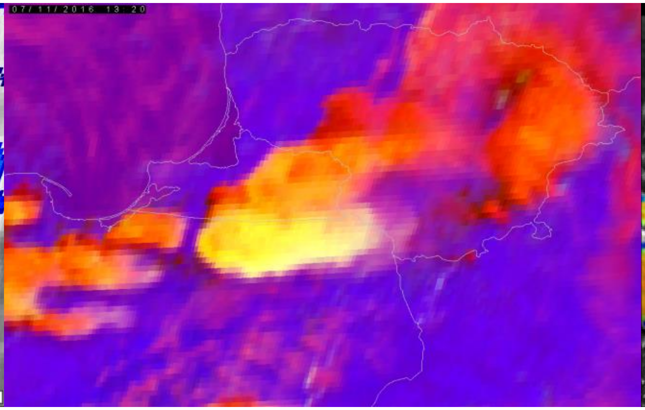
VISUALIZATION TECHNIQUES

- detection of various cloud-top features:
  - overshooting tops, plumes, gravity waves
  - cold-U or cold-ring shapes, small ice particles

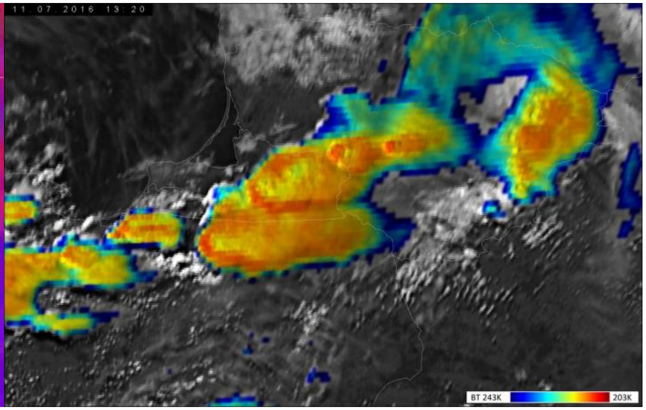
IR 10.8 BT color-enhancement



Storm RGB product

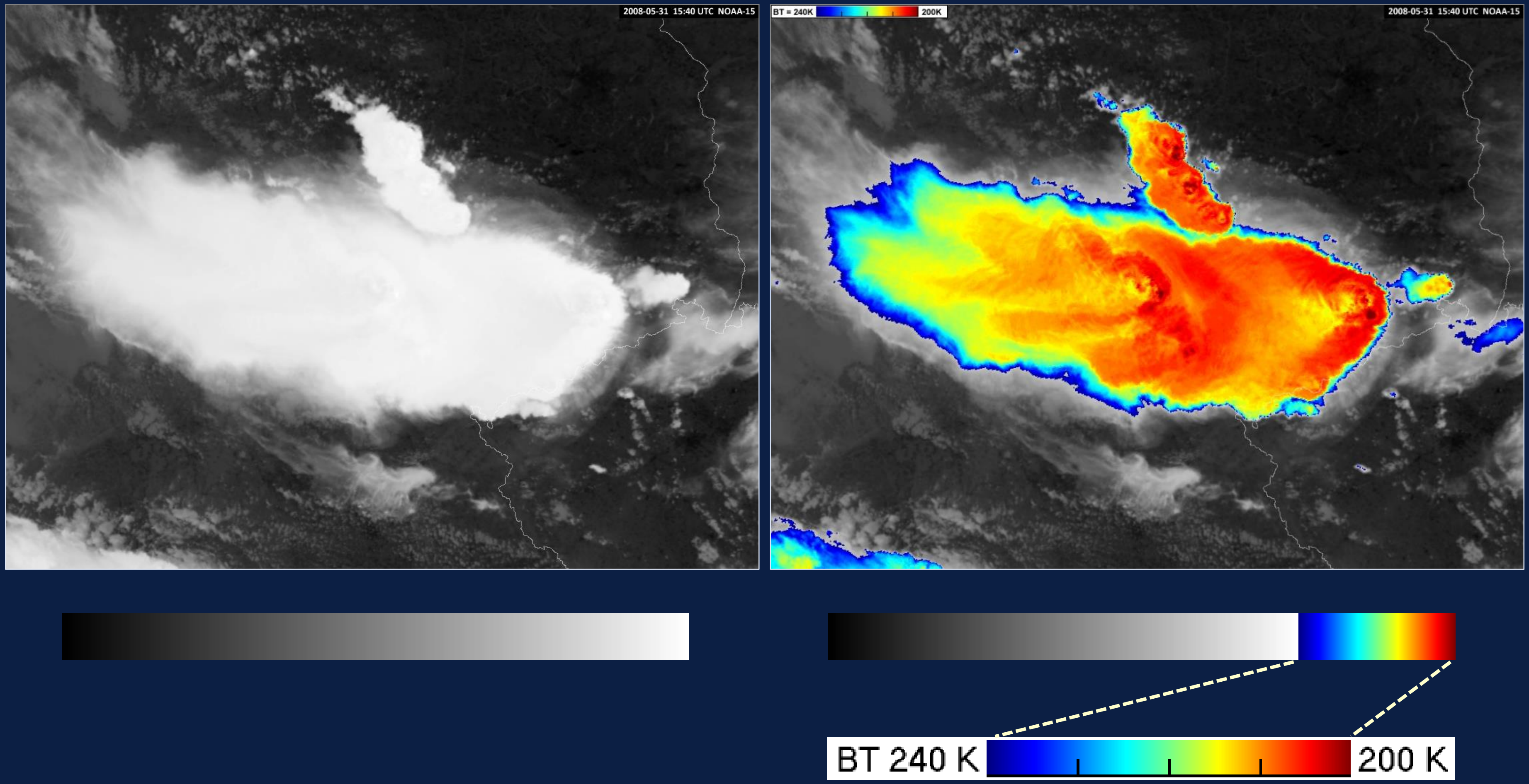


Sandwich product



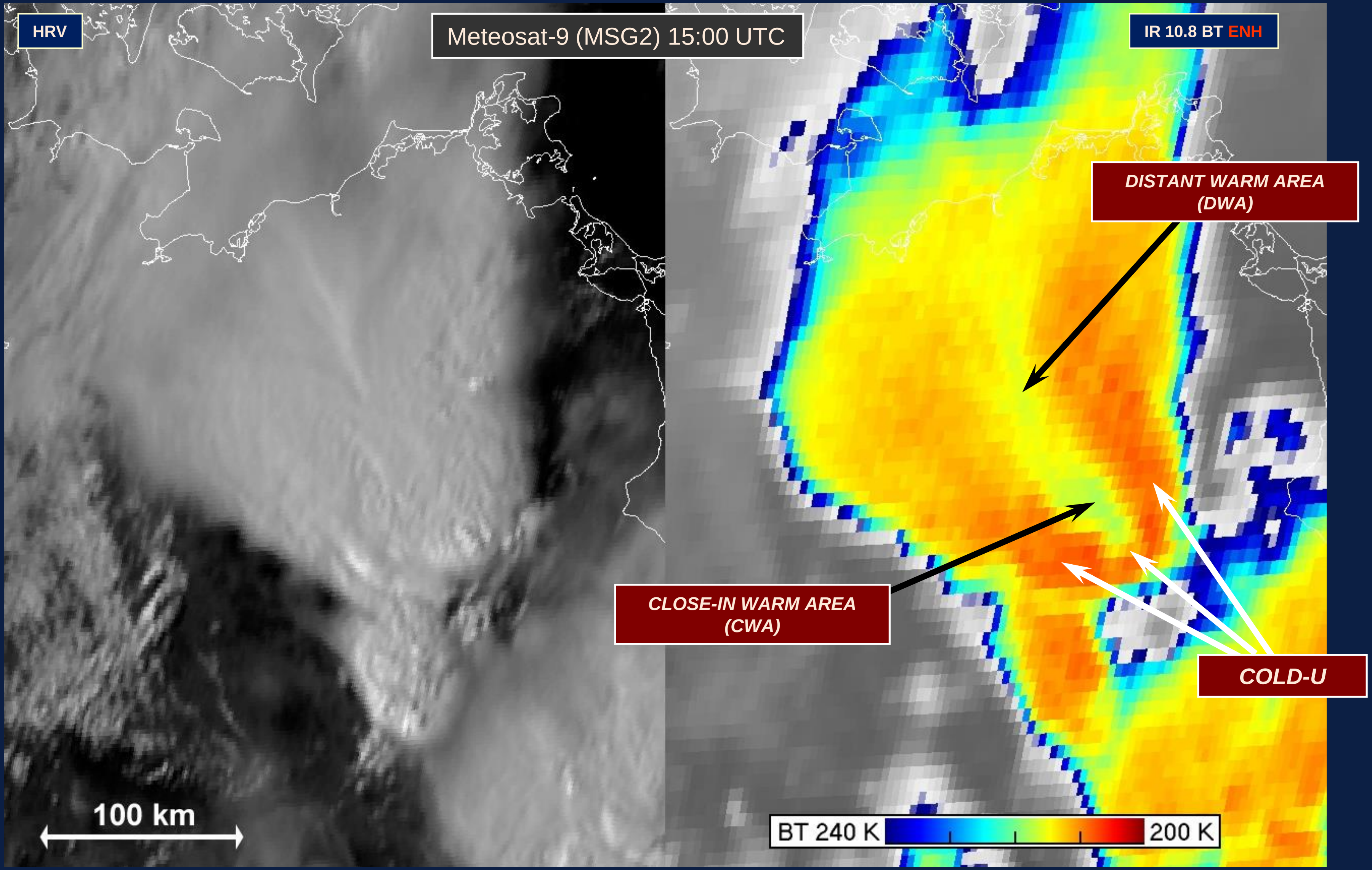
11 June 2016 13:20 UTC, The Baltics, Meteosat-9 (RSS data)

Color enhancement of the IR brightness temperature imagery



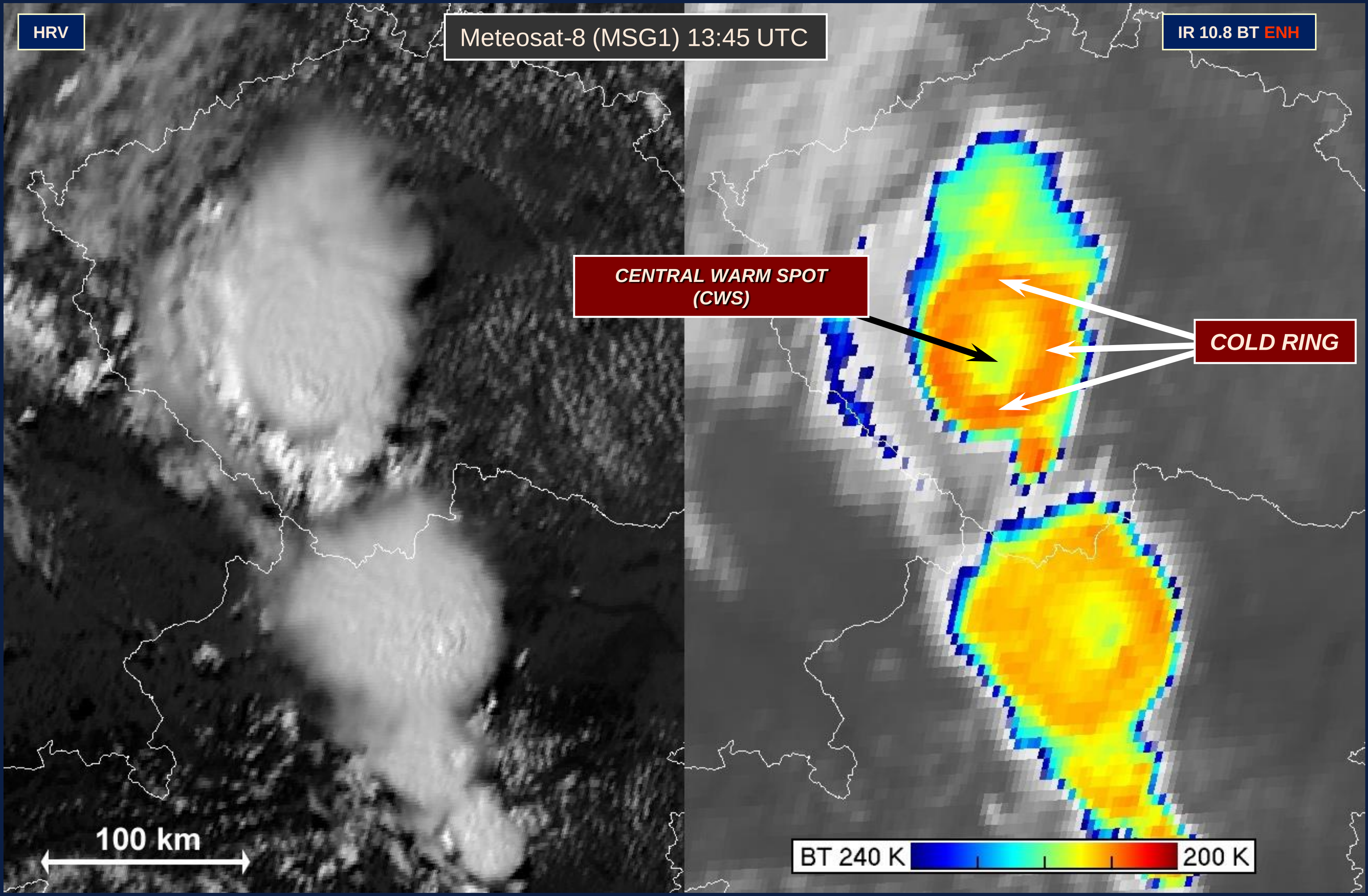
Color enhancement of the IR Brightness Temperature (BT) imagery – replacement of a part of the grey scale, representing a certain temperature range, by dedicated colors. The color scale can either be continuous - using a maximum of available colors, or a step-scale, using only a limited number of colors (each color representing a smaller BT interval).

Cold-U/V (enhanced-V) shaped storms … example and terminology:



26 May 2007, Germany

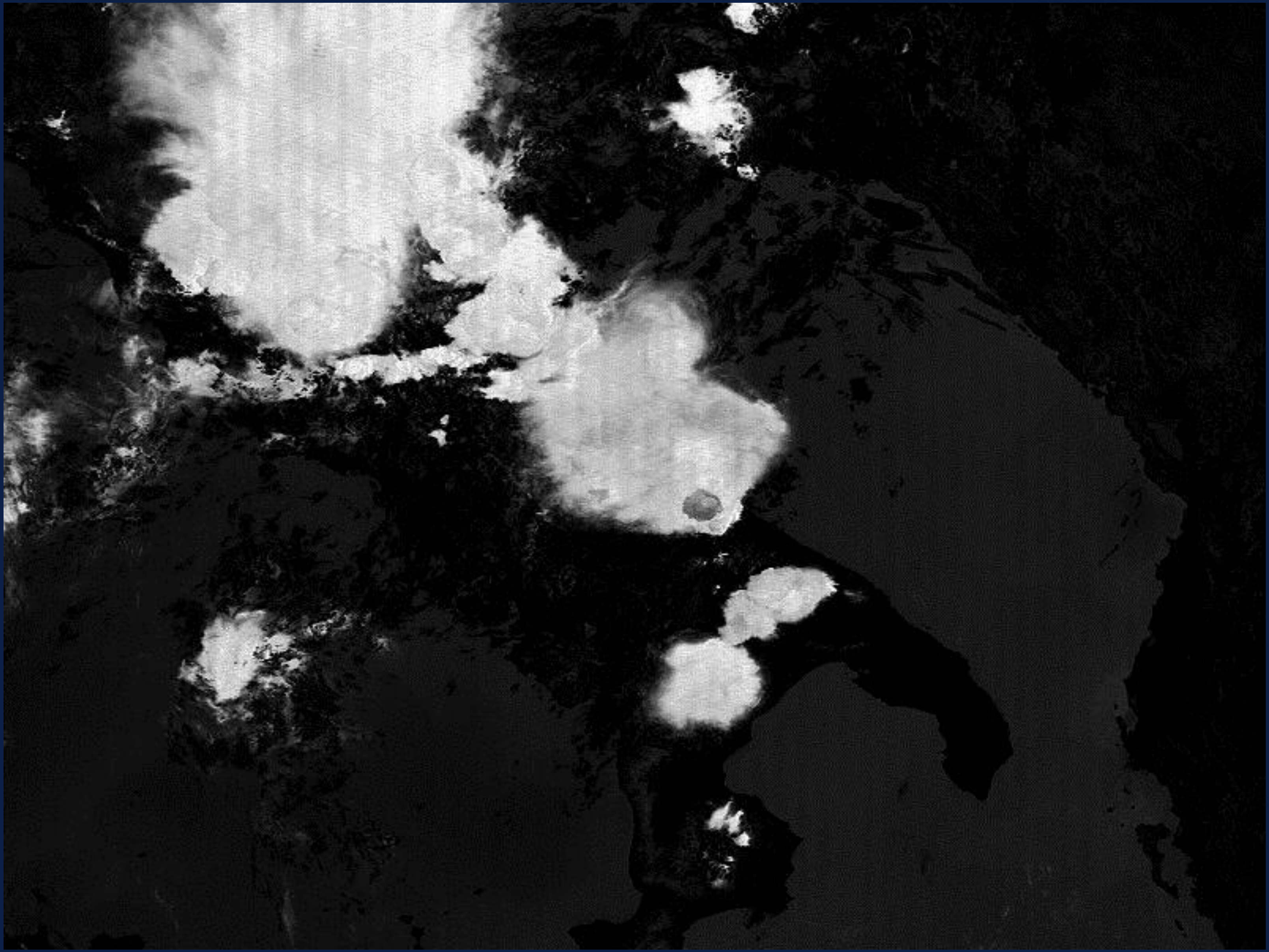
Cold-ring-shaped storms … example and terminology:



25 June 2006, Czech Republic and Austria

The 3.7 (3.9) µm cloud-top reflectivity of convective storms

09 July 1987, 1354 UTC, NOAA 9

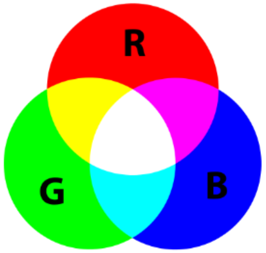


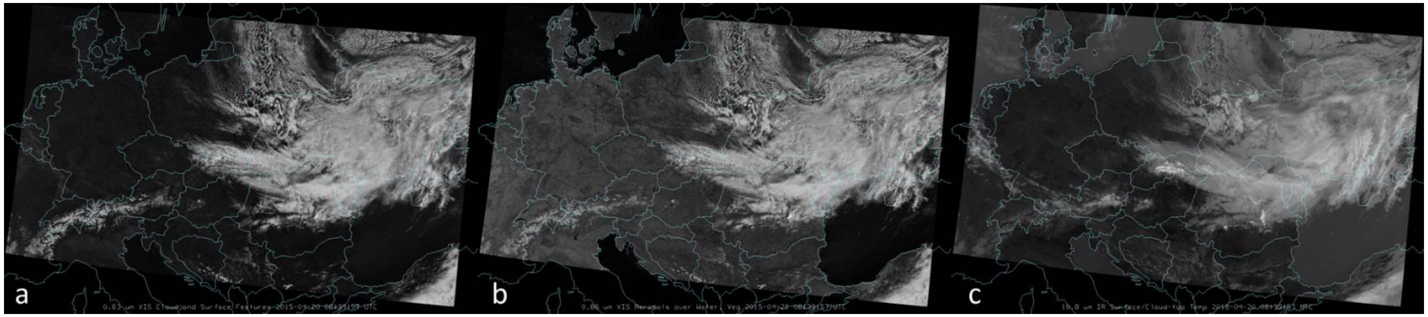
AVHRR
CH 1+2+4

AVHRR
CH 4 ENH

AVHRR
CH 3 ENH

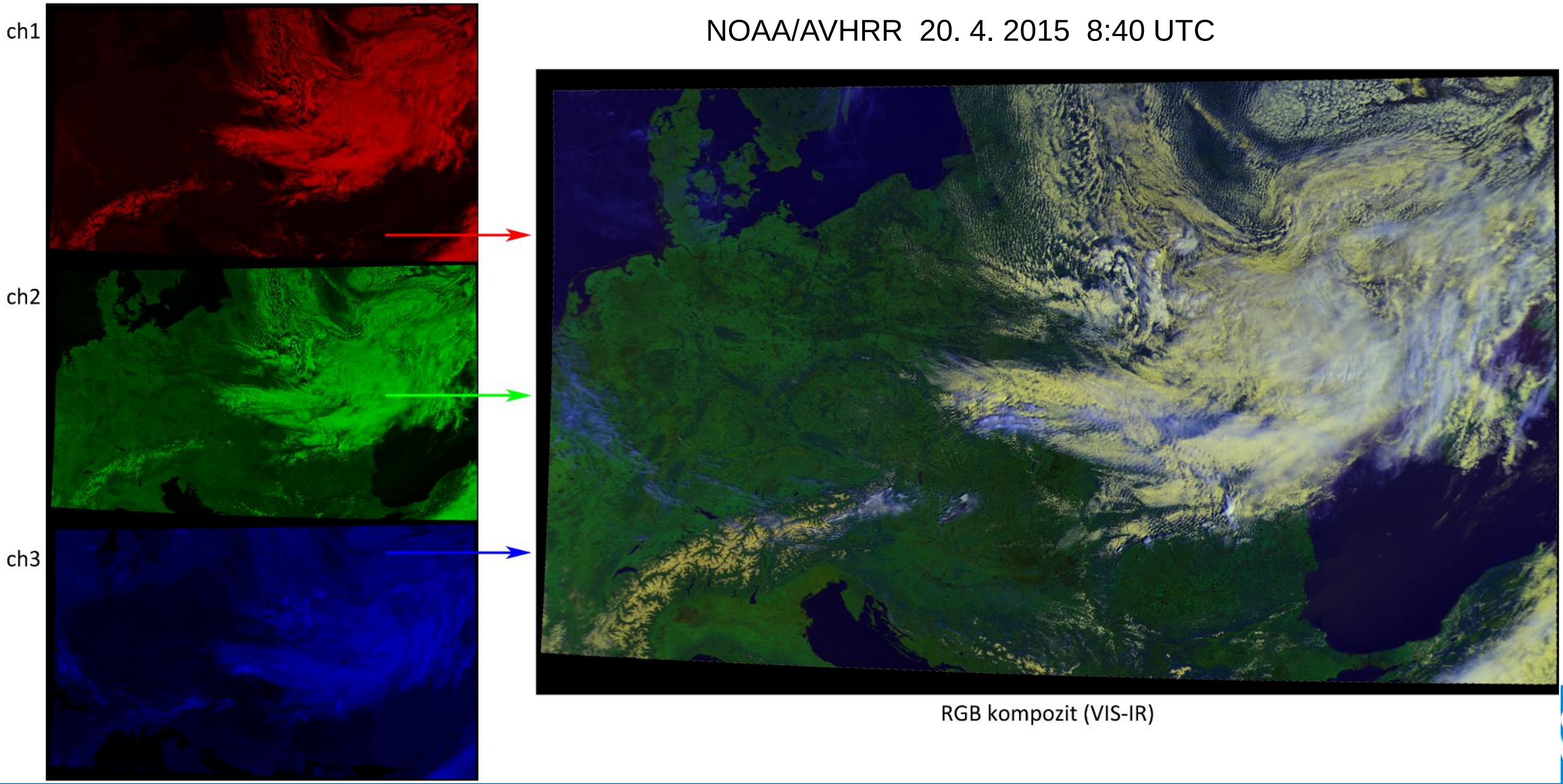
RGB PRODUCTS





a channel 1
(0,58-0,68 µm)
b channel 2
(0,73-1,00 µm)
c channel 4
(10,3-11,3 µm)

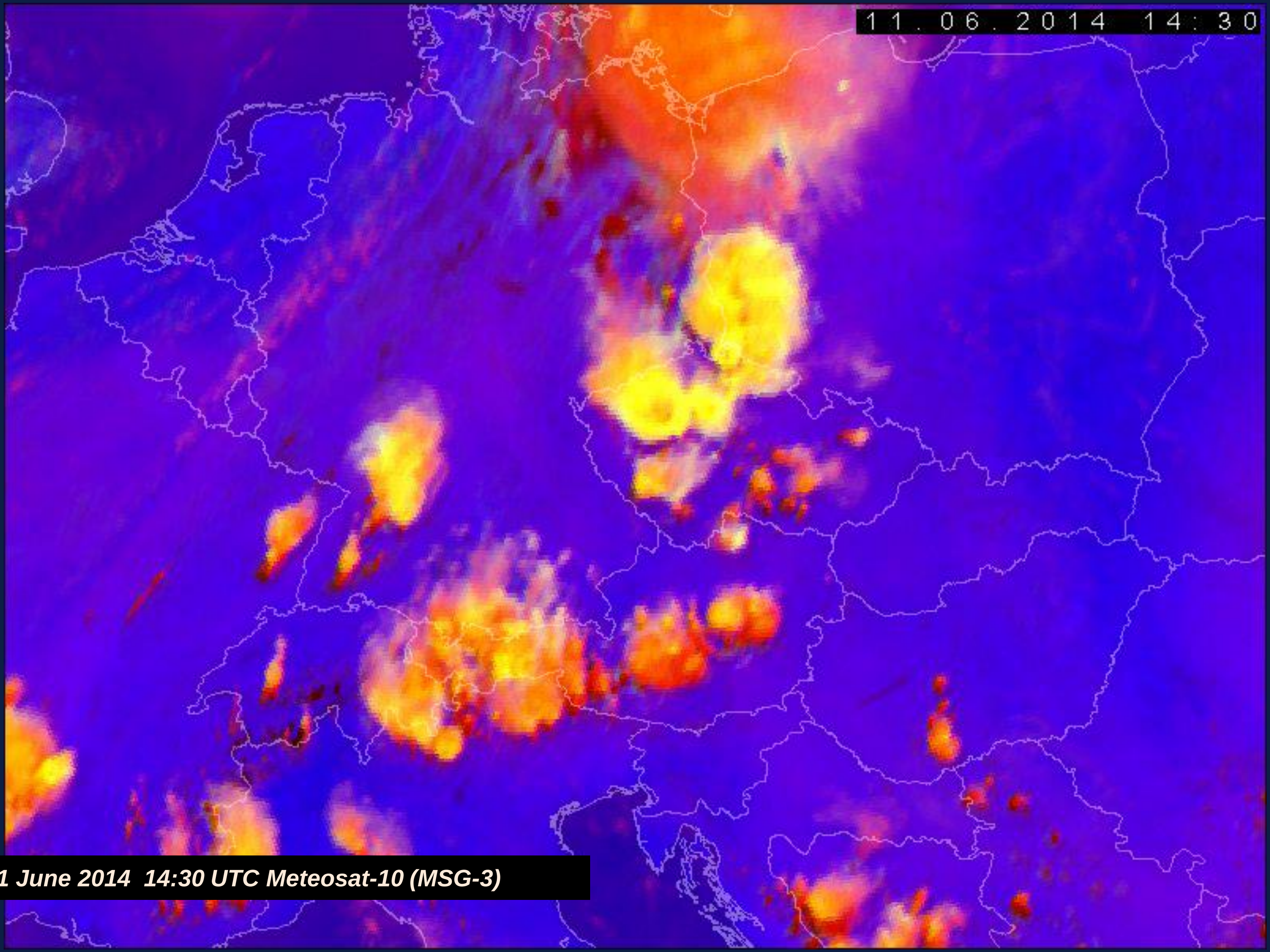
NOAA/AVHRR 20. 4. 2015 8:40 UTC



RGB kompozit (VIS-IR)

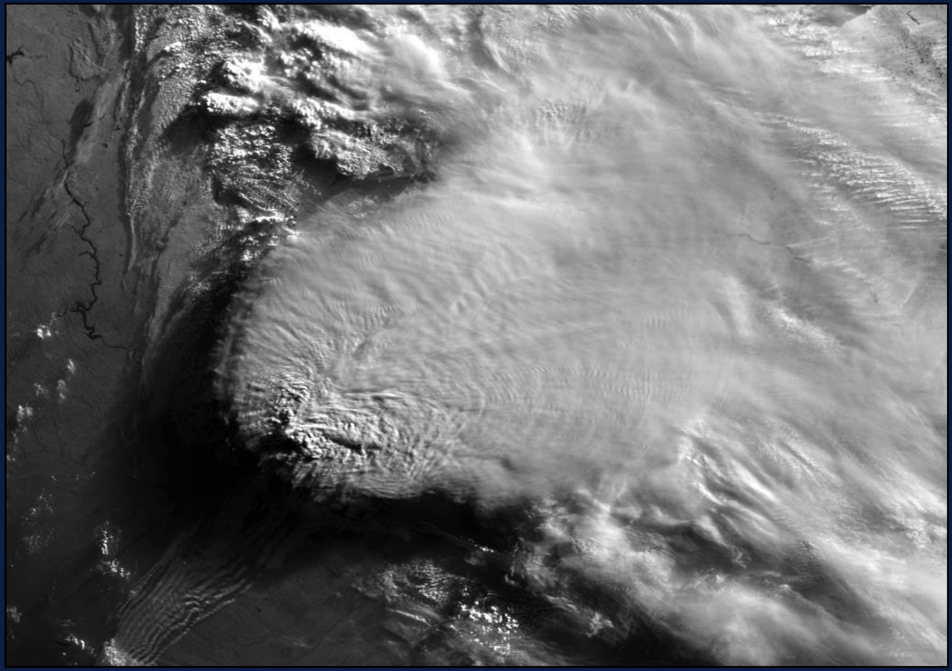
The 3.7 (3.9) µm cloud-top reflectivity of convective storms

Example of the "storm RGB" (or "convection RGB") product:

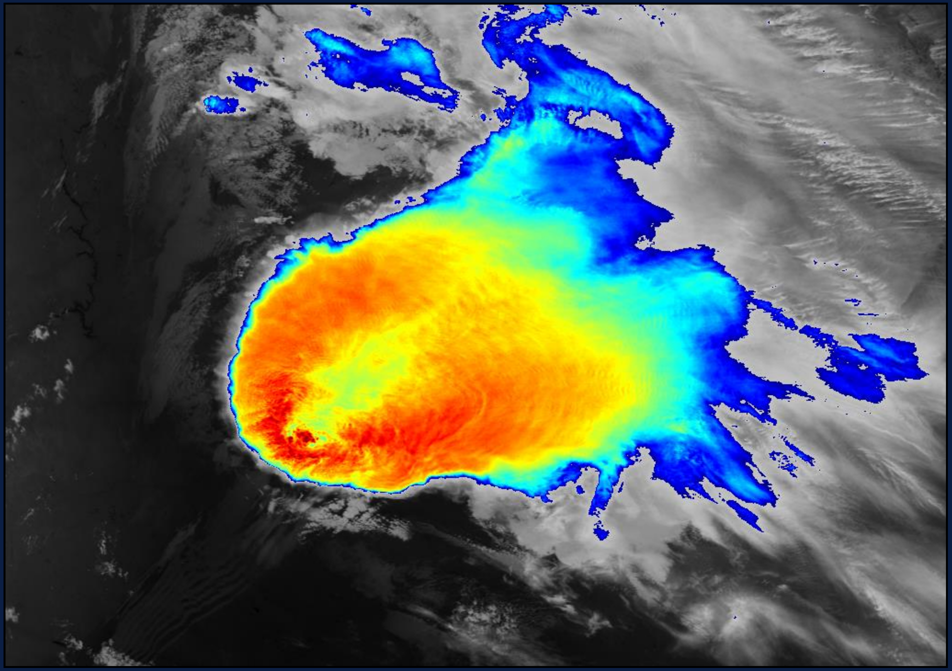


11 June 2014 14:30 UTC Meteosat-10 (MSG-3)

The “sandwich” product of IR-window and visible bands



AVHRR band 2



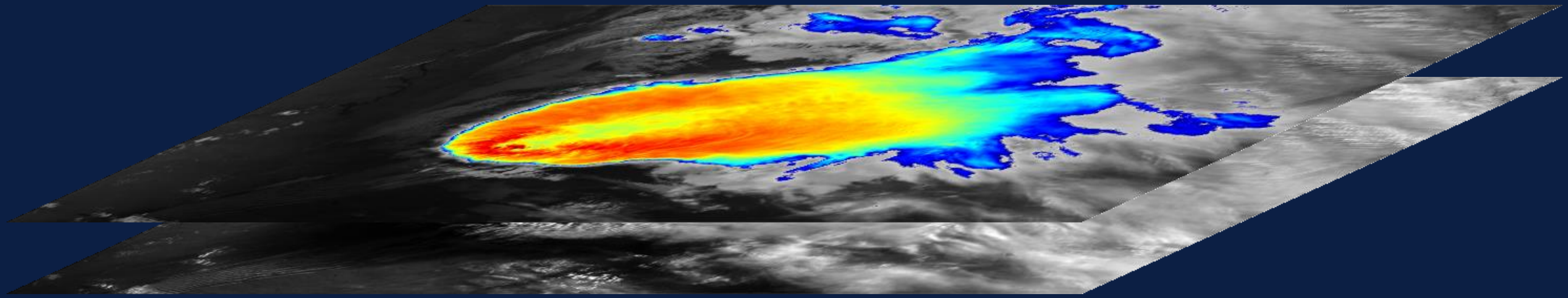
AVHRR band 4 BT (198 – 233 K)

2009-07-09 11:35 UTC NOAA 15 (South Dakota, Minnesota, Nebraska, Iowa, U.S.A.)

Visible – color enh. IR-BT sandwich product – principle of the method

Upper layer: IR-window BT image

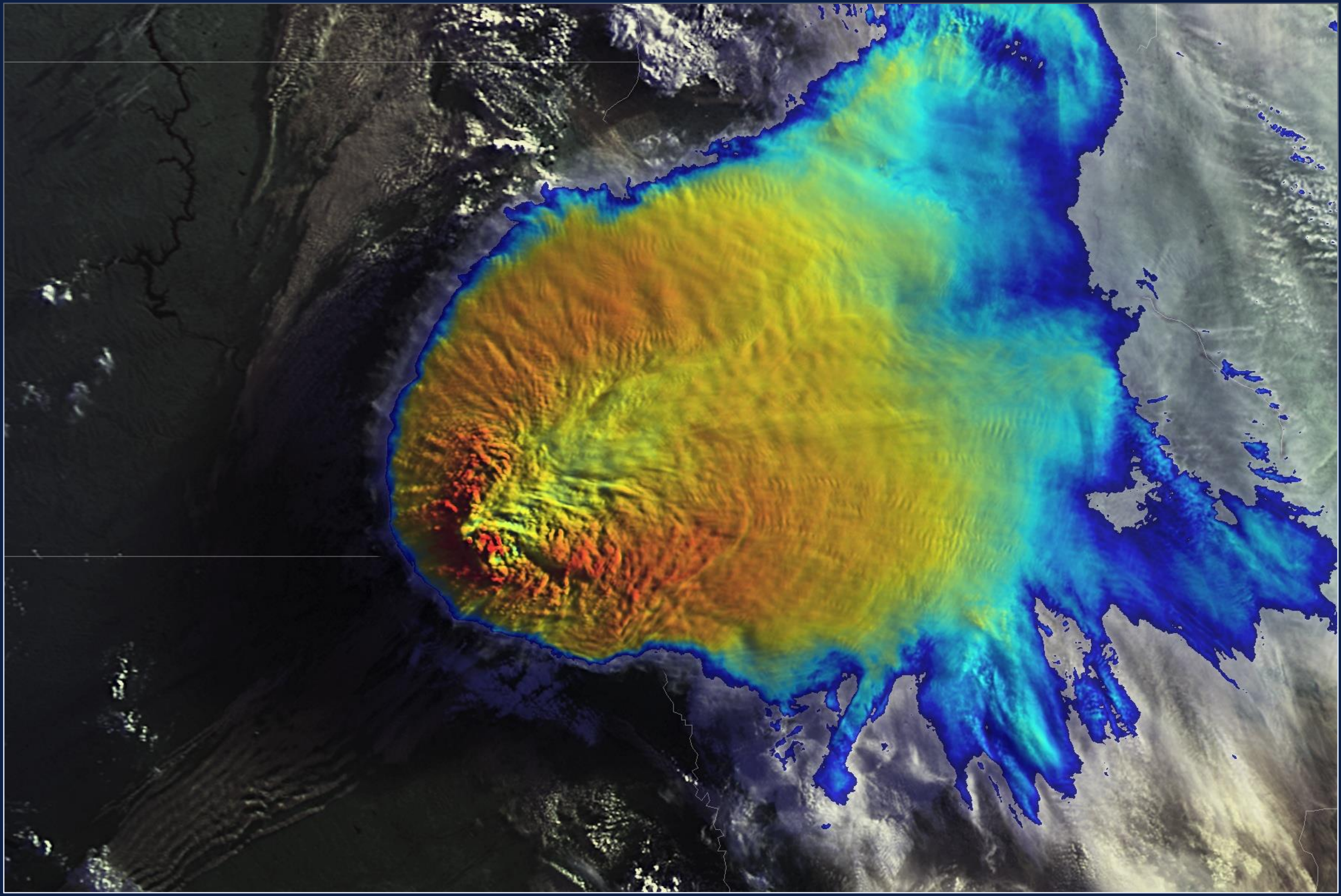
Bottom layer (“background”): VIS image



Multi-layer image (in this case 2 layers) … e.g. PSD format (Photoshop)

