www.bsc.es

EXCELENCIA SEVERO OCHOA

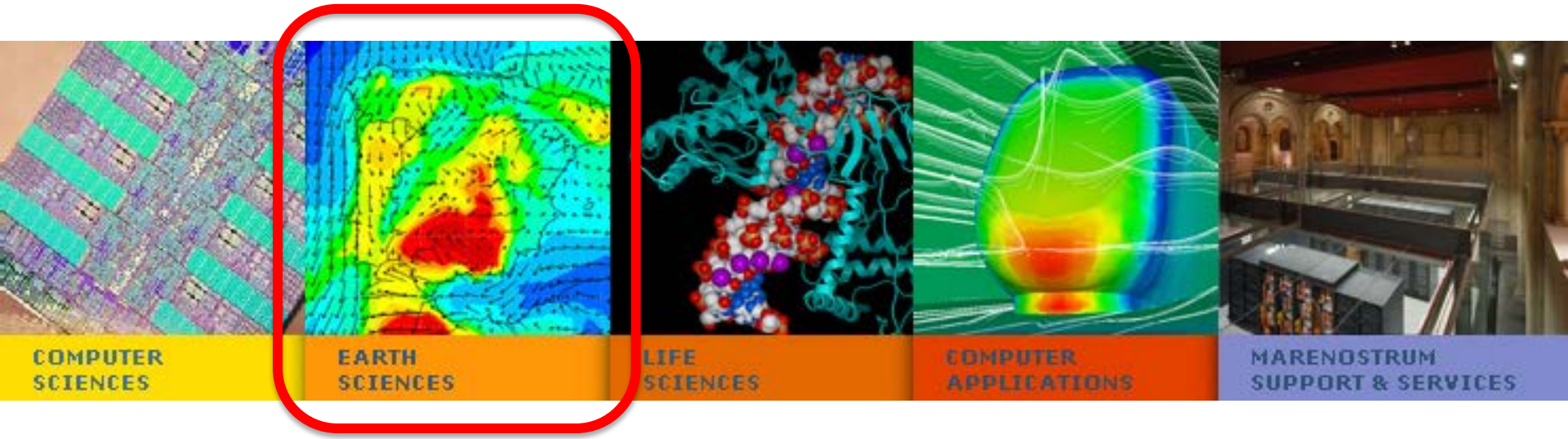
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Desert dust modelling and forecasting in the BSC: Activities and developments

S. Basart, O. Jorba, E. Terradellas, F. Benincasa and J.M. Baldasano
Earth Sciences Department
Barcelona Supercomputing Center

5th ICAP meeting, Tsukuba, Japan, 5-8 November 2013

The BSC-CNS (www.bsc.es)



The Earth Sciences Department is devoted to the development and implementation of regional and global state-of-the-art models for air quality, meteorology and climate applications

Earth Science research lines

- High resolution air quality forecast: **www.bsc.es/caliope**
- Transfer technology (EIA and AQ studies)
- Climate Change modelling
- New on-line CTM model: **NMMB/BSC-CTM**
- Dust daily forecast:
  - **BSC-DREAM8b**

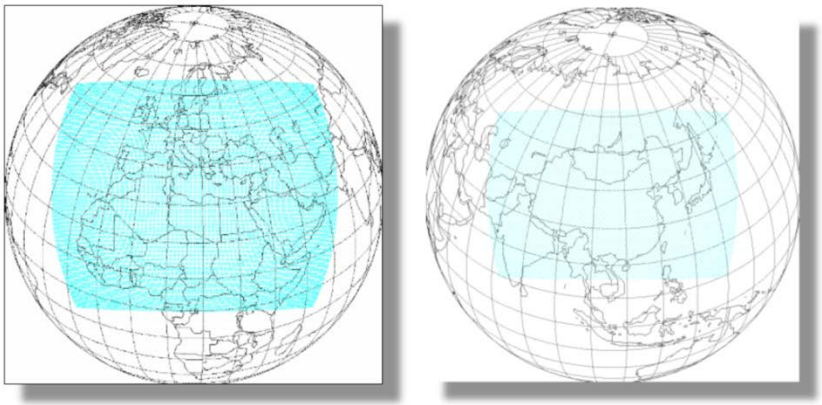
    http://www.bsc.es/projects/earthscience/BSC-DREAM/
  - **NMMB/BSC-Dust:**

    http://www.bsc.es/projects/earthscience/NMMB-BSC-DUST/
  - **Mineral dust database:** Files download

    http://www.bsc.es/earth-sciences/mineral-dust/catalogo-datos-dust/

The BSC-DREAM8b model

- Daily forecasts in 2 domains:
  - North Africa-Middle East-Europe (1/3º x 1/3º)
  - East Asia (0.5º x 0.5º)



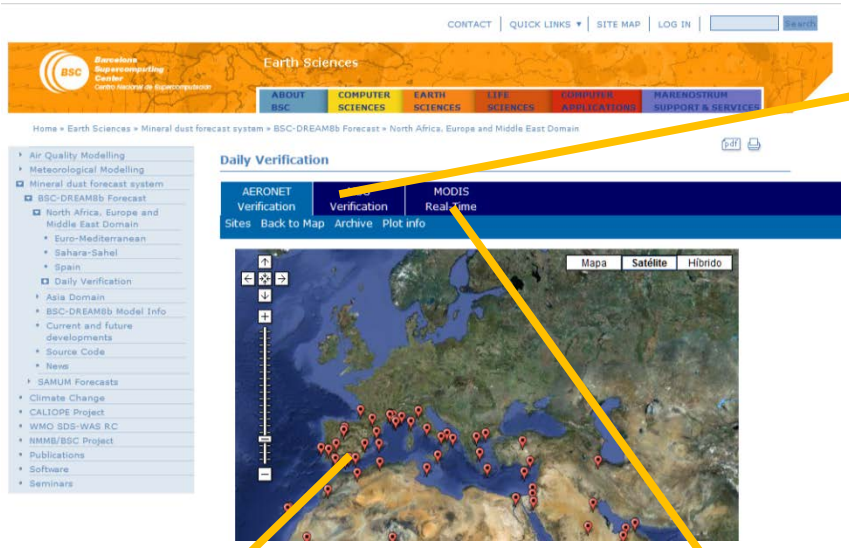
- Main features
  - USGS 1km and FAO 4km soil texture data
  - 8 particle size bin distribution (0.1 -10 μm)
  - Dust radiative feedbacks (Pérez et al., 2006)
  - *Updated dry and wet deposition*
  - *Inclusion of a preferential source mask*

Dust forecast evaluation studies:

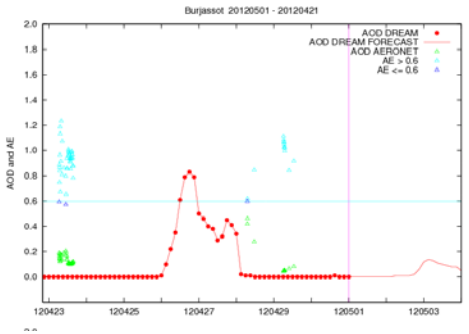
- Single events in the ***Mediterranean*** (e.g., Papayannis et al., 2005; Pérez et al., 2006)
- Experimental campaigns in ***source regions***
  - BoDEX 2005 (Todd et al., 2008)
  - SAMUM 2006 (Haustein et al., 2009)
- Anual evaluation over North Africa, Mediterranean and Middle East (Pay et al., 2011; Basart et al., 2012)
  → ***New model developments***

Near-real time evaluation

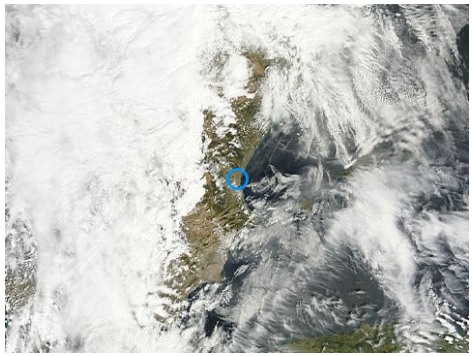
The BSC-DREAM8b model: Near-real time daily evaluation



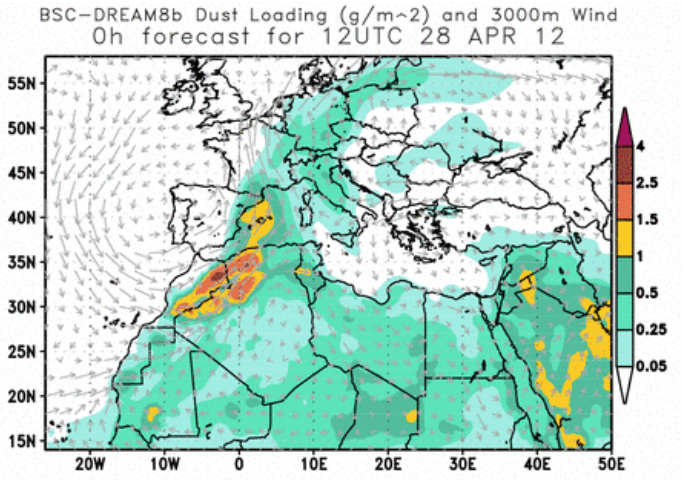
AERONET

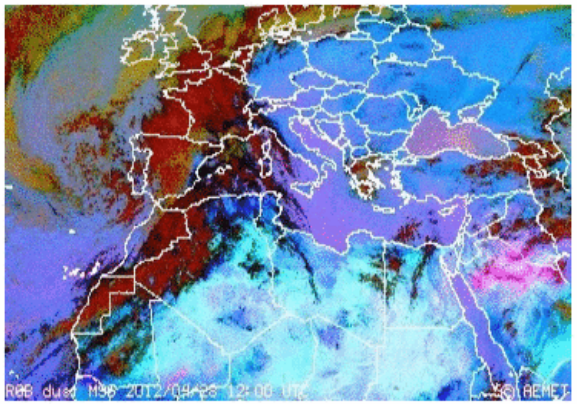


MODIS

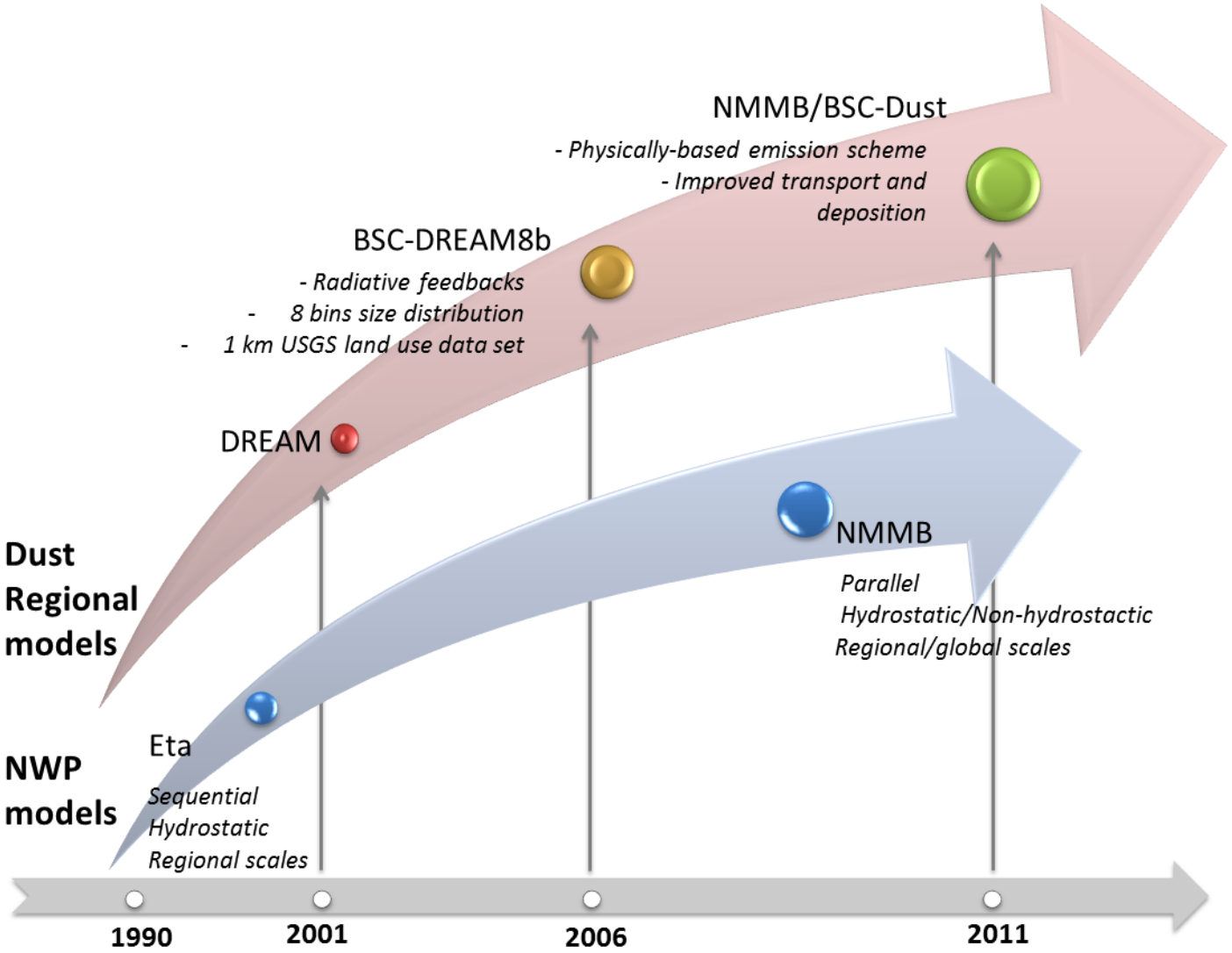


MSG/RGB





BSC dust forecasting models

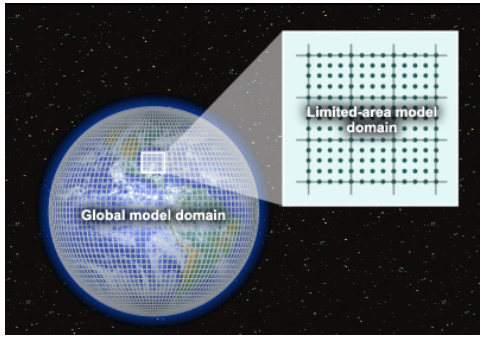


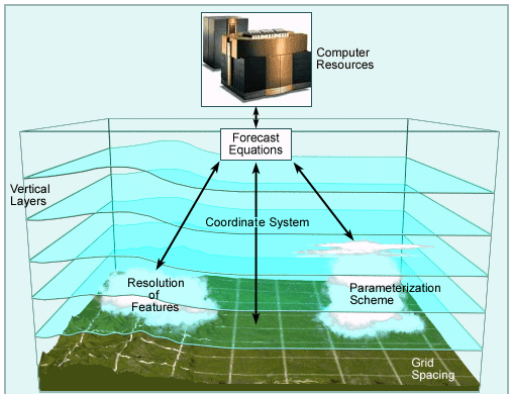
The NMMB/BSC-CTM Project

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

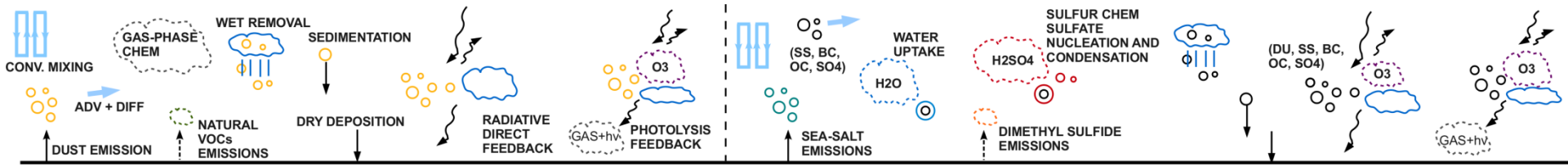
- Under development at NCEP (Janjic, 2005; Janjic and Black, 2007) as evolution of the WRF-NMM model
- Developed within the Earth System Modeling Framework (ESMF)
- Arakawa B grid and regular (global) or rotated (regional) lat/lon coordinate
- NMMB is the regional operational meteorological model in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

