



World  
Meteorological  
Organization



GOBIERNO  
DE ESPAÑA

MINISTERIO  
DE MEDIO AMBIENTE  
Y MEDIO RURAL Y MARINO

AEMet  
Agencia Estatal de Meteorología

EXCELENCIA  
SEVERO  
OCHOA



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*

# WMO SDS-WAS: TOWARDS CONTINUOUS EVALUATION OF DUST MODELS IN NORTHERN AFRICA

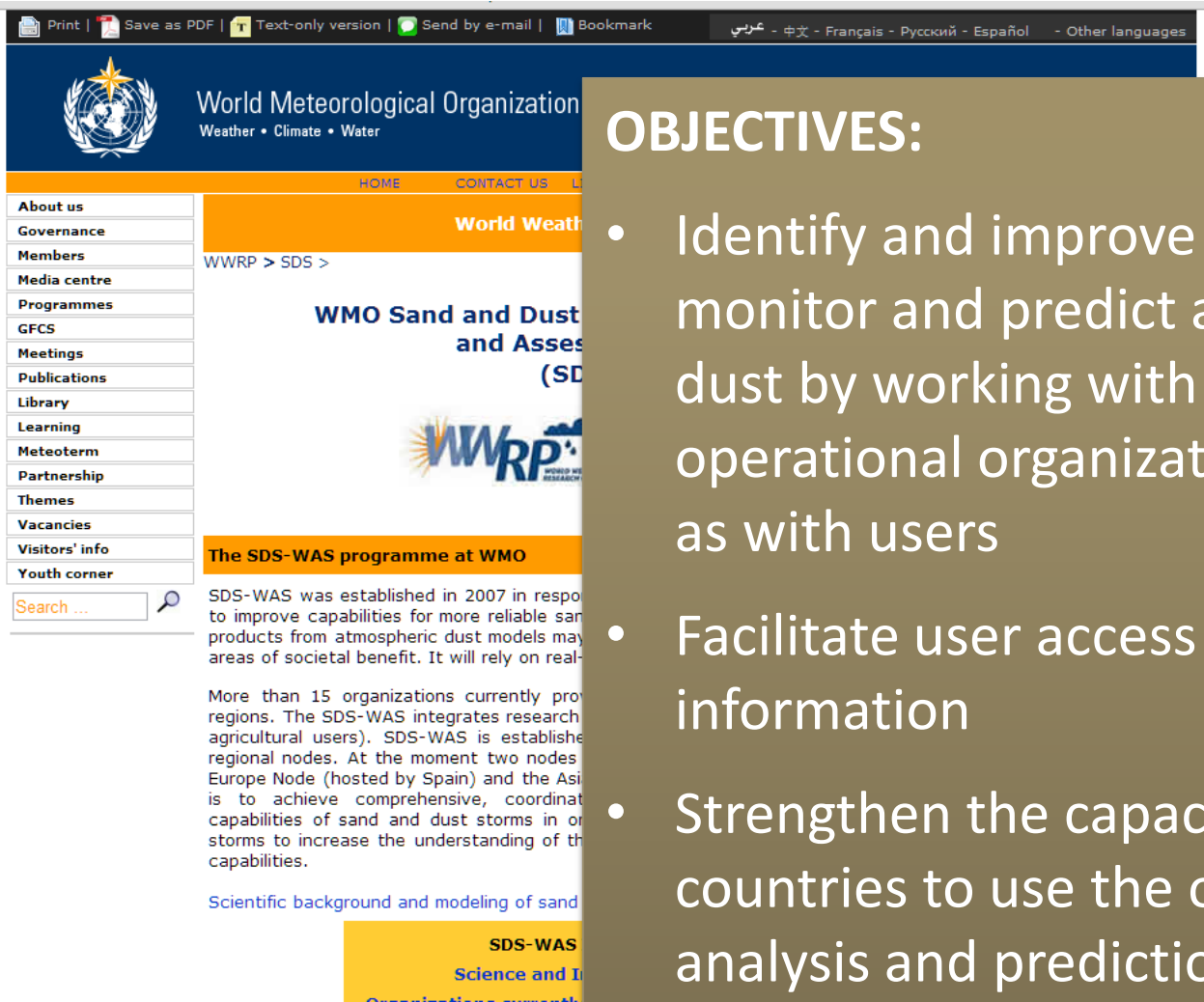
S. Basart<sup>1</sup>, G. García-Castrillo<sup>2</sup>, E. Terradellas<sup>2</sup> and E. Cuevas<sup>3</sup>

<sup>1</sup>Earth Sciences Department, BSC, Barcelona, Spain

<sup>2</sup>AEMET, Barcelona, Spain

<sup>3</sup>CIAM-AEMET, Tenerife, Spain

8<sup>th</sup> International Workshop on Sand/Duststorms and Associated Dustfall  
Lisbon, Portugal, 2-4 May, 2016

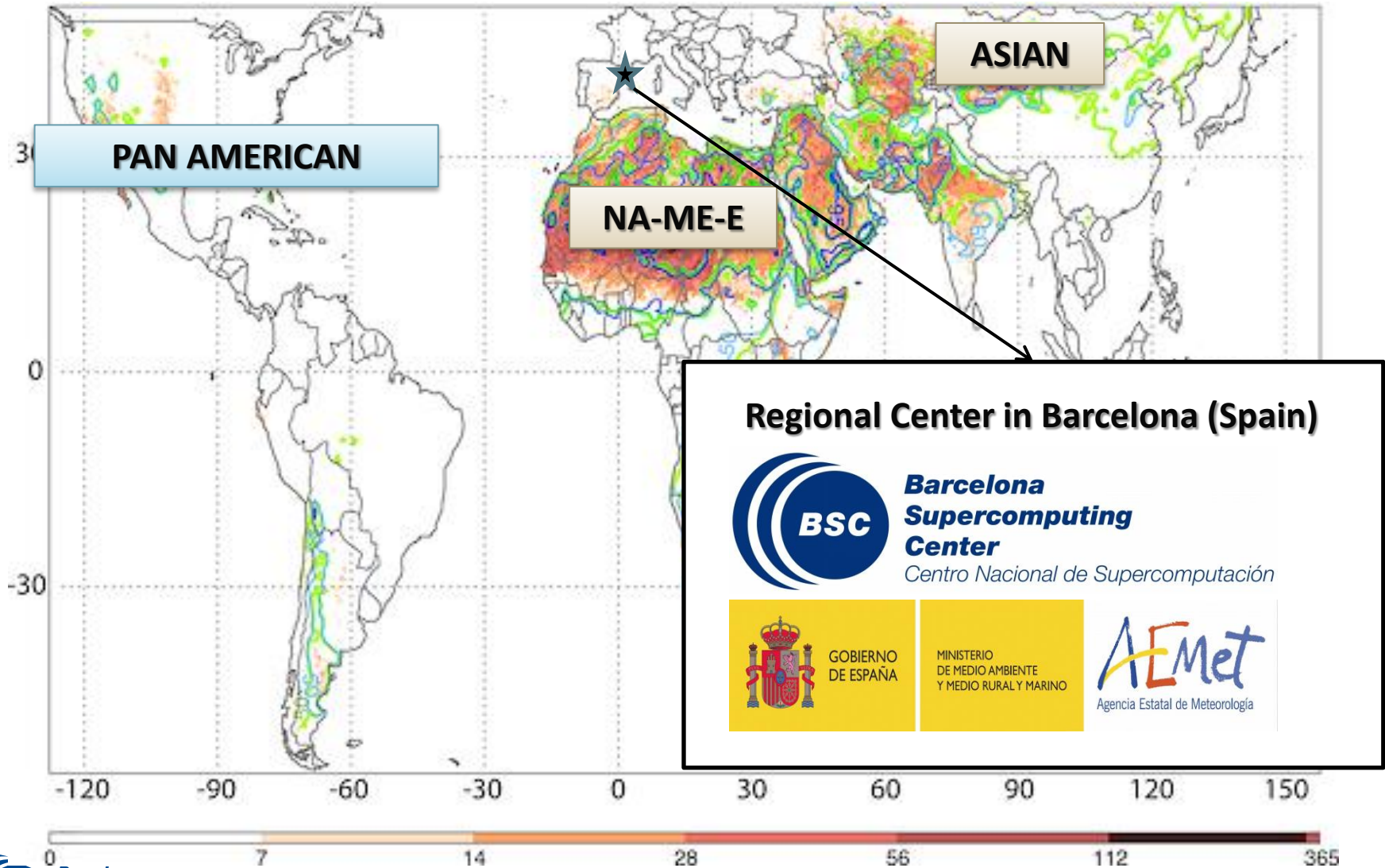


The screenshot shows the WMO website interface. At the top, there is a navigation bar with links for 'Print', 'Save as PDF', 'Text-only version', 'Send by e-mail', and 'Bookmark'. Below this is the WMO logo and the text 'World Meteorological Organization Weather • Climate • Water'. A secondary navigation bar contains 'HOME' and 'CONTACT US'. A left sidebar menu lists various categories: 'About us', 'Governance', 'Members', 'Media centre', 'Programmes', 'GFCS', 'Meetings', 'Publications', 'Library', 'Learning', 'Meteterm', 'Partnership', 'Themes', 'Vacancies', 'Visitors' info', and 'Youth corner'. Below the menu is a search box. The main content area features a header 'World Weather' and a breadcrumb trail 'WWRP > SDS >'. The main heading is 'WMO Sand and Dust and Asses (SD)'. Below this is a sub-heading 'The SDS-WAS programme at WMO'. The text describes the program's establishment in 2007 to improve capabilities for more reliable sand products from atmospheric dust models in areas of societal benefit. It mentions that more than 15 organizations currently provide data from various regions and that the program integrates research and operational users. It also notes the establishment of regional nodes, specifically the Europe Node (hosted by Spain) and the Asia Node, with the goal of achieving comprehensive, coordinated capabilities of sand and dust storms in order to increase the understanding of the capabilities. At the bottom of the visible content, there is a link for 'Scientific background and modeling of sand' and a yellow box with the text 'SDS-WAS Science and I'.

