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Enhancement of the IR imagery

EUMeTrain 14 June 2011

Image enhancement – general notes and examples

Image enhancement – a process of image modification or improvement of its quality, the aim of which is to achieve a more pleasing appearance of the final image.

In science, the main goal of image enhancement is to increase the **interpretability** of the image to a human eye and brain, typically focusing on a certain feature carried by the image.

Image enhancement – general notes and examples

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Example of image enhancement: all digital cameras utilize some level of built-in (software-based) image enhancement, in order to provide good image quality, appealing to a human eye *(however, this does not apply to the "raw" images, which are stored exactly as captured by the camera sensor.)* Typically, most of the "out of the camera" images can be further improved by simple computer post-processing (= enhancement).

Image enhancement – general notes and examples

Example of an image as captured by a camera (slightly overexposed, poor details) ...

Image enhancement – general notes and examples

... and the same image after computer enhancement (post-processing in Photoshop).

Image enhancement – general notes and examples

General image enhancement can be achieved by various methods or "tools", such as:

- histogram-based methods - "auto-color", "auto-contrast", (interactive) adjustment of levels, brightness and contrast modification, color balance, etc.;
- curves adjustment, gamma function, noise reduction, unsharp mask, sharpening, advanced (mathematical) filters, …

Typically included in most photo-editing software; can be also used for interactive or automatic processing of satellite imagery.

Poll: who has ever tried to perform some level of (regular camera) image post-processing?

(click "Yes" or "No")

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Image enhancement and data from the meteorological satellites:

- Used to show more details in the solar bands (typically shifting/stretching the grayscale range, gamma function, curves, unsharp mask, etc.) – either focusing at the cloud tops, or ground details;

- in the "microphysical bands" (1.6 and 3.9 μm) to show subtle details and differences between the cloud-top microphysics;

- in the emissive bands to stress a certain temperature range – e.g. details of the sea surface temperature, or details of cloud-top temperature.

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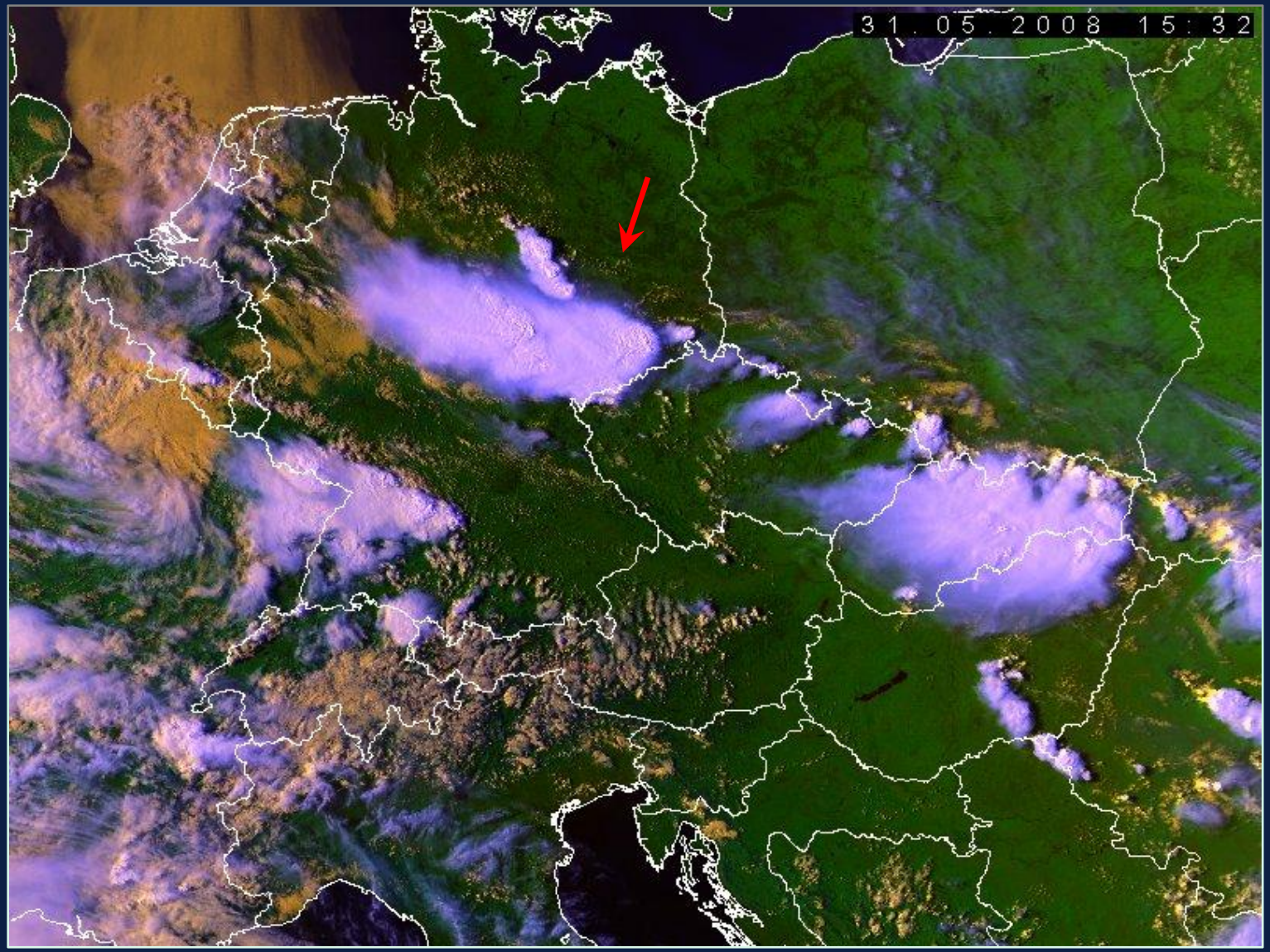
- in the emissive bands to stress a certain temperature range – e.g. details of the sea surface temperature, or details of cloud-top temperature.

- Also used when defining the RGB products – applied in the form of recommended thresholds and gamma functions for the individual input bands and/or their differences.

Image enhancement – example:

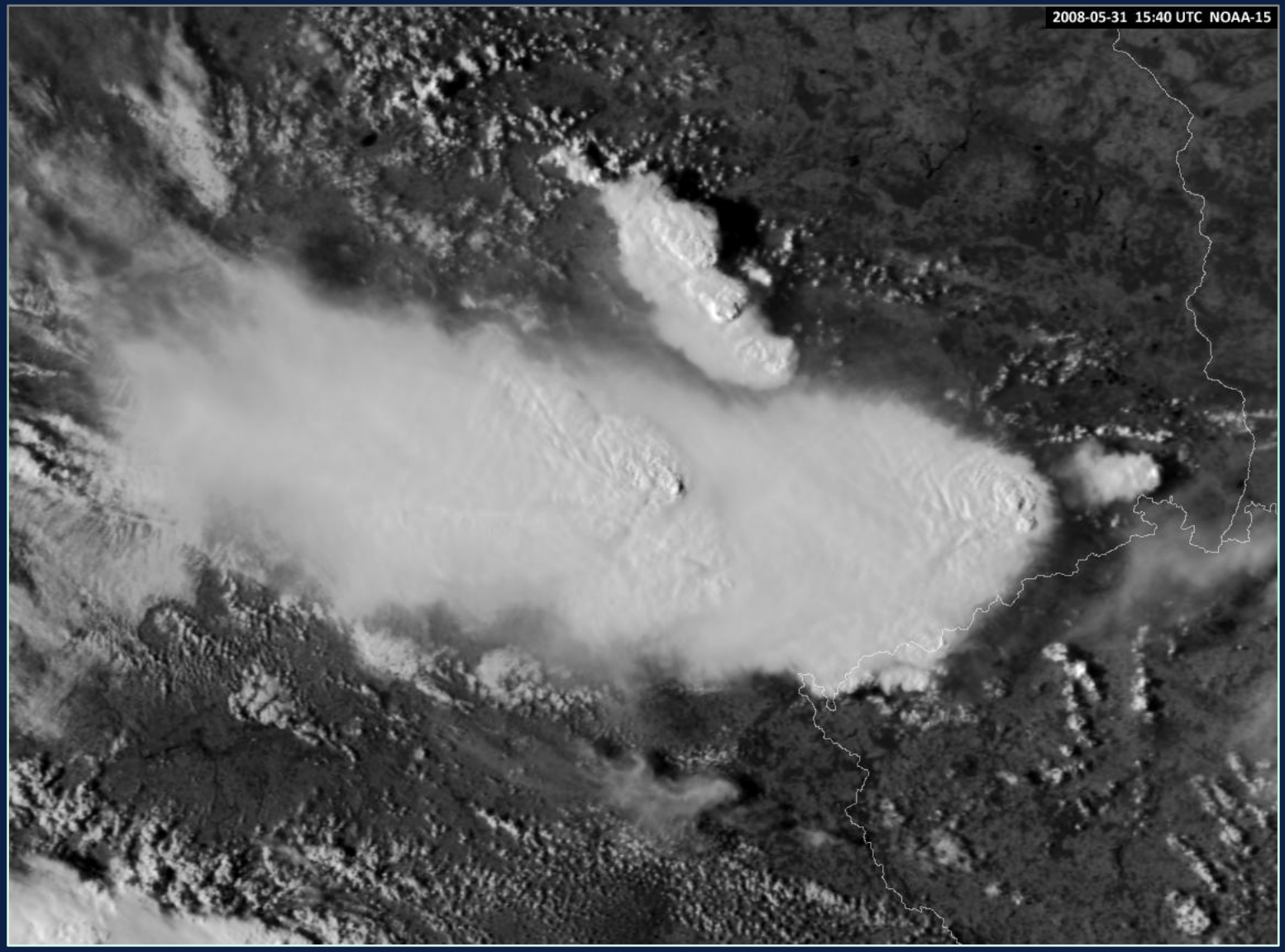
31 May 2008 15:40 UTC, Germany



AVHRR RGB image – composite of bands 1, 2 and 4 (CHMI operational product)

Image enhancement – example:

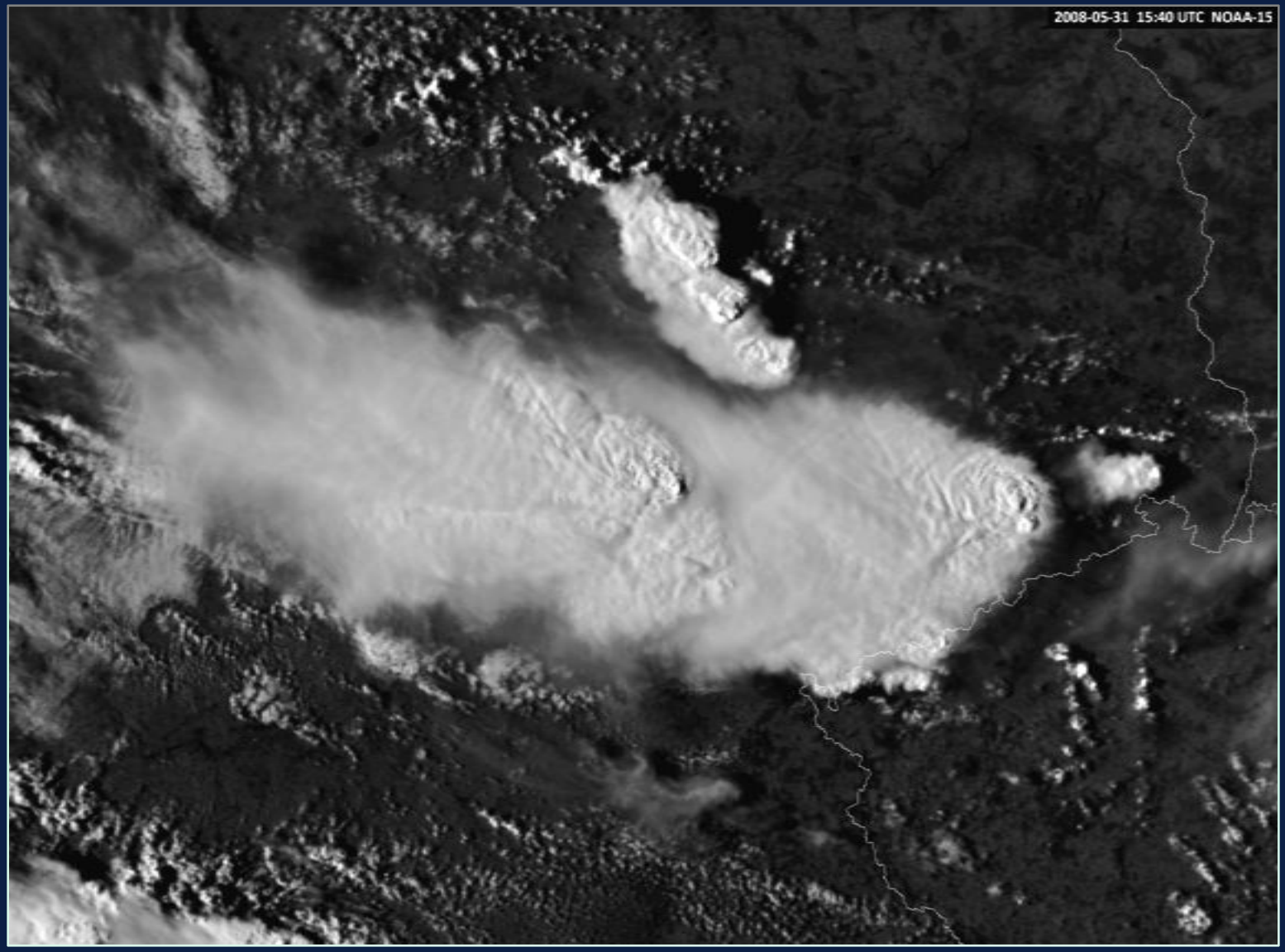
31 May 2008 15:40 UTC, Germany



AVHRR band 2 (0.9 μm) - no enhancement

Image enhancement – example:

