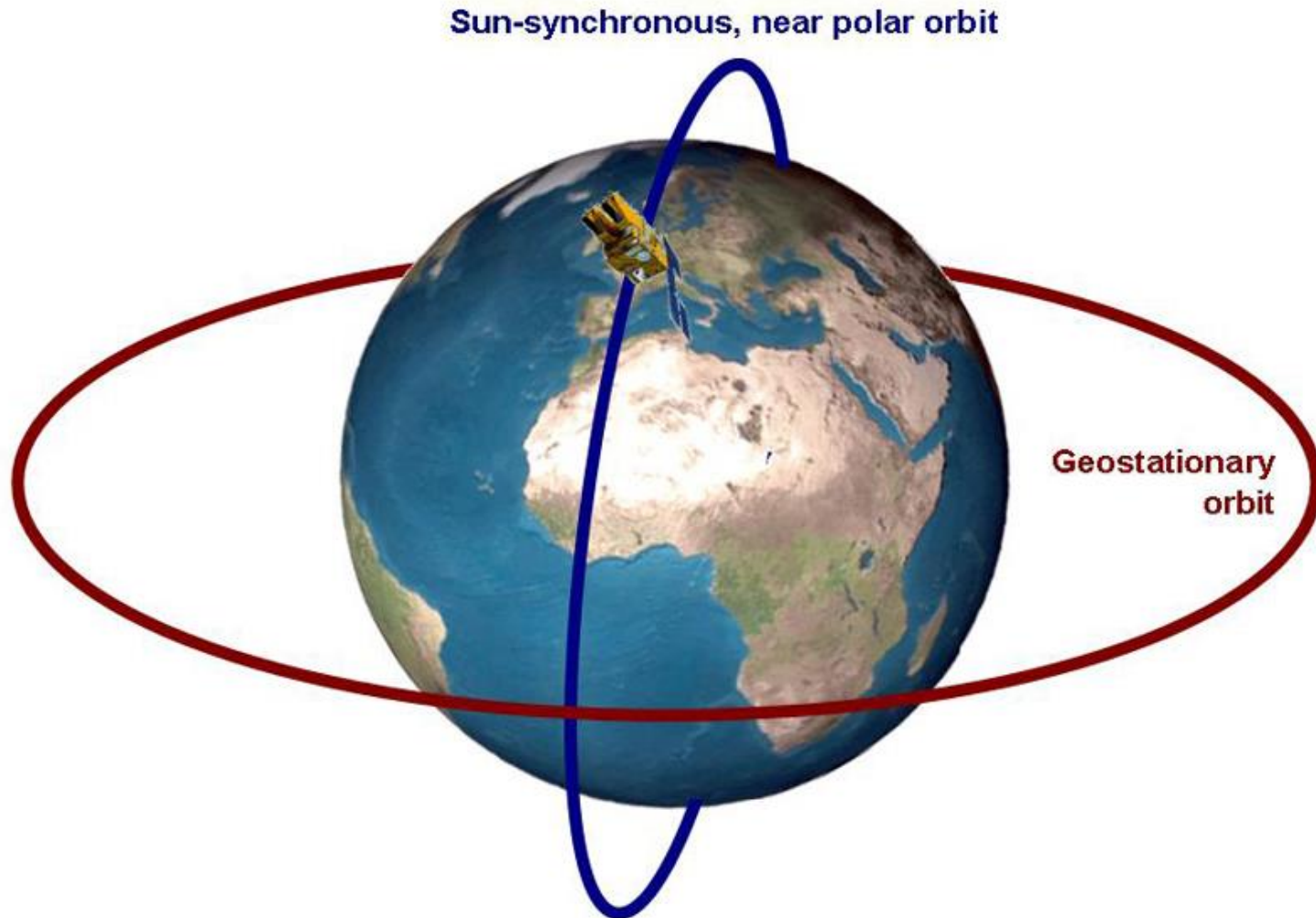


# Satellite monitoring of airborne dust

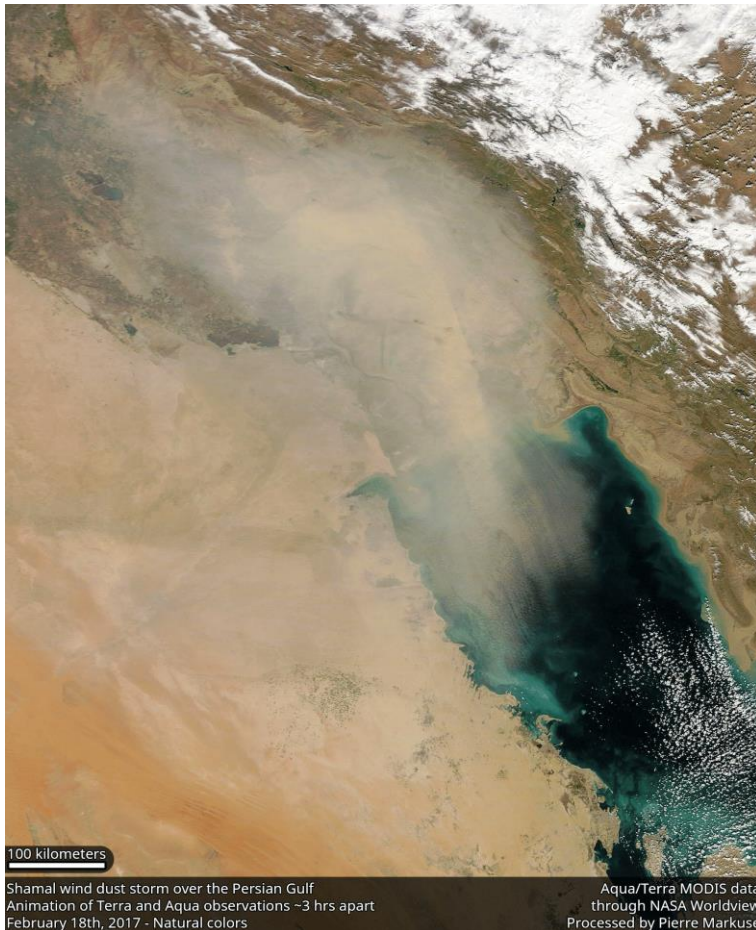
Enric Terradellas, AEMET, Barcelona, [eterradellasj@aemet.es](mailto:eterradellasj@aemet.es)



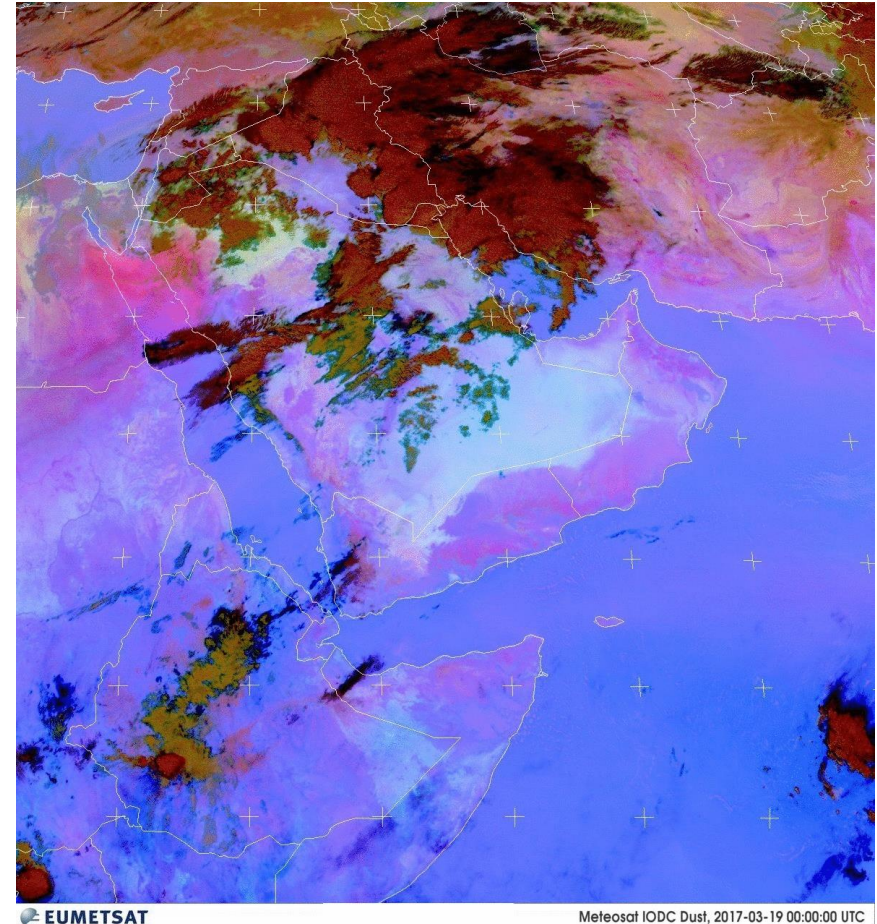
# What kind of satellites is suitable for **dust monitoring**? Polar vs GEO satellites



# What kind of satellites is suitable for **dust monitoring**? Polar vs GEO satellites



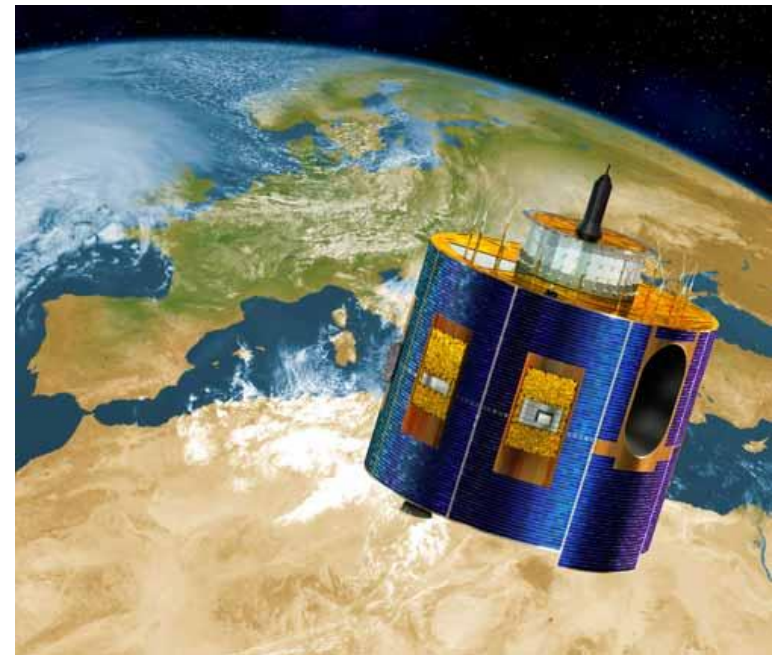
Terra/MODIS & Aqua/MODIS  
Natural colour. 18 Feb 2017