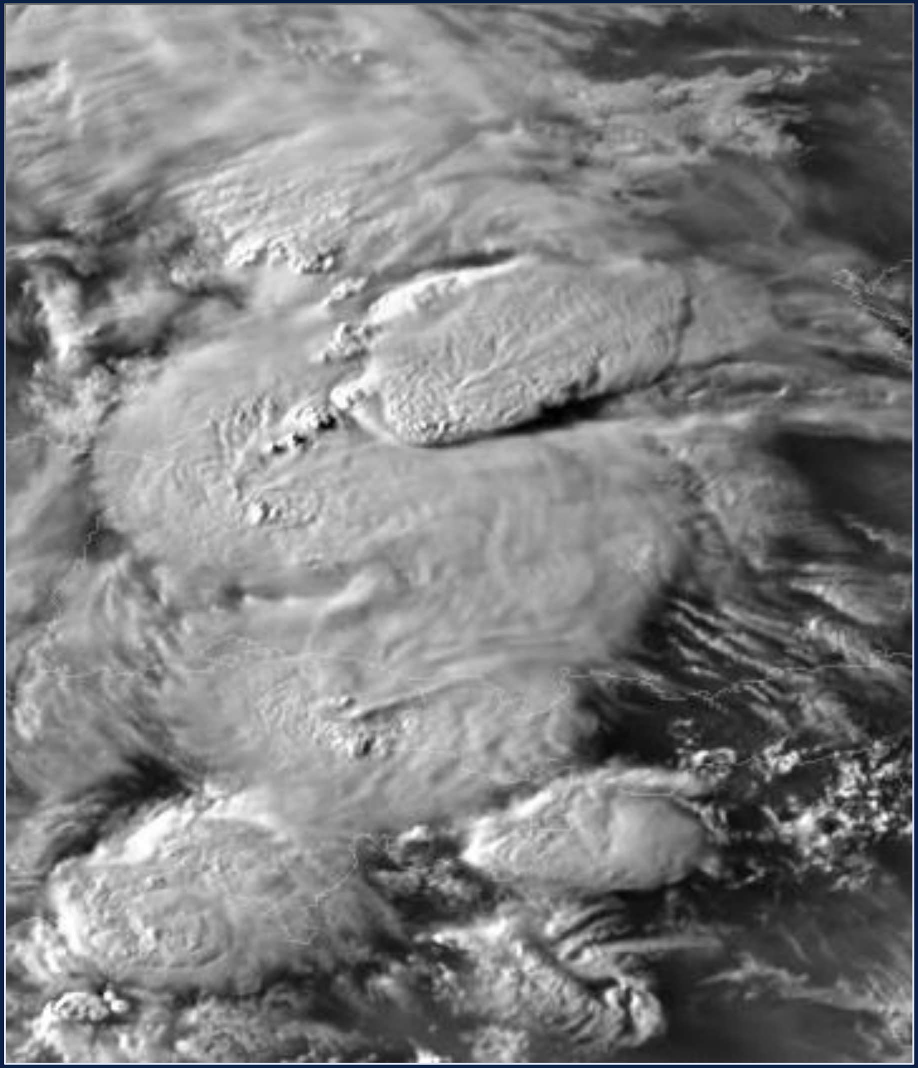
Blending options – applied to the upper layer !!!

The “sandwich” product of IR-window and visible bands

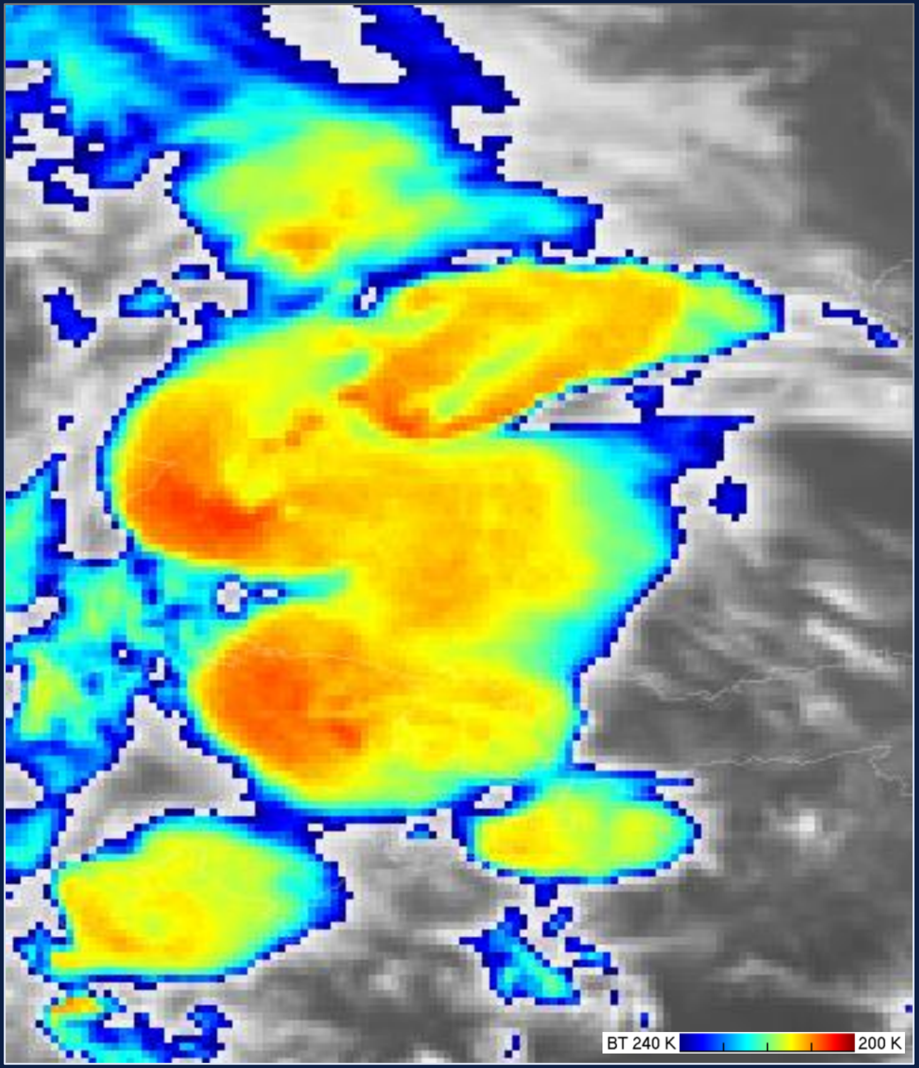


2009-07-09 11:35 UTC NOAA 15 (South Dakota, Minnesota, Nebraska, Iowa, U.S.A.)

