Australian Government

Bureau of Meteorology

Australian VLab Centre of Excellence

National Himawari-8 Training Campaign

The Airmass RGB product

Should you use these resources please acknowledge the Australian VLab Centre of Excellence. In addition, you need to retain acknowledgement in the PowerPoint slides of EUMETSAT, the Japan Meteorological Agency, the Bureau of Meteorology and any other sources of information.

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

Australian Government
Bureau of Meteorology

Learning Outcomes

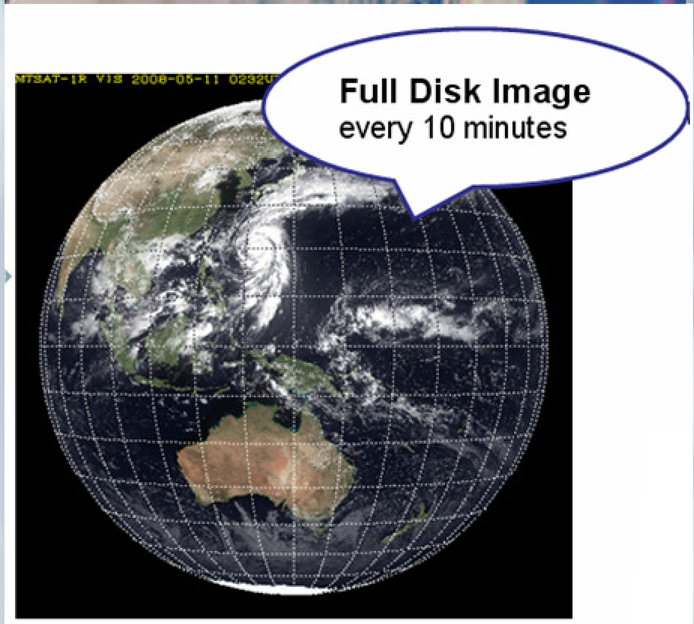
At the end of this exercise you will:

- Have a basic knowledge how the Airmass RGB product is constructed from multiple satellite channels and the physics and meteorology underpinning this.
- Be able to identify and locate mid and upper atmosphere features such as ozone rich intrusions associated with jetstreams, upper lows etc. and their developments in the Airmass RGB product.
- Have a better understanding of the advantages and the limitations of the Airmass 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 nowcast and short term forecast mid-upper atmospheric features.
- Have a better appreciation of using the Airmass RGB product when monitoring, nowcasting and short term forecasting of middle and upper atmospheric features.
- Note – corresponding WMO-1083 Capabilities and BOM Enabling Skills are given in Appendix 1

Contents

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



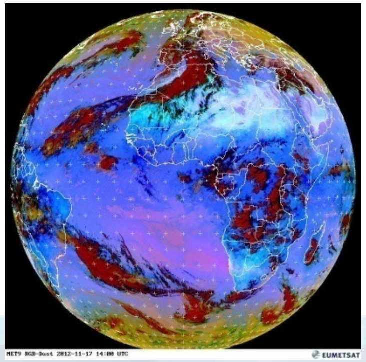
気象庁
Japan Meteorological Agency

from JMA

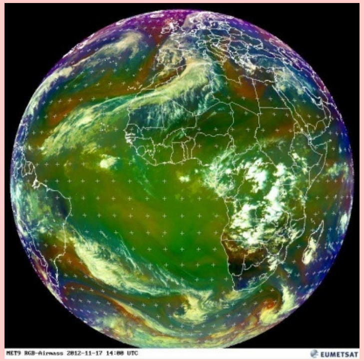
RGB products for Operational Forecasting – EumetSAT recommendation – the Airmass RGB

Australian Government
Bureau of Meteorology

Two RGB composites which complement each other



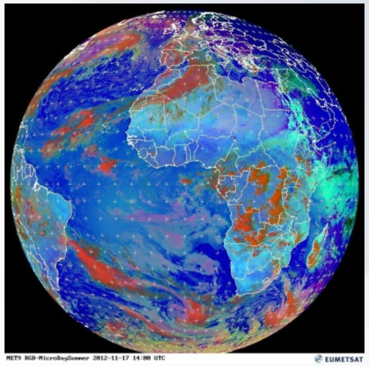
24 hour Microphysical RGB



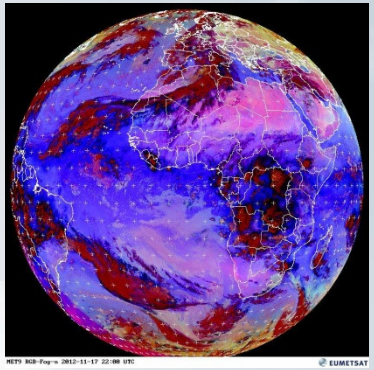
Airmass RGB

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

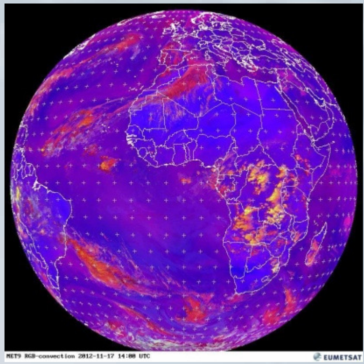
Five application specific RGBs



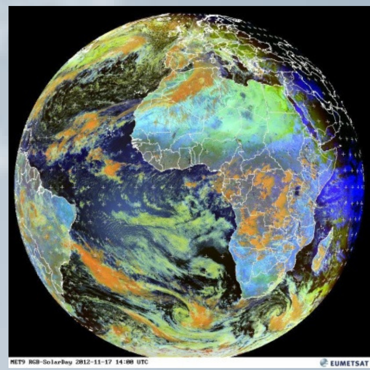
Day Microphysical RGB



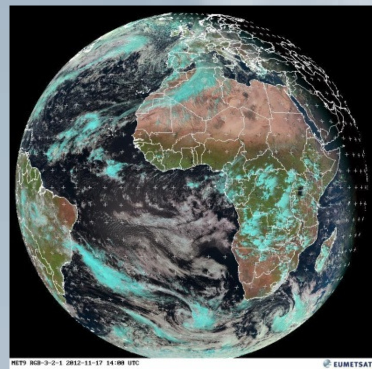
Night Microphysical RGB



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.

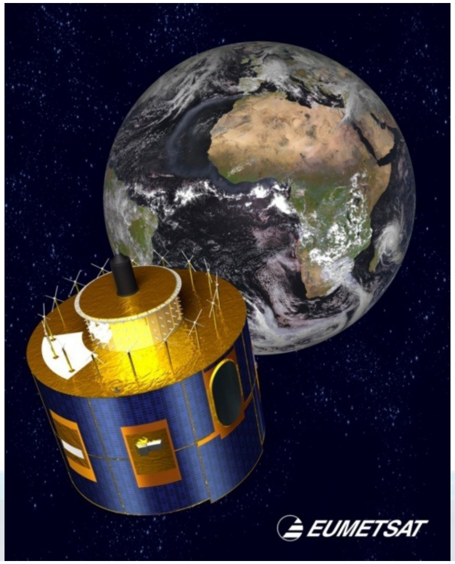
At World Meteorological Organisation (WMO) level: agree on a strict minimum of harmonised RGB composites. The following strategies for the application of RGB products to the forecasting routine were outlined:

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

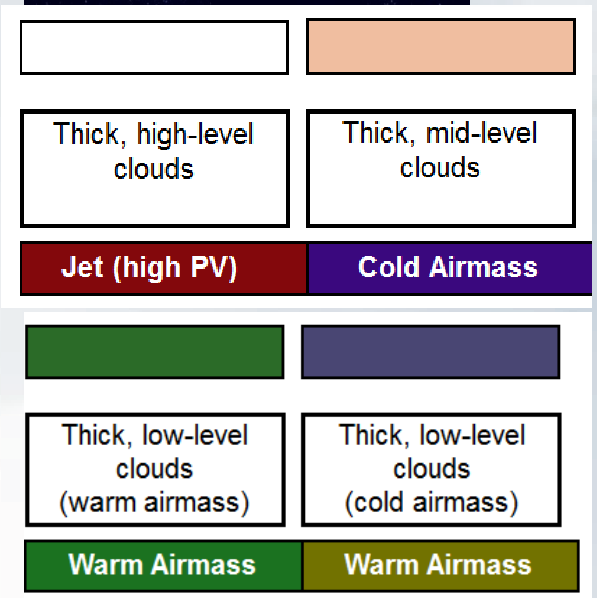
EUMETSAT processing of METEOSAT data – Airmass RGB



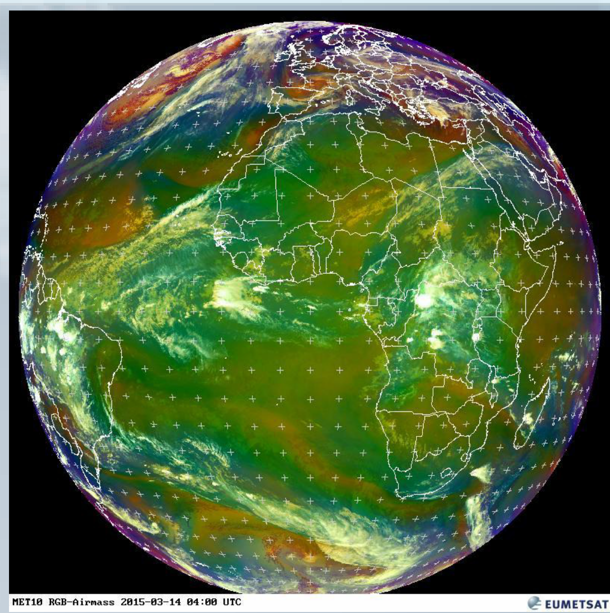
Ranges and Enhancements:

Beam	Channel	Range	Gamma
Red	WV6.2 - WV7.3	-25 … 0	1.0
Green	IR9.7 - IR10.8	-40 … +5	1.0
Blue	WV6.2	+243 … +208	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 – Airmass RGB

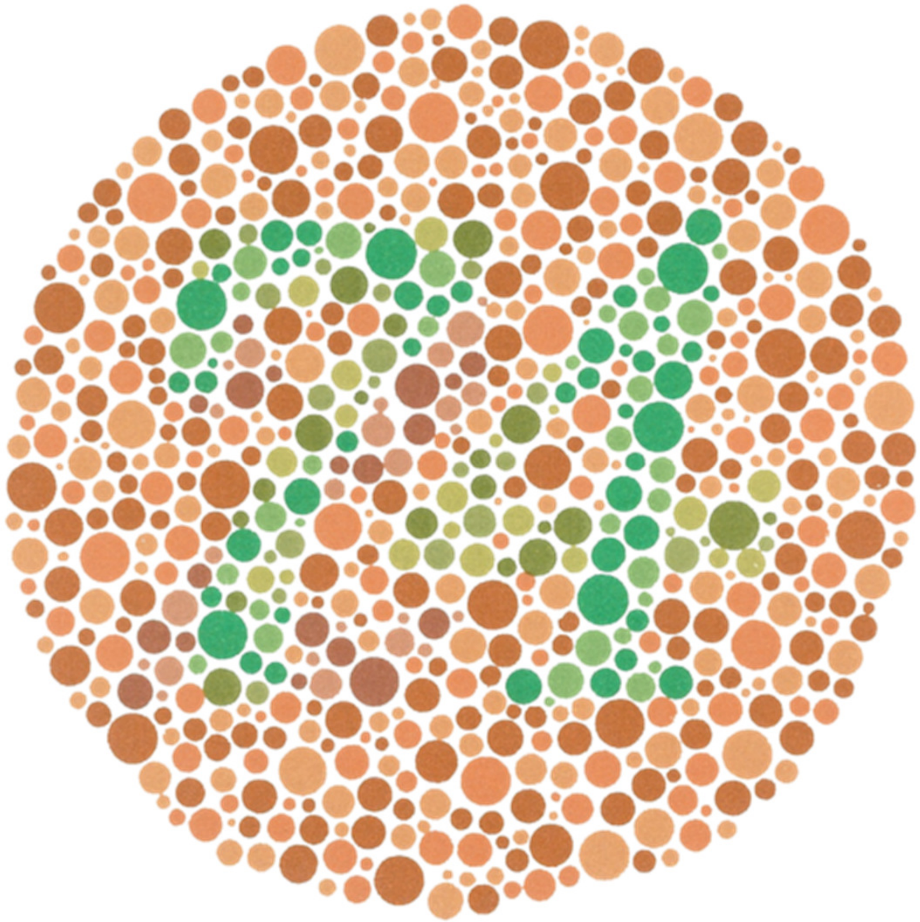
The previous slide shows the channels used in the RGB product and the thresholds (range) applied to the Beams as per EUMETSAT recipe

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

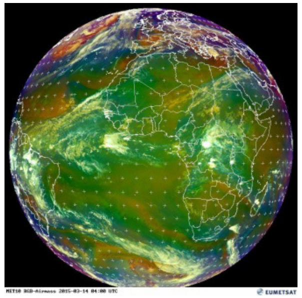
To take full advantage of the RGB products you should be able to see the number "74" in the pattern on the right.



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

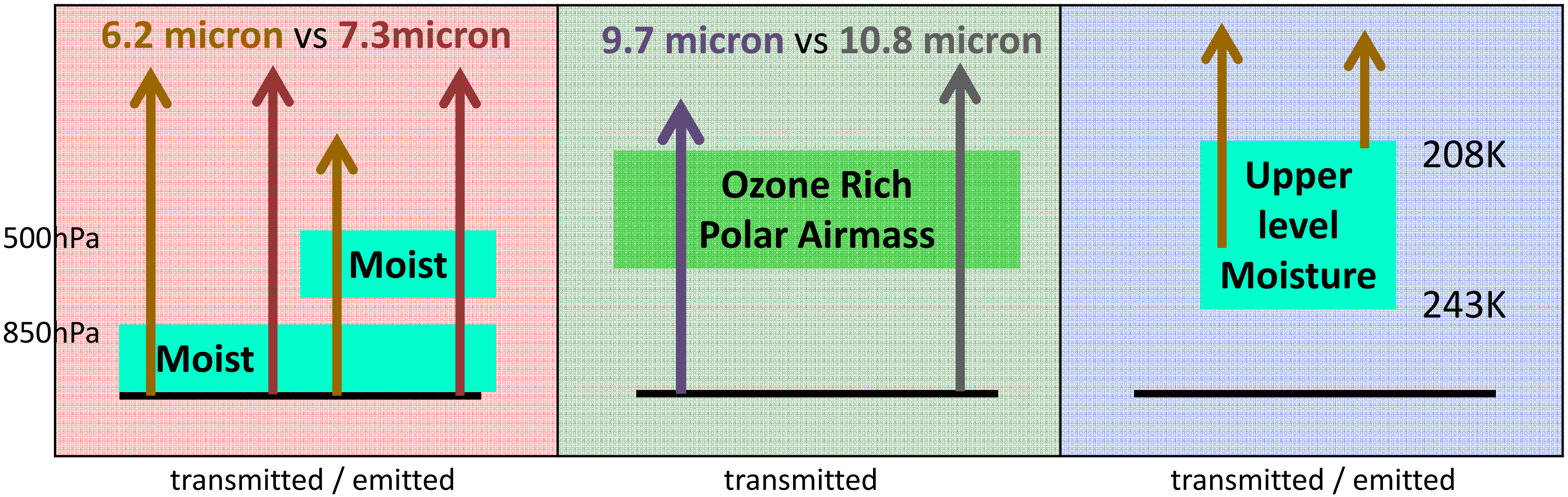
Channel combination recipe of the Airmass RGB

(For more details see Appendix 2)



Recommended Range and Enhancement

Beam	Channel	Range	Gamma	Gamma 2
Red	WV6.2 – WV7.3	-25 … 0	1.0	1.0
Green	IR9.7 – IR10.8	-40 … +5	1.0	1.0
Blue	WV6.2	+243 … +208	1.0	1.0



Channel combination recipe of the Airmass RGB

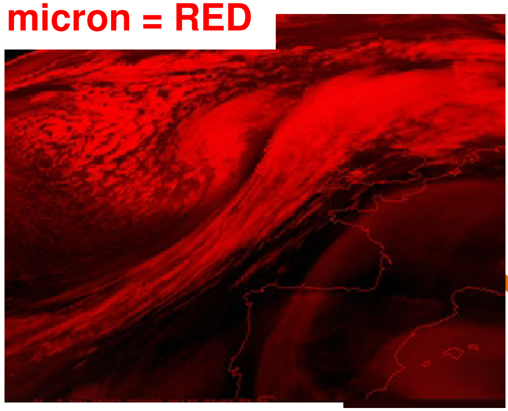
- **In the Red beam:** Due to the difference in the weighting functions for the 6.2 and 7.3 micron radiation, a strong signal in this beam corresponds to radiation emitted by high level clouds. An atmosphere that is moist below ~850hPa and very dry above this will also have a strong red beam component. However, if the atmosphere has 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.

- **In the Green beam:** The 9.7 micron channel is strongly absorbed by atmospheric ozone. Therefore an ozone poor tropical atmosphere will have a strong green beam component. An ozone-rich polar atmosphere will have a weak green beam component.

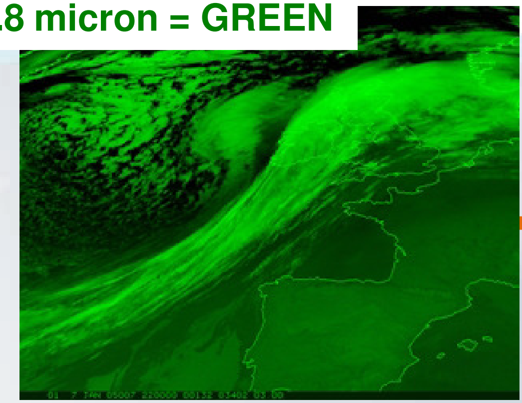
- **In the Blue beam:** The weighting function of the 6.2 micron channel has a maximum in the mid-upper levels of the troposphere (~200-500 hPa). The scaling of the beam ensures that cold and moist upper atmospheric features have a strong blue beam component. Low level and surface features have no contribution in the blue.

The input beams that go to make up the Airmass RGB.

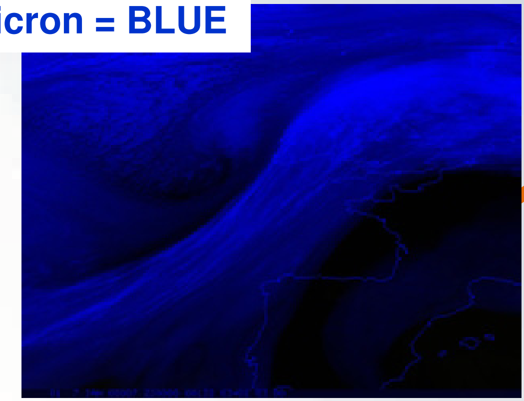
6.2-7.3 micron = RED



9.7-10.8 micron = GREEN

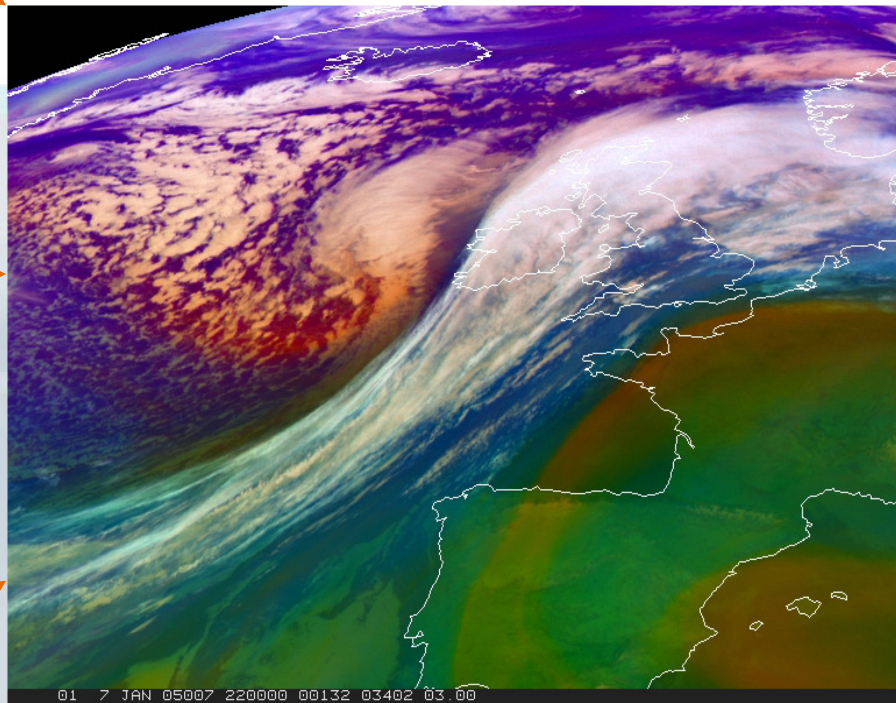


6.2 micron = BLUE



Ranges and Enhancements:

Beam	Channel	Range	Gamma
Red	WV6.2 - WV7.3	-25 … 0	1.0
Green	IR9.7 - IR10.8	-40 … +5	1.0
Blue	WV6.2	+243 … +208	1.0



North Atlantic Ocean and Northwest Europe
7 January 2005

images from EUMETSAT

The input beams that go to make up the Airmass RGB.

In the preceding slide you can familiarize yourself with the output of each of the beams for the Airmass RGB product output over the north Atlantic Ocean and northwest Europe, 7 January 2005

In the red beam, note the strong contribution from the high cloud tops of the cold front conveyor belt cloud band. Note also the strong contribution from the region of shallow low level moisture corresponding to the speckled post frontal cloud.

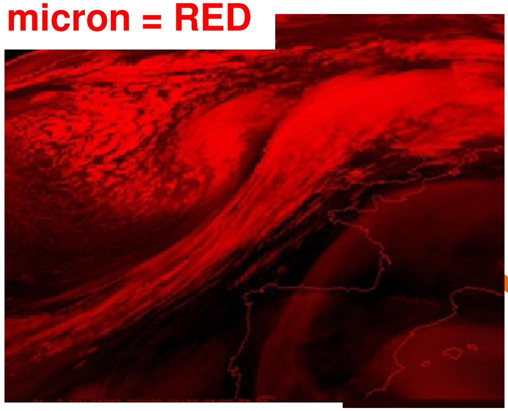
In the green beam, note the strong contribution from the high cloud of the cloud band, from the region of the speckled post frontal cloud and from the lower latitude atmosphere to the southeast of the cloud band. The ozone rich air behind the frontal cloud band shows no signal in this beam.

