Australian Government
Bureau of Meteorology

Australian VLab Centre of Excellence

National Himawari-8 Training Campaign

The Dust 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

Learning Outcomes

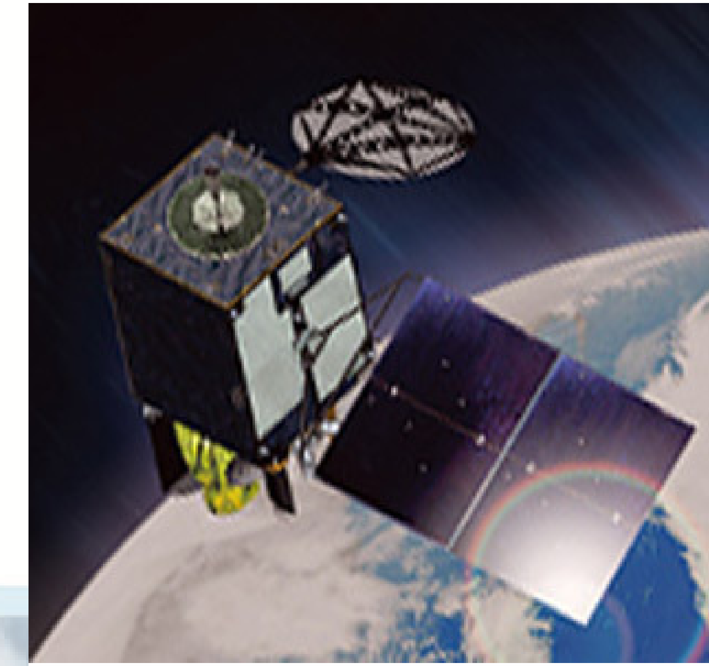
At the end of this exercise you will:

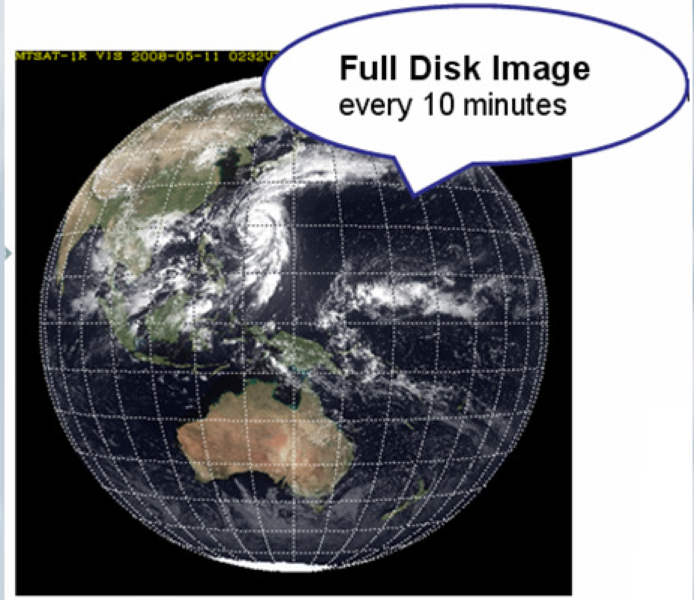
- Have a basic knowledge how the Dust RGB product is constructed from multiple satellite channels and the underpinning physics and meteorology.
- Have a better understanding of the advantages and the limitations of the Dust RGB product.
- Be able to identify and locate dust and other specific meteorological features using the Dust 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 the advantages in using the Dust RGB product when monitoring, nowcasting and short term forecasting of Dust.
- 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



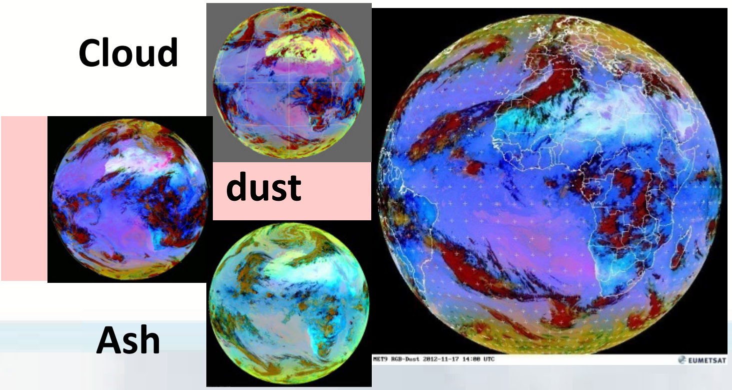


気象庁
Japan Meteorological Agency

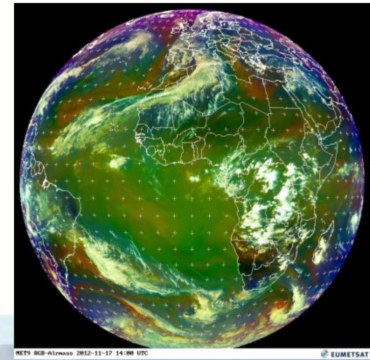
from JMA

RGB products for Operational Forecasting – EumetSAT / WMO recommendation – the Dust RGB

Two RGB composites which complement each other



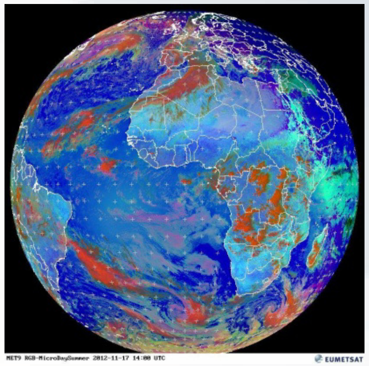
24 hour Microphysical RGB



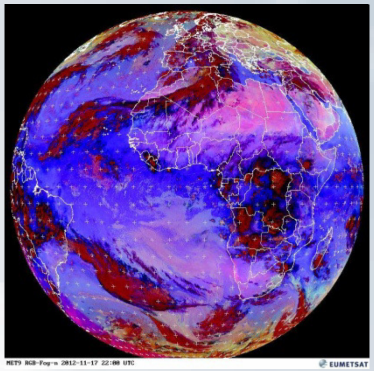
Airmass RGB

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

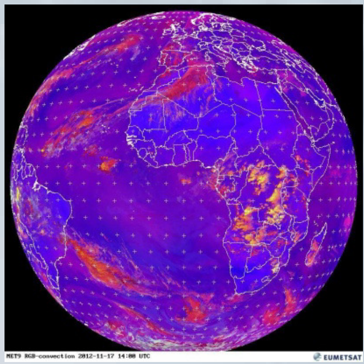
Five application specific RGBs



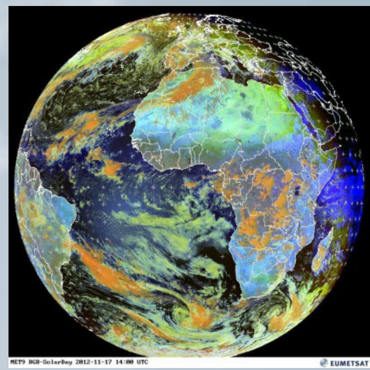
Day Microphysical RGB



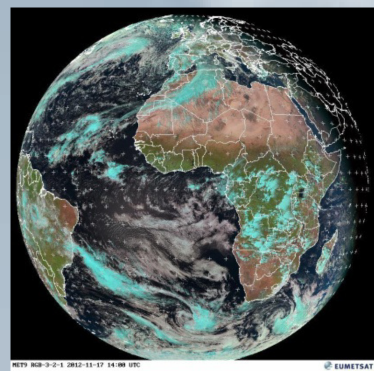
Night Microphysical RGB



Day Convection RGB



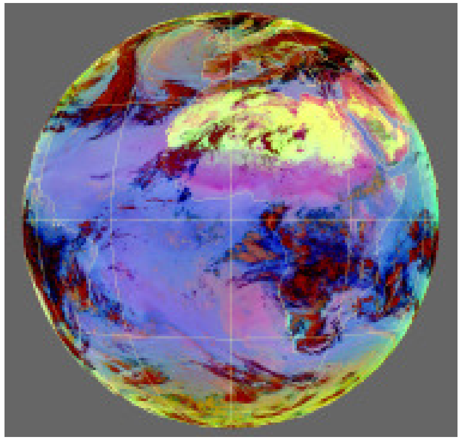
Snow / fog RGB

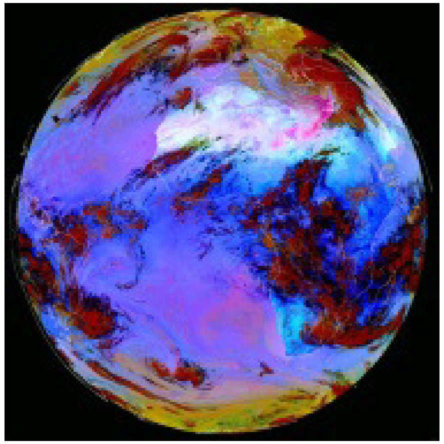


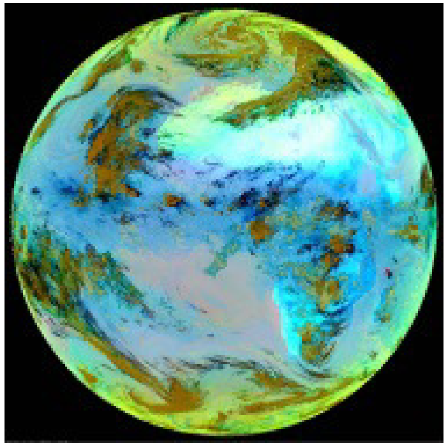
Natural Colours RGB

For reference: Channel combination recipe for the three classes of 24-hour Microphysics RGB product

Beam	Channel	Range	Gamma	Range	Gamma	Range	Gamma
Red	IR12.0 – IR10.8	-4 ... +2 K	1.0	-4 ... +2 K	1.0	-4 ... +2 K	1.0
Green	IR10.8 – IR8.7	0 ... +6 K	1.2	0 ... +15 K	2.5	-4 ... +5 K	1.0
Blue	IR10.8	+248...+303	1.0	+261...+289	1.0	+243...+303	1.0
		24 hour Cloud Microphysics RGB		24 hour Dust Microphysics RGB		24 hour Ash Microphysics RGB	







from Tri-spectral Window RGB Applications with MSG SEVIRI (24-h Microphysics RGB) J. Kerkmann

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:

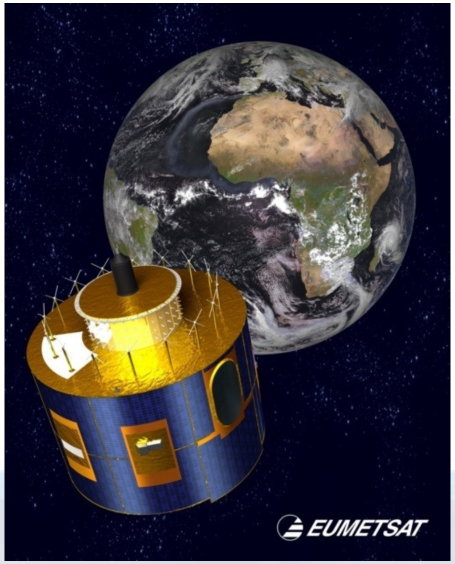
Two RGB composites which complement each other are used all of the time. These are the 24 hour Microphysics RGB and the Airmass RGB.

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.

Note that the 24 hour Microphysics RGB product has been variously tuned to give three derivative RGB products – the cloud, dust and ash RGB products.

images courtesy Eumetsat

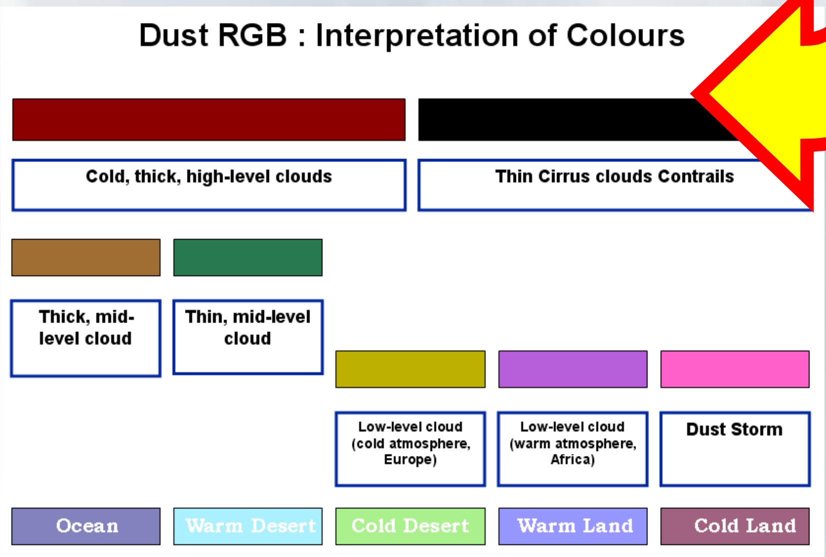
EUMETSAT processing of METEOSAT data – Dust RGB

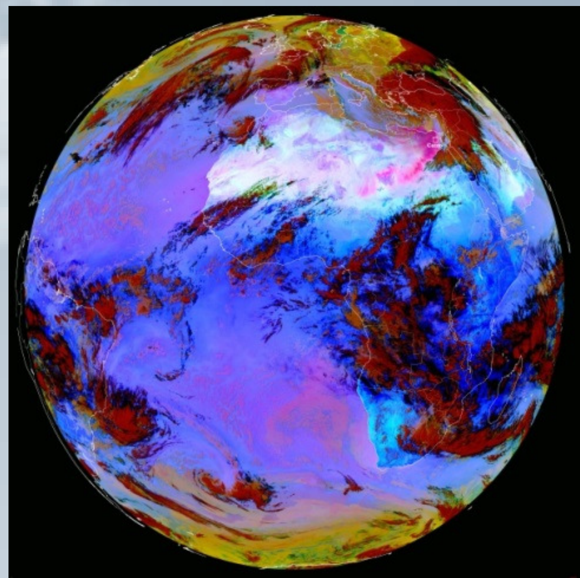


Recommended Range and Enhancement:

Beam	Channel	Range	Gamma	Gamma2
Red	IR12.0 - IR10.8	-4 … +2	1.0	1.0
Green	IR10.8 - IR8.7	0 … +15	2.5	1.0
Blue	IR10.8	+261 … +289	1.0	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 – Dust RGB

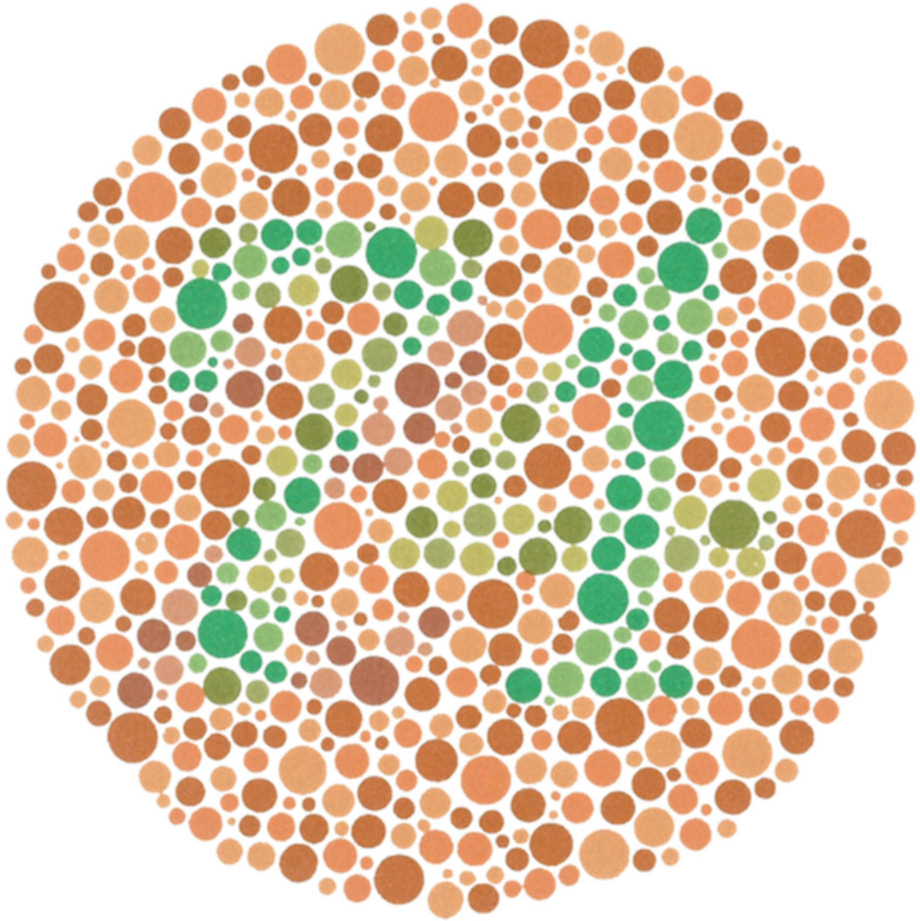
The previous slide shows the channels used in the RGB product, the thresholds (range) applied to the Beams and the Gamma correction that is applied to selected Beams as per EUMETSAT recipe

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

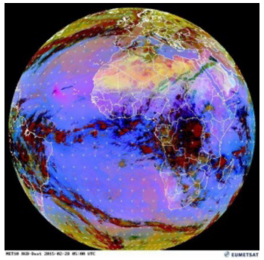
To take full advantage of the RGB products you should be able to see the number "74" in the pattern on the right.



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

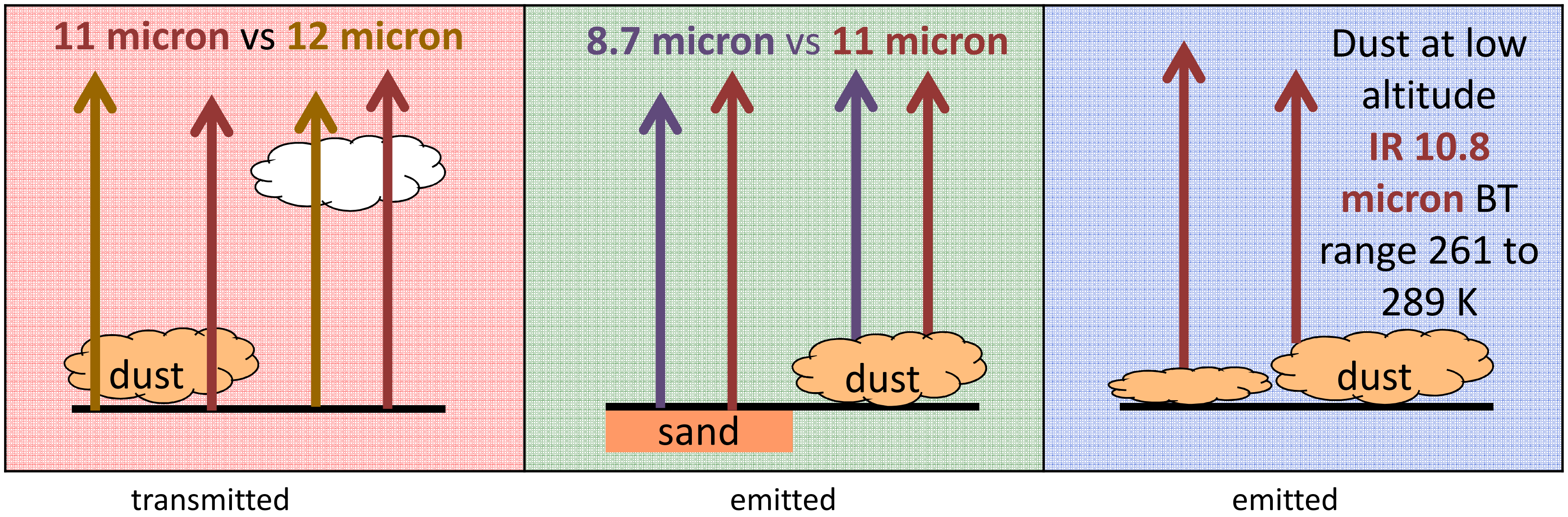
Channel combination recipe of the 24 hour Microphysics (Dust) RGB

(For more details see Appendix 2)



Recommended Range and Enhancement

Beam	Channel	Range	Gamma	Gamma 2
Red	IR12.0 – IR10.8	-4 … +2K	1.0	1.0
Green	IR10.8 – IR8.7	0 … +15 K	2.5	1.0
Blue	IR10.8	+261 … +289 K	1.0	1.0



Channel combination "recipe" of the Dust RGB

- **In the Red beam:** The 12-11 micron channel difference distinguishes dust from ice clouds. Dust absorbs 11 micron radiation more than ice clouds. Therefore dust has a strong contribution to the red beam.

- **In the Green beam:** The 11-8.7 micron 0-15 K threshold takes advantage of the low emissivity signal of sand in the 8.7 micron channel. Sand surfaces will have a strong contribution to the Green beam whereas atmospheric dust has little contribution to this beam.

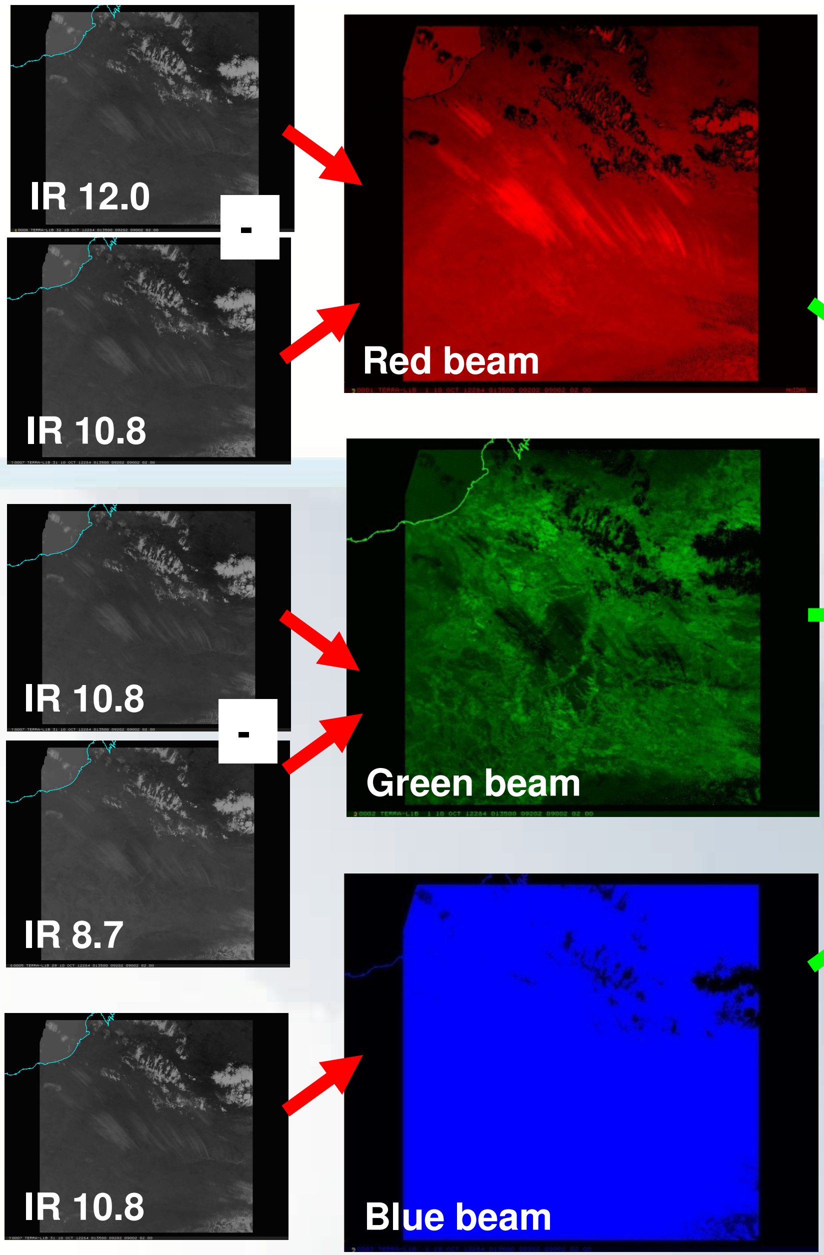
- **In the Blue beam:** The temperature range of 261 to 289 K in the 11 micron channel gives a strong signal in the warm atmosphere where most of the dust exists.

