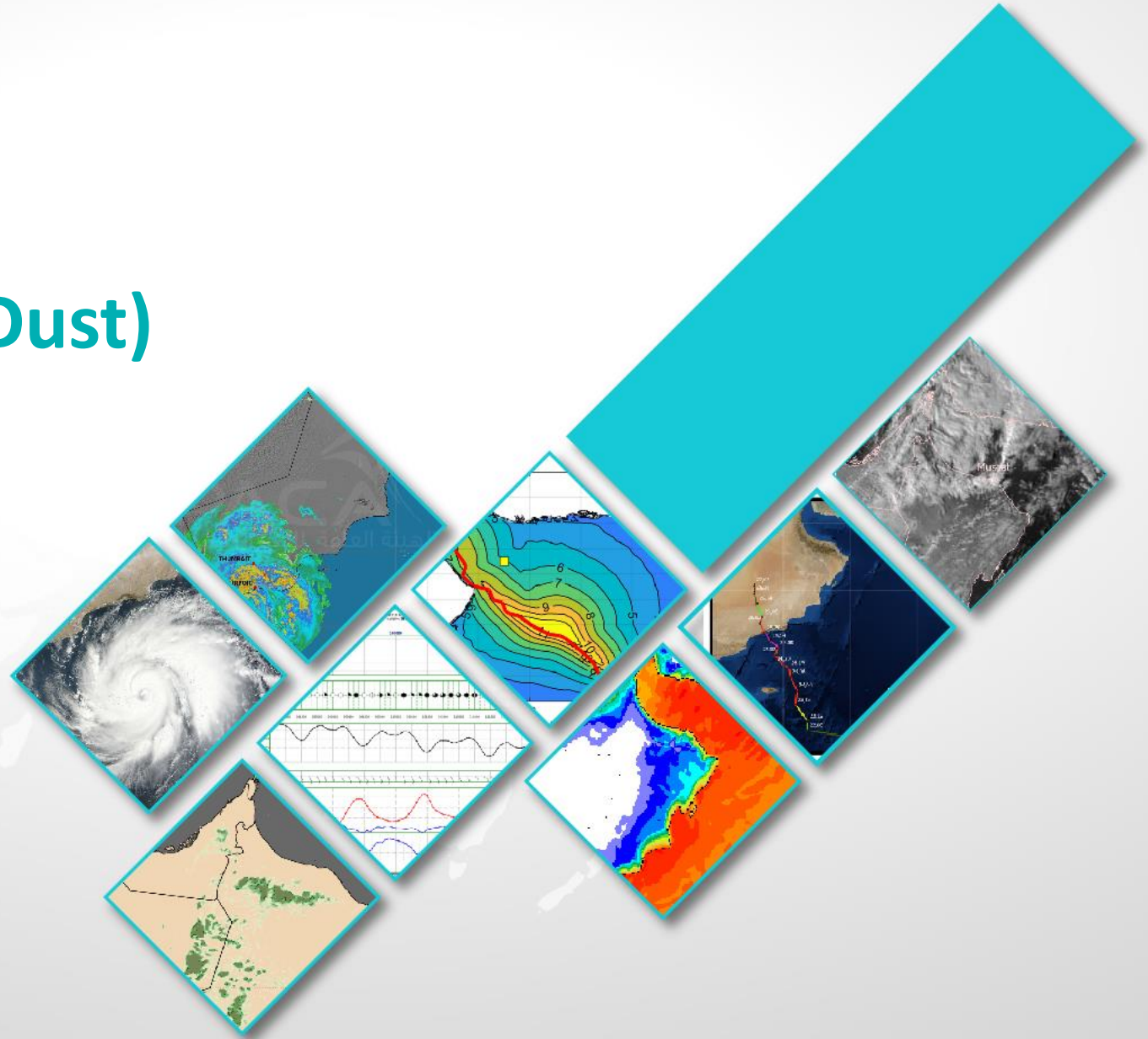
Weather phenomena (Westerlies/Easterlies/Dust)



Contect creator: Dr. Humaid Al Badi
Ibrahim Al Abdulsalam
Kauthar Al Jabri

Lecturer:
Ibrahim AL Abdulsalam

Content

- Westerlies
- Easterlies
- Dust Storm

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Westerly Waves or westerlies : The upper-air westerlies flow generally from west-to-east around the planet in a wave-like pattern of ridges and troughs as shown below.

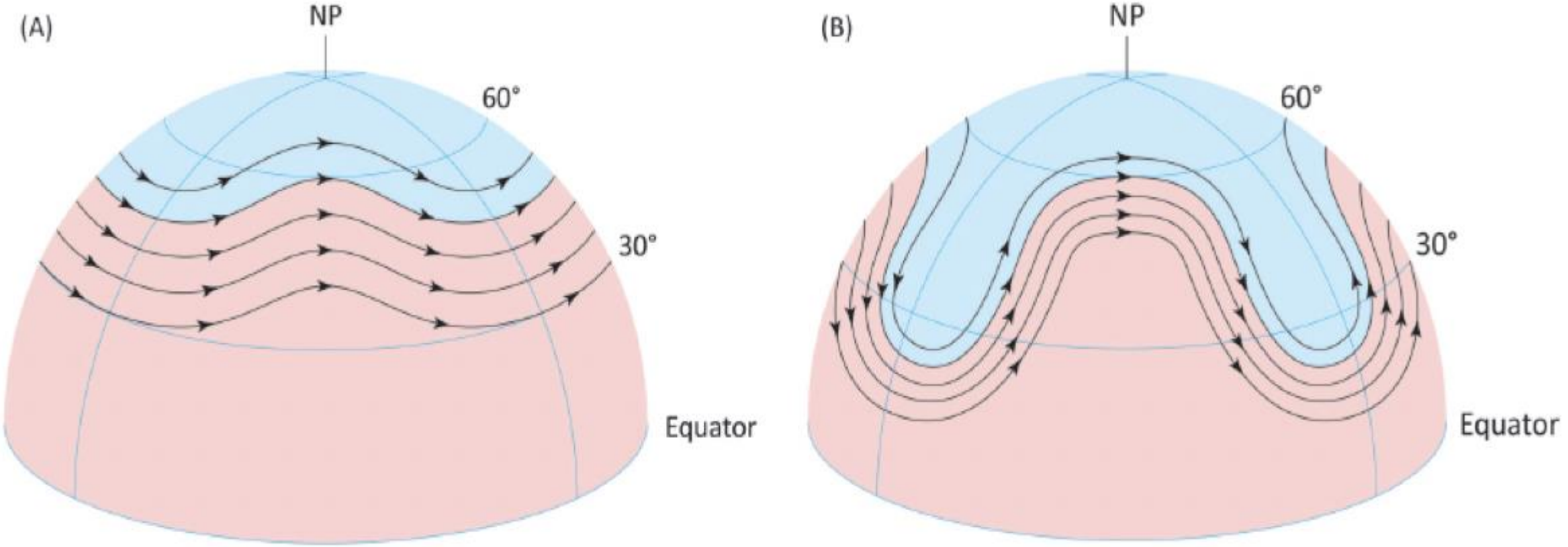
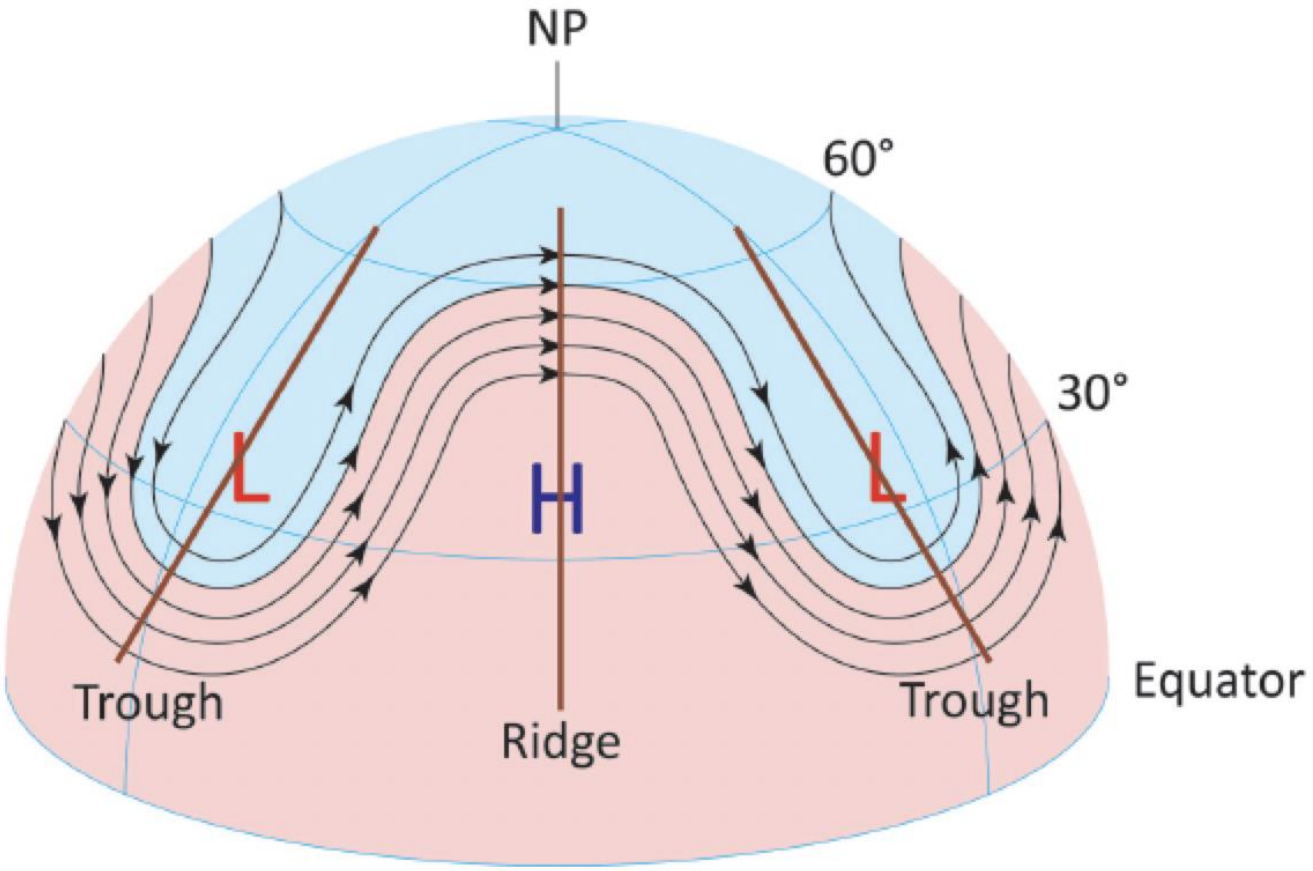


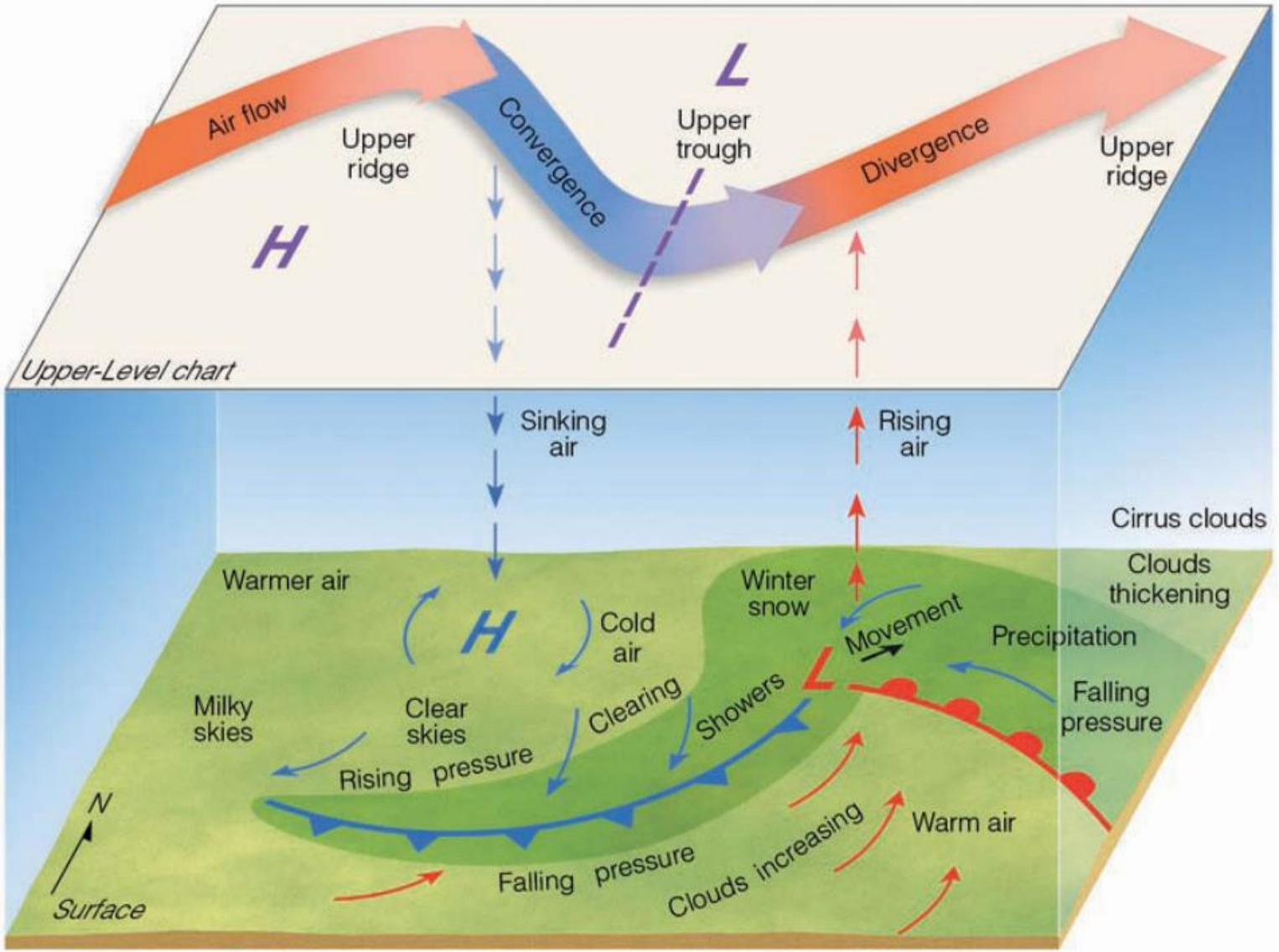
Figure 9A-2. (A) A zonal upper-air wave pattern with little north-south variation and (B) a meridional pattern with great north-south variation.

Credit : www.meted.ucar.edu/

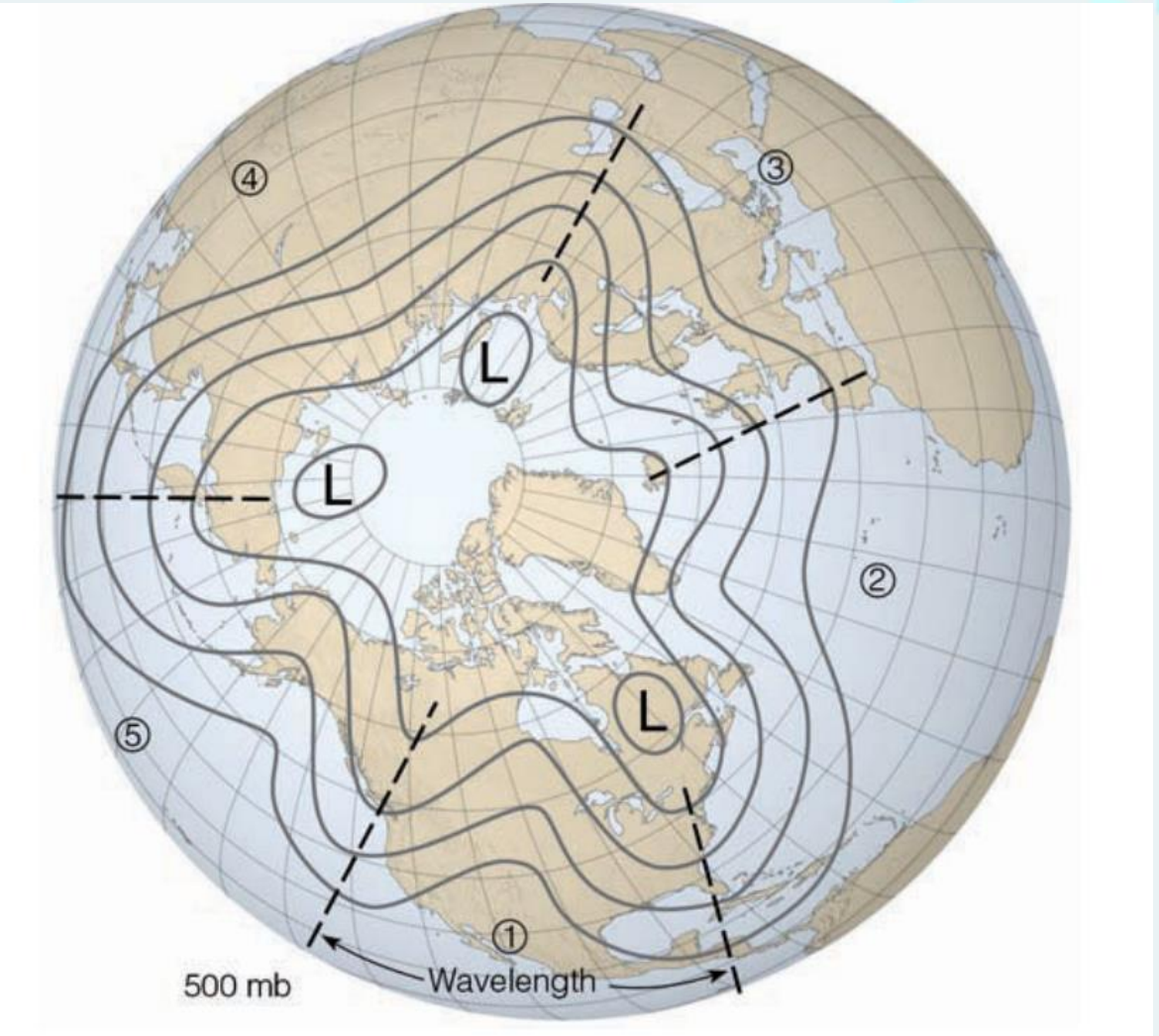
Westerly Waves or westerlies : The upper-air westerlies flow generally from west-to-east around the planet in a wave-like pattern of ridges and troughs as shown below.



gure 9A-1. Wave pattern in upper-air westerlies.

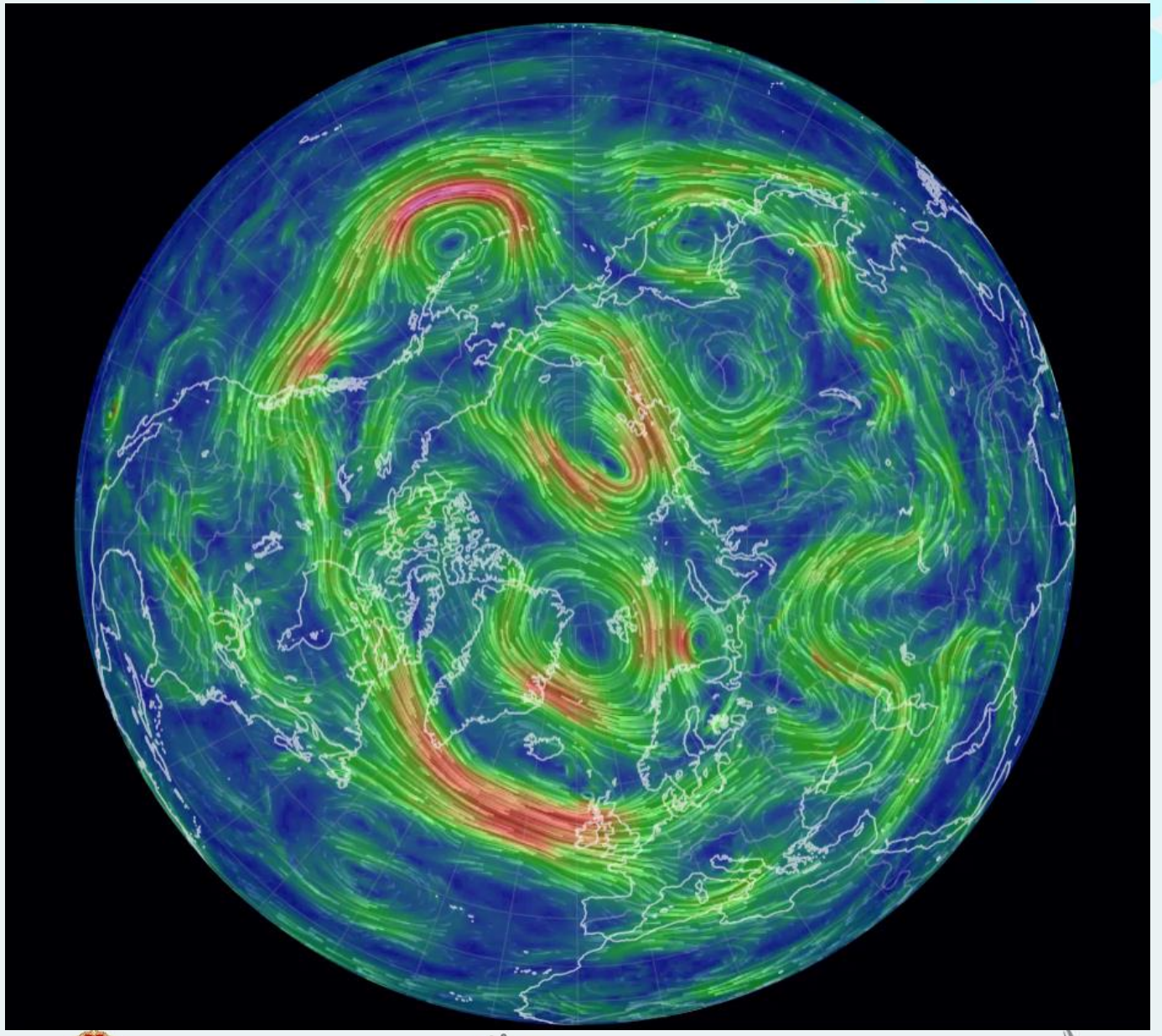

Air flow
Upper ridge
Convergence
L
Upper trough
Divergence
Upper ridge
H
Upper-Level chart
Sinking air
Rising air
Cirrus clouds
Clouds thickening
Warmer air
H
Cold air
Winter snow
Movement
Precipitation
L
Milky skies
Clear skies
Clearing
Showers
Falling pressure
Rising pressure
N
Warm air
Falling pressure
Clouds increasing
Surface

500 mb height



500 mb wind

Summer



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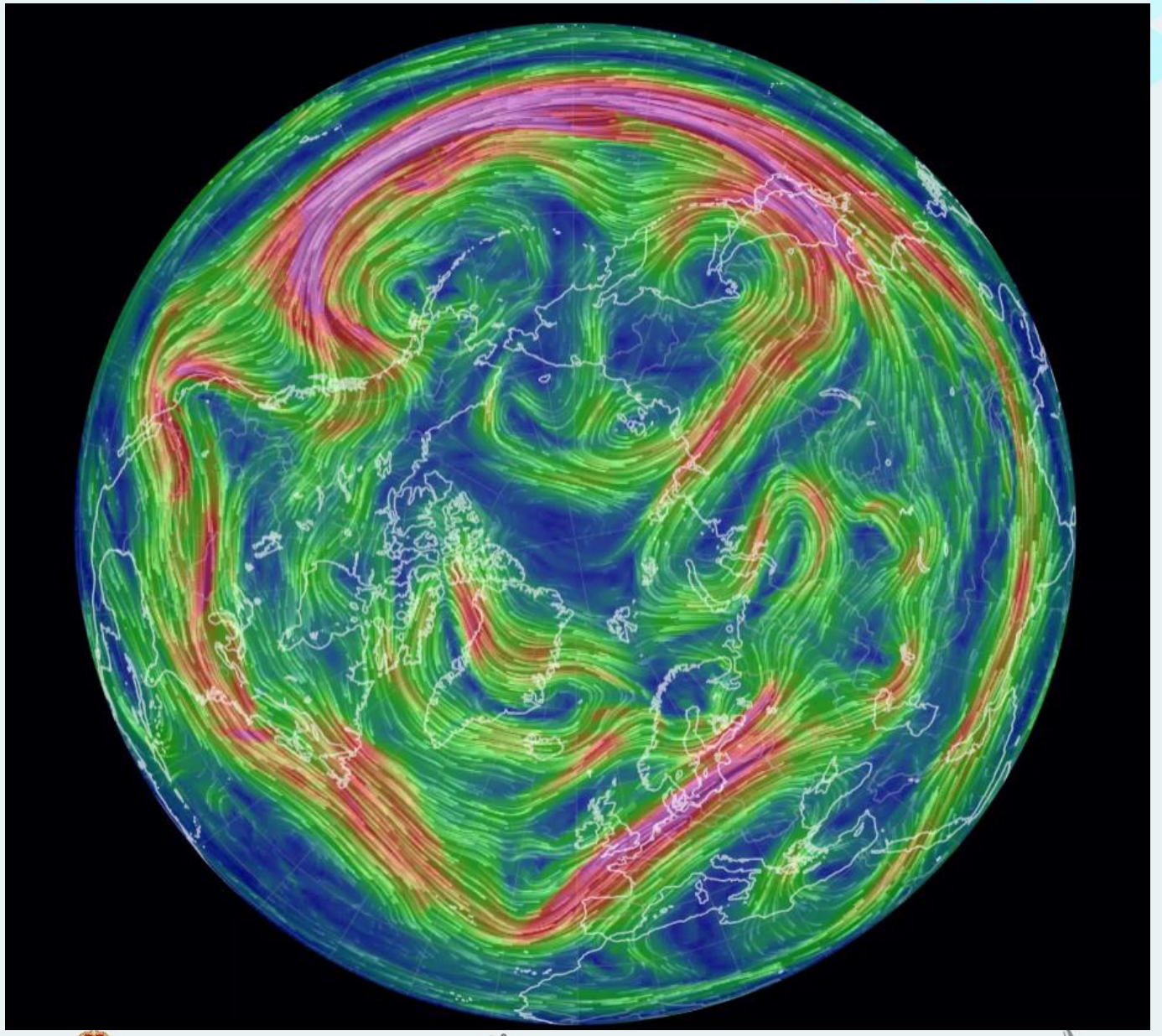
500 mb wind