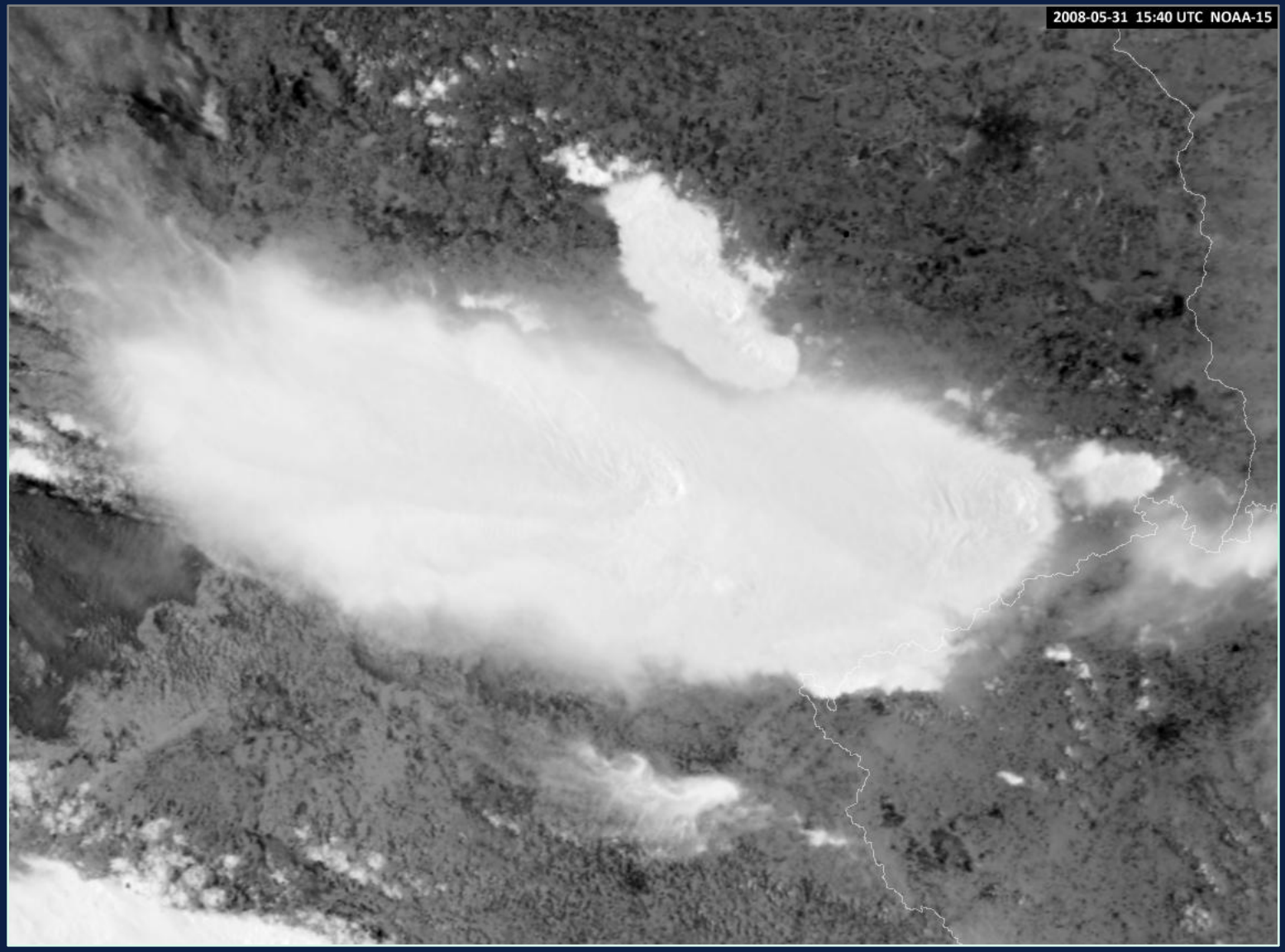
31 May 2008 15:40 UTC, Germany



AVHRR band 2 (0.9 μm) - enhanced

Image enhancement – example:

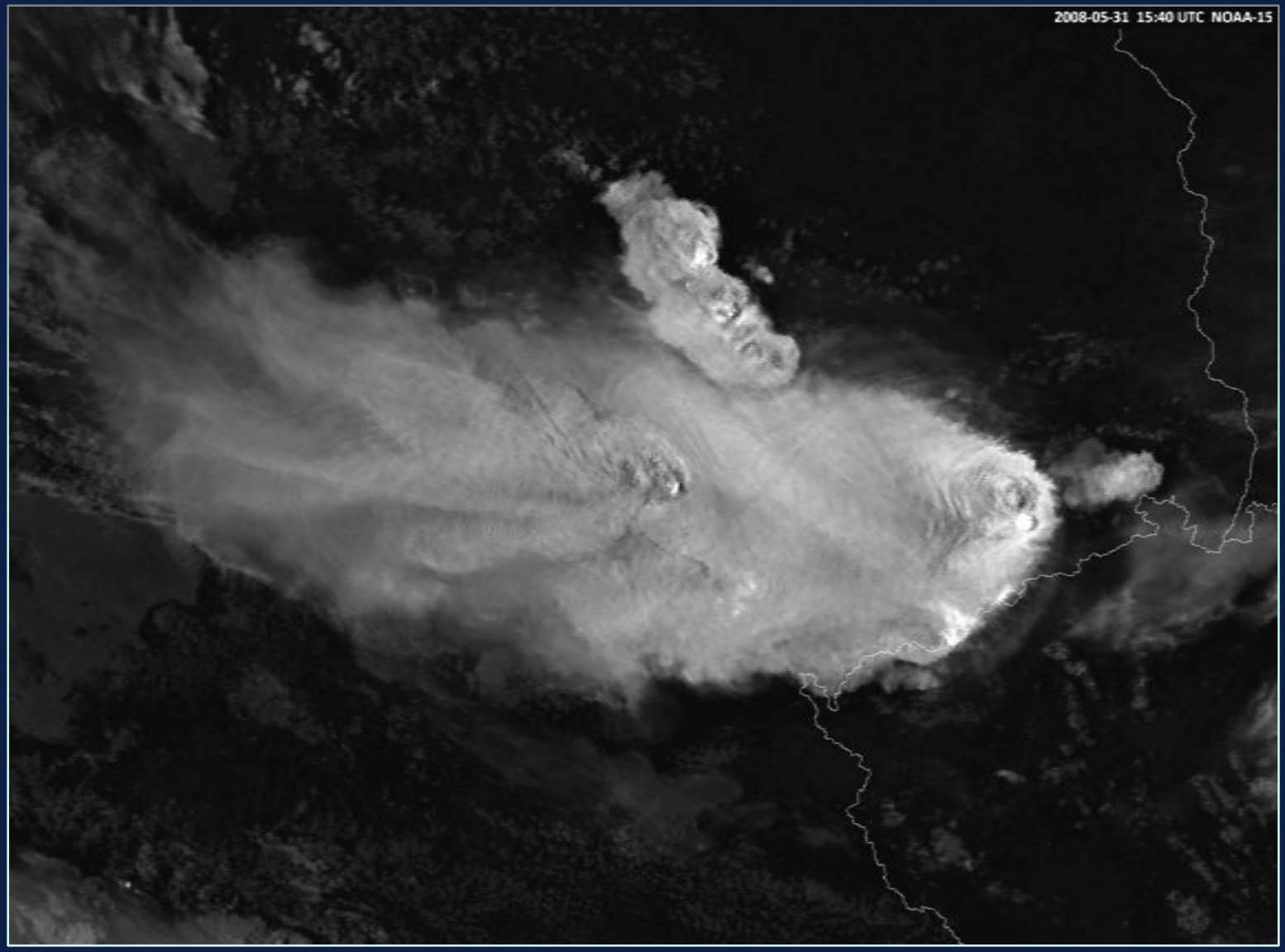
31 May 2008 15:40 UTC, Germany



AVHRR band 3B (3.7 μm) - no enhancement, raw image

Image enhancement – example:

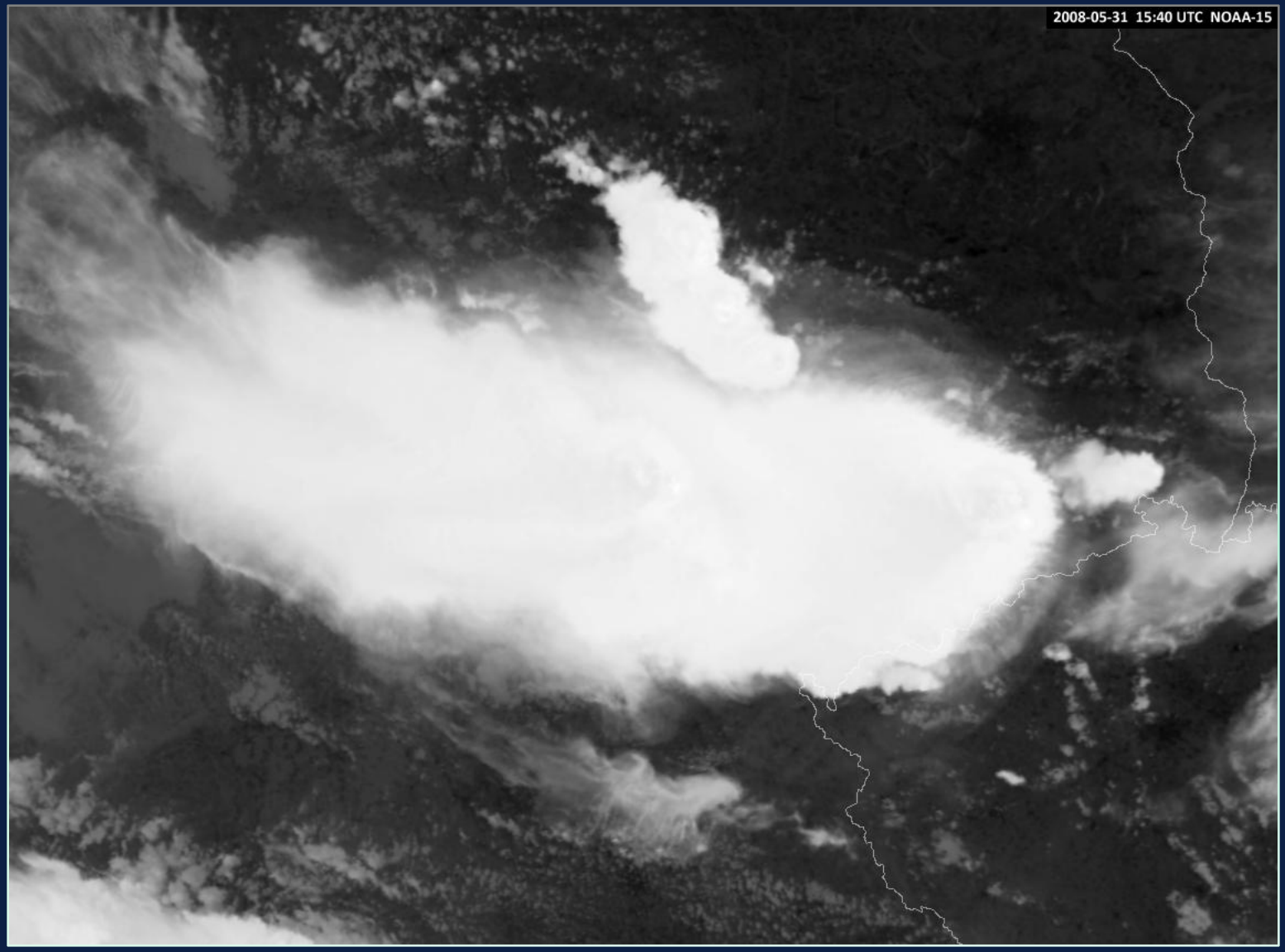
31 May 2008 15:40 UTC, Germany



AVHRR band 3B (3.7 μm) - enhanced (BTD b3-b4 image)

Image enhancement – example:

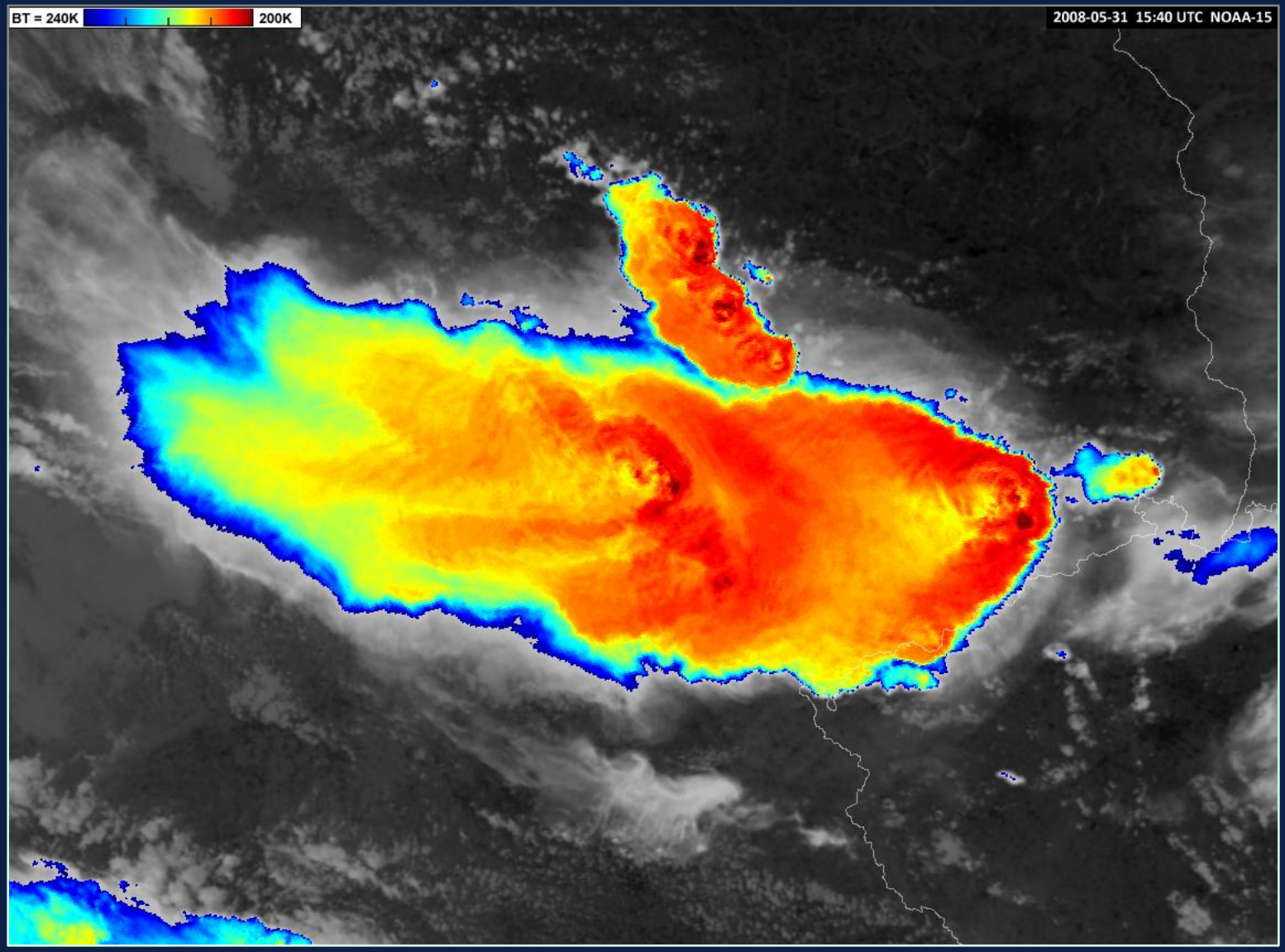
31 May 2008 15:40 UTC, Germany



AVHRR band 4 (10.8 μm) BT - no enhancement

Image enhancement – example:

