Australian Government
Bureau of Meteorology

Australian VLab Centre of Excellence

National Himawari-8
Training Campaign

The Night Microphysics 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 Night Microphysics 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 Night Microphysics 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. By applying Conceptual Models be able to identify the conditions conducive to a duststorm from the data
- Have a better appreciation of using the Night Microphysics RGB product in monitoring, nowcasting and short term forecasting of fog and low cloud
- 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

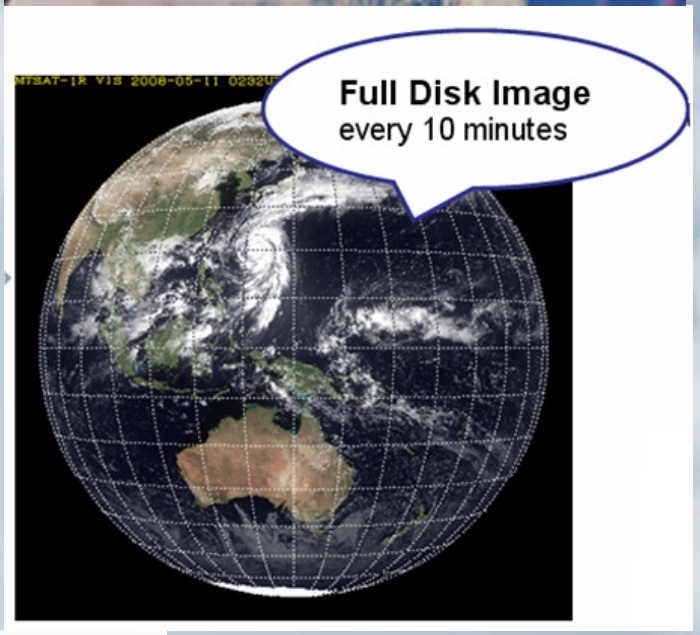
Case Study

- Displaying the data (EUMETSAT ePort)
- Comparing single channels with the RGB product, overlaying model fields, Derived Products etc.and interpreting the data using a Conceptual Model
- 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



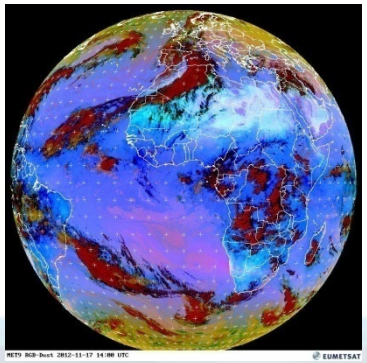
気象庁
Japan Meteorological Agency

from JMA

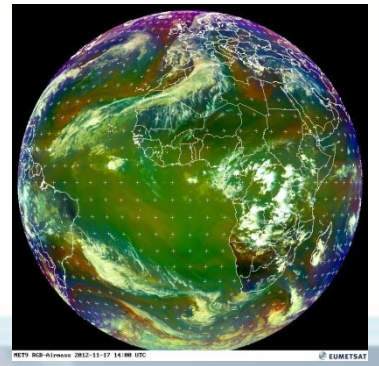
RGB products for Operational Forecasting – EumetSAT recommendation – the Night Microphysics RGB

Australian Government
Bureau of Meteorology

Two RGB composites which complement each other



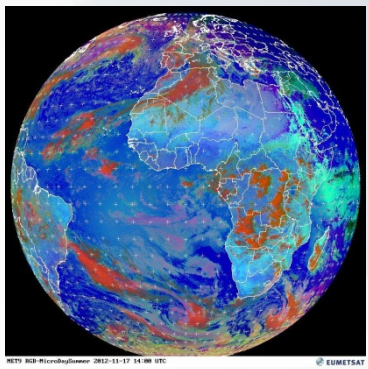
24 hour Microphysical RGB



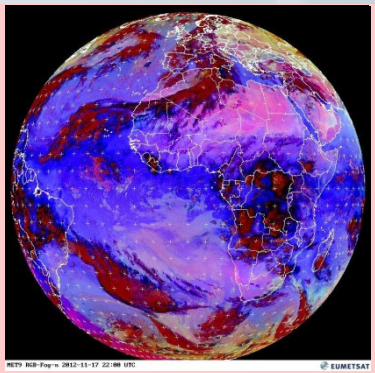
Airmass RGB

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

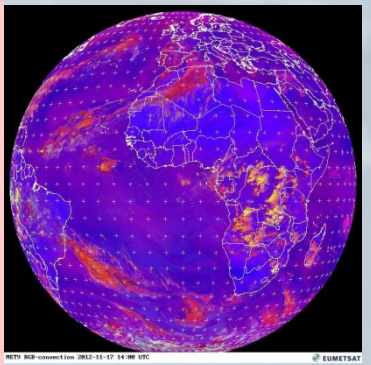
Five application specific RGBs



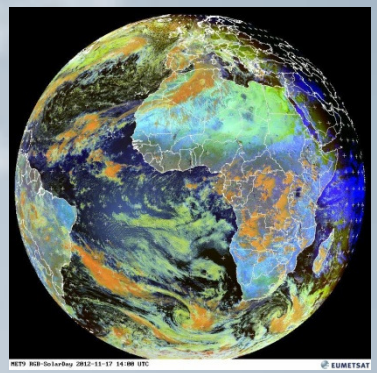
Day Microphysical RGB



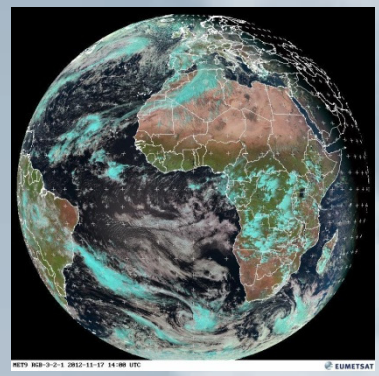
Night Microphysical RGB



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.

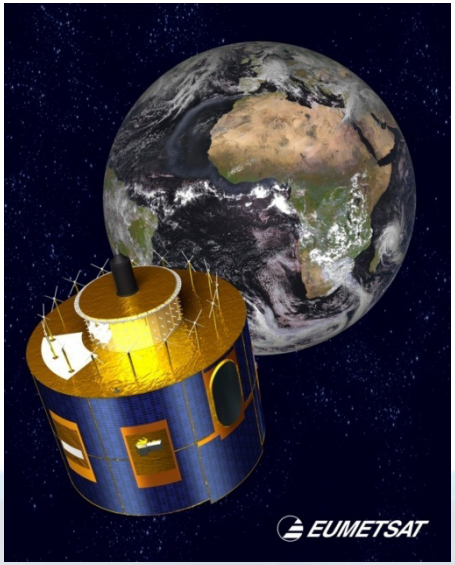
At World Meteorological Organisation (WMO) level: agree on a strict minimum of harmonised RGB composites. The following strategies for the application of RGB products to the forecasting routine were outlined:

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

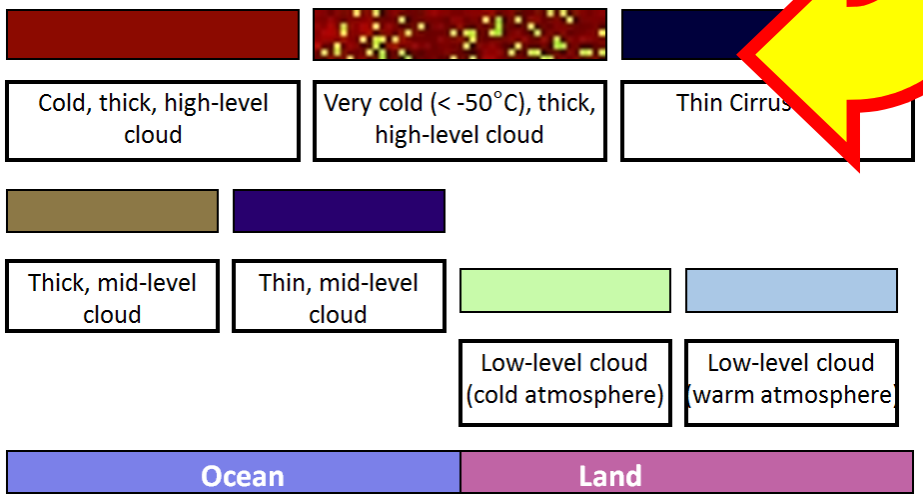
EUMETSAT processing of METEOSAT data – Night Microphysics RGB

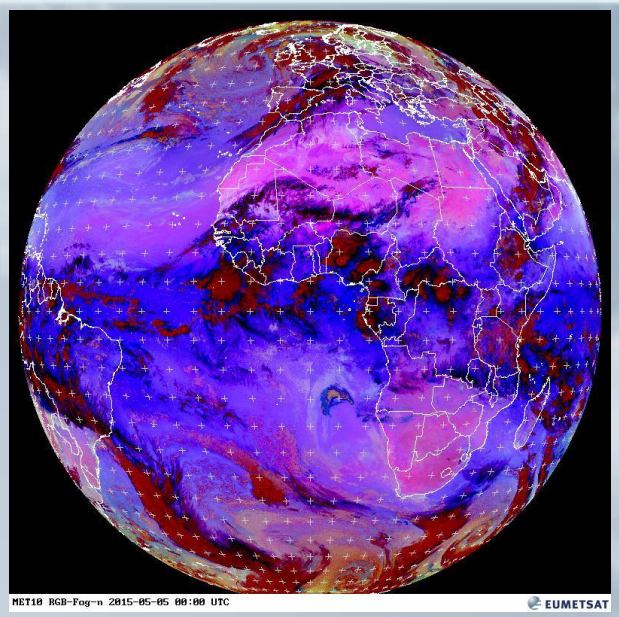


Recommended Range and Enhancement:

Beam	Channel	Range	Gamma
Red	IR12.0 - IR10.8	-4 … +2 K	1.0
Green	IR10.8 - IR3.9	0 … +10 K	1.0
Blue	IR10.8	+243 … +293 K	1.0

CHANNEL COMBINATION





EUMETSAT 0 degree RGB Composite

COLOUR INTERPRETATON

EUMETSAT = European Organization for the Exploitation of Meteorological Satellites

EUMETSAT processing of METEOSAT data – Night Microphysics RGB

The previous slide shows the channels used in the RGB product and the thresholds (range) applied to the Beams as per EUMETSAT recipe

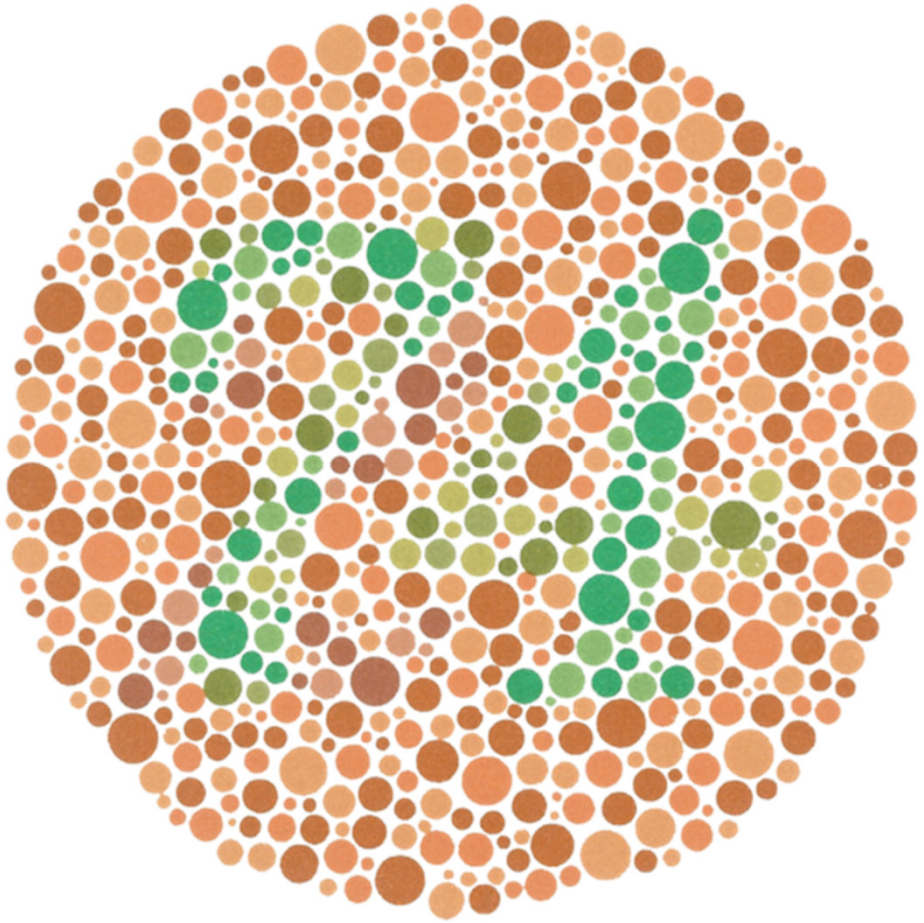
The appearance of the RGB product for the full disk earth image scanned by the Meteosat satellite is also shown. Note that this looks very different from the familiar single channel visible and infrared images. This RGB product also looks very different from the true colour earth image.

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.

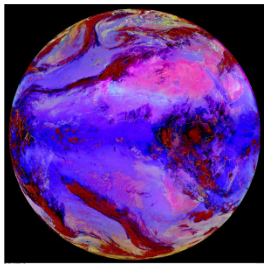
If you cannot see this number, please send an email to b.zeschke@bom.gov.au and I will adapt this training resource accordingly



construction courtesy B.Zeschke BOM

Channel combination recipe of the Night Microphysics RGB

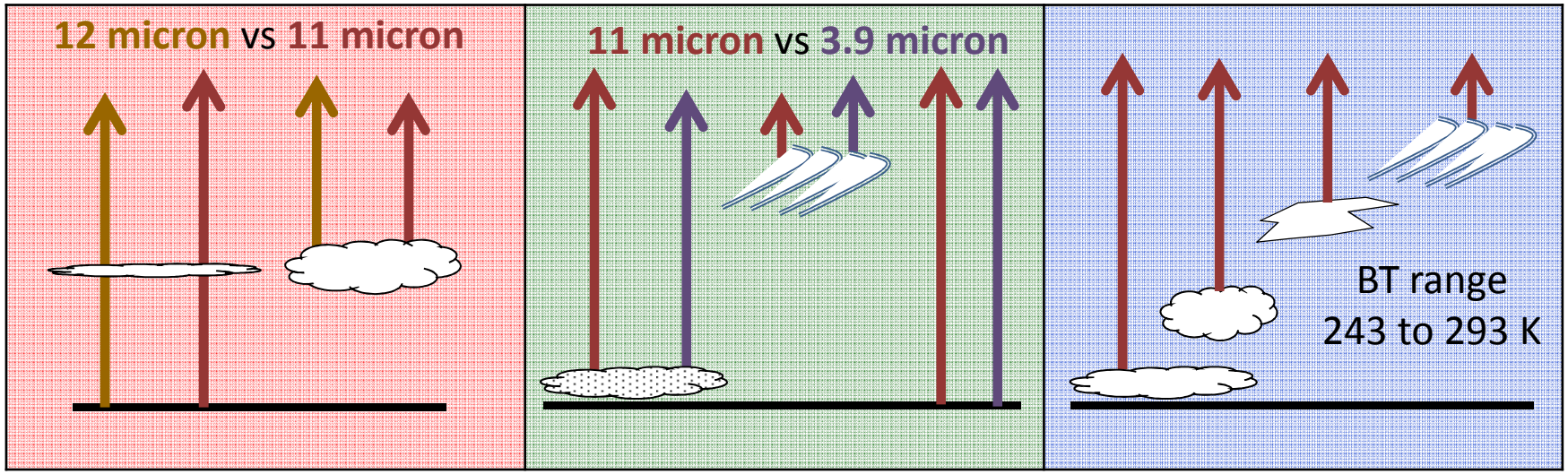
(For more details see Appendix 2)



images courtesy Eumetsat

Recommended Range and Enhancement

Beam	Channel	Range	Gamma	Gamma 2
Red	**IR12.0 – IR10.8**	-4 … +2K	1.0	1.0
Green	**IR10.8 – NIR3.9**	0 … +10 K	1.0	1.0
Blue	**IR10.8**	+243 … +293 K	1.0	1.0



