

# The dust cycle

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WMO SDS-WAS Regional Center for Northern Africa, Middle East and Europe  
Barcelona Dust Forecast Center



**Barcelona  
Supercomputing  
Center**

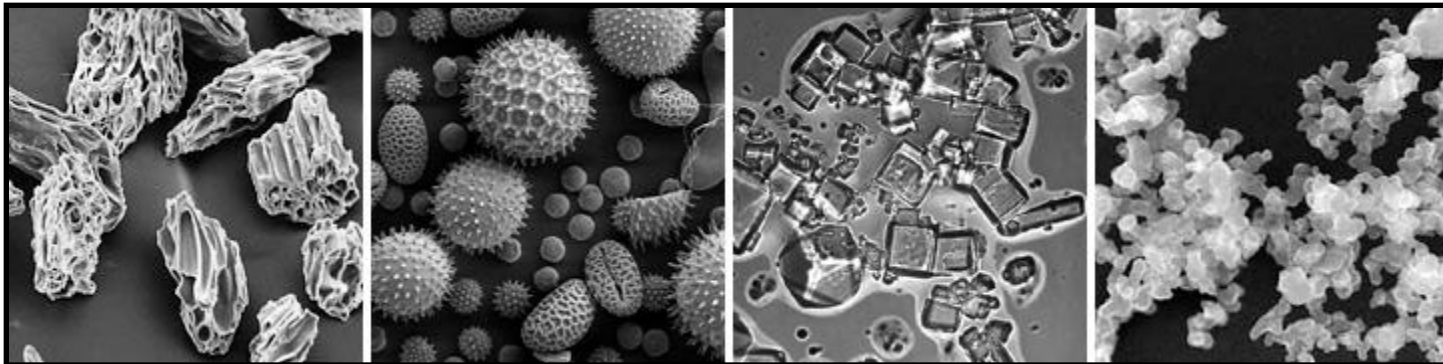
*Centro Nacional de Supercomputación*

**1st Africa / Middle East Expert Meeting and Workshop on the Health Impact of Airborne Dust  
Amman, Jordan, 2 Nov 2015**

# Atmospheric aerosol

Solid or liquid particles suspended in the air. They have different

- Origin (primary / secondary, natural / anthropogenic)
- Size (Diameter:  $\sim 2 \text{ nm} - 100 \mu\text{m}$ )
- Chemical, mineralogic composition
- Optical properties
- ...

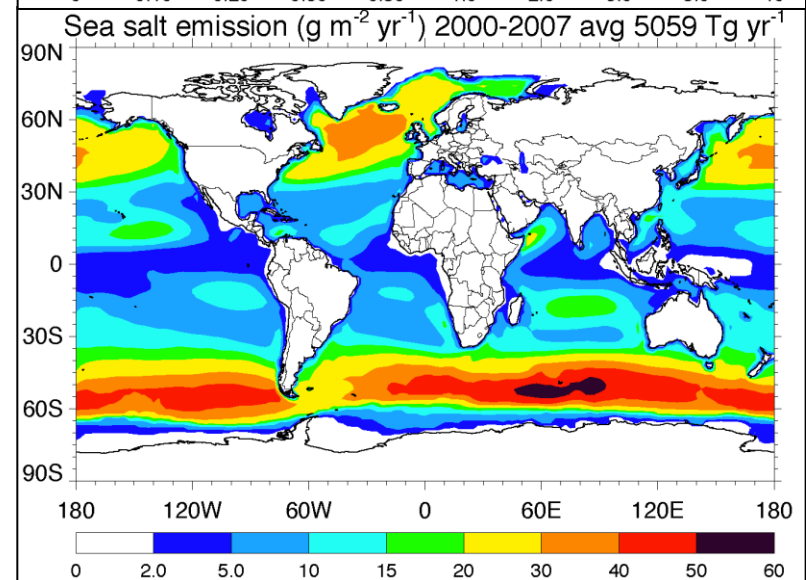
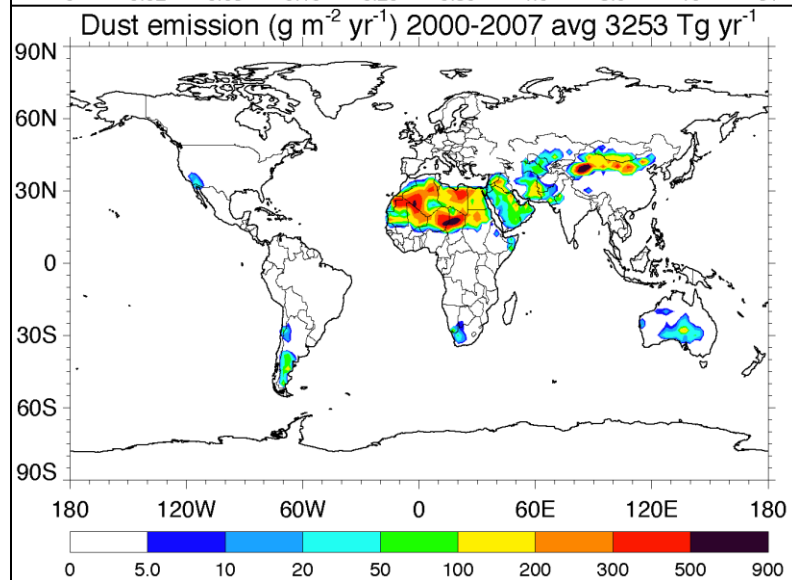
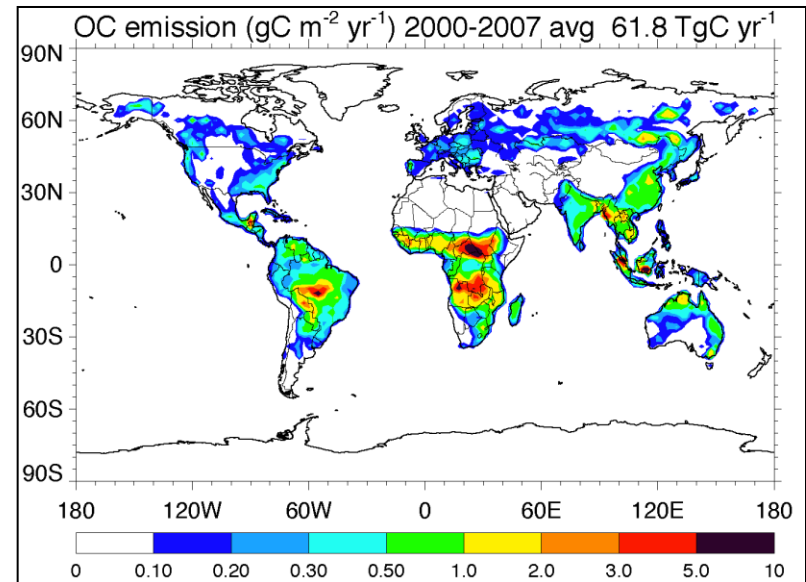
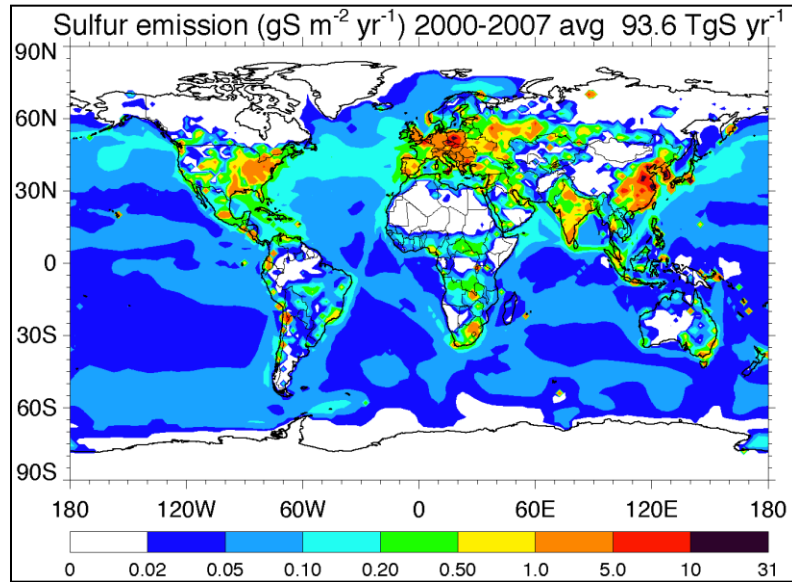


# Atmospheric aerosol. Sources



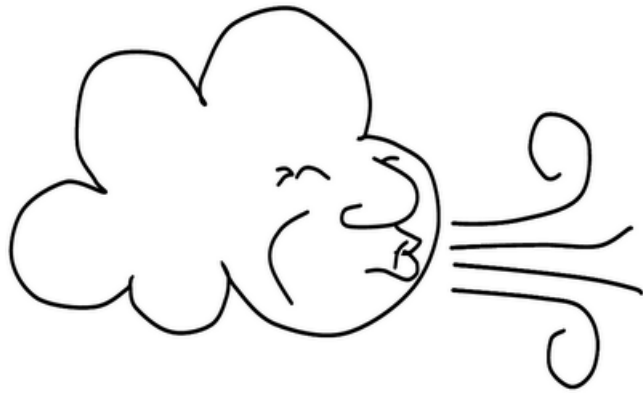
- Volcanic eruptions
- Sea salt
- Biomass burning
- Anthropogenic pollution
- Organic particles
- **MINERAL DUST**

