Australian Government
Bureau of Meteorology

Australian VLab Centre of Excellence

National Himawari-8
Training Campaign

The Day 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 Day 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 Day 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.
- Have a better appreciation of using the Day Microphysics RGB product in monitoring, nowcasting and short term forecasting of various meteorological phenomena.

- 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
- Some interesting features the RGB product can show

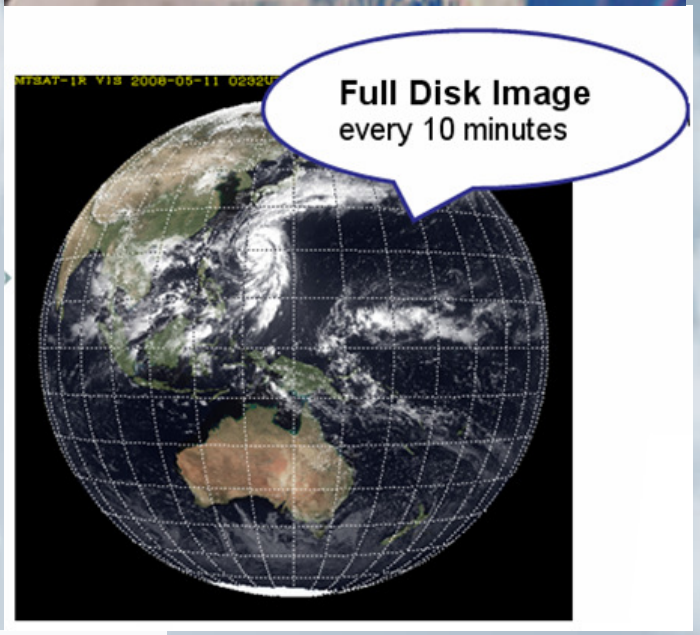
Case Study

- Displaying the data (EUMETSAT ePort)
- Comparing the RGB product with single channel data, overlaying Derived Product.
- 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 Microphysics RGB

Australian Government
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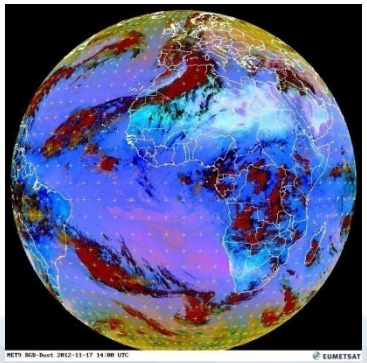
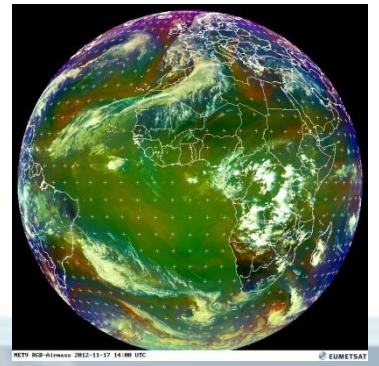
Two RGB composites which complement each other



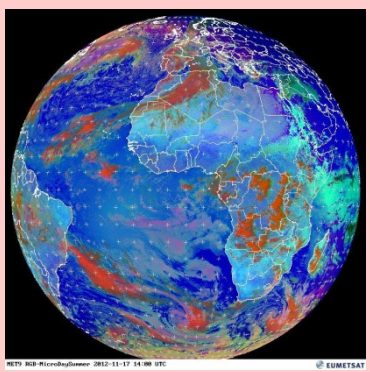
24 hour Microphysical RGB



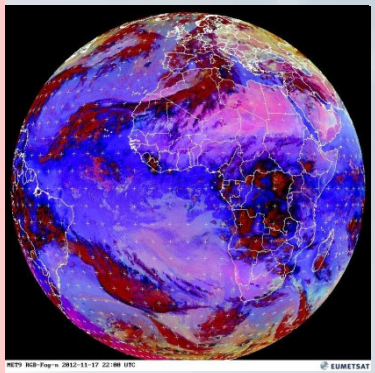
Airmass RGB

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

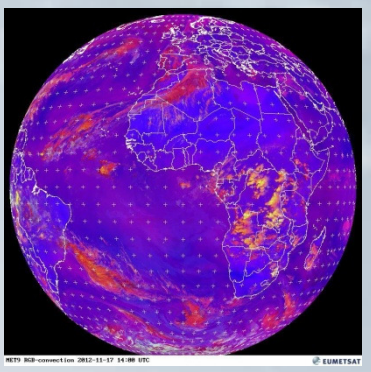
Five application specific RGBs



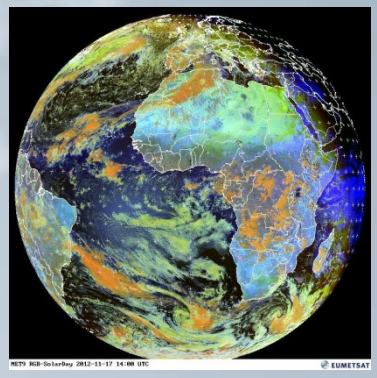
Day Microphysical RGB



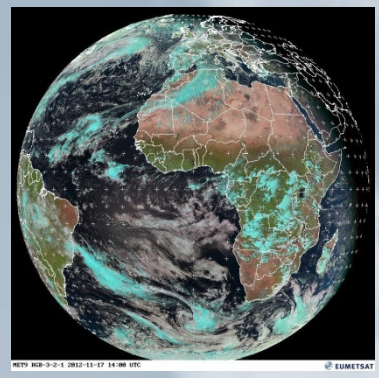
Night Microphysical RGB



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.

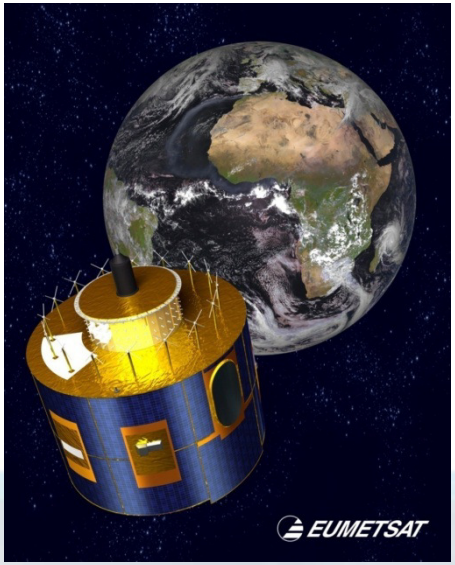
At World Meteorological Organisation (WMO) level: agree on a strict minimum of harmonised RGB composites. The following strategies for the application of RGB products to the forecasting routine were outlined:

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 Microphysics RGB

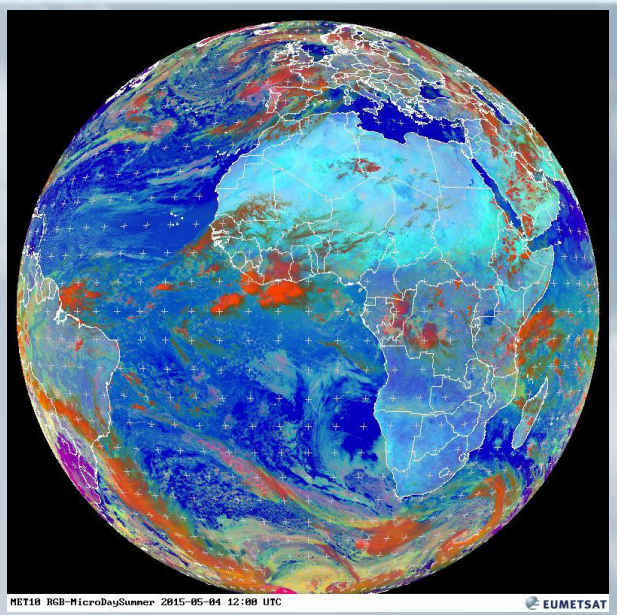


Recommended Range and Enhancement:

Beam	Channel	Range	Gamma
Red	02 (VIS0.8)	0 …+100 %	1.0
Green	04r (IR3.9r)	0 … +60 %	2.5
Blue	09 (IR10.8)	+203 … +323 K	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 Microphysics 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

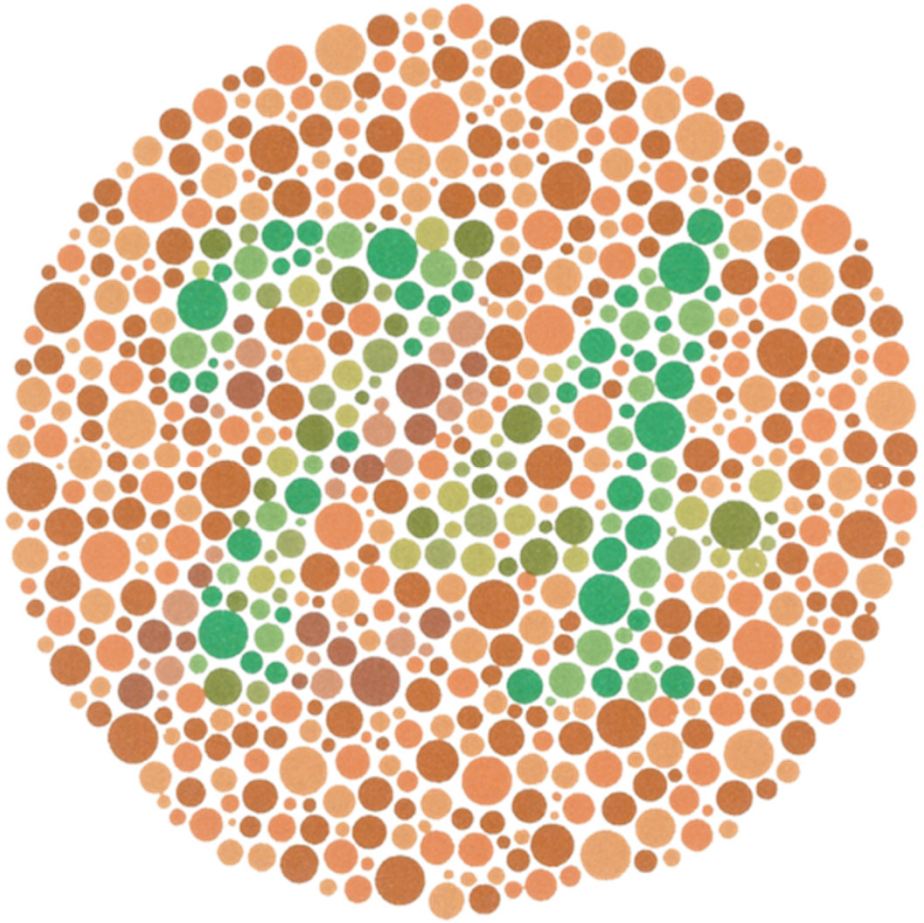
The appearance of the RGB product for the full disk earth image scanned by the Meteosat satellite is also shown. Note that this looks very different from the familiar single channel visible and infrared images. This RGB product also looks very different from the true colour earth image.

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
Microphysics RGB

(For more details see Appendix 2)

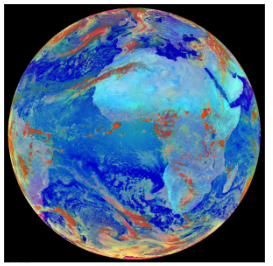
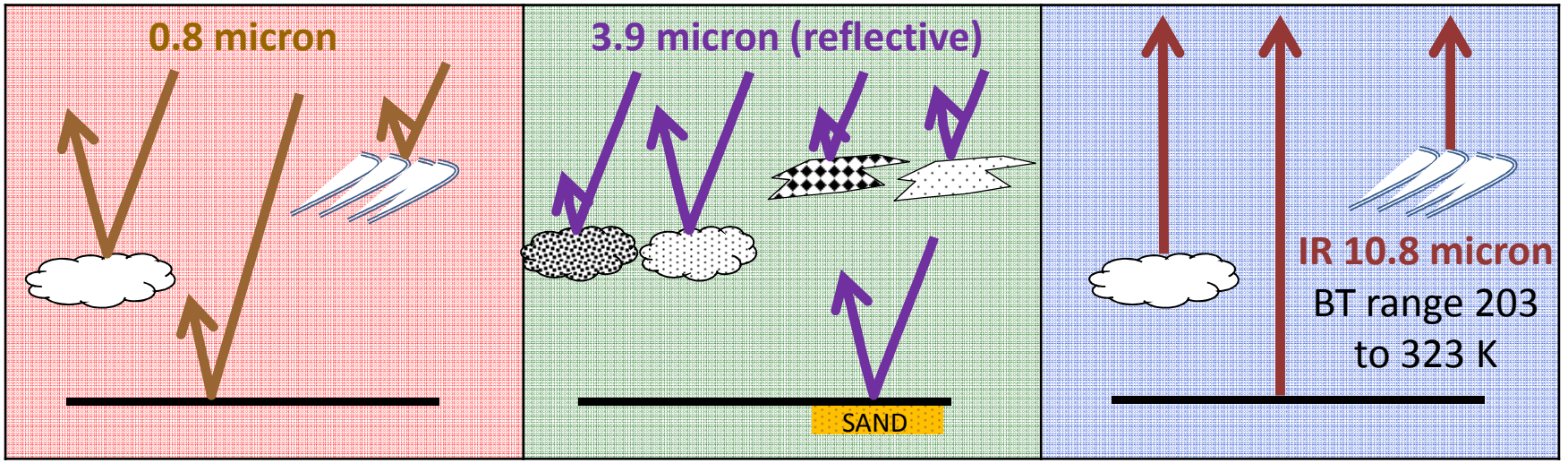


image courtesy
EUMETSAT

Recommended Range and Enhancement

Beam	Channel	Range	Gamma	Gamma 2
Red	**VIS0.8**	0 … 100%	1.0	1.0
Green	**NIR3.9 (r)** (reflected / solar component)	0 … 60%	2.5	1.0
Blue	**IR10.8**	+203 … +323 K	1.0	1.0



reflected reflected emitted

Channel combination “recipes’ of the Day Microphysics RGB

- **In the RED beam** - The visible reflectance at 0.8 microns approximates the cloud optical depth (thickness) and amount of cloud water and ice. Typically, water cloud is more reflective than ice cloud and thus will have a stronger red beam component. This channel also gives information about the surface of the earth. For example, vegetated land, desert and snow cover are all very reflective
- **In the GREEN beam** - the 3.9 µm shortwave infrared solar reflectance gives a qualitative measure for cloud particle size and phase. Typically smaller water droplets or small ice particles have a higher reflectivity, resulting in a stronger green beam component. A sandy earth surface also has a strong reflectance in this channel.
- **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, whereas cold cloud tops will not have any contribution in this beam.

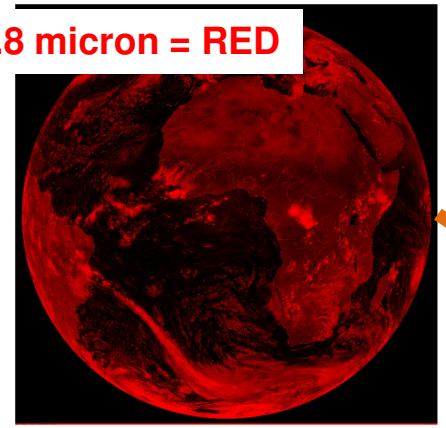
Obtaining the reflective component for the 3.9 micron channel

- For the 3.9 micron channel at daytime the outgoing radiance is due to solar reflection and thermal emission. Thus in order to determine a channel reflectance, it is necessary to subtract the thermal part from the satellite signal.
- To do this, the temperature of the observed object is needed. The usual candidate at hand is the 11 brightness temperature (e.g. VIIRS I5 or M12), since most objects behave approximately as blackbodies in this spectral interval.
- If the satellite observation is given in terms of the brightness temperature, then the corresponding spectral radiance can be derived by convolving the relative spectral response with the Planck function and diving by the equivalent band width. This gives the spectral radiance given the brightness temperature and may be expressed in . In order to get the total radiance over the band one has to multiply with the equivalent band width.

