

**AEMET-BSC-EUMETSAT-WMO**

WMO SDS-WAS Regional Center for Northern  
Africa, Middle East and Europe:  
<http://www.bsc.es/sds-was>

**Lectures on atmospheric  
mineral dust and its impact  
on human health,  
environment and economy**

**Barcelona, 13 November 2010**



# Numerical Prediction of Mineral Dust

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Earth Sciences Department, Barcelona Supercomputing Center (BSC-CNS), Barcelona, Spain  
Environmental Modeling Laboratory, Technical University of Catalonia (UPC), Barcelona, Spain

<http://www.wmo.int/sdswas>

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## World Weather Research Programme (WWRP)



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### WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)



#### SDS-WAS Implementation

- Draft Implementation Plan

Organizations currently delivering  
or developing SDS systematic  
forecasts

#### Northern Africa-Middle East-Europe (NA-ME-E) Node

- Members of the SDS-WAS  
Regional Steering Group (RSG)
- First Meeting of the Regional  
Steering Group  
(24-25 November 2008, Tunis,  
Carthage, Tunisia)

#### Asia Node

- Dust Forecasts for the Asian  
Region
- Members of the SDS-WAS  
Regional Steering Group (RSG)
- Workshop on the  
Implementation of the WMO  
SDS-WAS Asia Node  
(28- 30 October 2009, Seoul,  
Korea)



AREP

#### WWRP

WWRP Joint Scientific  
Committee

2009 Calendar

2010 Calendar

Publications

Newsletters



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### Products

#### ▼ Dust forecasts

- BSC-DREAM 8b
- ECMWF/MACC
- LMDZT-INCA
- CHIMERE
- METEO-FRANCE
- SKIRON
- TAU-DREAM
- NAAPS

#### ▼ Near real time observations

- AERONET
- MODIS
- OMI
- SEAWIFS
- CALIPSO
- MSG – EUMETSAT
- MSG – U.K. Met Office
- PARASOL
- METAR

- Forecast Verification
- Reanalysis
- Data access

### Forecasts & Products

Dust Forecasts are produced with atmospheric transport models.

Results of dust transport simulations are by no means observations and can only be used as advisory information.



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### WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)



## Dust Forecasts for the Asian Region

### Regional Dust Models

- [China Meteorological Authority](#)
- [Japan Meteorological Authority](#)
- [Barcelona Supercomputer Centre](#)

### Global Dust Models

- [ECMWF](#)
- [NRL Monterey](#)

Note: SDS-WAS Portal for the Asian SDS-WAS Node is under development and will be posted when ready

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- ▶ NRL/Monterey Aerosol Page
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- ▶ NASA Natural Hazards
- ▶ SAMUM
- ▶ BodEx2005
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- ▶ IJA-CSIC
- ▶ SDS WAS

### EURO-MEDITERRANEAN

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

BSC-DREAM8b Total Cloud Cover  
24h forecast for 12z 13 NOV 10

BSC-DREAM8b Dust Opt. Depth 550nm and 5000nm Wind  
24h forecast for 12z 13 NOV 10

### SAHARA-SAHEL

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

BSC-DREAM8b Total Cloud Cover  
24h forecast for 12z 13 NOV 10

BSC-DREAM8b Dust Opt. Depth 550nm and 5000nm Wind  
24h forecast for 12z 13 NOV 10

### SPAIN zoom

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

BSC-DREAM8b Total Cloud Cover  
42h forecast for 06z 14 NOV 10

### EAST-ASIA experimental

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

BSC-DREAM8b Total Cloud Cover  
12h forecast for 12z 13 NOV 10

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ECMWF/MACC

Monitoring atmospheric composition & climate

maccc Monitoring atmospheric composition & climate

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MACC Products > Global Atmospheric Composition > Near-real-time Analysis and Forecast > Forecast of Aerosols Optical Depth >

Species

- Total
- Natural
- Anthropogenic

Area

- Global
- Europe

Base time finder

Forecast base times with forecast valid for the displayed valid time: Fri 12 Nov 03UTC

Fri 12 Nov 00UTC

Open in new window

Show overview

Step (-> valid time)

Species

Area

Forecast base time

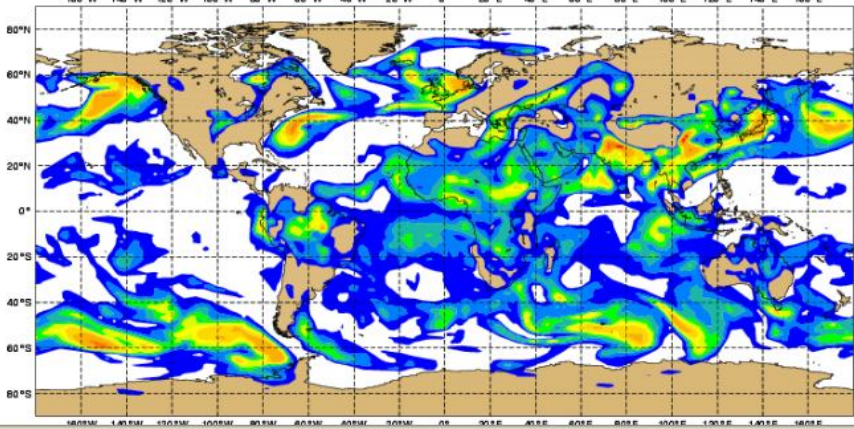
Forecast of Aerosols Optical Depth

Step (-> valid time) Forecast base time

03 (Fri 12 Nov 2010 03UTC) Fri 12 Nov 2010 00UTC

Friday 12 November 2010 00UTC MACC Forecast t+003 VT: Friday 12 November 2010 03UTC

Total Aerosol Optical Depth at 550 nm



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## LMDZT-INCA

EXPERIMENTAL CHEMICAL WEATHER FORECAST CATALOGUE

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PATH :: [home](#) / [Forecast Description Page](#) / [Interface with abbreviated menus and 2 images](#)

- limit choices -> FORECAST

Data Source ->  
INCA-ECMWF\_latest

Species ->  
DUST = DUST

Parameter ->  
EMI = emission rate

Region -- Forecast date -->  
WORLD 2010 DAY-J0

INCA-FORECAST 20100621 EMI\_DUST

Forecast run of 2010-JUN-21 11:35:26 GMT-0200

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CHIMERE | SDS-WAS

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**CHIMERE**

**COSY** [What is COSY?] [Qu'est-ce que COSY?]  
 [Meteorology] [maps] [time series] [vertical profiles]  
 [Pollutants concentrations] [maps] [surface time series]  
 [Dust concentrations] [maps] [size distr.] [AERONET]  
 [Database] [Meteo]

**Chimere DUST** [Model web site]

Date and parameter

2008  
 2009  
 2010

o HORIZONTAL MAPS  
 dust load [g/m2]  
 conc.surf. [ug/m3]  
 AOT  
 U10m (m/s)  
 conv.precip. (mm/h)  
 Emissions (g/cm2/day)  
 Dry dep. (g/m2/midday)  
 Wet dep. (g/m2/midday)

o SLICES  
 south - north  
 conc. (17W) [ug/m3]  
 conc. (0W) [ug/m3]  
 west - east  
 conc. (14N) [ug/m3]

January  
 February  
 March  
 April  
 May  
 June  
 July  
 August  
 September  
 October  
 November

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MM5/CHIMERE-DUST  
 WRF3/CHIMERE

Dust Eros.+Res.: at 12 UT, Fcst [D+0] 2010-11-13

60°  
40°  
20°  
0°  
260° 280° 300° 320° 340° 0° 20° 40° 60° 80°

100.00  
15.00  
10.00  
6.00  
3.00  
1.00  
0.50  
0.20  
0.05  
0.01  
0.00

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**Dust Forecast** University of Athens (AM&WFG) SKIRON Forecast

SKIRON Model Characteristics

Select Domain:  
Mediterranean-Europe  
North Atlantic

Select Field:  
Dust Concentration  
Dust Load  
Dust deposition(Dry)  
Dust deposition(Wet)  
MSL Pres. & Precip.  
T&GH at 850hPa

Select Period (in UTC):  
(Time in Greek: UTC +02:00)

13/11/2010 at 00:00  
13/11/2010 at 06:00  
13/11/2010 at 12:00  
13/11/2010 at 18:00  
14/11/2010 at 00:00  
14/11/2010 at 06:00  
14/11/2010 at 12:00  
14/11/2010 at 18:00  
15/11/2010 at 00:00  
15/11/2010 at 06:00  
15/11/2010 at 12:00  
15/11/2010 at 18:00  
16/11/2010 at 00:00

Weather Forecast  
High Resolution  
Regional  
Dust  
Meteo/Dust Grams  
Local Forecast  
Wave Forecast  
Air Quality Forecast  
Google Maps (Weather & Wave Forecast)  
Current Weather  
Satellite Images  
Surface  
Observations  
Airport Observations  
Radar  
Active Projects  
CIRCE  
MARINA  
WAUDIT  
POSEIDON  
DIAVLOS  
MOON  
SEAWATCH  
Finished Projects

Animate

Dust Concentration Near Ground ( $\mu\text{g}/\text{m}^3$ ) 13/11/10 at 12 UTC

1-10 10-25 25-50 50-100 100-500 500-1000 >1000

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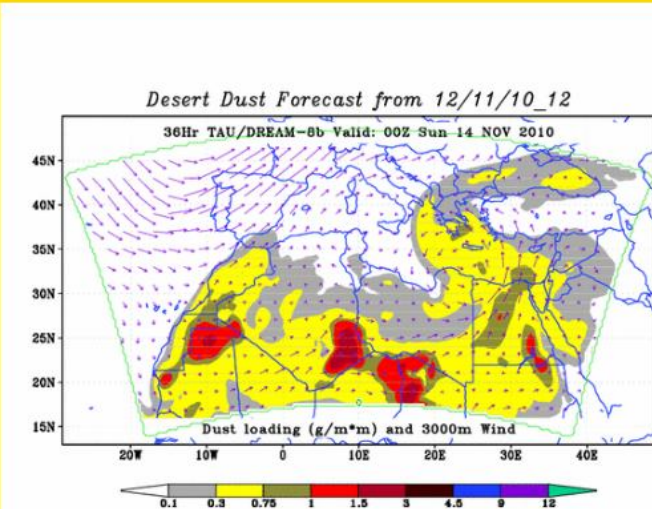
**TAU-DREAM**

**Tel-Aviv University Weather Research Center (TAU WeRC)**

**TAU DESERT DUST FORECAST**

*Desert Dust Forecast from 12/11/10\_12*

36Hr TAU/DREAM-8b Valid: 00Z Sun-14 NOV 2010



Dust loading (g/m²) and 3000m Wind

0.1 0.3 0.75 1 1.5 3 4.5 9 12

Maps of dust loading  
[Transatlantic Dust Transport](#)  
[Europe, the Middle East, and North Africa](#)  
[WEST-EAST \(35N\) cross-section \(animation\)](#)  
[Evolution of dust over Israel](#)  
[Surface dust concentration in Israel](#)  
[Evolution of dust over Rome \(Italy\)](#)  
[Past days](#)  
[About the dust model - 8 dust-size-bins DREAM-8b](#)

[SEA-SALT Aerosol Forecasts at TAU](#)

[ISA-MEIDA](#)

DUST Forecast Contact at TAU - Dr. Pavel Kishcha

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## NAAPS

The Naval Research Laboratory (NRL) in Monterey, CA, has developed a near-operational system for predicting the distribution of tropospheric aerosols, **NAAPS** (Navy Aerosol Analysis and Prediction System) Global Aerosol Model. The NRL version uses global meteorological fields from the Navy Operational Global Atmospheric Prediction System (NOGAPS) (Hogan and Rosmond, 1991; Hogan and Brody 1993) analyses and forecasts on a 1 X 1 degree grid, at 6-hour intervals and 24 vertical levels reaching 100 mb. The original model used northern hemispheric, 12-hourly ECMWF fields on a 2.5 X 2.5 degree grid.

NAAPS Total Optical Depth for 12:00Z 17 Nov 2010  
Sulfate: Orange/Red, Dust: Green/Yellow, Smoke: Blue

Sulfate Surface Concentration (ug/m\*\*3) for 12:00Z 17 Nov 2010

Dust Surface Concentration (ug/m\*\*3) for 12:00Z 17 Nov 2010

Smoke Surface Concentration (ug/m\*\*3) for 12:00Z 17 Nov 2010

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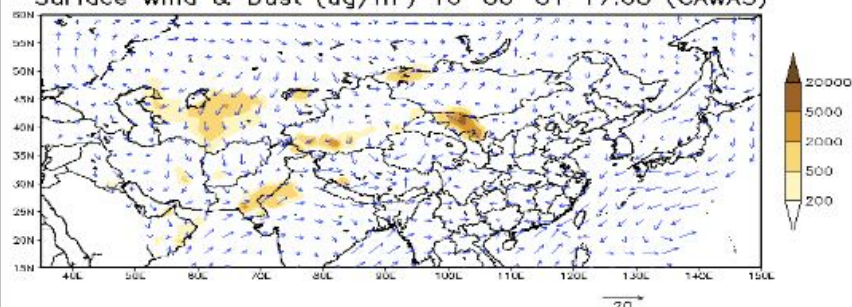
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Surface Wind & Dust (ug/m<sup>3</sup>) 10-06-01 17:00 (CAWAS)



[more](#)

### Forecast Highlights [More](#)

#### SDS forecast results2010-05-31-16

May 31, No obvious dust weather in China. June 1, Suspended dust in part area of south basin of Xinjiang and west of inner Mongolia. June 2, Suspended dust in part area of south basin of Xinjiang and west of inner Mongolia.