Winter



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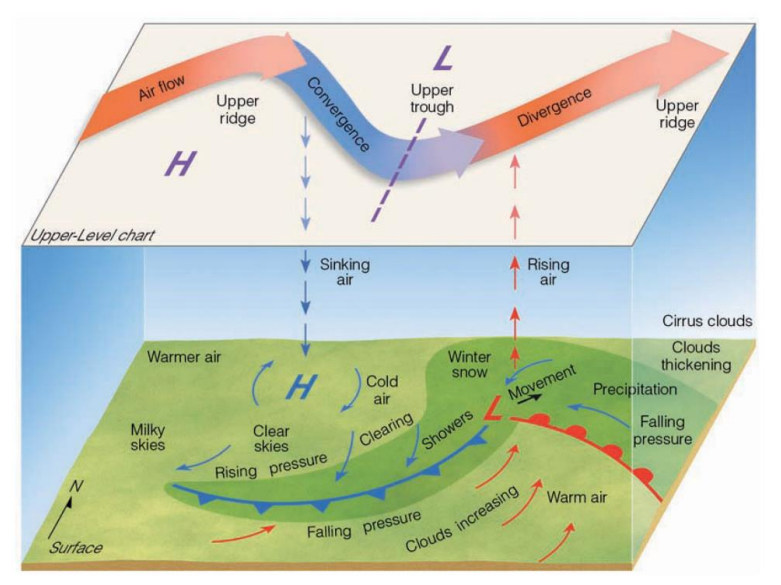

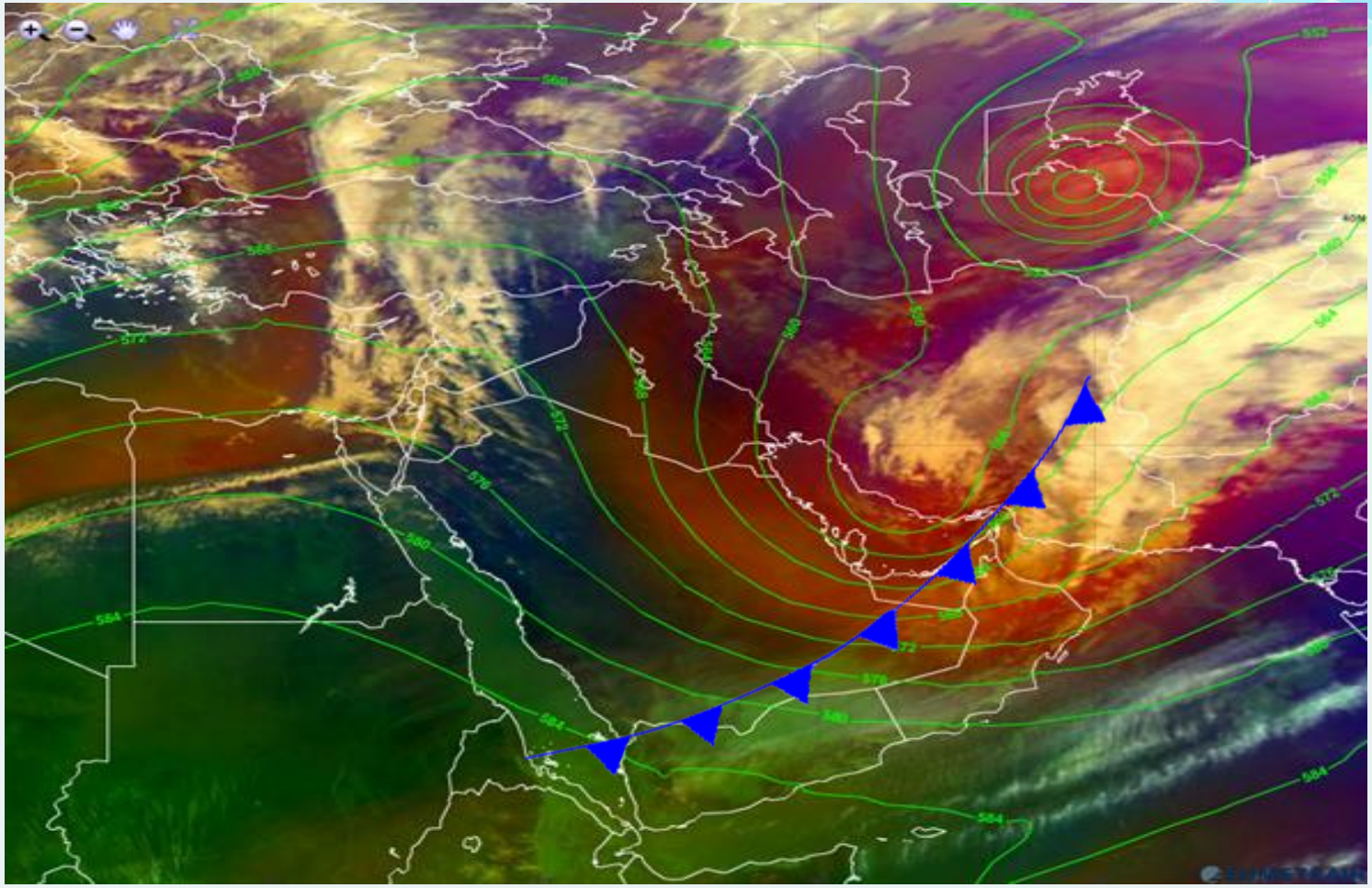

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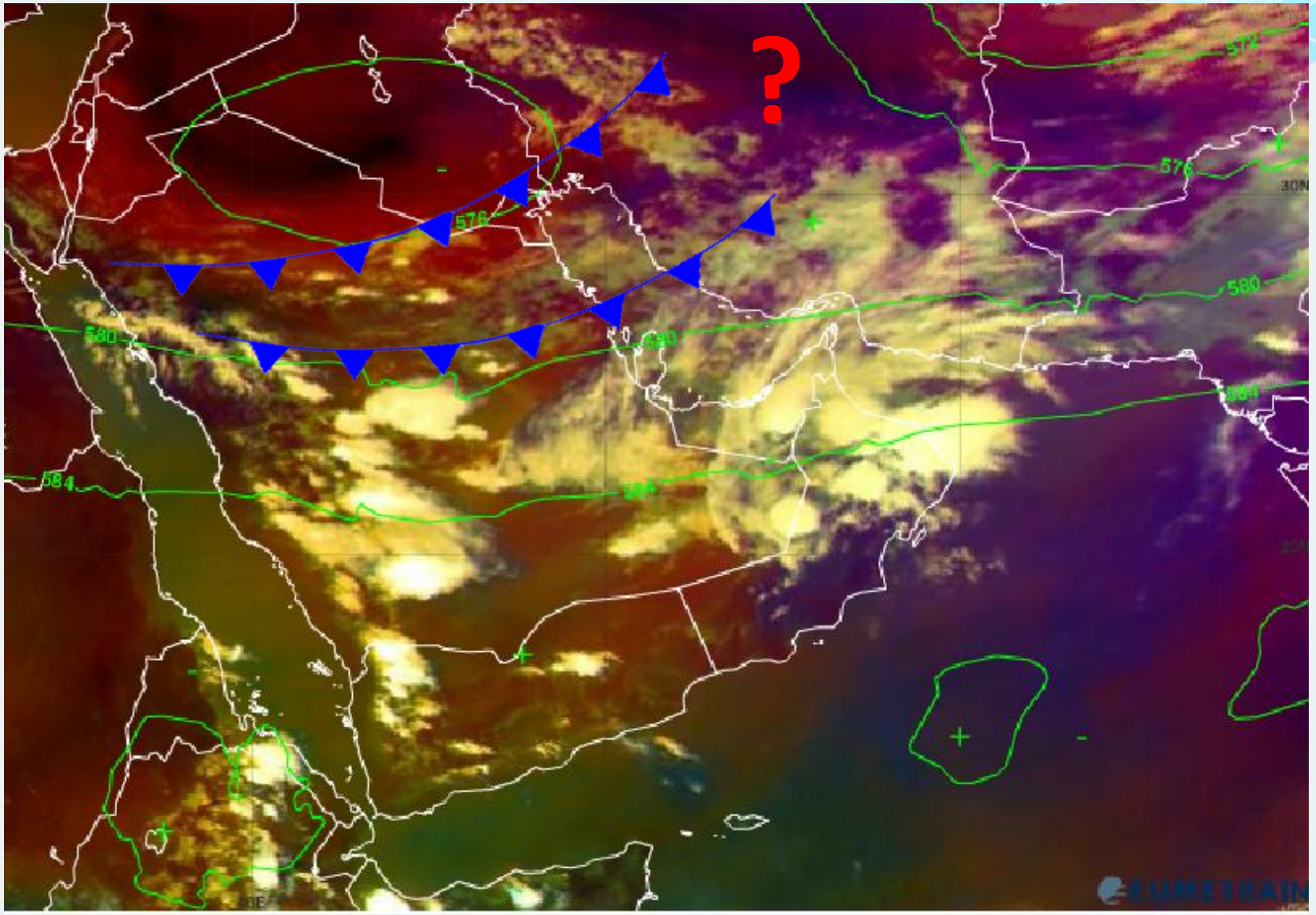
هيئة الطيران المدني



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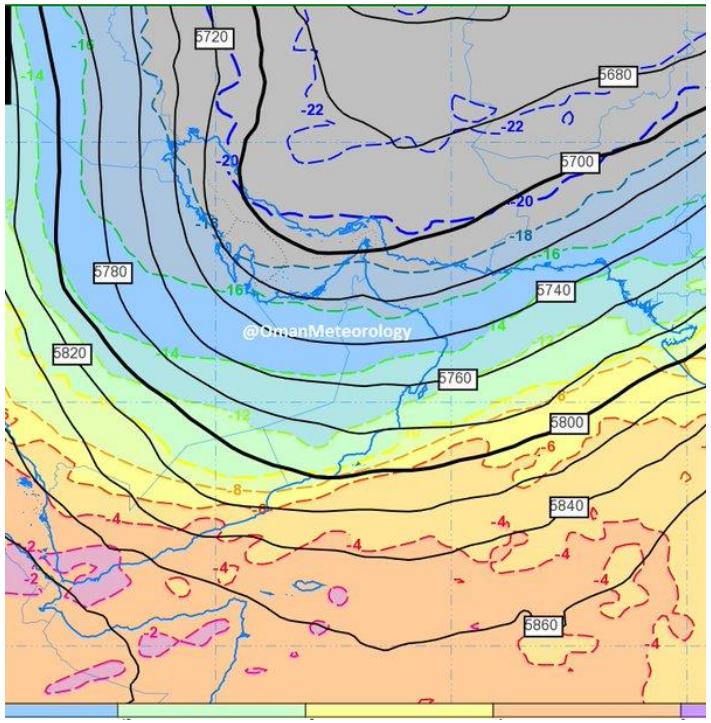
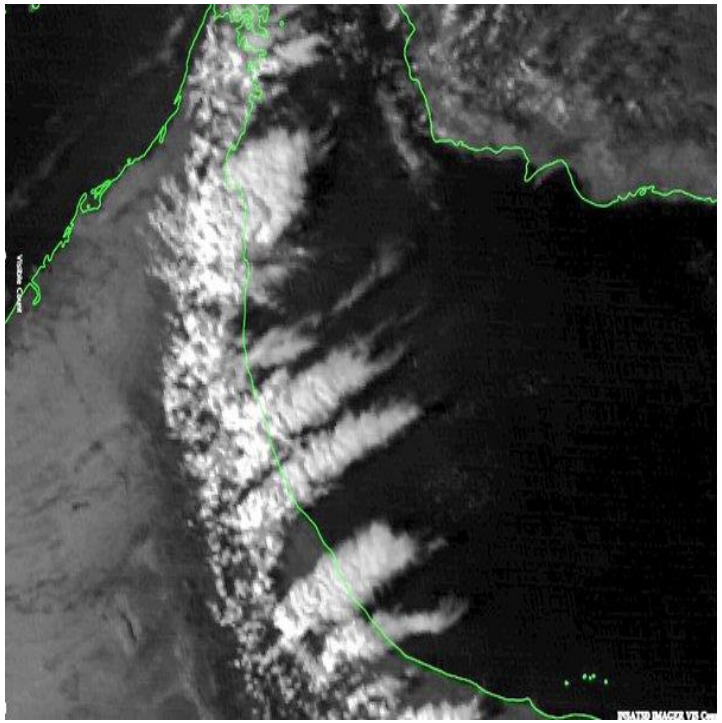
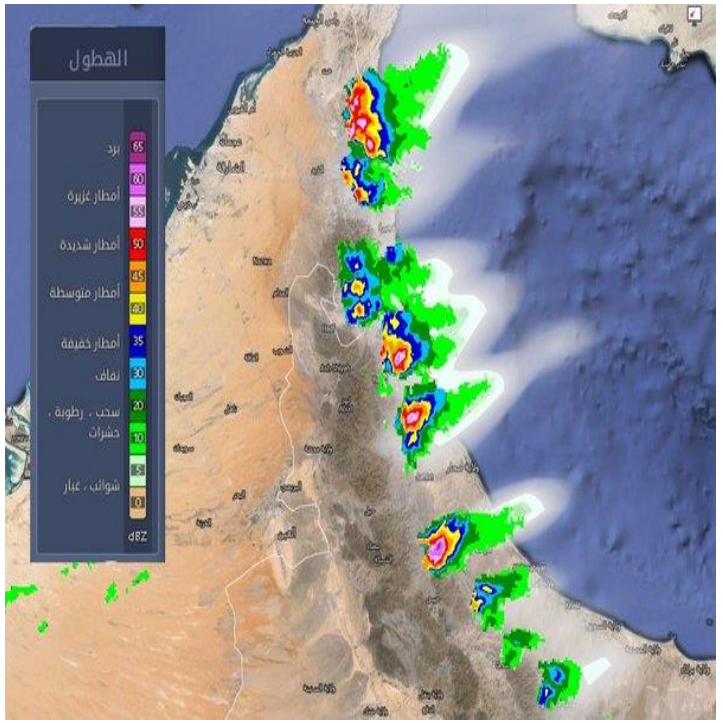
16th Feb 2015 (cold air mass)



Geopotential height 500mb



Satellite Image



Radar Image

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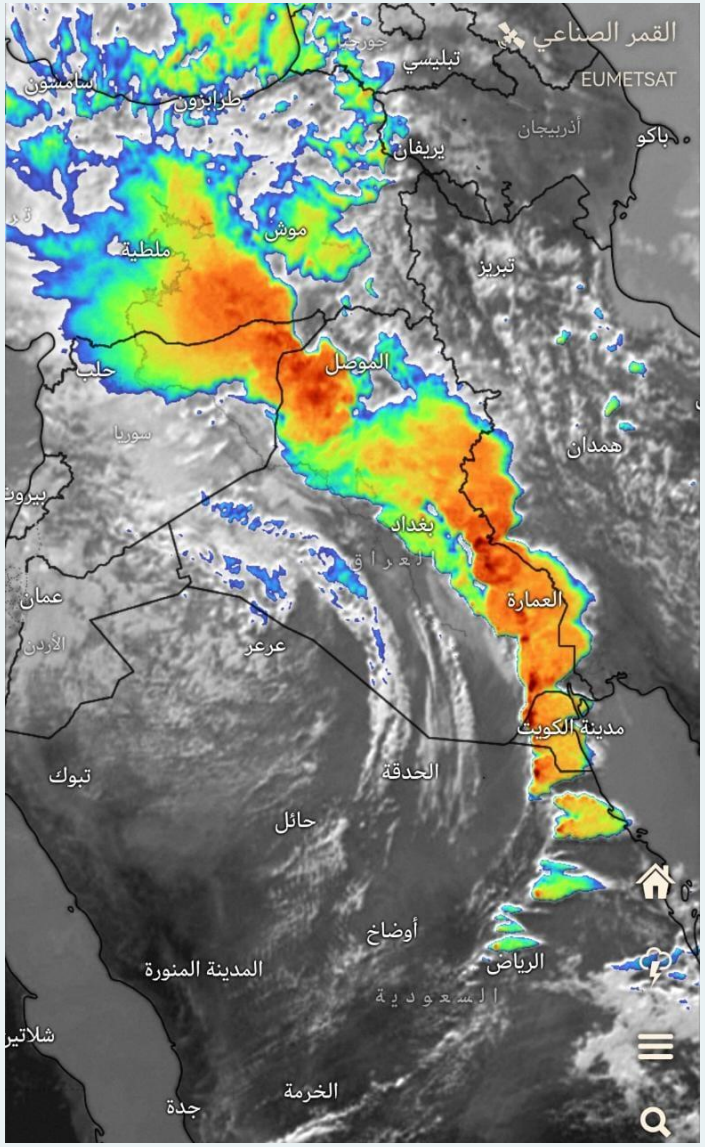

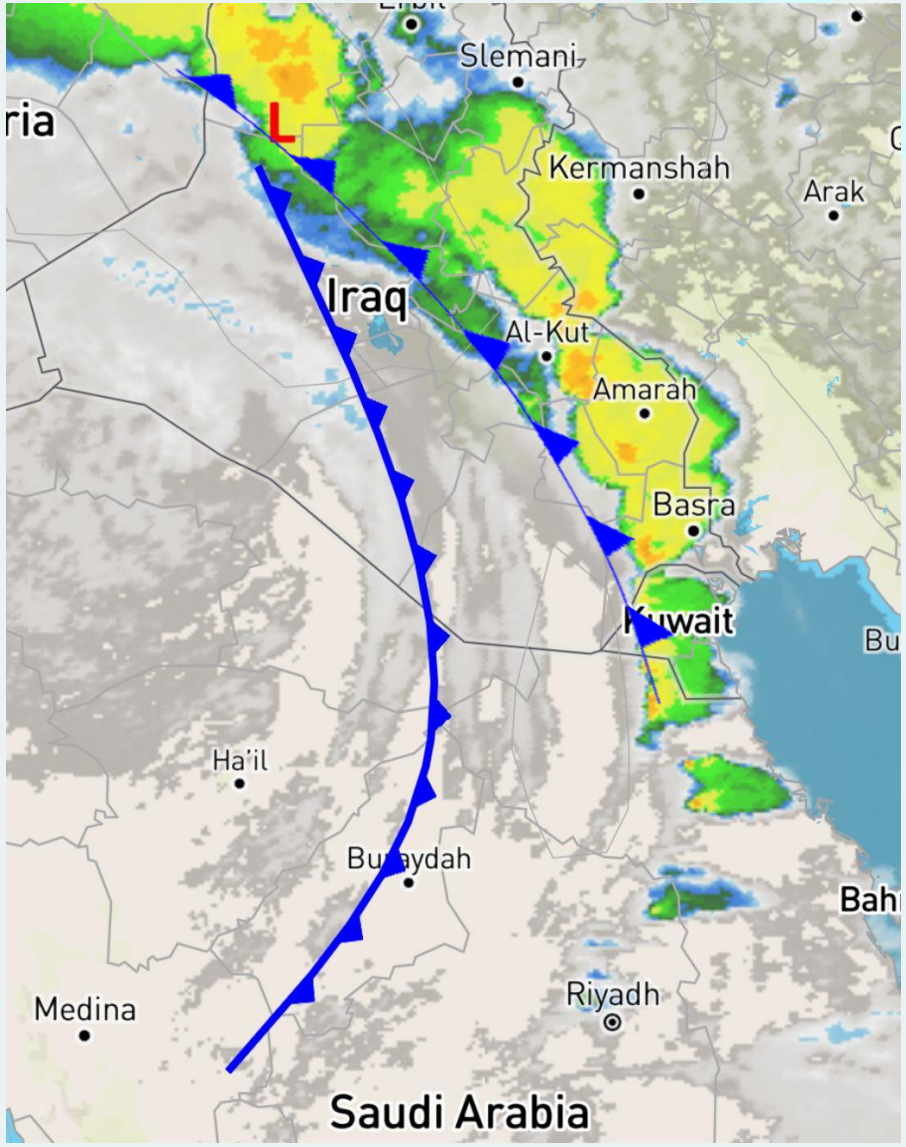

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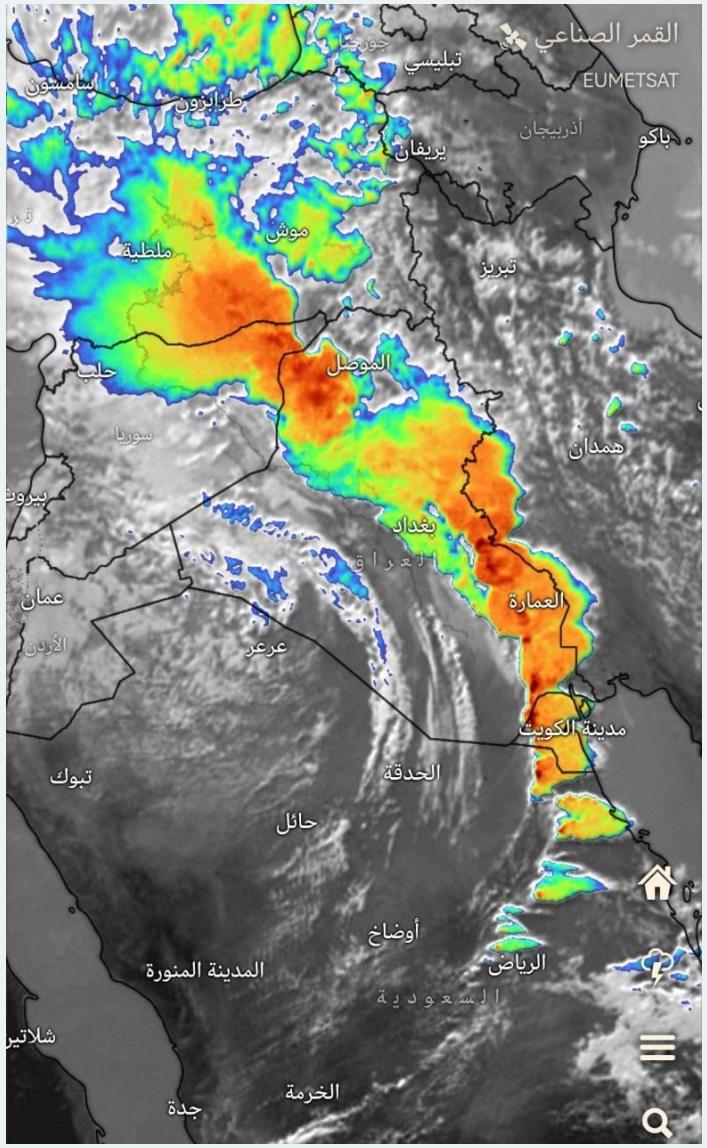
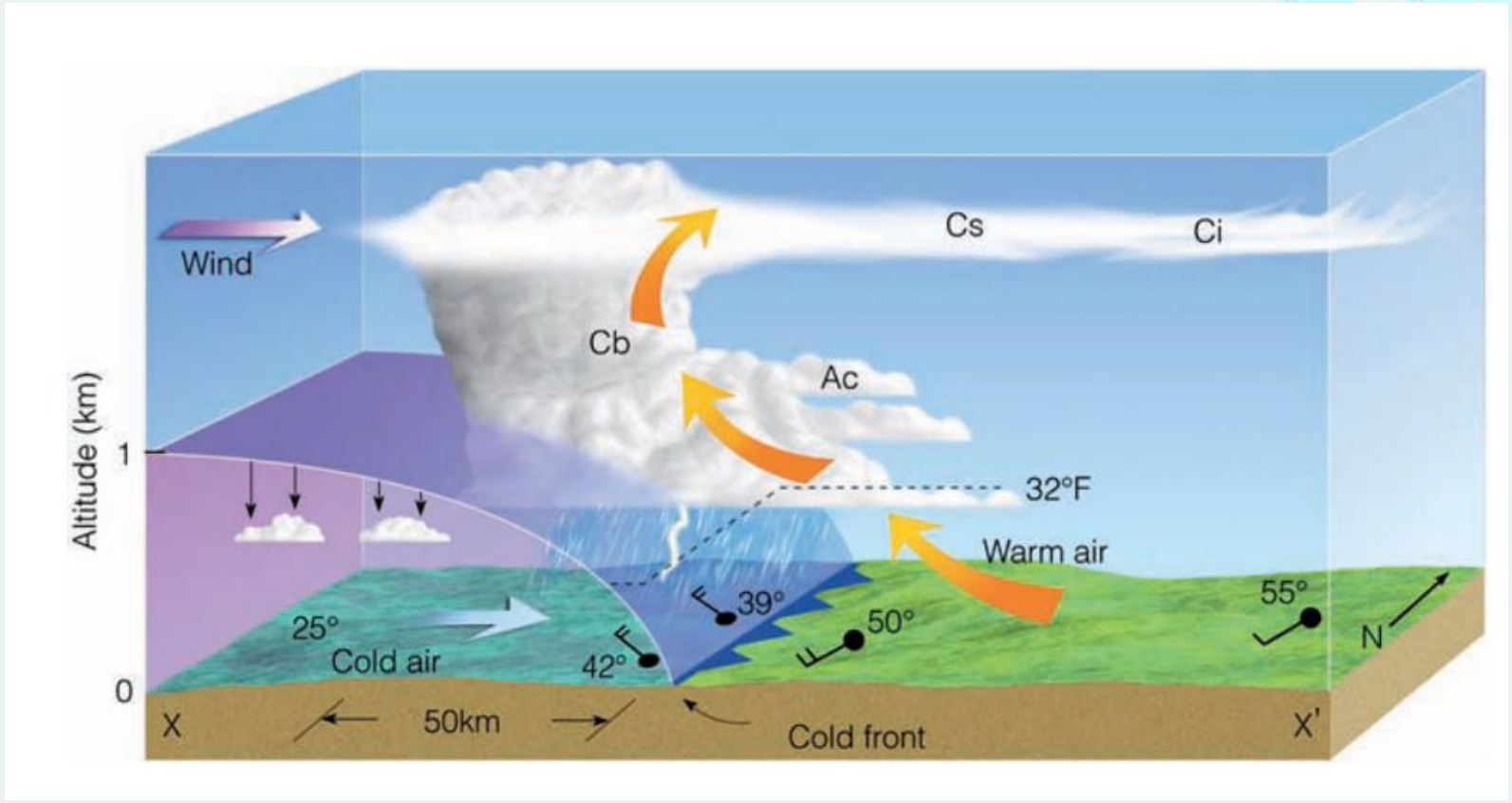
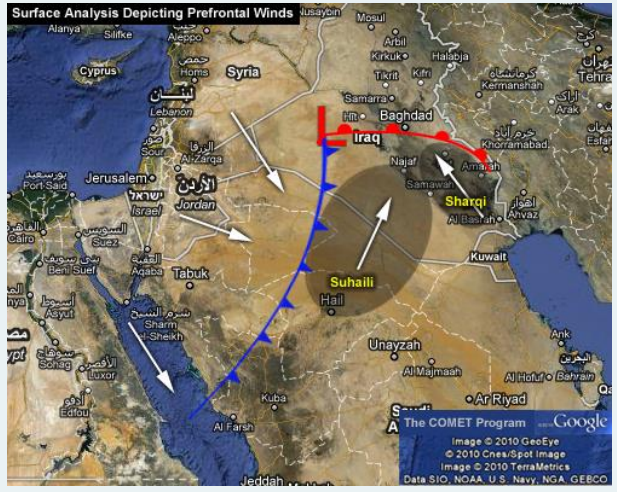
Typical Cold Front