# Atmospheric aerosol. Emissions



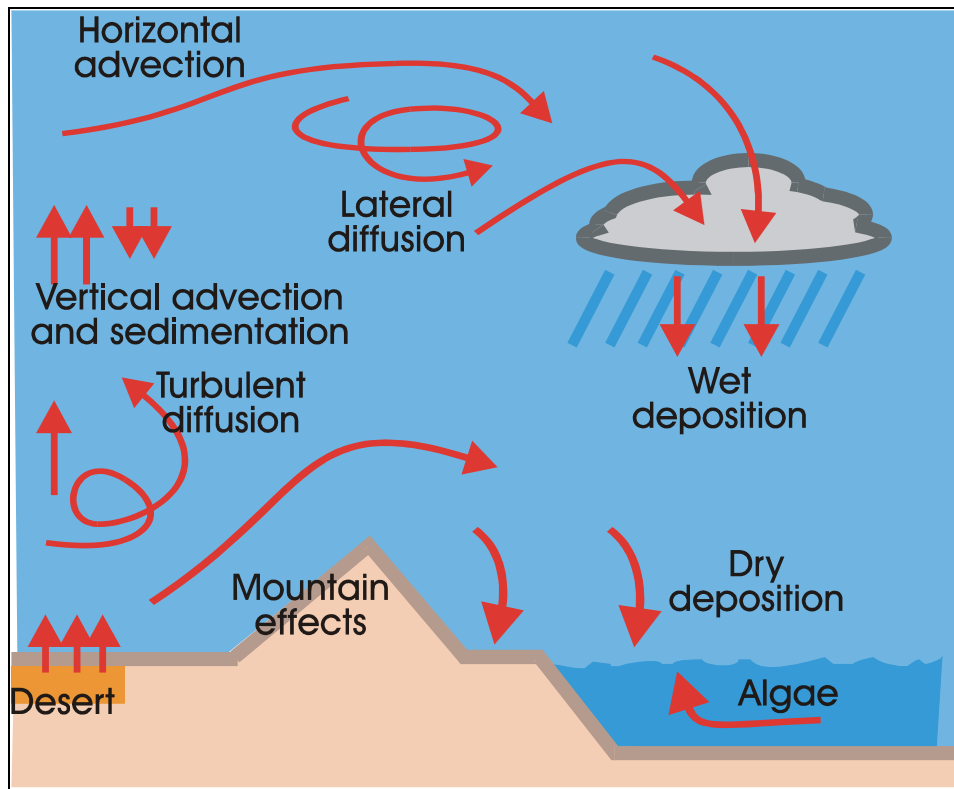


# The dust cycle



MODIS 4 Feb 2013

# The dust cycle

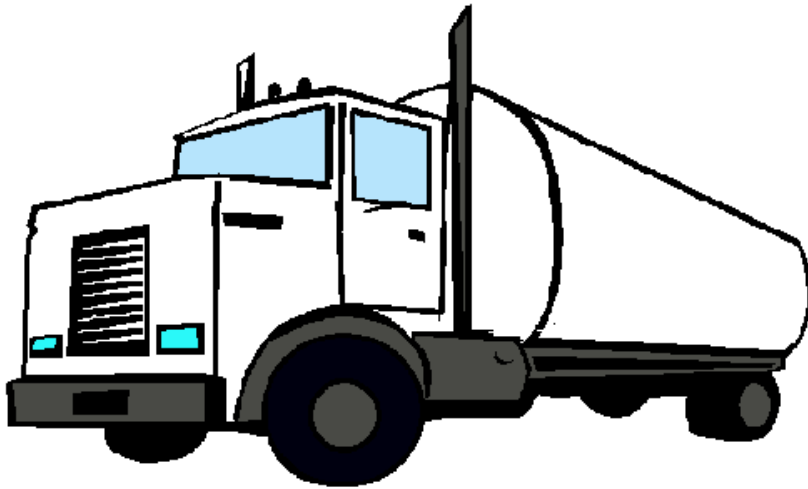


- Dust release (emission)
- Turbulent mixing
- Long-distance transport
- Dry / wet deposition

# The dust cycle. Total emissions

~ 30,000 – 60,000 kg / s  
~ 1 – 3·10<sup>12</sup> kg / year

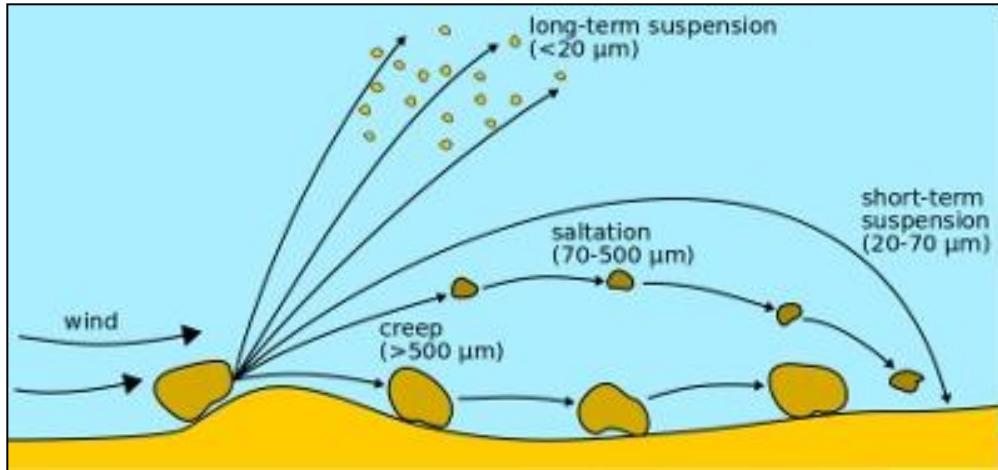
50,000,000 lorries



3,000 ULCC



# Dust emission



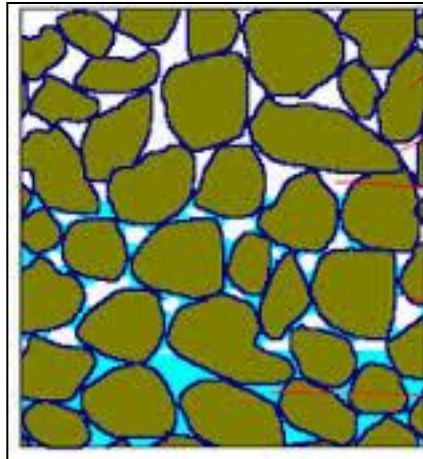
The threshold wind for the mobilisation of soil particles depends on the forces acting to keep these particles in the soil (weight, cohesion between particles, cohesion induced by moisture)

## Meteorological factors:

- Wind
- Near-surface turbulence

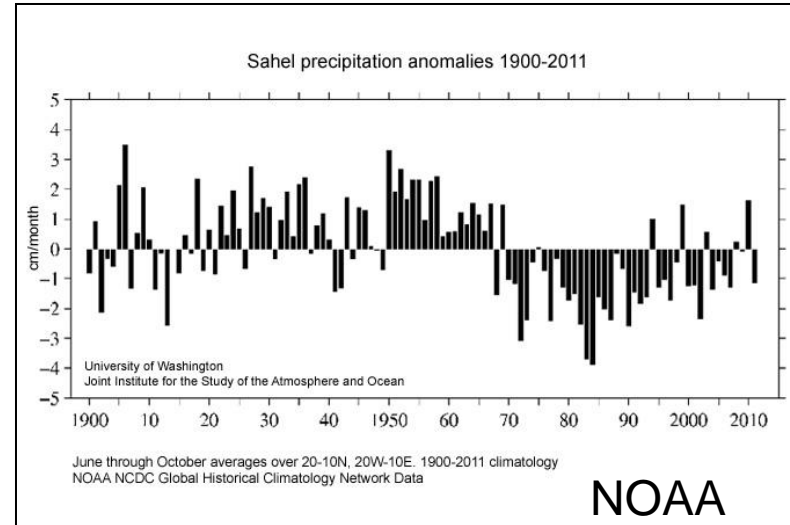
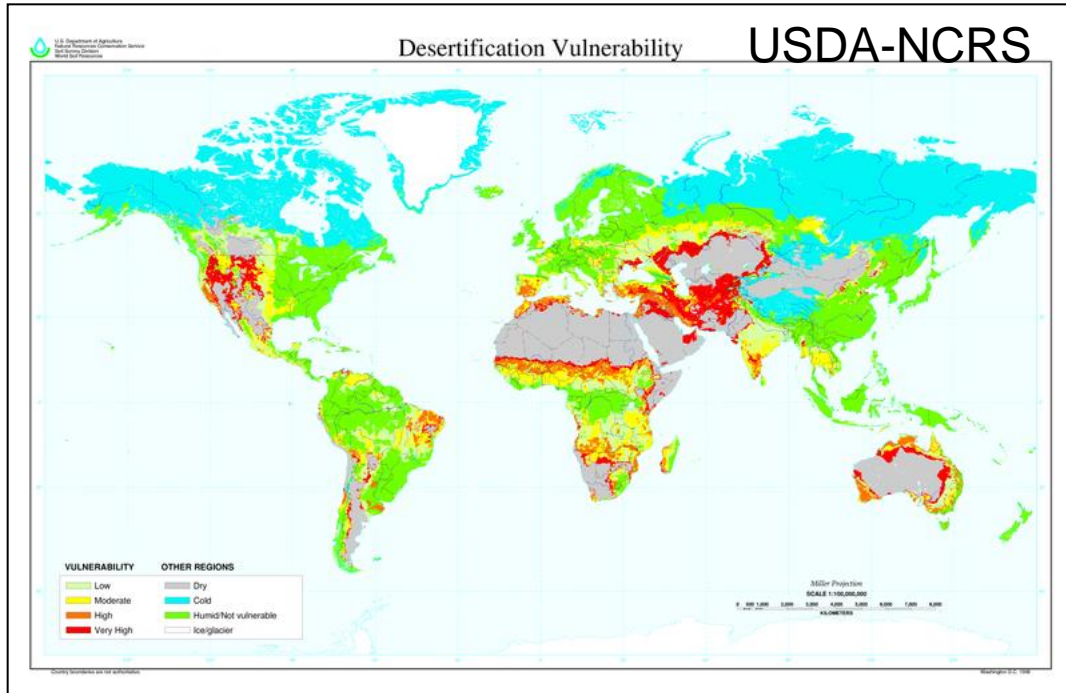
## Soil factors:

- Soil texture
- Soil humidity
- Vegetation





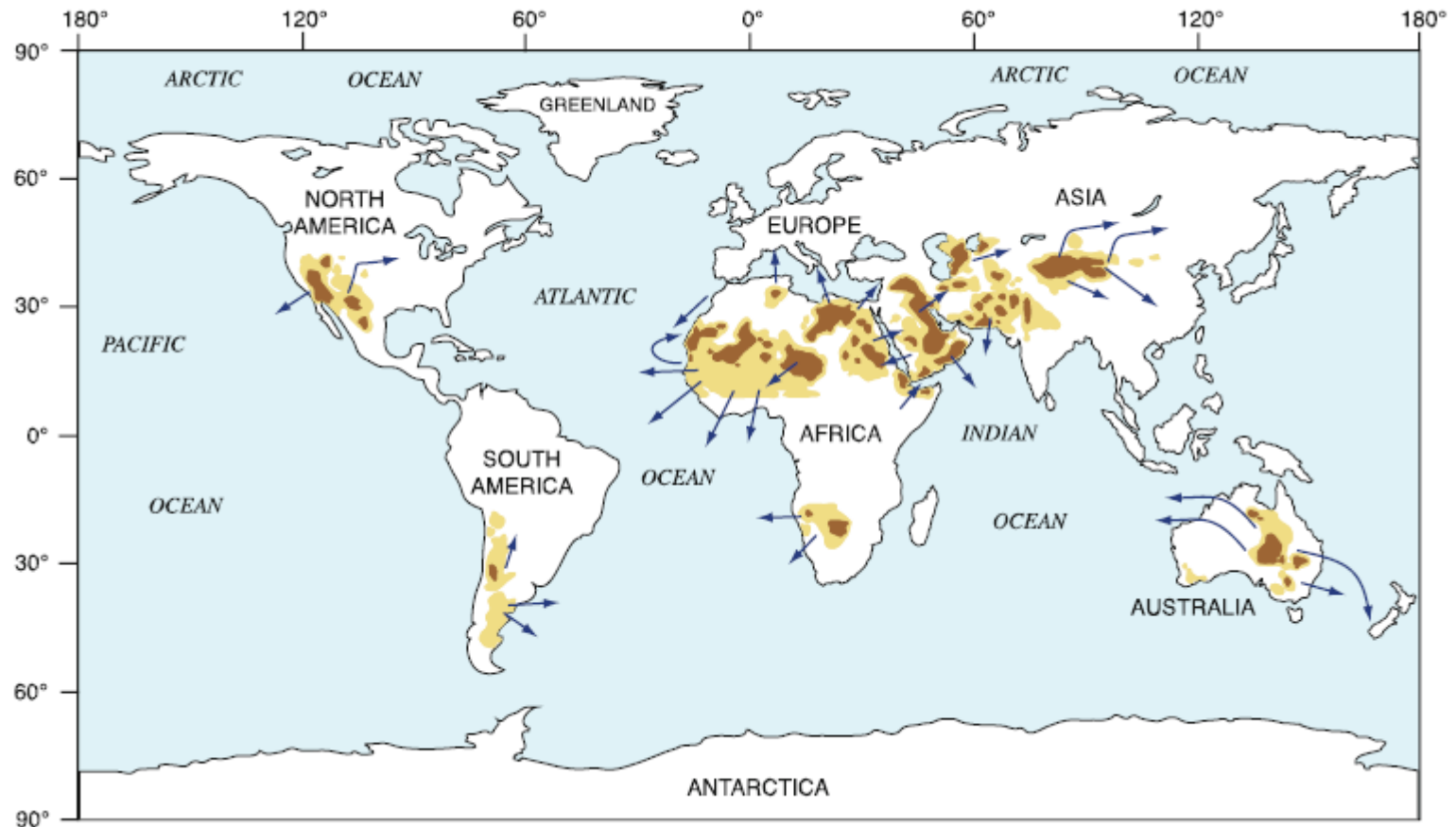
# Desertification



- Drought
- Poor farming practices
- Overgrazing
- Deforestation
- Inadequate water management



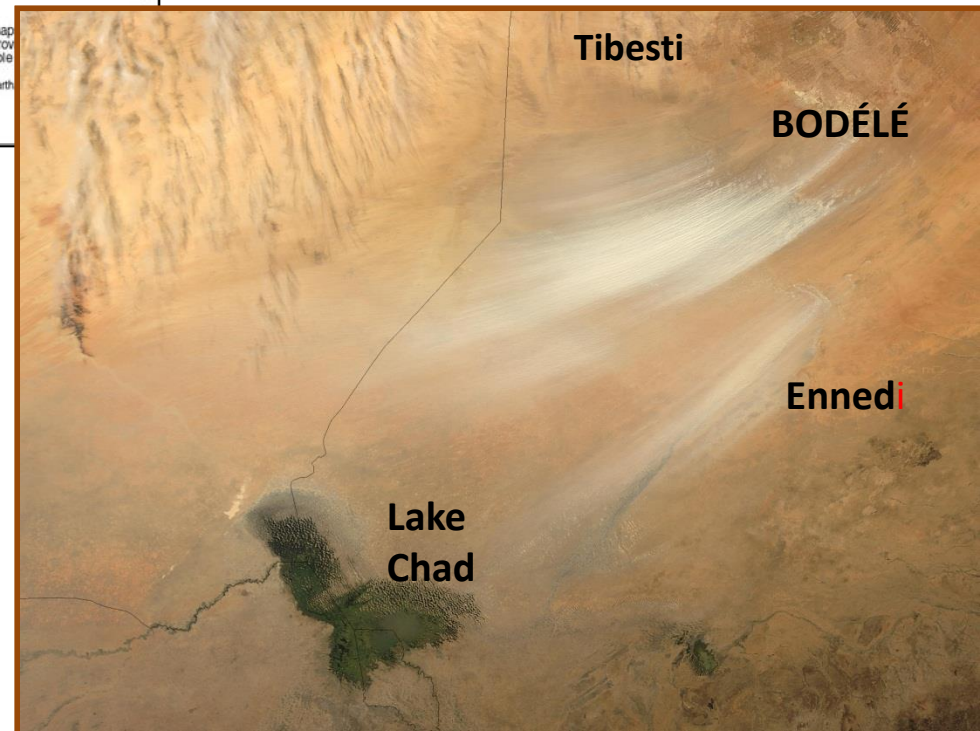
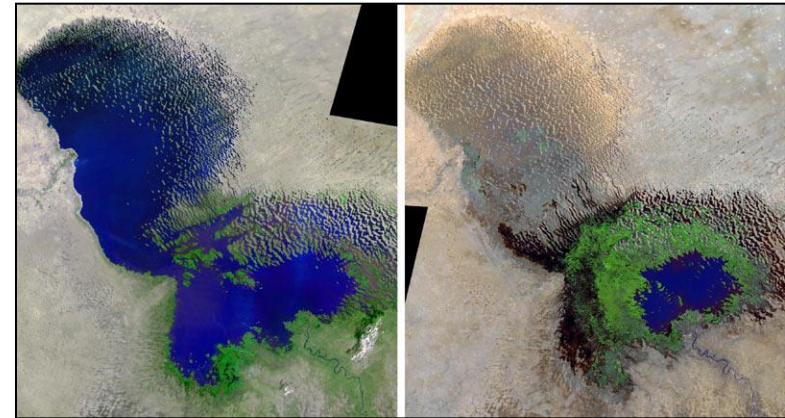
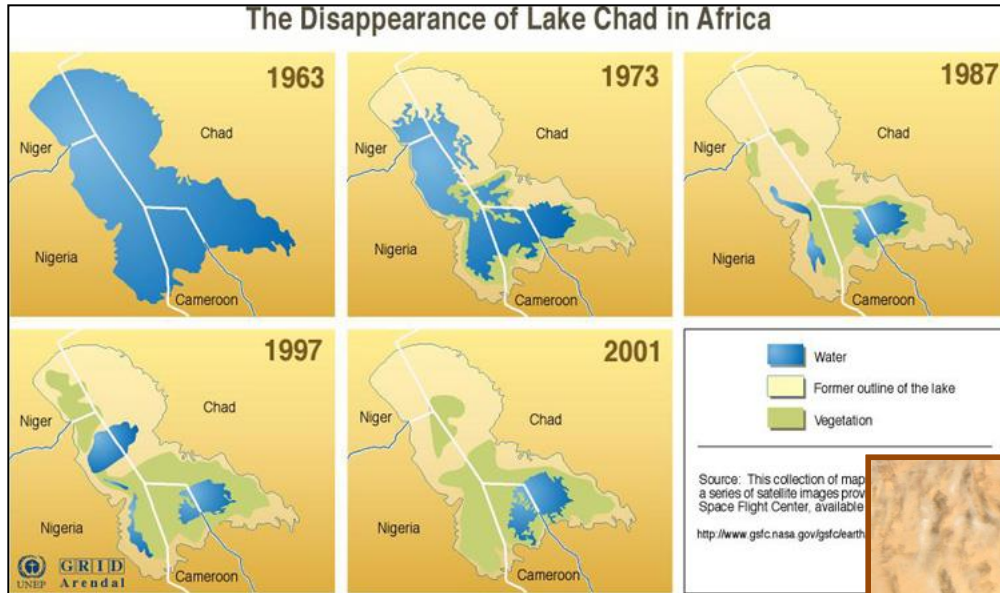
# Dust sources



