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

Training Workshop on Sand and Dust Storms in the Arab Region, Cairo, Egypt, 10-12 February 2018

BSC Earth Sciences Department

What

Environmental modelling and forecasting

Why

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

MareNostrum supercomputer

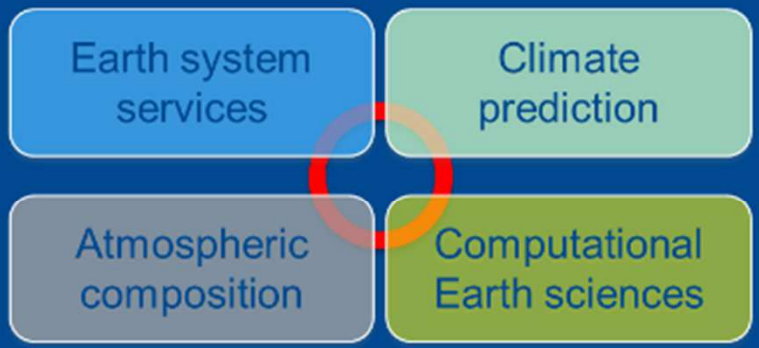
How

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

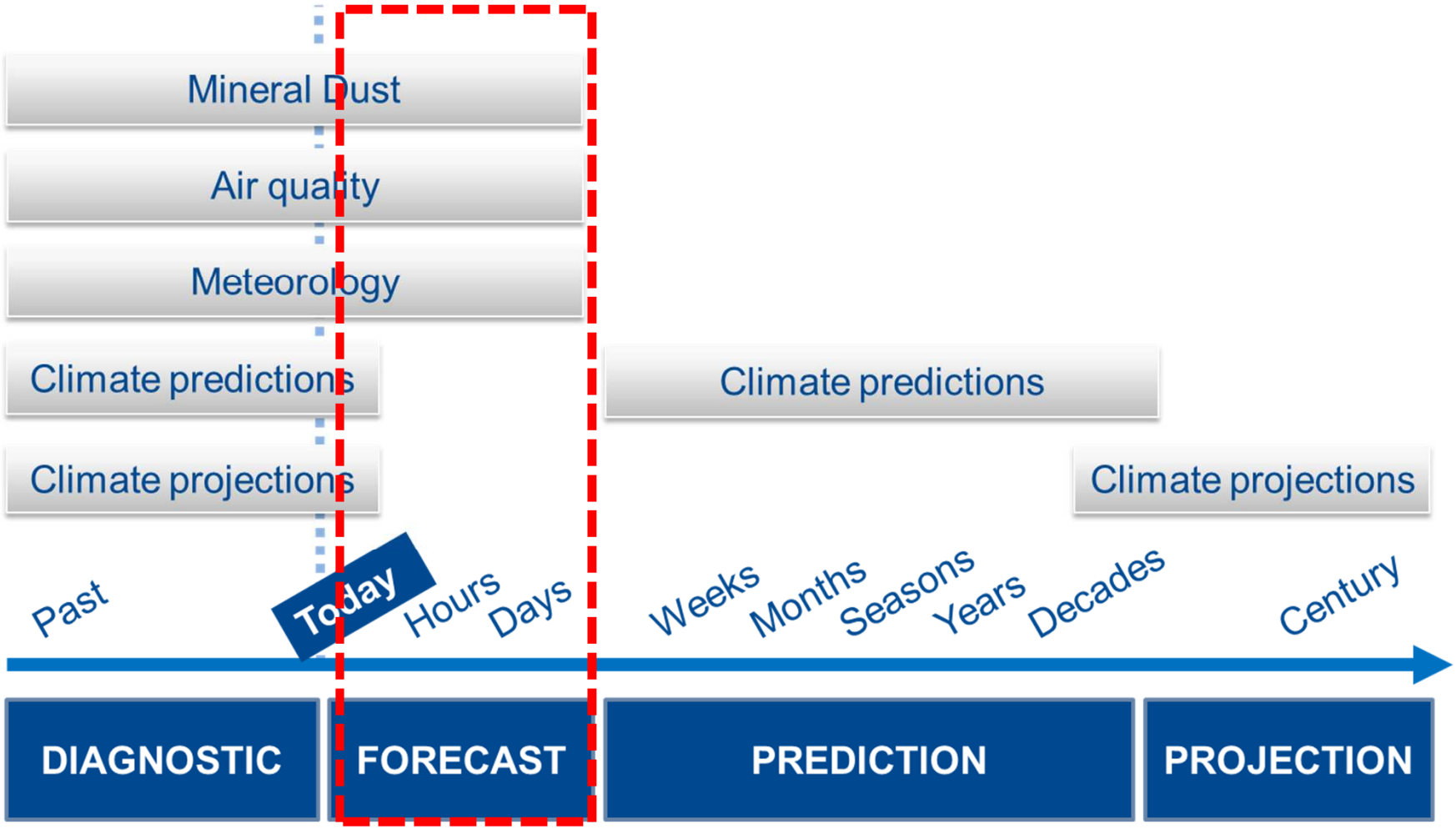
Implement climate prediction system for subseasonal-to-decadal climate prediction

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



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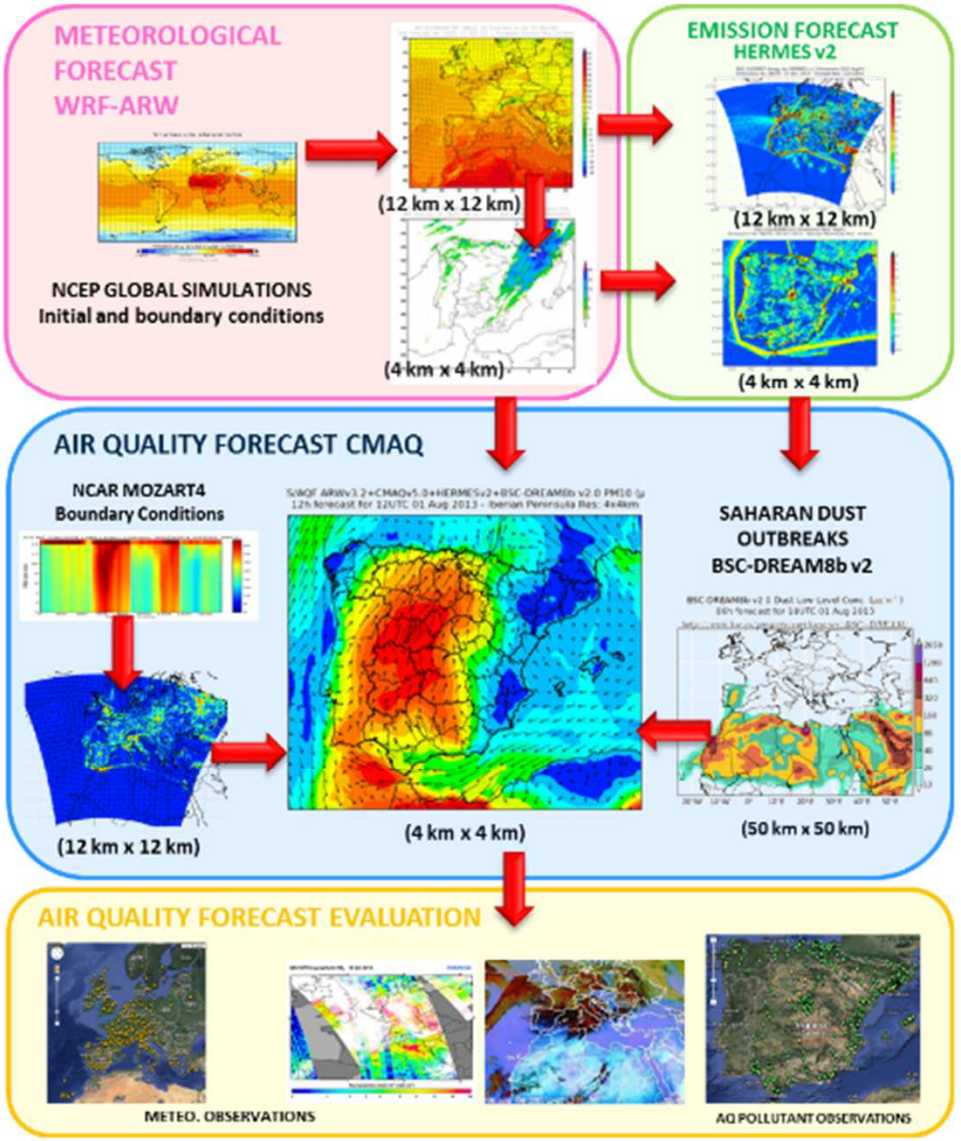
Short-term forecast