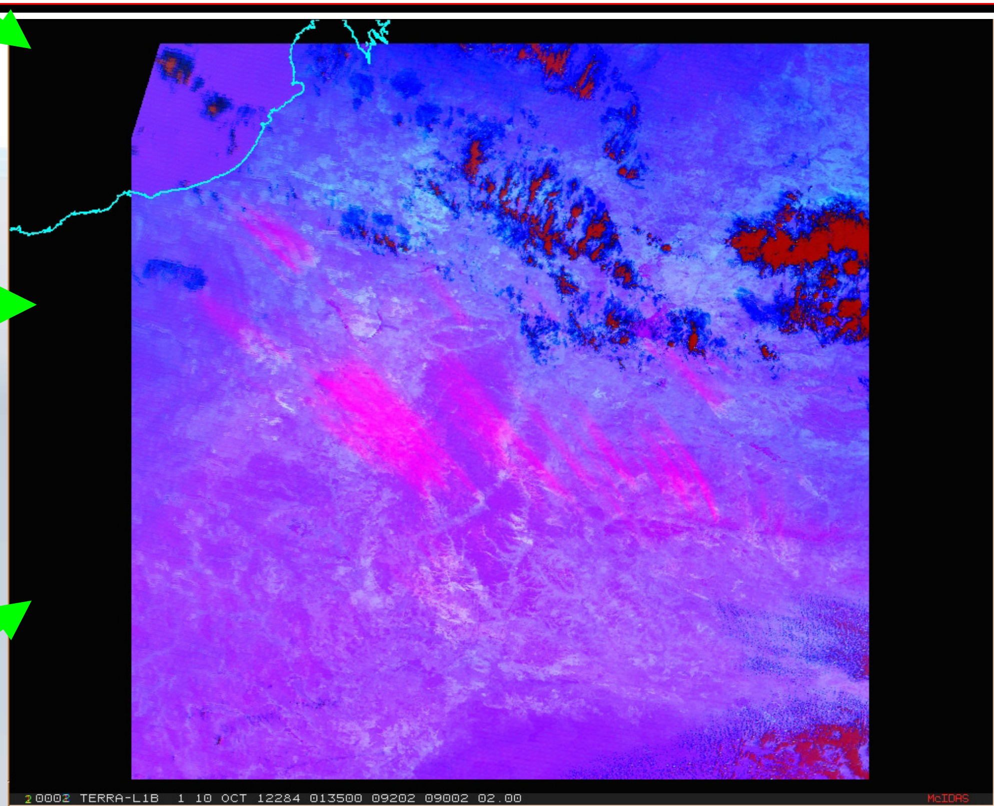
- This product reveals atmospheric dust as bright pink (strong red and blue components).

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

Recommended Range and Enhancement:

Beam	Channel	Range	Gamma	Gamma2
Red	IR12.0 - IR10.8	-4 ... +2 K	1.0	1.0
Green	IR10.8 - IR8.7	0 ... +15 K	2.5	1.0
Blue	IR10.8	+261 ... +289 K	1.0	1.0





North-western Australia, 10 October 2012

images courtesy JMA and BOM

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

In the preceding slide you can familiarize yourself with the output of each of the beams for the Dust RGB product output of the dust storm over north-western Australia, 10 October 2012

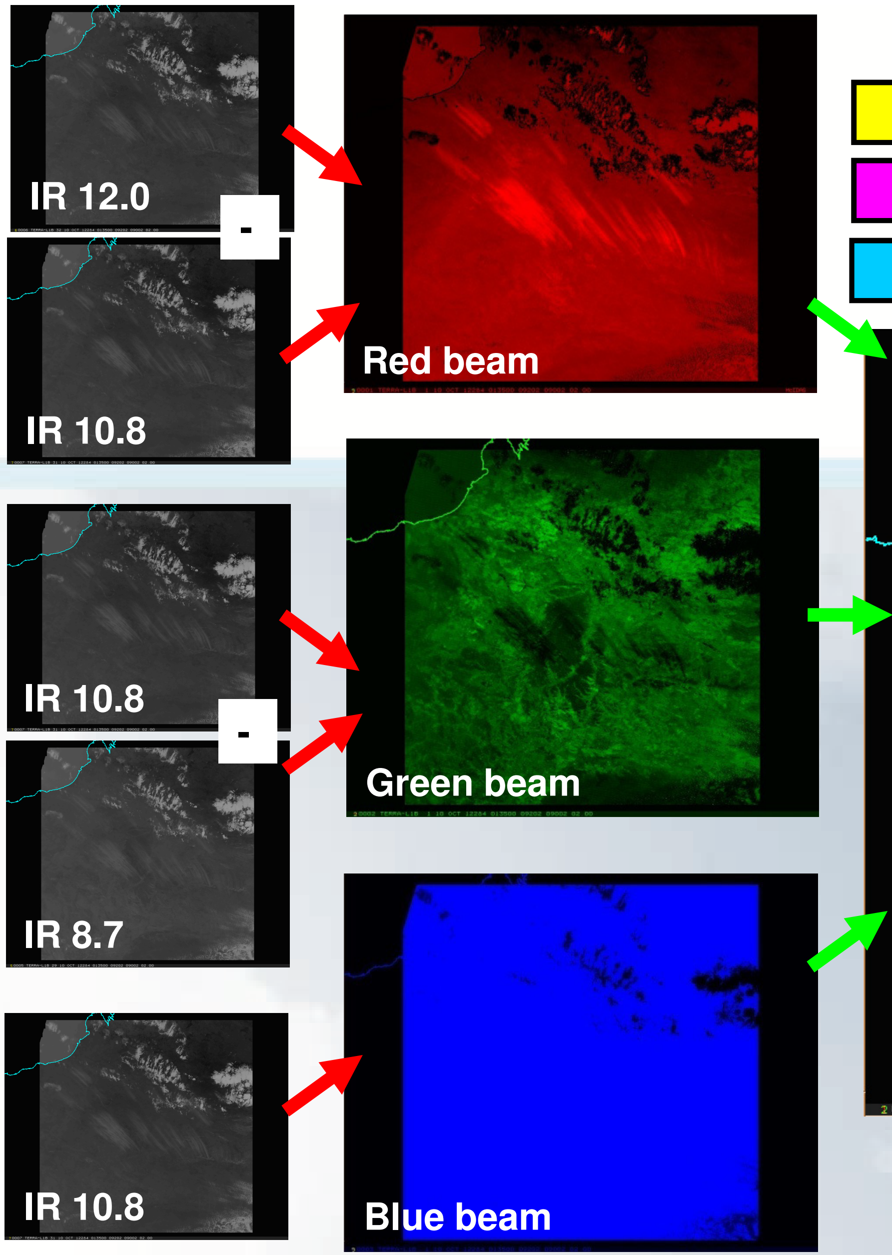
In the red beam, note the strong contribution from the dust plumes.

In the green beam, note the strong contribution from the sandy desert surface. Note the lack of a signal from the dust plumes.

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

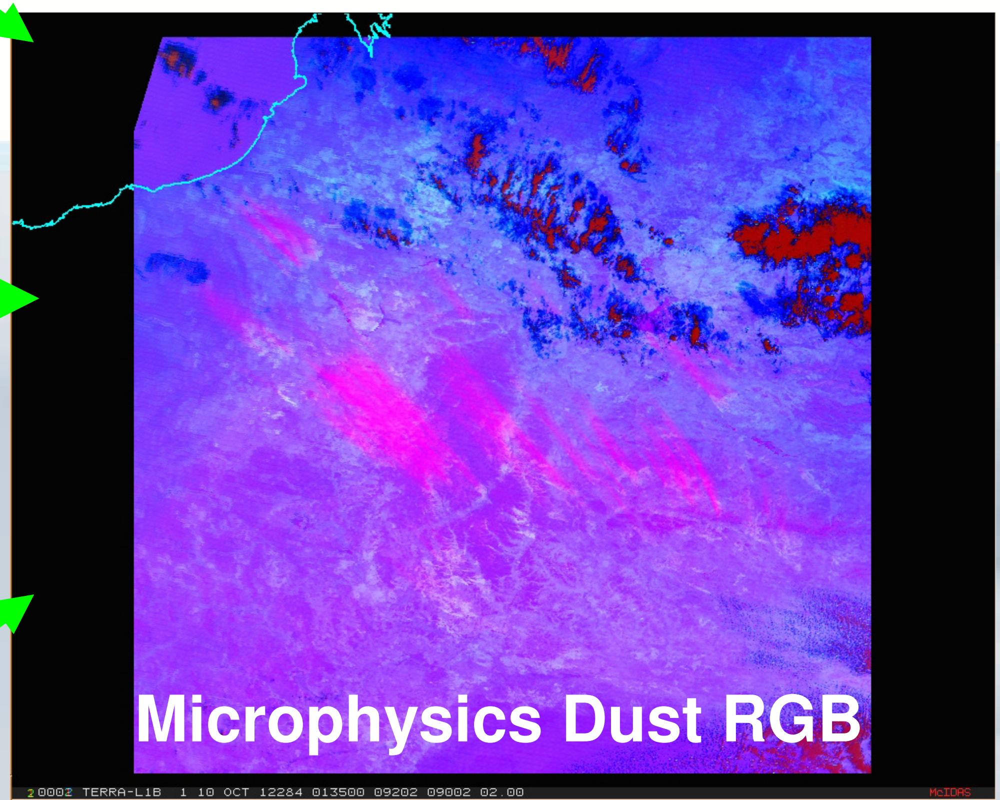
The next slide shows the effect of combining two beams.

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



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

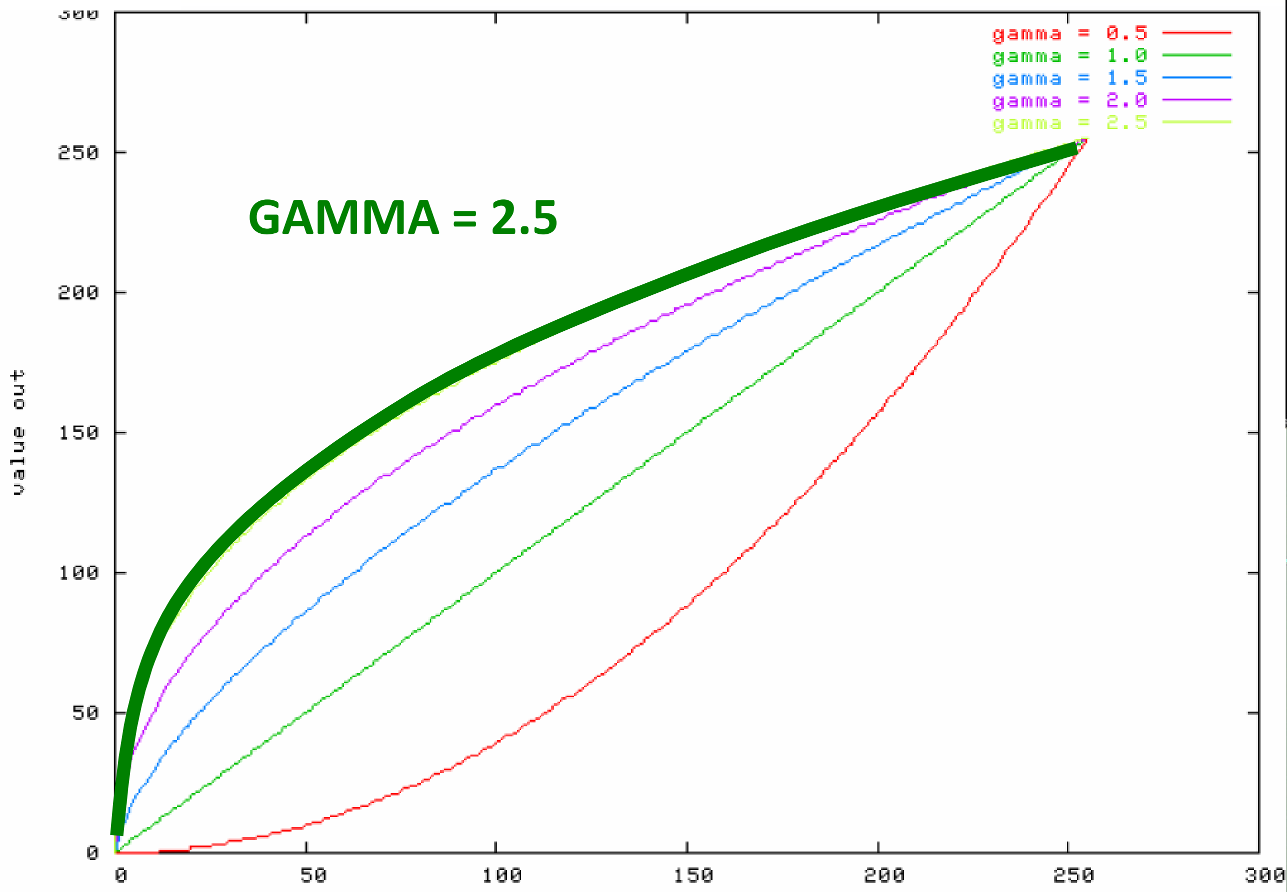


North-western Australia, 10 October 2012

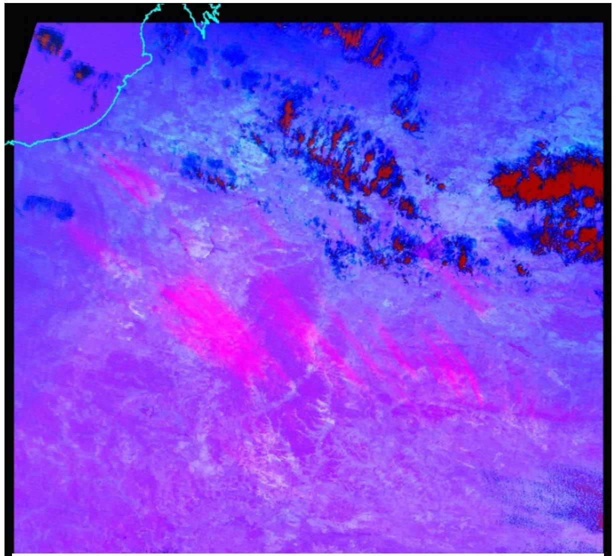
images courtesy JMA and BOM

GAMMA Correction applied

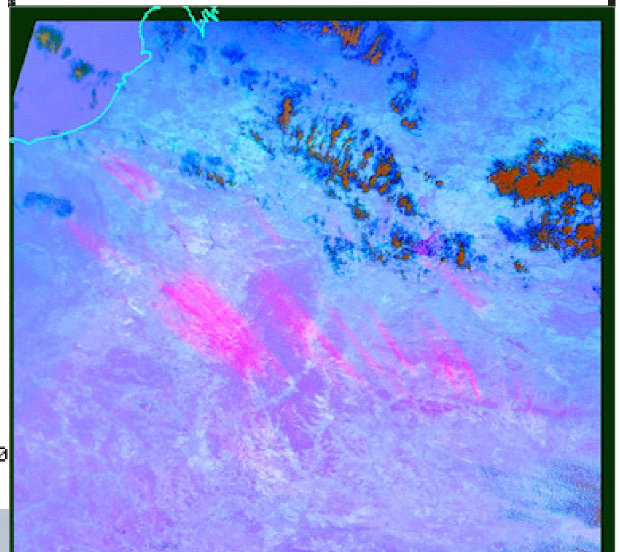
VALUE OUT



VALUE IN



Before GAMMA correction



After GAMMA correction

The GAMMA enhancement. GAMMA=2.5 applied to a Dust RGB enhancement over South Australia. Top, without GAMMA, bottom with GAMMA = 2.5.

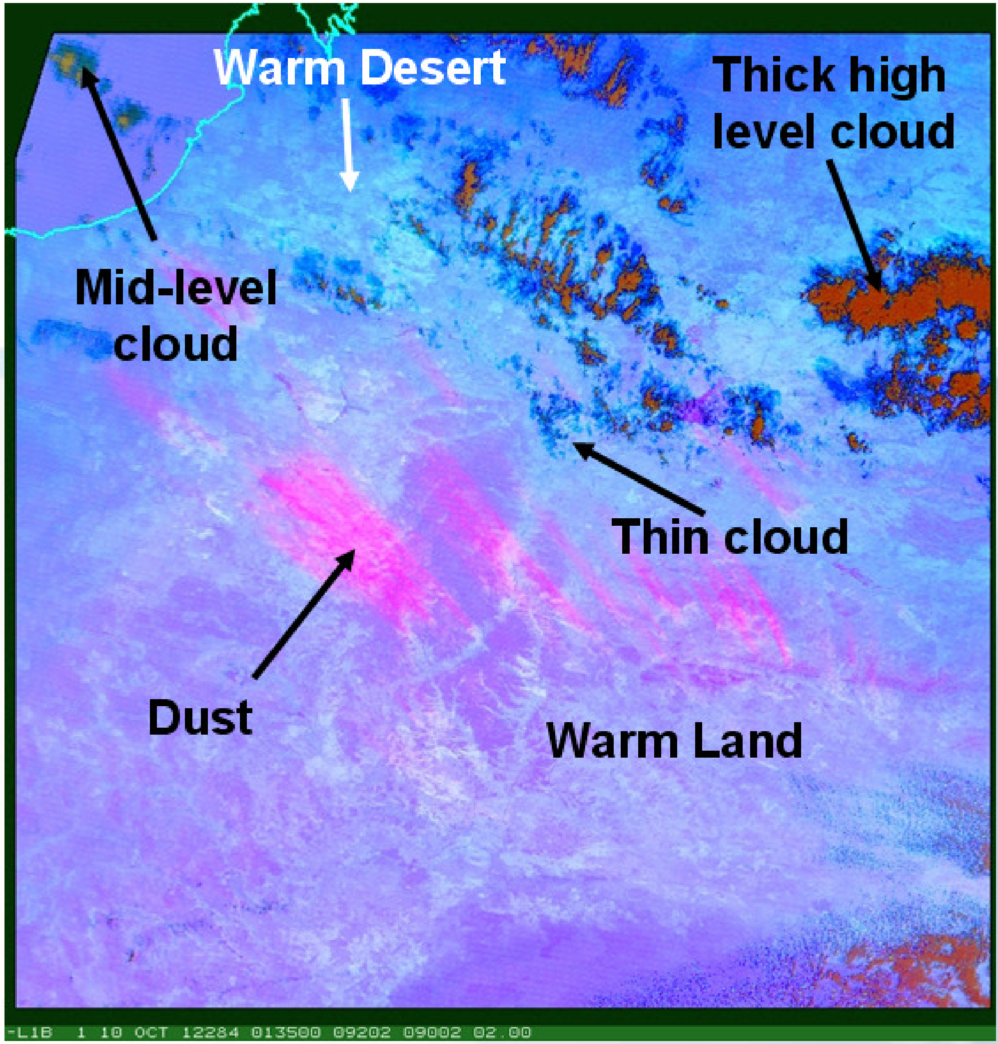
Dust

GAMMA Correction applied

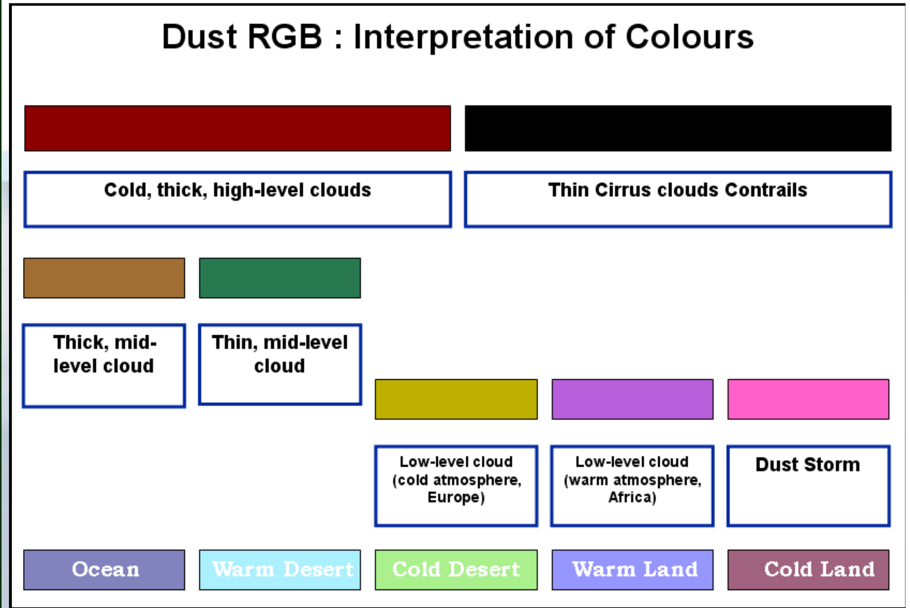
- The Gamma correction changes the linear spreading of a selected range of pixel values over the full intensity scale to a convex (GAMMA < 1) or concave (GAMMA >1) curve.
- The GAMMA correction enhances the contrast of the higher (GAMMA < 1) or lower parts (GAMMA >1) of the pixel values in an image.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

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

What the different colours in the RGB product mean



North-western Australia, 10 October 2012

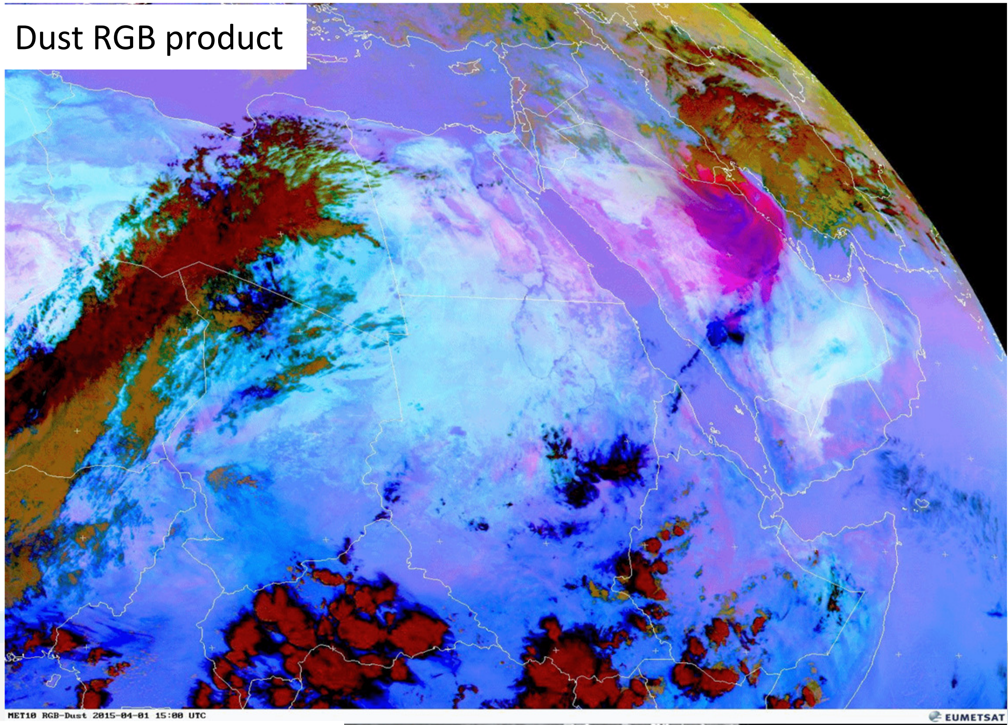


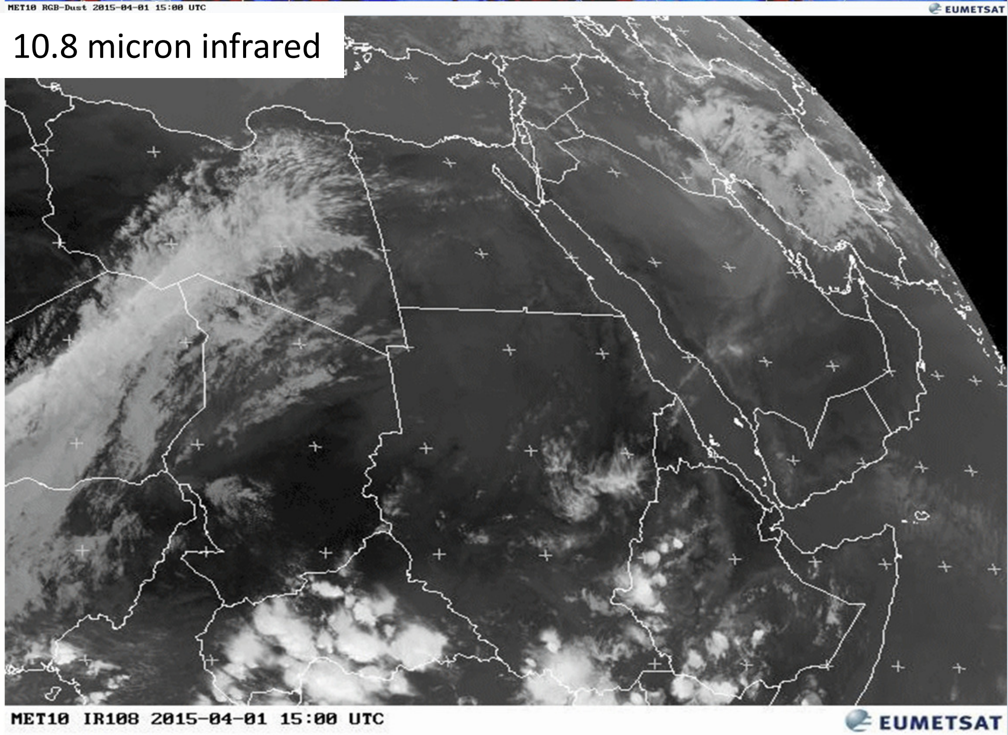
High-level / Mid-level / Low level Cloud / earth surface palette exercises.