## 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

# SDS-WAS Regional Centers



Log in

NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER  
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

World Meteorological Organization  
Aemet  
BSC Barcelona Supercomputing Center

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› About us

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› Projects & Research

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› News

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Latest News

UN Envoy Supports Greenbelts in Iraq to Combat Sandstorms  
Feb 25, 2013

UNEP Global Environmental Alert Service releases 'Forecasting and early warning of dust storms'  
Feb 18, 2013

Scholarship on desert dust at the Univ. of Reading, UK

Multimodel

WMO SDS-WAS

Forecast ev

Compared o

Dust forec

WMO SDS-WAS

Run: 12

60°N

50°N

40°N

30°N

20°N

10°N

0°

20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E

0.2

0.1

0

0 10 20 30 40 50 60

Days

## 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

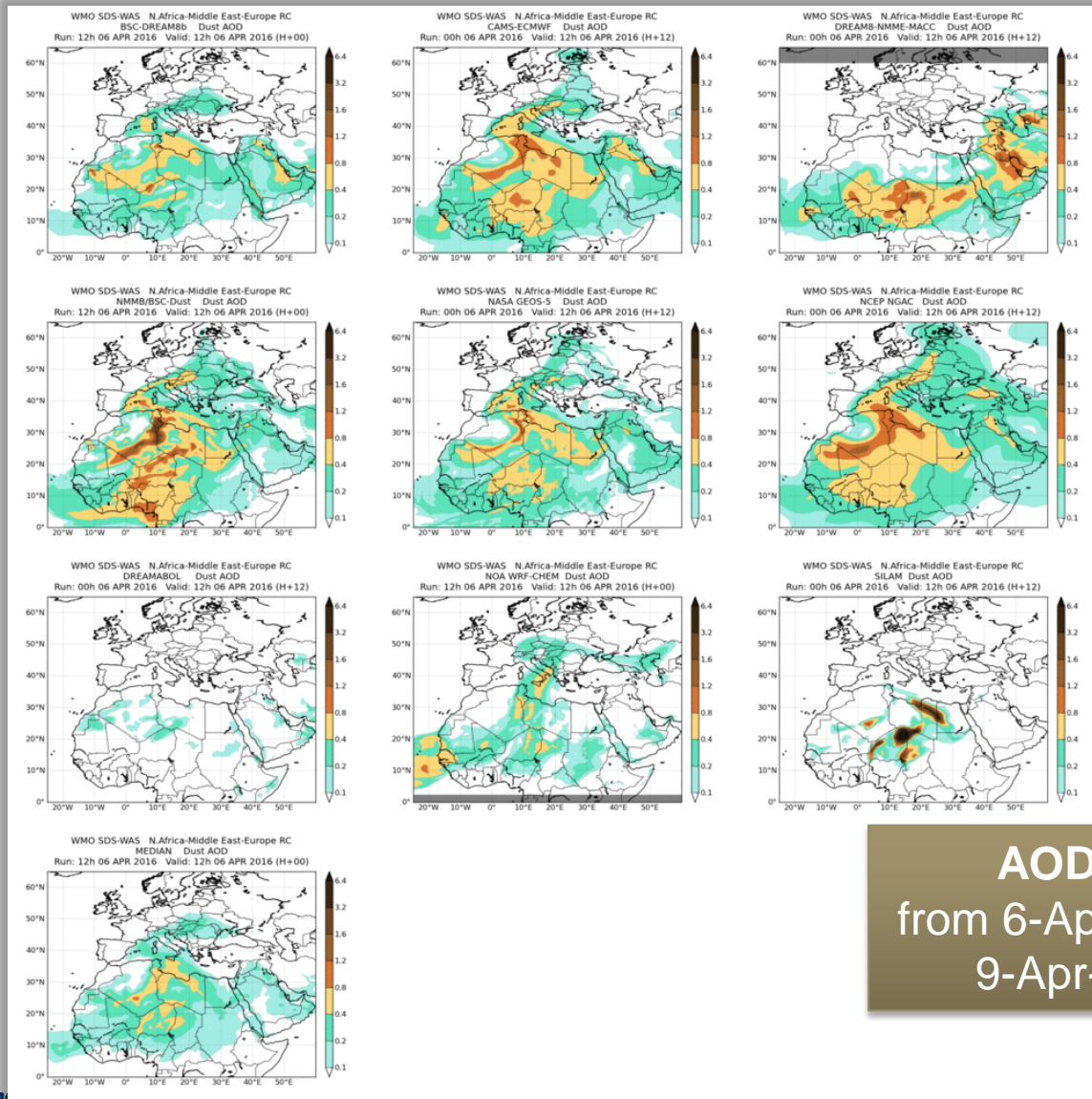
# Dust Forecasts

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



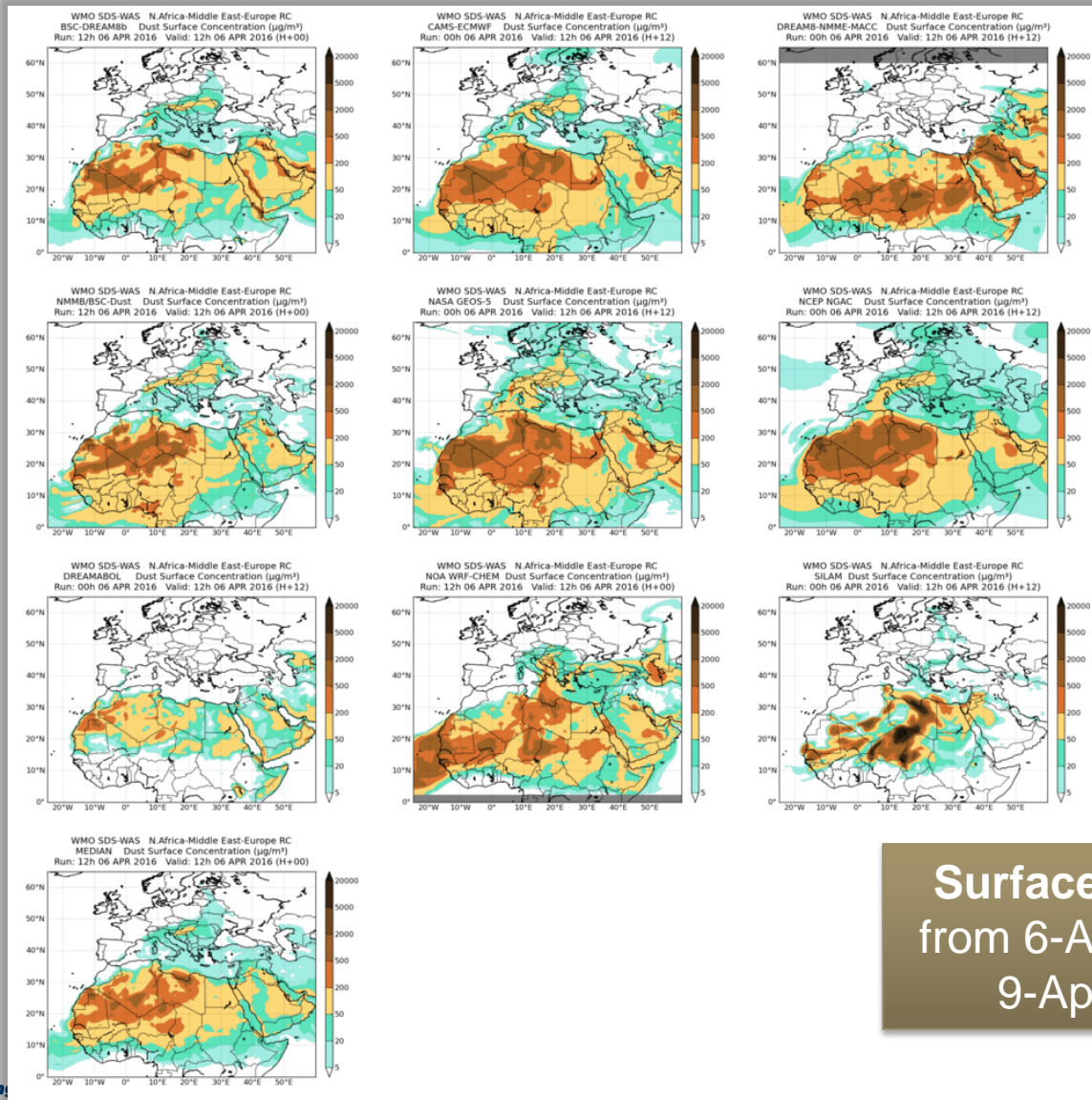
MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b v2.0	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
CAMS-ECMWF	00	Global	MODIS AOD
DREAM8-NMME	00	Regional	CAMS analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
EMA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

# DOD joint visualization



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

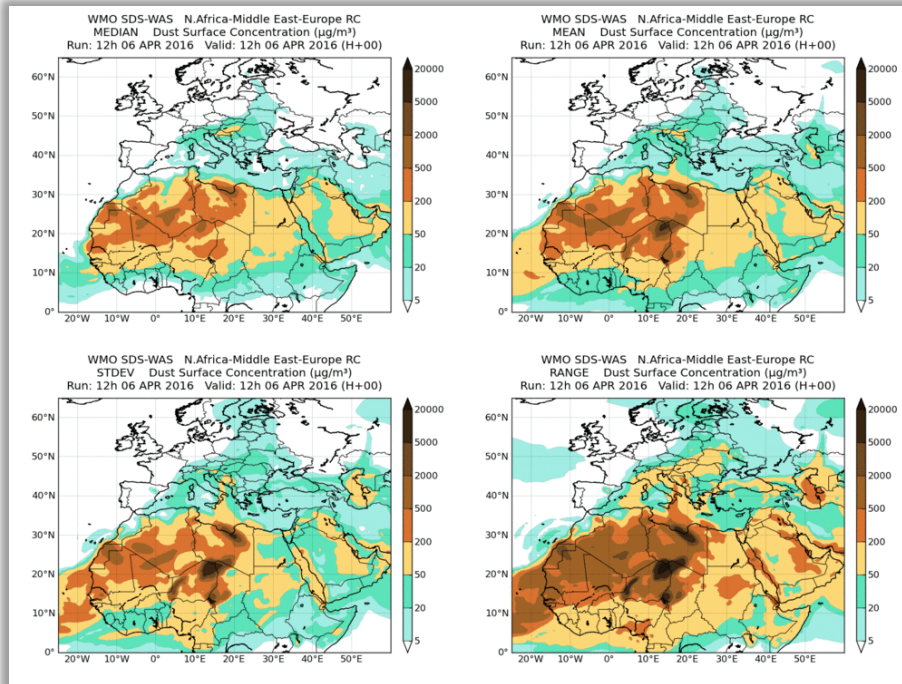
# Surface concentration joint visualization



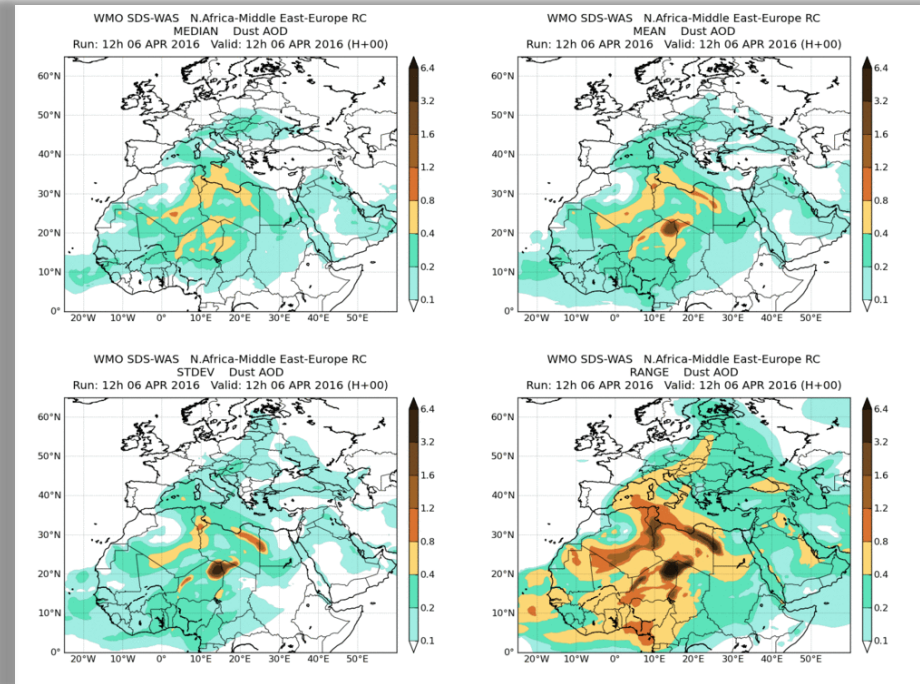
Surface concentration  
from 6-Apr-2016 12:00 to  
9-Apr-2016 00:00