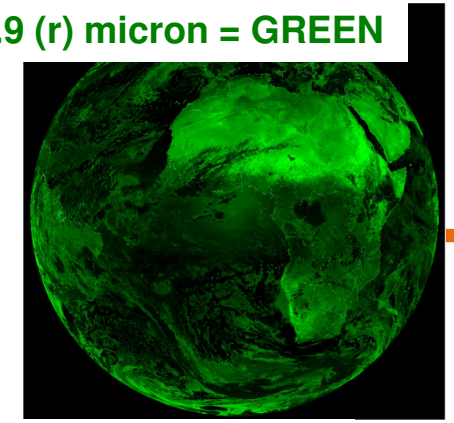
From https://pyspectral.readthedocs.org/en/latest/37_reflectance.html

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

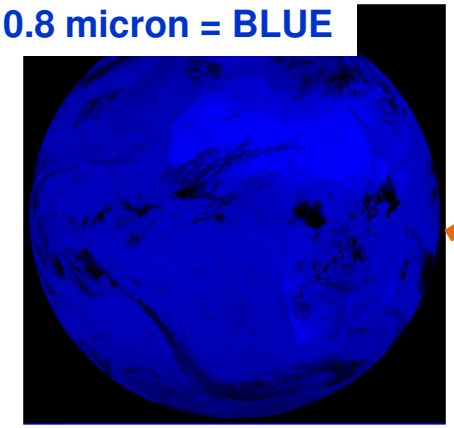
0.8 micron = RED



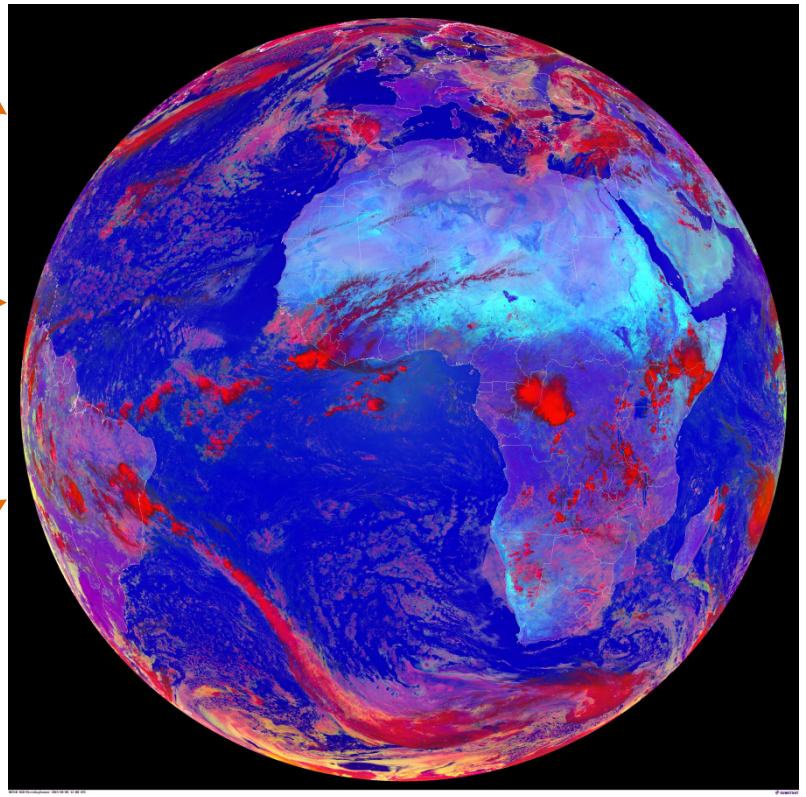
3.9 (r) micron = GREEN



10.8 micron = BLUE



Beam	Channel	Range	Gamma	Gamma 2
Red	VIS0.8	0 … 100%	1.0	1.0
Green	NIR3.9 (r) (reflected / solar component)	0 … 60%	2.5	1.0
Blue	IR10.8	+203 … +323 K	1.0	1.0



Western Hemisphere 8 April 2015 1200 UTC

images courtesy EUMETSAT

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

In the preceding slide you can familiarize yourself with the output of each of the beams for the Day Microphysics RGB product output of the Western Hemisphere 8 April 2015 1200 UTC.

In the red beam, note the strong contribution from the highly reflective cloud tops.

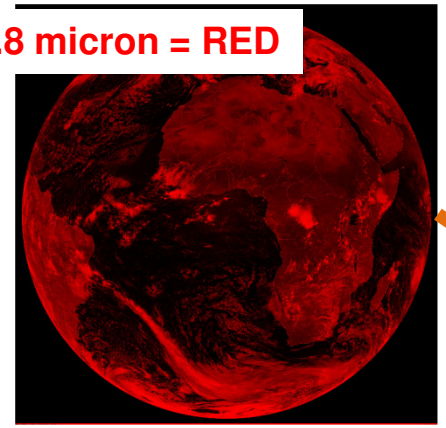
In the green beam, note the strong contribution from desert surfaces (Sahara, Kalahari deserts of Africa). Note that the storm tops over central Africa have very little contribution in this beam, indicating that the stormtops are likely to have large ice crystals.

In the Blue beam it is clear to see that all of the high cloud tops do not have any contribution.

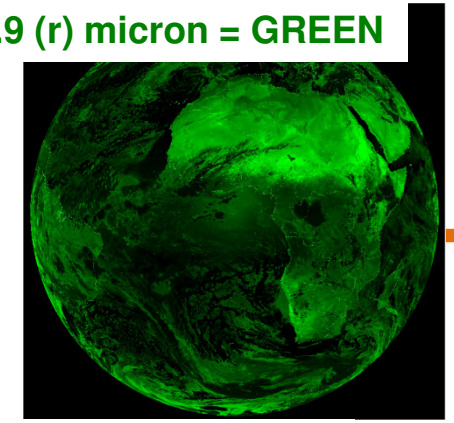
The next slide shows the effect of combining two beams.

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

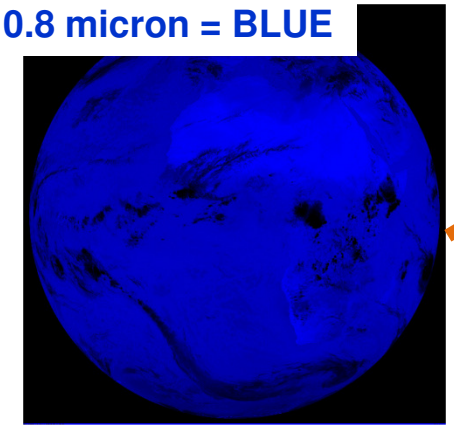
0.8 micron = RED



3.9 (r) micron = GREEN



10.8 micron = BLUE

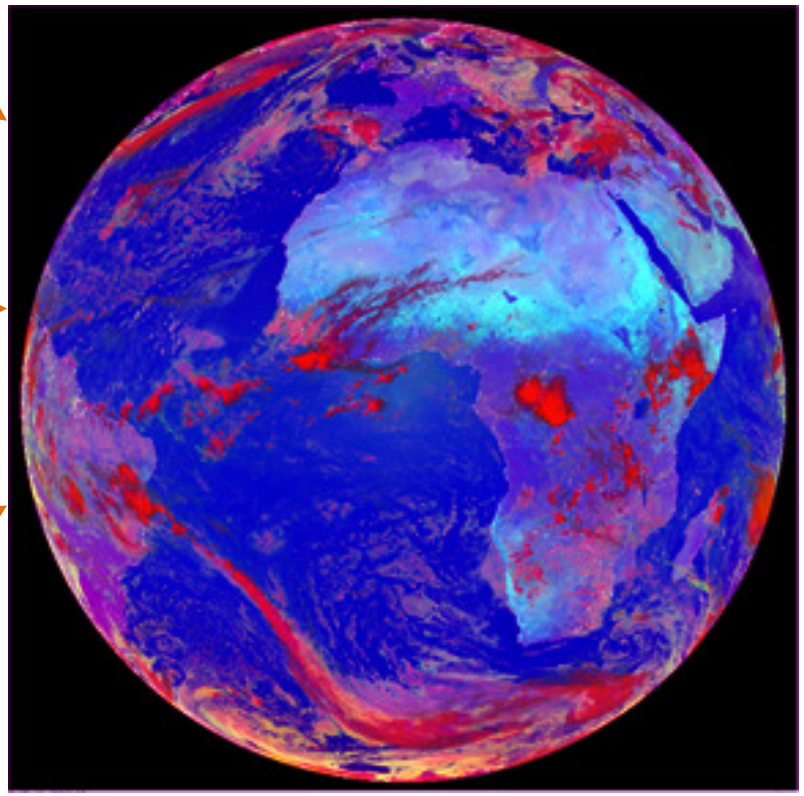


Combining beams

Yellow is made by mixing red and green

Magenta is made by mixing red and blue

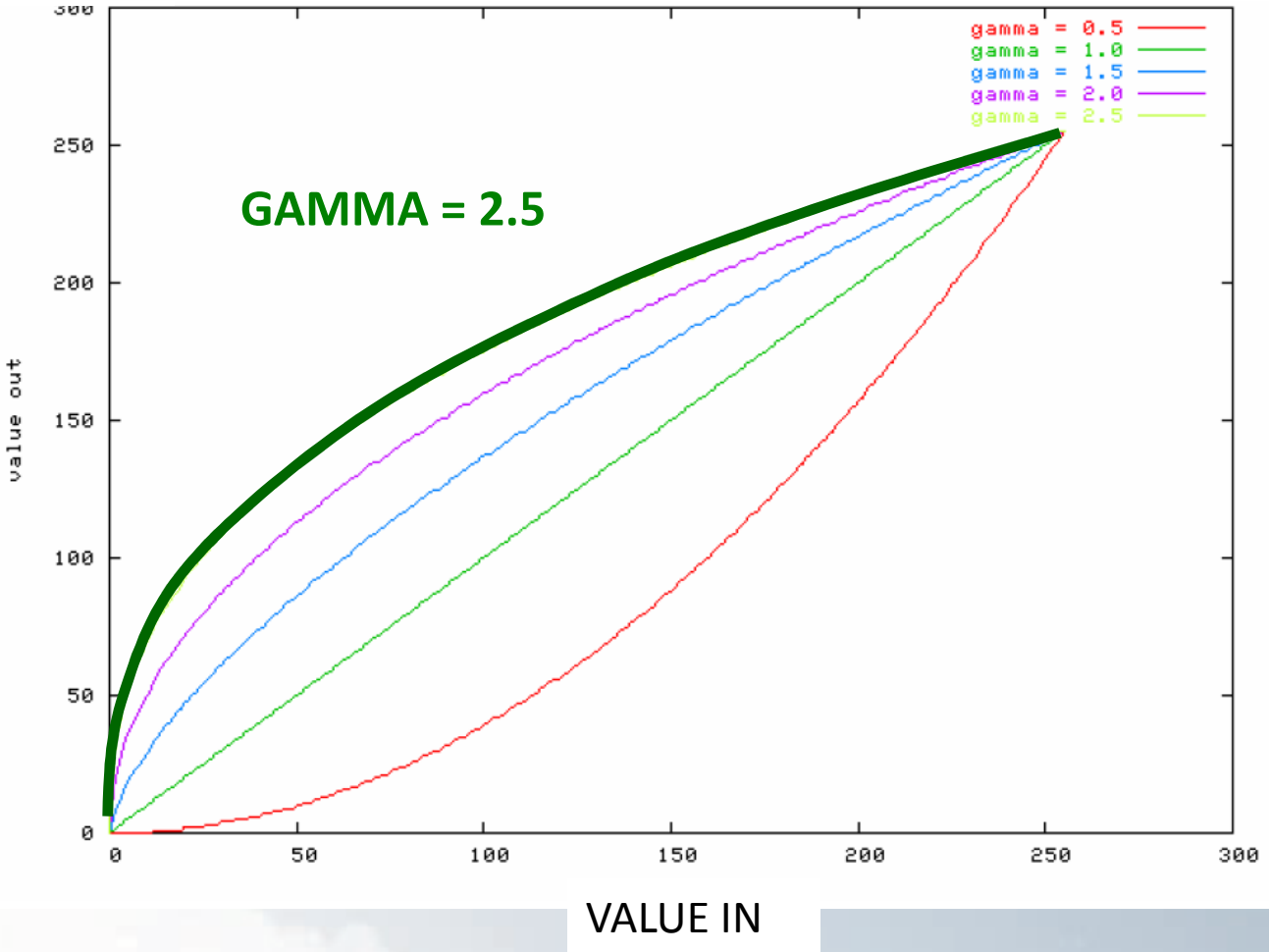
Cyan is made by mixing green and blue

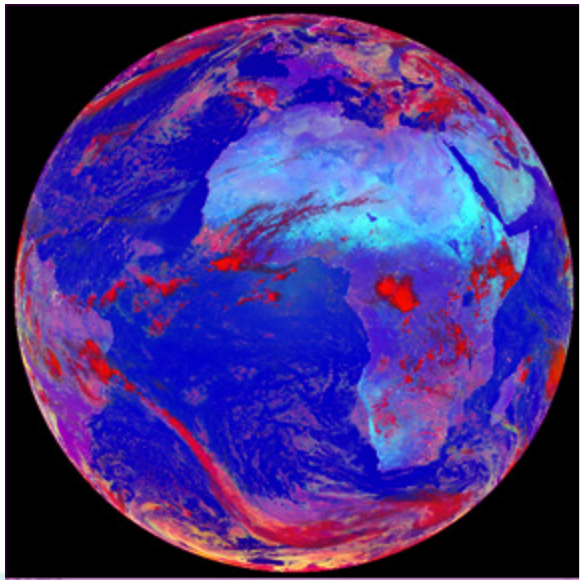


Western Hemisphere 8 April 2015 1200 UTC

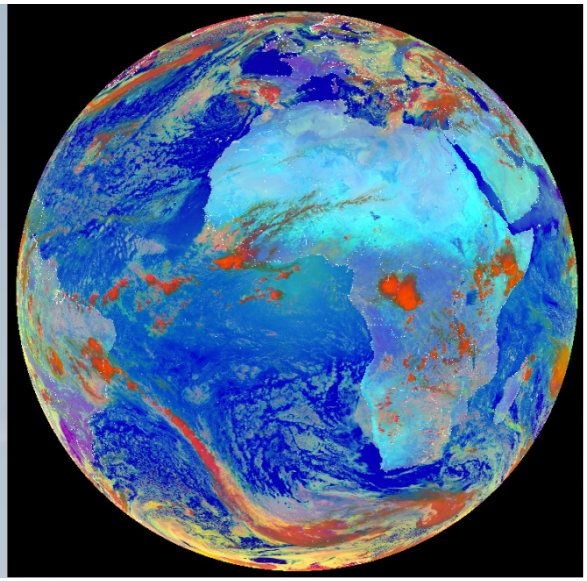
images courtesy EUMETSAT

GAMMA Correction applied





Before GAMMA correction



After GAMMA correction

The GAMMA enhancement. GAMMA=2.5 applied to a Day Microphysics RGB enhancement over the Western Hemisphere. Top, without GAMMA, bottom with GAMMA = 2.5.

images courtesy EUMETSAT

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 Day Microphysics 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 / Mid-level / Low level Cloud / earth surface palette exercises.

