EUMETSAT

Monitoring weather, climate and the environment

Dr. Jochen Kerkmann

Satellite Meteorologist

Training Officer

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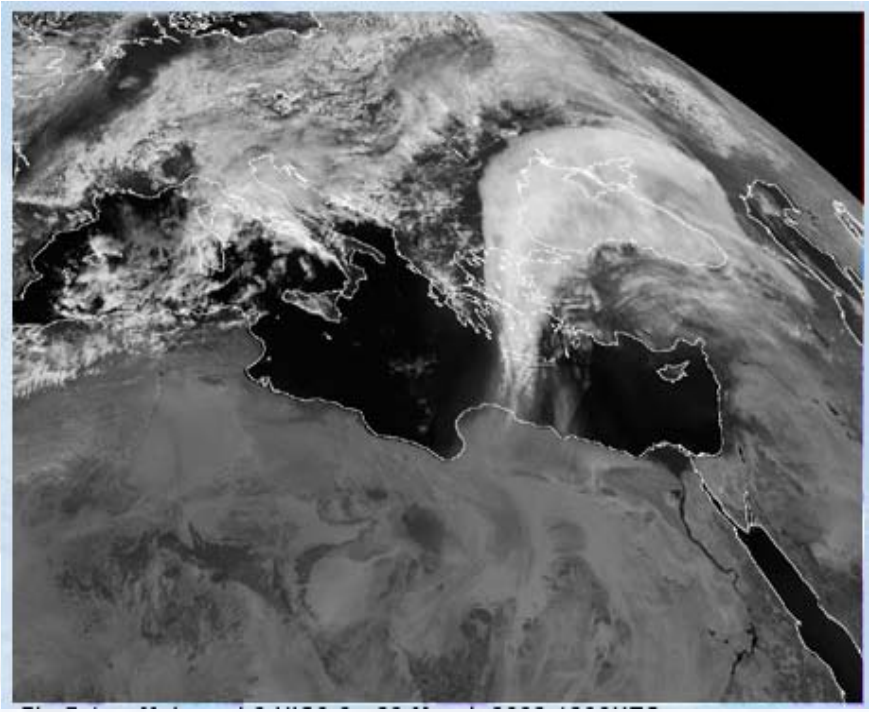
Exercise - where is the dust ?

Visible (VIS0.6) image



23/03/2008 – 12 UTC

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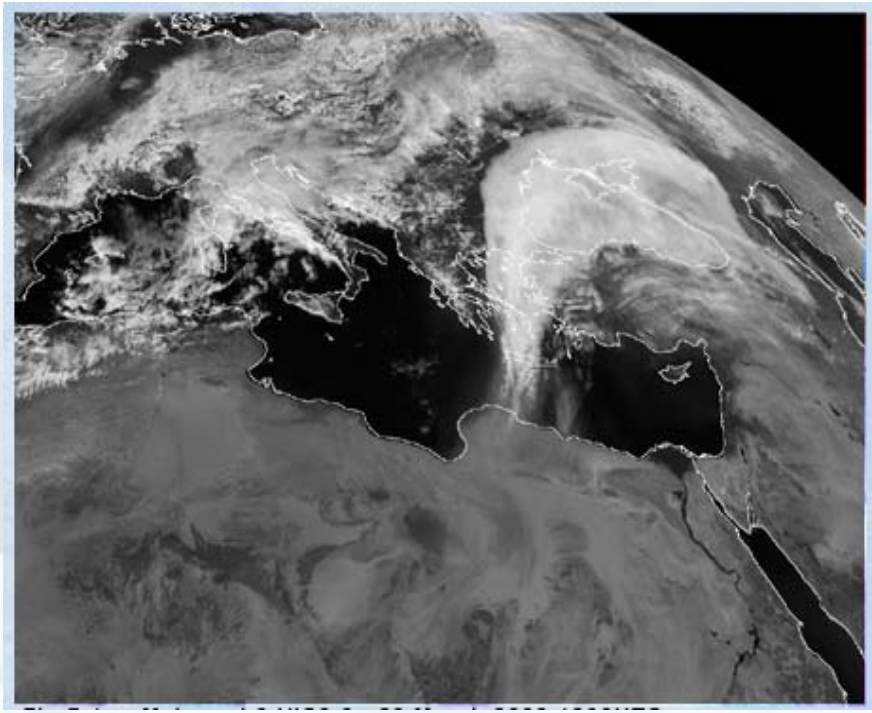
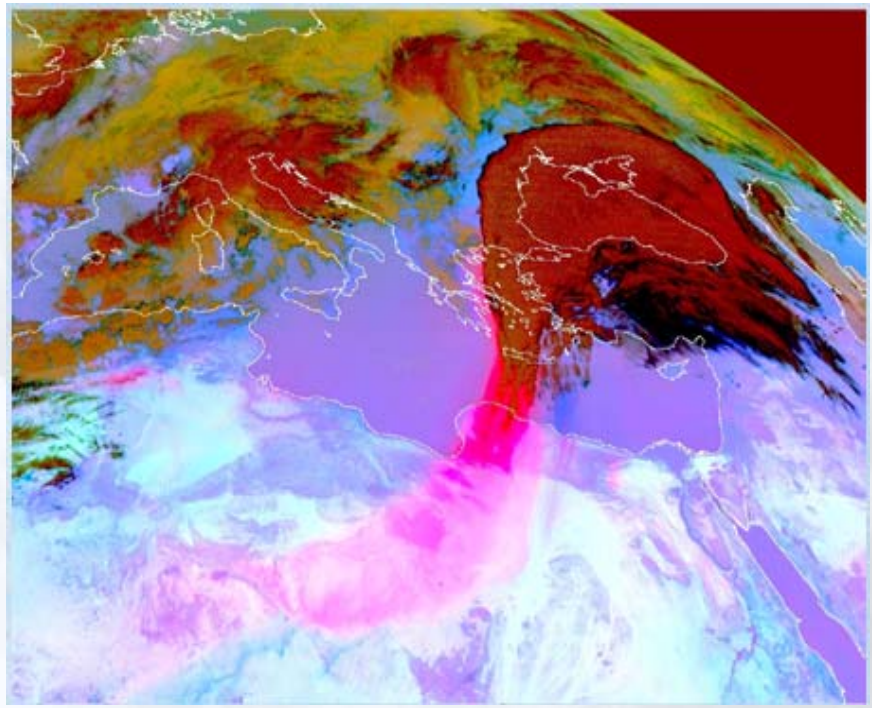
Exercise - where is the dust ?

Visible (VIS0.6) image



Dust RGB Product



23/03/2008 – 12 UTC

EUMETRAIN Module on RGB images:
http://www.zamg.ac.at/eumetrain/Seiten/CAL_Topic.htm

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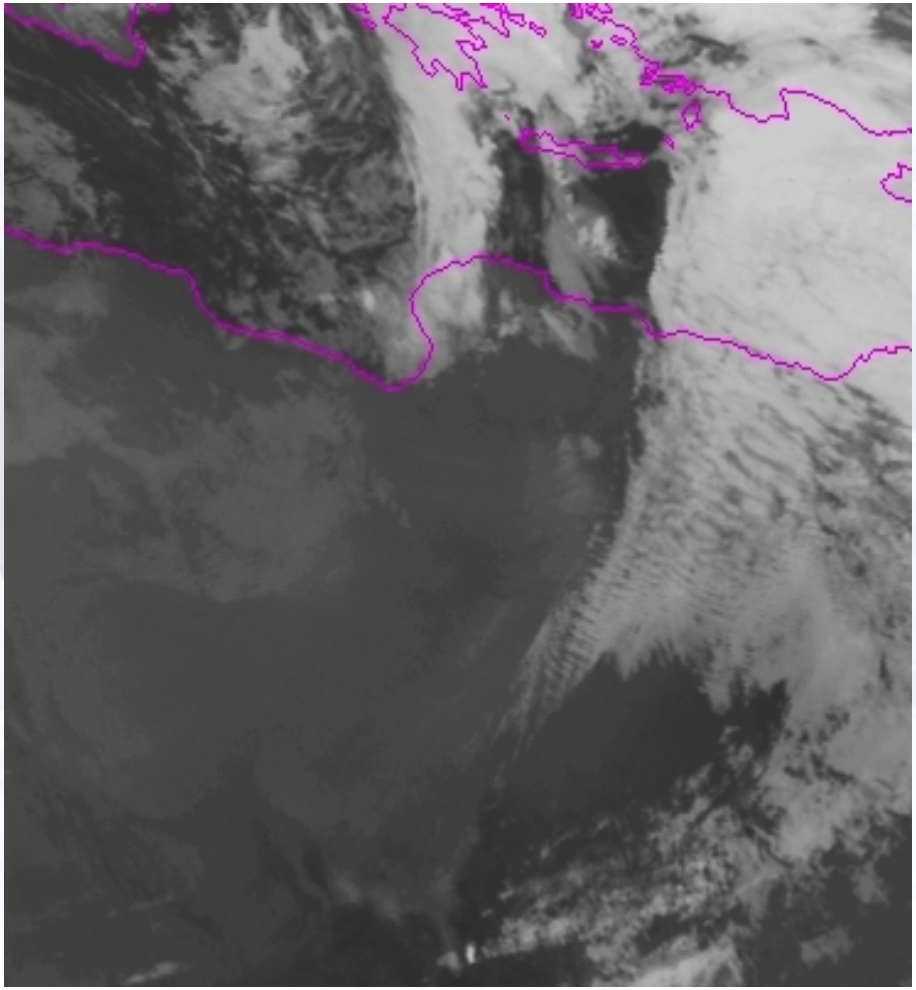
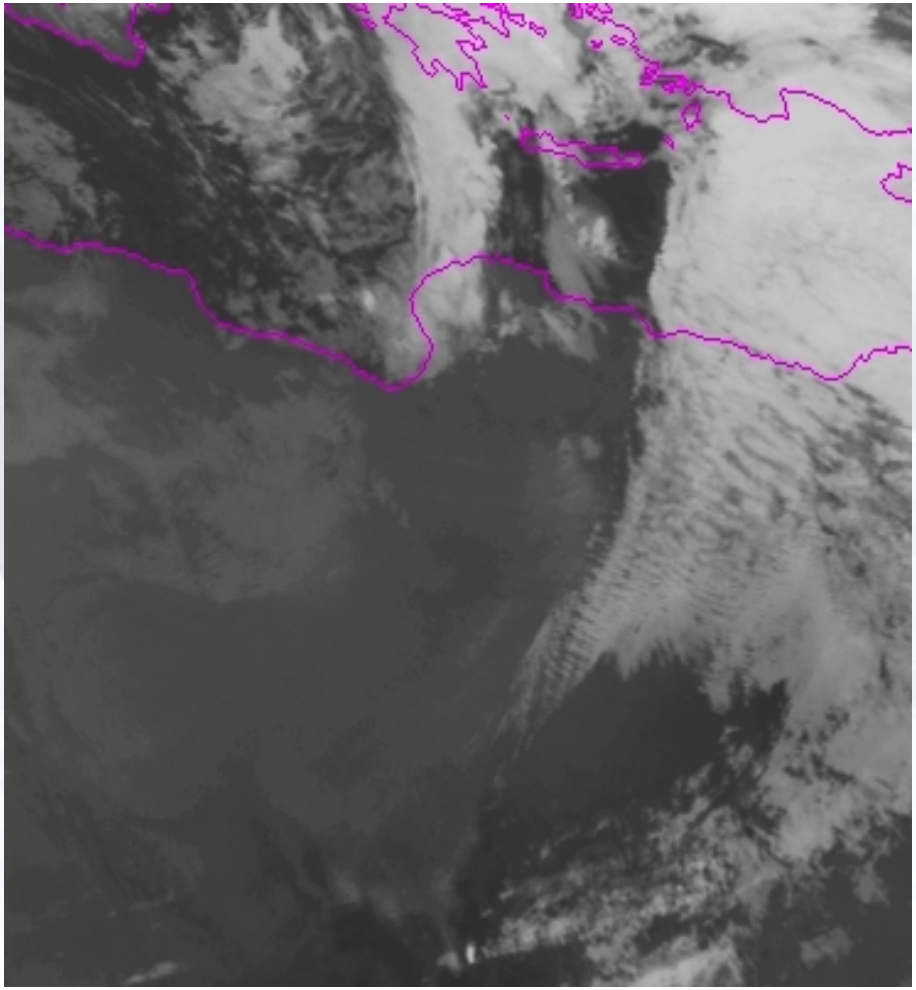
Exercise - where is the dust ?

Met-7 IR image (night)

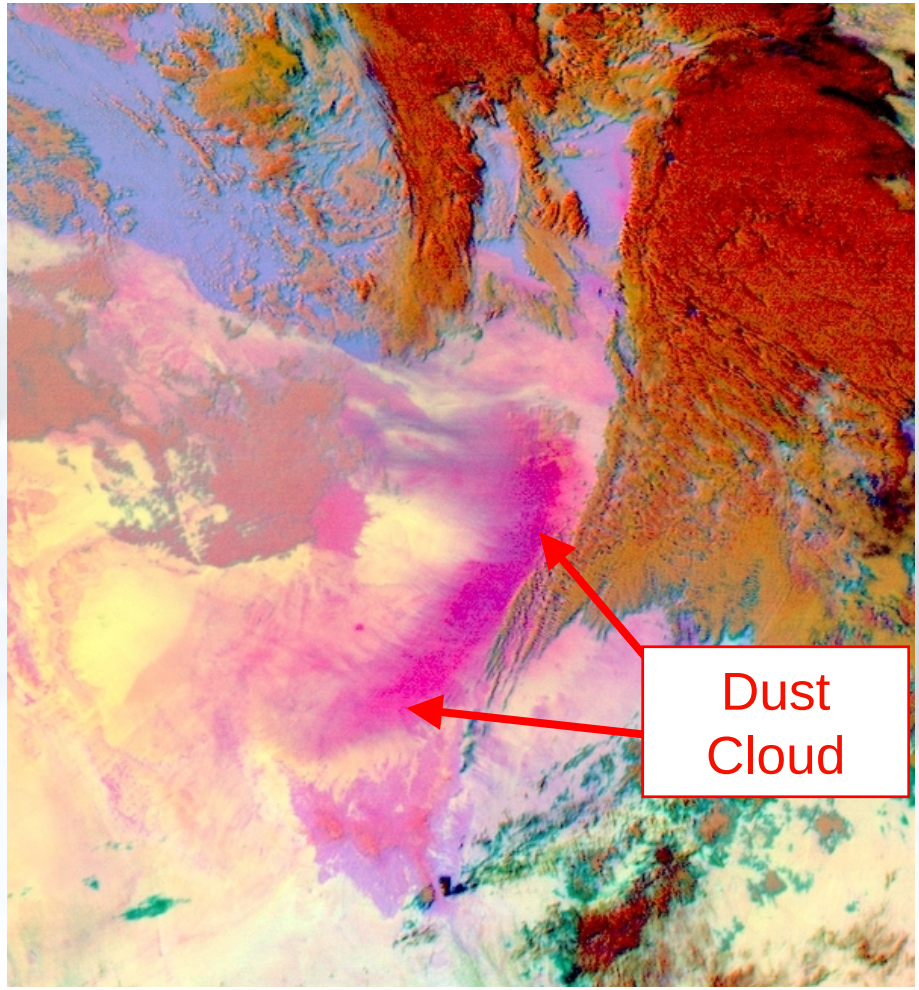


Exercise - where is the dust ?

Met-7 IR image



Met-8 Dust RGB Product



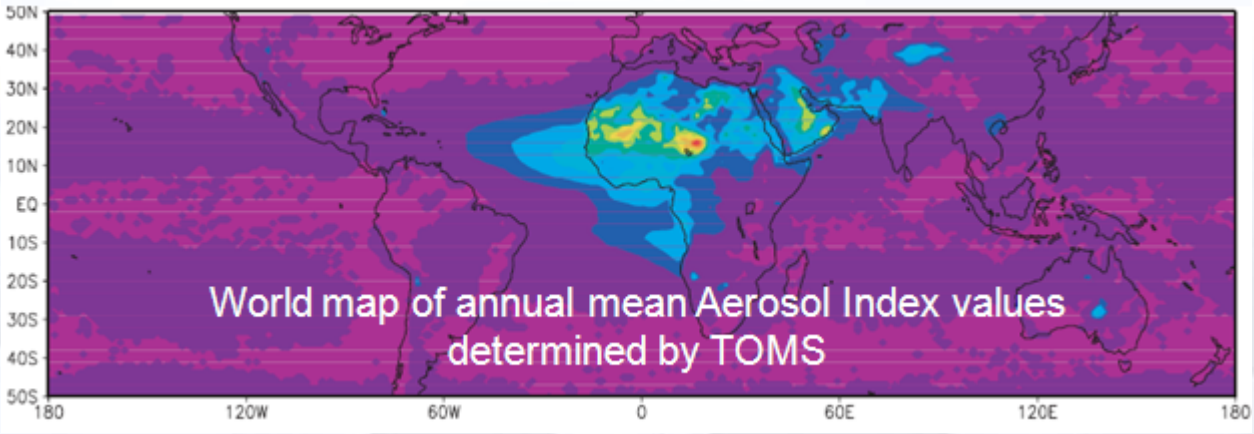
Title: Dust Outbreaks - Synoptic dust outbreaks versus mesoscale dust squalls

At the end of this section you should be able to do the following things:

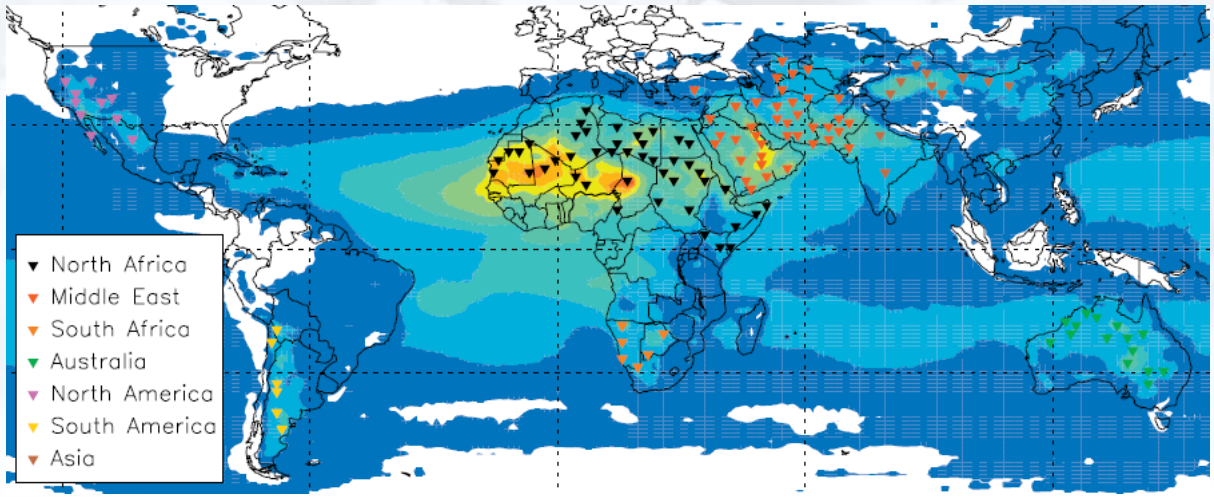
- (Better) describe dust source regions & dust climatology
- (Better) detect dust on satellite images (dust RGB, natcol RGB)
- (Better) discriminate low-level from high-level dust
- (Better) describe the global impacts of dust outbreaks

- Describe the synoptic patterns that lead to dust outbreaks
- Describe some basic Cloud – Dust Interactions
- Describe the diurnal cycle of dust outbreaks
- Basic ability to forecast movement of dust clouds
- List mesoscale phenomena that can cause dust outbreaks
- Describe the typical size, height, and longevity of a dust squall

Dust is a Global Issue (Problem?)



From Engelstaedter and Washington, 2007



With location of 131 dust hot spots
(colour coded by Regions)

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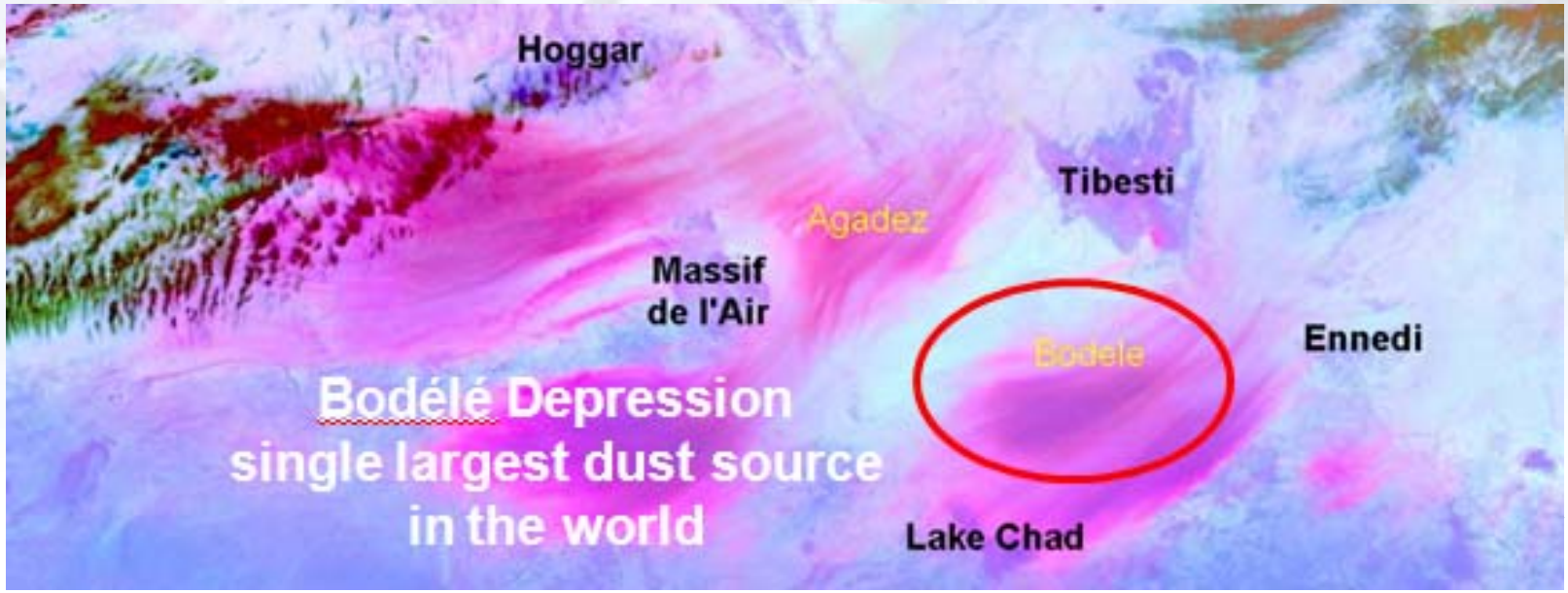
Dust Outbreaks: Ingredients

For lifting dust up in the air two things must come together:

- Strong surface winds (“Most large scale duststorms require about 15 knots to get started”, Wilkerson, 1991)
- Dust source (“Most duststorms originate in specific source areas that can be identified in satellite imagery”)



Loop 1

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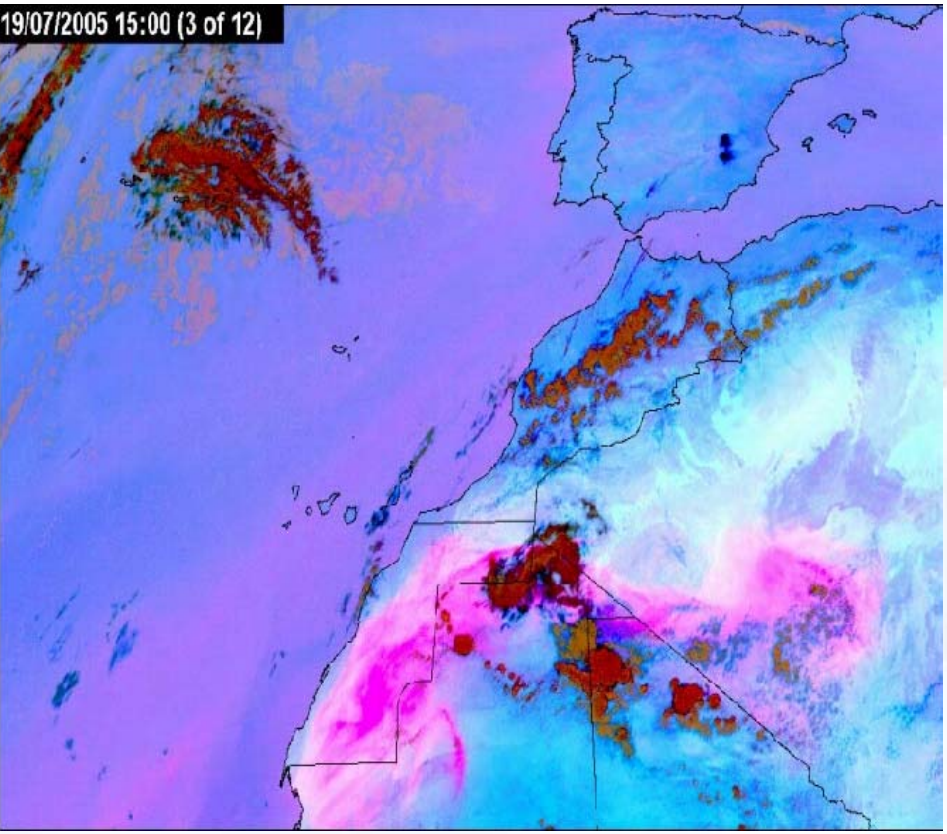
The Dust RGB Product



How do we get a picture like this?