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)



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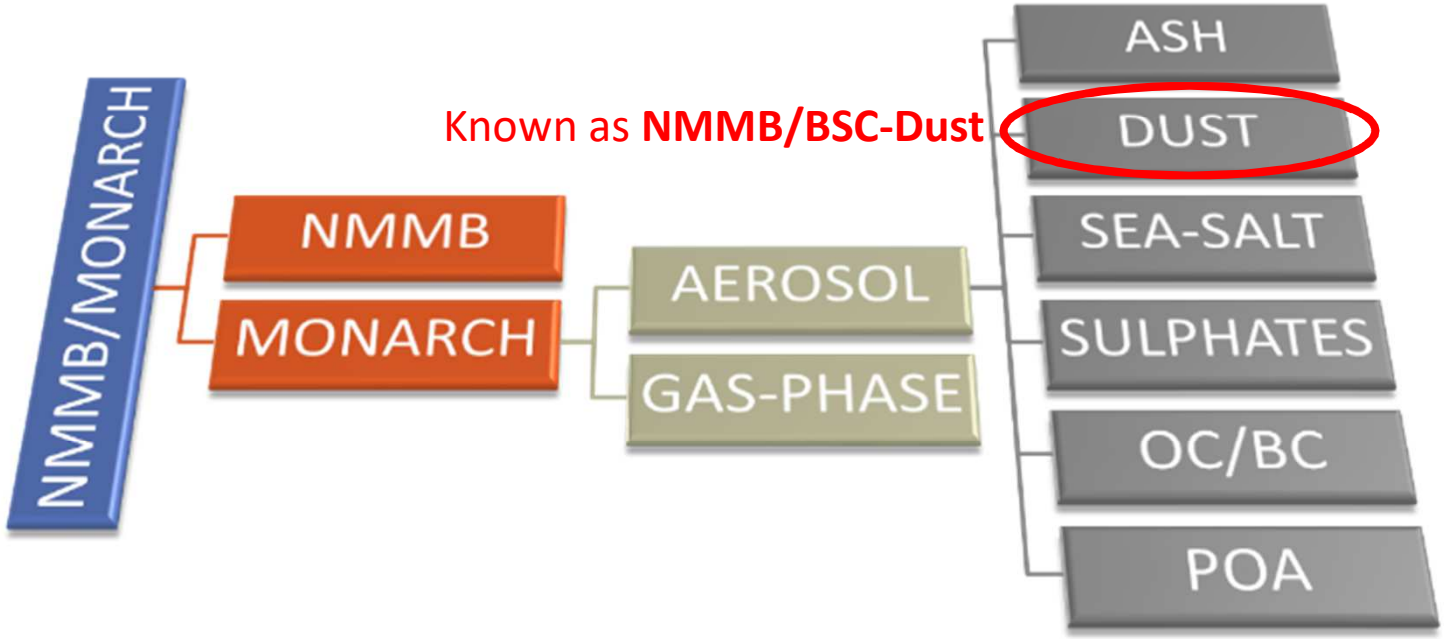
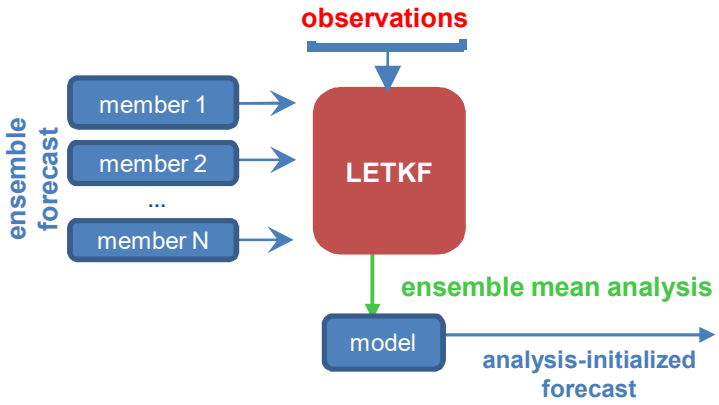
NMMB-MONARCH:
Atmospheric Composition and Air Quality

- 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



NMMB-MONARCH: Data Assimilation

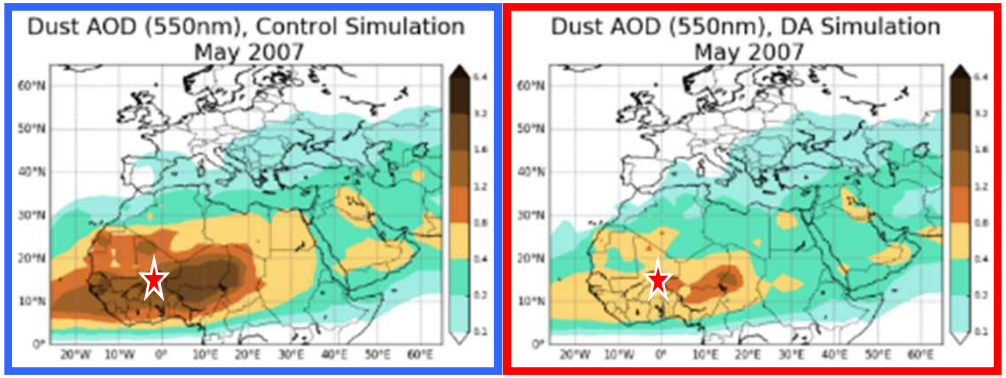
NMMB-MONARCH coupled with a Local Ensemble Transform Kalman Filter (**LETKF**) for the assimilation of aerosol optical depth observations

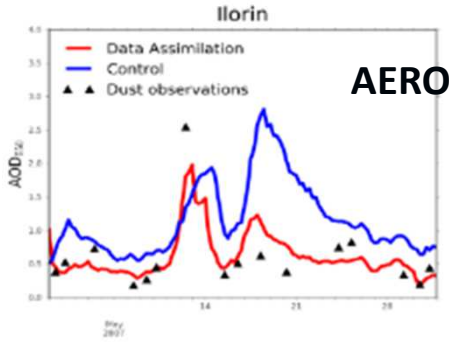


Mineral dust application
The ensemble forecast is based on uncertainties in the dust emission scheme

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

(DiTomaso et al., GMD, 2016)