# Generation of multi-model products

## 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  $0.5^\circ \times 0.5^\circ$  grid mesh. Then, different multi-model products are generated:

**CENTRALITY:** median - mean

**SPREAD:** standard deviation – range of variation

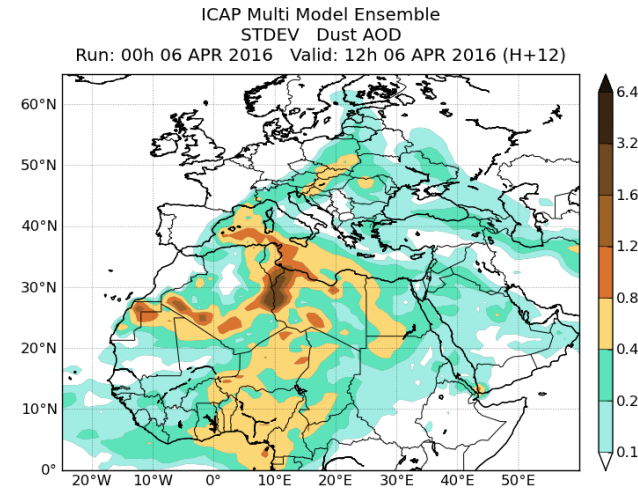
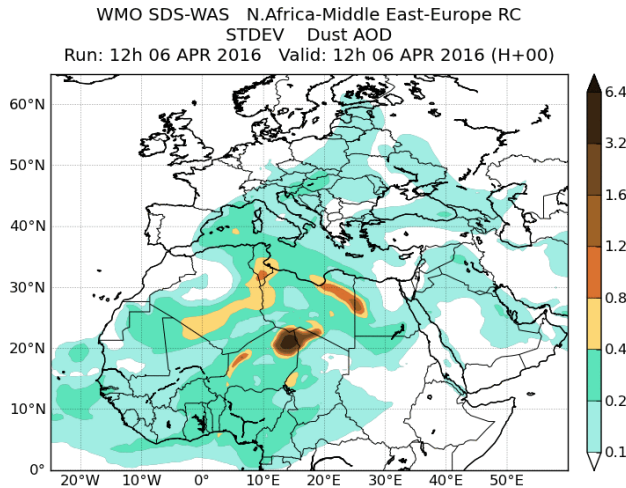
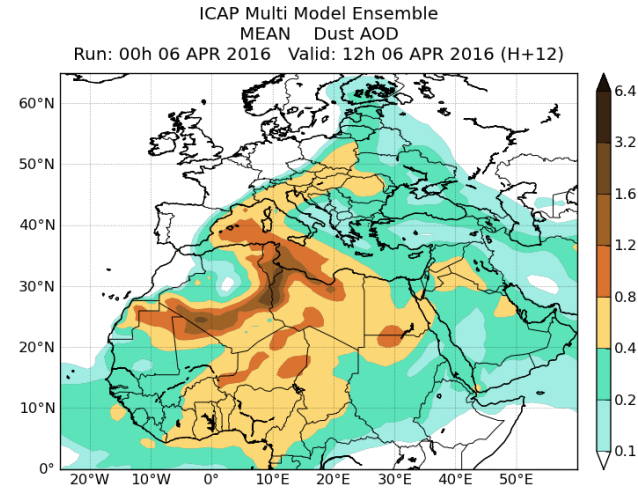
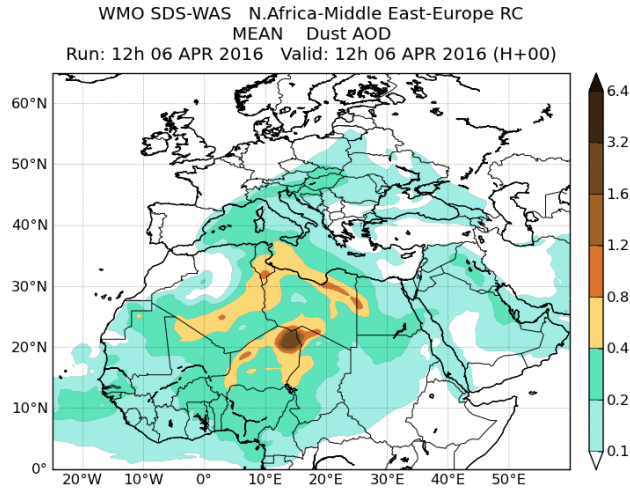


# DOD comparison with ICAP-MME model

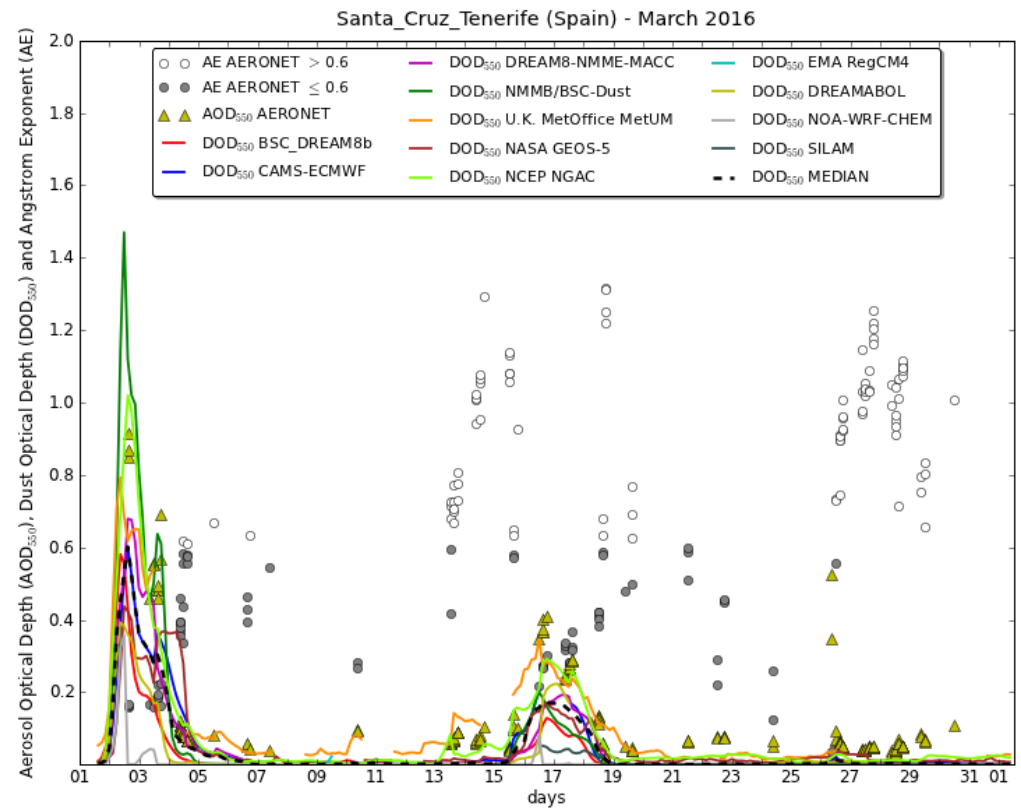
**SDS-WAS**

**ICAP-MME (Only global models)**

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



# NRT Evaluation using AERONET



# Evaluation using 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*

## Seasonal scores

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

Date:

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

### BIAS

	BSC_ DREAMbb	CAMS- ECMWF	DREAMB-NMME- MACC	NMMB/BSC- Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	MEDIAN
<b>Sahel/Sahara</b> show stations	-0.33	-0.17	-0.23	0.05	-0.06	-0.16	-0.10	0.10	-0.34	-0.25	-0.21
<b>Middle East</b> show stations	-0.12	-0.03	-0.07	-0.25	-0.03	-0.15	-0.17	0.13	-0.22	-0.17	-0.16
<b>Mediterranean</b> show stations	-0.17	-0.17	-0.15	-0.18	-0.09	-0.16	-0.13	-0.09	-0.16	-0.16	-0.16
<b>TOTAL</b>	-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_ DREAMbb	CAMS- ECMWF	DREAMB-NMME- MACC	NMMB/BSC- Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	MEDIAN
<b>Sahel/Sahara</b> show stations	0.54	0.41	0.51	0.42	0.36	0.37	0.38	0.66	0.56	0.53	0.43
<b>Middle East</b> show stations	0.32	0.28	0.34	0.41	0.33	0.34	0.35	0.34	0.37	0.39	0.33
<b>Mediterranean</b> show stations	0.32	0.33	0.30	0.32	0.30	0.31	0.30	0.40	0.31	0.34	0.31
<b>TOTAL</b>	0.46	0.38	0.44	0.39	0.34	0.35	0.35	0.57	0.48	0.47	0.39

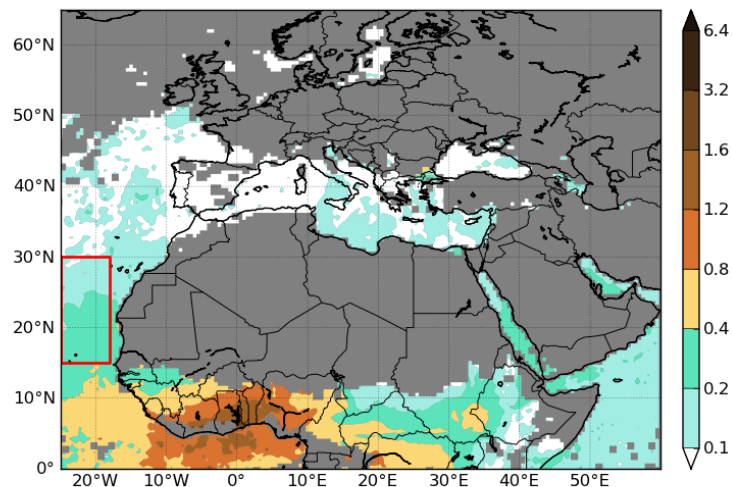
### CORRELATION COEFFICIENT

	BSC_ DREAMbb	CAMS- ECMWF	DREAMB-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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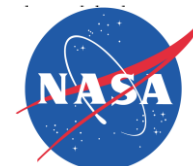
# Evaluation using MODIS



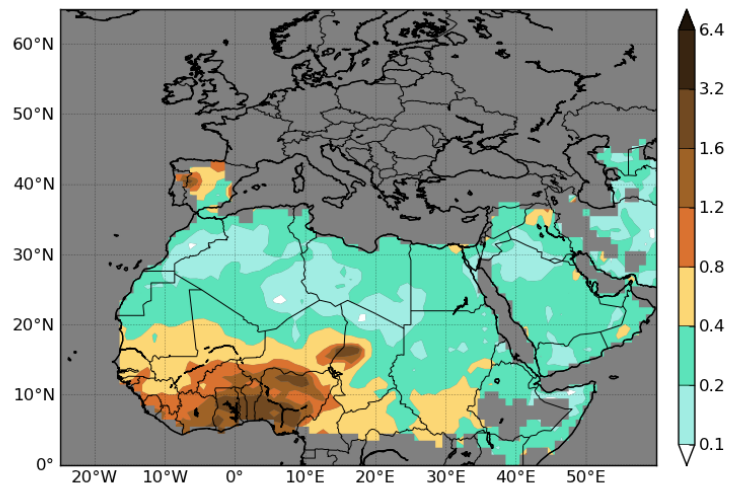
WMO SDS-WAS N.Africa-Middle East-Europe RC  
MODIS AOD<sub>550</sub> - DEC 2015 - FEB 2016