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RGB 10-09, 09-07, 09 ("24-hour Dust Microphysics")

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

Not used:

VIS0.6 or HRV: good over Oceans, only daytime

IR3.9r (reflectance part): good over Oceans, only daytime

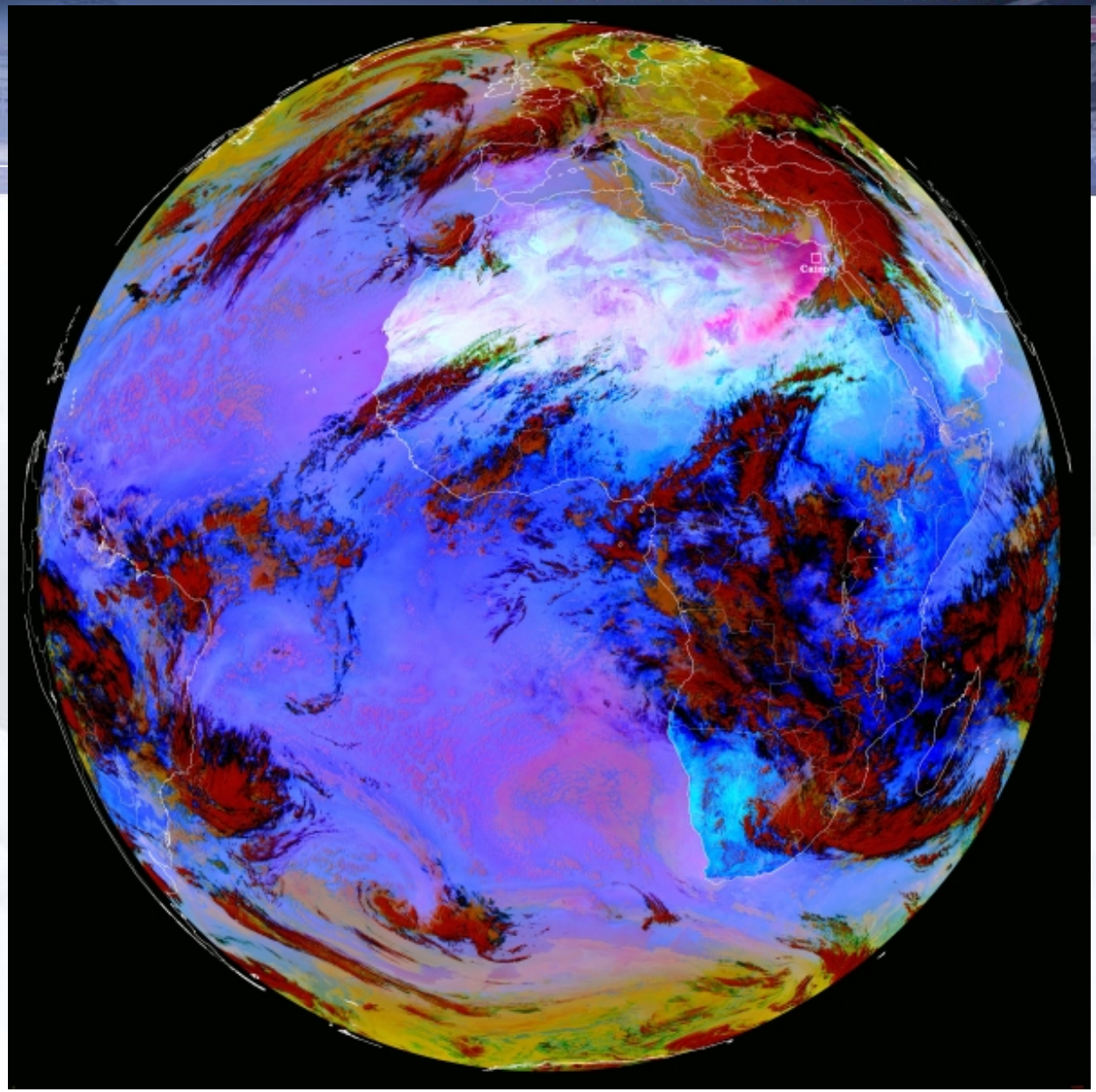
Difference IR3.9 – IR10.8 (known from AVHRR)
good over Land and Oceans, only daytime

Physical Interpretation (for dust/ash/water/ice clouds)

R = Difference IR12.0 - IR10.8
Optical Thickness, Tsurf-Tcloud

G = Difference IR10.8 - IR8.7
Optical Thickness, Tsurf-Tcloud, Phase

B = Channel IR10.8
Top Temperature



RGB 24-hour Dust Microphysics Global View

MSG-1
22 January 2004
12:00 UTC

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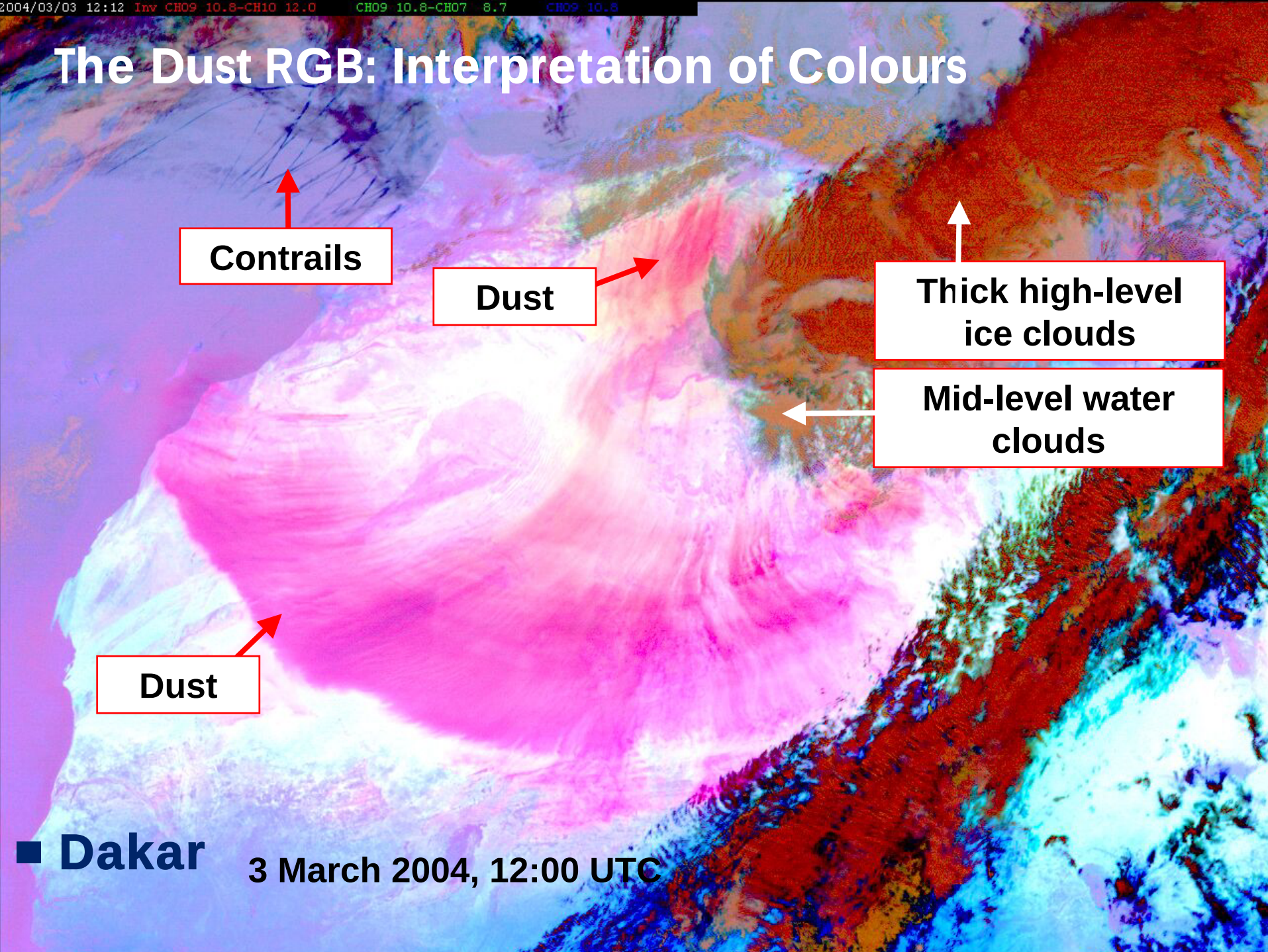
The Dust RGB Works Day & Night !

Saudi Arabia

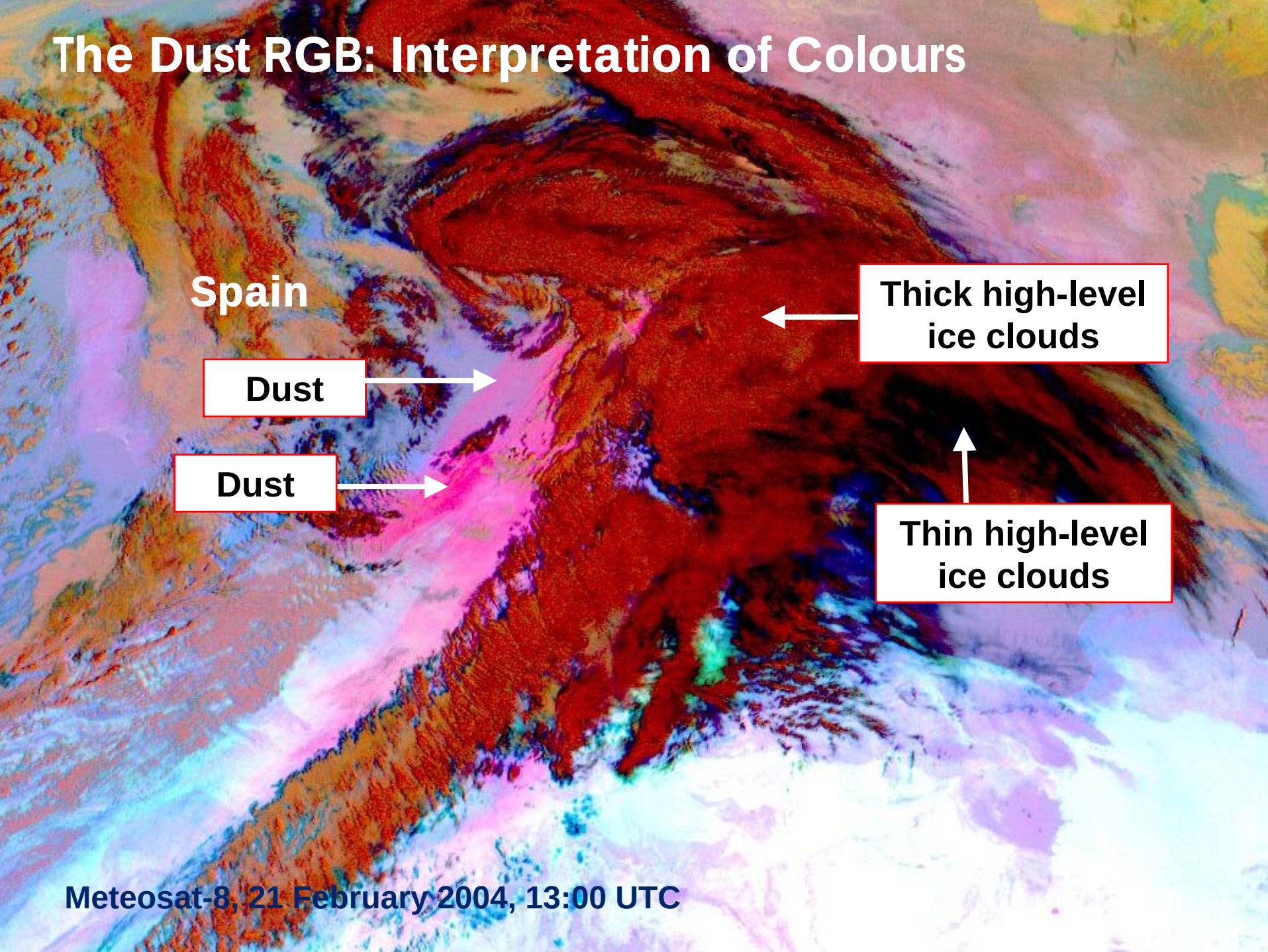
Riyadh

Where are the Jets?
(polar, subtropical)

Meteosat-9, 10 March 2009, 09:00 UTC

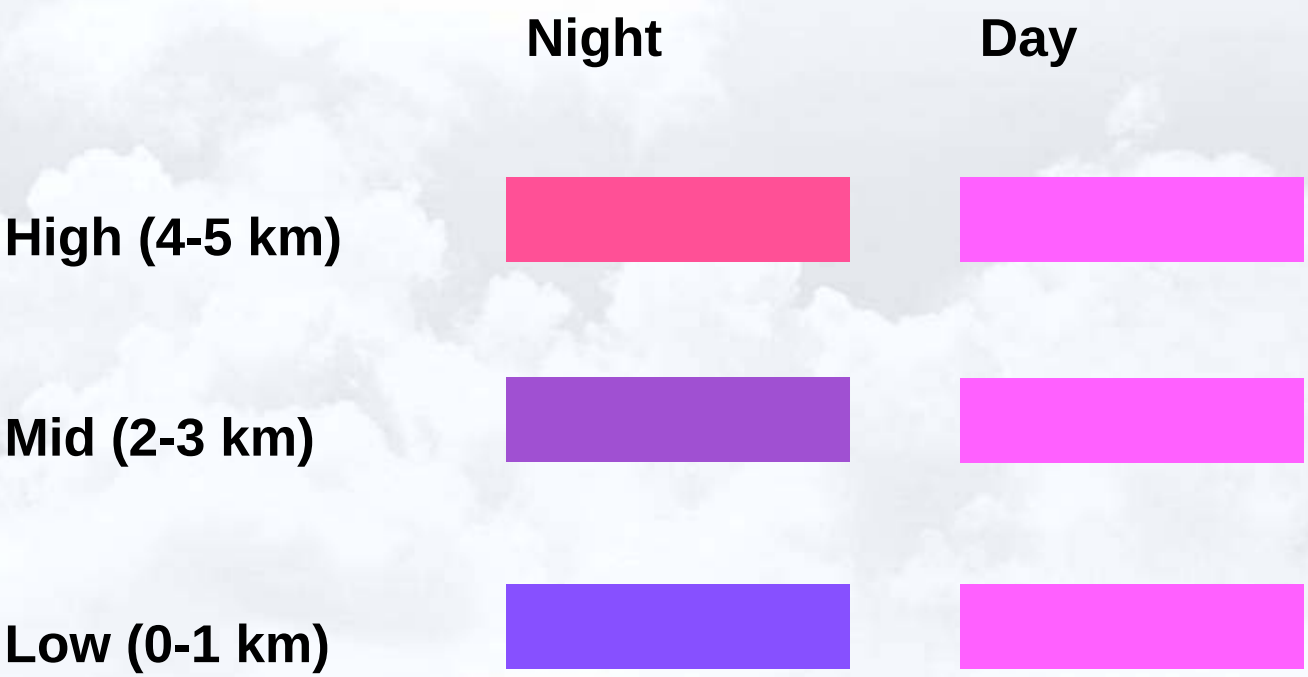

2004/03/03 12:12 Inv CH09 10.8-CH10 12.0 CH09 10.8-CH07 8.7 CH09 10.8
The Dust RGB: Interpretation of Colours
Contrails
Dust
Thick high-level ice clouds
Mid-level water clouds
Dust
Dakar
3 March 2004, 12:00 UTC

The Dust RGB: Interpretation of Colours



Meteosat-8, 21 February 2004, 13:00 UTC

The Dust RGB: Interpretation of Colours
1. Thin Dust Clouds



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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)		

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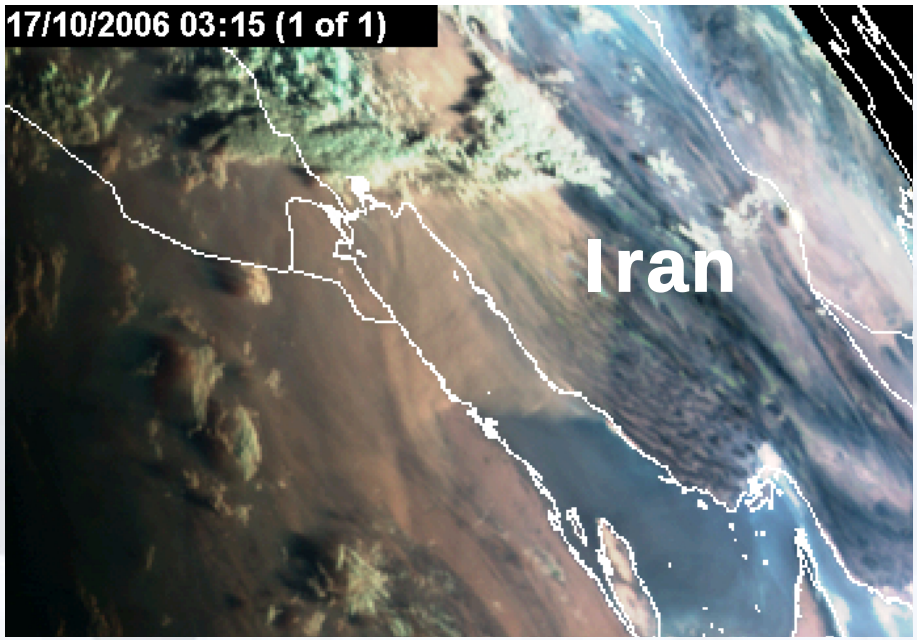
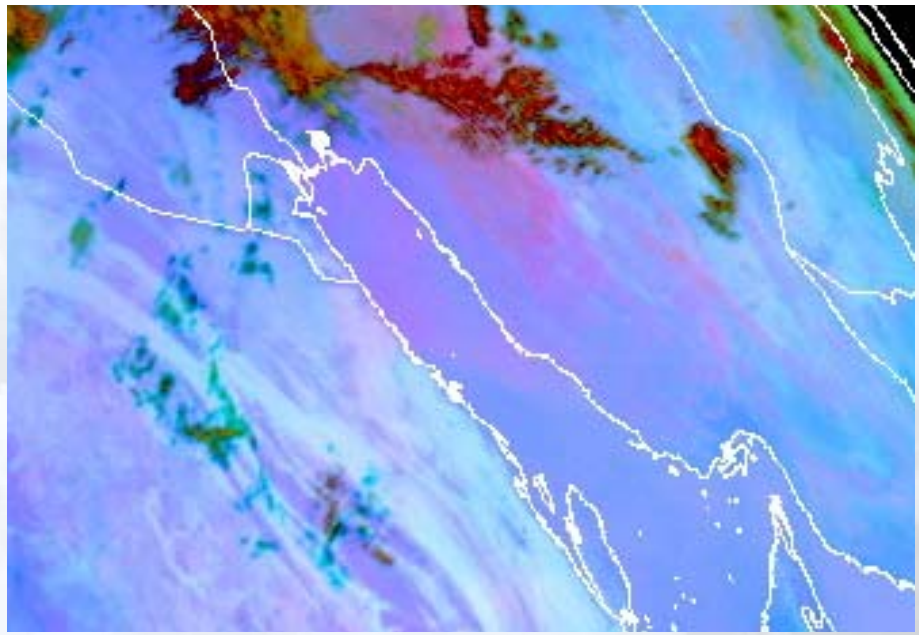
The Dust RGB: Limitations for Low Level Dust Clouds (Ocean)





03:15 UTC
Natural Colours RGB

05:00 UTC
Dust RGB

MSG-1, 17 October 2006

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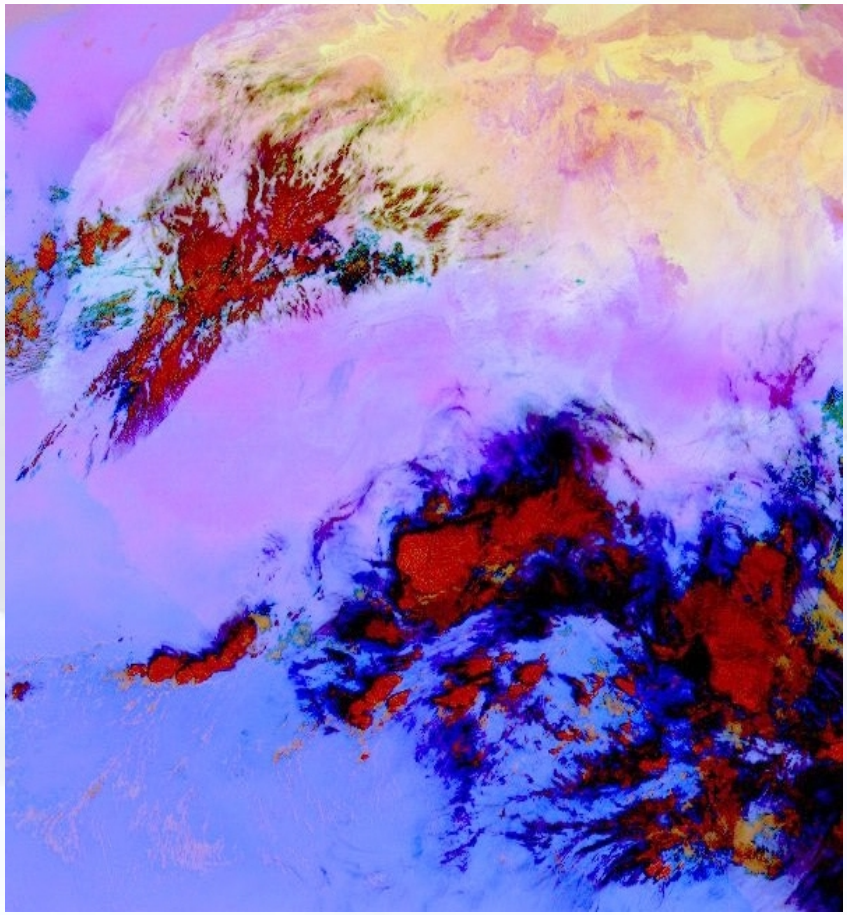
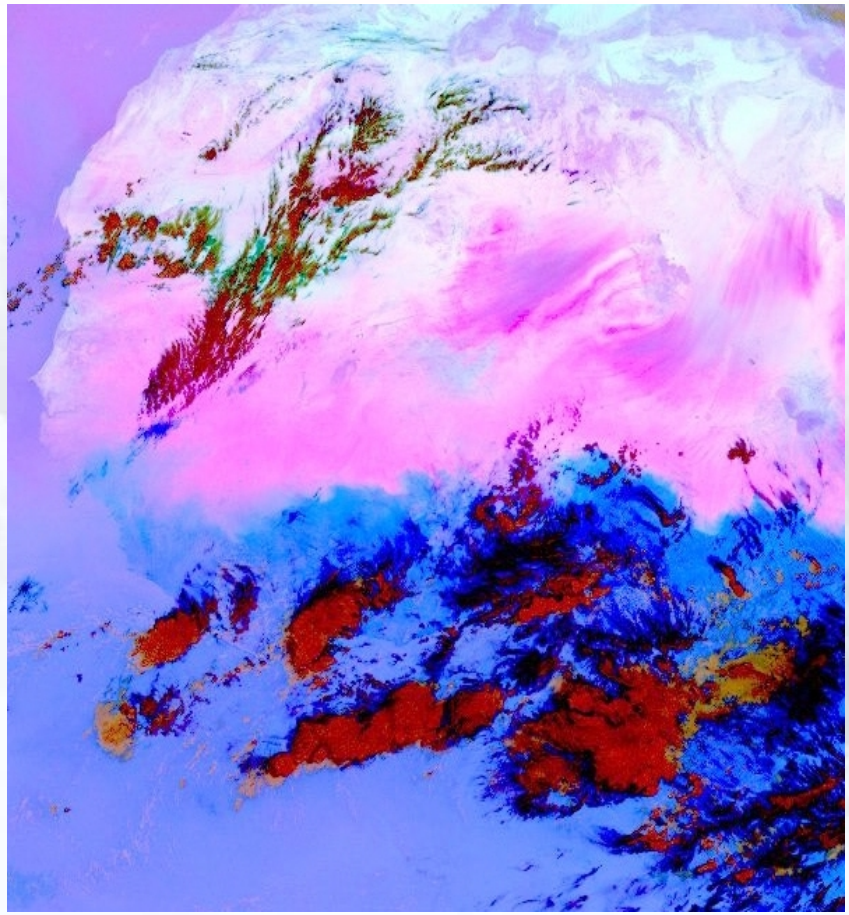
The Dust RGB: Limitations for Low Level Dust Clouds (Night)



Night (00:00 UTC)



Day (12:00 UTC)

MSG-1, 8 March 2006

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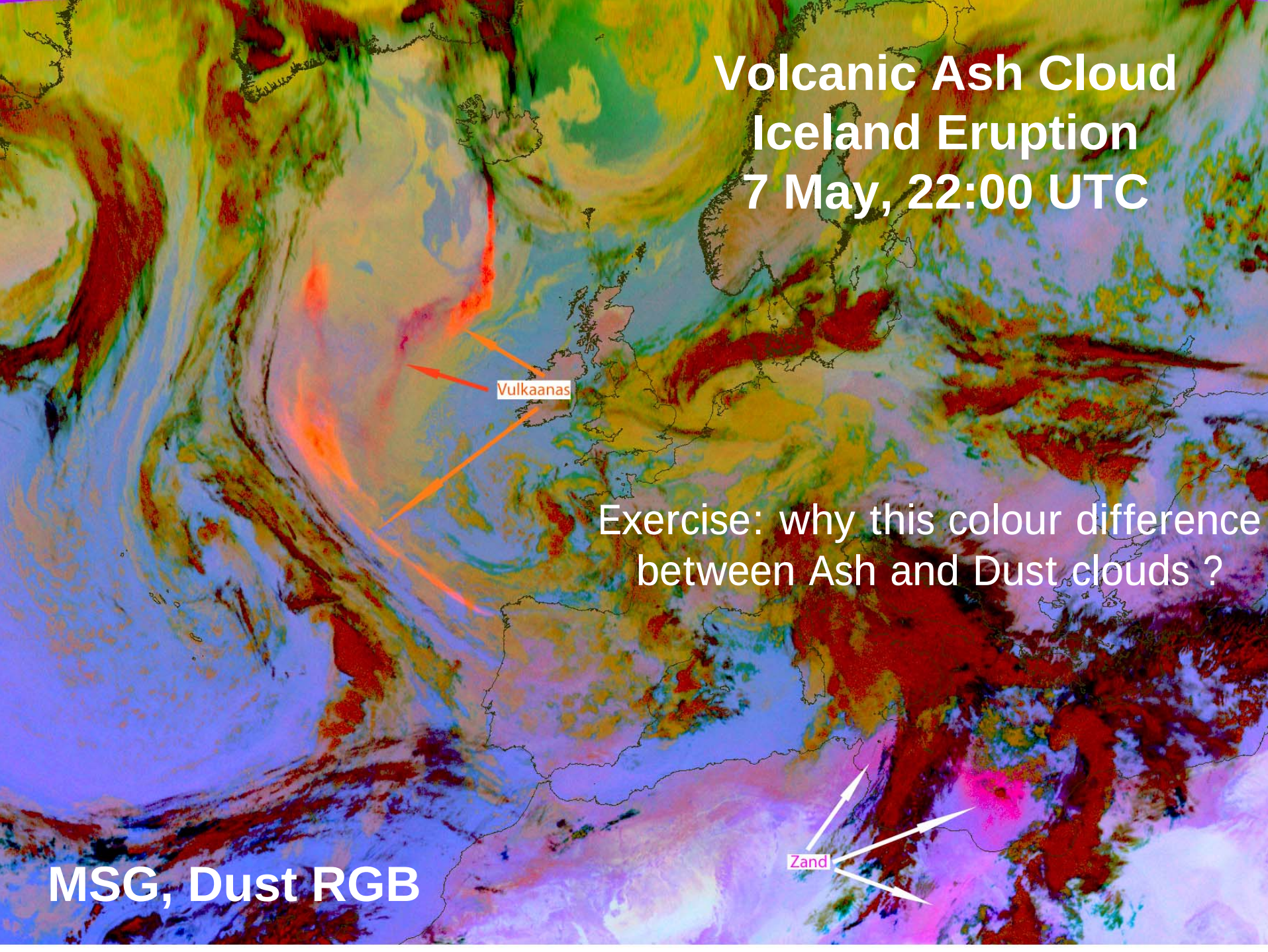

Volcanic Ash Cloud
Iceland Eruption
7 May, 22:00 UTC
Vulkaanas
Exercise: why this colour difference between Ash and Dust clouds ?
Zand
MSG, Dust RGB

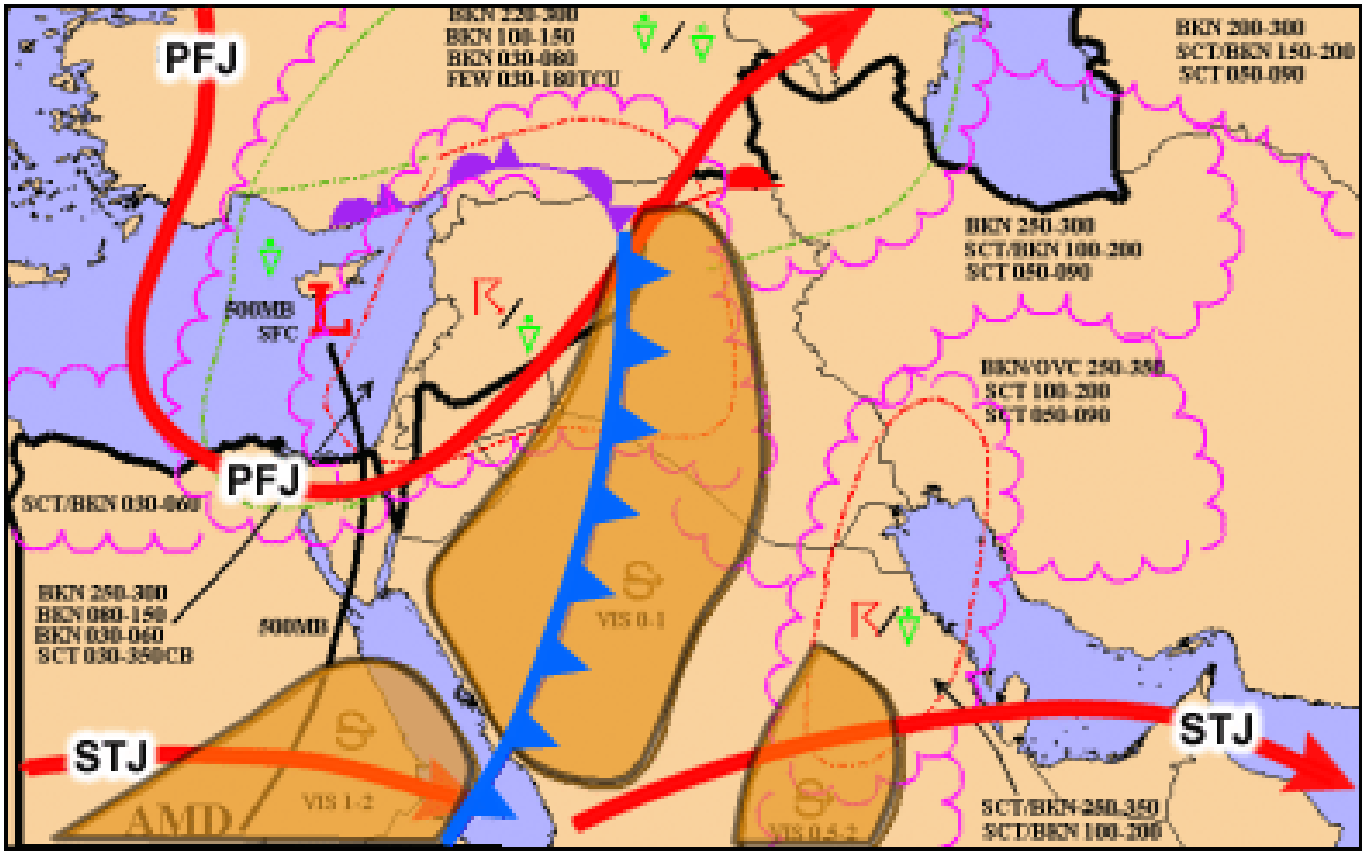
Synoptic-Scale Dust Outbreaks (N. Hemisphere)