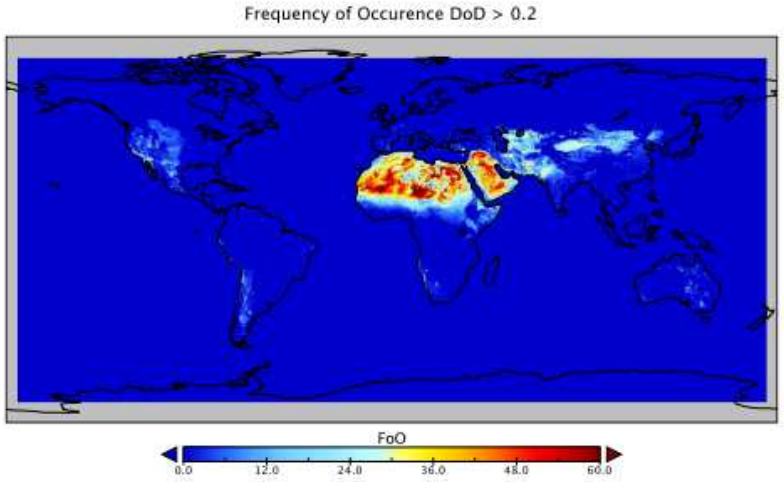


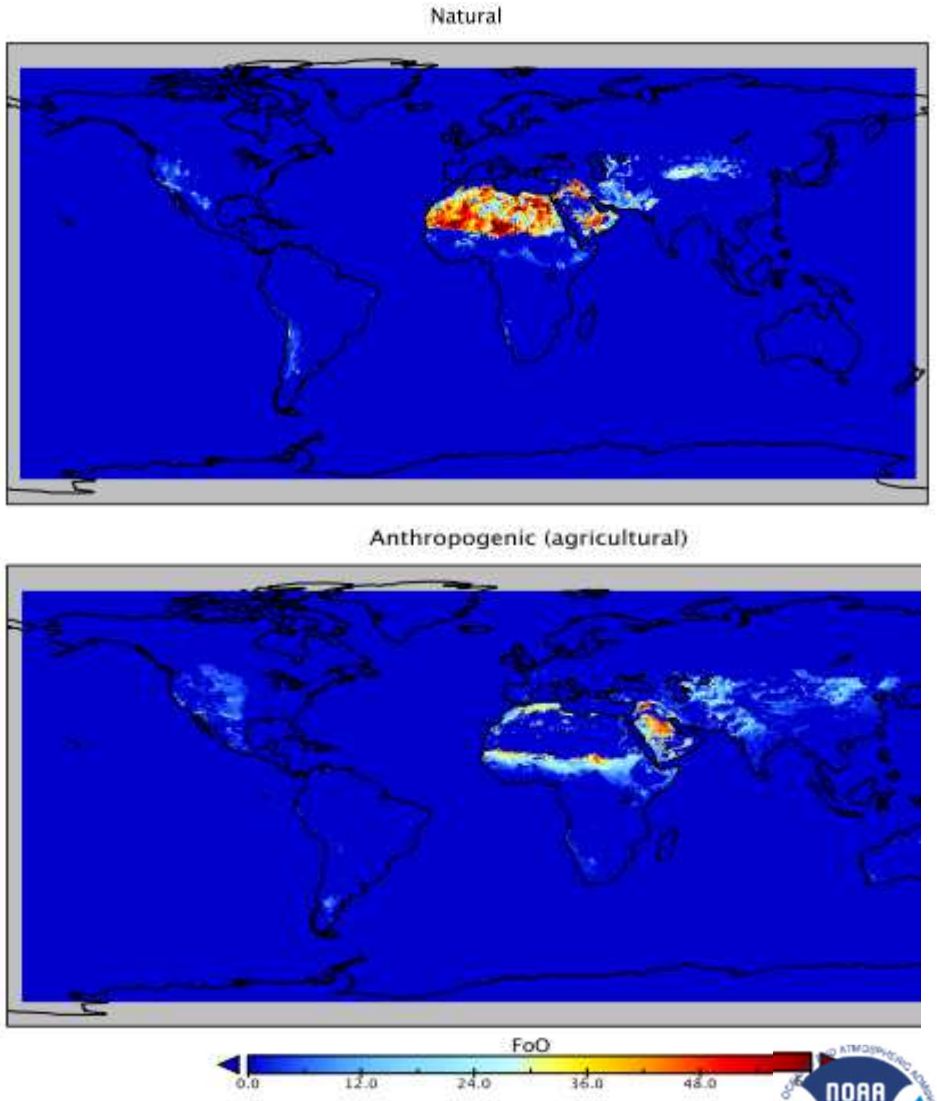


AERONET Validation

Mineral Dust modelling: Dust sources

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





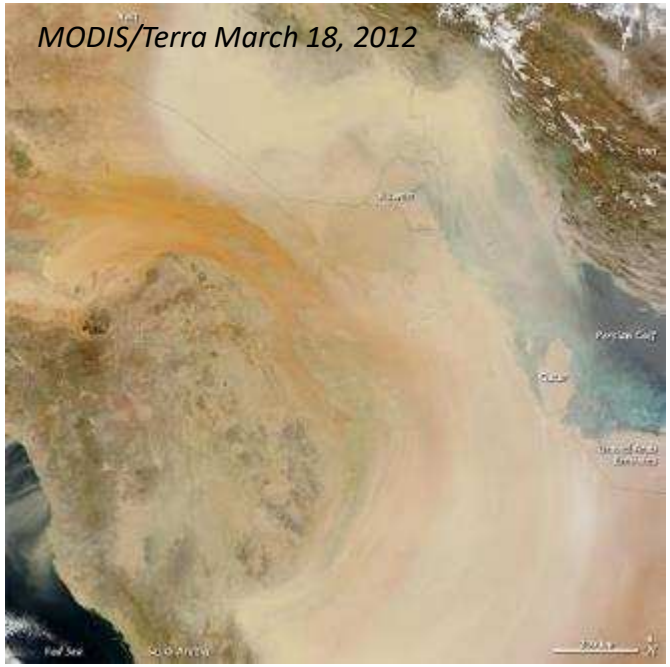
In collaboration P. Ginoux (NOAA-GFDL)