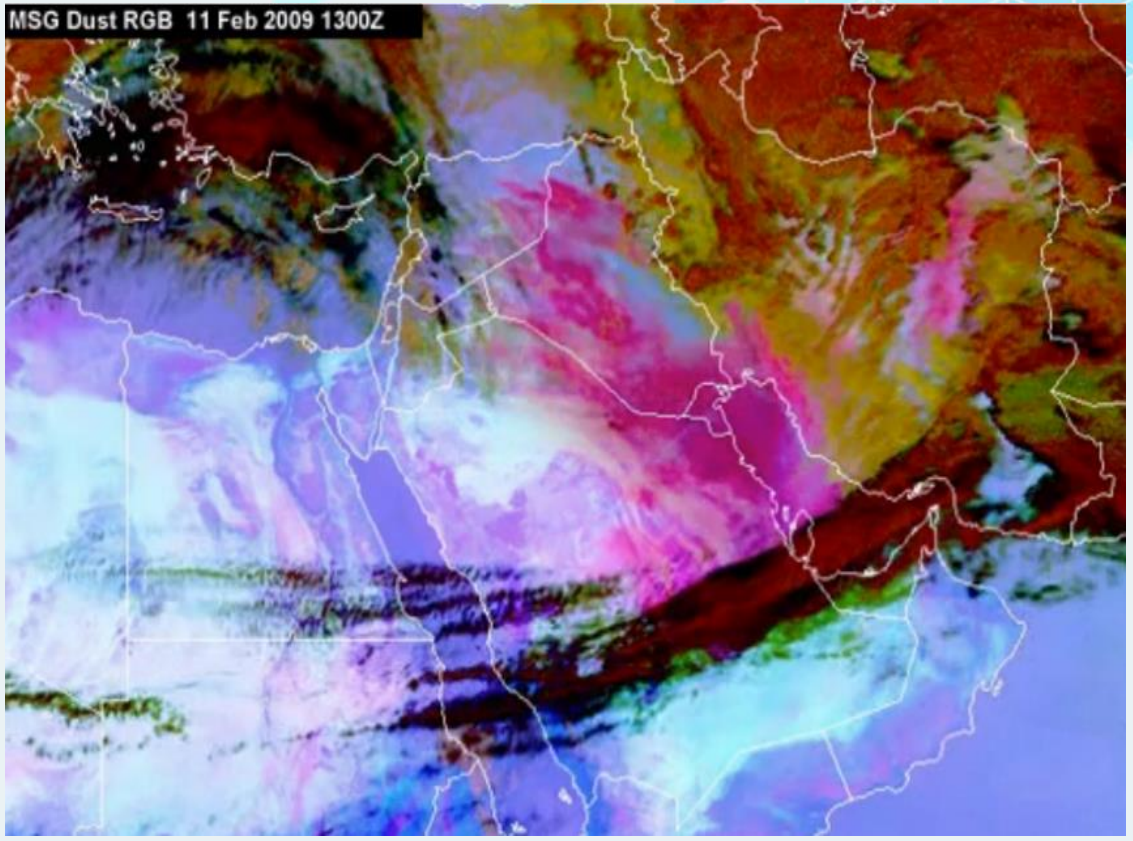


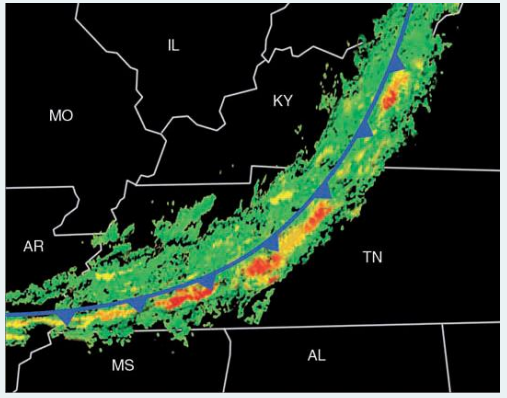


Typical case of Westerly wave (frontal System) over Arabian Peninsula can cause :

- **High winds**
  - **North Westerly and Southeasterly**
- **Sever thunderstorms and Heavy rain**
- **Dust Storm**
- **Rough Sea**
- **Coldness**
- **Dryness**







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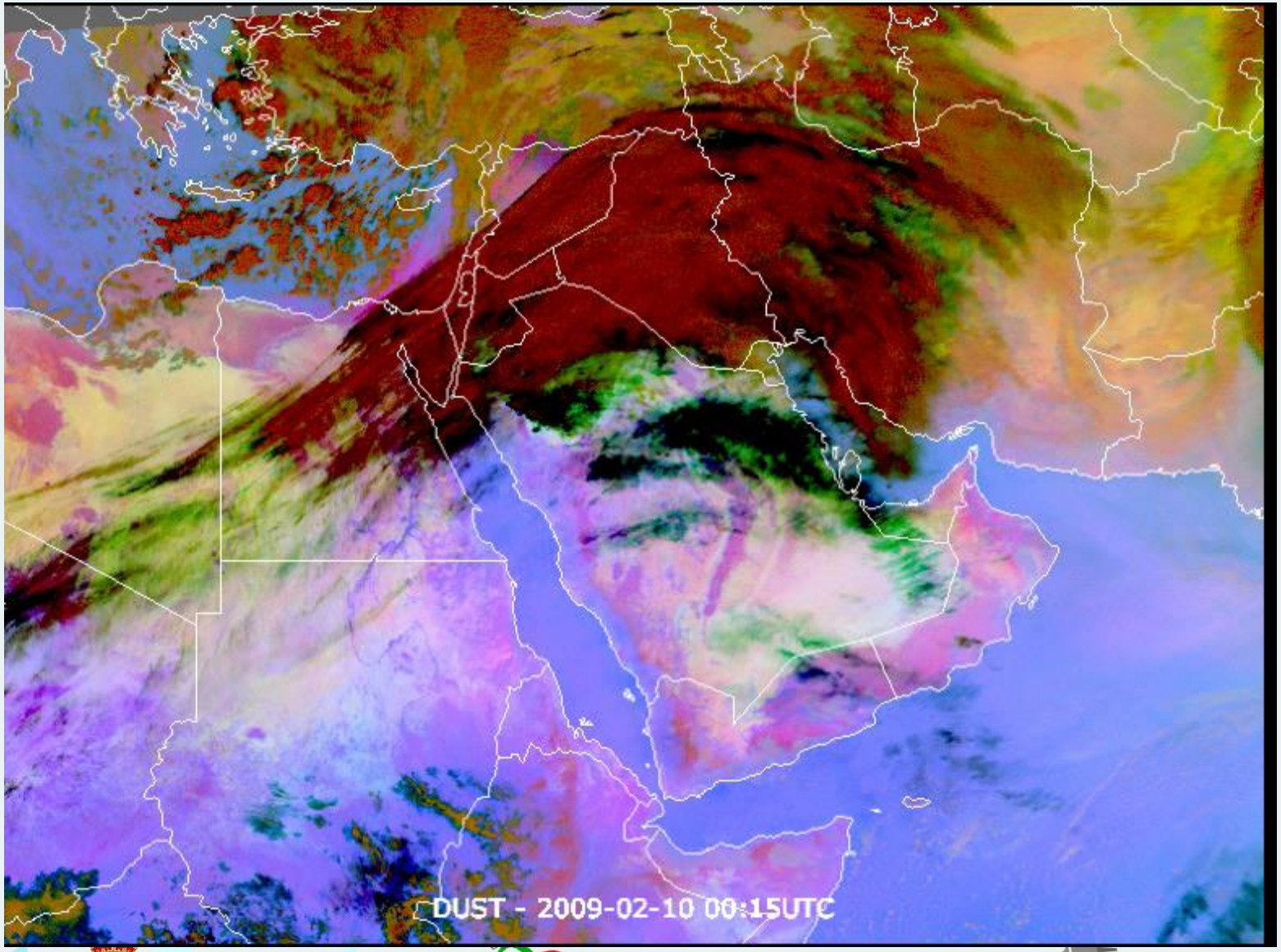
Typical case of Westerly Wave (frontal System)



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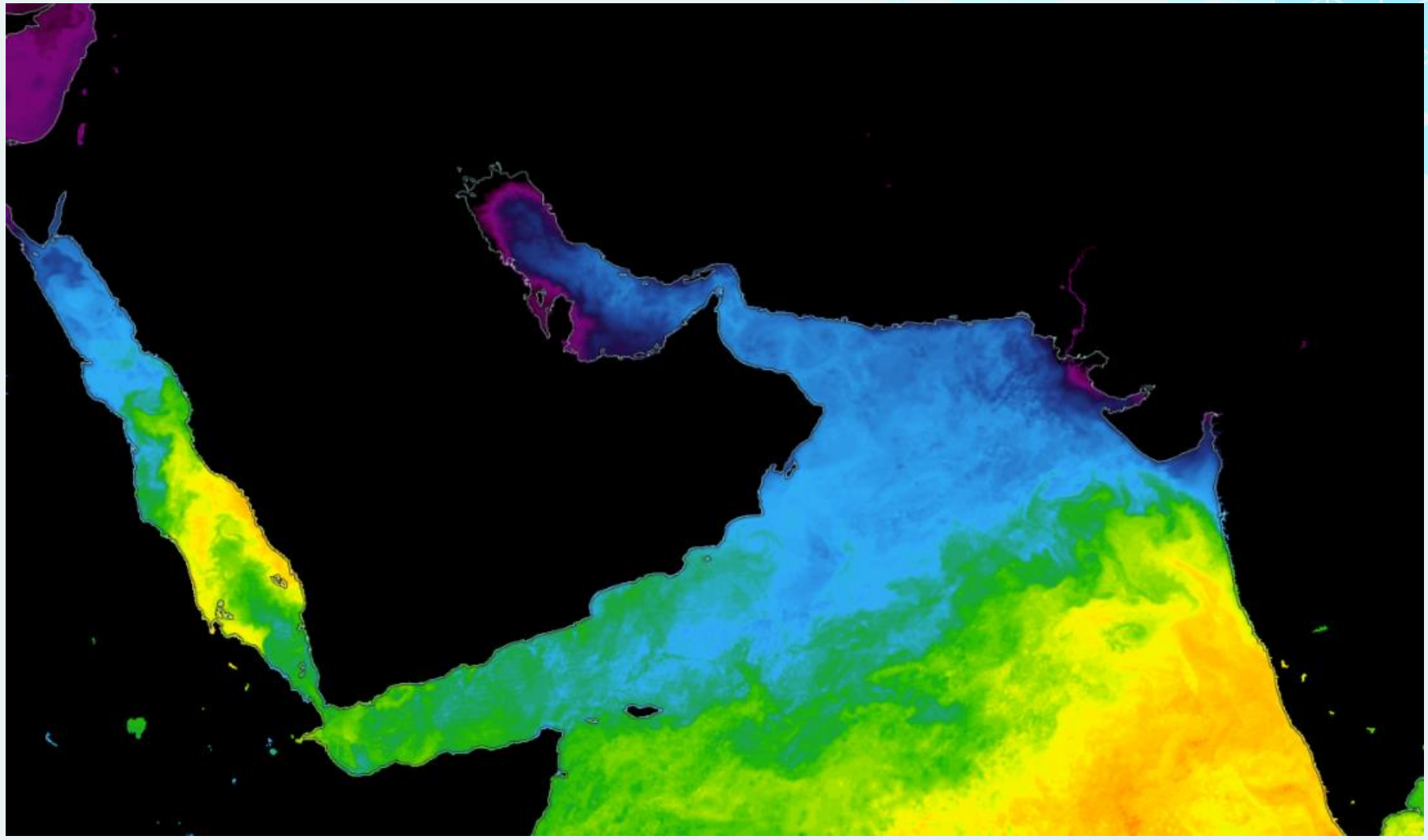

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ctance_TrueColor(hidden),MODIS_Terra_CorrectedReflectance_TrueColor(hidden)&lg=true&t=2023-10-19-
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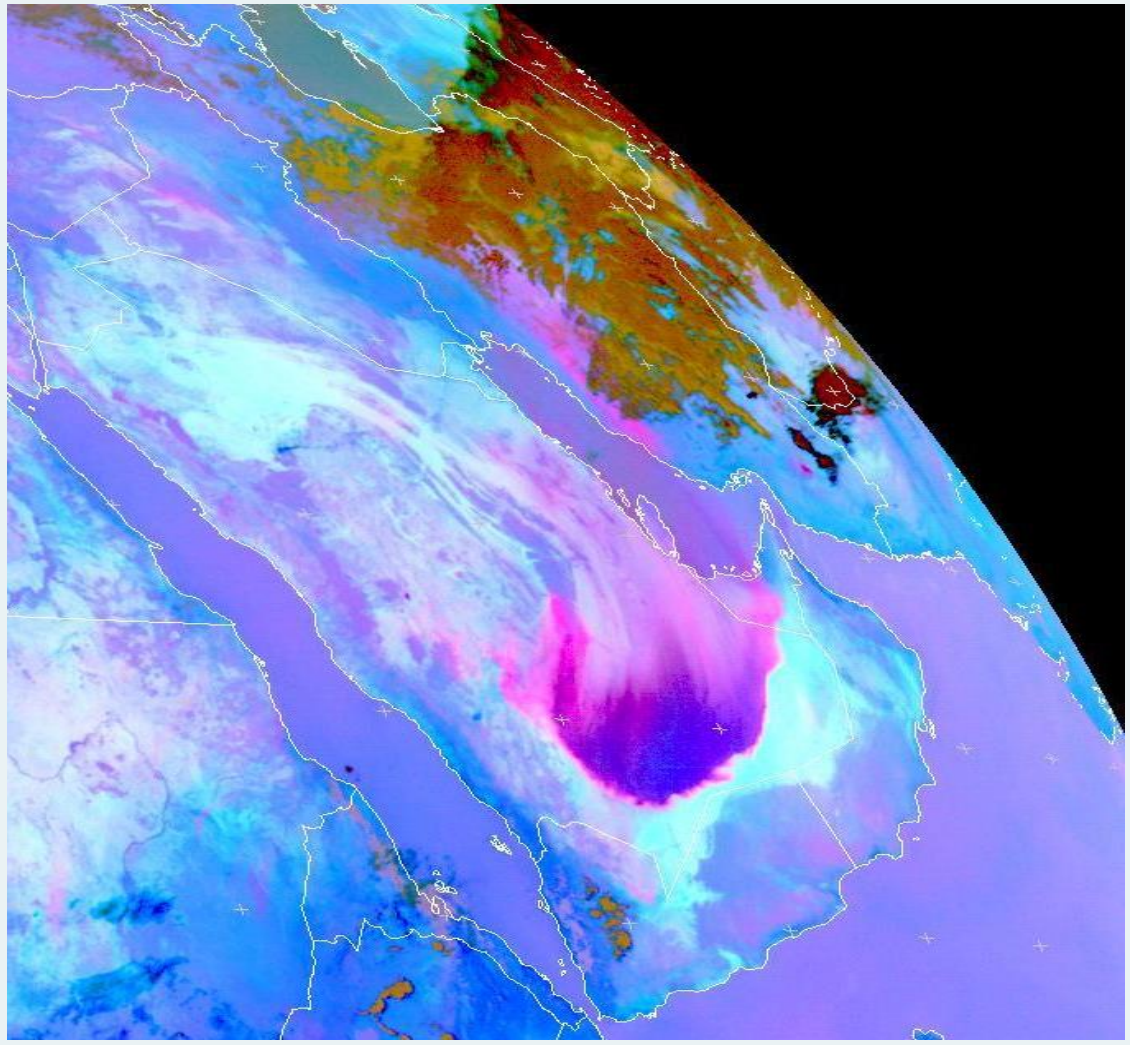
CAA
هيئة الطيران المدني

Dust and Dust Storm

Dust and Dust Storm



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What is dust ?

- Particles, and aerosols
- Diameter size of less than 62.5 µm
- Average size is 2 µm
- Top height : more than 6000 meter
- Affect areas thousands of miles away
- Oxides SiO_2, Al_2O_3, FeO, Fe_2O_3, CaO, Carbonates $CaCO_3$, $MgCO_3$

(Blott & Pye, 2001) (Kok et al., 2012).

What is the difference between Dust and Sand ?

Sand is larger in Size. Any particles greater that 62.5 microns is Sand

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Dust impacts

➢ Health

- Direct
- Moving germs and pollutions from infected areas

➢ Equipments damage

- The more sophisticated an electrical system is, the more dust will affect it
- Reduce engines efficiency by reducing Heat exchange
- interruption of radio services
- Cause leak from the electrical power lines.

➢ Aviation and traffic hazards

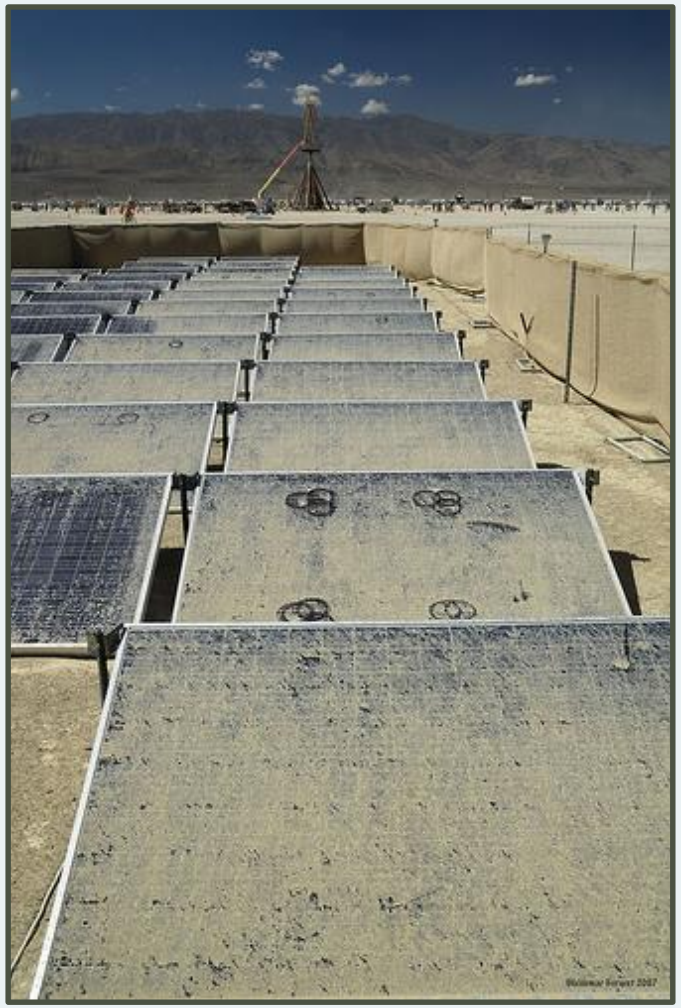
- Sudani Airline incident (2003/12/13)

Dust impacts

- **Generation of Solar Energy**

Aerosols interact with light:
Reflect, absorb, transmit

as a result, reduce the available energy and the efficiency of solar electrical generation systems

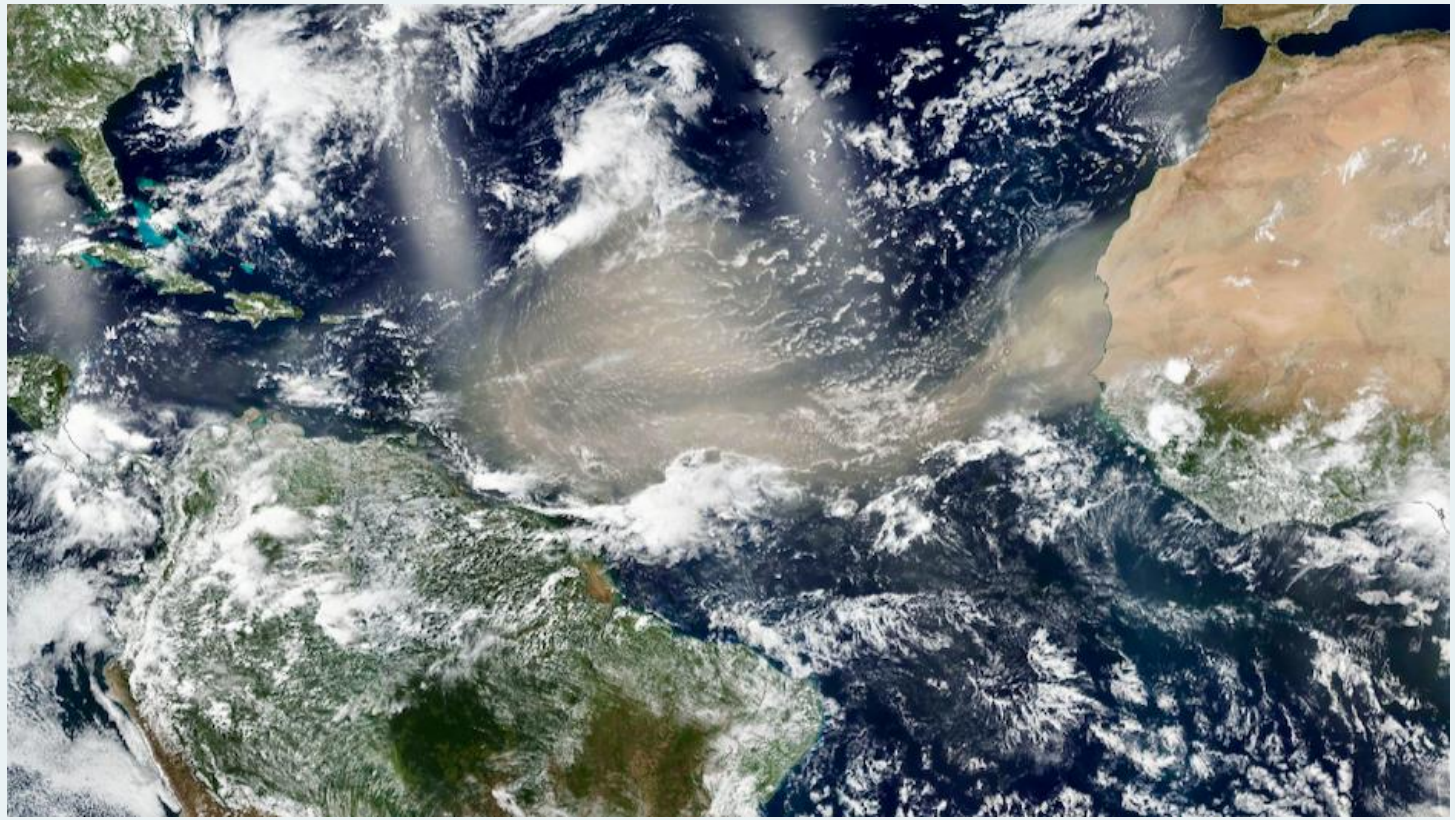


Dust impacts

Fertilizer

“**MODIS** showed that a total of some 50 million tons of dust make their way from Africa to the Amazon region every year”

“The data revealed that some 56 percent of the dust reaching the Amazon forest originates in the Bodele valley"