Season from February to June (peak in Spring), but also in summer; nearly absent in Autumn

-Frontal dust clouds (prefrontal, postfrontal)
-Non-frontal dust clouds (trade winds)
    Northeasterlies (**Harmattan**, Sahel)
    Northerlies (**Shamal**, Middle East)
    Northwesterlies (Asia-Gobi)

Pre-Frontal Dust Clouds

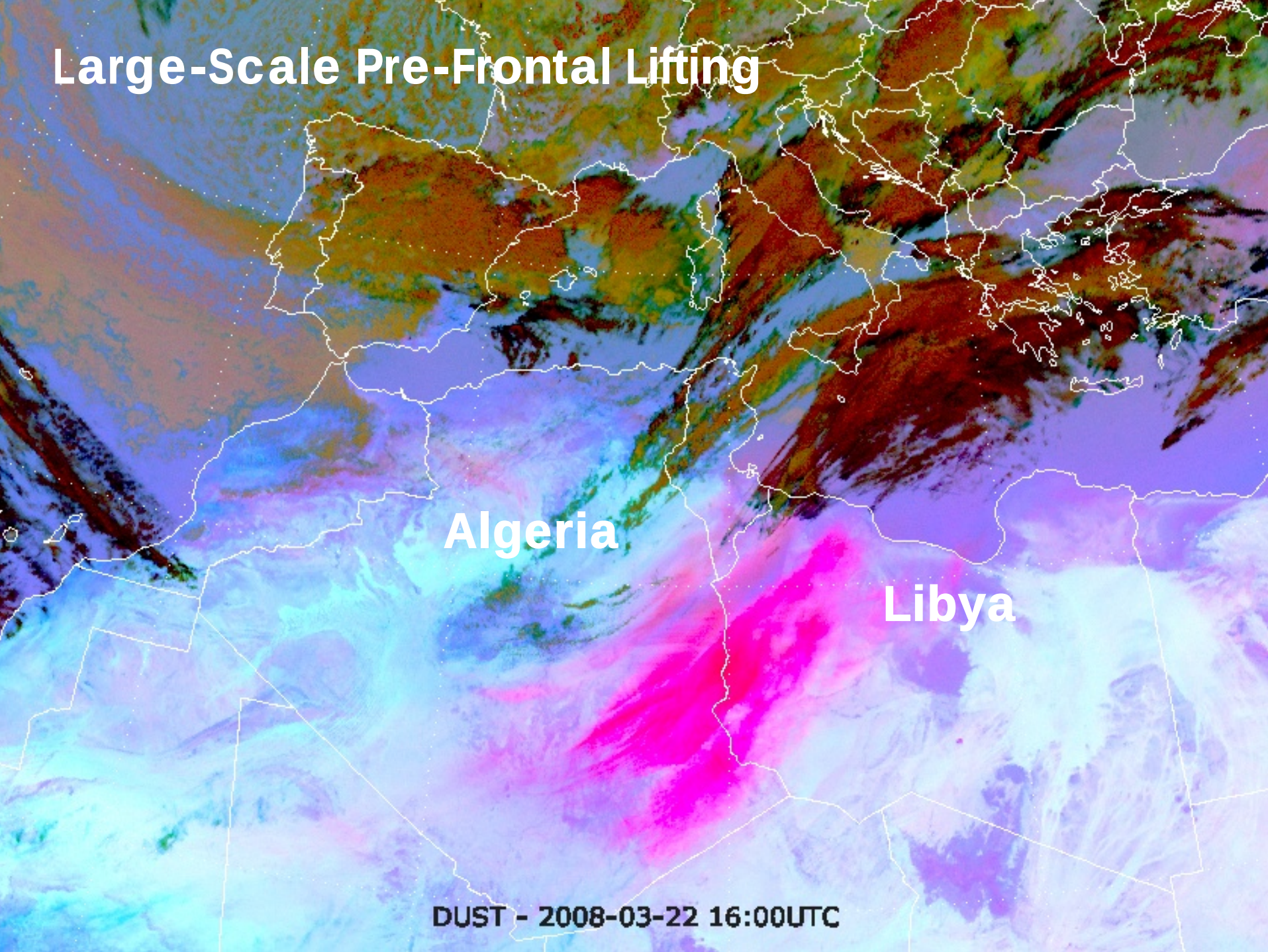
Weather Map for the Middle East Showing Conditions for a Prefrontal Dust Storm
24-hr Prognosis Valid 1200 UTC 25-Mar-03

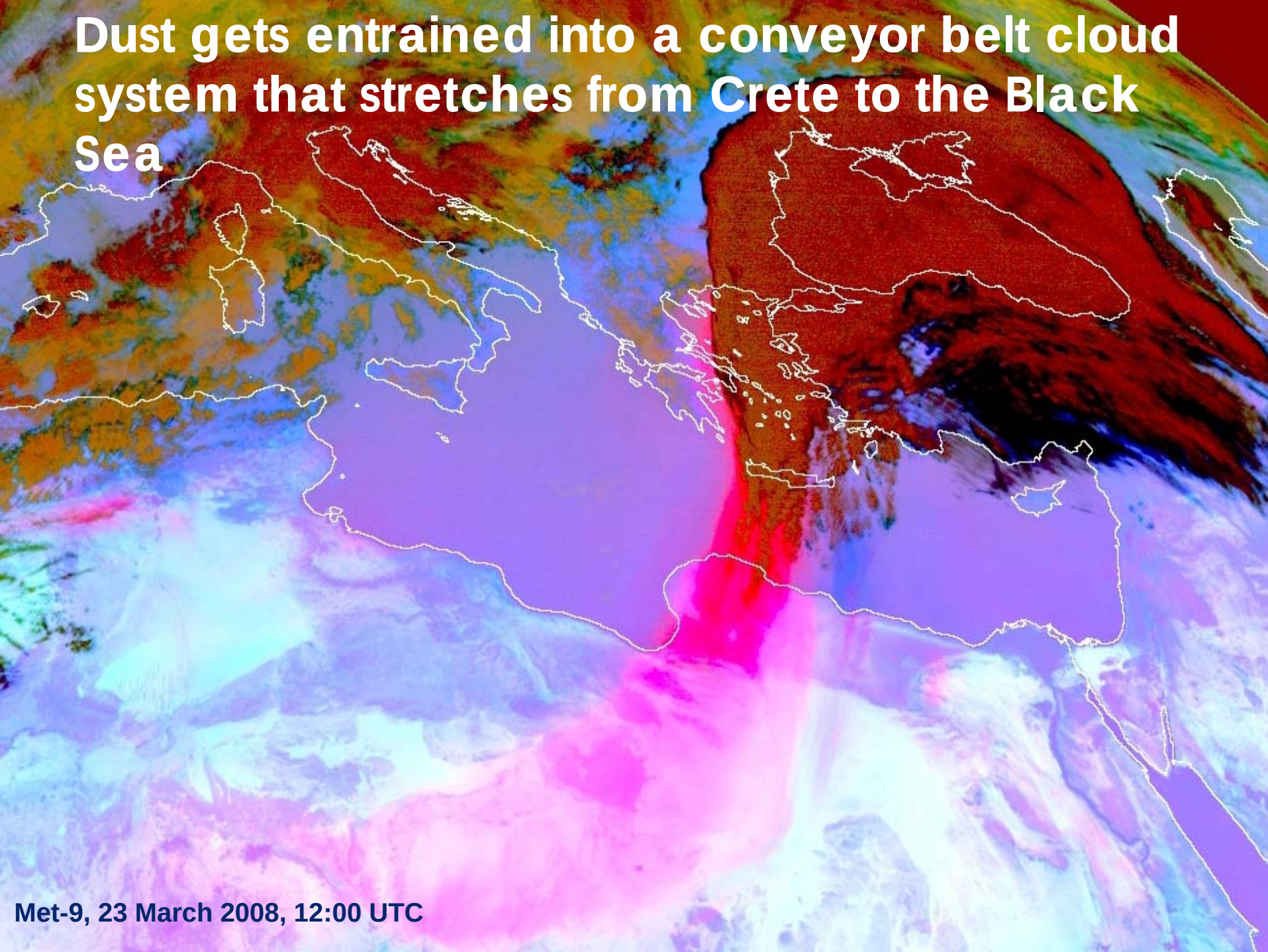


AFWA

Source: COMET

EUMETSAT

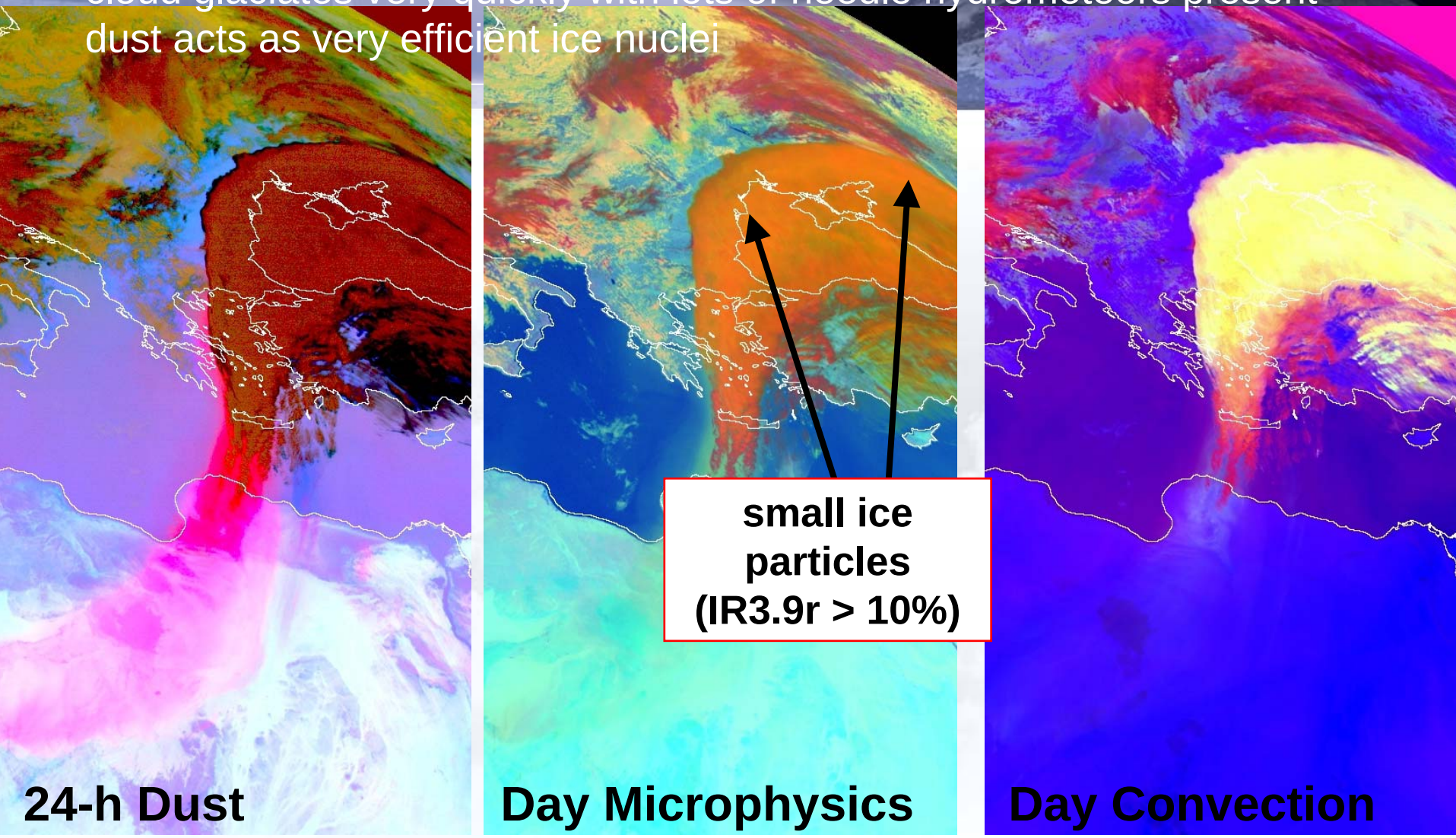

Large-Scale Pre-Frontal Lifting
Algeria
Libya
DUST - 2008-03-22 16:00UTC


Dust gets entrained into a conveyor belt cloud system that stretches from Crete to the Black Sea
Met-9, 23 March 2008, 12:00 UTC

Dust Changes Cloud Microphysics

cloud glaciates very quickly with lots of needle hydrometeors present

dust acts as very efficient ice nuclei



Met-9, 23 March 2008, 12:00 UTC

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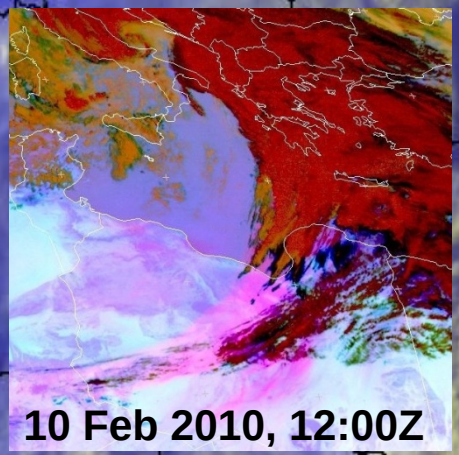
Dust causes Granular Structure of Cirrus Shield

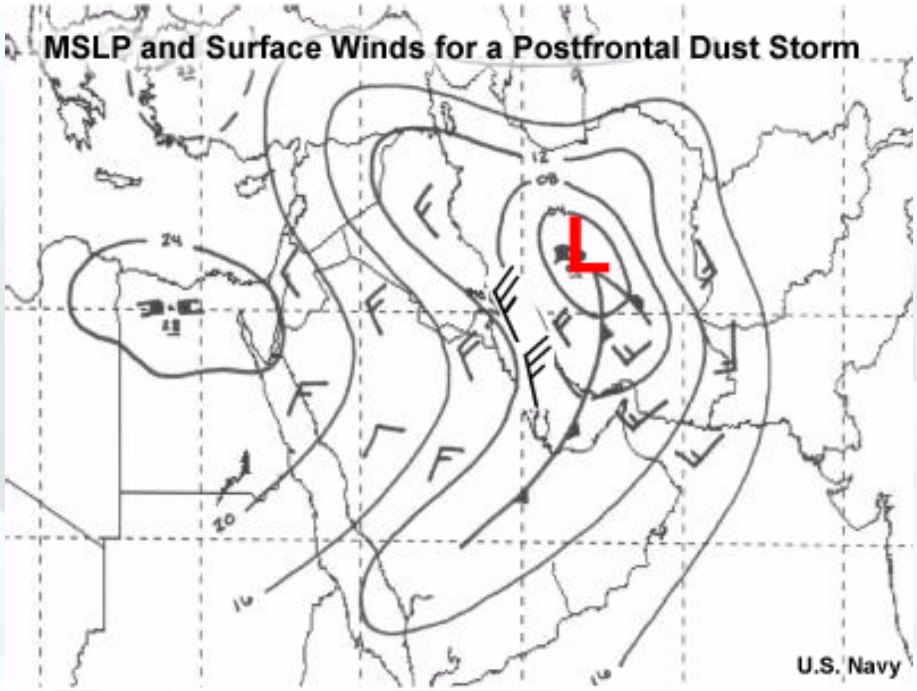
Poland

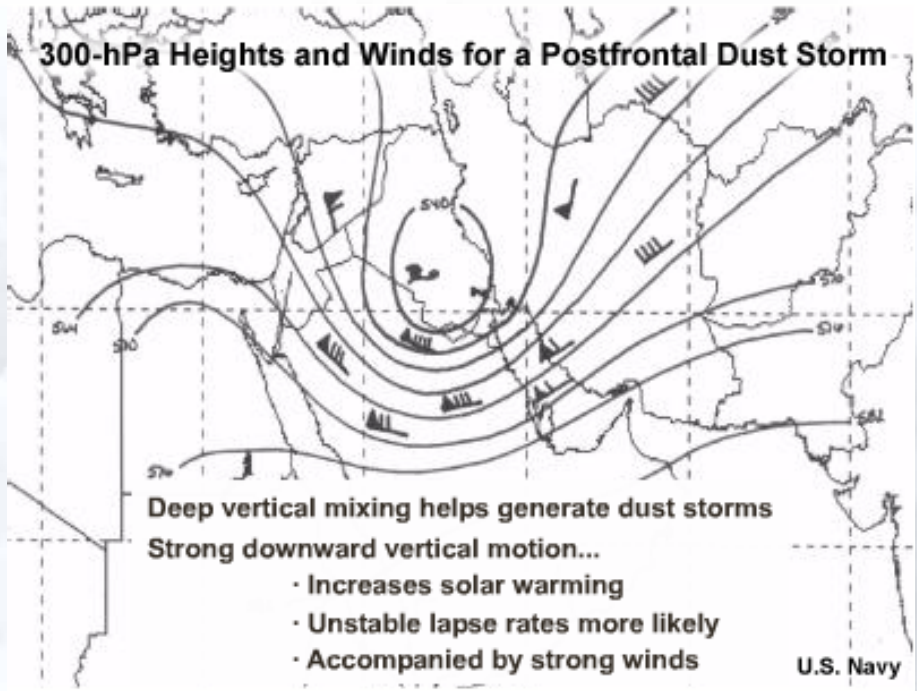
Ukraine



Met-9, 11 February 2010, 06:00 UTC, HRV
Source: K. Kollath, Hungary

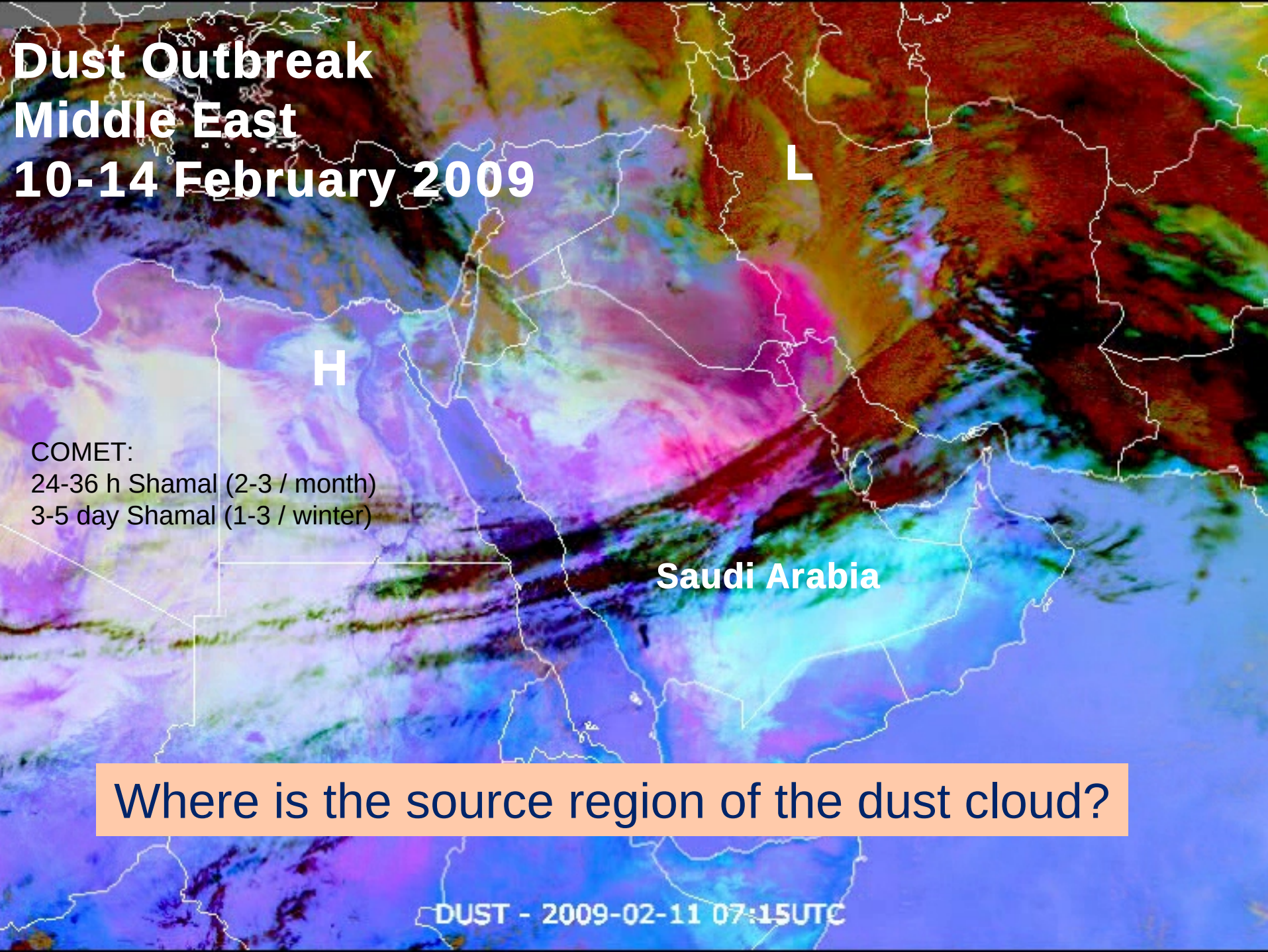
Post-Frontal Dust Clouds

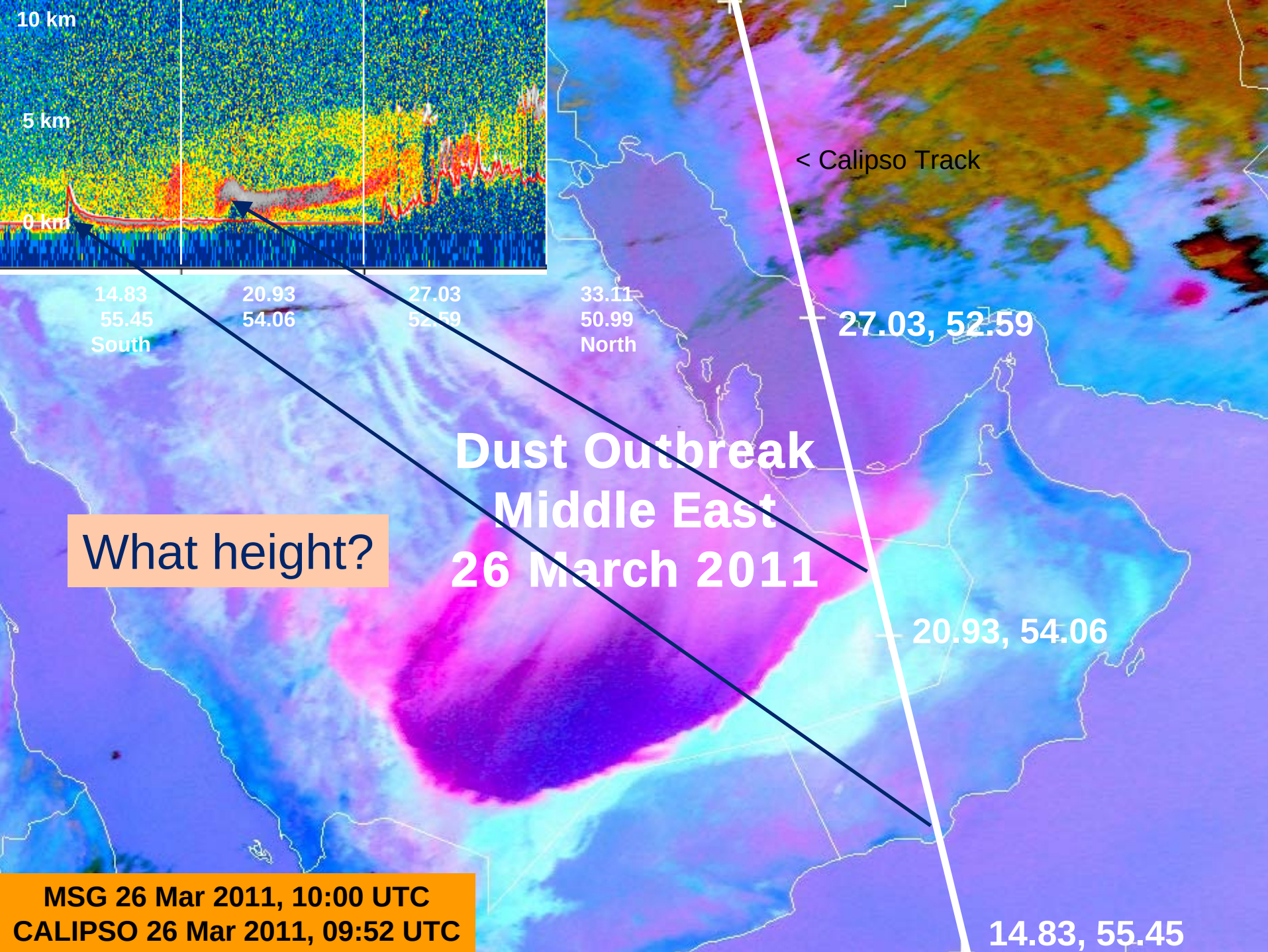




Source: COMET

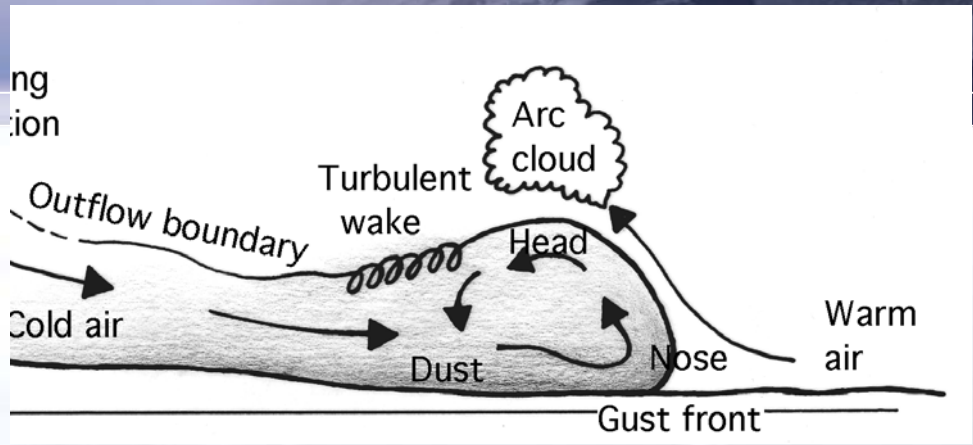
EUMETSAT


Dust Outbreak
Middle East
10-14 February 2009
L
H
COMET:
24-36 h Shamal (2-3 / month)
3-5 day Shamal (1-3 / winter)
Saudi Arabia
Where is the source region of the dust cloud?
DUST - 2009-02-11 07:15UTC

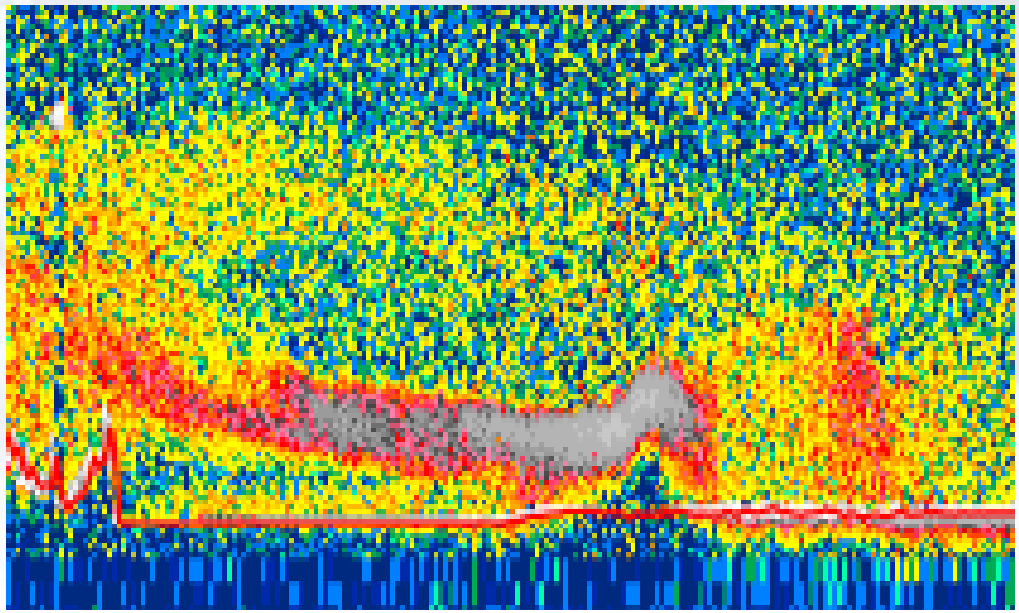

10 km
5 km
0 km
14.83
55.45
South
20.93
54.06
27.03
52.59
33.11
50.99
North
< Calipso Track
27.03, 52.59
Dust Outbreak
Middle East
26 March 2011
What height?
20.93, 54.06
14.83, 55.45
MSG 26 Mar 2011, 10:00 UTC
CALIPSO 26 Mar 2011, 09:52 UTC