Multiscale (global to regional) and ***Nonhydrostatic*** (up to 1km^2 lat-lon resolution)

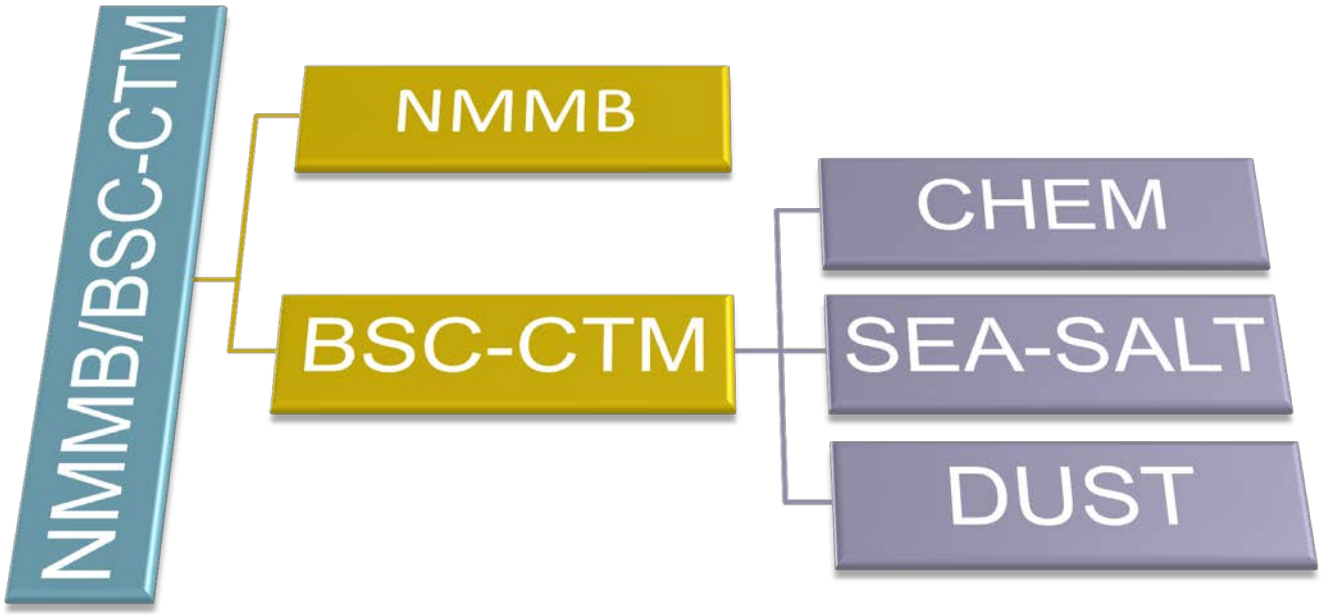




NMMB/BSC-Chemical Transport Model

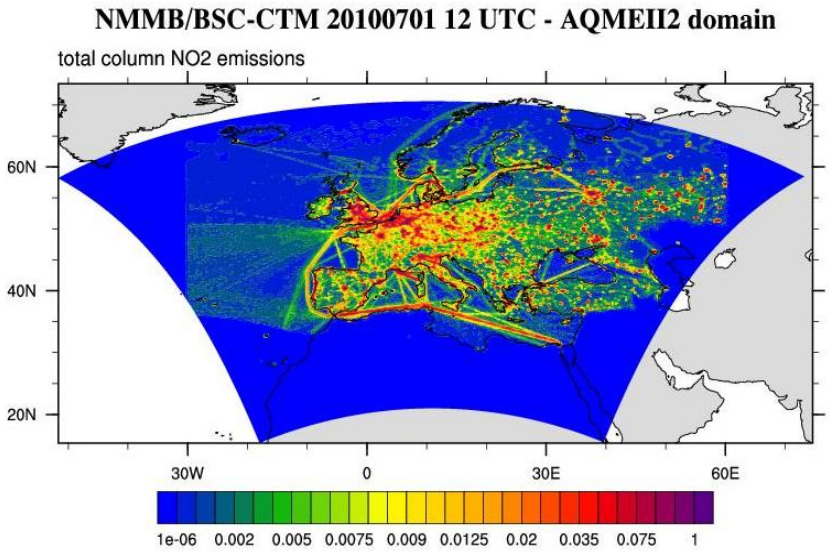


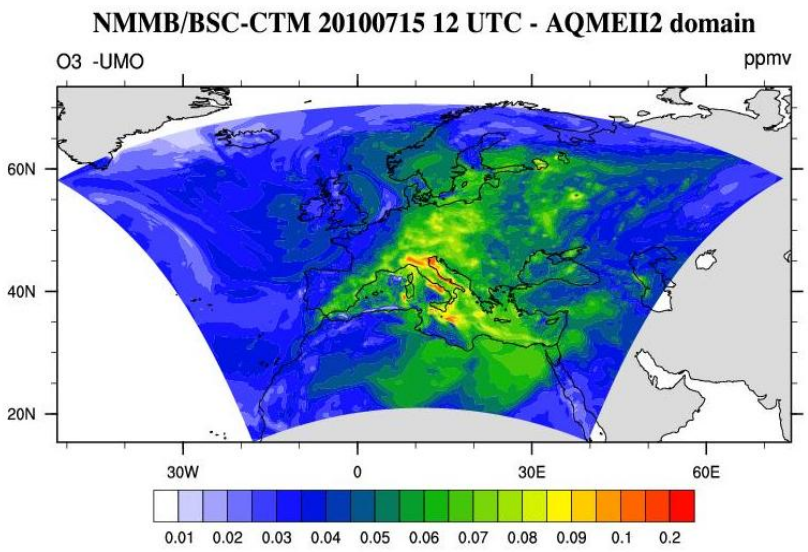
- Fully ***on-line*** access coupling: feedback processes allowed
- ***Multiscale***: global to regional scales allowed

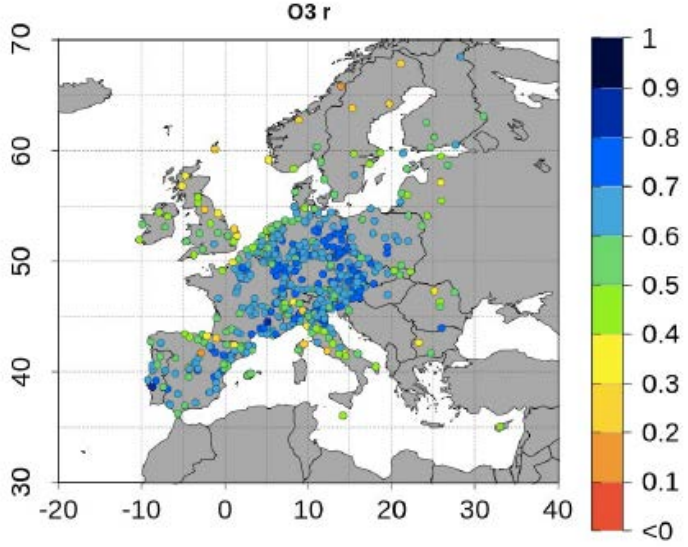


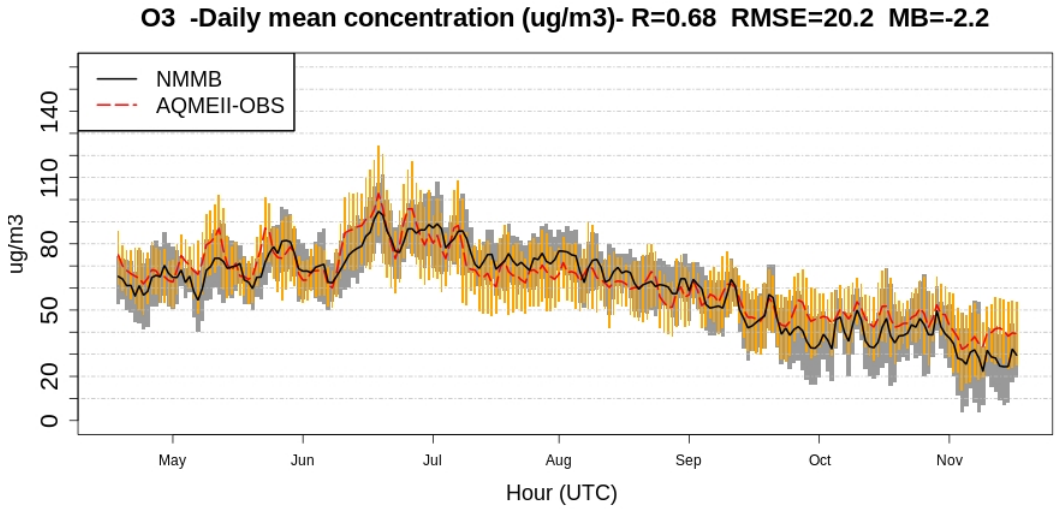
NMMB/BSC-Gas Phase (Jorba et al. 2012)

Regional run: 2010



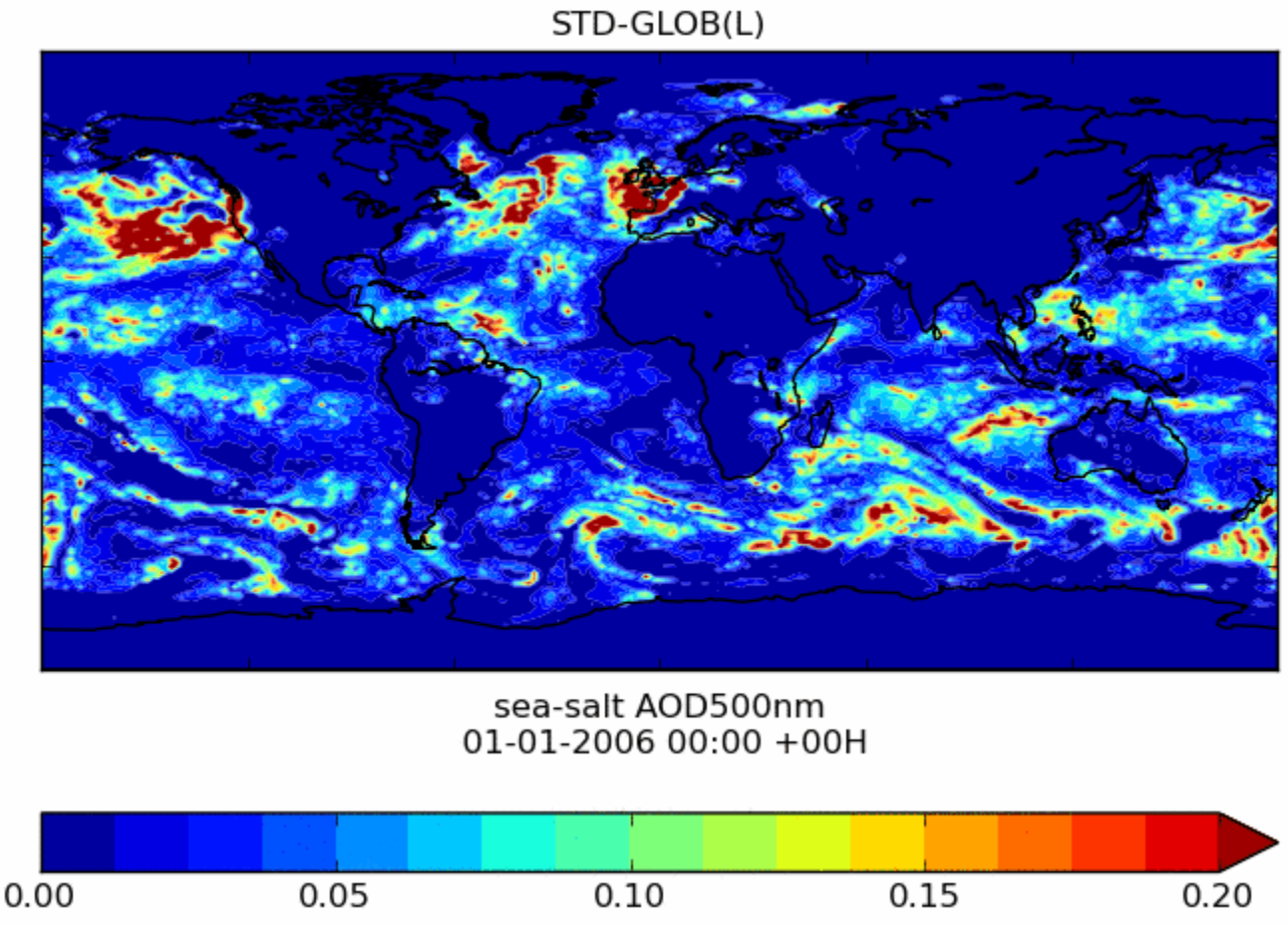






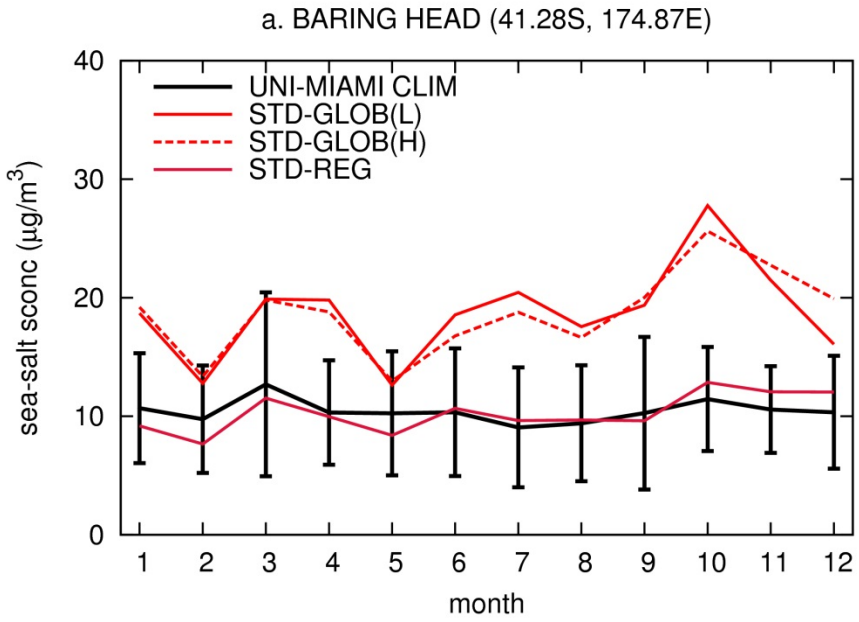
NMMB/BSC-SSA (Spada et al. 2013)

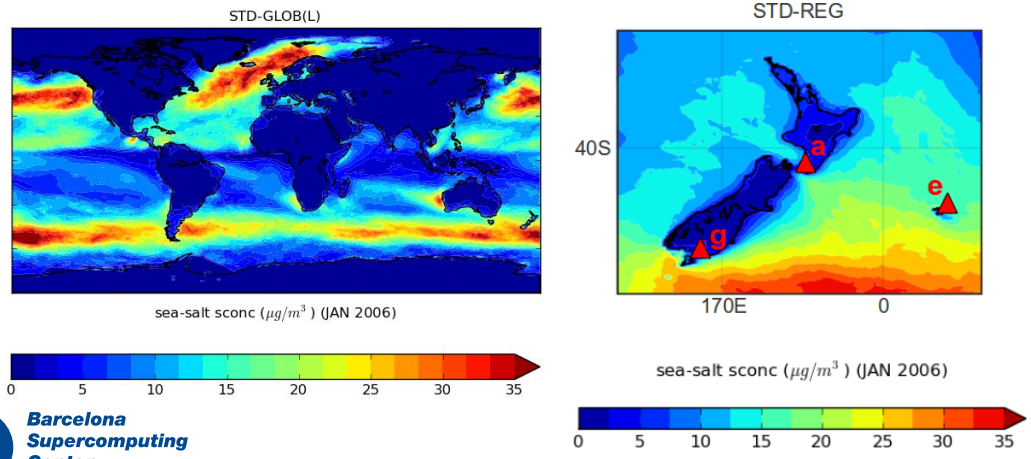
Global run: AOD at 550nm 2006



NMMB/BSC-SSA (Spada et al. 2013)

· GLOB(L) and GLOB(H) resolutions seem to give quite similar results, although...