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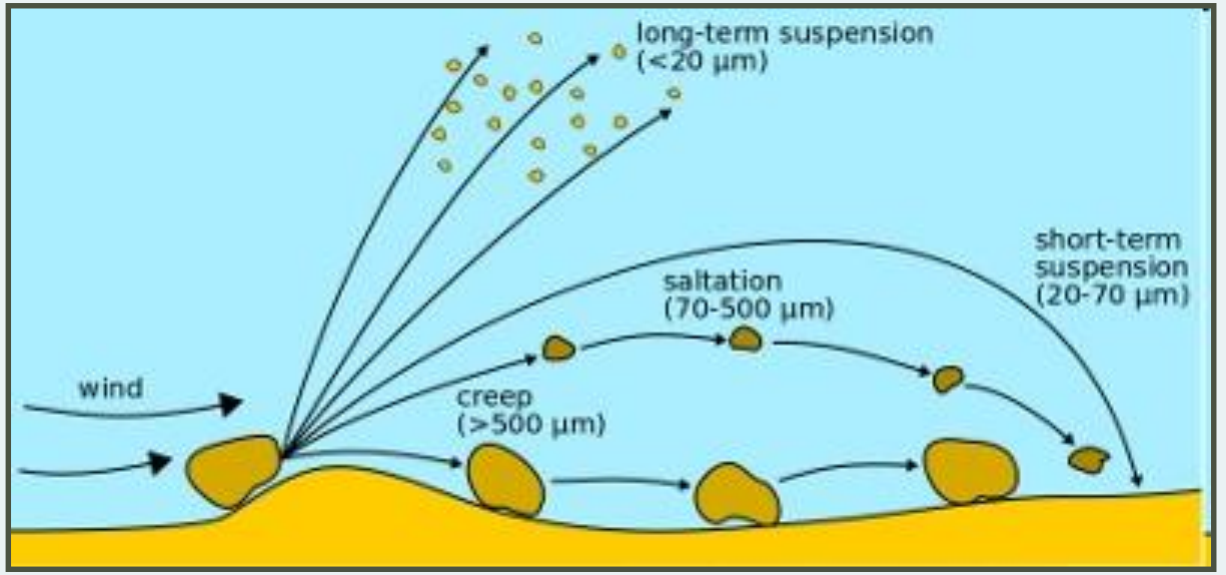
The dust cycle

Emission

Controlling Factors

1) Wind speed
2) Near-surface turbulence
3) Soil texture and moisture
4) Vegetation
5) Air Humidity

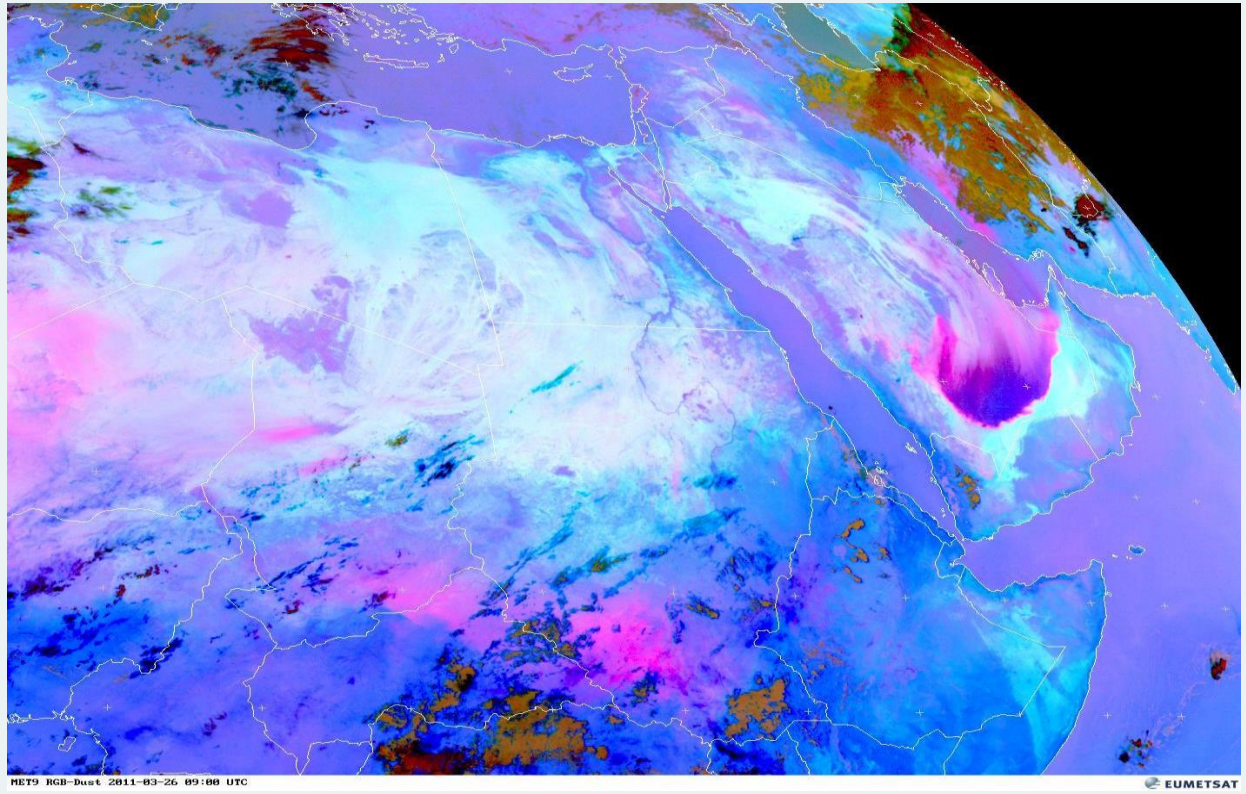


The dust cycle

Emission: Meteorological conditions

Large Scale Dust Storm

- **Frontal systems (Westerly Disturbances)**
- **Reinforced trade winds**



EUMETSAT

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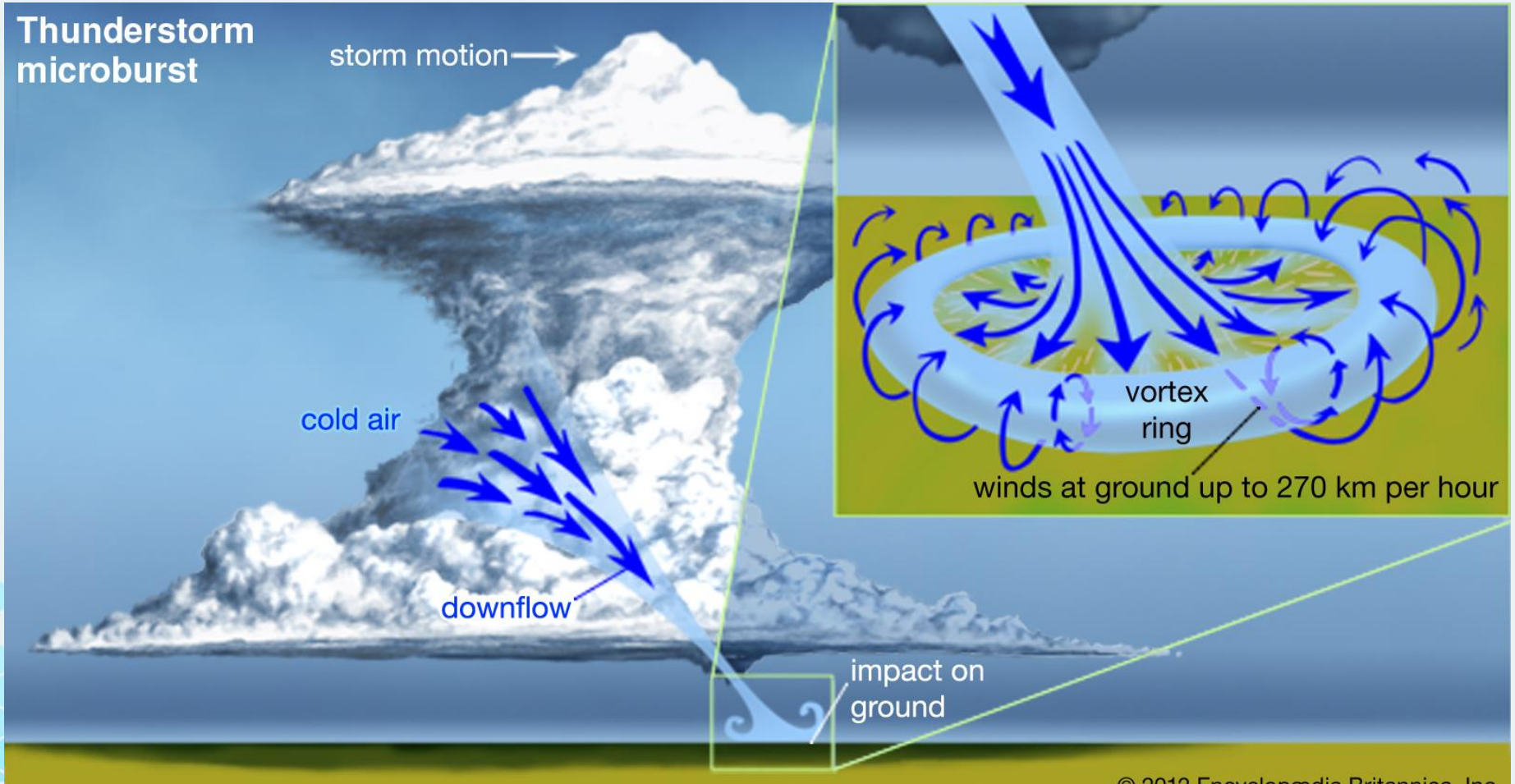
The dust cycle

Emission: Meteorological conditions

Mesoscale –Microscale Scale Dust storm

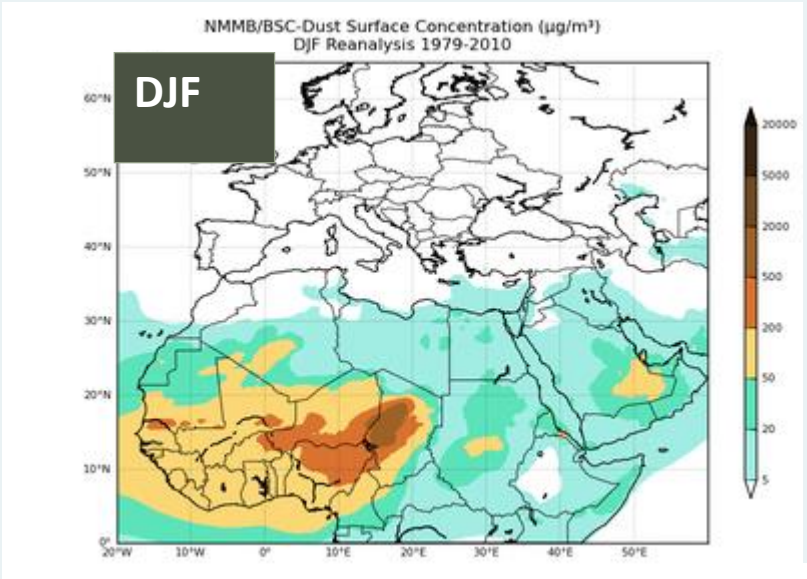
- **Thunderstorms**

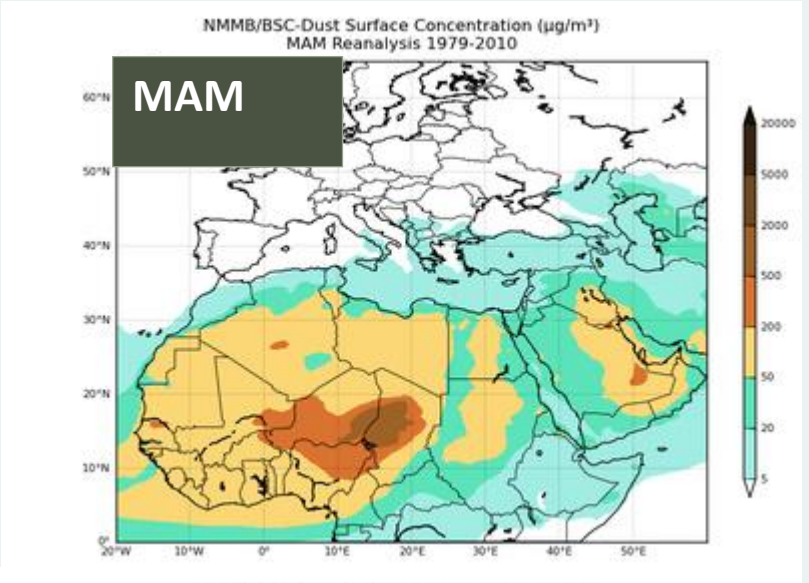


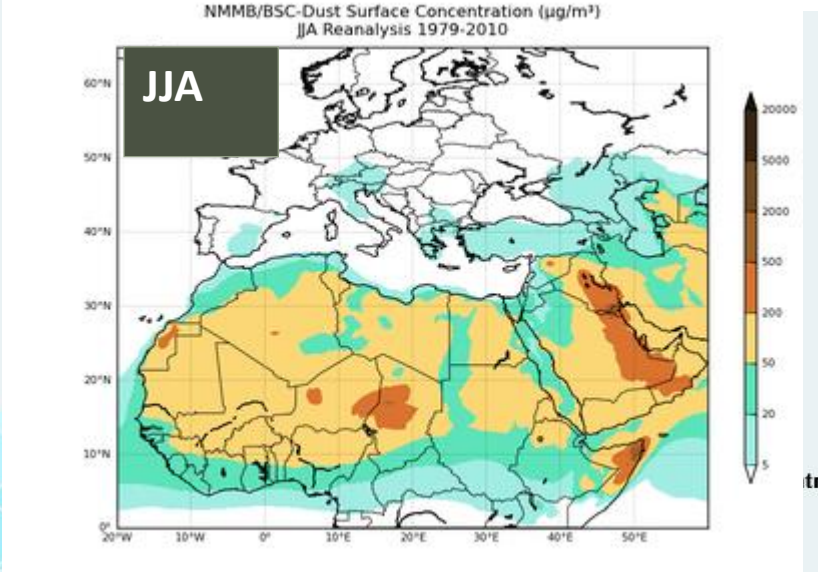
The dust cycle

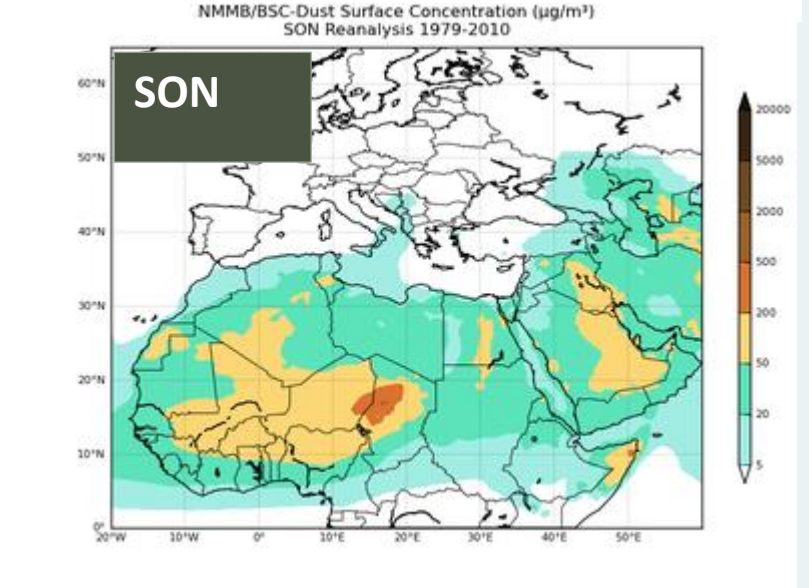
Seasonal variability

More dust emitted in Summer









- Seasonal meteorology
- Phenology

Dust sources

Characteristics of Favourable Dust Sources

- Recent aridity or frequently flooded areas
- Topographical role
- Human activities

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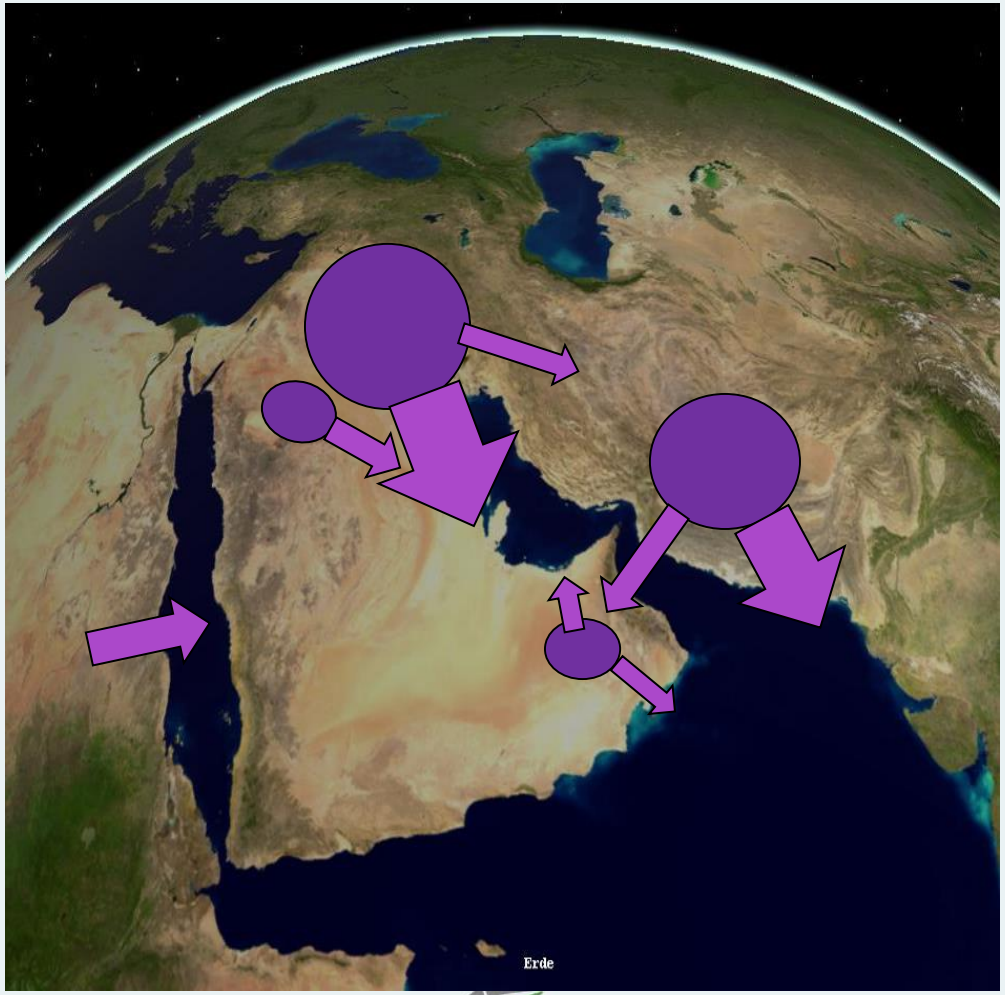
Characteristics of Favourable Dust Sources

Topographical Role & Recent aridity or frequently flooded areas

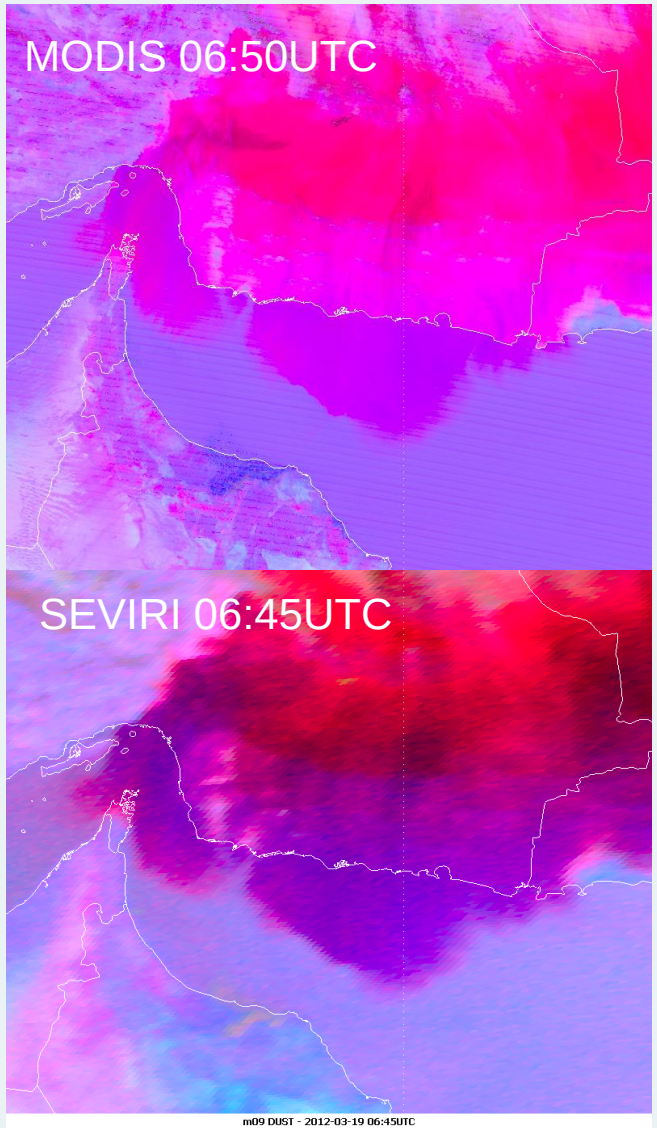
Main Dust sources Affecting Arabian Peninsula

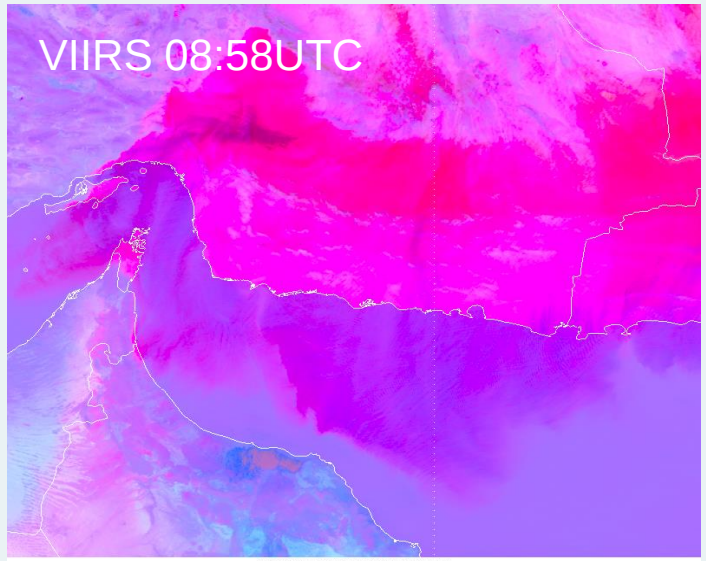
- Tigris and Euphrates basin
- Sistan Basin & Baloushistan
- East of Alhejaz Mountains
- Southwest Alhajar Mountains

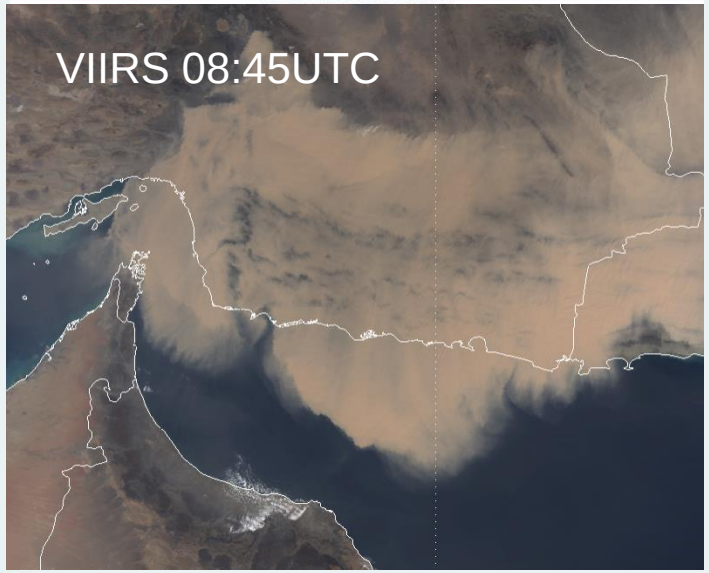


Dust monitoring: Satellites

Dust – Sea of Oman







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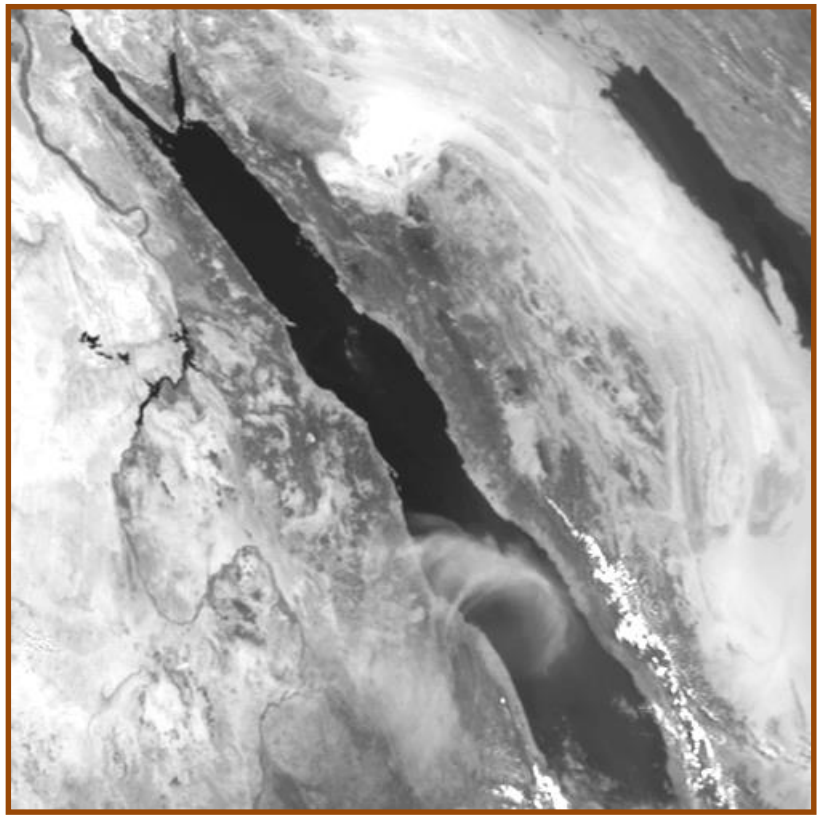
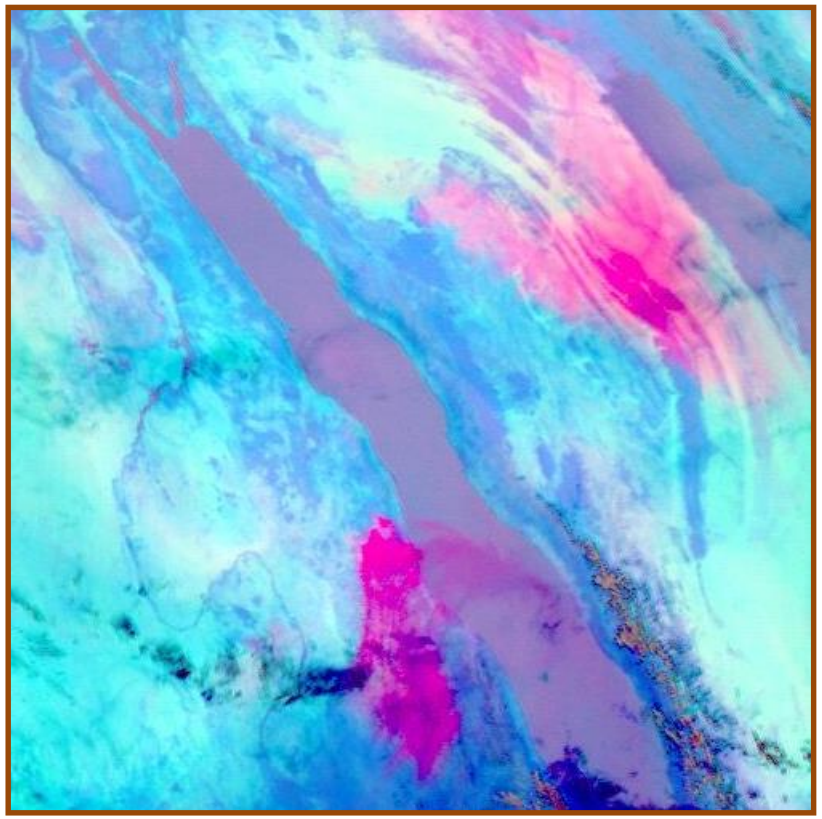
Dust monitoring: SEVIRI Dust RGB

The dust storm over the
Arabian Peninsula is not visible in VIS imagery.