Examine the next two slides and see if you can identify the various features in the Dust RGB product for the great dust storm event over the Middle East of the 1st April 2015.

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

Also examine the third slide which shows the Dust RGB product, the true colour visible image and the infrared image from Terra/MODIS of the great Chinese dust storm of the 12th March 2010. See if you can identify the various features shown in the RGB palette.

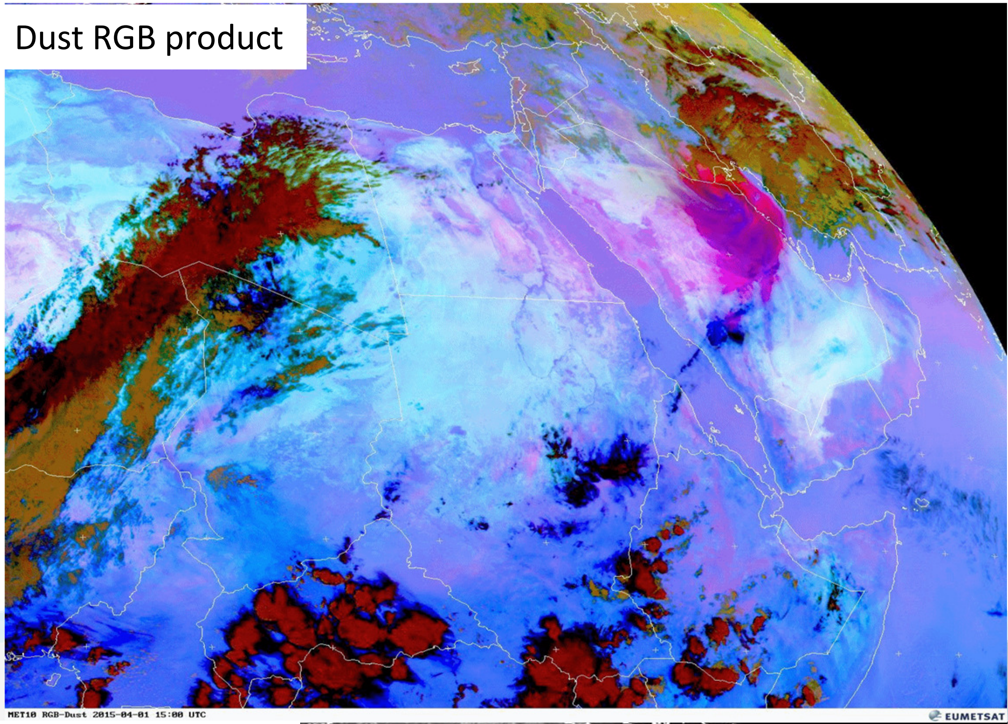


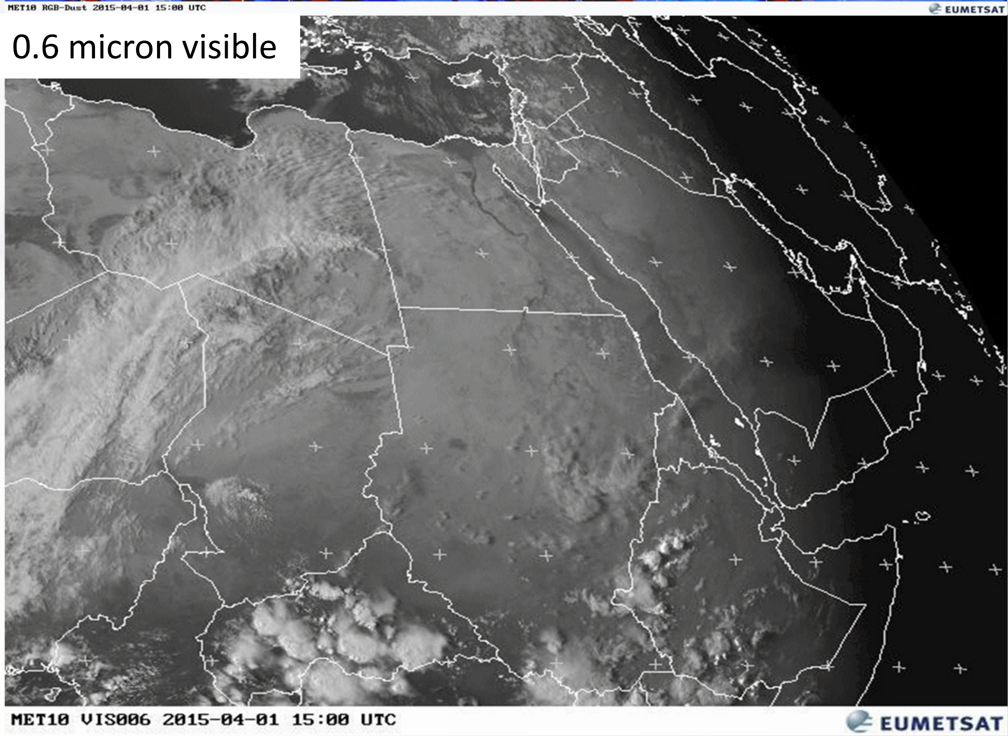


Dust RGB product compared to the infrared image – please annotated features

(green) Thin, mid-level cloud	(pink) Dust Storm
(dark red) Cold, thick, high-level clouds	(brown) Thick, mid-level cloud
Cold Desert	Warm Land
Ocean	Warm Desert

North Africa and Middle East
15UTC, 1 April 2015
Images courtesy EUMETSAT



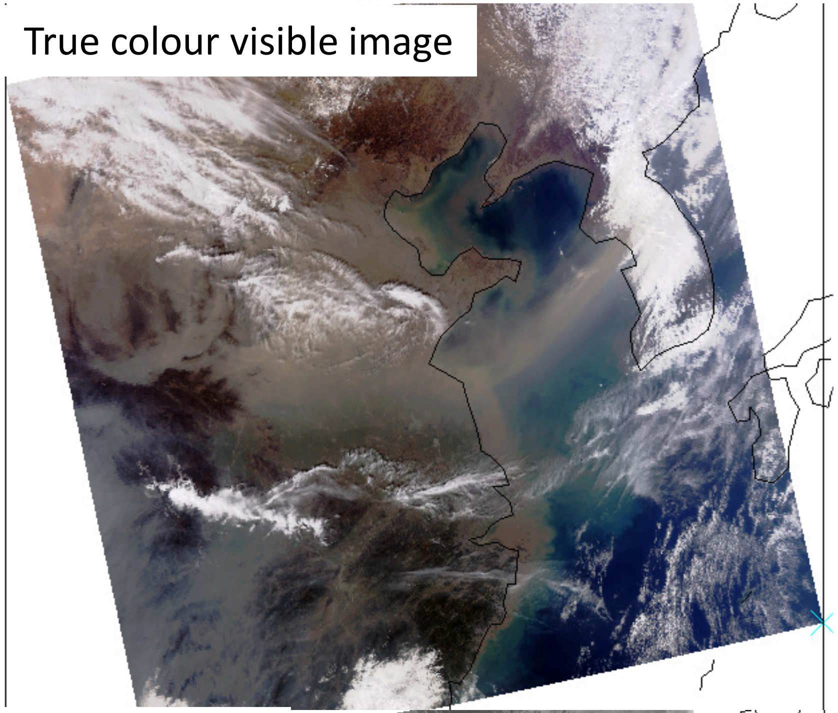


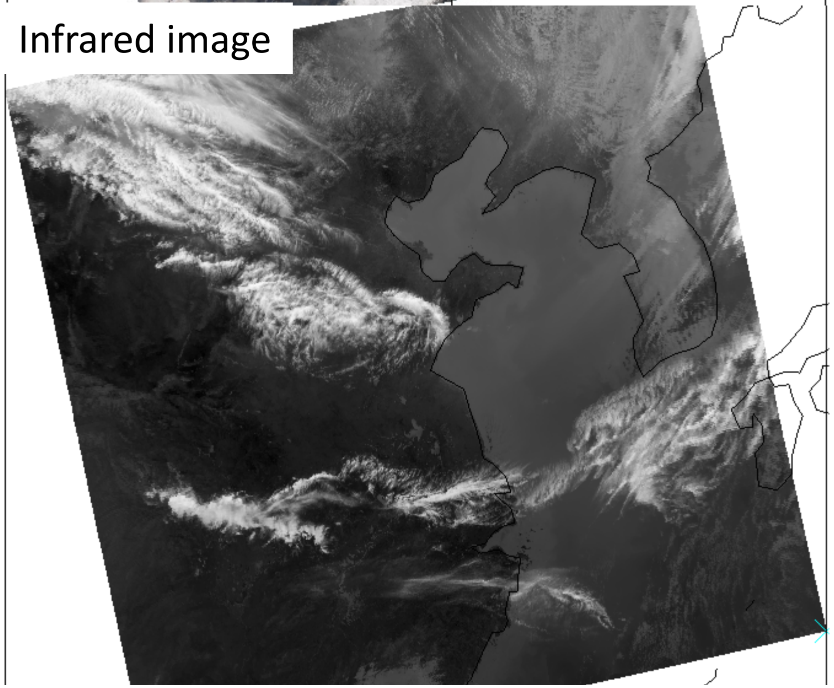
Dust RGB product compared to the visible image – please annotated features

Thin, mid-level cloud	Dust Storm
Cold, thick, high-level clouds	Thick, mid-level cloud
Cold Desert	Warm Land
Ocean	Warm Desert

North Africa and Middle East
15UTC, 1 April 2015
Images courtesy EUMETSAT

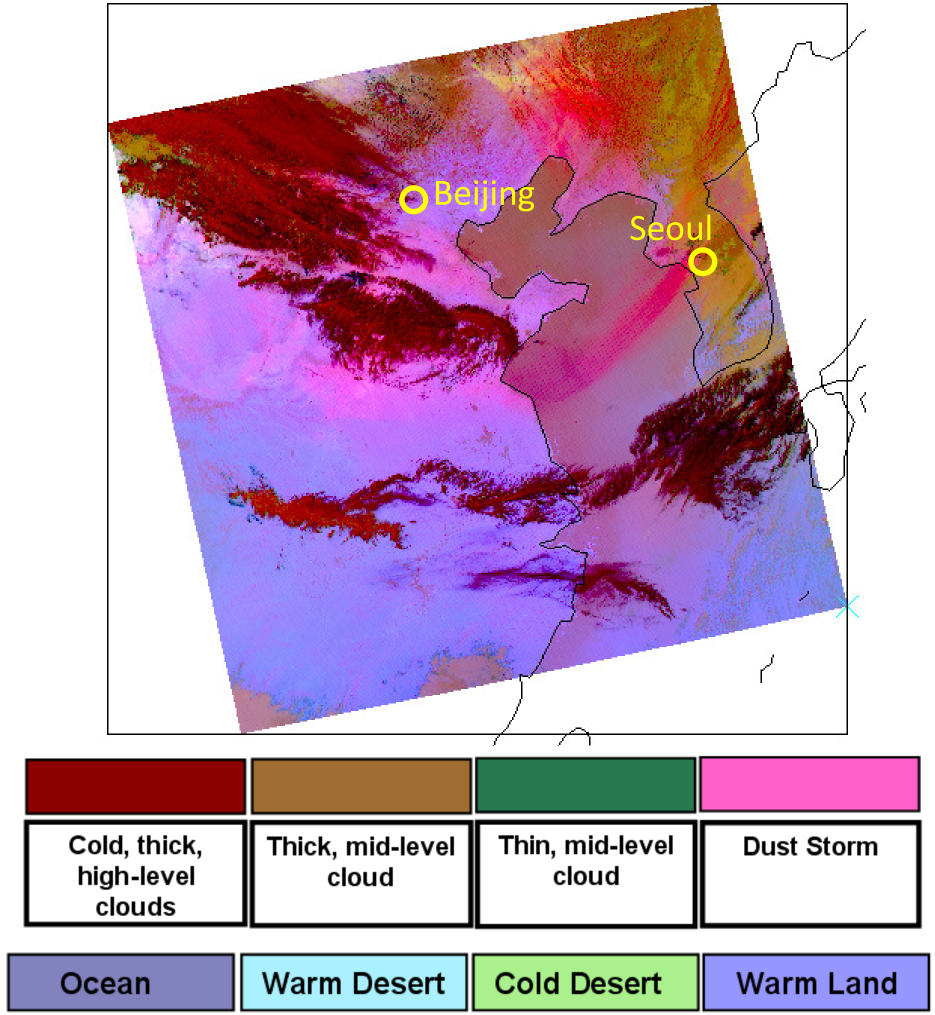
Dust RGB product compared to the true colour visible and infrared images – please annotated features





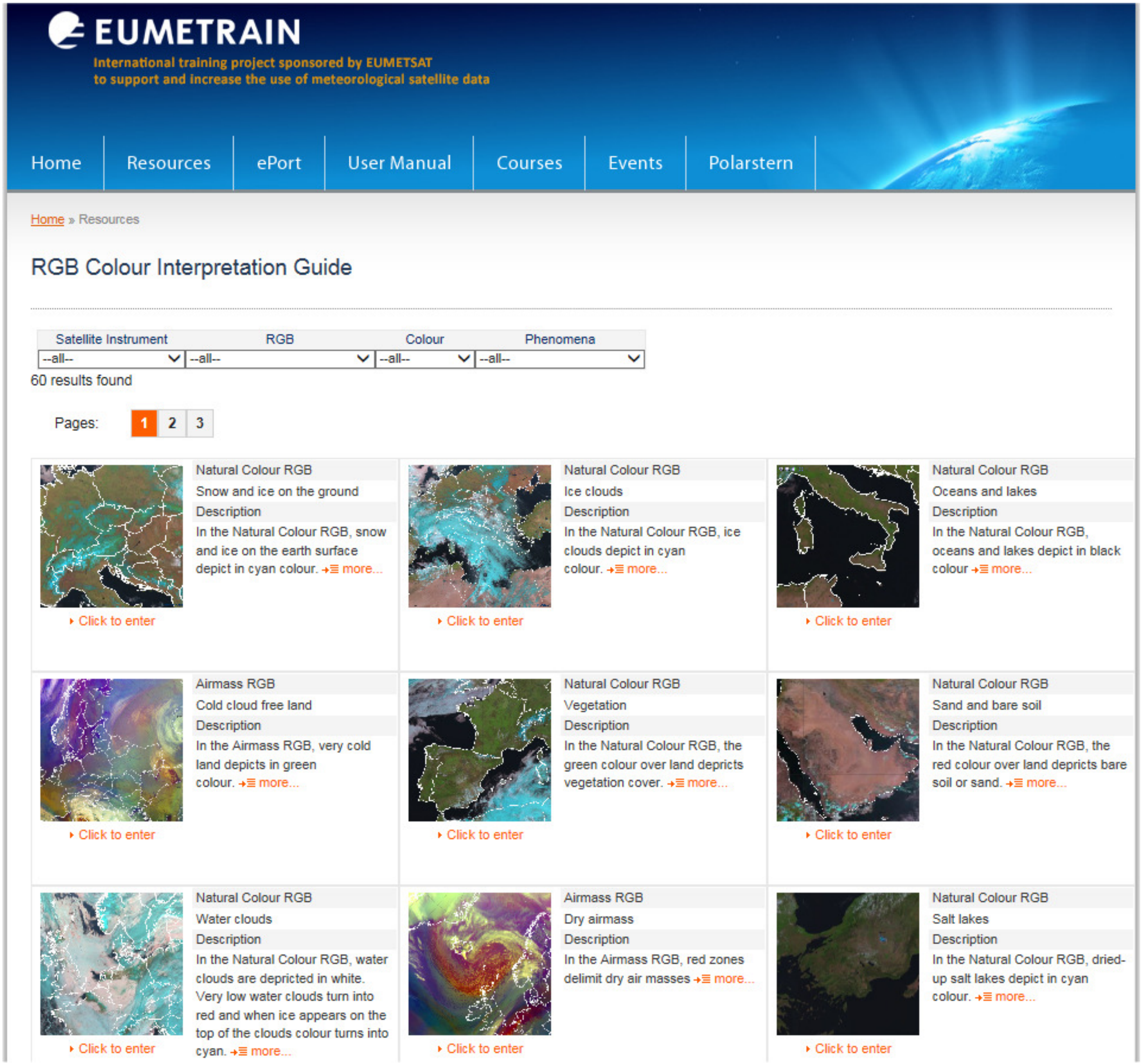
images courtesy NASA/EOSDIS/Lance Rapid Response

Chinese dust storm Terra/MODIS March 12 2010, 0520UTC



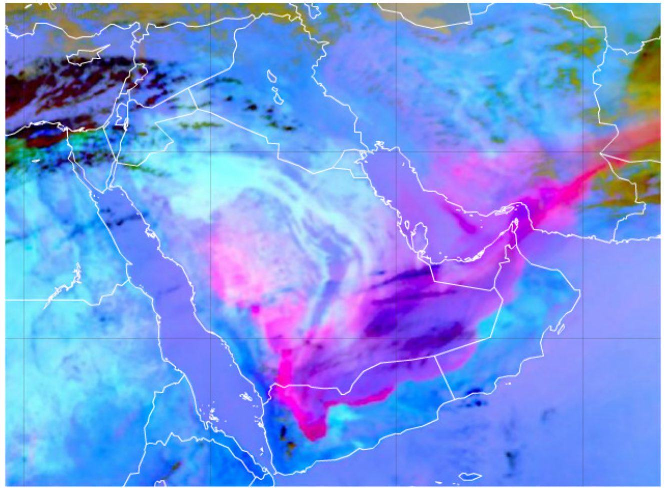
Very useful website for reference – the EUMETRAIN RGB Colour Interpretation Guide

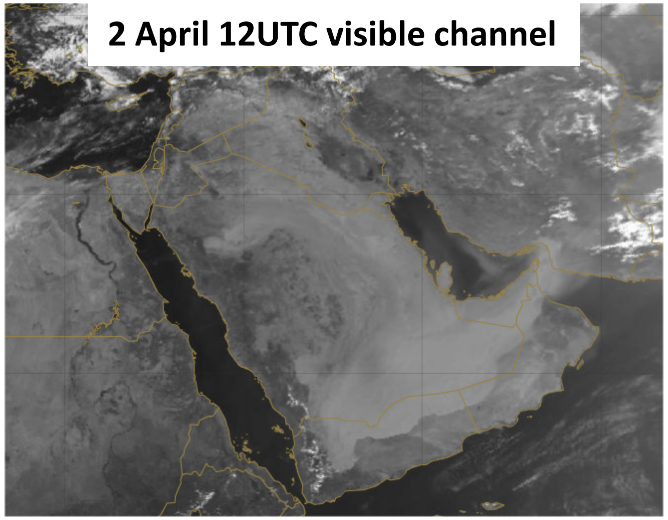
http://www.eumetrain.org/RGBguide/rgbs.html



Variations in the Dust RGB – variations in the product due to diurnal cycle, height and thickness of dust.

2 April 12UTC Dust RGB – Middle East





2 April 12UTC visible channel

Exercise: match the dust cloud types to the signal in the RGB image

- Thin Dust Clouds -

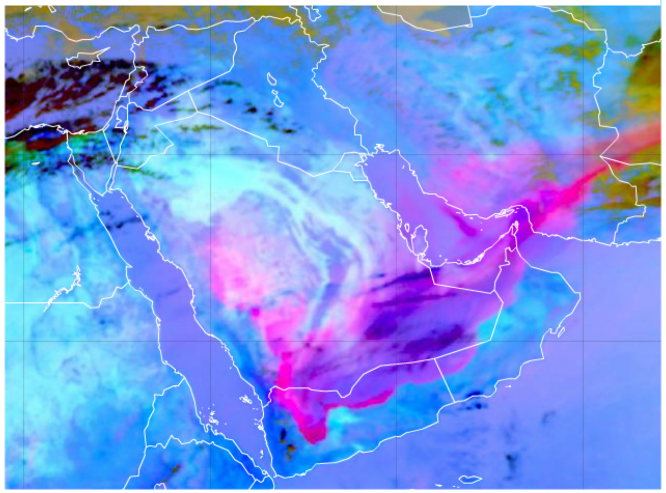
	Night	Day
High (4-5 km)	A	D
Mid (2-3 km)	B	D
Low (0-1 km)	B	D

- Very Thick Dust Clouds -

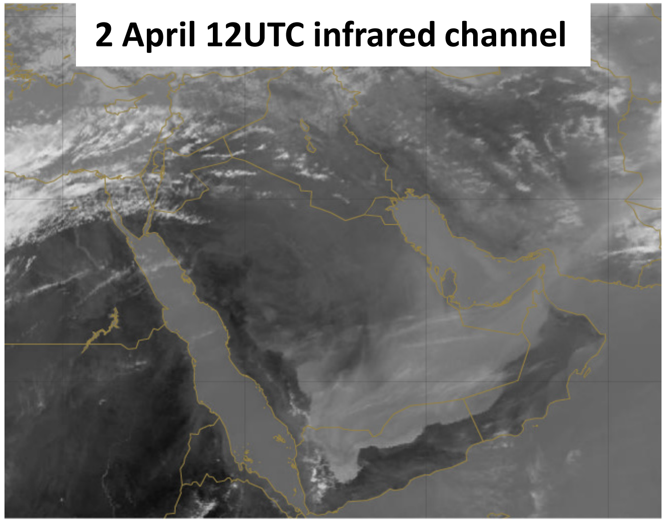
	Night	Day
High (4-5 km)		
Mid (2-3 km)		
Low (0-1 km)	C	E

Variations in the Dust RGB – variations in the product due to diurnal cycle, height and thickness of dust.

2 April 12UTC Dust RGB – Middle East



2 April 12UTC infrared channel



Exercise: match the dust cloud types to the signal in the RGB image

- Thin Dust Clouds -

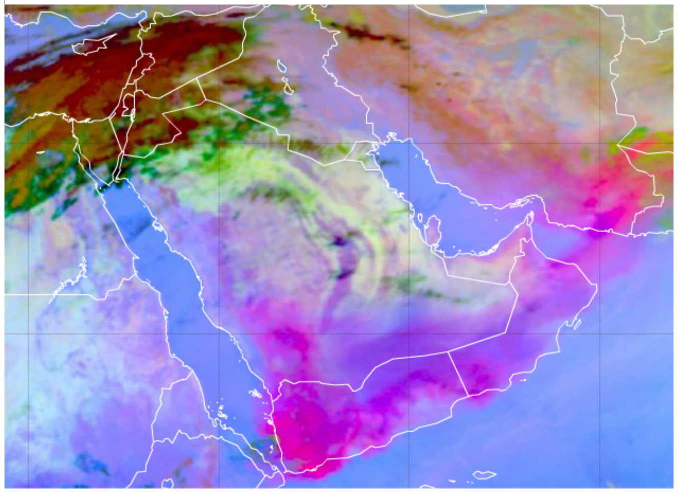
	Night	Day
High (4-5 km)	A	D
Mid (2-3 km)	B	D
Low (0-1 km)	B	D

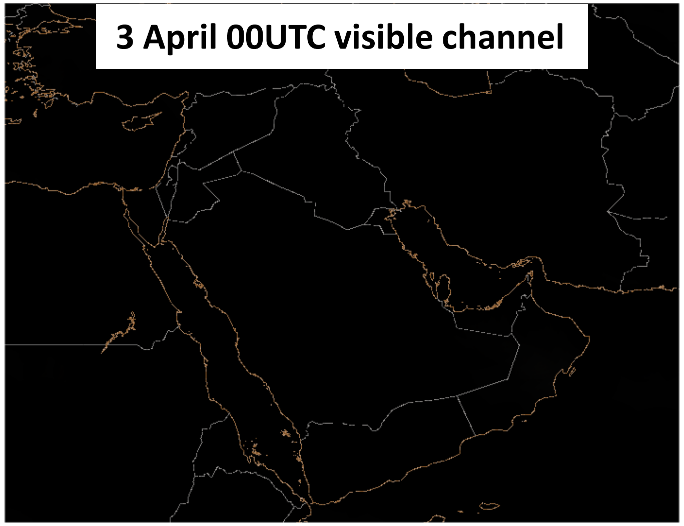
- Very Thick Dust Clouds -

	Night	Day
High (4-5 km)		
Mid (2-3 km)		
Low (0-1 km)	C	E

Variations in the Dust RGB – variations in the product due to diurnal cycle, height and thickness of dust.