#### SDS Forecast OF [ Beijing ] (BST)[More](#)

MON/DAY	DAY	NIGHT
05/31	-	No SDS
06/01	No SDS	No SDS
06/02	No SDS	-

SDS COLORS

No SDS

Suspended dust

Blowing sand

Sand And Dust Storm

Severe SDS

Extreme Severe SDS

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camera signal error

13th November 2010 10:11:04 AM



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## Aeolian Dust Information (Prediction)

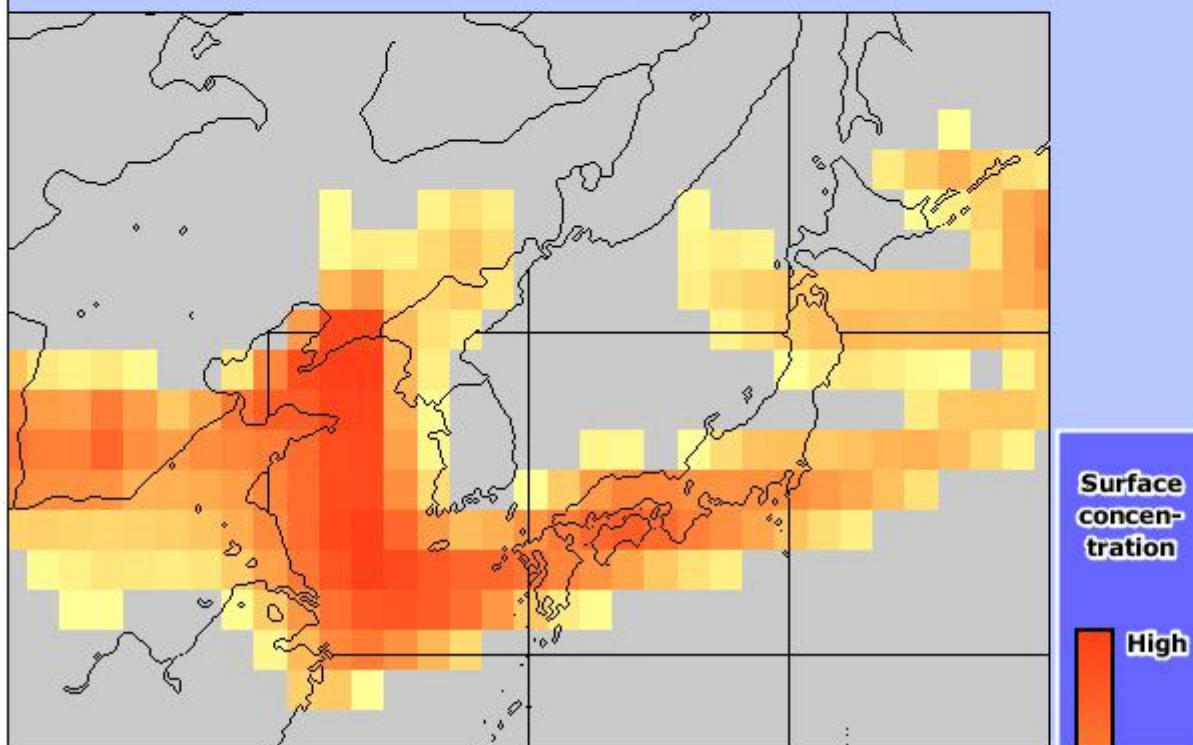
Select Surface / Total

[Aeolian Dust Information \(Observation\)](#)

Valid for

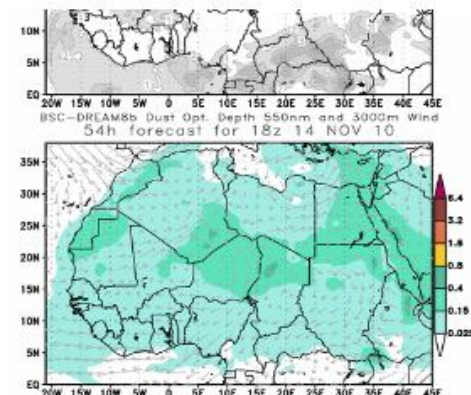
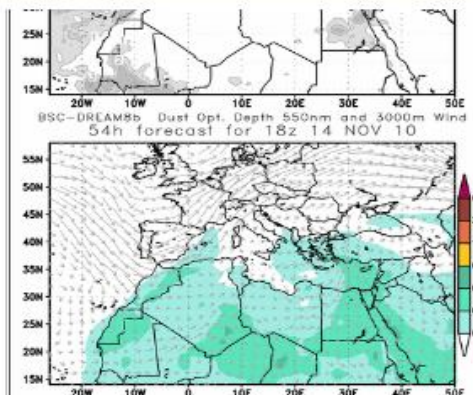
[Notes](#)

**Analyzed surface concentration for 09:00 JST, 13 November 2010**





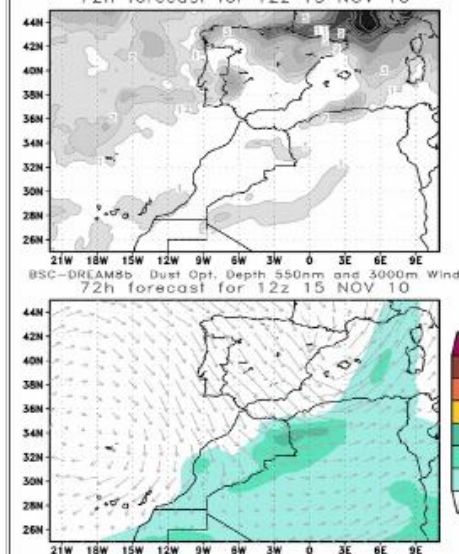
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#### SPAIN zoom

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

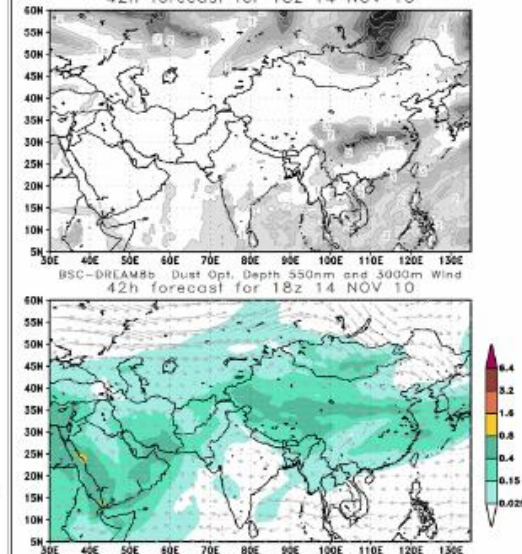
BSC-DREAM8b Total Cloud Cover  
72h forecast for 12z 15 NOV 10



#### EAST-ASIA experimental

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

BSC-DREAM8b Total Cloud Cover  
42h forecast for 18z 14 NOV 10

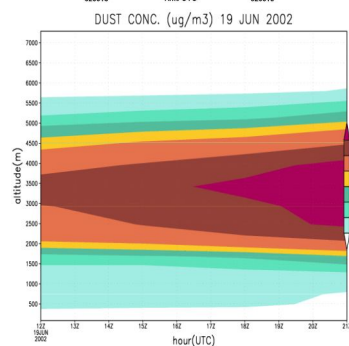
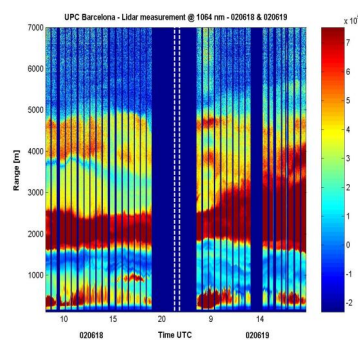




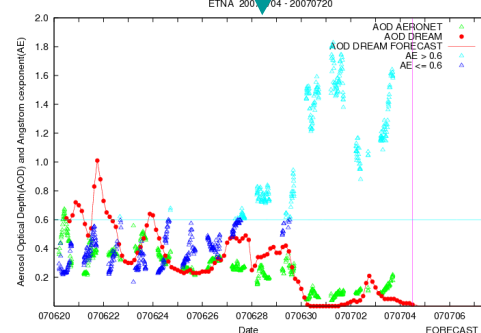
# Dust forecast and daily evaluation



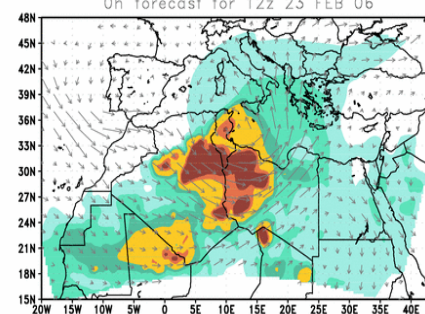
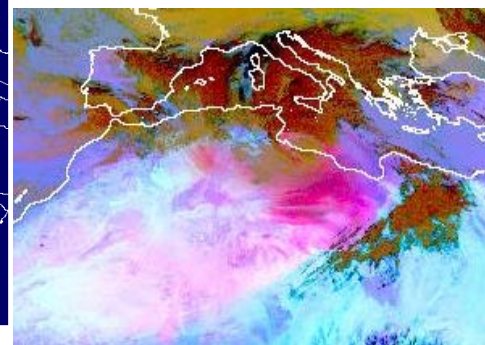
## Lidars - EARLINET



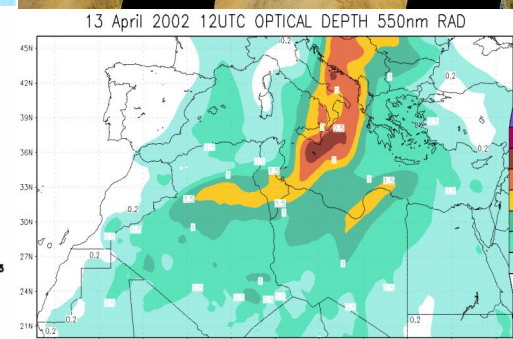
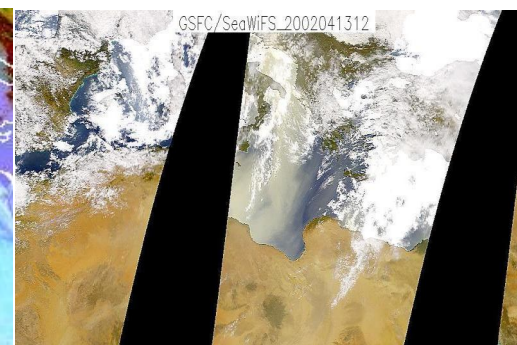
## AERONET - ONLINE



## Meteosat Second Generation



## SeaWiFS

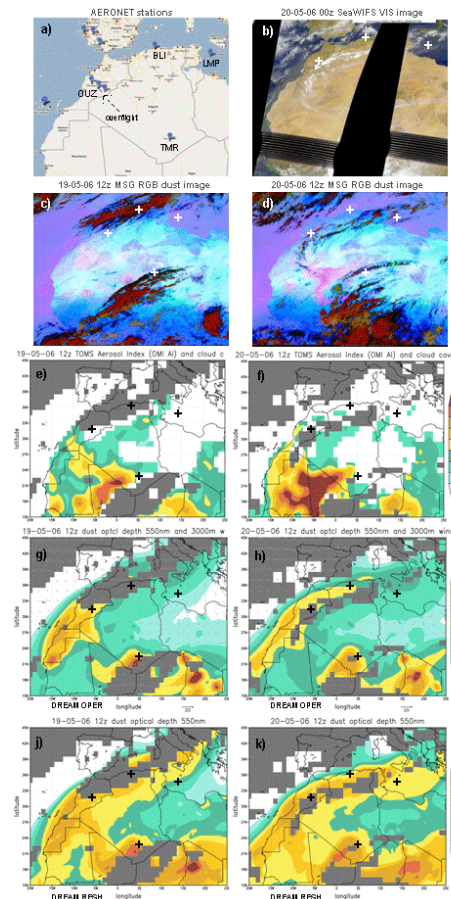
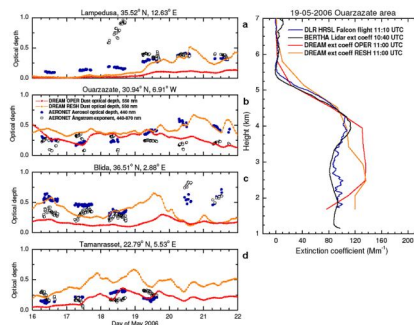
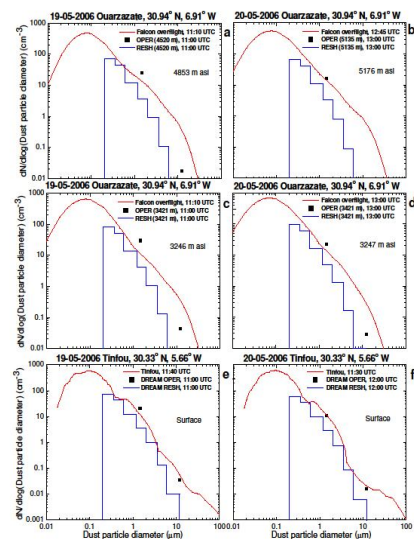


Model has shown good agreement with observations in a number of studies of single events (e.g., Ansmann et al., 2003, Papayannis et al., 2005; Balis et al., 2006; Pérez et al., 2006a;b; Jiménez et al., 2006 ....)

