Australian Government
Bureau of Meteorology

Australian VLab Centre of Excellence

National Himawari-8
Training Campaign

The Day Convection RGB product

Compiled by Bodo Zeschke, BMTC, Australian Bureau of Meteorology, using information from various sources, May 2015

Australian Government
Bureau of Meteorology

Learning Outcomes

At the end of this exercise you will:

- Have a basic knowledge how the Day Convection RGB product is constructed from multiple satellite channels and the physics and meteorology underpinning this.
- Have a better understanding of the advantages and the limitations of the Day Convection RGB product
- Through using the EUMETSAT ePort gain a "hands on experience" in using this RGB product in combination with other observations, Derived Products and Numerical Weather Prediction (NWP) models.
- Have a better appreciation of using the Day Convection RGB product when monitoring, nowcasting and short term forecasting of thunderstorms.

- Note – corresponding WMO-1083 Capabilities and BOM Enabling Skills are given in Appendix 1.

Contents

Introduction

- The many channels of Himawari-8
- The seven WMO endorsed RGB products

Familiarisation with the RGB product

- Colour blindness test
- How the RGB product is created (channel combination recipe, beams explained)
- Identifying features in the RGB product and relating this to the palette
- Complications in the imagery

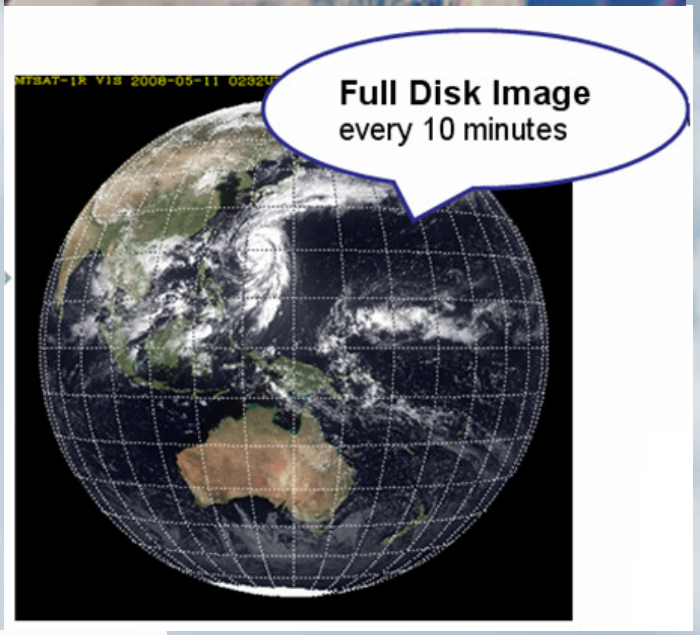
Case Study

- Displaying the data (EUMETSAT ePort)
- Comparing the RGB product with single channel data, overlaying model fields, Derived Products etc.
- Examining the RGB product in animation

Summary and Appendix – useful reference material

The Japanese Geostationary Satellites Himawari 8/9

Band	Central Wavelength [μm]	Spatial Resolution
1	0.43 - 0.48	1Km
2	0.50 - 0.52	1Km
3	0.63 - 0.66	0.5Km
4	0.85 - 0.87	1Km
5	1.60 - 1.62	2Km
6	2.25 - 2.27	2Km
7	3.74 - 3.96	2Km
8	6.06 - 6.43	2Km
9	6.89 - 7.01	2Km
10	7.26 - 7.43	2Km
11	8.44 - 8.76	2Km
12	9.54 - 9.72	2Km
13	10.3 - 10.6	2Km
14	11.1- 11.3	2Km
15	12.2 - 12.5	2Km
16	13.2 - 13.4	2Km



気象庁
Japan Meteorological Agency

from JMA

RGB products for Operational Forecasting – EumetSAT recommendation – the Day Convection RGB

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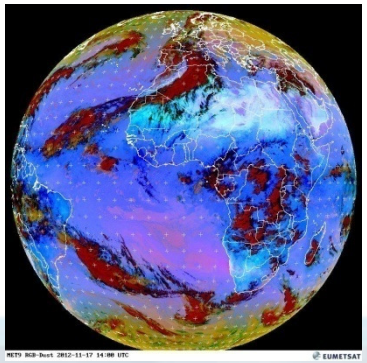
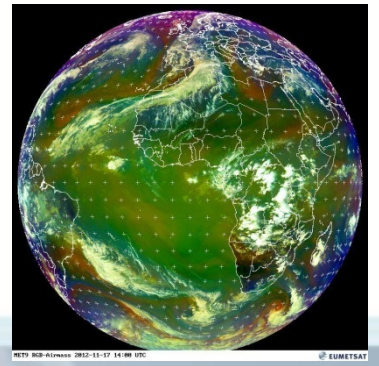
Two RGB composites which complement each other



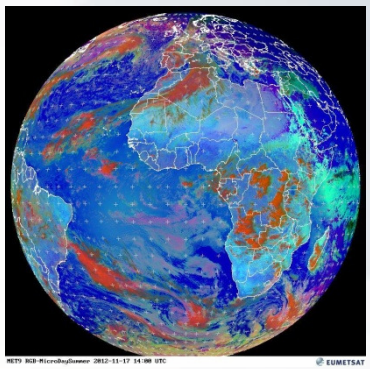
24 hour Microphysical RGB



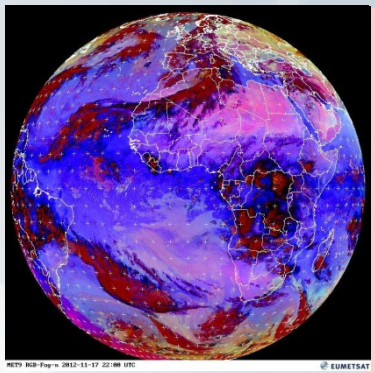
Airmass RGB

from RGB Products Overview (RGB Tutorial) J. Kerkmann EumetSAT

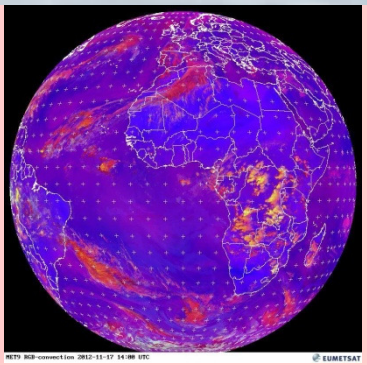
Five application specific RGBs



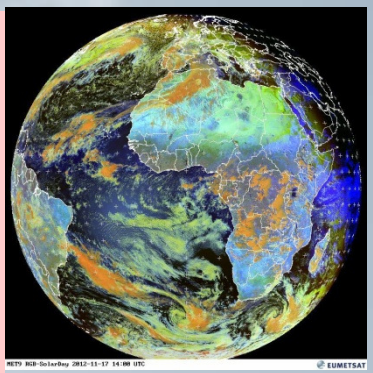
Day Microphysical RGB



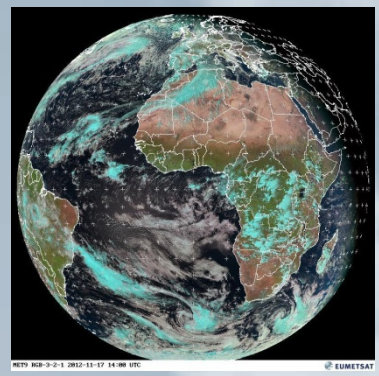
Night Microphysical RGB



Day Convection RGB



Snow / fog RGB



Natural Colours RGB

EUMETSAT strategy of using RGB products – two “24-hour products” that are used all the time and five application specific RGB products.

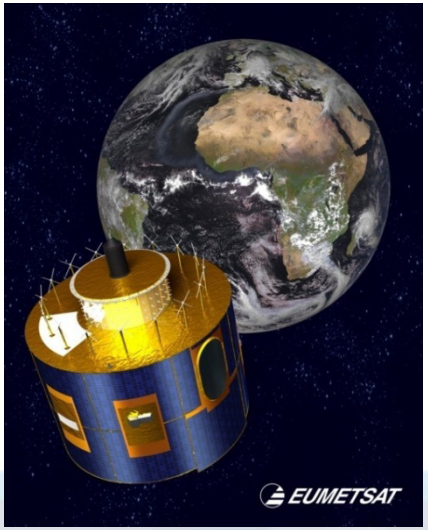
At World Meteorological Organisation (WMO) level: agree on a strict minimum of harmonised RGB composites. The following strategies for the application of RGB products to the forecasting routine were outlined:

Two RGB composites which complement each other are used all of the time. These are the 24 hour Microphysics RGB and the Airmass RGB.

Five application specific RGB products (Day Microphysics RGB, Night Microphysics RGB, Day Convective Storm RGB, Day Snow-Fog RGB, Natural Colours RGB) are used selectively when appropriate.

images courtesy Eumetsat

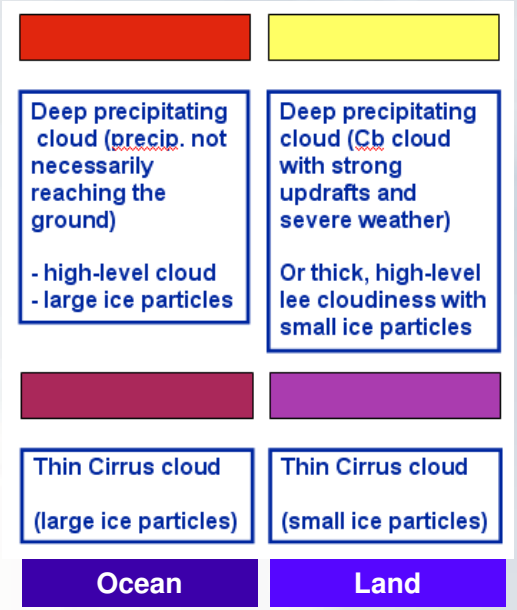
EUMETSAT processing of METEOSAT data – Day Convection RGB



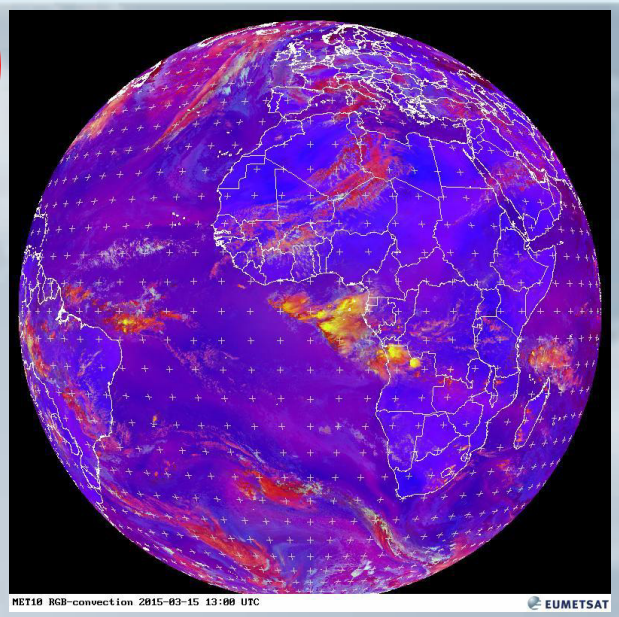
Recommended Range and Enhancement

Beam	Channel	Range	Gamma	Gamma 2
Red	WV6.2 – WV7.3	-35 … +5	1.0	1.0
Green	IR3.9 – IR10.8	-5 … +60	0.5	1.0
Blue	NIR1.6 – VIS0.6	-75 … +25	1.0	1.0

CHANNEL COMBINATION



COLOUR INTERPRETATON



EUMETSAT 0 degree RGB Composite

EUMETSAT = European Organization for the Exploitation of Meteorological Satellites

EUMETSAT processing of METEOSAT data – Day Convection RGB

The previous slide shows the channels used in the RGB product, the thresholds (range) applied to the Beams and the Gamma correction that is applied to selected Beams as per EUMETSAT recipe

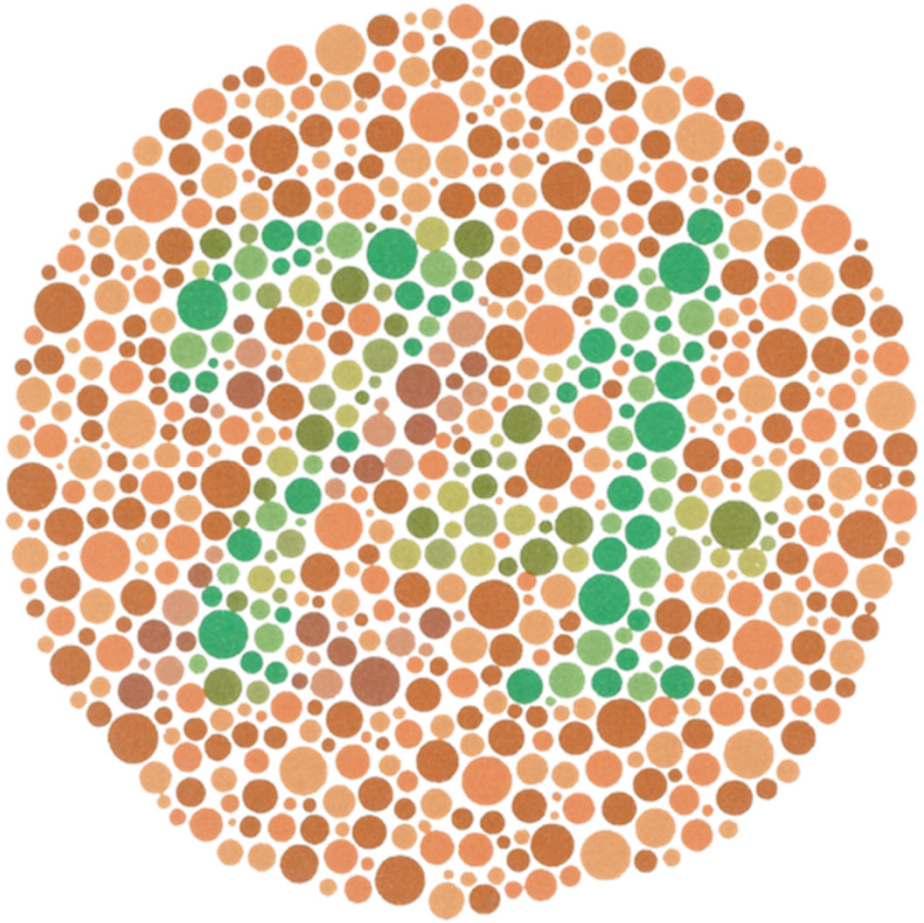
The appearance of the RGB product for the full disk earth image scanned by the Meteosat satellite is also shown. Note that this looks very different from the familiar single channel visible and infrared images. This RGB product also looks very different from the true colour earth image.

For this reason the colour palette assists in interpreting the features of interest to the Forecaster in the RGB product output.

Intermission

To take full advantage of the RGB products you should be able to see the number "74" in the pattern on the right.

If you cannot see this number, please send an email to b.zeschke@bom.gov.au and I will adapt this training resource accordingly

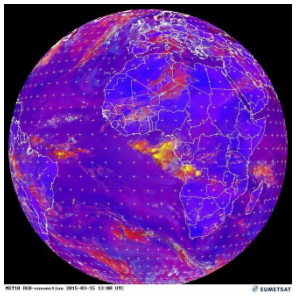


construction courtesy B.Zeschke BOM

Channel combination recipe of the Day

Convection RGB

(For more details see Appendix 2)



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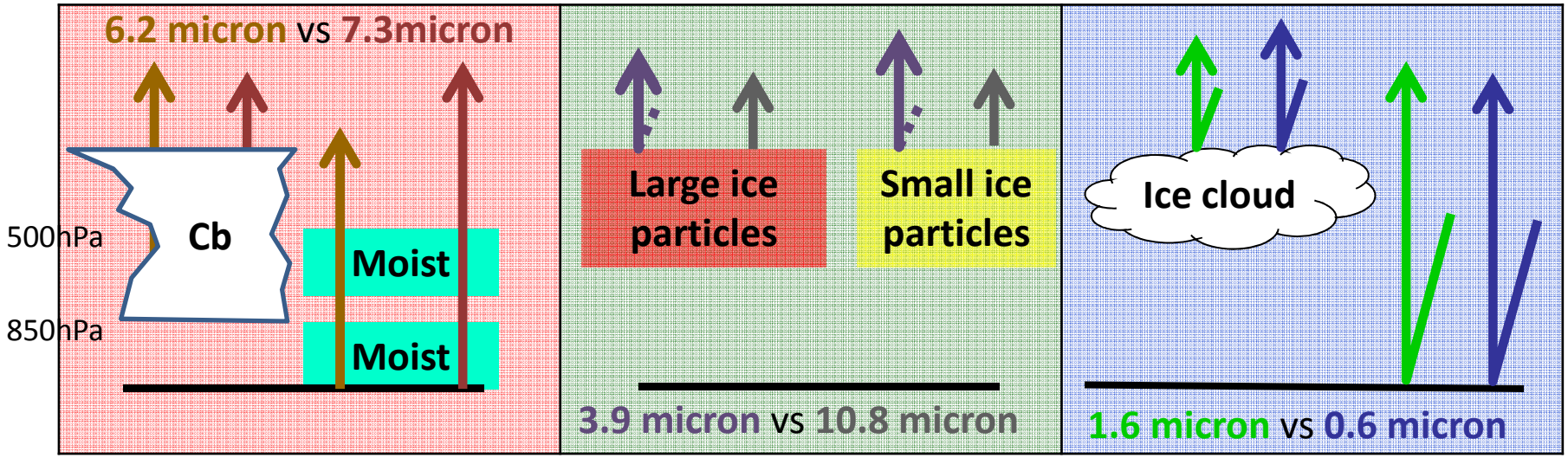
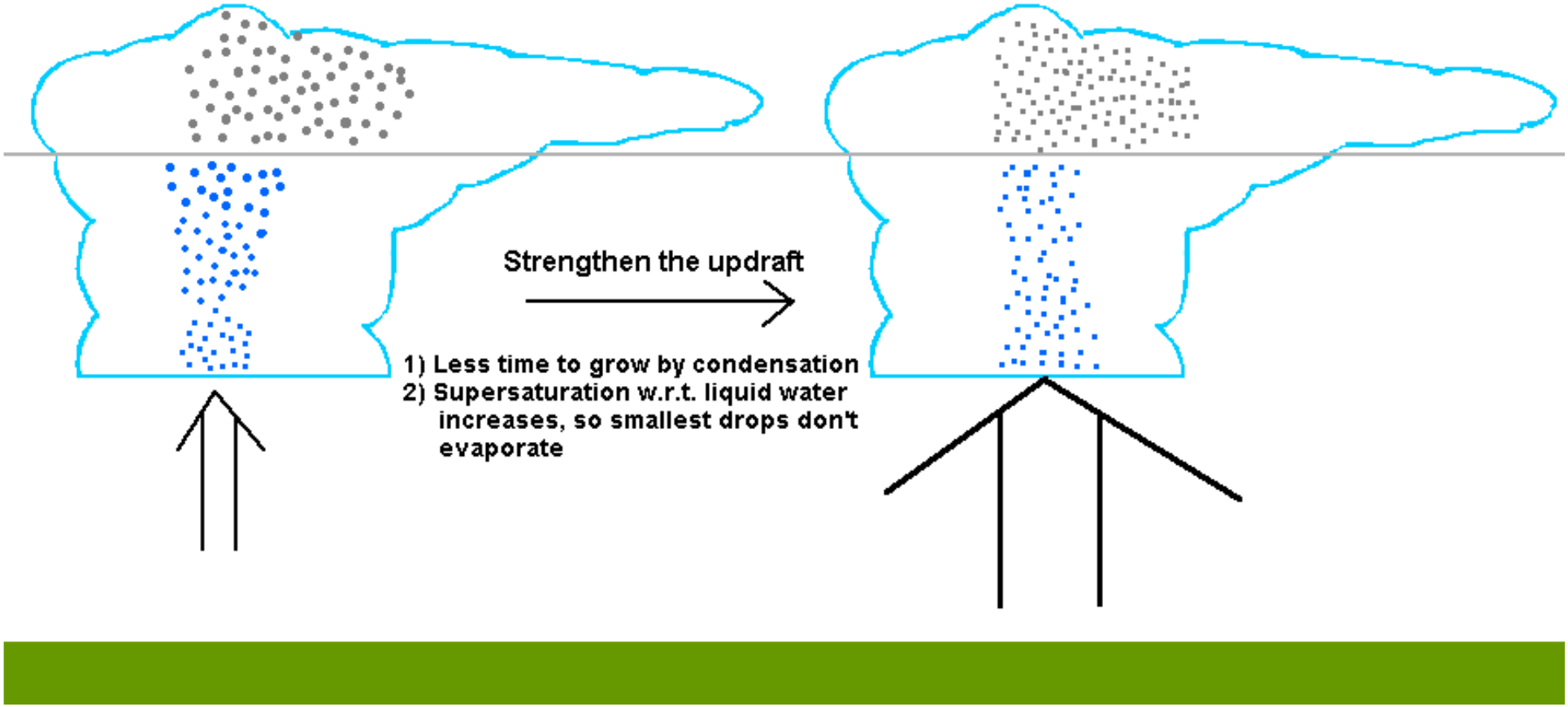


Channel combination recipe of the Day Convection RGB

- **In the RED beam:** Due to the difference in the weighting functions for the 6.2 and 7.3 micron radiation, a strong signal in this beam corresponds to radiation emitted by high level clouds, especially stormtops. If the atmosphere has significant moisture in the mid/upper levels of the atmosphere, the 6.2 micron radiation is absorbed more than the 7.3 micron radiation resulting in a weak contribution to the red beam. If the atmosphere is dry in the mid/upper levels then there will be a reasonable signal in this beam
- **In the Green beam:** The 3.9 micron radiation has high reflectivity for small ice crystals and this results in large positive values for the brightness temperature difference 3.9-10.8 micron during the day. Therefore there is a large contribution to the green beam for small ice particles at and above stormtop level. This situation can correspond to strong storm updraft and may therefore indicate storm severity (see next slide).
- **In the Blue beam**: Ice particles strongly absorb the 1.6 micron radiation. According to the scaling of this beam ice clouds will have little or no signal in this beam. The surface of the earth generally has a strong signal in this beam.

The relation between the strength of the storms updraft and the size of ice crystals at storm top

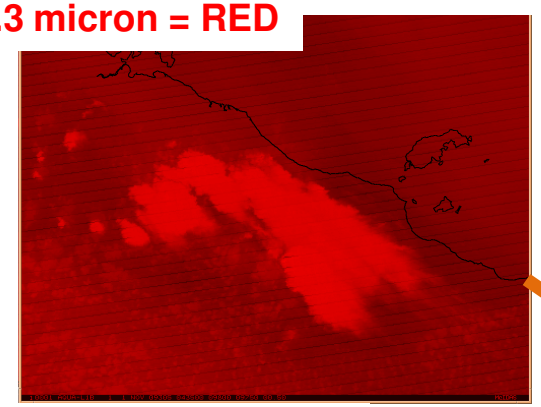


This idea follows from results from multiple papers by D. Rosenfeld, and Heymsfield et al. (2005)

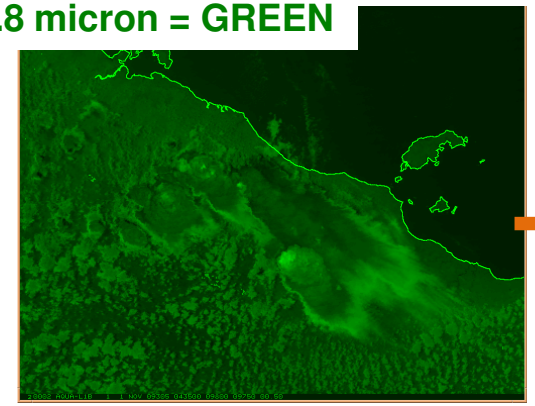
from "UNDERSTANDING CONVECTIVE CLOUDS THROUGH THE EYES OF (MSG): Cloud Particle Size". J.Kerkmann EUMETSAT

The input beams that go to make up the Day Convection RGB.