3 April 00UTC Dust RGB – Middle East





3 April 00UTC visible channel

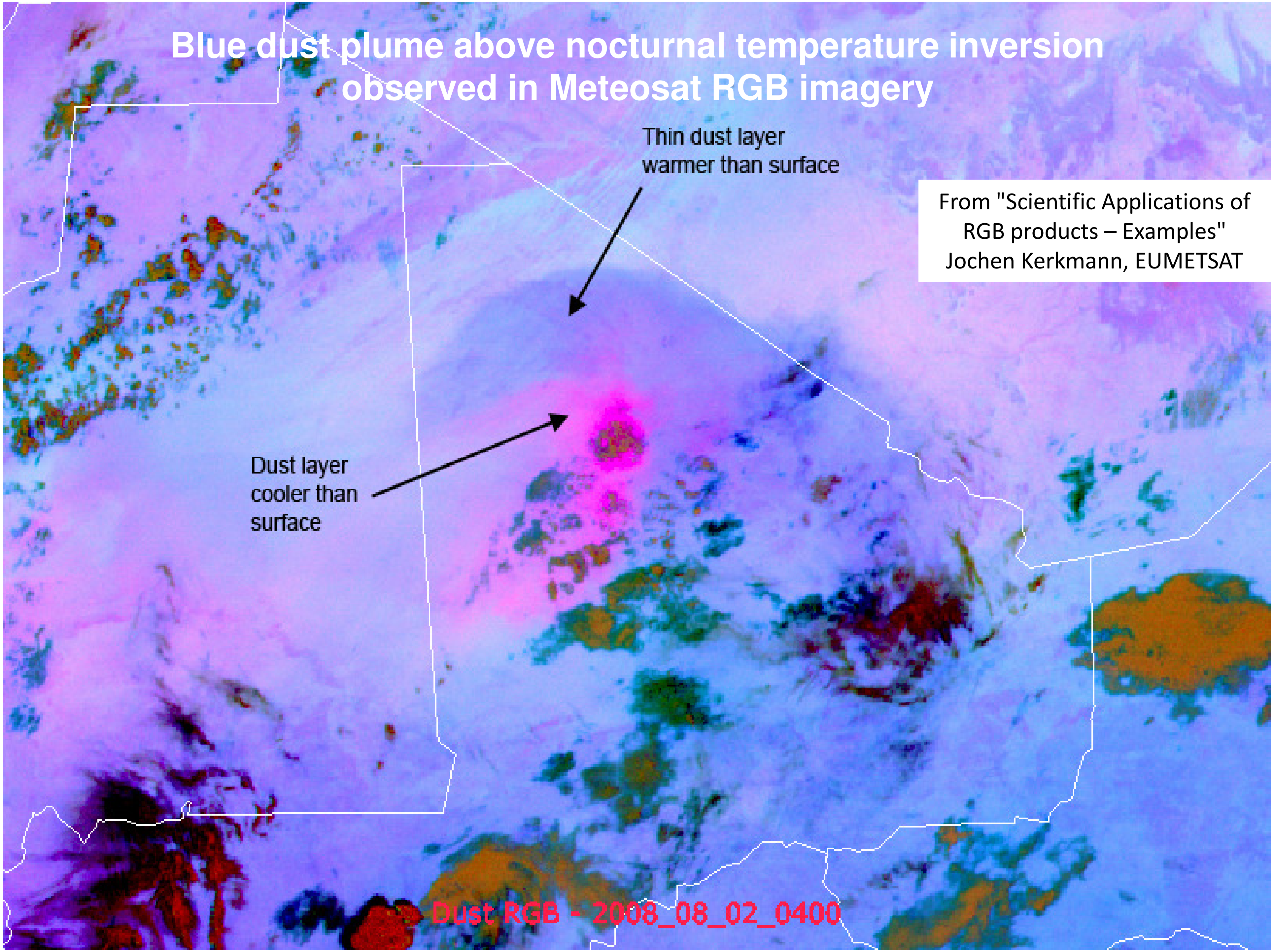
Exercise: match the dust cloud types to the signal in the RGB image

- Thin Dust Clouds -

	Night	Day
High (4-5 km)	A	D
Mid (2-3 km)	B	D
Low (0-1 km)	B	D

- Very Thick Dust Clouds -

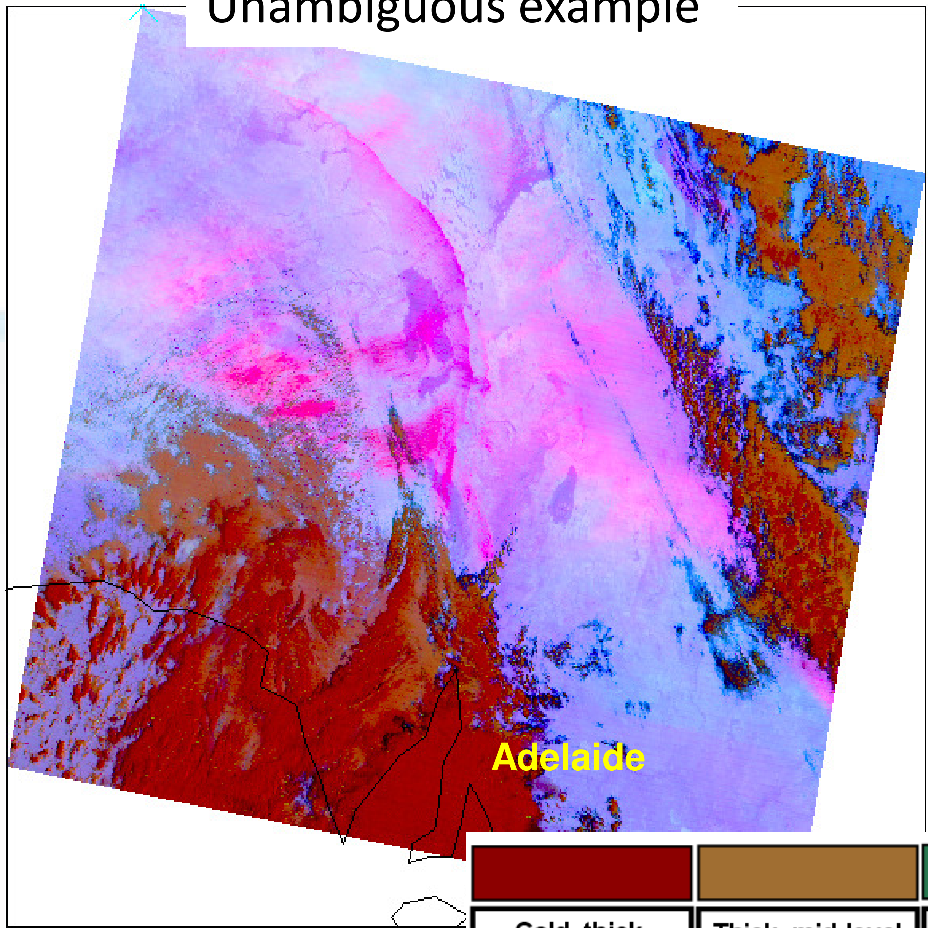
	Night	Day
High (4-5 km)		
Mid (2-3 km)		
Low (0-1 km)	C	E



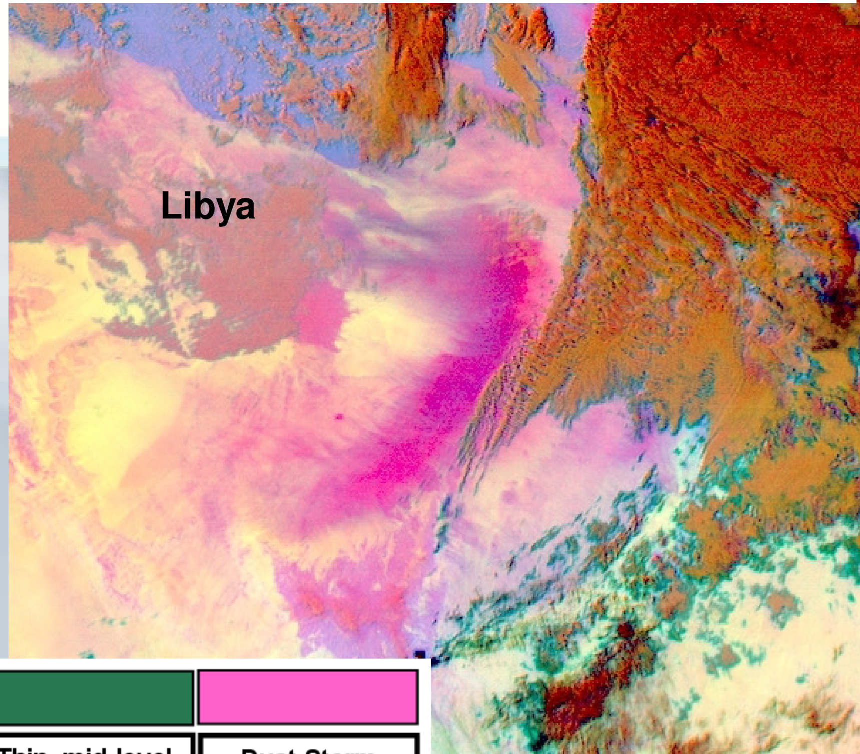
Blue dust plume above nocturnal temperature inversion observed in Meteosat RGB imagery
Thin dust layer warmer than surface
From "Scientific Applications of RGB products – Examples" Jochen Kerkmann, EUMETSAT
Dust layer cooler than surface
Dust RGB - 2008_08_02_0400

Limitations in the Dust RGB – simple versus ambiguous examples.

Unambiguous example



Complicated – difficult to discriminate between dust and surface features



Cold, thick, high-level clouds	Thick, mid-level cloud	Thin, mid-level cloud	Dust Storm

Ocean	Warm Desert	Cold Desert	Warm Land

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

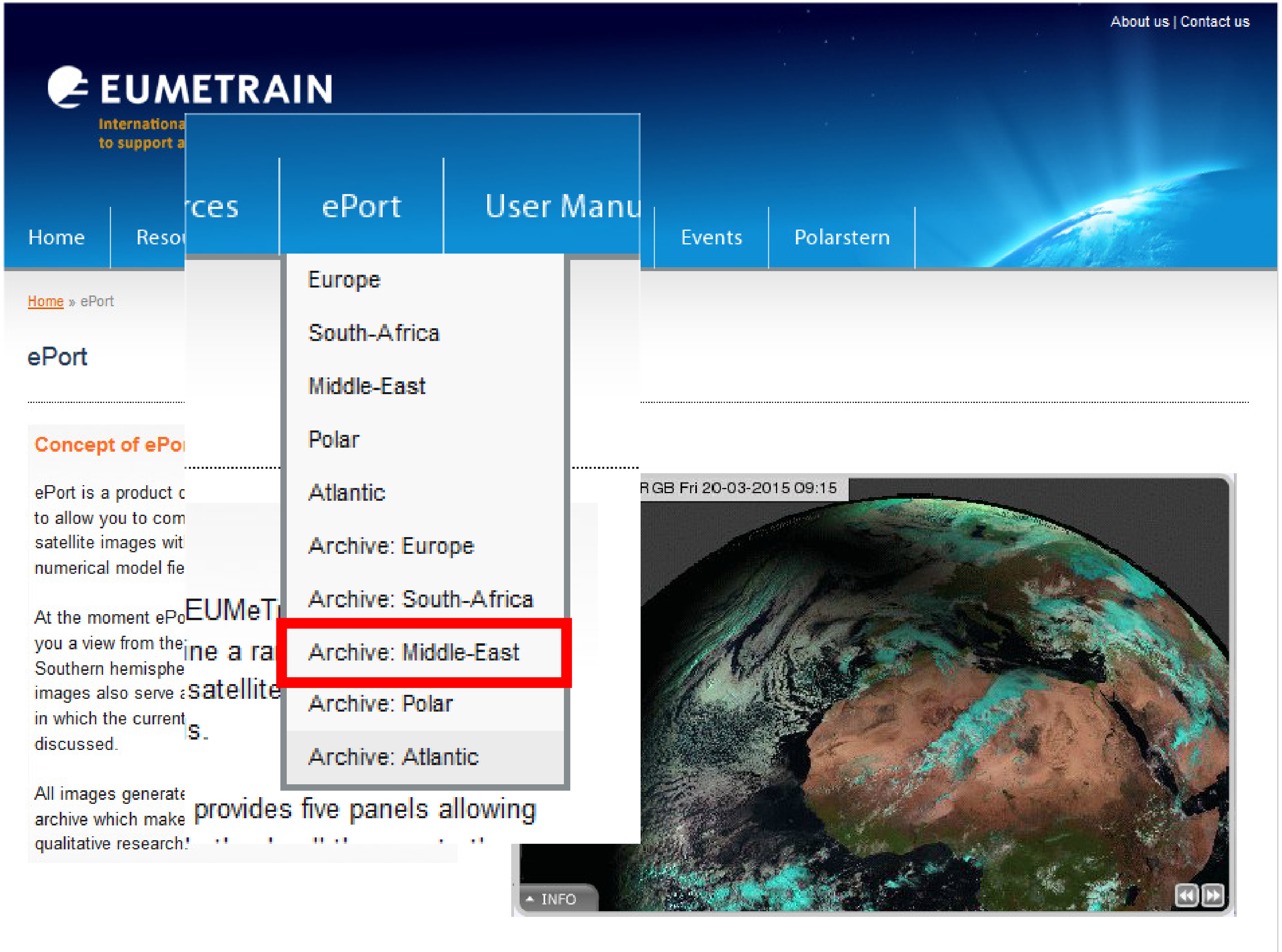
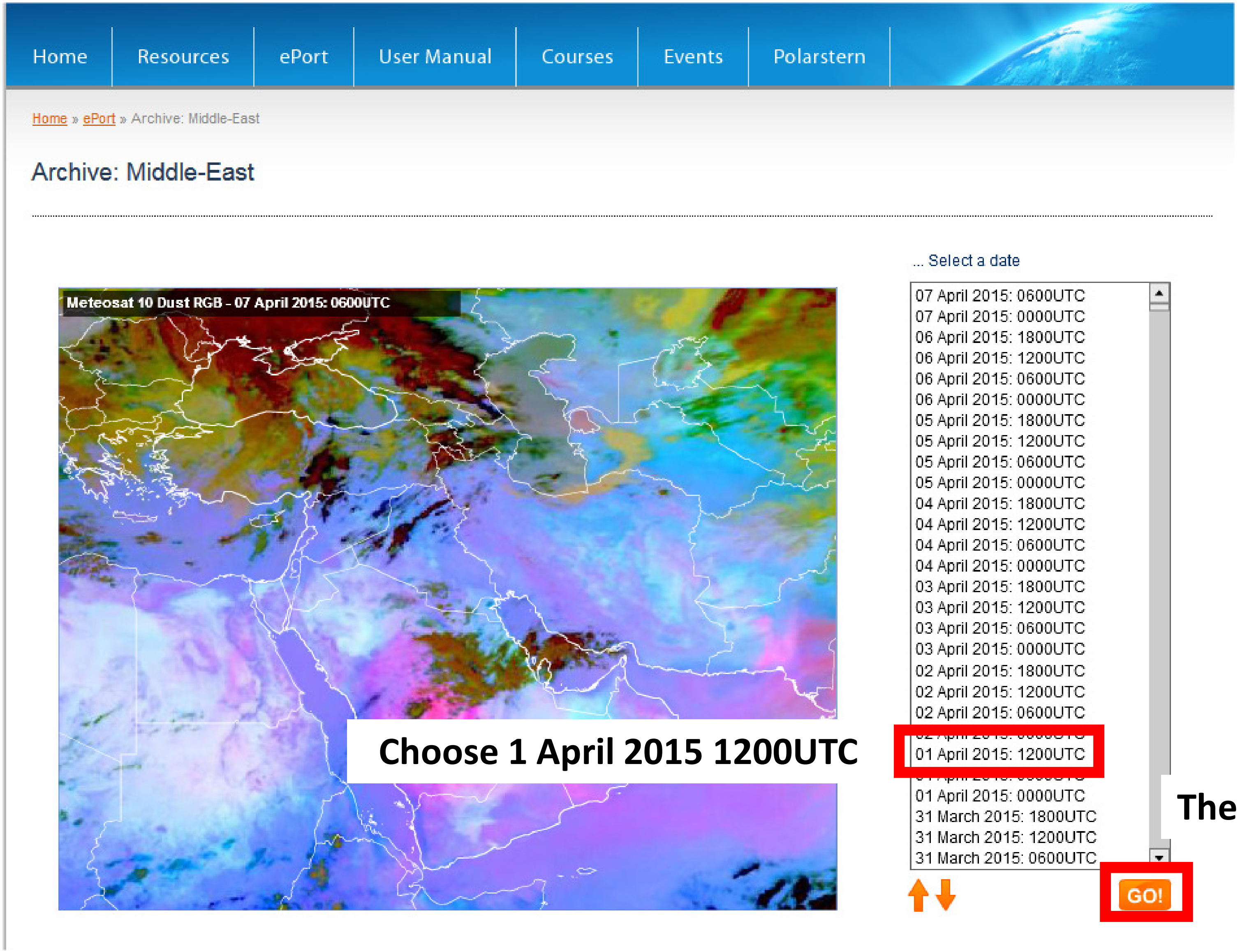


image courtesy EUMETSAT

Activity: Looking at the dust storm at the time of its formation ePort – Archive: Middle-East



Choose 1 April 2015 1200UTC

Then "GO"

image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort

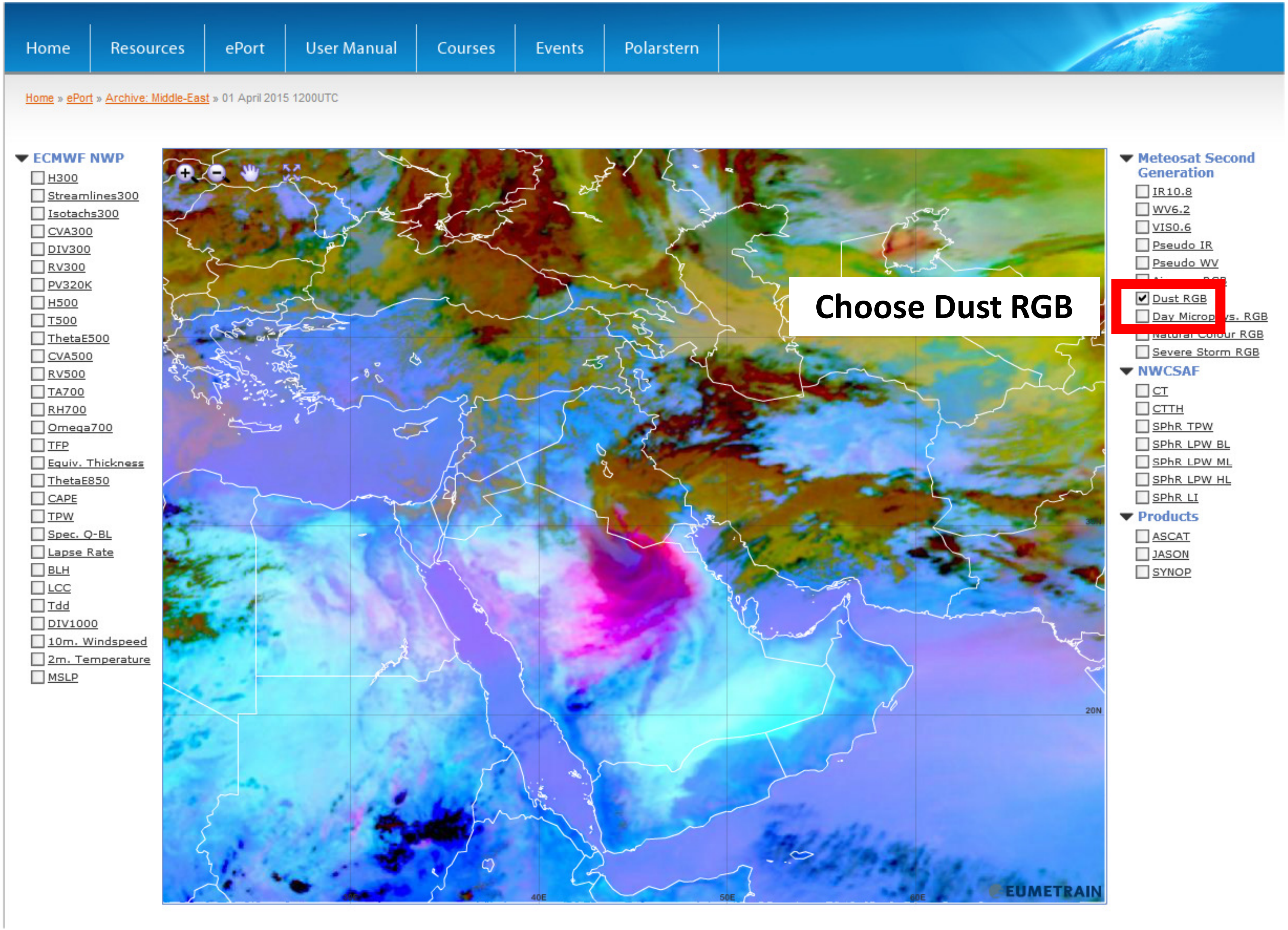
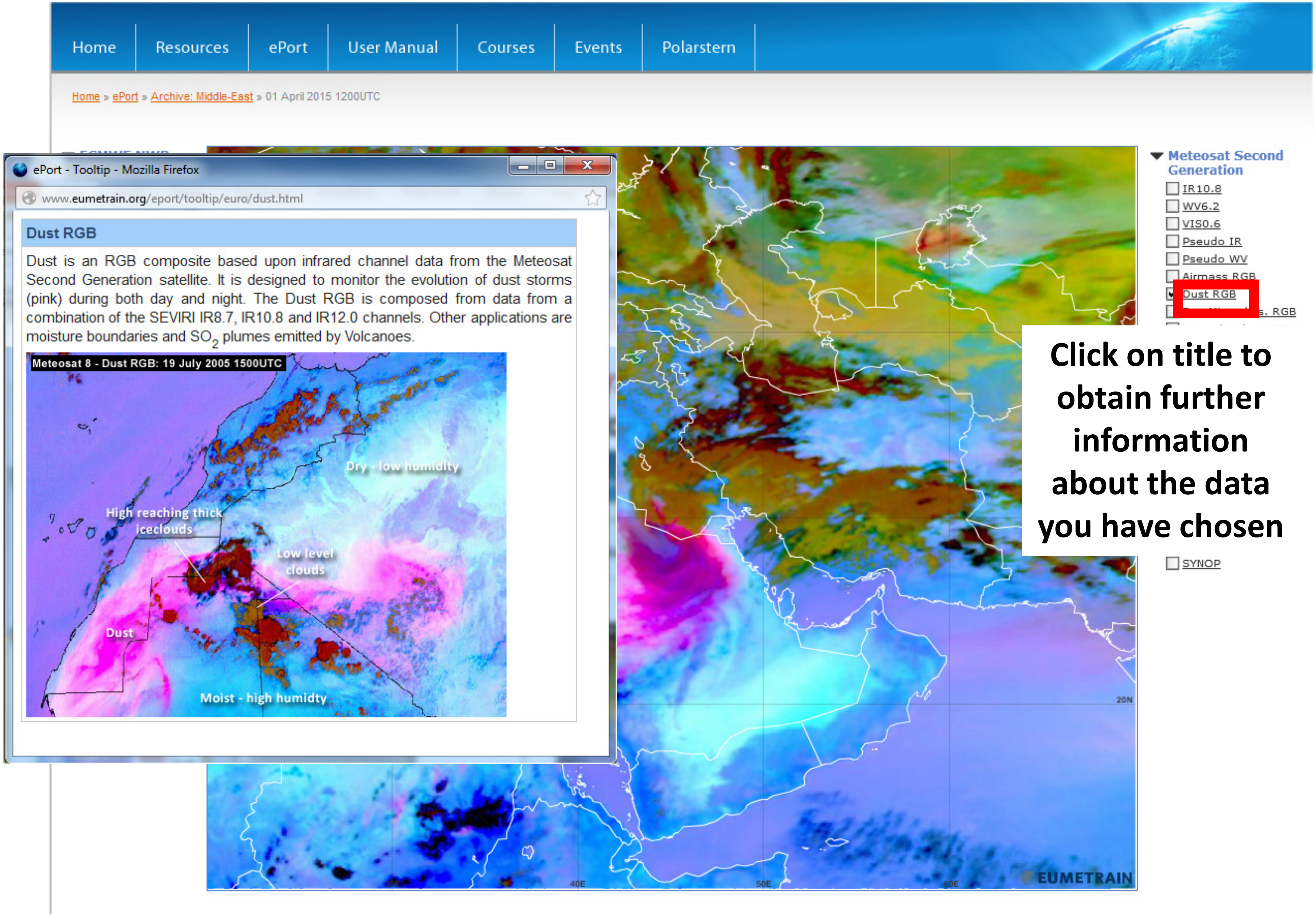
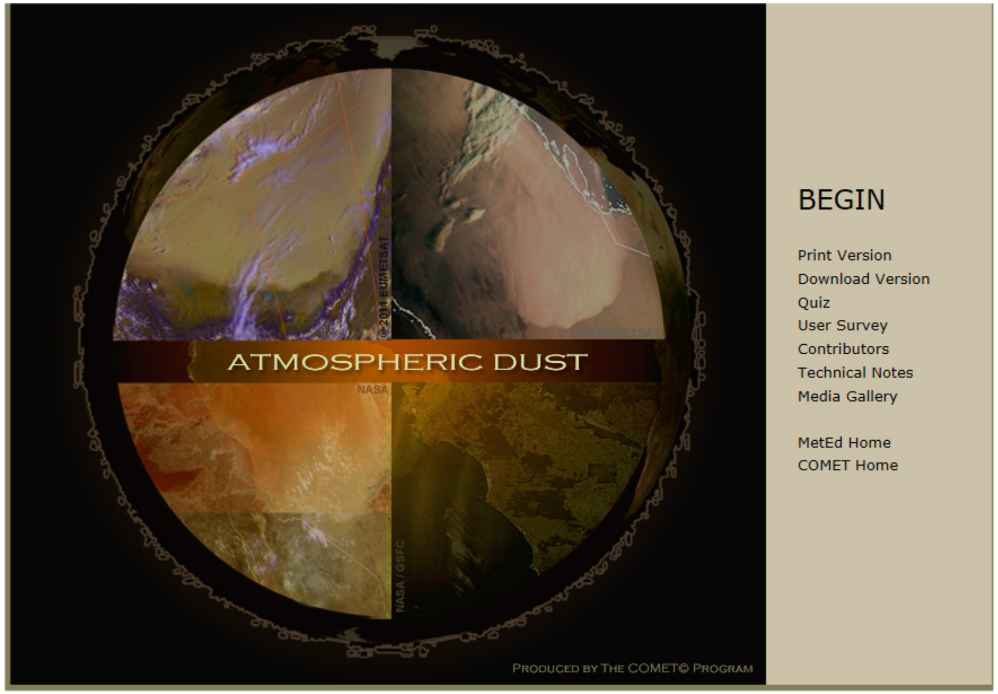