In the Blue beam there is a strong contribution from the cloud band. The cold atmosphere near the limb of the earth also has a contribution in this beam.

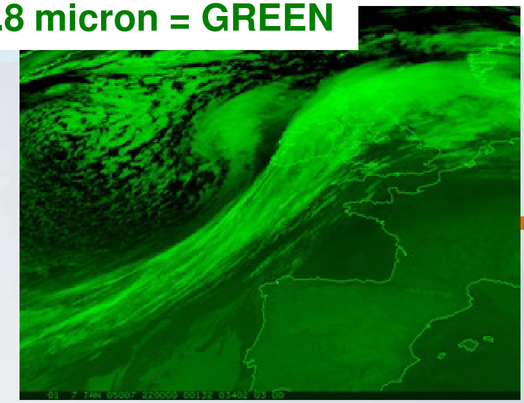
The next slide shows the effect of combining two beams.

The input beams that go to make up the Airmass RGB.

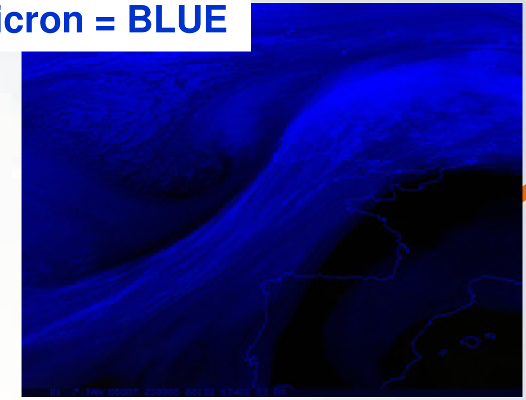
6.2-7.3 micron = RED



9.7-10.8 micron = GREEN



6.2 micron = BLUE

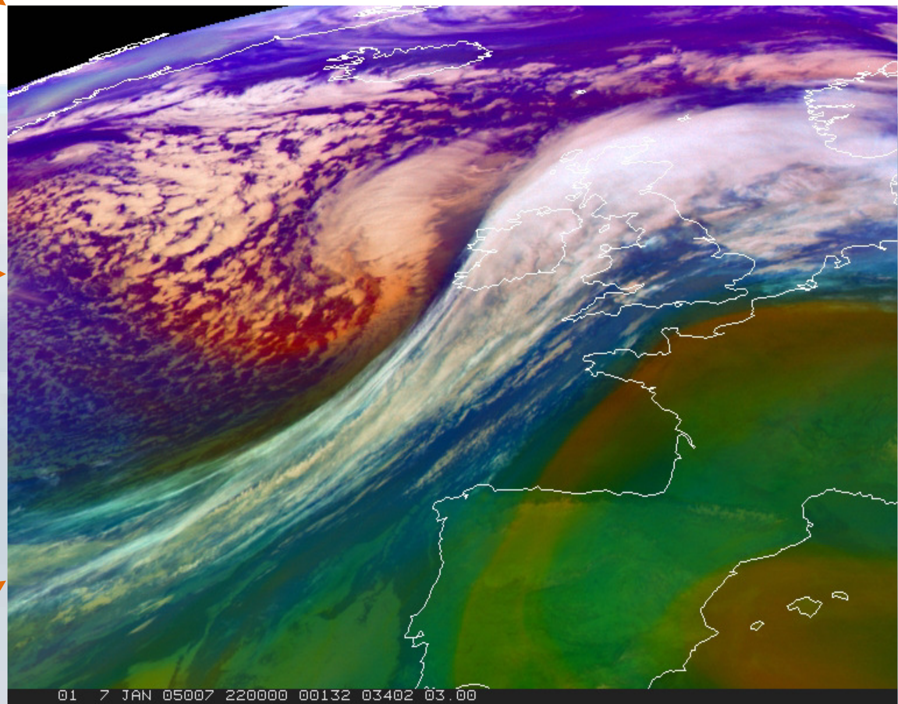


Combining beams

Yellow is made by mixing red and green

Magenta is made by mixing red and blue

Cyan is made by mixing green and blue

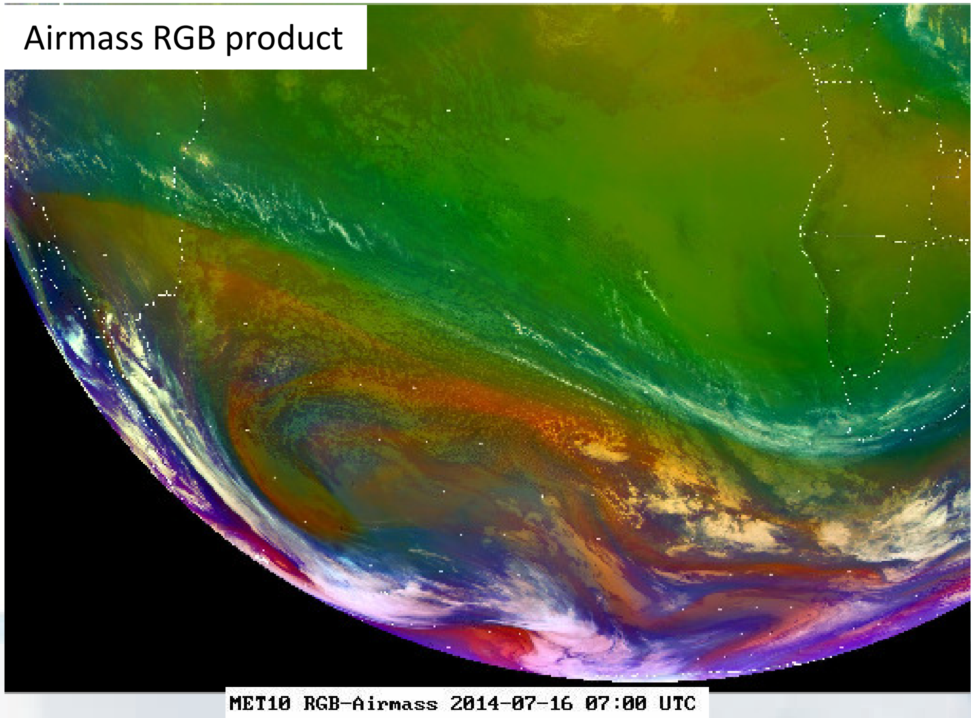


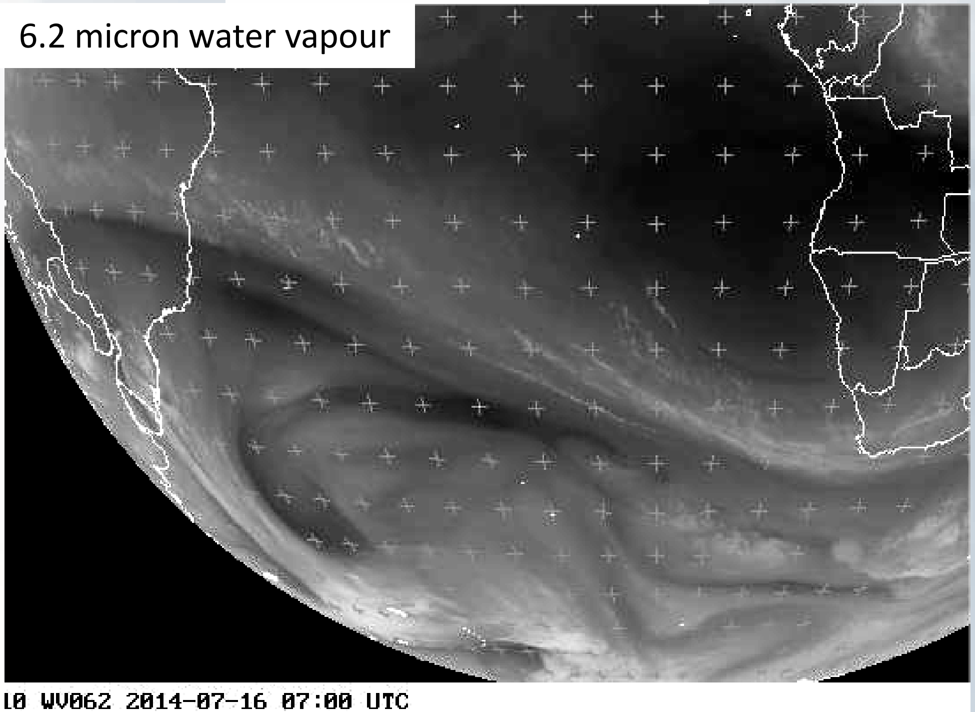
North Atlantic Ocean and Northwest Europe
7 January 2005

images from EUMETSAT

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

Examine the next two slides and see if you can identify the various features in the Airmass RGB product. For reference I have also included a corresponding 6.2 micron water vapour image and an infrared image of each of the examples.



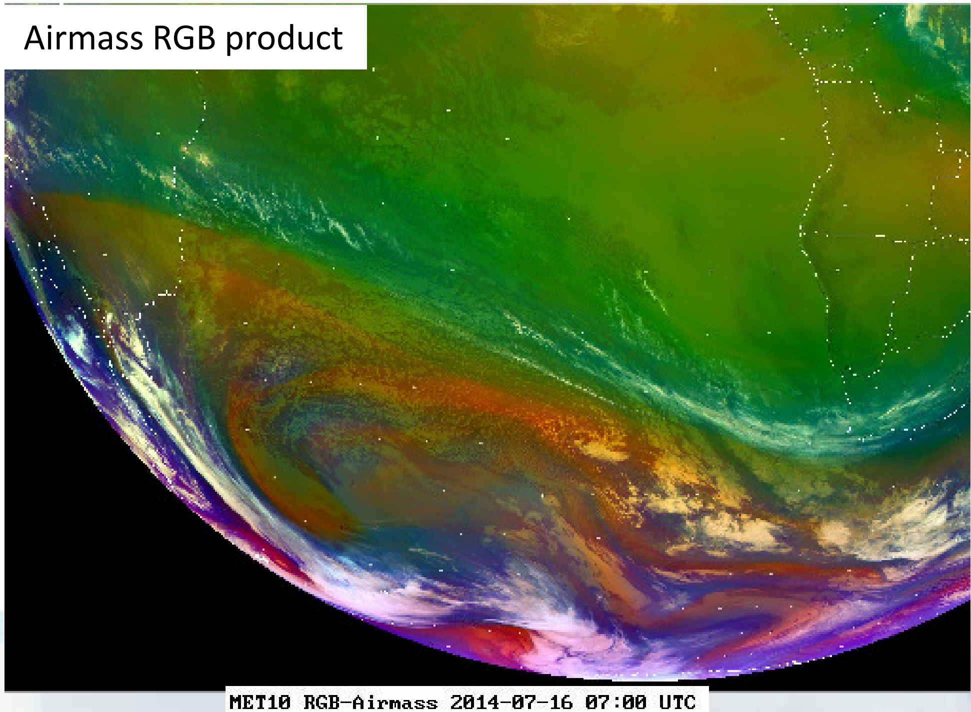


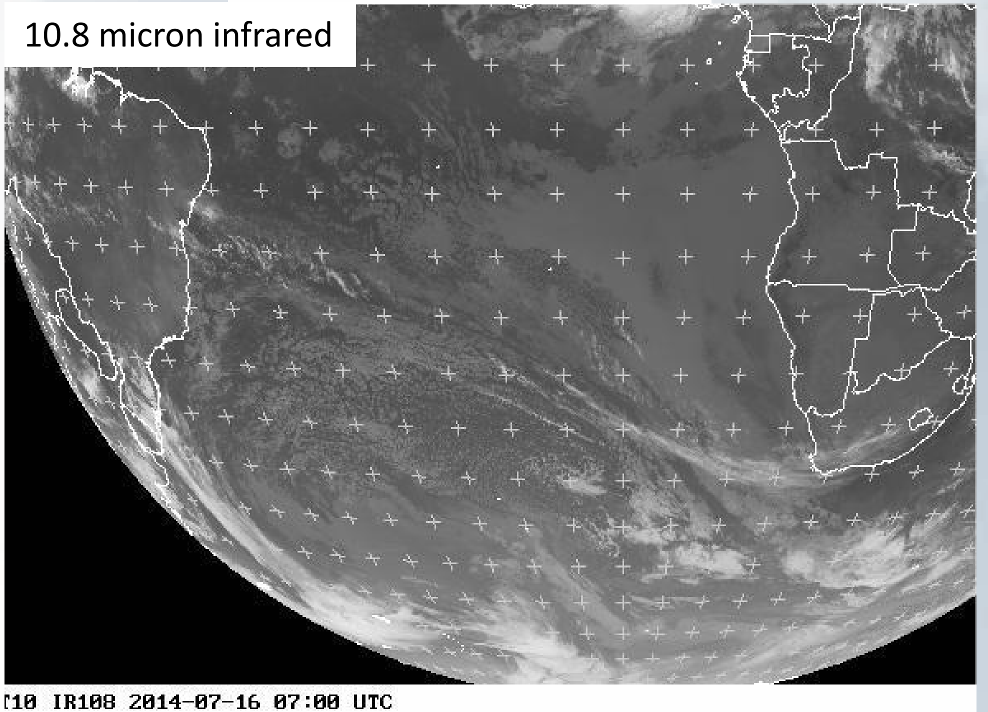
Airmass RGB product compared to the 6.2 micron water vapour image – please annotated features

Thick, high-level clouds	Thick, mid-level clouds
Jet (high PV)	**Cold Airmass**

Thick, low-level clouds (warm airmass)	Thick, low-level clouds (cold airmass)
Warm Airmass	**Warm Airmass**

South Atlantic Ocean
07UTC, 16 July 2014
Images courtesy EUMETSAT





Airmass RGB product compared to the 10.8 micron infrared image – please annotated features

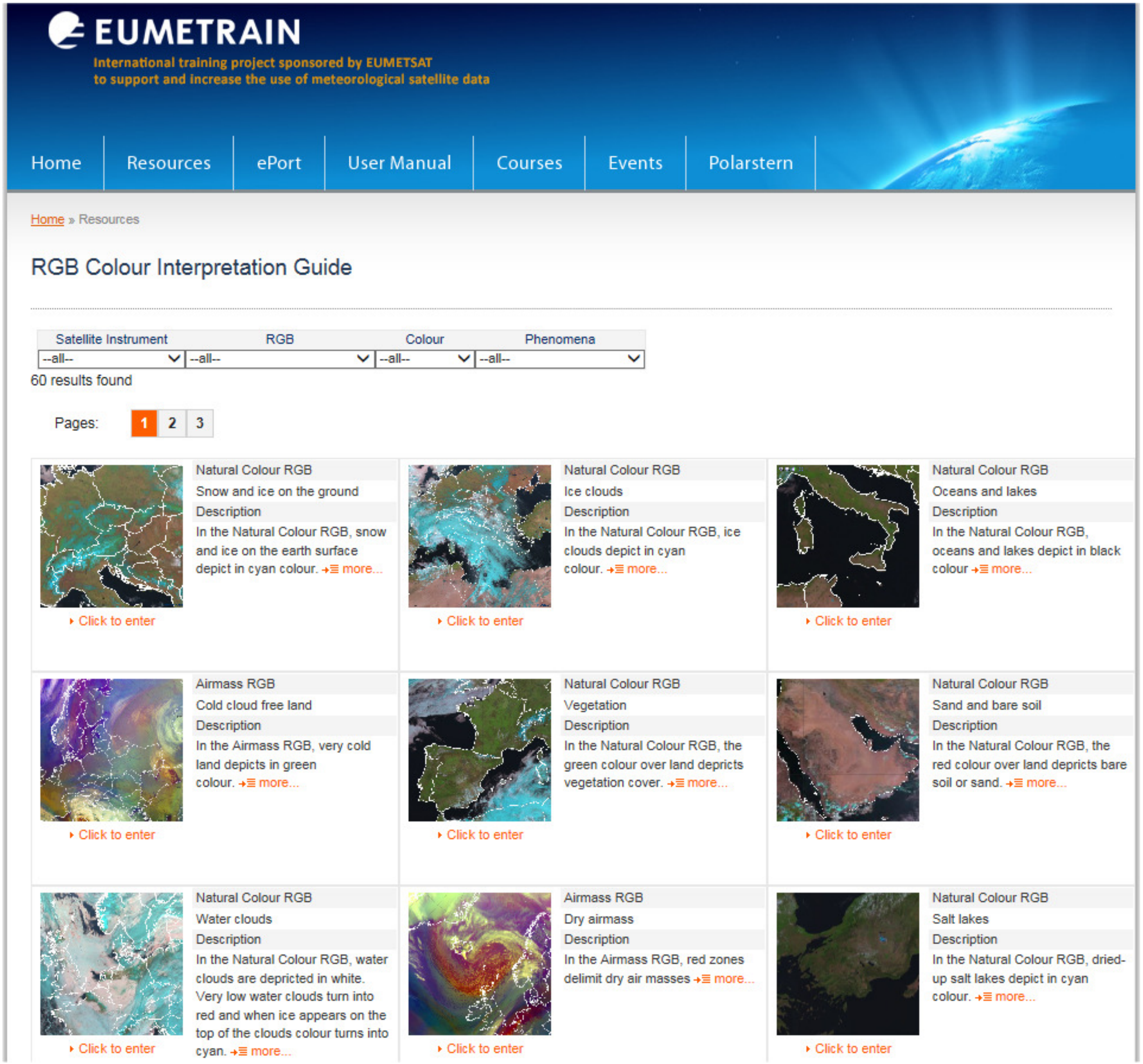
Thick, high-level clouds	Thick, mid-level clouds
Jet (high PV)	Cold Airmass

Thick, low-level clouds (warm airmass)	Thick, low-level clouds (cold airmass)
Warm Airmass	Warm Airmass

South Atlantic Ocean
07UTC, 16 July 2014
Images courtesy EUMETSAT

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

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



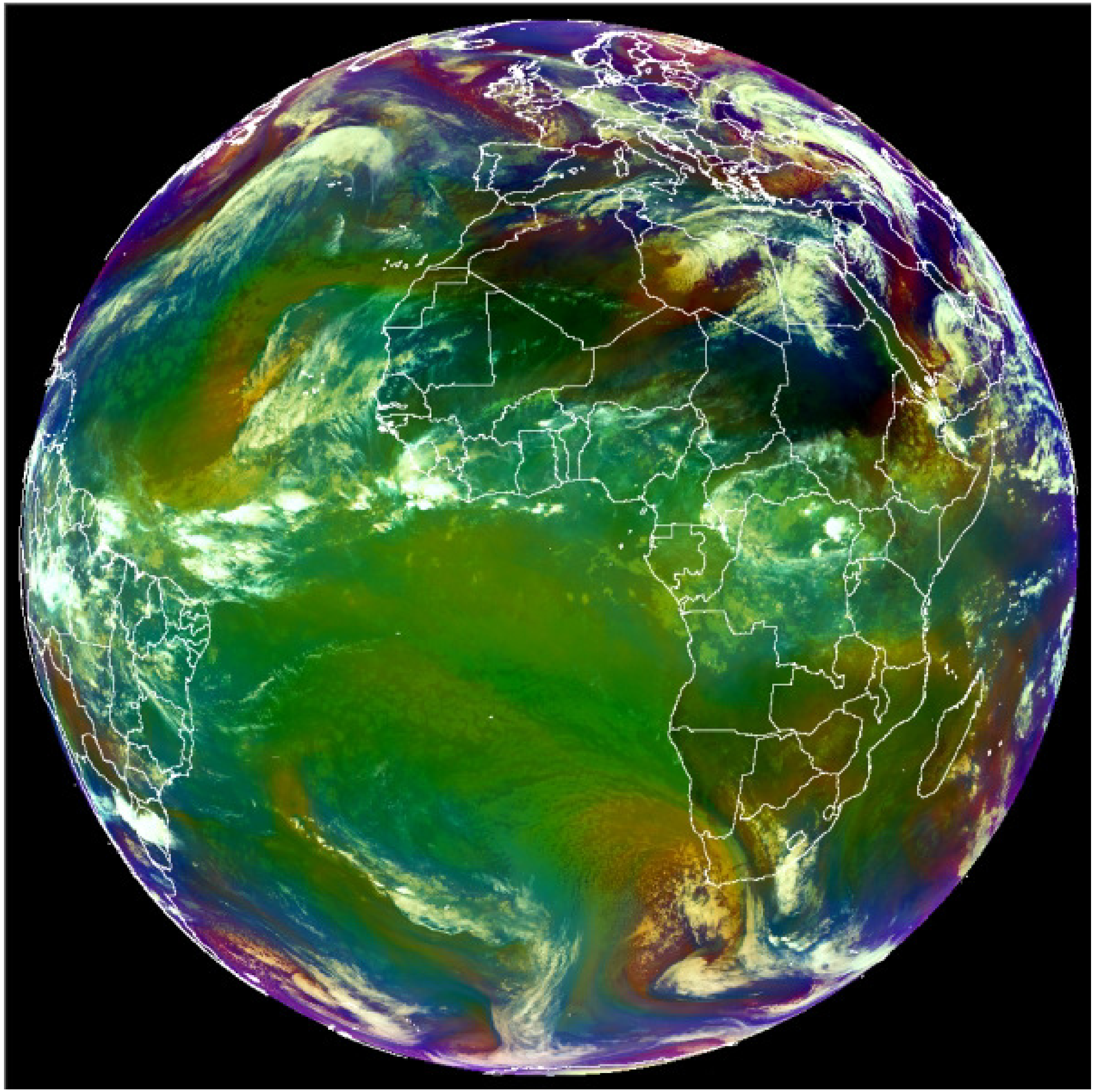


Image from EUMETSAT

Airmass RGB Complications

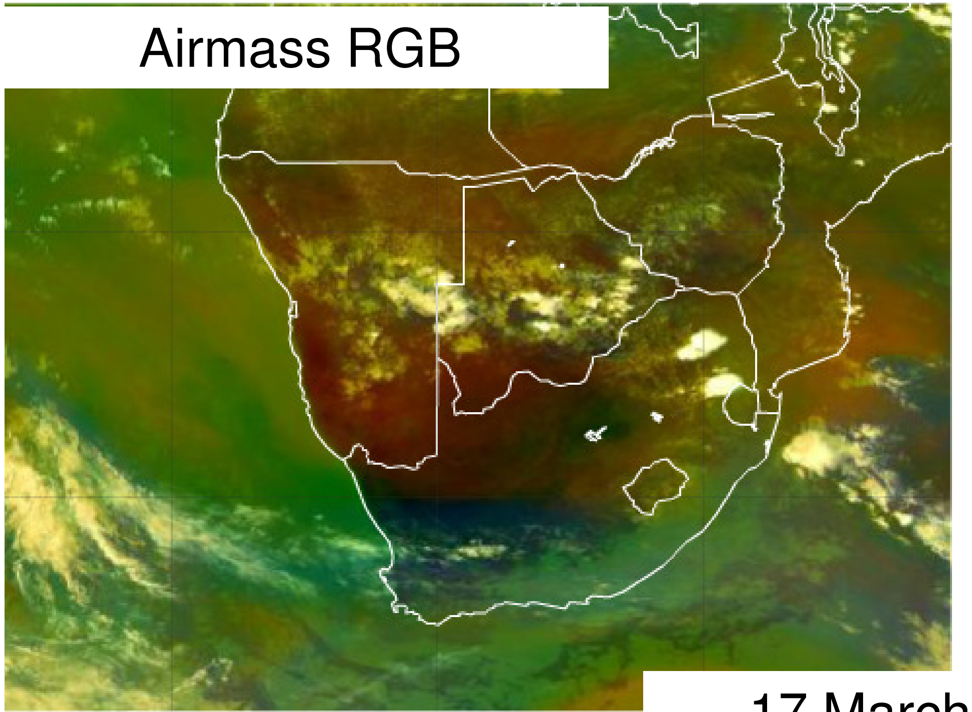
The larger the satellite viewing angle, the stronger the ozone absorption effect. Therefore warm airmasses seen at high satellite viewing angle have a bluish colour (limb cooling) !

