www.bsc.es

Observacion y prediccion del contenido de polvo mineral en la atmosfera,
Barcelona, Spain, 19 October 2017

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Modeling the dust cycle at BSC

From R&D to operational forecast

Sara Basart (sara.basart@bsc.es)
C. Pérez García-Pando, O. Jorba, E. Di Tomaso, L. Vendrell, E. Terradellas, G. García-Castrillo, F. Benincasa and K. Serradell

BSC Earth Sciences Department

Barcelona Supercomputing Center
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EXCELENCIA SEVERO OCHOA

What

Environmental modelling and forecasting

Why

Our strength …
- … research …
- … operations …
- … services …
- … high resolution …

MareNostrum supercomputer

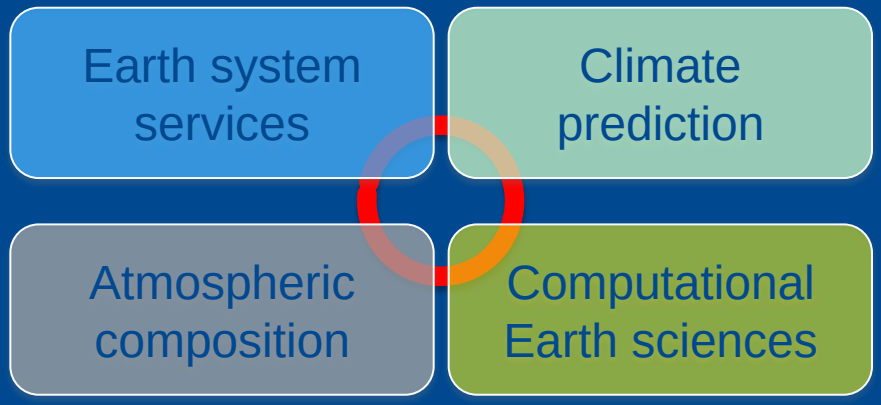
How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

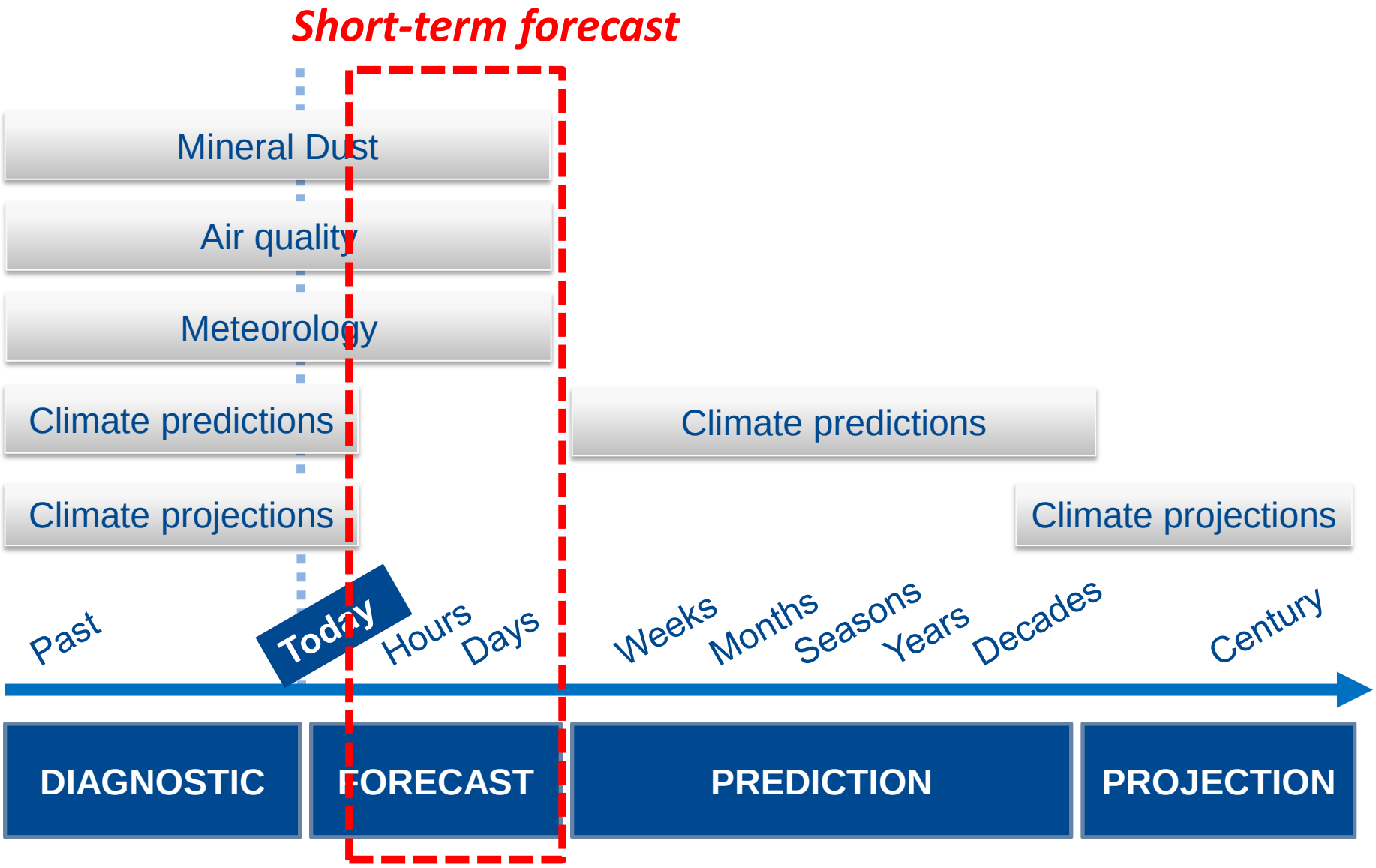
Implement climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models



BSC Earth Sciences Department

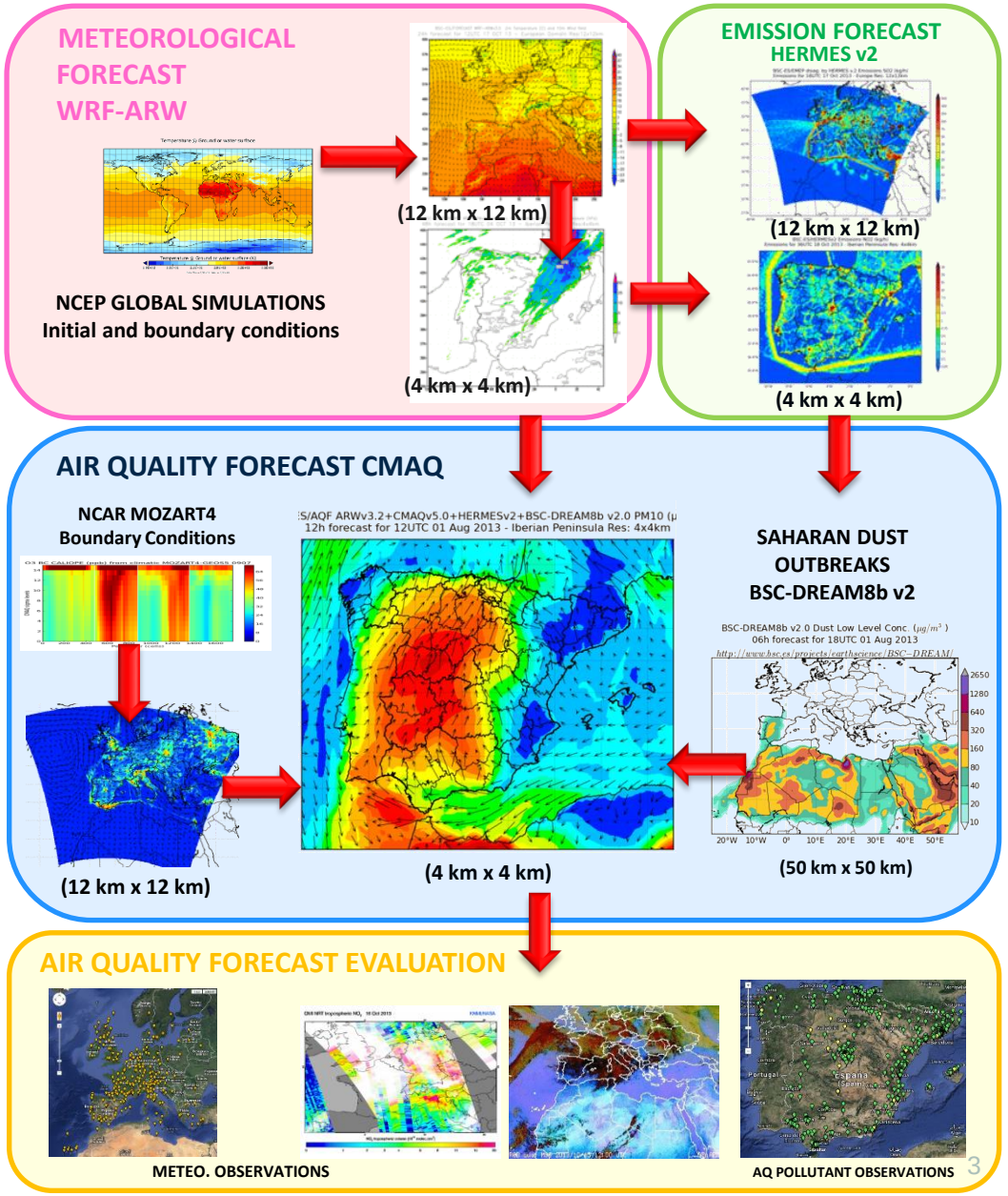


AC group: Air Quality Modelling

CALIOPE
(www.bsc.es/caliope)

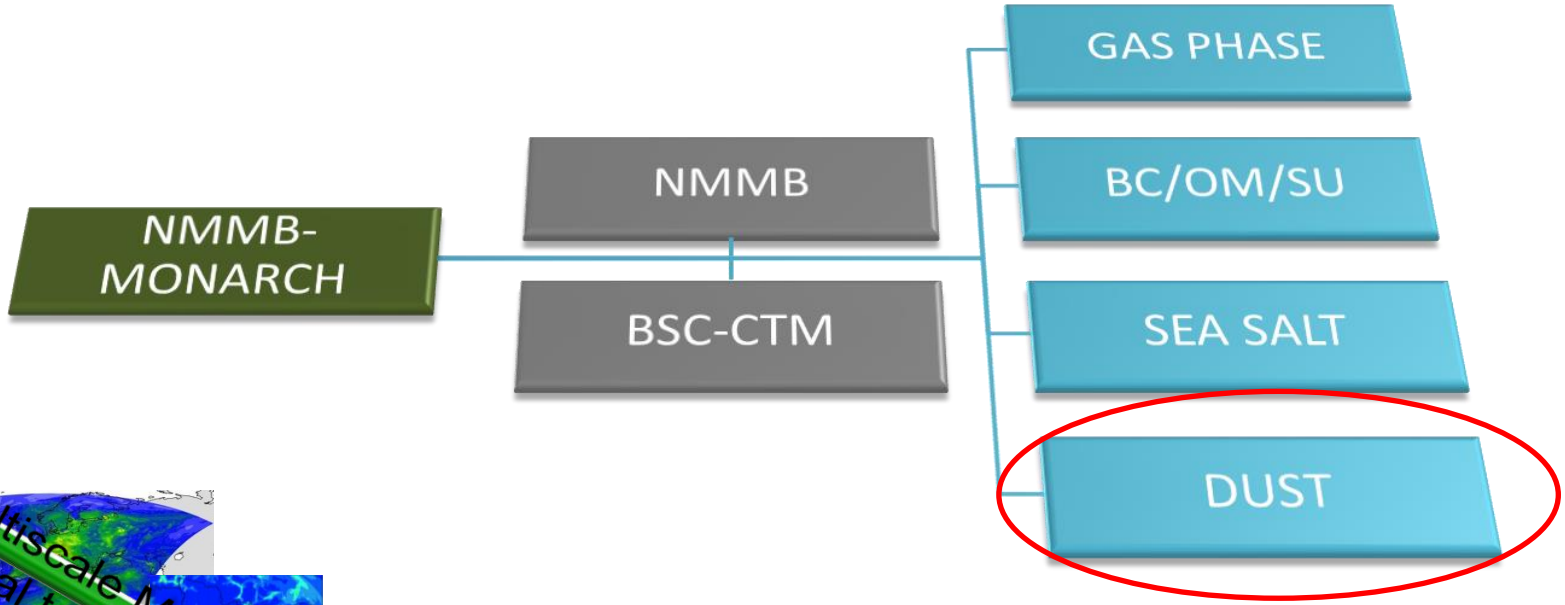
- Quantify relation between emissions, meteorology and air concentration
- Forecast air pollution episodes
- Provide and develop short and long term mitigation plans

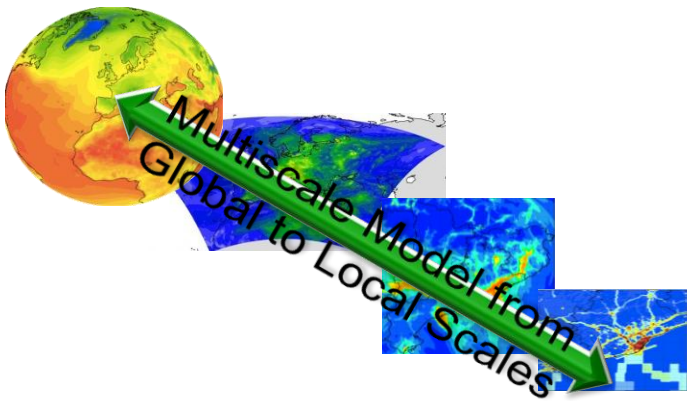
Domains:
Europe (12 km, 480 x 400 cells)
Spain (4 km, 399 x 399 cells)



AC group: NMMB-MONARCH

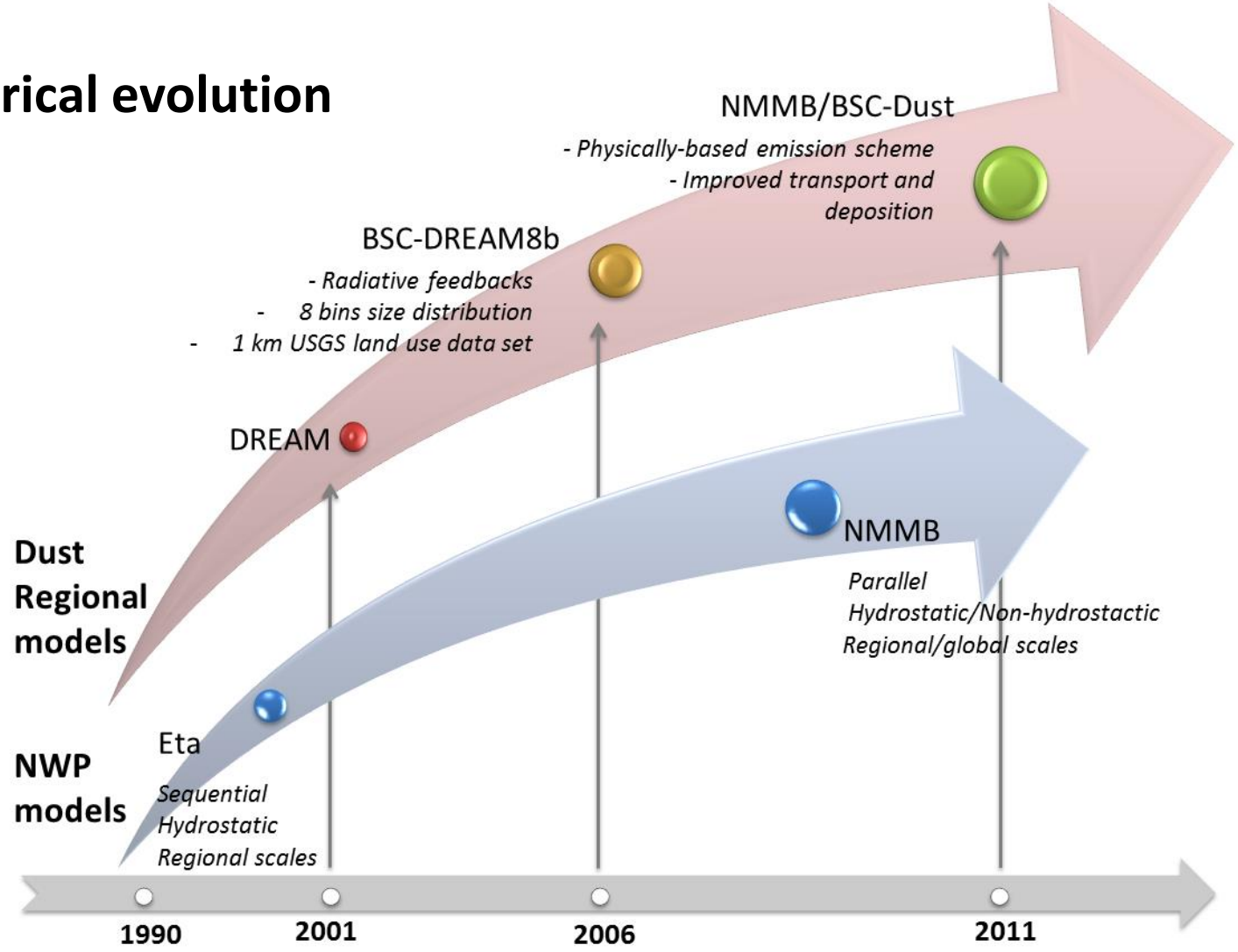
- The main system is build on the **meteorological driver NMMB**
- ***Multiscale***: global to regional scales allowed (nesting capabilities)
- ***Nonhydrostatic*** dynamical core: single digit kilometre resolution allowed
- Fully ***on-line*** coupling: weather-chemistry feedback processes allowed
- Enhancement with a ***data assimilation*** system





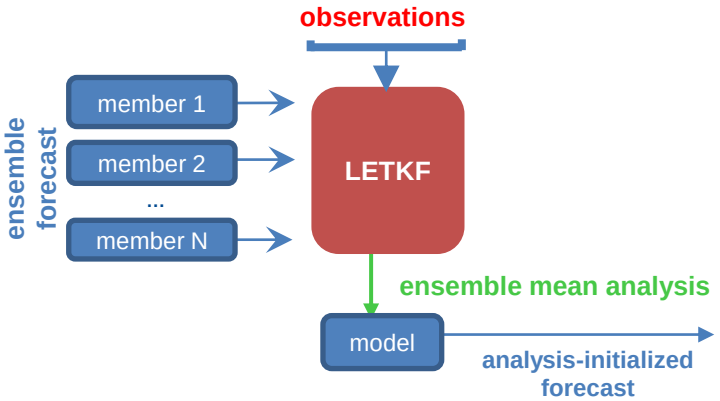
Known as **NMMB/BSC-Dust**

Historical evolution



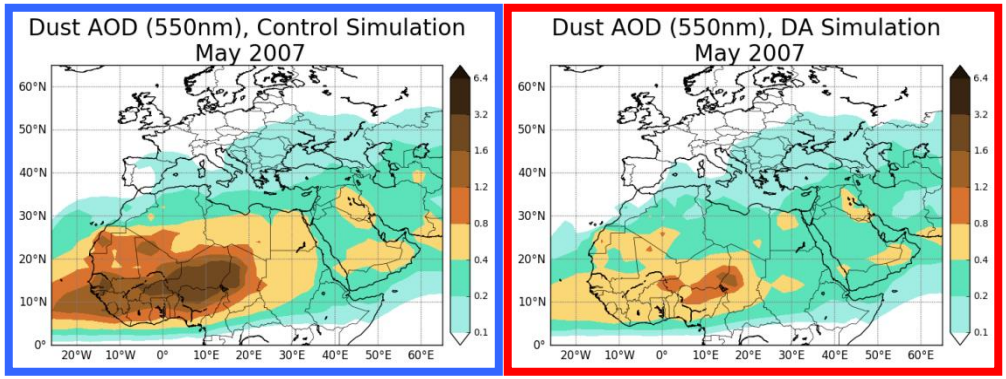
NMMB-MONARCH: Dust data assimilation

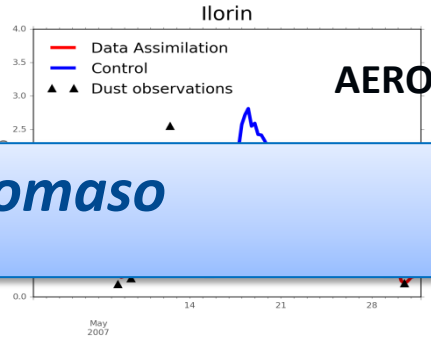
NMMB-MONARCH coupled with a Local Ensemble Transform Kalman Filter (**LETKF**) for the assimilation of aerosol optical depth observations



Mineral dust application
The ensemble forecast is based on uncertainties in the dust emission scheme

- vertical flux,
- size distribution at emission
- threshold on friction velocity





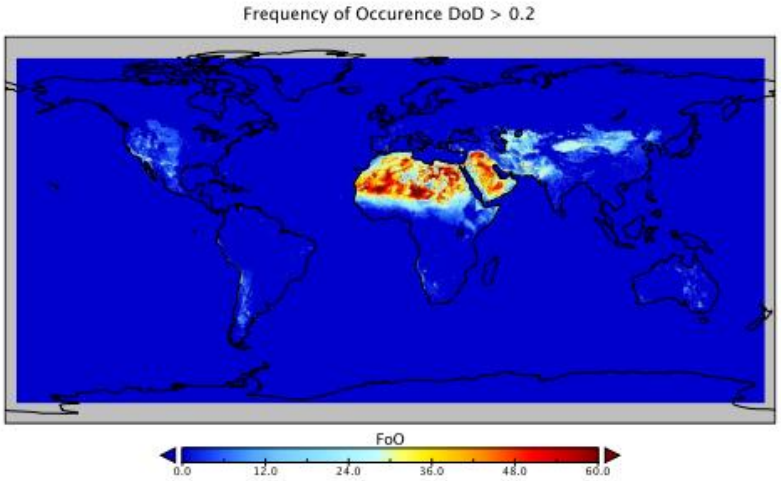
AERONET Validation

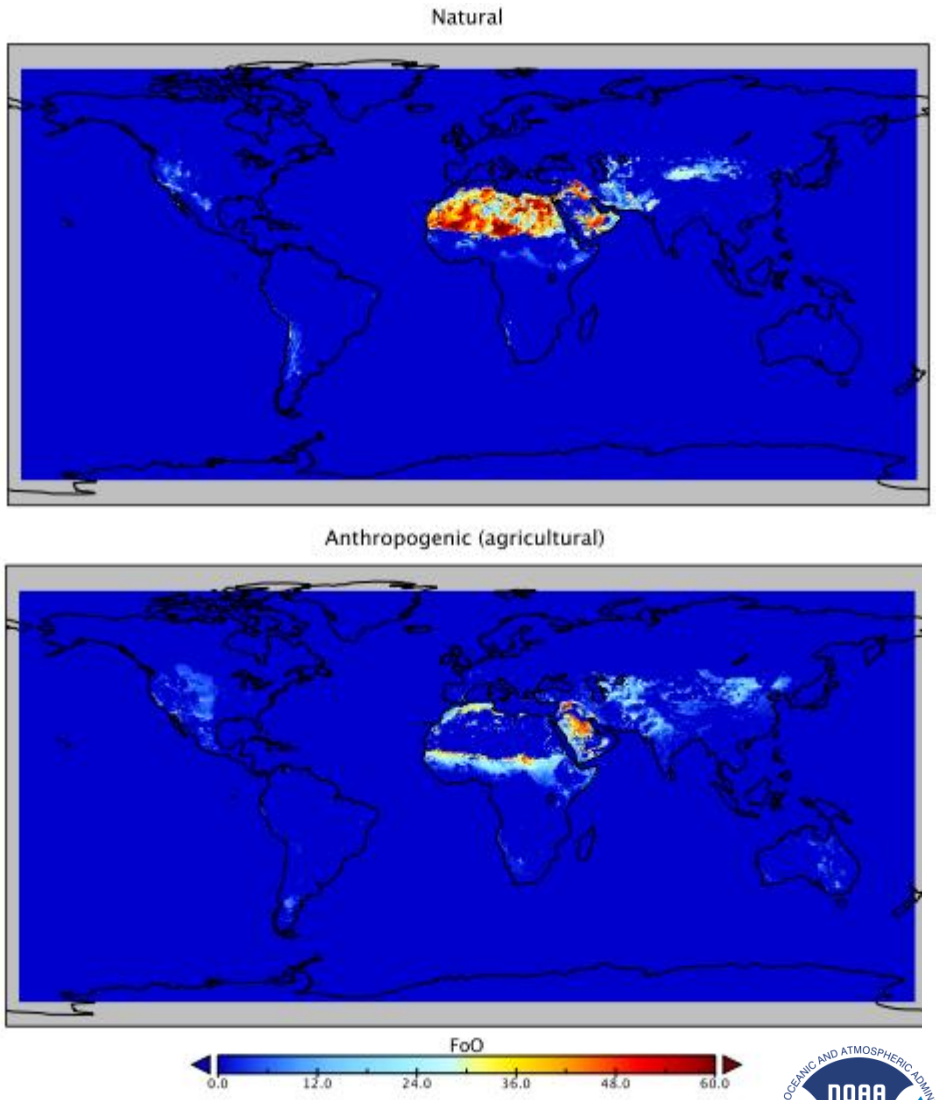
Seminar by Enza Di Tomaso

(DiTomaso et al., GMD, submitted)