# BSC-DREAM8b assessment

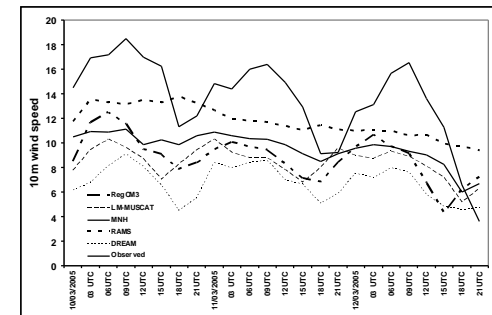


- BSC-DREAM8b validation activities → BoDEX intercomparison [Todd et al., 2008]
- SAMUM-I comparison [Haustein et al., 2009]



Regional model  
intercomparison  
in the Bodélé

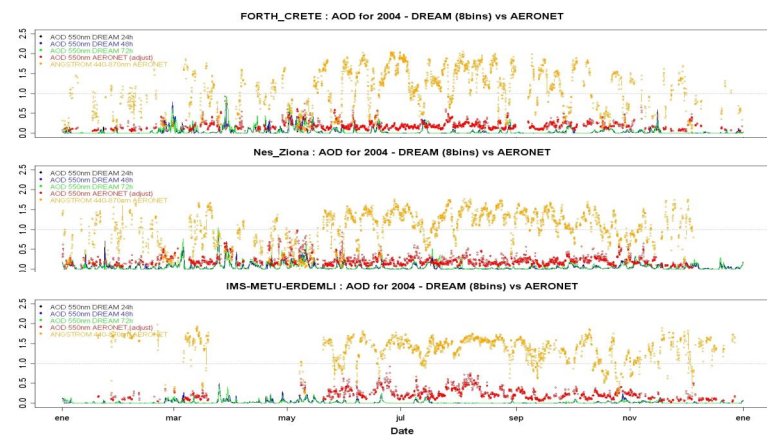
RegCM3  
LM-MUSCAT  
Meso-NH  
RAMS-DPM  
**BSC/DREAM**



→ AERONET comparison

Ongoing evaluation (Basart et al 2009)

Full year 2004 validation of BSC-DREAM8b versus AERONET





## Previous work: NMMB/BSC-DUST



- Eta/DREAM model [Nickovic et al., 2001]
- Eta/BSC-DREAM8b regional dust forecast model [Pérez et al., 2006]  
<http://www.bsc.es/projects/earthscience/DREAM>
- NMMB introduction
  - The NCEP-ETA weather forecast model is replaced by a state-of-the-art regional/global model with improved dynamics and physics:

### → **NCEP-NMMb**

[Janjic, 2005,  
2007, 2009]

- ***Under development at NCEP as evolution of the ETA model***
- Unified model with regional and global domain (embedded in ESMF architecture)
- Arakawa B grid and pressure-sigma hybrid coordinate [Arakawa and Lamb, 1977]
- NMMB regional will become the next-generation NCEP mesoscale model for ***operational weather forecasting in 2010***

- Global dust forecasts up to 7 days at sub-synoptic resolutions:

### → **NMMb/BSC-DUST**

[Pérez et al., 2008;  
Haustein et al., 2009]

- Implementation of all common on-line dust modules for global simulations
- Nested regional domains at very high resolution will be 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

## NMMb – Nonhydrostatic Multiscale Model – Main characteristics

Under development at NCEP (Janjic, 2005; Janjic, 2007; Janjic, 2009)

### Unified nonhydrostatic dynamical core (list of features is not exhaustive)

- ✓ Wide range of spatial and temporal scales (from meso to global)
- ✓ Regional and global domains (just a simple switch)
- ✓ Evolutionary approach, built on NWP experience by relaxing hydrostatic approximation (instead of extending cloud models to large scales; Janjic et al., 2001, MWR; Janjic, 2003, MAP)
  - Applicability of the model extended to nonhydrostatic motions
  - Favorable features of the hydrostatic formulation preserved
- ✓ The nonhydrostatic option as an add-on nonhydrostatic module
- ✓ No problems with weak stability on mesoscales
- ✓ Conservation of important properties of the continuous system (Arakawa, 1966, 1972, ...; Janjic, 1977, ...; Sadourny, 1968; aka “mimetic” approach in Comp. Math)
- ✓ Arakawa B grid (in contrast to the WRF-NMM E grid)
- ✓ Pressure-sigma hybrid (Arakawa and Lamb, 1977)

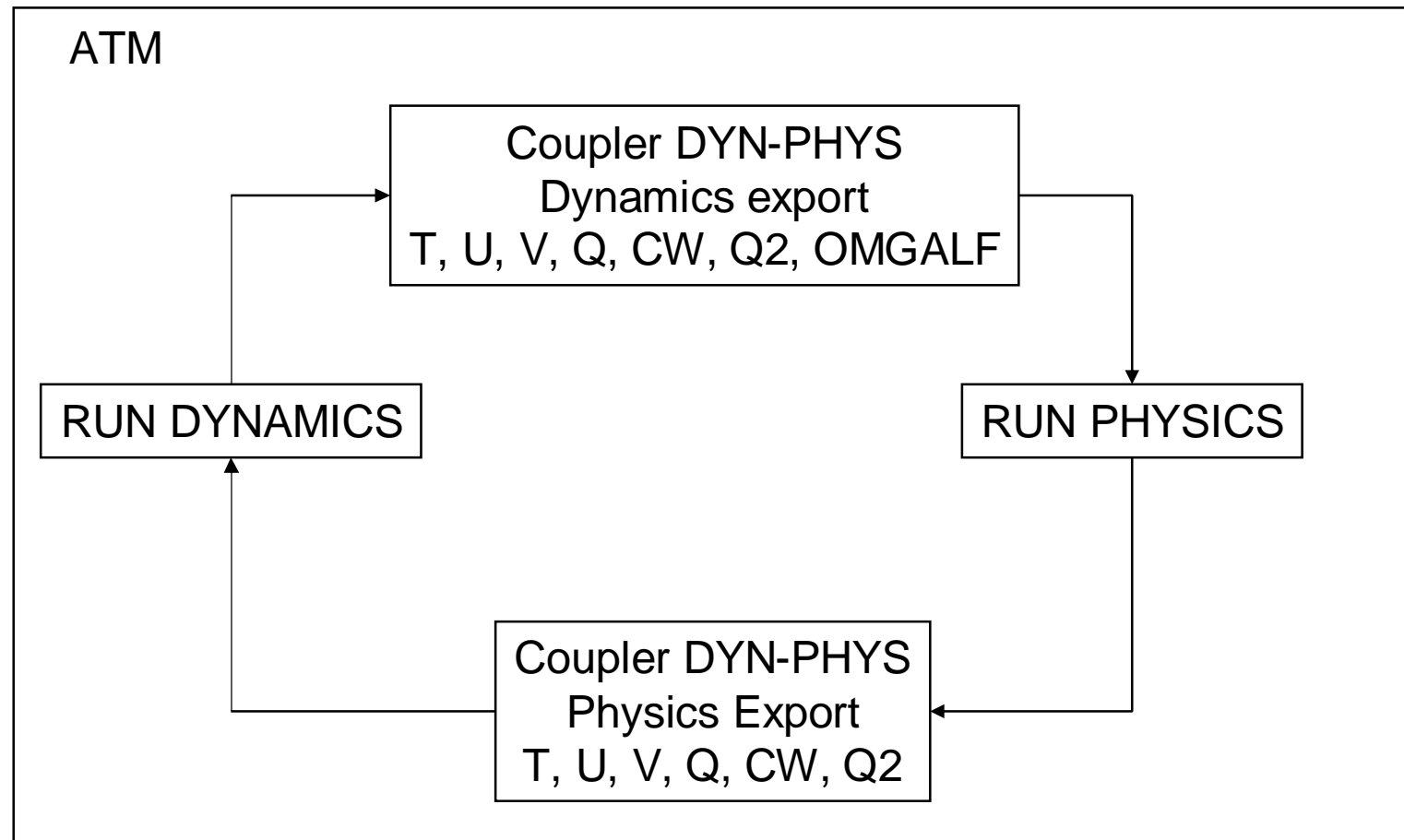


## NMMb – Nonhydrostatic Multiscale Model – Dynamics

Under development at NCEP (Janjic, 2005; Janjic, 2007; Janjic, 2009)

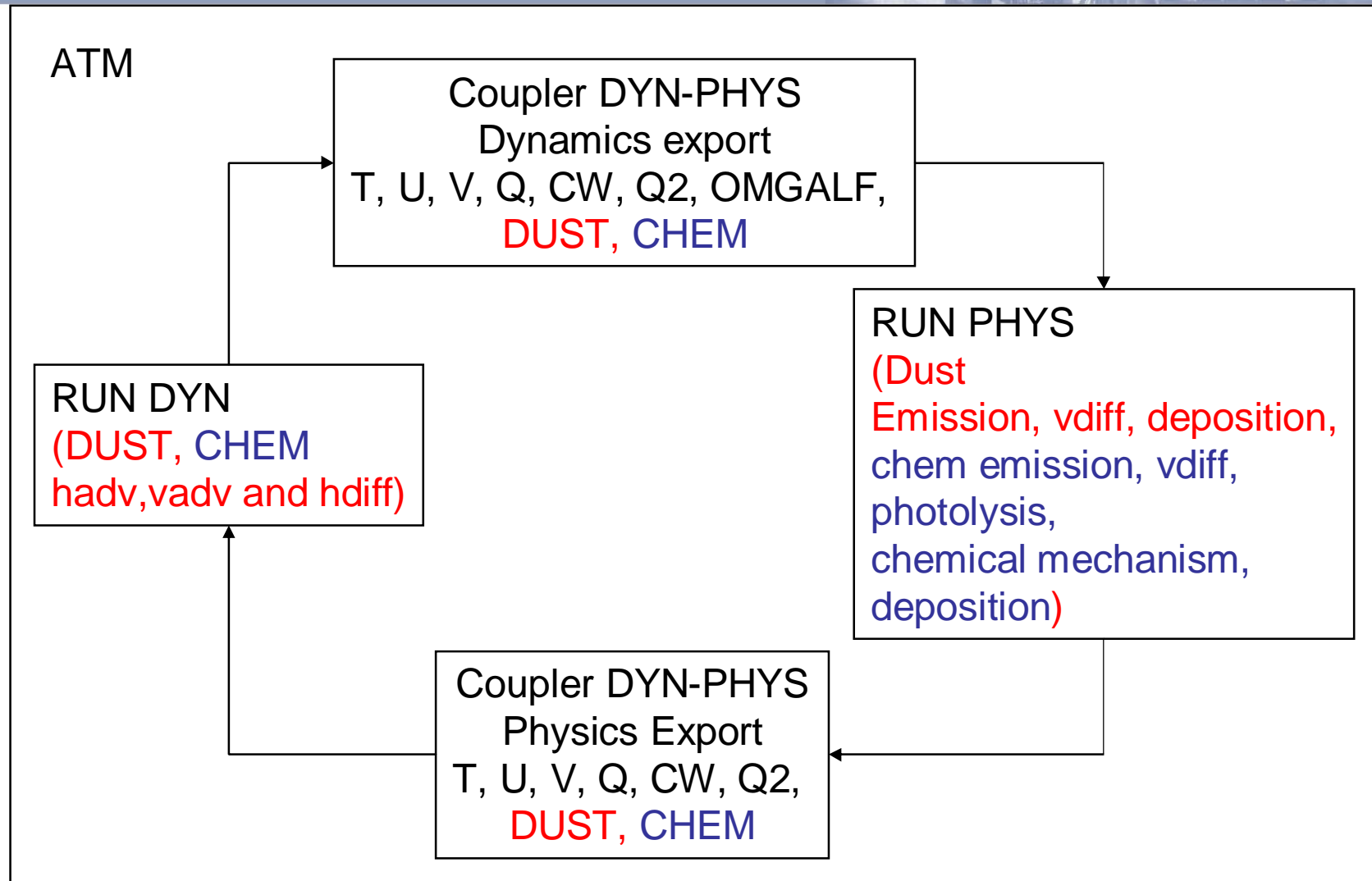
- ✓ Adams-Bashforth for horizontal advection of  $u$ ,  $v$ ,  $T$  and Coriolis force
- ✓ Crank-Nicholson for vertical advection of  $u$ ,  $v$ ,  $T$  (implicit)
- ✓ Forward-Backward (Ames, 1968; Janjic and Wiin-Nielsen, 1977; Janjic 1979, Beitrage) for fast waves
- ✓ Implicit for vertically propagating sound waves (Janjic et al., 2001, MWR; Janjic, 2003, MAP)
- ✓ **Improved tracer advection**: Eulerian, positive definite, mass conservative and monotonic
- ✓ A variety of **physical parameterization schemes from WRF** modeling system will be available
- ✓ **NMMb regional** will become the next-generation **NCEP** mesoscale model for **operational weather forecasting in 2010**

## Structure of NMMb using Earth System Modeling Framework (ESMF)





## NMMb/BSC-DUST-CHEM using Earth System Modeling Framework (ESMF)



***DUST and gas-phase CHEM modules fully embeded within the atmospheric driver***



## • NMMB/BSC-DUST emission scheme

→ Threshold friction velocity [Bagnold, 1941; Iversen and White, 1982; Marticorena and Bergametti, 1995]

**DREAM:**  $u_{*total}(D, w) = u_{*dry}(D) \cdot H(w)$

**NMMB-DUST :**  $u_{*total}(D, z_0, w) = \frac{u_{*dry}^{MB}(D)}{R(z_0, z_{0S})} \cdot H(w)$  H=Moisture correction  
R=Drag partition correction

→ Horizontal flux [White, 1979]

**DREAM:** Implicit in vertical flux

**NMMB-DUST:**  $G = \frac{\rho_{air}}{g} \cdot u_*^3 \cdot \sum_i \left( \left( 1 + \frac{u_{*total}}{u_*} \right) \cdot \left( 1 - \frac{u_{*total}^2}{u_*^2} \right) \cdot s_i \right)$   $s_i$ =relative surface area of each soil fraction

→ Vertical flux [Shao et al., 1993; Marticorena and Bergametti, 1995; Tegen et al., 2002]

**DREAM:**  $F_S = c \cdot \delta_{DREAM} \cdot u_*^3 \cdot \left( 1 - \frac{u_{*total}^2}{u_*^2} \right)$

**NMMB-DUST:**  $F_S = c \cdot \alpha \cdot \delta \cdot G \implies (u_* \geq u_{*total})$   $\alpha$ =sandblasting efficiency  
 $\delta$ =new source function

→ Viscous sublayer effects near the surface [Janjic, 2001]





- NMMB/BSC-DUST deposition scheme

- Threshold friction velocity [Bagnold, 1941; Iversen and White, 1982; Marticorena and Bergametti, 1995]
- Horizontal flux [White, 1979]
- Vertical flux [Shao et al., 1993; Marticorena and Bergametti, 1995; Tegen et al., 2002]
- Viscous sublayer effects near the surface [Janjic, 2001]