31 May 2008 15:40 UTC, Germany



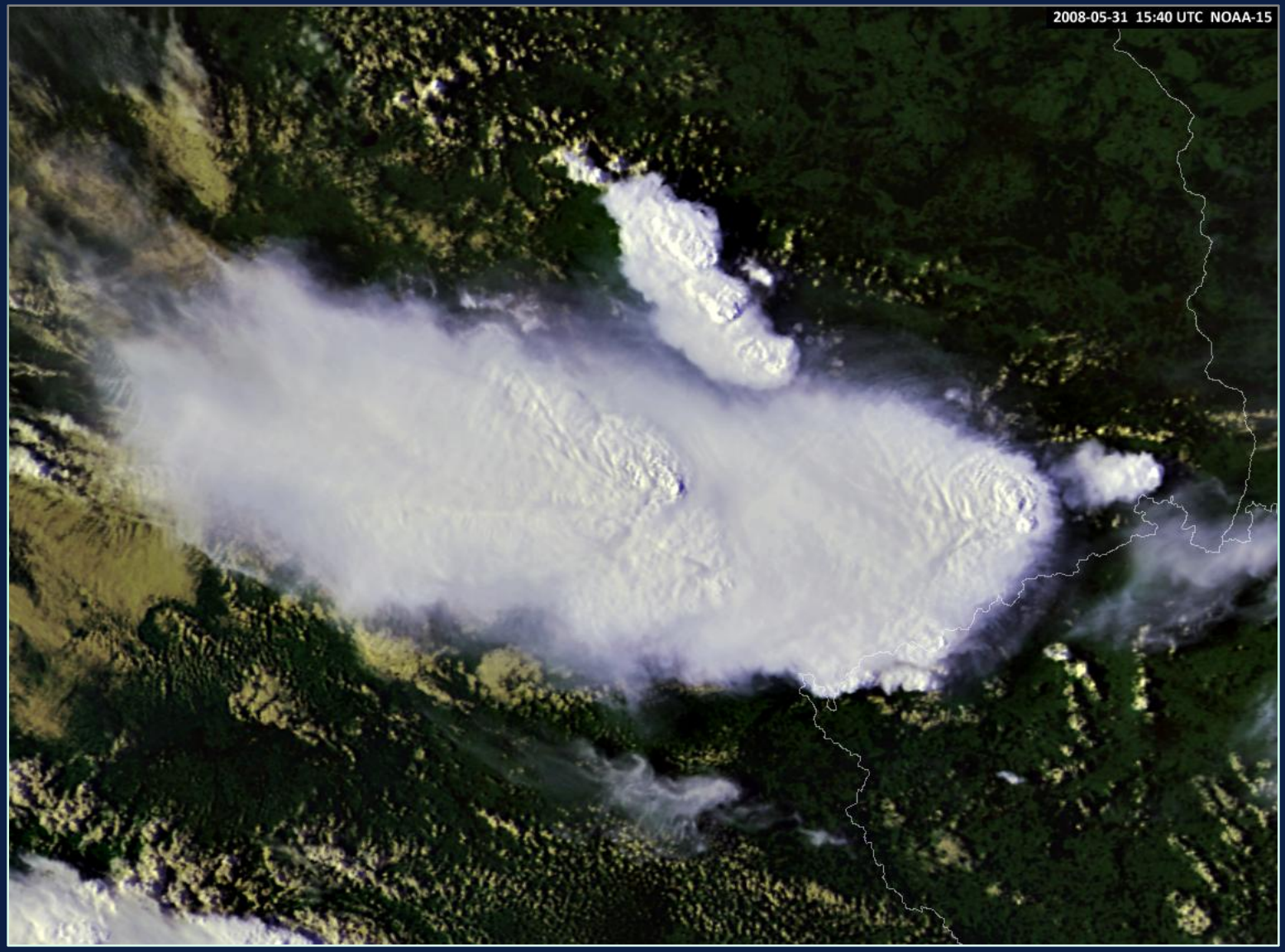
AVHRR band 4 (10.8 μm) BT - ***color enhanced***

Image enhancement

Use of single-band enhanced images as an input for “advanced” products – in the RGB composite images and in the sandwich products …

Image enhancement – example:

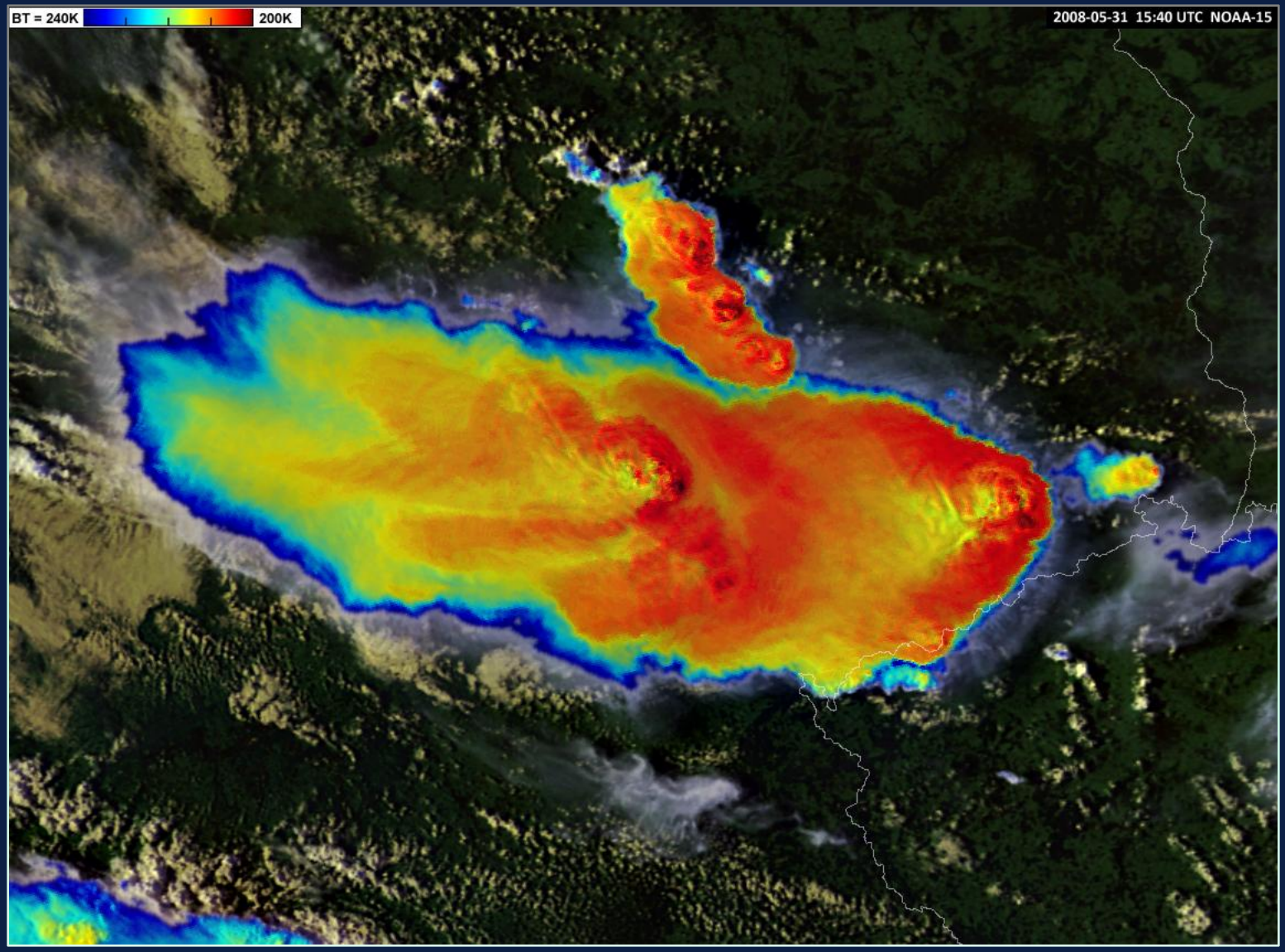
31 May 2008 15:40 UTC, Germany



AVHRR RGB image – composite of bands 1, 2 and 4 (fine-tuned in Photoshop CS3)

Image enhancement – example:

31 May 2008 15:40 UTC, Germany

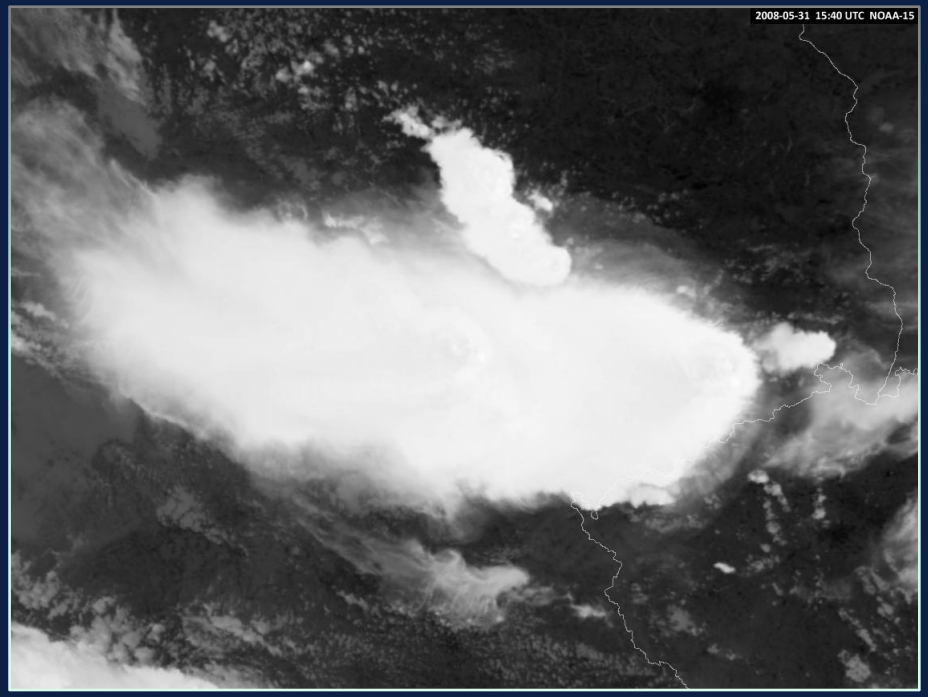


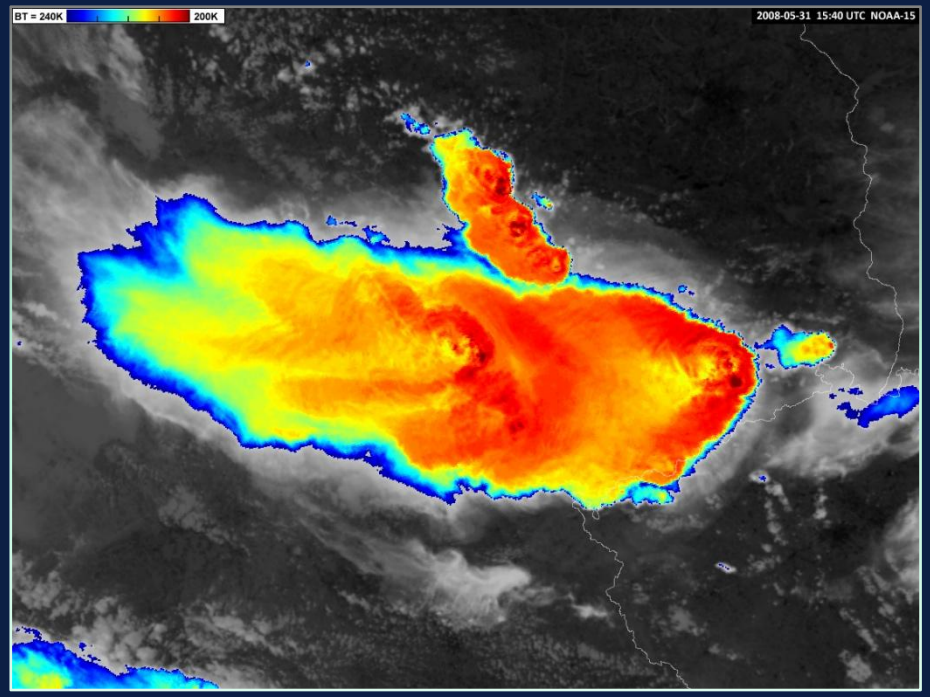
AVHRR IR-BT sandwich product – blended RGB124 image and color-enhanced b4 BT image

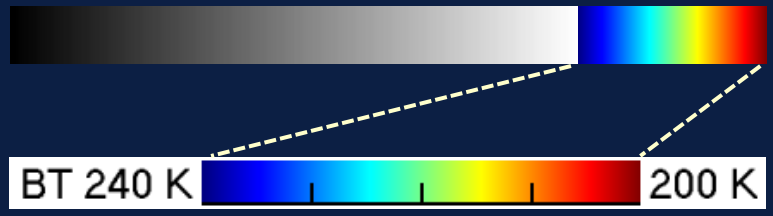
Enhancement of the IR window imagery

… with focus at the Brightness Temperature (BT) enhancement and the color schemes

Color enhancement of IR-window 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 representing a smaller BT interval).