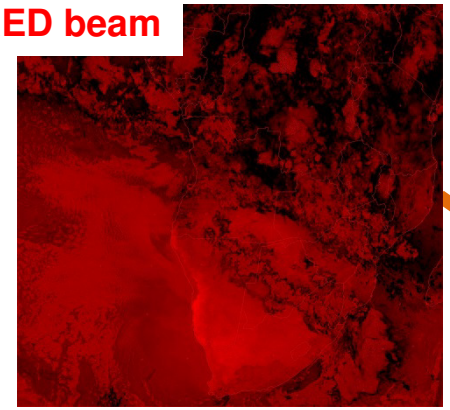
transmitted / emitted | emitted | emitted

Channel combination recipe of the Night Microphysics RGB

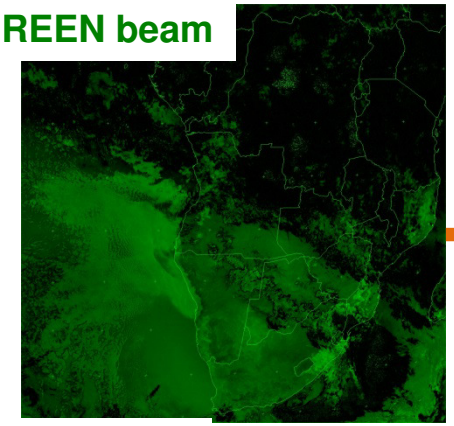
- **In the RED beam:** The channel differencing gives an indication of optical depth. There is a strong signal in this beam for thick clouds. For thin meteorological cloud there is greater absorption by the "dirty window" 12micron channel. In addition the 12 micron radiation is absorbed more strongly in ice phase cloud compared to water phase clouds.
- **In the GREEN beam:** This channel differencing is used in Gary Weymouth's fog/low cloud detection method. The 3.9 micron radiation has lower emissivity compared to the 10.8 micron radiation for small water droplet clouds. Therefore there is a large contribution to the green beam in this RGB product for water clouds with small droplets. There is also a significant contribution from desert surfaces.
- **In the BLUE beam:** The 10.8 µm infrared brightness temperature is a function of surface and cloud top temperatures. The scaling for this beam results in a strong blue beam component for warm surfaces.

The input beams that go to make up the Night Microphysics RGB.

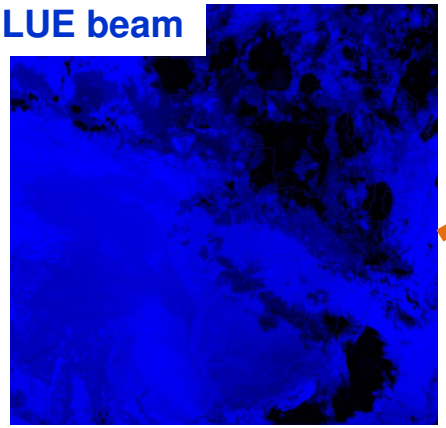
RED beam



GREEN beam



BLUE beam



Recommended Range and Enhancement:

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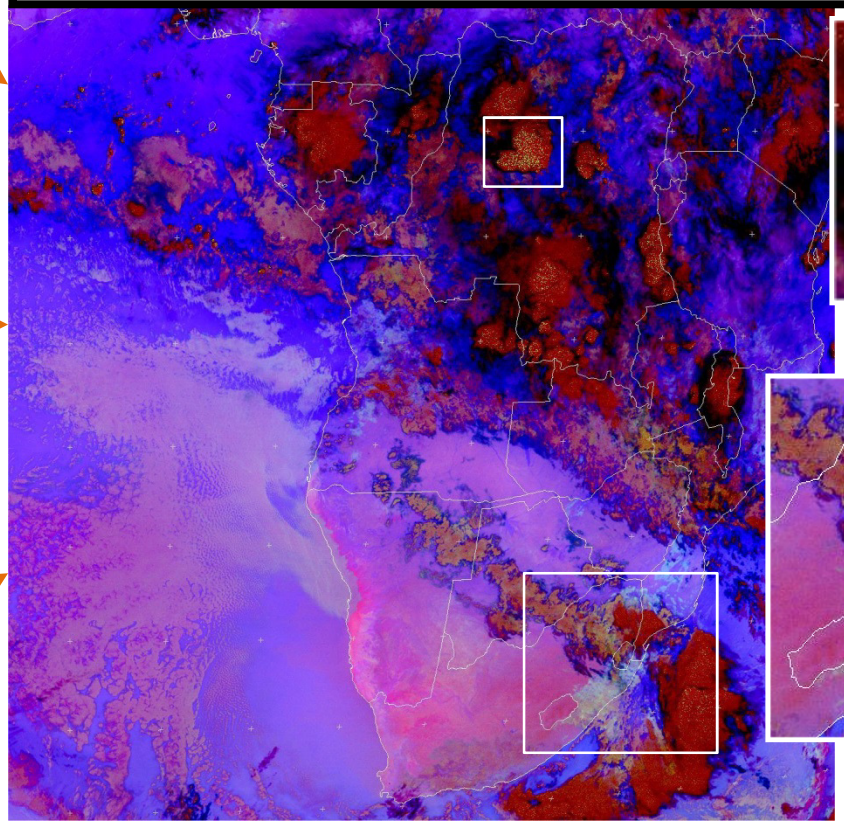
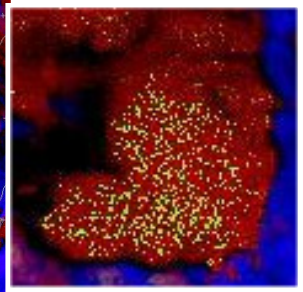
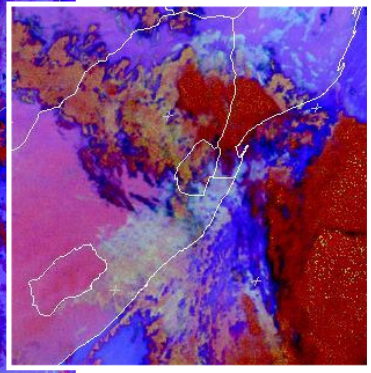




Stormtops



Fog / low cloud

Southern and Central Africa 17 April 2015 0300 UTC

images courtesy EUMETSAT

The input beams that go to make up the Night Microphysics RGB.

In the preceding slide you can familiarize yourself with the output of each of the beams for the Night Microphysics RGB product output of Southern and Central Africa on the 17th April 2015

In the red beam, note the strong contribution from the land surface and the stratiform cloud over the adjacent Atlantic Ocean. Note the lack of a red beam signal in the regions of thin cloud around the deep convection over Central Africa.

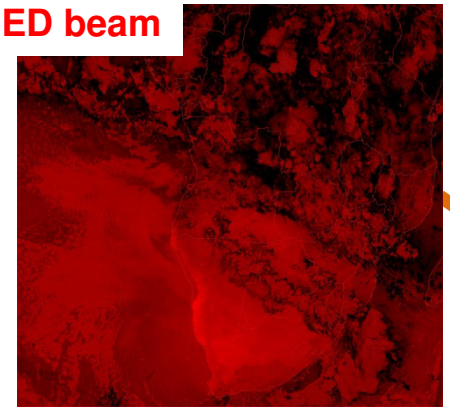
In the green beam, note the strong contribution from the fog / low cloud over eastern South Africa and the maritime cloud over the Atlantic Ocean.

In the Blue beam it is clear to see that all of the high cloud tops do not have any contribution. A strong contribution from low level features.

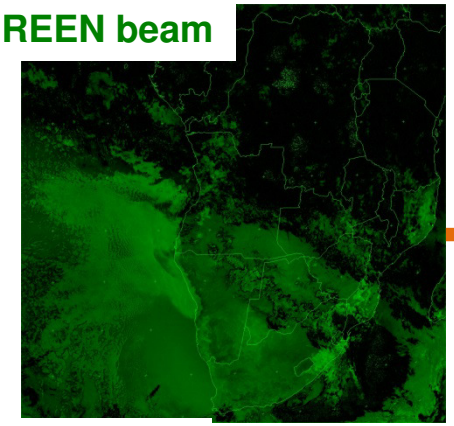
The next slide shows the effect of combining two beams.

The input beams that go to make up the Night Microphysics RGB.

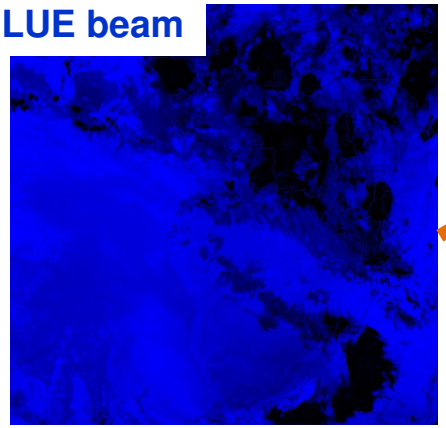
RED beam



GREEN beam



BLUE beam

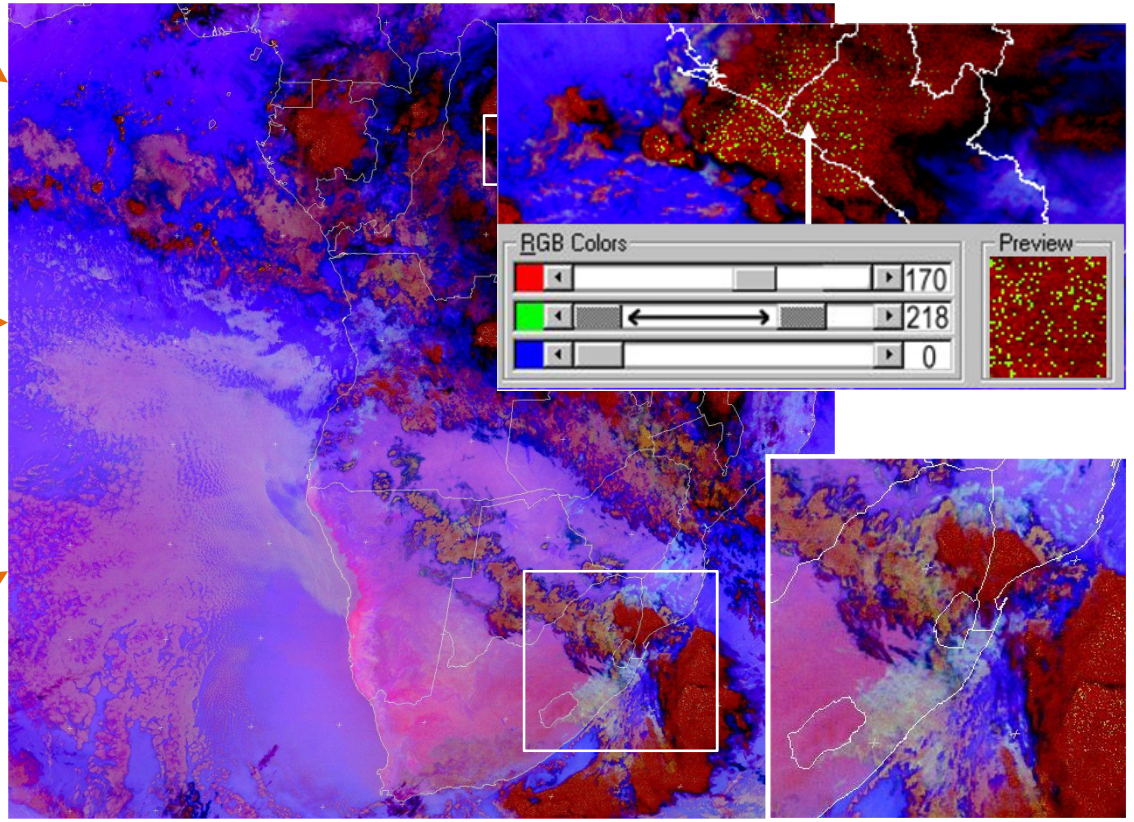


Combining beams

Yellow is made by mixing red and green

Magenta is made by mixing red and blue

Cyan is made by mixing green and blue



Southern and Central Africa 17 April 2015 0300 UTC

images courtesy EUMETSAT

The input beams that go to make up the Night Microphysics RGB.

In the preceding slide you can familiarize yourself with how the beams combine for the Night Microphysics RGB product output of Southern and Central Africa on the 17th April 2015

Note that the insensitivity of the 3.9 micron channel at very low temperatures results in great variations in the Green beam output. This results in the "speckled" appearance of the thunderstorm tops in the RGB product as shown in the inset on the right hand side of the previous slide.

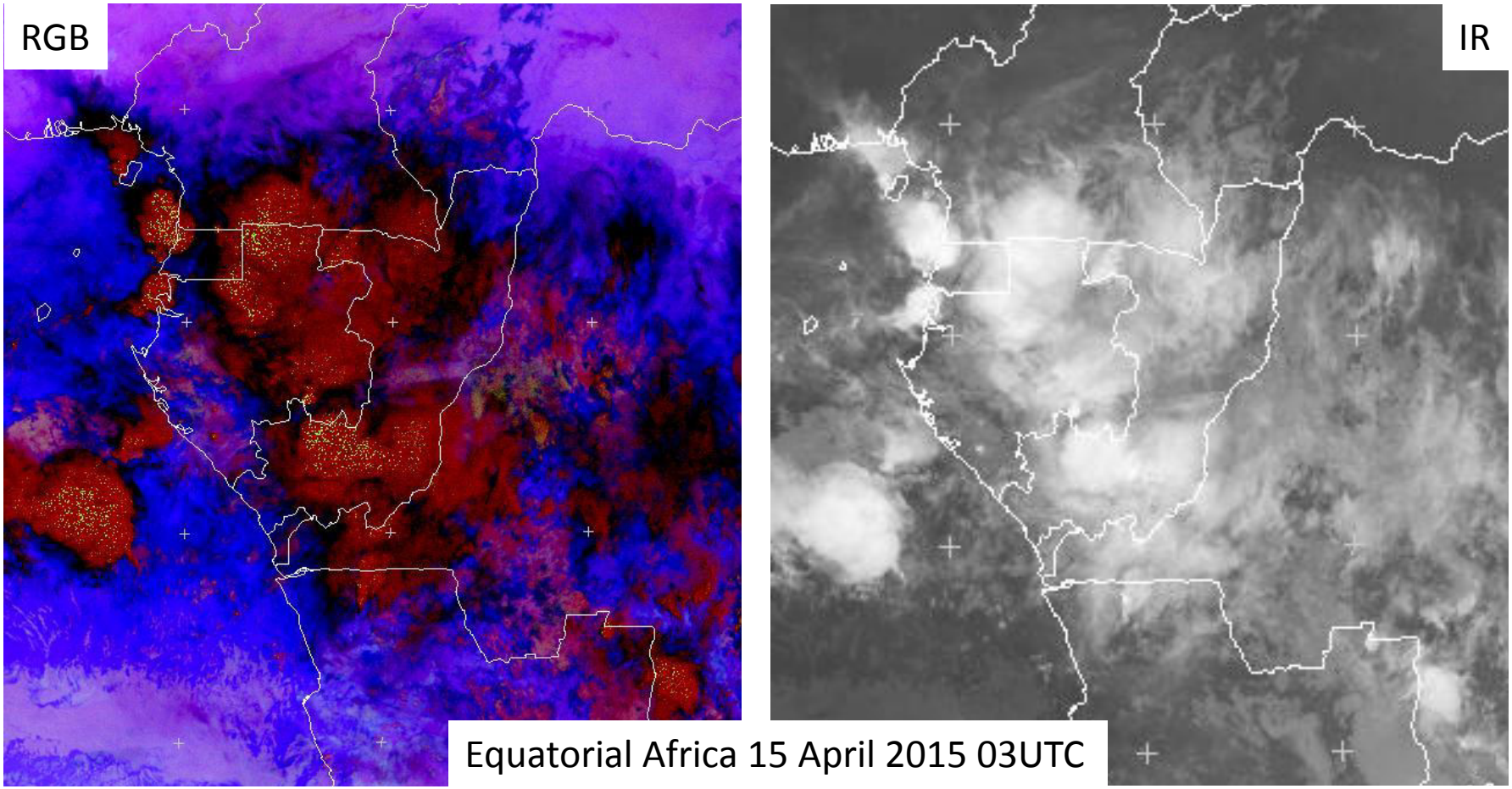
High-level / Mid-level / Low level Cloud / earth surface palette exercises.