Mineral dust: Dust Sources

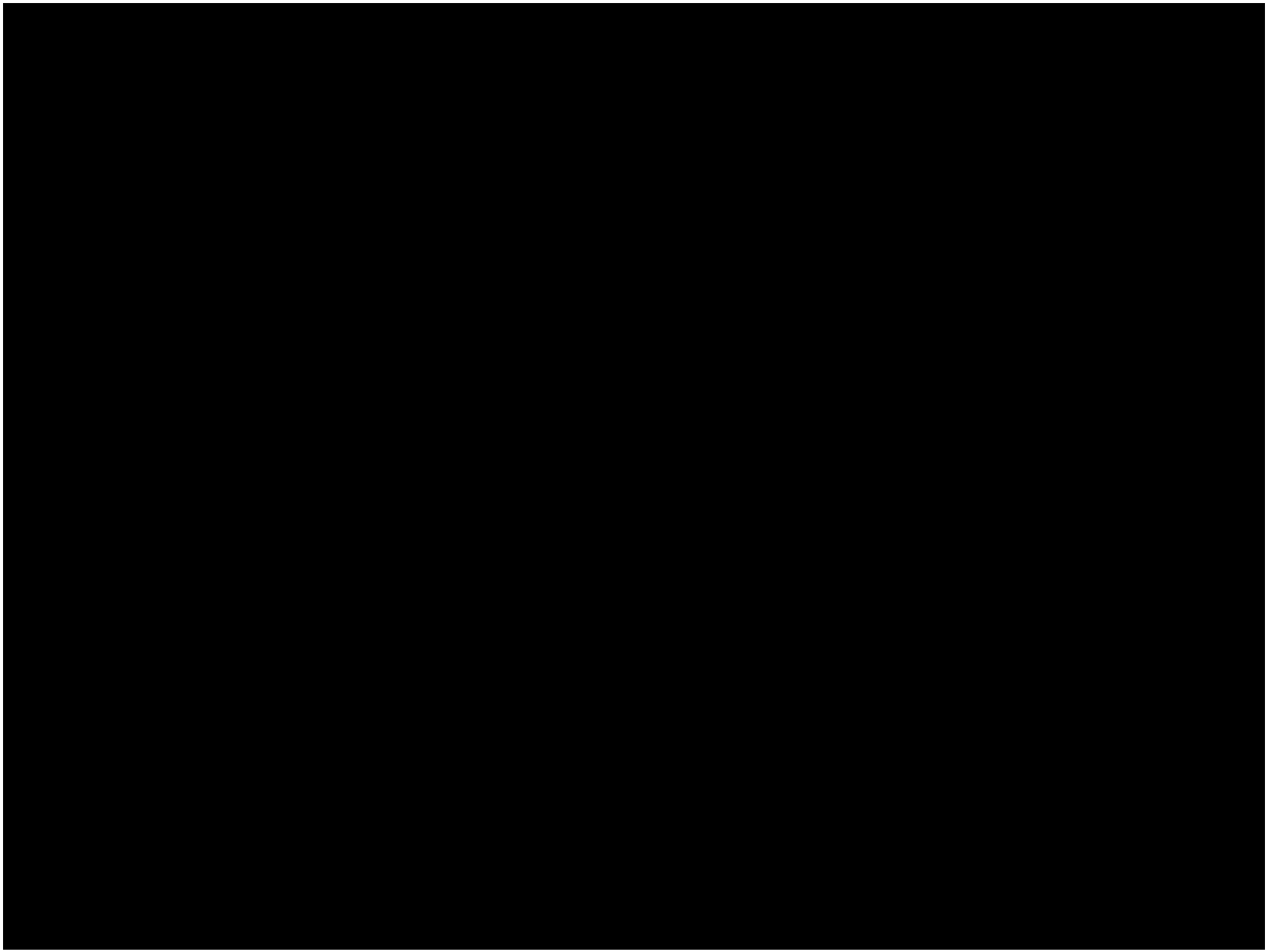
Understanding of he mineral dust sources
Natural and anthropogenic based on MODIS Deep





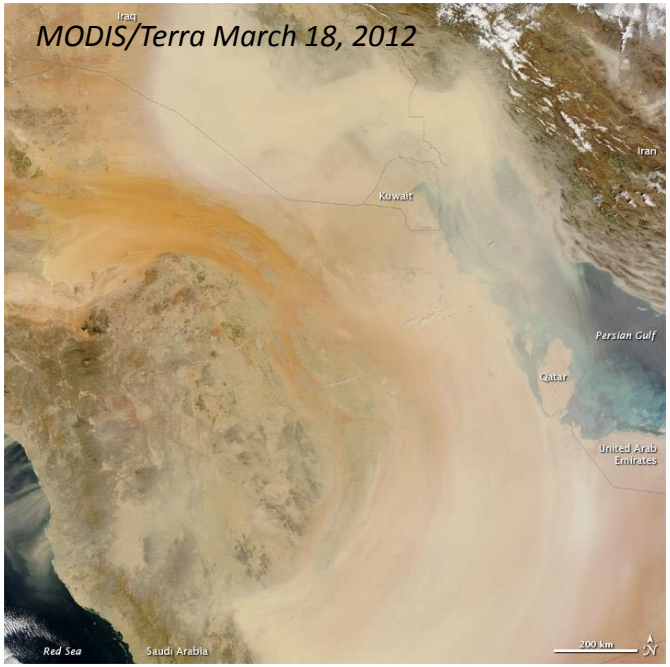
In collaboration P. Ginoux (NOAA-GFDL)

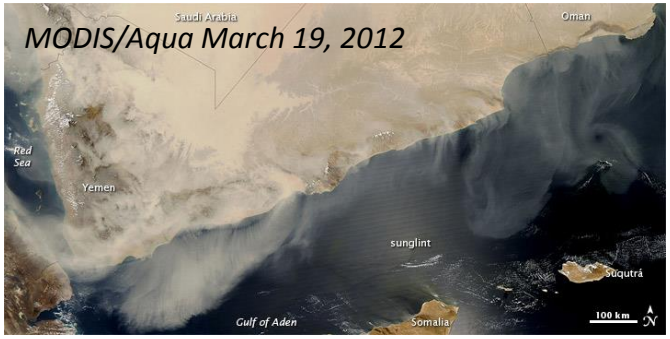
Mineral dust: Topographical impacts



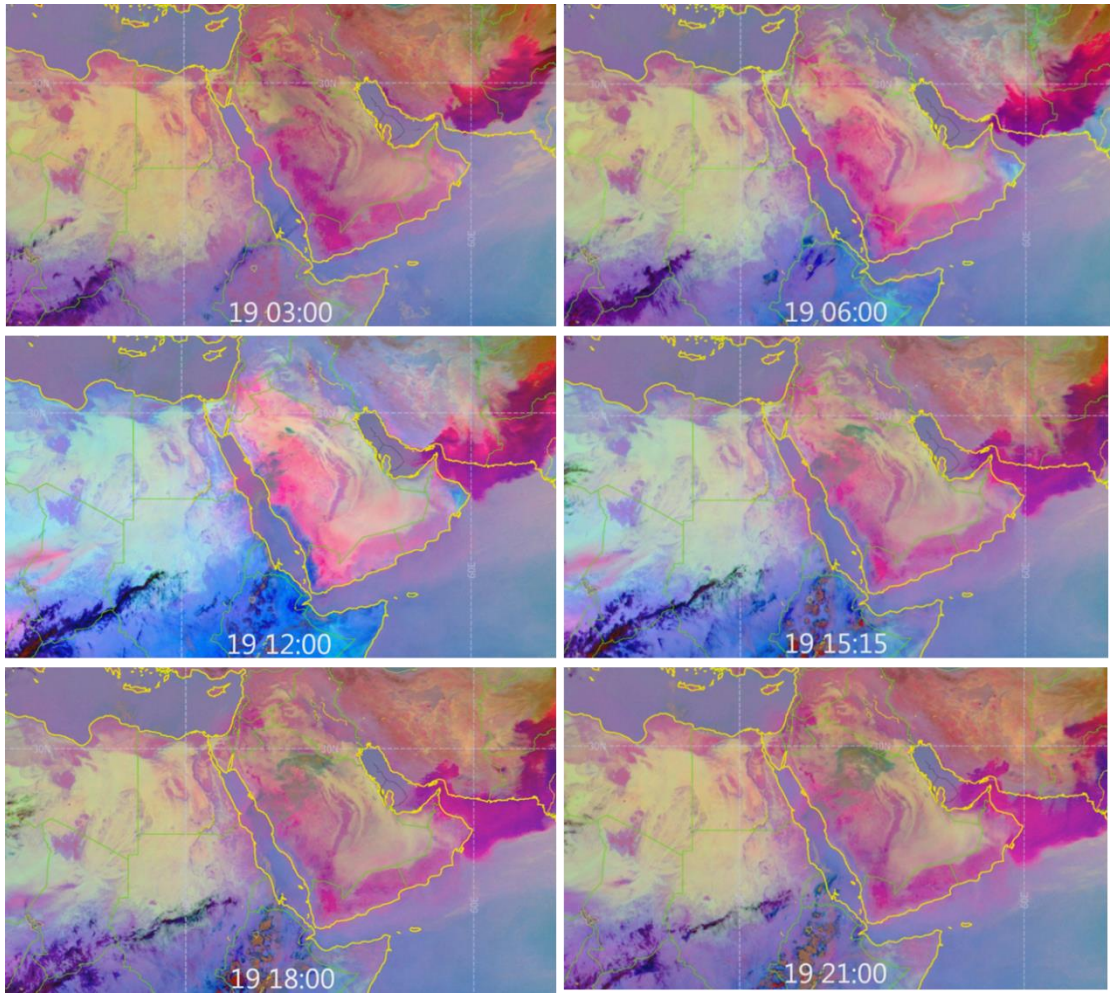
Mineral dust: Topographical impacts

Impact of the topography on dust transport



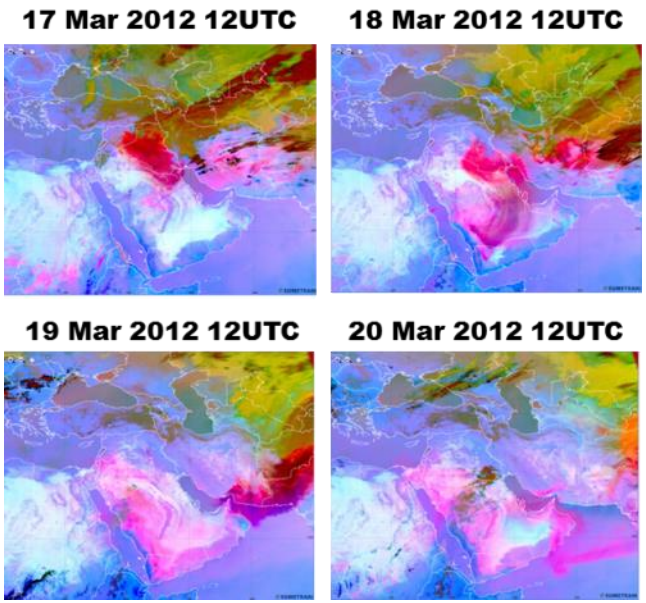


MSG/RGB March 19, 2012



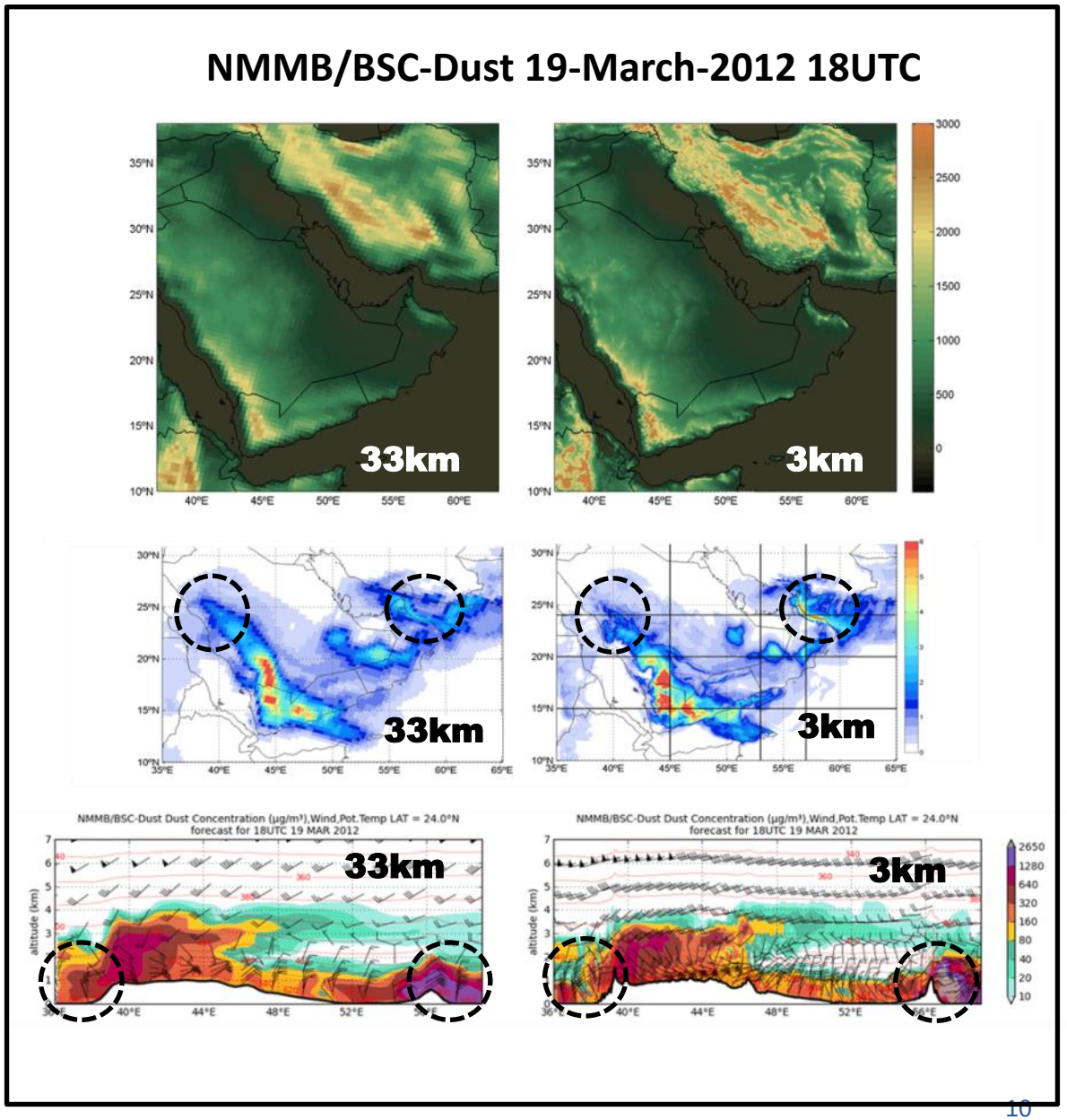
(Basart et al., Aeolian Research, 2016)

Mineral dust: Topographical impacts

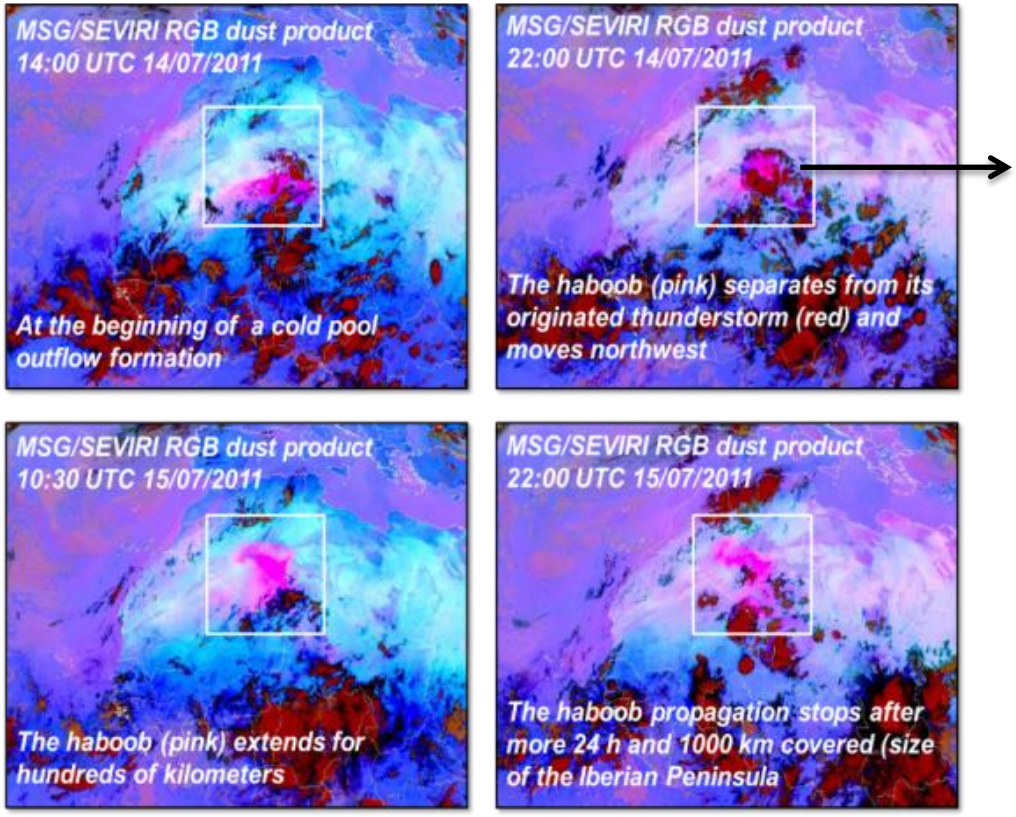


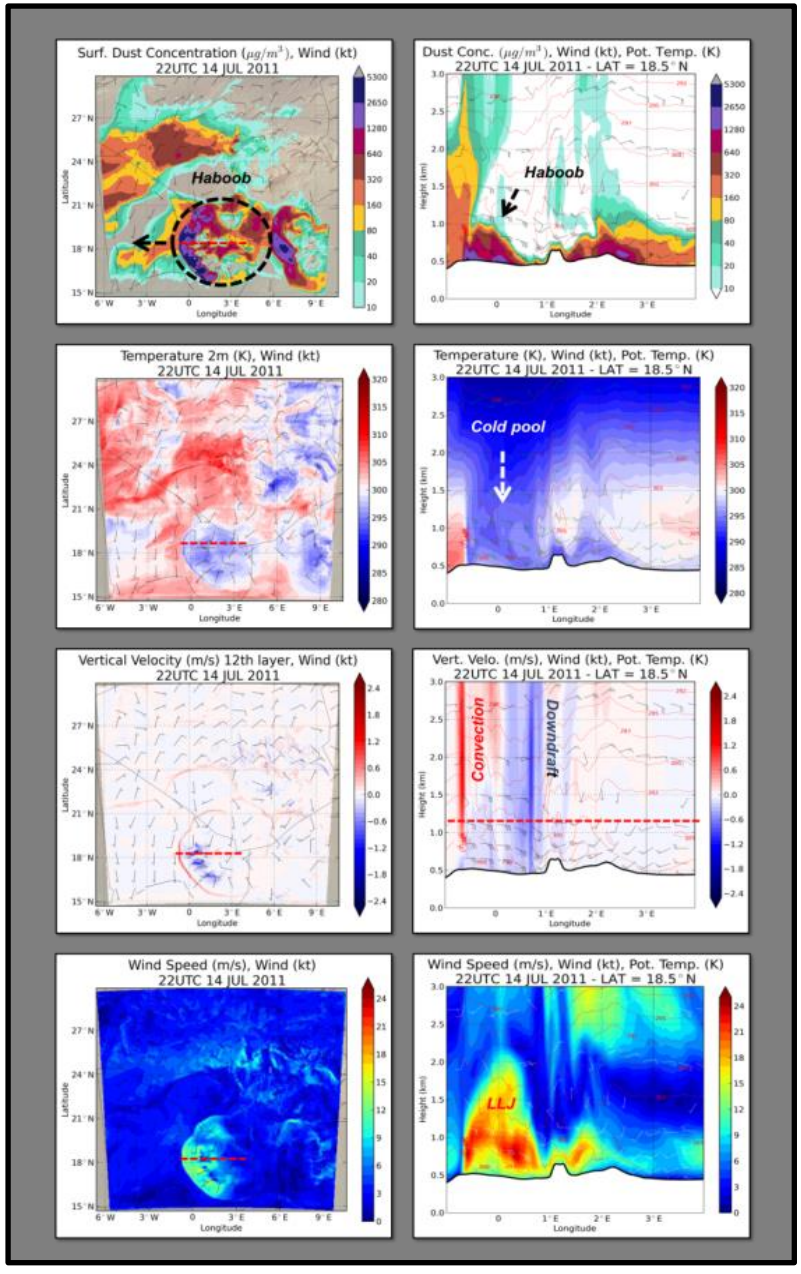
Two simulations using the **NMMB/BSC-Dust** model demonstrates results demonstrate how the dust prediction in the vicinity of complex terrains improves using high-horizontal resolution simulations.

(Basart et al., Aeolian Research, 2016)



Mineral dust: Haboobs (with explicit convection)





MODEL CONFIGURATION
Study domain: *6ºW-10ºE to 15ºN-31ºN*
Study period: *from 14 to 15 July 2011*
Horizontal resolution: *0.03ºx0.03º (about 3 km)*
Vertical resolution: *60σ-layers (12-15σ-layers in the first 1000 m)*
Cold start *(No data assimilation)*

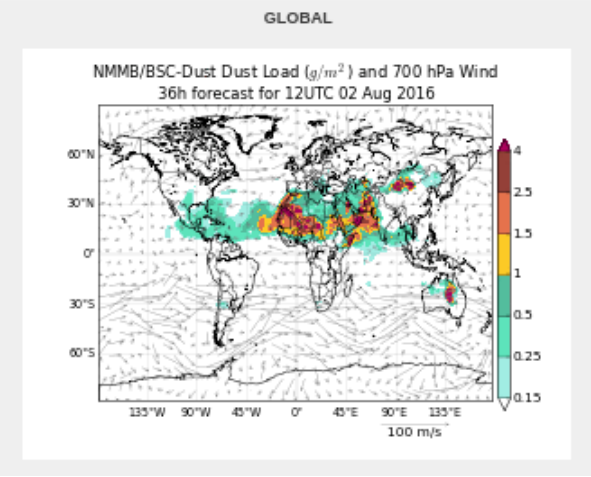
(Vendrell et al., in preparation)

Mineral Dust Services

Daily dust operational forecast (global and regional domains)

http://www.bsc.es/ESS

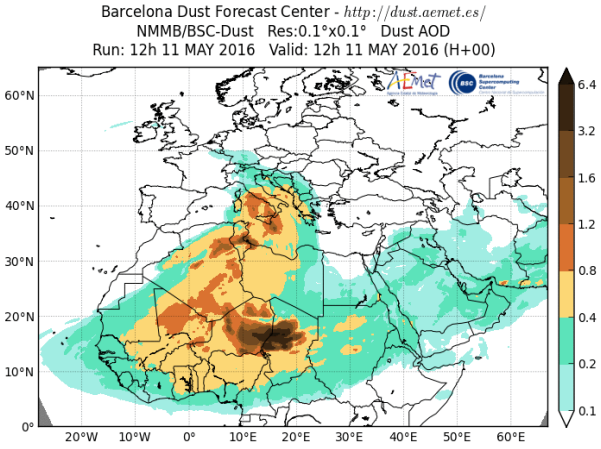
✓ *Contribution to the **ICAP** multi-model ensemble (global) http://icap.atmos.und.edu*



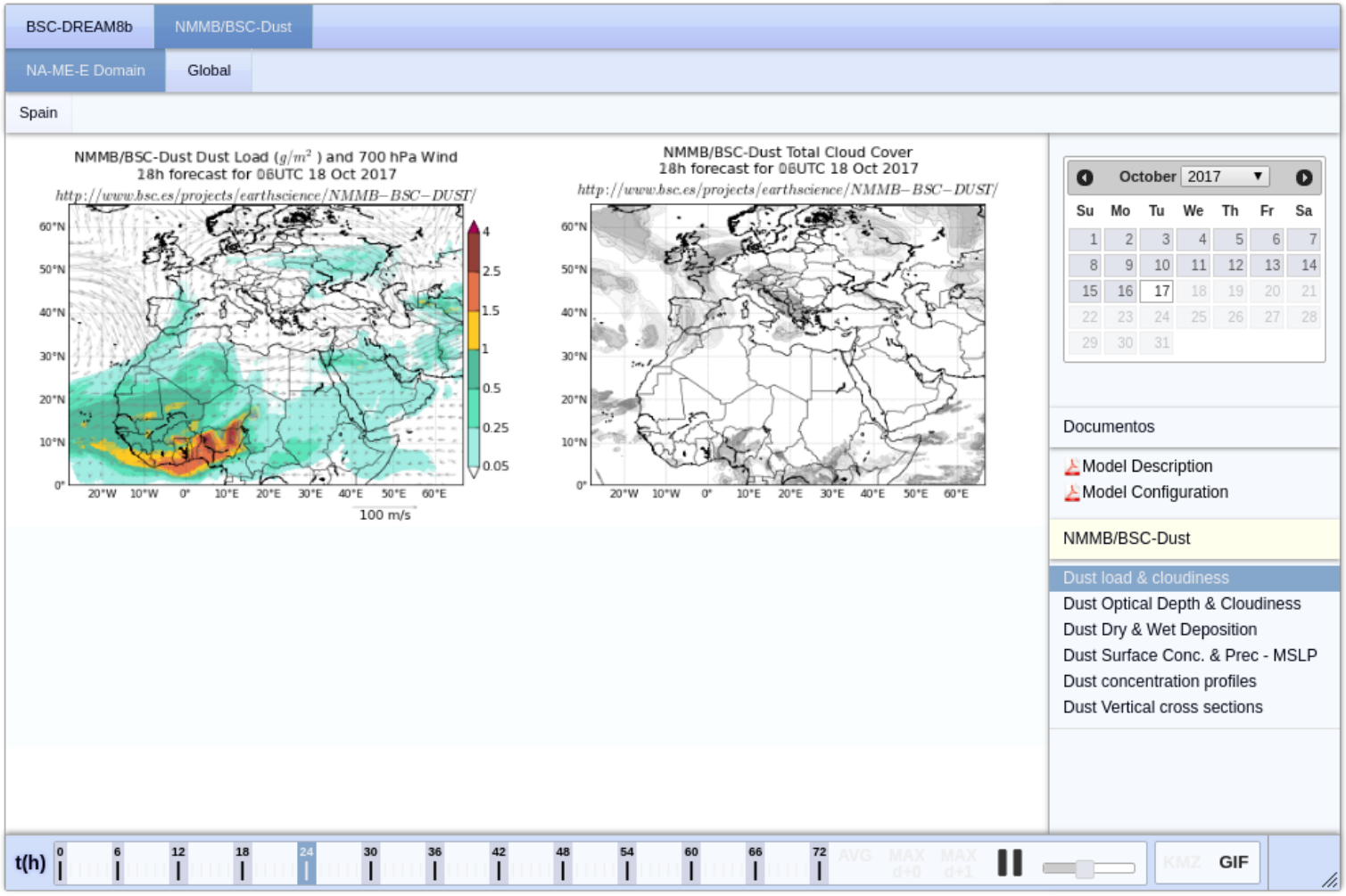
WMO Dust Centers

SDS-WAS. North Africa, Middle East and Europe Regional Center. *http://sds-was.aemet.es started in 2010 – Research*

