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AXA
Research Fund
Through Research, Protection

Dust Storms: characteristics, effects and prediction

Dr. Carlos Pérez García-Pando

AXA Professor on Sand and Dust Storms

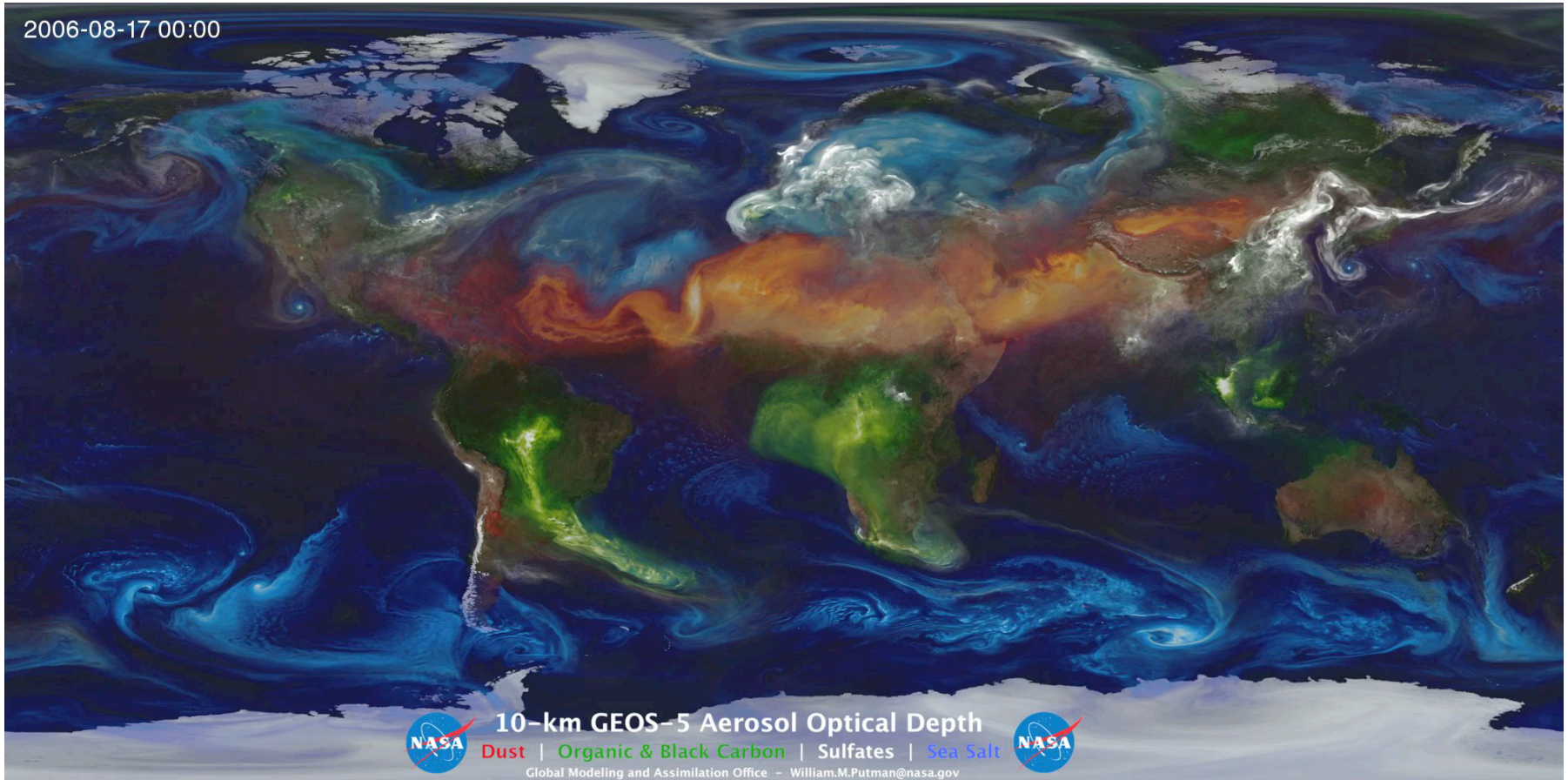
Head of Atmospheric Composition

Department of Earth Sciences

14/11/2016

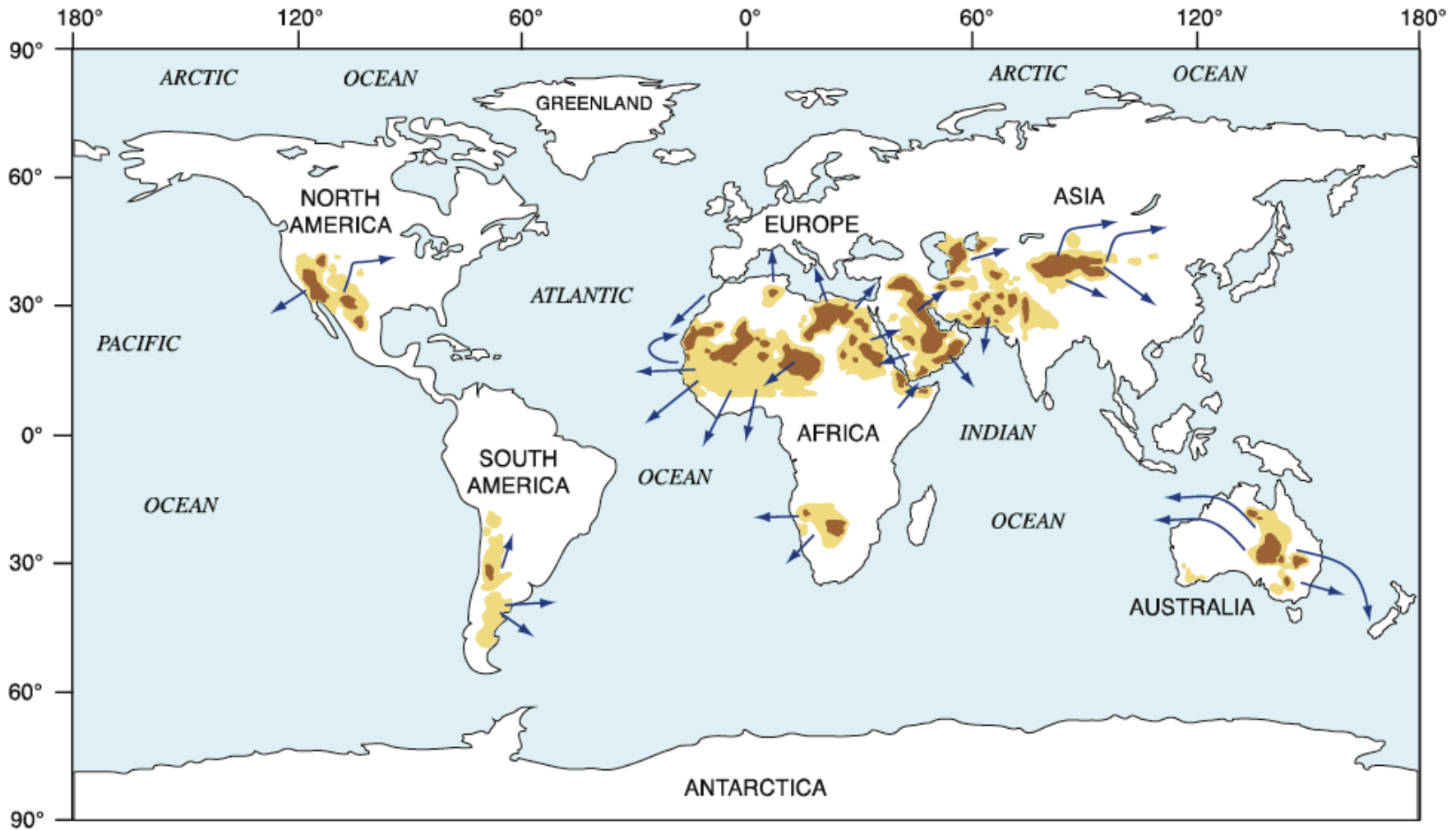
Atmospheric aerosol and the dominance of mineral dust

2006-08-17 00:00



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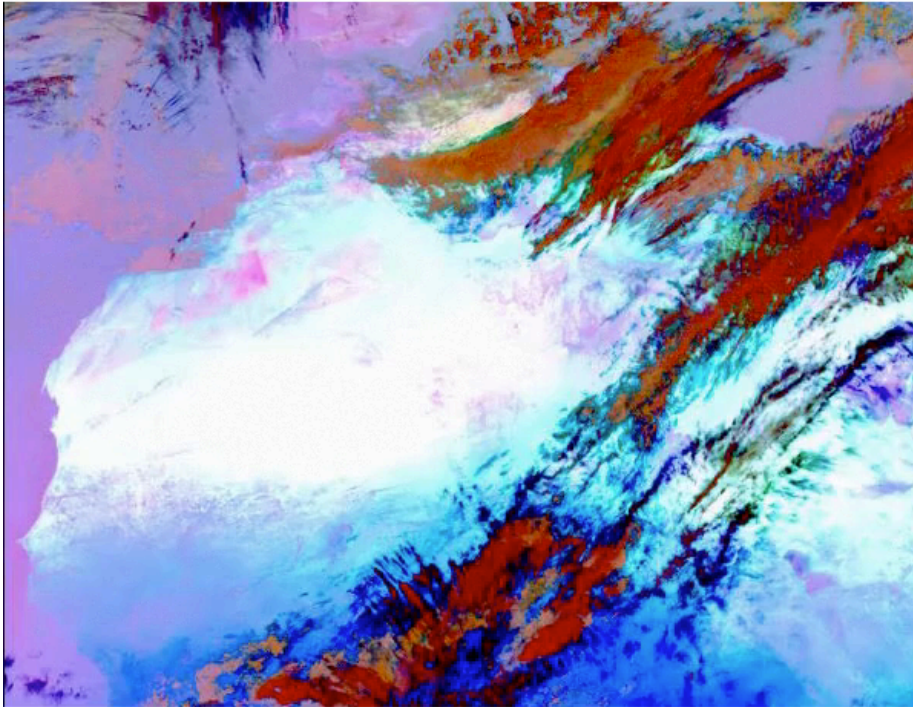
¿Where is dust emitted?



¿How?

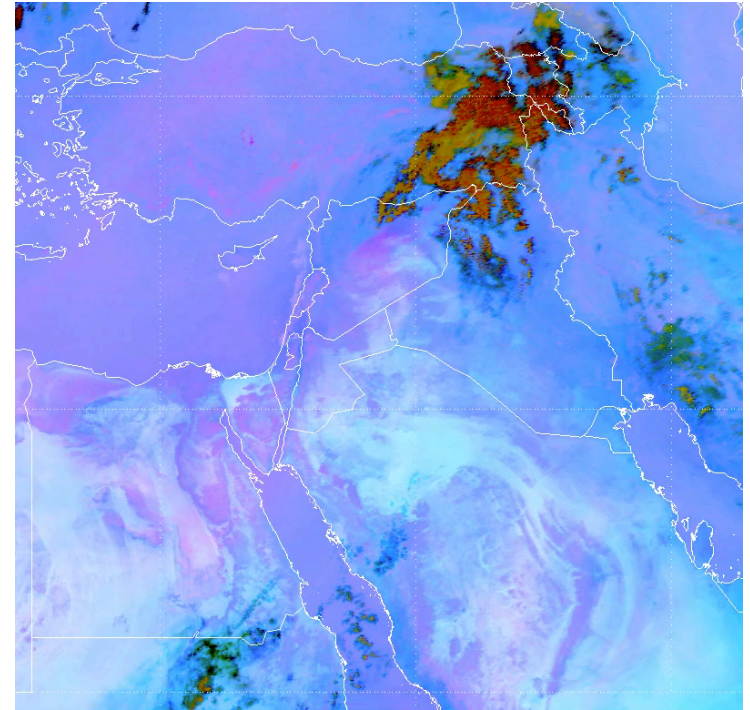
Synoptic dust storm

MSG Dust RGB 02 to 03 Mar 2004



© 2004 EUMETSAT

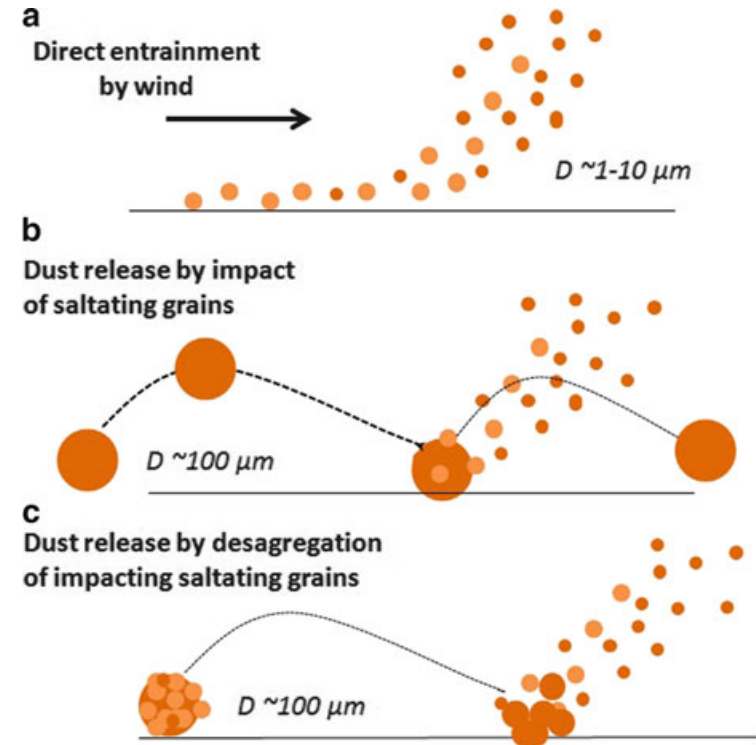
Haboob (moist convection)



m10 DUST - 2015-09-06 06:00UTC

¿What are the dust emission mechanisms?