Examine the next three slides and see if you can identify the various features in the Night Microphysics RGB product.

For reference I have also included a corresponding infrared image of each of the examples.

High-level Clouds palette – please annotate features

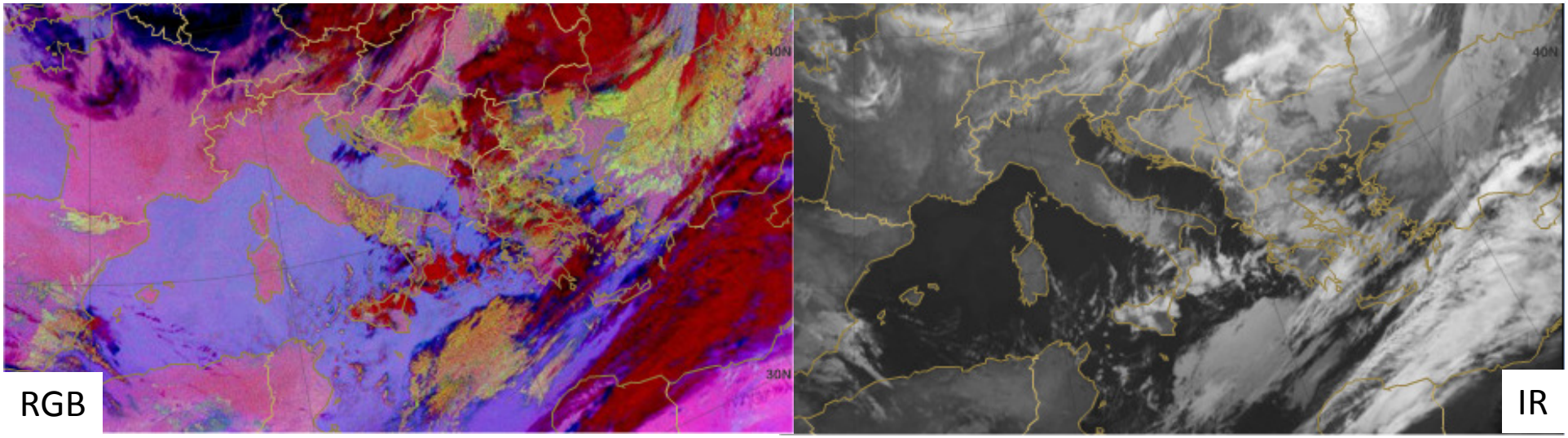
A	B	C
Cold, thick, high-level cloud	Very cold (< -50°C), thick, high-level cloud	Thin Cirrus cloud



Equatorial Africa 15 April 2015 03UTC

images courtesy EUMETSAT

Mid-level Clouds palette – please annotate features



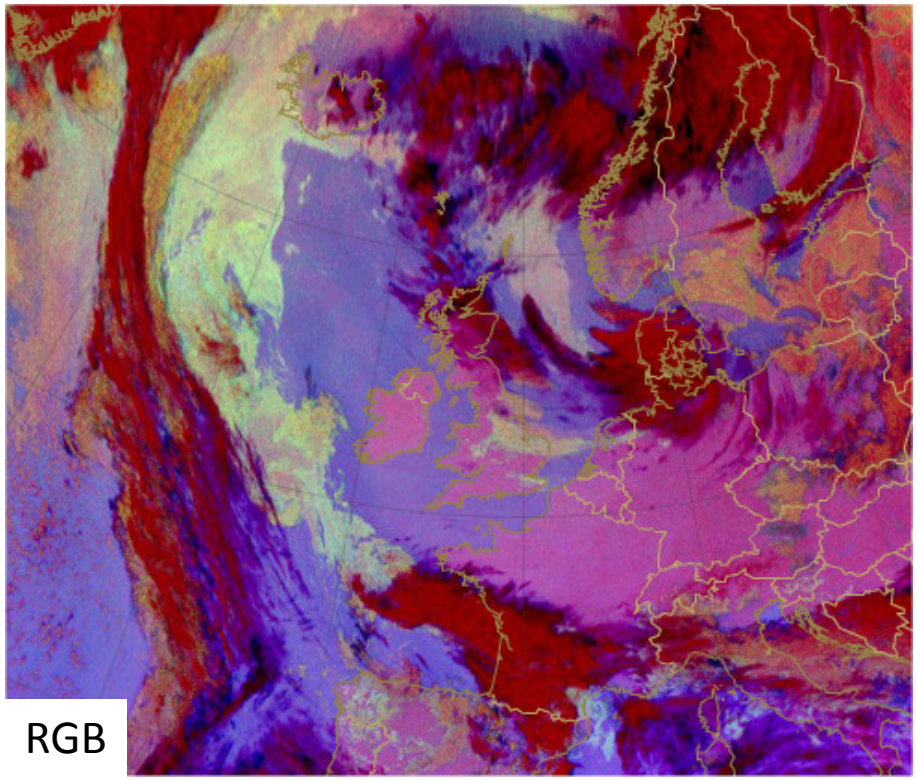
Mediterranean Sea, 8 April 2015 00UTC

D	E
Thick, mid-level cloud	Thin, mid-level cloud

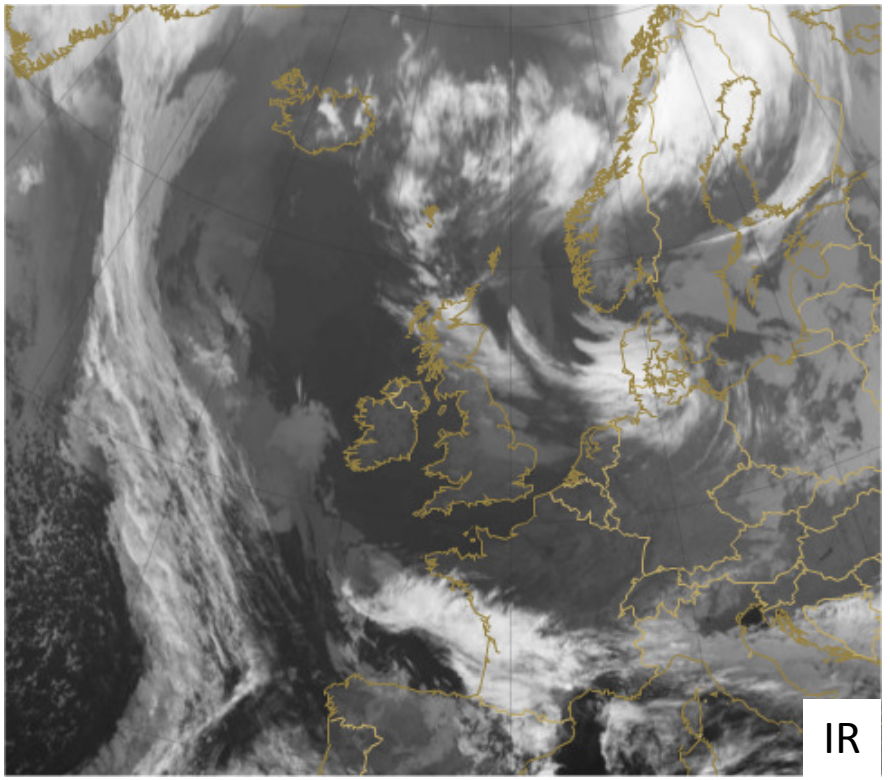
Ocean (O)	Land (L)

images courtesy EUMETSAT

Low-level Clouds palette – please annotate features



RGB



IR

Europe, North Atlantic
19 April 2015 00UTC

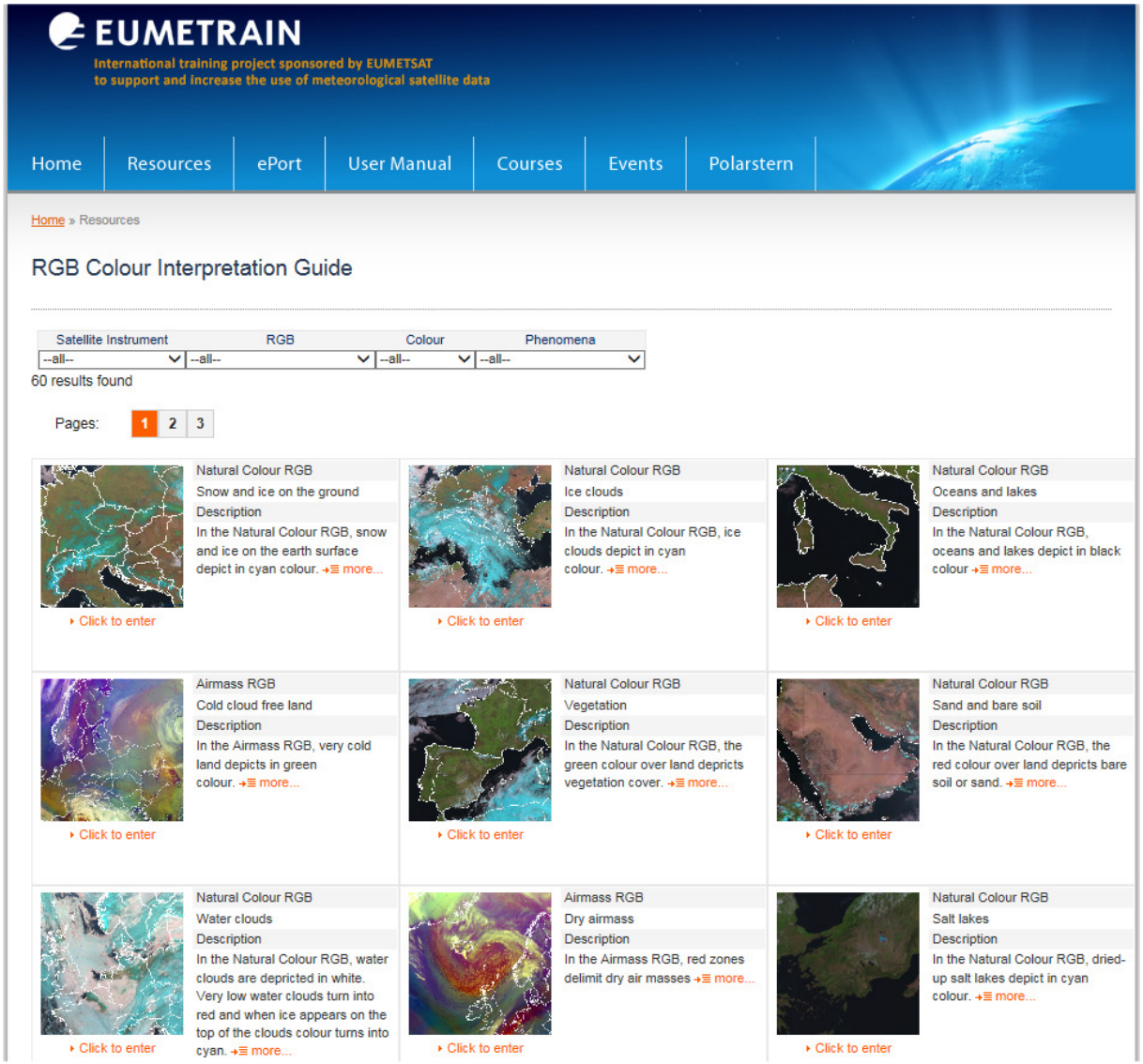
D	E
Low-level cloud (cold atmosphere, Europe)	Low-level cloud (warm atmosphere, Africa)

Ocean (O)	Land (L)

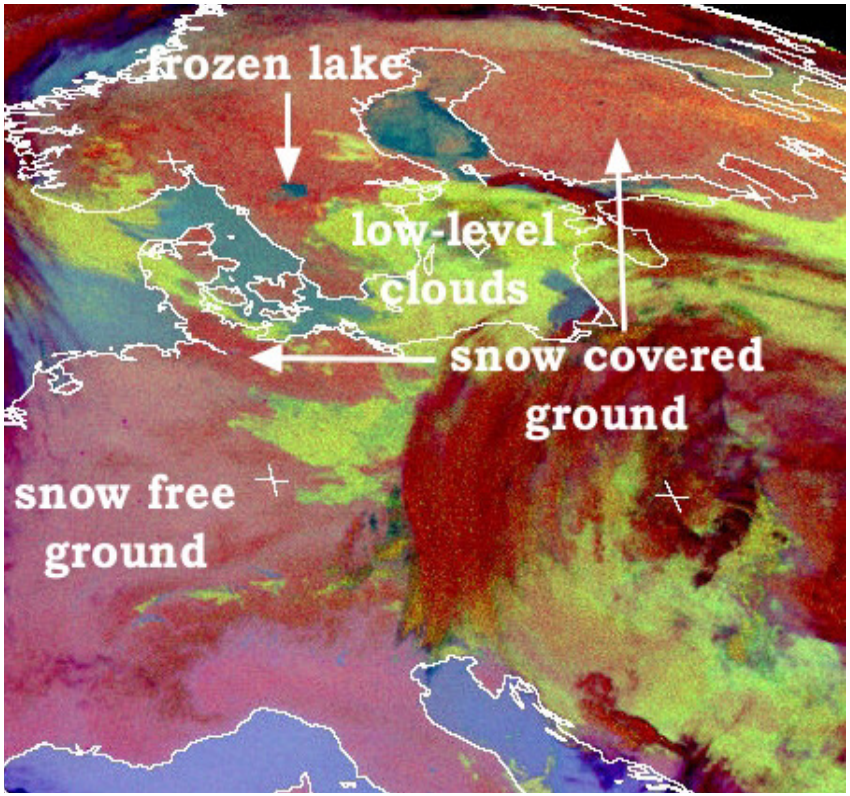
images courtesy EUMETSAT

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

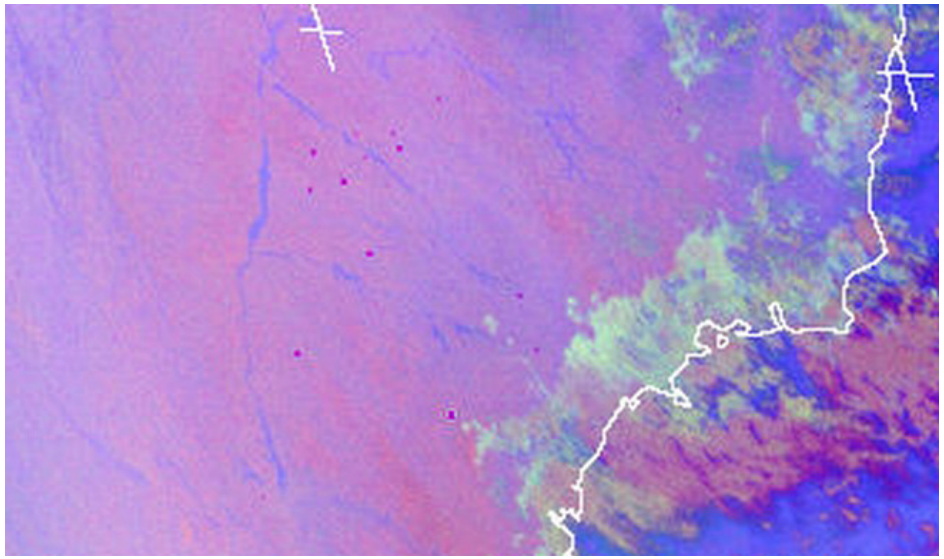
http://www.eumetrain.org/RGBguide/rgbs.html