Met-8 Vis
25 Jun 2003 10:00

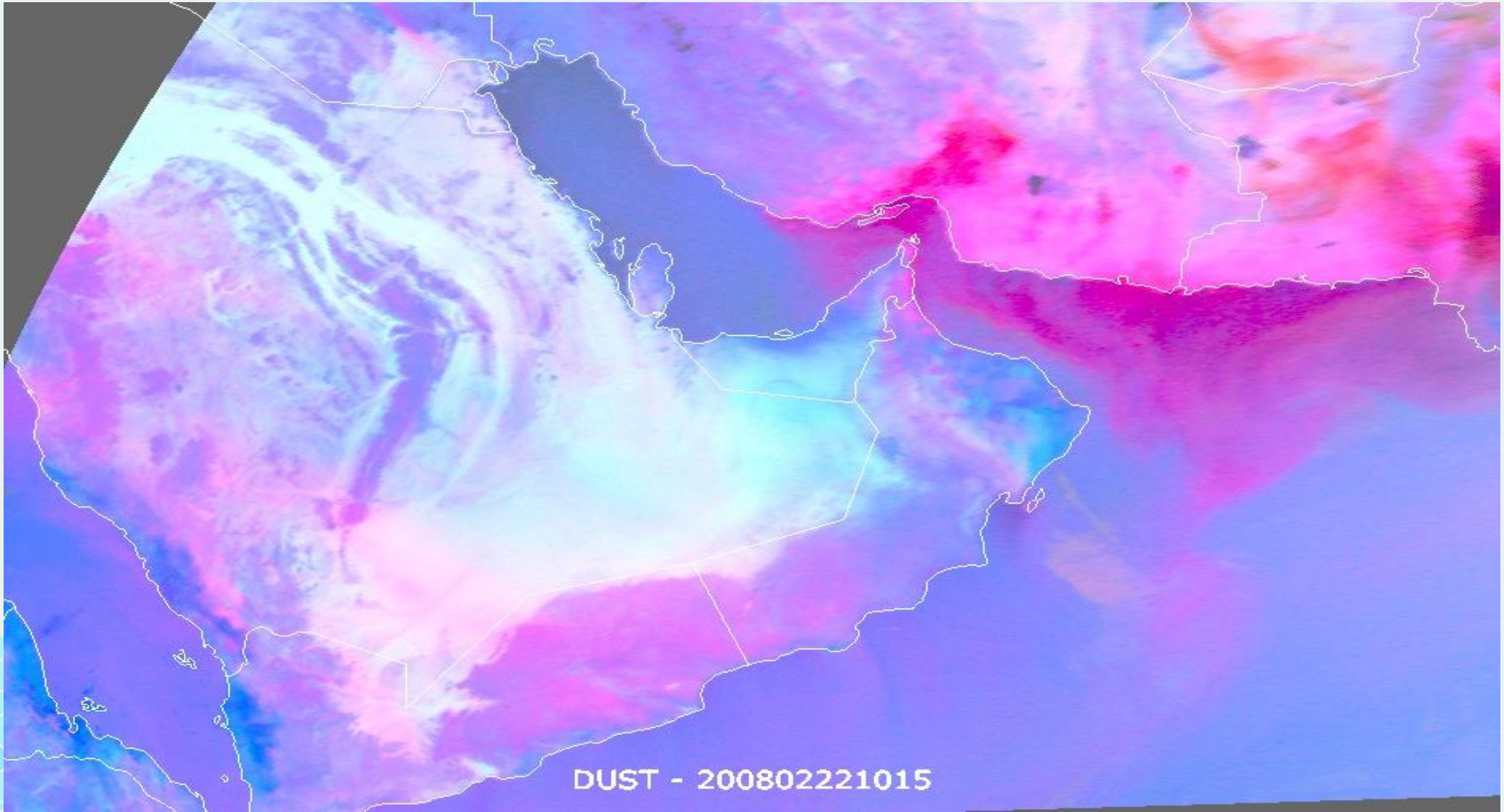


EUM RGB-Dust
25 Jun 2003 10:00

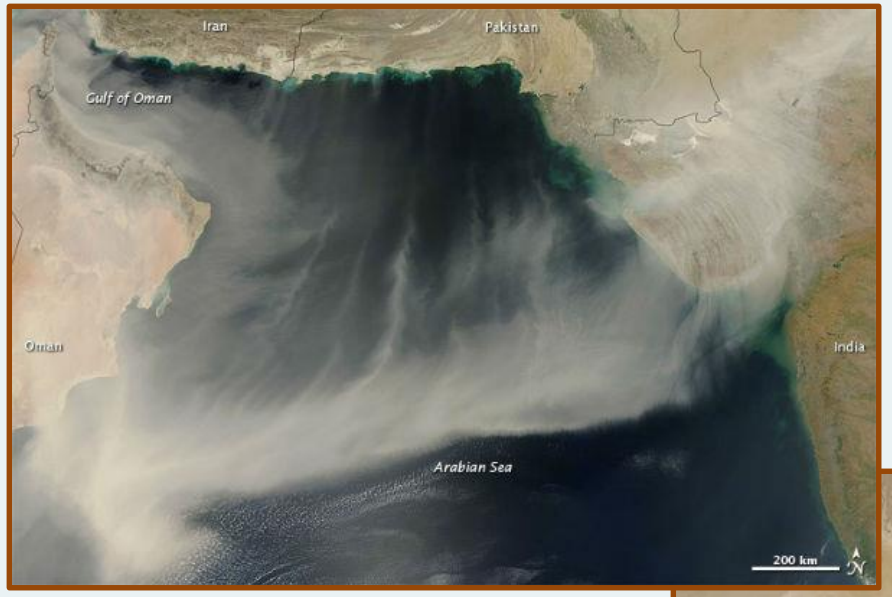


Dust monitoring: SEVIRI Dust RGB

Sistan Basin

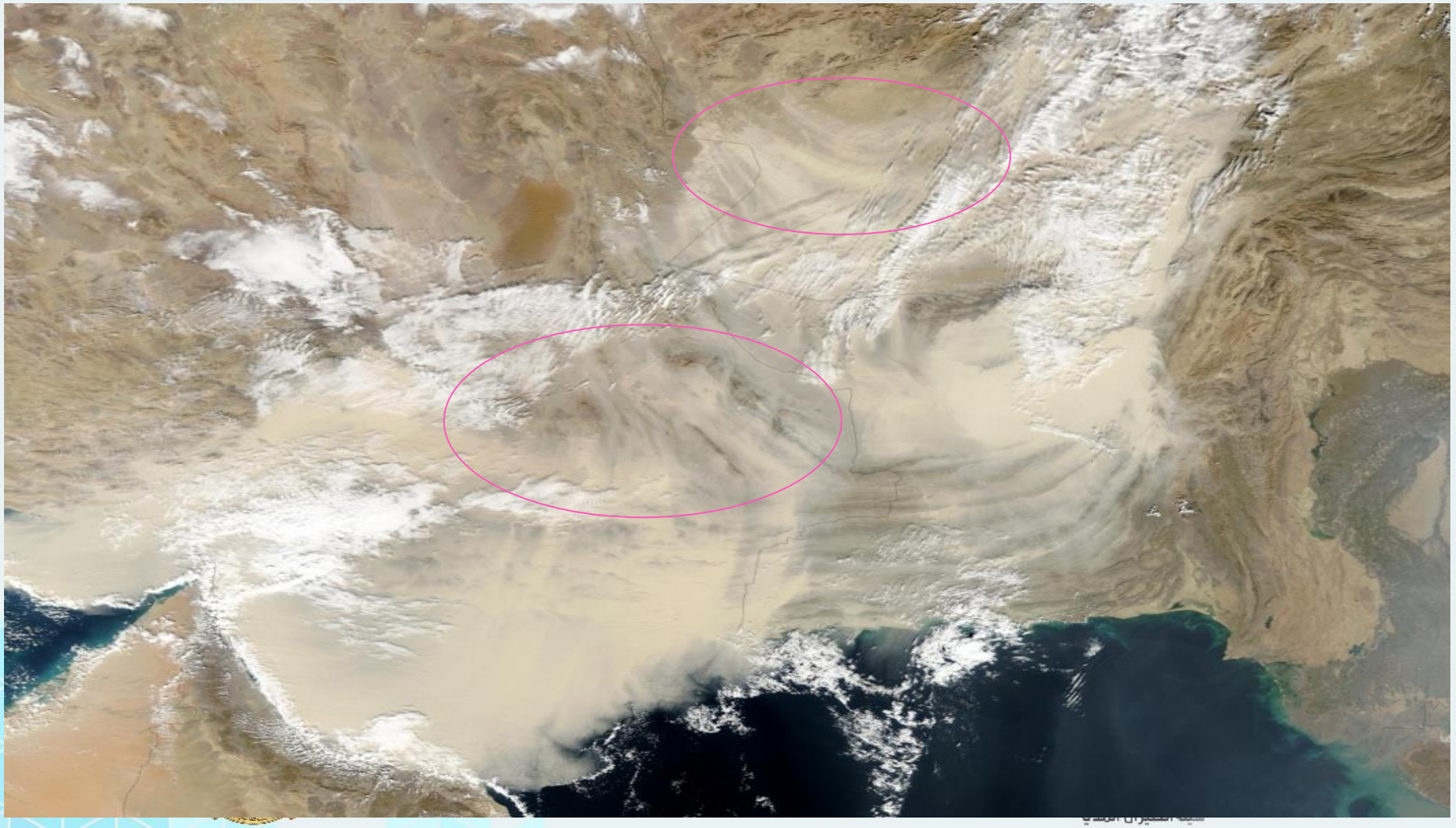


Dust monitoring: MODIS &VIIRS

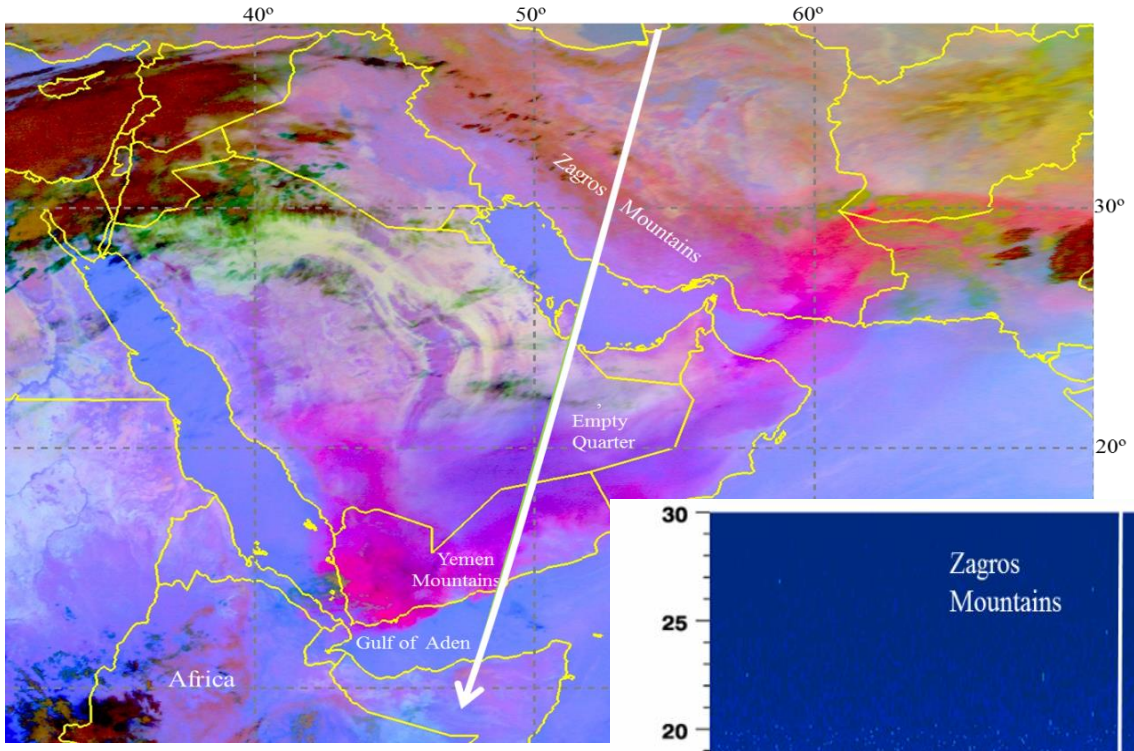


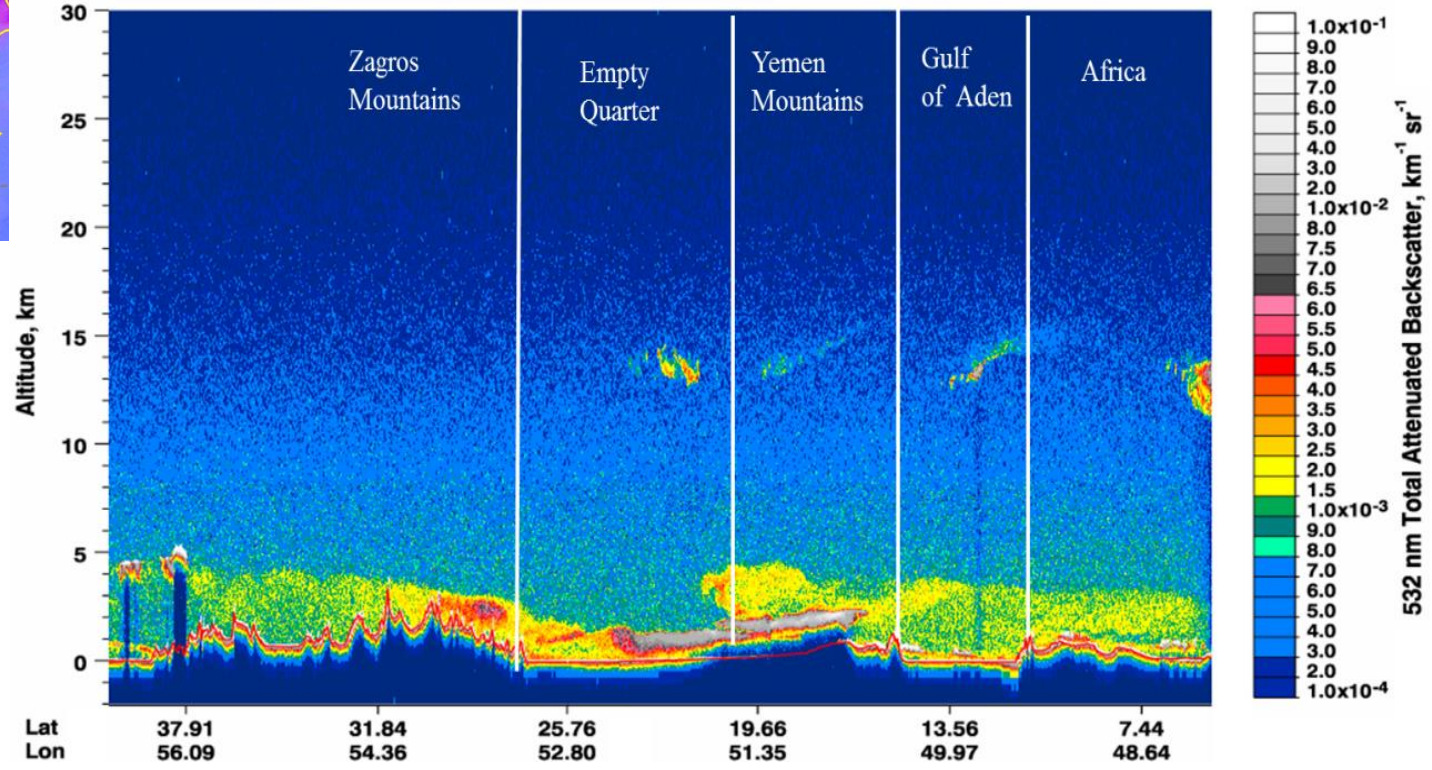
Dust monitoring: MODIS &VIIRS

Using MODIS true colur RGB reveals fine details of the dust emission as can be seen in this case over Sistan Basin & Baloushistan



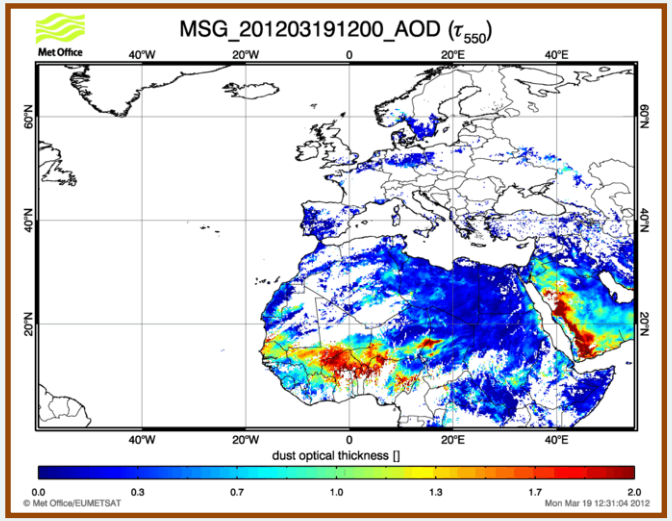
Dust monitoring: CALIPSO

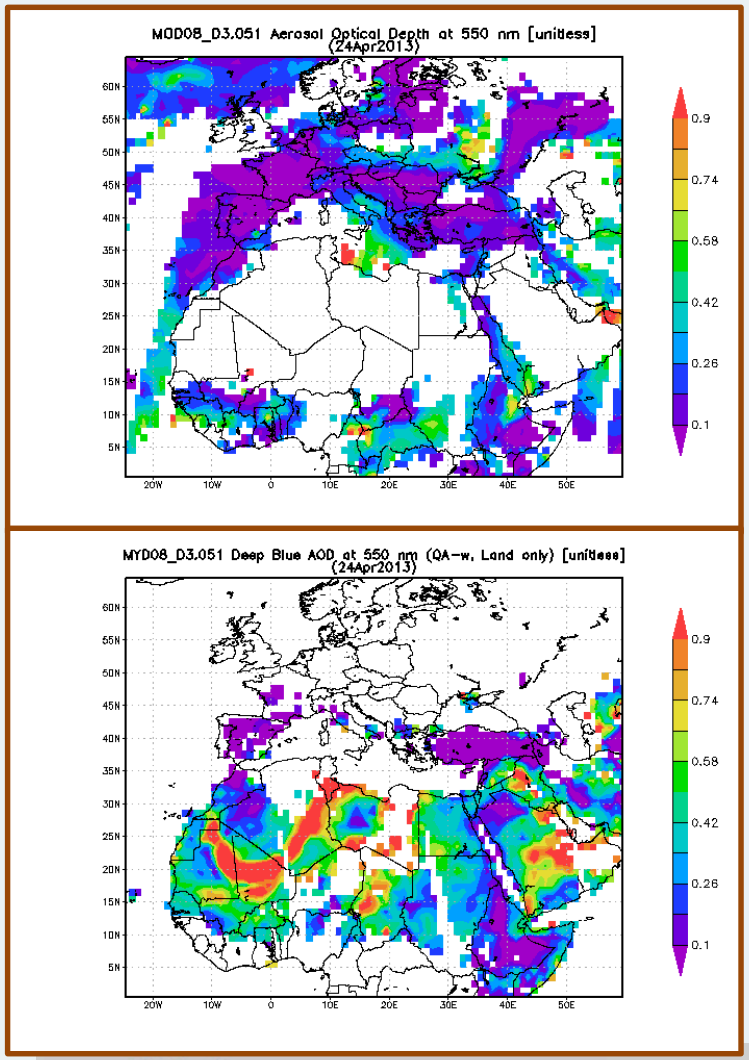


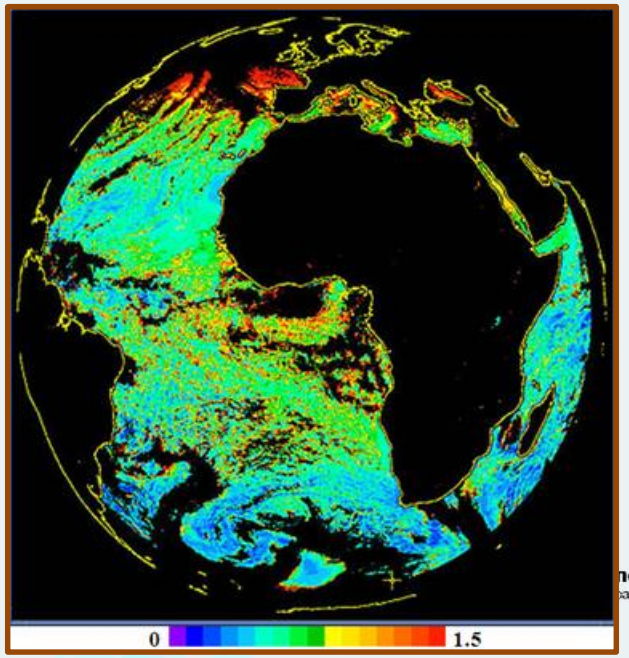


Quantitative estimations of Dust

Aerosol Optical Depth (AOD)