Wind-Driven Movement of Sand and Dust Particles by Creep, Saltation, and Suspension



¿What is the composition of dust?

Size

Airborne Particle Sizing

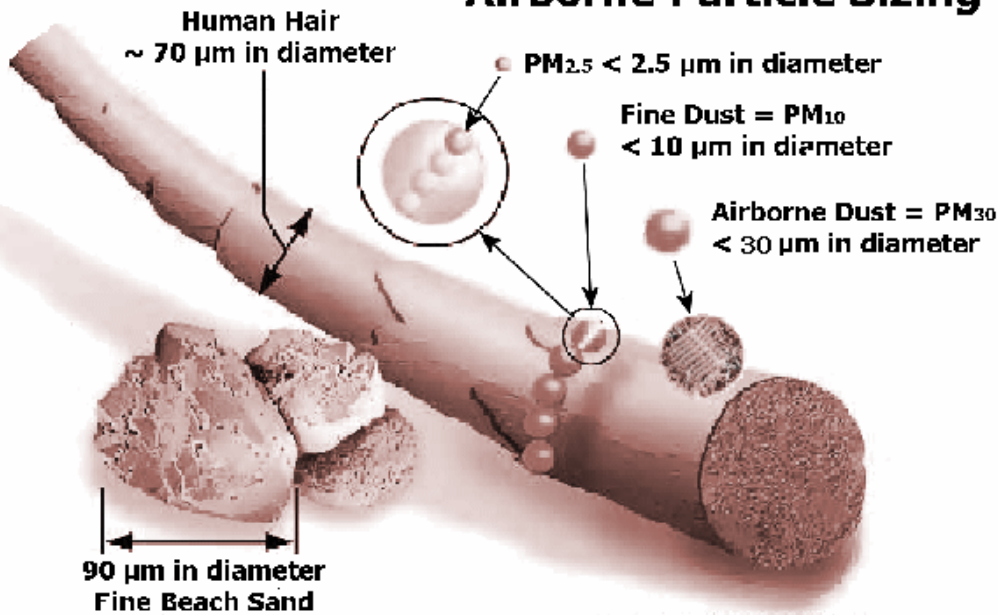
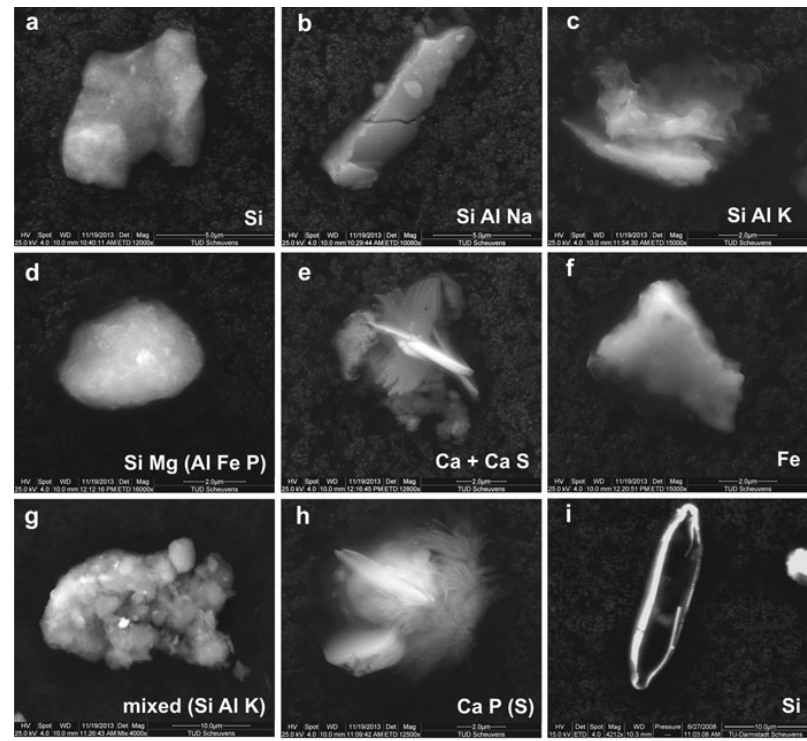


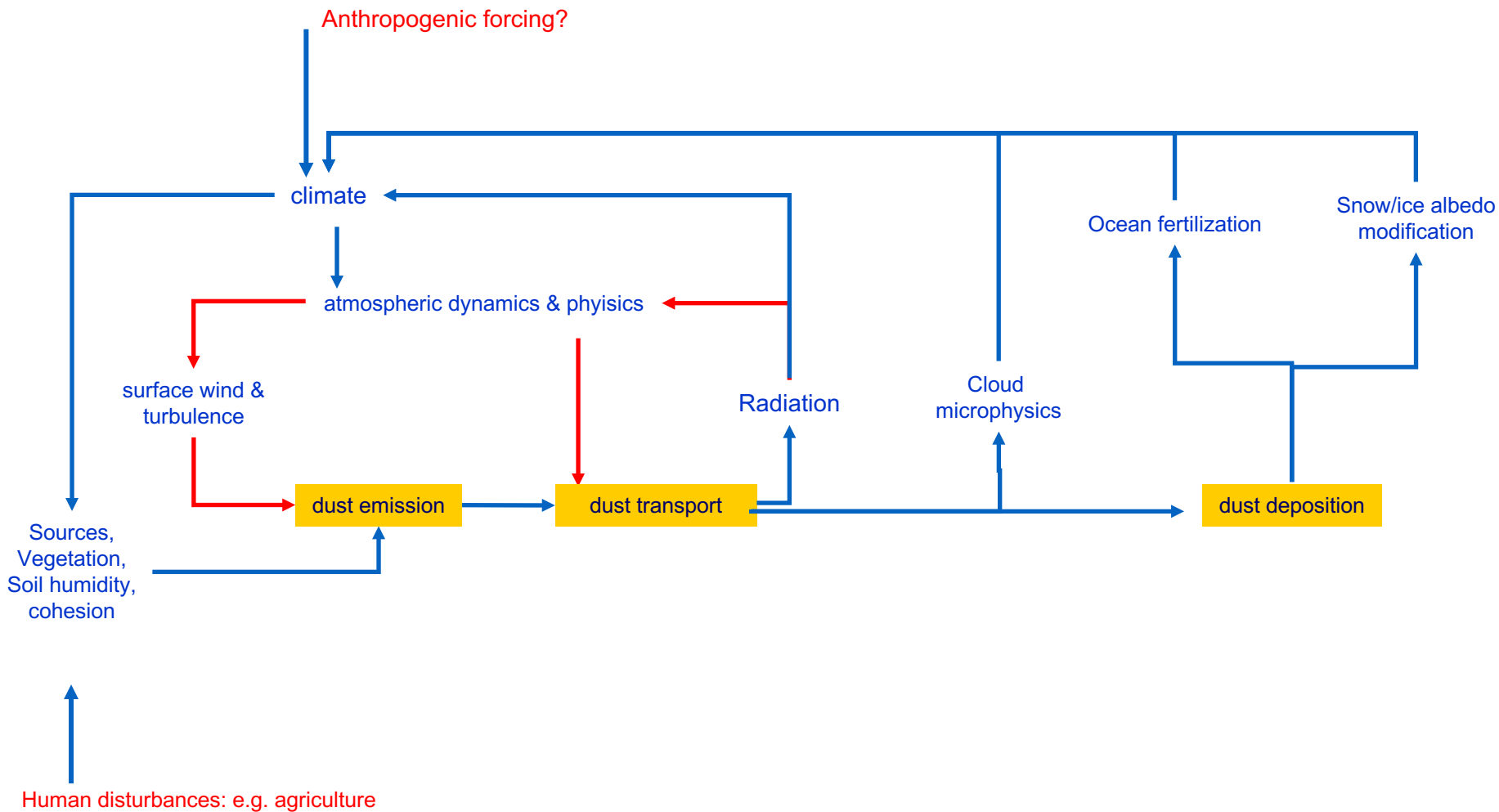
Image courtesy of EPA, Office of Research and Development

Aggregation, irregular shapes

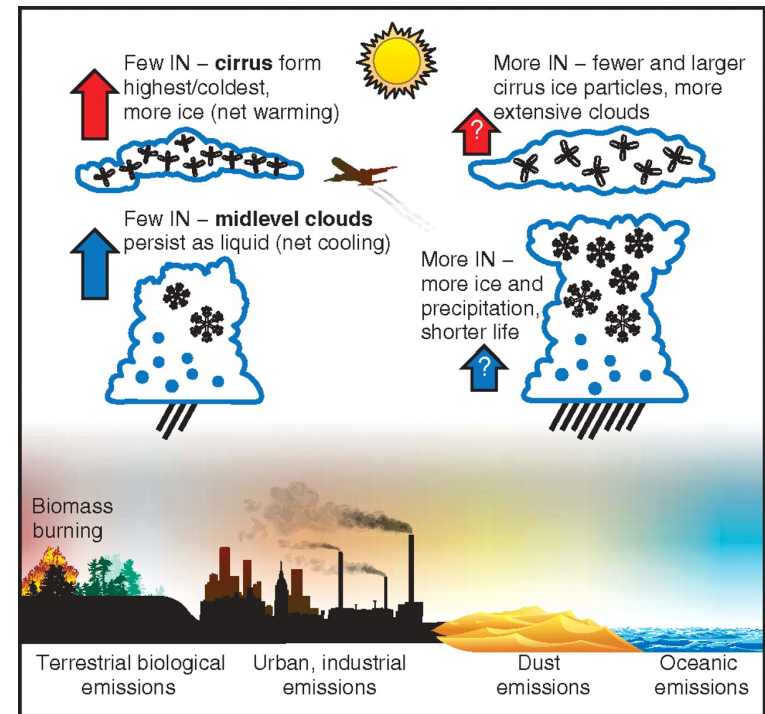
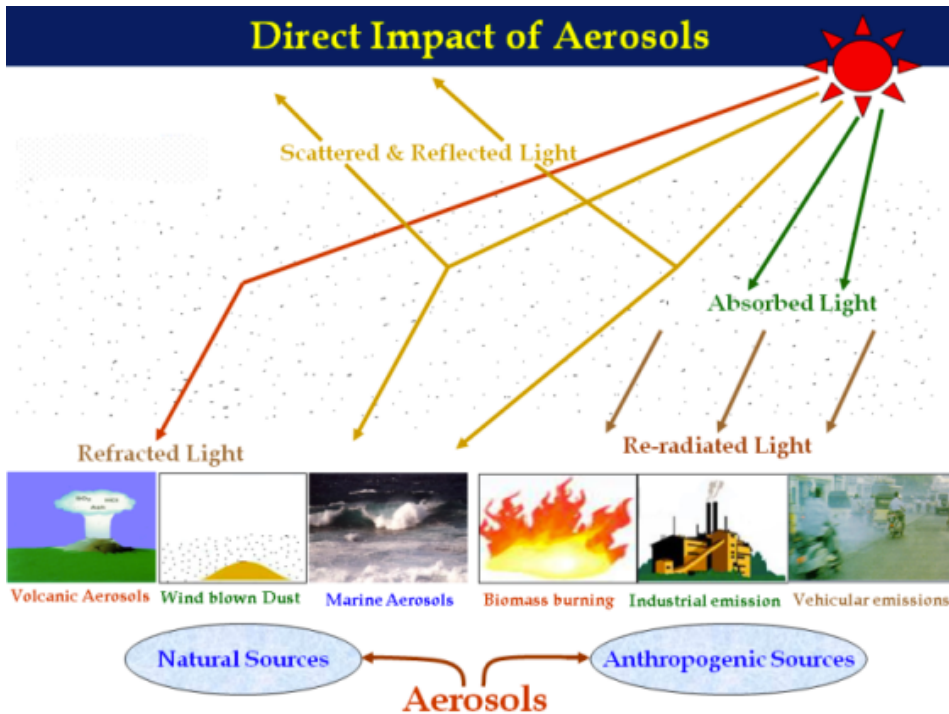


illite, smectite, kaolinite, chlorite, feldspar, calcite, quartz, iron oxides

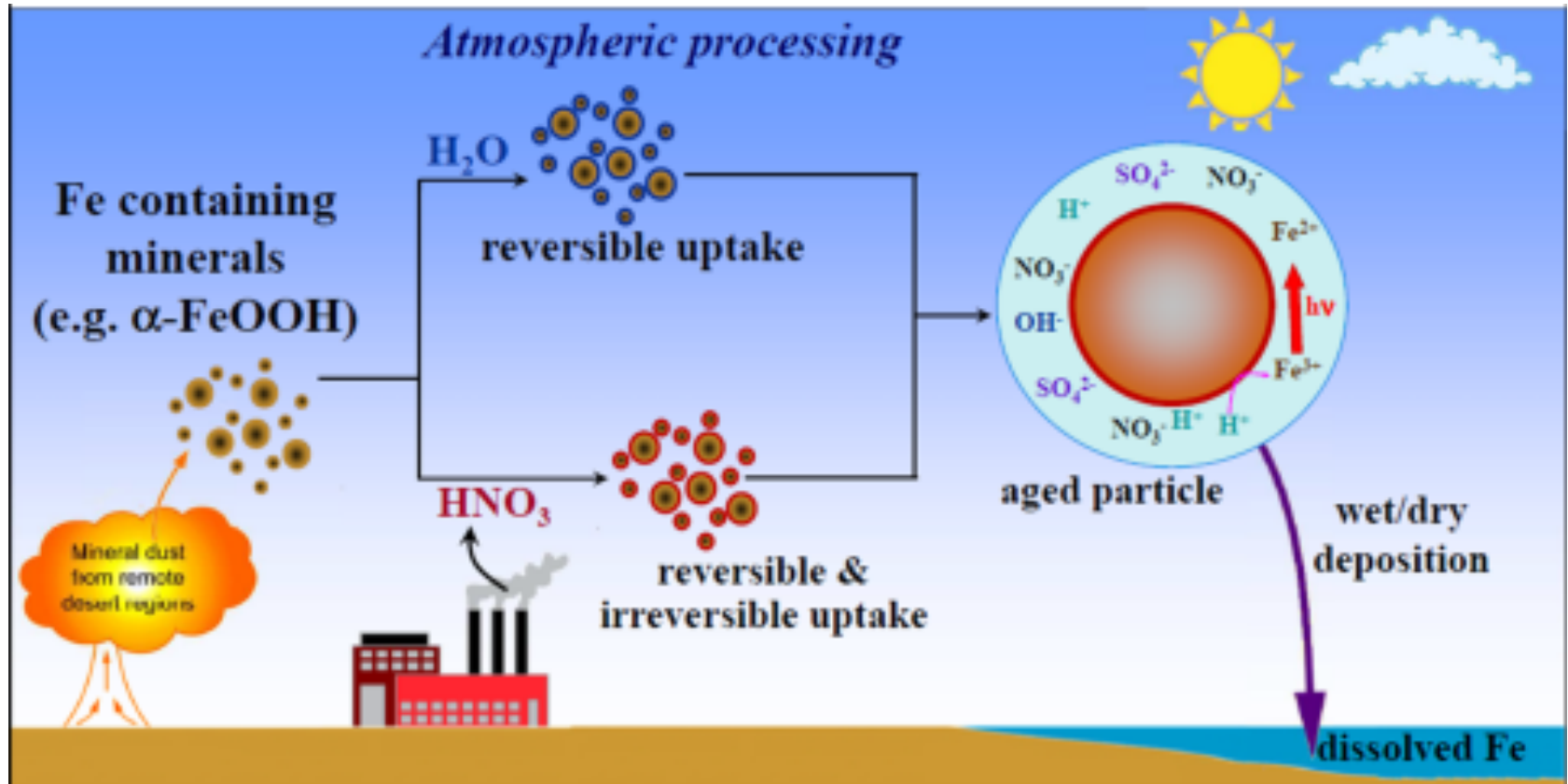
¿How dust interacts with weather and climate?



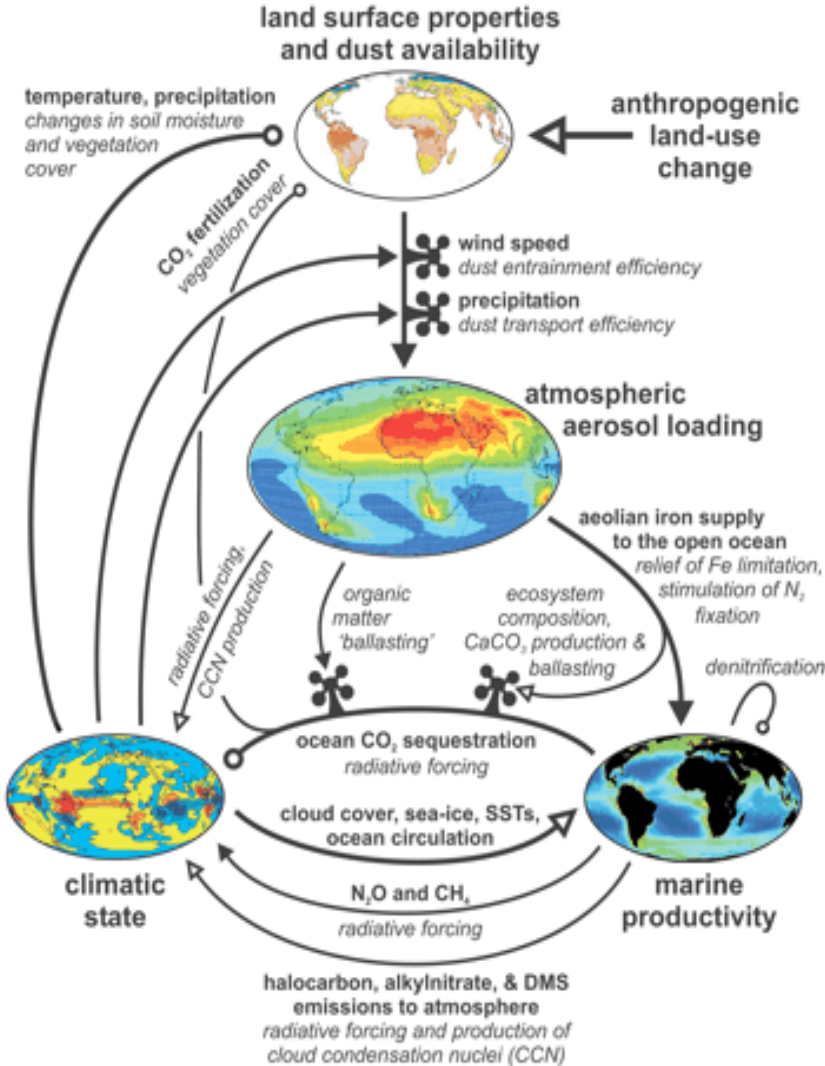
Dust-radiation and Dust-cloud interactions



Heterogeneous chemistry of dust

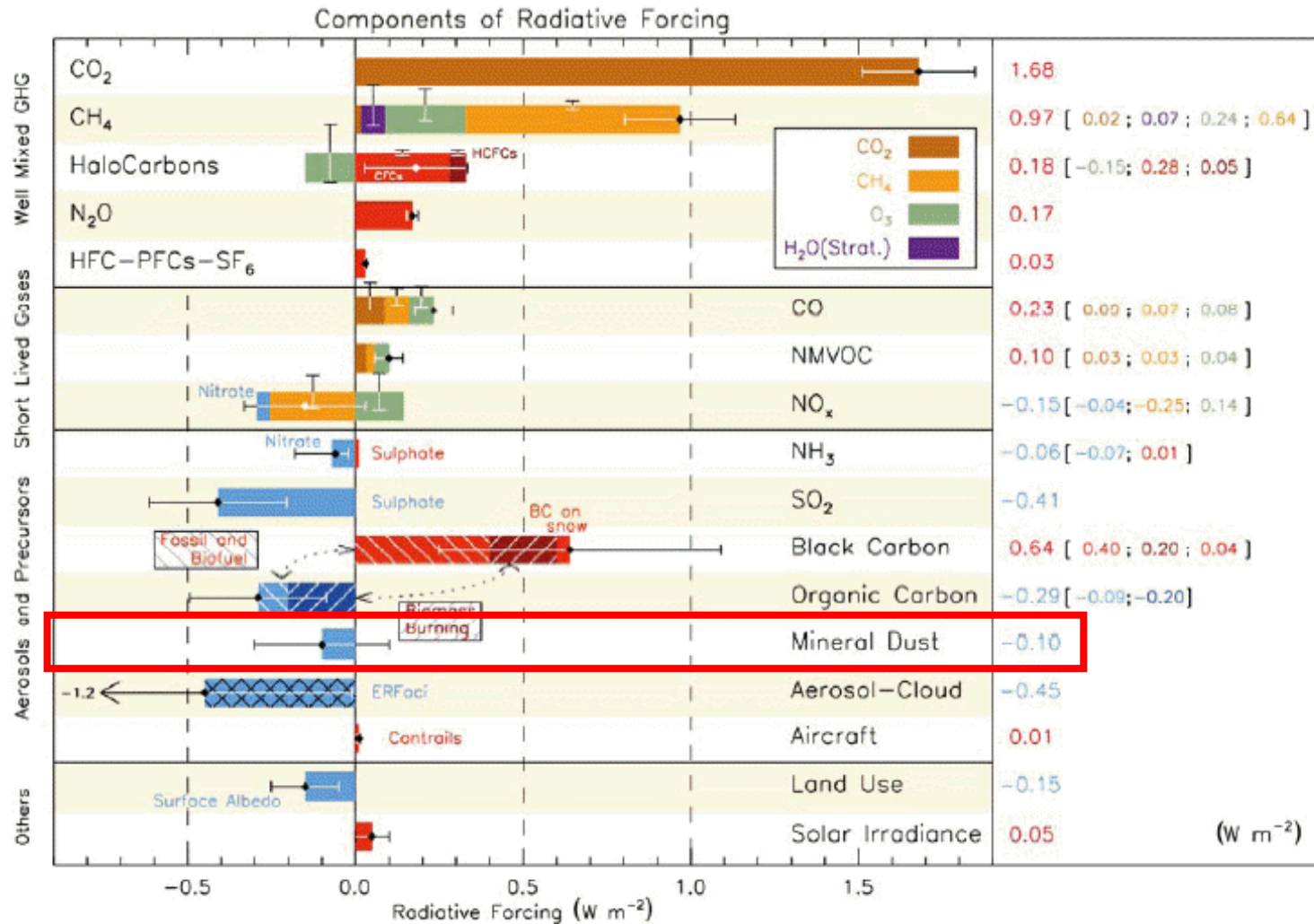


Biogeochemical cycles

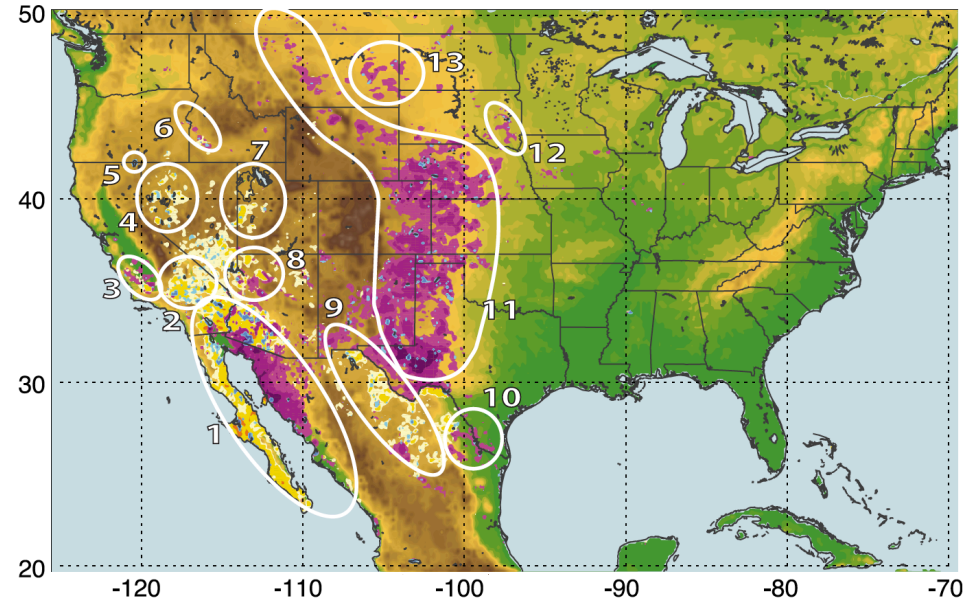
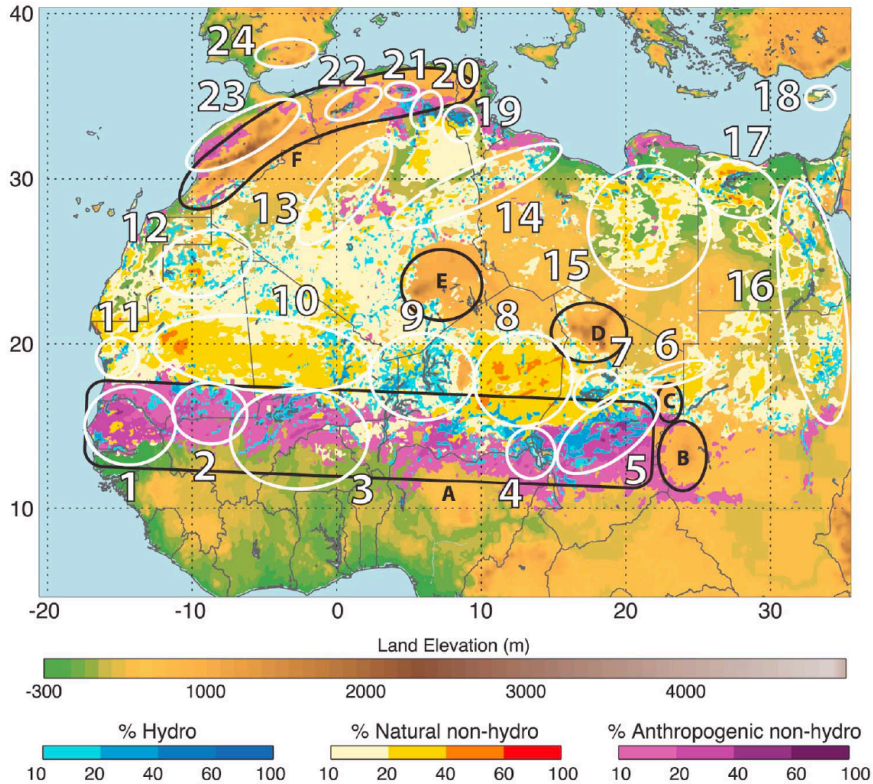


Iron
 Phosphorous
 Nitrogen
 Carbon

¿How does it relate to climate change?



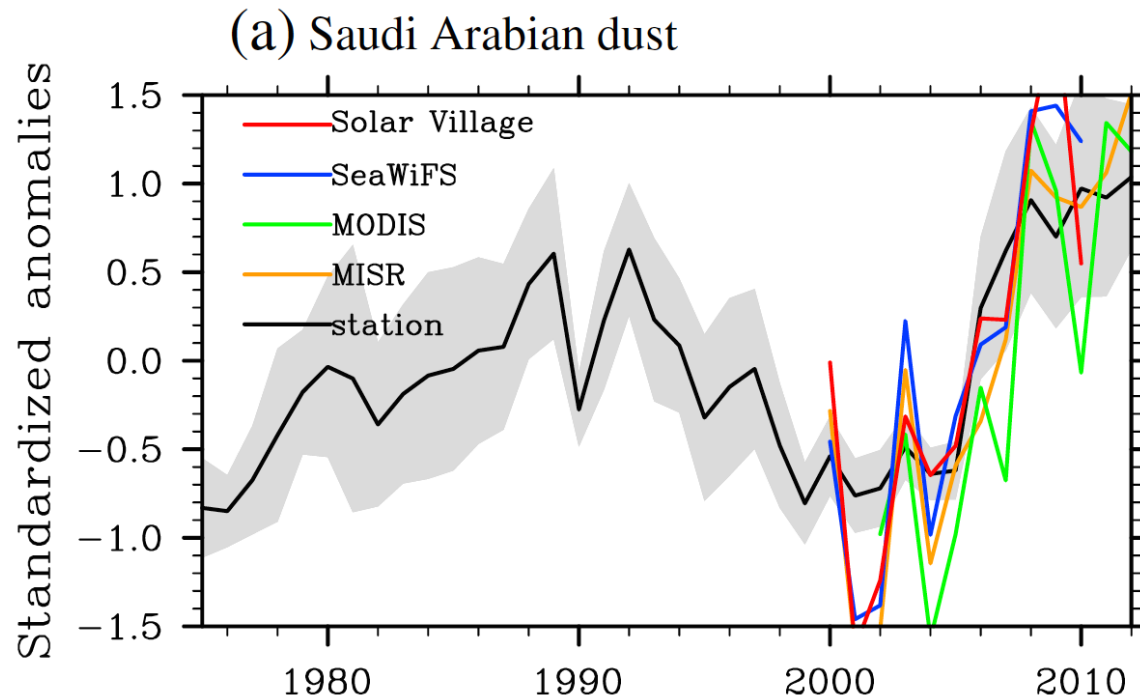
¿Are dust storms natural phenomena?



¿Are dust storms natural phenomena?



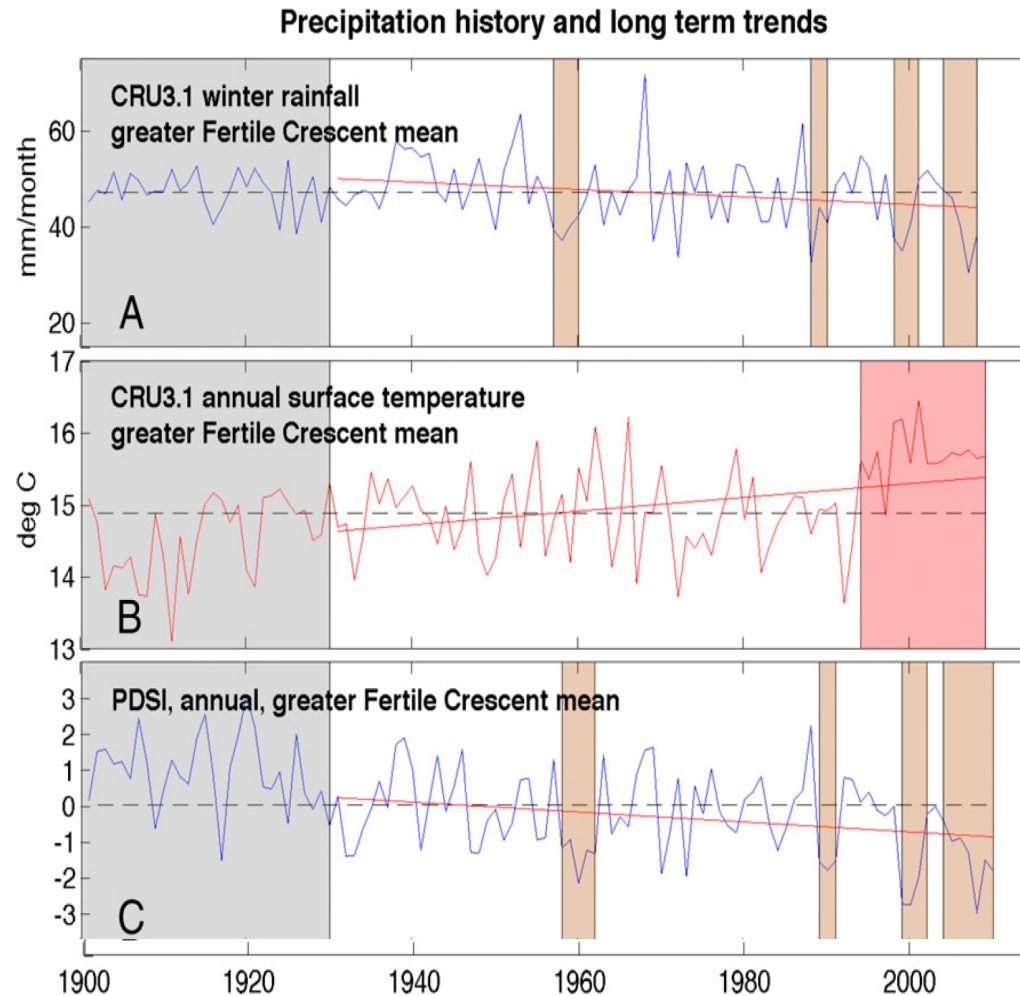
Interannual and Decadal Variability



Yu et al., 2015

Long-term trend

Kelley, et al 2015, PNAS doi:10.1073/pnas.1421533112)

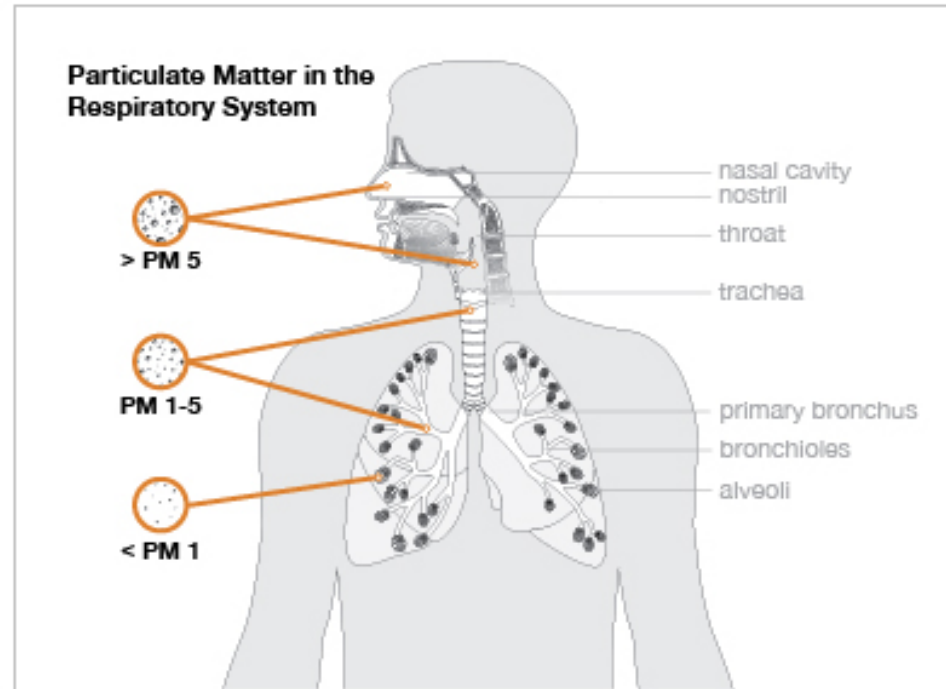


Agriculture

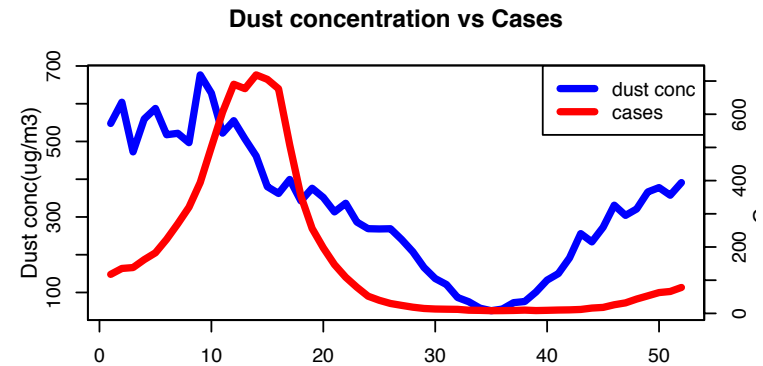
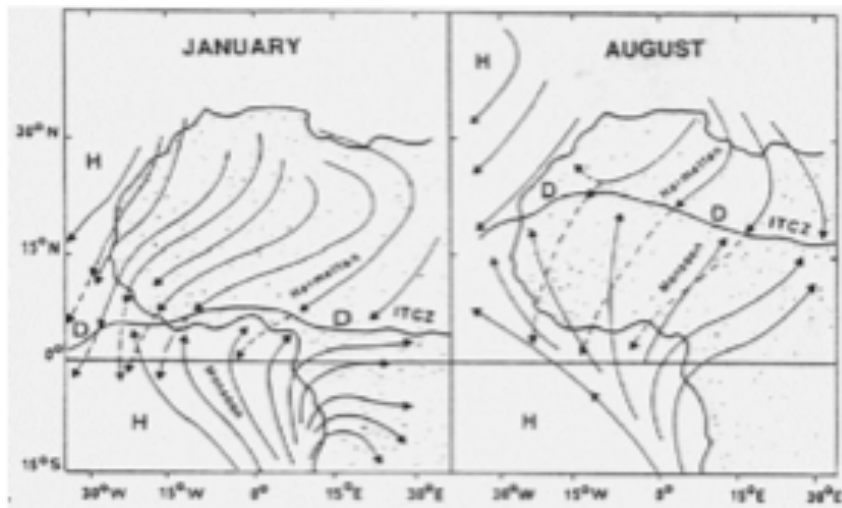
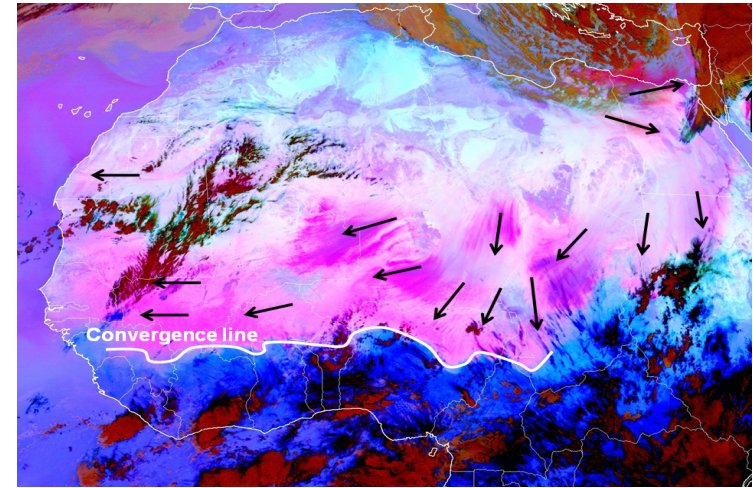
Dust Bowl in the US (1930's)



Health



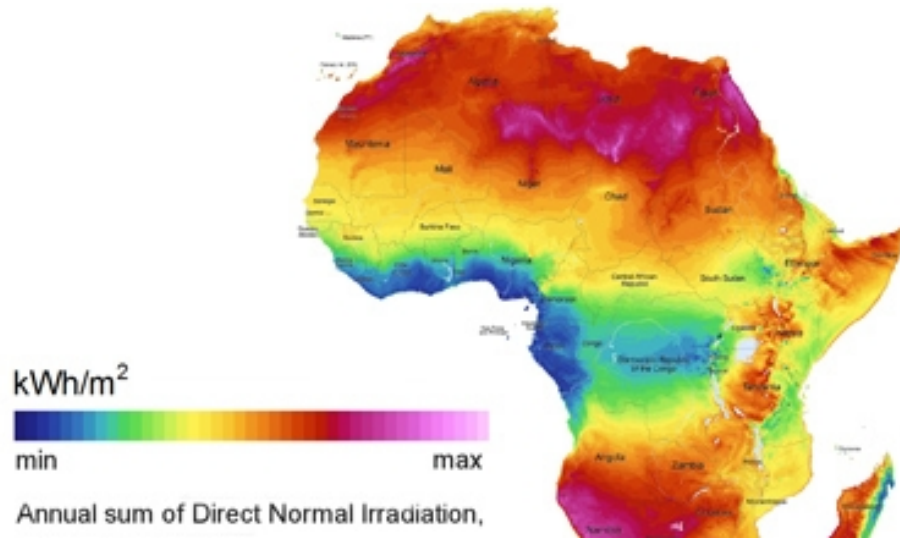
Epidemics of meningitis in the Sahel



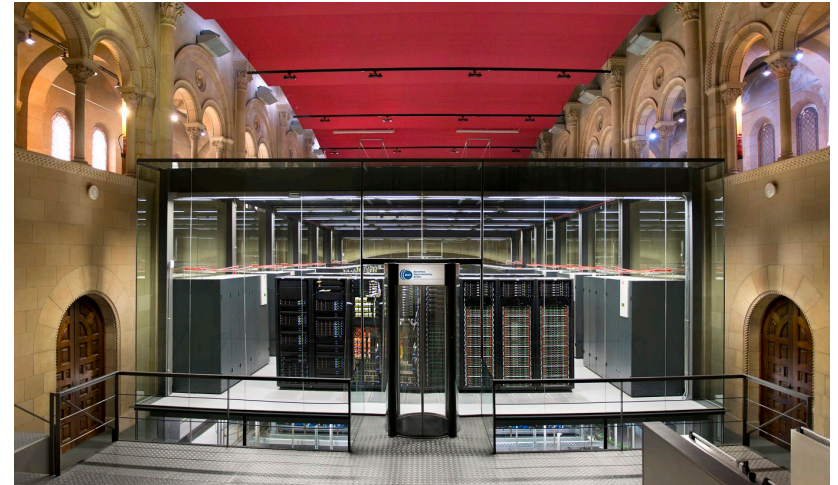
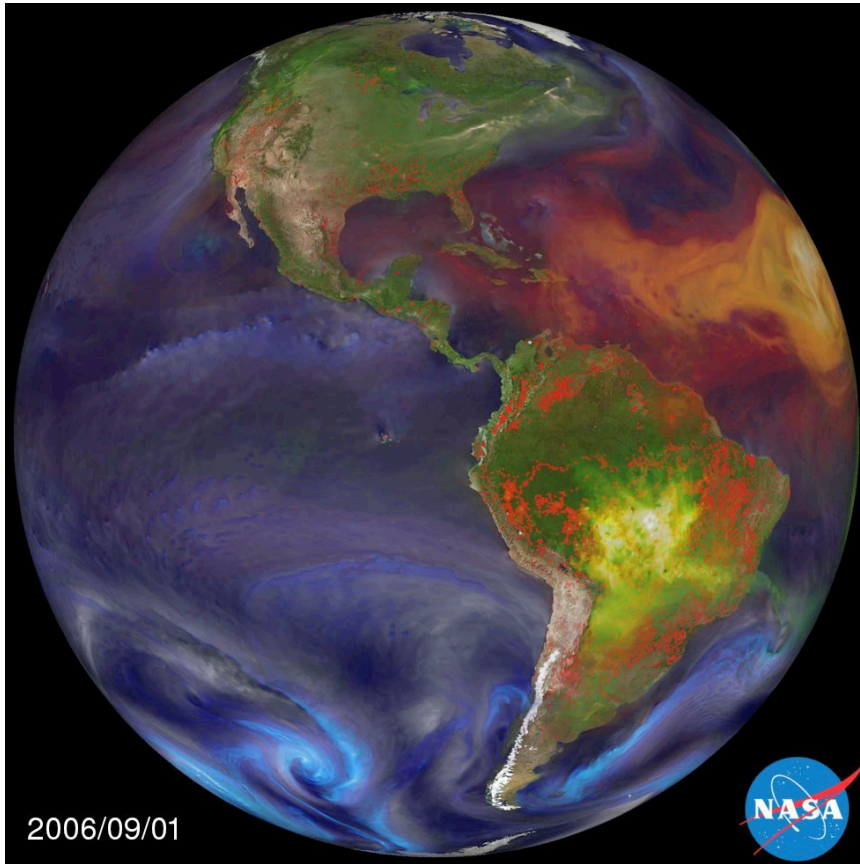
Transport



Solar Energy production



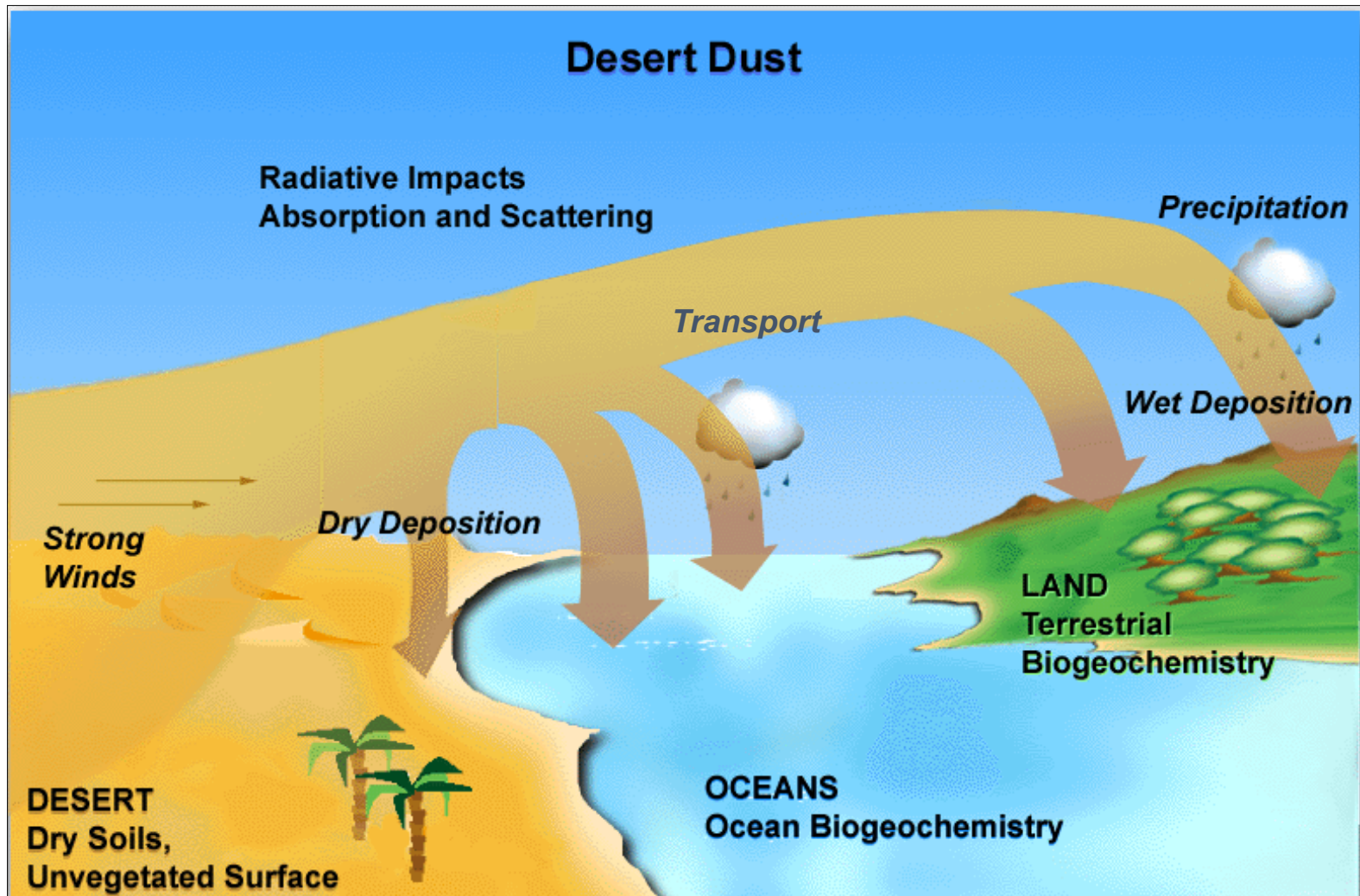
Models and prediction



sds-was.aemet.es

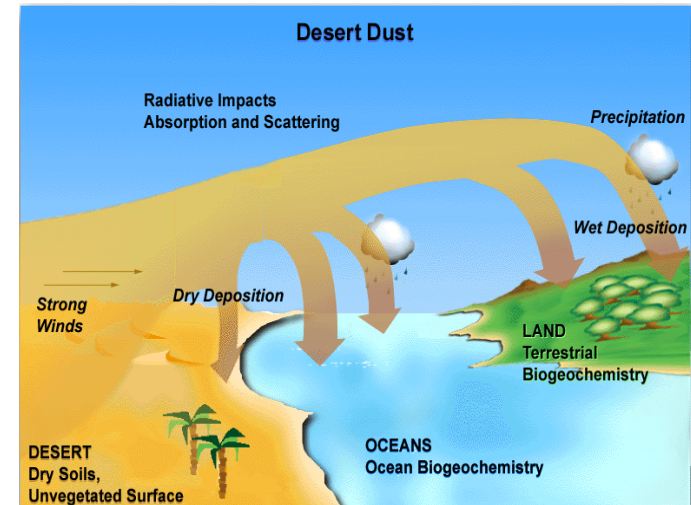
dust.aemet.es

Prediction of dust distribution requires representation of sources, transport, sinks



Dust models

- Dust models simulate the atmospheric dust cycle:
- Dust emission
- Advective and convective transport
- Turbulent diffusion
- Sedimentation, wet and dry deposition



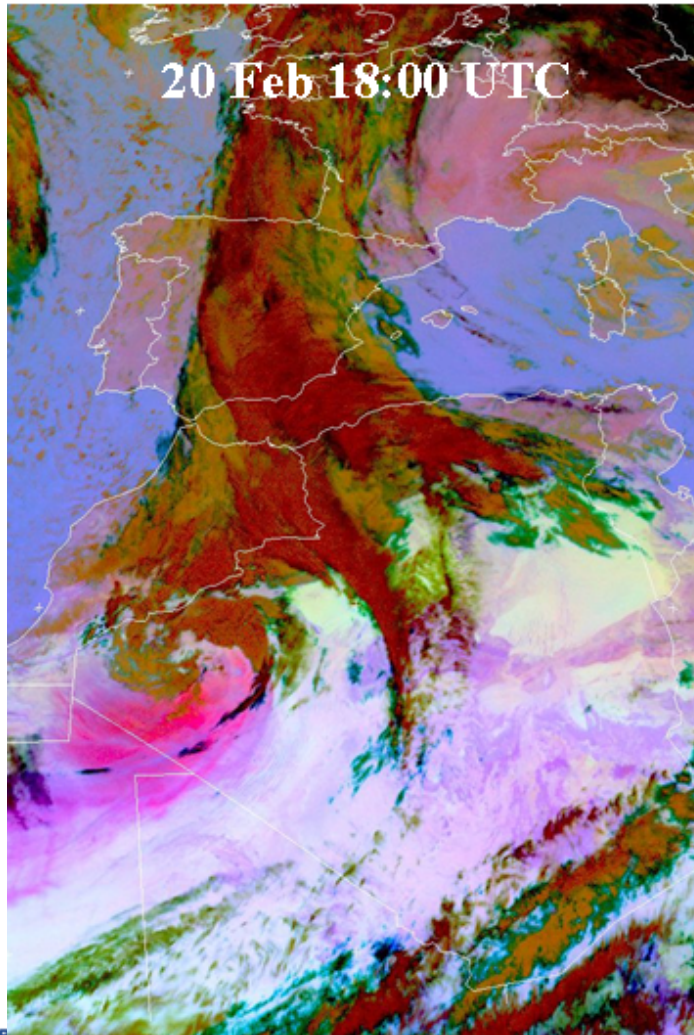
- ✓ ADEQUATELY **CONSTRAINED** BY THE AVAILABLE OBSERVATIONS CAN PROVIDE HISTORICAL AND CONTINUOUS DATA **FILLING** THE TEMPORAL AND SPATIAL GAPS OF THE OBSERVATIONS
- ✓ THEY CAN BE USED AS **SHORT-TERM FORECASTING TOOLS** (3-5 days ahead)

Types of dust storms and model skills

- Synoptic dust storms (large scale weather systems)
 - Prefrontal winds
 - Postfrontal winds
 -

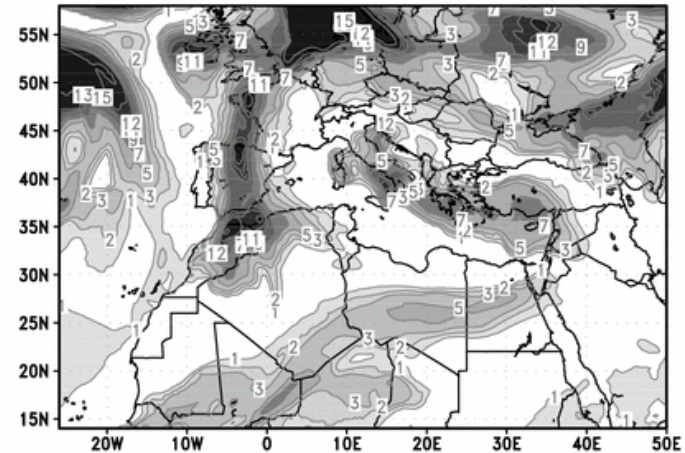
- Mesoscale dust storms
 - Gap flows
 - Haboobs
 - Inversion downbursts
 - Dust devils
 -

Synoptic dust storms: February 2007

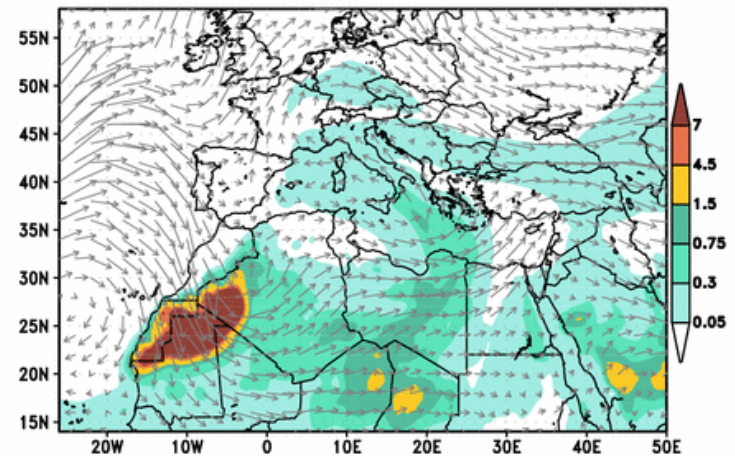


<http://www.bsc.es/projects/earthscience/DREAM>

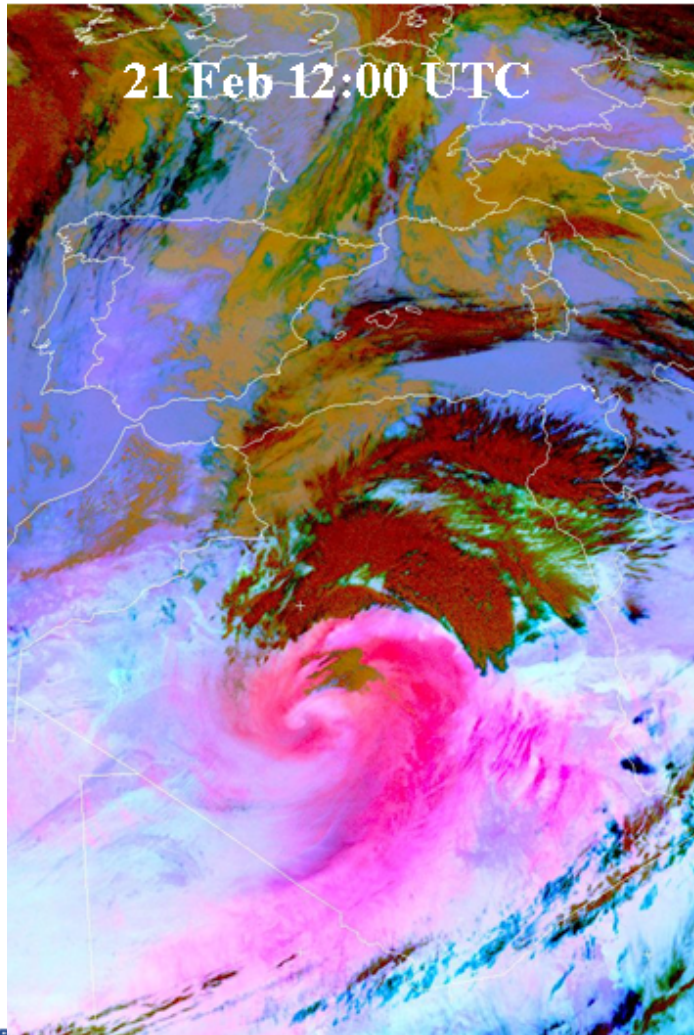
BSC/DREAM Total Cloud Cover
6h forecast for 18z 20 FEB 07



BSC/DREAM Dust Loading (g/m^2) and 3000m Wind
6h forecast for 18z 20 FEB 07

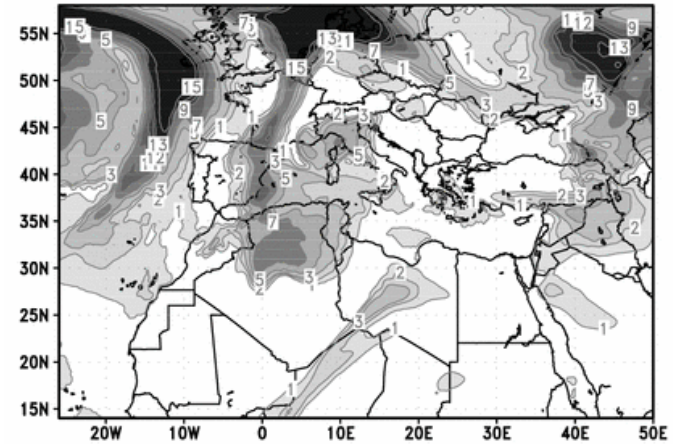


Synoptic dust storms: February 2007

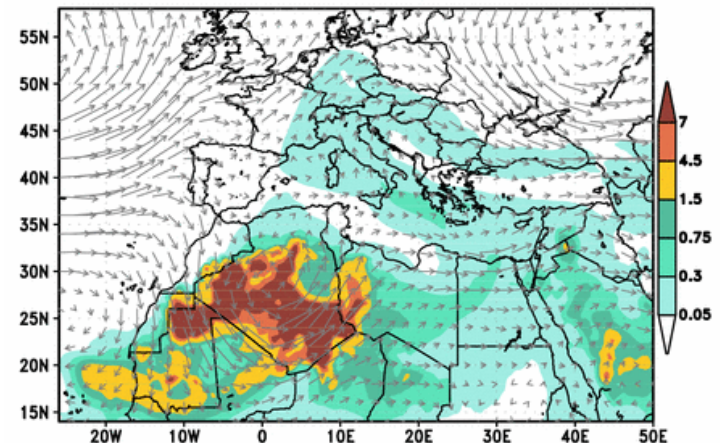


<http://www.bsc.es/projects/earthscience/DREAM>

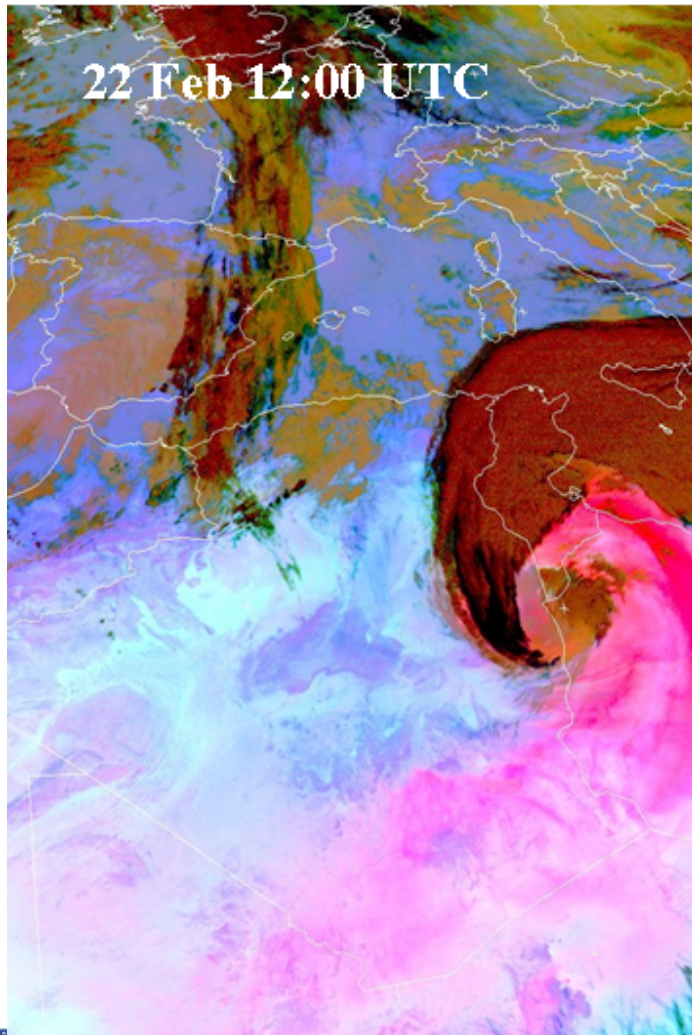
BSC/DREAM Total Cloud Cover
24h forecast for 12z 21 FEB 07



BSC/DREAM Dust Loading (g/m^2) and 3000m Wind
24h forecast for 12z 21 FEB 07

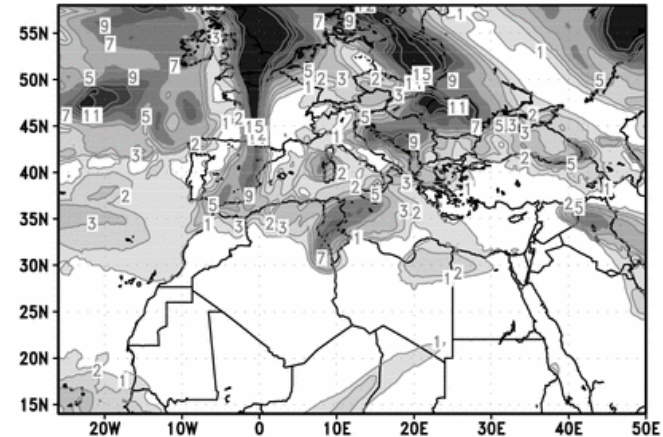


Synoptic dust storms: February 2007

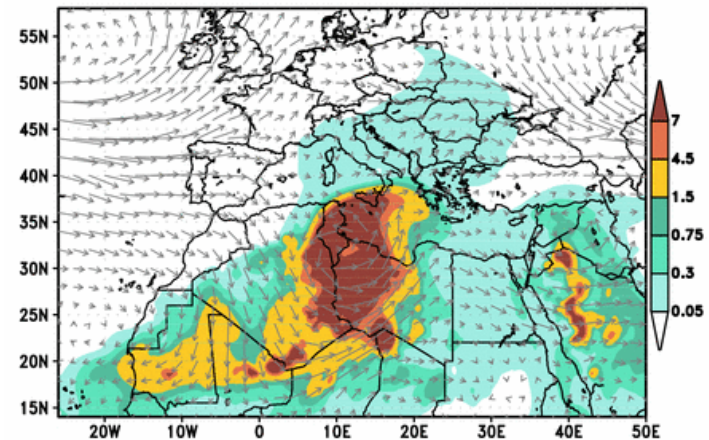


<http://www.bsc.es/projects/earthscience/DREAM>

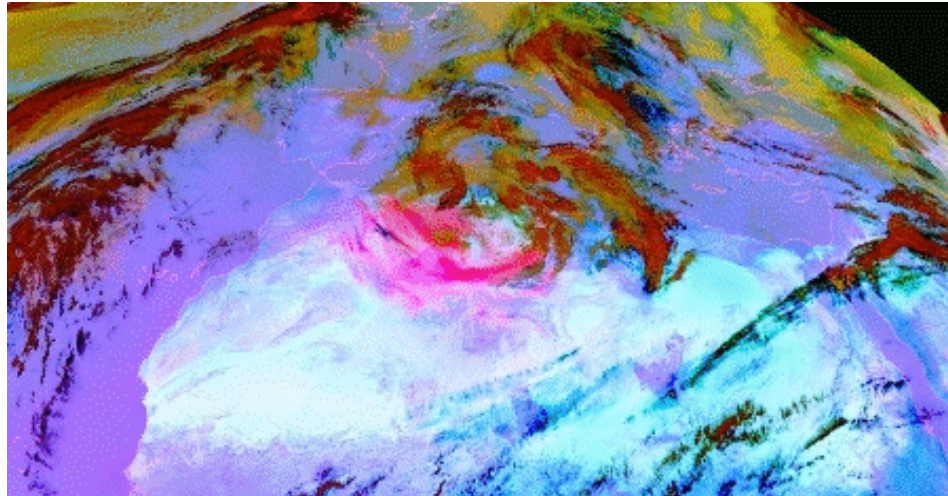
BSC/DREAM Total Cloud Cover
24h forecast for 12z 22 FEB 07



BSC/DREAM Dust Loading (g/m^2) and 3000m Wind
24h forecast for 12z 22 FEB 07

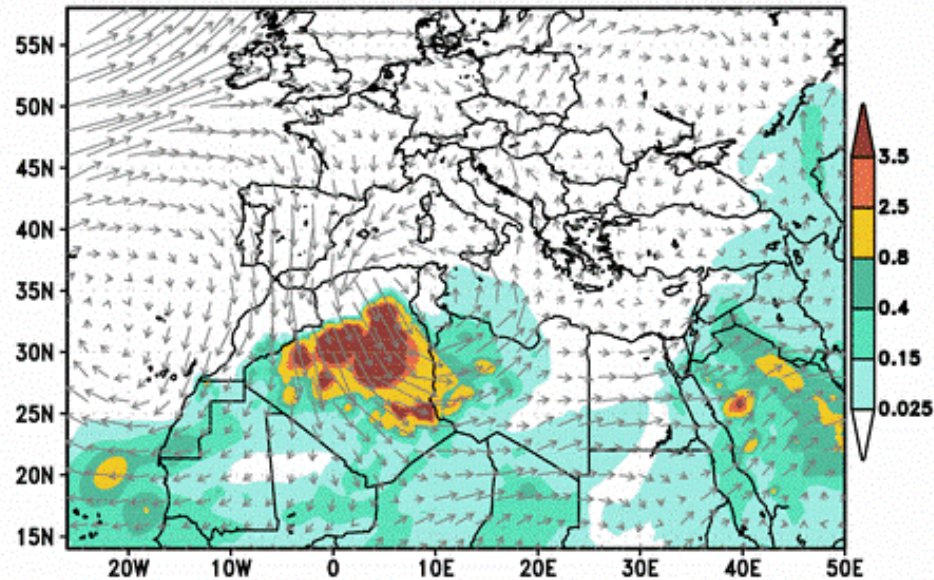


Synoptic dust storms: March 2007



- cold, thick, high level clouds
- thin cirrus clouds
contrails
- thick mid-level cloud
- thin, mid-level cloud
- low-level cloud (cold atm, Europe)
- low-level cloud (warm atm, Africa)
- dust storm

BSC/DREAM Dust Opt. Depth 550nm and 3000m Wind
0h forecast for 12z 08 MAR 07



Mesoscale dust storms (Haboobs)

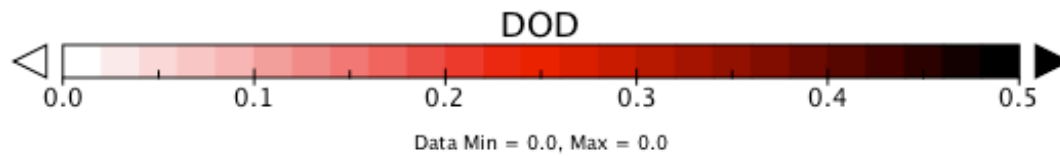
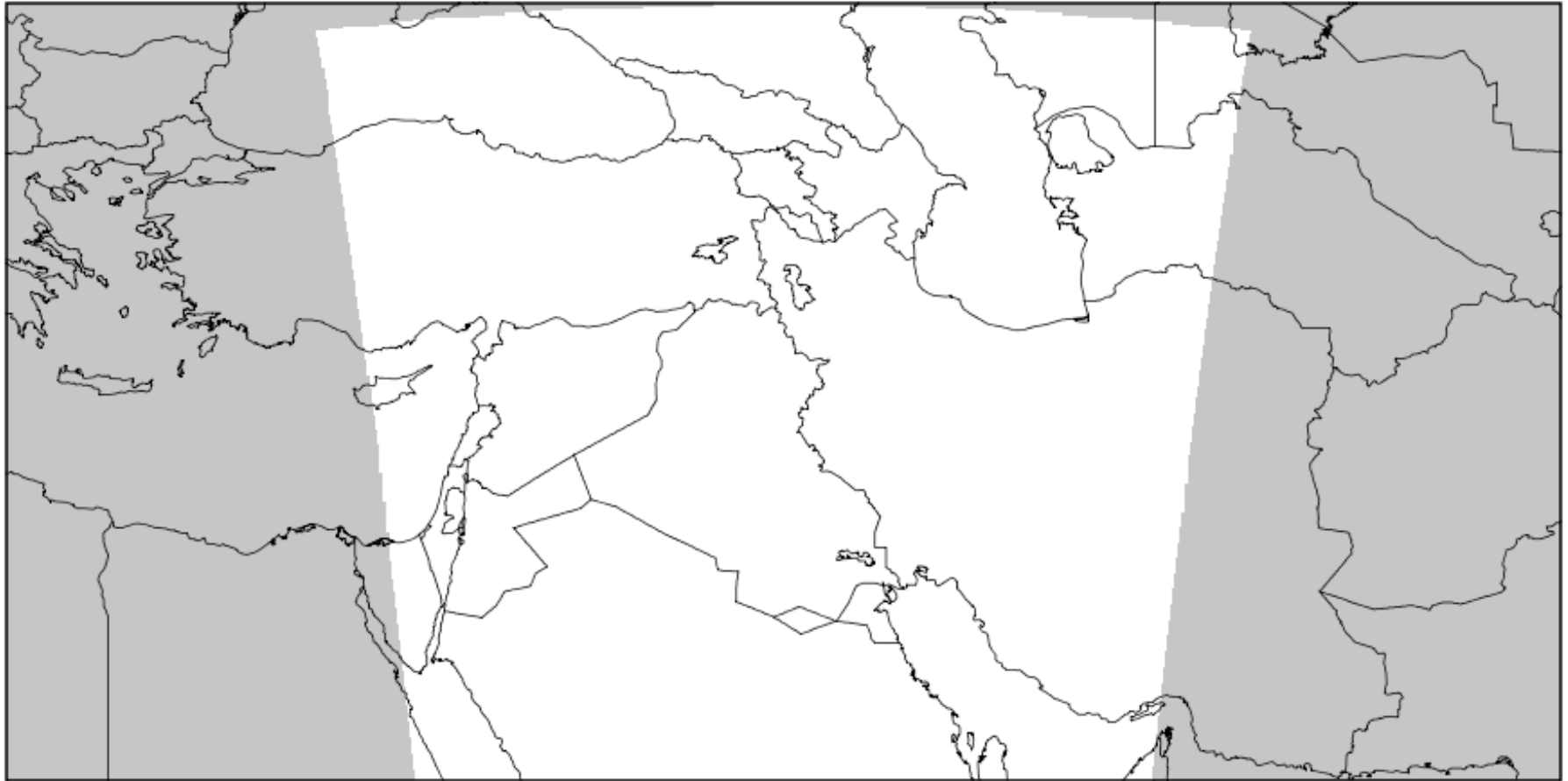


©The COMET Program

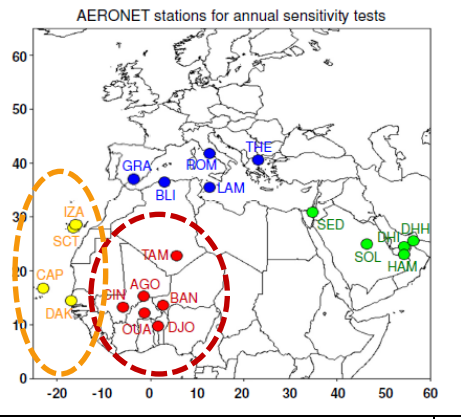


Dust Optical Depth

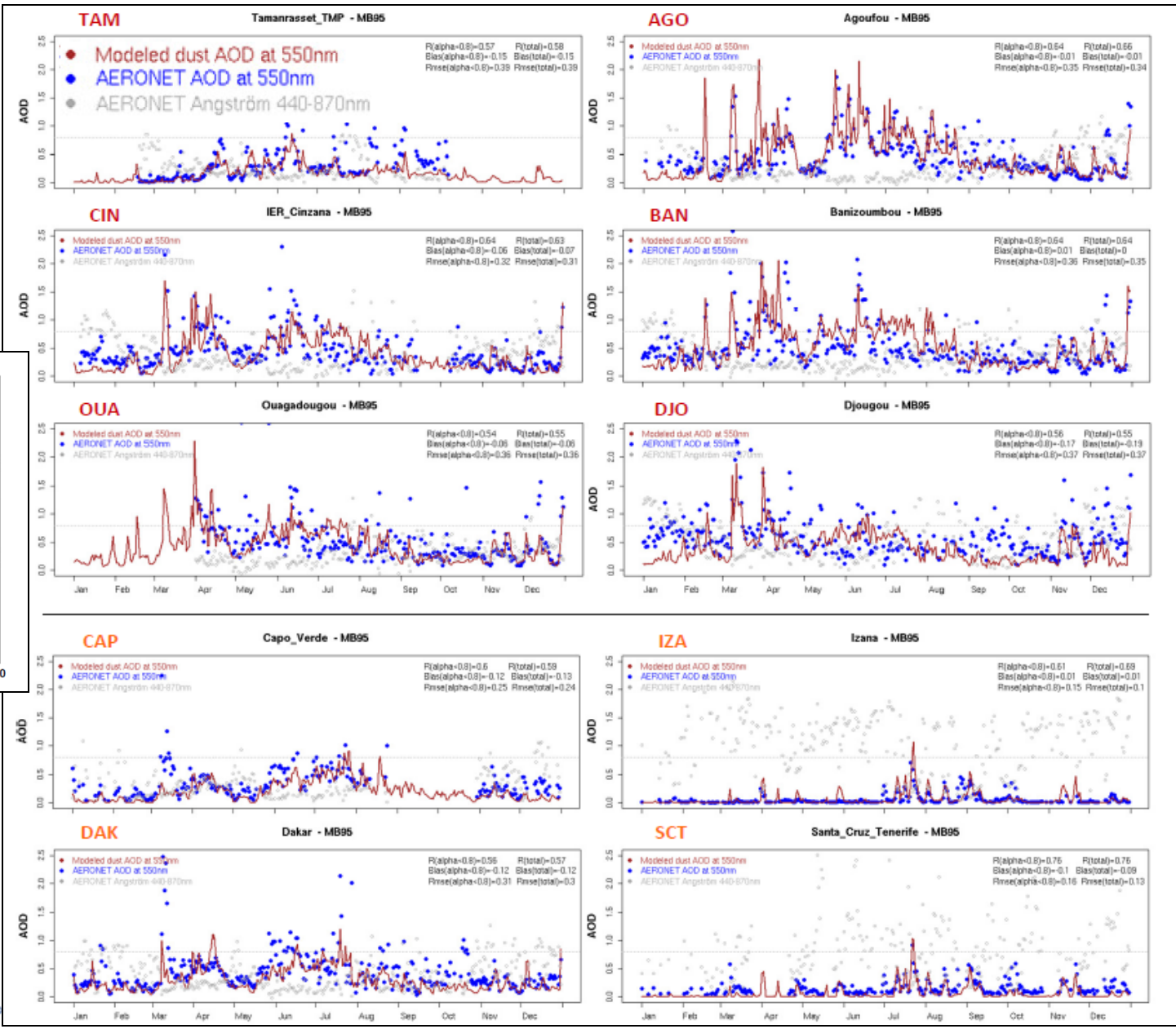
Time: 2015-09-06 00



**TAMANRASSET
AGOUFOU
CINZANA
BANIZOUMBOU
OUAGADOUGOU
DJOUGOU**



**CAPO VERDE
IZANA (TENER.)
DAKAR
SANTA CRUZ T.**



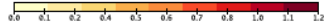
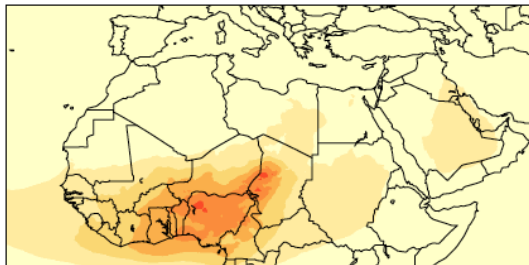
model

MISR

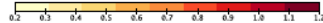
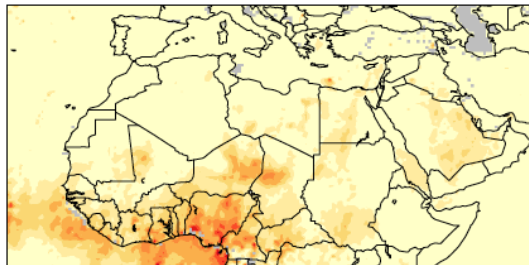
OMI

JAN-MARCH

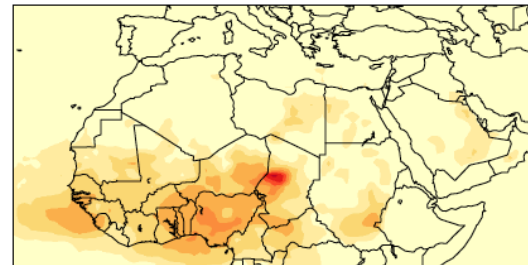
JAN-FEB-MARCH Modeled Dust Optical Depth at 550 nm



JAN-FEB-MARCH MISR Aerosol Optical Depth at 555 nm

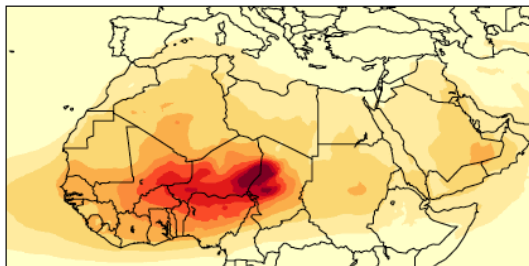


JAN-FEB-MARCH OMI Aerosol Index

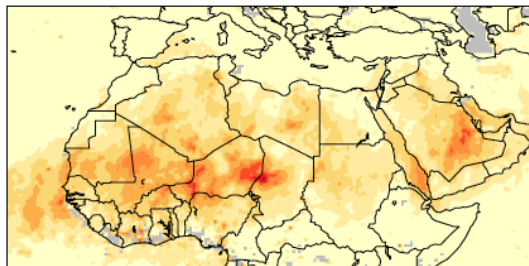


APR-JUN

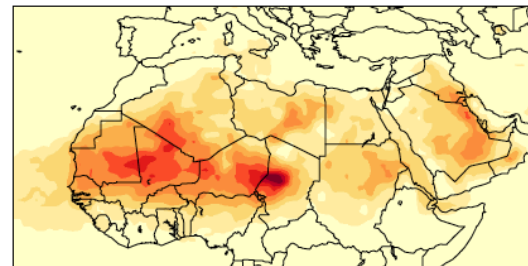
APRIL-MAY-JUNE Modeled Dust Optical Depth at 550 nm



APRIL-MAY-JUNE MISR Aerosol Optical Depth at 555 nm

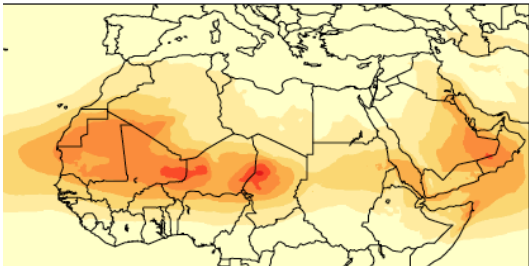


APRIL-MAY-JUNE OMI Aerosol Index

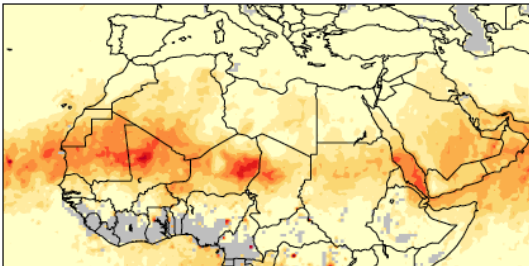


JUL-SEPT

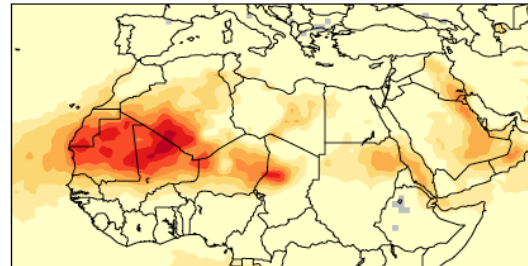
JULY-AUG-SEP Modeled Dust Optical Depth at 550 nm



JULY-AUG-SEP MISR Aerosol Optical Depth at 555 nm

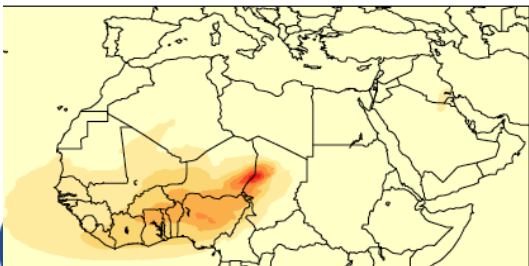


JULY-AUG-SEP OMI Aerosol Index

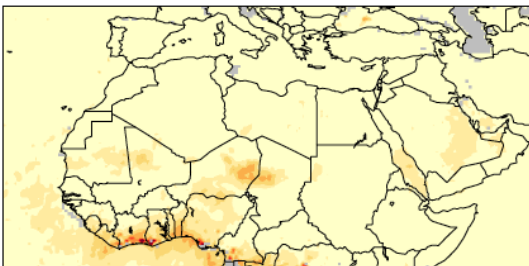


OCT-DEC

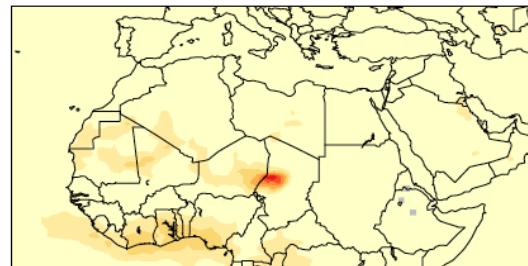
OCT-NOV-DEC Modeled Dust Optical Depth at 550 nm



OCT-NOV-DEC MISR Aerosol Optical Depth at 555 nm



OCT-NOV-DEC OMI Aerosol Index



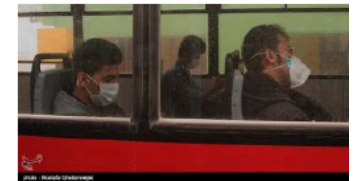
Who can use predictions to benefit society and economy?

- Air quality agencies (regional and local)
- National Meteorological Services
- Aviation and ground transportation authorities
- Decision makers (health, agriculture)
- Solar Energy industry
- Researchers (ocean community, health community, planning experimental campaigns)



Applications

- **Solar energy**
 - Power forecasting
 - Mid-term maintenance planning
 - Site planning for new projects
- **Transportation**
 - (air) Visibility assessments for airlines and flight management
 - (ground) Transportation impacts
- **Health**
 - Early-warning system for people with respiratory problems
- **Agriculture/ Insurance**
 - Crop damage



Contact us at:
info-services-es@bsc.es

BSC and AEMET are managing the WMO SDS-WAS NAMEE Regional Center (<http://sds-was.aemet.es/>) and the Barcelona Dust Forecast Center (<http://dust.aemet.es/>).



- Dust impacts have motivated the creation (in 2007) of WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) programme.

The screenshot shows the website for the Northern Africa-Middle East-Europe (NA-ME-E) Regional Center of the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS). The page is titled "Compared dust forecasts" and includes a navigation menu with options like Home, About Us, Forecast & Products, Projects & Research, Materials, News, Events, and Contact Us. The main content area features a date selector for "2014-09-16" and a "Forecast evaluation" section with tabs for "Doc on model inter-comparison", "Forecast evaluation", and "Multimodel Products". Below this, there are nine maps showing dust optical depth forecasts from various models, arranged in a 3x3 grid. The maps are color-coded to show dust concentration levels. A note at the bottom of the page reads "Please be sure to read the data policy." and "NOTE: Click on the images to enlarge." The page also includes a search bar, a latest news section with articles about mineral dust and dust storms, and an upcoming events section.

☞ The objective of this programme is to improve the understanding of dust processes and dust prediction capabilities.

☞ WMO SDS-WAS programme has 2 regional nodes, which are managed in 2 regional centers (RC):

- **NAMEE RC: AEMET-BSC, Barcelona**
- **ASIA/Central Pacific RC: China Meteorological Agency, Beijing**

☞ **WMO SDS-WAS NAMEE RC:**

- **8 dust models** (e.g. NMMB/BSC-DUST, BSC-DREAM8b) → Dust forecast (DOD, Surf. Conc.)
- **NRT evaluation** (e.g. AERONET sun-photometers, MODIS)

WMO Barcelona Dust Forecast center (BDFC):

It is the first specialized center for mineral dust prediction of the WMO

NMMB/BSC-Dust model was selected by WMO as dust model of reference for the dust forecast of this center

Dust forecast (NMMB/BSC-Dust):

- **0.1°x0.1°**
- 72h (daily updated)
- Various variables (e.g. DOD, Dust surf. Con.)
- North Africa, Middle East, and Europe

NRT, monthly, and seasonal evaluation:

- AERONET sun-photometers (e.g. AOD, AE)

Next

- Kuwait dust forecasting system at KISR !?



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Through Research, Protection

Thank you

carlos.perez@bsc.es

14/11/2016