Mineral Dust modelling: Topography

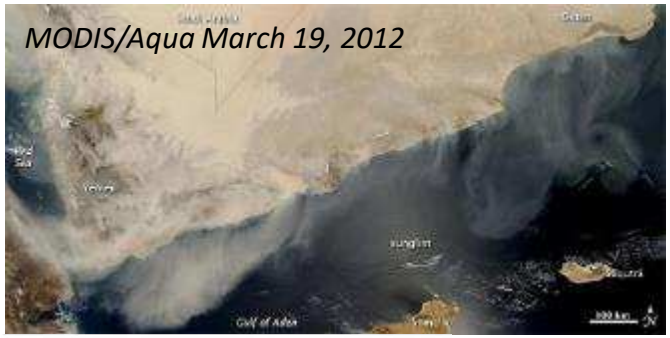
Mineral Dust modelling: Topography

Impact of the topography on dust transport

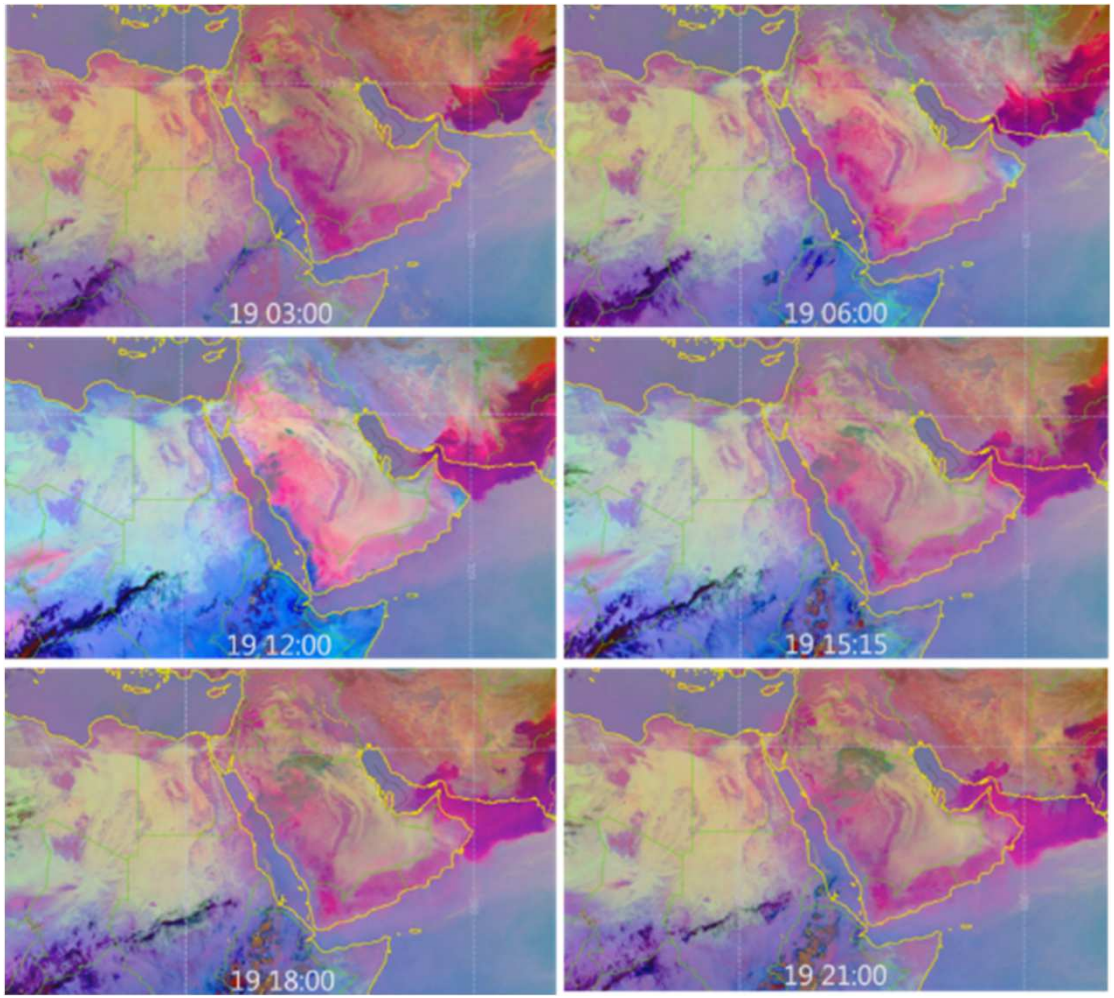
MODIS/Terra March 18, 2012



MODIS/Aqua March 19, 2012

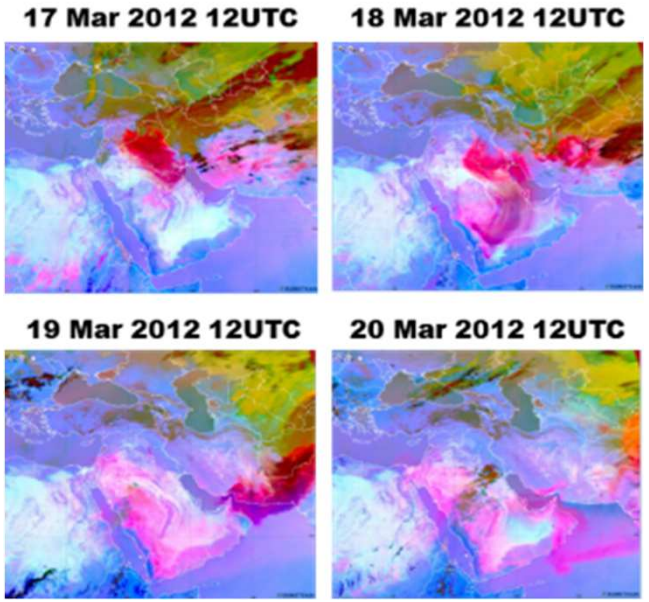


MSG/RGB March 19, 2012

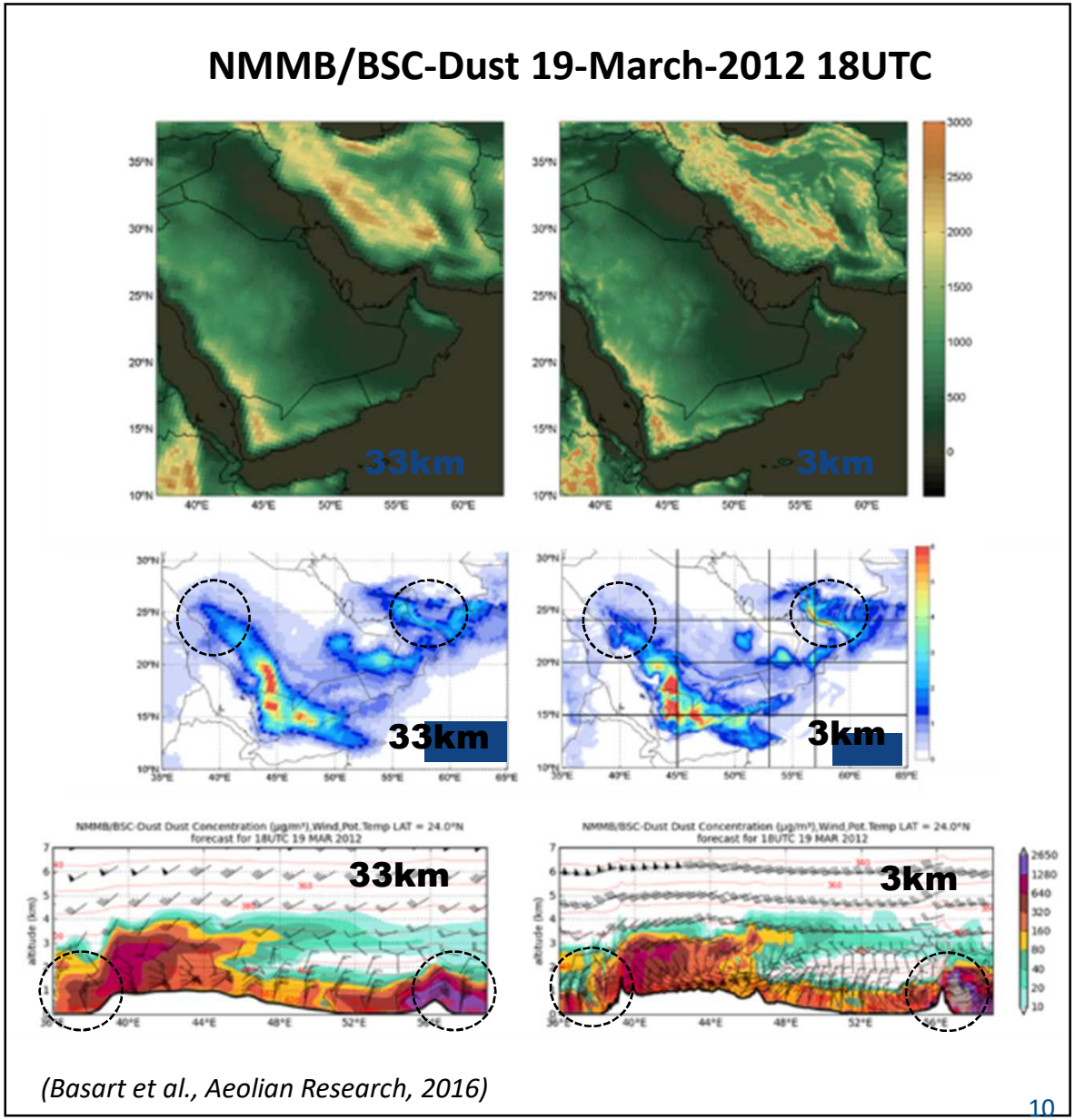


(Basart et al., Aeolian Research, 2016)

Mineral Dust modelling: Topography



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)