Barcelona Dust Forecast Center.
First specialized WMO Center for mineral dust prediction. http://dust.aemet.es started in 2014 - Operational

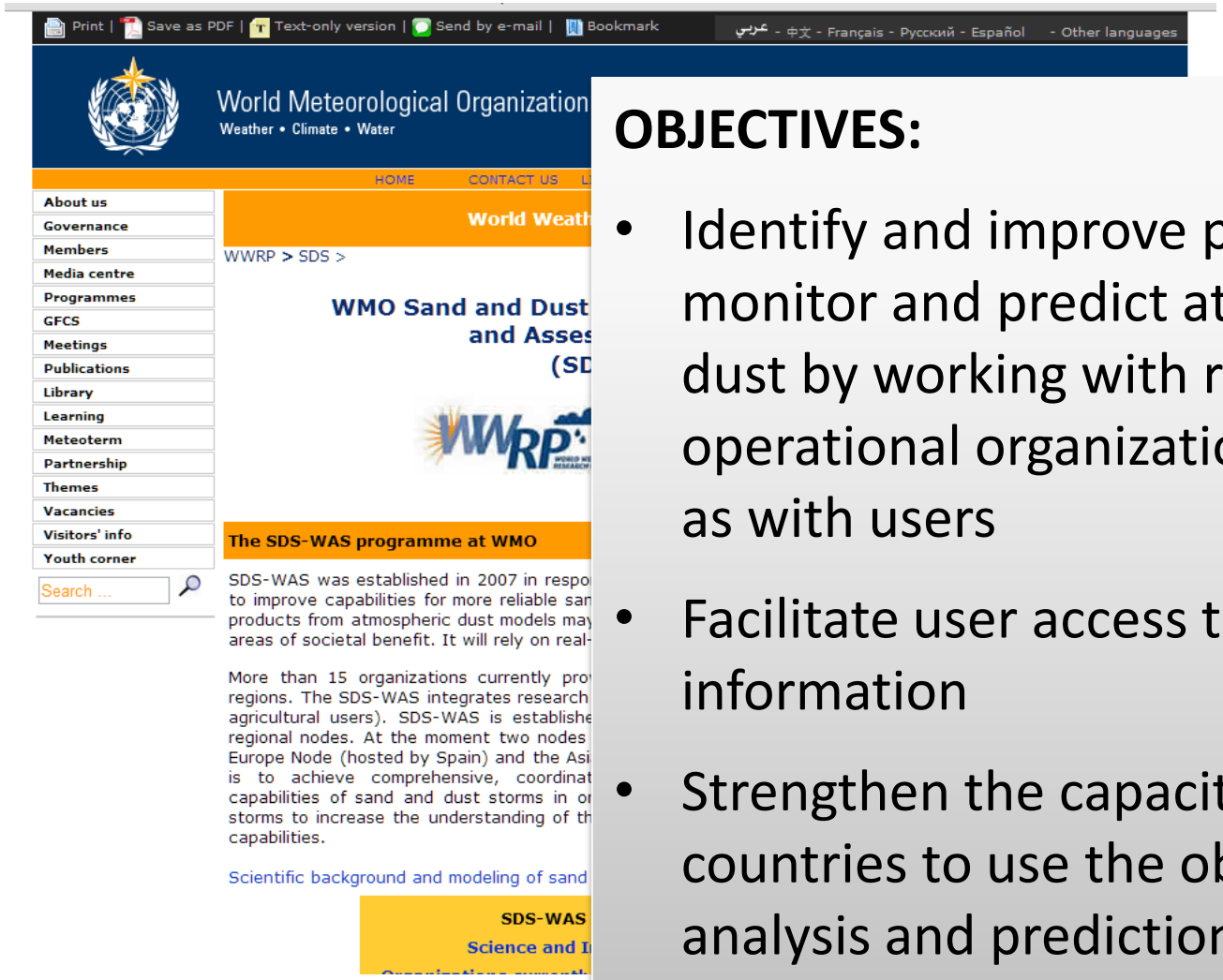


Daily dust operational forecast



http://www.bsc.es/ESS

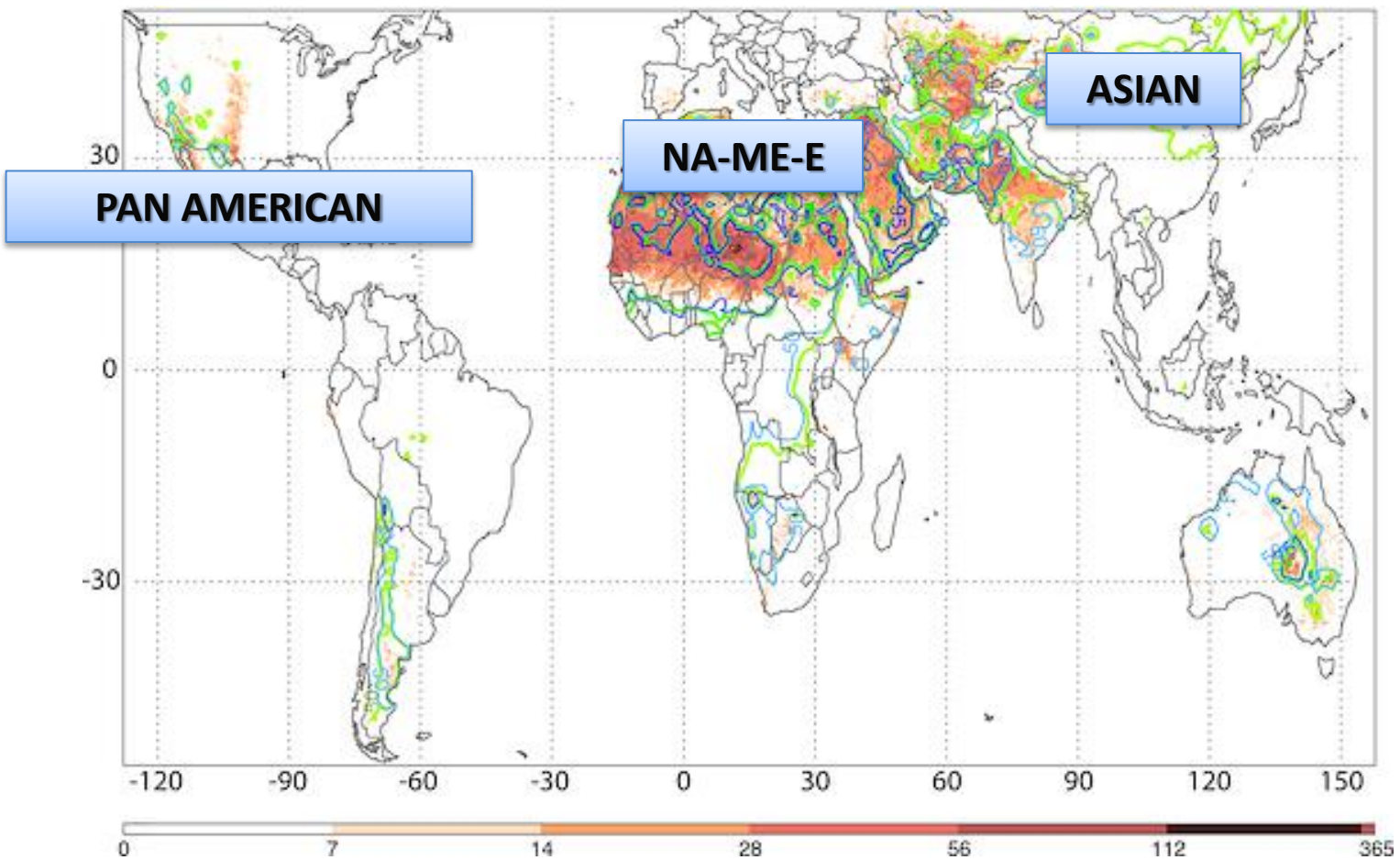
The WMO SDS-WAS project



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 project

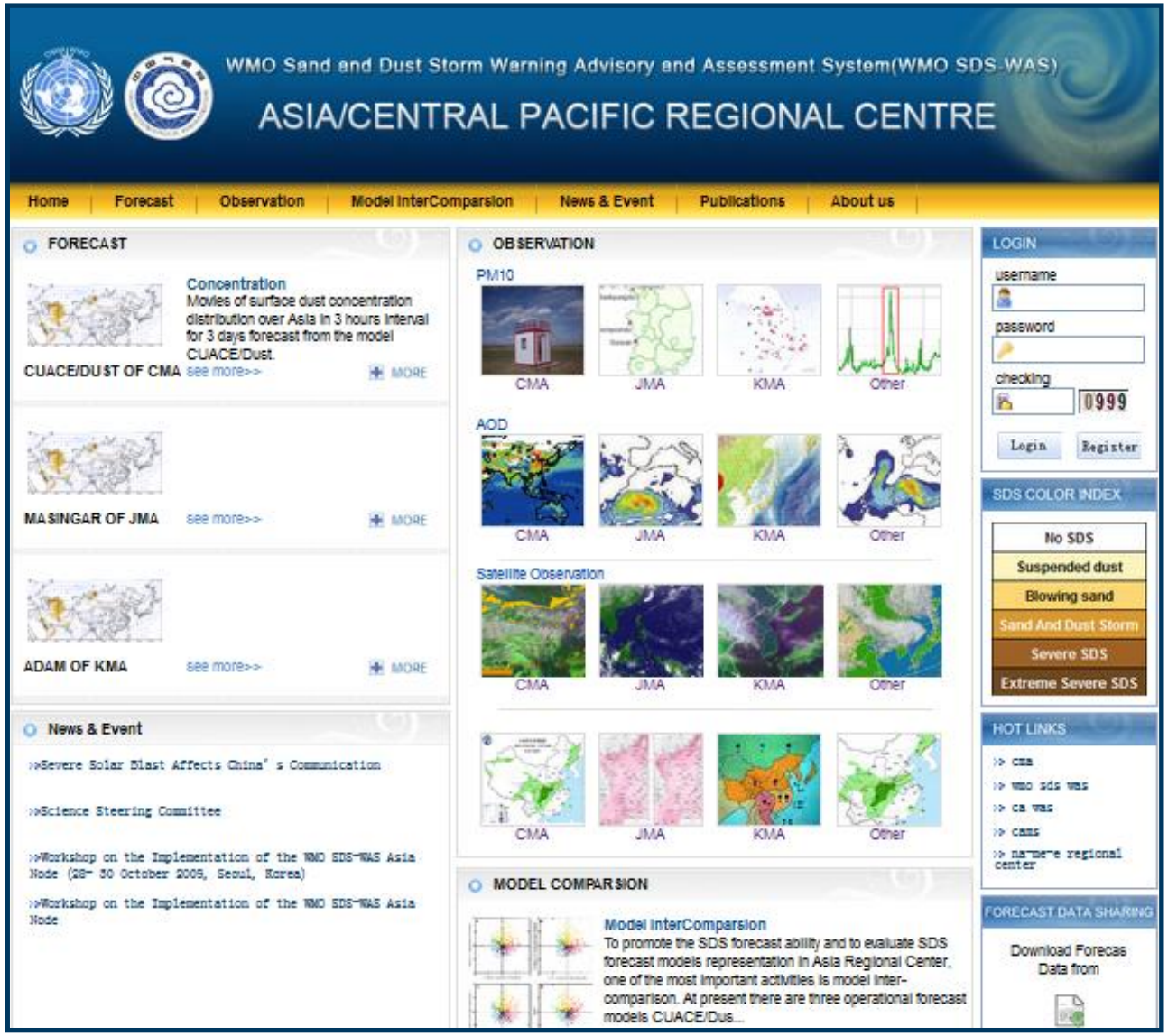
The SDS-WAS Regional Centers



Annual mean frequency distribution of M-DB2 (2003–2009) DOD > 0.2 (red), TOMS (1980–1991) aerosol index ≥ 0.5 (blue), and OMI (2004–2006) aerosol index ≥ 0.5 (green). The isocontours of TOMS and OMI have been removed over oceans for clarity.

Extracted from Ginoux et al. (2012, Rev. Geophys.)

SDS-WAS Asian RC



http://www.sds.cma.gov.cn

SDS-WAS NAMEE RC

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

http://sds-was.aemet.es

SDS-WAS NAMEE RC

Log in

NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER

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

WMO SDS WAS | | Asia Regional Center

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Latest News

Paper on dust emission recently published
Oct 19, 2016

Recent paper on cloud ice caused by dust
Oct 13, 2016

Paper on topographic impacts recently published
Oct 07, 2016

You are here: Home

Northern Af (NA-ME-E) Regional Center

by Francesco Benincasa

Outstanding

- Recent paper on cloud ice caused by dust
- Paper on topographic impacts recently published
- Aerosol climatology in Dakar recently published
- TNO contributes to SDS-WAS
- Global Assessment of Sand and Dust Storms

Subscribe to the Public Newsletter!

To be informed about our activities, news and events related to dust. Frequency is almost monthly.

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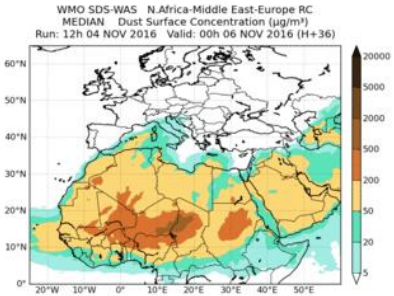
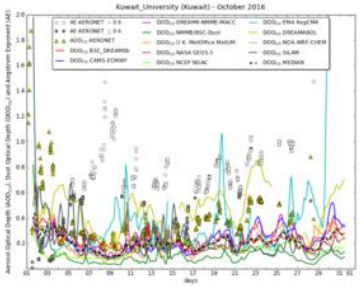
Portal manual

Please find a brief manual here.

Dust forecasts



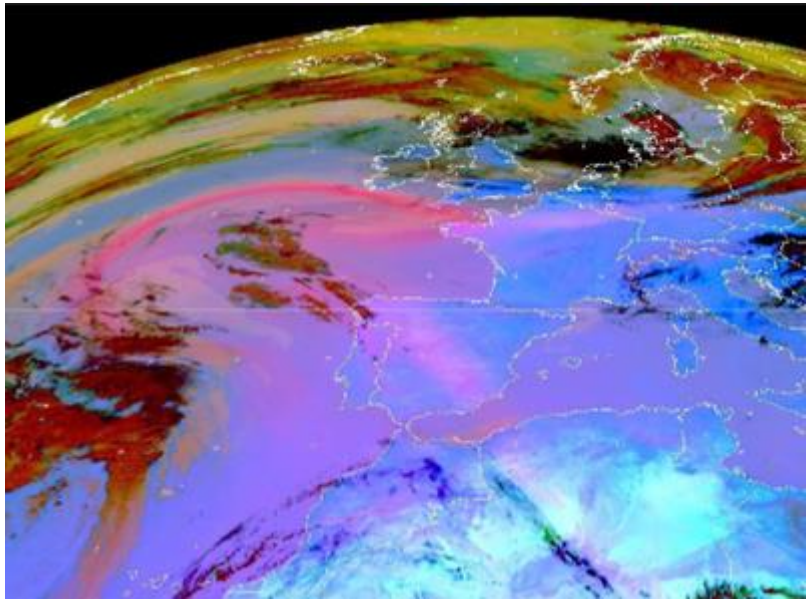
Compared Dust Forecasts



Forecast Evaluation

SDS-WAS NAMEE: Model intercomparison

European dust outbreak on April 2011



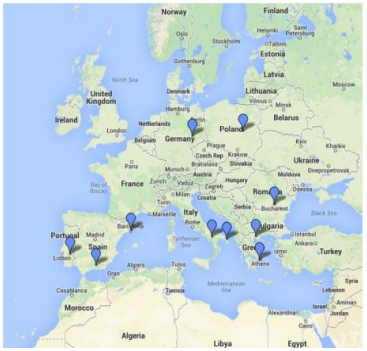
MSG/SEVIRI RGB product 7 April
Courtesy of EUMETSAT

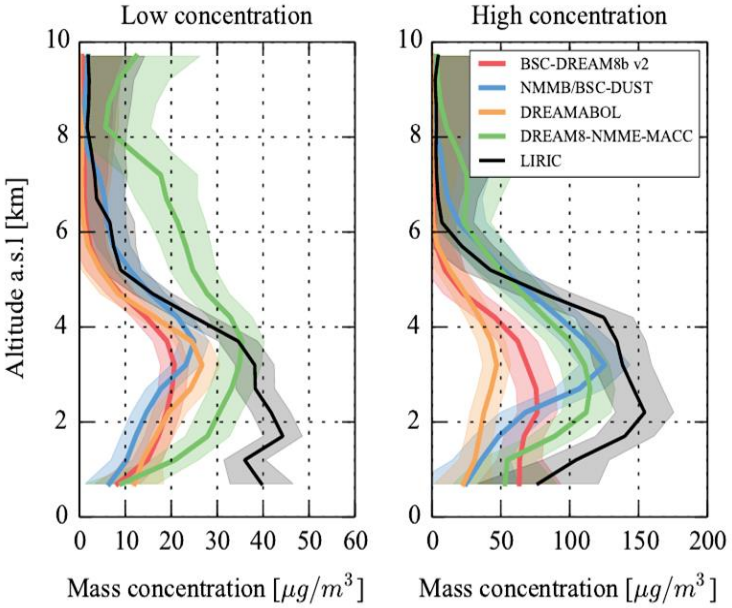
- The selected dust event corresponds to the one which occurred between the 5th and 11th of April of 2011.
- Participating models: BSC-DREAM8b, NMMB/BSC-Dust, ECMWF-MACC, UKMetOffice-UM and NMME-DREAM-MACC
- Comparison of each forecast (at 24, 48 and 72h) output to in-situ measurements of AOD (from AERONET),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

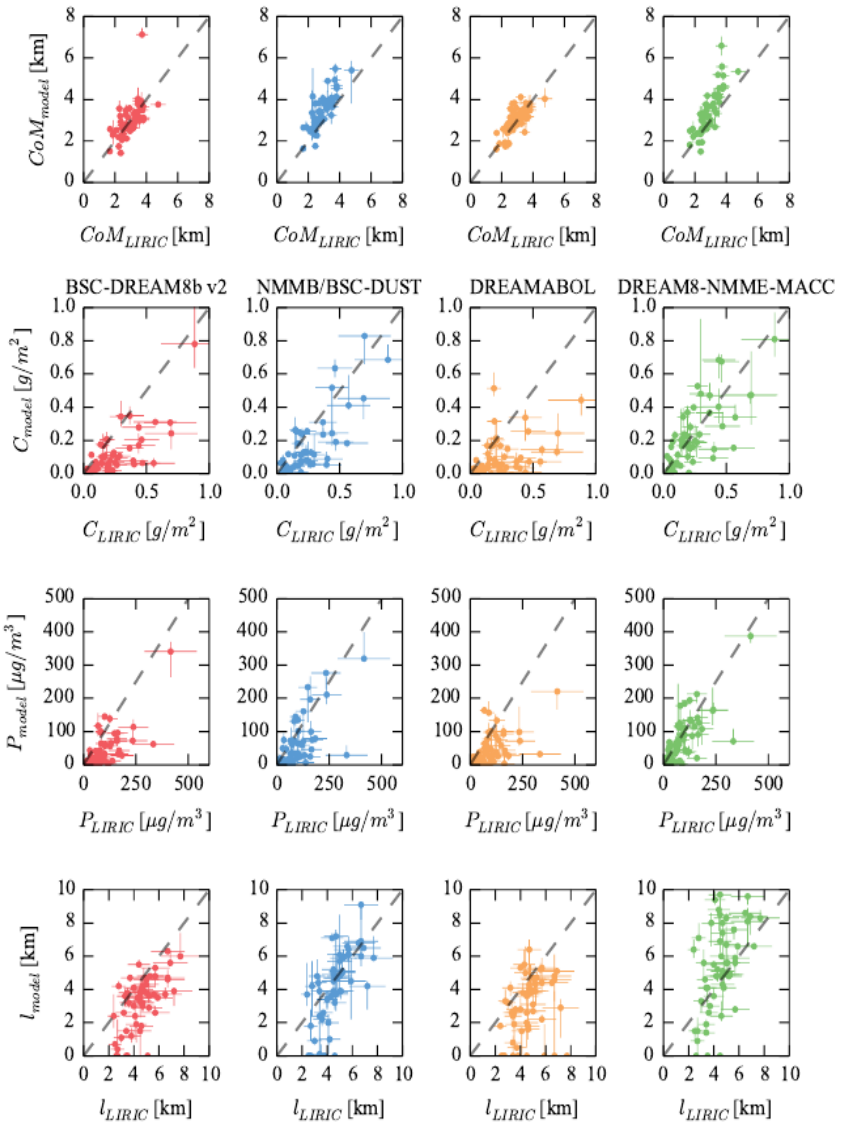
(Huneeus et al., ACP, 2016)

SDS-WAS NAMEE: Model intercomparison

EARLINET vertical dust profiles: 2011-2013







(Binietoglou et al., ATM, 2015)

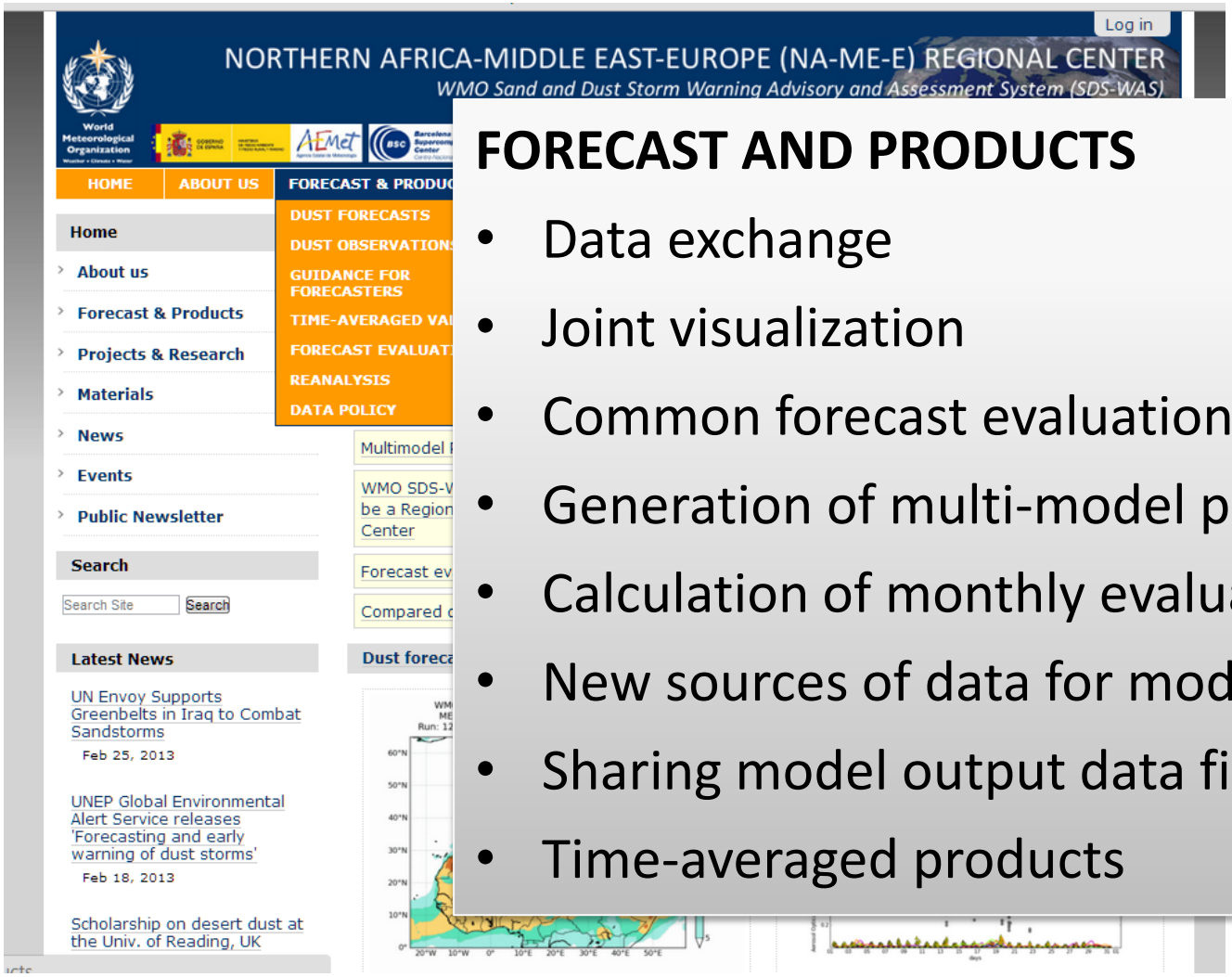
SDS-WAS NAMEE: Model intercomparison

The extreme dust storm occurred in Tehran (Iran) on **2nd June 2014** lasting less than 2 hours according to public evidence.

Based on public news, the dust storm caused several deaths, reduction of visibility to several tenths meters in the city, and adverse disturbance of the public traffic. The blowing wind reached 110 km/h.

This project aims to **better understand generation and development of small-scale dust storms** contributing so to exploring a potential of dust models to more accurately simulate such events, considering them as the most difficult ones to be operationally predicted.