Middle East Dust Storm 26 March 2011

Conceptual Model



Calipso Data



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Loop 2

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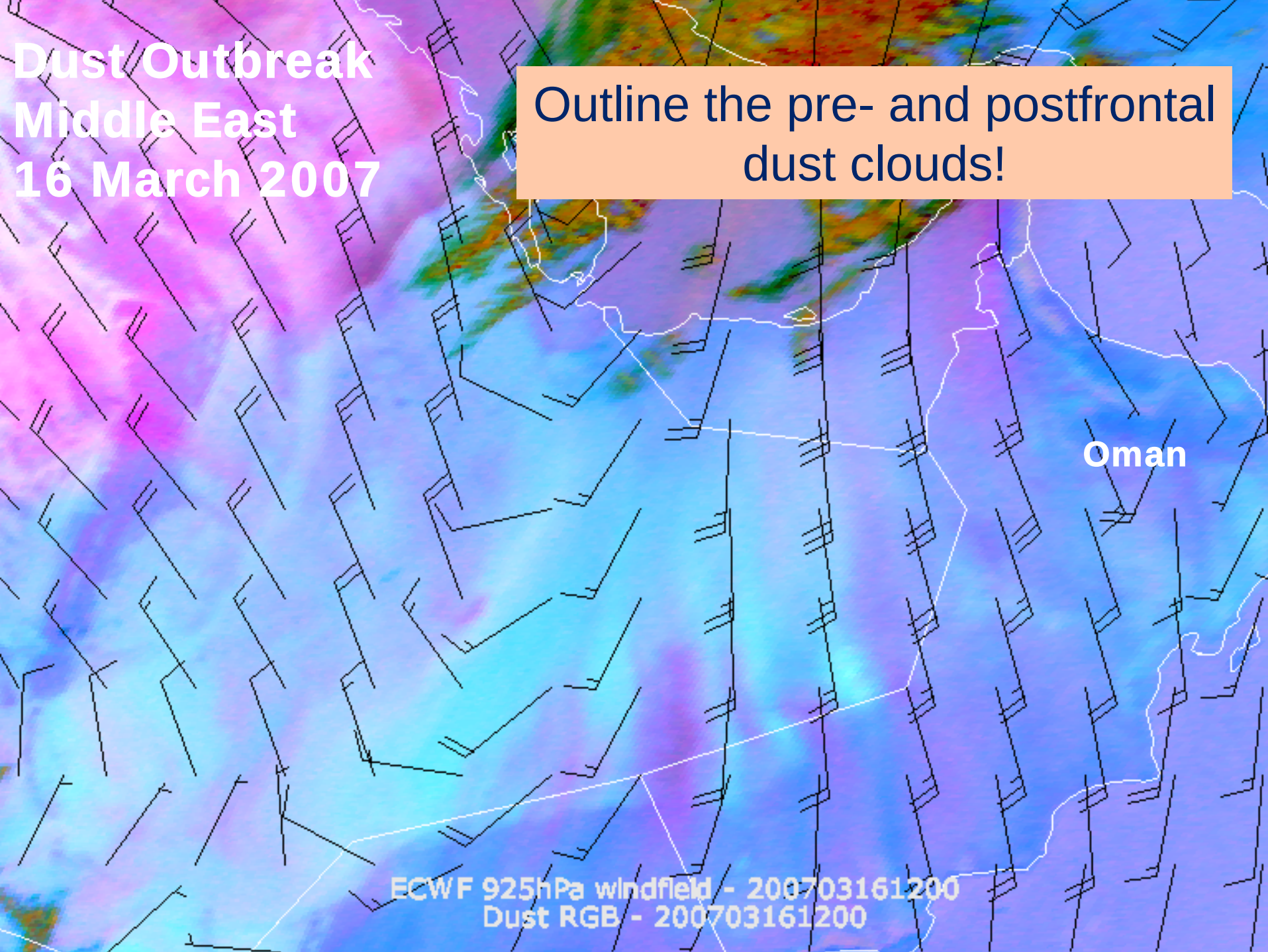
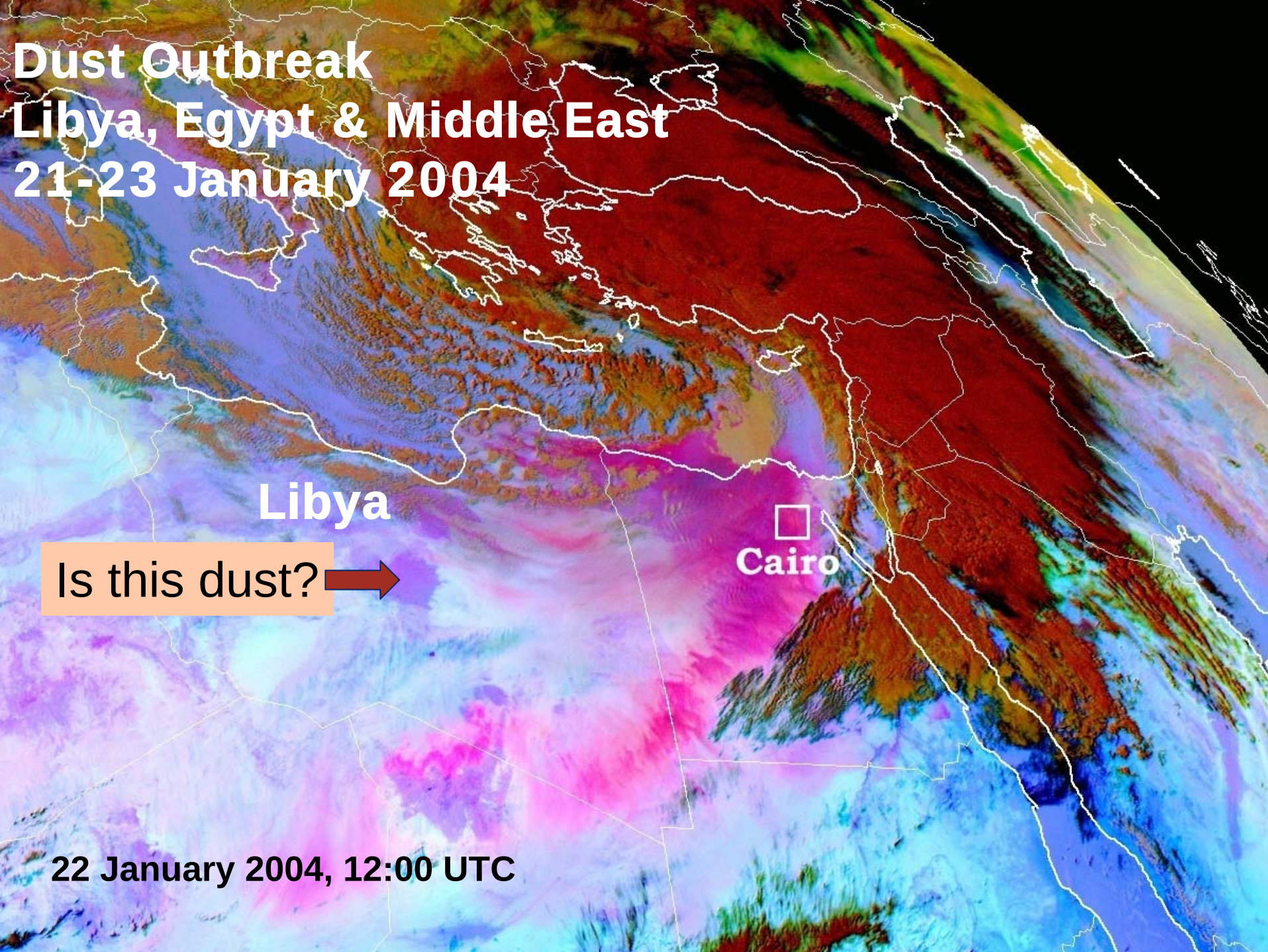
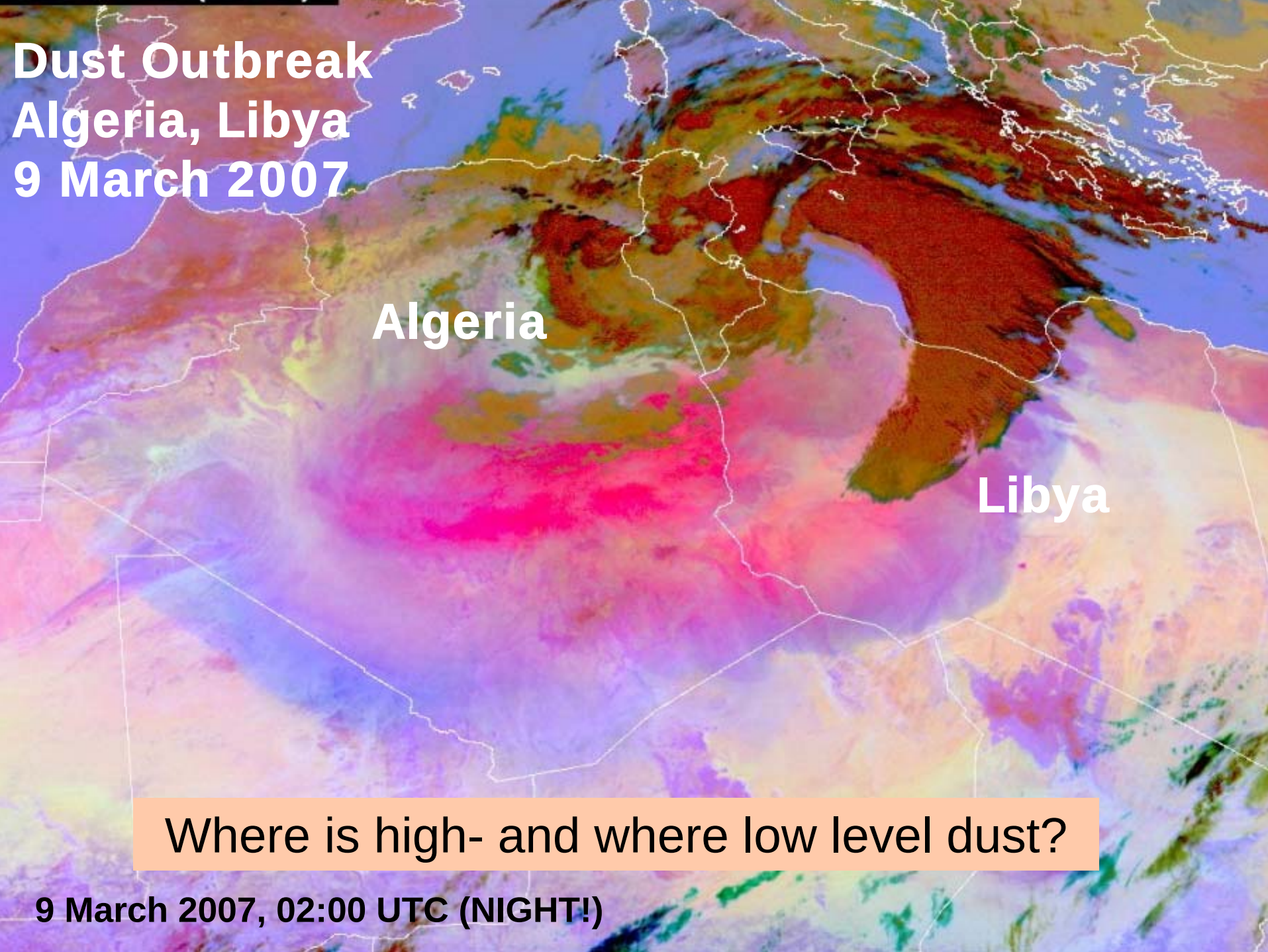
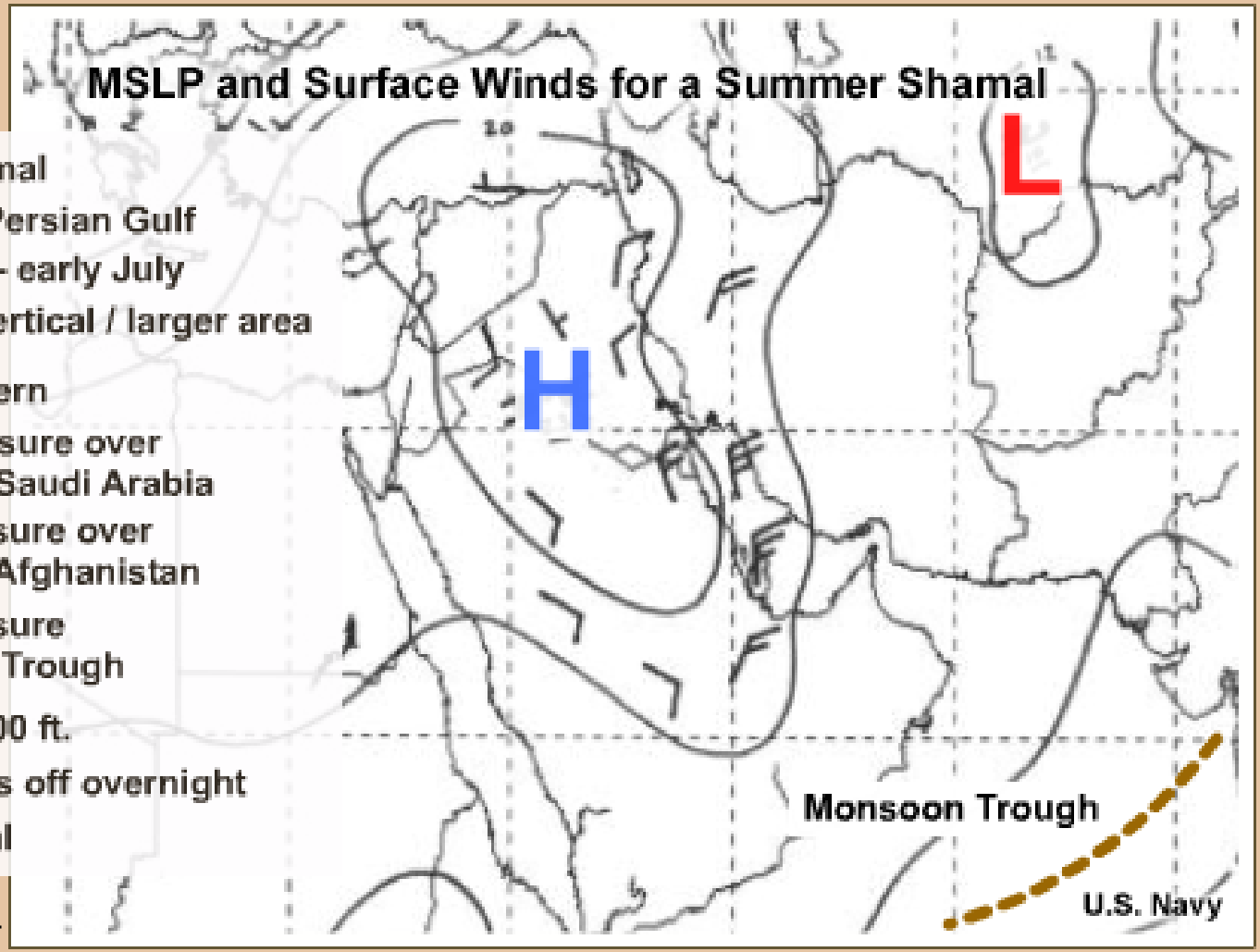

Dust Outbreak
Middle East
16 March 2007
Outline the pre- and postfrontal dust clouds!
Oman
ECWF 925hPa windfield - 200703161200
Dust RGB - 200703161200


Dust Outbreak
Libya, Egypt & Middle East
21-23 January 2004
Libya
Is this dust?
Cairo
22 January 2004, 12:00 UTC


Dust Outbreak
Algeria, Libya
9 March 2007
Algeria
Libya
Where is high- and where low level dust?
9 March 2007, 02:00 UTC (NIGHT!)

Non-Frontal Dust Clouds (Trade Winds)



Summer Shamal

- Iraq and Persian Gulf
- Late May - early July
- Greater vertical / larger area

Synoptic pattern

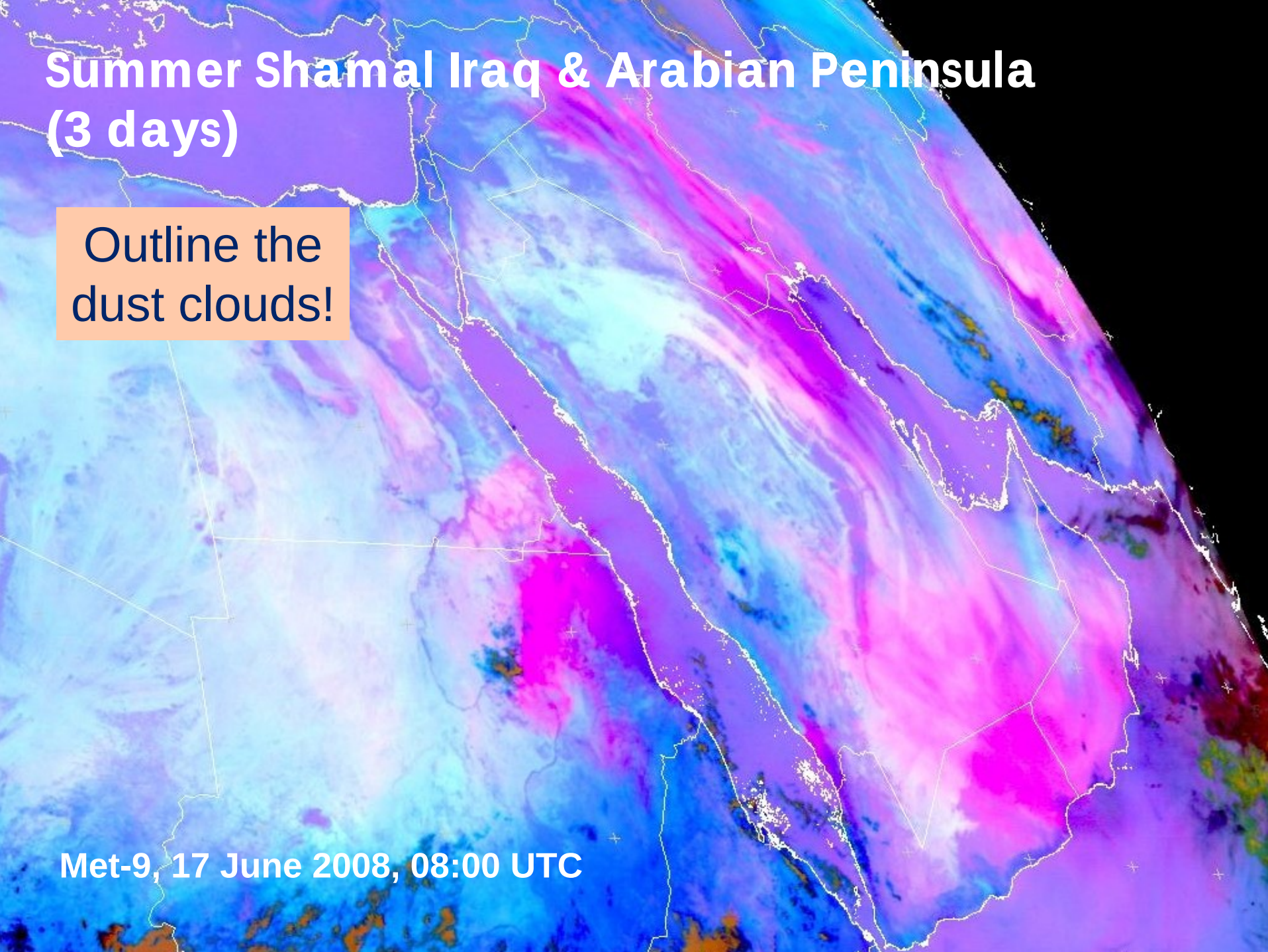
- High pressure over Northern Saudi Arabia
- Low pressure over Northern Afghanistan
- Low pressure Monsoon Trough

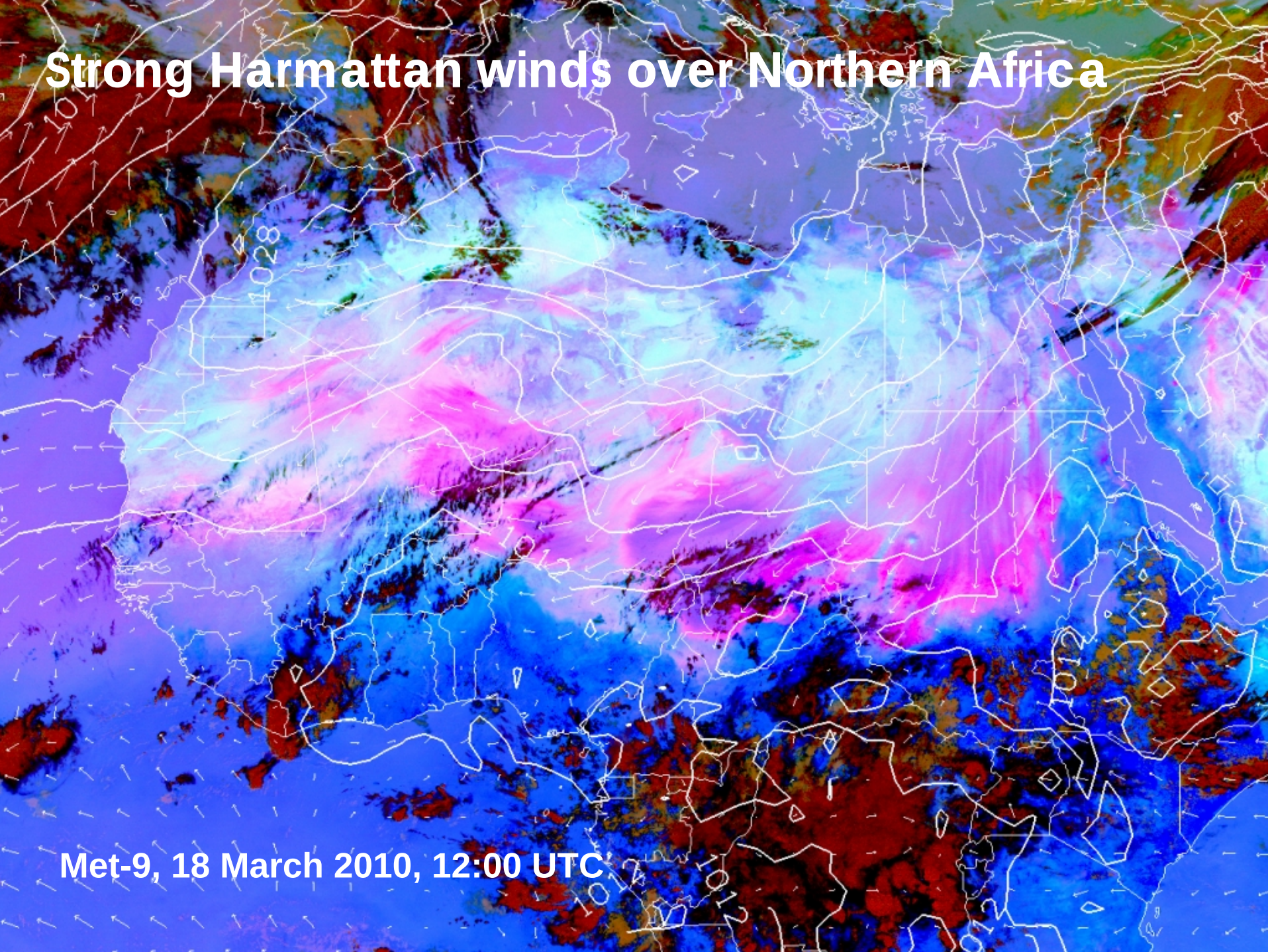
Surface to 5000 ft.

