

# Dust & Smoke Detection with MSG SEVIRI RGB Products



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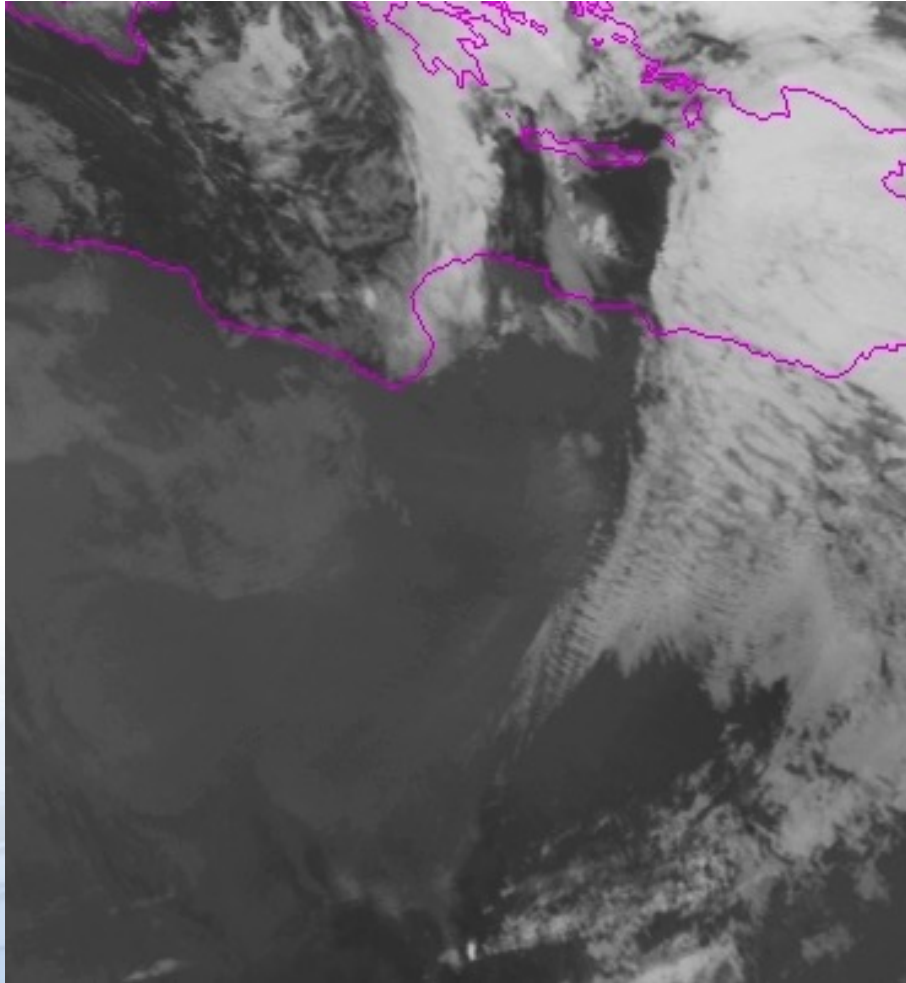


# Motivation & Background

## Exercise - where is the dust ?

3

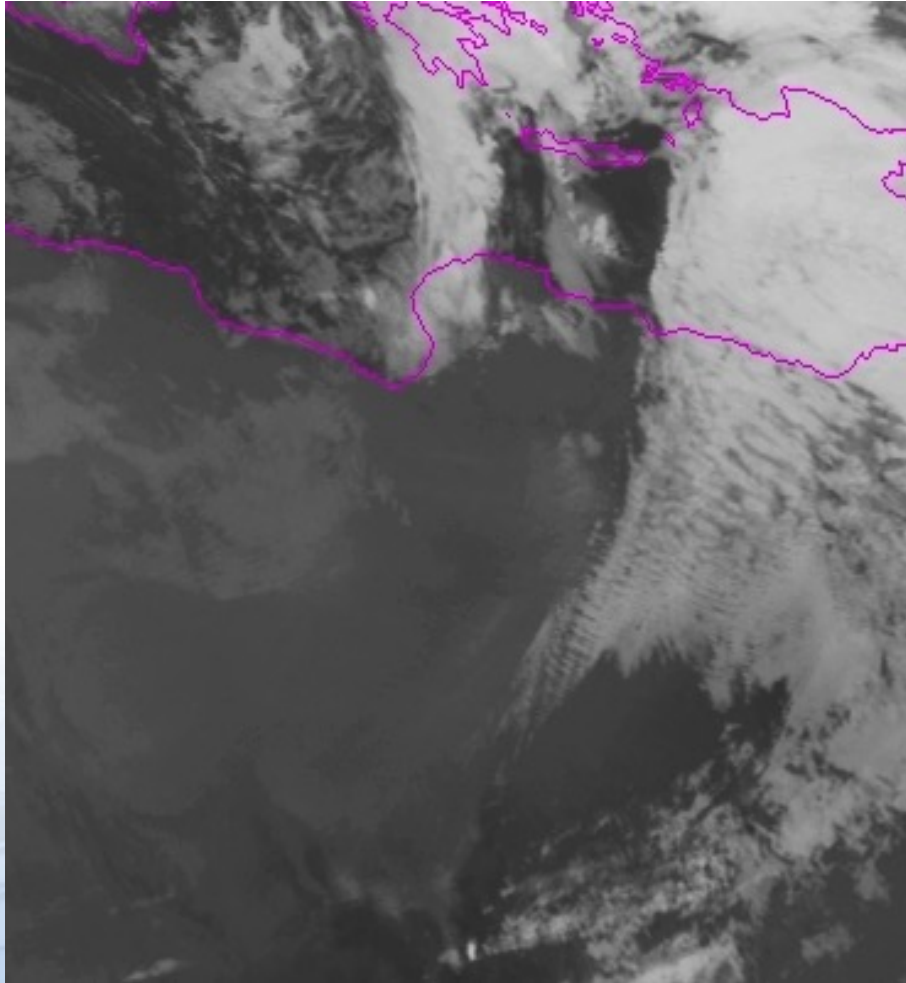
Met-7 IR image



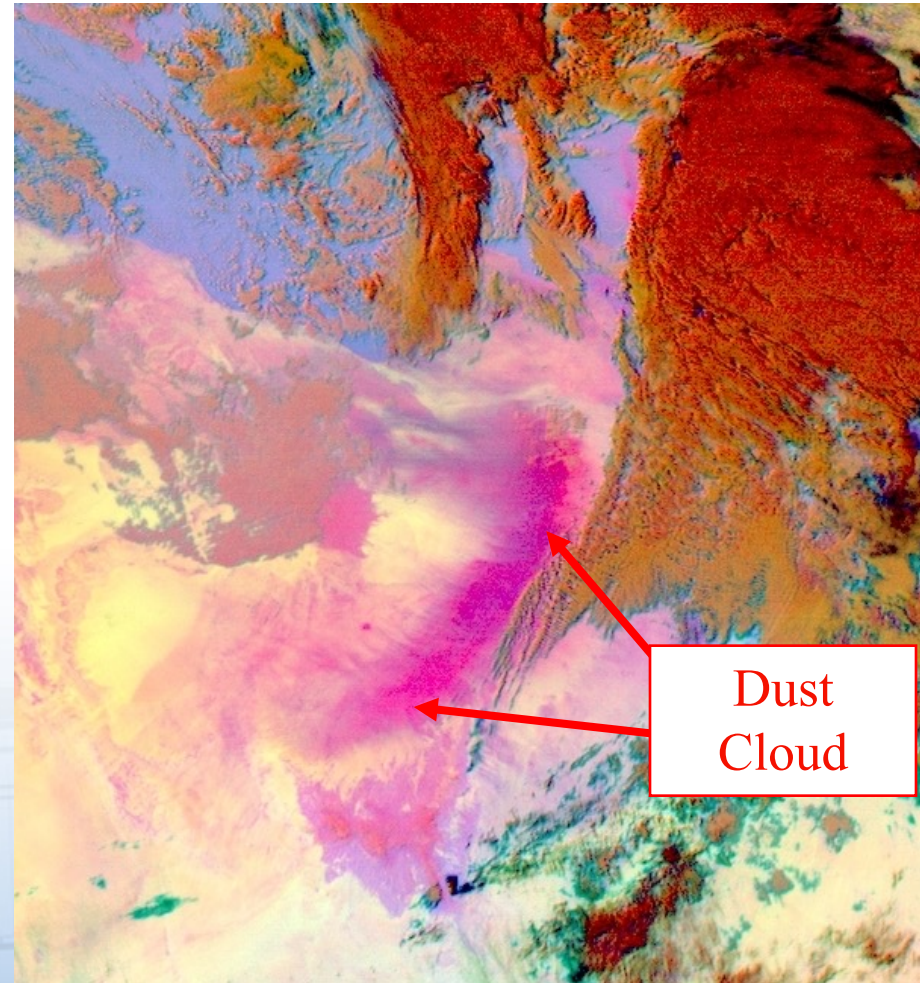
## Exercise - where is the dust ?

4

Met-7 IR image



Met-8 Dust RGB Product

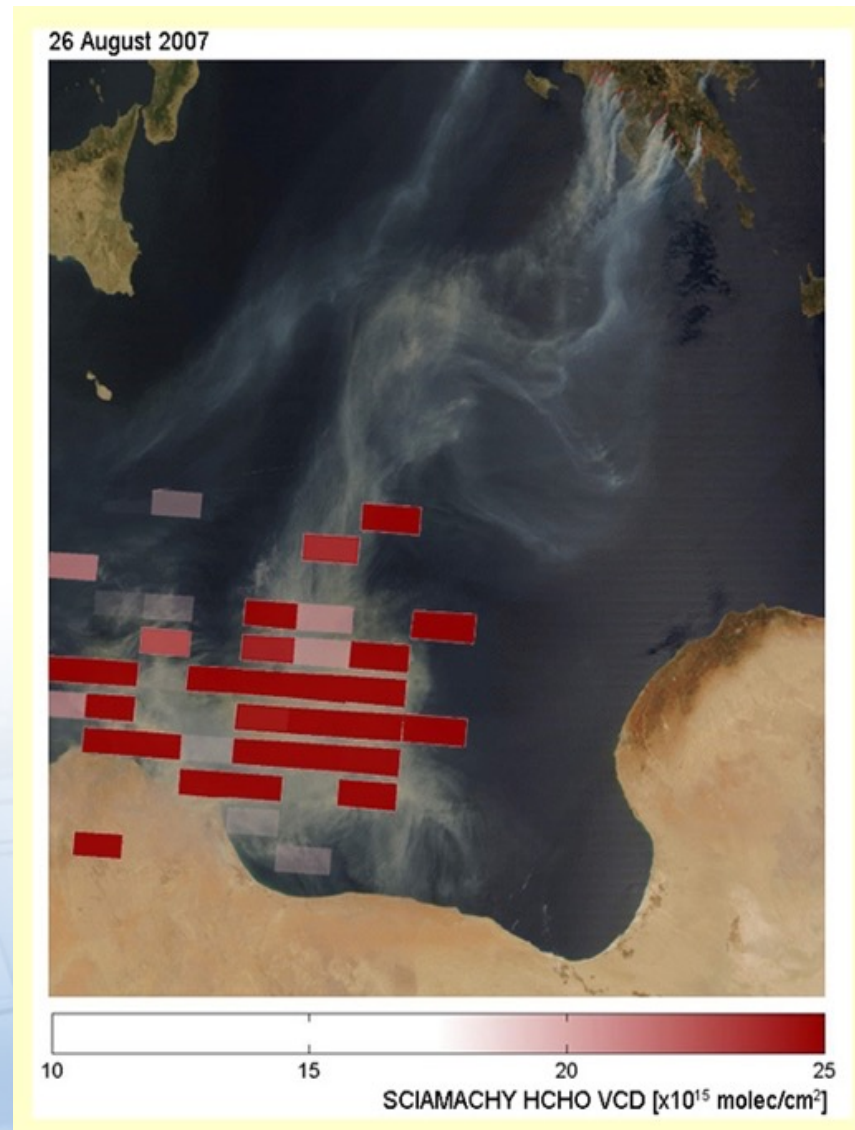


# Neighbouring impacts of Smoke

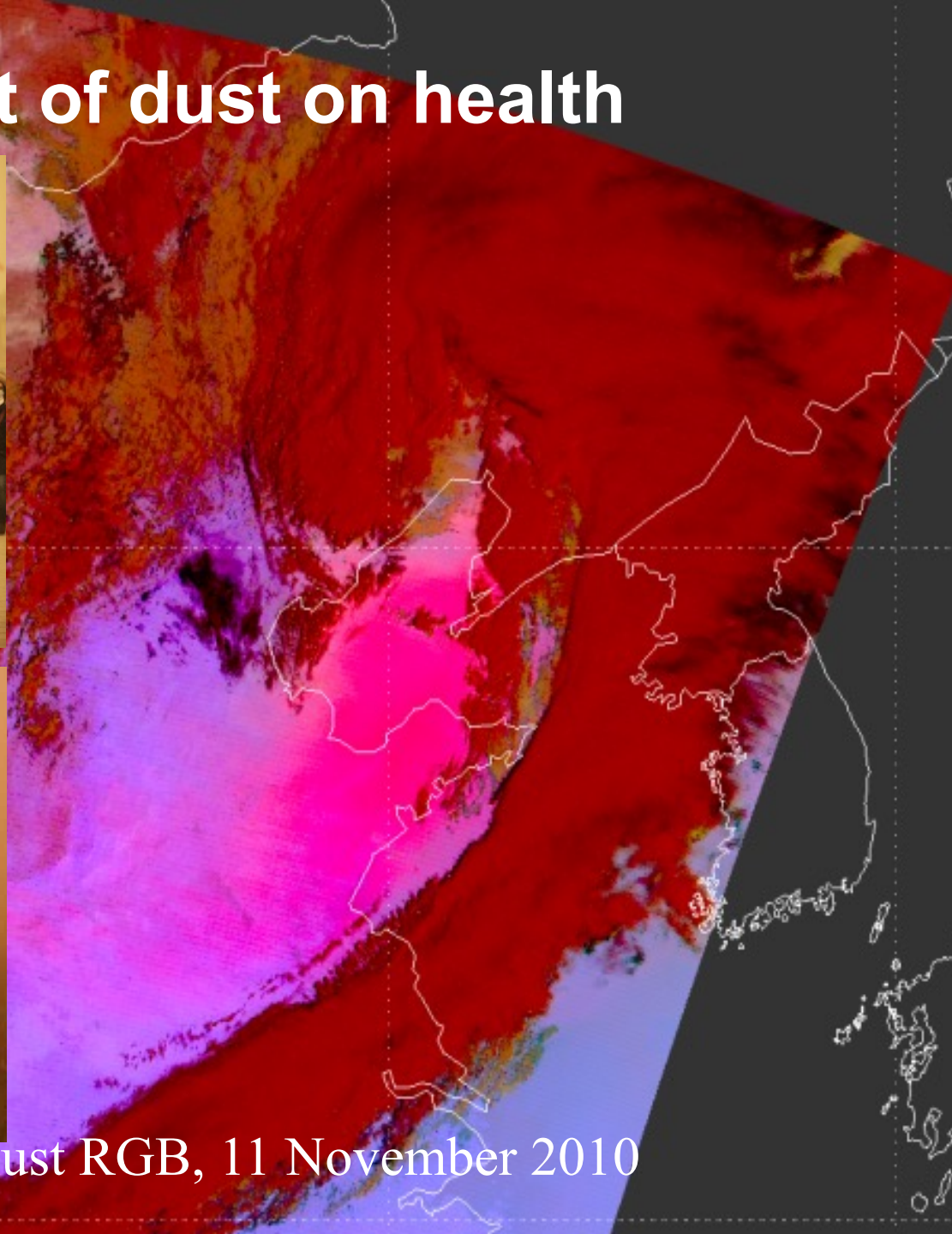


Formaldehyde concentration  
from SCIAMACHY:

Poisonous gas released by  
biomass burning in Greece  
reaches the coast of Libya.



# The impact of dust on health



Terra, MODIS, Dust RGB, 11 November 2010

# The impact of dust on traffic



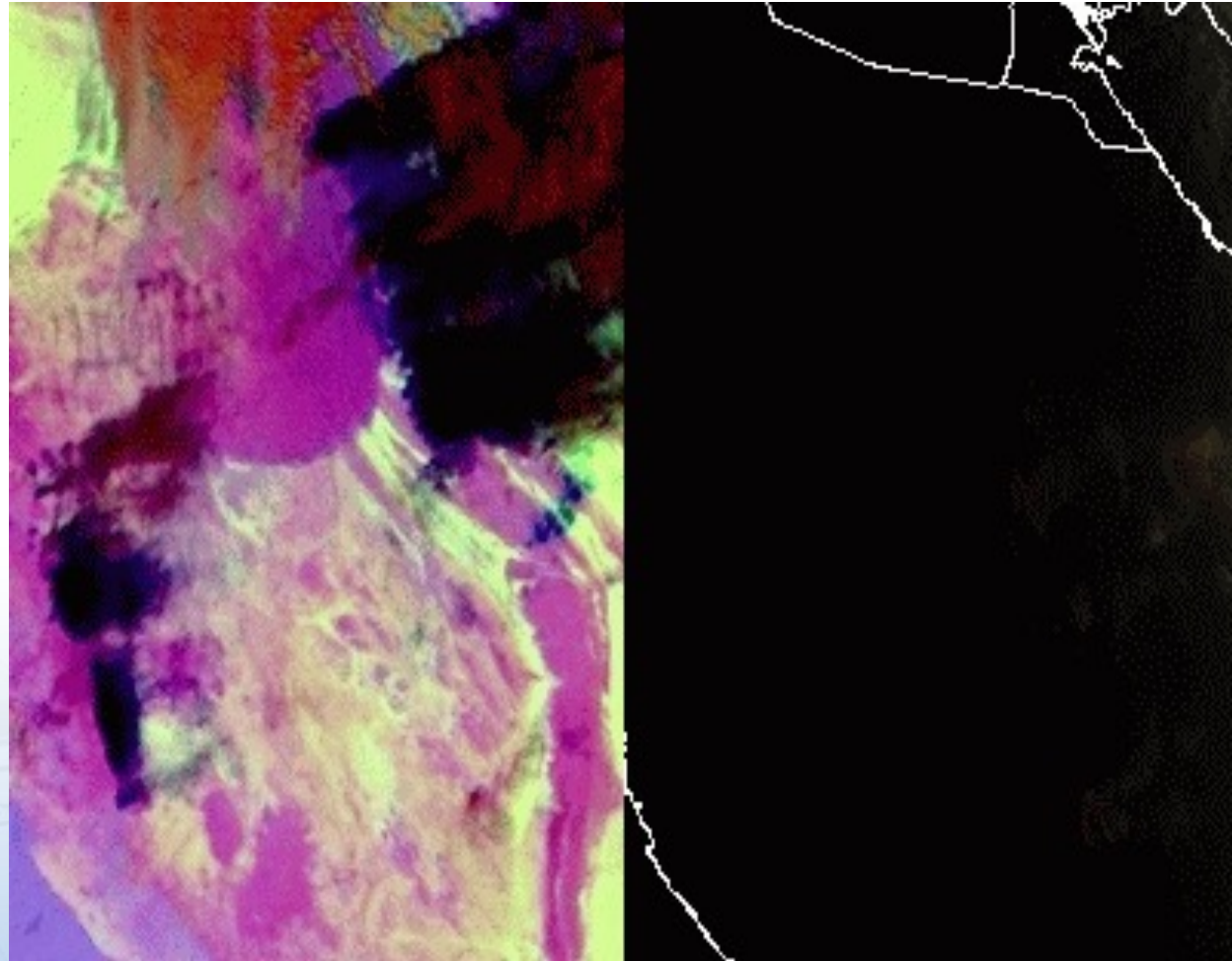
GOES, VIS, 29 October 2010

# The impact of dust on (air)traffic



Dust squall hits Riyadh, Saudi Arabia, on 10 March 2009

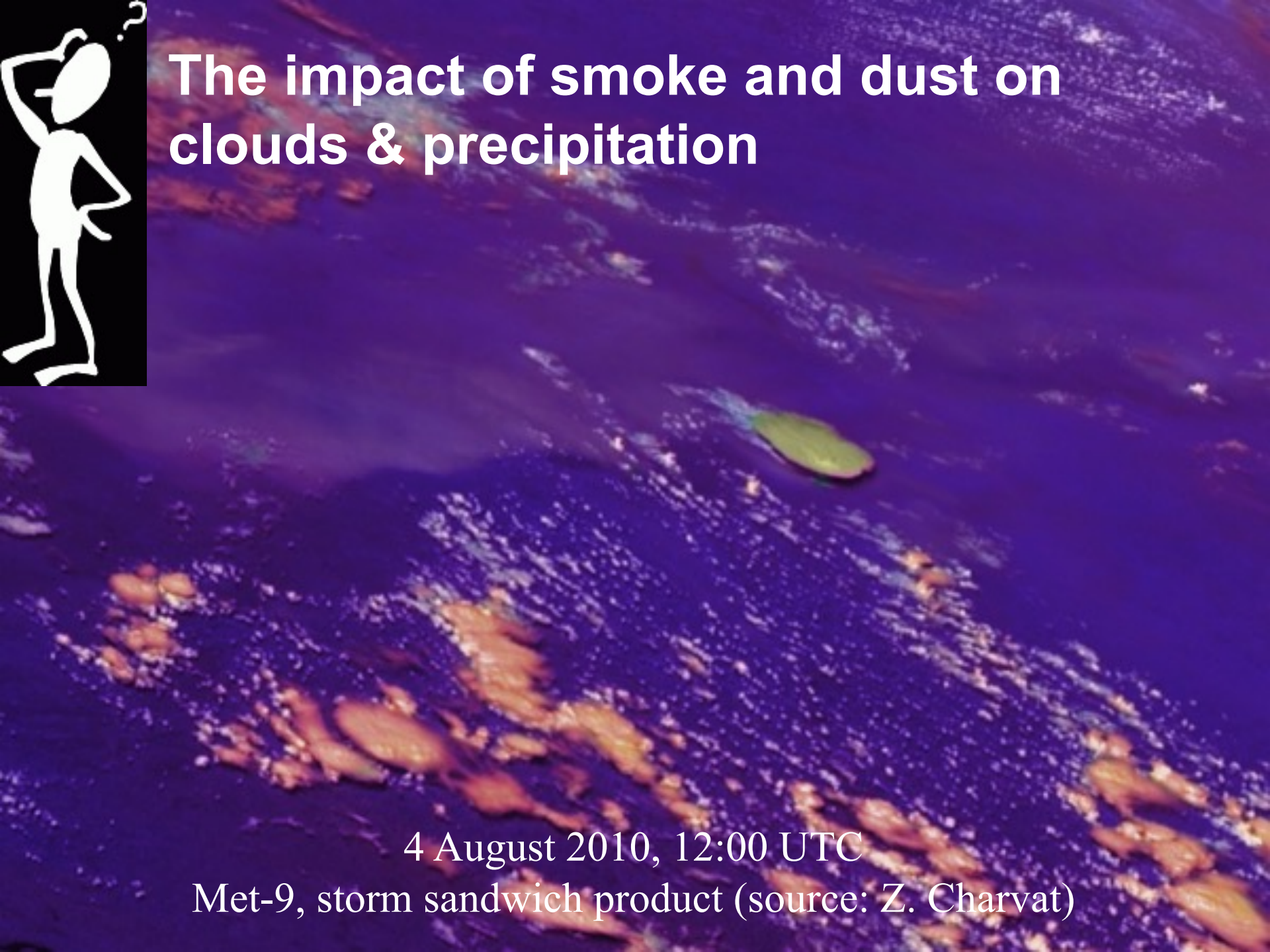
# The impact of dust on (air)traffic



Met-8, 5-min rapid scans, 10 March 2009



# The impact of smoke and dust on clouds & precipitation



4 August 2010, 12:00 UTC

Met-9, storm sandwich product (source: Z. Charvat)