Question: please highlight areas affected by the "limb cooling"

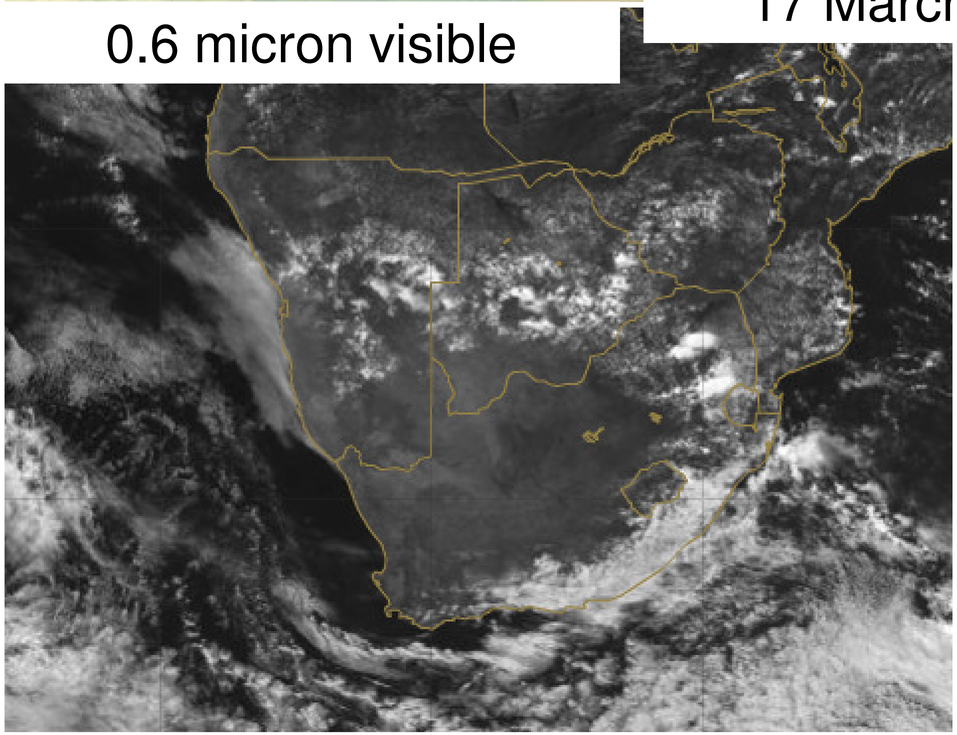
MSG-1
19 April 2005
10:00 UTC

Airmass RGB Complications

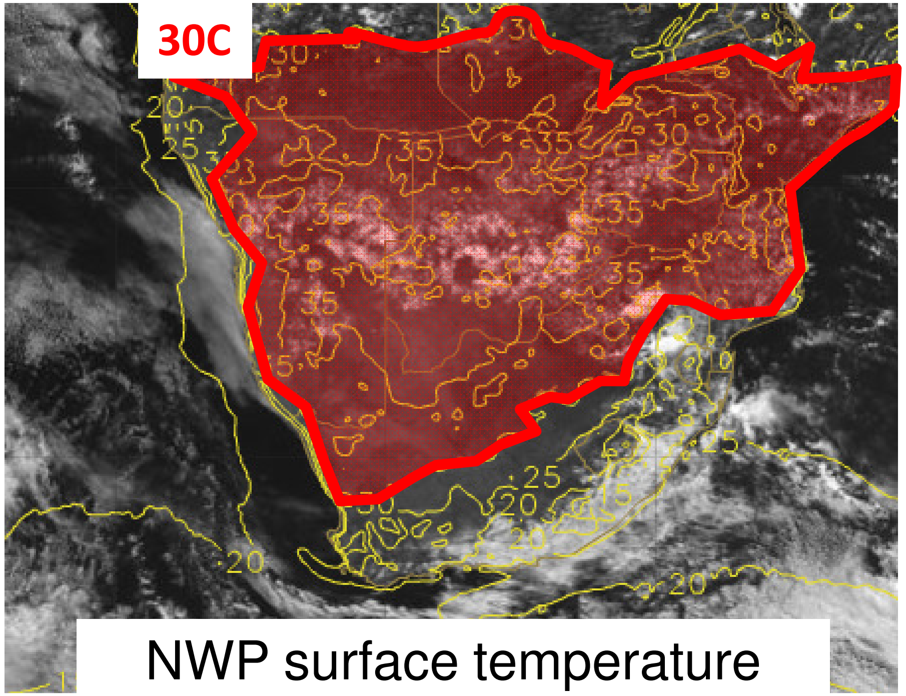
In cloud free areas, especially over hot land surfaces during daytime, the BTD of the green channel (9.7micron – 10.8 micron) is very large and negative.


Airmass RGB

17 March 12UTC


0.6 micron visible

Images from EUMETSAT



NWP surface temperature

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

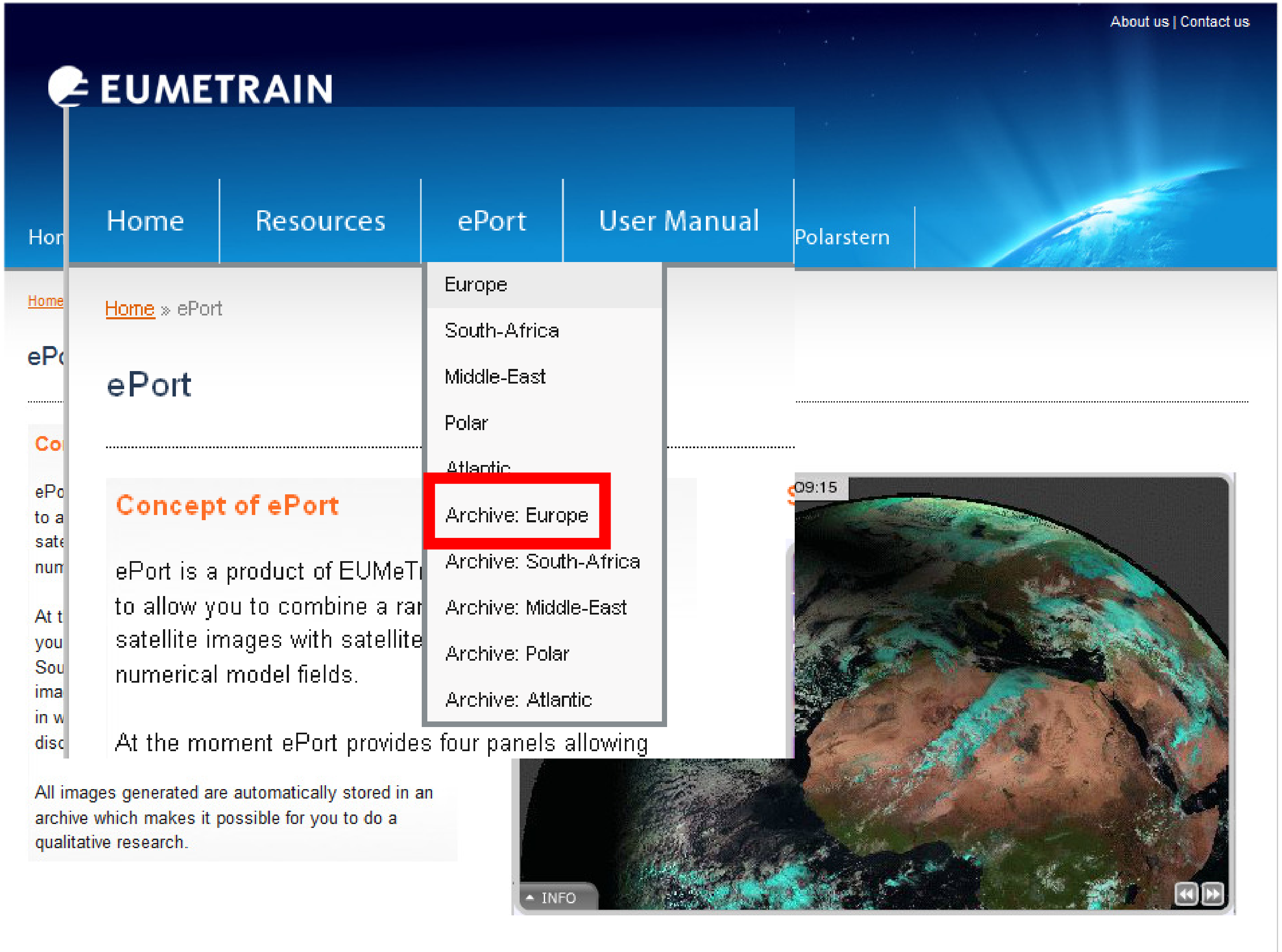
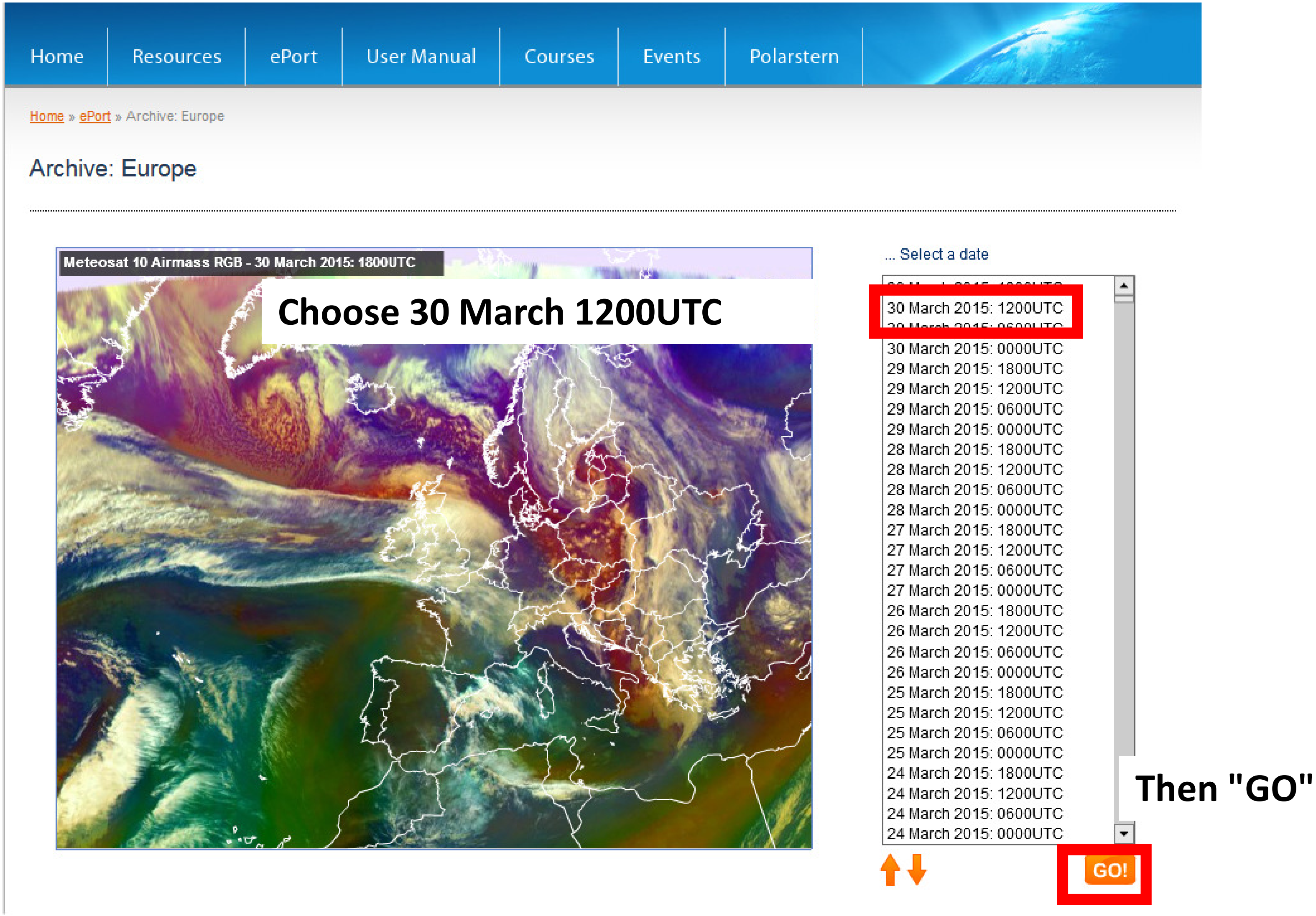


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort – choosing Archive: Europe



Activity: Exploring EUMETRAIN ePort

Activity: Exploring EUMETRAIN ePort

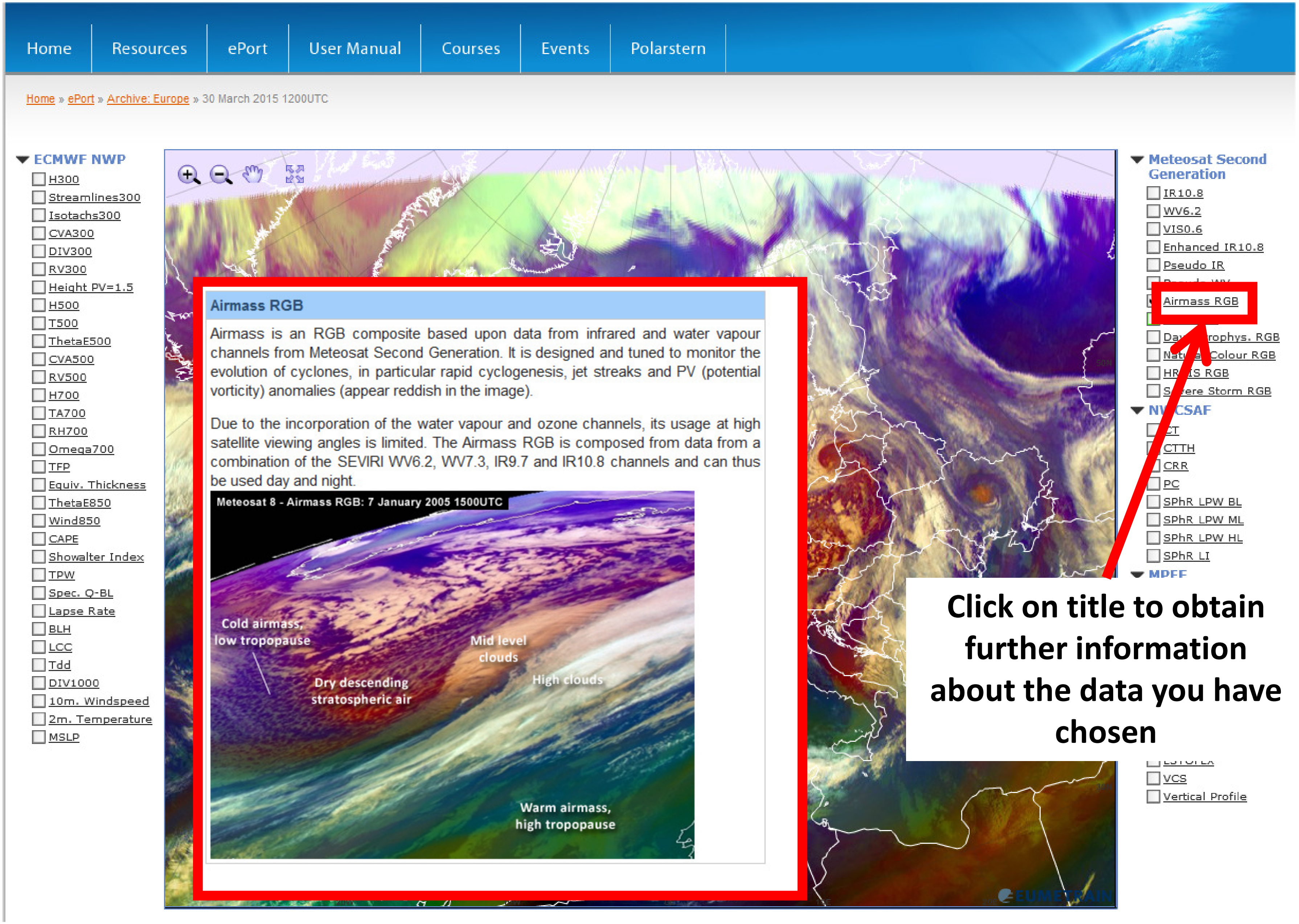
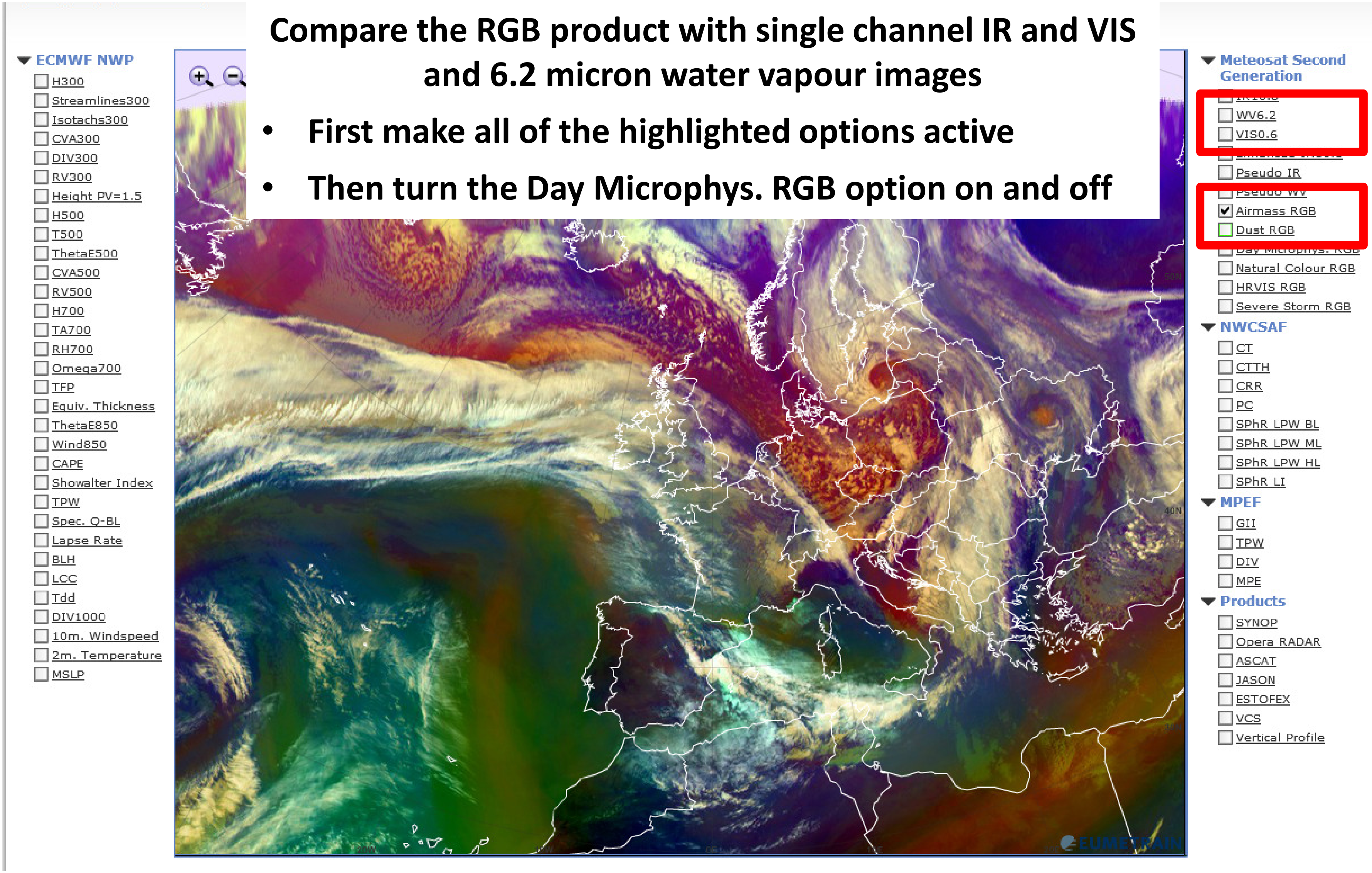


image courtesy EUMETSAT

Activity: Comparing single channel images with RGB product

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



Compare the RGB product with single channel IR and VIS and 6.2 micron water vapour images