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort



COMET resources used here



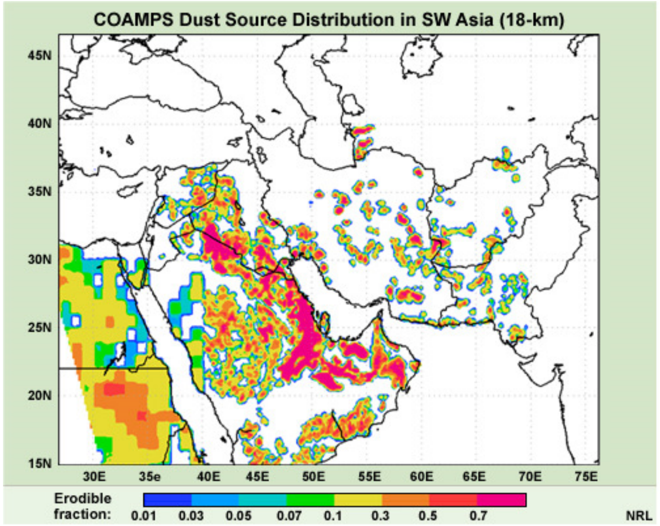
http://www.meted.ucar.edu/mesoprim/dust/index.htm

https://www.meted.ucar.edu/EUMETSAT/at_dust/

Especially Section II. Dust Detection and Forecasting

images courtesy COMET

Conceptual Model – requirements for dust formation
(from COMET)



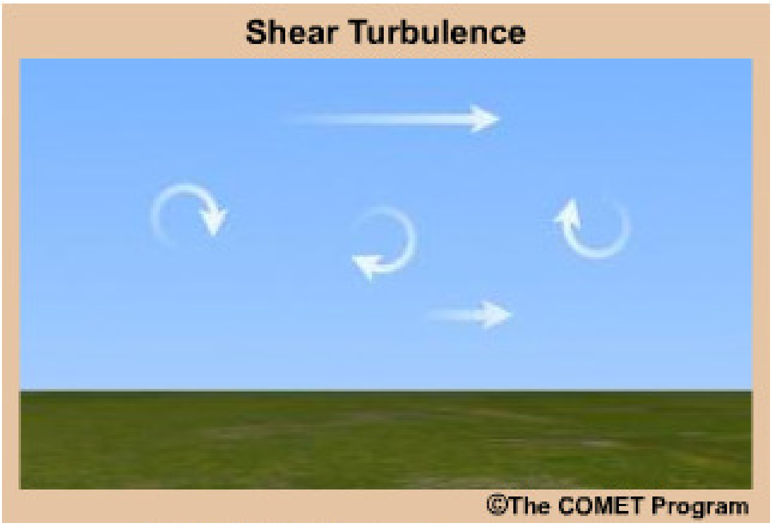
Dust Sources

Threshold Dust-Lofting Wind Speeds for Different Desert Environments

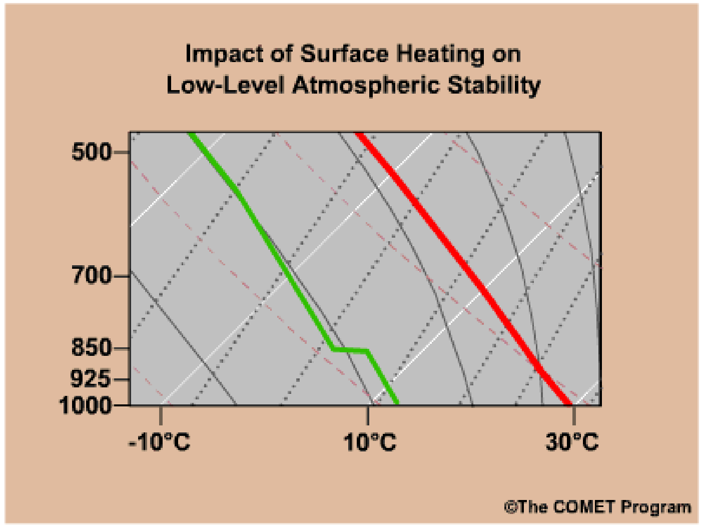
Environment	Threshold Wind Speed
Fine to medium sand in dune-covered areas	10 to 15 mph (8.7 to 13 knots)
Sandy areas with poorly developed desert pavement	20 mph (17.4 knots)
Fine material, desert flats	20 to 25 mph (17.4 to 21.7 knots)
Alluvial fans and crusted salt flats (dry lake beds)	30 to 35 mph (26.1 to 30.4 knots)
Well-developed desert pavement	40 mph (36.8 knots)

The COMET Program & NASA

Wind



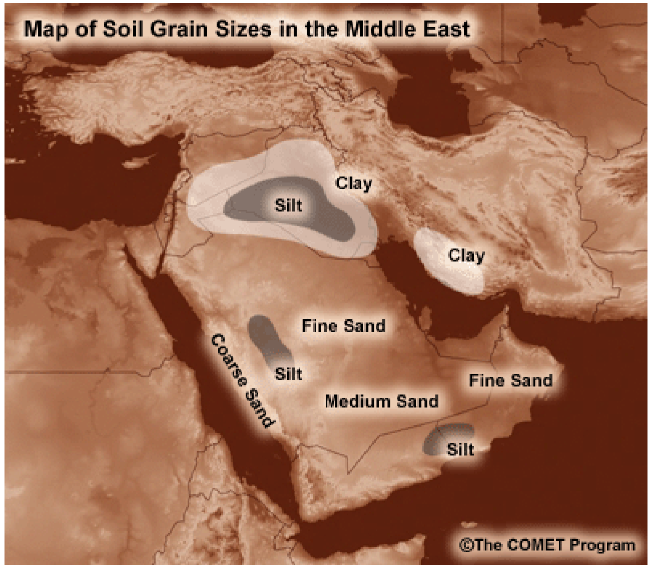
Shear Turbulence



Stability

images courtesy COMET

Conceptual Model – requirements for dust formation
(from COMET)



Dust Sources

Threshold Dust-Lofting Wind Speeds for Different Desert Environments

Environment	Threshold Wind Speed
Fine to medium sand in dune-covered areas	10 to 15 mph (8.7 to 13 knots)
Sandy areas with poorly developed desert pavement	20 mph (17.4 knots)
Fine material, desert flats	20 to 25 mph (17.4 to 21.7 knots)
Alluvial fans and crusted salt flats (dry lake beds)	30 to 35 mph (26.1 to 30.4 knots)
Well-developed desert pavement	40 mph (36.8 knots)

The COMET Program & NASA

Wind

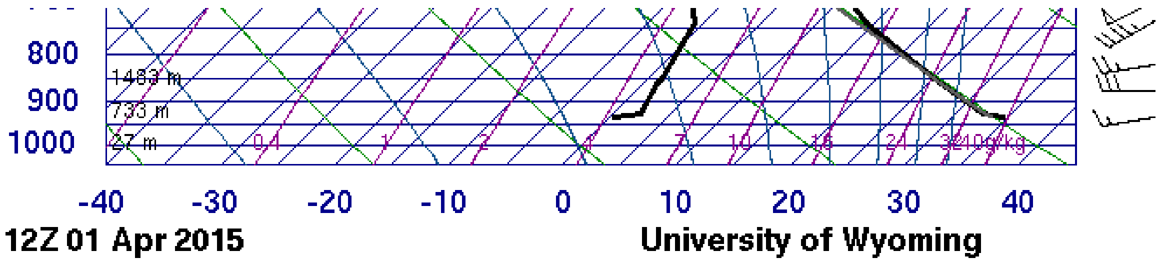
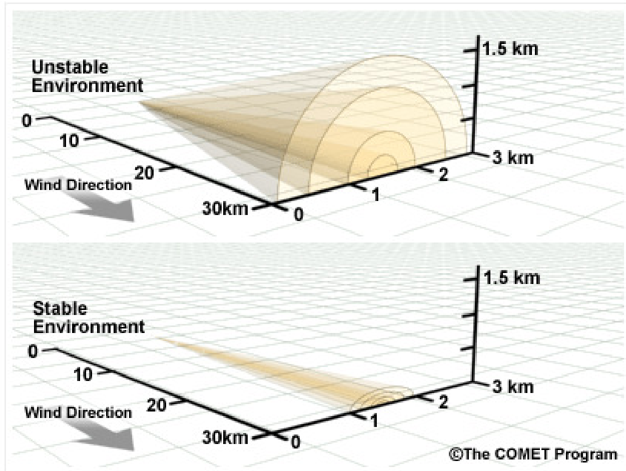


image courtesy University of Wyoming



This graphic shows dust plumes dispersing under both stable and unstable conditions.

Shear Turbulence

Stability

Conceptual Model – requirements for dust formation

(from http://www.meted.ucar.edu/mesoprim/dust/print.htm) **– Notes (1)**

Dust Sources

- Source regions for dust storms have fine grained soils rich in clay and silt.
- The low-lying regions of the eastern Arabian Peninsula, southern Syria, and western Iraq are particularly prone to dust storm generation because prevailing west/northwesterly winds are unimpeded by higher terrain.
- The region, these fine-grained soils are found in areas with dry lake beds and river flood plain deposits.
- Using TOMS AI to identify dust source regions, Prospero et. al., 2001 hypothesized that dust sources are associated with topographical lows and depressions.
- Cataloguing the individual point sources in dust enhancement products has led to the development of the NRL high-resolution (1-km) Dust Source Database (DSD).
- This plot shows the NRL 1-km dust sources averaged on an 18-km grid where the grid erodible fraction varies from 0 (non-erodible or non-dust producing) to 1.0 (completely erodible and dust producing).

Conceptual Model – requirements for dust formation

(from http://www.meted.ucar.edu/mesoprim/dust/print.htm) – Notes (2)

Wind

- The first sand and dust particles to move are those from 0.08 to 1 mm in diameter. This occurs with wind speeds of 10 to 25 knots.
- As a rule of thumb, winds at the surface need to be 15 knots or greater to mobilize dust. The table shows the wind speeds required to lift particles in different source environments.
- Once a dust storm starts, it can maintain the same intensity even when wind speeds slow to below initiation levels. That's because the bond between the dust particles and the surface is broken and saltation (small particles move forward through a series of jumps or skips) allows dust to lift.

Shear Turbulence

- Typically, wind shear creates the turbulence and horizontal roll vortices that loft dust up and away from the surface. As a rule of thumb, if the wind at the surface is blowing 15 knots, the wind at 1,000 feet (305 meters) must be about 30 knots to keep the dust particles aloft.

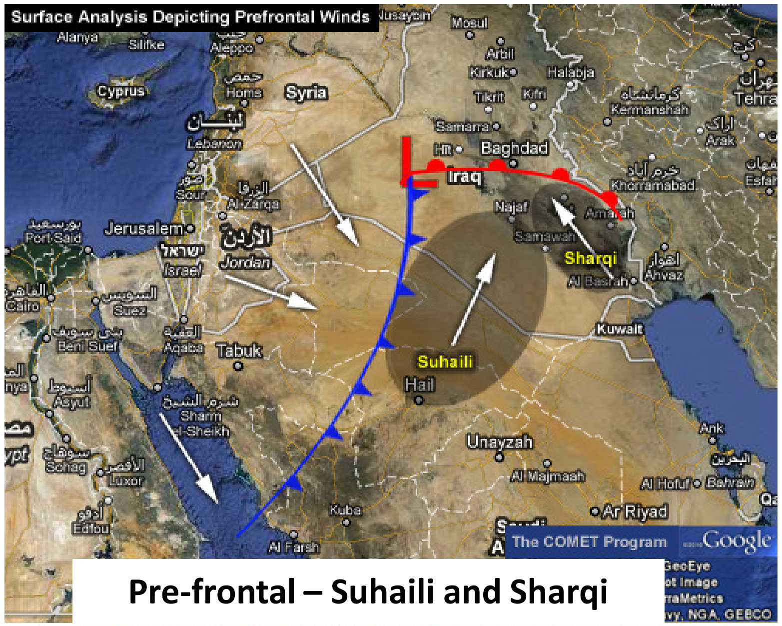
Conceptual Model – requirements for dust formation

(from http://www.meted.ucar.edu/mesoprim/dust/print.htm) **– Notes (3)**

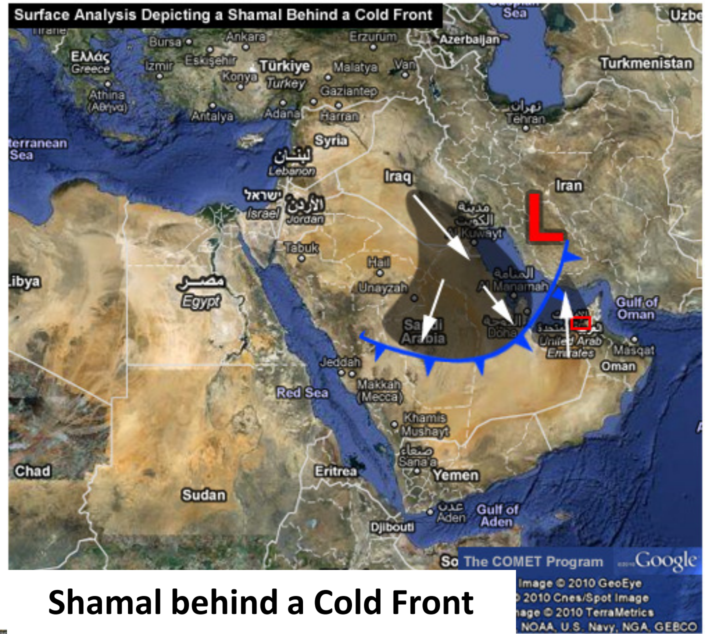
Stability

- Because vertical motions are required to loft dust particles, it stands to reason that dust storms are favored by an unstable boundary layer. In contrast, stable boundary layers suppress vertical motion and inhibit dust lofting.
- With the lack of vegetation in dust-prone regions, the ground can experience extreme daytime heating, which creates an unstable boundary layer. As the amount of heating increases, the unstable layer deepens.
- When you are evaluating the potential for dust lofting, be aware of when the boundary layer has a dry adiabatic lapse rate, for the strongest winds aloft can be brought down to the surface, creating gusty conditions.
- Be sure to examine winds at 925 mb (approximately 2,500 feet or about 750 meters above the surface when at sea level) where stronger winds allow more dust to be suspended aloft and persist for longer periods due to turbulent mixing.

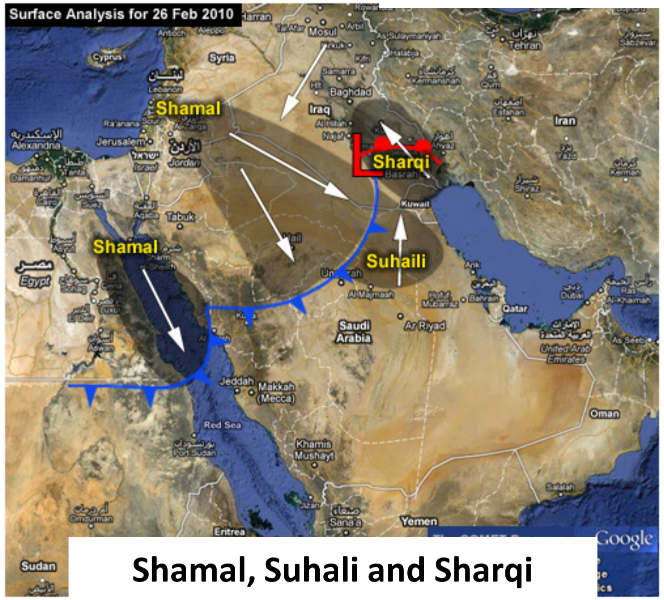
Conceptual Model – Synoptically Forced Dust Storms over the Arabian peninsula (from COMET)



Pre-frontal – Suhaili and Sharqi



Shamal behind a Cold Front



Shamal, Suhali and Sharqi

images courtesy COMET

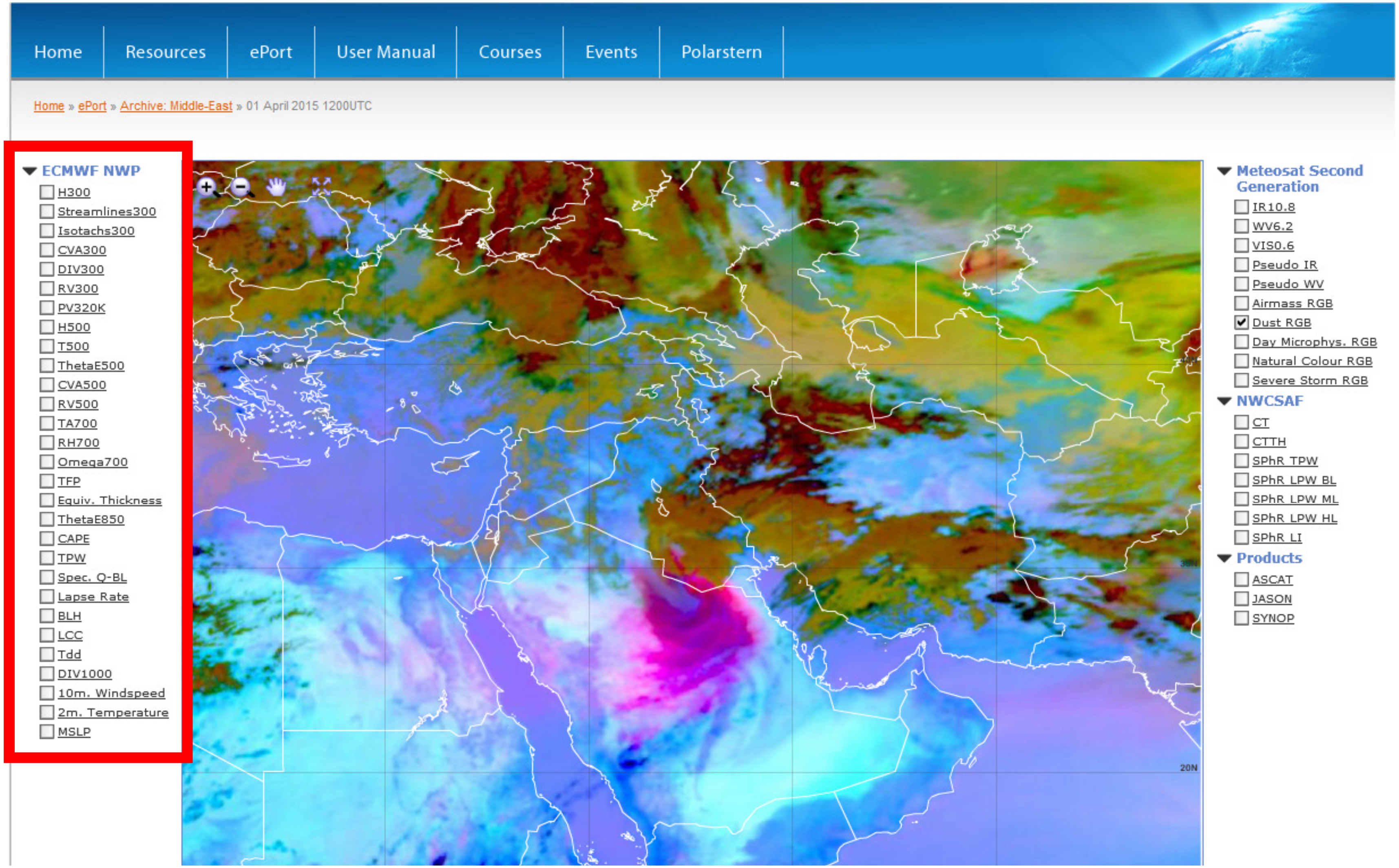
Conceptual Model – Synoptically Forced Dust Storms over the Arabian peninsula

(from http://www.meted.ucar.edu/mesoprim/dust/print.htm)