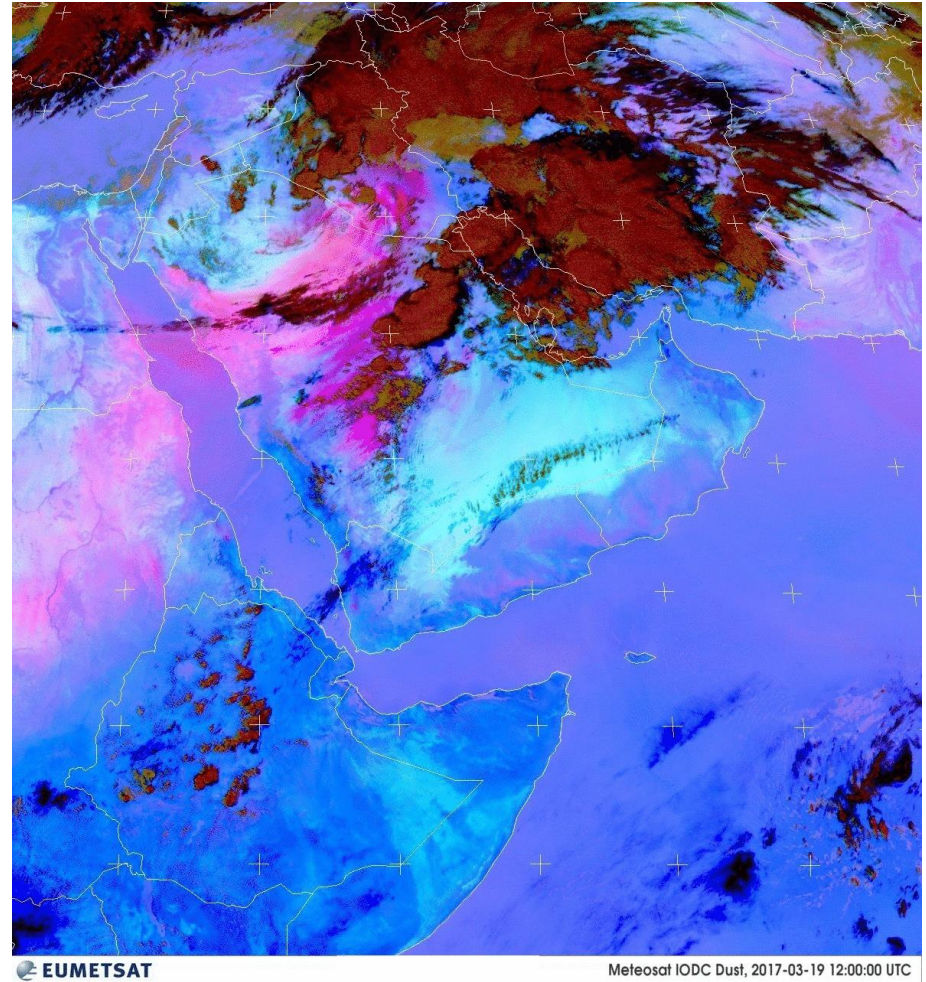
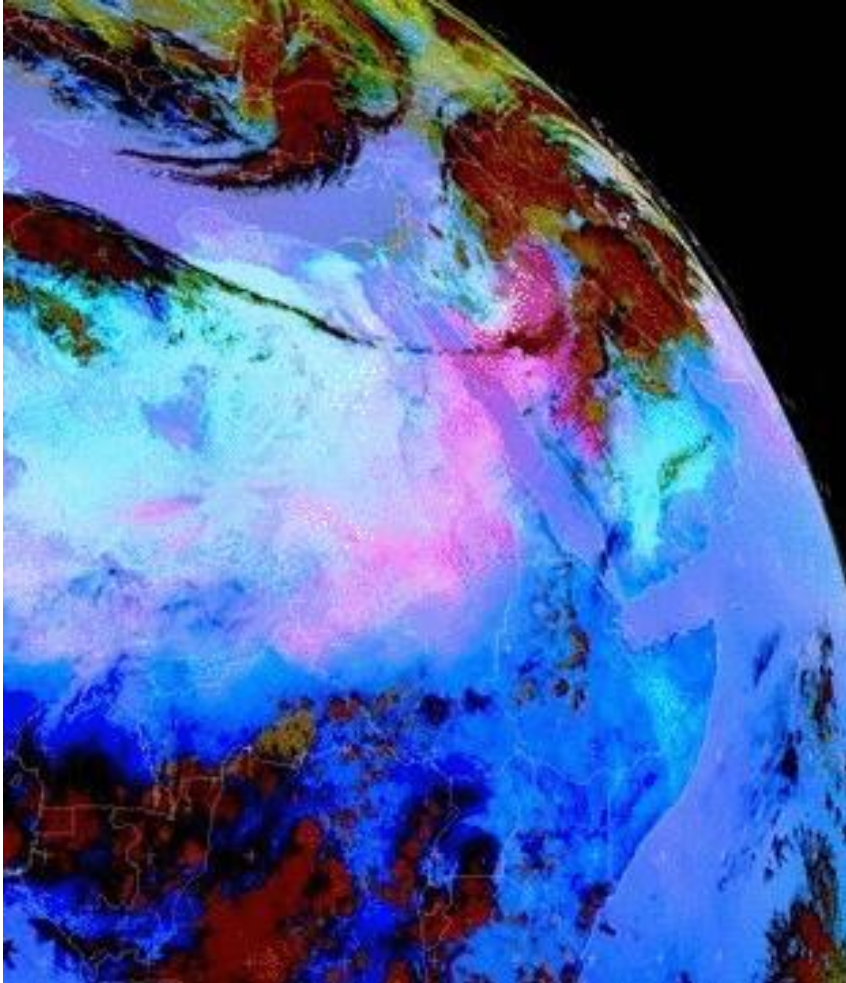
MSG/SEVIRI  
RGB-Dust. 19 Mar 2017

# Operational GEO meteorological satellites

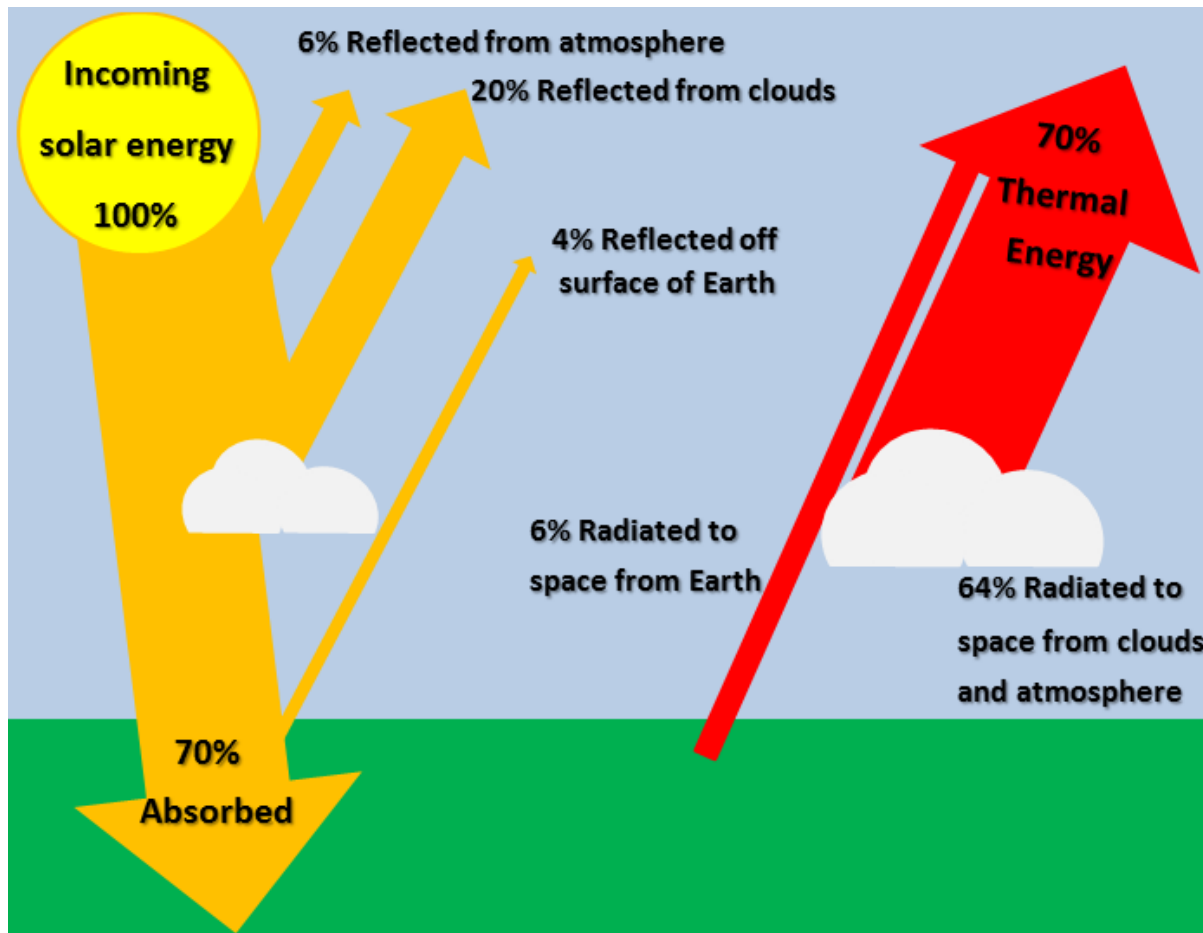
Satellite	Location	Operated by
GOES-15	135°W	NOAA
GOES-16	75.2°W	NOAA
Meteosat-11	0°	EUMETSAT
Meteosat-10	9.5°E	EUMETSAT
Meteosat-8	41.5°E	EUMETSAT
INSAT-3DR	74°E	ISRO
Electro-L N2	76°E	RosHydroMet
FY-2H	79°E	CMA
FY-2G	105°E	CMA
FY-4A	105°E	CMA
COMS	128.2°E	KMA
Himawari-8	140.68°E	JMA