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



WMO SDS-WAS N.Africa-Middle East-Europe RC  
MODIS DEEPBLUE AOD<sub>550</sub> - DEC 2015 - FEB 2016



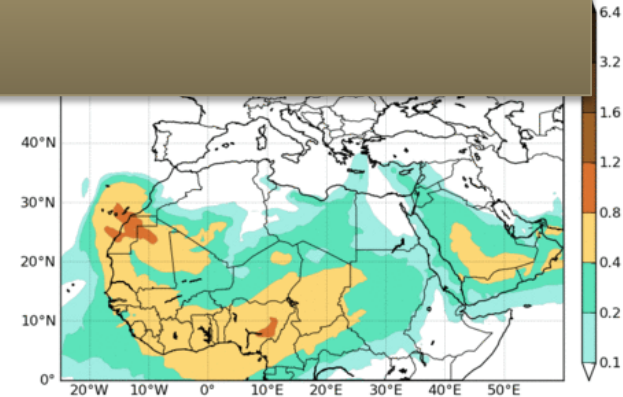
	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
<b>BSC_DREAM8b</b>	-0.23	0.44	0.45	0.89	51308
<b>NMMB/BSC-Dust</b>	-0.11	0.34	0.78	1.03	47494
<b>NCEP NGAC</b>	-0.14	0.34	0.69	0.66	48659
<b>EMA RegCM4</b>	0.17	0.59	0.35	0.82	12050
<b>DREAMABOL</b>	-0.25	0.46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

# NRT Evaluation using satellite aerosol products



**7 March 2015**

***New observational datasets for model evaluation in Northern Africa***



# PM10 evaluation using AMMA sites: 2013



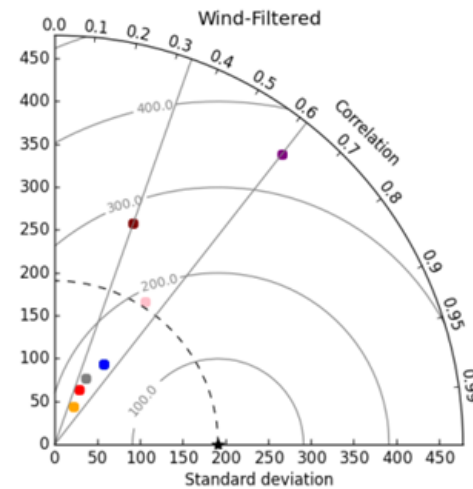
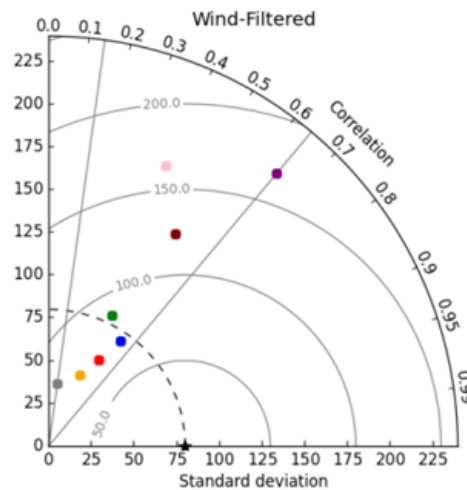
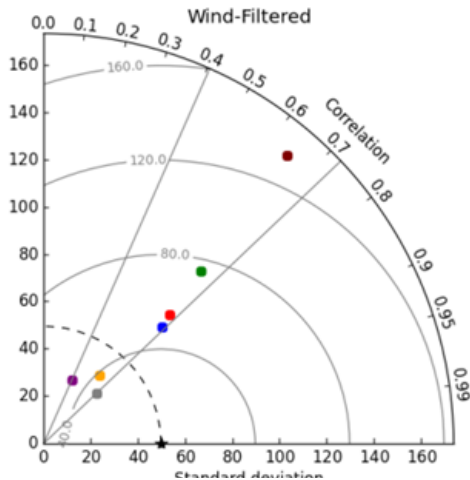
*Not all PM10 is dust: Local and biomass burning from Savannah fires.*

*Dust filter: Considering the localizations of the desert dust sources the filter is based on wind direction.*

M'Bour-Senegal

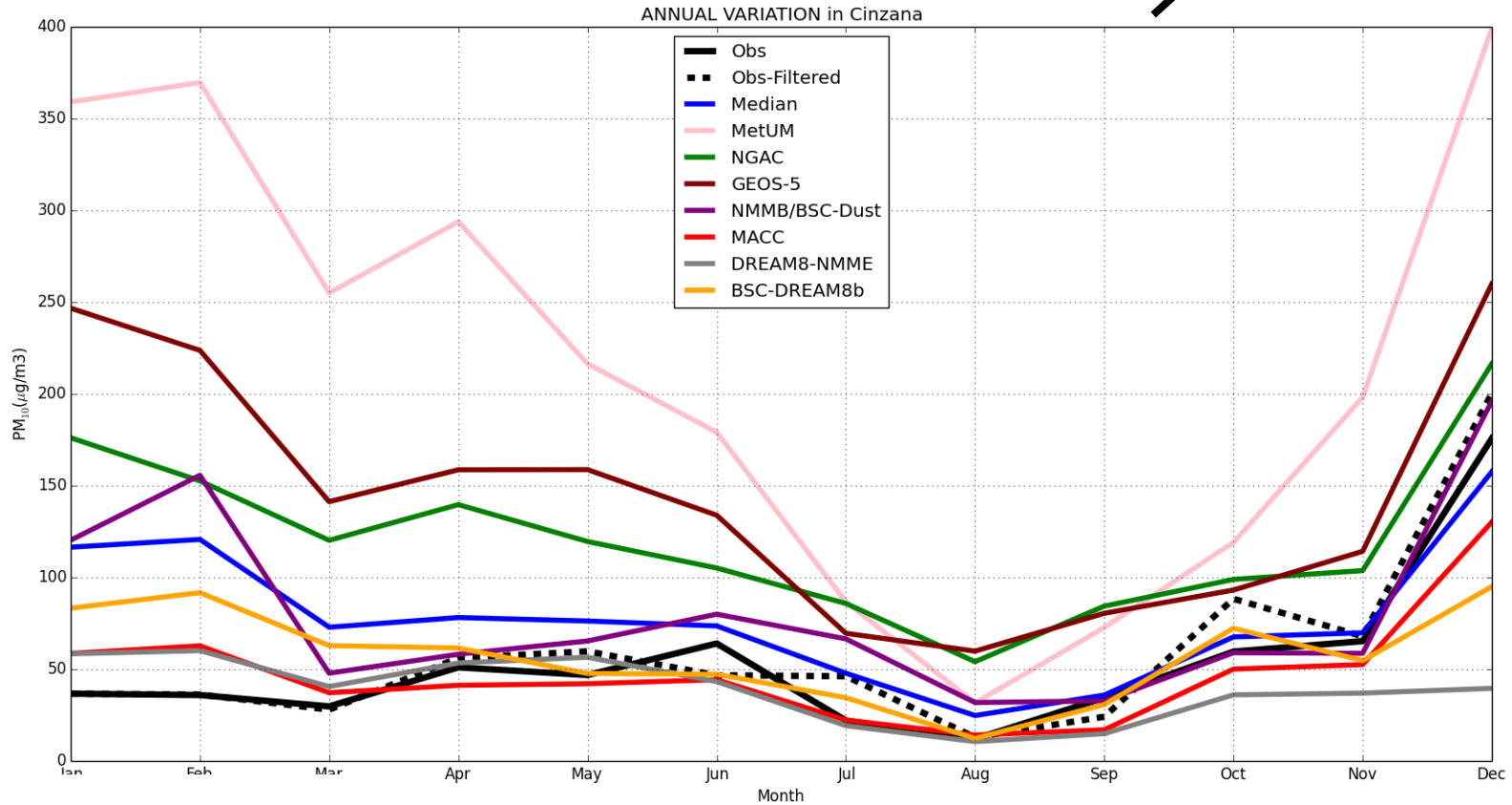
Cinzana-Mali

Banizoumbou-Niger



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

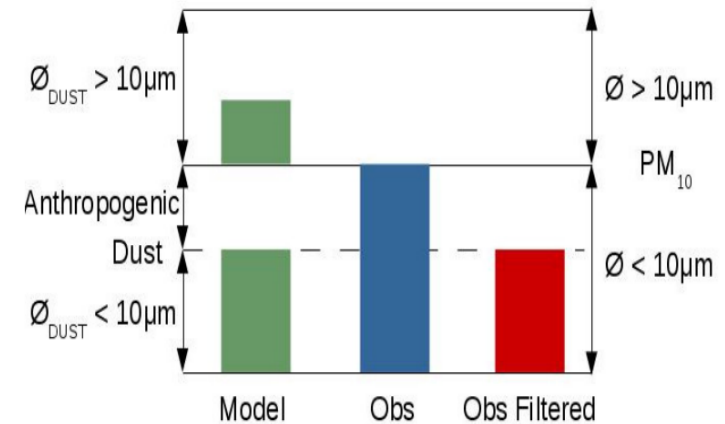
# PM10 evaluation using AMMA sites: 2013



# PM10 evaluation using AQ networks: Canary Islands

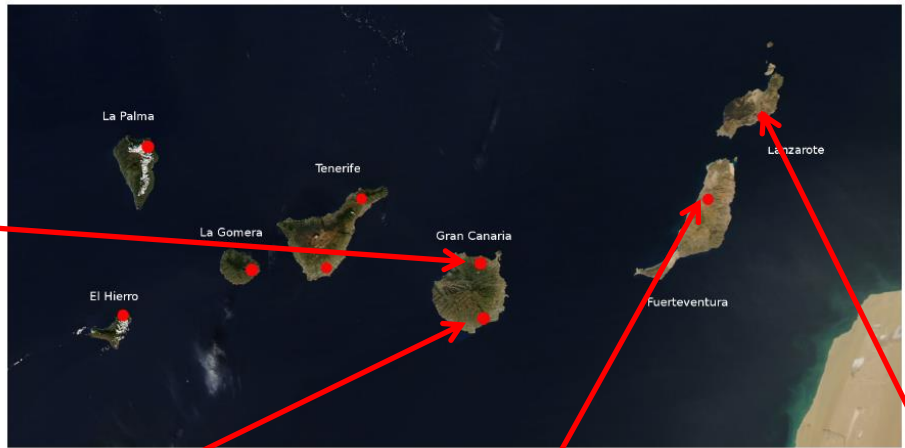
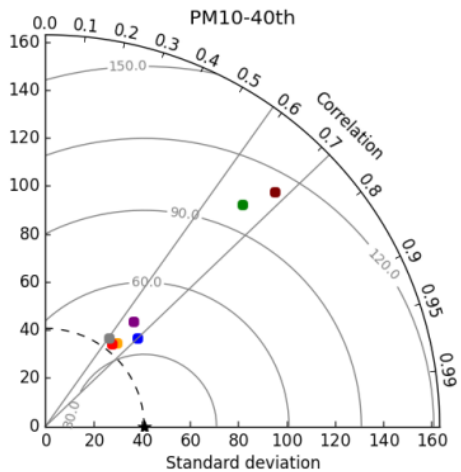