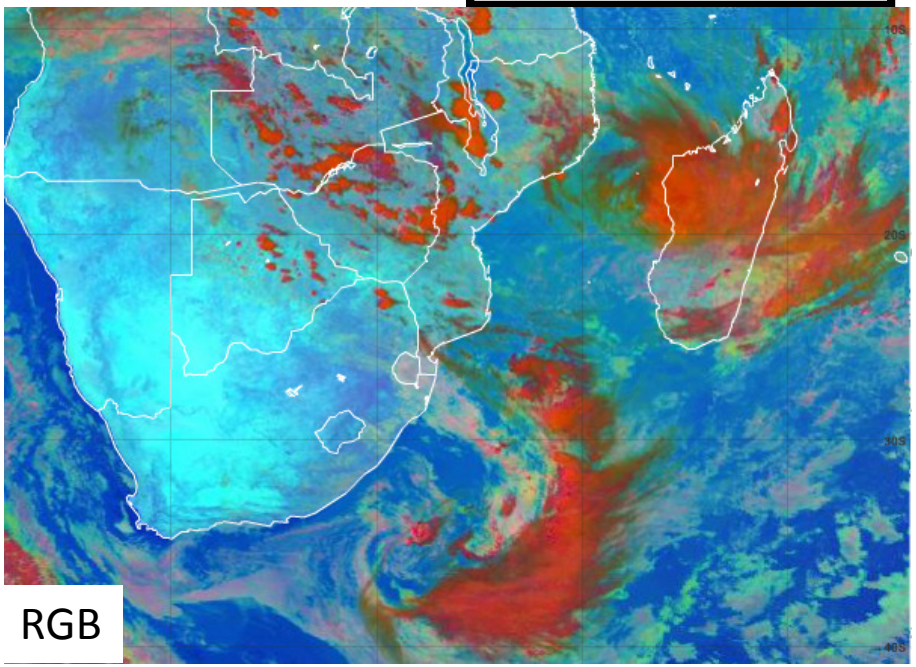
Examine the next three slides and see if you can identify the various features in the Day Microphysics RGB product.

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

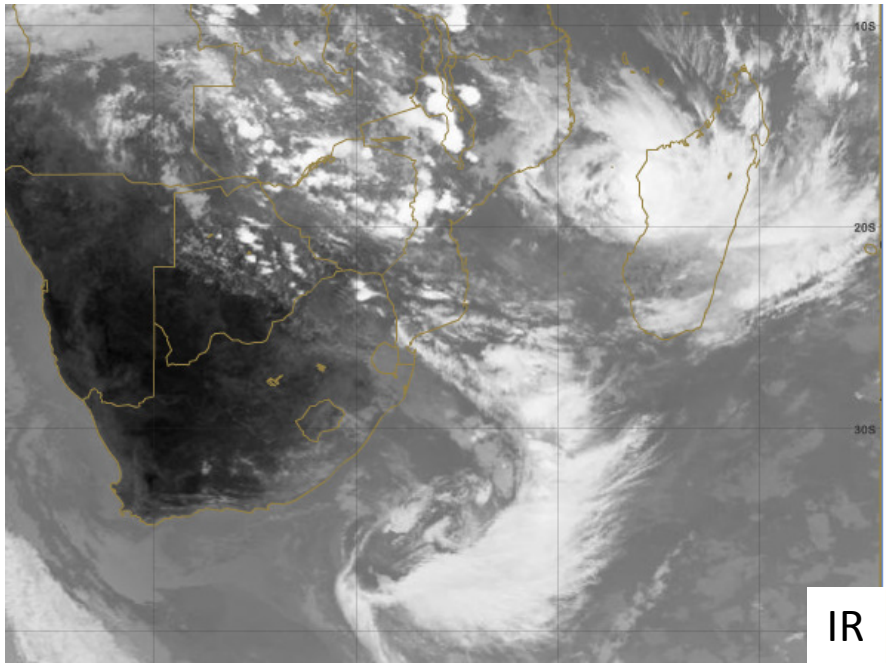
High-level Clouds palette – please annotate features

A	B	C	D
Deep precipitating cloud (precip. not necessarily reaching the ground)	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)

Southern Africa 5 February 2015 12UTC



RGB

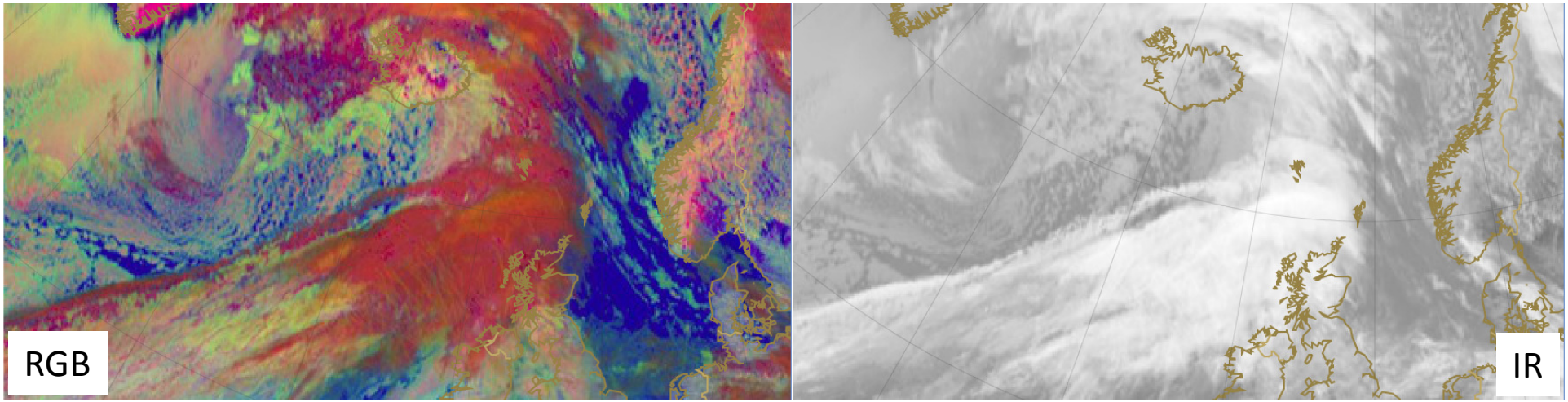


IR

Ocean (O)	Veg. Land (V)	Fires / Desert (D)	Snow (S)

images courtesy EUMETSAT

Mid-level Clouds palette – please annotate features



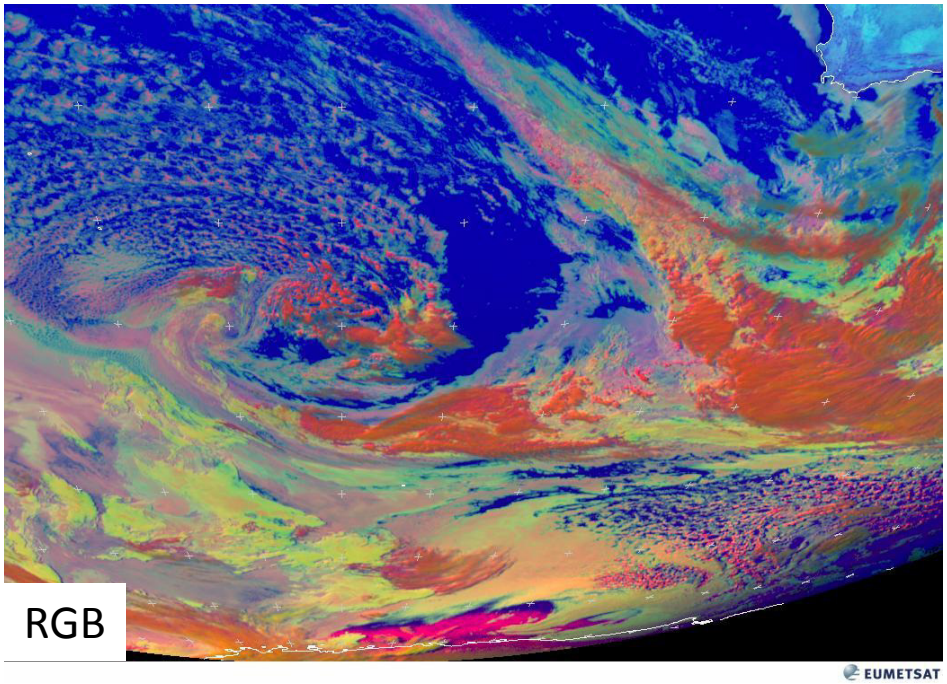
North Atlantic Ocean 13 April 2015 1800UTC

E	F	G	H
Supercooled, thick water cloud – large droplets	Supercooled, thick water cloud – small droplets	Supercooled thin water cloud with large droplets	Supercooled, thin water cloud with small droplets

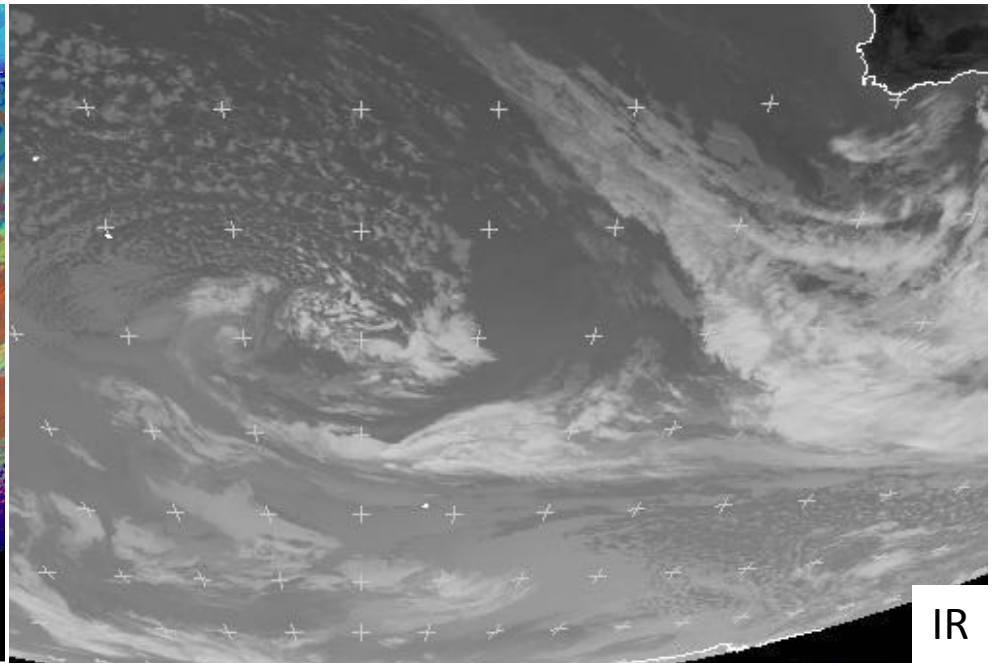
Ocean (O)	Veg. Land (V)	Fires / Desert (D)	Snow (S)

images courtesy EUMETSAT

Low-level Clouds palette – please annotate features



RGB



IR

South Atlantic Ocean 12 April 2015 14UTC

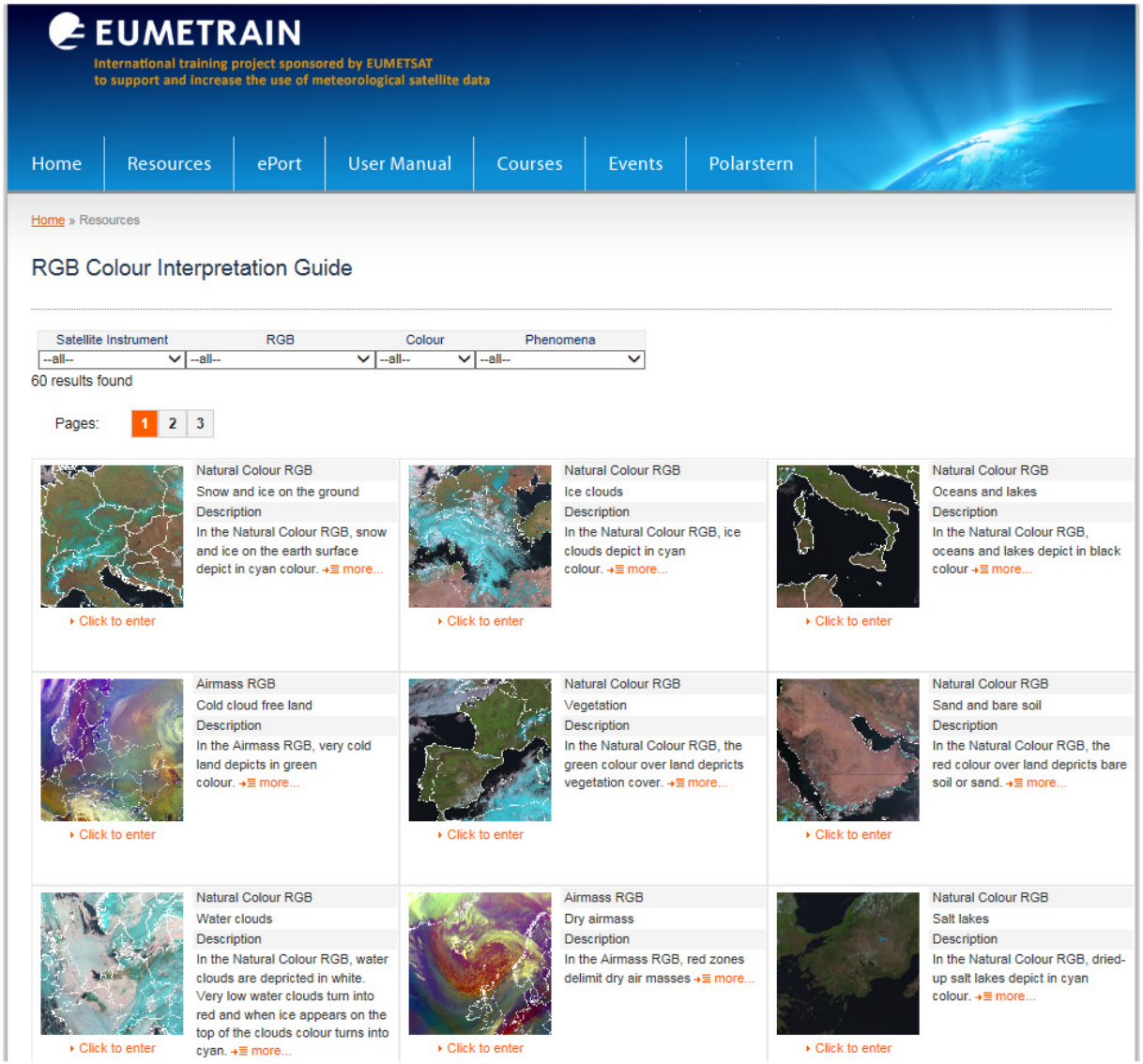
I	J	K	L
Thick water cloud (warm rain cloud) - large droplets	Thick water cloud (no precipitation) – small droplets	Thin water cloud with large droplets	Thin water cloud with small droplets