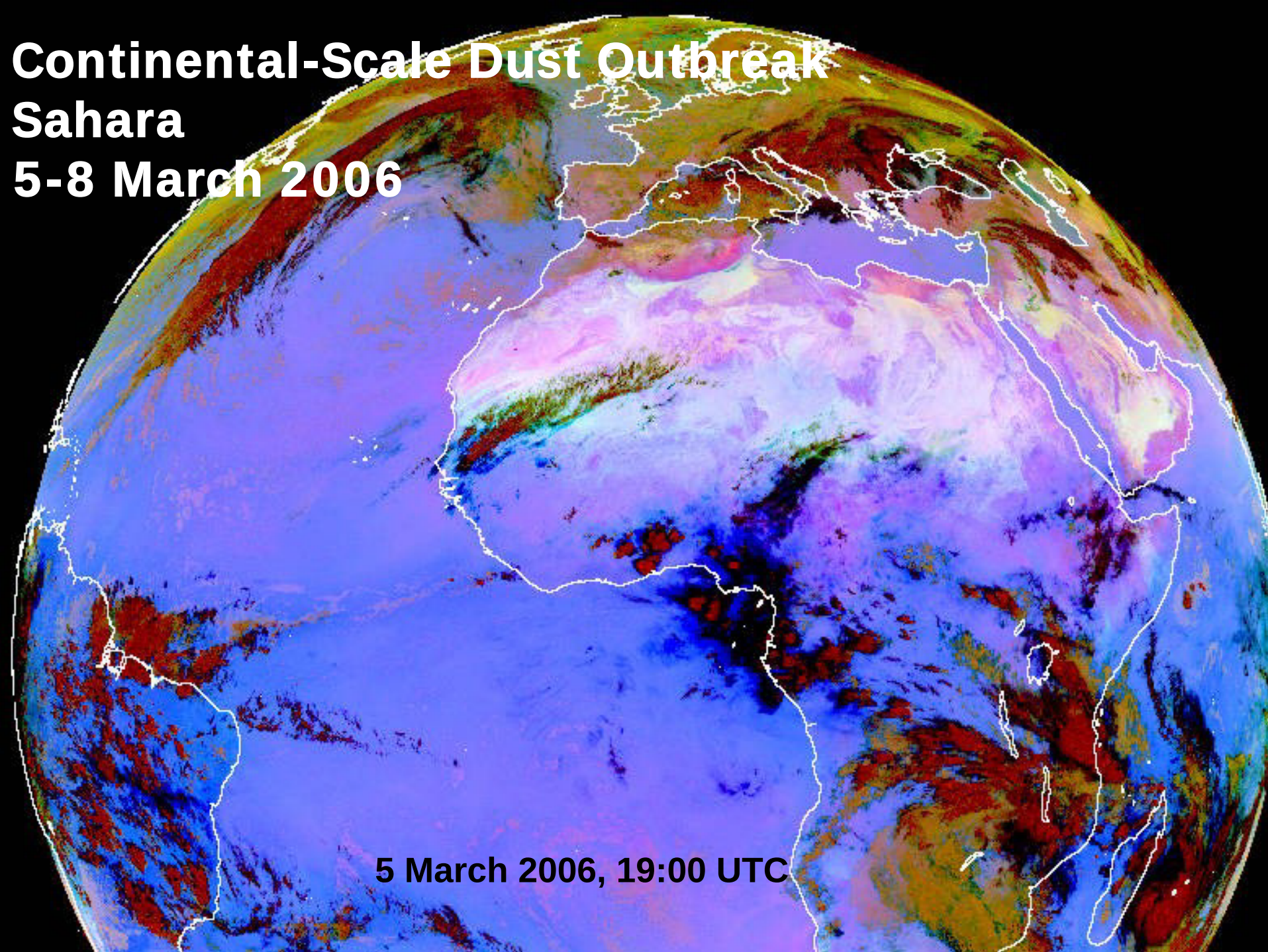
Strenghth falls off overnight

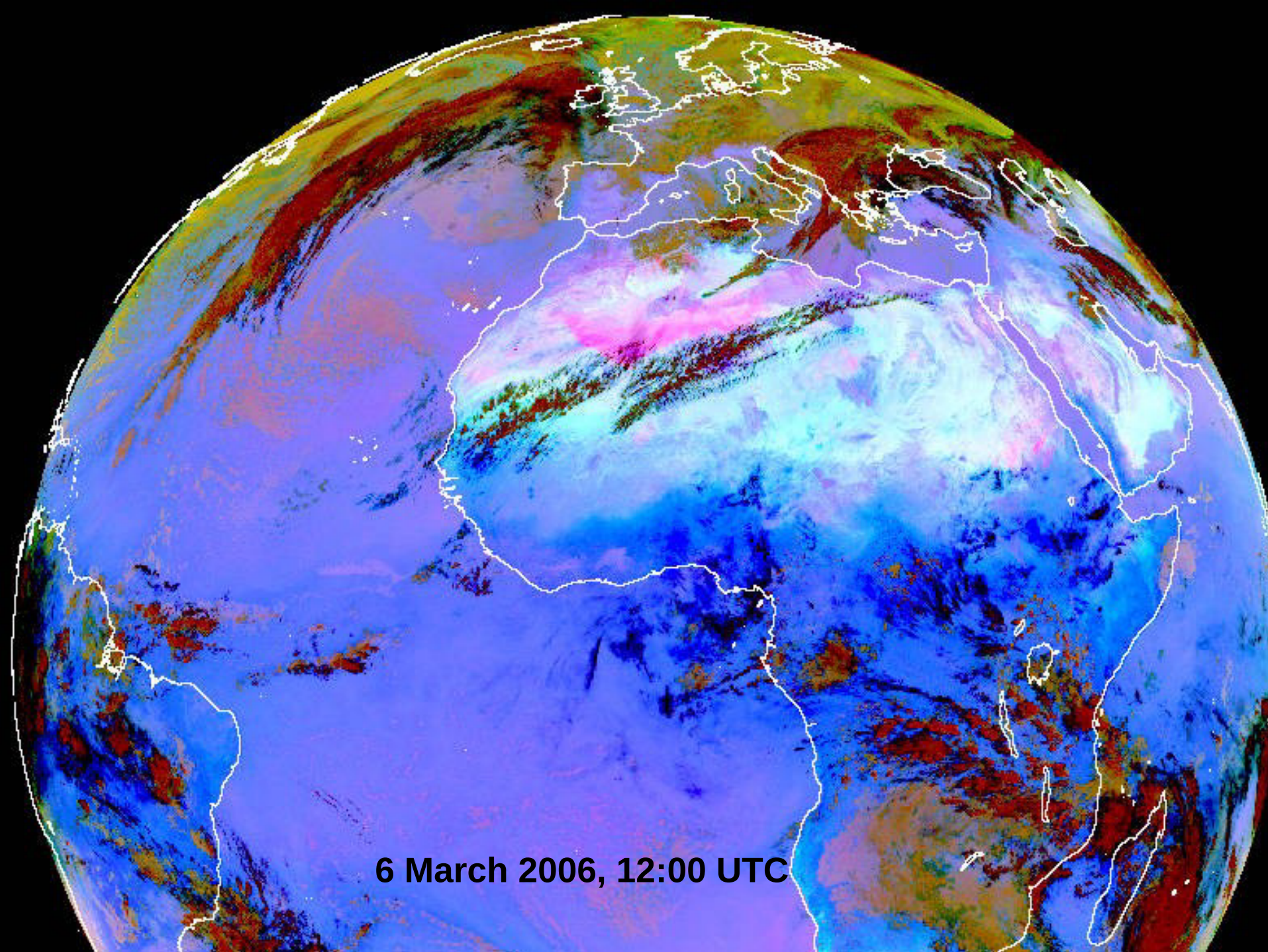
40-day Shamal

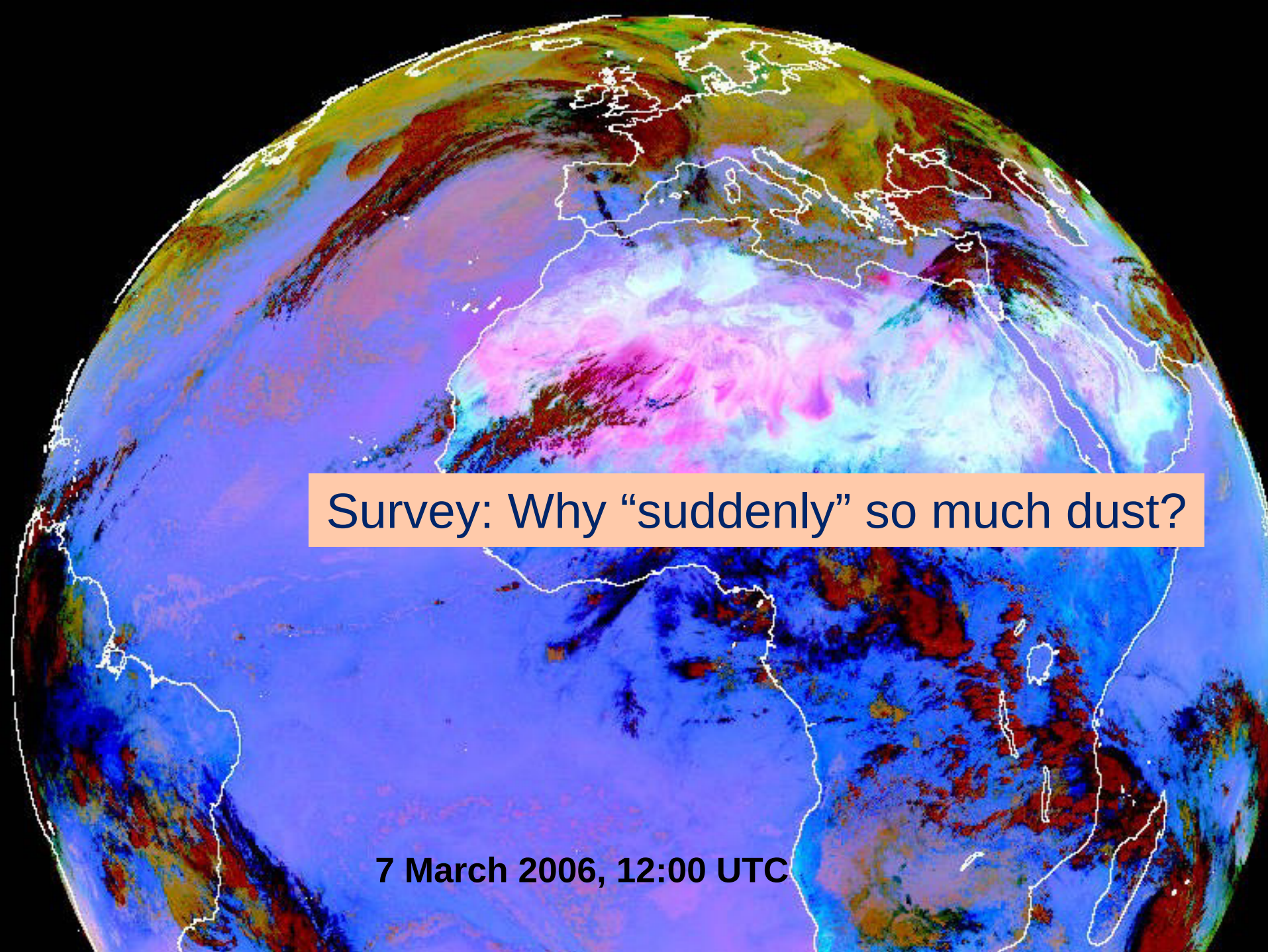
Source: COMET


Summer Shamal Iraq & Arabian Peninsula
(3 days)
Outline the
dust clouds!
Met-9, 17 June 2008, 08:00 UTC


Strong Harmattan winds over Northern Africa
Met-9, 18 March 2010, 12:00 UTC


Continental-Scale Dust Outbreak
Sahara
5-8 March 2006
5 March 2006, 19:00 UTC


6 March 2006, 12:00 UTC


Survey: Why “suddenly” so much dust?
7 March 2006, 12:00 UTC

Survey

What do you think is the reason for this huge dust outbreak?

A) Strong post-frontal winds related to the cyclone over the Mediterranean

B) Strong winds from thunderstorm gust fronts

C) Strong Harmattan winds due to pressure increase from cold air over northern Africa

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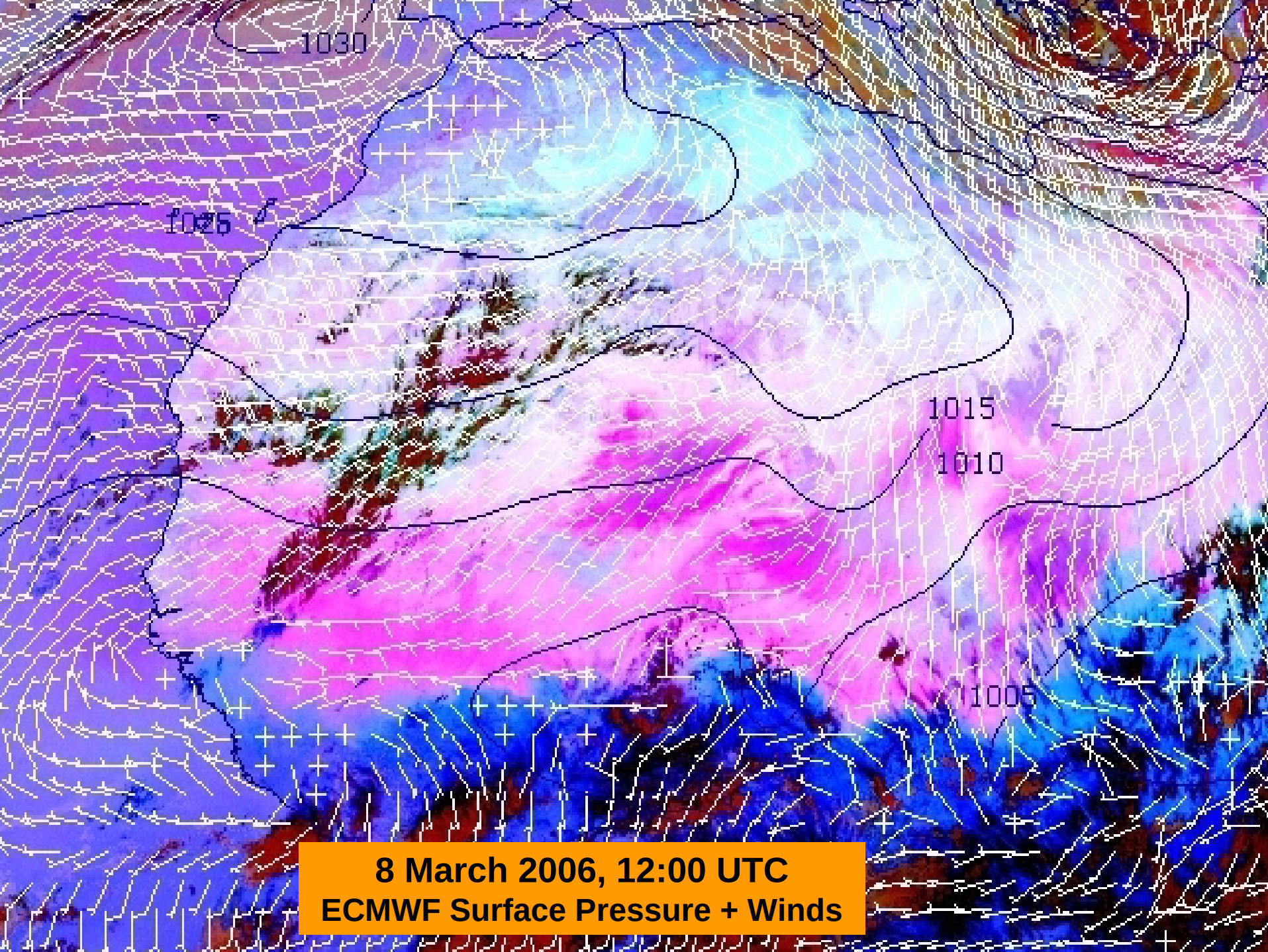
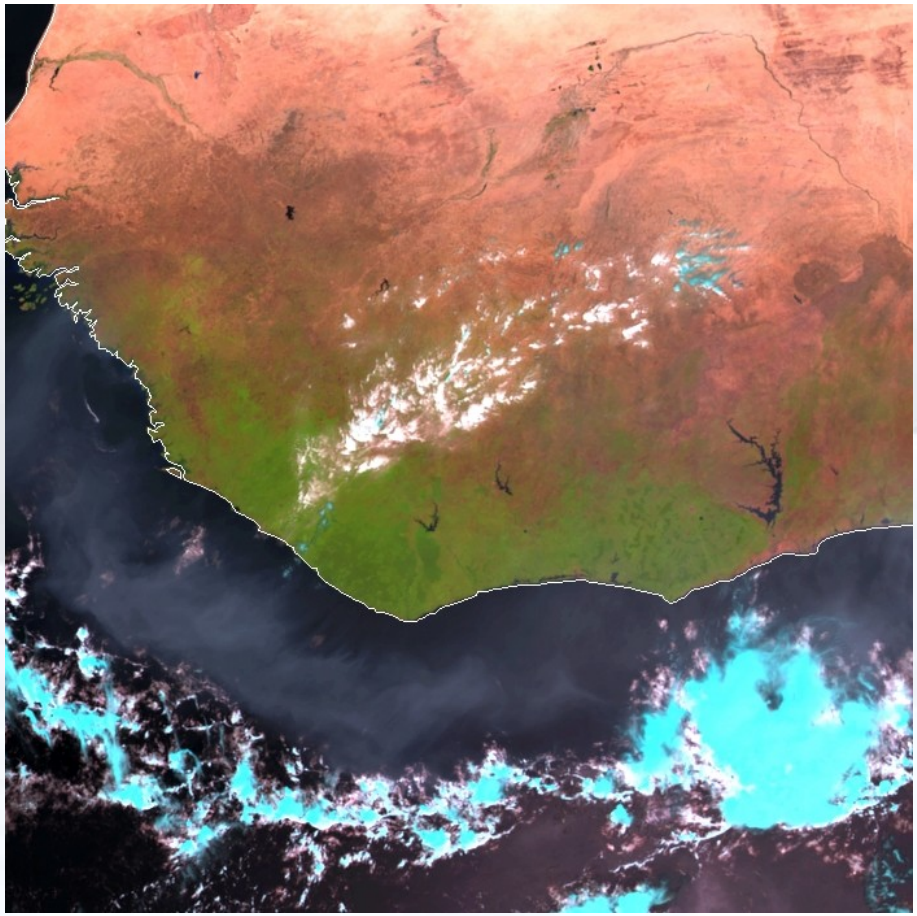
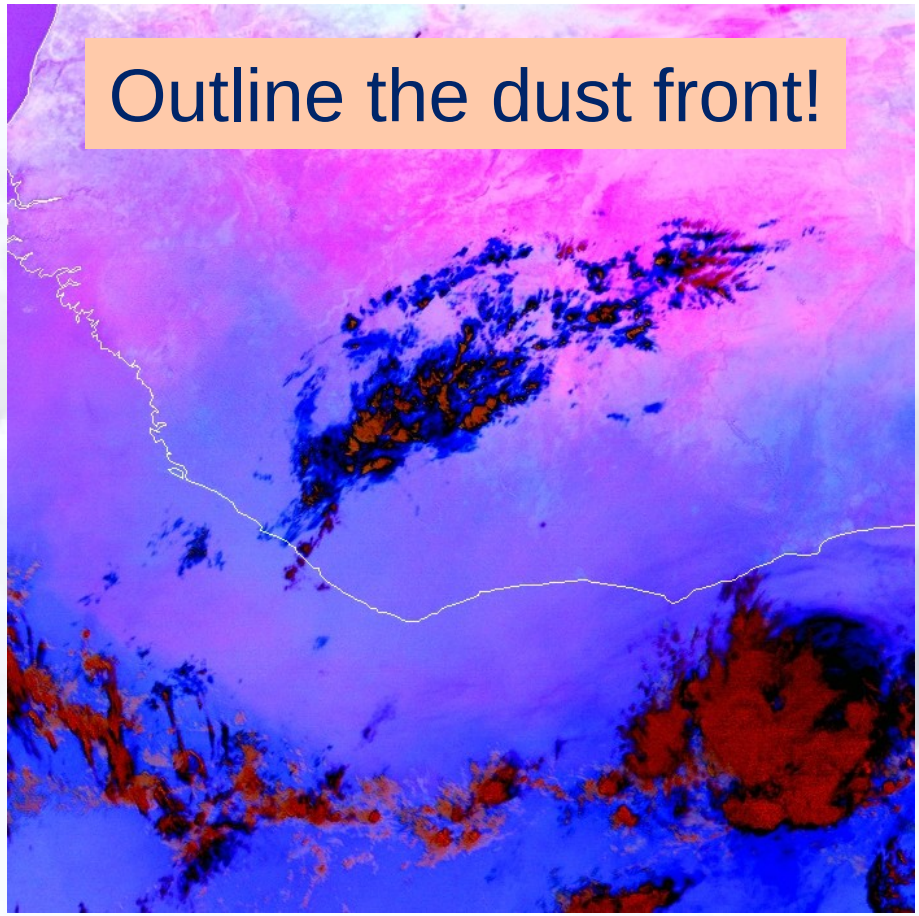

1030
1025
1015
1010
1005
8 March 2006, 12:00 UTC
ECMWF Surface Pressure + Winds

Southward Propagation of Dust Cloud





6 March 2004, 12:00 UTC

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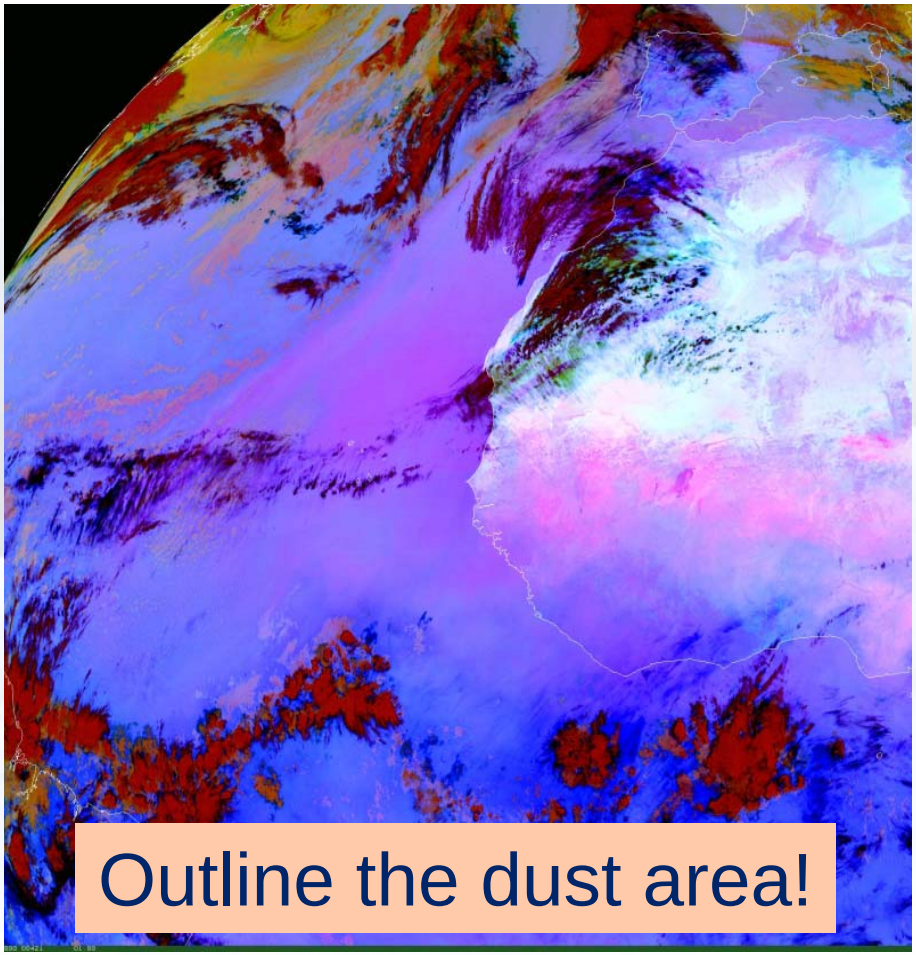
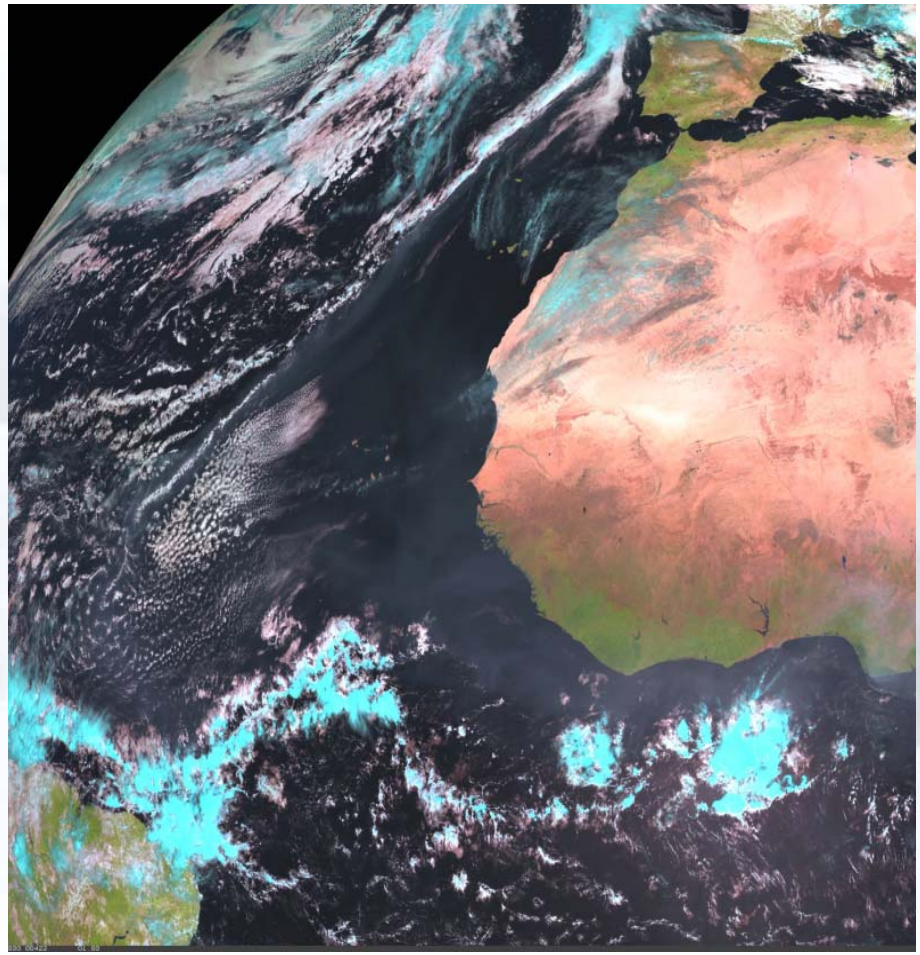
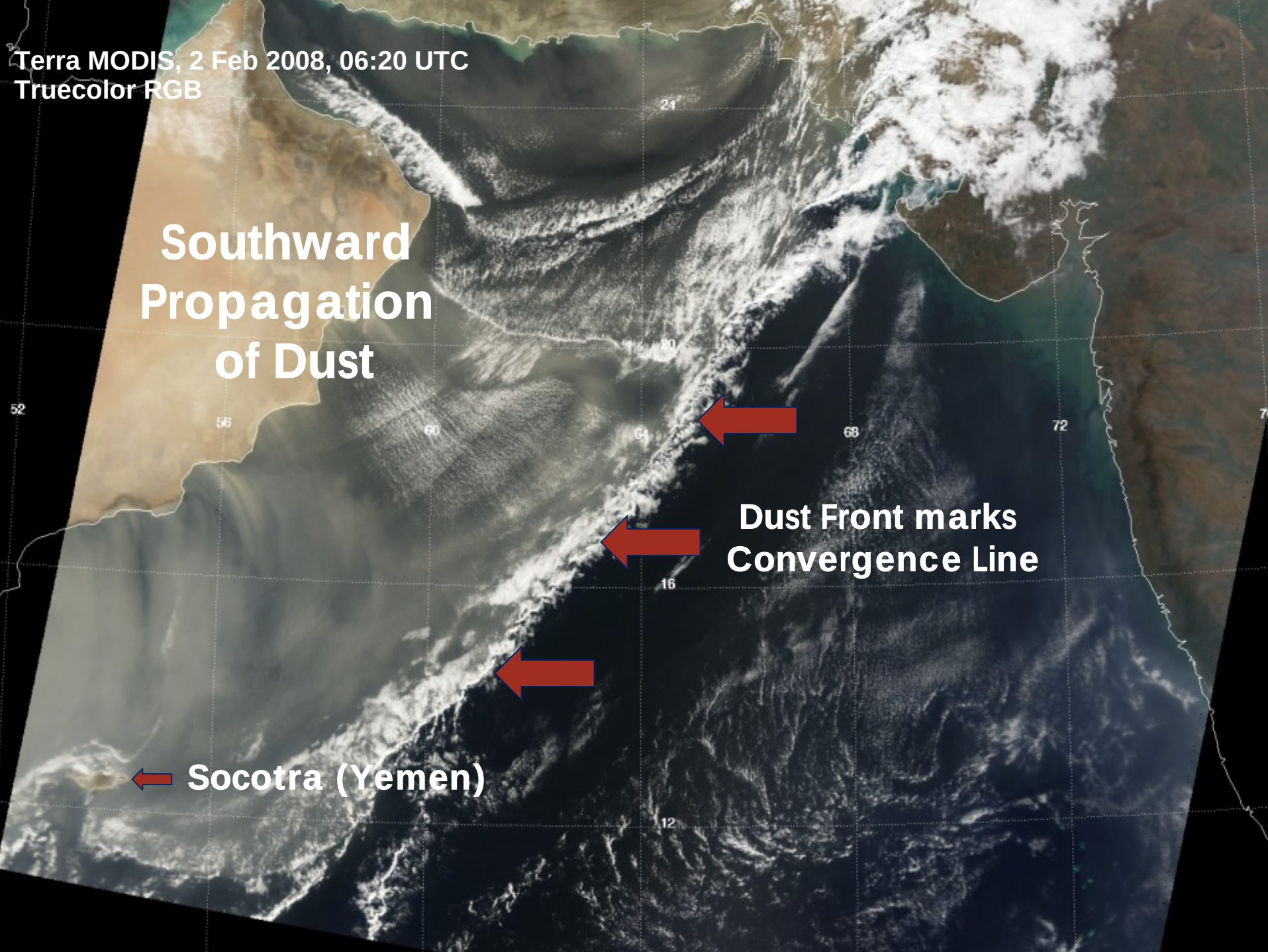
Westward Propagation of Dust Cloud with Trade Winds