Color enhancement of IR-window imagery

Why the color enhancement? What is it good for?

To enable or to ease detection of various cloud-top features, related to storm dynamics, structure and possible storm severity – such as overshooting tops, cold-U/V (enhanced-V) or cold-rings, embedded warm spots/areas, ...

Color enhancement of IR-window imagery

Possible problems with assignment of colors (color “schemes”) used for the purposes of the color enhancement, different color palettes used by various users – uneasy interpretation, necessity to “get used” to the color schemes used by the others …

Color enhancement of IR-window imagery

Possible problems with assignment of colors (color "schemes") used for the purposes of the color enhancement, different color palettes used by various users – uneasy interpretation, necessity to "get used" to the color schemes used by the others …

Example: color enhancement of the GOES and AVHRR IR imagery used for many years in the U.S. (step-scale enhancement) versus the "smooth" IR color enhancement recently recommended by the Convection Working Group (CWG, http://www.convection-wg.org/) of EUMETSAT and ESSL …

Image enhancement – different color schemes

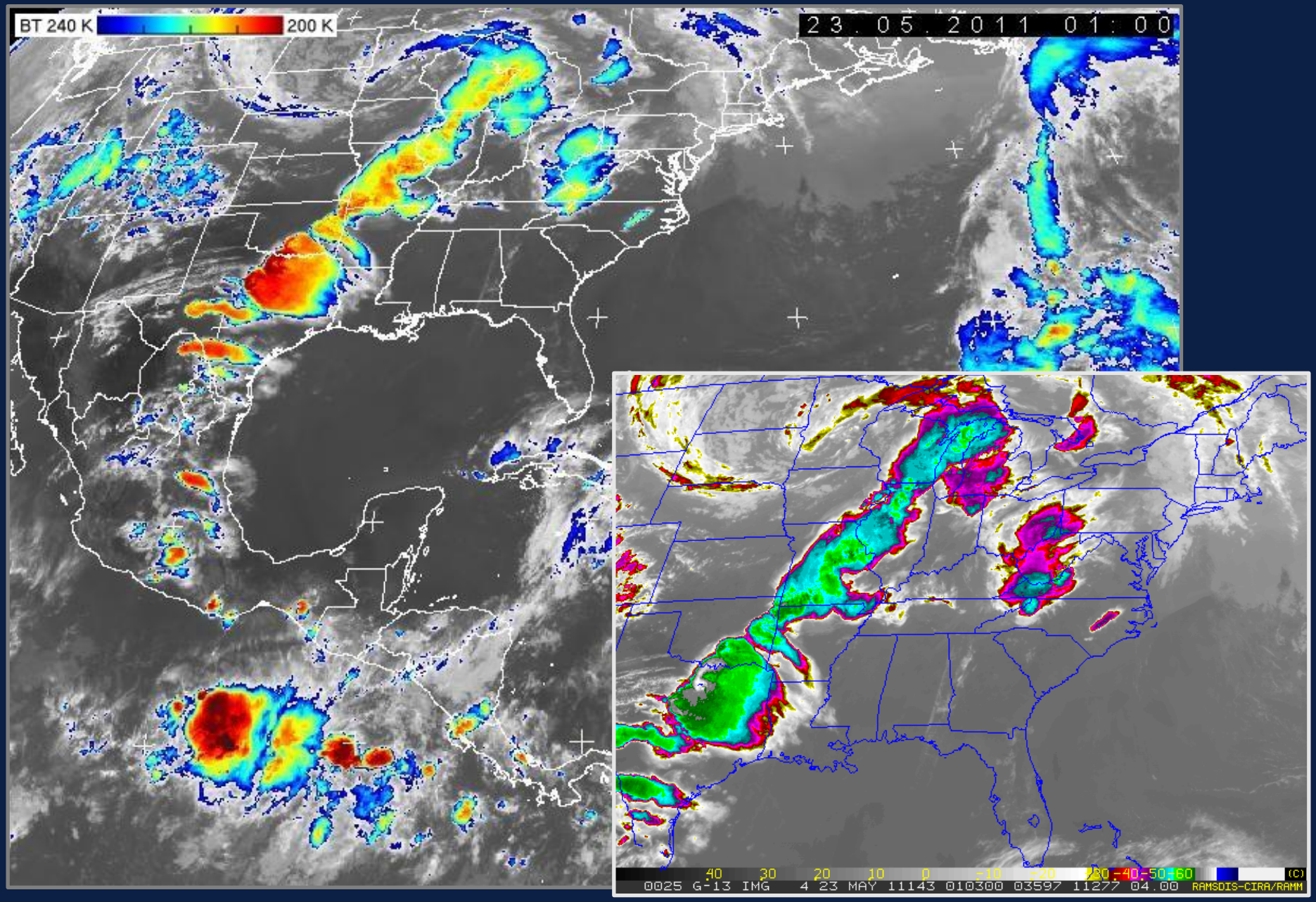
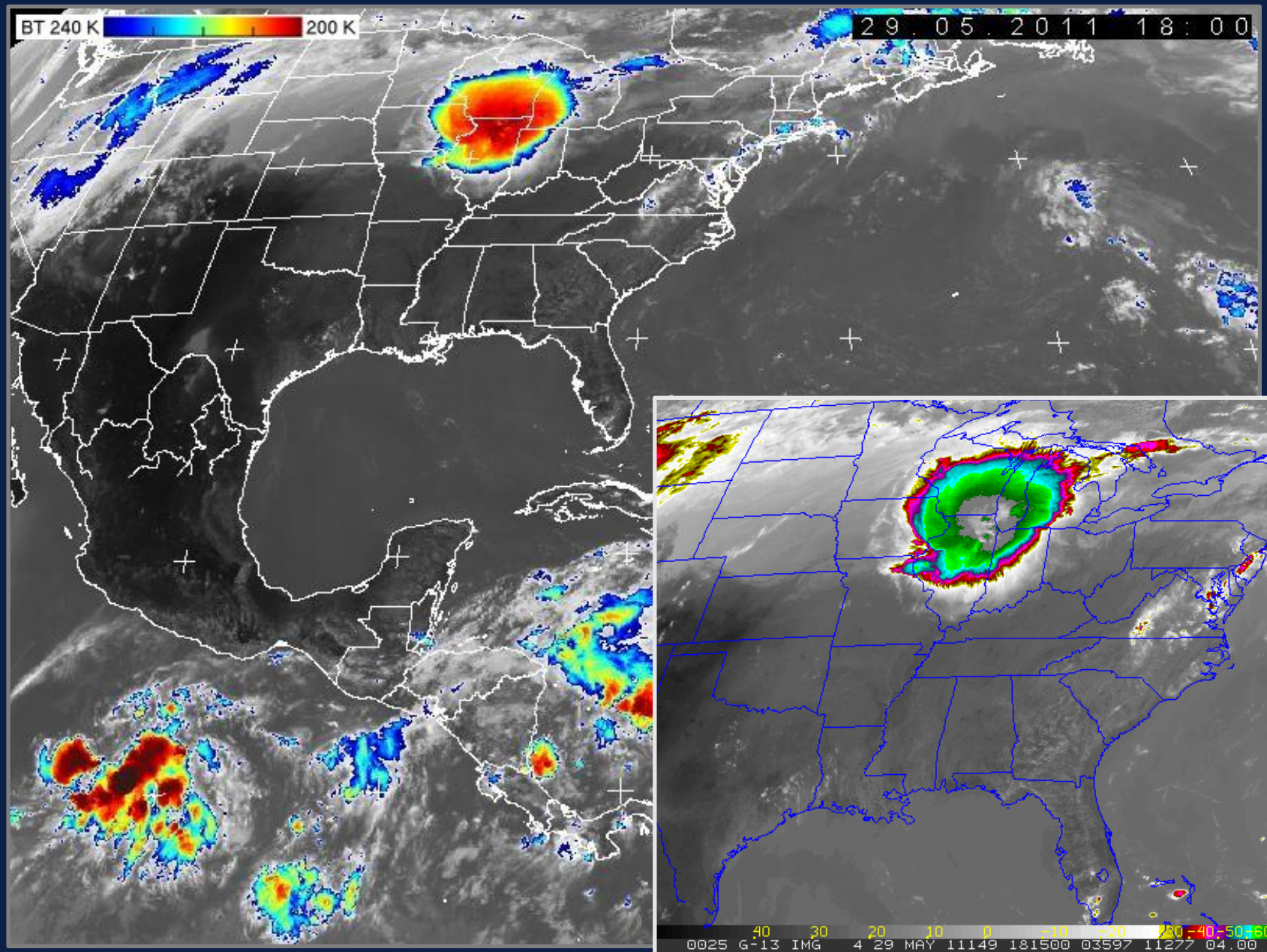
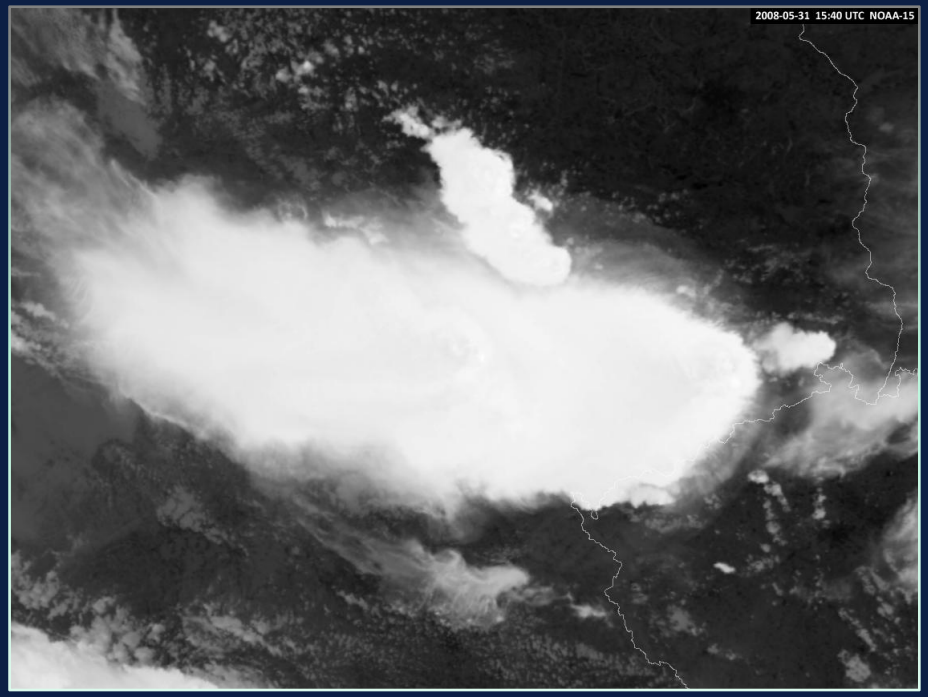
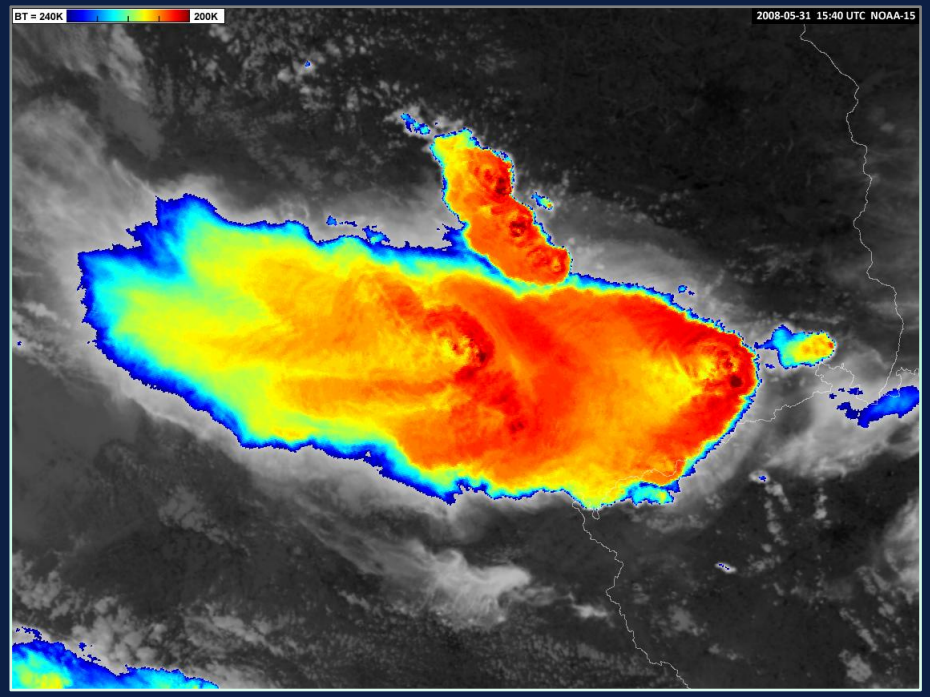


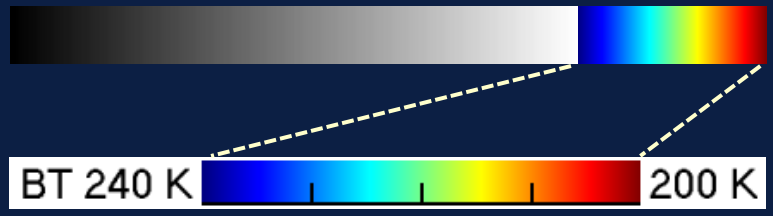
Image enhancement – different color schemes



Color enhancement of IR-window imagery (recommended by EUMETSAT/CWG)