SDS-WAS NAMEE: Dust Forecasts



FORECAST AND PRODUCTS

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

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

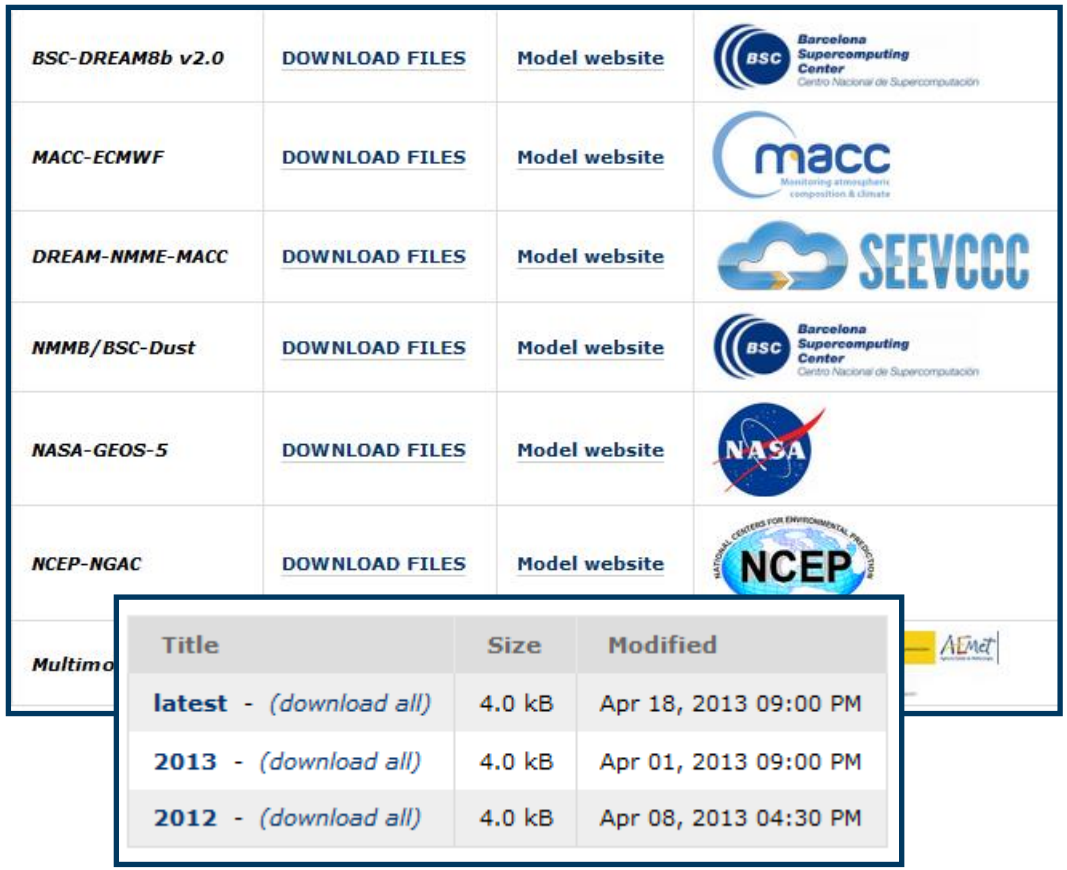
SDS-WAS NAMEE: Dust Forecasts

Dust prediction models provide 72 hours (at 3-hourly basis) of dust forecast (AOD at 550nm and surface concentration) covering the NAMEE region.

MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b v2.0	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
CAMS-ECMWF	00	Global	MODIS AOD
DREAM8-NMME	00	Regional	CAMS analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
EMA REG CM4	12	Regional	No
DREAMABOL	12	Regional	No
NOA WRF-CHEM	12	Regional	No
FMI-SILAM	12	Global	No
TNO LOTOS	12	Regional	No

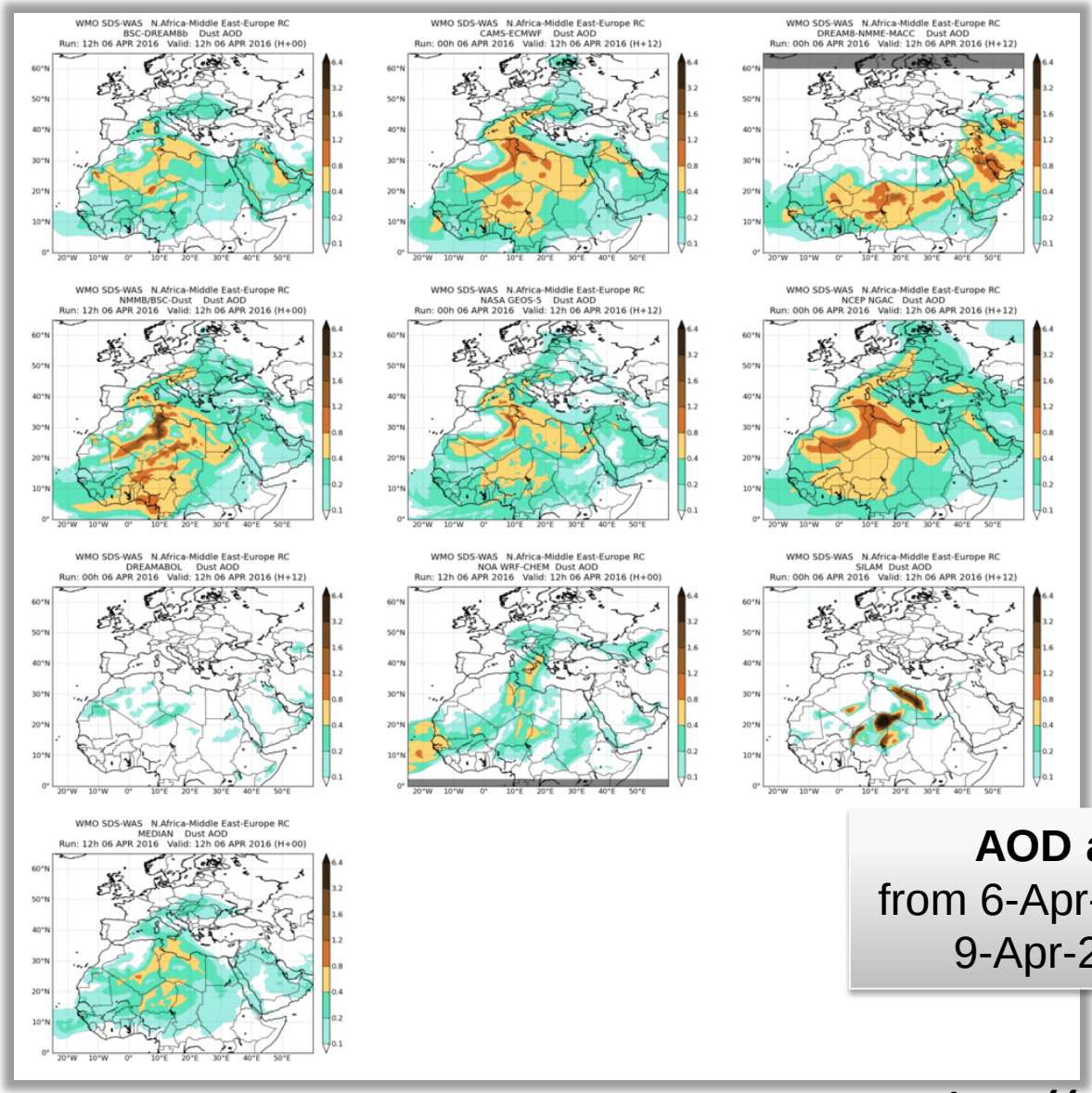
http://sds-was.aemet.es/

SDS-WAS NAMEE: 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.

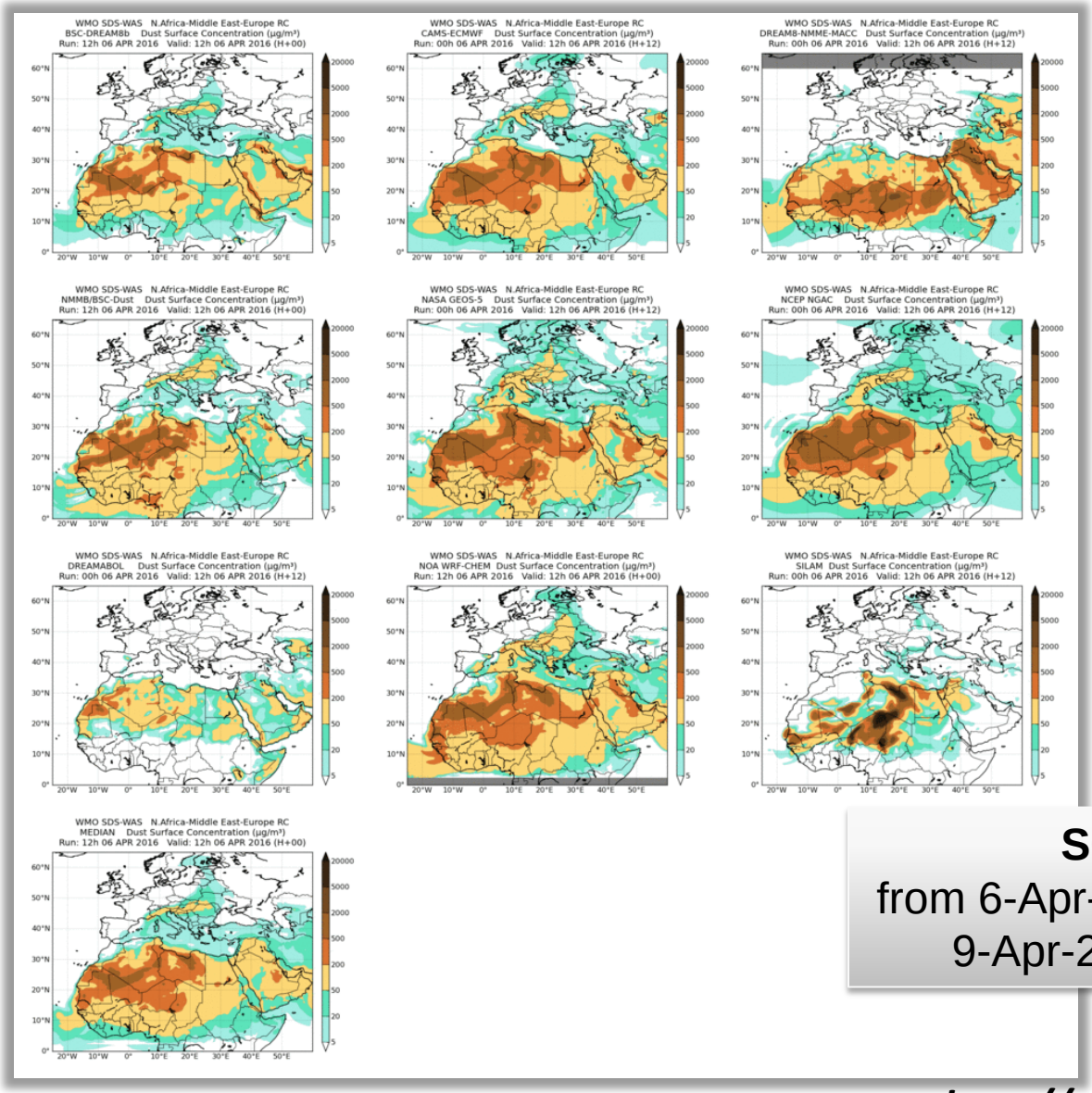
SDS-WAS NAMEE: Joint visualization



AOD at 550nm
from 6-Apr-2016 12:00 to
9-Apr-2016 00:00

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

SDS-WAS NAMEE: Joint visualization



SCON
from 6-Apr-2016 12:00 to
9-Apr-2016 00:00

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

SDS-WAS NAMEE: Multi-model

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

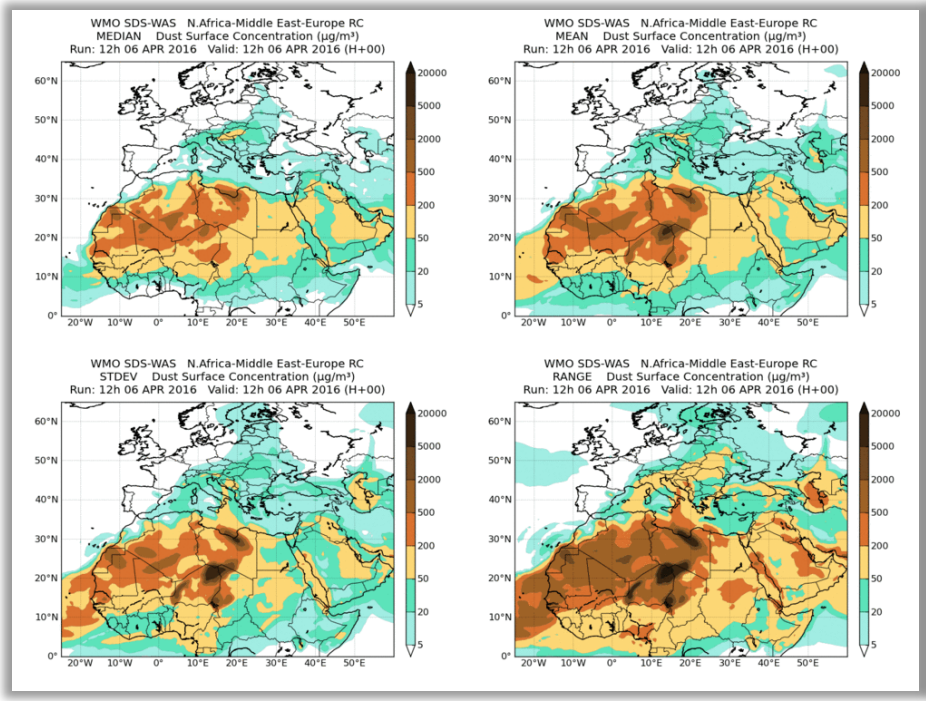
EXCELENCIA SEVERO OCHOA

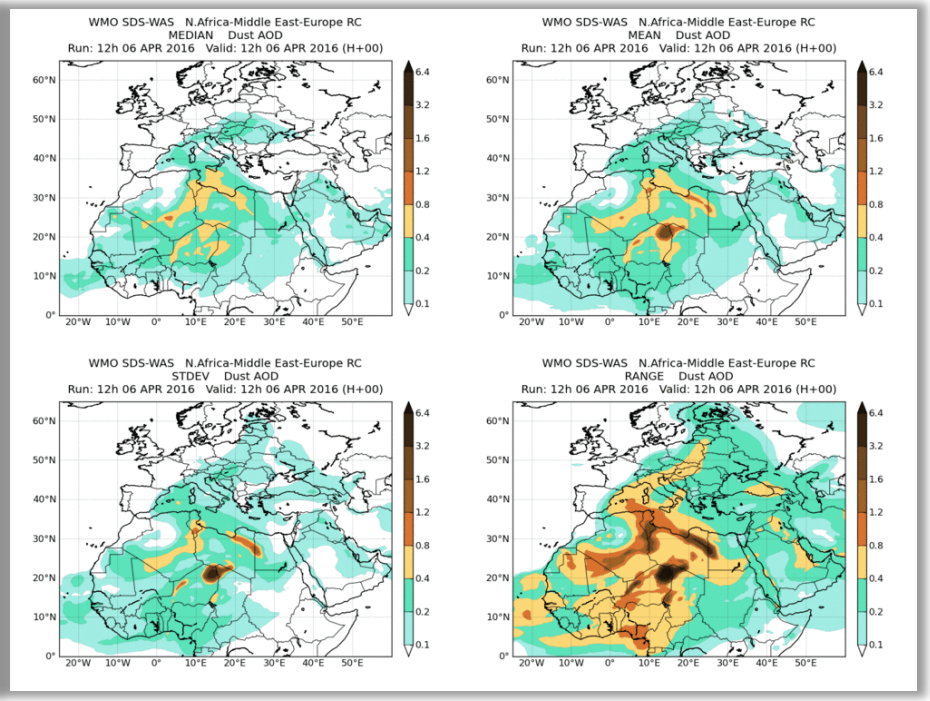
AEMet Agencia Estatal de Meteorología

World Meteorological Organization

Surface concentration

DOD at 550nm





from 6-Apr-2016 12:00 to 9-Apr-2016 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

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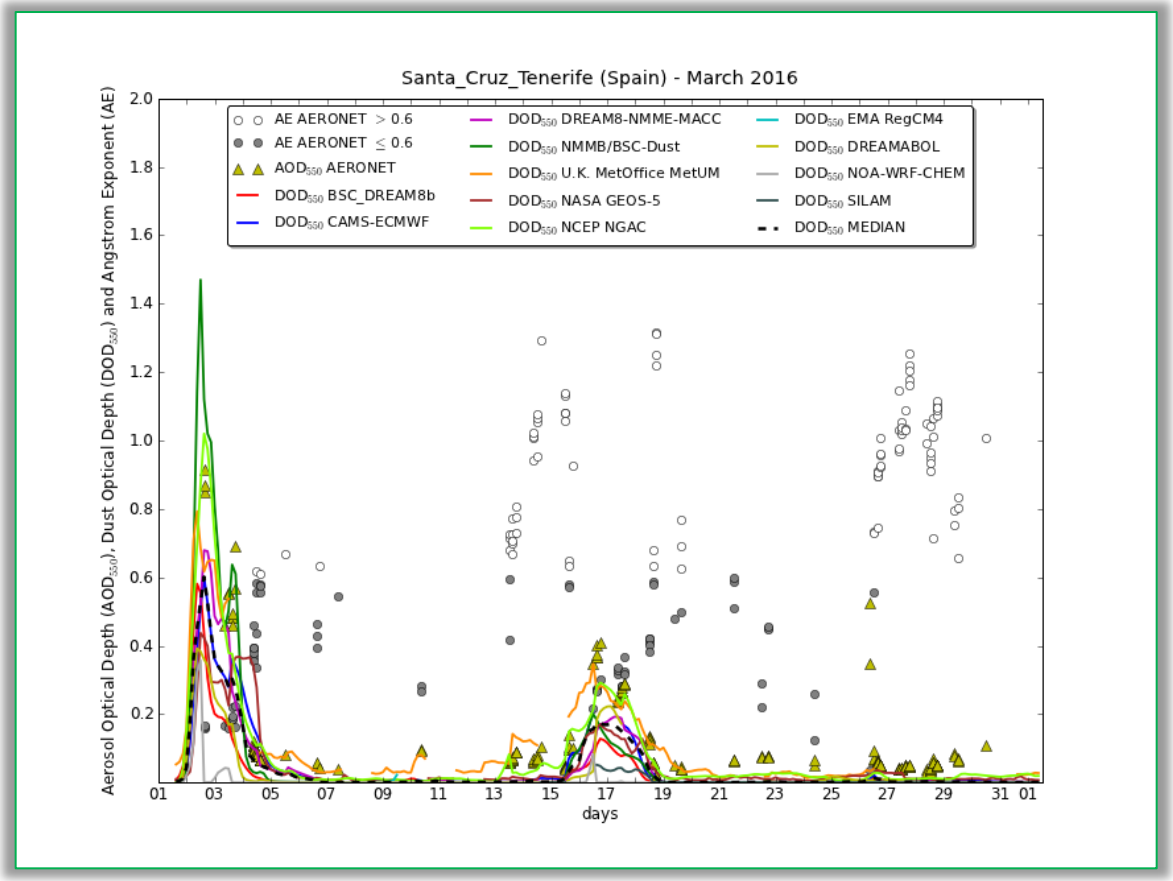
SDS-WAS NAMEE: NRT AERONET



A set of evaluation metrics are selected: ***Bias, RMSE, correlation coefficient and FGE***

Calculations evaluation metrics are done for:

- ***monthly/seasonal/annual***
- ***sites and regions***

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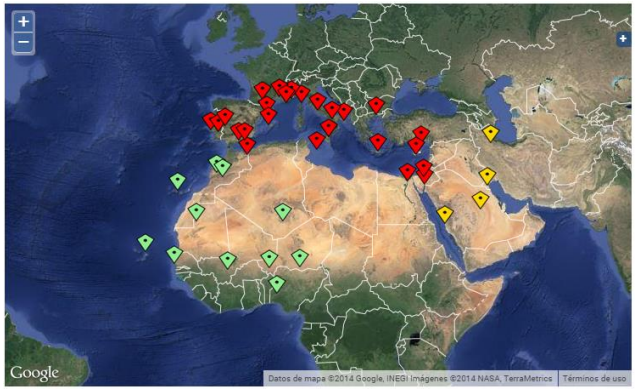
SDS-WAS NAMEE: NRT AERONET



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- ***monthly/seasonal/annual***
- ***sites and regions***

Seasonal scores

by Francesco Benincasa — last modified Jan 14, 2016 04:52 PM

Date: - Select Year - ▾ - Select Season - ▾

Dec 2015 - Feb 2016. Dust Optical Depth.
Threshold Angstrom Exponent = 0.600

BIAS

	BSC_DREAM8b	CAMS-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF-CHEM	MEDIAN
Sahel/Sahara show stations	-0.33	-0.17	-0.23	0.05	-0.06	-0.16	-0.10	0.10	-0.34	-0.25	-0.21
Middle East show stations	-0.12	-0.03	-0.07	-0.25	-0.03	-0.15	-0.17	0.13	-0.22	-0.17	-0.16
Mediterranean show stations	-0.17	-0.17	-0.15	-0.18	-0.09	-0.16	-0.13	-0.09	-0.16	-0.16	-0.16
TOTAL	-0.26	-0.17	-0.20	-0.04	-0.07	-0.16	-0.11	0.03	-0.27	-0.21	-0.19

ROOT MEAN SQUARE ERROR

	BSC_DREAM8b	CAMS-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF-CHEM	MEDIAN
Sahel/Sahara show stations	0.54	0.41	0.51	0.42	0.36	0.37	0.38	0.66	0.56	0.53	0.43
Middle East show stations	0.32	0.28	0.34	0.41	0.33	0.34	0.35	0.34	0.37	0.39	0.33
Mediterranean show stations	0.32	0.33	0.30	0.32	0.30	0.31	0.30	0.40	0.31	0.34	0.31
TOTAL	0.46	0.38	0.44	0.39	0.34	0.35	0.35	0.57	0.48	0.47	0.39

CORRELATION COEFFICIENT

	BSC_DREAM8b	CAMS-ECMWF	DREAM8-NMME-MACC	NMMB/BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF-CHEM	MEDIAN

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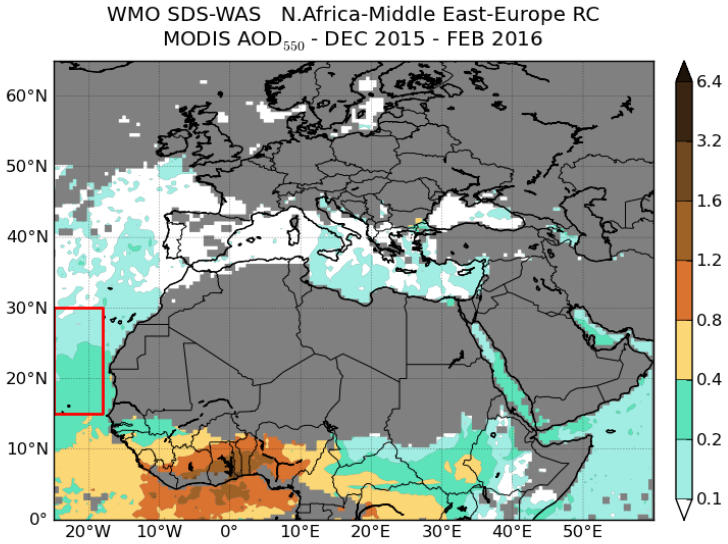
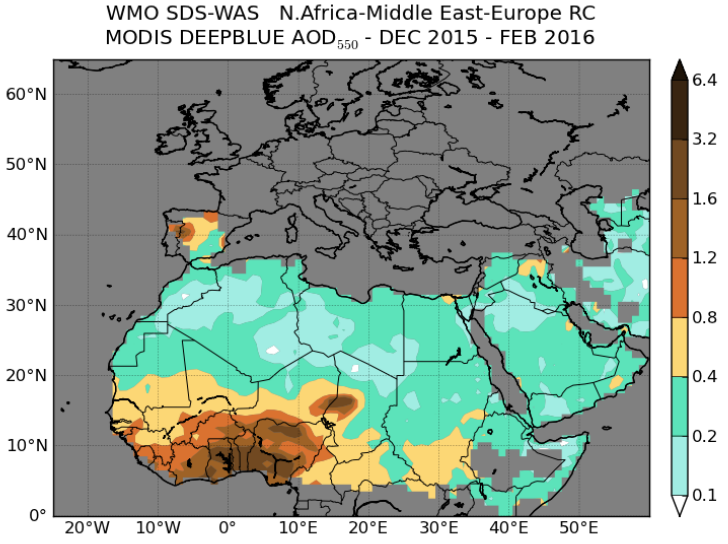
SDS-WAS NAMEE: MODIS





	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.24	0.43	0.63	1.07	207012
NMMB/BSC-Dust	-0.10	0.29	0.78	0.98	201353
NCEP NGAC	-0.12	0.32	0.68	0.71	207012
EMA RegCM4	0.11	0.54	0.29	0.94	39231
DREAMABOL	-0.21	0.44	0.36	0.96	198954
NOA-WRF-CHEM	-0.19	0.41	0.46	1.04	198463

	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.23	0.44	0.45	0.89	51308
NMMB/BSC-Dust	-0.11	0.34	0.78	1.03	47494
NCEP NGAC	-0.14	0.34	0.69	0.66	48659
EMA RegCM4	0.17	0.59	0.35	0.82	12050
DREAMABOL	-0.25	0.46	0.41	0.91	48036
NOA-WRF-CHEM	-0.22	0.43	0.48	1.03	51220