# 3 Window Channels in VIS/NIR

## 3 Window Channels in IR

11

Window	Band (um)	Airmass	Band (um)
VIS 0.6	0.56 - 0.71	WV 6.2	5.35 - 7.15
VIS 0.8	0.74 - 0.88	WV 7.3	6.85 - 7.85
NIR 1.6	1.50 - 1.78	IR 9.7	9.38 - 9.94
MIR 3.9	3.40 - 4.20	IR 13.4	12.40 - 14.40
IR 8.7	8.30 - 9.10		
IR 10.8	9.80 - 11.80	High Res VIS	
IR 12.0	11.00 - 13.00	HRV	0.4 - 1.1



# Smoke & Dust Solar Channels

2007/08/26 11:12

CH01 0.6

CH01 0.6

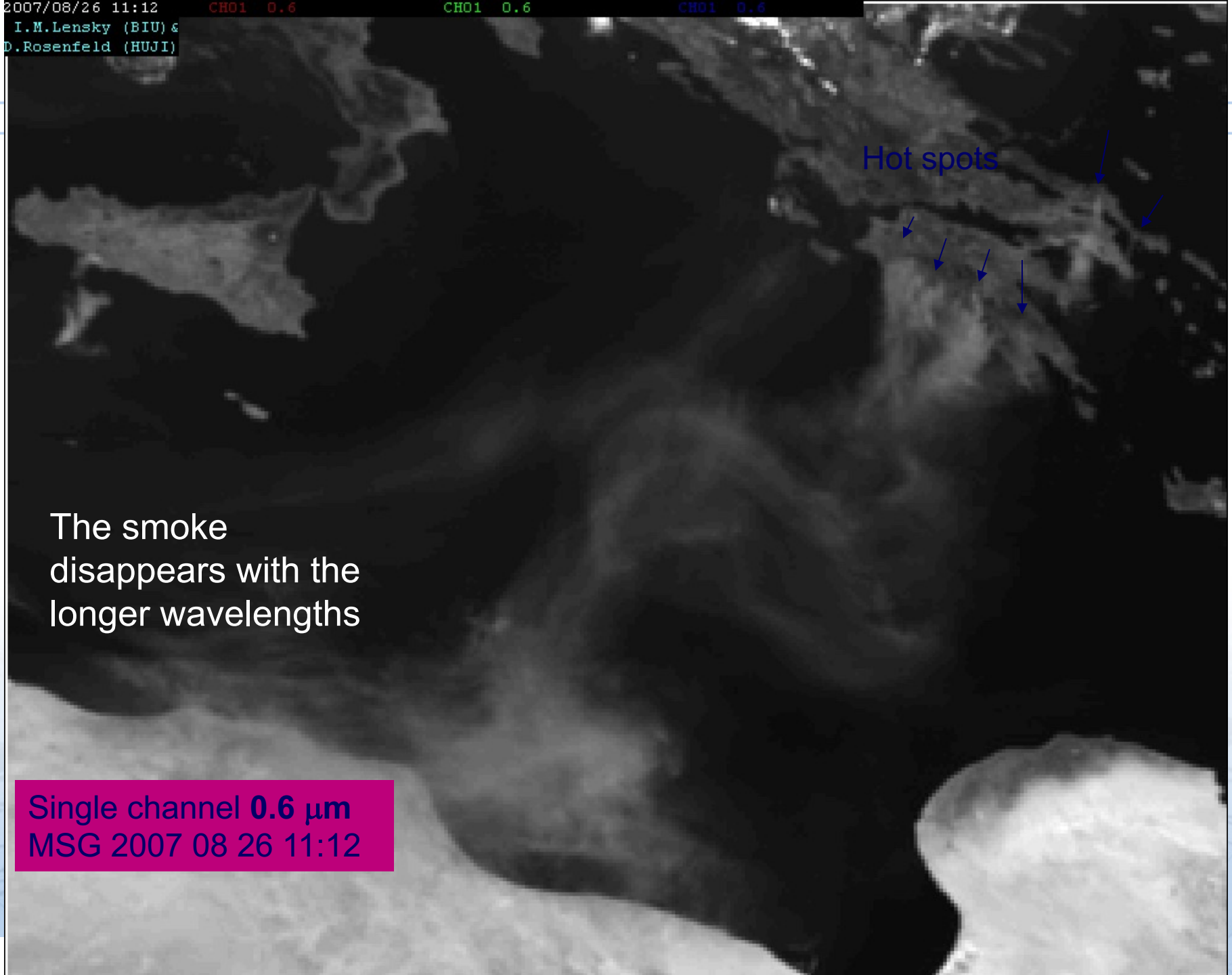
CH01 0.6

I.M.Lensky (BIU) &  
D.Rosenfeld (HUJI)

Hot spots

The smoke  
disappears with the  
longer wavelengths

Single channel **0.6  $\mu\text{m}$**   
MSG 2007 08 26 11:12



2007/08/26 11:12

CH02 0.8

CH02 0.8

CH02 0.8

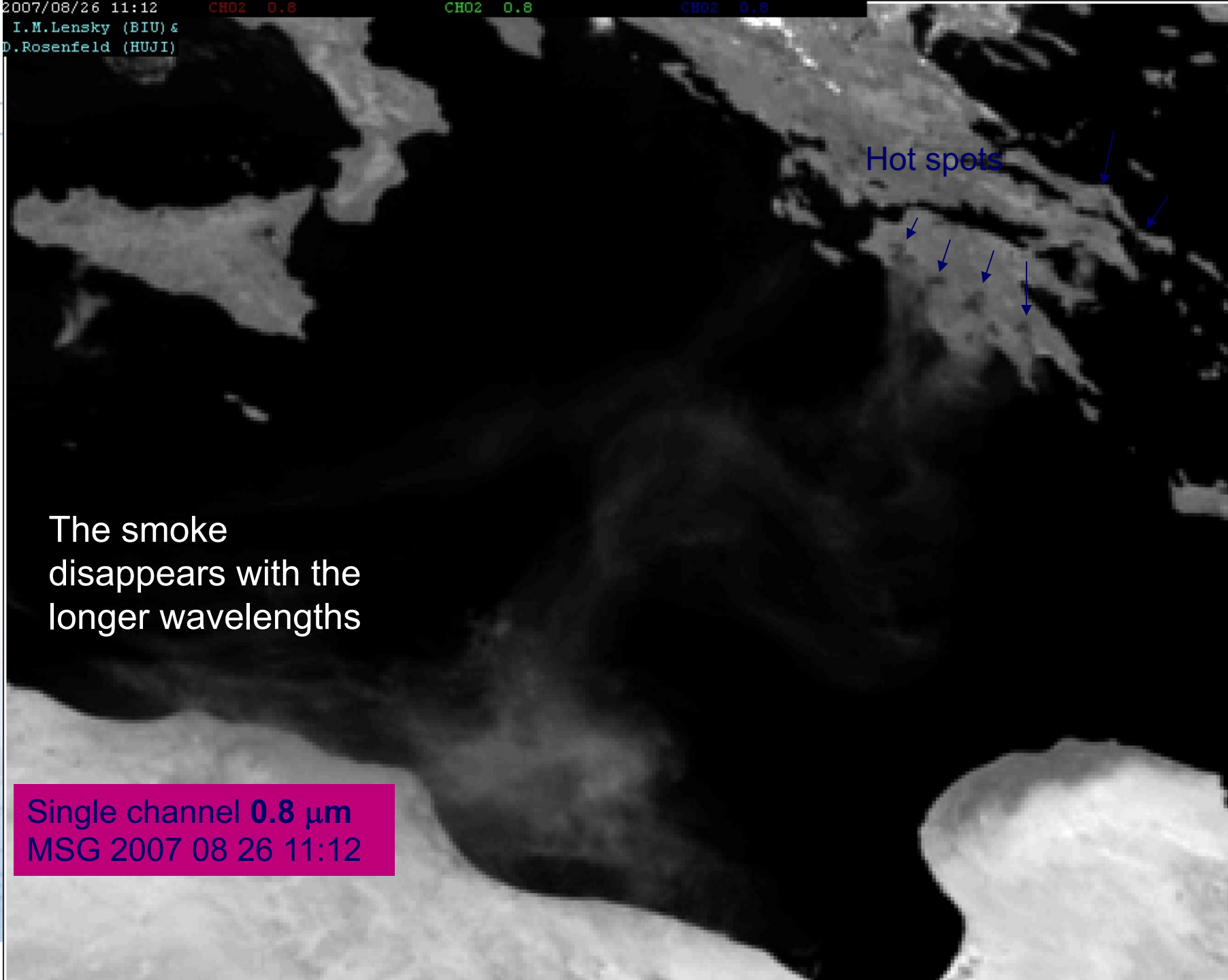
I.M.Lensky (BIU) &

D.Rosenfeld (HUJI)

Hot spots

The smoke  
disappears with the  
longer wavelengths

Single channel  $0.8 \mu\text{m}$   
MSG 2007 08 26 11:12



2007/08/26 11:12

CH03 1.6

CH03 1.6

CH03 1.6

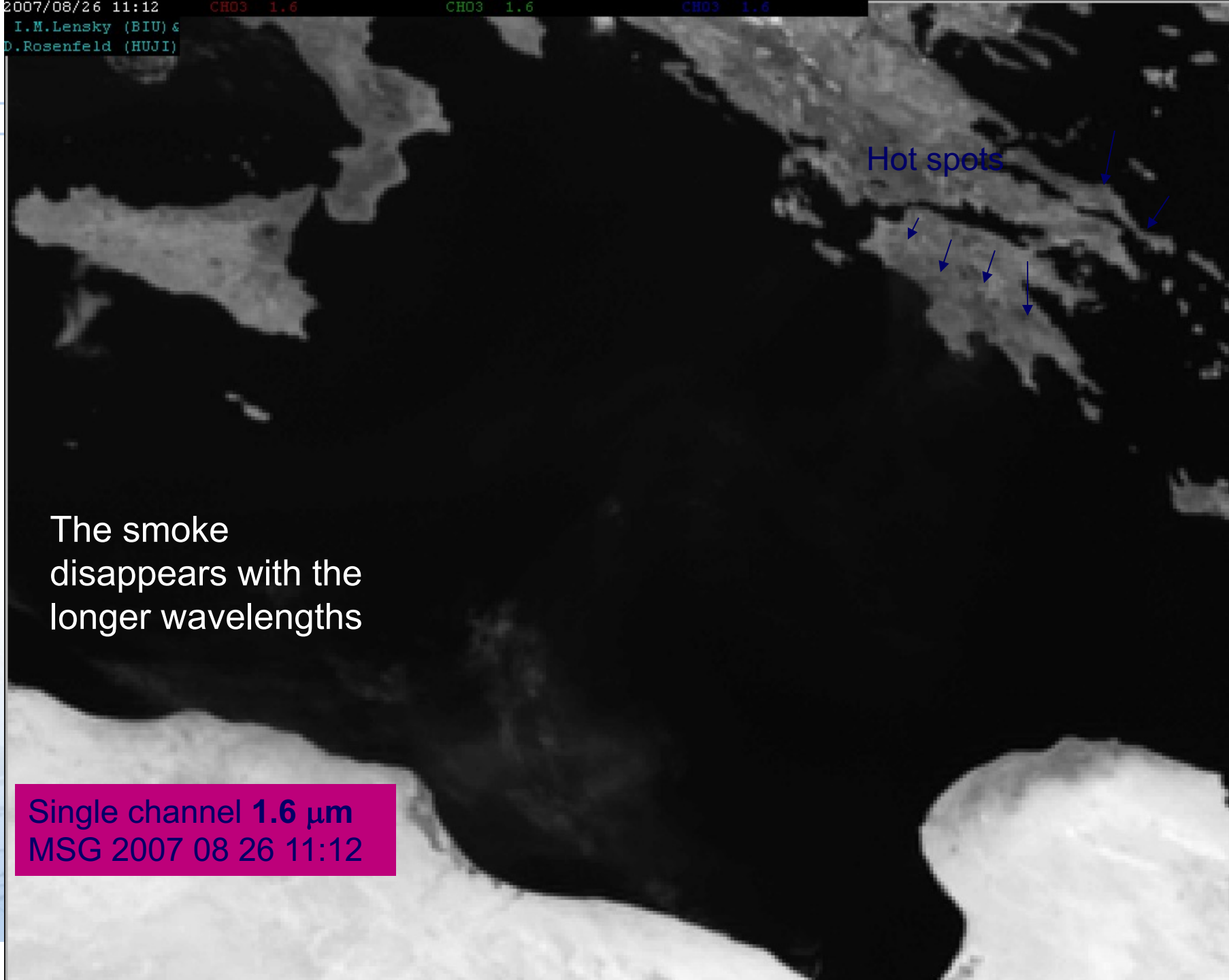
I.M.Lensky (BIU) &

D.Rosenfeld (HUJI)

Hot spots

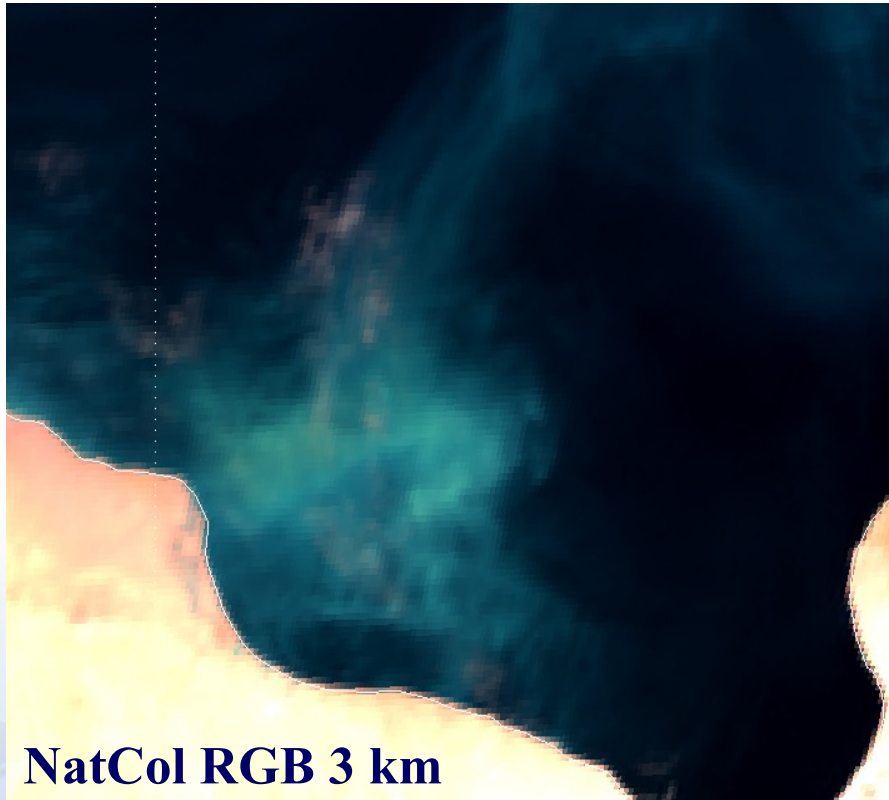
The smoke  
disappears with the  
longer wavelengths

Single channel **1.6  $\mu\text{m}$**   
MSG 2007 08 26 11:12

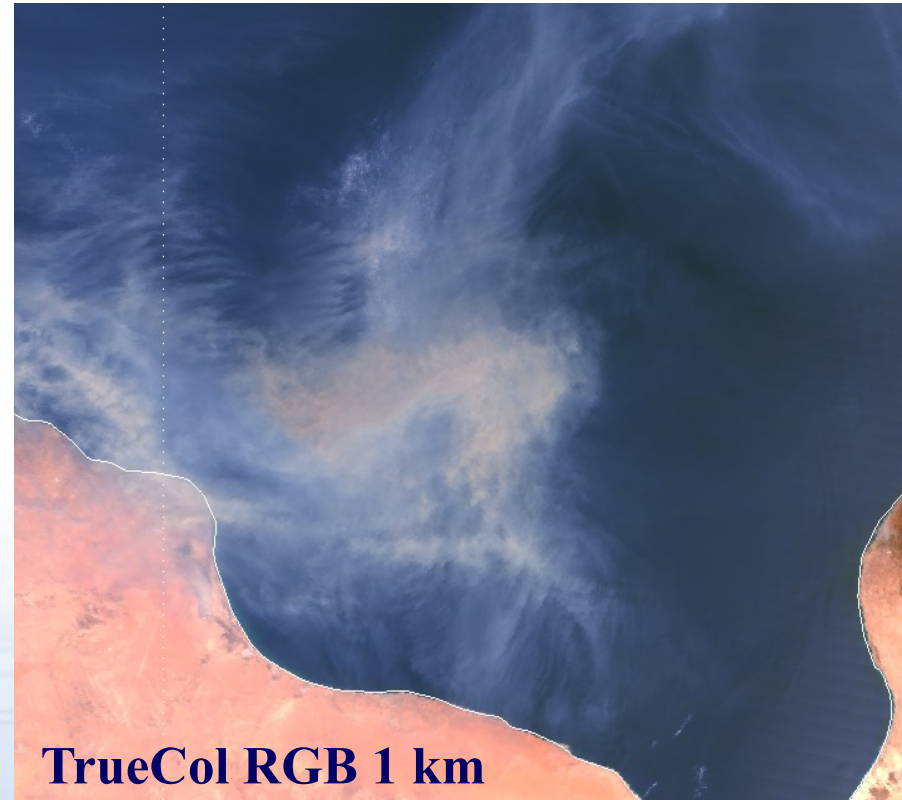


# MTG Improvements: smoke detection

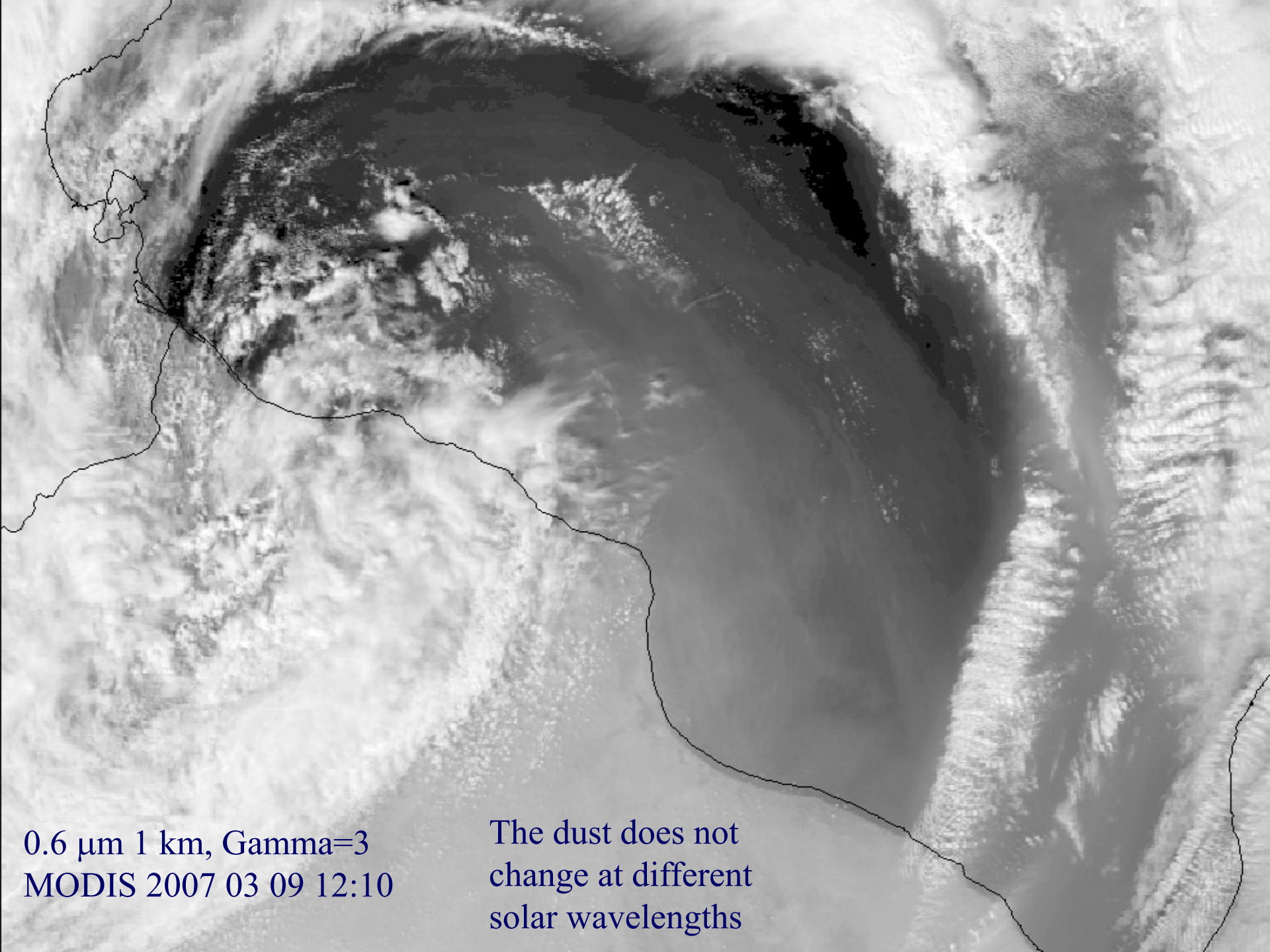
SEVERI (11:00 UTC)