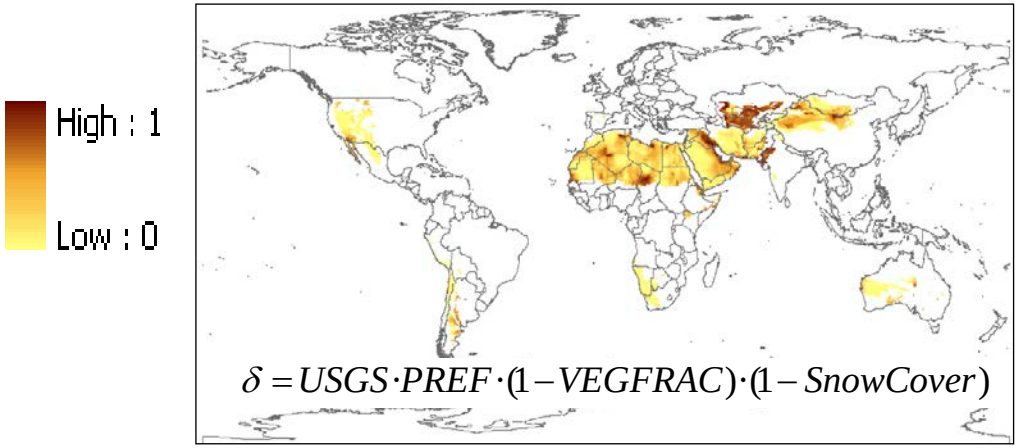
→ at smaller scales (REG = 0.1 x 0.1) the model becomes able to resolve steep topographies

→ in these cases (such as for the New Zealand domain), the observed SCONC climatologies are reproduced

→ obvious but not trivial: smaller scales (≈0.1deg) effects may affect larger scales (>1deg)

NMMB/BSC-Dust (Pérez et al. 2011)

- **Source function: update databases**



- **Physically-based emission scheme: Saltation and sandblasting**

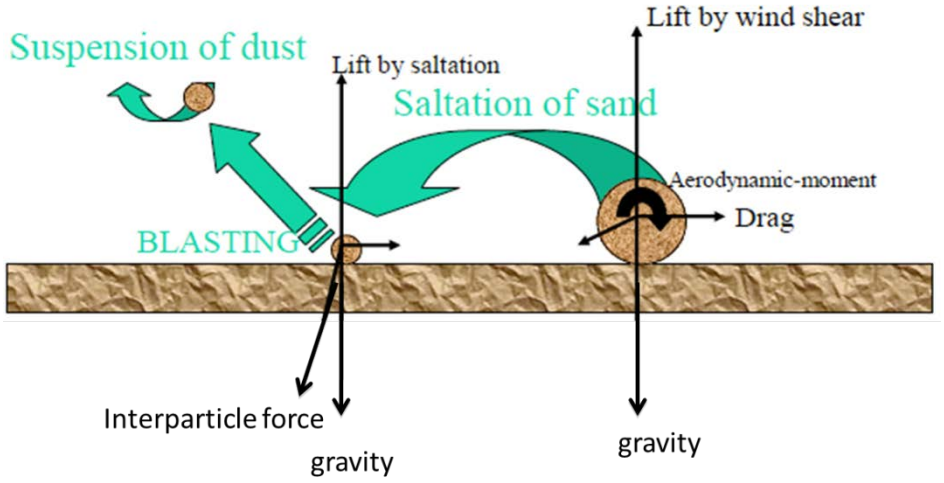
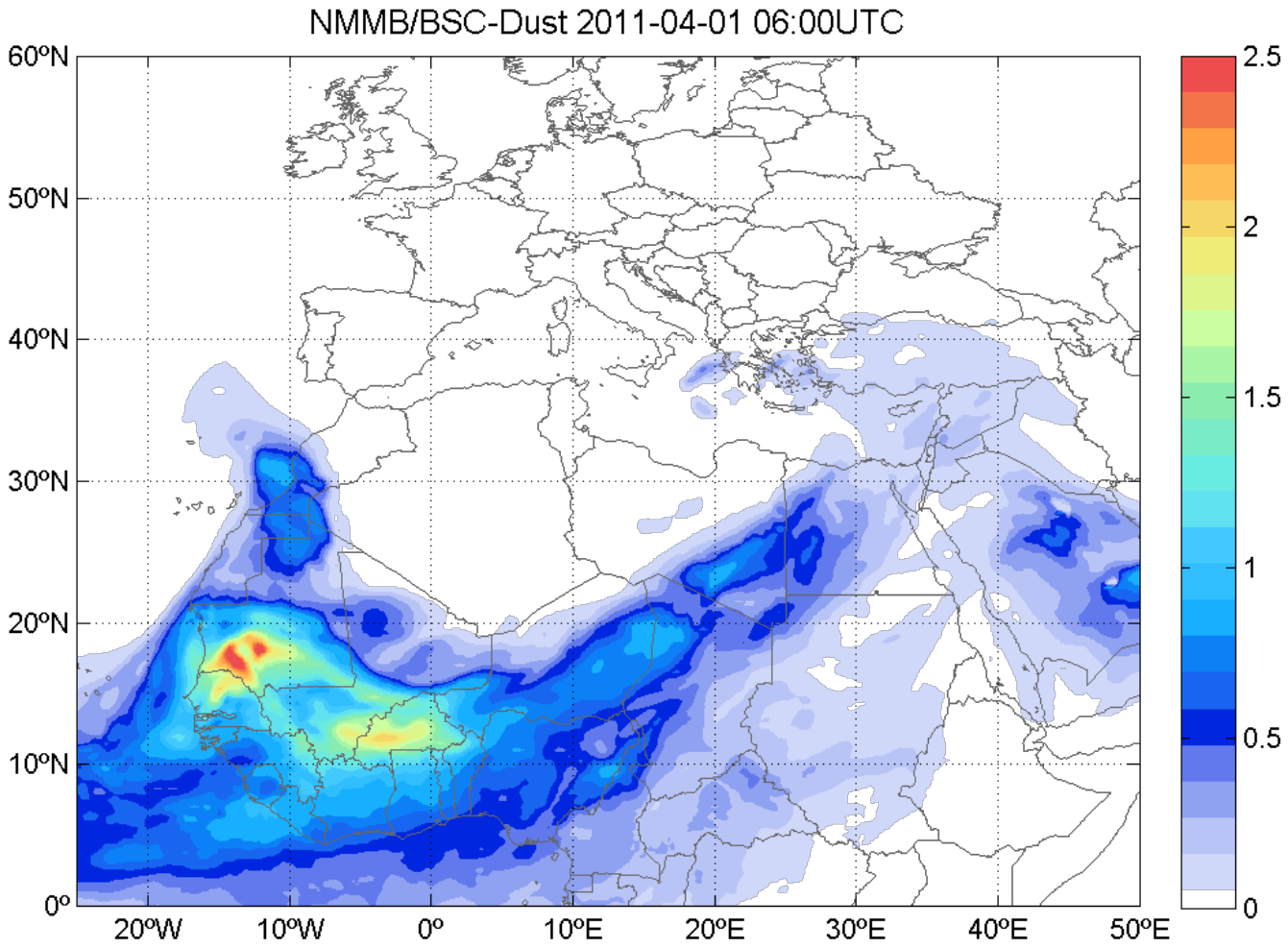


Image from Carlos Pérez

NMMB/BSC-Dust (Pérez et al. 2011)

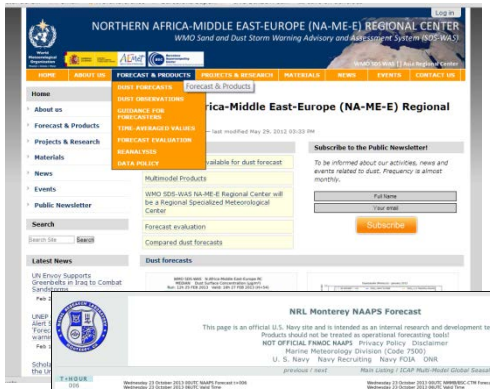
Regional run: AOD at 550nm April 2011

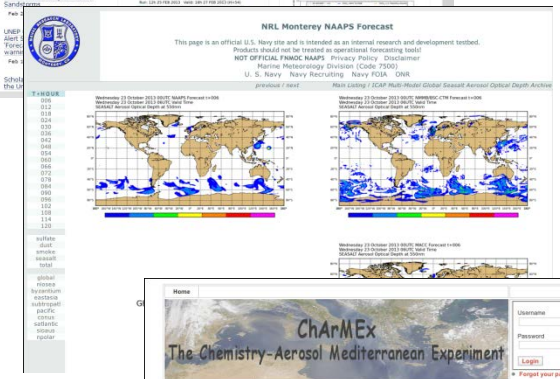


NMMB/BSC-CTM: Future Developments

- Coupling of chemistry gas-phase with a secondary aerosol scheme for LAM applications at high-resolutions.
- Implementation of the other global relevant aerosol species, i.e. black (BC) and organic carbon (OC), and sulfate (SO4), in addition to dust (DU) and sea salt (SSA).
- Implementation of a volcanic ash module (Fall3D model, Folch et al., 2008)
- Implement effects of aerosols on meteorology
- Coupling the model with an ocean model for climate applications
- Explore methodologies for aerosol data assimilation

BSC dust forecasting collaborations





· **Mineral dust forecasts for SDS-WAS North Africa, Middle East and Europe portal**

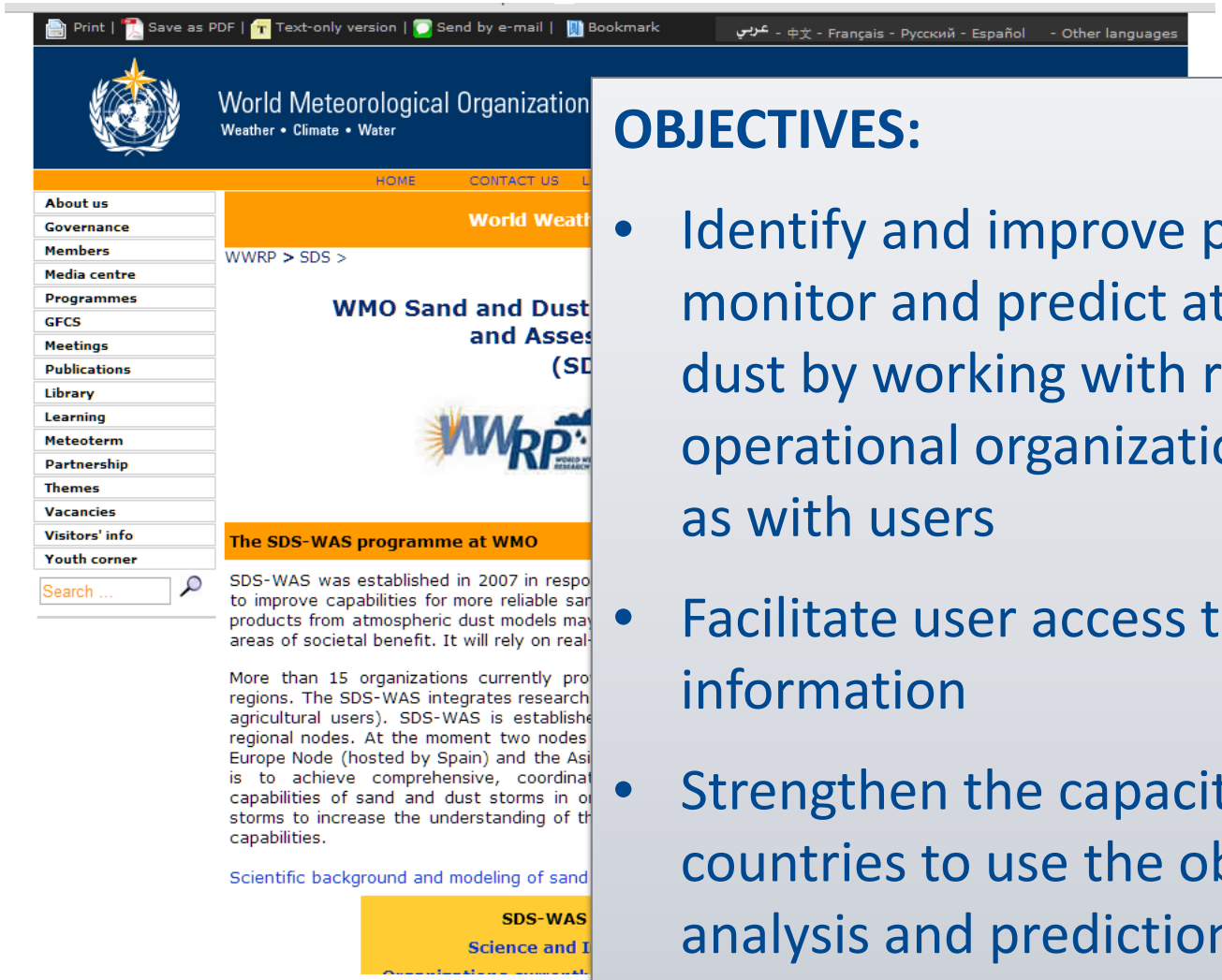
http://sds-was.aemet.es/

· **Participate in the ICAP global-model intercomparison project**

· **Participate in the Charmex Chemistry-Aerosol Mediterranean experiment**

· **Participate in the AQMEII on-line Air Quality model intercomparison project**