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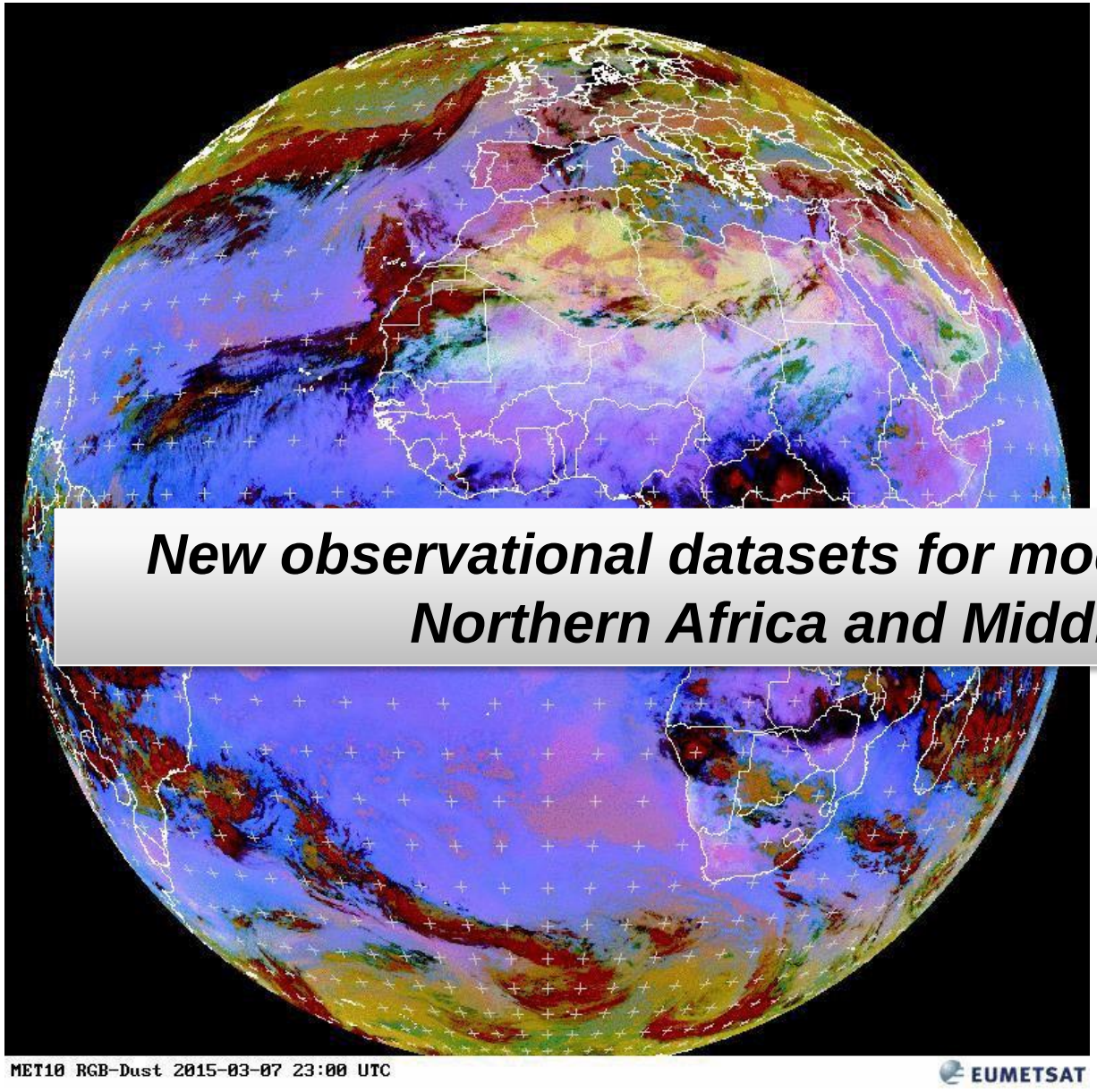
SDS-WAS NAMEE: Model evaluation

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

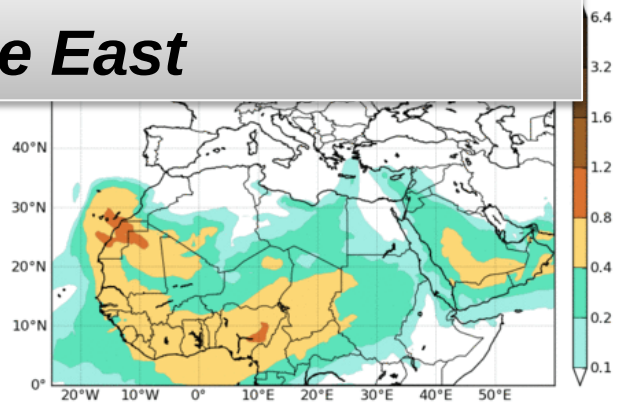
AEMet Agencia Estatal de Meteorología

EUMETSAT



7 March 2015

New observational datasets for model evaluation in Northern Africa and Middle East



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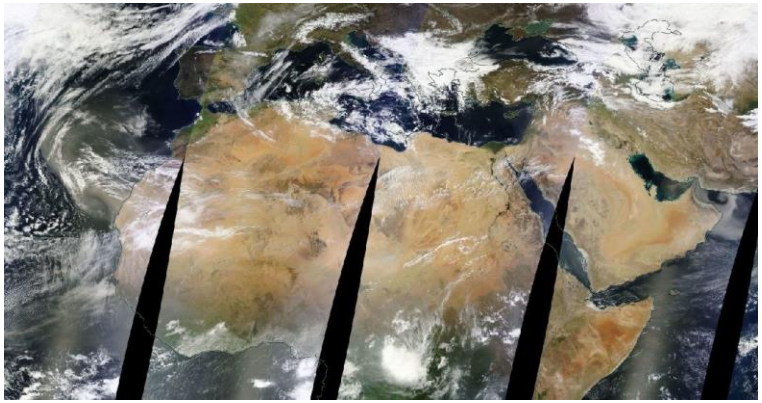
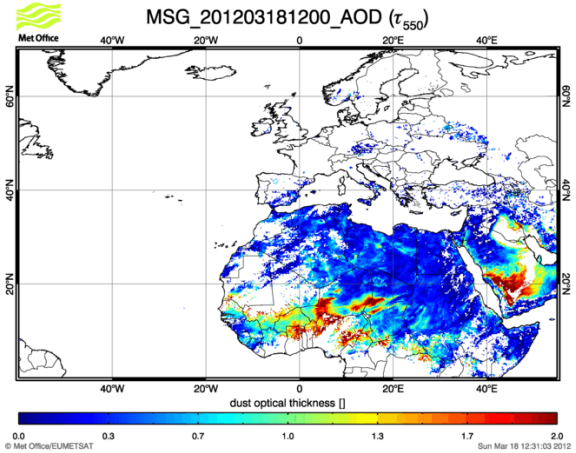
SDS-WAS NAMEE: Model evaluation

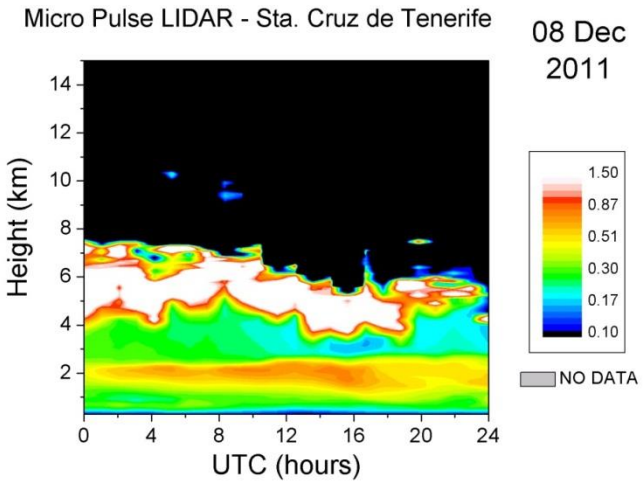
New observational datasets for model evaluation in Northern Africa and Middle East

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



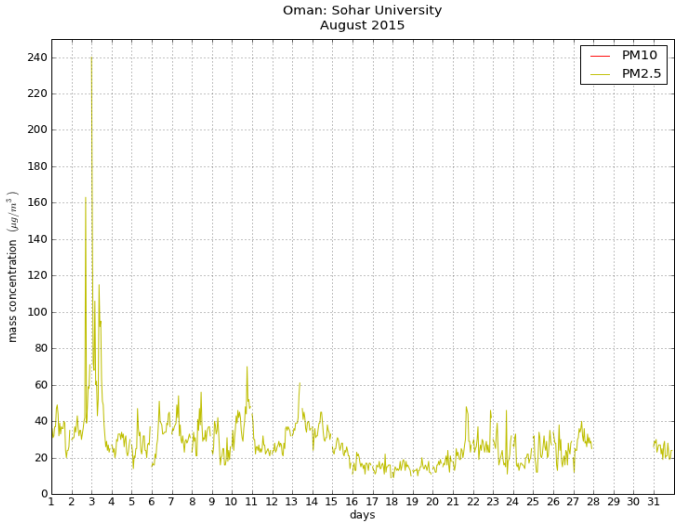
MODIS composite 8th March 2015 from EOSDIS World Viewer

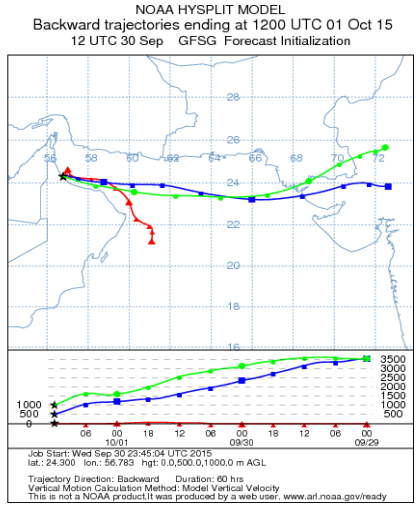


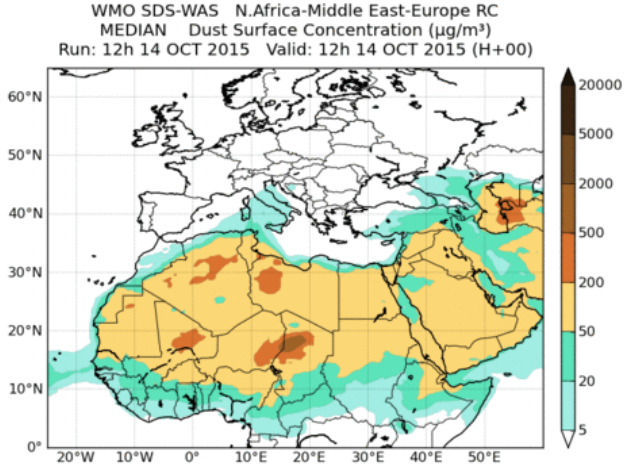


SDS-WAS NAMEE: Model evaluation

NRT surface concentration





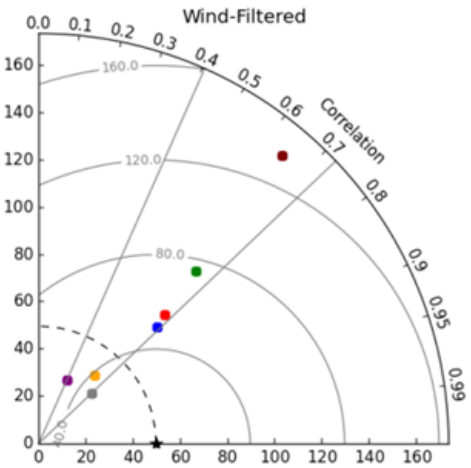


SDS-WAS NAMEE: Model evaluation

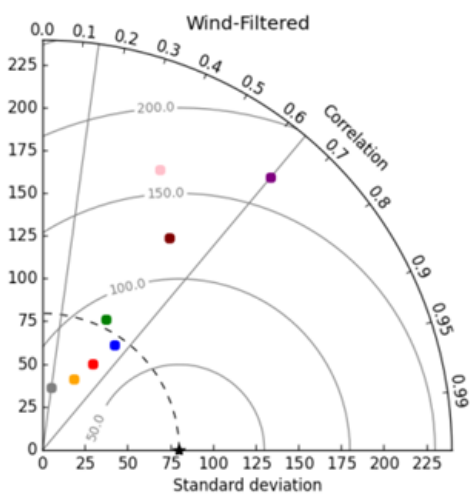
AMMA network: PM10 in Sahel for the year 2013

Not all PM10 is dust: *Local and biomass burning from Savannah fires.*
Dust filter: *Considering the localizations of the desert dust sources the filter is based on wind direction.*

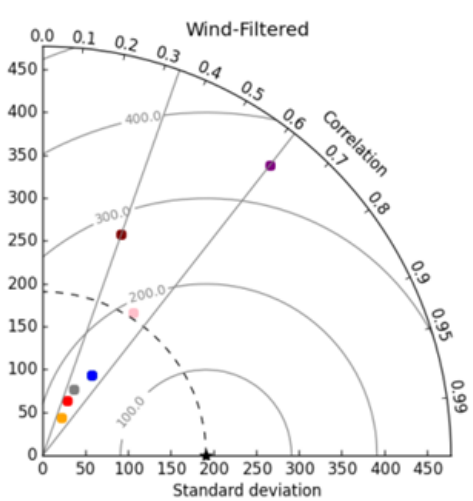
M'Bour-Senegal



Cinzana-Mali



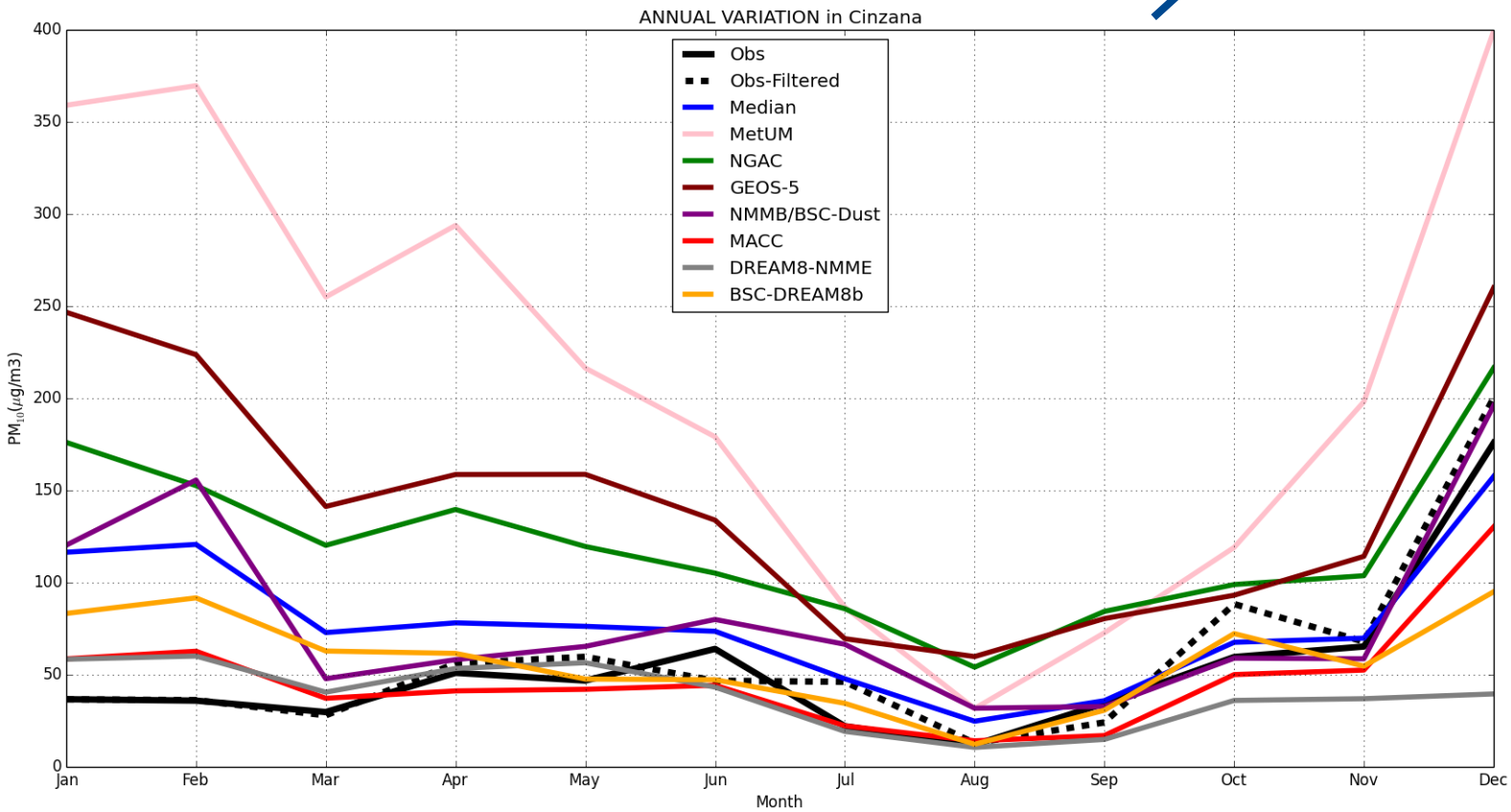
Banizoumbou-Niger



AMMA (Marticorena et al., 2010)

SDS-WAS NAMEE: Model evaluation

AMMA network: PM10 in Sahel for the year 2013

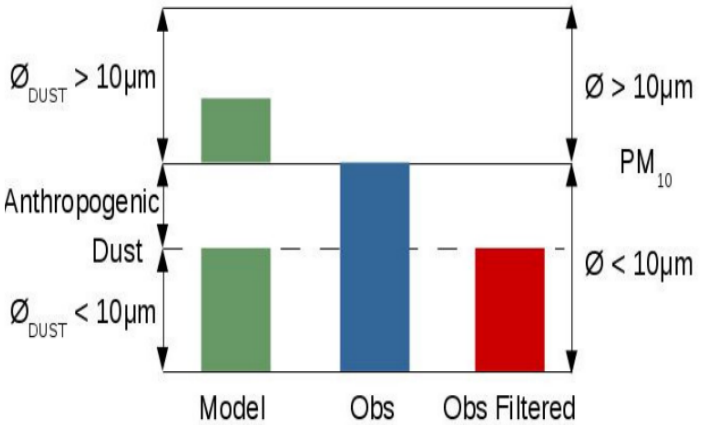


AMMA (Marticorena et al., 2010)

SDS-WAS NAMEE: Model evaluation

AQ network: Canary Islands 2013-2014

Not all PM10 is dust: *Local sources*
Dust filter: *Moving 40th percentile of 30 days, 15 days before and 15 days after (Escudero at al. 2007).*



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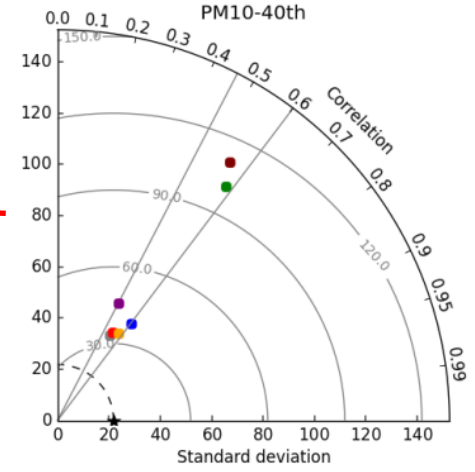
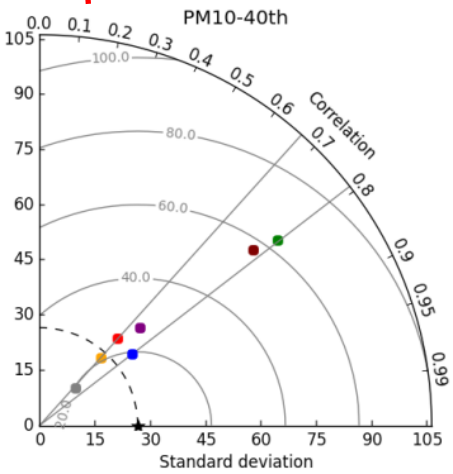
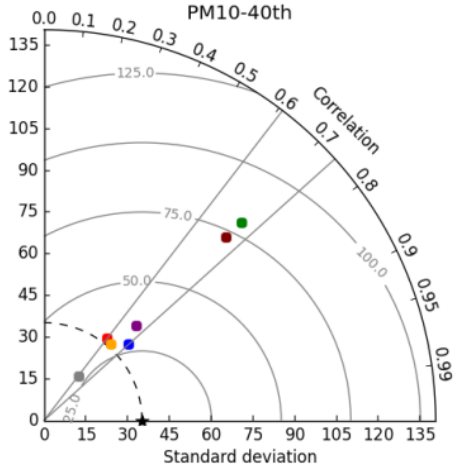
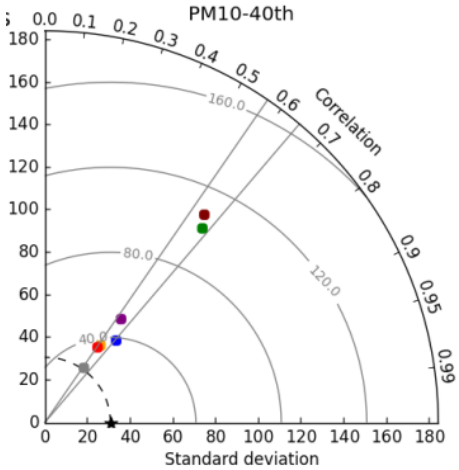
SDS-WAS NAMEE: Model evaluation

AQ network: Canary Islands 2013-2014









- Reference
- CAMS
- Median
- NGAC
- NMMB/BSC-Dust
- BSC-DREAM8b
- GEOS-5
- DREAM8-NMME

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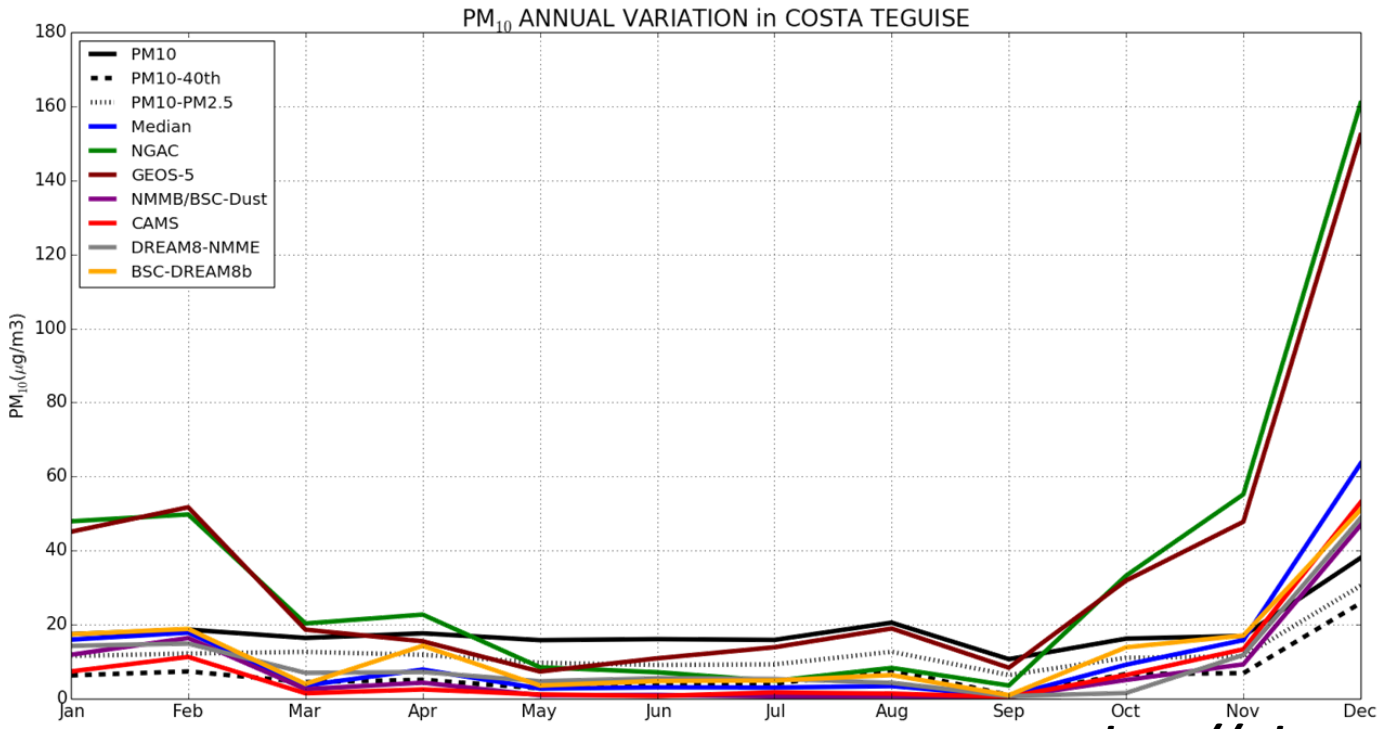
SDS-WAS NAMEE: Model evaluation

AQ network: Canary Islands 2013-2014



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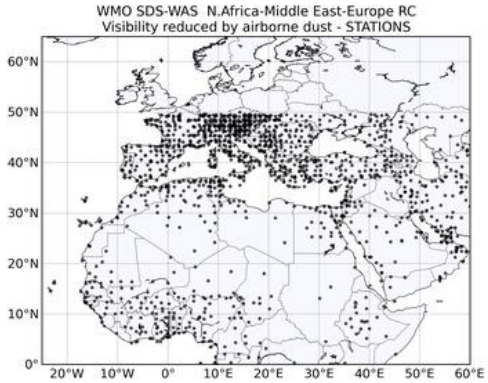
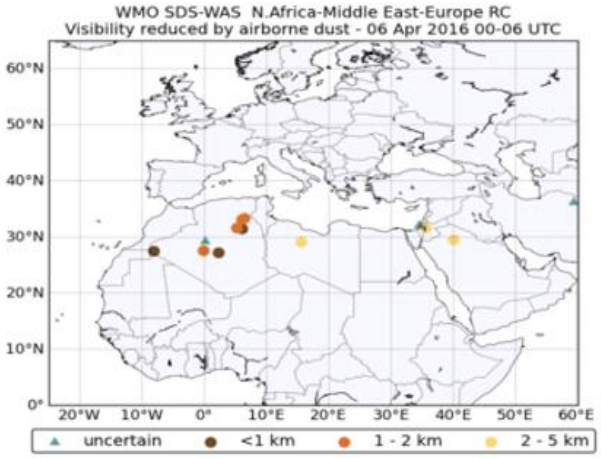
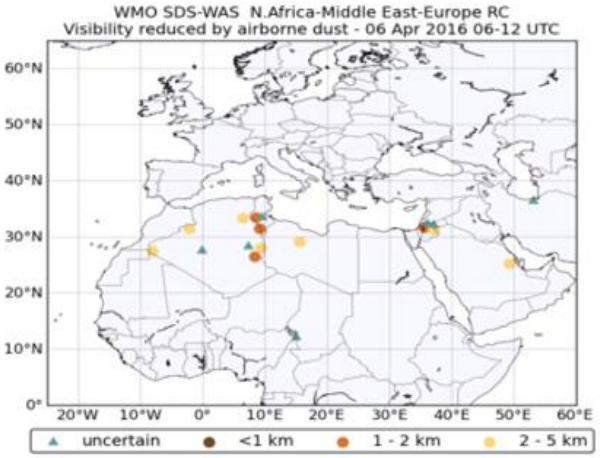
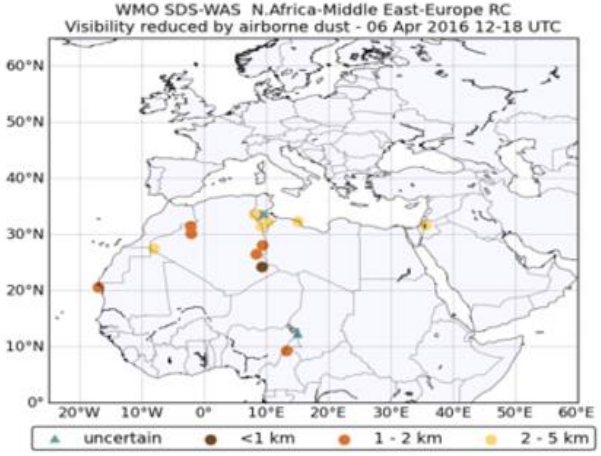
SDS-WAS NAMEE: Model evaluation