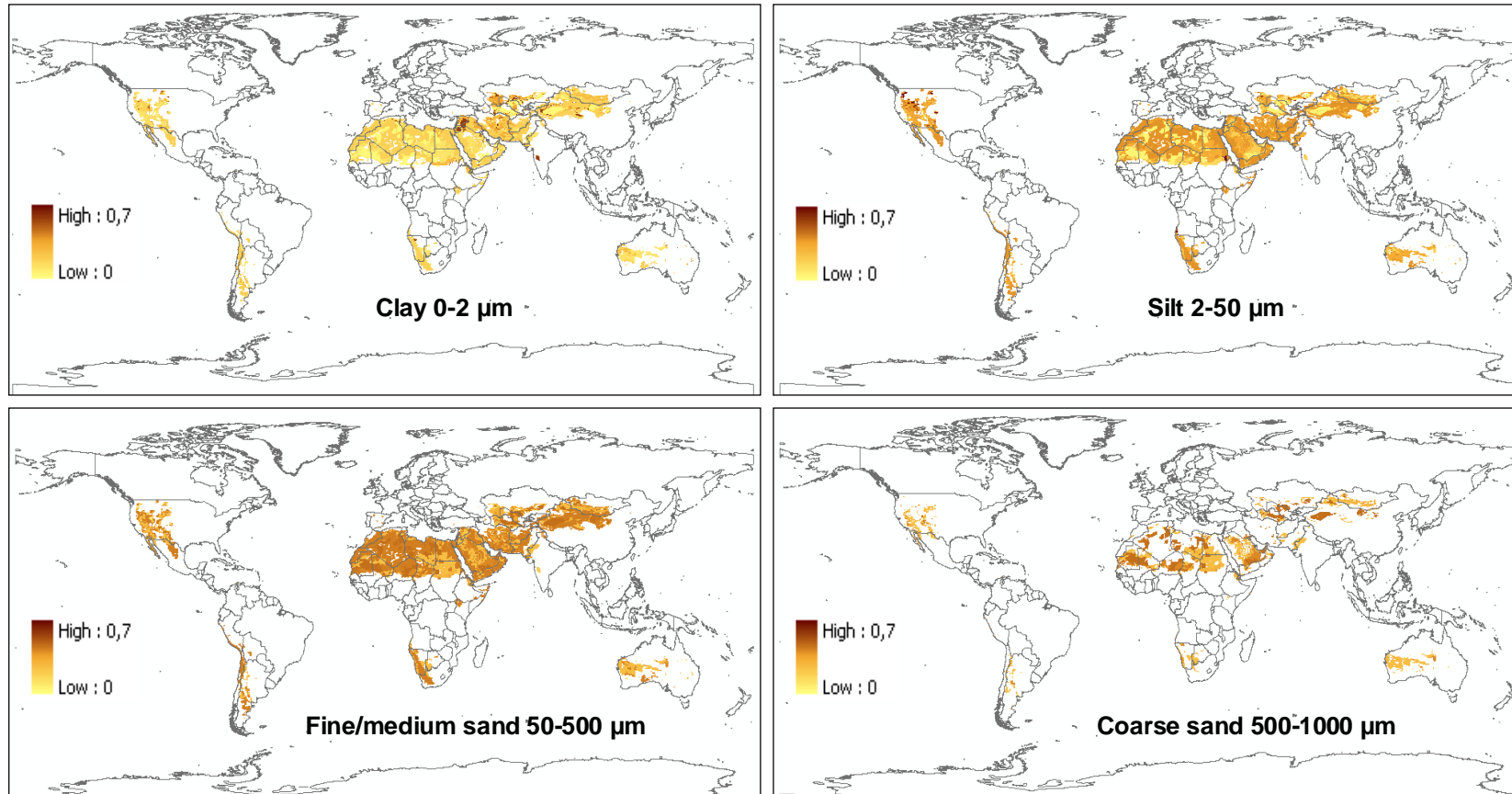
- 
- Turbulent deposition [Giorgi, 1986] 
$$v_{dep} = \frac{1}{\frac{1}{v_{SL}} + \frac{1}{f_{B0} \cdot v_{IL}}}$$
 **(DREAM + NMMB-DUST)**  
Brownian diffusion, interception, impaction is considered

- 
- |  |  |
|--|--|
| → Gravitational settling [Giorgi, 1986]                                      |  |
| <b>DREAM:</b> $v_g = \frac{2 \cdot g \cdot \rho_k \cdot R_k^2}{9 \cdot \nu}$ | <b>NMMB-DUST:</b> $v_g = \frac{2 \cdot g \cdot \rho_k \cdot R_k^2}{9 \cdot \nu} \cdot Cc$ Cc=Cunningham correction |
- 

- Grid scale precipitation [Slinn, 1983; 1984]
  - Convective precipitation [Loosmore and Cederwall, 2004]
- NMMB-DUST:**  
**In-cloud scavenging** and **Below-cloud scavenging** (Ferrier microphysics for grid scale and BMJ microphysics for convection)



- NMMB DUST parent soil size distribution



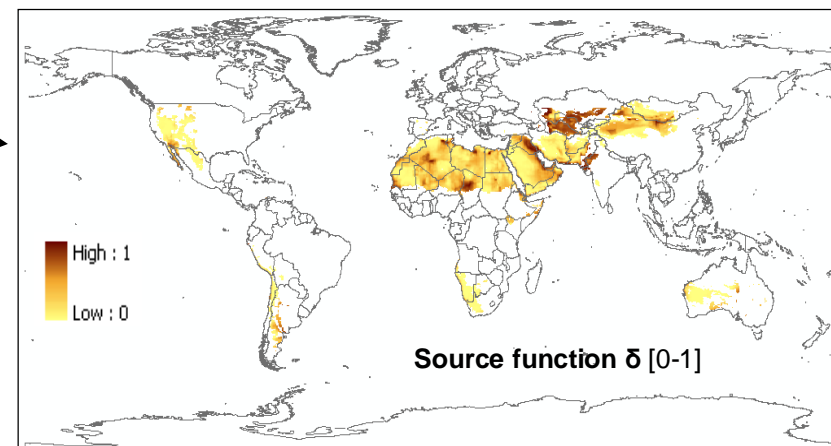
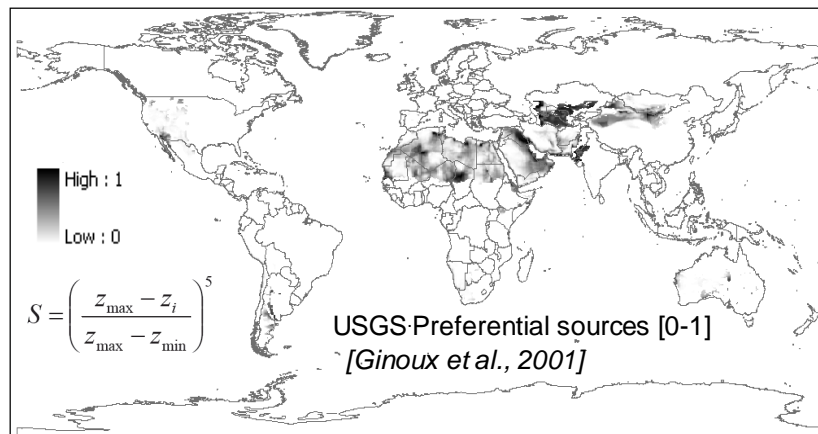
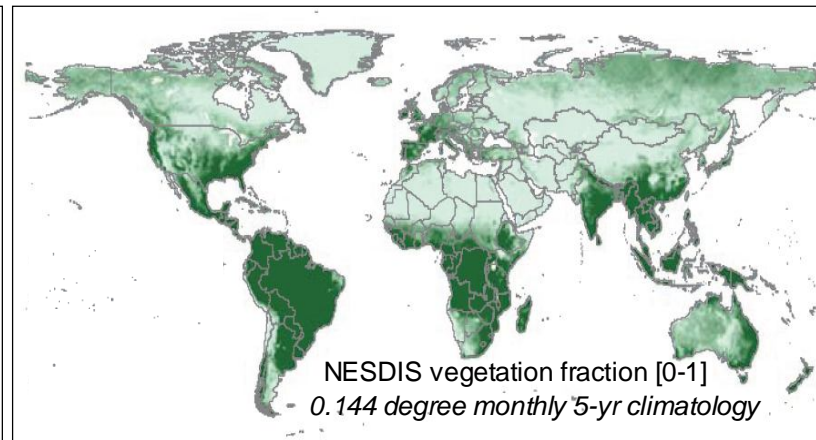
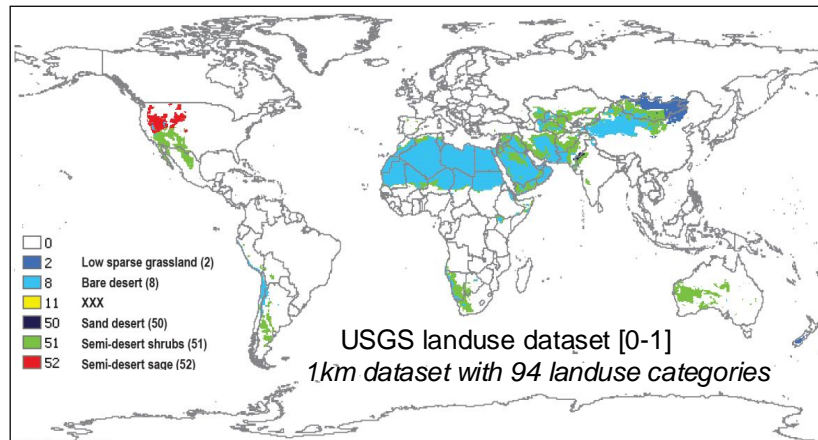
Four top soil texture classes according STASGO-FAO 1km database are converted to 4 parent soil size categories following Tegen et al. [2002]

They are used to calculate **horizontal flux**

Dust **horizontal concentration** is calculated distributing the **vertical flux** of the **first two parent soil categories** over the **8 model particle bins**



- NMMB DUST source function



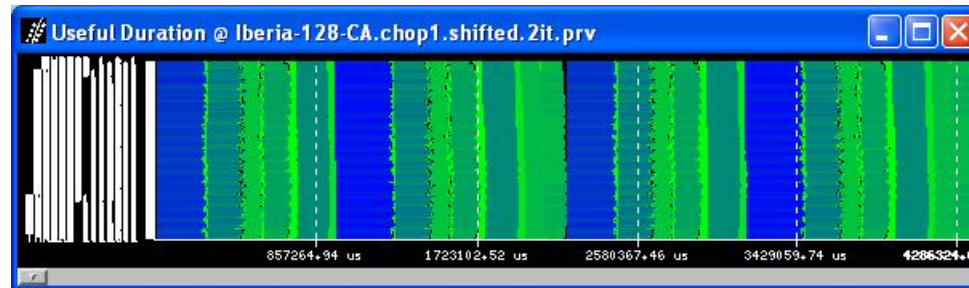
$$\delta = USGS \cdot PREF \cdot (1 - VEGFRAC) \cdot (1 - SnowCover)$$



# NMMB/BSC-DUST traces @ MareNostrum (REGIONAL)

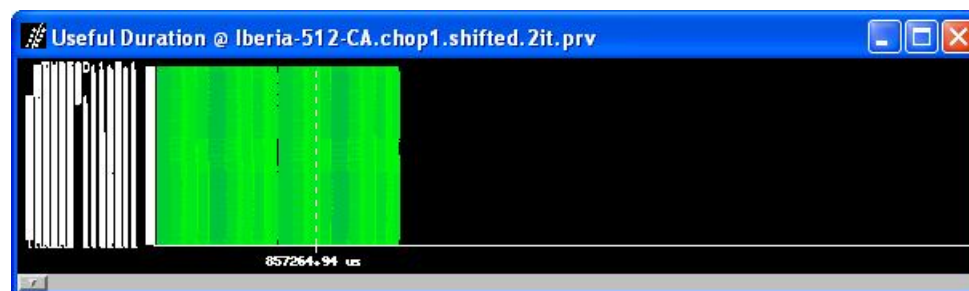
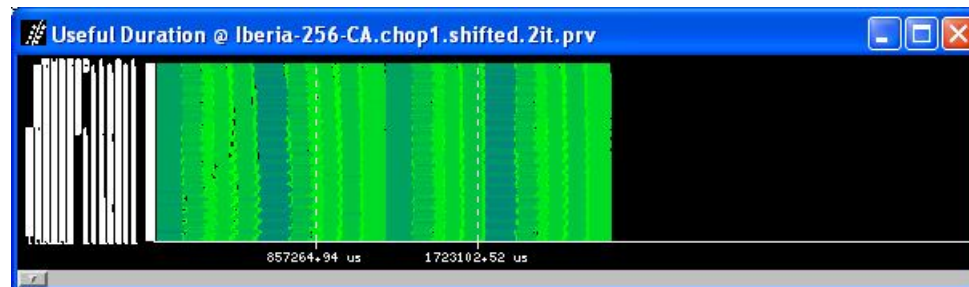


- 128 CPUs



Iberian Peninsula 4km

- 256 CPUs Computational time





- NMMB model setup → define the simulation characteristics

- Global domain
- $1^\circ \times 1^\circ$  NCEP analysis meteorology data updated every 24 hours
- Non-hydrostatic physics
- $1/2^\circ \times 1/2^\circ$  model grid resolution
- 64 vertical (sigma) layers
- Dust cold start period of 3 days
- SAMUM period in May 2006
- No wet deposition in this simulation
- All results are preliminary!

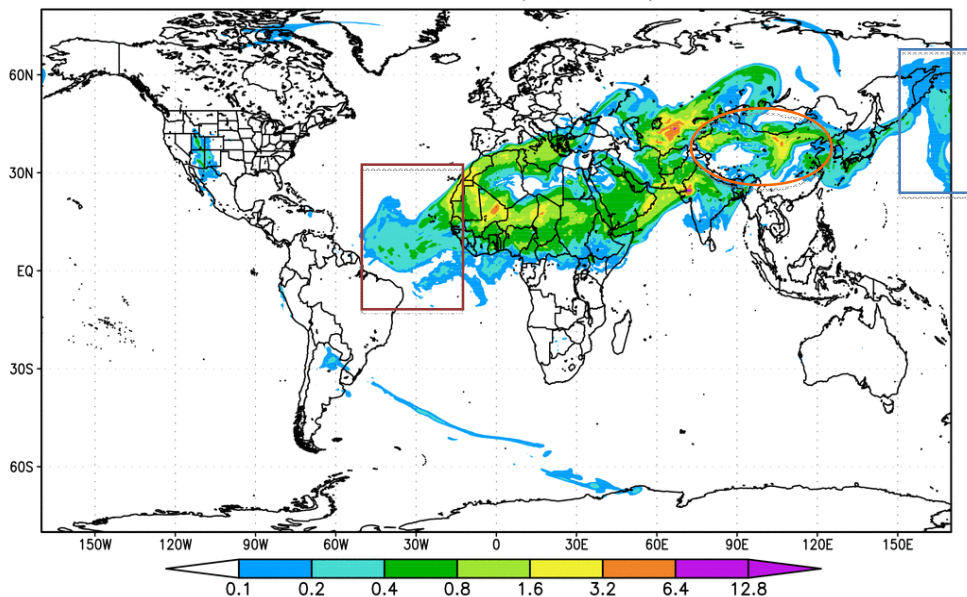


BSC - Mare Nostrum

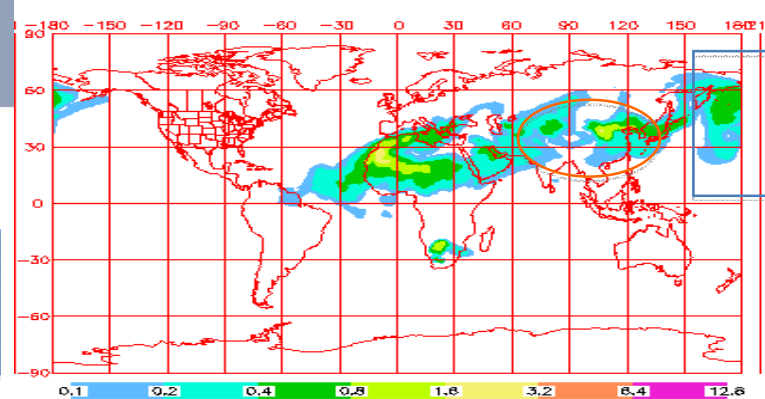
# NMMb/BSC-Dust

May 20th, 2006

20-05-06 12z dust optical depth 550nm

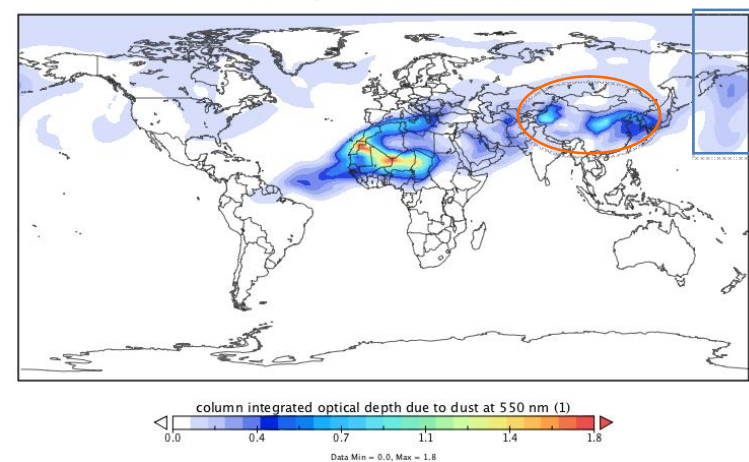


NAAPS Dust Optical Depth for 12:00Z 20 May 2006  
Contoured at 0.1, 0.2, 0.4, 0.8 etc.