Ocean (O)	Veg. Land (V)	Fires / Desert (D)	Snow (S)

images courtesy EUMETSAT

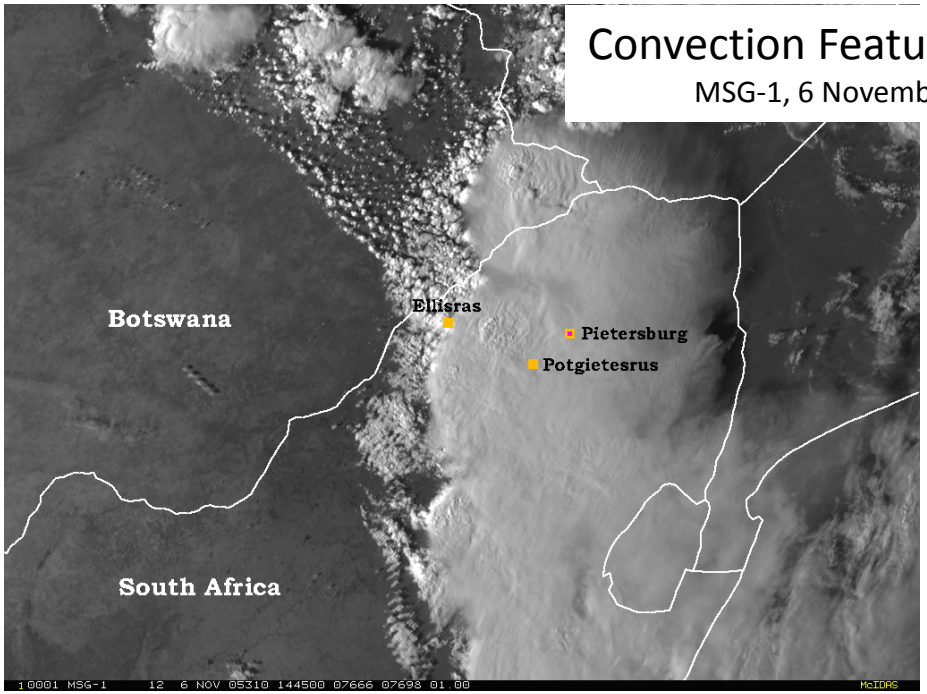
Very useful website for reference – the EUMETRAIN RGB Colour Interpretation Guide

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



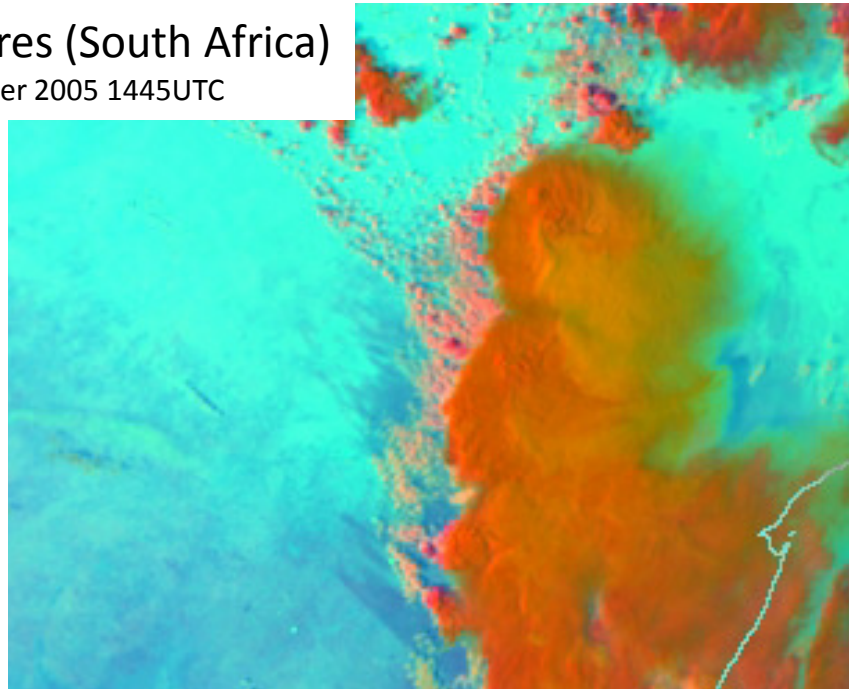
images from EUMETSAT

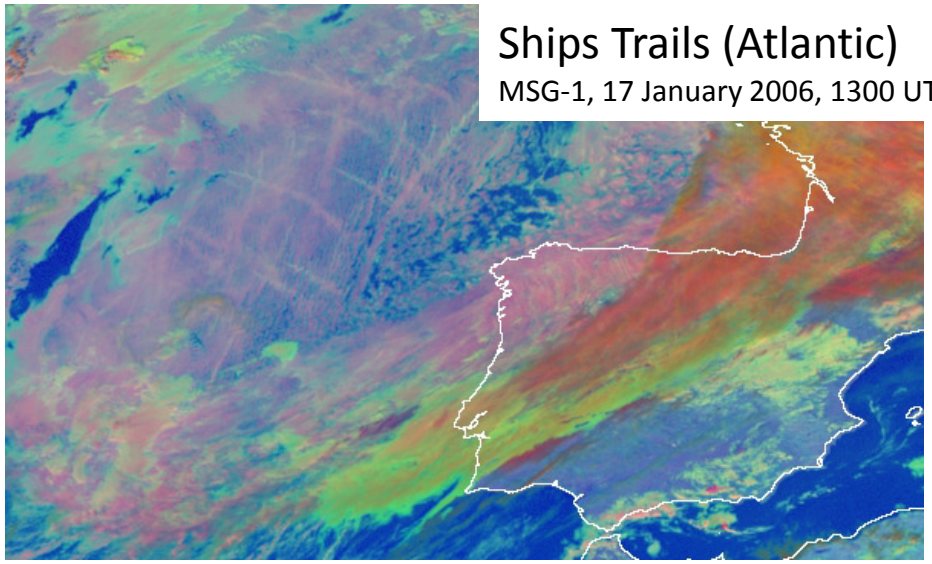
Some interesting features this RGB product can show



Convection Features (South Africa)

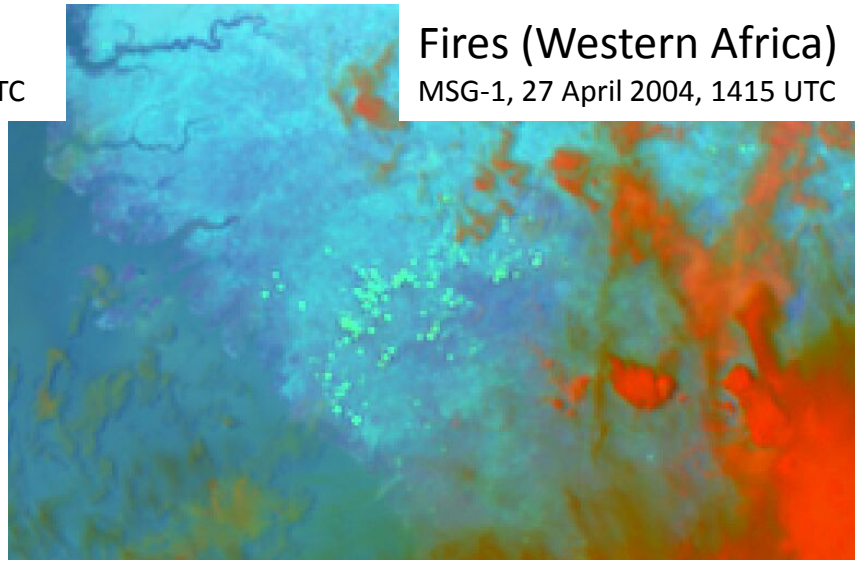
MSG-1, 6 November 2005 1445UTC





Ships Trails (Atlantic)

MSG-1, 17 January 2006, 1300 UTC



Fires (Western Africa)

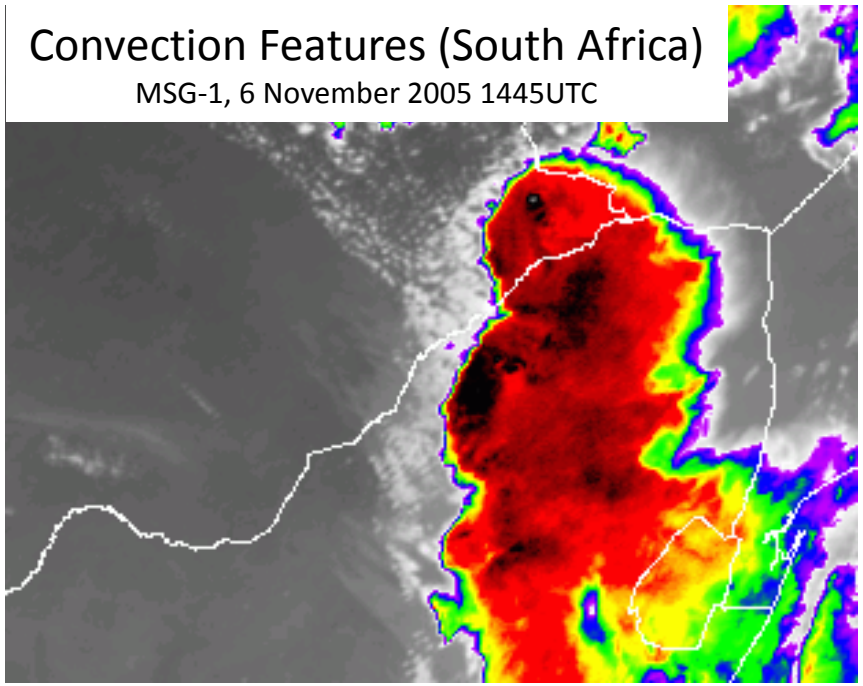
MSG-1, 27 April 2004, 1415 UTC

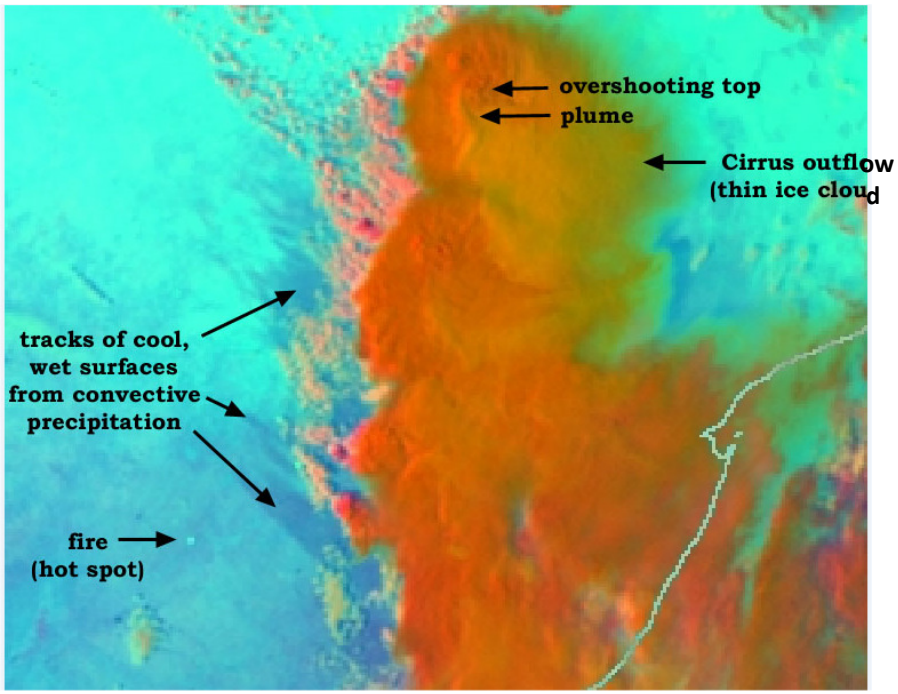
images from EUMETSAT

Some interesting features this RGB product can show

Convection Features (South Africa)

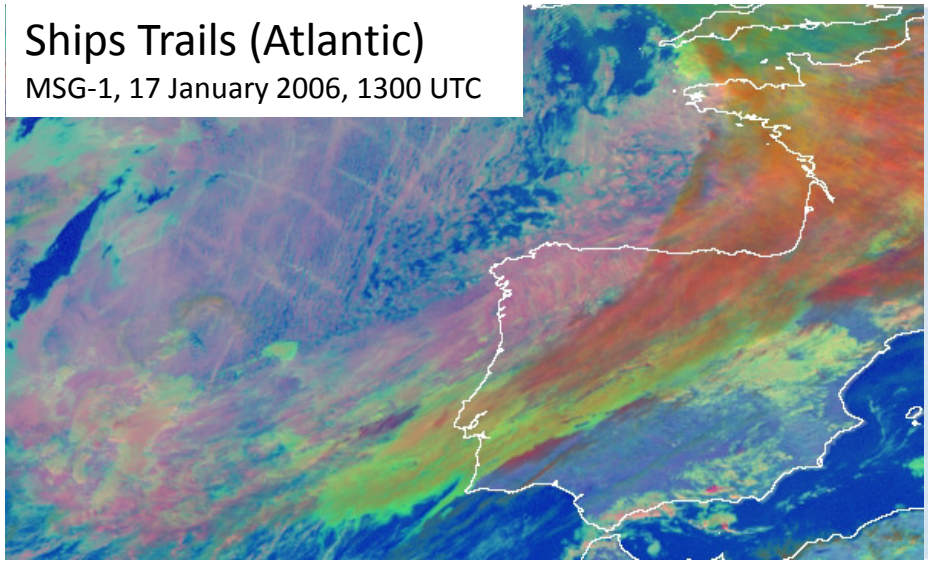
MSG-1, 6 November 2005 1445UTC





Ships Trails (Atlantic)

MSG-1, 17 January 2006, 1300 UTC



Ships trails and Fires (Africa)

MSG-1, 7 September 2003 1145UTC

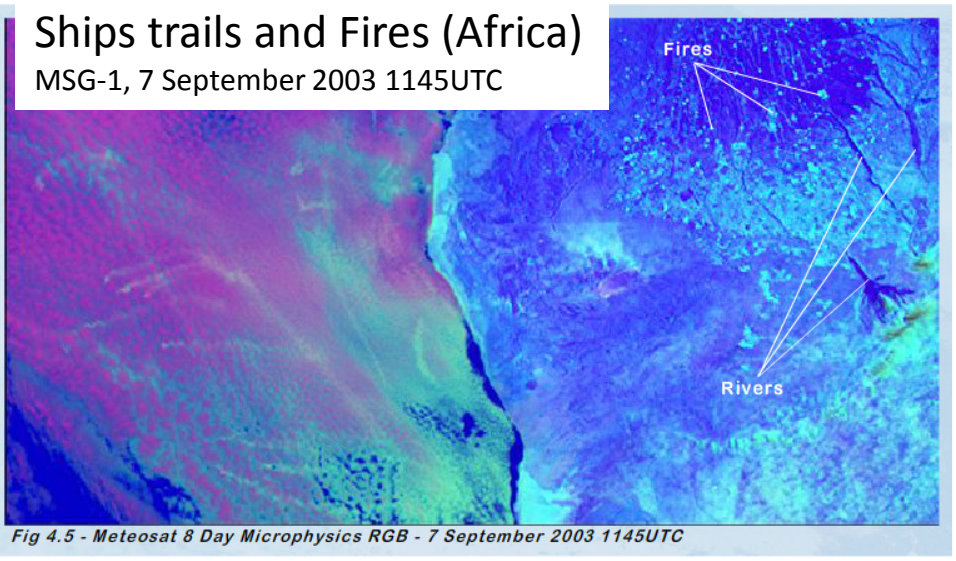


Fig 4.5 - Meteosat 8 Day Microphysics RGB - 7 September 2003 1145UTC

Some interesting features this RGB product can show

- The Day Microphysics RGB product can distinguish between storm tops with different populations of ice particles. Large ice particle cloudtops will typically show up as reddish-orange in the RGB products, whereas small ice particle cloudtops will show up as orange-yellow. Stormtops with small ice crystals may indicate strong updrafts and storm severity.
- Note that after the passage of the storms new moisture streaks left by the heavy convection are visible in the infrared images, but even more clearly in the Day Microphysics RGB product as dark blue land features on the western flank of the storm complex.
- Ship tracks can be detected because the exhaust from the funnel of the ship will result in small droplet clouds. These are quite different from the typically large droplet marine clouds.
- Fires have a very strong signal in the 3.9 micron channel and thus show up will in this RGB product.