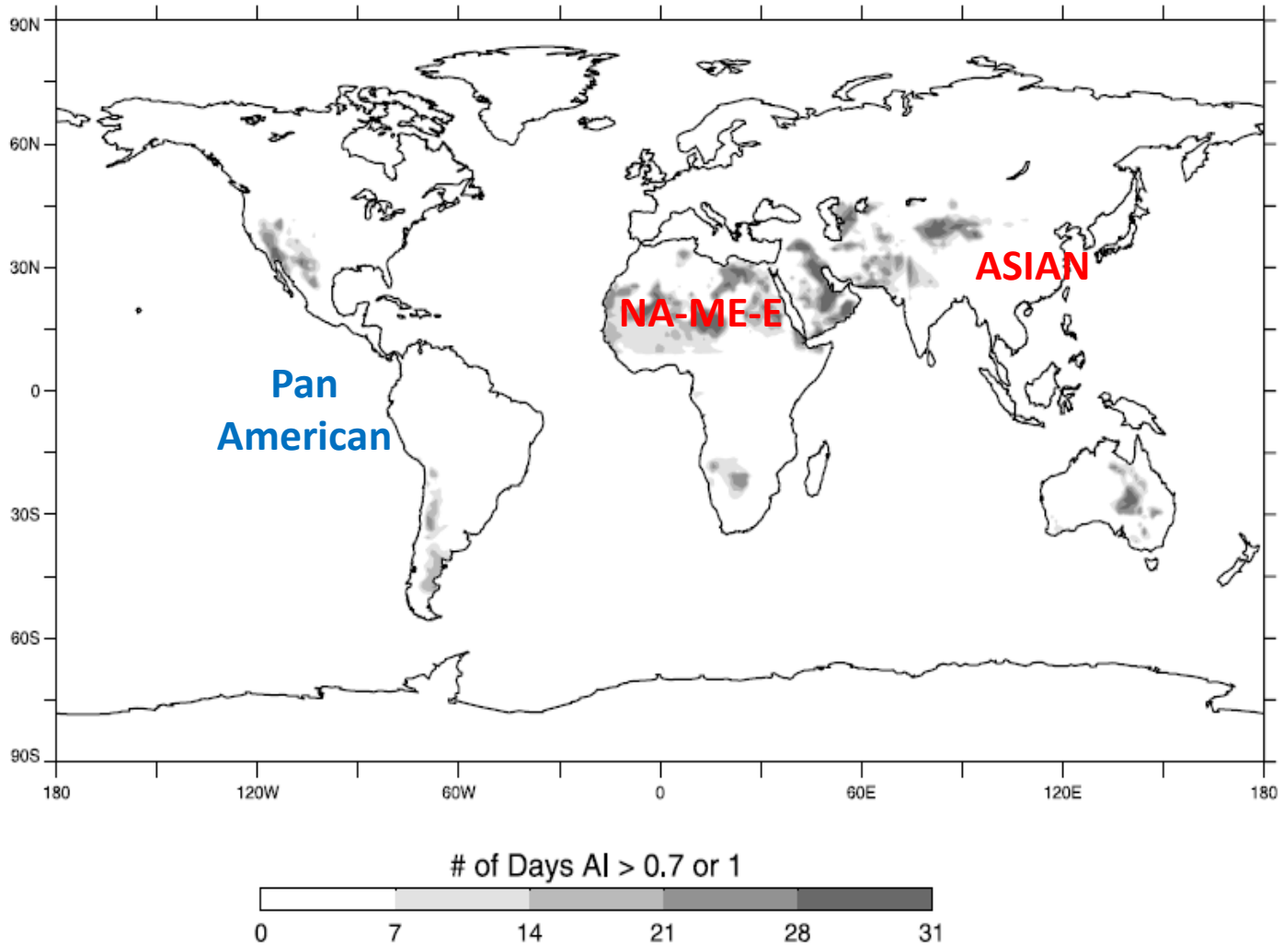
SDS-WAS: http://www.wmo.int/sdswas



OBJECTIVES:

- Identify and improve products to monitor and predict atmospheric dust by working with research and operational organizations, as well as with users
- Facilitate user access to information
- Strengthen the capacity of countries to use the observations, analysis and predictions provided by the WMO SDS-WAS programme

SDS-WAS Regional Centers



The global distribution of TOMS dust sources.
Extracted from Prospero et al. (2002, Rev. Geophys.)

SDS-WAS: Asian RC (http://www.sds.cma.gov.cn)

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

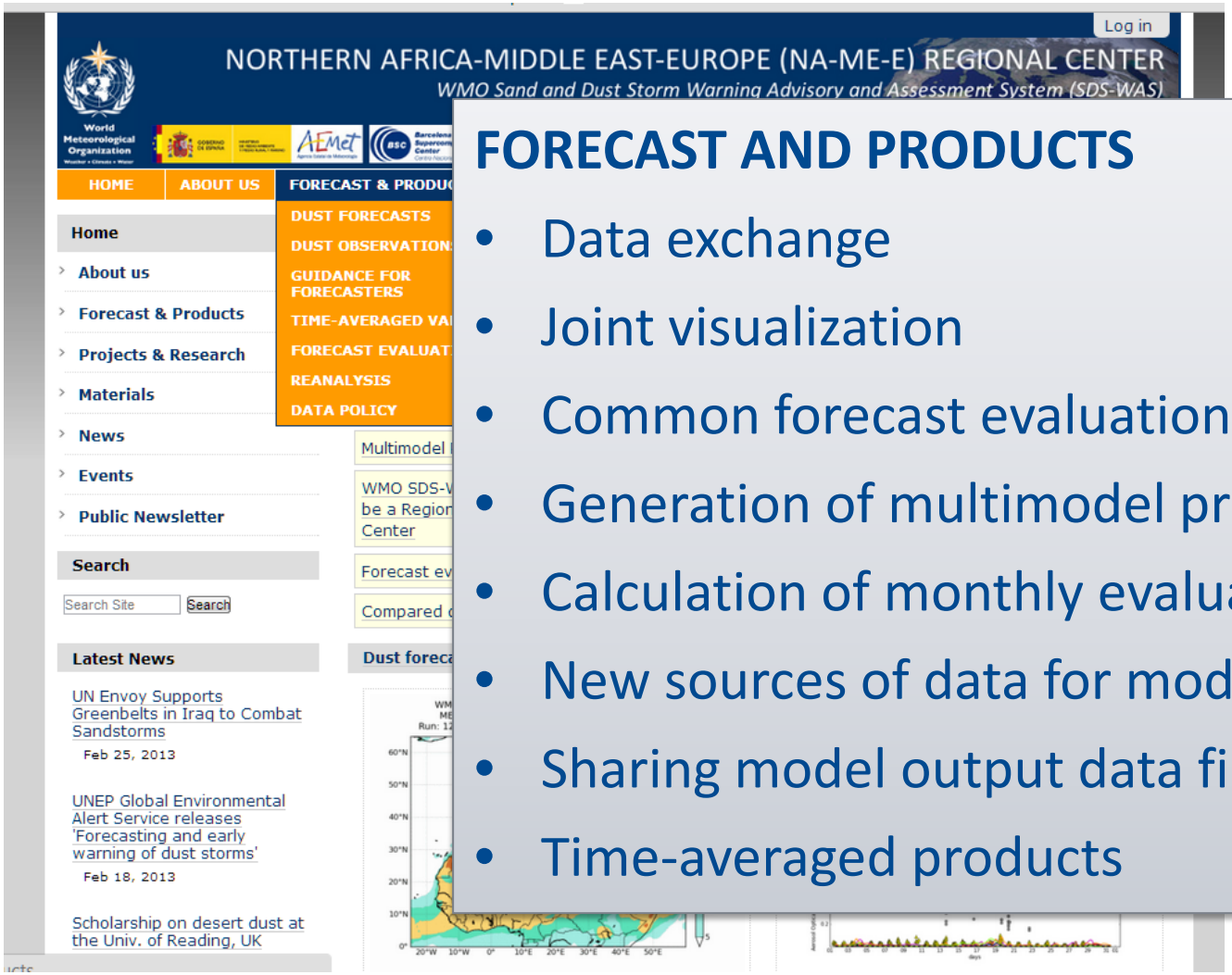
The Center is managed by a consortium of AEMET and the Barcelona Supercomputing Center (BSC-CNS)

GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
AEMet Agencia Estatal de Meteorología
BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

Nexus II Building. Barcelona

MareNostrum supercomputer

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

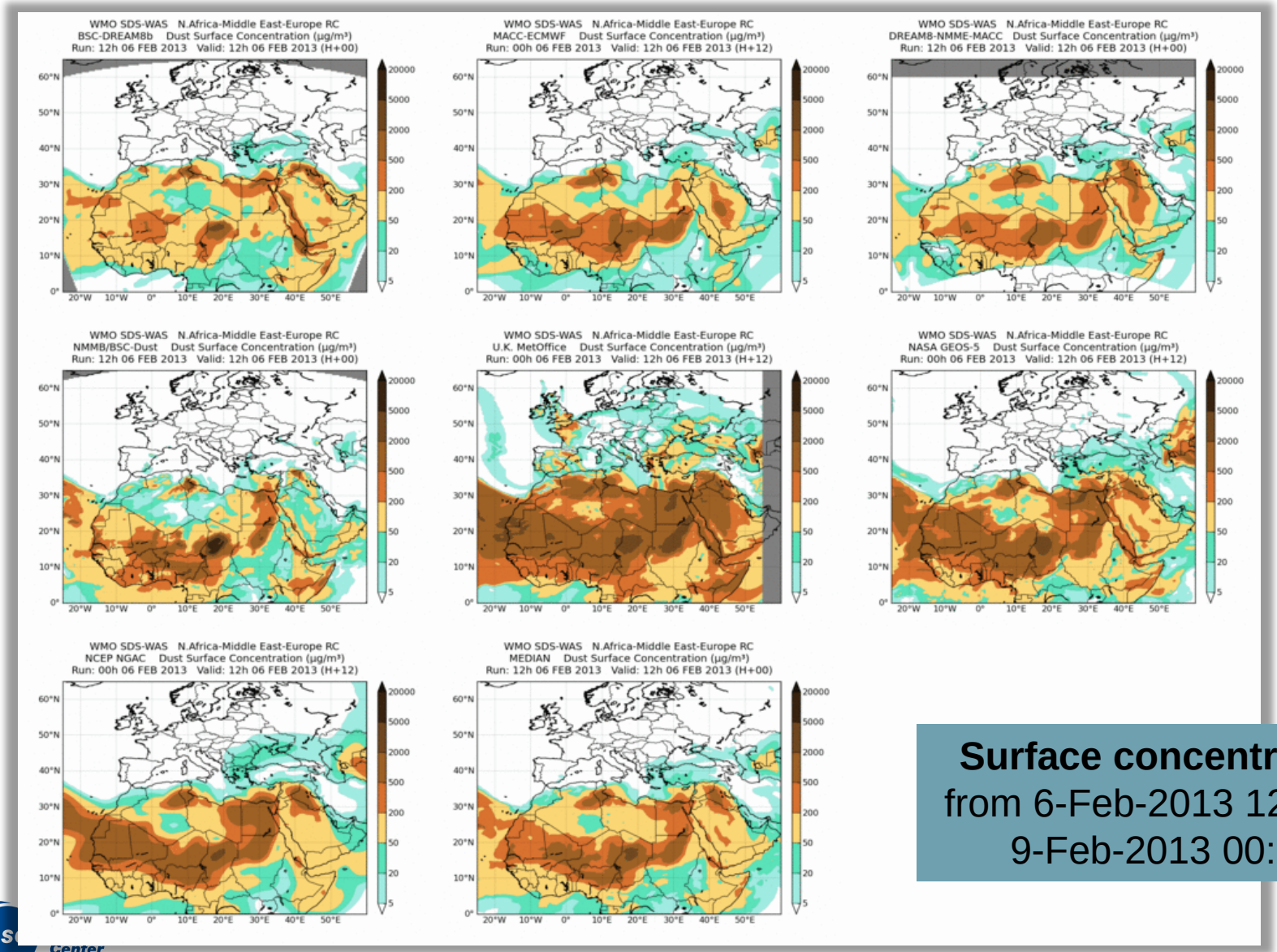
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

sdswas@aemet.es

SDS-WAS: Dust models

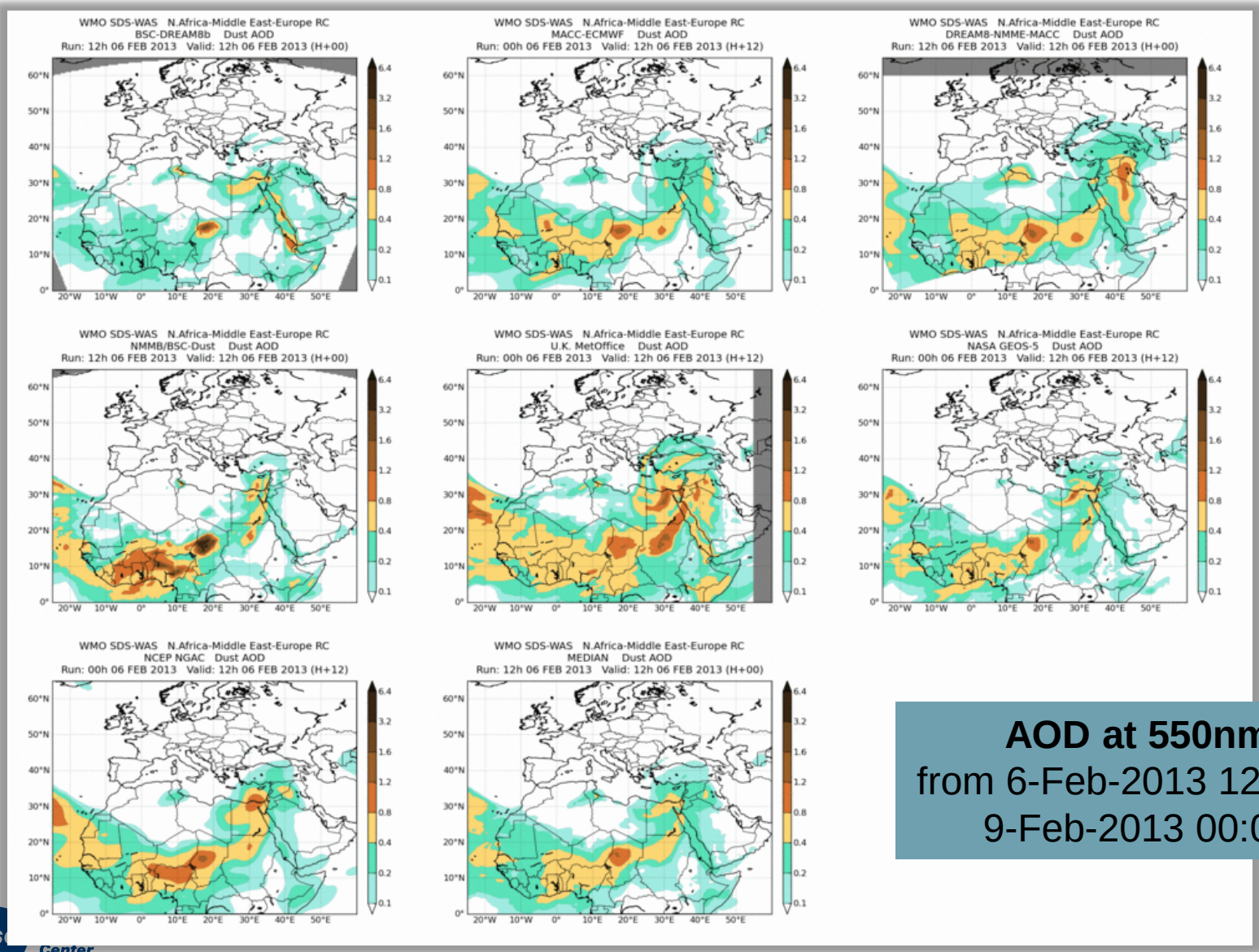
MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
MACC	00	Global	MODIS AOD
DREAM-NMME-MACC	12	Regional	MACC analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No