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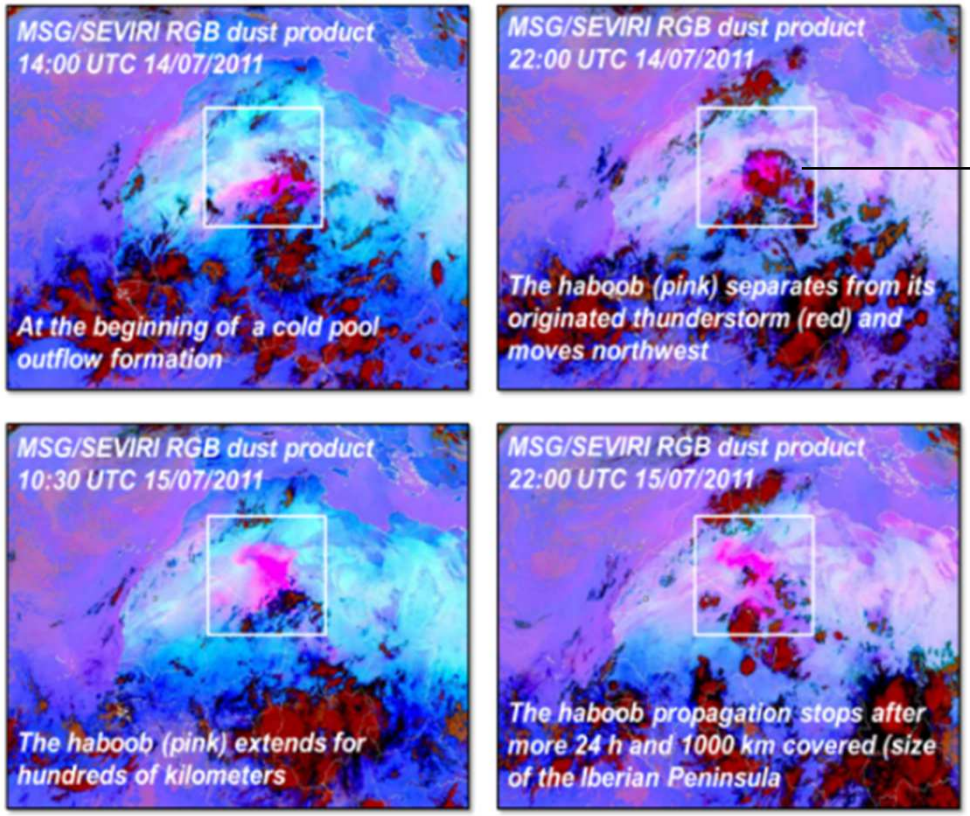
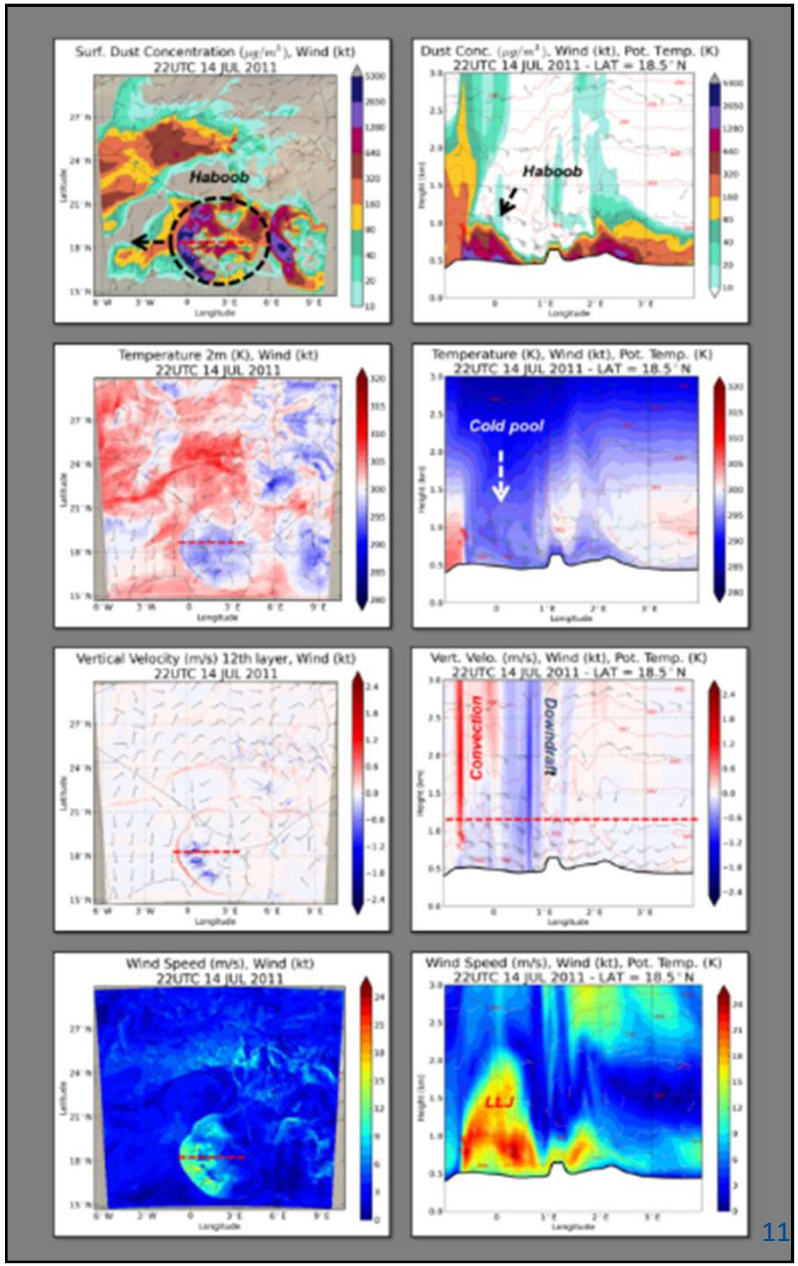
Mineral Dust modelling: Haboobs





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)* → ***allowing explicit convection***
Vertical resolution: *60σ-layers (12-15σ-layers in the first 1000 m)*
Cold start *(No data assimilation)*

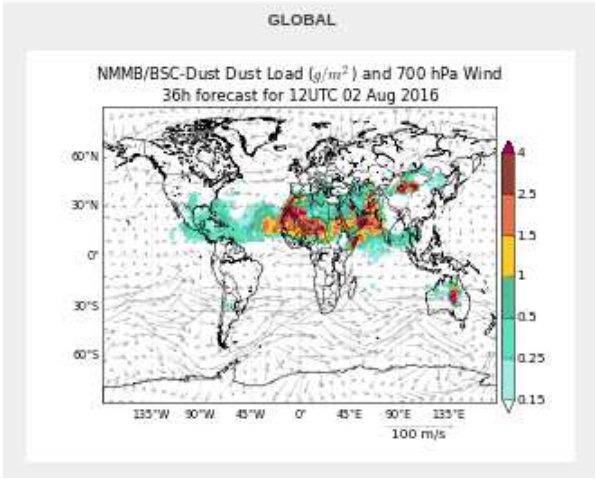
(Vendrell et al., in preparation)

Mineral dust Services

BSC dust operational forecast (global and regional domains)

http://www.bsc.es/ESS

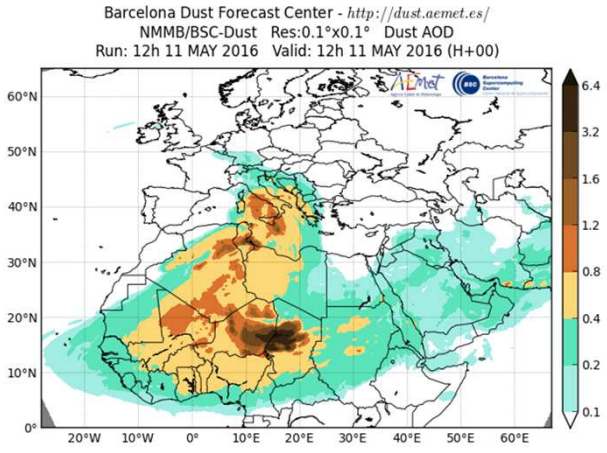
✓ *Contribution to the **ICAP** multi-model ensemble (global) http://icap.atmos.und.edu*