# Products of what GEO satellite are useful in **West Asia**? MSG 0° vs MSG 41.5°?



# Which satellite products are useful for **dust monitoring**? Visible vs Infrared channels

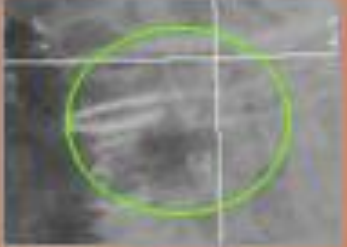
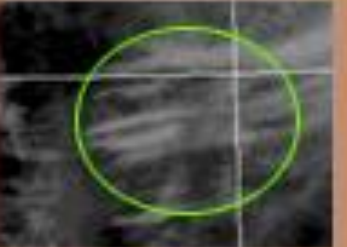




**Visible or  
Solar or  
Shortwave**

**Infrared or  
Terrestrial or  
Longwave or  
Thermal**

# Which satellite products are useful for **dust monitoring**? Visible vs Infrared channels

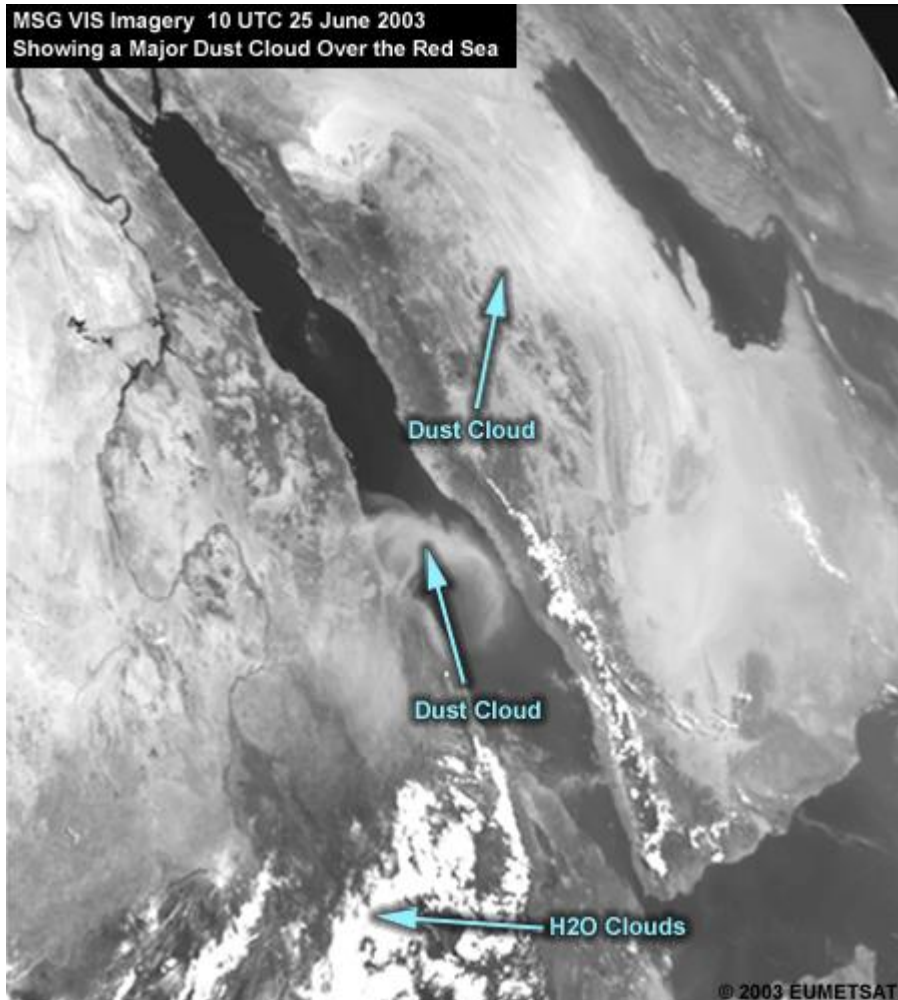
## Daytime Dust Interpretation

	Visible	Infrared
Land	<p>Dust partially disappears over deserts</p> 	<p>Cool dust contrasts well over heated land</p> 
Sea	<p>Dust contrasts well over dark ocean background</p> 	<p>Dust partially disappears over cool ocean background</p> 

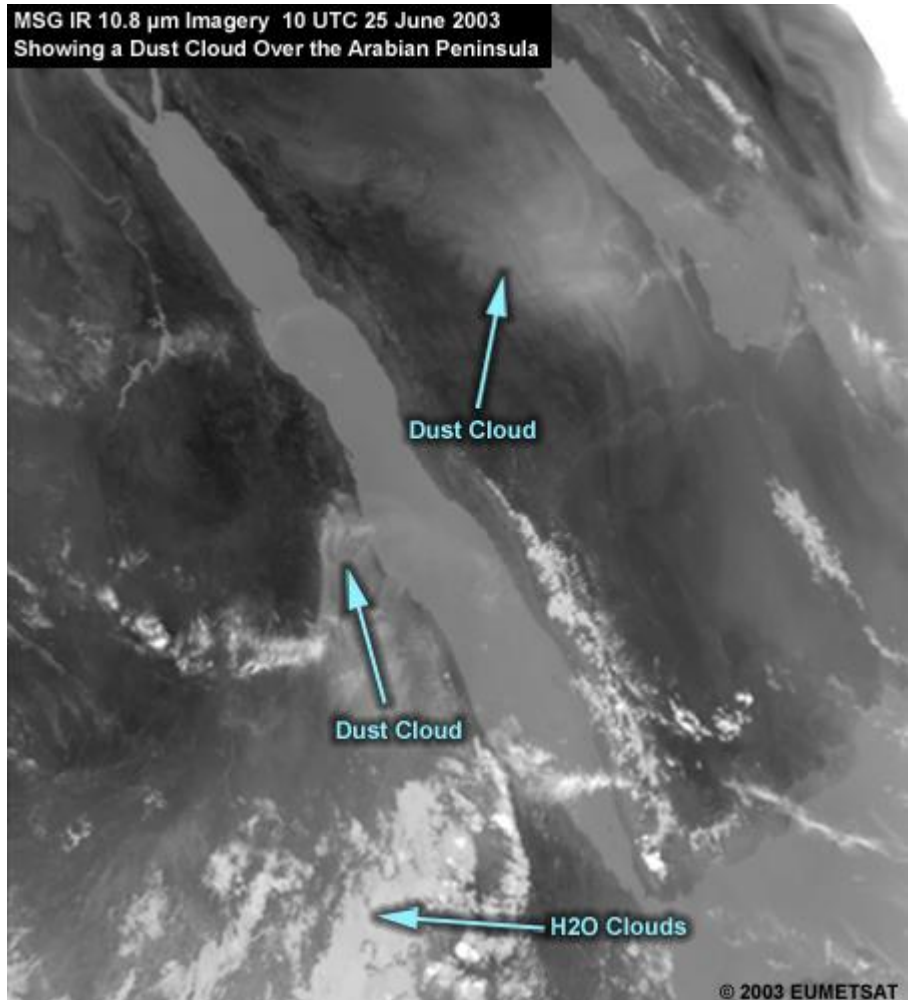
Images are from MSG

# Which satellite products are useful for **dust monitoring**? Visible vs Infrared channels

MSG VIS Imagery 10 UTC 25 June 2003  
Showing a Major Dust Cloud Over the Red Sea

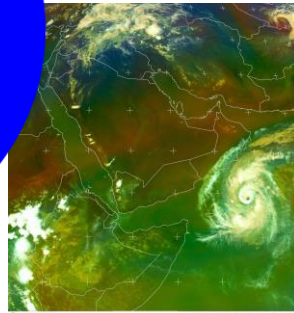
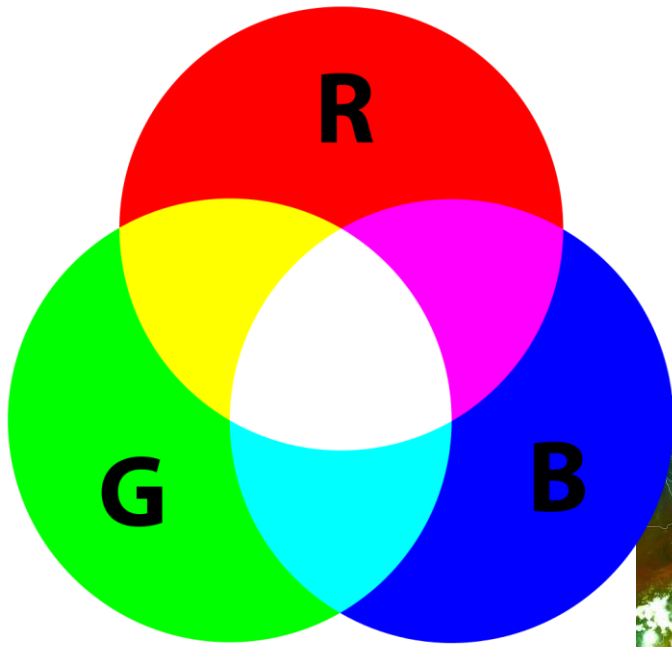


MSG IR 10.8  $\mu\text{m}$  Imagery 10 UTC 25 June 2003  
Showing a Dust Cloud Over the Arabian Peninsula