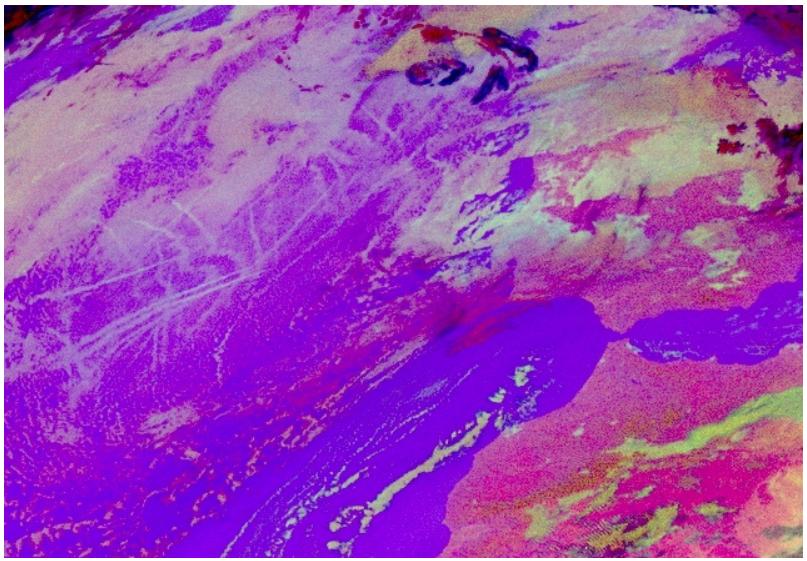
The Night Microphysics RGB product - what else it can view



Snow, Europe
MSG-1 (Met-8), 14 March 2006, 00UTC



Fires, South America
MSG-1, 16 May 2006, 00UTC



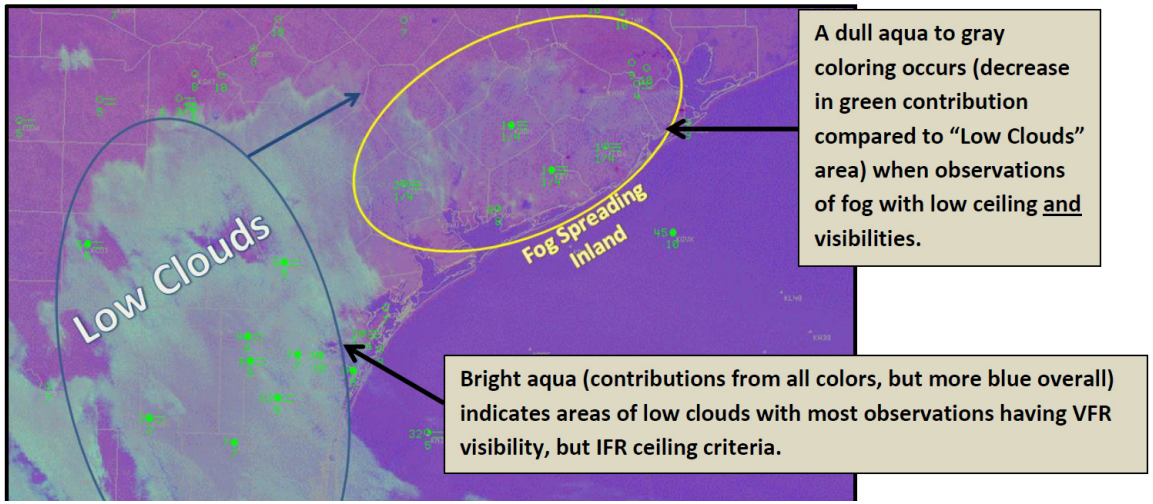
Ships trails, North Atlantic Ocean
MSG-1, 18 January 2006, 04UTC

images courtesy EUMETSAT

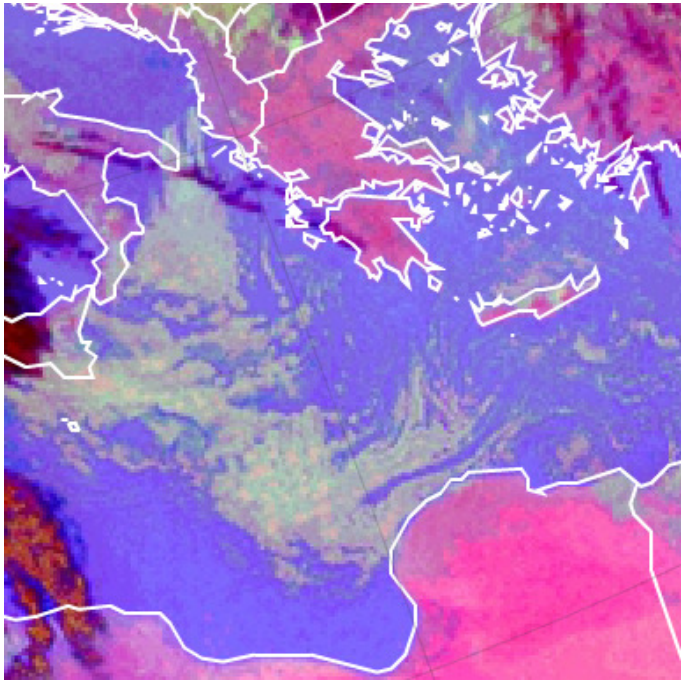
image courtesy
NASA / Sport

image courtesy EUMETSAT

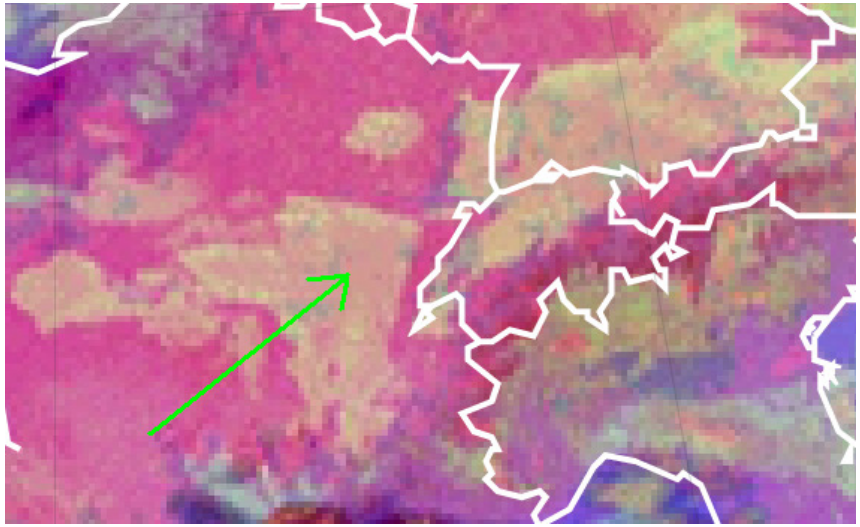
Variations in the fog/low cloud signal



Low cloud and Fog, Texas, MODIS, 25 March 2012



Low cloud over water,
Mediterranean Sea



Thin Fog / Low cloud, France

Low clouds, warm climate	Low clouds, cold climate
Fog at surface, warm climate	Fog at surface, cold climate

Warm versus Cold Climates

image courtesy EUMETSAT

Variations in the fog/low cloud signal (1)

(from http://www.eumetrain.org/RGBguide/rgbs.html)

Thick cloud / fog

Thick cloud or fog that extends above the surface may have nearly equal amounts of red and blue contributions with a larger amount of green in the RGB.

This combination produces the aqua or light green color.

Thin fog

The green colour beam is of varying intensity depending on the thickness of the low cloud layer. The thinner the fog layer, the more the contributions from the ground below. The resulting RGB colour in these areas appear to have more of a purplish / reddish tinge. (Point out top and bottom left insets to prove your point).

Low water clouds over land and sea

When low water clouds are warmer (e.g. over the Mediterranean sea) then the colours turns into blue as the blue colour beam gains intensity.

Variations in the fog/low cloud signal (2)

(from http://www.eumetrain.org/RGBguide/rgbs.html)

Warm and cold climates

Fog and low clouds in warm climates tend to have aqua or light blue areas in the RGB. This appears very light green in colder climates because the 10.8 thermal channel used for the blue band contributes less.

Fog/low cloud at high latitudes (Korea / China)

The 3.9 channel is subject to noise at very cold temperatures. Fog at high latitudes in winter may have noise in the pixels representing fog.

Daylight

When the sun rises toward the end of the loop, the low clouds turn red.

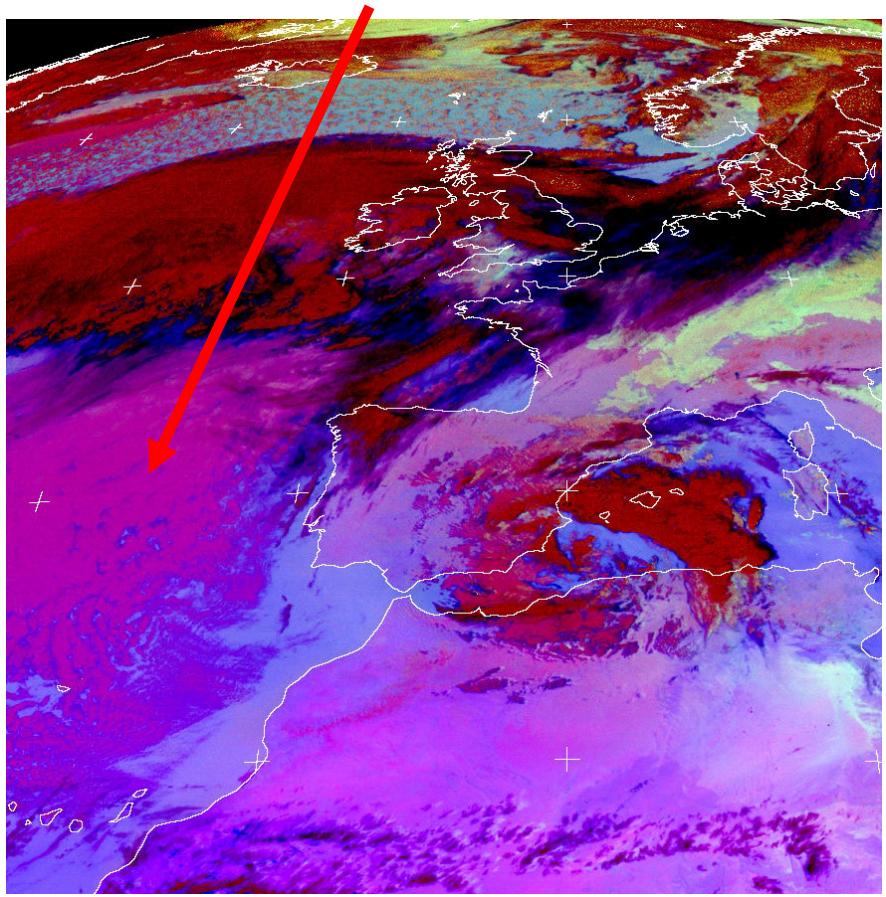
That's due to the solar reflection off the fog and stratus in the 3.9-µm infrared channel, which causes contamination. For this reason, the RGB is only useful during nighttime.

Fog vs mid level clouds

Mid-level clouds also show a strong contribution on the green colour beam due to positive BTD. As these clouds are colder than low-level water clouds, the blue colour beam is weak.

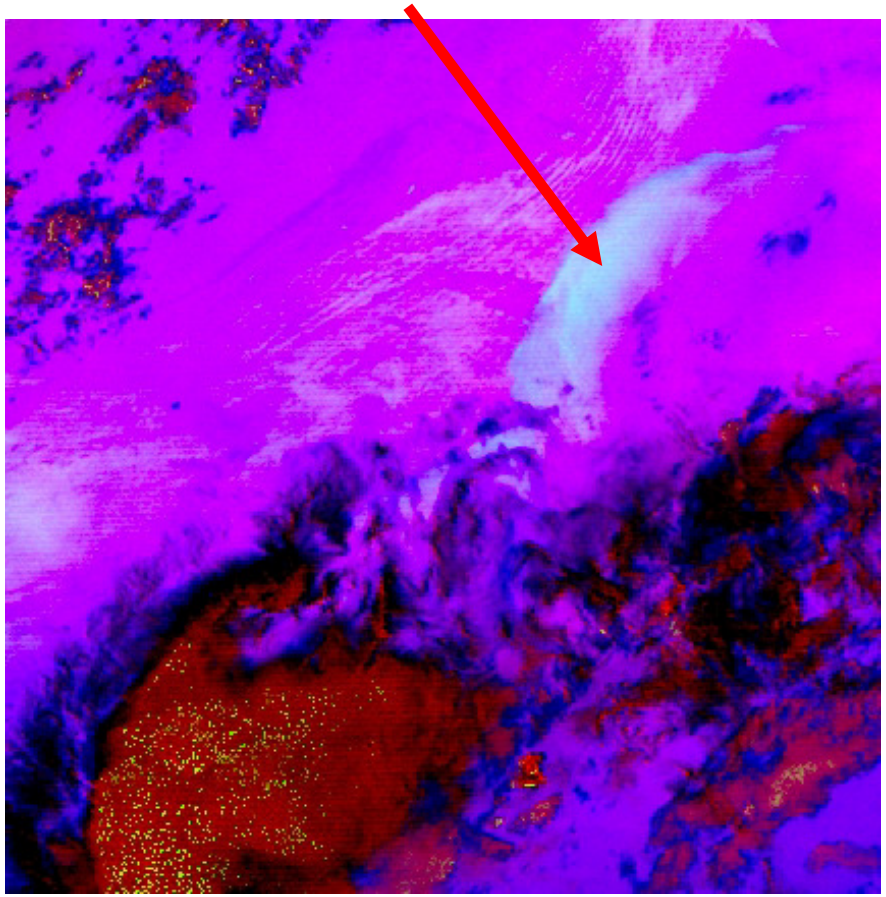
Unusual colours because of:

reflected sun light



10 November 2005, 16:00 UTC

dust cloud

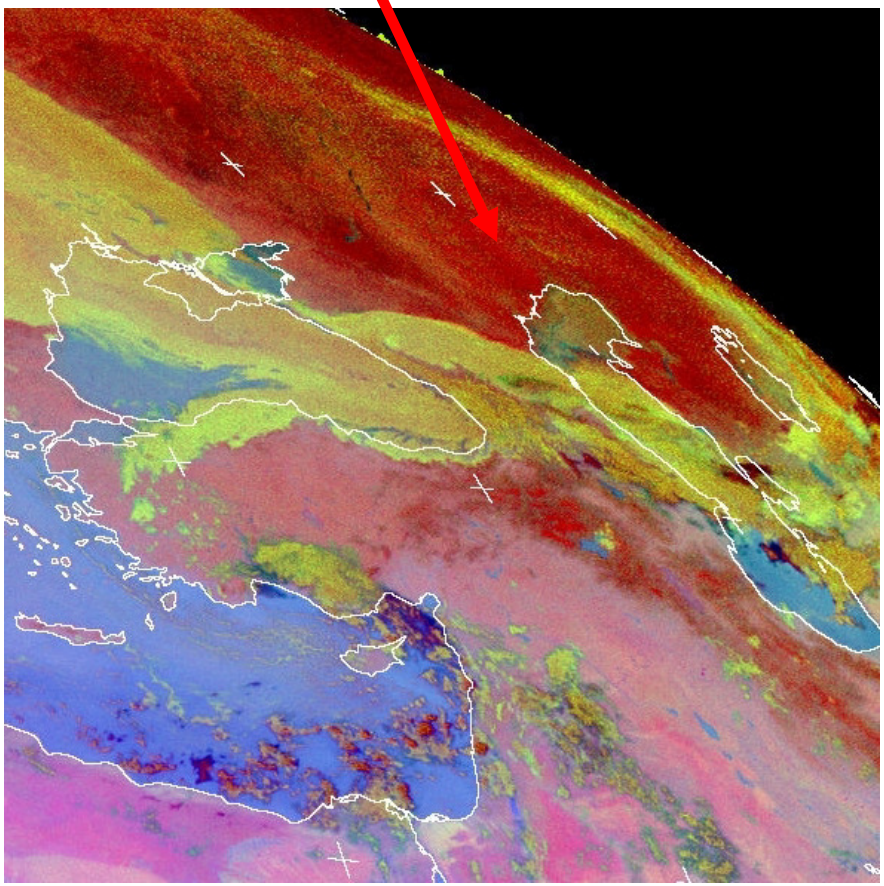


14 July 2003, 02:00 UTC

images courtesy EUMETSAT

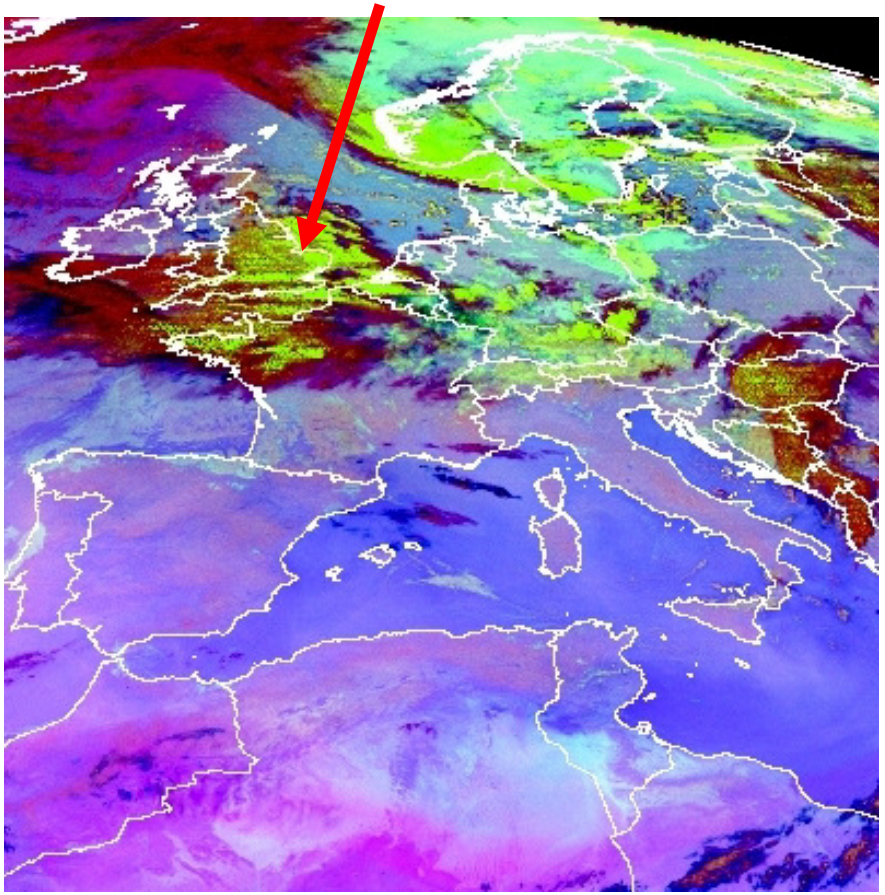
Unusual colours because of:

very cold snow surface
(note the speckled appearance)



17 January 2006, 16:00 UTC

stray light during eclipse



28 August 2006, 00:00 UTC

images courtesy 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.

image courtesy EUMETSAT

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

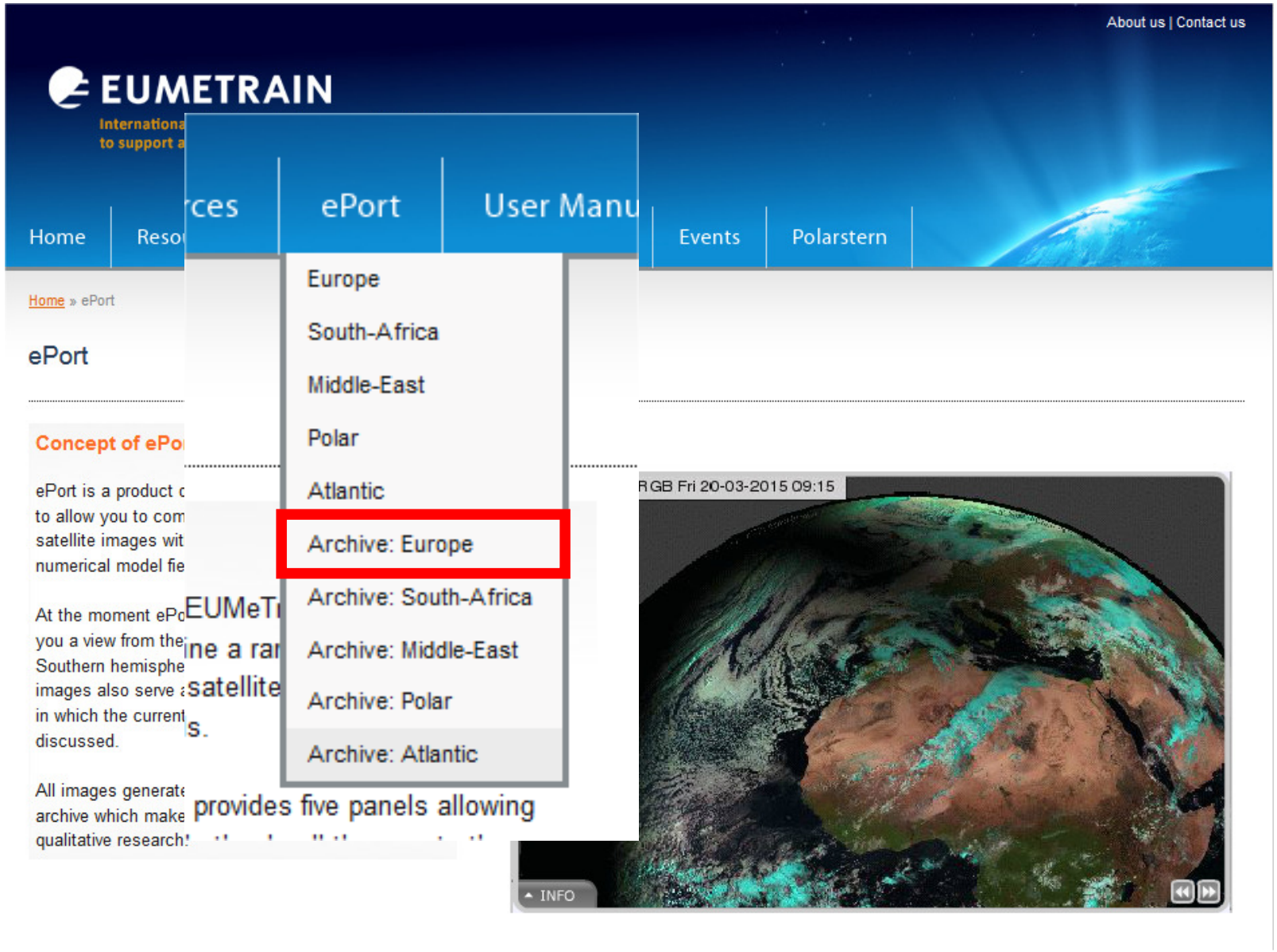


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort – choosing Archive: Europe

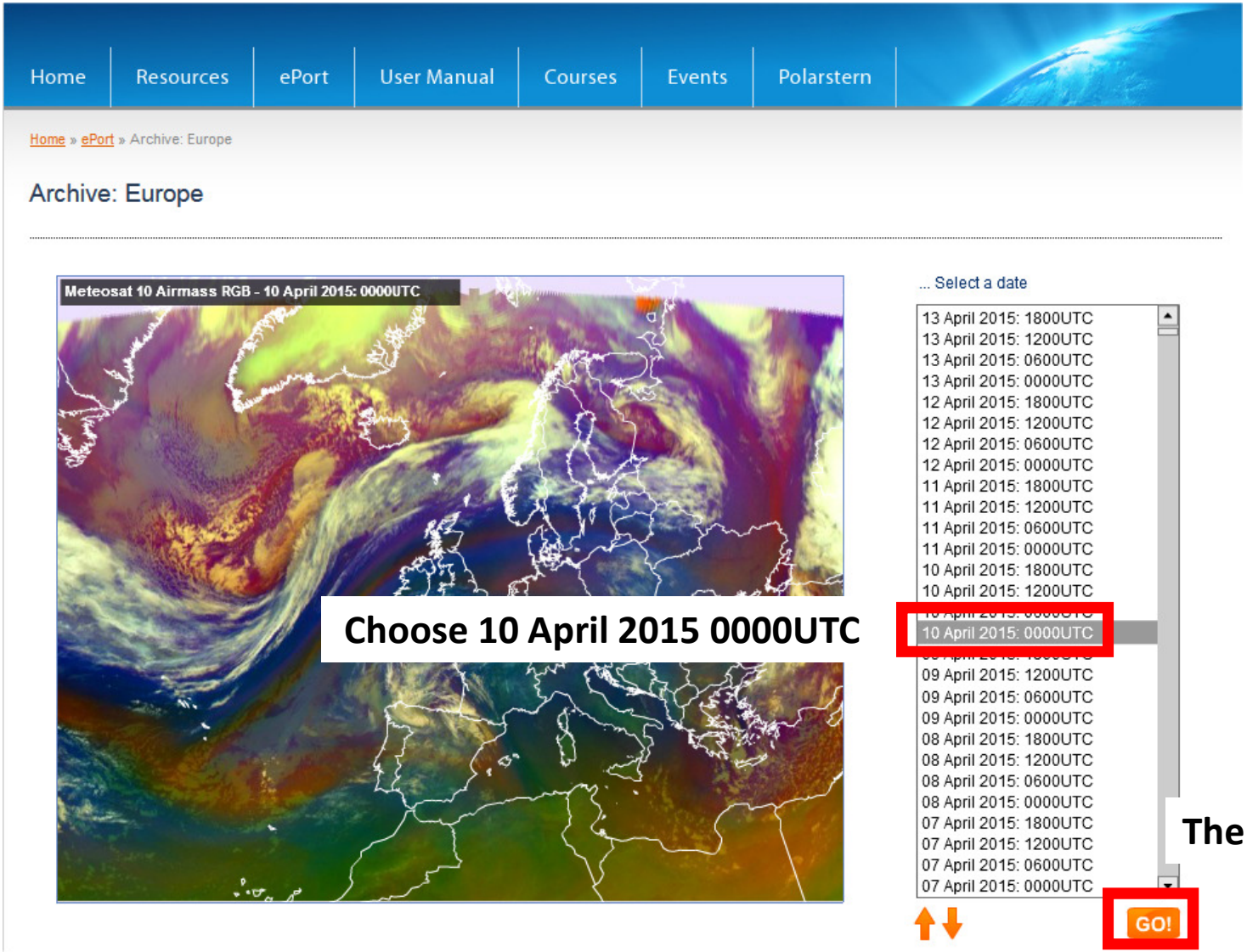


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

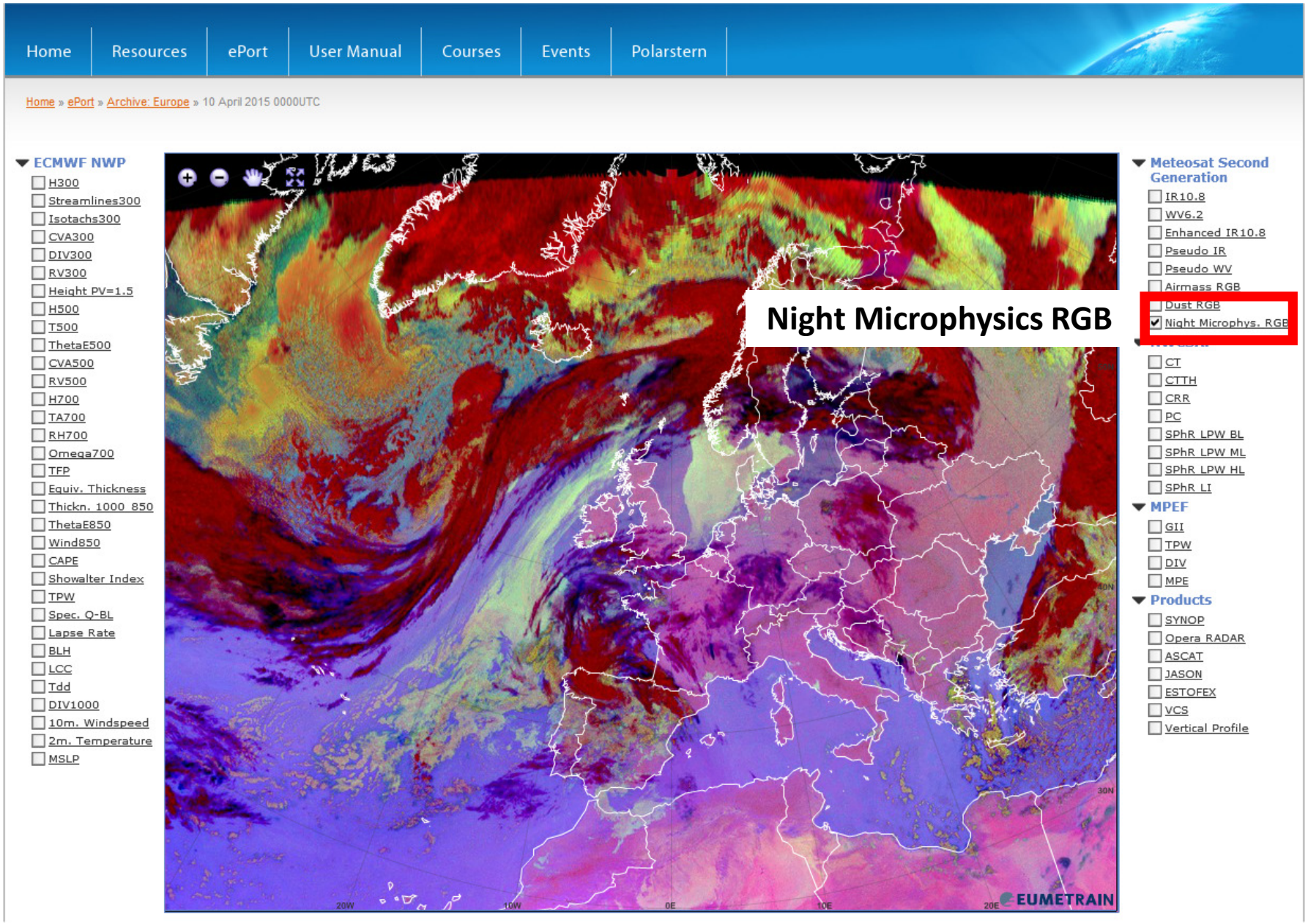
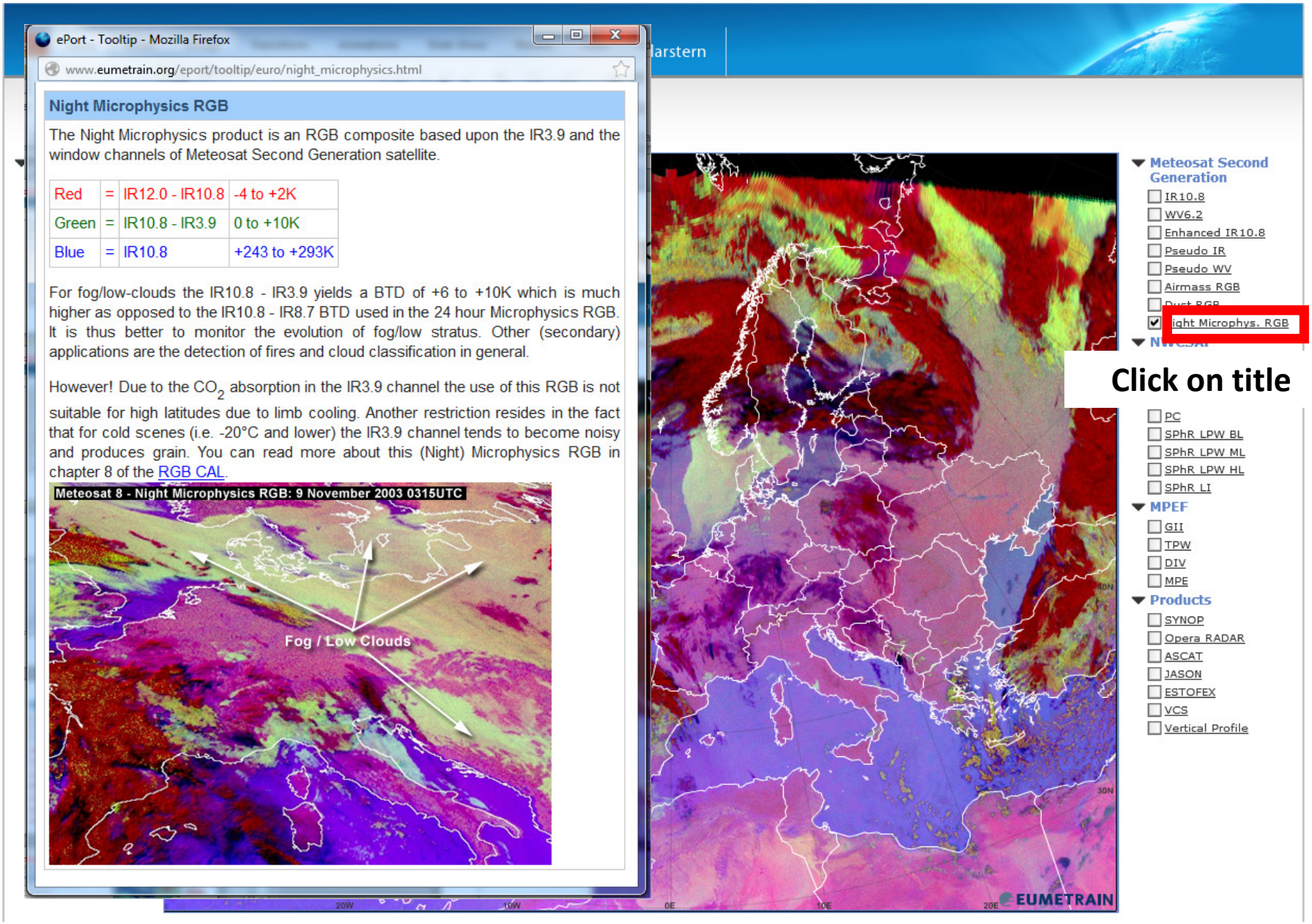