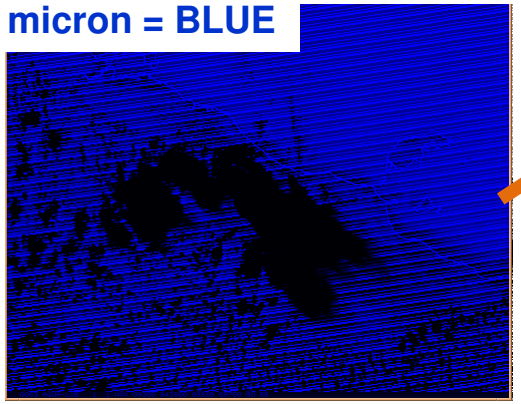
6.2-7.3 micron = RED



3.9-10.8 micron = GREEN



1.6-0.6 micron = BLUE



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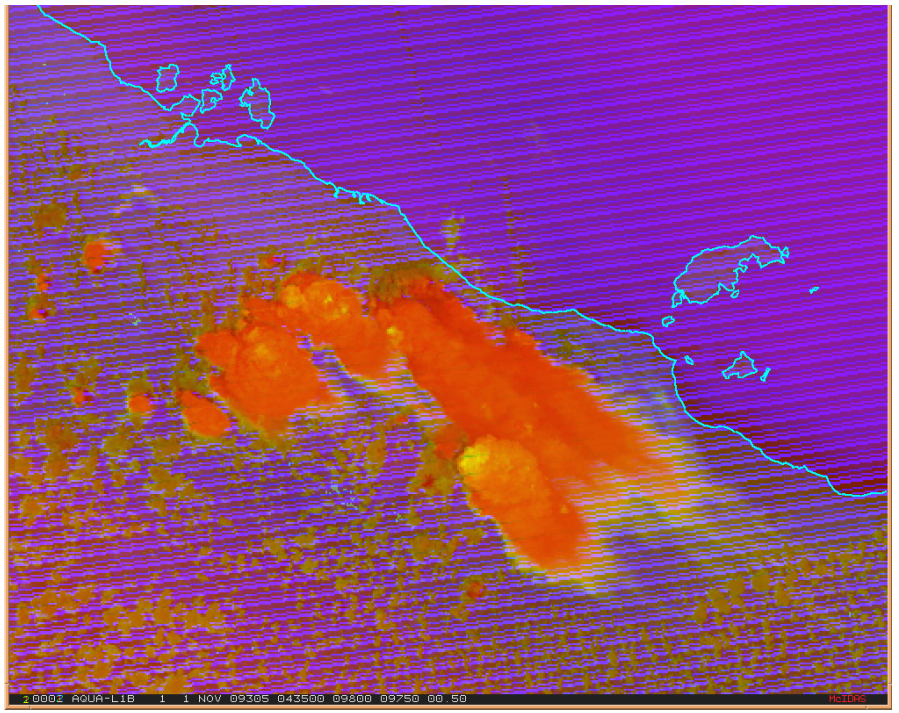


Gulf Country, Queensland

1 November 2009 0435 UTC

images courtesy JMA / BOM

The input beams that go to make up the Day Convection RGB.

In the preceding slide you can familiarize yourself with the output of each of the beams for the Day Convection RGB product output of the Gulf Country of Queensland, 1 November 2009

In the red beam, note the strong contribution from the stormtops. The signal from the adjacent moist tropical atmosphere is a lot weaker.

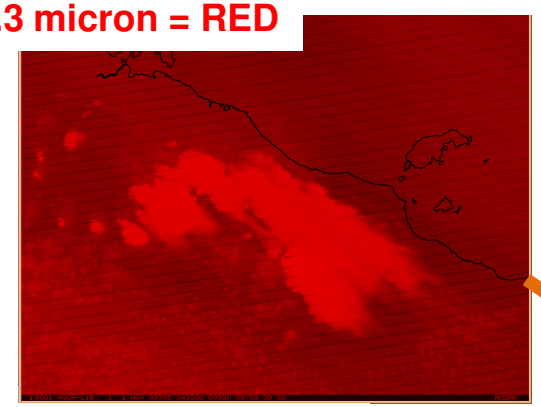
In the green beam, note the strong contribution from areas at and above the stormtops. There is also a contribution from the lower level clouds. It is possible that these have small cloud droplets.

In the Blue beam it is clear to see that the storm tops do not have any contribution. The low level features around the stormtops have a strong contribution in this beam.

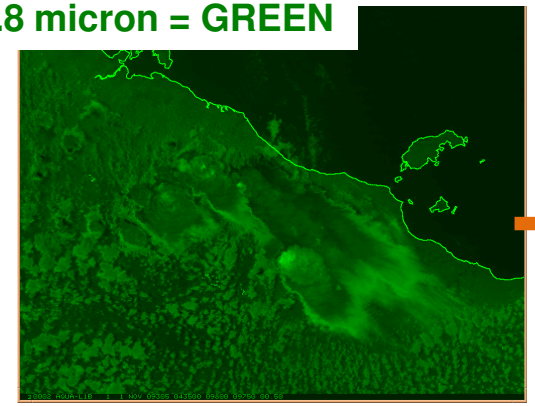
The next slide shows the effect of combining two beams.

The input beams that go to make up the Day Convection RGB.

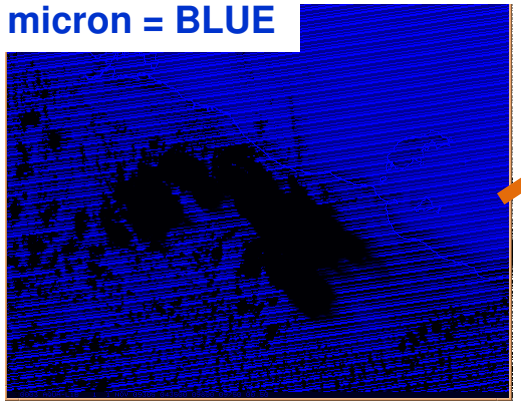
6.2-7.3 micron = RED



3.9-10.8 micron = GREEN

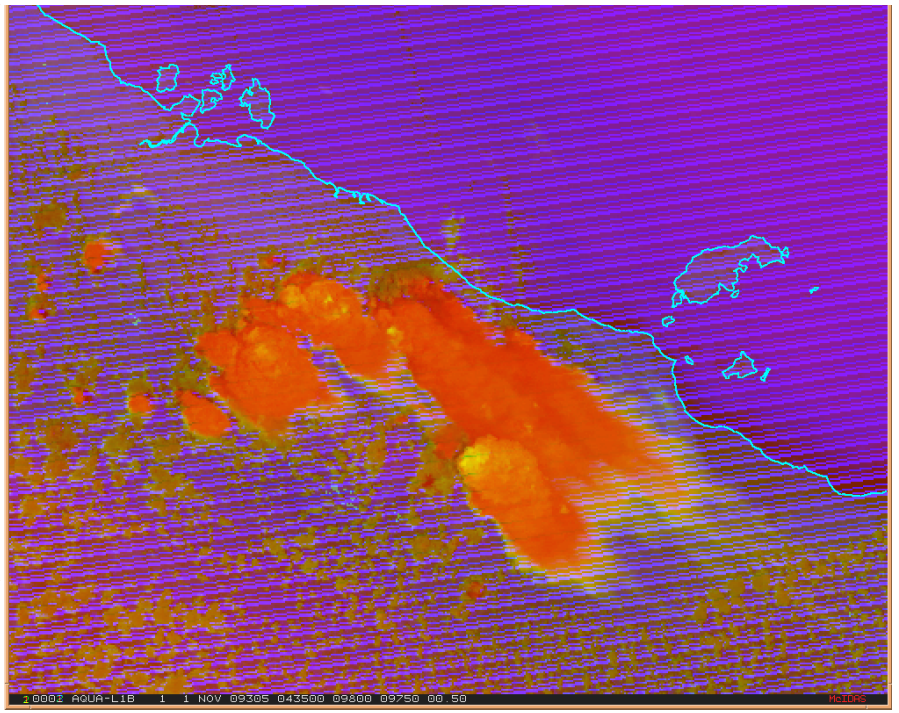


1.6-0.6 micron = BLUE



Combining beams

- Yellow is made by mixing red and green
- Magenta is made by mixing red and blue
- Cyan is made by mixing green and blue

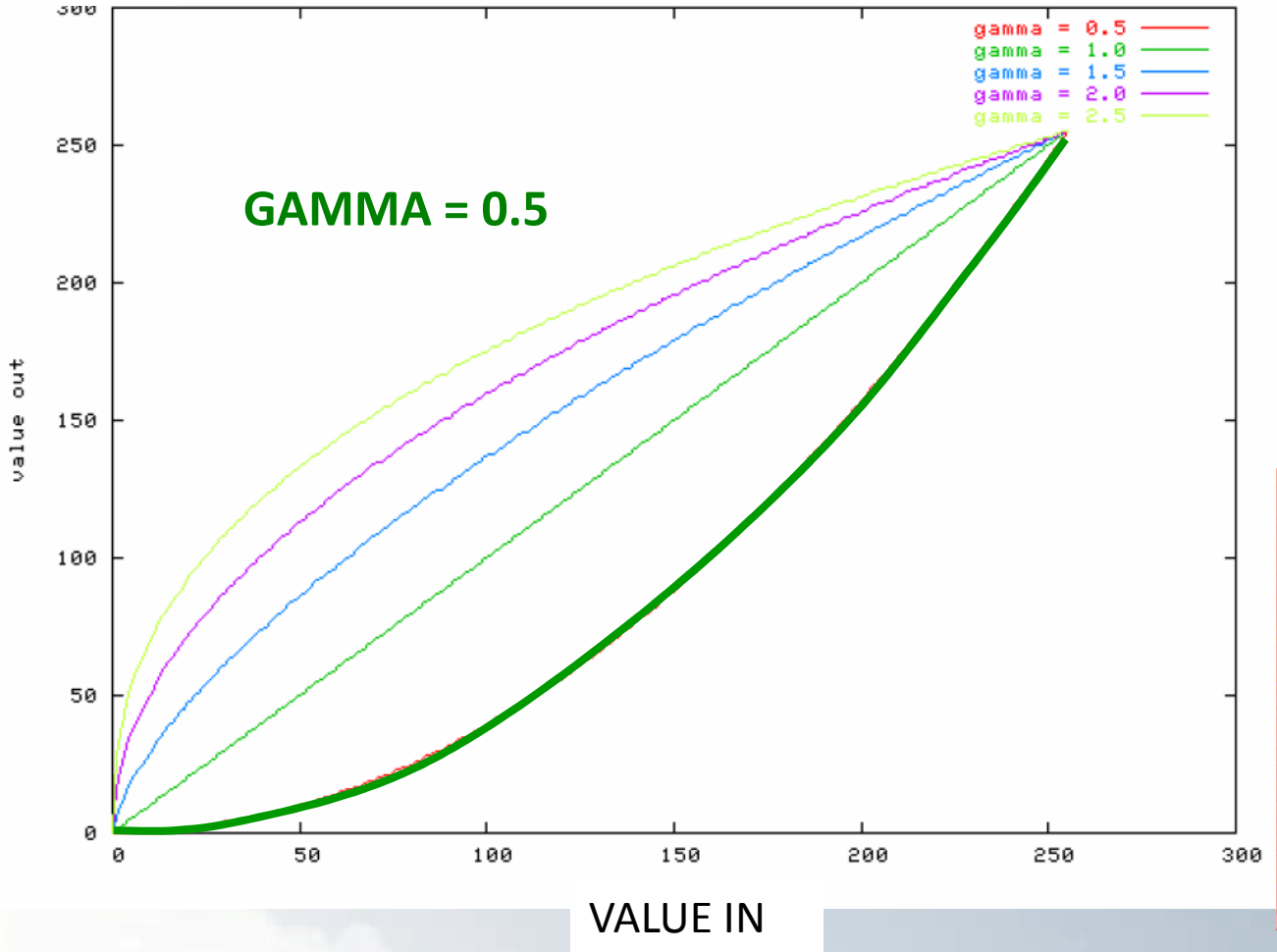


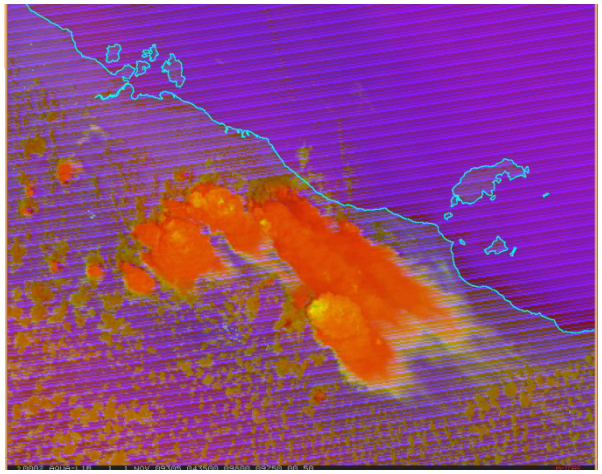
Gulf Country, Queensland

1 November 2009 0435 UTC

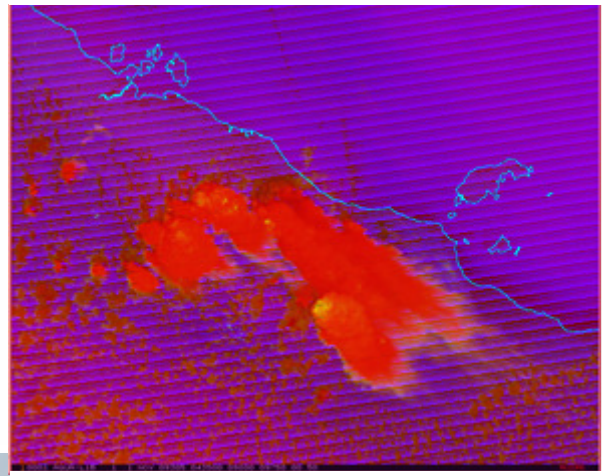
images courtesy JMA / BOM

GAMMA Correction applied





Before GAMMA correction



After GAMMA correction

The GAMMA enhancement. GAMMA=0.5 applied to a Day Convective RGB enhancement over Tropical Queensland. Top, without GAMMA, bottom with GAMMA = 0.5.

images courtesy JMA / BOM

GAMMA Correction applied

- The Gamma correction changes the linear spreading of a selected range of pixel values over the full intensity scale to a convex (GAMMA < 1) or concave (GAMMA >1) curve.
- The GAMMA correction enhances the contrast of the higher (GAMMA < 1) or lower parts (GAMMA >1) of the pixel values in an image.
- Inspection of the result of applying the GAMMA correction to the green beam of the Dust RGB shows that a much more "colour balanced" image is produced. Much of the strong red colour overtones are removed.

- For more information please see http://oiswww.eumetsat.int/~idds/html/doc/best_practices.pdf

High-level cloud and earth surface palette exercises.

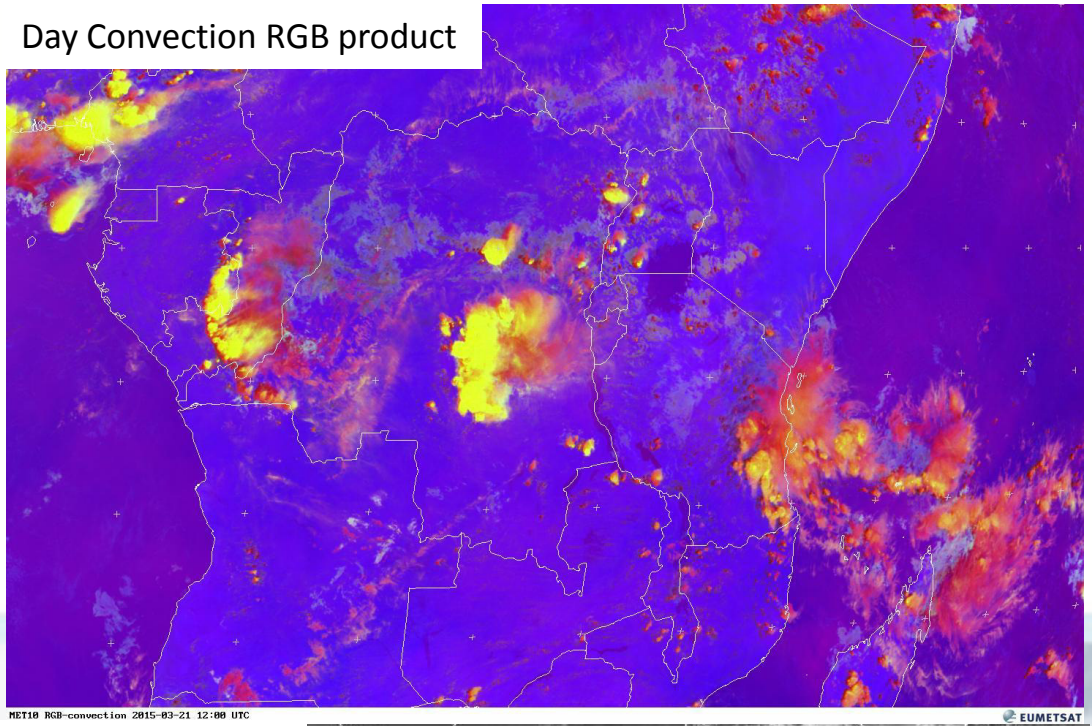
Examine the next two slides and see if you can identify the various features in the Day Convection RGB product for the thunderstorm complexes over Central Africa of the 21st March 2015.

For reference I have also included a corresponding infrared and visible image of the same time.

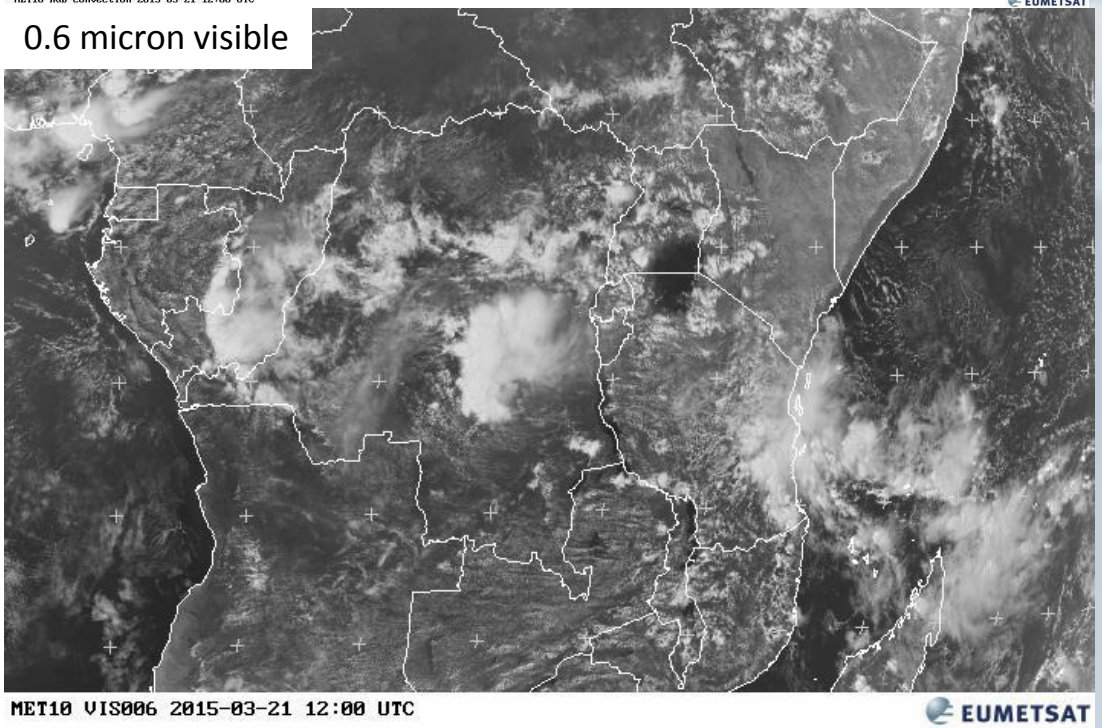
Also examine the detailed Day Convection RGB product and the visible images of the Gulf Country (Queensland) storms of 1st November 2009. Try to identify the stormtop features shown in the yellow enhancement in the Day Convection RGB product.

Question: From inspection of the location of the yellow enhancement of the Day Convective RGB product in the visible image can you see some limitations in the RGB product ?

Day Convection RGB product



0.6 micron visible

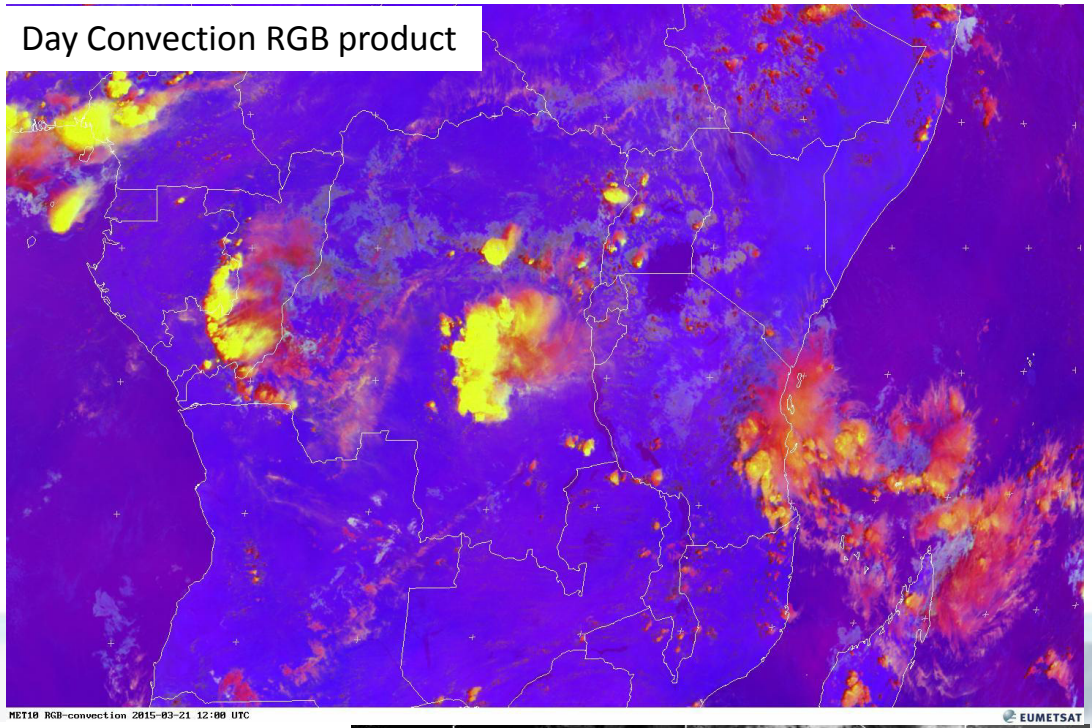


Day Convection RGB product compared to the visible channel – please annotate features

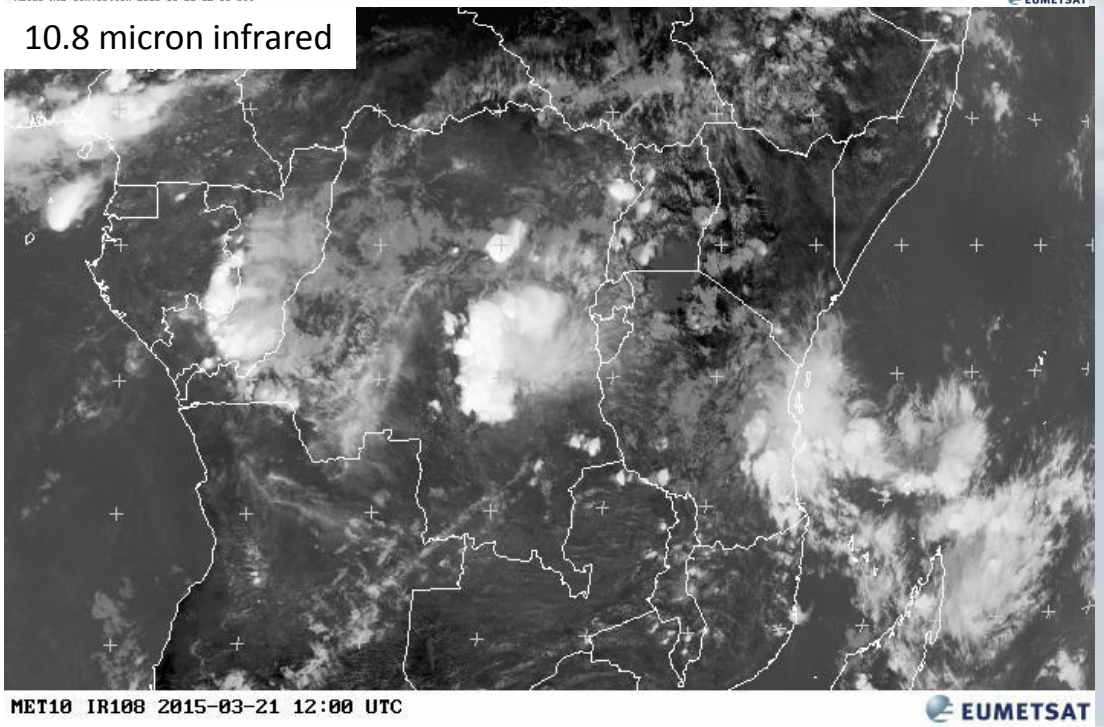
Deep precipitating cloud (precip. not necessarily reaching the ground) - high-level cloud - large ice particles	Deep precipitating cloud (Cb cloud with strong updrafts and severe weather) Or thick, high-level lee cloudiness with small ice particles
Thin Cirrus cloud (large ice particles)	Thin Cirrus cloud (small ice particles)
Ocean	Land