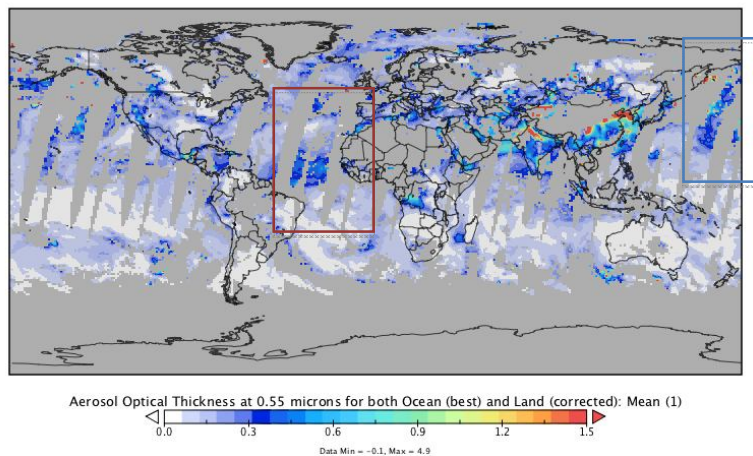
NAAPS

GOCART Average AOD 500nm for 20 May 2006

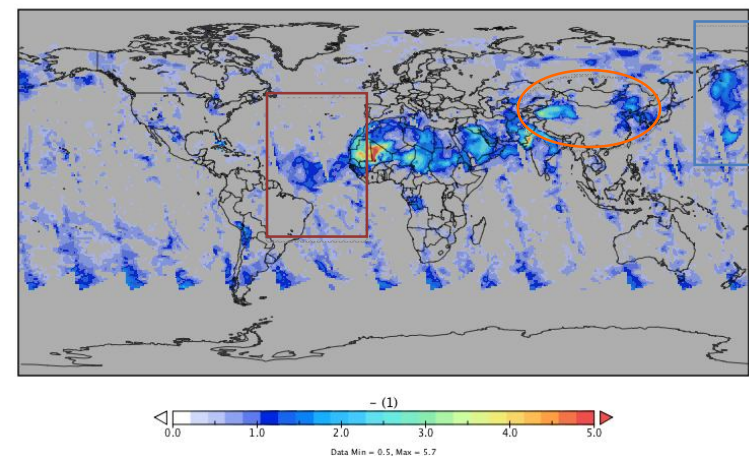


GOCART

Aerosol Optical Thickness at 0.55 microns for both Ocean (best) and Land (corrected): Mean



MODIS



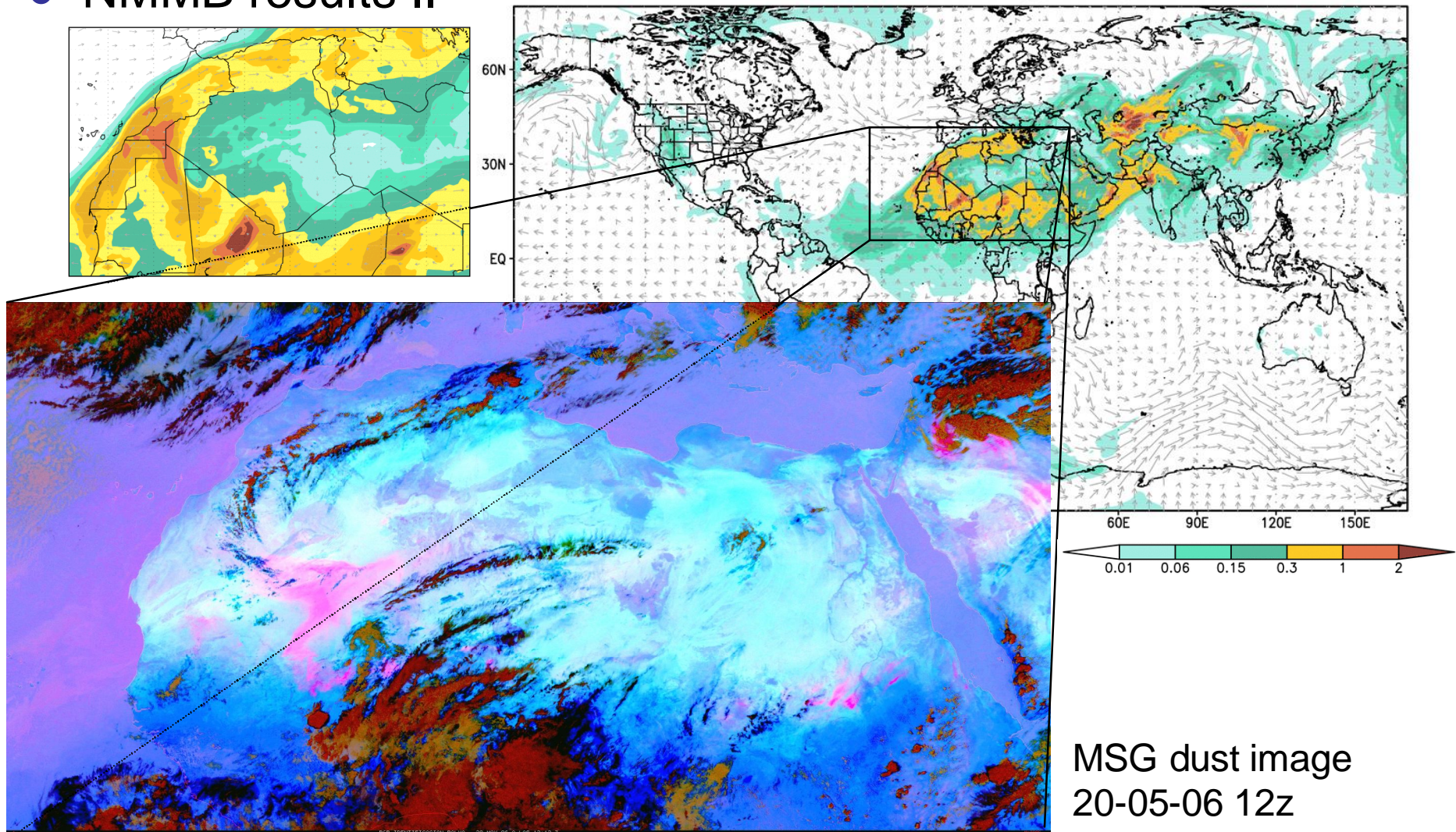
AEROSOL INDEX





- NMMB results II

20-05-06 12z dust col load ( $\text{g}/\text{m}^2$ ) and 3km wind



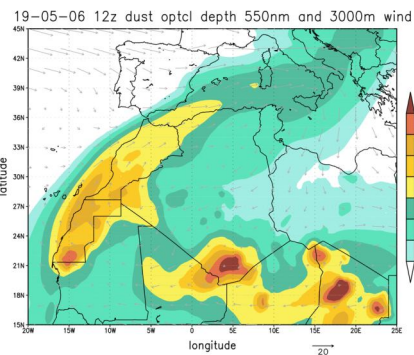


# NMMB/BSC-DUST

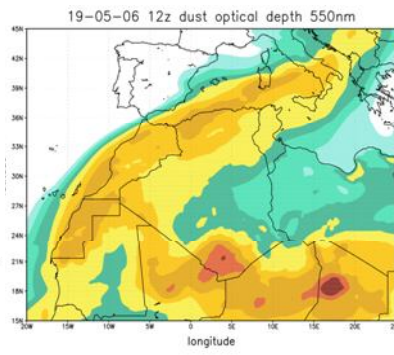


## ● NMMB results III comparison dust AOD 550nm & OMI aerosol index

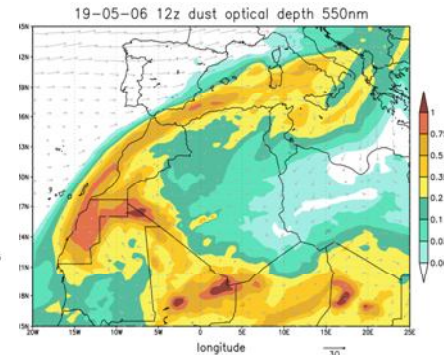
### DREAM



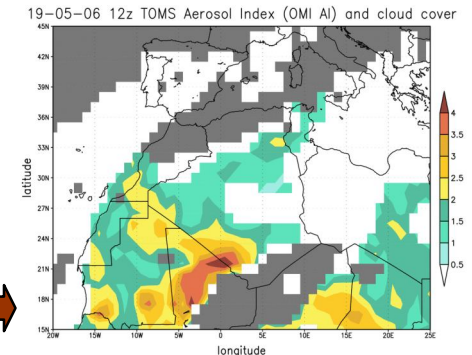
### BSC-DREAM8b



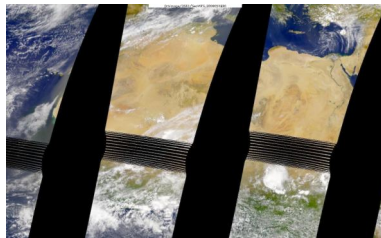
### NMMB/BSC-DUST



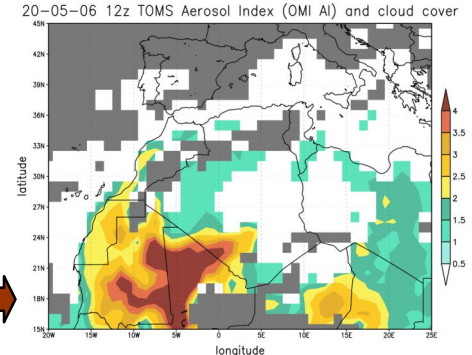
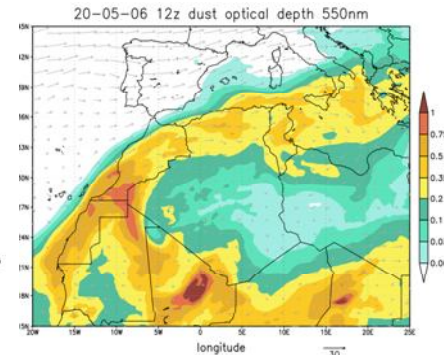
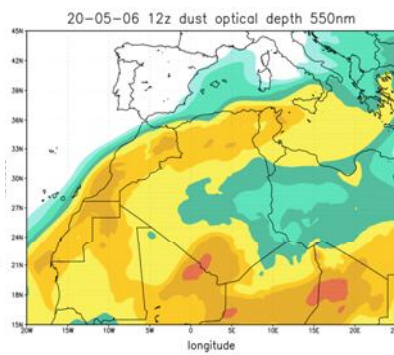
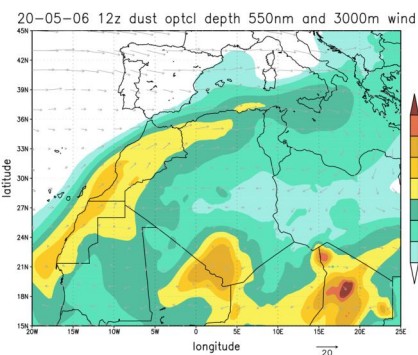
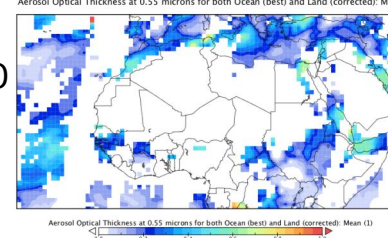
### OMI AI