SDS-WAS: Surface concentration joint visualization



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

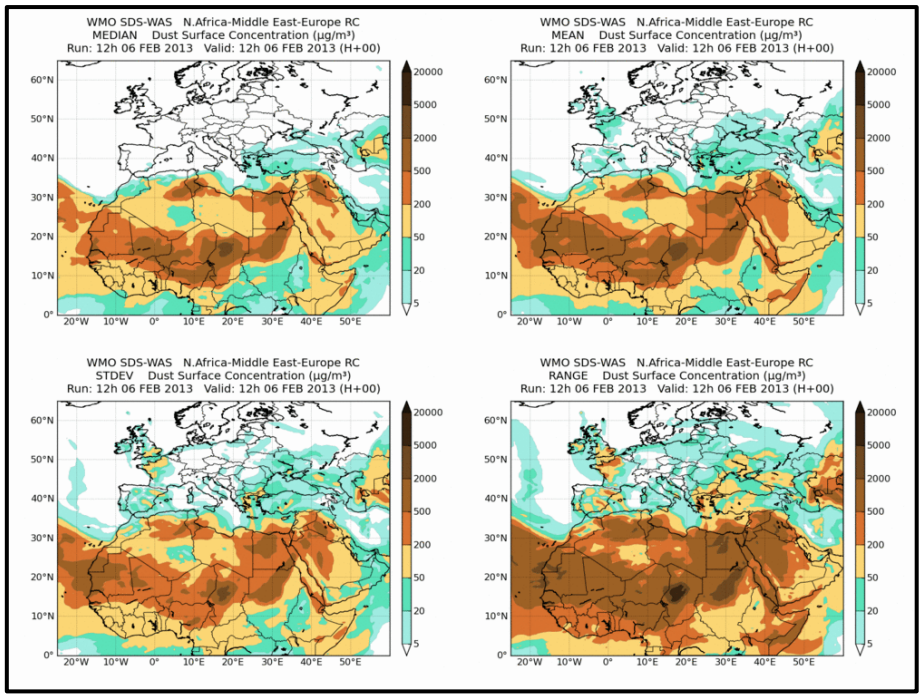
SDS-WAS: AOD joint visualization



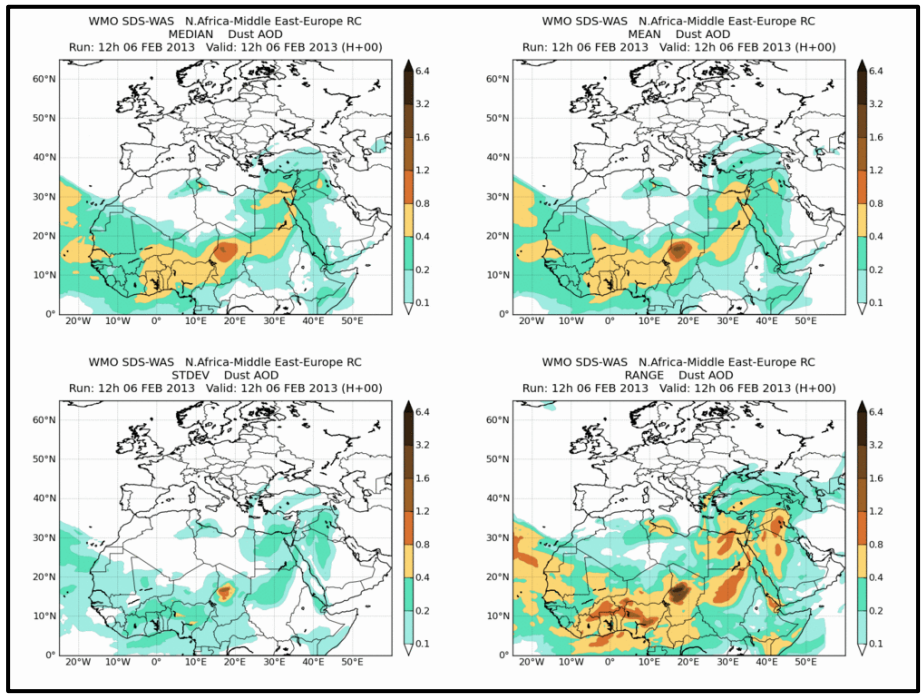
AOD at 550nm
from 6-Feb-2013 12:00 to
9-Feb-2013 00:00

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:

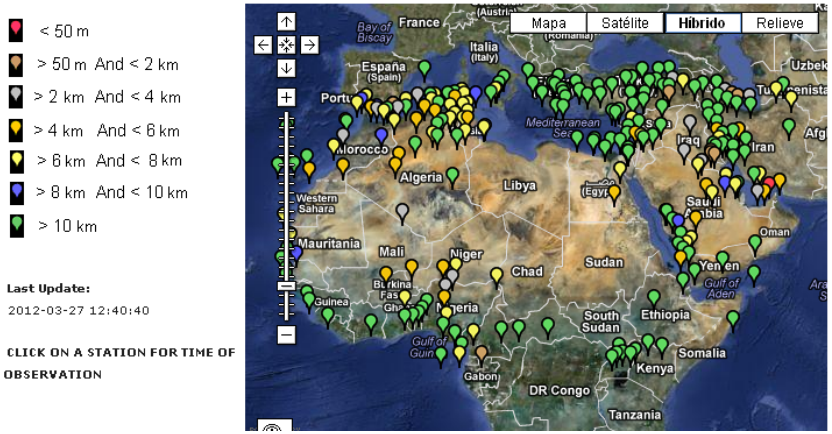
CENTRALITY: median - mean

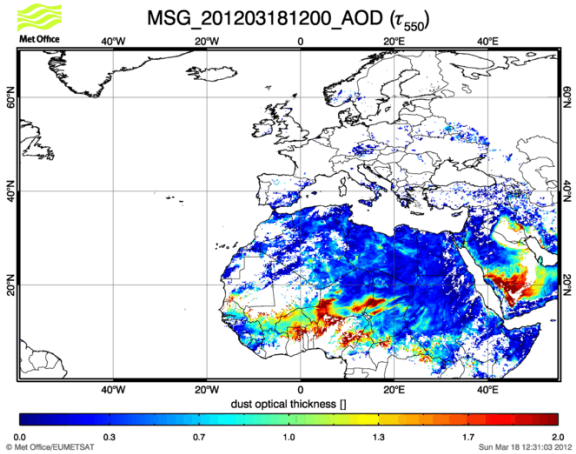
SPREAD: standard deviation – range of variation

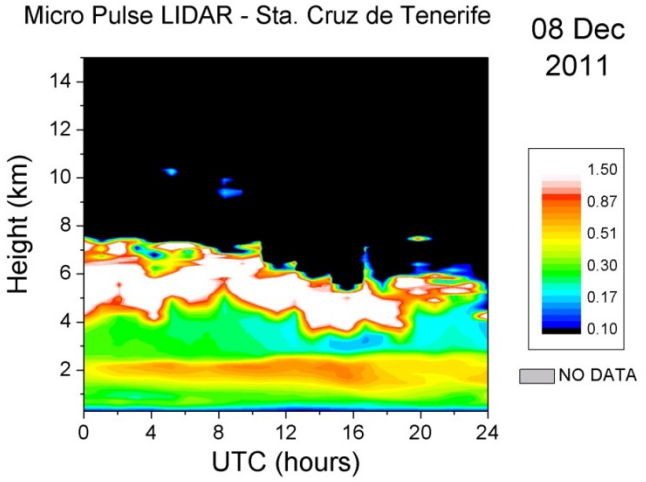
SDS-WAS: Dust observations

New sources of data for model evaluation

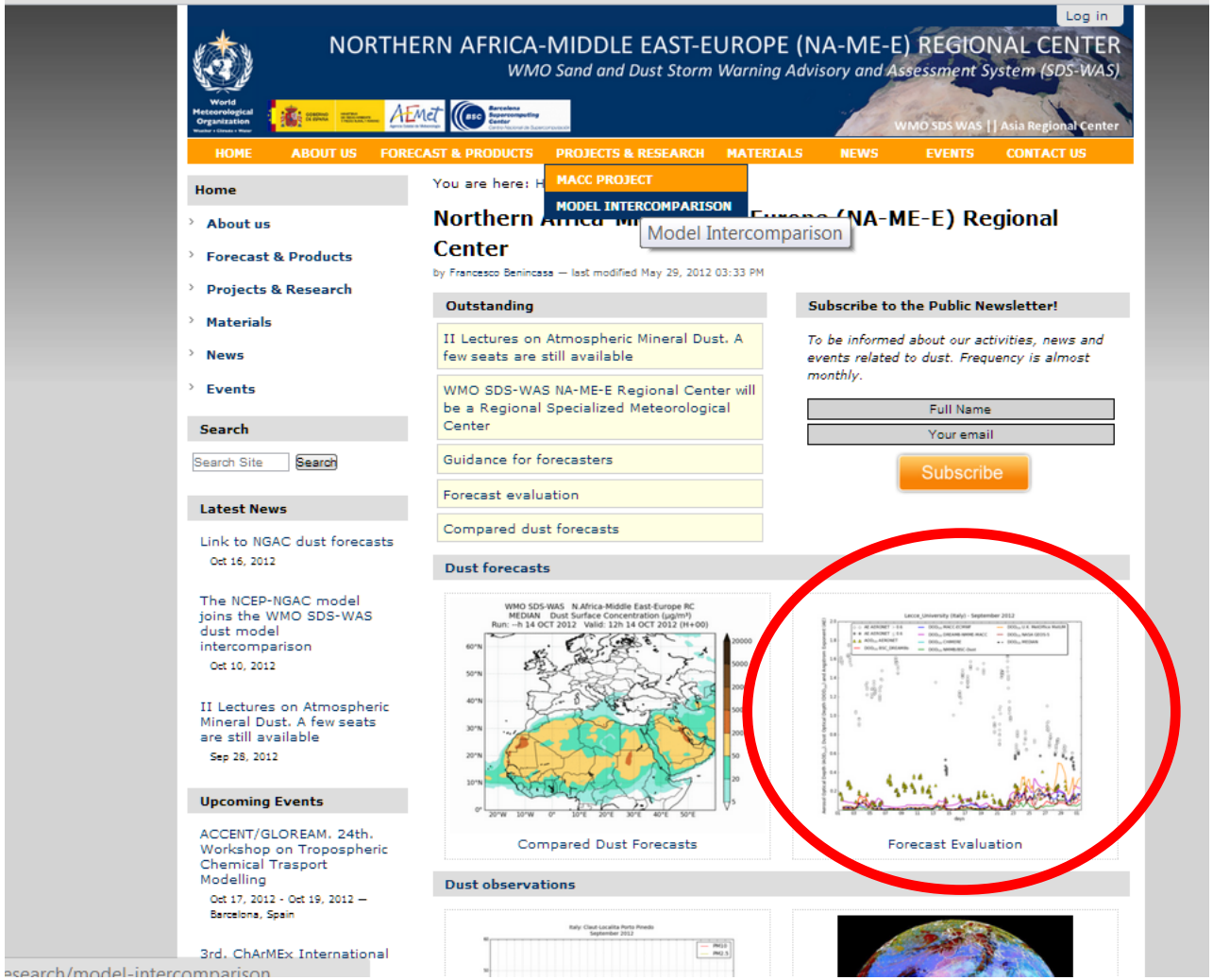
- Visibility
- MSG
- MODIS
- OMI
- CALIPSO
- PARASOL
- MPLNET
- PM_{10}