MODIS (09:35 UTC)

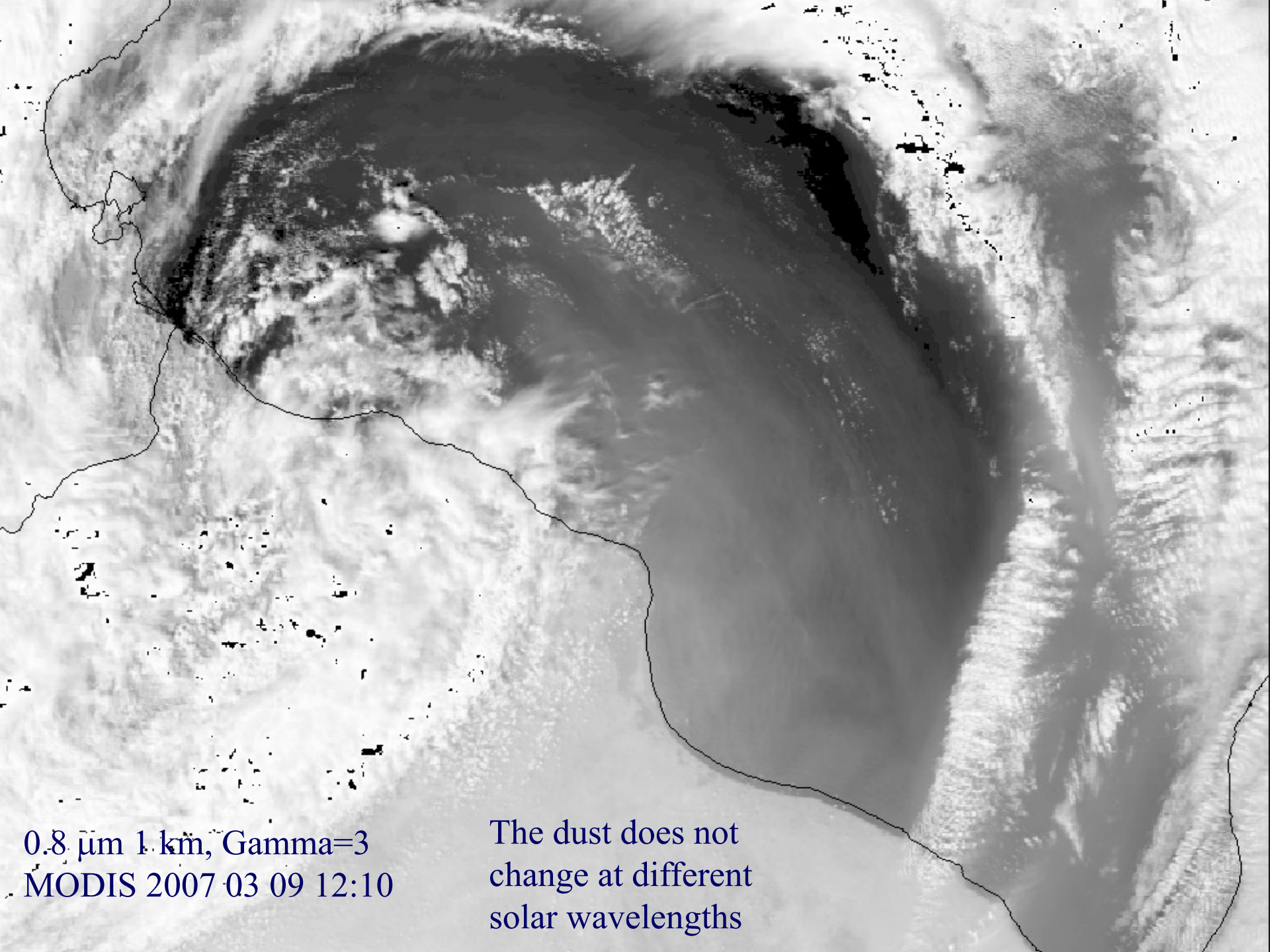


26 August 2007



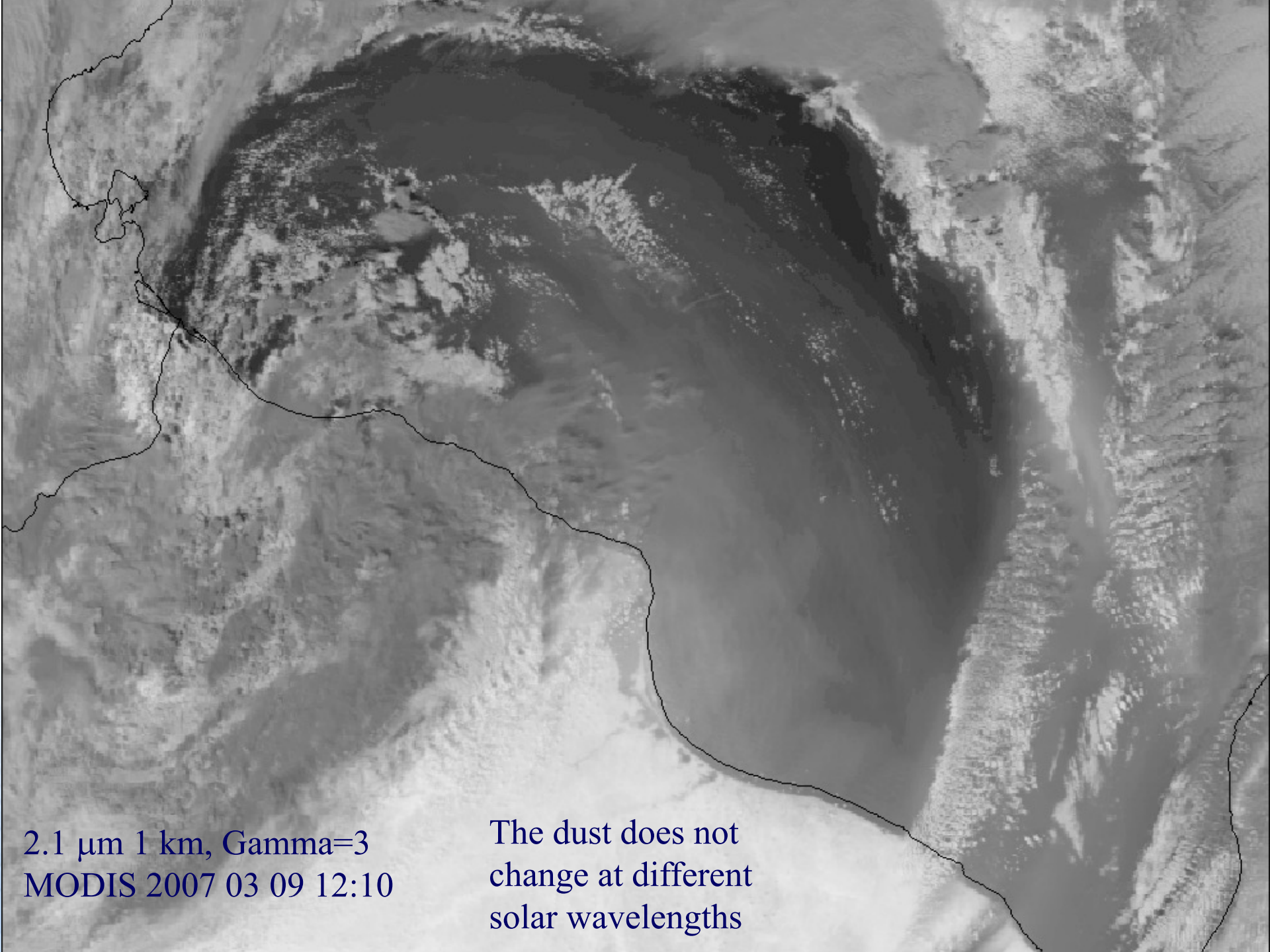
0.6  $\mu\text{m}$  1 km, Gamma=3  
MODIS 2007 03 09 12:10

The dust does not  
change at different  
solar wavelengths



0.8  $\mu\text{m}$  1 km, Gamma=3  
MODIS 2007 03 09 12:10

The dust does not  
change at different  
solar wavelengths

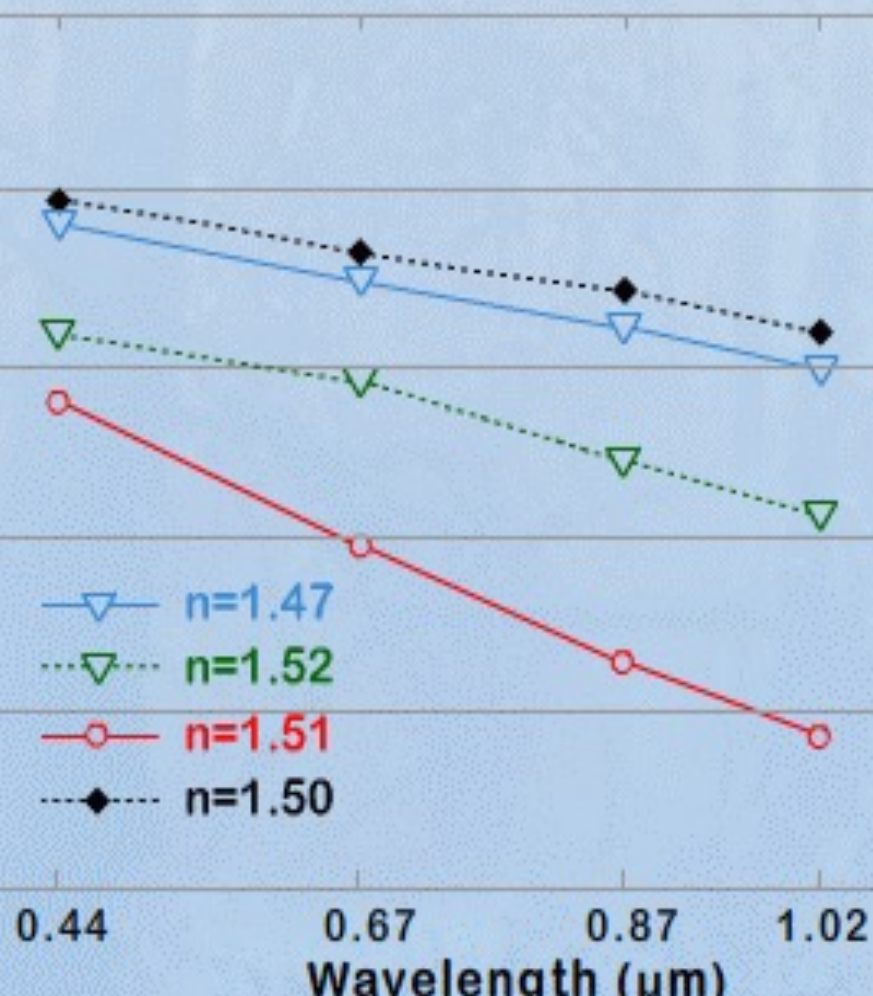


2.1  $\mu\text{m}$  1 km, Gamma=3  
MODIS 2007 03 09 12:10

The dust does not  
change at different  
solar wavelengths

## Biomass Burning

- ▽— Amazonian Forest
- ▽--- South American Cerrado
- African Savanna
- ◆--- Boreal Forest

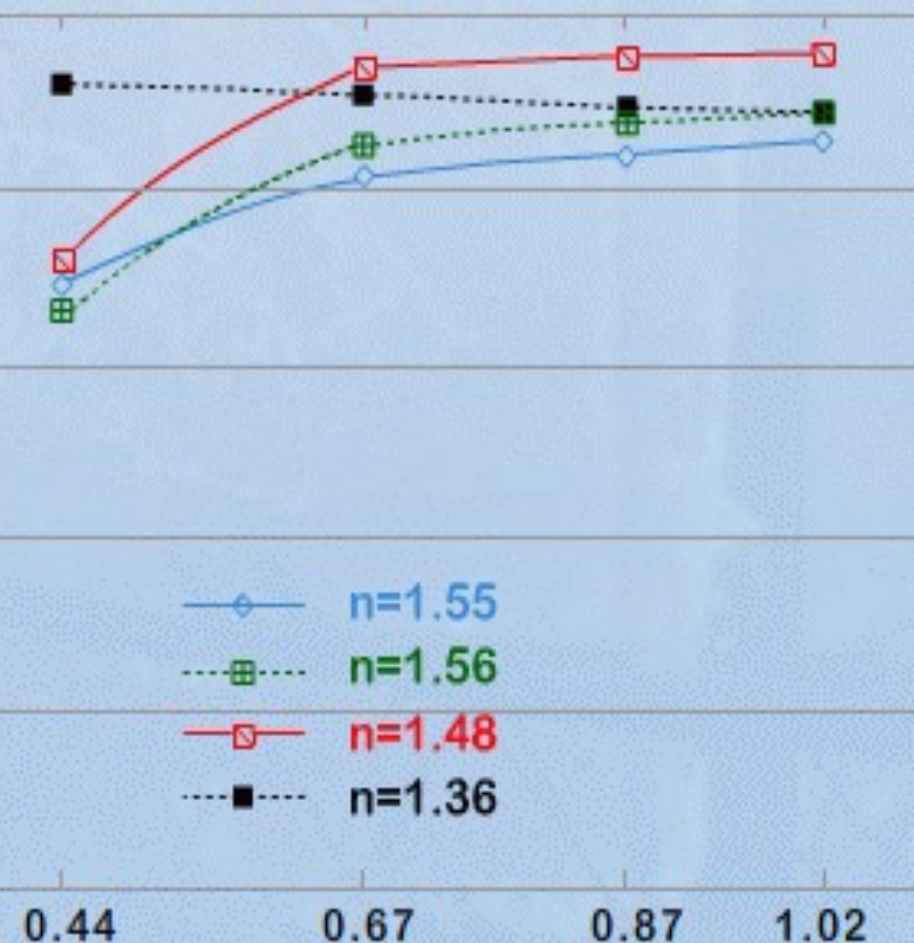


## Desert Dust

- ◇— Bahrain / Persian Gulf
- Solar Village / Saudi Arabia
- Cape Verde

## Oceanic Aerosol

- Lanai / Hawaii





# Natural Colours RGB: smoke colour ?



**Fire detection using ch. IR3.9**

Met-9 imagery on  
31 Aug / 1 Sep 2008



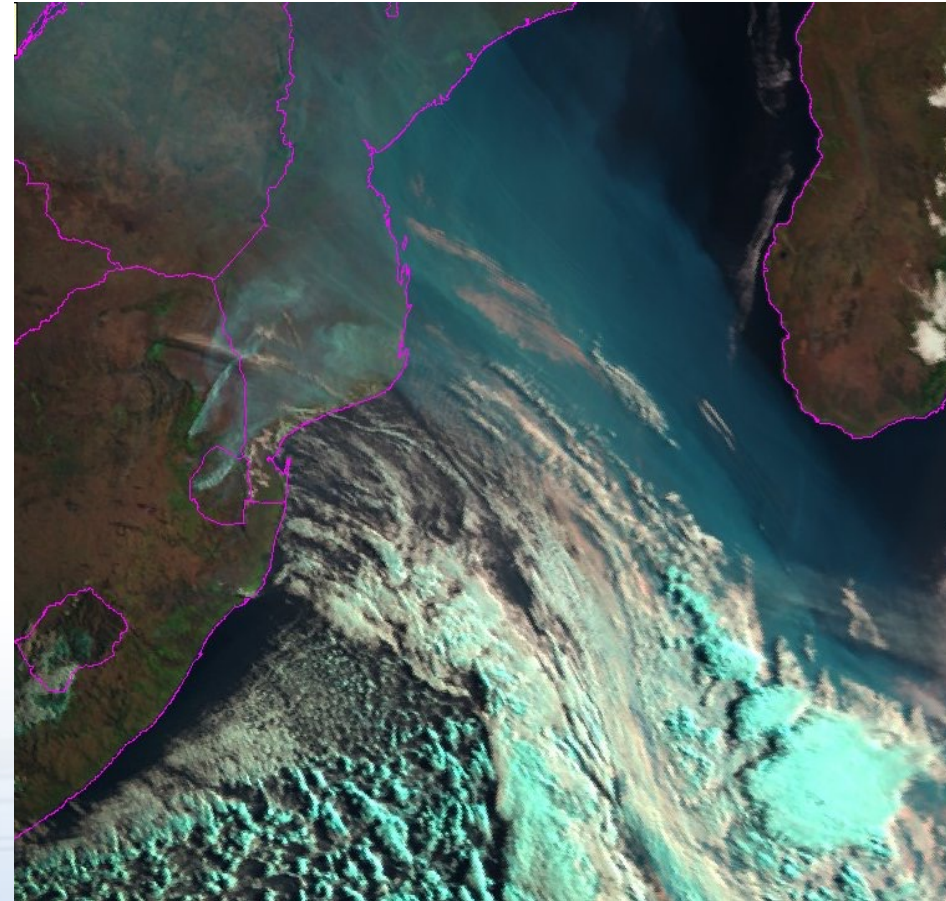
# Natural Colours RGB: smoke colour ?



South Africa

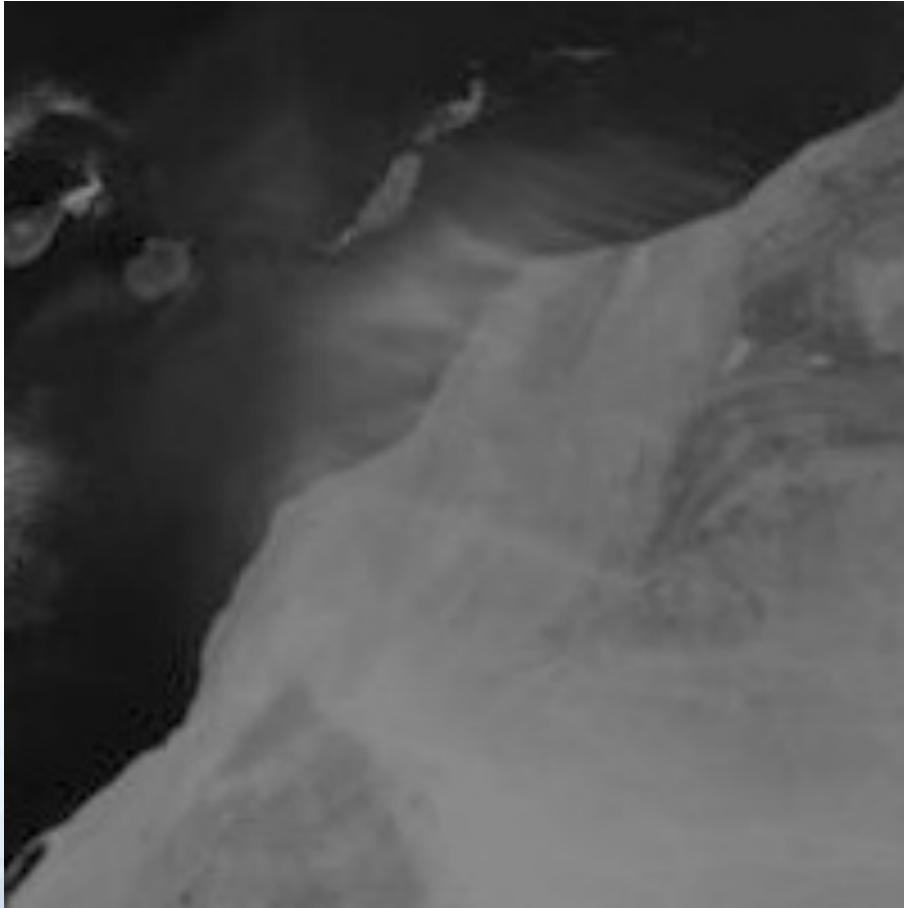
Fire detection using ch. IR3.9

Met-9 imagery on  
31 Aug / 1 Sep 2008



Visible imagery showing smoke

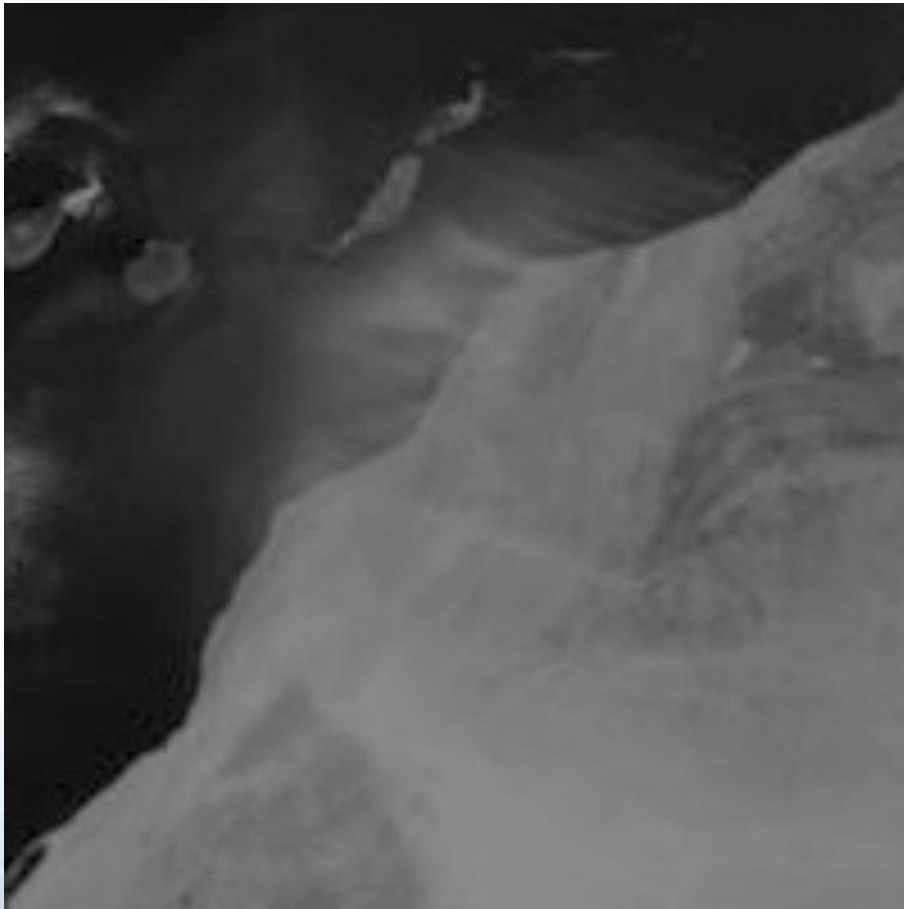
# Natural Colours RGB: dust colour ?



