

Dust Detection with MSG SEVIRI RGB Products

Exercises

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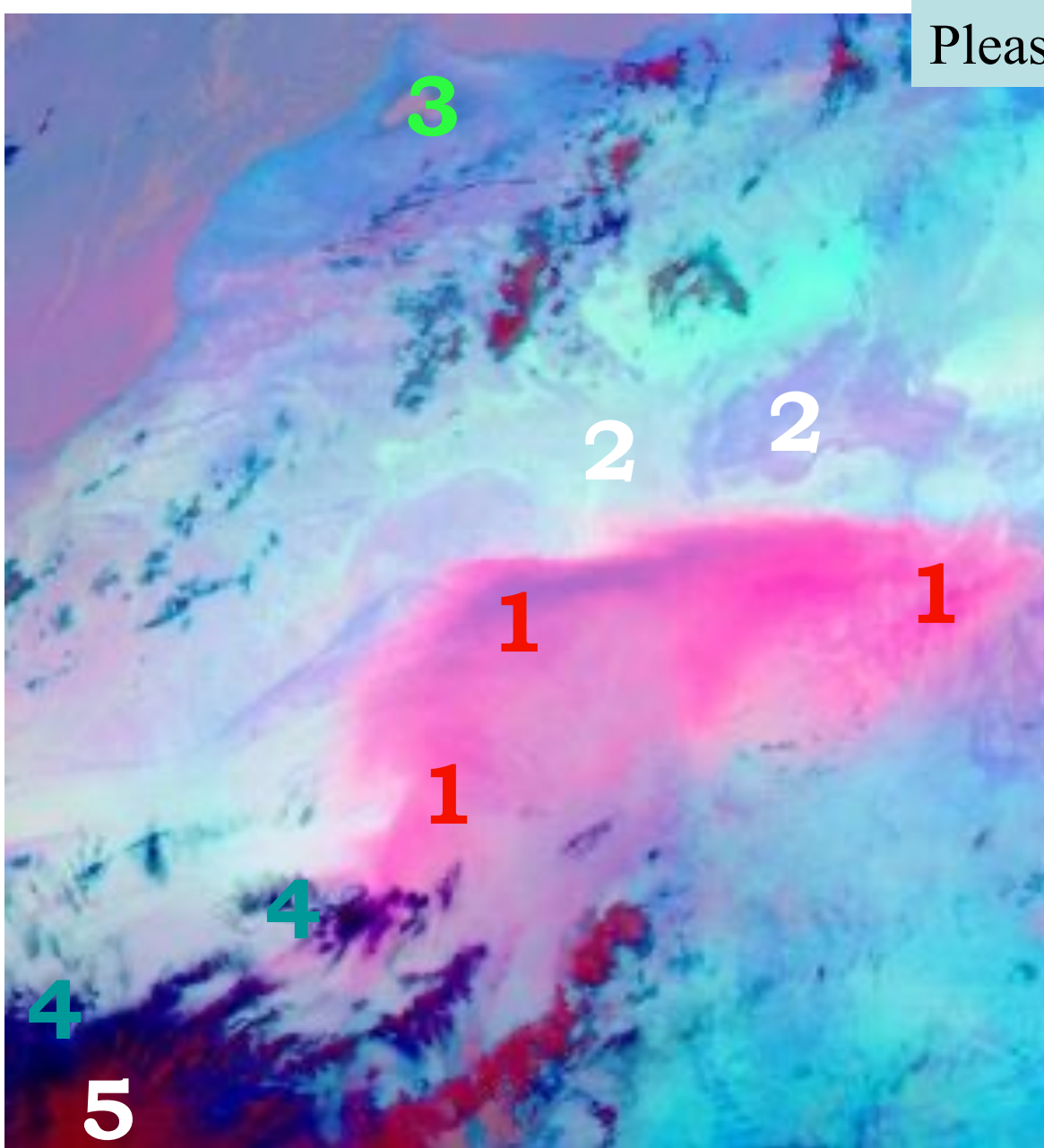
(jochen.kerkmann@eumetsat.int)

Content

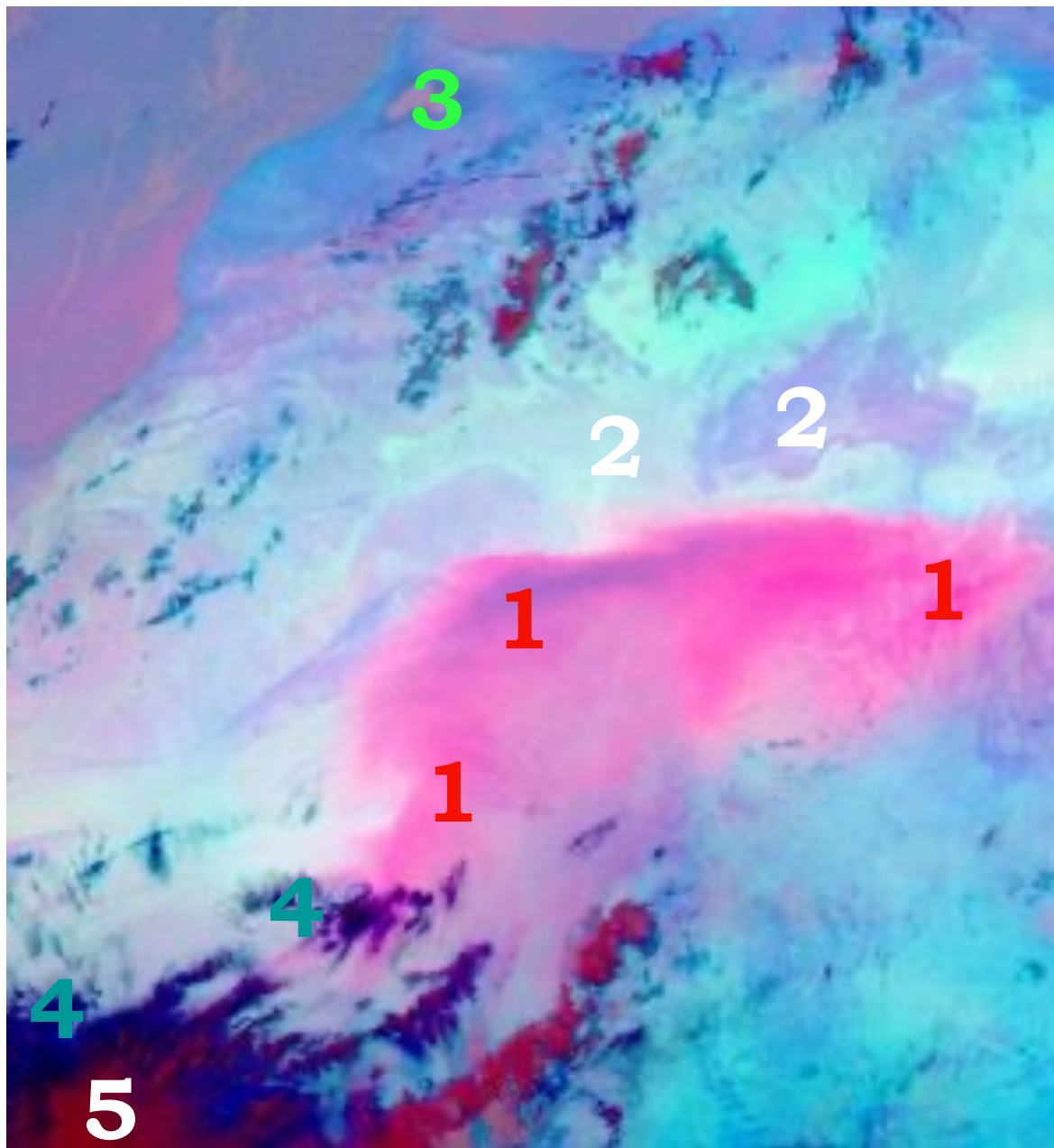
- 1) Dust RGB Colour Exercise
- 2) General Quiz / Questions
- 3) Detection / Outline of Dust Clouds
- 4) Height Determination of Dust Clouds
- 5) Dust Nowcasting Exercise

Dust RGB
Colour Exercise
(Feature Identification)

Please, identify the 5 features!



MSG-1
14 July 2003
10:00 UTC



1= dust cloud

2= clear ground

3 = low-level clouds

4 = thin high-level ice clouds

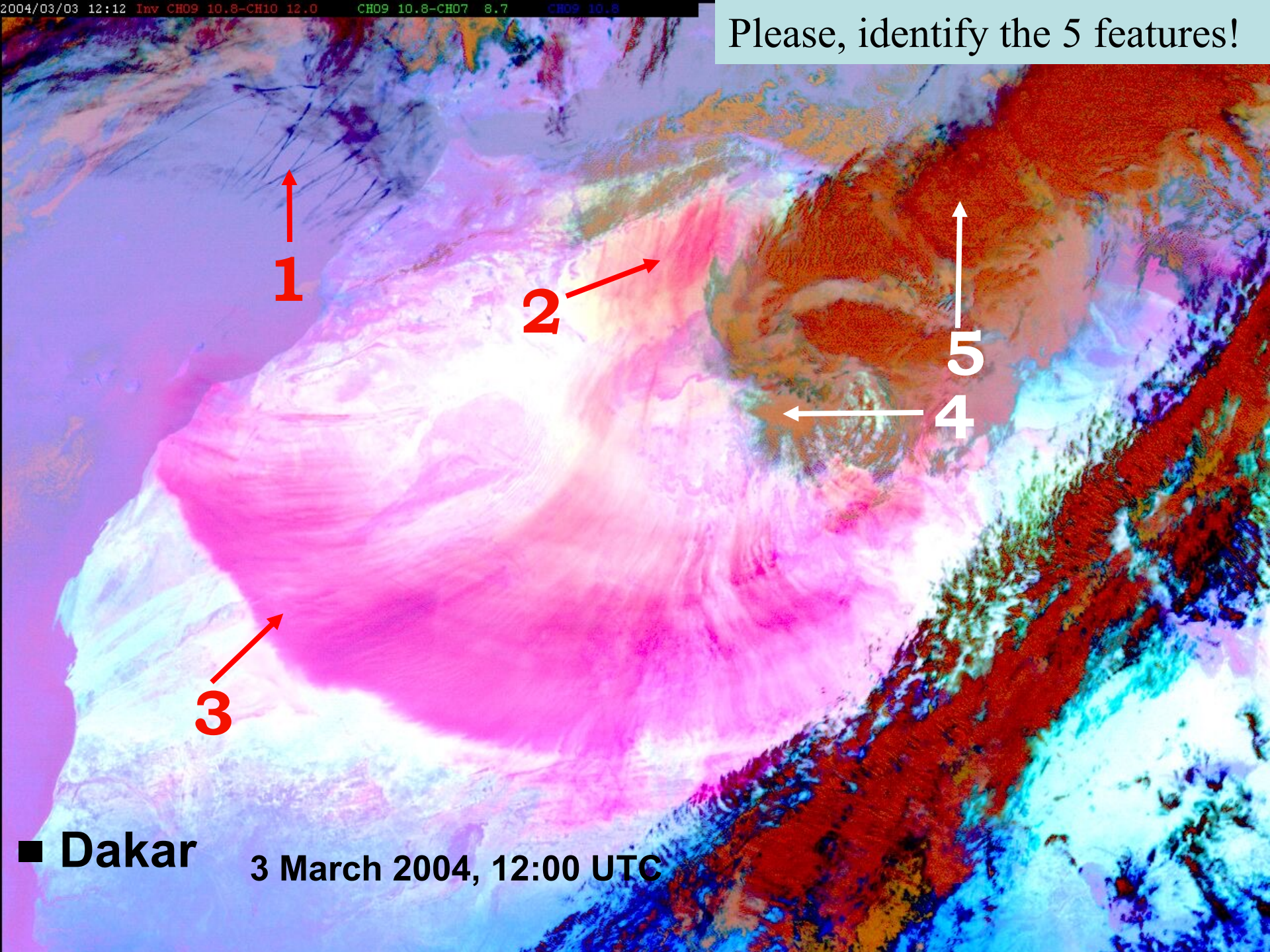
5 = thick high-level ice clouds

MSG-1

14 July 2003

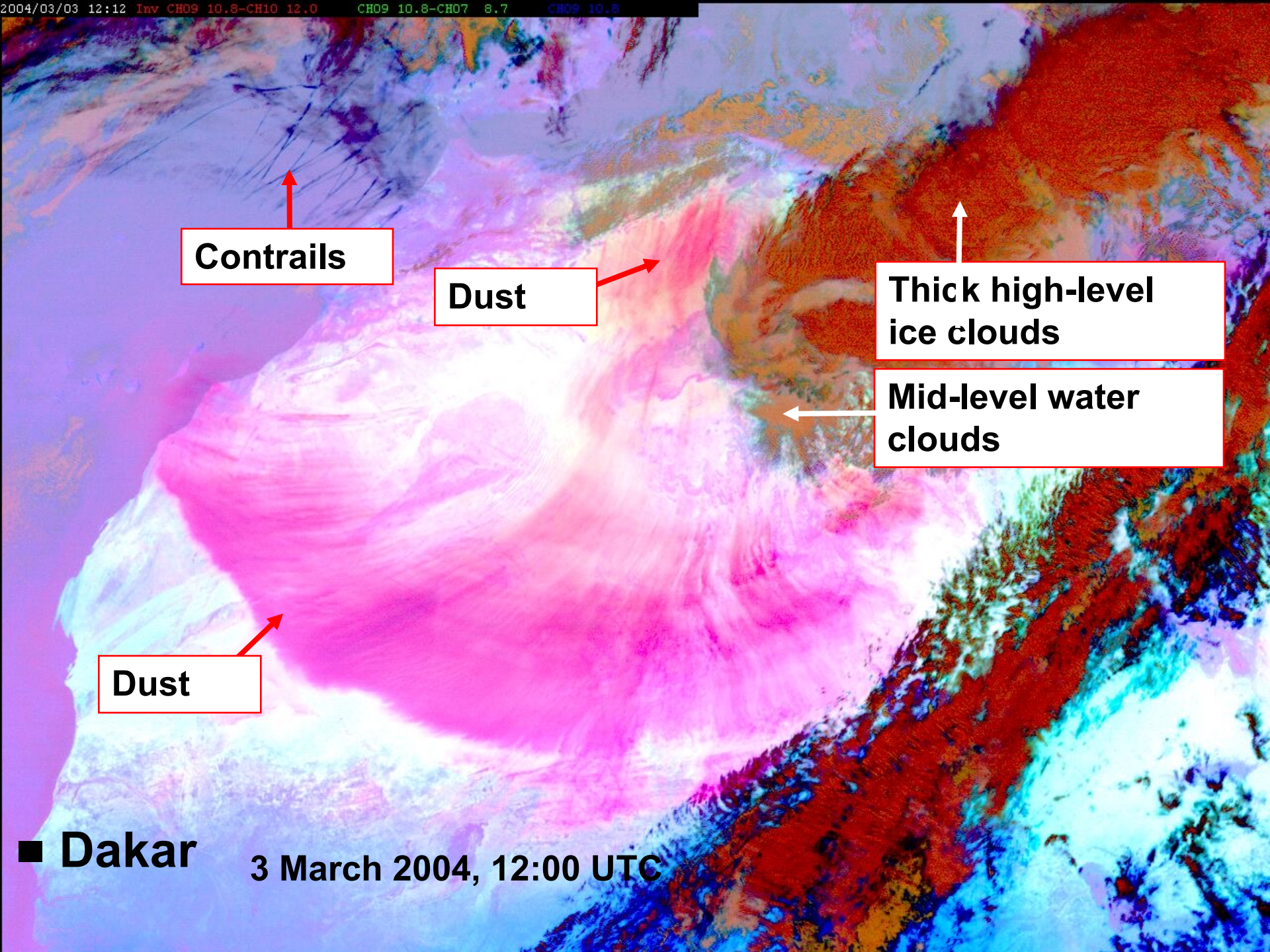
10:00 UTC

Please, identify the 5 features!



■ Dakar

3 March 2004, 12:00 UTC



Contrails

Dust

**Thick high-level
ice clouds**

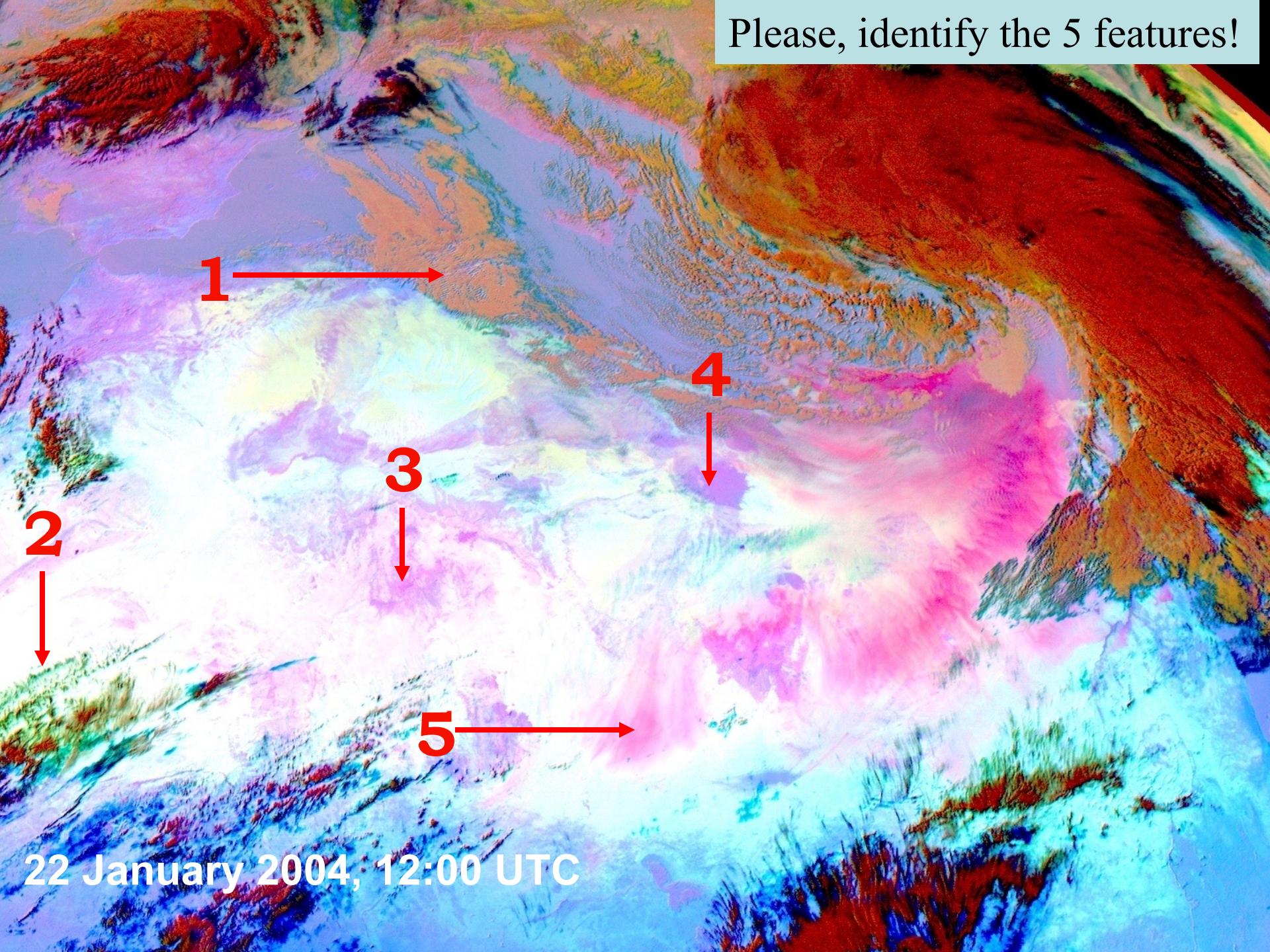
**Mid-level water
clouds**

Dust

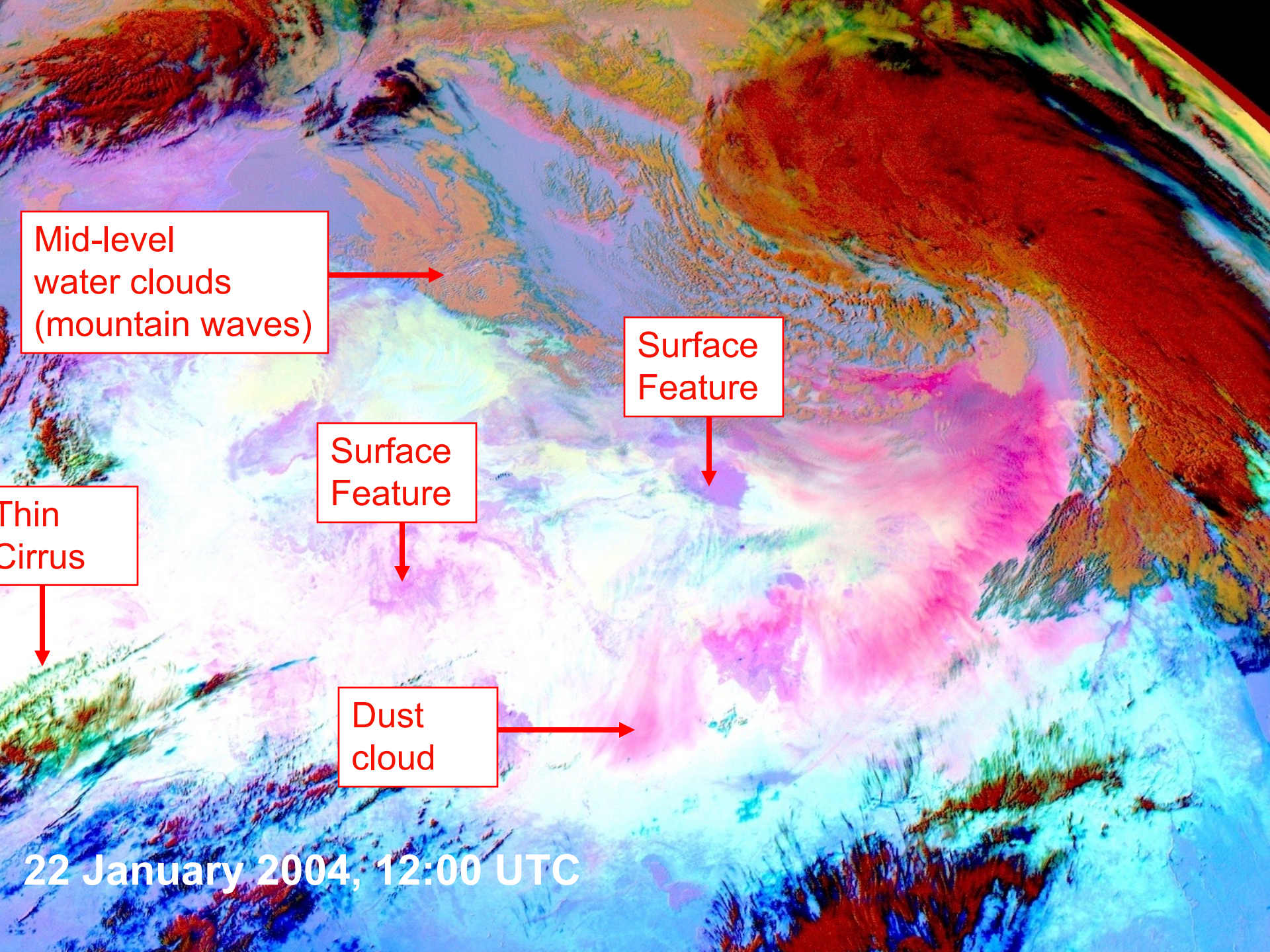
■ **Dakar**

3 March 2004, 12:00 UTC

Please, identify the 5 features!



22 January 2004, 12:00 UTC



Mid-level
water clouds
(mountain waves)

Surface
Feature

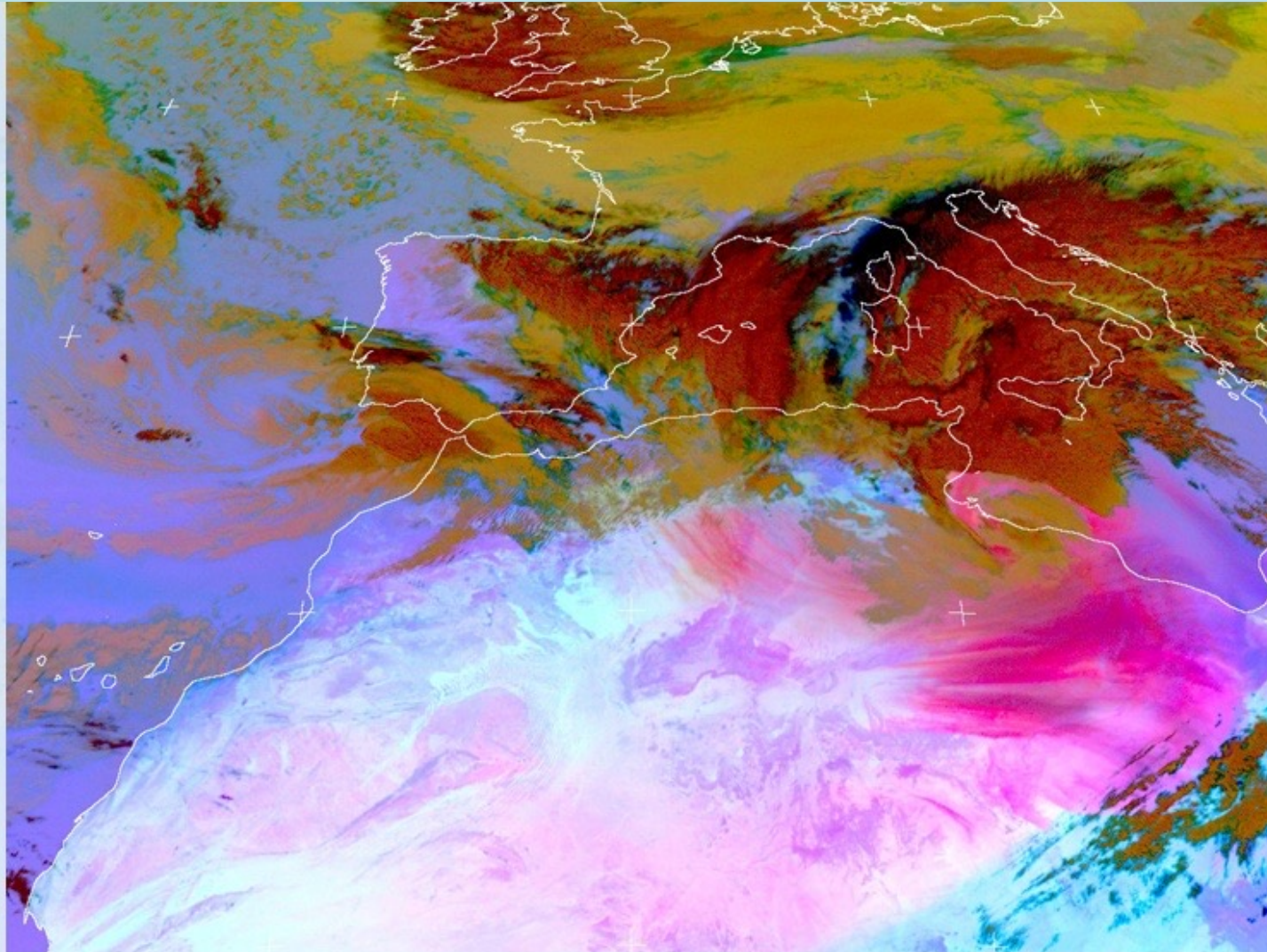
Surface
Feature

Thin
Cirrus

Dust
cloud

22 January 2004, 12:00 UTC

To the right you see six different clouds and features that you are able to recognise on this Dust RGB. Can you drag and place them on the correct position!



Low Clouds

Cirrus

Thick Iceclouds

Moist

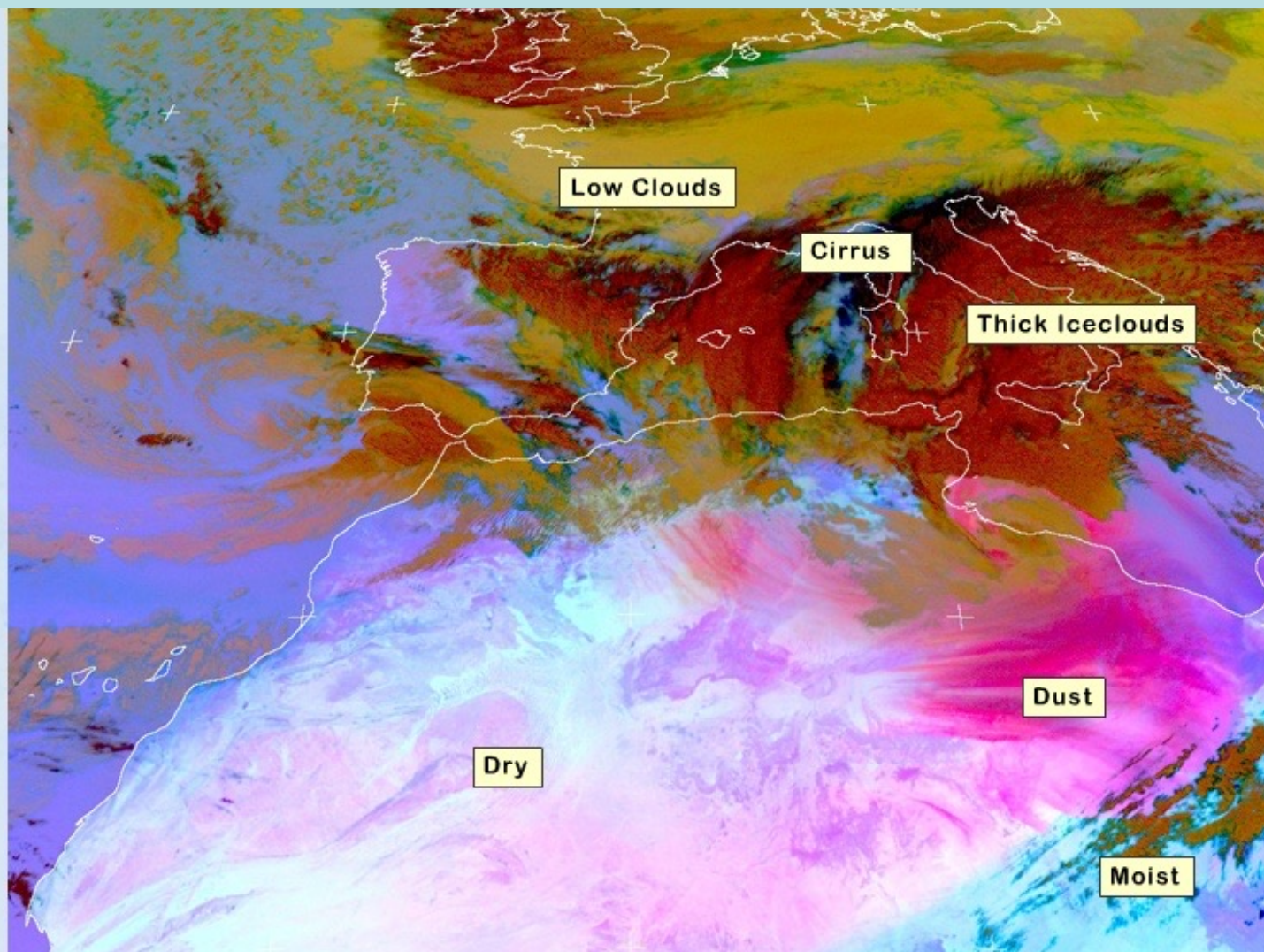
Dry

Dust

Submit answer

Reset

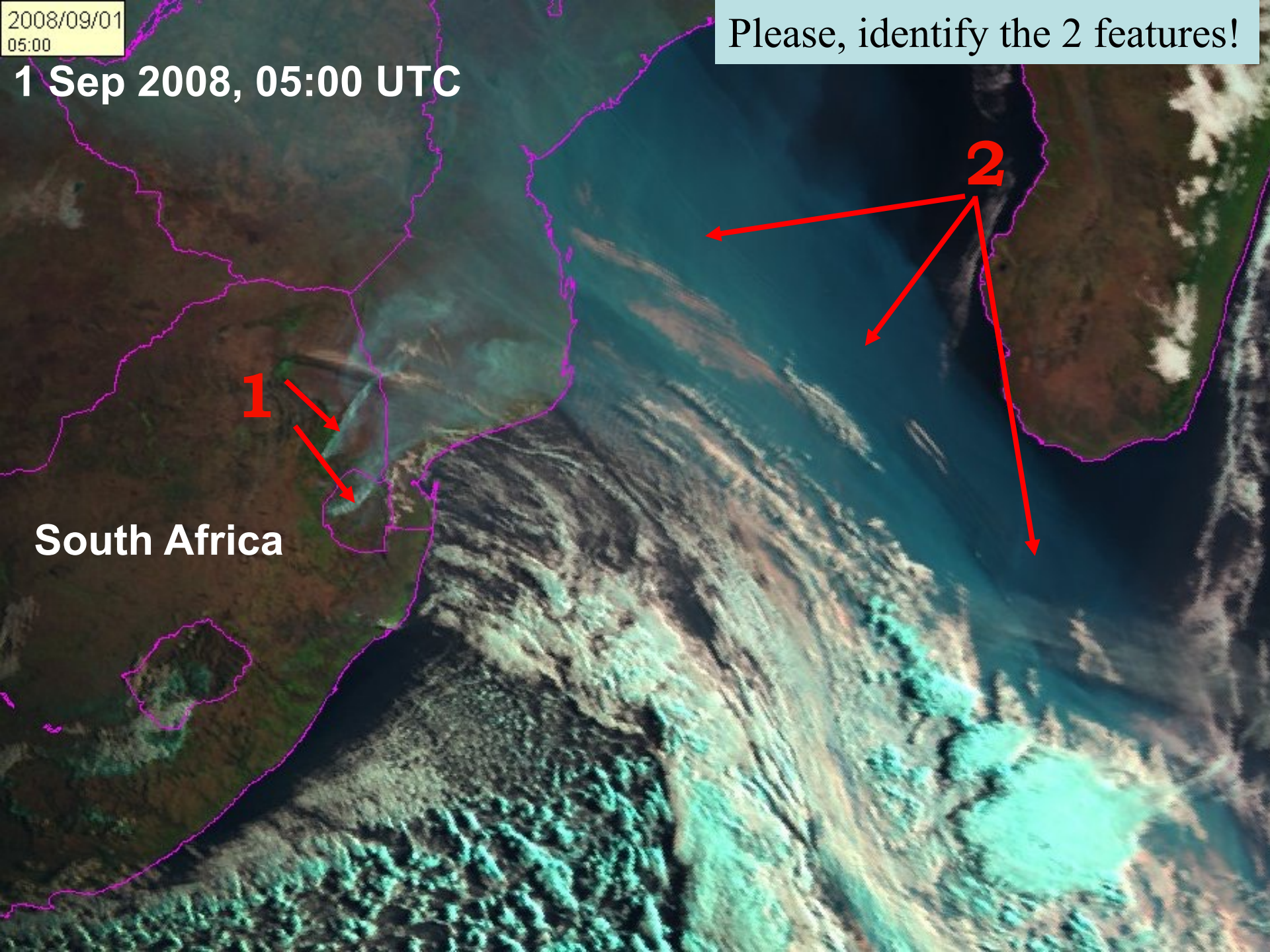
Select a Conceptual Model and
drag it to the correct position



Submit answer

Reset

Yes, well done! Absolutely correct! Press "next chapter" to continue.



2008/09/01
05:00

1 Sep 2008, 05:00 UTC

Please, identify the 2 features!

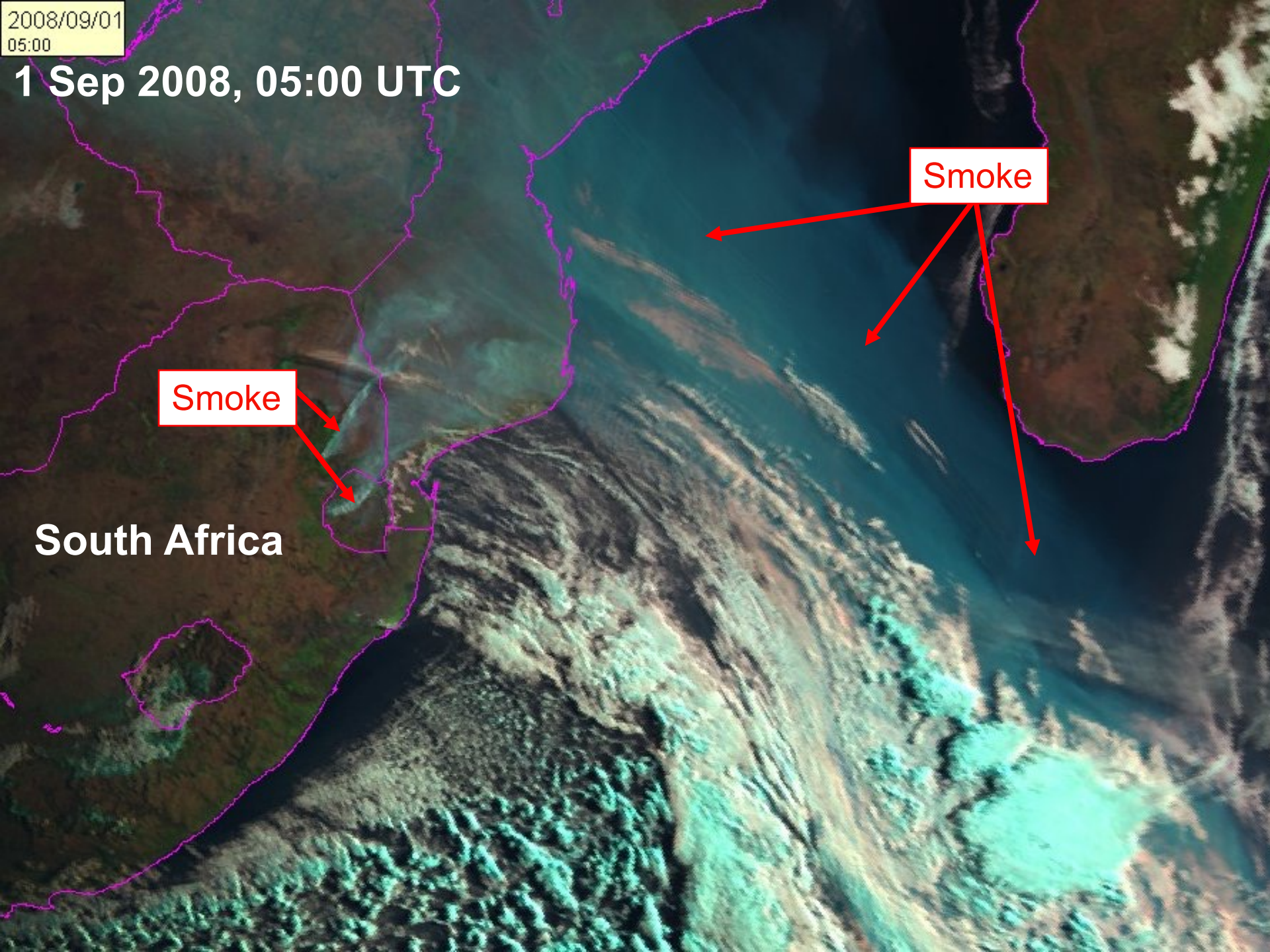
1

South Africa

2

2008/09/01
05:00

1 Sep 2008, 05:00 UTC



Smoke

Smoke

South Africa

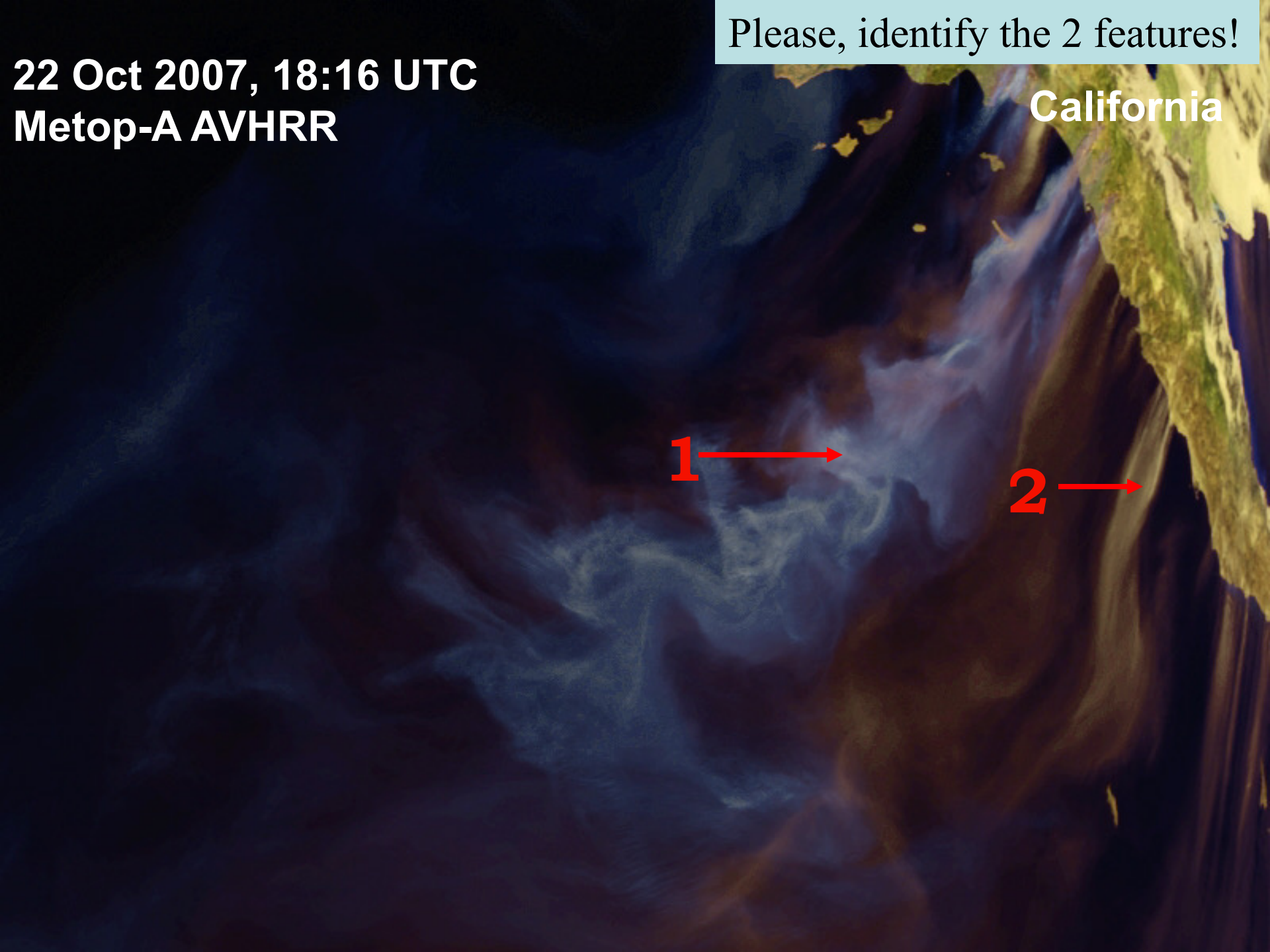
Please, identify the 2 features!

22 Oct 2007, 18:16 UTC
Metop-A AVHRR

California

1 →

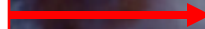
2 →



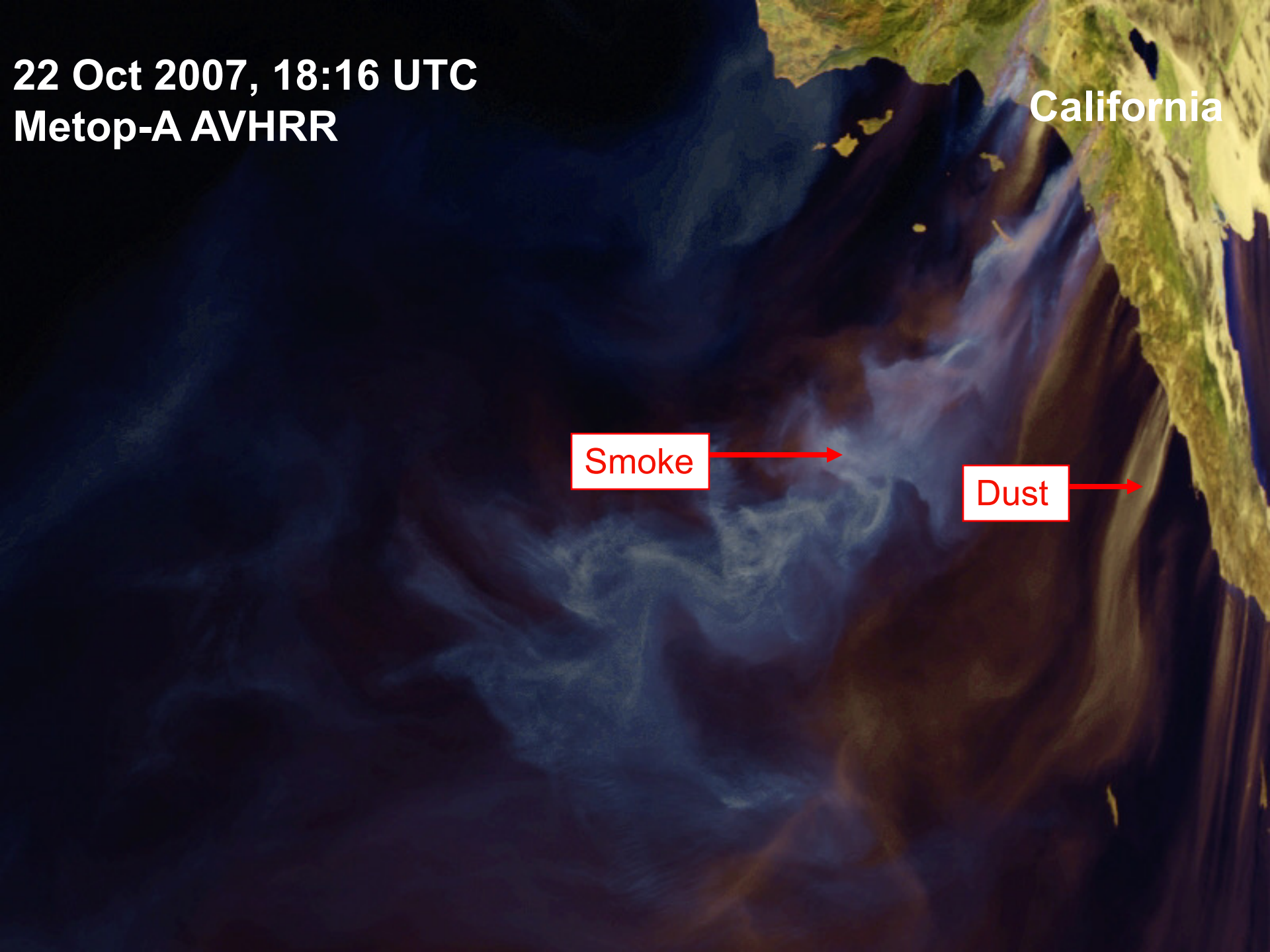
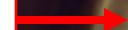
22 Oct 2007, 18:16 UTC
Metop-A AVHRR

California

Smoke



Dust

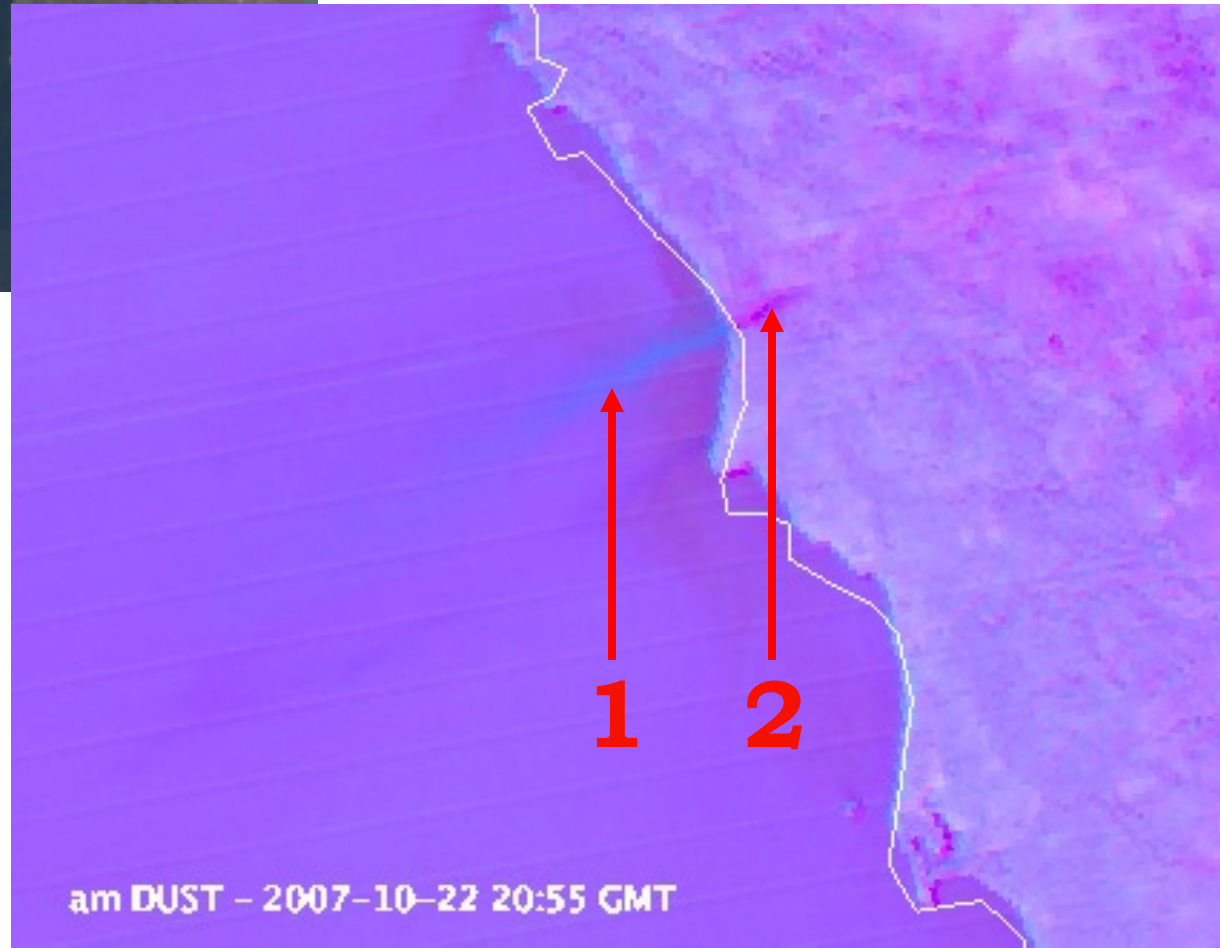


Dust



Why does the colour of the
dust plume change?

amTCOL - 2007-10-22 20:55UTC



am DUST - 2007-10-22 20:55 GMT

Please, identify the 3 features!