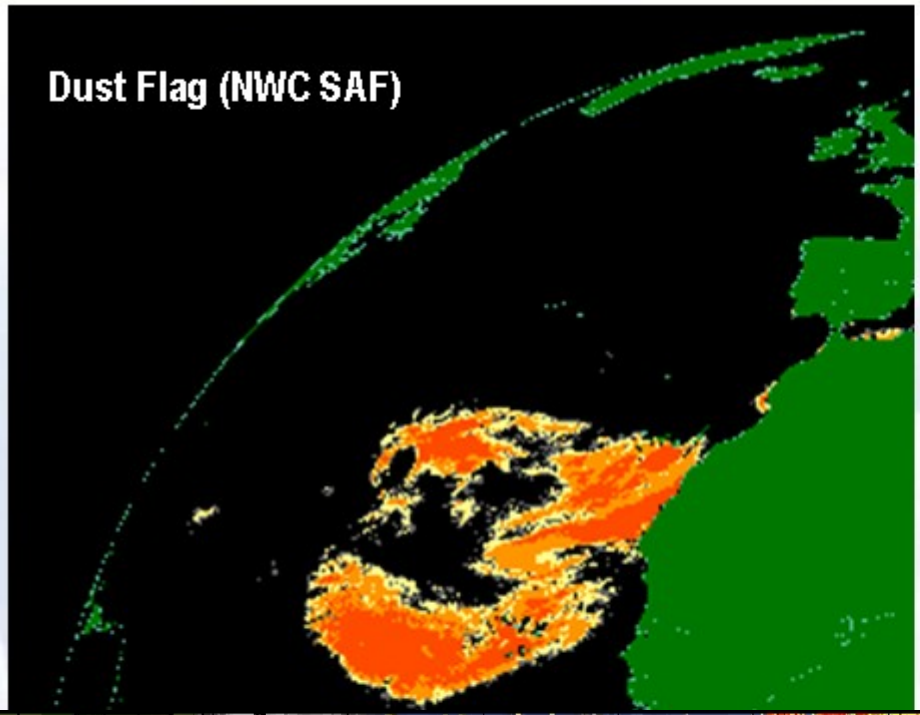


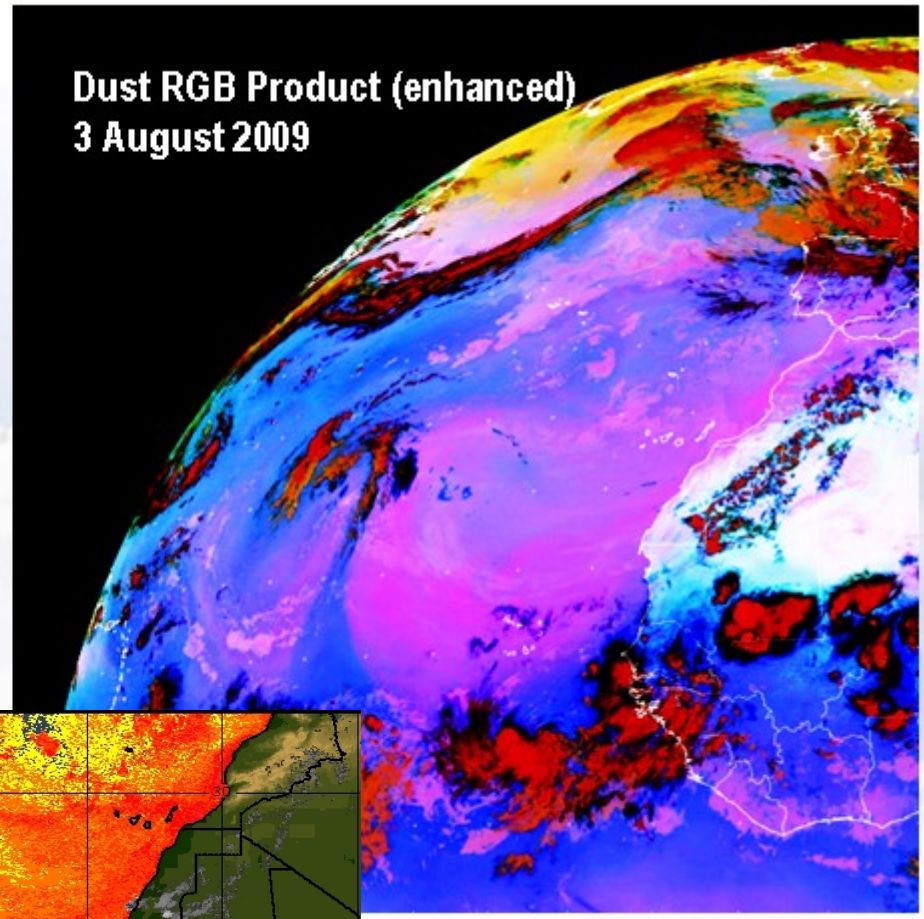
8 March 2004, 12:00 UTC

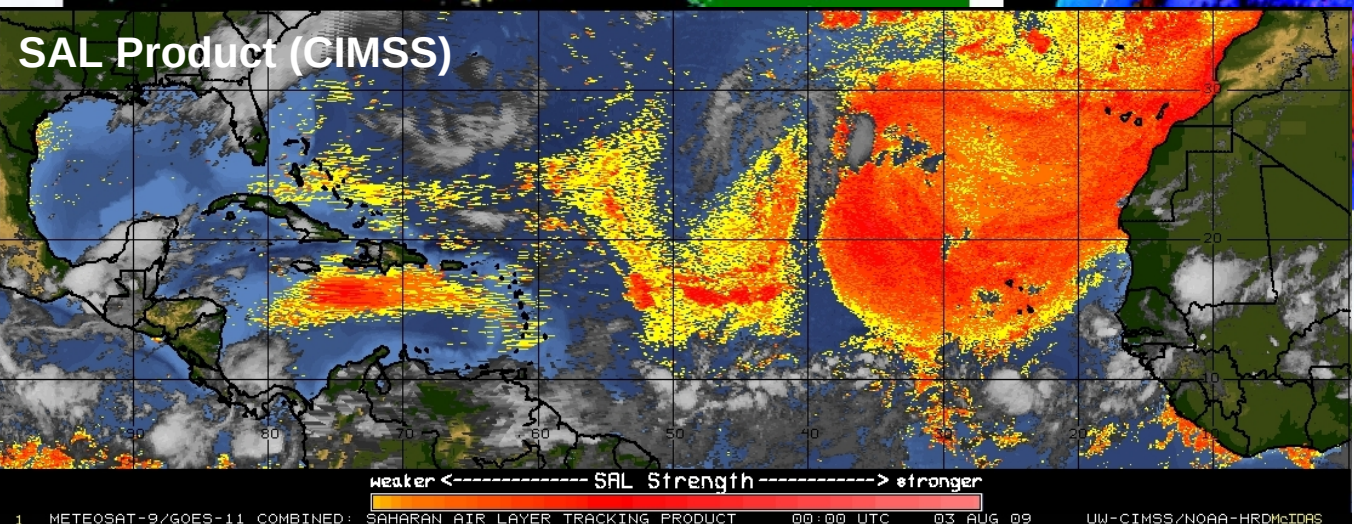
EUMETSAT


Terra MODIS, 2 Feb 2008, 06:20 UTC
Truecolor RGB
Southward Propagation of Dust
Dust Front marks Convergence Line
Socotra (Yemen)
24
20
16
12
52
56
60
64
68
72

Impact of Dry Saharian Air on Hurricane Season

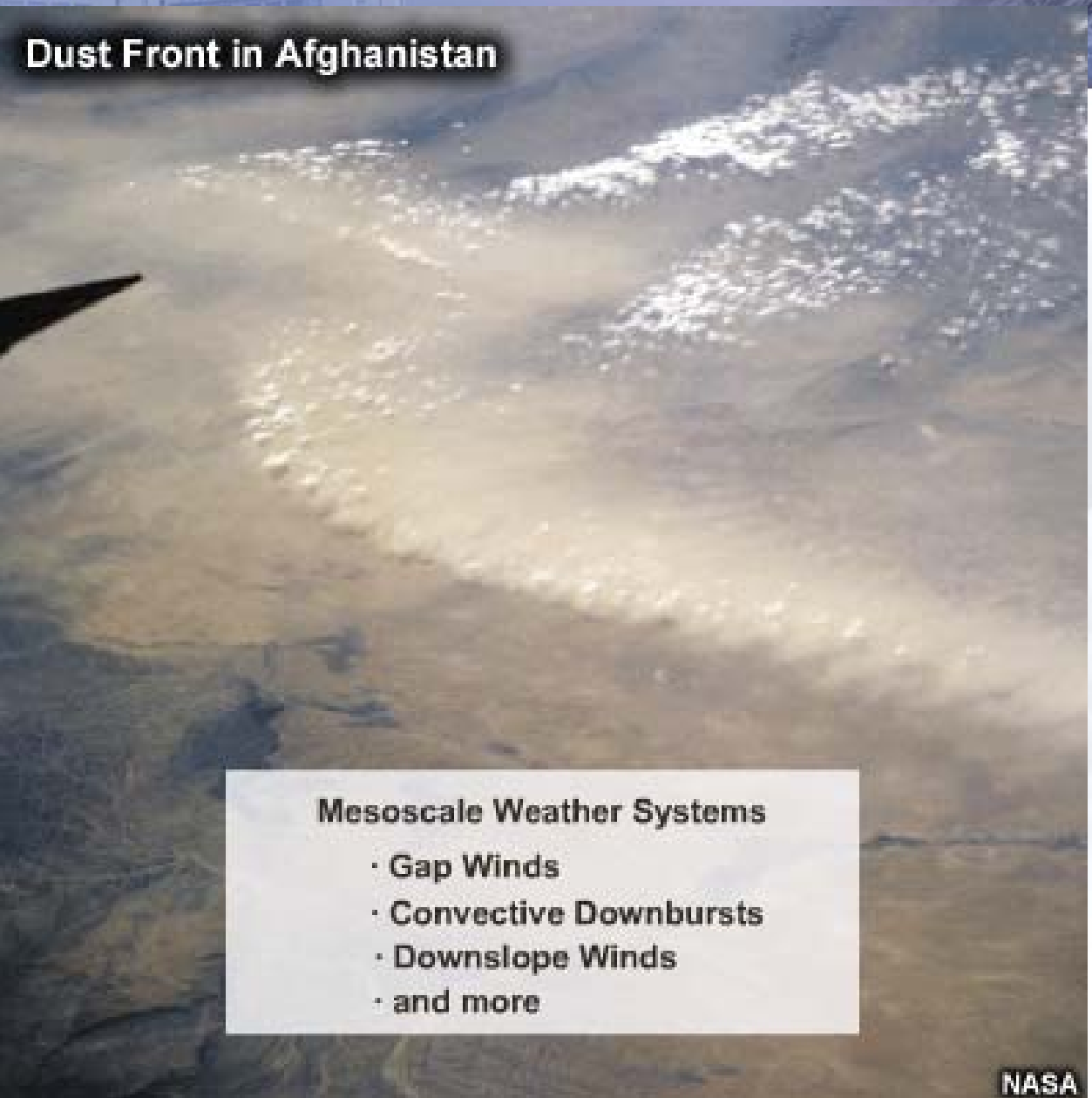






EUMETSAT

Meso-Scale Dust Outbreaks (N. Hemisphere)

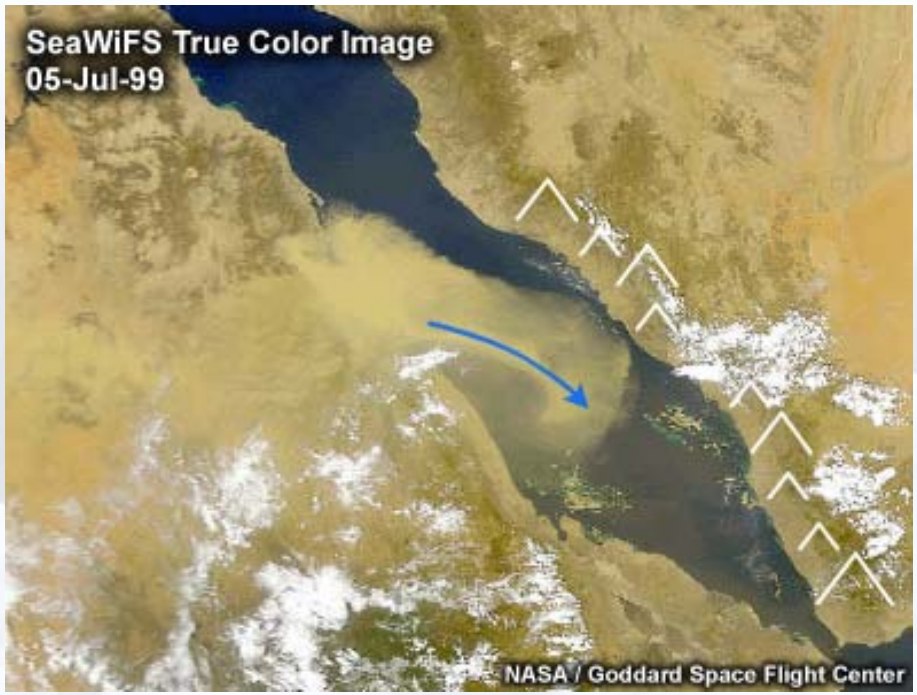


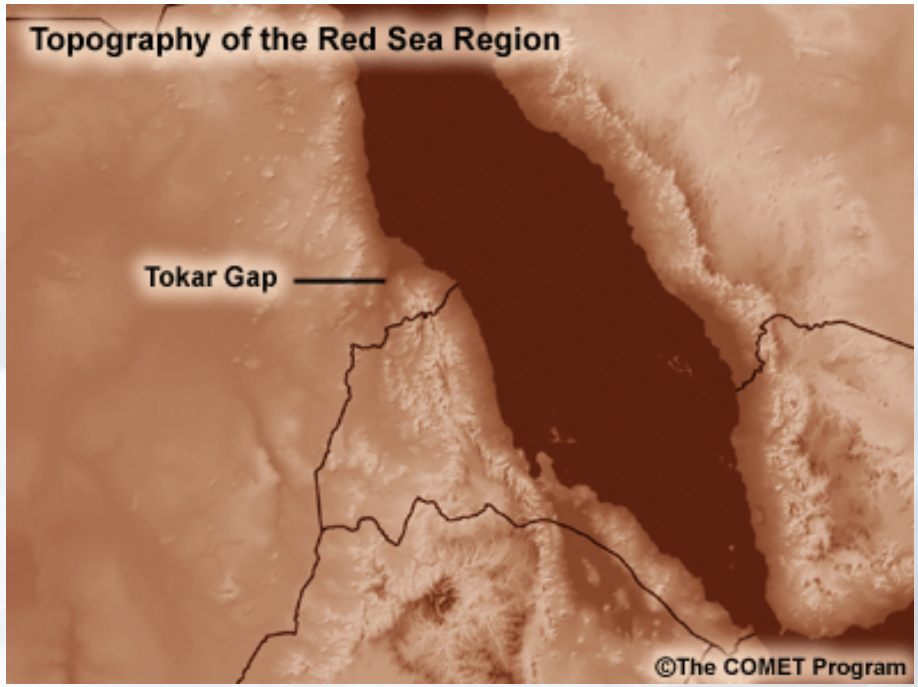
Season from May to October (peak in summer)

Source: COMET

EUMETSAT

Mountain Gap Winds

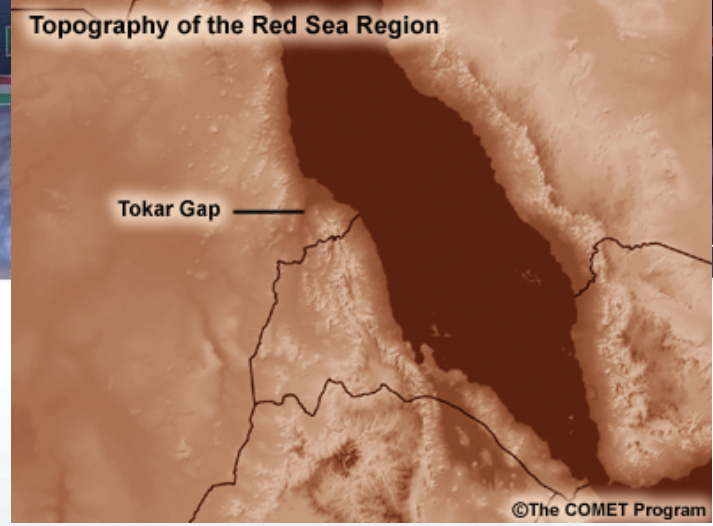




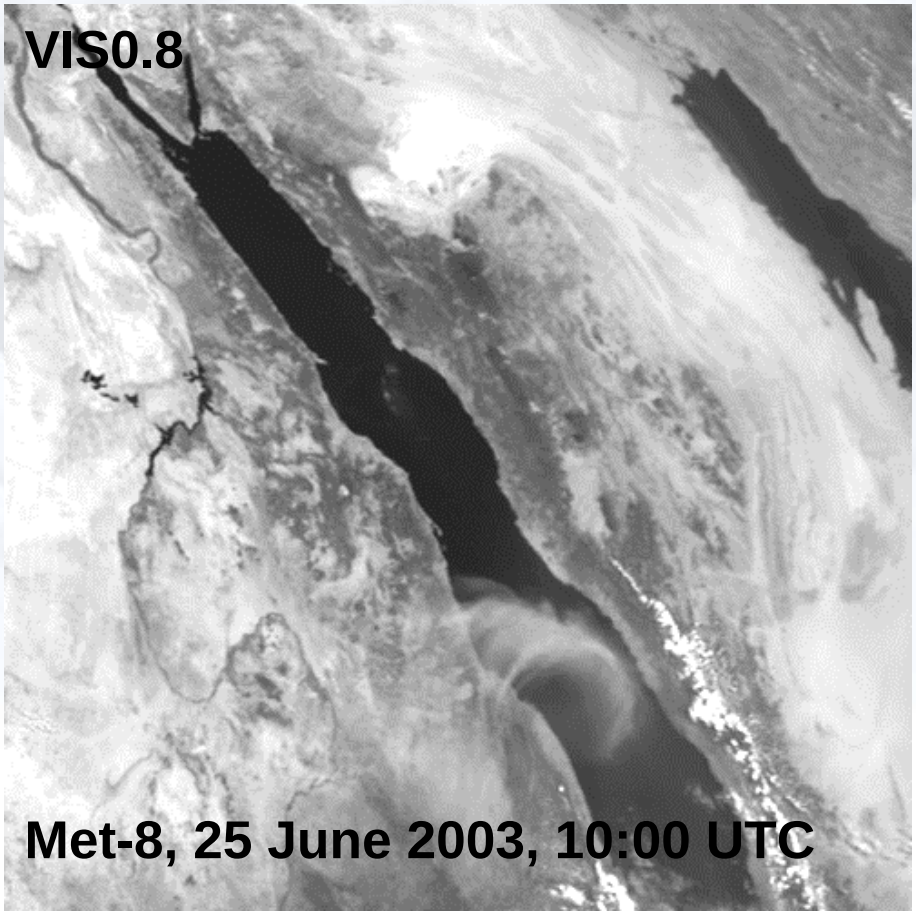
Source: COMET

EUMETSAT

Mountain Gap Winds

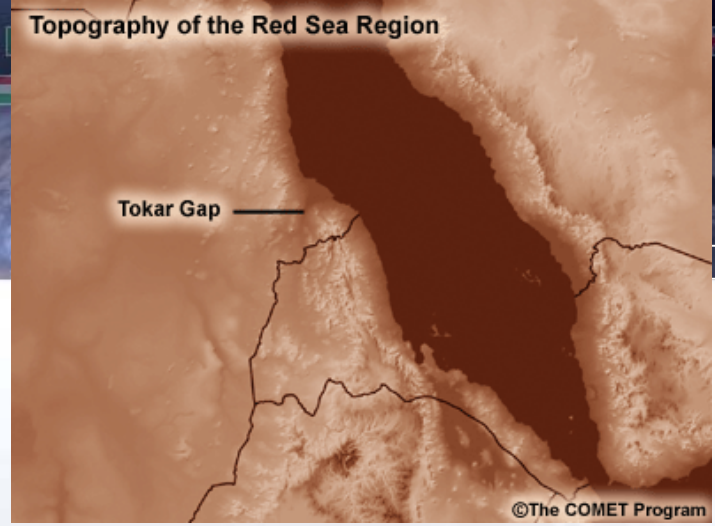


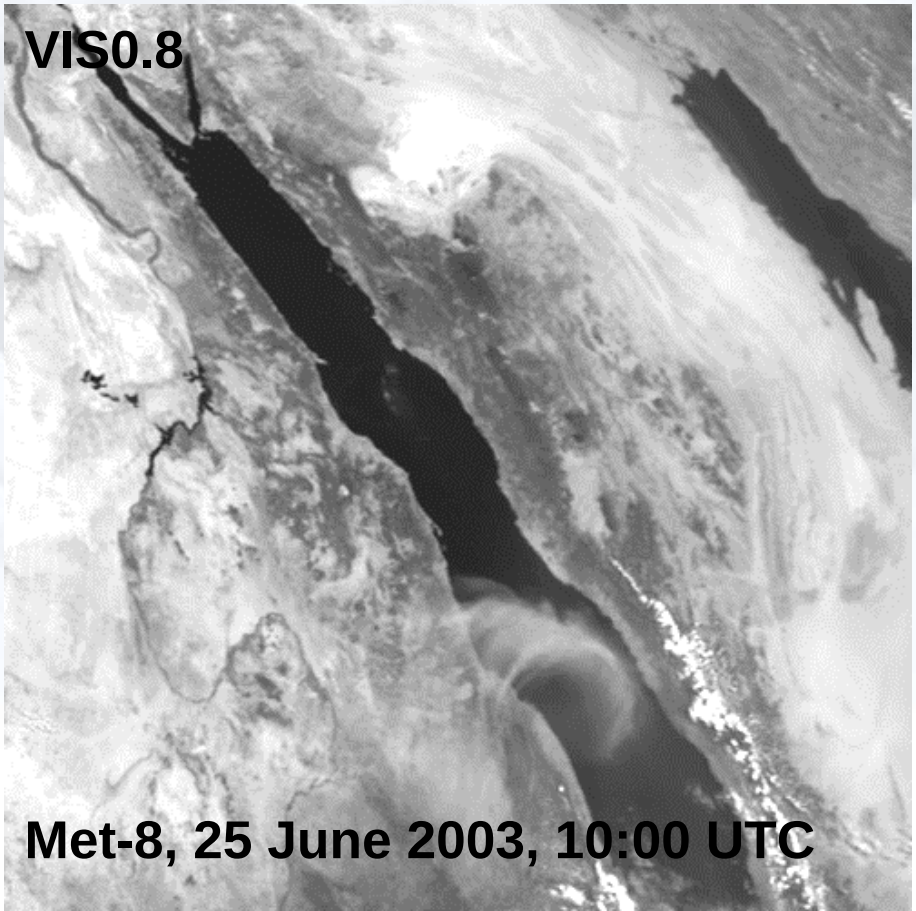
Outline the dust areas!

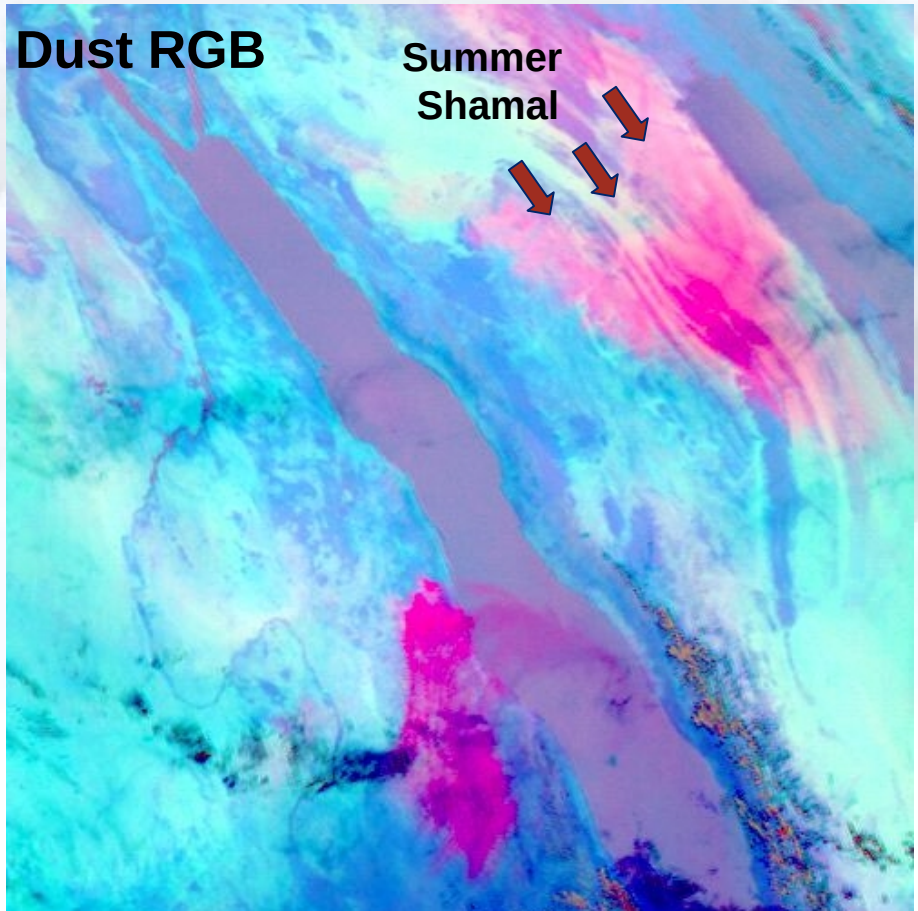


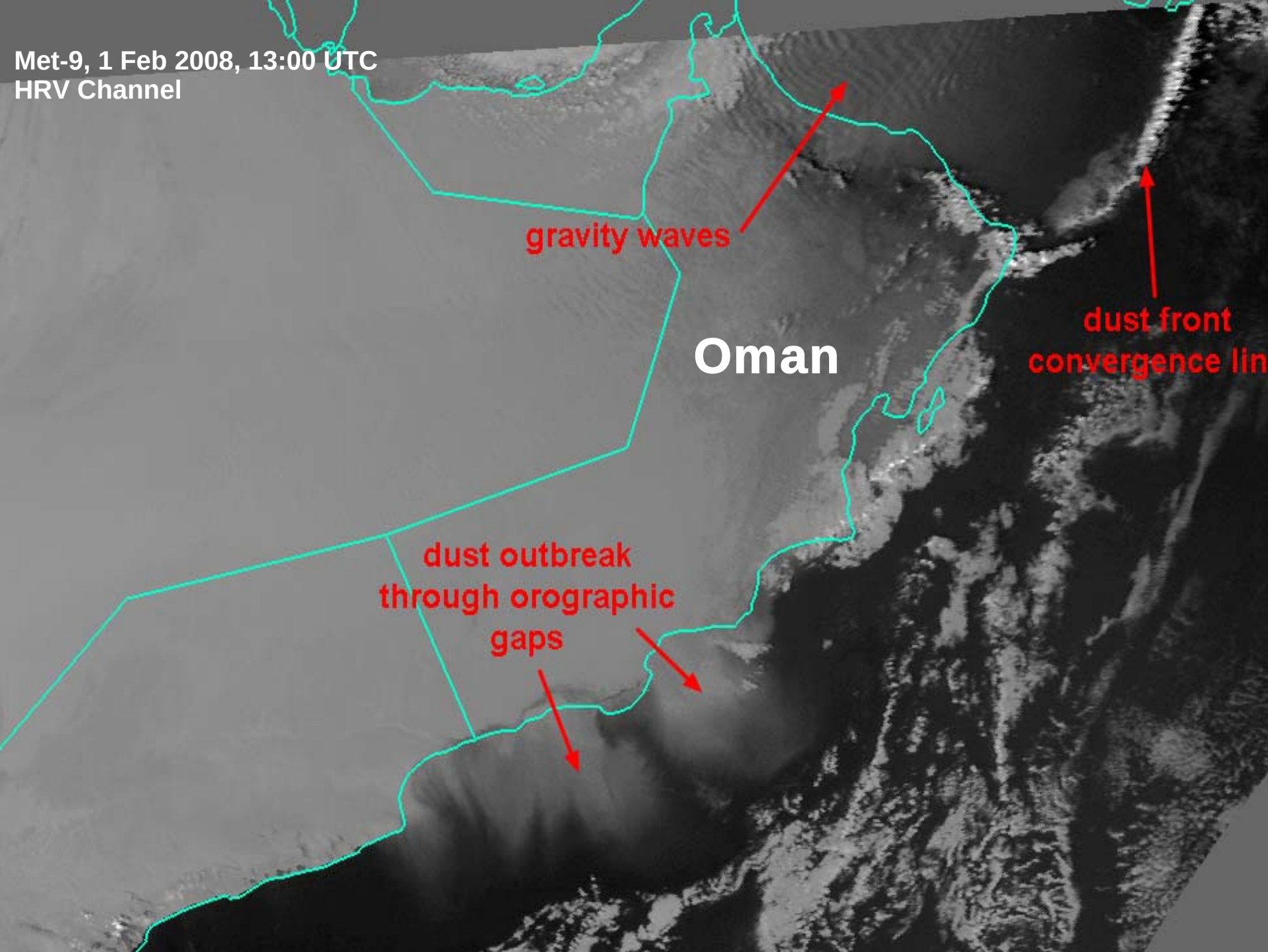
EUMETSAT

Mountain Gap Winds

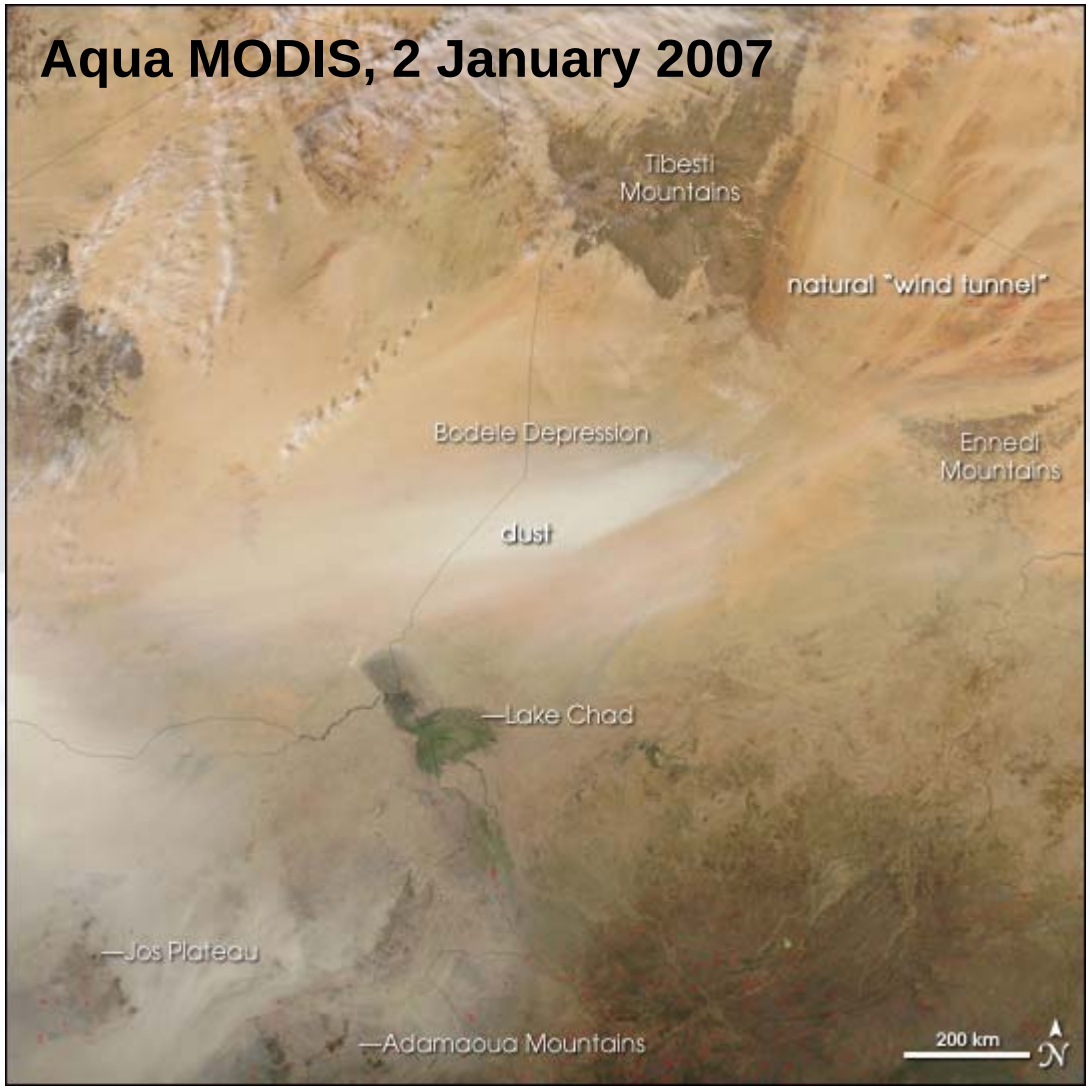







Met-9, 1 Feb 2008, 13:00 UTC
HRV Channel
gravity waves
Oman
dust front
convergence lin
dust outbreak
through orographic
gaps