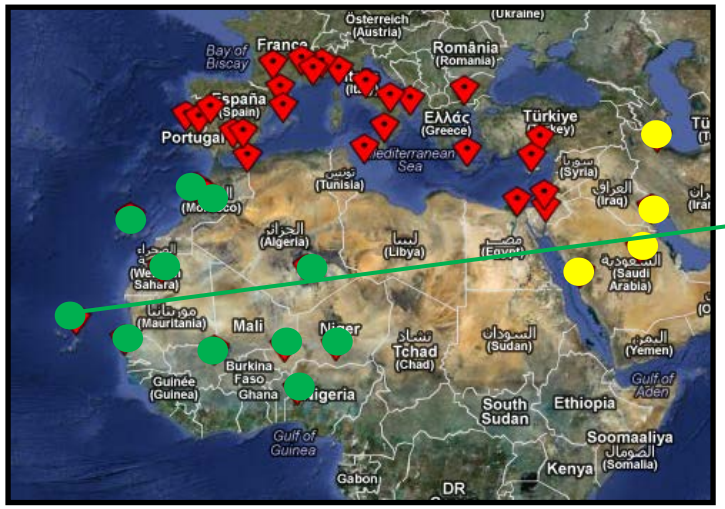


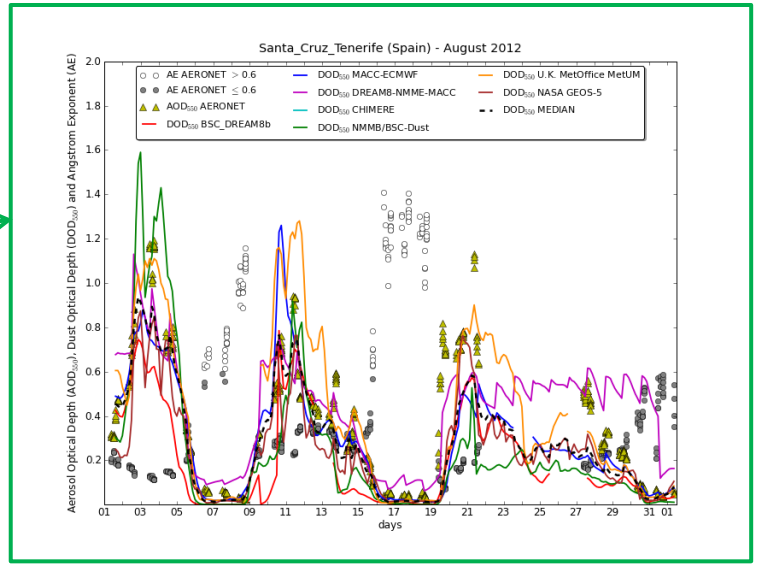
SDS-WAS: Model intercomparison



http://sds-was.aemet.es

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

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

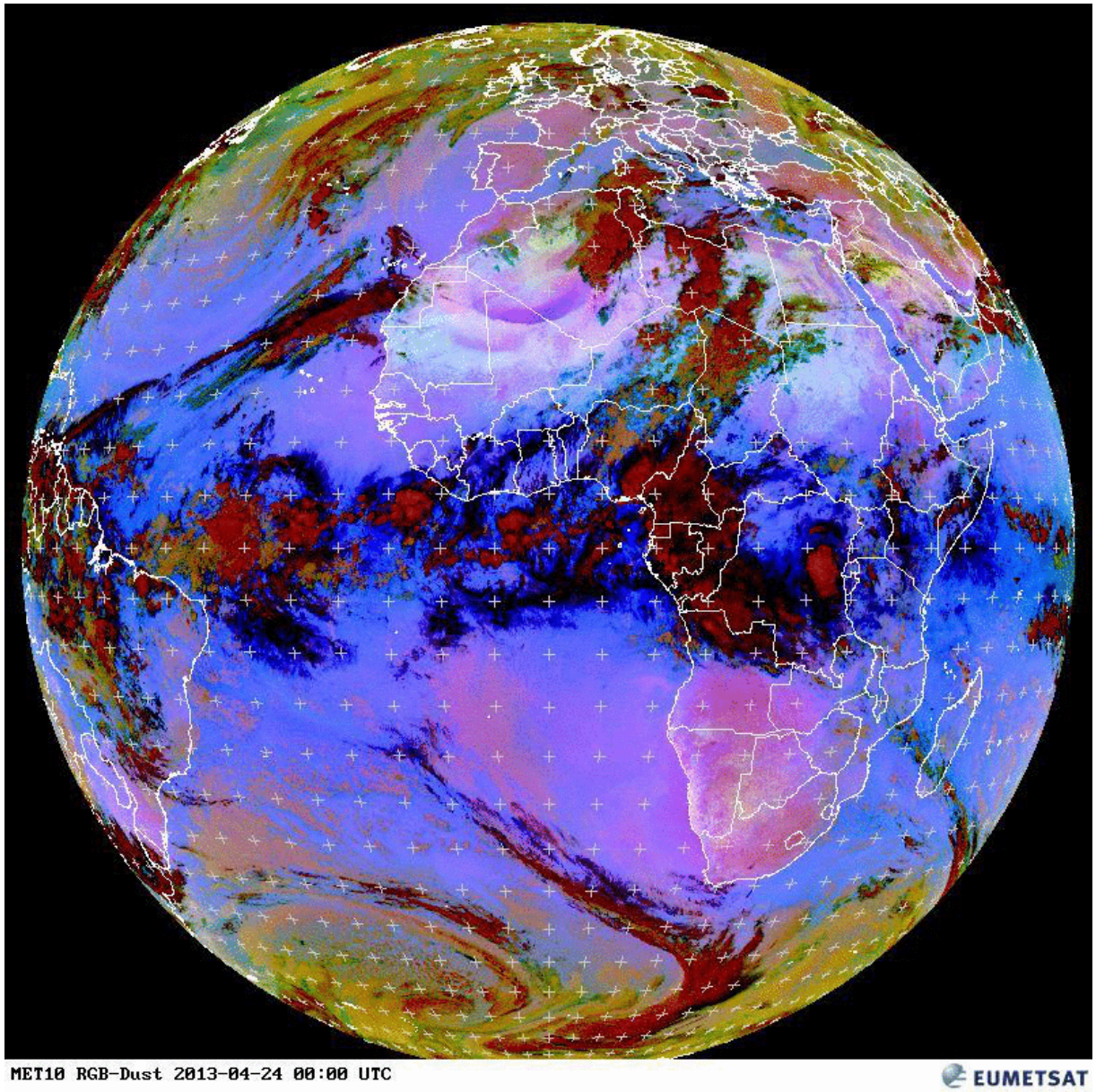
	BSC_ DREAM8b	MACC-ECMWF	DREAM8-NMME-MACC	CHIMERE	NMMB/BSC-Dust	MEDIAN
TOTAL	0.62	0.57	0.45	0.59	0.50	0.53

NUMBER OF CASES show stations

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

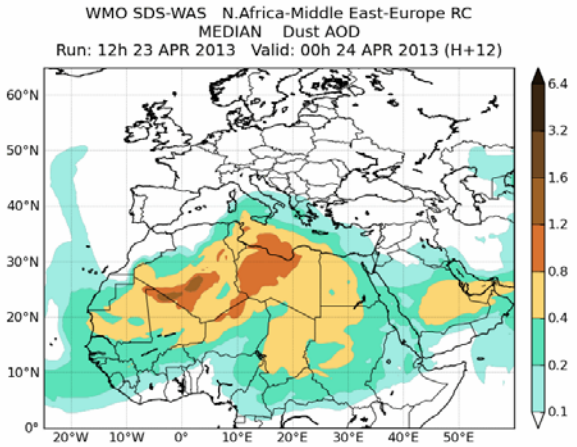
- Besides dust, there might be other aerosol types (anthropogenic, biomass burning, etc.). Then, a small BE could be expected.
- Scores for individual sites can be little significant for being calculated from a small number of data.
- The RMSE is strongly dominated by the largest values. Especially in 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



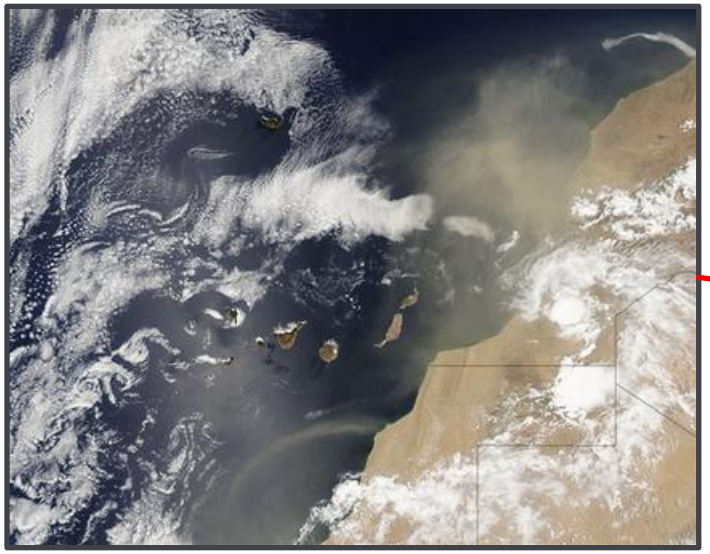
EUMETSAT

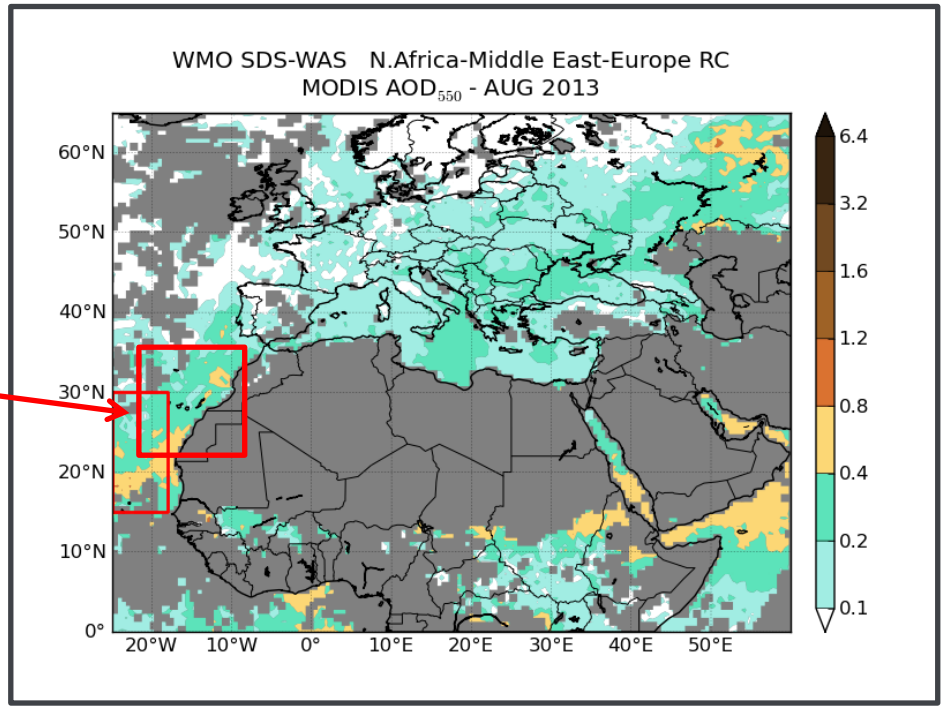
24 April 2013



SDS-WAS: NRT Evaluation using MODIS

19th August 2013

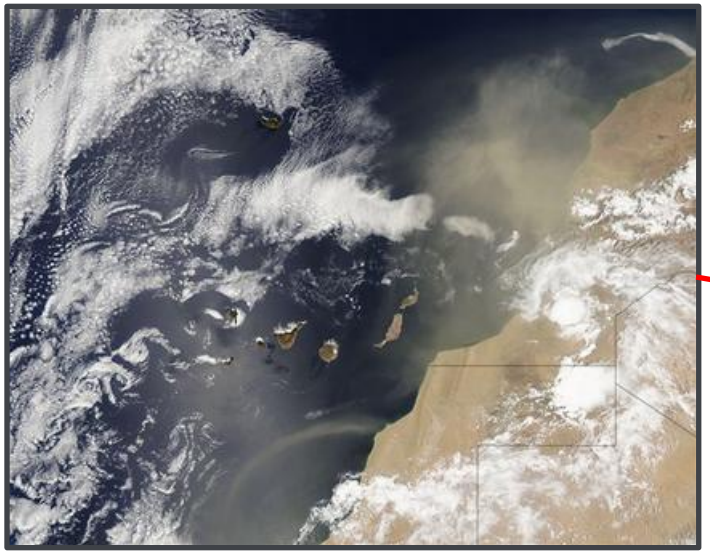


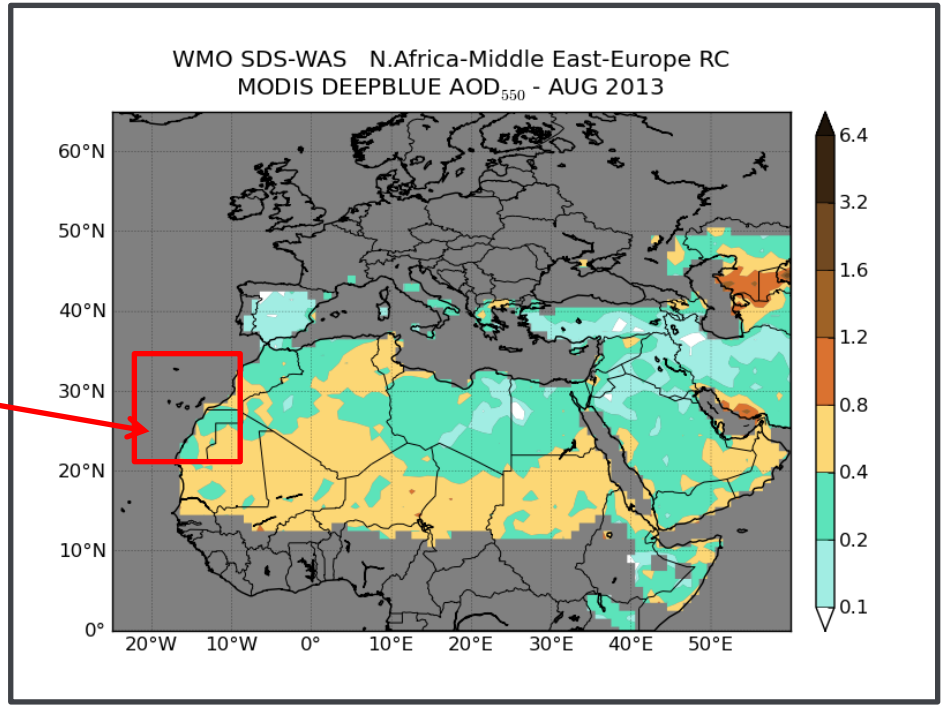


	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.16	0.21	0.70	0.87	1220
NMMB/BSC-Dust	-0.13	0.20	0.68	0.81	1038
NCEP NGAC	0.14	0.21	0.78	0.41	1228

SDS-WAS: NRT Evaluation using MODIS Deep Blue

19th August 2013





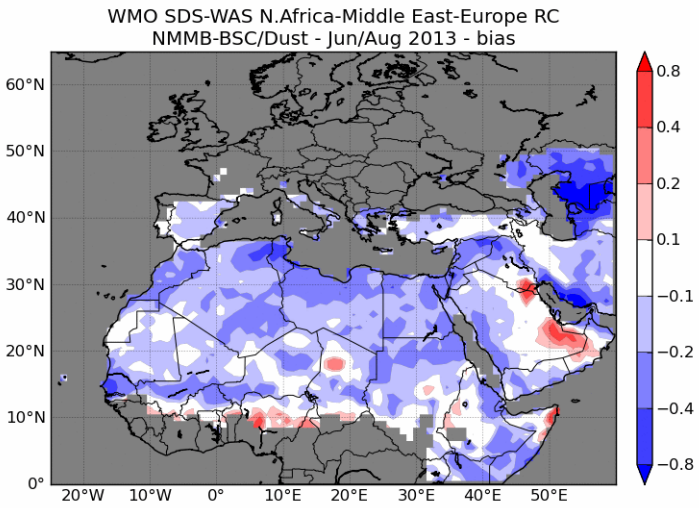
	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.17	0.31	0.28	0.96	42618
NMMB/BSC-Dust	-0.20	0.33	0.29	1.05	41049
NCEP NGAC	-0.06	0.29	0.32	0.64	42664

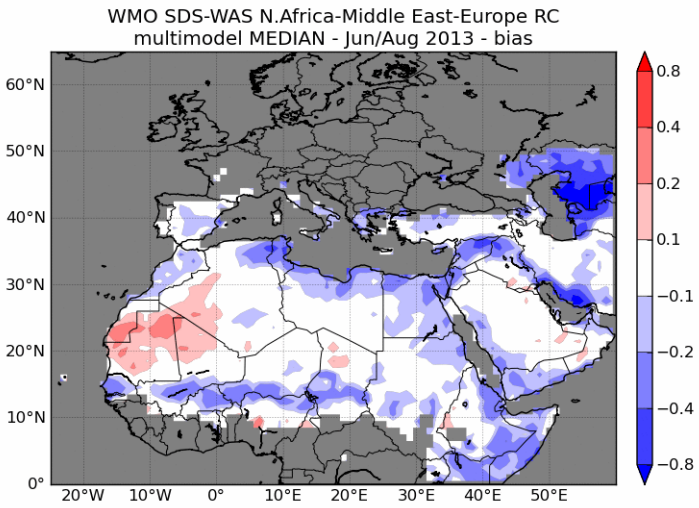
SDS-WAS: NRT Evaluation using MODIS Deep Blue