25 Nov 2009, 14:00 UTC



1



2



3

Nigeria



Niger Inland Delta
(vegetation)

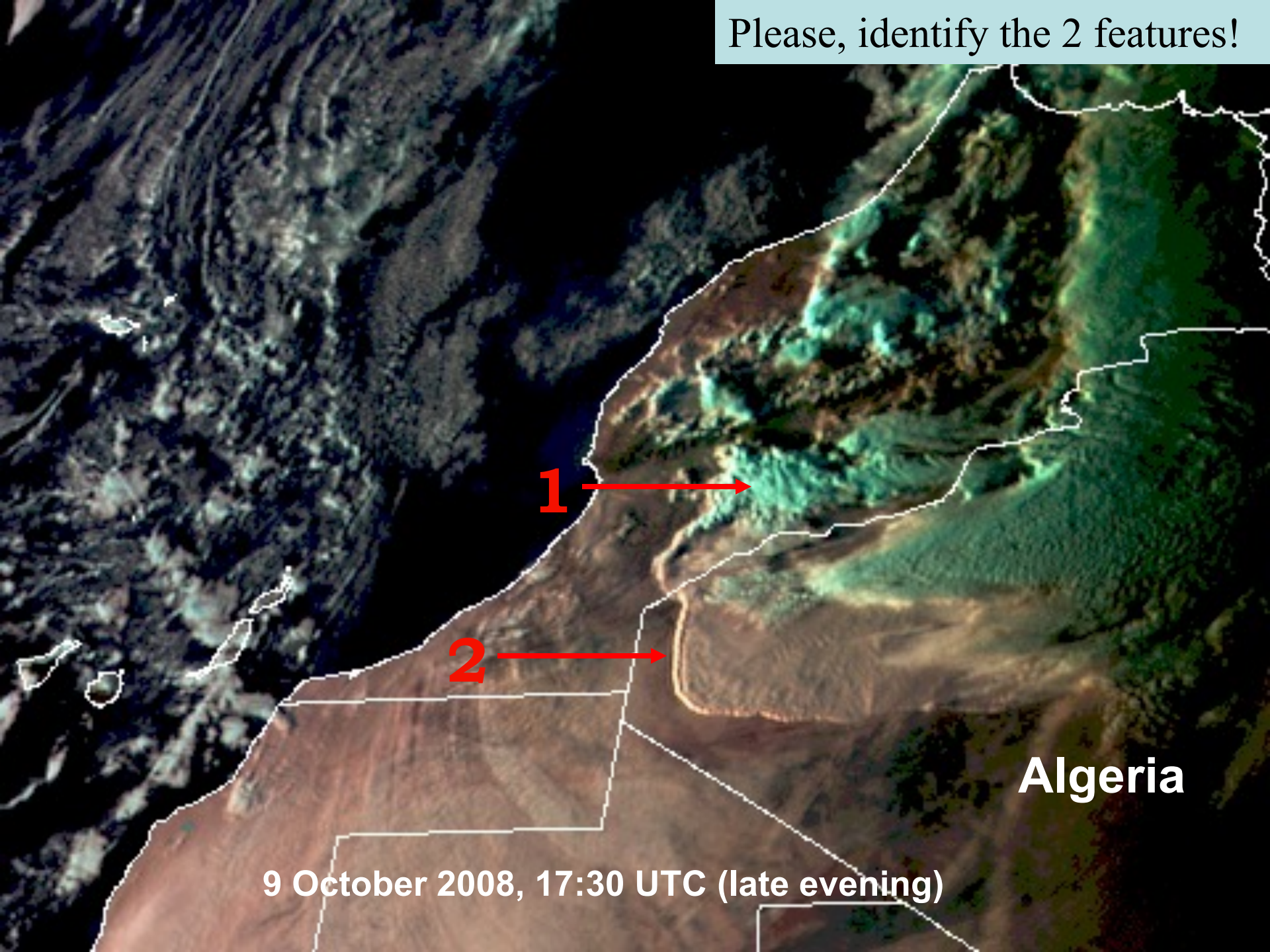
25 Nov 2009, 14:00 UTC

Burned area
(burn scars)

Thin Cirrus

Nigeria

Please, identify the 2 features!

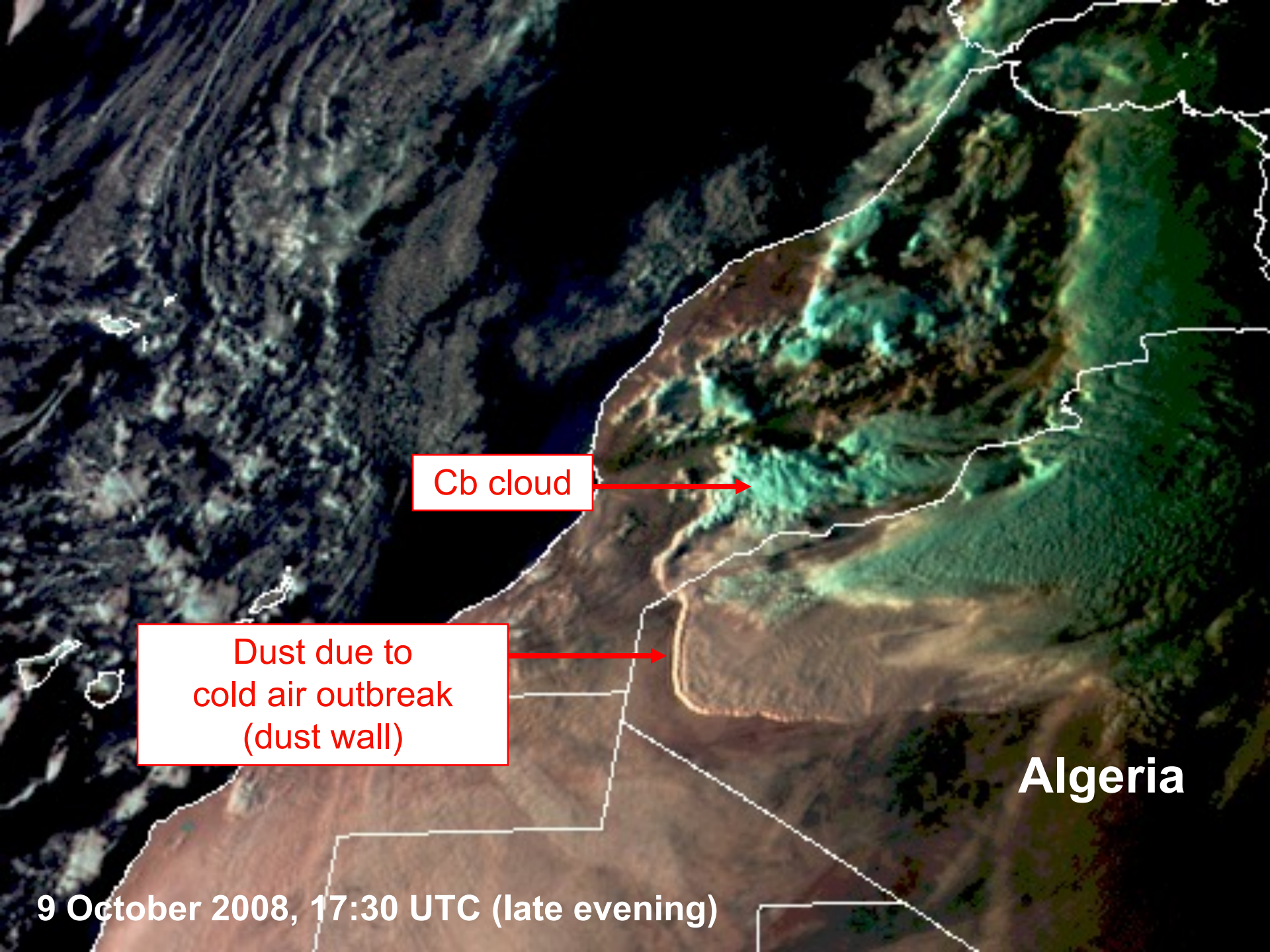


1

2

Algeria

9 October 2008, 17:30 UTC (late evening)



Cb cloud

Dust due to
cold air outbreak
(dust wall)

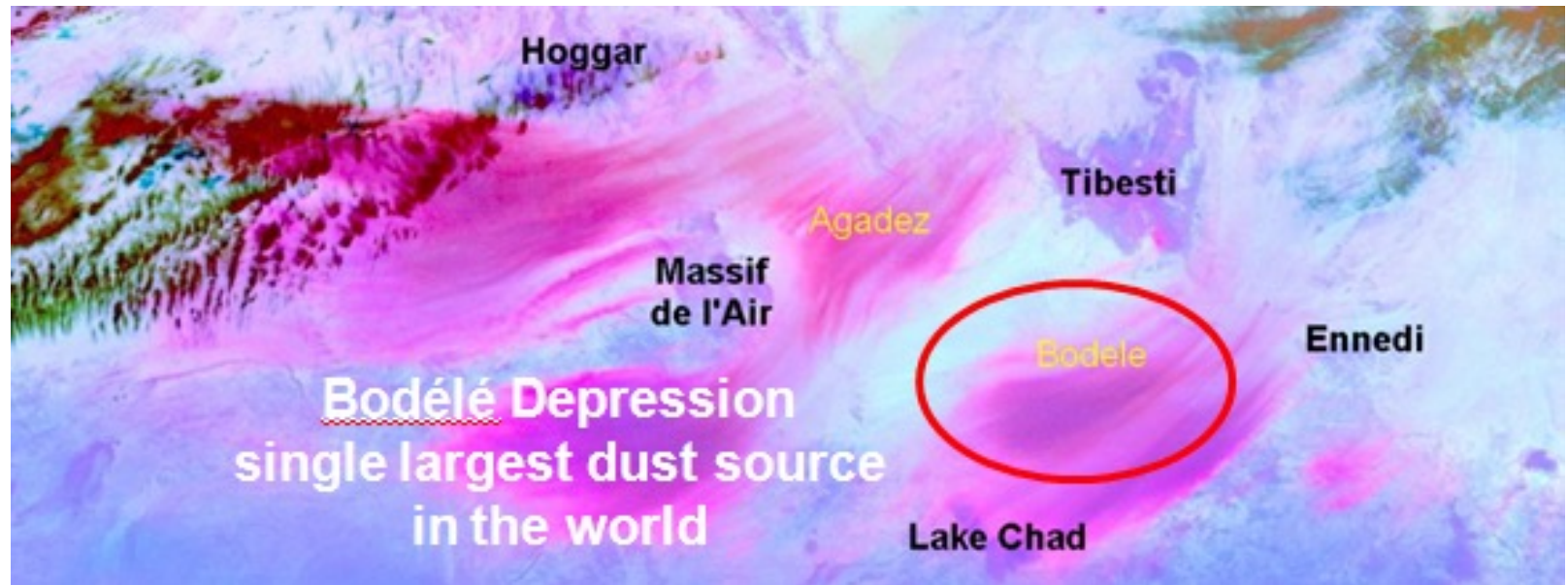
Algeria

9 October 2008, 17:30 UTC (late evening)

General Quiz / Questions

Dust Outbreaks: Ingredients

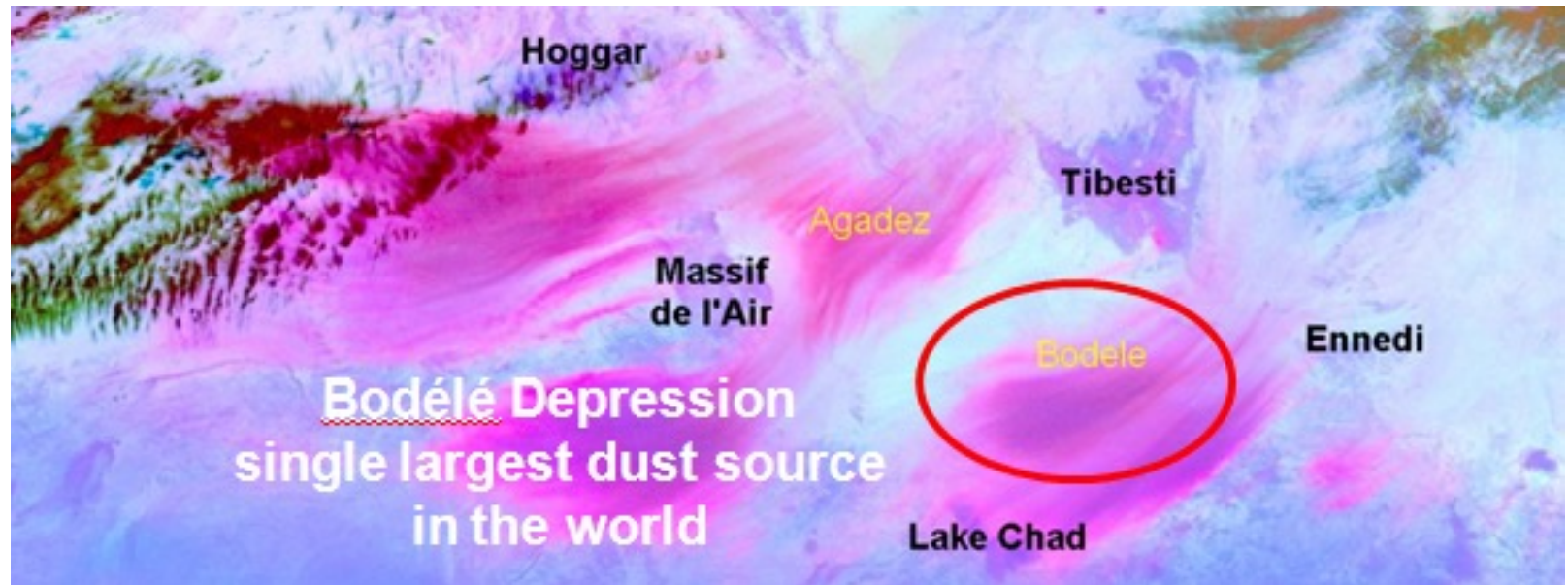
For lifting dust up in the air, which two ingredients must come together?



Dust Outbreaks: Ingredients

For lifting dust up in the air, which two ingredients must come together?

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



Synoptic-Scale Dust Outbreaks (N. Hemisphere)

Which is the main season for synoptic (frontal) dust outbreaks in Northern Africa ?

Winter (Dec-Feb)

☐

Spring (Mar-May)

☐

Summer (Jun-Aug)

☐

Autumn (Sep-Nov)

☐

Synoptic-Scale Dust Outbreaks (N. Hemisphere)

Which is the main season for synoptic (frontal) dust outbreaks in Northern Africa ?

Winter (Dec-Feb)

☐

Spring (Mar-May)

☒

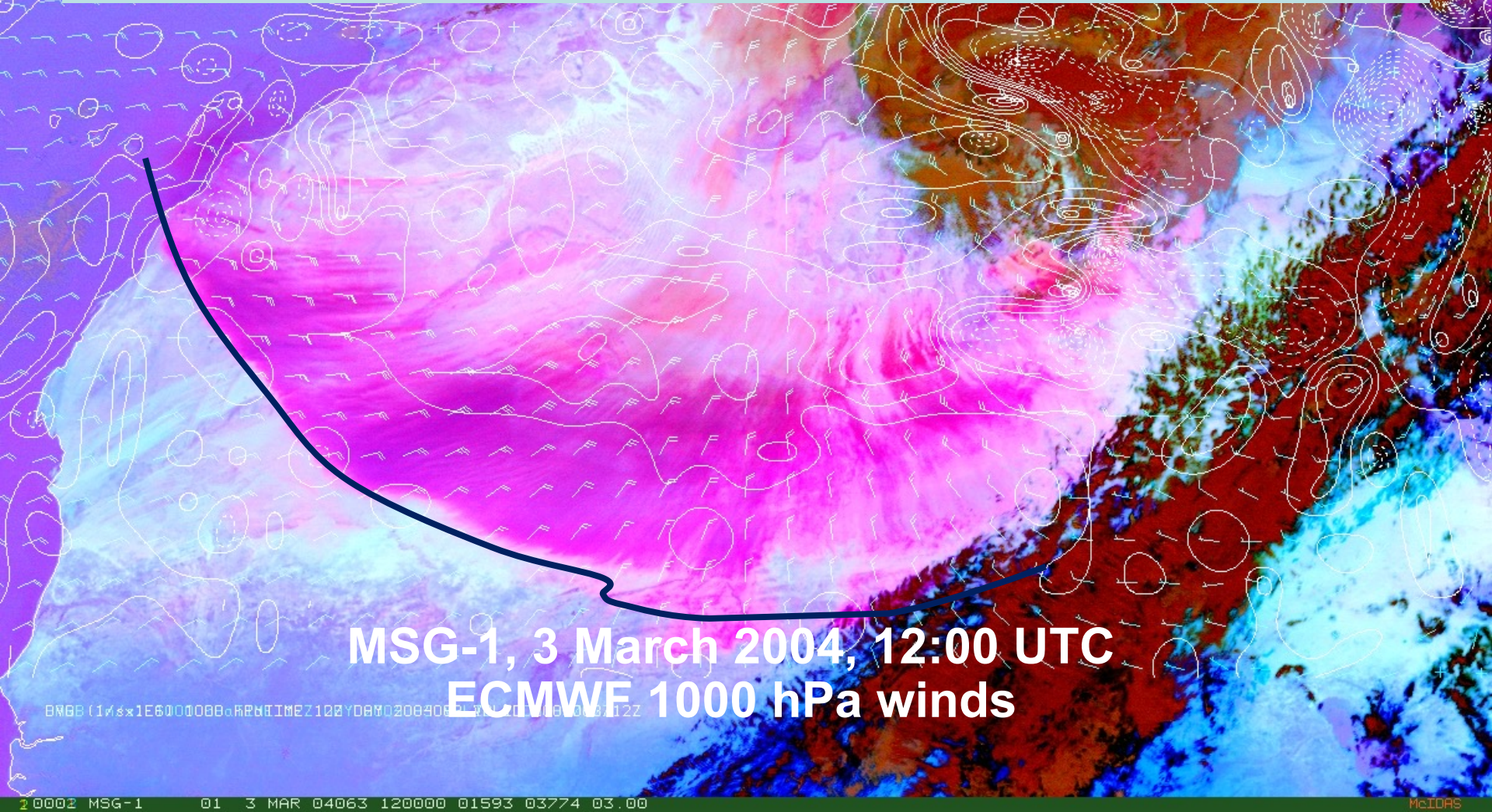
Summer (Jun-Aug)

☐

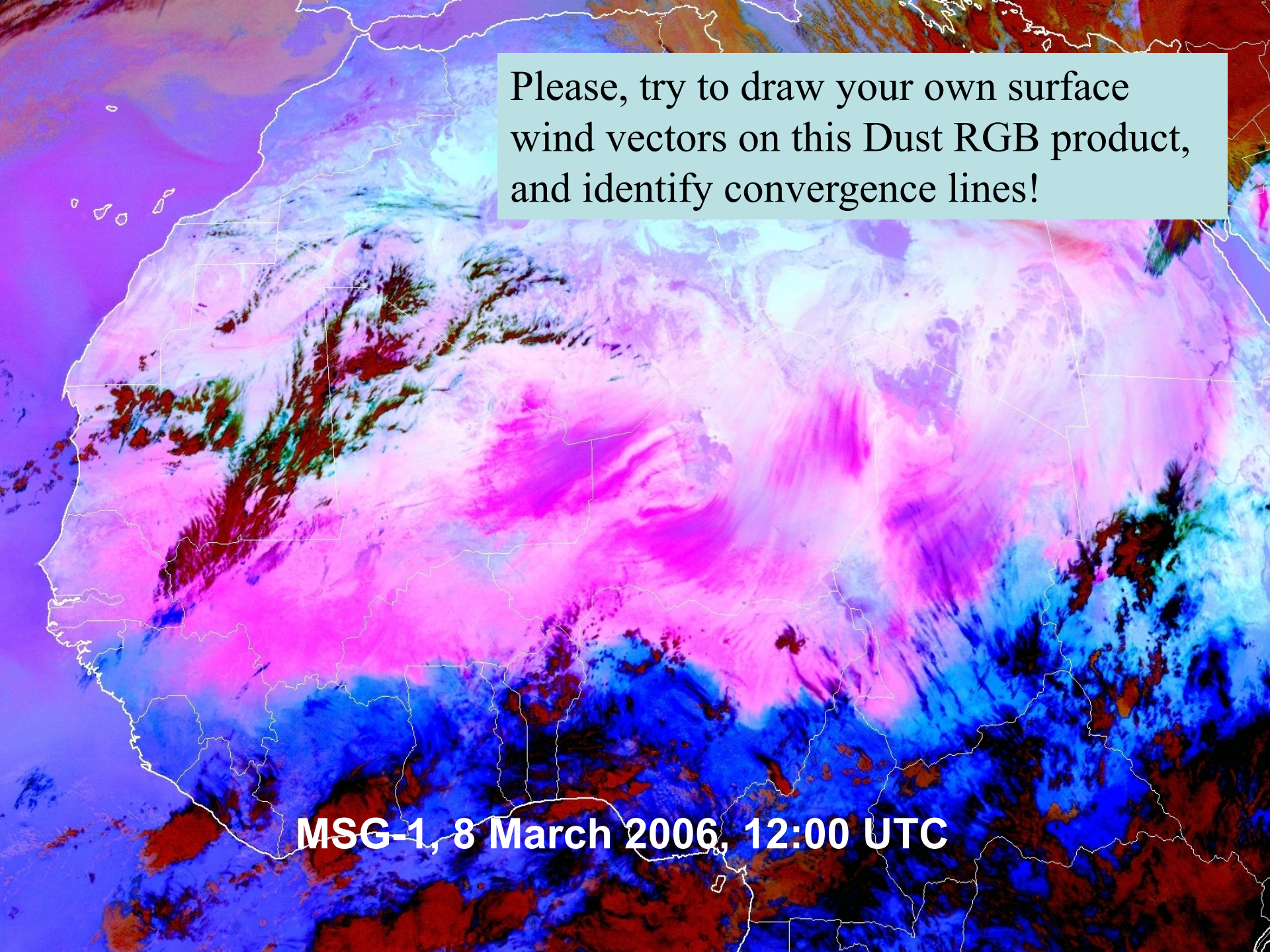
Autumn (Sep-Nov)

☐

The near-surface winds are strong just to the rear of the front, serving to push it forward in time
The leading edge of dust marks the advancement of one air mass into another
The field of vectors just behind the dust front suggests anticyclonic curvature indicative of a post-frontal region of high pressure

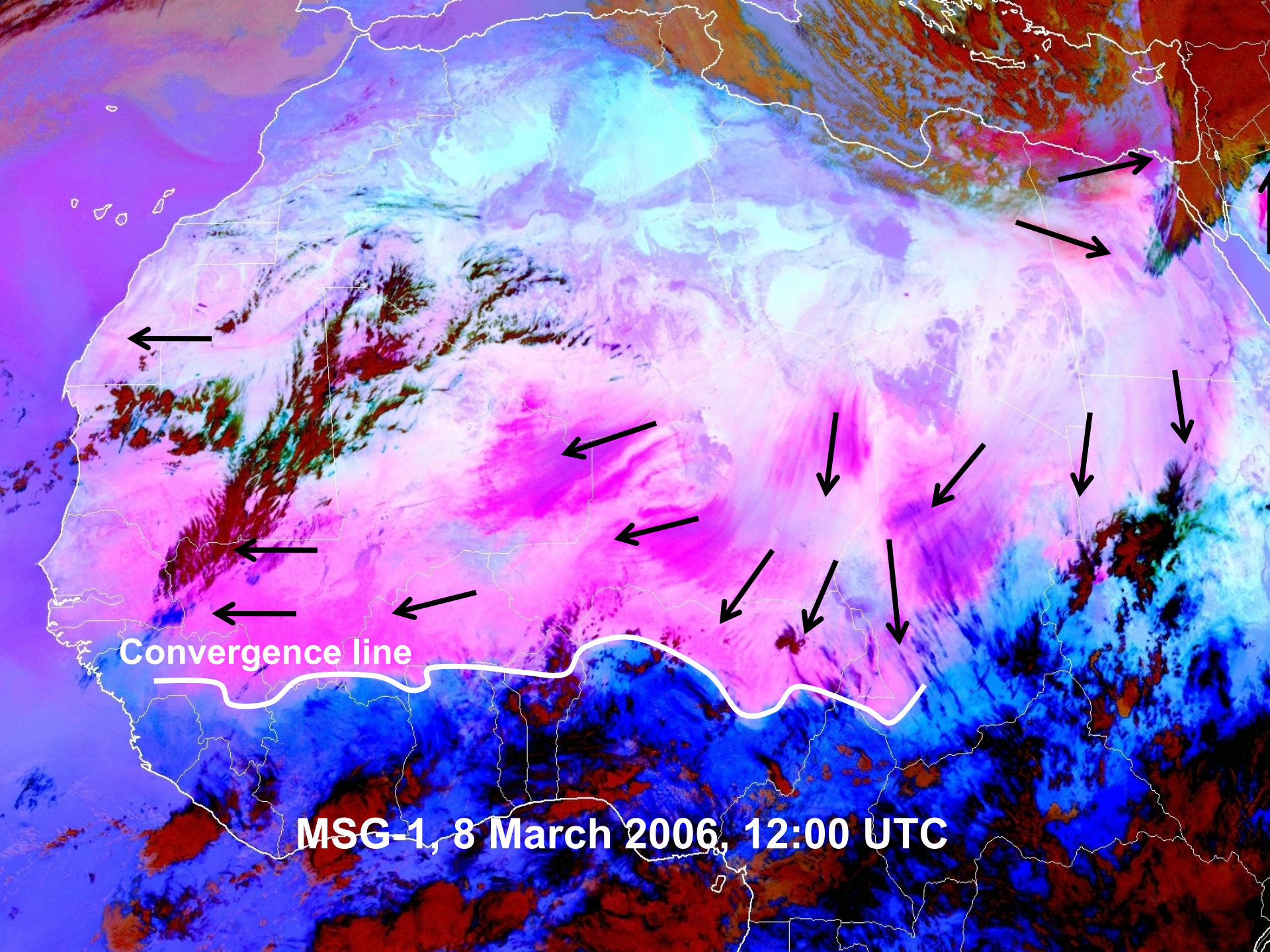


[illegible][illegible][illegible]

A satellite image of Africa and surrounding regions, processed as a Dust RGB product. The map shows various dust concentrations using a color scale where red and brown indicate higher dust levels, and blue and green indicate lower levels. A large, prominent red and brown area is visible in the central and eastern parts of the continent, likely representing a major dust source or transport event. The image is overlaid with a light blue text box in the upper right corner and a white text box at the bottom center.

Please, try to draw your own surface
wind vectors on this Dust RGB product,
and identify convergence lines!

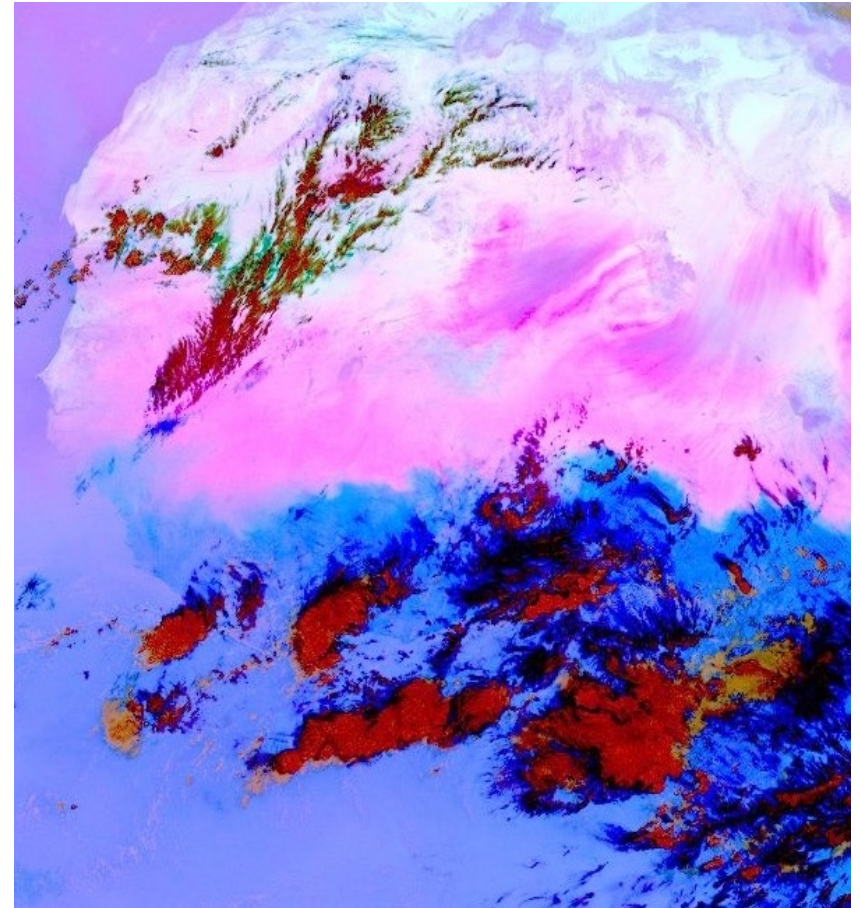
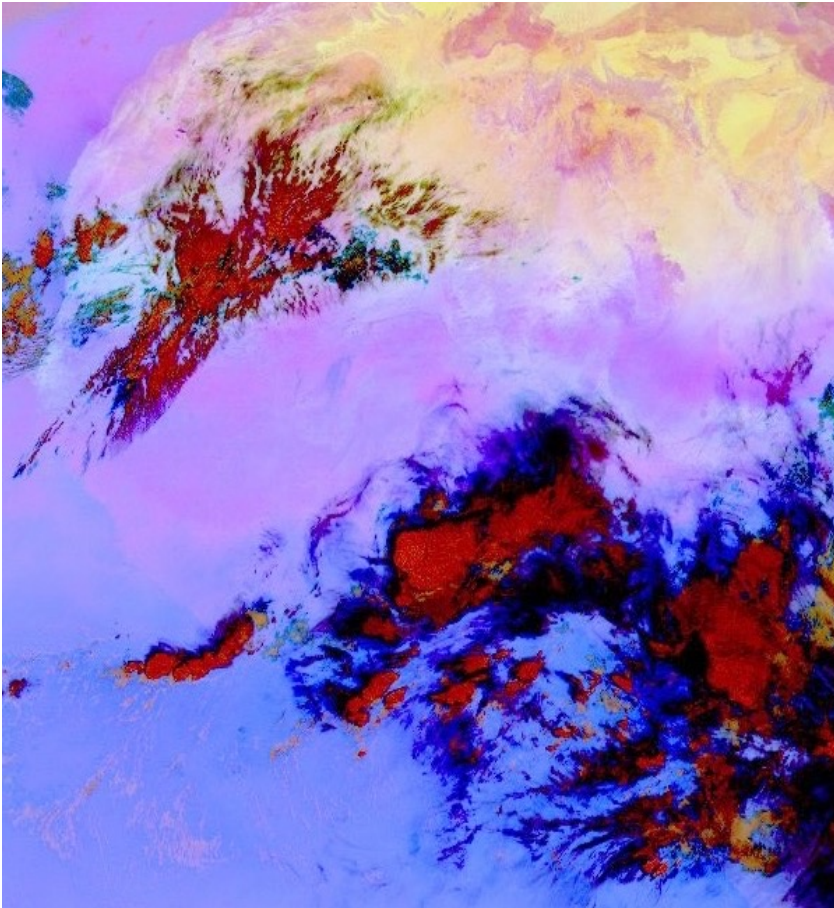
MSG-1, 8 March 2006, 12:00 UTC



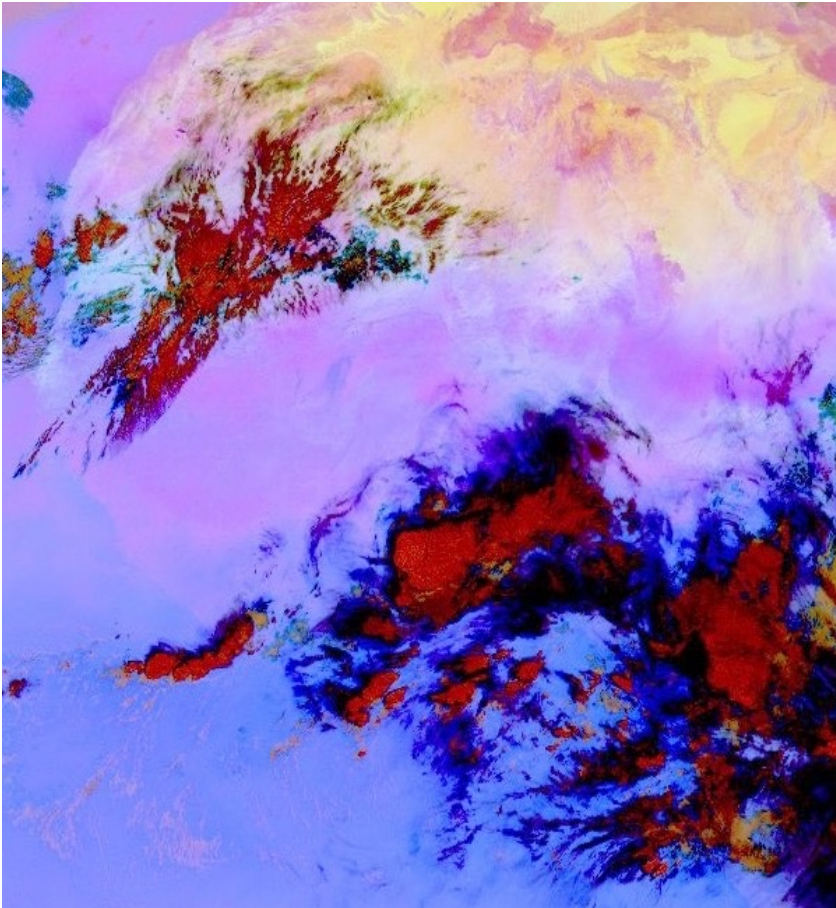
Convergence line

MSG-1, 8 March 2006, 12:00 UTC

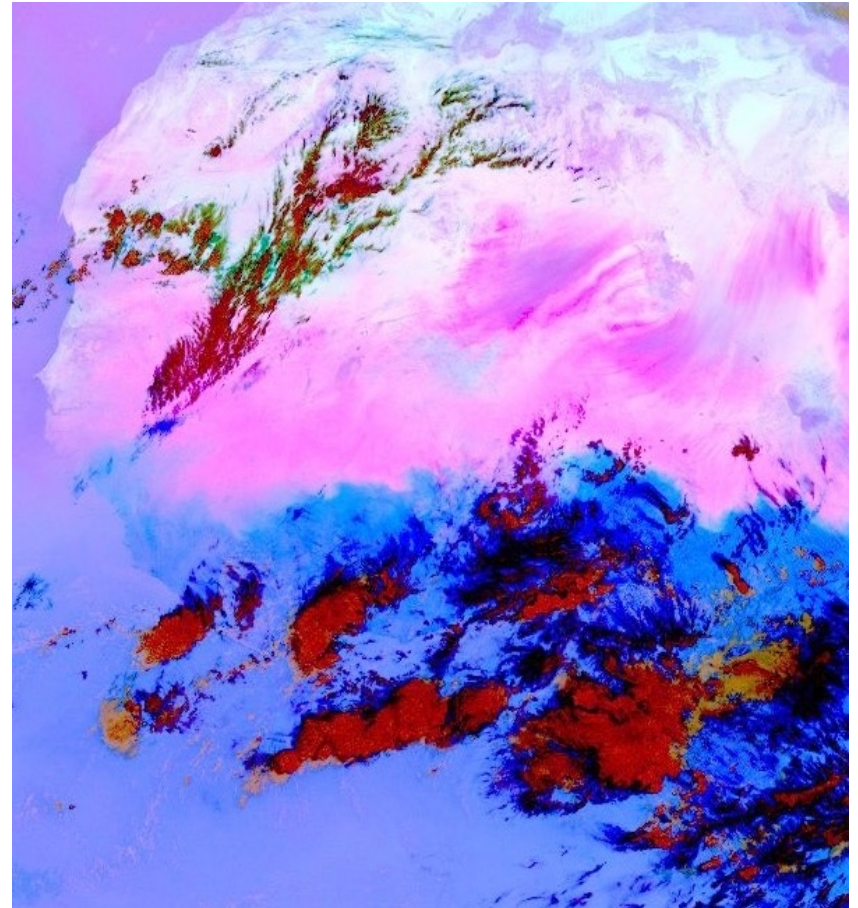
Which image is night, and which daytime?



MSG-1, 8 March 2006



Night (00:00 UTC)



Day (12:00 UTC)

MSG-1, 8 March 2006

Which type of dust outbreak is this ?

Algeria

Libya

Synoptic: Post-frontal

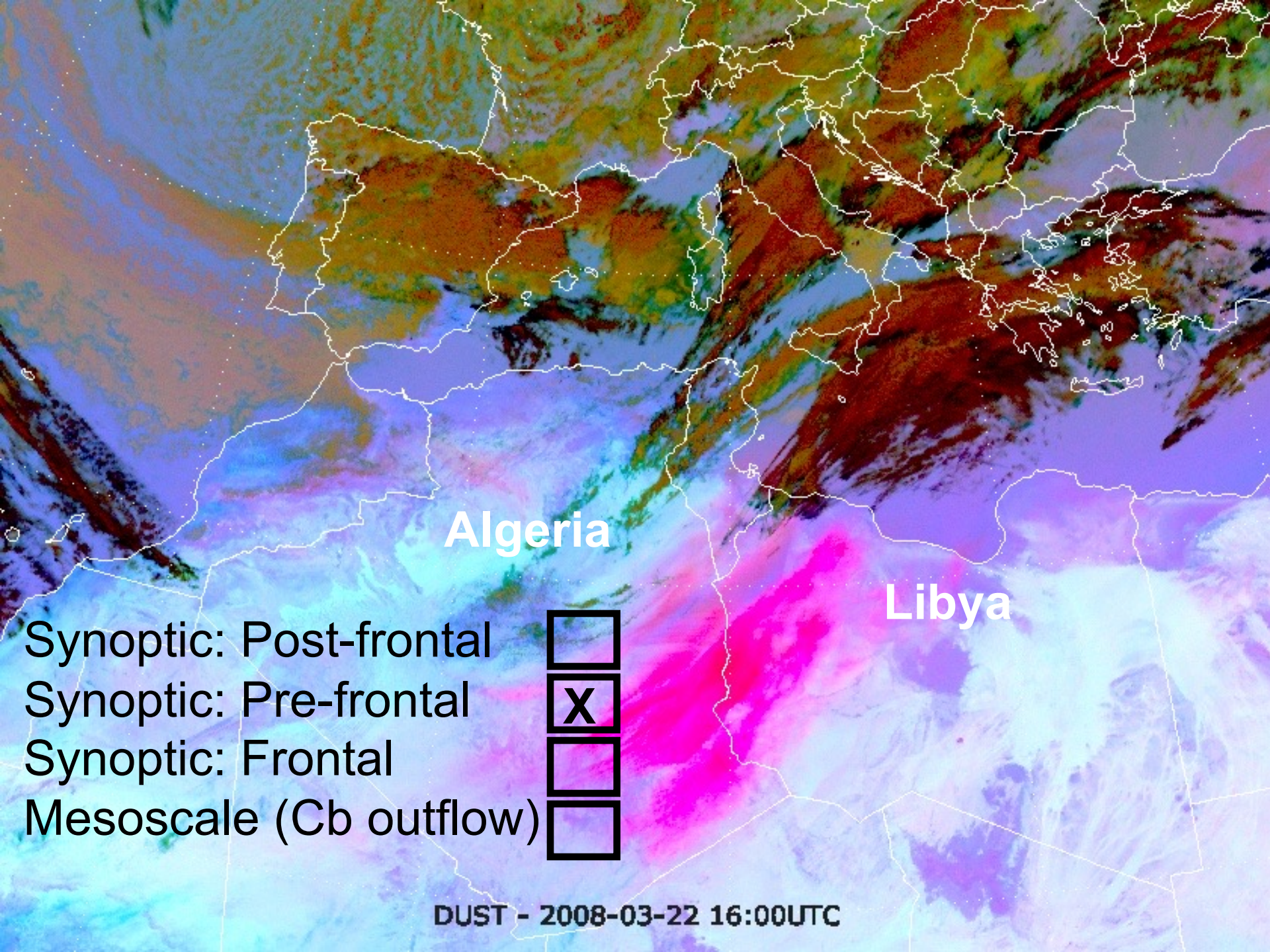
Synoptic: Pre-frontal

Synoptic: Frontal

Mesoscale (Cb outflow)



DUST - 2008-03-22 16:00UTC



Algeria

Libya

Synoptic: Post-frontal

Synoptic: Pre-frontal

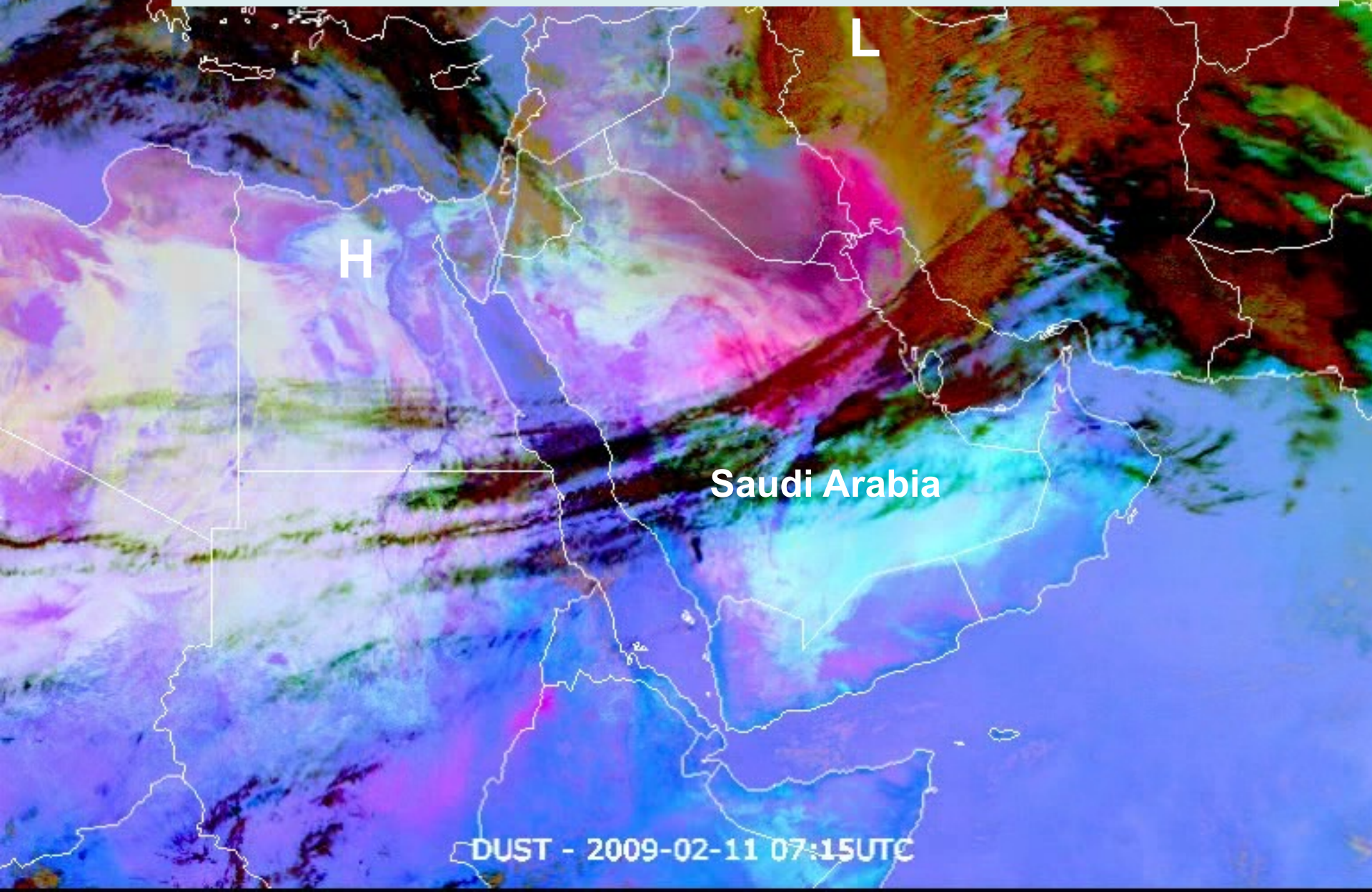
Synoptic: Frontal

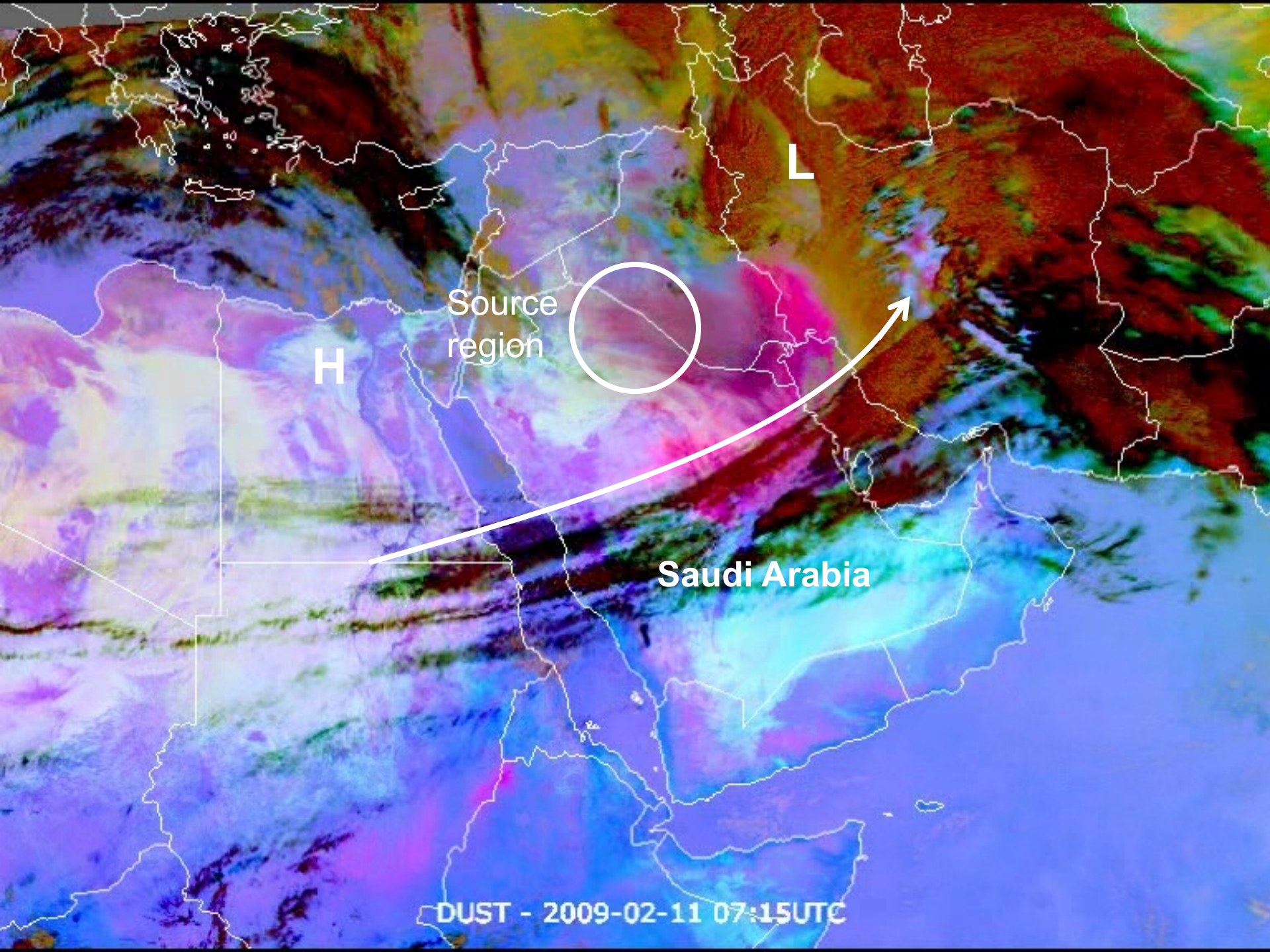
Mesoscale (Cb outflow)



DUST - 2008-03-22 16:00UTC

Where is the source region of this dust cloud ?
Mark the position of the Jet Stream !