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

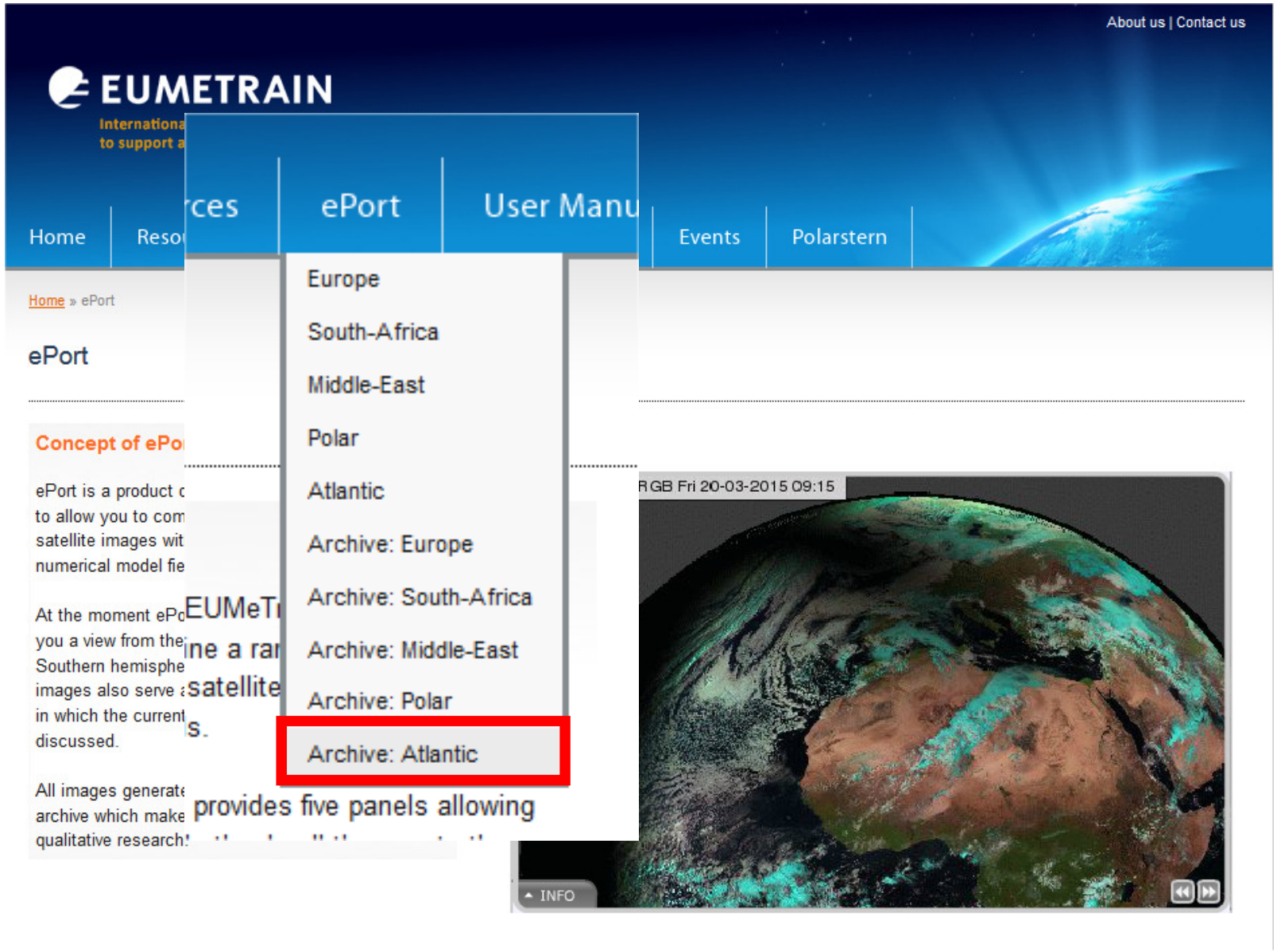


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort – choosing Archive: Atlantic (Northern and Southern Hemisphere)

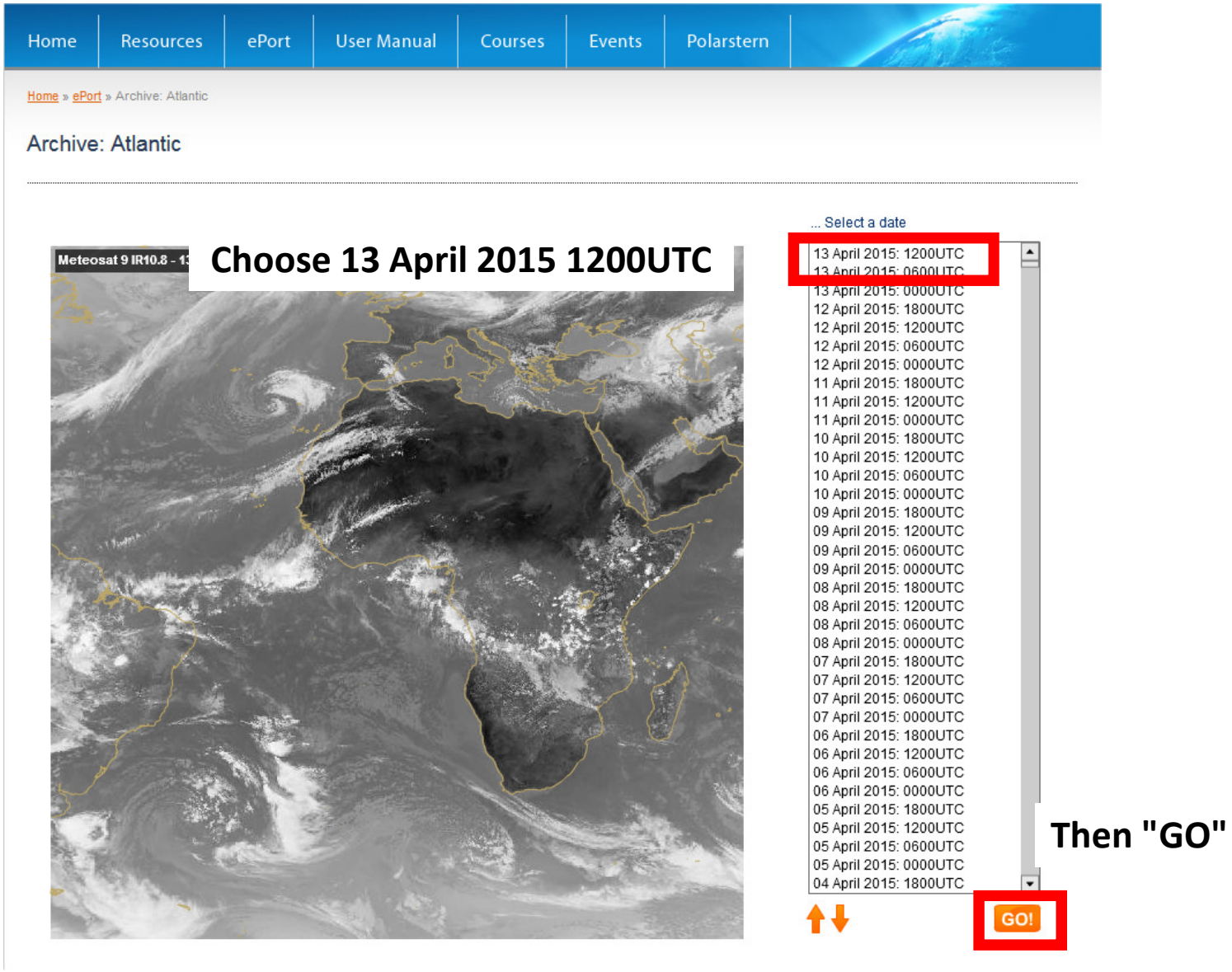


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

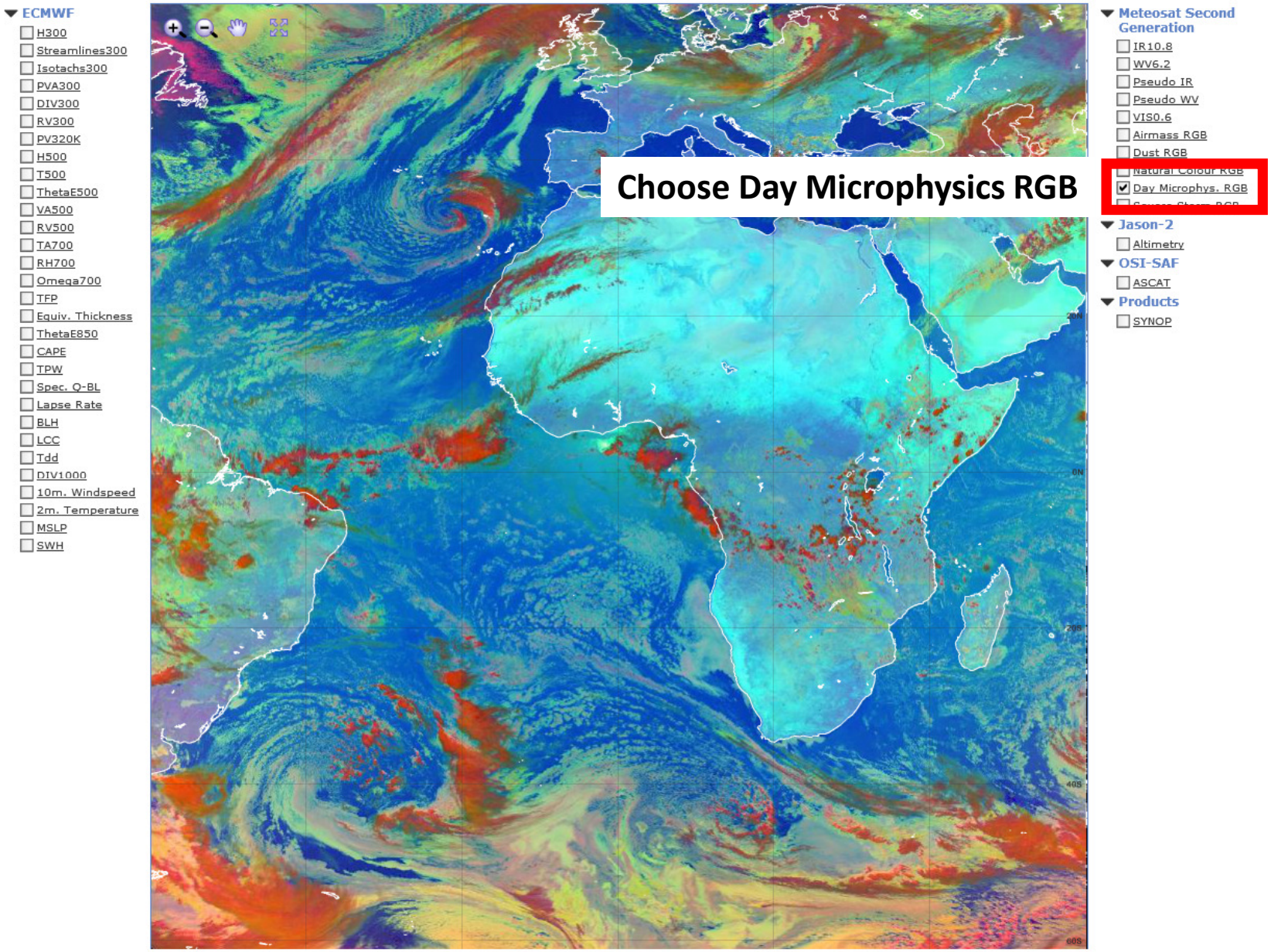
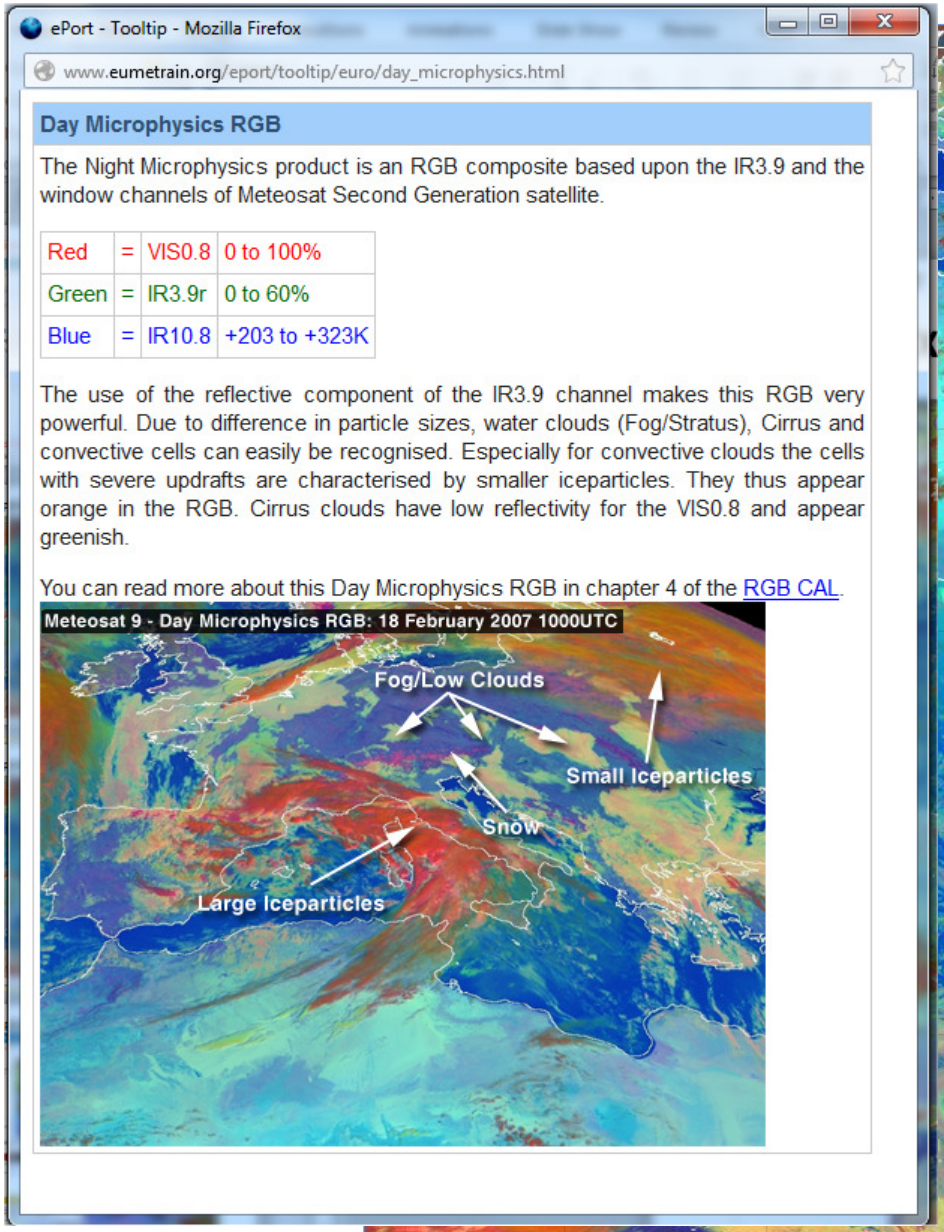