NMMB-BSC/Dust

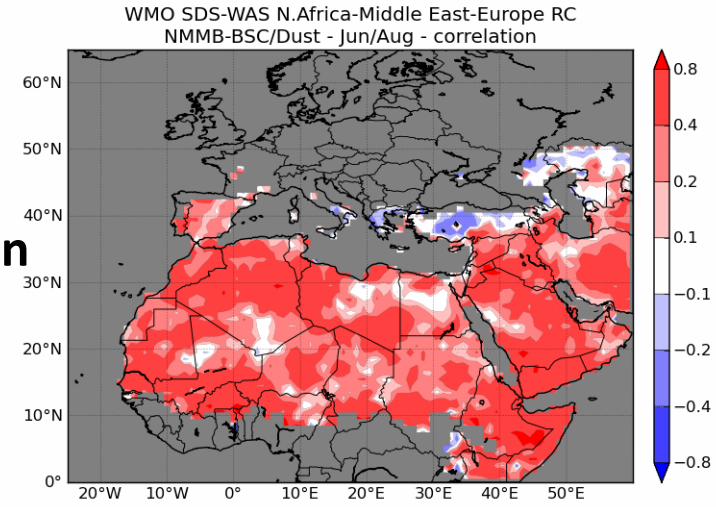
Multimodel MEDIAN

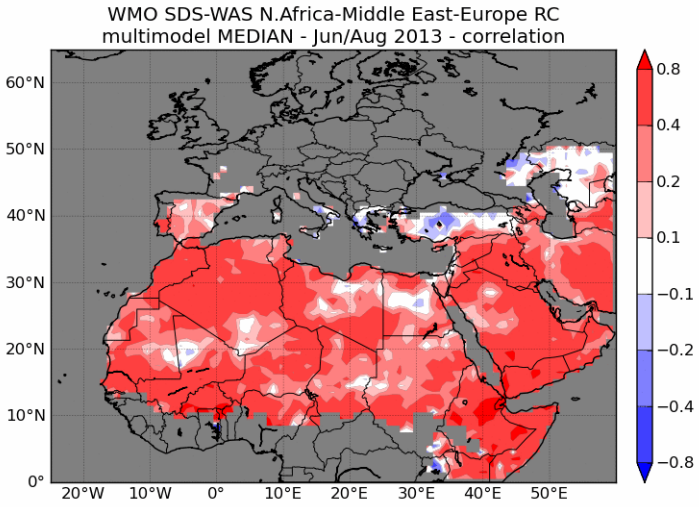
MB





Correlation



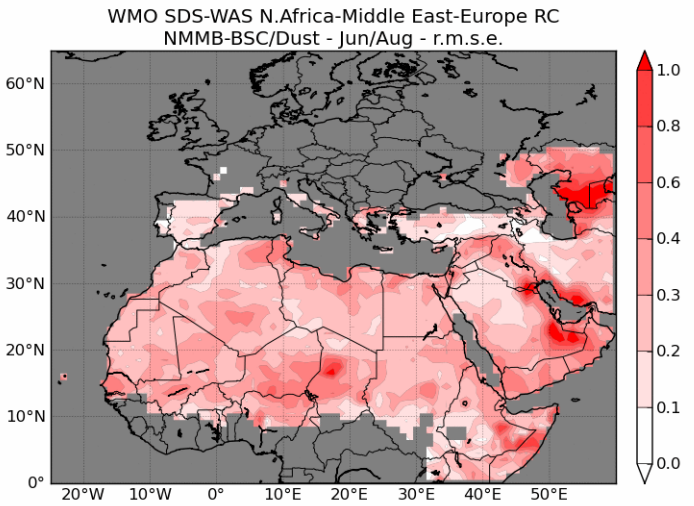


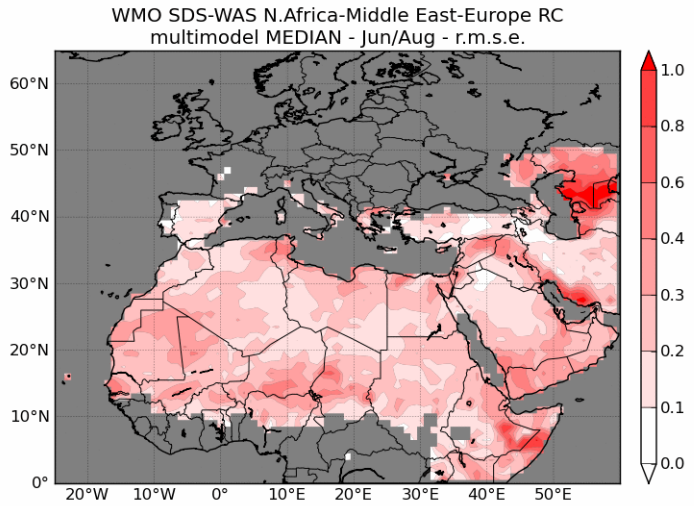
SDS-WAS: NRT Evaluation using MODIS Deep Blue

NMMB-BSC/Dust

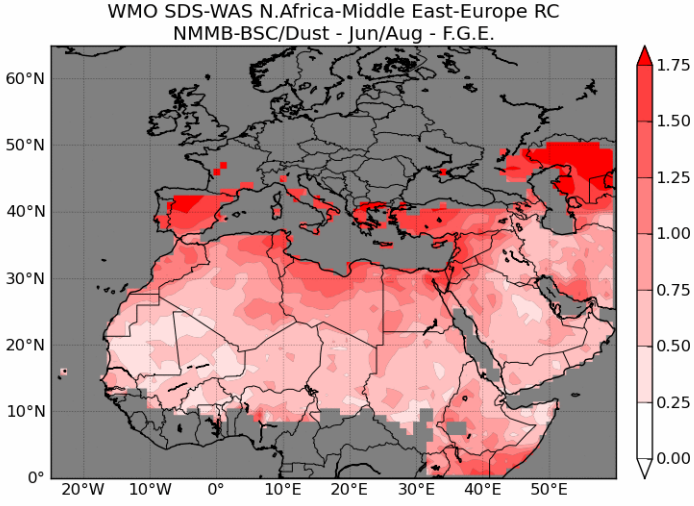
Multimodel MEDIAN

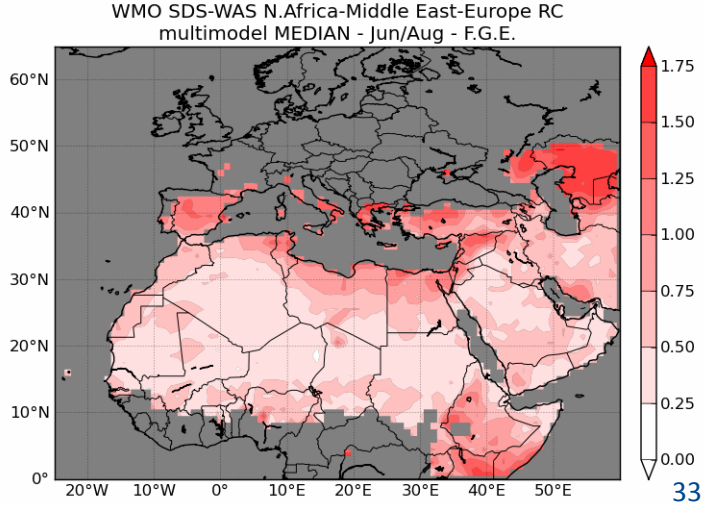
RMSE



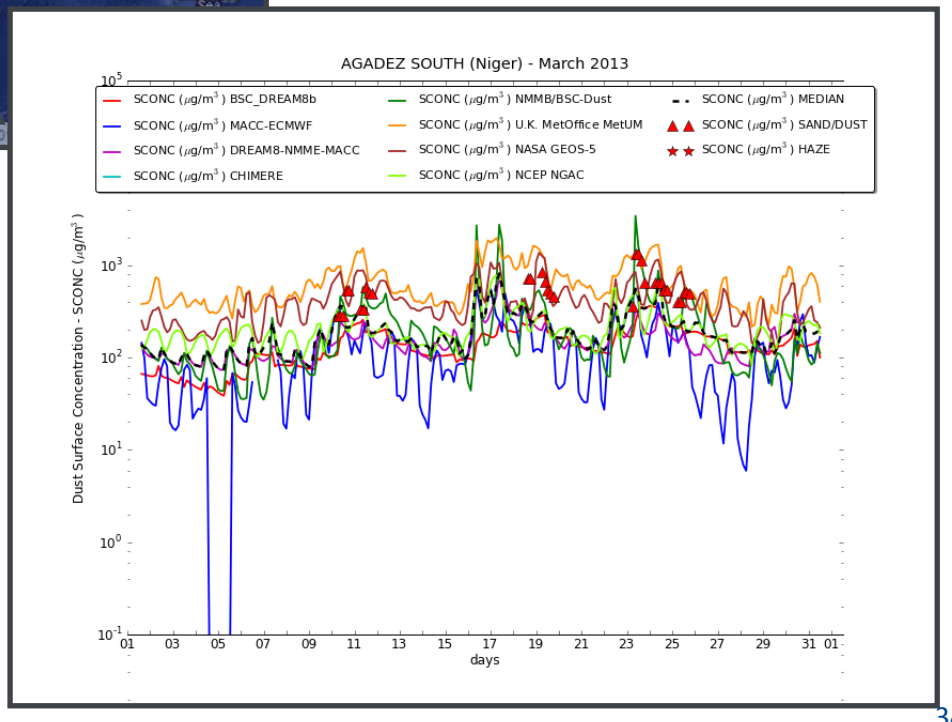


FGE





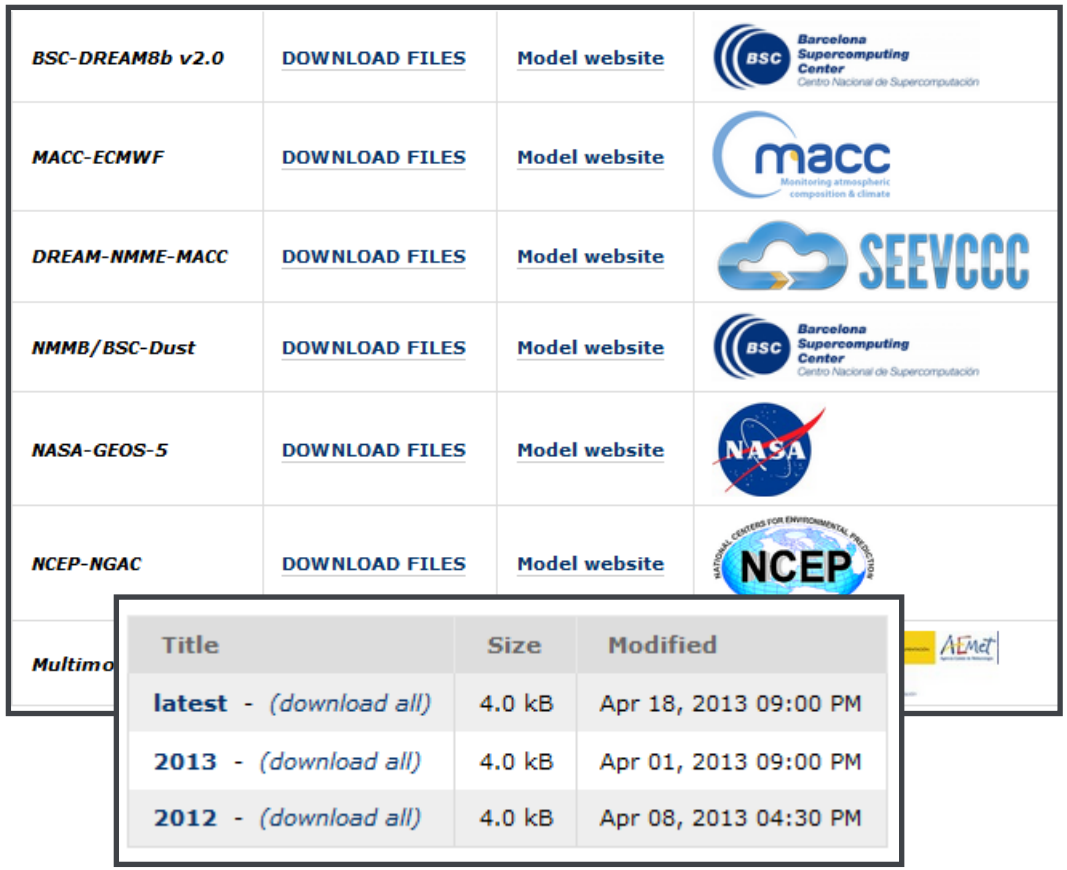
SDS-WAS: Evaluation using VISIBILITY data



PM10 = 1339.84 $V^{-0.67}$
Ben Mohamed et al. (1992)

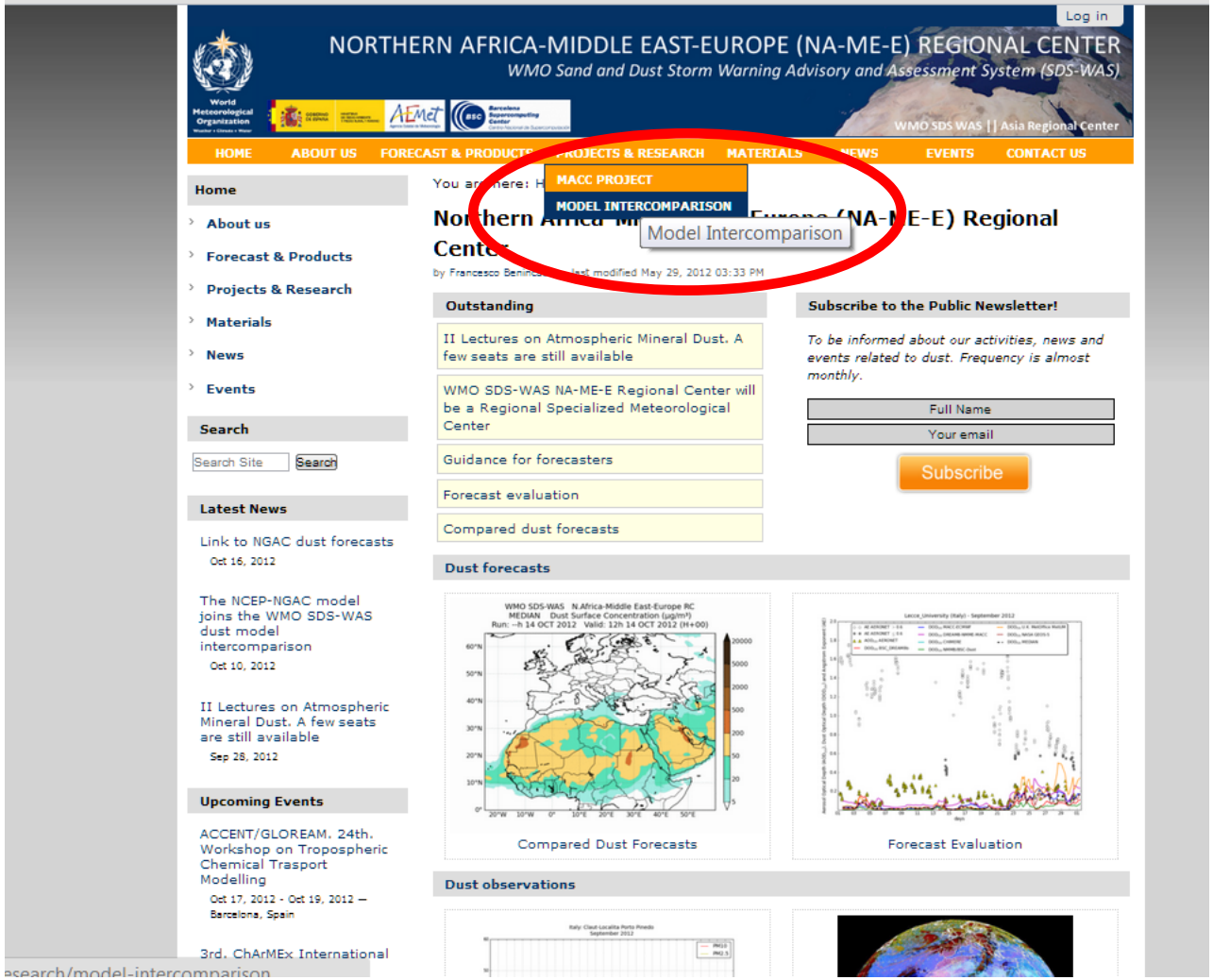
AGADEZ SOUTH, Niger
March 2013

SDS-WAS: Files download



- 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



http://sds-was.aemet.es

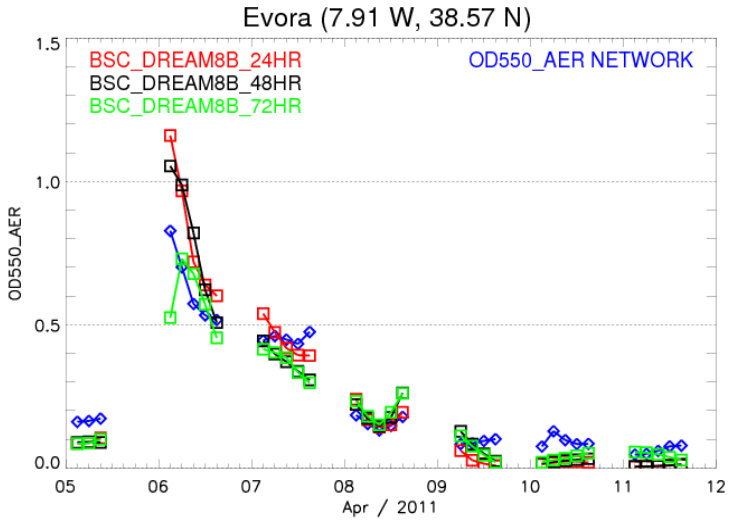
SDS-WAS: Model intercomparison April 2011