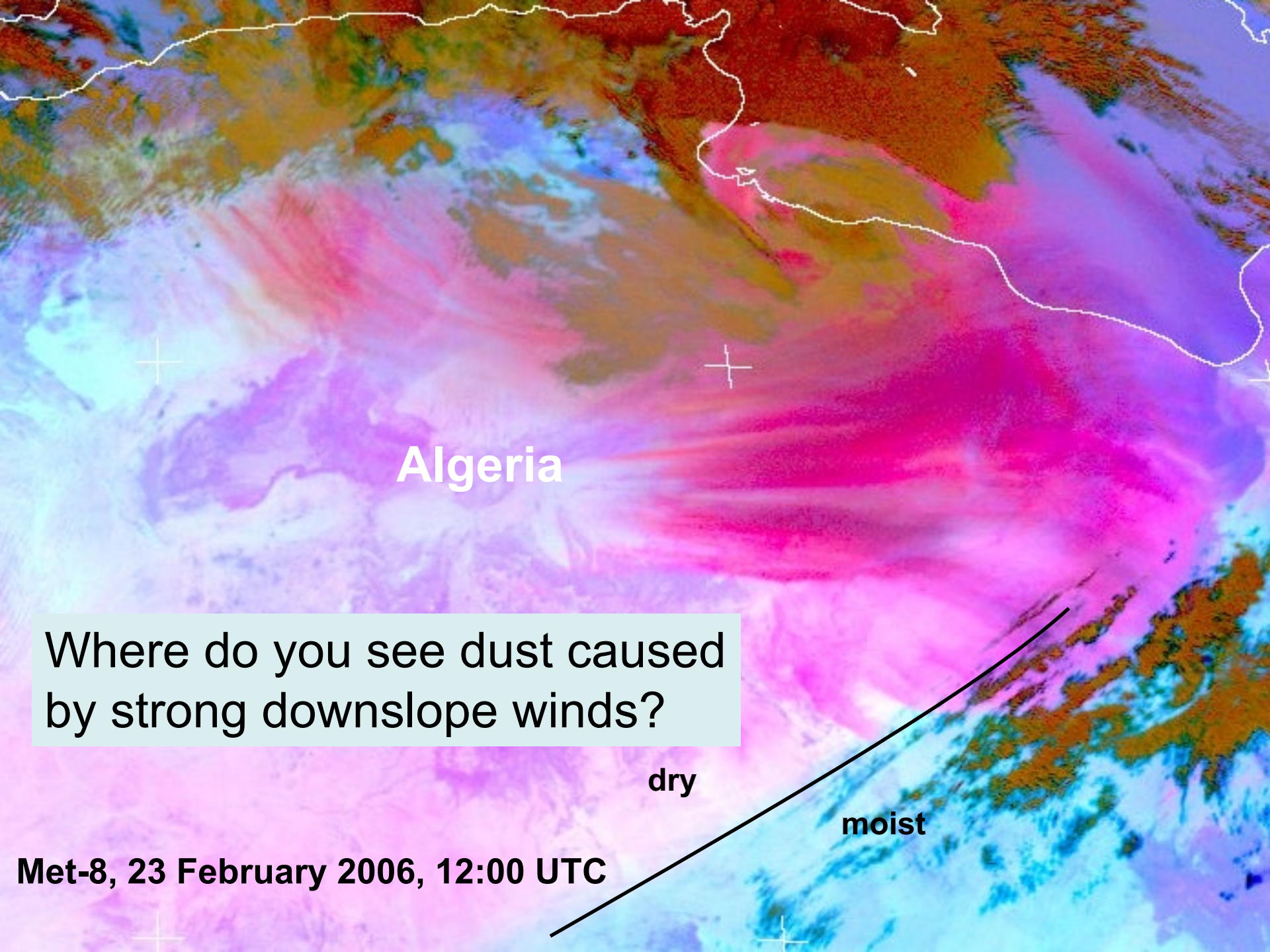
Source
region

H

L

Saudi Arabia

DUST - 2009-02-11 07:15UTC



Algeria

Where do you see dust caused
by strong downslope winds?

dry

moist

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

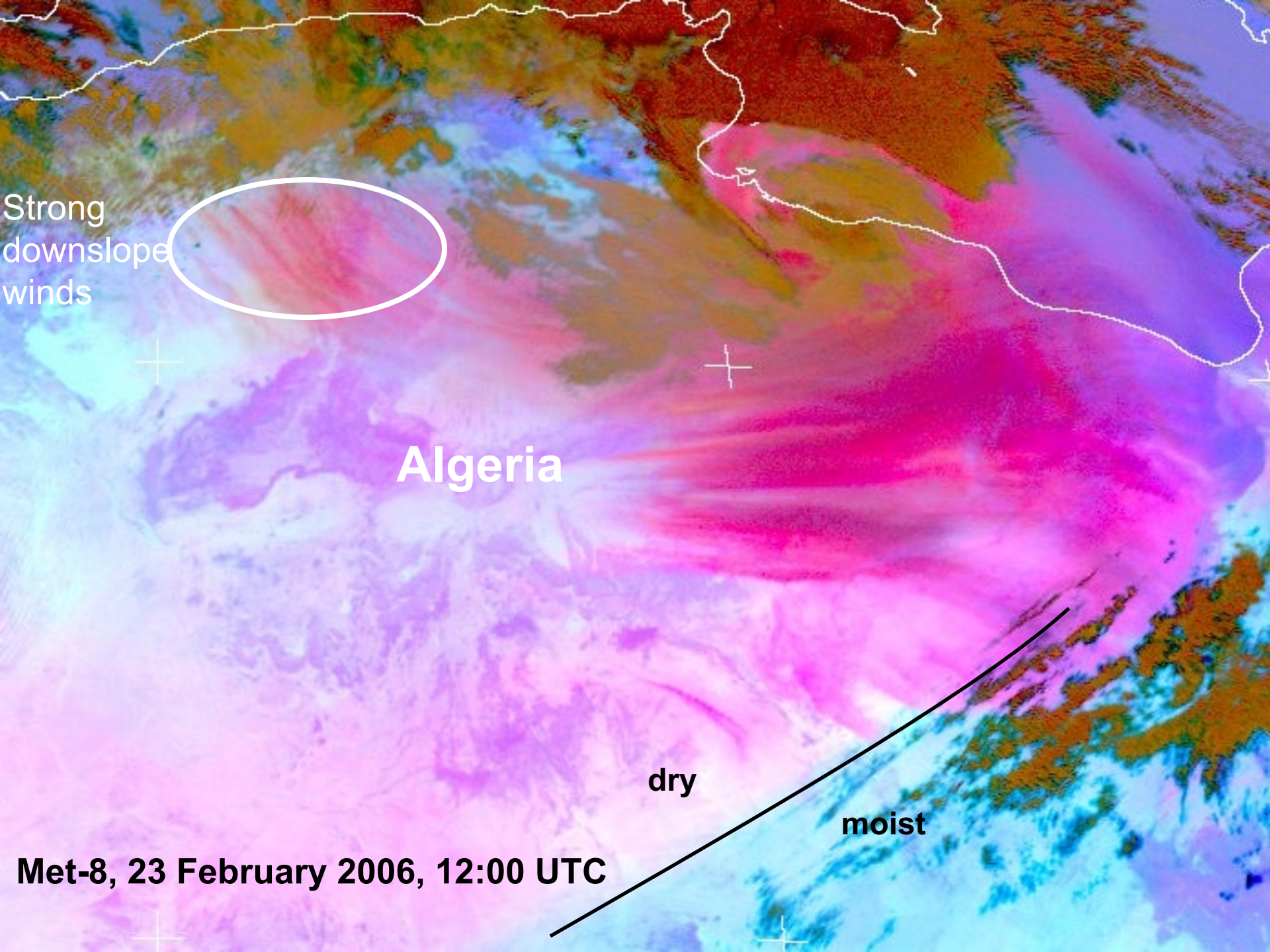
Strong
downslope
winds

Algeria

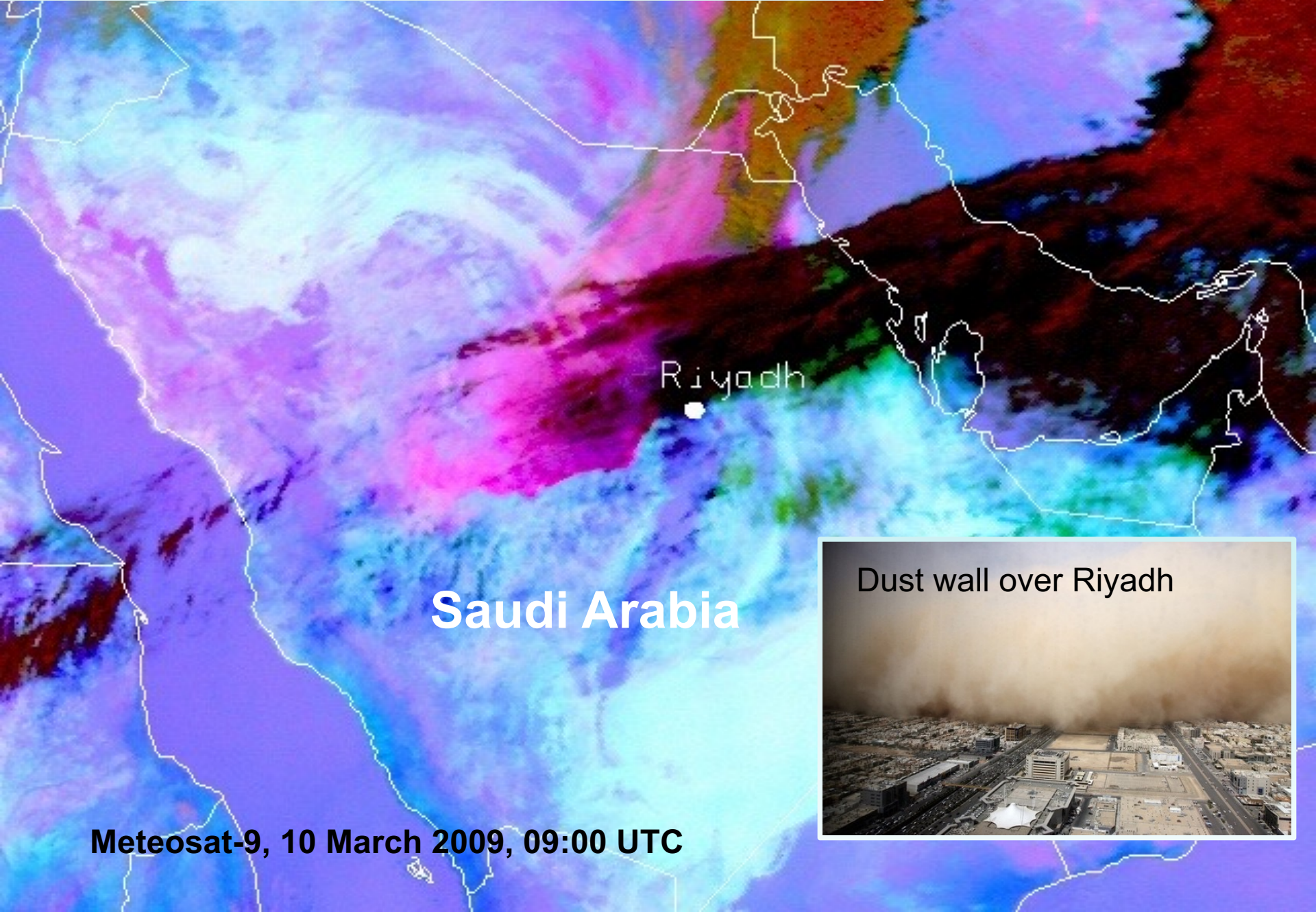
dry

moist

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



Mark the position of the Jet Streams !



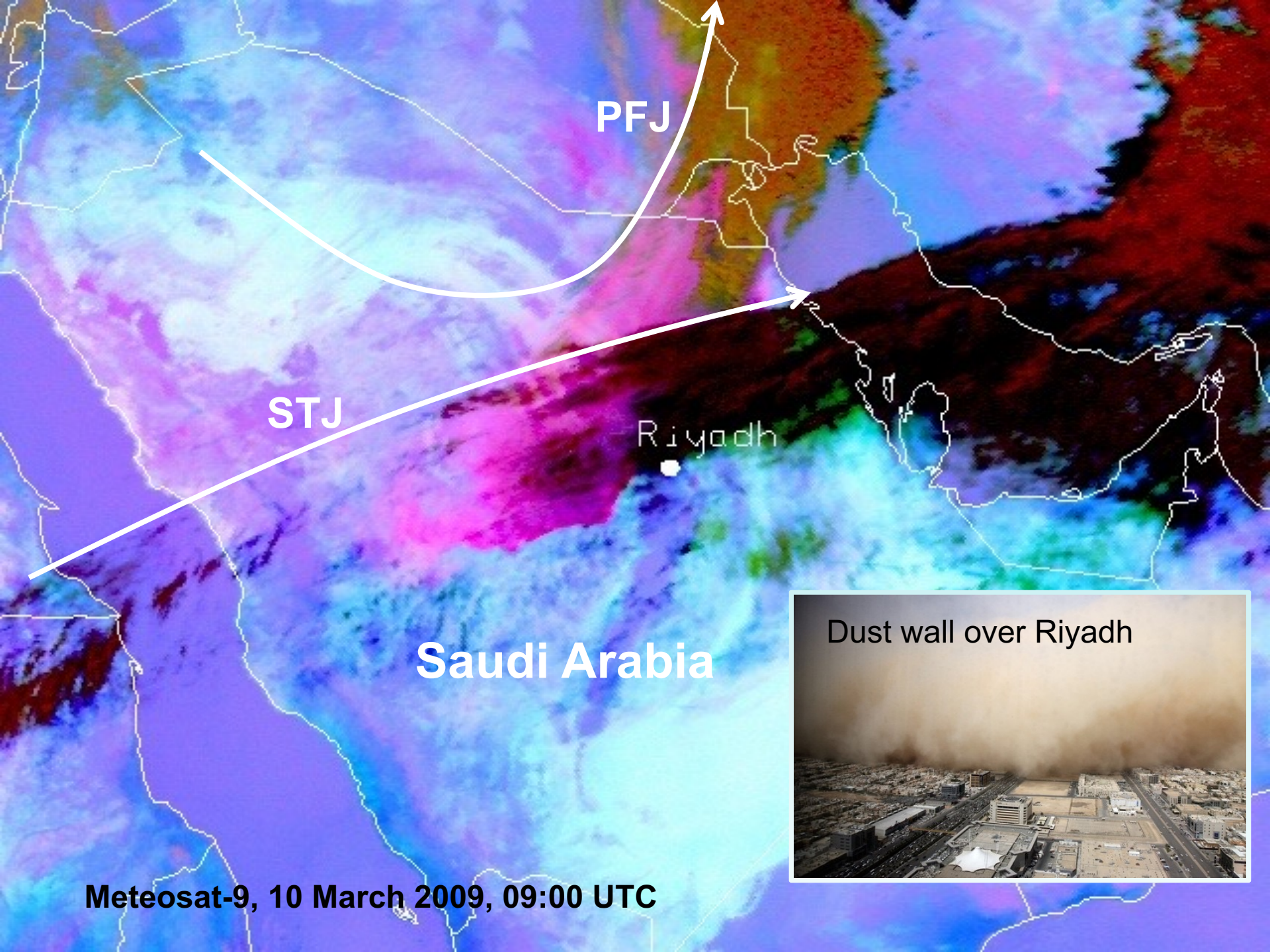
Riyadh

Saudi Arabia

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

Dust wall over Riyadh





PFJ

STJ

Riyadh

Saudi Arabia

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

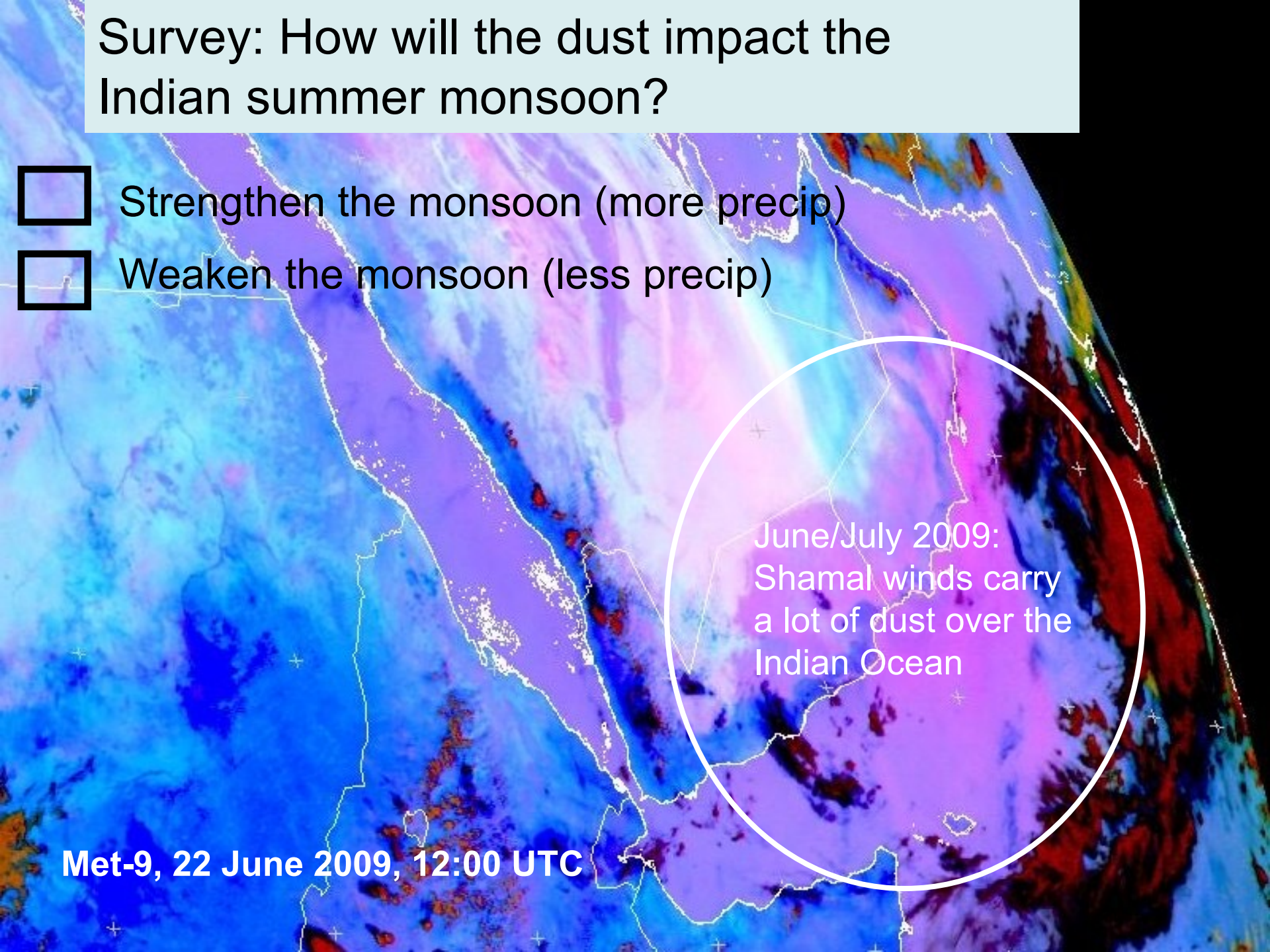
Dust wall over Riyadh



Survey: How will the dust impact the Indian summer monsoon?

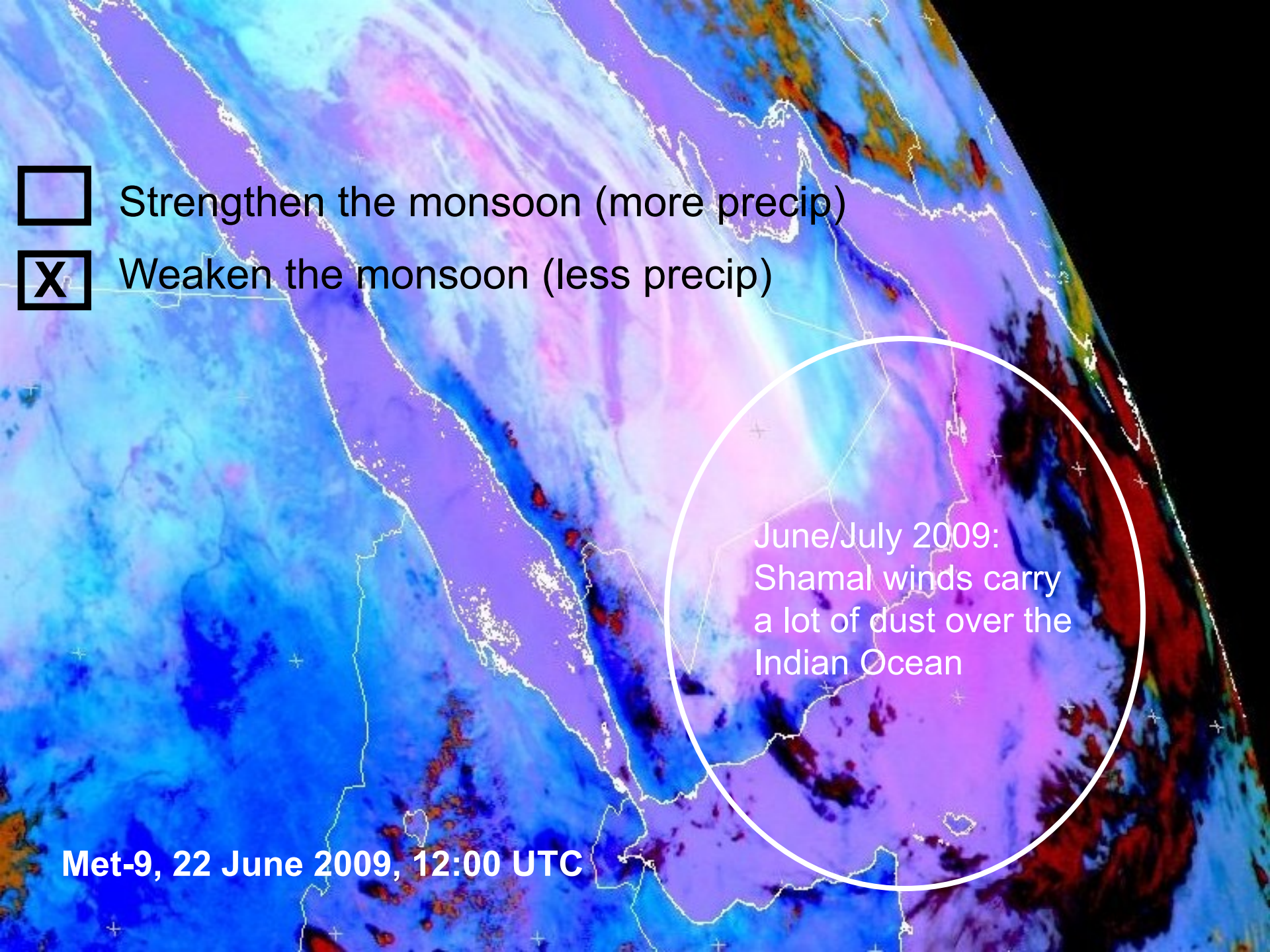
 Strengthen the monsoon (more precip)

 Weaken the monsoon (less precip)



June/July 2009:
Shamal winds carry
a lot of dust over the
Indian Ocean

Met-9, 22 June 2009, 12:00 UTC



Strengthen the monsoon (more precip)

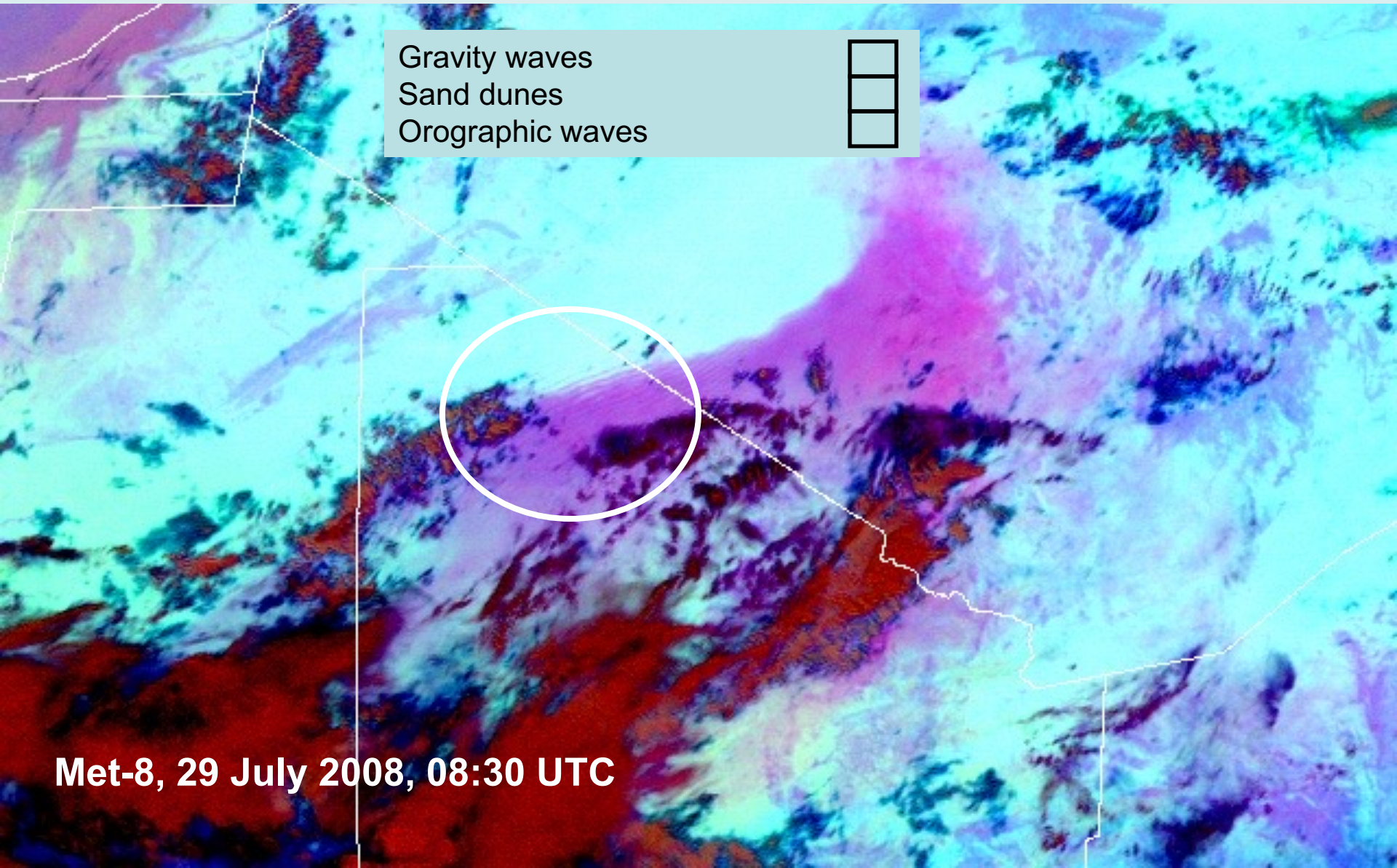


Weaken the monsoon (less precip)

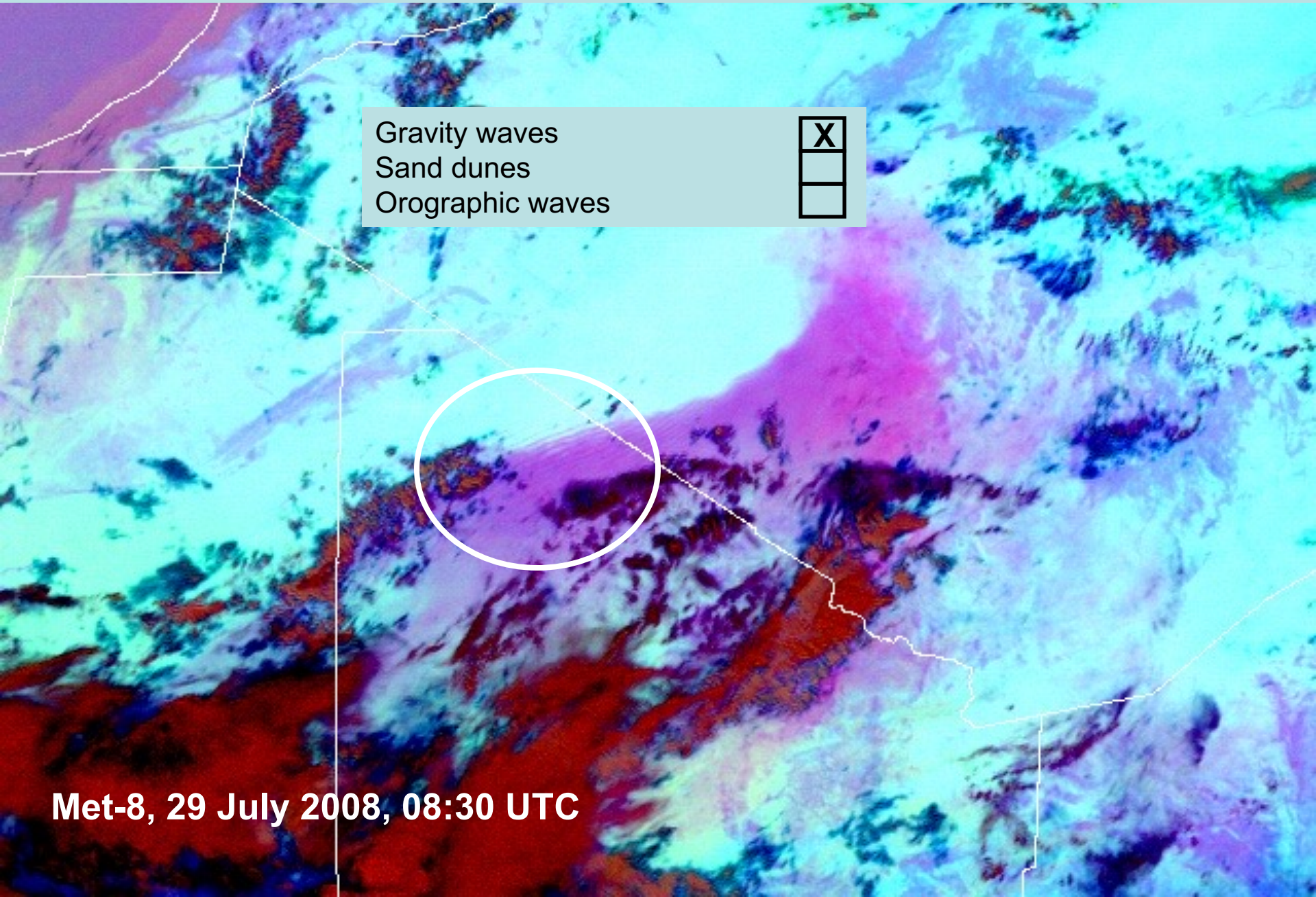
June/July 2009:
Shamal winds carry
a lot of dust over the
Indian Ocean

Met-9, 22 June 2009, 12:00 UTC

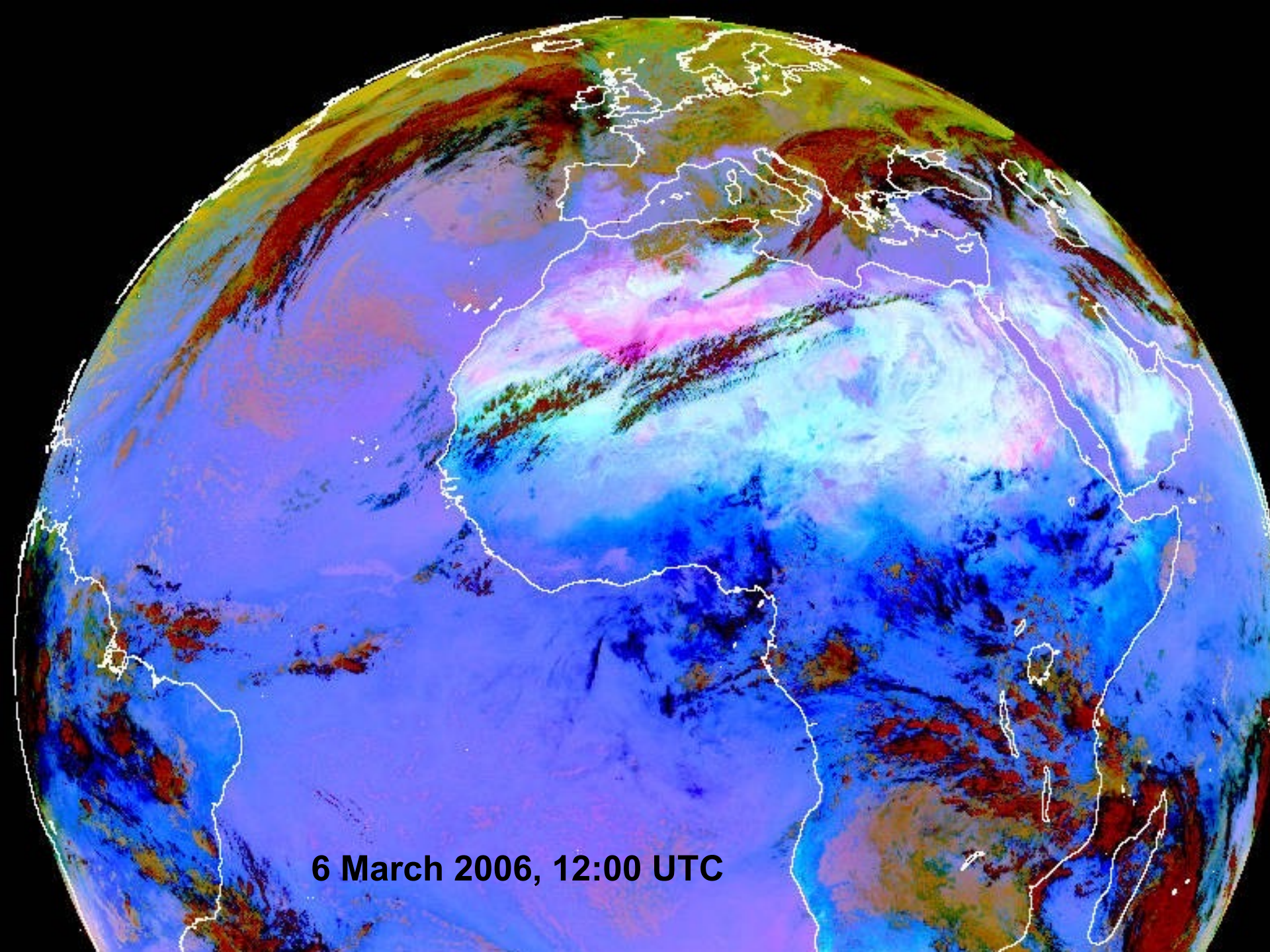
Look at this gust front (dust squall) caused by thunderstorms.
What is the feature in the white circle ?
What is strange with this Dust RGB image ?



This is a modified Dust RGB product, called the 24-hour Microphysics RGB, with a different range for the Green beam (0-6 K, instead of 0-15 K)

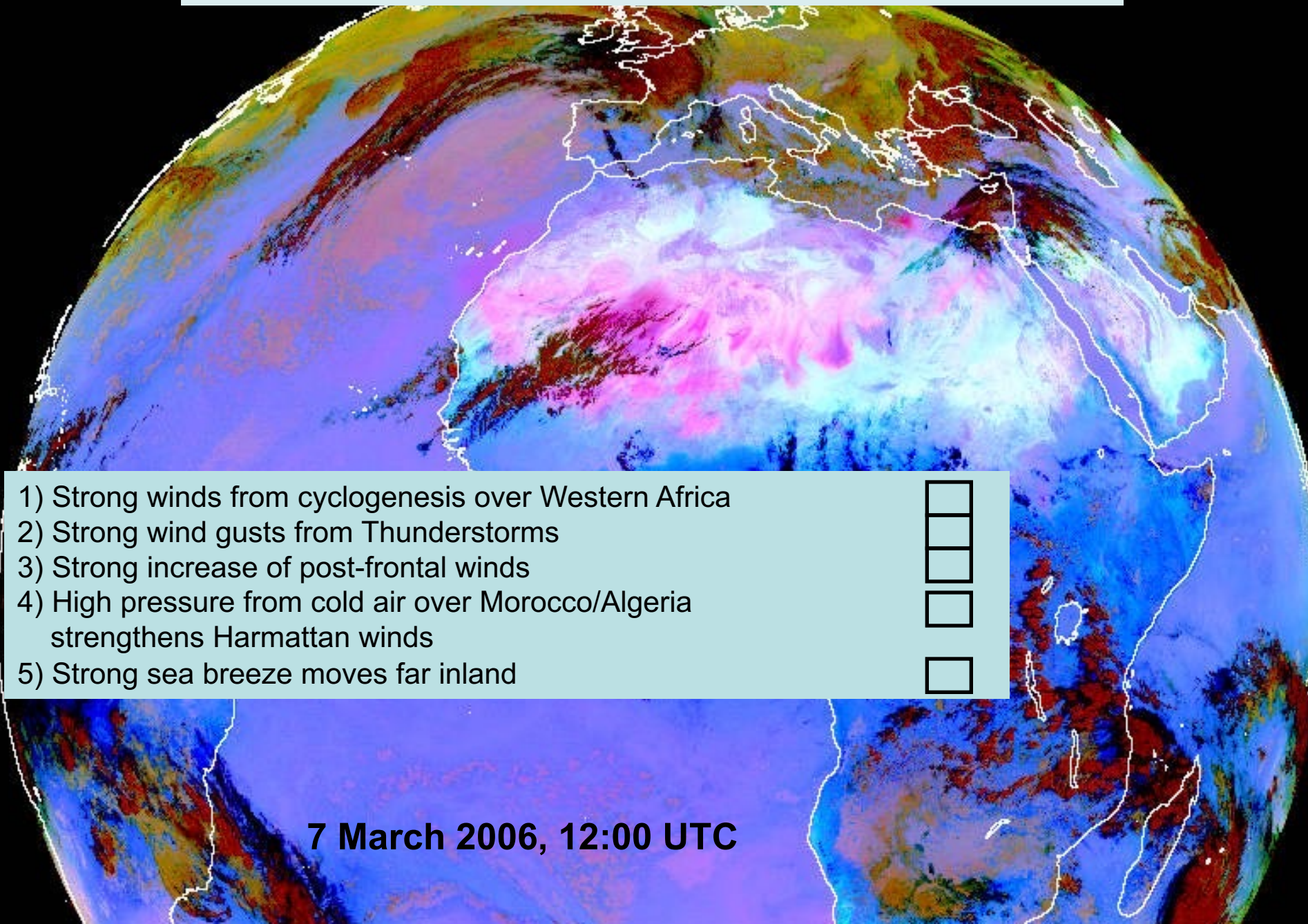


Met-8, 29 July 2008, 08:30 UTC



6 March 2006, 12:00 UTC

Why is there “suddenly” so much dust ?

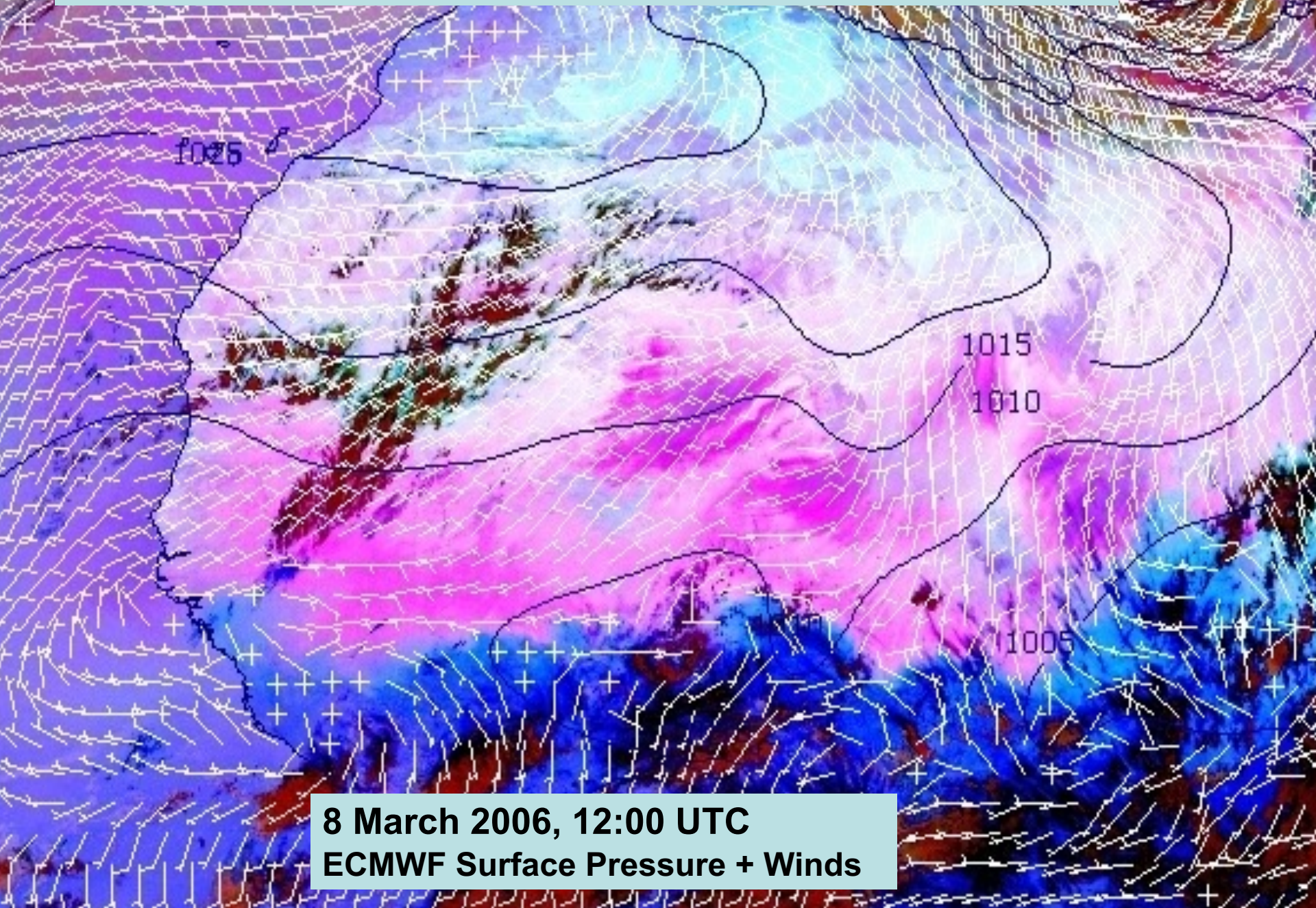


- 1) Strong winds from cyclogenesis over Western Africa
- 2) Strong wind gusts from Thunderstorms
- 3) Strong increase of post-frontal winds
- 4) High pressure from cold air over Morocco/Algeria strengthens Harmattan winds
- 5) Strong sea breeze moves far inland

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>

7 March 2006, 12:00 UTC

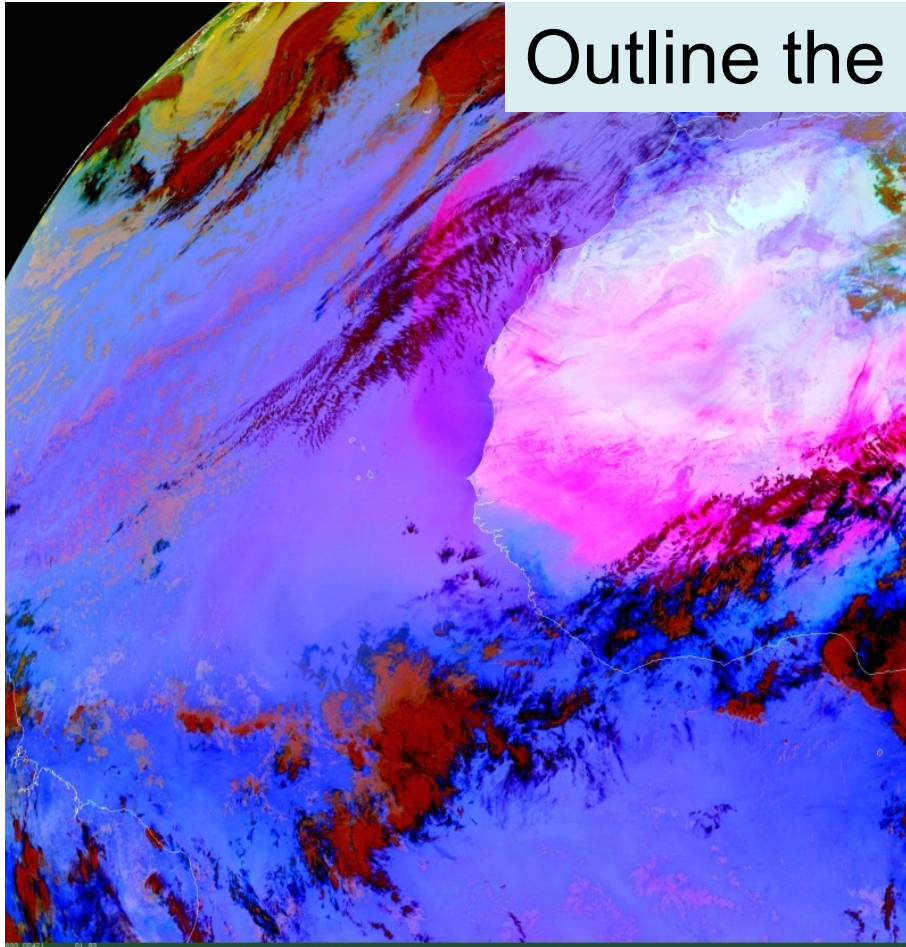
Answer: Cold air outbreak from Europe to North Africa leads to high pressure over Morocco/Algeria which strengthens Harmattan winds !



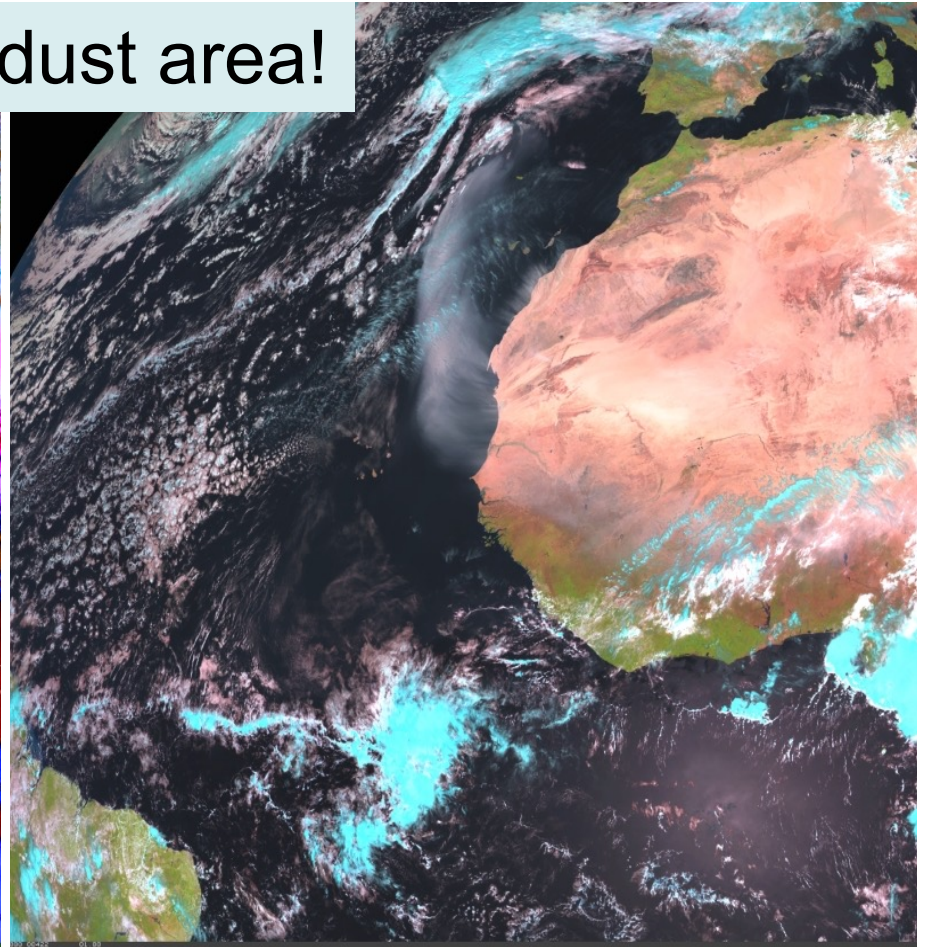
8 March 2006, 12:00 UTC
ECMWF Surface Pressure + Winds

Detection/Outline of Dust Clouds

Outline the dust area!