Central Africa
12UTC, 21 March 2015
Images courtesy EUMETSAT

Day Convection RGB product



10.8 micron infrared



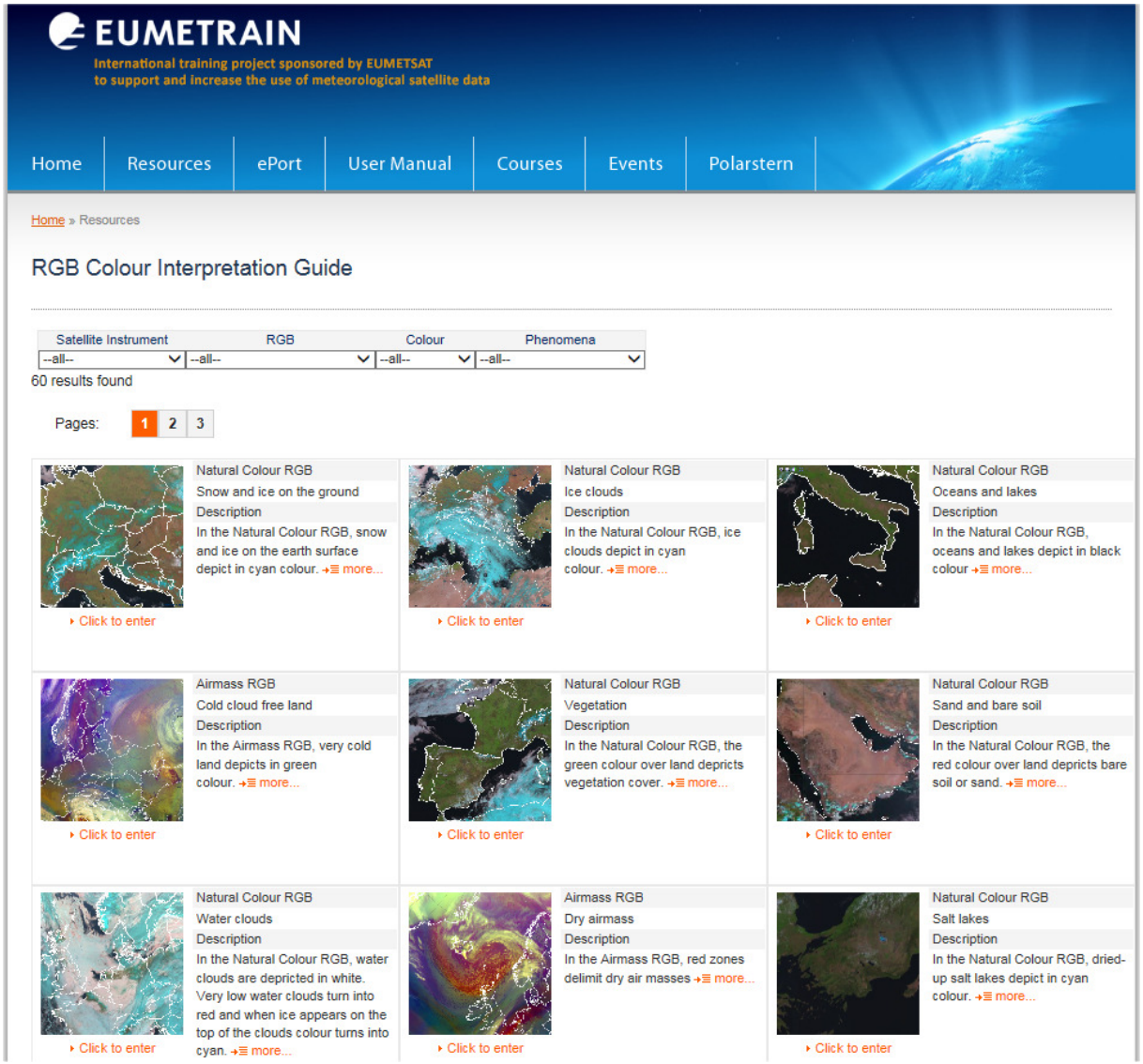
Day Convection RGB product compared to the infrared channel – please annotate features

Deep precipitating cloud (precip. not necessarily reaching the ground) - high-level cloud - large ice particles	Deep precipitating cloud (Cb cloud with strong updrafts and severe weather) Or thick, high-level lee cloudiness with small ice particles
Thin Cirrus cloud (large ice particles)	Thin Cirrus cloud (small ice particles)
Ocean	Land

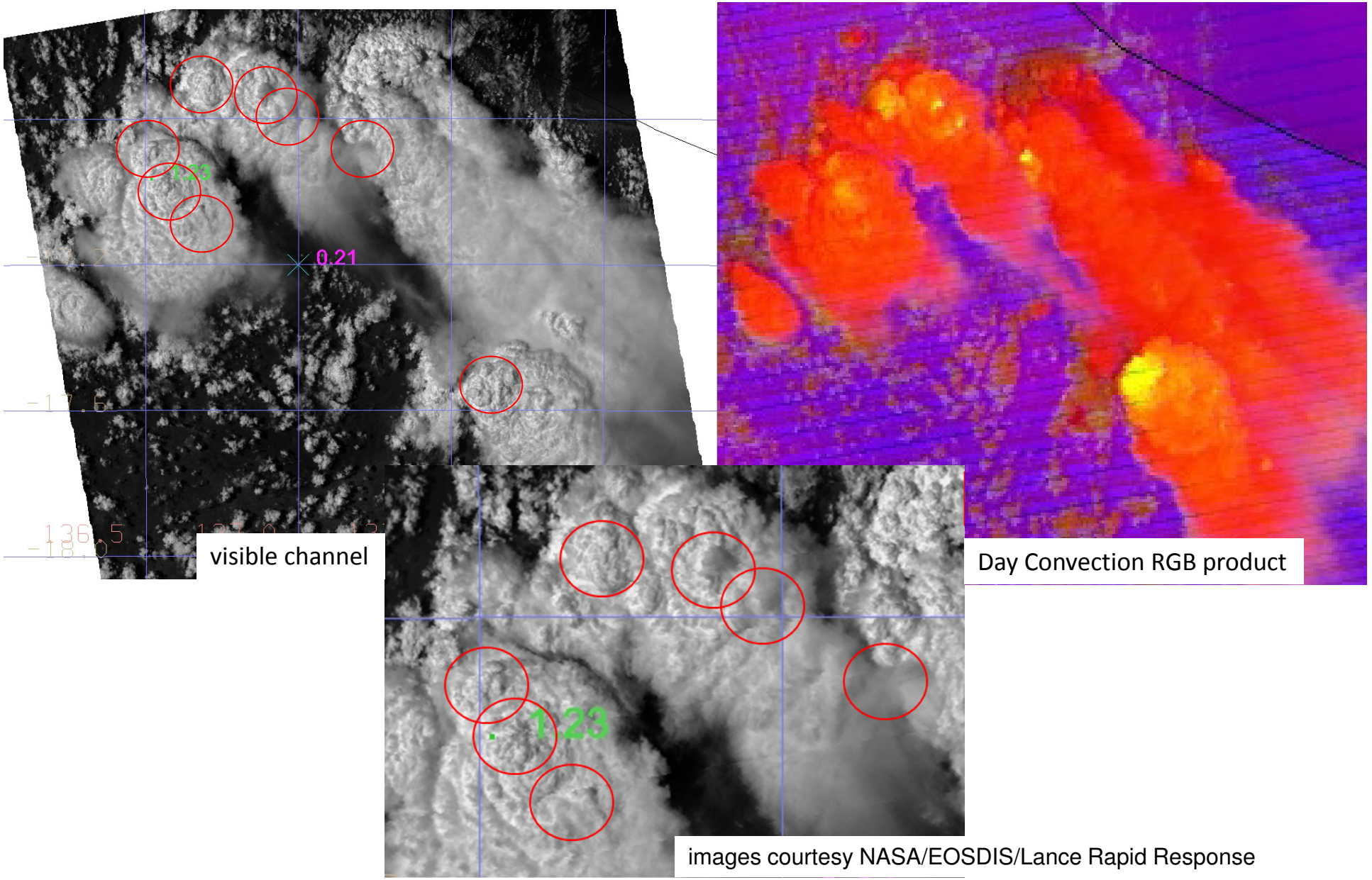
Central Africa
12UTC, 21 March 2015
Images courtesy EUMETSAT

Very useful website for reference – the EUMETRAIN RGB Colour Interpretation Guide

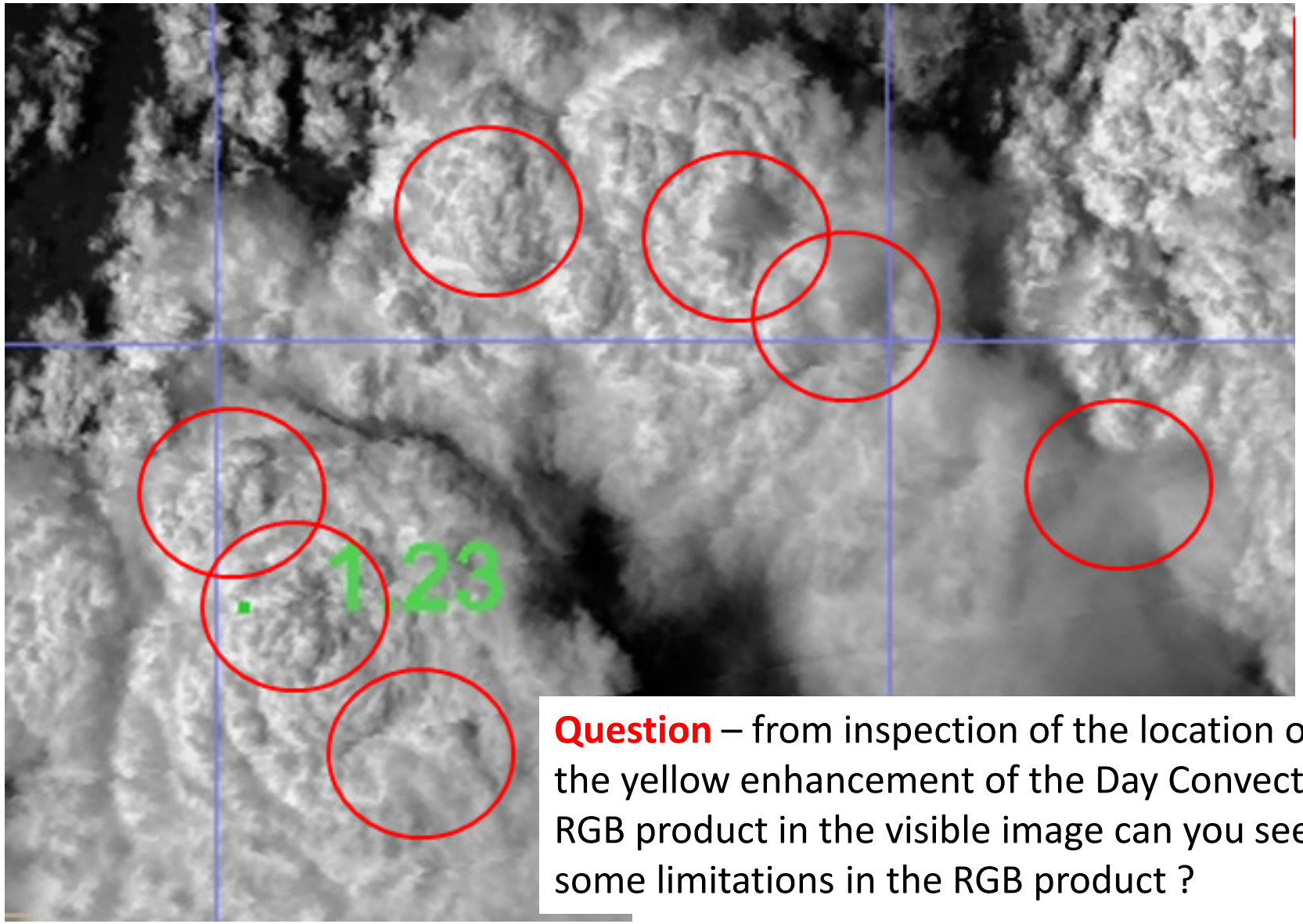
http://www.eumetrain.org/RGBguide/rgbs.html



Comparing Day Convection RGB product with high resolution visible imagery for storm tops. Queensland storms, 1 November 2009.



Comparing the yellow enhancement in the Day Convection RGB with MODIS high resolution visible imagery

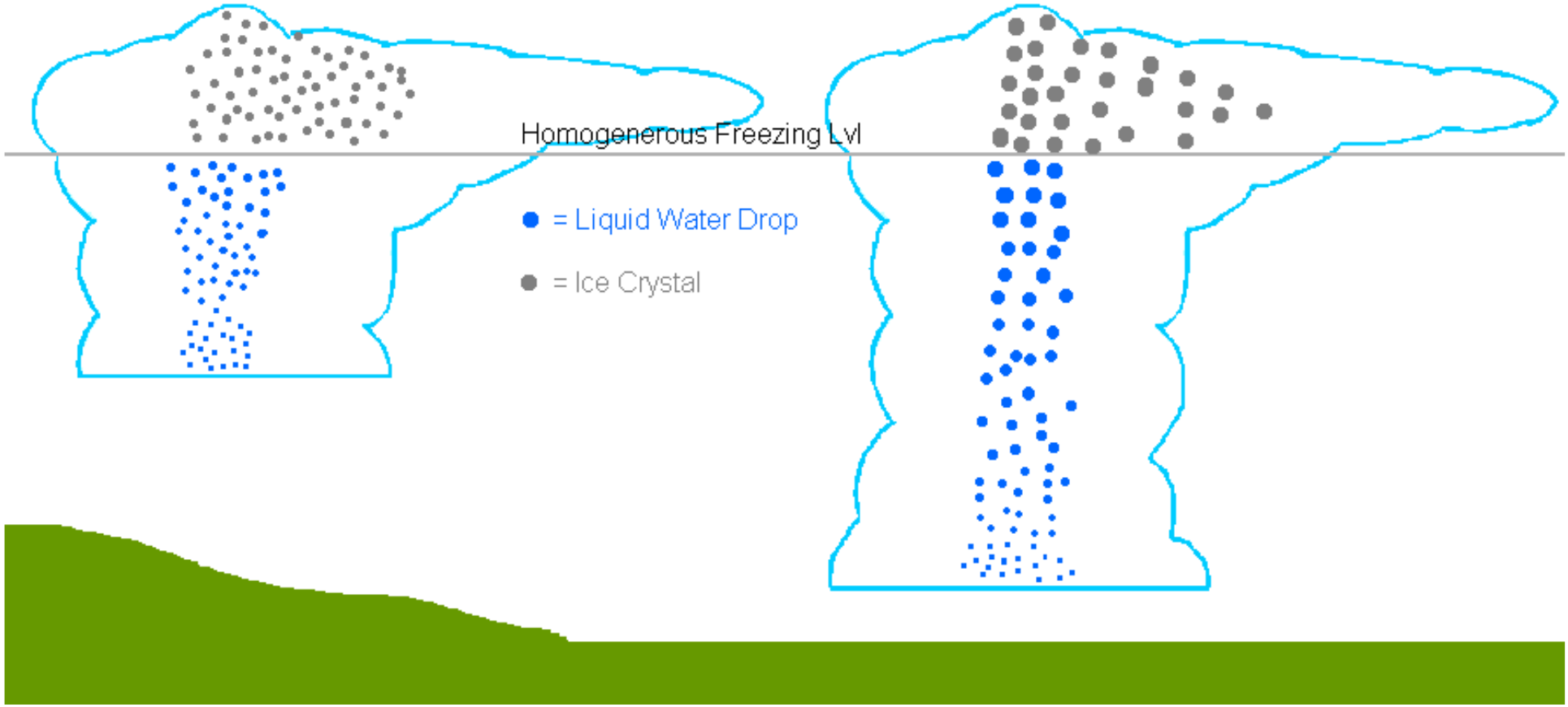


Question – from inspection of the location of the yellow enhancement of the Day Convective RGB product in the visible image can you see some limitations in the RGB product ?

image courtesy NASA/EOSDIS/Lance Rapid Response

Limitations in the Day Convection RGB product

„Cloud Depth“ Effect



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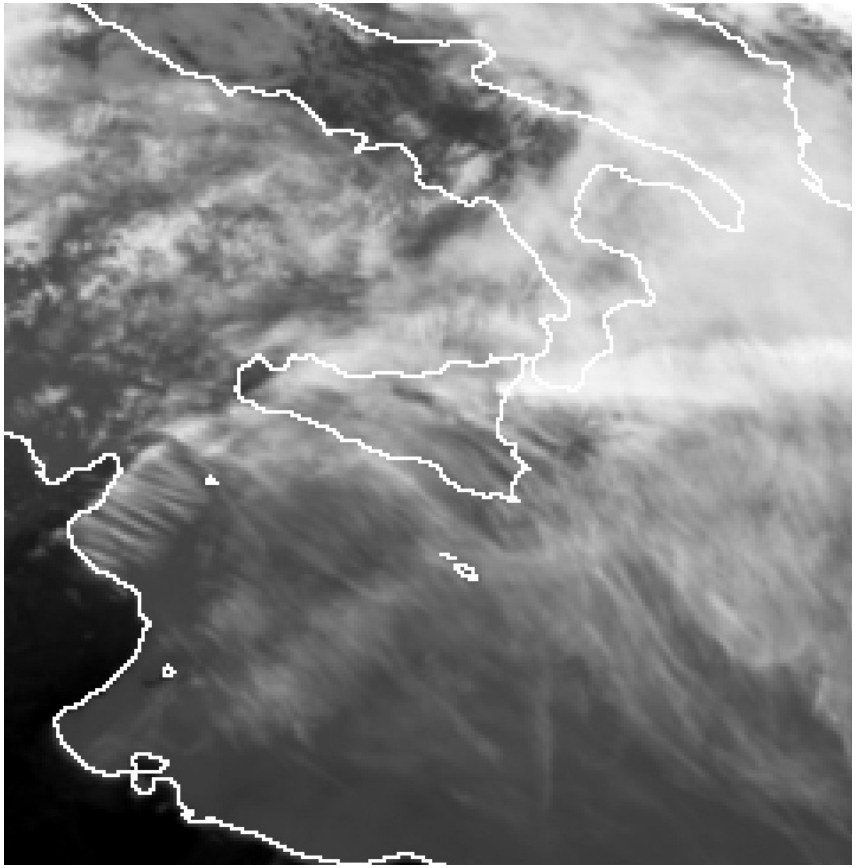
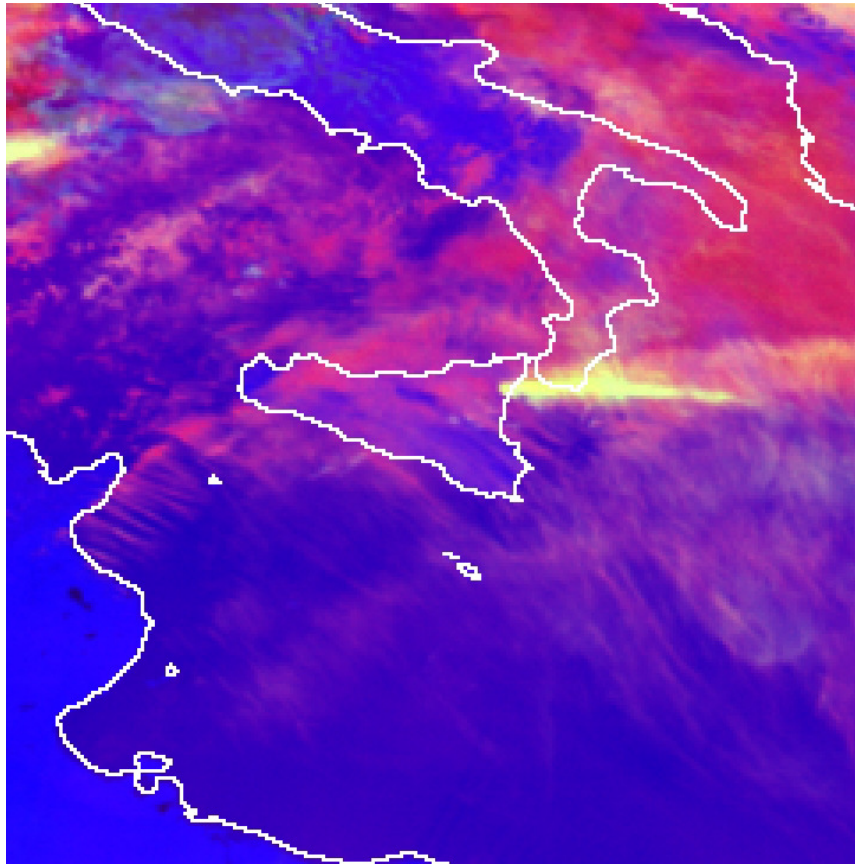
From UNDERSTANDING CONVECTIVE CLOUDS THROUGH THE EYES OF (MSG): Cloud Particle Size. J.Kerkmann EUMETSAT