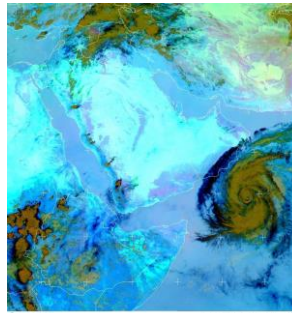




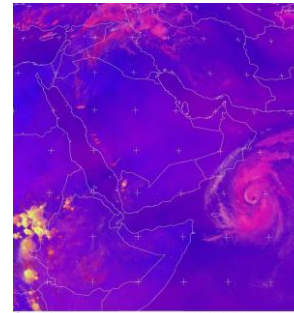
# EUMETSAT RGB products



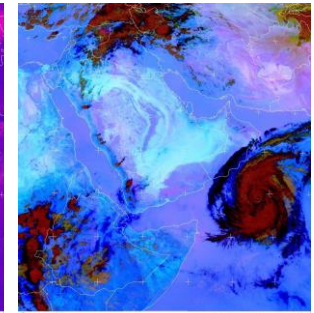
Air masses



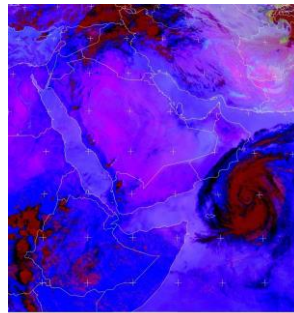
Ash



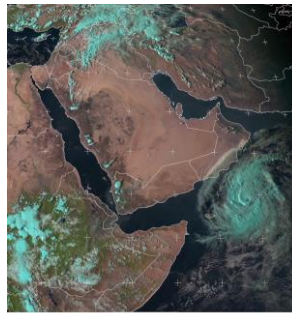
Convection



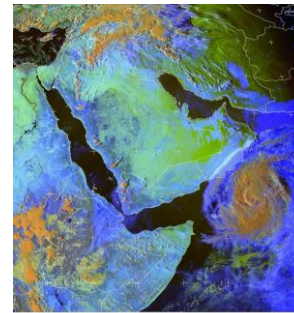
Dust



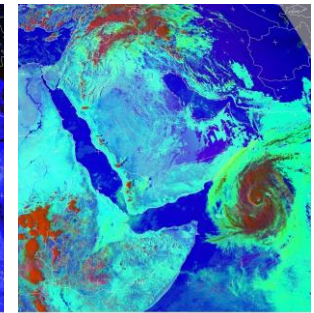
Fog



Natural colour



Snow



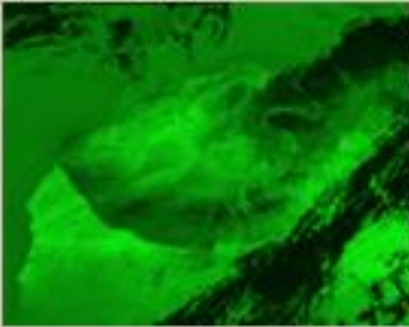
Day microphysics

# EUMETSAT RGB-Dust

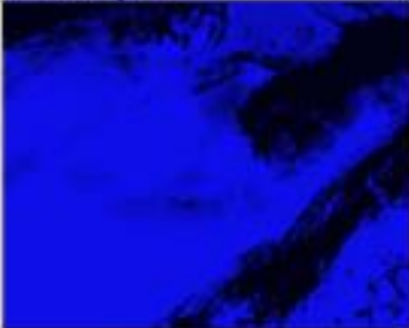
IR 12.0 - 10.8  $\mu\text{m}$



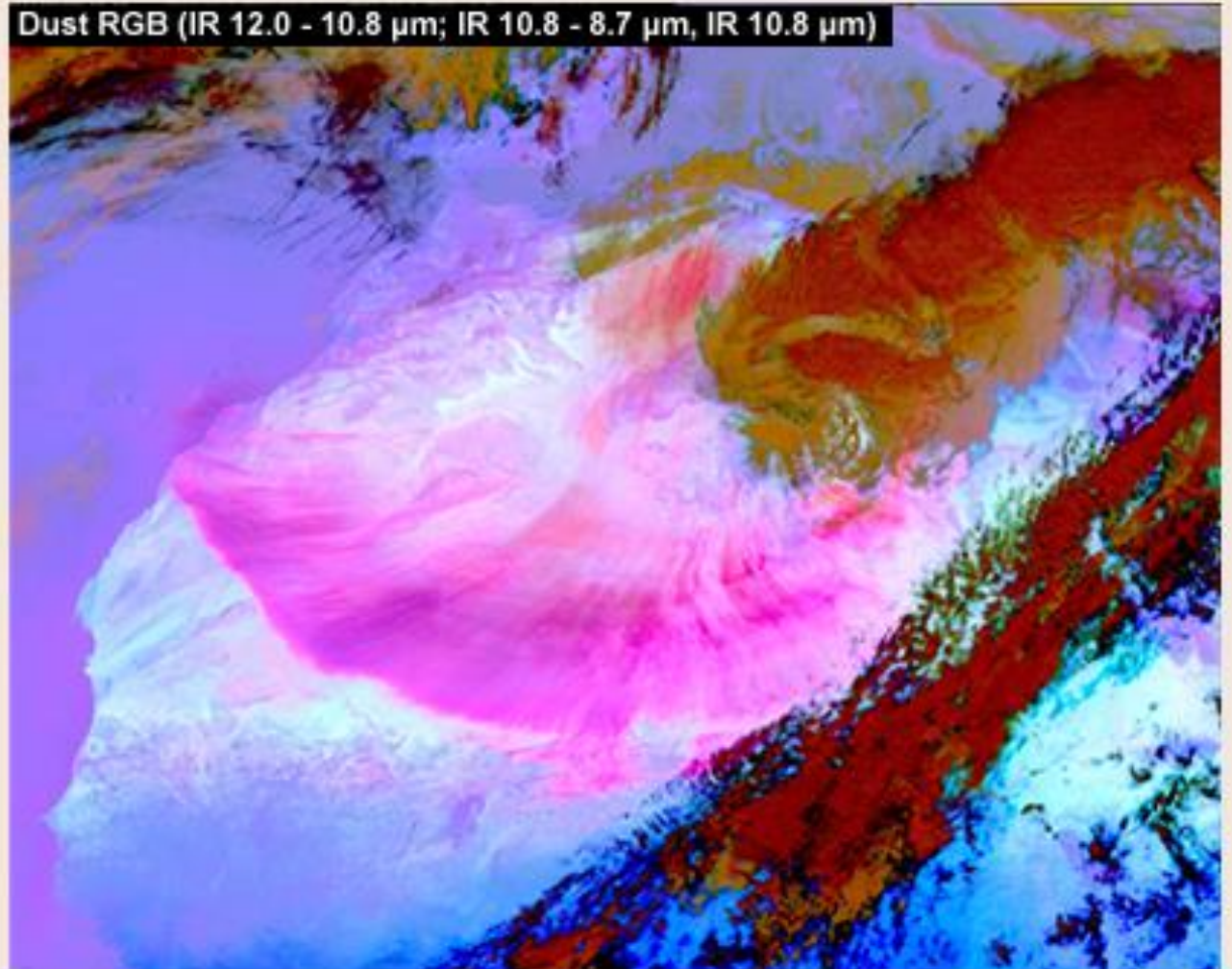
IR 10.8 - 8.7  $\mu\text{m}$



IR 10.8  $\mu\text{m}$



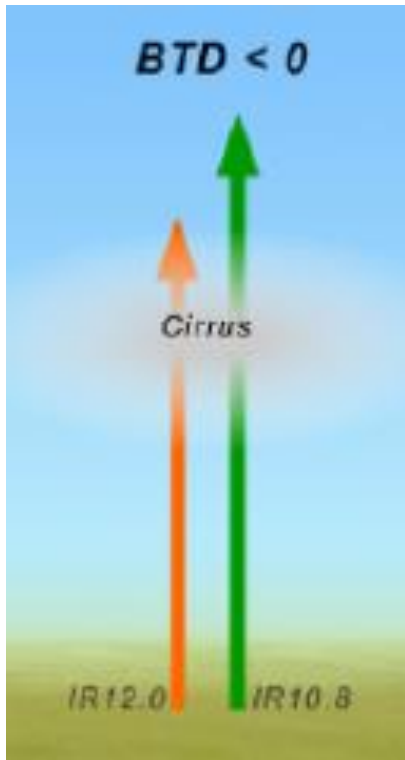
Dust RGB (IR 12.0 - 10.8  $\mu\text{m}$ ; IR 10.8 - 8.7  $\mu\text{m}$ , IR 10.8  $\mu\text{m}$ )