*Not all PM10 is dust: Local sources  
Dust filter: Moving 40th percentile of 30 days, 15 days before and 15 days after  
(Escudero et al. 2007).*

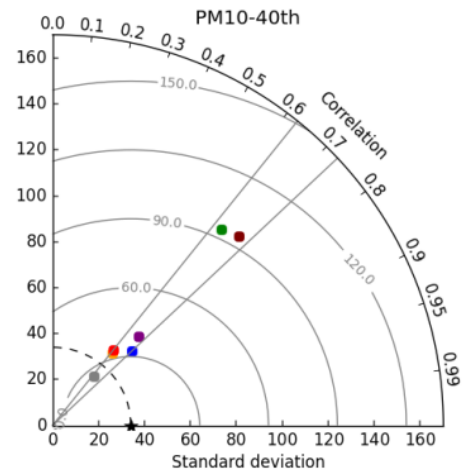
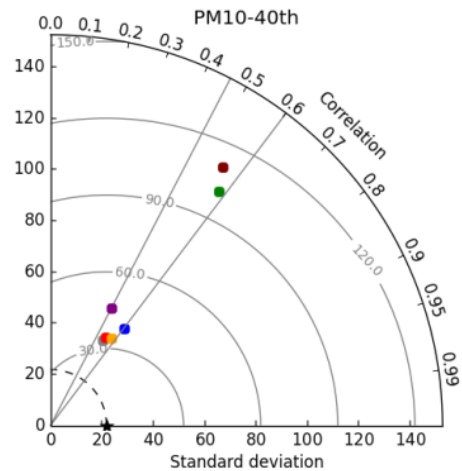
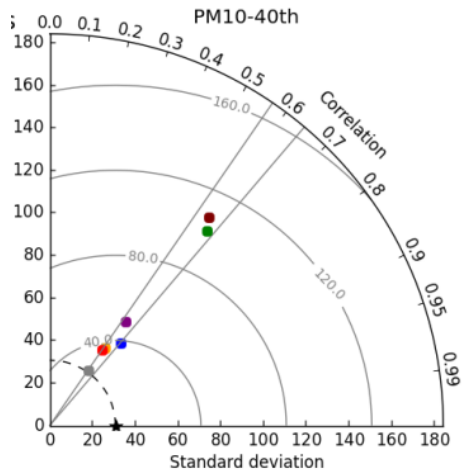




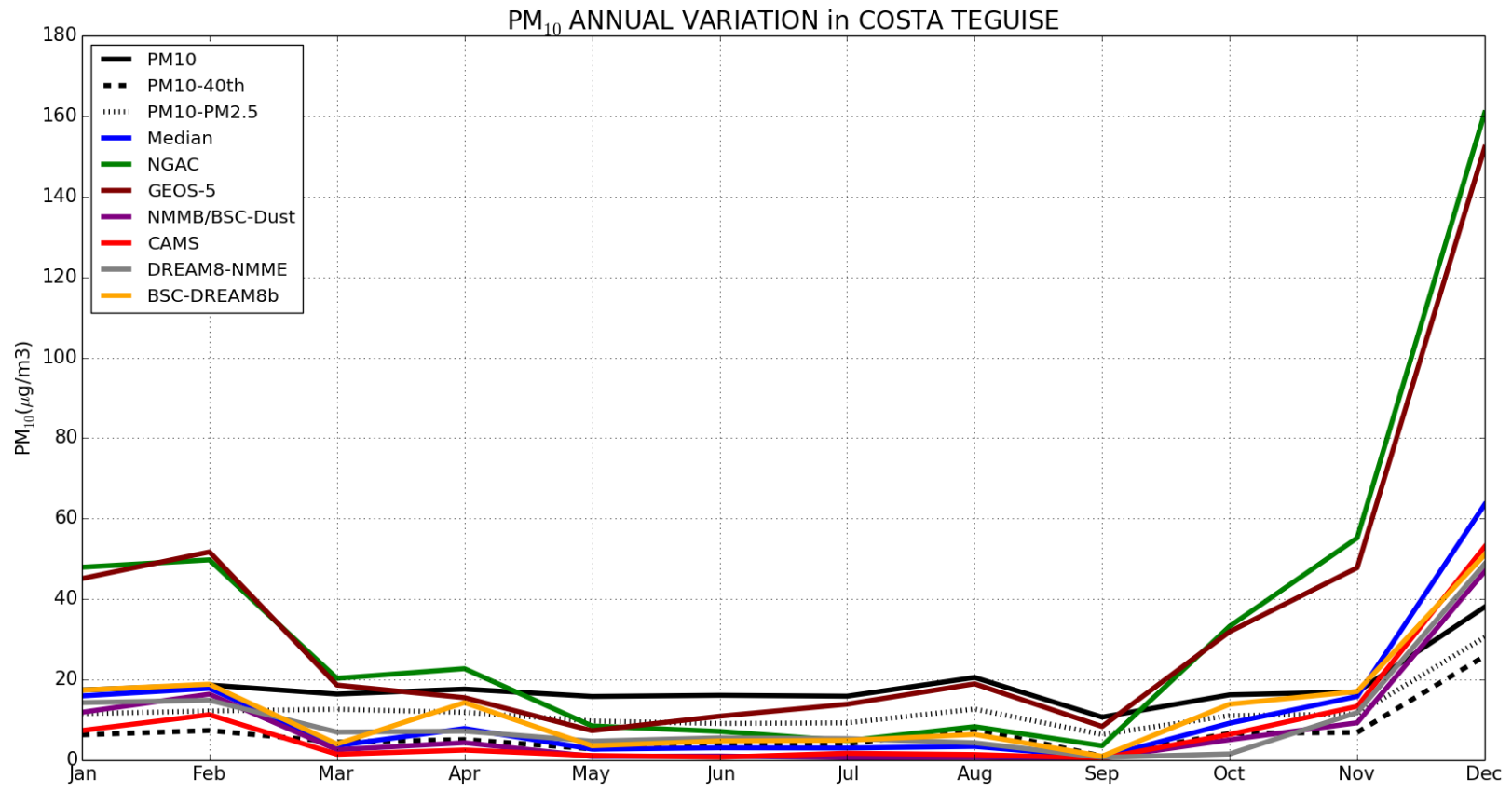
# PM10 evaluation using AQ networks: 2013-2014



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

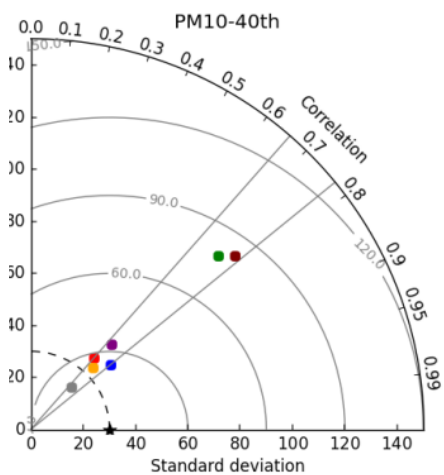
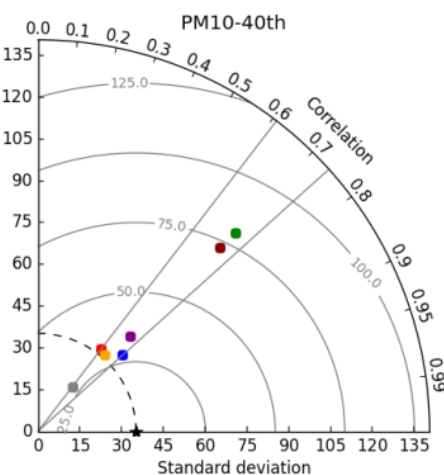
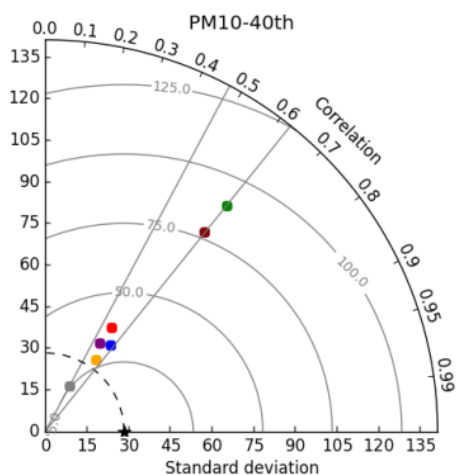
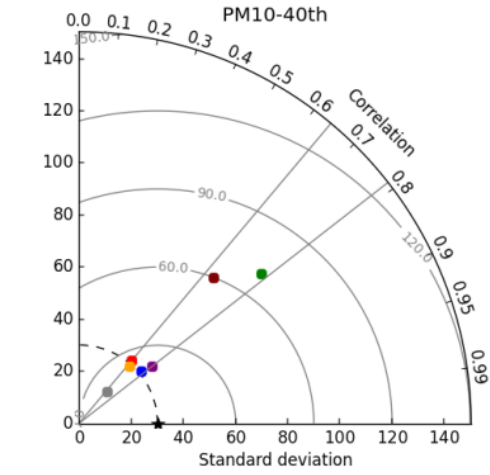
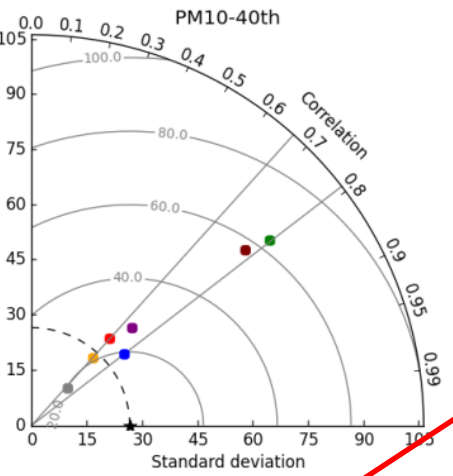