Limitations in the Day Convection RGB product

Lee cloudiness – Sicily



Infrared image

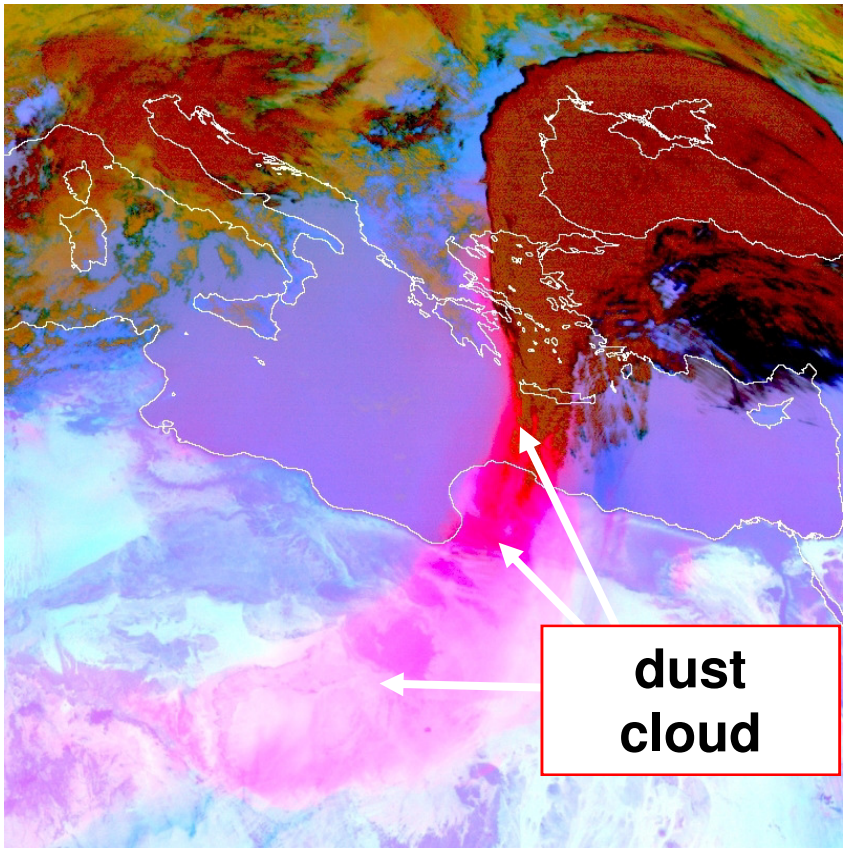


Convection RGB

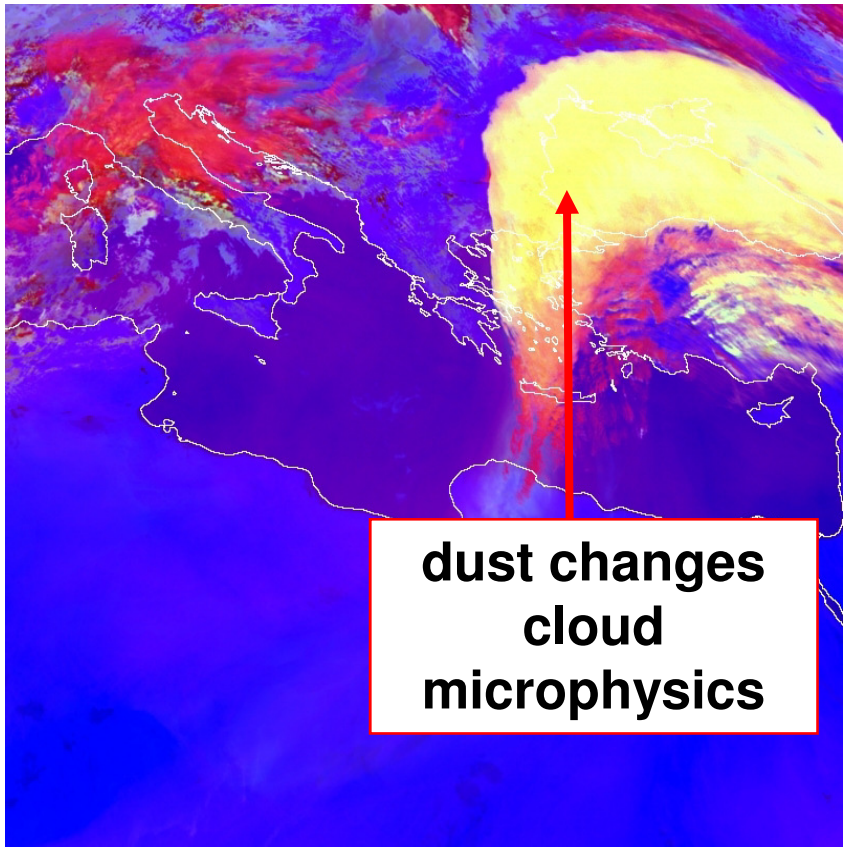
RGB Products Overview (RGB Tutorial), J.Kerkmann, Eumetsat 2012

Limitations in the Day Convection RGB product

Coloured rain - Bulgaria



Dust RGB



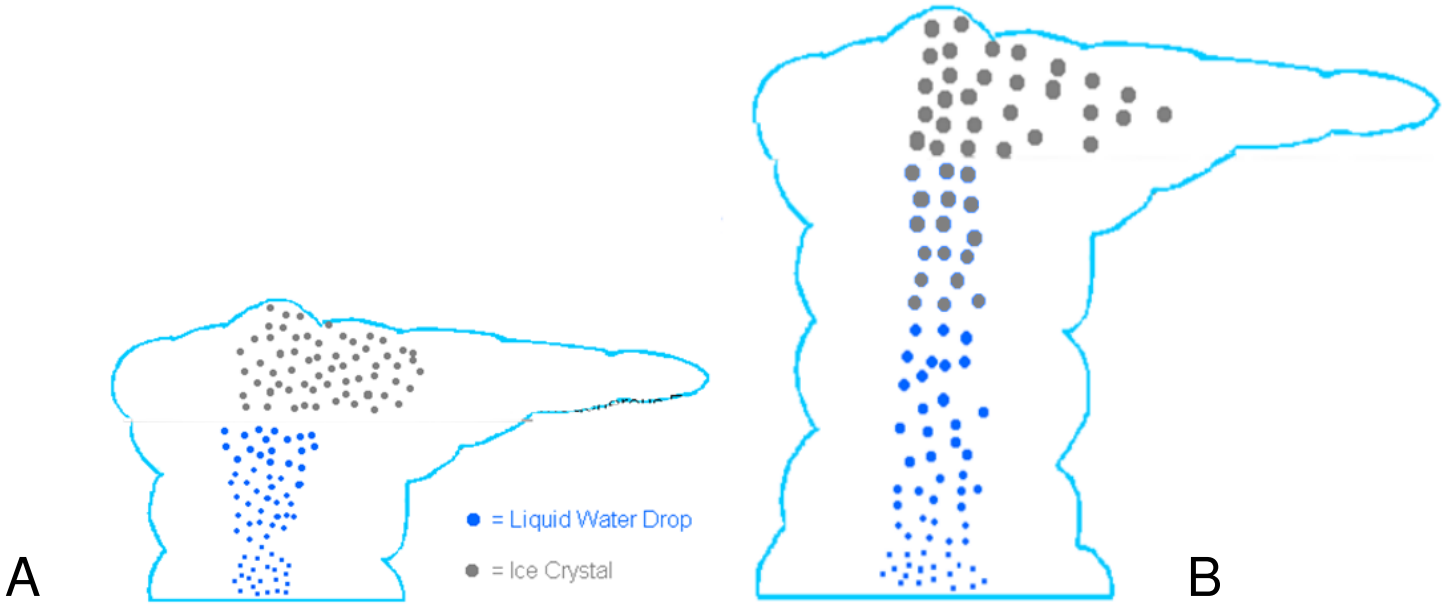
Convection RGB

Meteosat-9, 23 March 2008, 12:00 UTC

RGB Products Overview (RGB Tutorial), J.Kerkmann, Eumetsat 2012

Limitations in the Day Convection RGB product

„Higher tropopause“ Effect



A	Small ice crystals – highly reflective. STRONG signal in 3.9 micron channel	Cold cloud tops. WEAK signal at 10.8 microns	T3.9-T10.8 = **LARGE**
B	Larger ice crystals – less reflective MODERATE signal at 3.9 microns	Very cold cloud tops. VERY WEAK signal at 10.8 microns	T3.9-T10.8 = **LARGE**

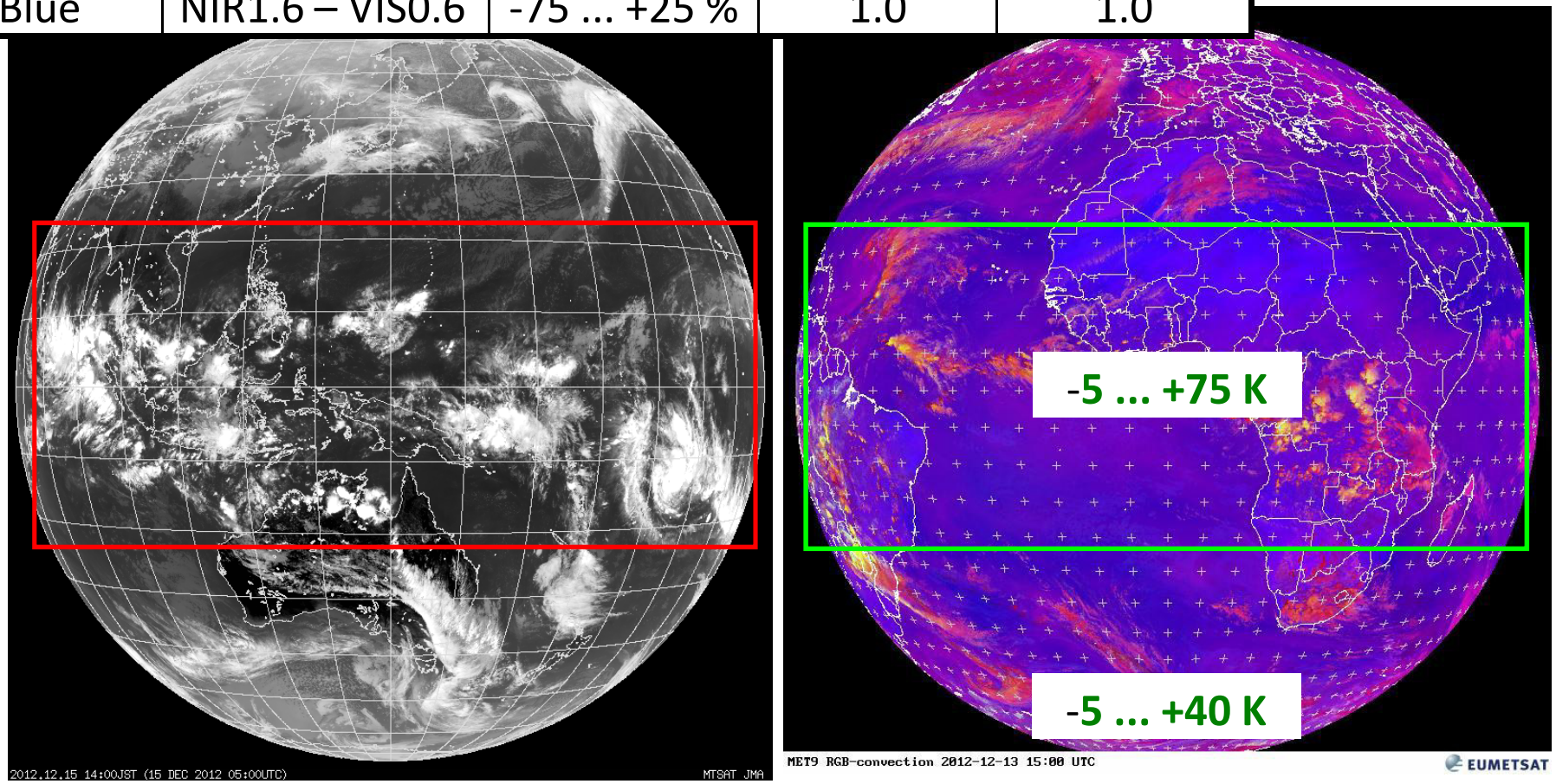
Modified from UNDERSTANDING CONVECTIVE CLOUDS THROUGH THE EYES OF (MSG): Cloud Particle Size. J.Kerkmann EUMETSAT

Solution to the "higher tropopause" – adapting the RGB colour tables to lower latitudes

Beam	Channel	Range	Gamma	Gamma 2
Red	WV6.2 - WV7.3	-35 ... +5	1.0	1.0
Green	IR3.9 – IR10.8	**-5 ... +60**	0.5	1.0
Blue	NIR1.6 – VIS0.6	-75 ... +25 %	1.0	1.0

Green channel +40K cold low troposphere +75K tropical

Kerkmann pers. comm. 2012)



Limitations in the Day Convection RGB product - summary

Small ice particles can form in non-severe Cb clouds:

- in Cb clouds with cold (high) cloud base (short time from cloud base to spontaneous freezing level)
- Pileus cloud on top of developing thunderstorms. These thunderstorms need not necessarily be severe.

Small ice particles can occur in areas where there are no cumulonimbus clouds:

- in mountain wave clouds
- in highly “polluted” clouds

Ambiguities in the green channel due to:

- Tropopause height variations
- Solar angle variations, as IR3.9 - IR10.8 brightness temperature difference depends on both cloud particle size and cloud top temperature as well as sun/satellite viewing angle

From UNDERSTANDING CONVECTIVE CLOUDS THROUGH THE EYES OF (MSG): Cloud Particle Size. J.Kerkmann EUMETSAT

Activity: Exploring EUMETRAIN ePort

- To gain "hands on experience" in using this RGB product in combination with other observations, Derived Products and NWP, please take some time to work through the following ePort activities.
- EUMETRAIN ePort helps to integrate the RGB products with single channel satellite data.
- It helps to integrate RGB products with Derived Products.
- You can explore the RGB products by overlaying model parameters to get a better feel for the products.
- The ePort can give a "flavour" of what we might expect with the display of Himawari-8 data, although the way this data will be displayed in Visual Weather, SatAID and on the web may be different from the ePort.

Activity: Exploring EUMETRAIN ePort – may work best in **FireFox** http://eumetrain.org/eport.html

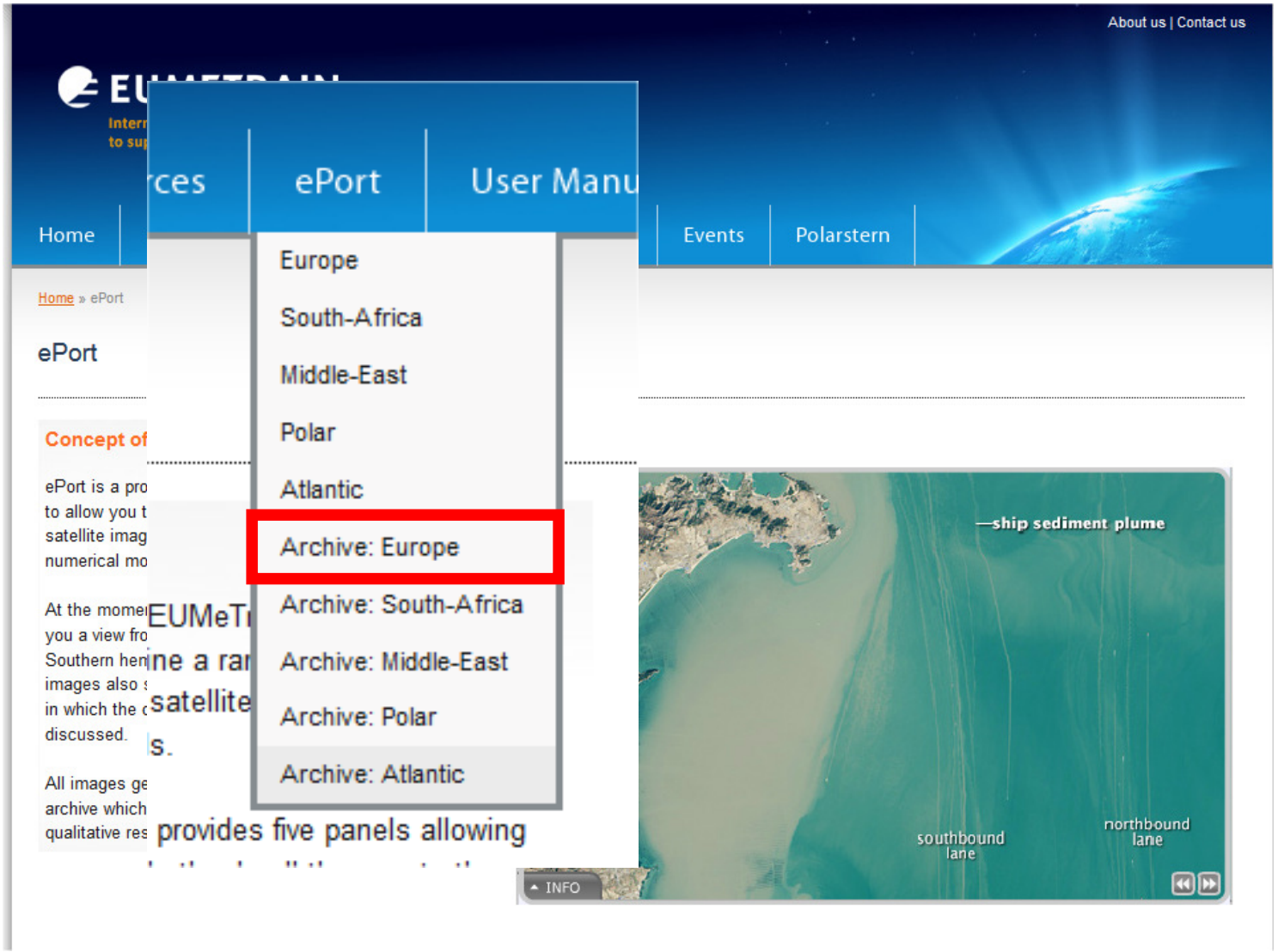


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort – choosing Archive: Europe

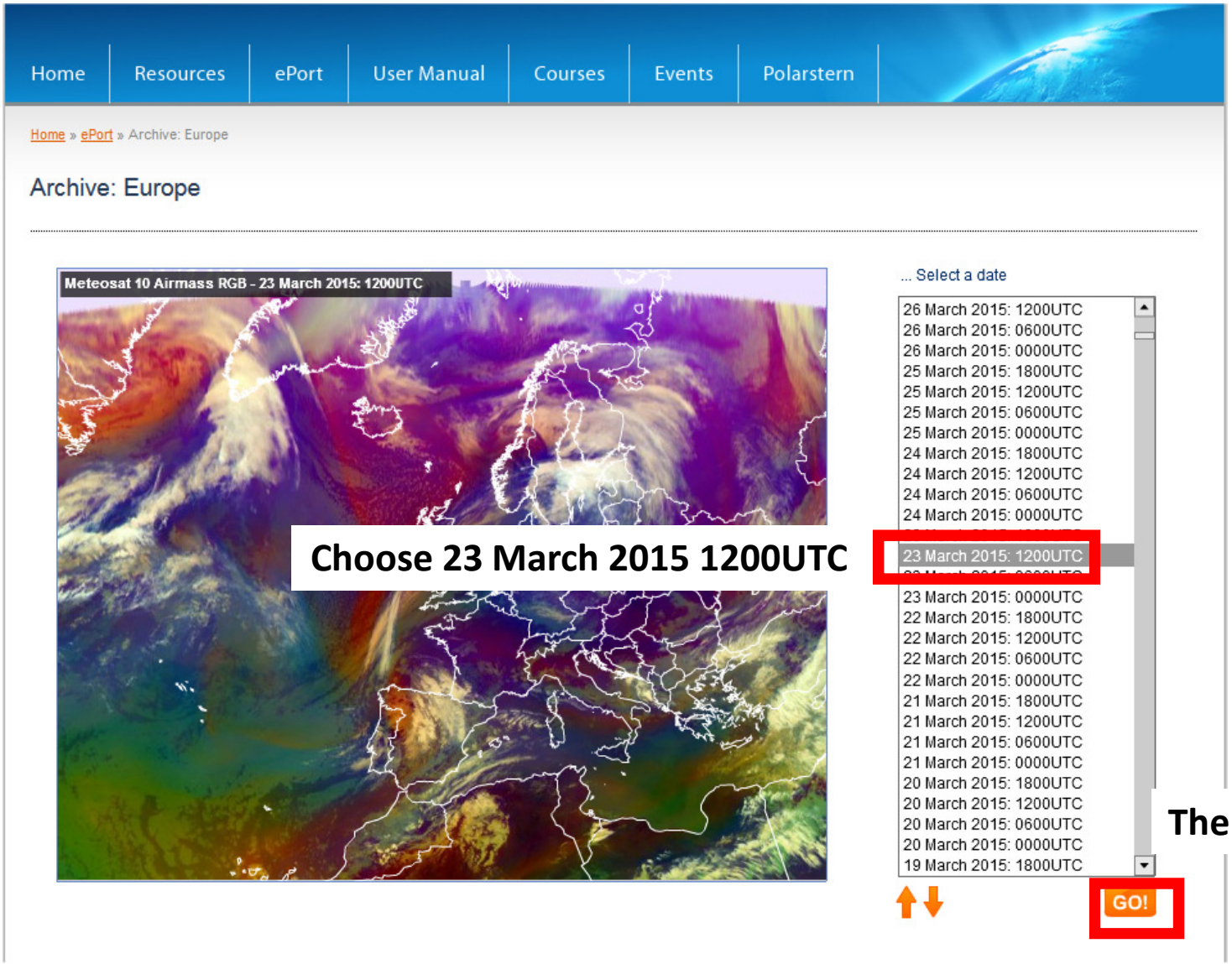
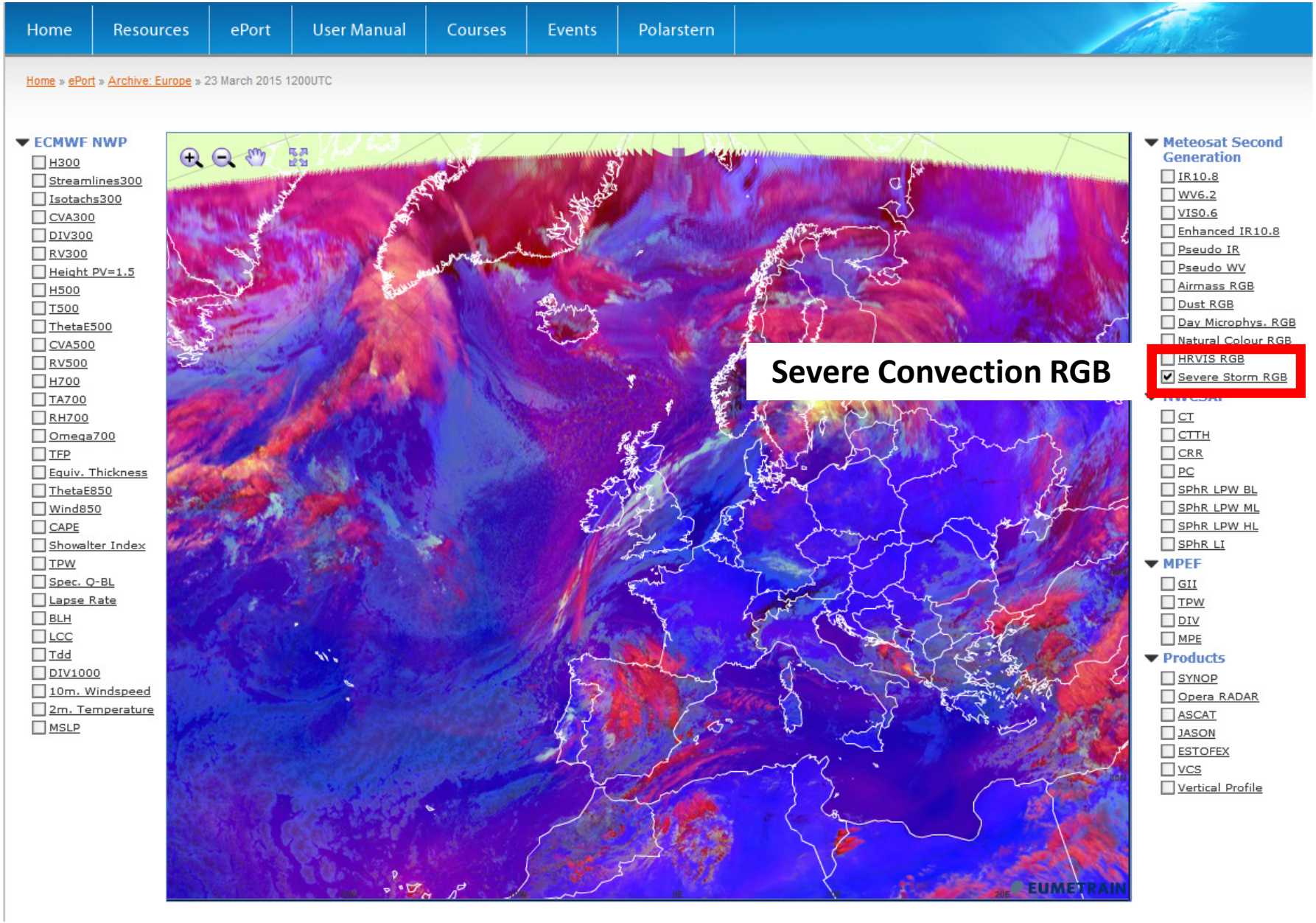