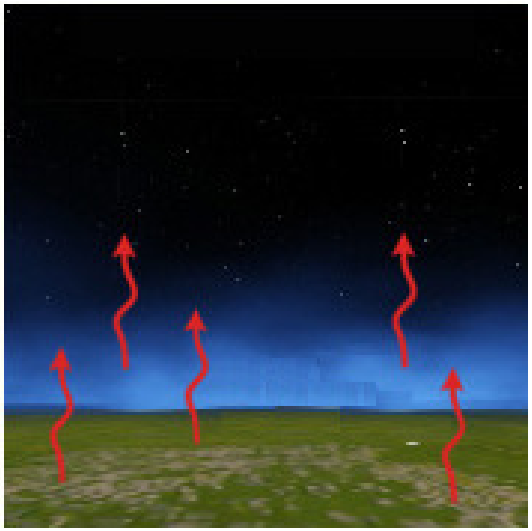
image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

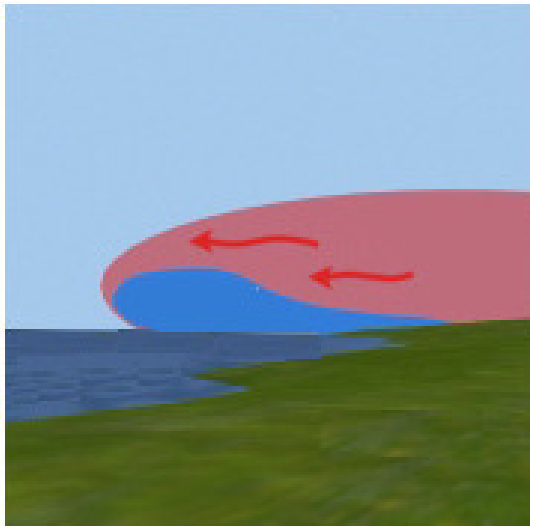


animations from COMET

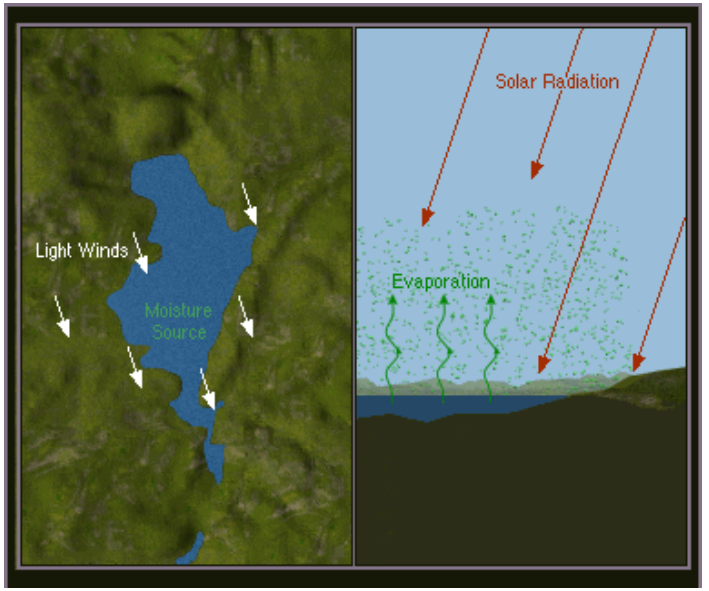
Conceptual Model – Radiation and Advection Fog Formation and Growth

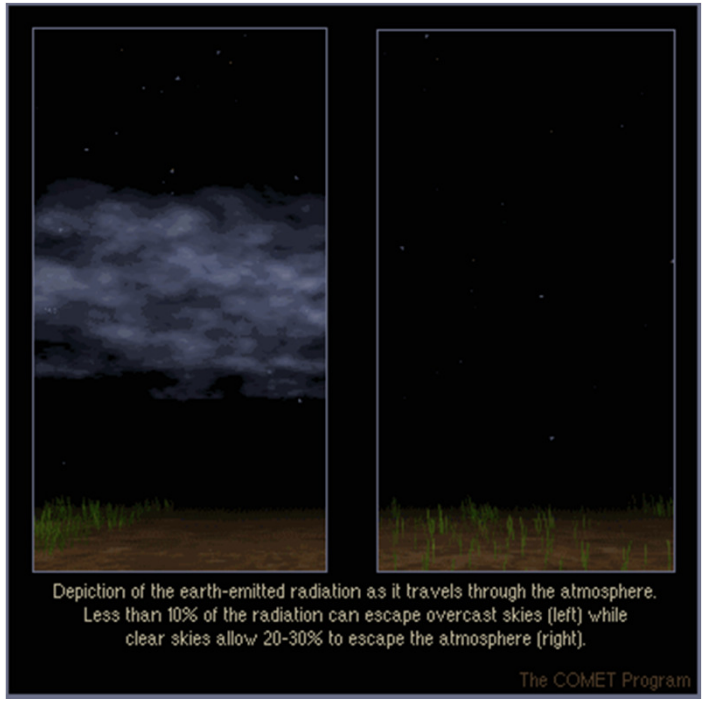


Radiation fog



Advection fog





<u>Radiation fog</u>

- Light low level winds
- Source of moisture
- Dry mid-upper atmosphere

<u>Advection fog</u>

- Air that is warmer and more moist moves over a cooler surface (most sea fog is advection fog)

Conceptual Model – Radiation and Advection Fog Formation and Growth (from http://www.theweatherprediction.com/habyhints2/435/)

Advection fog is fog produced when air that is warmer and more moist than the ground surface moves over the ground surface. The term advection means a horizontal movement of air. Unlike radiation fog, advection fog can occur even when it is windy. Also unlike radiation fog, advection fog can occur when the skies aloft are initially cloudy.

The setup for advection fog will often include an advection pattern bringing in warmer and more moist air from the south. The set-up for the ground surface will be a snow covered ground or a saturated ground that has been chilled by cold temperatures before the winds shift back from a southerly type direction. Since the ground surface is very cold it will influence the temperature of the air adjacent to the ground surface. This air will be chilled more than it otherwise would be due to the very cold surface ground temperature. If there is snow or moisture on the ground then the air will be cold and moist. When winds shift to the south it will bring in warmer air. This warmer air will be cooled due to the influence of the cold land surface. As air cools the temperature drops closer to the dewpoint. If the mixing of the warmer air with the colder air produces a relative humidity of 100% then fog can form.

image courtesy EUMETSAT

Question: Annotate areas of fog and/or low cloud.

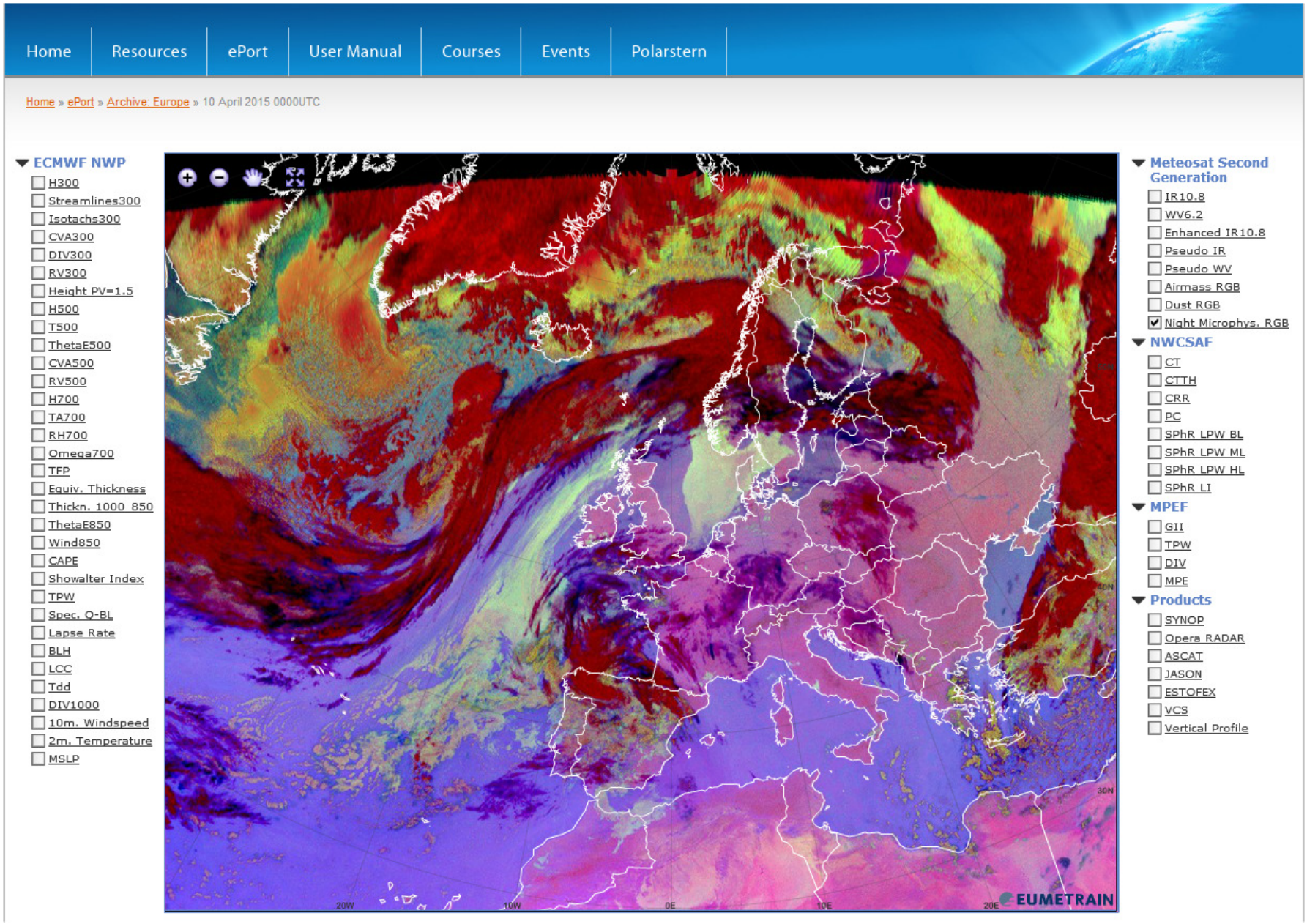
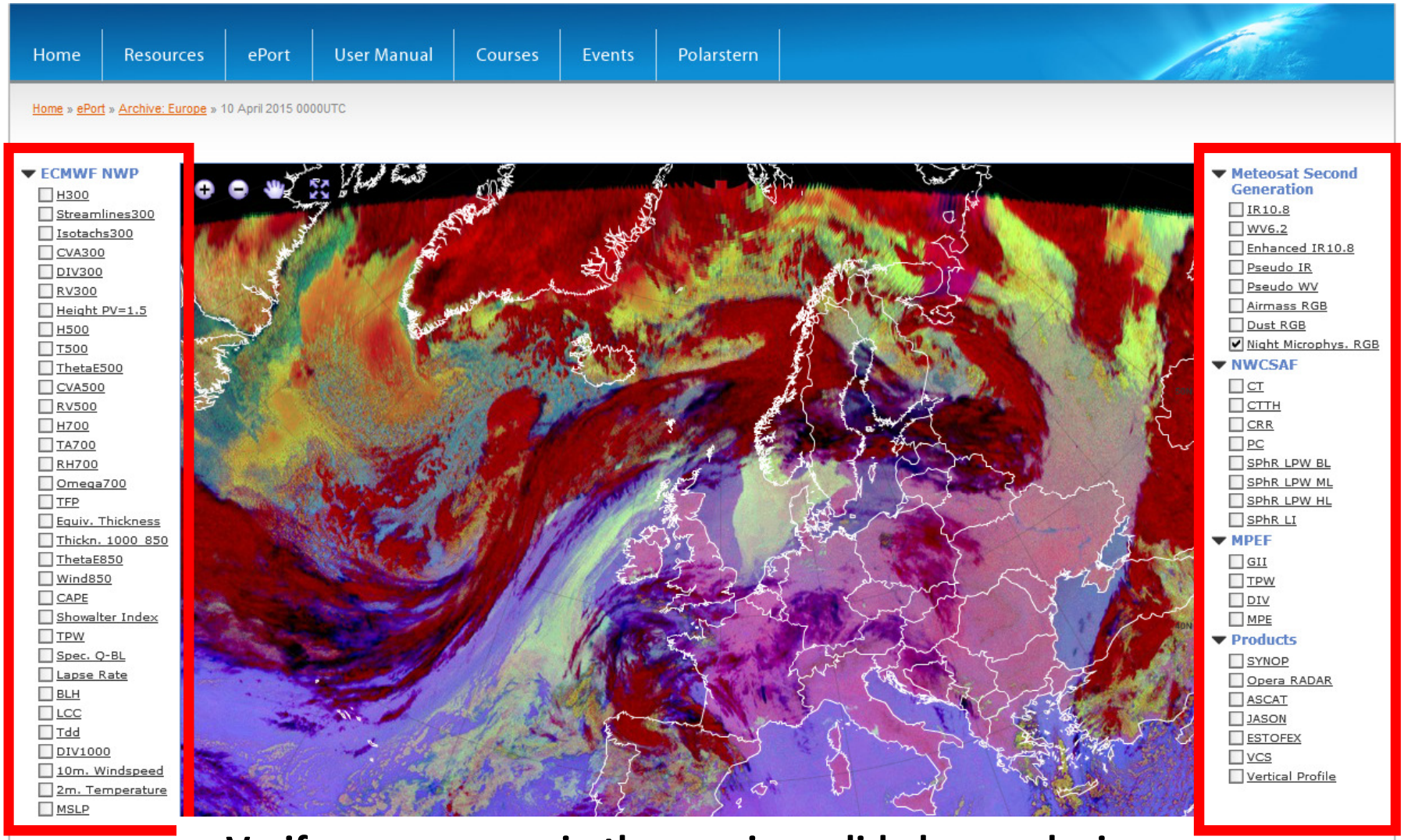