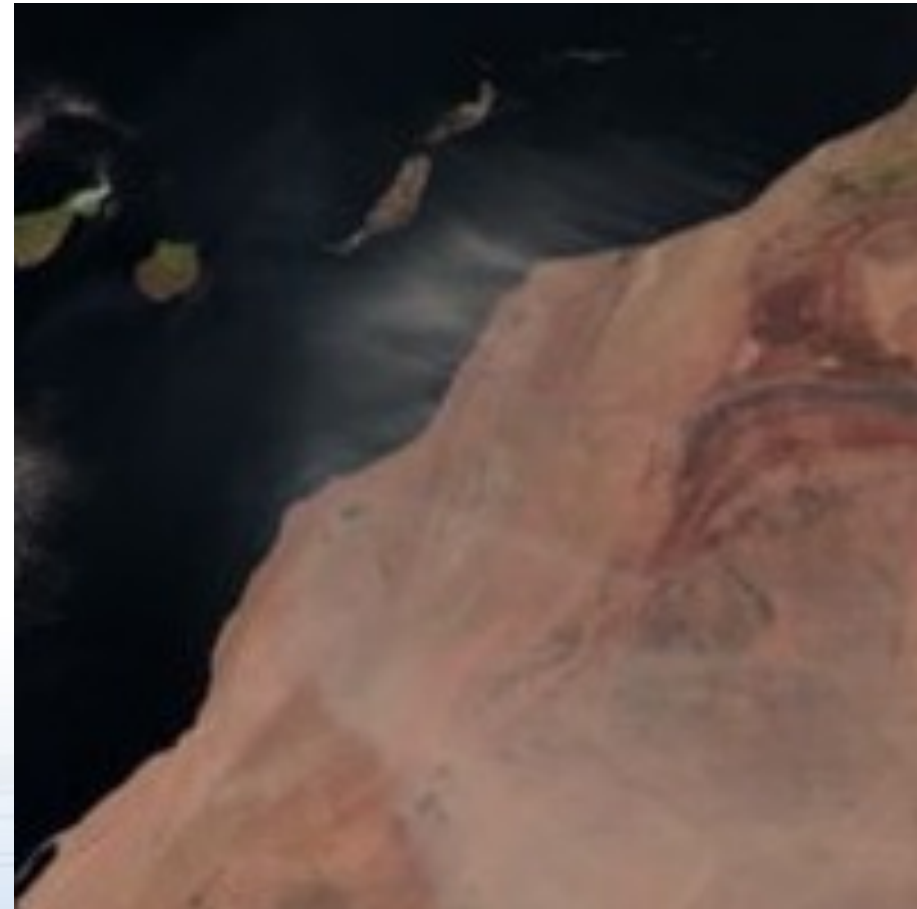
Channel 01 (0.6  $\mu\text{m}$ )

3 March 2004 at 12:00 UTC  
**dust cloud** over the Canary Islands

# Natural Colours RGB: dust colour ?

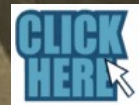


Channel 01 (0.6  $\mu\text{m}$ )



RGB Natural Colours

3 March 2004 at 12:00 UTC  
**dust cloud** over the Canary Islands



MSG-1, 28 July 2005, 07:00 UTC, RGB HRV, HRV, IR10.8



# Natural Colours RGB: smoke & dust

Metop-A, AVHRR, 22 October 2007 at 18:16 UTC

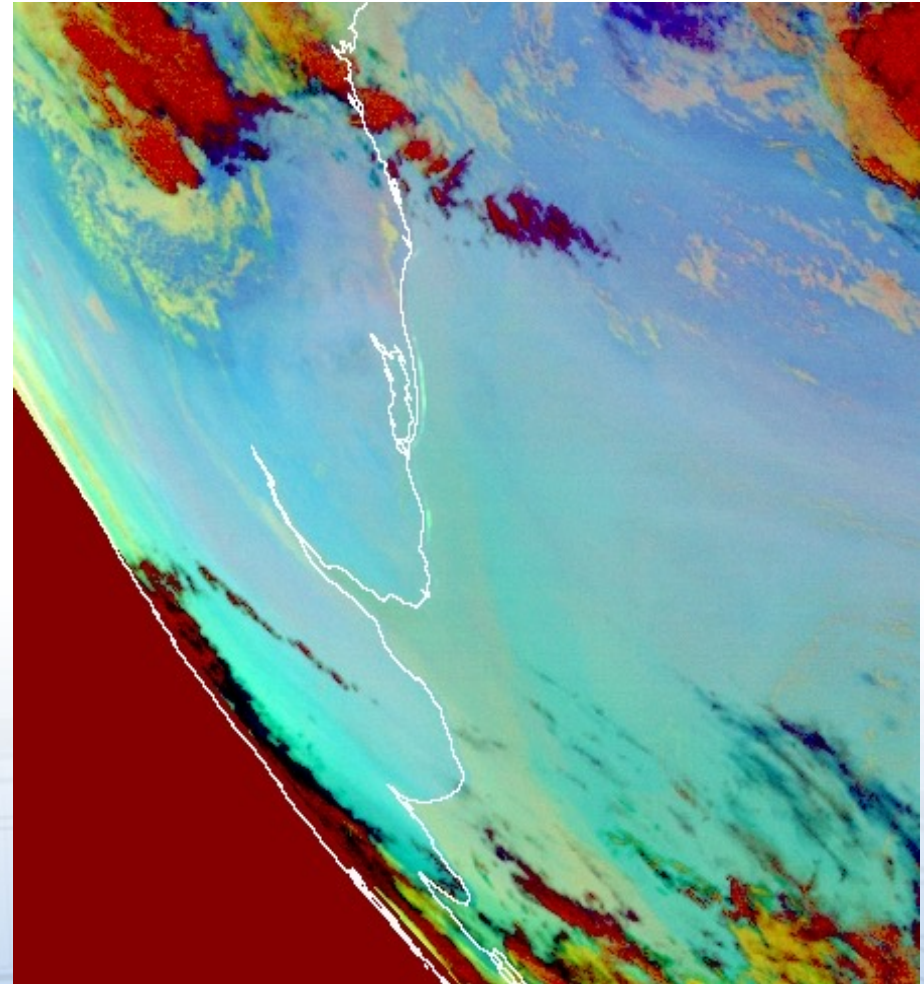
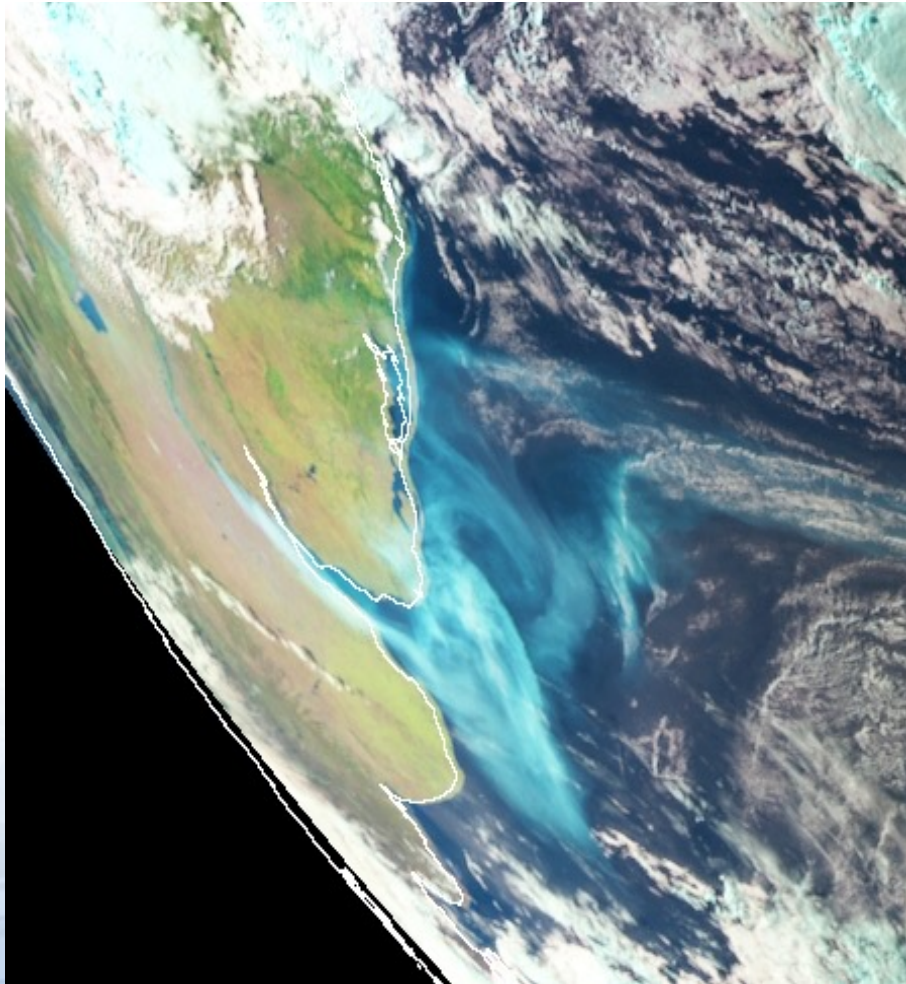
**Catastrophic fires California**

# Smoke & Dust IR Channels



Seeing Through Forest Fire Smoke and Fire Fighting with  
Short Wave Infrared (SWIR) Cameras

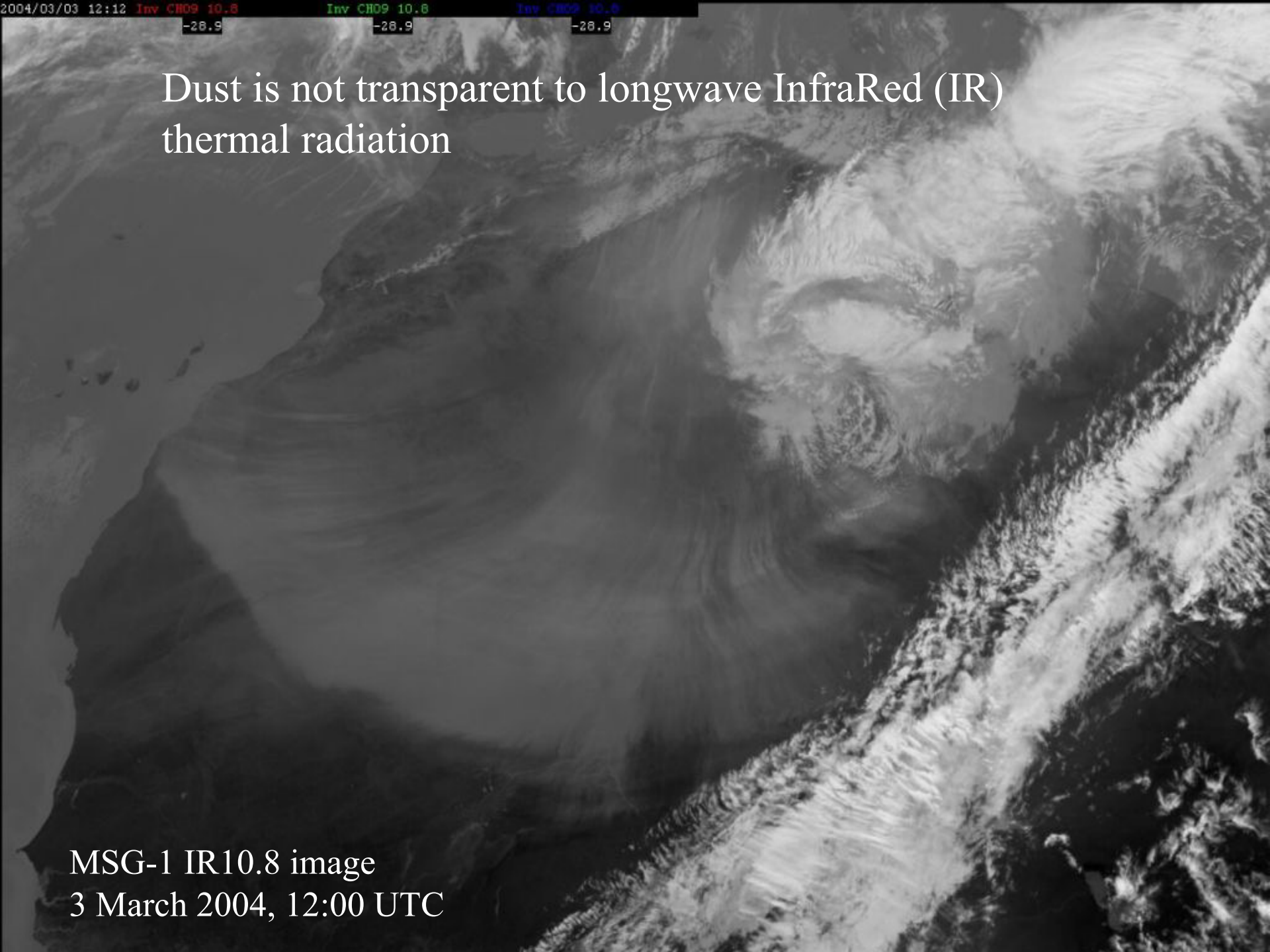
# Dense Smoke over Argentina and Uruguay

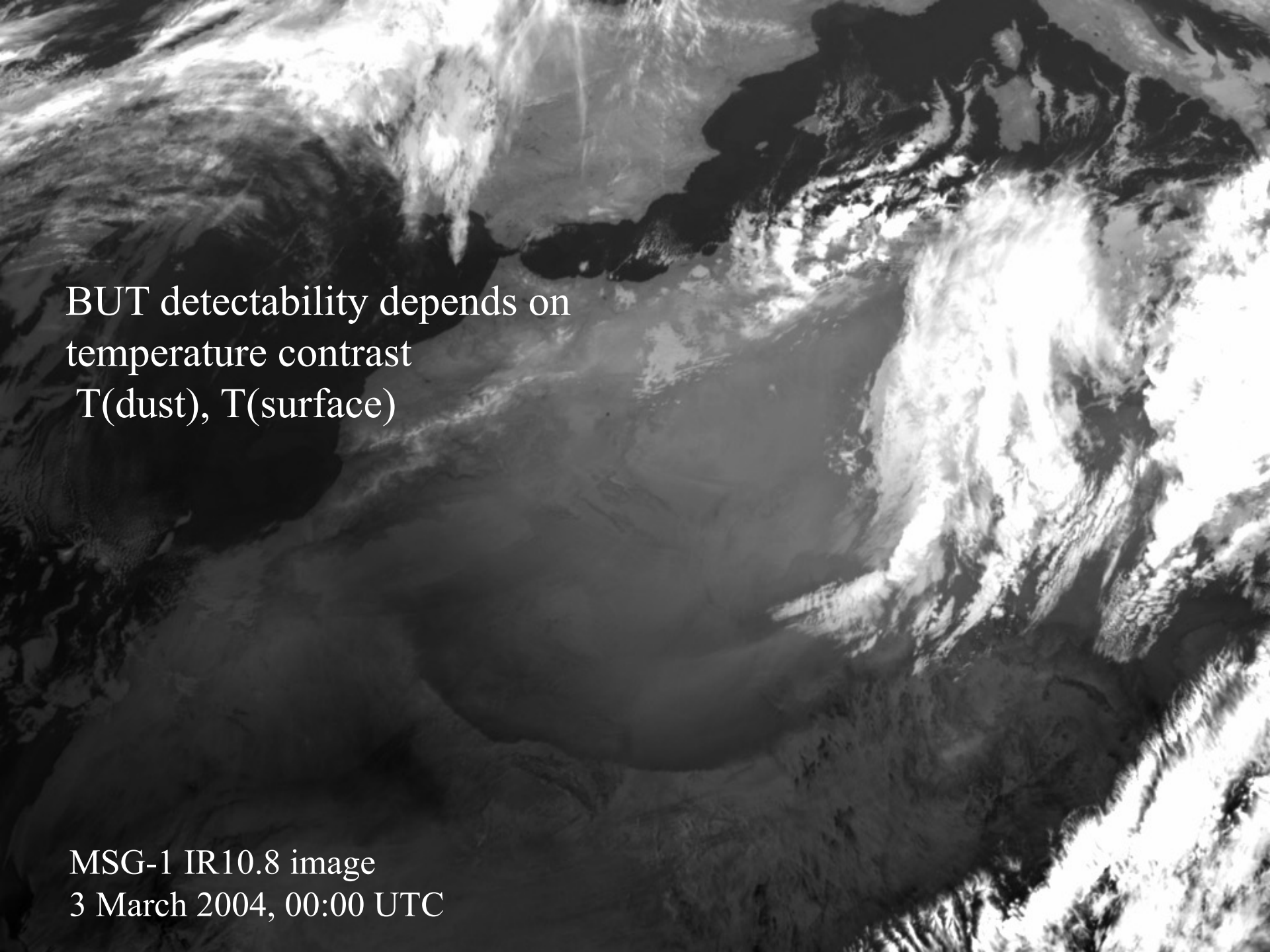


Met-9, 18 April 2008, 19:15 UTC

Dust is not transparent to longwave InfraRed (IR)  
thermal radiation

MSG-1 IR10.8 image  
3 March 2004, 12:00 UTC

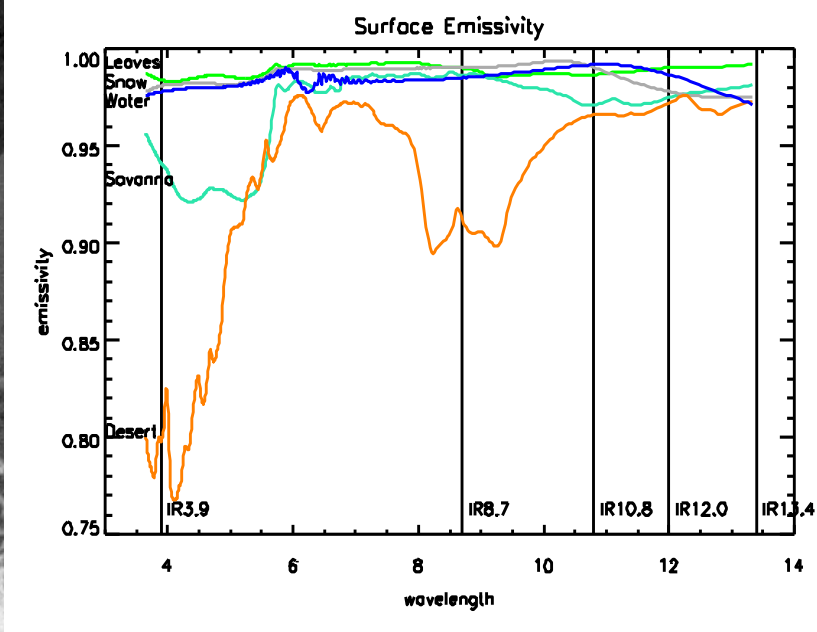


A black and white satellite image from MSG-1 IR10.8 showing a large, dark, diffuse plume of dust or smoke extending from the west coast of Africa across the Atlantic Ocean. The plume is most prominent in the center-left of the frame. To the right, there are bright, swirling cloud patterns over the Americas. The text is overlaid on the left side of the image.