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



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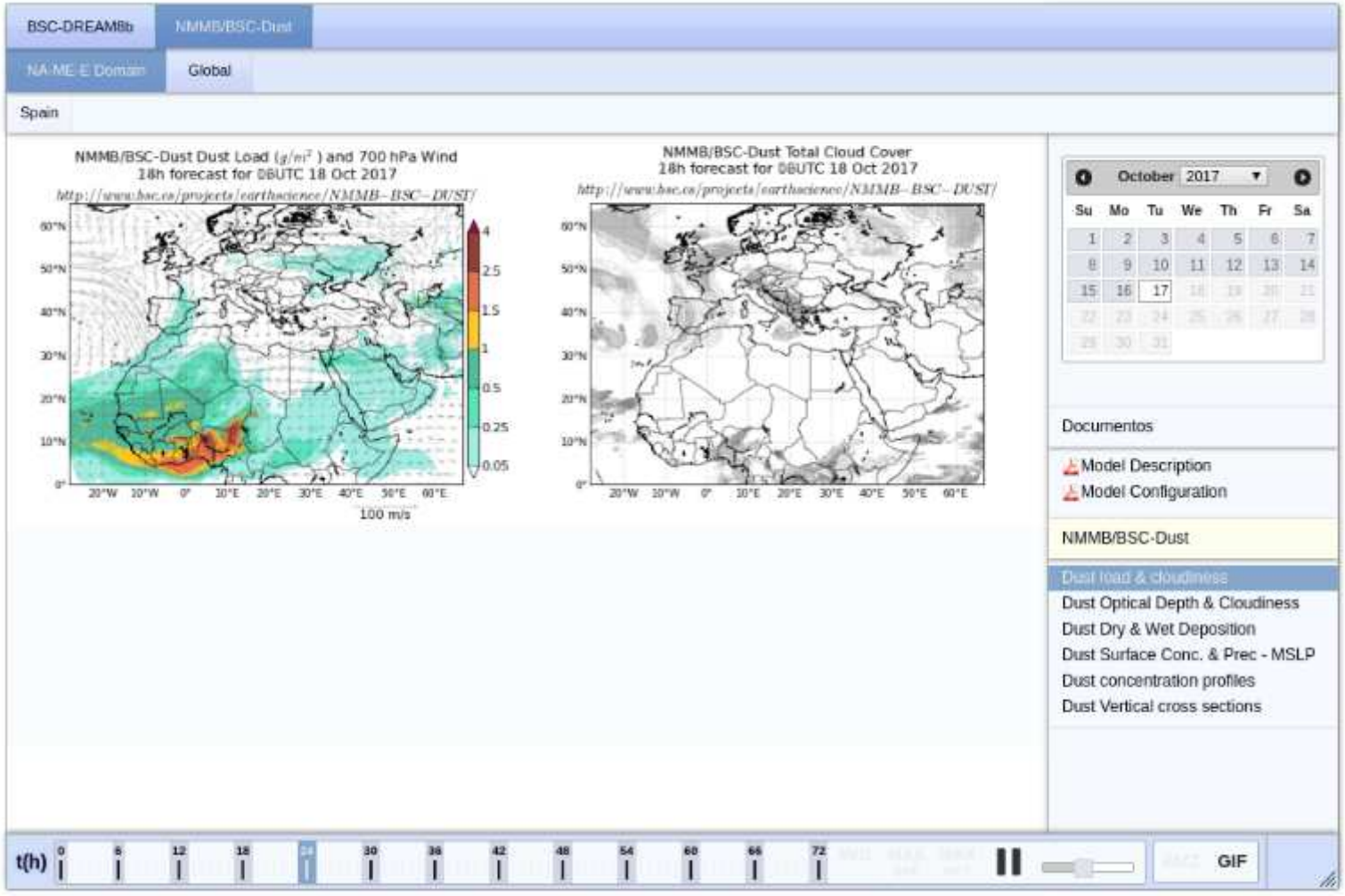
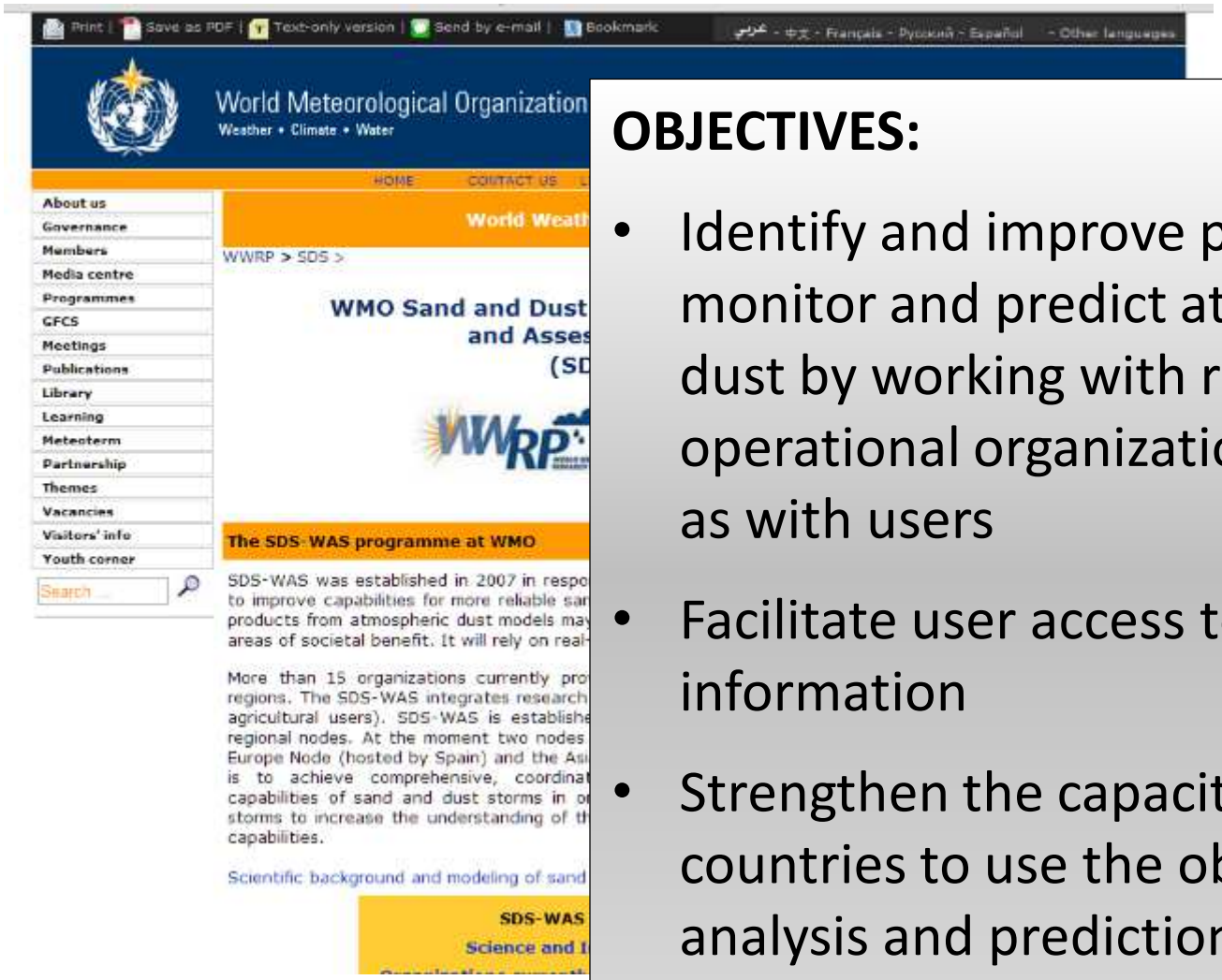
GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE
AEMet Agencia Estatal de Meteorología