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort



Activity: Exploring EUMETRAIN ePort

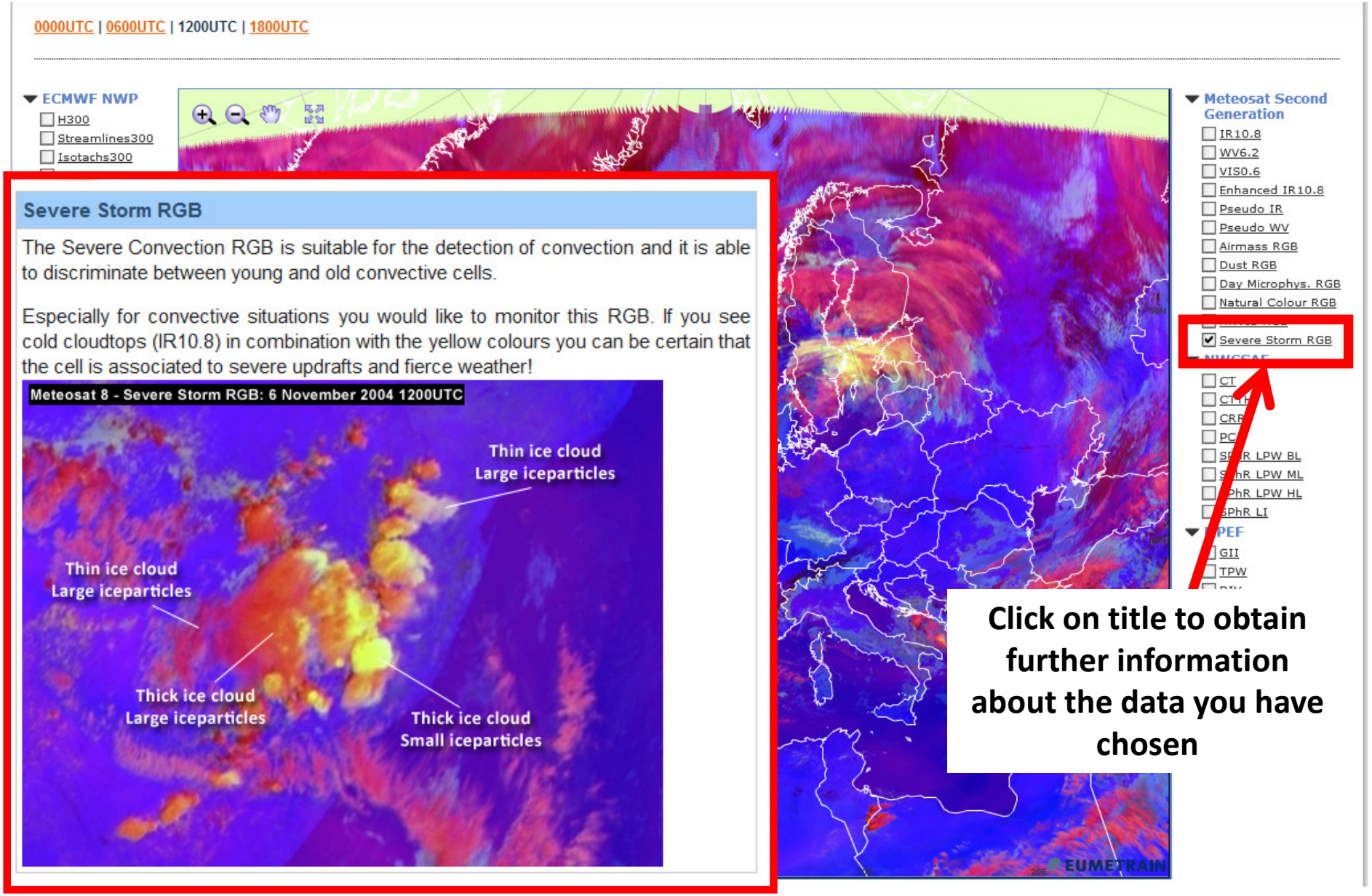
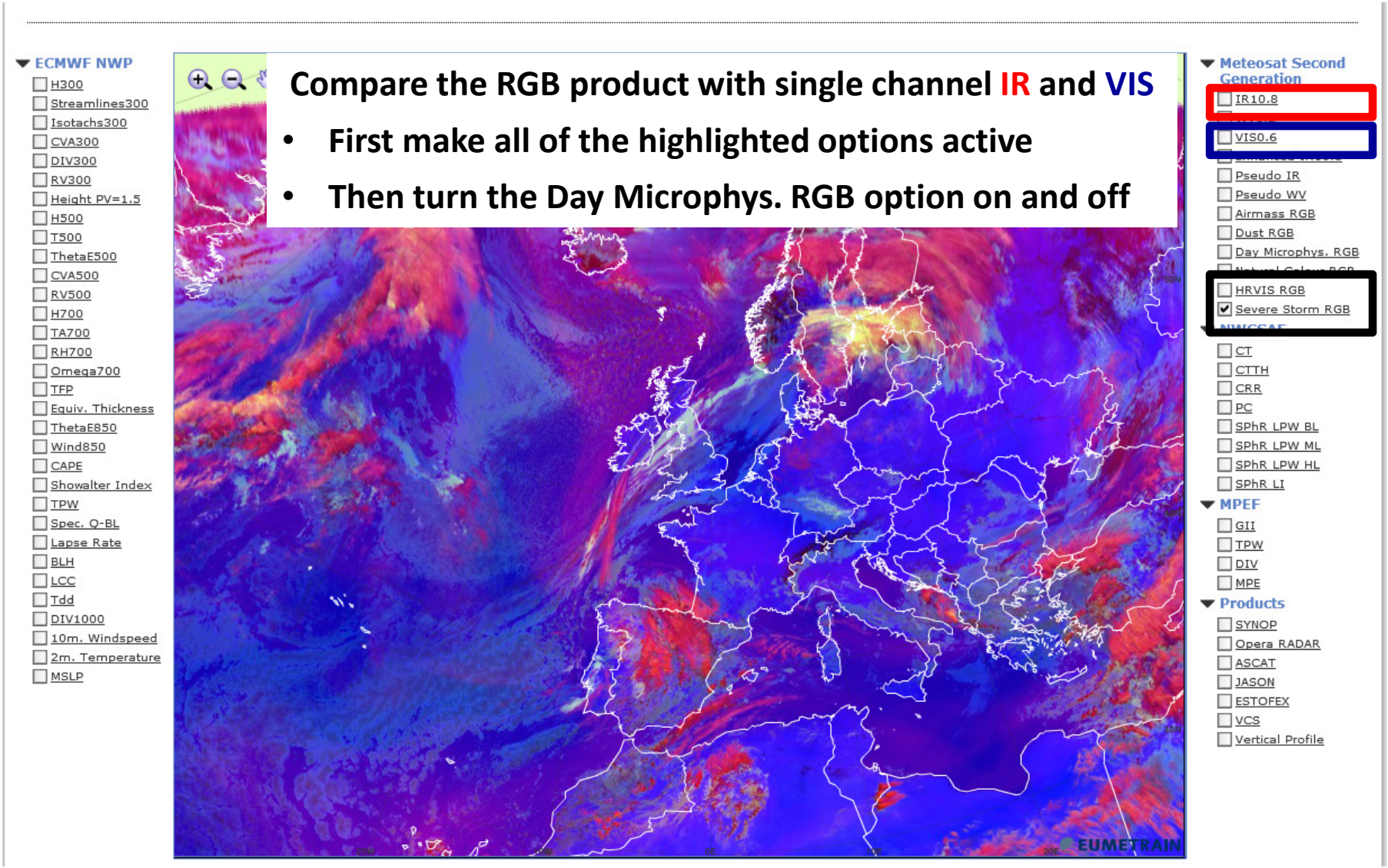


image courtesy EUMETSAT

Activity: Comparing single channel image with RGB product

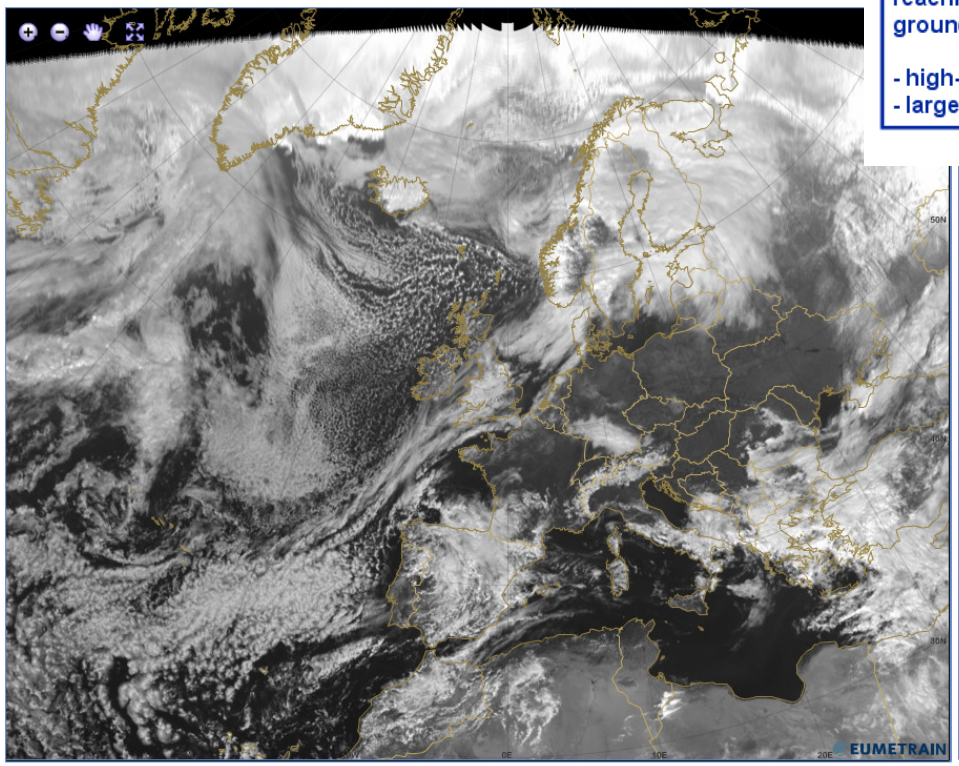
Question: annotate the areas where the RGB product is giving more information



images from EUMETSAT

The Day Convection RGB vs 0.6 micron visible channel

0.6 micron visible channel



Deep precipitating cloud (precip. not necessarily reaching the ground)

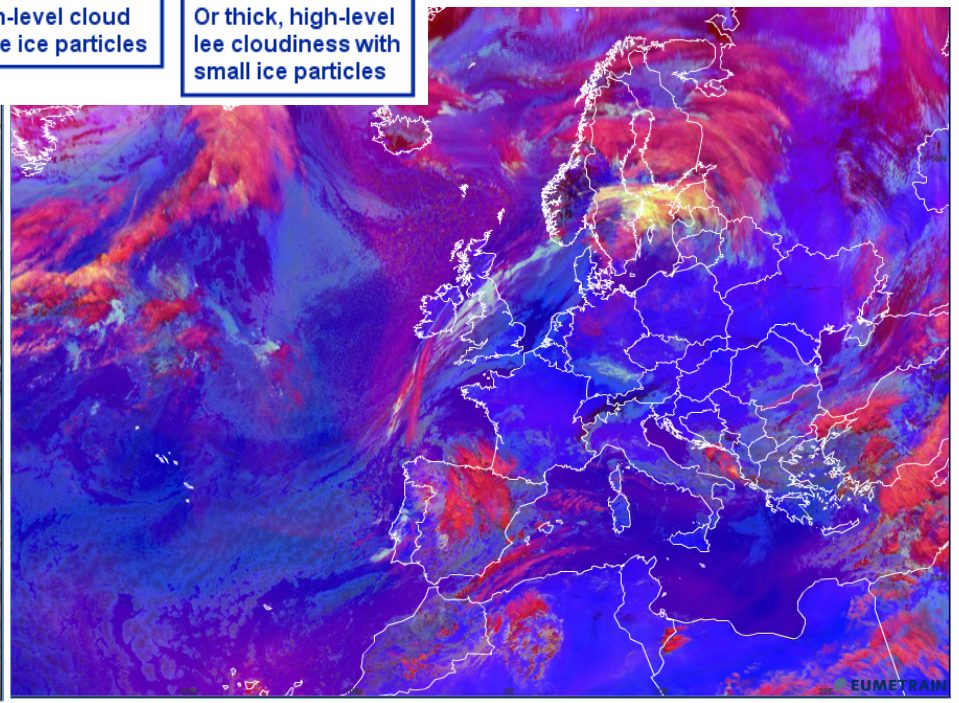
- high-level cloud
- large ice particles

Deep precipitating cloud (Cb cloud with strong updrafts and severe weather)

Or thick, high-level lee cloudiness with small ice particles

Thin Cirrus cloud (large ice particles) — Ocean

Thin Cirrus cloud (small ice particles) — Land

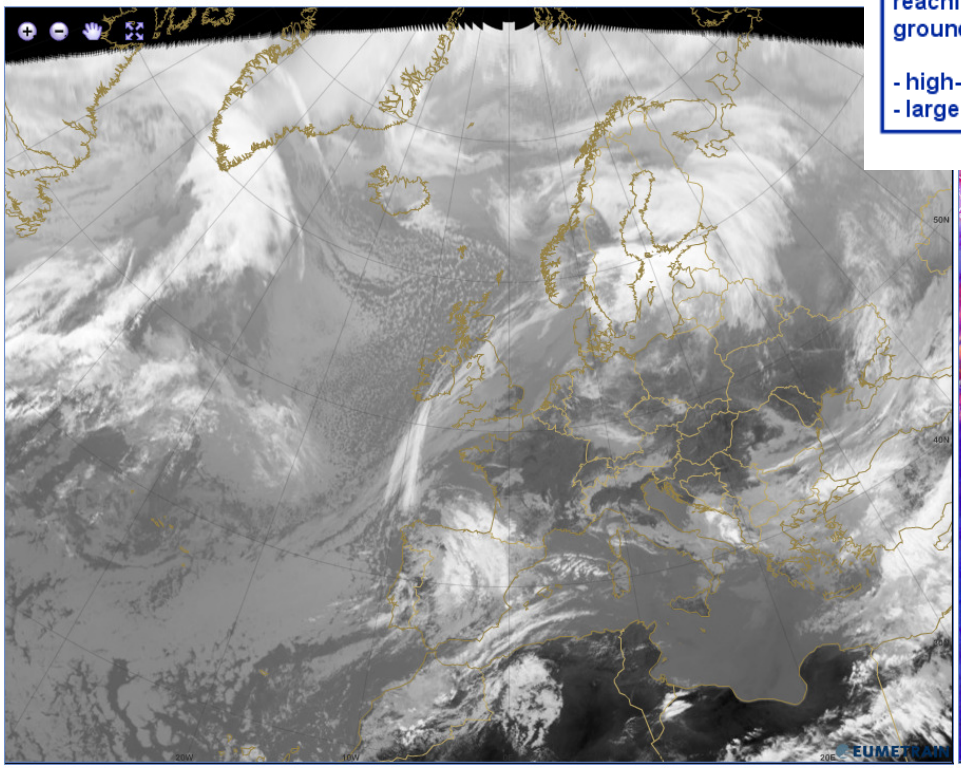


Question – what additional information does the Day Convection RGB give you, compared to the 0.6 micron visible channel ?	**Your answer:**
Question – what additional detail is the visible channel giving you ?.	**Your answer:**

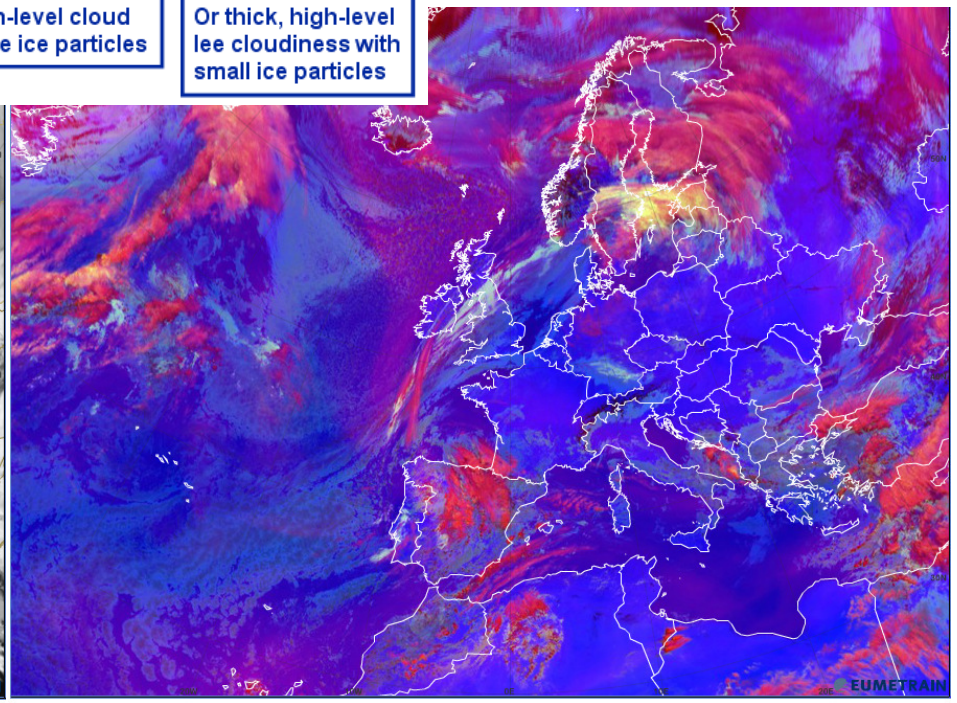
images from EUMETSAT

The Day Convection RGB vs 10.8 micron infrared channel

10.8 micron infrared channel

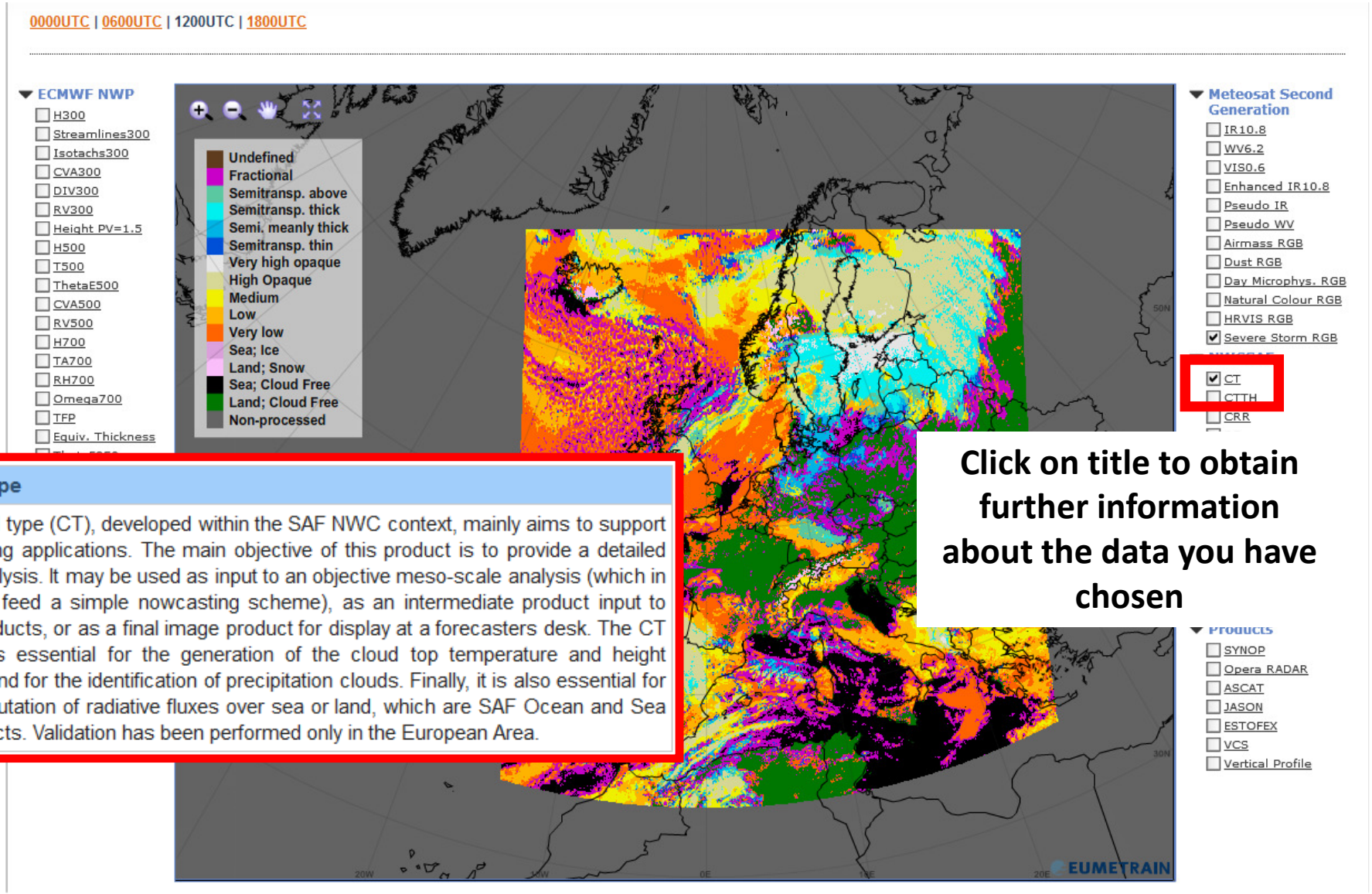


Deep precipitating cloud (precip. not necessarily reaching the ground) - high-level cloud - large ice particles	Deep precipitating cloud (Cb cloud with strong updrafts and severe weather) Or thick, high-level lee cloudiness with small ice particles	Thin Cirrus cloud (large ice particles)	Thin Cirrus cloud (small ice particles)



Question – what additional information does the Day Convection RGB give you, compared to the 10.8 micron infrared channel ?	**Your answer:**
Question – what additional detail is the infrared channel giving you ?.	**Your answer:**

Activity: Overlaying some relevant Derived Products – Cloud Type

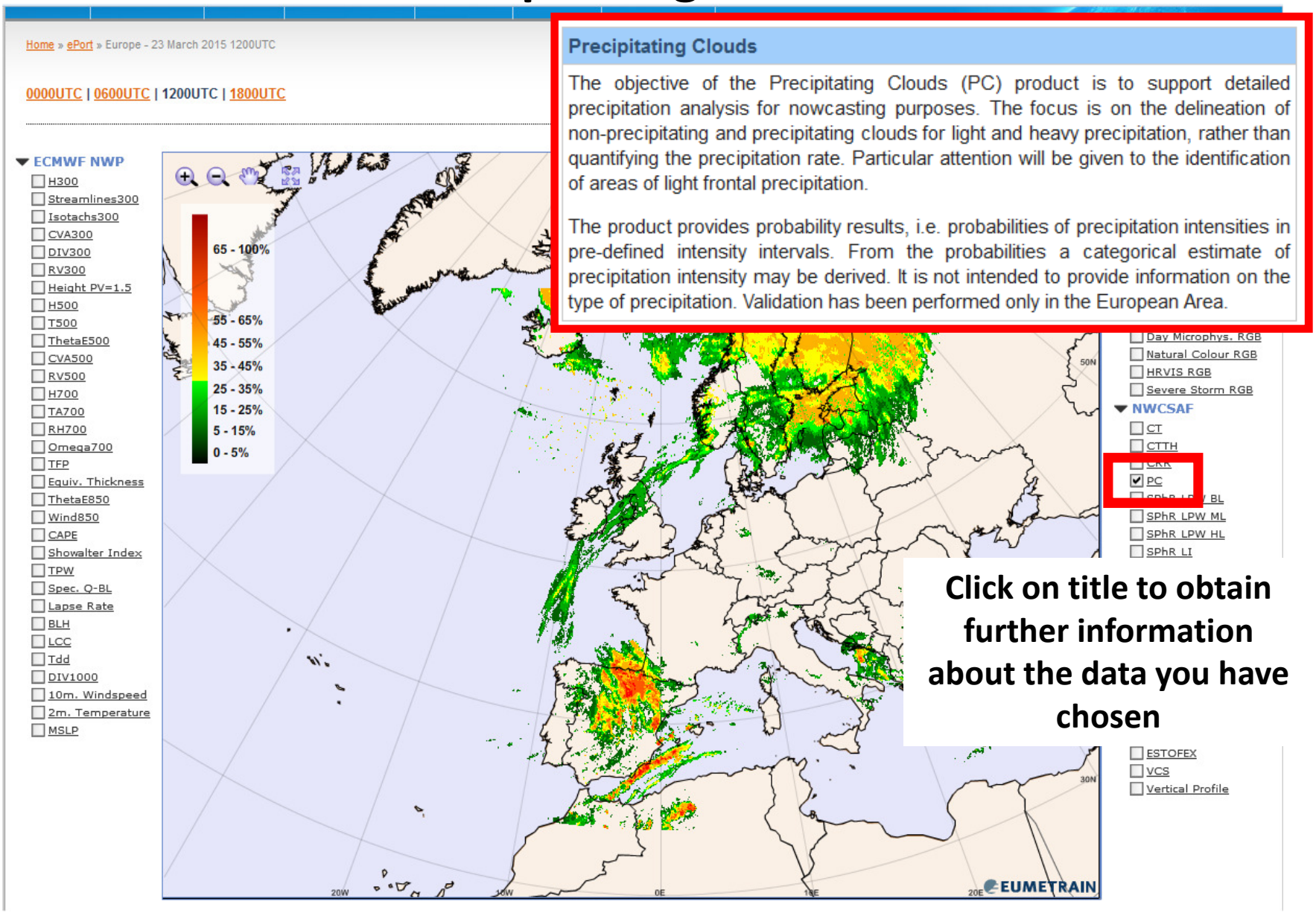


Cloud Type

The cloud type (CT), developed within the SAF NWC context, mainly aims to support nowcasting applications. The main objective of this product is to provide a detailed cloud analysis. It may be used as input to an objective meso-scale analysis (which in turn may feed a simple nowcasting scheme), as an intermediate product input to other products, or as a final image product for display at a forecasters desk. The CT product is essential for the generation of the cloud top temperature and height product and for the identification of precipitation clouds. Finally, it is also essential for the computation of radiative fluxes over sea or land, which are SAF Ocean and Sea Ice products. Validation has been performed only in the European Area.