Identification of dust sources based on TOMS' aerosol absorbing index

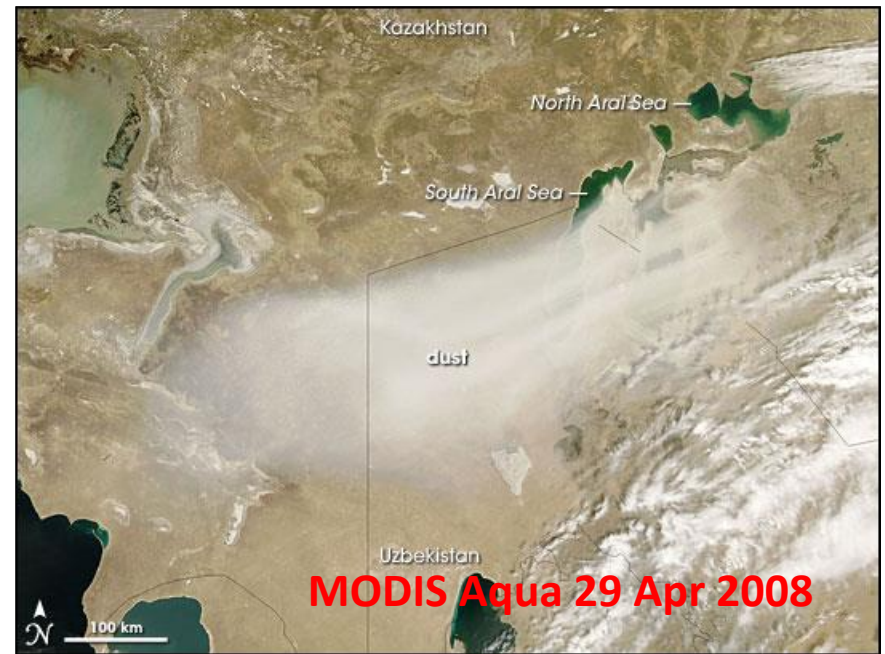


# Dried lakes: the Bodélé depression





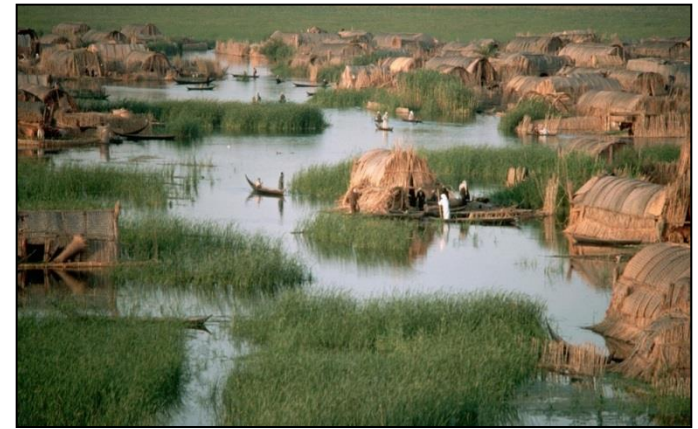
# Dried lakes: the Aral sea



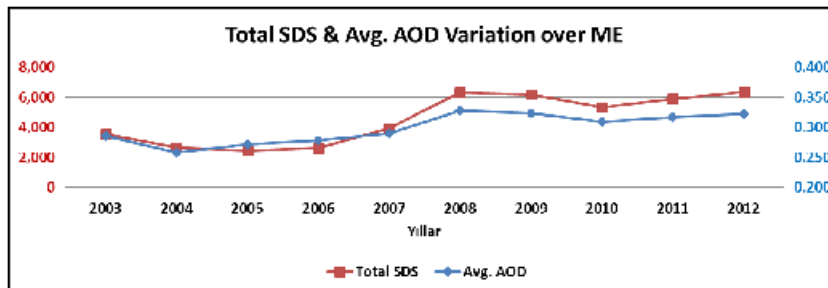


# Southern Iraq's marshes

2011



1974



Courtesy of Cihan Dunder (TSMS)



2009

# Owens lake mitigation program



Shallow flooding



Managed vegetation  
(saltgrass)