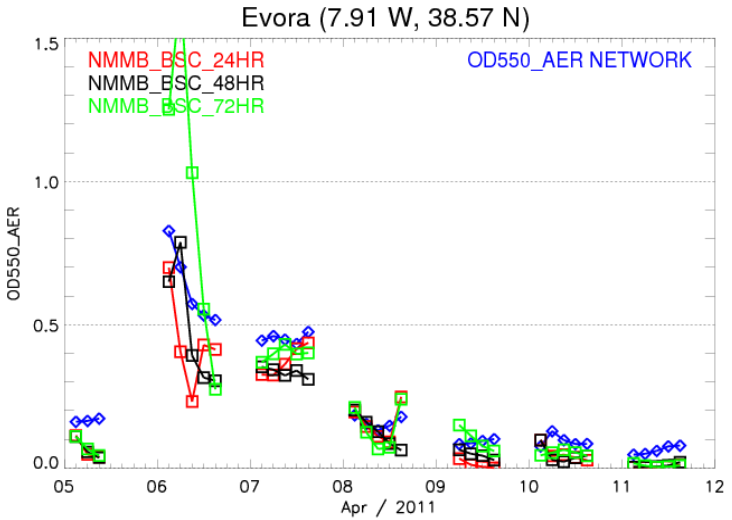
MODIS True color 7 April 18:00

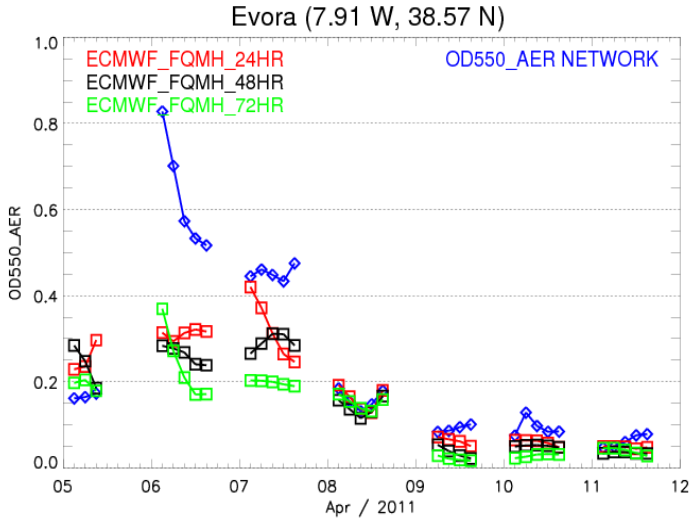
- The selected dust event corresponds to the one which occurred between the 5th and 11th of April of 2011.
- Participating models: BSC-DREAM8b, NMMB/BSC-Dust, ECMWF-MACC and UKMetOffice-UM
- Comparison of each forecast (at 24, 48 and 72h) output to in-situ measurements of AOD (from AERONET), surface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

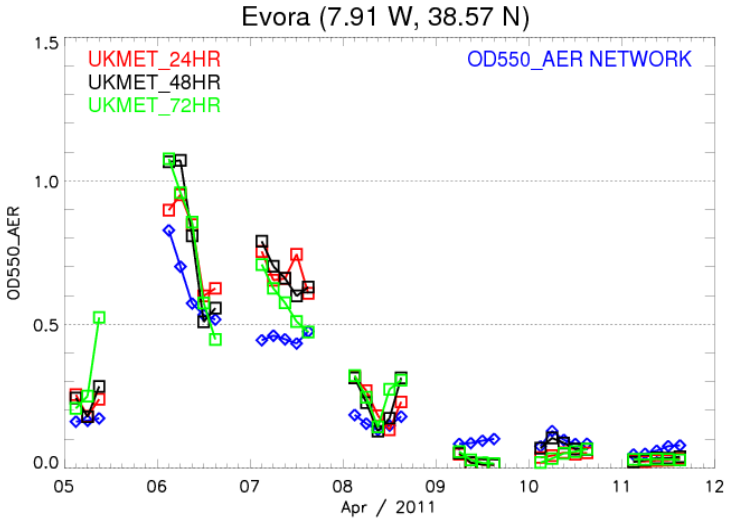
(Huneeus et al., in preparation)

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

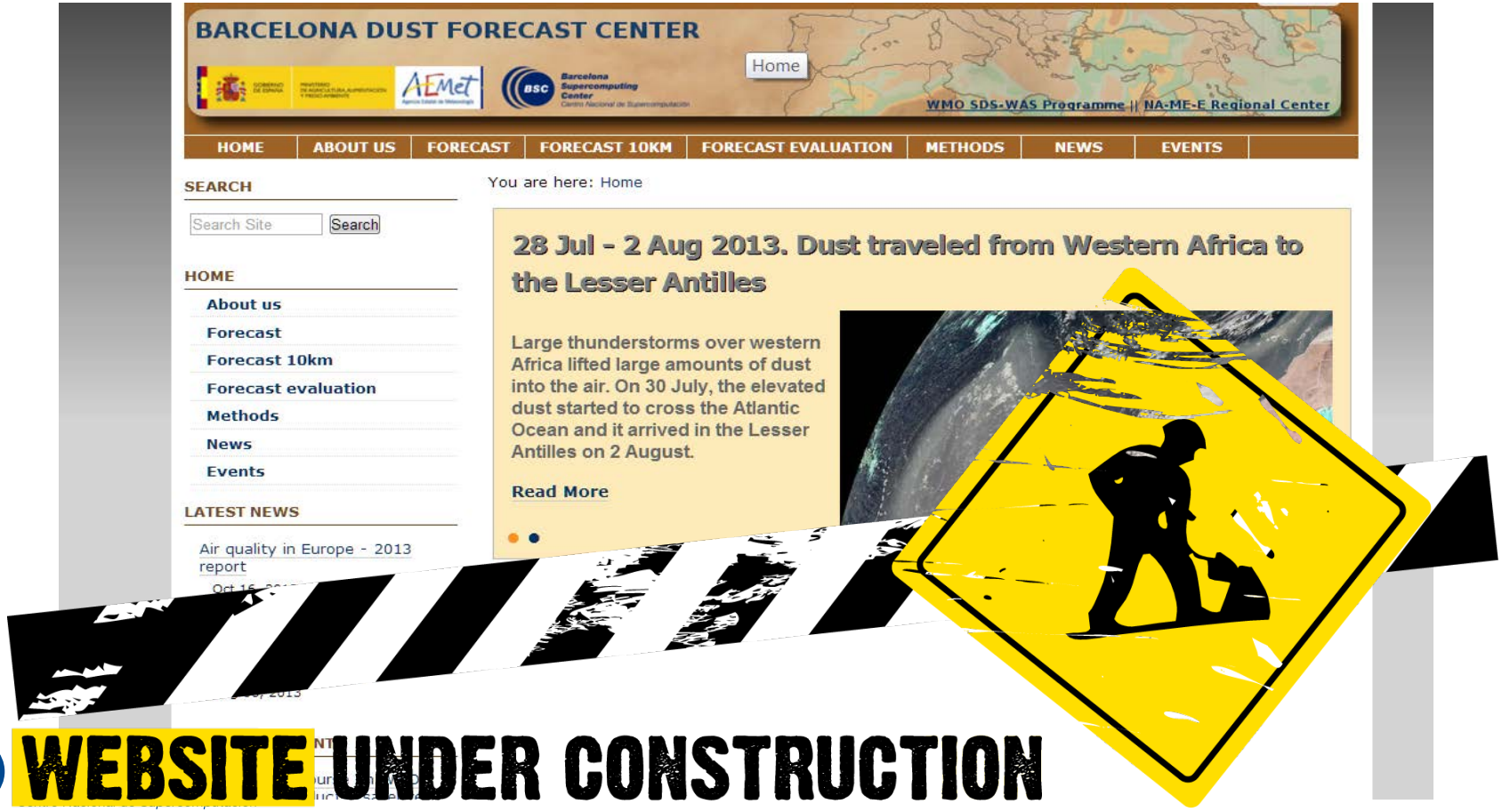
Consiglio Nazionale delle Ricerche

BOLCHEM

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

Barcelona Dust Forecast Center

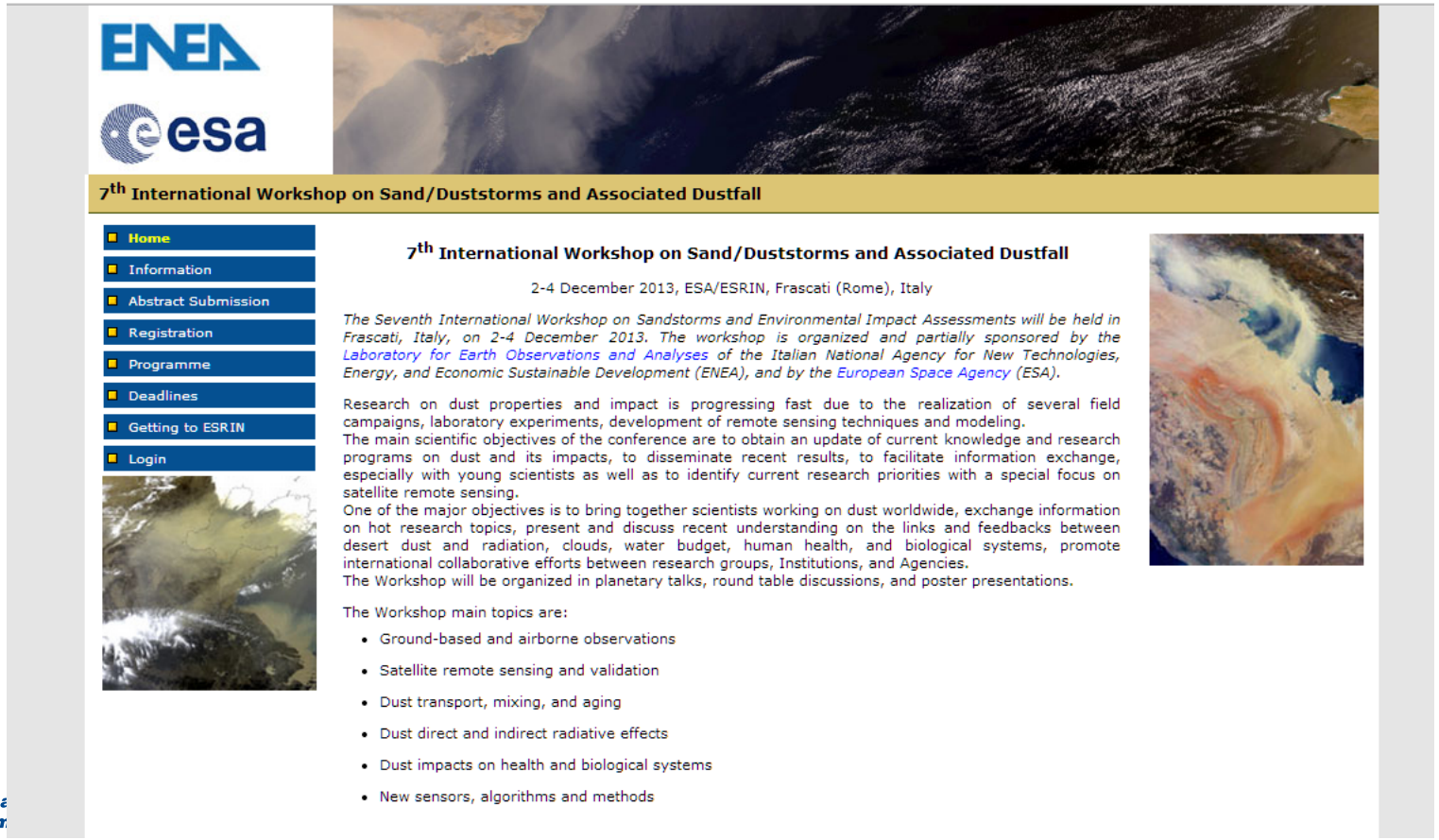
First Specialized Center for Mineral Dust Prediction of WMO ***NMMB/BSC-CTM*** *selected* *provide operational forecasts*



Next Dust events

7th International Workshop on Sand/Duststorms and Associated Dustfall

2-4 December 2013, ESA/ESRIN, Frascati (Rome), Italy



ENEA

esa

7th International Workshop on Sand/Duststorms and Associated Dustfall

- Home
- Information
- Abstract Submission
- Registration
- Programme
- Deadlines
- Getting to ESRIN
- Login

7th International Workshop on Sand/Duststorms and Associated Dustfall

2-4 December 2013, ESA/ESRIN, Frascati (Rome), Italy

The Seventh International Workshop on Sandstorms and Environmental Impact Assessments will be held in Frascati, Italy, on 2-4 December 2013. The workshop is organized and partially sponsored by the Laboratory for Earth Observations and Analyses of the Italian National Agency for New Technologies, Energy, and Economic Sustainable Development (ENEA), and by the European Space Agency (ESA).

Research on dust properties and impact is progressing fast due to the realization of several field campaigns, laboratory experiments, development of remote sensing techniques and modeling.
The main scientific objectives of the conference are to obtain an update of current knowledge and research programs on dust and its impacts, to disseminate recent results, to facilitate information exchange, especially with young scientists as well as to identify current research priorities with a special focus on satellite remote sensing.
One of the major objectives is to bring together scientists working on dust worldwide, exchange information on hot research topics, present and discuss recent understanding on the links and feedbacks between desert dust and radiation, clouds, water budget, human health, and biological systems, promote international collaborative efforts between research groups, Institutions, and Agencies.
The Workshop will be organized in planetary talks, round table discussions, and poster presentations.

The Workshop main topics are:

- Ground-based and airborne observations
- Satellite remote sensing and validation
- Dust transport, mixing, and aging
- Dust direct and indirect radiative effects
- Dust impacts on health and biological systems
- New sensors, algorithms and methods

Next Dust events

Session Modelling and field Studies - Atmospheric dust modelling and forecast

Convened by J.M. Baldasano and E. Terradellas

www.bsc.es

Contact: sara.basart@bsc.es

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Thank you!

Acknowlegments:

C. Pérez, K. Haustein, N. Huneeus, M Shculz, Z. Janjic, A. Badia, M. Spada, T. Black, D. Dabdub, K. Haustein, M. Carreras, K. Serradell and all the SDS-WAS NAMEE participants.

We thank the AERONET, EARLINET and MODIS community for their valuable data.
This work is funded by the projects CGL2006-11879, CGL2008-02818, CGL2010-19652 of the Spanish Ministry of Science and Innovation.
Simulations have been performed in the Marenostrum supercomputer.