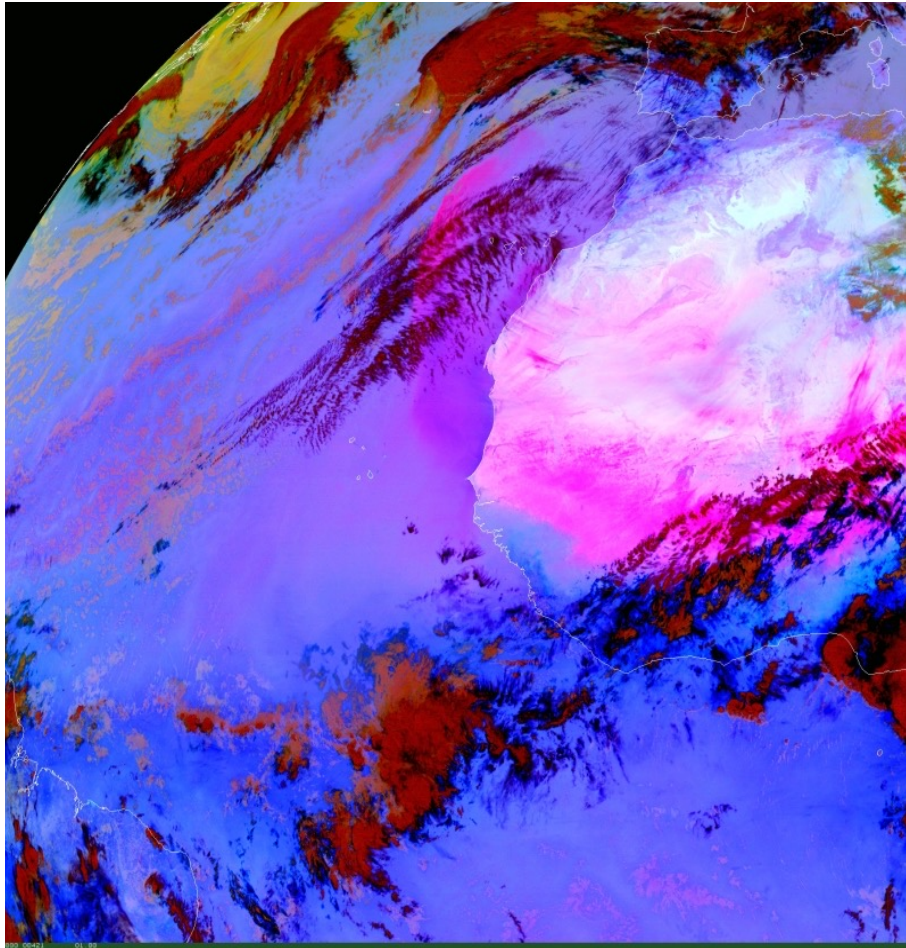


Dust RGB

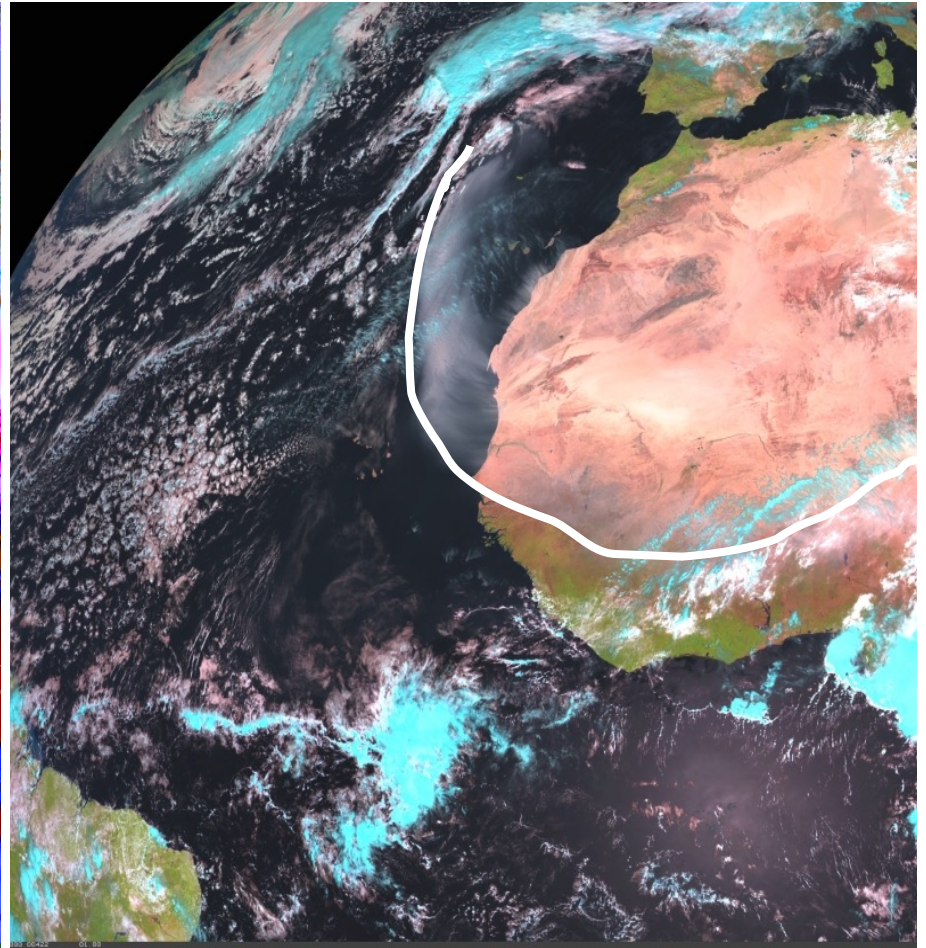


Natural Colours RGB

MSG-1, 04 March 2004, 12:00 UTC



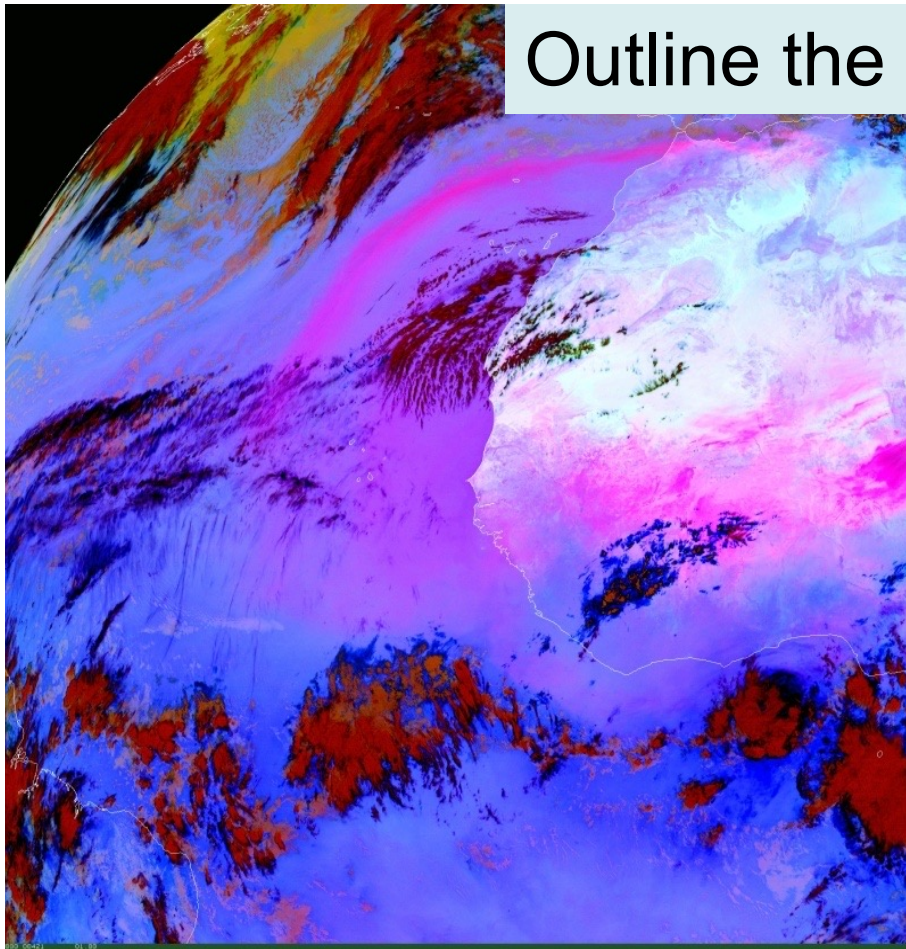
Dust RGB



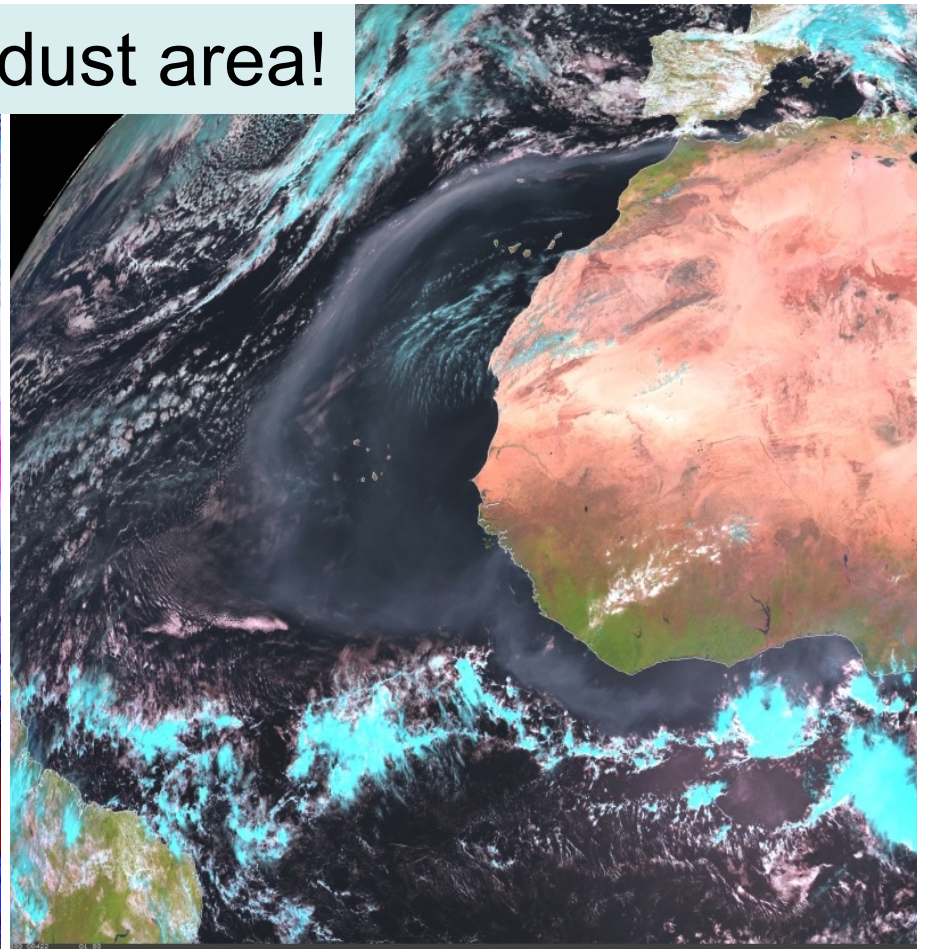
Natural Colours RGB

MSG-1, 04 March 2004, 12:00 UTC

Outline the dust area!

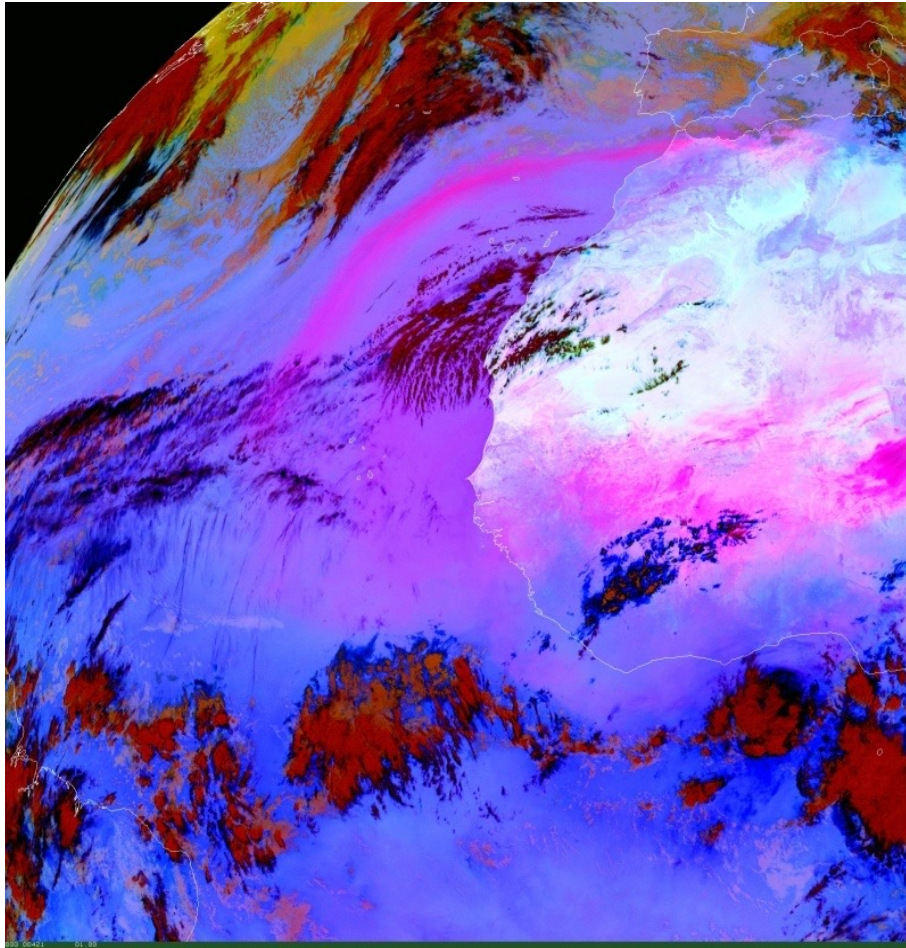


Dust RGB

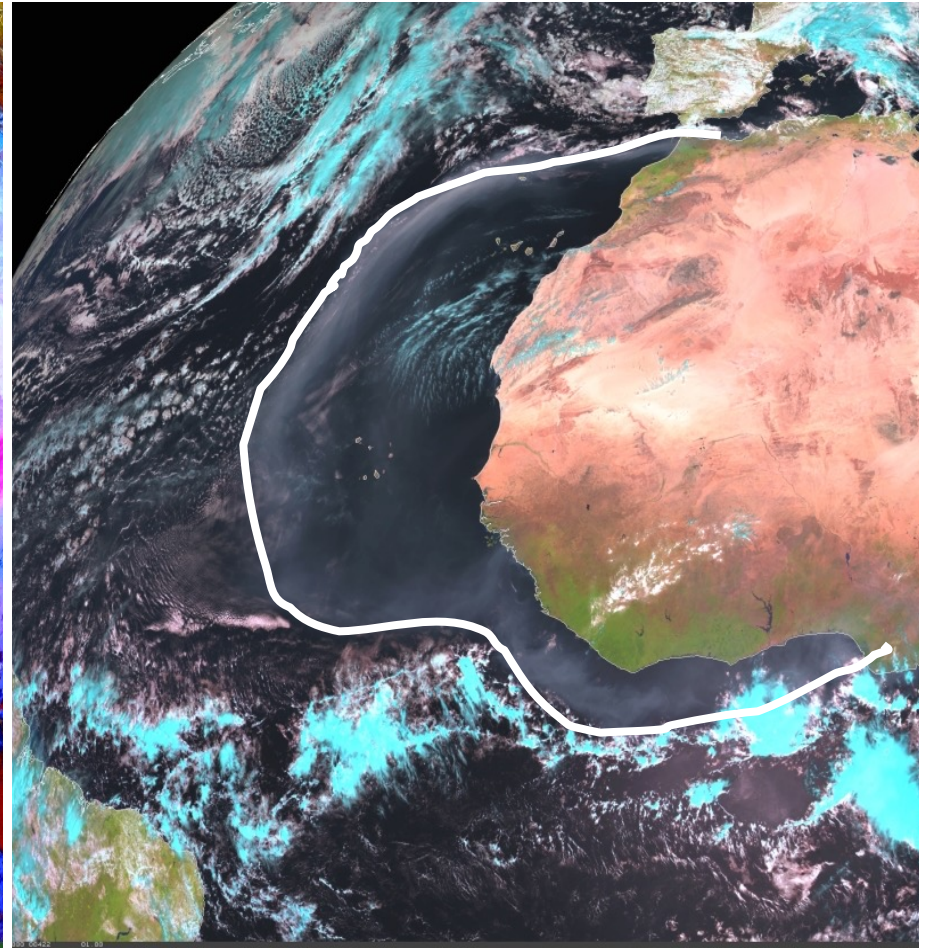


Natural Colours RGB

MSG-1, 06 March 2004, 12:00 UTC



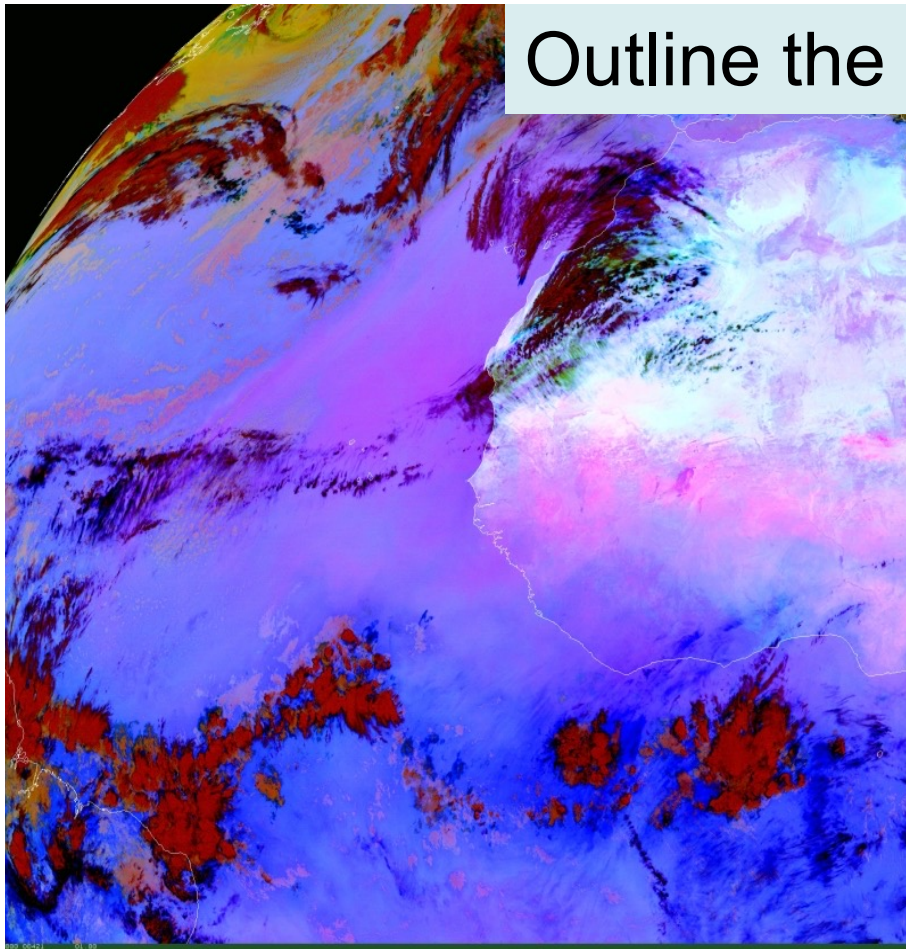
Dust RGB



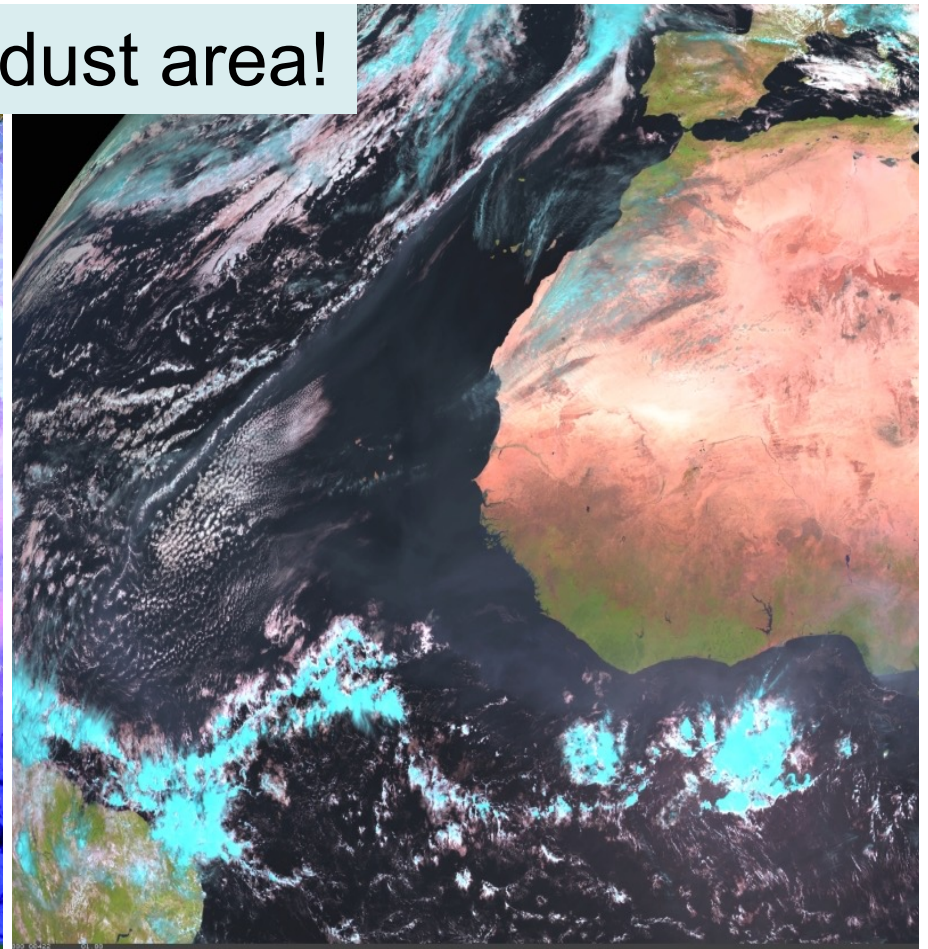
Natural Colours RGB

MSG-1, 06 March 2004, 12:00 UTC

Outline the dust area!

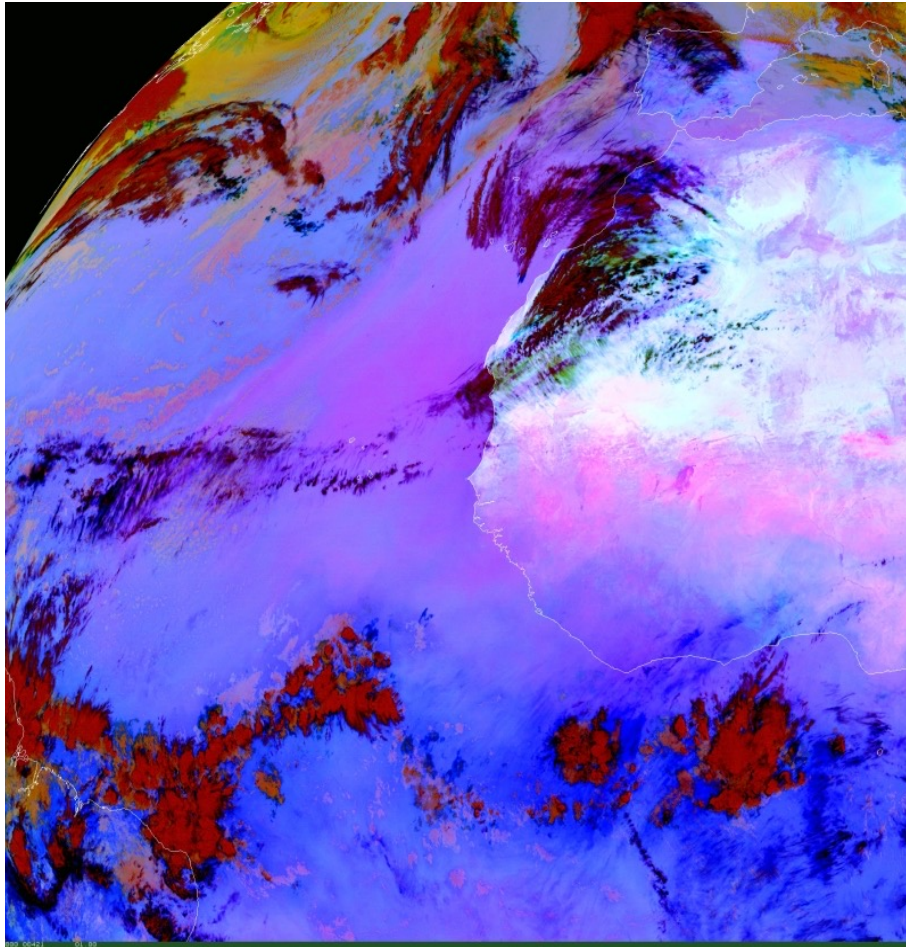


Dust RGB

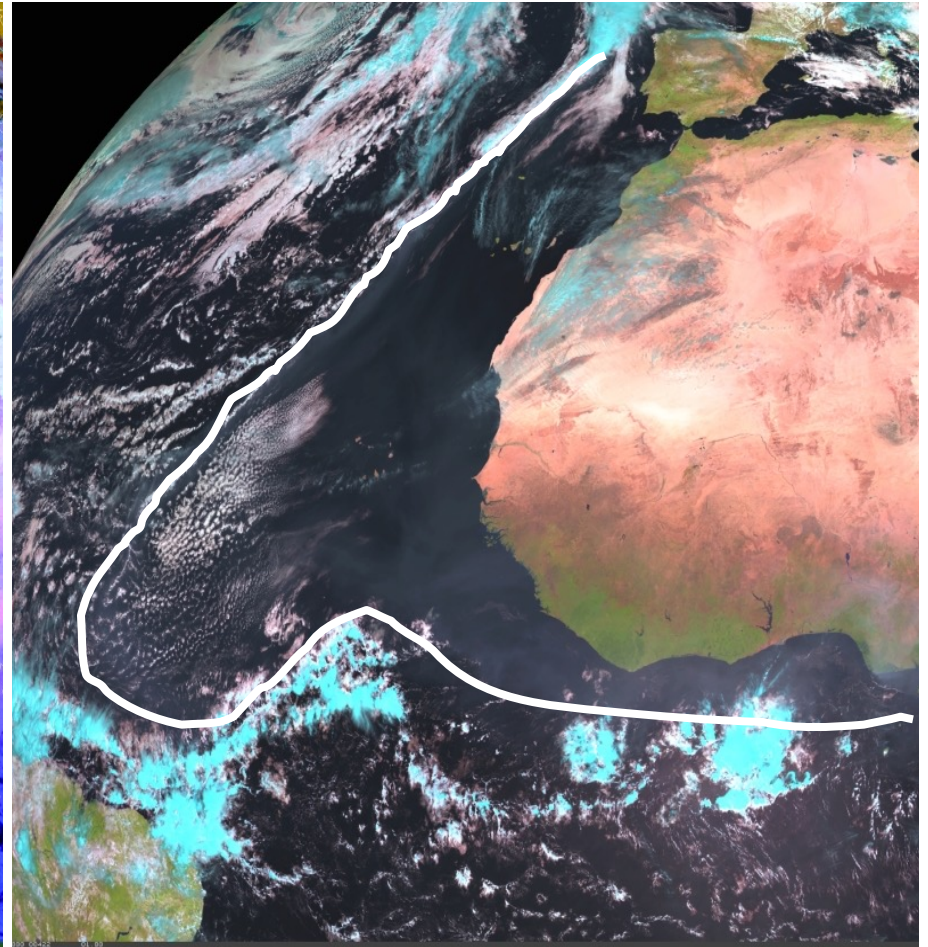


Natural Colours RGB

MSG-1, 08 March 2004, 12:00 UTC



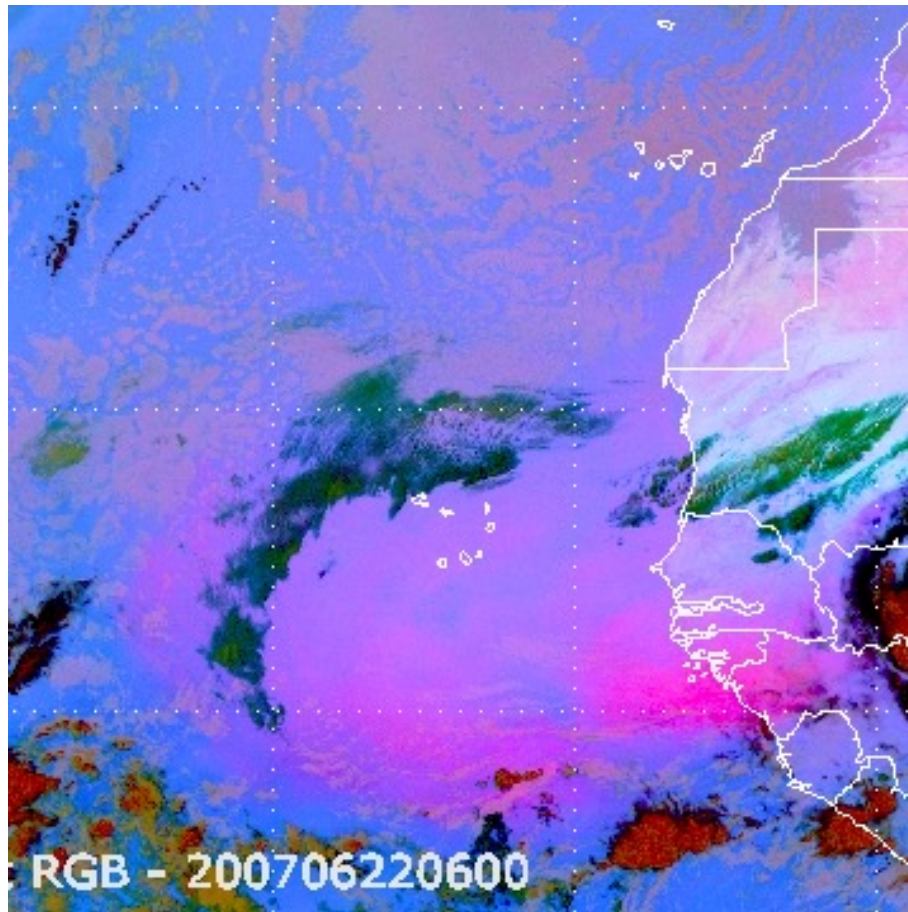
Dust RGB



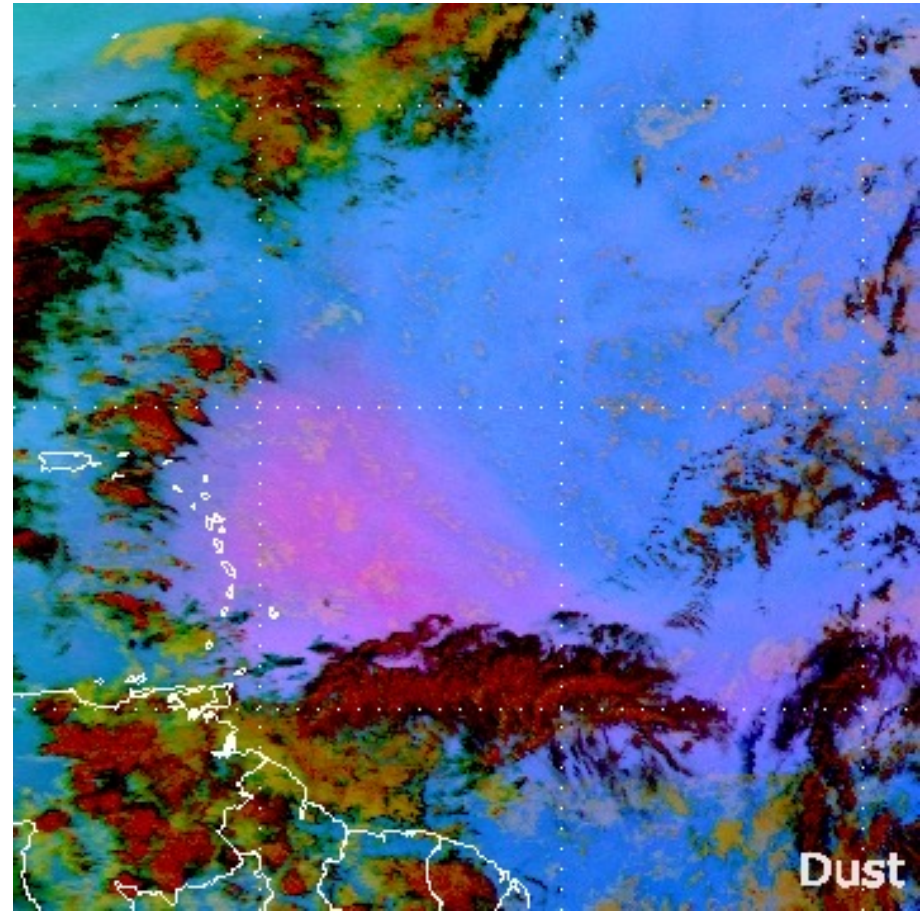
Natural Colours RGB

MSG-1, 08 March 2004, 12:00 UTC

Outline the dust areas!

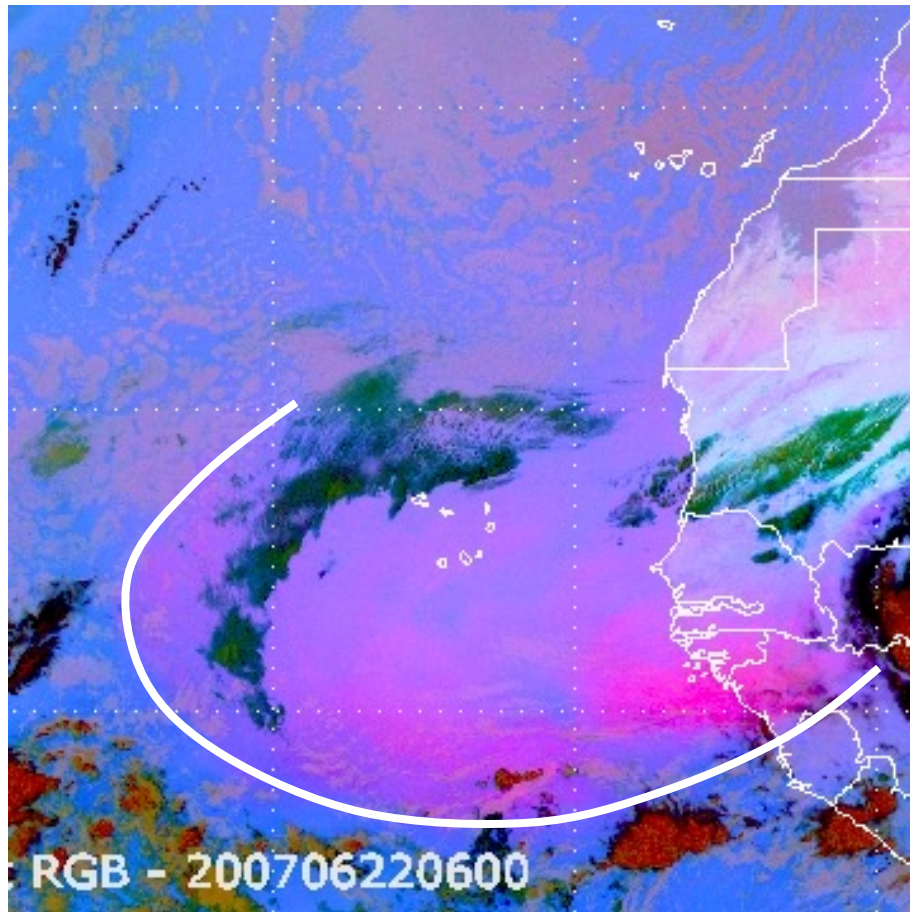


22 June 06:00 UTC

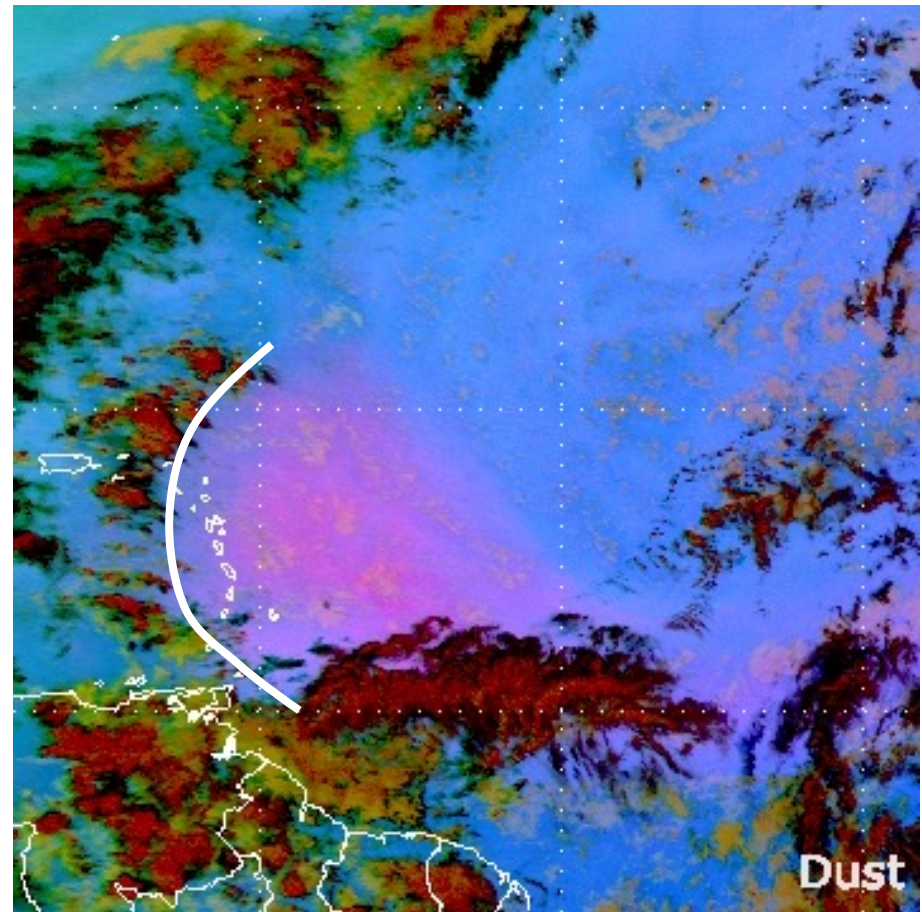


26 June 00:00 UTC

Dust crosses the Atlantic Ocean



22 June 06:00 UTC



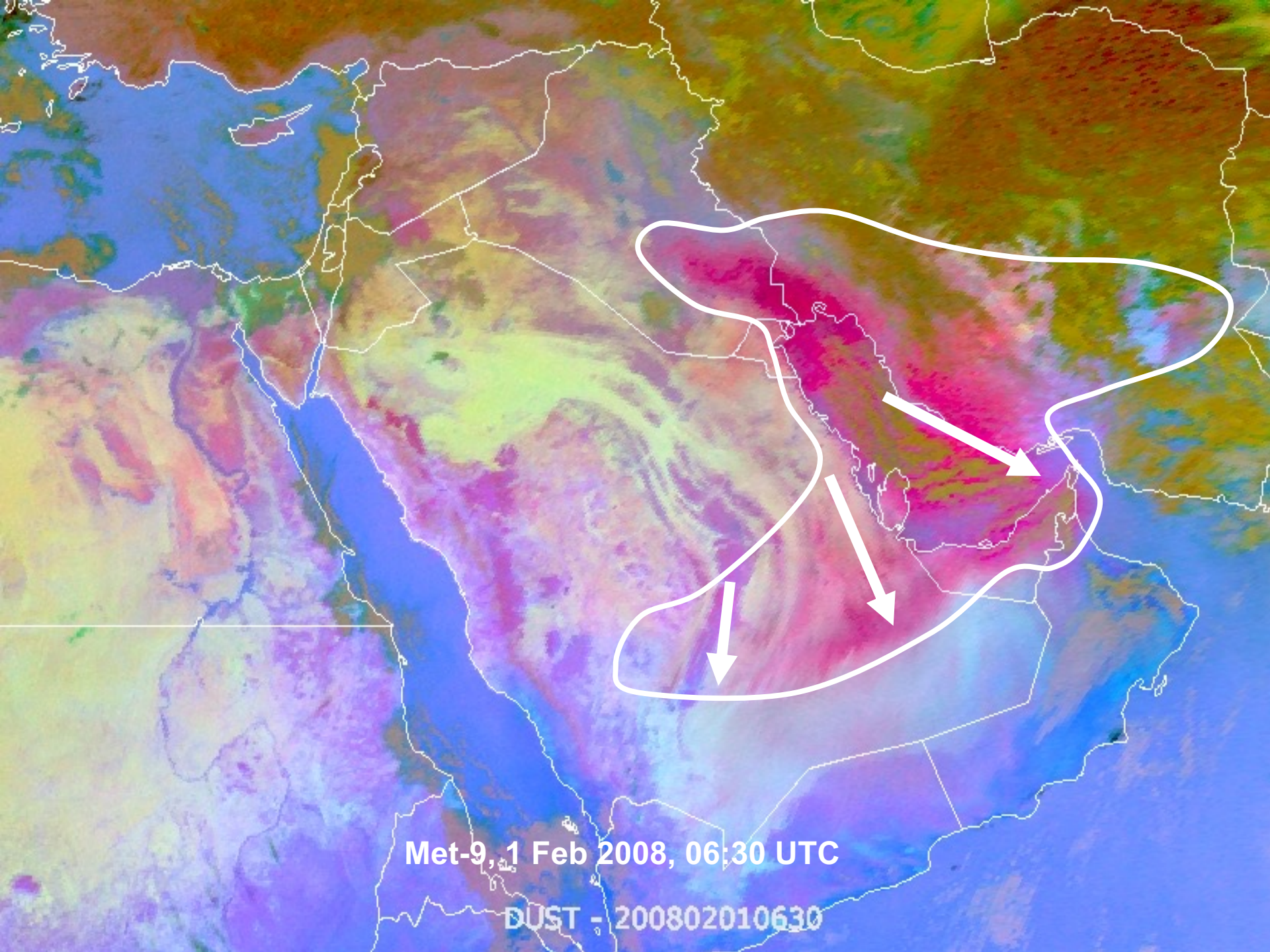
26 June 00:00 UTC

Dust crosses the Atlantic Ocean

Outline the dust areas!
Indicate the wind direction!

Met-9, 1 Feb 2008, 06:30 UTC

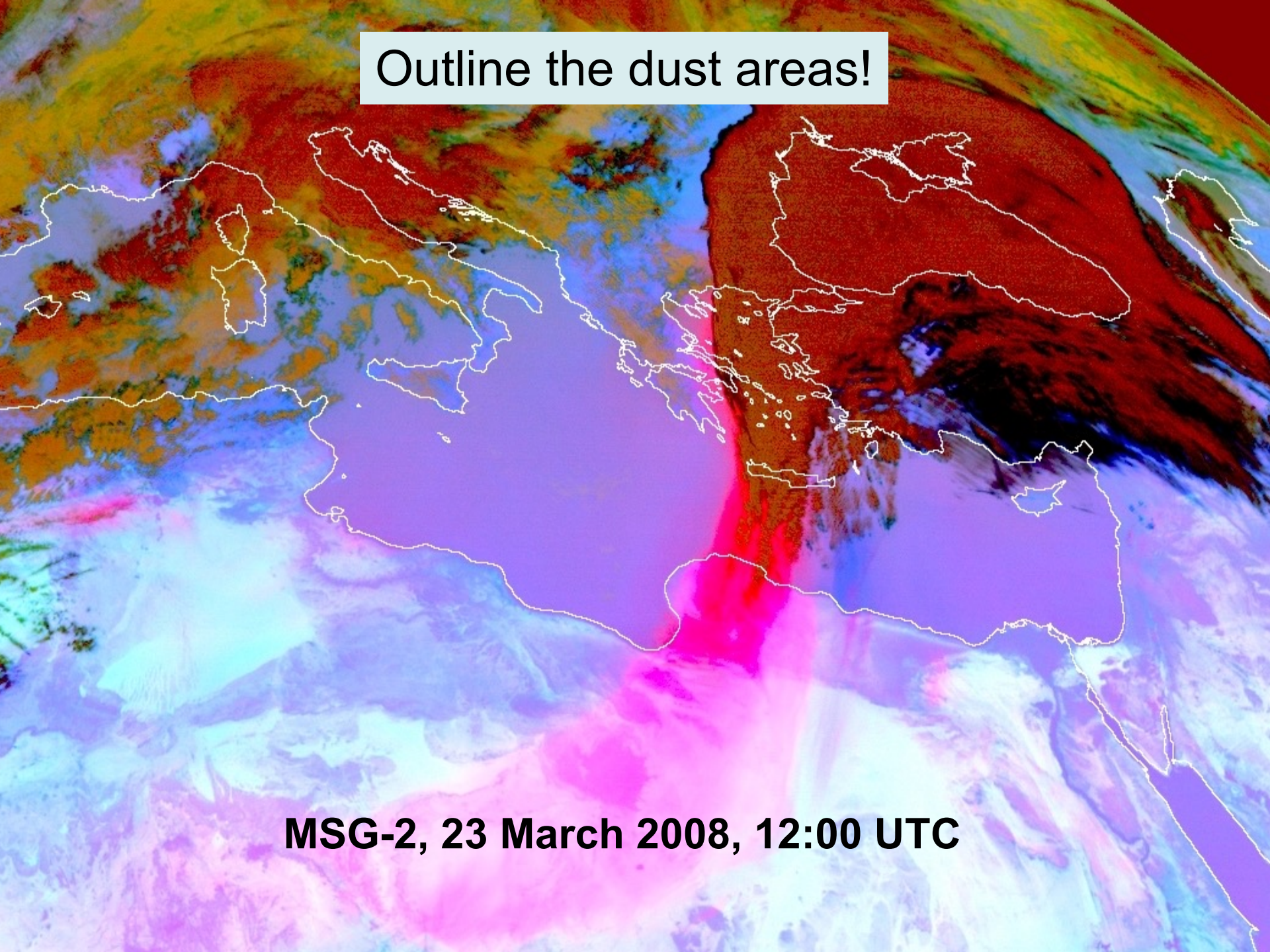
DUST - 200802010630



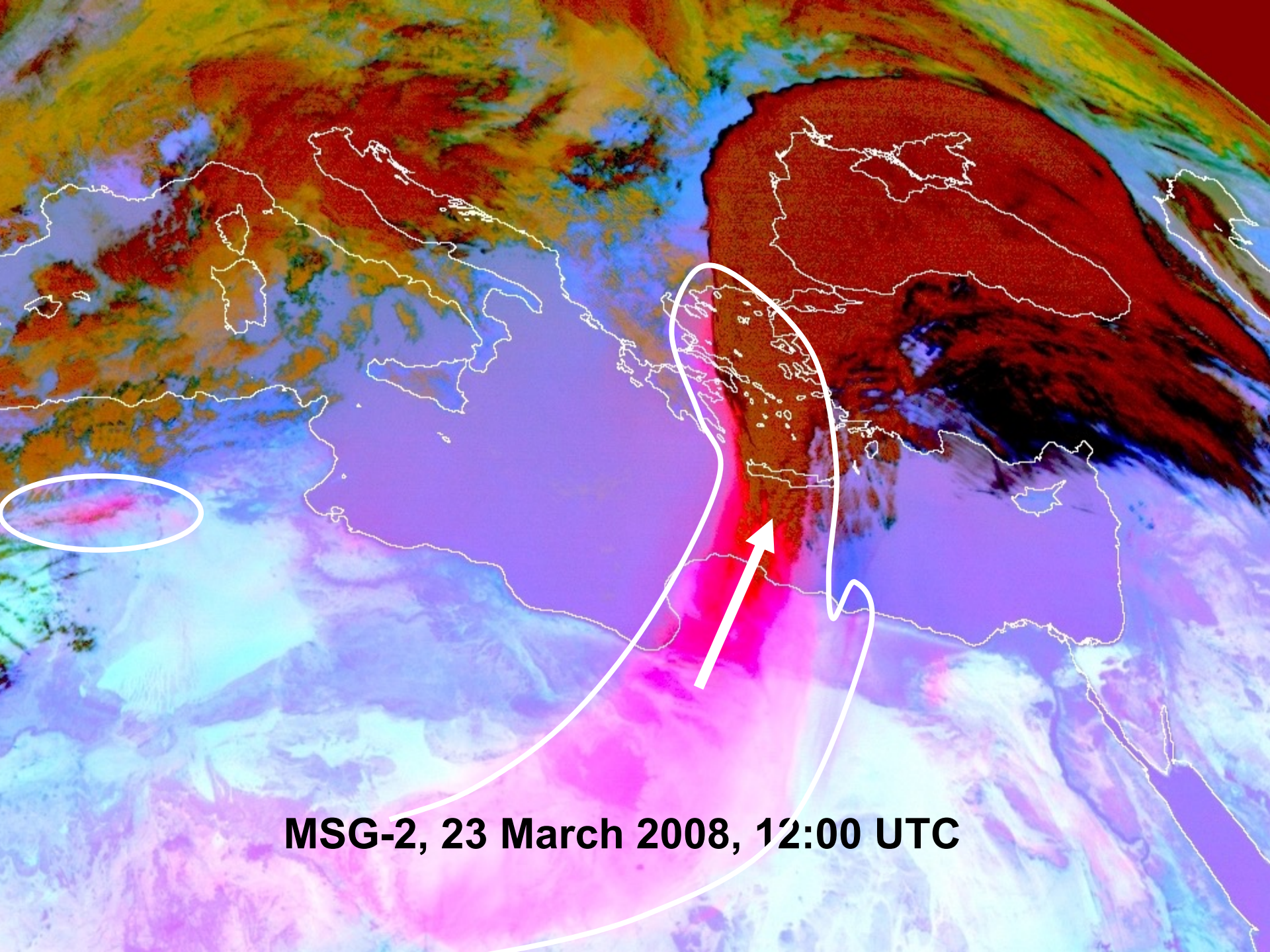
Met-9, 1 Feb 2008, 06:30 UTC

DUST - 200802010630

Outline the dust areas!

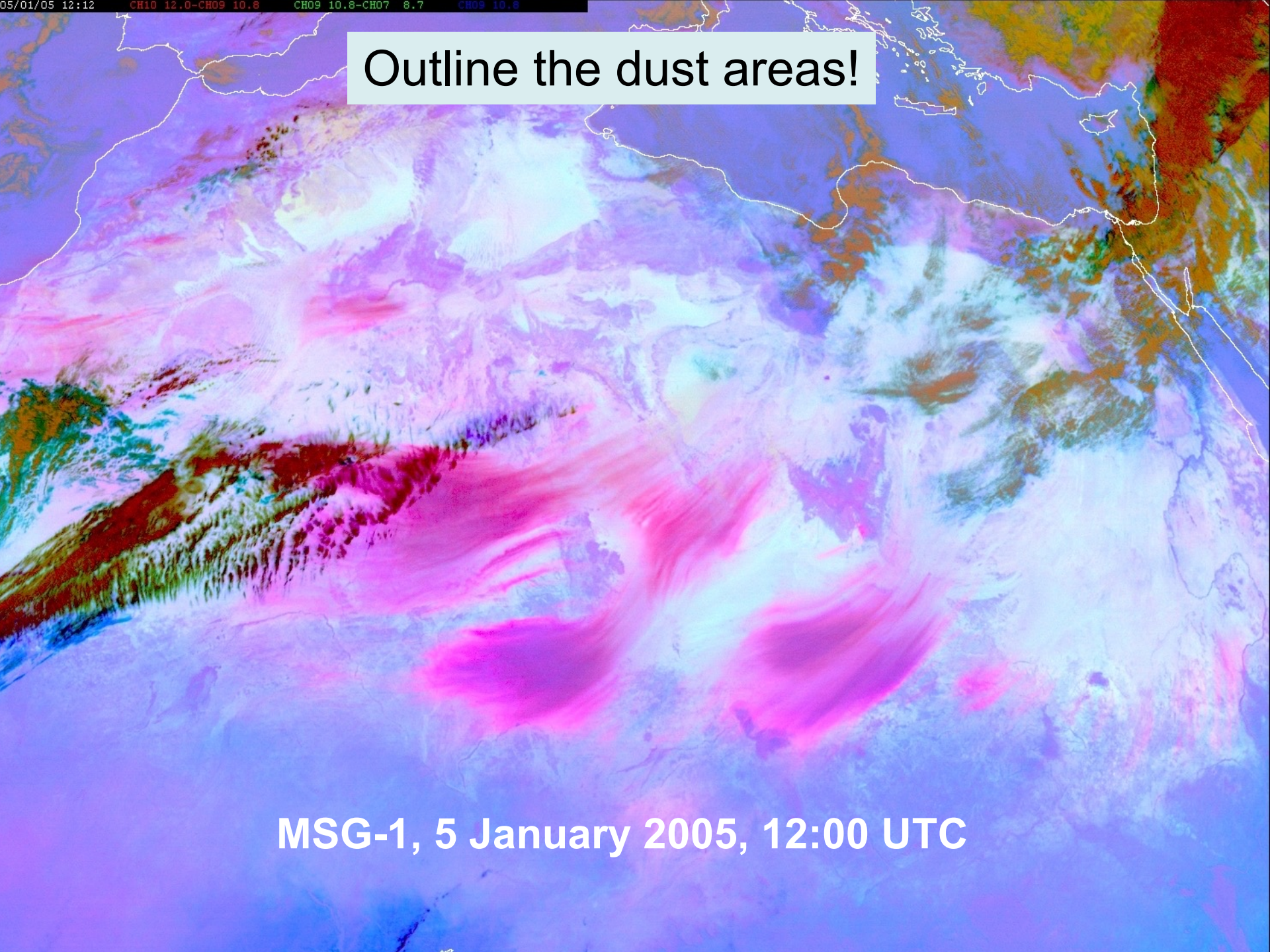


MSG-2, 23 March 2008, 12:00 UTC



MSG-2, 23 March 2008, 12:00 UTC

Outline the dust areas!