# EUMETSAT RGB-Dust

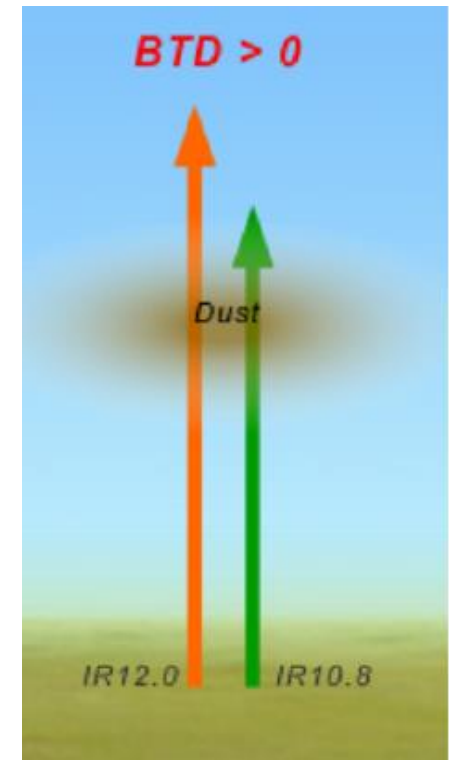
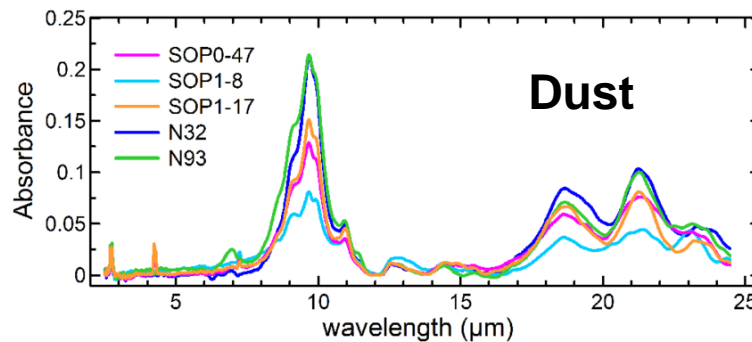
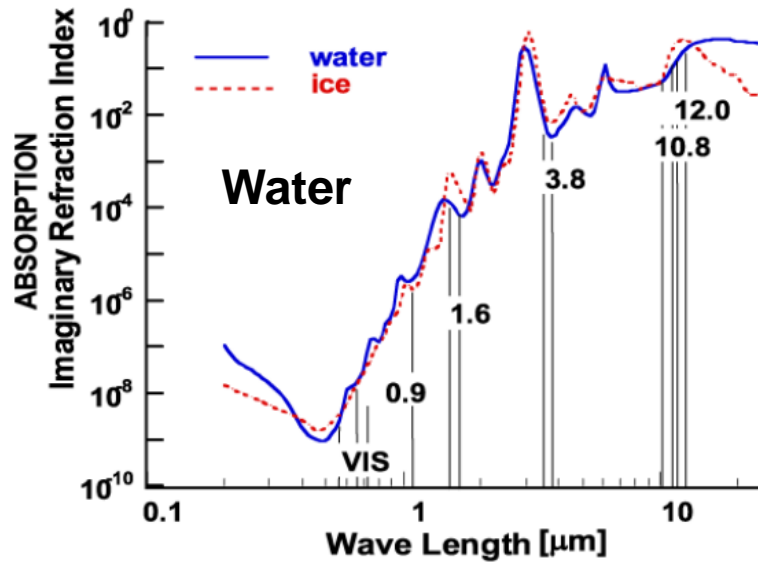
Red component: Rad@12.0 - Rad@10.8.

The goal is to distinguish dust and water clouds



Water / Ice : BT (12.0) < BT (10.8)

**No Red**



**Reverse absorption**

Dust / Ash : BT (12.0) > BT (10.8)

**Red**

# EUMETSAT RGB-Dust

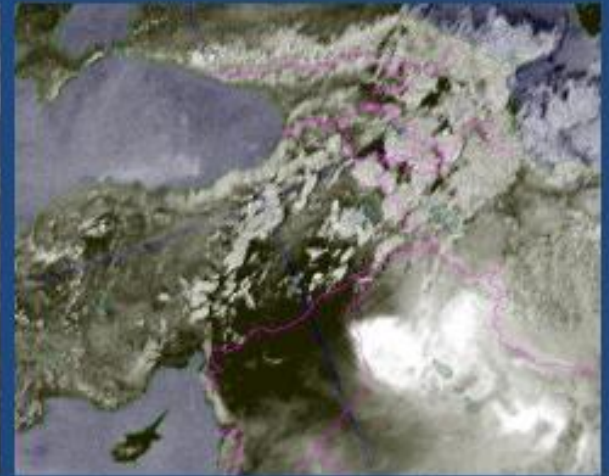
Channel 9, 10.8 $\mu$ m



Channel 10, 12.0 $\mu$ m



Difference ch 10 – ch 9



---

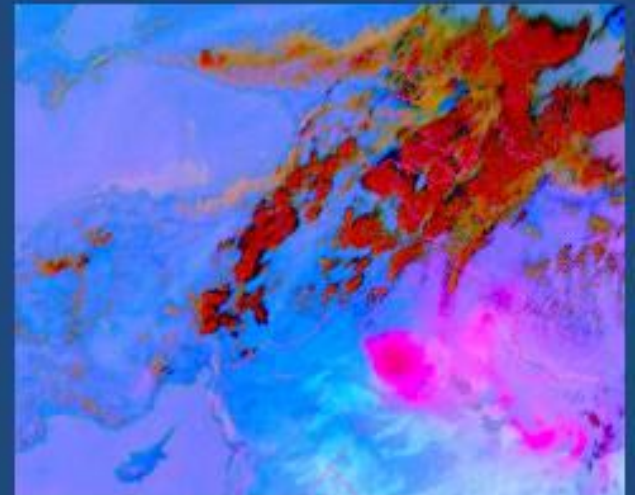
**Red: IR 12.0 – IR 10.8**

**Range of values: - 4 ... + 2 K**

So full Red means

$$BT(IR12.0) - BT(IR10.8) = + 2 K$$

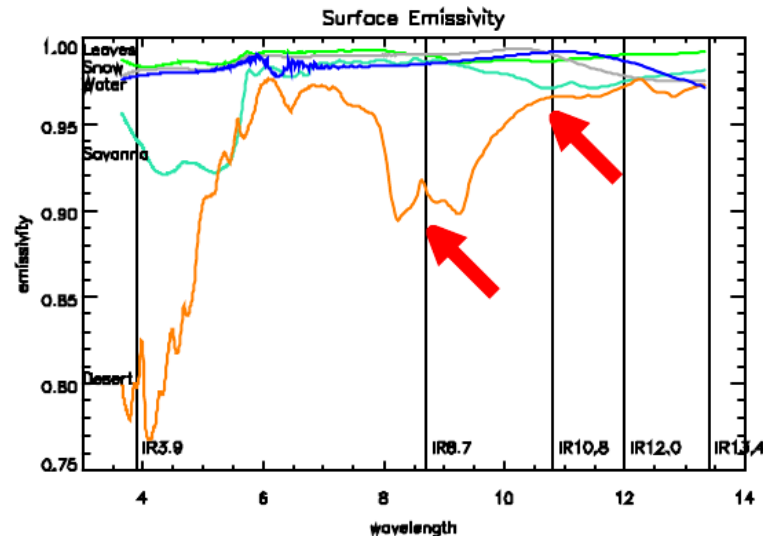
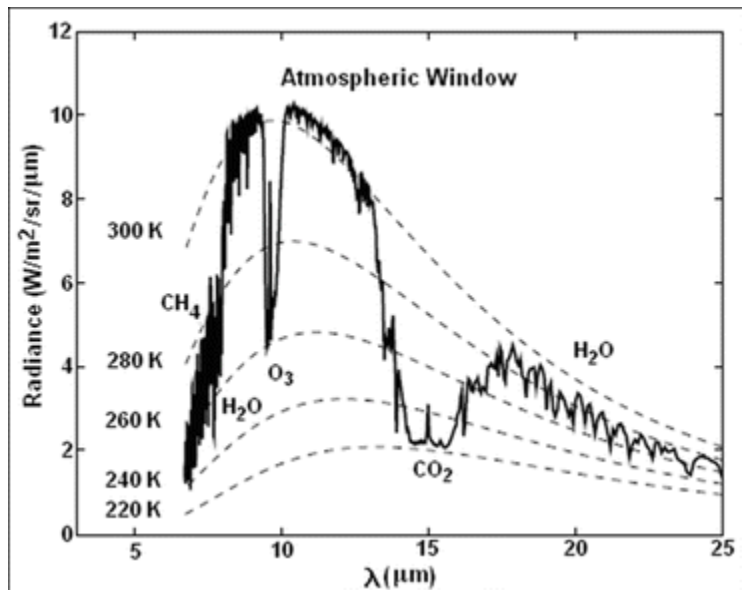
Dust RGB



# EUMETSAT RGB-Dust

Green component: Rad@10.8 - Rad@8.7.

The goal is to distinguish airborne dust and desert soils



Emission:  $J = \sigma T^4$

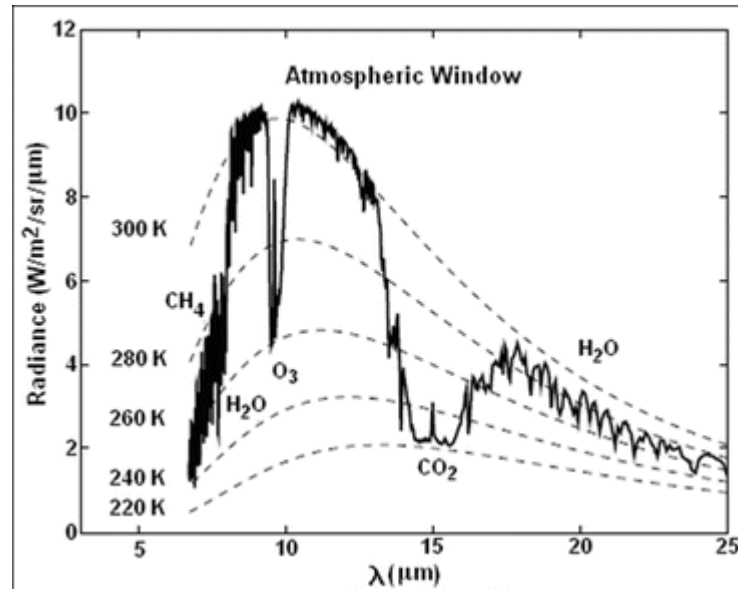
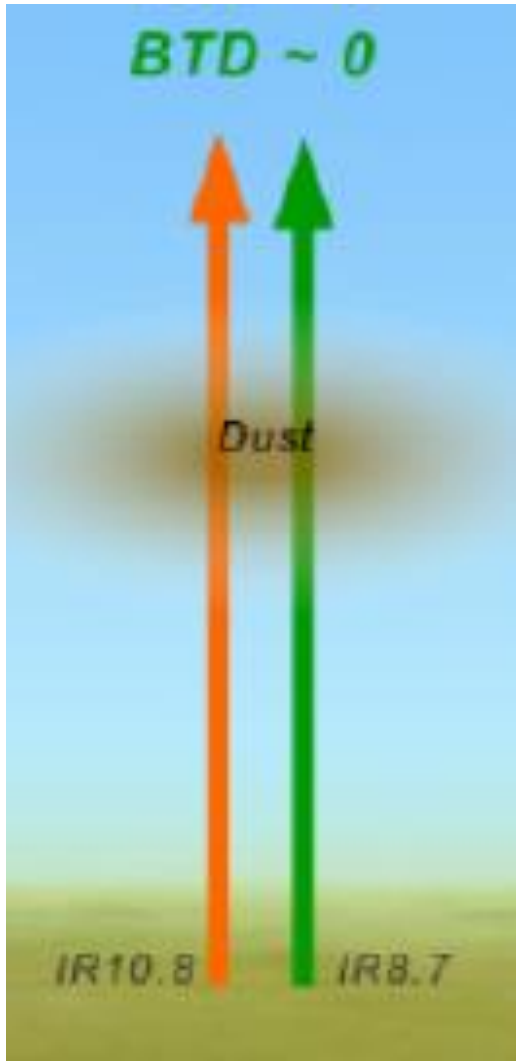
---