Visible – color enhanced IR-BT sandwich product



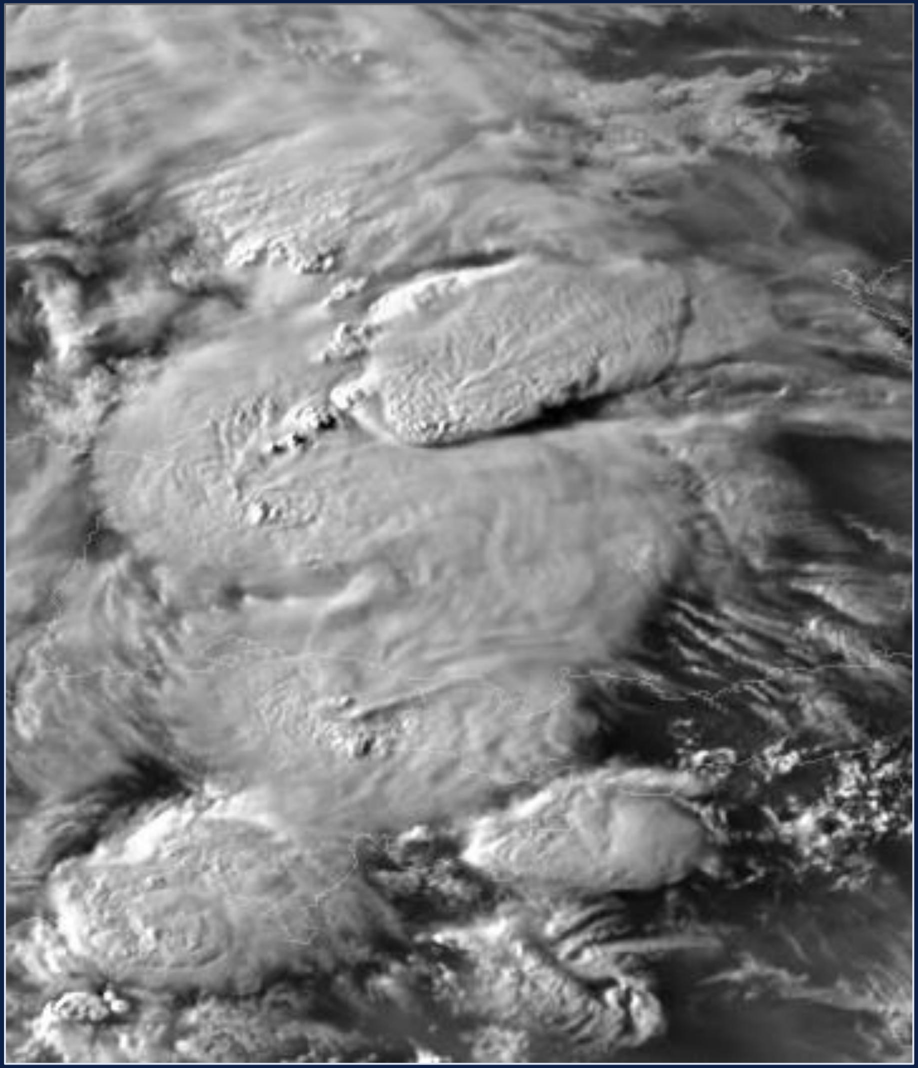
HRV



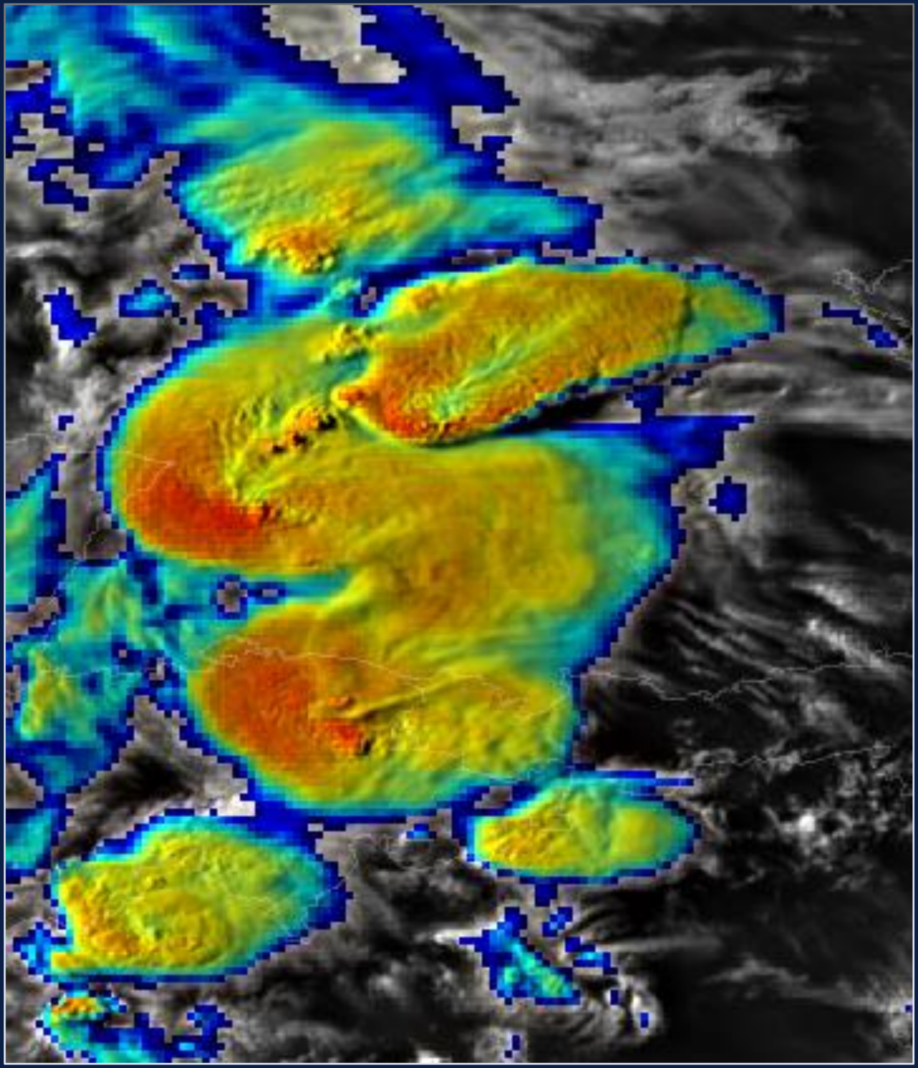
IR10.8-BT

12 July 2011 17:40 UTC MSG-1, Germany

Visible – color enhanced IR-BT sandwich product



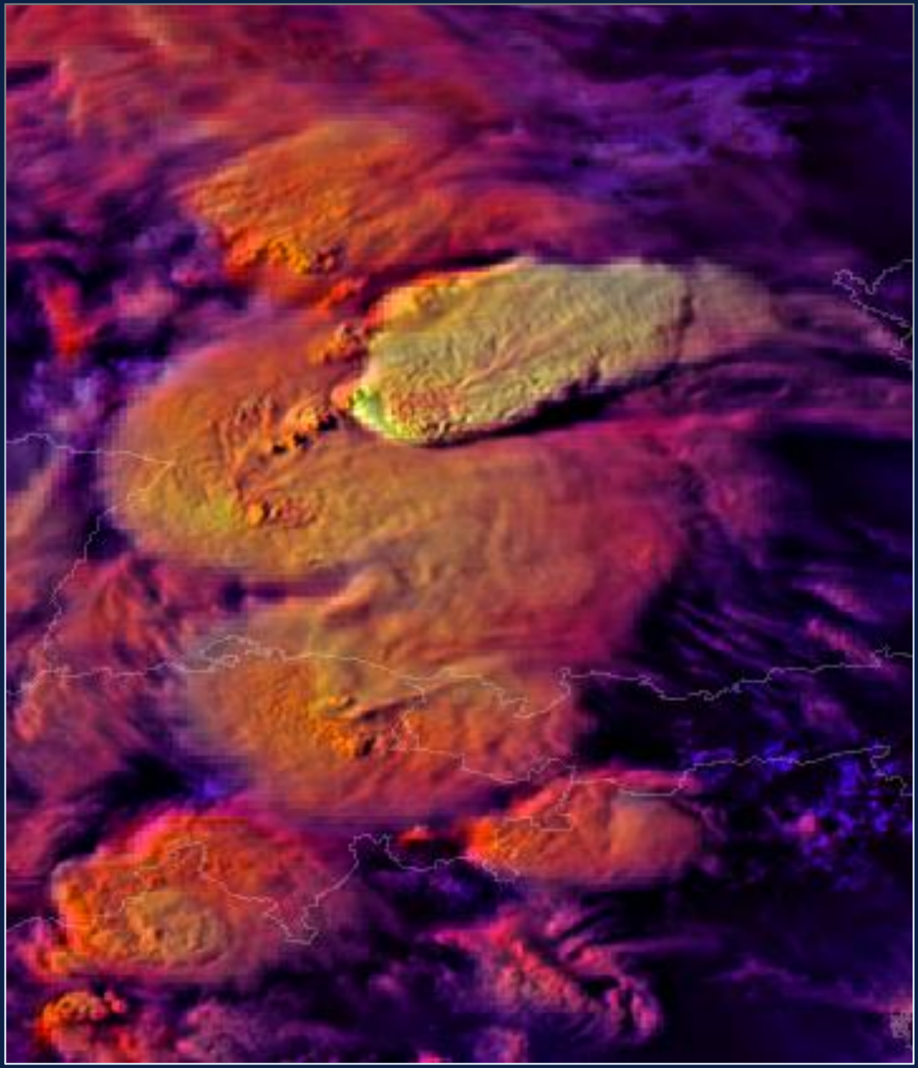
HRV



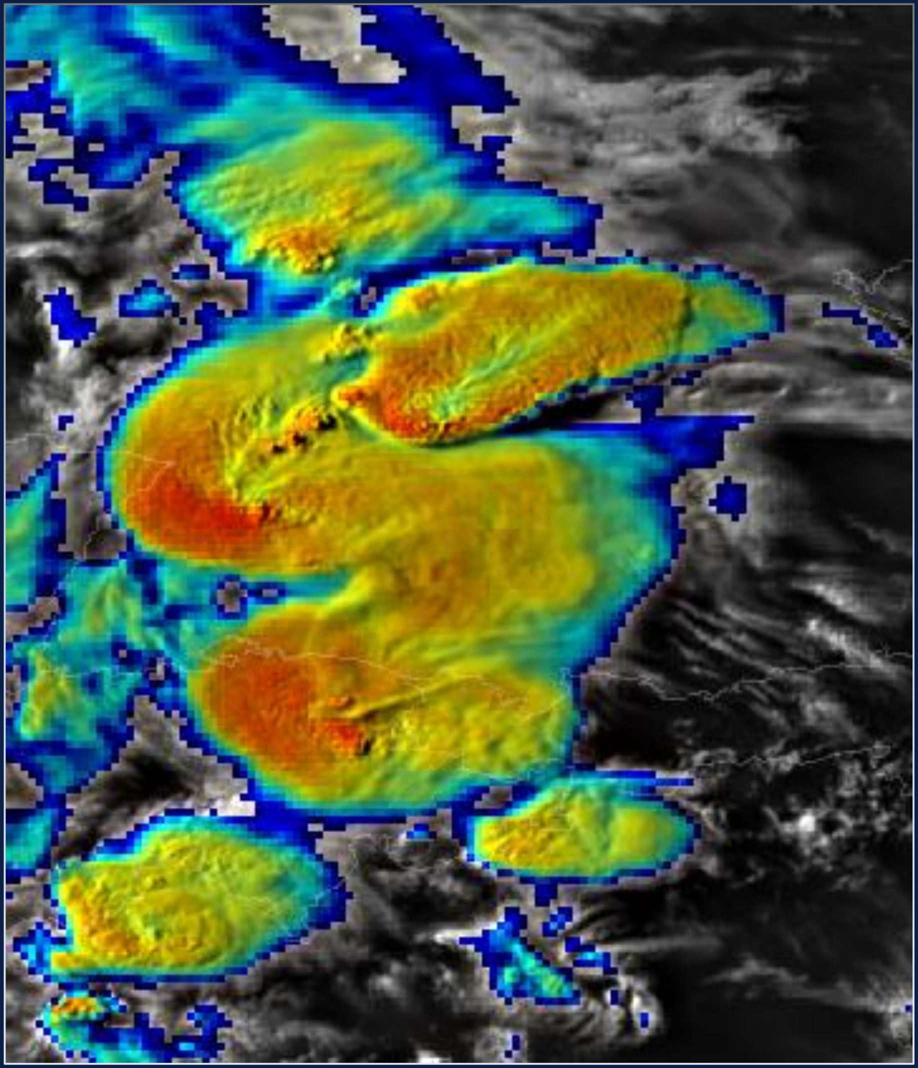
sandwich HRV & IR10.8-BT

12 July 2011 17:40 UTC MSG-1, Germany

Visible – color enhanced IR-BT sandwich product



sandwich HRV & storm RGB

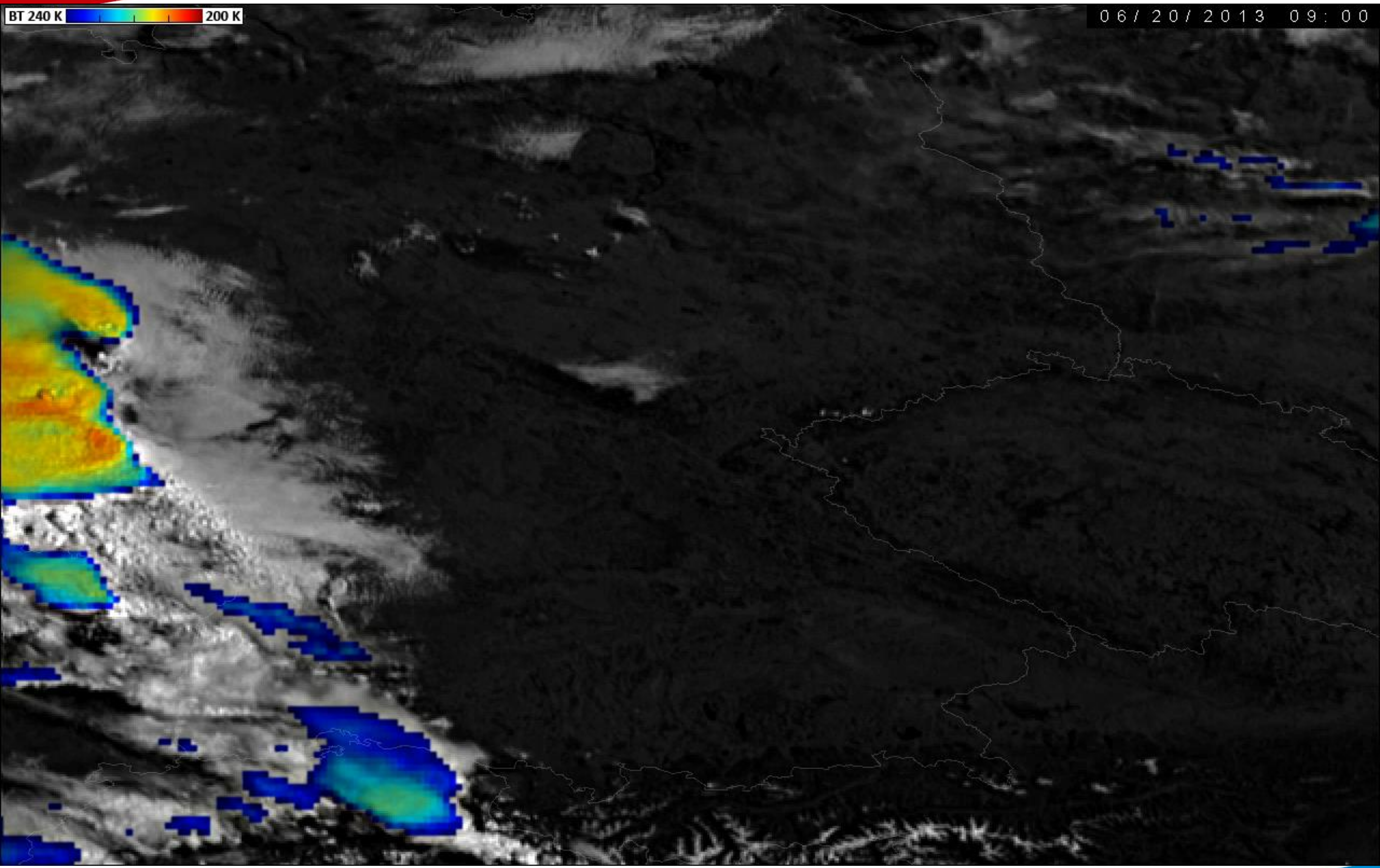


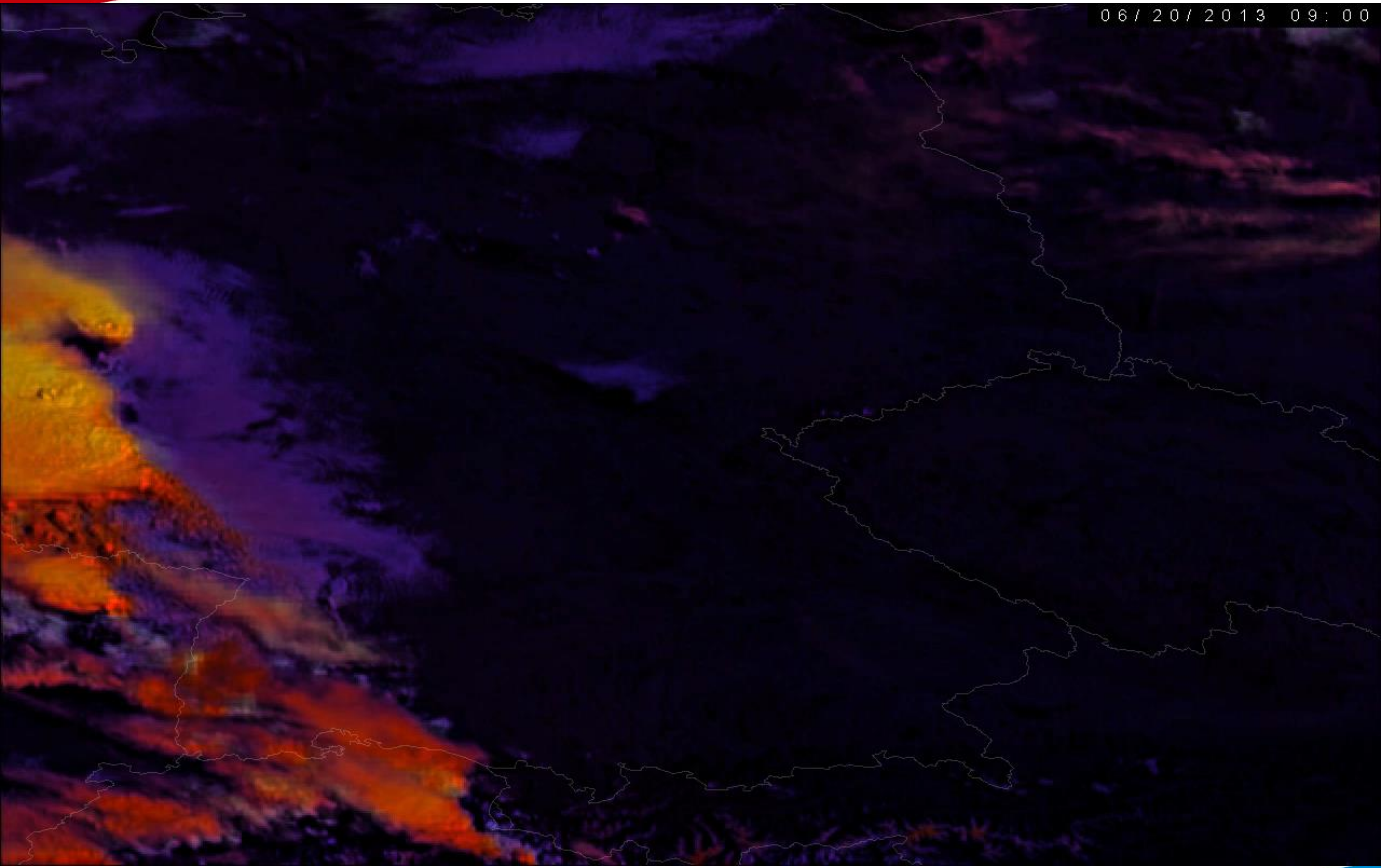
sandwich HRV & IR10.8-BT

12 July 2011 17:40 UTC MSG-1, Germany

SEVERE STORM CHARACTERISTICS

- **lifecycle:**
  - rapid development, long lasting
  - outflow, splitting, right-mover
- **cloud-top features:**
  - overshooting tops (OT) ~ storm activity, intensity of updrafts
  - cold-U or cold-ring shape in IR-BT ~ related with OT, rapid cooling
  - small ice particles, plume
  - gravity waves, ship waves ~ related with OT
- **shape of the anvil:**
  - weak/strong wind shear or storm-relative winds


BT 240 K
200 K
06/ 20/ 2013 09: 00

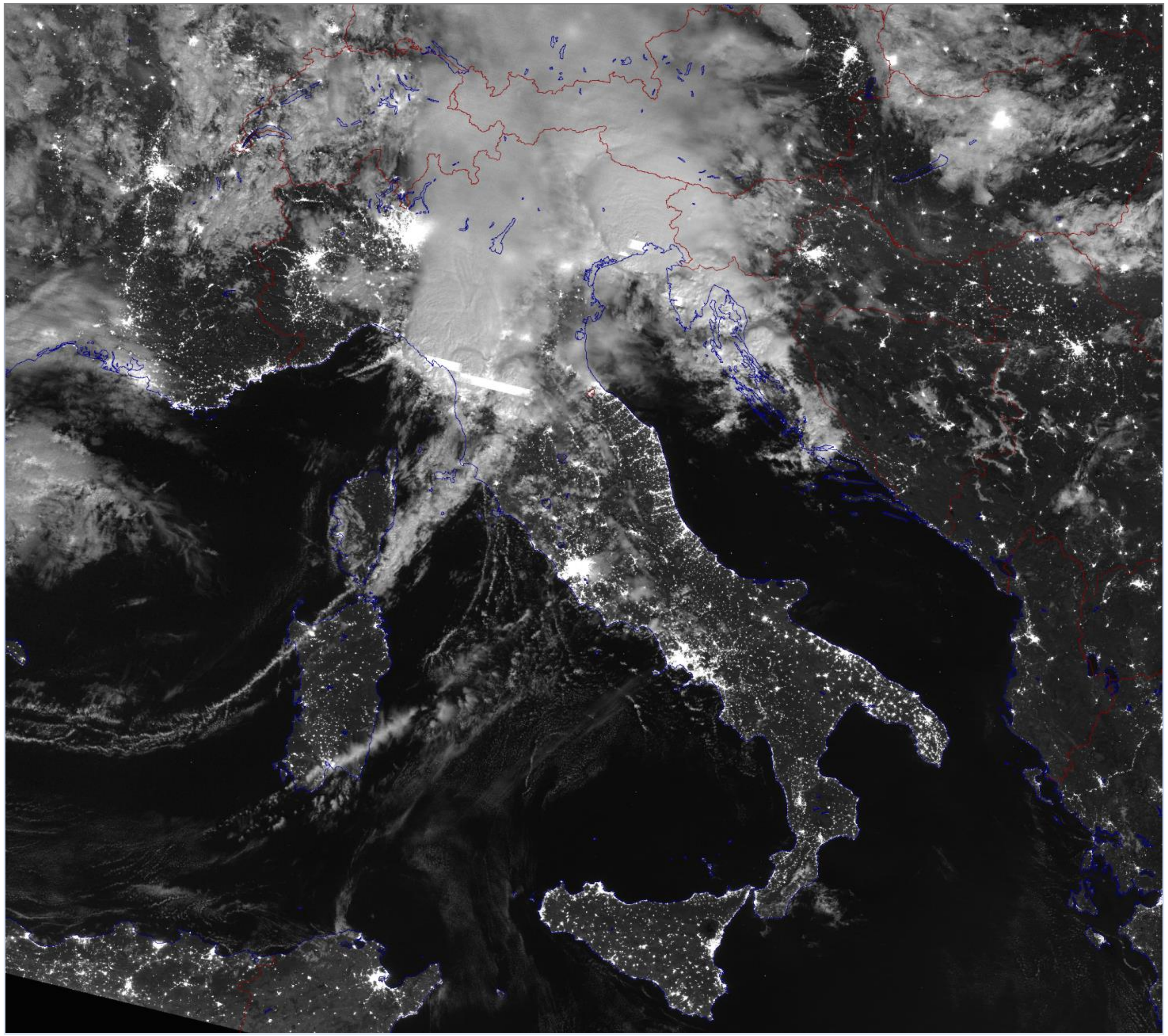

06/ 20/ 2013 09: 00

APPLICATIONS

- storms observed by satellites FIRST
- cloud-top features as an indicator of severity
- satellite data as part of nowcasting tools:
    - ProbSevere (USA, CIMSS SSEC)
    - COALITION (Switzerland, MeteoSwiss)

- Nowcasting SAF (Pilar Ripodas)

THANK YOU



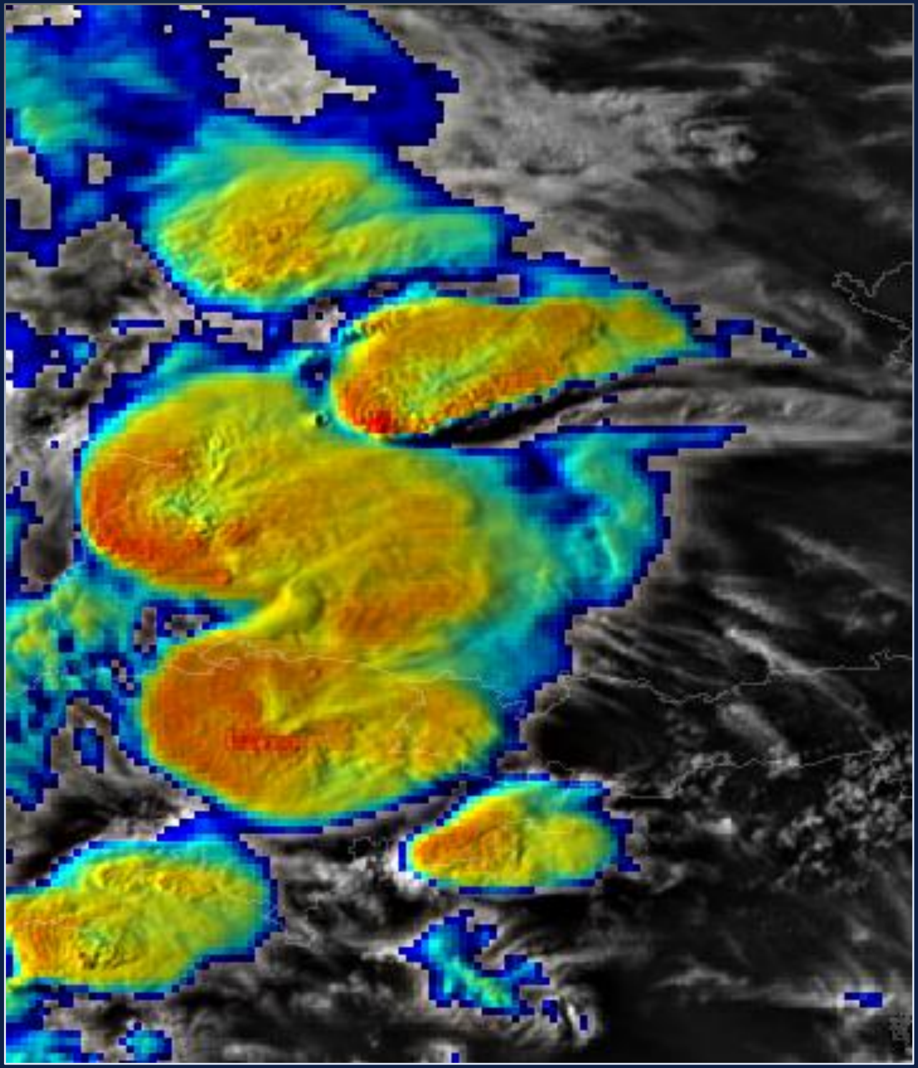
2013-08-25 00:43 UTC

VIIRS Day-Night Band (DNB)