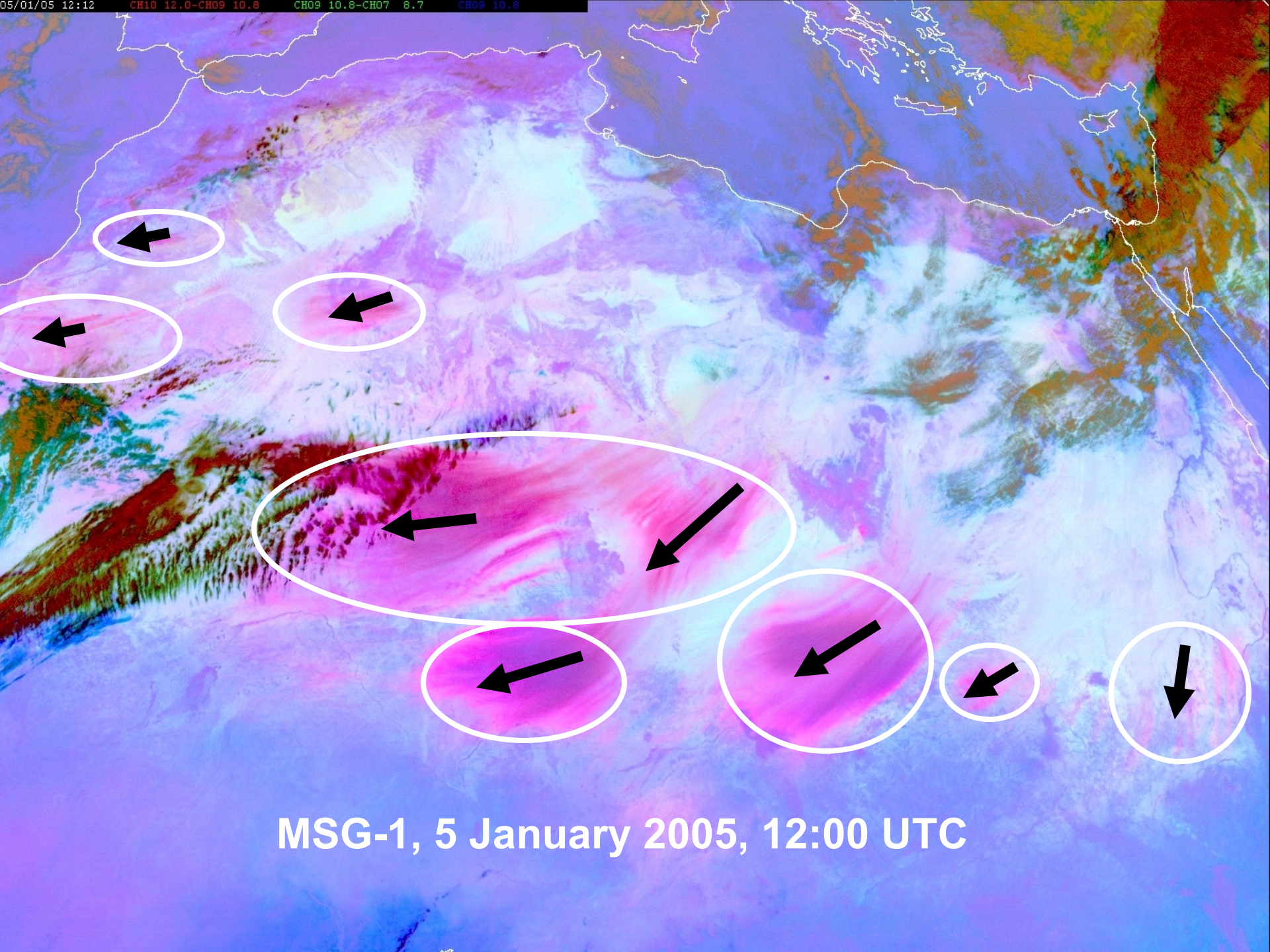
MSG-1, 5 January 2005, 12:00 UTC

5/01/05 12:12

CH10 12.0-CH09 10.8

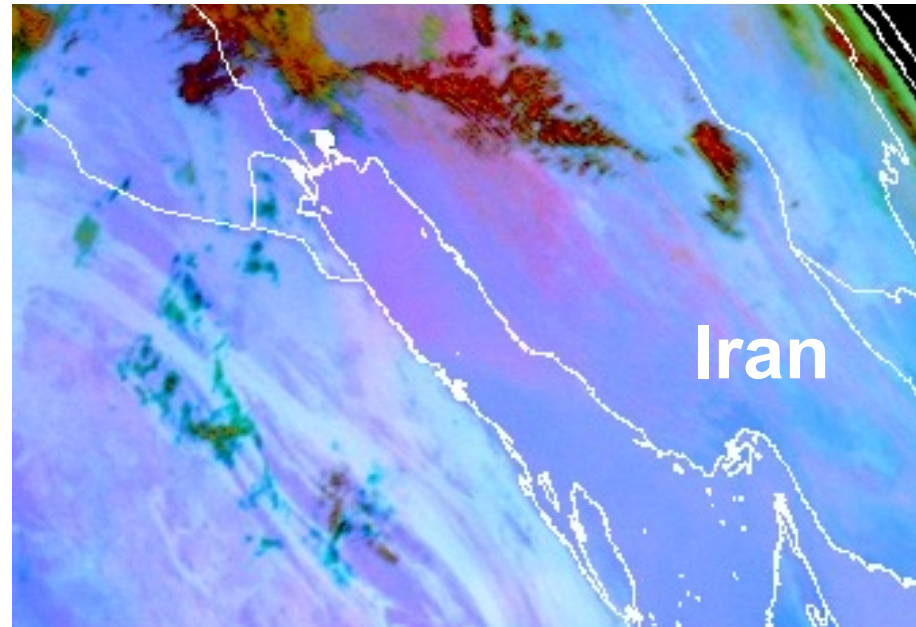
CH09 10.8-CH07 8.7

CH09 10.6



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

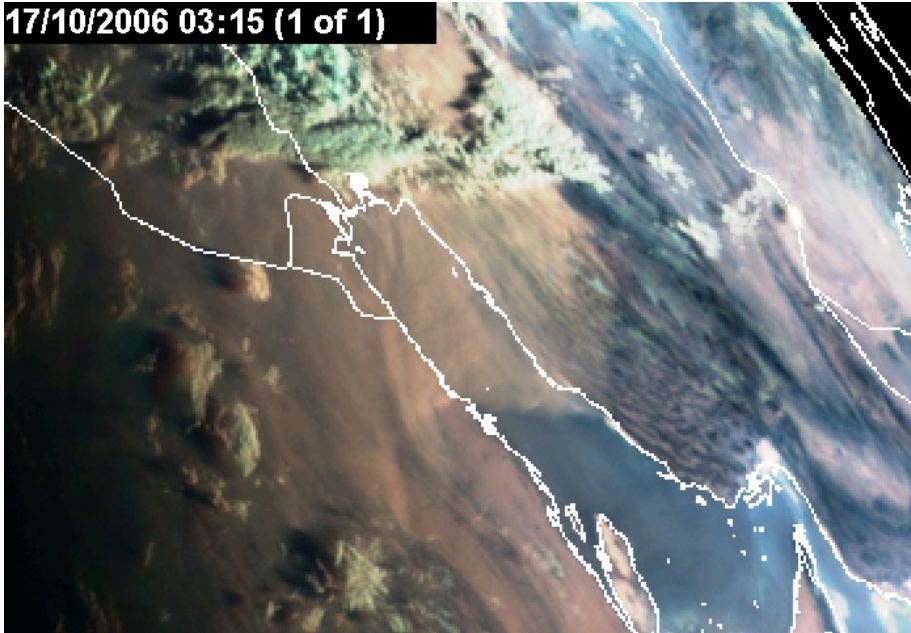
Outline the dust areas!



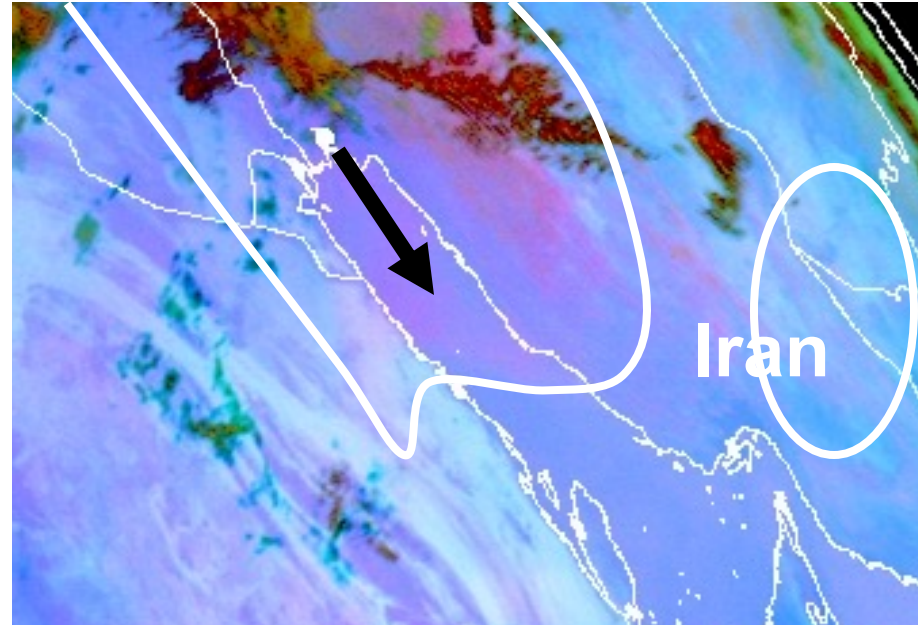
05:00 UTC
Dust RGB

MSG-1, 17 October 2006

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



03:15 UTC
Natural Colours RGB



05:00 UTC
Dust RGB

MSG-1, 17 October 2006

Outline the dust areas!

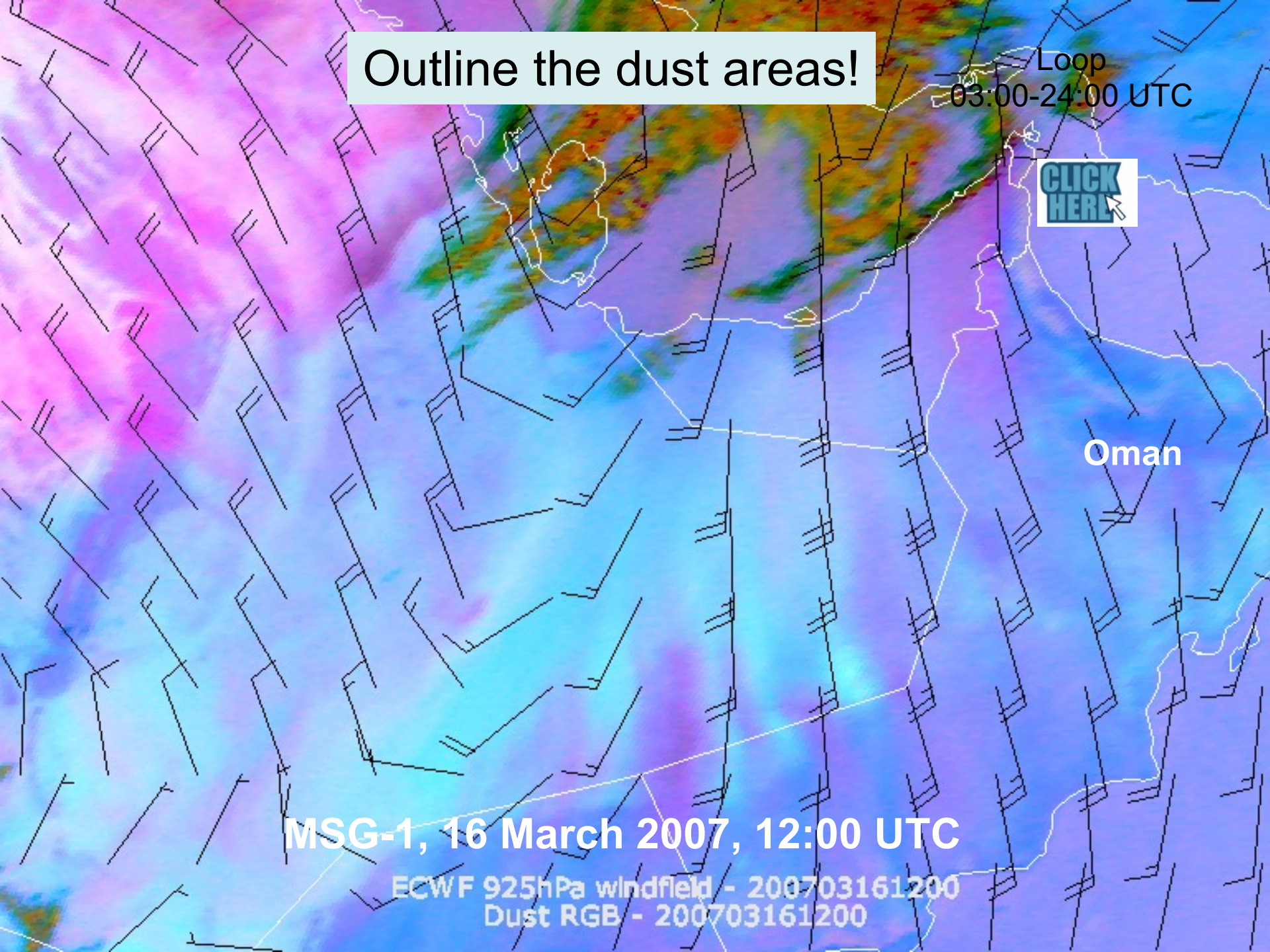
Loop
03:00-24:00 UTC

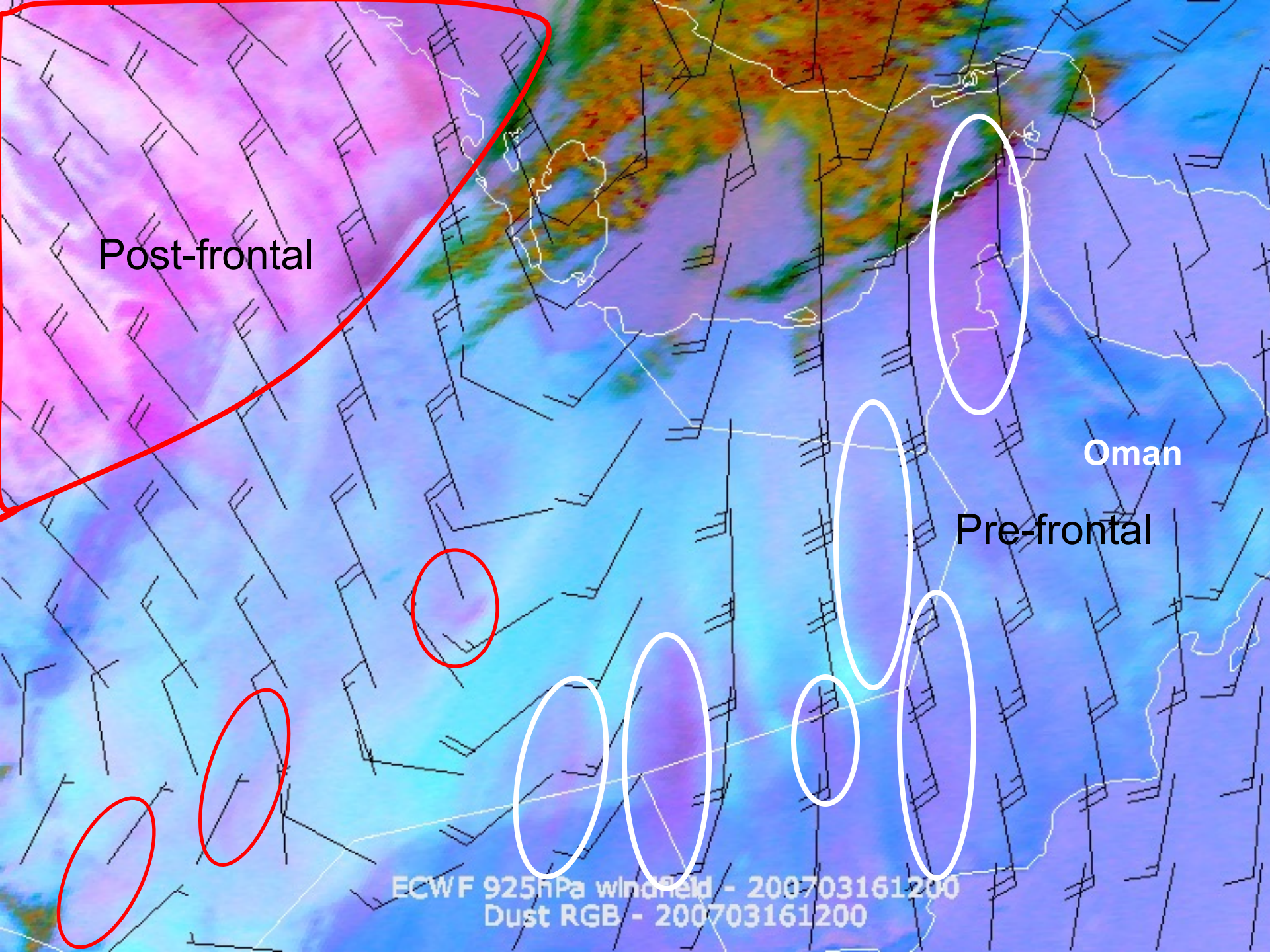
**CLICK
HERE**

Oman

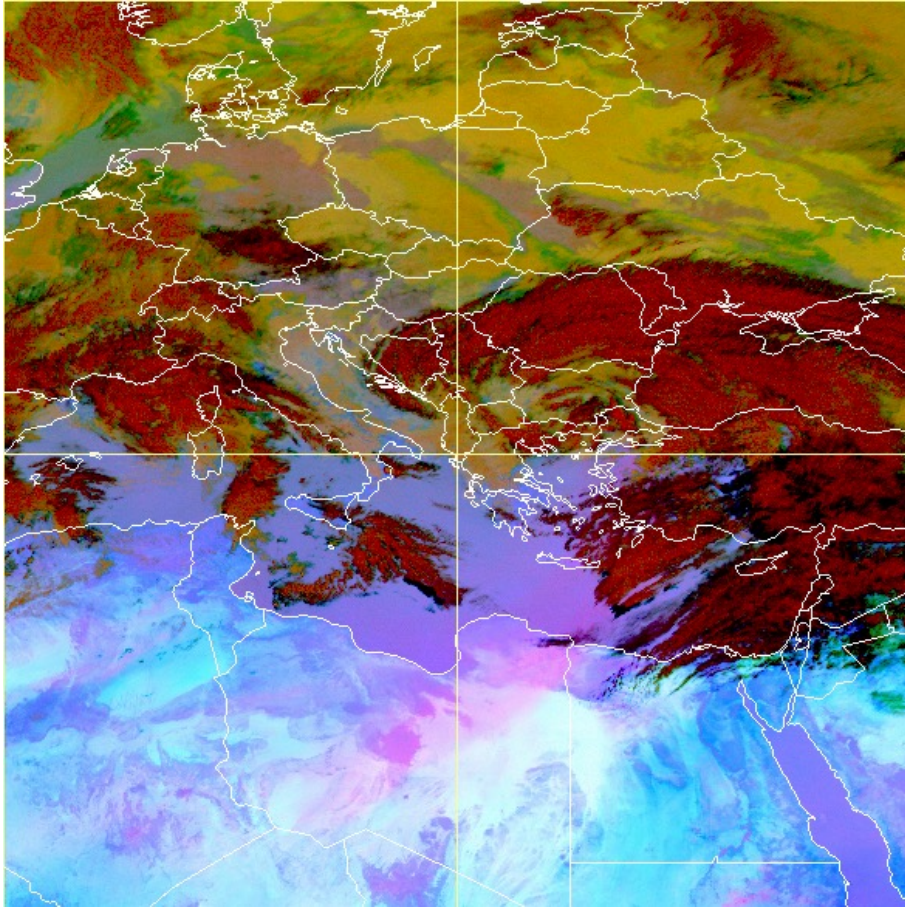
MSG-1, 16 March 2007, 12:00 UTC

ECWF 925hPa windfield - 200703161200
Dust RGB - 200703161200

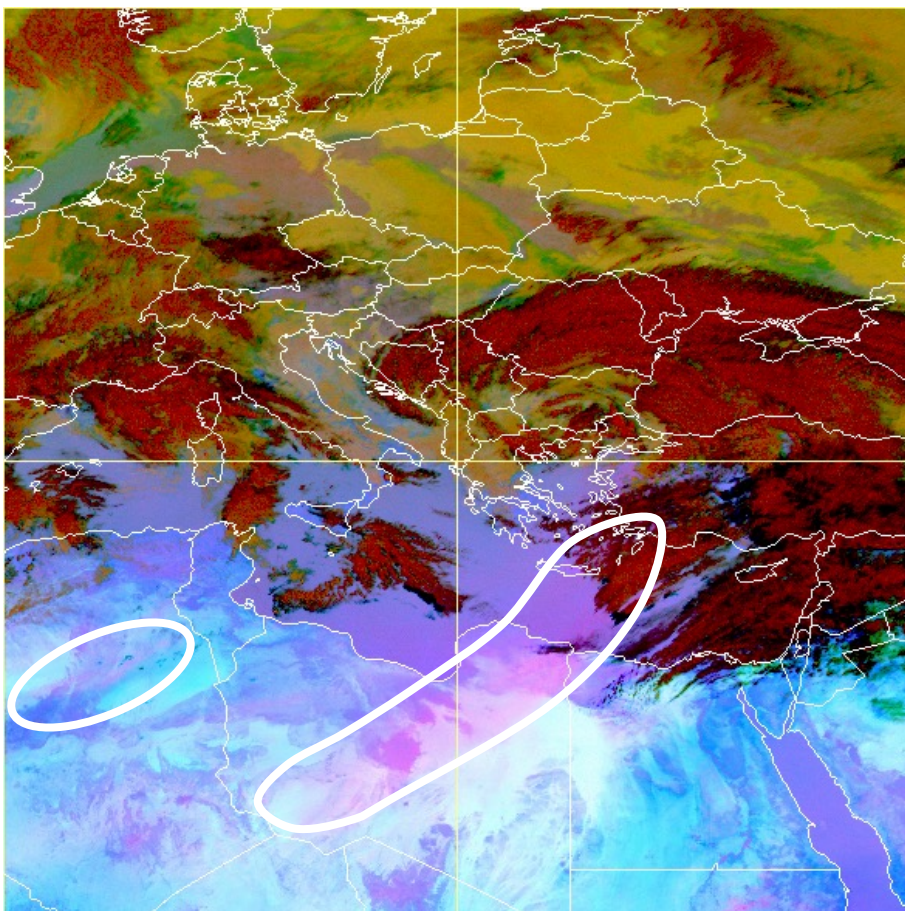




Outline the dust areas!

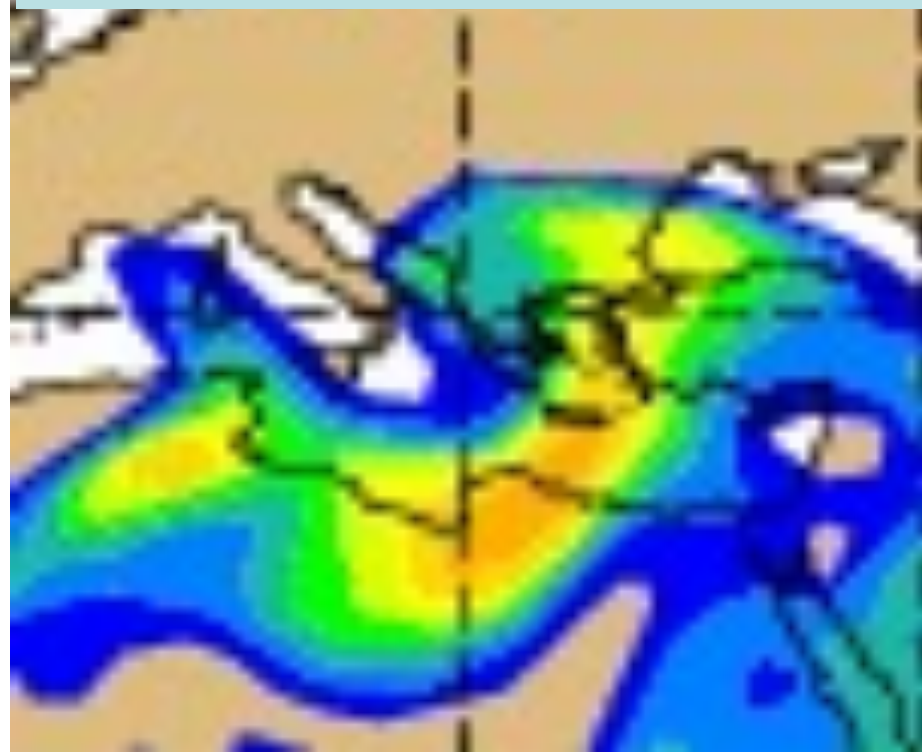


17 February 2010, 12 UTC



17 February 2010, 12 UTC

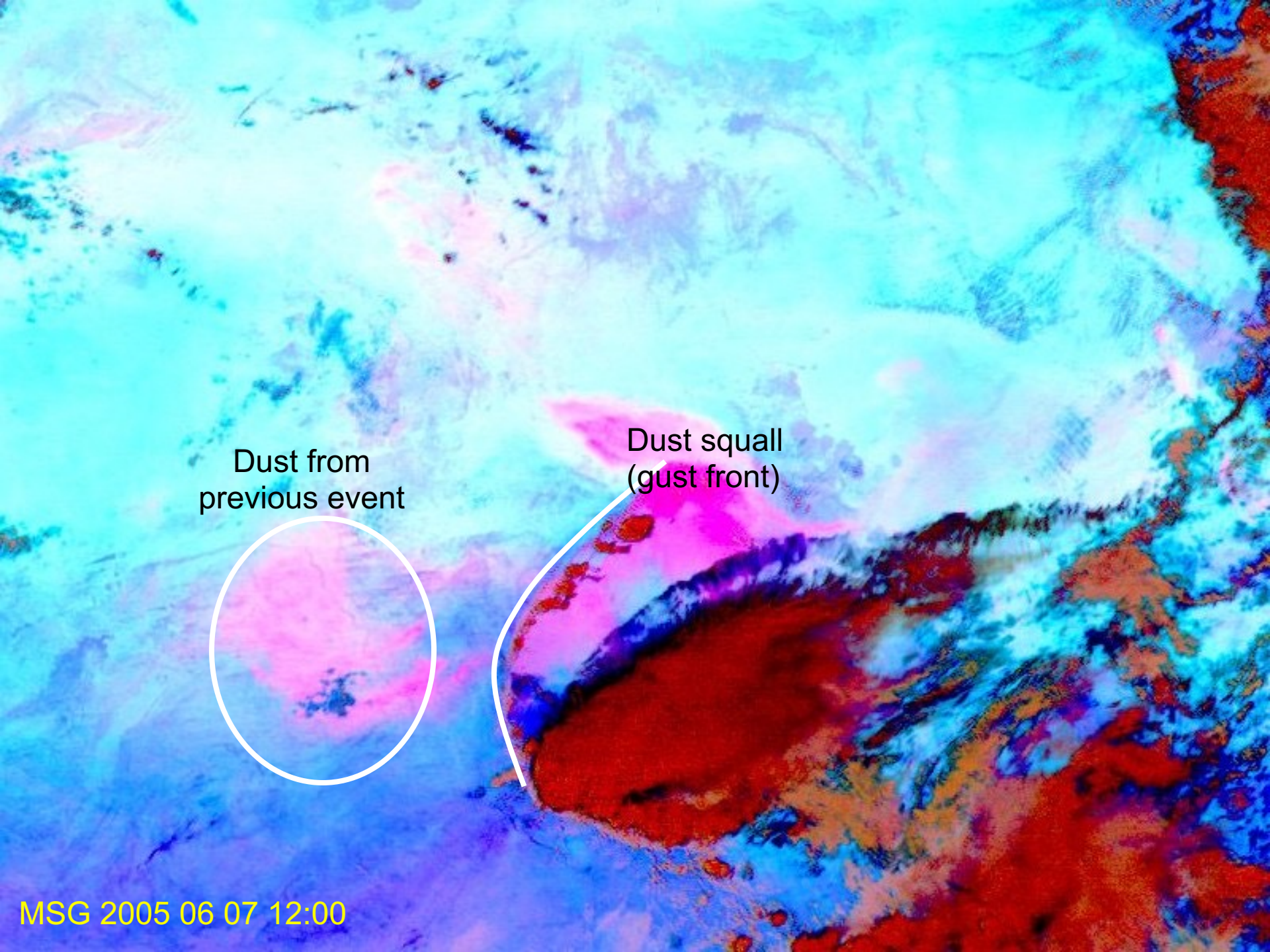
**ECMWF/MACC 12h forecast
Natural Aerosols (dust + sea salt)**



Outline the dust squall!



MSG 2005 06 07 12:00

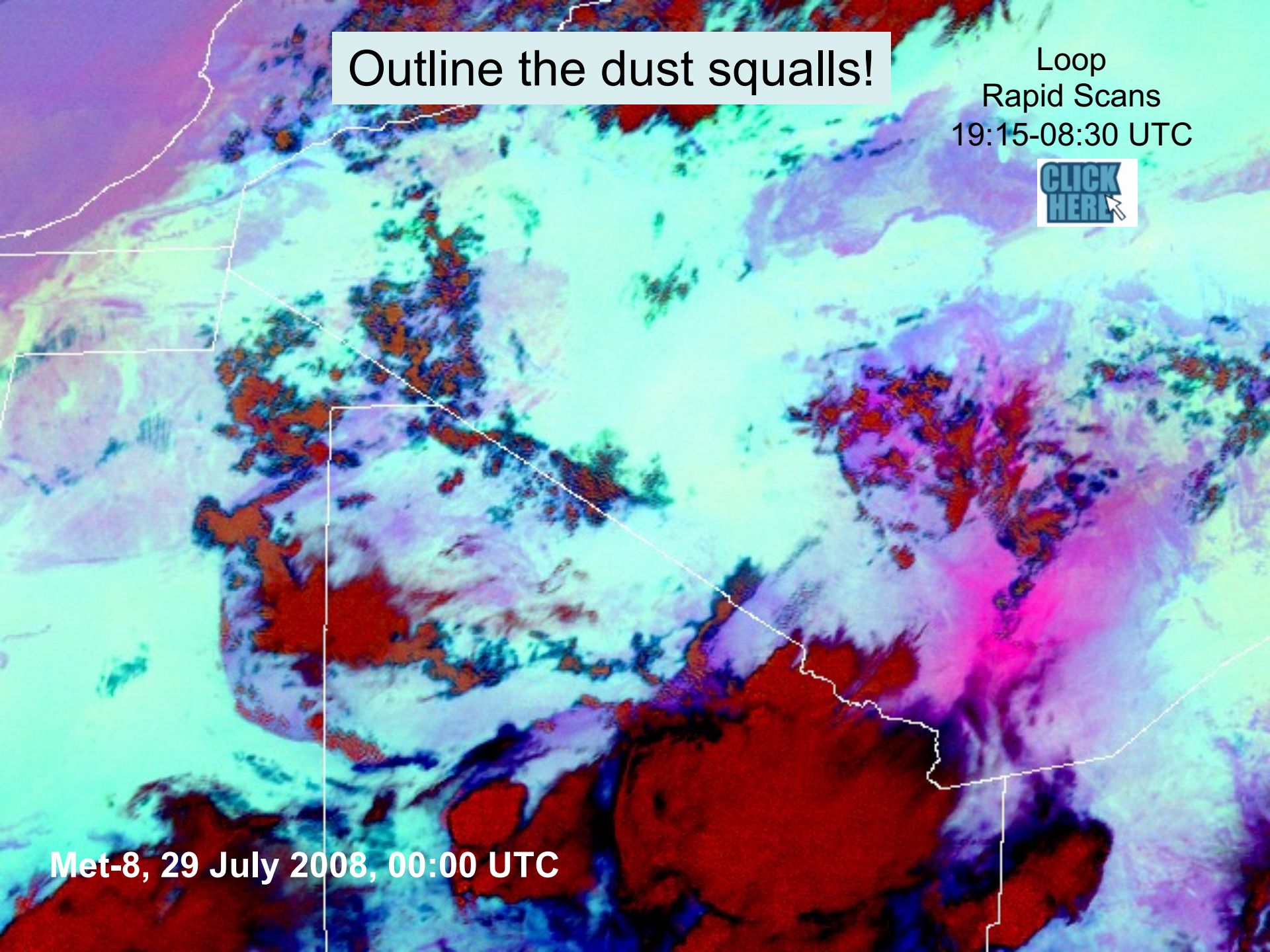


A satellite image showing a large-scale weather system. A prominent, bright white cloud mass is visible in the upper right quadrant. Below and to the left of this mass, a large area of orange and red coloration indicates a significant dust storm. A white oval highlights a specific area within the dust storm, and a white line points to the leading edge of the dust front.

Dust from
previous event

Dust squall
(gust front)

MSG 2005 06 07 12:00

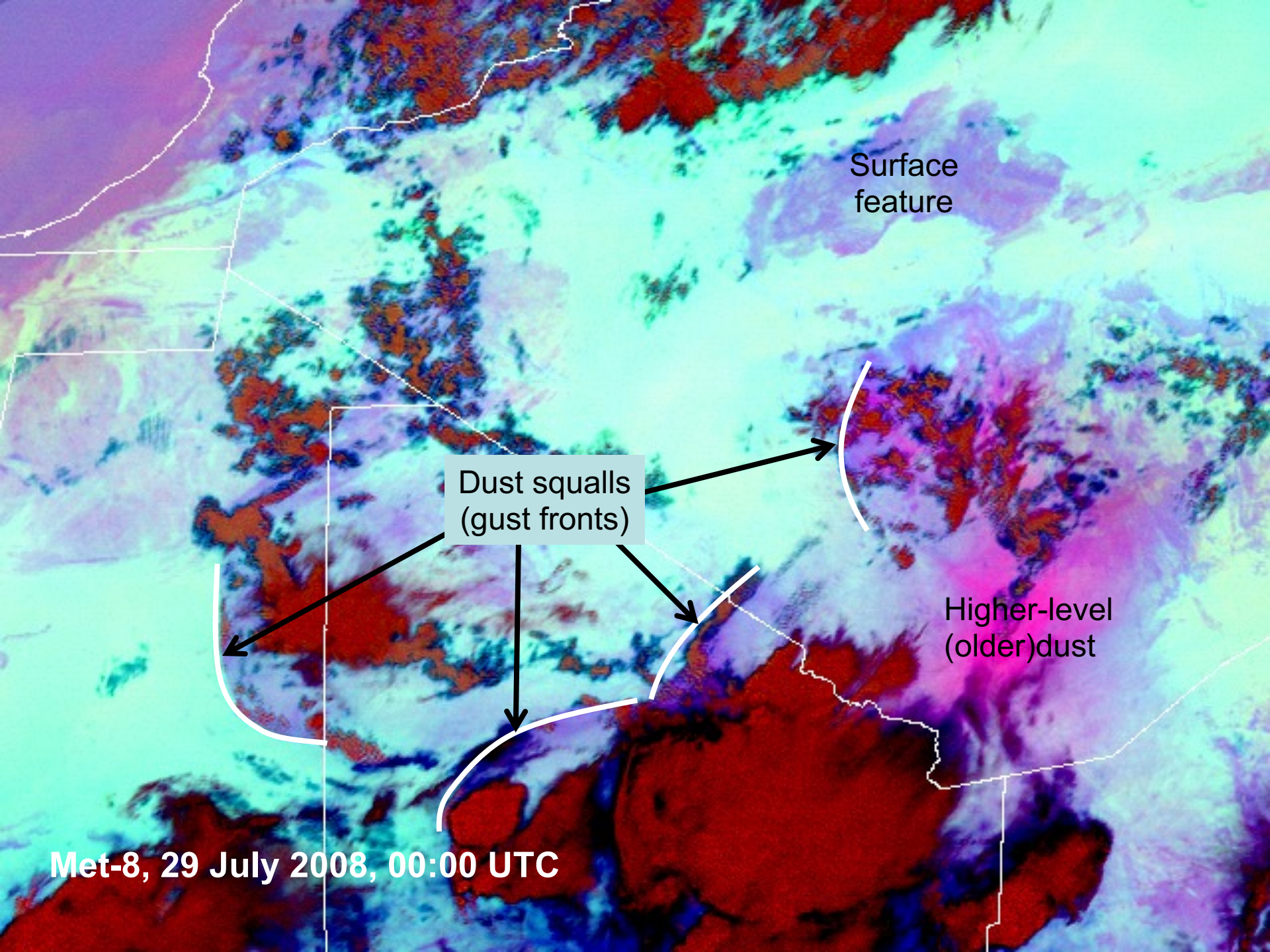
A satellite image of Africa and surrounding regions, showing dust squalls. The image is color-coded, with red and orange indicating dust concentrations. The dust is visible as large, irregular patches across the continent and surrounding waters. The text "Outline the dust squalls!" is overlaid on the top left. The text "Loop Rapid Scans 19:15-08:30 UTC" is overlaid on the top right. A "CLICK HERE" button is also present on the top right. The text "Met-8, 29 July 2008, 00:00 UTC" is overlaid on the bottom left.

Outline the dust squalls!

Loop
Rapid Scans
19:15-08:30 UTC



Met-8, 29 July 2008, 00:00 UTC



Surface
feature

Dust squalls
(gust fronts)

Higher-level
(older) dust

Met-8, 29 July 2008, 00:00 UTC

Outline & Height of Dust Clouds

Low = 0 - 1 km

Mid = 2 - 4 km

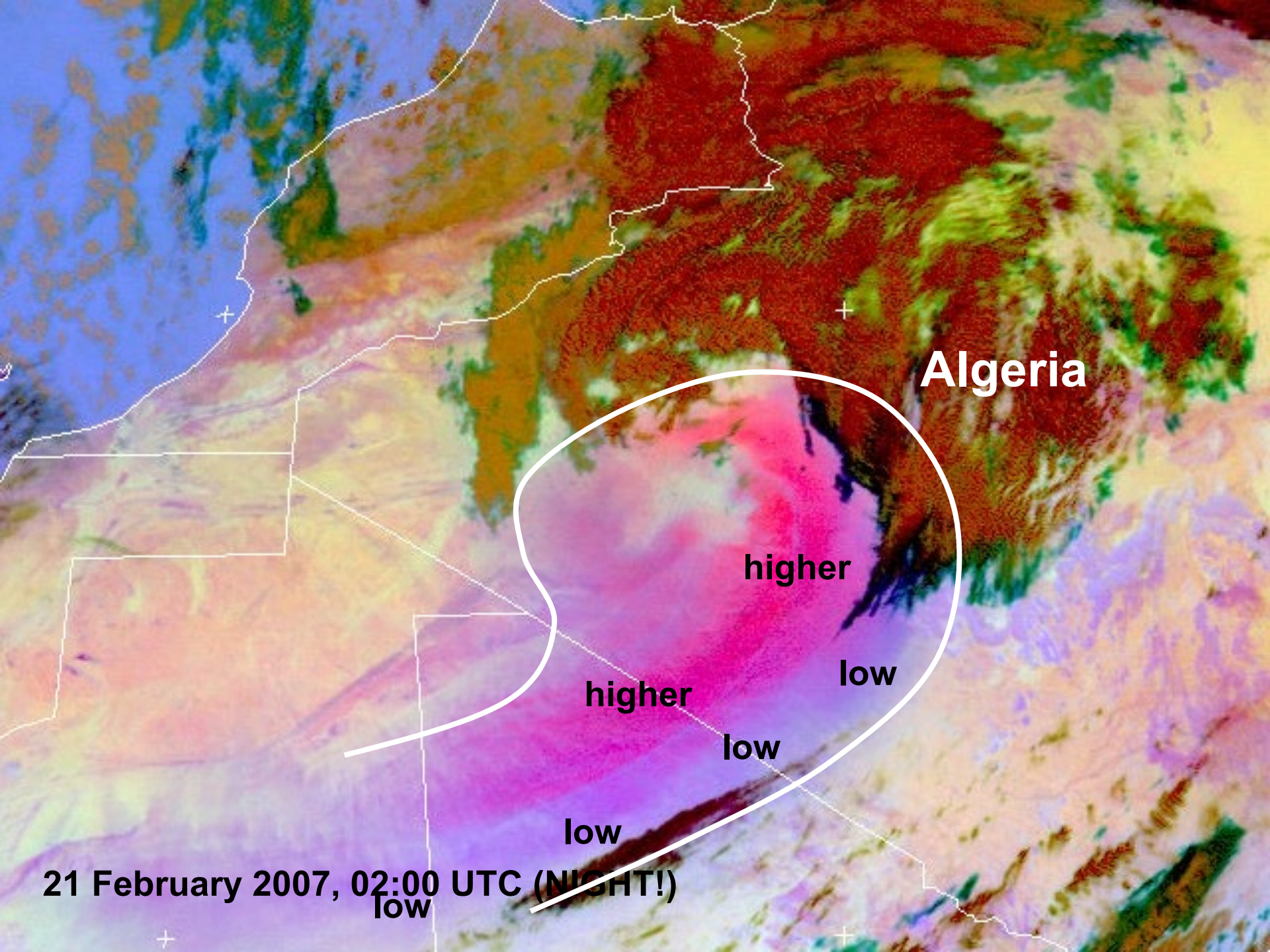
High = 5 - 6 km

Outline the dust areas!
What is the height of the dust cloud ?

Algeria

A satellite image of North Africa, specifically focusing on Algeria and Libya. A large, dense dust cloud is visible, originating from the coastal region of Algeria and extending southwards into Libya. The dust cloud is depicted in shades of pink, magenta, and purple, contrasting with the green and brown landmasses. The word "Algeria" is written in white text on the right side of the image. The image also shows the Mediterranean Sea to the west and the Red Sea to the east. Several small white crosses are visible on the map, likely indicating specific locations of interest.

21 February 2007, 02:00 UTC (NIGHT!)



Algeria

higher

low

higher

low

low

21 February 2007, 02:00 UTC (NIGHT!)

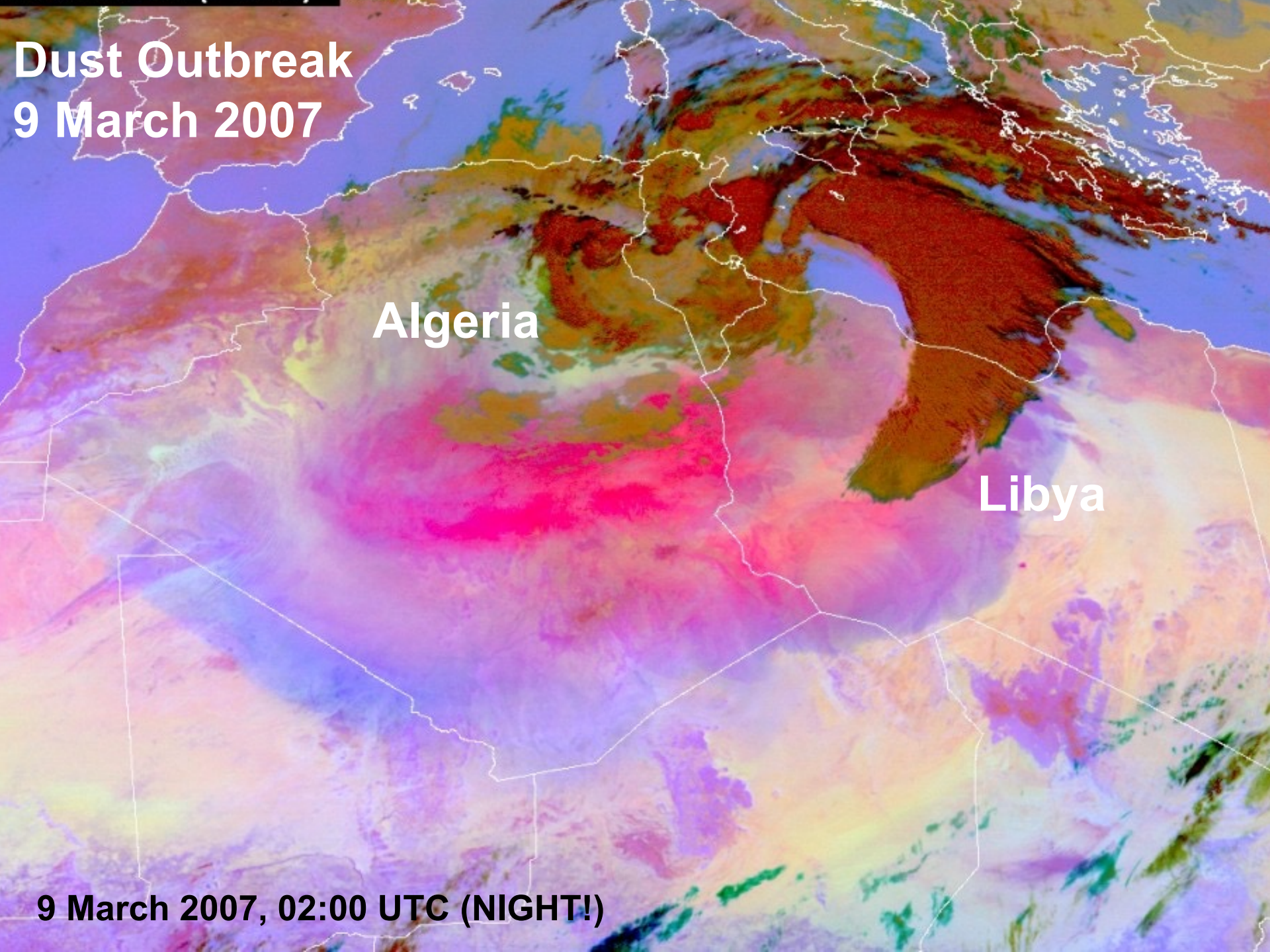
low

Dust Outbreak 9 March 2007

Algeria

Libya

9 March 2007, 02:00 UTC (NIGHT!)



Dust Outbreak

9 March 2007

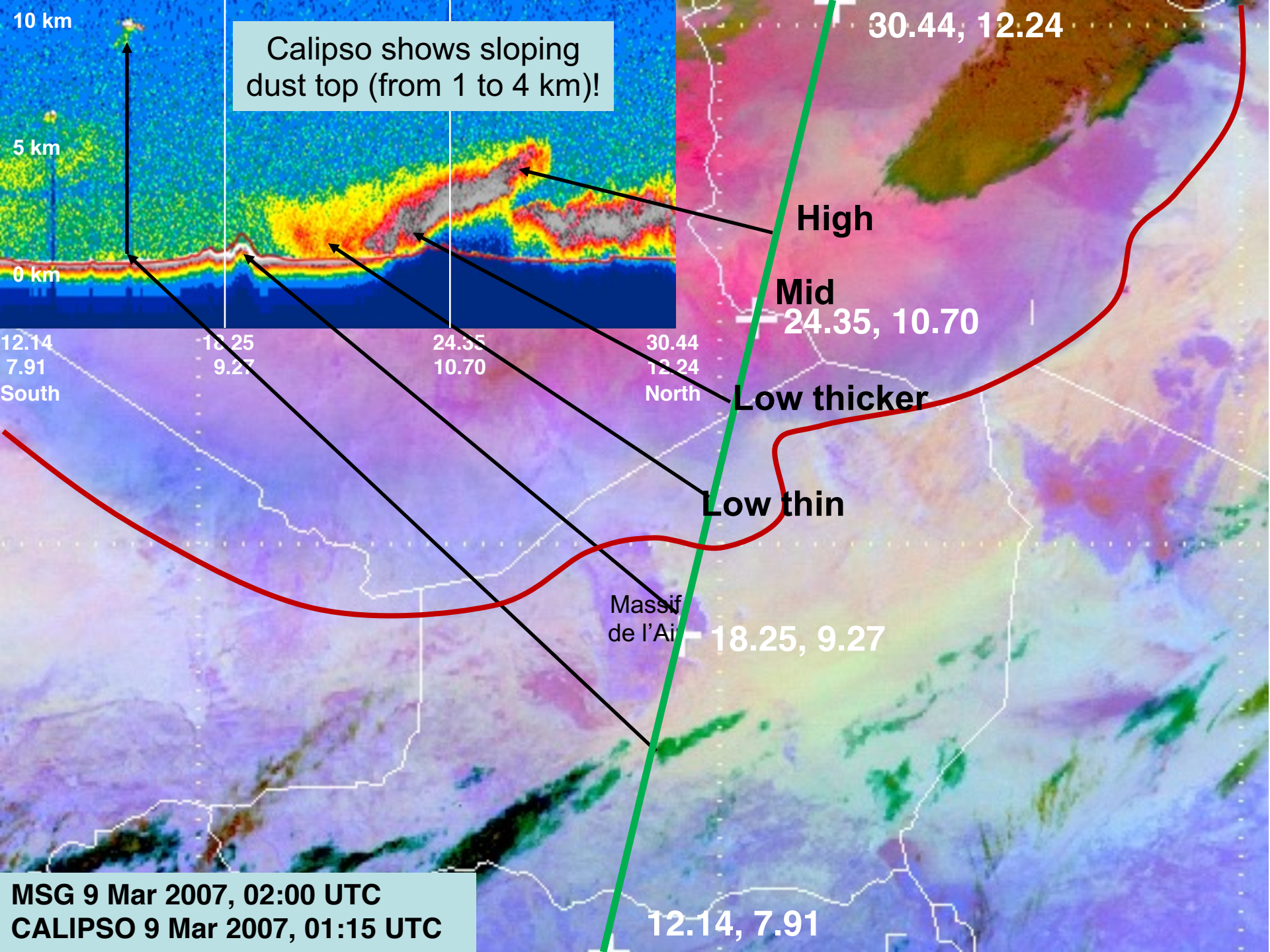


Loop 02:00-08:45 UTC

< Calipso Track

Where & how high is the dust cloud?