BSC dust operational forecast



http://www.bsc.es/ESS

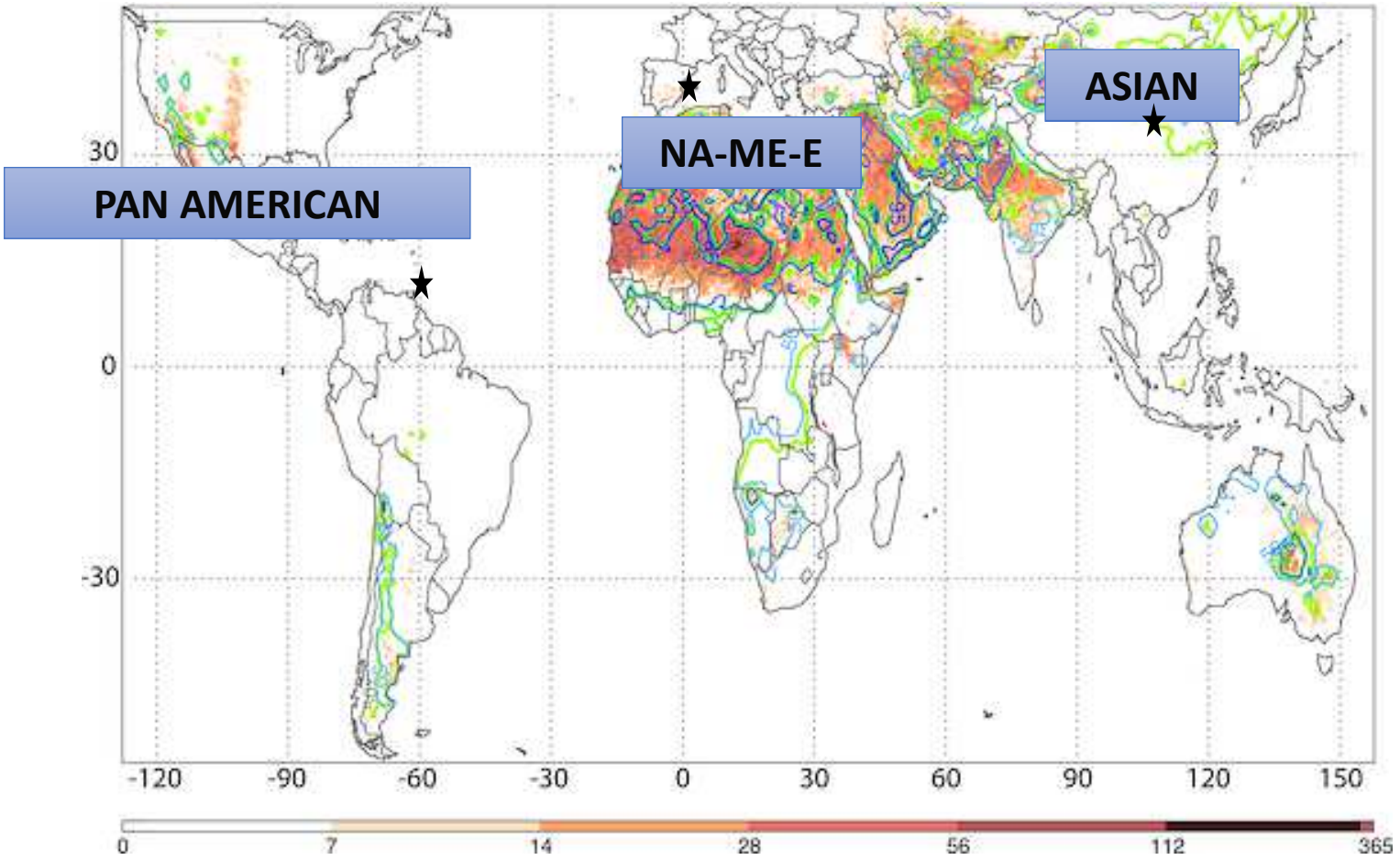
The WMO SDS-WAS project



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 NAMEE RC

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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	12	Regional	No
CAMS ECMWF	00	Global	MODIS AOD
DREAM8-NMME	00	Regional	CAMS analysis
NMMB/BSC-Dust	00	Regional	No
MetUM	12	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
RegCM4 EMA	00	Global	No
DREAMABOL	12	Regional	No
WRF-CHEM NOA	12	Regional	No
SILAM	12	Regional	No
LOTOS-EUROS	12	Regional	No

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Agencia Estatal de Meteorología

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

SDS-WAS NAMEE: Files Download

BSC-DREAM8b v2.0	PUBLIC Files RESTRICTED Files	Model website	
CAMS-ECMWF	PUBLIC Files RESTRICTED Files	Model website	
DREAM-NMME-MACC	PUBLIC Files RESTRICTED Files	Model website	
NMMB/BSC-I			
NASA-GEOS-I			
NCEP-NGAC			
DREAMABOI			
EMA-RegCM4			

Title	Size	Modified
latest - (download all)	4.0 kB	Oct 19, 2017 10:40 PM
2017 - (download all)	4.0 kB	Oct 03, 2017 10:40 PM
2016 - (download all)	4.0 kB	Dec 03, 2016 10:40 PM
2015 - (download all)	4.0 kB	Mar 07, 2016 12:49 PM
2014 - (download all)	4.0 kB	Mar 07, 2016 12:49 PM
2013 - (download all)	4.0 kB	Mar 07, 2016 12:49 PM
2012 - (download all)	4.0 kB	Mar 07, 2016 12:49 PM

- 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.

Needed registered user!