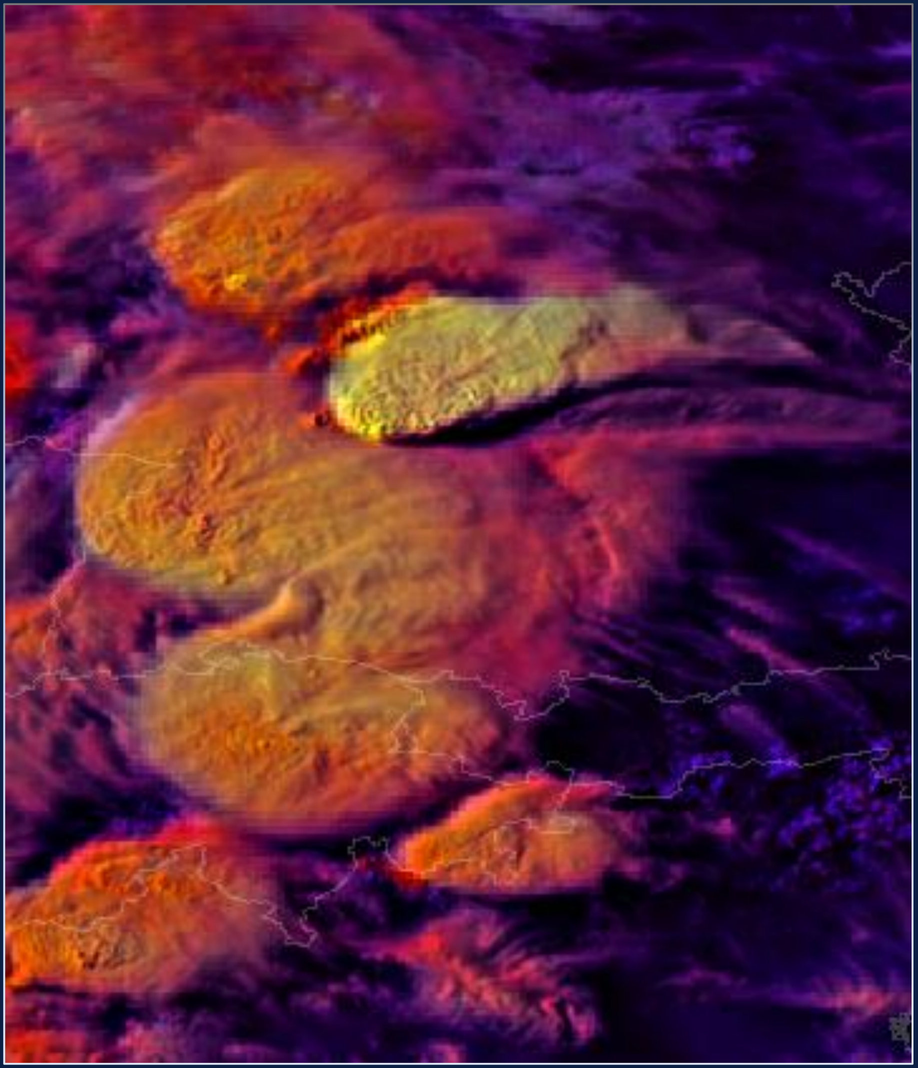
Italy, Croatia, Slovenia

- City lights
- Land and storms illuminated by Moon
  (4 days after full Moon and 3 days before third quarter)
- Lightning