**Green:** IR 10.8 – IR 8.7  
 Range of values: 0 ... + 15 K

---

**Deserts**  
 BT 10.8 > BT 8.7  
**Green**

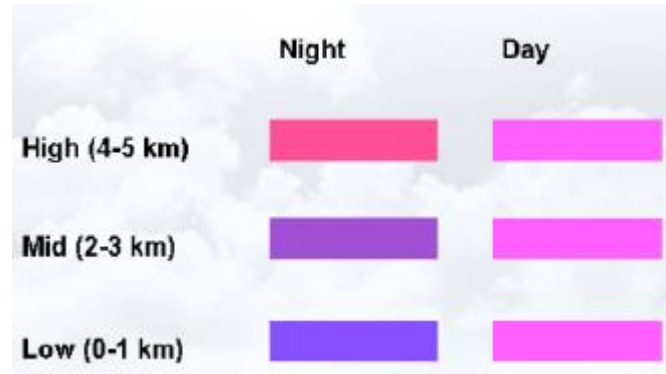
# EUMETSAT RGB-Dust



**Dust**  
BT 10.8 = BT 8.7  
**No Green**

# EUMETSAT RGB-Dust

Blue component: Rad@10.8



By night, it allows estimating height of dust cloud

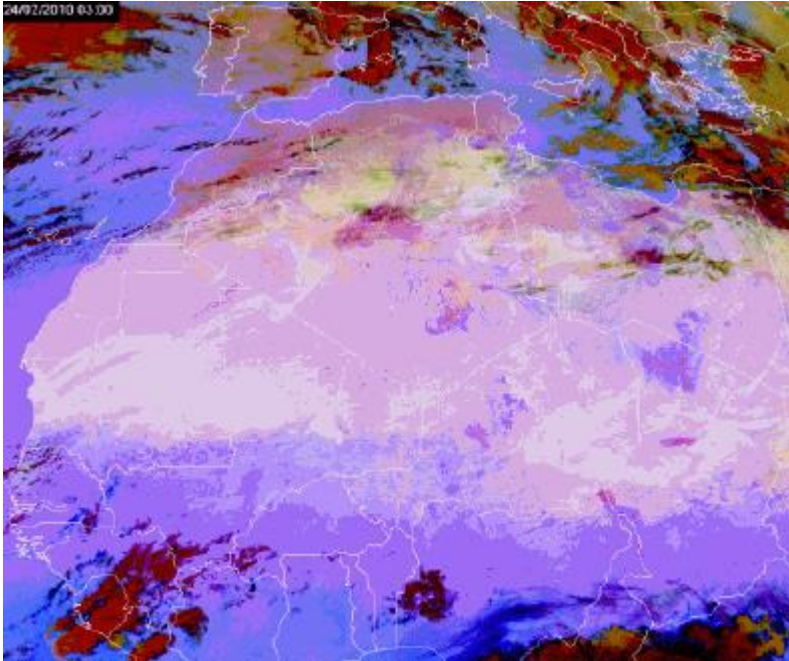
---

**Blue:** IR 10.8

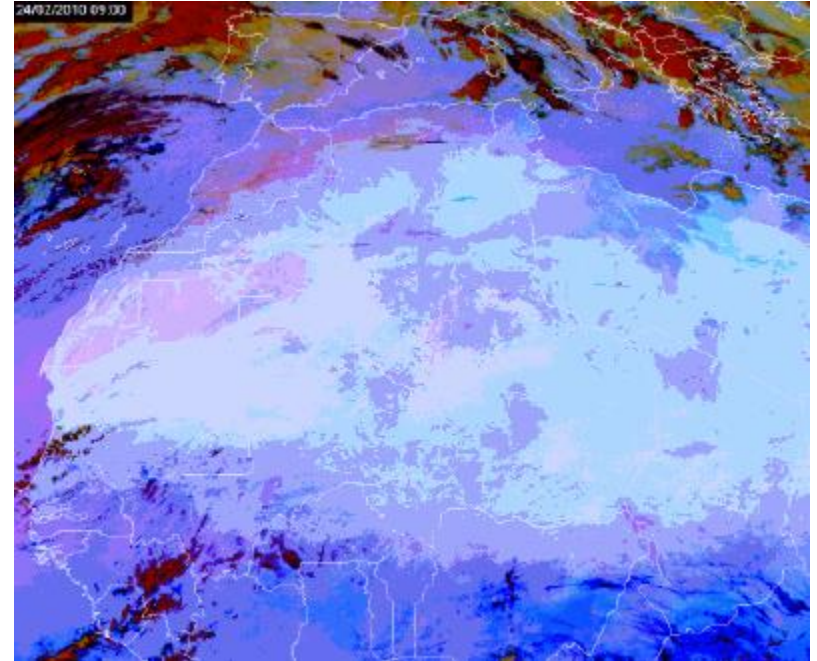
**Range of values:** -12°C ... 16°C

# EUMETSAT RGB-Dust

Diurnal variation of temperature



**Desert by night**

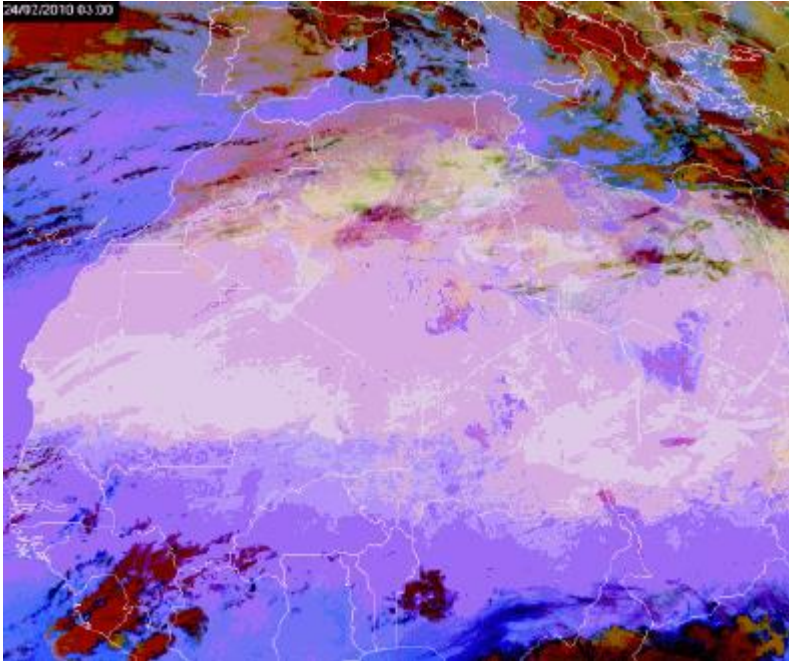


**Desert by day**  
(higher temperature → higher blue contribution)

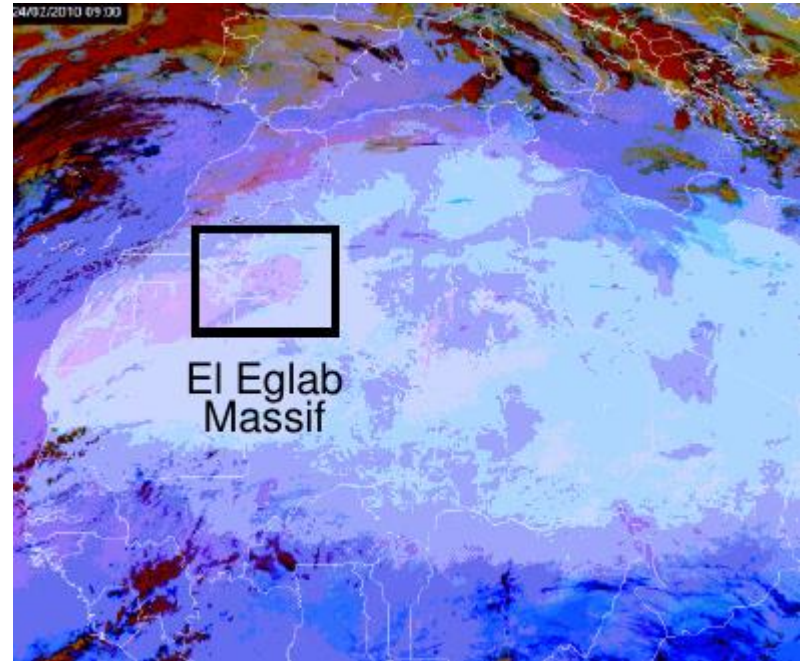


# EUMETSAT RGB-Dust

Diurnal variation of temperature



**Desert by night**



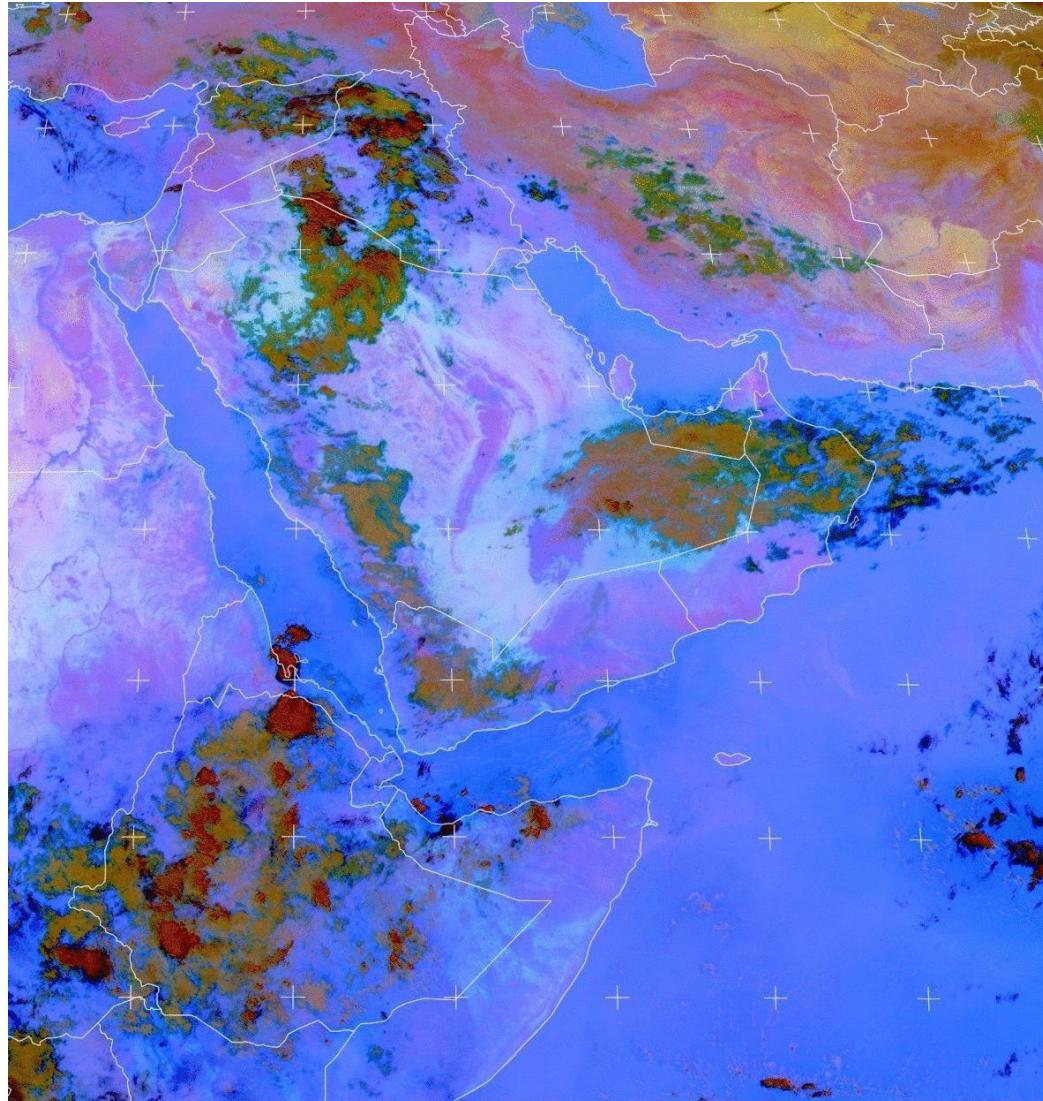
**Desert by day**

(higher temperature → higher blue contribution)