# PM10 evaluation using AQ networks: 2013-2014

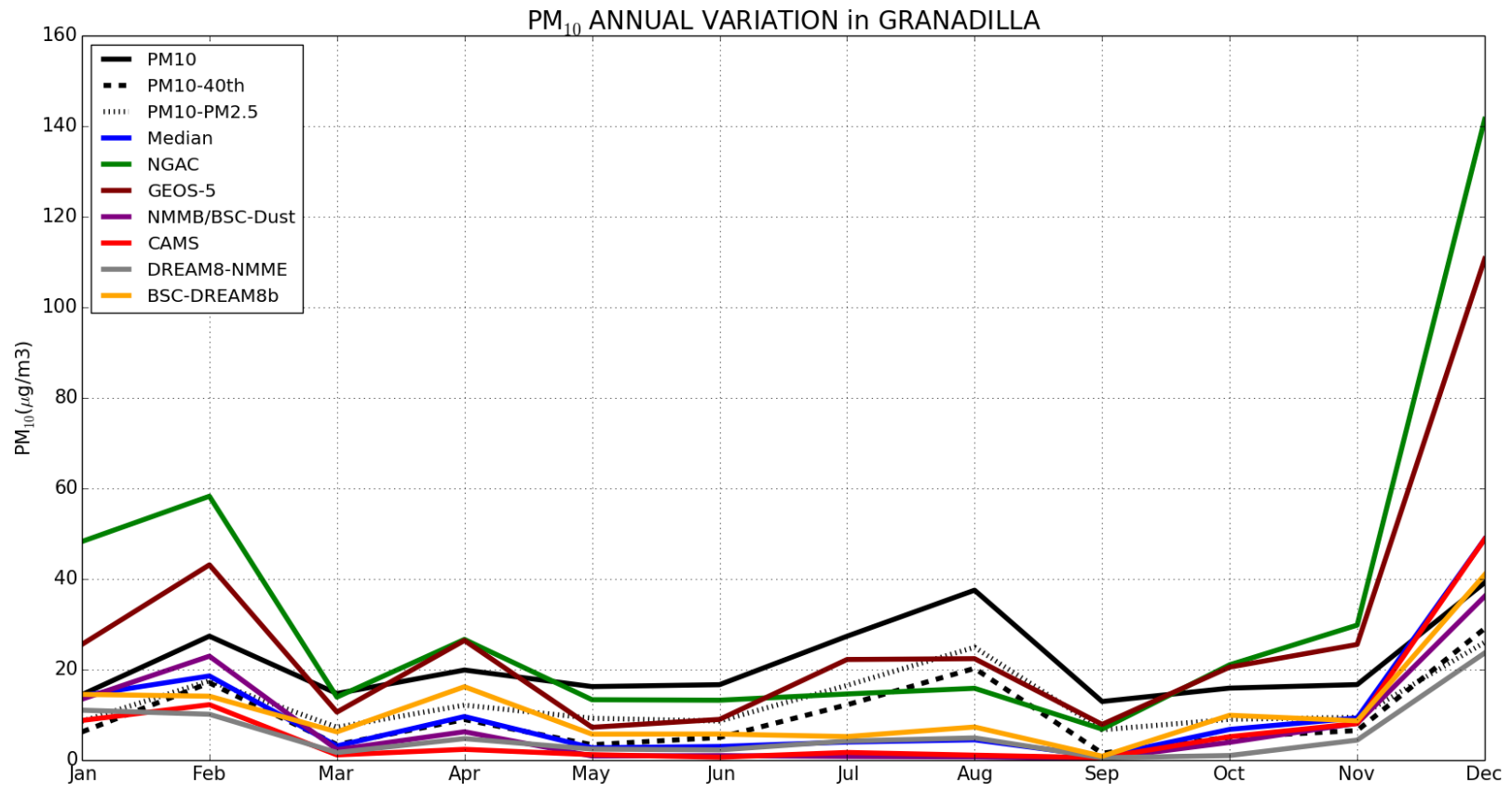


# PM10 evaluation using AQ networks: 2013-2014

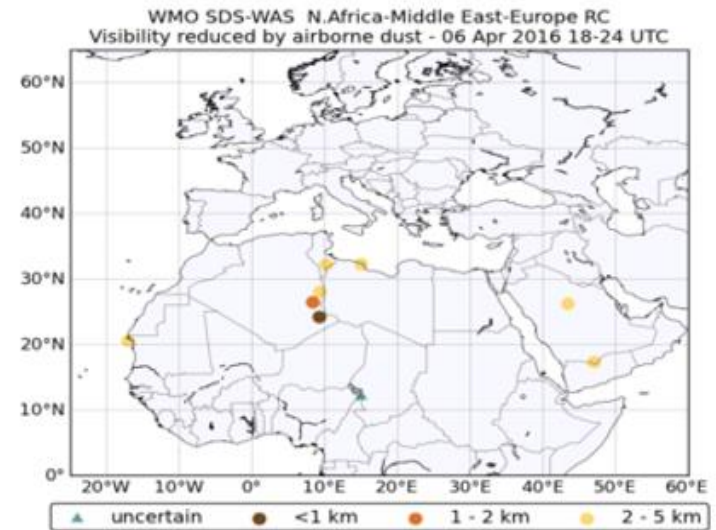
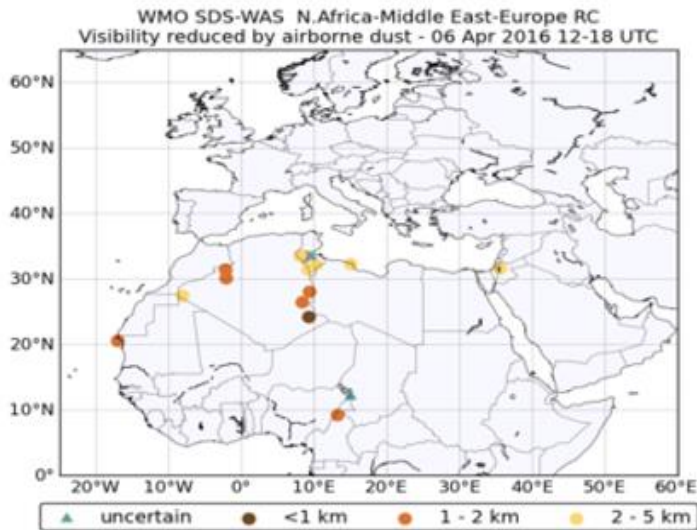
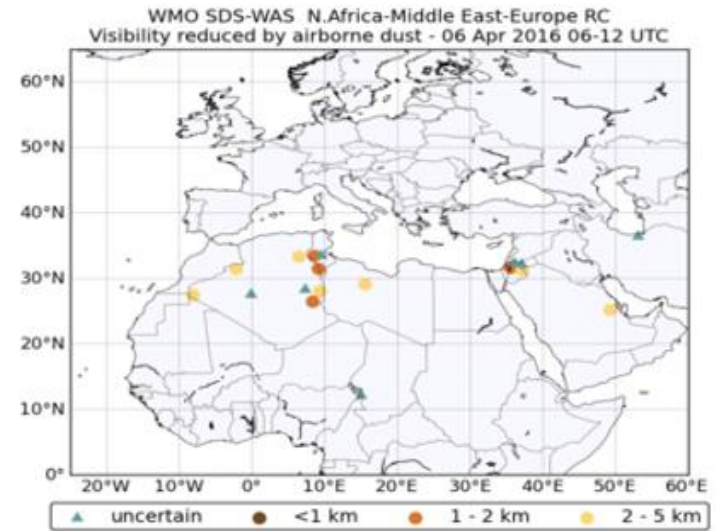
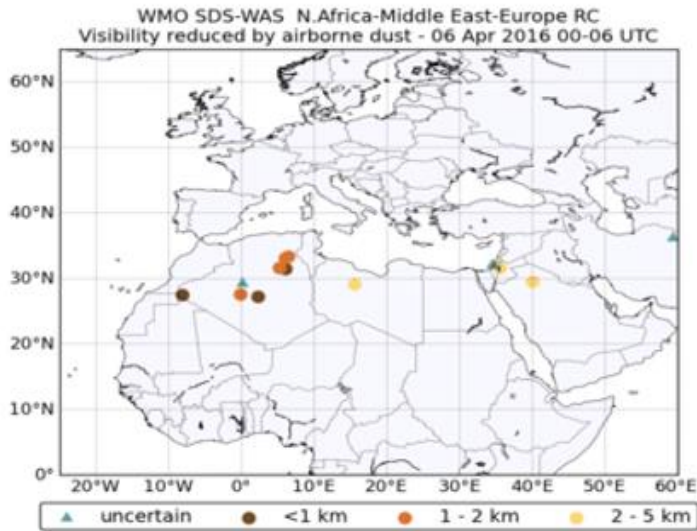
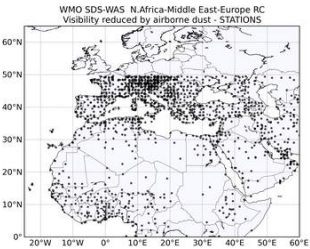
- ★ Reference
- CAMS
- Median
- NGAC
- NMMB/BSC-Dust
- BSC-DREAM8b
- GEOS-5
- DREAM8-NMME



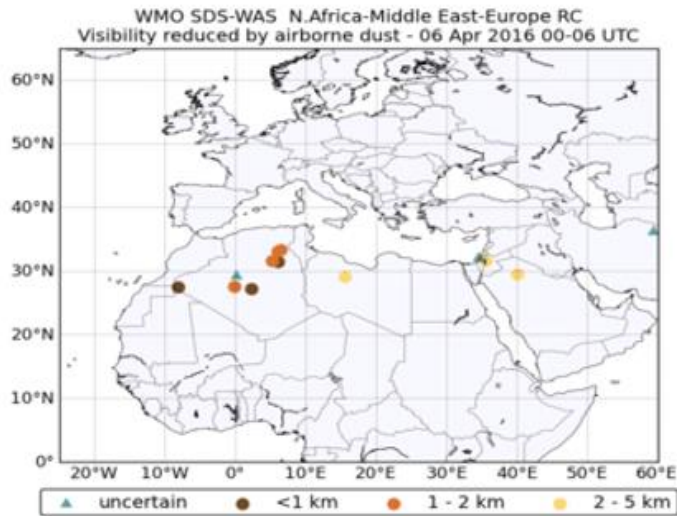
# PM10 evaluation using AQ networks: 2013-2014



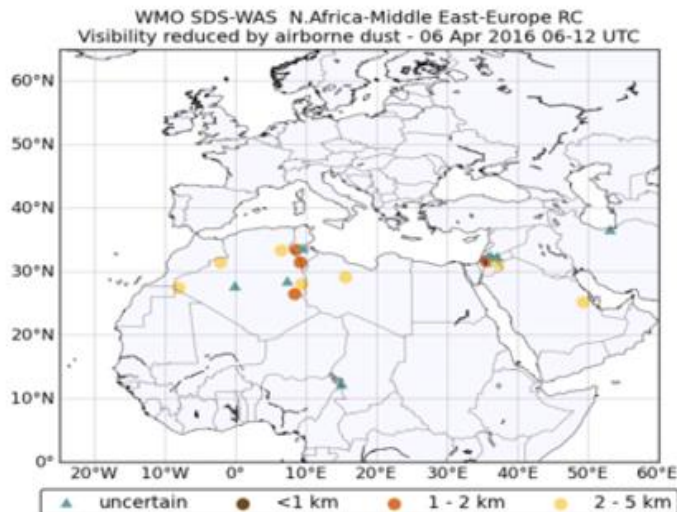
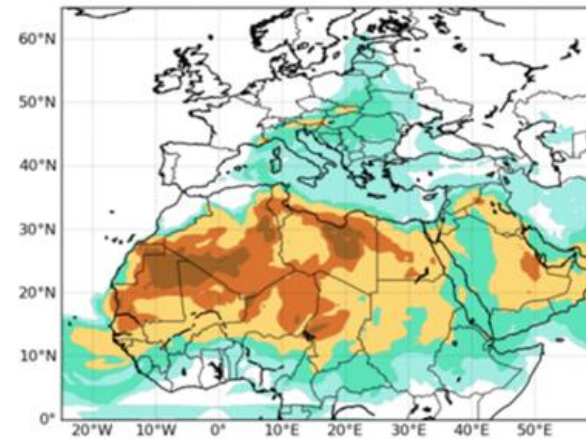
# NRT visibility from METAR and SYNOP: 6-hourly reports