BUT detectability depends on  
temperature contrast  
 $T(\text{dust})$ ,  $T(\text{surface})$

MSG-1 IR10.8 image  
3 March 2004, 00:00 UTC

# IR10.8 – IR8.7 BTD



- ? Large positive BTD for desert surfaces (WHITE)
- ? Small positive BTD for dust and water clouds (DARK GREY)

2004/03/03 12:12

CH10 12.0-CH09 10.8

CH10 12.0-CH09 10.8

CH10 12.0-CH09 10.8

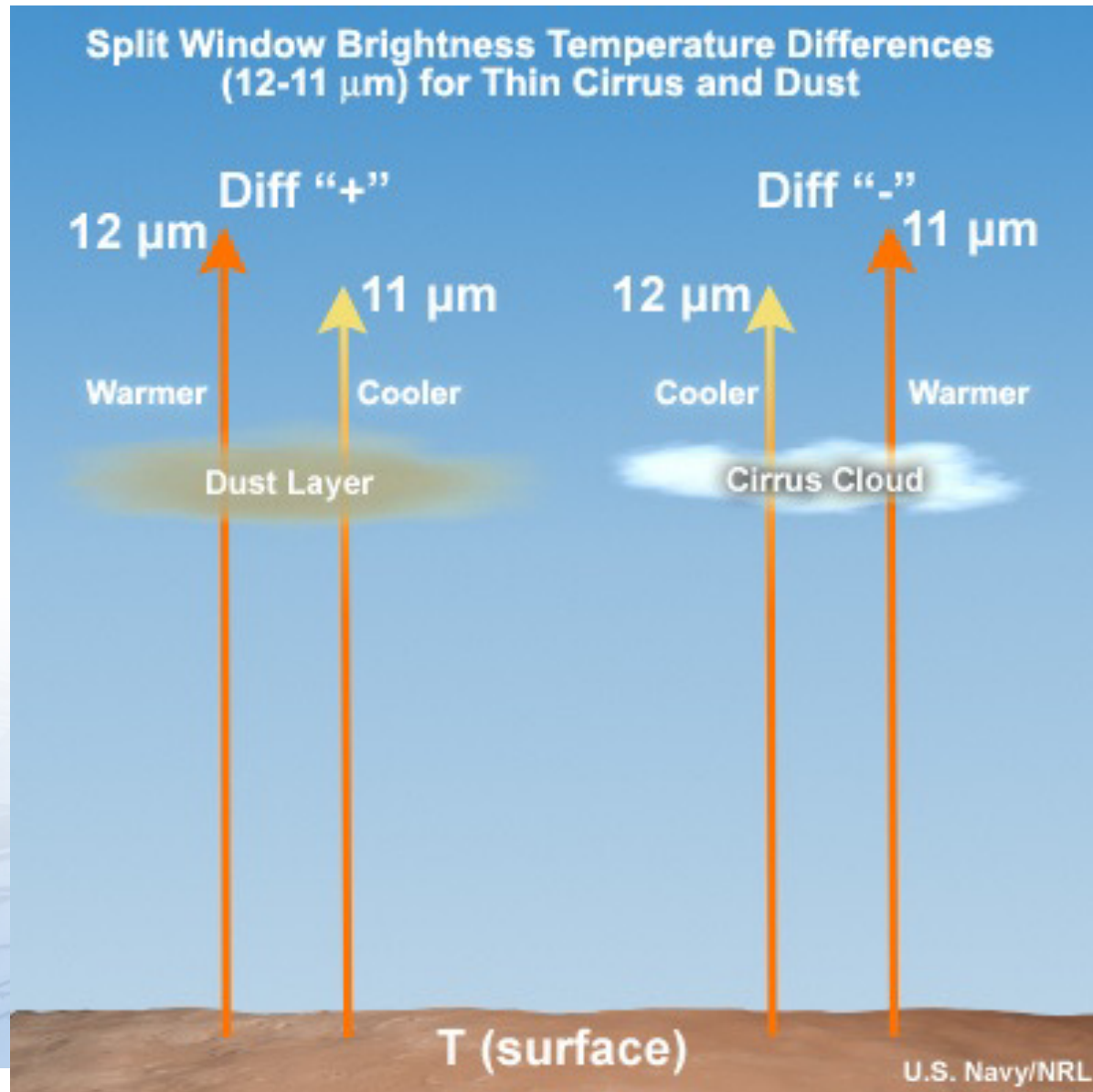
I.M.Lensky (BIU)  
D.Rosenfeld (HUJI)

# IR12.0 - IR10.8 BTD

- Positive BTD for thin dust clouds (WHITE)
- Negative BTD for thin water and ice clouds (BLACK)
- Zero BTD for thick ice clouds (GREY)

Met-8, 3 March 2004, 12:00 UTC

# Transmission Spectra for Dust & Ice Clouds



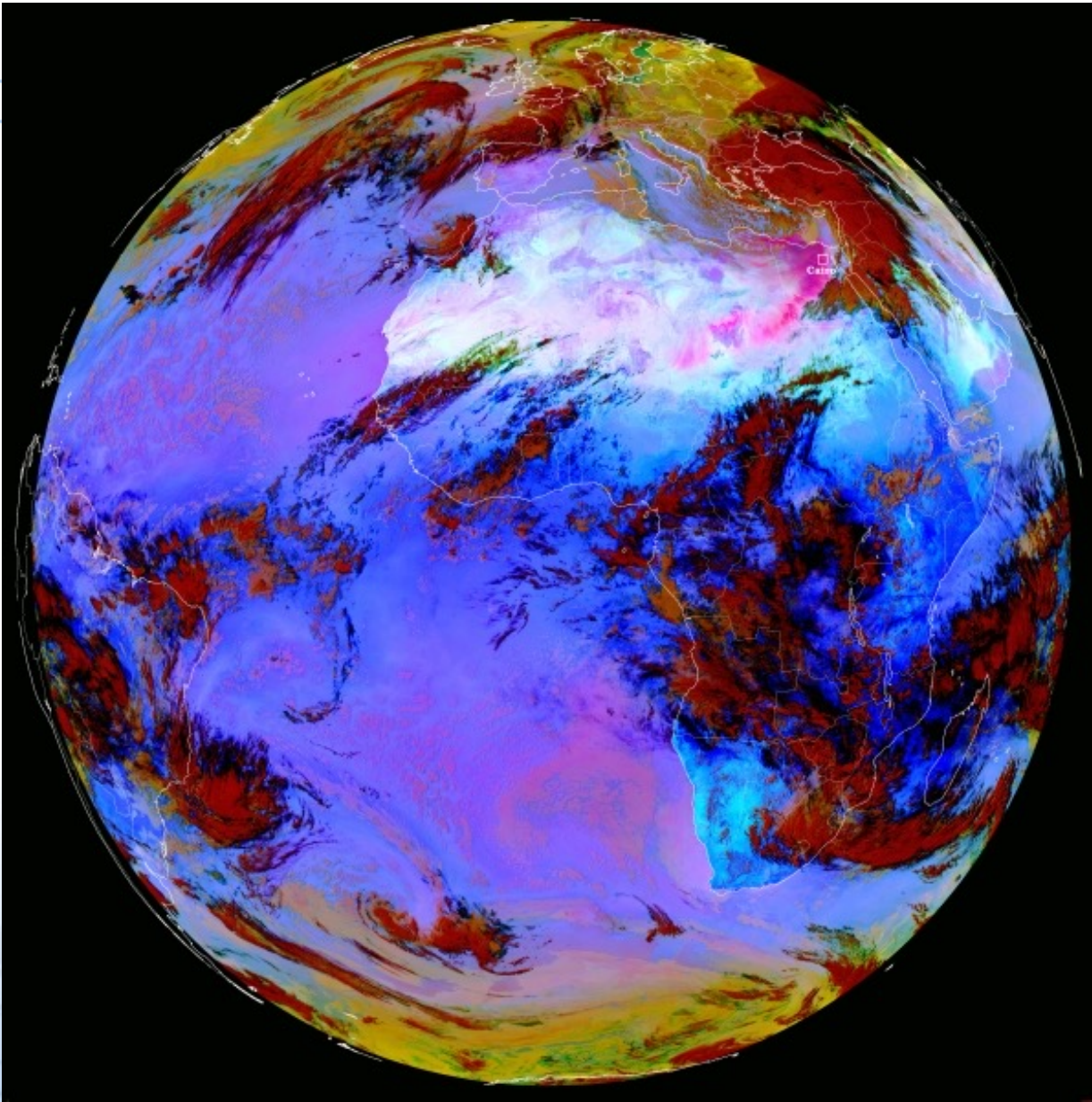
# The Dust RGB Product

# 24-hour Dust Microphysics RGB

*Devised by: D. Rosenfeld*

## Recommended Range and Enhancement:

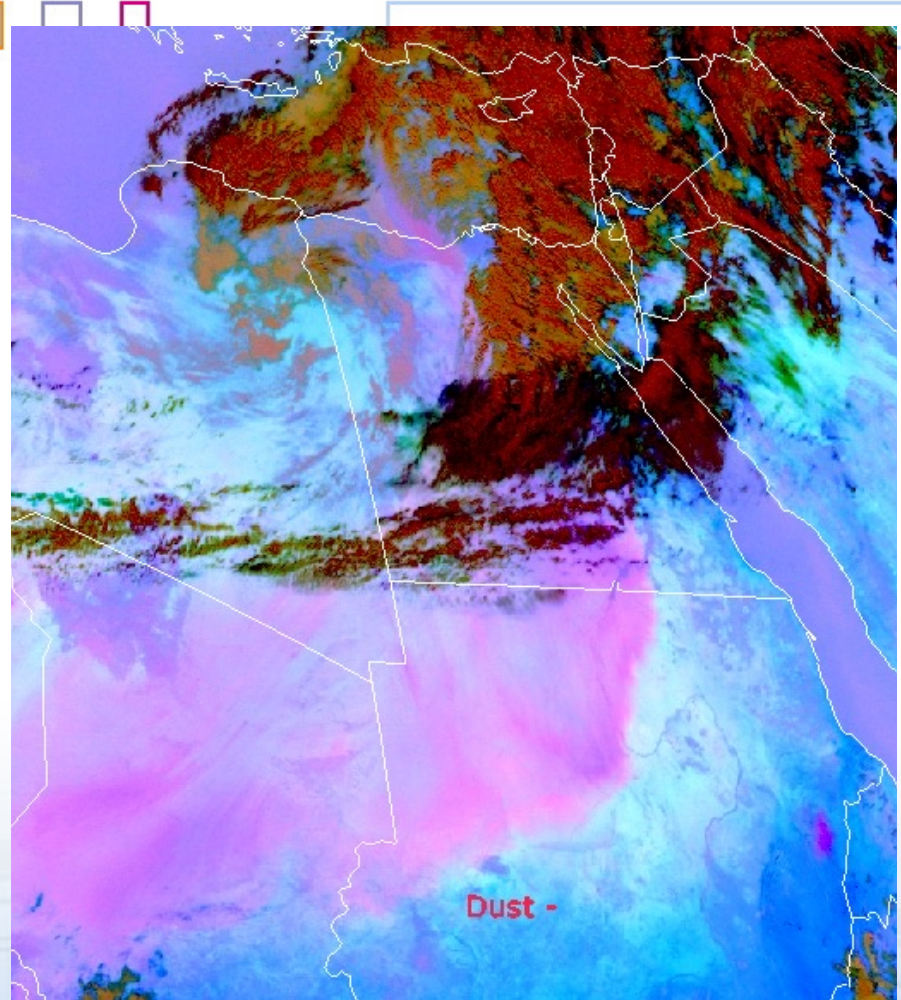
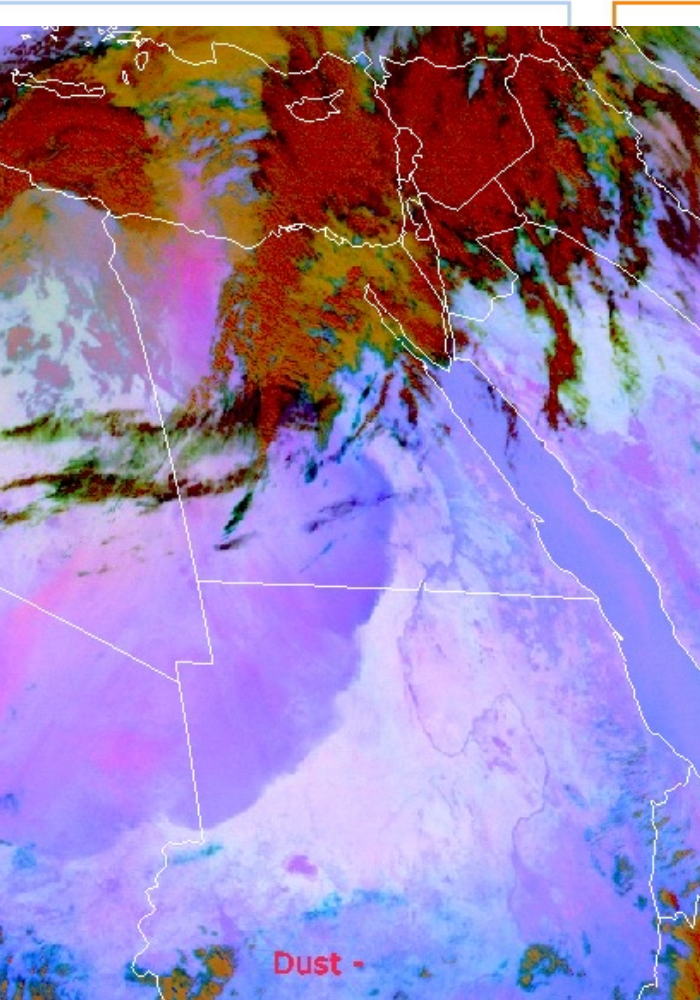
Beam	Channel	Range	Gamma
Red	IR12.0 - IR10.8	-4 ... +2 K	1.0
Green	IR10.8 - IR8.7	0 ... +15 K	2.5
Blue	IR10.8	+261 ... +289 K	1.0



**RGB  
24-hour  
Dust  
Microphysics  
Global View**

MSG-1  
22 January 2004  
12:00 UTC

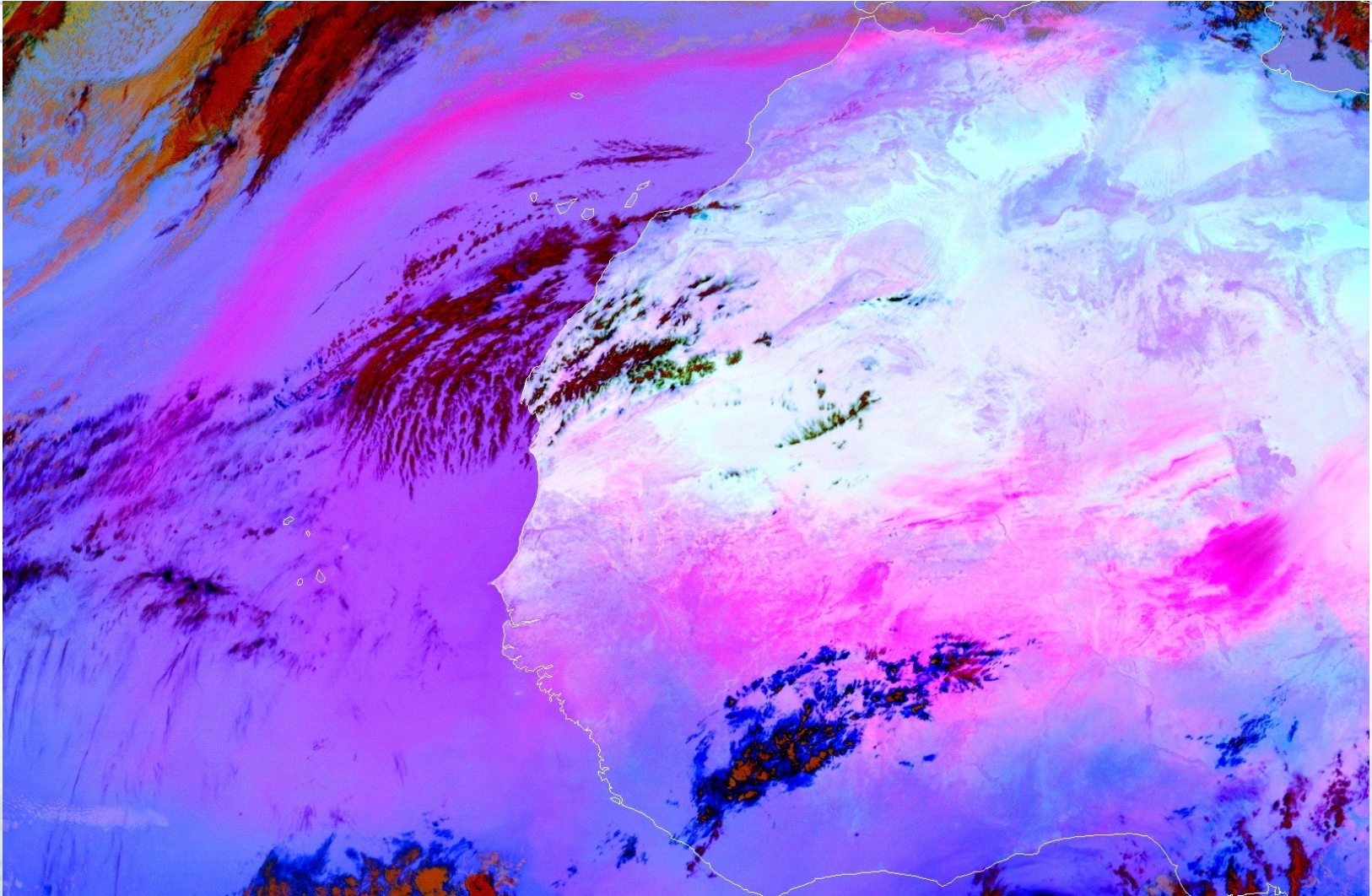
# Comparison: Night versus Day



MSG-1, 10 May 2007

Which is night, which is day ?

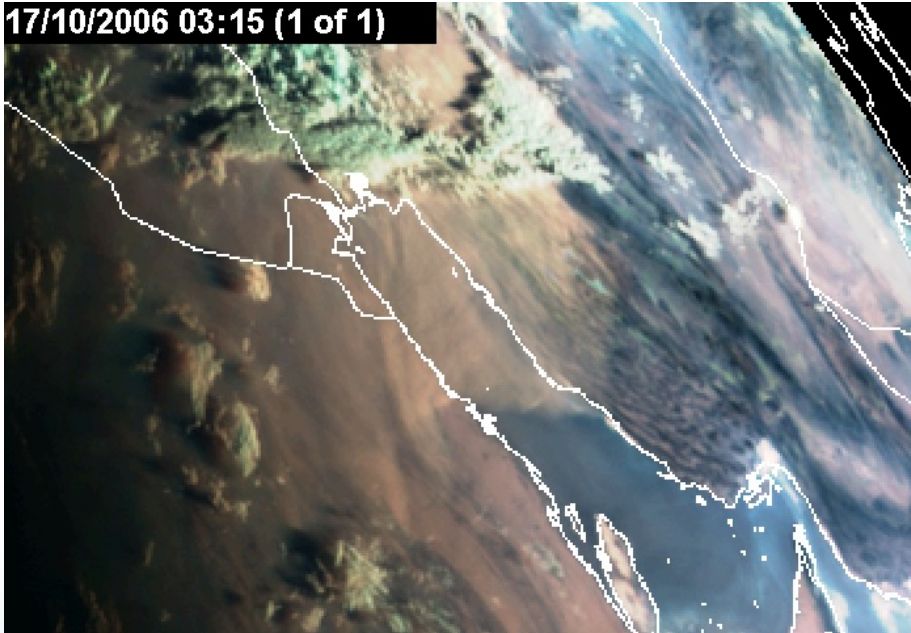
# Example: High-level Dust over Ocean



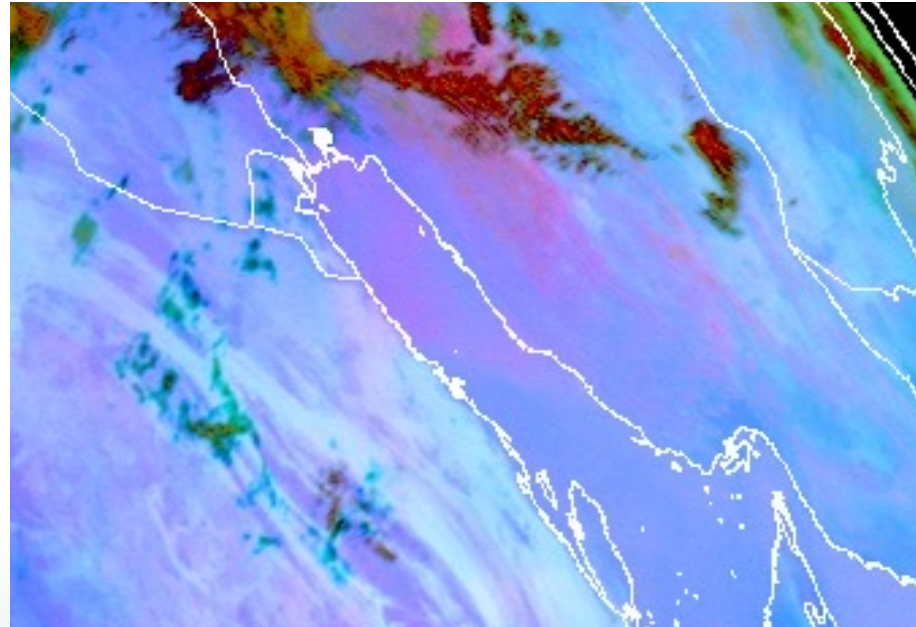
MSG-1, 6 March 2004, 12:00 UTC

# Example: Low-level Dust over Ocean

17/10/2006 03:15 (1 of 1)