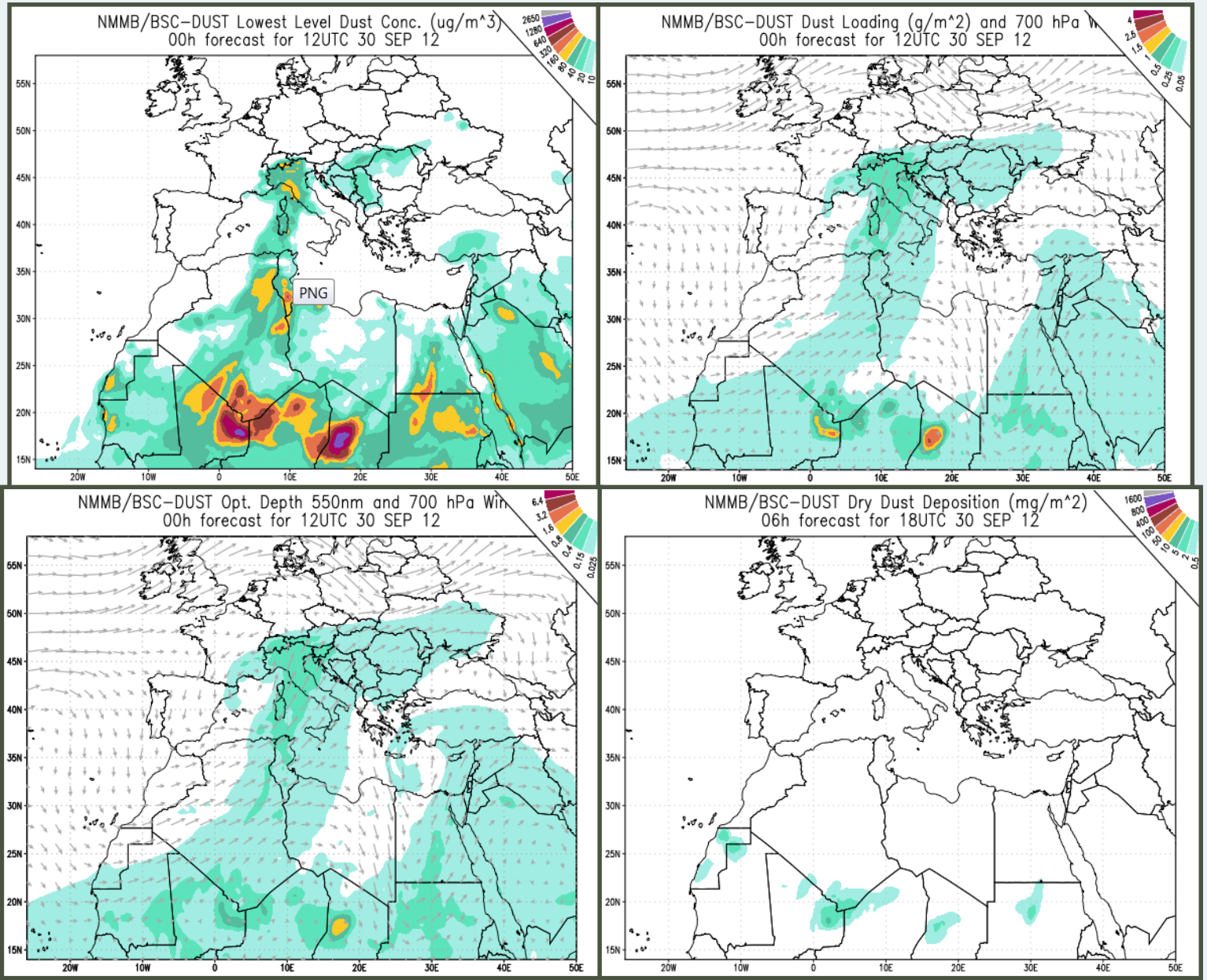






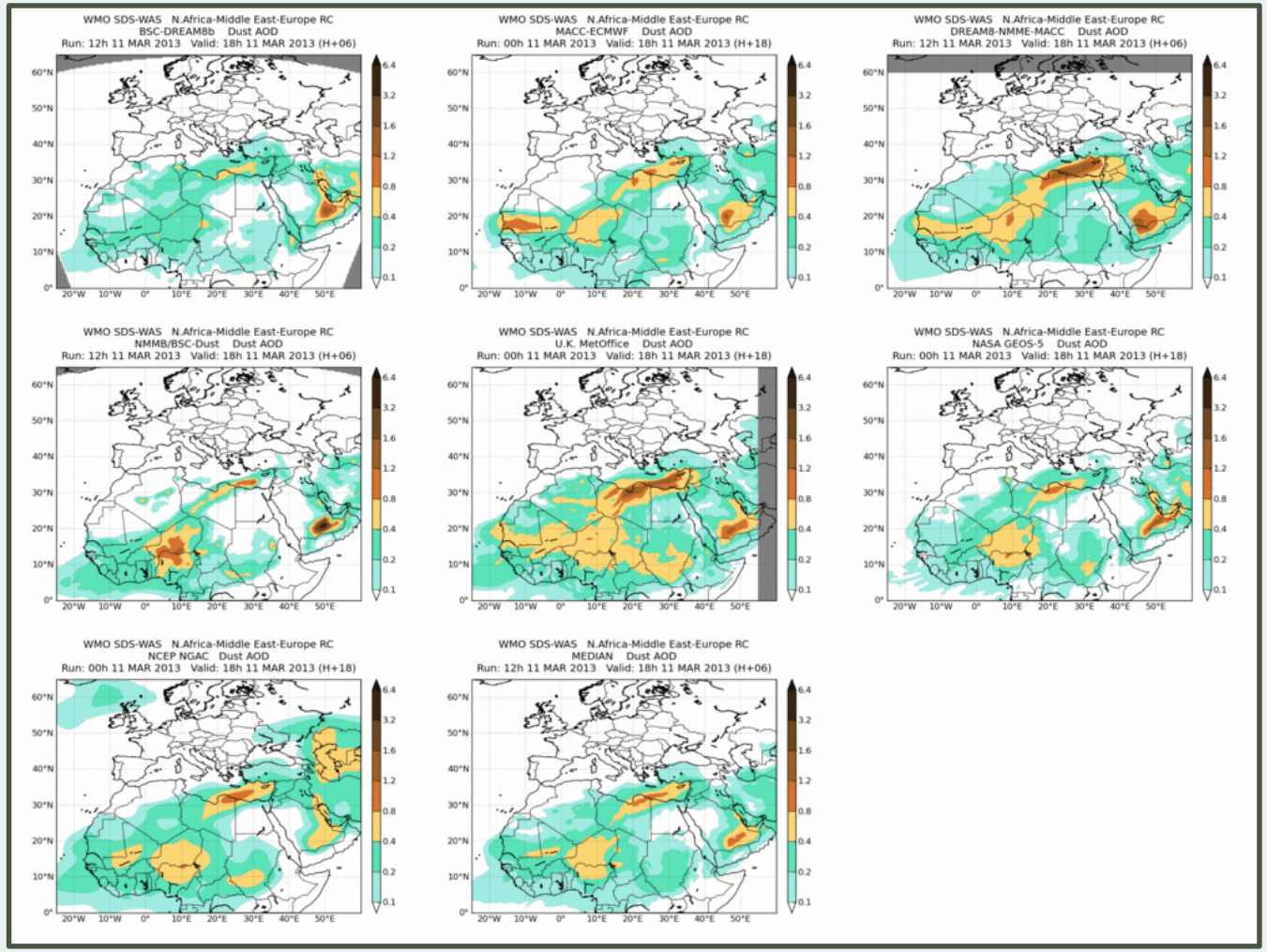
Dust modelling: Forecast products

NMMB/BSC-Dust model



Dust modelling: Forecast products

Dust optical depth at 550 nm

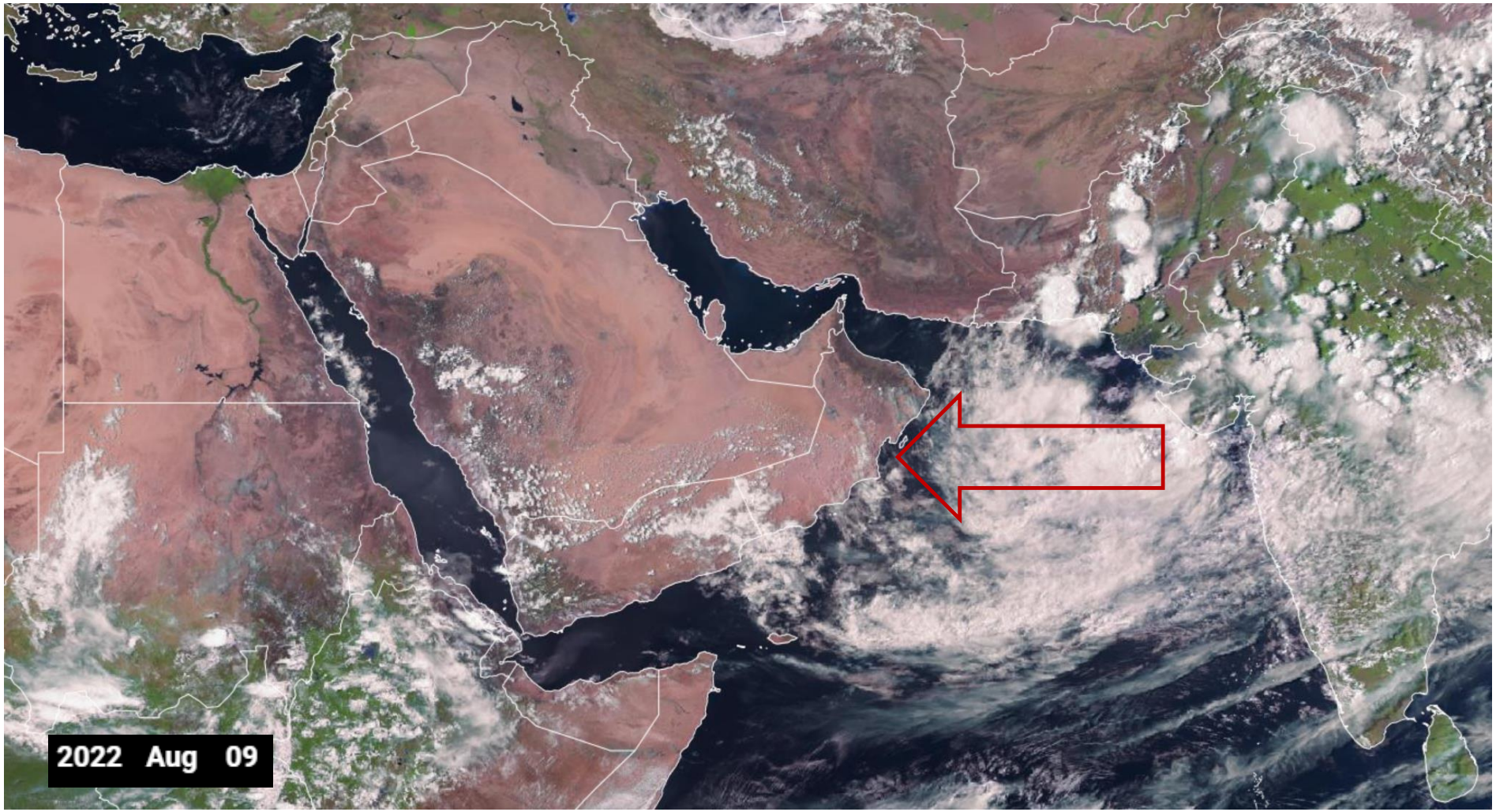


RUN: 11 Mar 2013

VALID: 11 Mar 2013 12:00 – 14 Mar 2013 00:00

Easterly Wave :

Humid tropical air mass moving west ward



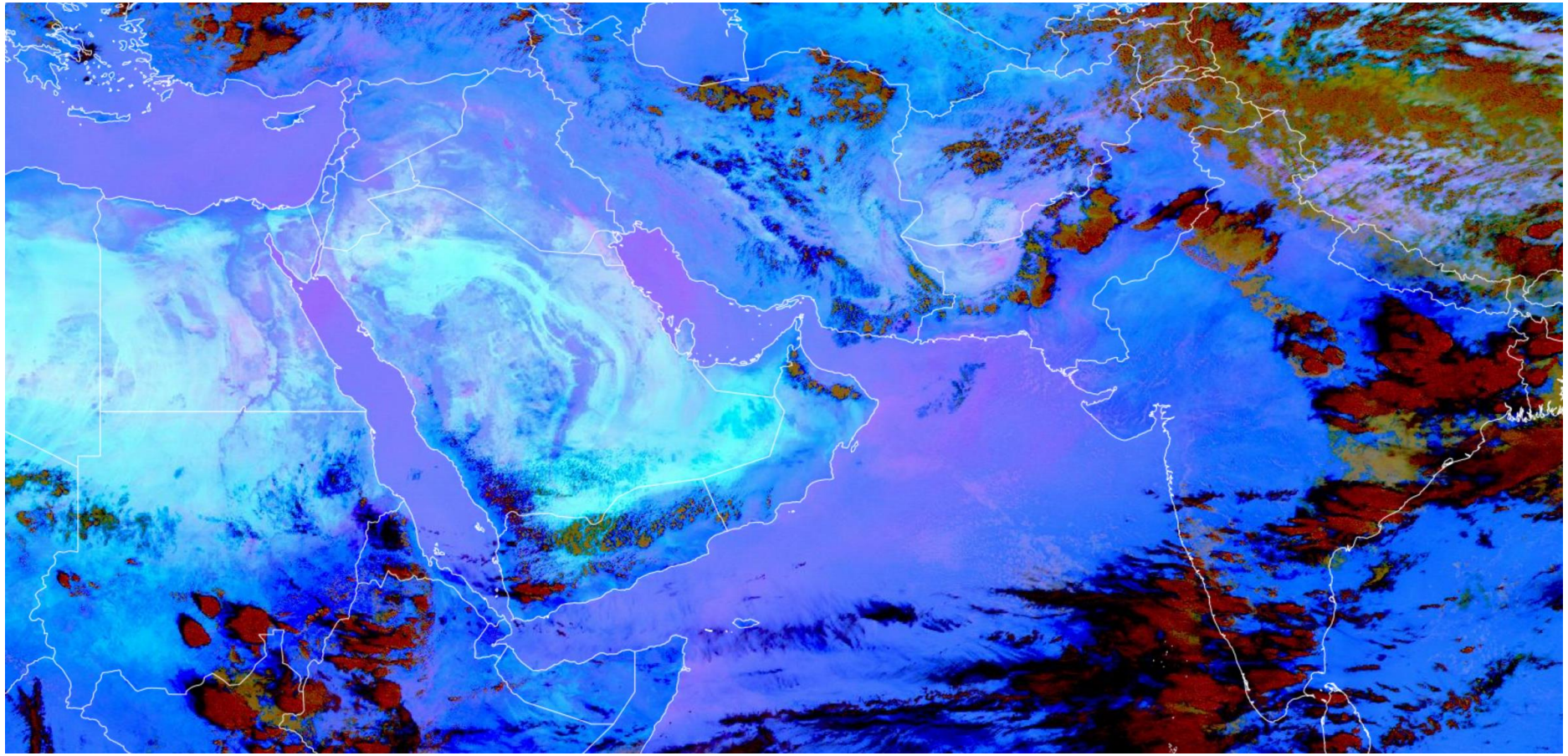
Normal July

Dust RGB 03 Jul 2021 / 1200 UTC

Usual Features :

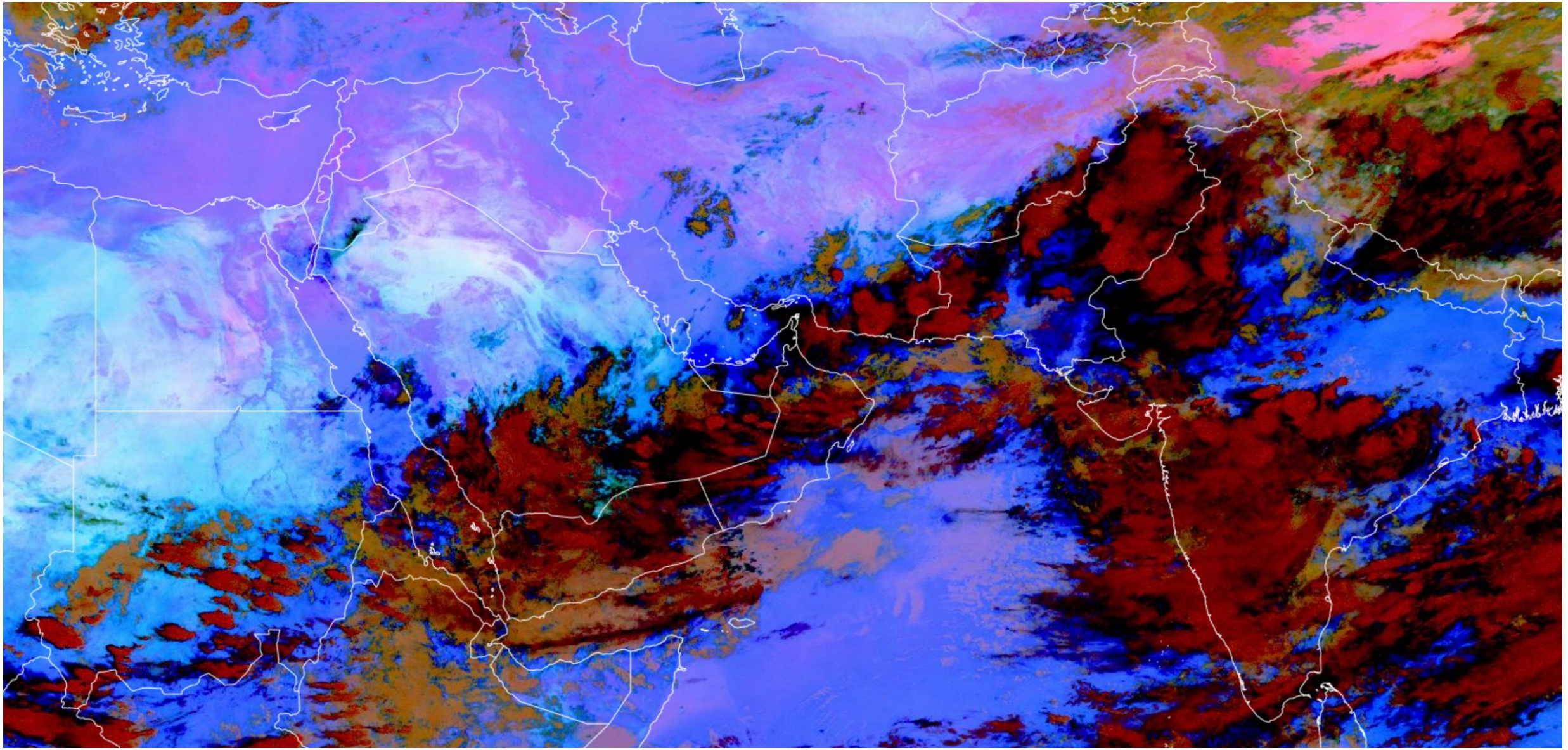
High pressure
Shallow thermal low pressure
Hot shamal winds
Heat Waves
Dust and dust storms
Mountain convection activities

Monsoon winds over Arabian Sea and Oman (khareef)
.
.
.



July 2022
Extraordinary!

Dust RGB Jul 09 2022 / 1600 UTC



K index (From Atmospheric Sounding)

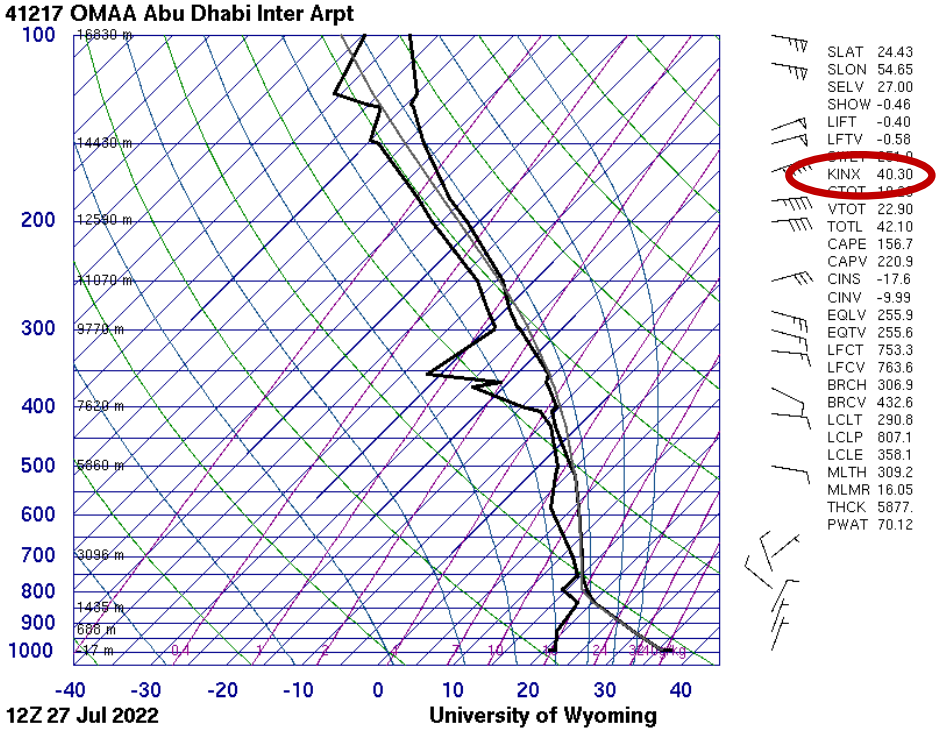
A stability index that is a measure of thunderstorm potential based on temperature lapse rate, moisture content of the lower troposphere, and the vertical extent of the moist layer.

https://glossary.ametsoc.org

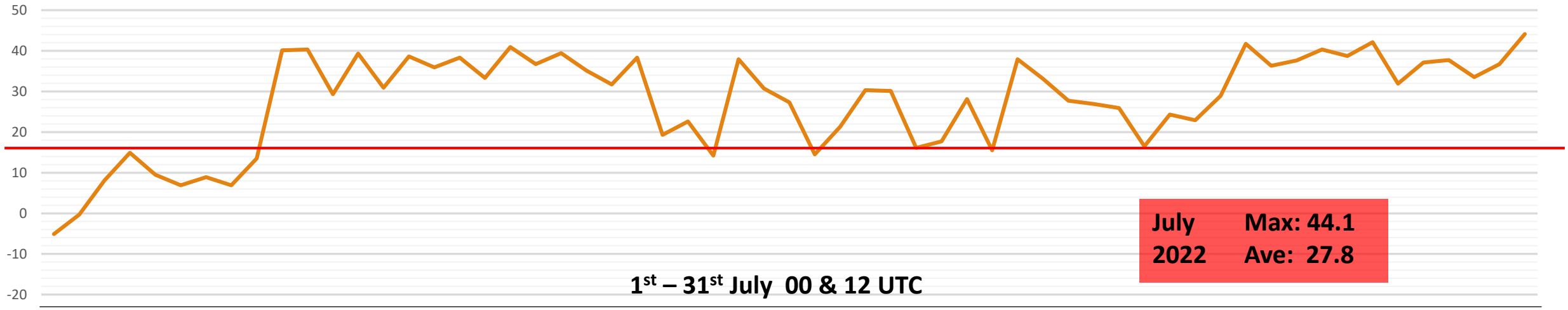
K index = (T850 - T500) + TD850 - (T700 - TD700)

KI	Thunderstorm Potential
0 to 15	0%
16 to 19	20% unlikely
20 to 25	35% isolated thunderstorm
26 to 29	50% widely scattered thunderstorms
30 to 35	85% numerous thunderstorms
>36	100% chance for thunderstorms

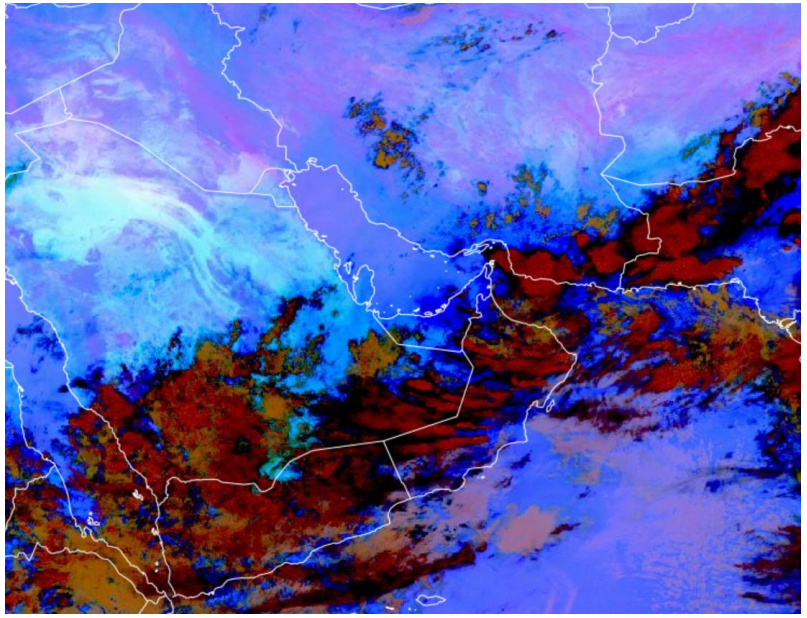
https://www.researchgate.net



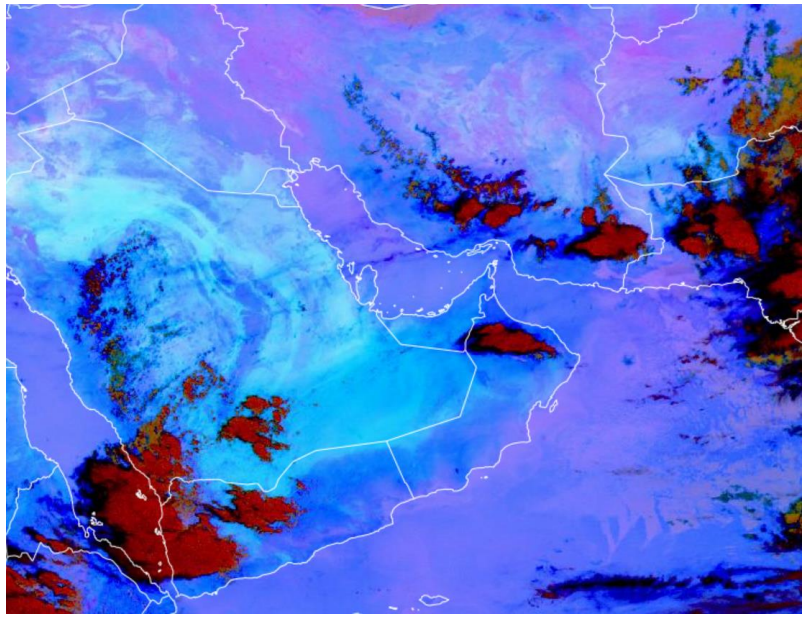
Abu Dhabi Sounding Station K-index / July 2022



