

The dust cycle

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chair of the WMO SDS-WAS Steering Committee



Summary

- Atmospheric aerosol
- The cycle of mineral dust
- WMO SDS-WAS
- Barcelona Dust Forecast Center
- Dust observation
- Dust forecast

Summary

- **Atmospheric aerosol**
- The cycle of mineral dust
- WMO SDS-WAS
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- Dust forecast

Atmospheric aerosol

Atmospheric aerosol

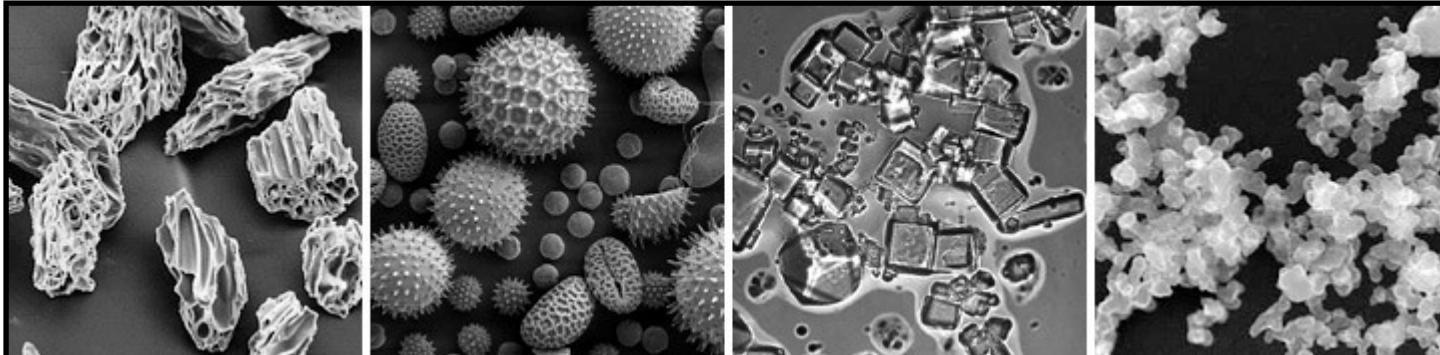
Solid or liquid particles suspended in the air

Origin (primary / secondary particles, natural / anthropogenic)

Size (Diameter: ~ 0.002 – 100 μm)

Chemical, mineralogical composition

Optical properties (absorption, scattering)



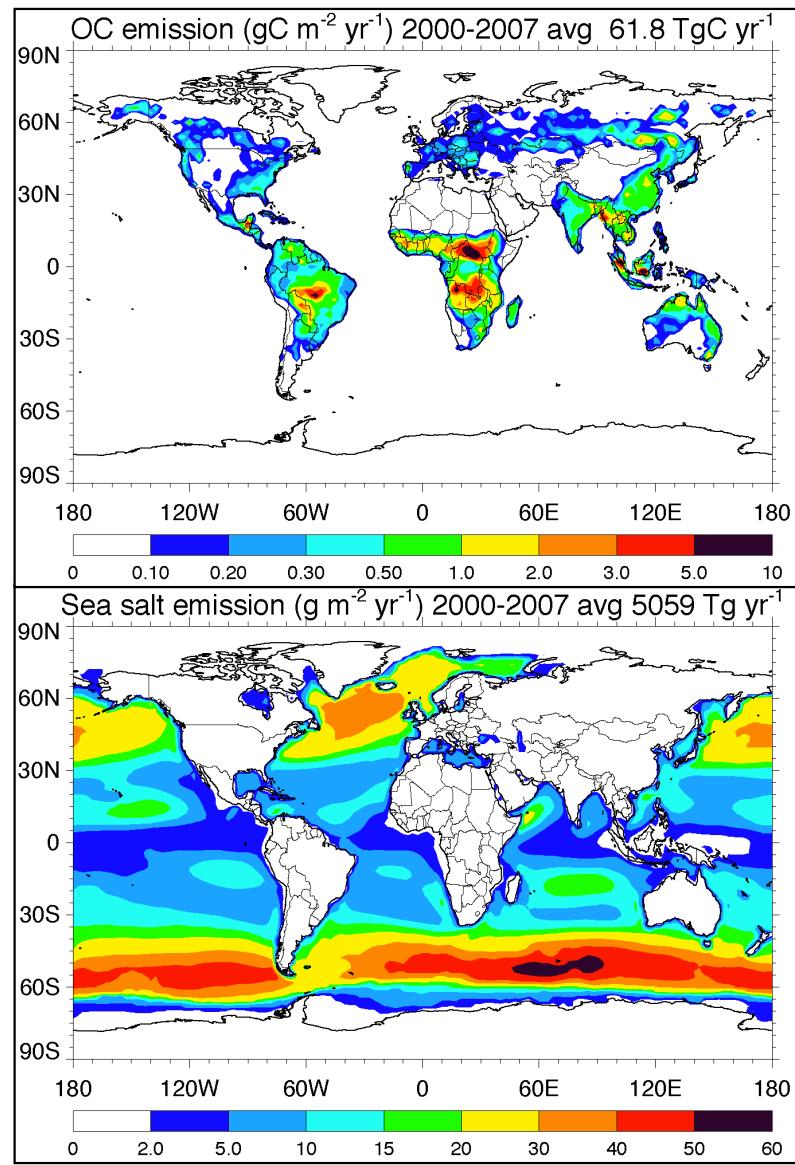
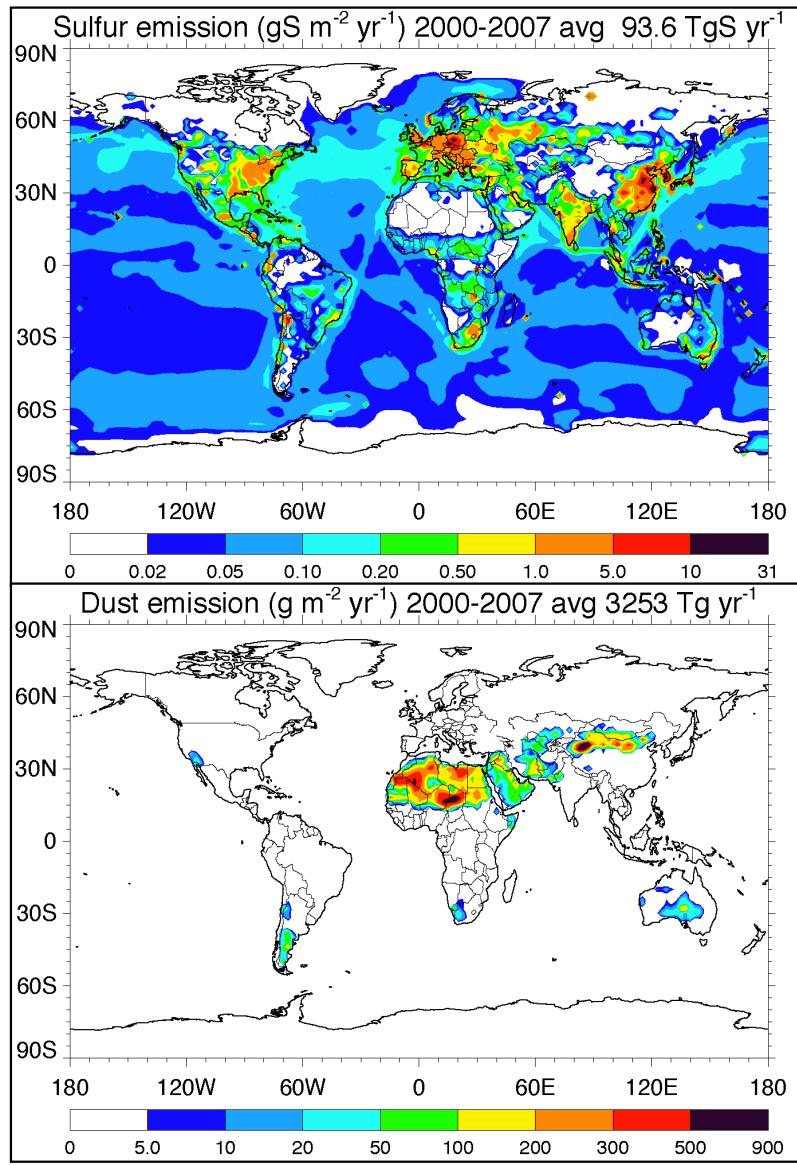
ARIZONA STATE
UNIVERSITY

Atmospheric aerosol. Sources

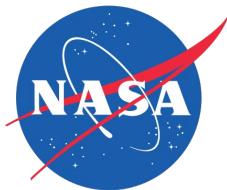


Volcanoes, sea salt, products from biomass burning, anthropic pollution, organic particles, MINERAL DUST

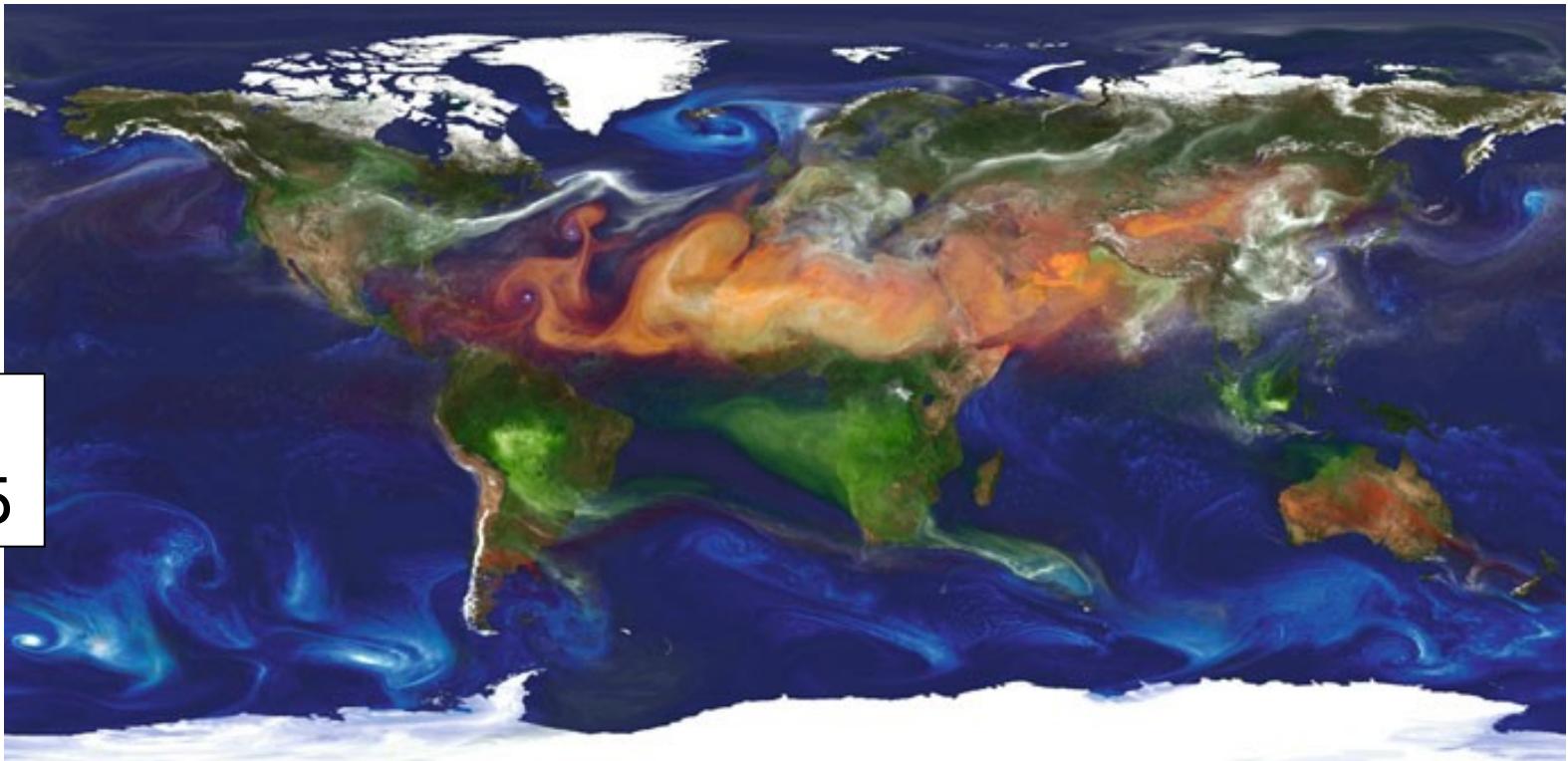
Atmospheric aerosol. Emissions



Atmospheric aerosol. Distribution



NASA
GEOS-5

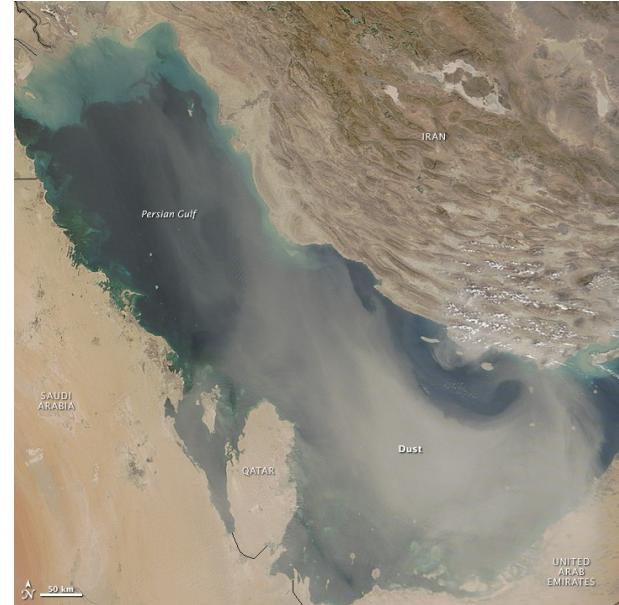
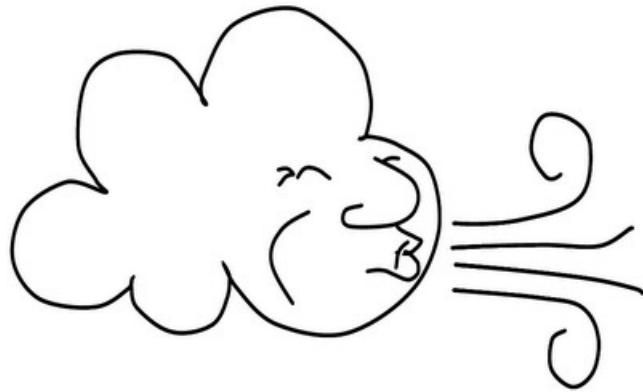


- Mineral dust (reddish)
- Sea salt (blue)
- Products of biomass burning (green)
- Sulphates (white)

Summary

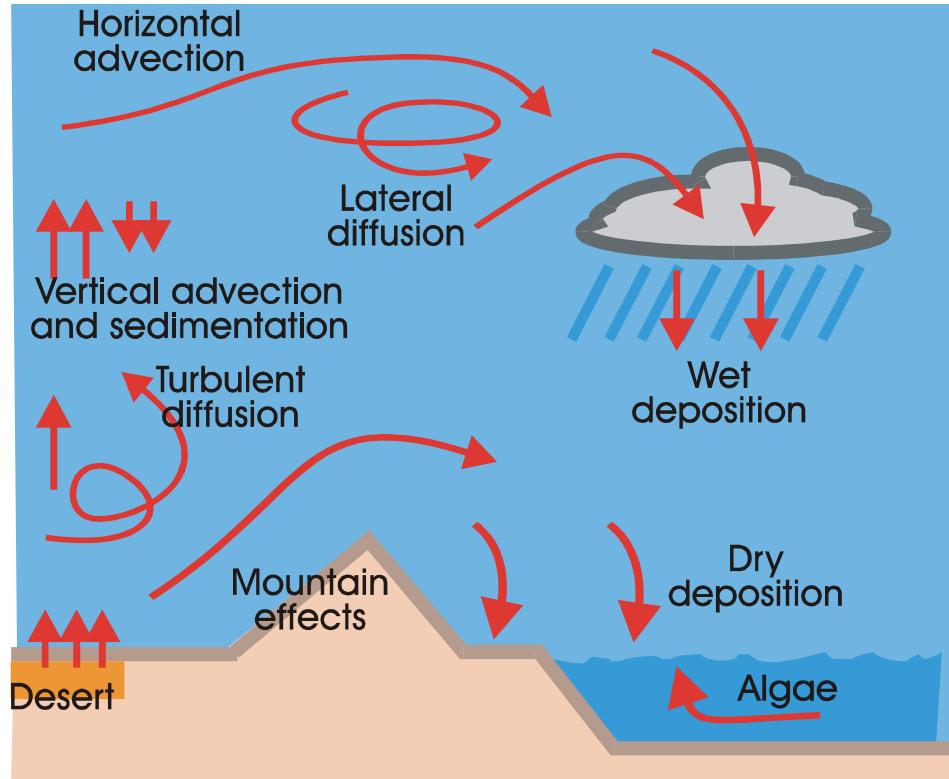
- Atmospheric aerosol
- **The cycle of mineral dust**
- WMO SDS-WAS
- Barcelona Dust Forecast Center
- Dust observation
- Dust forecast

The dust cycle



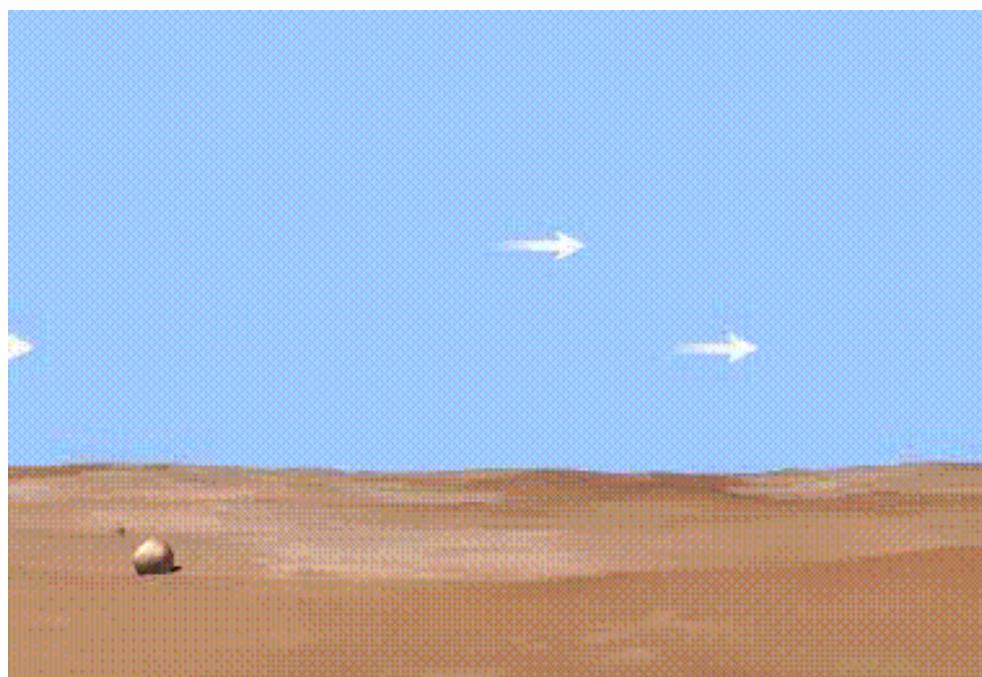
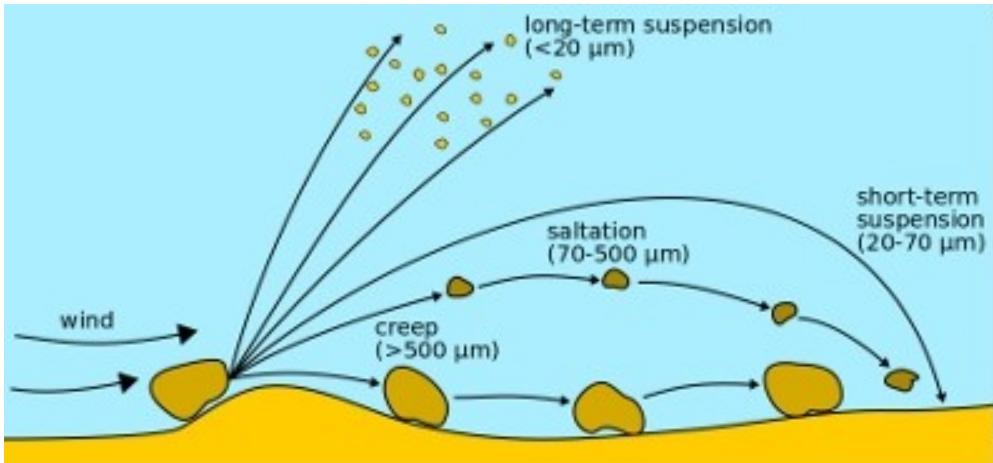
MODIS 3 Sep 2015

The dust cycle



- Emission
- Turbulent diffusion
- Transport
- Dry / wet deposition

The dust cycle. Emission



Soil factors

- Soil texture
- Soil humidity
- Vegetation

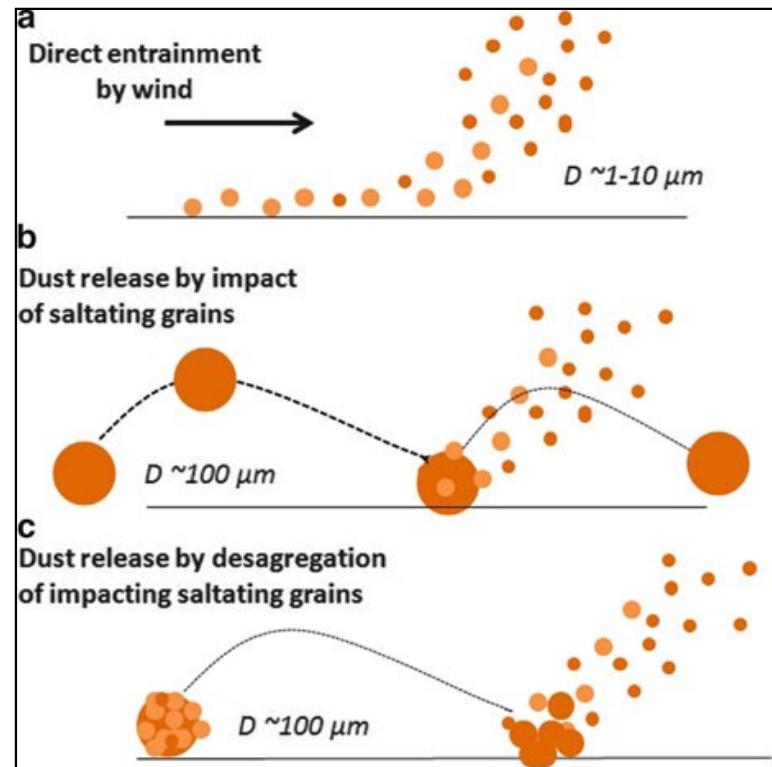
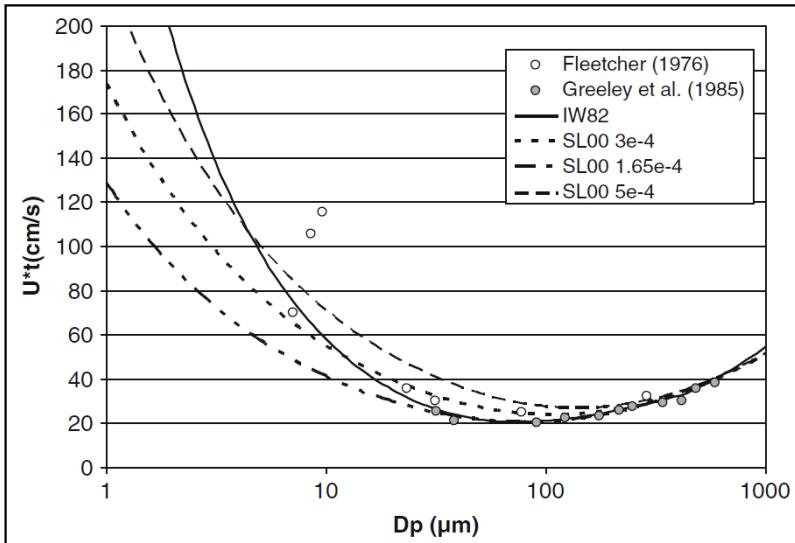
Meteorological factors

- Wind
- Near-surface turbulence

The dust cycle. Erosion threshold

The threshold for particle mobilization is the result of the balance between the wind shear stress and the forces acting to keep the particles in the soil (weight, cohesive force between particles, cohesive forces induced by moisture)

$$u^* = (\tau / \rho)^{0.5}$$



The dust cycle Erosion threshold

Elements increasing the erosion threshold

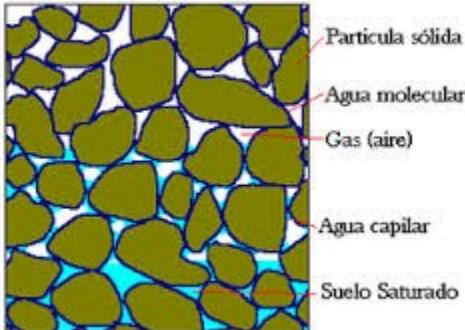


Non-erodible elements
(i. e. vegetation)



Crusted soils

Soil humidity



Nieve

The dust cycle. Saltation

$$Q = c \frac{\rho}{g} U^{*3} \left(1 - \frac{U_t^*}{U^*}\right) \left(1 + \frac{U_t^{*2}}{U^{*2}}\right)$$

White (1979)

- Strong dependence on wind speed (proportional to u^{*3})
- Strong dependence on particle size (through u_t^*)

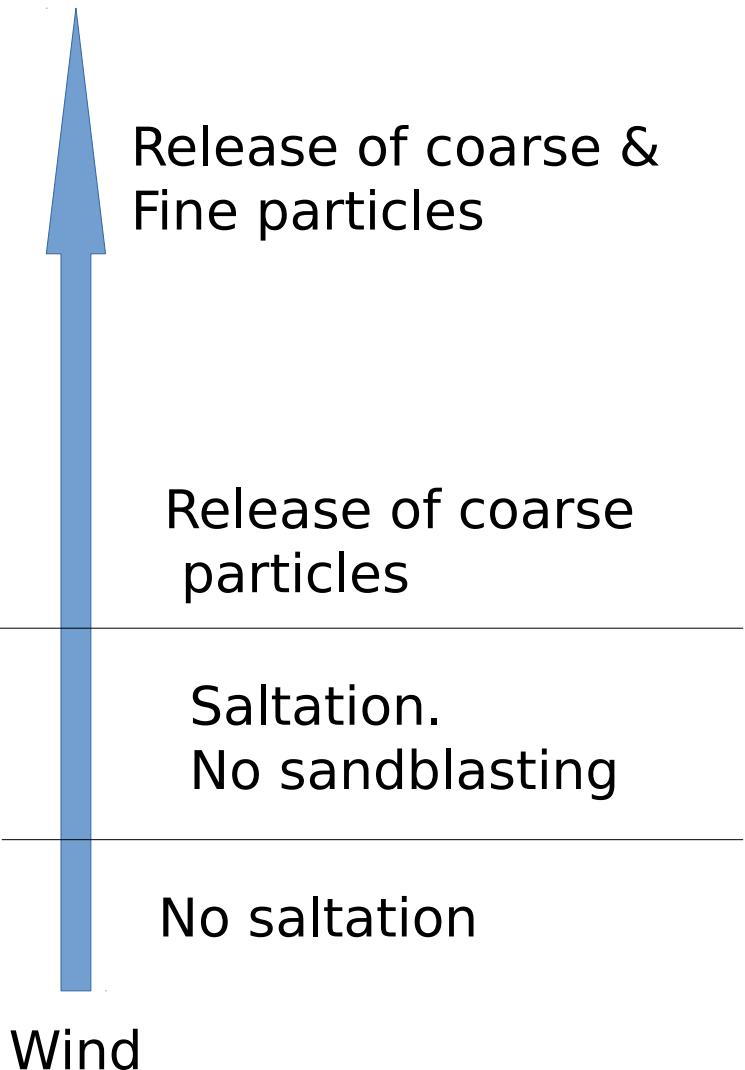


- Need for a very precise wind forecast
- The horizontal flux must be computed for different size bins



The dust cycle. Sandblasting

- The kinetic energy of the saltation breaks the particle aggregates and originates a vertical flow (sandblasting)
- There is a threshold (minimum kinetic energy) to trigger the 'sandblasting'
- The larger particles are less cohesive and are the first to be released
- Only the most intense episodes cause the emission of fine particles



The dust cycle. Anthropic emissions



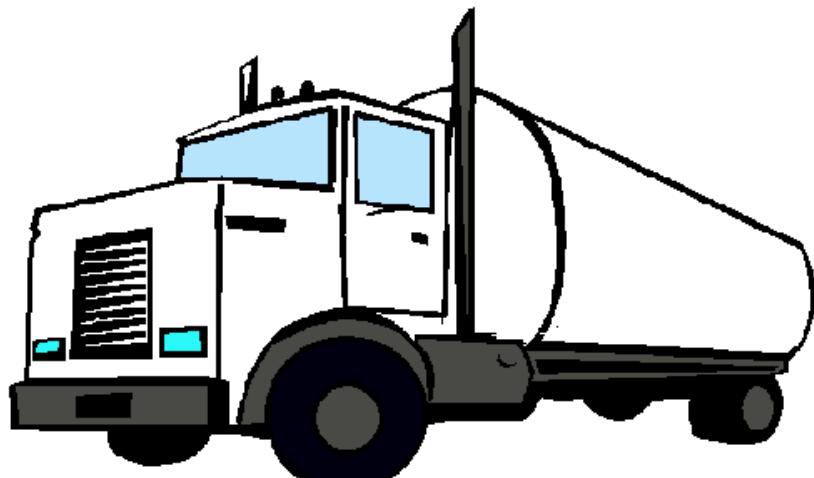
www.5DT.com



The dust cycle. Total emissions

~ 30,000 - 60,000 kg / s
~ 1 - 3 • 10¹² kg / year

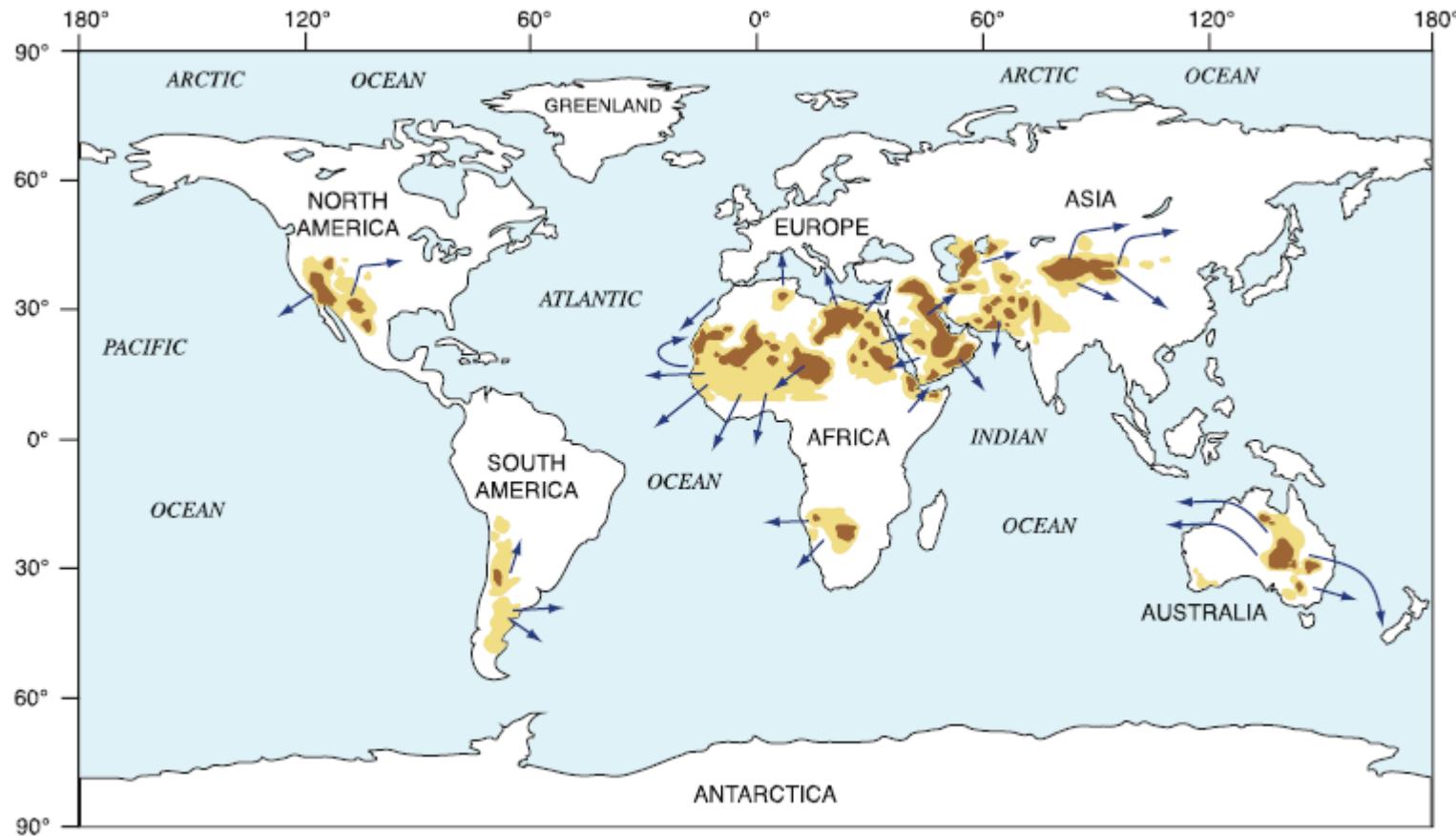
50,000,000 trucks



3,000 ULCC

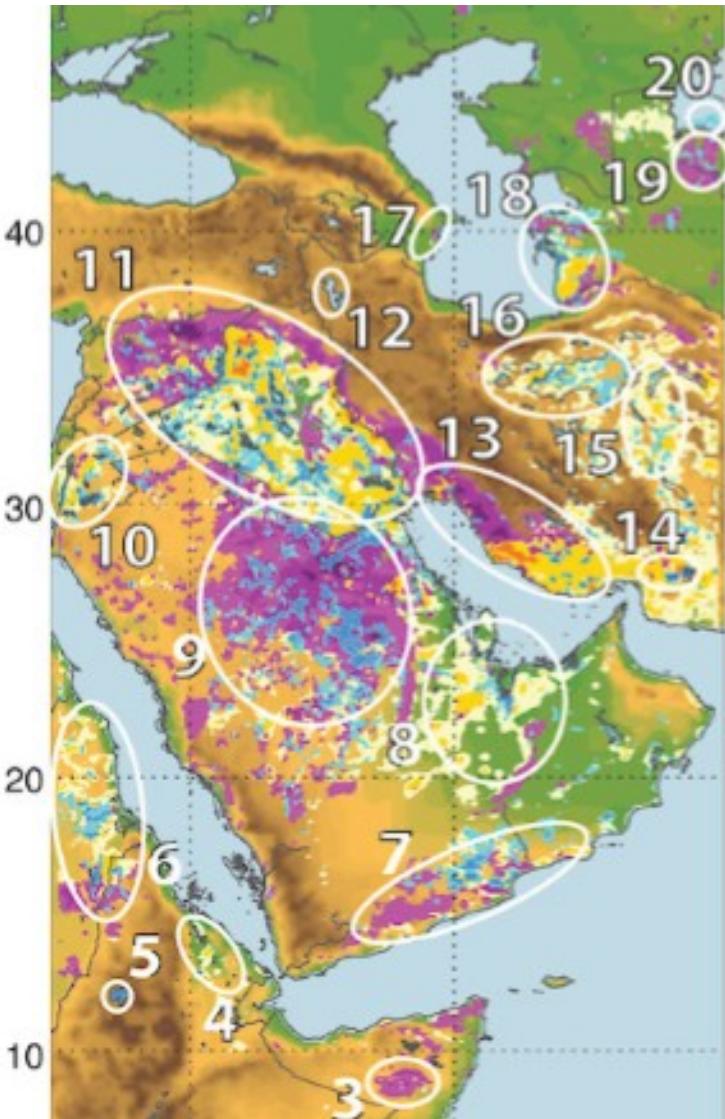


The dust cycle. Sources



Identification of dust sources based on the TOMS' Absorbing Aerosol Index (AAI)
AAI > 0 for absorbing aerosols at 360 nm

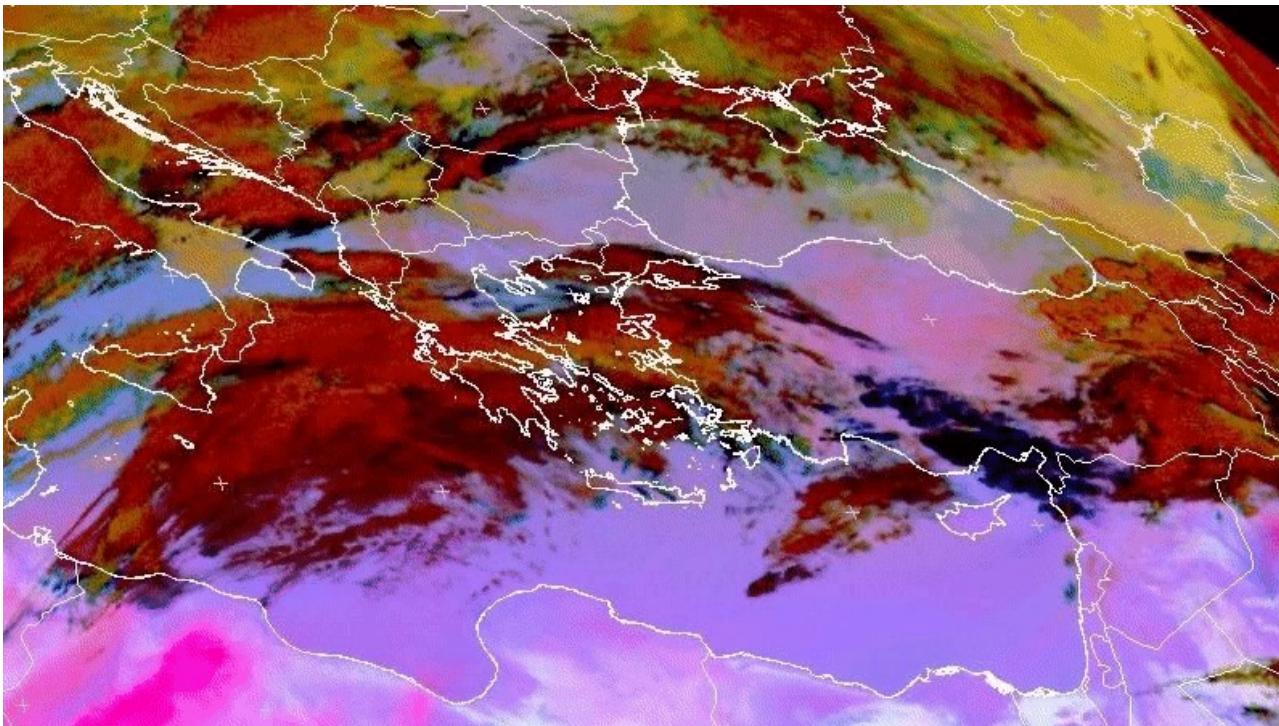
The dust cycle. Sources



Identification of dust sources based on the number of days with $AOD > 0.2$ (Ginoux et al., 2012)

8. Empty Quarter
9. Highlands of Saudi Arabia
10. Jordan basin of Jordan river
11. Mesopotamia
- 12. Urumia lake**
- 13. Coastal desert of Iran**
14. Hamun-i Mashkel
- 15. Dasht-e Lut desert of Iran**
- 16. Dasht-e Kavir desert of Iran**
17. Qobustan (Azerbaijan)
18. Atrek delta (Turkmenistan)
19. Turan plain (Uzbekistan)
20. Aral sea

The dust cycle. Meteorological conditions



22-24 Mar
2008

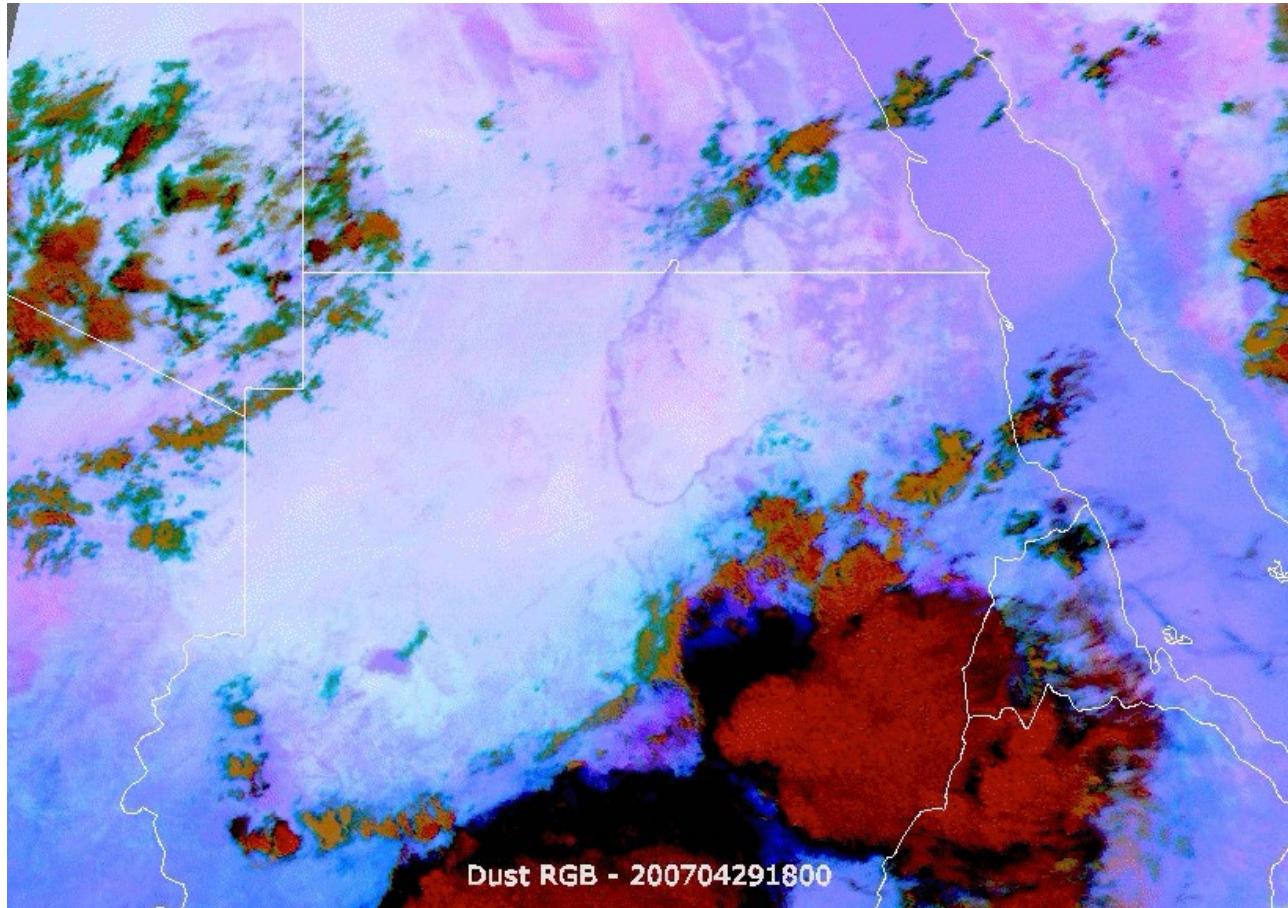
RGB-dust 2008-03-22 16:00 UTC



SYNOPTIC SCALE

- Frontal systems
- Reinforced trade winds

The dust cycle. Meteorological conditions

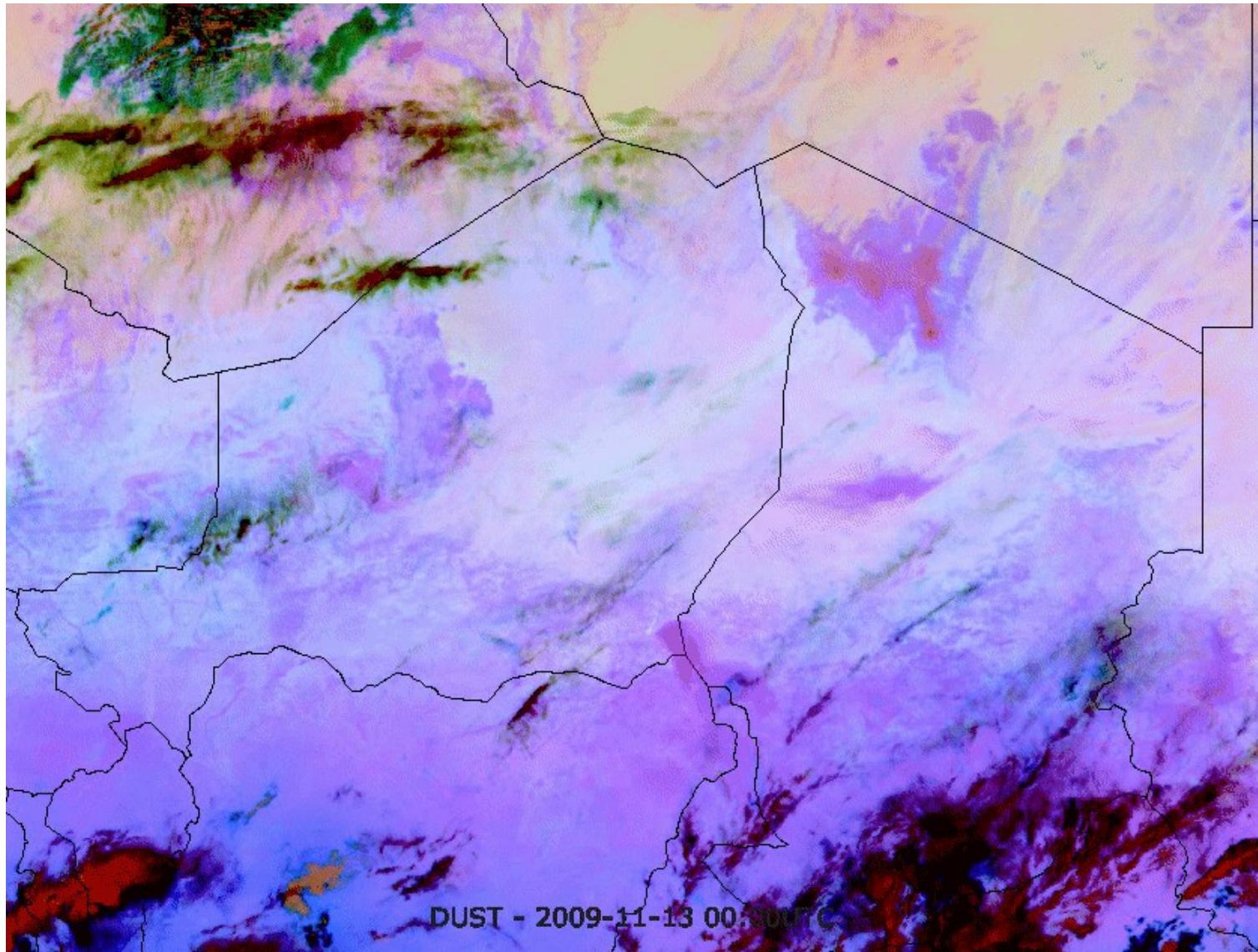


MESOSCALE- MICROSCALE

- Convection
- Drainage winds
- Low-level jets
- Gap winds
- ...

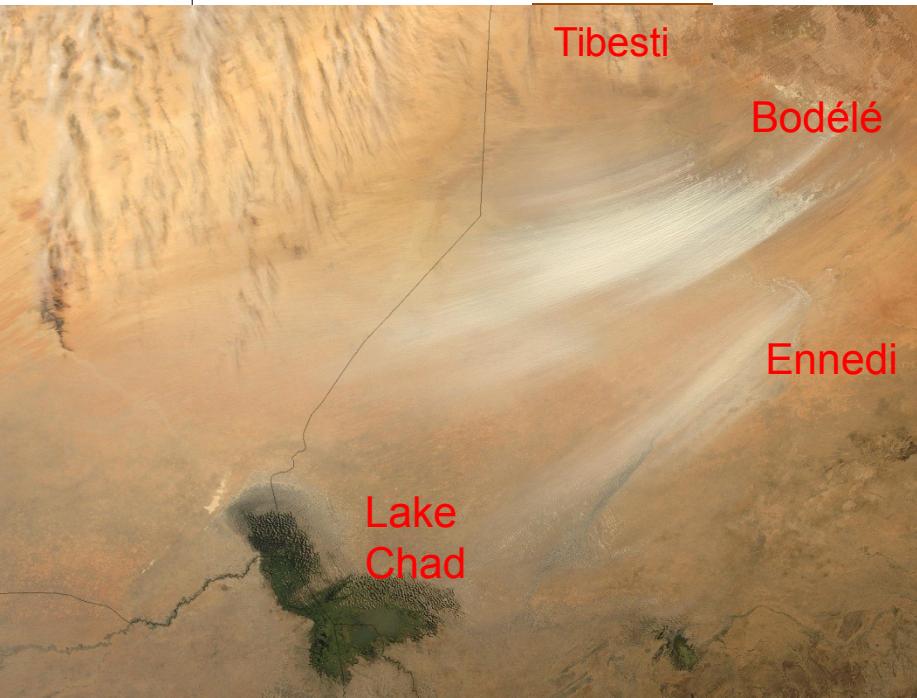
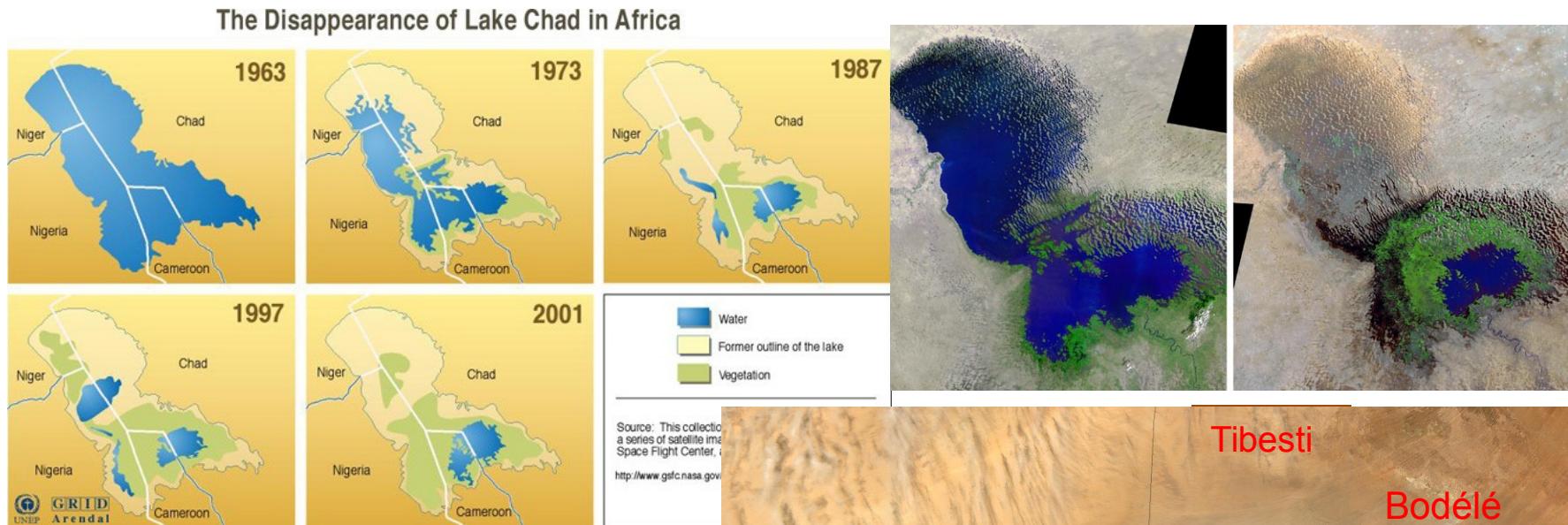
29 Apr – 1 May
2007

The dust cycle. Meteorological conditions

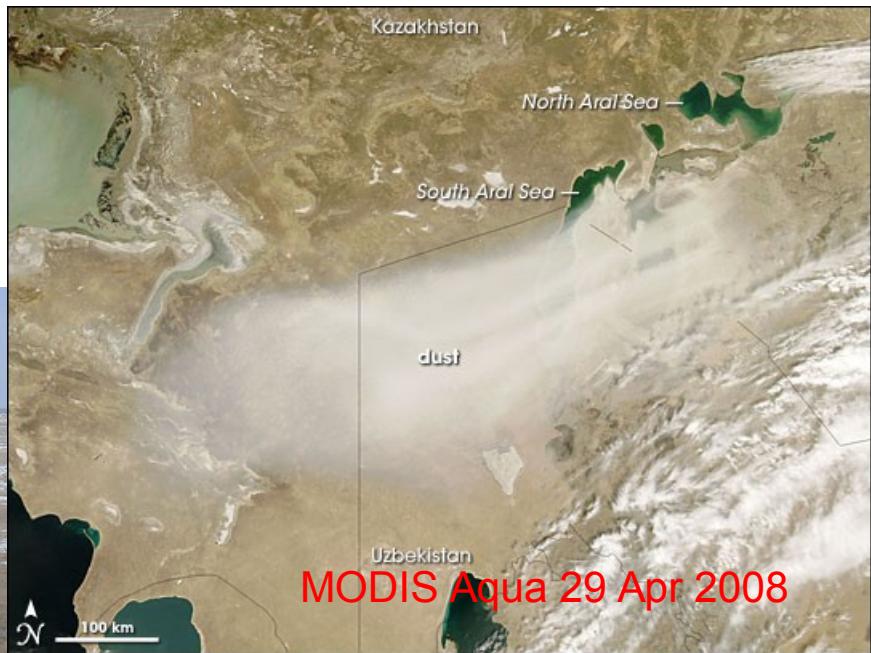


13 – 14 Nov
2009

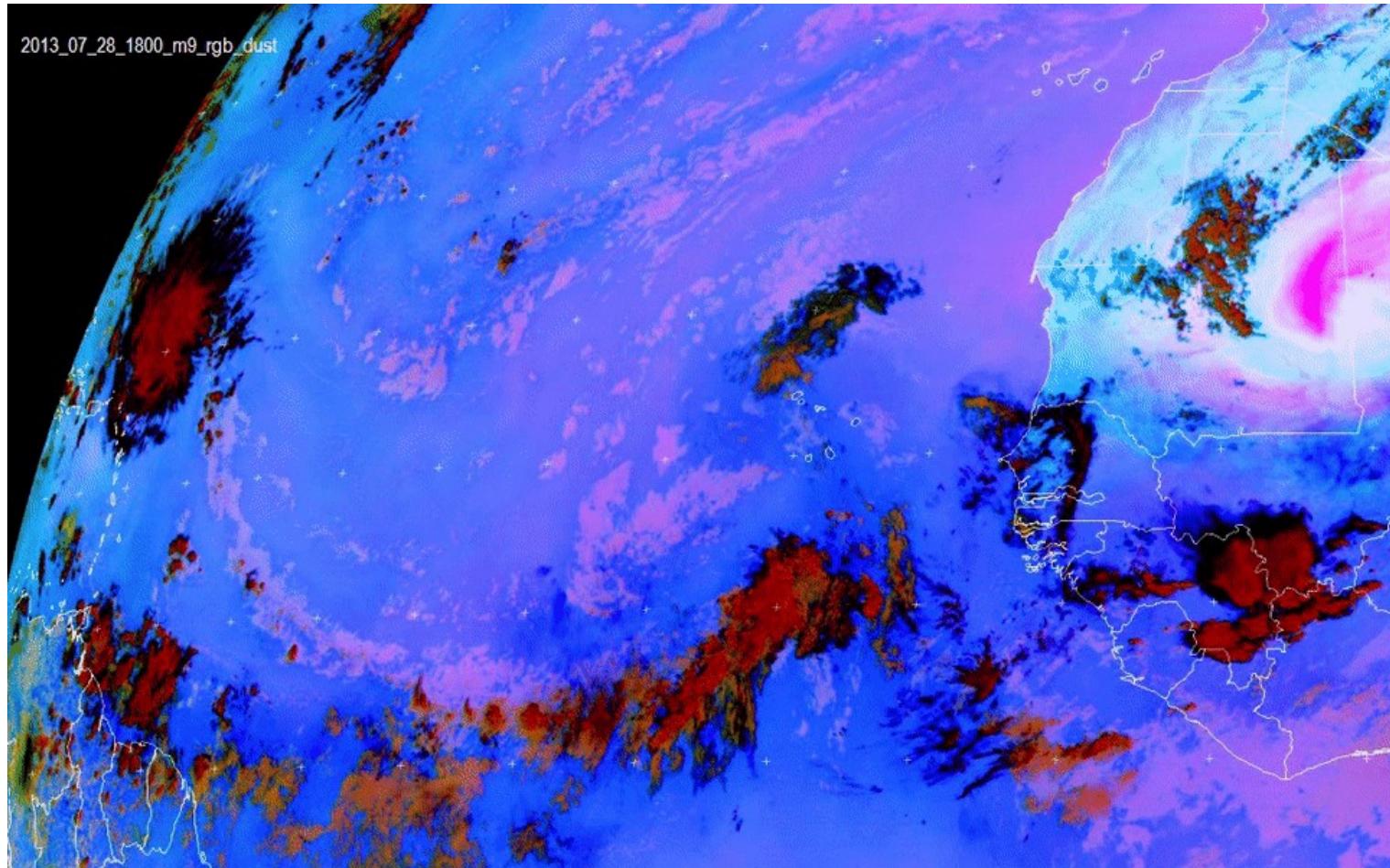
The dust cycle: the Bodélé depression



The dust cycle: the Aral sea

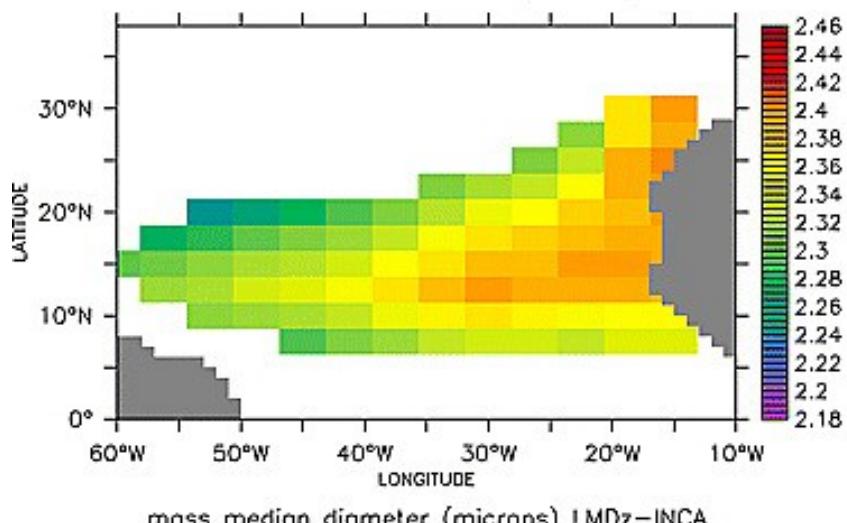
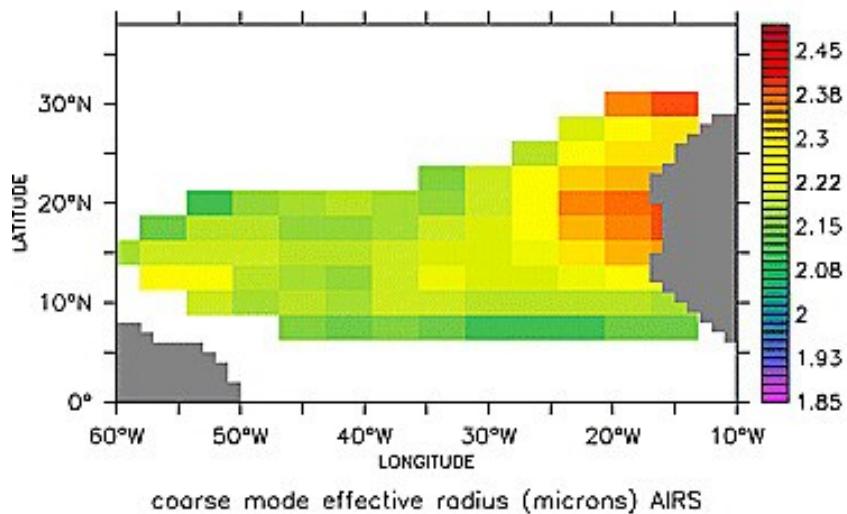


The dust cycle. Transport

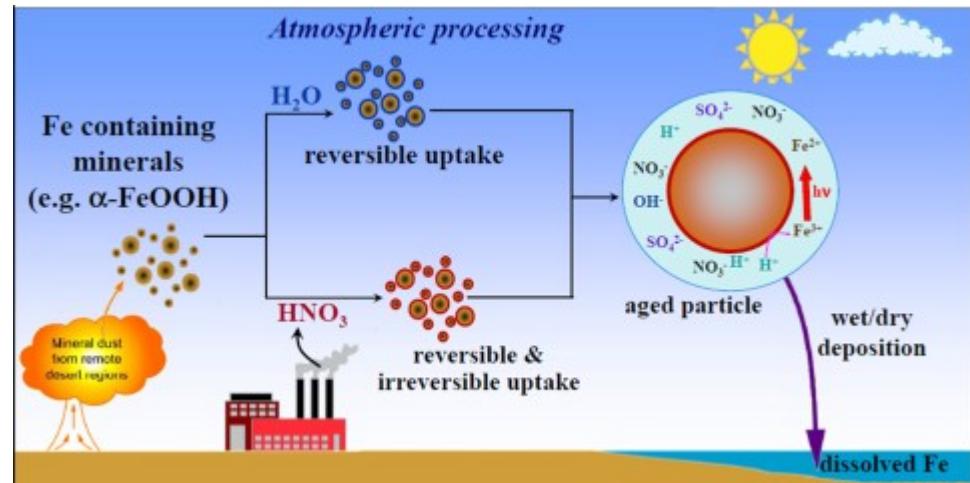


29 – 30 Jul 2013

The dust cycle. Transport

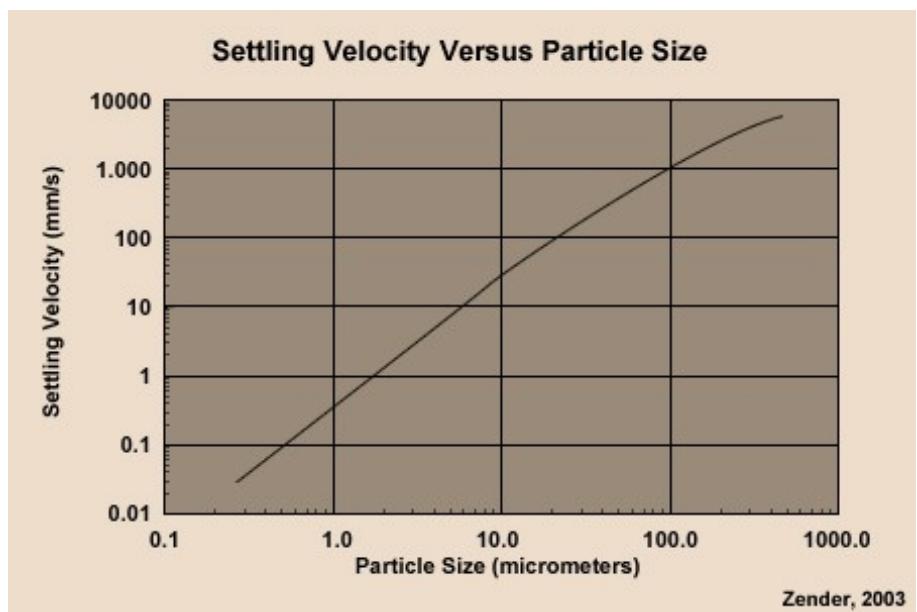
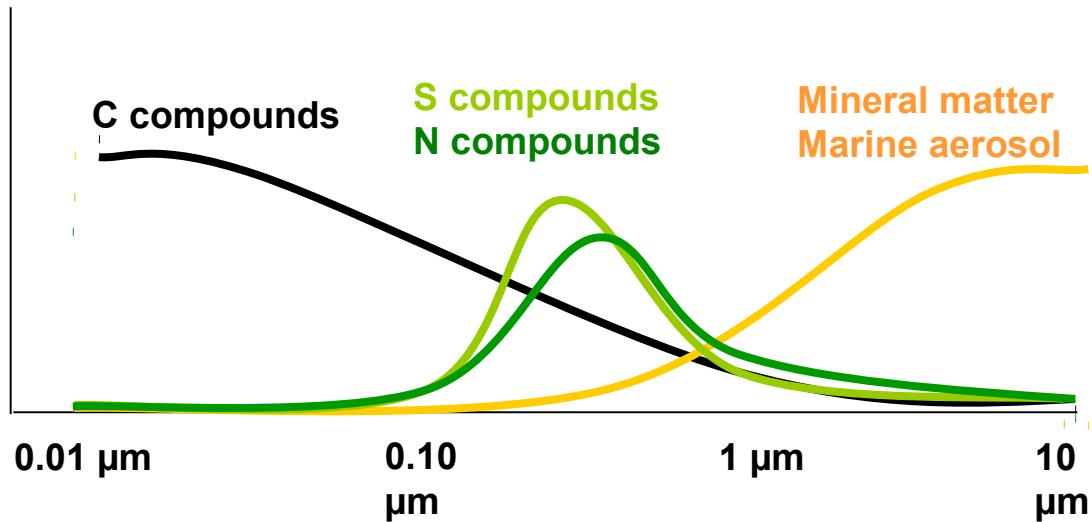


Pierangelo et al. (2005)



- The average particle size decreases during transport
- The chemical composition may change
- The optical properties may change
- The ability of dust particles to act as CCN increases
- Iron increases its solubility

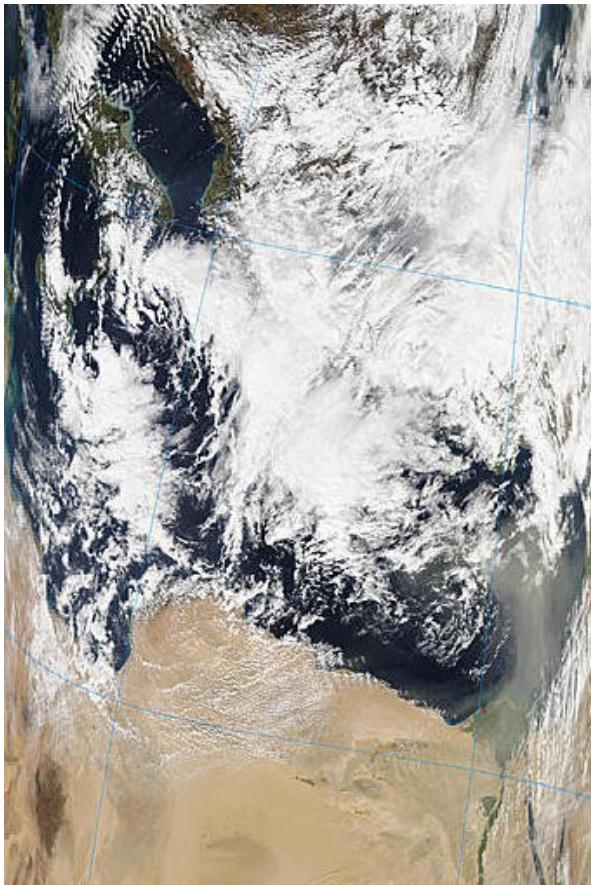
The dust cycle. Dust deposition



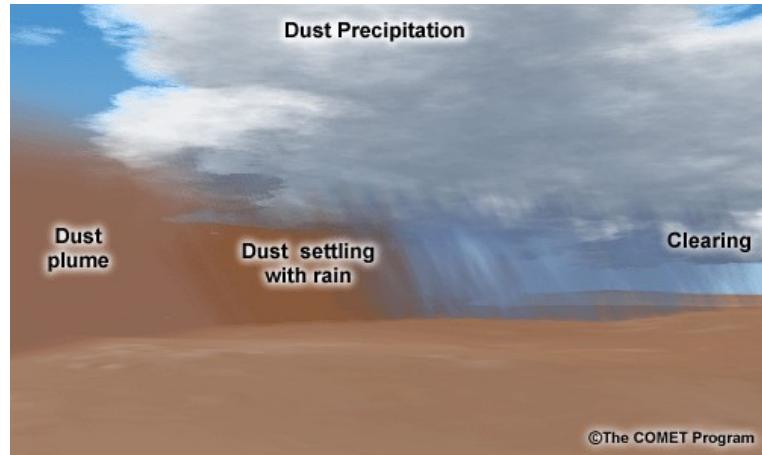
SIZE (μm)	AVERAGE LIFETIME (h)
0.1 - 0.18	231
0.18 - 0.3	229
0.3 - 0.6	225
0.6 – 1	219
1 - 1.8	179
1.8 – 3	126
3 – 6	67
6 - 10	28

Tegen and Lacis (1996)

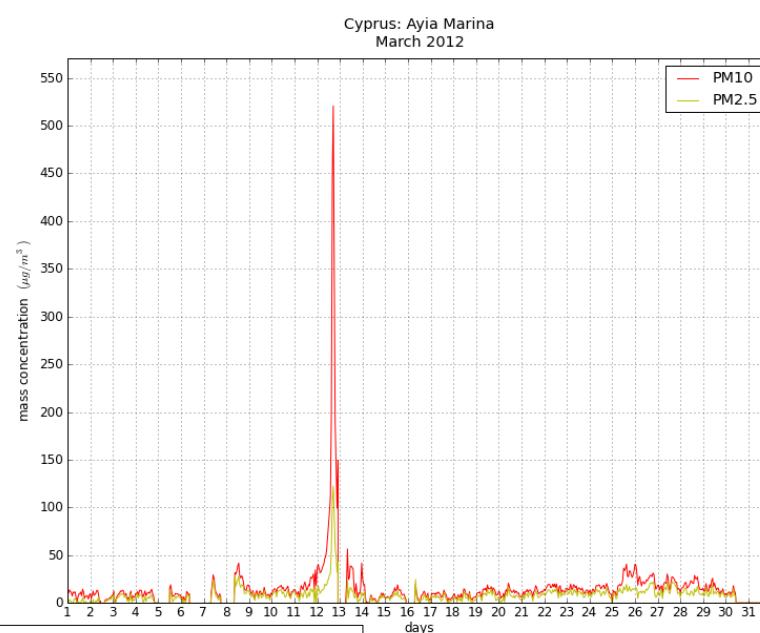
The dust cycle. Wet deposition



MODIS 12 Mar 2012



©The COMET Program



PM Ayia Marina, Cyprus, Mar 2012

The dust cycle. Composition

MINERALOGICAL (X-ray diffractometry)

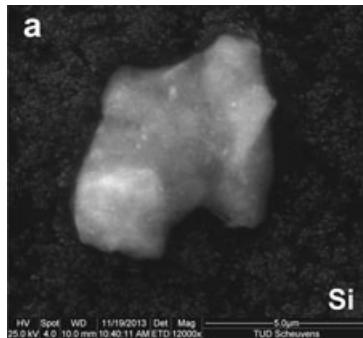
- Silicates: quartz, feldspar, phyllosilicates (illite, kaolinite, esmectite)
- Carbonates (calcite, dolomite)
- Hematite, gypsum, halite, ...

ISOTOPICAL (Sr, Nd, Pb)

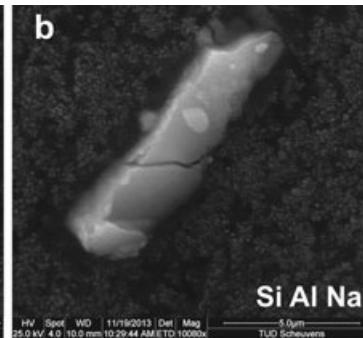
CHEMICAL (spectroscopy)

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

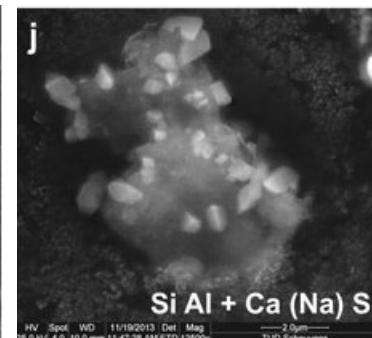
- Information on the source region
- Influence the optical properties
- Influence the impact on health, ecosystems, ...



Quartz

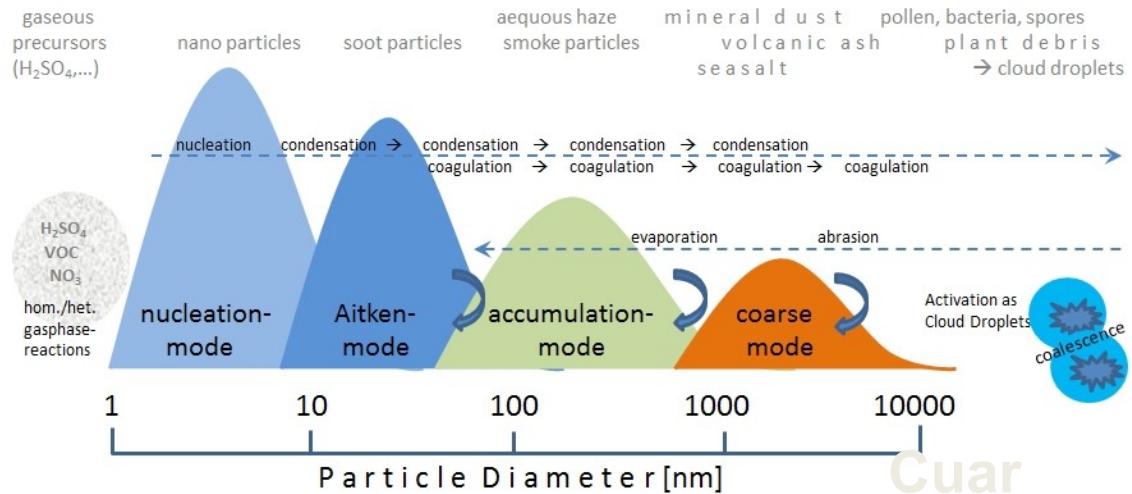


Albite

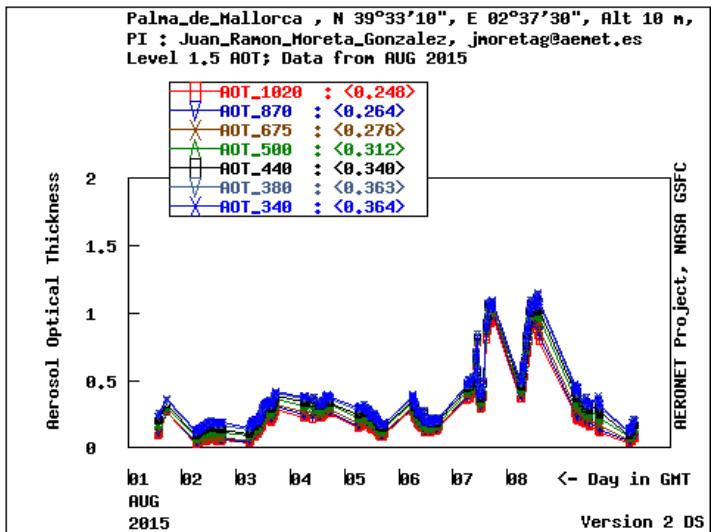
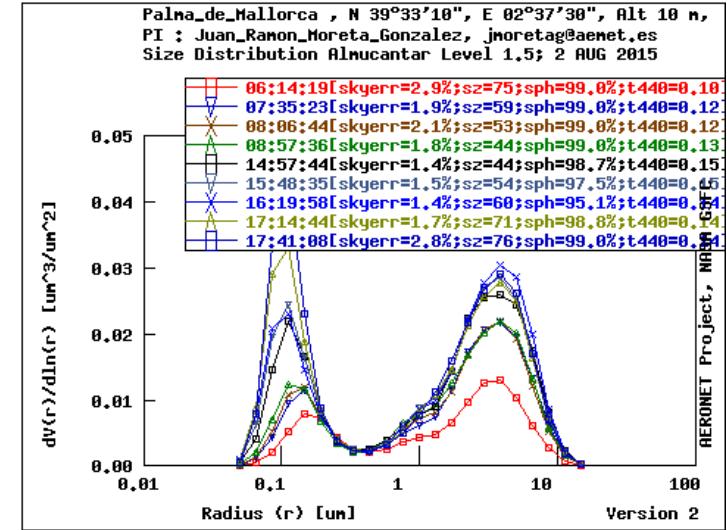


Gypsum

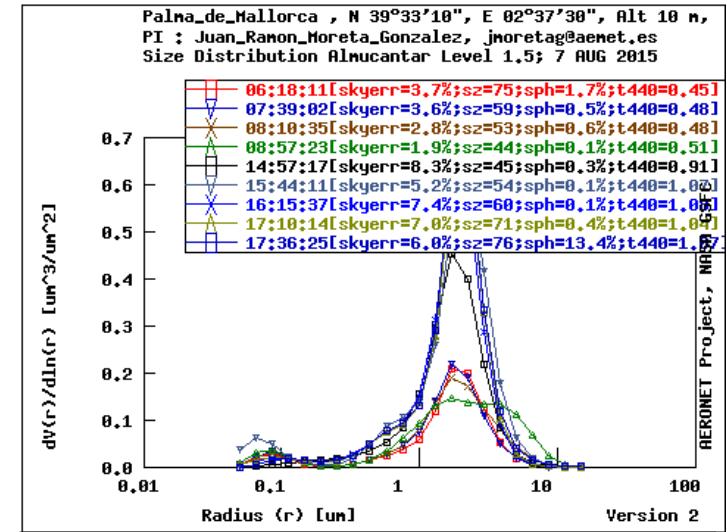
The dust cycle. Particle size



Cuar

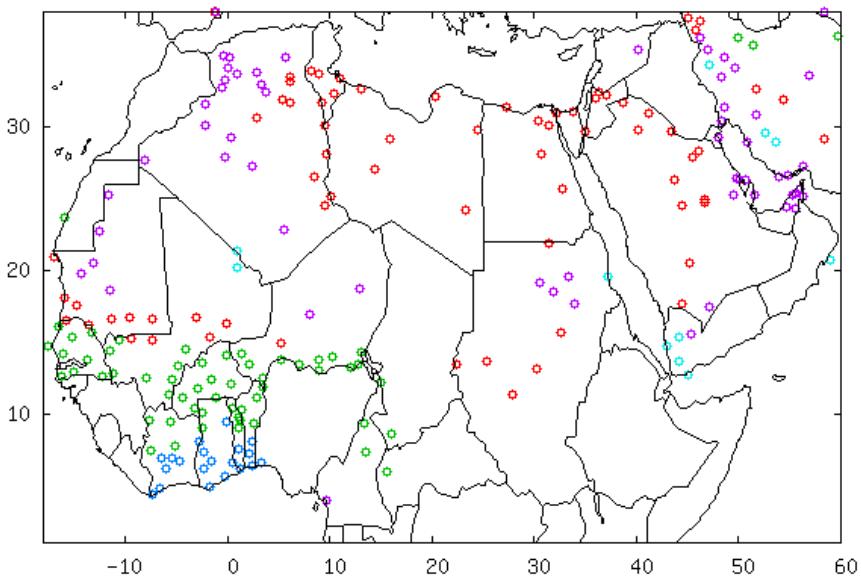


AOD. Palma de Mallorca. Aug 2015



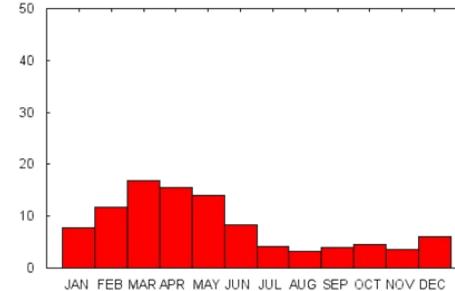
Palma de Mallorca 2 / 7 Aug 2015

The dust cycle. Seasonal variability

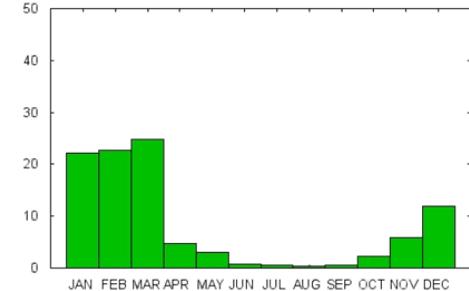


1996-2010

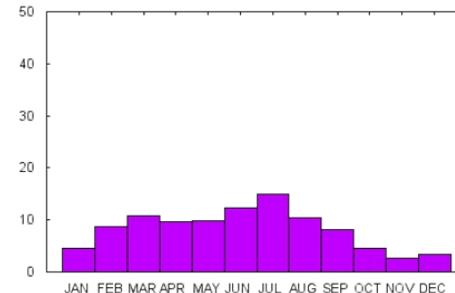
cluster 1. Monthly % of Visibility reductions by sand or dust



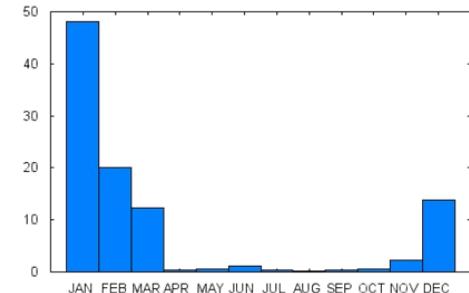
Cluster 2. Monthly % of Visibility reductions by sand or dust



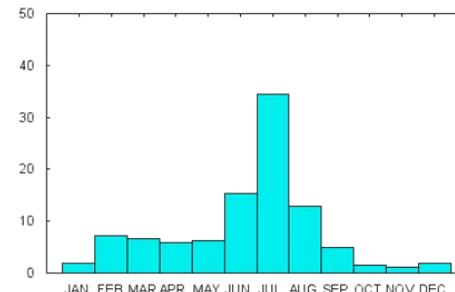
Cluster 4. Monthly % of Visibility reductions by sand or dust



Cluster 3. Monthly % of Visibility reductions by sand or dust



Cluster 5. Monthly % of Visibility reductions by sand or dust



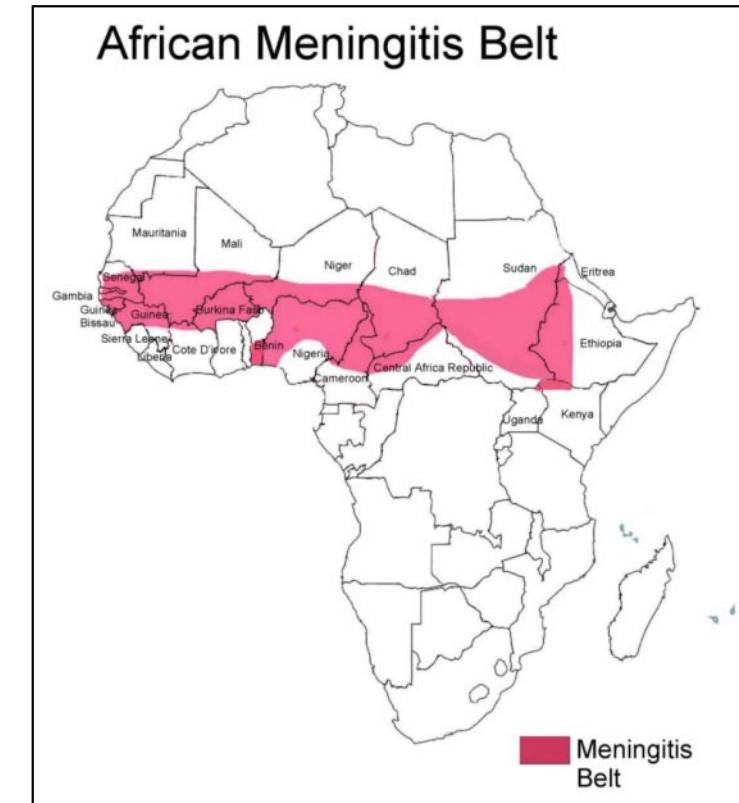
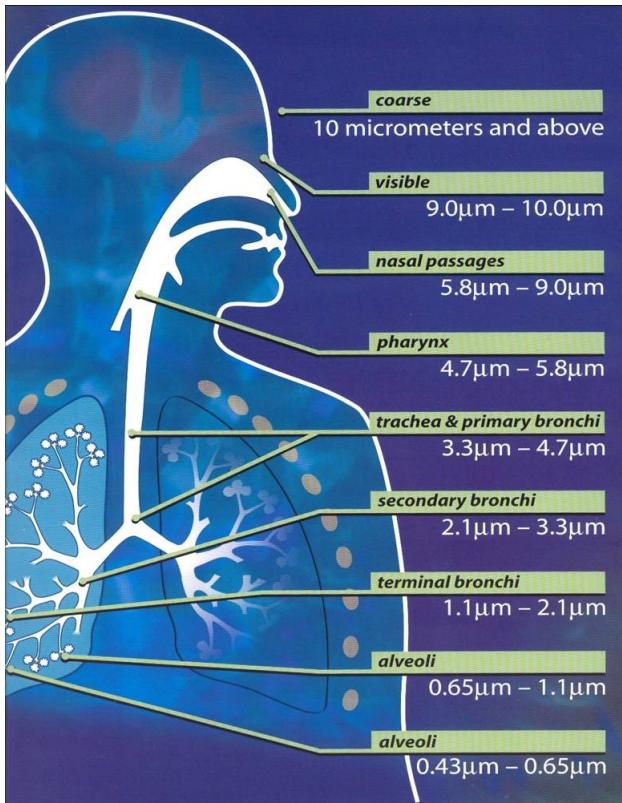
The dust cycle. Impacts

- Health
- Weather and climate
- Transportation
(visibility reduction)
- Energy
- Agriculture, fishing
- ...



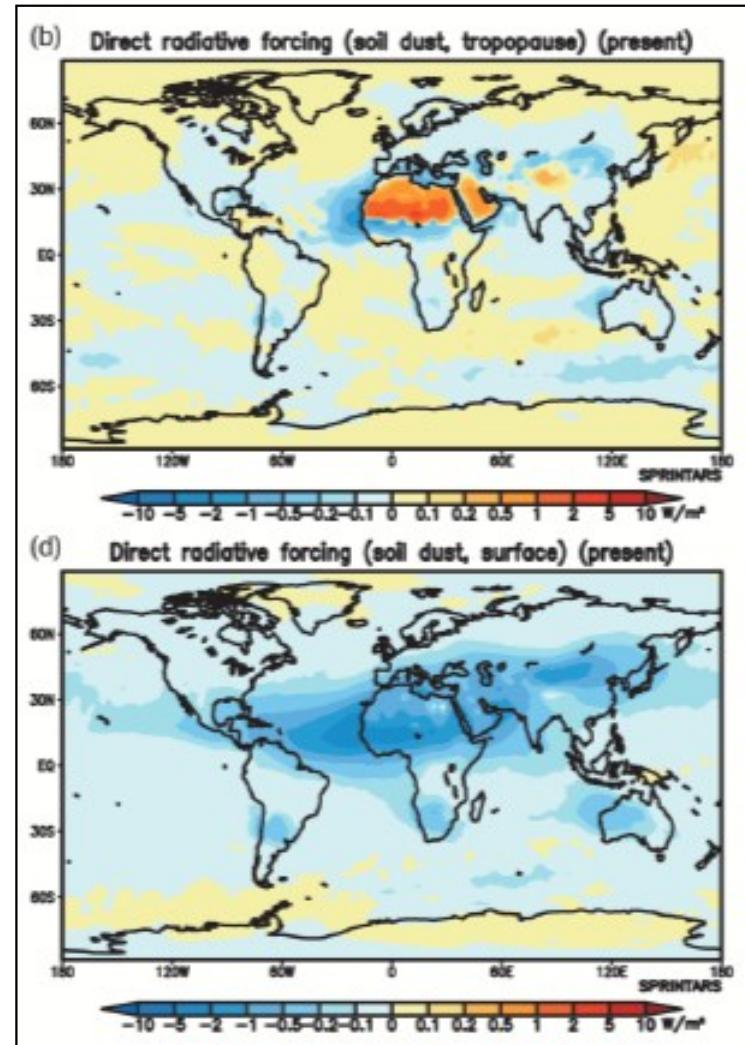
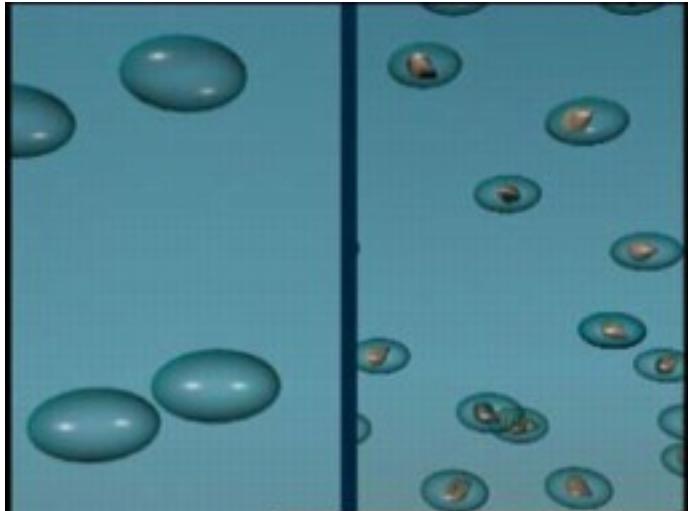
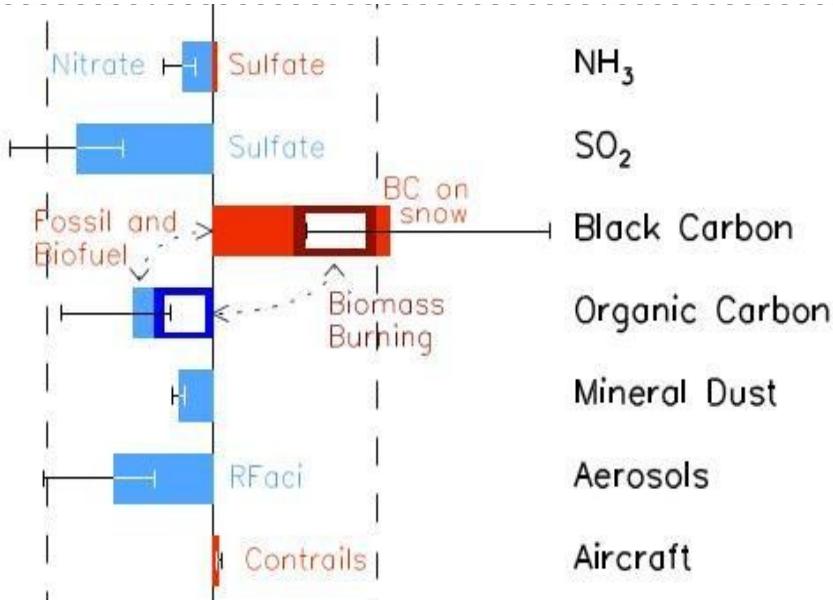
3:35P	On Time
3:45P	Cancelled
4:15P	On Time
4:24P	Delayed
4:30P	Cancelled
5:00P	On Time
5:12P	On Time
5:15P	On Time

The dust cycle. Health impact



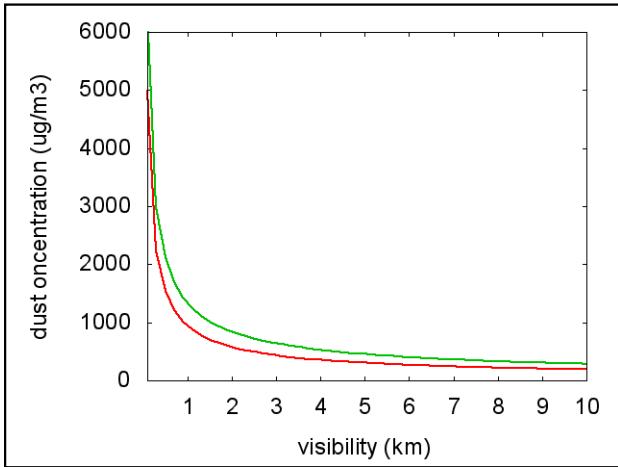
- Particle size
- Chemical and mineralogical composition
- Carrying bacteria, viruses, fungi, ...
- Time and intensity of exposition

The dust cycle. Impact on weather and climate



Takemura et al. (2009)

The dust cycle. Impact on transportation



D'Almeida (1986)
Ben Mohamed et al. (1992)



Arizona, 29 Oct 2013



Tunis, 7 May 2002

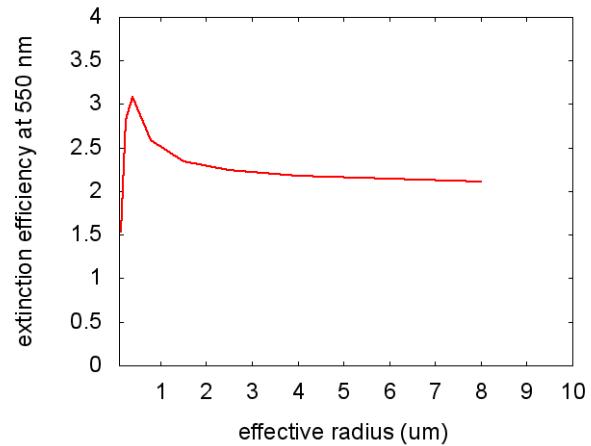
The dust cycle. Impact on transportation

$$V = \frac{3.912}{\beta}$$

Koschmieder eq.

$$\beta_\lambda = \sum_{k=1}^N \sigma_k Q_{k\lambda}$$

$$\beta_\lambda = \sum_{k=1}^N \frac{3}{4} \frac{c_k}{r_k \rho_k} Q_{k\lambda}$$



Tegen and Lacis (1996)



The dust cycle. Solar energy

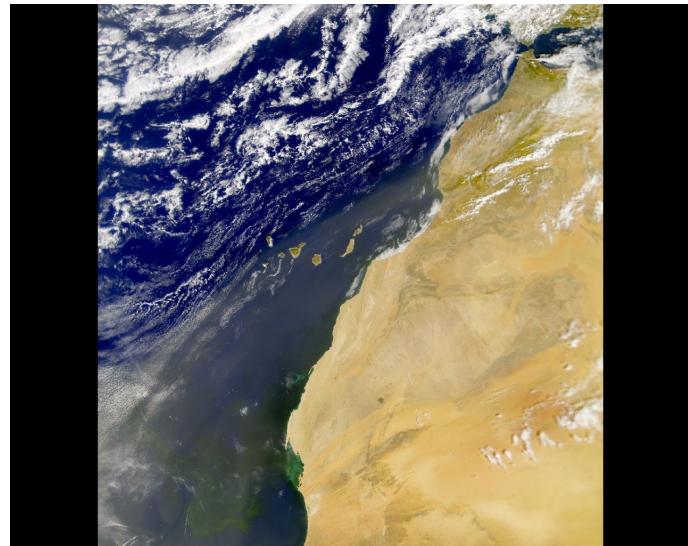
- Reduction of available energy
- Reduction of efficiency due to dust deposition



The dust cycle. Agriculture, fishing



SeaWiFS



Morocco



Summary

- Atmospheric aerosol
- The cycle of mineral dust
- **WMO SDS-WAS**
- Barcelona Dust Forecast Center
- Dust observation
- Dust forecast

WMO SDS-WAS

Mission:

Enhance the capacity of countries to generate and distribute to end-users dust observations, forecasts, information and knowledge

Structure:

Regional center for Northern Africa, Middle East and Europe, Barcelona

Regional Center for Asia, Beijing

Regional Center for Pan-America, Barbados

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)



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación

Campus UPC. Edificio Nexus II



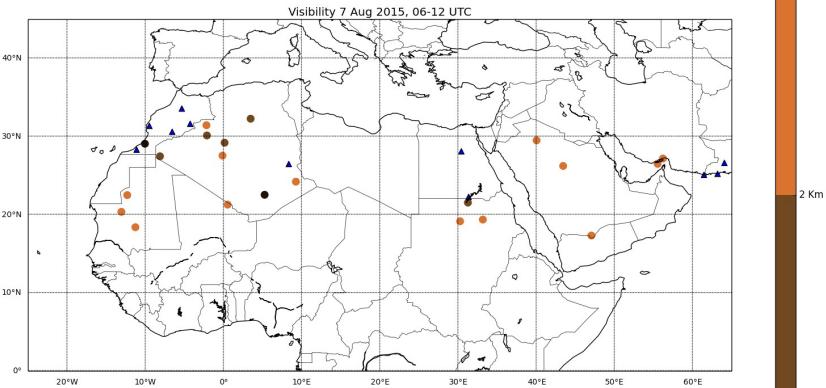
MareNostrum III supercomputer



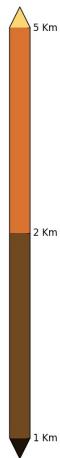
OBJETIVES:

- **Identify and improve products for observation and prediction of airborne dust, in collaboration with research and operational institutions, as well as end-users**
- **Facilitate the user access to information**
- **Build capacity of countries to use the provided products**

WMO SDS-WAS. RC developments



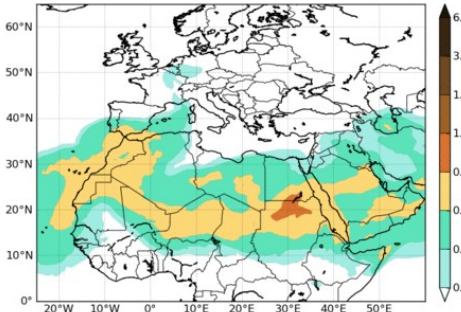
7 Aug 2015 06-12 UTC



9 Aug 2015

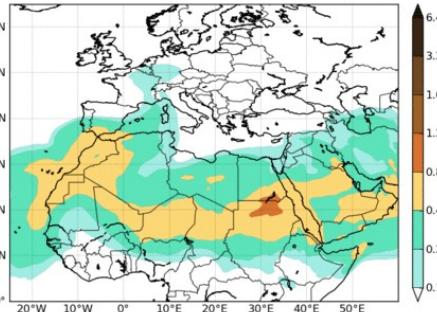
WMO SDS-WAS N Africa-Middle East-Europe RC
MEDIAN Dust AOD

Run: 12h 09 AUG 2015 Valid: 12h 09 AUG 2015 (H+00)



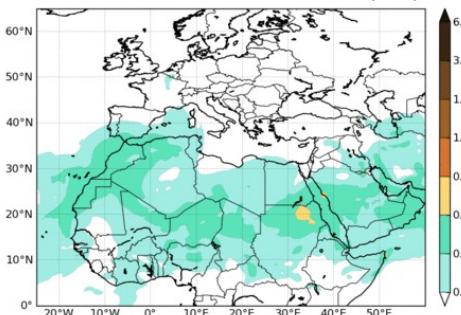
WMO SDS-WAS N.Africa-Middle East-Europe RC
MEAN Dust AOD

Run: 12h 09 AUG 2015 Valid: 12h 09 AUG 2015 (H+00)



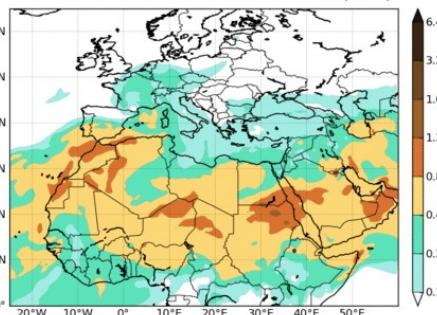
WMO SDS-WAS N.Africa-Middle East-Europe RC
STDEV Dust AOD

Run: 12h 09 AUG 2015 Valid: 12h 09 AUG 2015 (H+00)



WMO SDS-WAS N.Africa-Middle East-Europe RC
RANGE Dust AOD

Run: 12h 09 AUG 2015 Valid: 12h 09 AUG 2015 (H+00)



WMO SDS-WAS. RC's web portal

NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

Log In

World Meteorological Organization

AEWA
AEWA
AEMET
European Monitoring Center

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Northern Africa-Middle East-Europe (NA-ME-E) Regional Center

by Francesco Belincasa — last modified May 29, 2012 02:03 PM

Outstanding

- Guidance for forecasters
- 11 Lectures on atmospheric mineral dust
- Forecast evaluation
- Compared dust forecasts

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Latest News

Back trajectories are now available
Sep 04, 2012

Comparison of dust models
Aug 29, 2012

User data and quicklooks
Aug 29, 2012

Upcoming Events

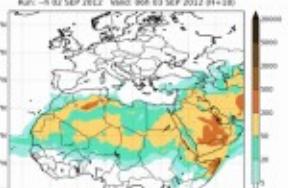
European Aerosol Conference EAC-2012
Sep 02, 2012 - Sep 07, 2012 — Granada, Spain

2012 EUMETSAT Meteorological Satellite Conference
Sep 03, 2012 - Sep 07, 2012 — Szczecin, Poland

9th International Symposium on Tropospheric Profiling
Sep 03, 2012 - Sep 07, 2012 — Szczecin, Poland

Dust forecasts

WMO SDS-WAS Northern Africa-Middle East-Europe RC
MEDIAN - Dust Surface Concentration (ug/m³)
Run: n 02 SEP 2012 - Valid: 00 03 SEP 2012 (01-100)



Compared Dust Forecasts

WMO SDS-WAS Northern Africa-Middle East-Europe RC
MEDIAN - Dust Surface Concentration (ug/m³)
Run: n 02 SEP 2012 - Valid: 00 03 SEP 2012 (01-100)



Forecast Evaluation

Dust observations

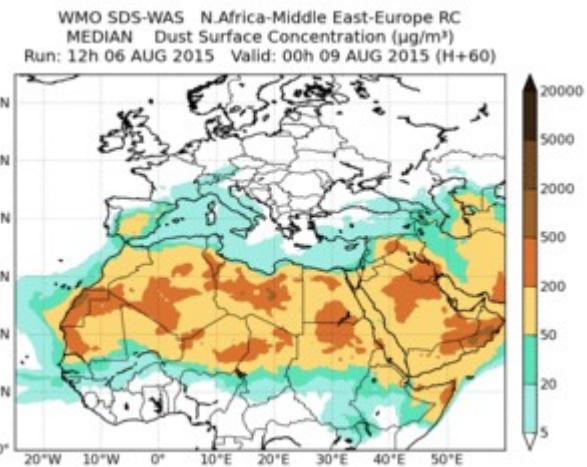
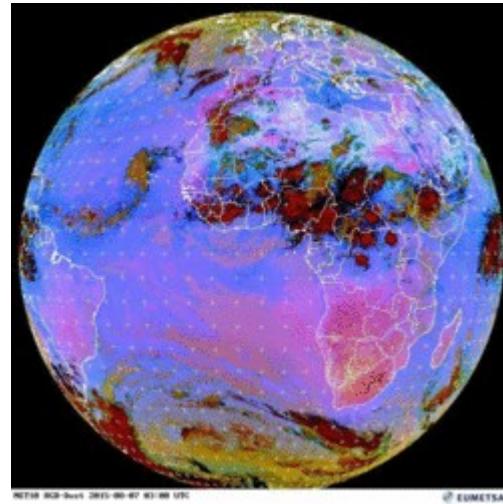
WMO SDS-WAS Northern Africa-Middle East-Europe RC
MEDIAN - Dust Surface Concentration (ug/m³)
Run: n 02 SEP 2012 - Valid: 00 03 SEP 2012 (01-100)



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

WMO SDS-WAS. RC's web portal

- SDS-WAS
- OBSERVATION
 - In-situ
 - Visibility
 - AERONET
 - Lidar
 - Satellites
- PREDICTION
 - Model comparison
 - Models download
 - Multi-model products
 - Forecast evaluation
- PROJECTS & RESEARCH
- MATERIALS
- NEWS
- EVENTS



WMO SDS-WAS. Capacity building



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

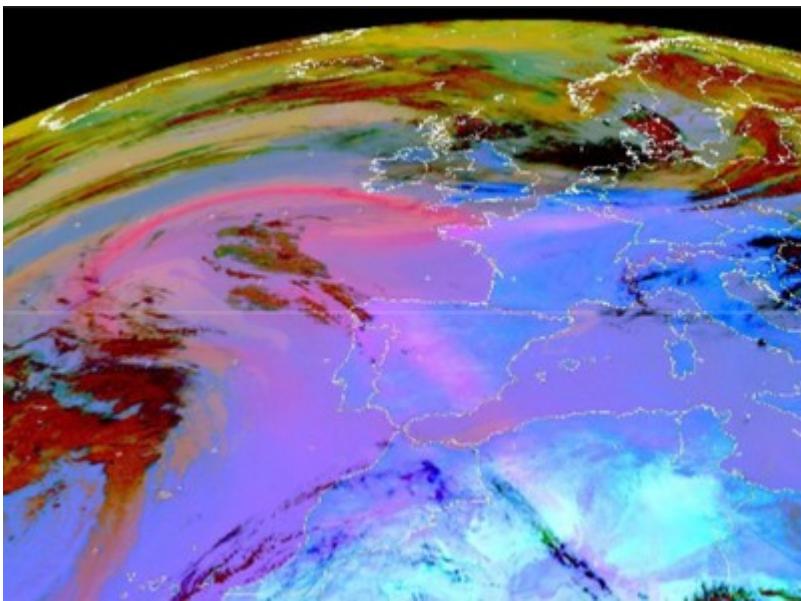


Sultan Qaboos University
**Barcelona
Supercomputing
Center**
Centro Nacional
de Supercomputación



**TRAINING
COURSES**
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Addis-Ababa
Ankara
Antalya
Barcelona
Casablanca
Istanbul
Muscat
Niamey
Ouagadougou
Tbilisi
Tehran

WMO SDS-WAS. Collaborative studies



Prediction of the Saharan dust outbreak into Europe of April 2011. Leader: Nicolas Huneeus



Models / Lidar comparison. Leader: Ioannis Binietoglou



Study of a haboob in Tehran.
Leader: Ana Vukovic

Summary

- Atmospheric aerosol
- The cycle of mineral dust
- WMO SDS-WAS
- **Barcelona Dust Forecast Center**
- Dust observation
- Dust forecast

Barcelona Dust Forecast Center



May 2013

WMO designates the consortium of AEMET and BSC to host the first RSMC-ASDF. The Centre will generate and distribute operationally dust forecasts for Northern Africa, Middle East and Europe.

Feb 2014

The Centre starts operations under the name of **Barcelona Dust Forecast Center** (BDFC)

Barcelona Dust Forecast Center

BARCELONA DUST FORECAST CENTER

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➤ Evaluation
➤ Methods
➤ News
➤ Events
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LATEST NEWS

Establishing a WMO SDS-WAS Regional Node for West Asia

Training events in Muscat, Oman

Dust-related training events organized by the Regional Center for Northern Africa, Middle East and Europe of WMO SDS-WAS

[Read More](#)



• • •

Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Conc. (µg/m³)
Run: 12h 13 NOV 2013 Valid: 00h 14 NOV 2013 (H+12)



Dust forecast

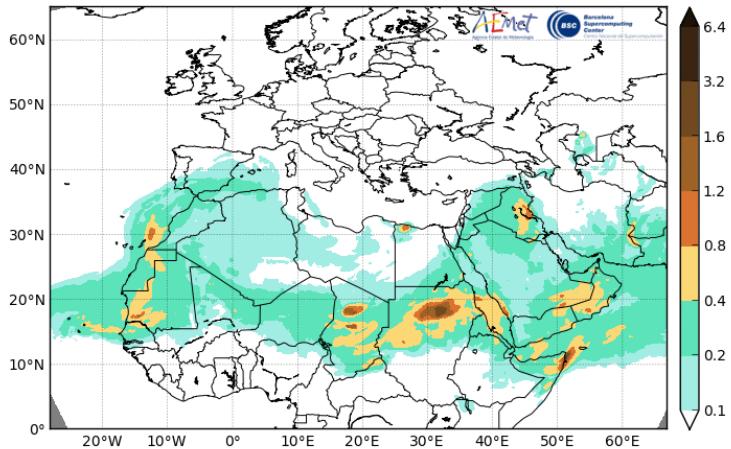
Latest dust forecast for Northern Africa, Middle East and Europe

[Check it here](#)

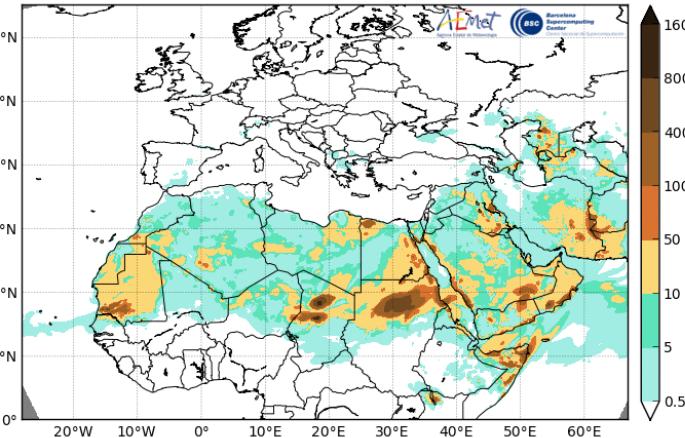
<http://dust.aemet.es>
dust.aemet.es

Barcelona Dust Forecast Center. Products

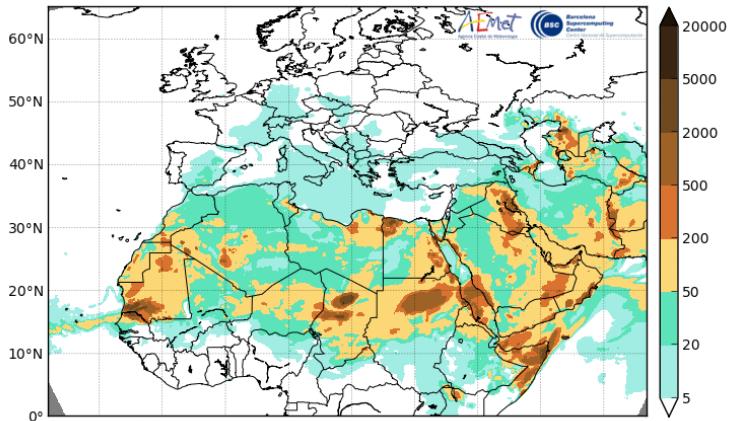
Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 06 AUG 2015 Valid: 12h 06 AUG 2015 (H+00)



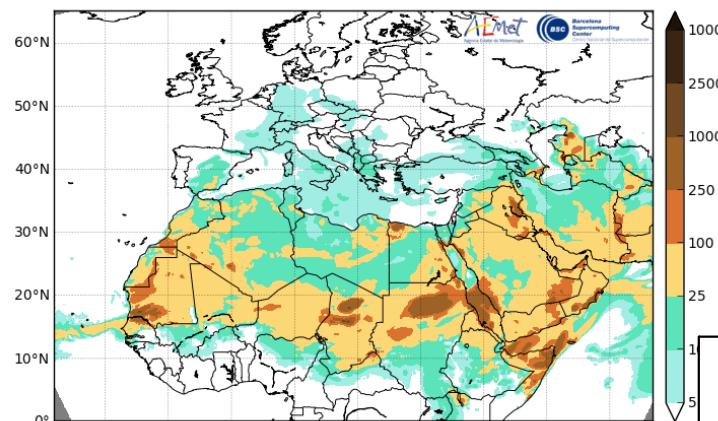
Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB/BSC-Dust Res:0.1°x0.1° 3h Acc. Dust Dry Depos. (mg/m²)
Run: 12h 06 AUG 2015 Valid: 12h 06 AUG 2015 (H+00)



Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Conc. (µg/m³)
Run: 12h 06 AUG 2015 Valid: 12h 06 AUG 2015 (H+00)

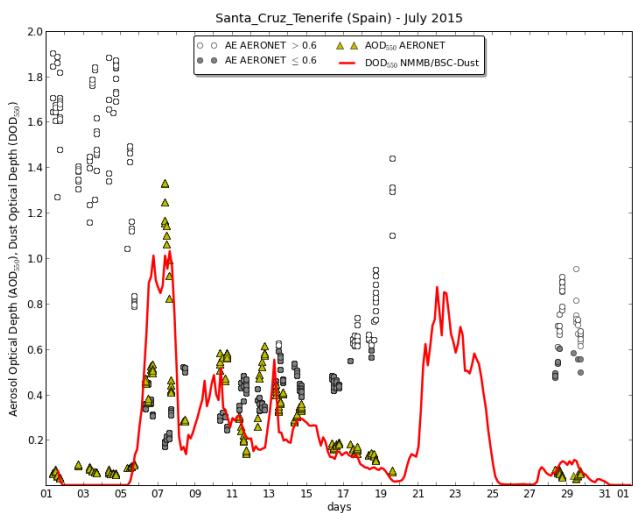


Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Ext. (Mm⁻¹)
Run: 12h 06 AUG 2015 Valid: 12h 06 AUG 2015 (H+00)

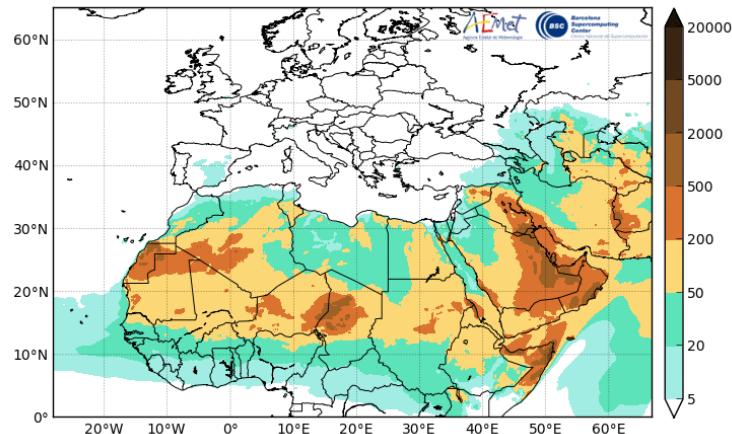


6 variables
Forecast: 0-72 h

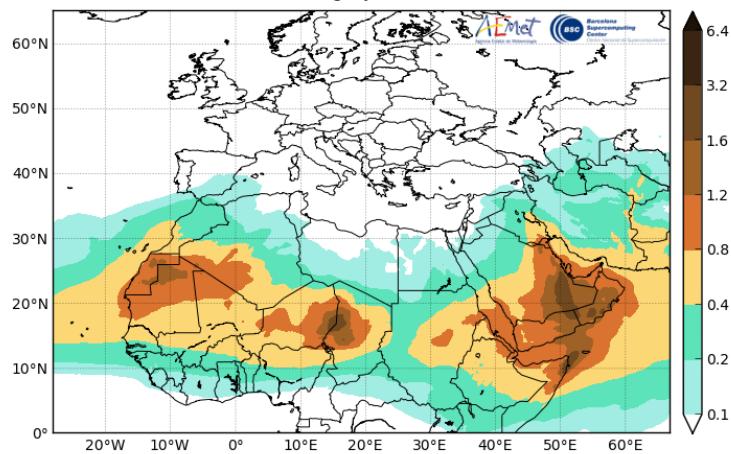
Barcelona Dust Forecast Center. Also...



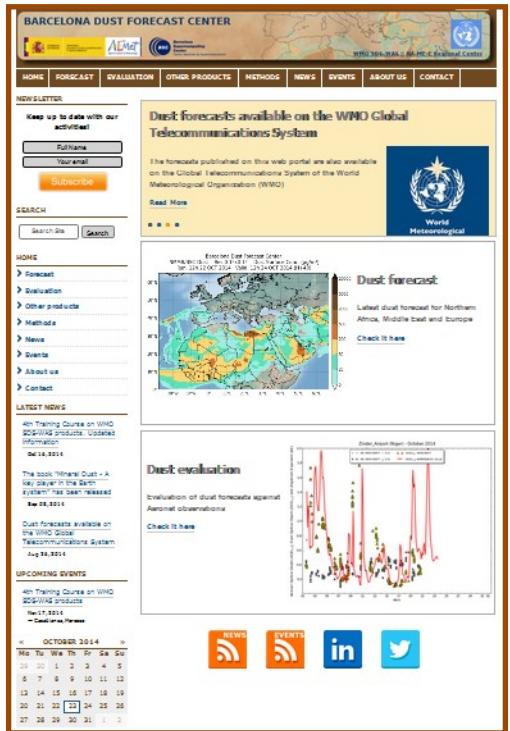
Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Conc. ($\mu\text{g}/\text{m}^3$)
Average: JUL 2015



Barcelona Dust Forecast Center - <http://dust.aemet.es/>
NMMB/BSC-Dust Res:0.1°x0.1° Dust Load (g/m^2)
Average: JUL 2015



Barcelona Dust Forecast Center. Dissemination

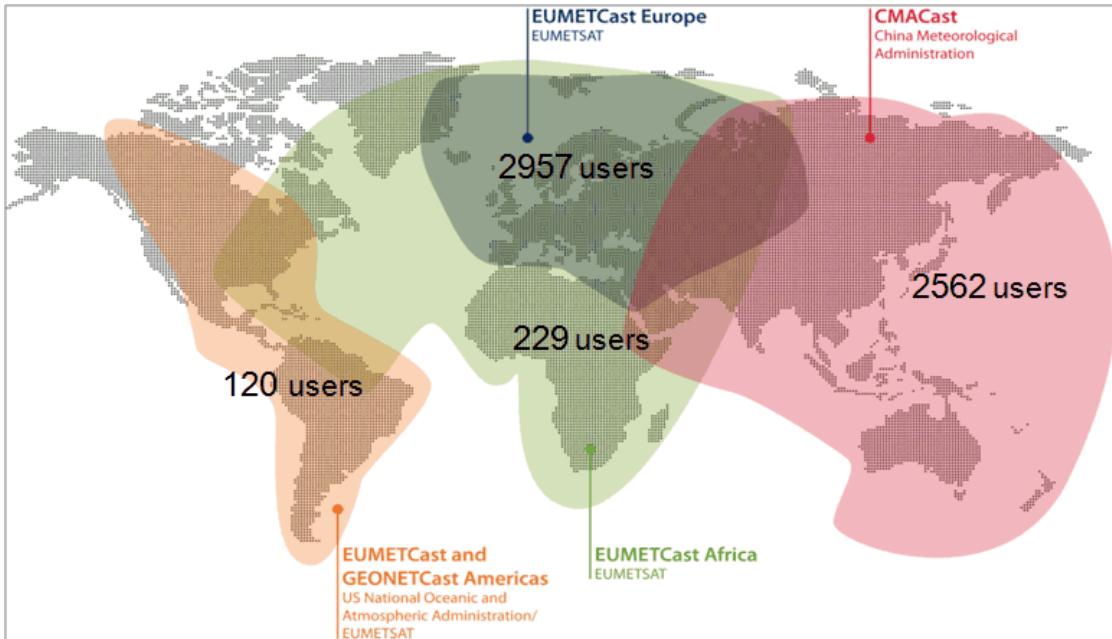


The screenshot shows the homepage of the Barcelona Dust Forecast Center. It features a top navigation bar with links for Home, Forecast, Evaluation, Other Products, Methods, News, Events, About Us, and Contact. Below this is a newsletter sign-up form and a search function. The main content area includes a map of Europe and North Africa showing dust forecasts, a chart of dust evaluation, and a calendar for October 2014. Social media icons for RSS, Events, LinkedIn, and Twitter are at the bottom.

<http://dust.aemet.es>

EUMETCast

WMO Global Telecommunications System



Barcelona Dust Forecast Center. Dissemination



<http://uneplive.unep.org>



Summary

- Atmospheric aerosol
- The cycle of mineral dust
- WMO SDS-WAS
- Barcelona Dust Forecast Center
- **Dust observation**
- Dust forecast

Dust observation. Why?

- Monitoring dust events
- Data assimilation into numerical models
- Forecast evaluation
- Validation of other observations (I. e. ground observations to validate satellite products)

Mali, 2001

Photo: Remi Benali/Corbis

Dust observation. A comprehensive system

Ground observation

- In-situ (ie PM10)
- Indirect (visibility)

Ground-based remote sensing

- Photometers (ie AERONET)
- Lidar/Ceilometers

Satellite observation

- GEO satellites
- Polar satellites

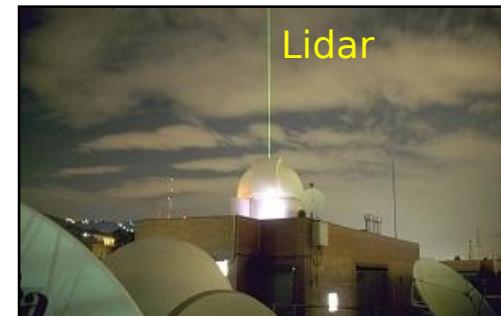
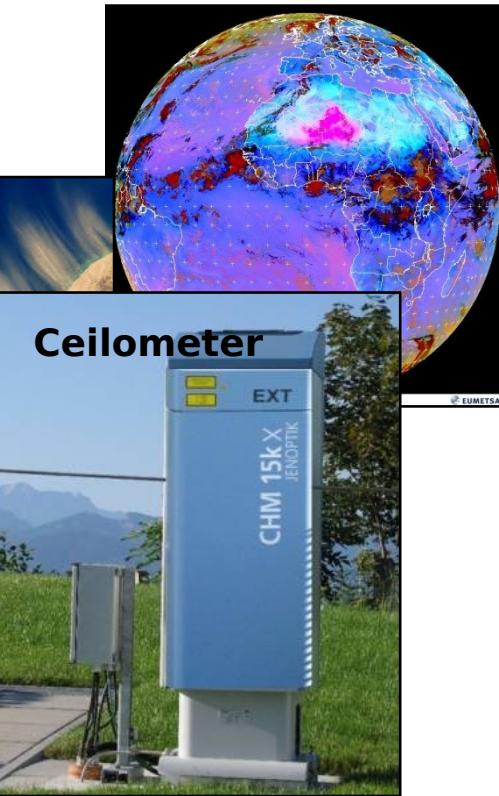
AQ station



Transmissometer



Sun photometer



Dust observation. In-situ



W_1



W_2



TEOM



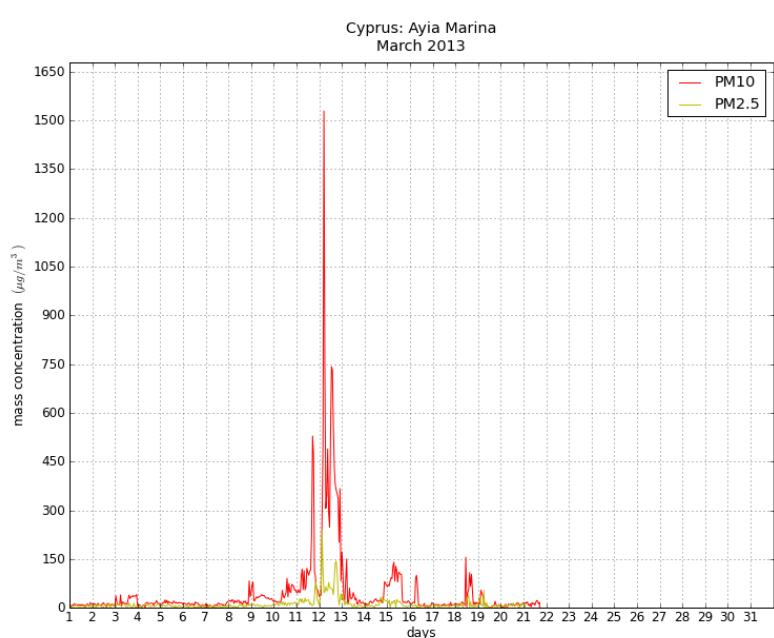
Beta

$$PM = \frac{(W_2 - W_1)}{\text{Volume}} \mu\text{g}/\text{m}^3$$

Dust observation. In-situ

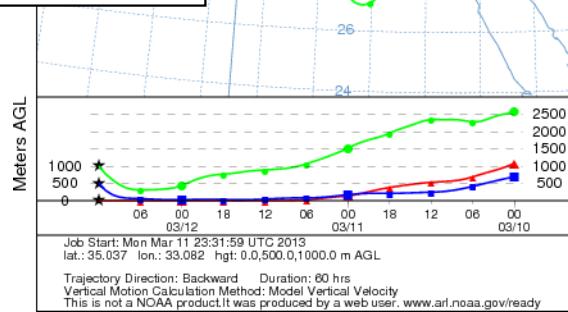
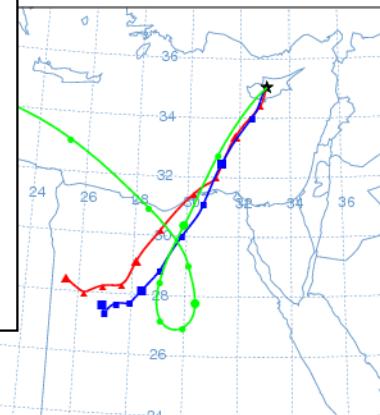


Dust observation. In-situ

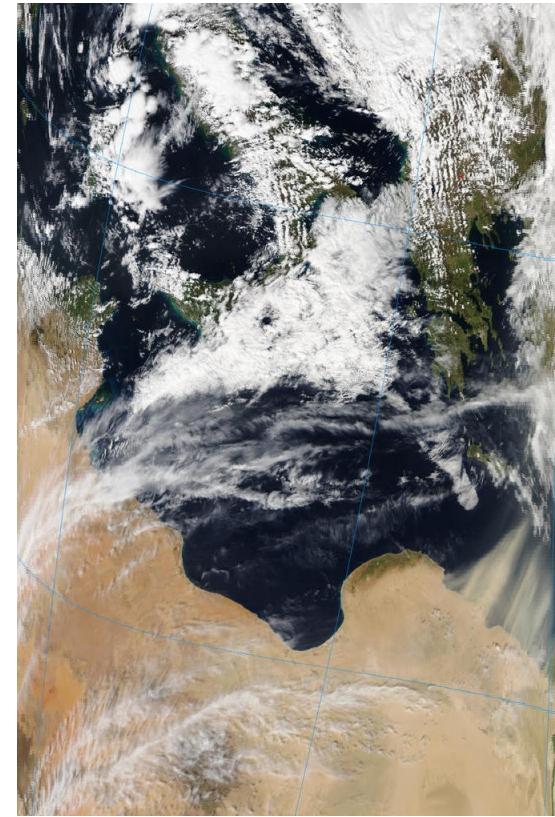


March 2013

NOAA HYSPLIT MODEL
trajectories ending at 1200 UTC 12 Mar 13
Mar GFSG Forecast Initialization

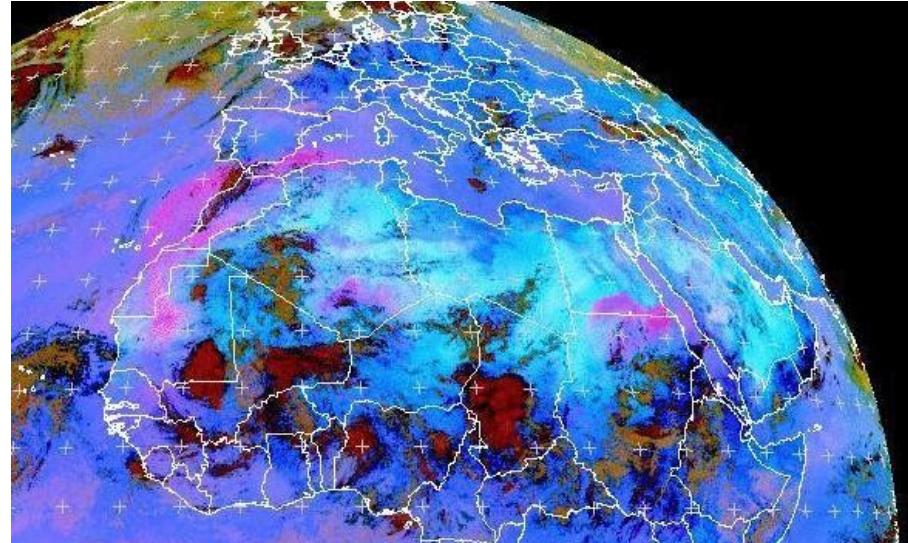
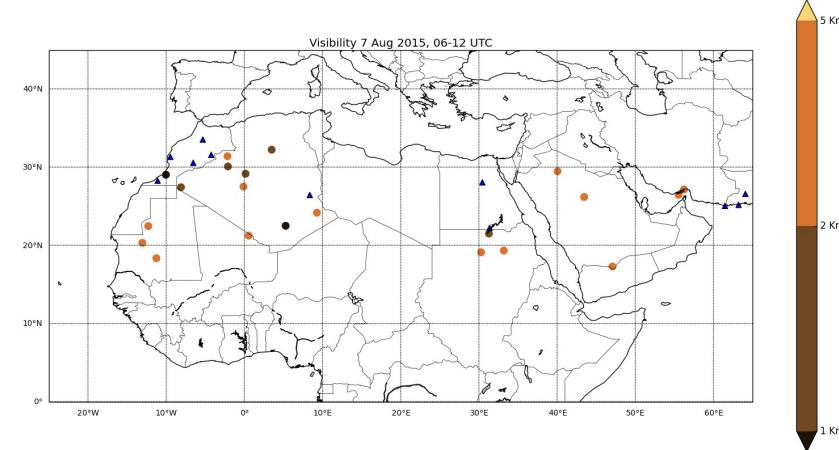
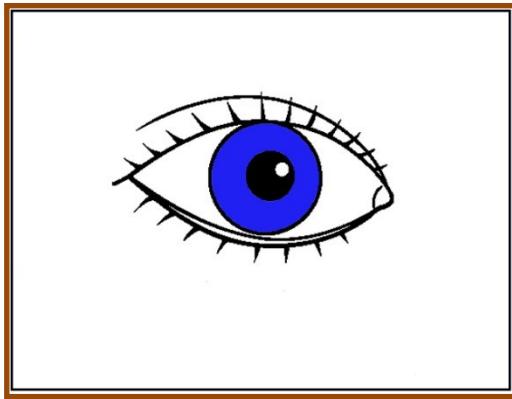


12 March 2013

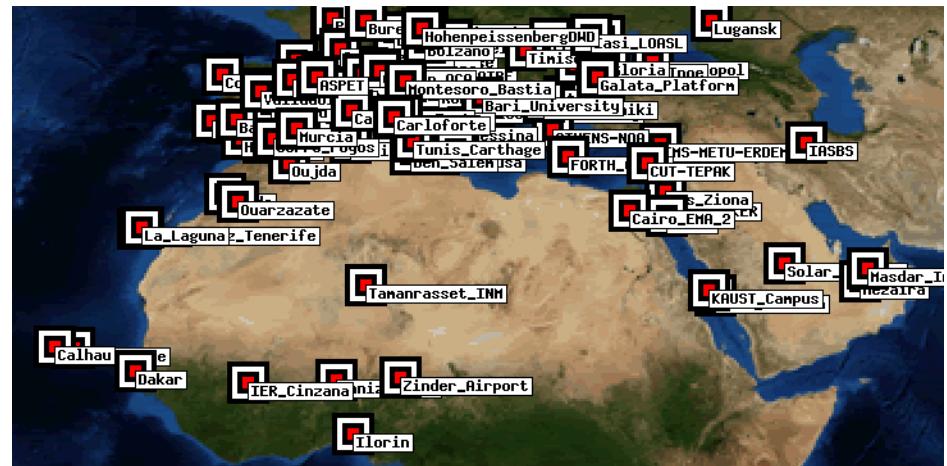


11 March 2013

Dust observation: Visibility

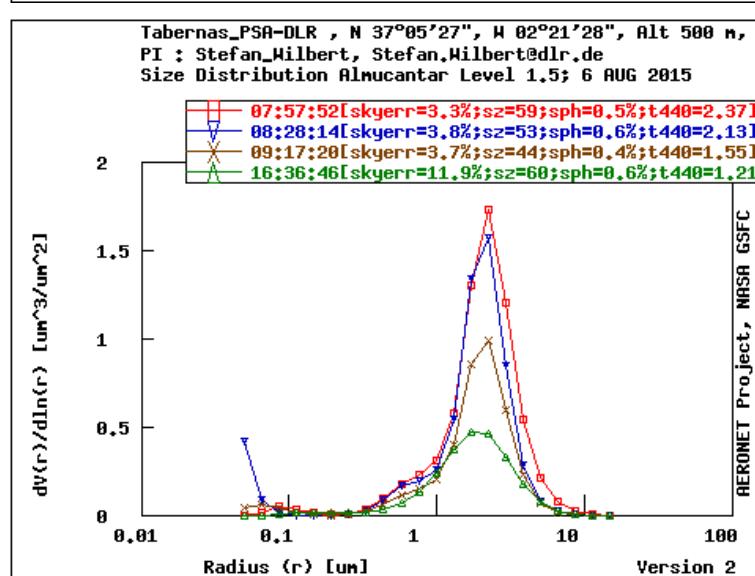
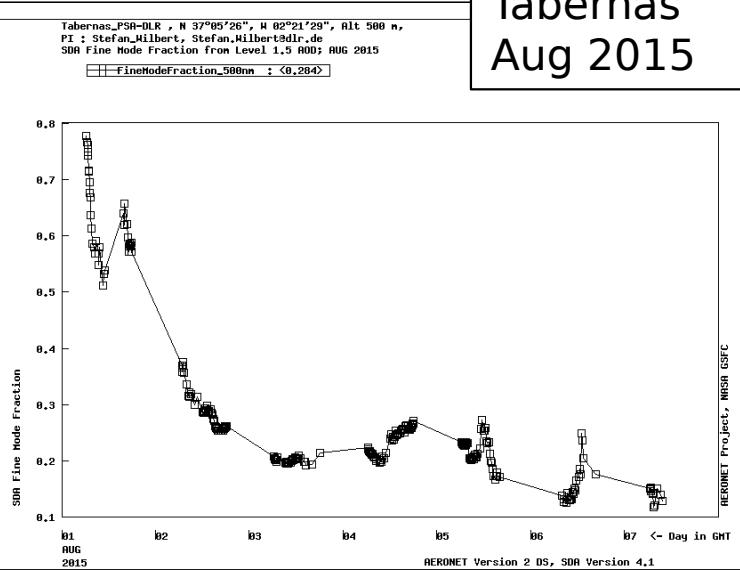
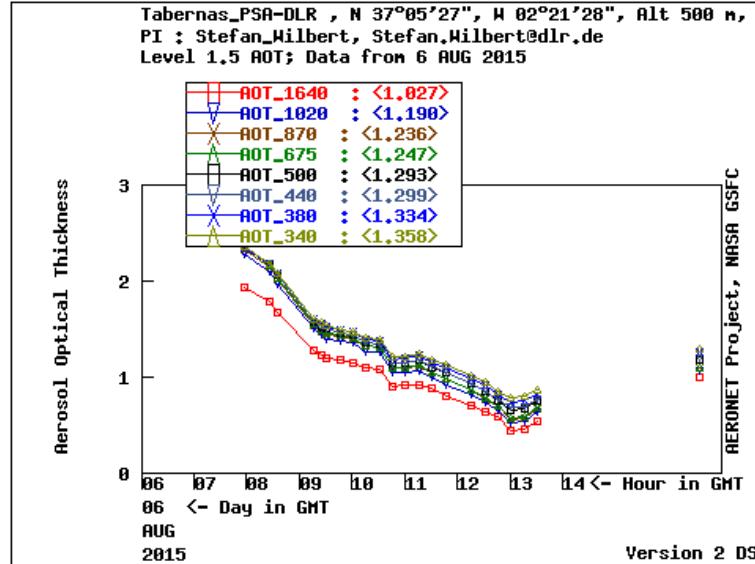
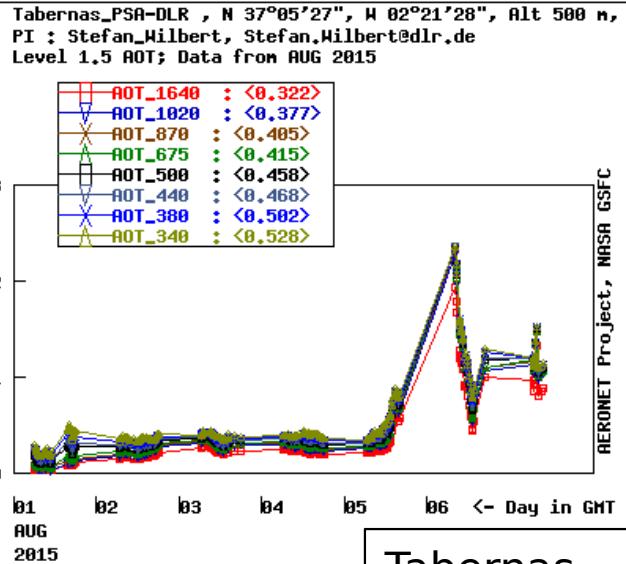


Dust observation. Sun-photometers

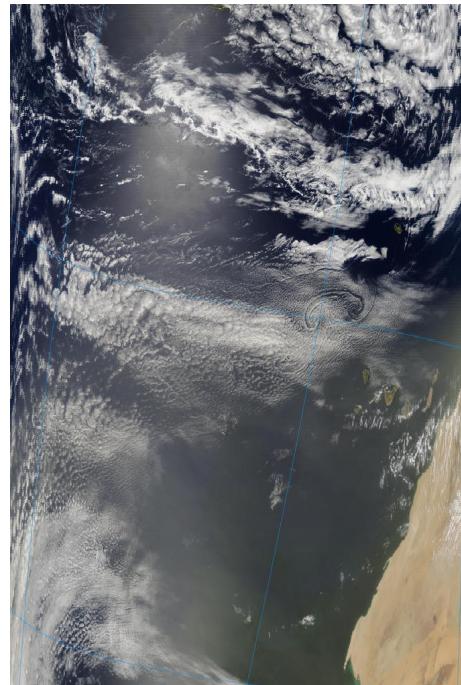
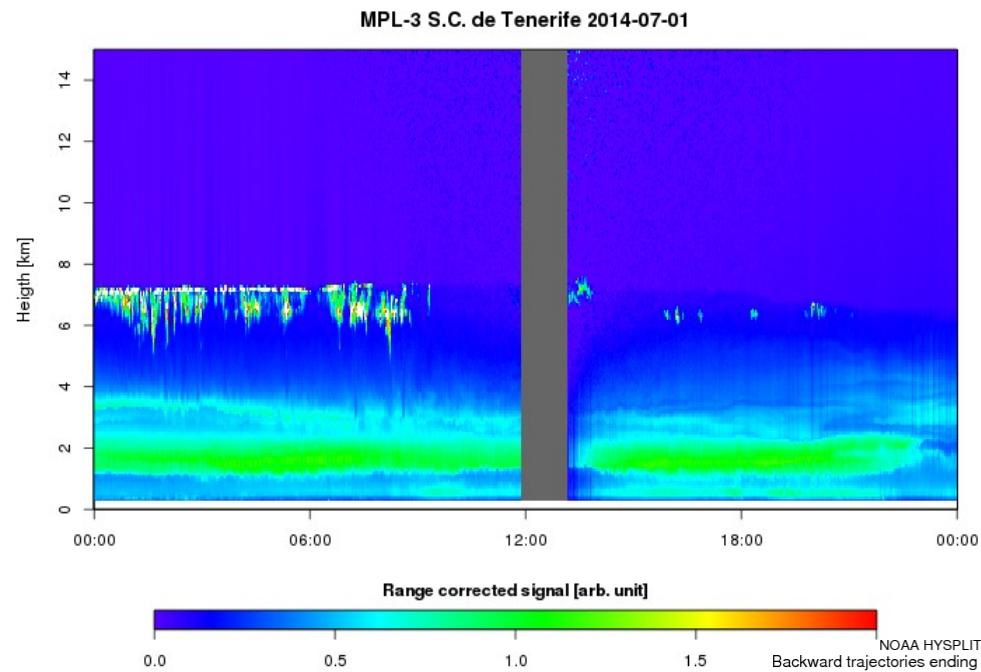


- Solar radiation at the TOA is known
- Airborne particles attenuate this radiation (absorption, scattering)
- Sun-photometers measure the direct radiation reaching the Earth's surface
- Measurement at different wavelengths allows retrieval of the aerosol contents and some of its properties (i. e. size distribution)

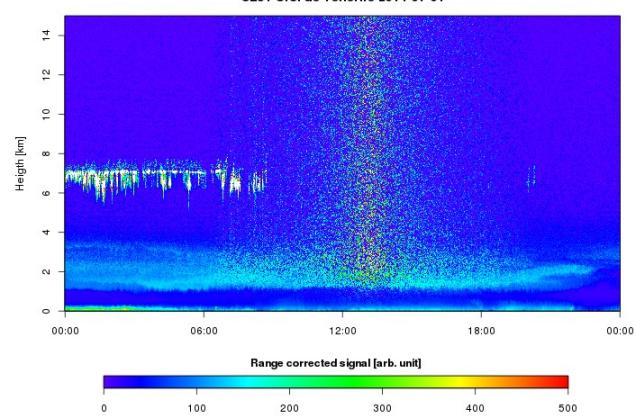
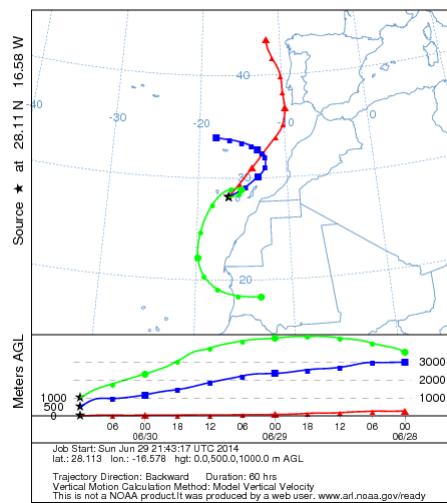
Dust observation. Sun photometers

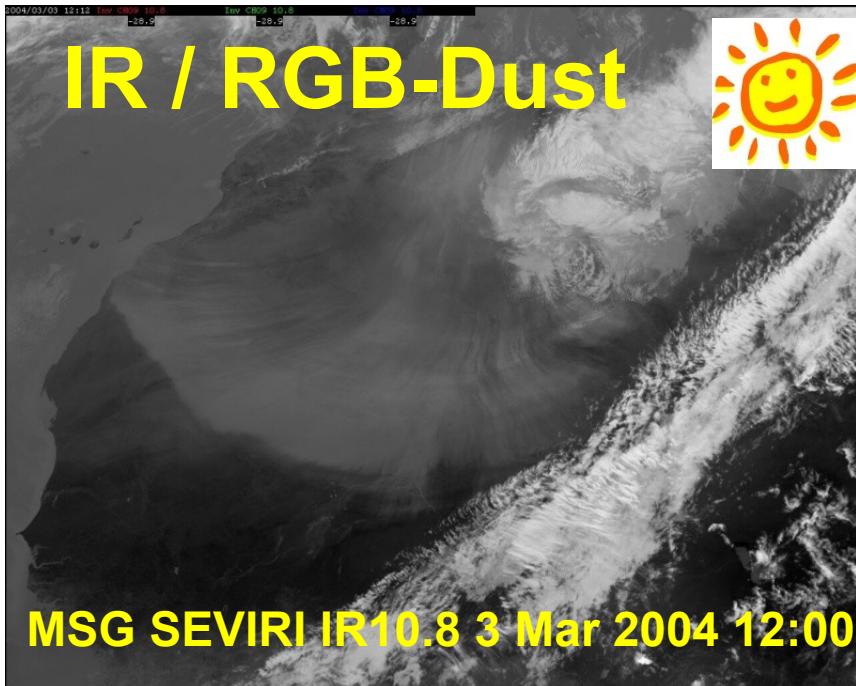


Dust observation. Lidar/ceilometers

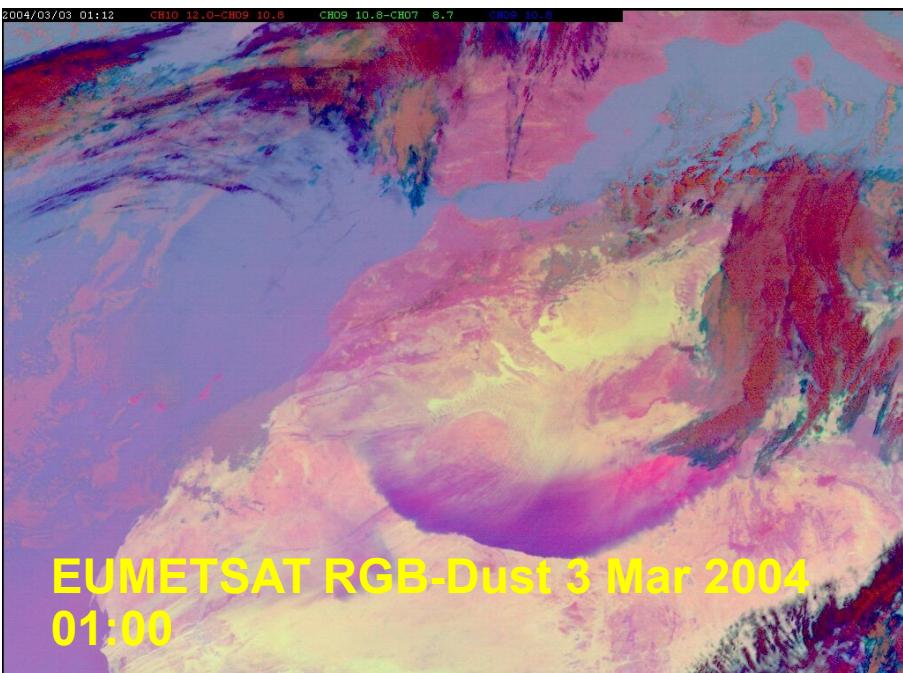
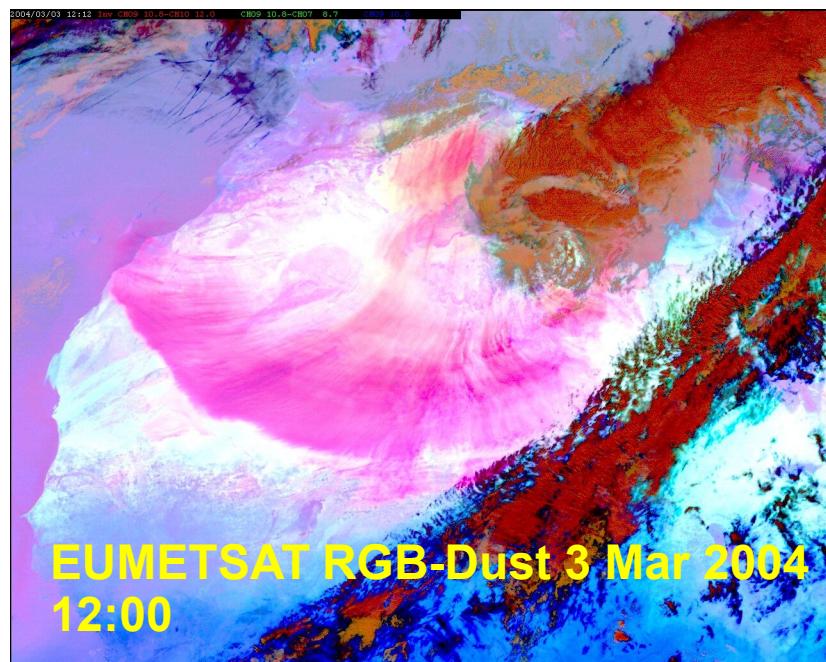
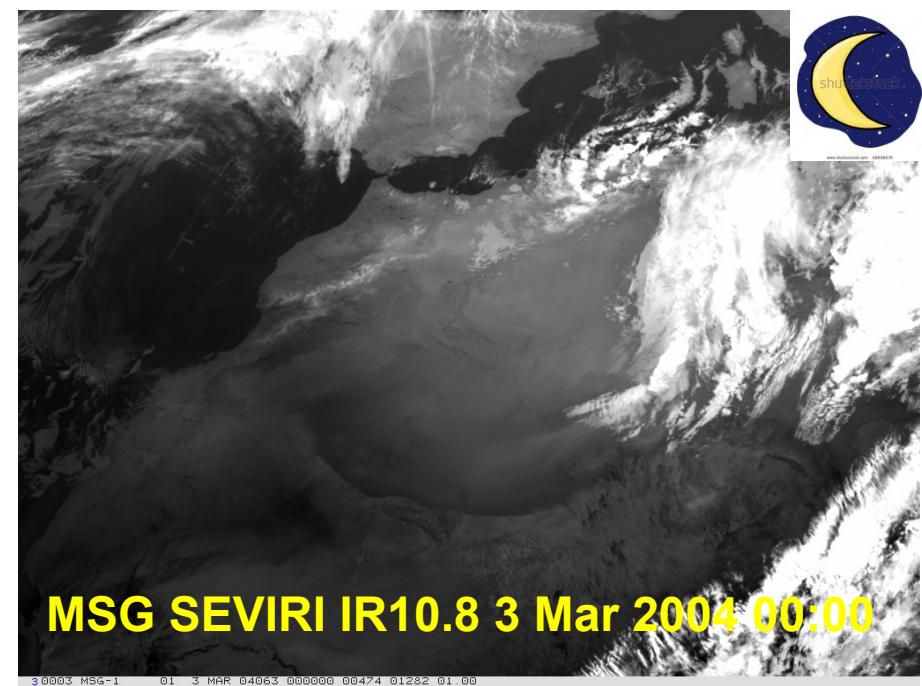


Sta. Cruz de Tenerife
1 July 2014

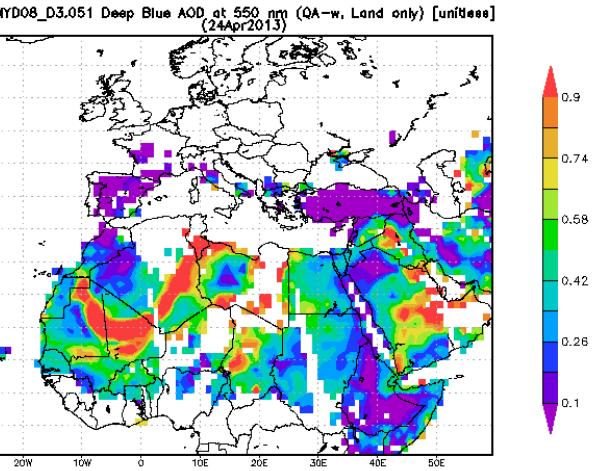
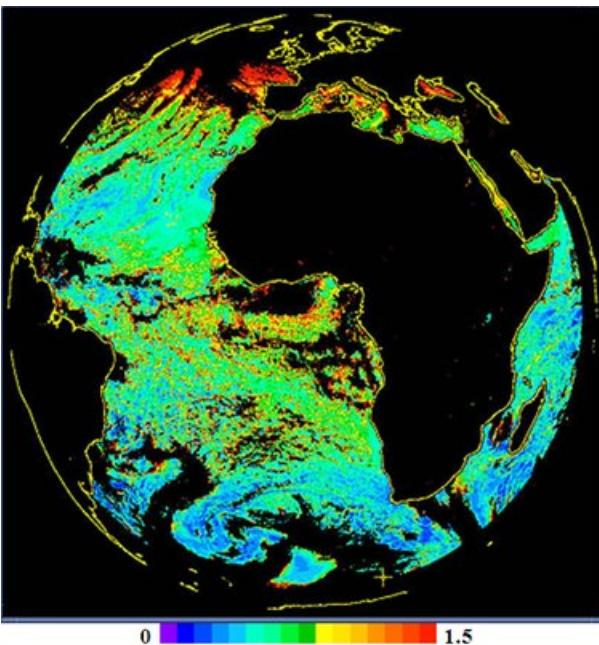
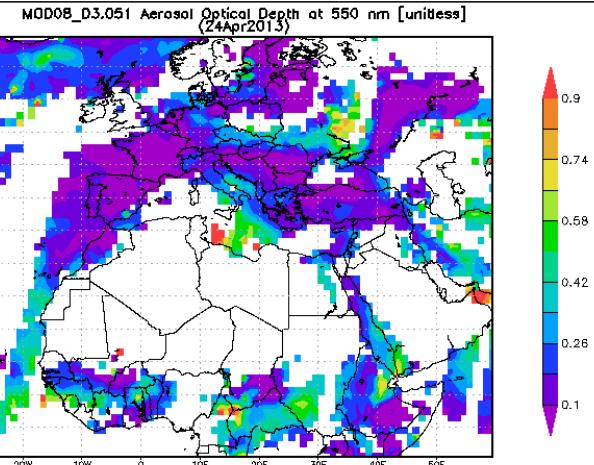
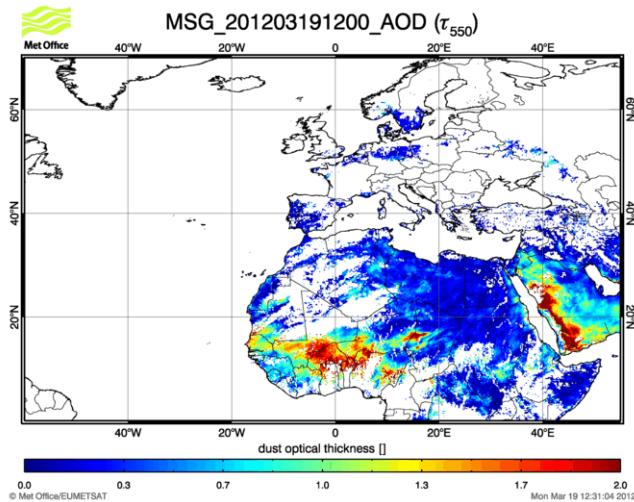




MSG SEVIRI IR10.8 3 Mar 2004 12:00



Dust observation. Quantitative retrievals



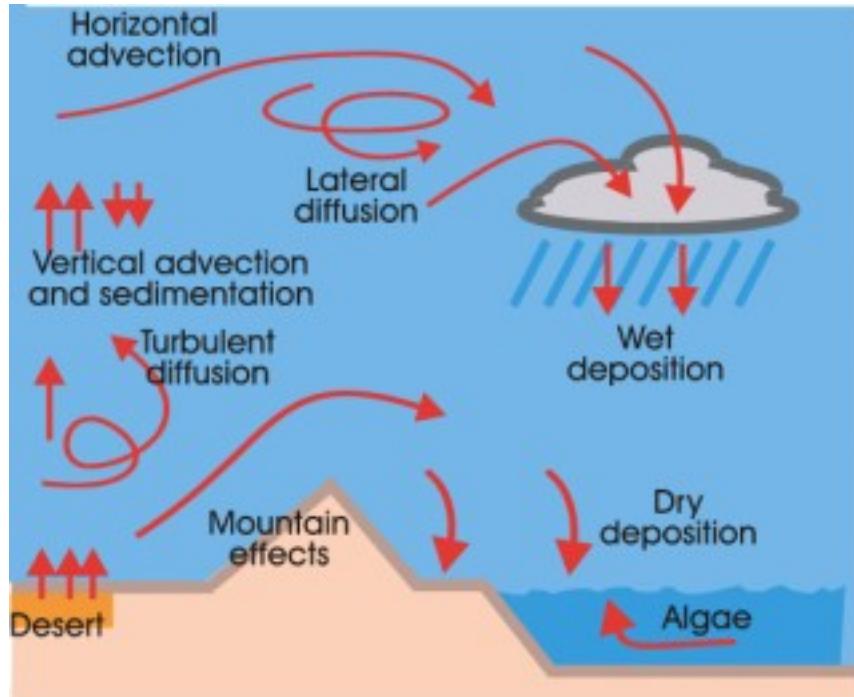
GODDARD
SPACE FLIGHT CENTER

Summary

- Atmospheric aerosol
- The cycle of mineral dust
- WMO SDS-WAS
- Barcelona Dust Forecast Center
- Dust observation
- **Dust forecast**

Dust forecast. Models

NWP model
+
Parametrization of dust cycle
=
Dust prediction model



- Emission
- Transport (diffusion, advection)
- Dry / wet deposition

- Interaction with radiation
- Interaction with cloud droplets
- Atmospheric chemistry
- ...

Dust forecasts. Problems

- Incomplete knowledge of the physical processes involved in the dust cycle
- Processes of very different scales
- Need of a very precise wind forecast
- Lack of suitable observations for data assimilation and forecast evaluation

Tegen et al. (1994)

$$F = \sum_i c_i u^2 (u - 6.5)$$

Marticorena et al. (1997)

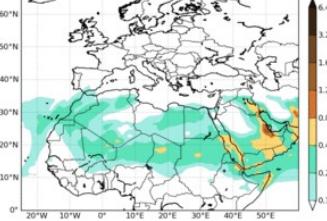
$$F = \alpha \frac{\rho}{g} u_*^3 \sum_i s_i \left(1 + \frac{u_{*tri}}{u_*}\right) \left(1 - \frac{u_{*tri}^2}{u_*^2}\right)$$

Ginoux et al. (2001)

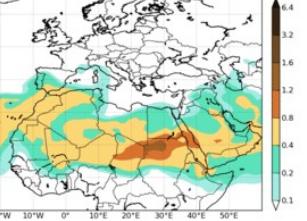
$$F = CS \sum_i u^2 s_i w_0 (u - u_{tri})$$

Dust forecasts. SDS-WAS model intercomparison

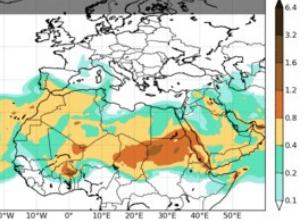
WMO SDS-WAS N.Africa-Middle East-Europe RC
BSC-DREAMBb Dust AOD
Run: 12h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+00)



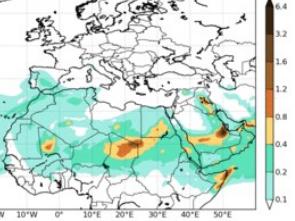
WMO SDS-WAS N.Africa-Middle East-Europe RC
MACC-ECMWF Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



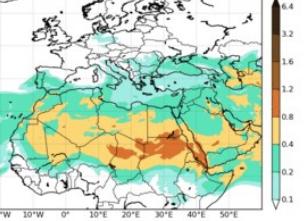
WMO SDS-WAS N.Africa-Middle East-Europe RC
DREAMB-NMME-MACC Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



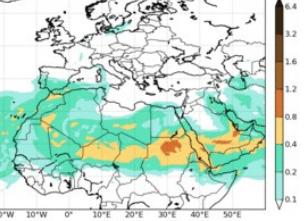
WMO SDS-WAS N.Africa-Middle East-Europe RC
NNMB/BSC-Dust Dust AOD
Run: 12h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+00)



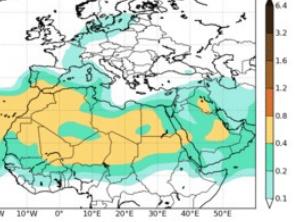
WMO SDS-WAS N.Africa-Middle East-Europe RC
U.K. MetOffice Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



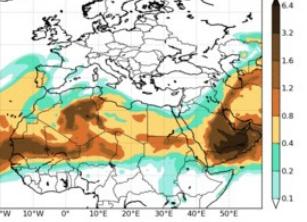
WMO SDS-WAS N.Africa-Middle East-Europe RC
NASA GEOS-5 Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



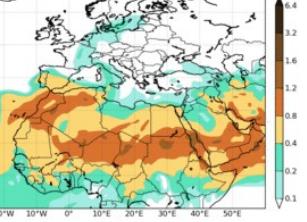
WMO SDS-WAS N.Africa-Middle East-Europe RC
NCEP NGAC Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



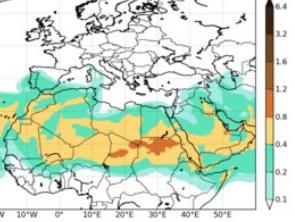
WMO SDS-WAS N.Africa-Middle East-Europe RC
EMA RegCM4 Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



WMO SDS-WAS N.Africa-Middle East-Europe RC
DREAMBOL Dust AOD
Run: 00h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+12)



WMO SDS-WAS N.Africa-Middle East-Europe RC
MEDIAN Dust AOD
Run: 12h 10 AUG 2015 Valid: 12h 10 AUG 2015 (H+00)



10 Aug 2015



**Barcelona
Supercomputing
Center**

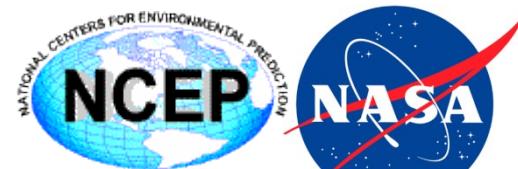
Centro Nacional de Supercomputación



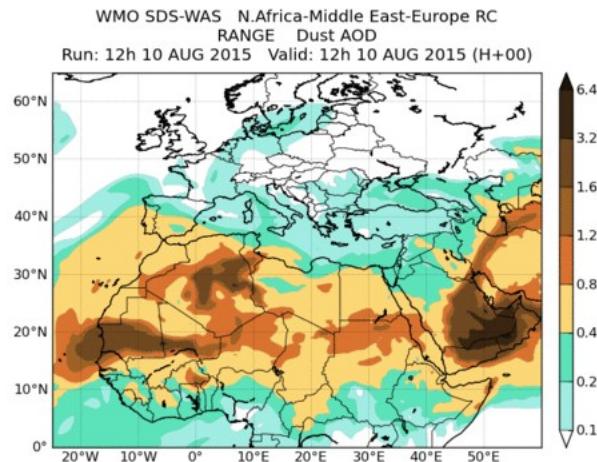
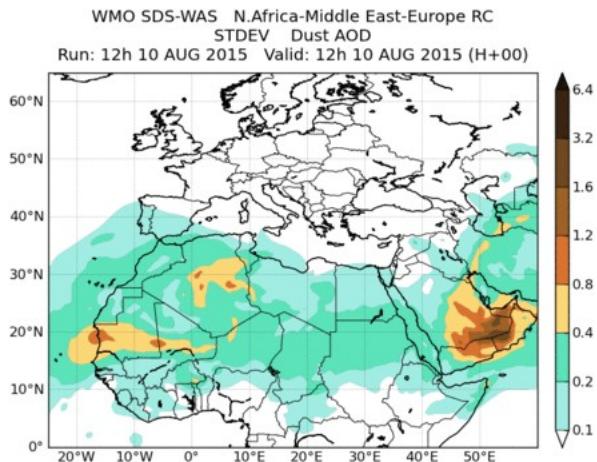
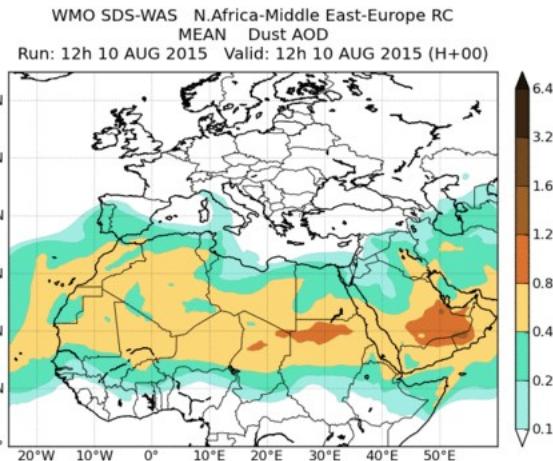
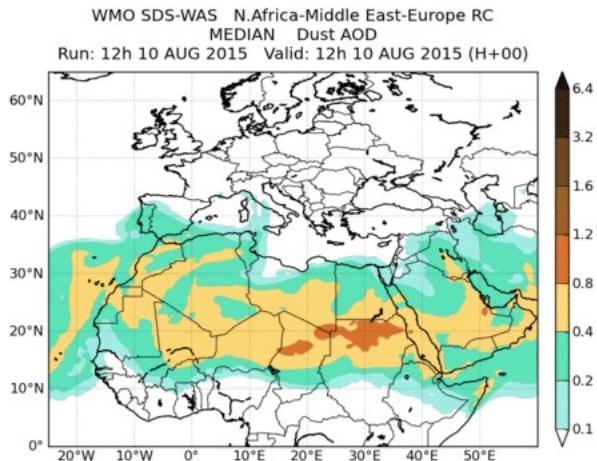
macc
Monitoring atmospheric
composition & climate



Met Office

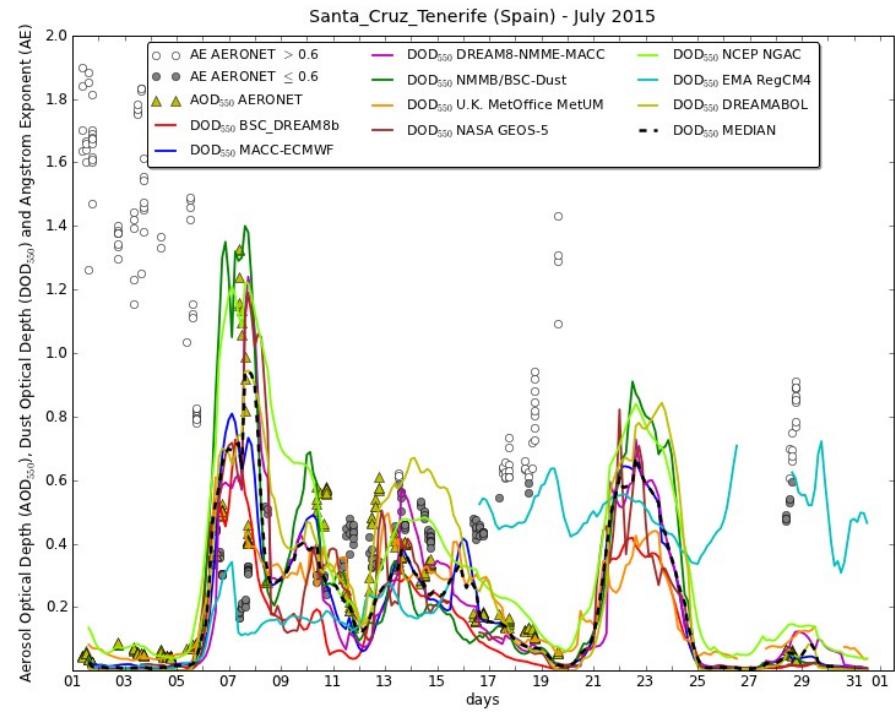


Dust forecasts. Multi-model products



10 Aug 2015

Dust forecasts. SDS-WAS forecast evaluation



Santa Cruz de Tenerife (Spain)
July 2015

Dust forecasts. SDS-WAS forecast evaluation

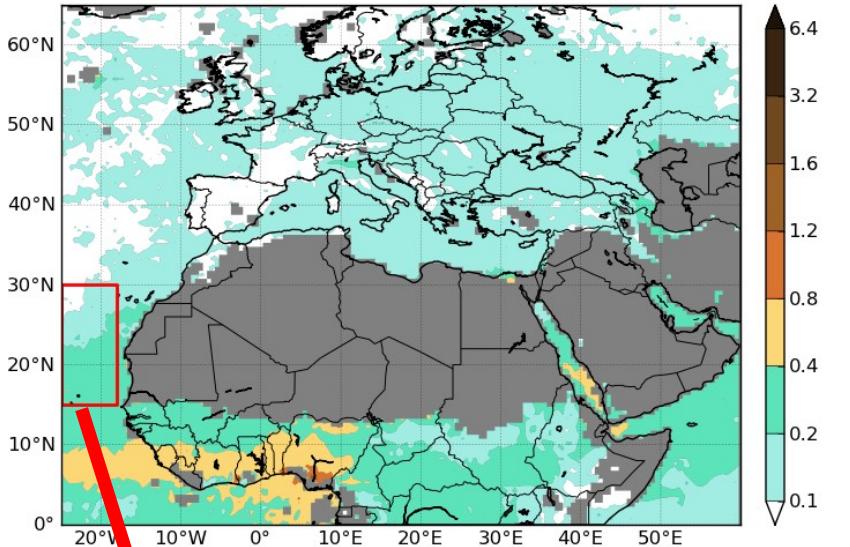
CORRELATION COEFFICIENT

	BSC_DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	MEDIAN
Sahel/Sahara show stations	0.53	0.56	0.47	0.53	0.57	0.58	0.60	0.25	0.30	0.62
Middle East show stations	0.36	0.36	0.44	0.42	0.36	0.37	0.32	0.29	0.20	0.35
Mediterranean show stations	0.38	0.51	0.40	0.48	0.47	0.49	0.46	0.20	0.34	0.51
TOTAL	0.51	0.56	0.47	0.54	0.56	0.58	0.58	0.28	0.35	0.61

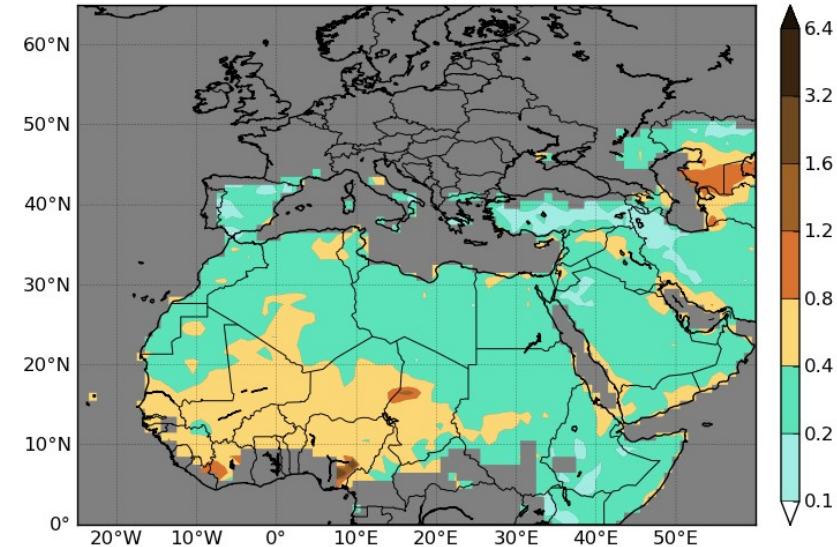
2014

Dust forecasts. SDS-WAS forecast evaluation

WMO SDS-WAS N.Africa-Middle East-Europe RC
MODIS AOD₅₅₀ - 2014

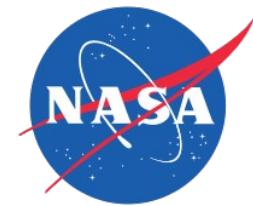


WMO SDS-WAS N.Africa-Middle East-Europe RC
MODIS DEEPBLUE AOD₅₅₀ - 2014



	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.14	0.20	0.72	1.07	22154
NMMB/BSC-Dust	-0.13	0.18	0.79	1.09	22154
NCEP NGAC	0.04	0.15	0.81	0.59	21608
EMA RegCM4	-0.04	0.37	0.26	1.09	13300
DREAMABOL	-0.04	0.17	0.69	0.92	13611

MODIS



2014

Thanks for your attention

R&D

NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

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Northern Africa-Middle East-Europe (NA-ME-E) Regional Center

by Francisco Gutiérrez - last modified May 29, 2012 22:22 PM

Outstanding

Guidelines for forecasters

13沙尘暴和沙尘暴矿物尘埃

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Compared dust forecast

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Under Sand and guidelines

Aug 26, 2012

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European Arrest Conference

SDS-WAS

Aug 22, 2012 - Aug 27, 2012 - Geneva, Switzerland

2012 WMO Meteorological Satellite Conference

Aug 26, 2012 - Sep 07, 2012 - Rome, Italy

20th International Symposium on Tropospheric Profiling

Dust forecasts

WMO SDS-WAS Northern Africa-Middle East-Europe Regional Center - May 29, 2012 - May 29, 2012 22:00 UTC - May 29, 2012 00:00 UTC

Compared Dust Forecast

Forecast Evaluation

Dust observations

Operational Forecast

BARCELONA DUST FORECAST CENTER

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Eastern East Europe (Aug 29, 2012 - Sep 05, 2012 00:00 UTC - Sep 05, 2012 06:00 UTC)

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Nov 17, 2012

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OCTOBER 2014

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