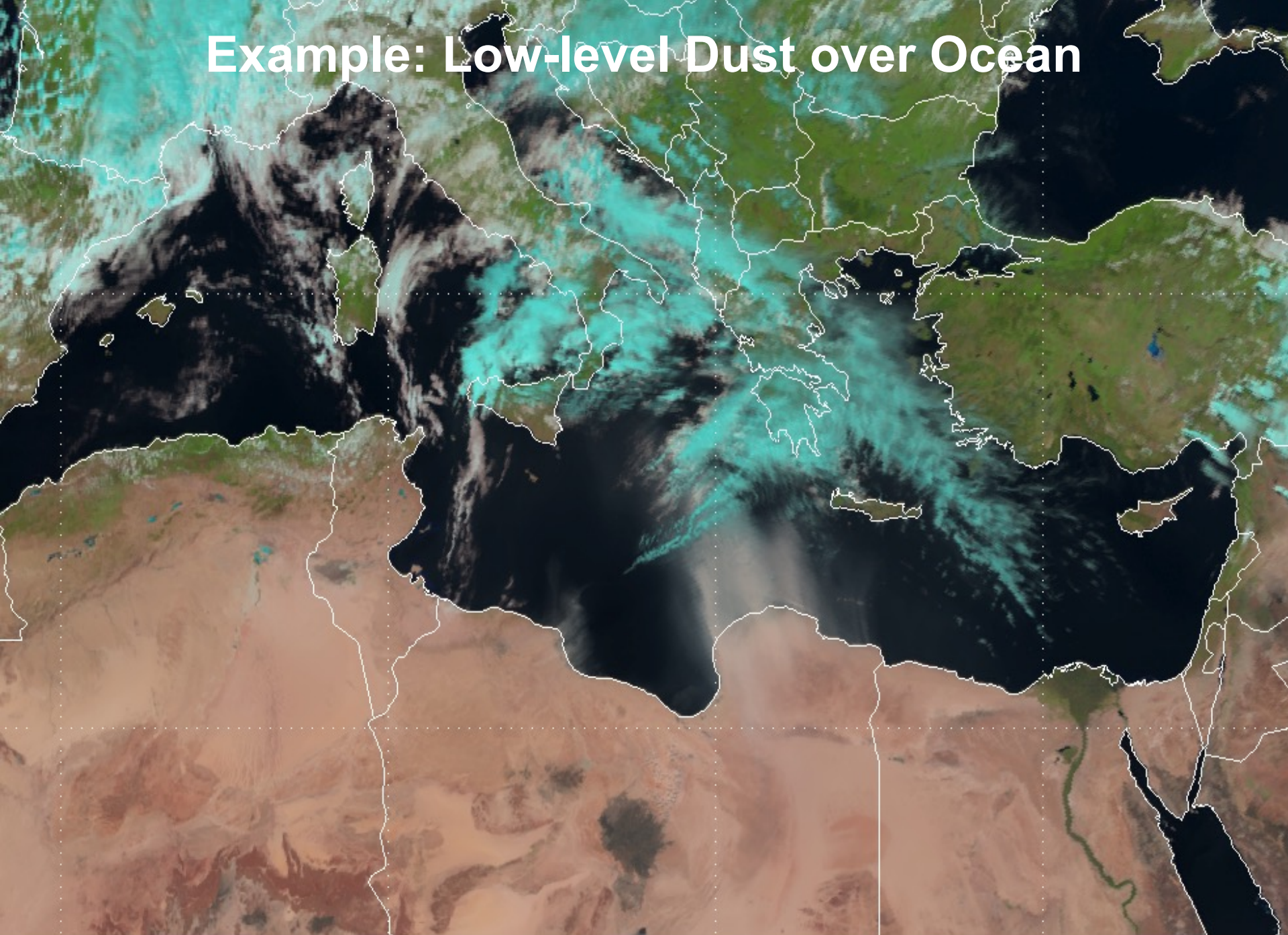
03:15 UTC  
Natural Colours RGB



05:00 UTC  
Dust RGB

MSG-1, 17 October 2006

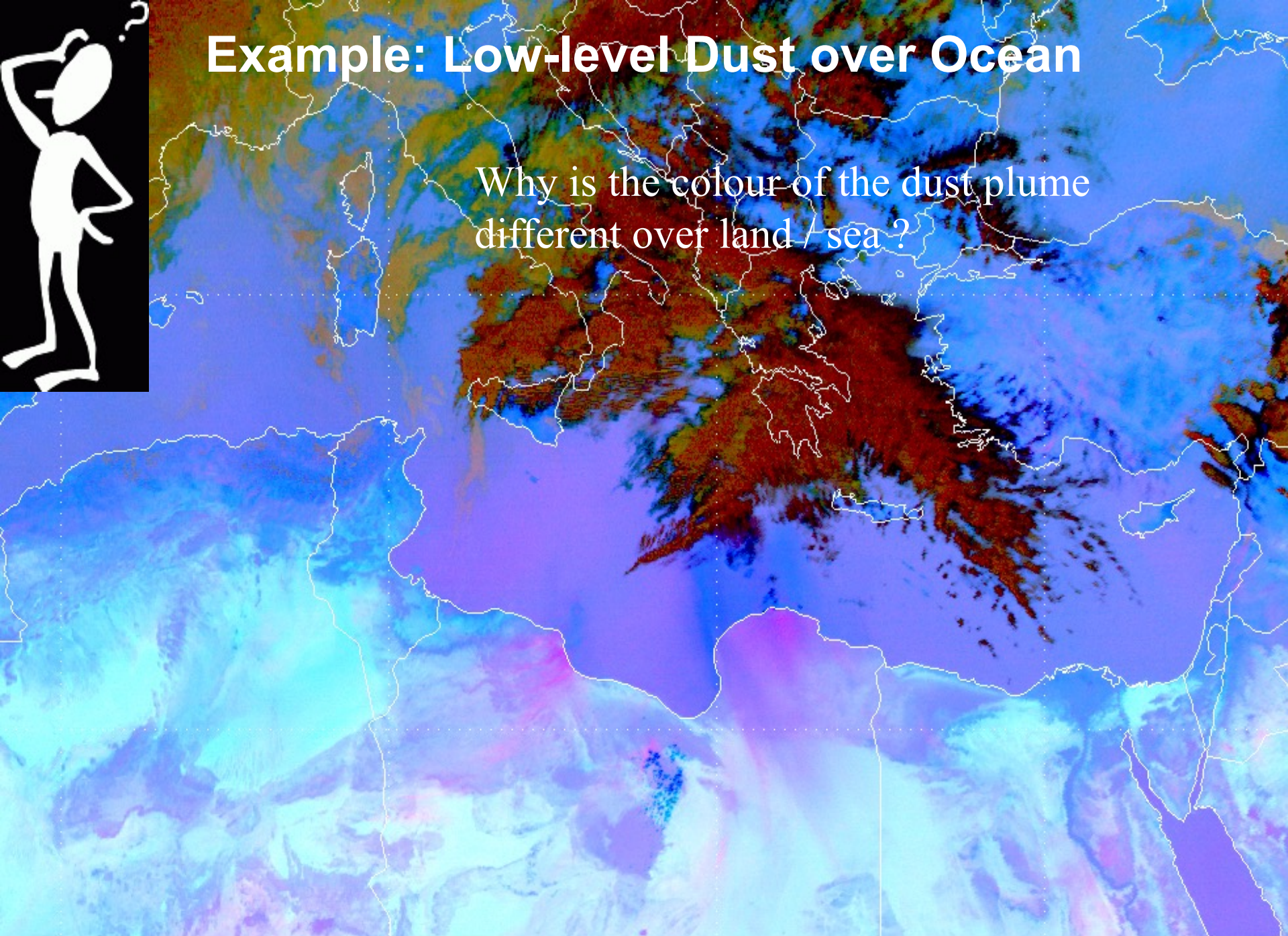
# Example: Low-level Dust over Ocean









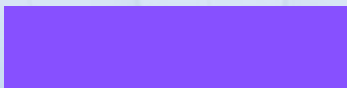
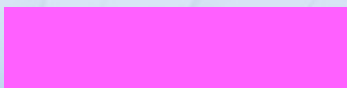
# Example: Low-level Dust over Ocean

Why is the colour of the dust plume different over land / sea ?



# The Dust RGB: Interpretation of Colours

## 1. Thin Dust Clouds

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

# The Dust RGB: Interpretation of Colours

## 2. Very Thick Dust Clouds

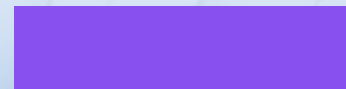
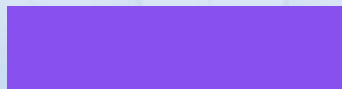
Night

Day

High (4-5 km)

Mid (2-3 km)

Low (0-1 km)

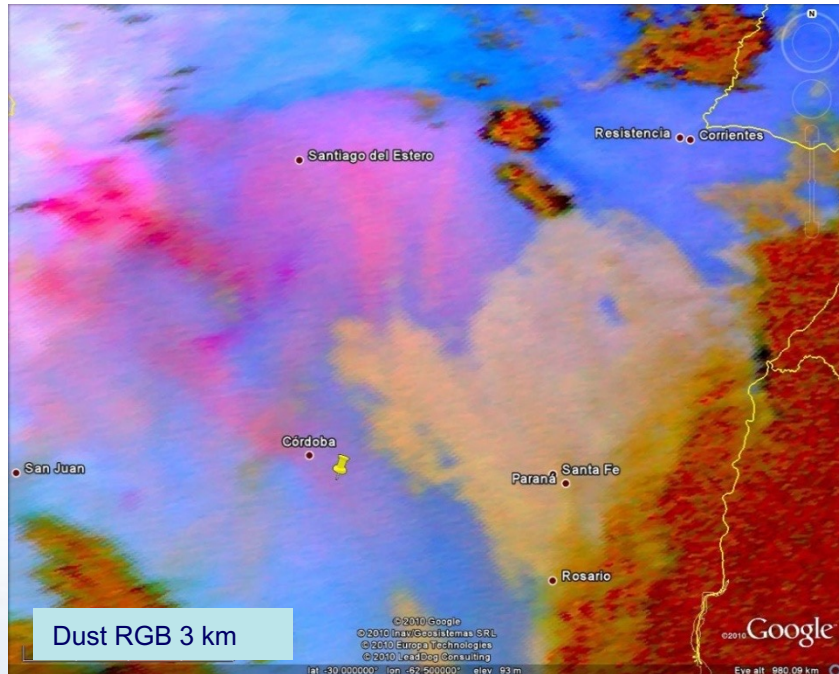


# Challenges to using the Dust RGB product

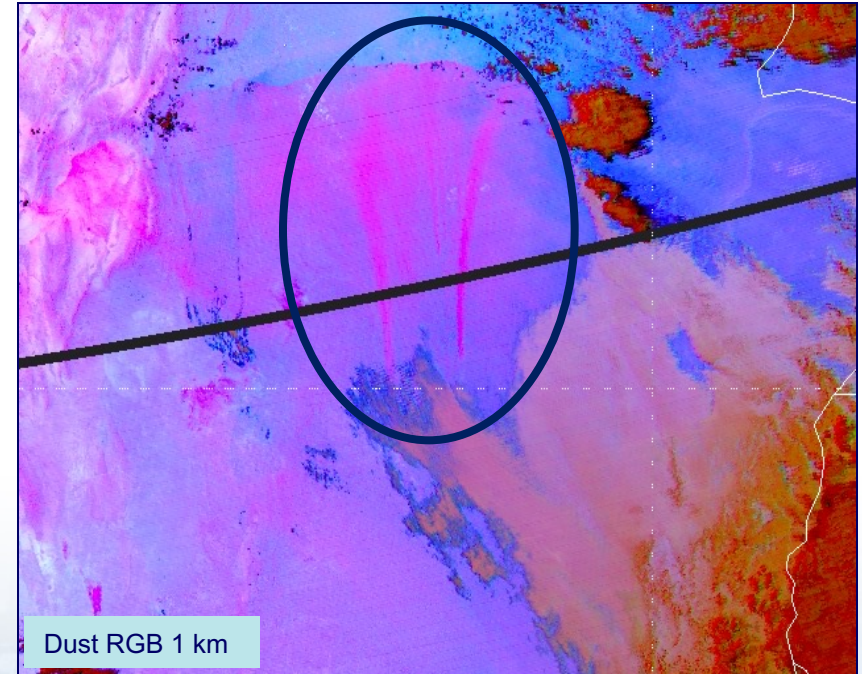
- Low dust clouds
  - at night
  - over Ocean
  - obscured by higher clouds

# MTG Improvements: dust monitoring

SEVERI (18:00 UTC)



MODIS (18:15 UTC)



**Dust streaks better visible because of better spatial resolution !**

29 October 2010  
Dust Squall Argentina



# Other Applications of the Dust RGB



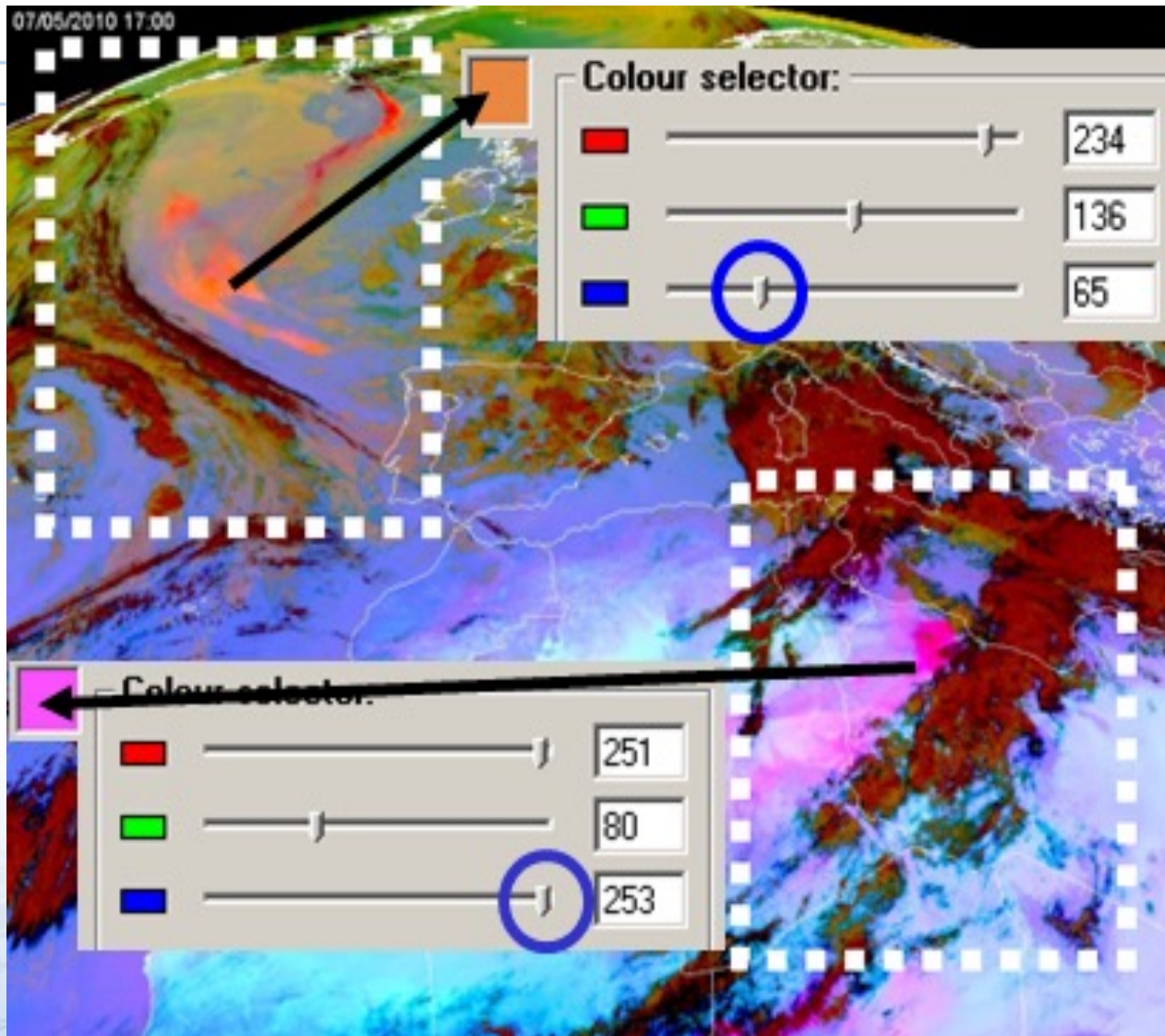
# Volcanic Ash Cloud Iceland Eruption 7 May, 22:00 UTC

Vulkaanas

Why this colour difference between Ash  
and Dust clouds ?

MSG, Dust RGB

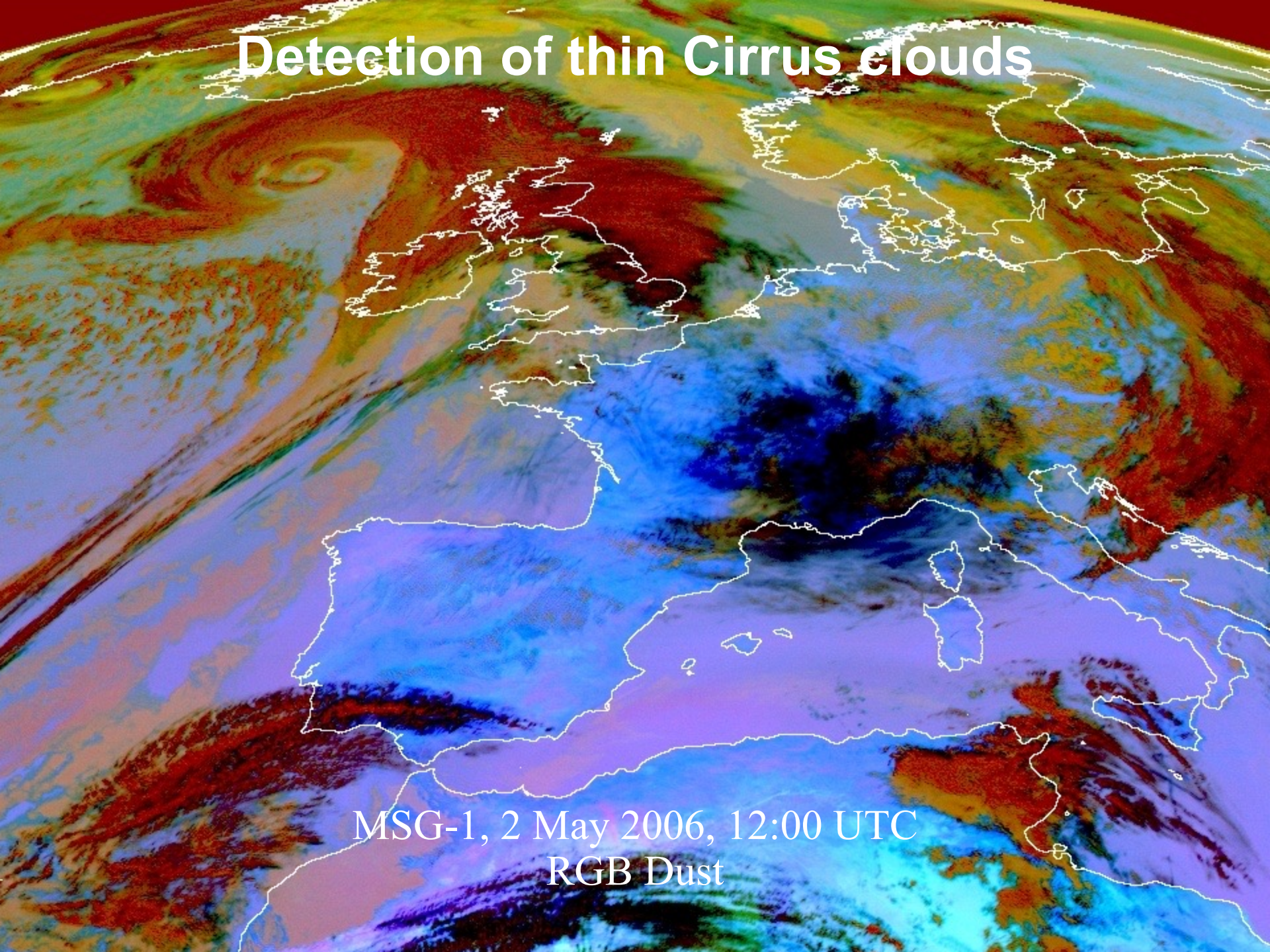
Zand



The dust cloud is much warmer (lower level) than the ash cloud, which travelled at a height of 6-10 km.

# Detection of thin Cirrus clouds

MSG-1, 2 May 2006, 12:00 UTC  
RGB Dust

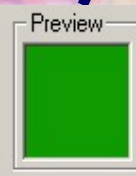
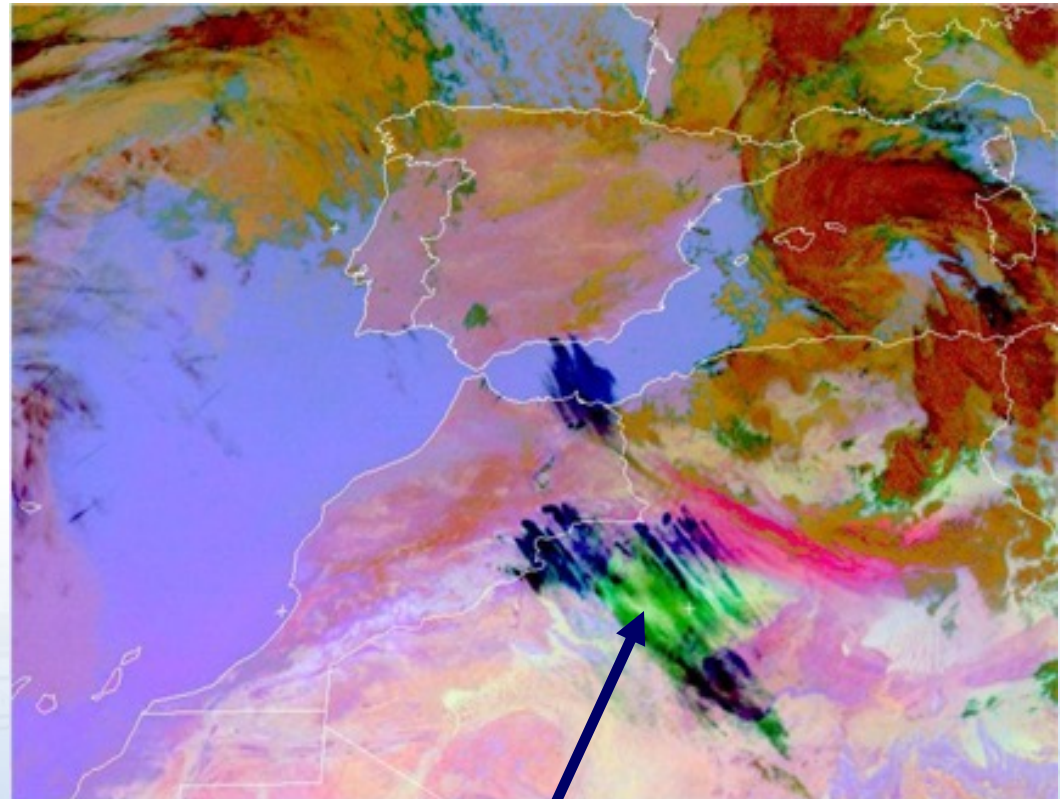


# Detection of thin Cirrus clouds

A satellite image of Europe and the surrounding Mediterranean Sea. The image is a false-color composite where thin cirrus clouds are highlighted in bright cyan. These clouds are visible as wispy, streaky patterns across the sky, particularly over the Atlantic and the Mediterranean. The landmasses of Europe, North Africa, and parts of Asia are shown in natural colors (greens, browns, and blues). The image is titled "Detection of thin Cirrus clouds" and includes a timestamp and color specification at the bottom.