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

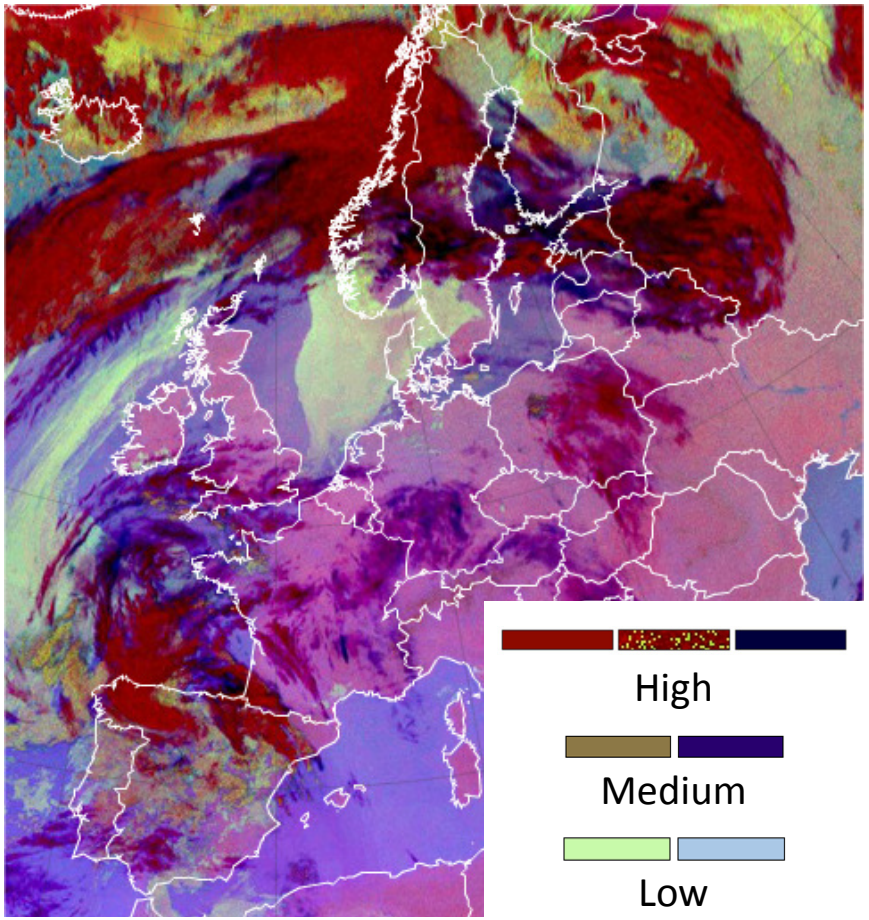


Verify your answer in the previous slide by overlaying appropriate Satellite data, Derived Products and NWP.

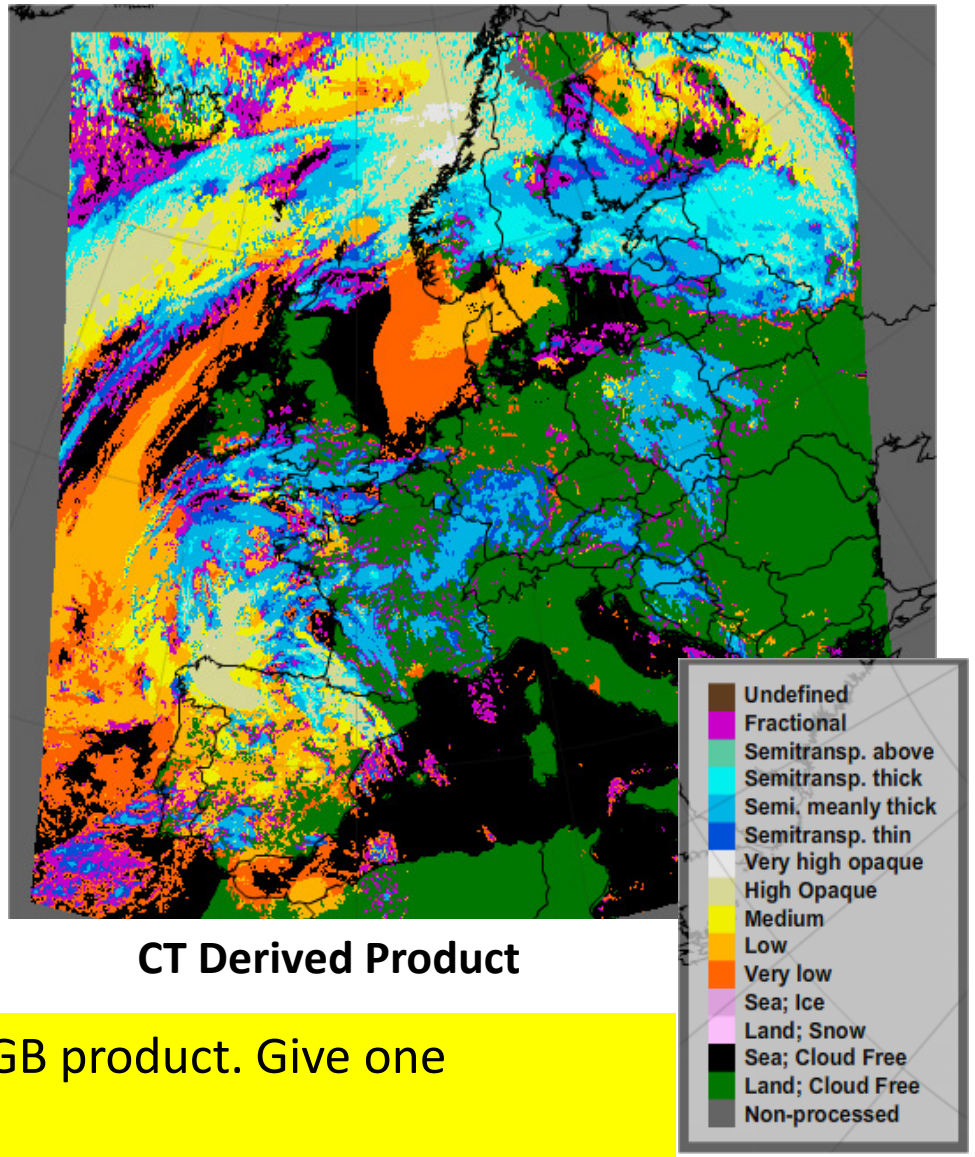
Do you think the fog is radiation or advection fog ?

image courtesy EUMETSAT

Recommended answer: Night Microphysics RGB and Cloud Type (CT)



Day Microphysics RGB product

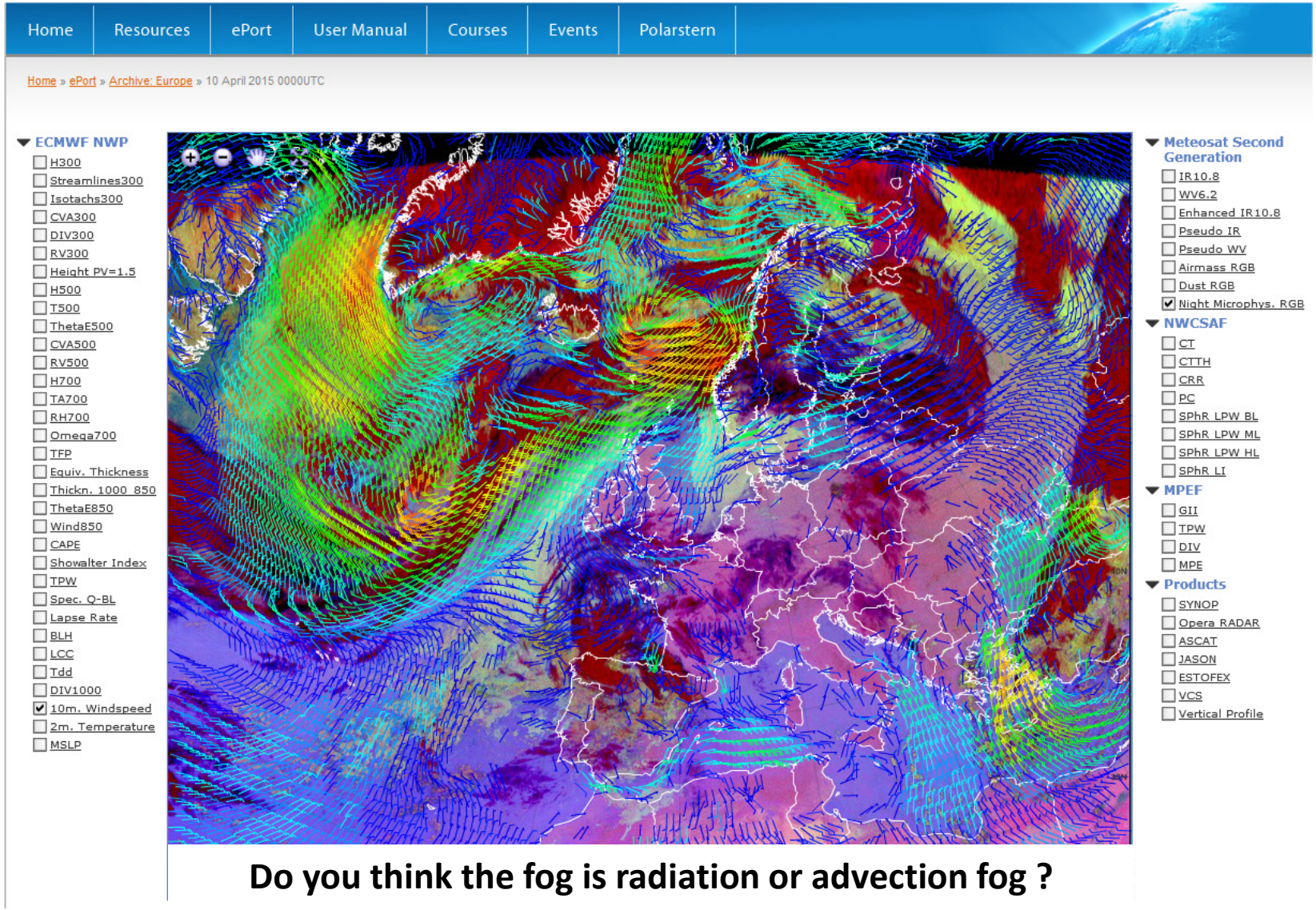


CT Derived Product

Question: Give one advantage of the RGB product. Give one advantage of the Derived Product.

image courtesy EUMETSAT

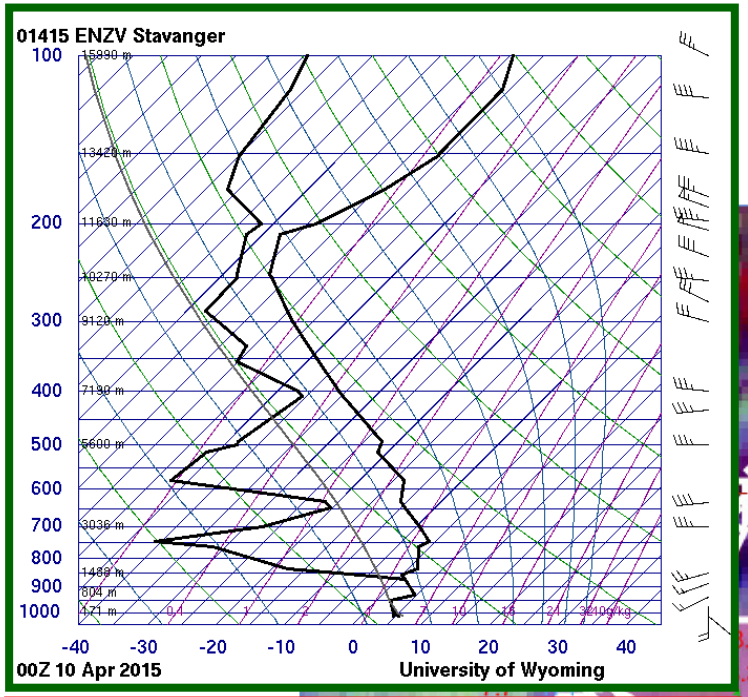
Recommended answer: Night Microphysics RGB and 10m wind

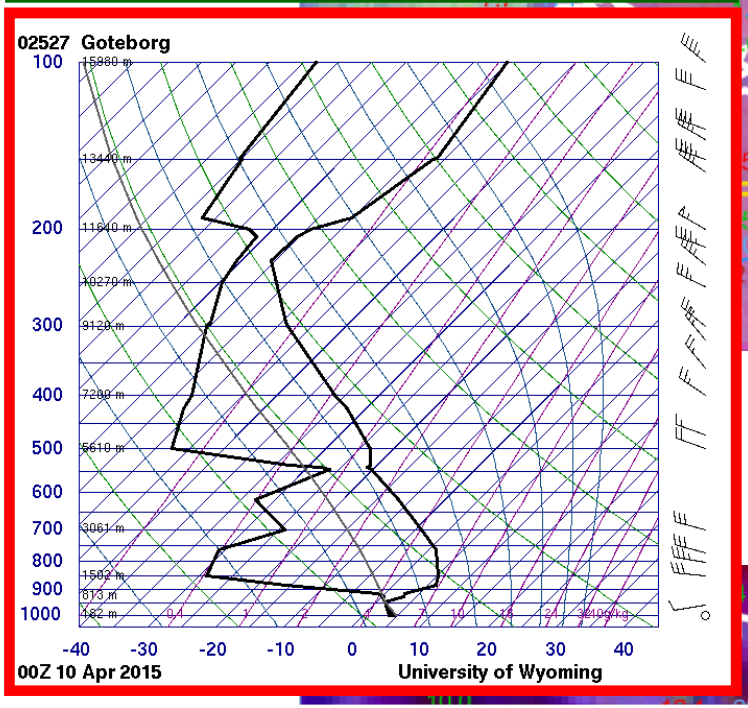


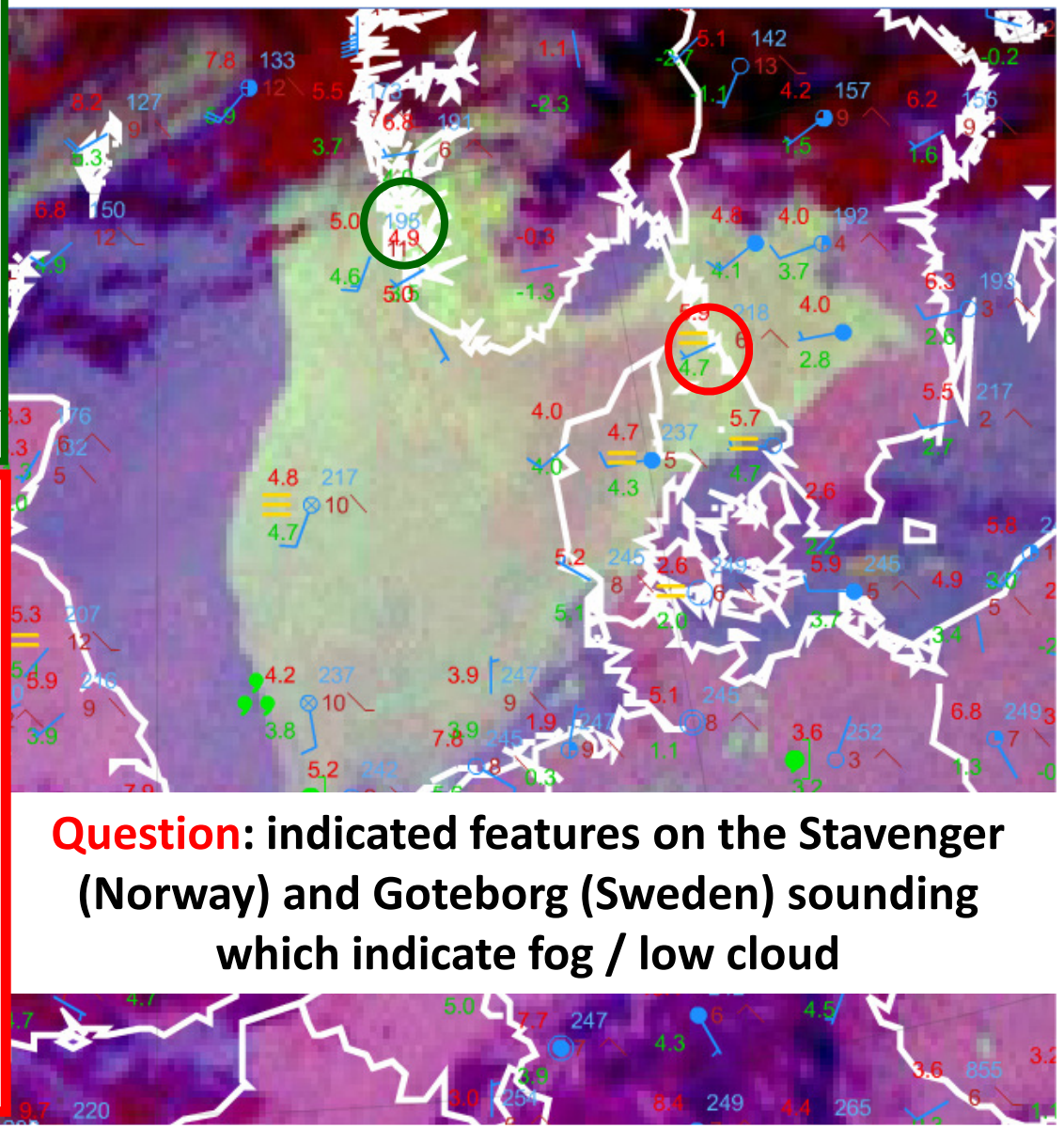
soundings courtesy University of Wyoming