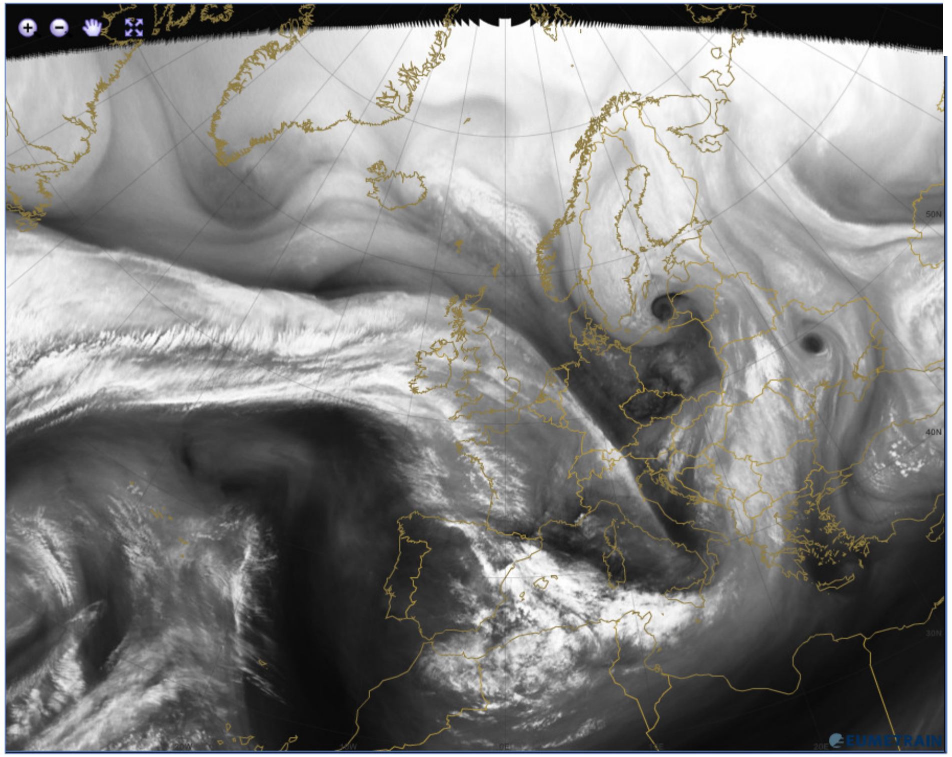
- **First make all of the highlighted options active**
- **Then turn the Day Microphys. RGB option on and off**

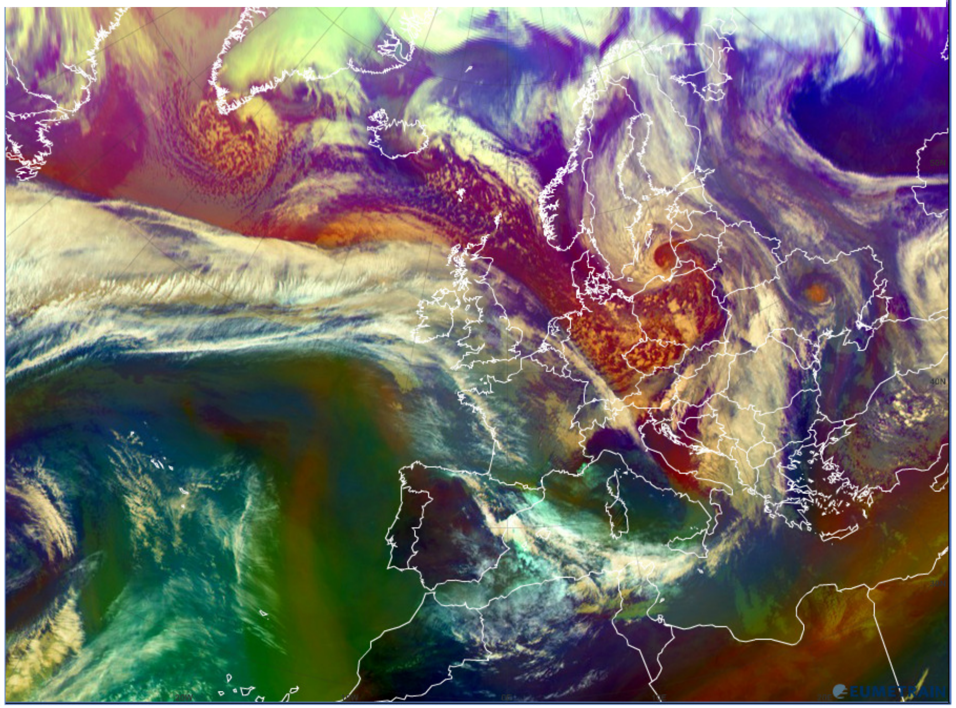
images from EUMETSAT

The Airmass RGB vs 6.2 micron water vapour channel

6.2 micron water vapour channel

Thick, high-level clouds	Thick, mid-level clouds	Thick, low-level clouds (warm airmass)	Thick, low-level clouds (cold airmass)
Jet (high PV)	Cold Airmass	Warm Airmass	Warm Airmass



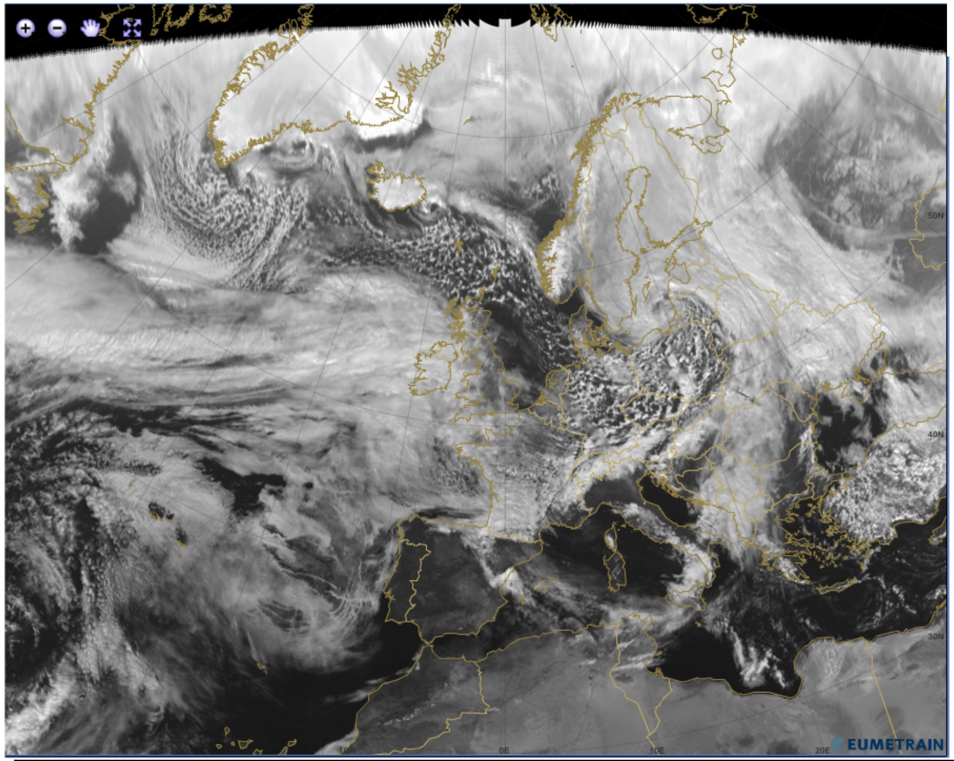


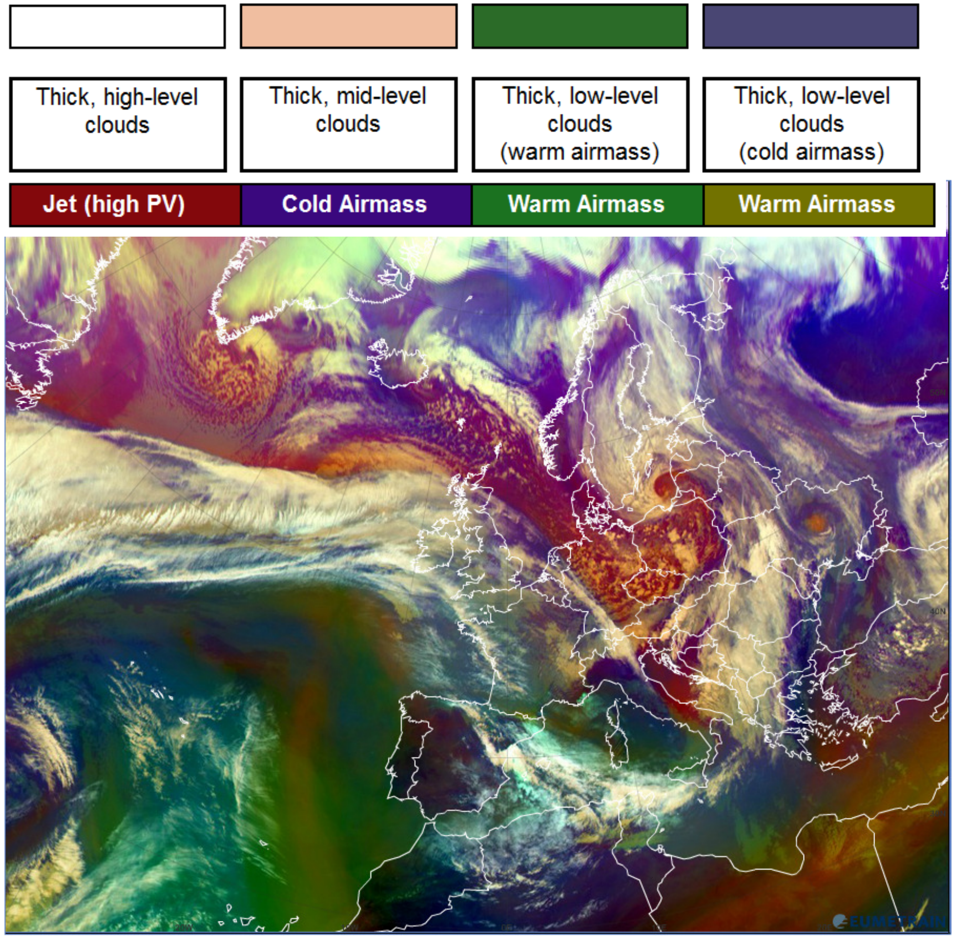
Question – what additional information does the Airmass RGB give you, compared to the 6.2 micron water vapour channel ?	**Your answer:**
Question – what additional detail is the water vapour channel giving you ?.	**Your answer:**

images from EUMETSAT

The Airmass RGB vs 0.6 micron visible channel

0.6 micron visible channel





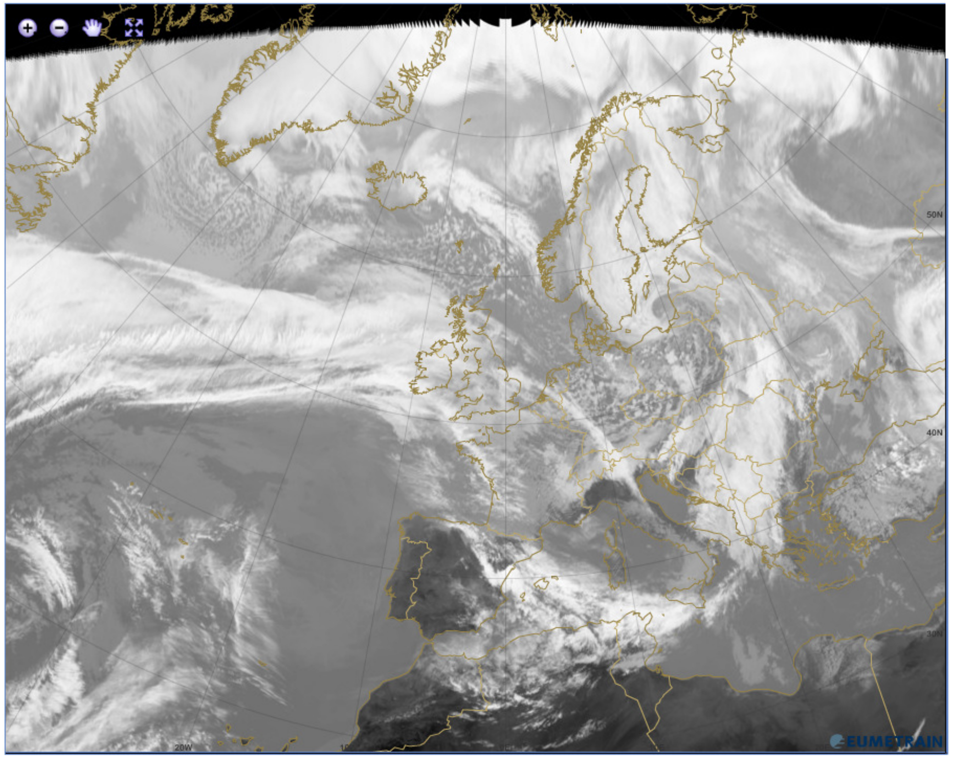
Question – what additional information does the Airmass RGB give you, compared to the 0.6 micron visible channel ?	**Your answer:**
Question – what additional detail is the visible channel giving you ?.	**Your answer:**

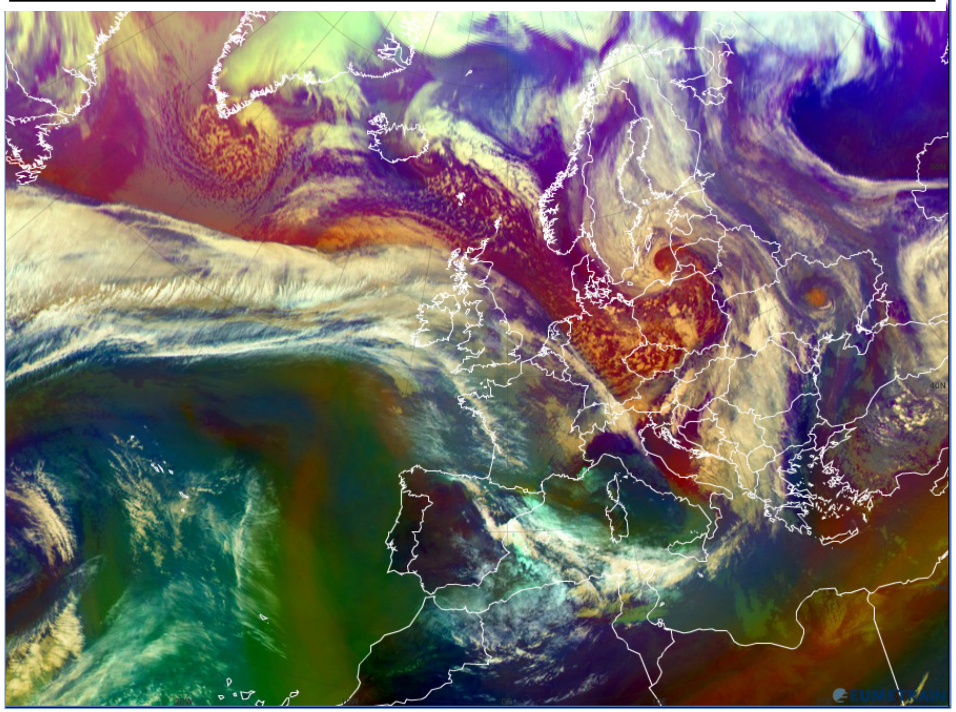
images from EUMETSAT

The Airmass RGB vs 10.8 micron infrared channel

10.8 micron infrared channel

Thick, high-level clouds	Thick, mid-level clouds	Thick, low-level clouds (warm airmass)	Thick, low-level clouds (cold airmass)
Jet (high PV)	Cold Airmass	Warm Airmass	Warm Airmass





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

image courtesy EUMETSAT

Activity: Overlaying Derived Products – Cloud Top Temperature and Height

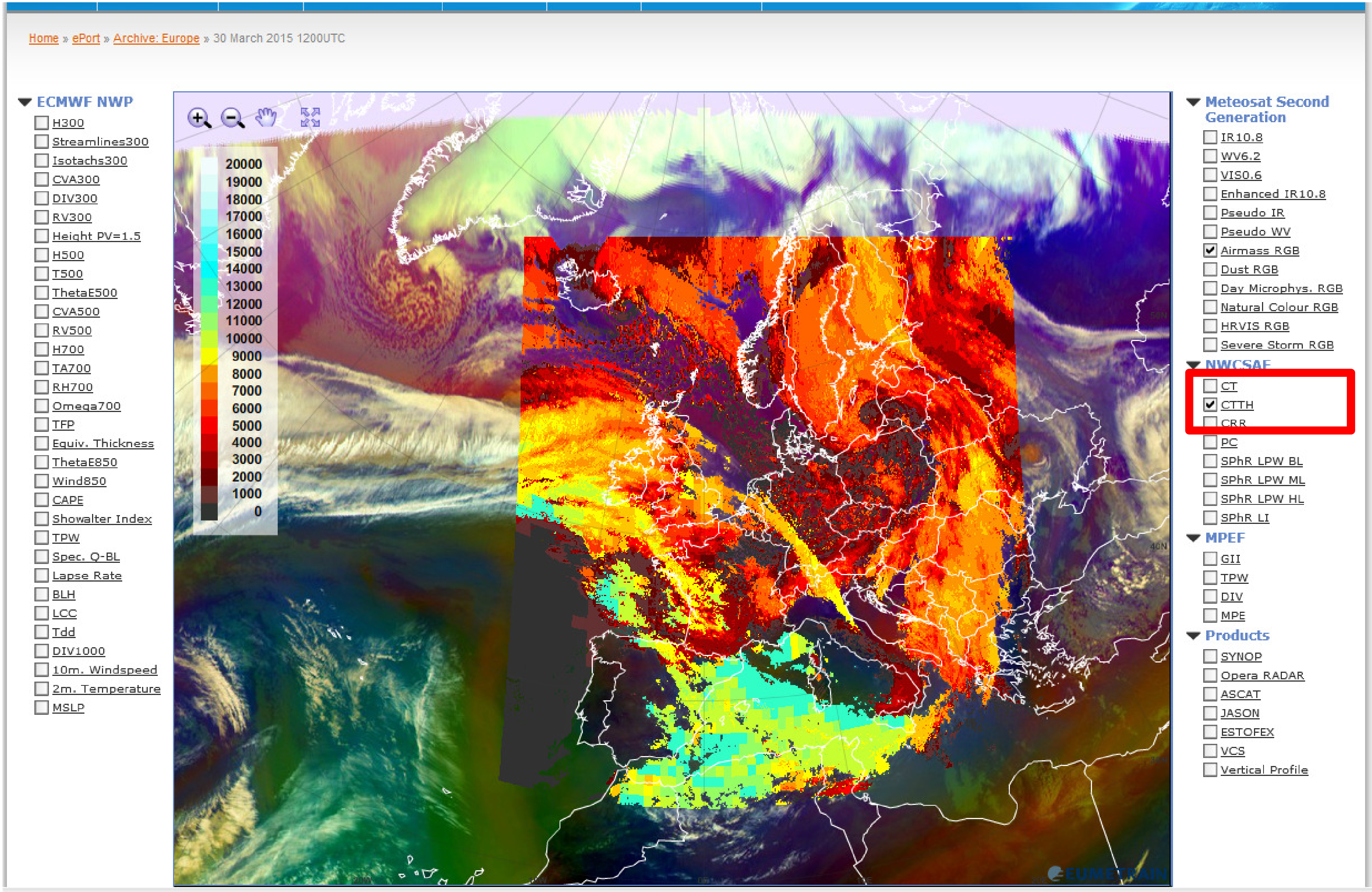
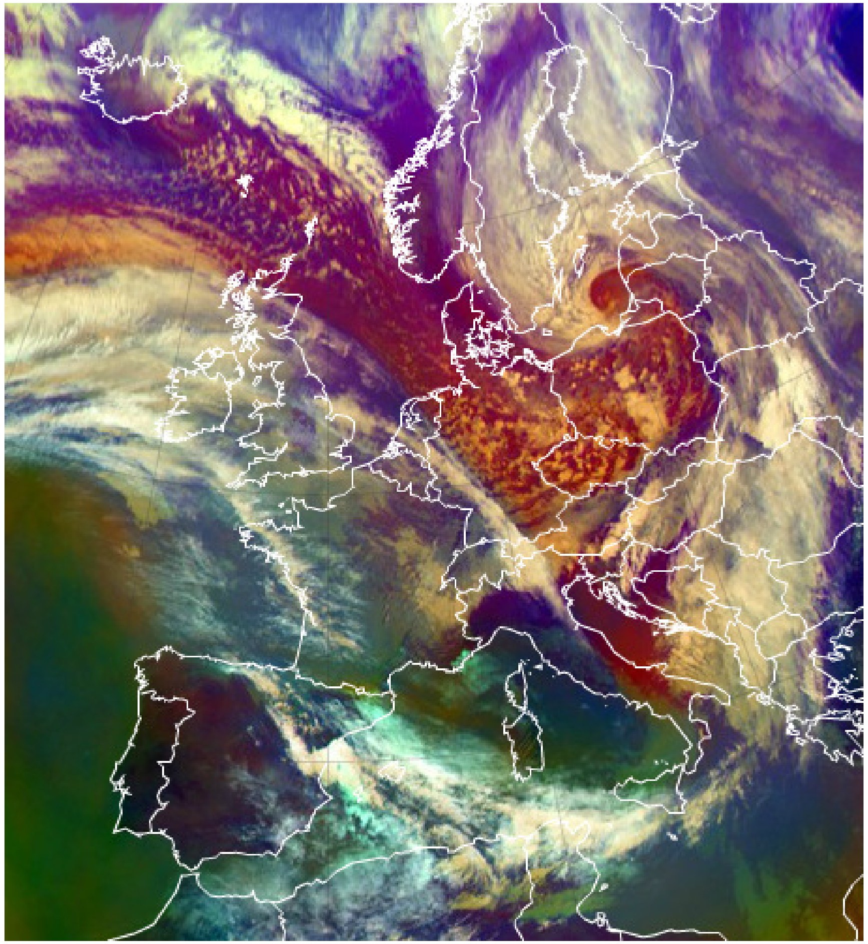
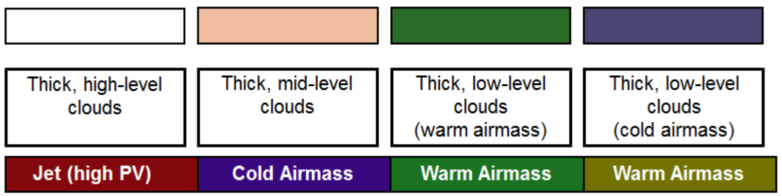


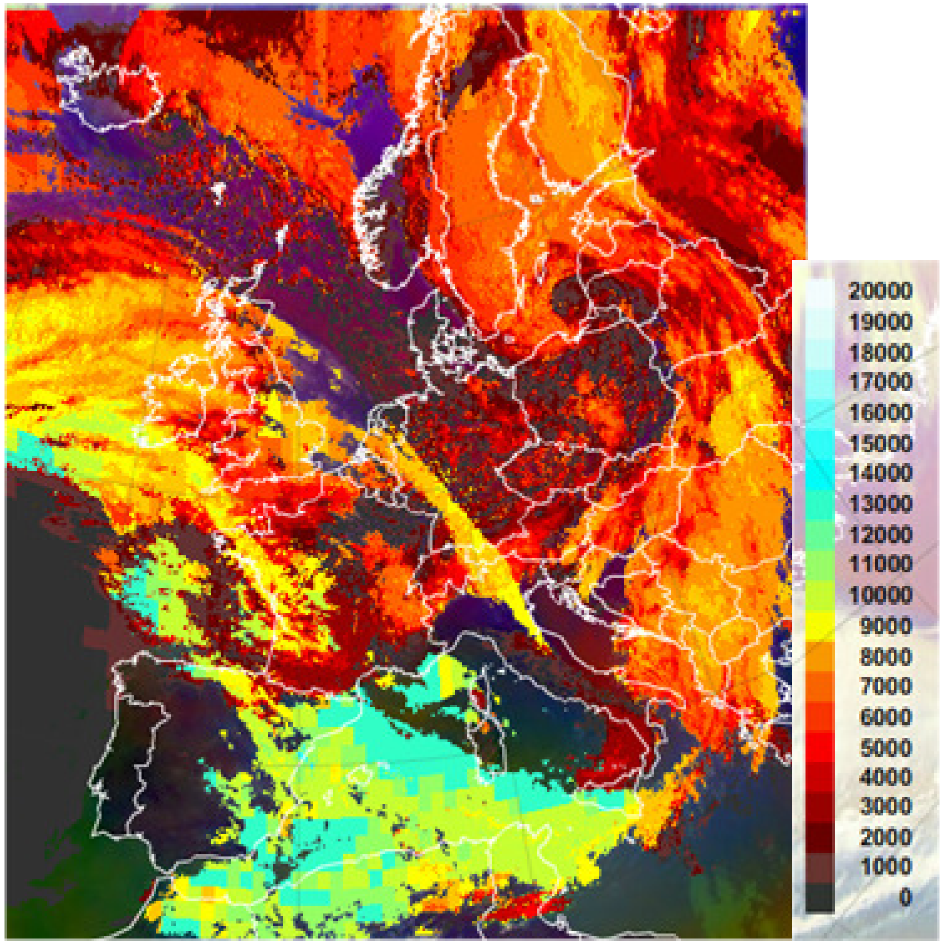
image courtesy EUMETSAT

Activity: Comparing the RGB with the Derived product



Airmass RGB product





CTTH Derived Product

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

Cloud Top Temperature and Height (CTTH) Derived Product algorithm summary description (1)

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

Note that Himawari-8 Cloud Property Applications for Visual Weather includes **Cloud Top Temperature and Cloud Top Height** derived product.