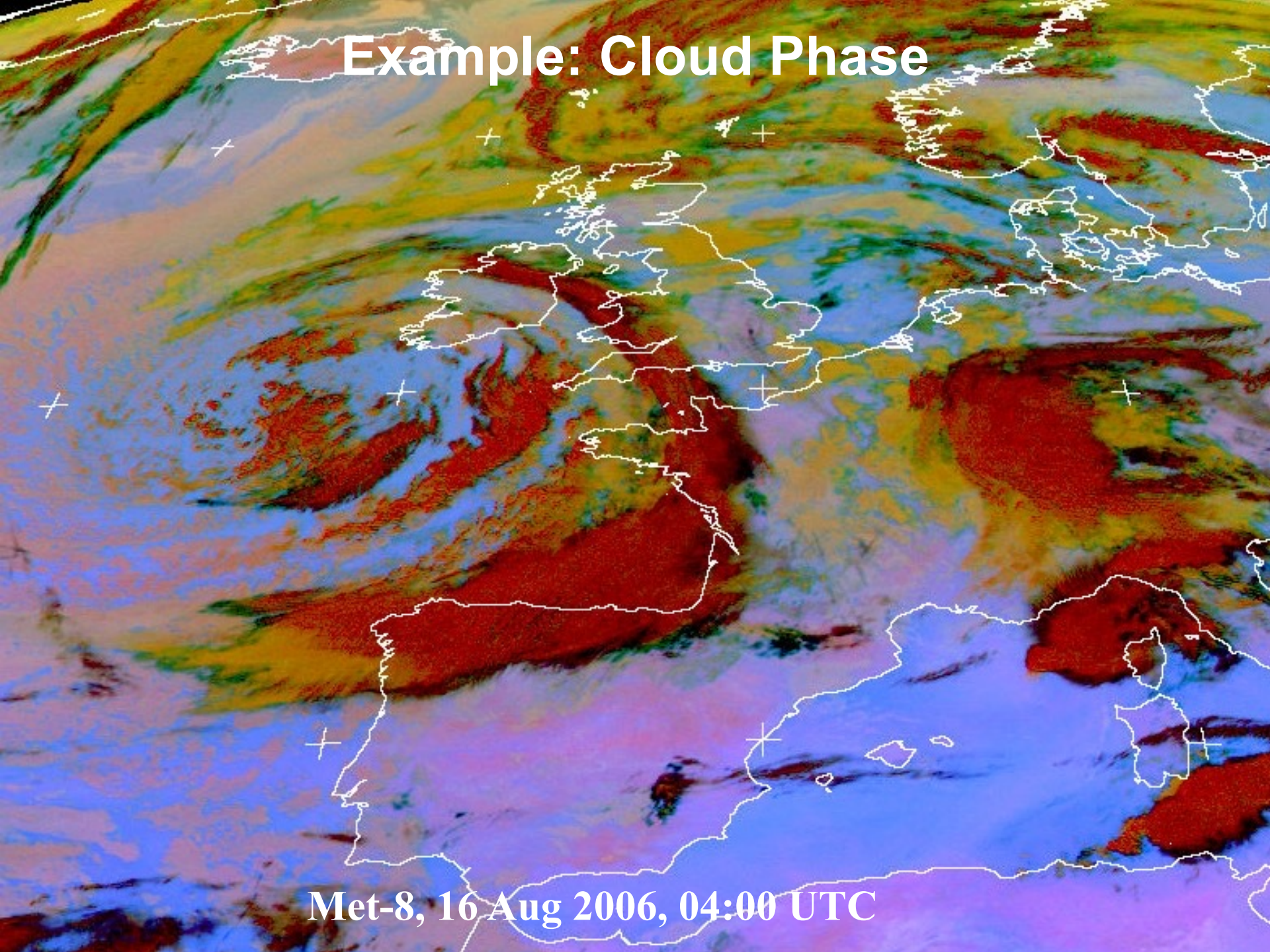
MSG-1, 2 May 2006, 12:00 UTC  
RGB Natural Colours

Attention - **Thin cirrus** can also look green over some desert areas due to a different emissivity of the surface at IR 8.7



EUMETSAT

# Example: Cloud Phase



Met-8, 16 Aug 2006, 04:00 UTC

# Example: Moisture Boundary

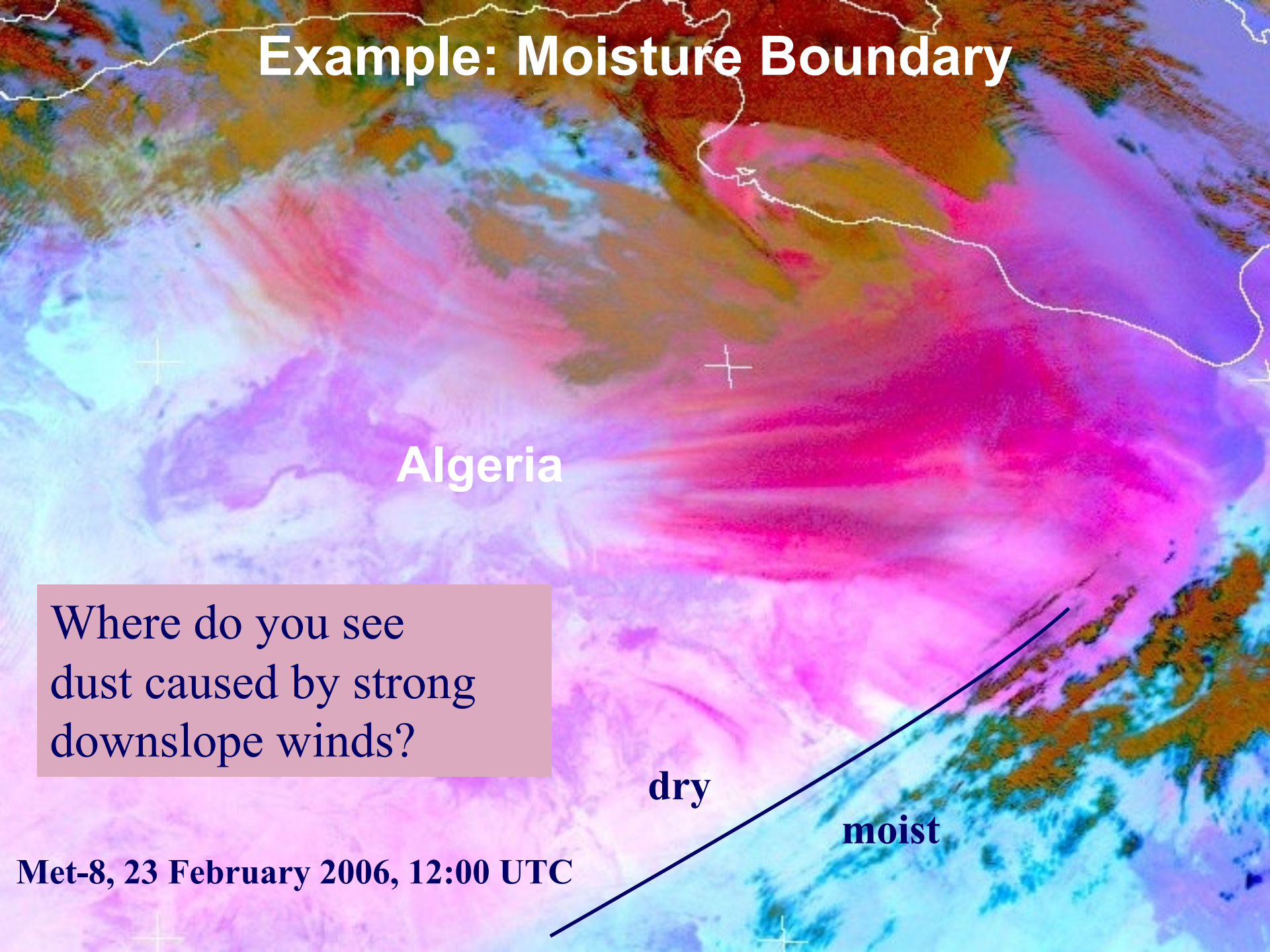
Algeria

Where do you see  
dust caused by strong  
downslope winds?

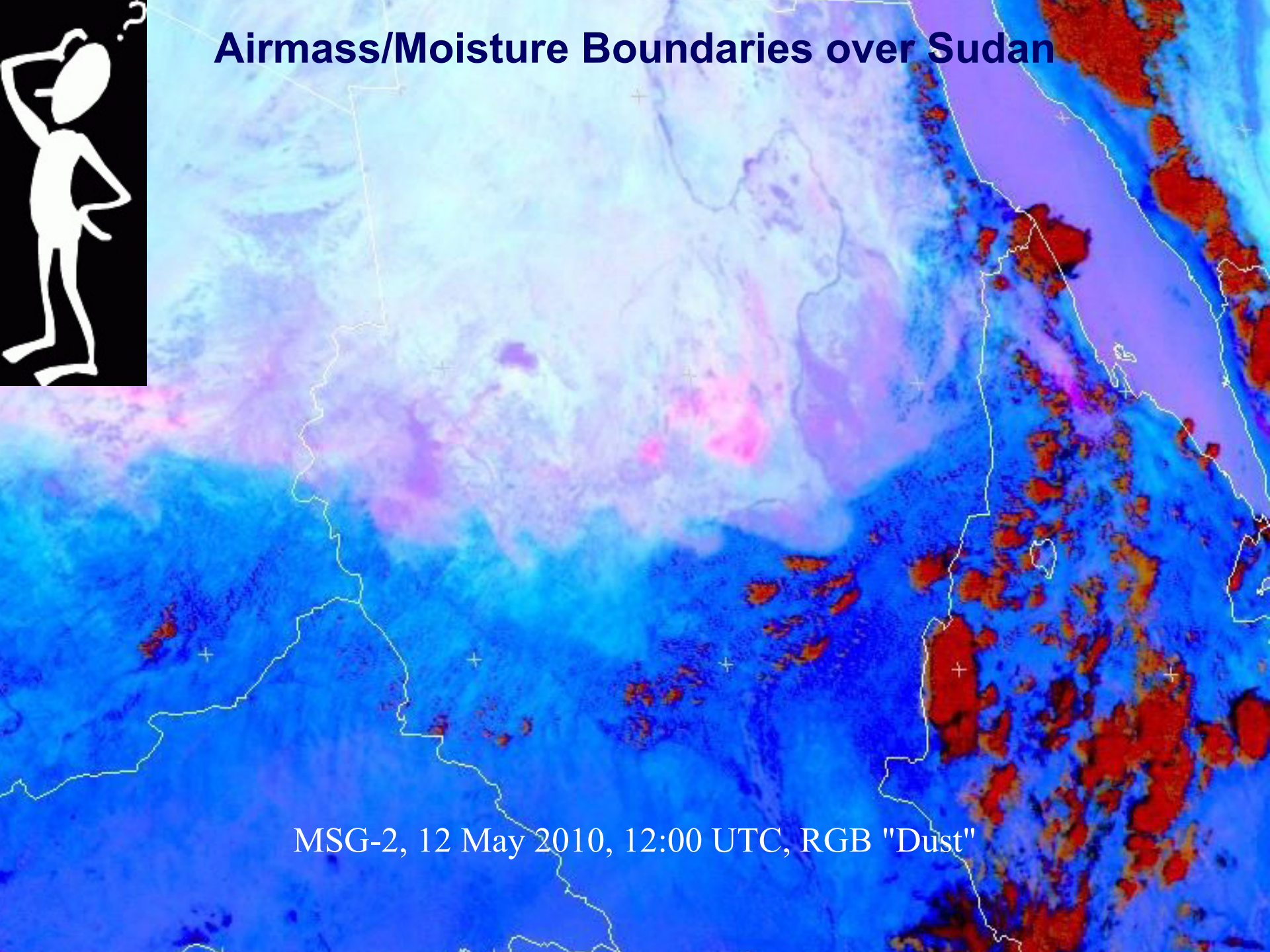
dry

moist

Met-8, 23 February 2006, 12:00 UTC

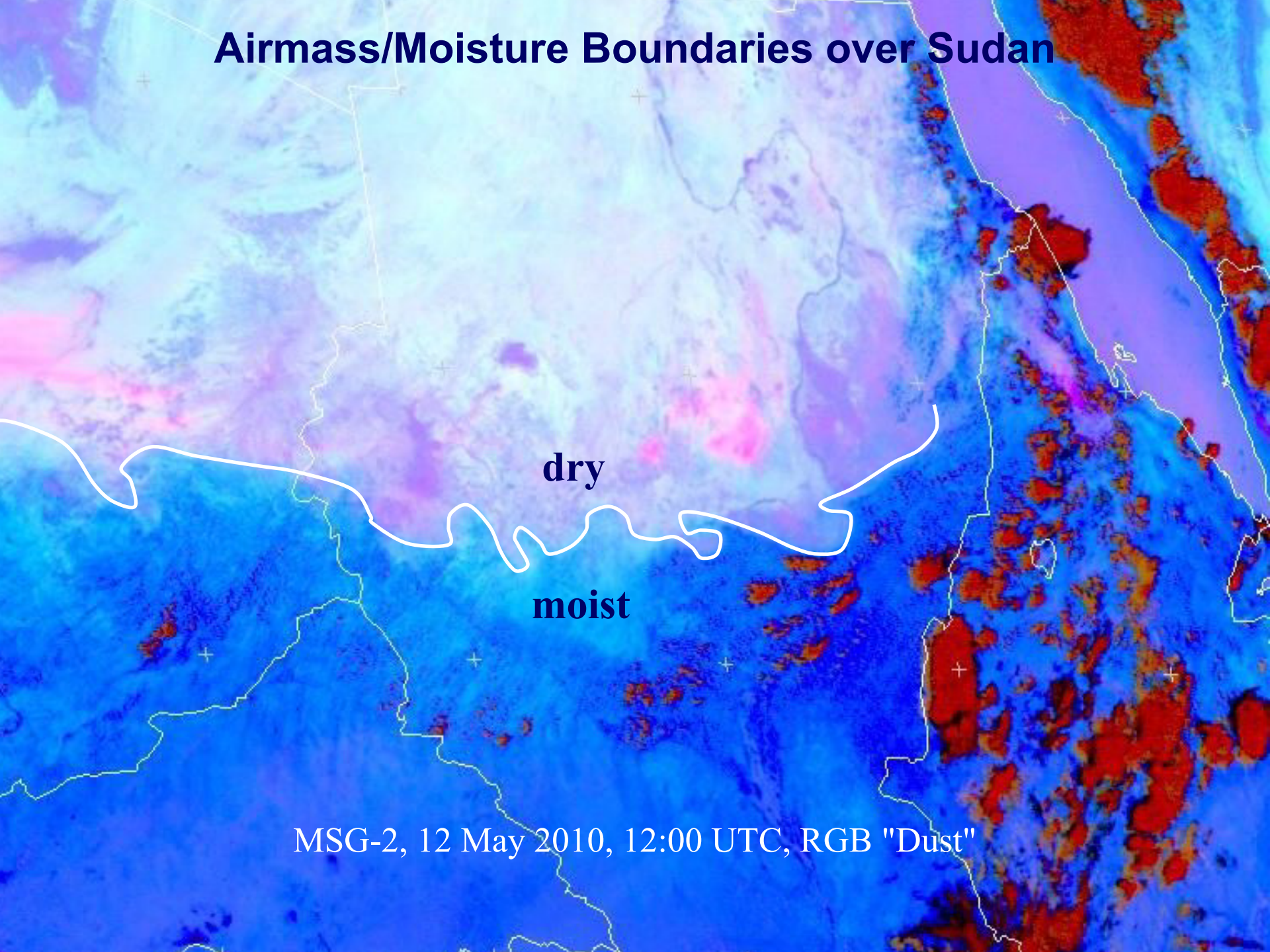


# Airmass/Moisture Boundaries over Sudan



MSG-2, 12 May 2010, 12:00 UTC, RGB "Dust"

# Airmass/Moisture Boundaries over Sudan



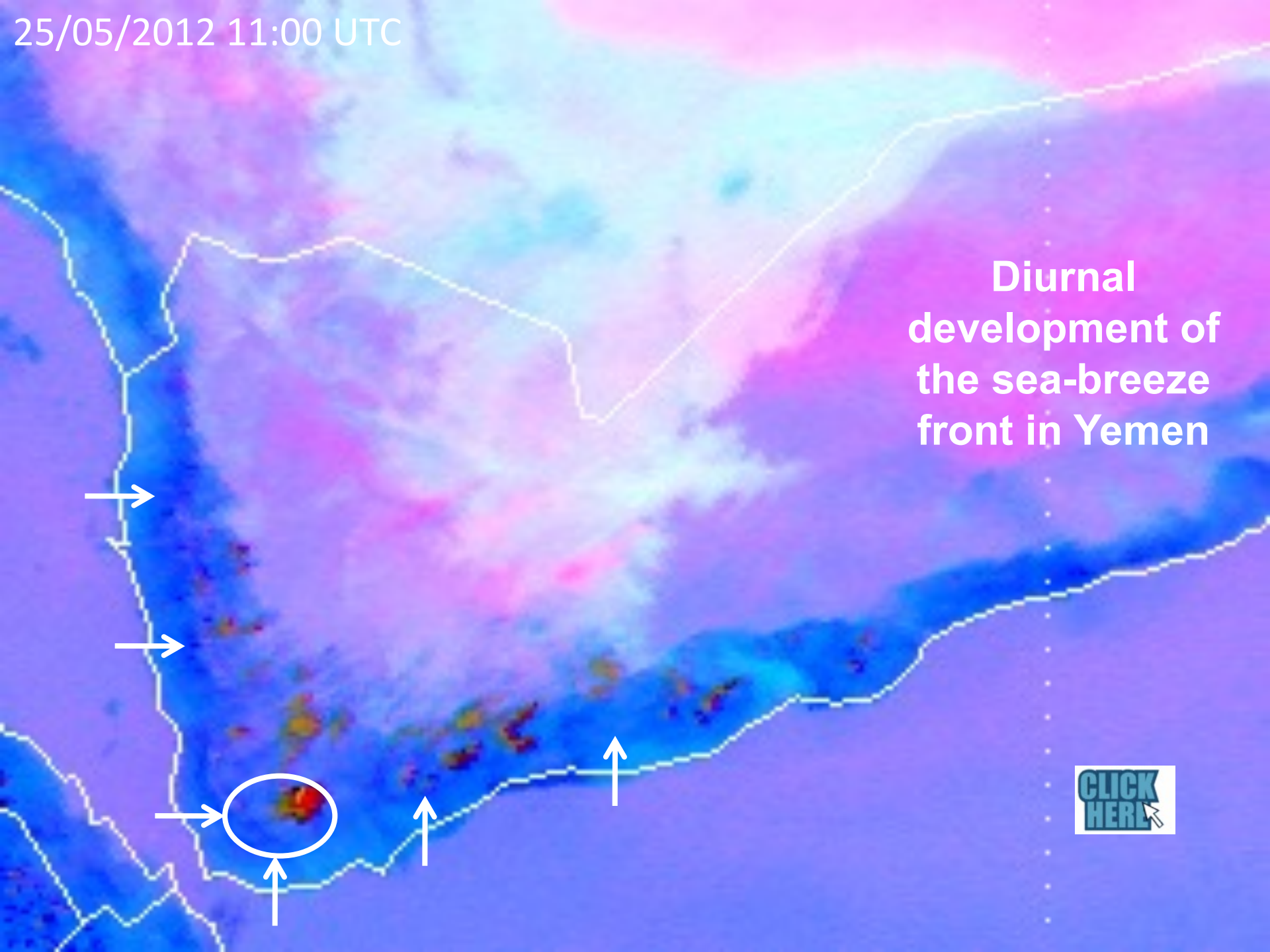
**dry**

**moist**

MSG-2, 12 May 2010, 12:00 UTC, RGB "Dust"