image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort







Question: indicated features on the Stavenger (Norway) and Goteborg (Sweden) sounding which indicate fog / low cloud

Activity: Exploring EUMETRAIN ePort

Note that both Goteborg and Stavenger soundings are near saturated at the surface.

Notice the strong inversion at Goteborg (900-950hPa) and at Stavenger (750-850hPa).

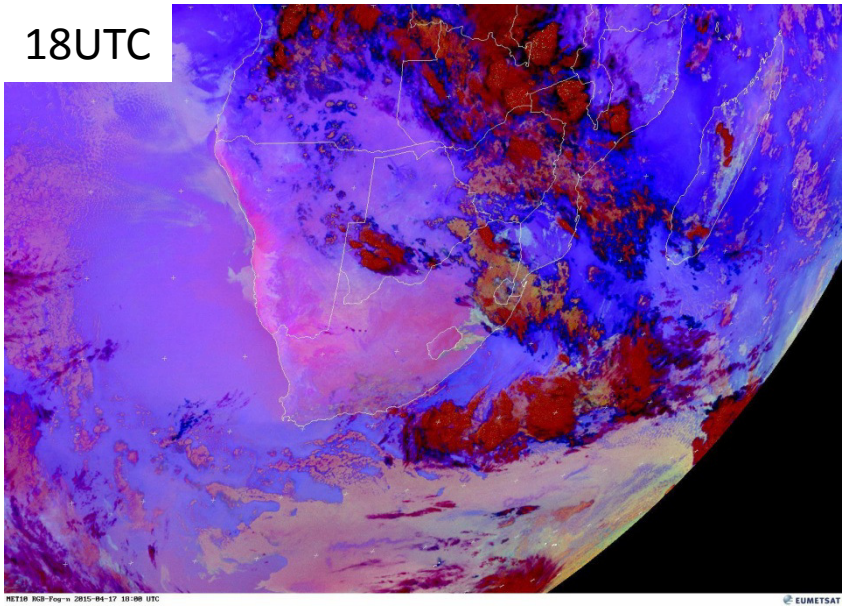
Clearly the depth of the low level cloud layer at Goteborg is a lot less than that at Stavenger. You can see this in the Night Microphysics RGB product as a reddish tinge within the aqua blue signature of the fog near Goteborg and over Denmark.

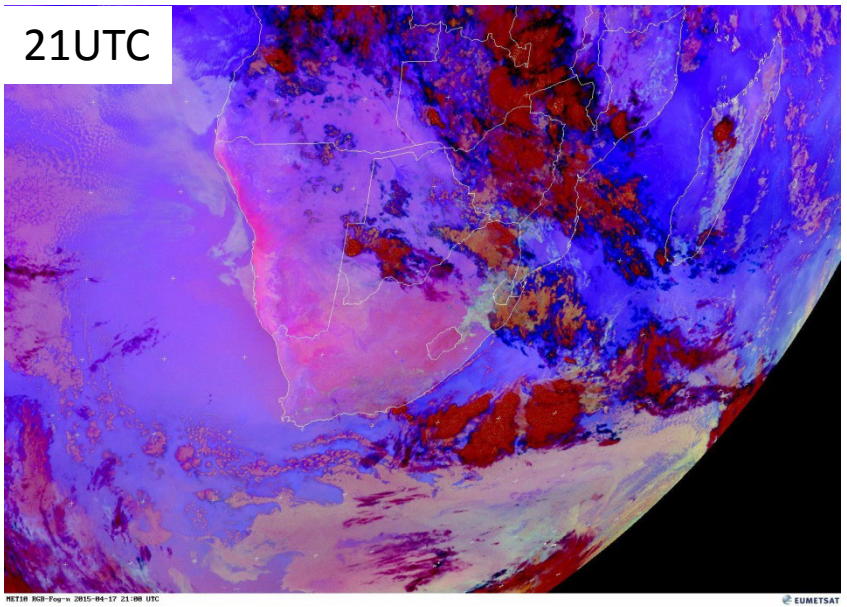
Note the shallower fog toward Goteborg, with the reddish tinge in the RGB signal

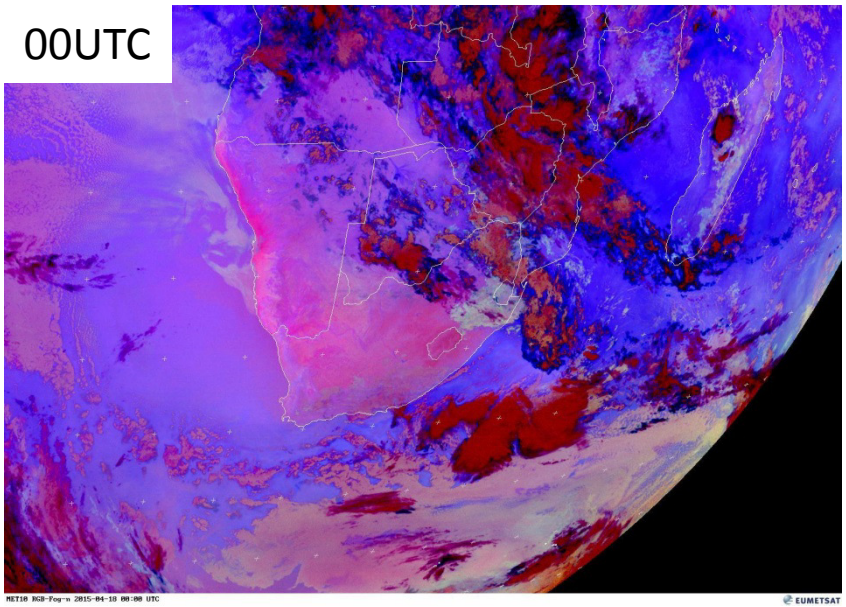
Note the cold airmass within the saturated lower part of the Stavenger sounding. It appears that the southerly airmass has passed over a very much colder ocean surface.

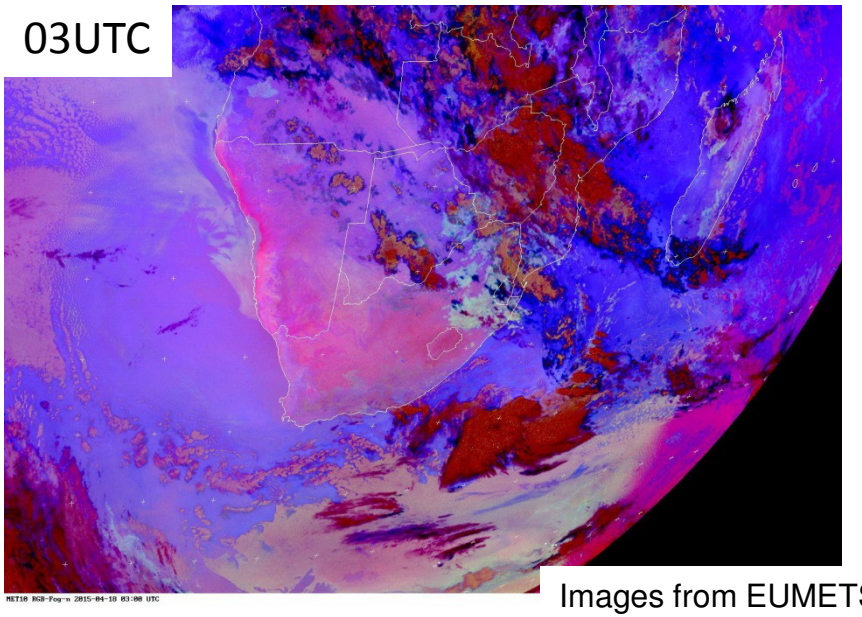
From the overlay of the 10 meter winds and the soundings advection fog is inferred at Stavenger. It is also likely for Goteborg.

Summary of Night Microphysical RGB animation – Southern Africa, Meteosat-10, 17 April 2015









Images from EUMETSAT

Night-time Microphysics RGB product – Summary (1)

(from http://www.goes-r.gov/users/comet/npoess/multispectral_topics/rgb/print.htm#page_6.13.0)

The Night Microphysics RGB product is designed and tuned for monitoring the evolution of nighttime fog and stratus.
Secondary applications include detecting fires, classifying clouds in general, snow and even low-level moisture boundaries.

Advantages:
This RGB enhances the fog/stratus signal.
Is very important for aviation, public weather forecasting, especially with higher resolution (2km) Himawari-8 data.
It may even be useful for tropical locations, as can be seen in the animation examples, over northern Mozambique and southern Angola.

Night-time Microphysics RGB product – Summary (2)

(from http://www.goes-r.gov/users/comet/npoess/multispectral_topics/rgb/print.htm#page_6.13.0)

Limitations:

Thin cirrus may obscure the view of fog and stratus

May be noisy and difficult to interpret in cold temperature environments (below approximately -10ºC)

Is difficult to detect thin radiation fog

The actual area of fog and low cloud is always slightly larger than in the image due the 3.9 µm IR channel's increased sensitivity to warm pixels around the edges of the cloud cover

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;

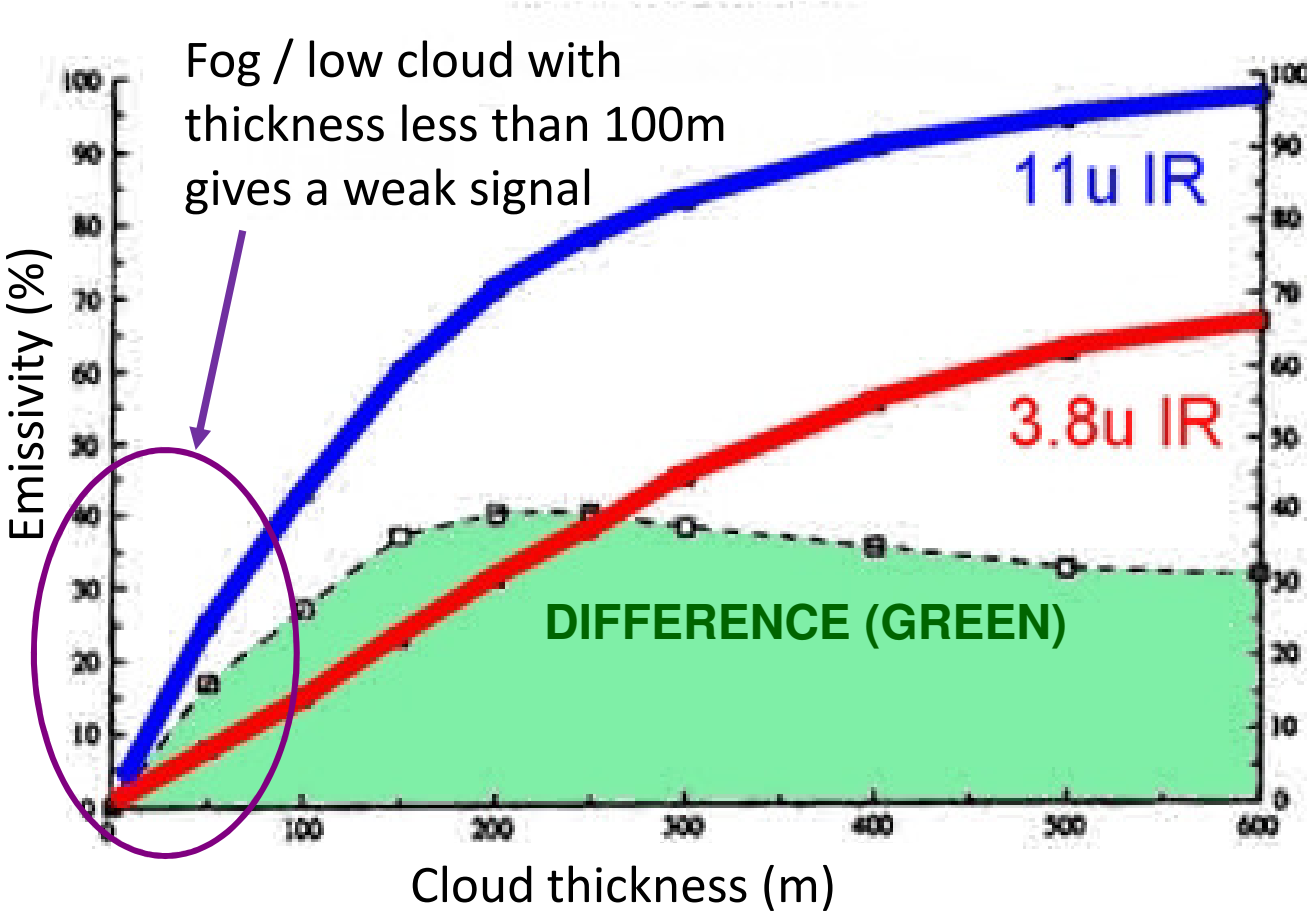
Enabling Skills Document Element 2, Performance Component 3 - **Identify fogs and discriminate between fog and low cloud**

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

Enabling Skills Document Element 4, Skills, **Performance component pertaining to "Fires and Smoke"**

Appendix 2: Explaining the channel combination recipe in more detail – the Green beam

from http://eumetrain.org/data/2/208/208.pdf



Emissivity Difference between 3.8 and 11 micron infrared channels (from Ellrod 1995)

Appendix 2: Explaining the channel combination recipe in more detail

- As shown in the previous slide, the emissivity of clouds containing small water droplets at 3.8 μm < 11 μm.
- That is because small water droplets are close to 3.8 μm in size.
- Therefore, subtracting the 3.9 from the 11 μm channel gives an infrared temperature difference of between 2 and 5 degrees Kelvin for fog and low cloud. This is sufficient to reveal these classes of cloud in night-time satellite images.