Example of temporal variability of storm-top features in 5-minute MSG data



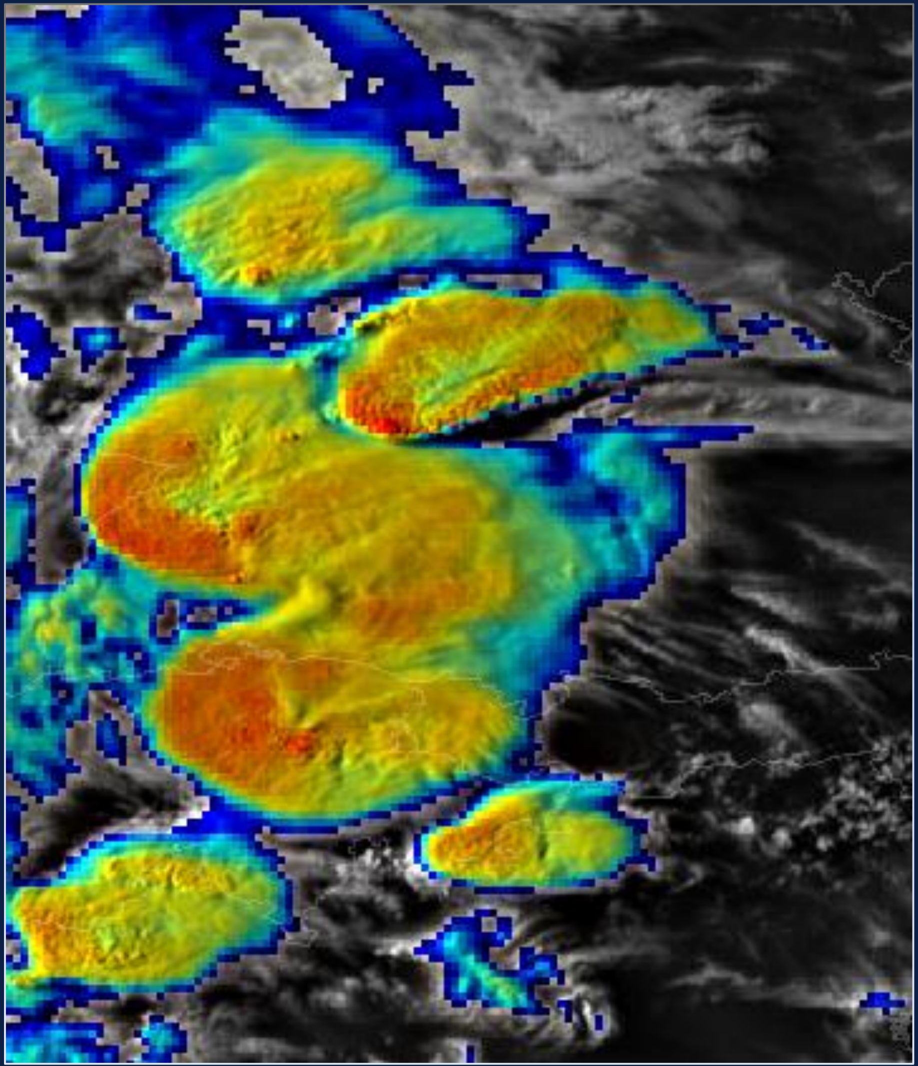
sandwich HRV & IR10.8-BT



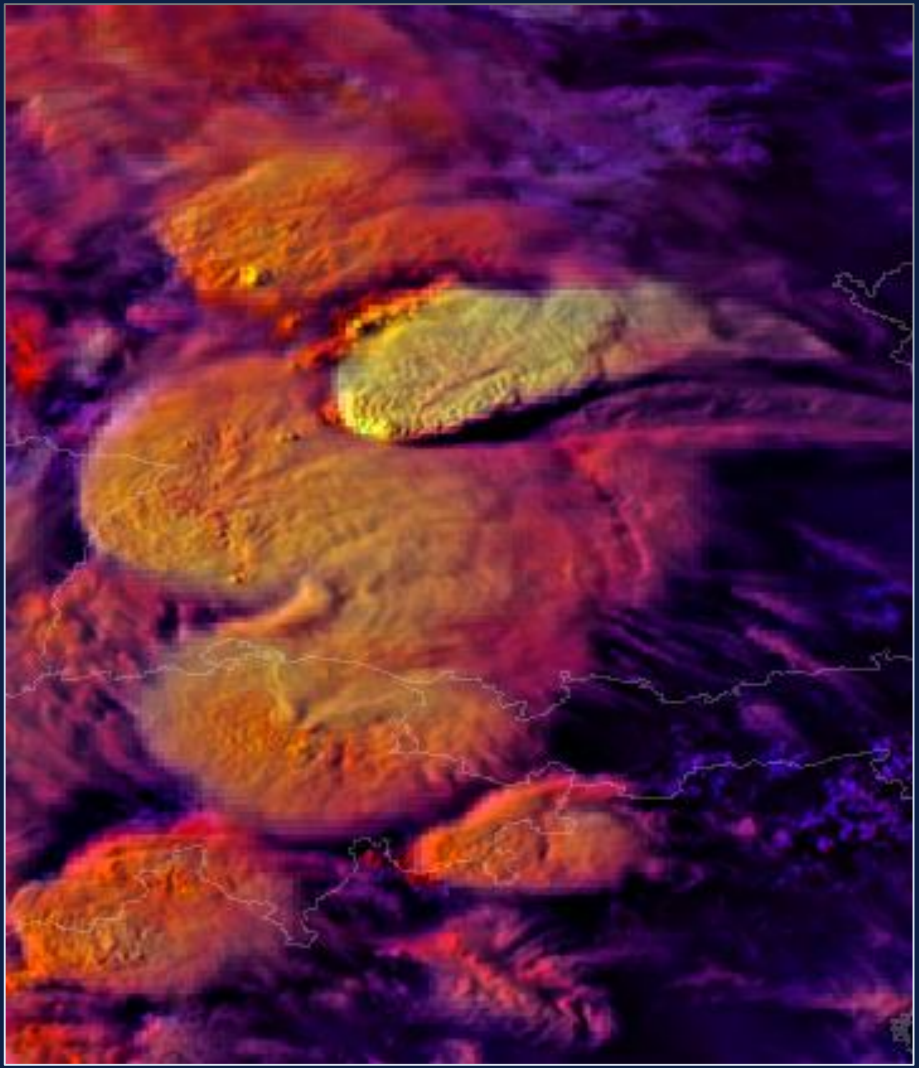
sandwich HRV & storm RGB

12 July 2011 17:20 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



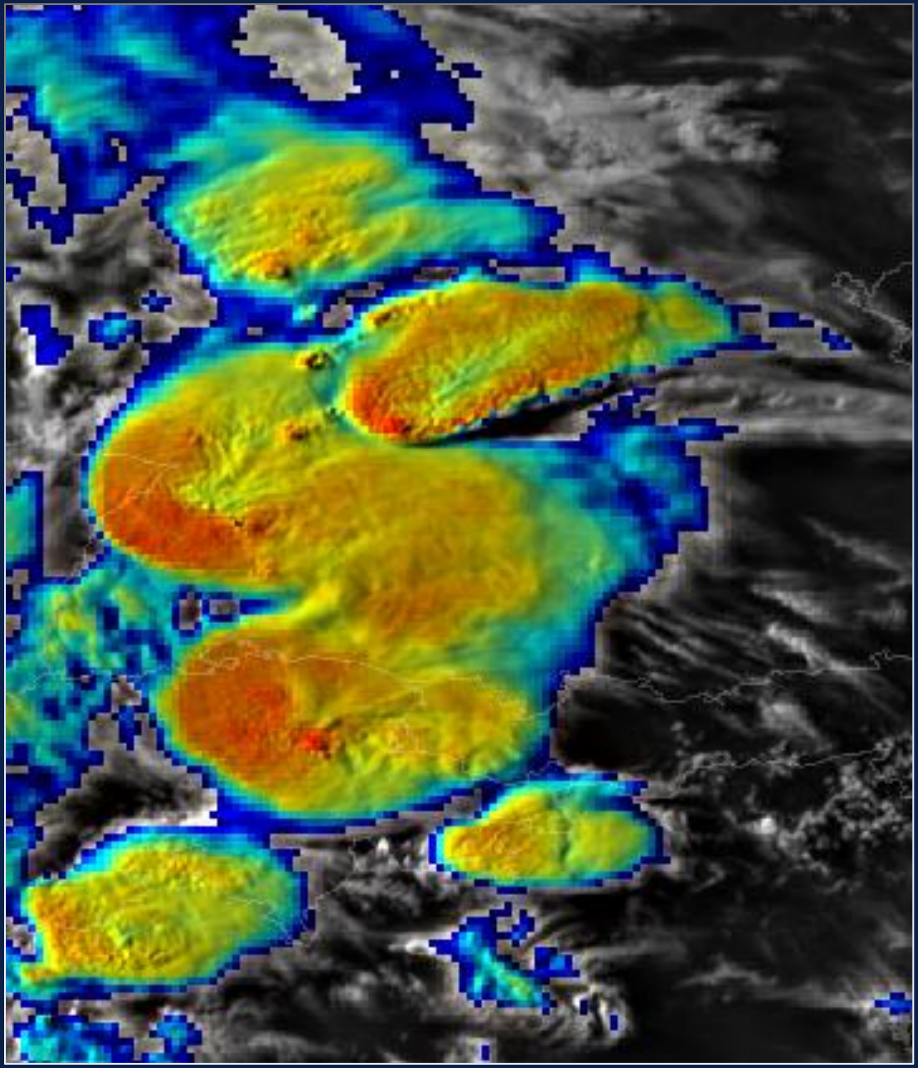
sandwich HRV & IR10.8-BT



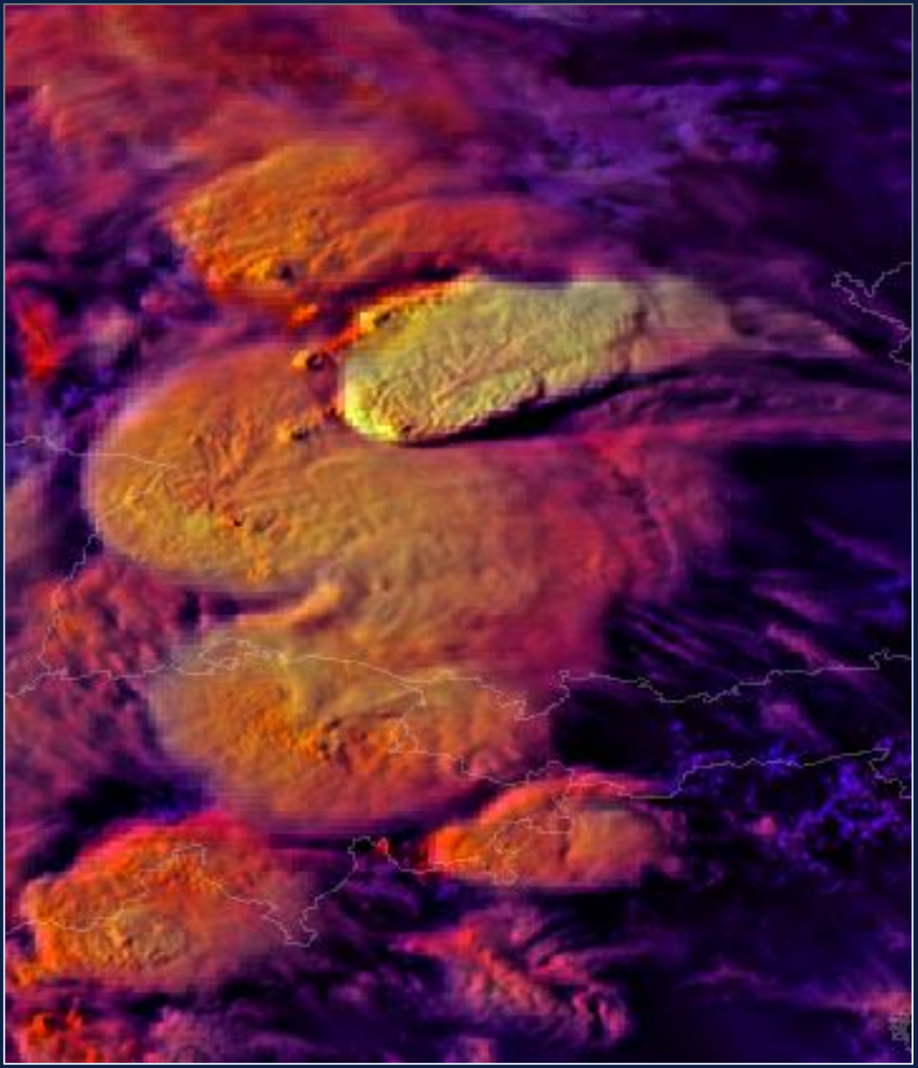
sandwich HRV & storm RGB

12 July 2011 17:25 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



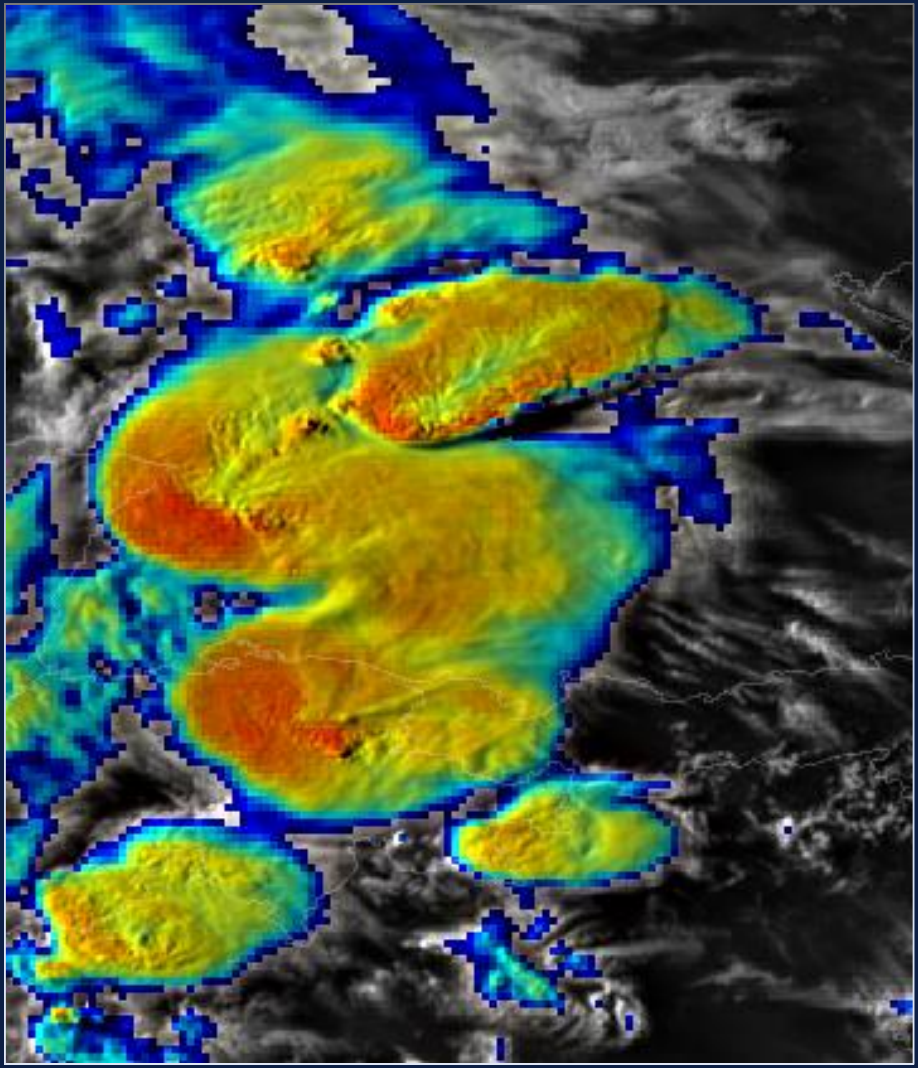
sandwich HRV & IR10.8-BT



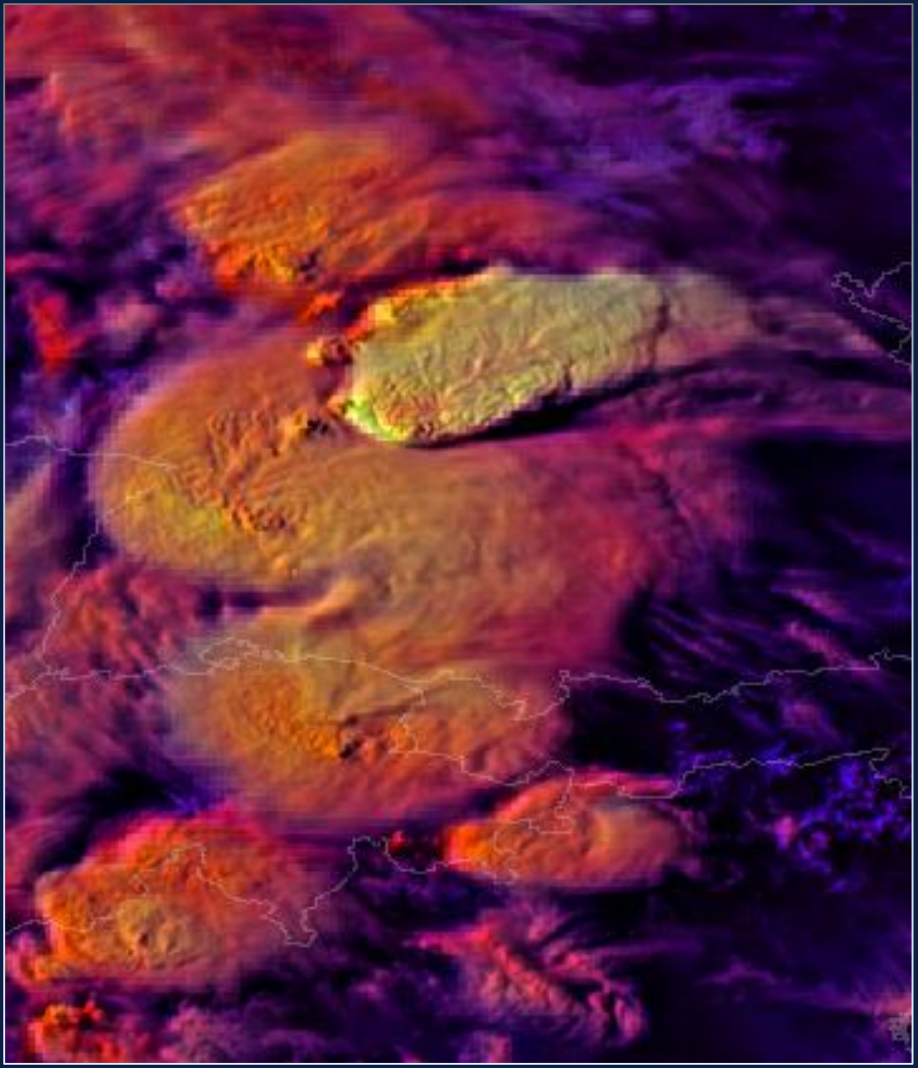
sandwich HRV & storm RGB

12 July 2011 17:30 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



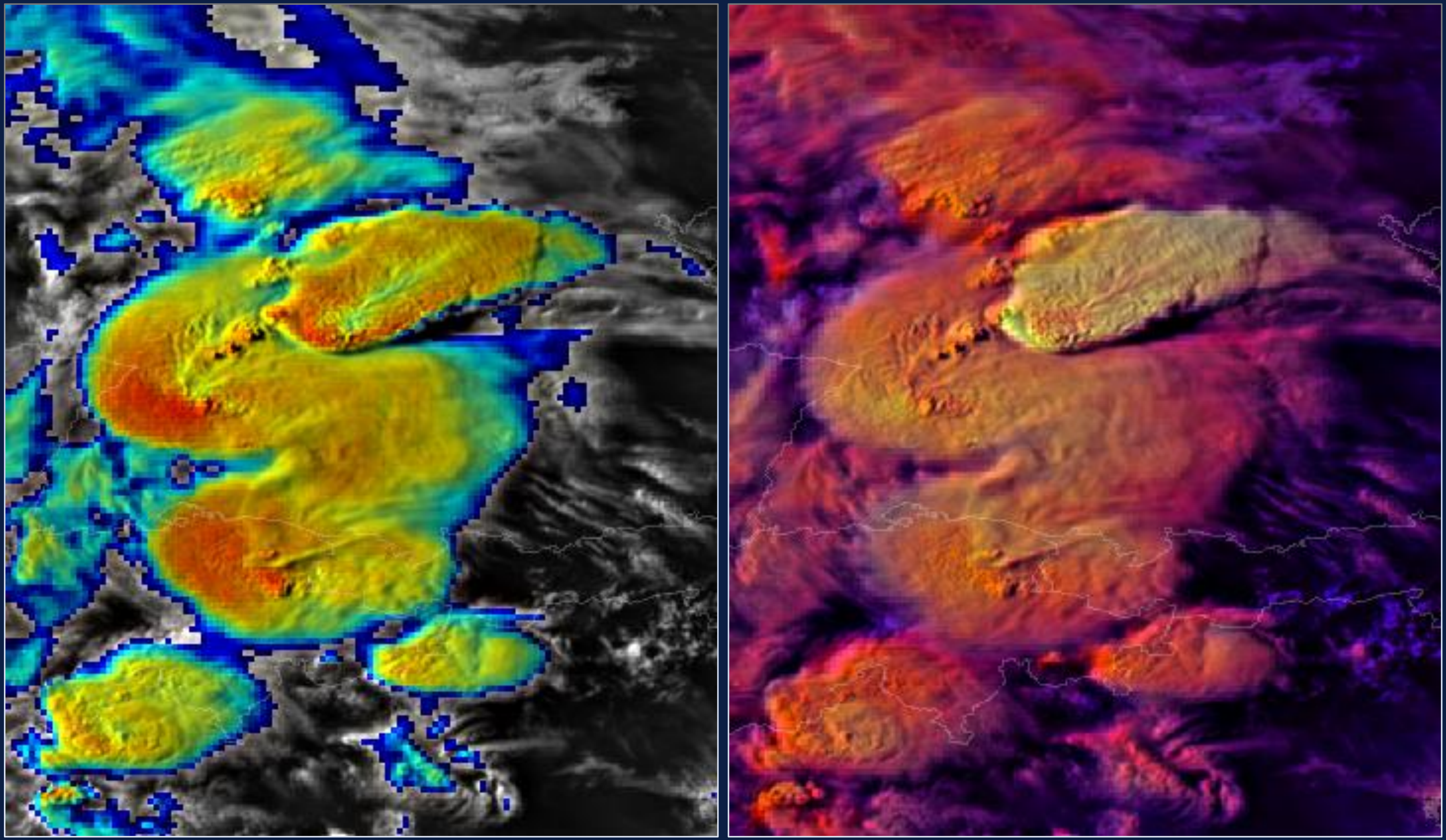
sandwich HRV & IR10.8-BT



sandwich HRV & storm RGB

12 July 2011 17:35 UTC   MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data