SeaWiFS image  
19-05-06 00z



MODIS AOD  
20-05-06



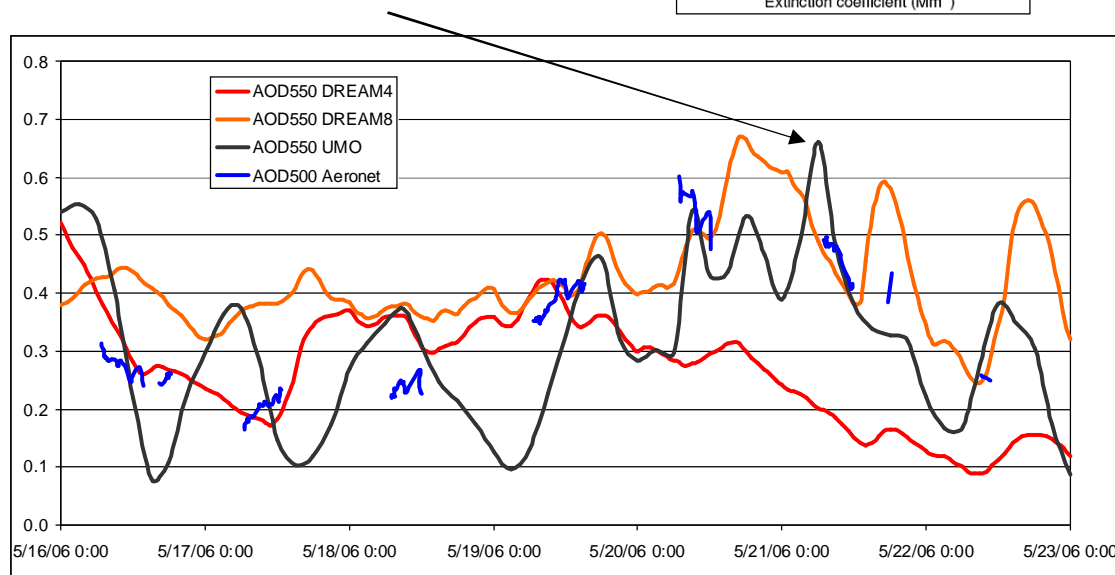
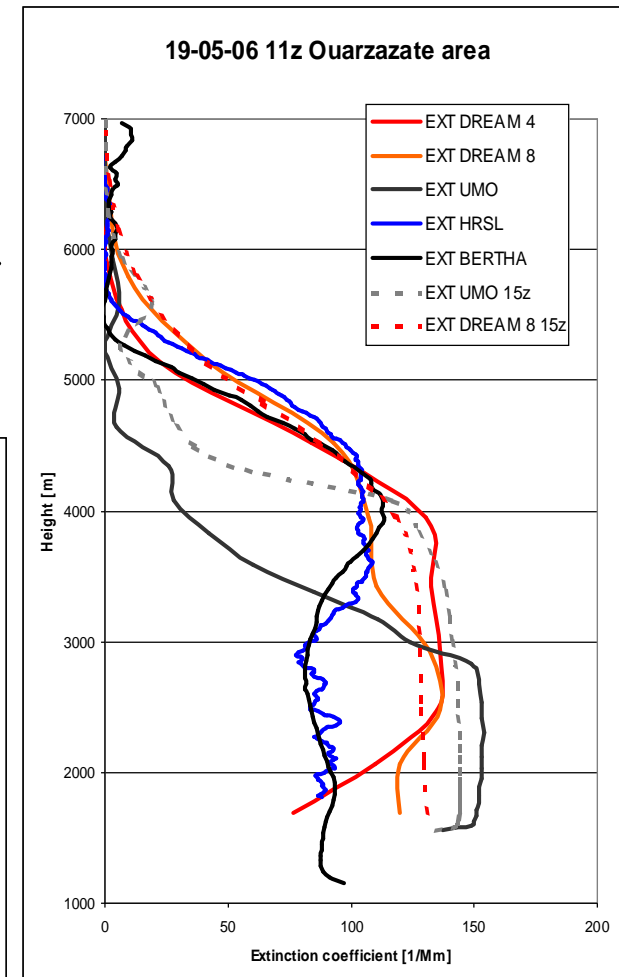
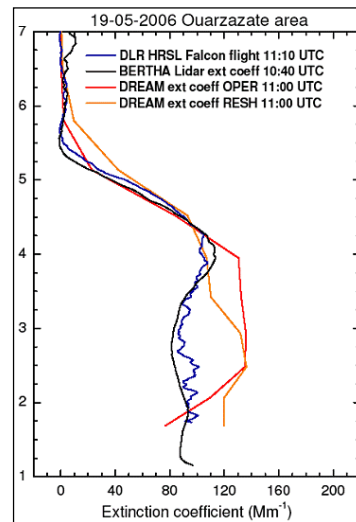
Moist convective event  
no captured by models



## • NMMB results IV



- very pronounced diurnal dust cycle
- noticeable variations in case of dust events



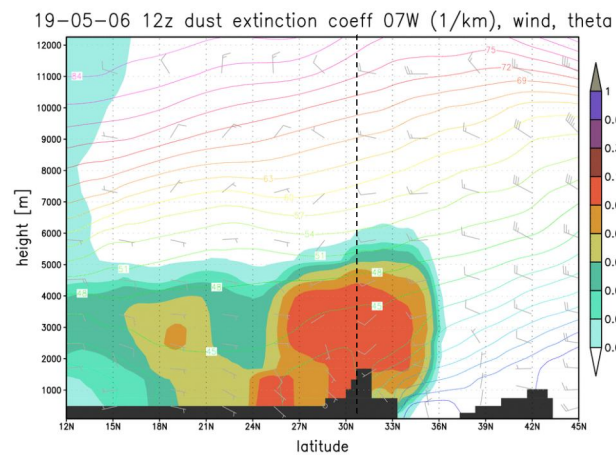


# NMMb/BSC-DUST

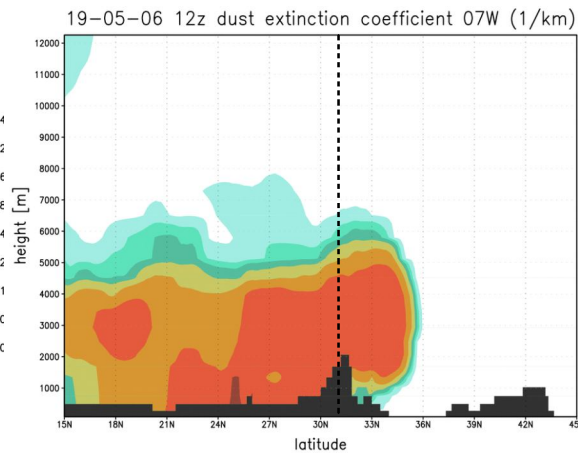
(Pérez et al., 2008; Haustein et al., 2009)



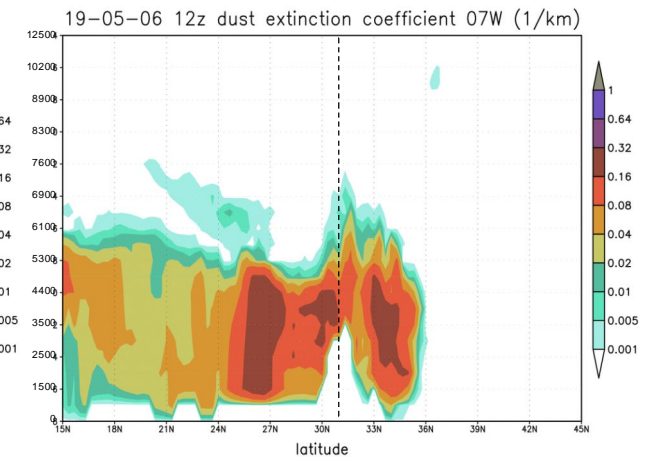
## • NMMb/BSC-DUST results vertical cross section dust extinction coefficient (Ouarzazate)



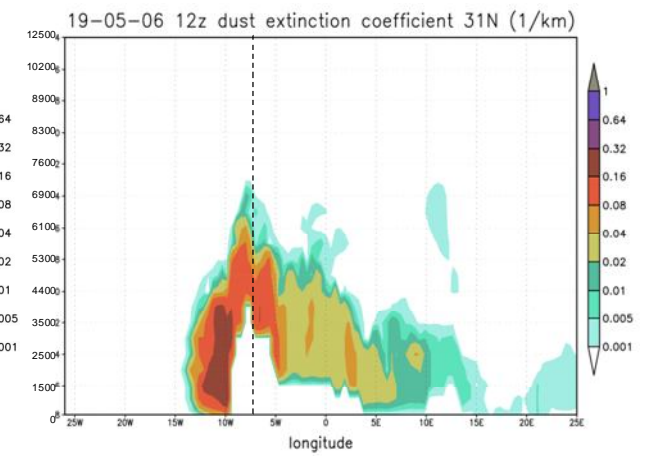
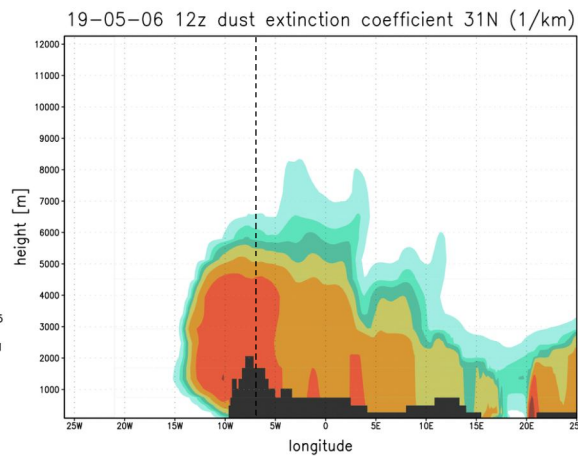
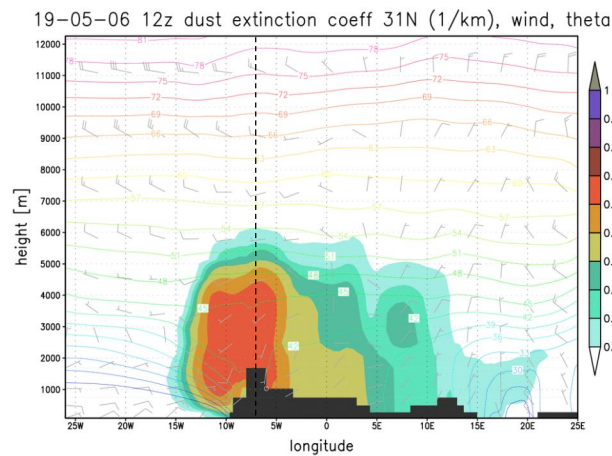
DREAM



BSC-DREAM8b operational



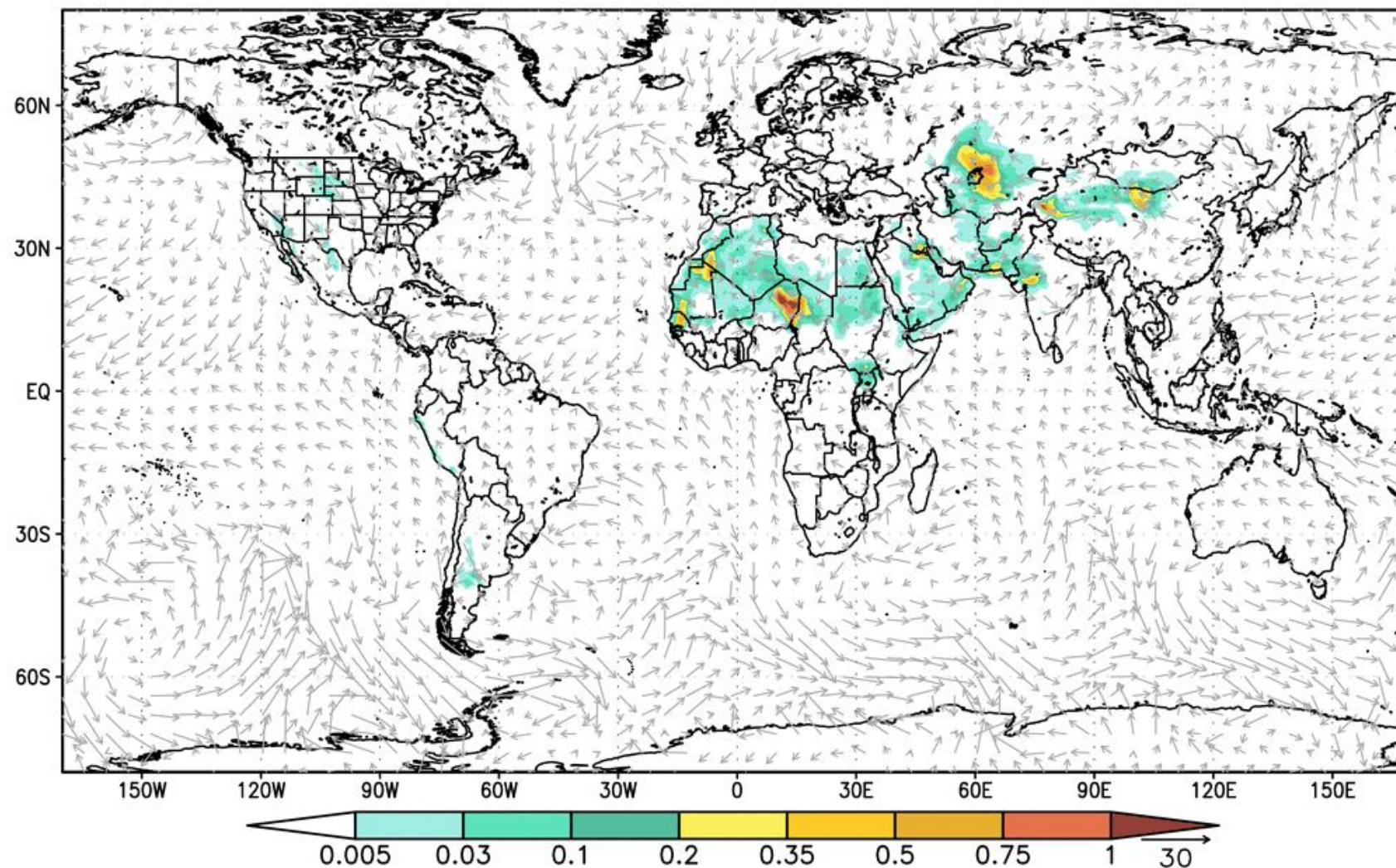
NMMB-DUST



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

11-05-06 00z dust optical depth 550nm





## Simulation:

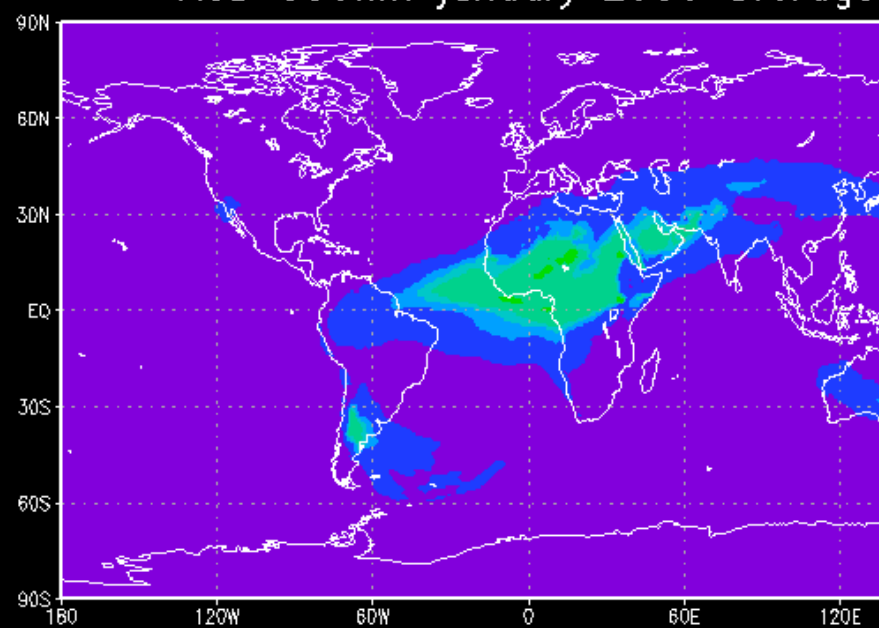
- Global simulation for year 2006
- $0.7^\circ \times 0.5^\circ \times 40$  vertical levels
- Cold start without data assimilation
- Initial conditions from NCEP analysis  $1 \times 1^\circ$ . Meteorological fields updated with NCEP every 24 hours.