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort



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

image courtesy EUMETSAT

Activity: Comparing single channel image with RGB product

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

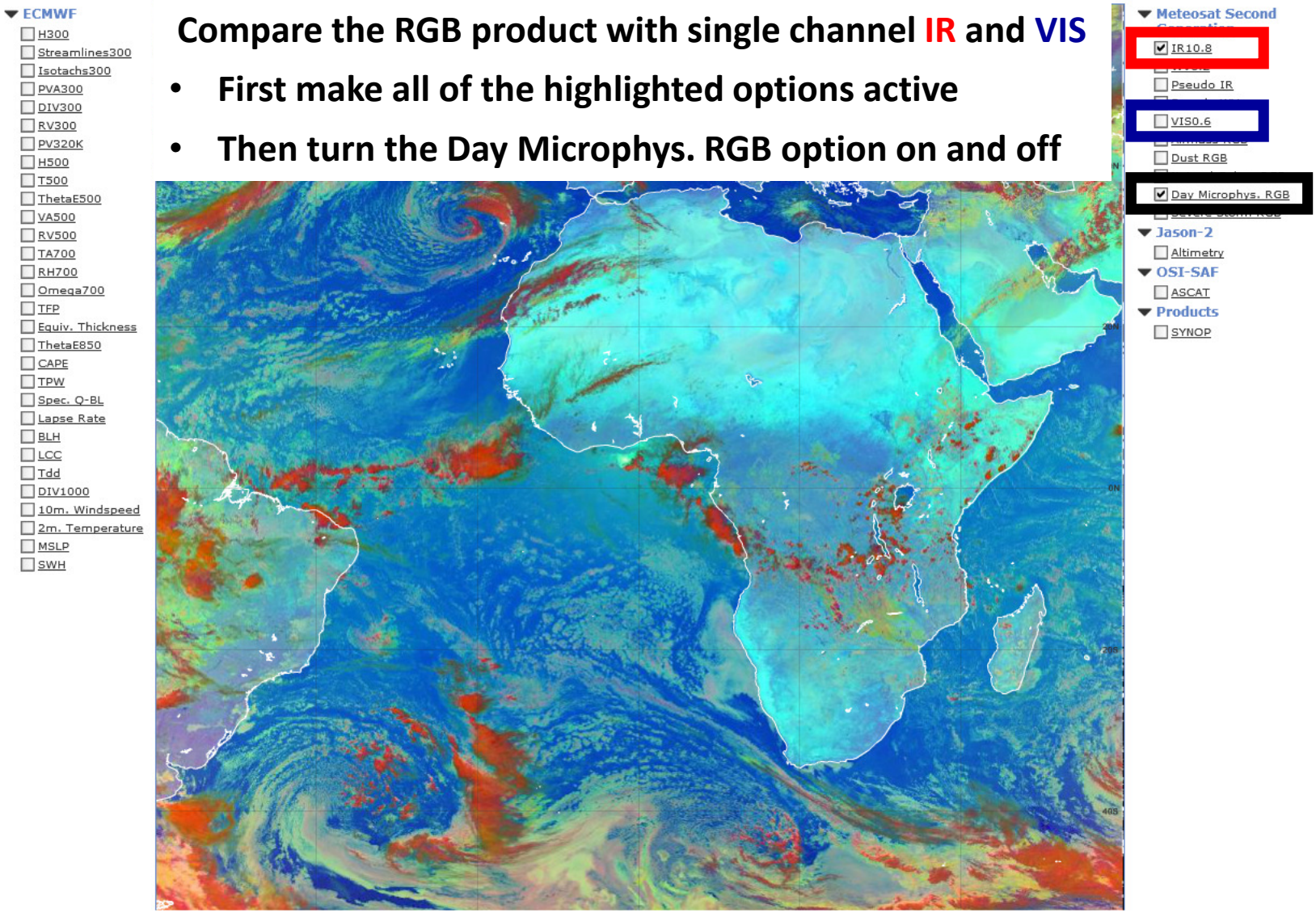


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

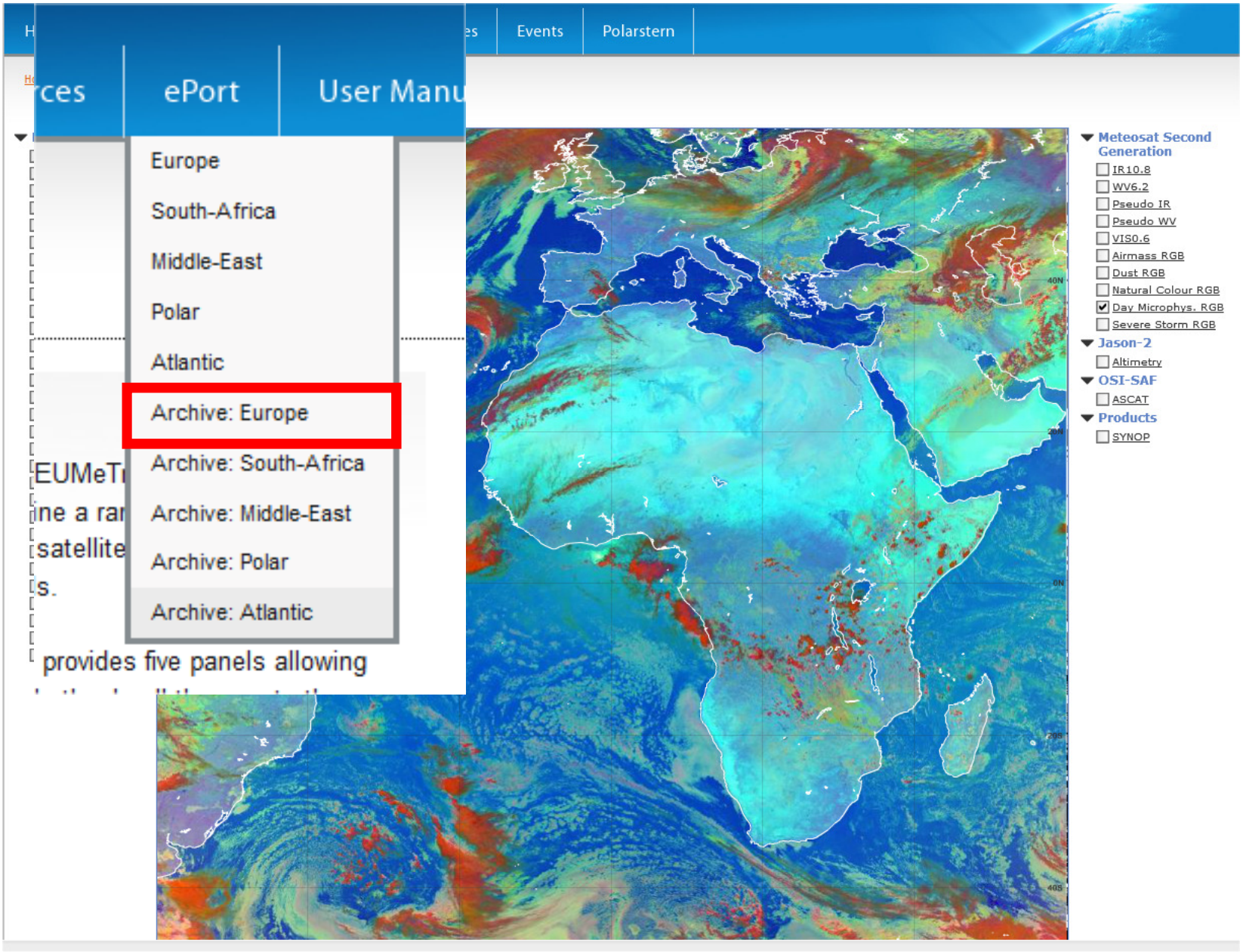


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort – choosing Archive: Europe