25/05/2012 11:00 UTC

**Diurnal  
development of  
the sea-breeze  
front in Yemen**

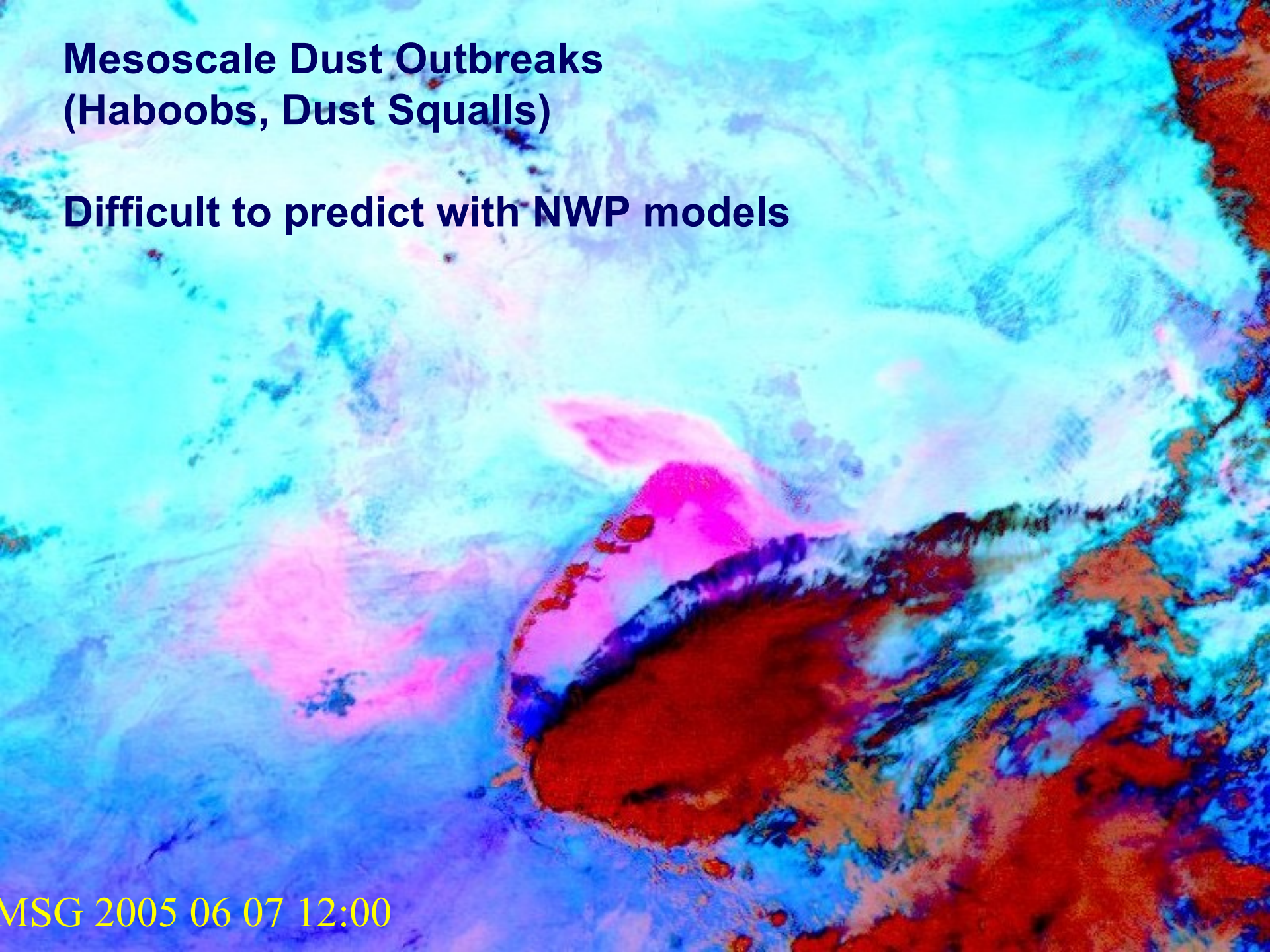


# Types of Dust Outbreaks

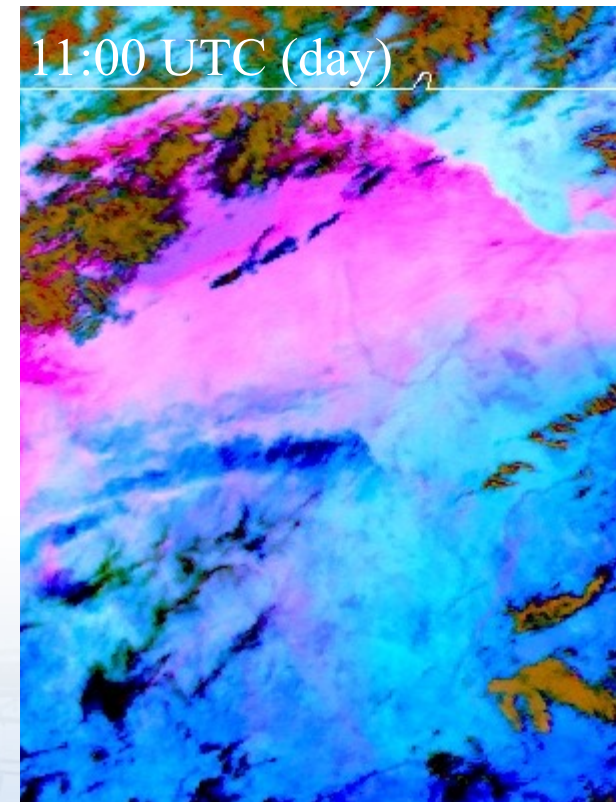
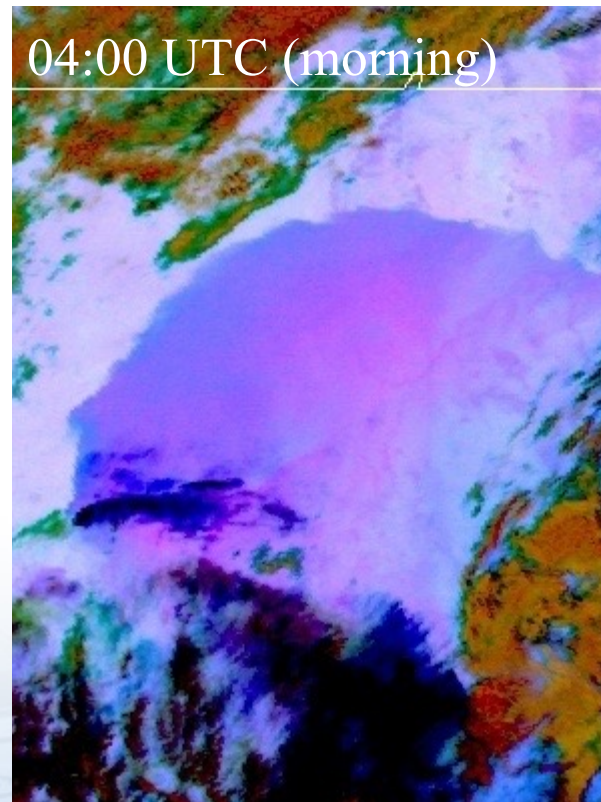
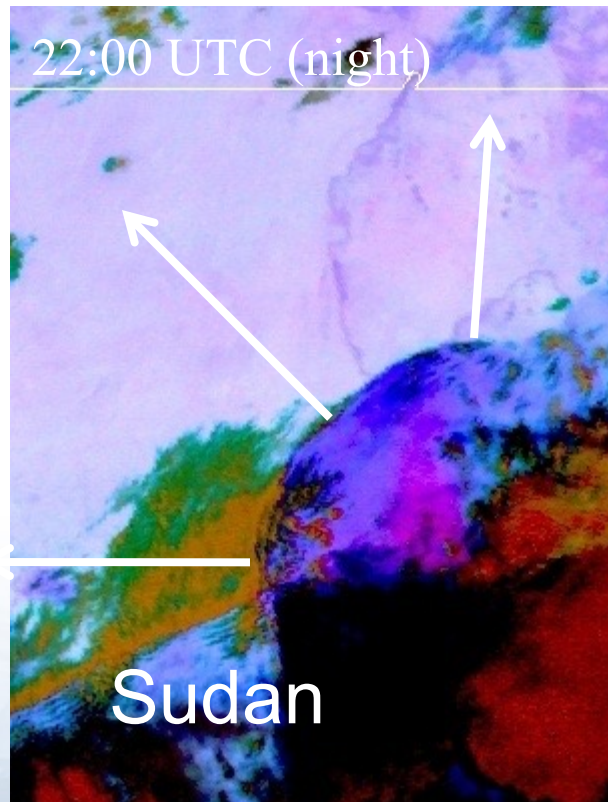
# Mesoscale Dust Outbreaks (Haboobs, Dust Squalls)

Difficult to predict with NWP models

MSG 2005 06 07 12:00

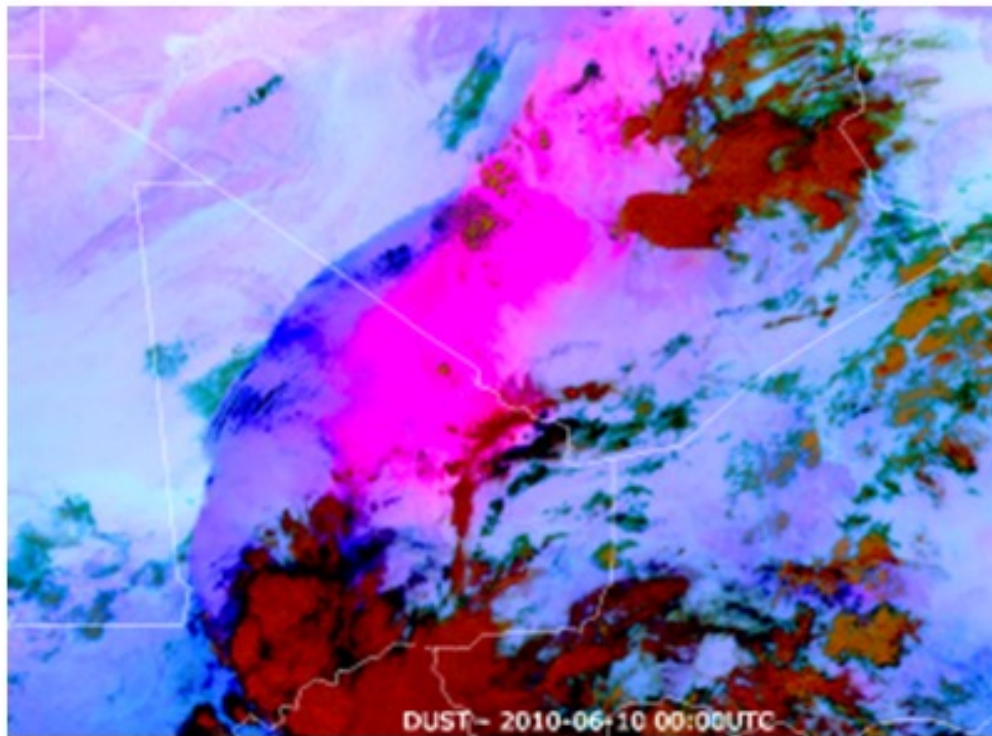


# Dust Haboobs can travel fast at night (undular bore?)



Met-8, 29-30 April 2007

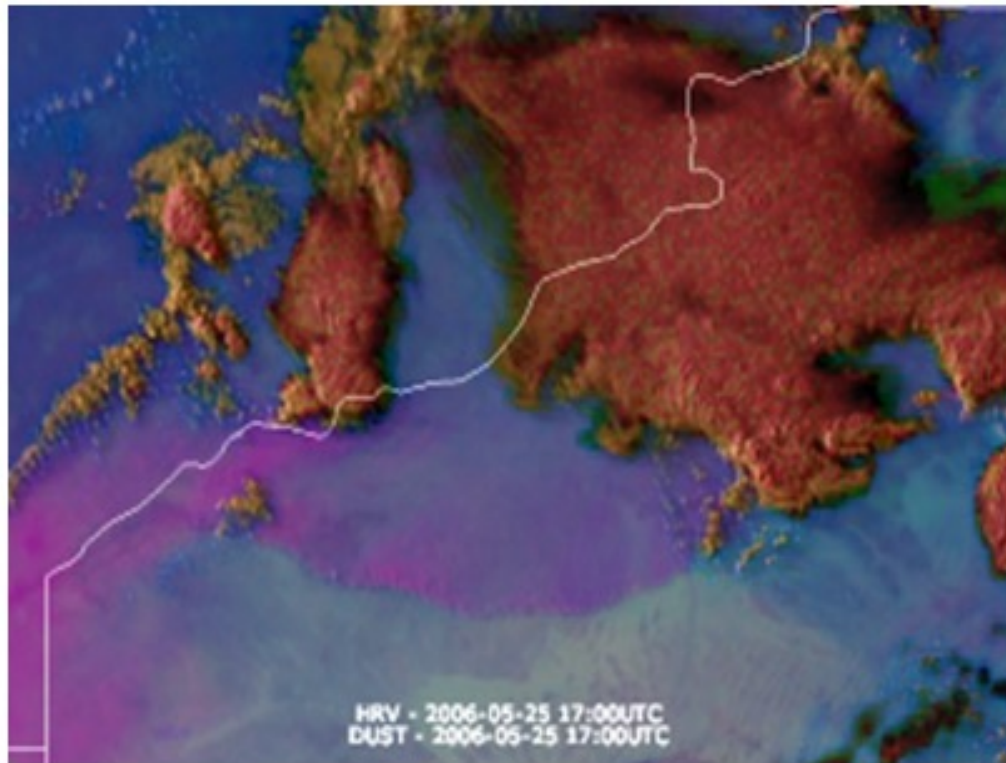
# Dust Haboobs can travel long distances



34-hour sequence of MSG (Meteosat-9) Dust RGB products on 9-10 June 2010. Source: EUMETSAT. Images created by HansPeter Roesli.

This MSG Dust RGB sequence shows a large dust squall over Niger, Mali and southern Algeria (highlight), triggered by a thunderstorm system visible in the lower part of the images, that travelled hundreds of kilometers westwards over the Sahara. This shows how long a distance strong haboobs can propagate and how well defined they can be at night. On 9 June, daytime convection lifts part of the low-lying dust higher up -- above the boundary layer -- where westerly winds carry it back in an easterly direction. The higher level dust can be seen very well in the late afternoon and night hours (highlight) by its bright magenta colour (as compared to the dark magenta colour of the low-level dust squall). Note that towards the end of this animation, the westward propagation of the dust squall slows down as it approaches a deformation zone.

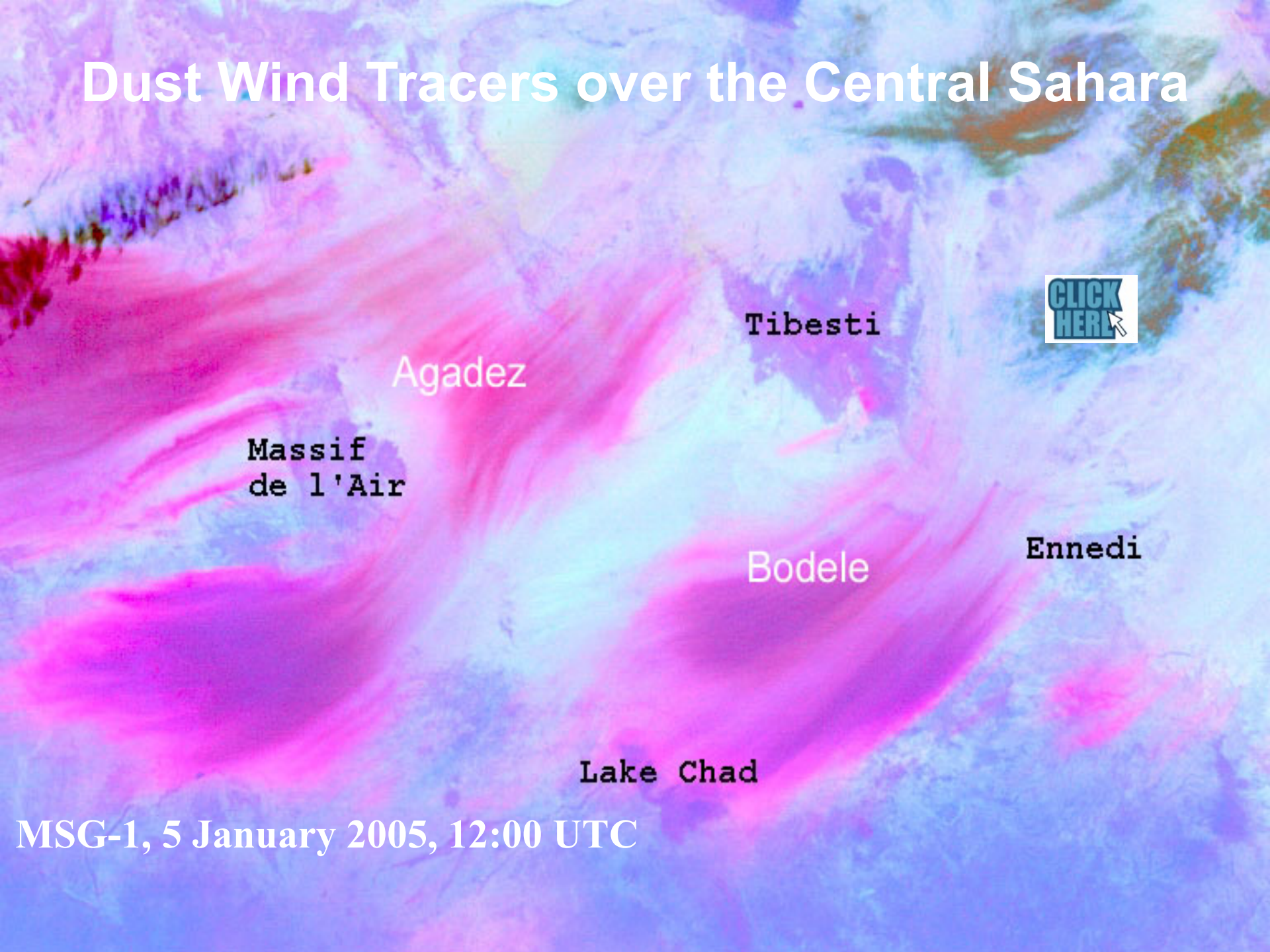
# Combination of HRV & Dust RGB



5-hour sequence of MSG (Meteosat-8) blended HRV and Dust RGB products on 25 May 2006 from 12:00 to 17:00 UTC. Source: EUMETSAT. Images created by HansPeter Roesli. ¶

Note that this animation shows the HRV / Dust RGB "sandwich product", which is an image combination of the HRV channel and the Dust RGB product, allowing one to spatially co-locate the cloud features like the storm's overshooting top and outflow boundaries (at high resolution) with the dust clouds seen in the Dust RGB (at lower resolution). During daytime, this blended product is probably the best geostationary satellite product to monitor haboobs. ¶

# Dust Wind Tracers over the Central Sahara



Tibesti

Agadez

Massif  
de l'Air

Bodele

Ennedi

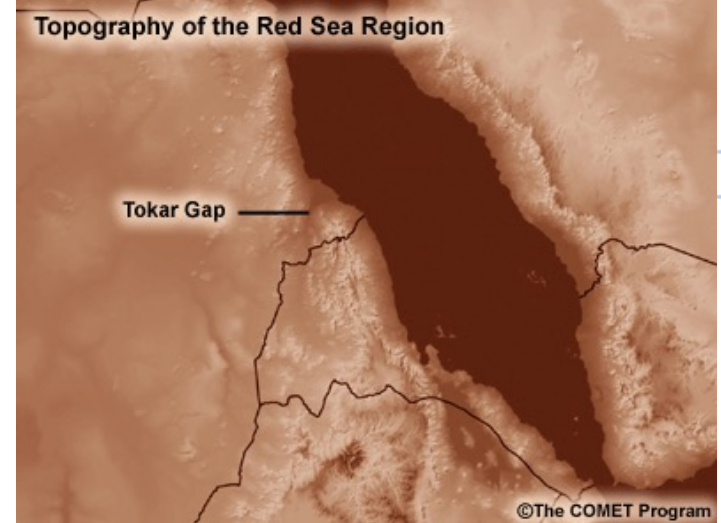
Lake Chad

MSG-1, 5 January 2005, 12:00 UTC

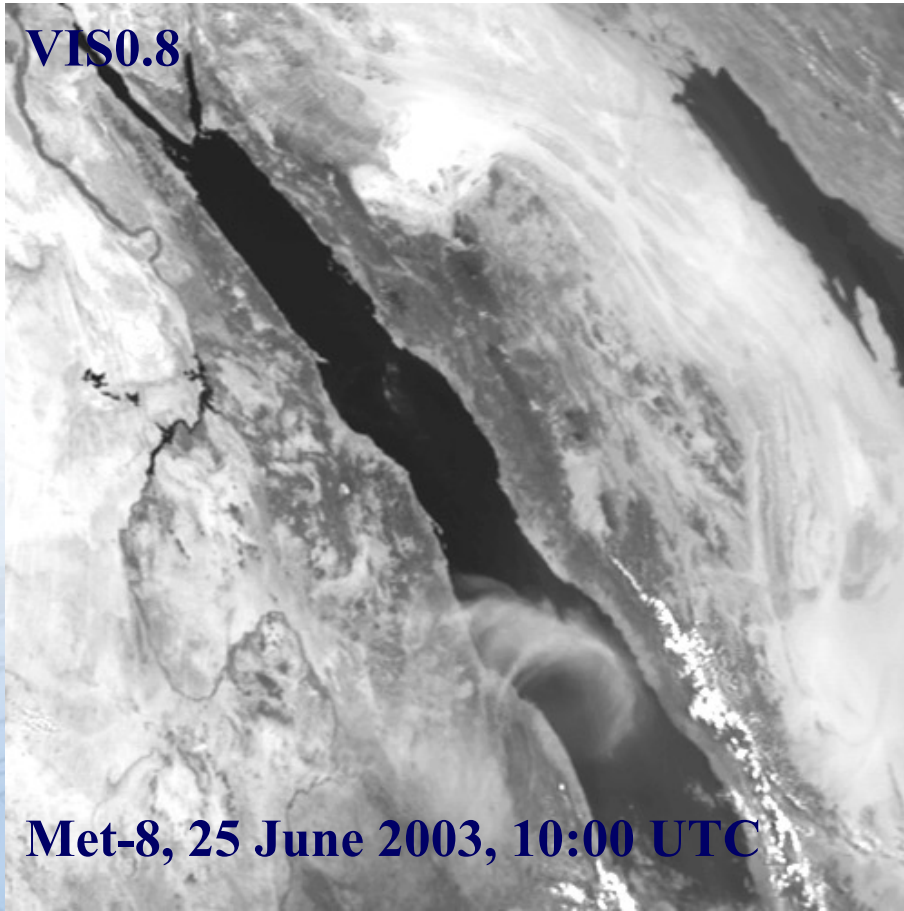
# Mountain Gap Winds



Outline the dust areas!



VIS0.8



Met-8, 25 June 2003, 10:00 UTC