## Aeronet validation:

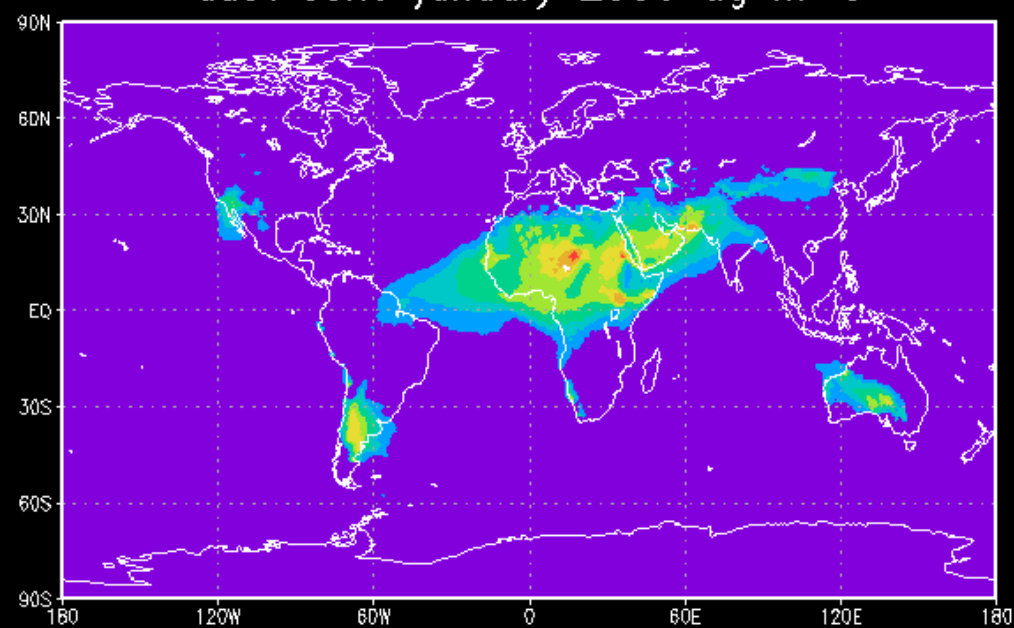
- Aeronet data here is Coarse AOD (mainly dust over dust affected stations)
- We validate daily averages



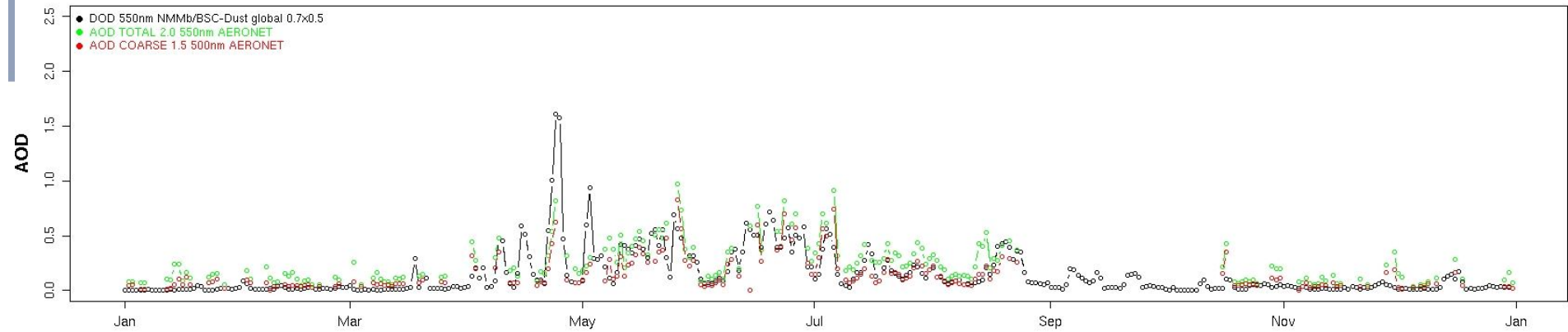
AOD 550nm january 2006 average



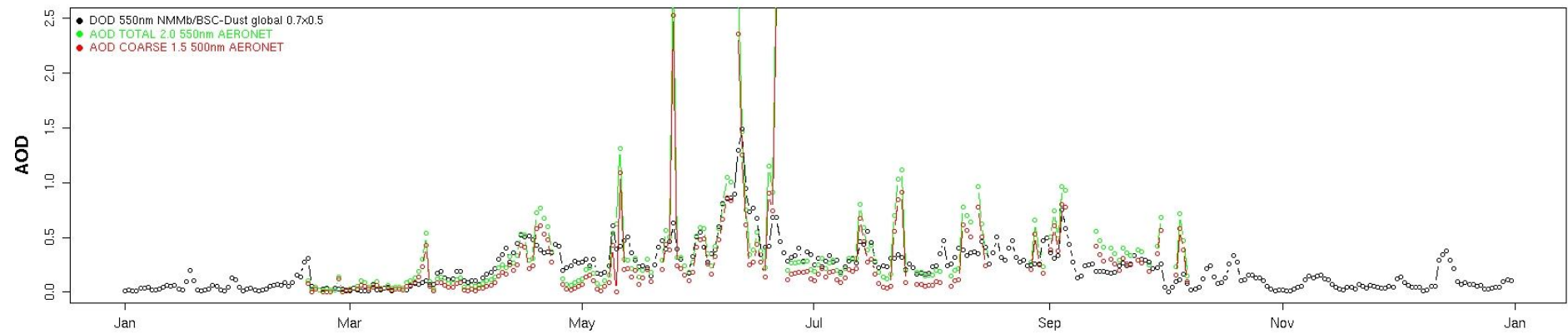
dust conc january 2006  $\mu\text{g m}^{-3}$



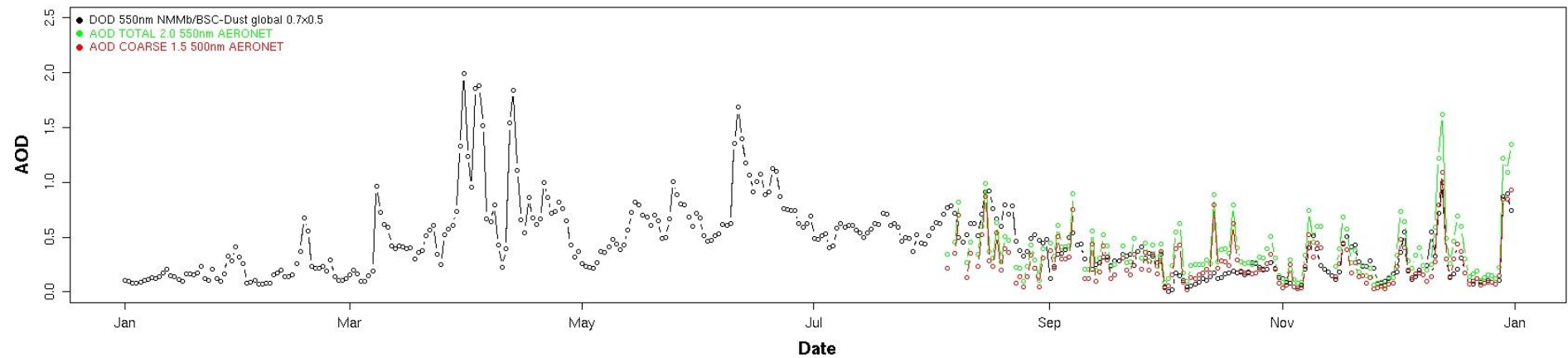
Blida : AOD for 2006 - NMMb/BSC-Dust vs AERONET



Tamanrasset\_TMP : AOD for 2006 - NMMb/BSC-Dust vs AERONET



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

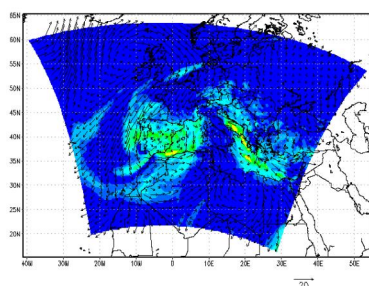


# BSC air quality modelling activites

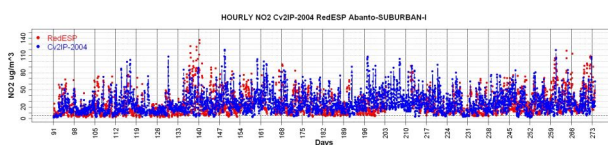
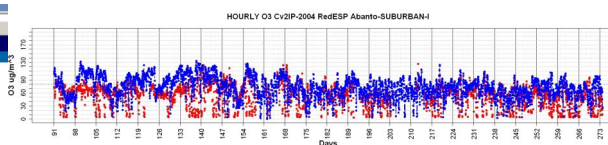
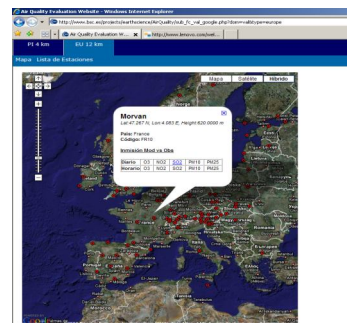
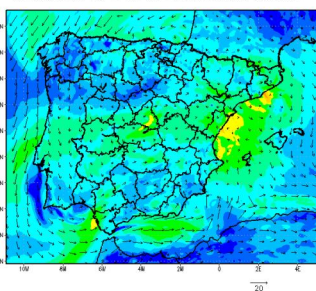
## ● CALIOPE daily experimental forecast and verification

- ✓ Daily experimental forecasts for meteorology and air quality (12 km for Europe and 4 km for the Iberian Peninsula) (<http://www.bsc.es/caliope>).

BSC-ES/Air Quality Forecast ARW3+CM4Q4.5 Ozone (ug/m3)  
12h forecast for 12z 16 SEP 09 — Europe Res:12x12km



BSC-ES/Air Quality Forecast ARW3+CM4Q4.5 Ozone (ug/m3)  
12h forecast for 12z 16 SEP 09 — Iberian Peninsula Res:4x4km

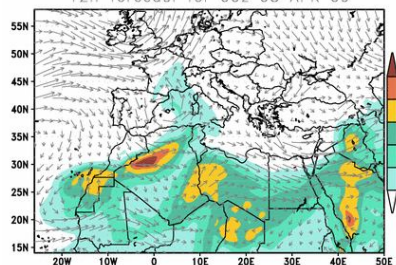


## ● BSC-DREAM8b daily forecast and verification

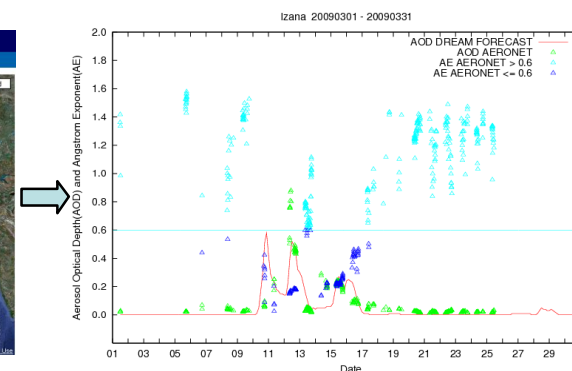
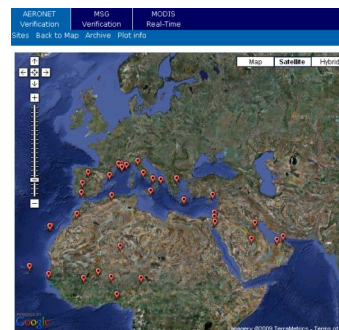
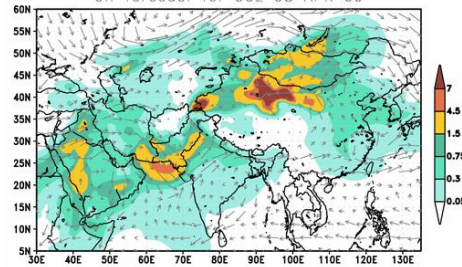
North Africa/Mediterranean - 1/3 x 1/3 degree resolution

Asia domain - 1/2 x 1/2 degree resolution

BSC/DREAM Dust Loading (g/m-2) and 3000m Wind  
12h forecast for 00z 08 APR 09



BSC/DREAM Dust Loading (g/m\*\*2) and 3000m Wind  
0h forecast for 00z 08 APR 09

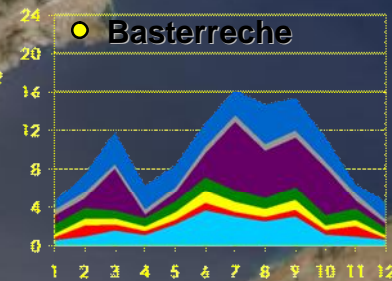
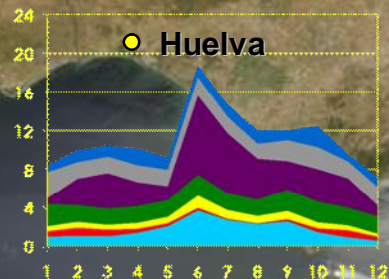
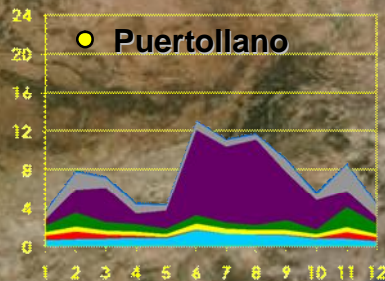
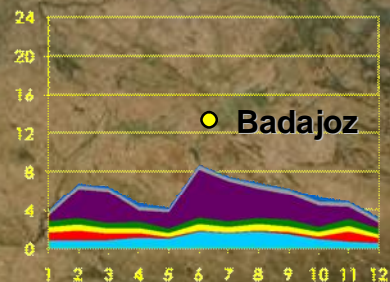
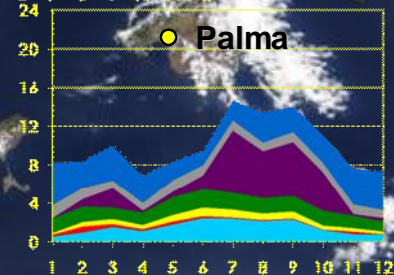
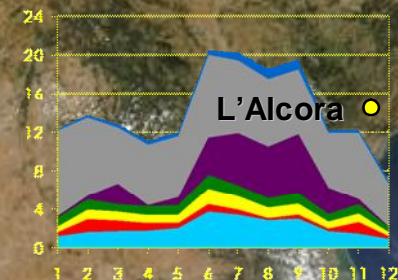
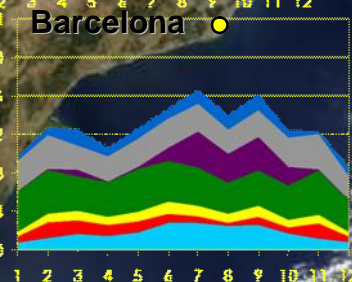
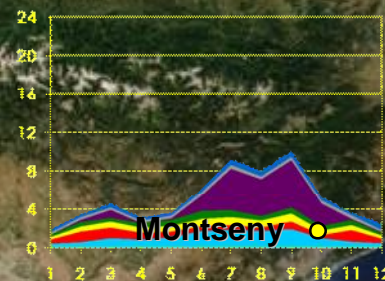
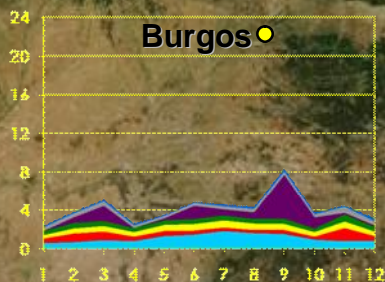