Process of producing this derived product:

- RTTOV radiative transfer model is applied using NWP temperature and humidity vertical profile to simulate 6.2µm, 7.3µm, 13.4µm, 10.8µm, and 12.0µm cloud free and overcast radiances and brightness temperatures.
- The vertical profiles used are temporally interpolated to the exact slot time using the two nearest in time NWP fields input by the user.
- A number of techniques are then used to retrieve the cloud top pressure This depends on the cloud type as derived from the Cloud Type (CT) derived product.
- Cloud top temperature and height (above sea level) is then computed from the pressure.

Cloud Top Temperature and Height (CTTH) Derived Product algorithm summary description (2)

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

Process of producing this derived product (continued):

- Effective cloudiness (defined as the fraction of the field of view covered by the cloud (the cloud amount) multiplied by the cloud emissivity in the 10.8µm window channel) is also computed during the processing. It is equal to 1.0 for thick clouds and takes a value between 0.0 and 1.0 for semi-transparent clouds.

Use of the product:

- This product contributes to the analysis and early warning of thunderstorm development.
- Other applications include the cloud top height assignment for aviation forecast activities.
- The product may also be used as input to mesoscale models or to other SAF NWC product generation elements.
- Validation has been performed only in the European Area.

image courtesy EUMETSAT

Activity: Vertical Cross Sections

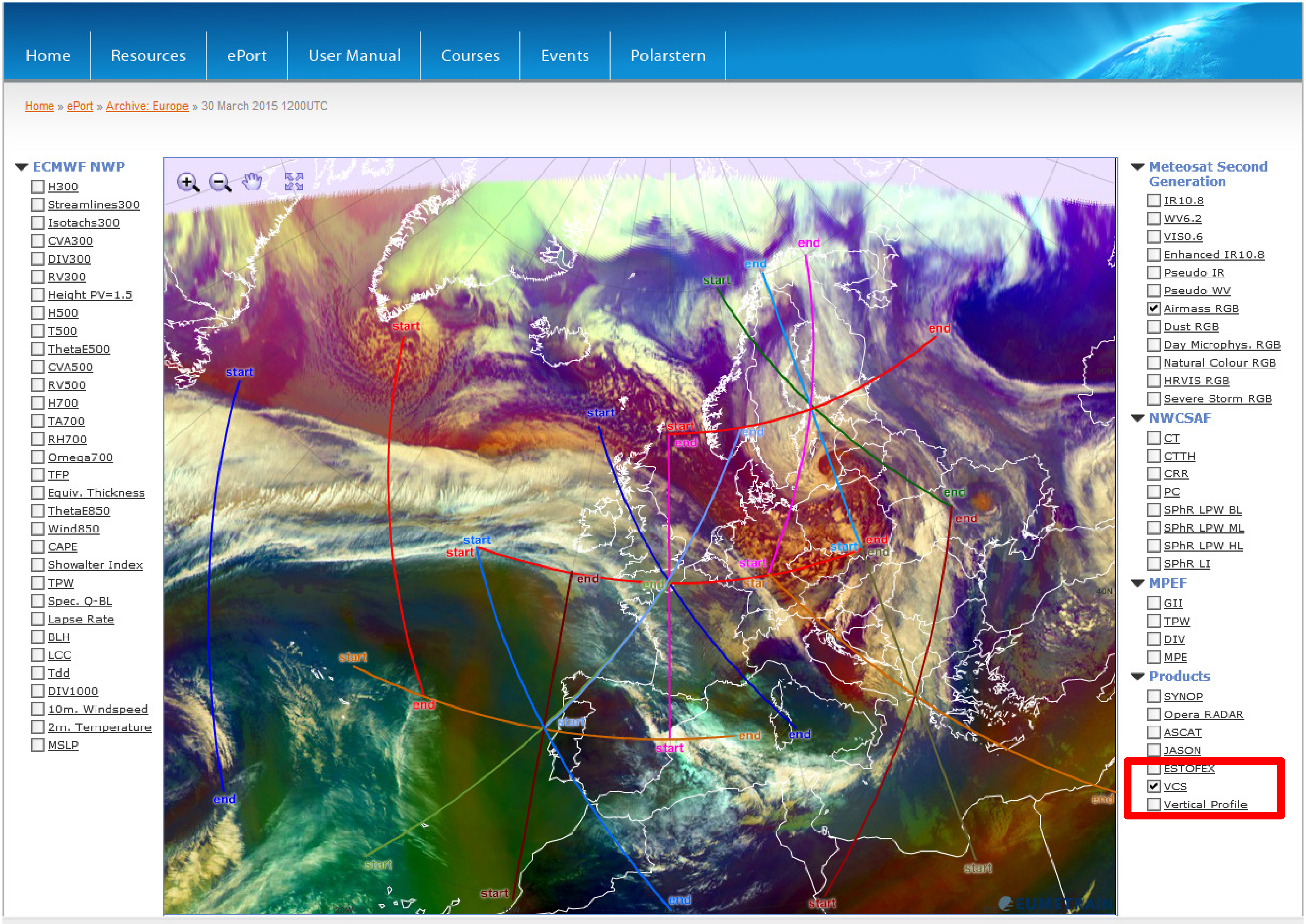
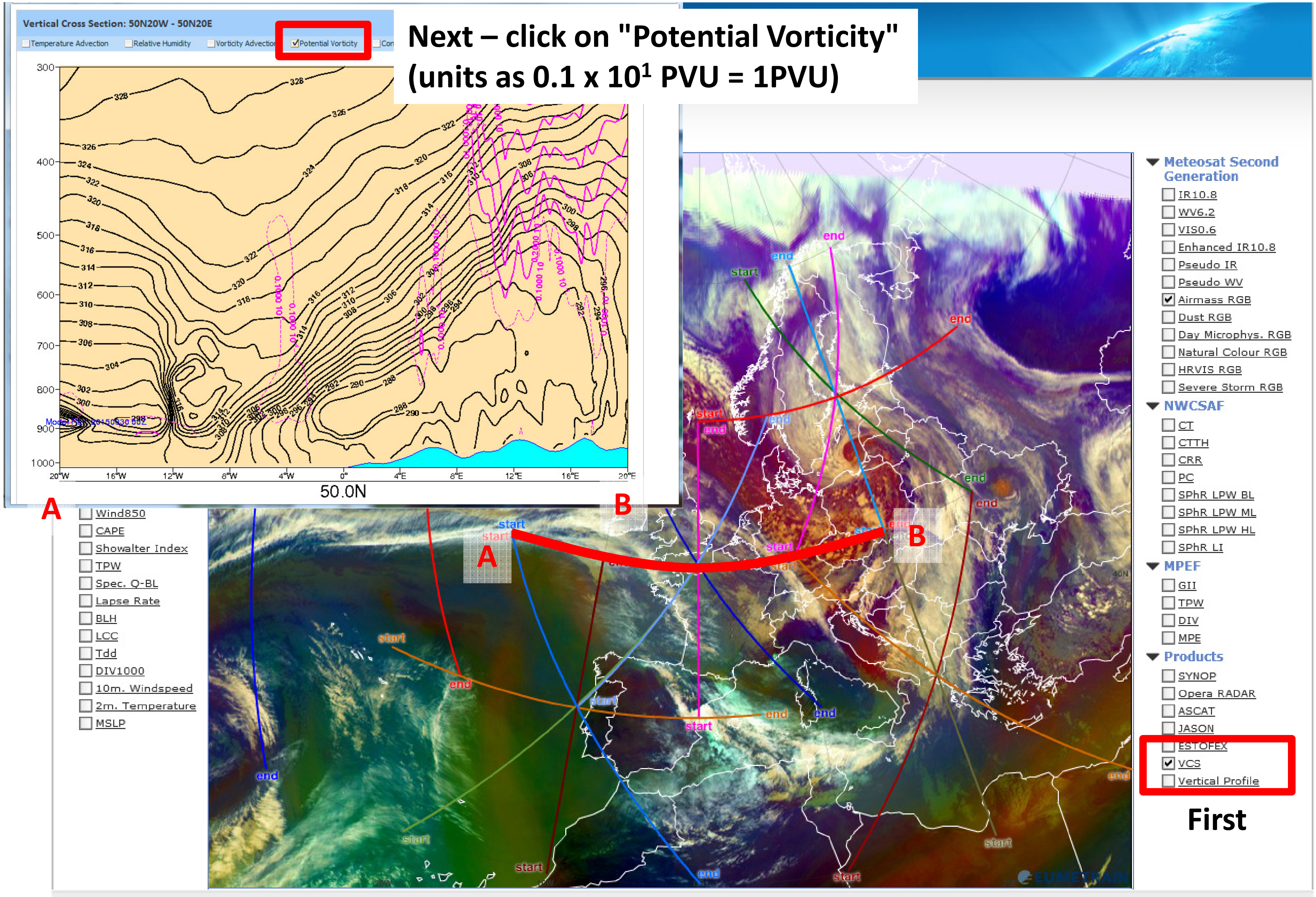


image courtesy EUMETSAT

Activity: Vertical Cross Sections – Isentropes (theta E) and PV



Next – click on "Potential Vorticity"
(units as 0.1 x 10^1 PVU = 1PVU)

First

Isentrope (Theta E) explained

- An Isentrope is an isopleth (contour line) of potential temperature. In the example on the previous slide this is equivalent potential temperature (Theta E).
- Isentropic surfaces are closer together in the vertical in stable air and further apart in less stable air.
- Isentropes slope down towards warm air and slope upwards towards cold air
- Isentrope values normally increase with height. Where Isentrope values decrease with height the atmosphere is conditionally unstable.
- Isentropic surfaces have a steep slope in regions of strong baroclinicity. Flat isentropes indicate barotropic conditions.

Activity: from the cross section in the previous slide, identify locations of warm and cold air

Activity: from the cross section in the previous slide, identify regions of stable air and regions of conditionally unstable air.

Theta E (Equivalent Potential Temperature) explained

- THETA-E (Equivalent Potential Temperature) is the temperature that results after all latent heat is released in a parcel of air and the then brought adiabatically to the 1000 mb level.
- How THETA-E is determined. First determine the pressure level of interest. Locate the temperature and dewpoint at that pressure level. Raise that parcel adiabatically from that pressure level to the 200-mb level. Next, bring the parcel down dry adiabatically to the 1000 mb level. The temperature once the parcel is at 1000 mb is the THETA-E.
- The Theta-E of an air parcel increases with increasing temperature and increasing moisture content.
- Theta-e is used operationally to map out which regions have the most unstable and thus positively buoyant air. A region with a relatively high THETA-E is often the region with the most instability. Warmer low level temperatures and higher low level dewpoints increase instability.

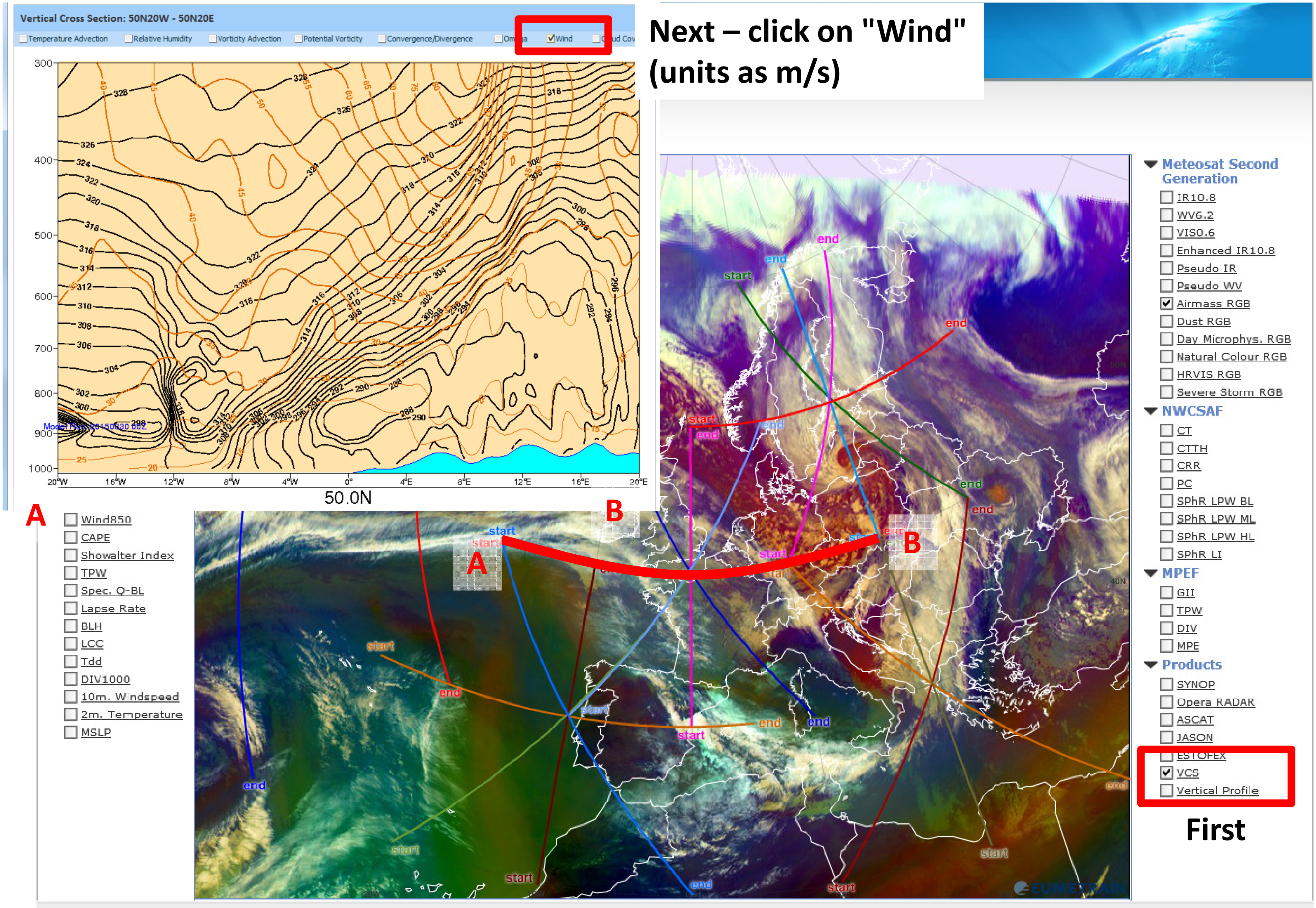
Potential Vorticity (PV) explained

- PV is a product of absolute vorticity (on an isentropic surface) and static stability.
- Stratospheric air has high static stability and therefore has high absolute values of PV.
- An upper PV anomaly shows up dark in watervapour (greyscale) imagery. In the Airmass RGB an upper PV anomaly shows up as a brown enhancement colour. That is because an upper PV anomaly typically corresponds to an intrusion of an ozone rich stratospheric airmass to lower altitudes.
- Conversely, a low level PV anomaly often corresponds to strong baroclinic zones where much latent heat release takes place
- **Activity:** please indicate the location of the PV anomaly in the cross section of the preceding slide. Check this with the location on the RGB product image. Does this correspond to a region of subsiding ozone rich stratospheric air ?

image courtesy EUMETSAT

Activity: Vertical Cross Sections – Isentropes (theta E) and wind

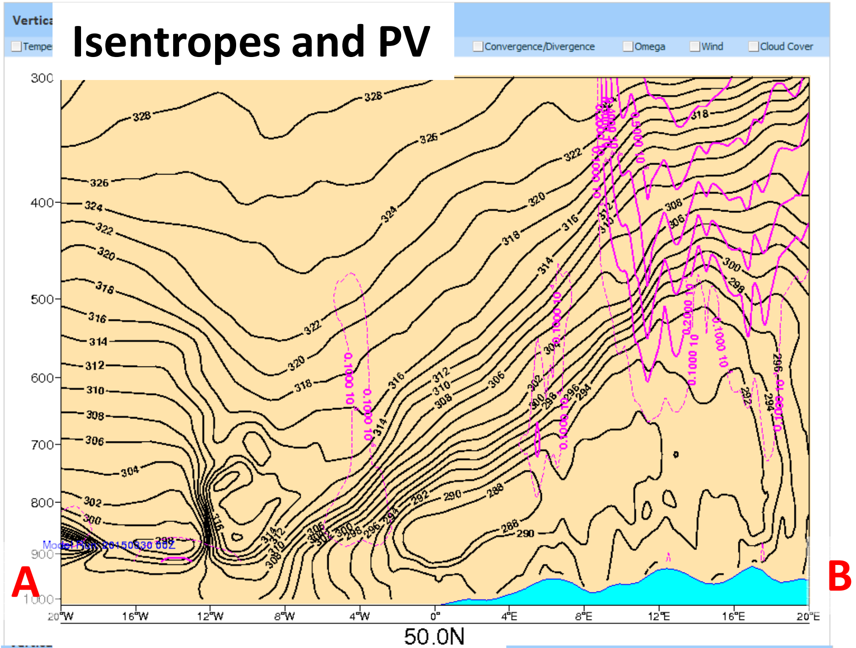
Next – click on "Wind" (units as m/s)

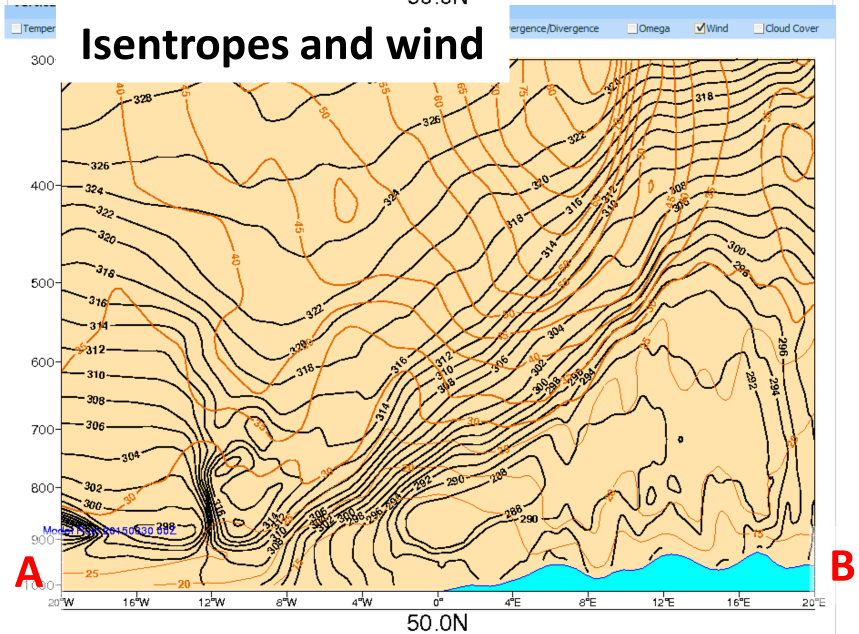


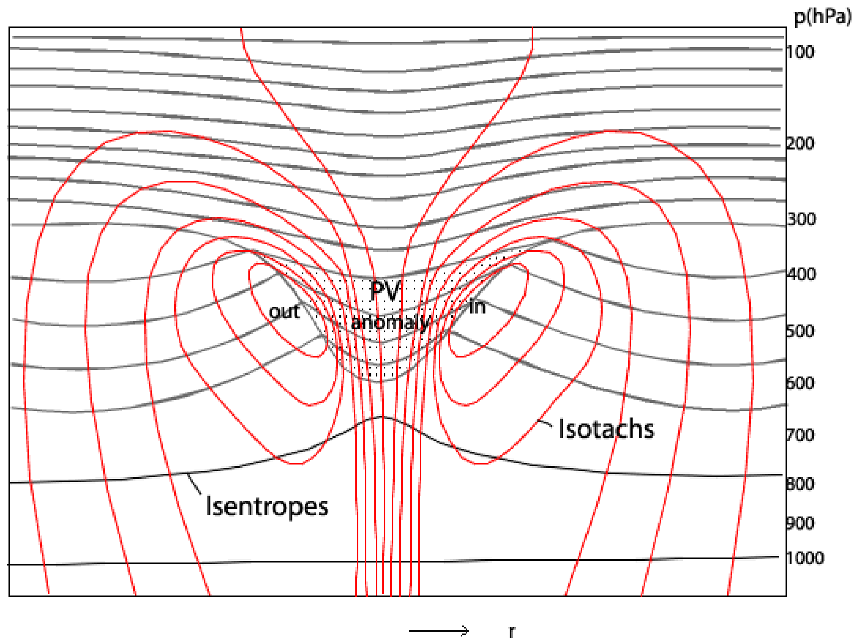
First

image courtesy EUMETSAT

Conceptual Model – upper PV anomaly, Isentropes and Wind







Conceptual model of an upper level PV anomaly (shaded), isotachs (red) and Isentropes (black).