... but mountains can remain relatively cold → low blue contribution

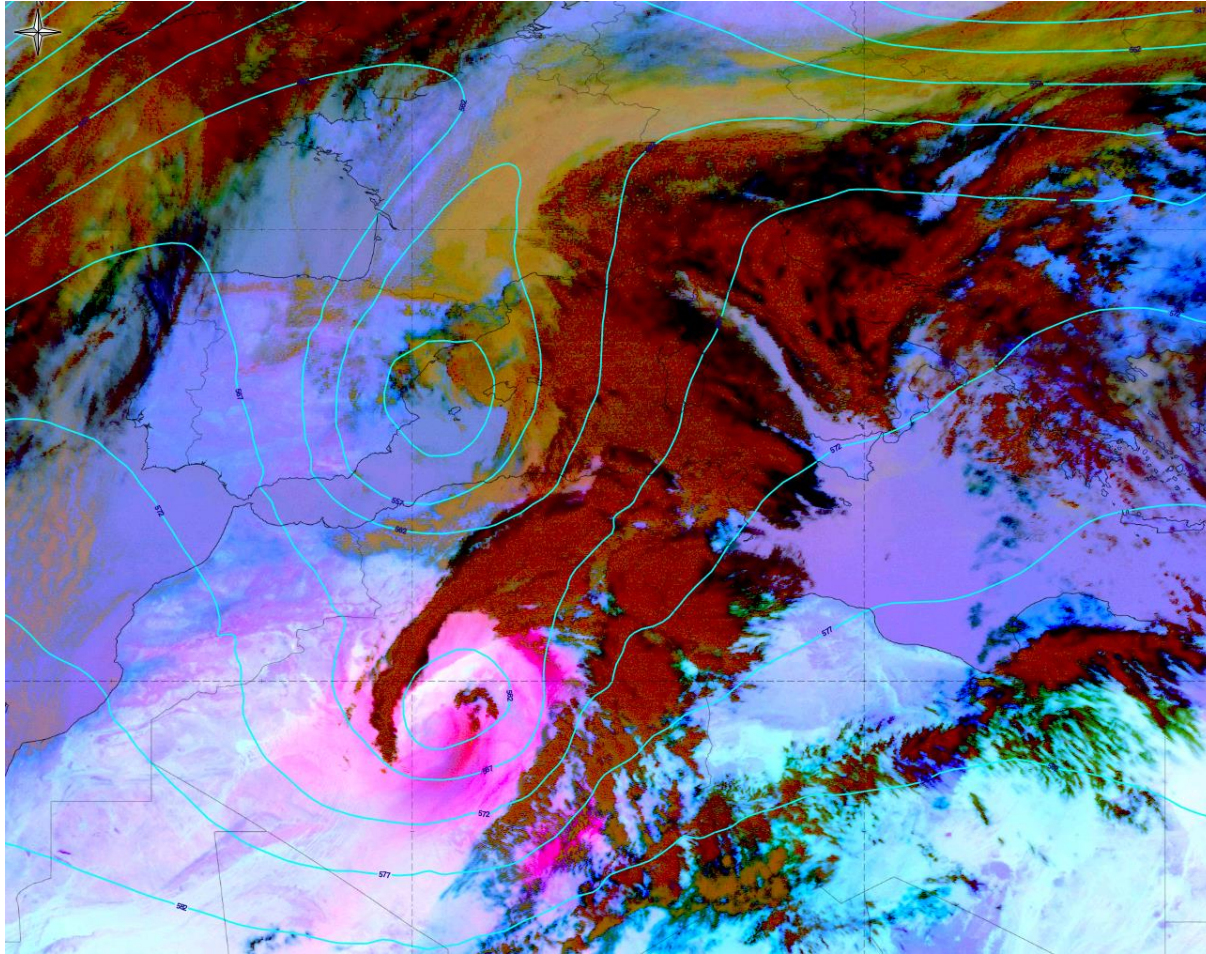
# EUMETSAT RGB-Dust

Diurnal variation of temperature



# EUMETSAT RGB-Dust

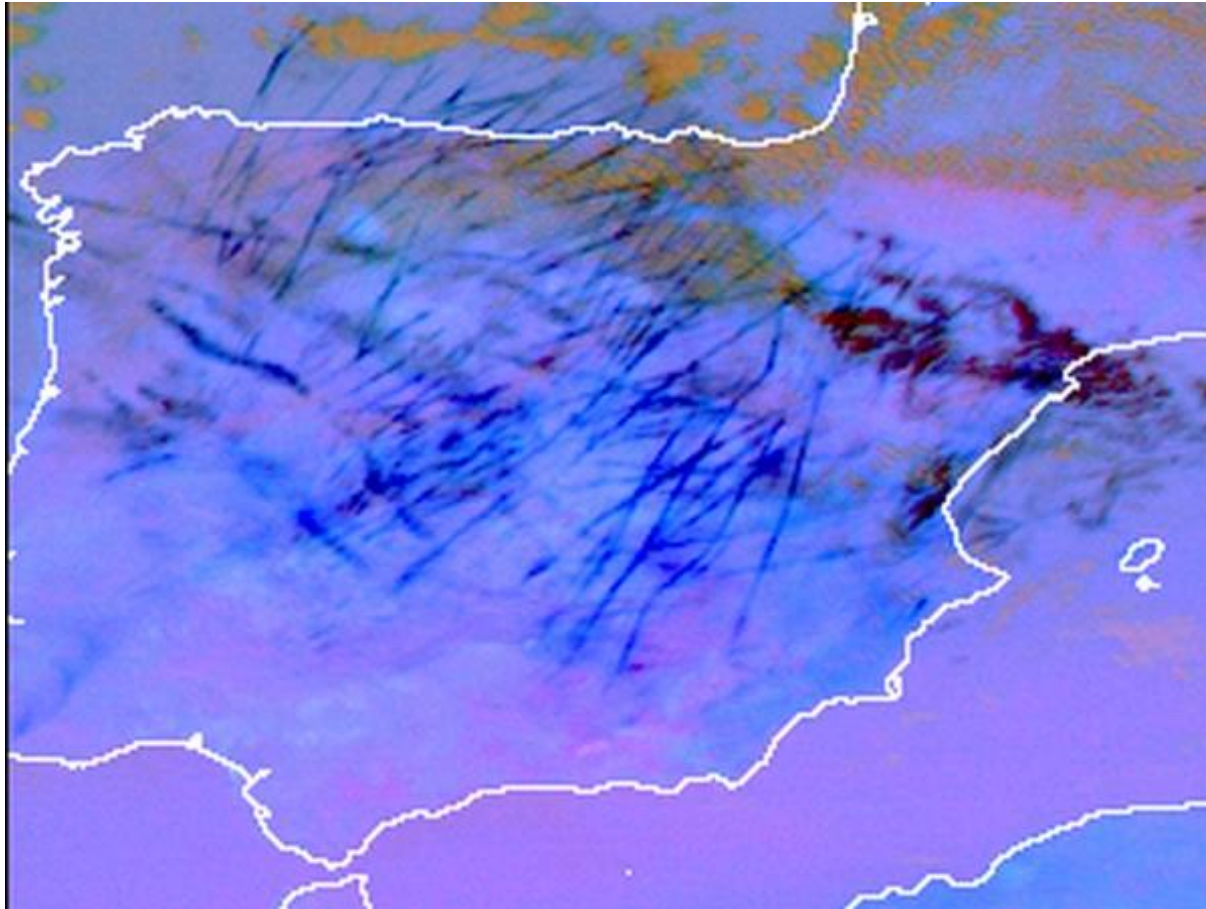
Other features



**Cold thick high-level clouds**  
**Cold thin high-level clouds, contrails**  
**Thick mid-level cloud**

# EUMETSAT RGB-Dust

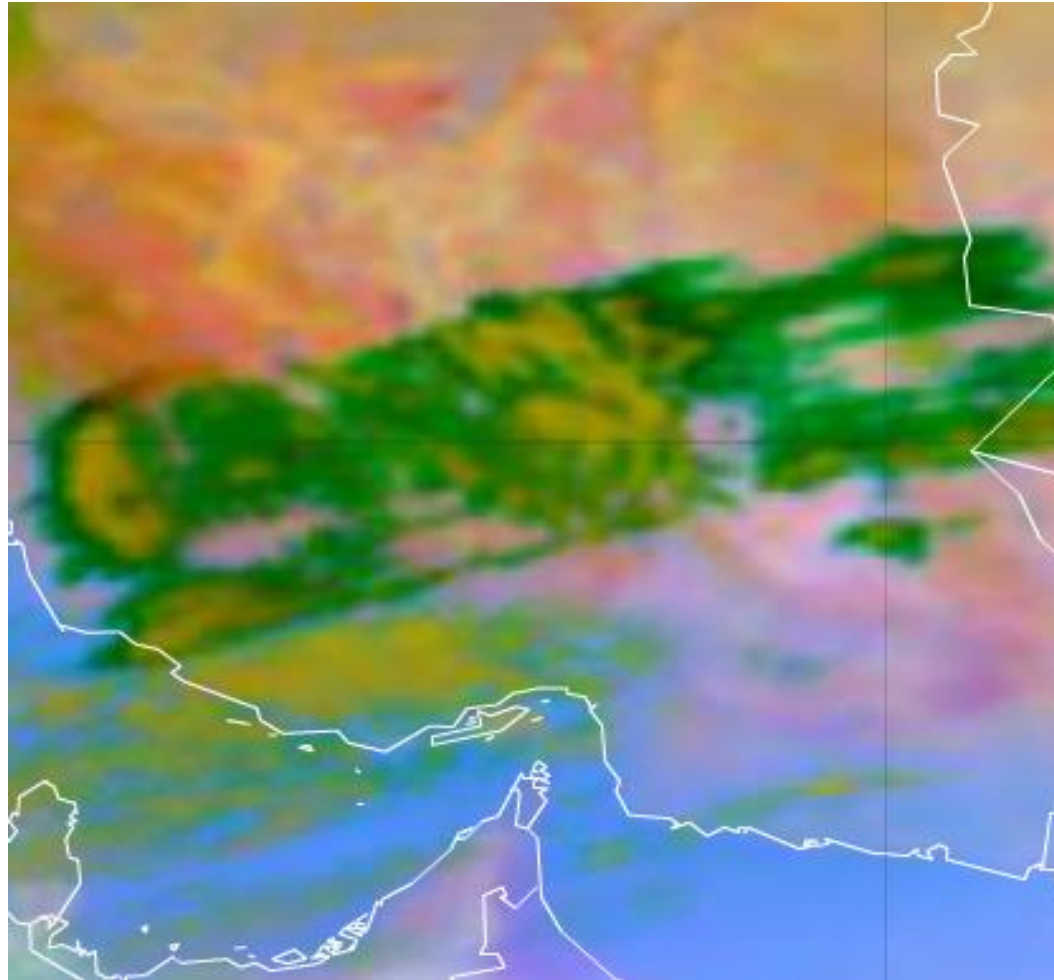
Other features



**Contrails can sometimes be dark blue**

# EUMETSAT RGB-Dust

Other features