→ <http://www.bsc.es/projects/earthscience/DREAM>



# Spatial distribution of PM<sub>10</sub> 2004 monthly composition (µg/m<sup>3</sup>) in the location of CSIC-IJA stations

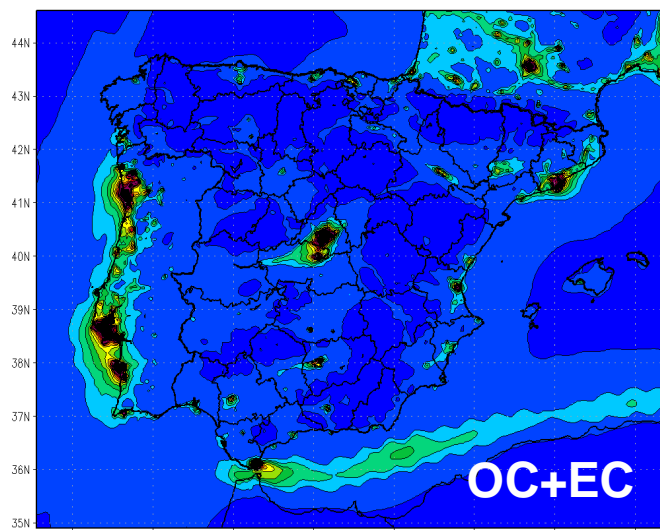
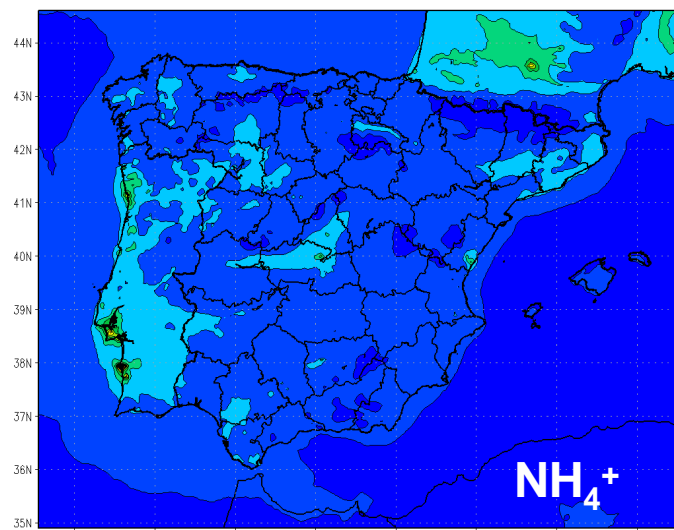
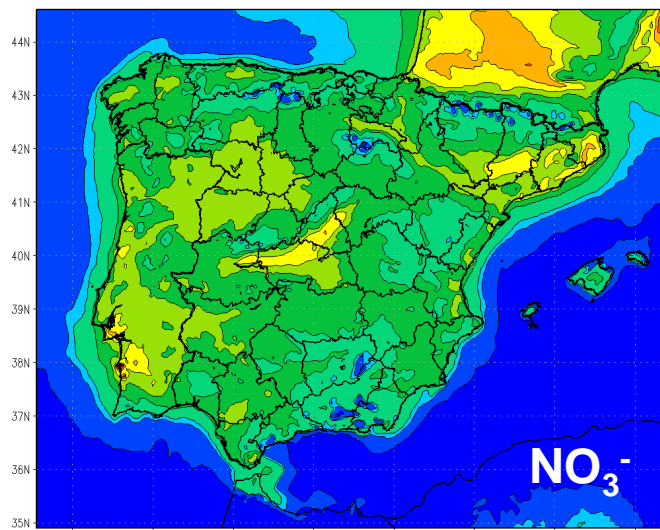
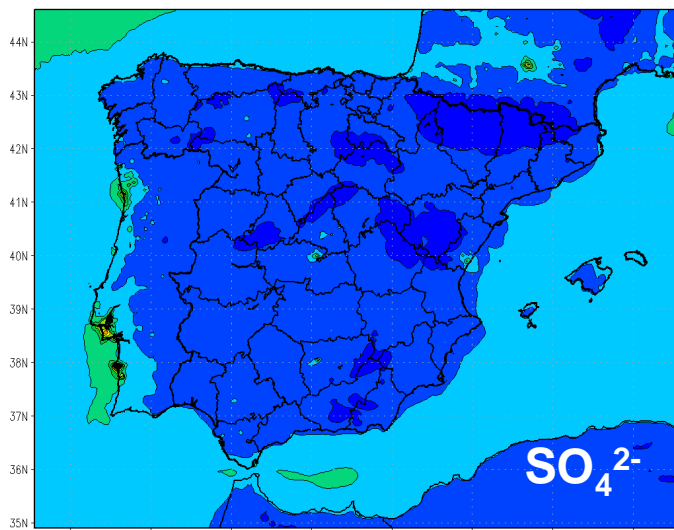
- Marine
- Anthr. Undetr.
- Desert Dust
- OC+EC
- Ammonia
- Nitrate
- Sulfate



# Spatial distribution in 2004 Winter (DJF)

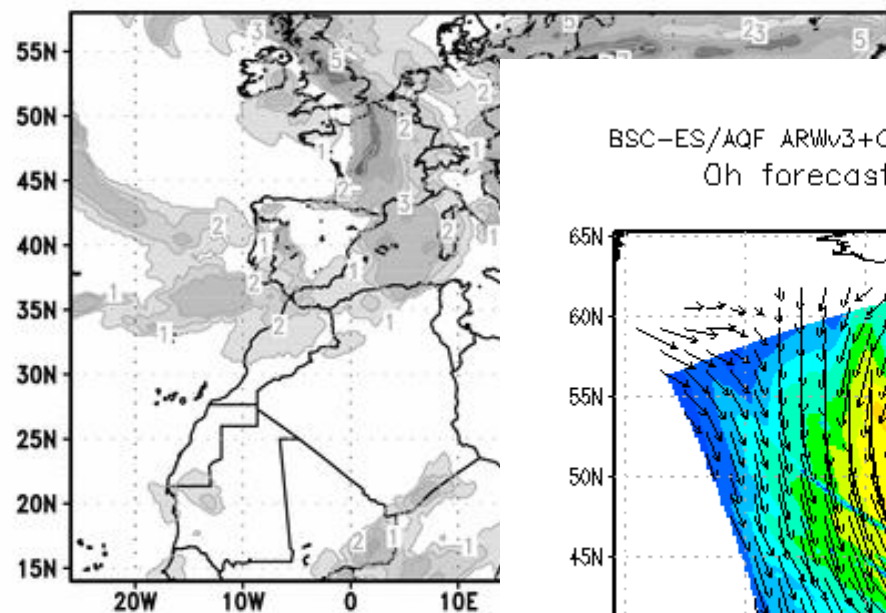


**BSC-ES/AQM ARW3.0+HERMES+CMAQv4.5 ( $\mu\text{g}/\text{m}^3$ ) - Iberian Peninsula Res: 4 km x 4 km**

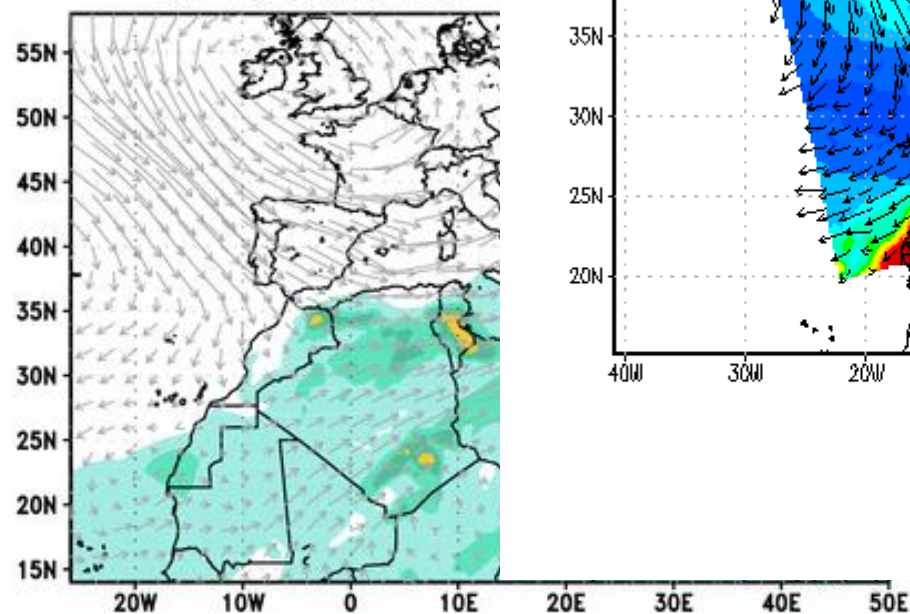




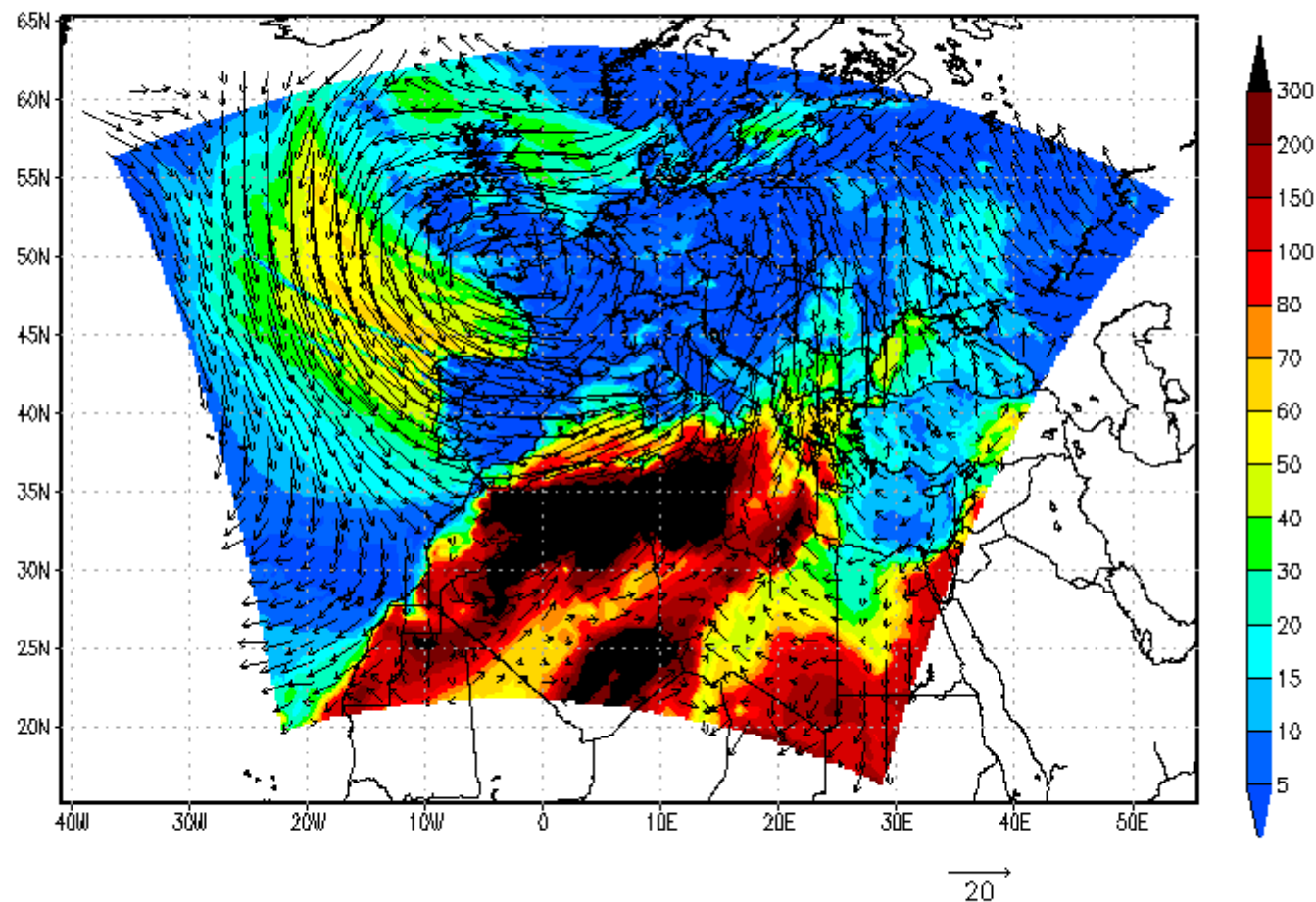
BSC-DREAM8b Total Cloud Cover  
0h forecast for 12z 08 NOV 10



BSC-DREAM8b Dust Loading  
0h forecast for



BSC-ES/AQF ARWv3+CMAQv4.5+HERMES+BSC-DREAM8b Particulate Matter PM10 ( $\mu\text{g}/\text{m}^3$ )  
0h forecast for 00z 09 NOV 10 – Europe Res:12x12km





**THANK YOU FOR  
YOUR ATTENTION**



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