- The southeasterly or Sharqi winds that blow northward up the Tigris/Euphrates River basin are intensified as low-level flow is funneled between the Zagros Mountains to the east and the pressure gradient to the west.
- Toward the west, southwesterly or Suhaili winds pick up dust from western Arabia and move it northeast in advance of the cold front.
- A Shamal is a northwesterly wind that blows over Iraq and the Persian Gulf states. It is often strong during the day and decreases at night

image courtesy EUMETSAT

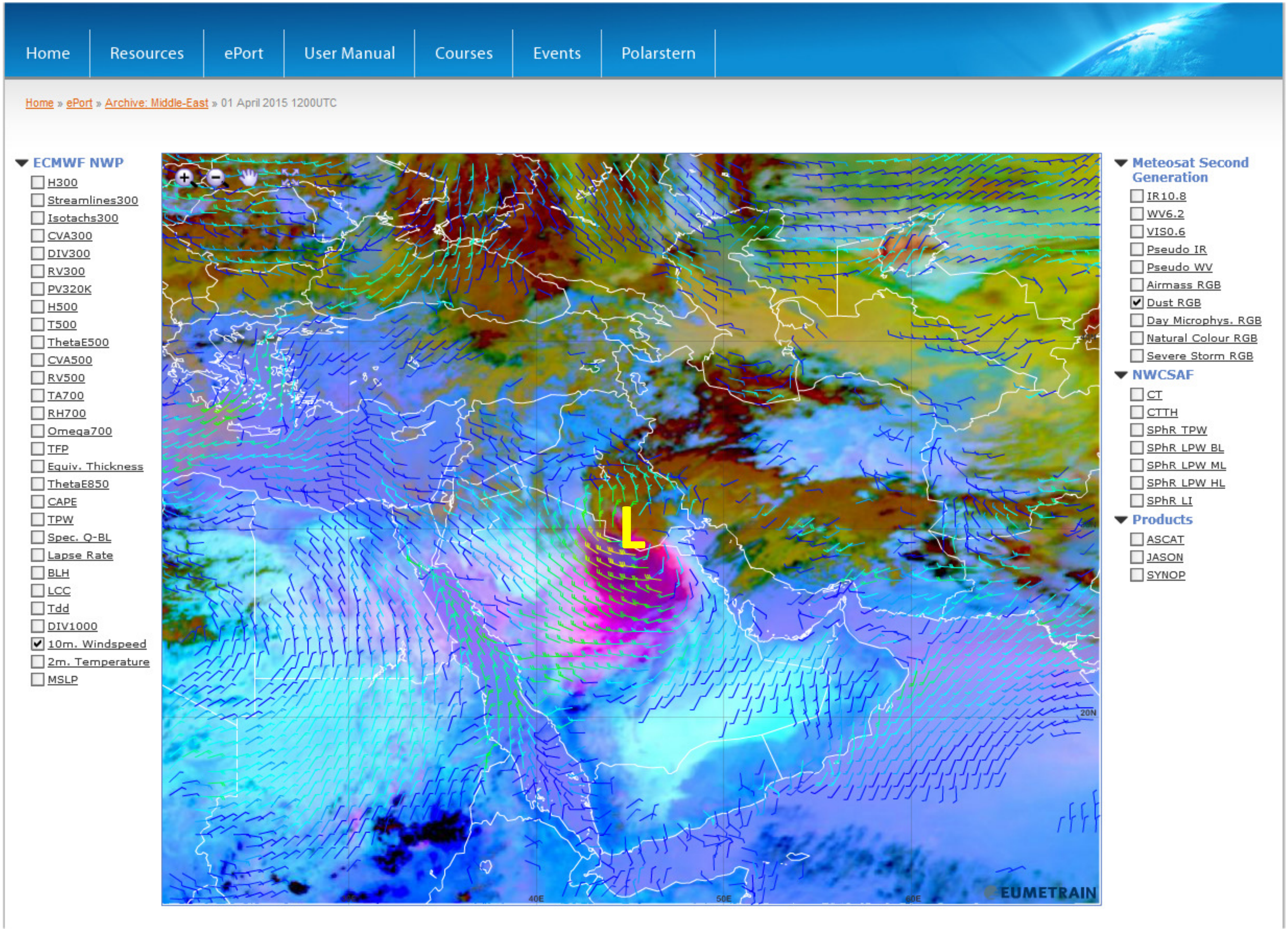
Activity: Exploring EUMETRAIN ePort



Activity: Please explore the ECMWF NWP fields and indicate which of these may be used to nowcast / forecast the dust

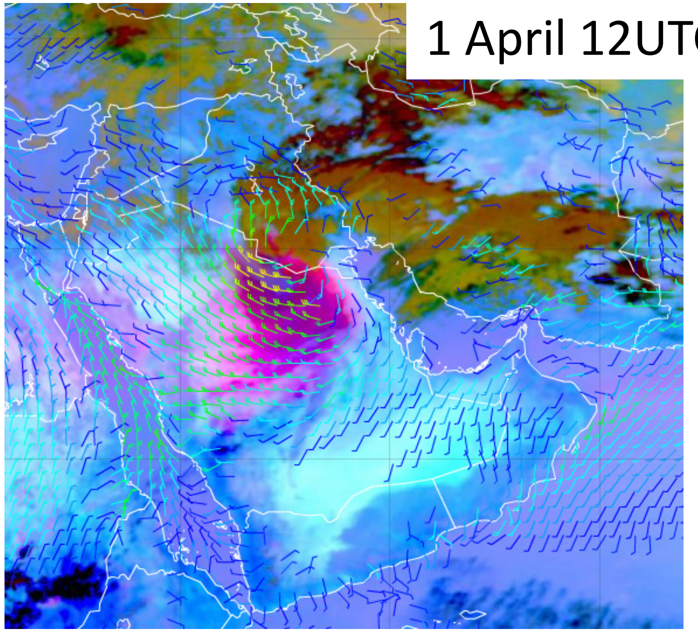
image courtesy EUMETSAT

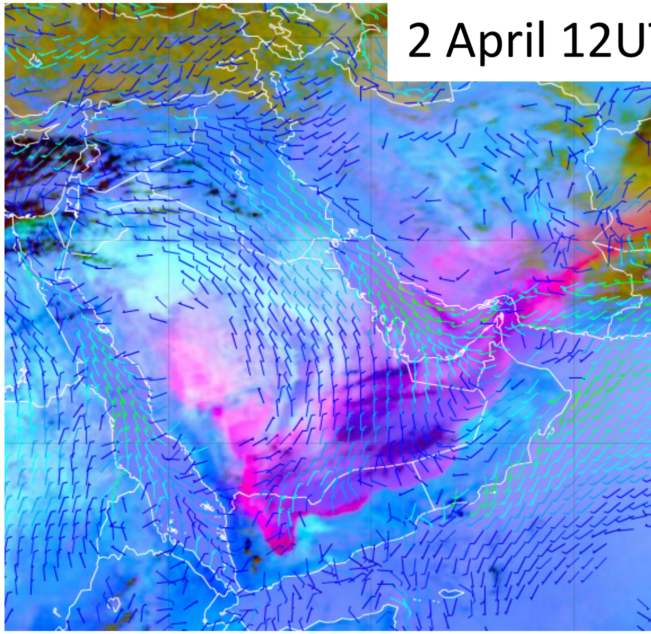
Activity: Exploring EUMETRAIN ePort – 10m winds

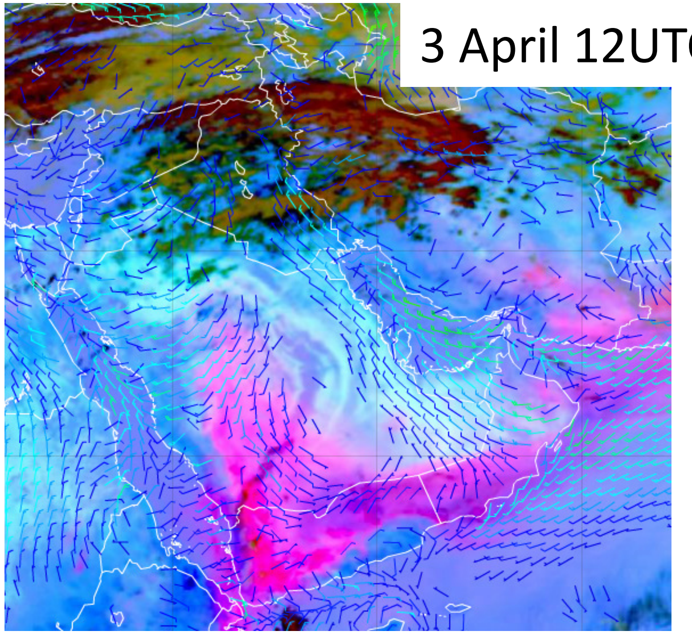


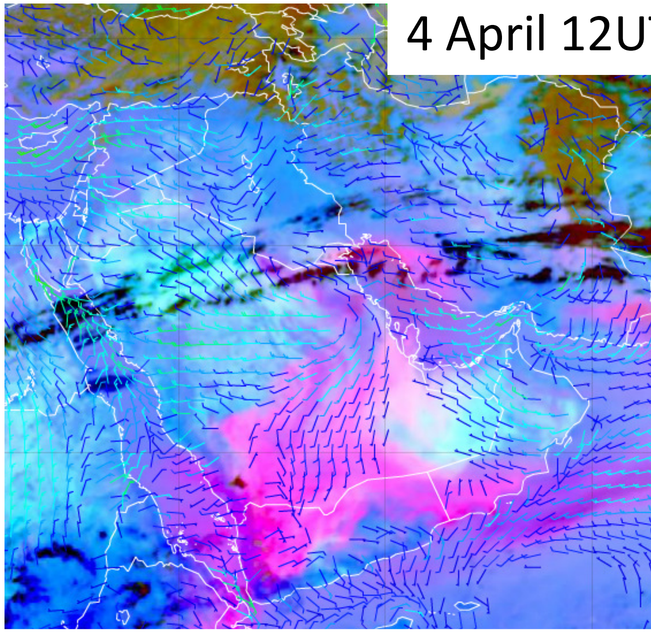
images courtesy EUMETSAT

The Saudi Arabian Dust Storm – 10m wind – April 2015


1 April 12UTC

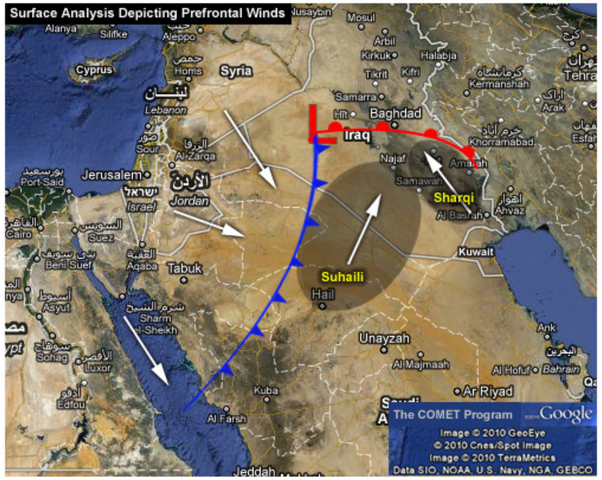

2 April 12UTC


3 April 12UTC


4 April 12UTC

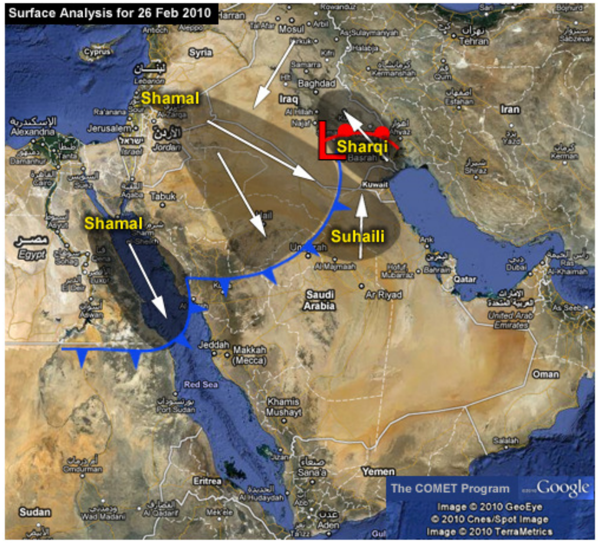
RGB images courtesy EUMETSAT

What kind of Dust Storm is the event of April 2015 ?

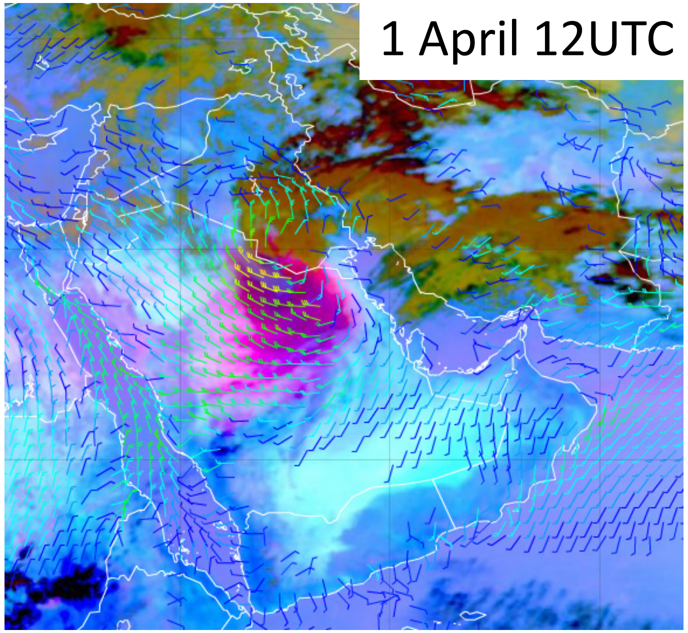


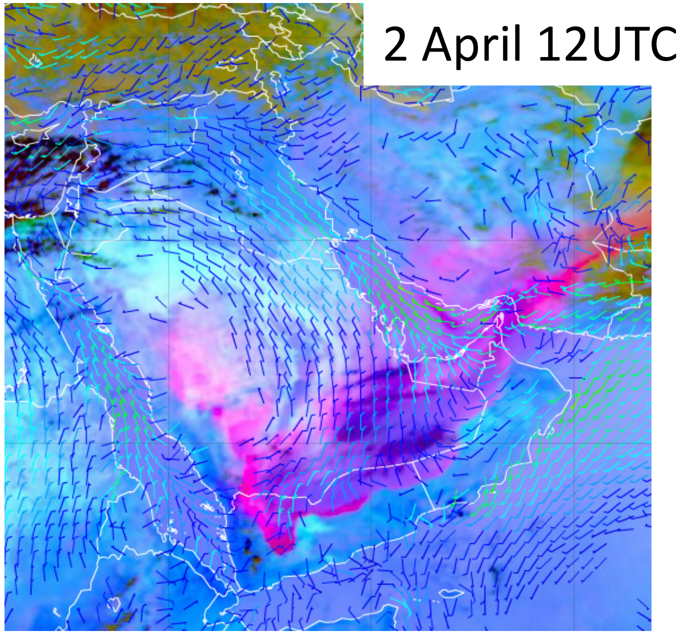
A - Pre-frontal – Suhaili and Sharqi

B - Shamal behind a Cold Front



C - Shamal, Suhali and Sharqi





images courtesy COMET

image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort – 700hPa Temperature Advection

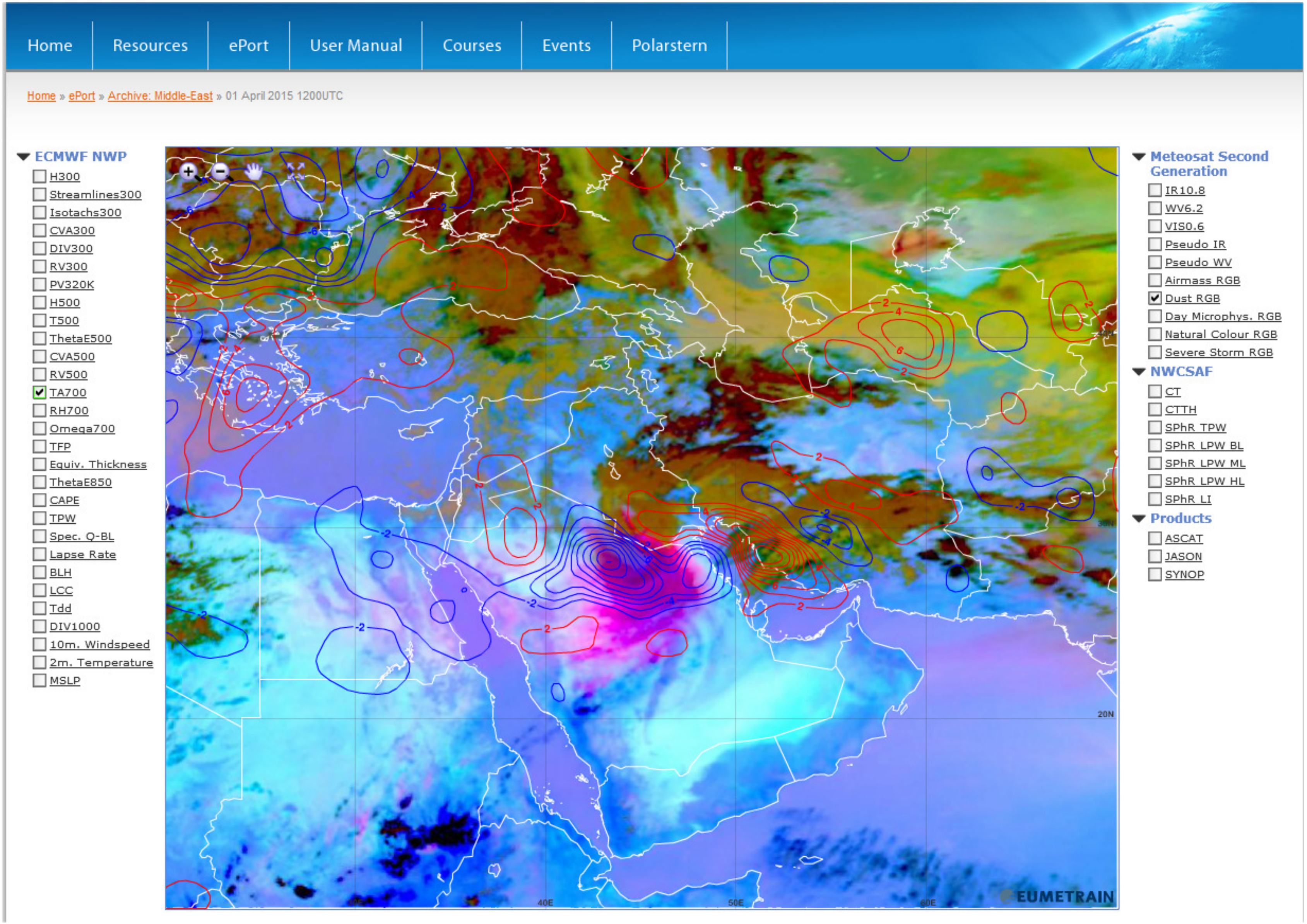


image courtesy EUMETSAT

Activity: Exploring EUMETRAIN ePort –500hPa Height

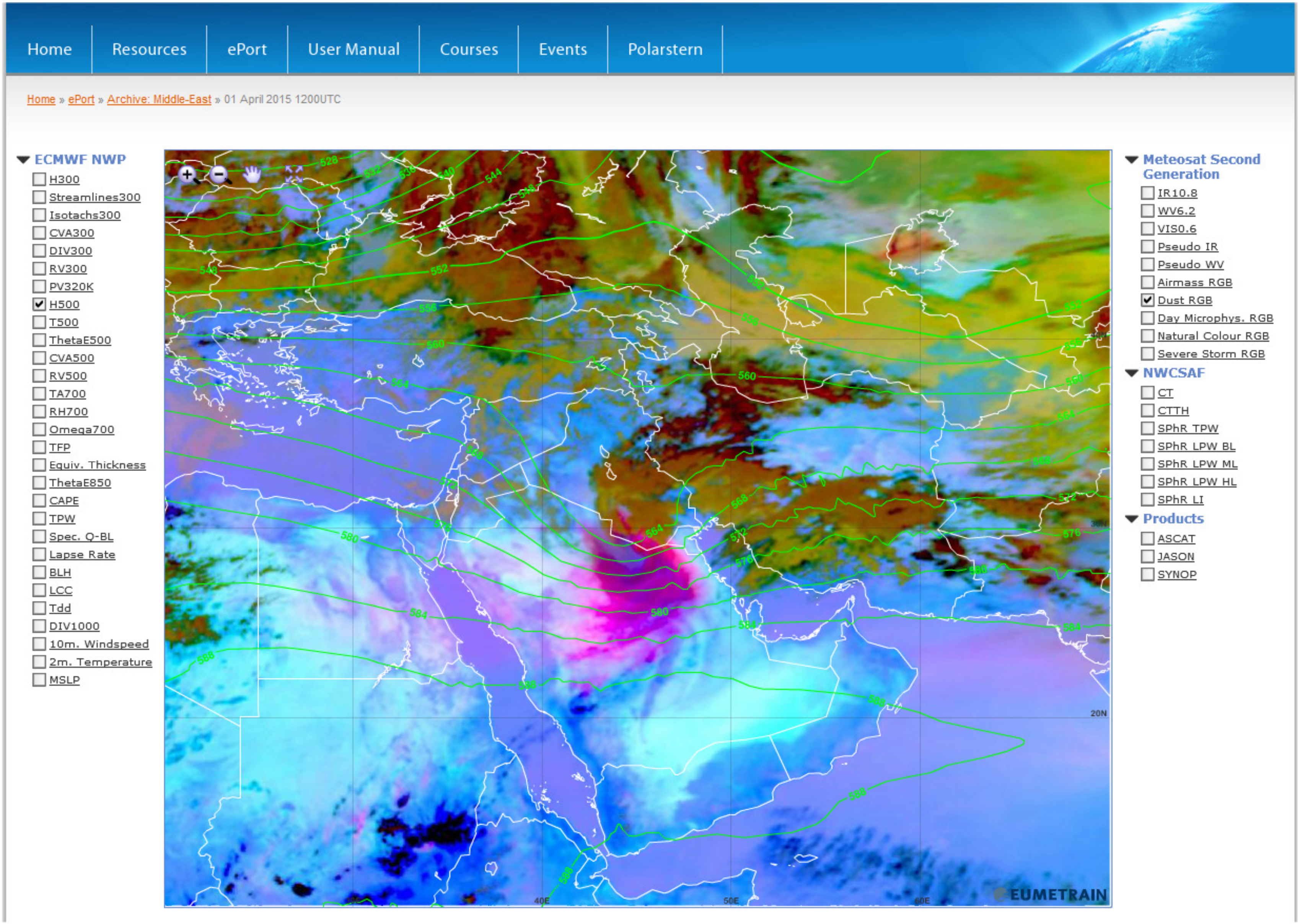
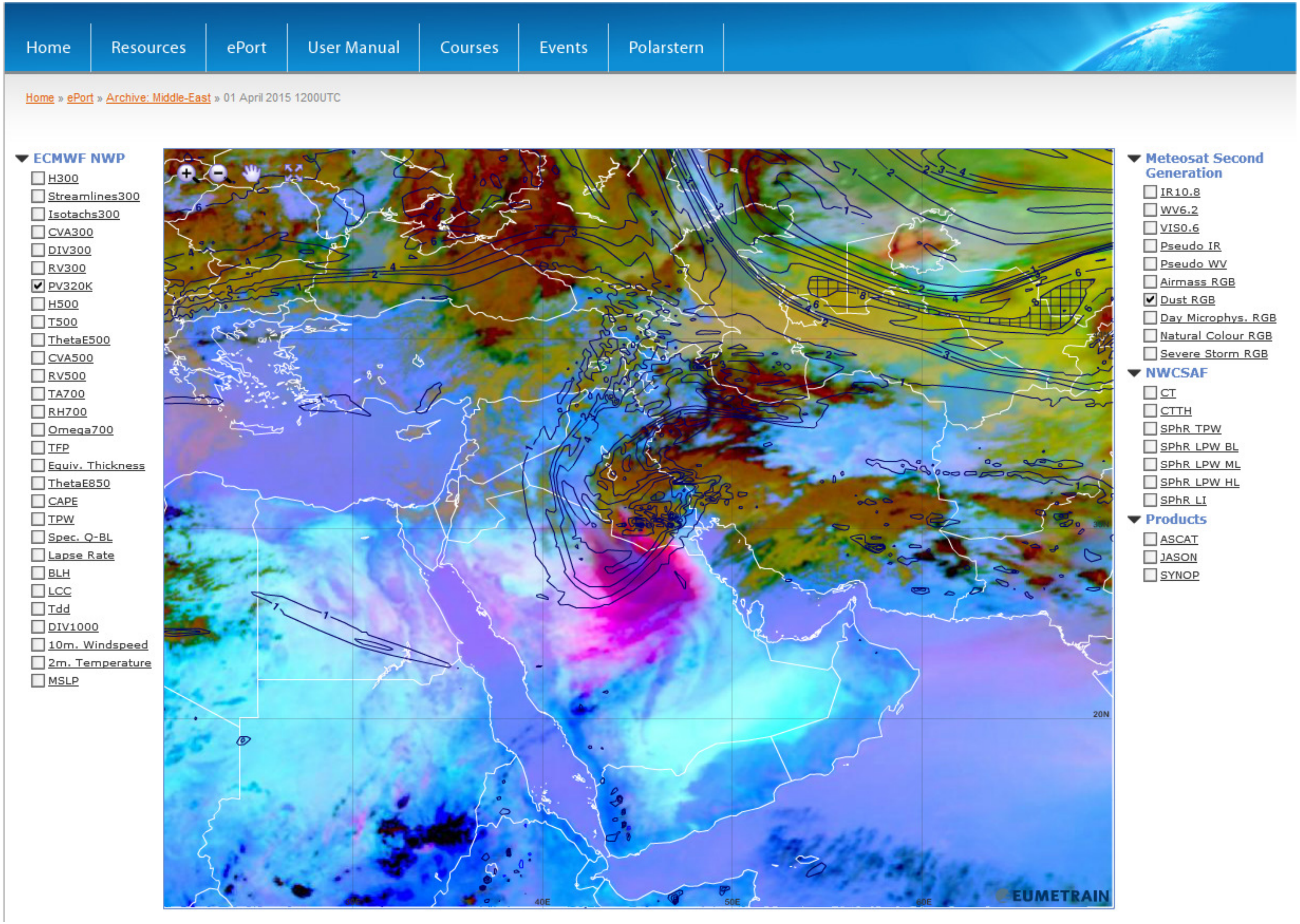
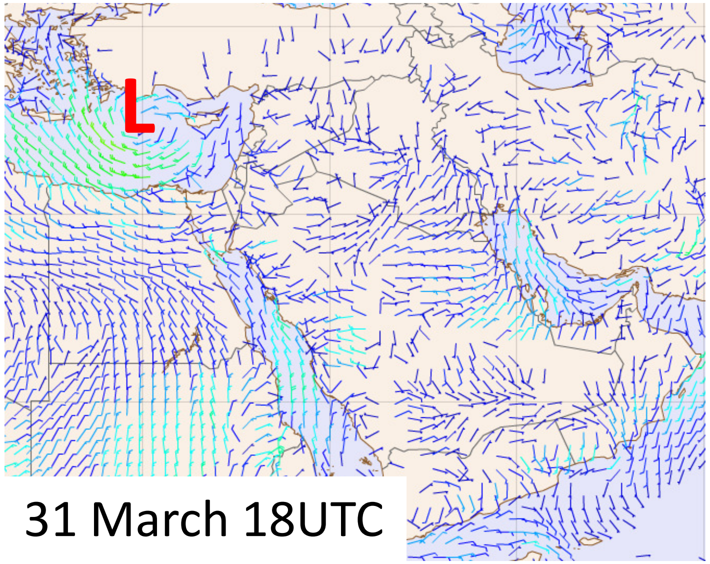