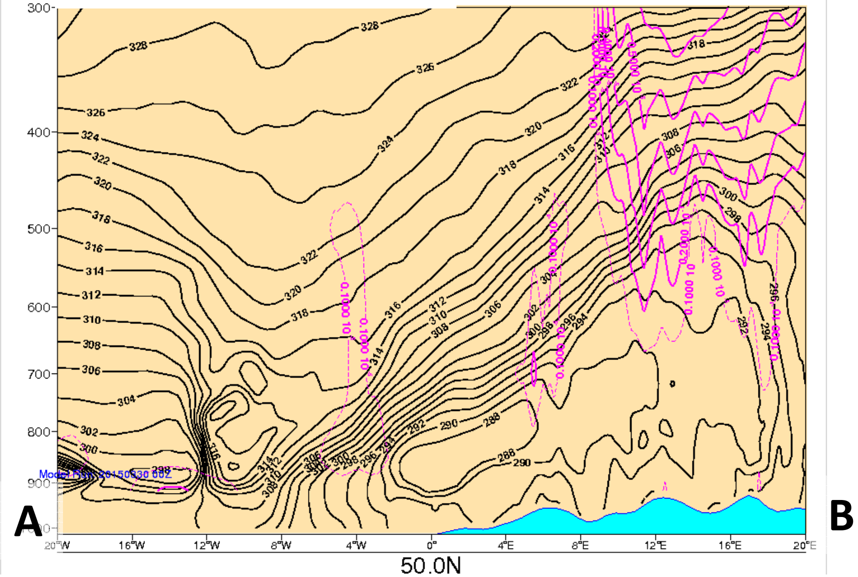
Image from SATMANU, ZAMG

Conceptual Model – upper PV anomaly, Isentropes and Wind

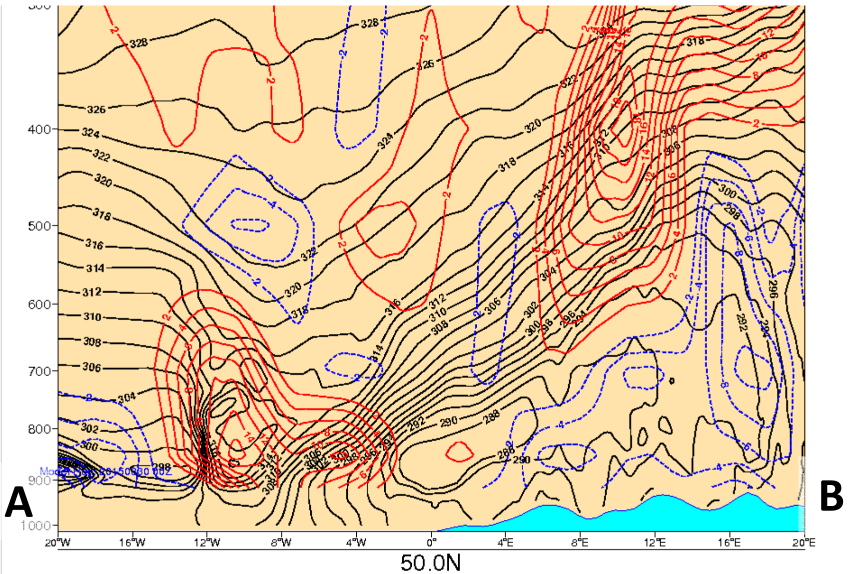
- In the preceding slide you can see the cross section from the Atlantic Ocean (A) to Central Europe (B) showing Isentropes and PV (top left panel) and Isentropes and Wind Isotachs (bottom left panel)
- On the right hand side is shown the Conceptual model of an upper PV anomaly from the Manual of Synoptic Satellite Meteorology from the Austrian Meteorological Institute (ZAMG). Also shown are associated Isentropes and Wind Isotachs
- **Activity:** see if you can identify important features of the PV anomaly in the cross sections A-B

images courtesy EUMETSAT

Isentropes and PV

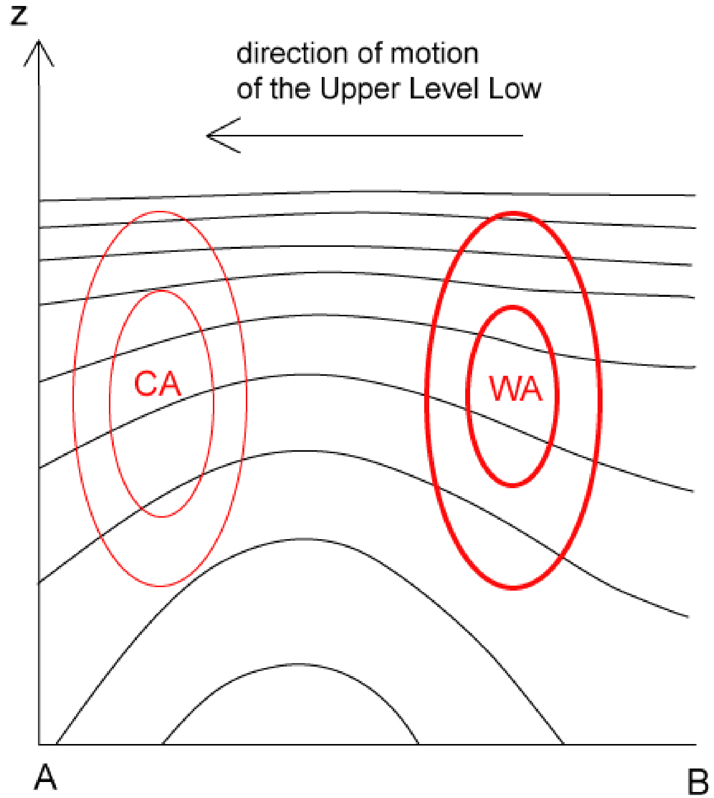


Isentropes and temperature advection



(red = warm air advection, blue = cold air advection)

Conceptual Model – upper PV anomaly, Isentropes and Temperature Advection



Conceptual model of an upper level PV anomaly, temperature advection (red) and Isentropes (black).

Image from SATMANU, ZAMG

Conceptual Model – upper PV anomaly, Isentropes and Temperature Advection

- In the preceding slide you can see the cross section from the Atlantic Ocean (A) to Central Europe (B) showing Isentropes and PV (top left panel) and Isentropes and Temperature advection(bottom left panel). Note that warm temperature advection is annotated in red, cold temperature advection is annotated in blue.

- On the right hand side is shown the Conceptual model of an upper PV anomaly from the Manual of Synoptic Satellite Meteorology from the Austrian Meteorological Institute (ZAMG). Also shown are associated Isentropes, temperature advection and the resultant movement of the upper atmospheric PV anomaly.

- **Activity:** see if you can identify the direction of movement of the upper air PV anomaly (westwards or eastwards). Check this by examining the evolution of the upper PV anomaly in the sequence of Airmass RGB images on the next slide.

image courtesy EUMETSAT

Activity: Forecasts overlaid - ESTOFEX

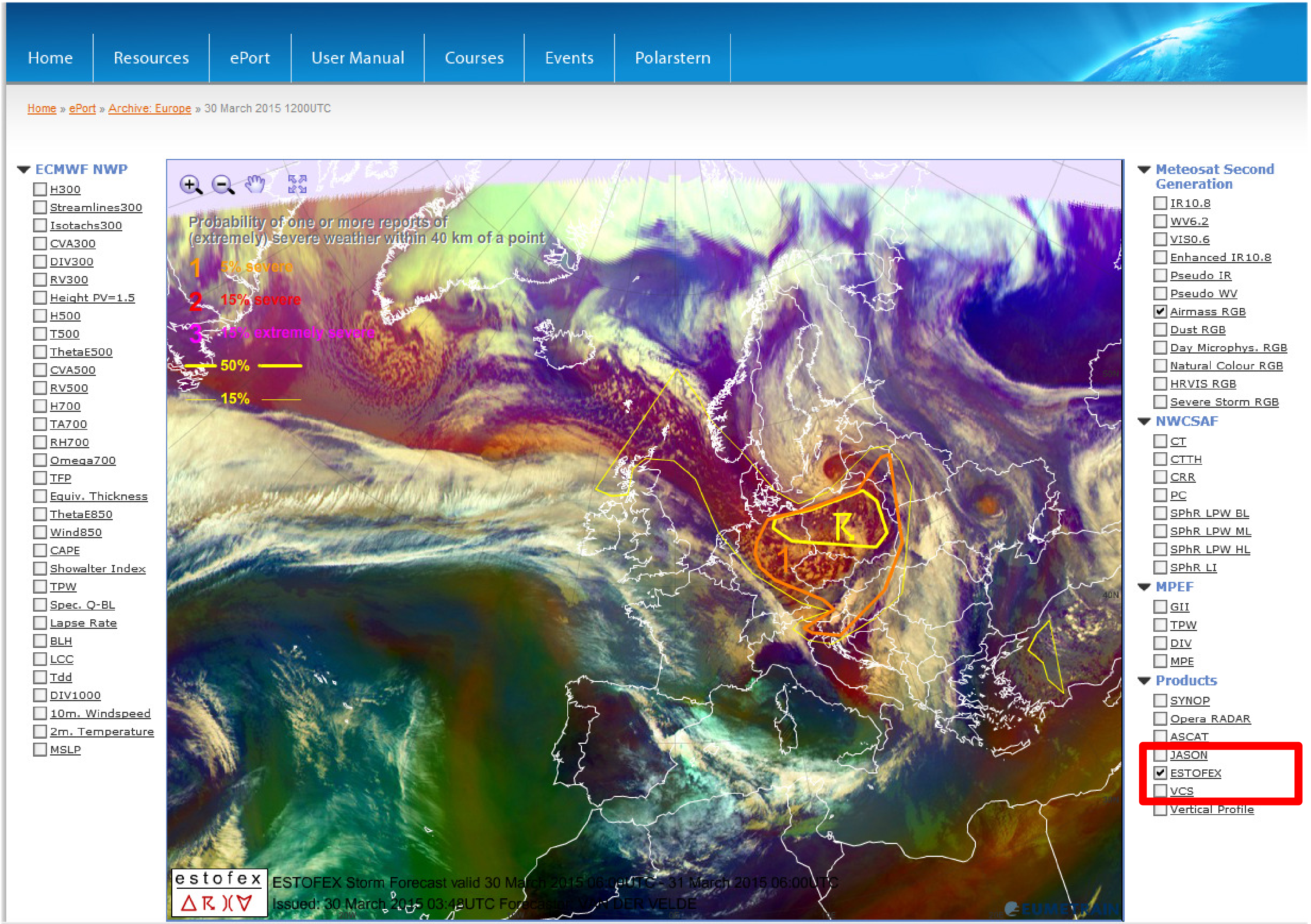
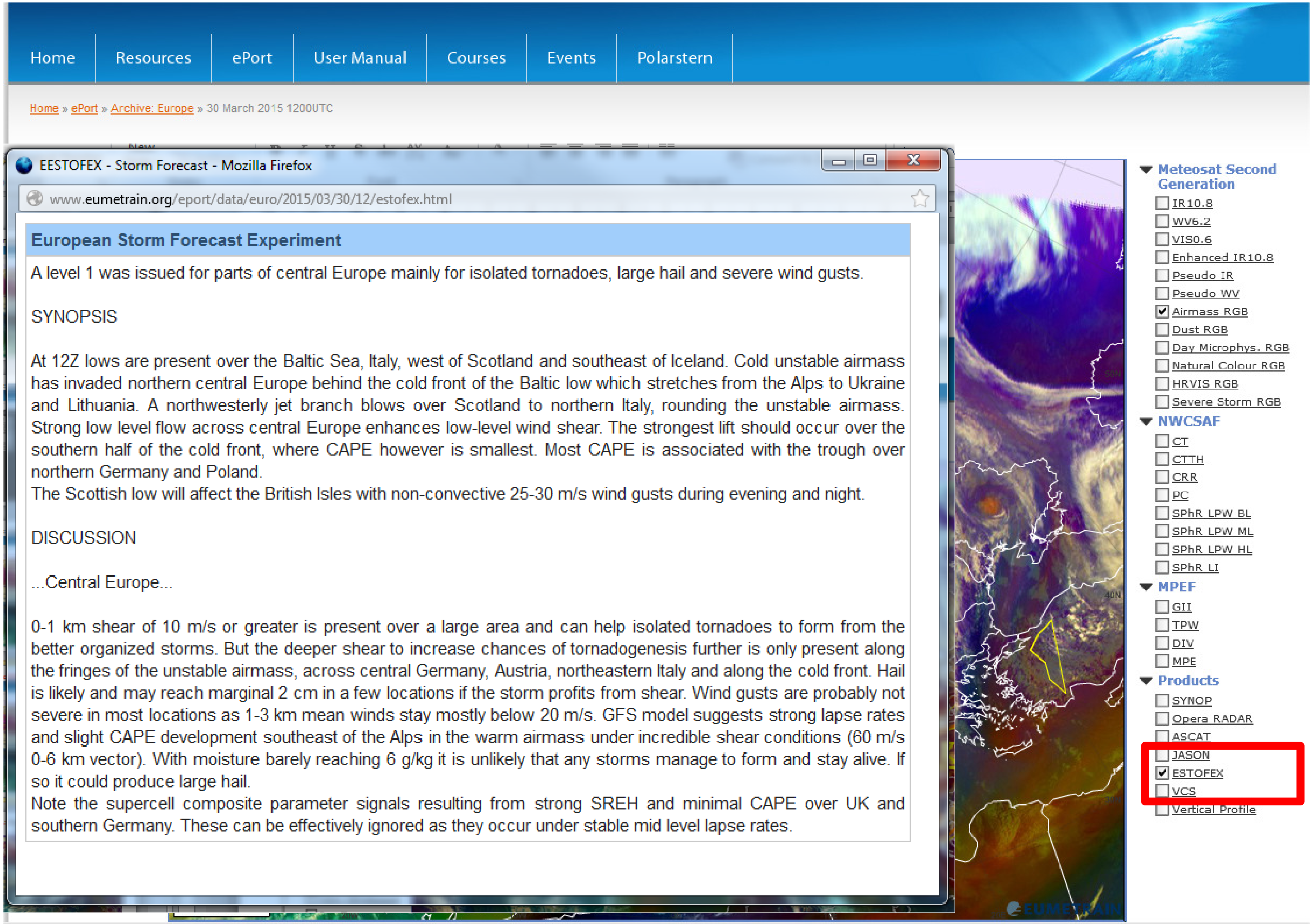


image courtesy EUMETSAT

Activity: Forecasts overlaid - ESTOFEX



Activity: Forecasts overlaid - ESTOFEX

European Storm Forecast Experiment

A level 1 was issued for parts of central Europe mainly for isolated tornadoes, large hail and severe wind gusts.

SYNOPSIS

At 12Z lows are present over the Baltic Sea, Italy, west of Scotland and southeast of Iceland. **Cold unstable airmass has invaded northern central Europe behind the cold front of the Baltic low which stretches from the Alps to Ukraine and Lithuania. A northwesterly jet branch blows over Scotland to northern Italy, rounding the unstable airmass.** Strong low level flow across central Europe enhances low-level wind shear. The strongest lift should occur over the southern half of the cold front, where CAPE however is smallest. Most CAPE is associated with the trough over northern Germany and Poland.

The Scottish low will affect the British Isles with non-convective 25-30 m/s wind gusts during evening and night.

DISCUSSION

...Central Europe...

0-1 km shear of 10 m/s or greater is present over a large area and can help isolated tornadoes to form from the better organized storms. But the deeper shear to increase chances of tornadogenesis further is only present along the fringes of the unstable airmass, across central Germany, Austria, northeastern Italy and along the cold front. Hail is likely and may reach marginal 2 cm in a few locations if the storm profits from shear. Wind gusts are probably not severe in most locations as 1-3 km mean winds stay mostly below 20 m/s. GFS model suggests strong lapse rates and slight CAPE development southeast of the Alps in the warm airmass under incredible shear conditions (60 m/s 0-6 km vector). With moisture barely reaching 6 g/kg it is unlikely that any storms manage to form and stay alive. If so it could produce large hail.

Note the supercell composite parameter signals resulting from strong SREH and minimal CAPE over UK and southern Germany. These can be effectively ignored as they occur under stable mid level lapse rates.

image courtesy EUMETSAT

Activity: Vertical Profile

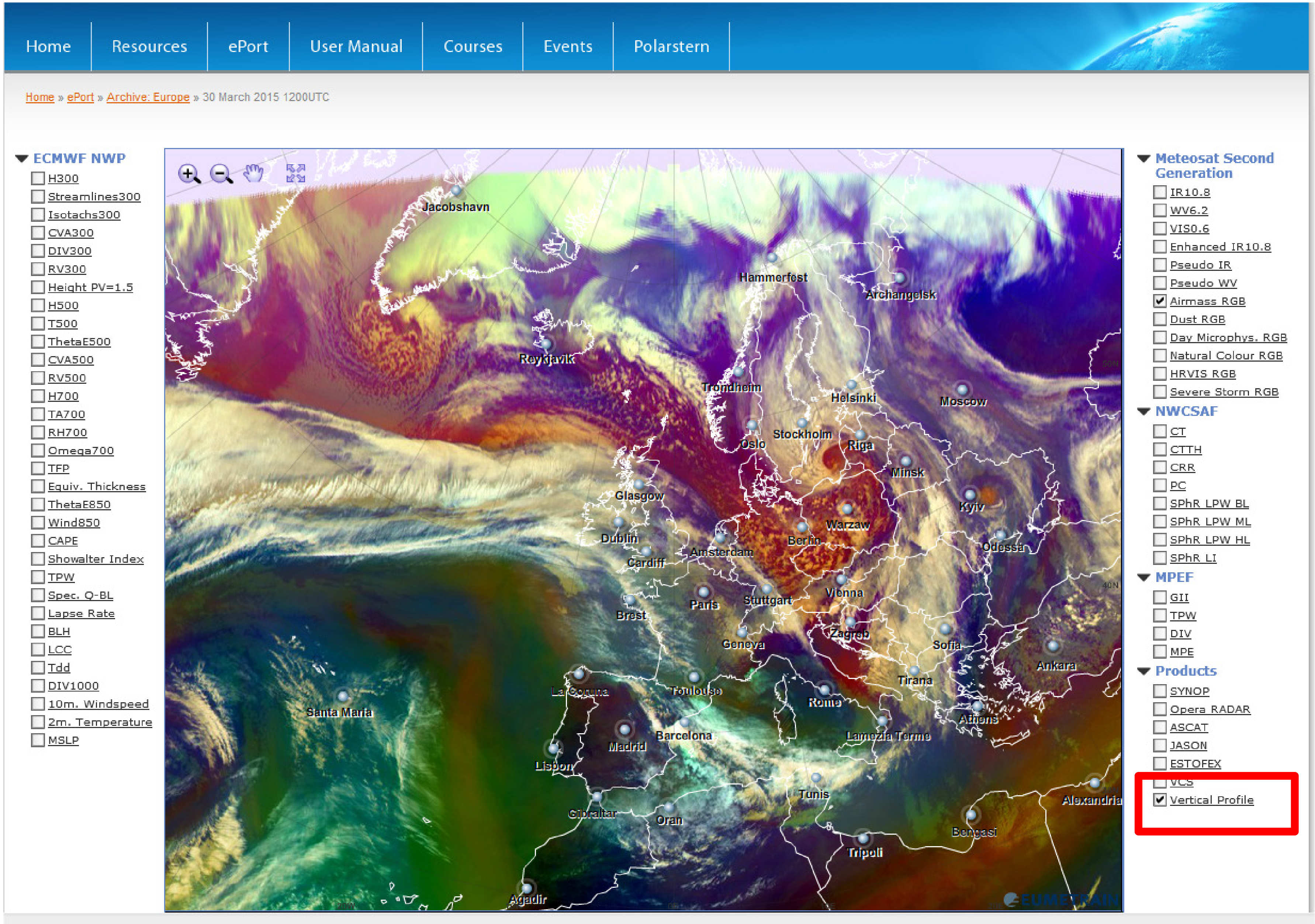
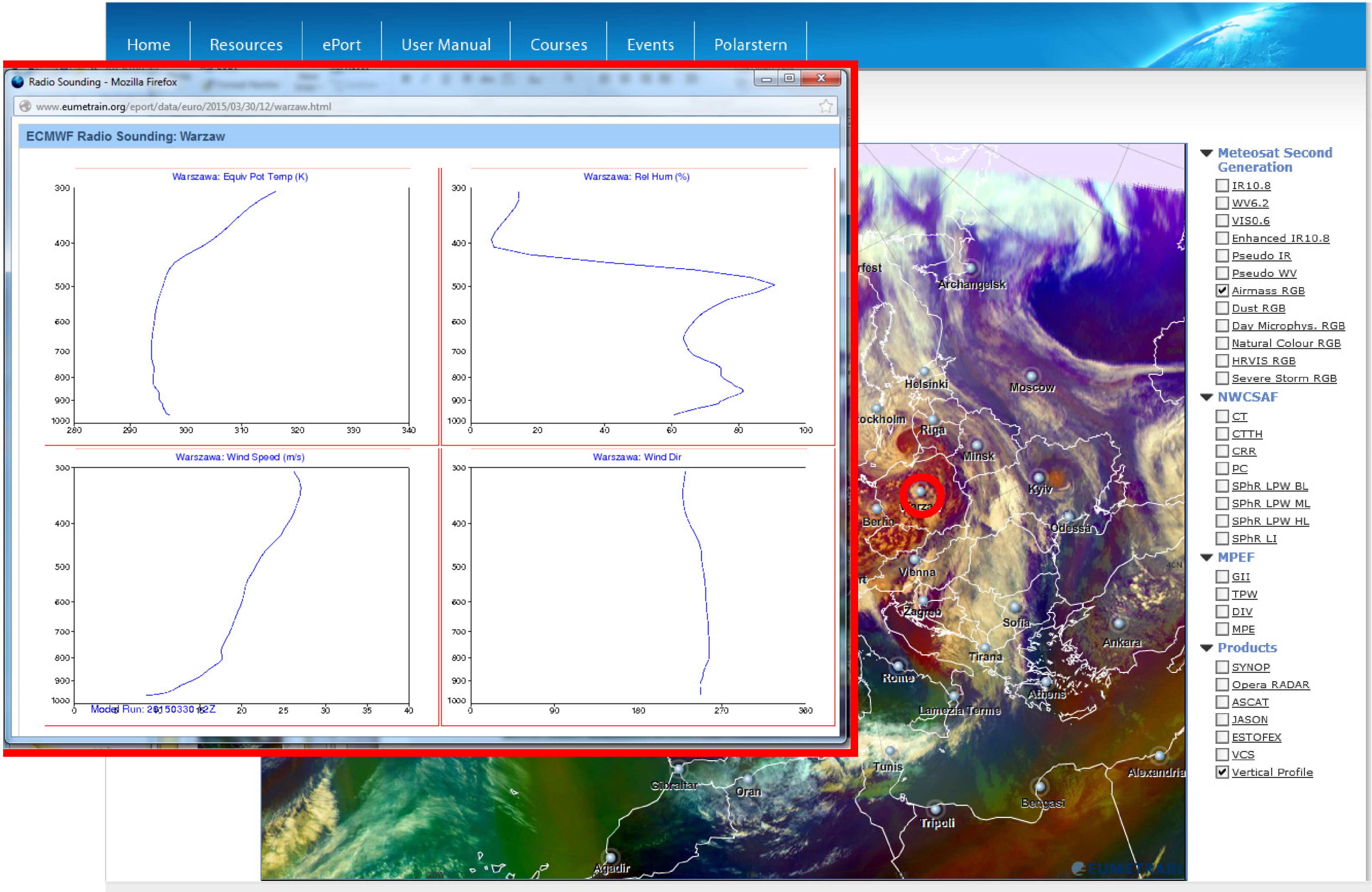