Gravel blanket



# Anthropic emissions



Agriculture



Opencast mining

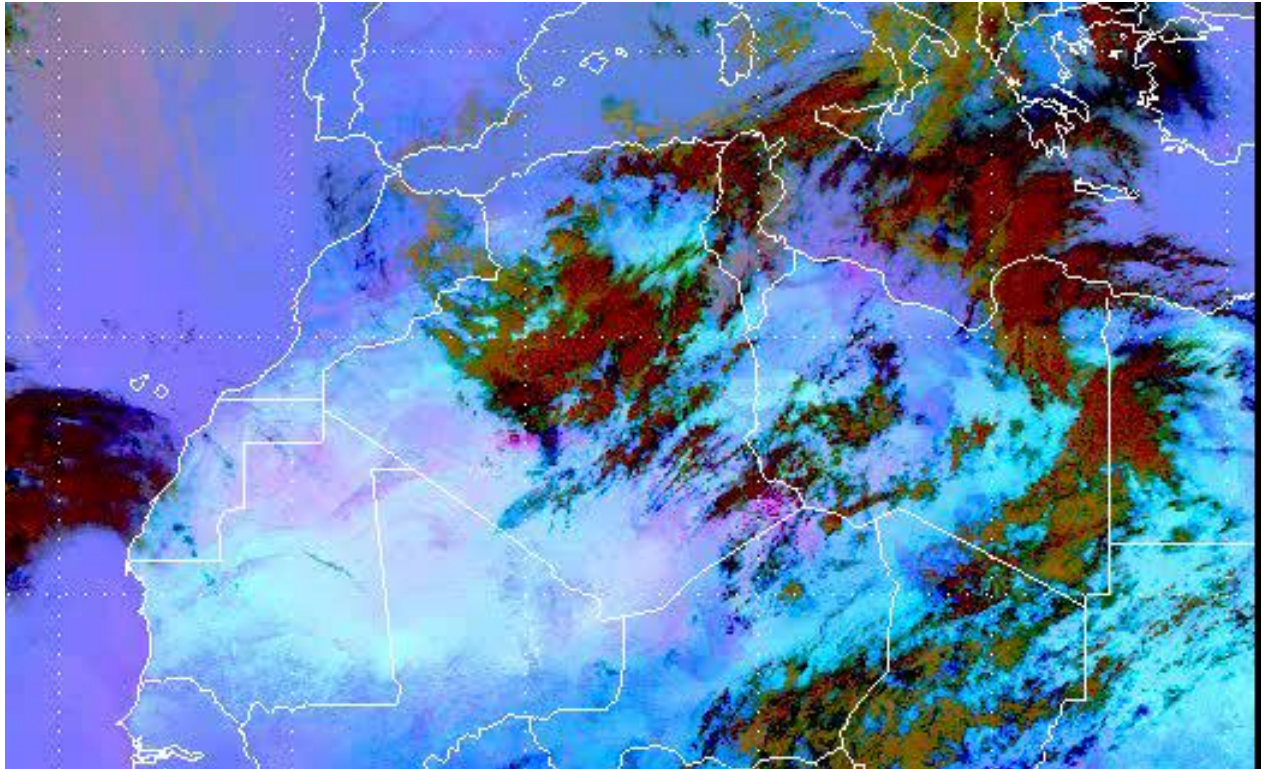


Construction, demolition



Driving on unpaved roads

# Meteorological conditions



24 Apr 2013

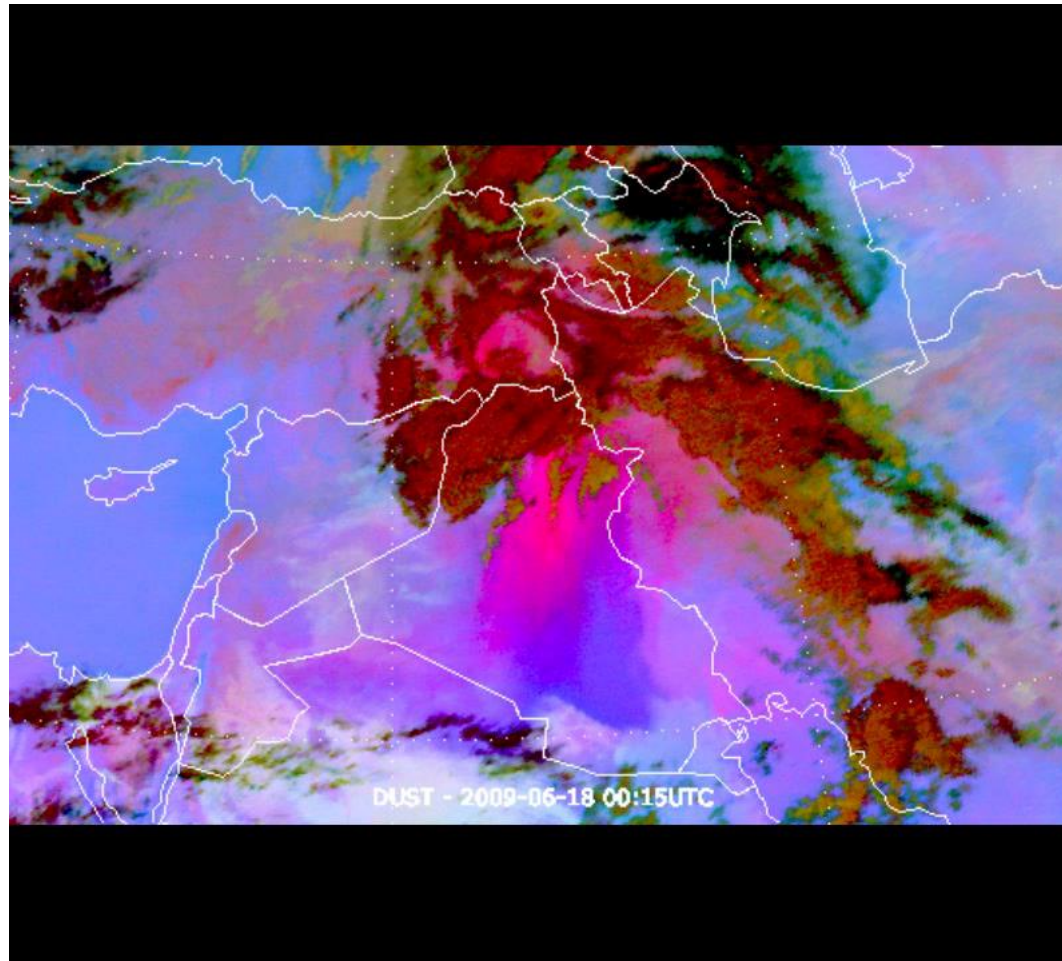


## SYNOPTIC SCALE

- Frontal systems
- Reinforced trade winds



# Meteorological conditions



18 Jun 2009



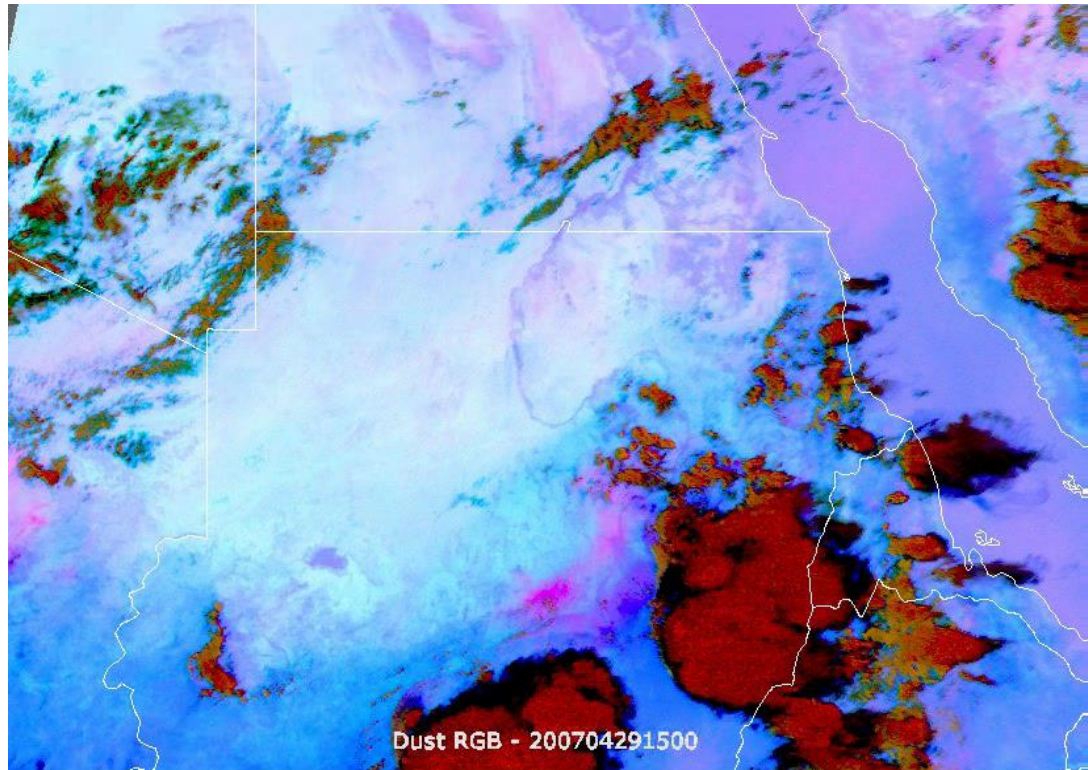
# Meteorological conditions



## MESOSCALE - MICROSACLE

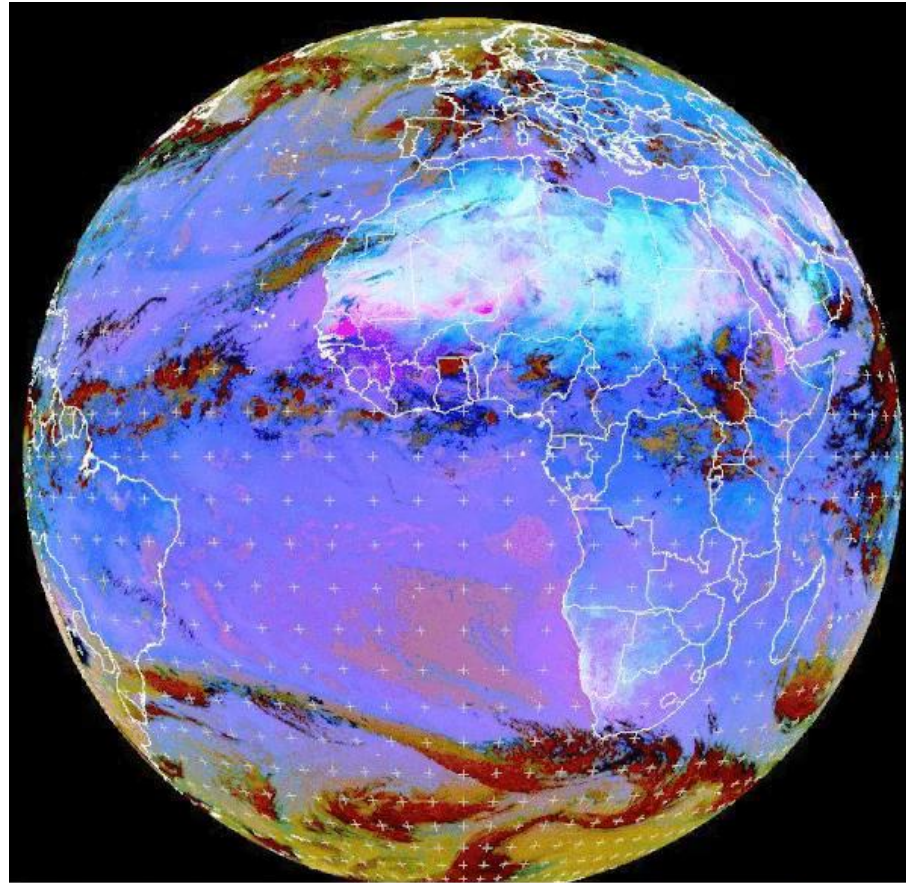
- Convection
- Drainage (katabatic) winds
- Low-level jets
- Gap winds

# Meteorological conditions



Sudan, 29 apr – 1 May 2007

# Long-term transport



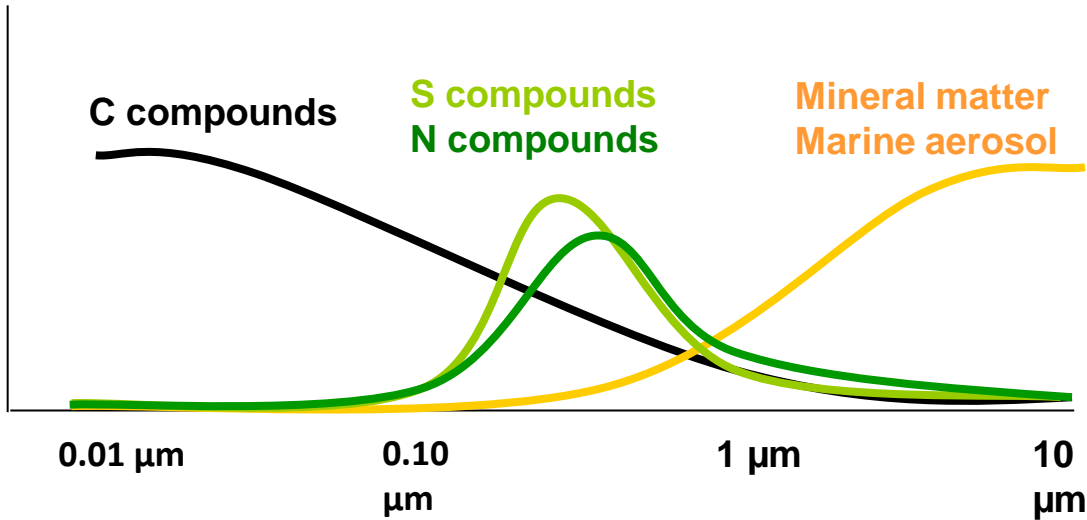
MCT10 RGB-Dust 2015-06-13 12:00 UTC

EUMETSAT

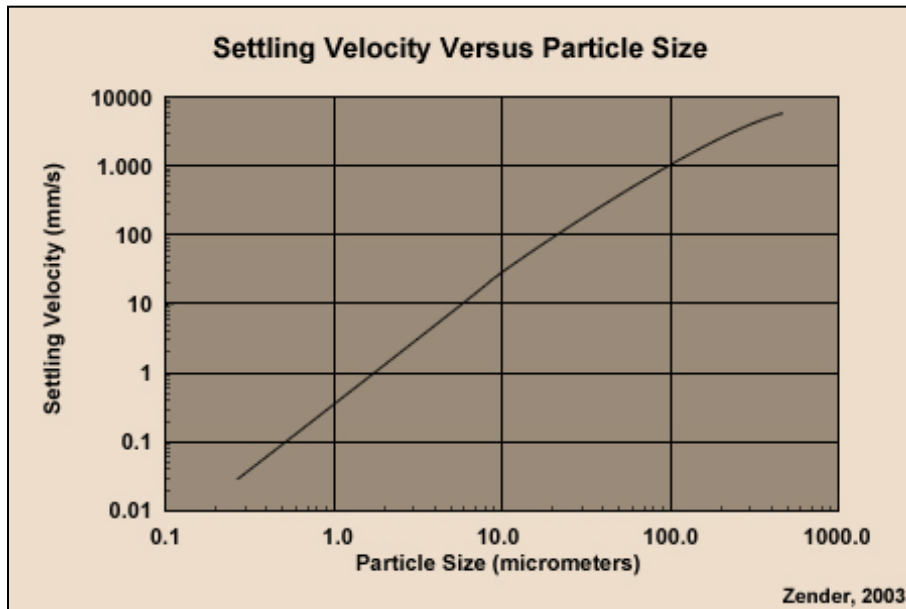
EUMETSAT RGB Dust 13-16 Jun 2015



# Particle size



SIZE ( $\mu\text{m}$ )	AVERAGE LIFETIME (h)
0.1 - 0.18	231
0.18 - 0.3	229
0.3 - 0.6	225
0.6 - 1	219
1 - 1.8	179
1.8 - 3	126
3 - 6	67
6 - 10	28



Tegen and Lacis (1996)

# Dust composition

## MINERALOGIC COMPOSITION (X-ray diffractometry)

- Silicates: quartz, feldspar, phyllosilicates (illite, kaolinite, smectite)
- Carbonates: calcite, dolomite
- Hematite, gypsum, halite

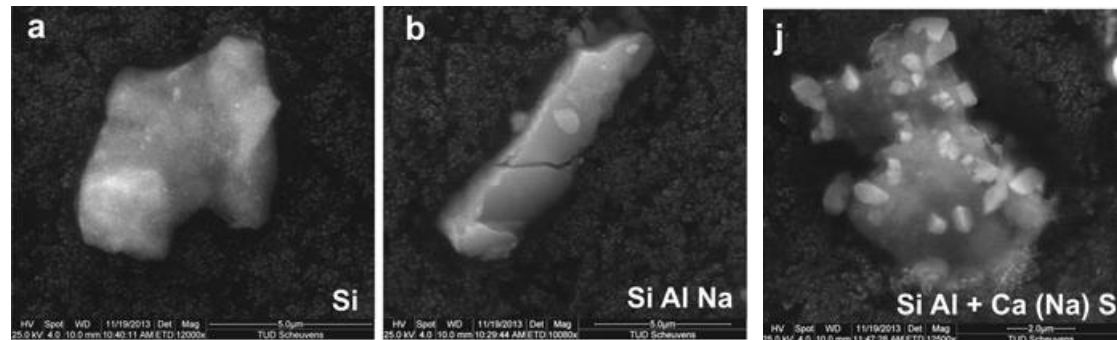
## ISOTOPIC COMPOSITION

- Sr, Nd, Pb

## CHEMICAL COMPOSITION (spectroscopy)

- Si, Al, Ca, Mg, Fe, K, Na, Mn, Ti, P, ..