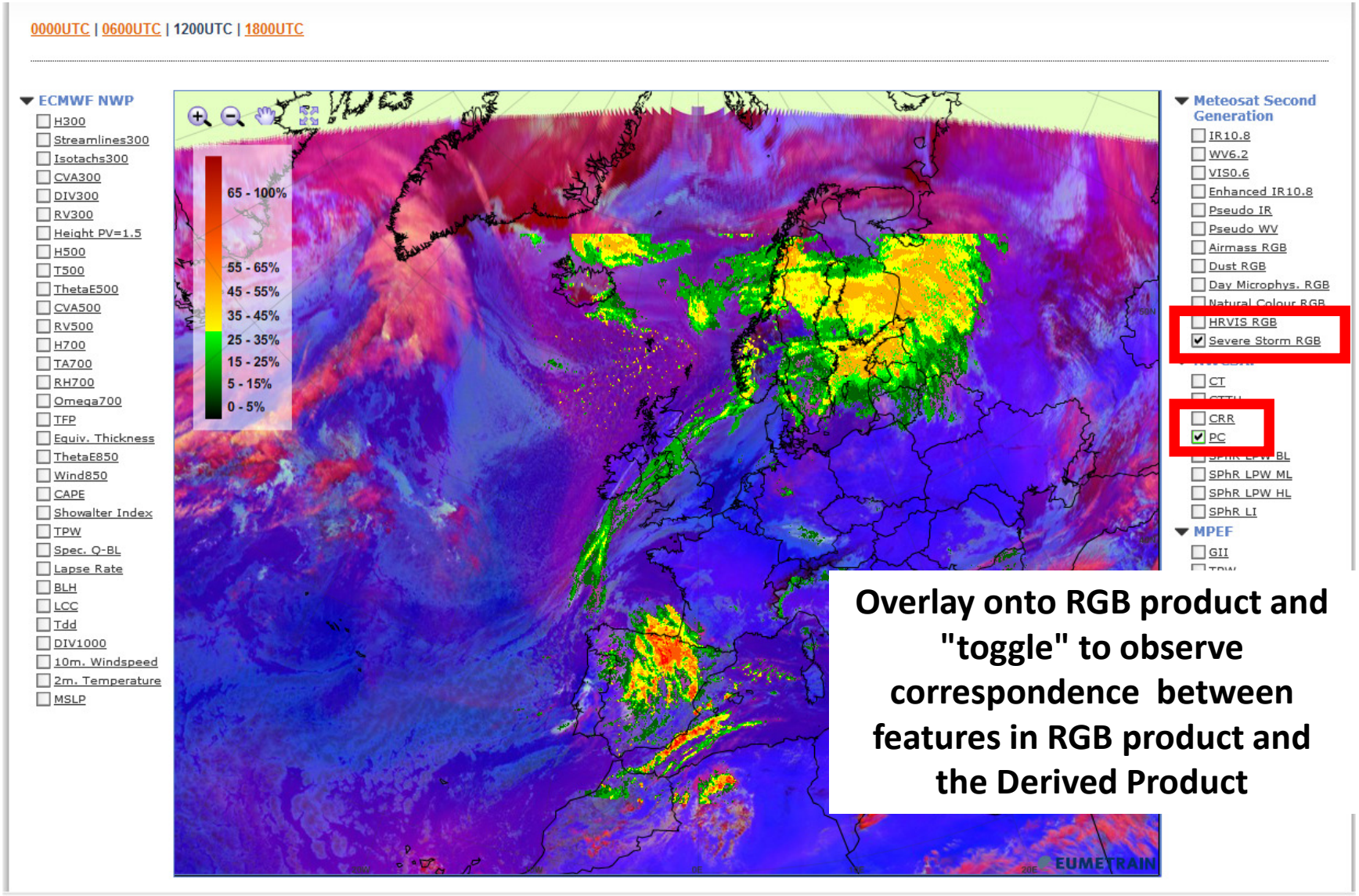
Click on title to obtain further information about the data you have chosen

Activity: Overlaying some relevant Derived Products – Precipitating Clouds



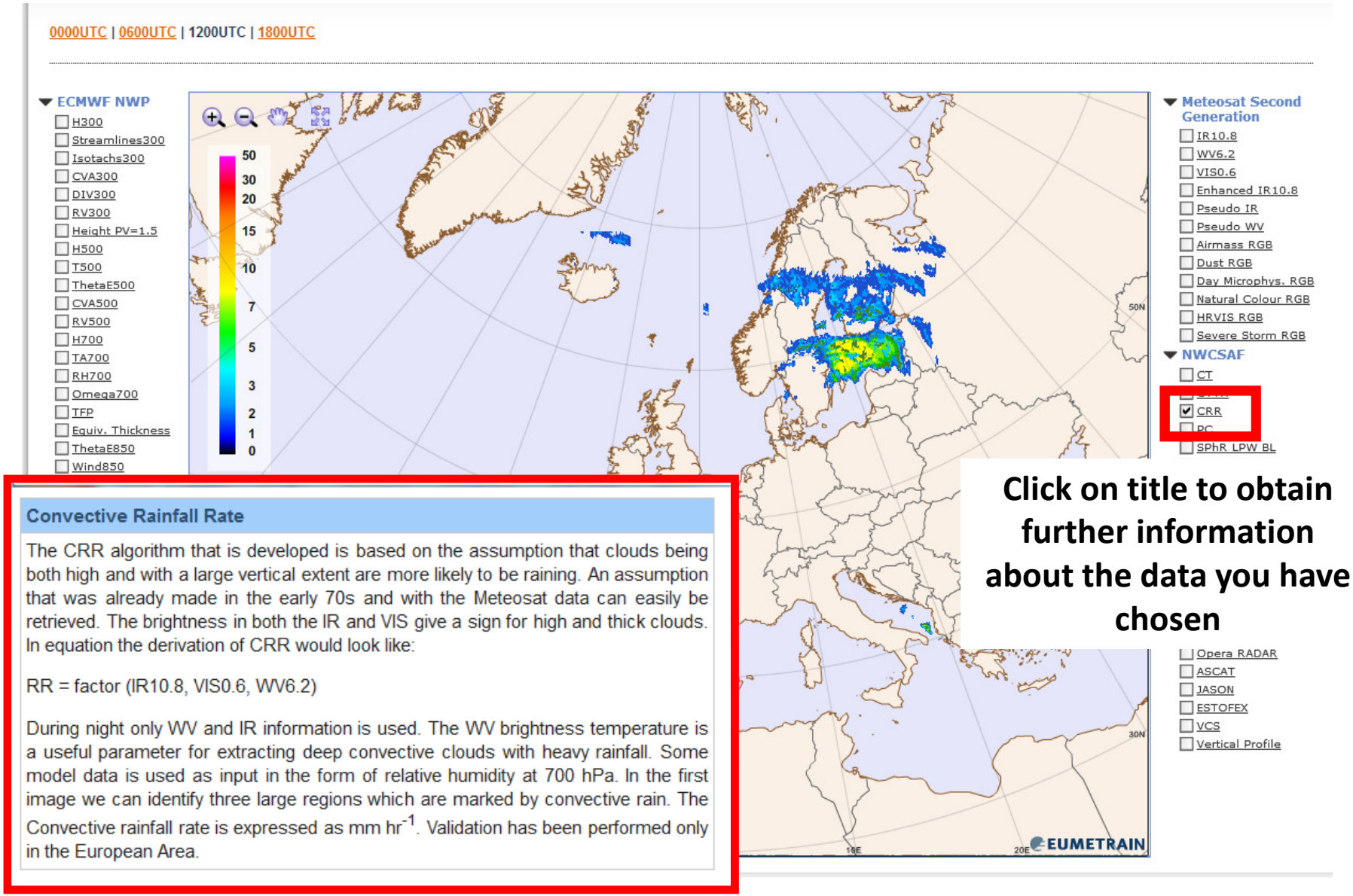
Click on title to obtain further information about the data you have chosen

Activity: Overlaying some relevant Derived Products – Precipitating Clouds



Overlay onto RGB product and "toggle" to observe correspondence between features in RGB product and the Derived Product

Activity: Overlaying some relevant Derived Products – Convective Rainfall Rate



Convective Rainfall Rate

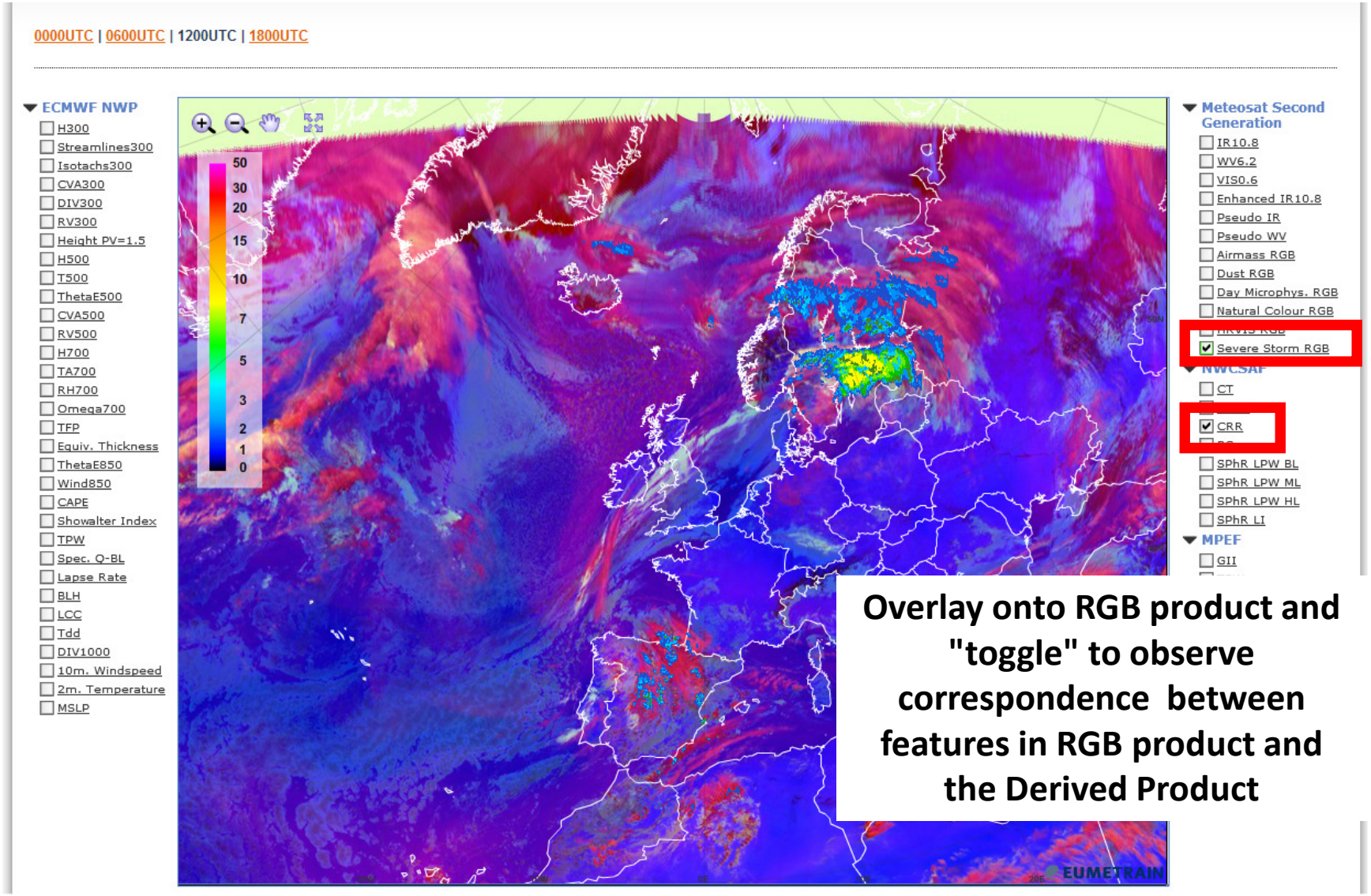
The CRR algorithm that is developed is based on the assumption that clouds being both high and with a large vertical extent are more likely to be raining. An assumption that was already made in the early 70s and with the Meteosat data can easily be retrieved. The brightness in both the IR and VIS give a sign for high and thick clouds. In equation the derivation of CRR would look like:

RR = factor (IR10.8, VIS0.6, WV6.2)

During night only WV and IR information is used. The WV brightness temperature is a useful parameter for extracting deep convective clouds with heavy rainfall. Some model data is used as input in the form of relative humidity at 700 hPa. In the first image we can identify three large regions which are marked by convective rain. The Convective rainfall rate is expressed as mm hr^{-1}. Validation has been performed only in the European Area.

Click on title to obtain further information about the data you have chosen

Activity: Overlaying some relevant Derived Products – Convective Rainfall Rate



Overlay onto RGB product and "toggle" to observe correspondence between features in RGB product and the Derived Product

image courtesy EUMETSAT

Activity: Forecasts overlaid - ESTOFEX

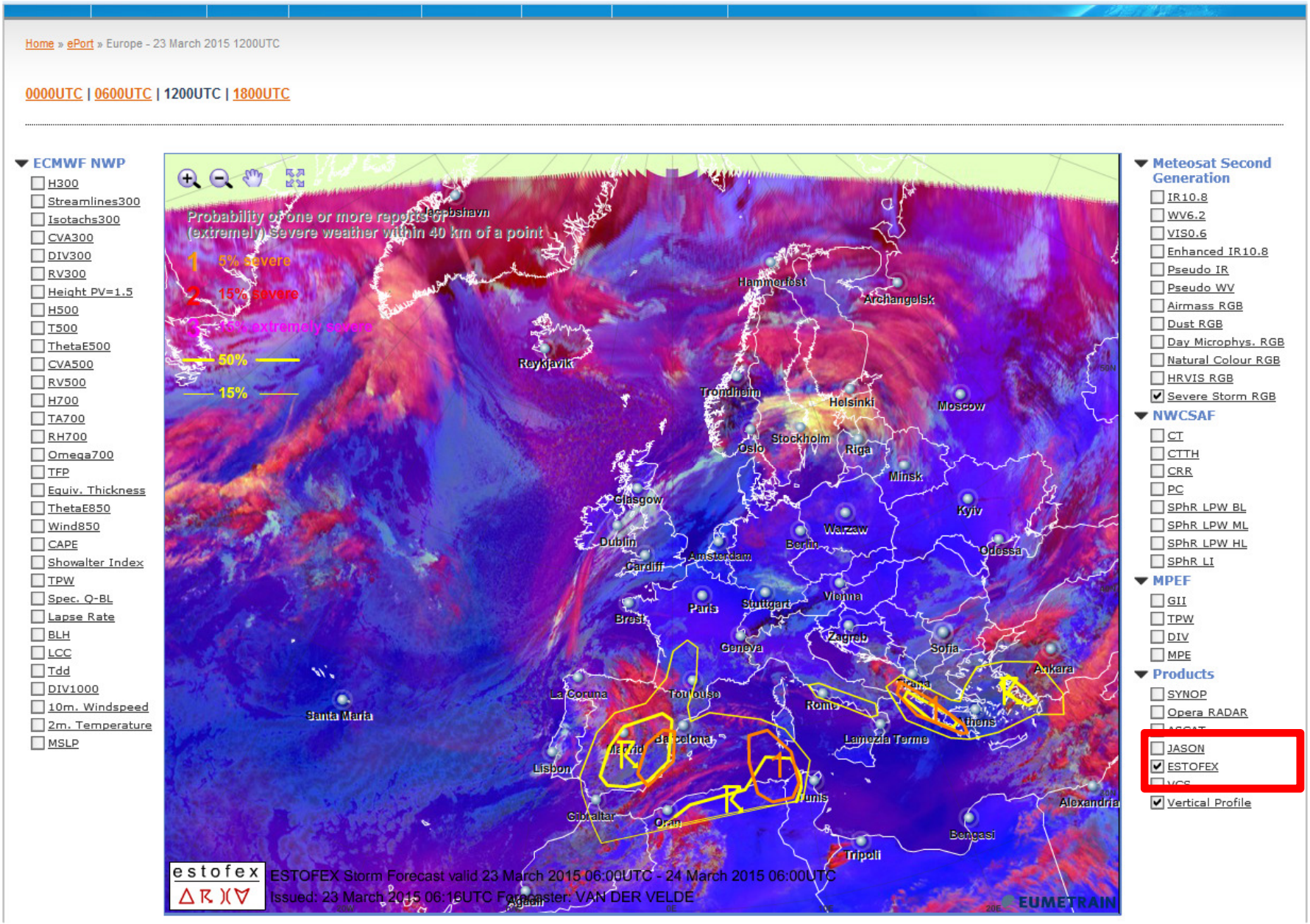
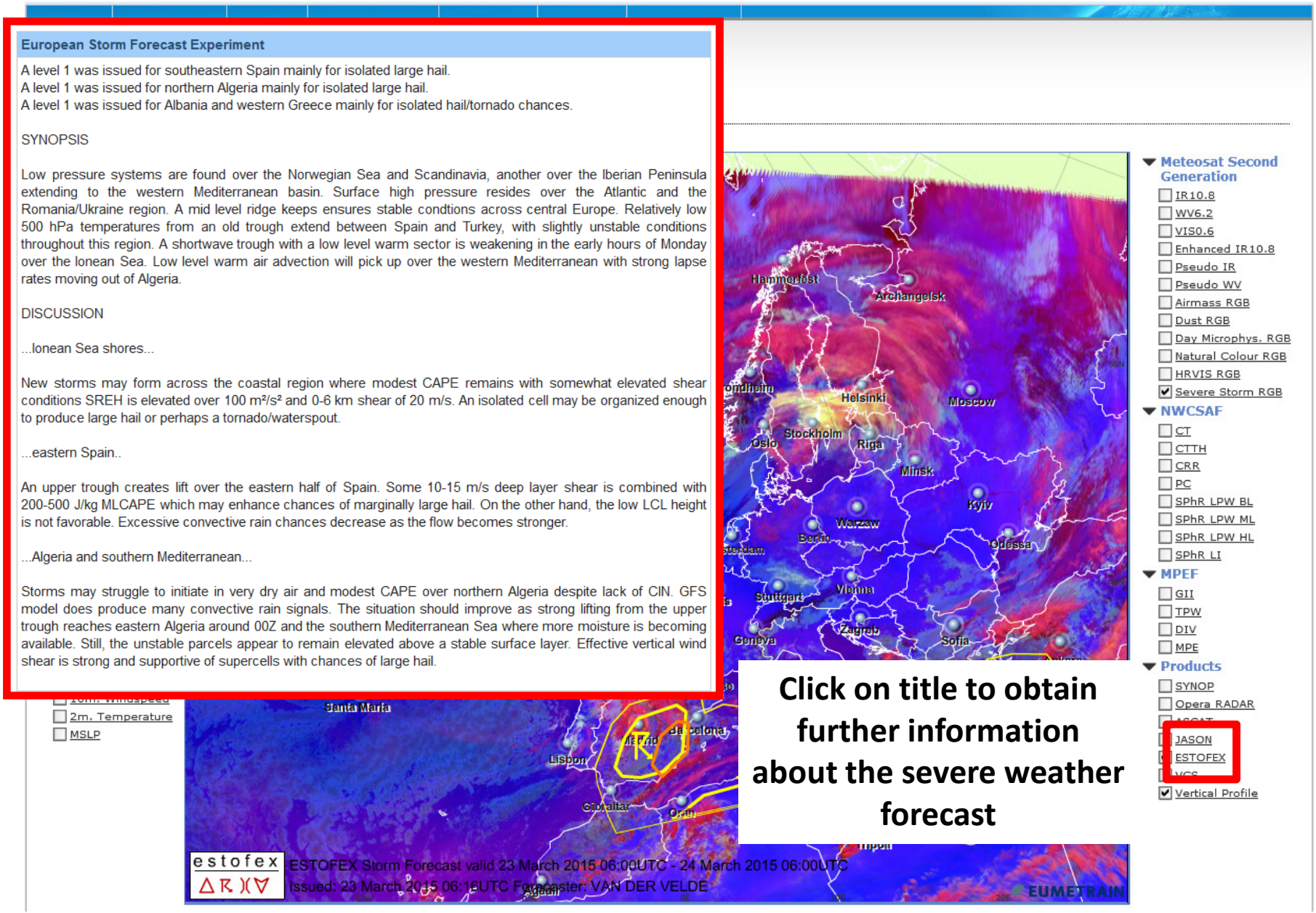


image courtesy EUMETSAT

Activity: Forecasts overlaid - ESTOFEX



Activity: Forecasts overlaid - ESTOFEX

European Storm Forecast Experiment

A level 1 was issued for southeastern Spain mainly for isolated large hail.
A level 1 was issued for northern Algeria mainly for isolated large hail.
A level 1 was issued for Albania and western Greece mainly for isolated hail/tornado chances.

SYNOPSIS

Low pressure systems are found over the Norwegian Sea and Scandinavia, another over the Iberian Peninsula extending to the western Mediterranean basin. Surface high pressure resides over the Atlantic and the Romania/Ukraine region. A mid level ridge keeps ensures stable condtions across central Europe. Relatively low 500 hPa temperatures from an old trough extend between Spain and Turkey, with slightly unstable conditions throughout this region. A shortwave trough with a low level warm sector is weakening in the early hours of Monday over the Ionean Sea. Low level warm air advection will pick up over the western Mediterranean with strong lapse rates moving out of Algeria.

DISCUSSION

...Ionean Sea shores...

New storms may form across the coastal region where modest CAPE remains with somewhat elevated shear conditions SREH is elevated over 100 m^2/s^2 and 0-6 km shear of 20 m/s. An isolated cell may be organized enough to produce large hail or perhaps a tornado/waterspout.

...eastern Spain..