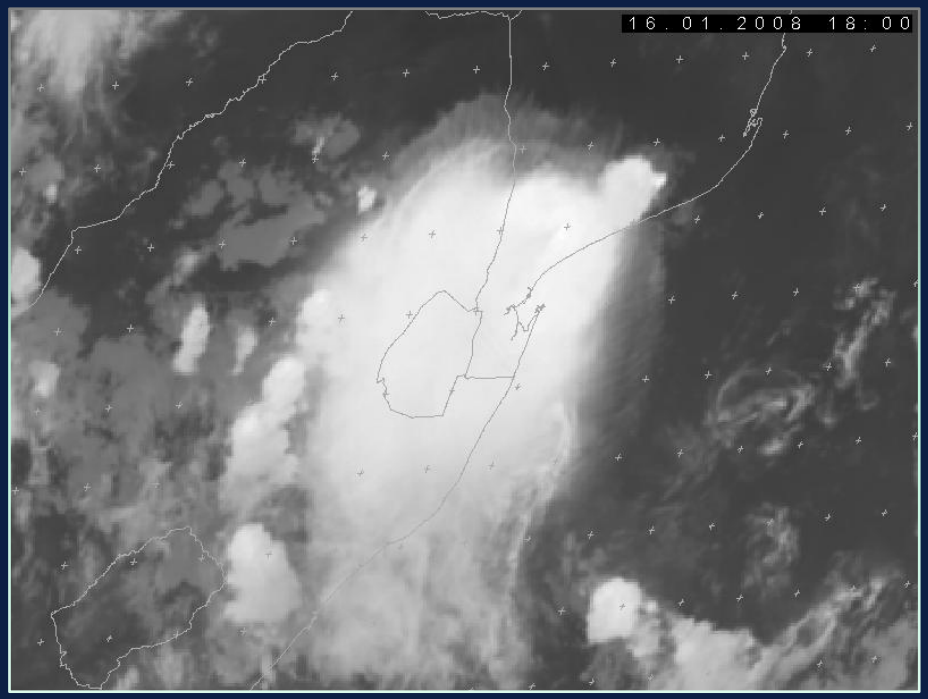


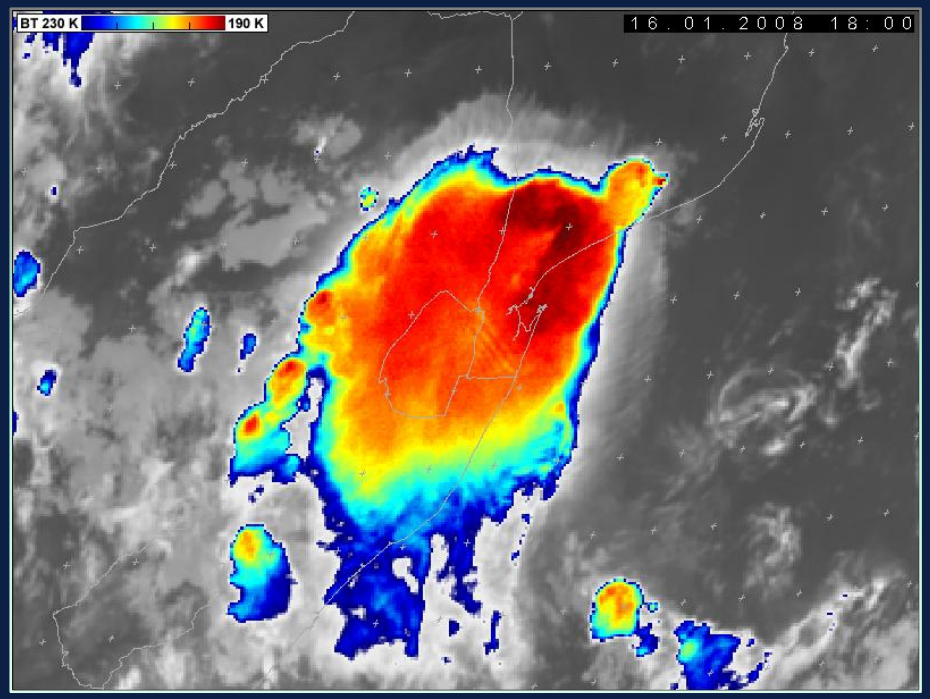


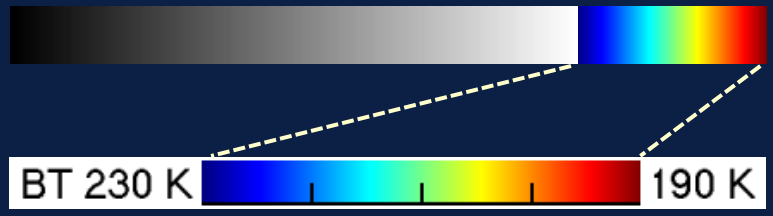


This specific brightness temperature range (***BT 240K-200K***) of the color enhancement is suitable for typical (central) European storms; however in some cases or for other geographic regions it may need some adjustment (shift and/or stretch of the brightness temperature range represented in colors), mainly depending on the tropopause temperature and height.

Color enhancement of IR-window imagery (recommended by EUMETSAT/CWG)







For lower latitudes (tropics, sub-tropics and southernmost regions of mid-latitudes) the BT scale needs to be shifted to about ***230K-190K*** or even ***220K-180K***, depending on the tropopause temperature/height.

Image enhancement – color scale shift

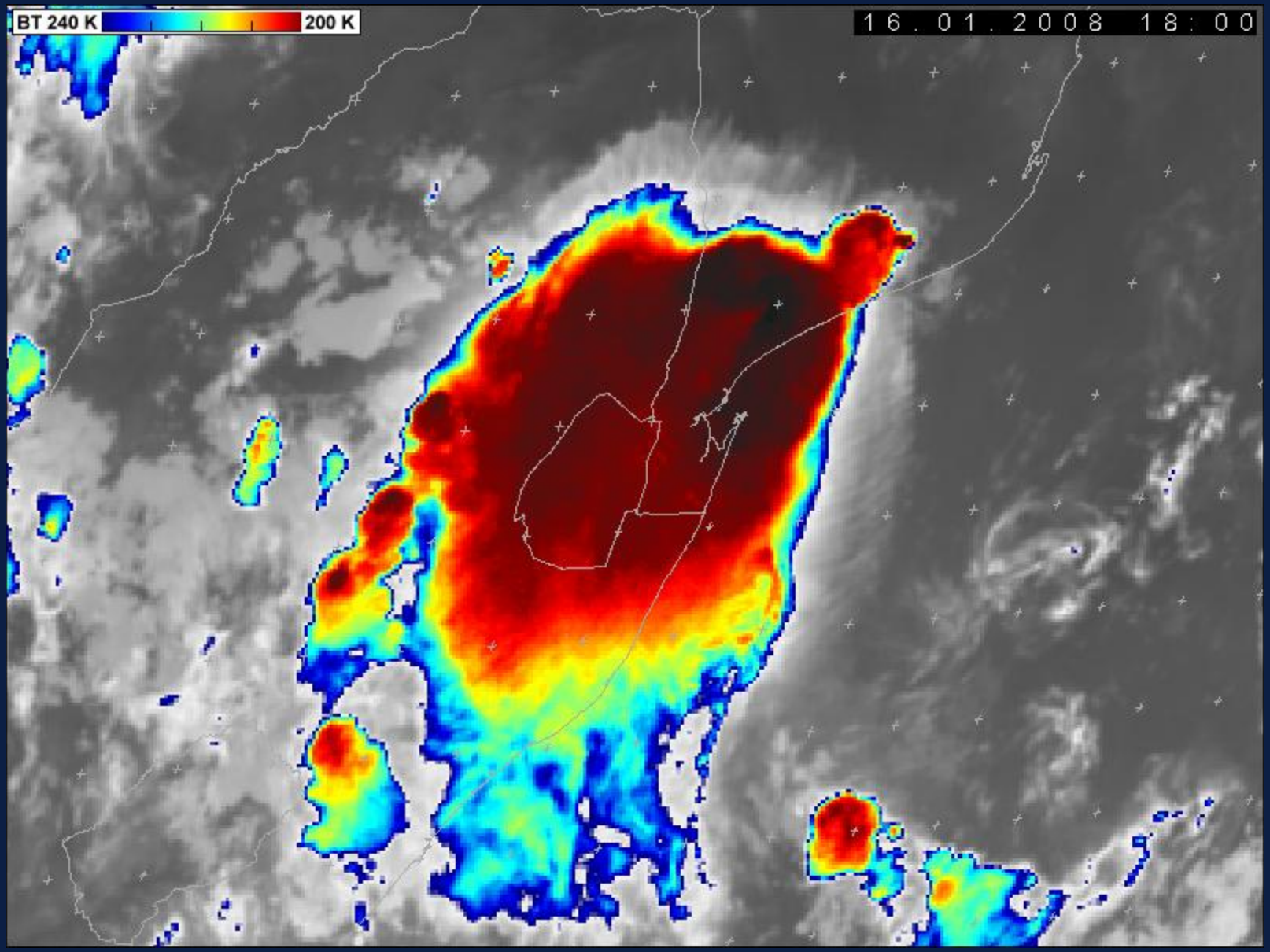
The next few slides document how the storm-top appearance changes with a shift of the color-scale range to the lower temperatures …

… necessity to find the most suitable enhancement for a given geographical region.

(storms at southern parts of Africa, at about 25°S)

Image enhancement – color scale shift

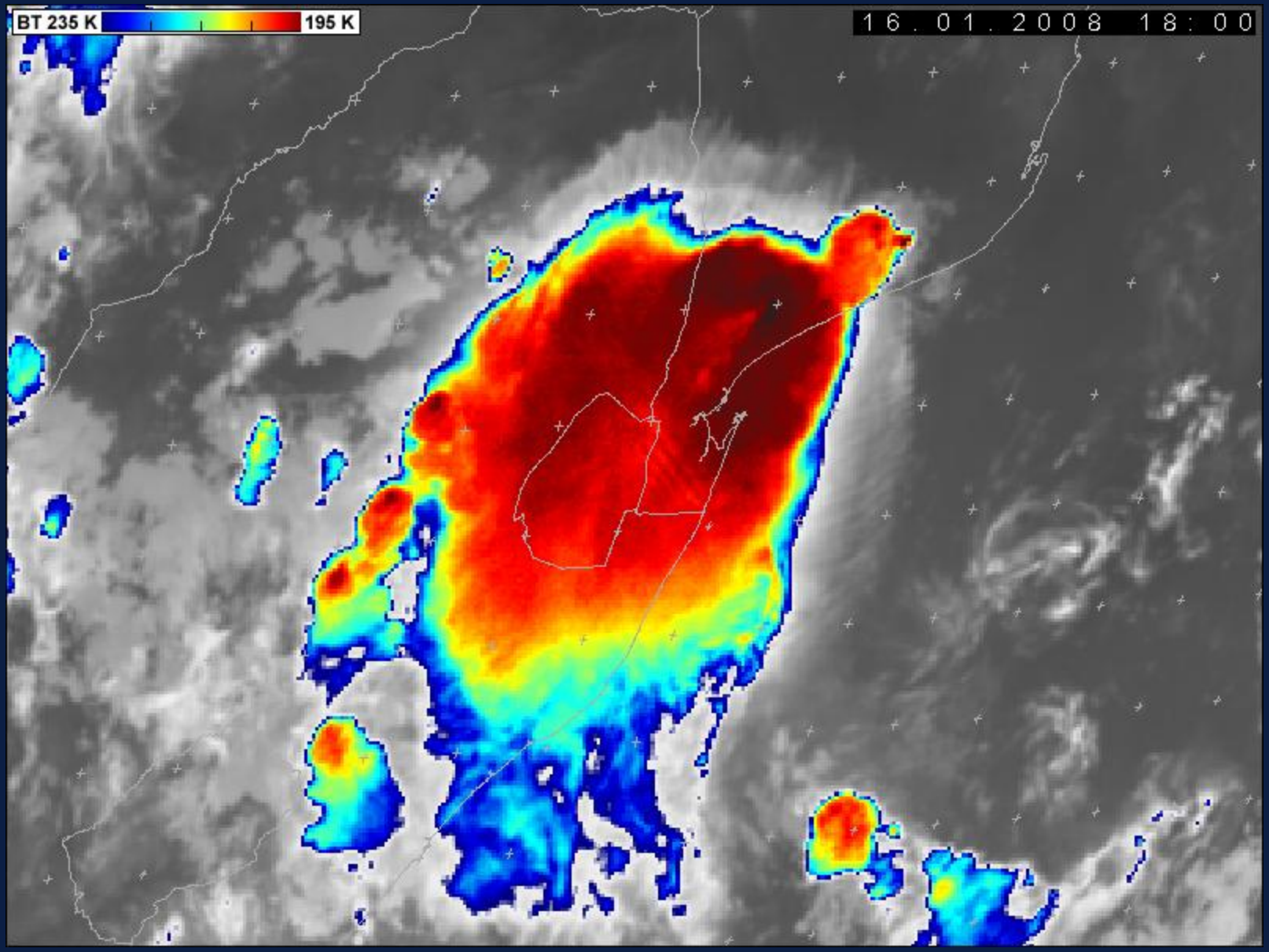
2008-01-16 18:00 UTC Meteosat-9, IR10.8 BT