9 March 2007, 02:00 UTC (NIGHT!)

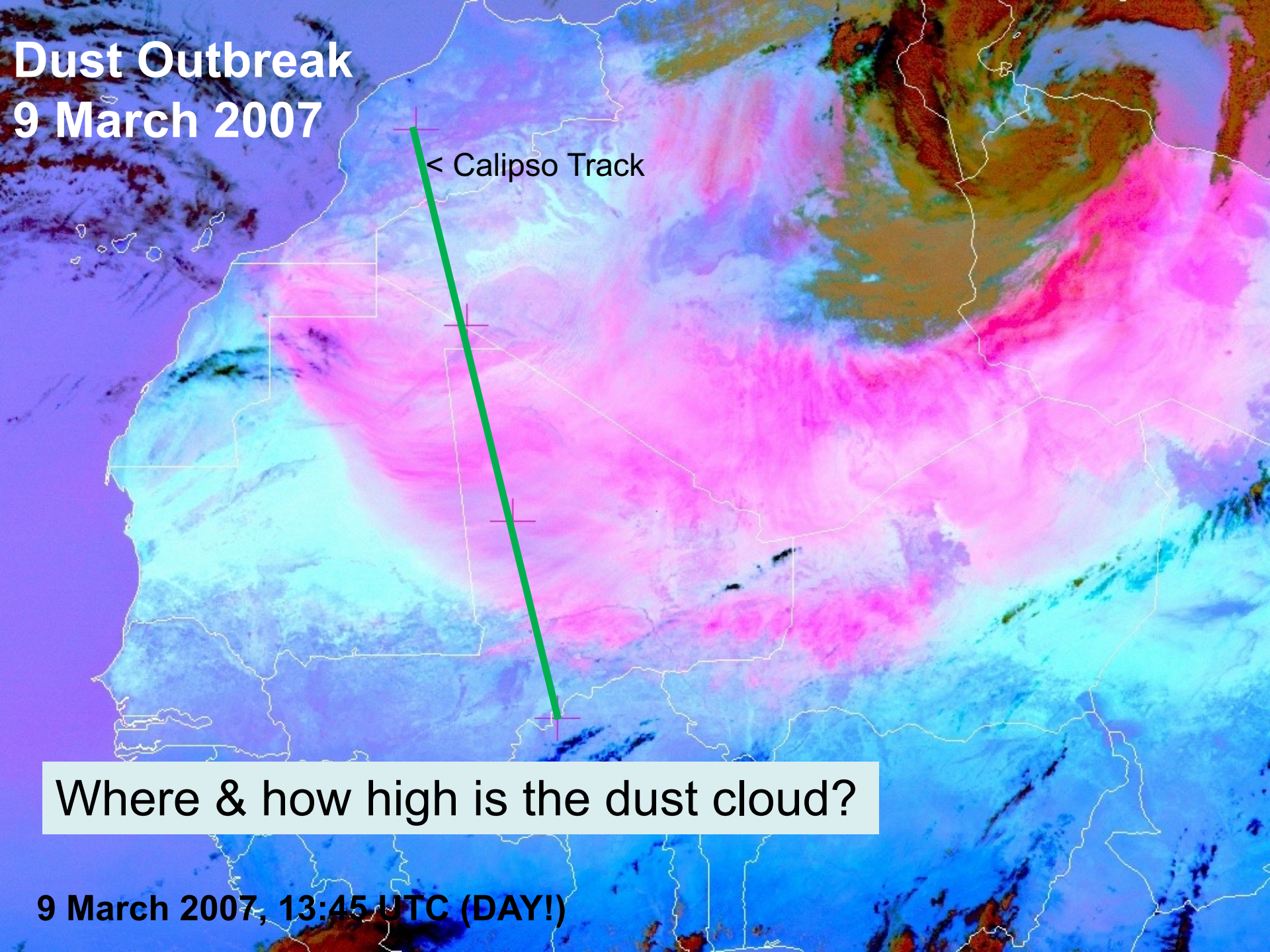


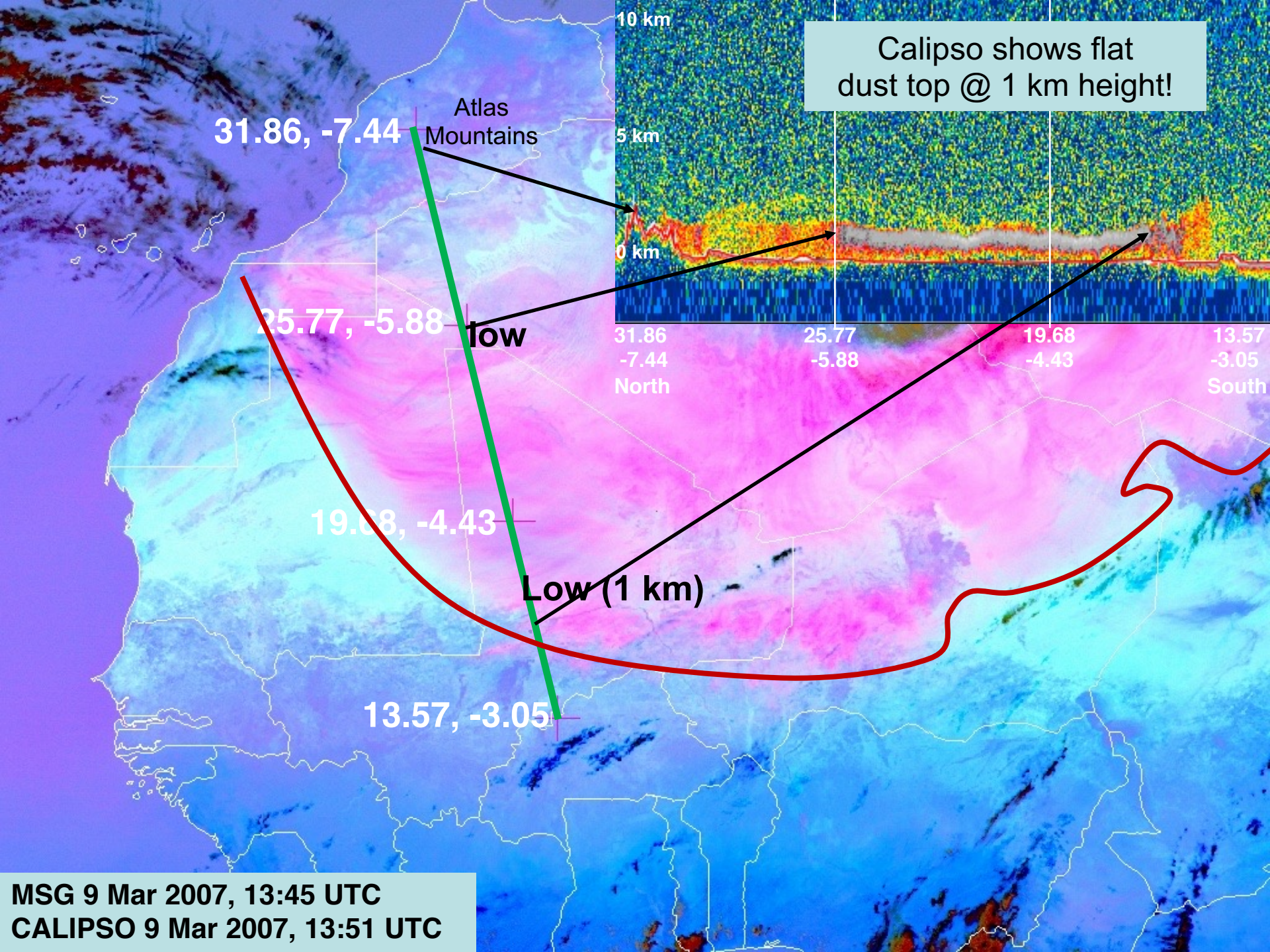
Dust Outbreak 9 March 2007

< Calipso Track

Where & how high is the dust cloud?

9 March 2007, 13:45 UTC (DAY!)





MSG 9 Mar 2007, 13:45 UTC
CALIPSO 9 Mar 2007, 13:51 UTC

Dust Outbreak

20-26 June 2007

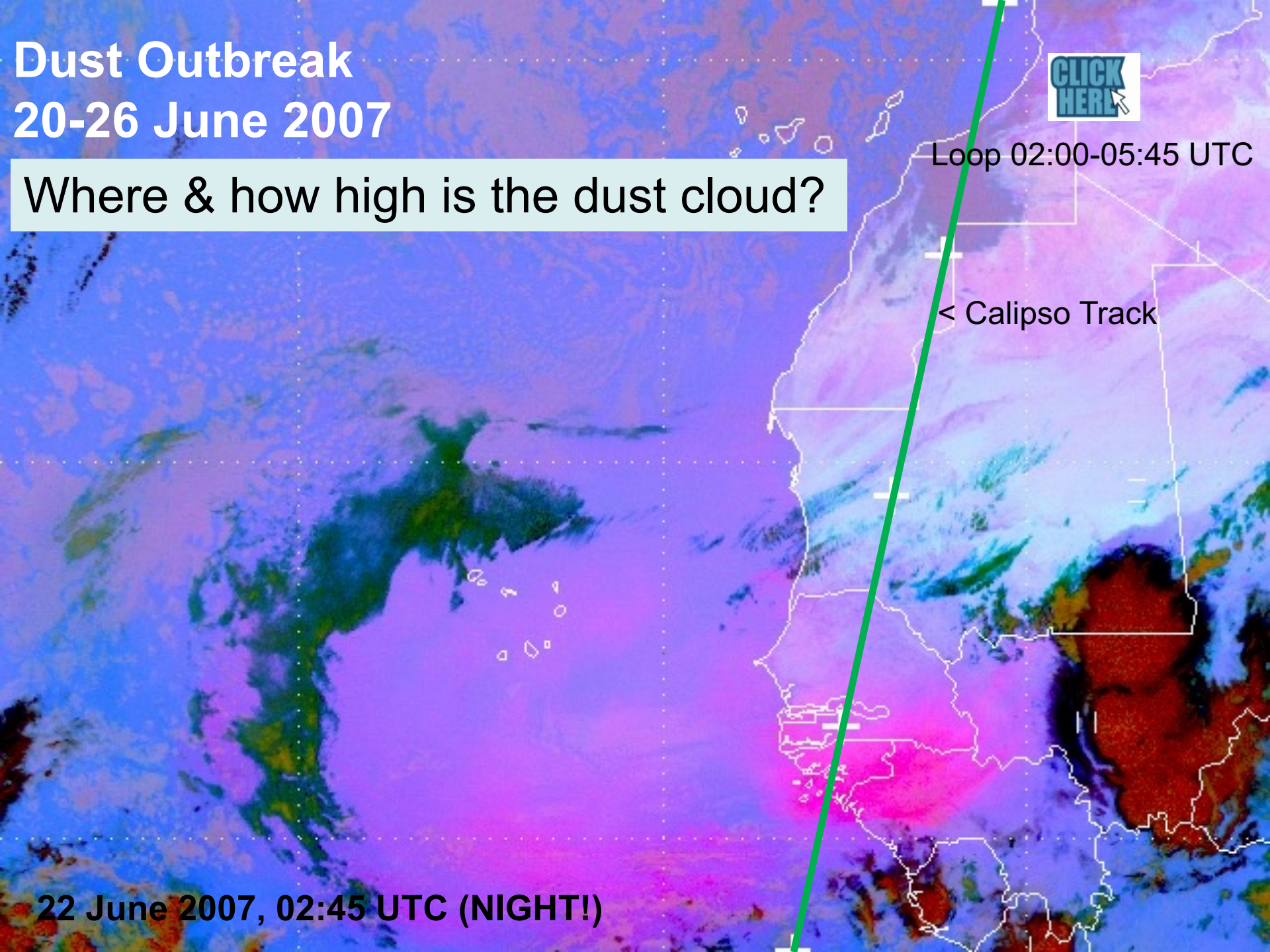
Where & how high is the dust cloud?

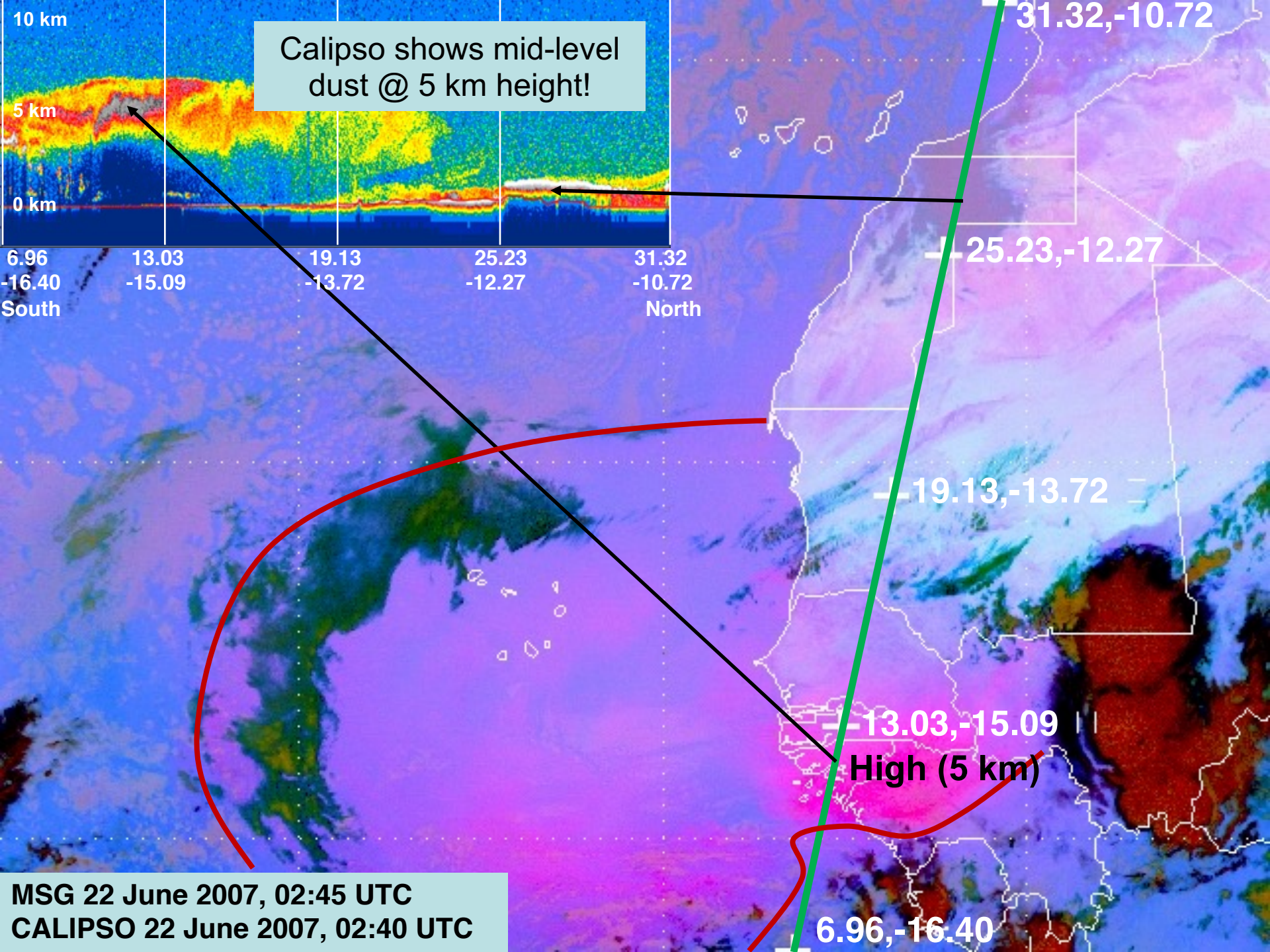


Loop 02:00-05:45 UTC

< Calipso Track

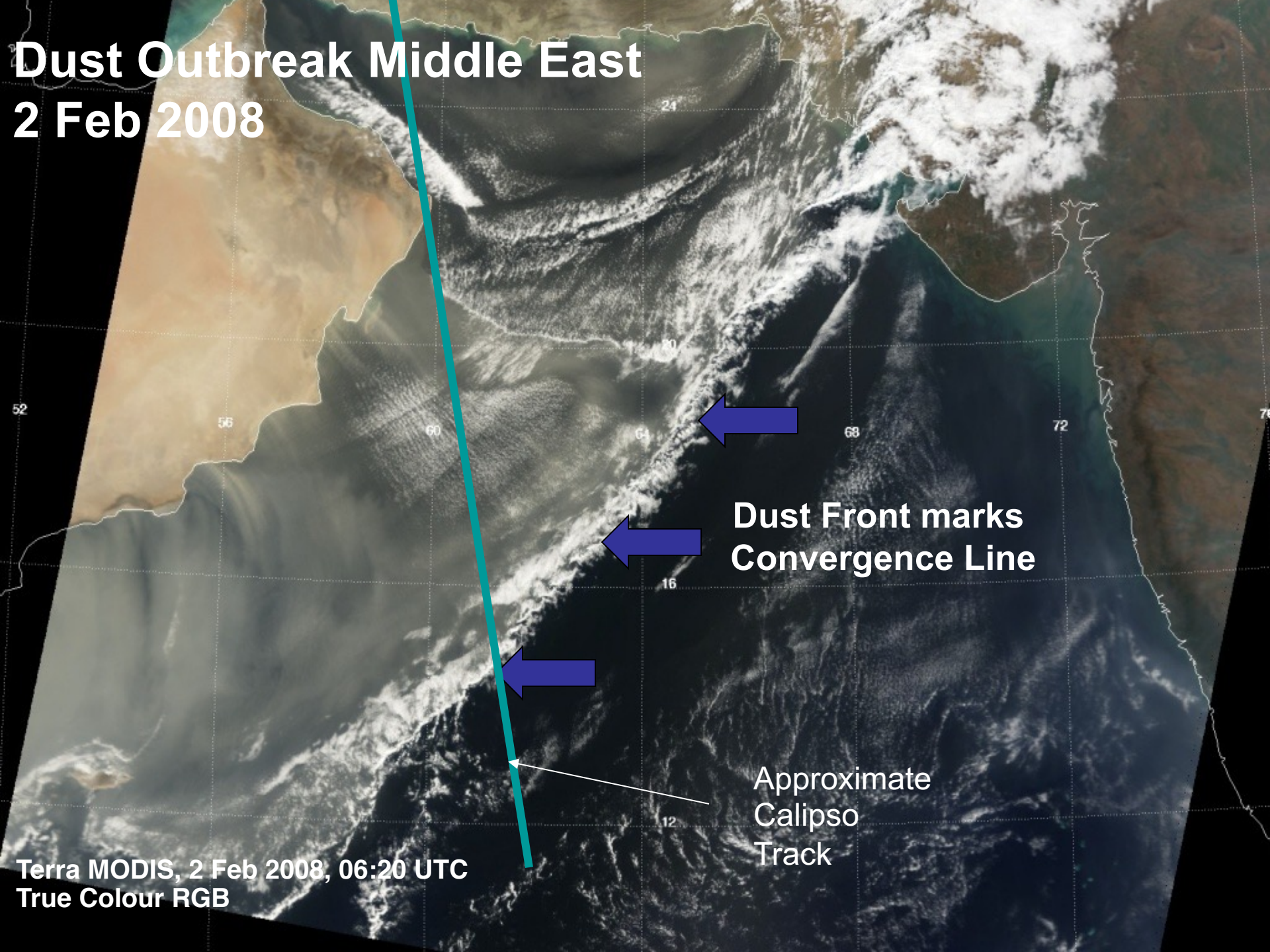
22 June 2007, 02:45 UTC (NIGHT!)





Dust Outbreak Middle East

2 Feb 2008



Terra MODIS, 2 Feb 2008, 06:20 UTC
True Colour RGB

Dust Outbreak Middle East

2 Feb 2008

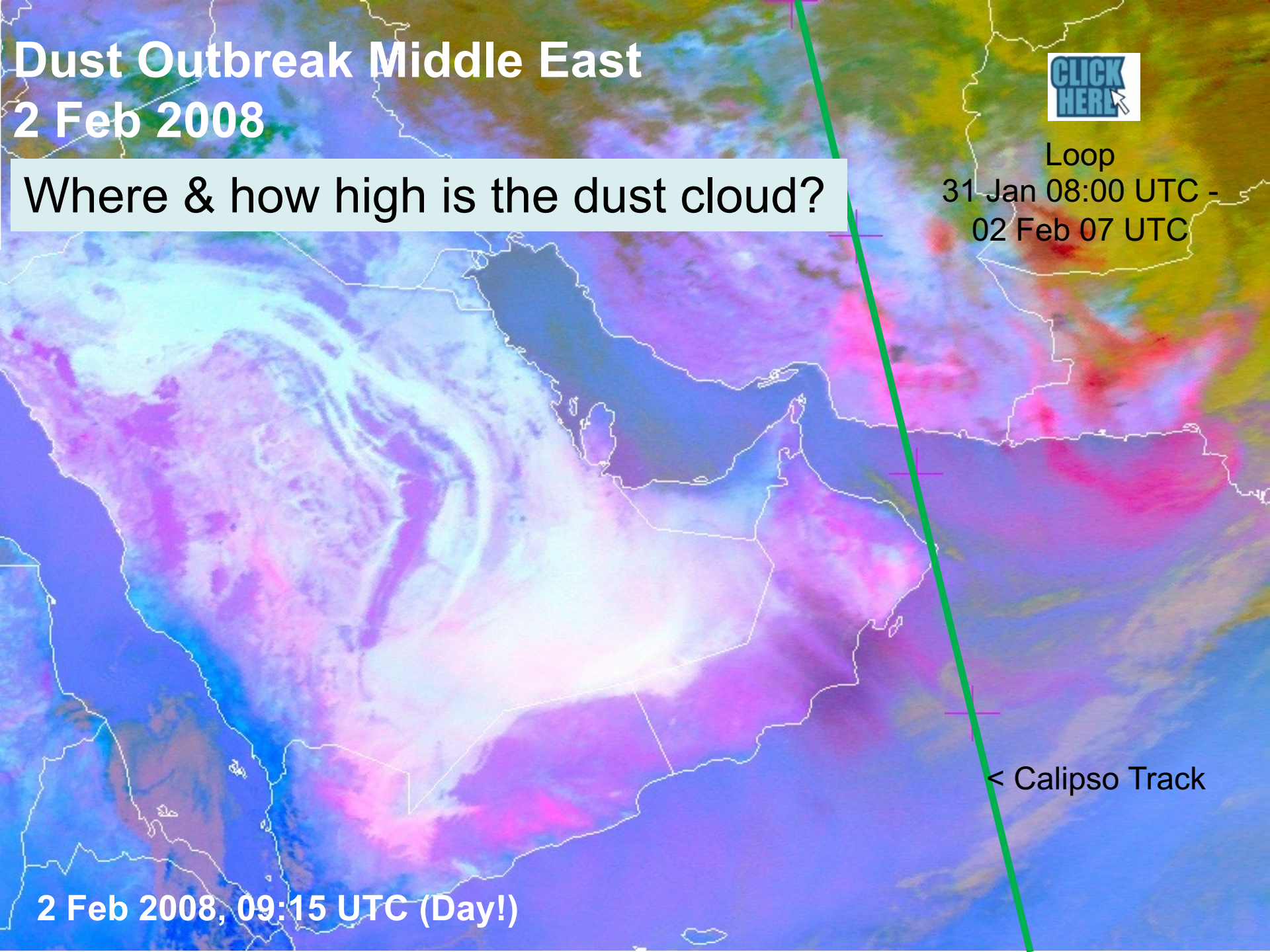


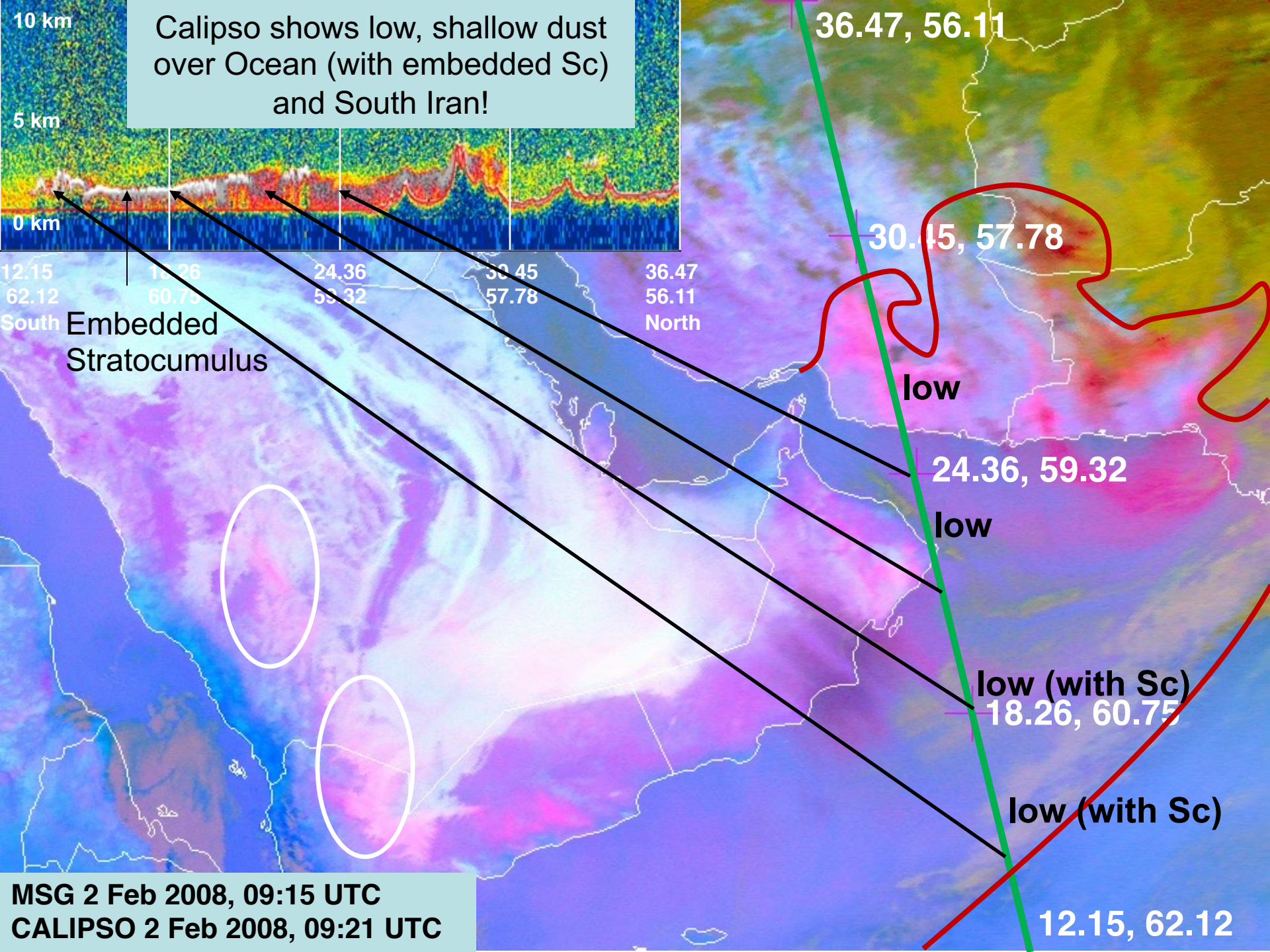
Where & how high is the dust cloud?

Loop
31 Jan 08:00 UTC -
02 Feb 07 UTC

< Calipso Track

2 Feb 2008, 09:15 UTC (Day!)





Dust Outbreak North Africa

8-13 June 2010

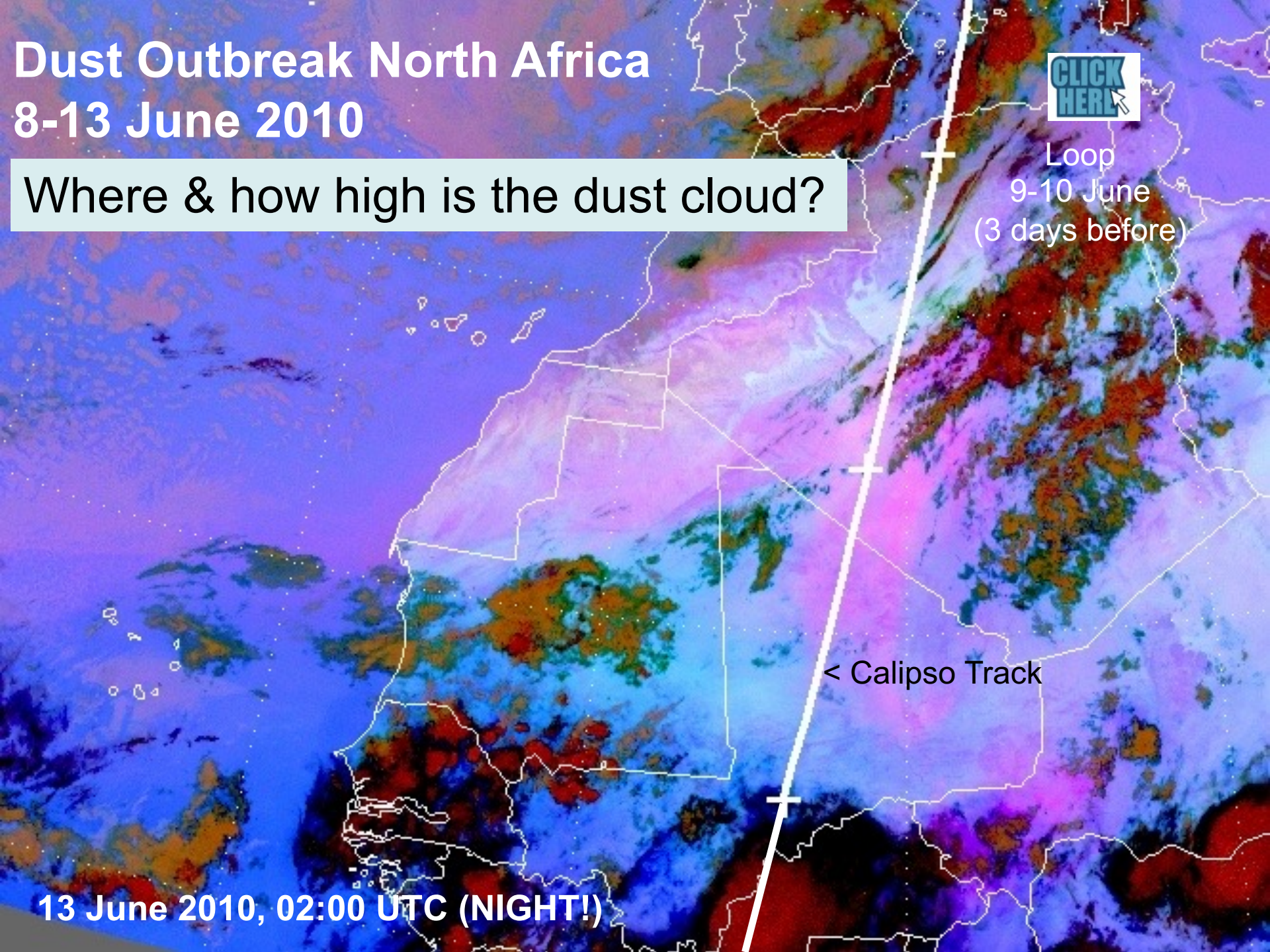
Where & how high is the dust cloud?

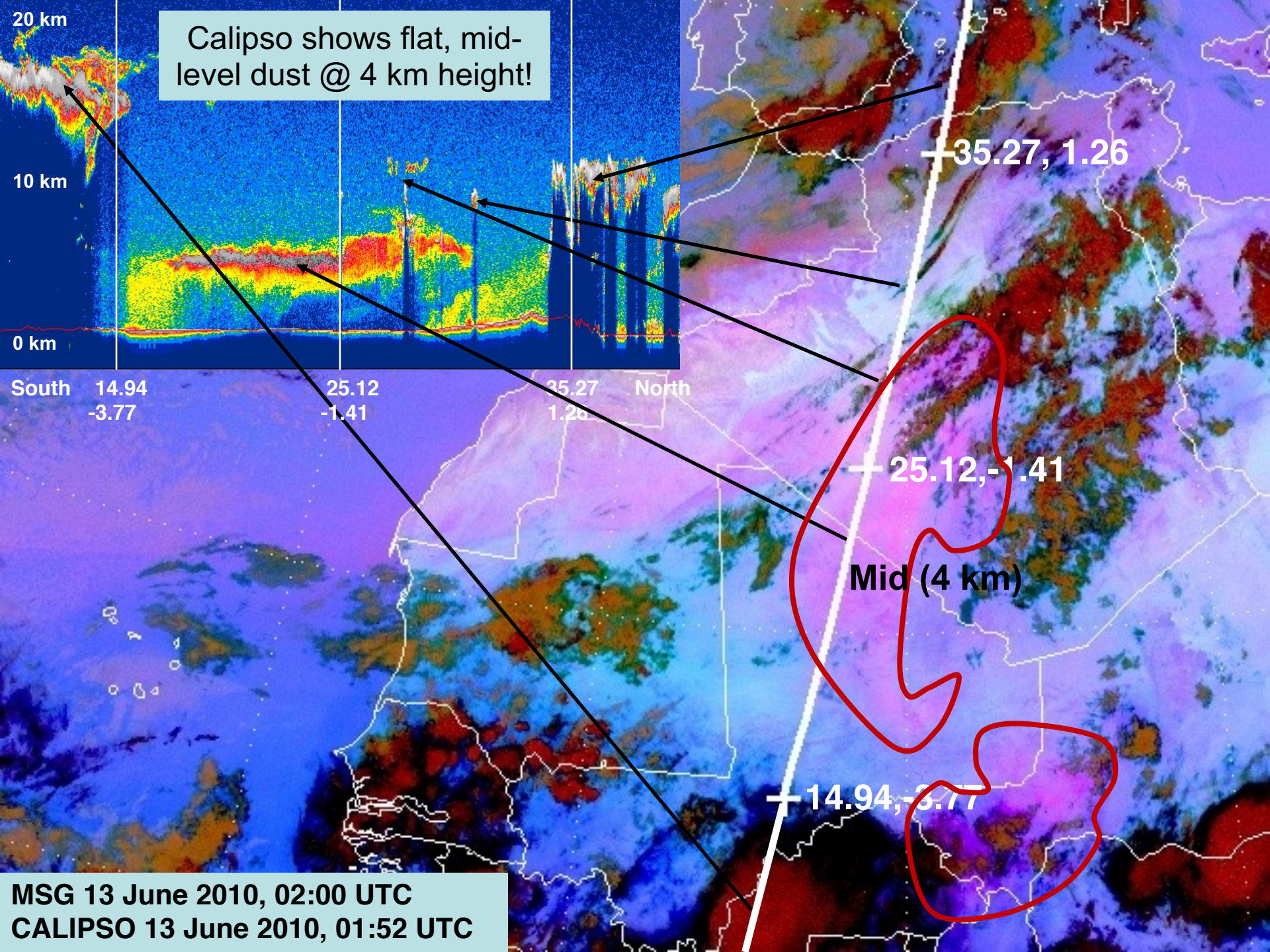


Loop
9-10 June
(3 days before)

< Calipso Track

13 June 2010, 02:00 UTC (NIGHT!)





Dust Outbreak Middle East

24 June 2010

[CLICK HERE](#)

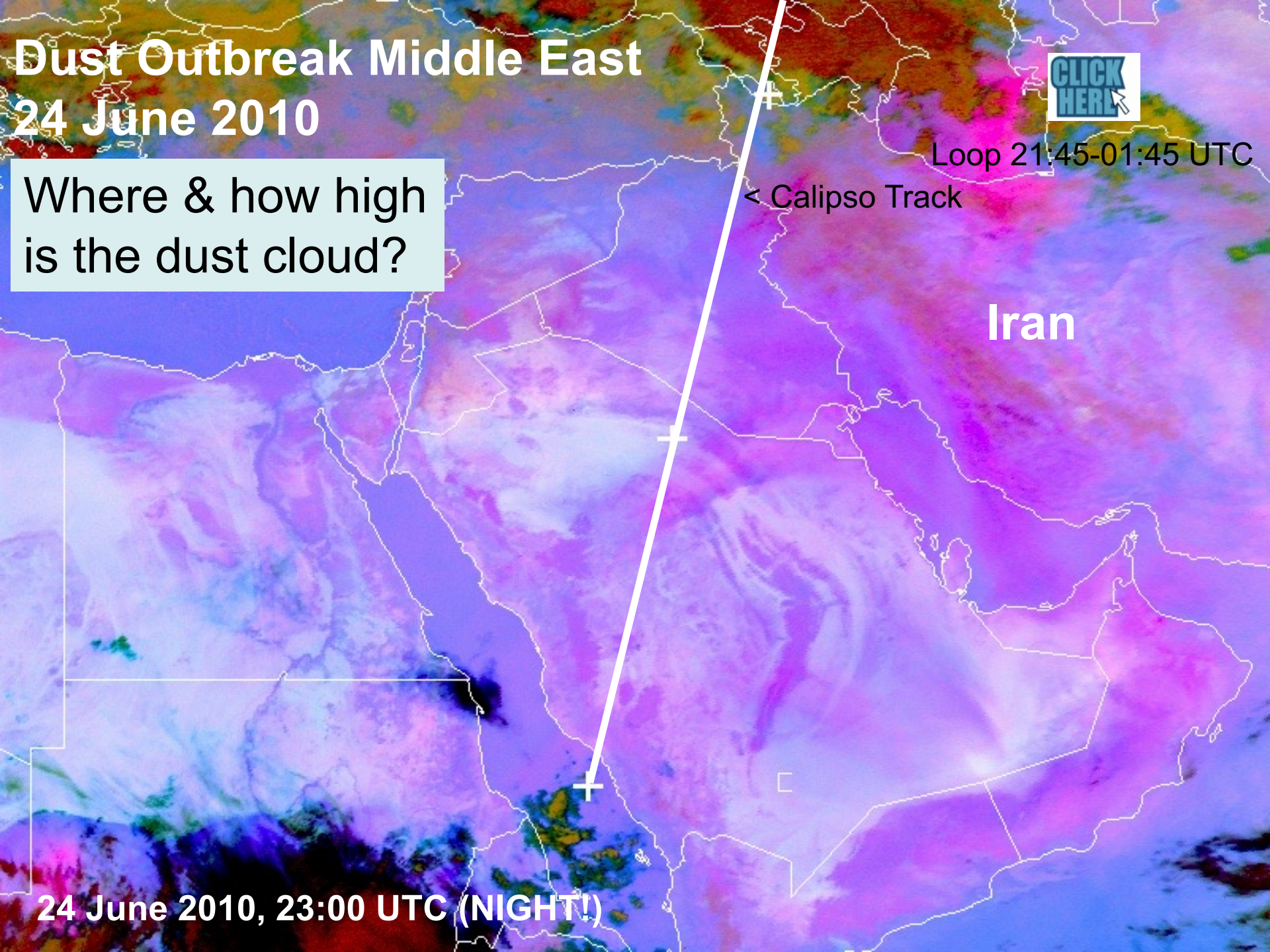
Loop 21:45-01:45 UTC

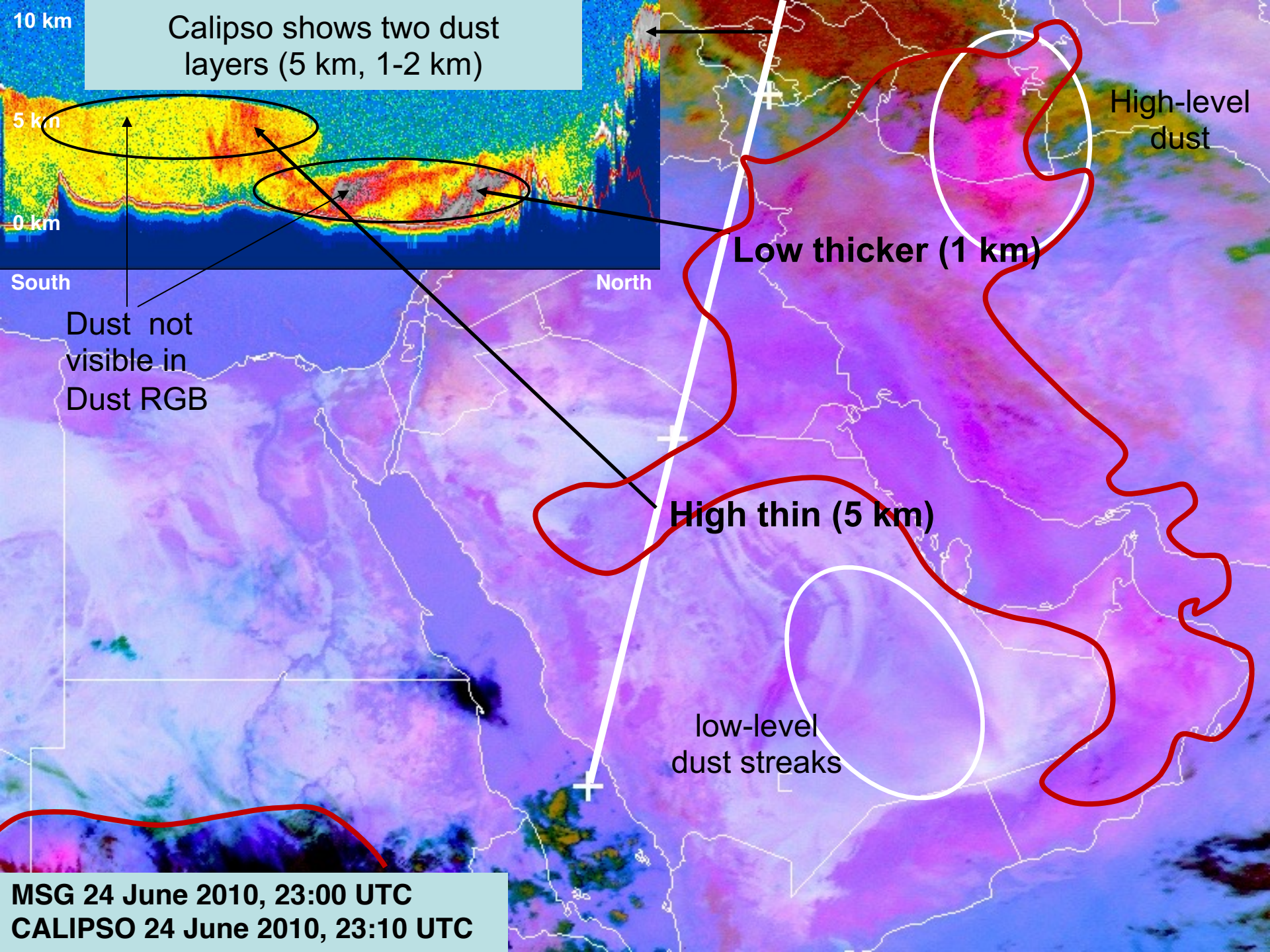
< Calipso Track

Iran

Where & how high
is the dust cloud?

24 June 2010, 23:00 UTC (NIGHT!)



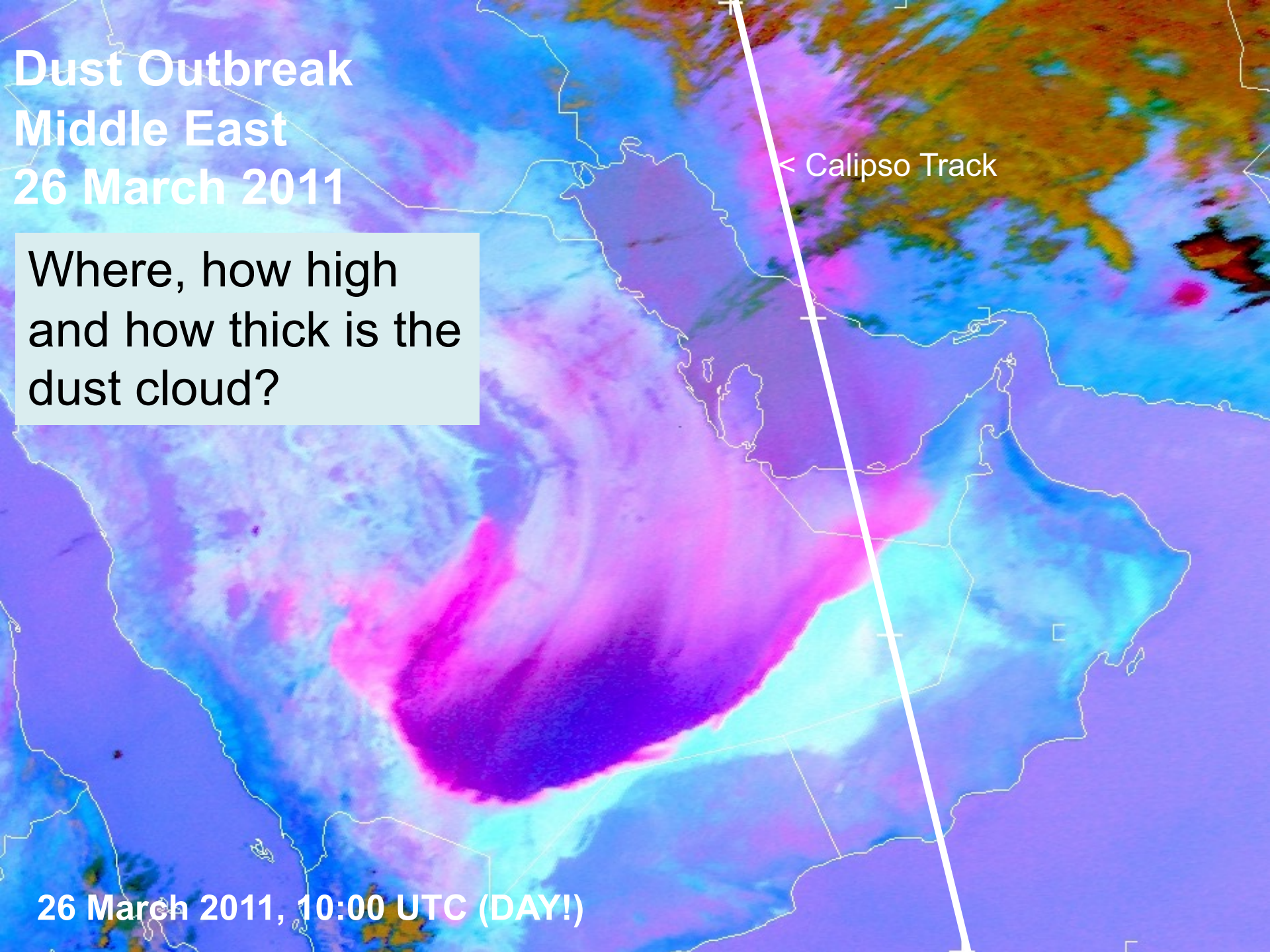


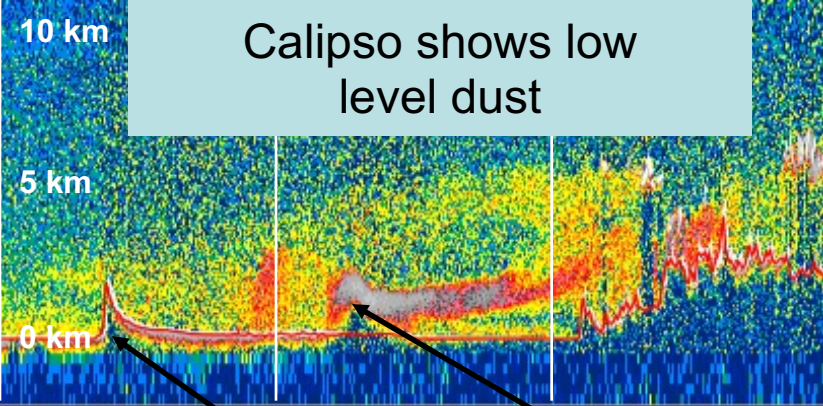
Dust Outbreak Middle East 26 March 2011

Where, how high
and how thick is the
dust cloud?

< Calipso Track

26 March 2011, 10:00 UTC (DAY!)





14.83 20.93 27.03 33.11
55.45 54.06 52.59 50.99
South North

Dust Outbreak Middle East 26 March 2011

< Calipso Track

27.03, 52.59

20.93, 54.06



Youtube

MSG 26 Mar 2011, 10:00 UTC
CALIPSO 26 Mar 2011, 09:52 UTC

14.83, 55.45

Dust Outbreak Argentina

29 October 2010



Loop 07:00-22:00 UTC

Chile

< Calipso Track

Argentina

Where & how high is the dust cloud?

29 Oct 2010, 18:00 UTC (DAY!)

Calipso shows low-level dust
in boundary layer (surface dust)!