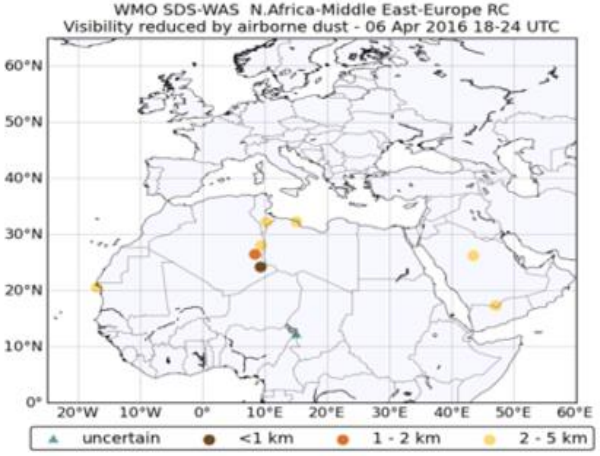
NRT visibility evaluation: 6th April 2016 0-12UTC











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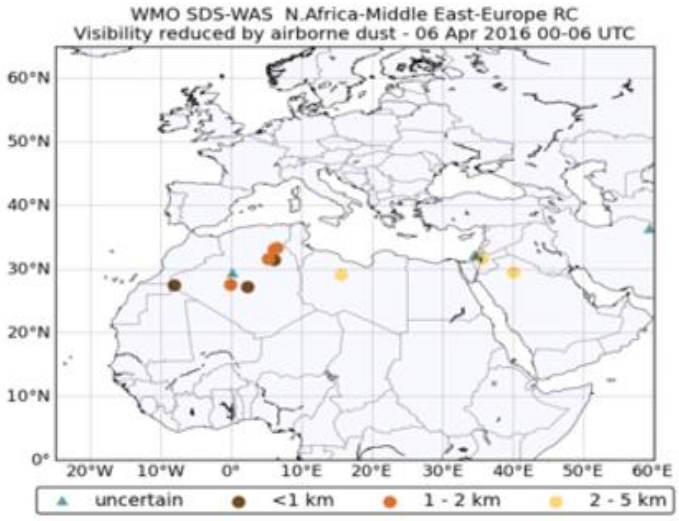
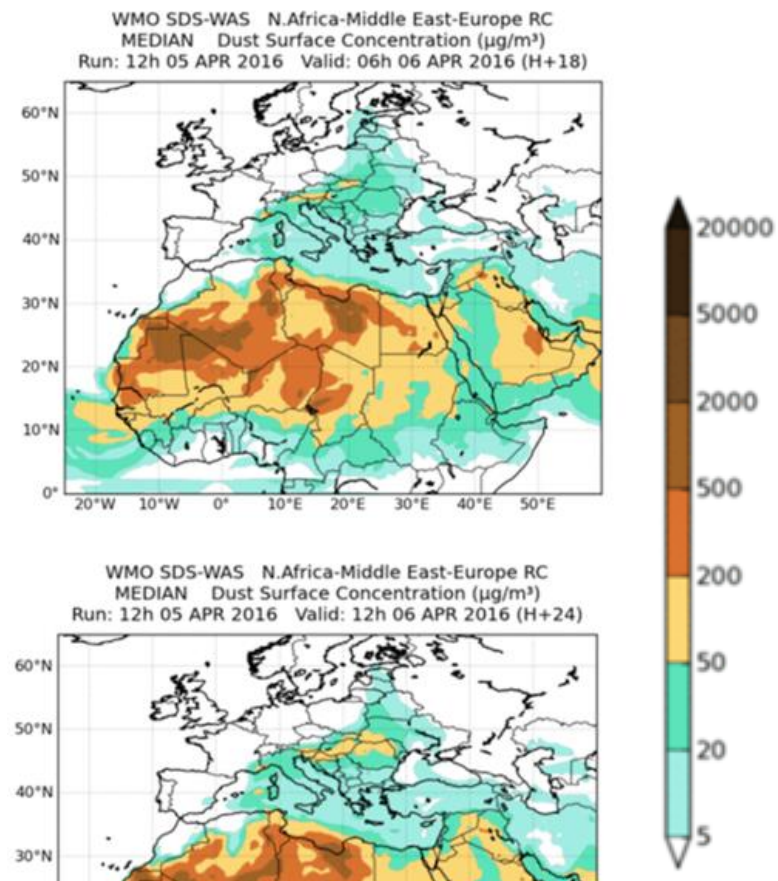
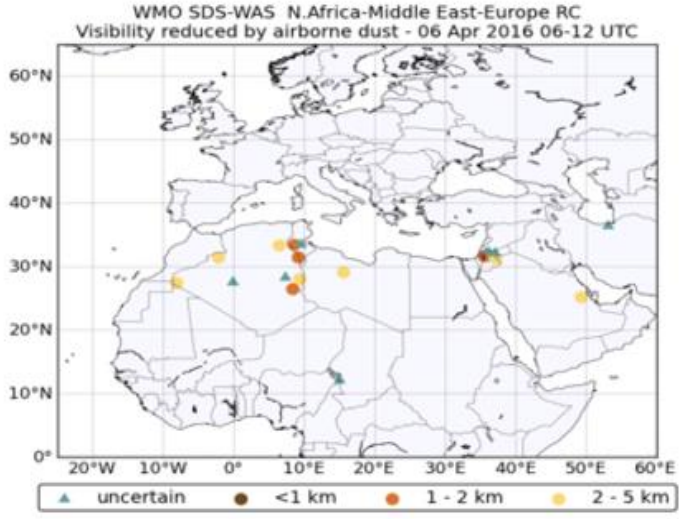
SDS-WAS NAMEE: Model evaluation

NRT visibility evaluation: 6th April 2016 0-12UTC



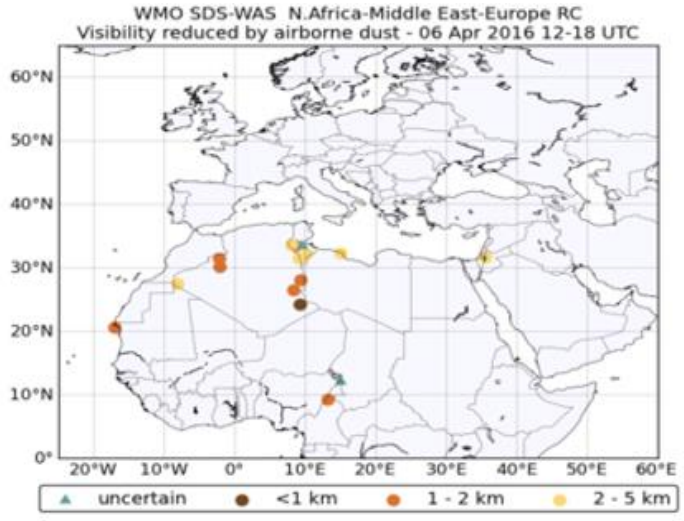


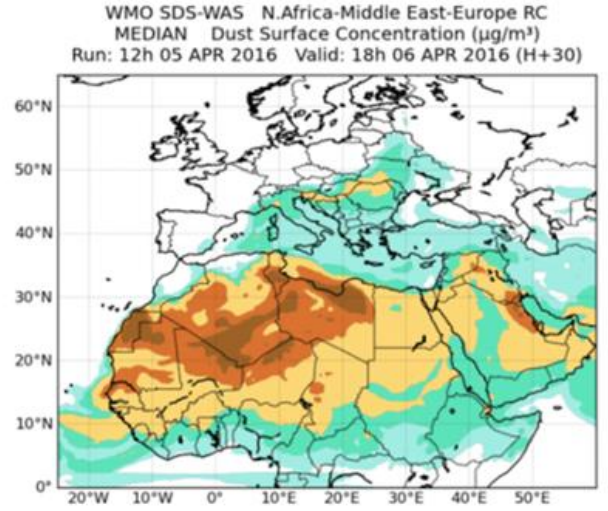


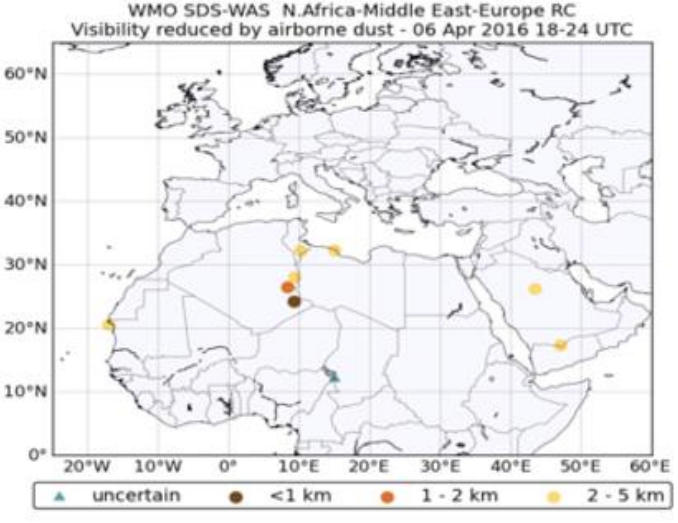
http://sds-was.aemet.es/

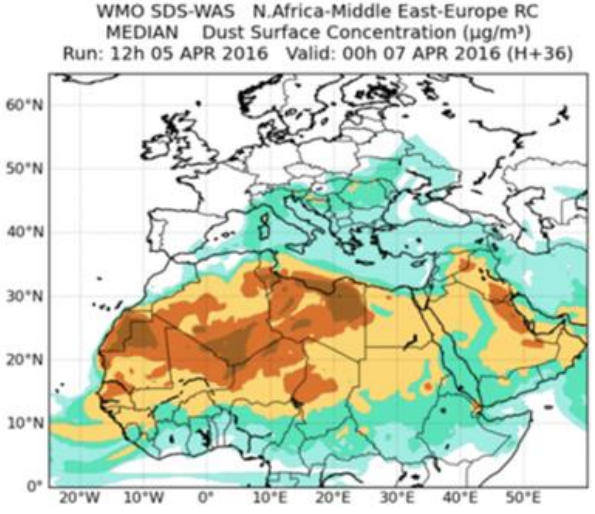
SDS-WAS NAMEE: Model evaluation

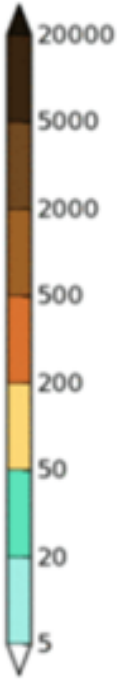
NRT visibility evaluation: 6th April 2016 0-12UTC











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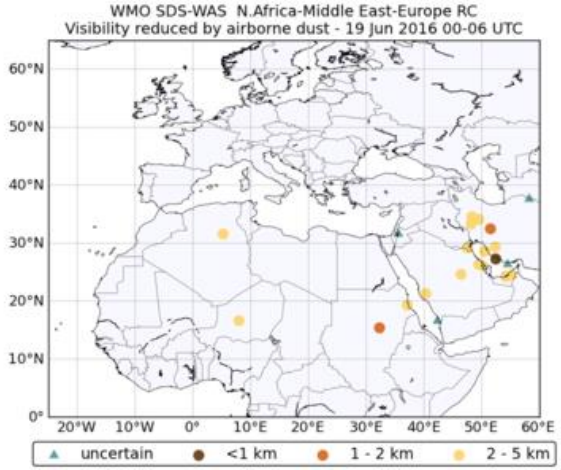
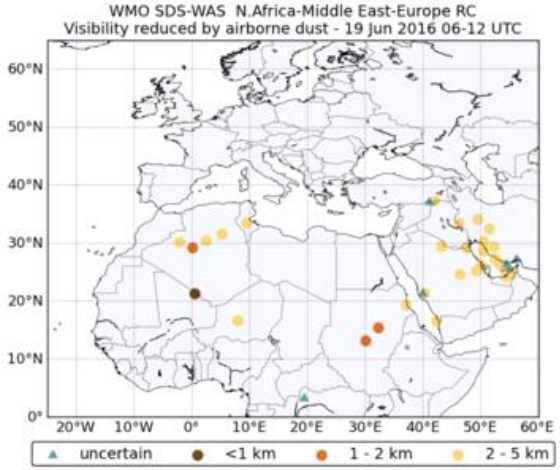
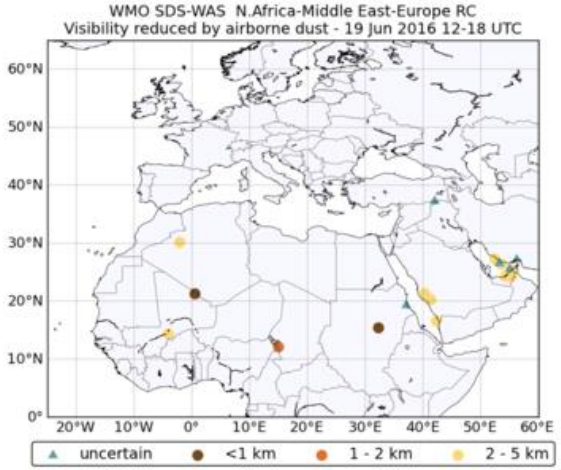
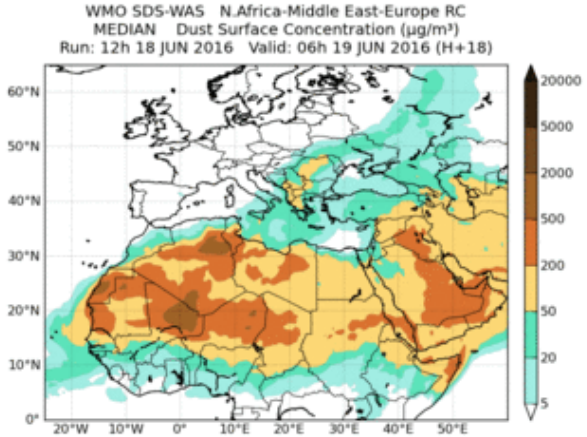
SDS-WAS NAMEE: Model evaluation

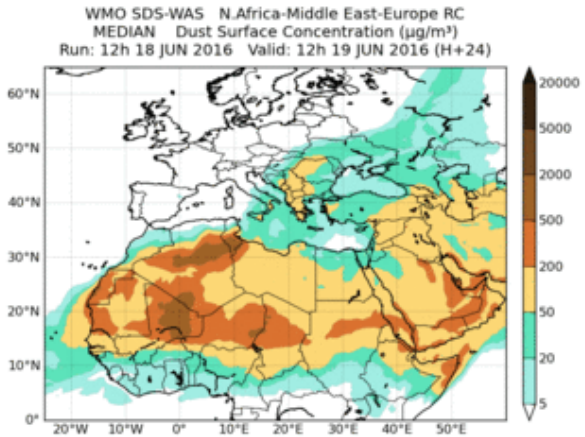
NRT visibility evaluation: 19th june 2016

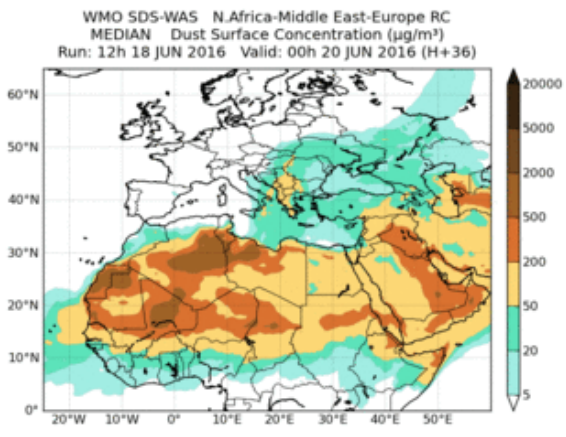










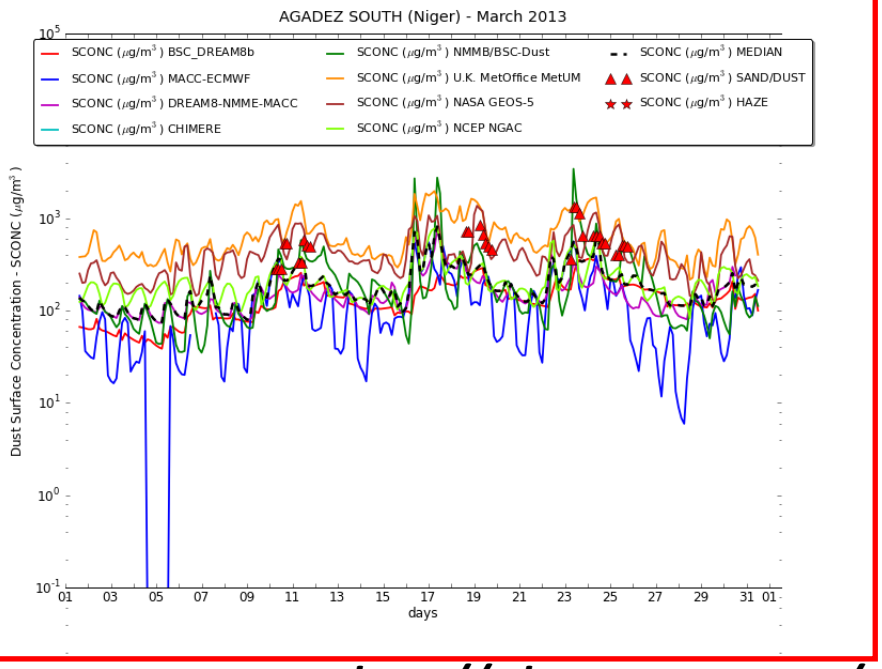


http://sds-was.aemet.es/

SDS-WAS NAMEE: Model evaluation

NRT visibility evaluation: 19th june 2016

AGADEZ SOUTH, Niger



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

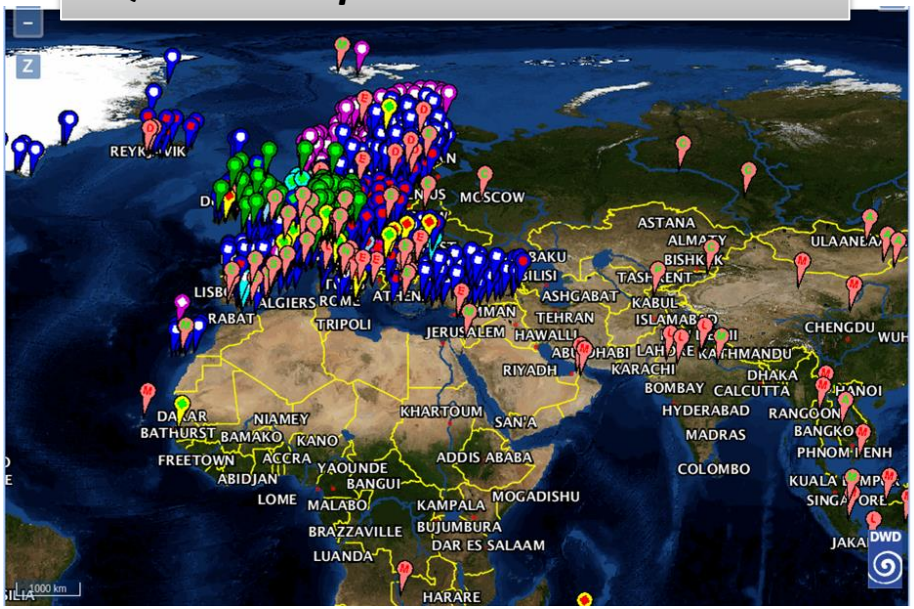
PM10 = 1772.24 $V^{-1.1}$
Camino et al. (2014, Aeolian Res.)

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

SDS-WAS NAMEE: Model evaluation

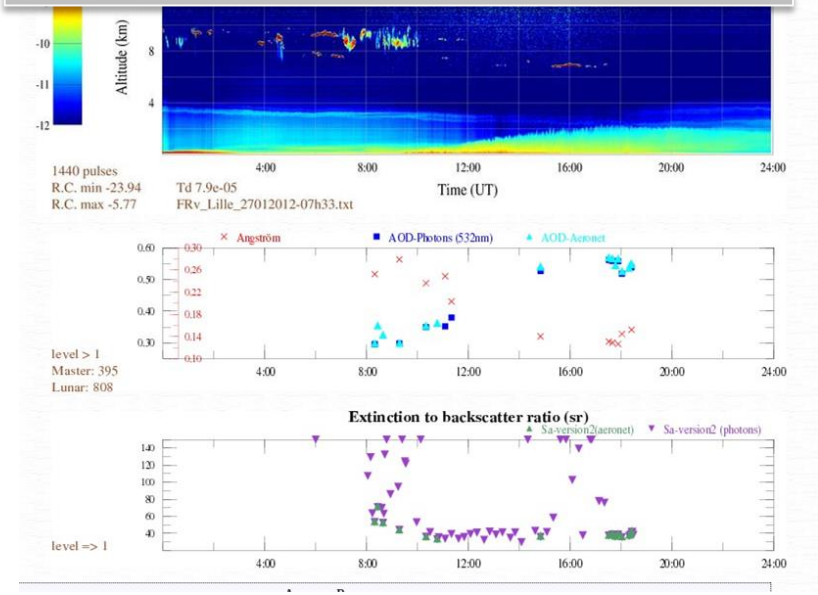
Ceilometer
Santa Cruz de Tenerife, Granada and Montsec (Spain)

+ High density of stations
- Qualitative products



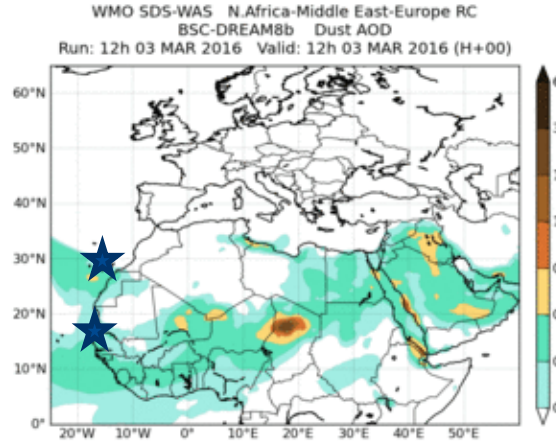
Lidar
M'Bour (Senegal)

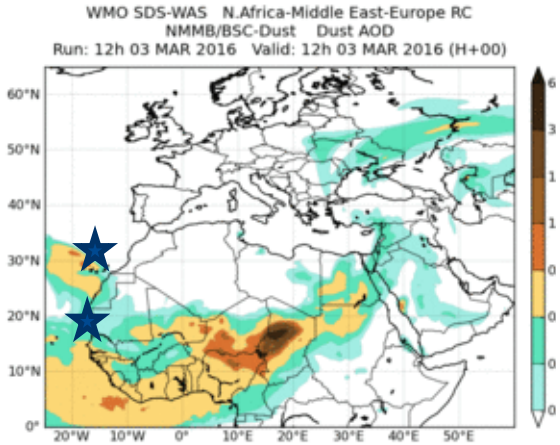
- Low number of stations
+ Quantitative products

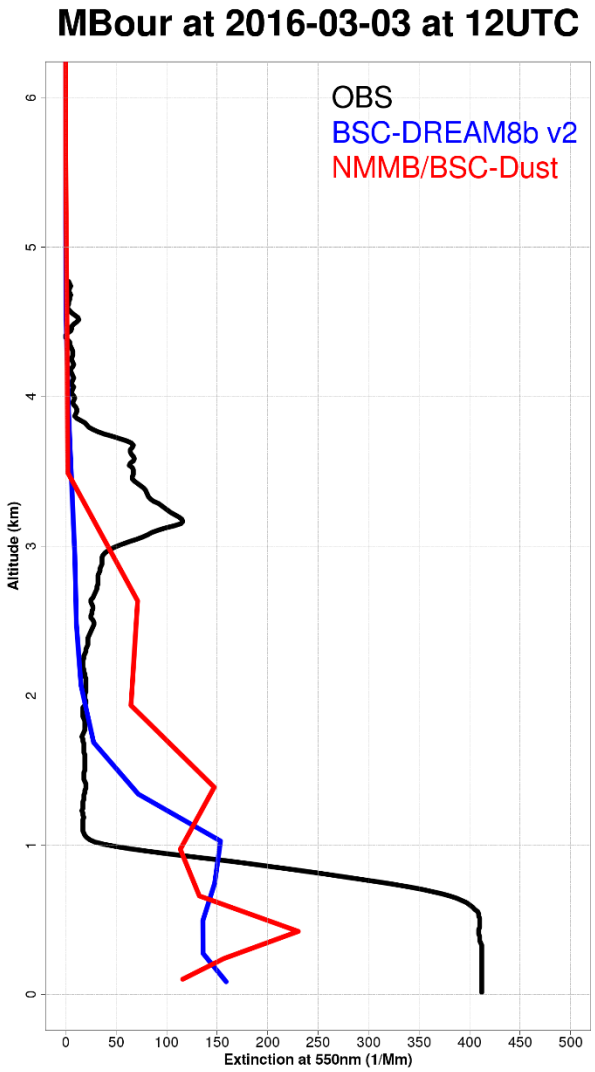


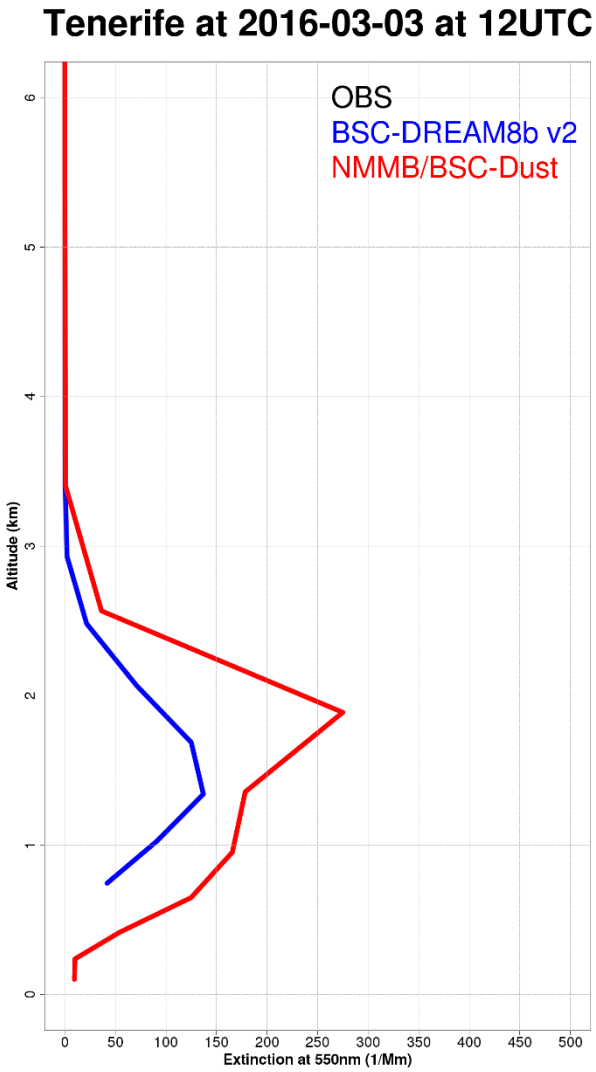
http://sds-was.aemet.es/projects-research/evaluation-of-model-derived-dust-vertical-profiles