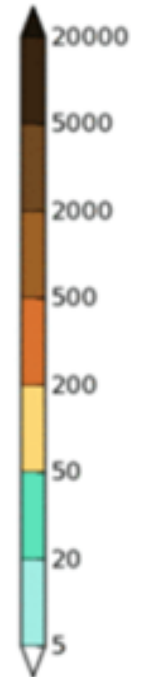
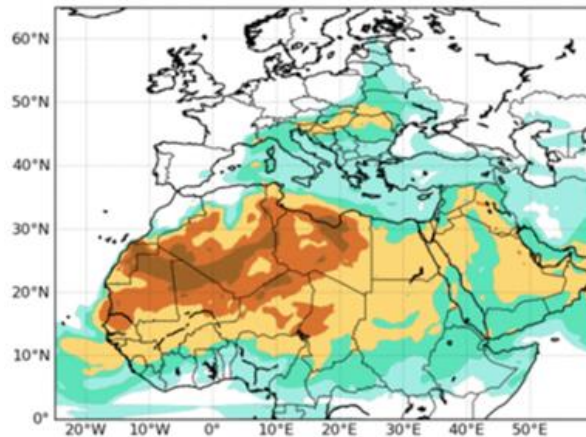
# NRT visibility evaluation: 6<sup>th</sup> April 2016 0-12UTC



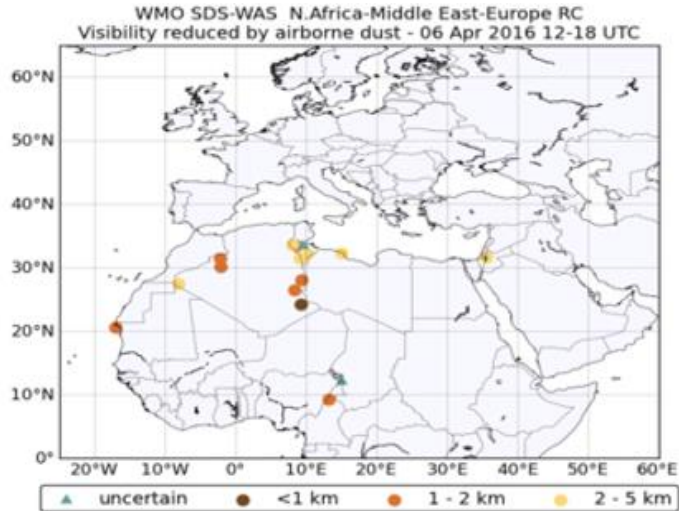
WMO SDS-WAS N.Africa-Middle East-Europe RC  
 MEDIAN Dust Surface Concentration ( $\mu\text{g}/\text{m}^3$ )  
 Run: 12h 05 APR 2016 Valid: 06h 06 APR 2016 (H+18)



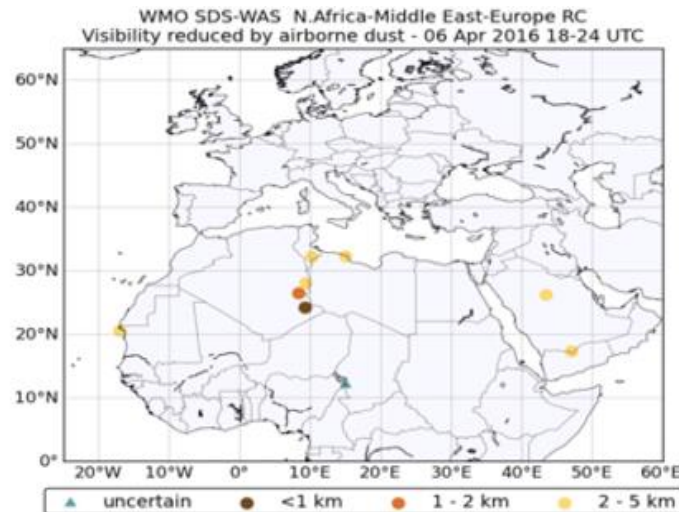
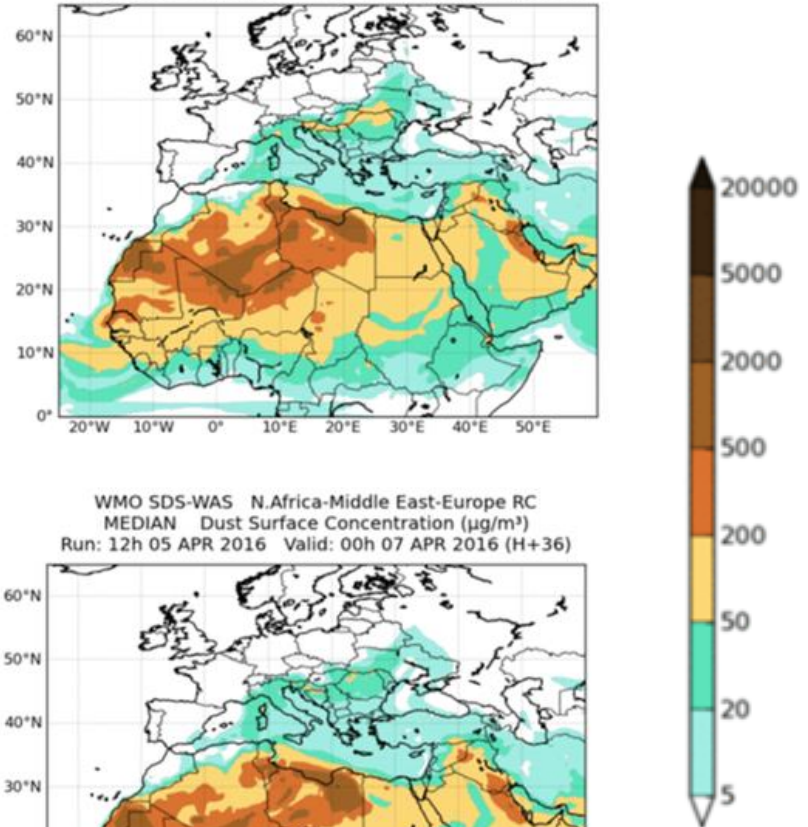
WMO SDS-WAS N.Africa-Middle East-Europe RC  
 MEDIAN Dust Surface Concentration ( $\mu\text{g}/\text{m}^3$ )  
 Run: 12h 05 APR 2016 Valid: 12h 06 APR 2016 (H+24)



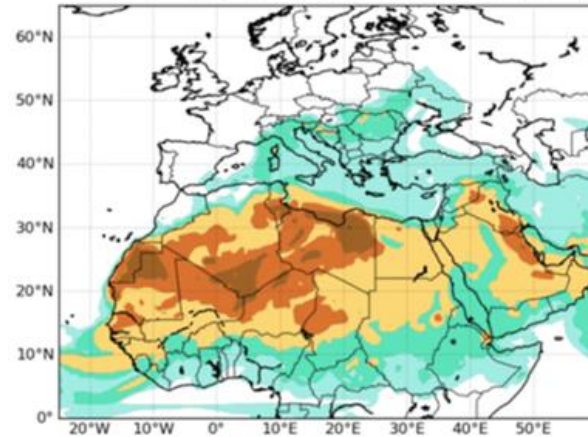
# NRT Visibility evaluation: 6<sup>th</sup> April 2016 12-24UTC



WMO SDS-WAS N.Africa-Middle East-Europe RC  
MEDIAN Dust Surface Concentration ( $\mu\text{g}/\text{m}^3$ )  
Run: 12h 05 APR 2016 Valid: 18h 06 APR 2016 (H+30)



WMO SDS-WAS N.Africa-Middle East-Europe RC  
MEDIAN Dust Surface Concentration ( $\mu\text{g}/\text{m}^3$ )  
Run: 12h 05 APR 2016 Valid: 00h 07 APR 2016 (H+36)



# NRT Vertical profiles: Tenerife and Dakar

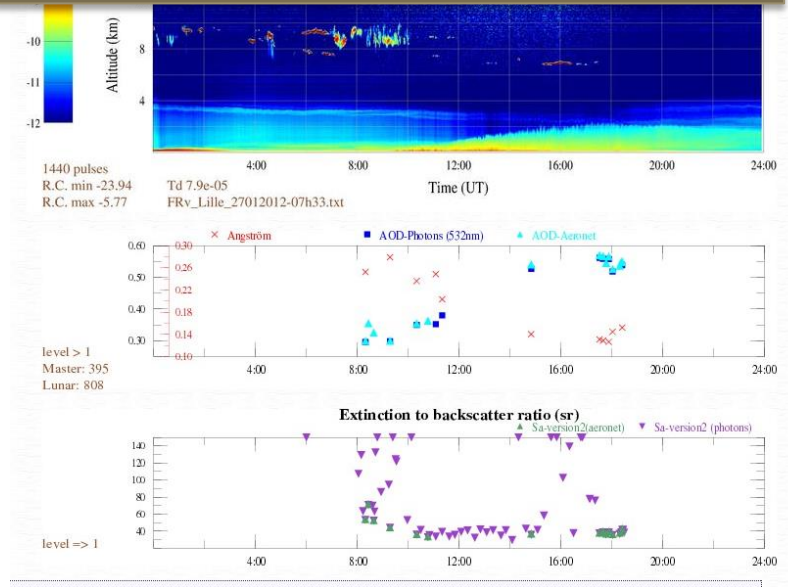
## Ceilometer Santa Cruz de Tenerife (Spain)

- + High density of stations
- Qualitatively products



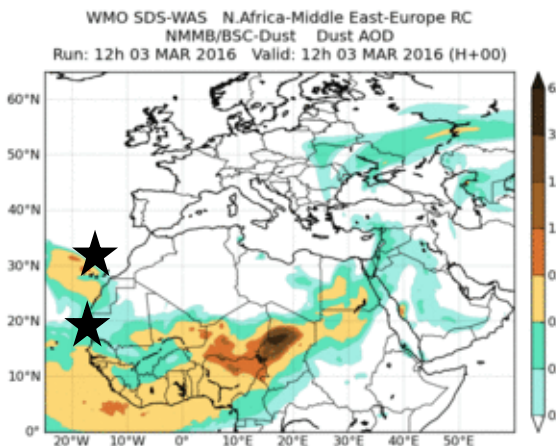
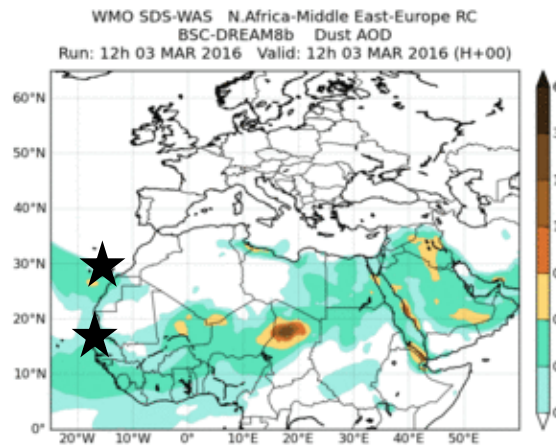
## Lidar M'Bour (Senegal)