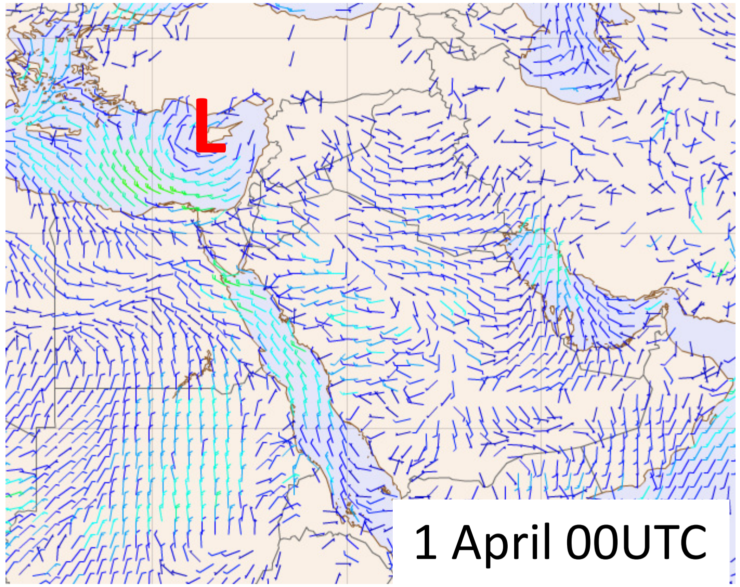
image courtesy EUMETSAT

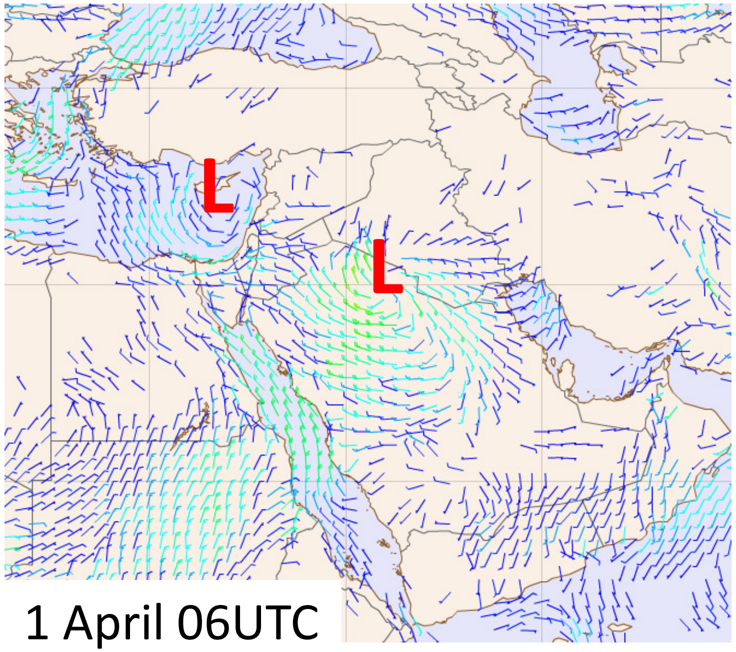
Activity: Exploring EUMETRAIN ePort – Middle East – PV 320K



Exploring EUMETRAIN ePort – Middle East – 10m winds leading up to the time of the event.







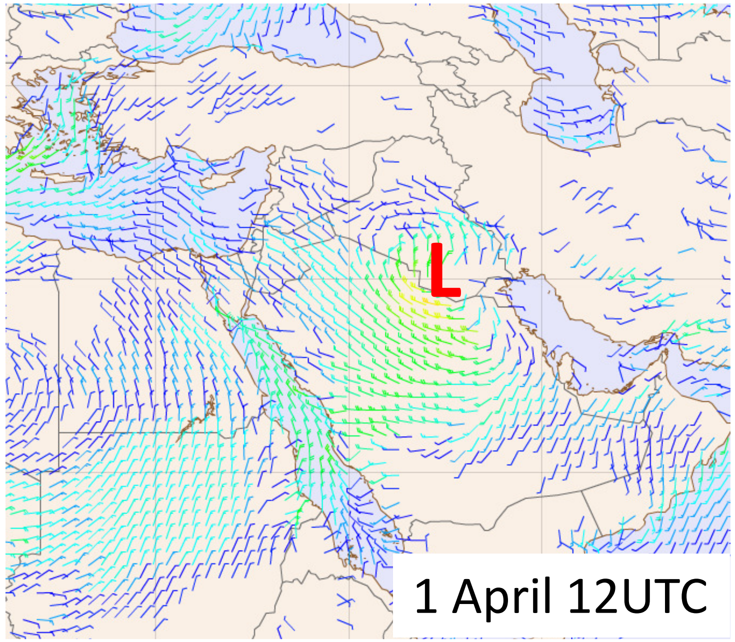
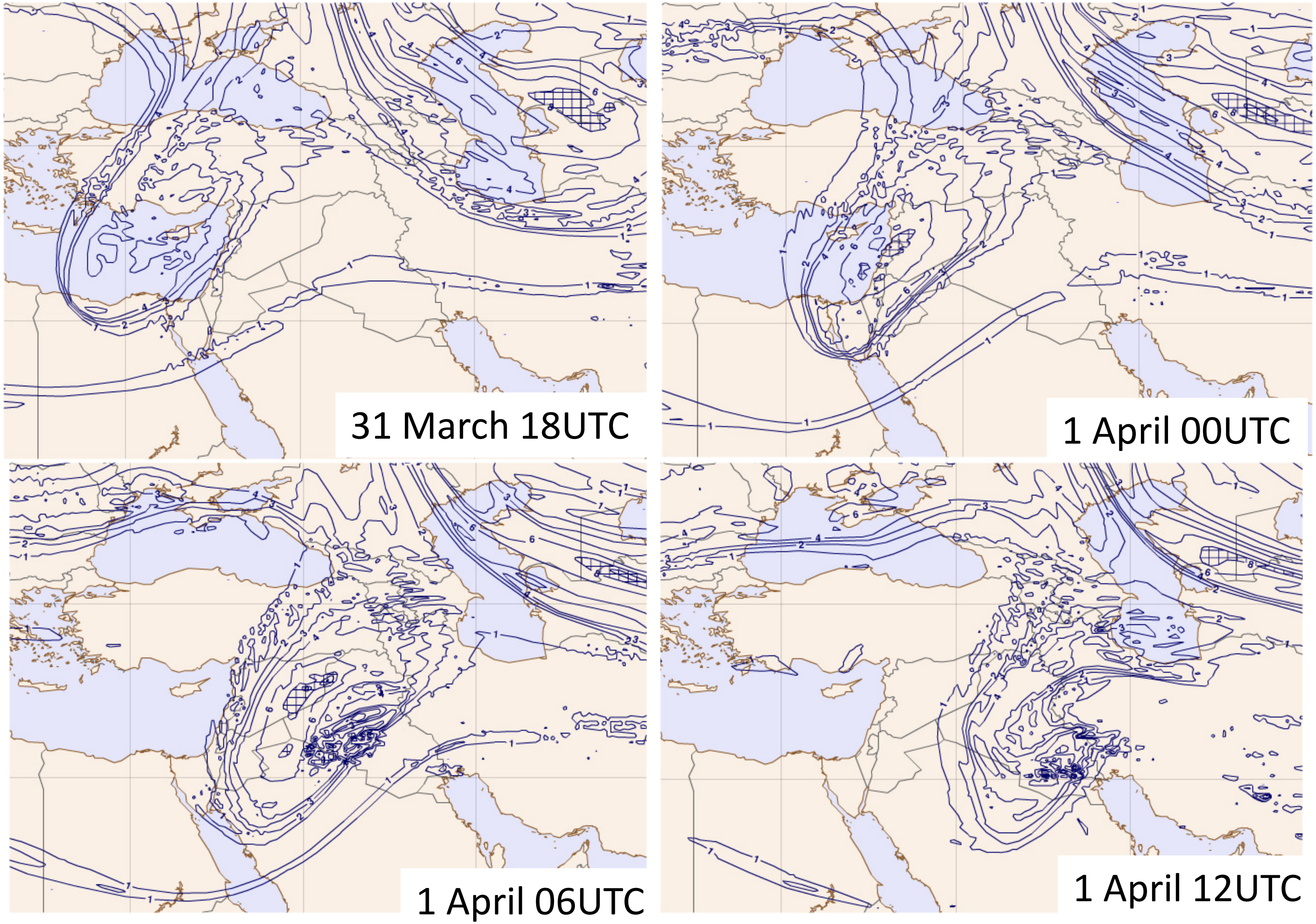


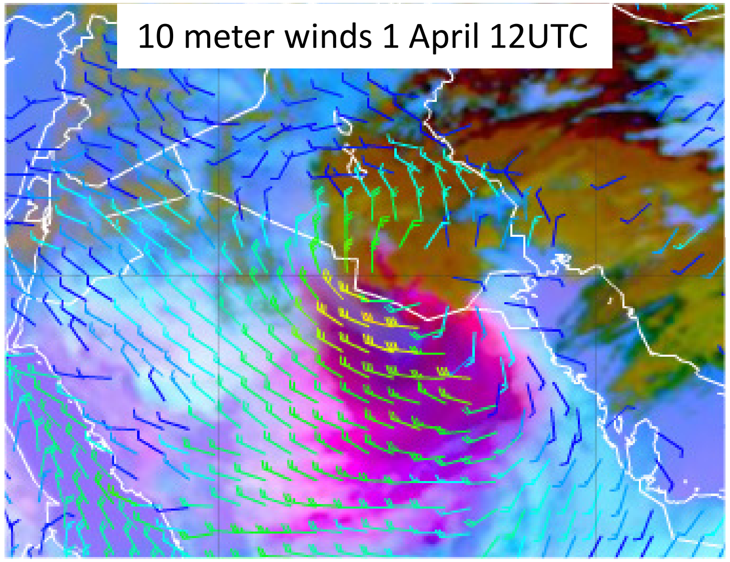
image courtesy EUMETSAT

Exploring EUMETRAIN ePort – Middle East – PV 320K, leading up to the time of the event. (in PV units)

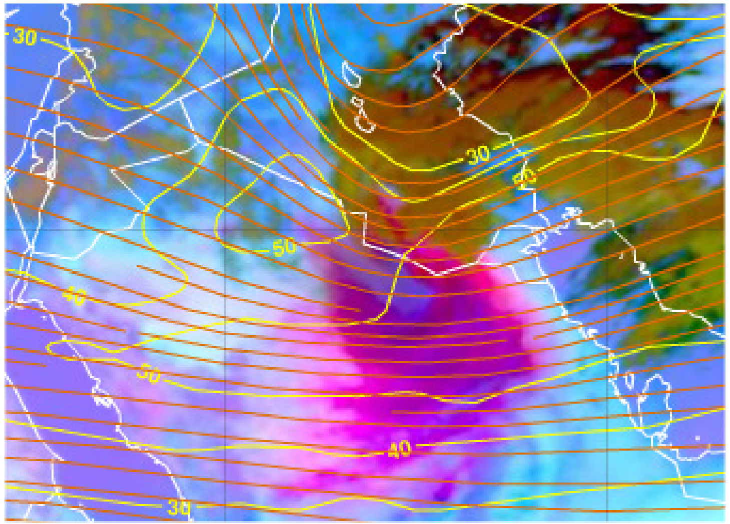


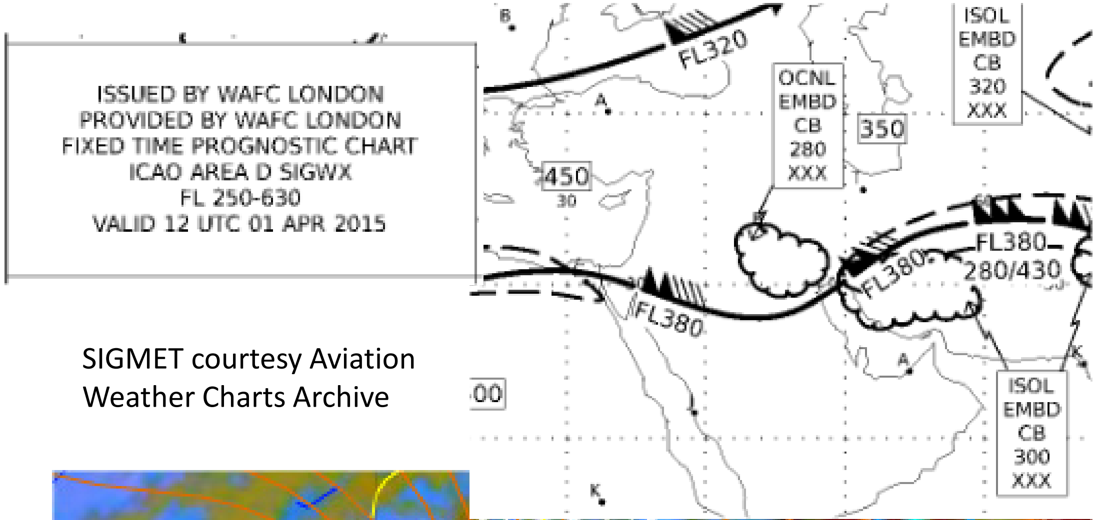
images courtesy EUMETSAT

Upper and lower atmosphere interaction

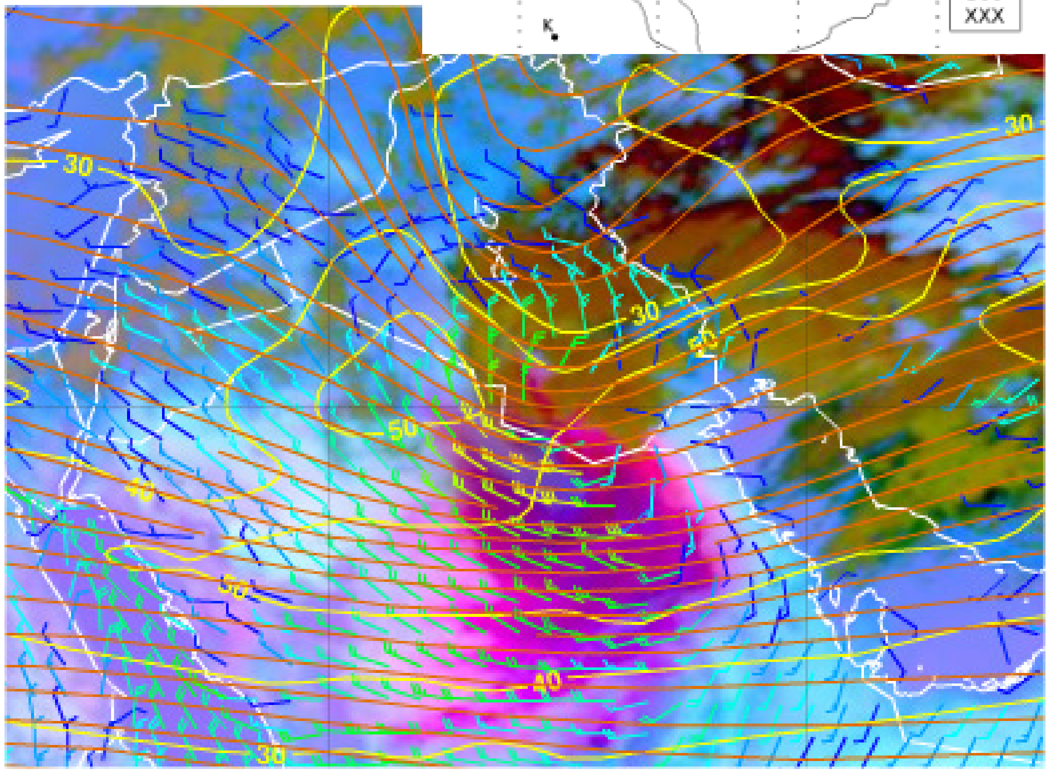

10 meter winds 1 April 12UTC

300hPa isotachs and streamlines 1 April 12UTC


Isotach contours in m/s



SIGMET courtesy Aviation Weather Charts Archive



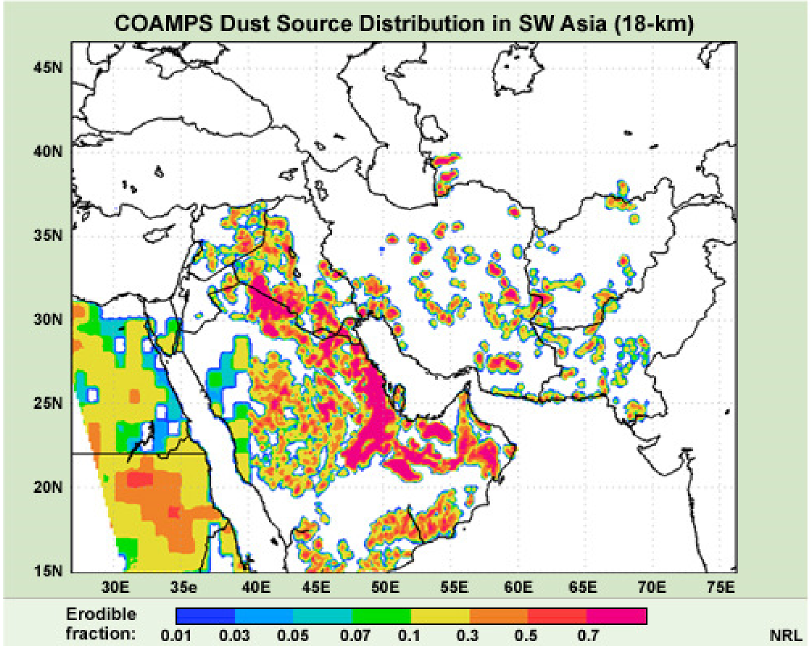
Genesis of the sandstorm

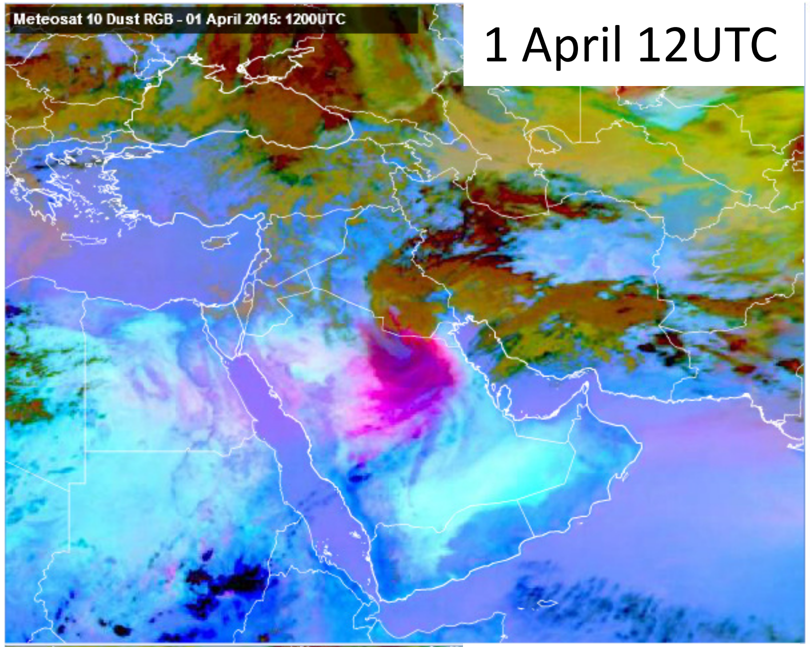
- Generation of a surface low pressure system over Saudi Arabia / Iraq which can be seen in the 10 meter winds on 1st April 06UTC.
- The Generation of the low pressure system (cyclogenesis) may have been enhanced by the eastward moving upper PV anomaly. In particular, upward motion is expected ahead of the anomaly.
- Looking at the ECMWF 300hPa isotachs and the SIGWX chart there is an upper jet in the vicinity of the dust storm and this could also have influenced the cyclogenesis, upward motion and the mobilisation of the dust.
- In the low-mid levels (700 hPa temperature advection and 500 hPa heights), it appears that a cold airmass is moving into northern Saudi Arabia and appears to be associated with the dust storm.