image courtesy EUMETSAT

Activity: Vertical Profile - Warsaw

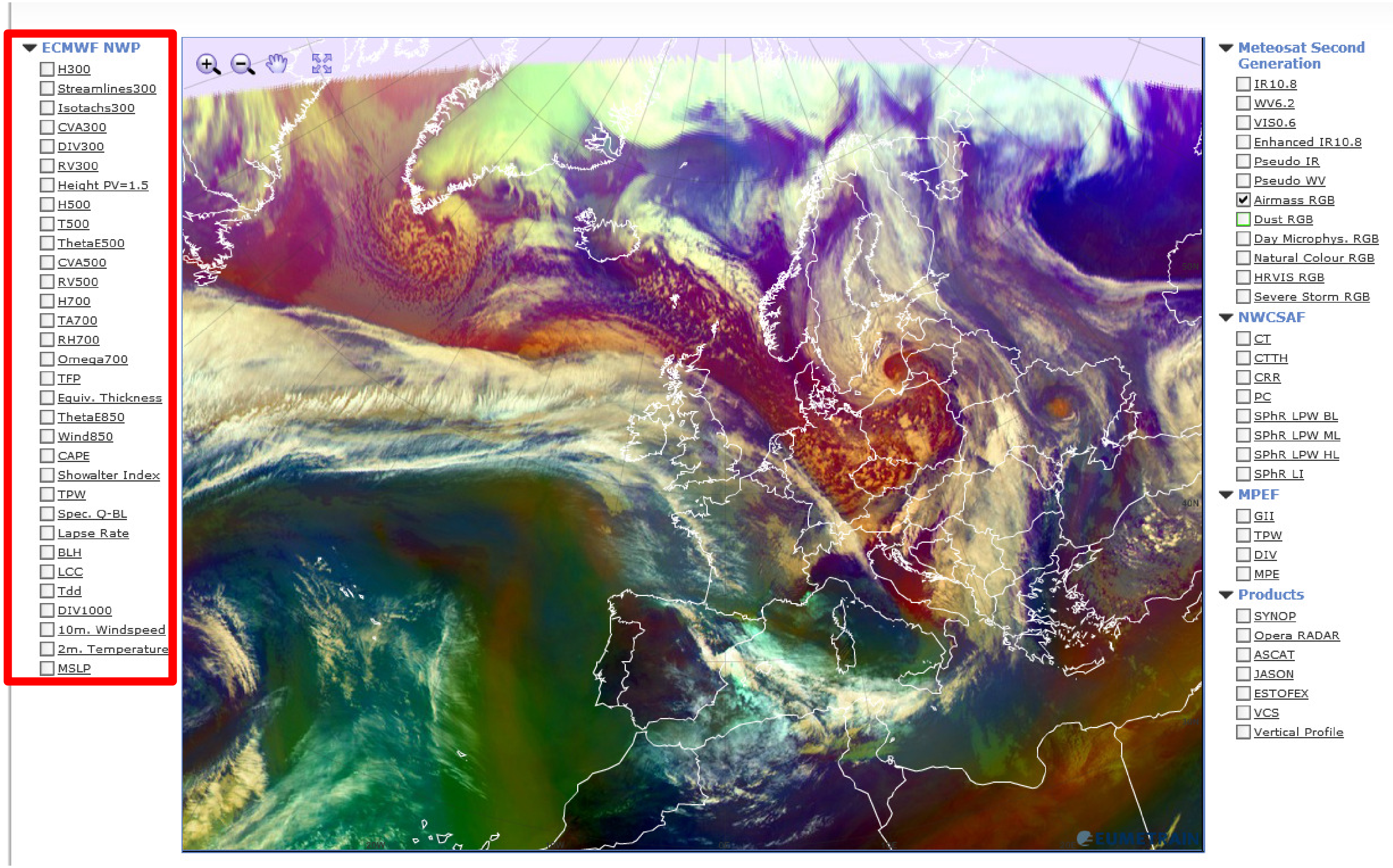


Activity: Vertical Profile - Warsaw

- Examination of the Equivalent Potential Temperature (Theta E) for Warsaw as shown in the top left hand panel, shows that from 1000 to 800 hPa this is decreasing with height. This indicates that the atmosphere is conditionally unstable over these levels.
- At high levels, above 450 hPa, Theta E is rapidly increasing and this indicates transition into the very stable stratosphere.
- Inspection of Relative Humidity (top right hand panel) shows that above 450 hPa the air is very dry. This would be expected with transition into the stratosphere above 450 hPa.
- There is also an increase in windspeed above 450 hPa as shown in the bottom right hand panel.

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 Airmass RGB product

image courtesy EUMETSAT

Recommended answer: Airmass RGB and Isotachs 300hPa

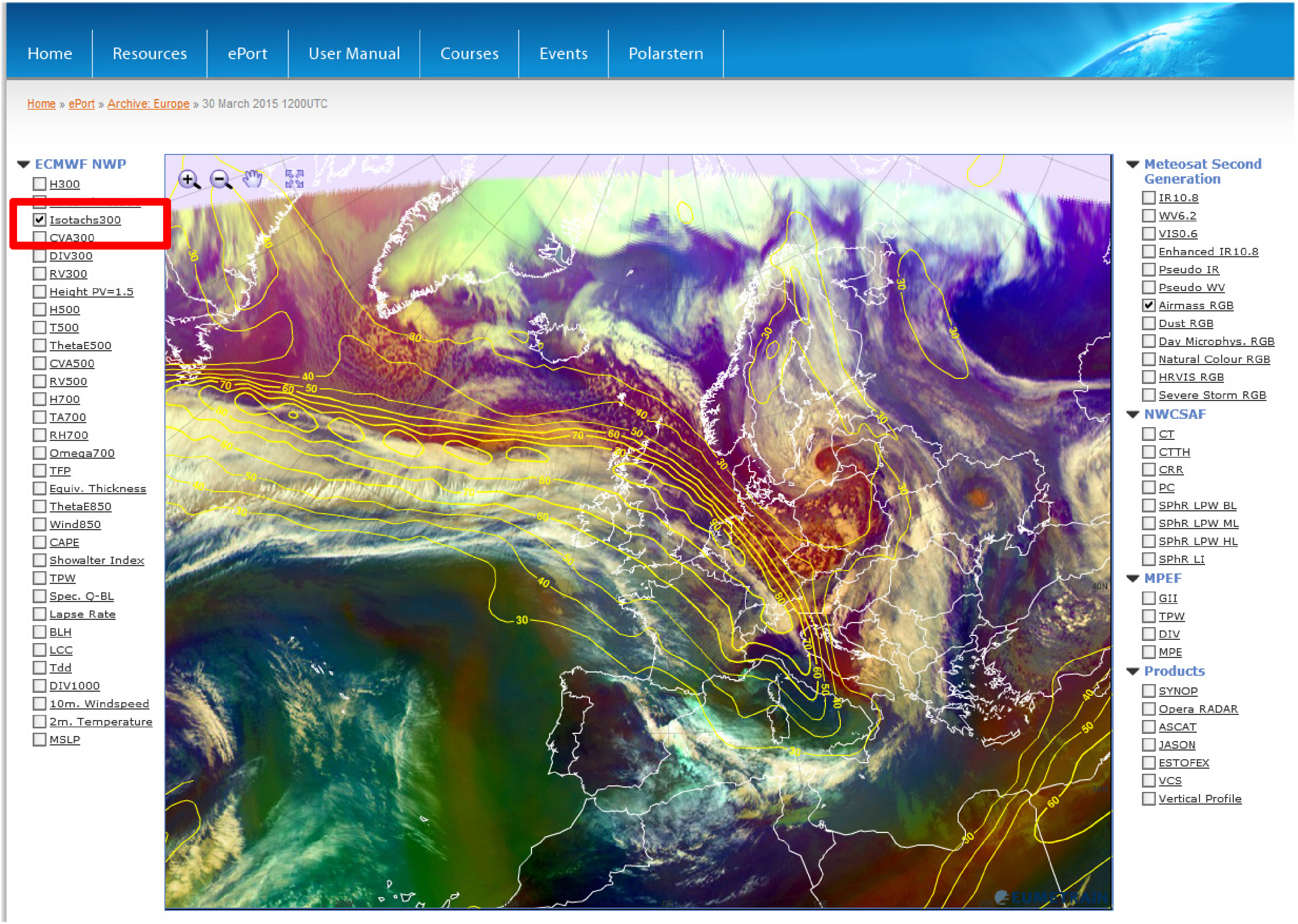
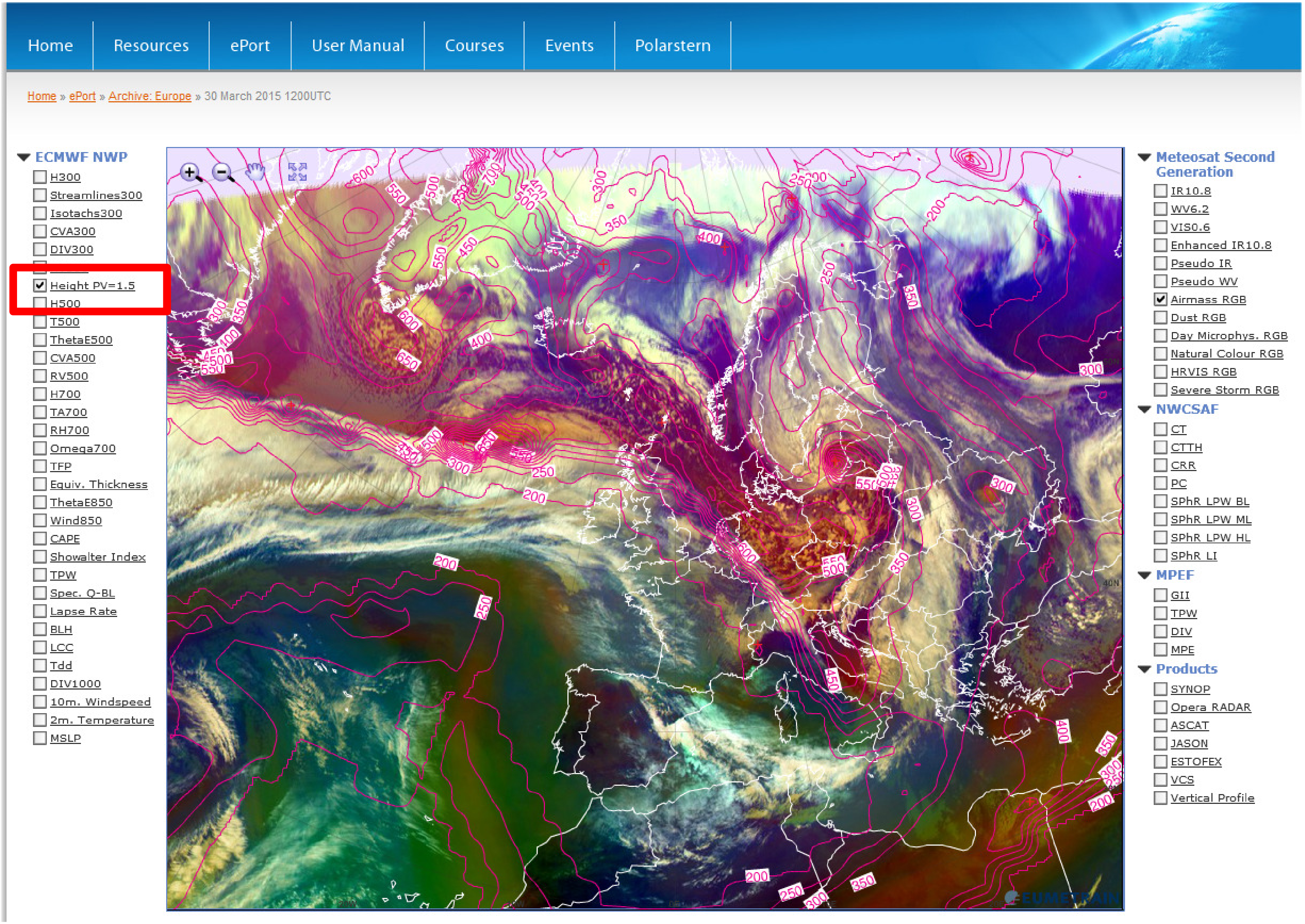
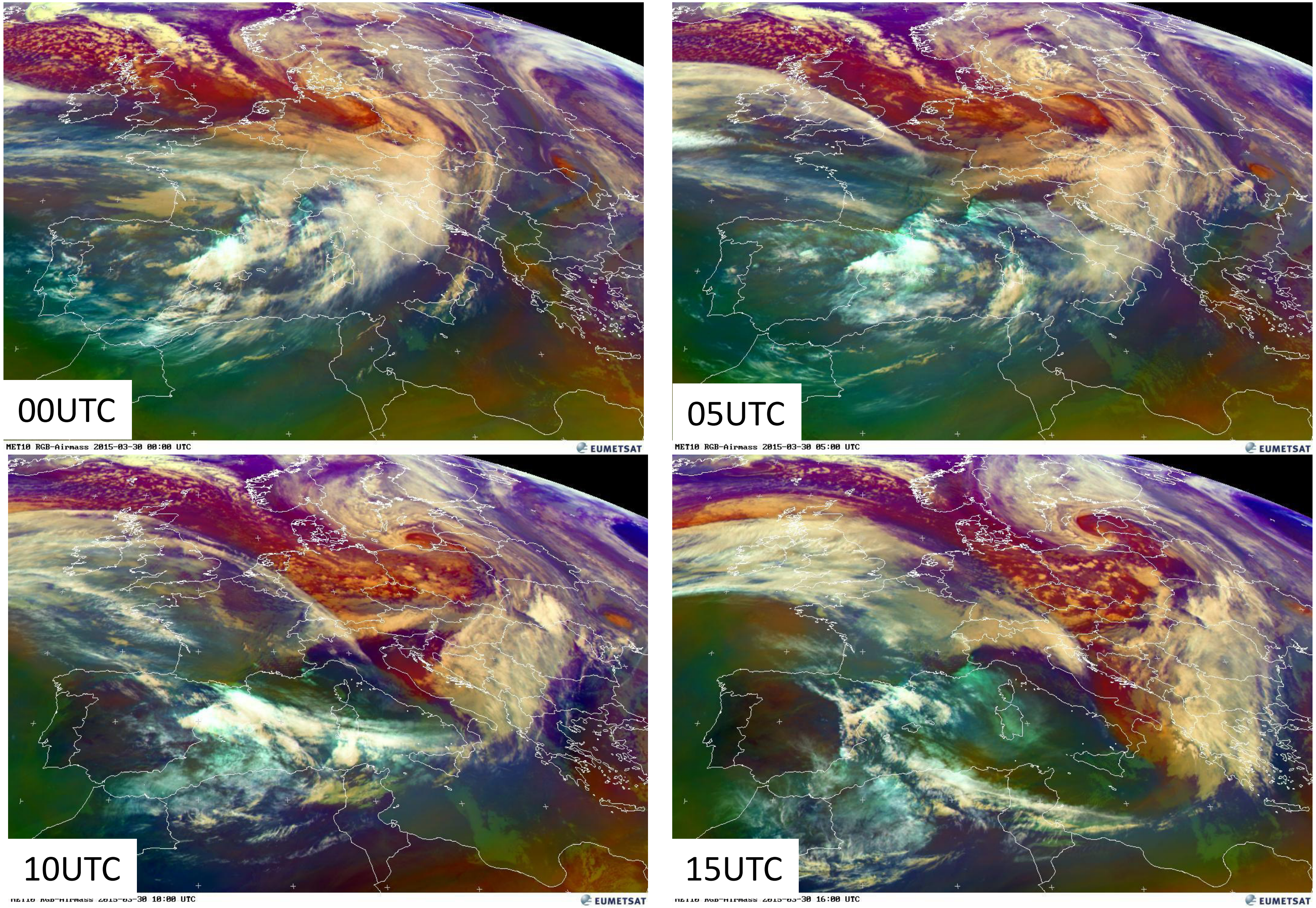


image courtesy EUMETSAT

Recommended answer: Airmass RGB and Height PV=1.5



Summary of Airmass RGB animation – Western Europe, Meteosat 10, 30th March 2015, 00-15UTC



Summary – the Airmass RGB product (1)

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

The Air Mass RGB is designed and tuned for monitoring the evolution of cyclones, in particular, rapid cyclogenesis, jet streaks, and potential vorticity (PV) anomalies. Since the product relies heavily on infrared channels in the water vapor and ozone absorption regions of the spectrum, it provides information primarily about the middle and upper levels of the troposphere, not so much the lower levels and near-surface conditions.