Mountain Gap Winds



NASA Earth Observatory: "A gap between the Tibesti and Ennedi Mountains creates a natural wind tunnel that focuses and intensifies the winds across the Bodele Depression

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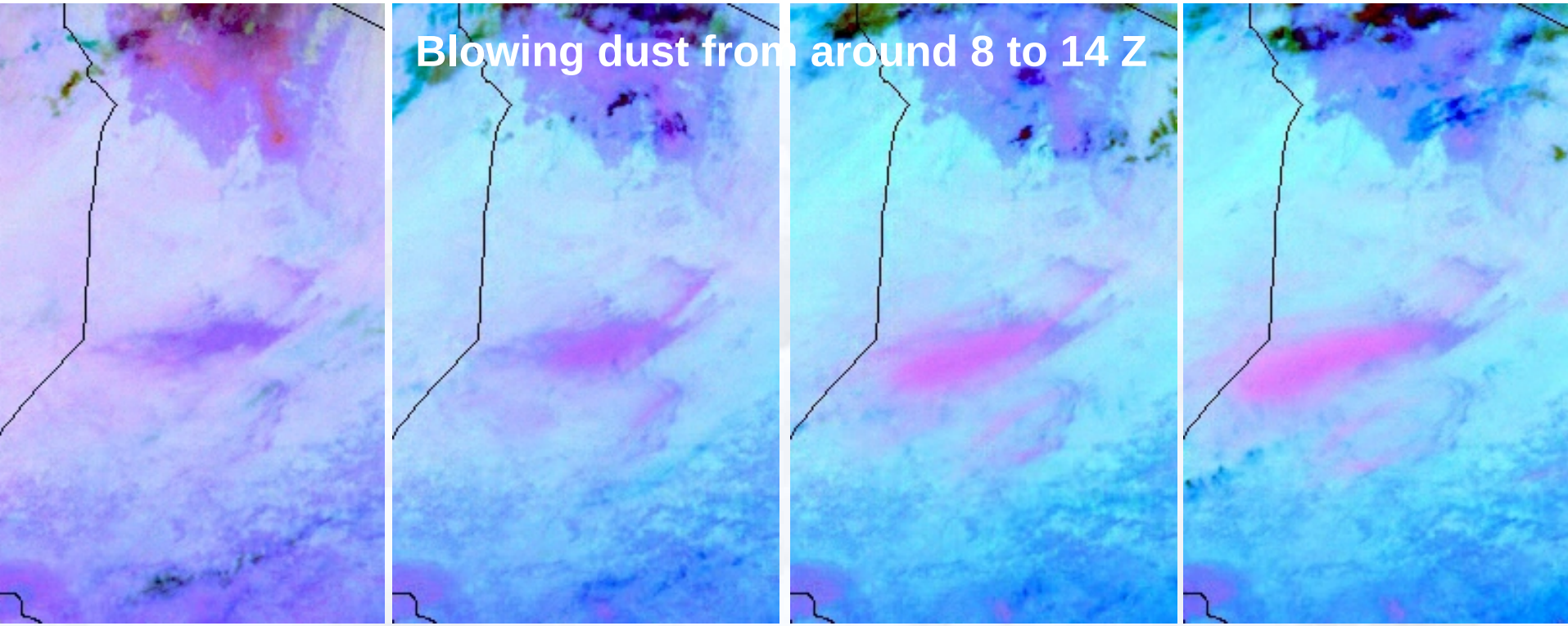
Bodele: Diurnal Dust Pulses



06:00 Z 08:00 Z 10:00 Z 12:00 Z

Met-9, 13 November 2009

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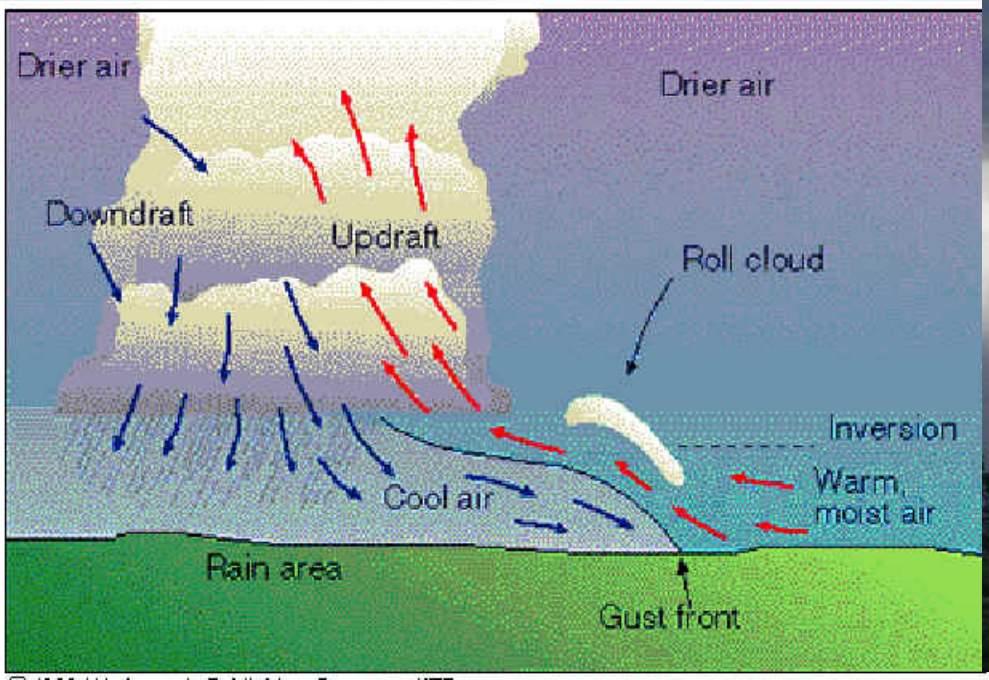
Dust Squalls from Convective Downbursts (Haboobs)