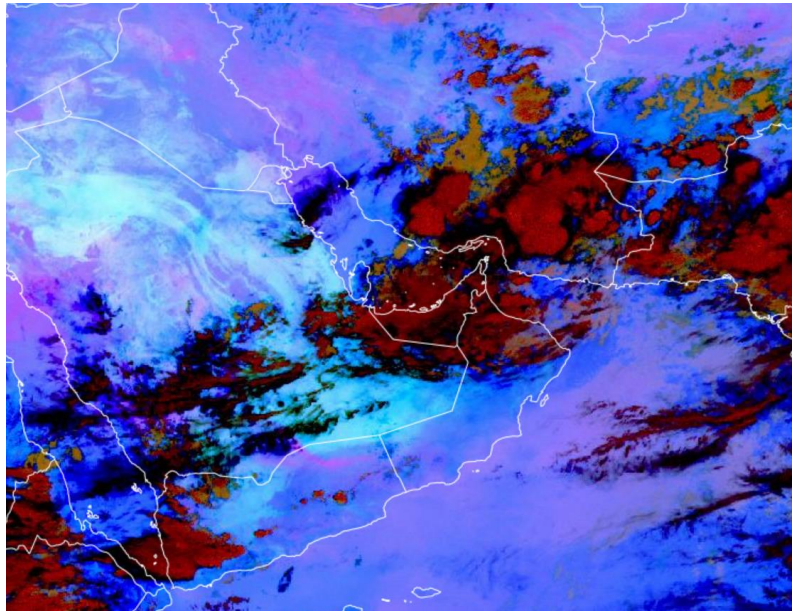
July 09



July 23

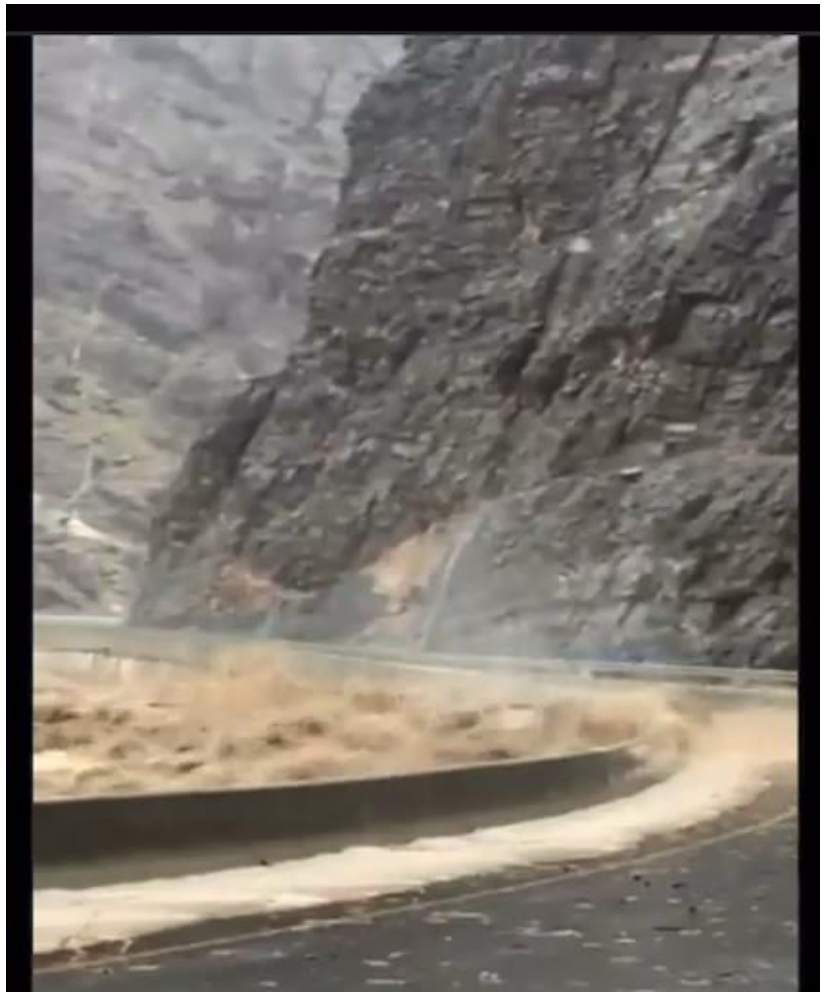


July 26



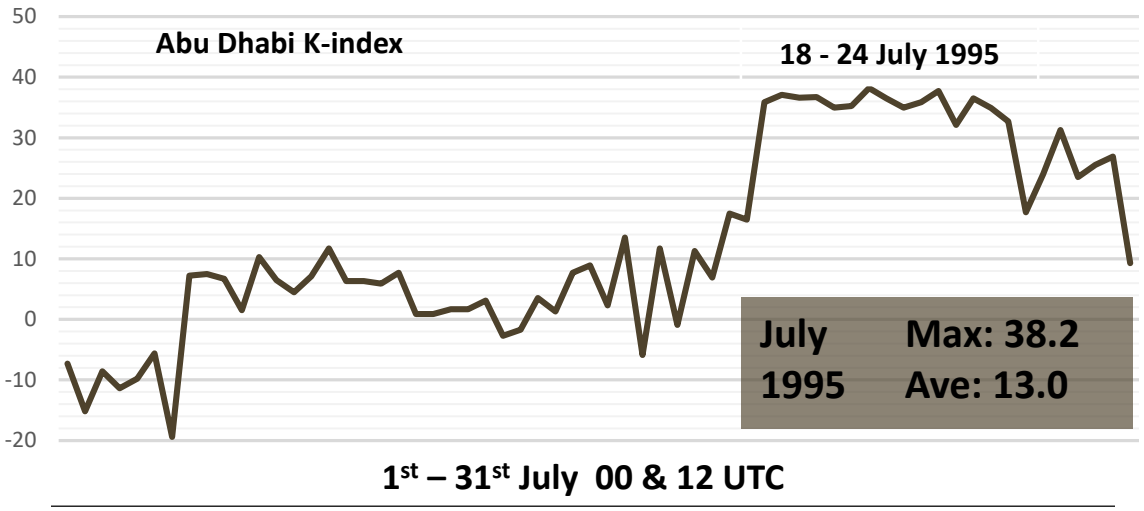
On the Ground!

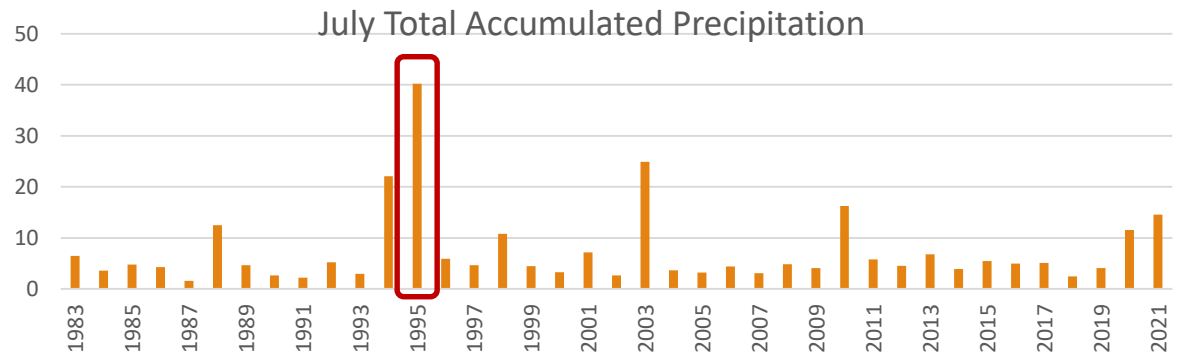
North of Oman
07 July 2022

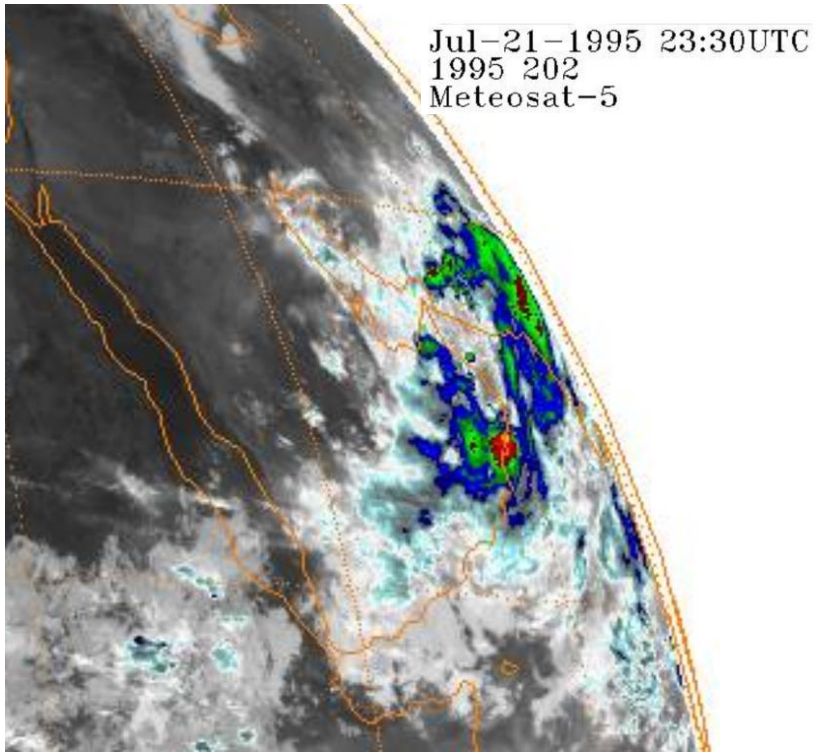


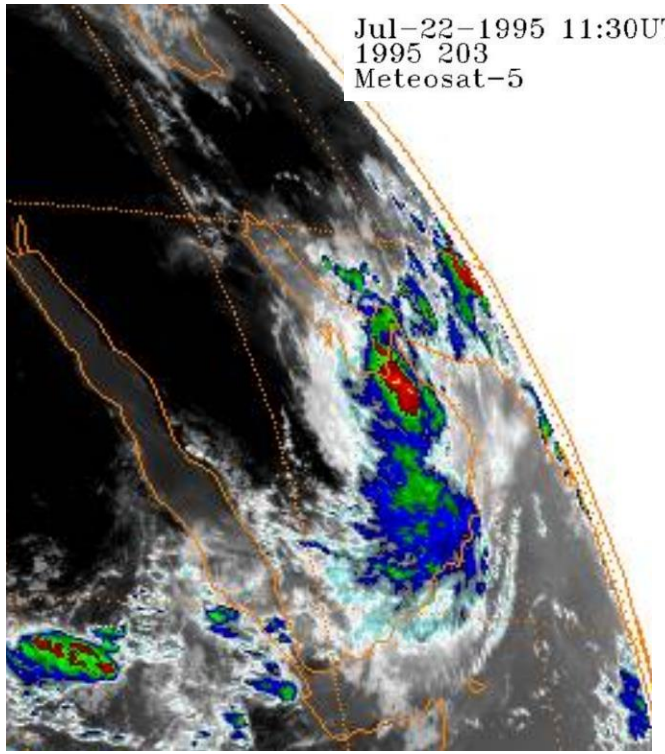
On the Ground!

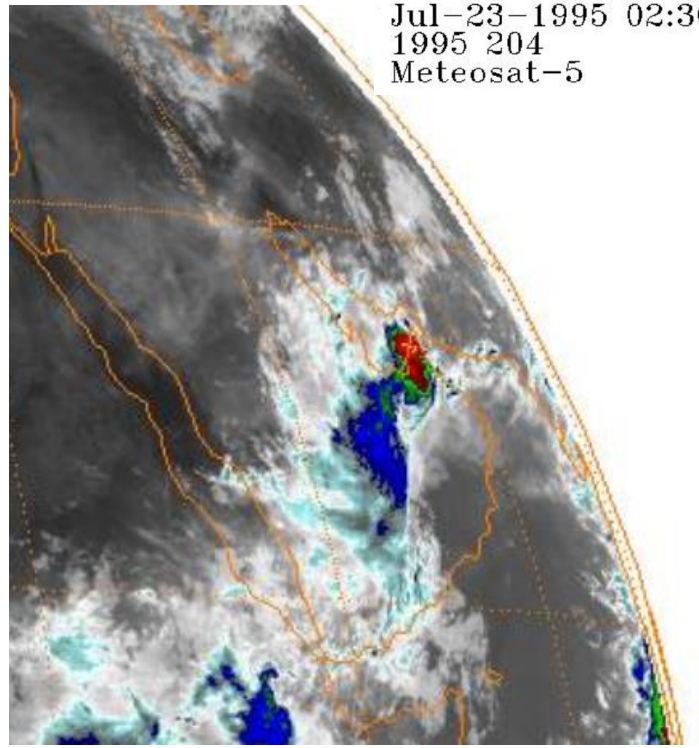
UAE 27 and 28 July









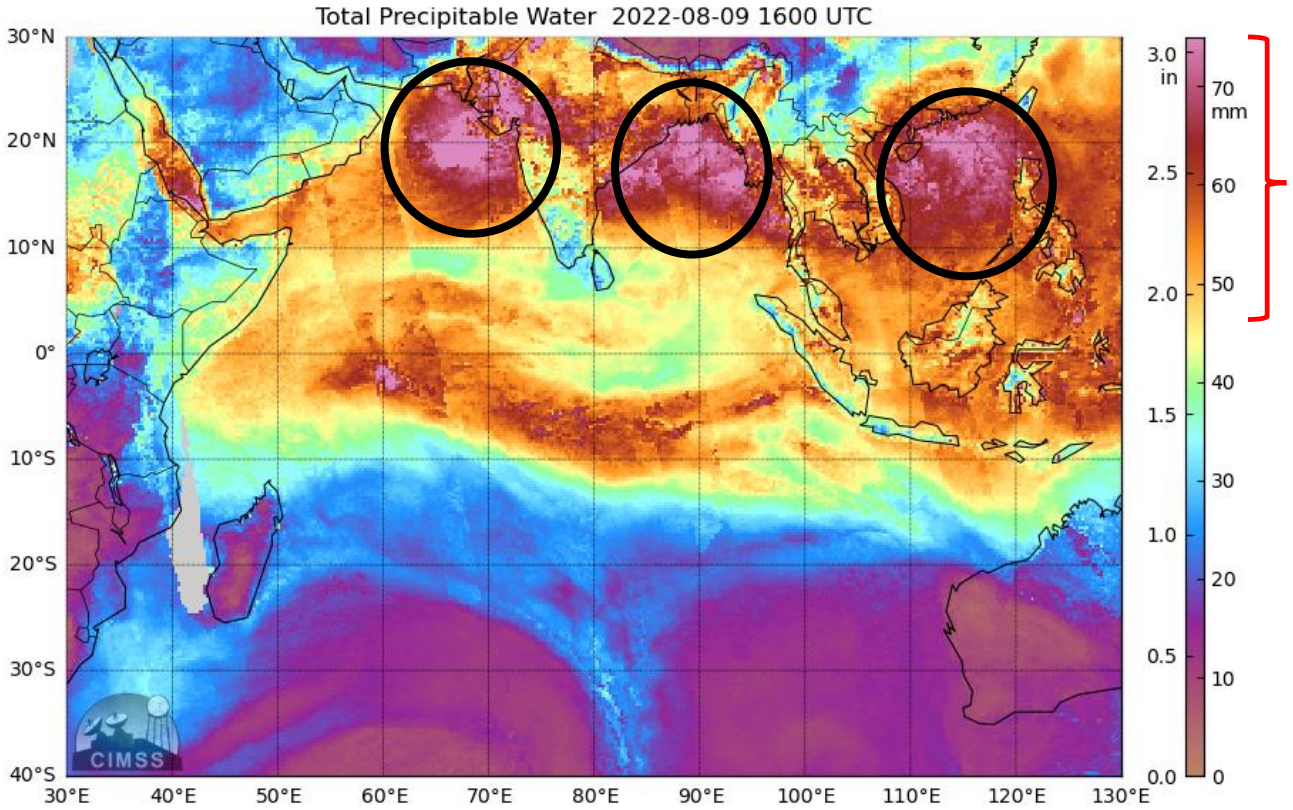


https://www.ncdc.noaa.gov/gibbs/html/MET-5/IR/1995-07-23-12

Satellite Products to Monitor EW and its Storms

Total Precipitable Water : Measure of the depth of liquid water at the surface that would result after precipitating all of the water vapor in a vertical column over a given location, usually extending from the surface to 300 mb (NOAA).

Total Precipitable Water (MIMIC-TPW)
Morphed Integrated Microwave Imagery at CIMSS Cooperative Institute for Meteorological Satellite Studies



These Humid Tropical Air Masses can move/develop as :

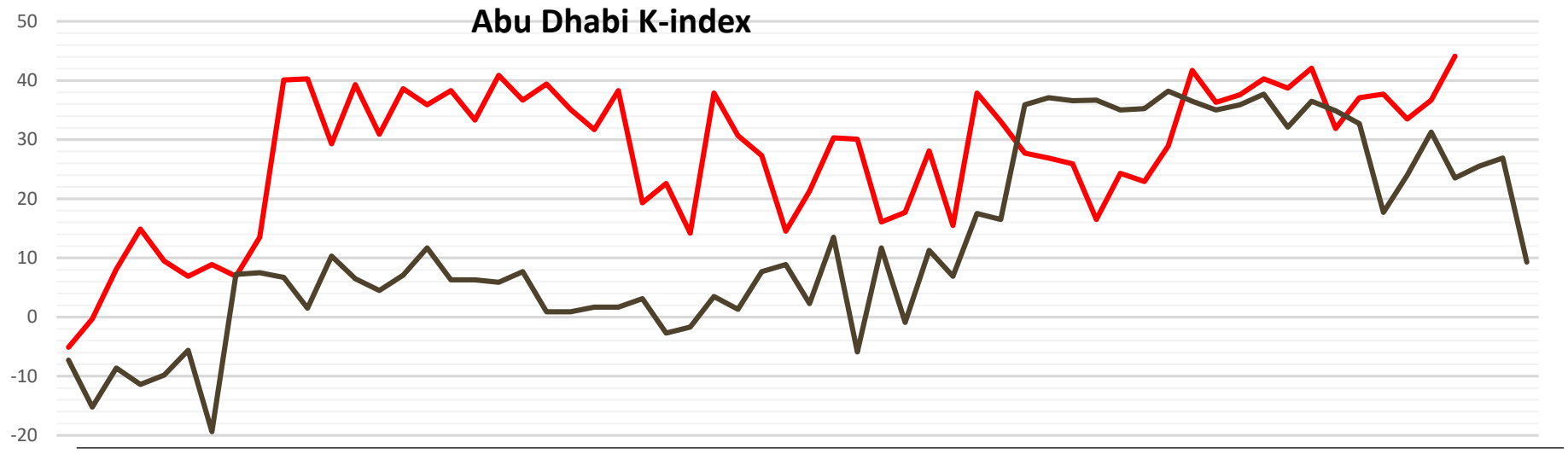
- Tropical Systems like TC or TS
- Easterly Wave
- Indian monsoon depression

Product Benefits :

- To monitor development and movement of systems
- Identify area of potential impact
- NWP

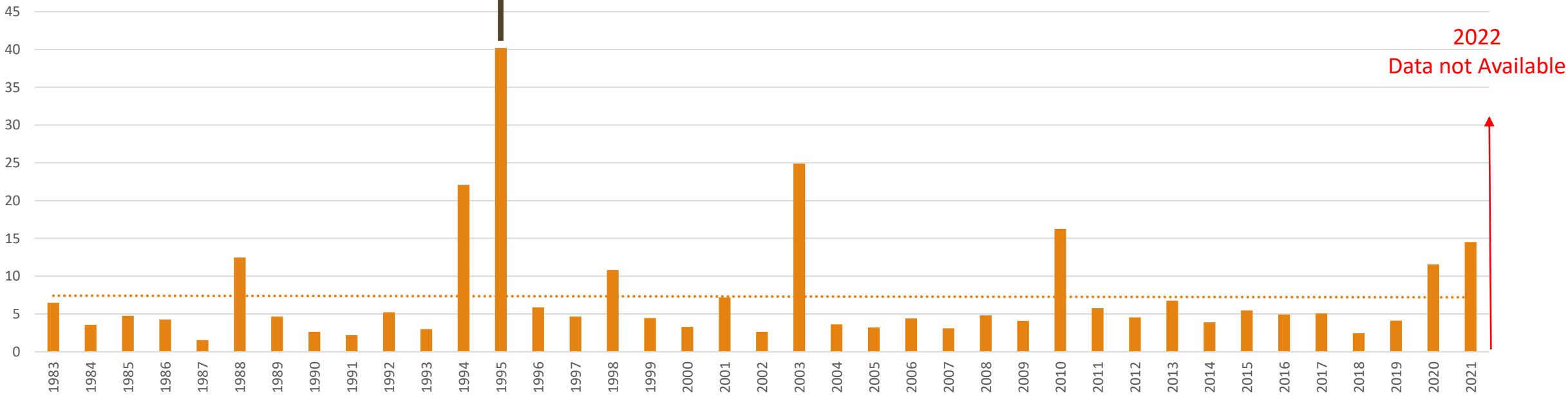
http://tropic.ssec.wisc.edu/real-time/mtpw2/product.php?color_type=tpw_nrl_colors&prod=indo&timespan=24hrs&anim=html5

July 1995 vs July 2022



July 1995 Max: 38.2 Ave: 13.0

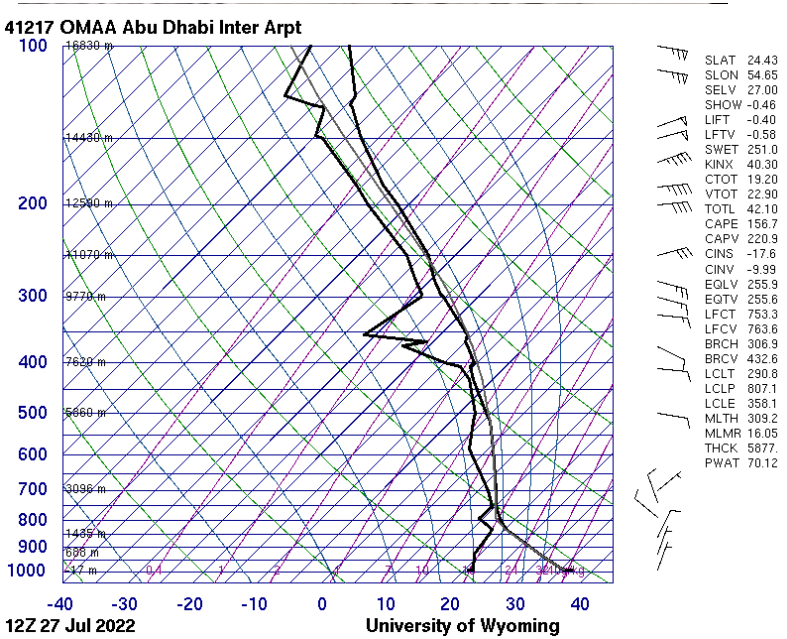
July 2022 Max: 44.1 Ave: 27.8

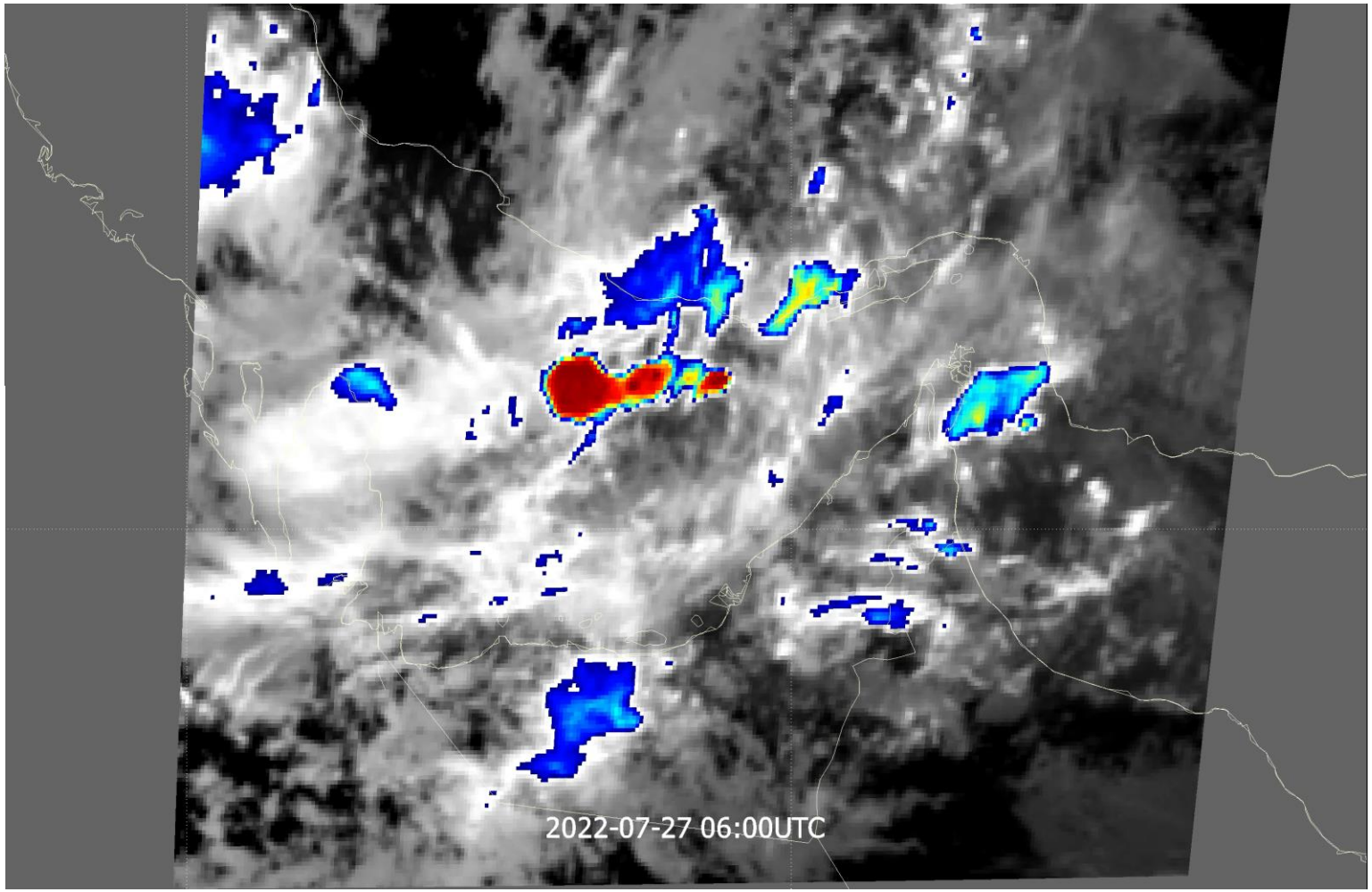


Meteosat-9 IR 10.8 um
UAE Flash Flood 27 and 28 July

IR Images 10.8 um
" Cloud Top Temperature Alert "