- Low number of stations
- + Quantitative products

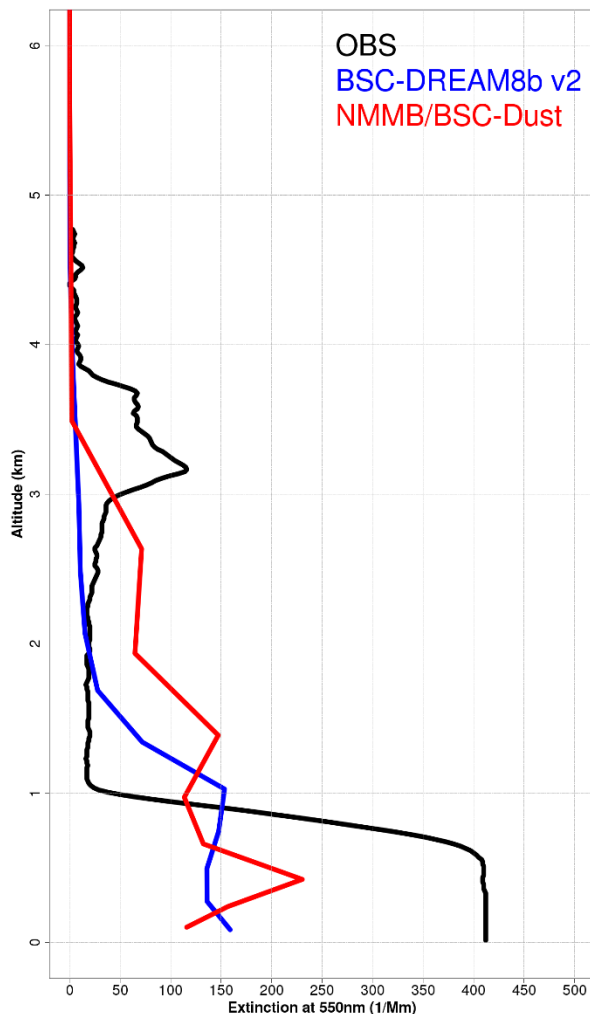




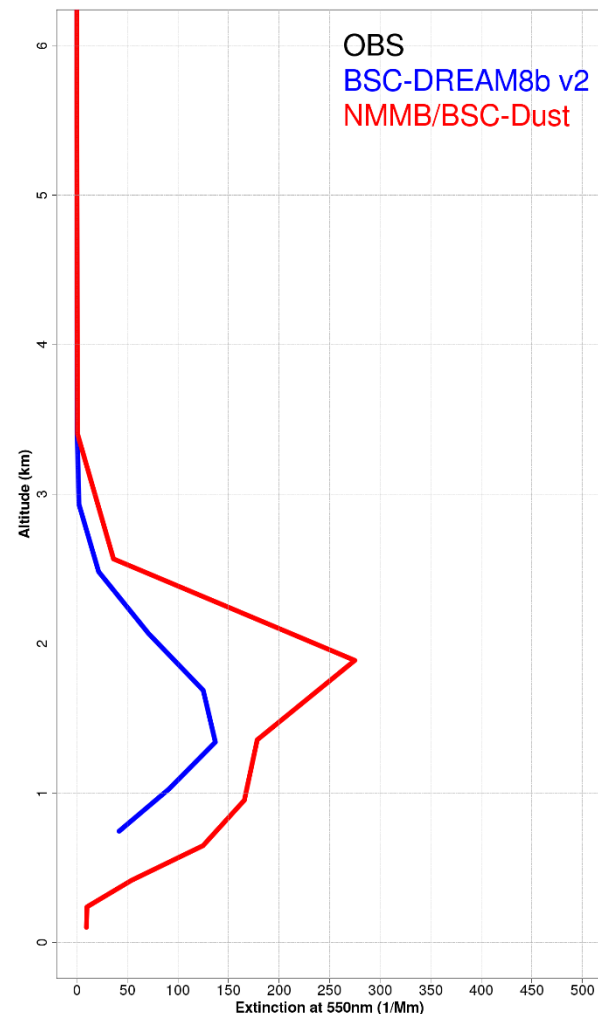
# NRT Vertical profiles evaluation: at 12UTC



## MBour at 2016-03-03 at 12UTC



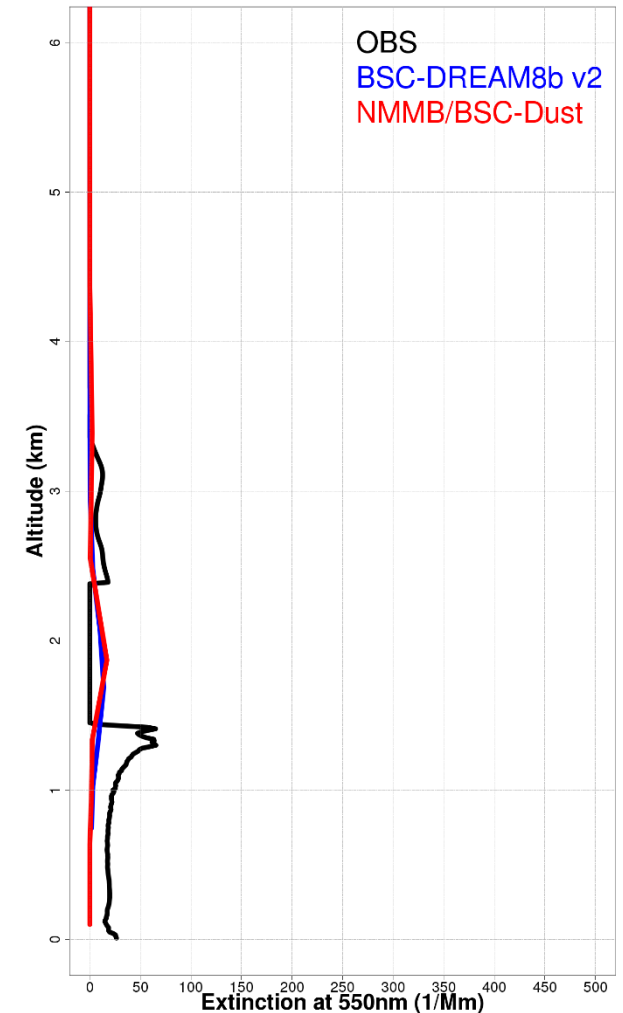
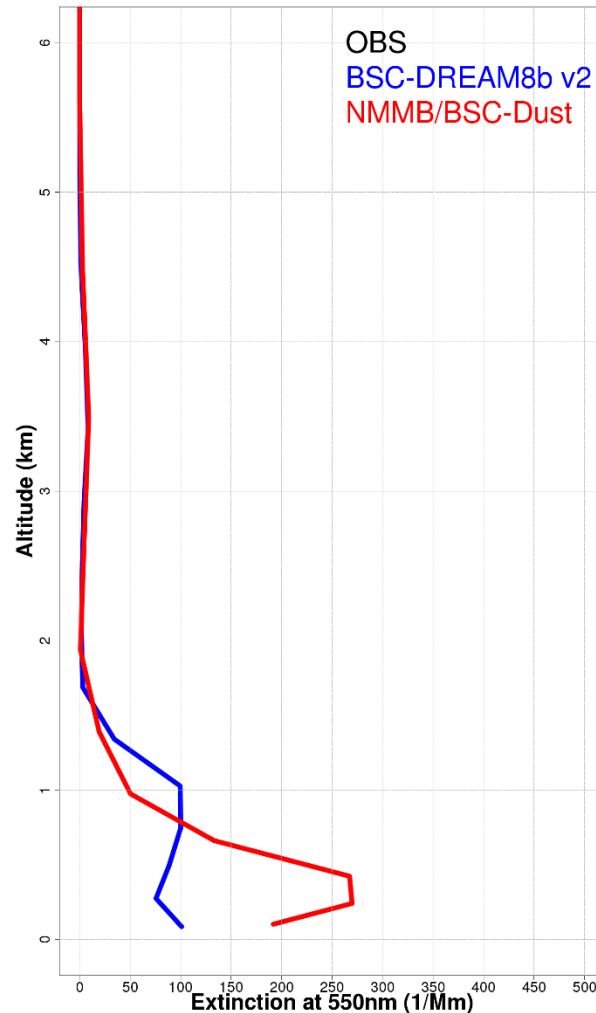
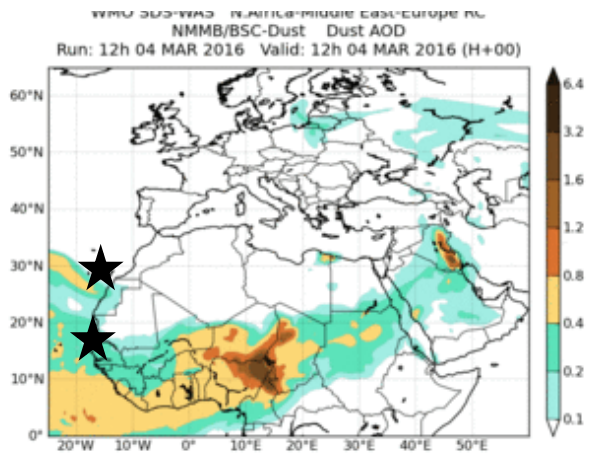
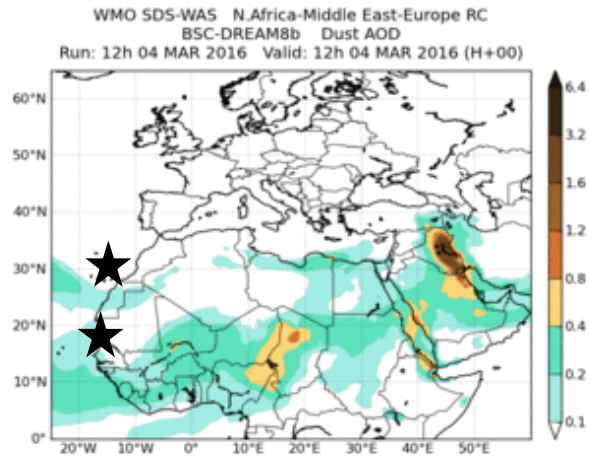
## Tenerife at 2016-03-03 at 12UTC



# NRT Vertical profiles evaluation: at 12UTC

## MBour at 2016-03-04 at 12UTC

## Tenerife at 2016-03-04 at 12UTC



# Conclusions

- **Model evaluation activities (NRT and a posteriori) provide useful information for model developments**
  - The comparison with multi-model products (as that from SDS-WAS NAMEE RC) provides additional information about the state-of-the-art of atmospheric models.
- **At present, there is a lack of ground-based mineral dust observations over North Africa for an accurate model evaluation:**
  - PM10 from AQMS can be used for a preliminary evaluation of surface concentration in NRT
  - Visibility from METAR and SYNOP stations is a new operational product useful for operational prediction and model verification
  - Vertical aerosol products from lidar and ceilometers is starting to be deployed in the NRT evaluation

The screenshot shows the top section of the website. At the top right is a "Log in" button. Below it is the header "BARCELONA DUST FORECAST CENTER" with logos for the Spanish Government, AEMet, BSC, and the UN. A navigation menu contains links for HOME, ABOUT US, FORECAST, EVALUATION, METHODS, NEWS, EVENTS, and CONTACT. Below the menu is a "NEWSLETTER" section with a yellow background and the text "Keep up to date with our Barcelona Dust Forecast Center starts operations".

*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*

The screenshot shows the main content area. On the left is a vertical navigation menu with links for About us, Forecast, Evaluation, Methods, News, Events, and Contact. Below the menu is a "LATEST NEWS" section. The main content features a map titled "NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Conc. (µg/m³) Run: 12h 19 MAY 2014 Valid: 18h 20 MAY 2014 (H+30)". The map shows dust concentration over Northern Africa, the Middle East, and Europe. To the right of the map is a vertical color scale from 20 to 20000 µg/m³. Text next to the map reads "Dust forecast Latest dust forecast for Northern Africa, Middle East and Europe" and includes a link "Check it here".

<http://dust.aemet.es/>

 [@Dust\\_Barcelona](https://twitter.com/Dust_Barcelona)



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Agencia Estatal de Meteorología



EXCELENCIA  
SEVERO  
OCHOA



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*

# Thank you!

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