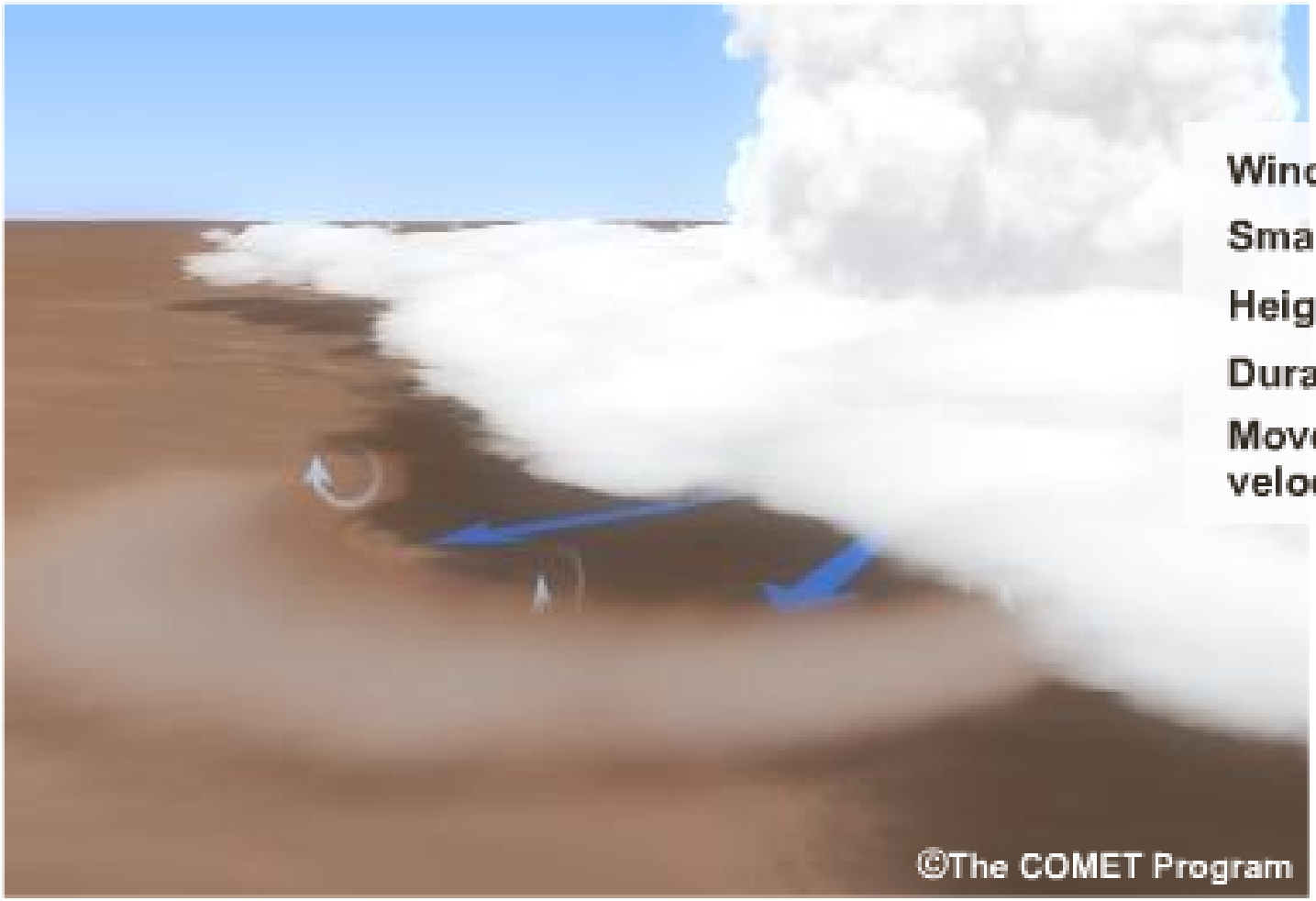
Thunderstorms raising dust squalls

Dust squalls triggering thunderstorms



Source: Daniel Rosenfeld, Dubrovnik Conference, 2005

Properties of a Haboob



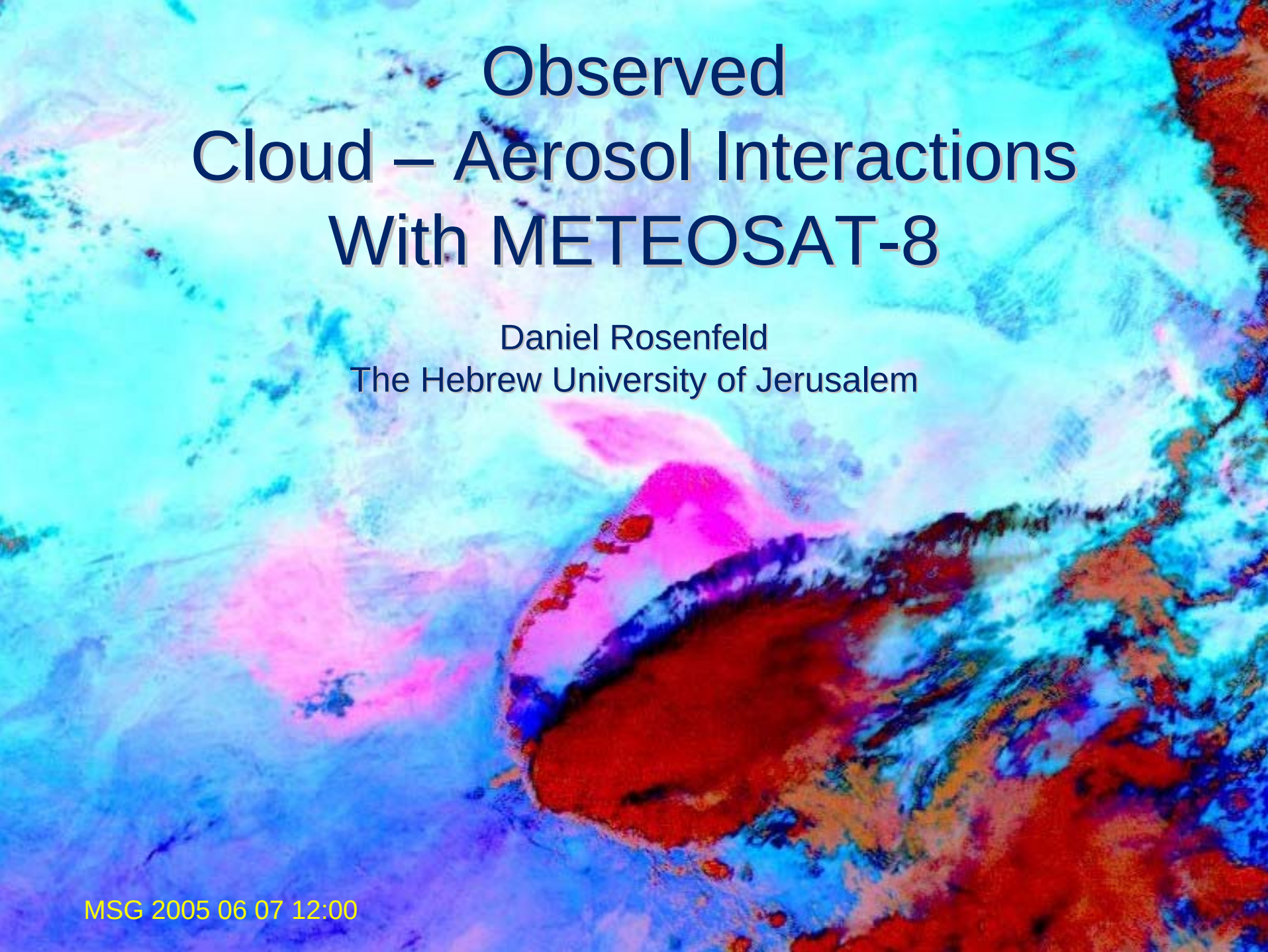
Winds: 35-50 kt

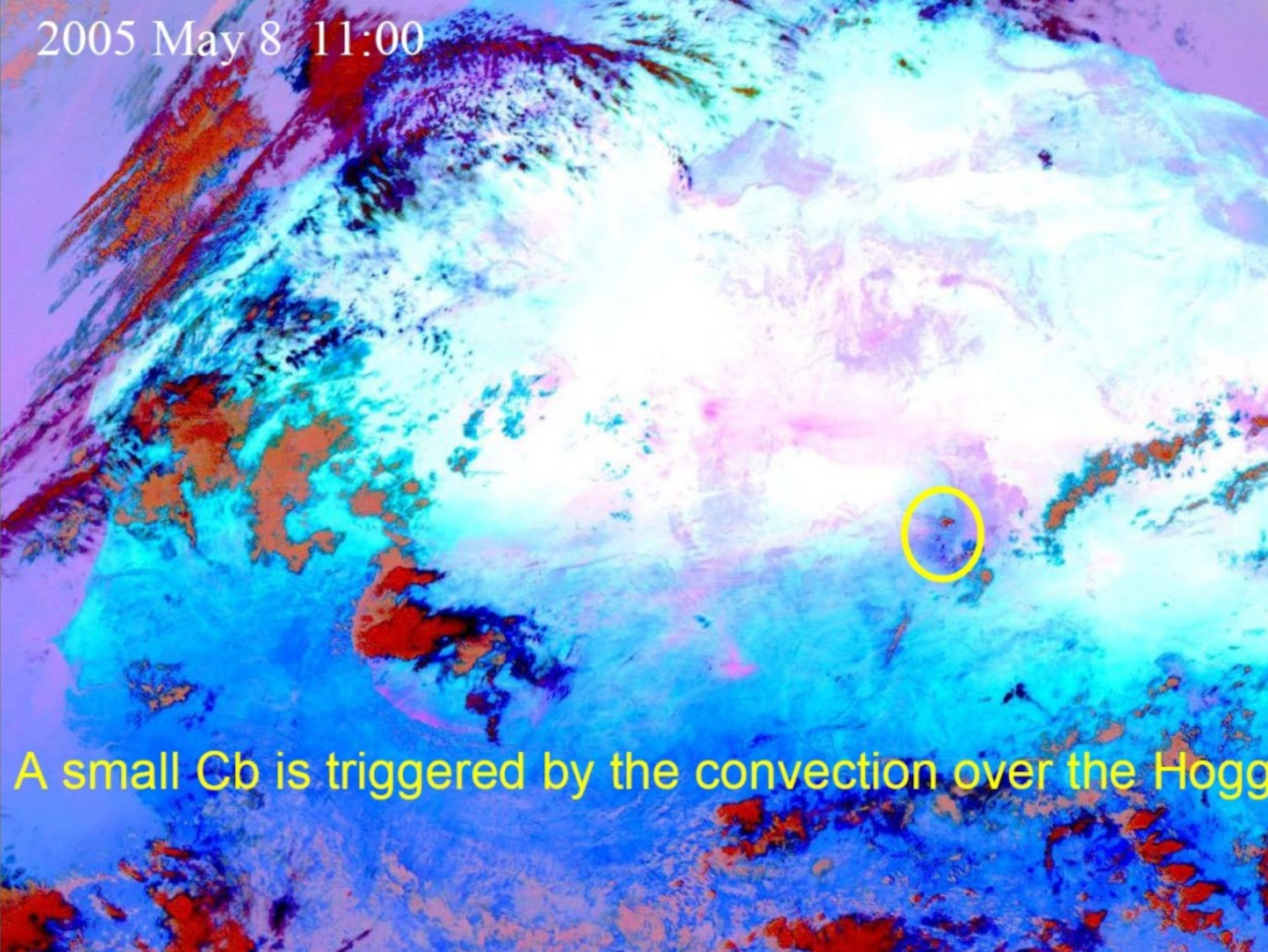
Small: 60-90 miles

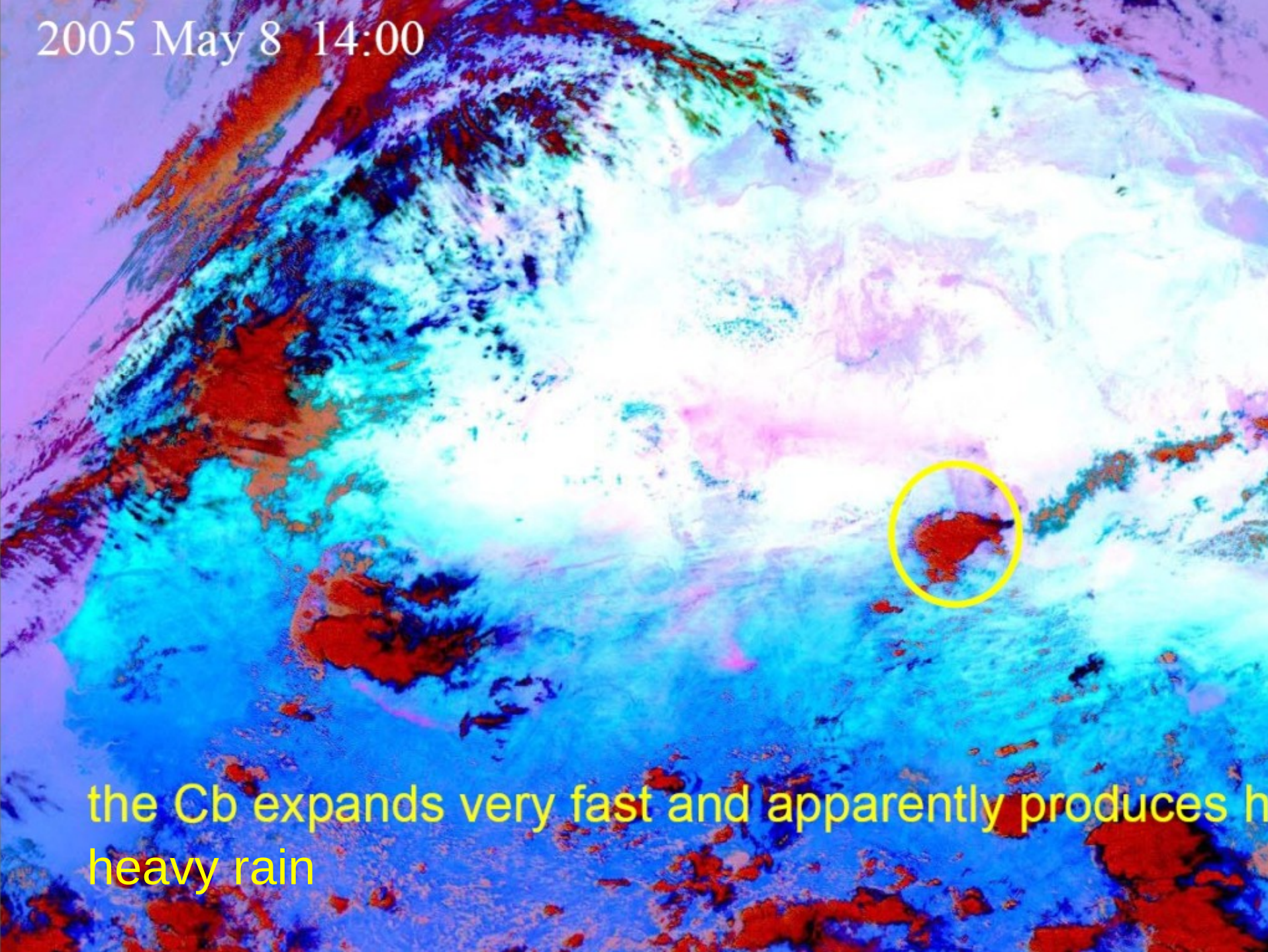
Height: 5000-8000 ft

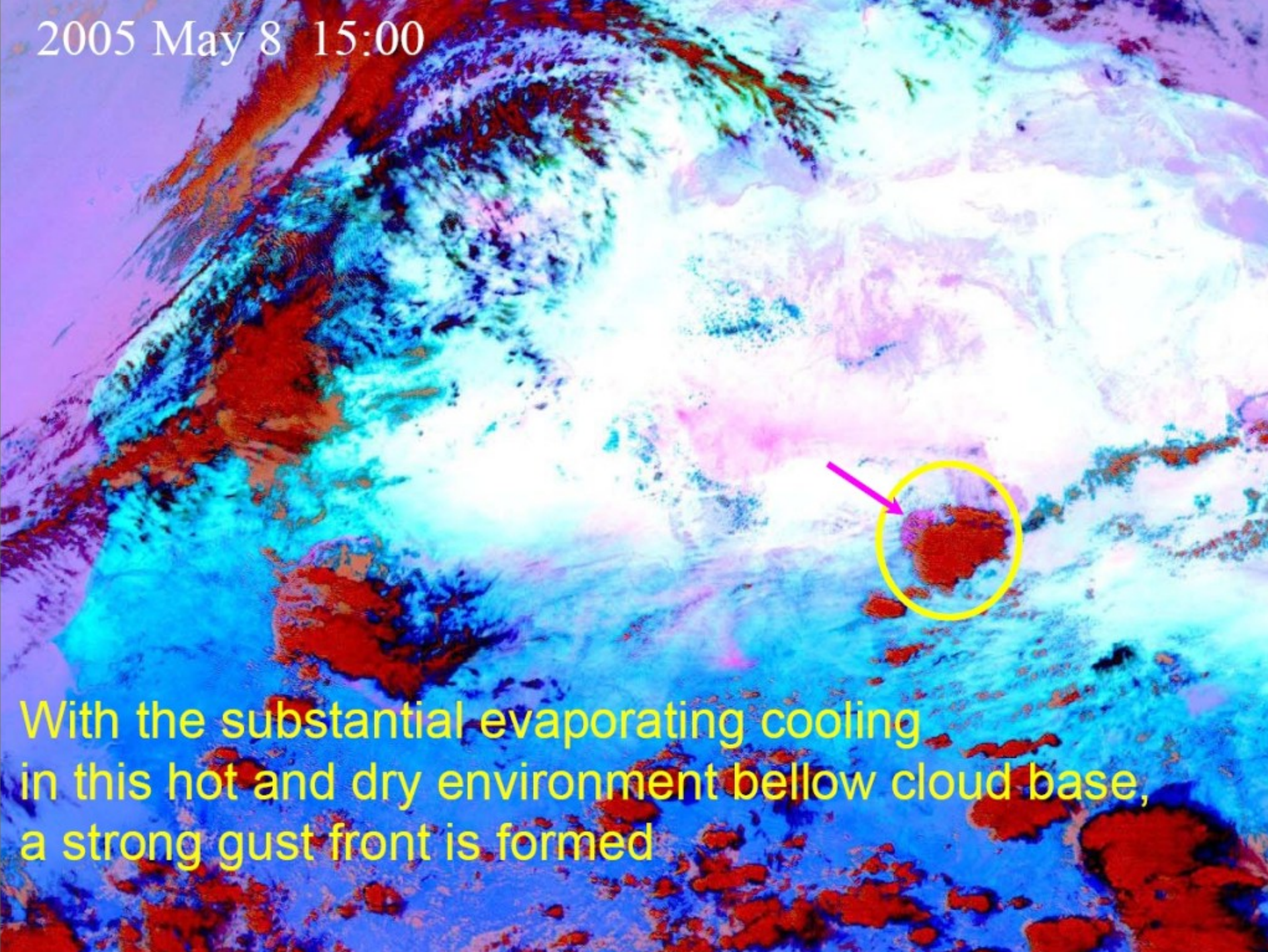
Duration: 3 hours

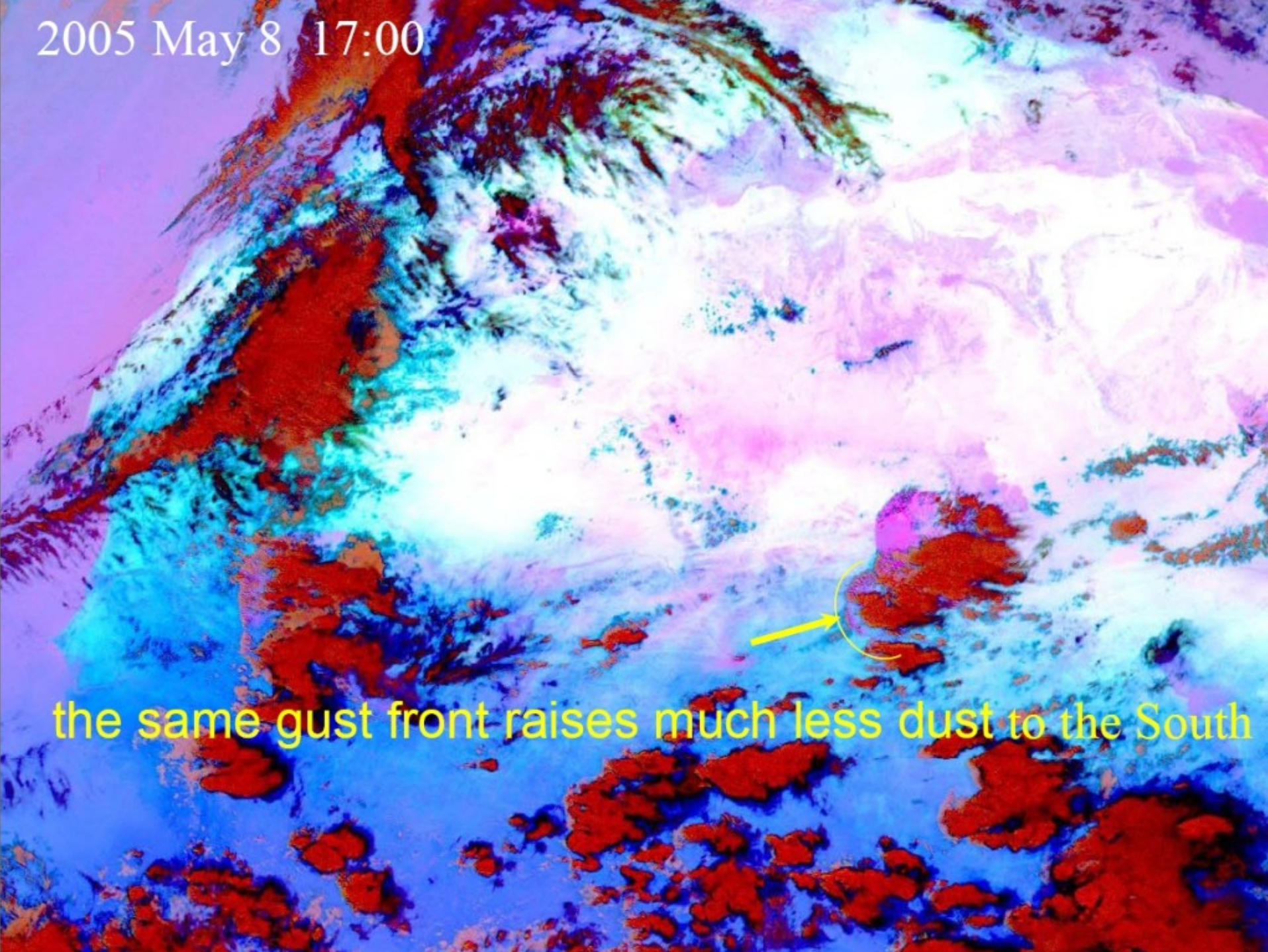
Move at 1/2 velocity of winds

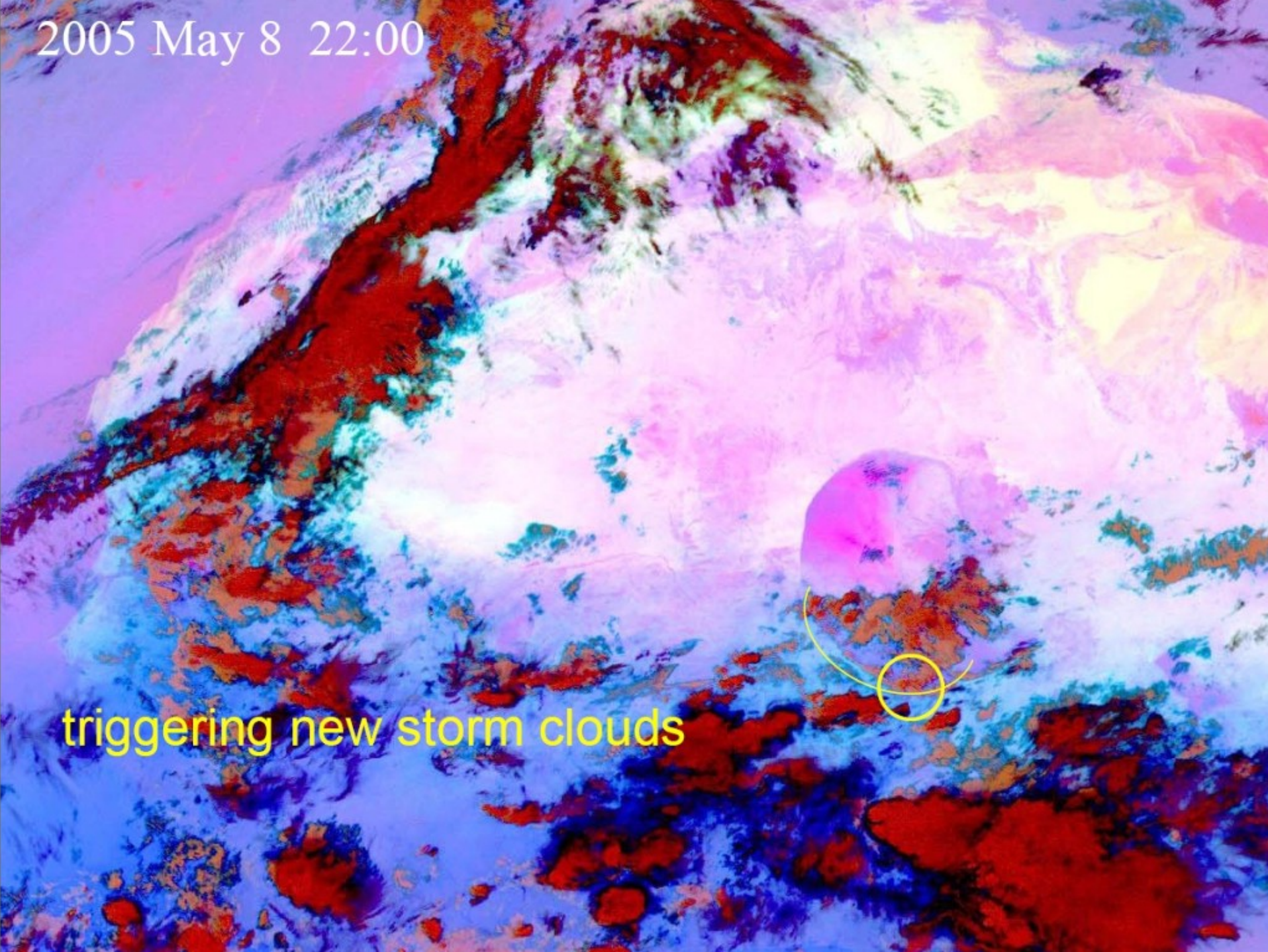

Observed
Cloud – Aerosol Interactions
With METEOSAT-8
Daniel Rosenfeld
The Hebrew University of Jerusalem
MSG 2005 06 07 12:00

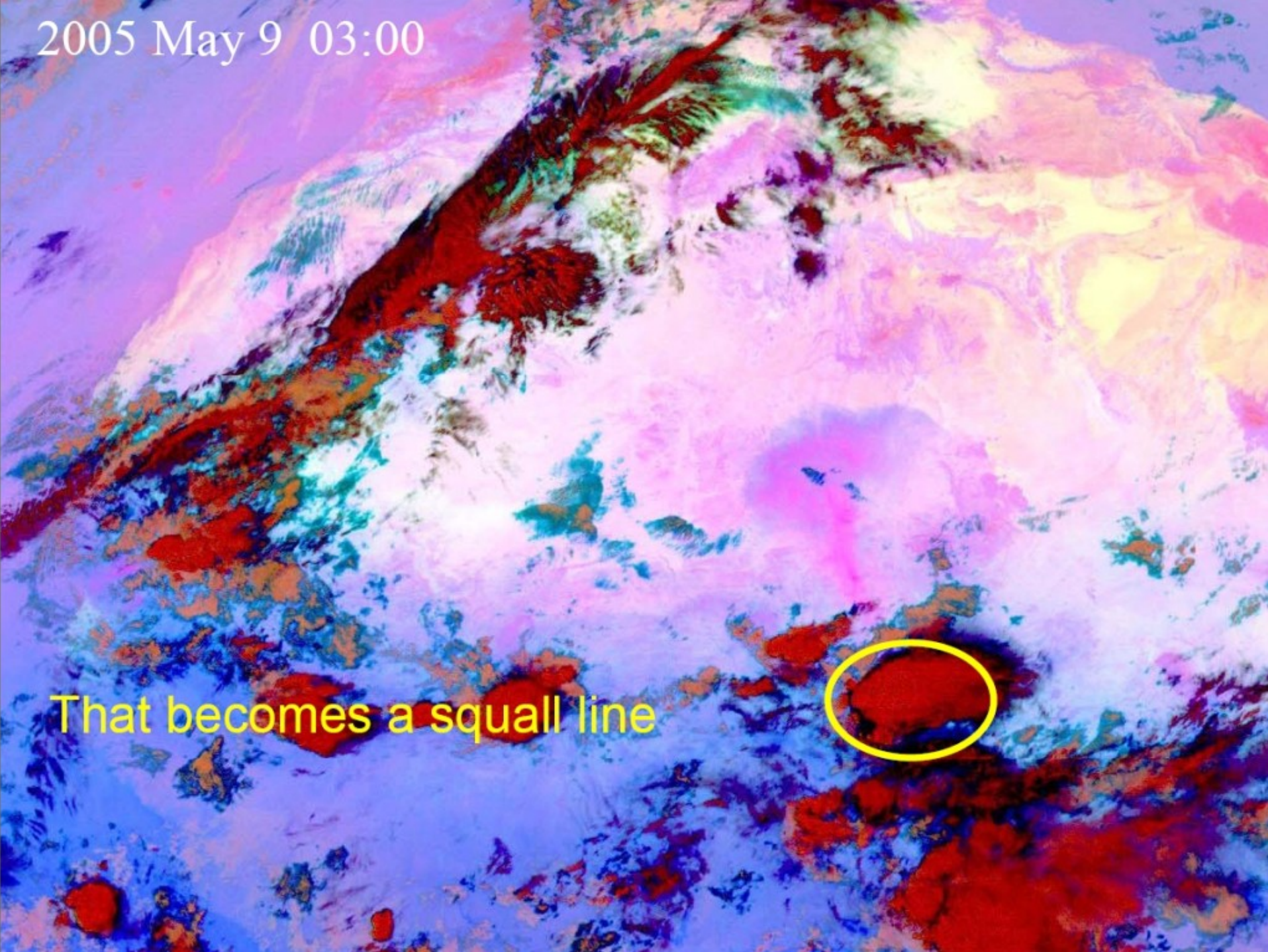

2005 May 8 11:00
A small Cb is triggered by the convection over the Hogg


2005 May 8 14:00
the Cb expands very fast and apparently produces h
heavy rain


2005 May 8 15:00
With the substantial evaporating cooling
in this hot and dry environment bellow cloud base,
a strong gust front is formed

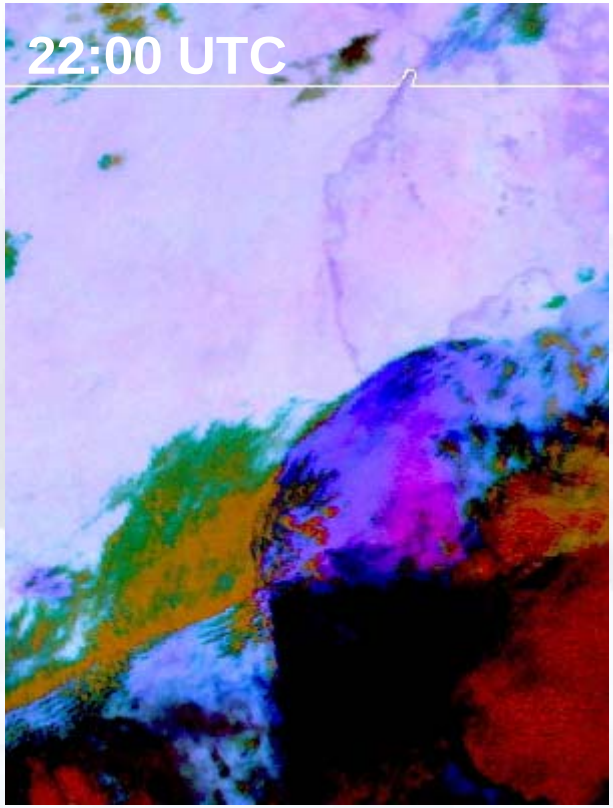

2005 May 8 17:00
the same gust front raises much less dust to the South

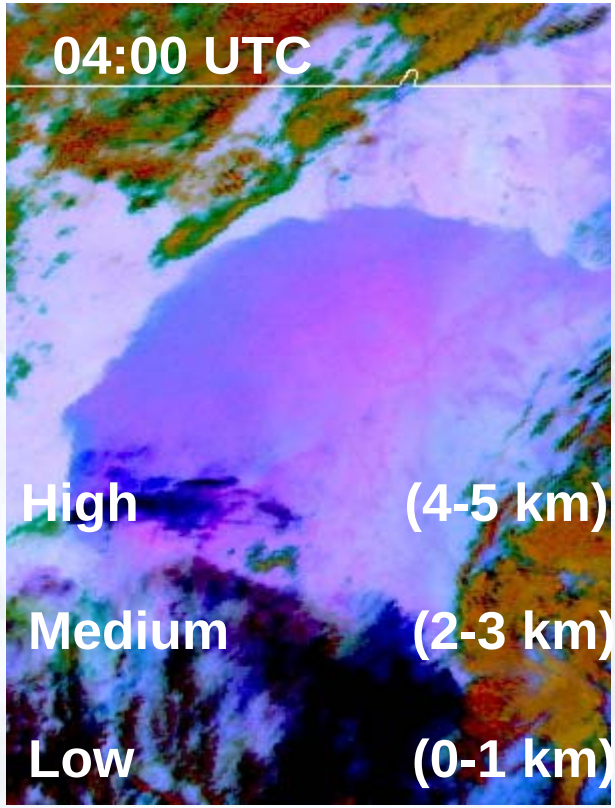

2005 May 8 22:00
triggering new storm clouds

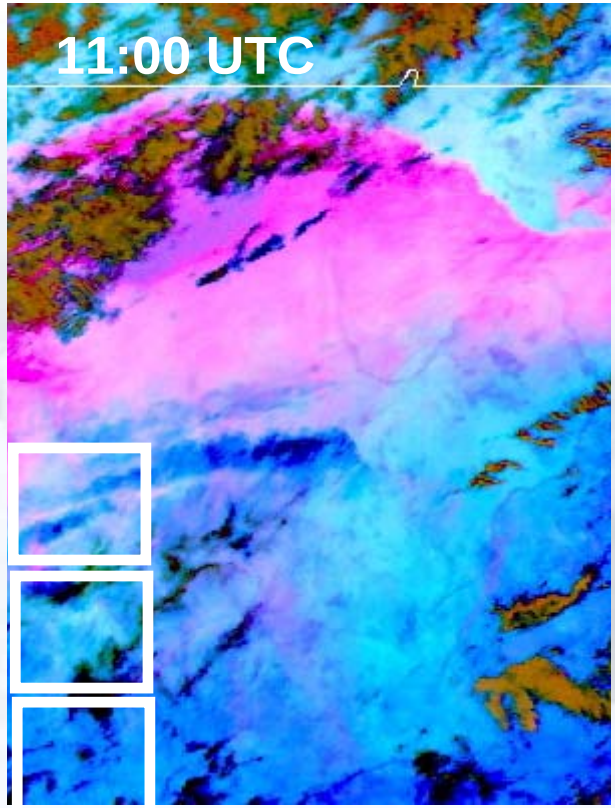

2005 May 9 03:00
That becomes a squall line

Haboob over Sudan

What level do you expect for the dust cloud over Sudan ?







Met-8, 29-30 April 2007

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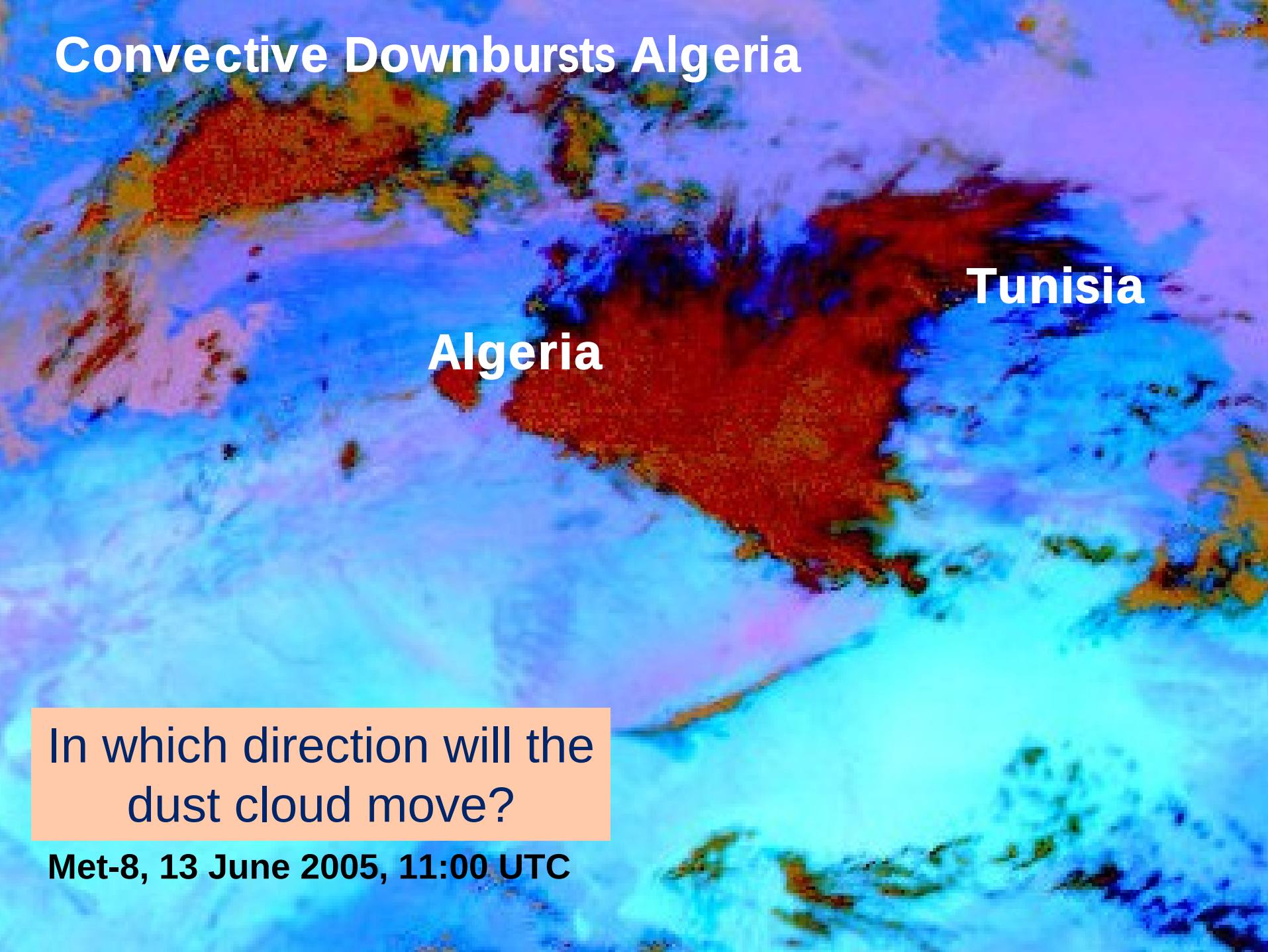
Convective Downbursts Algeria



In which direction will the dust cloud move?

Met-8, 13 June 2005, 11:00 UTC

Loop 3

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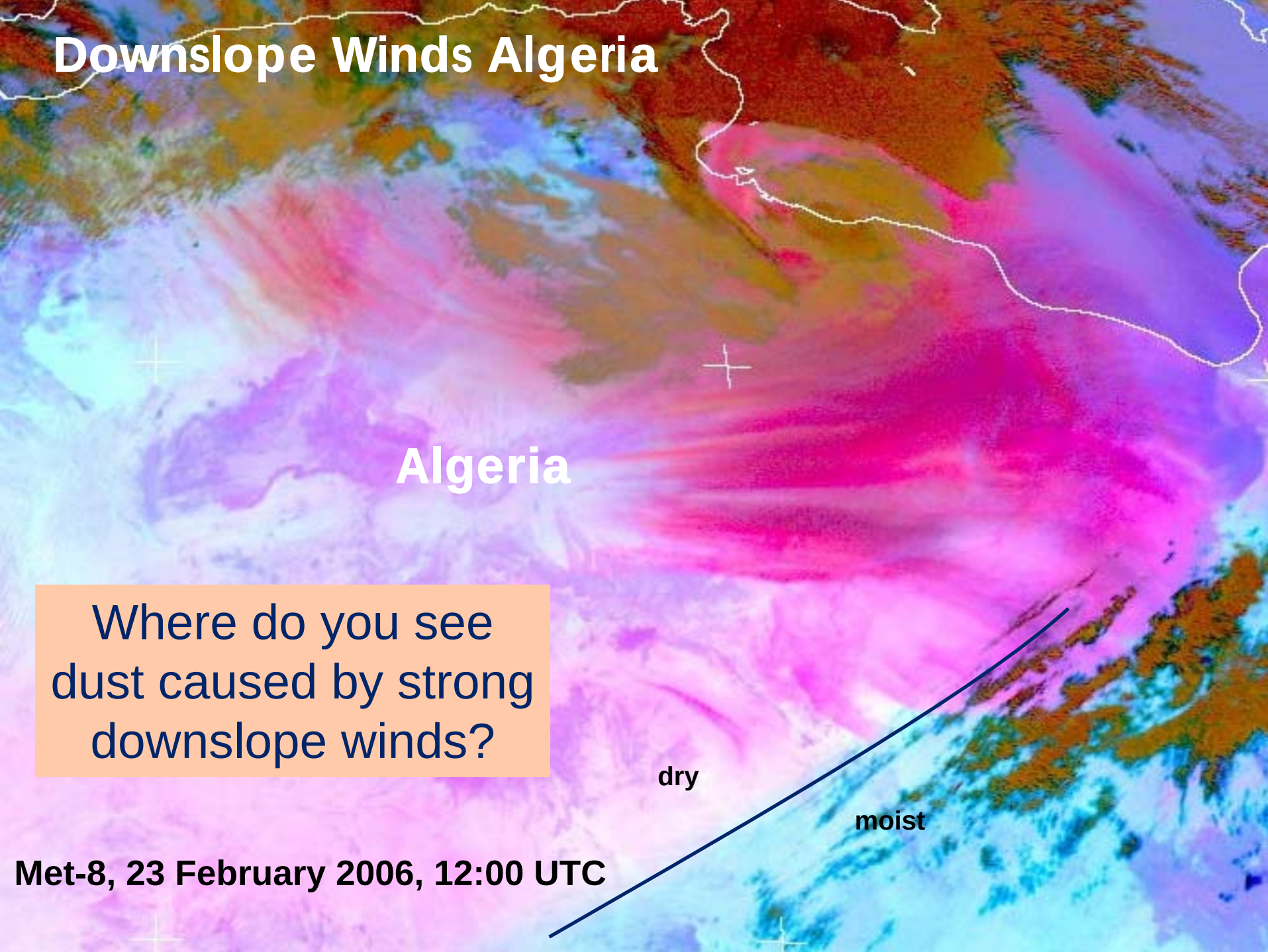
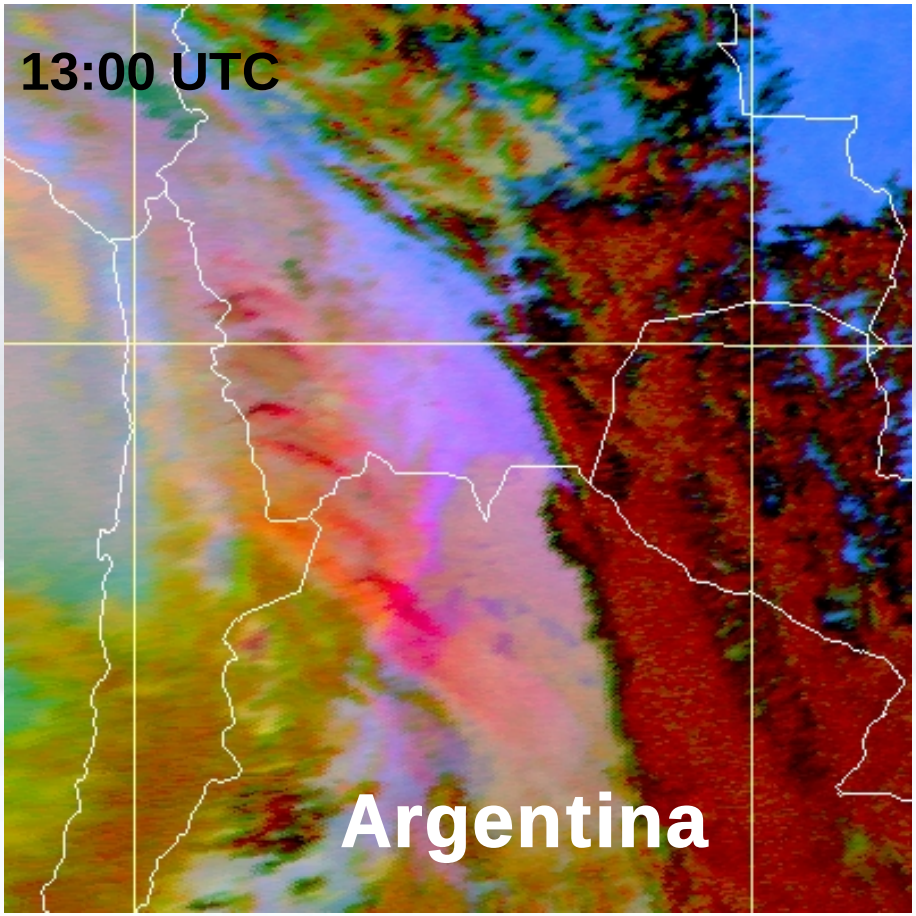
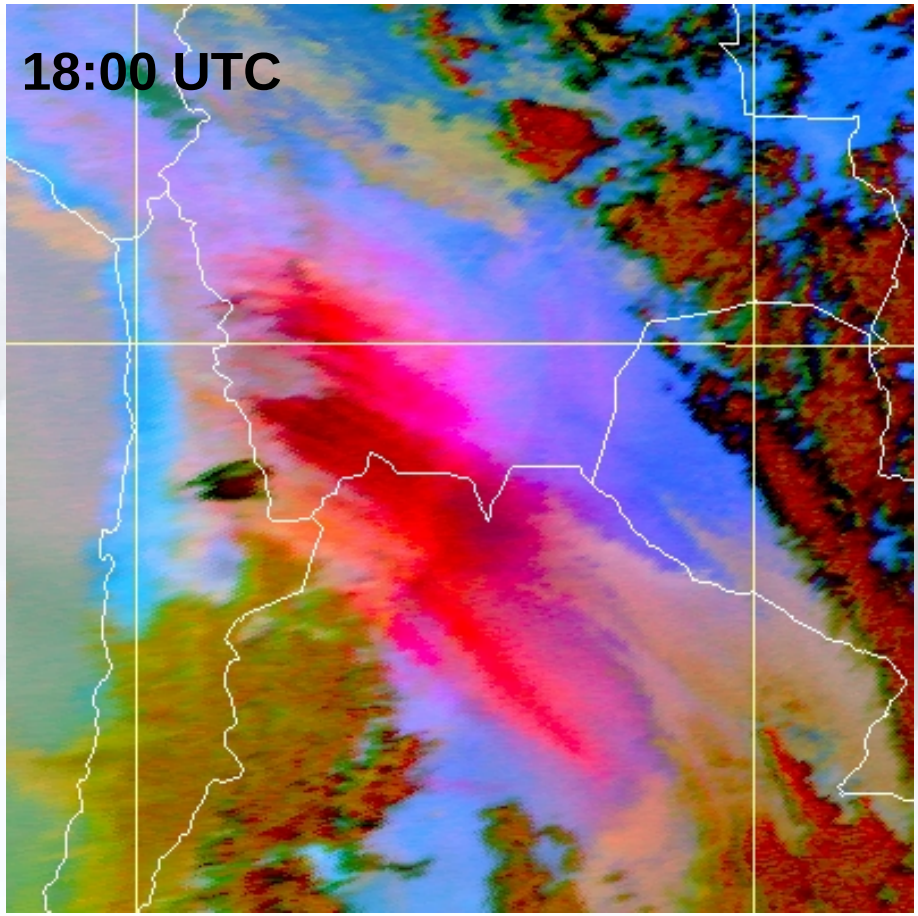

Downslope Winds Algeria
Algeria
Where do you see dust caused by strong downslope winds?
dry
moist
Met-8, 23 February 2006, 12:00 UTC

Downslope Winds Argentina (Zonda Winds)





Met-9, 21 July 2009

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Summary: Key Messages 1

- The Dust RGB can be used during day and night

- Dust Level identification is difficult but not totally impossible

- More contrast to backgroud over land than over ocean

- Over ocean visible imagery is preferable during the day (e.g. Natural Colour RGB)

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Summary: Key Messages 2

- Dust changes cloud microphysics

- Mesoscale dust outbreaks cannot be forecasted with dust model (satellite data!)

- HRV / Dust RGB blended product very useful during daytime

- Haboobs can travel very fast at night!

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Thank you for your attention !

More information: www.eumetsat.int

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