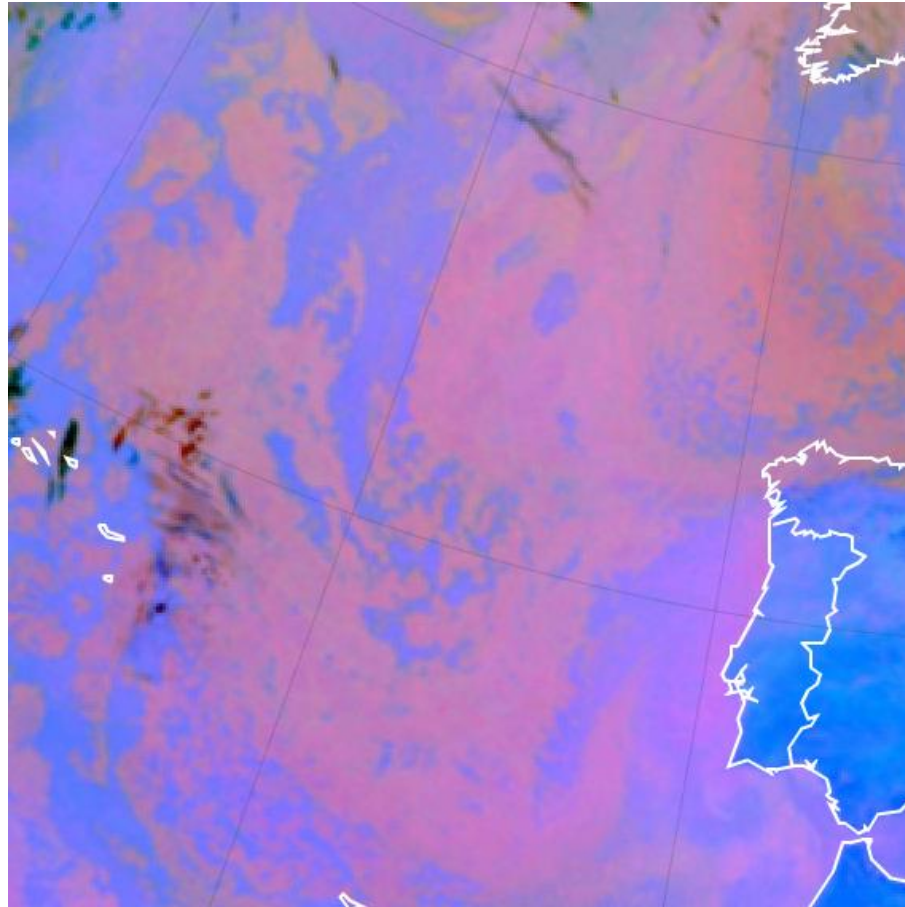
**Thin (semi-transparent) mid-level cloud**



**Thick mid-level cloud**

# EUMETSAT RGB-Dust

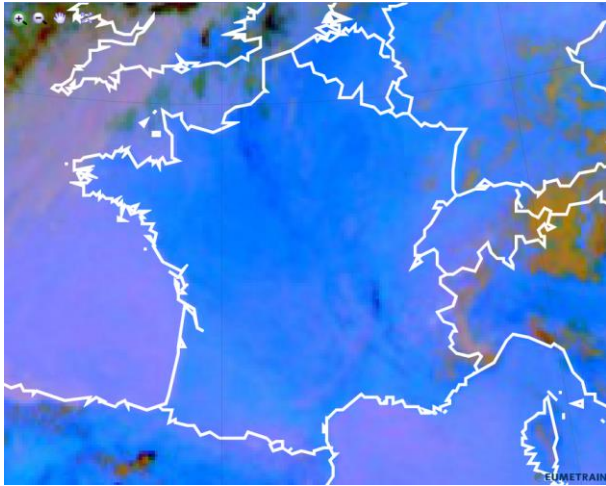
Other features



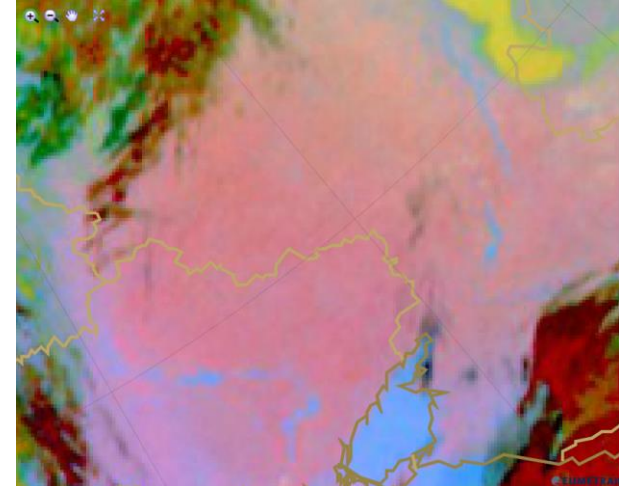
-  Low-level water clouds (cold)
-  Low-level water clouds (warm)

# EUMETSAT RGB-Dust

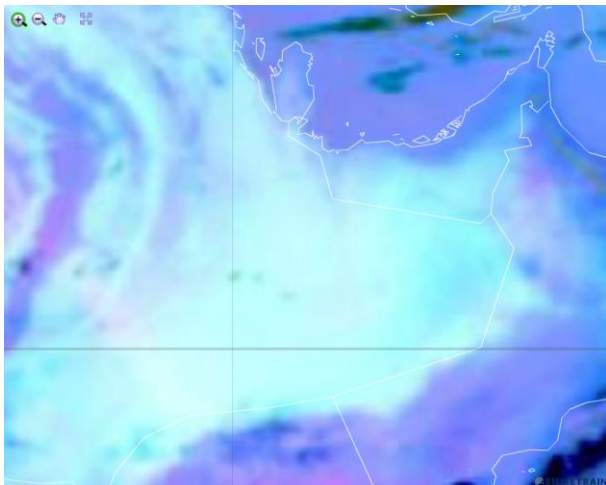
Other features



**Cloud-free vegetated surface in a warm day**



**Cloud-free vegetated surface in a cold summer night**



**Hot sandy desert (left)**

**Cold sandy desert (right)**