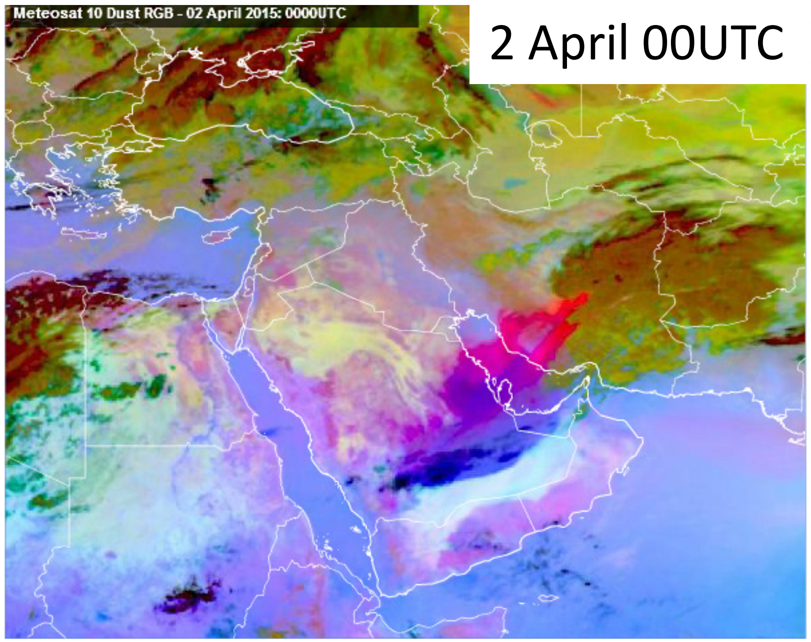
image courtesy COMET

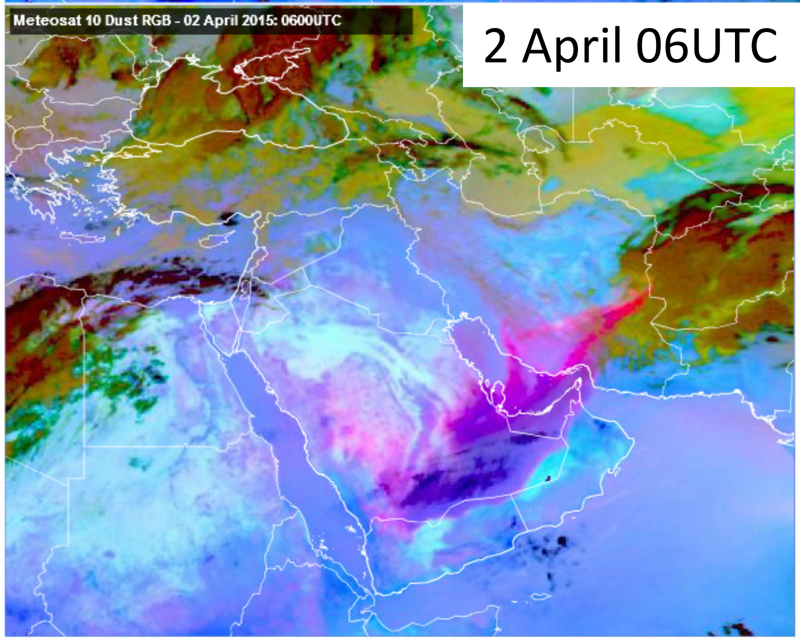
images courtesy EUMETSAT

Formation of the Saudi Arabian Dust Storm – April 2015









Formation of the Saudi Arabian Dust Storm – 1 April 2015

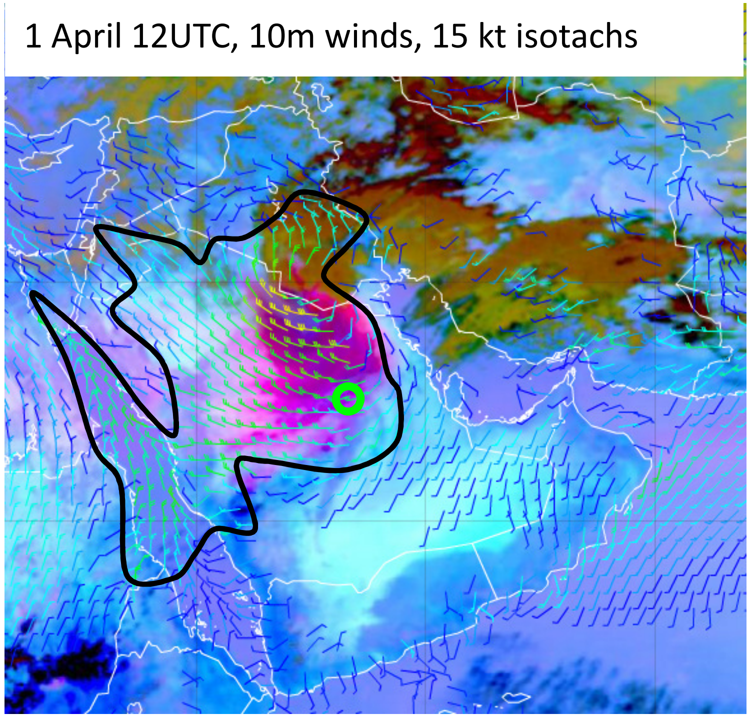


image courtesy EUMETSAT

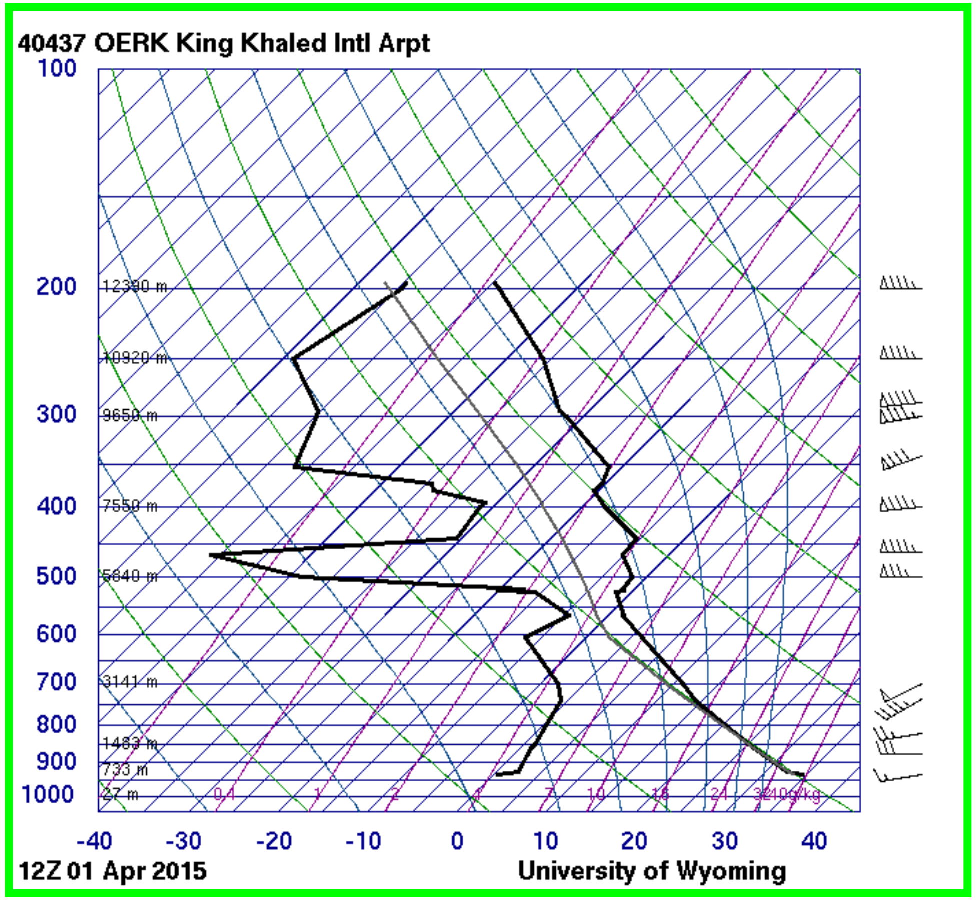


image courtesy University of Wyoming

King Khaled International Airport TAF

OERK 010430Z 0106/0212 20010G20KT 6000 FEW040 SCT100
BECMG 0111/0113 26012G25KT
TEMPO 0106/0118 3000 DU/BLDU

TAF courtesy Aviation Weather Charts Archive

Question: What are some of the factors that would assist dust storm formation ?

Requirements for dust formation in the previous two slides that is consistent with the conceptual model

Wind

- Near surface windspeeds between 10 and 25 knots and greater (as a rule of thumb, winds at the surface need to be 15 knots or greater to mobilize dust)

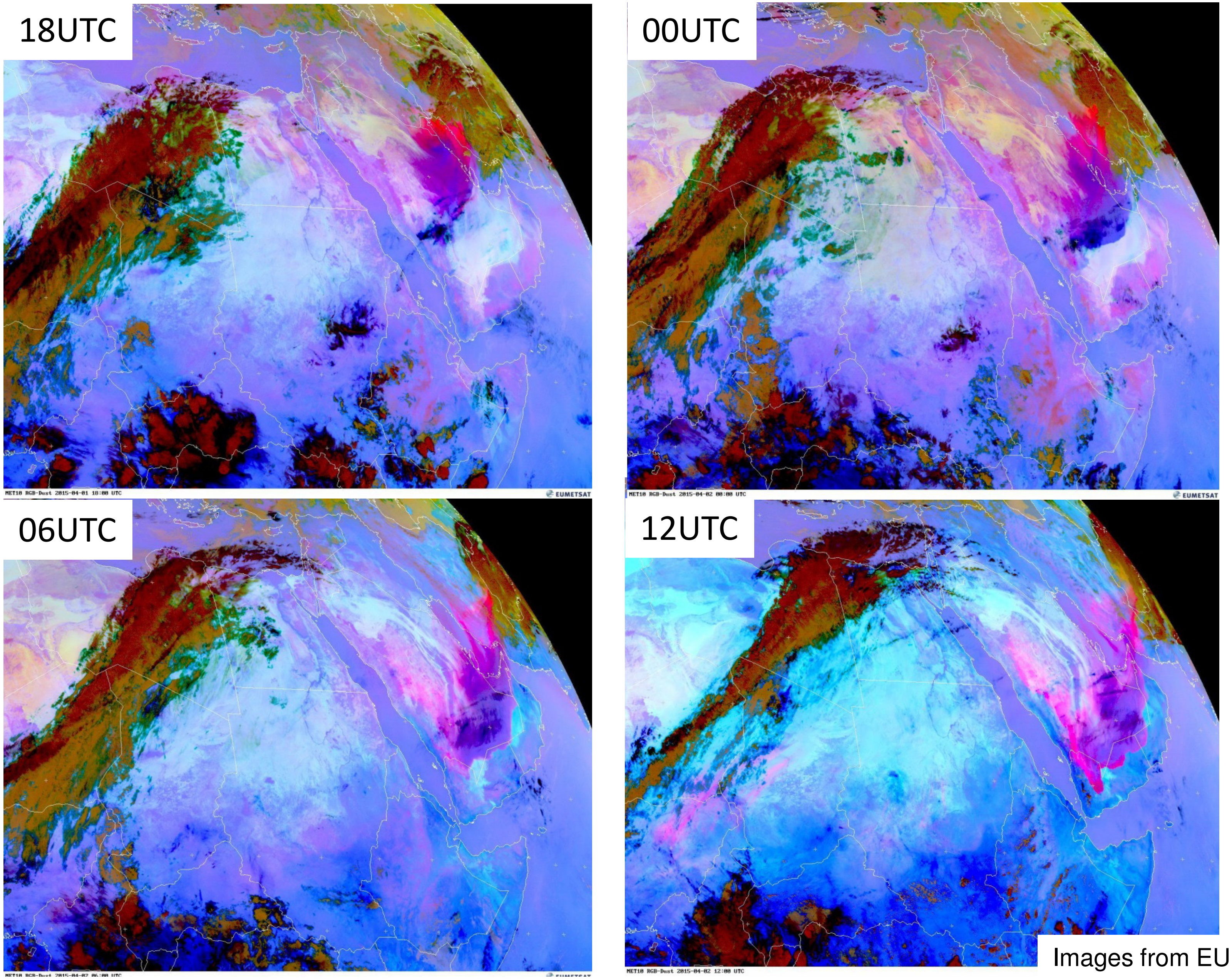
Shear Turbulence

- The winds at 1,000 ft above the surface at King Khaled International Airport are between 15-30 knots (as a rule of thumb, if the wind at the surface is blowing 15 knots, the wind at 1,000 feet must be about 30 knots to keep the dust particles aloft).

Stability

- Dry adiabatic lapse rate to 750hPa in the King Khaled International Airport sounding. A superadiabatic lapse rate near the surface (an unstable boundary layer favours dust storms. A dry adiabatic lapse rate in the low levels permits stronger winds aloft to be brought down to the surface, creating gusty conditions).

Summary of Dust RGB animation 1 – Middle East, Meteosat-10, 31st March 18UTC to 1st April 2015 12UTC



Images from EUMETSAT

Dust RGB: Summary (1)

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

- Based on infrared channel data, this RGB is designed to monitor the evolution of dust storms during both day and night.
- This is challenging because the appearance of dust changes radically from day to night.
- The dust RGB is nearly identical to the ash RGB but has slightly different tuning. Temperature difference thresholds and enhancement of individual red, green, and blue inputs are slightly modified.

Advantages:

- Can follow the evolution of dust plumes during both day and night
- Can depict dust plumes over land and water surfaces

Dust RGB: Summary (2)

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

Limitations:

- The lack of solar channels can impede the detection of dust plumes, especially over the ocean; however, high-level dust clouds are always easy to detect given the large thermal contrast between elevated dust and the underlying surface
- It is almost always easier to detect low-level dust clouds during the day when there is a larger thermal contrast between the land and elevated dust; this thermal contrast is smaller at night, making it more difficult to detect low-level dust with satellite products at night

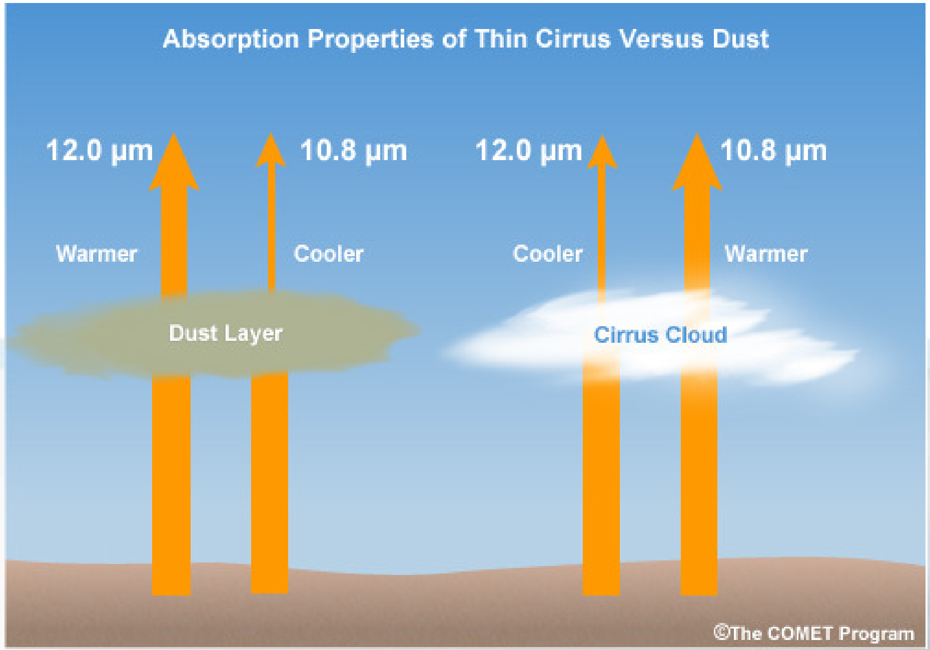
Appendix 1: Underpinning WMO-1083 and Enabling Skills

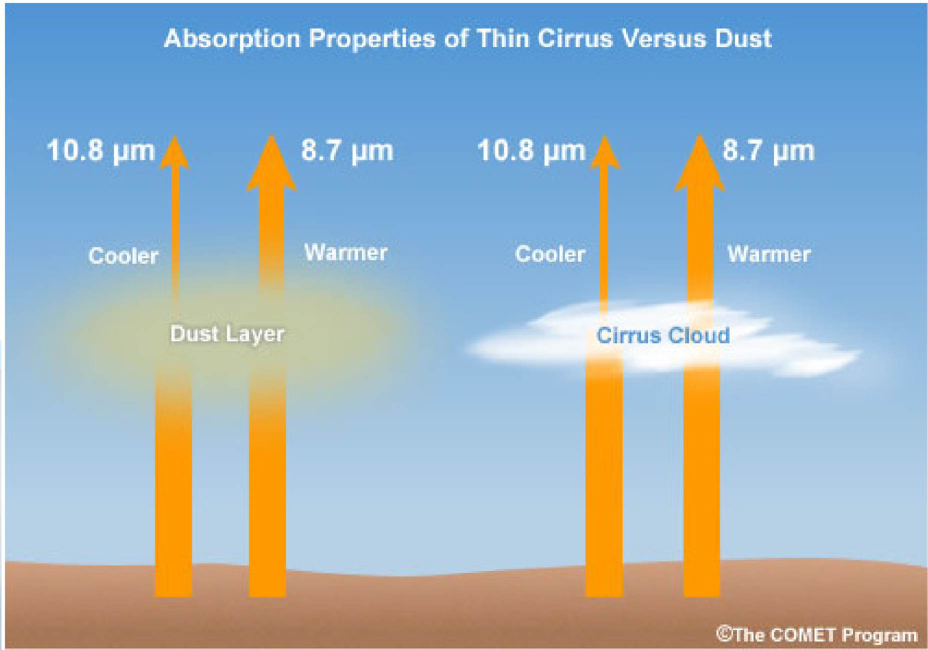
WMO 1083 2.3.3.4 **– Interpreting satellite imagery: Interpret satellite images, including use of common wavelengths (infrared, visible**, water vapour and near infrared) **and enhancements and animated imagery, to identify cloud types** and patterns, synoptic and mesoscale systems, **and special features**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

Enabling Skills Document: Element 4, **Performance Component "Dust and sandstorms and plumes and areas of raised dust"**

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

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

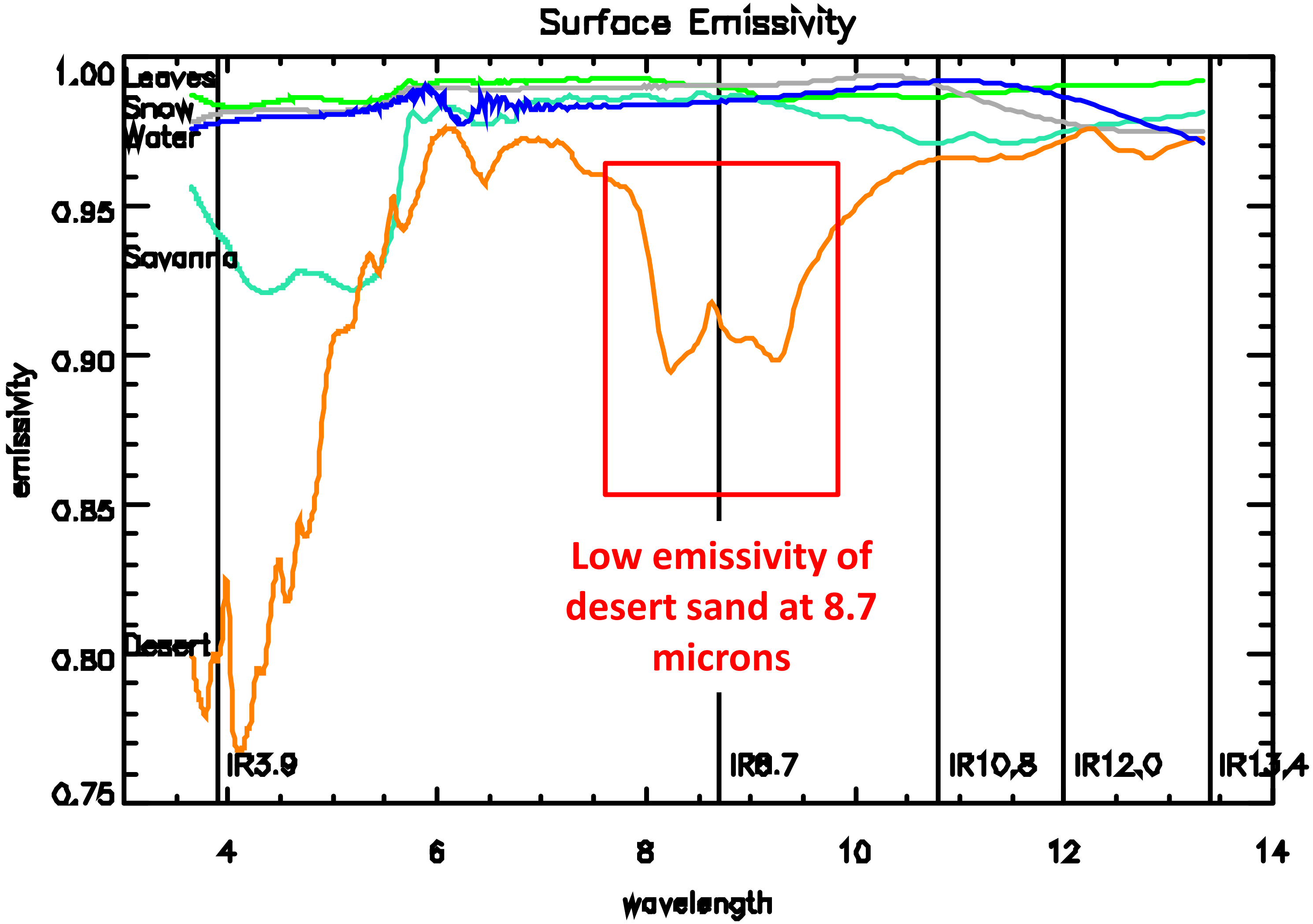




The effectiveness of the BTD stems from the interaction of upwelling energy from the surface of the Earth with the dust cloud. Infrared energy passing through a dust layer has a colder brightness temperature at 10.8 µm than 12.0 µm because dust is more sensitive to and absorbs more energy at 10.8 µm. In effect, dust blocks more upwelling radiation from reaching the satellite at this wavelength.

Both ice clouds and dust have negative brightness temperature differences in the 10.8 µm IR minus 8.7 µm IR channel difference, making it hard to tell them apart on the resulting image. However, sand has low emissivity in the 8.7 micron channel, giving a strong signal in the green beam (see next slide).

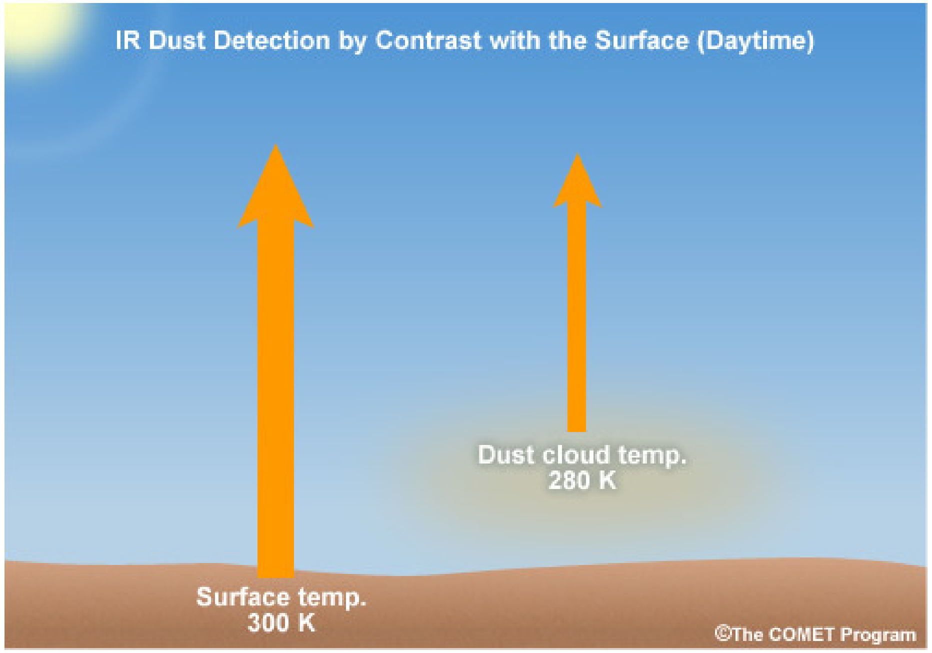
Surface emission properties of desert, savanna, water, snow and leaves for the different wavelengths

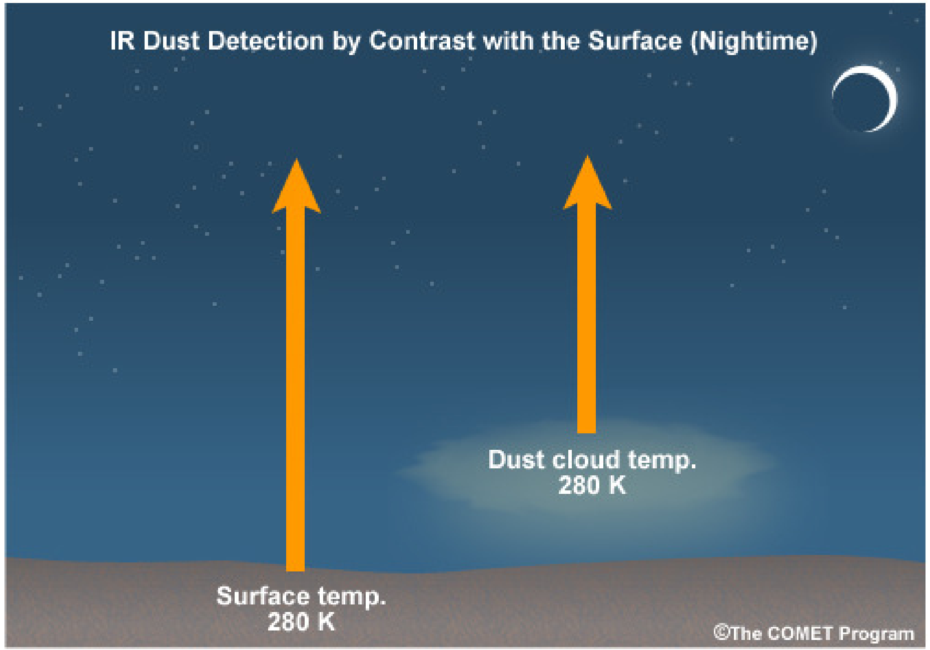


From "Applications of the SEVIRI window channels in the infrared" Jose Prieto, EUMETSAT

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

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





The radiating temperature of the surface is greater than that of the dust aloft, therefore the dust stands out against the hotter background.

But the contrast is often limited. For example, at night, the temperatures of the dust and background surface are similar.