South Africa, Swaziland and Mozambique

Image enhancement – color scale shift

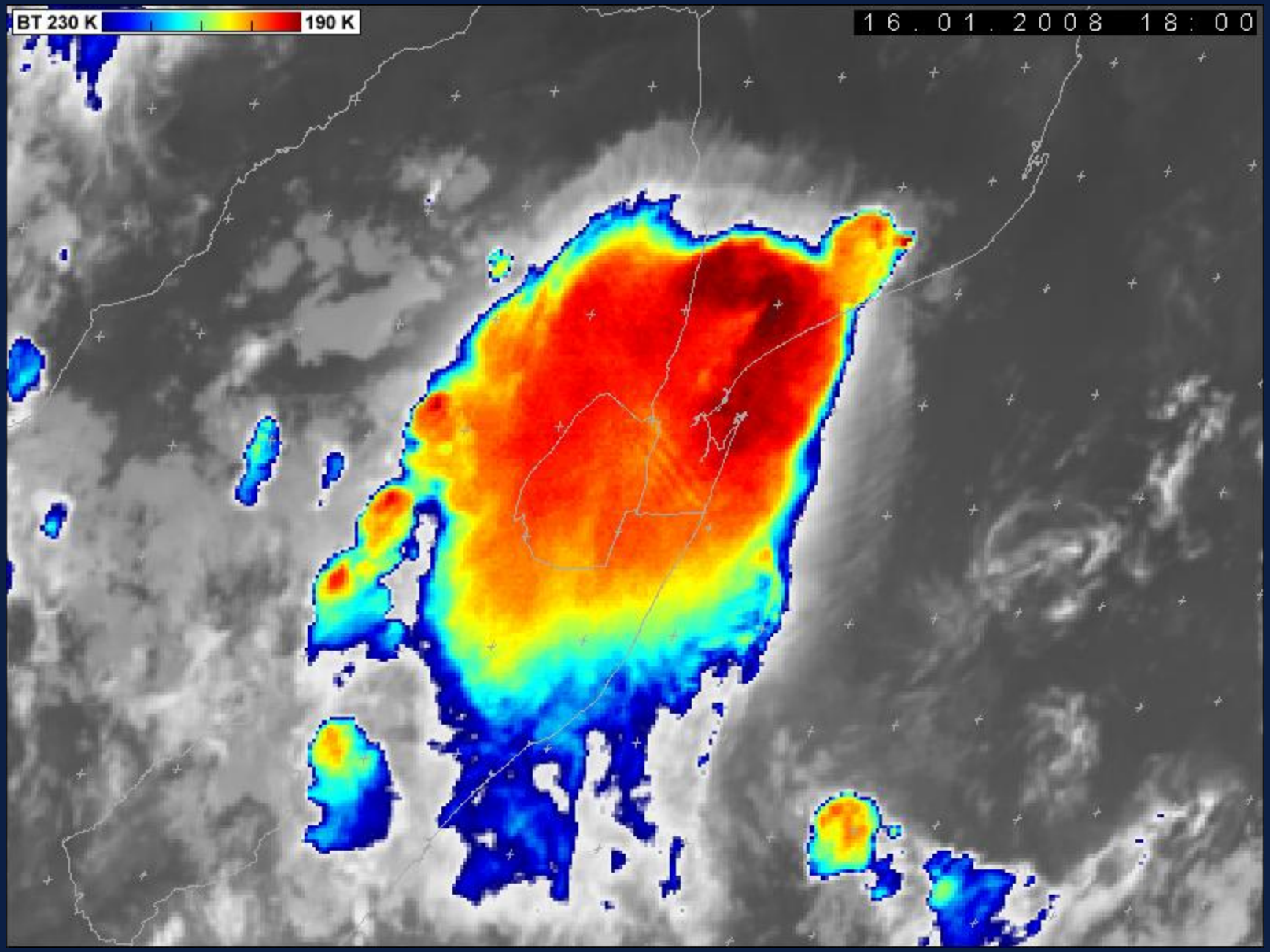
2008-01-16 18:00 UTC Meteosat-9, IR10.8 BT



South Africa, Swaziland and Mozambique

Image enhancement – color scale shift

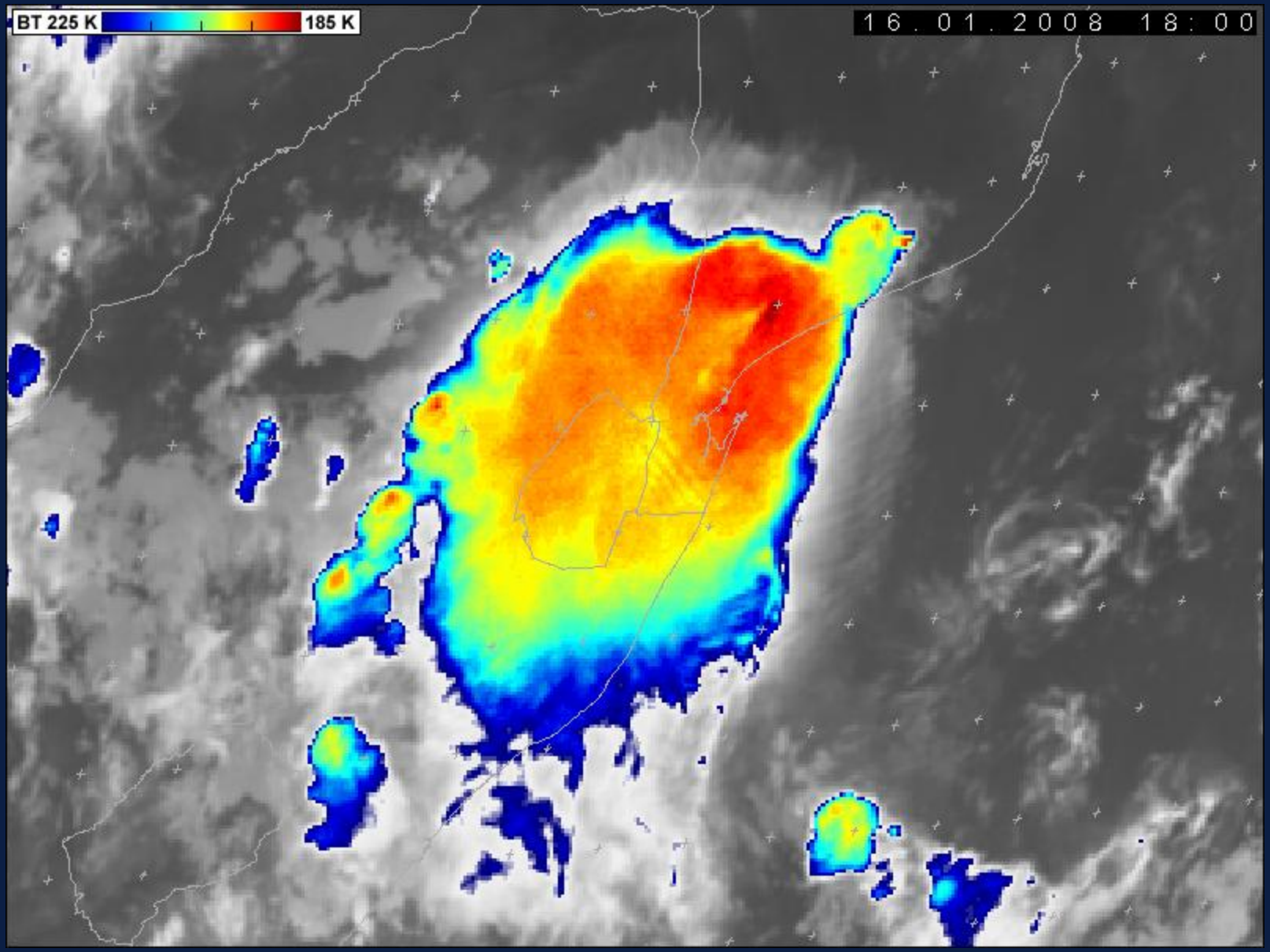
2008-01-16 18:00 UTC Meteosat-9, IR10.8 BT



South Africa, Swaziland and Mozambique

Image enhancement – color scale shift

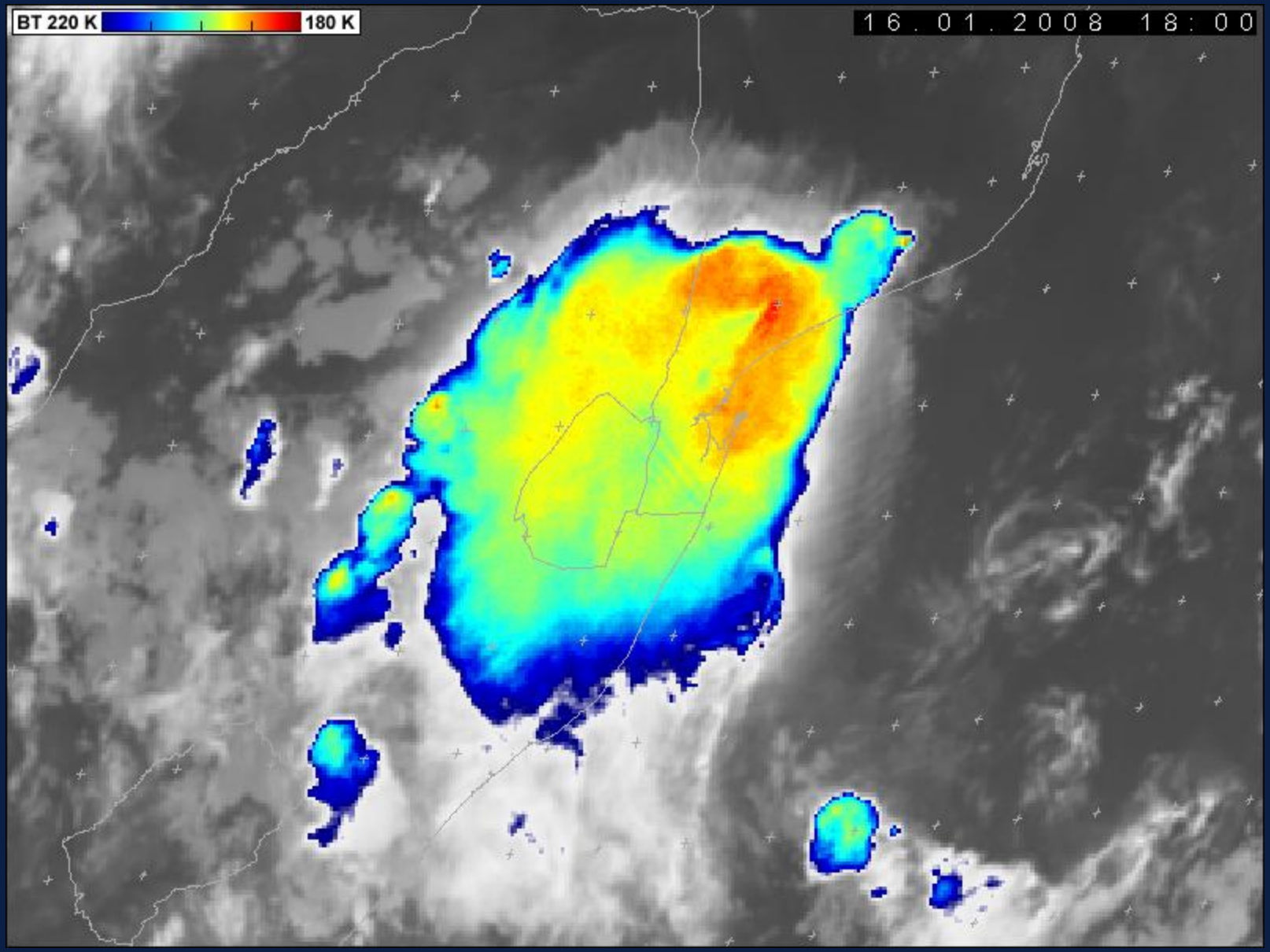
2008-01-16 18:00 UTC Meteosat-9, IR10.8 BT



South Africa, Swaziland and Mozambique

Image enhancement – color scale shift

2008-01-16 18:00 UTC Meteosat-9, IR10.8 BT



South Africa, Swaziland and Mozambique

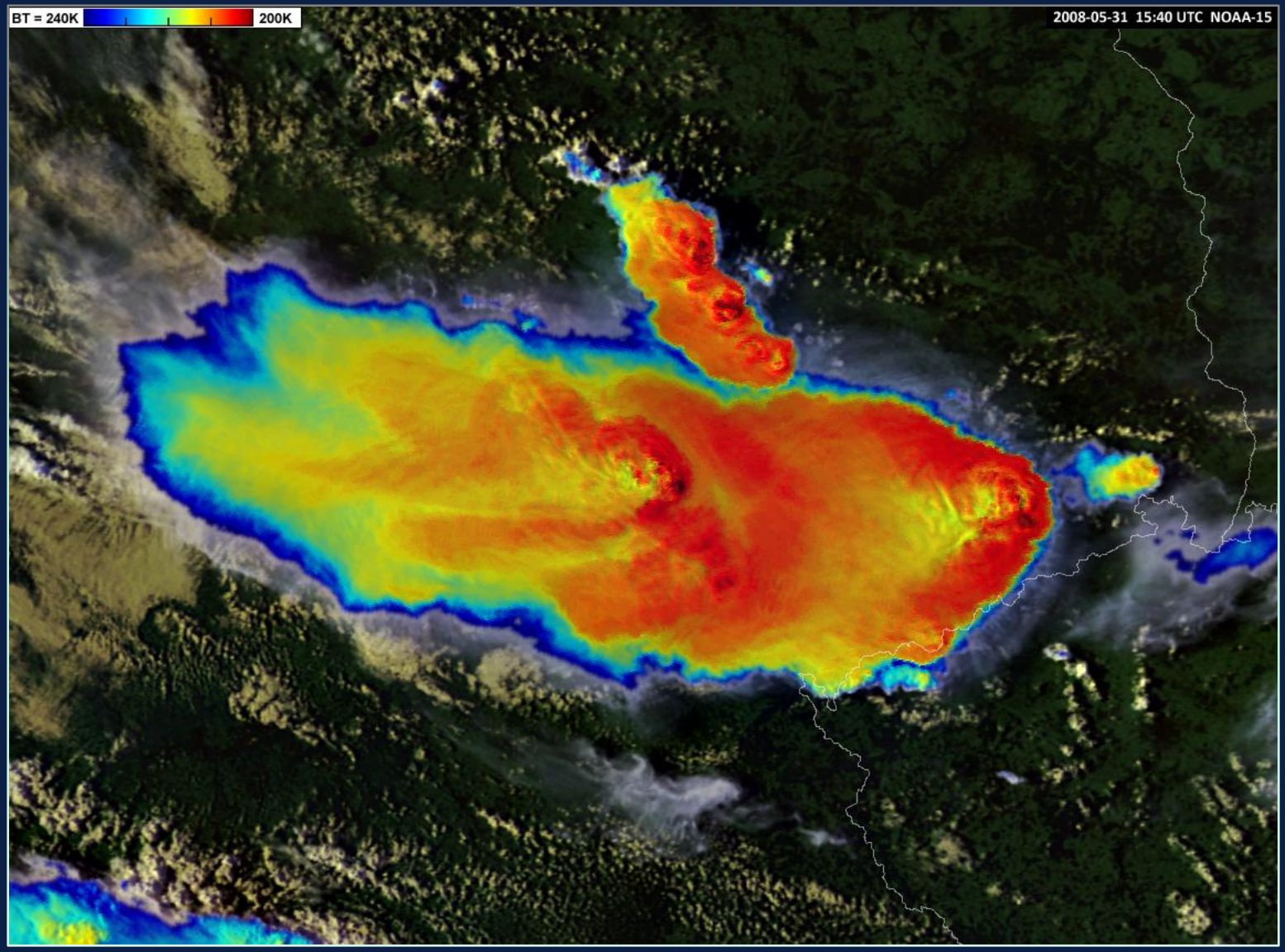
Image enhancement – color scale shift

The next two slides illustrate that even for the mid-latitudes it may be sometimes (for extremely cold tops) useful to shift or broaden the color-scale range to lower temperatures …

(demonstrated using the IR-BT sandwich product)

Image enhancement – color scale shift

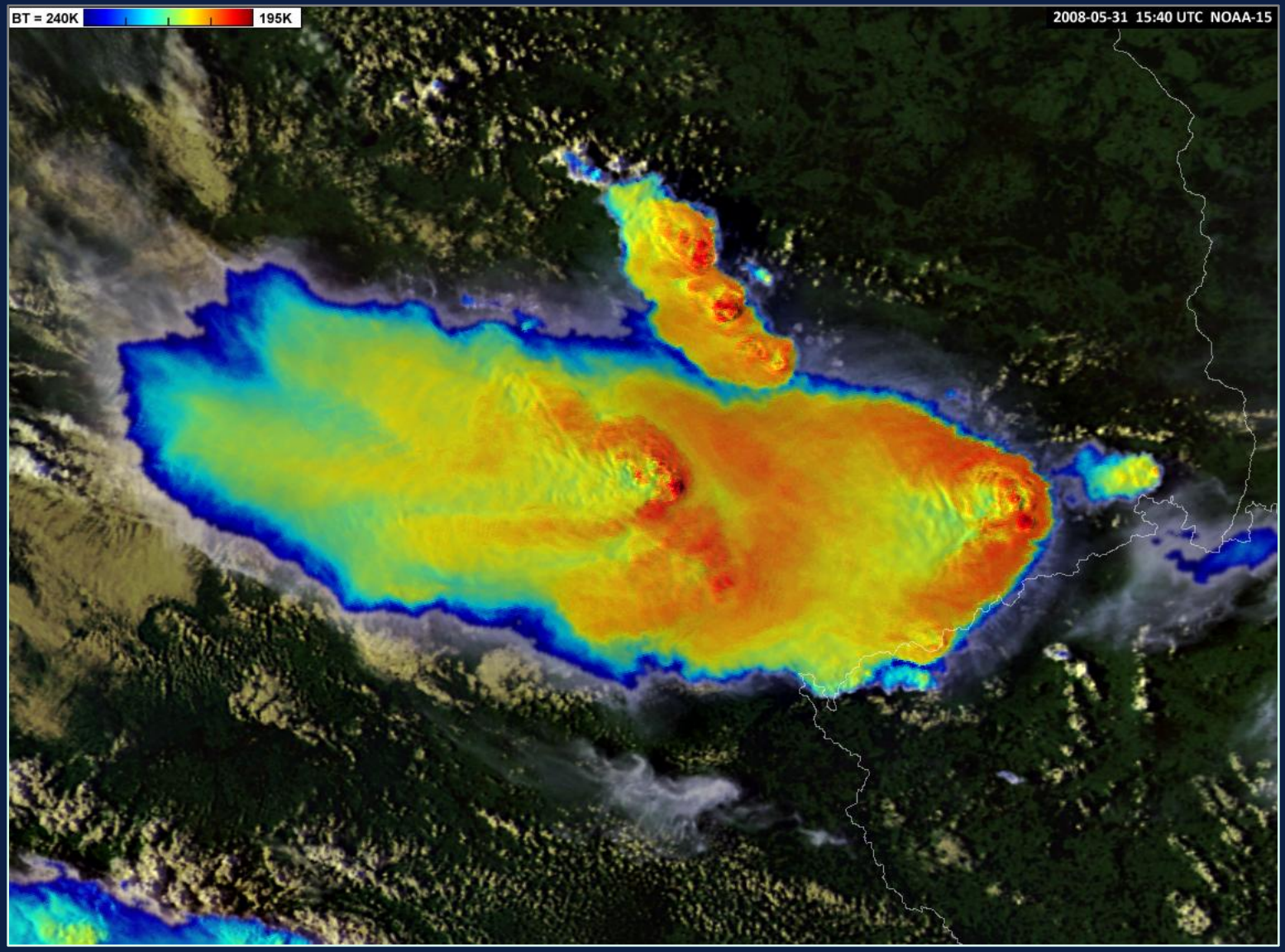
31 May 2008 15:40 UTC, Germany



AVHRR IR-BT sandwich product – range 200 K … 240 K

Image enhancement – color scale shift

31 May 2008 15:40 UTC, Germany



AVHRR IR-BT sandwich product – range 195 K … 240 K

Image enhancement – color scale shift

Sometimes just the opposite – storms with warm tops …

(15 August 2010 Prague hailstorm)

Image enhancement – color scale shift

2010-08-15 18:00 UTC Meteosat-8, IR10.8 BT

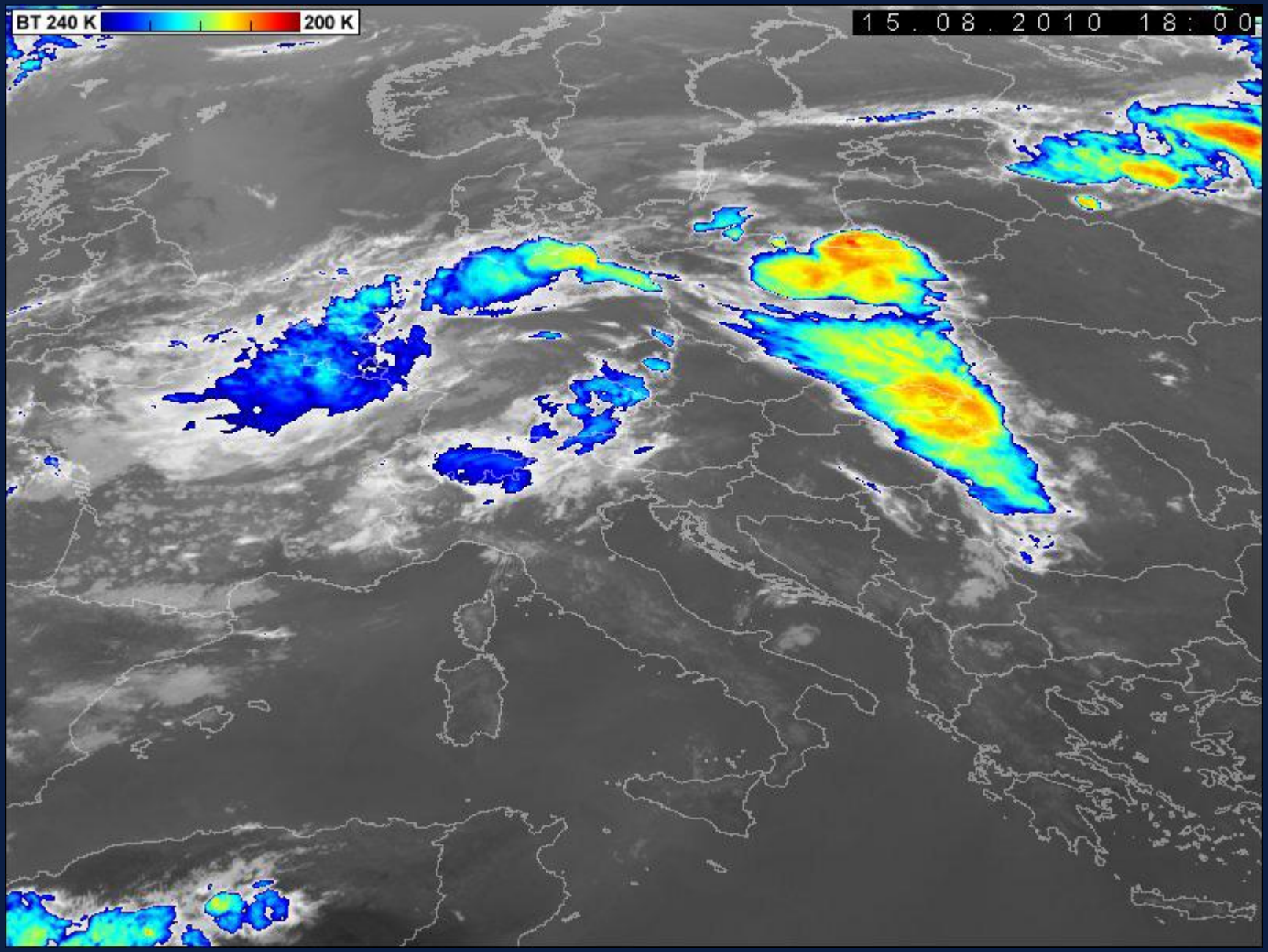


Image enhancement – color scale shift

2010-08-15 18:00 UTC Meteosat-8, IR10.8 BT

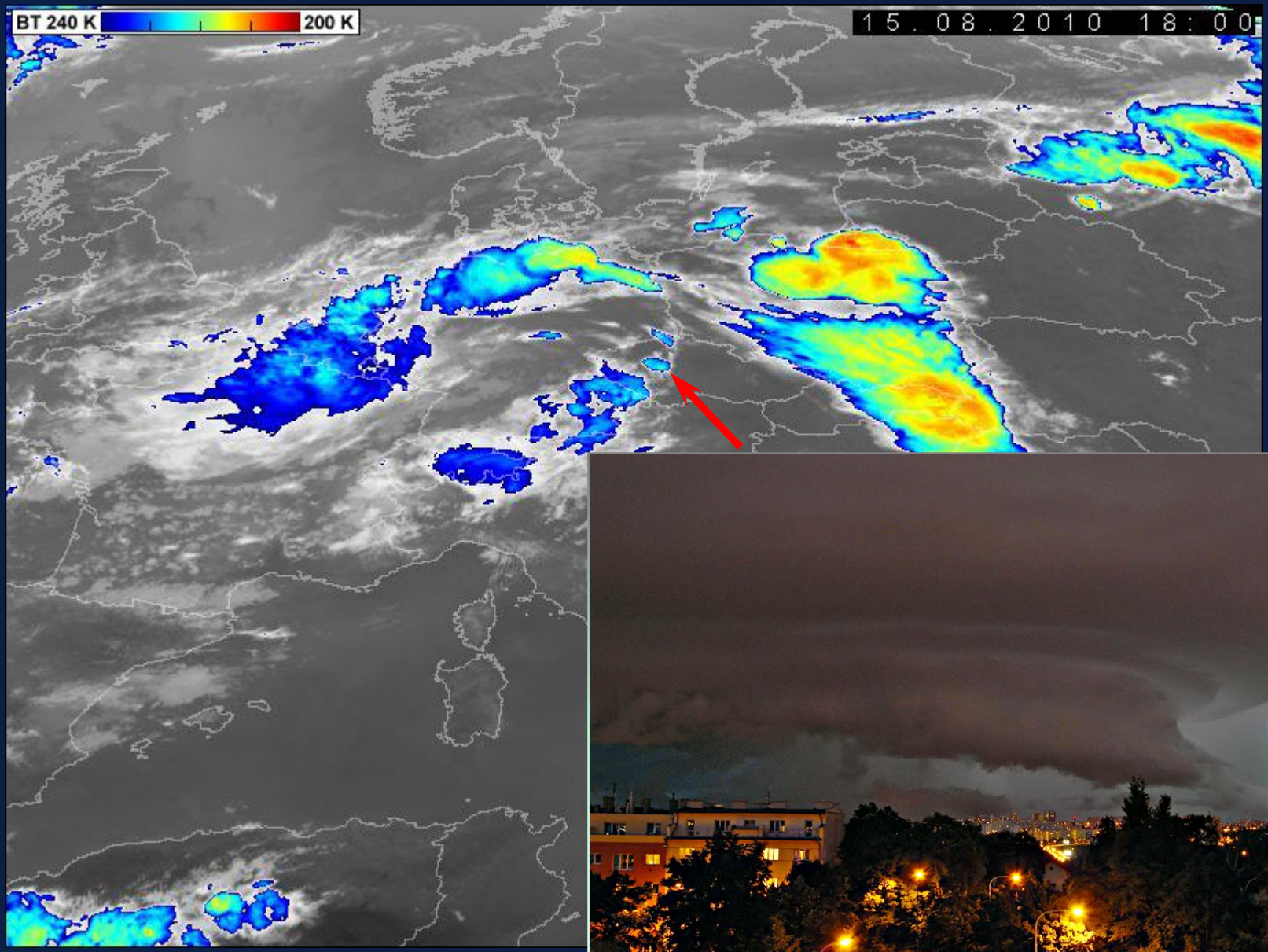
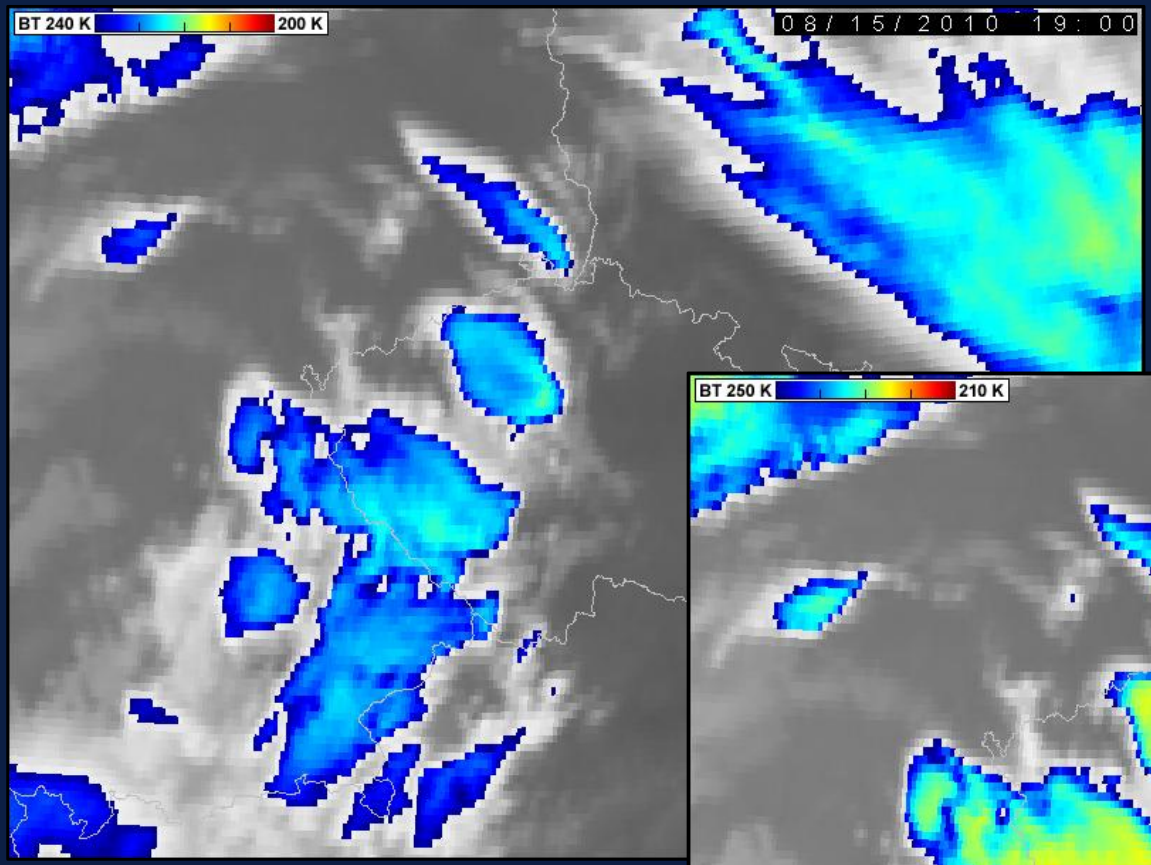
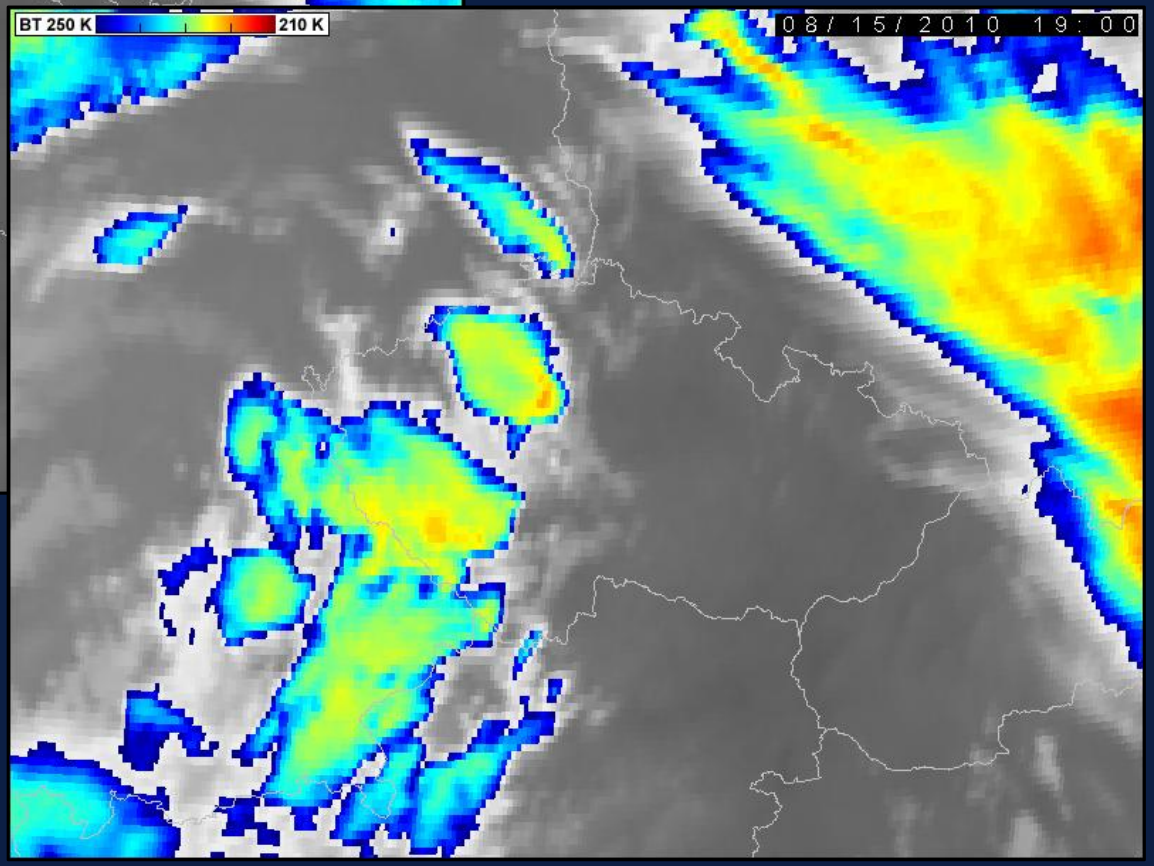


Image enhancement – color scale shift



BT 240K – 200K



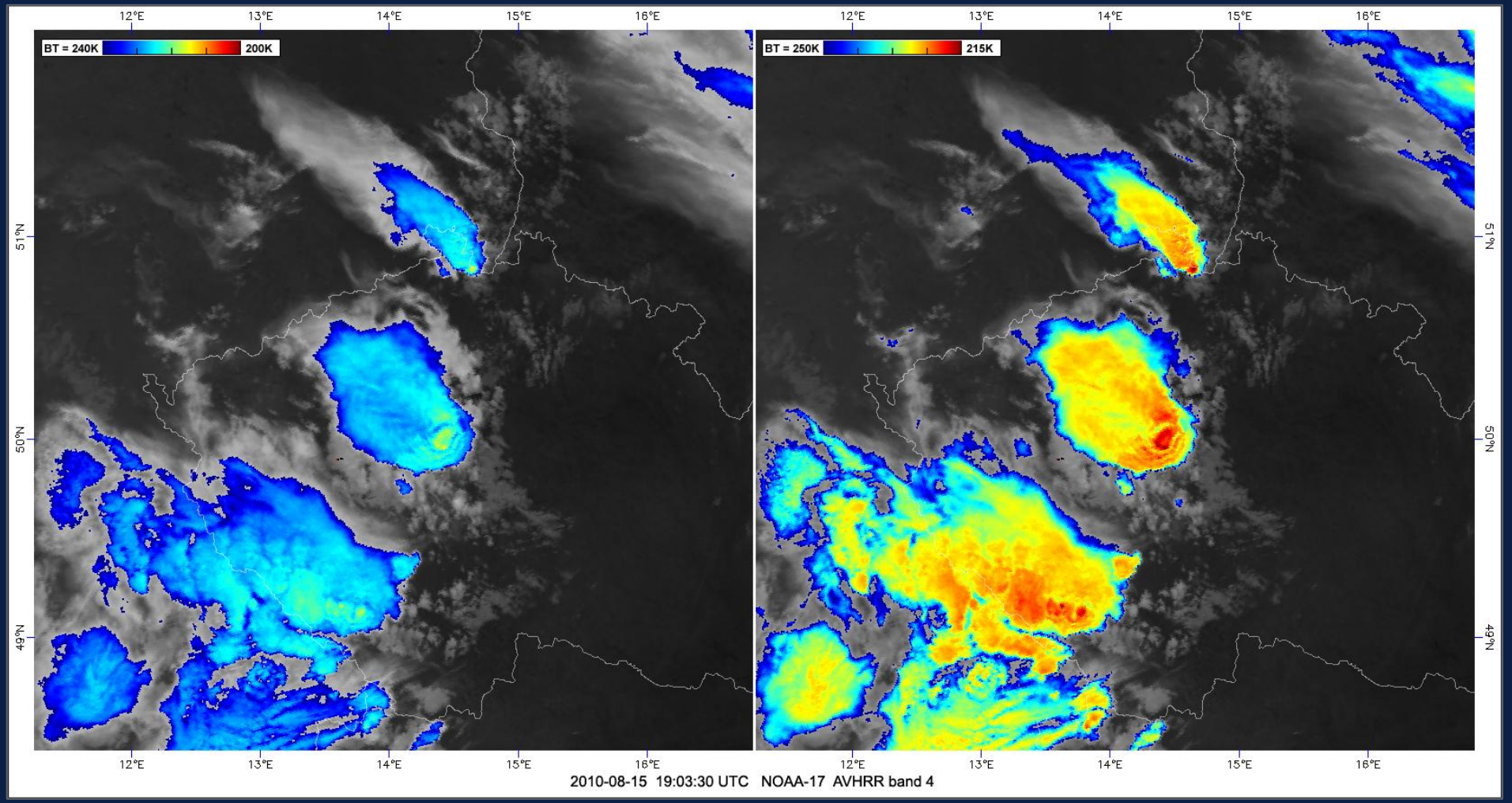
BT 250K – 210K

2010–08–15 19:00 UTC
Meteosat-8 (MSG-1) RSS

IR10.8 BT

Image enhancement – color scale shift

2010-08-15 19:03 UTC NOAA-17 IR10.8 BT



BT 240K – 200K

BT 250K – 215K

Image enhancement – color scale shift

To shift or not to shift (the color scale) – that is the question …

- possibility of automatic (operational) shifting/stretching of the color scale according to the actual (or forecasted) tropopause height and/or temperature
- several "pros" and "cons" … to be discussed as your homework

---

Poll: how many of you, in your institutions, use regularly (operationally) the color-enhanced IR imagery?

(click "Yes" or "No")

Image enhancement – color scale shift

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Poll: how many of you, in your institutions, regularly use (operationally) the color-enhanced IR imagery?

(click "Yes" ✔ or "No" ✘)

Color enhancement of IR-window imagery (recommended by EUMETSAT/CWG)

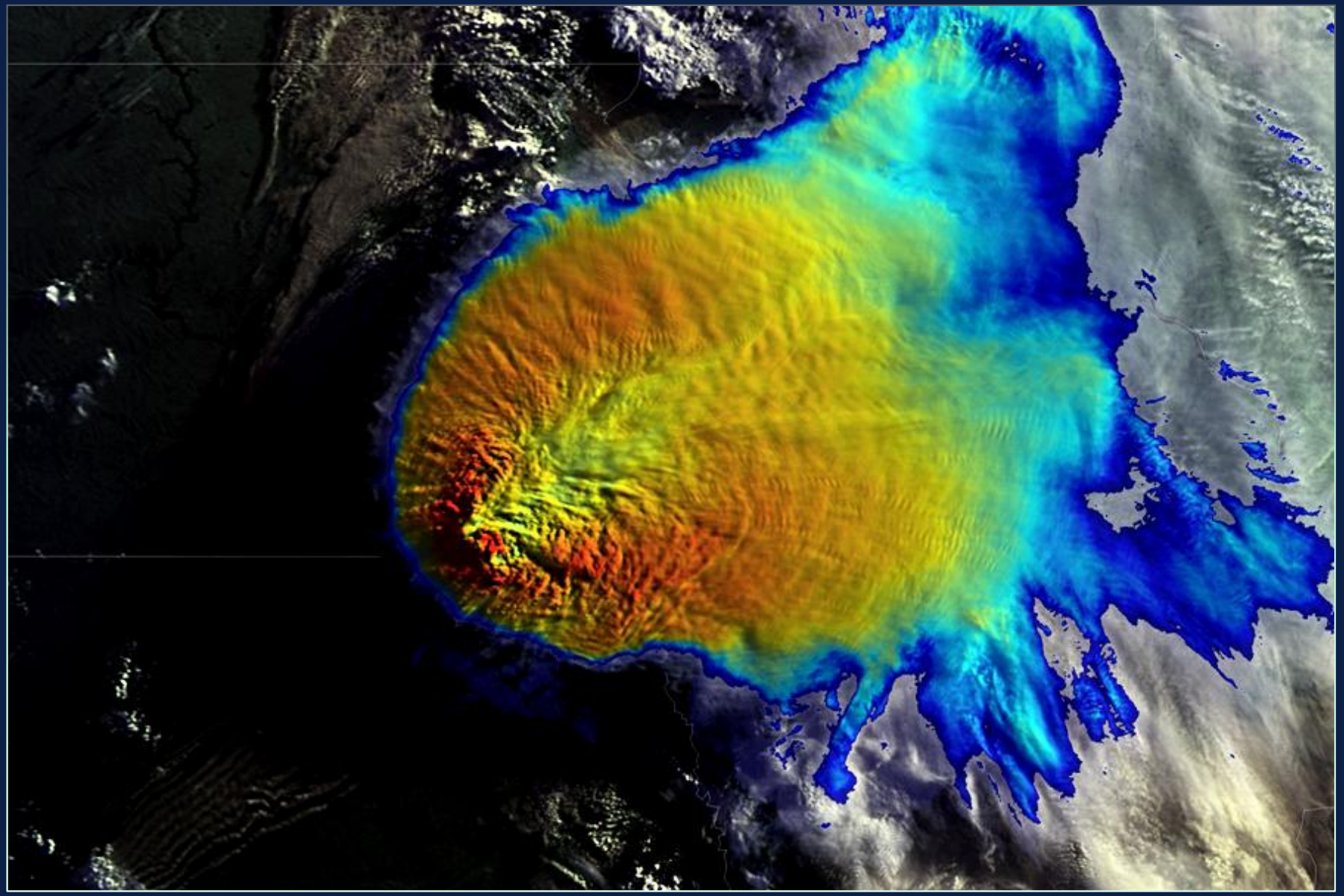
Why red for the coldest temperatures?

- For a human, red is typically associated with some form of "danger";
- in satellite IR imagery, the highest "overshooting" or "penetrating" tops of convective storms are typically represented by the coldest pixels in the image, and at the same time these represent the core of the storm, thus the most active and dangerous part of it;
- By Wien's displacement law, red stands for cold, blue for hot (similar as with the colors of stars – red stars being the cold ones, blue stars the hot ones)

More information and examples at the Convection Working Group website
http://www.convection-wg.org/color_enhancement.php

and in the EUMETSAT Case studies gallery
http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20080116_convection/20080116_convection.html

THE END ...



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