- How Sever is the Storm
- Monitor Development and Movement
- Precipitation Estimation



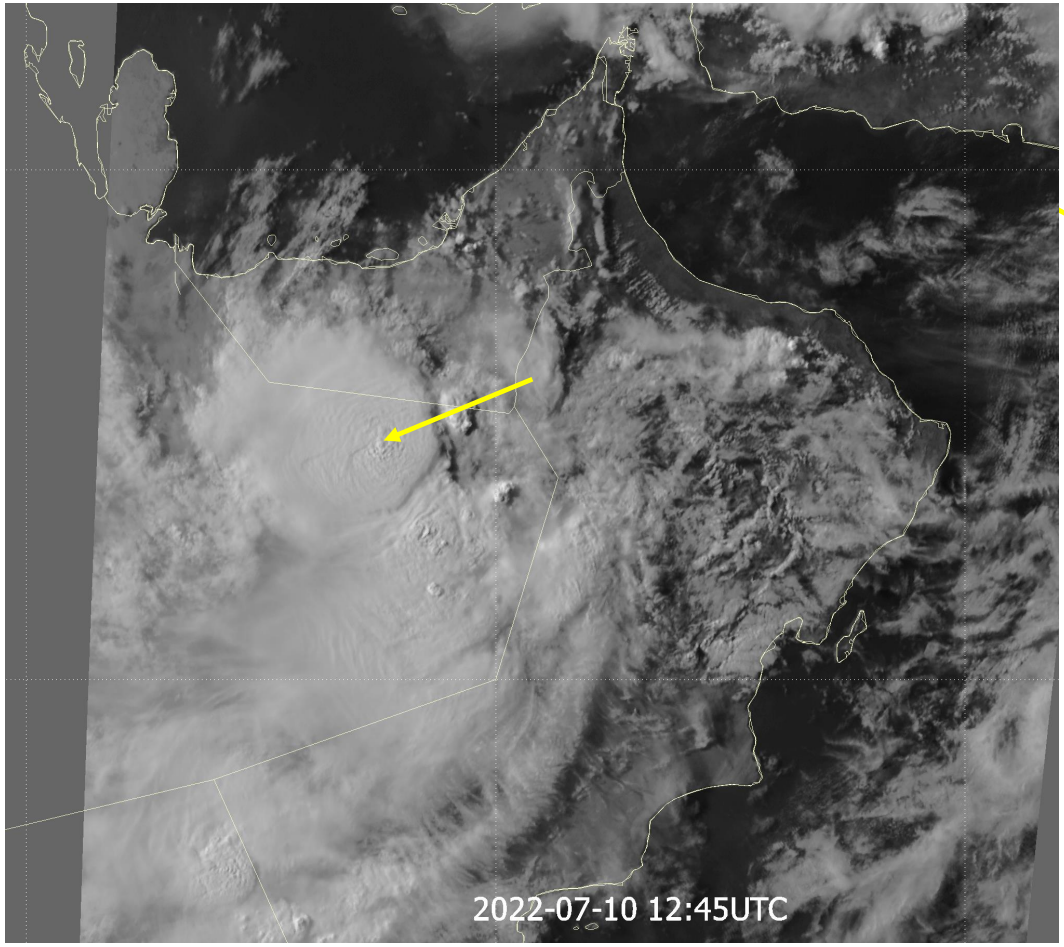


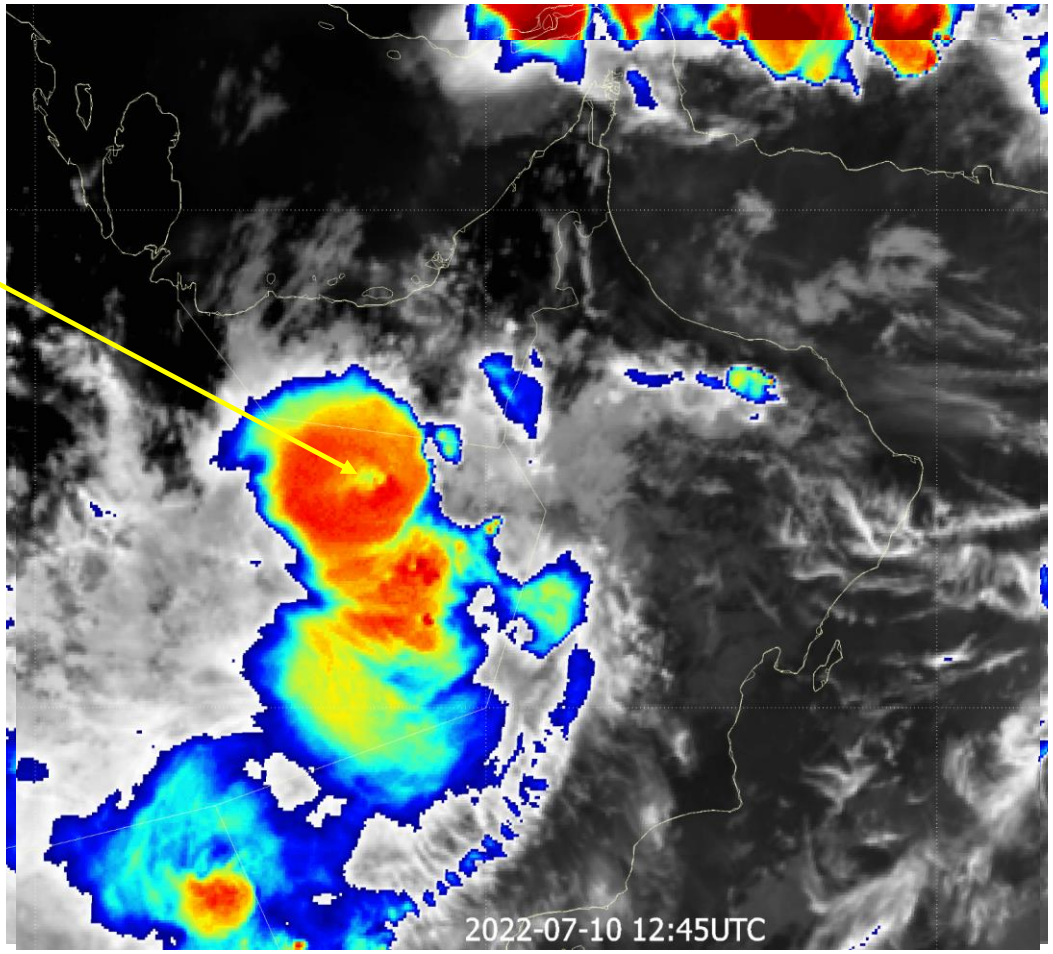
Weather Radar

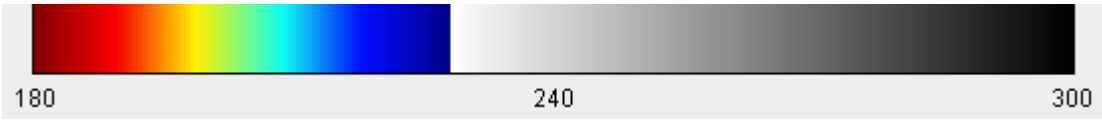
IR and Visible images

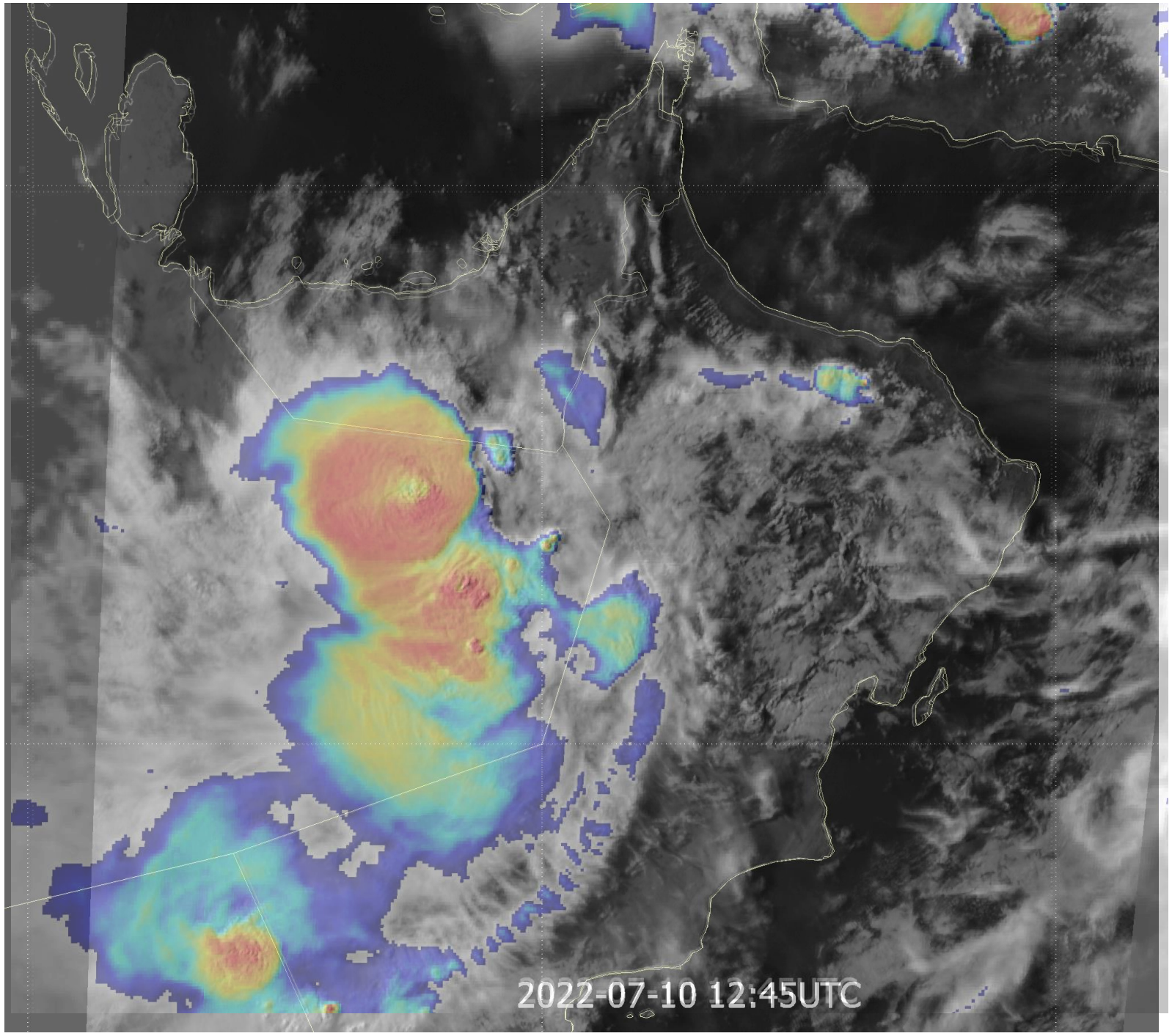
Feature Identification

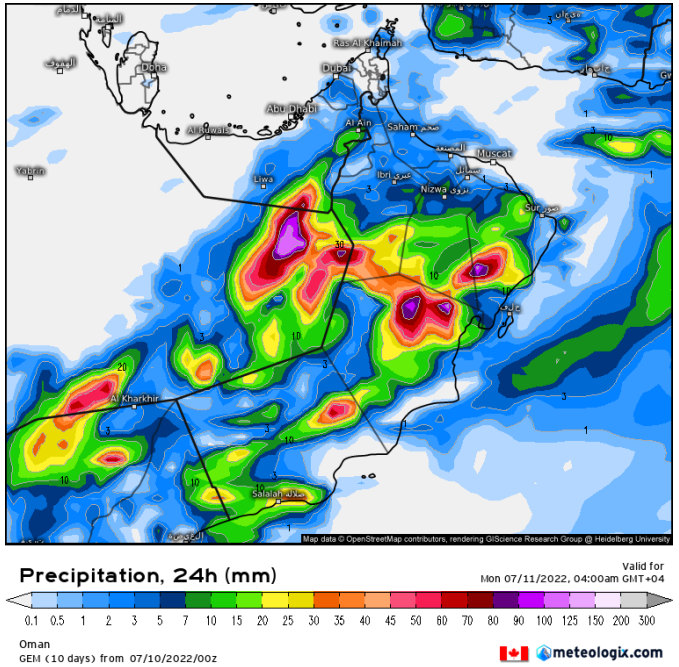
Empty Quarter Storms 10 July 2022

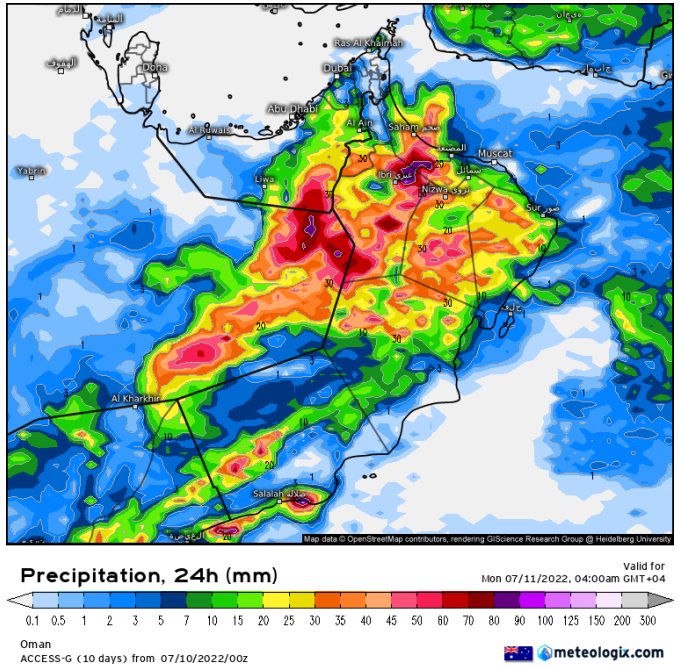


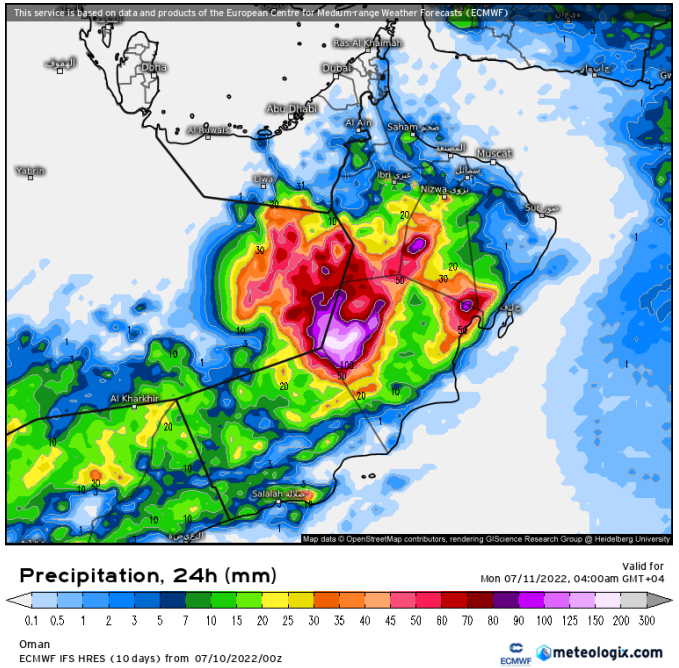





2022-07-10 12:45UTC

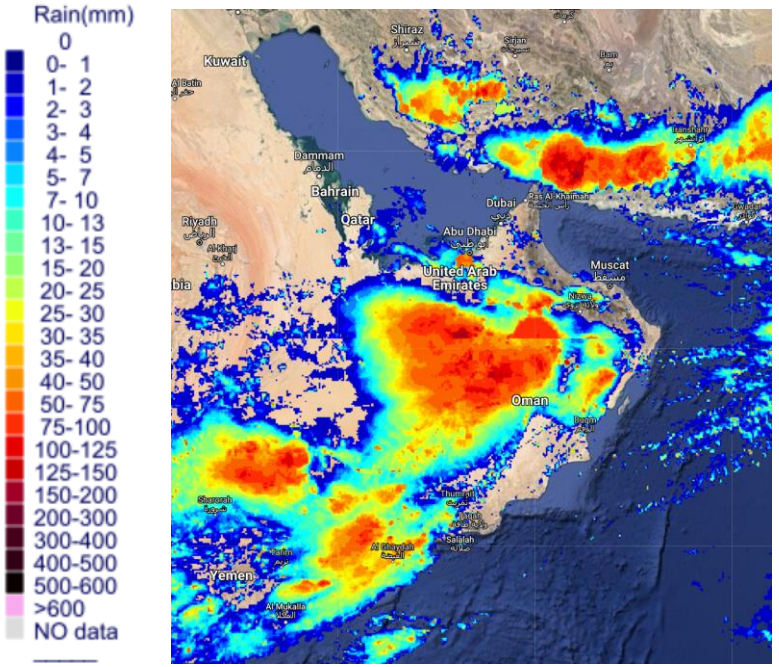


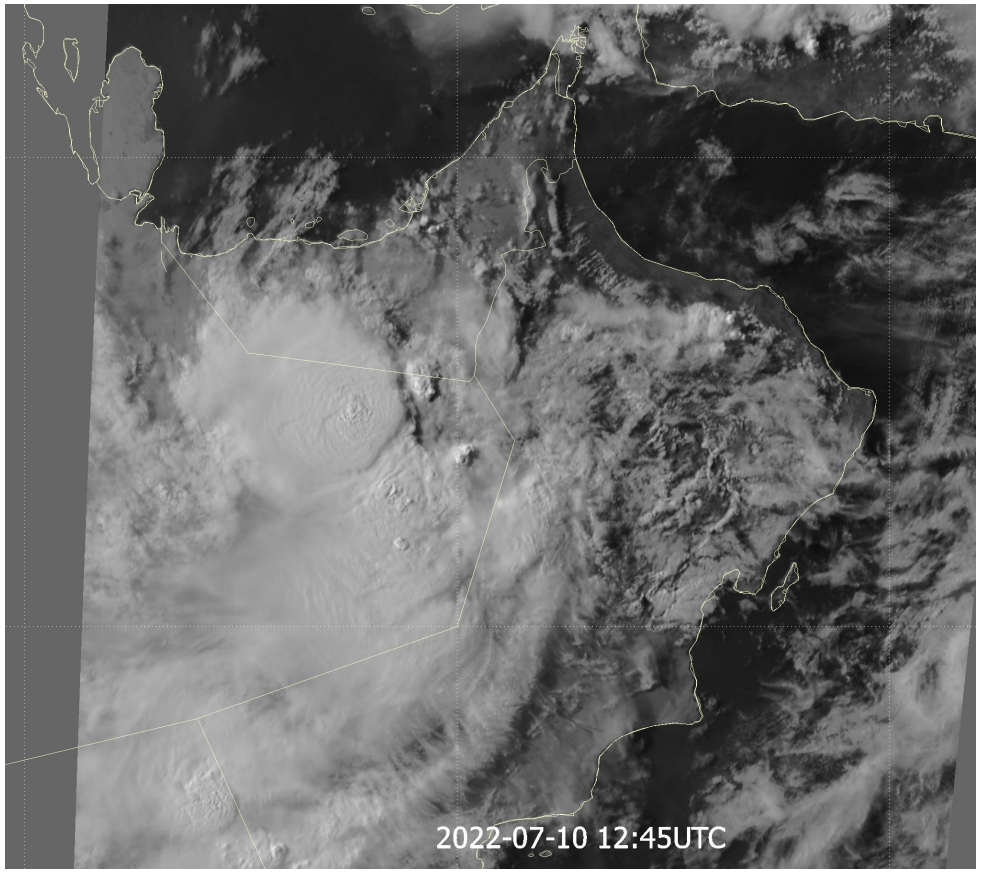




NWP

Optimal Resolution for land and Orography
More Ground Observation
More studies and tunings for regional model





Something similar From Space station !

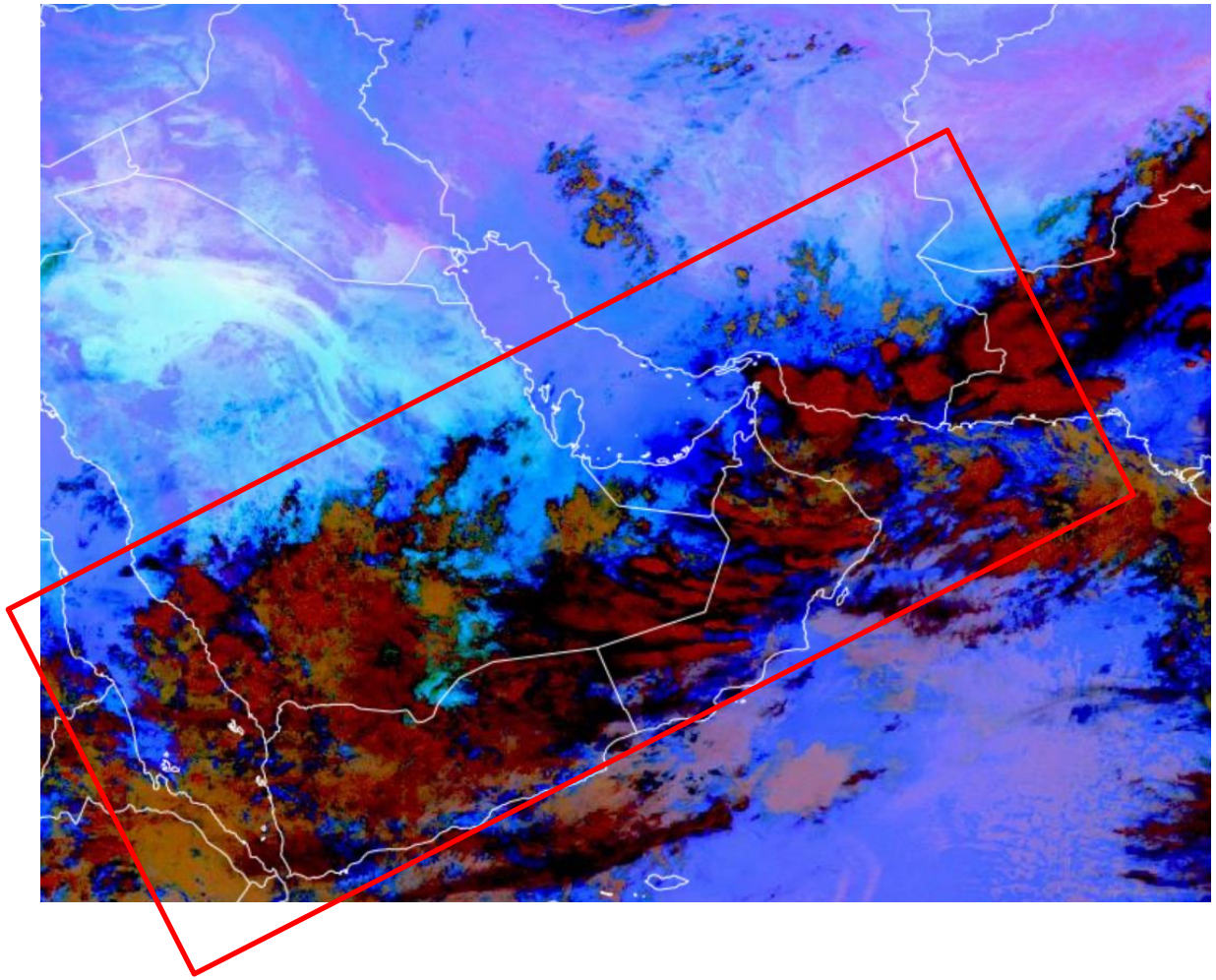
Forecasting Challenges and NWP Performance:

Vast area under the passage of the tropical humid air mass

→ the potential of sever convection is over vast area

→ convection initiation can take places over/by

- Mountains
- Valleys
- Down draft from other convection
- Urban heat Islands.
- Different land features
- .
- .



Was July 2022 Extraordinary and Way ?

Further investigation!
Climate Variability / Climate Change

Indian Monsoon Surplus!!

Climate Indices

Timeseries Name	Start Year	End Year
Southern Oscillation Index (SOI)	1866	Aug 2021
Southern Oscillation Index (SOI) 20CR	1871	Dec 2012
North Atlantic Oscillation (NAO): here, the normalized pressure difference between Gibraltar and SW Iceland.	1821	Jul 2021
Reconstructed North Atlantic Oscillation (RNAO): Reconstructed monthly NAO.	1658	Jul 2001
Arctic Oscillation (AO)	1871	Sep 2020
Southern Annular Mode (SAM)	1851	Dec 2011
Trans Polar Index (TPI): normalized pressure difference between Hobart and Stanley	1895	Mar 2021
Pacific Decadal Oscillation (PDO): From JIASO	1900	Jun 2021
TPI (IPO) Tripole Index for the Pacific Interdecadal Oscillation (ERSSTV5 version): From U of Melbourne	1854	Mar 2021
Dipole Mode Index (DMI) (HadISST1.1 version): Japan Agency for Marine-Earth Science and Technology (JMASTEC)	1870	Dec 1911
North Pacific Index: From NCAR	1899	Feb 2021
Pacific North American Index: From 20CRV2	1871	2012

SST Indices

Timeseries Name	Start Year	End Year
Niño 3: SST 5N-5S,150W-90W	1870	Sep 2021
Niño 3.4: SST 5N-5S,170W-120W	1870	Sep 2021
Niño 4: SST 5N-5S, 160E-150W	1870	Sep 2021
Niño 1+2: SST 0N-10S, 90W-80W	1870	Sep 2021
AMO: SST Atlantic north of 0N.	1871	Jun 2006

https://psl.noaa.gov/gcoswgsp/Timeseries/

Thank you

Kindly scan this “QR code”
to evaluate this lectutre