SDS-WAS NAMEE: Model evaluation

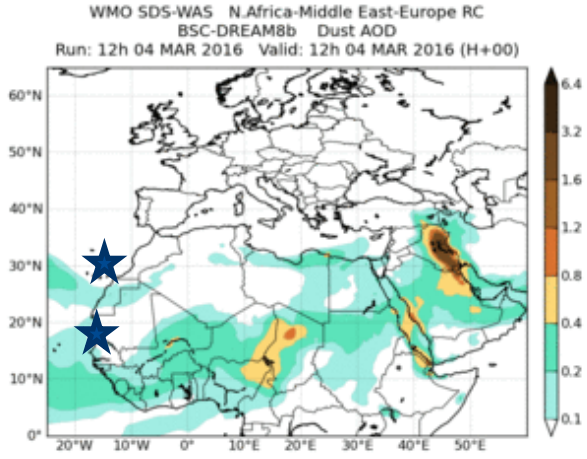


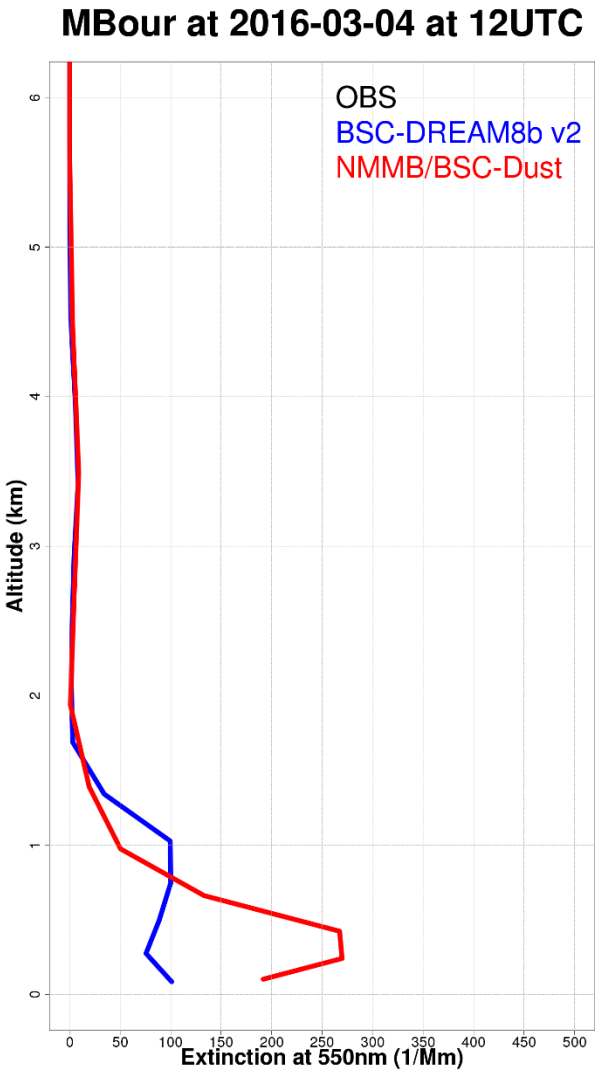


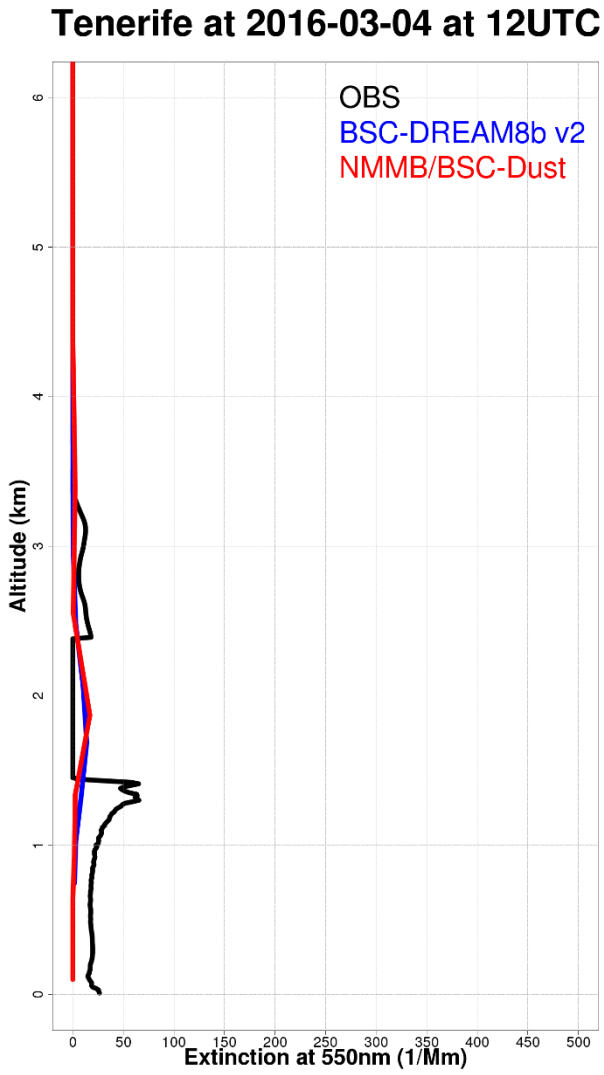




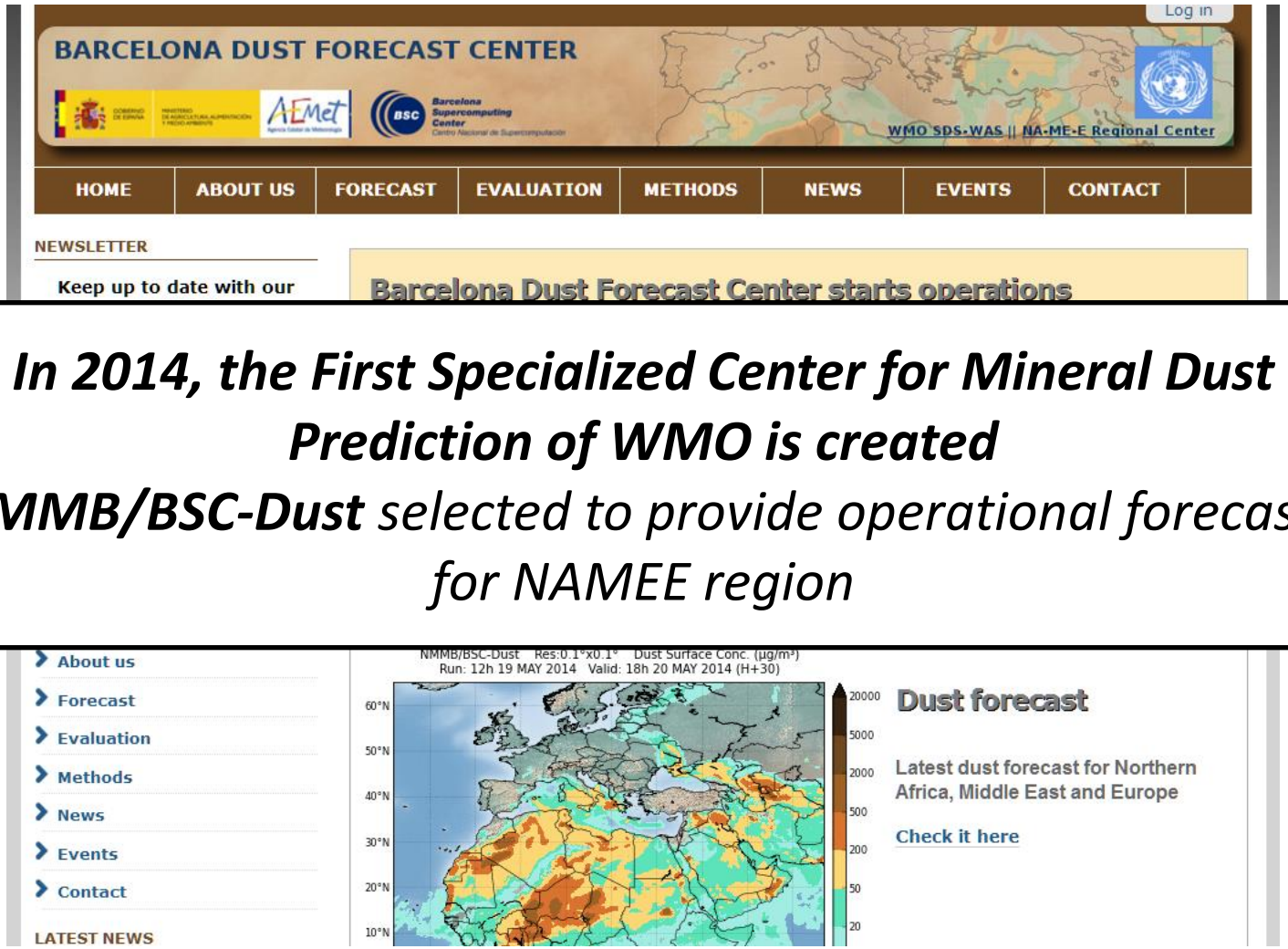
SDS-WAS NAMEE: Model evaluation







Barcelona Dust Forecasting Center



In 2014, the First Specialized Center for Mineral Dust Prediction of WMO is created

NMMB/BSC-Dust *selected to provide operational forecasts for NAMEE region*

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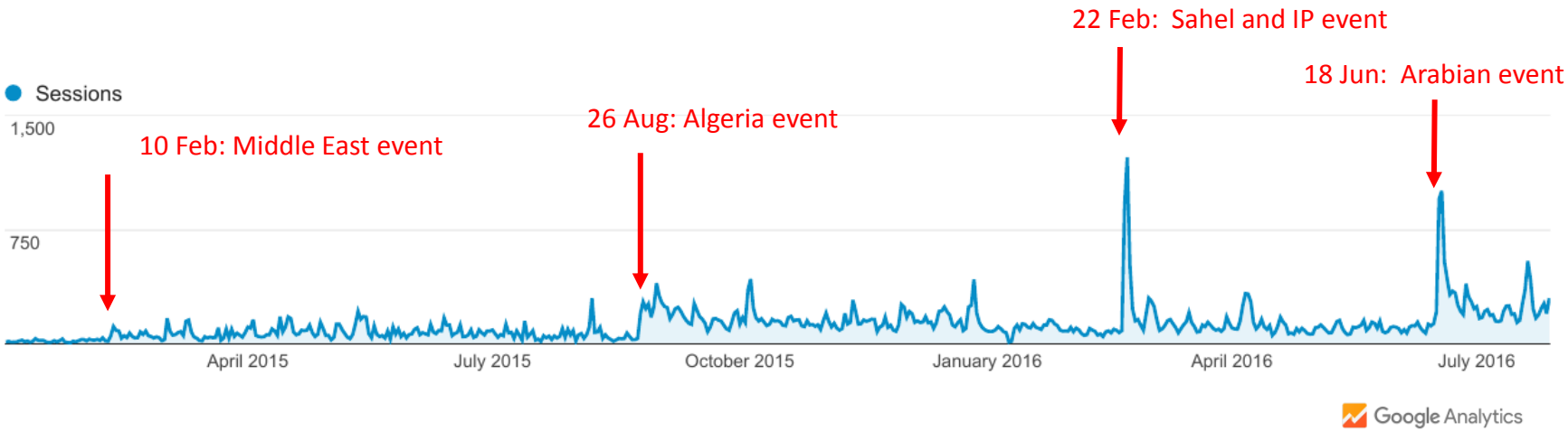
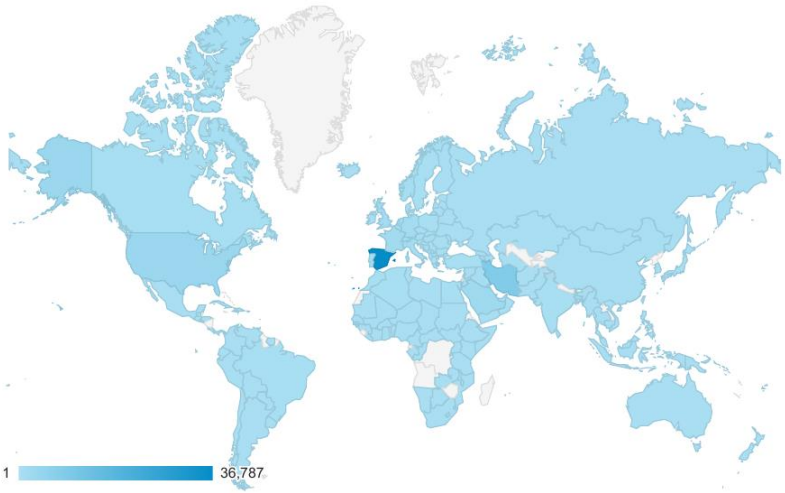
BDFC: Users

Website visits: 1 January 2015 – 28 July 2016





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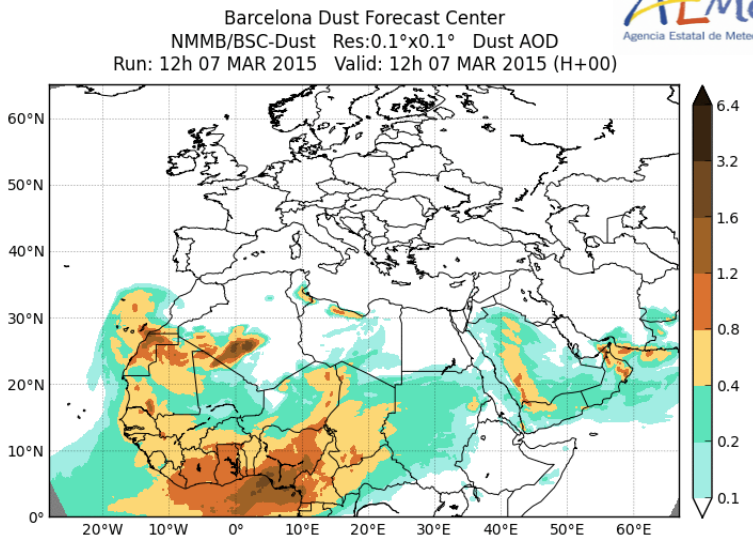
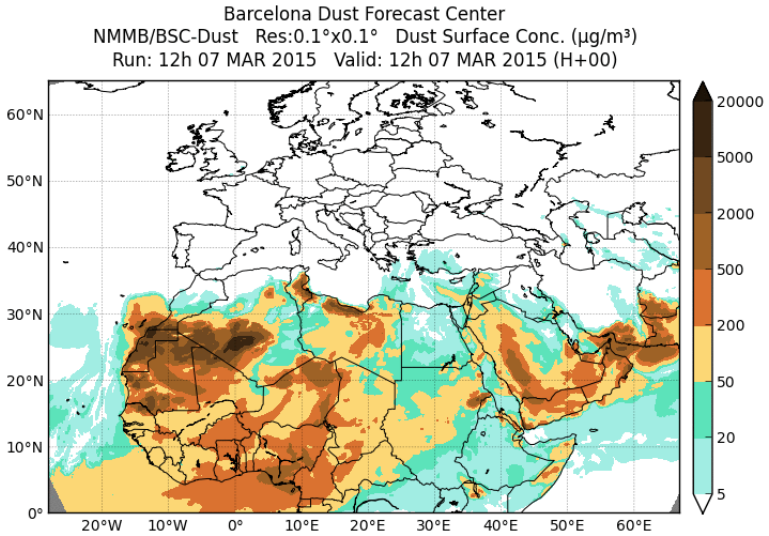
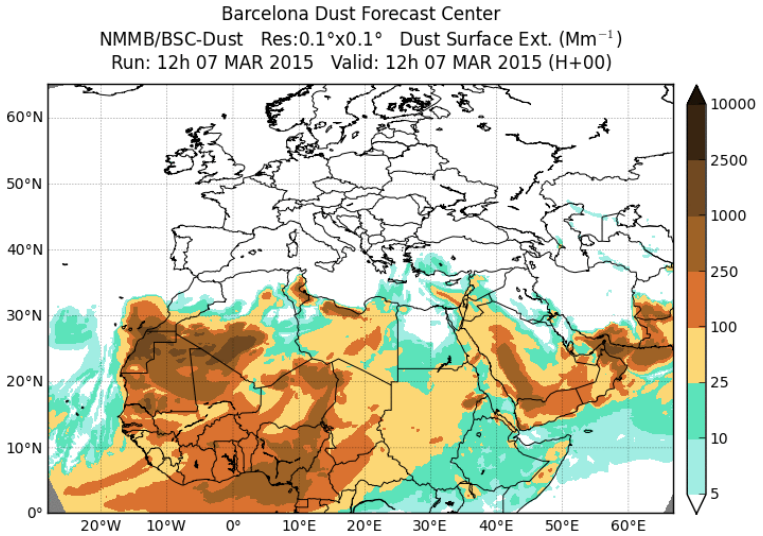
BDFC: Dust Forecasts products

Dust Optical Depth at 550nm
Dust Dry Deposition
Dust Load
Dust Surface Concentration
Dust Surface Extinction at 550nm
Dust Wet Deposition







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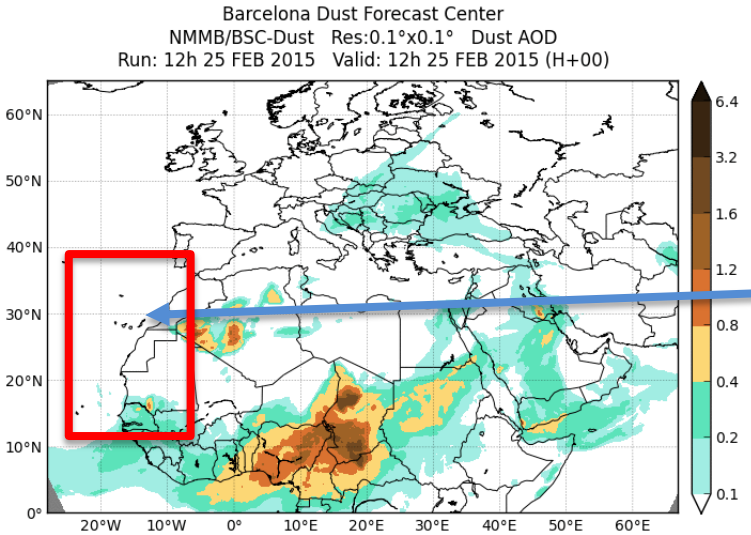
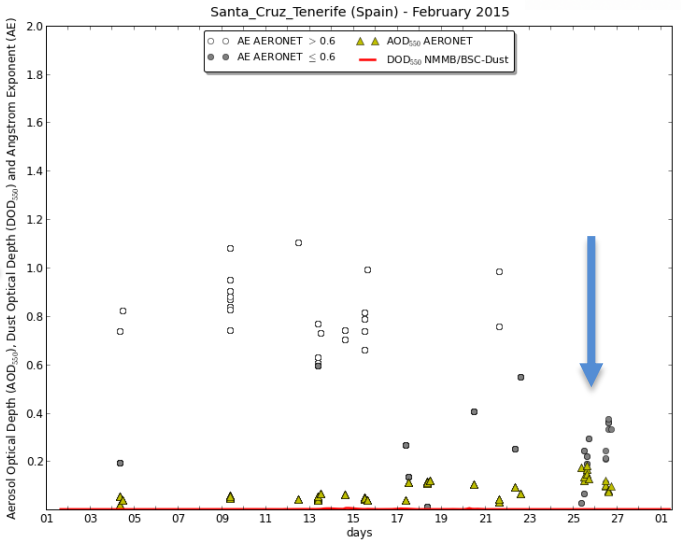
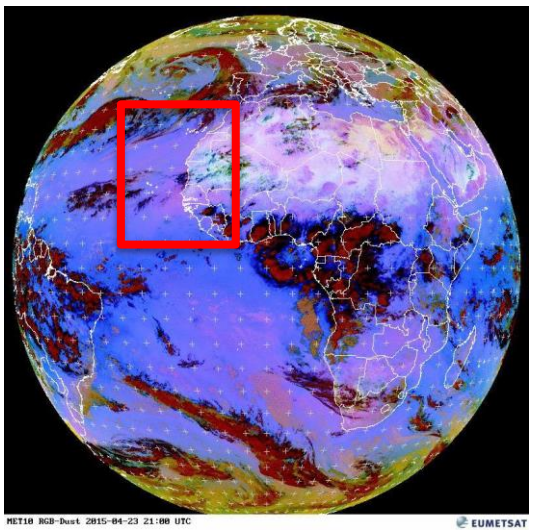
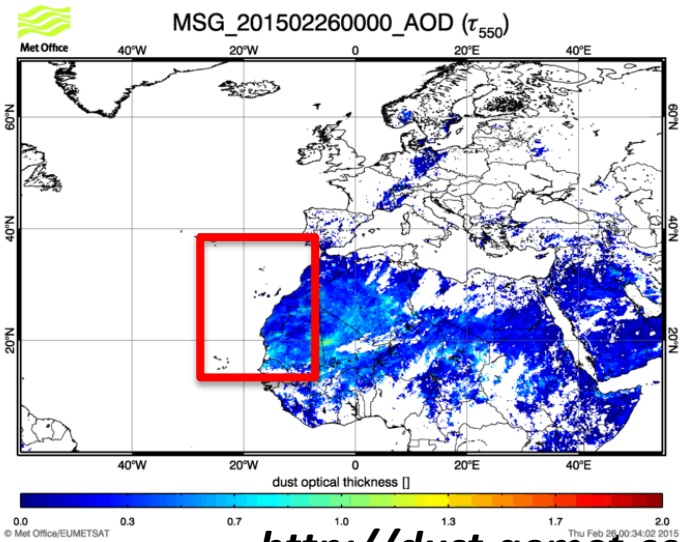
BDFC: Dust event Canary Islands Feb 2015









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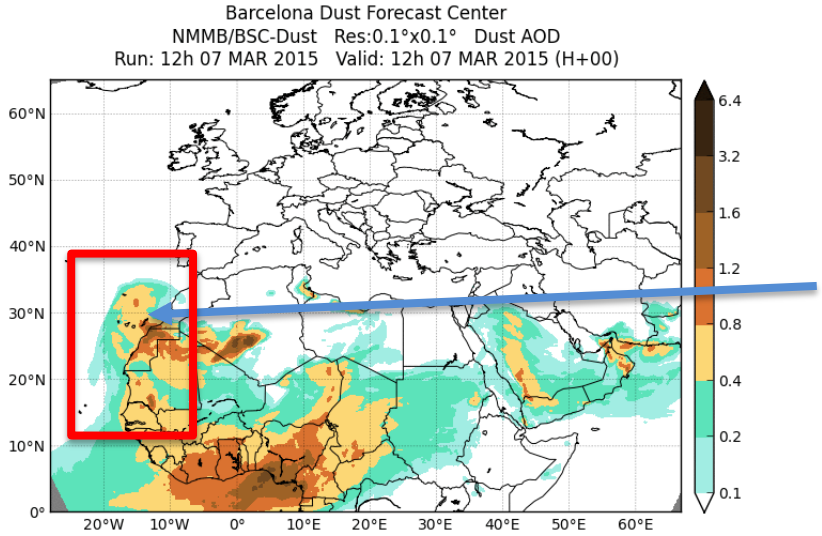
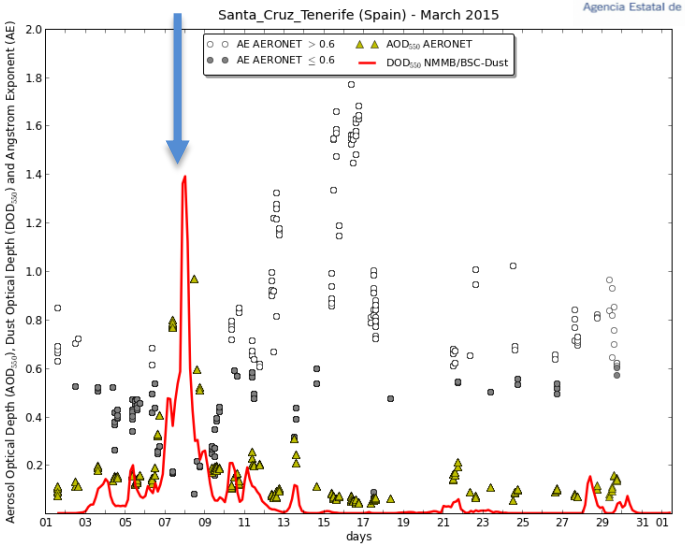
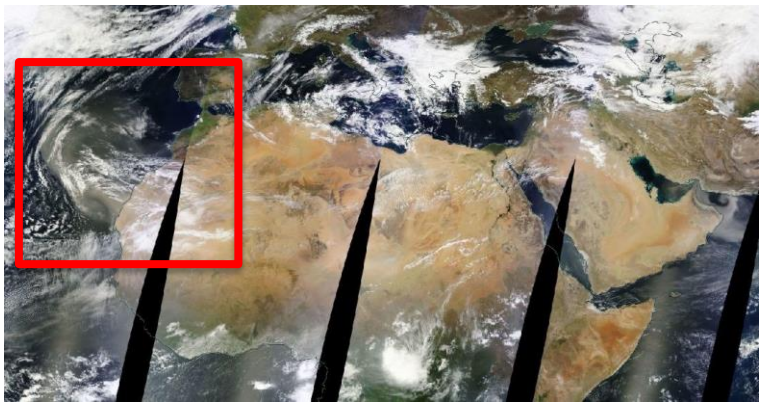
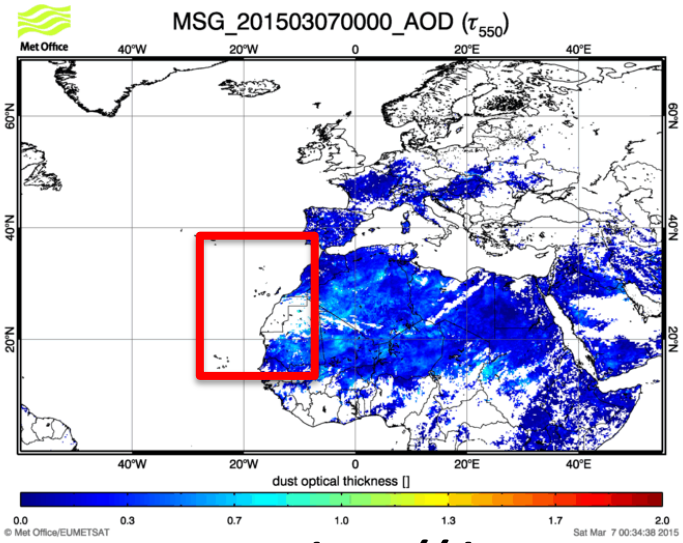
BDFC: Dust event Canary Islands Mar 2015