Advantages:

- Can see important boundaries between air masses, such as tropical and polar, at a glance; these are often invisible on single channel images
- Helps detect the position of jet streams and areas of dry, descending stratospheric air with high PV; these appear in red
- Can detect features commonly seen in water vapor images, such as deformation zones, wave features, and PV anomalies
- The infrared channels make it possible to monitor cloud development at low, middle, and high altitudes

Summary – the Airmass RGB product (2)

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

Limitations:

- Air masses are only detectable in areas free of high cloud cover
- Tends to depict conditions in the middle and upper troposphere, but not at the surface
- At the edge of the Earth’s disk, air masses can have a magenta color but this does not represent true air mass characteristics, rather limb darkening/cooling due to the large satellite viewing angles

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.);

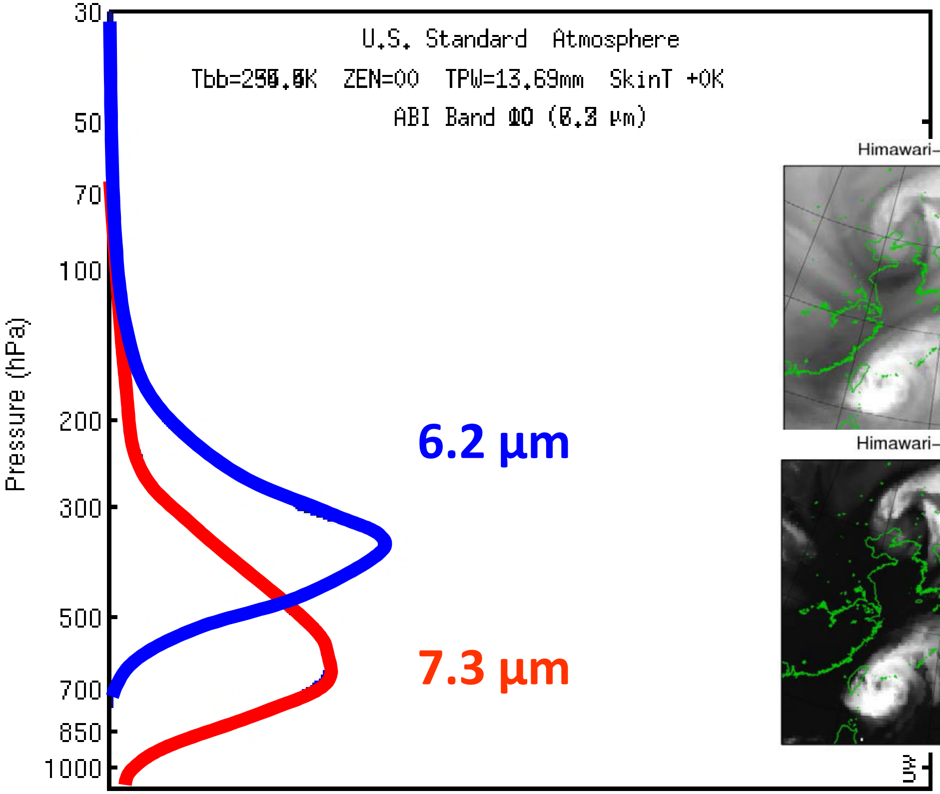
WMO 1083 2.3.1.5 - Passive sensing systems: **Explain how passive sensing systems are used to provide** digital **data (such as** visible, near infrared, infrared and **water vapour imagery channels) and derived information about** surface temperature and lightning, and **atmospheric properties (including** temperature, **humidity**, wind and **atmospheric constituents**);

No Enabling Skills for this topic

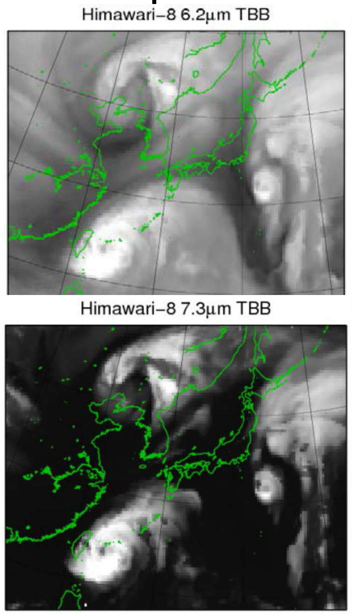
Appendix 2: Explaining the channel combination recipe in more detail. Components of the Red Beam

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
(US standard atmosphere)



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



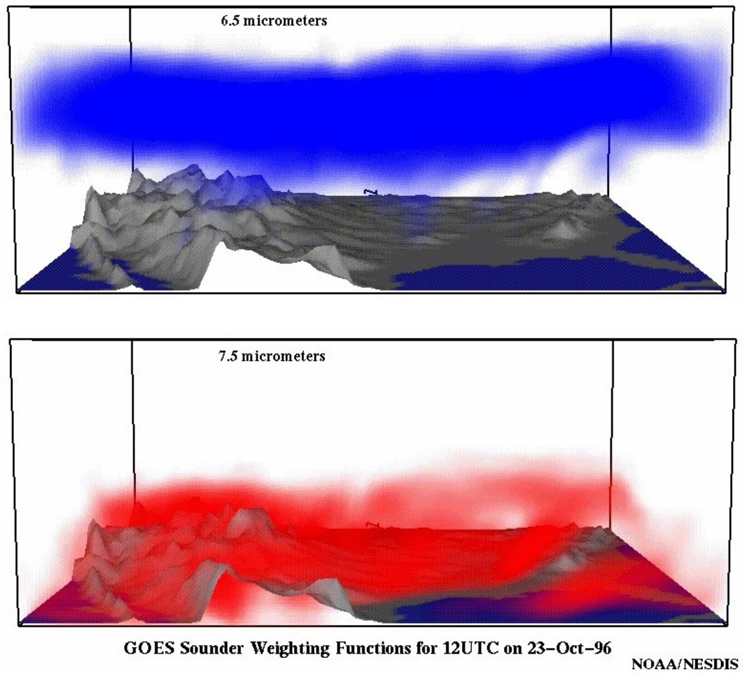
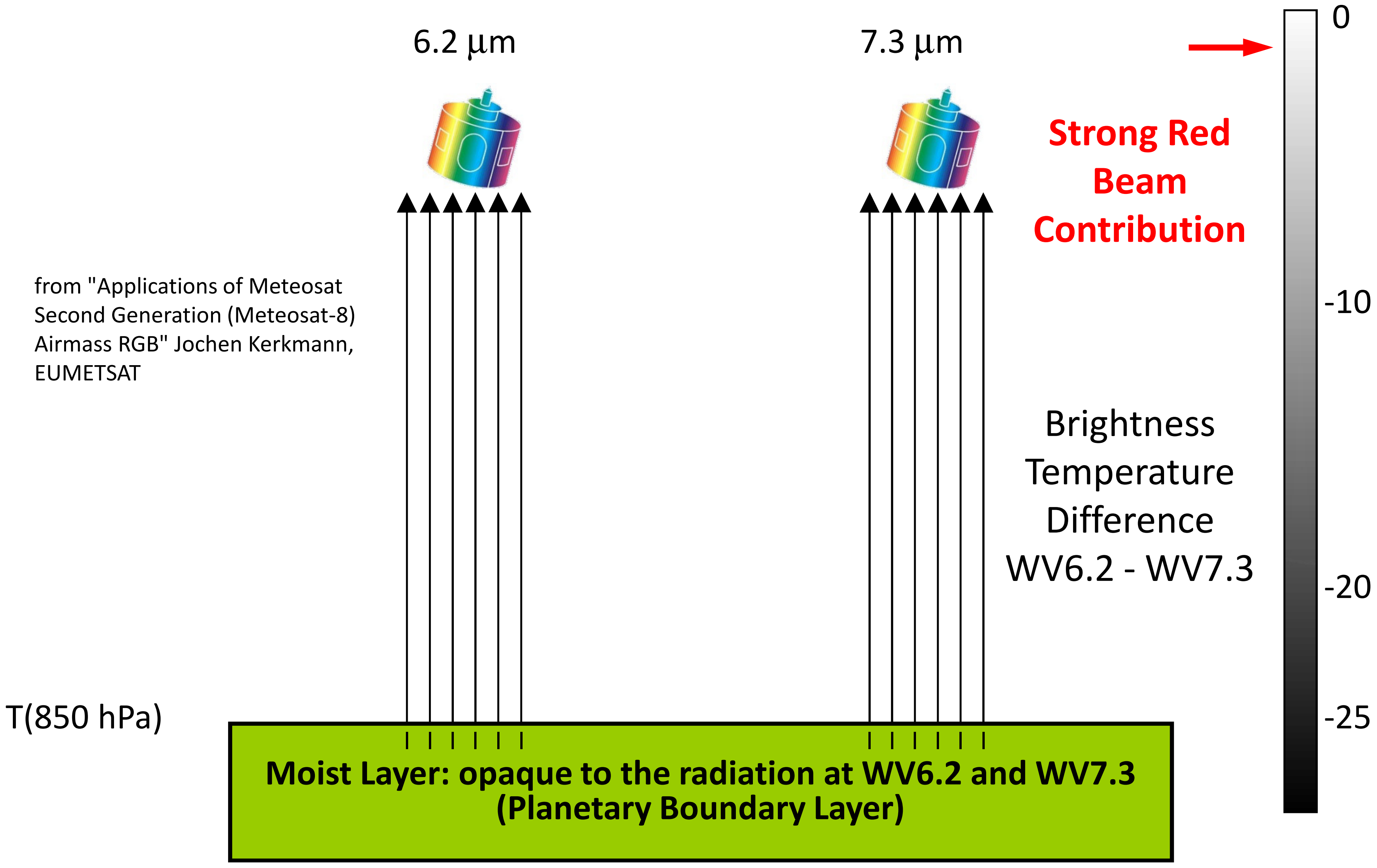


Image courtesy CIMSS (UW Madison / NOAA)

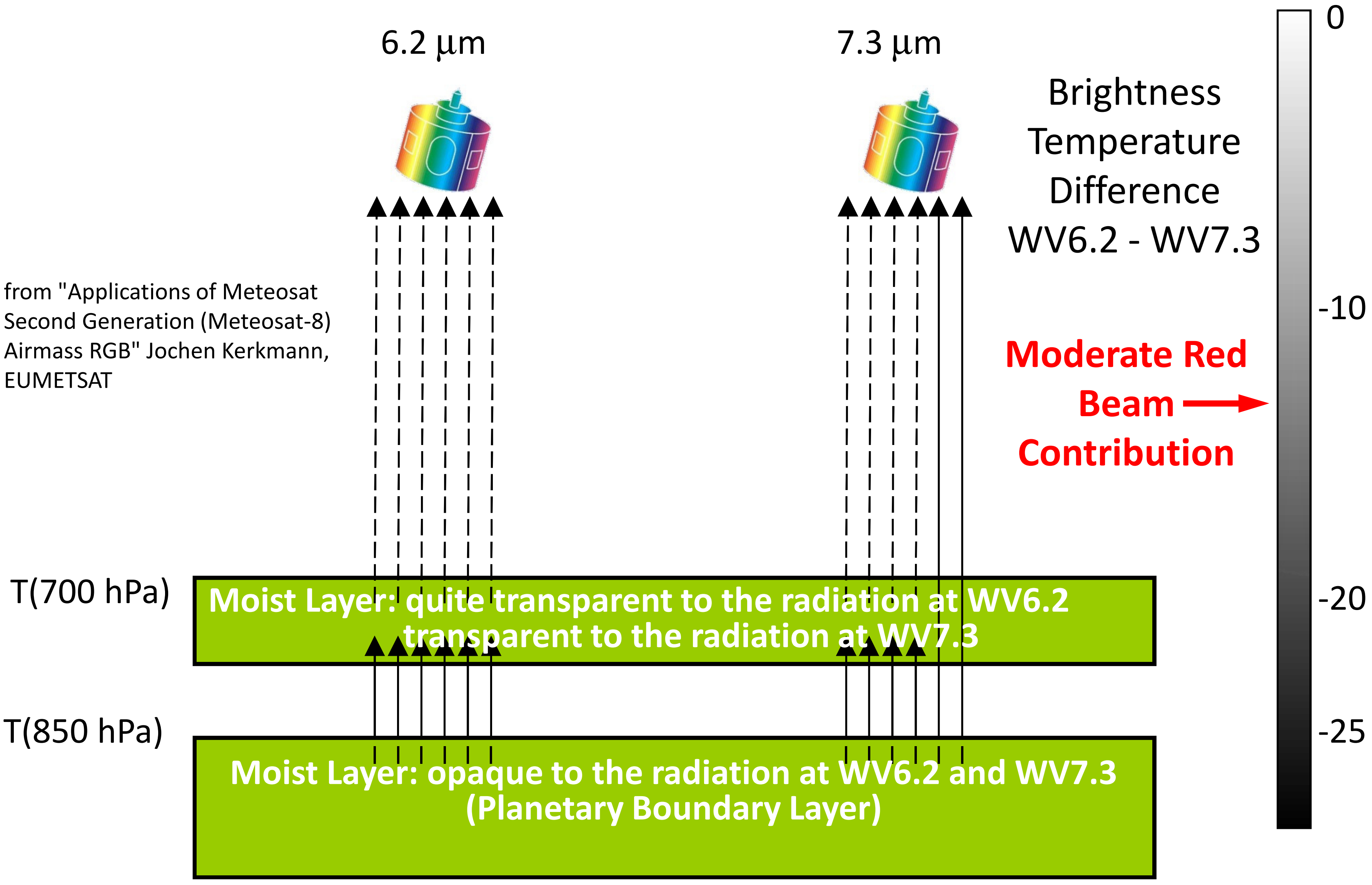
Red Beam, case 1: very dry atmosphere above 850hPa

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

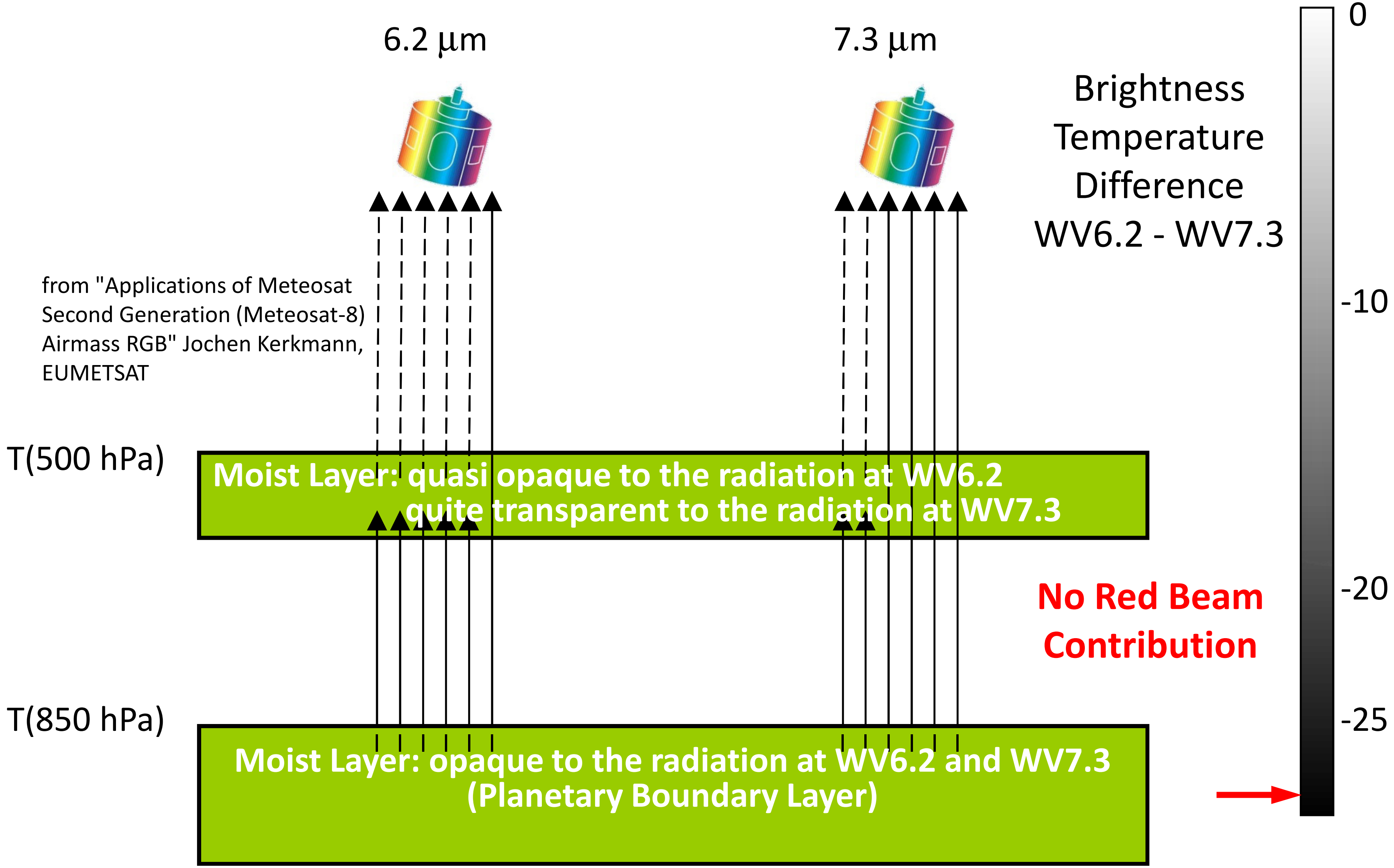


Red Beam, case 2: moist layer at 700 hPa

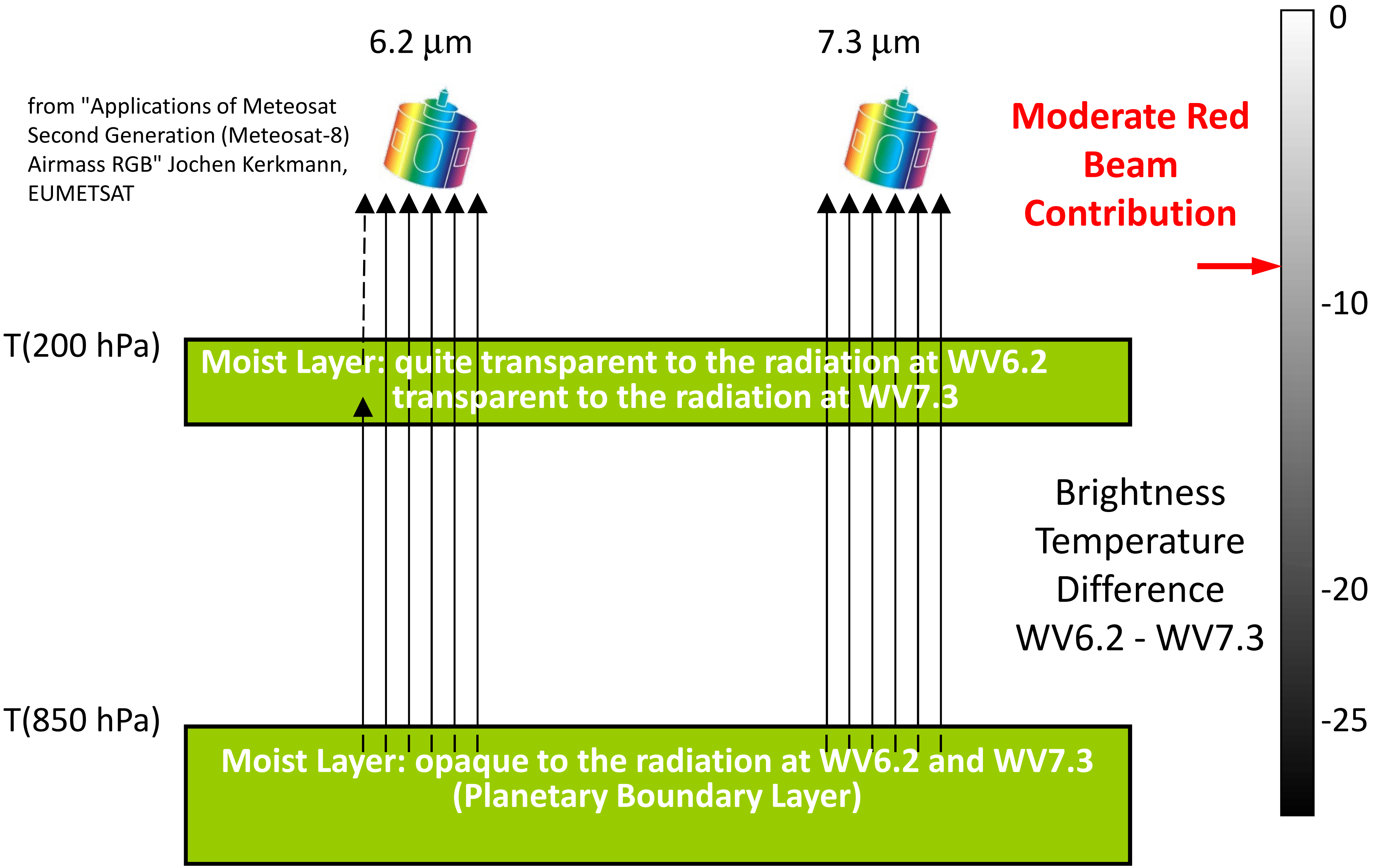
from "Applications of Meteosat Second Generation (Meteosat-8) Airmass RGB" Jochen Kerkmann, EUMETSAT



Red Beam, case 3: moist layer at 500 hPa

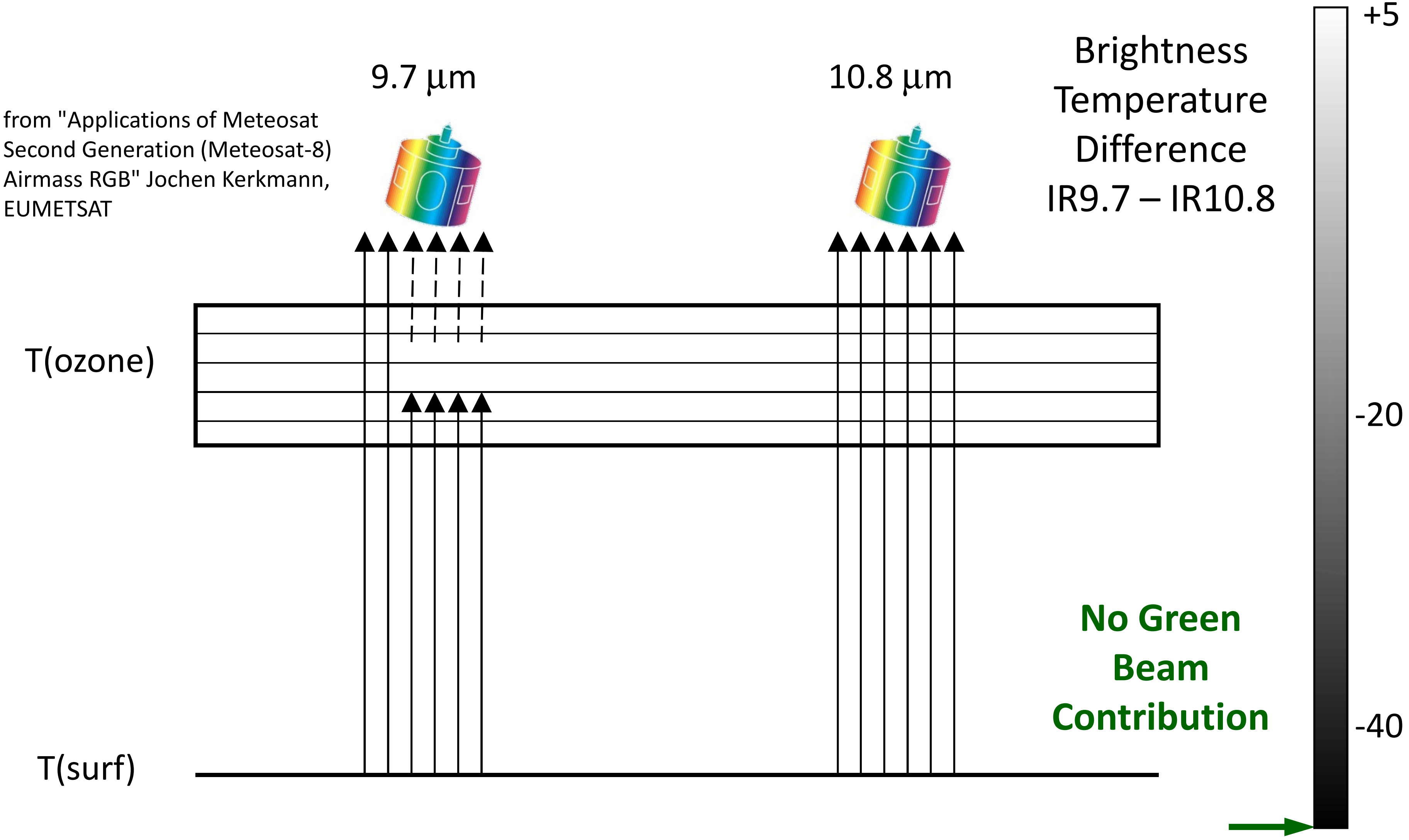


Red Beam, case 4: moist layer at 200 hPa



Green Beam, case 1: Rich ozone polar airmass

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



Green Beam, case 2: Low ozone tropical airmass

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