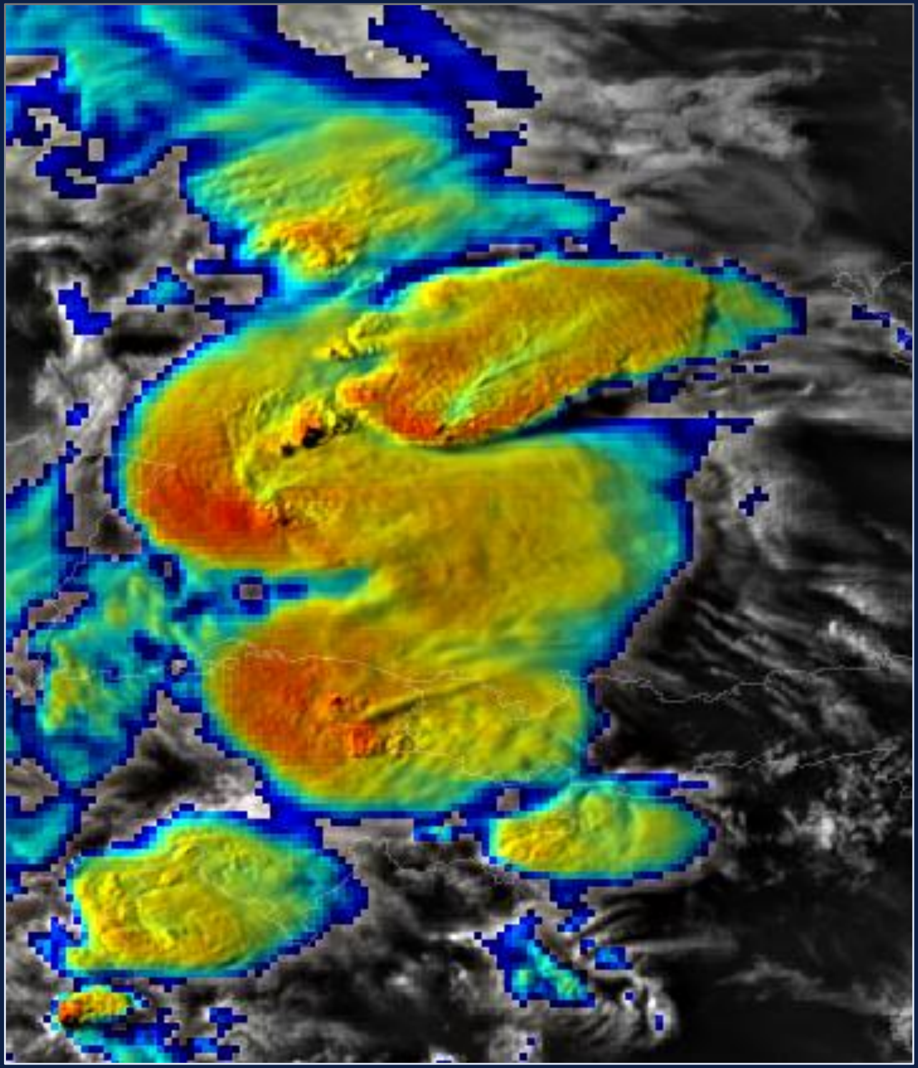


sandwich HRV & IR10.8-BT

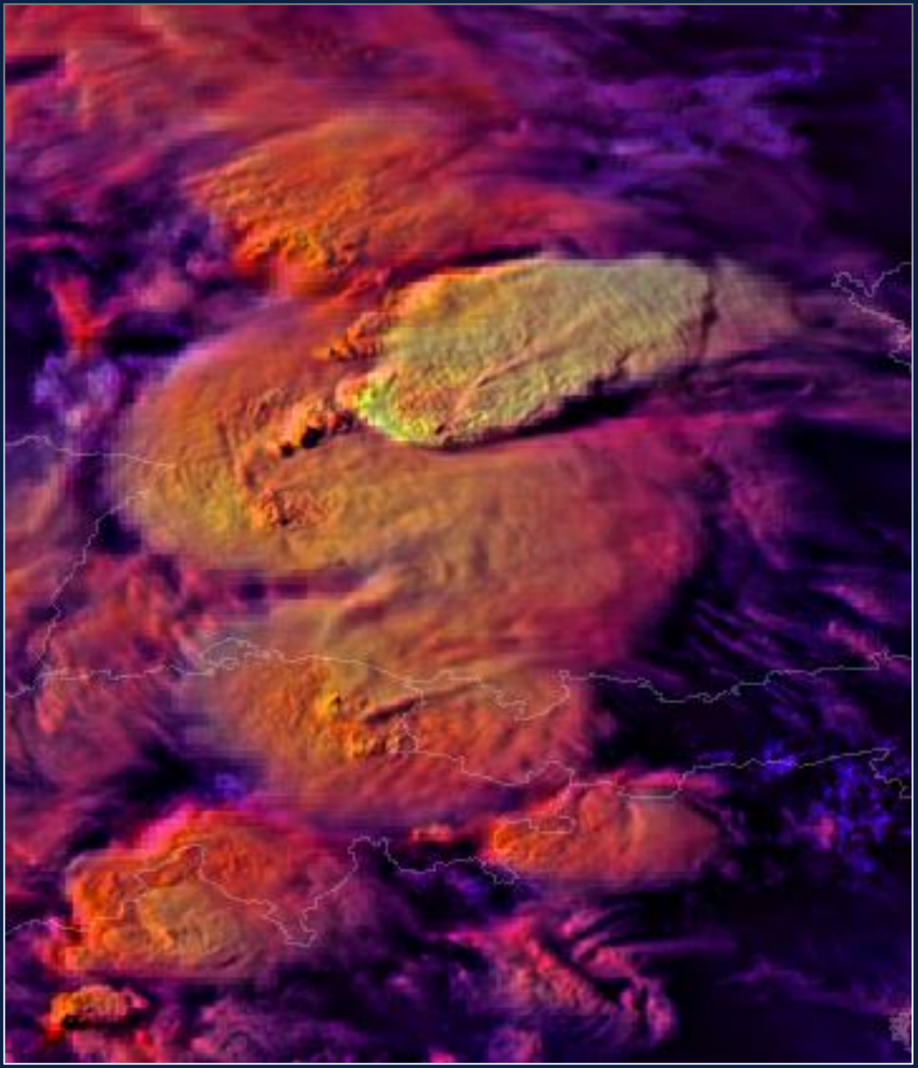
sandwich HRV & storm RGB

12 July 2011 17:40 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



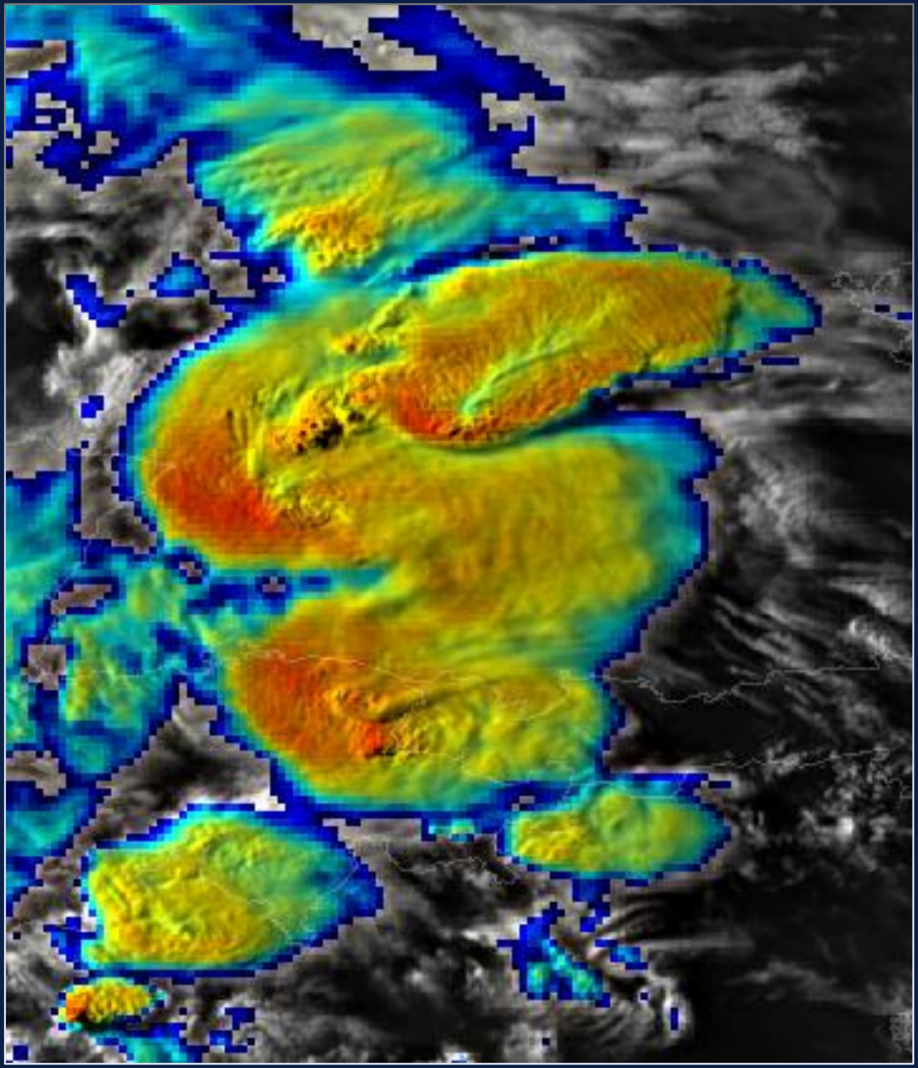
sandwich HRV & IR10.8-BT



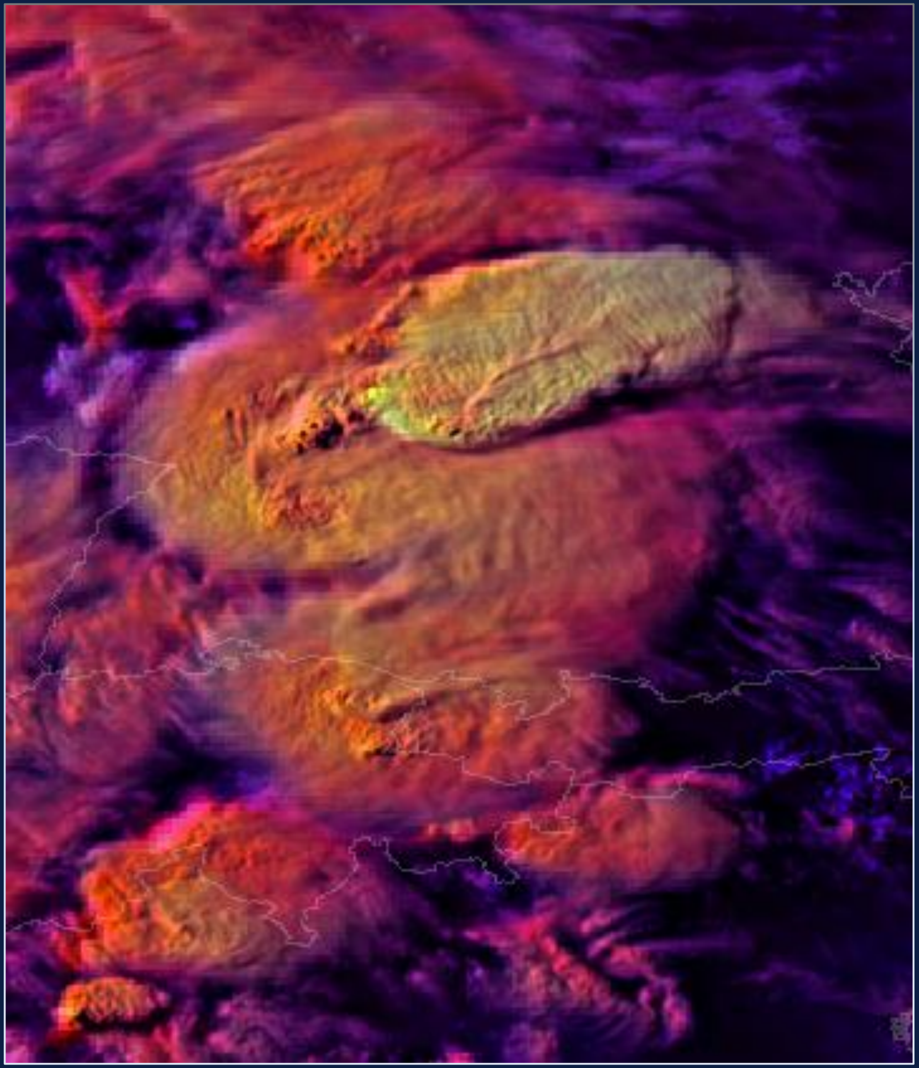
sandwich HRV & storm RGB

12 July 2011 17:45 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



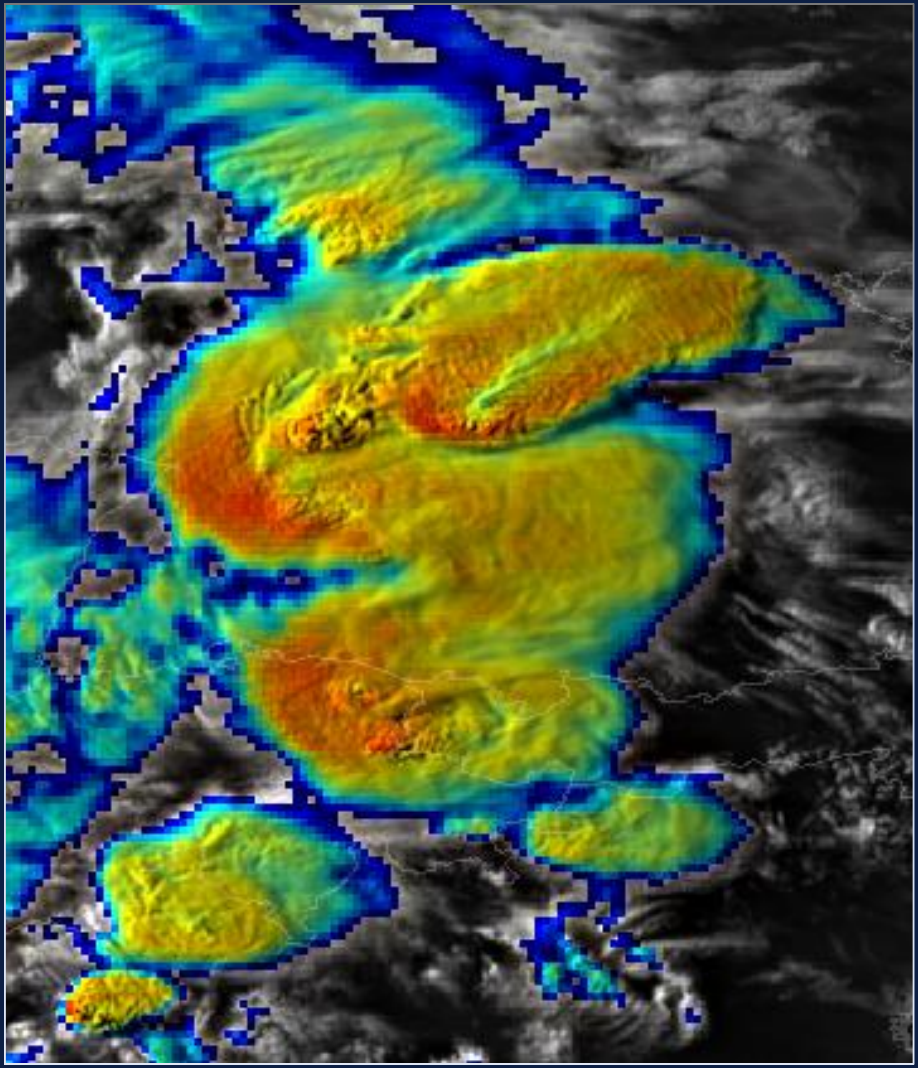
sandwich HRV & IR10.8-BT



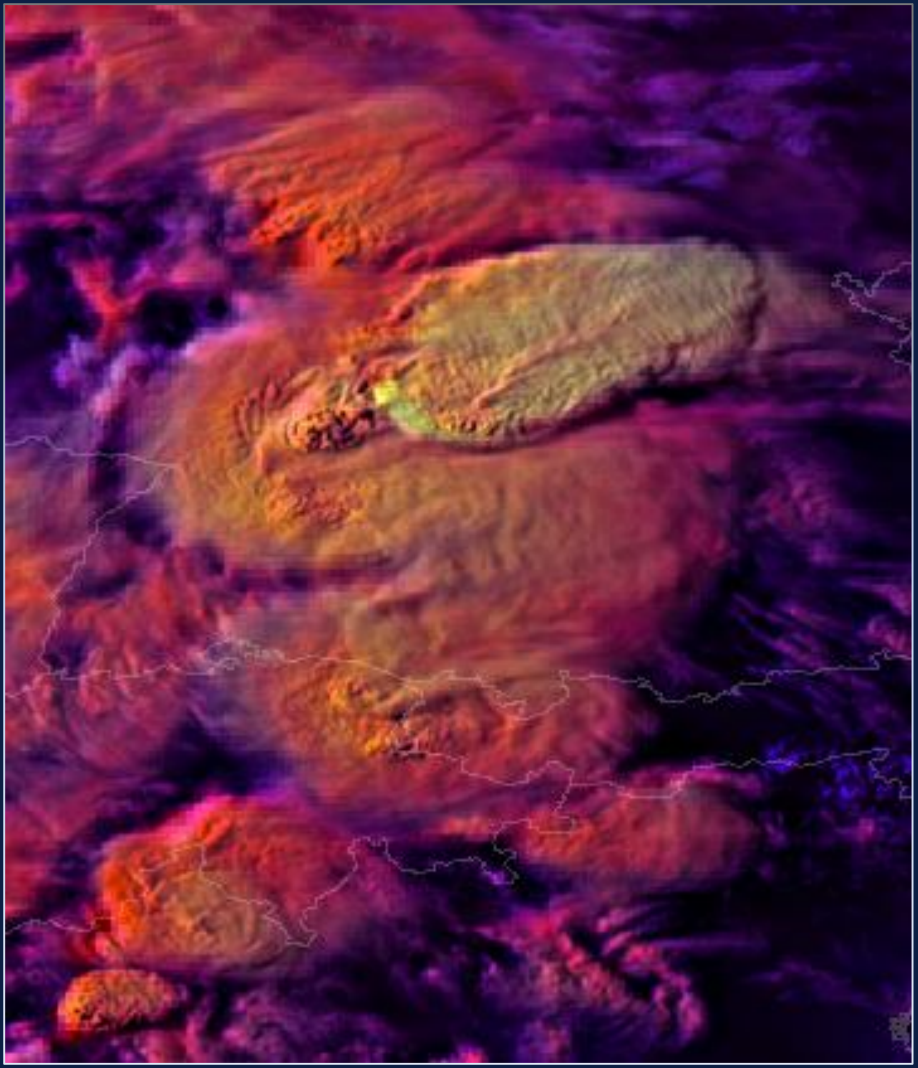
sandwich HRV & storm RGB

12 July 2011 17:50 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



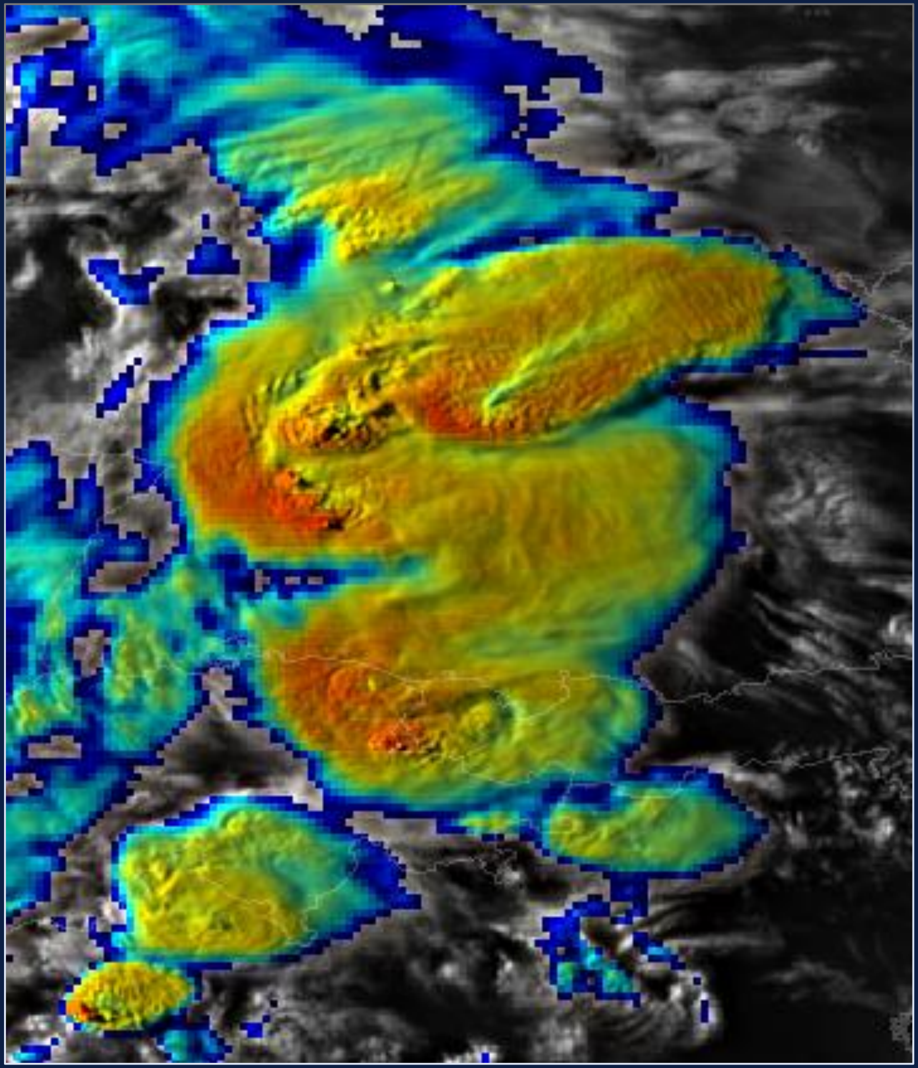
sandwich HRV & IR10.8-BT



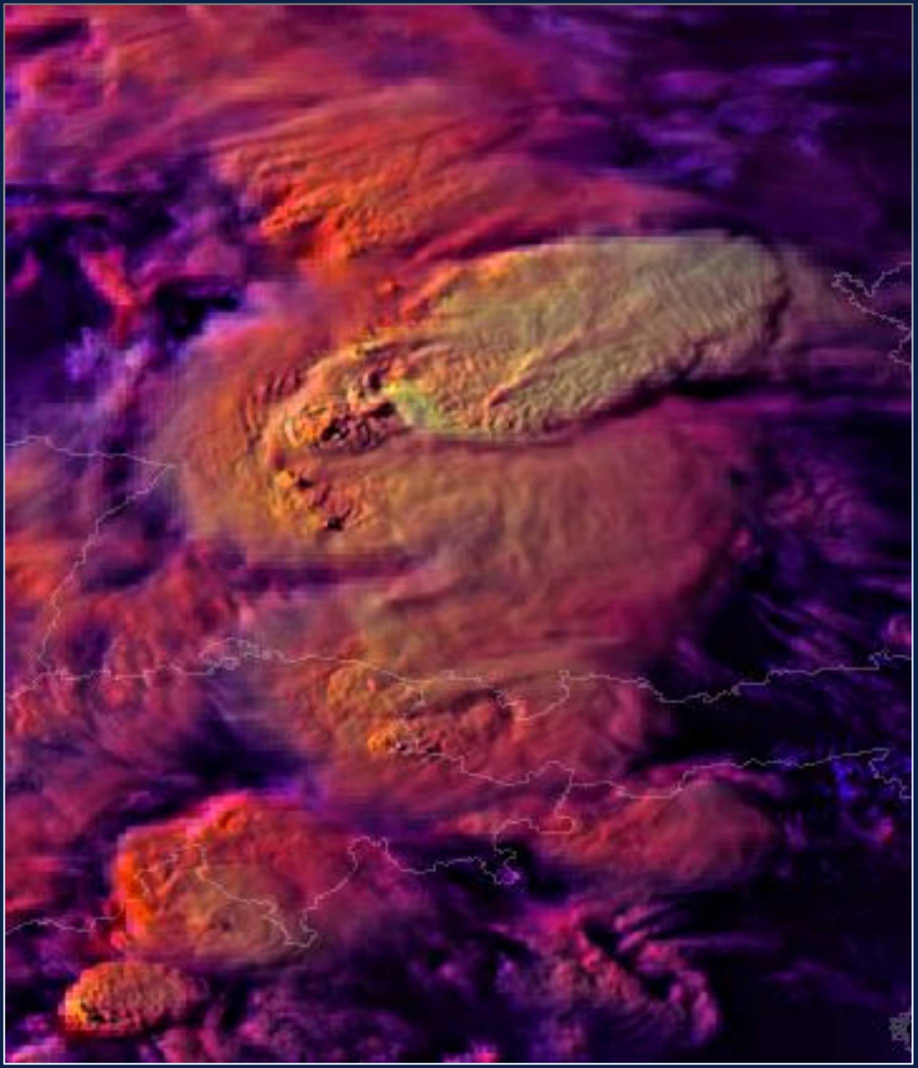
sandwich HRV & storm RGB

12 July 2011 17:55 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



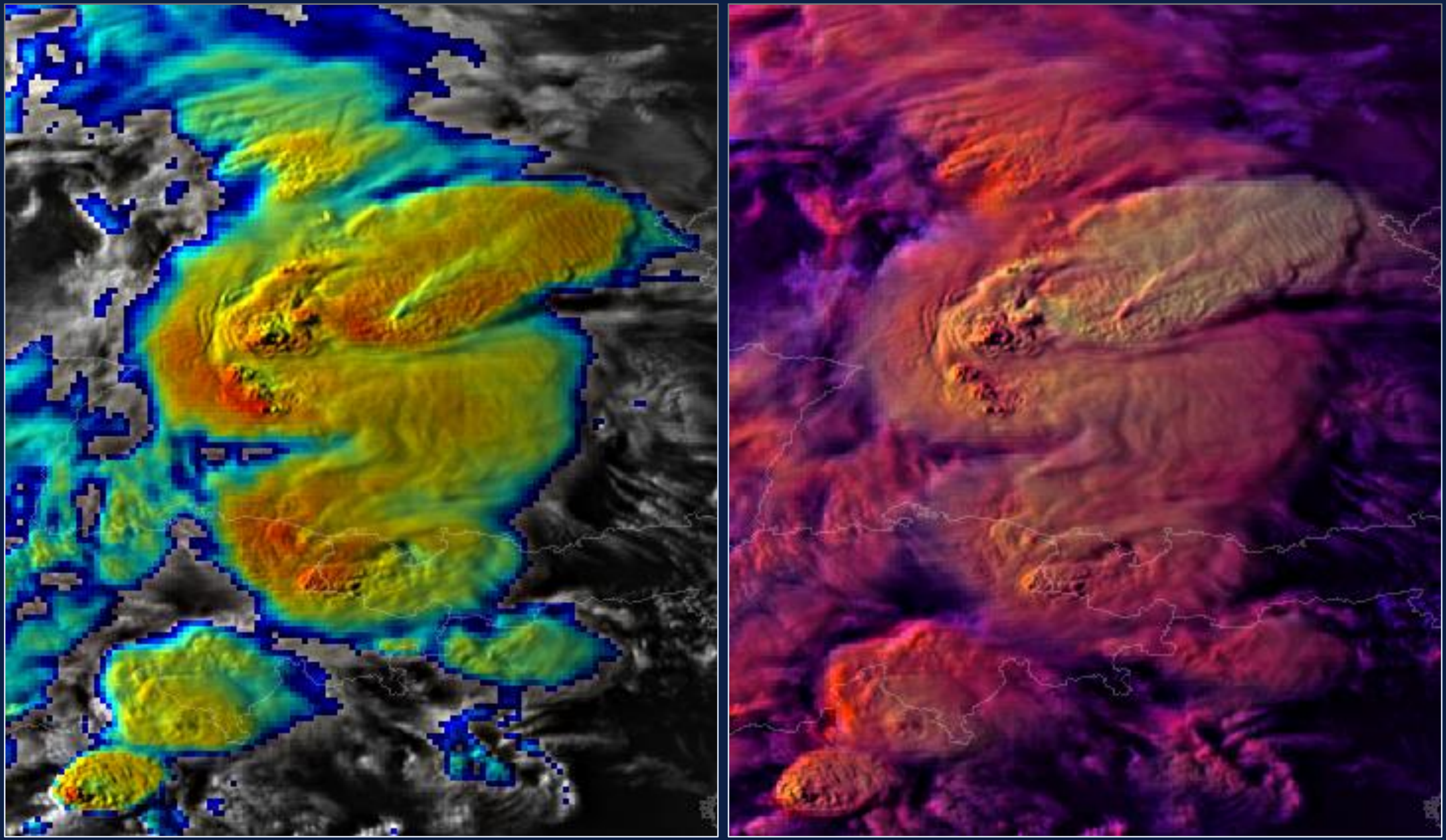