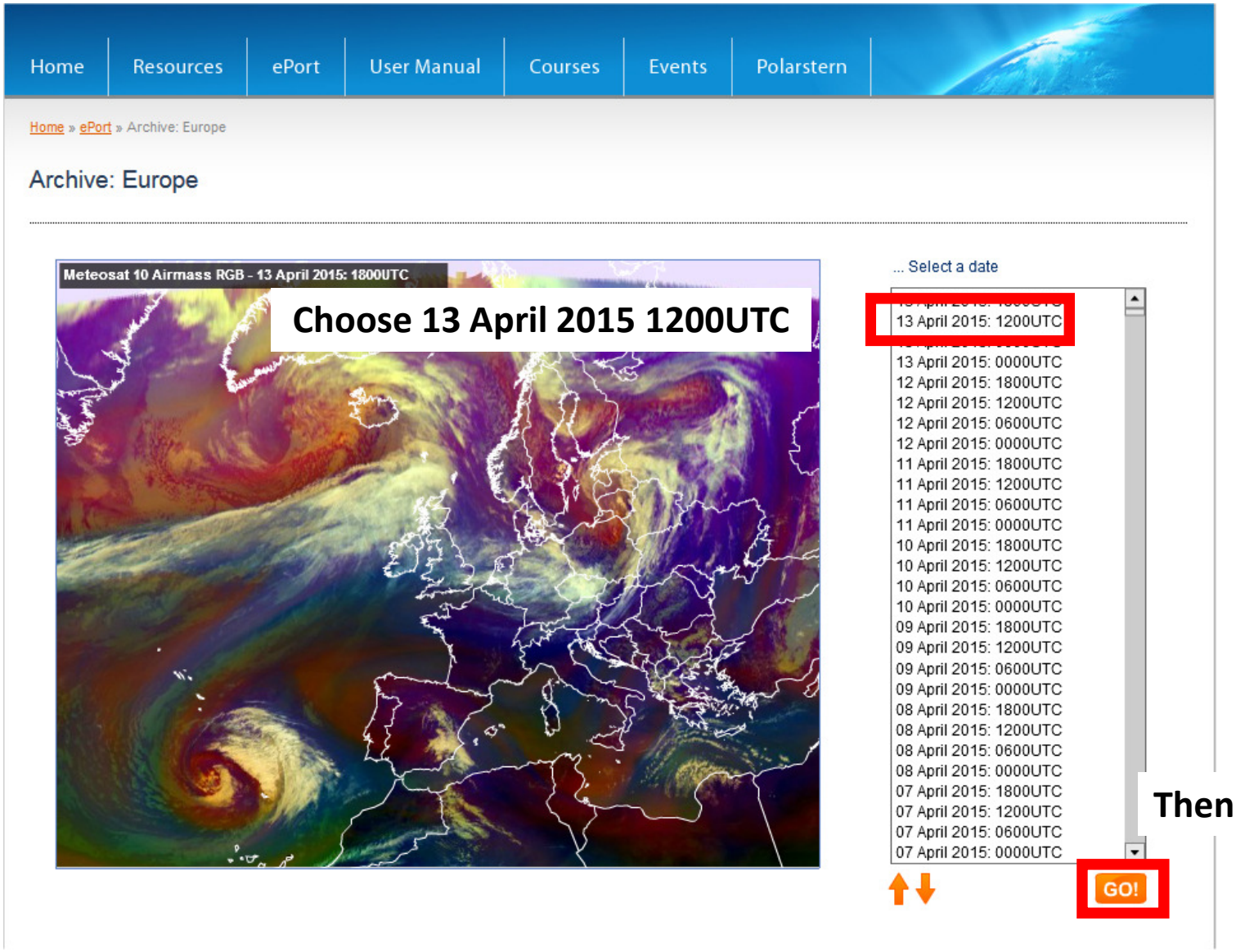


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

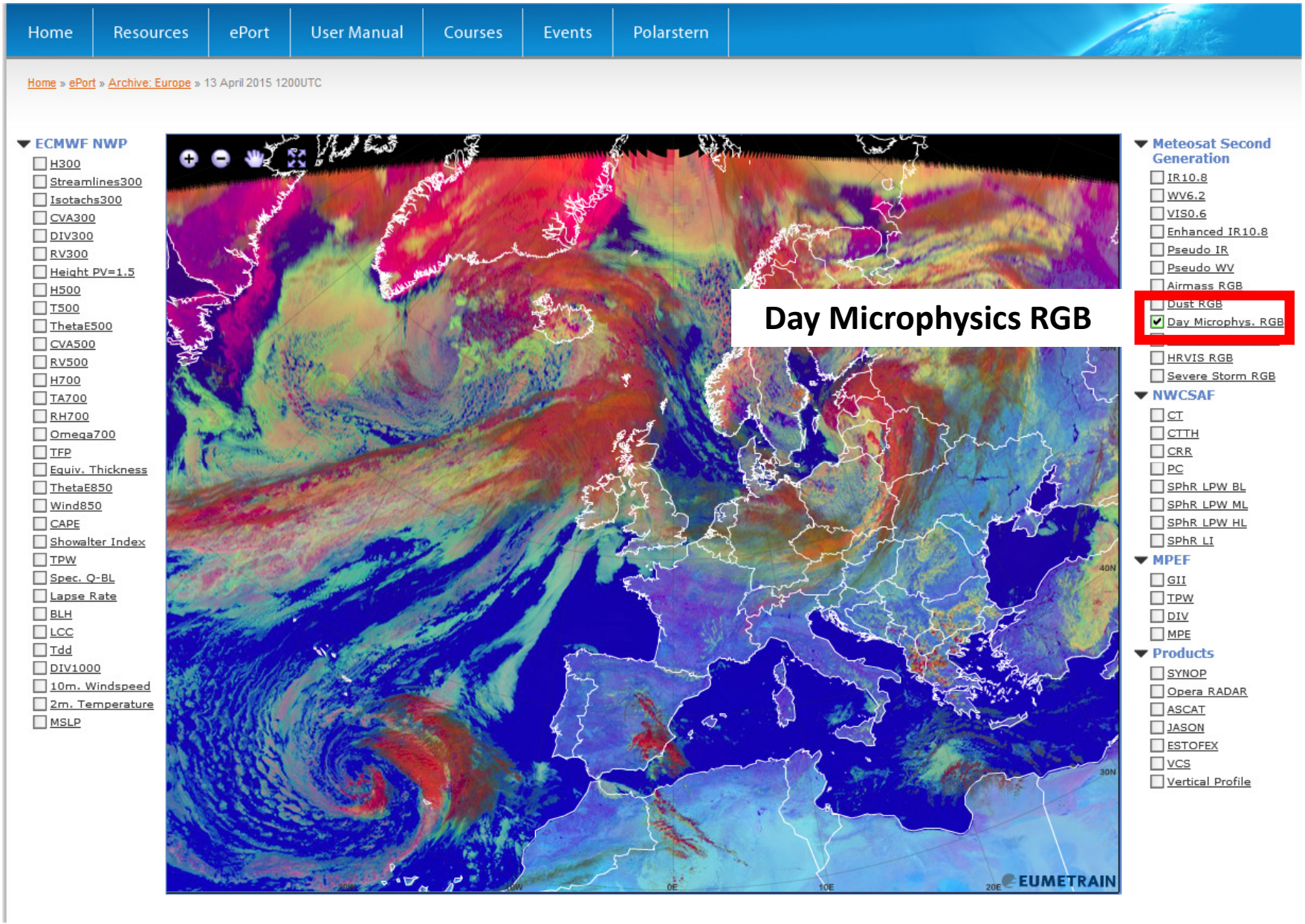


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

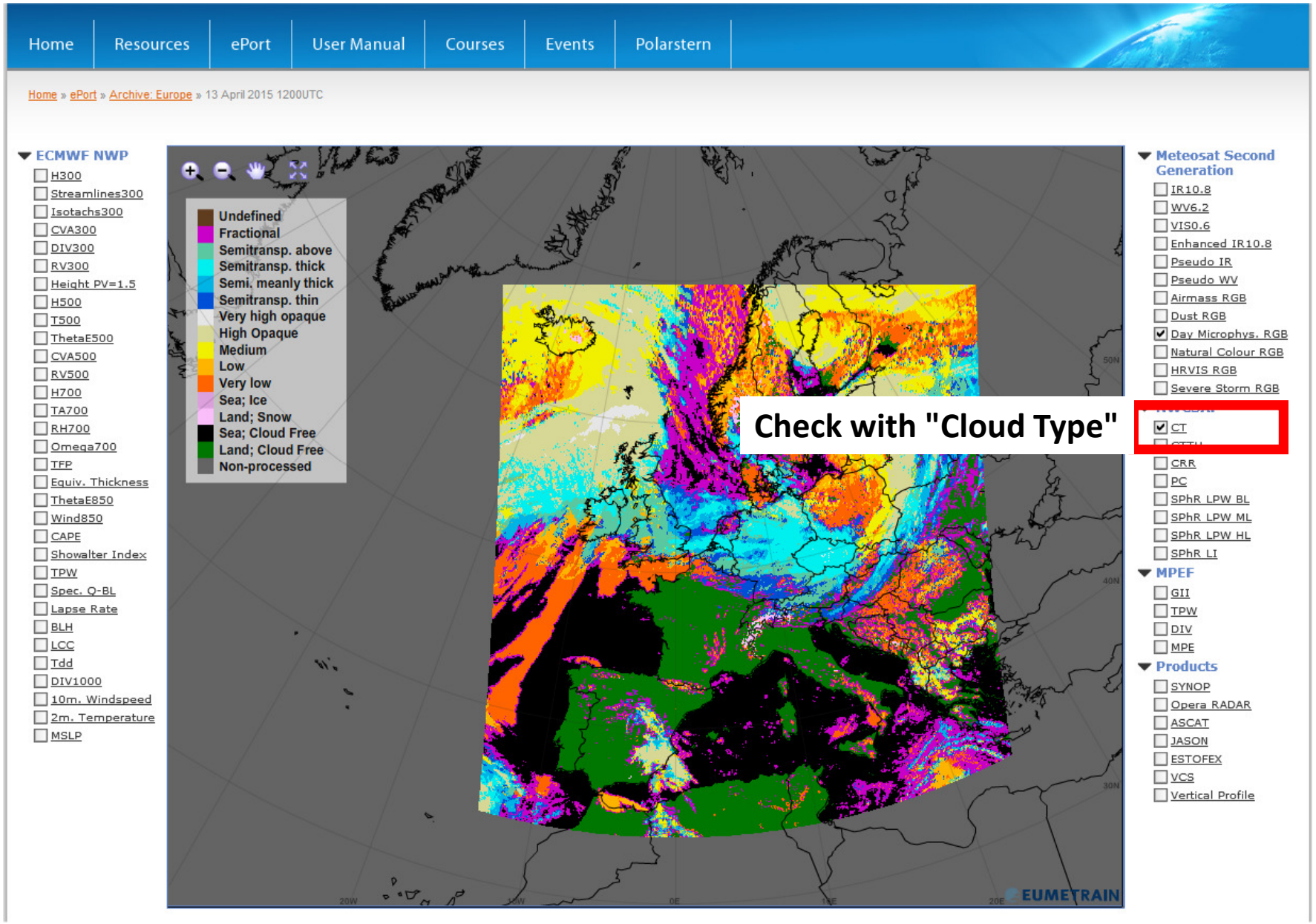
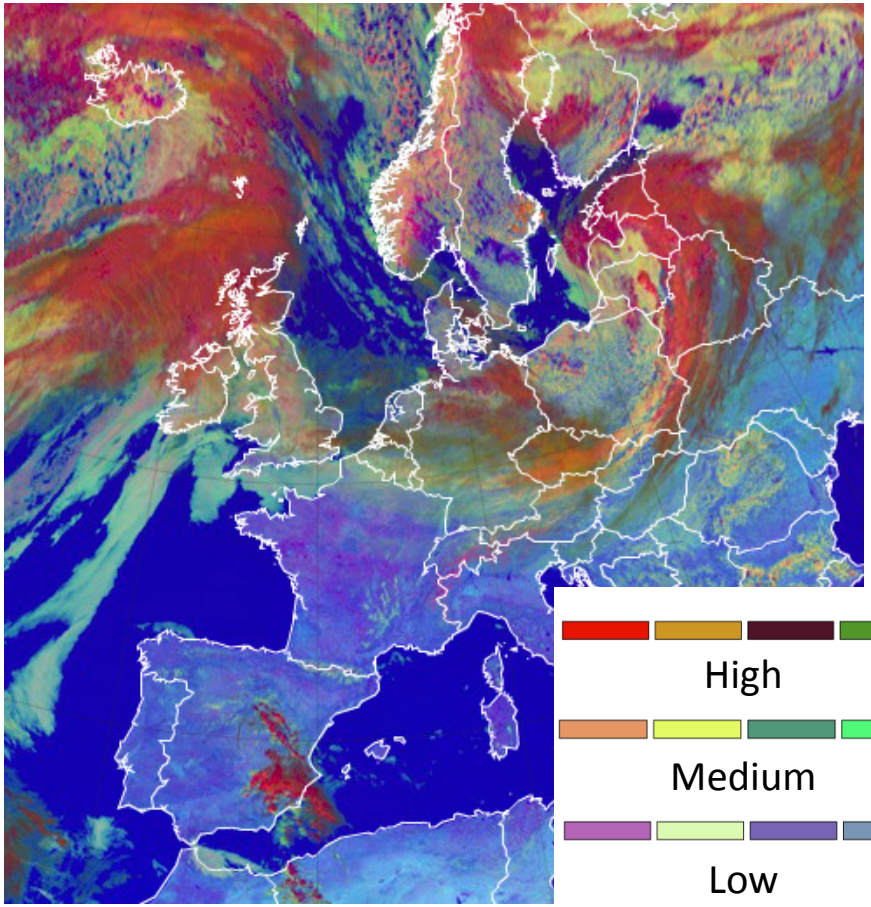
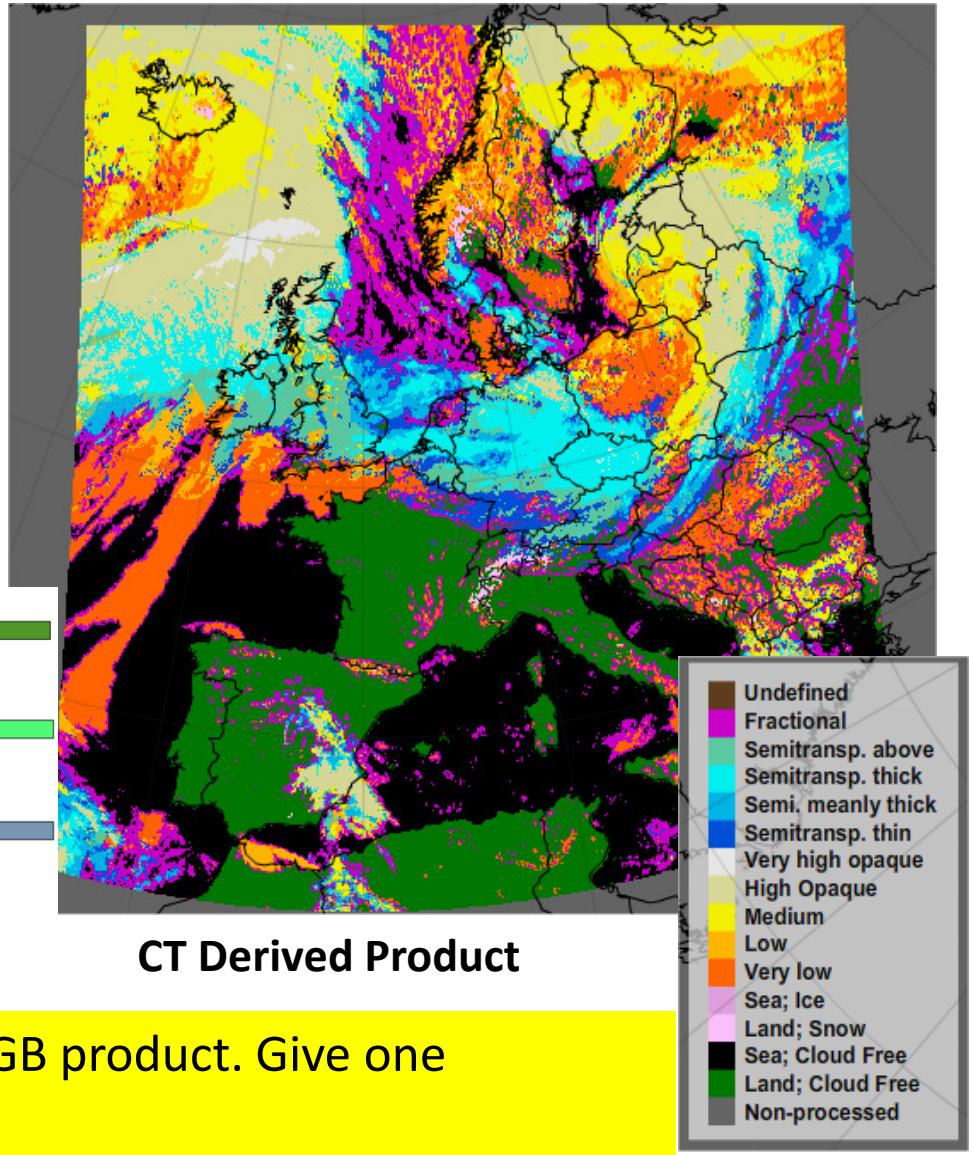


image courtesy EUMETSAT

Activity: Comparing the RGB with the Derived product



Day Microphysics RGB product



CT Derived Product

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

Cloud Type (CT) Derived Product algorithm summary description (1)

(from http://www.nwcsaf.org/HD/MainNS.jsp)

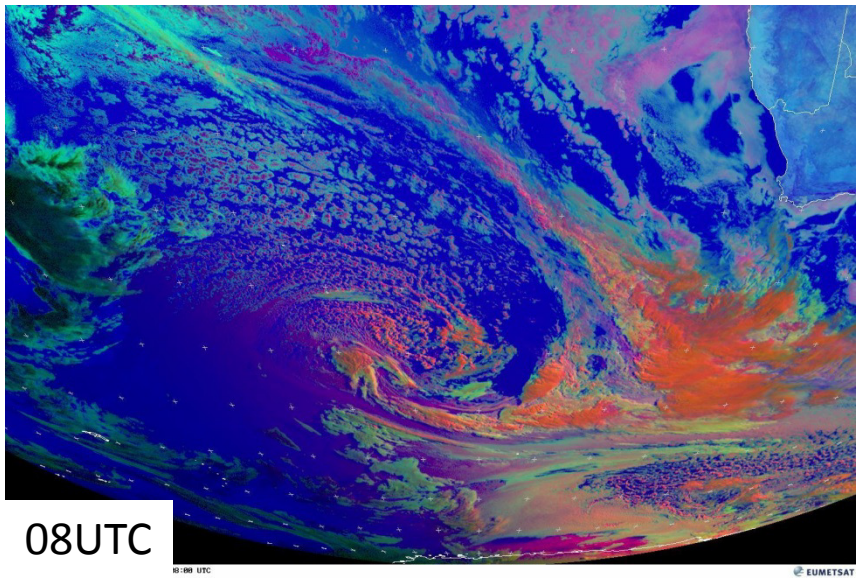
- The CT algorithm is a threshold algorithm applied at the pixel scale, based on the use of CMa and spectral & textural features computed from the multispectral satellite images and compared with a set of thresholds.
- The set of thresholds to be applied depends mainly on the illumination conditions, whereas the values of the thresholds themselves may depend on the illumination, the viewing geometry, the geographical location and NWP data describing the water vapour content and a coarse vertical structure of the atmosphere.
- The CT classification algorithm is based on the following approach:
- Main cloud types are separable within two sets: the fractional and high semitransparent clouds, from the low/medium/high clouds. These two systems are distinguished using spectral features : T10.8µm-T12.0µm, T3.9µm-T10.8µm (in night-time conditions only), R0.6µm (in day-time conditions only), and textural features (variance T10.8µm coupled to variance R0.6µm in daytime conditions) .

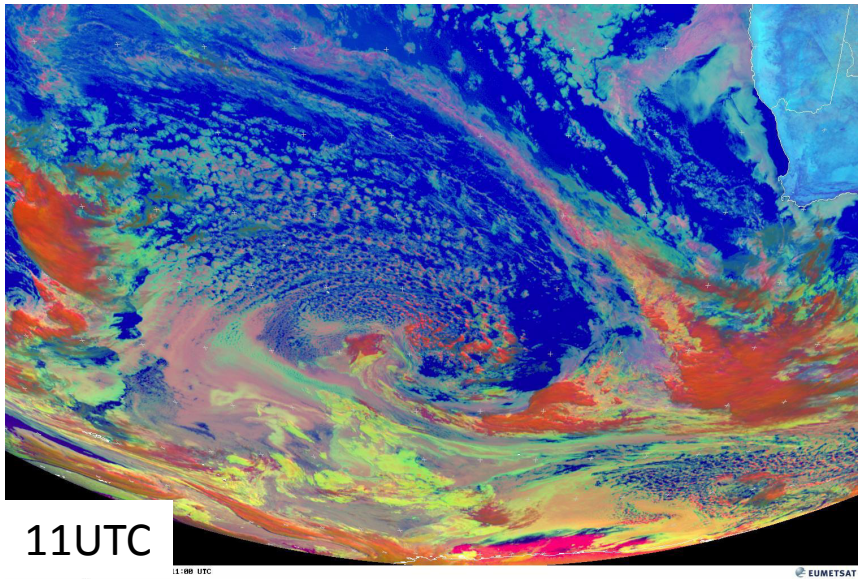
Cloud Type (CT) Derived Product algorithm summary description (2)

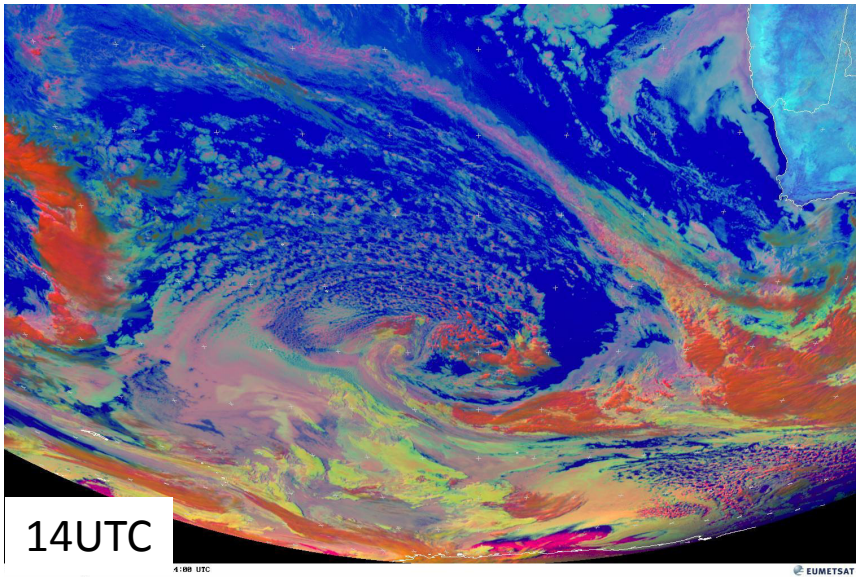
(from http://www.nwcsaf.org/HD/MainNS.jsp)

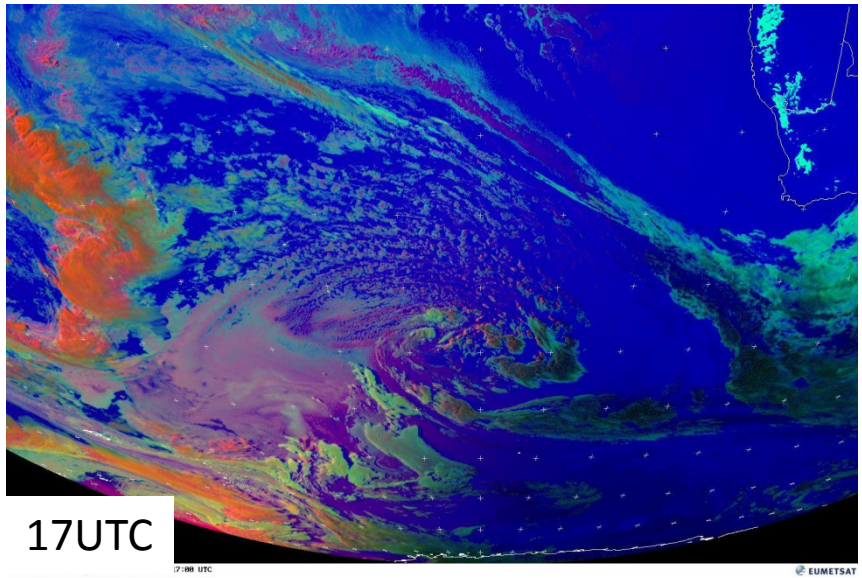
- Within the first set, the fractional and high semitransparent are separated mainly using their T8.7µm-T10.8µm brightness temperature differences, but also their R0.6µm visible reflectance (in daytime conditions only).
- The remaining categories are distinguished through the comparison of their T10.8µm to NWP forecast temperatures at several pressure levels. T7.3µm and T8.7µm are also used to refine the separation between low and medium clouds, especially useful in case of low level thermal inversion.
- No separation between cumuliform and stratiform clouds is performed in the current version of CT.
- A separate processing is applied to compute a cloud phase flag, based on the use of CT cloud type, T8.7µm, T10.8µm (all illumination), R0.6µm and R1.6µm (at daytime only).