- Information on the dust source
- Influence on the dust impact on health, ecosystems, ...
- Influence on the optical properties

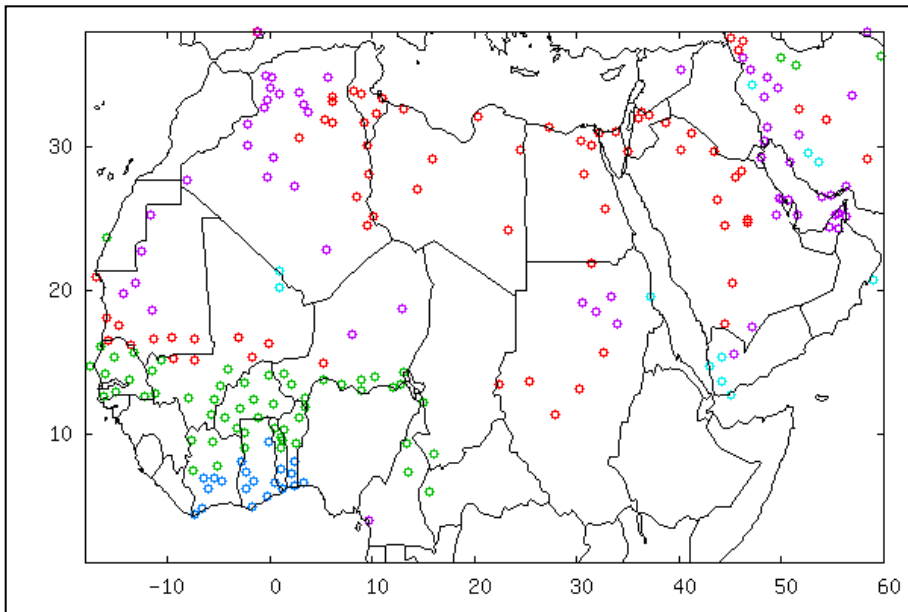


Quartz

Albite

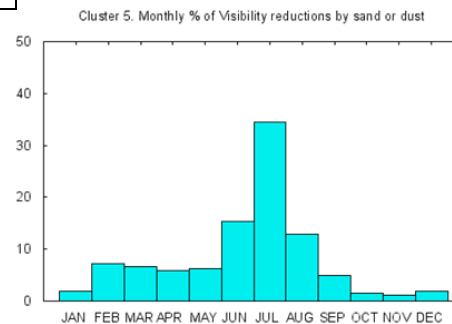
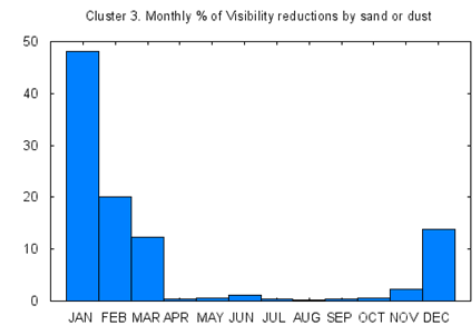
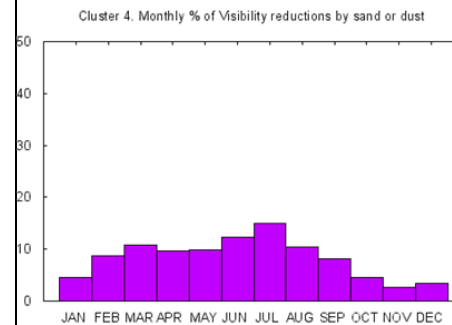
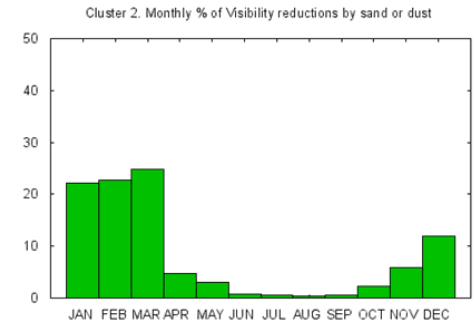
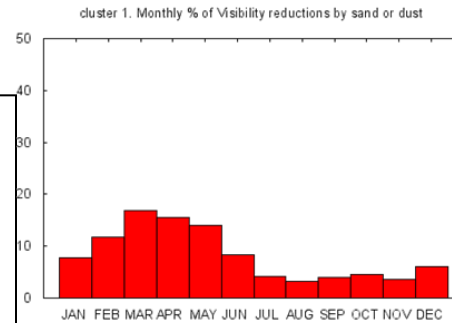
Gypsum

# Seasonal variability



1996 - 2010

(Terradellas et al., 2012)





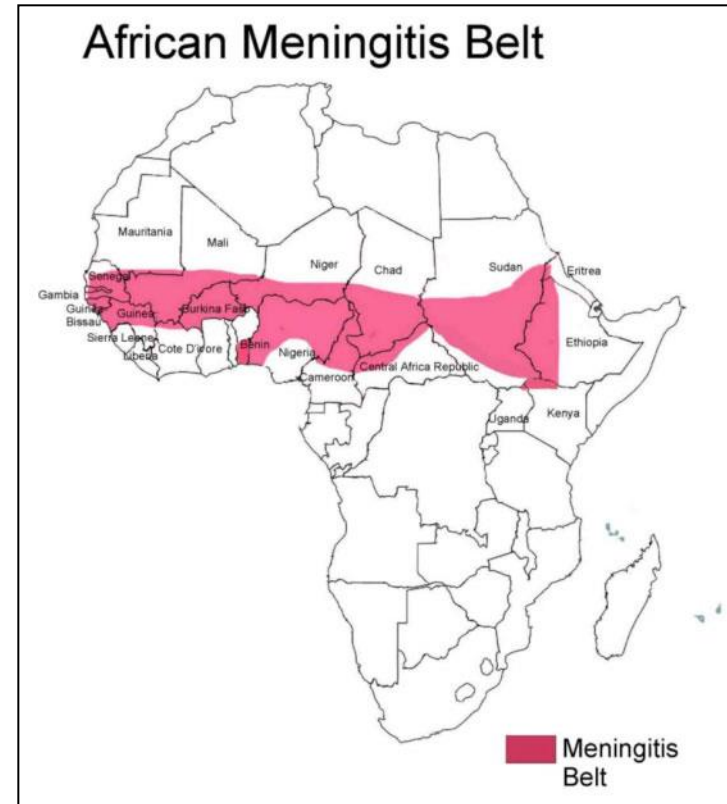
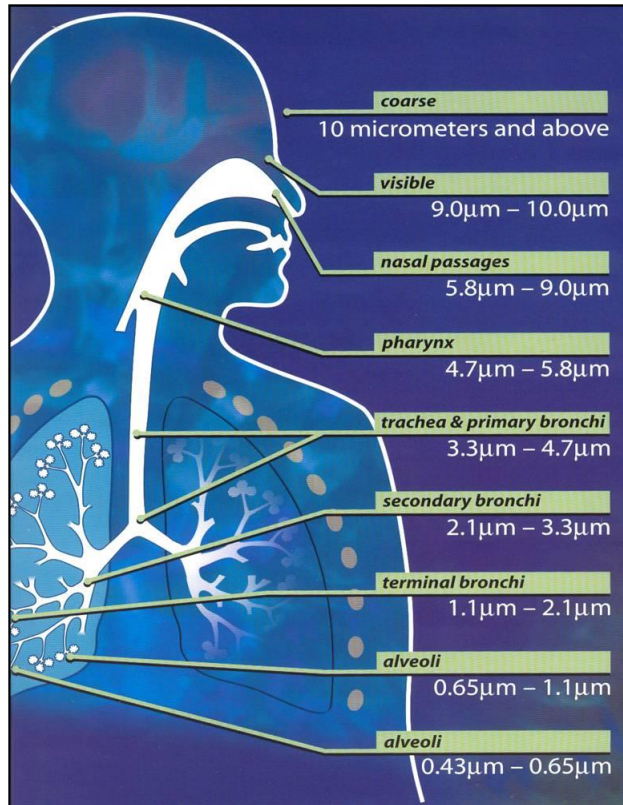
# Dust impacts

- Air quality and health
- Weather and climate
- Transportation
- Solar energy
- Agriculture
- ...



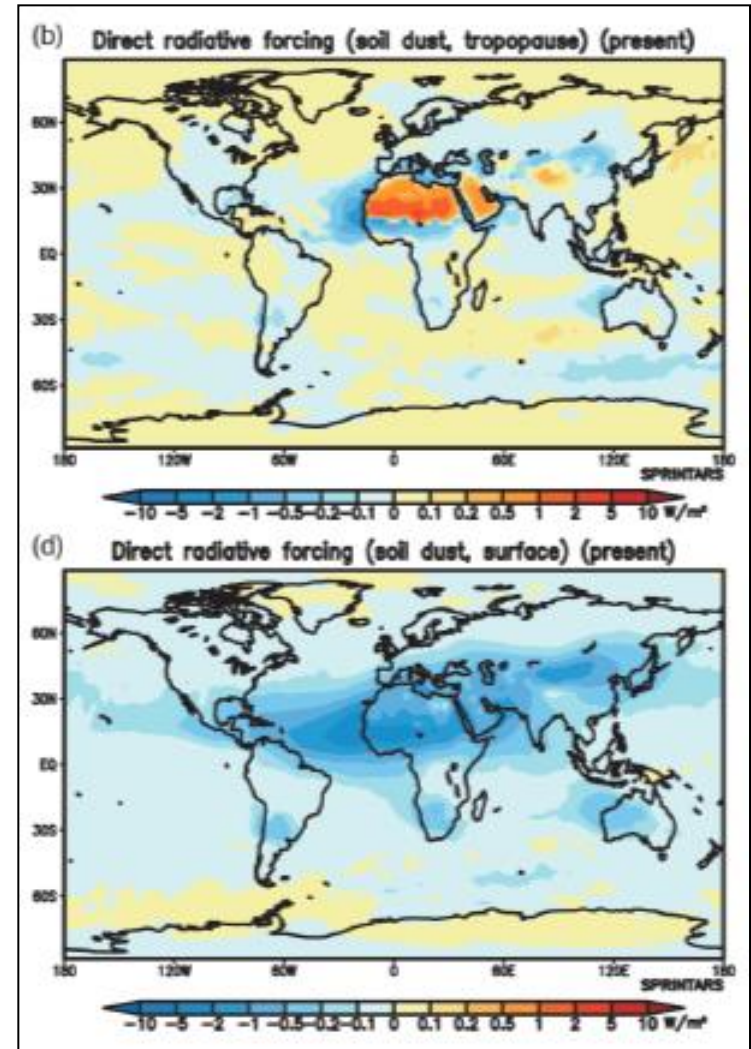
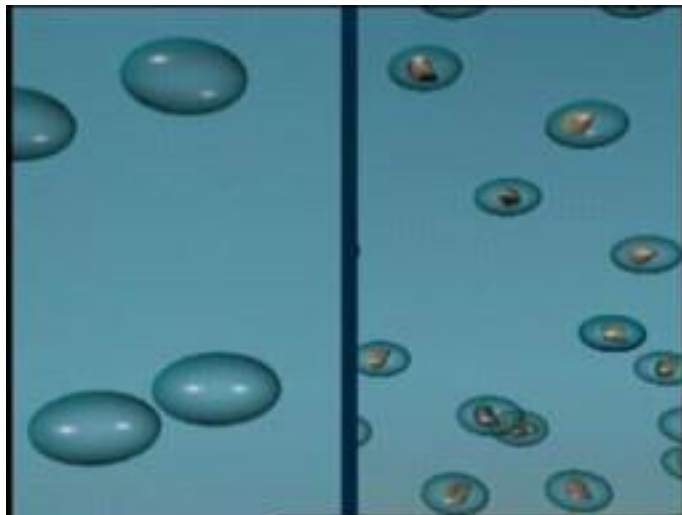
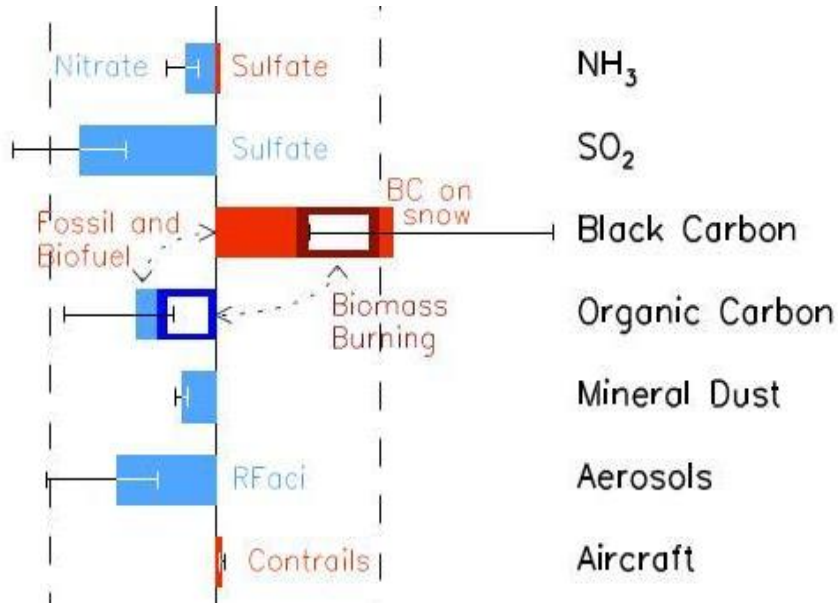
3:35P	On Time
3:45P	Cancelled
4:15P	On Time
4:24P	Delayed
4:30P	Cancelled
5:00P	On Time
5:12P	On Time
5:15P	On Time

# Impact on human health



- Particle size
- Chemical and mineralogical composition
- Pathogens (bacteria, fungi, viruses, ...) transported by dust
- Time and intensity of exposition

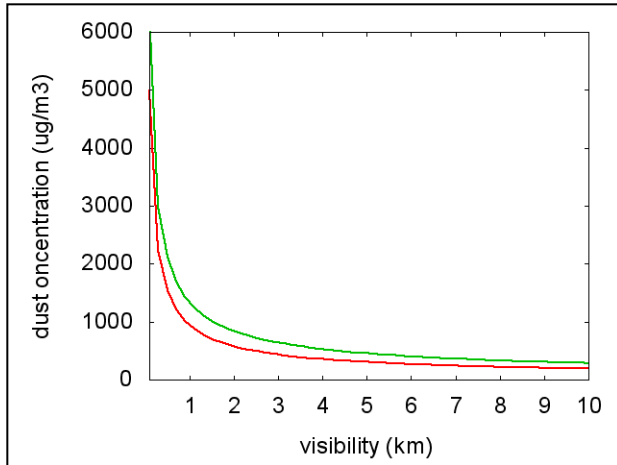
# Impact on climate and weather



Takemura et al., (2009)



# Impact on transport



D'Almeida (1986)

Ben Mohamed et al. (1992)



Arizona, 29 Oct 2013



Tunisia, 7 May 2002

11:16 A	CANCELLED
5A 10:30 A	CANCELLED
15A 10:15 A	CANCELLED
17A 6:50 A	DELAYED
17A 7:20 A	DELAYED
10:00 A	CANCELLED
17A 10:10 A	DELAYED

# Impact on solar energy

- Reduction in available energy
- Reduction in system efficiency
- Need for costly maintenance
- Need much water





# Impact on agriculture



- Crop damage (loss of plant tissue and reduced photosynthetic activity)
- Loss of topsoil
- Damage to infrastructure (irrigation canals, roads, ...)
- Reduction of water quality
- Supply of nutrients to the soil (Na, K, Mg, Ca, P)

# WMO SDS-WAS

## Mission:

Improve the capacity of countries to produce and distribute to end users accurate forecasts of the mineral dust content in the atmosphere

## Structure:

- Regional Center for Northern Africa, Middle East and Europe. Barcelona, Spain
- Regional Center for Asia, Beijing, China
- Regional Center for Pan America
- Regional center for West Asia ???



# WMO SDS-WAS. Regional Center NA-ME-E

The Center is jointly managed by the State Meteorological Agency of Spain (AEMET) AND THE Barcelona Supercomputing Center (BSC)



UPC campus. Nexus II building



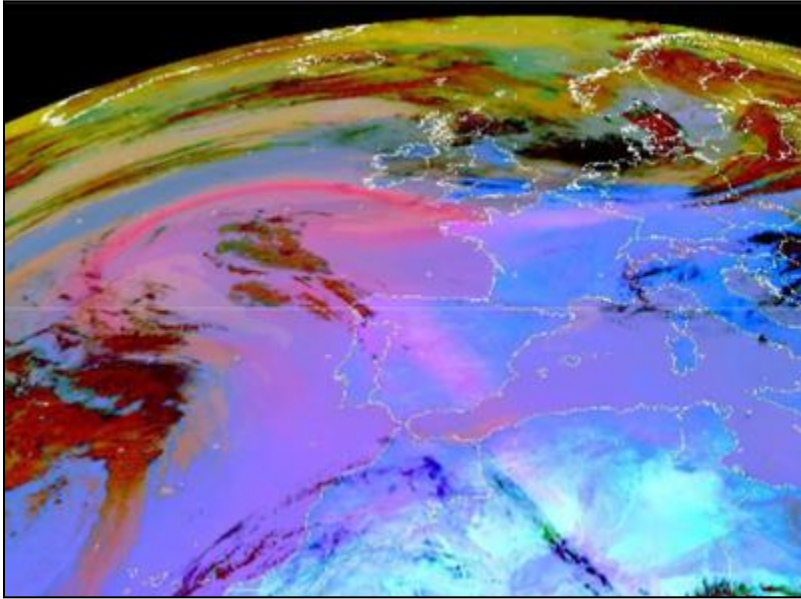
Marenostrum 3 supercomputer



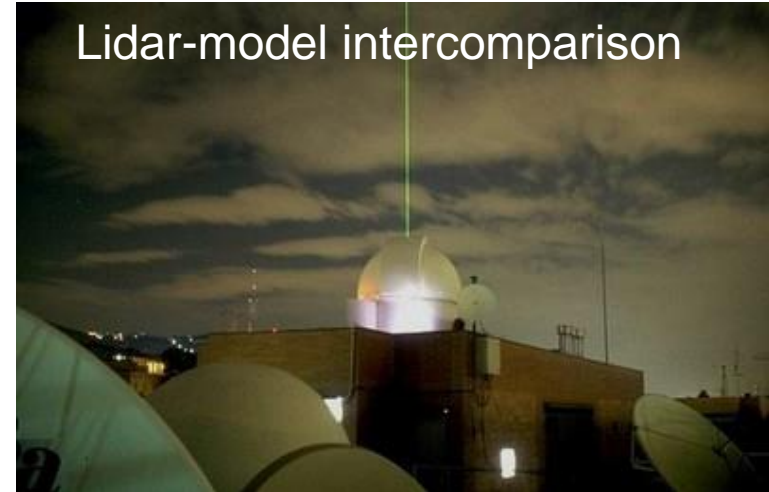
# Regional Center. Objectives

- **Identify and improve products for dust monitoring and prediction through collaboration with research and operational organizations, as well as with end-users**
- **Facilitate user-access to information**
- **Strengthen the capacity of countries to use observations, analysis and predictions supplied**

# Cooperative research



Model inter-comparison for a Saharan dust outbreak into Europe (Apr 2011).

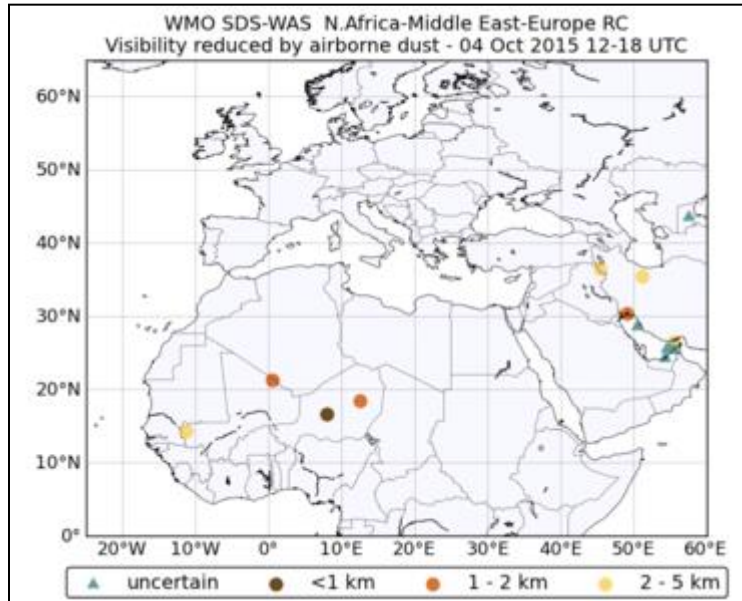


Study of a haboob in Tehran (Jun 2014)



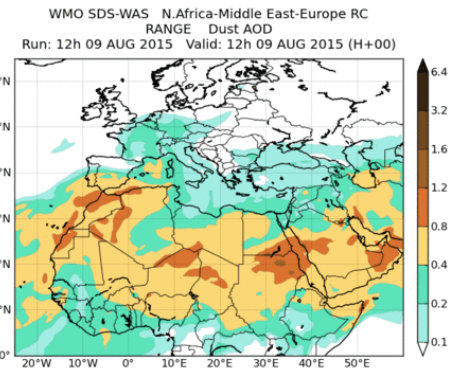
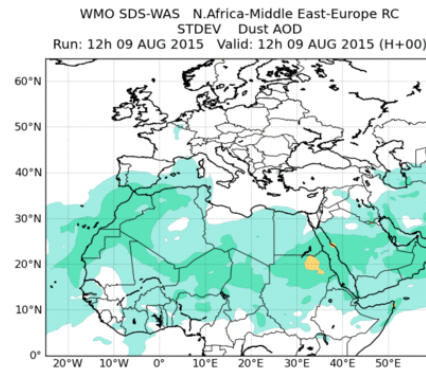
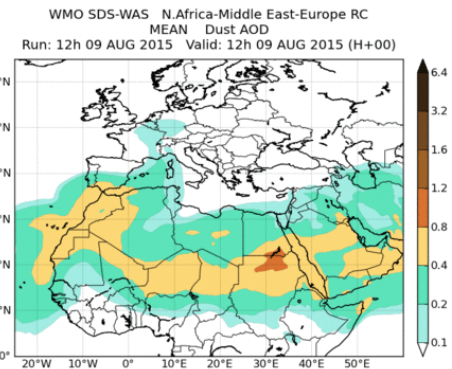
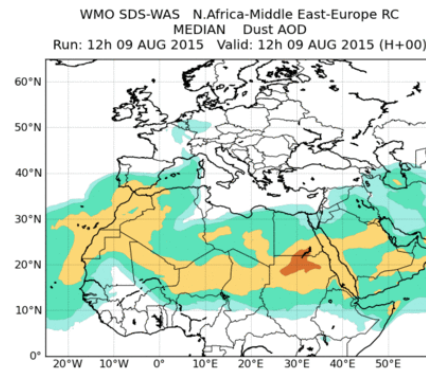


# New products



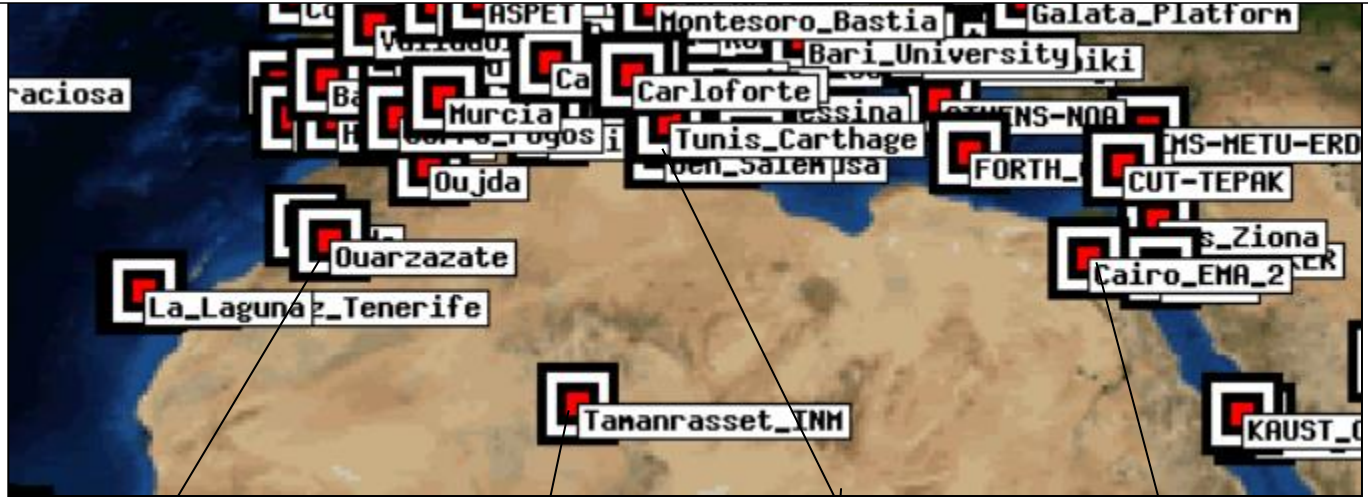
4 Oct 2015 12-18 UTC

9 Aug 2015





# SDS Africa



# Website

The screenshot shows the homepage of the Northern Africa-Middle East-Europe (NA-ME-E) Regional Center. The header includes the WMO logo and the text 'NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER' and 'WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)'. A navigation menu is located below the header, with options for HOME, ABOUT US, FORECAST & PRODUCTS, PROJECTS & RESEARCH, MATERIALS, NEWS, EVENTS, and CONTACT US. The main content area is divided into several sections:

- Home:** A 'You are here: Home' breadcrumb.
- Navigation:** A vertical sidebar on the left with links for Home, About us, Forecast & Products, Projects & Research, Materials, News, Events, and Search.
- Search:** A search bar with a 'Search' button.
- Outstanding:** A list of featured articles, including 'Guidance for forecasters', '11 Lecturas on atmospheric mineral dust', 'Forecast evaluation', and 'Compared dust forecasts'.
- Subscribe to the Public Newsletter:** A form with fields for 'Full Name' and 'Your email', and a 'Subscribe' button. A note states: 'To be informed about our activities, news and events related to dust. Frequency is almost monthly.'
- Dust forecasts:** Two sub-sections: 'Compared Dust Forecasts' showing a map of dust concentration over the region, and 'Forecast Evaluation' showing a line graph of dust surface concentration over time.
- Dust observations:** A section with a line graph and a satellite image of the Earth showing dust storms.
- Latest News:** A list of recent news items, including 'Backtrajectories are now available', 'Comparison of dust models', and 'Lidar data and quicklooks'.
- Upcoming Events:** A list of upcoming conferences, including the 'European Aerosol Conference EAC-2012' and the '2012 EUMETSAT Meteorological Satellite Conference'.

<http://sds-was.aemet.es>

[sdswas@aemet.es](mailto:sdswas@aemet.es)



# Capacity building



UNIVERSITAT POLITÈCNICA DE CATALUNYA  
BARCELONATECH



Sultan Qaboos University



Barcelona Supercomputing Center  
Centro Nacional de Supercomputación



## TRAINING COURSES

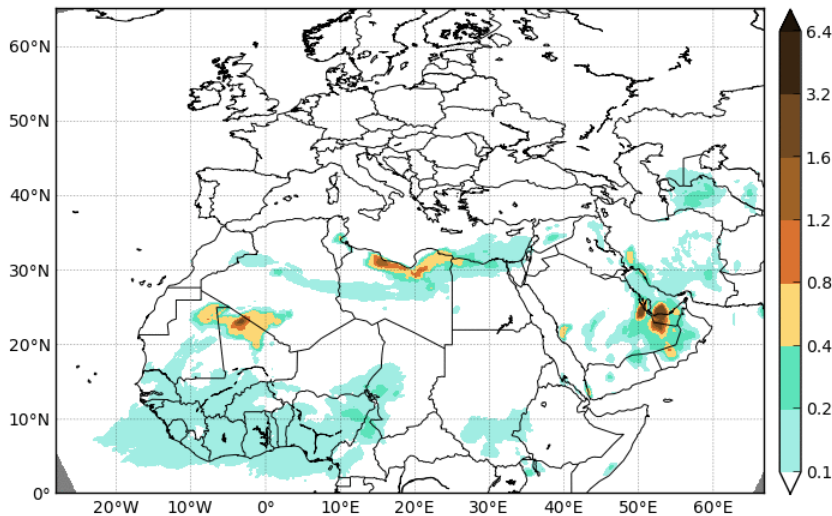
- Accra
- Addis-Ababa
- Ankara
- Antalya
- Barcelona
- Casablanca
- Istanbul
- Muscat
- Niamey
- Ouagadougou

## VISITORS FROM

- Iraq
- Romania
- Turkey

# Barcelona Dust Forecast Center

Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 09 FEB 2015 Valid: 12h 09 FEB 2015 (H+00)



May 2013

WMO designates the consortium of AEMET and BSC to host the first RSMC-ASDF. The Center will generate and distribute operational dust forecasts for Northern Africa (north of equator), Middle East and Europe

Feb 2014

The Center, called Barcelona Dust Forecast Center (BDFC) starts operations

Jun 2015

The BDFC is presented at the 17th WMO Congress





# Thanks for your attention

# شكرا على انتباهك

## WMO SDS-WAS Regional Center for Northern Africa, Middle East and Europe

<http://sds-was.aemet.es>  
[sdswas@aemet.es](mailto:sdswas@aemet.es)



## Barcelona Dust Forecast Center

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[dust@aemet.es](mailto:dust@aemet.es)