MODIS composite 8th March 2015 from EOSDIS World Viewer



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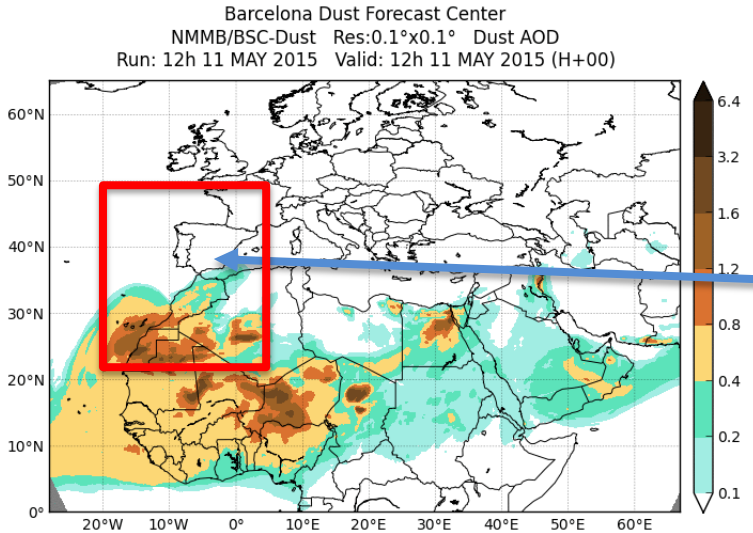
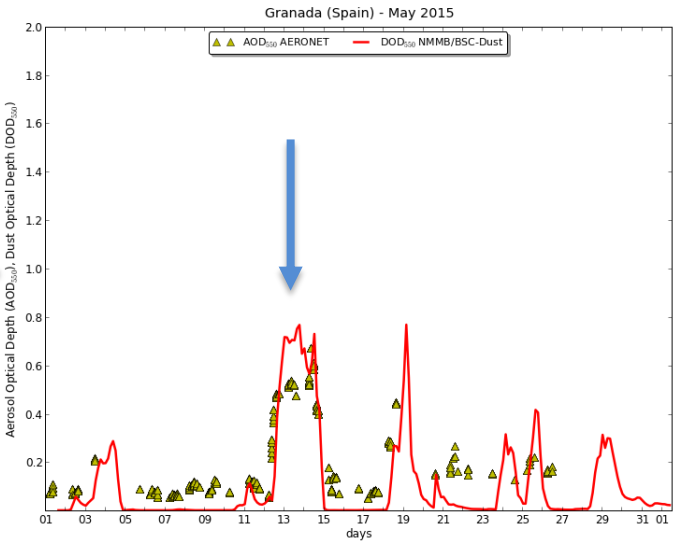
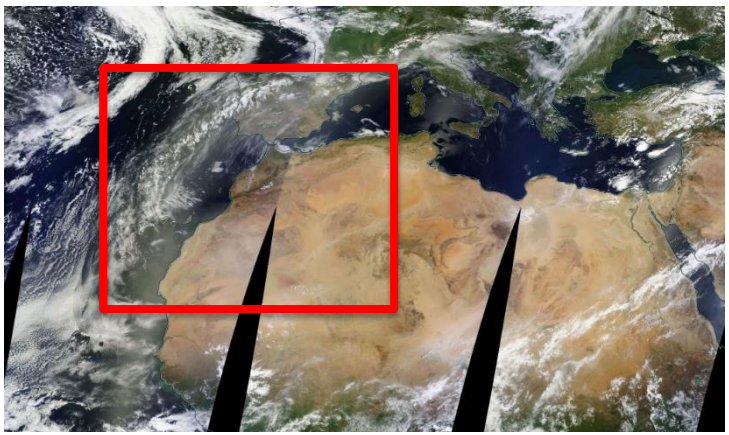
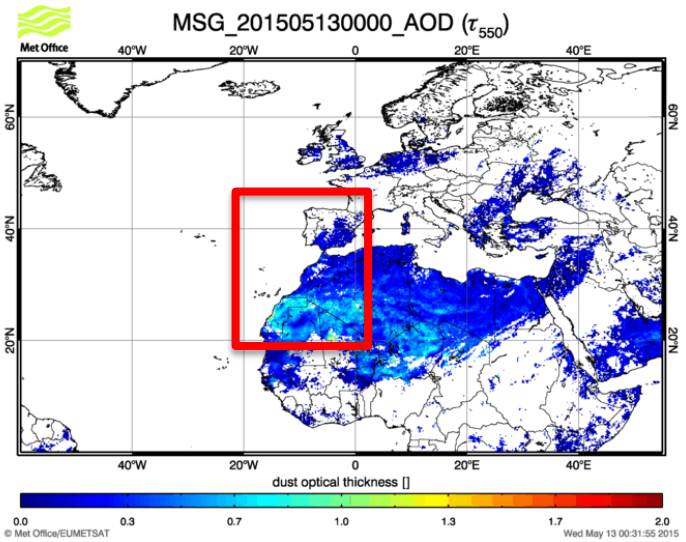
BDFC: Dust event Europe May 2015







MODIS composite 13th May from EOSDIS World Viewer



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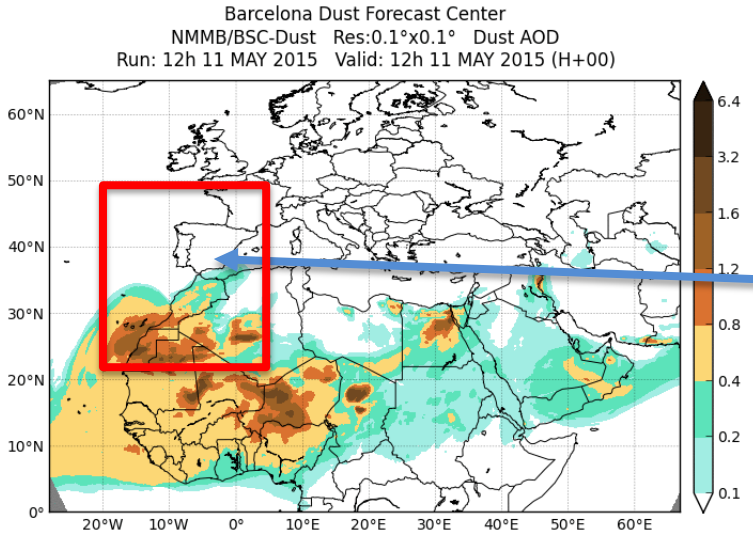
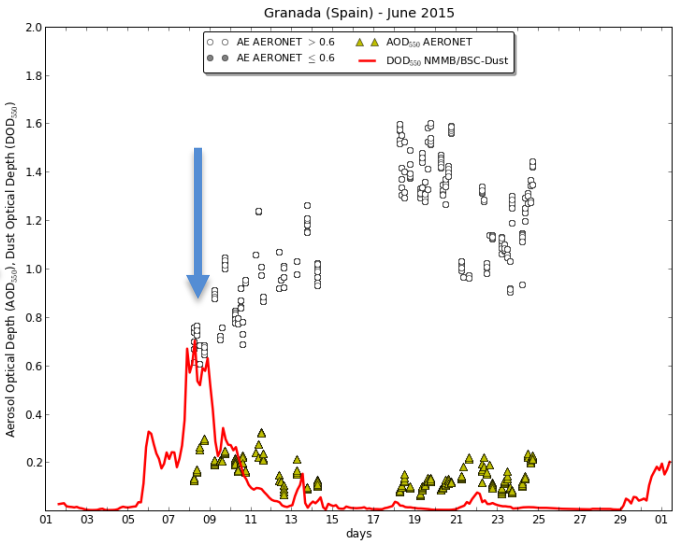
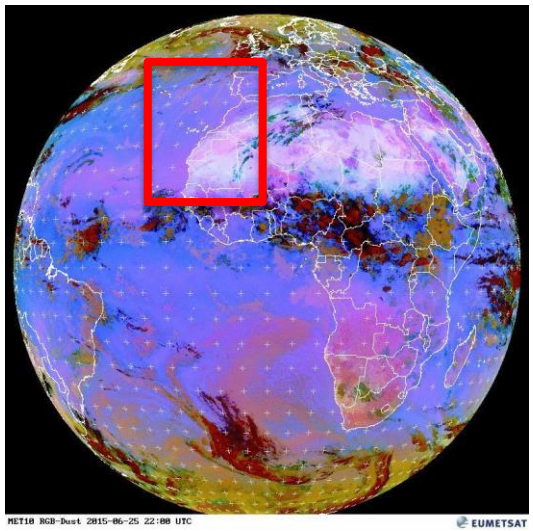
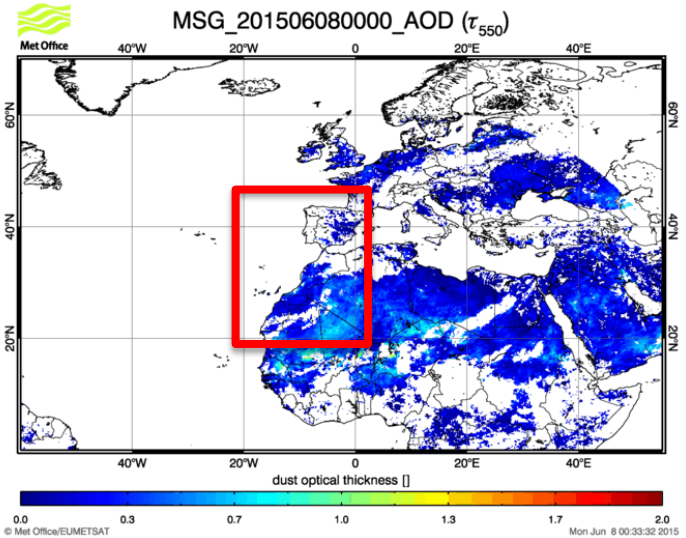
BDFC: Dust event Europe June 2015









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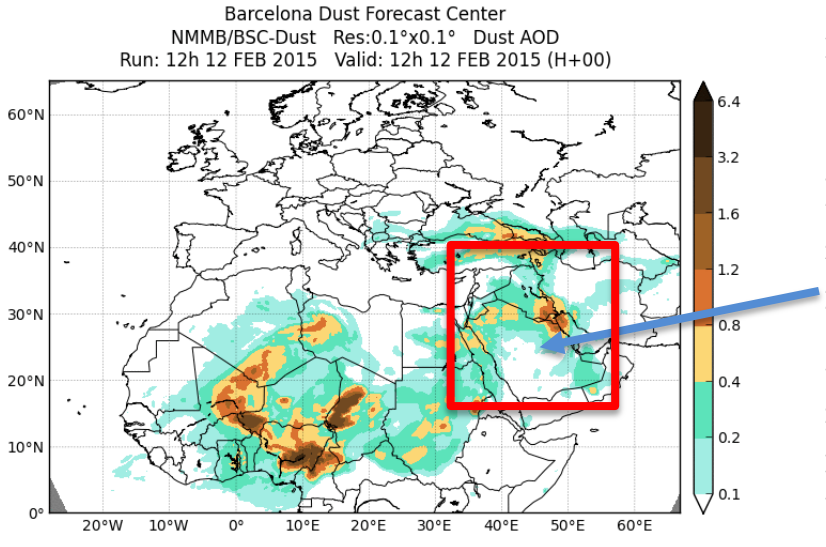
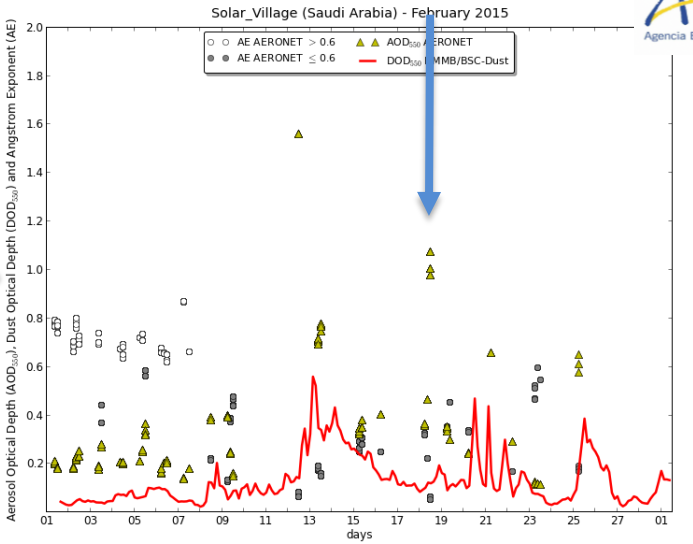
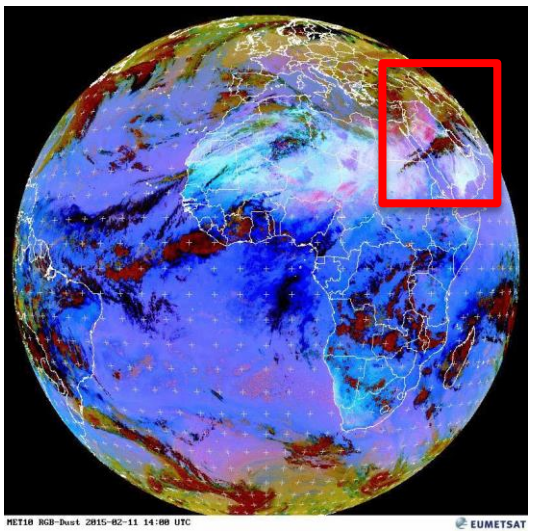
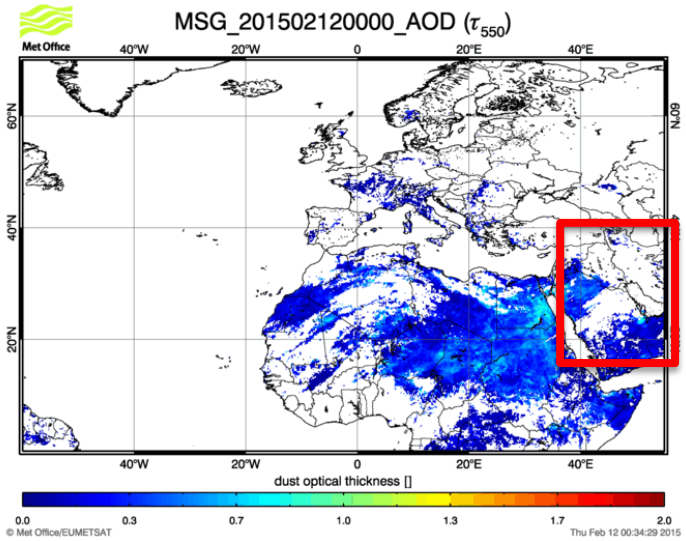
BDFC: Dust event Middle East Feb 2015









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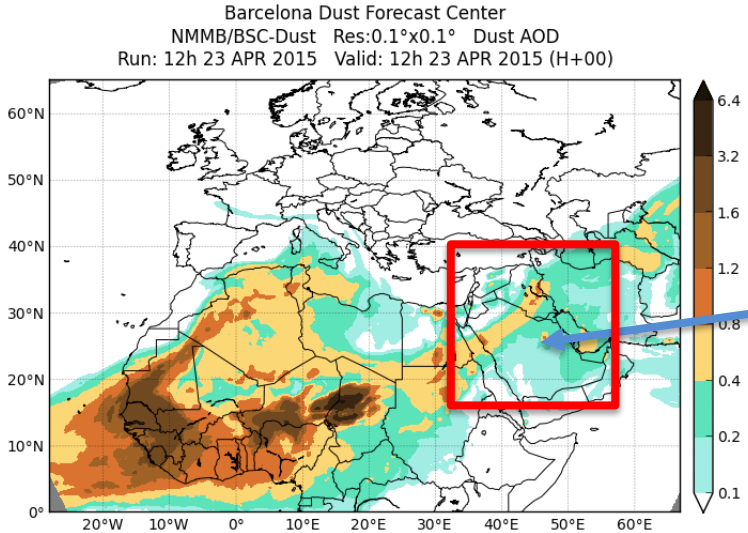
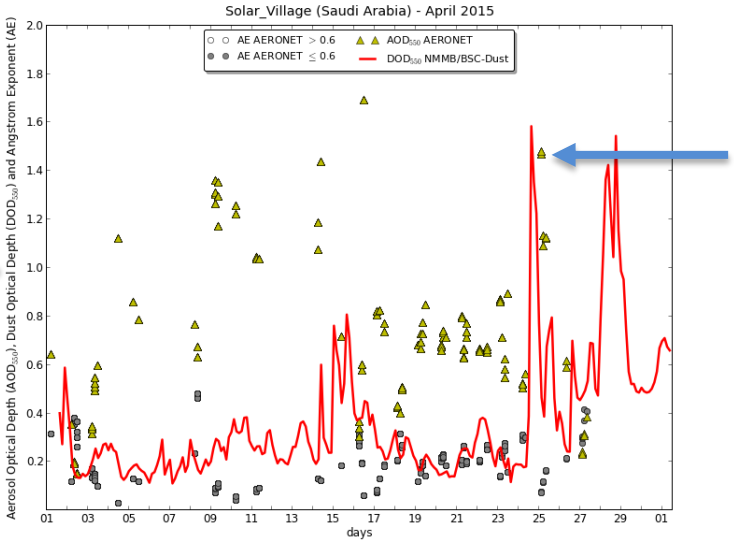
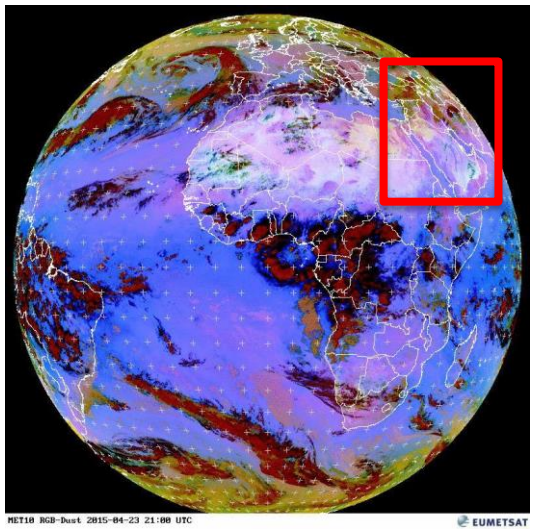
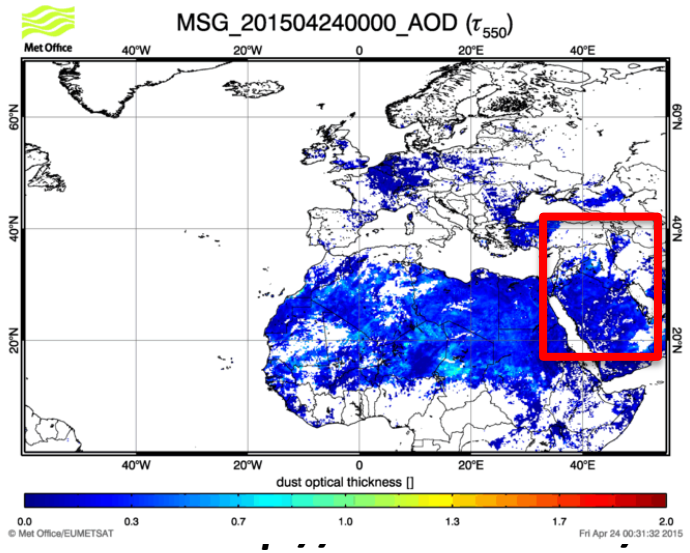
BDFC: Dust event Middle East Apr 2015









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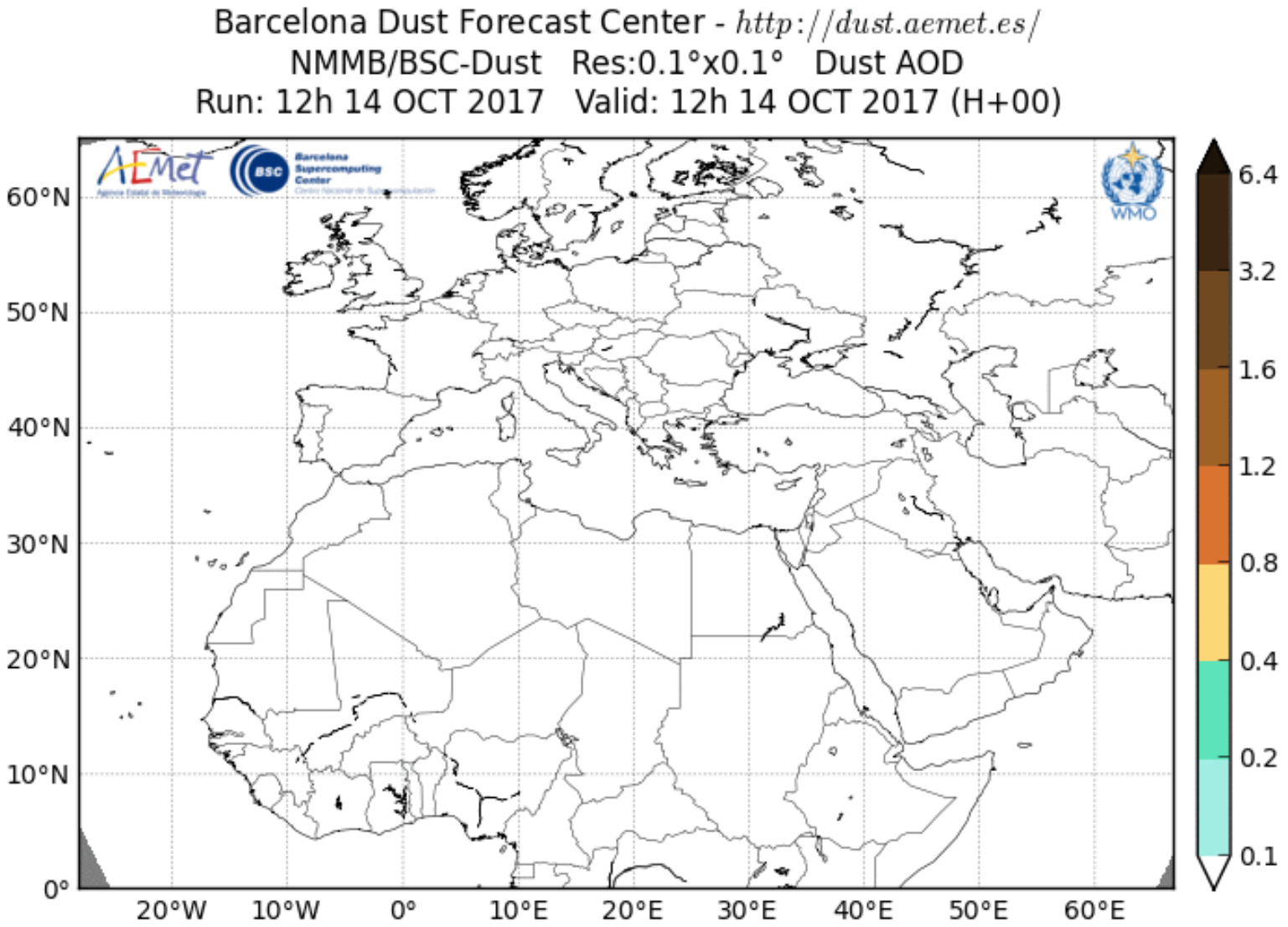
BDFC: Dust event EU October 2017



Summary and conclusions

Ongoing **NMMB/BSC-Dust** model developments to improve the quality of daily dust forecast includes:

- Data assimilation of satellite aerosol products for mineral dust analysis
- Exploration of the advantages of the high-resolution simulations (> 4km spatial horizontal resolution) → Dust sources, haboobs and complex terrains

Ongoing activities of the **WMO Dust Centers** includes:

- **Model evaluation** including data from satellites, and lidar, Sun-photometer and in-situ networks, both for gaseous and aerosol species, covering multiple time-scales.
- Increased education and awareness to promote the information and forecasts that are publically and freely available
- Establishment of appropriate communication channels for the dissemination of interpreted dust forecasts at a frequency that enables preparedness (i.e. through weather news networks, text message alerts)

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AEMet Agencia Estatal de Meteorología

World Meteorological Organization

BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Gracias

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