10 km

5 km

0 km

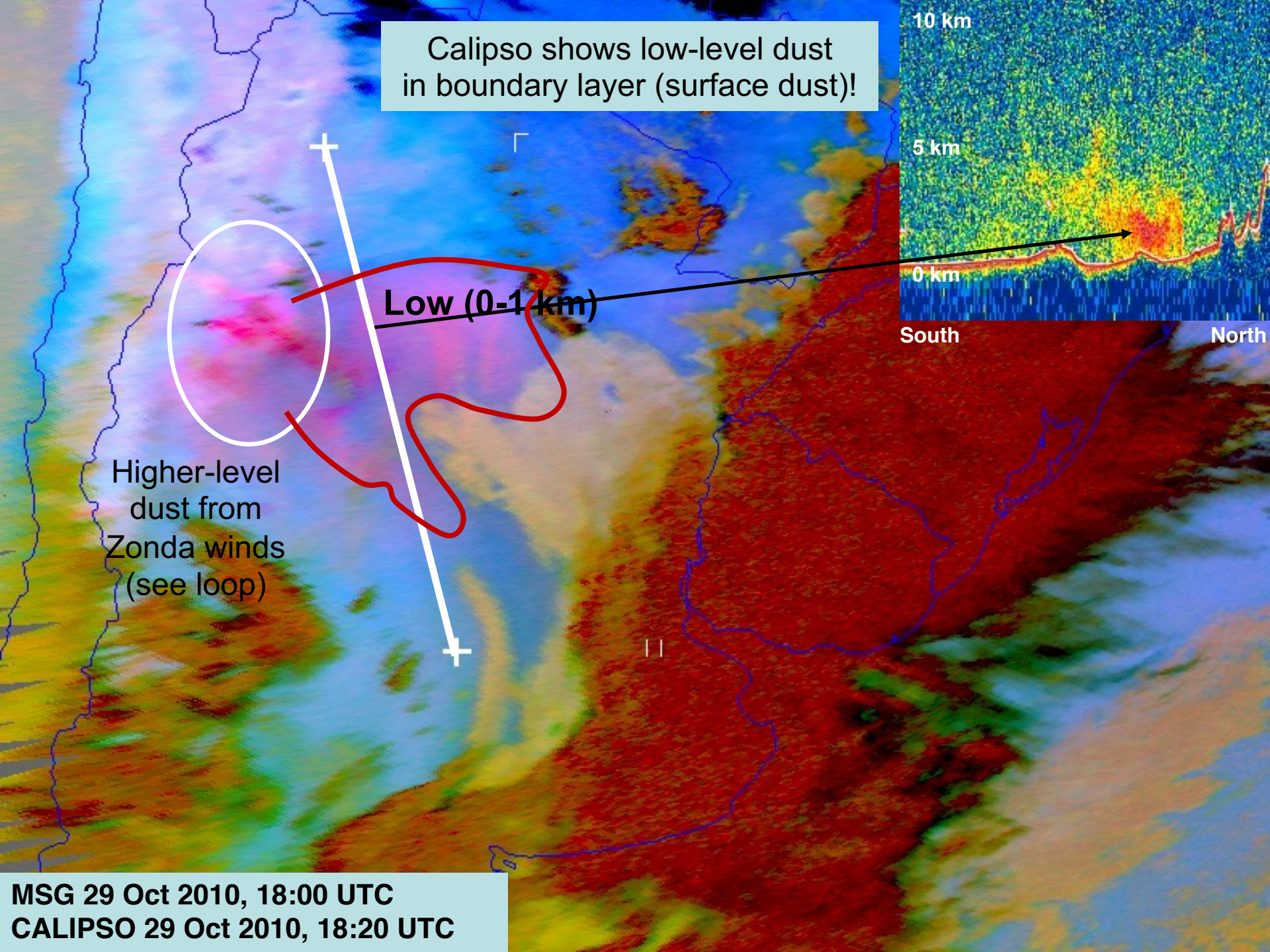
South

North

Low (0-1 km)

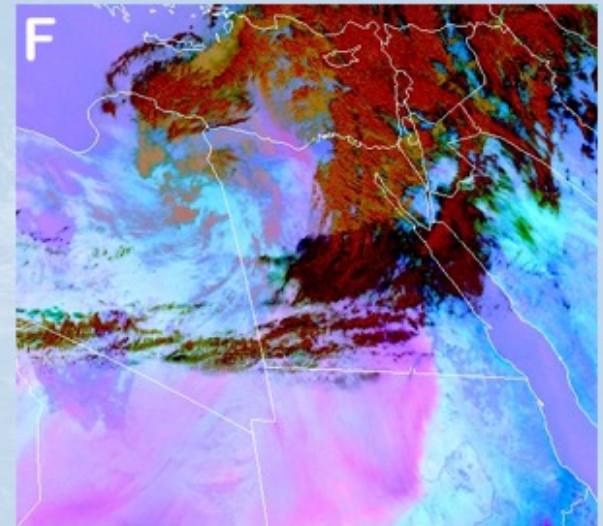
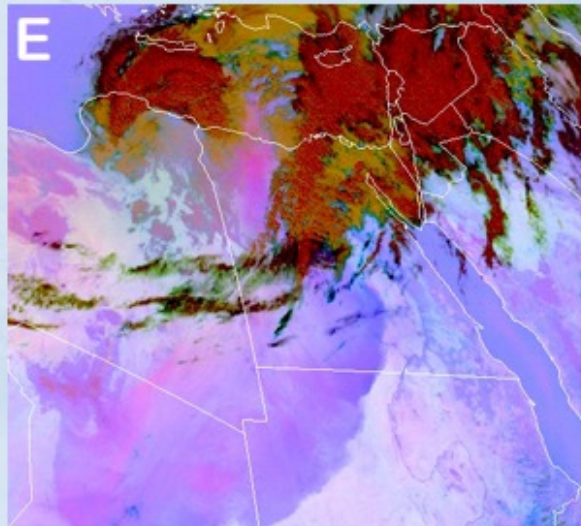
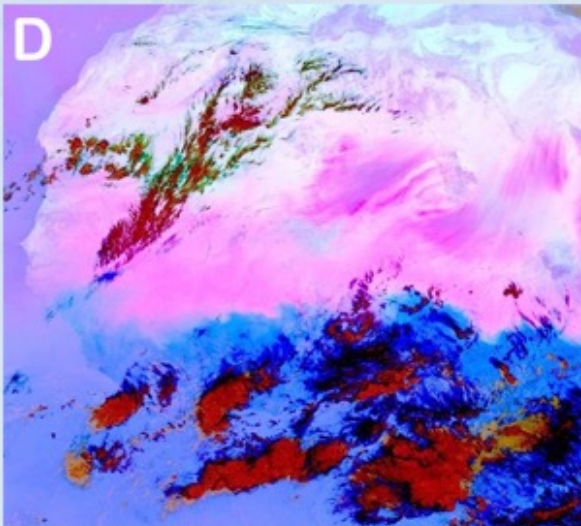
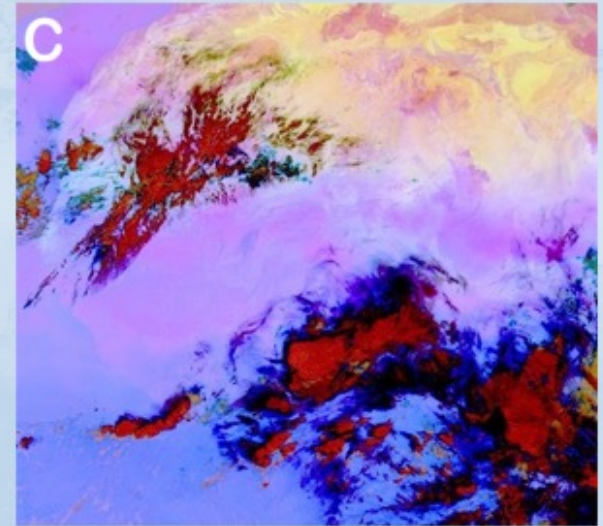
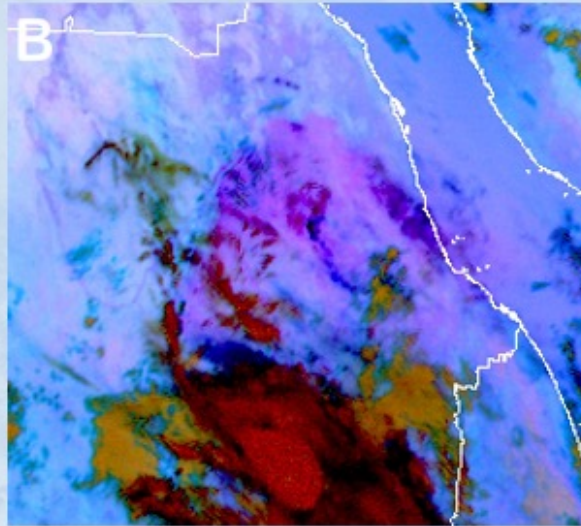
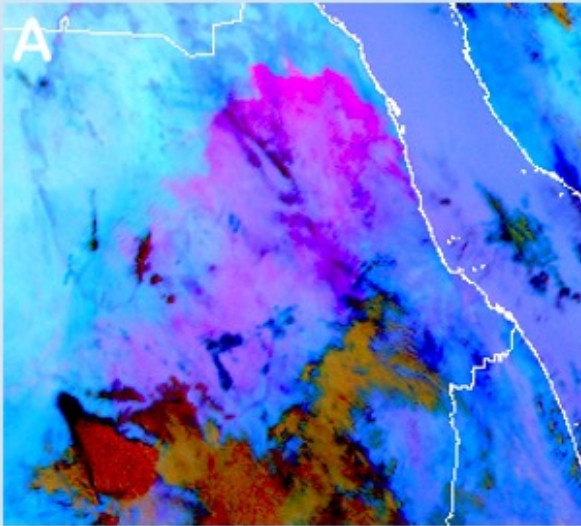
Higher-level
dust from
Zonda winds
(see loop)

MSG 29 Oct 2010, 18:00 UTC
CALIPSO 29 Oct 2010, 18:20 UTC



7. Dust RGB

Question: Below you find six images. The images are taken on three dates with one image taken during the night and the other during the day. Can you tell which is which?



☐ - A, C and E are nighttime images, B, D and F are daytime images

☐ - B, C and E are nighttime images, A, D and F are daytime images

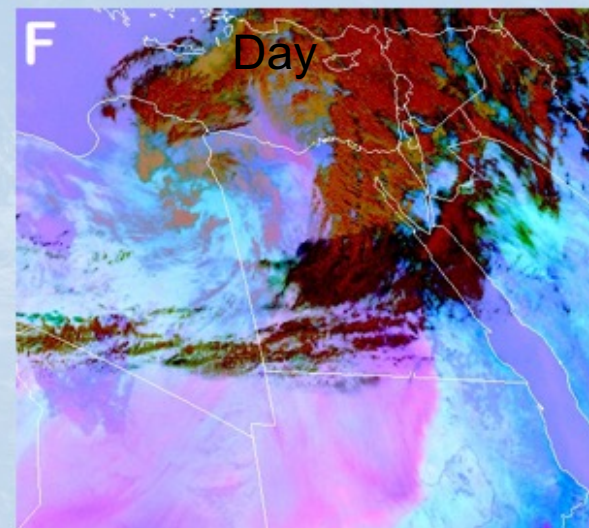
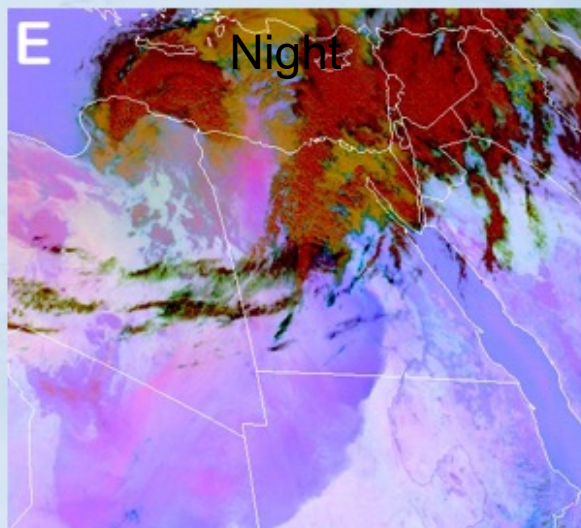
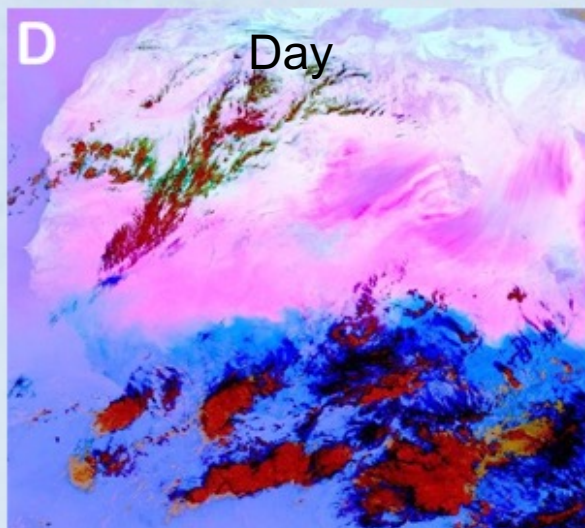
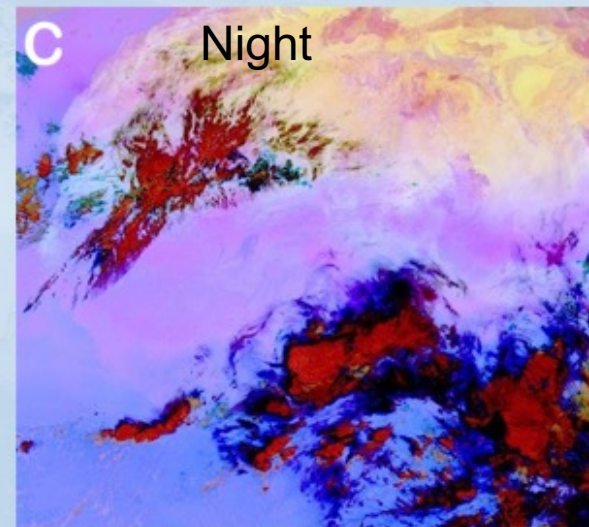
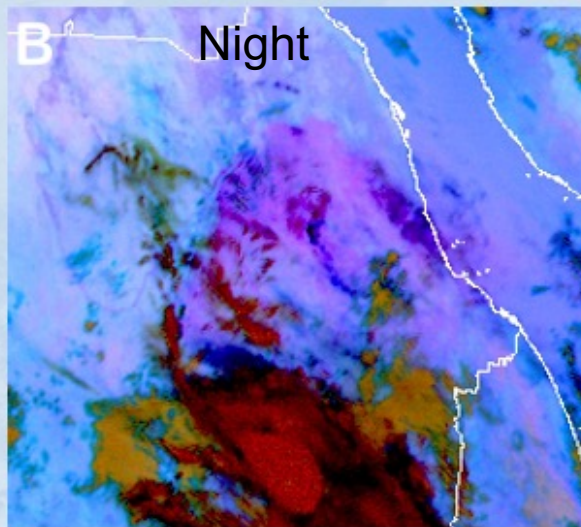
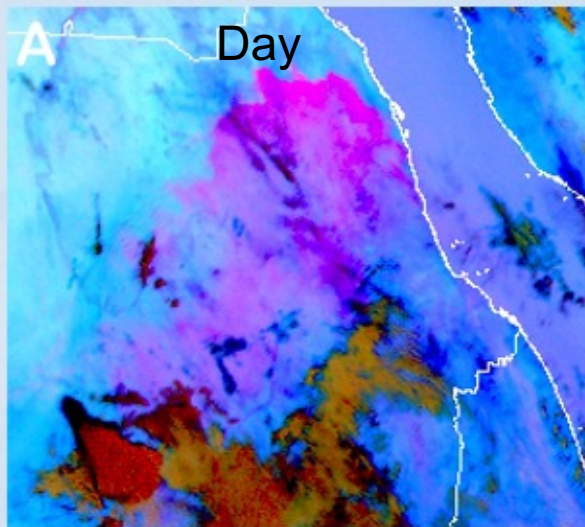
☐ - A, D and E are nighttime images, B, C and F are daytime images

☐ - A, C and F are nighttime images, B, D and E are daytime images

[Back](#)[Submit](#)

7. Dust RGB

Question: Below you find six images. The images are taken on three dates with one image taken during the night and the other during the day. Can you tell which is which?



☐ - A, C and E are nighttime images, B, D and F are daytime images

☒ - B, C and E are nighttime images, A, D and F are daytime images

☐ - A, D and E are nighttime images, B, C and F are daytime images

☐ - A, C and F are nighttime images, B, D and E are daytime images

Back

Submit

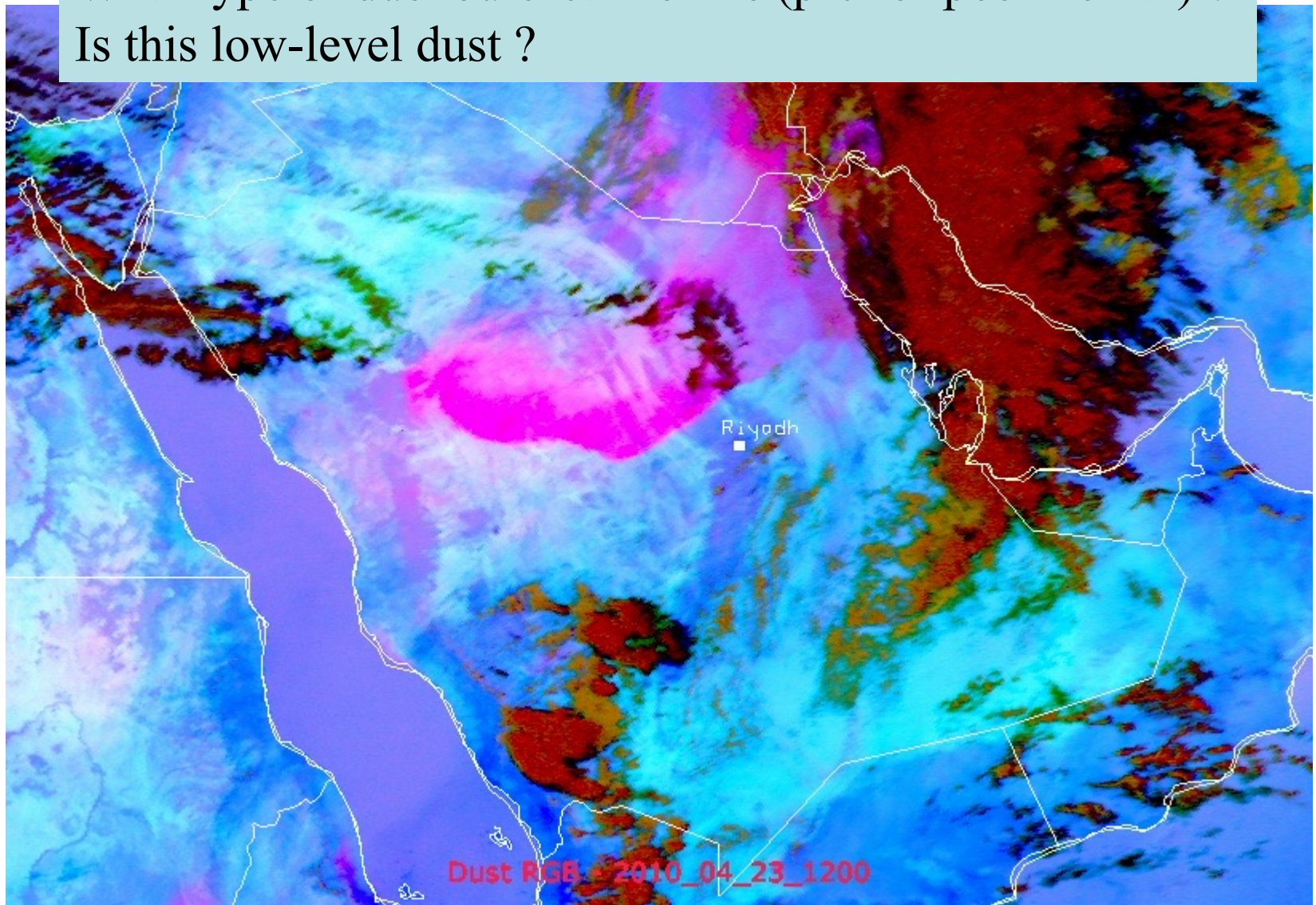
Correct answer

Dust Nowcasting Exercises

When will the dust cloud reach Riyadh ?

What type of dust outbreak is this (pre- or post frontal) ?

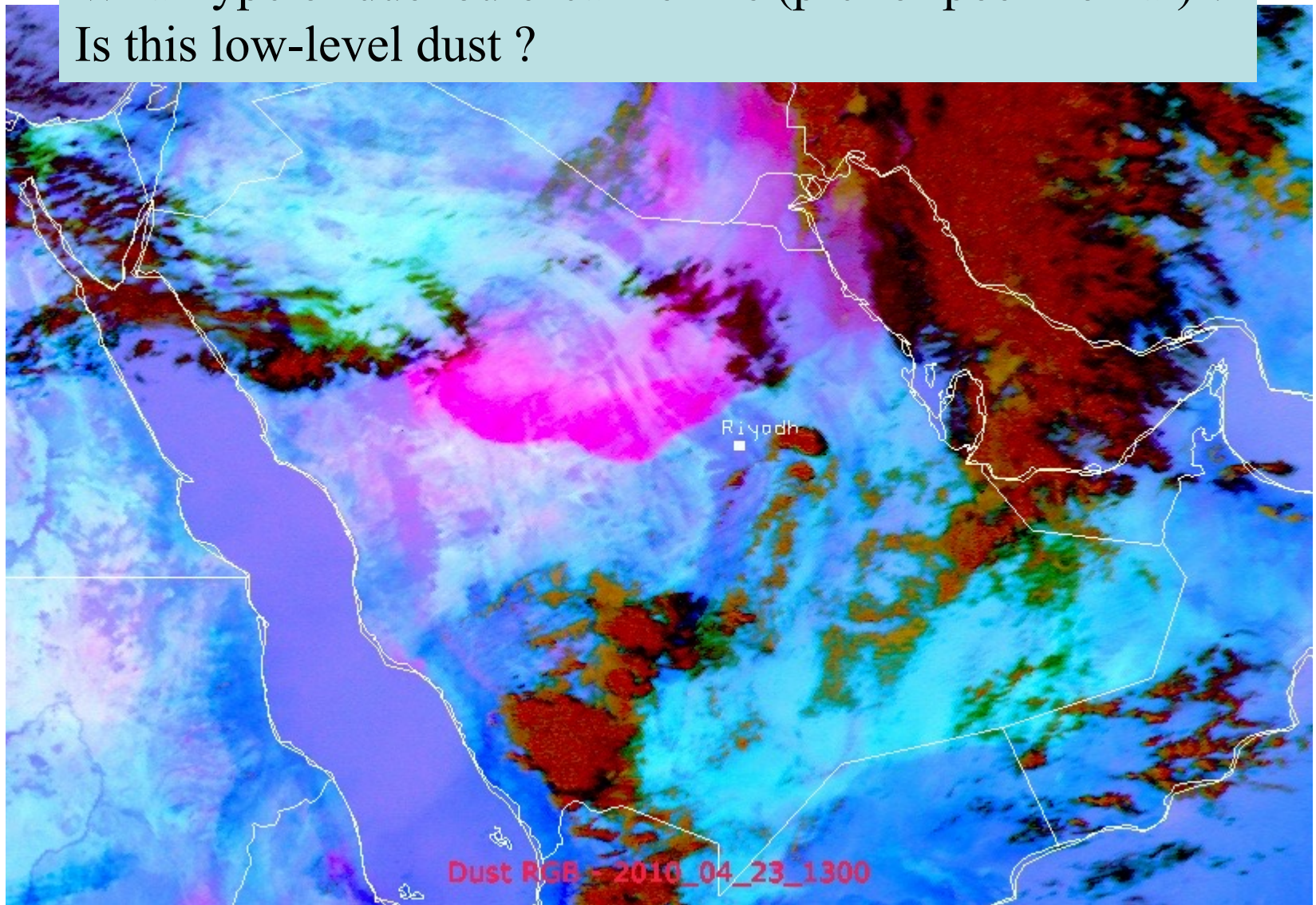
Is this low-level dust ?



When will the dust cloud reach Riyadh ?

What type of dust outbreak is this (pre- or post frontal) ?

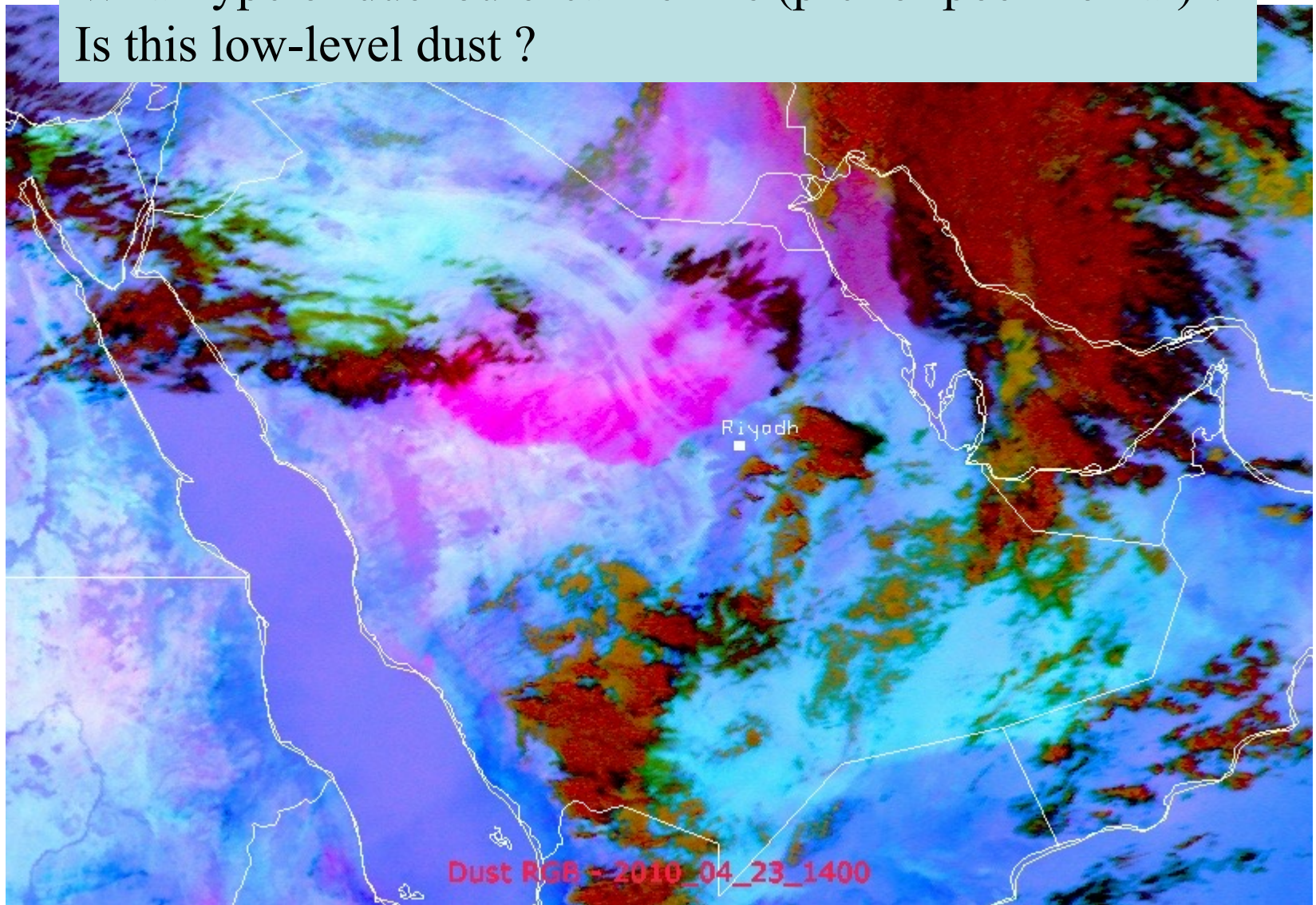
Is this low-level dust ?

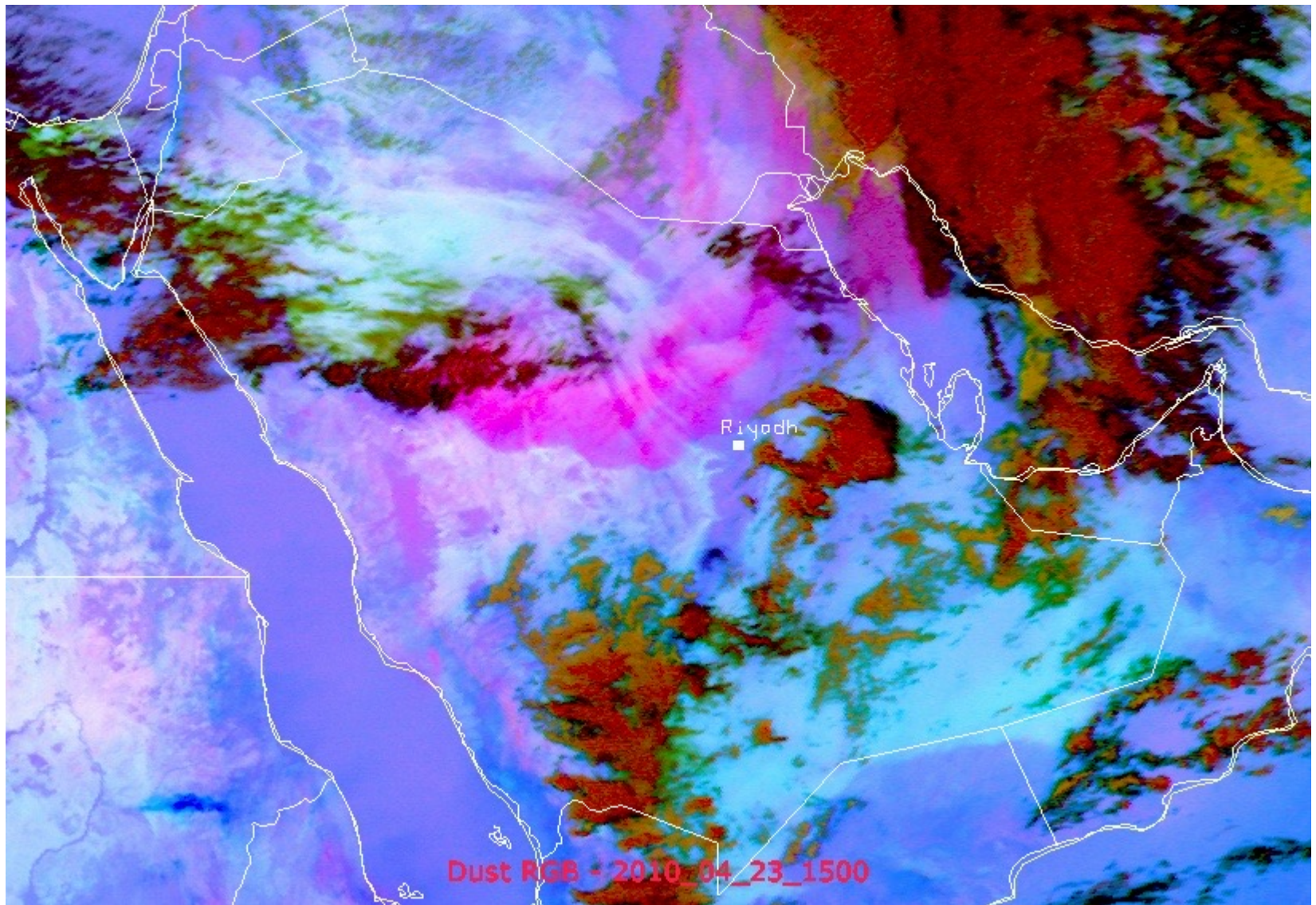


When will the dust cloud reach Riyadh ?

What type of dust outbreak is this (pre- or post frontal) ?

Is this low-level dust ?

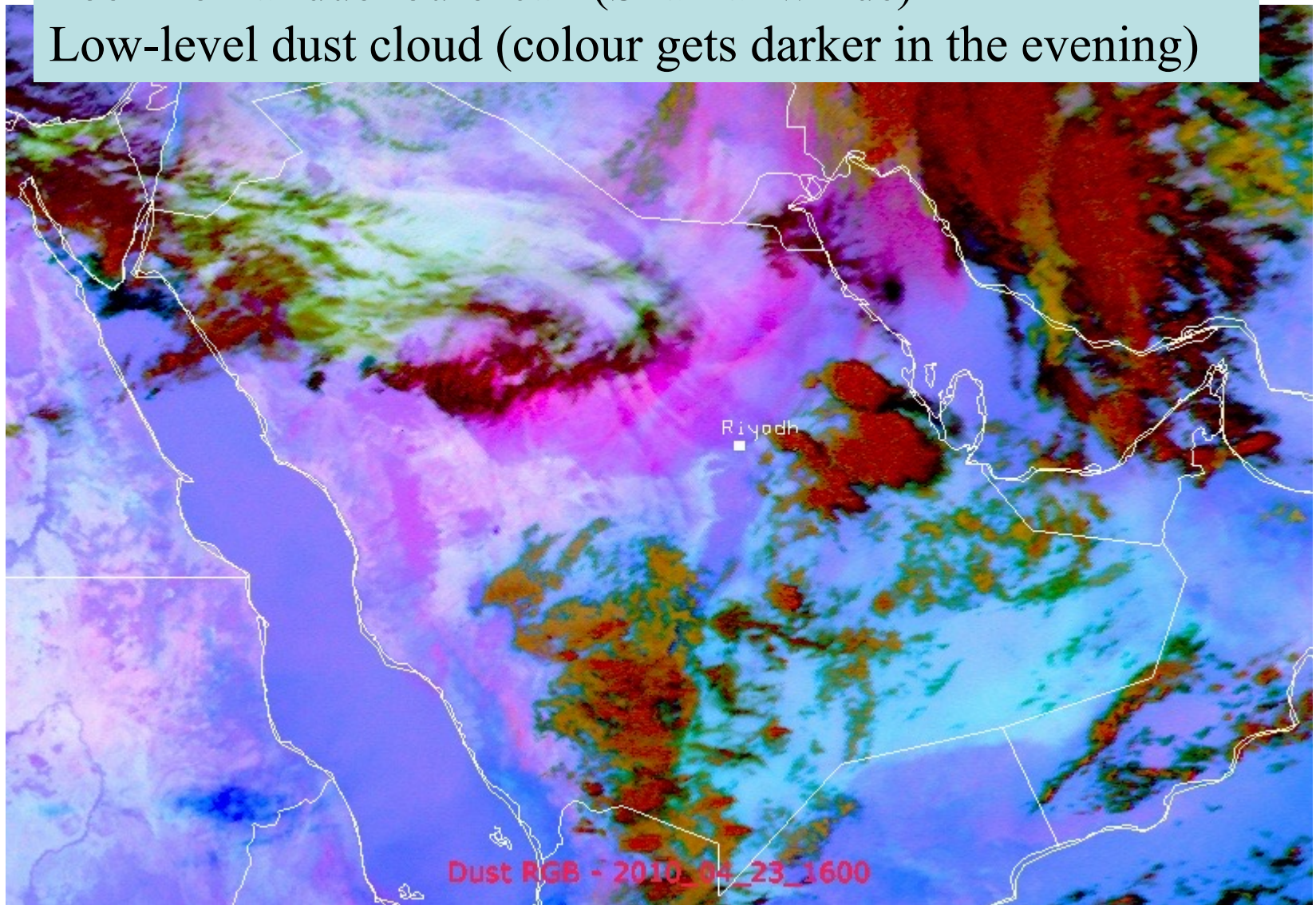




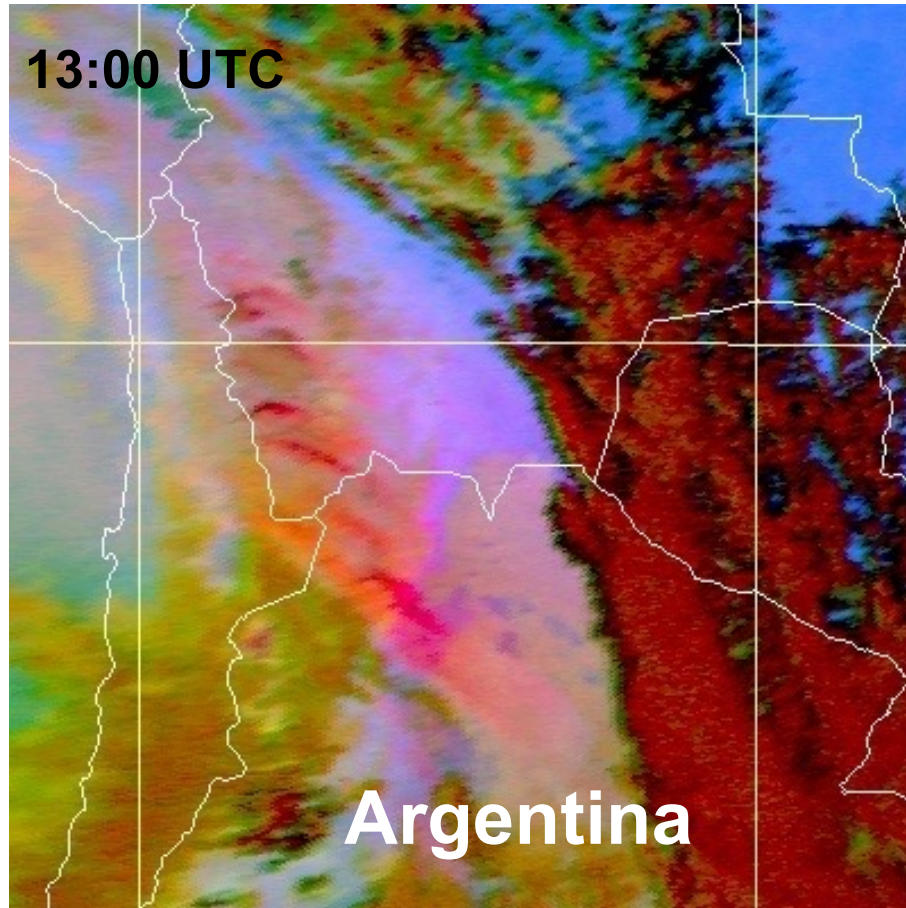
Dust arrives in Riyadh at around 16 UTC

Post-frontal dust outbreak (Shamal winds)

Low-level dust cloud (colour gets darker in the evening)

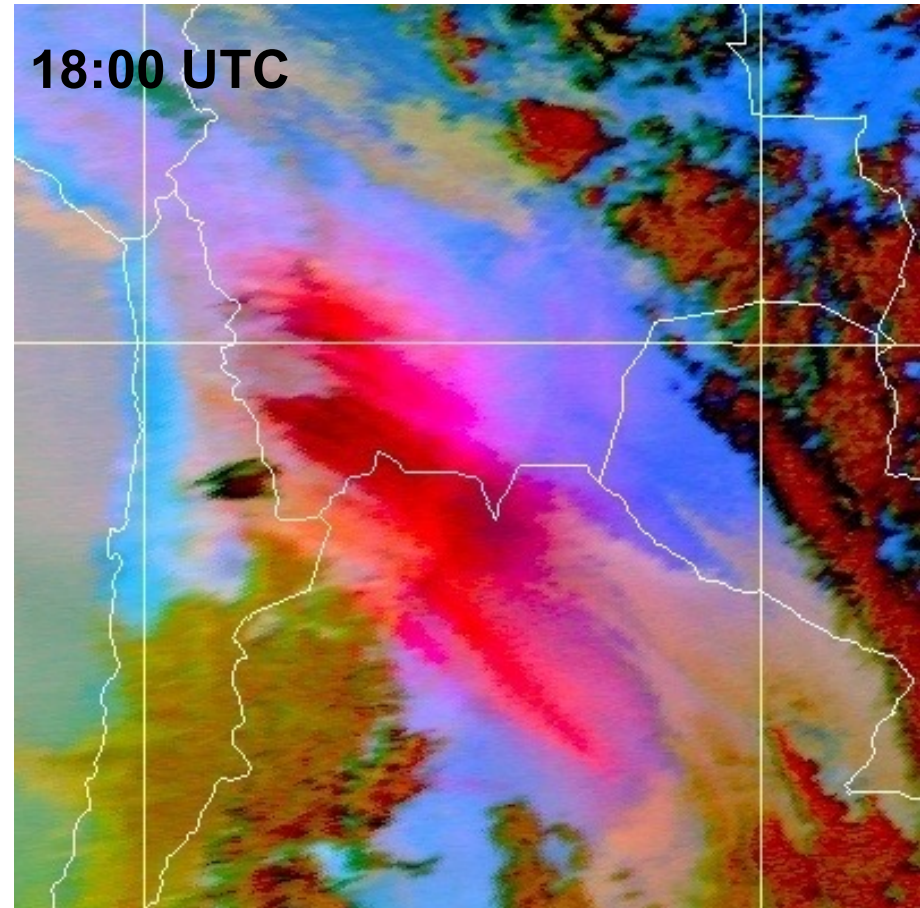
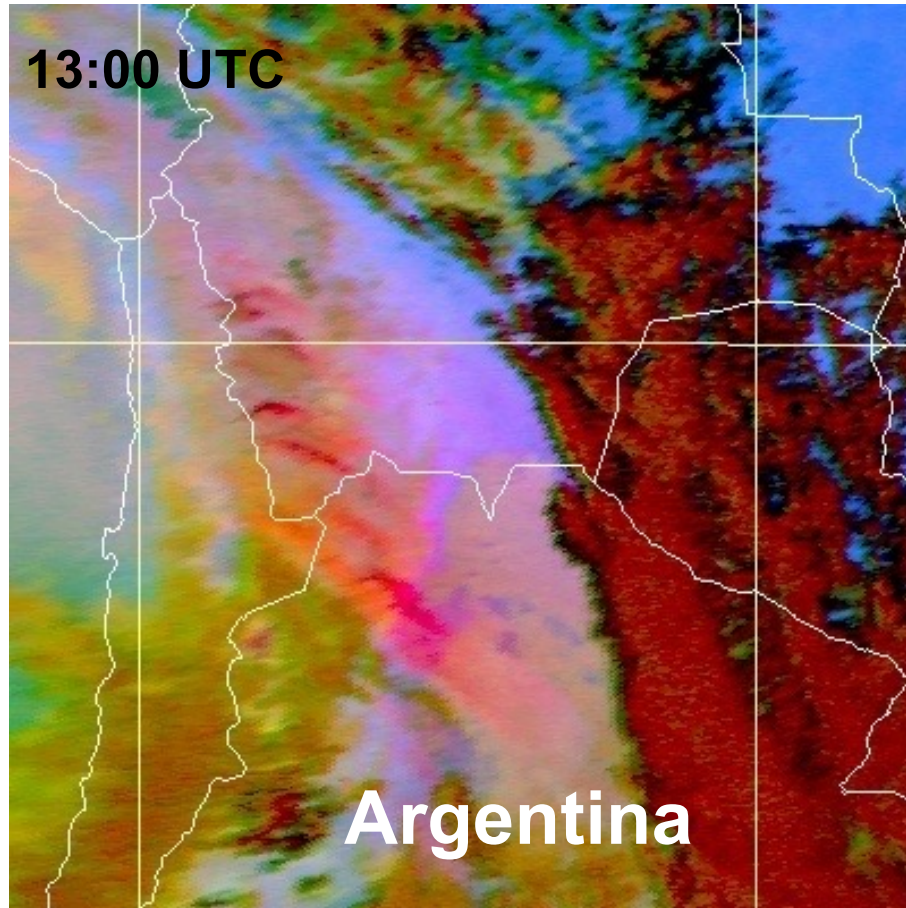


Make a dust forecast for 18:00 UTC ?
What type of dust outbreak is this ?
Is this high-level or low-level dust ?



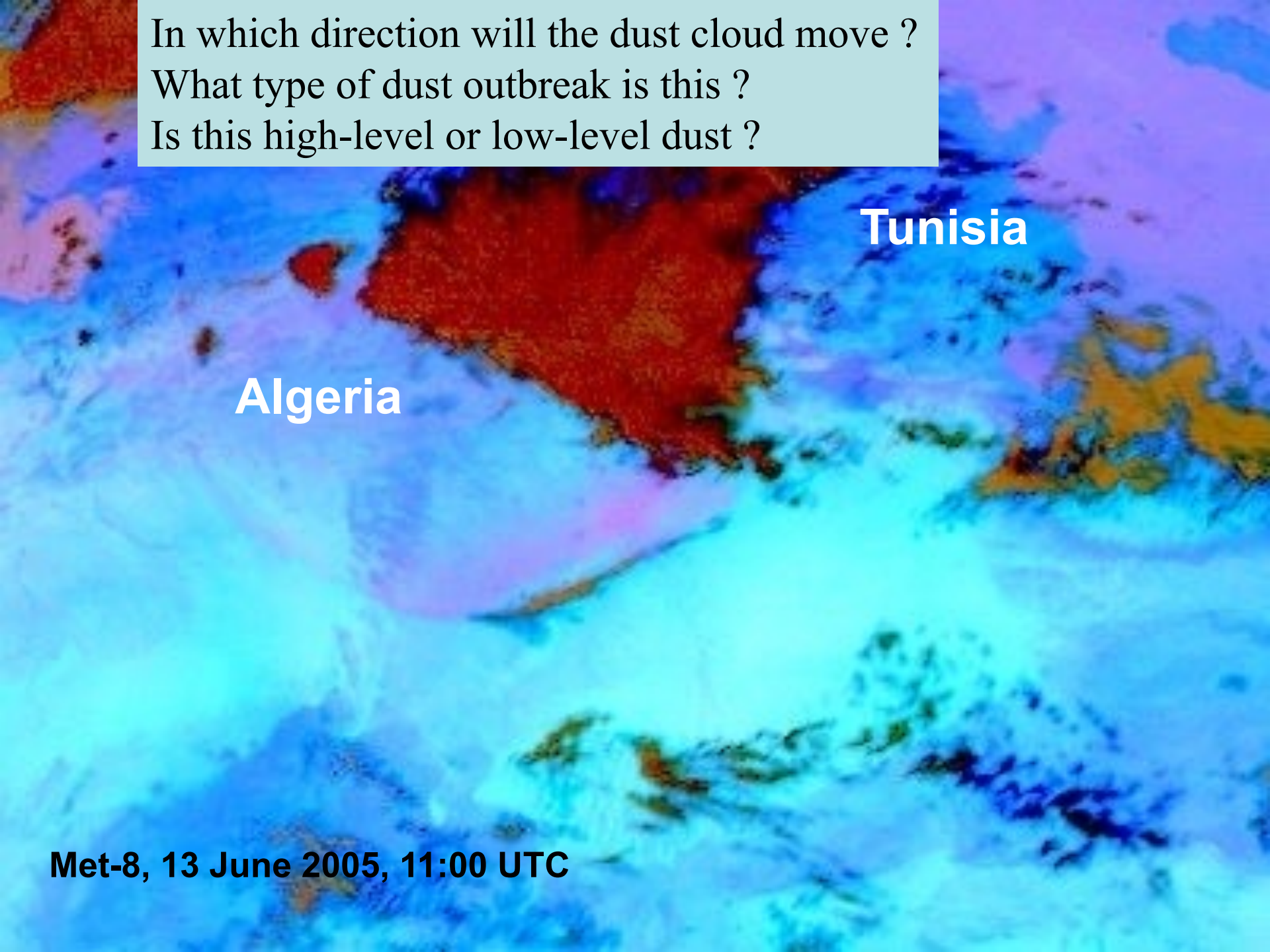
Met-9, 21 July 2009

Dust travels very fast following the frontal system
Dust caused by strong winds over the Andes (viento blanco)
Mainly High-level dust cloud

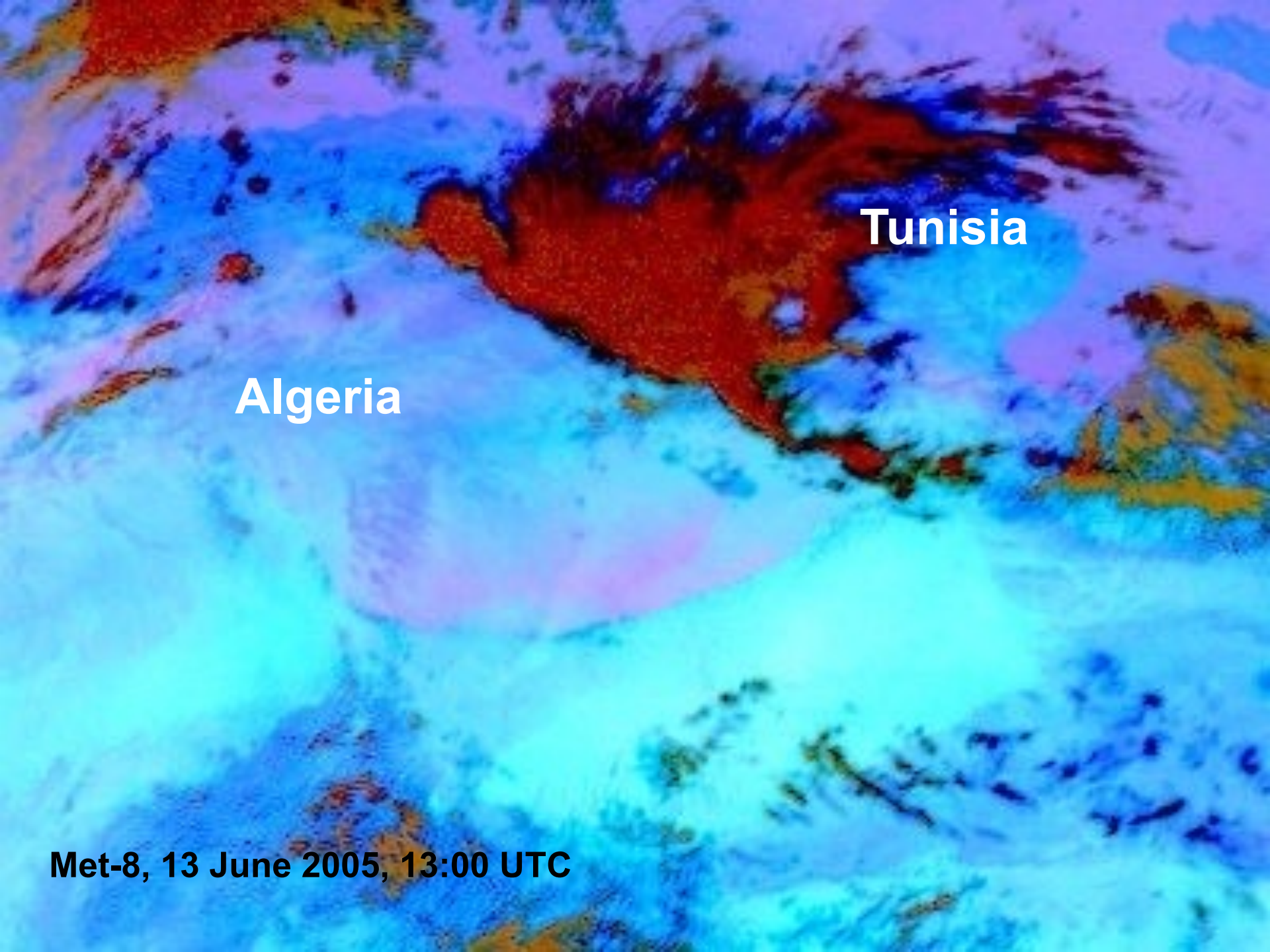


Met-9, 21 July 2009

In which direction will the dust cloud move ?
What type of dust outbreak is this ?
Is this high-level or low-level dust ?