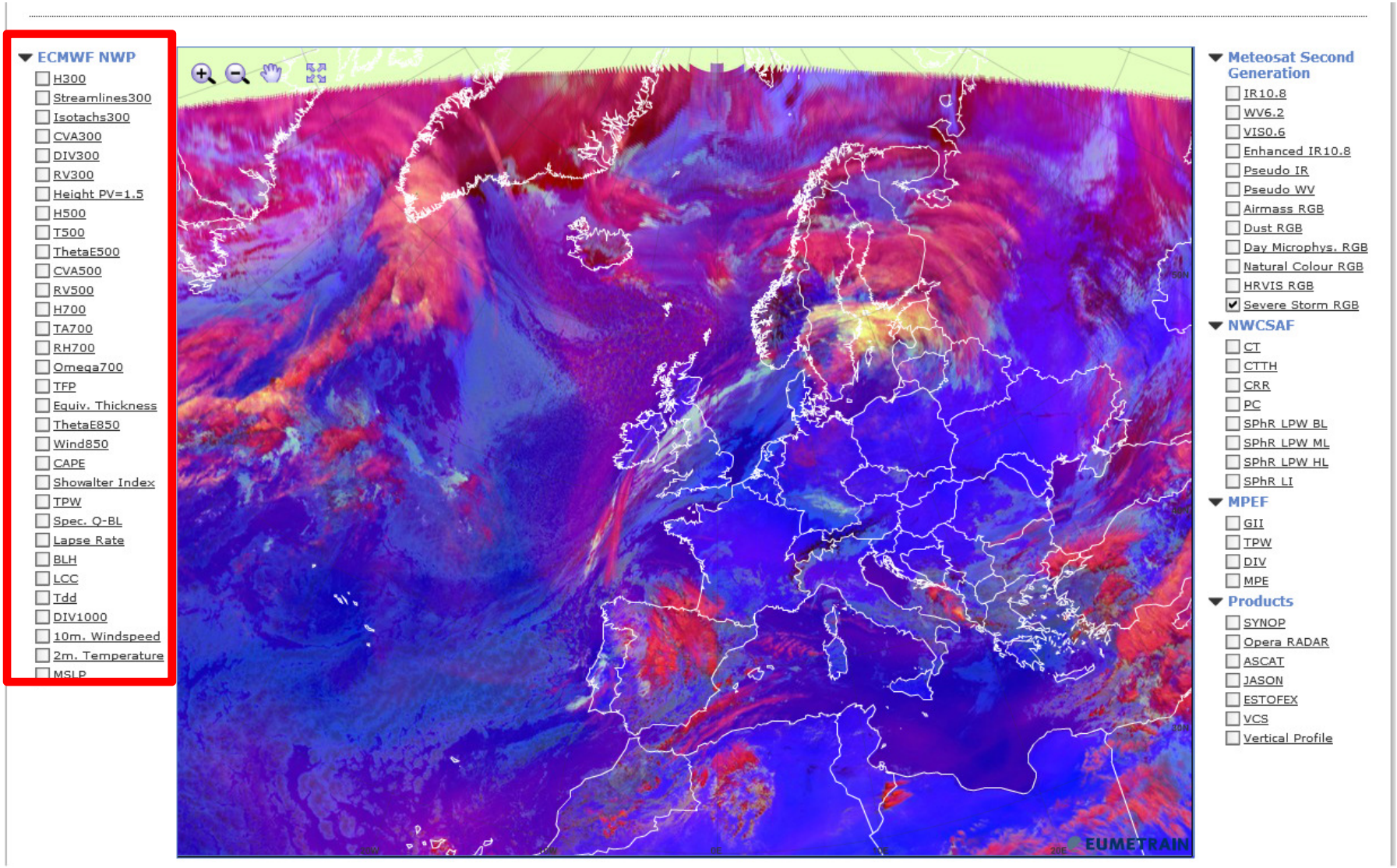
An upper trough creates lift over the eastern half of Spain. Some 10-15 m/s deep layer shear is combined with 200-500 J/kg MLCAPE which may enhance chances of marginally large hail. On the other hand, the low LCL height is not favorable. Excessive convective rain chances decrease as the flow becomes stronger.

...Algeria and southern Mediterranean...

Storms may struggle to initiate in very dry air and modest CAPE over northern Algeria despite lack of CIN. GFS model does produce many convective rain signals. The situation should improve as strong lifting from the upper trough reaches eastern Algeria around 00Z and the southern Mediterranean Sea where more moisture is becoming available. Still, the unstable parcels appear to remain elevated above a stable surface layer. Effective vertical wind shear is strong and supportive of supercells with chances of large hail.

image courtesy EUMETSAT

Activity: Exploring NWP



Activity: please explore the ECMWF NWP fields and indicate which of these NWP fields capture the key features identified in the Day Convection RGB product

image courtesy EUMETSAT

Recommended answer: Day Convection RGB and MSLP

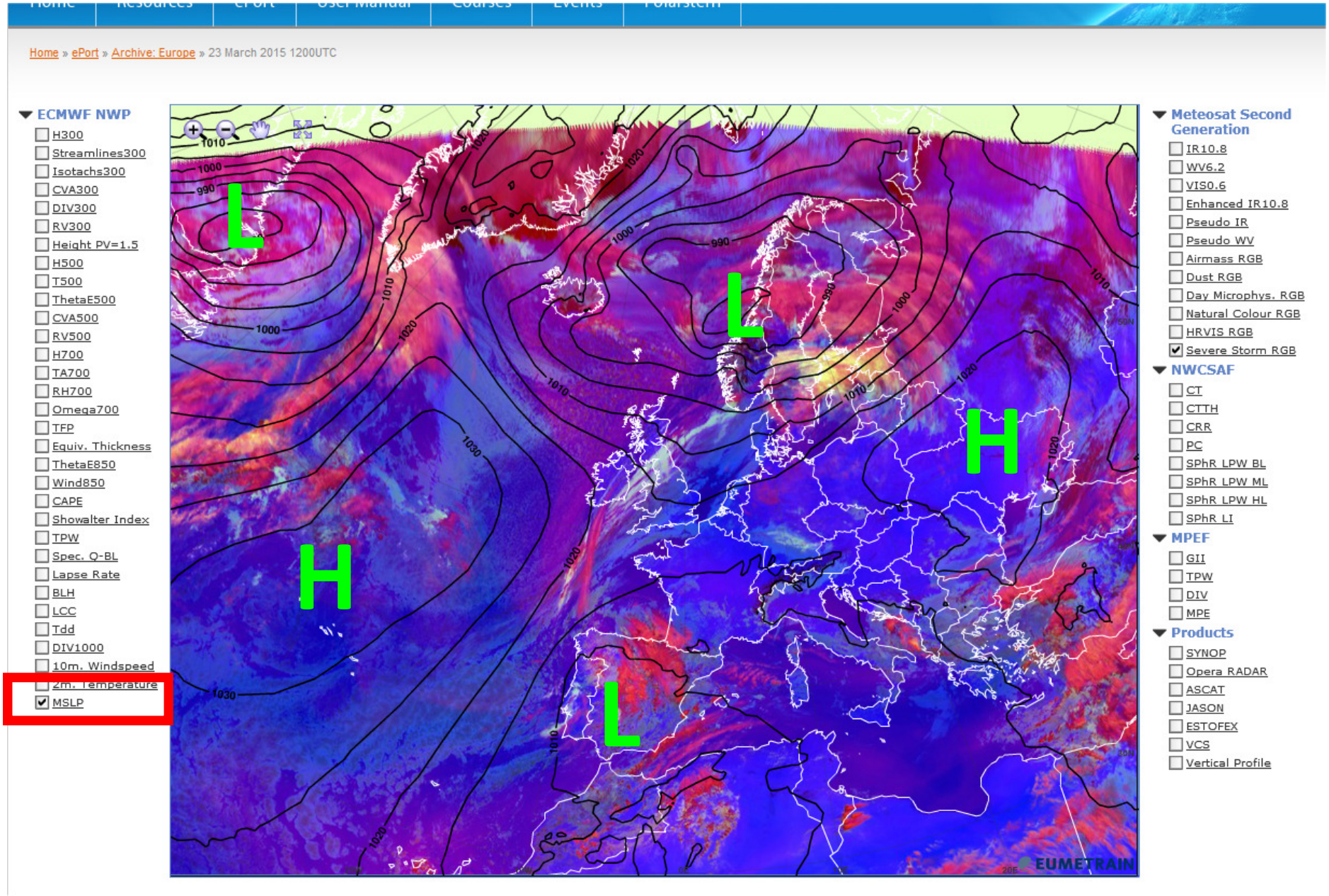


image courtesy EUMETSAT

Recommended answer: Day Convection RGB and 10m wind

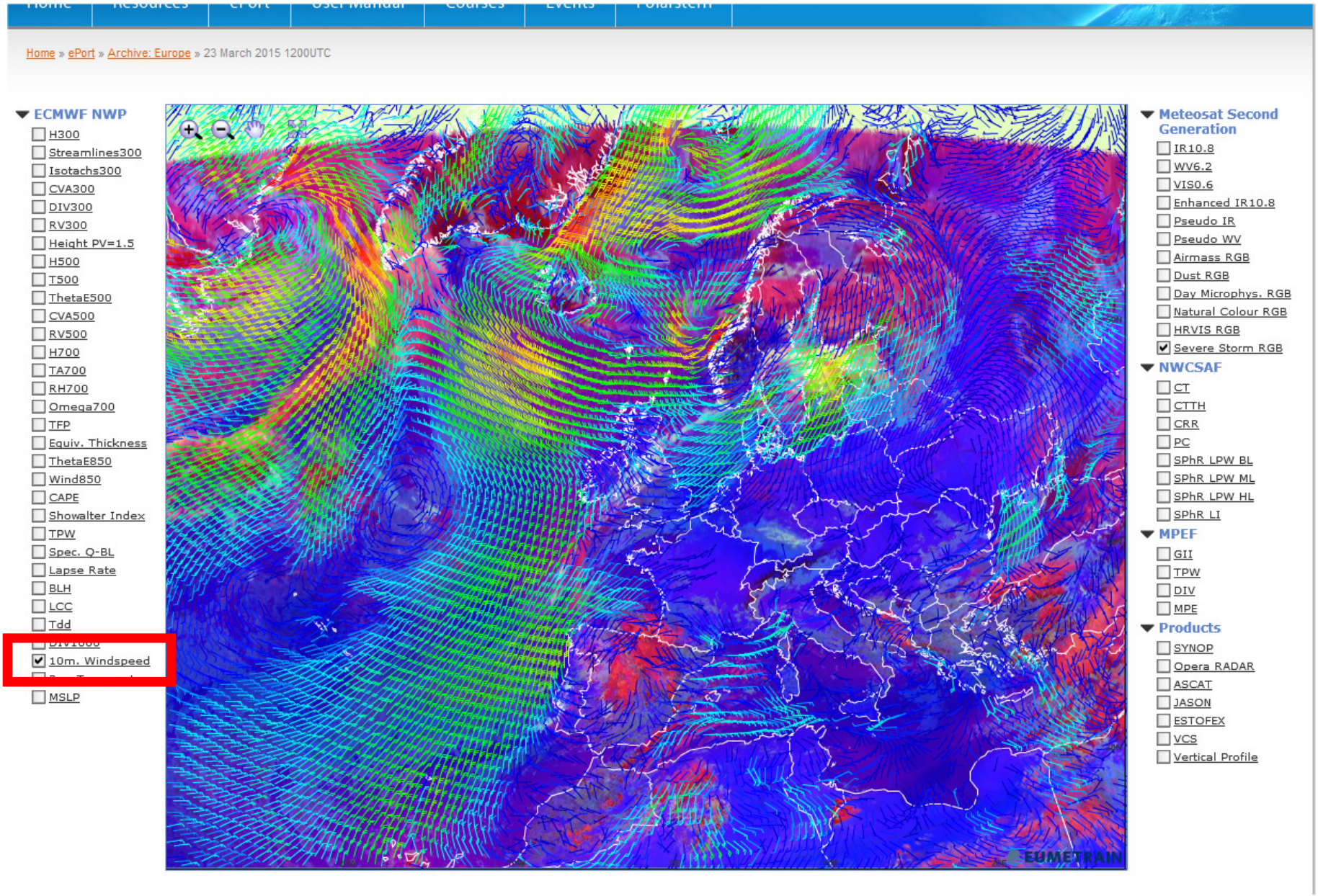
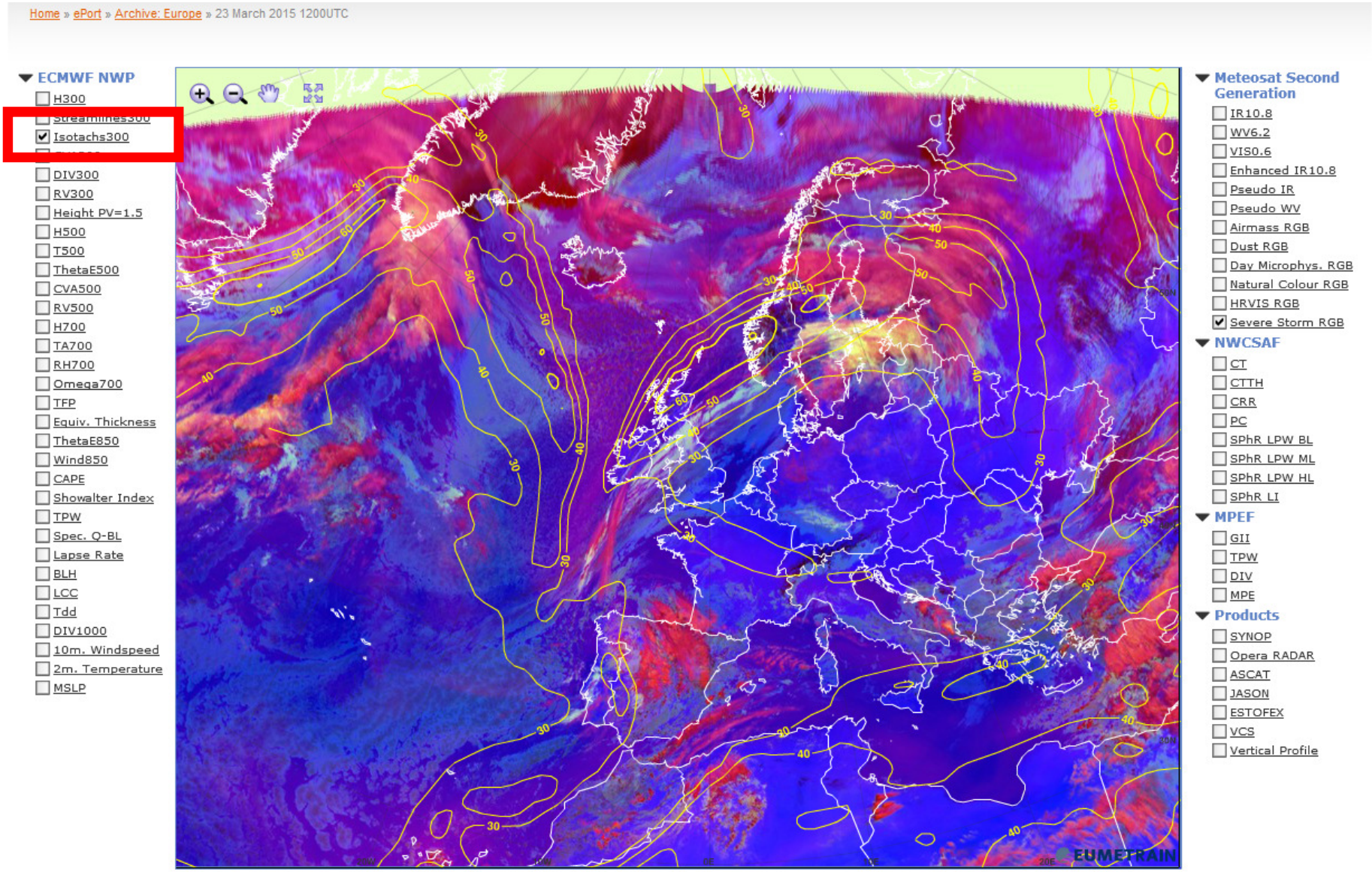
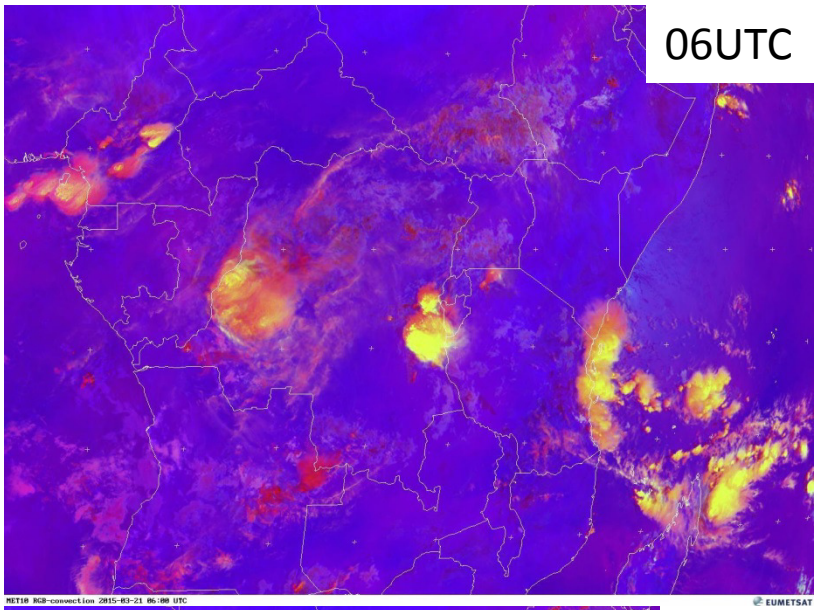


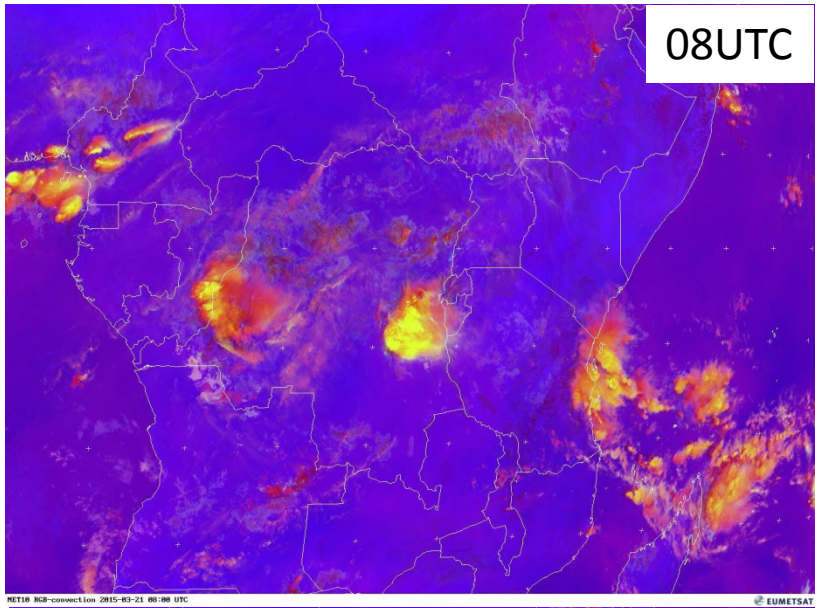
image courtesy EUMETSAT

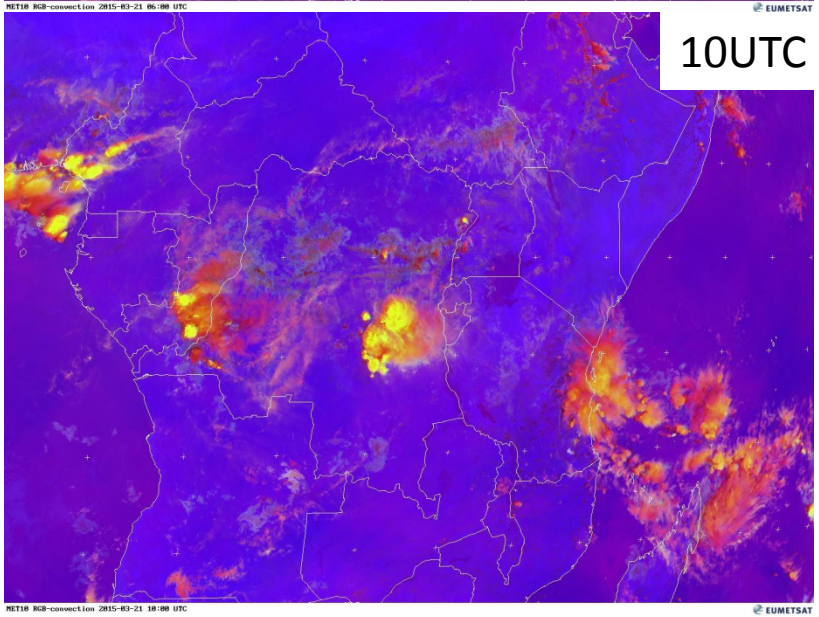
Recommended answer: Day Convection RGB and Isotachs at 300 hPa (upper support of the convection)

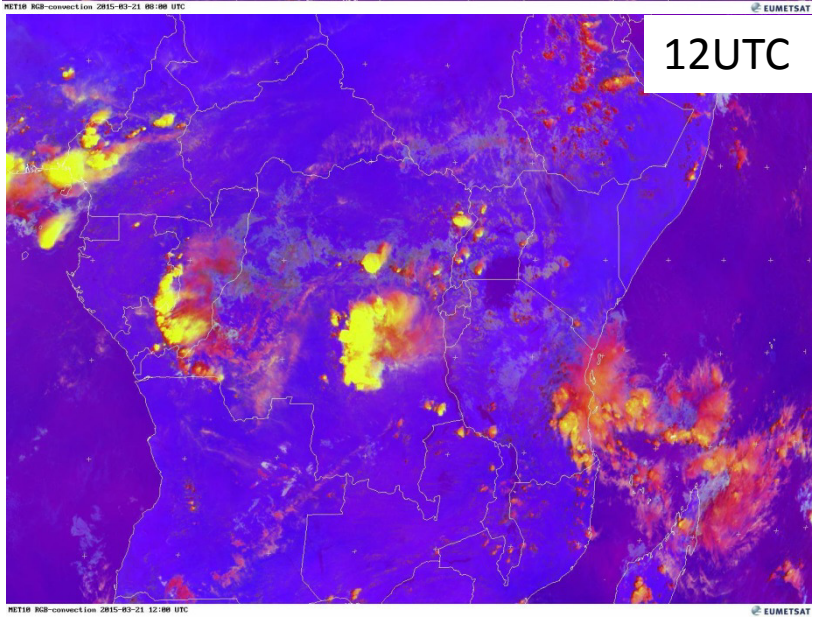


Summary of the Day Convection RGB animation – Central Africa, Meteosat 10, 21 March 2015









Summary – the Day Convection RGB (1)

from https://www.meted.ucar.edu/satmet/multispectral_topics/rgb/print.htm

- This RGB can identify important microphysical characteristics and trends in convection, including small ice particles that point to intense updrafts and are potential indicators of imminent severe weather.
- Severe Convection appear bright yellow in this RGB product due to strong contributions in the red beam from the storm tops, and strong contributions in the green beam due to small ice crystals at stormtop. Small ice crystals at stormtop can result from strong thunderstorm updrafts resulting in the homogeneous freezing of cloud drops
- With the Himawari-8 10 minute imaging during severe weather will give forecasters unprecedented views of convective development across the Asia/Australia/Pacific region
- Future Chinese FY-4 and Japanese Himawari geostationary satellites will also be able to provide this product.

Summary – the Day Convection RGB (2)

from https://www.meted.ucar.edu/satmet/multispectral_topics/rgb/print.htm

Advantages:

- Compared to many satellite images, this RGB highlights the youngest and most intense cells, showing overshooting thunderstorm tops, which can help distinguish new convection from dissipating convective activity.

Limitations:

- Daytime only, requires solar reflectance information
- Not effective for observing or discriminating types of weather other than convection
- Yellow is indicative of small ice particles, which can be associated with either strong convection or in some cases thick high level ice clouds such as found with orographic wave clouds

Appendix 1: Underpinning WMO-1083 and Enabling Skills

WMO 1083 2.3.3.4 – **Interpreting satellite imagery: Interpret satellite images, including use of common wavelengths** (infrared, **visible, water vapour** and **near infrared) and enhancements and animated imagery, to identify cloud types** and patterns, synoptic and mesoscale systems, and special features (fog, sand, volcanic ash, dust, fires, etc.);

WMO 1083 2.3.3.3 - Extreme weather: **Describe the weather, with emphasis on any extreme or hazardous conditions that might be associated with convective and mesoscale phenomena**, and the likely impact of such conditions;

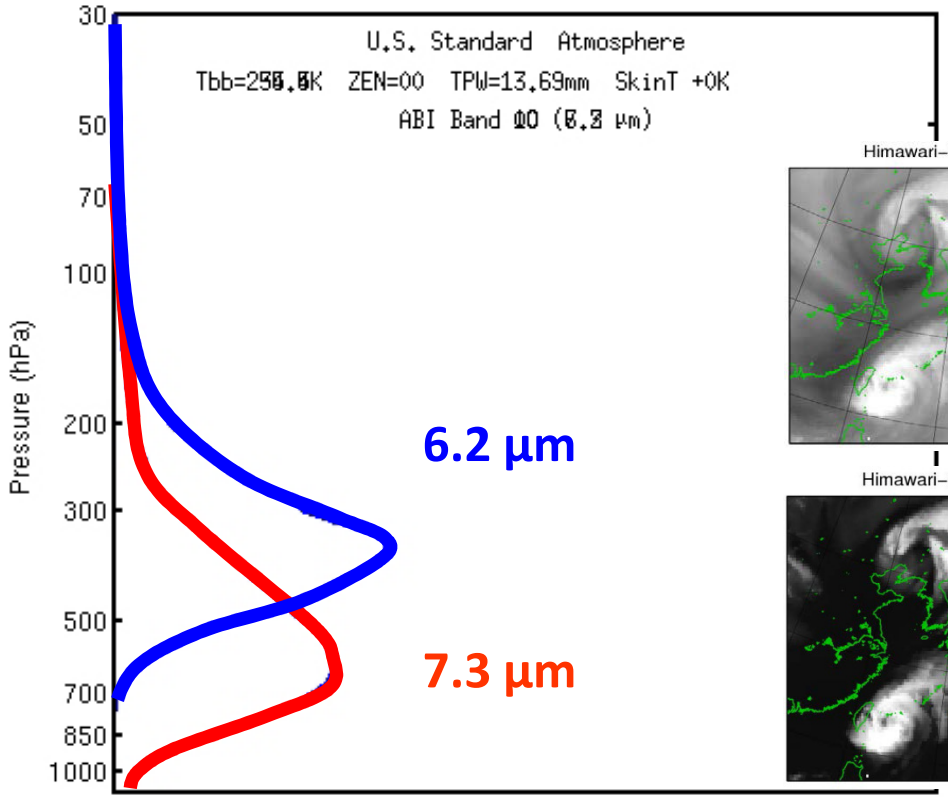
Enabling Skills Document Element 2, Performance Component 2 - **Identify cumulonimbus clouds, their intensity** and stage of development.