sandwich HRV & IR10.8-BT



sandwich HRV & storm RGB

12 July 2011 18:00 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data

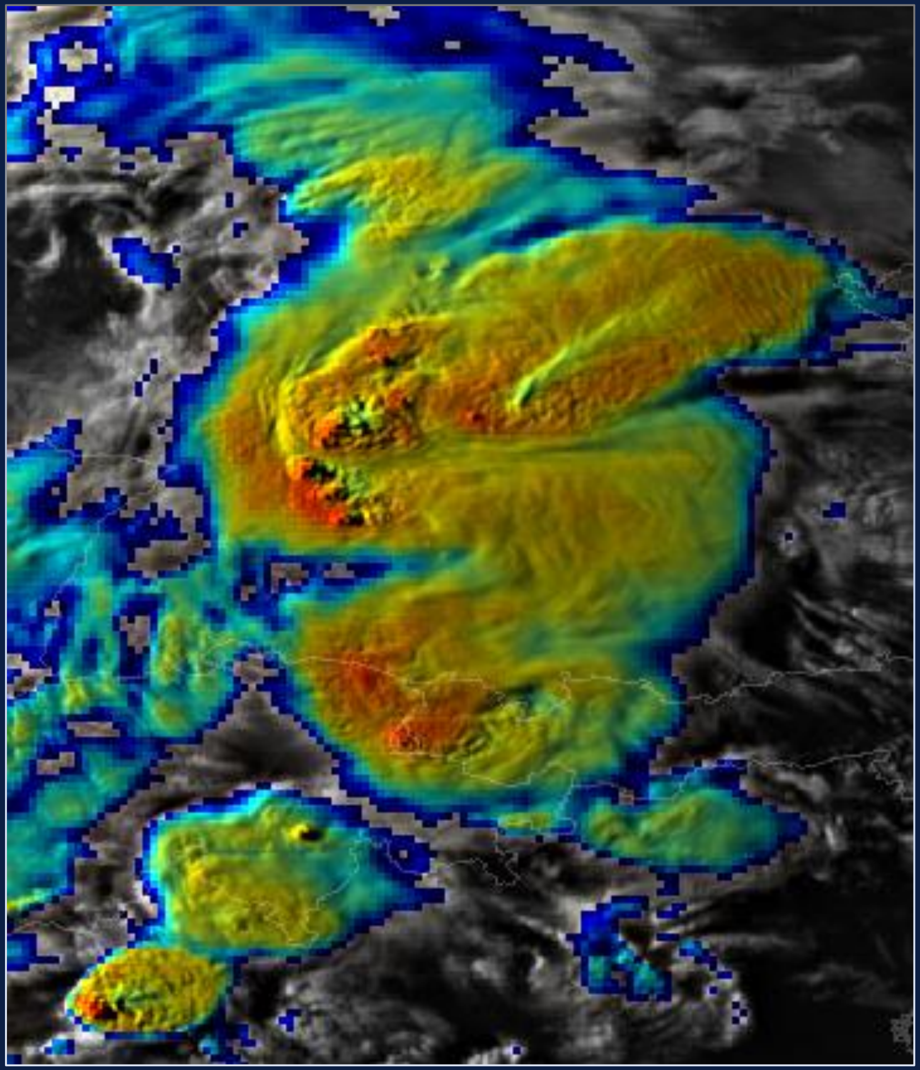


sandwich HRV & IR10.8-BT

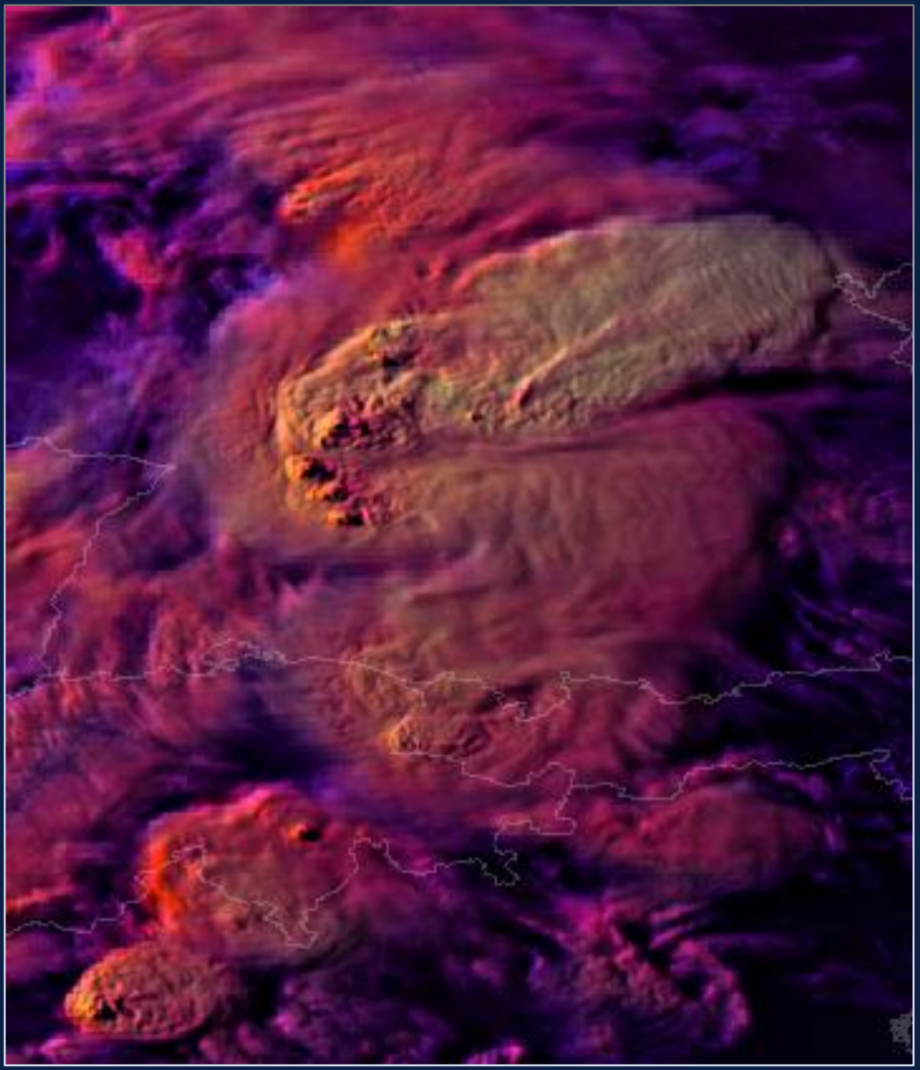
sandwich HRV & storm RGB

12 July 2011 18:05 UTC   MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



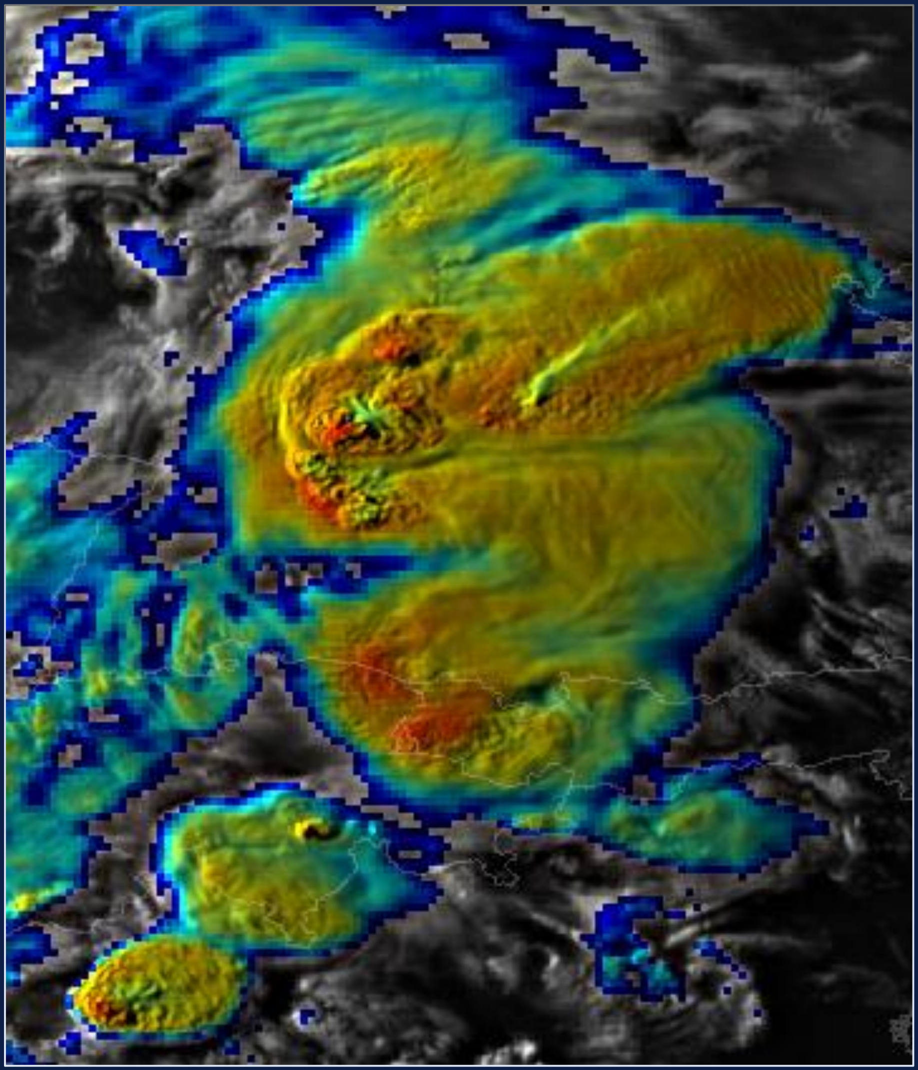
sandwich HRV & IR10.8-BT



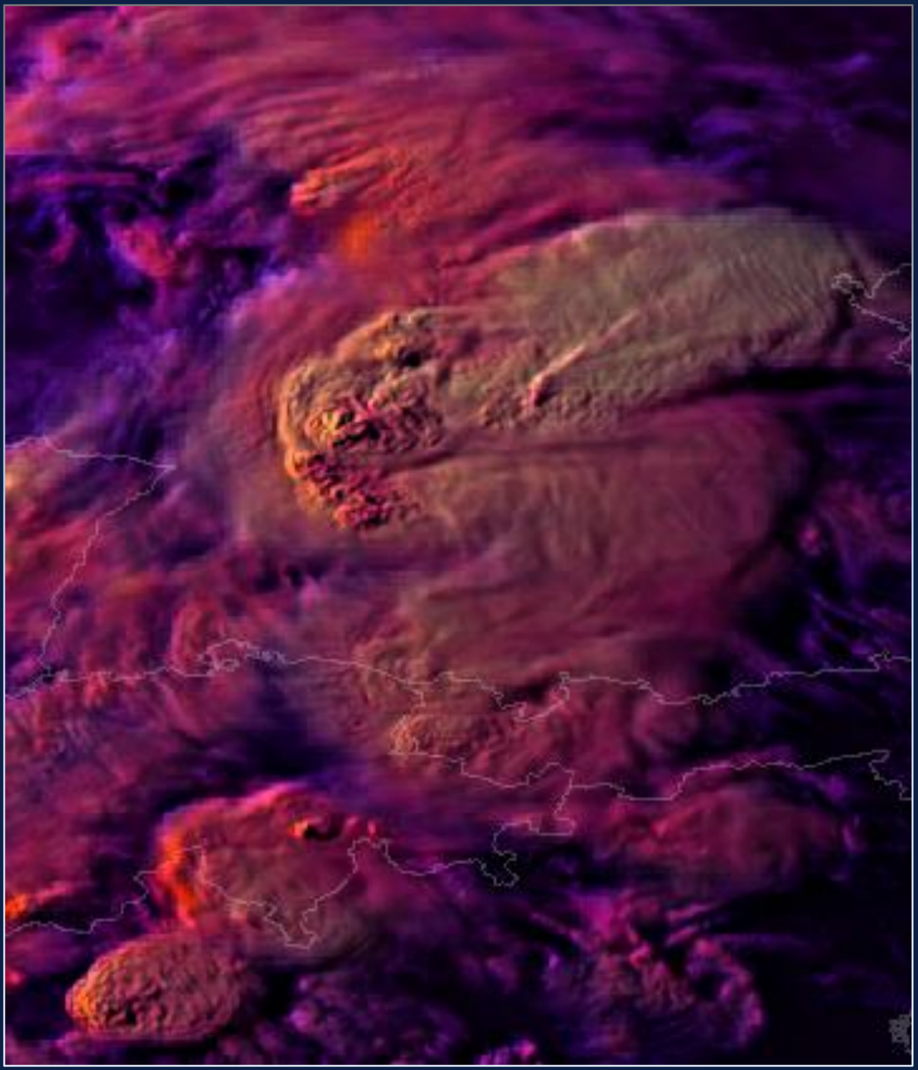
sandwich HRV & storm RGB

12 July 2011 18:10 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data



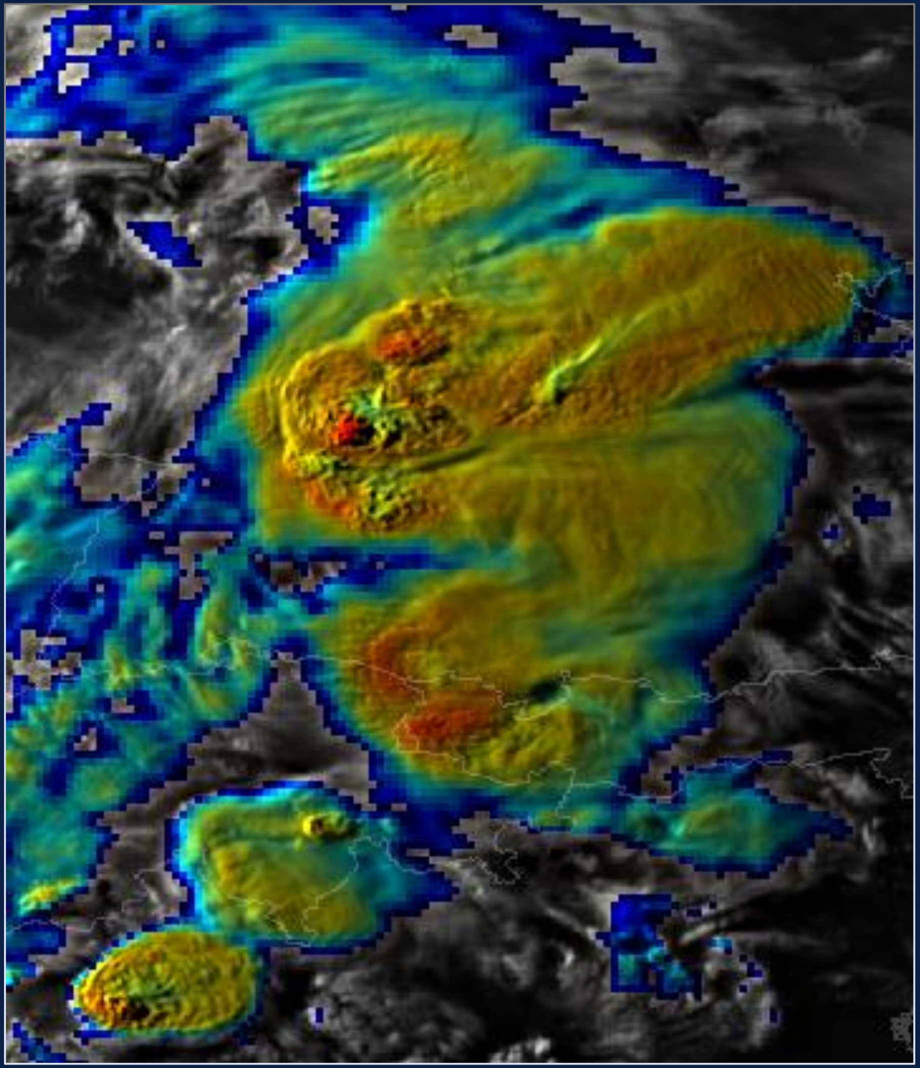
sandwich HRV & IR10.8-BT



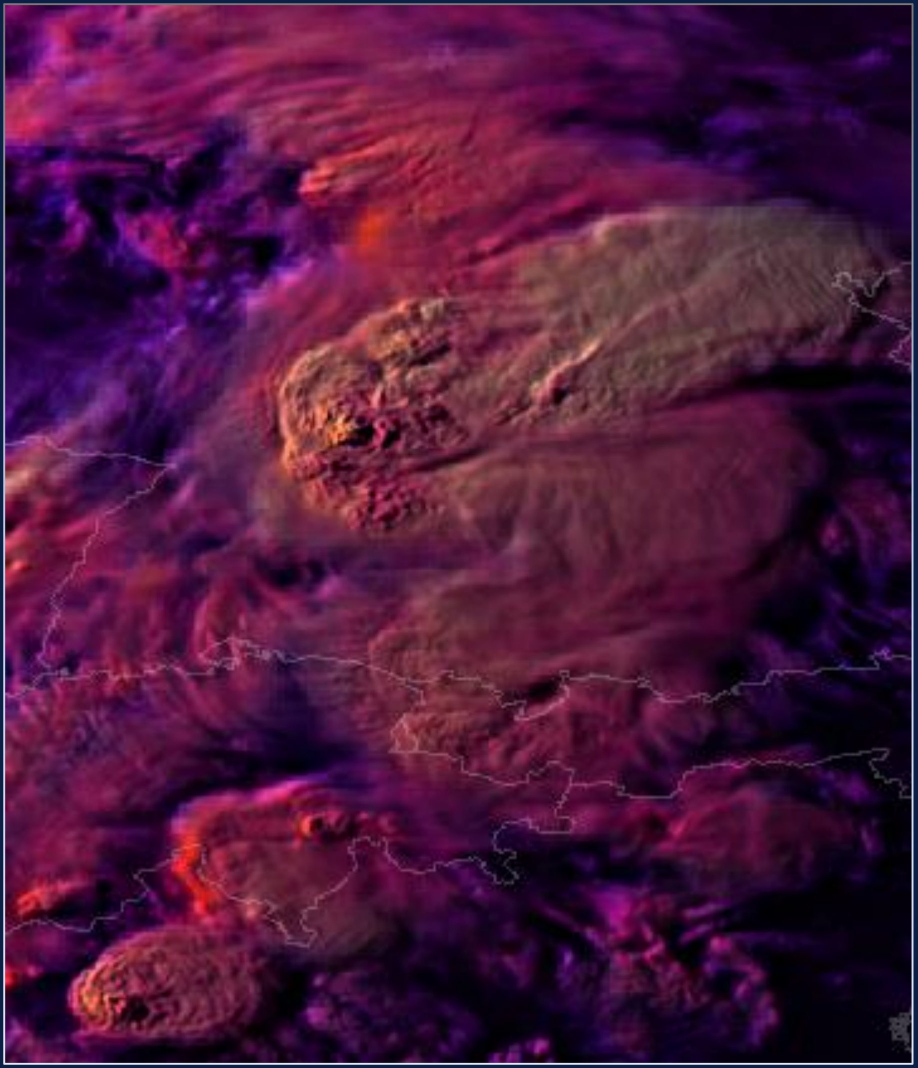
sandwich HRV & storm RGB

12 July 2011 18:15 UTC MSG-1

Example of temporal variability of storm-top features in 5-minute MSG data .



sandwich HRV & IR10.8-BT



sandwich HRV & storm RGB

12 July 2011 18:20 UTC MSG-1