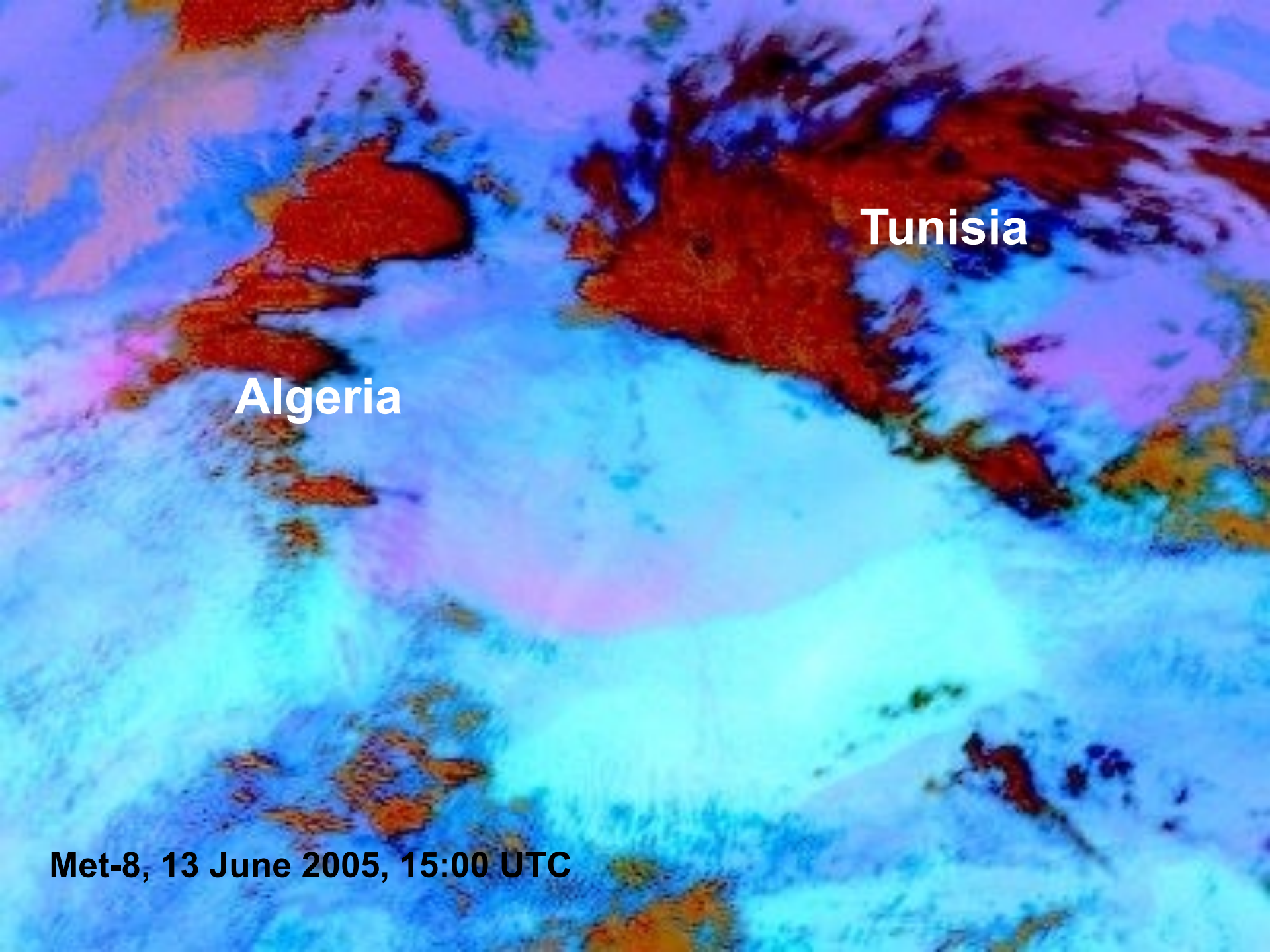
Met-8, 13 June 2005, 11:00 UTC



Tunisia

Algeria

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



Tunisia

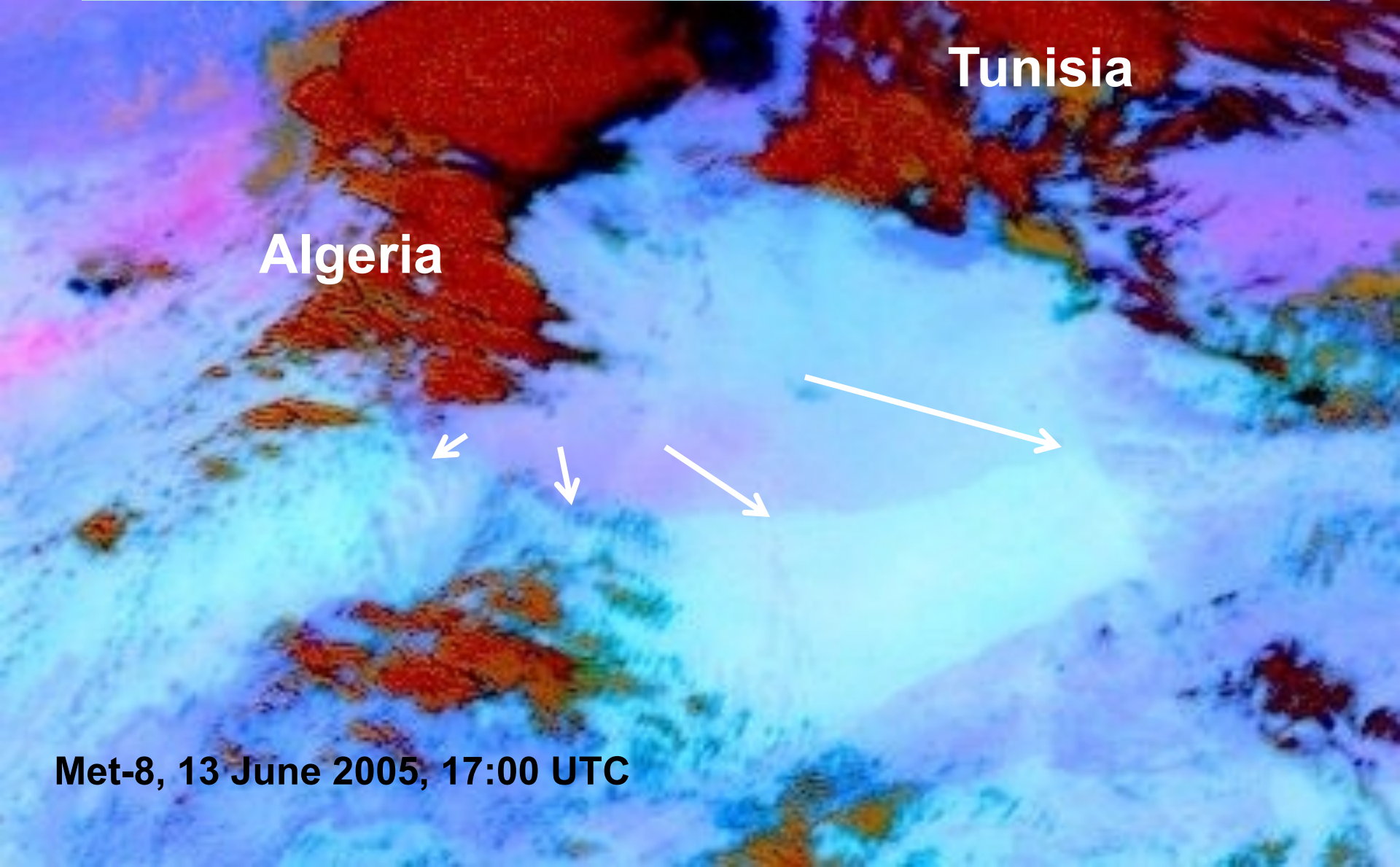
Algeria

Met-8, 13 June 2005, 15:00 UTC

Dust moves quickly eastwards (and a bit southwards)

Dust is caused by gust outflow from Cb system

Low-level (thin) dust cloud (colour gets darker in the evening)

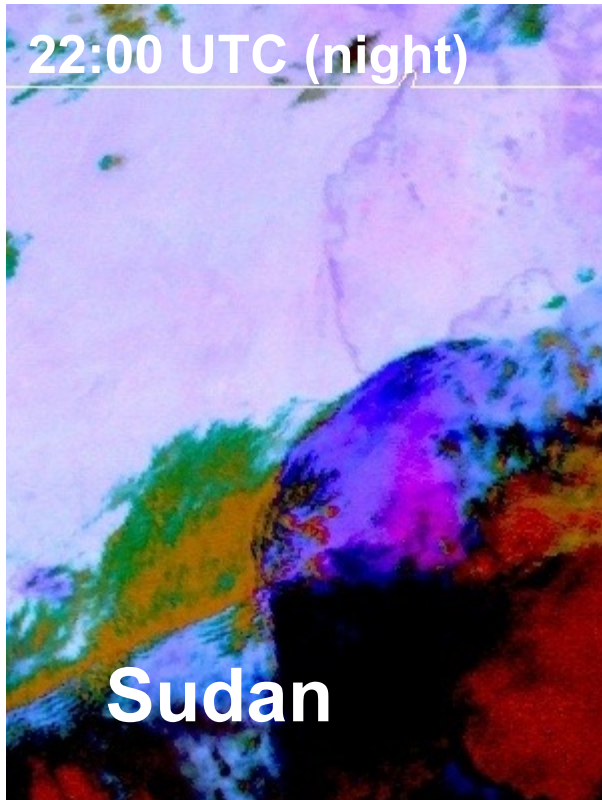


Met-8, 13 June 2005, 17:00 UTC

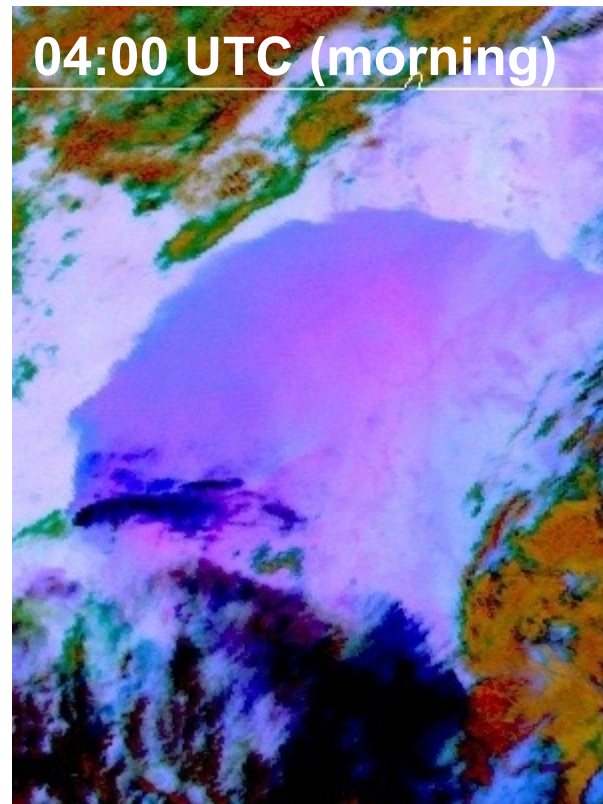
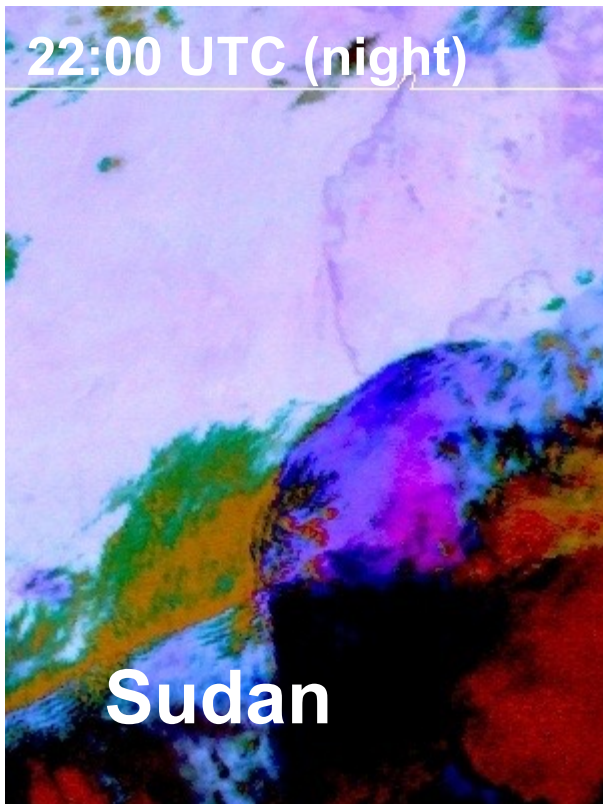
Make a 6 and 12 h dust forecast ?

What type of dust outbreak is this ?

Is this high-level or low-level dust ?



Met-8, 29-30 April 2007



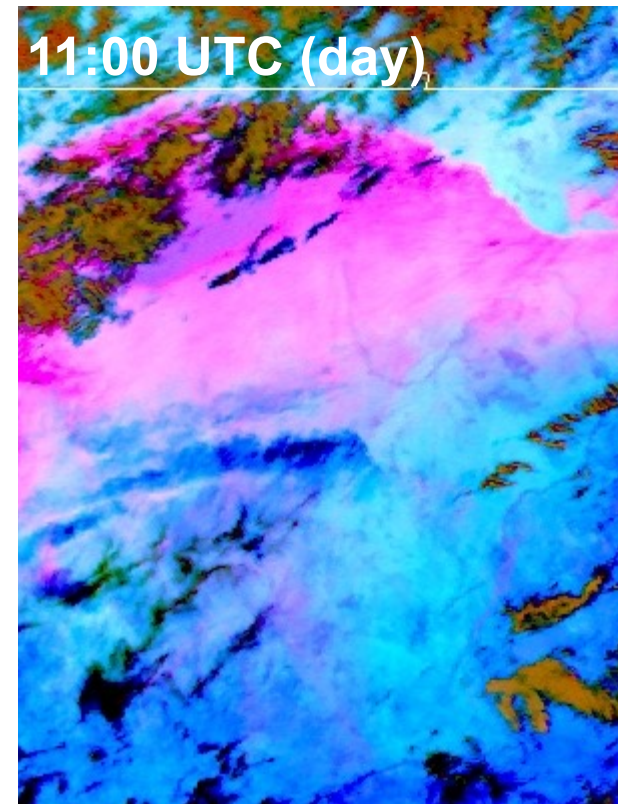
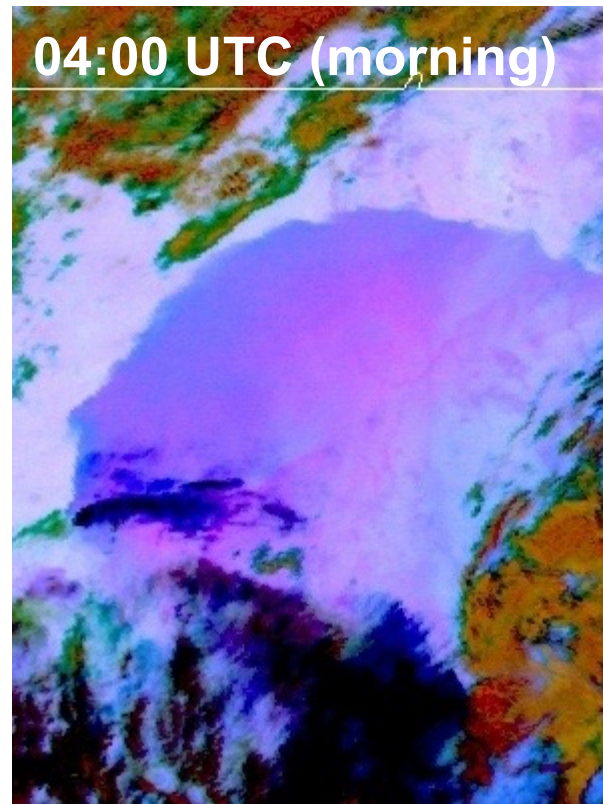
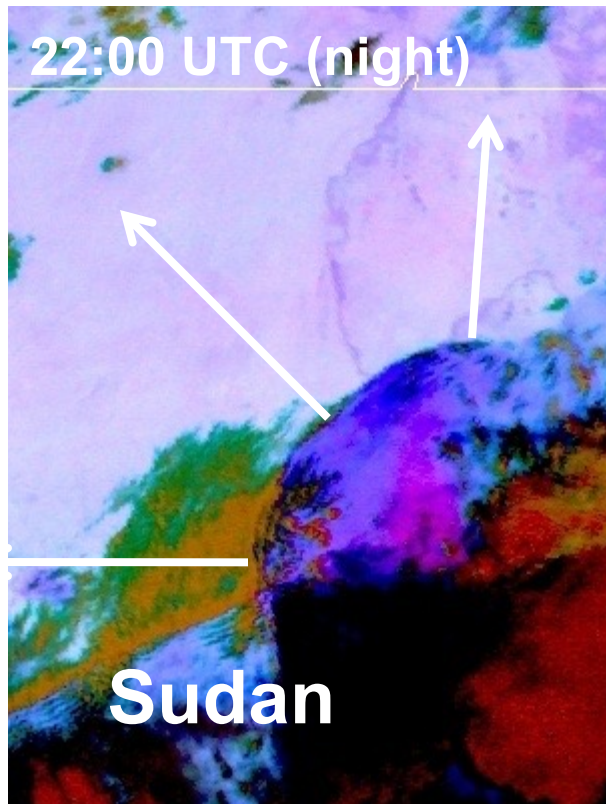
Met-8, 29-30 April 2007

Dust moves north- and westwards

Dust is caused by gust outflow from Cb system

Low-level dust cloud (colour is dark in the night)

at 11 UTC some dust may be lifted higher (diurnal convection)



Met-8, 29-30 April 2007

2005 May 8 11:00

What type of dust outbreak is this ?

Make a convection and dust forecast for the next 12 hours



A small Cb is triggered by the convection over the Hoggar

2005 May 8 14:00

What type of dust outbreak is this ?

Make a convection and dust forecast for the next 12 hours

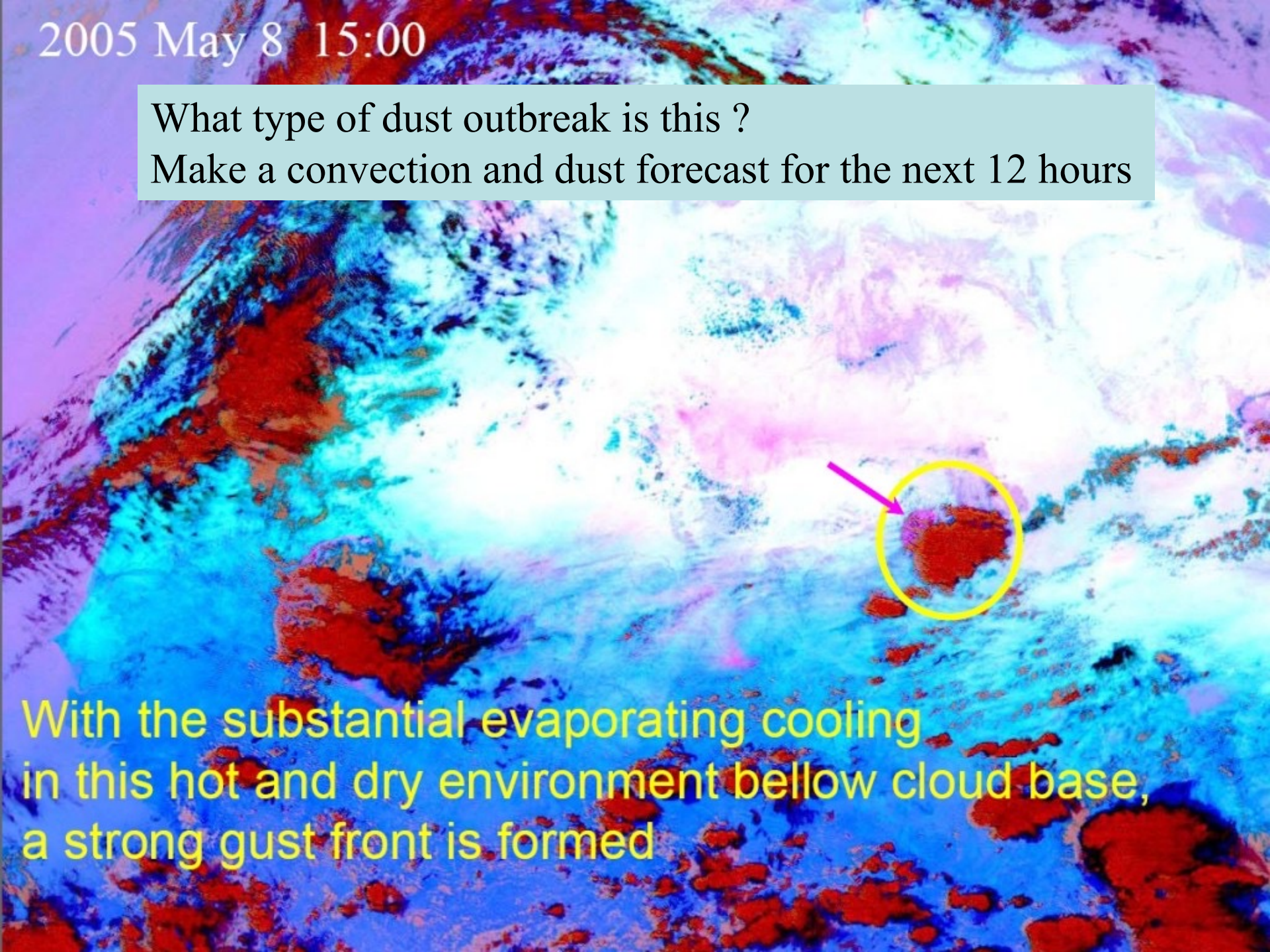


the Cb expands very fast and apparently produces h
heavy rain

2005 May 8 15:00

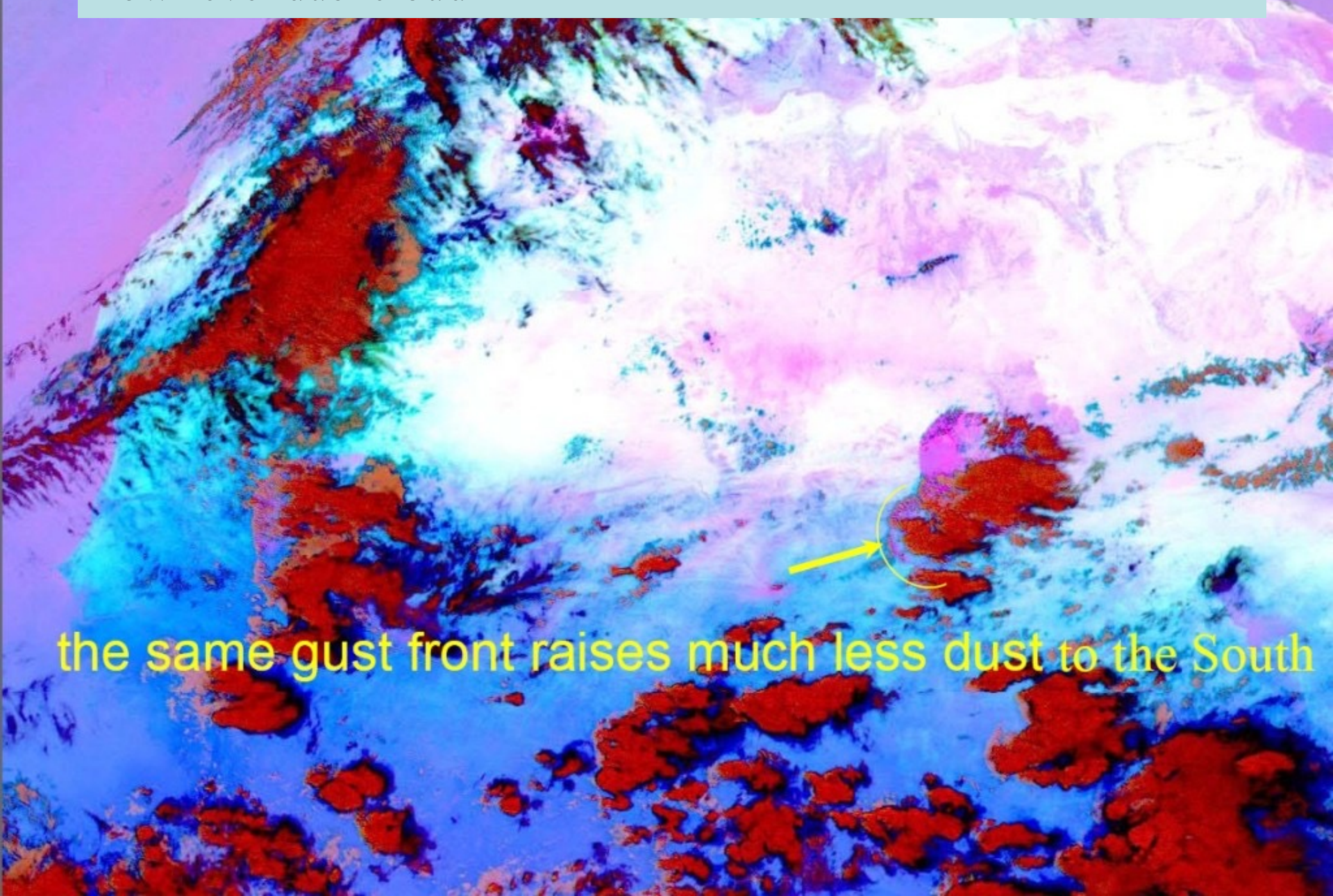
What type of dust outbreak is this ?

Make a convection and dust forecast for the next 12 hours



With the substantial evaporating cooling
in this hot and dry environment below cloud base,
a strong gust front is formed

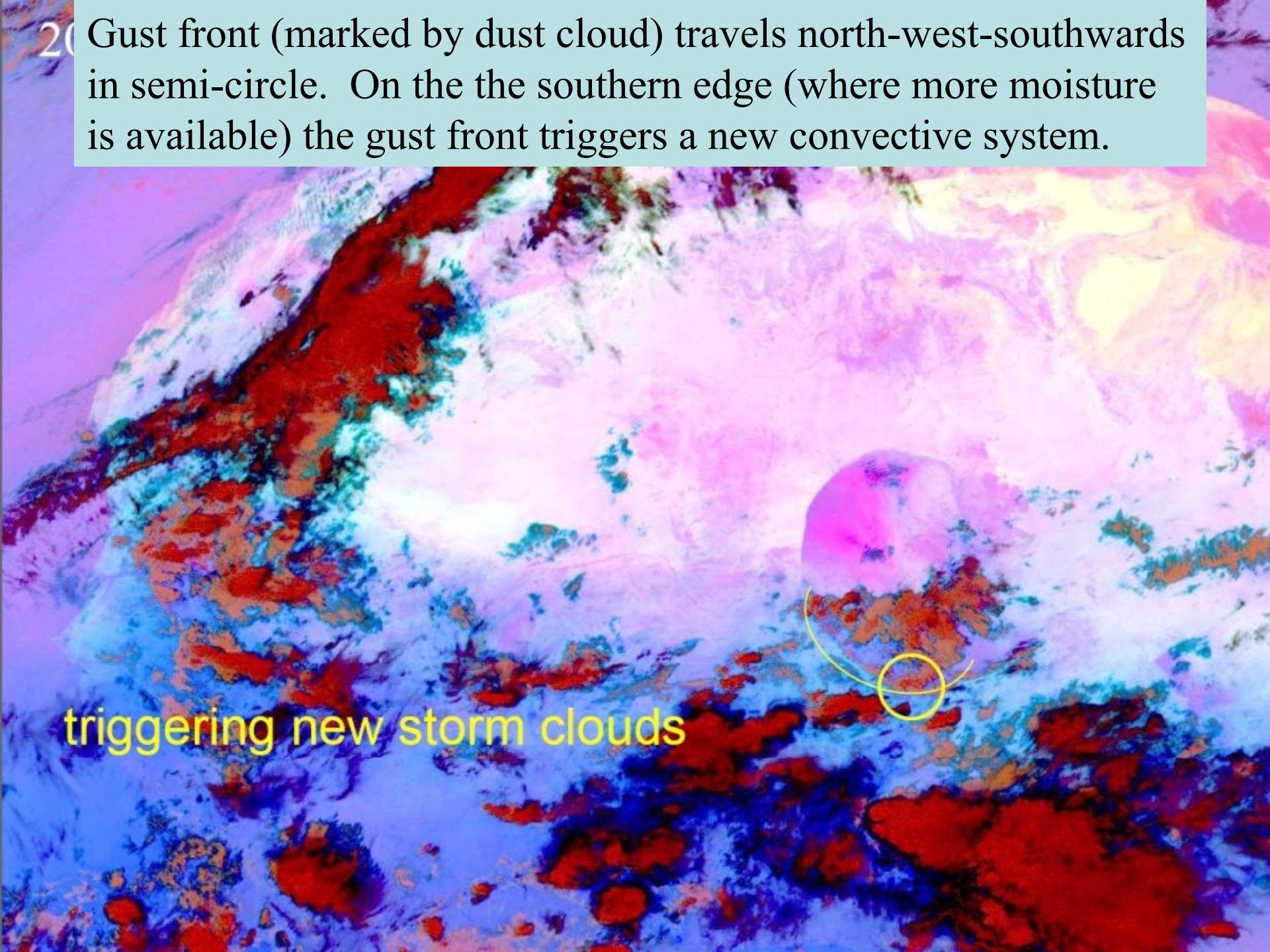
20 Dust is caused by gust outflow from Cb system
Low-level dust cloud



the same gust front raises much less dust to the South

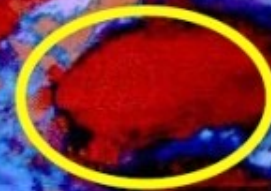
20 Gust front (marked by dust cloud) travels north-west-southwards in semi-circle. On the the southern edge (where more moisture is available) the gust front triggers a new convective system.

triggering new storm clouds



20 This new convective system becomes a new squall line that travels several thousand kilometres westward.

That becomes a squall line



13 Nov 2009, 06:00 Z

Make a 6 h dust forecast ?

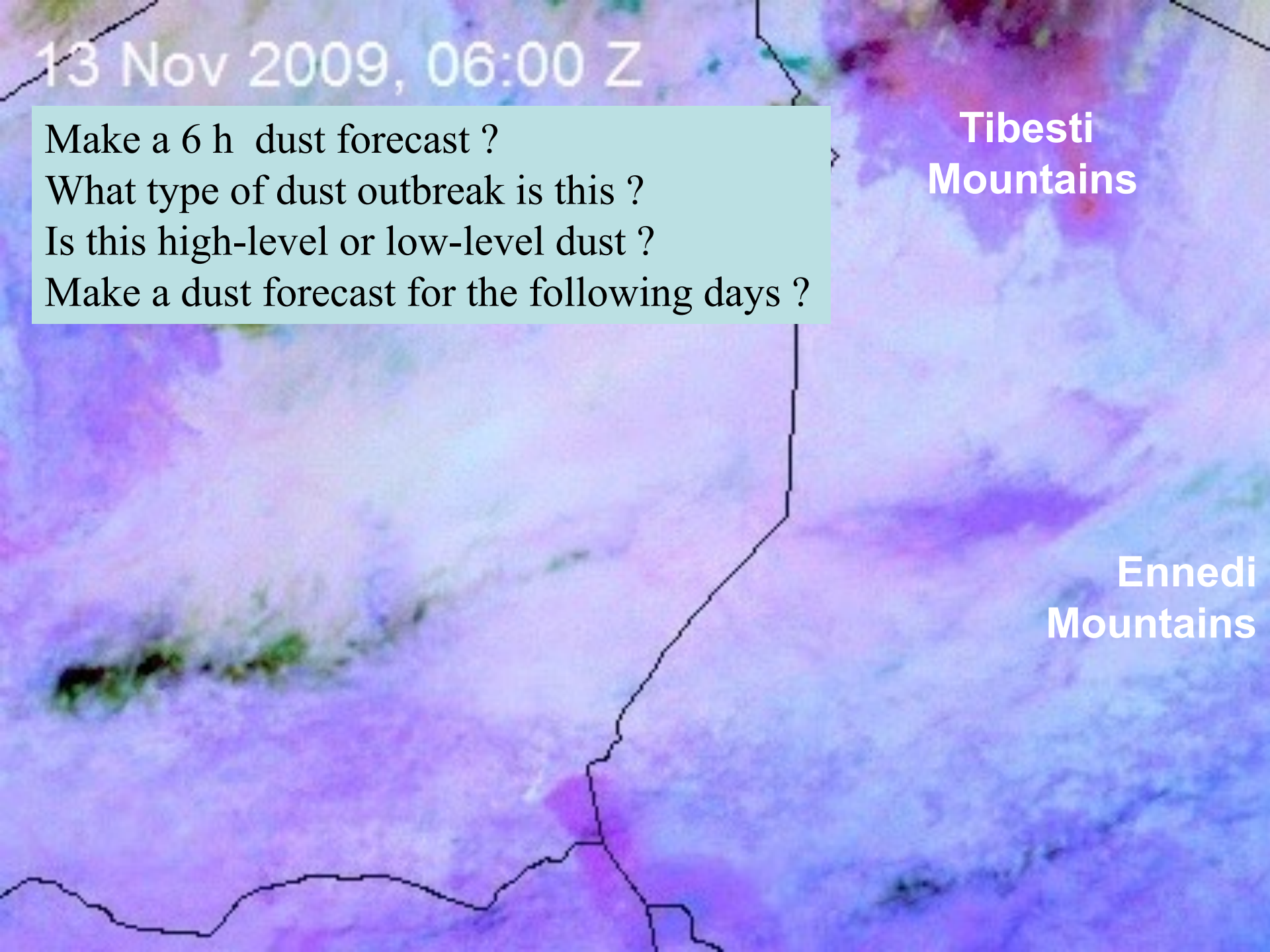
What type of dust outbreak is this ?

Is this high-level or low-level dust ?

Make a dust forecast for the following days ?

**Tibesti
Mountains**

**Ennedi
Mountains**



13 Nov 2009, 08:00 Z

Make a 6 h dust forecast ?

What type of dust outbreak is this ?

Is this high-level or low-level dust ?

Make a dust forecast for the following days ?

**Tibesti
Mountains**

**Ennedi
Mountains**

13 Nov 2009, 10:00 Z

Make a 6 h dust forecast ?

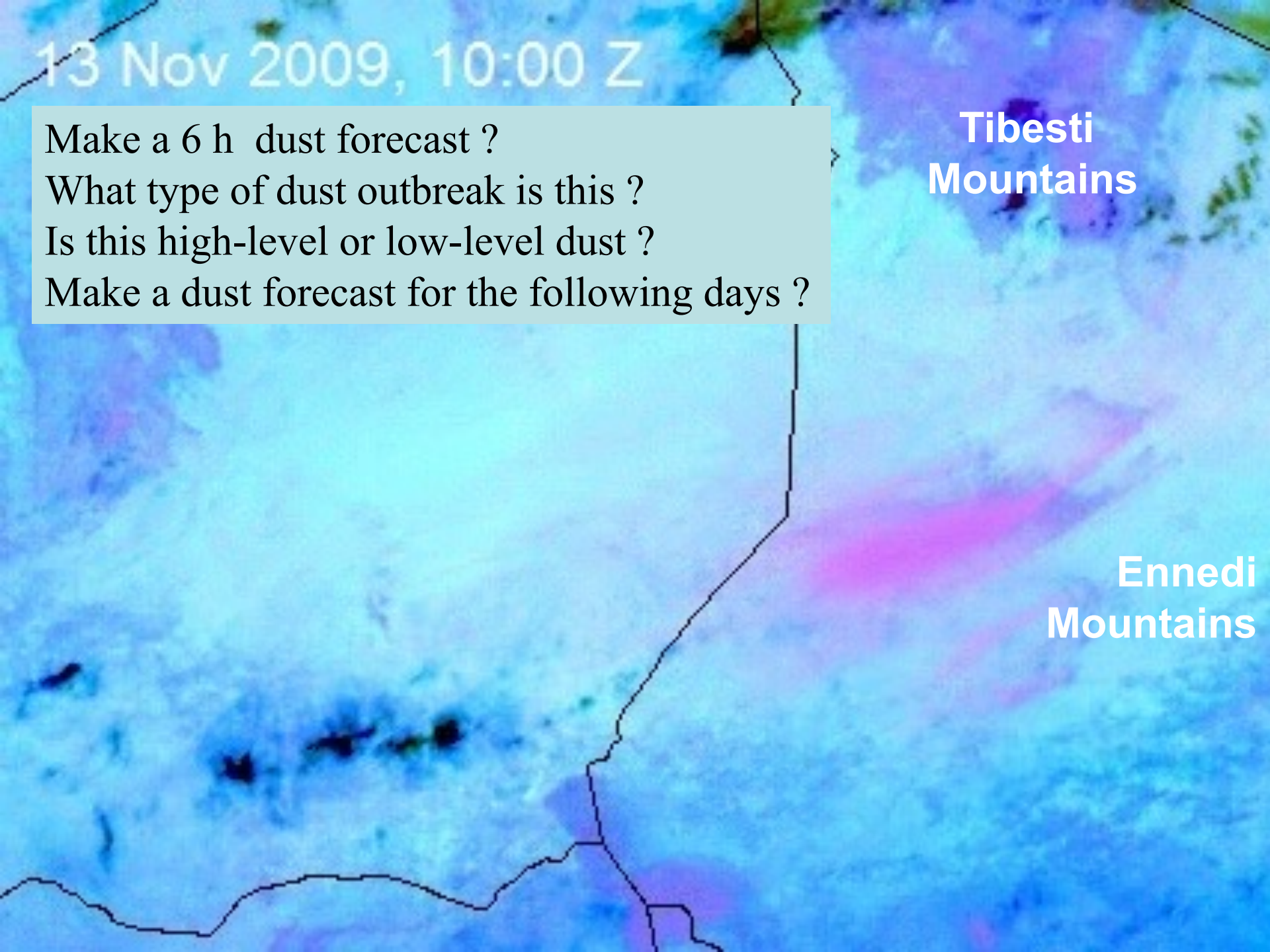
What type of dust outbreak is this ?

Is this high-level or low-level dust ?

Make a dust forecast for the following days ?

**Tibesti
Mountains**

**Ennedi
Mountains**



13 Nov 2009, 12:00 Z

Make a 6 h dust forecast ?

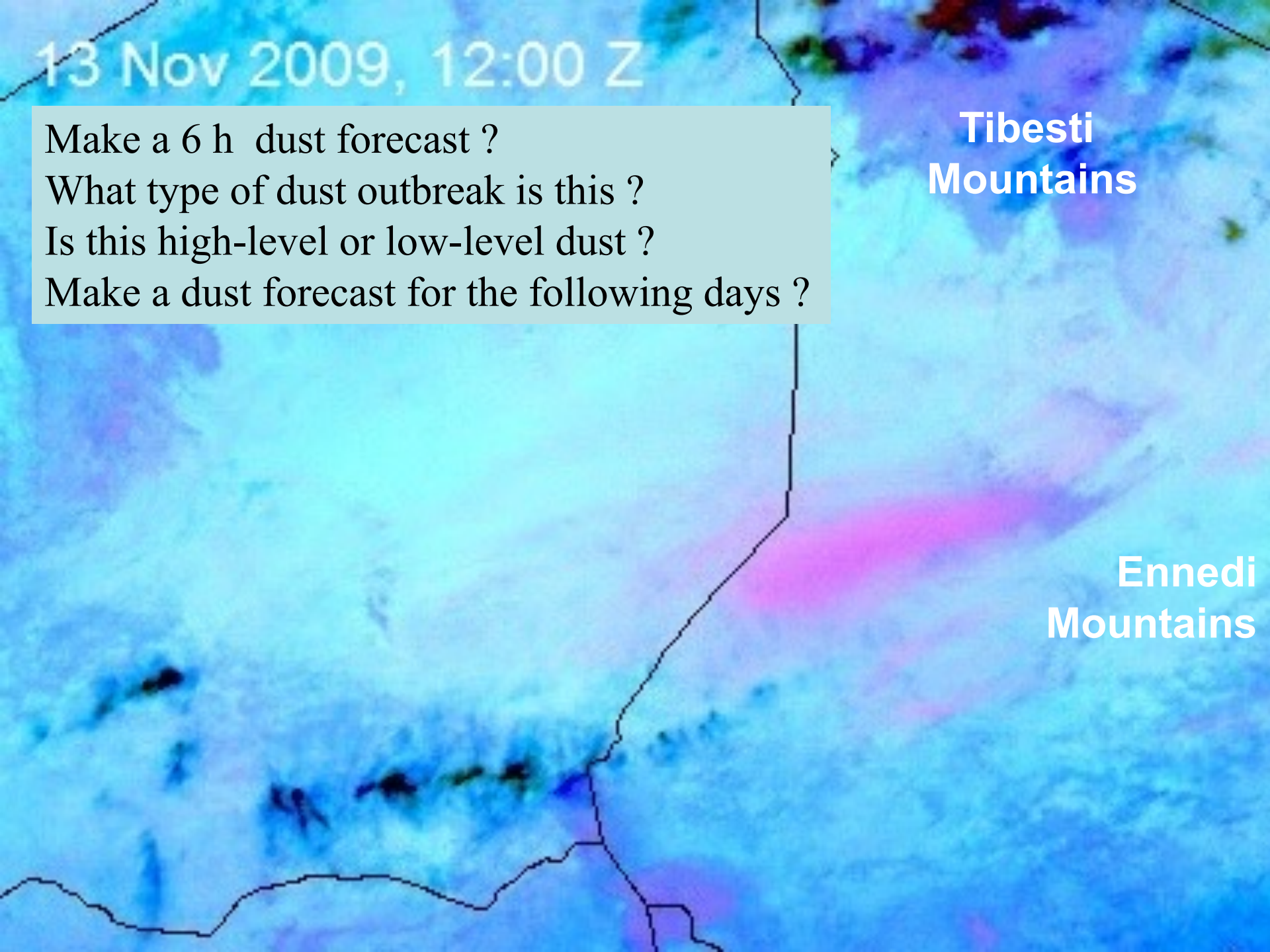
What type of dust outbreak is this ?

Is this high-level or low-level dust ?

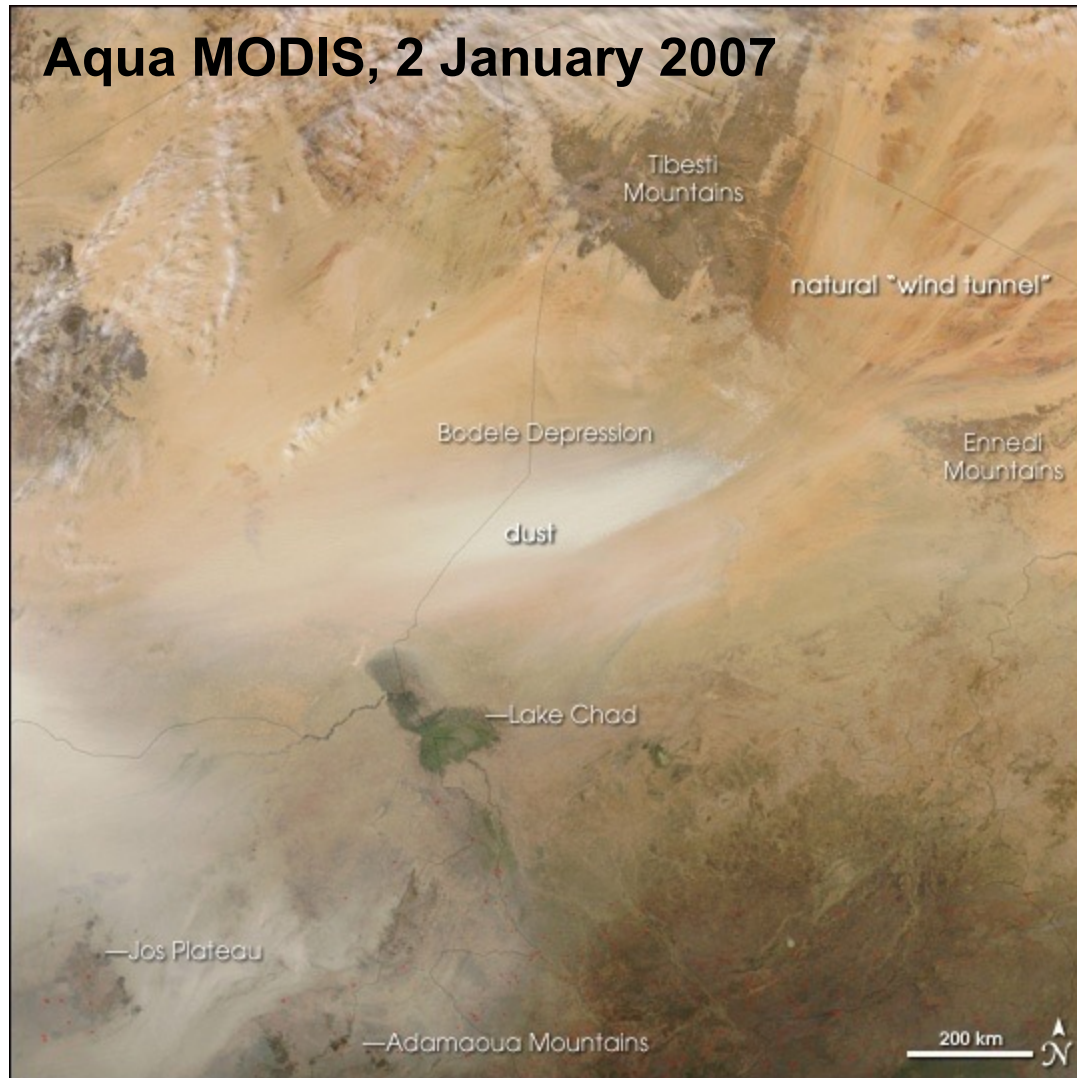
Make a dust forecast for the following days ?

**Tibesti
Mountains**

**Ennedi
Mountains**



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!

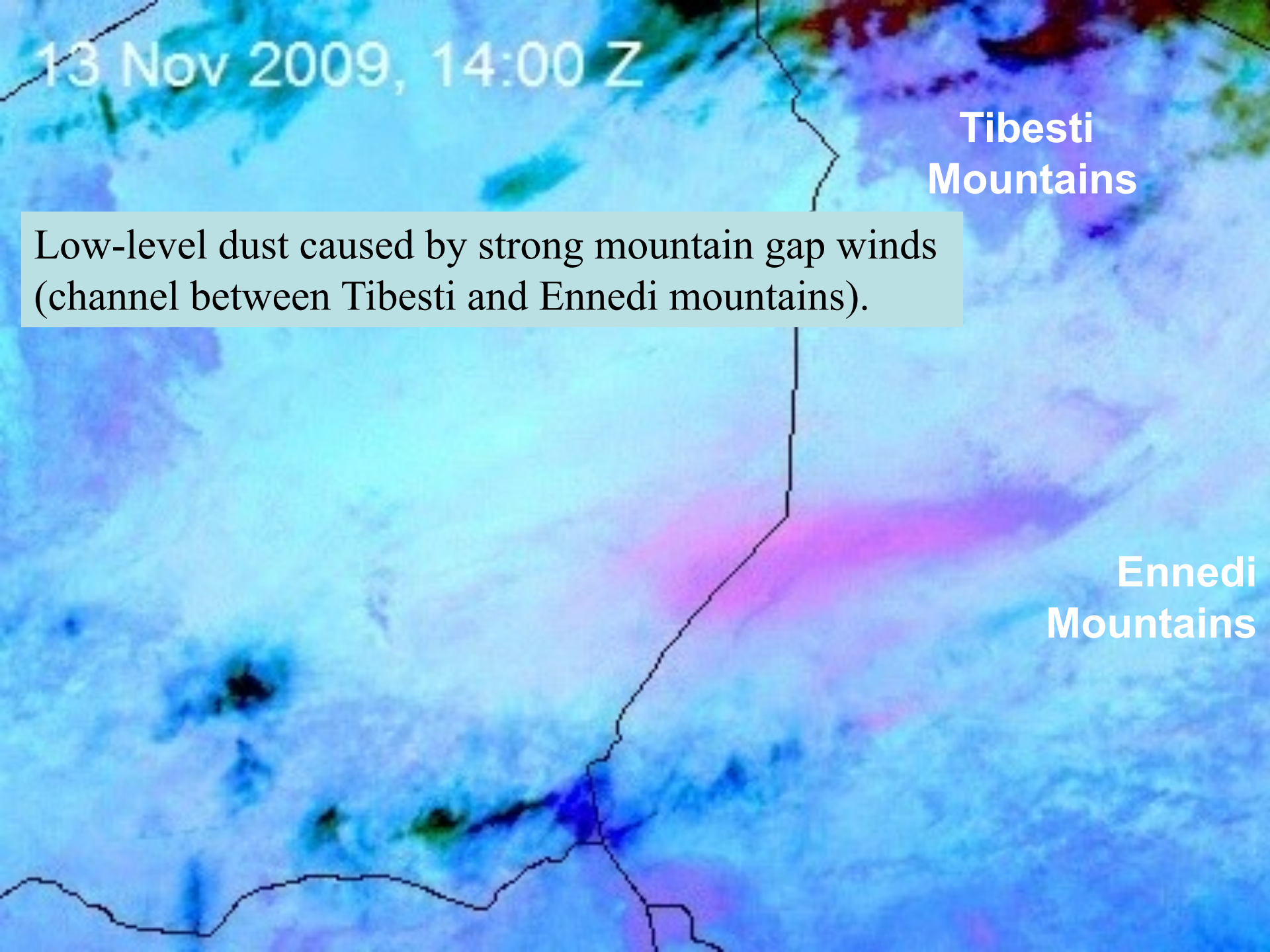
The dust blows from around 8:00 to 14:00 UTC!

13 Nov 2009, 14:00 Z

**Tibesti
Mountains**

Low-level dust caused by strong mountain gap winds
(channel between Tibesti and Ennedi mountains).

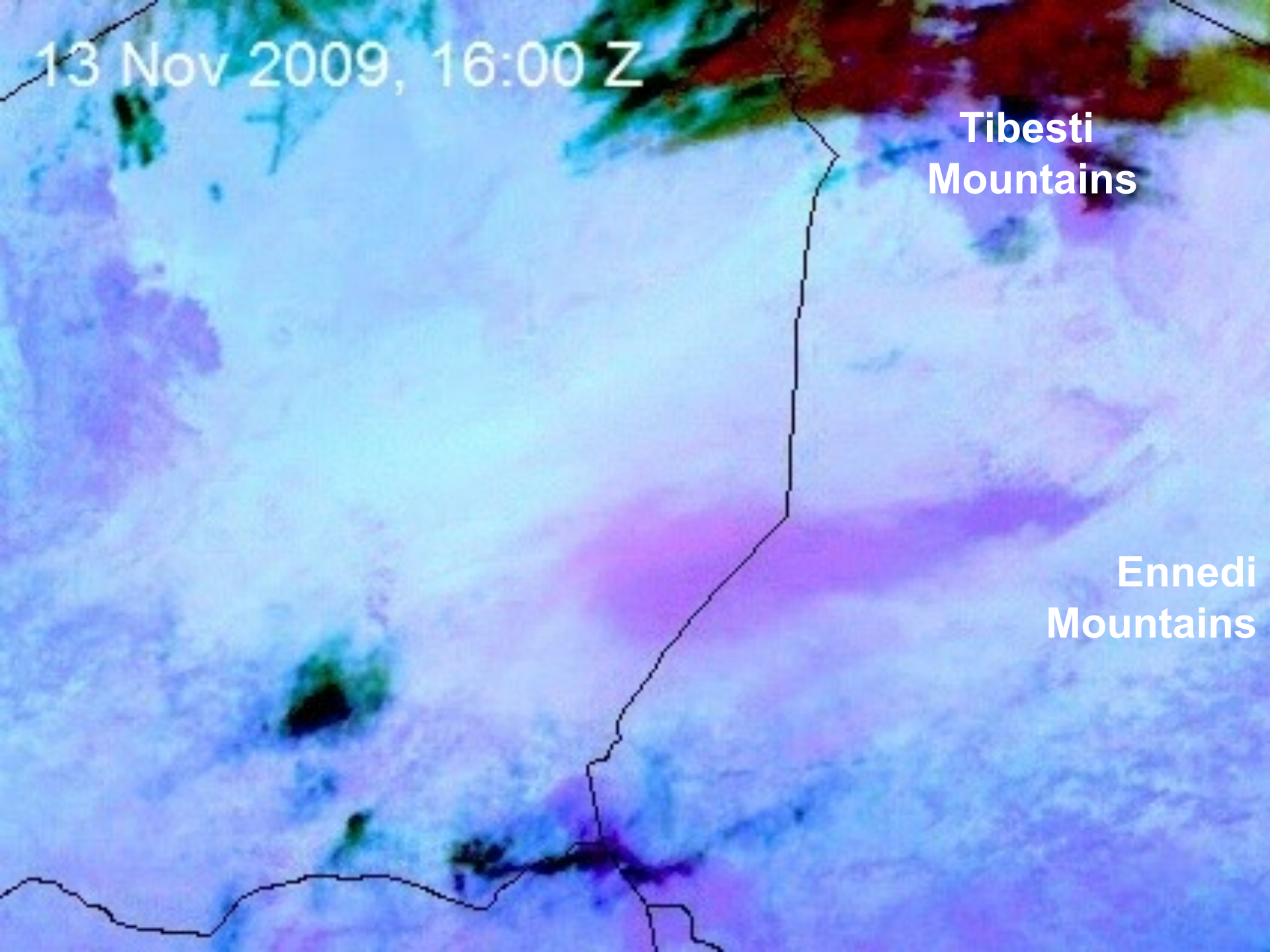
**Ennedi
Mountains**



13 Nov 2009, 16:00 Z

**Tibesti
Mountains**

**Ennedi
Mountains**



13 Nov 2009, 18:00 Z

Tibesti

At 18 UTC the dust cloud has moved into Eastern Niger. No new dust is picked up after 14 UTC (new dust between 8 and 14 UTC). Note the dark colour of the dust cloud (low dust). In the next days, more dust gets picked up and blown to Niger and Mali (see loop)!

**Ennedi
Mountains**



Loop 13-18 Nov 2009

Congratulations!

You have finished the exercises!