Enabling Skills Document Element 2, Performance Component 7 - **Discriminate between clouds with small or large cloud particles**

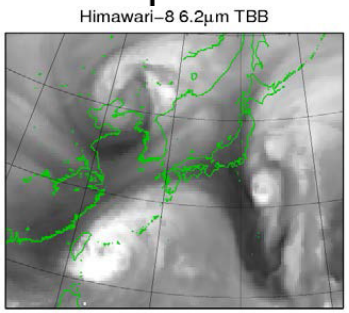
Appendix 2: Explaining the channel combination recipe in more detail. Components of the Red Beam

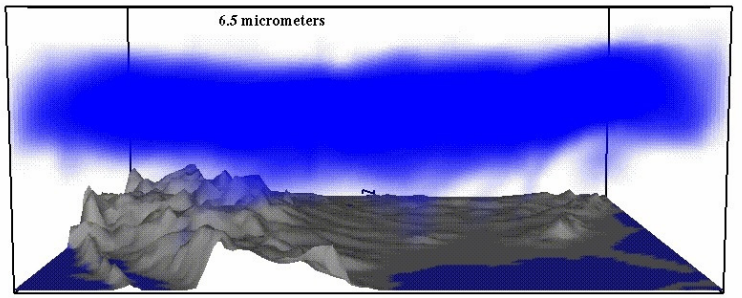
Himawari synthetic images from "A Correspondence Analysis of VIS and IR bands between MTSAT Imager and Himawari-8/9 AHI T.Kurino JMA/MSC

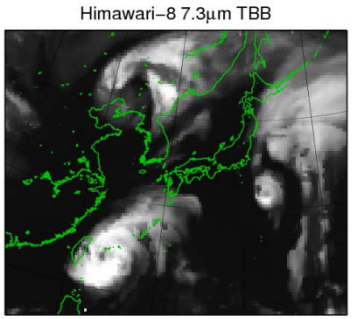
Weighting Functions of the 6.2 µm and 7.3 µm channels

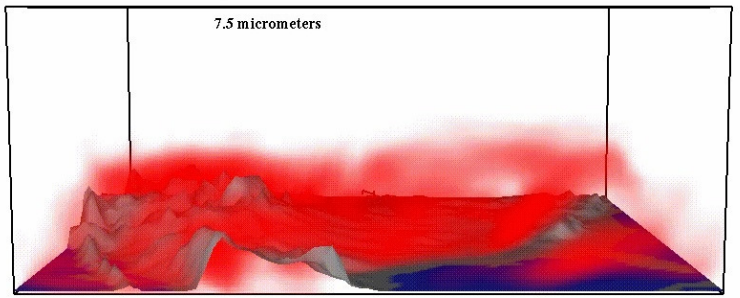


Synthetic satellite image output of the 6.2 and 7.3 micron imagery (centre). Three dimensional representation of location of the 6.5 and 7.5 micron signal







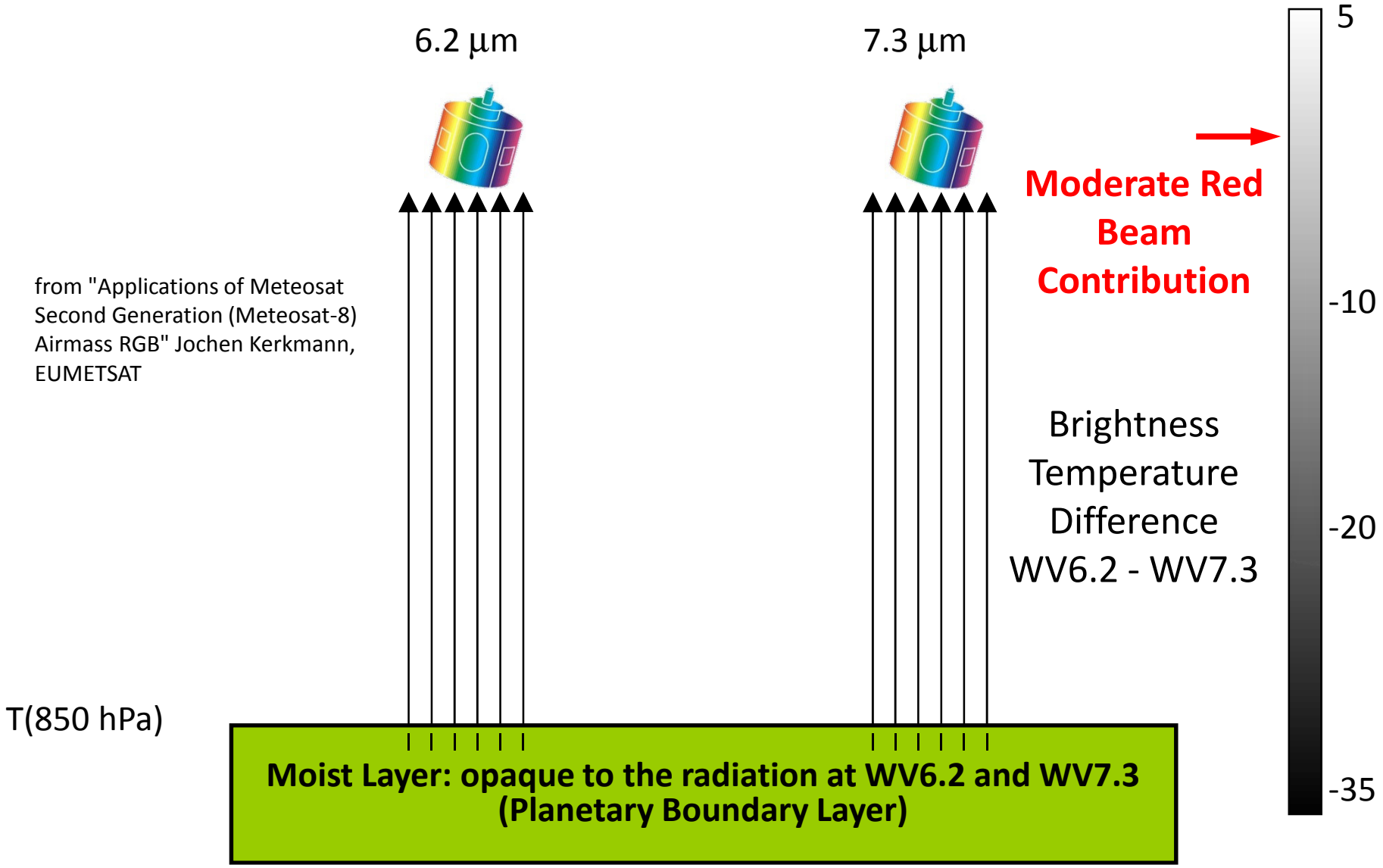


GOES Sounder Weighting Functions for 12UTC on 23-Oct-96

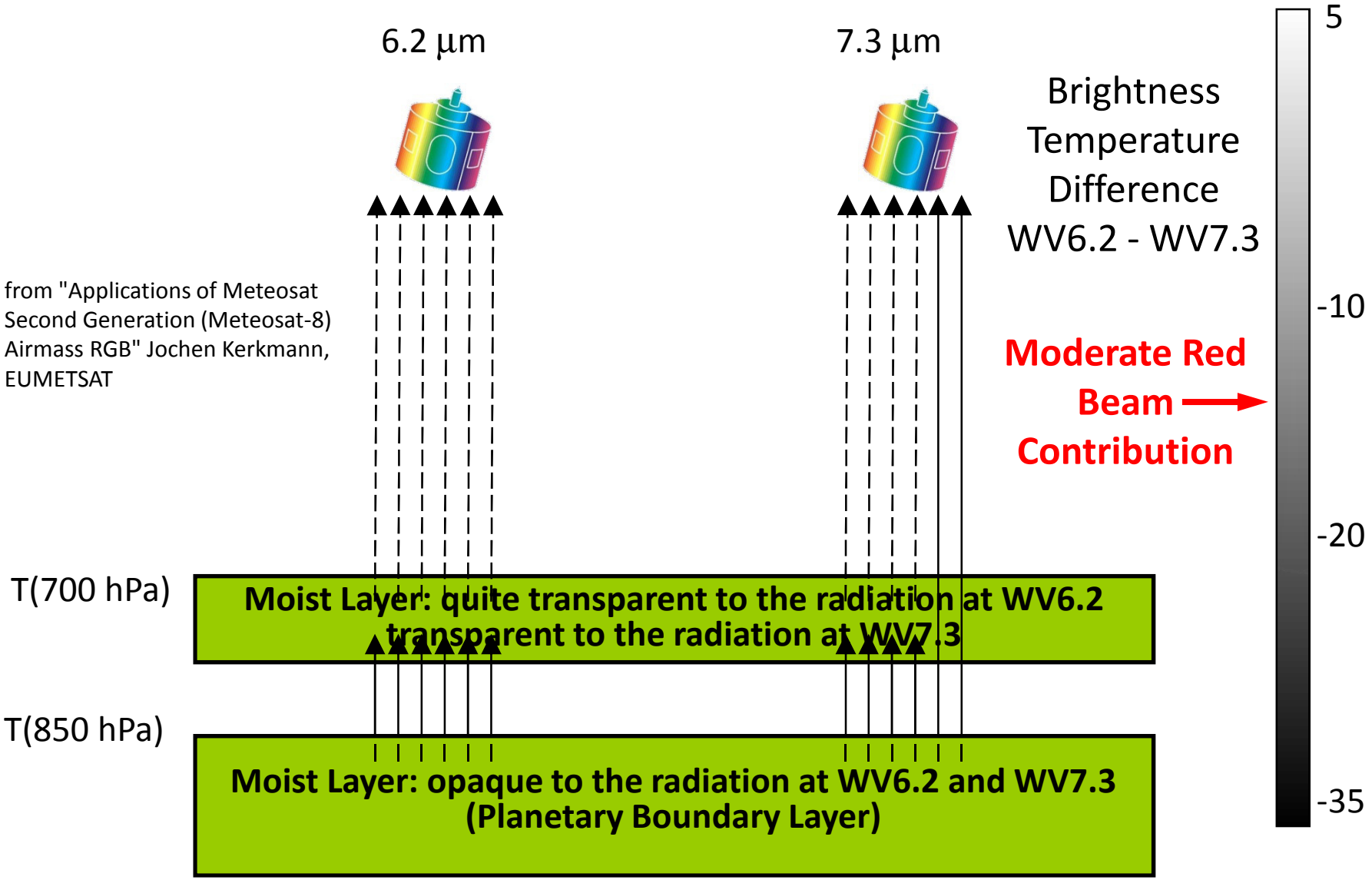
NOAA/NESDIS

Image courtesy CIMSS (UW Madison / NOAA)

Red Beam, case 1: very dry atmosphere above 850hPa

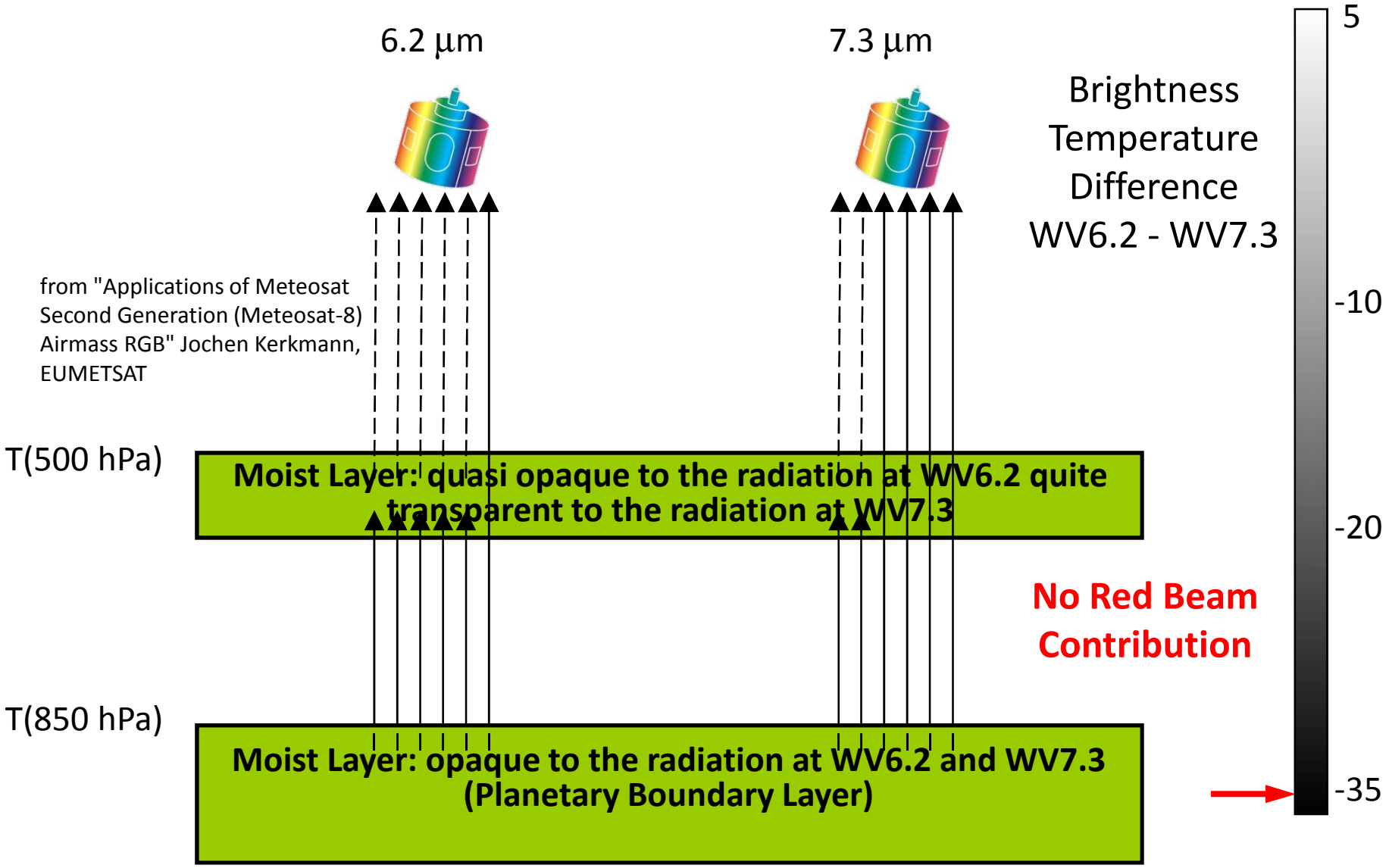


Red Beam, case 2: moist layer at 700 hPa

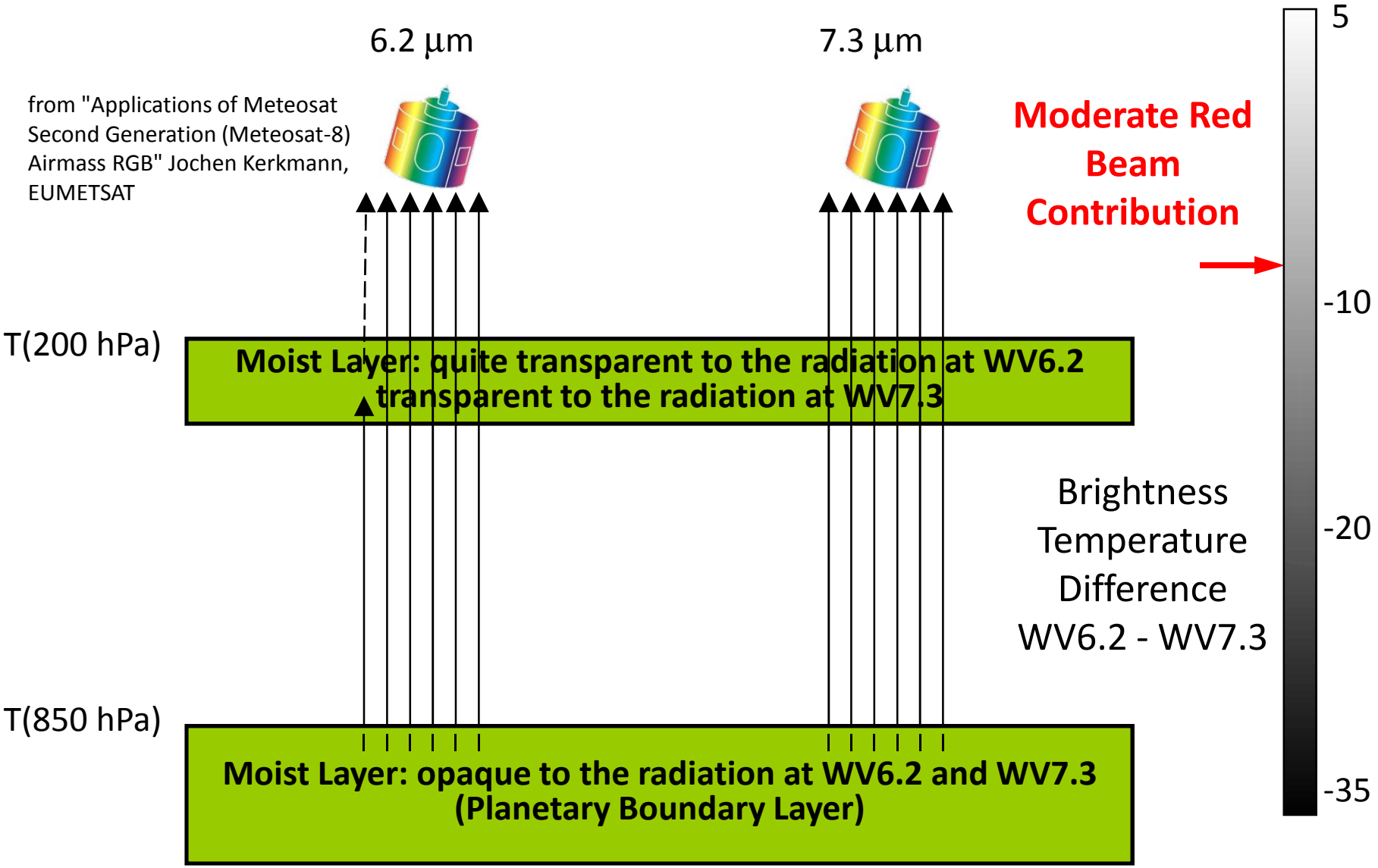


from "Applications of Meteosat Second Generation (Meteosat-8) Airmass RGB" Jochen Kerkmann, EUMETSAT

Red Beam, case 3: moist layer at 500 hPa

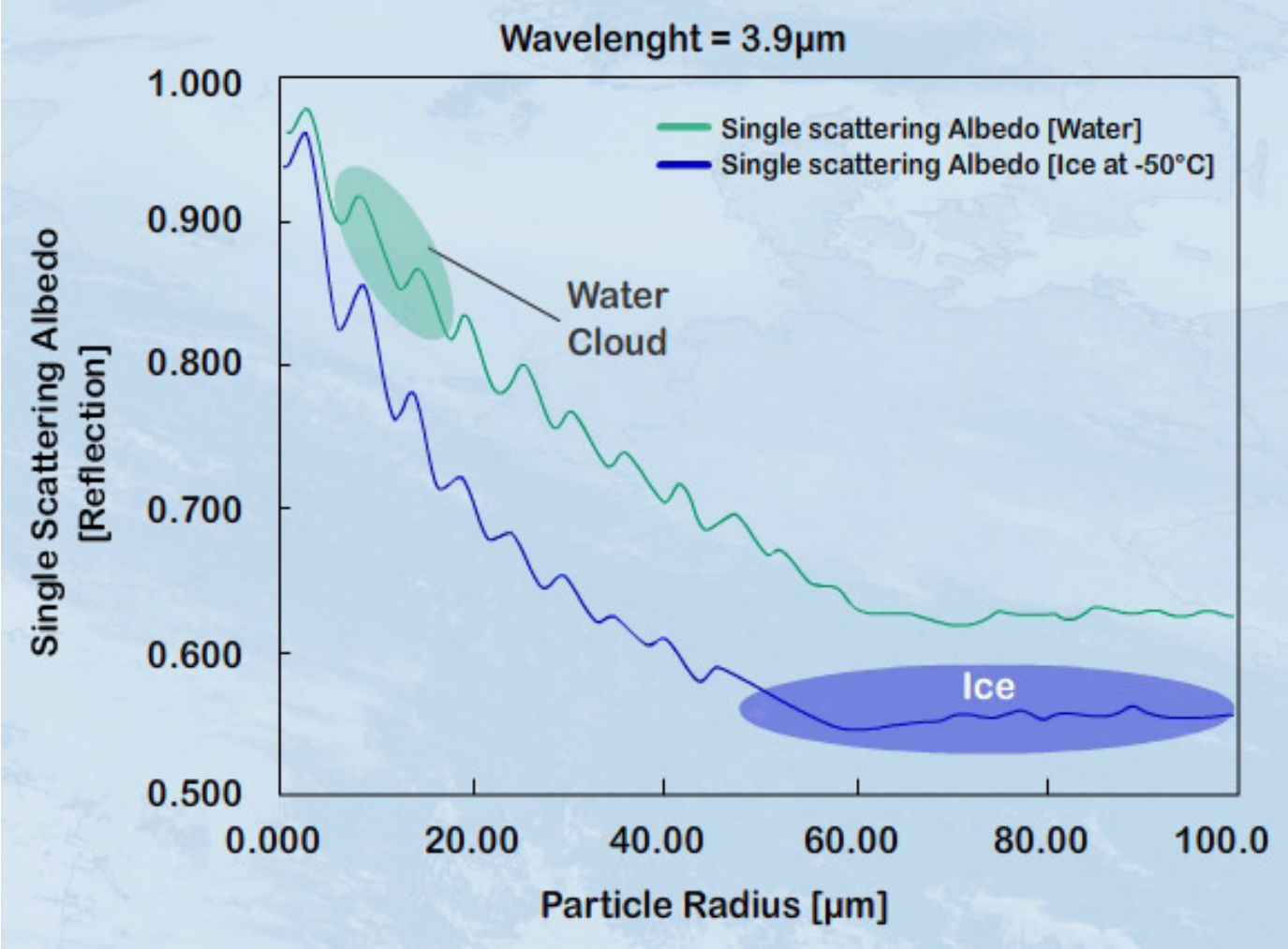


Red Beam, case 4: moist layer at 200 hPa



Appendix 2: Explaining the channel combination recipe in more detail. Components of the Green Beam

(from http://www.eumetrain.org/data/3/34/rgbcal_ch4.swf)



For the 3.9 micron channel used in the Green beam, the scattering is more pronounced for water cloud, compared to ice crystals. That is because water droplets are typically smaller in size. However, small ice crystals would also have a higher scattering albedo.

Appendix 2: Explaining the channel combination recipe in more detail. Components of the Blue Beam

http://eumetrain.org/data/2/204/204.pdf

Absorption of Ice and Water cloud according D. Rosenfeld: