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Dust prediction model

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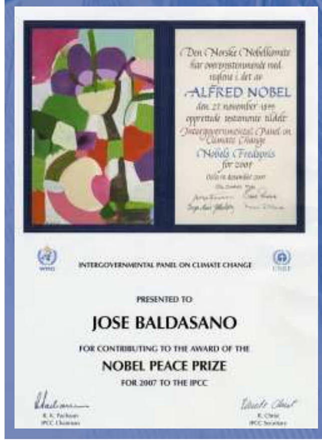
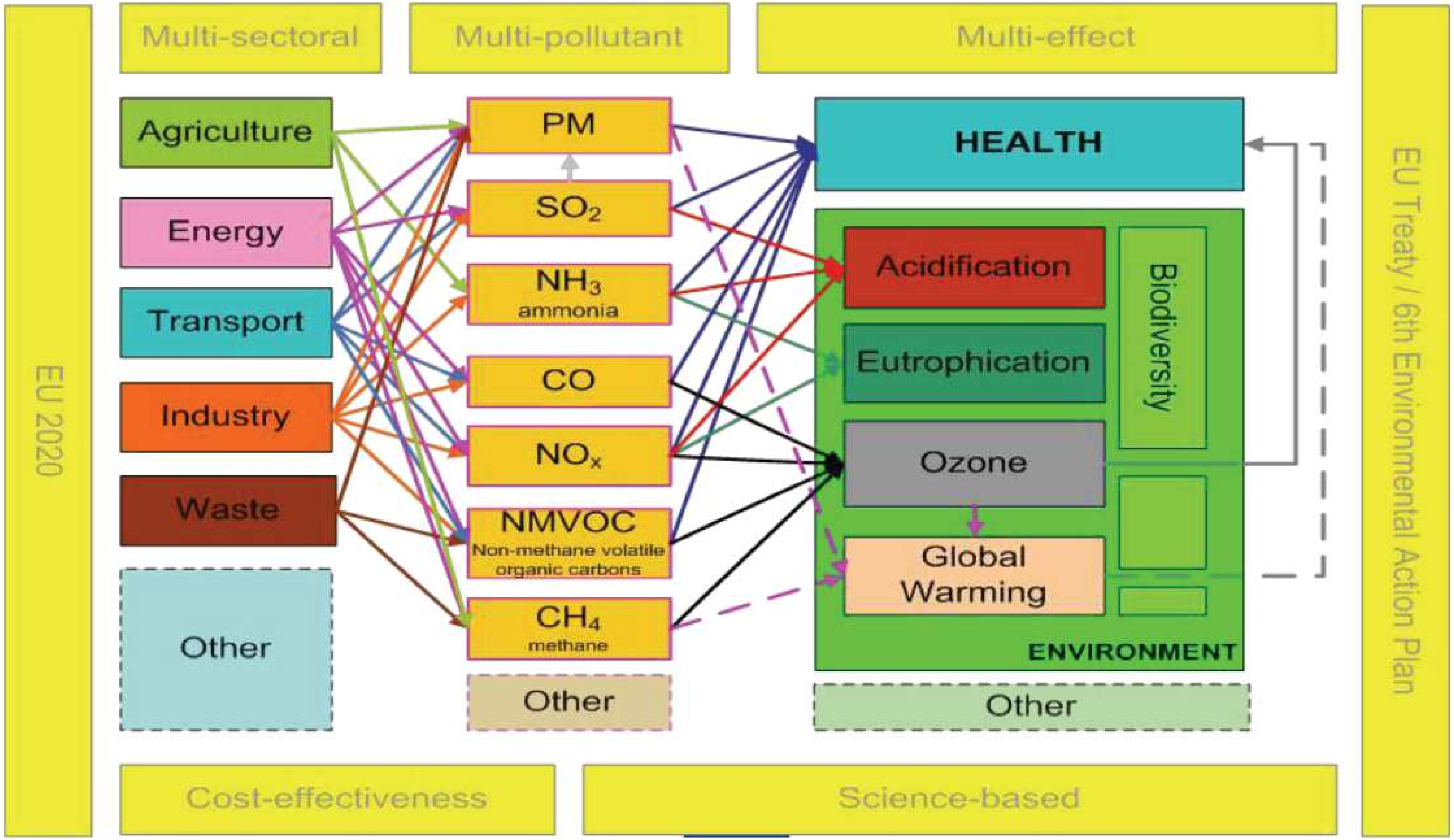


Air pollutants and their impact



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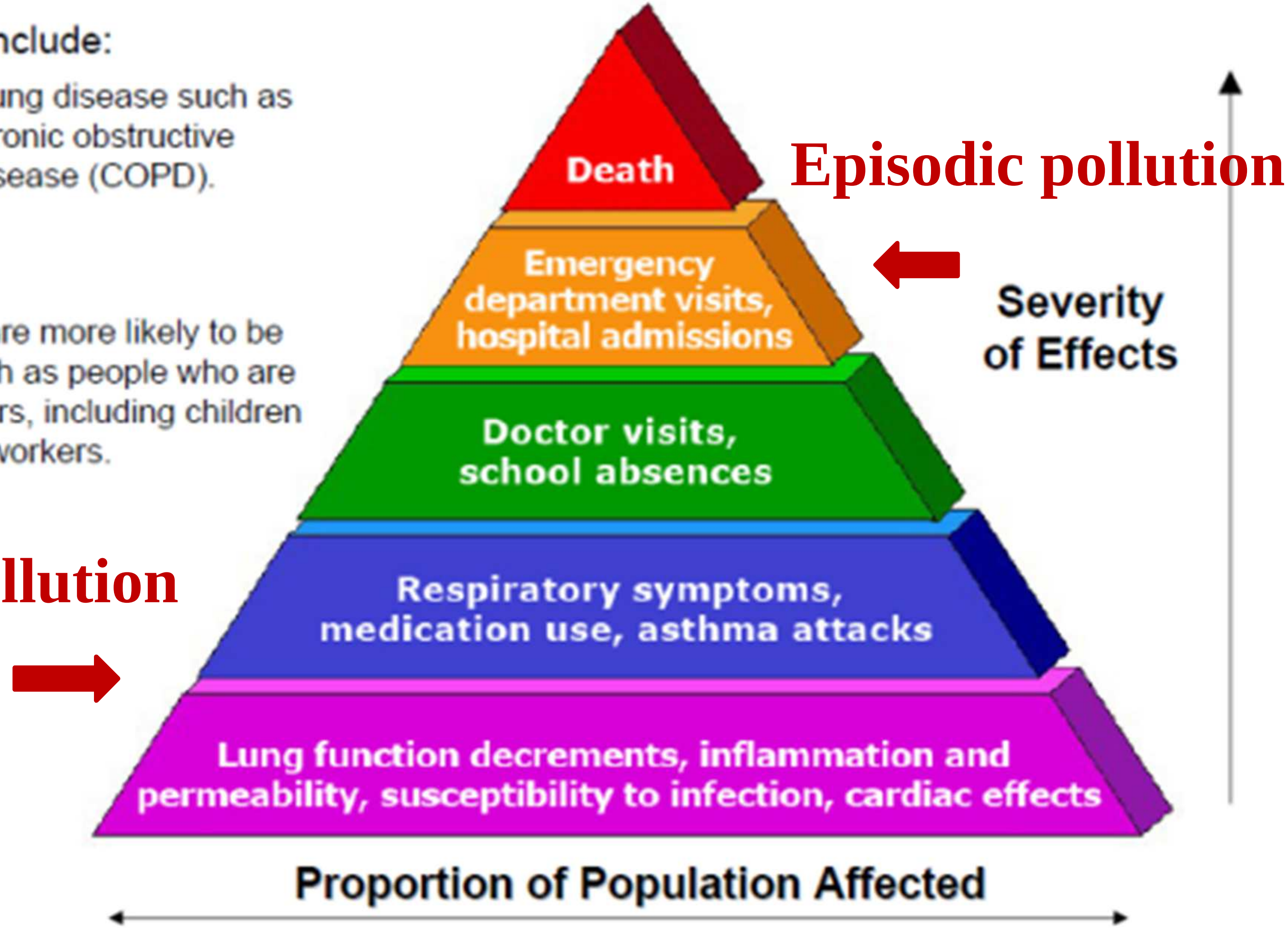
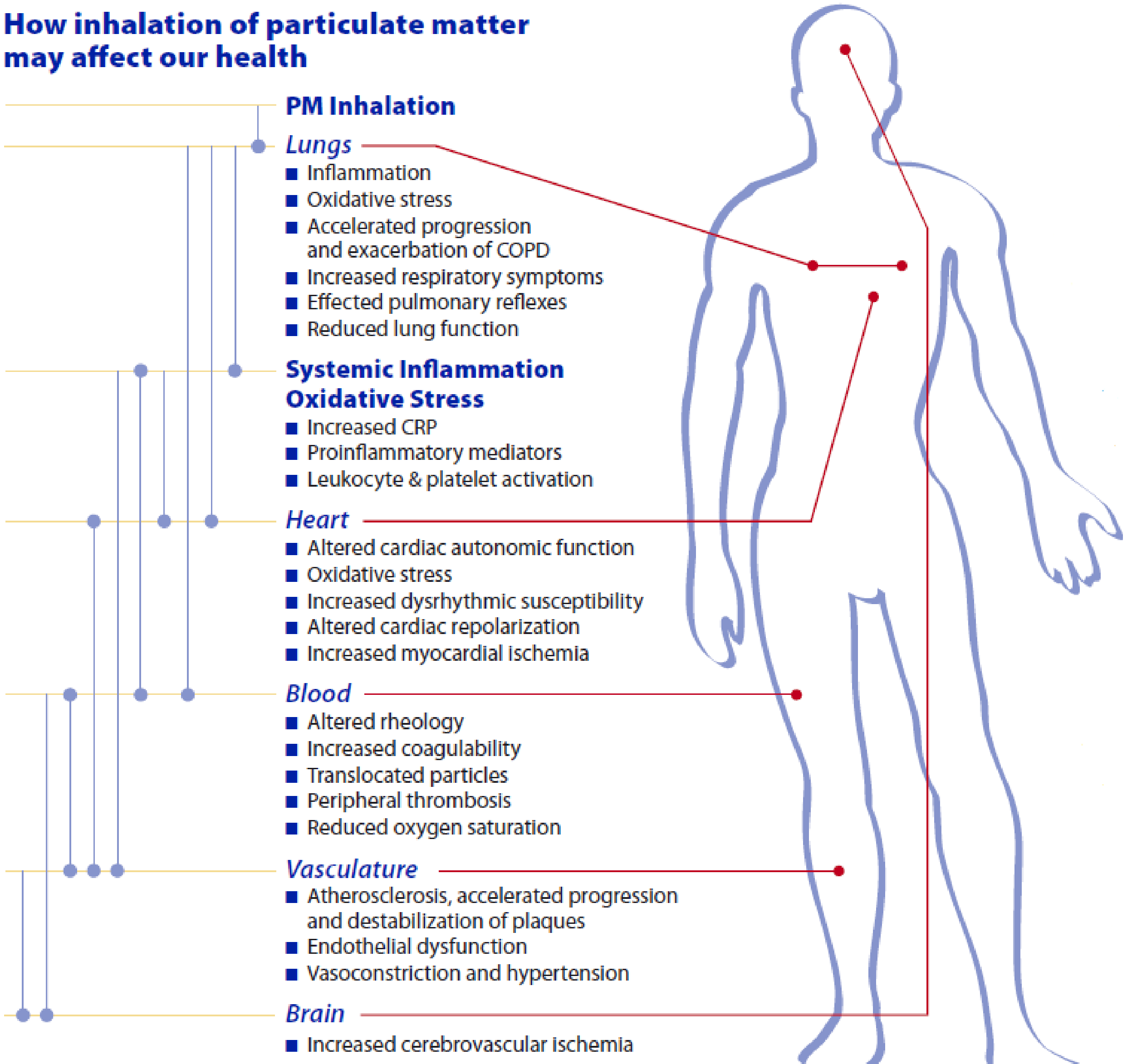
Health Impacts: "Pyramid of Effects"

- At-risk groups include:
  - People with lung disease such as asthma or chronic obstructive pulmonary disease (COPD).
  - Children.
  - Older adults.
  - People who are more likely to be exposed, such as people who are active outdoors, including children and outdoor workers.

Chronic pollution



Air pollutants and their health impact



Based on Pope and Dockery (J Air & Waste Management Association, 2006)

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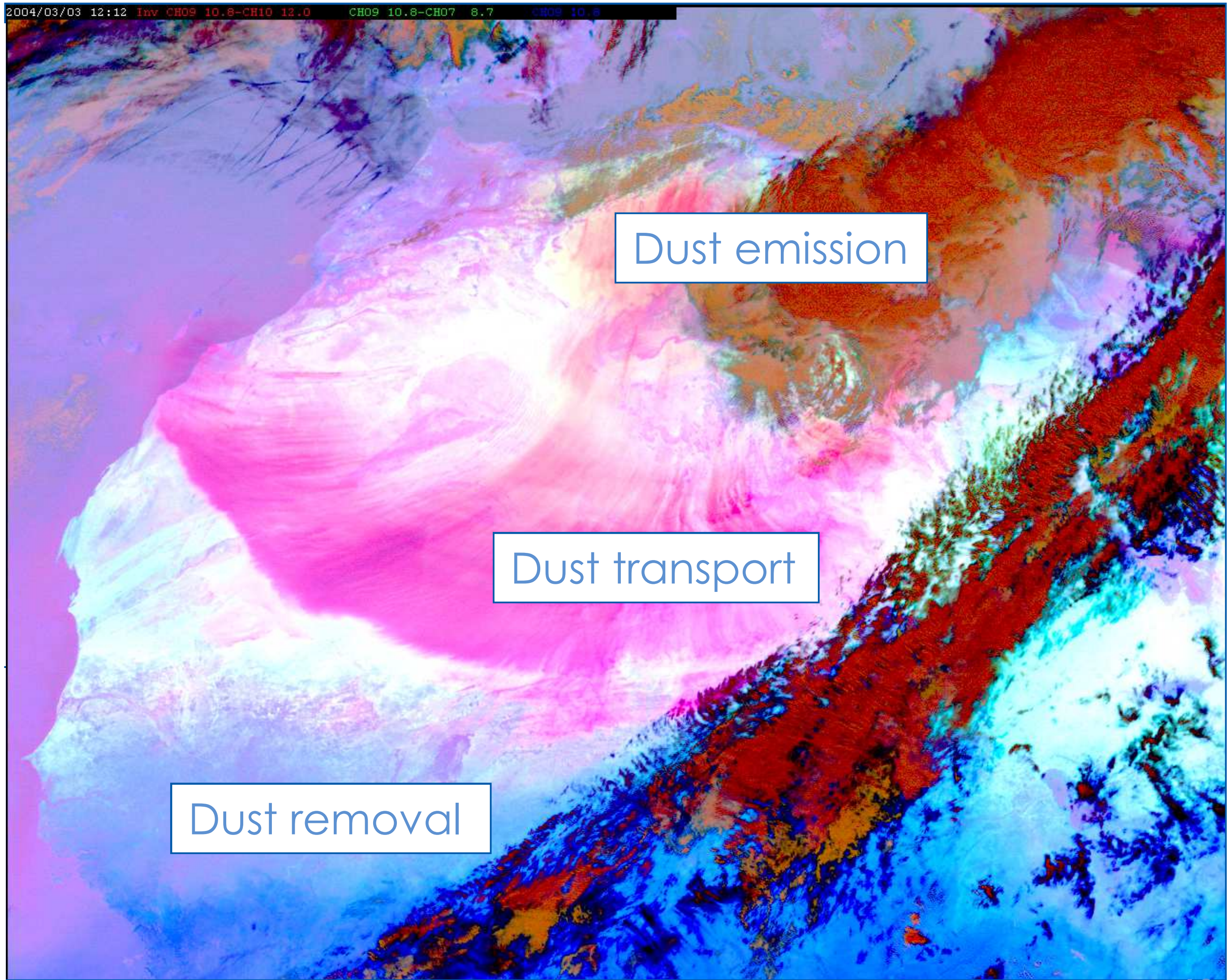
Dust cycle and associated processes

The following components have to take into account in the dust cycle:

Dust transport **is a global phenomenon.**

However, *dust emission* is a threshold phenomenon, sporadic and spatially heterogeneous, that is locally controlled on small spatial and temporal scales

Dust emission **is a complex physical process involving entrainment of soil particles by the surface winds.**



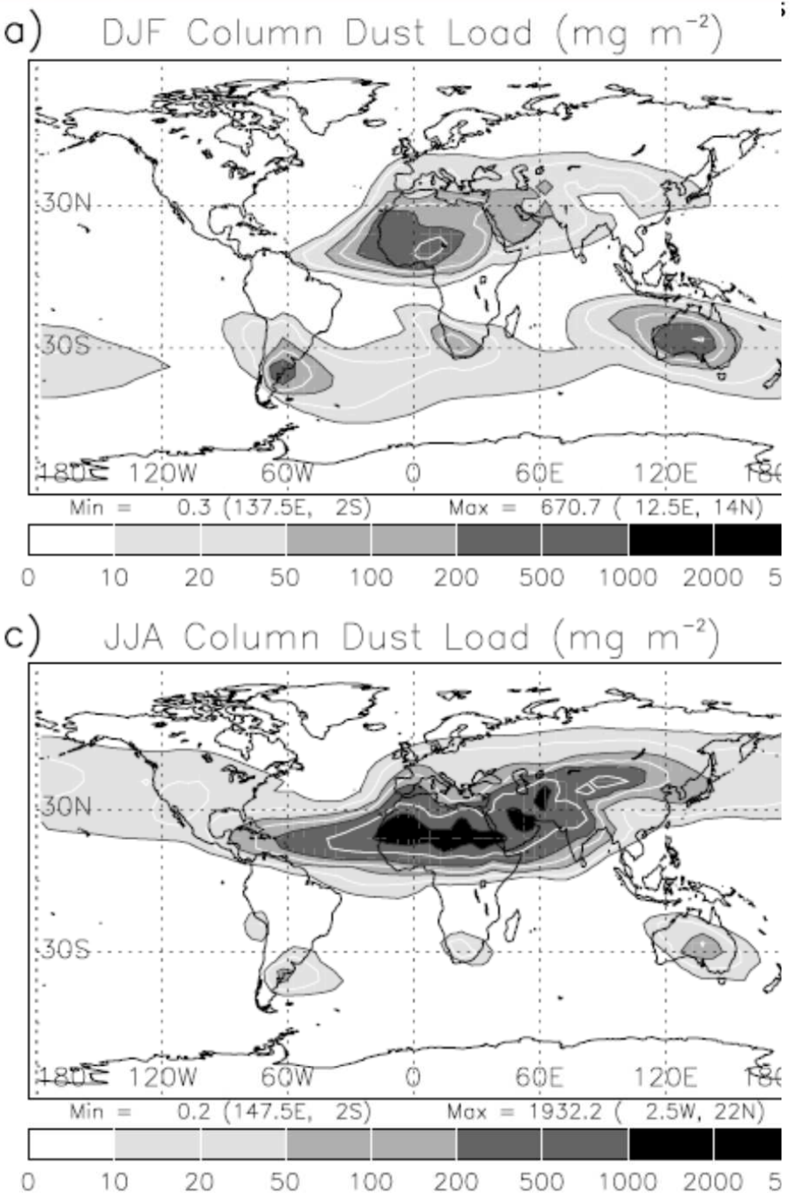


Figure 1.4: Global column dust load for
and fall (SON), derived from model estin
Cakmur et al. [2006].

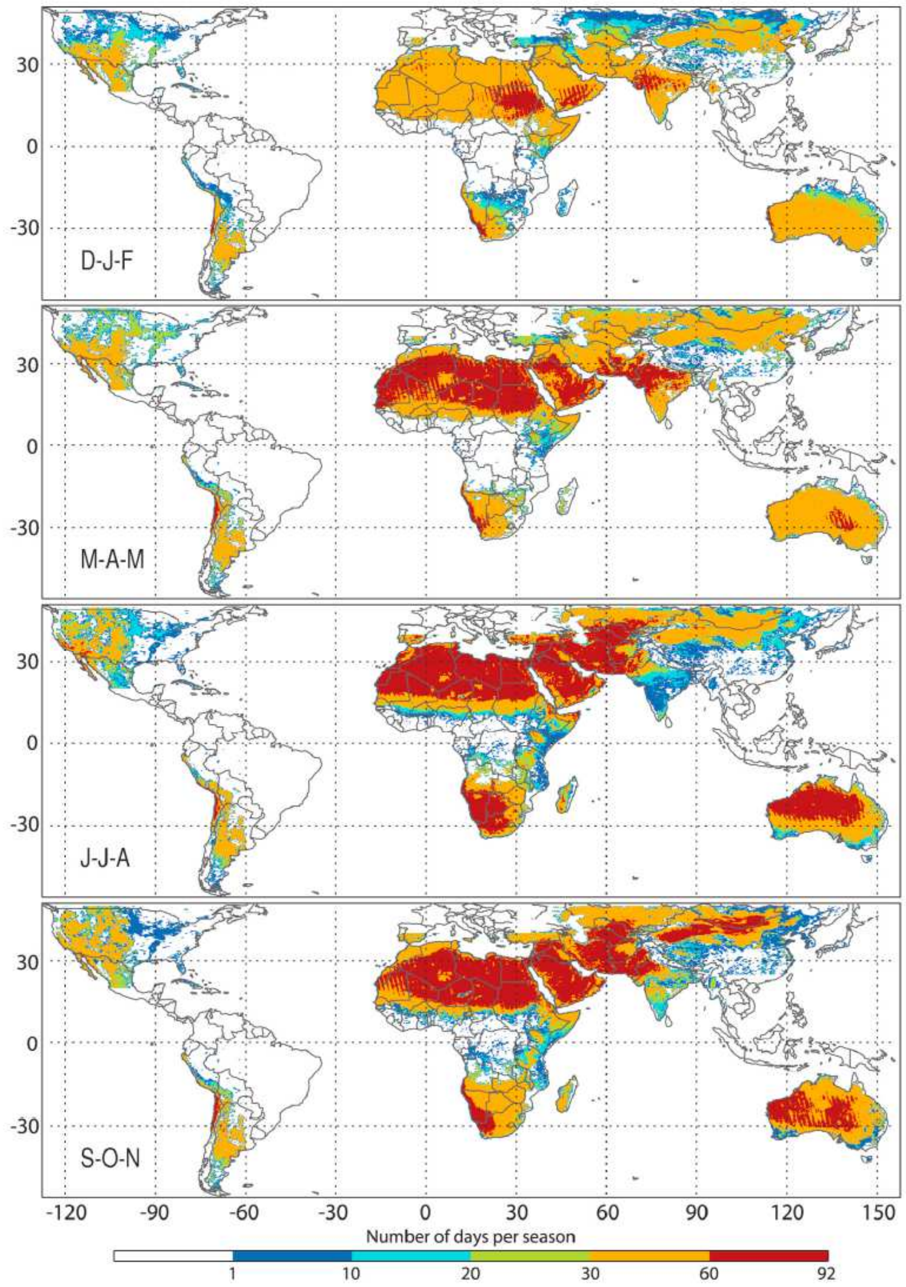
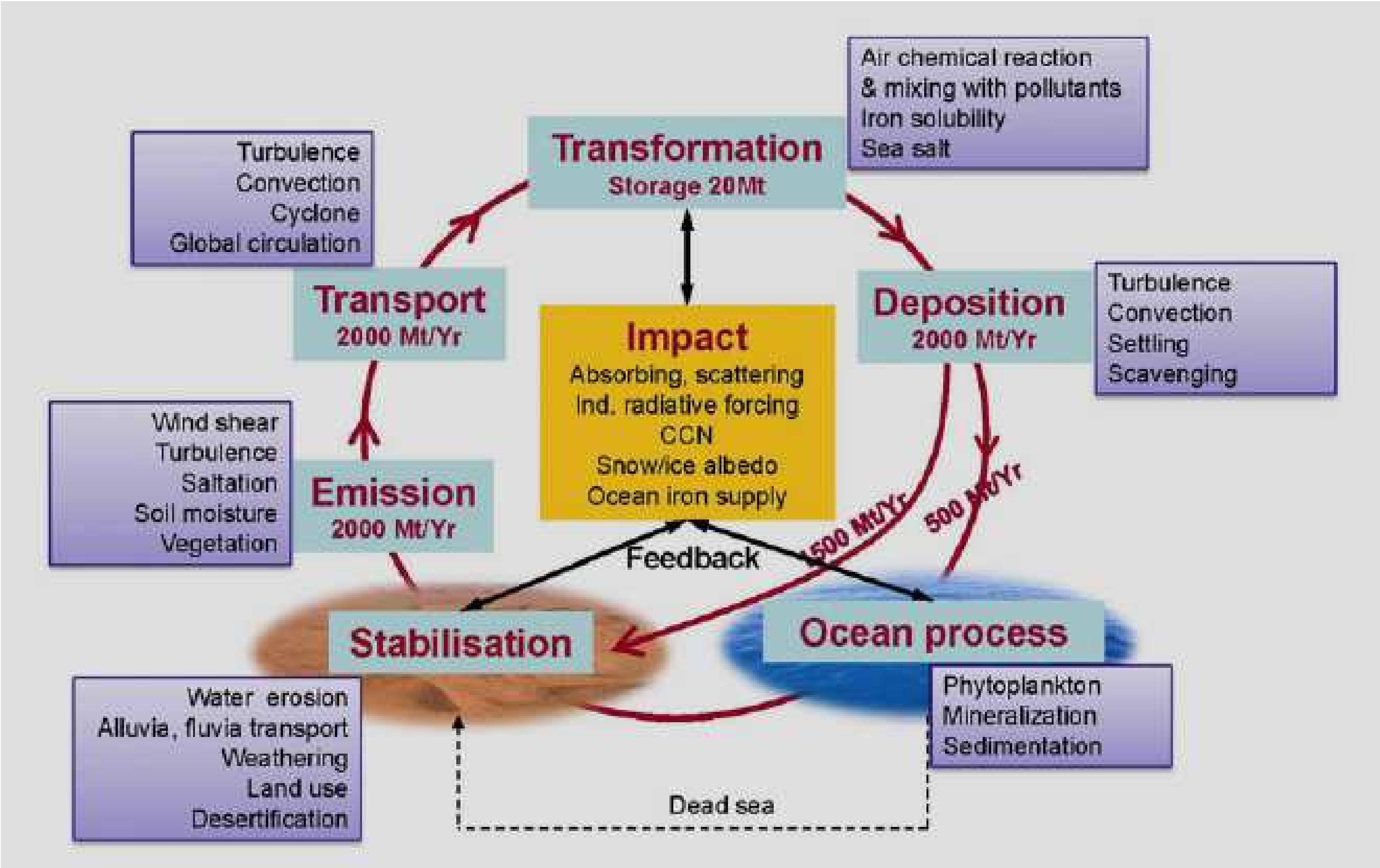


Figure 1. Global distribution of the number of MODIS DB AOD retrieval per 0.1° × 0.1° grid cell and per season, averaged from 2003 to 2009.

Illustration of the dust cycle in the Earth system and most important dust processes [Shao et al., 2011]



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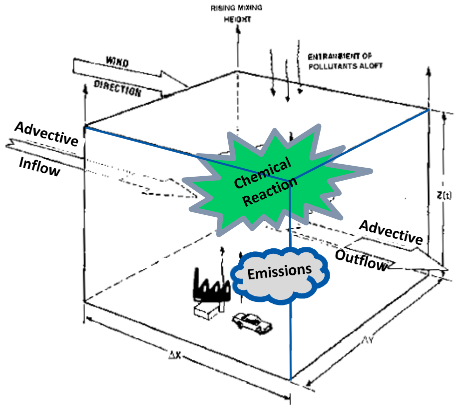
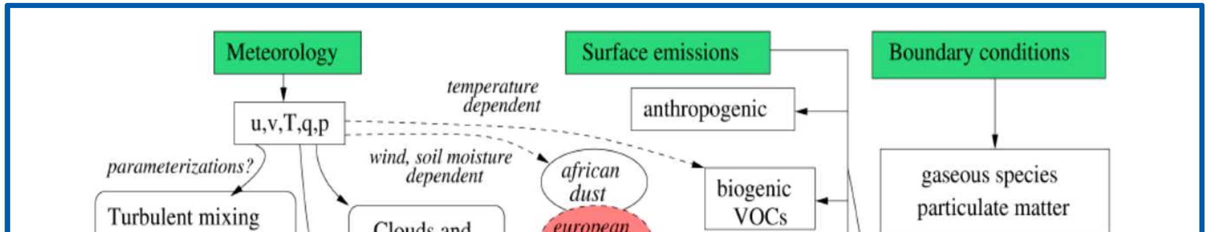
How do we model ?

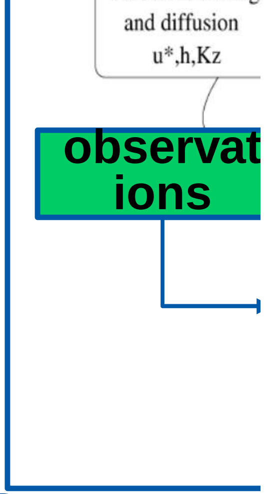
Numerical Deterministic

- Mathematical representation of processes that affect air pollution.
- Requires a system of models to simulate: the **emissions**, **transport** (adv. & diff.), **chemical transformation** (gas, aerosol, aq. phase), and **removal** (wet & dry deposition) of air pollution.



Modelling system flowchart





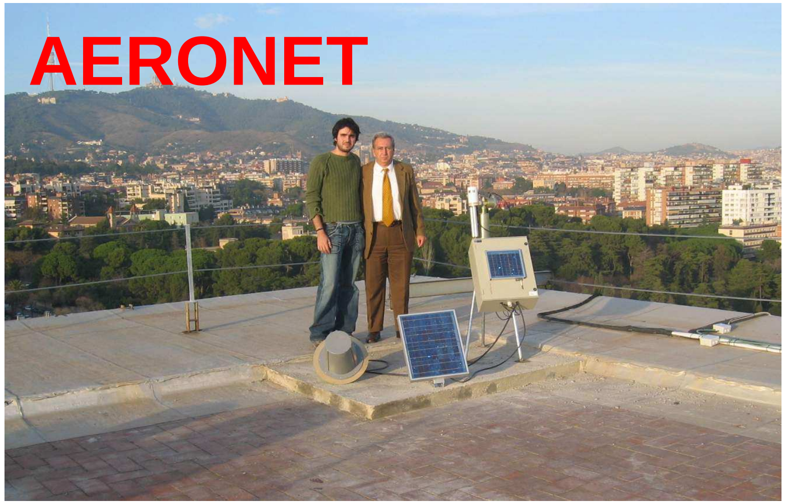
Model evaluation

- Determining the suitability of a model for a specific application & configuration.

The mineral dust cycle can be described by a set of k independent equations of mass continuity, with k to be the number of particle transport bins, as exemplary shown for the mixing ratio (χ):

$$\frac{\partial \chi_k}{\partial t} = -u \cdot \frac{\partial \chi_k}{\partial x} - v \cdot \frac{\partial \chi_k}{\partial y} - (w - \nu_{gk}) \cdot \frac{\partial \chi_k}{\partial z} - \nabla \left(K_H \cdot \nabla \chi_k \right) - \frac{\partial}{\partial z} \left(K_Z \cdot \frac{\partial \chi_k}{\partial z} \right) + \left(\frac{\partial \chi_k}{\partial t} \right)_{source} - \left(\frac{\partial \chi_k}{\partial t} \right)_{sink} \tag{1.1}$$

Technical University of Catalonia (UPC), Barcelona-Spain



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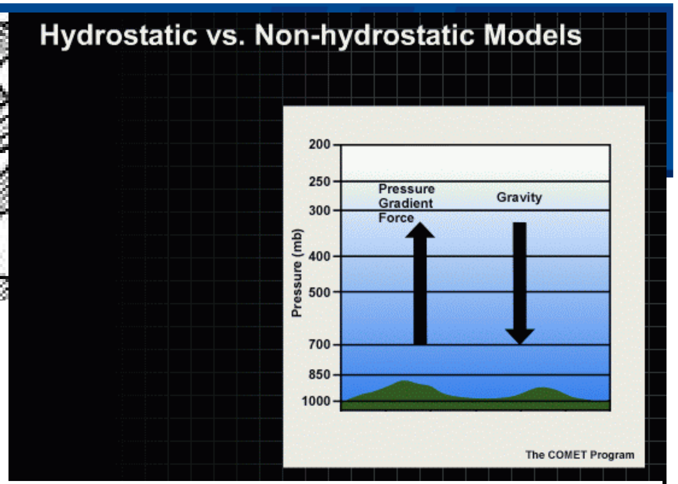
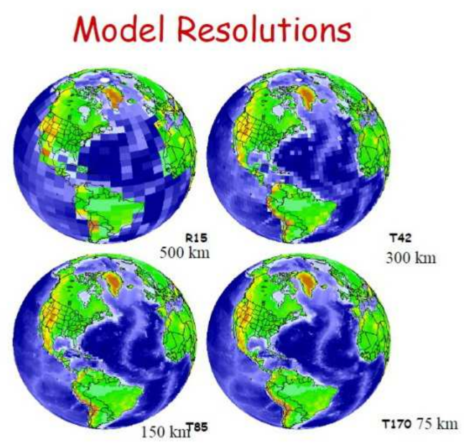
ACTRiS
Aerosols, Clouds, and Trace gases Research InfraStructure Network





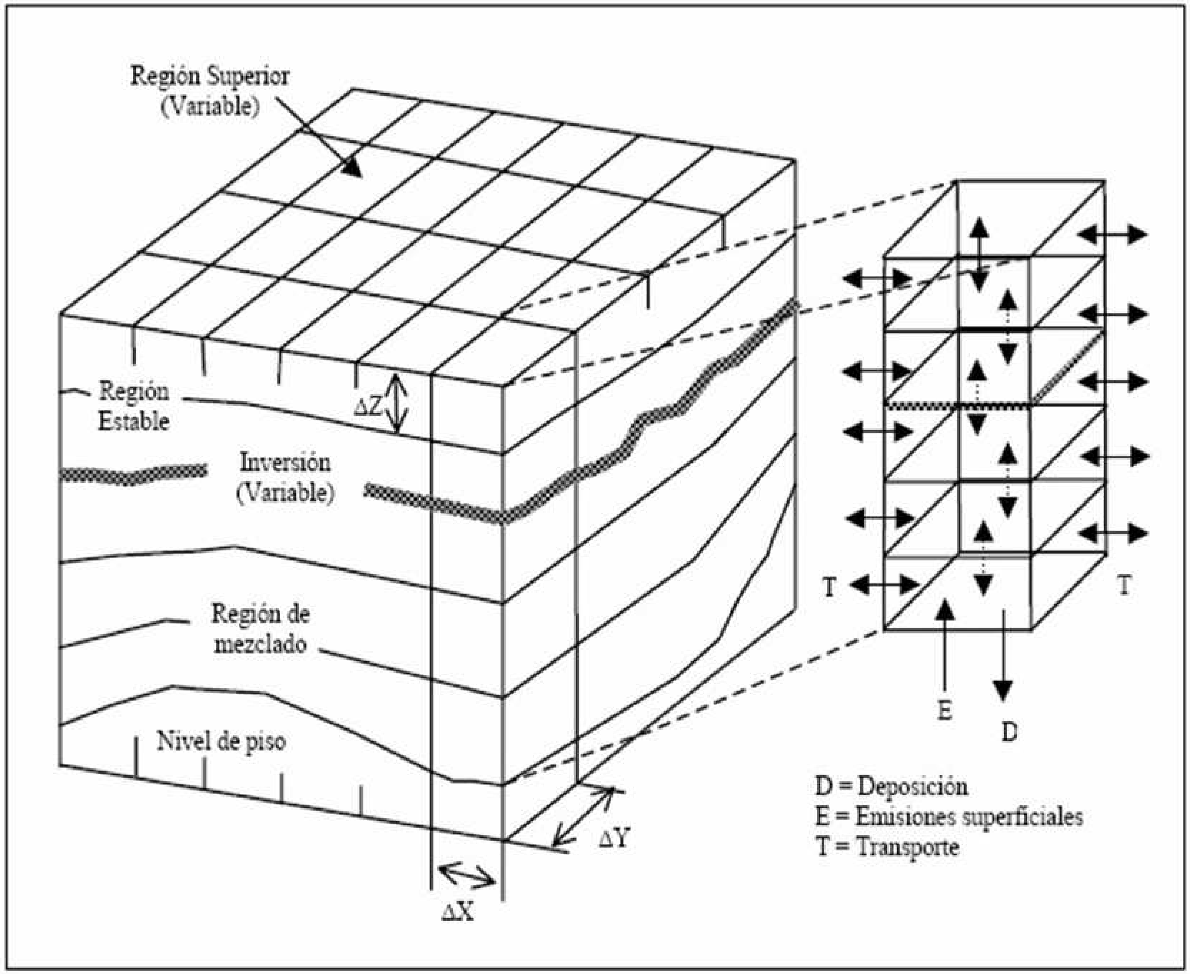
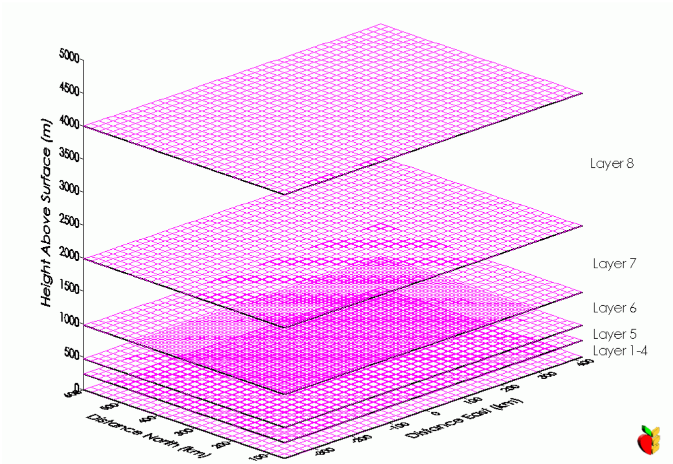
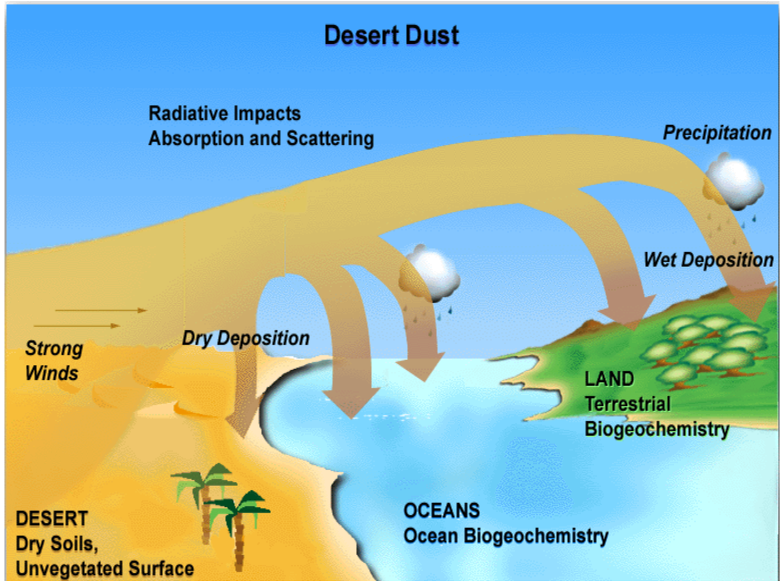


Figura 3. Representación esquemática de un mallado para un modelo Euleriano



Dust forecasting models



Dust models are a mathematical representation of atmospheric dust cycle.

- ✓ To complement dust-related observations, filling the temporal and spatial gaps of the observations.
- ✓ To help us to understand the dust processes and their interaction with climate and ecosystems.
- ✓ To predict the impact of dust on surface level concentrations used as SHORT-TERM FORECASTING TOOLS (3-5 days ahead) or CLIMATIC ANAYSIS (>30 years)

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Dust cycle and associated processes

Types of dust storms:

Synoptic dust storms (large scale weather systems)

- Prefrontal winds
- Postprontal winds
- Large-scale Trade winds
- ….

Well captured by models.

Mesoscale dust storms

- Downslope winds
- Gap flow
- Convection and Haboobs
- Inversion downburst storms
- …..

Is captured with difficulties by models. Some improvements in regional models.

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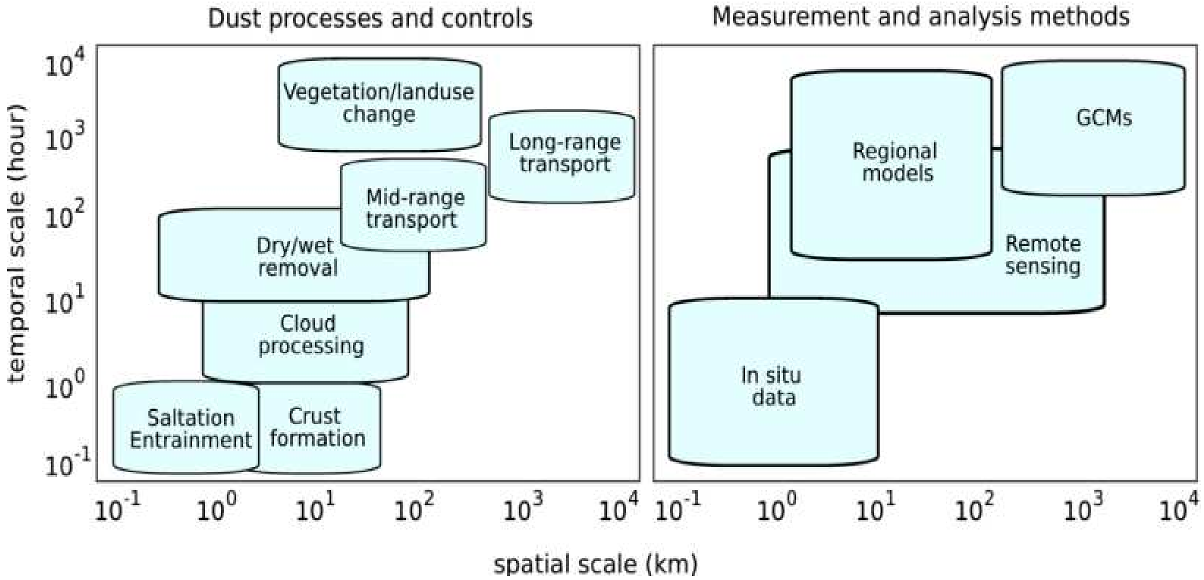
Dust cycle and associated processes



- Dust processes span over five orders of magnitude in space and time.

- To correctly describe and quantify the dust cycle, one needs to understand equally well local-scale processes such as saltation and entrainment of individual dust particles as well as large-scale phenomena such as mid- and long-range transport.

Accurate representation of dust sources and sinks is critical for providing realistic magnitudes and patterns of atmospheric dust fields.

Complexity of dust cycle

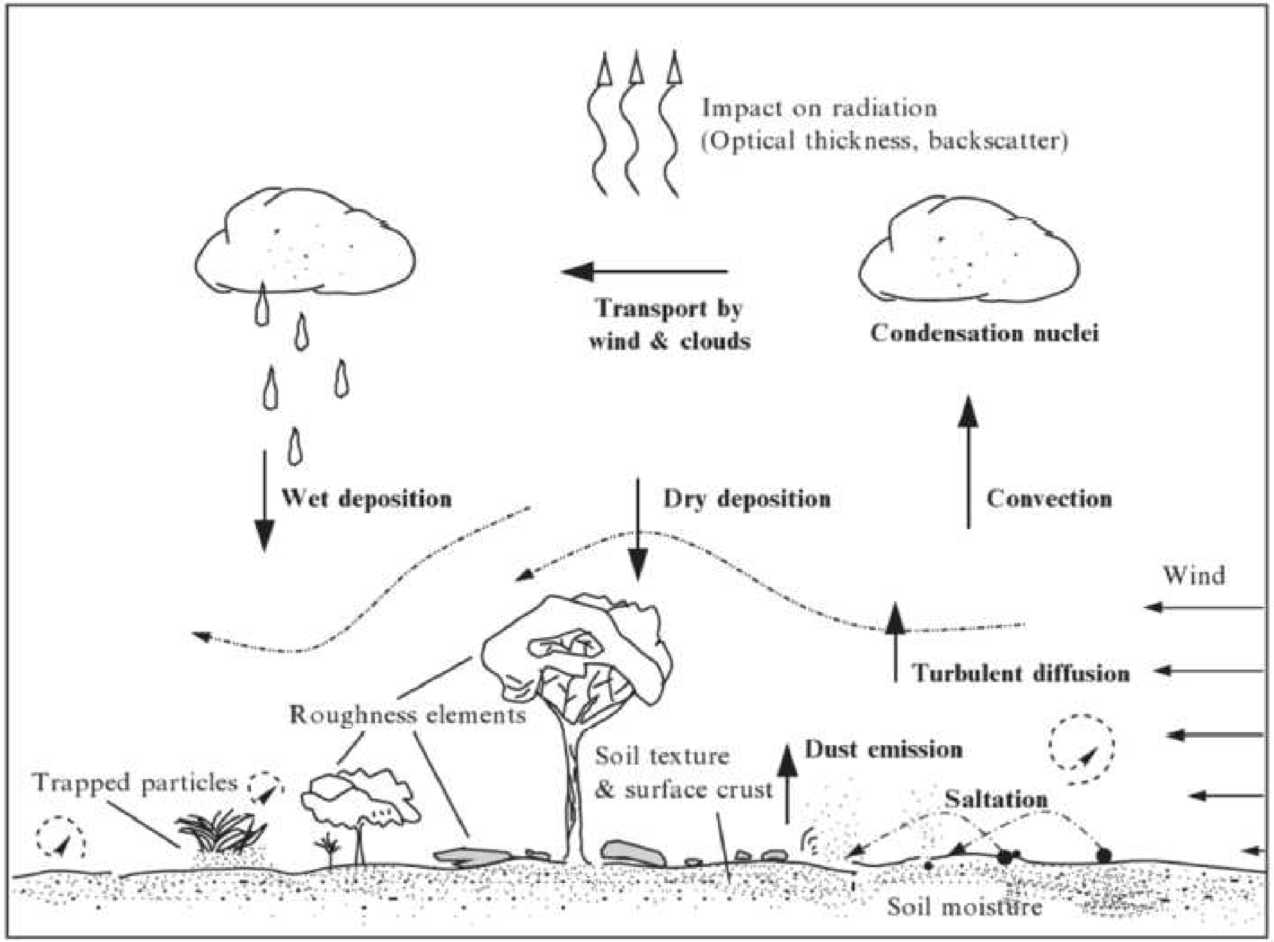


Figure 1.8: An illustration of the phases of the dust cycle: entrainment, transport and deposition. Atmospheric conditions, soil properties, land-surface characteristics and landuse practice control the erosion process. Extracted from Shao (2008).

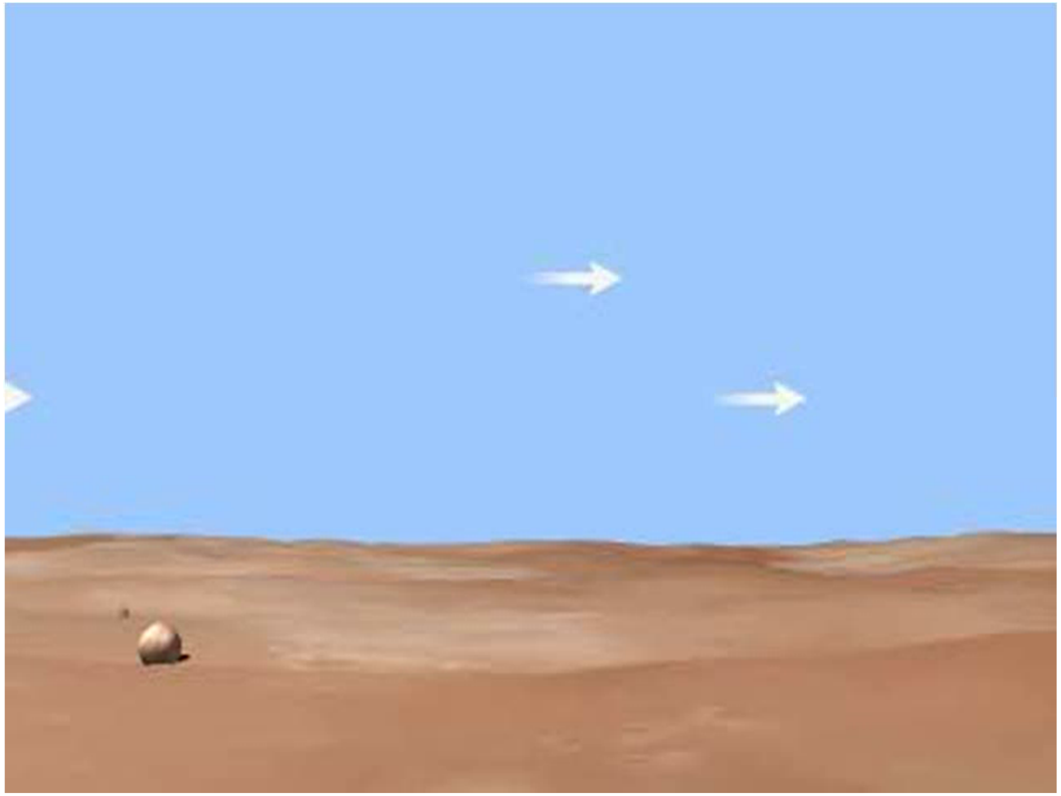
Mineral dust models

Mineral dust models simulate the atmospheric dust cycle and involves a variety of processes:

$$\frac{\partial C_k}{\partial t} = \underbrace{\boxed{-u\frac{\partial C_k}{\partial x} - v\frac{\partial C_k}{\partial y}}}_{\textit{Horizontal advection}} - \underbrace{\boxed{(w - v_{gk})\frac{\partial C_k}{\partial z}}}_{\textit{Vertical convection \& gravitational settling}} - \underbrace{\boxed{\nabla(K_H \nabla C_k)}}_{\textit{Horizontal diffusion}} - \underbrace{\boxed{\frac{\partial}{\partial z}\left(K_Z\frac{\partial C_k}{\partial z}\right)}}_{\textit{Vertical diffusion}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SOURCE}}}_{\textit{Dust emission}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SINK}}}_{\textit{Wet and dry deposition}}$$

Dust forecasting models: Emission scheme

- Complex physical process involving entrainment of soil particles by the surface winds.



- Creep or rolling motion of the largest particles (> 500 um)

- Saltation or horizontal motion of large soil grains (sand) (50-500um)

- Suspension of dust (after sandblasting or saltation bombardment) (0.1-50 um)

Movie from the COMET program at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR)

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Dust forecasting models: Emission scheme → soil condition (texture, moisture, …)

Dust source function

Main landscapes of the North Africa (Photos from Callot et al. 2000) :

A) Central part of Saharan Atlas. In the background, mountains, and in front, an overgrazed plain;

B) Northern part of Saharan Atlas. Esparto grass steppe degraded by a strong anthropic action. The sandy soil disappears, denuding the sandstone substratum;

C) The Great Hamada south-west of El-Abiodh-Sidi-Cheikh;

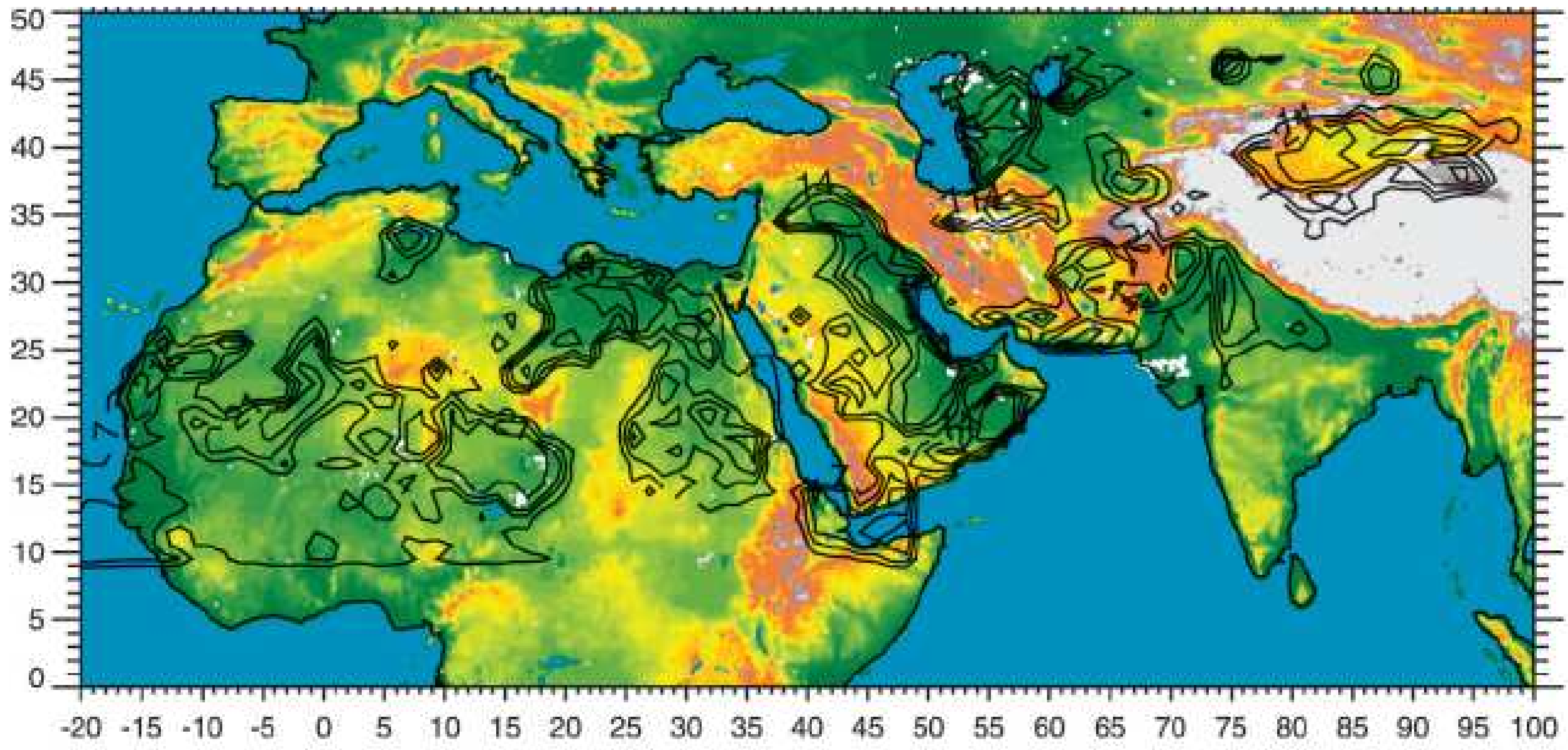
D) Daïa in the Mechfar, at Hassi Cheikh well;

E) North-east of the Great Western Erg: coarse sand interdune corridor with deflation cauldron and palaeolake deposits;

F) North-east of the Great Western Erg: great coarse sand dome dunes, covered by fine sand active dunes.

Dust forecasting models: Emission scheme

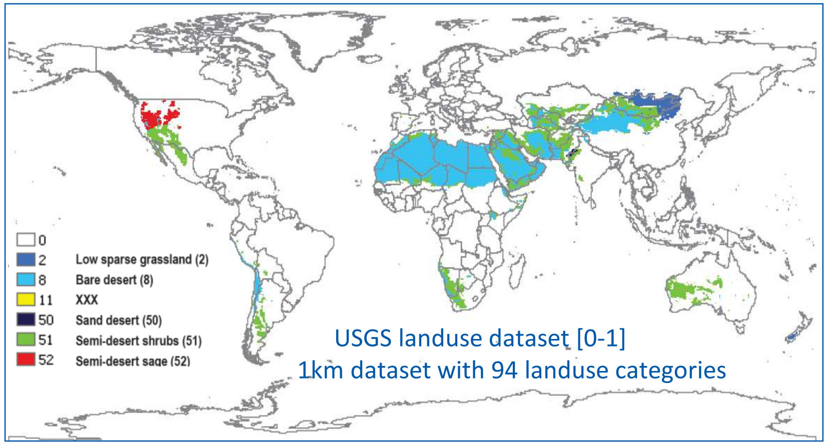
Dust source function

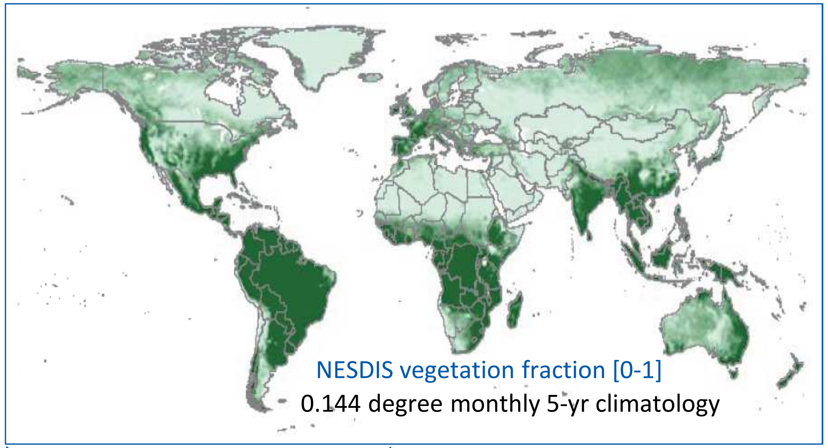


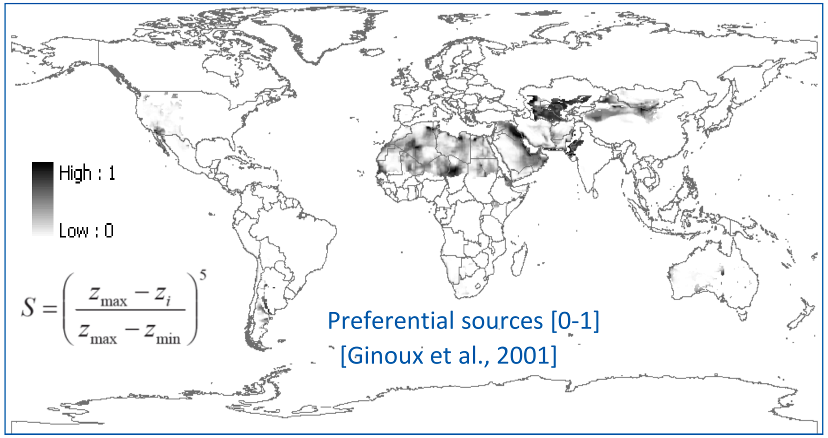
DUST HOT SPOTS ASSOCIATED WITH TOPOGRAPHIC DEPRESSIONS (Prospero et al., 2002)
Images show topography (color scale) and TOMS AI (contours)

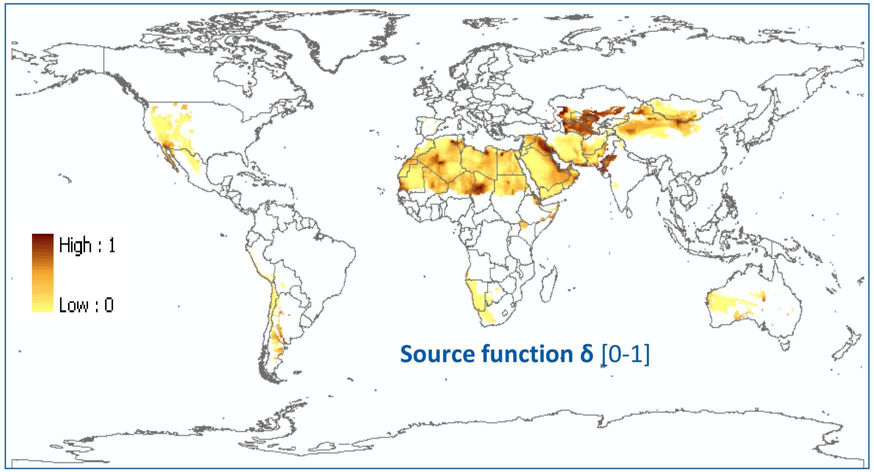
Dust forecasting models: Emission scheme

Dust source function: GOCART and NMMB/BSC-Dust models









$$\delta = USGS \cdot PREF \cdot (1 - VEGFRAC) \cdot (1 - SnowCover)$$

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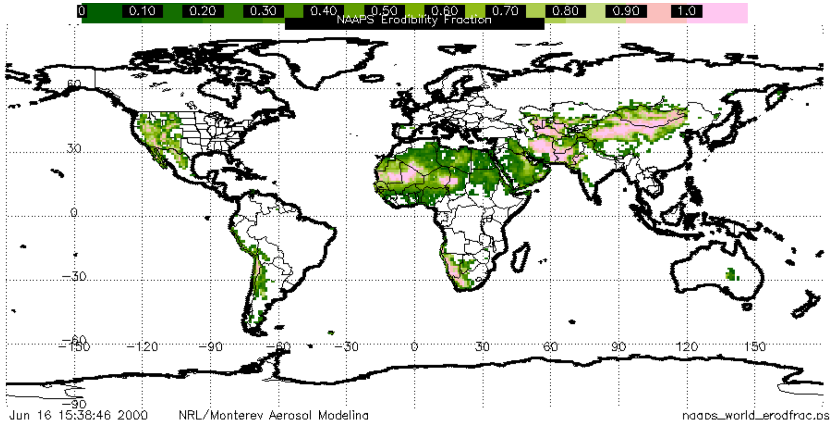
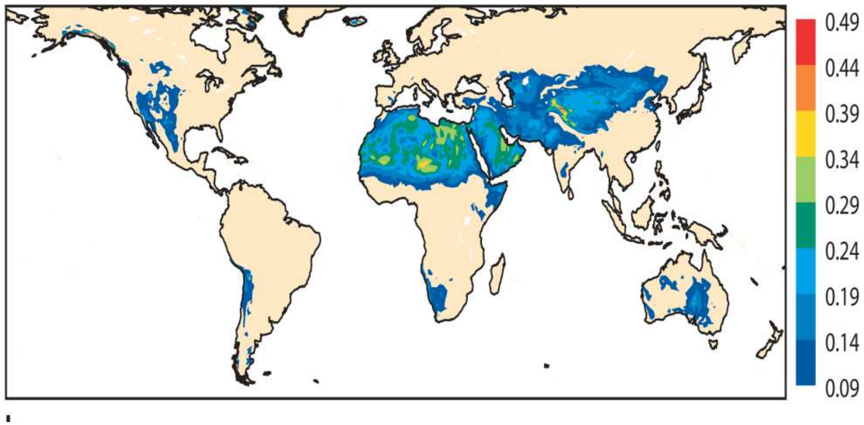
Dust forecasting models: Emission scheme

Dust source function: Other approaches



NAAPS model

Land use mask +
Erodibility map derived from TOMS
Satellite AI climatology

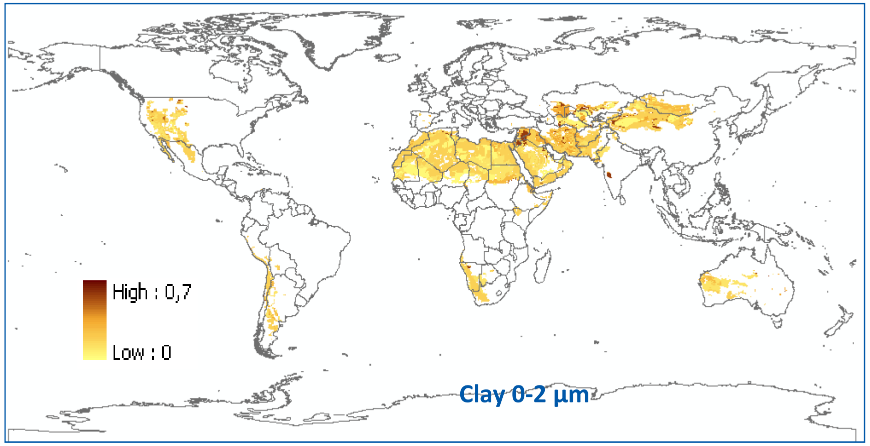


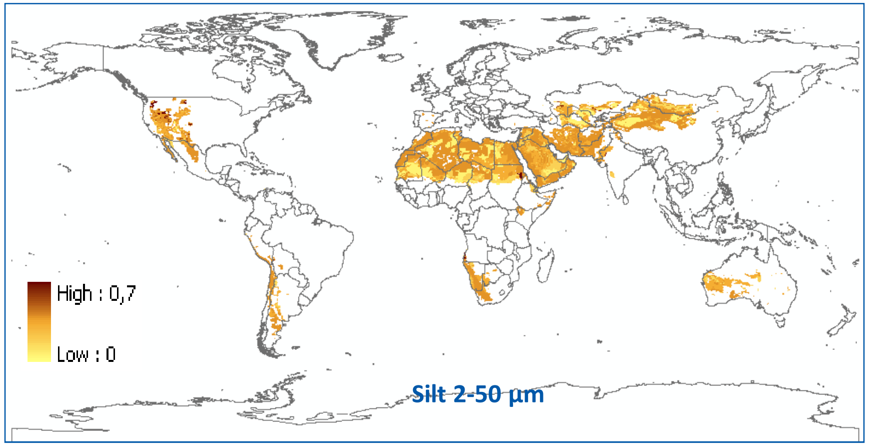
ECMWF-GEMS model

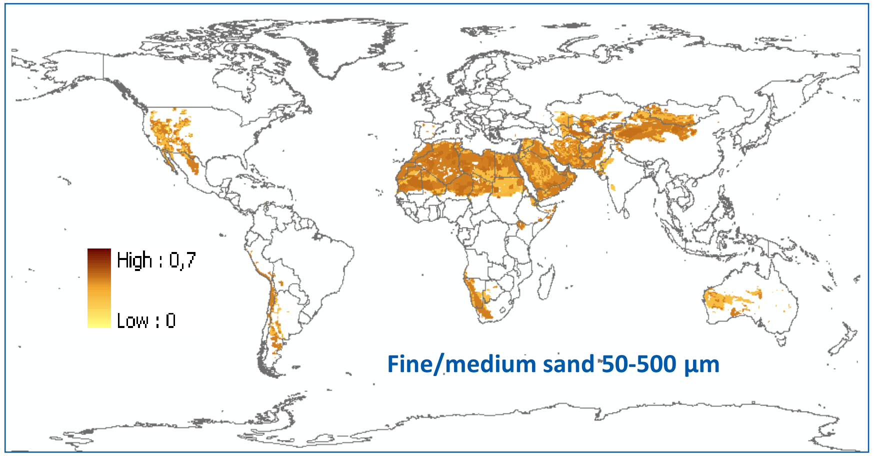
Background albedo in the ultraviolet-visible part of the shortwave spectrum. Only albedos with values between 0.09 and 0.54, assumed to be representative of light-colored soil and sparse vegetation are plotted.

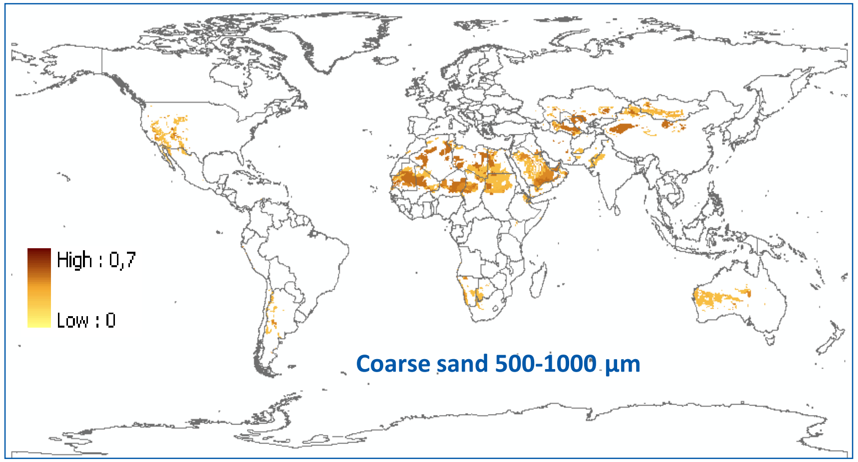
Dust forecasting models: Emission scheme

Parent soil size distribution









Four top soil texture classes according STASGO-FAO 1km database are converted to 4 parent soil size categories following Tegen et al. [2002]

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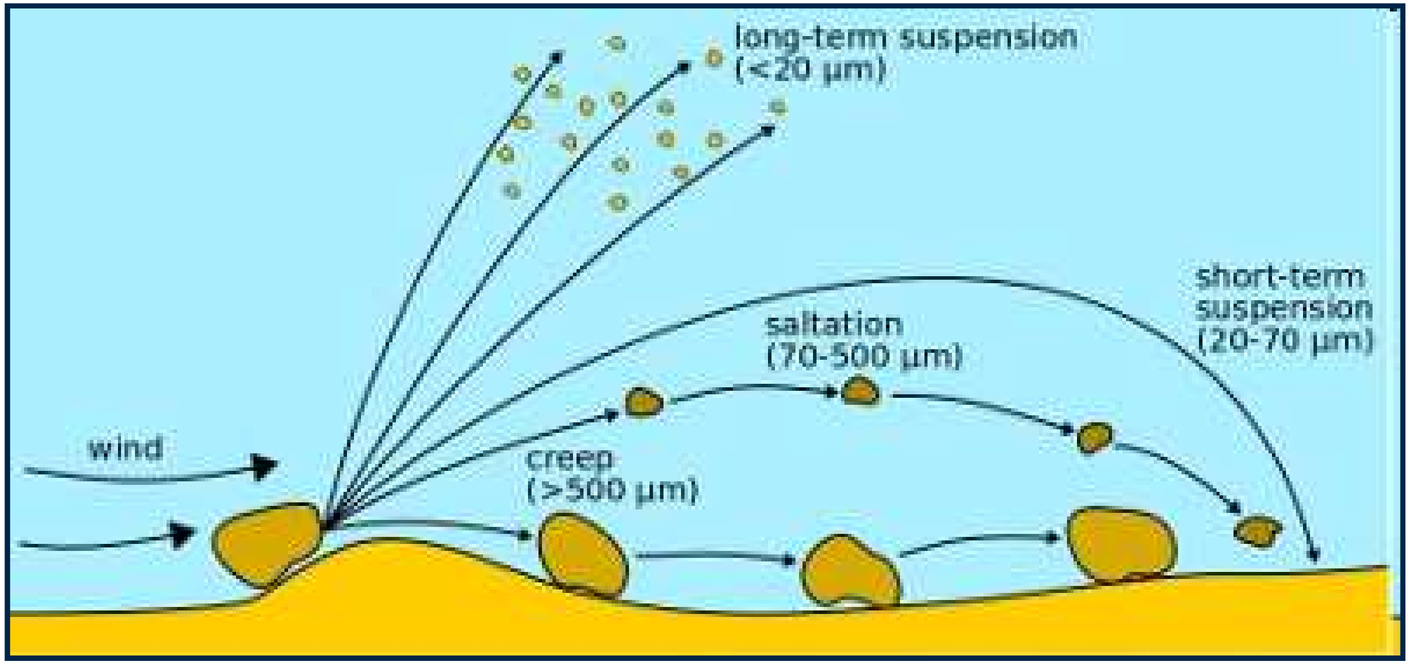
Dust forecasting models: Emission scheme



Scheme of the major wind erosion processes with saltation, creeping and suspension (due to sandblasting) in dependency of wind speed.

Extracted www.extension.purdu.edu/extmedia/AY/AY-271.html

Dust forecasting models: Emission scheme

Simple schemes

Formulation of vertical dust flux (F)

$$F = c \cdot f \cdot P(u_*^n, u_{*th}) \qquad \text{if} \quad u_* > u_{*t}$$

c: dimensional scale dependent constant proportionality
f: relative surface area of each soil particle fraction (which includes de source function, δ)
u_*: friction velocity
u_{*t}: threshold friction velocity
P: polinomial of degree n

Study	Scheme
Uno et al. (2001) CFORS	F= $cu_{10}{}^2(u_{10} - u_{10t})$
Liu and Westphal (2001) COAMPS	F= $fu_{10}{}^2(u_{10} - u_{10t})$
Liu and Westphal (2001) COAMPS	F= $fcu_*{}^4$

Dust forecasting models: Emission scheme

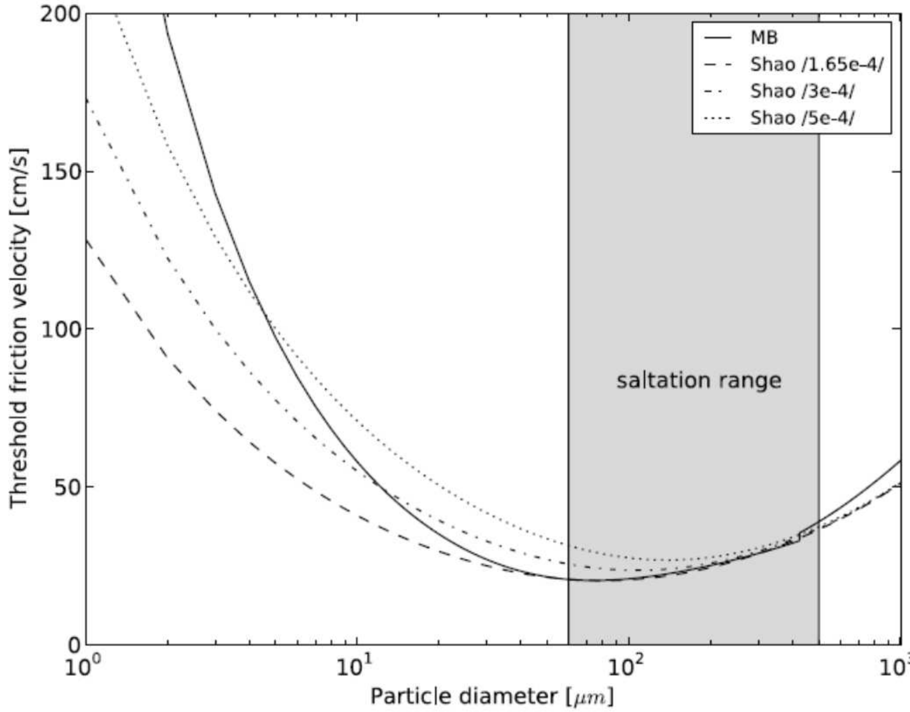
Threshold friction velocity (u_{*t})

Dust storm generation requires:

- High wind
- Wind shear and turbulence
- Unstable boundary layer

Friction velocity is the parameter used by dust models since it expresses wind speed, turbulence and stability

Threshold friction velocity vs particle radius →



Darmenova et al., 2009

Dust forecasting models: Emission scheme

Simple schemes

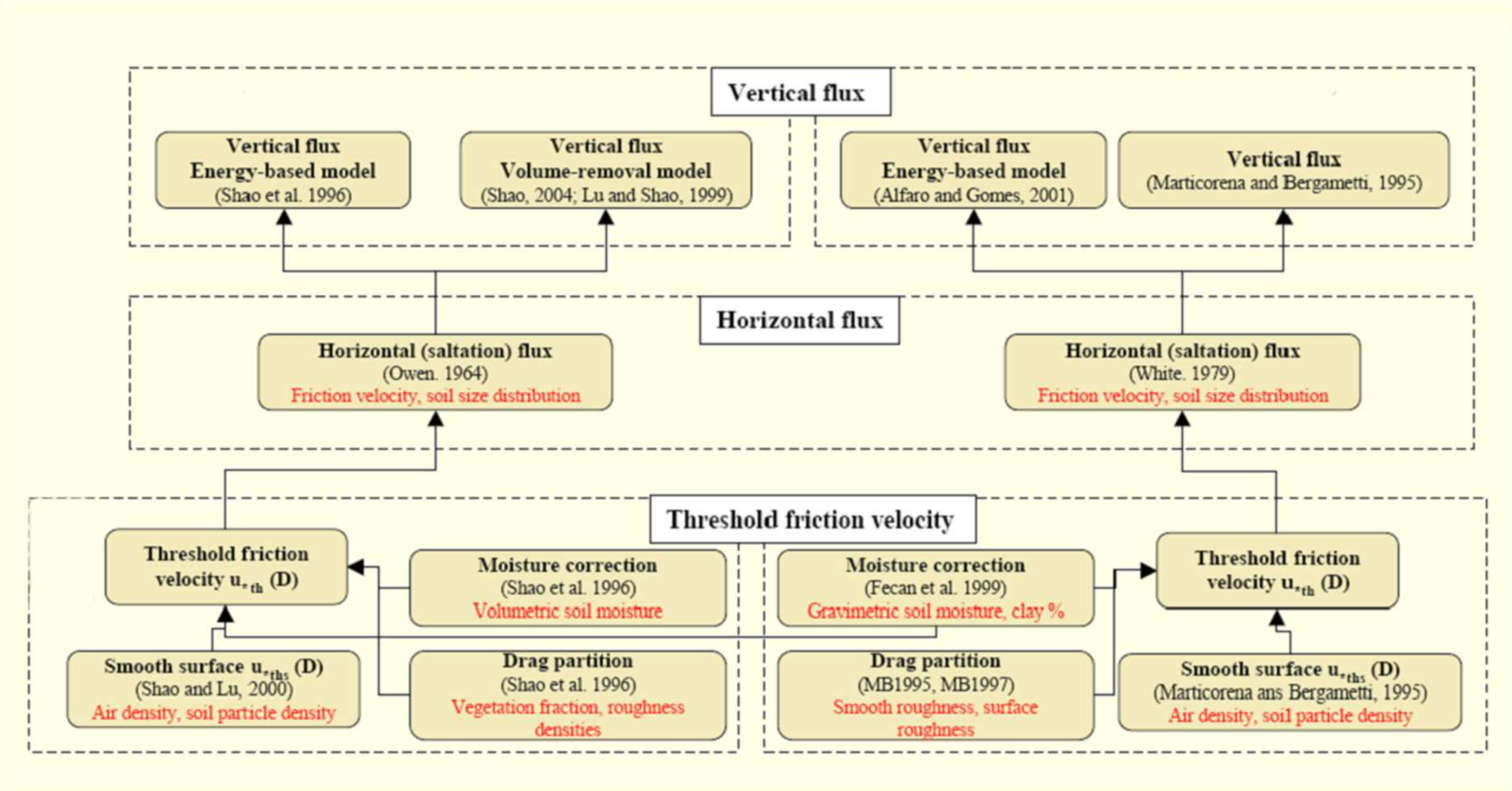
Limitations

- Oversimplified physical representation of dust emission.
- Normalization constant ***c*** is not known
- Erodible fraction is prescribed for predefined dust sources
- Threshold friction velocity is usually a fixed value (no dependence on the land surface properties)

- **Assuming constant threshold friction velocity will introduce bias in the modelling of the timing and intensity of dust events.**
- **The prescribed constant is model dependent and can result in large discrepancies in calculated dust loadings between different models.**

Dust forecasting models: Emission scheme

Physically based schemes



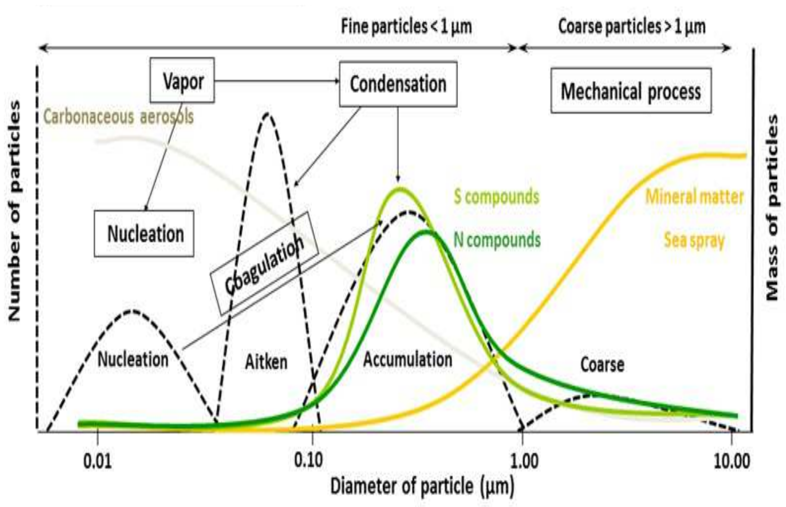
Physically-based **dust emission schemes** employ different parameterizations of the related physical processes, as well as require different input data.

Dust forecasting models: Emission scheme

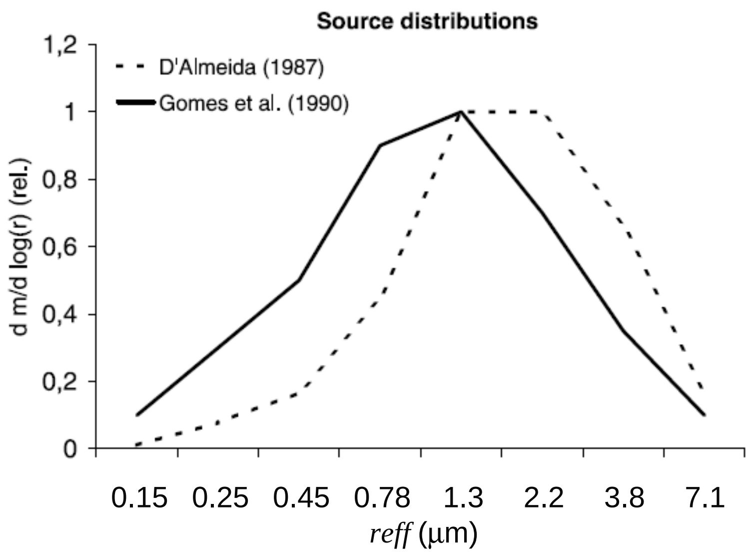
Parent soil size distribution are used to calculate **horizontal flux (H).**
Dust **horizontal concentration** is calculated distributing the **vertical flux (F)** of the **first two parent soil categories** (clay and silt) over the **model particle bins.**

Parameterizations of mass size distribution of the model at sources

Modal



Sectorial



8 bin size distribution from
Tegen and Lacis (1996)

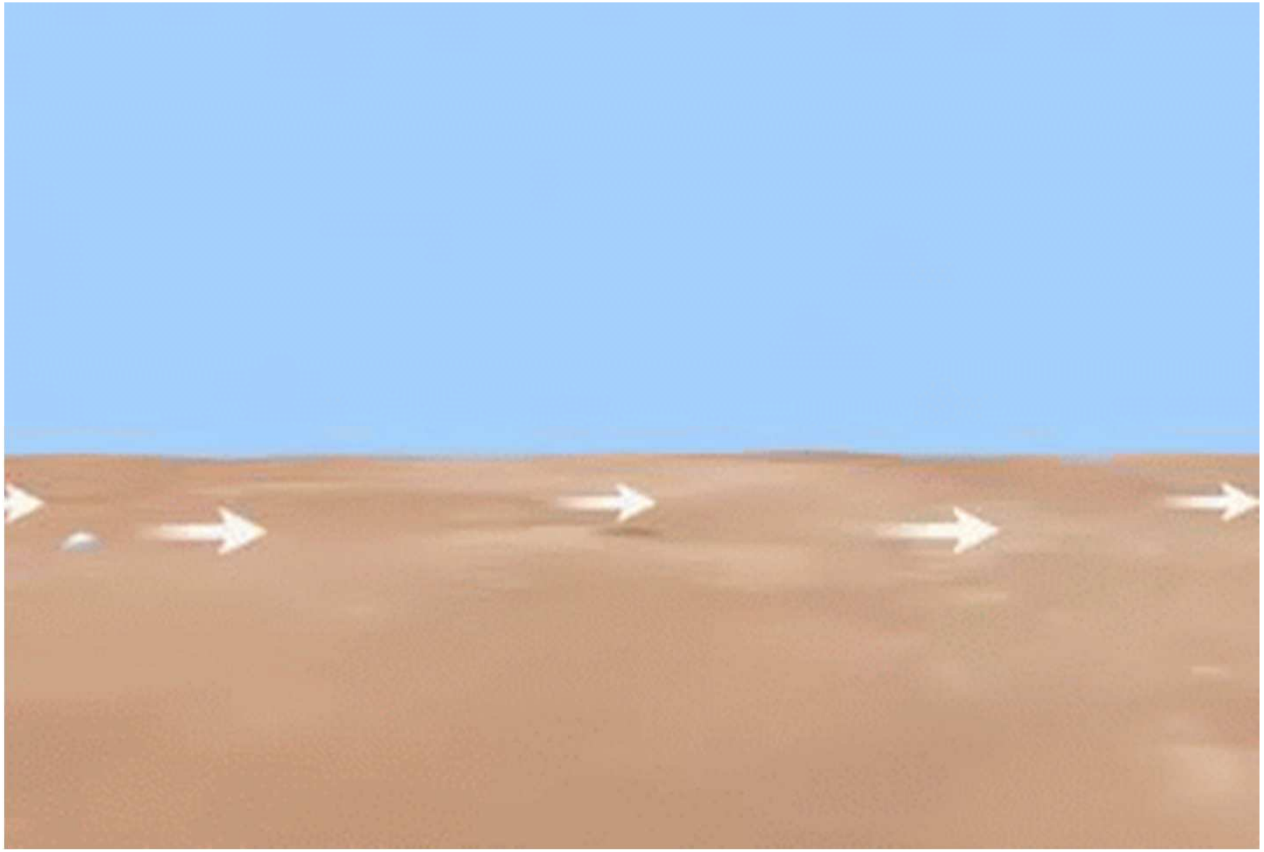
Mineral dust models

Mineral dust models simulate the atmospheric dust cycle and involves a variety of processes:

$$\frac{\partial C_k}{\partial t} = \underbrace{\boxed{-u\frac{\partial C_k}{\partial x} - v\frac{\partial C_k}{\partial y}}}_{\textit{Horizontal advection}} - \underbrace{\boxed{(w - v_{gk})\frac{\partial C_k}{\partial z}}}_{\textit{Vertical convection \& gravitational settling}} - \underbrace{\boxed{\nabla(K_H \nabla C_k)}}_{\textit{Horizontal diffusion}} - \underbrace{\boxed{\frac{\partial}{\partial z}\left(K_Z \frac{\partial C_k}{\partial z}\right)}}_{\textit{Vertical diffusion}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SOURCE}}}_{\textit{Dust emission}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SINK}}}_{\textit{Wet and dry deposition}}$$

Dust forecasting models: Dry deposition scheme

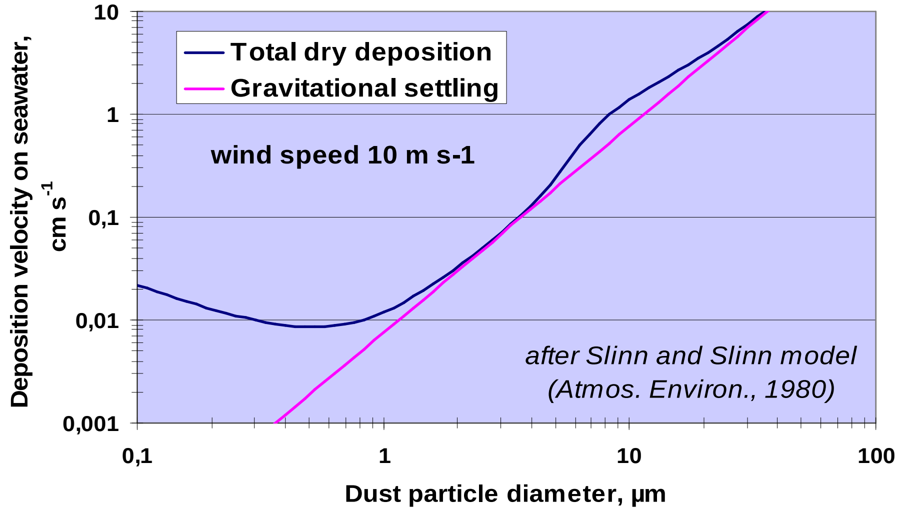
Sedimentation and dry deposition



Movie from the COMET program at http://meted.ucar.edu/ of the
University Corporation for Atmospheric Research (UCAR)

Dust forecasting models: Dry deposition scheme

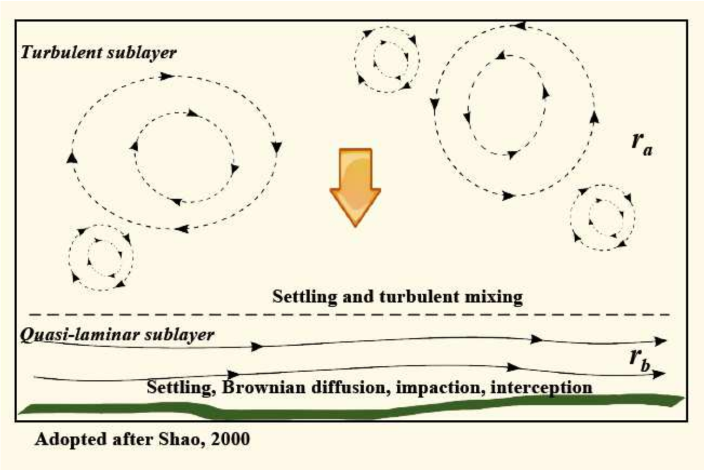
Dry deposition depends on the variety of factors such as meteorological conditions near the surface, physicochemical properties of mineral dust and the nature of the surface itself.



Dry deposition velocity is represented as 3 resistances in series parallel to a second pathway - gravitational settling velocity:

- Aerodynamic resistance to transfer (r_a)
- Quasi-laminar surface layer resistance (r_b)
- Resistance to surface uptake (r_c)

$$v_d = \frac{1}{r_a + r_b + r_c} \longrightarrow F_d = -C \cdot v_d$$



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Dust forecasting models: Wet deposition scheme

Wet scavenging

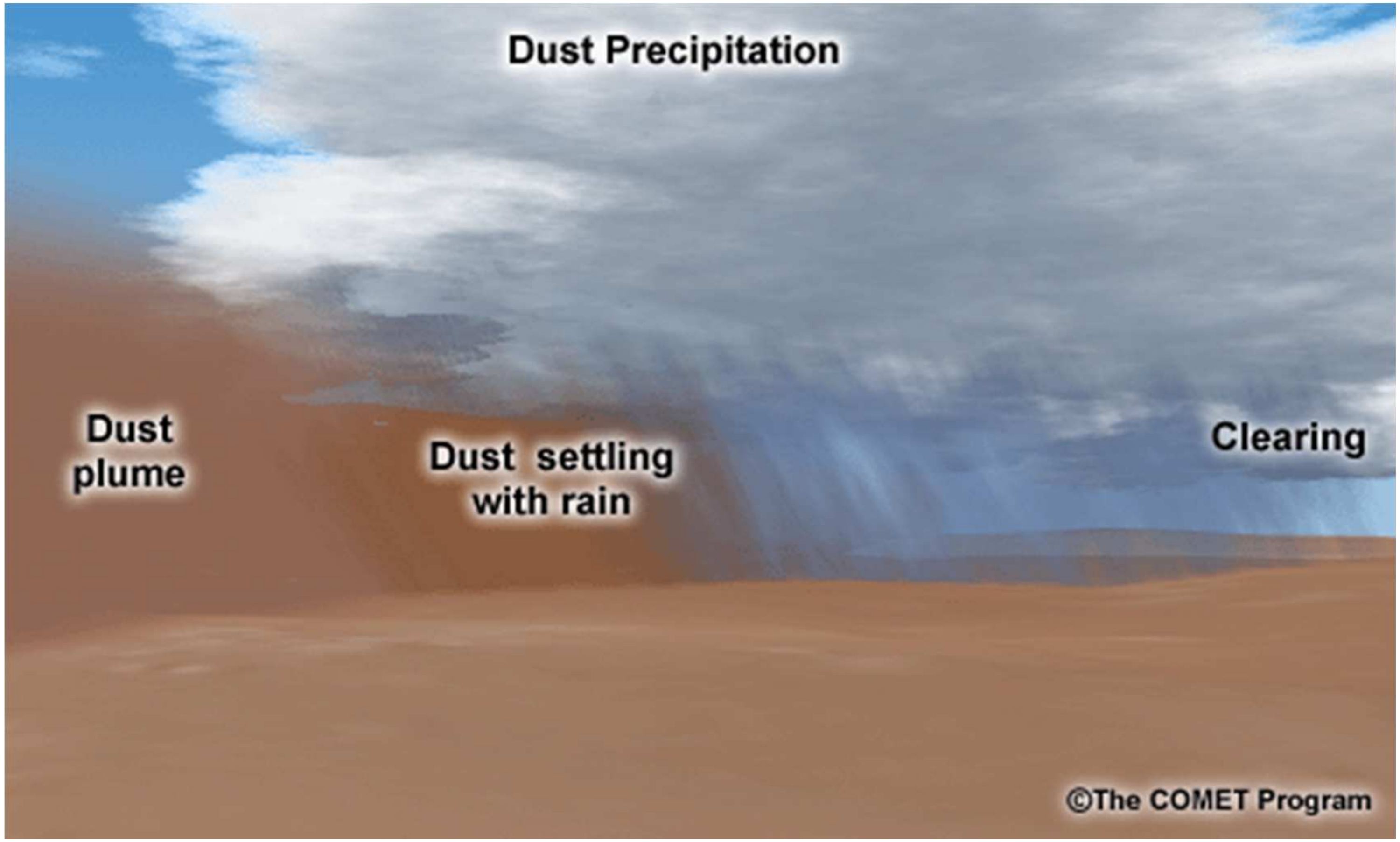
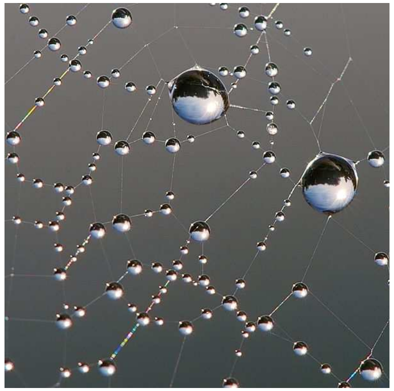
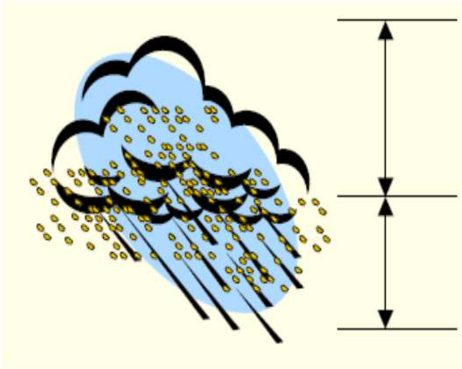


Image from the COMET program at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR)

Dust forecasting models: Wet deposition scheme





In-cloud scavenging:

- **nucleation scavenging** by activation and growth of particles to cloud droplets
- **collection** of a non-activated fraction of particles by coagulation with cloud and rain droplets

Below-cloud scavenging:

Collection by falling raindrops of particles under their collision.

Decrease rate of the aerosol concentration due to **wet scavenging** in a layer with uniform concentration can be described by a first-order equation:

$$\frac{\partial C}{\partial t} = -\lambda C$$

The **scavenging coefficient (C)** depends on:

• the particle size and solubility
• the collectors size distribution and fall speeds
• precipitation rate and phase (rain or snow).

Dust forecasting models: Wet deposition scheme

Existing problems

- **Rainout:** The soluble fraction of dust is not well known, so assigned scavenging efficiencies do not reflect regional specifics of dust properties and their dynamics (i.e., mineralogical composition, aging, etc.)

- **Washout:** Problems in modelling of clouds and precipitation remain a long-standing issue. Precipitation rates during violent convective rains are often underpredicted.

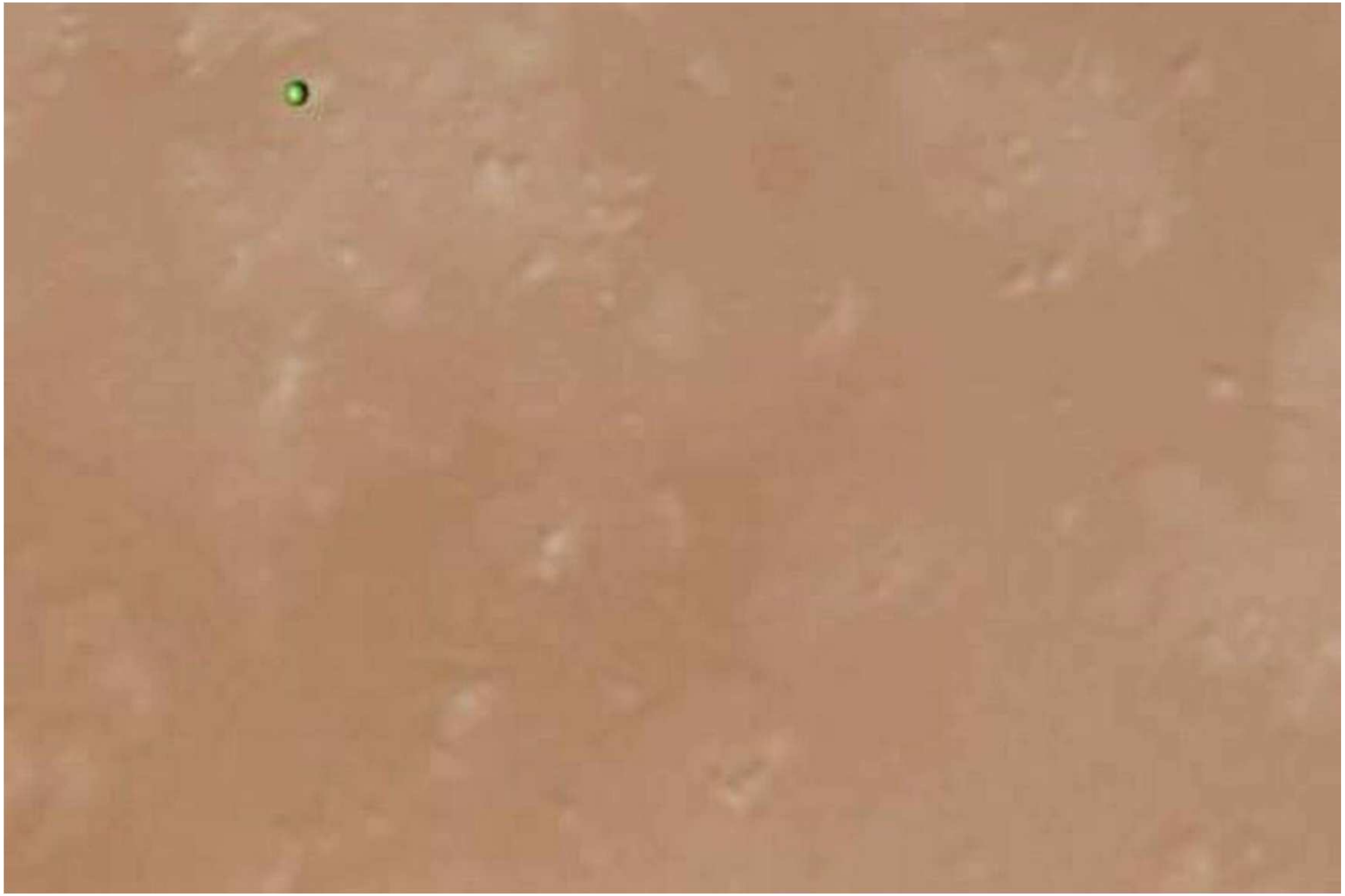
- **Dry versus wet deposition:** The relative importance of dry or wet deposition processes differs regionally and depends on the meteorological conditions and used parameterizations.

Mineral dust models:
Dispersion: advection, convection and diffusion

Mineral dust models simulate the atmospheric dust cycle and involves a variety of processes:

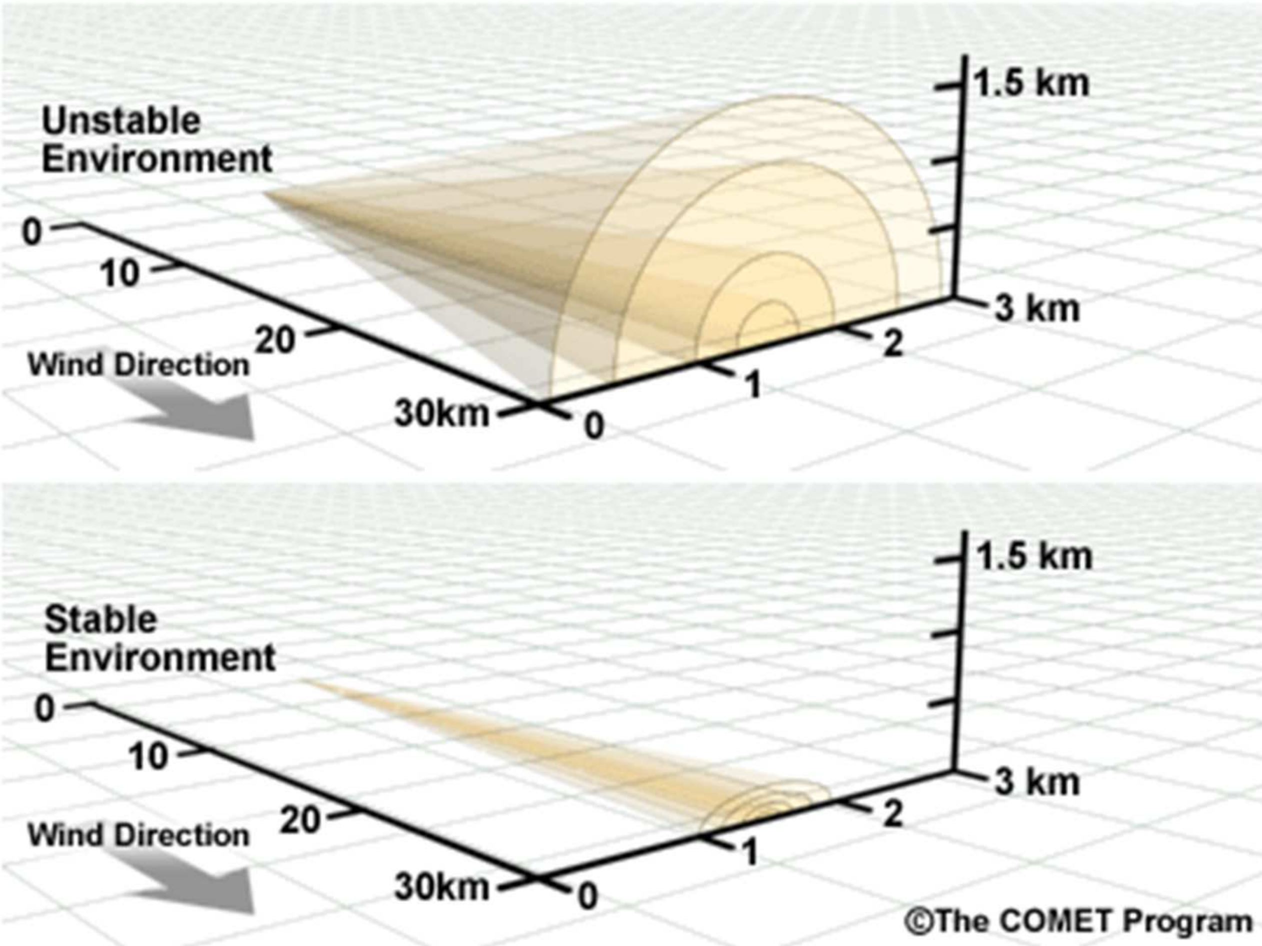
$$\frac{\partial C_k}{\partial t} = \underbrace{\boxed{-u\frac{\partial C_k}{\partial x} - v\frac{\partial C_k}{\partial y}}}_{\text{Horizontal advection}} - \underbrace{\boxed{(w - v_{gk})\frac{\partial C_k}{\partial z}}}_{\text{Vertical convection \& gravitational settling}} - \underbrace{\boxed{\nabla(K_H \nabla C_k)}}_{\text{Horizontal diffusion}} - \underbrace{\boxed{\frac{\partial}{\partial z}\left(K_Z \frac{\partial C_k}{\partial z}\right)}}_{\text{Vertical diffusion}} + \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SOURCE}}}_{\text{Dust emission}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SINK}}}_{\text{Wet and dry deposition}}$$

Dust forecasting models: Dispersion



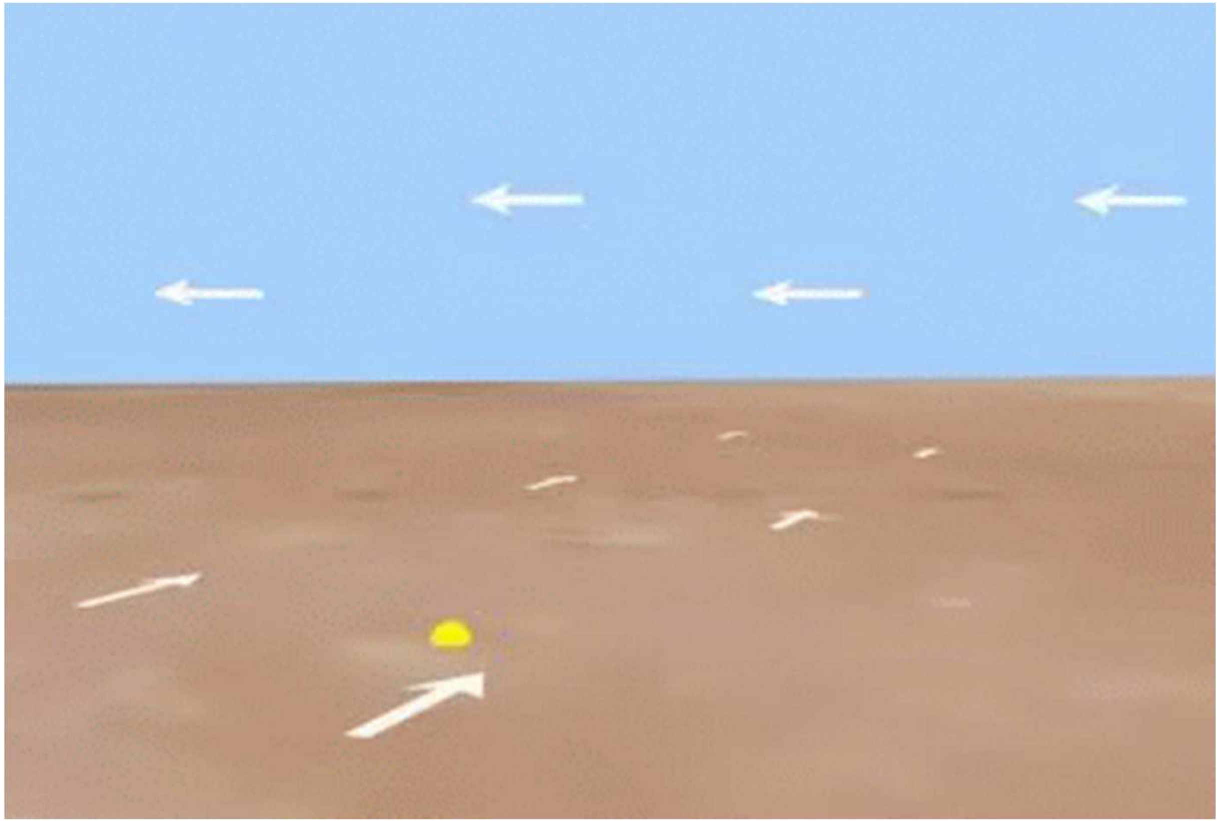
Movie from the COMET program at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR)

Dust forecasting models: Dispersion



Dispersion: f(atmospheric conditions)

Dust forecasting models: advection, convection and diffusion



Movie from the COMET program at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR)

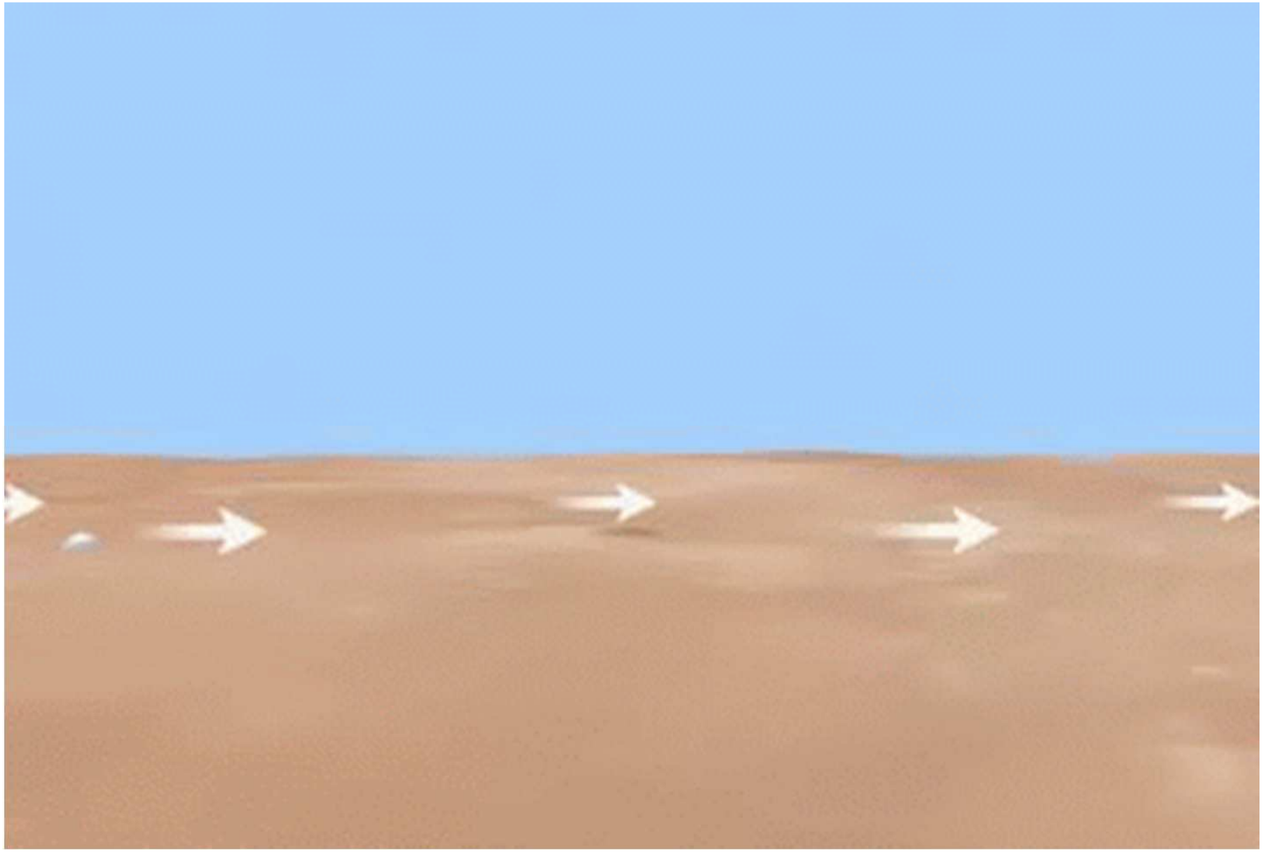
Mineral dust models

Mineral dust models simulate the atmospheric dust cycle and involves a variety of processes:

$$\frac{\partial C_k}{\partial t} = \underbrace{\boxed{-u\frac{\partial C_k}{\partial x} - v\frac{\partial C_k}{\partial y}}}_{\textit{Horizontal advection}} - \underbrace{\boxed{(w - v_{gk})\frac{\partial C_k}{\partial z}}}_{\textit{Vertical convection \& gravitational settling}} - \underbrace{\boxed{\nabla(K_H \nabla C_k)}}_{\textit{Horizontal diffusion}} - \underbrace{\boxed{\frac{\partial}{\partial z}\left(K_Z \frac{\partial C_k}{\partial z}\right)}}_{\textit{Vertical diffusion}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SOURCE}}}_{\textit{Dust emission}} - \underbrace{\boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SINK}}}_{\textit{Wet and dry deposition}}$$

Dust forecasting models: Dry deposition scheme

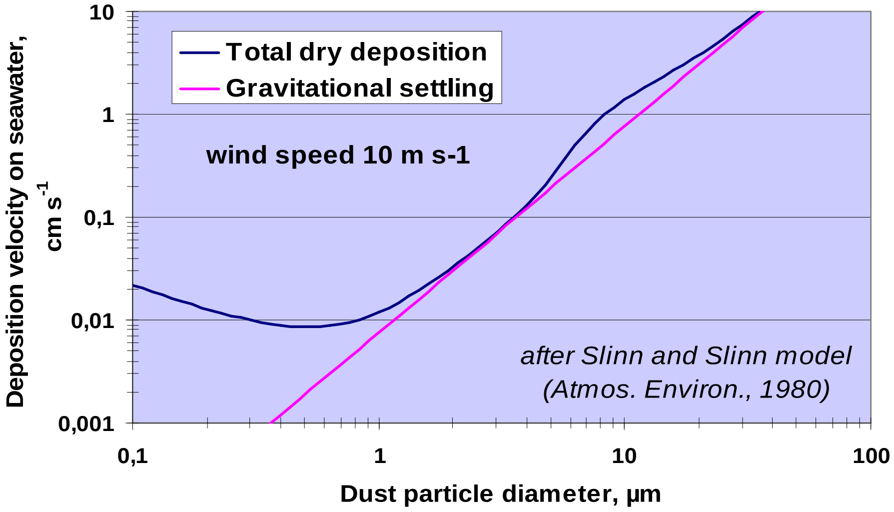
Sedimentation and dry deposition



Movie from the COMET program at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR)

Dust forecasting models: Dry deposition scheme

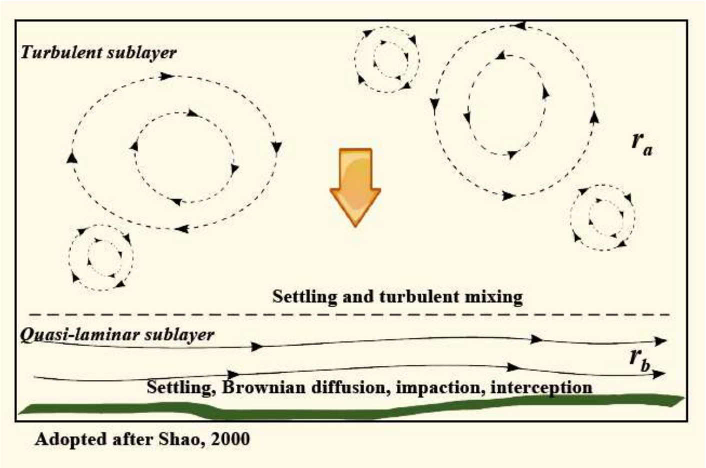
Dry deposition depends on the variety of factors such as meteorological conditions near the surface, physicochemical properties of mineral dust and the nature of the surface itself.



Dry deposition velocity is represented as 3 resistances in series parallel to a second pathway - gravitational settling velocity:

- Aerodynamic resistance to transfer (r_a)
- Quasi-laminar surface layer resistance (r_b)
- Resistance to surface uptake (r_c)

$$v_d = \frac{1}{r_a + r_b + r_c} \longrightarrow F_d = -C \cdot v_d$$



Mineral dust models

Mineral dust models simulate the atmospheric dust cycle and involves a variety of processes:

$$\frac{\partial C_k}{\partial t} = \boxed{-u\frac{\partial C_k}{\partial x} - v\frac{\partial C_k}{\partial y}} - \boxed{(w - v_{gk})\frac{\partial C_k}{\partial z}} - \boxed{\nabla(K_H \nabla C_k)} - \boxed{\frac{\partial}{\partial z}\left(K_Z \frac{\partial C_k}{\partial z}\right)} - \boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SOURCE}} - \boxed{\left(\frac{\partial C_k}{\partial t}\right)_{SINK}}$$

Horizontal advection

Vertical convection & gravitational settling

Horizontal diffusion

Vertical diffusion

Dust emission

Wet and dry deposition

Dust forecasting models: Wet deposition scheme

Wet scavenging

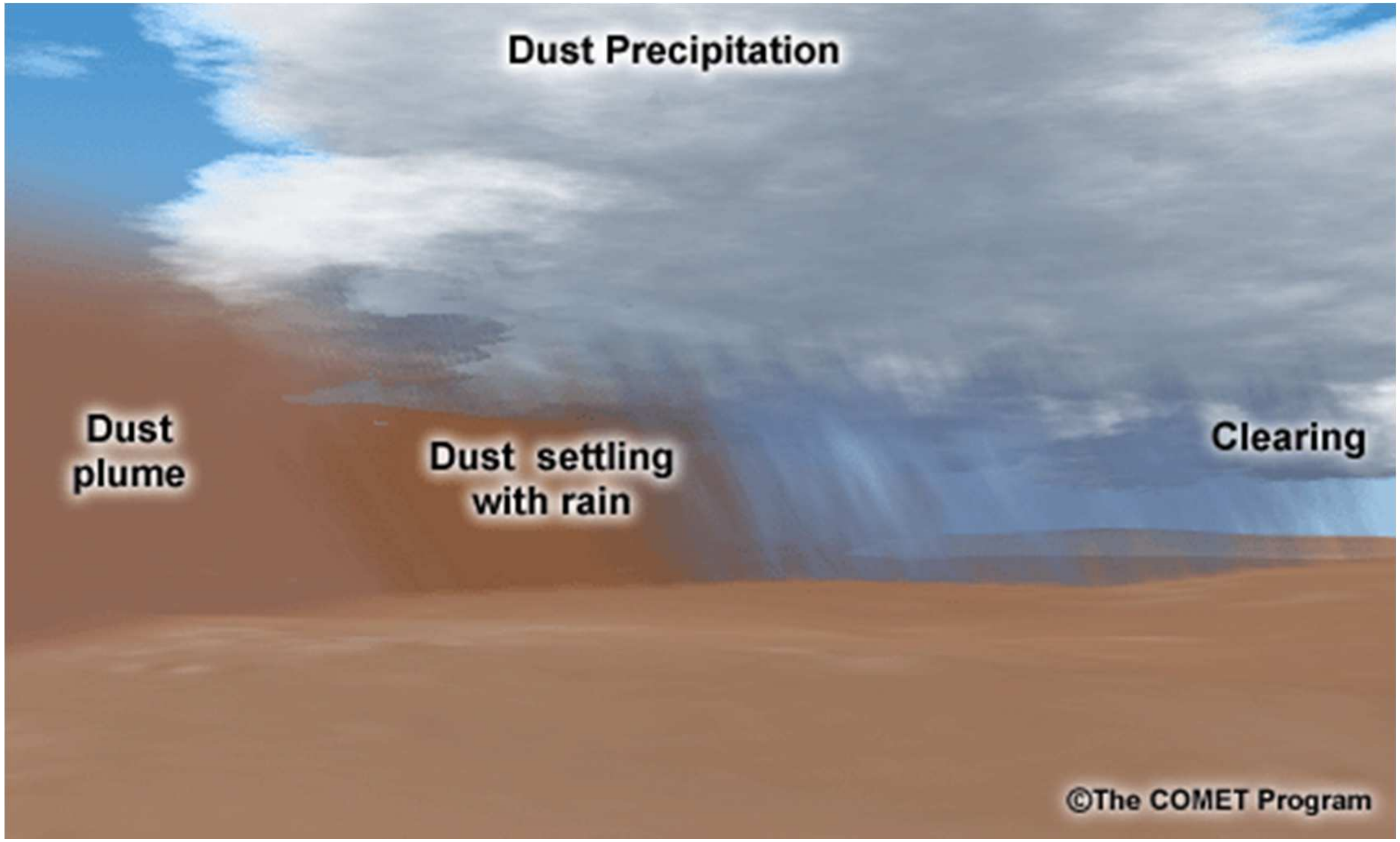
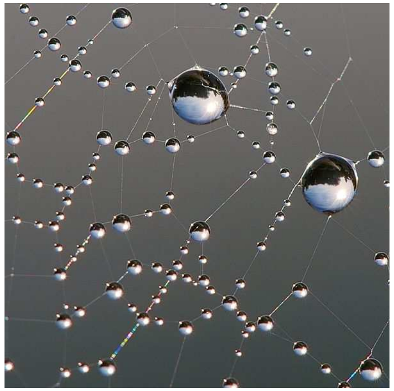
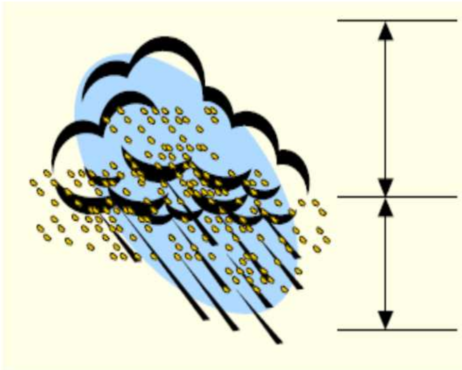


Image from the COMET program at http://meted.ucar.edu/ of the University Corporation for Atmospheric Research (UCAR)

Dust forecasting models: Wet deposition scheme





In-cloud scavenging:

- **nucleation scavenging** by activation and growth of particles to cloud droplets
- **collection** of a non-activated fraction of particles by coagulation with cloud and rain droplets

Below-cloud scavenging:

Collection by falling raindrops of particles under their collision.

Decrease rate of the aerosol concentration due to **wet scavenging** in a layer with uniform concentration can be described by a first-order equation:

$$\frac{\partial C}{\partial t} = -\lambda C$$

The **scavenging coefficient (C)** depends on:

- the particle size and solubility
- the collectors size distribution and fall speeds
- precipitation rate and phase (rain or snow).

Dust forecasting models: Wet deposition scheme

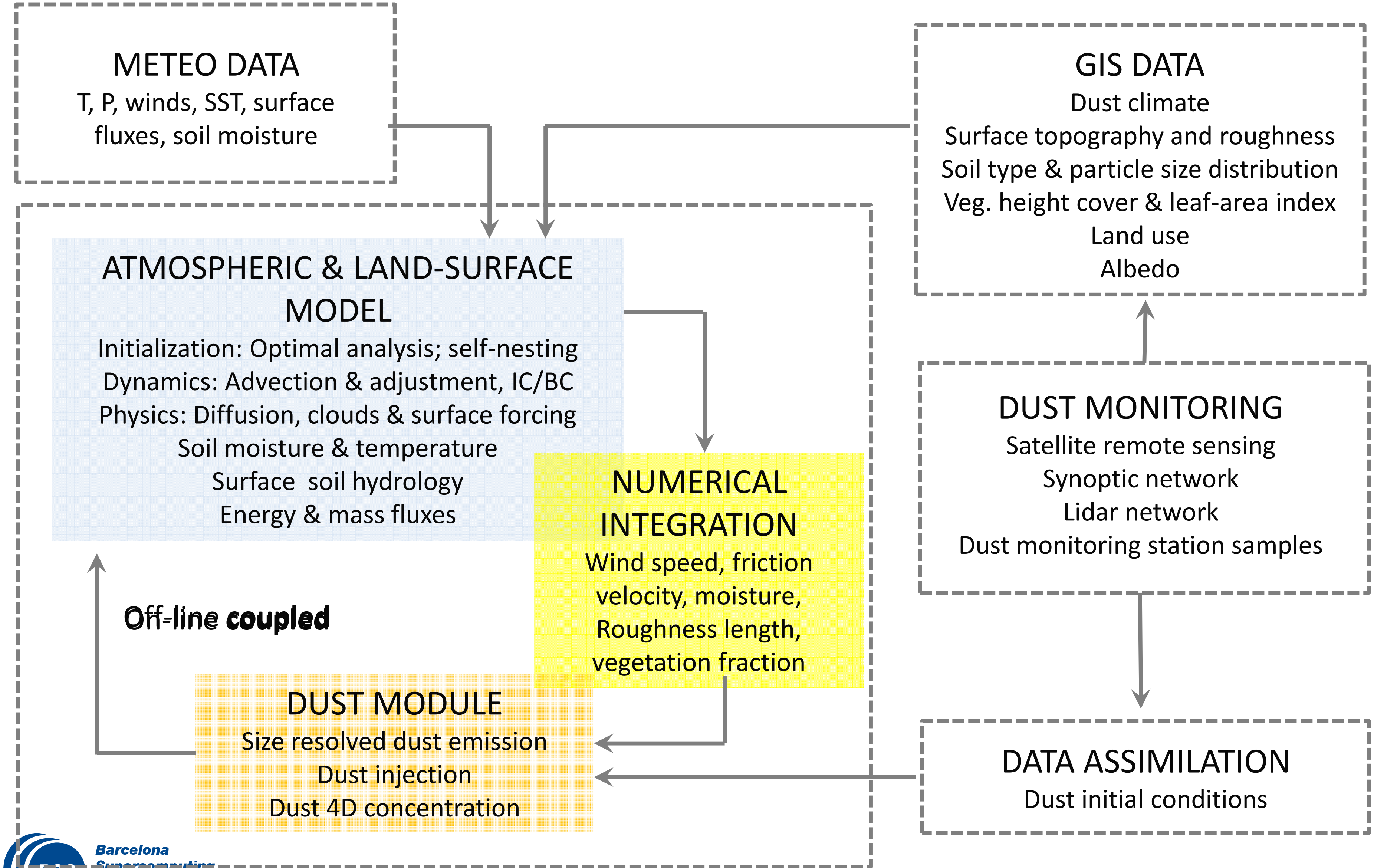
Existing problems

- **Rainout:** The soluble fraction of dust is not well known, so assigned scavenging efficiencies do not reflect regional specifics of dust properties and their dynamics (i.e., mineralogical composition, aging, etc.)

- **Washout:** Problems in modelling of clouds and precipitation remain a long-standing issue. Precipitation rates during violent convective rains are often underpredicted.

- **Dry versus wet deposition:** The relative importance of dry or wet deposition processes differs regionally and depends on the meteorological conditions and used parameterizations.

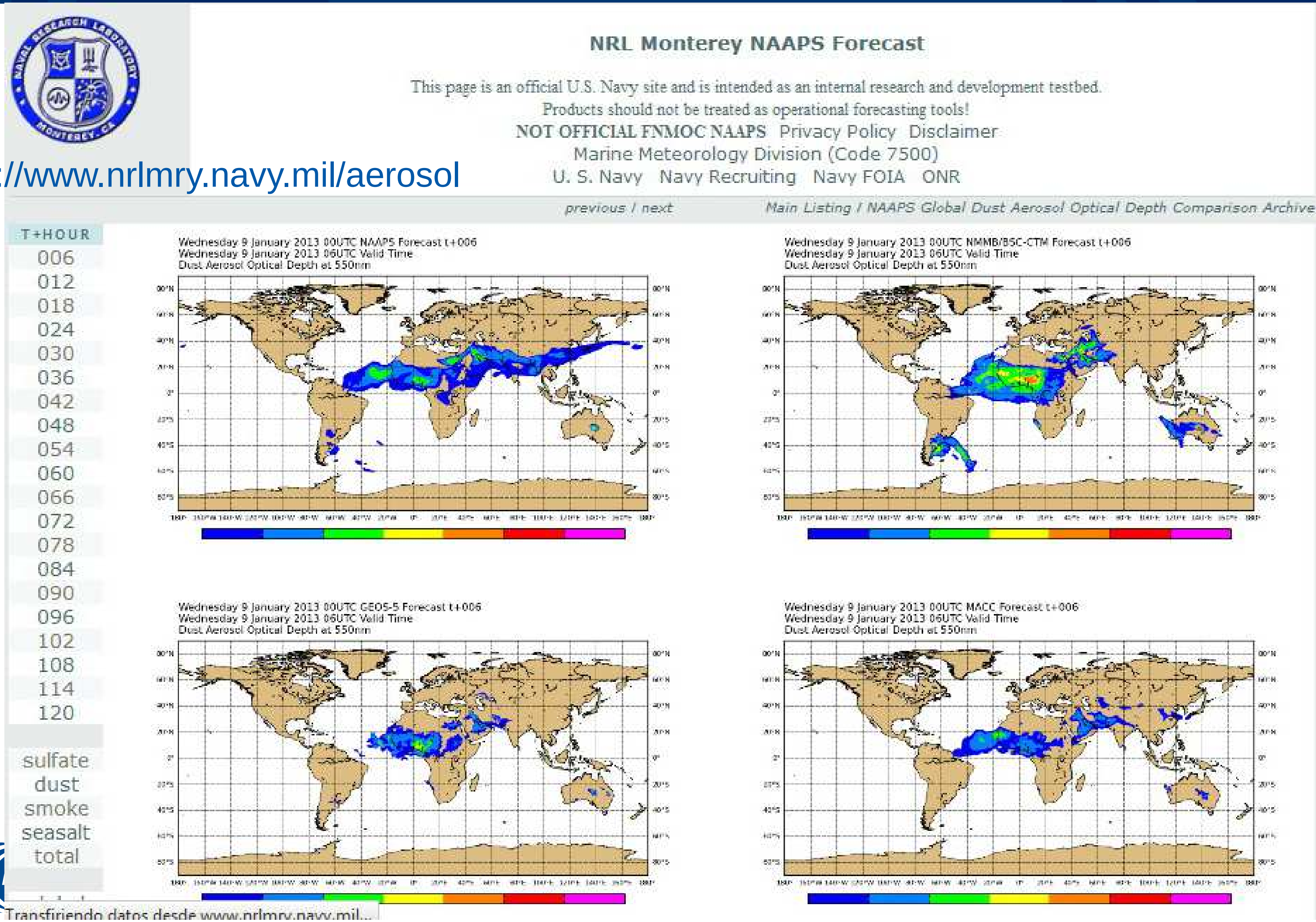
Dust forecasting models



http://www.nrlmry.navy.mil/aerosol/icap.1087.php
http://www.nrlmry.navy.mil/aerosol/icap.1087.php

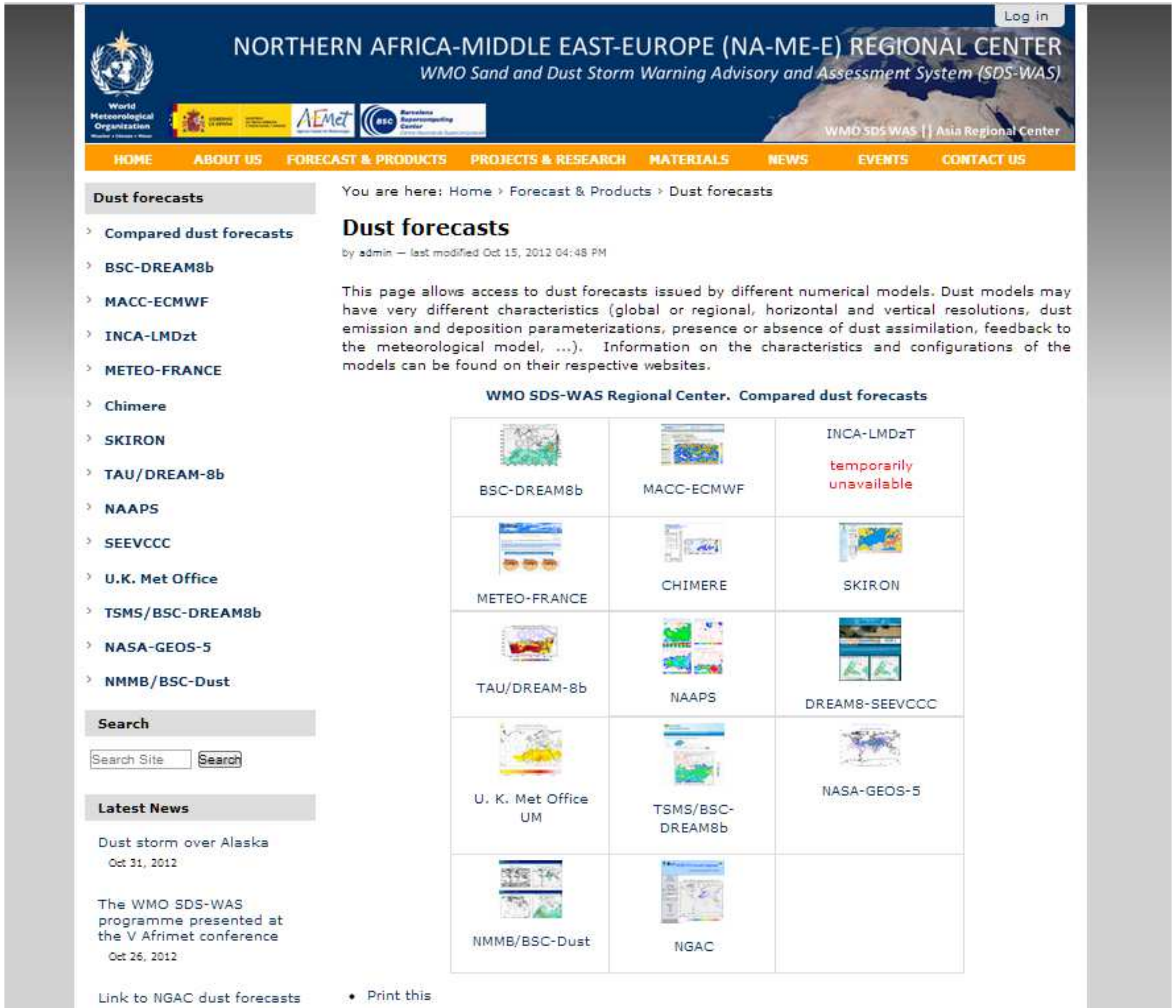
International Cooperative on Aerosol Prediction (ICAP)

http://www.nrlmry.navy.mil/aerosol



Dust forecasting models: SDS-WAS NA-ME-E RC

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



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http://www.nrlmry.navy.mil/aerosol/icap.1087.php

http://www.nrlmry.navy.mil/aerosol/icap.1087.php

Dust forecasting models

Main differences between dust models

1. *Atmospheric driver*
2. *Meteorological input files IBC*
3. *Emission scheme*
4. *Geographic-information database*
5. *Land-surface scheme*
6. *Dry deposition scheme*
7. *Wet depositioon scheme*
8. *Spatio-temporal resolution*
9. *Data assimilation*
10. *….*

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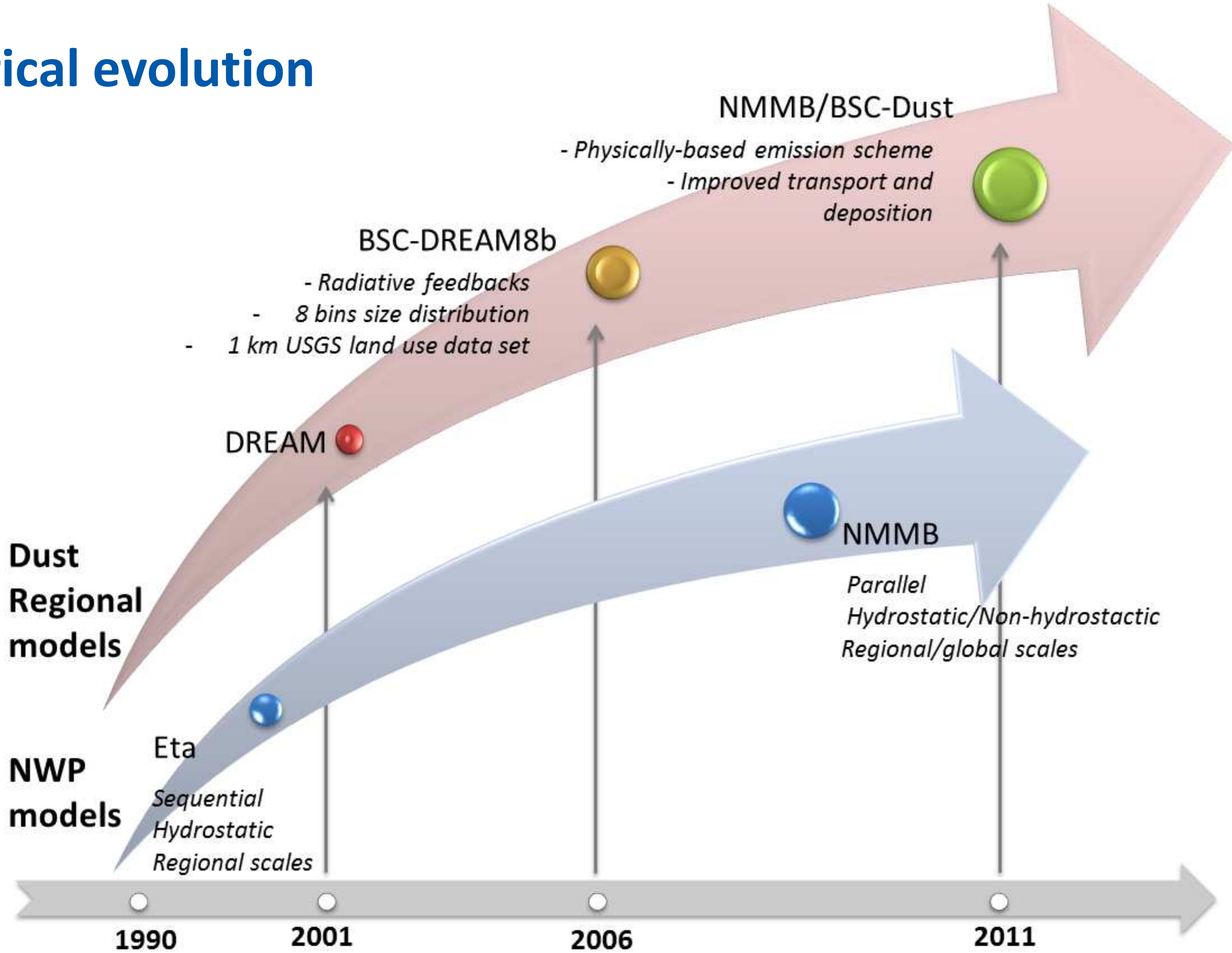
Dust forecasting models: WMO SDS-WAS NA-ME-E RC

Atmospheric driver and dust model	Regional Global	Meteo. initial fields	Radiation interaction	Horiz./Vert. resolution	Emission Scheme	Surface wind speed	Transport size bins	Data assimilation
ETA/NCEP BSC-DREAM8b	Regional	NCEP	radiation feedback	0.3ºx0.3º 24 η-layers	Uplifting SHAO	viscous sublayer	8 bins 0.1-10 μm	no
NMMB/NCEP NMMB/BSC-Dust	Regional /Global	NCEP	radiation feedback	0.25ºx0.25º 40 σ-layers	Uplifting MB	viscous sublayer	8 bins 0.1-10 μm	no
ECMWF MACC	Global	ECMWF	no	1ºx1º 91 layers	Uplifting GINOUX	surface wind field	3 bins 0.03-20 μm	yes
MetUM MetUM	Global	MetUM	no	0.35ºx0.23º 70 layers	Uplifting WOOD	surface wind field	2 bins 0.1-10 μm	no
NOGAPS NAAPS/COAMPS	Global	NCEP	no	1ºx1º grid 25 layers	Uplifting WEST	friction velocity	10 bins 0.05-35 μm	yes
GEOS-5/NASA GEOS-5/NASA	Global	NASA	radiation feedback	0.25ºx0.31º 72 layers	Uplifting GINOUX	friction velocity	5 bins 0.73 -8 μm	yes

Dust forecasting models: BSC dust forecasting models

Historical evolution



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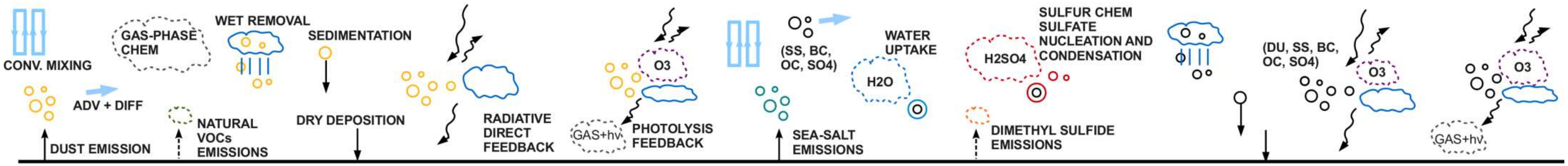
The NMMB/BSC-Chemical Transport Model



NMMB/BSC-CTM

- NMMB
- BSC-CTM
  - DUST
    Pérez et al., ACP, 2011
  - CHEM
    Jorba et al., JGR, 2012
  - SEA-SALT
    Spada et al, ACP, 2013

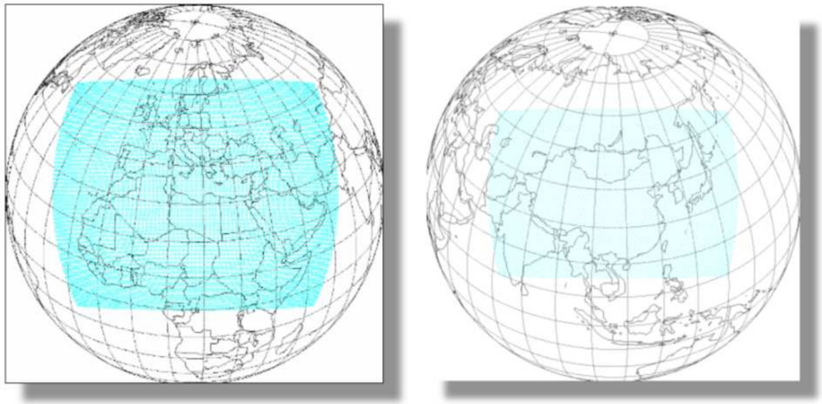
- The main system is build on the meteorological driver NMMB, under development at NCEP
  Unified model for a broad range of spatial and temporal scales
- ***Multiscale***: global to regional scales allowed
- Fully ***on-line*** access coupling: feedback processes allowed

Nonhydrostatic Multiscale Meteorological Model on the B grid

http://www.bsc.es/projects/earthscience/nmmbbsc-project

Dust forecasting models: The BSC-DREAM8b v2.0

- Daily forecasts in 2 domains:
  - North Africa-Middle East-Europe (0.3º x 0.3º)
  - East Asia (0.5º x 0.5º)



- Main features
  - 8 particle size bin distribution (0.1 -10 μm)
  - Dust radiative feedbacks (Pérez et al., 2006)
- Latest developments (version 2.0; Basart et al. 2012a)
  - Updated dry deposition
  - Inclusion of a preferential source mask

- Included in the CALIOPE AQF system
- Near-real time evaluation: AERONET
- Dust forecast evaluation studies:
  - Single events in the ***Mediterranean*** (e.g., Papayannis et al., 2005; Pérez et al., 2006; Gobbi et al., 2013, …)
  - Experimental campaigns in ***source regions***
    - BoDEX 2005 (Todd et al., 2008)
    - SAMUM 2006 (Haustein et al., 2009)
  - Anual evaluation over North Africa, Mediterranean and Middle East (Pay et al., 2011; Basart et al., 2012b)

…

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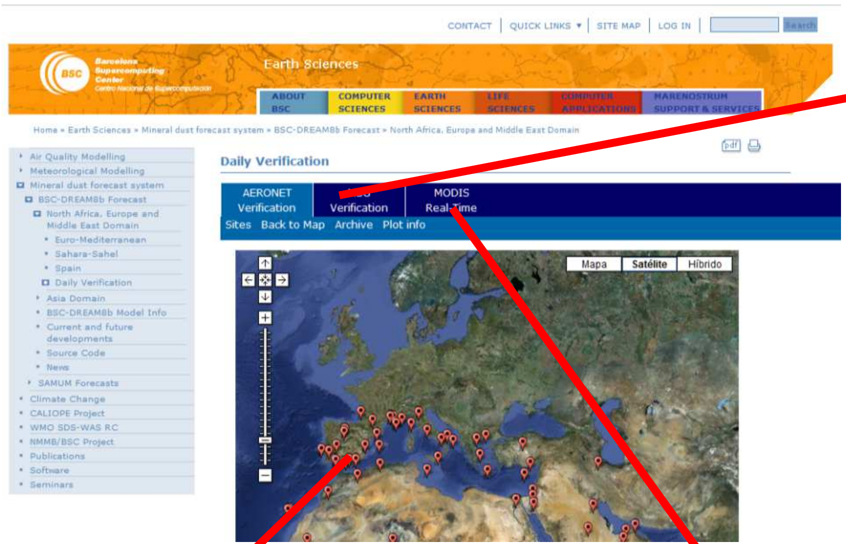
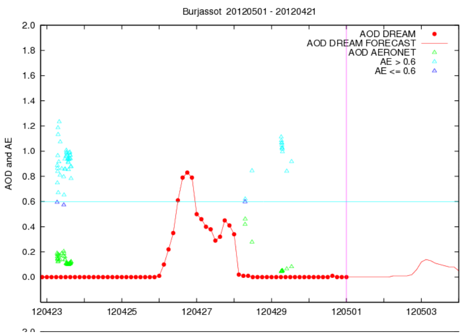
http://www.bsc.es/projects/earthscience/BSC-DREAM/

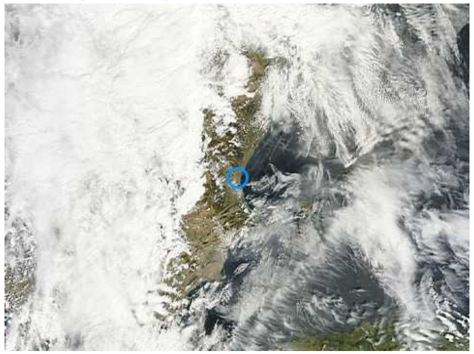
Dust forecasting models: The BSC-DREAM8b v2.0



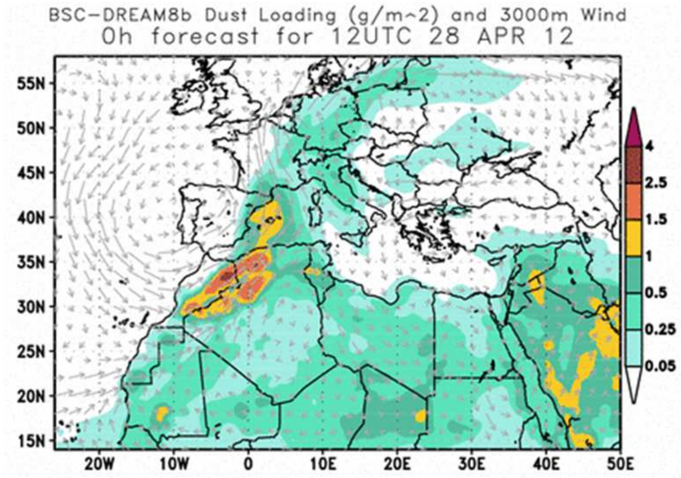
AERONET

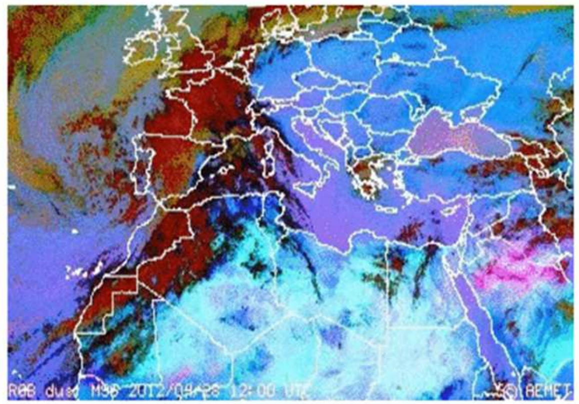


MODIS



MSG/RGB





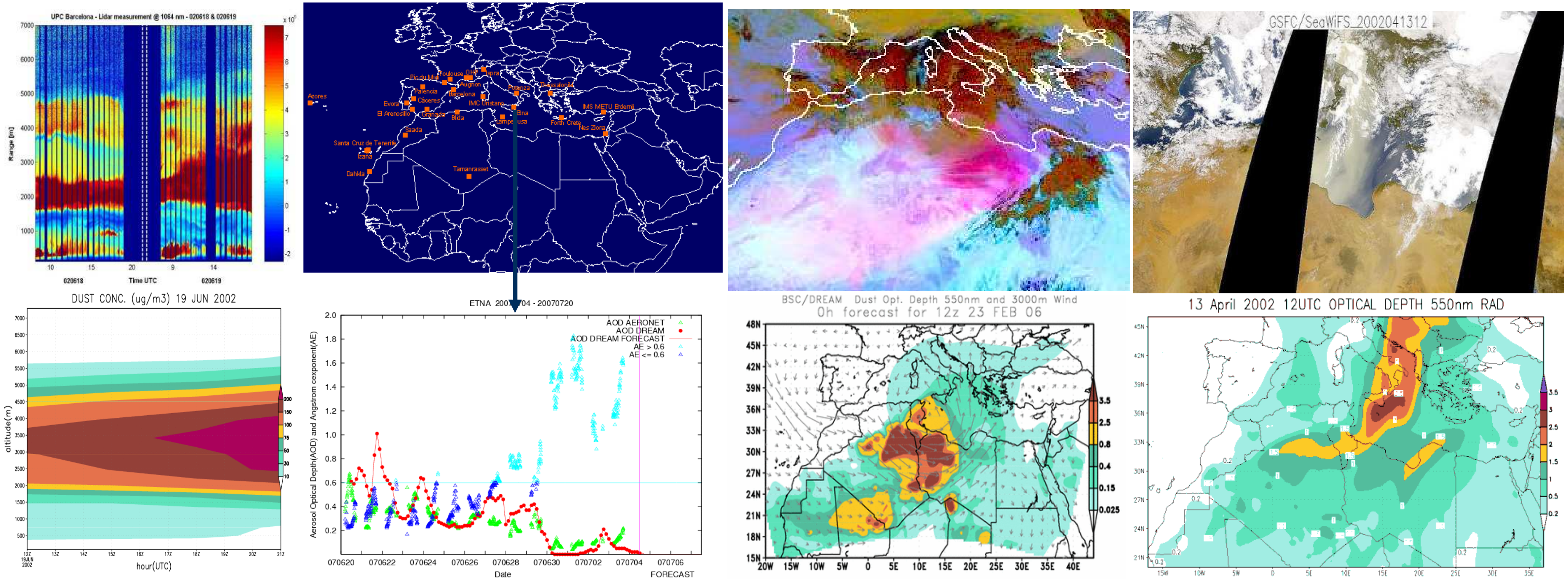
Inclusion of new satellite aerosol products: **OMI**, **CALIPSO** and **MISR**

Dust forecasting models: DREAM and BSC-DREAM8b

Study Region	Reference	Model version	Time period
North Africa-Middle East-Europe	Basart el al. (2009)	BSC-DREAM8b	Annual (2004)
	Basart et al. (2012b)	BSC-DREAM8b	Annual (2004)
Europe	Papayannis et al. (2008)	DREAM	Long-term (2000-2002)
	Pay et al. (2010)	BSC-DREAM8b	Annual (2004)
	Basart et al. (2012a)	BSC-DREAM8b	Annual (2004)
Western Mediterranean	Pérez et al. (2006a)	BSC-DREAM8b	Dust event (April 2002)
	Pérez et al. (2006b)	BSC-DREAM8b	Dust event (June 2002)
Spain	Jiménez-Guerrero et al. (2008)	DREAM	Dust event (June-July 2006)
	Pay et al. (2012)	BSC-DREAM8b	Annual (2004)
Portugal	Borrego et al. (2011)	BSC-DREAM8b	Annual (2010)
Italy	Kishcha et al. (2007)	DREAM	Long-term (2001-2003)
Eastern Mediterranean	Balis et al. (2006)	DREAM	Dust event (August-September 2003)
Greece	Papayannis et al. (2009)	DREAM	Long-term (2004-2006)
	Amiridis et al. (2009)	BSC-DREAM8b	Dust event (May 2008)
	Papanastasiou et al. (2010)	BSC-DREAM8b	Long-term (2001-2007)
Central Europe	Klein et al. (2010)	BSC-DREAM8b	Dust event (May-June 2008)
Georgia	Kokkalis et al. (2012)	BSC-DREAM8b	Dust event (May 2009)
Sub-Tropical Eastern North Atlantic	Alonso-Pérez et al. (2011)	DREAM	Long-term (1958-2006)
North-Central Africa	Todd et al. (2009)	BSC-DREAM8b	Dust event (BodEx, March 2005)
Morocco	Haustein et al. (2009)	BSC-DREAM8b	Dust event (SAMUM, May-June 2006)

Dust forecast evaluation

Lidars - EARLINET | AERONET - ONLINE | Meteosat Second Generation | SeaWIFS



Model has shown good agreement with observations in a number of studies of single events (e.g., *Ansmann et al.*, 2003, *Papayannis et al.,* 2005; Balis et al., 2006; *Pérez et al.*, 2006a;b; *Jiménez et al,* 2006 ….)

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Atmos. Chem. Phys., 13, 7395–7404, 2013
www.atmos-chem-phys.net/13/7395/2013/
doi:10.5194/acp-13-7395-2013

Atmospheric Chemistry and Physics
Open Access

Changes in particulate matter physical properties during Saharan advections over Rome (Italy): a four-year study, 2001–2004

G. P. Gobbi[1], F. Angelini[1], F. Barnaba[1], F. Costabile[1], J. M. Baldasano[2,3], S. Basart[2], R. Sozzi[4], and A. Bolignano[4]

[1]Institute of Atmospheric Sciences and Climate, ISAC-CNR, Rome, Italy
[2]Barcelona Supercomputing Centre – Centro Nacional de Supercomputación (BSC-CNS), Barcelona, Spain
[3]Environmental Modelling Laboratory, Technical University of Catalonia, Barcelona, Spain
[4]Latium Environmental Protection Agency (ARPA Lazio), Rome, Italy

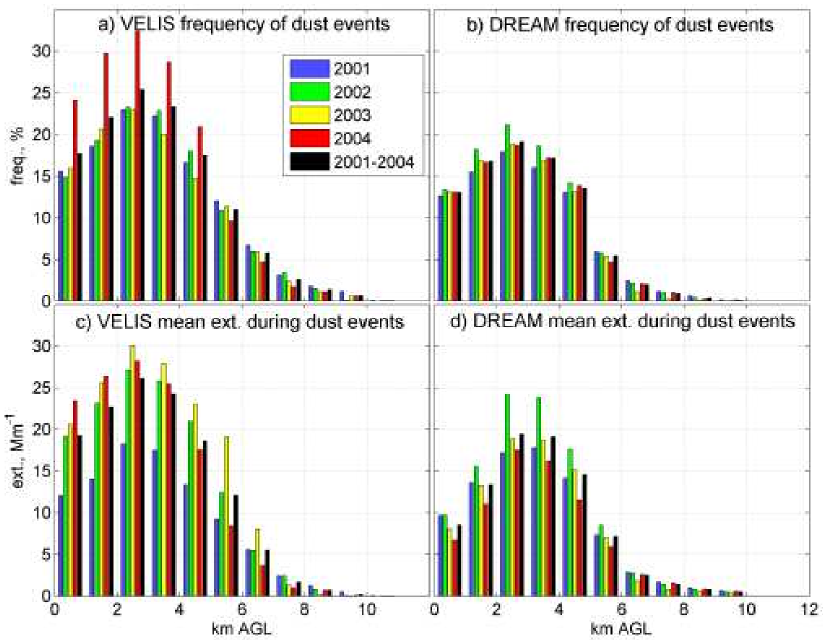
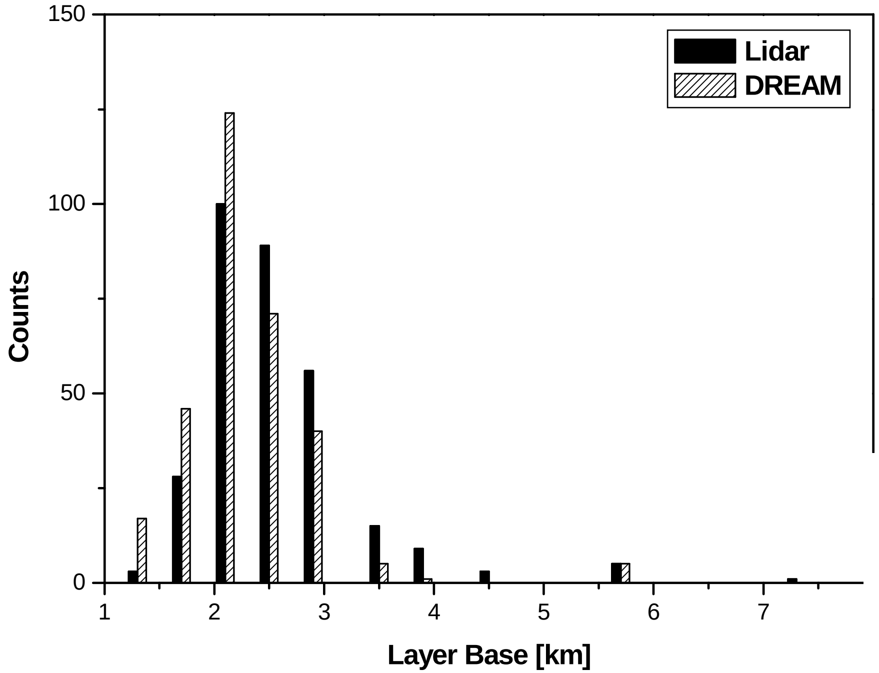


Fig. 2. Vertical distribution of Saharan dust layers properties as observed by VELIS (left column) and forecast by BSC-DREAM8b (right column), respectively: frequency of Saharan dust occurrences at least in one altitude bin **(a, b)** and average dust extinction coefficient (km^{-1} at 532 nm) per year **(c, d)**.

Table 2. Percent of advection days, ground contacts, average 532 nm optical depth and relevant standard deviation of Saharan dust events as observed by the VELIS Lidar and forecast by BSC-DREAM8b.

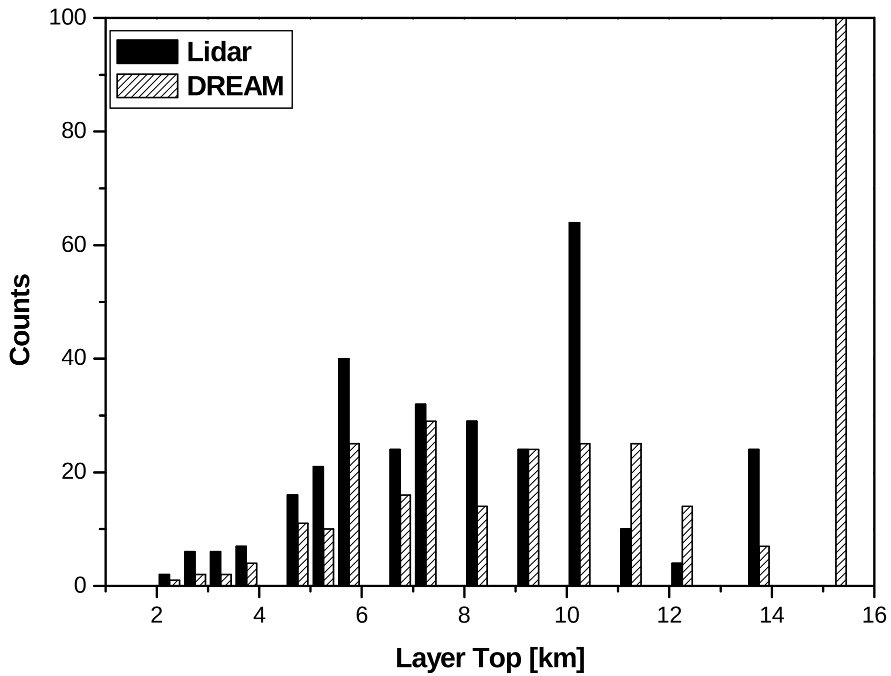
	2001	2002	2003	2004	AVG
% Dust Days					
Lidar	25.6	25.0	25.5	38.3	28.6
BSC-DREAM8b	25.9	26.0	24.9	26.8	25.9
% Ground Dust					
Lidar	15.6	14.7	15.6	24.0	17.5
BSC-DREAM8b	12.6	13.4	13.1	13.1	13.0
Avg. dust AOD					
Lidar	0.09	0.13	0.15	0.13	0.13
BSC-DREAM8b	0.08	0.10	0.08	0.07	0.08
St.dev.dust AOD					
Lidar	0.07	0.10	0.17	0.10	0.11
BSC-DREAM8b	0.09	0.11	0.09	0.08	0.09



MS Records

acp-2013-735 Submitted on 13 Sep 2013 **Systematic comparison of dust BSC-DREAM8b modeled profiles with Potenza EARLINET lidar database** L. Mona, N. Papagiannopoulos, S. Basart, J. Baldasano, I. Binietoglou, C. Cornacchia, and G. Pappalardo	
First Contact: Dr Lucia Mona, mona@imaa.cnr.it	
EC funded projects: ACTRIS (262254)	
Manuscript Type: Research Article	
Status: Editor Assignment (ACP Discussions)	**Iteration: Initial Submission**

$Base_{Lidar}$ = (2.5 ± 0.7) km
$Base_{Dream}$ = (2.3 ± 0.6) km



Top_{Lidar} = (8.0 ± 2.7) km
Top_{Dream} = (10 ± 4) km

Differences related to small quantity of aerosol and techniques sensitivity

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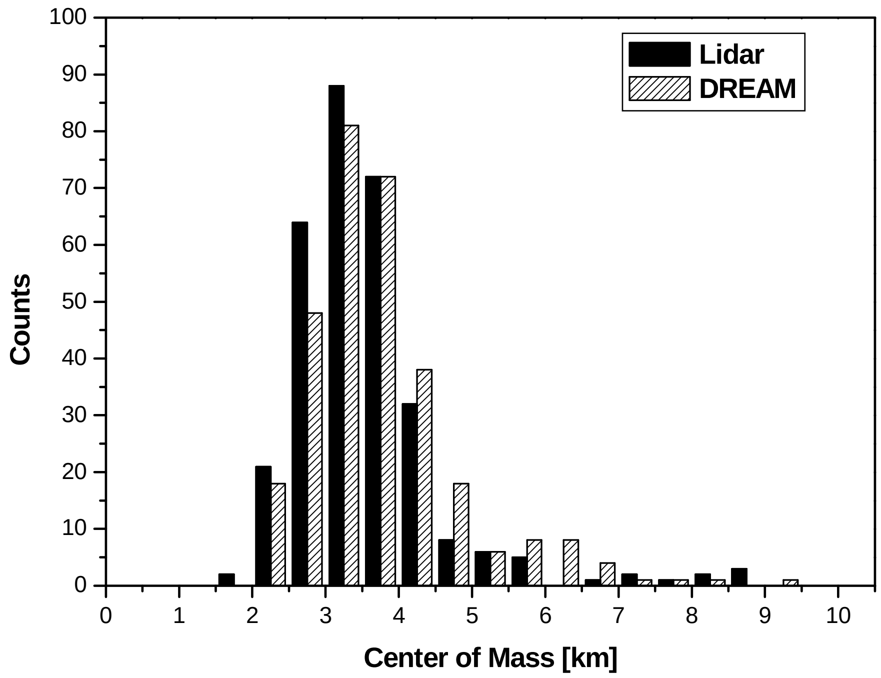
This estimate of the center of mass gives us information about the altitude where the most relevant part of the aerosol load is located.



$$CoM = \frac{\int_{Base}^{Top} z \cdot Parameter \quad dz}{\int_{Base}^{Top} Parameter \quad dz}$$

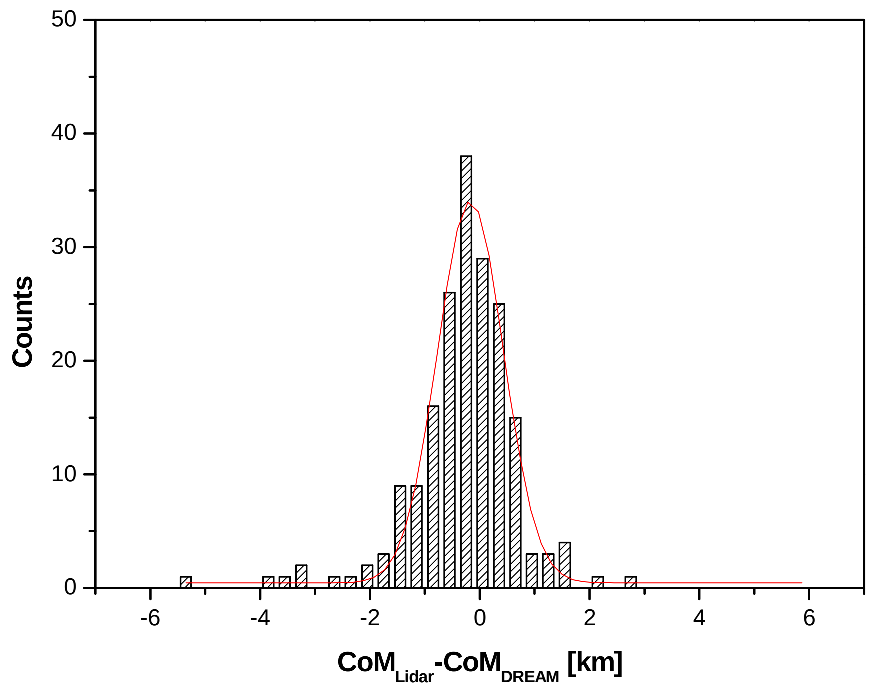
$$\mathrm{CoM}_{\mathrm{Lidar}} = (3.5 \pm 1.0)\ \mathrm{km}$$
$$\mathrm{CoM}_{\mathrm{Dream}} = (3.8 \pm 1.3)\ \mathrm{km}$$

Perfect agreement in terms of:

- mean value
- variability
- distribution

Point-to-point differences of estimated CoM

$CoM_{Diff} = (-0.3 \pm 1.0)$ km



GaussianFit

$x_C = (-0.17 \pm 0.02)$ km

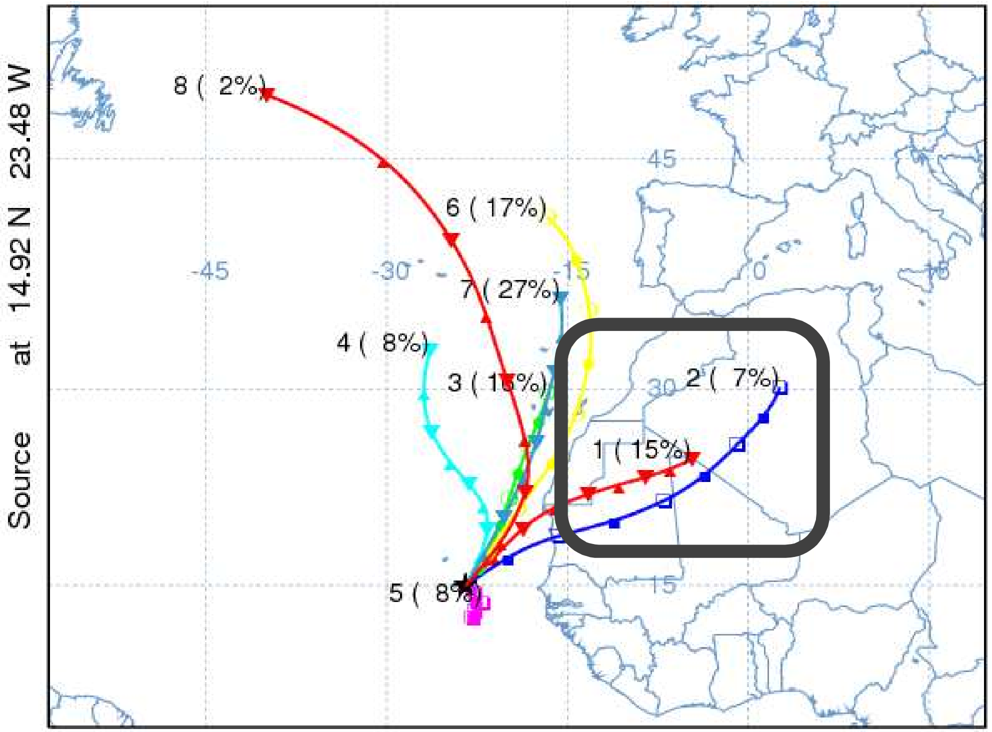
$\sigma = (0.60 \pm 0.02)$ km

r= 0.986

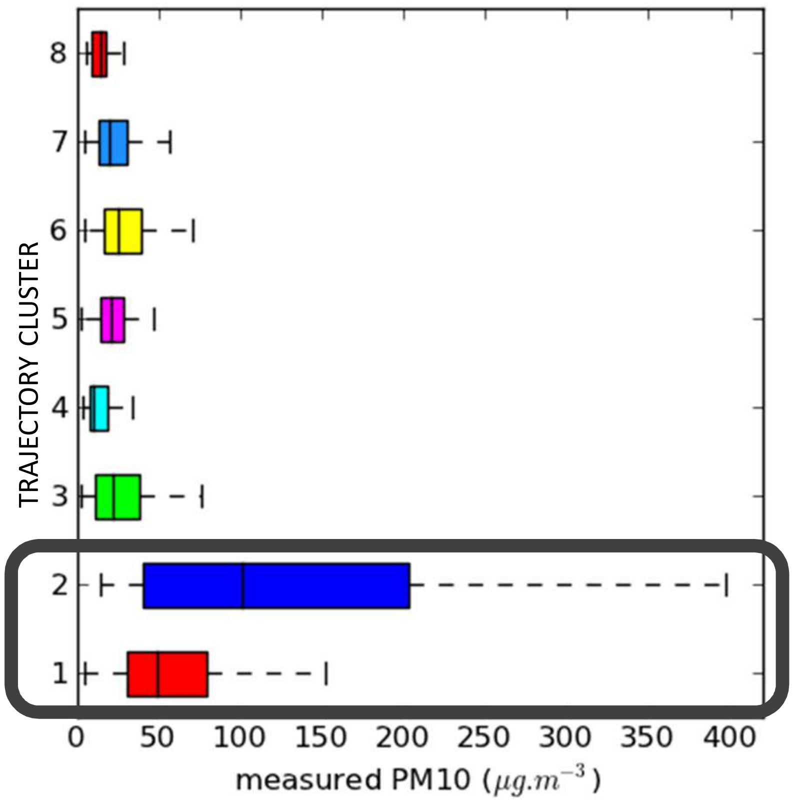
Good performances of BSC-DREAM8 also for the estimation of CoM for each single case.

Universidade de Aveiro – BSC-CNS

long-range transport patterns: PM10 concentration in Praia, Cape Verde

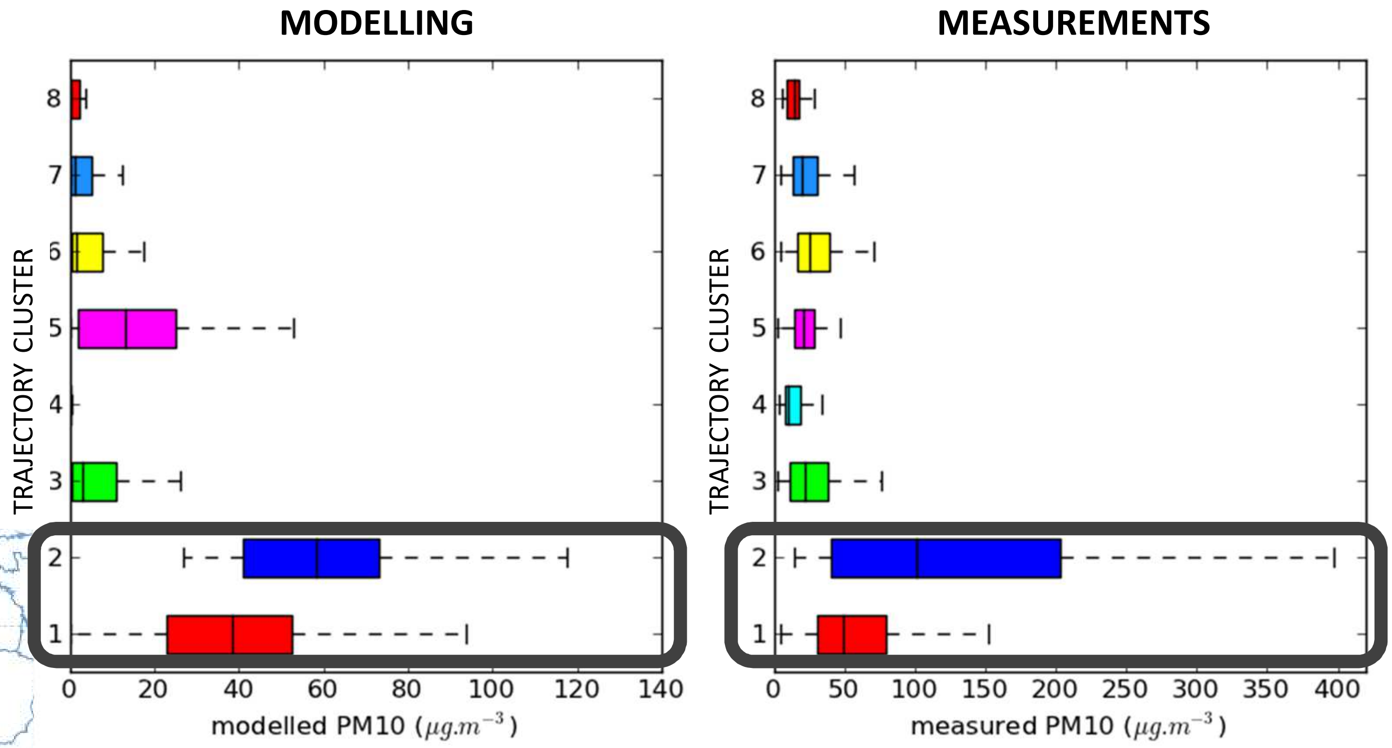


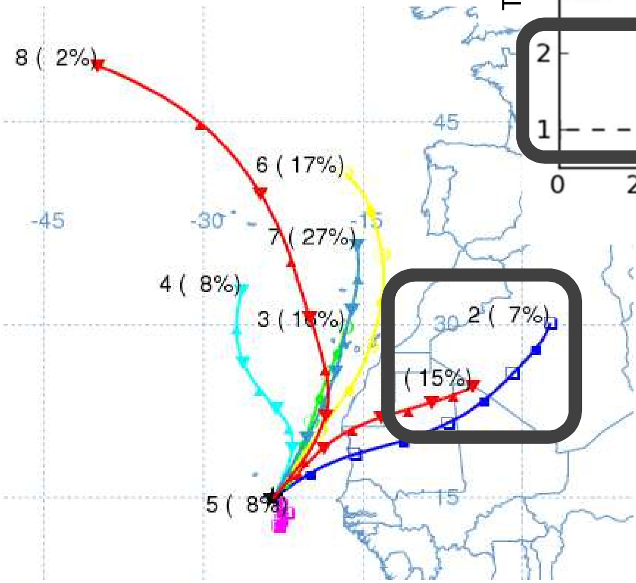
PM10 **MEASUREMENTS** IN PRAIA, 2011
GROUP BY TRAJECTORY CLUSTERS



PM10 concentrations measured are much higher when air masses arriving to Praia belong to cluster 2, followed by cluster 1 .

long-range transport patterns: PM10 concentration in Praia

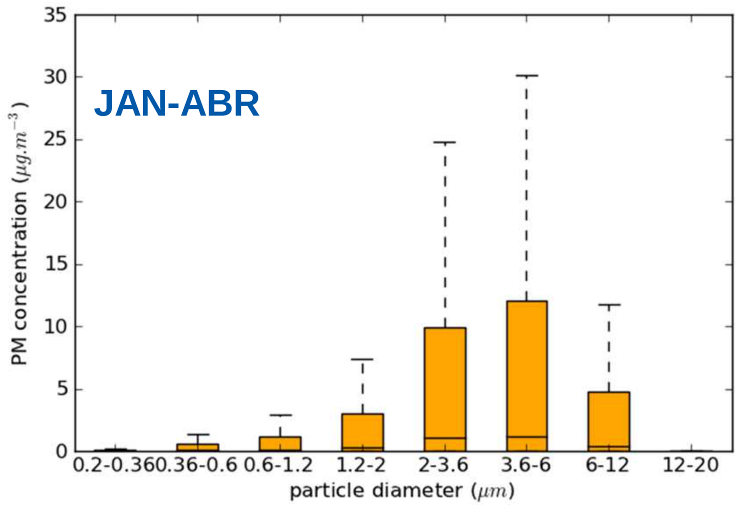


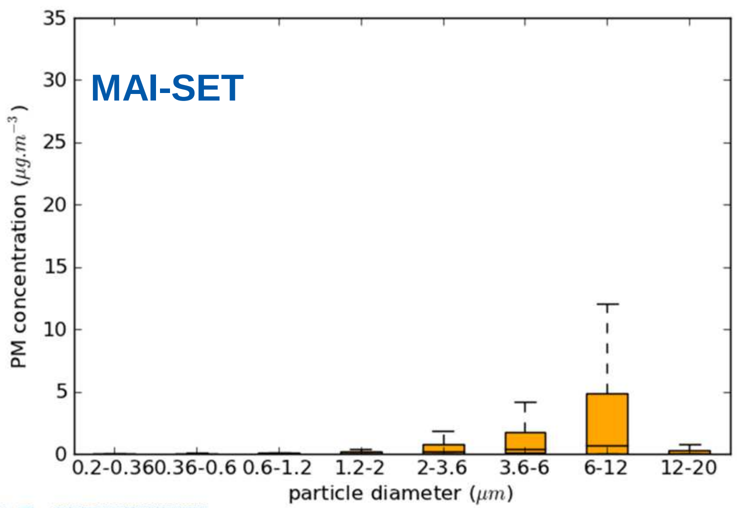


PM10 model simulations are also higher when air masses arriving to Praia belong to clusters 2 and 1.
However, measured and modeled concentration magnitudes are different.

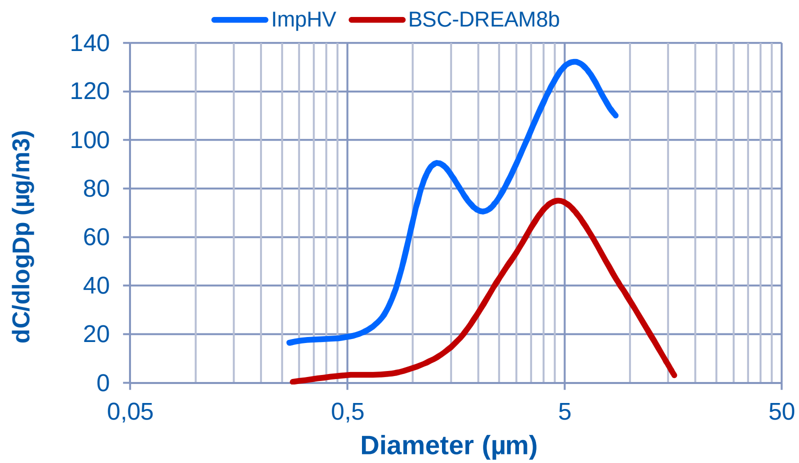
Universidade de Aveiro – BSC-CNS
Surface dust concentrations in Praia, Cape Verde

PM CONCENTRATION PROVIDED BY THE MODEL FOR DIFFERENT BINS



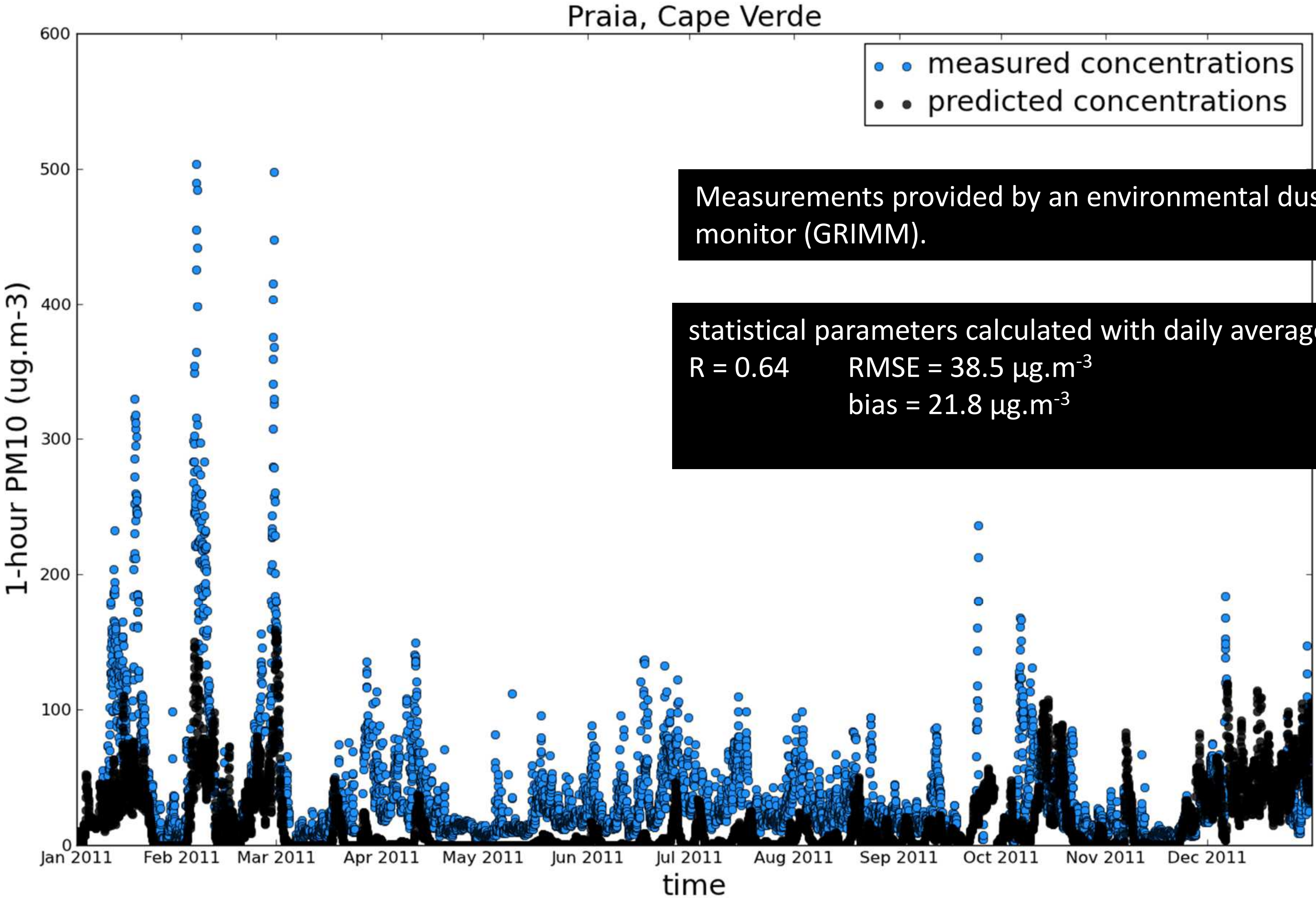


PM MEASURED AND MODELLED SIZE DISTRIBUTION (24-27 FEB)



PM measurements using a High-Volume cascade impactor with 6 collection stages (Dp < 0.49 to 10 µm).

Universidade de Aveiro – BSC-CNS
Surface dust concentrations in Praia, Cape Verde

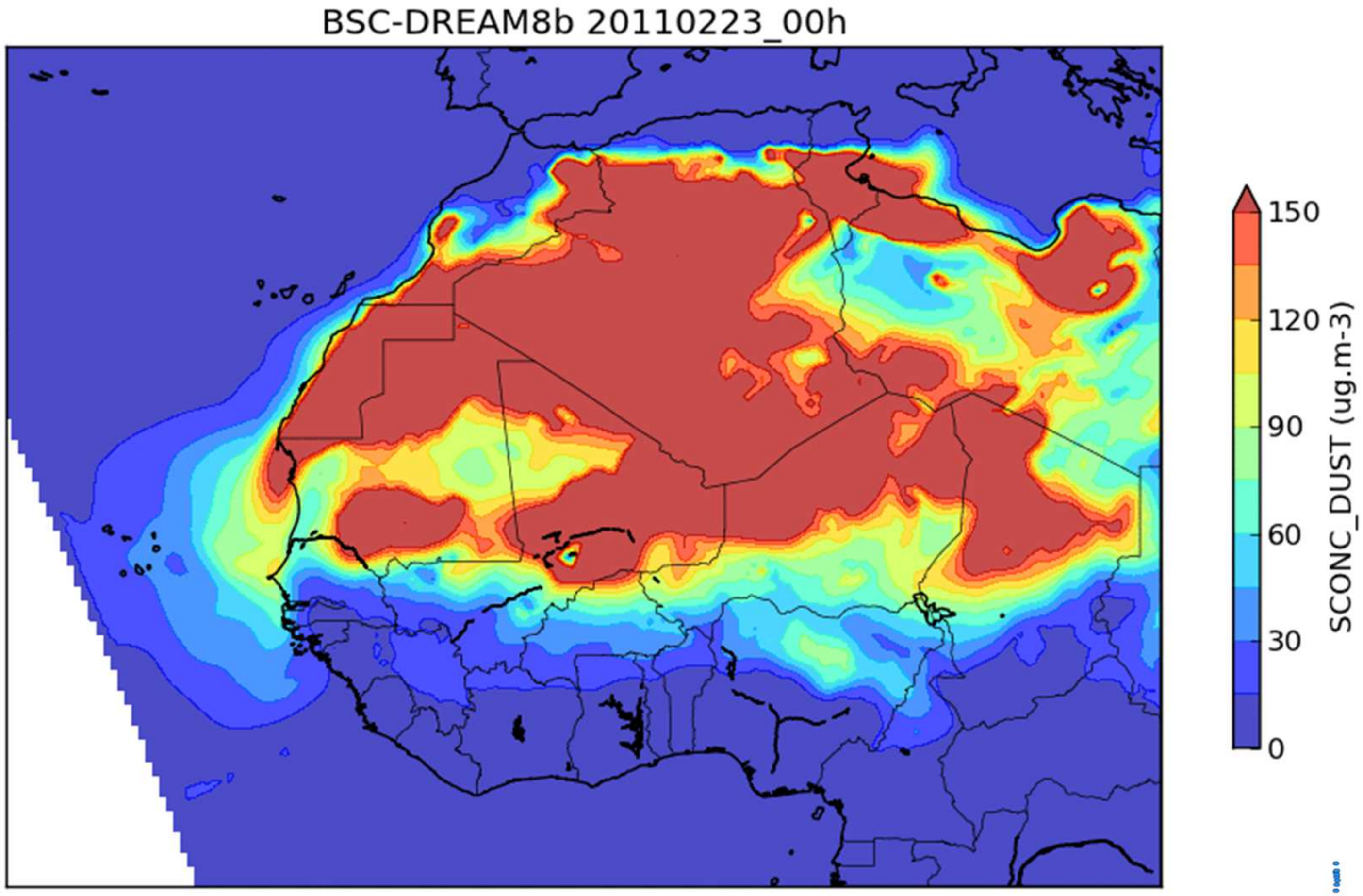


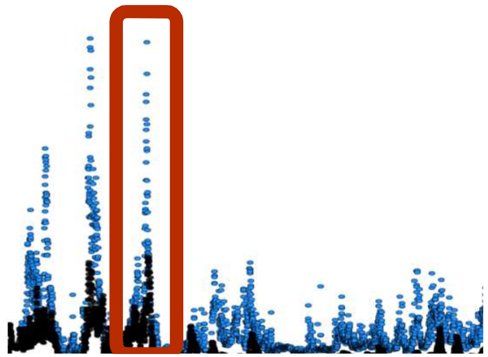
Measurements provided by an environmental dust monitor (GRIMM).

statistical parameters calculated with daily averaged data:
R = 0.64 RMSE = 38.5 μg.m^{-3}
bias = 21.8 μg.m^{-3}

spatial and temporal variation of PM concentrations

SURFACE CONCENTRATIONS – PERIOD ASSOCIATED WITH CLUSTER 2

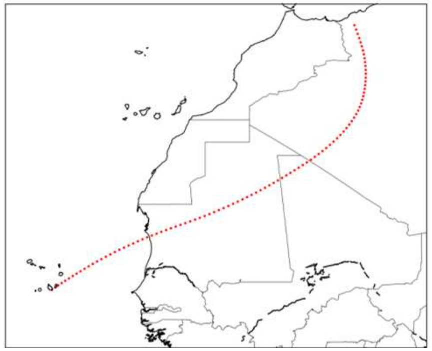


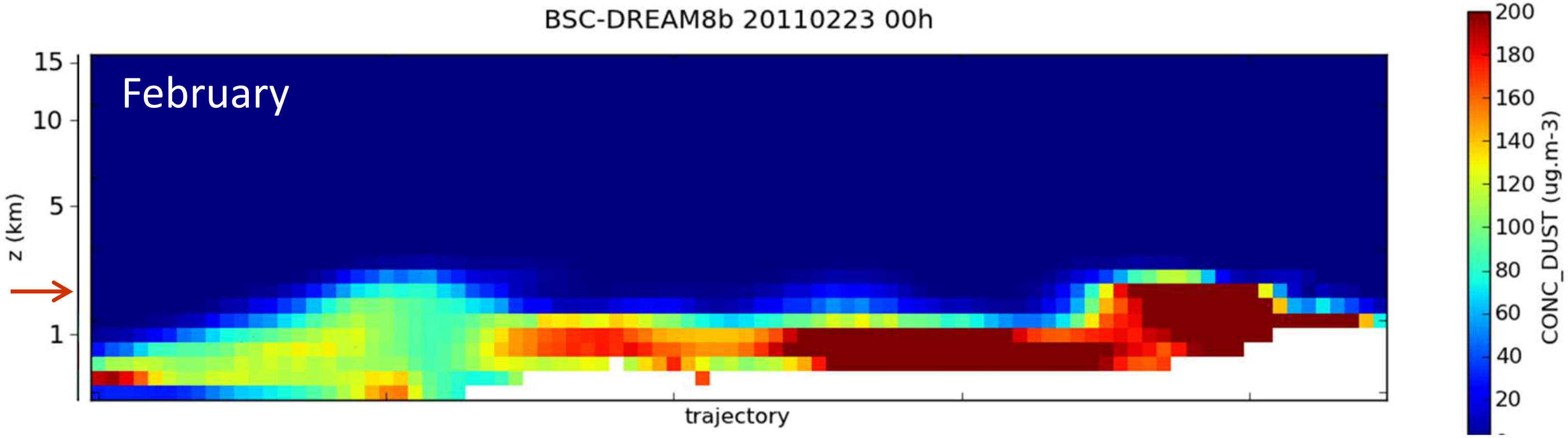


3D structure

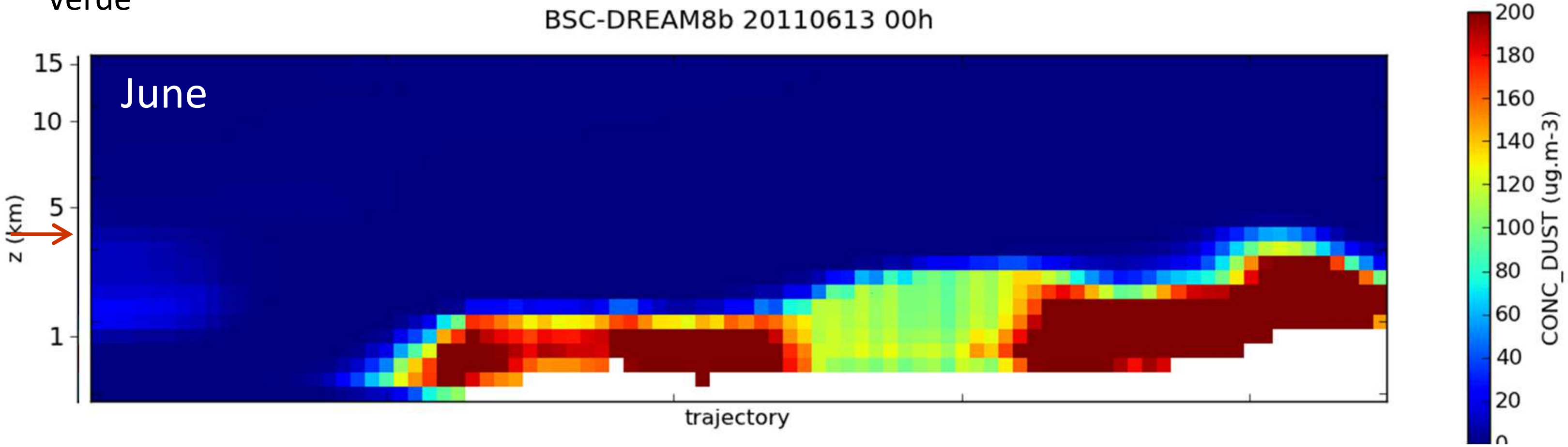
Mineral dust concentrations vertical profile, along a selected trajectory

February period versus June period





Cabo
Verde



Dust forecasting models: The NMMB/BSC-Dust model

- Evolution of the BSC-DREAM8b model (Nickovic et al., 2001; Pérez et al., 2006)
- **NMMB/BSC-Dust** is embedded into the NMMB model and solves the mass balance equation for dust.
- **NMMB/BSC-Dust** (Pérez et al., 2011; Haustein et al., 2012) main features:
  - Implementation of all common **on-line dust modules** for global and regional simulations
  - Nested regional domains at very high resolution are available
  - The current DREAM dust emission scheme is upgraded to a physically based scheme

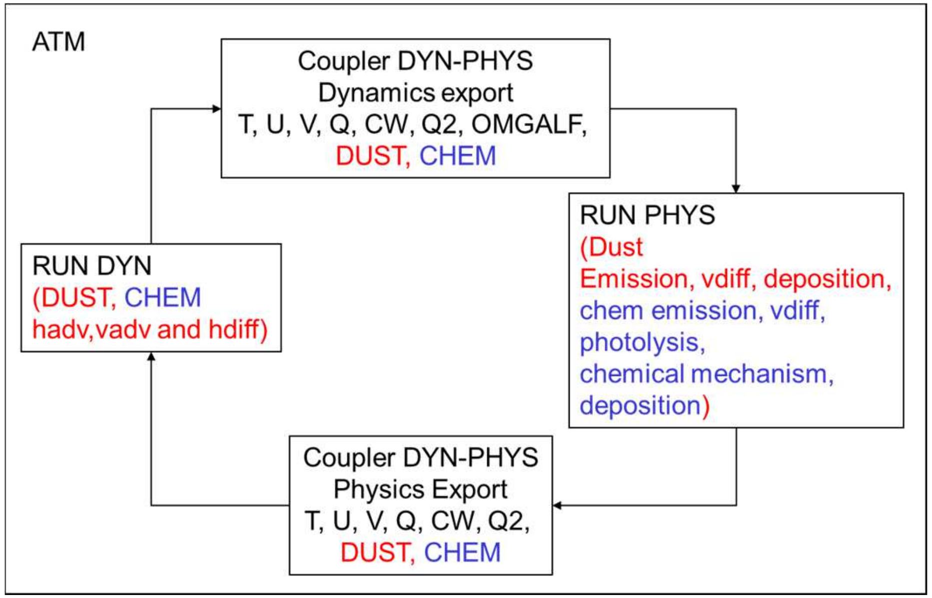
    → ***explicitly accounting for saltation and sandblasting***
  - New high resolution database for soil textures and vegetation fraction is included
- Pre-operational dust forecasts in the **BSC** website (global/regional) and participating in the **ICAP** initiative (global)

http://www.bsc.es/projects/earthscience/nmmbsc-dust-forecast

Dust forecasting models: The NMMB/BSC-CTM project

The **N**on-hydrostatic **M**ultiscale **M**odel (**NMMB**) :

- Development at NCEP (Janjic, 2005; Janjic and Black, 2007)
- Developed within the Earth System Modeling Framework (ESMF)
- Arakawa B grid and regular (global) or rotated (regional) lat/lon coordinate
- Unified model for a broad range of spatial and temporal scales
- NMMB is the regional operational meteorological model in NCEP since *October 2011*.

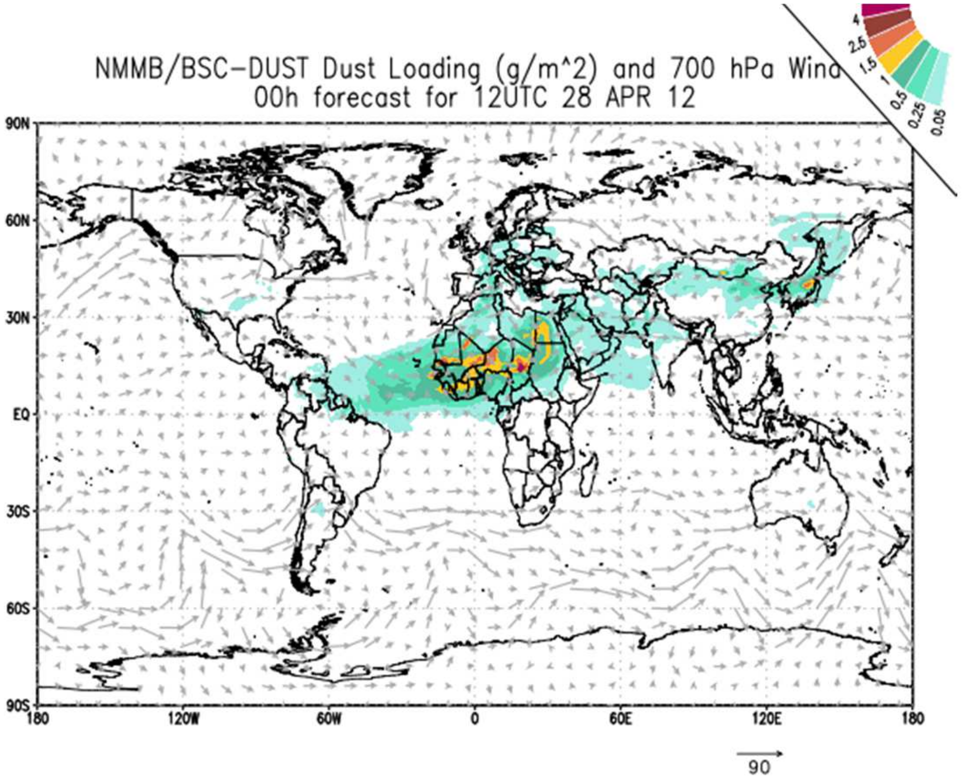


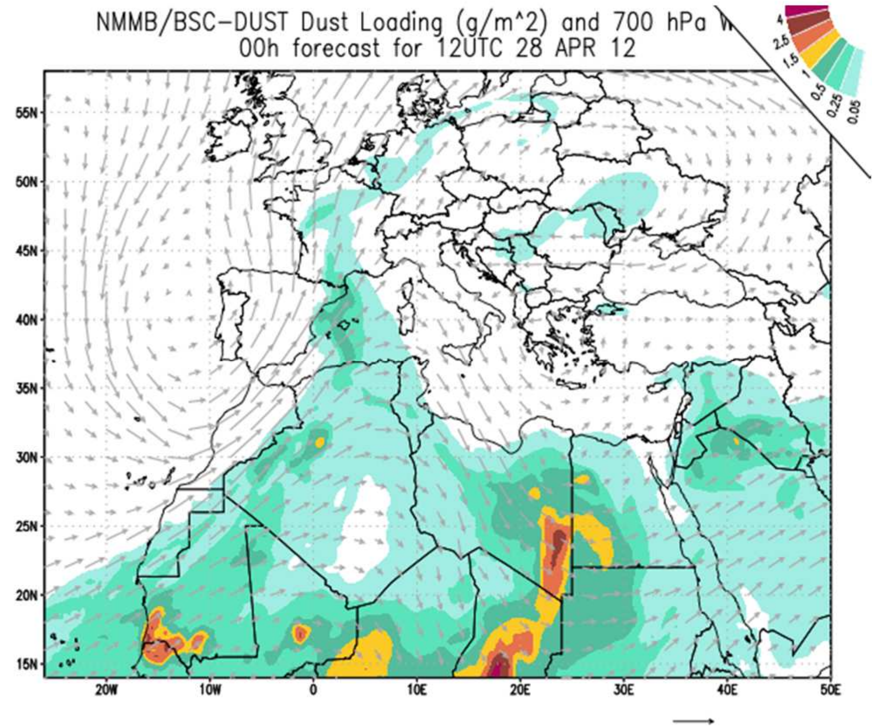
On-line approach:

SEA SALT (*Spada et al., 2012*), gas-phase **CHEM** (*Jorba et al., 2011; Badia et al., 2012*) and **Dust** (*Pérez et al., 2011; Haustein et al., 2012*) , modules fully embeded within the atmospheric driver.

Dust forecasting models: The NMMB/BSC-Dust model

*Dust forecasts on **global** and **regional** domains are running in pre-operational in the **BSC***





Dust forecasting models: The NMMB/BSC-Dust model

Global configuration:

- Global domain at 1.4º x 1º horizontal resolution
- 24 vertical levels
- fundamental time step of 180s
- Cold start without data assimilation
- Initial conditions from NCEP meteorological analysis 1x1º and Meteorological fields updated with NCEP every 24 h

Annual simulation: 2000 (Pérez et al., 2011)

Regional configuration:

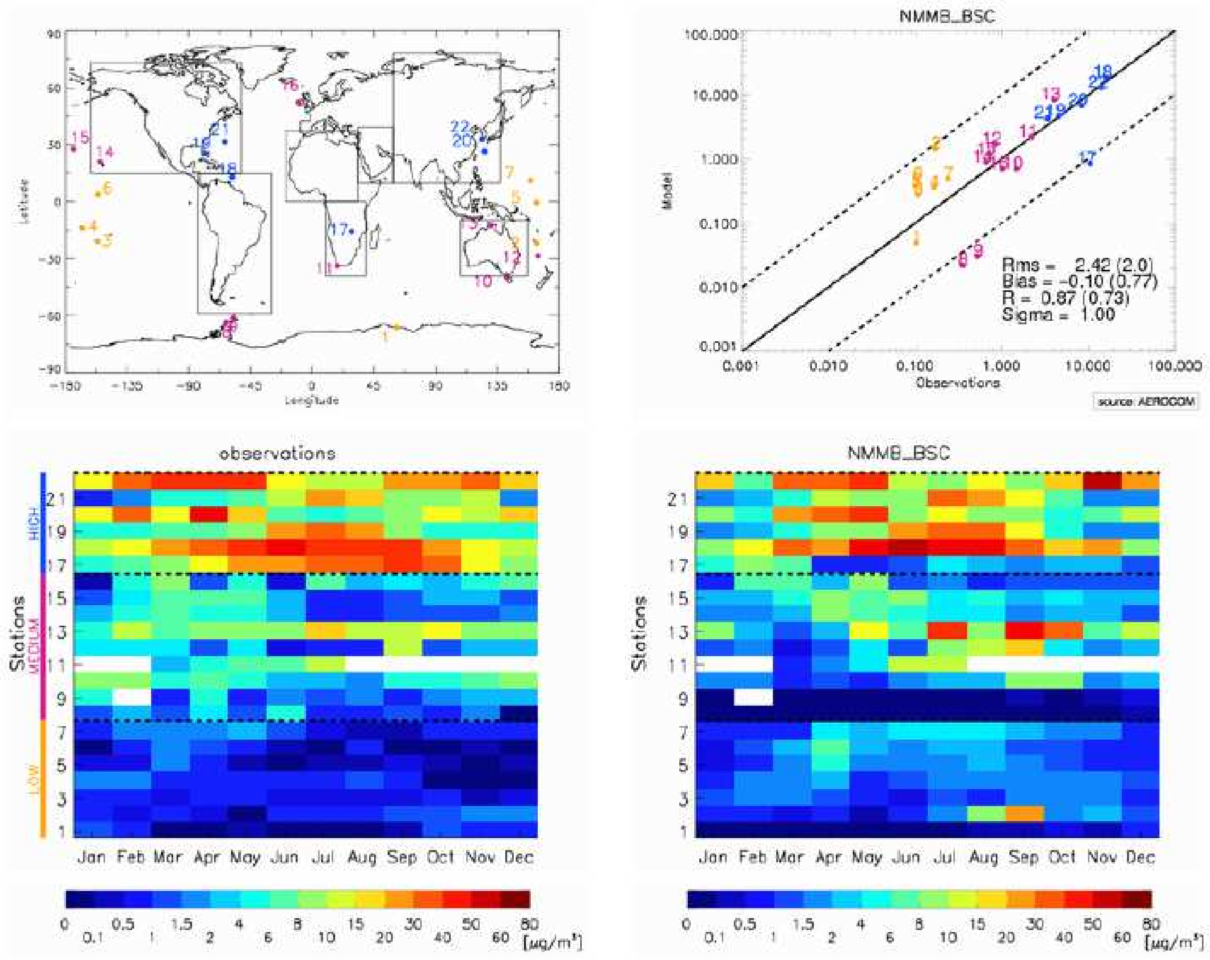
- North African domain at 0.25º x 0.25º horizontal spatial resolution
- 40 vertical layers
- fundamental time step of 40s
- Cold start without data assimilation
- Initial conditions from NCEP meteorological analysis 1x1º and meteorology fields updated boundary conditions every 6 h

Annual simulation: 2006 (Pérez et al., 2011)

SAMUM-I May 2006 (Haustein et al., 2012)

Dust forecasting models: The NMMB/BSC-Dust model

Surface concentration for global domain for 2000 (Pérez et al., 2011)



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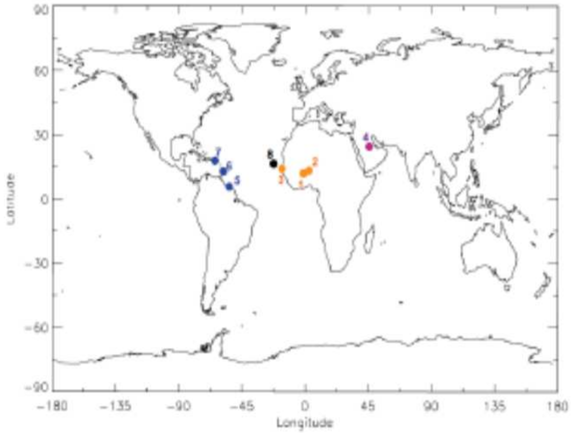
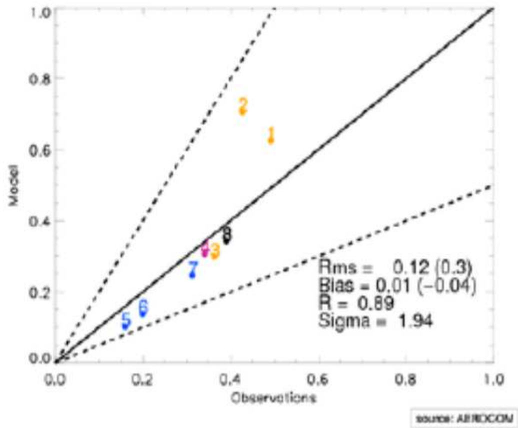
Dust forecasting models: The NMMB/BSC-Dust model

DOD for global domain for 2000 (Pérez et al., 2011)

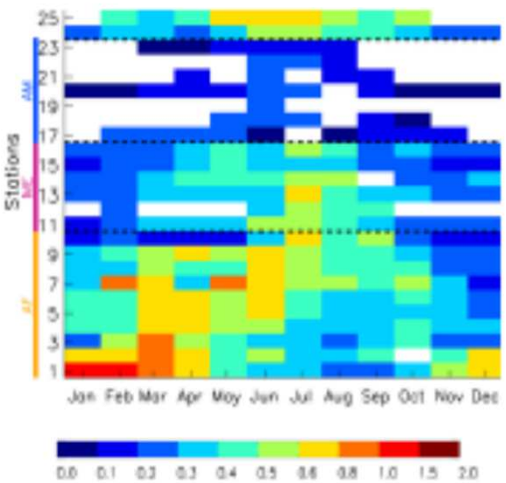
AERONET sites



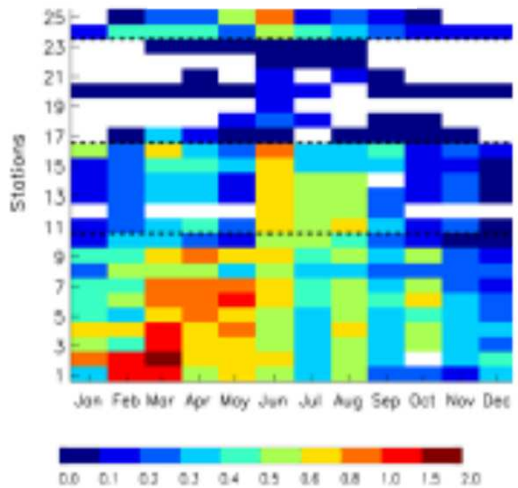
NMMB/BSC-DUST



Total AOD observations



NMMB/BSC-DUST



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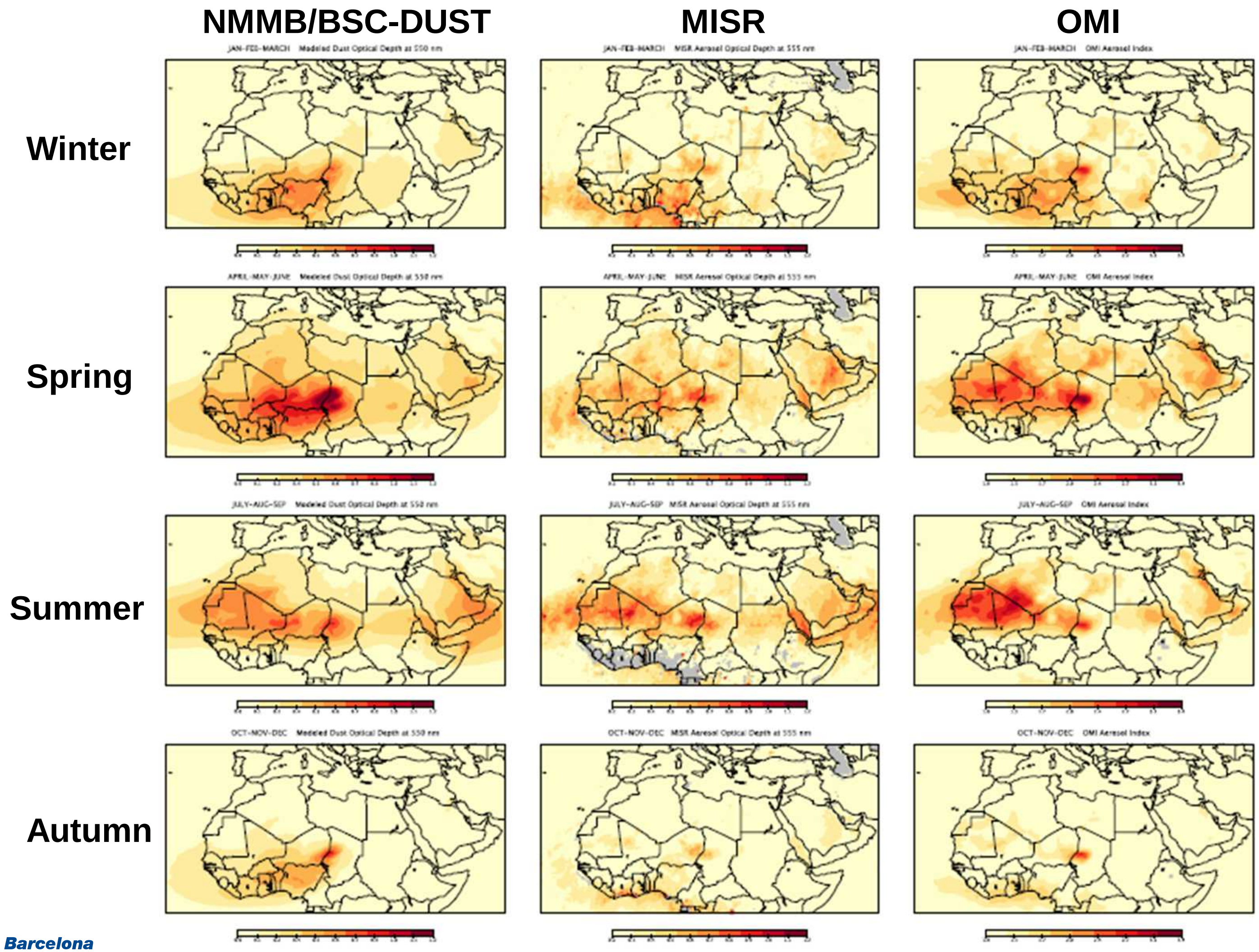
Dust forecasting models: The NMMB/BSC-Dust model

Satellite comparison for regional domain for 2006 (Pérez et al., 2011)



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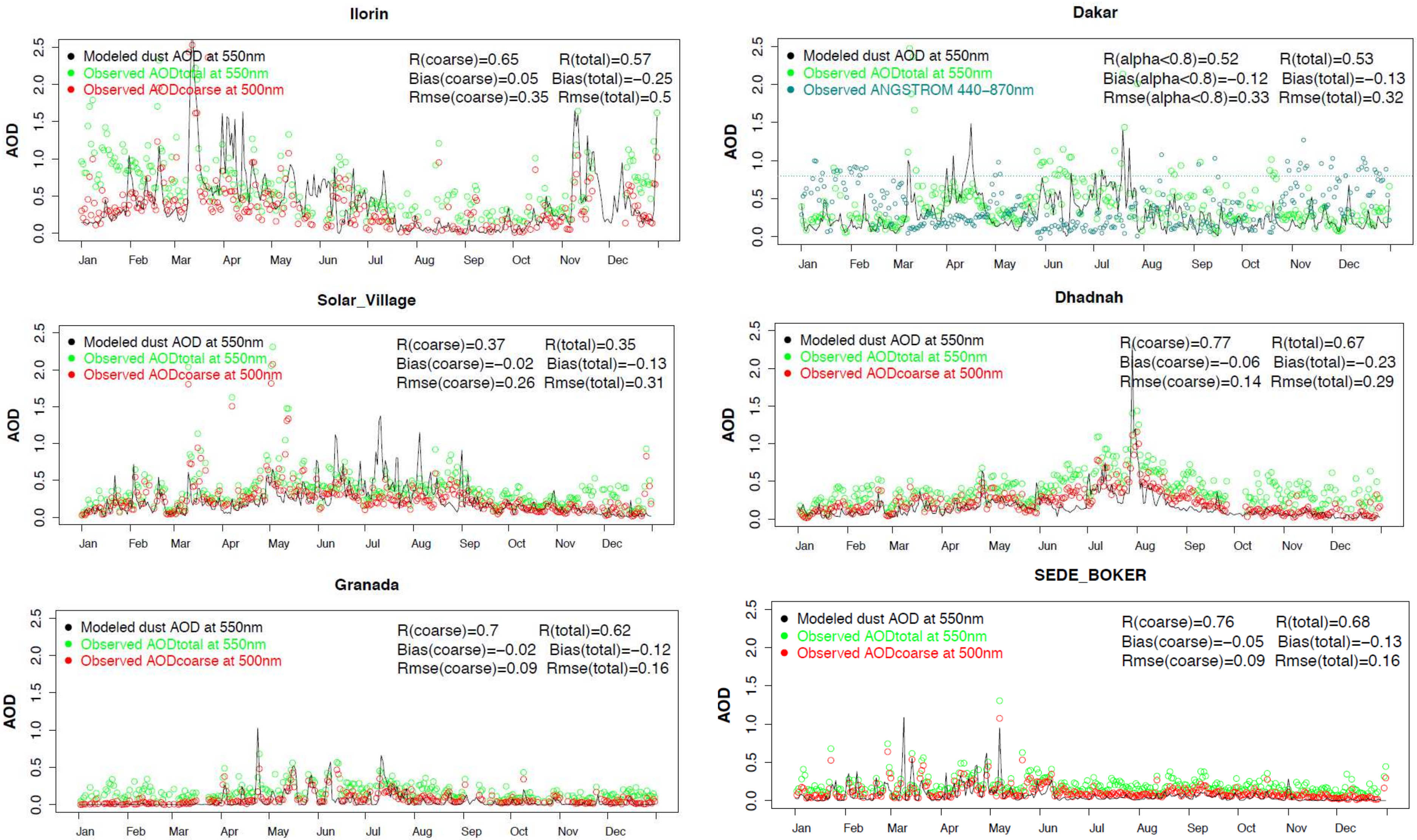
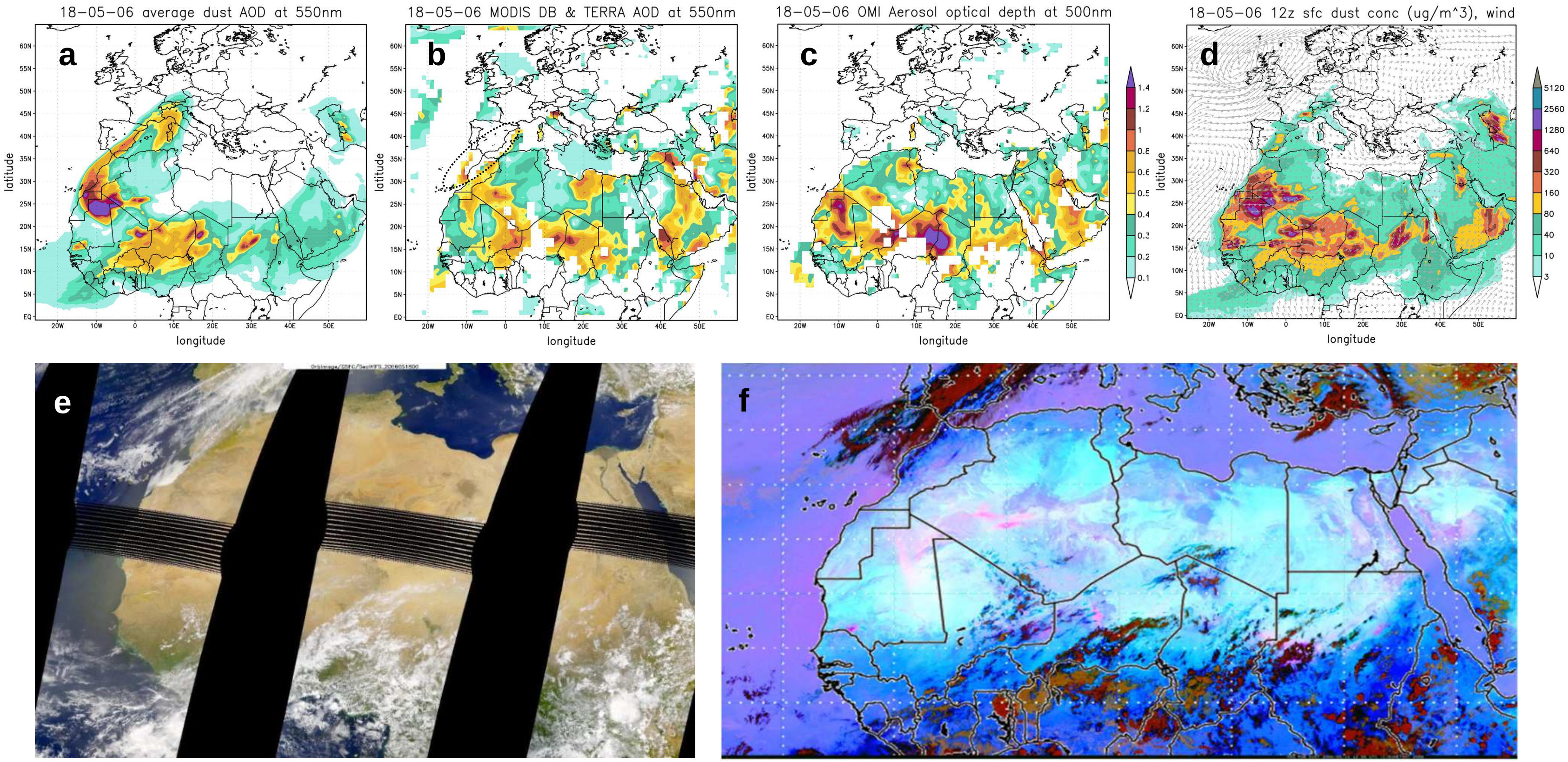
Dust forecasting models: The NMMB/BSC-Dust model

AERONET comparison for regional domain for 2006 (Pérez et al., 2011)



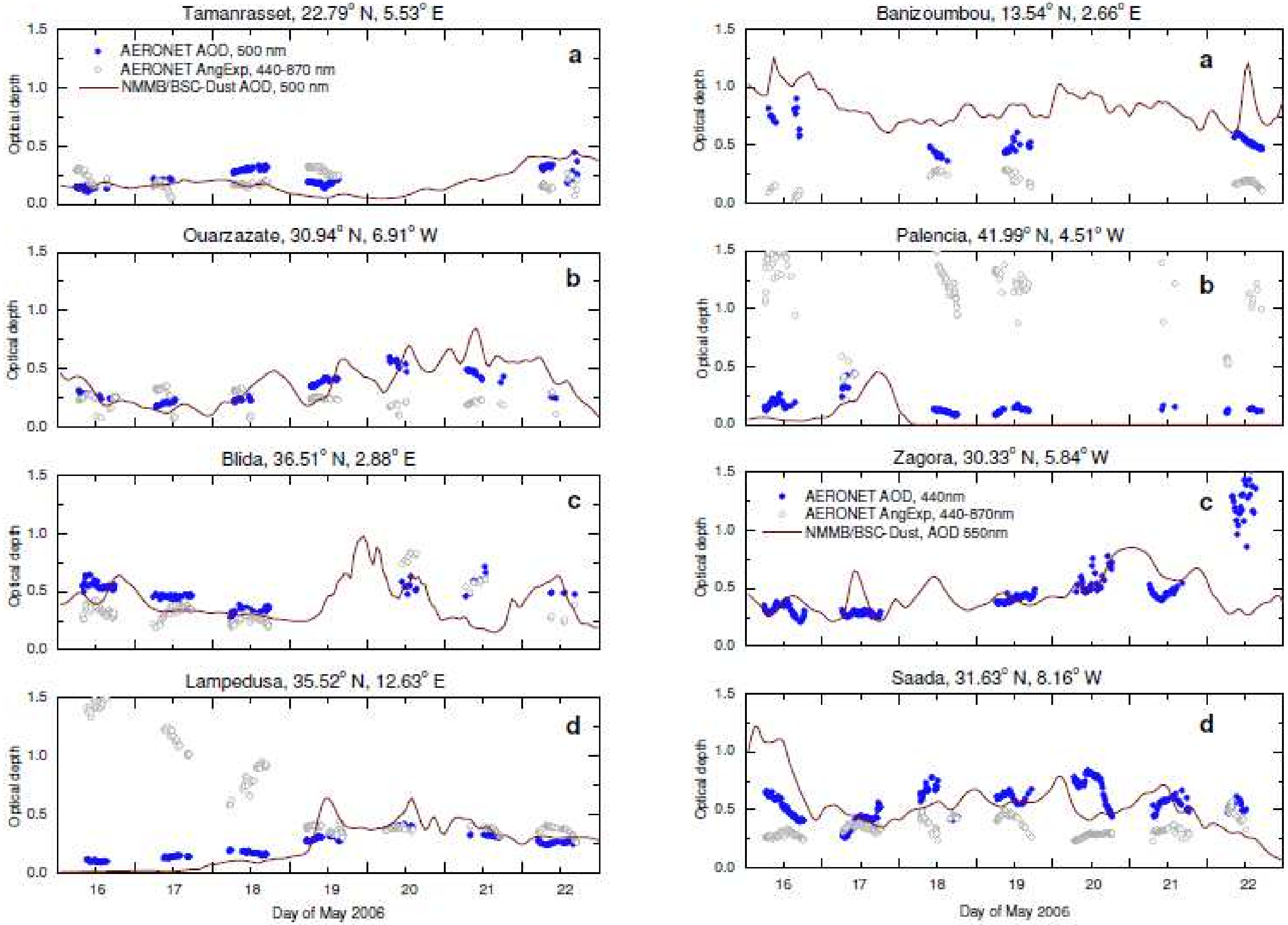
Dust forecasting models: The NMMB/BSC-Dust model

SAMUM-I on 18 May 2006 – Satellites (Haustein et al., 2012)



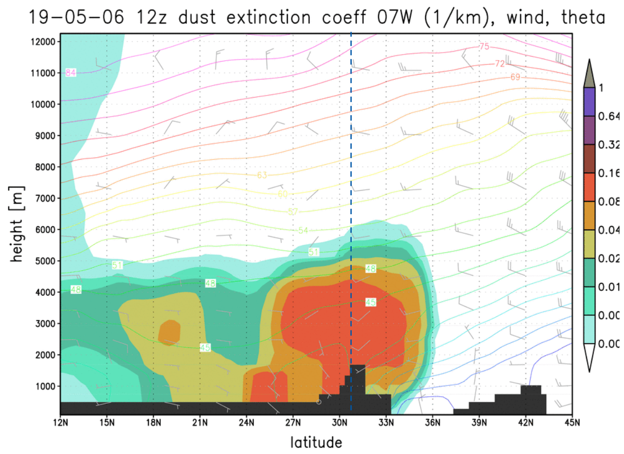
Dust forecasting models: The NMMB/BSC-Dust model

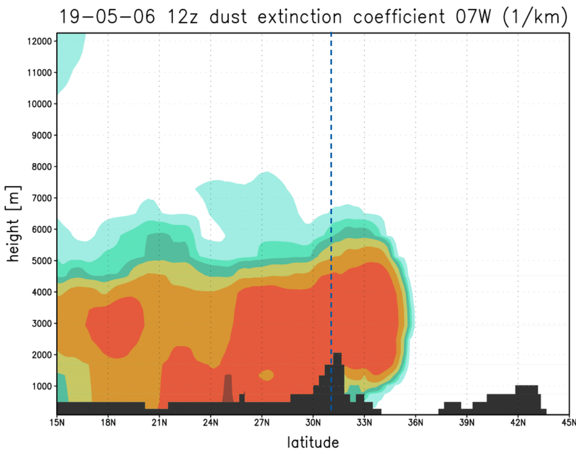
SAMUM-I May 2006 – AERONET (Haustein et al., 2012)

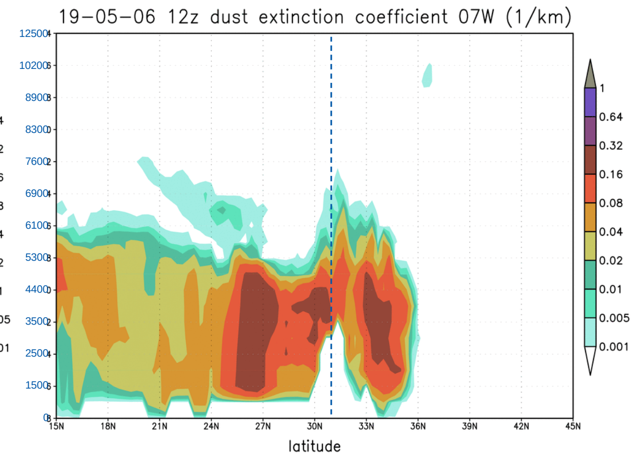


NMMb/BSC-DUST results

vertical cross section dust extinction coefficient (Ouarzazate)



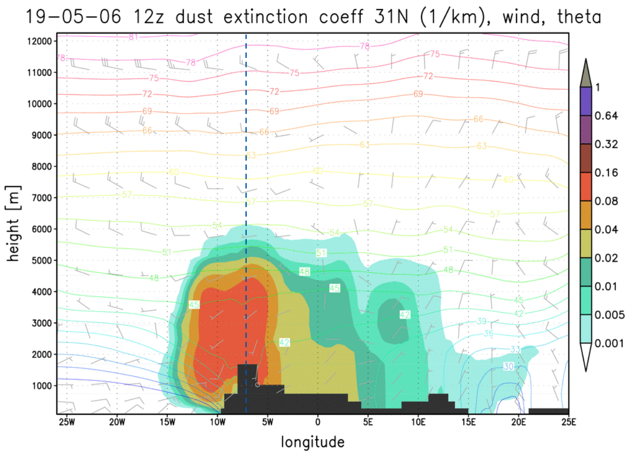


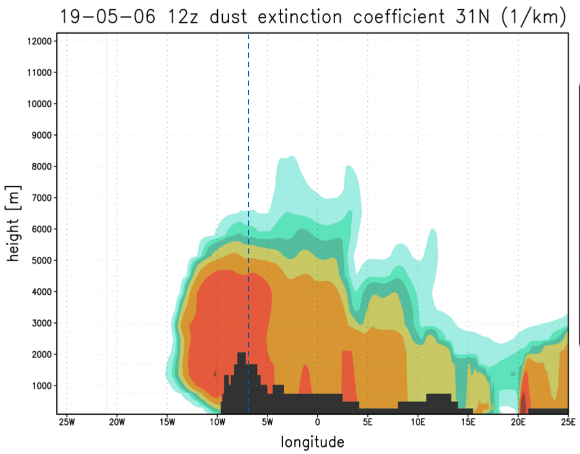


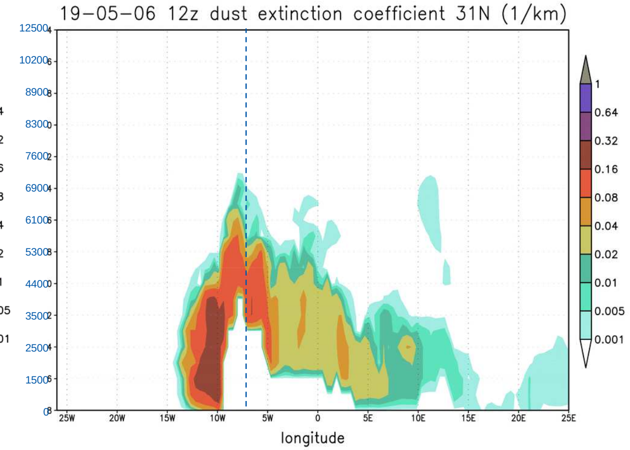
DREAM

BSC-DREAM8b operational

NMMB-DUST







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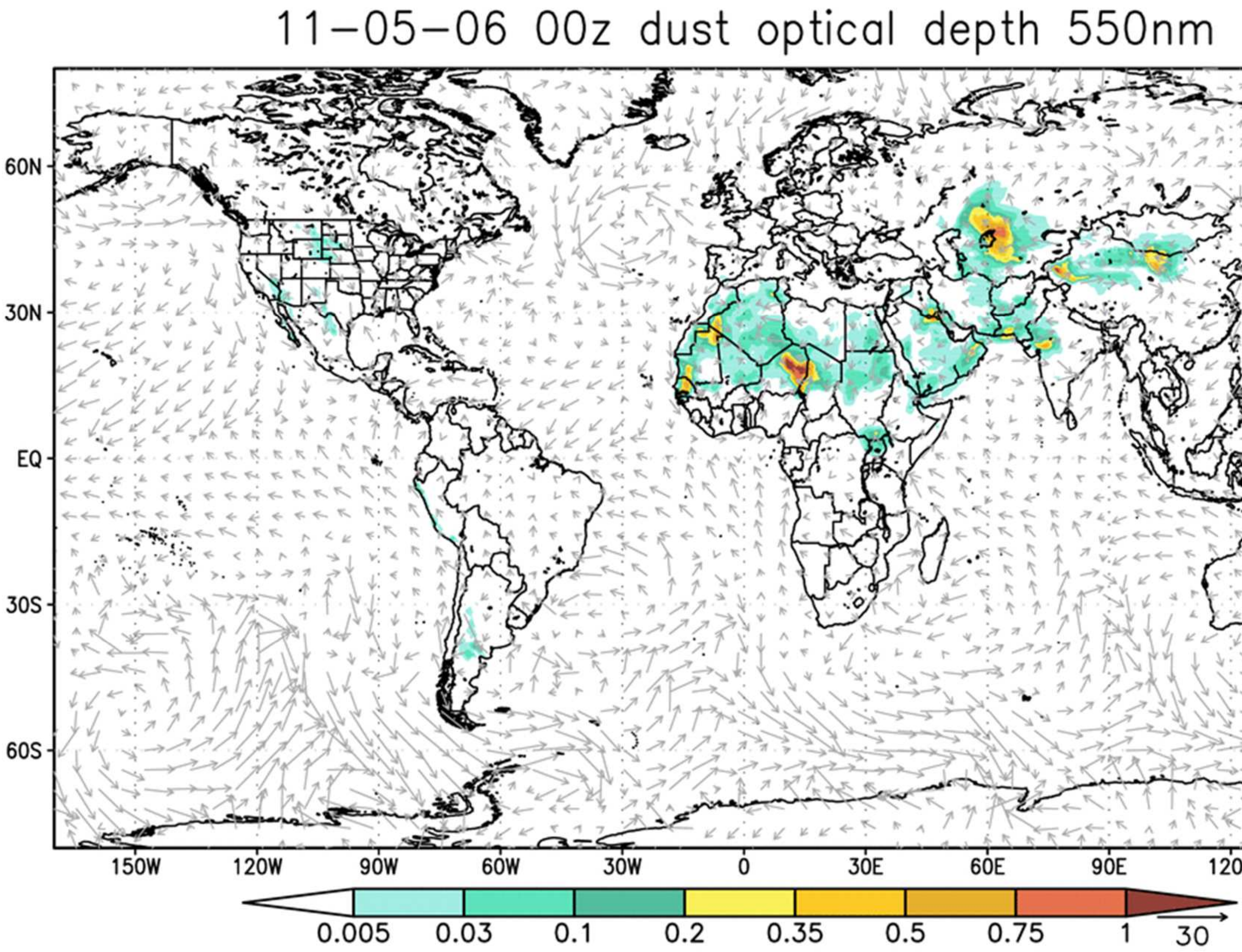
Global dust simulations with NMM/BSC-Dust
11-25 May 2006: Samum campaign period

0.3333 deg meridionally (37 km)
64 vertical levels resolution, comparable to operational GFS resolution



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Full year 2006 simulation

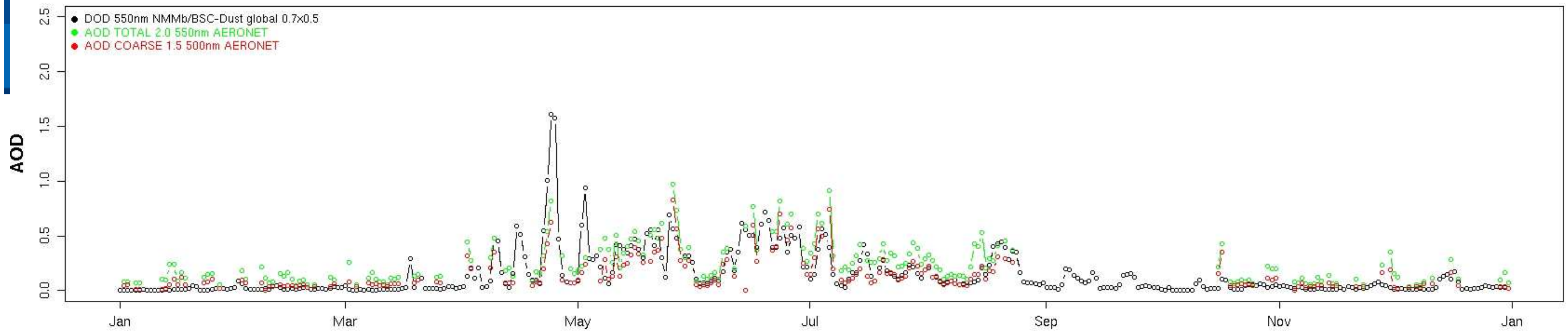
Simulation:

- Global simulation for year 2006
- 0.7º x 0.5º x 40 vertical levels
- Cold start without data assimilation
- Initial conditions from NCEP analysis 1x1º. Meteorological fields updated with NCEP every 24 hours.

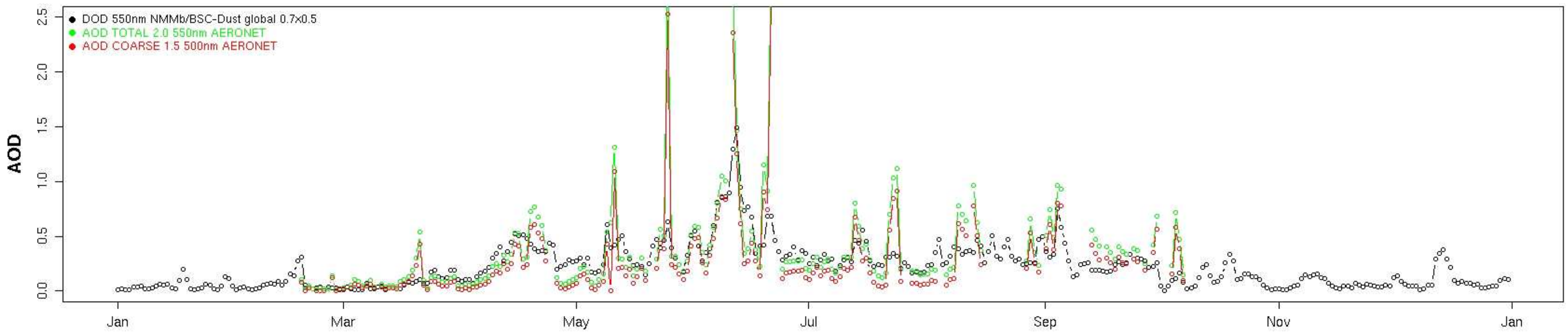
AERONET validation:

- AERONET data here is Coarse AOD (mainly dust over dust affected stations)
- We validate daily averages

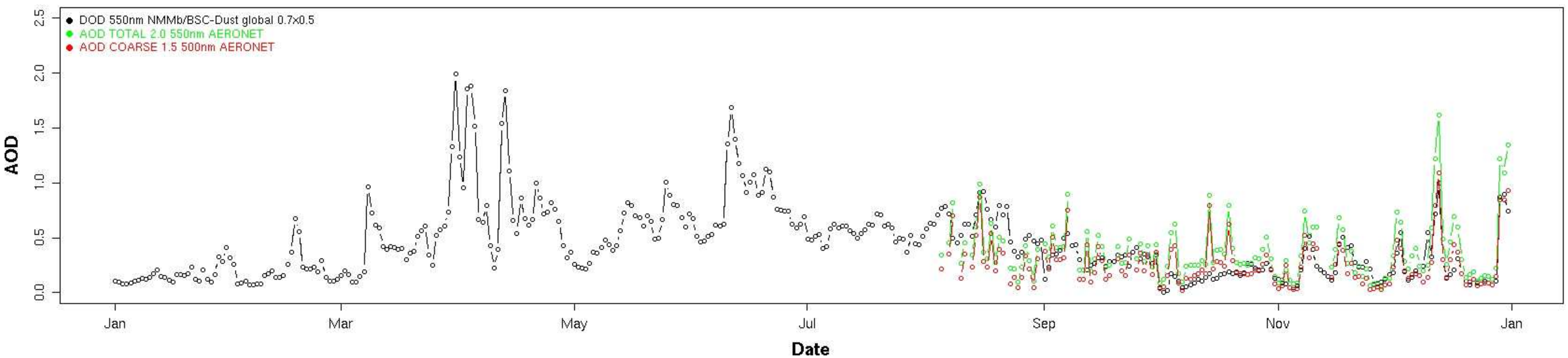
Blida : AOD for 2006 - NMMb/BSC-Dust vs AERONET



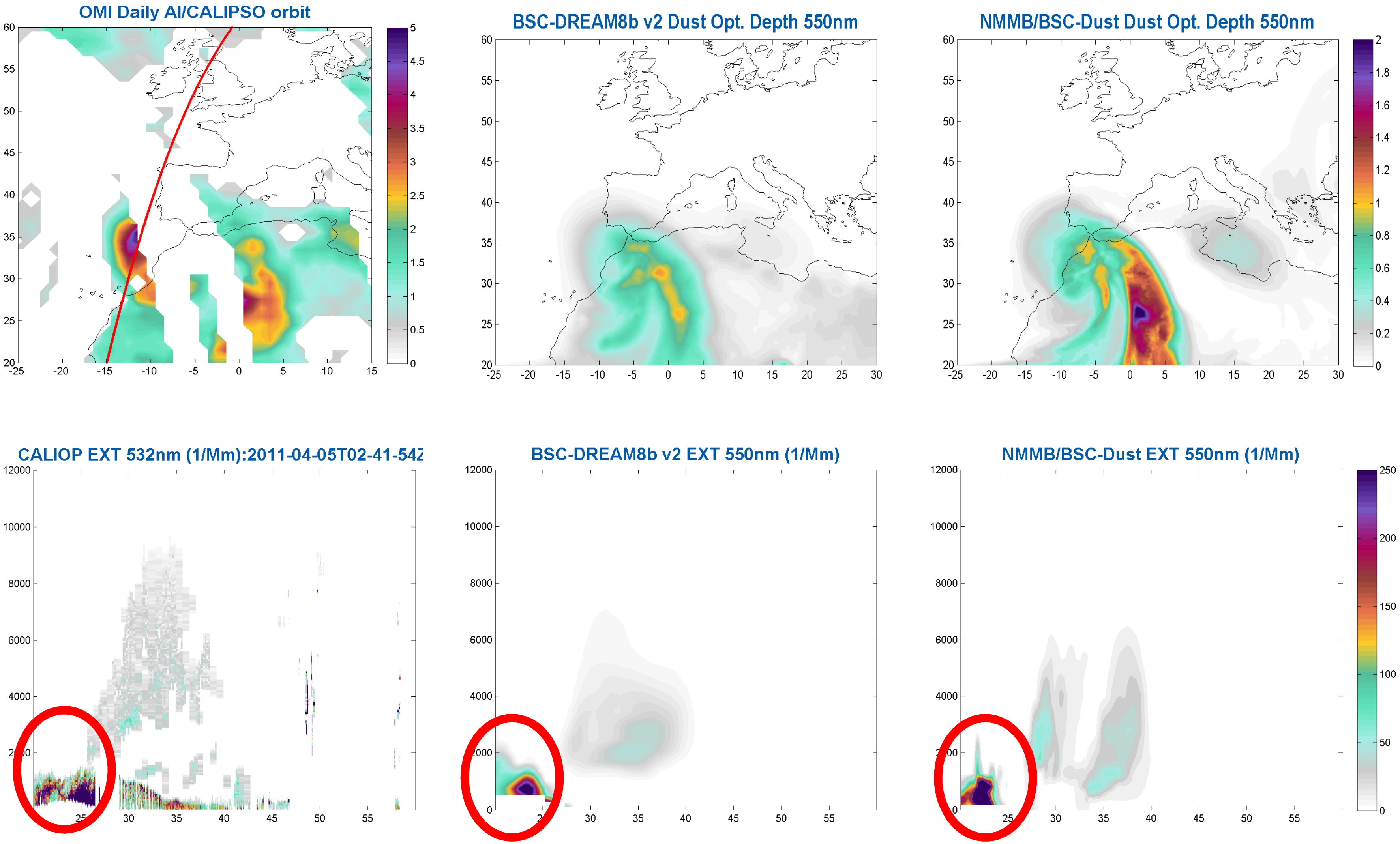
Tamanrasset_TMP : AOD for 2006 - NMMb/BSC-Dust vs AERONET



Niamey : AOD for 2006 - NMMb/BSC-Dust vs AERONET



AOD comparison: 2011-04-05



REANALISYS SIMULATIONS

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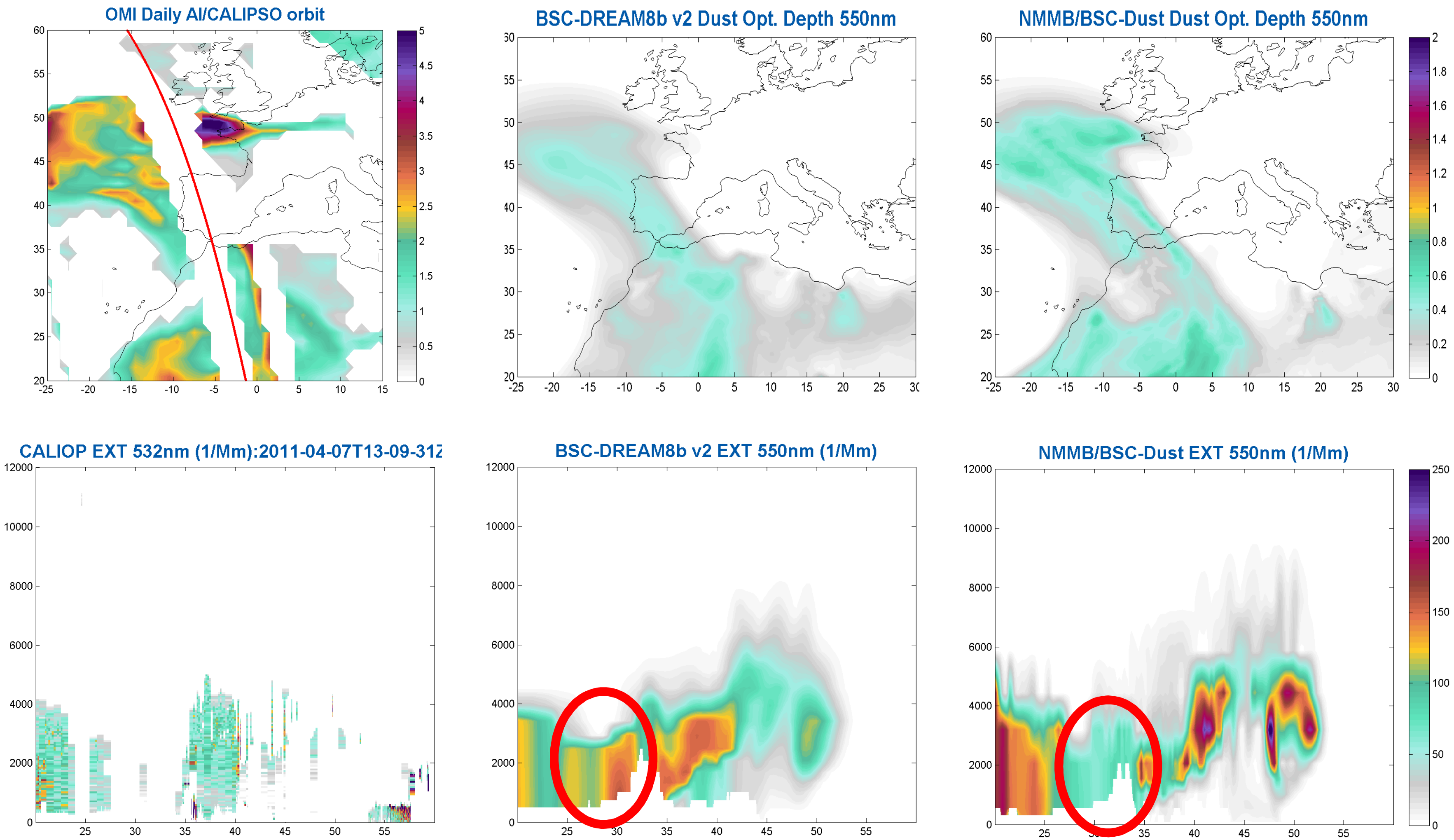
AOD comparison: 2011-04-07



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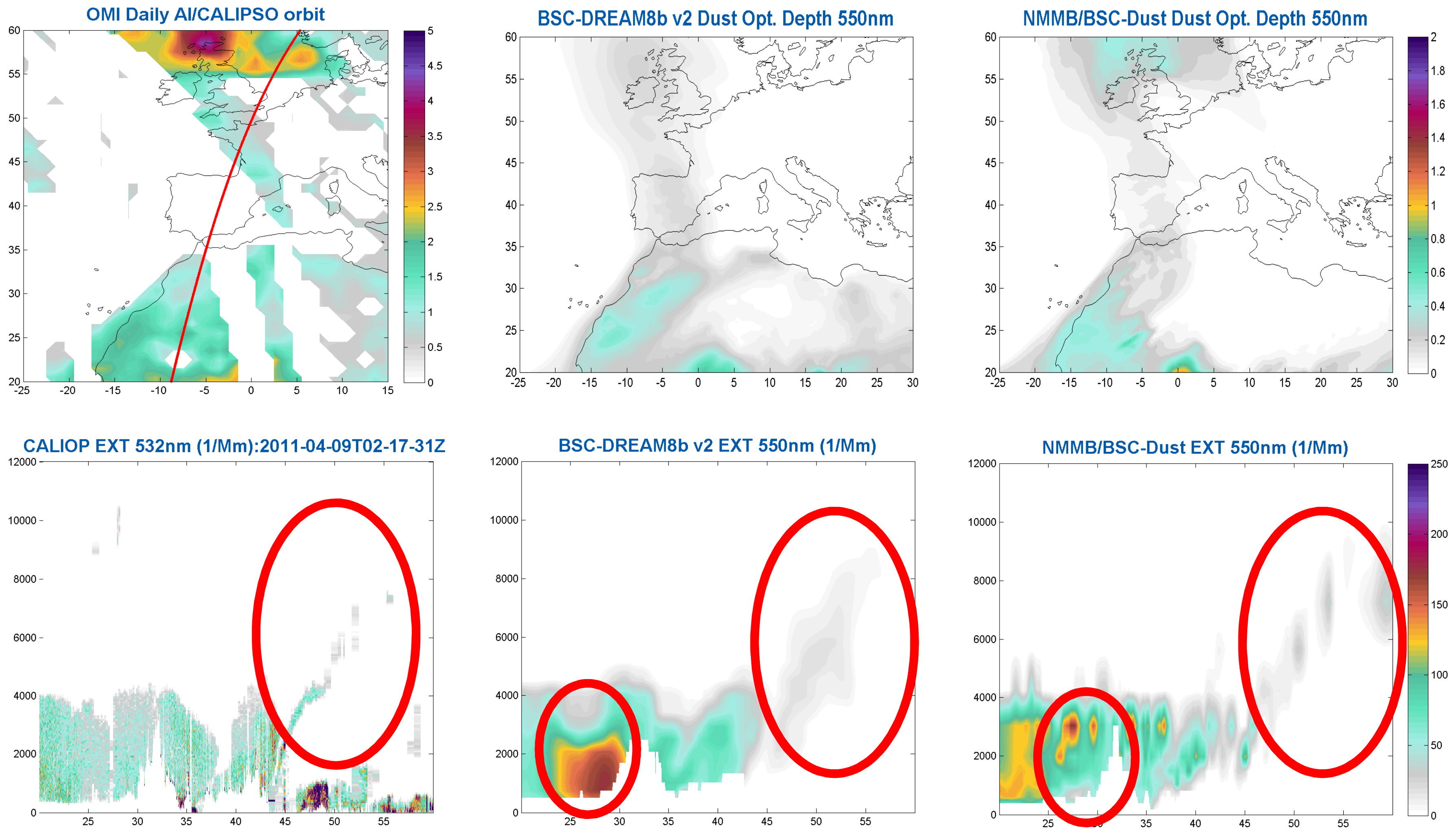
REANALISYS SIMULATIONS

AOD comparison: 2011-04-09



REANALISYS SIMULATIONS

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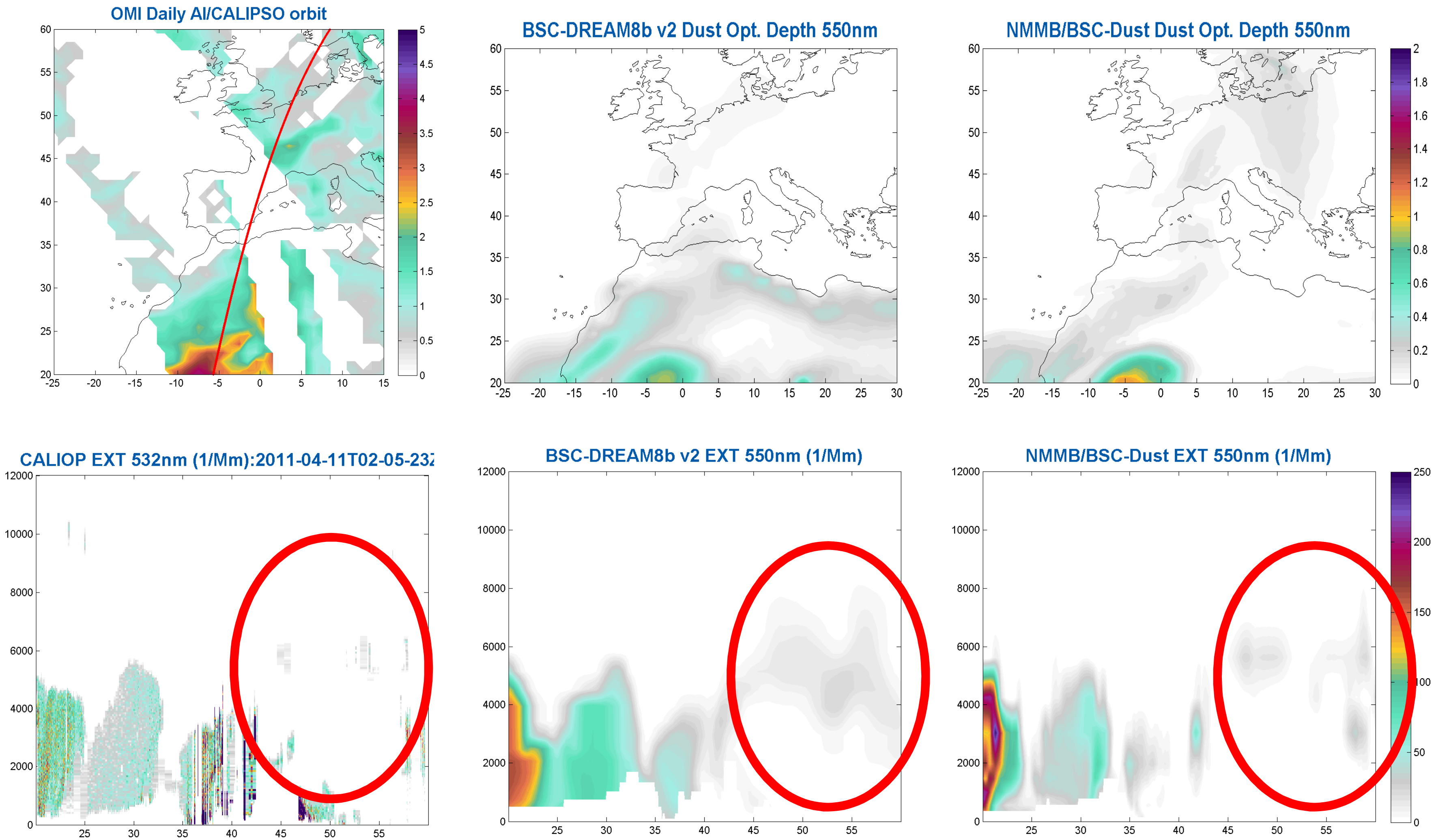
AOD comparison: 2011-04-11



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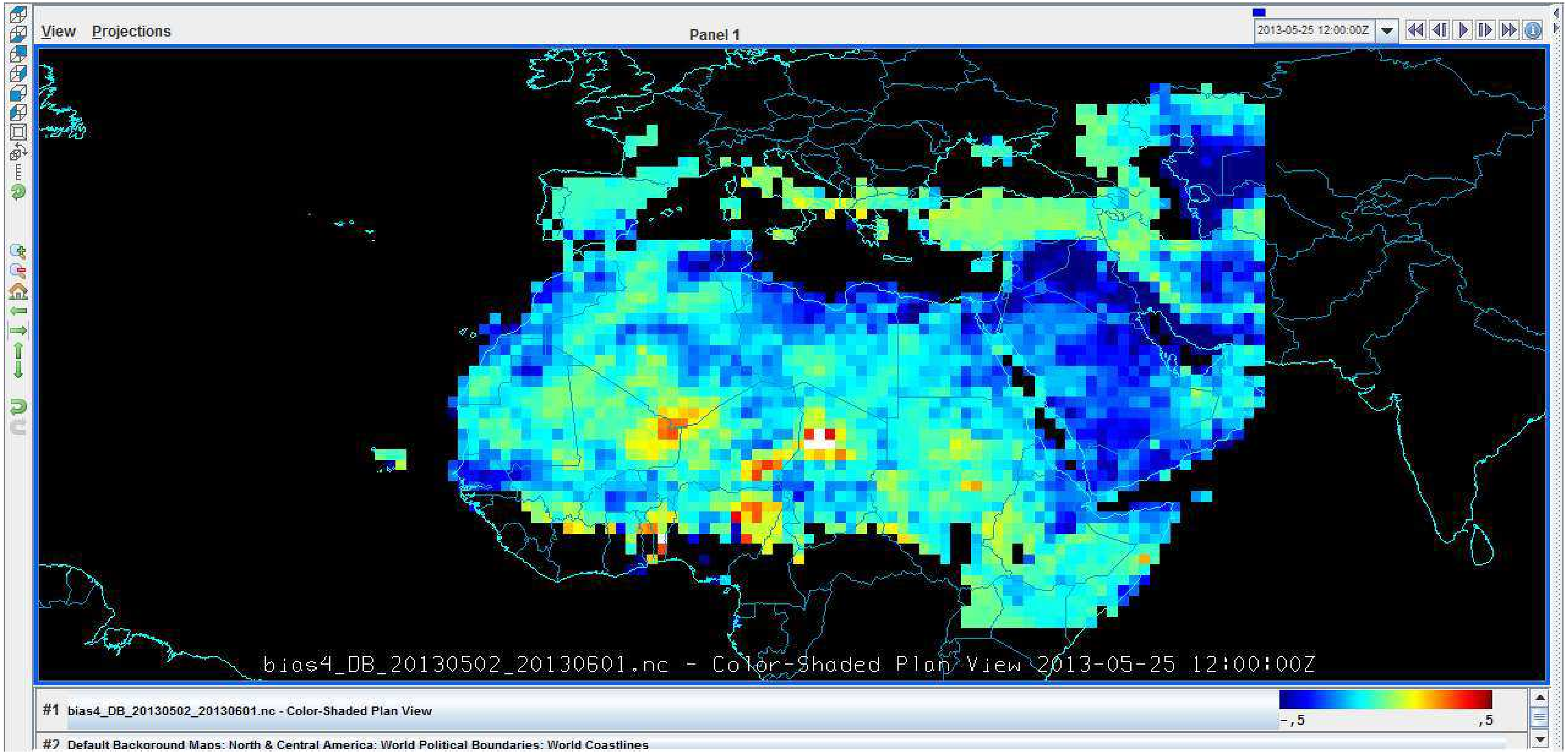
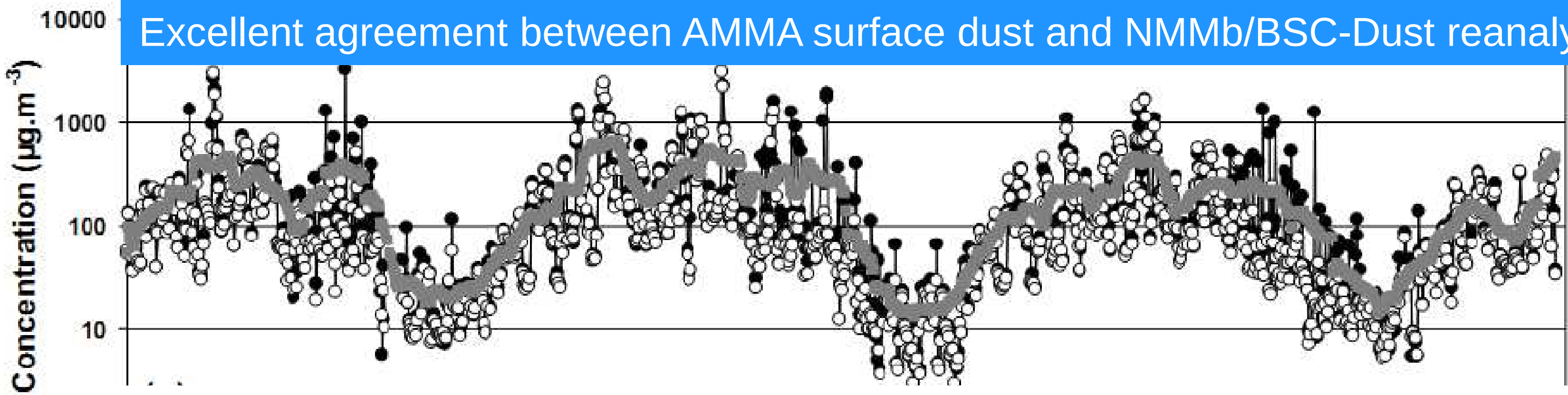
REANALISYS SIMULATIONS

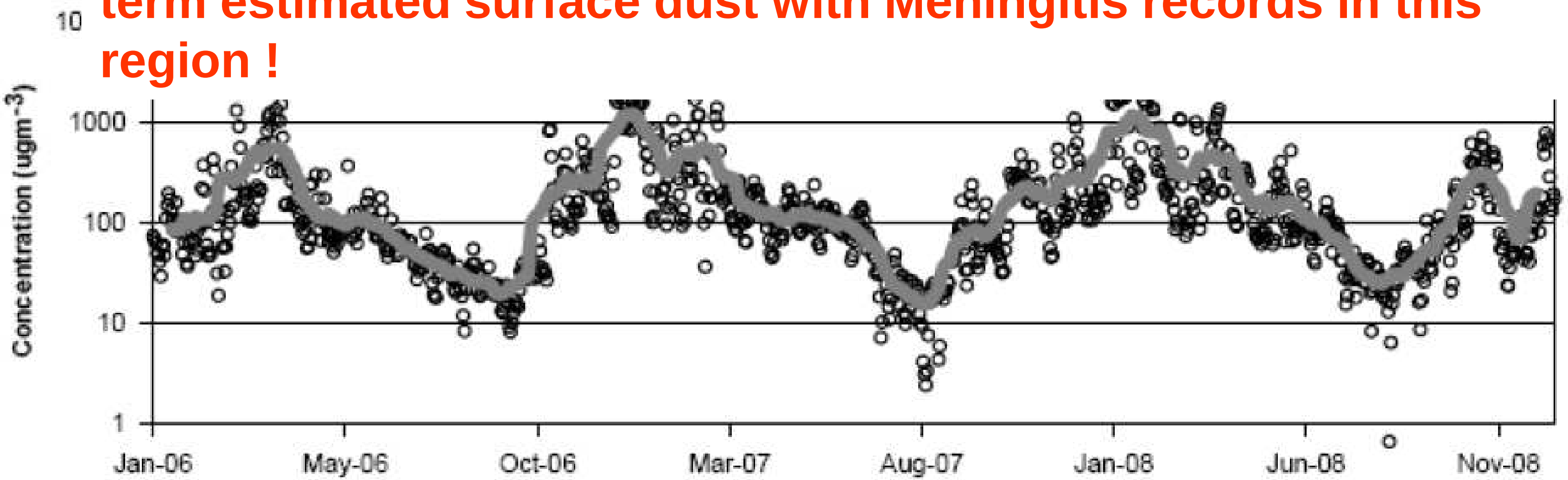
NMMB BSC-Dust 201305 vs MODIS deep-blue: bias



Excellent agreement between AMMA surface dust and NMMb/BSC-Dust reanalysis !!!



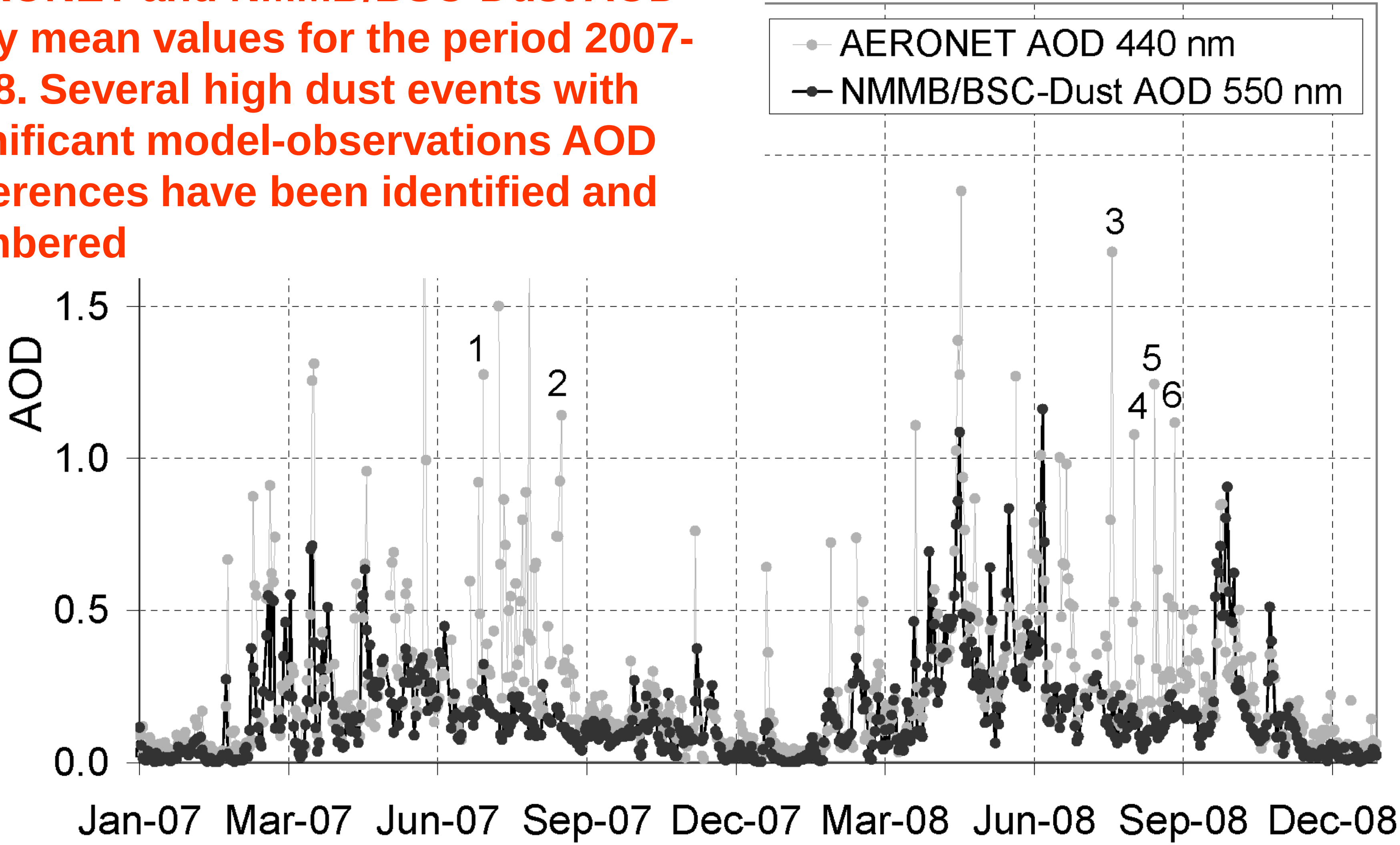
So, we can use NMMb/BSC-Dust reanalysis to cross long-term estimated surface dust with Meningitis records in this region !



PM10 Daily means (black circles) and medians (open circles) at Banizoumbou, from AMMA project (Marticorena et al., 2010) in upper panel. Surface dust concentration over Banizoumbou from NMMb/BSC-Dust reanalysis in lower panel. The grey line is the 30-day running average in both graphics.

Aerosol characterization at the Saharan AERONET site Tamanrasset (Guirado et al, 2013)

AERONET and NMMB/BSC-Dust AOD daily mean values for the period 2007-2008. Several high dust events with significant model-observations AOD differences have been identified and numbered



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Methods

***OBJECTIVE:* Full year evaluation of the sea salt and desert dust components for NMMB/BSC-CTM**

NMMB/BSC-CTM configuration:

- Year 2011
- North Africa, Middle East and Europe domain
- Horizontal spatial resolution: 0.25º x 0.25º
- Vertical resolution: 40 vertical layers
- Fundamental time step of 40s
- Cold start without data assimilation
- Initial conditions from NCEP/FNL meteorological analysis 1ºx1º at 0UTC and meteorology fields updated boundary conditions every 6 h
- Model outputs time resolution: 3-hourly

Observations:

- Satellite aerosol products (MODIS, MISR, Aura OMI)

  Seasonal averages
- Aerosol optical properties from AERONET Level 2.0

  15-minutes data
- Surface concentration measured in Praia, Cape Verde (from CV-DUST Project)

  Hourly data

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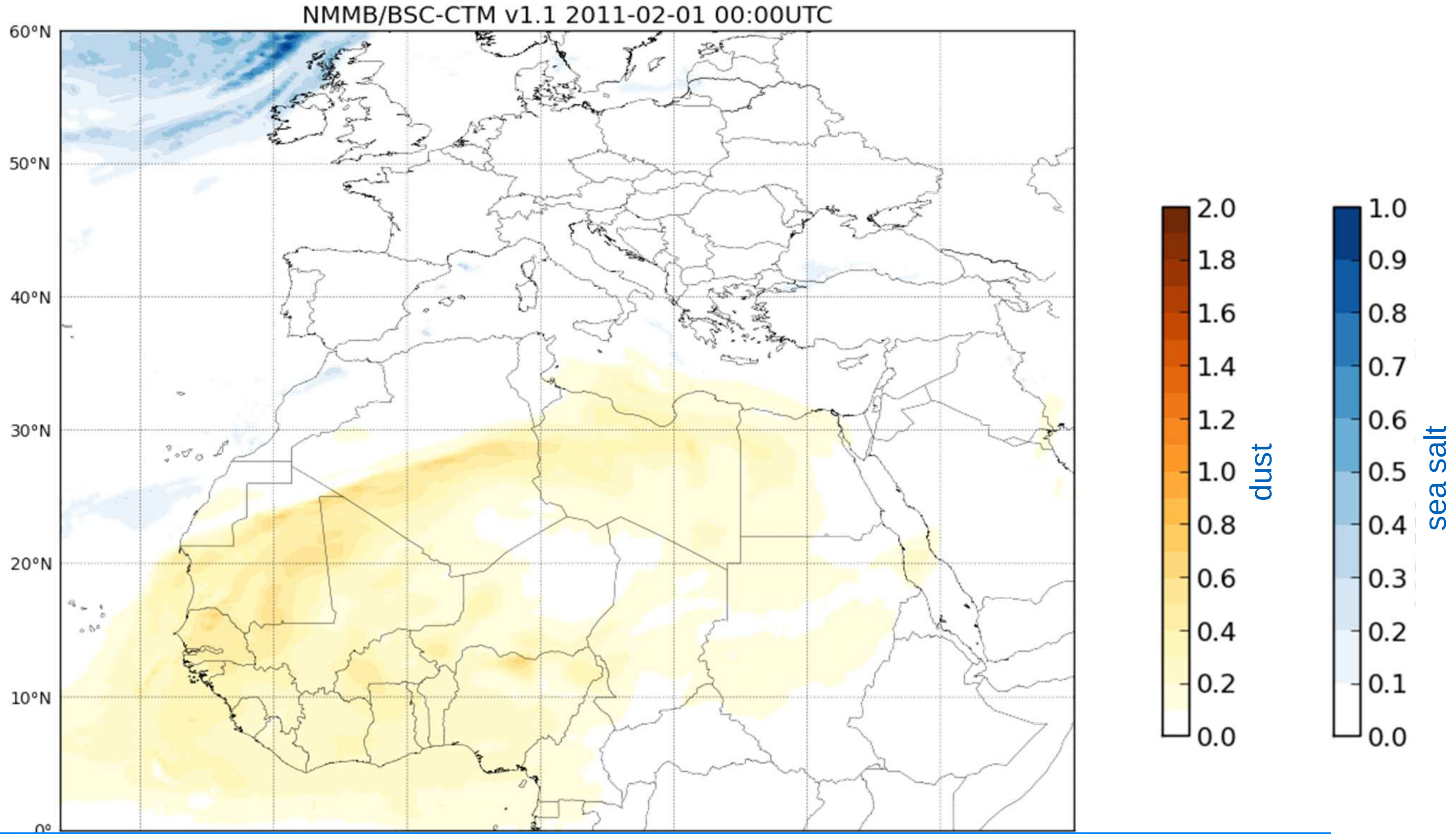
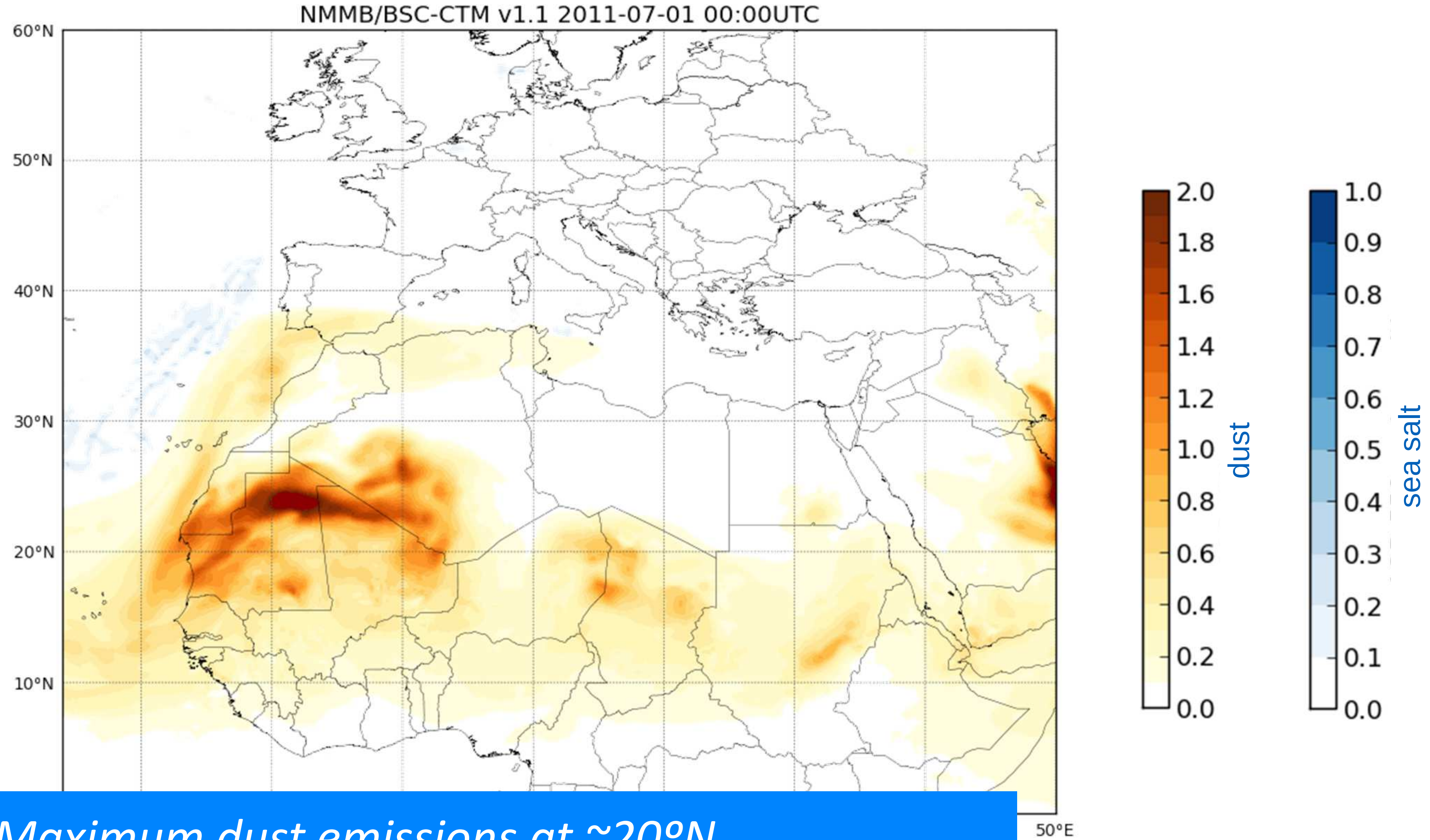
Model results: AOD at 550nm in Winter



High sea salt contributions in North Atlantic associated to deep depressions (strong surface winds $U_{10} > 9m/s$)

Model results: AOD at 550nm in Summer

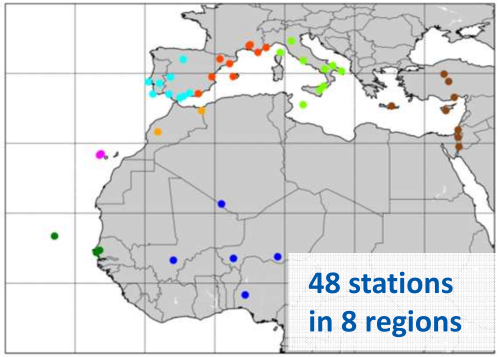


Maximum dust emissions at ~20ºN

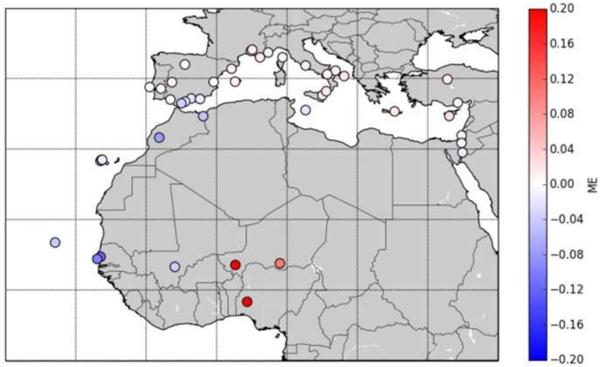
Minimum salt emission in North Atlantic

AERONET comparison: year 2011

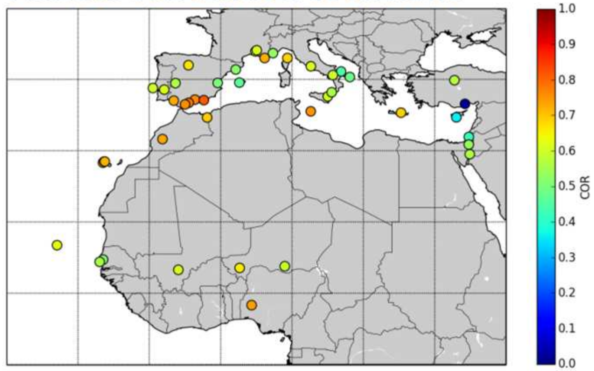
- 48 stations distributed in 8 regions
- Filter applied to the AERONET observations
  - AE < 0.75 is considered in the calculations
  - AE >= 0.75 and of the rest of cases we assign AOD observe = 0



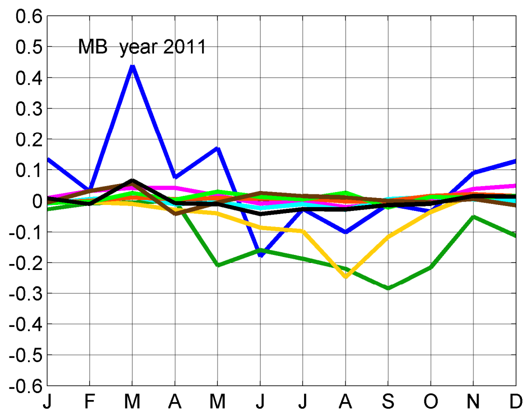
Annual MB

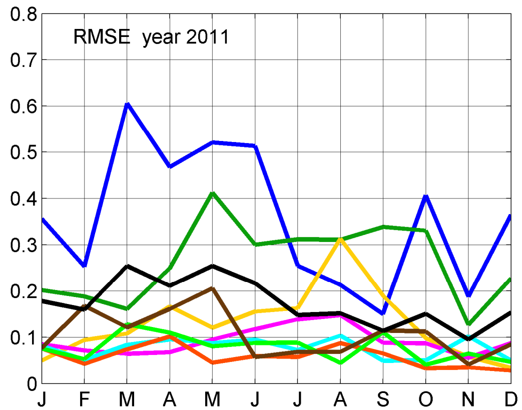


Annual correlation coeficient

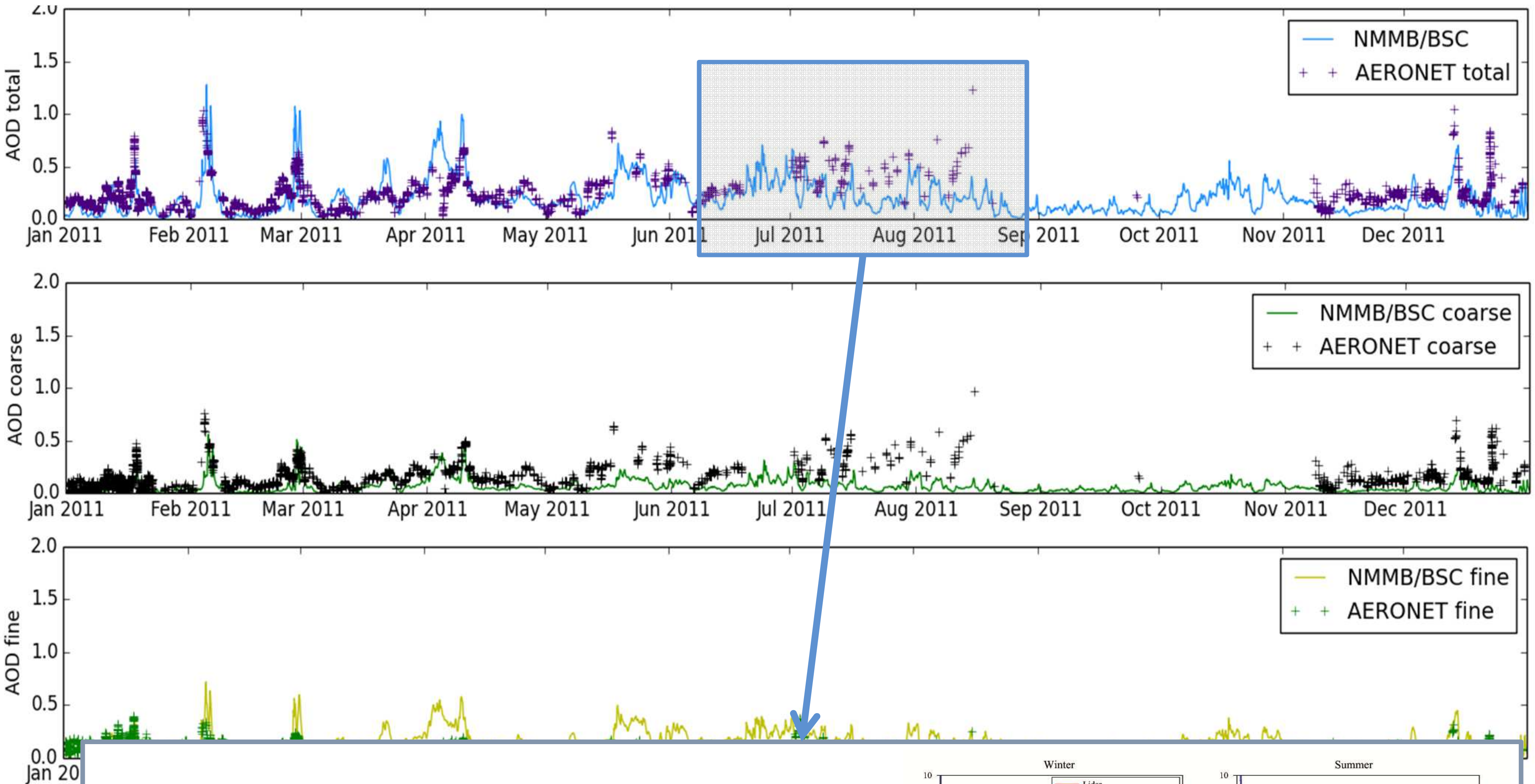


- Overestimations in Sahel during winter
  → *low-level instrusions*
- Underestimations in Sahara during summer
  → *Convective phenomena*
  → *Missing sources*
  → *Wet deposition scheme*

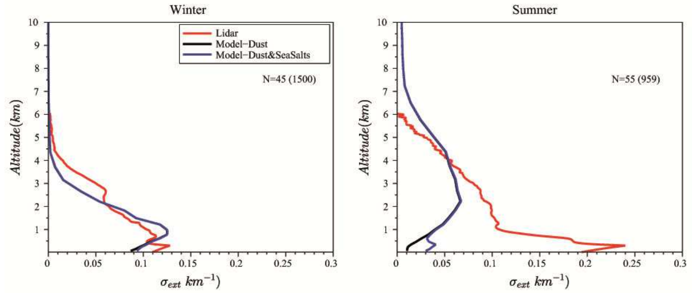




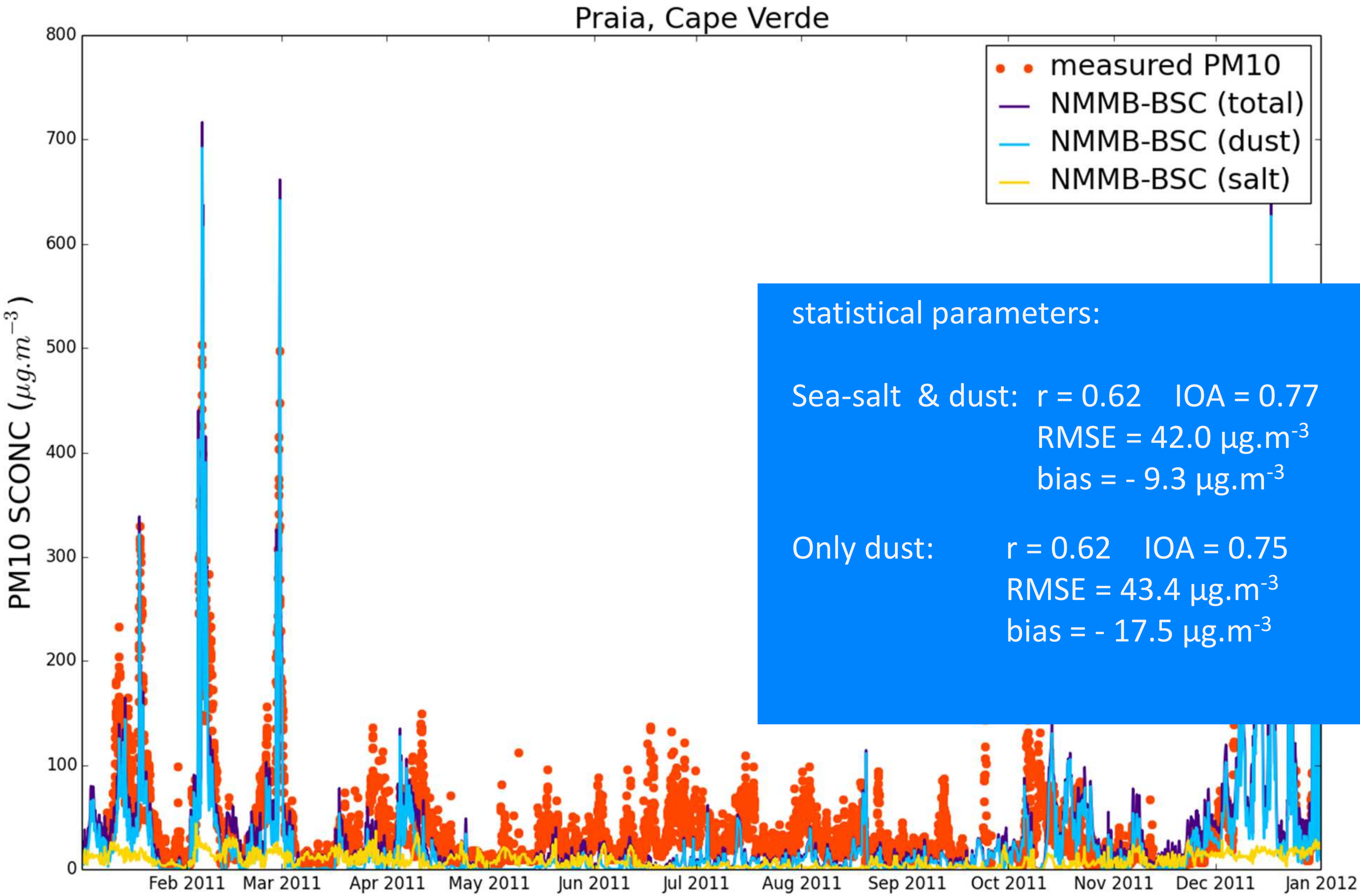
AERONET comparison: Capo Verde 2011



Vertical profile from M'Bour (Senegal)
Mortier et al., 2013



Cape Verde comparison: surface level PM10

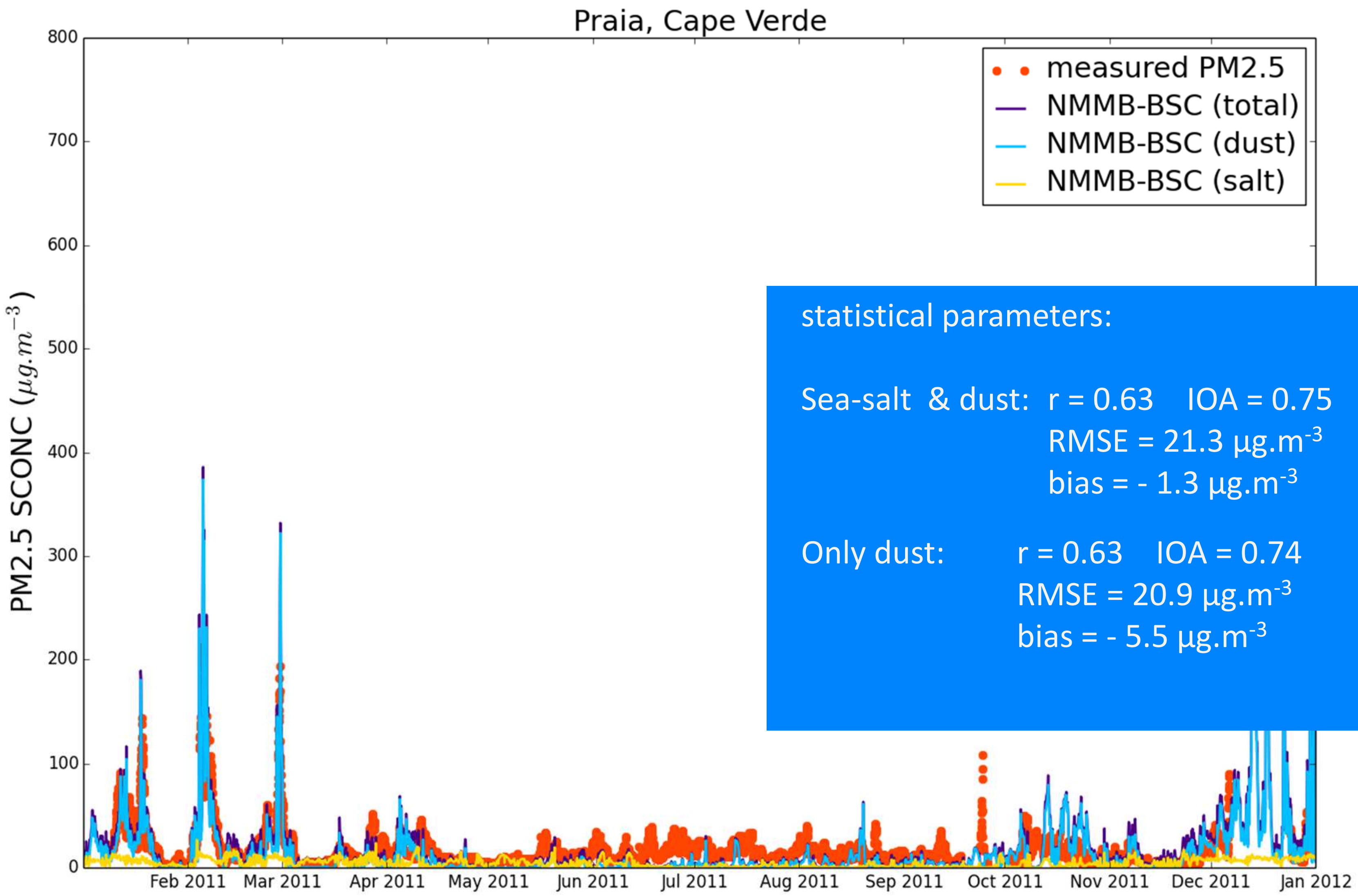


statistical parameters:

Sea-salt & dust: r = 0.62 IOA = 0.77
RMSE = 42.0 $\mu g.m^{-3}$
bias = - 9.3 $\mu g.m^{-3}$

Only dust: r = 0.62 IOA = 0.75
RMSE = 43.4 $\mu g.m^{-3}$
bias = - 17.5 $\mu g.m^{-3}$

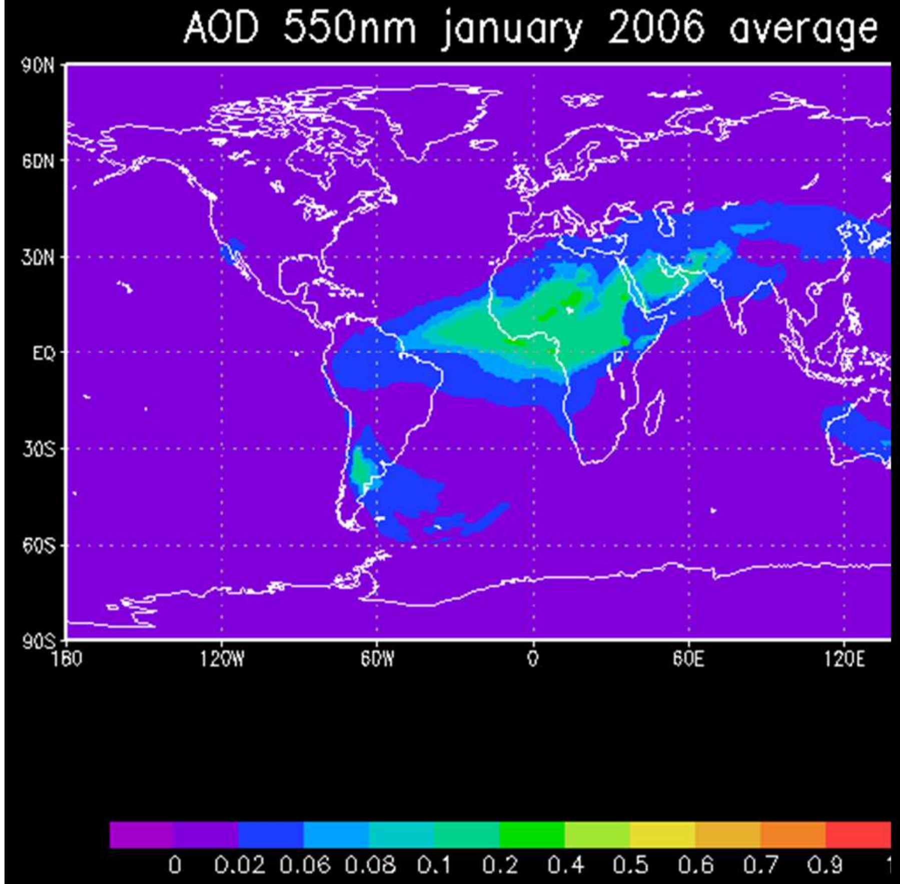
Cape Verde comparison: surface level PM2.5



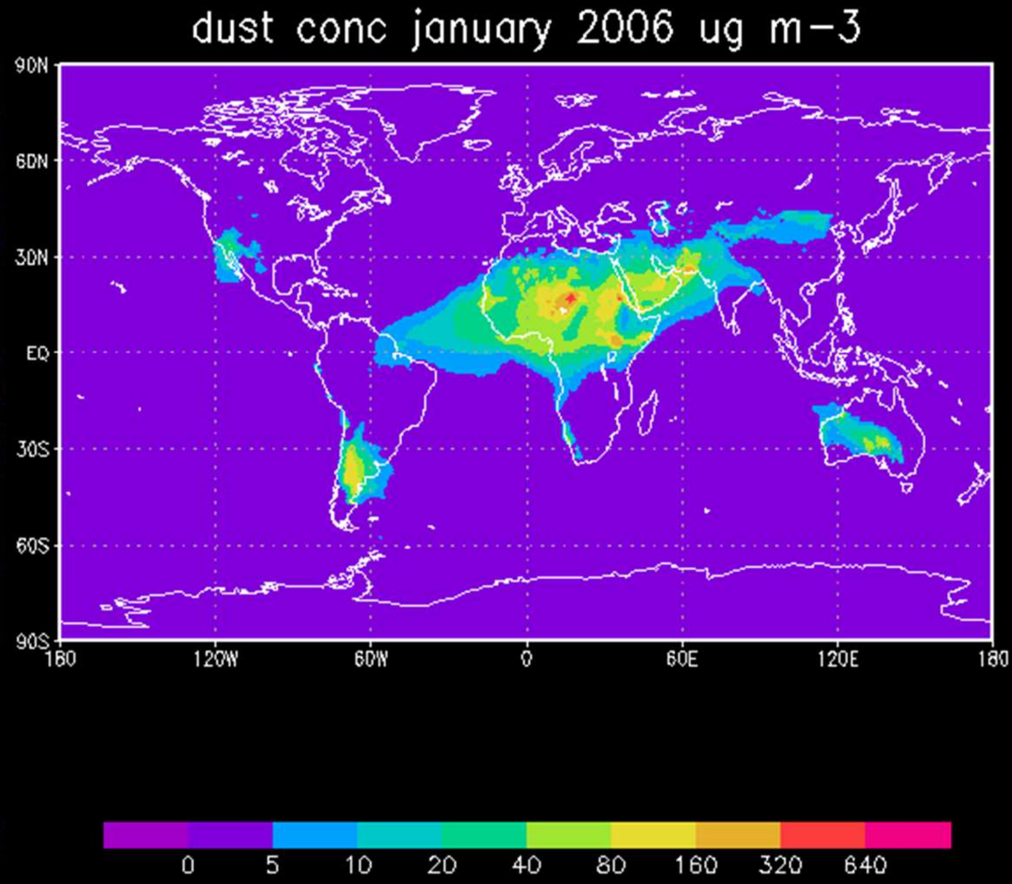
statistical parameters:

Sea-salt & dust: r = 0.63 IOA = 0.75
RMSE = 21.3 $\mu g.m^{-3}$
bias = - 1.3 $\mu g.m^{-3}$

Only dust: r = 0.63 IOA = 0.74
RMSE = 20.9 $\mu g.m^{-3}$
bias = - 5.5 $\mu g.m^{-3}$



AOD 550nm january 2006 average
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
0
0.02
0.06
0.08
0.1
0.2
0.4
0.5
0.6
0.7
0.9



dust conc january 2006 ug m-3
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180
0
5
10
20
40
80
160
320
640

WMO Sand and Dust Storm Warning and Assessment System (SDS WAS) in cooperation with World Meteorological Organization (WMO)

- To enhance the ability of participating countries to establish and improve systems for forecasting and warning to suppress the impact of Sand and Dust Storm

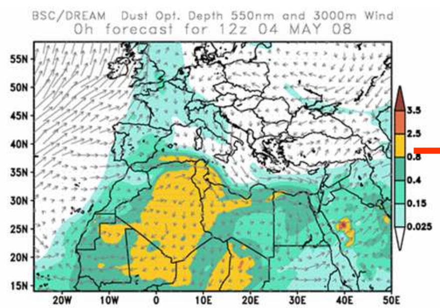
by

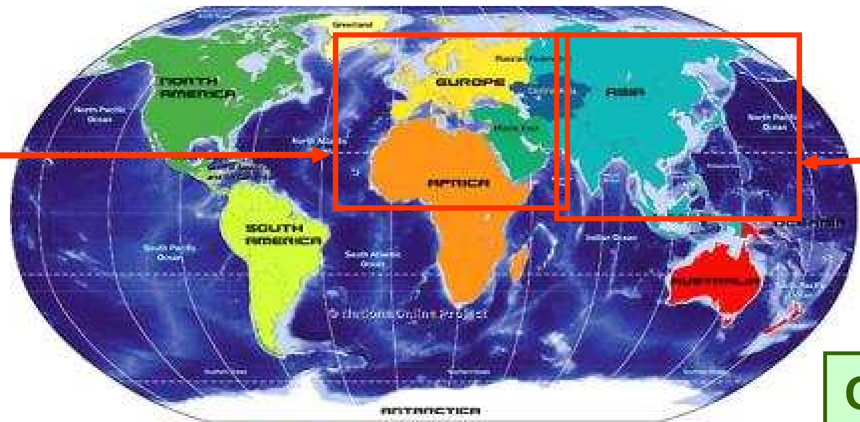
- Establishing a coordinated global network of Sand and Dust Storm forecasting centers delivering products useful to a wide range of users in understanding and reducing the impacts of SDS

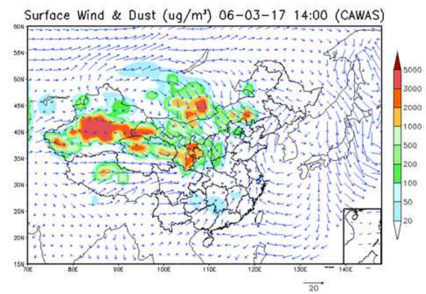
World Meteorological Organization
Weather • Climate • Water

North Africa, Middle East and Europe (http://sds-was.aemet.es/)

Asia







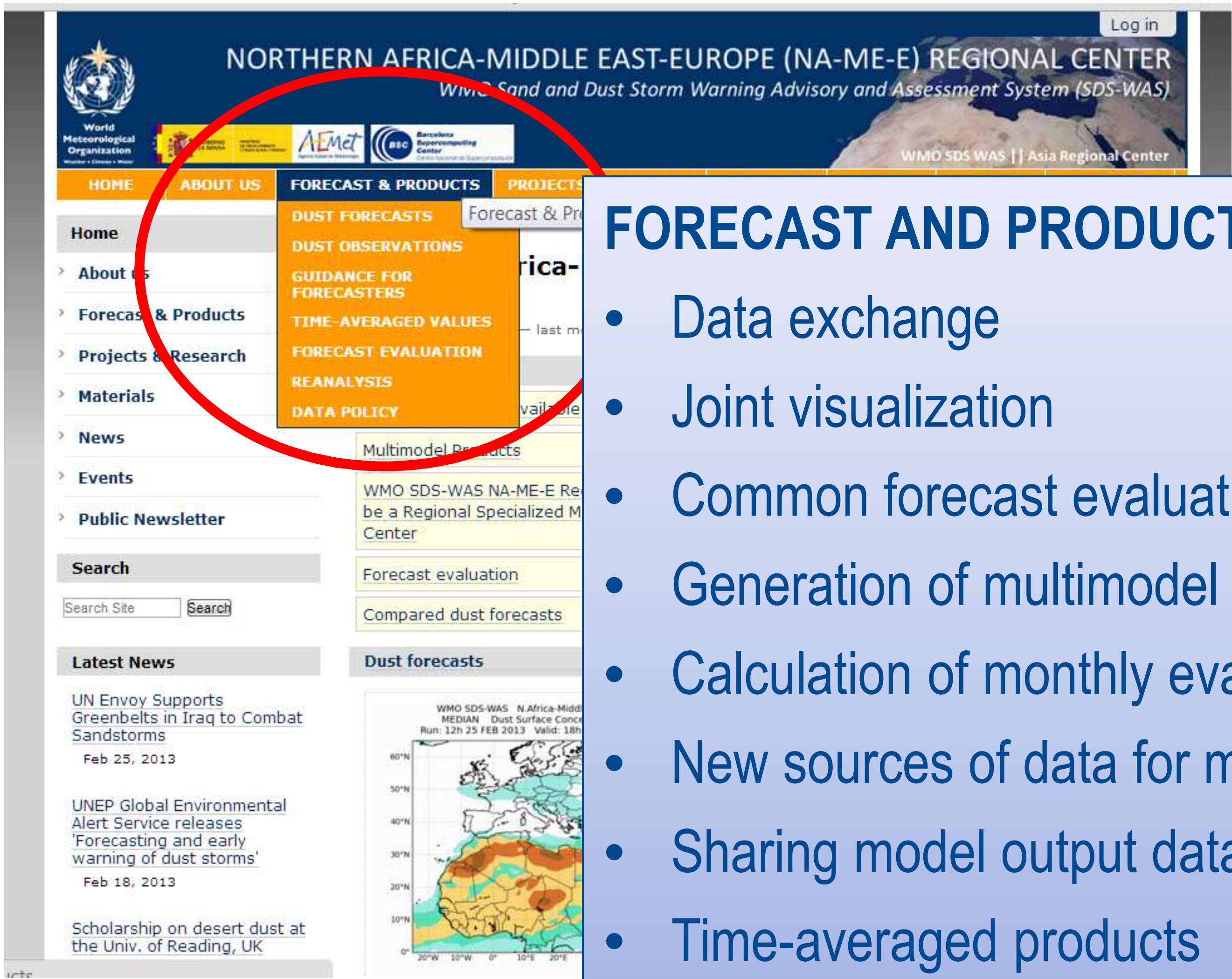
BSC-CNS
AEMET, Spain

China Meteorological Administration (CMA)

WMO REGIONAL CENTRES

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

SDS-WAS: NA-ME-E RC (http://sds-was.aemet.es)



FORECAST AND PRODUCTS

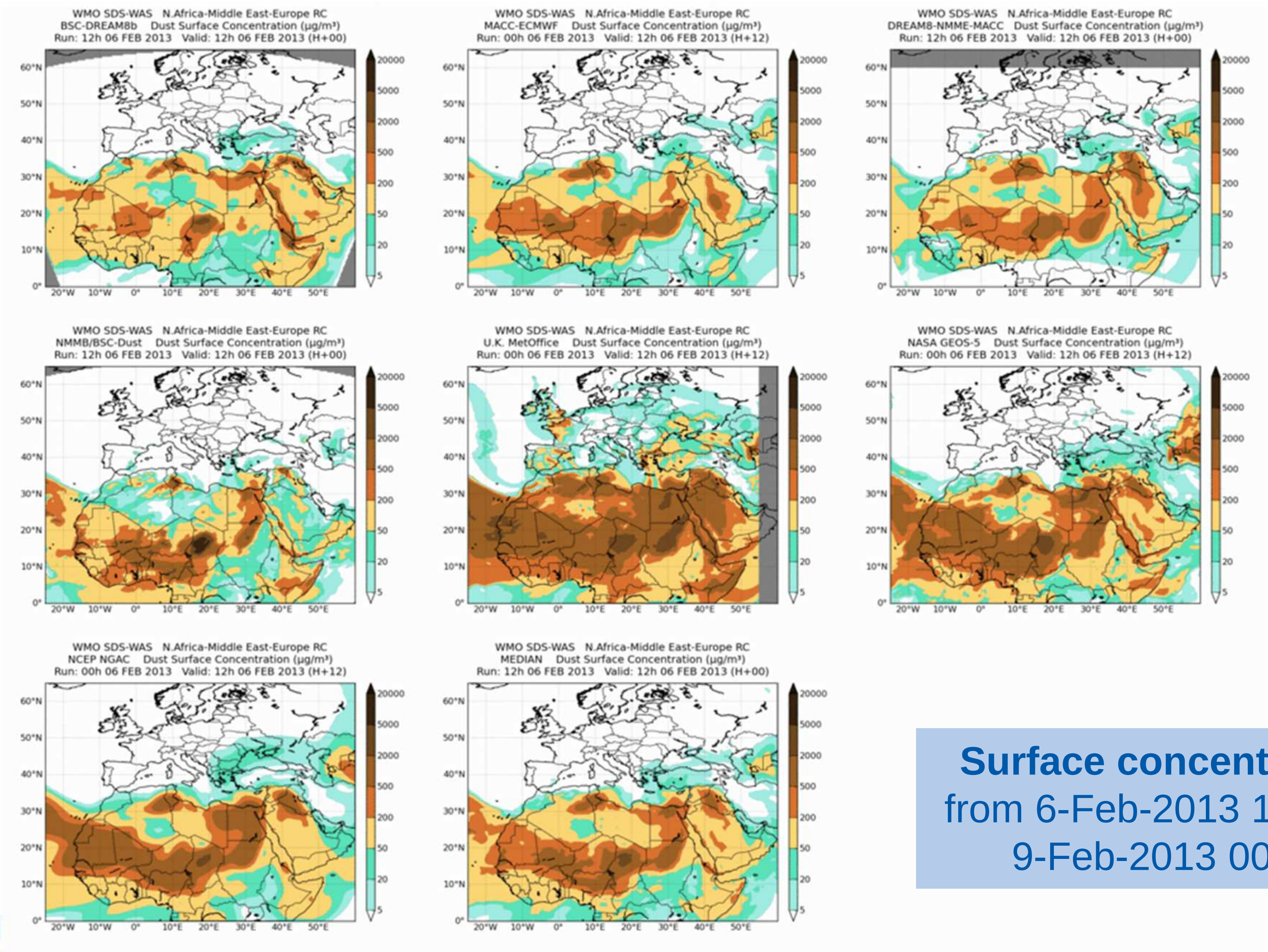
- Data exchange
- Joint visualization
- Common forecast evaluation
- Generation of multimodel products
- Calculation of monthly evaluation metrics
- New sources of data for model evaluation
- Sharing model output data files
- Time-averaged products

sdswas@aemet.es

SDS-WAS: Dust models

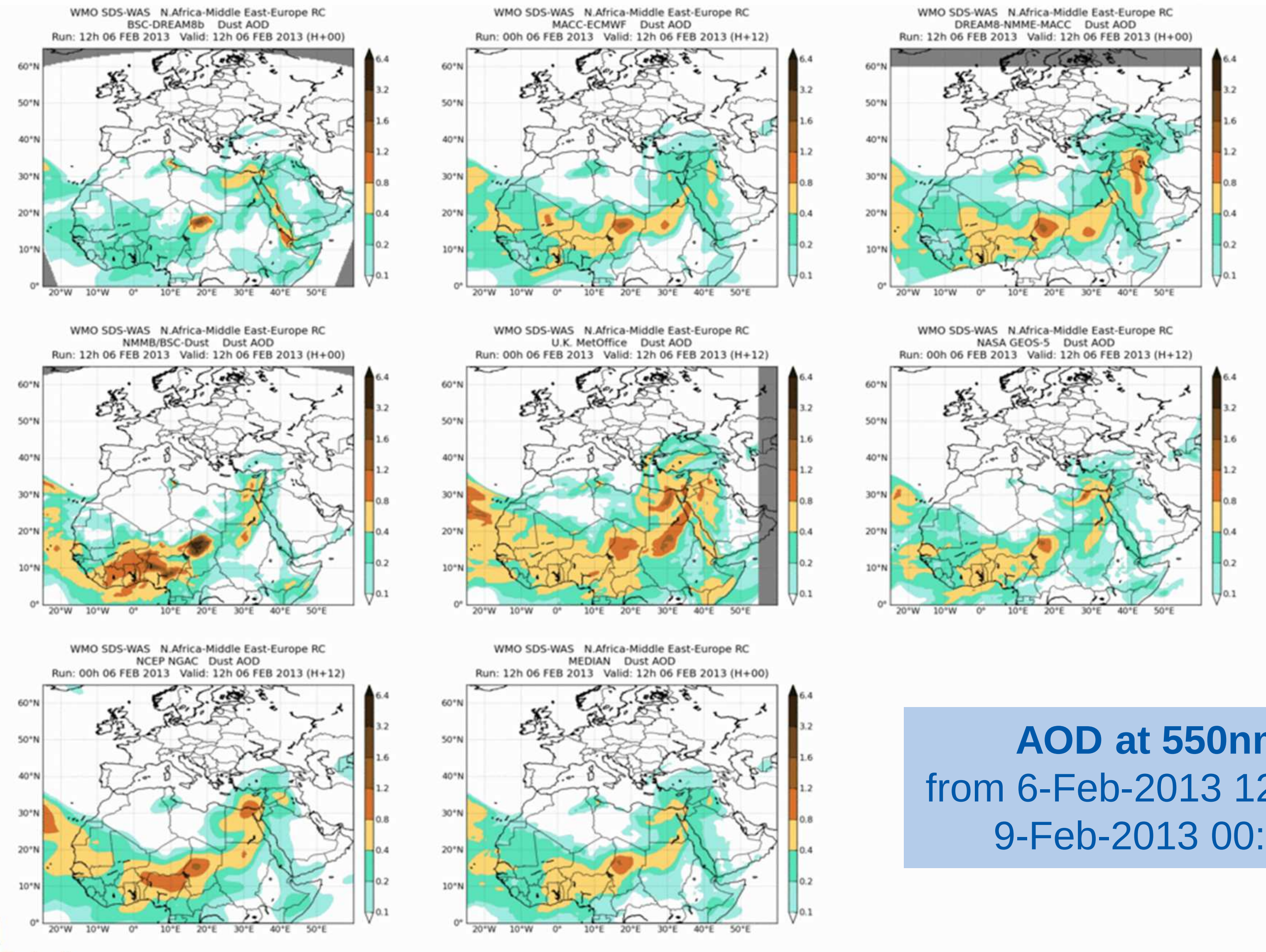
MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
MACC	00	Global	MODIS AOD
DREAM-NMME-MACC	12	Regional	MACC analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No

SDS-WAS: Surface concentration joint visualization



Surface concentration
from 6-Feb-2013 12:00 to
9-Feb-2013 00:00

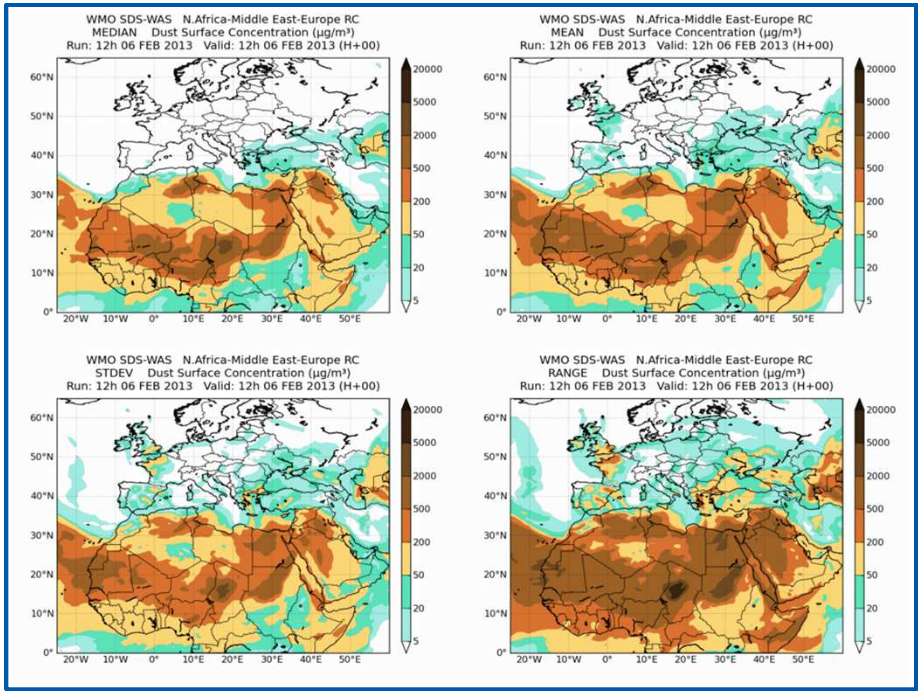
SDS-WAS: AOD joint visualization



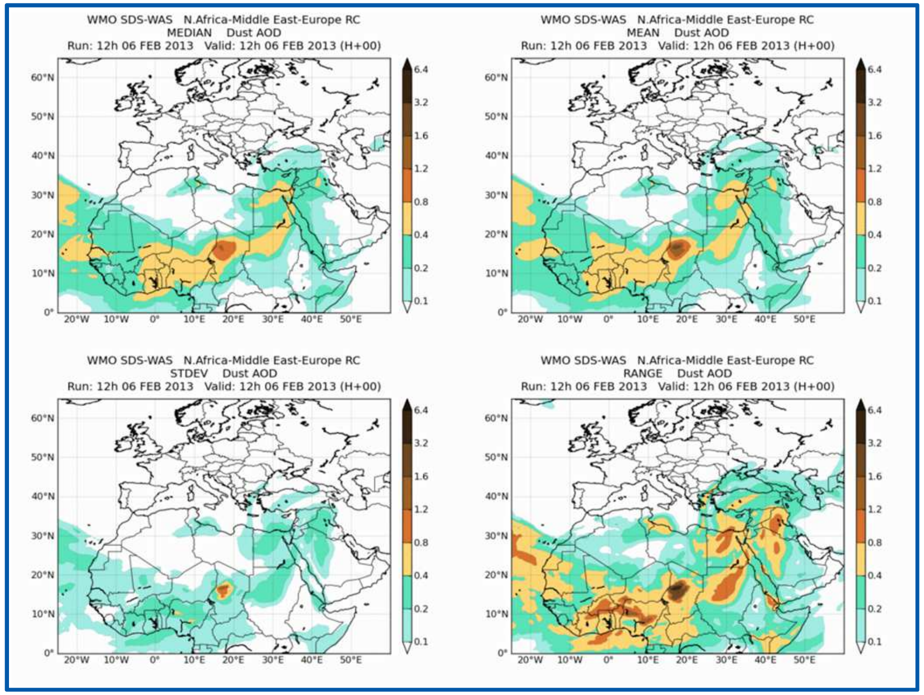
AOD at 550nm
from 6-Feb-2013 12:00 to
9-Feb-2013 00:00

SDS-WAS: Generation of multi-model products

Surface concentration



AOD at 550nm



from 6-Feb-2013 12:00 to 9-Feb-2013 00:00

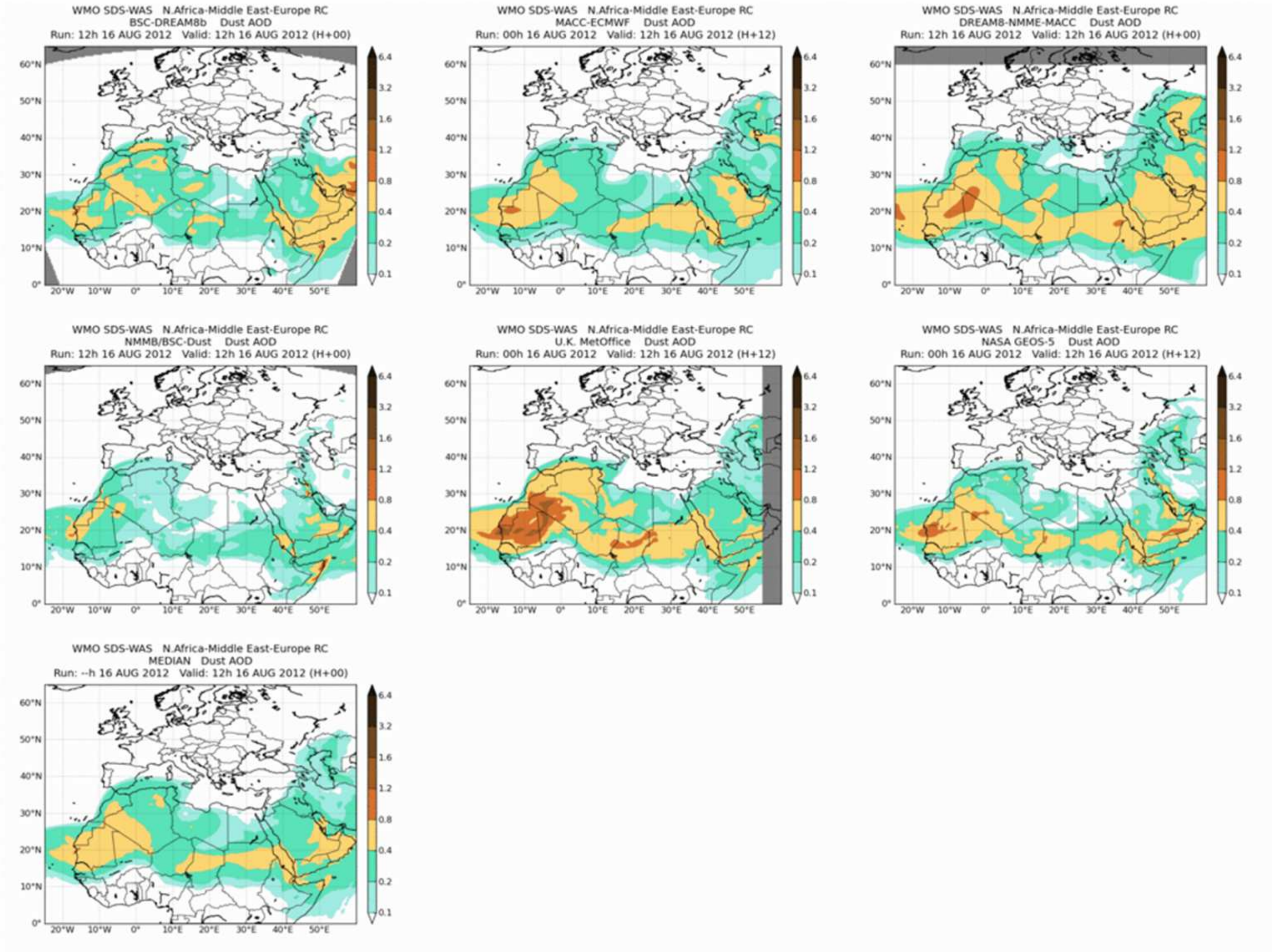
Model outputs are bi-linearly interpolated to a common 0.5ºx0.5º grid mesh. Then, different multi-model products are generated:

CENTRALITY: median - mean

SPREAD: standard deviation – range of variation

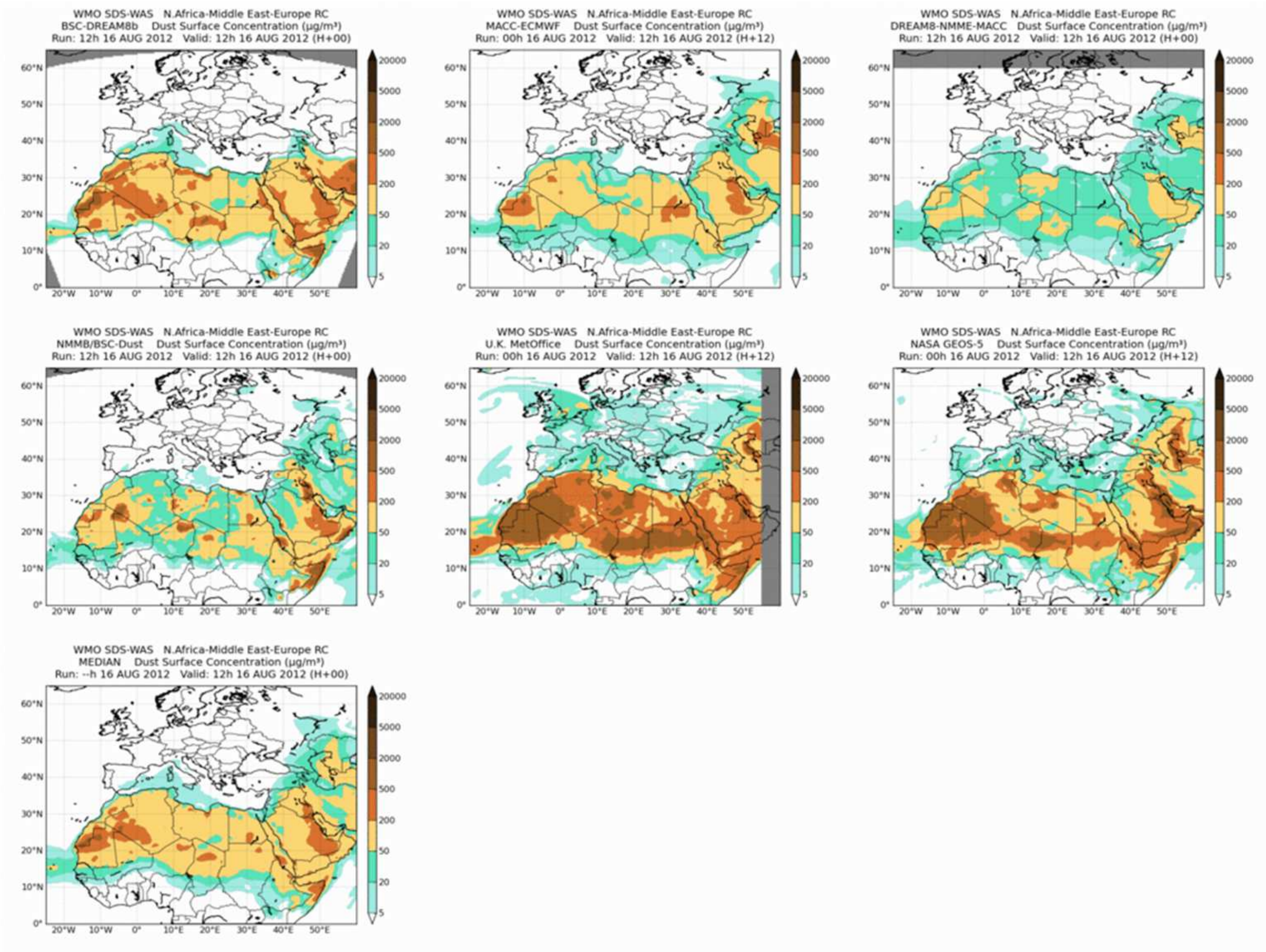
Dust forecasting models: WMO SDS-WAS NA-ME-E RC

Compared AOD for 16 August 2012



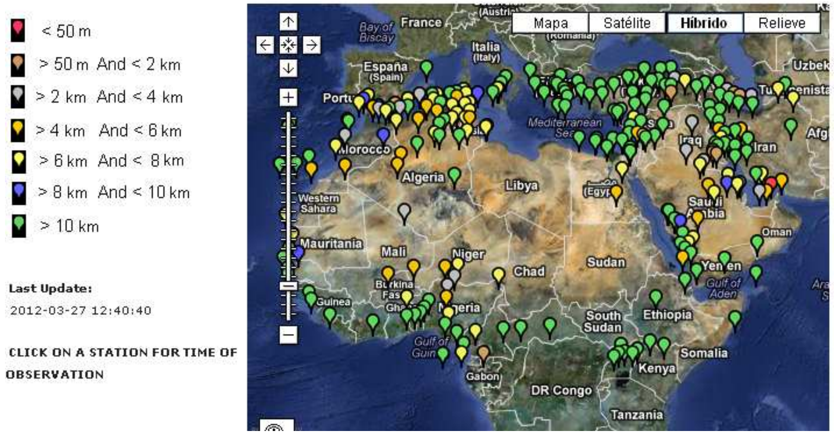
Dust forecasting models: WMO SDS-WAS NA-ME-E RC

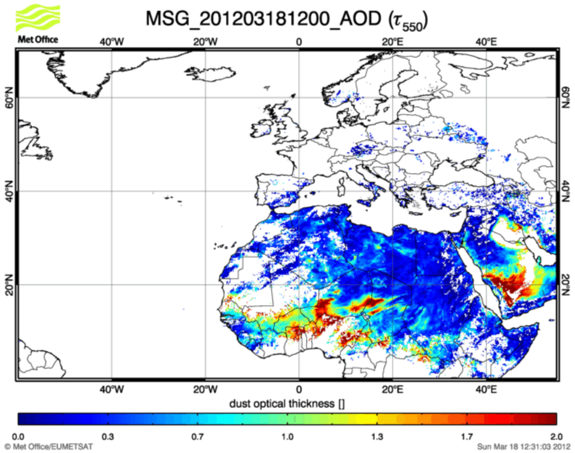
Compared SCONC for 16 August 2012

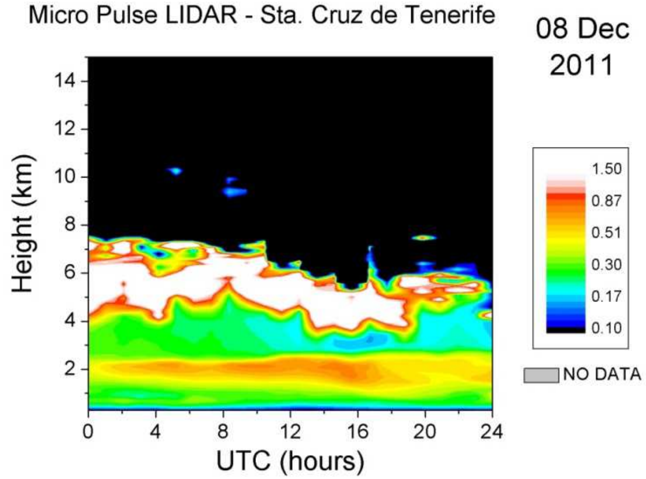


New sources of data for model evaluation

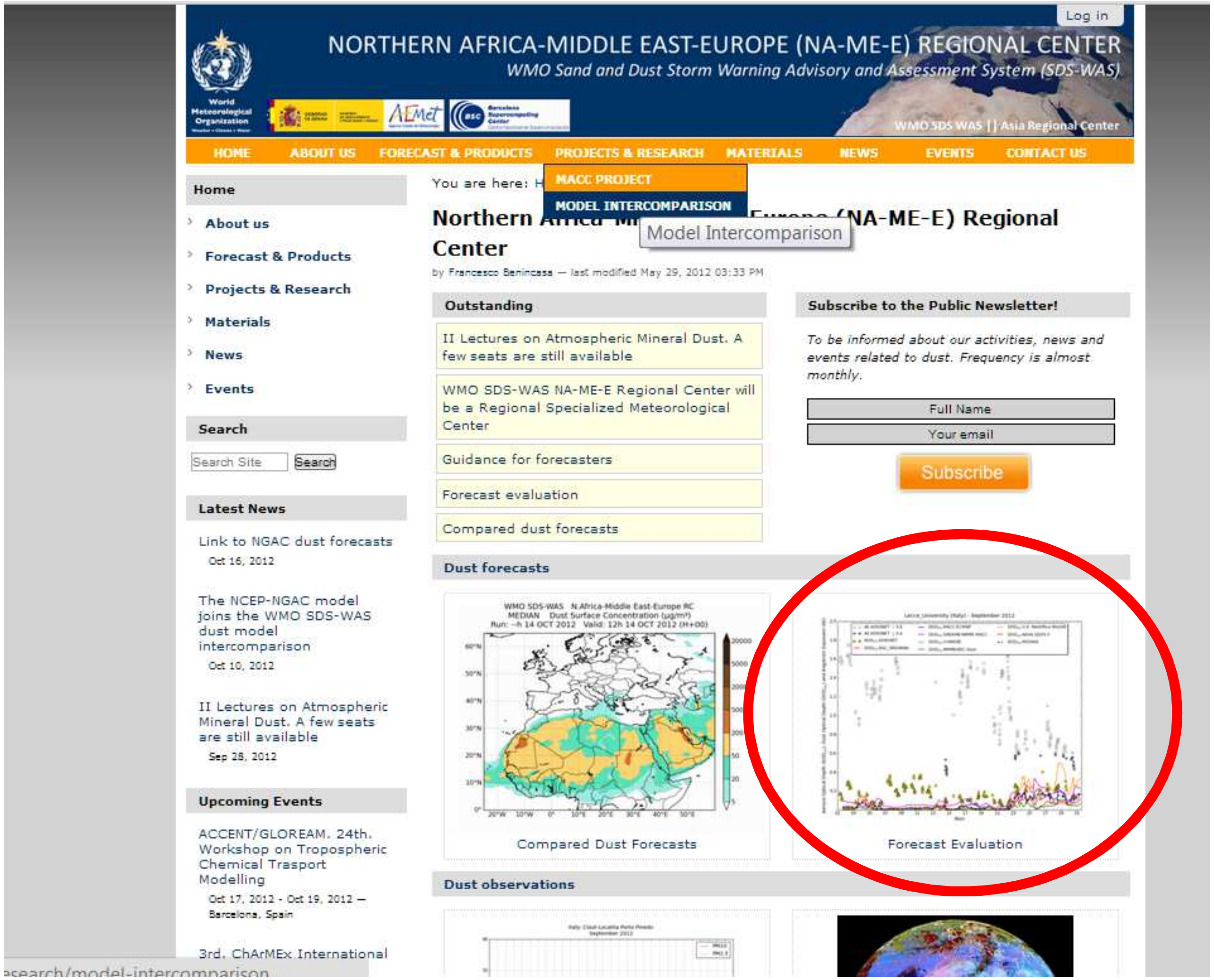
- Visibility
- MSG
- MODIS
- OMI
- CALIPSO
- PARASOL
- MPLNET
- PM_{10}







SDS-WAS: Model intercomparison



http://sds-was.aemet.es

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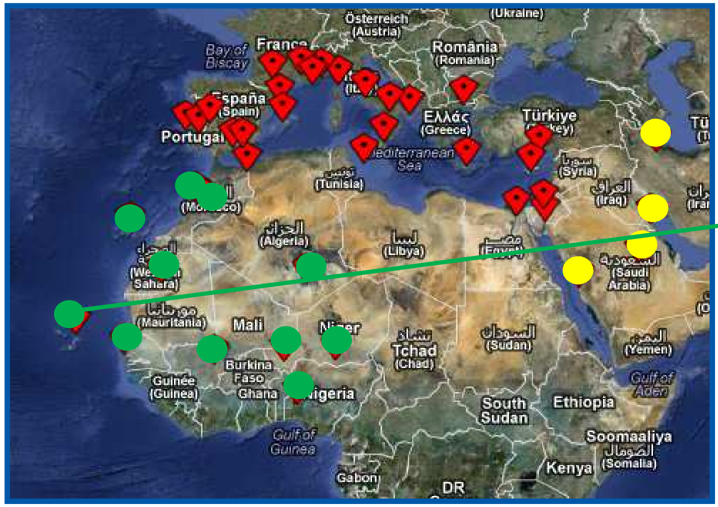
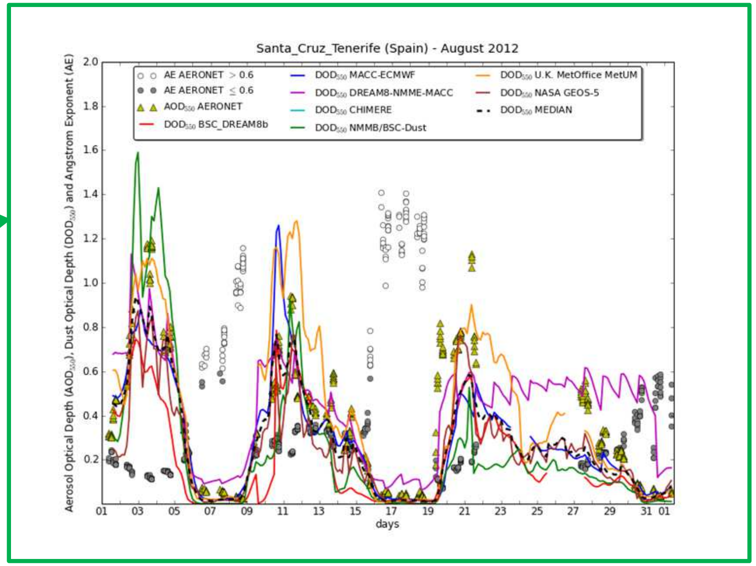
SDS-WAS: NRT Evaluation using AERONET





Model evaluation metrics (bias, correlation, RMSE and FGE) are calculated:

- By regions: NA-ME-E, Sahel/Sahara, Middle East and Mediterranean
- By time periods: monthly, seasonal and annual

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Centro Nacional de Supercomputación

SDS-WAS: NRT Evaluation using AERONET

Calculation of monthly evaluation metrics

Mar 2012. Dust Optical Depth.
Threshold Angstrom Exponent = 0.600

BIAS show stations

	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	CHIMERE	NMMB/BSC-Dust	MEDIAN
TOTAL	-0.36	-0.39	-0.20	-0.41	-0.15	-0.35

ROOT MEAN SQUARE ERROR show stations

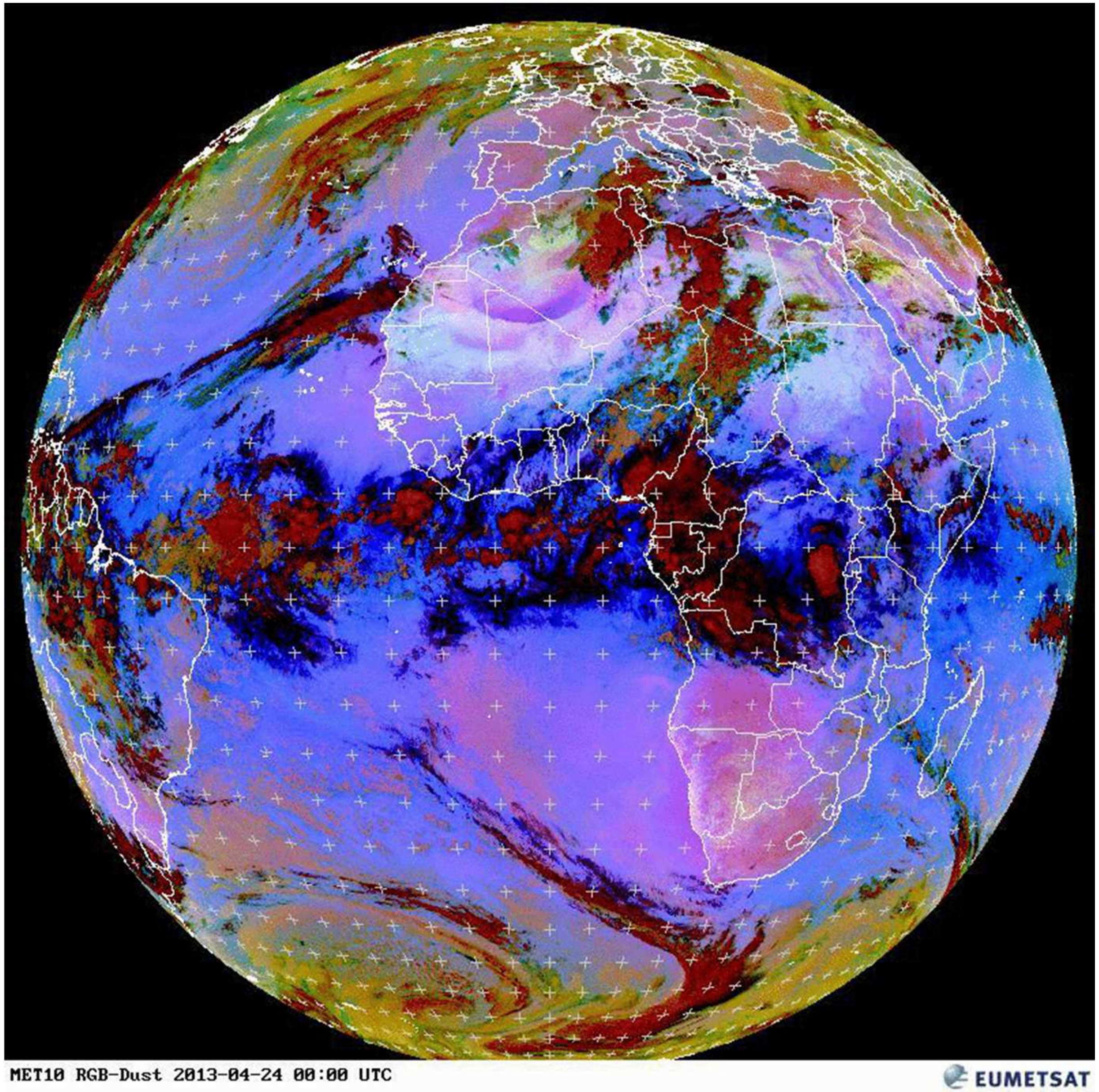
	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	CHIMERE	NMMB/BSC-Dust	MEDIAN
TOTAL	0.62	0.57	0.45	0.59	0.50	0.53

NUMBER OF CASES show stations

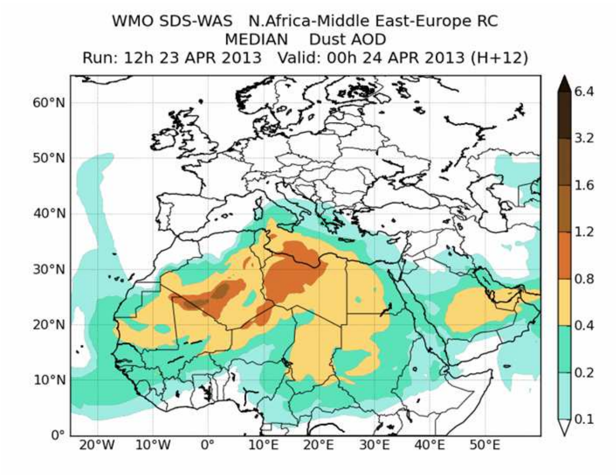
	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	CHIMERE	NMMB/BSC-Dust	MEDIAN
TOTAL	1033	846	977	1007	1007	1007

- Besides dust, there might be other aerosol types (anthropogenic, biomass burning, etc.). Then, a small BE could be expected.
- Scores for individual sites can be little significant for being calculated from a small number of data.
- The RMSE is strongly dominated by the largest values. Especially in cases where prominent outliers occur, the usefulness of the RMSE is questionable and the interpretation becomes more difficult.

SDS-WAS: NRT Evaluation using satellite aerosol products

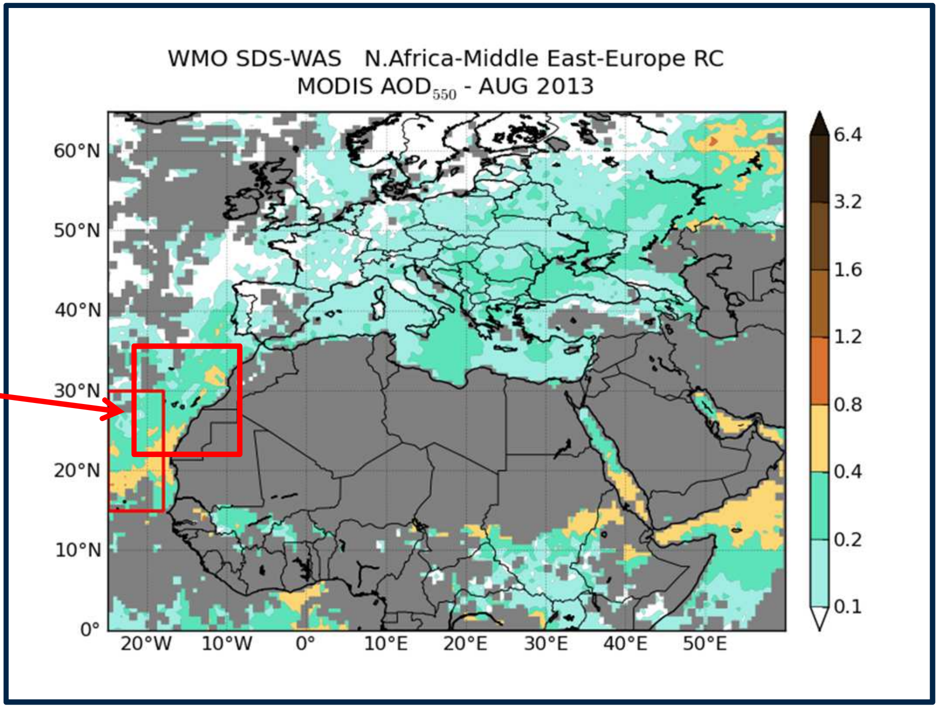


24 April 2013



SDS-WAS: NRT Evaluation using MODIS

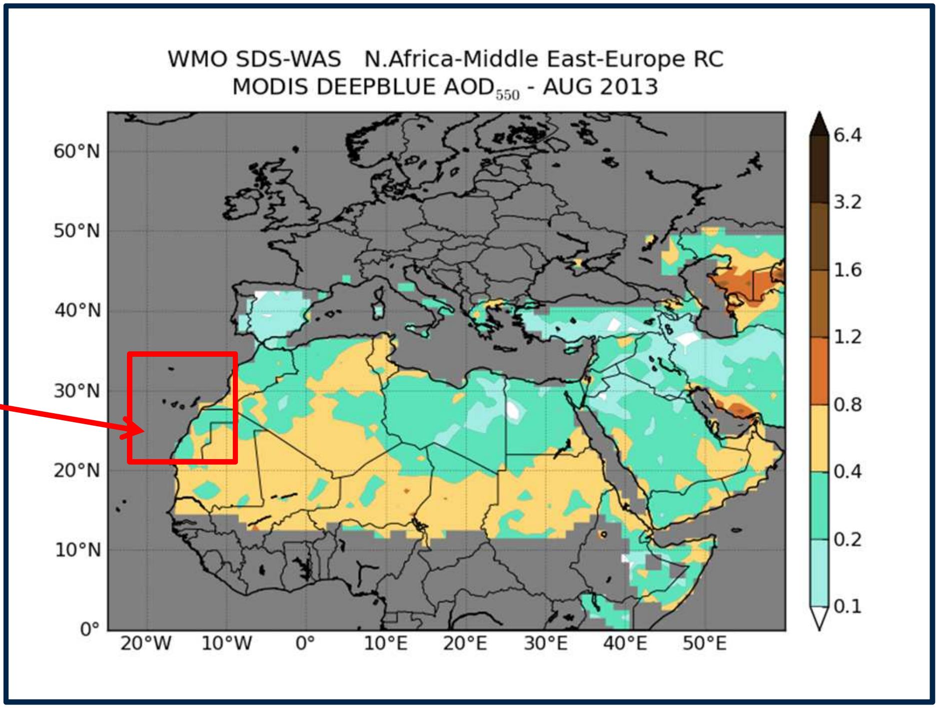
19th August 2013



	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.16	0.21	0.70	0.87	1220
NMMB/BSC-Dust	-0.13	0.20	0.68	0.81	1038
NCEP NGAC	0.14	0.21	0.78	0.41	1228

SDS-WAS: NRT Evaluation using MODIS Deep Blue

19th August 2013



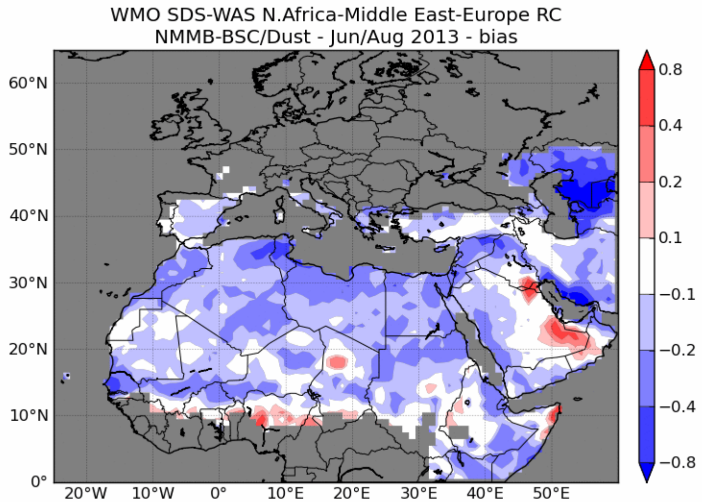
	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	**-0.17**	**0.31**	**0.28**	**0.96**	**42618**
NMMB/BSC-Dust	**-0.20**	**0.33**	**0.29**	**1.05**	**41049**
NCEP NGAC	**-0.06**	**0.29**	**0.32**	**0.64**	**42664**

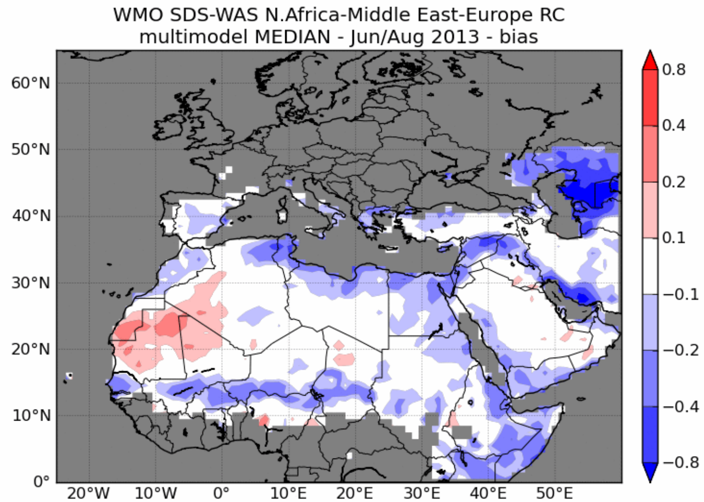
SDS-WAS: NRT Evaluation using MODIS Deep Blue

NMMB-BSC/Dust

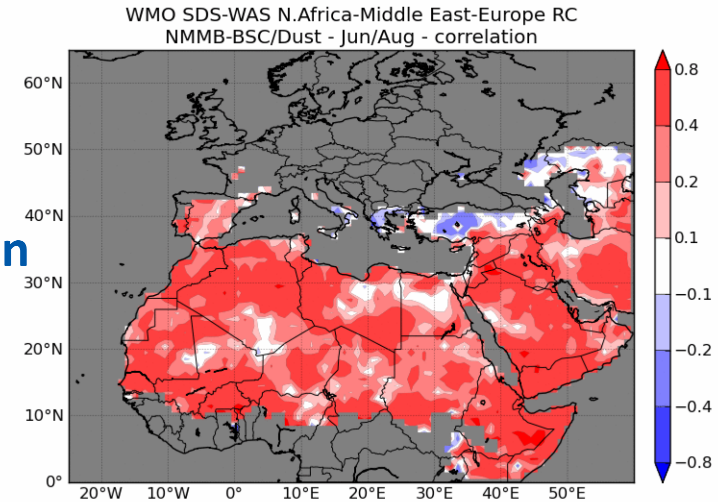
Multimodel MEDIAN

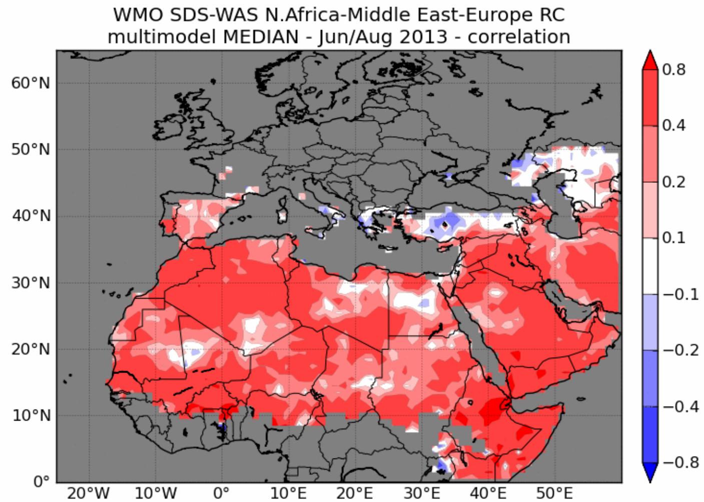
MB





Correlation





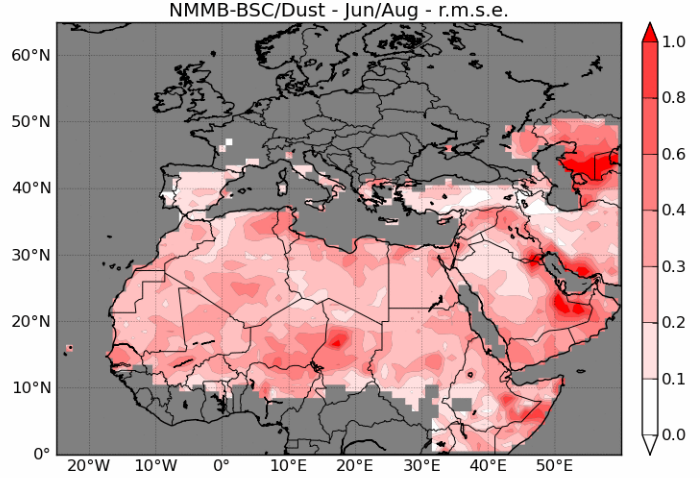
SDS-WAS: NRT Evaluation using MODIS Deep Blue

NMMB-BSC/Dust

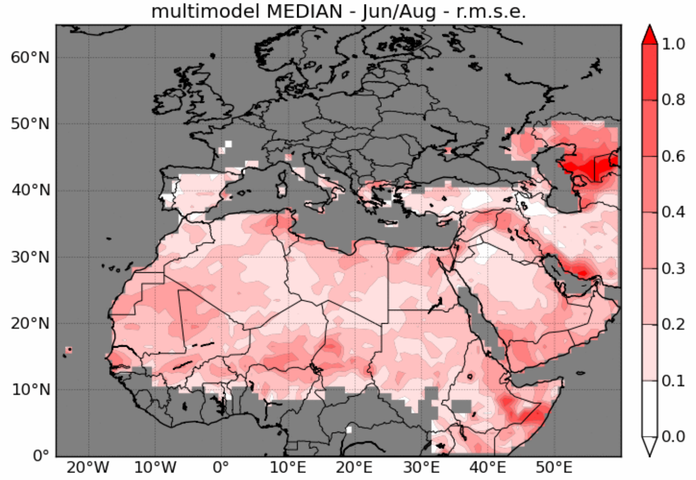
Multimodel MEDIAN

RMSE

WMO SDS-WAS N.Africa-Middle East-Europe RC
NMMB-BSC/Dust - Jun/Aug - r.m.s.e.

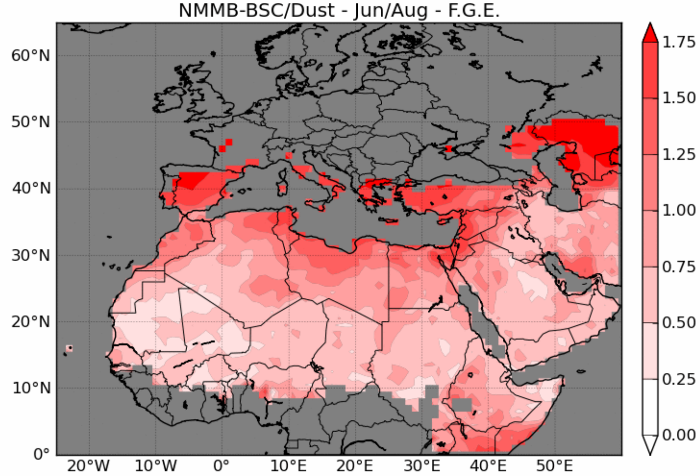


WMO SDS-WAS N.Africa-Middle East-Europe RC
multimodel MEDIAN - Jun/Aug - r.m.s.e.

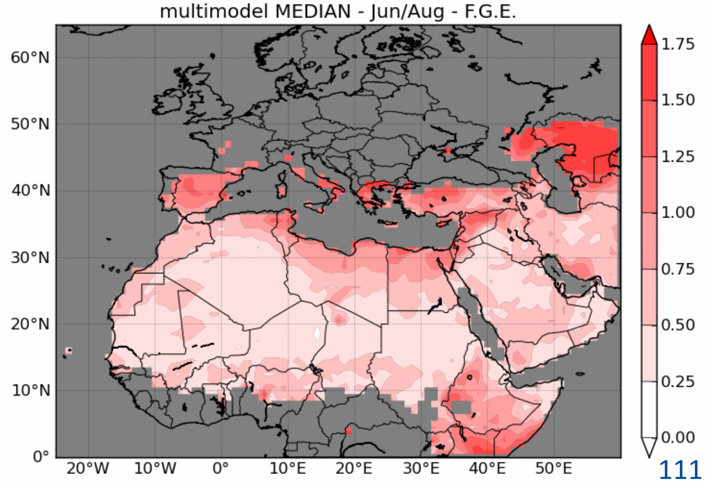


FGE

WMO SDS-WAS N.Africa-Middle East-Europe RC
NMMB-BSC/Dust - Jun/Aug - F.G.E.



WMO SDS-WAS N.Africa-Middle East-Europe RC
multimodel MEDIAN - Jun/Aug - F.G.E.



SDS-WAS: Files download

BSC-DREAM8b v2.0	DOWNLOAD FILES	Model website	Barcelona Supercomputing Center Centro Nacional de Supercomputación
MACC-ECMWF	DOWNLOAD FILES	Model website	macc
DREAM-NMME-MACC	DOWNLOAD FILES	Model website	SEEVCCC
NMMB/BSC-Dust	DOWNLOAD FILES	Model website	Barcelona Supercomputing Center Centro Nacional de Supercomputación
NASA-GEOS-5	DOWNLOAD FILES	Model website	NASA
NCEP-NGAC	DOWNLOAD FILES	Model website	NCEP
Multimo			AEMet

Title	Size	Modified
latest - (download all)	4.0 kB	Apr 18, 2013 09:00 PM
2013 - (download all)	4.0 kB	Apr 01, 2013 09:00 PM
2012 - (download all)	4.0 kB	Apr 08, 2013 04:30 PM

netCDF UCAR unidata

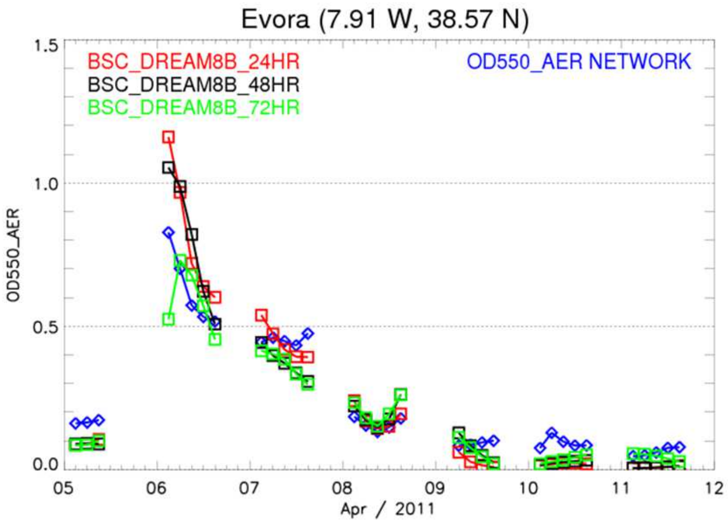
- Daily forecasts of dust surface concentration and dust optical depth will be displayed on a page together with a menu to allow visualization of the archived products and/or download of the numerical files for a selected range of dates.
- Access to the download pages shall be restricted to those groups that authorize the exchange of their own data.

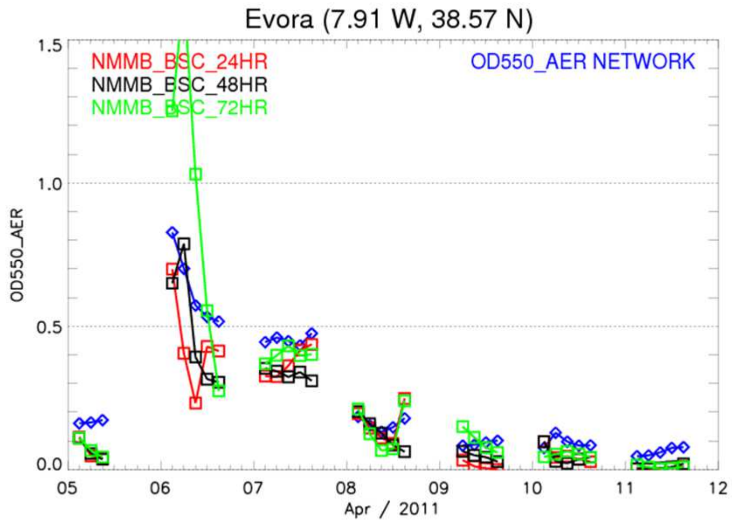
SDS-WAS: Model intercomparison April 2011

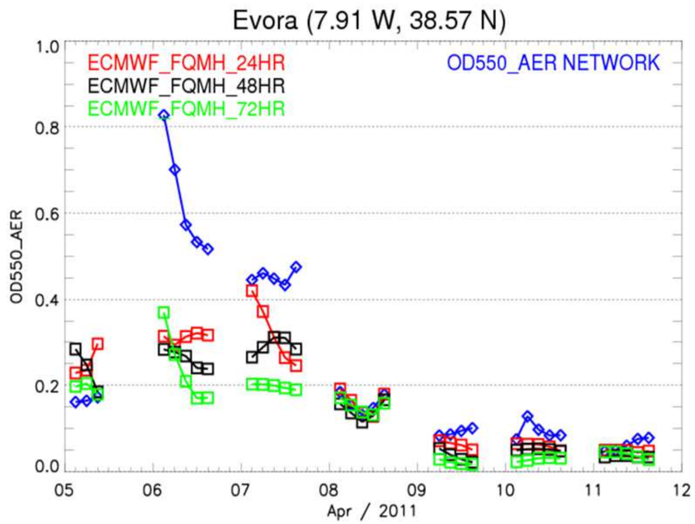
MODIS True color 7 April 18:00

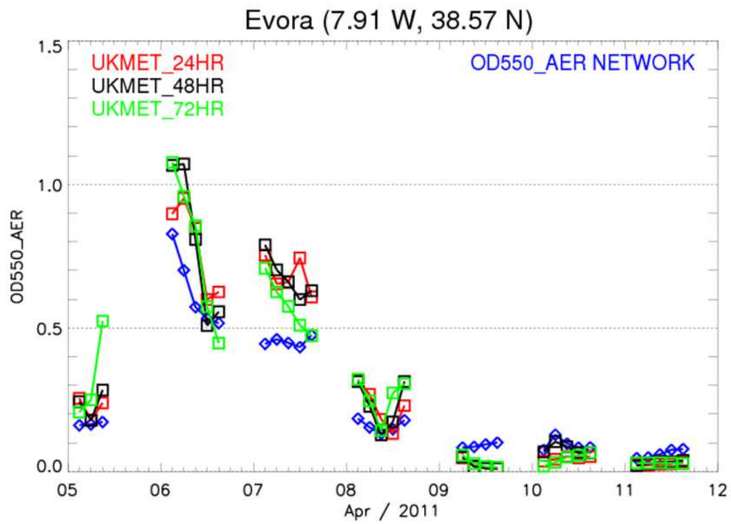
- The selected dust event corresponds to the one which occurred between the 5th and 11th of April of 2011.
- Participating models: BSC-DREAM8b, NMMB/BSC-Dust, ECMWF-MACC and UKMetOffice-UM
- Comparison of each forecast (at 24, 48 and 72h) output to in-situ measurements of AOD (from AERONET), surface concentration (PM) and satellite retrieved AOD (MODIS, CALIPSO).

SDS-WAS: AERONET Model intercomparison April 2011









SDS-WAS: Lidar and models intercomparison

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

BSC-DREAM8b v2
NMMB-BSC/Dust

SEEVCCC

DREAM8-NMME-MACC

Consiglio Nazionale delle Ricerche

BOLCHEM

60 – 80 dust cases for the period Jan 2011 – Jun 2013

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Barcelona Dust Forecast Center

NMMB/BSC-CTM selected to provide operational mineral dust forecast for the First Specialized Center for Mineral Dust Prediction of WMO

CALIOPE Air Quality Forecasting System (www.bsc.es/caliope)

Spain: 4 km (399x399 grid cells), Europe: 12 km (480x400 grid cells)

Modules

Meteorology: WRF-ARW

- Version 3.5
- IBC: GFS (NCEP)
- SST: SST MODEL (NCEP)
- 38 sigma levels
- Top of the atmosphere 50 hPa

Emissions: HERMES v2

Chemistry: CMAQ-CTM

- Version 5.0
- Carbon Bond V
- Cloud chem. (aqu.)
- Aerosol module (AERO5)
- BC: NCAR MOZART4 model
- 15 sigma levels

Mineral dust: BSC-DREAM8b v2

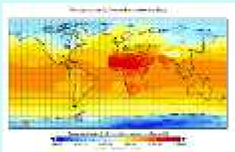
Post-processes by Kalman filter

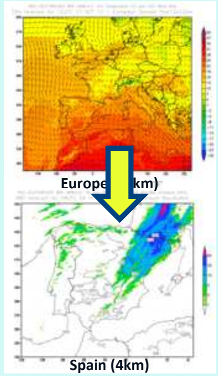
Evaluation:

- NRT-ground level observations
- Satellite
- Ozone sounds

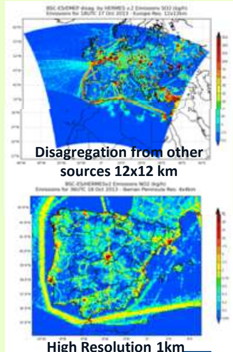
METEOROLOGICAL FORECAST WRF-ARW

GLOBAL SIMULATIONS
Initial and boundary conditions



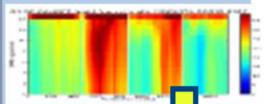


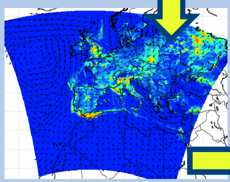
EMISSION MODELLING
HERMES v2 developped at BSC-CNS



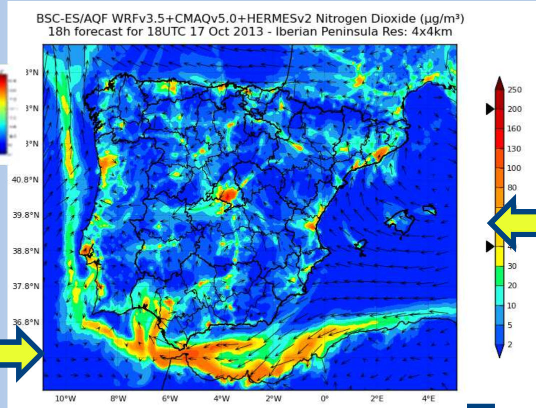
AIR QUALITY FORECAST CMAQ

NCAR MOZART4
Boundary Conditions



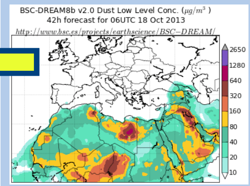


EUROPEAN AIR QUALITY FORECAST (12km)



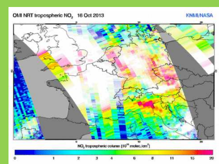
AIR QUALITY FORECAST FOR SPAIN
High resolution (4km)

SAHARAN DUST OUTBREAKS
Dust Regional Atmosferic Model (BSC-DREAM8b v2)



AQFS EVALUATION

METEOROLOGICAL OBSERVATIONS
Dynamics and model evaluation

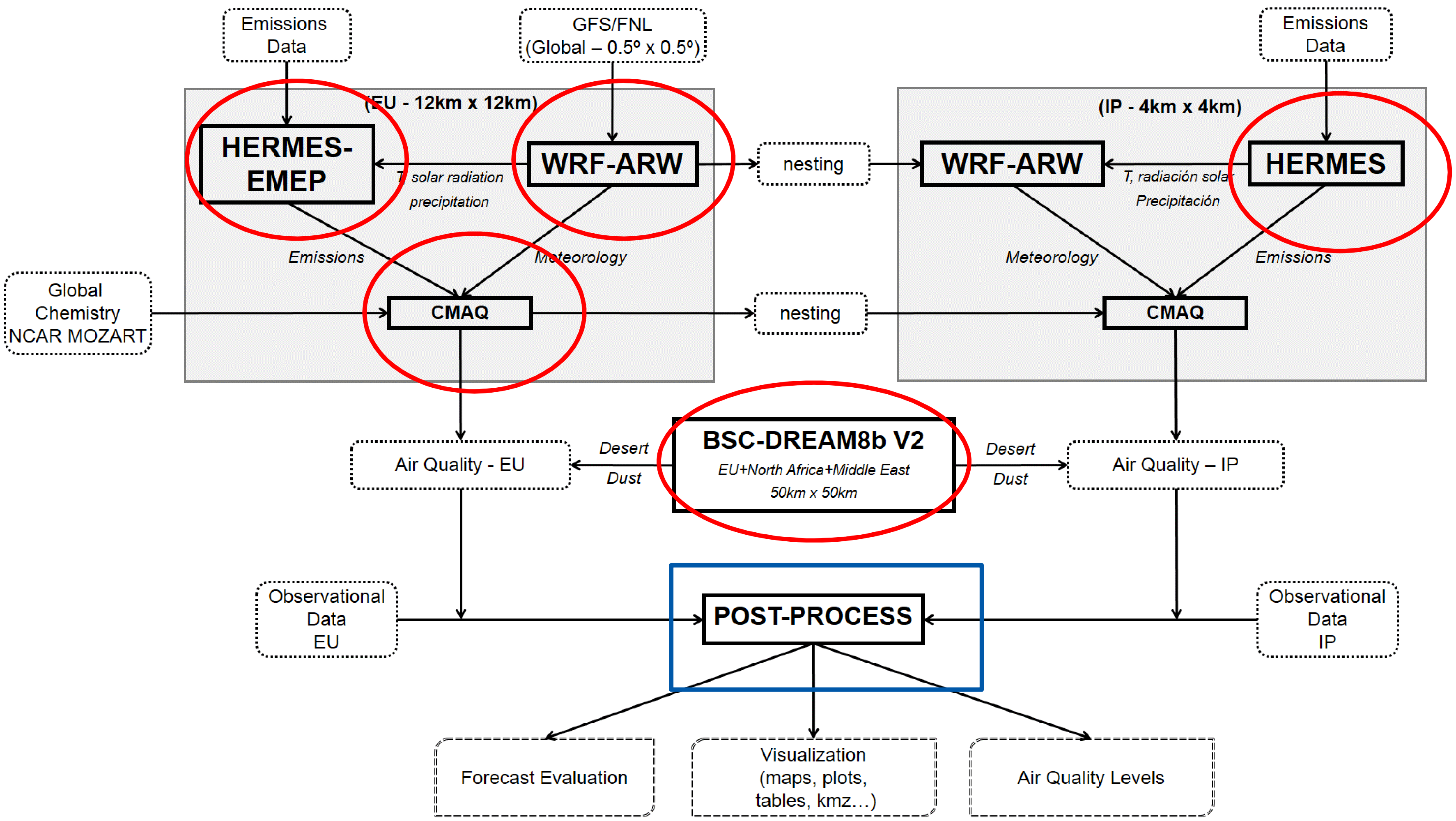


SATELLITE OBSERVATIONS
Surveillance and model verification

GAS AND PARTICLE MATTER OBSERVATIONS
Dynamics and model evaluation

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Models and post-processing



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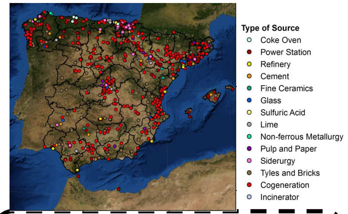
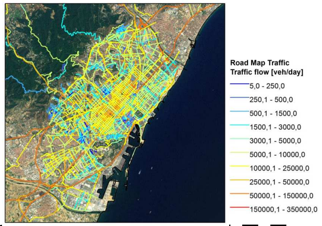
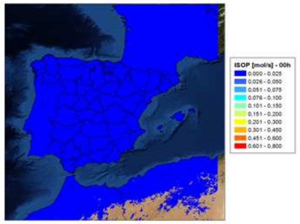
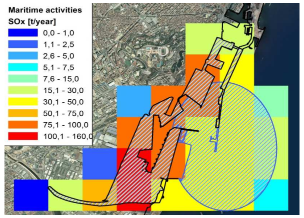
Centro Nacional de Supercomputación

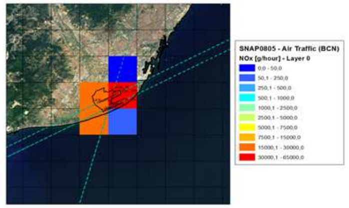
HERMES v2.0 (Guevara et al., 2013)









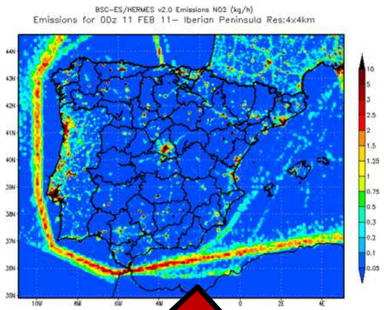


Inventario focos puntuales

COPERT IV tráfico rodado

MEGAN biogénicas

Emisiones puertos/aeropuertos

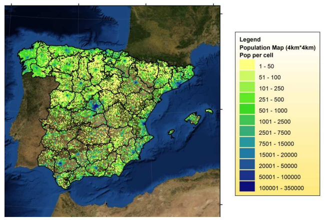


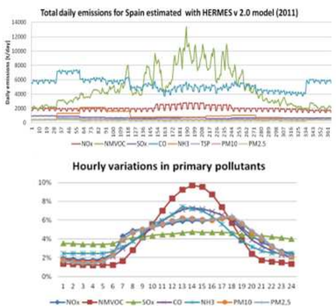
Patrones espaciales emisiones agrícolas y residenciales

Perfiles temporales

Especiación emisiones

Entrada emisiones para AQMS





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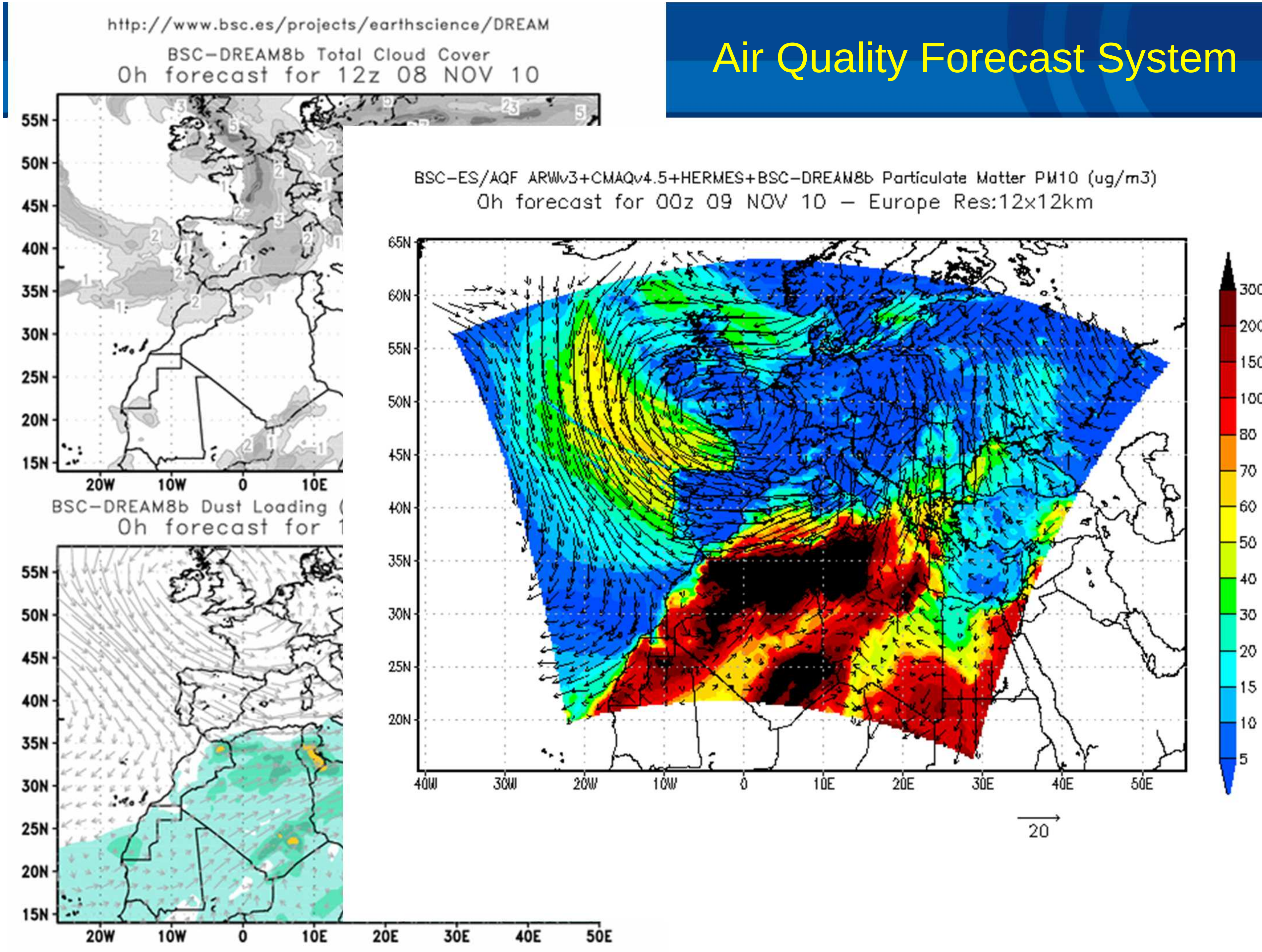
Air Quality Forecast System



Next Dust events

Session Modelling and field Studies -

Atmospheric dust modelling and forecast

Convened by J.M. Baldasano and E.Terradellas

Barcelona Supercomputing Center
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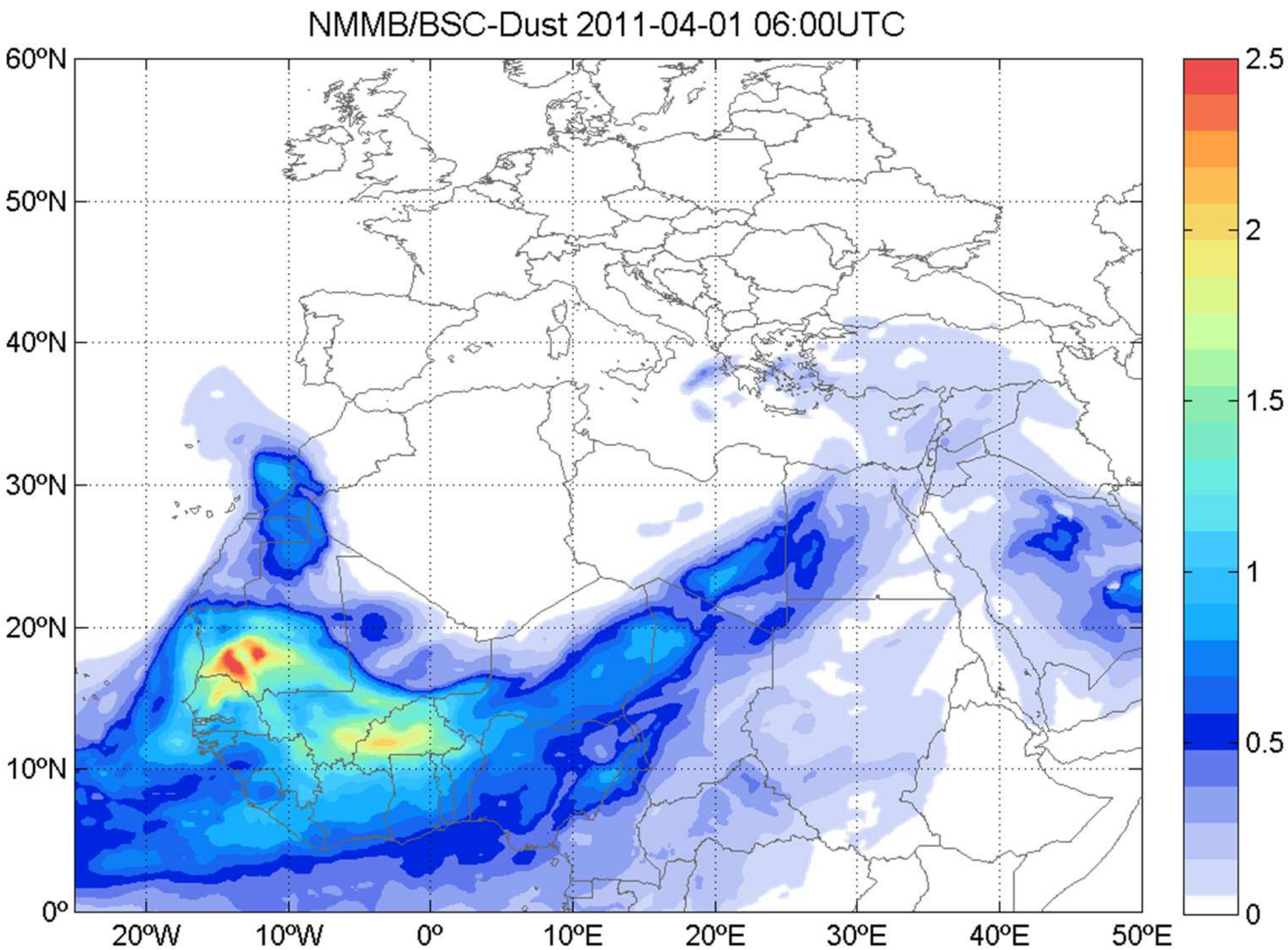
NMMB/BSC-Dust (Pérez et al. 2011)

Regional run: AOD at 550nm April 2011



Earth Sciences

Towards Modelling the Mother Earth System

Earth Sciences

OVERVIEW:

The Earth Sciences Department was established with the objective of carrying out research in Earth system modelling, initially focusing on atmospheric physics and chemistry. The group directed by Dr. José María Baldasano, coming from the Environmental Modelling Laboratory of the Technical University of Catalonia (LMA-UPC) has as main topics of research: air quality modelling, mineral dust modelling, atmospherical modelling and global and regional climate modelling.

EARTH SCIENCES DEPARTMENT DIRECTOR

Baldasano, José María

OBJECTIVES:

Changes in the composition of the atmosphere can affect the habitability of the planet by modifying the air quality and altering long-term climate. Research in this area is devoted to the development, implementation and refinement of global and regional state-of-the-art models for short-term air quality forecasting and long-term climate predictions.

Issues related to atmospheric dynamics, natural and anthropogenic emissions, improvement of air quality forecasts, the transport and dispersion of pollutants in complex terrain, urban air quality, aerosol optical properties, aerosol radiative effects and the feedback between meteorology and air pollution shapes the research agenda of the group. Together with the advances in the parallelization of air quality model codes, have allowed such high-resolution simulations.

The high performance capabilities of supercomputation allows to increase the spatial and temporal resolution of atmospheric modelling systems, in order to improve our knowledge on dynamic patterns of air pollutants in complex terrains and interactions and feedbacks of physico-chemical processes occurring in the atmosphere.

The Earth Sciences Department also maintains daily operational air quality (CALIOPE) and mineral dust forecasts for scientific purposes and to support national initiatives for air quality prevention.

RESEARCH LINES:

- AIR QUALITY
  José María Baldasano Recio

www.bsc.es

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Thank you!

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Satellite data used in this presentation were produced with the Giovanni online data system, developed and maintained by the NASA GES DISC.

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