Summary of Day Microphysics RGB animation – , South Atlantic Ocean, Meteosat-10, 12 April 2015 08-17UTC







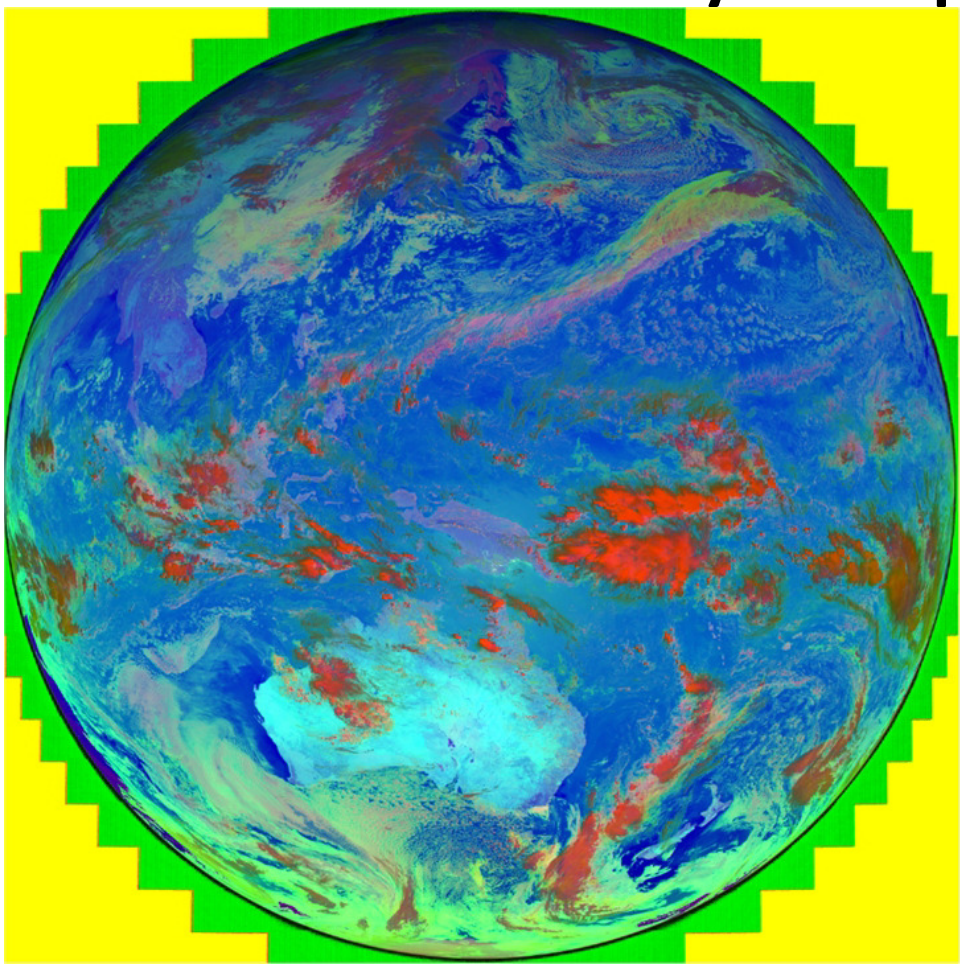


… and now, Himawari-8 compared to Meteosat-10

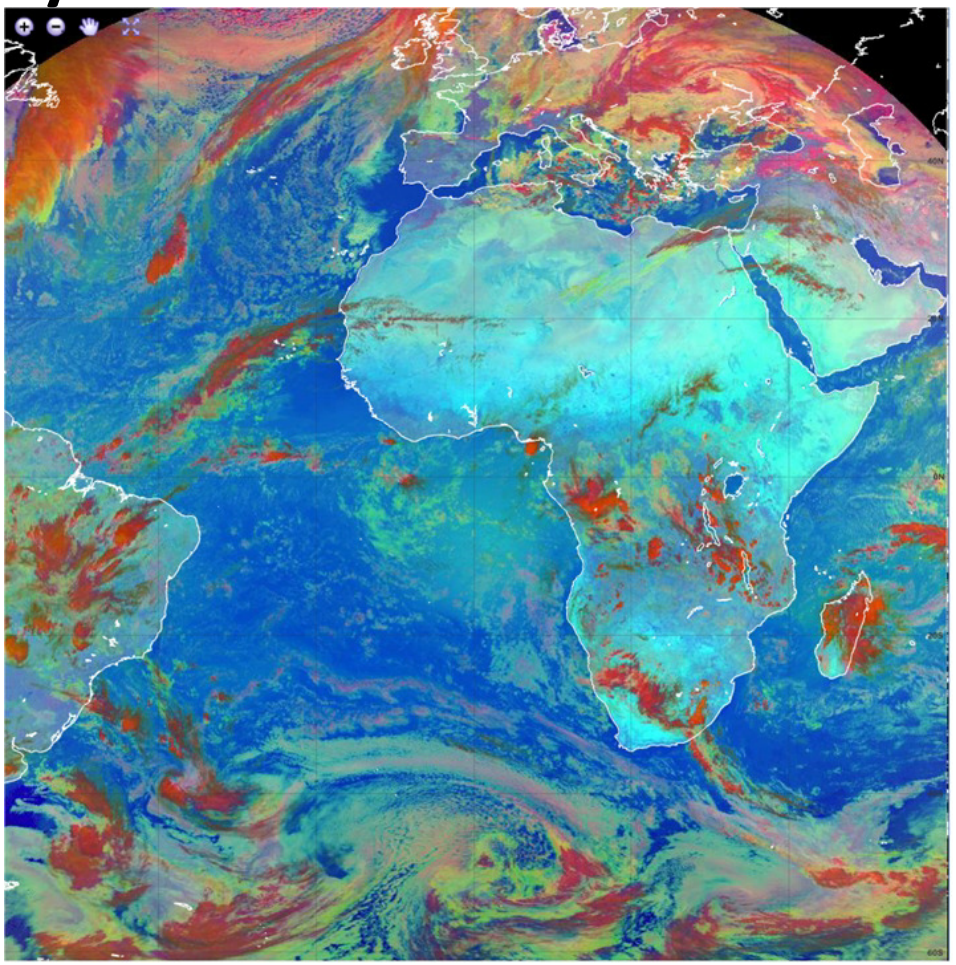
Day Microphysics RGB

image courtesy JMA and Chris Down (BOM)

image courtesy EUMETSAT



Himawari-8 25 January 2015, 0230UTC



Meteosat-10 25 January 2015 1200UTC

Question: Please highlight any differences that you note between the two images

Day Microphysics RGB product – Summary (1)

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

This RGB is useful for cloud analysis (for example cloud identification, type, and phase), monitoring convection, fog, and fires.

- The visible reflectance in red approximates the cloud optical depth and amount of cloud water and ice
- The 3.9 µm shortwave infrared solar reflectance in green gives a qualitative measure for cloud particle size and phase
- The 10.8 µm infrared brightness temperature produces blue shading as a function of surface and cloud top temperatures (the warmer the surface, the greater the blue contribution); therefore warmer land and ocean surfaces appear in shades of blue whereas colder cloud tops have less blue input and appear more orange and red

Day Microphysics RGB product – Summary (2)

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

Advantages:

- Can clearly distinguish between ice phase clouds at high elevations and water phase clouds at lower elevations, providing a pseudo three-dimensional view of the atmosphere
- Can identify subtle microphysical variations within clouds that are not apparent on other images or RGBs
- Helps discriminate between precipitating and non-precipitating water clouds
- Can help identify severe convective clouds with strong updrafts
- Can give information about the land surface

Limitations:

- The RGB is complicated in terms of the number and variety of colors and requires expertise to interpret it but it is a very powerful product
- Only available during daytime

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**

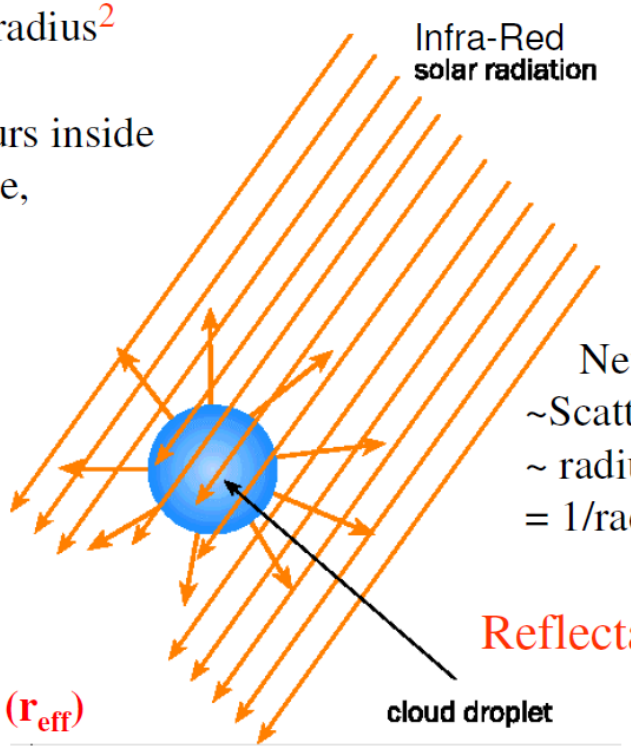
Enabling Skills Document Element 4, Skills, **Performance component pertaining to "Fires and Smoke"**

Appendix 2: Explaining the channel combination recipe in more detail – the Red, Green and Blue beams

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

Scattering occurs on the drop surface, ~ radius^2

Absorption occurs inside The drop volume, ~ radius^3



Net reflectance
~Scattering / Absorption
~ radius^2 / radius^3
= 1/radius

Reflectance ~ Radius^{-1}

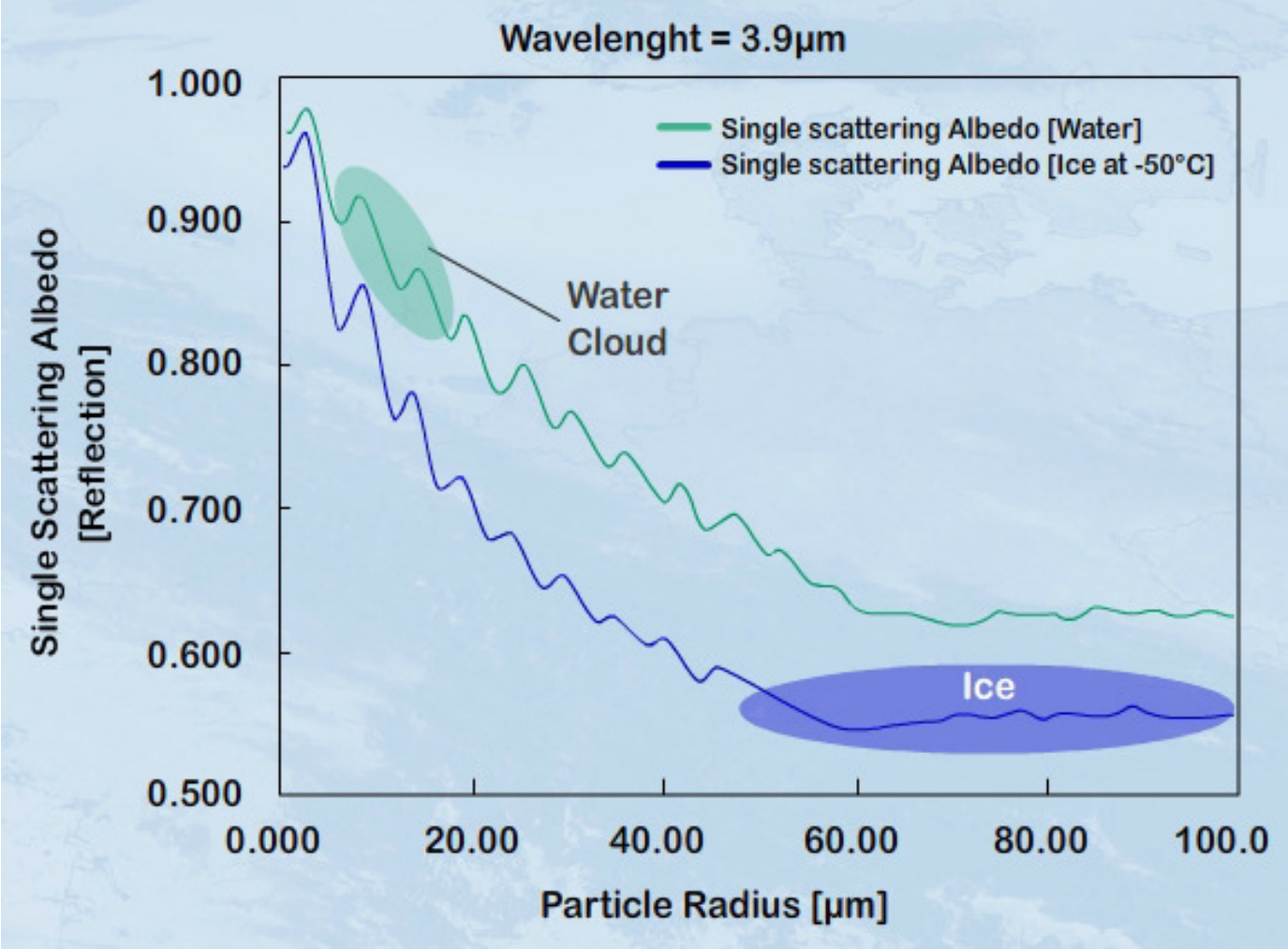
Definition of
Effective Radius (r_{eff})
of cloud droplets:
Sum of volumes / sum of surface areas
of the droplets in the measured cloud volume

For the visible channel used in the Red beam, reflectance ~ radius of the cloud droplet^{-1}

Therefore, small droplets are more reflective.

Appendix 2 - Explaining the channel combination recipe in more detail – 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.