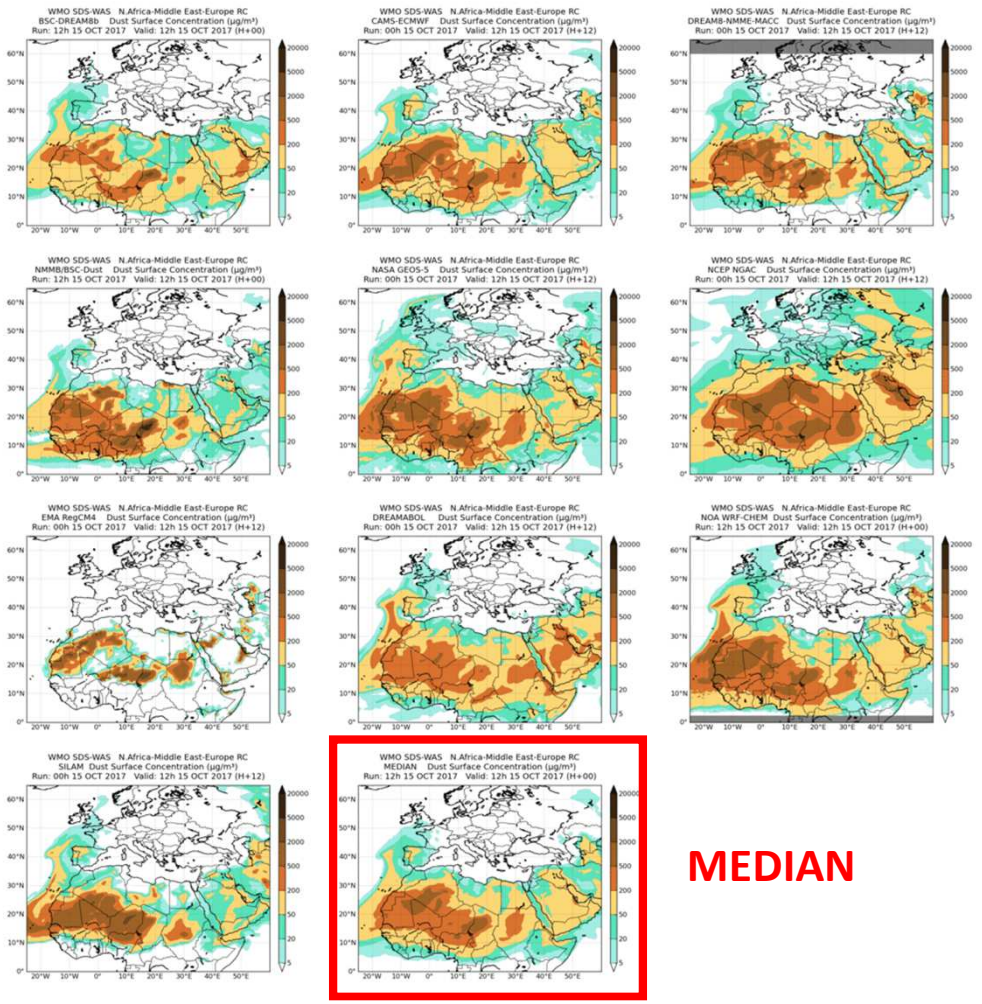
http://sds-was.aemet.es/

SDS-WAS Multi-model

SDS-WAS product

12 Global – Regional models
(from ~ 100 to 10 km)

Dust Surface Conc.
from 15-Oct-2017 12:00 to 18-Oct-2017 00:00



MEDIAN

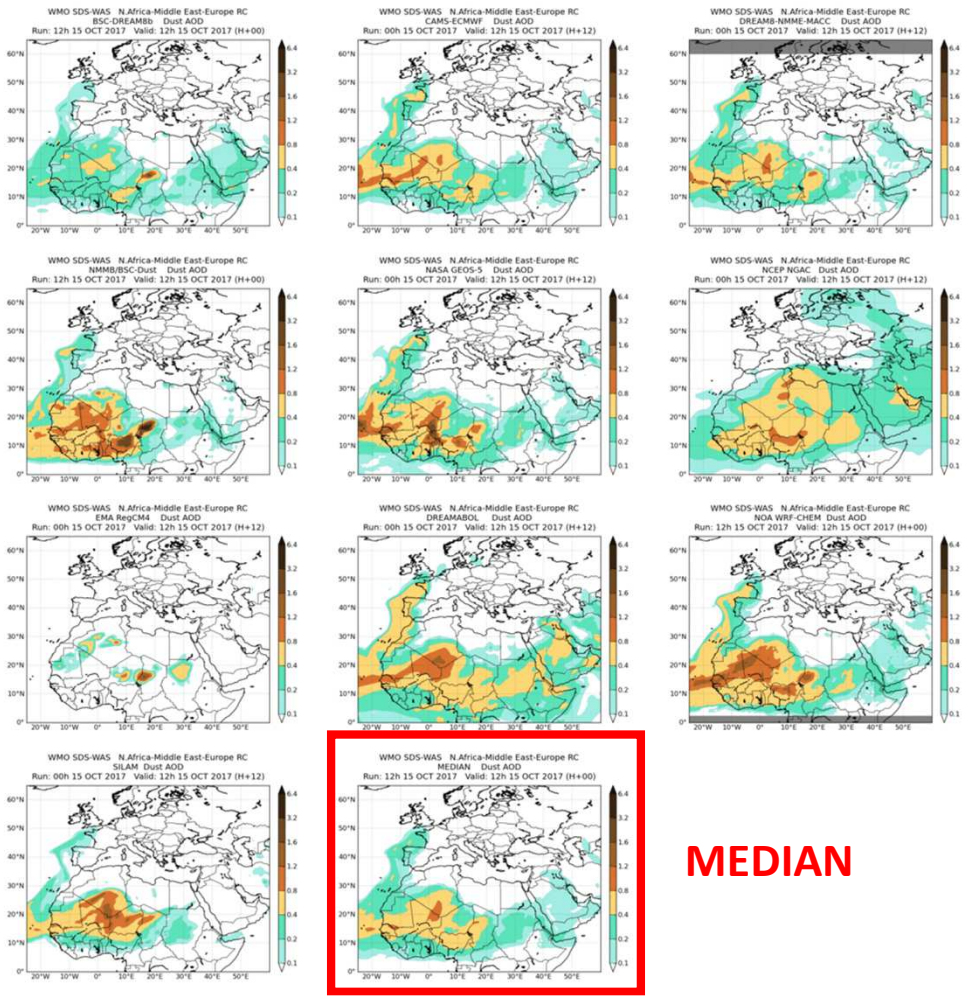
http://sds-was.aemet.es/

SDS-WAS Multi-model

SDS-WAS product

12 Global – Regional models
(from ~ 100 to 10 km)

Dust Optical Depth at 550nm
from 15-Oct-2017 12:00 to 18-Oct-2017 00:00

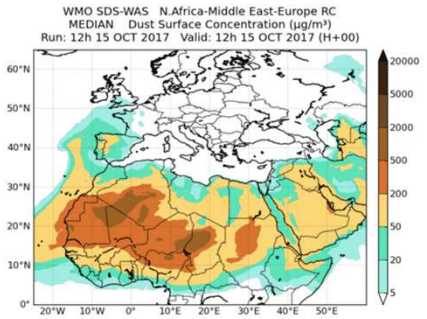


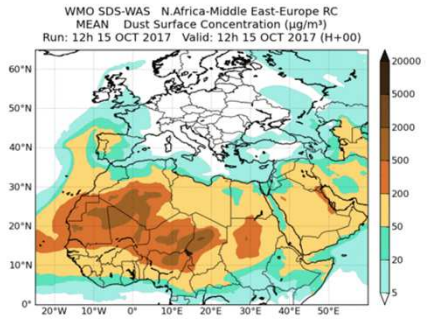
MEDIAN

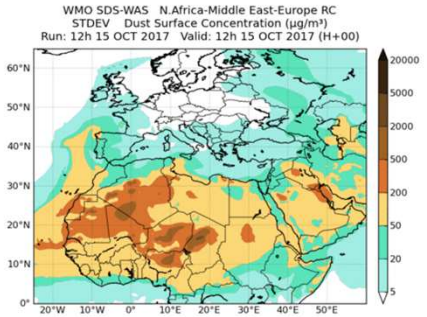
http://sds-was.aemet.es/

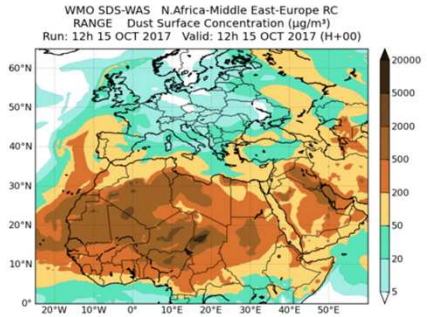
SDS-WAS NAMEE: Multi-model

Surface concentration

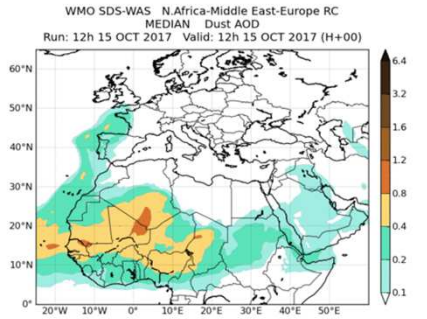


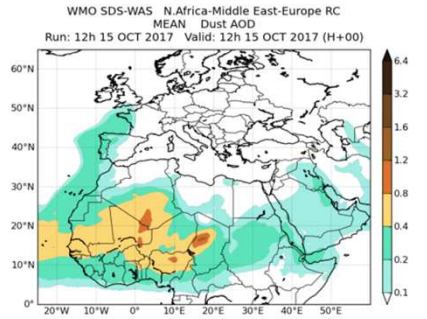


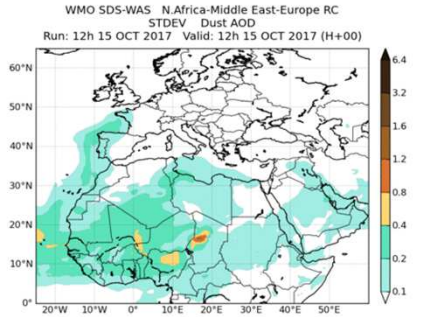


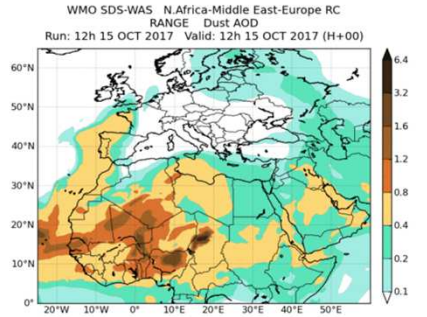


Dust AOD at 550nm









from 15-Oct-2017 12:00 to 18-Oct-2017 00:00

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

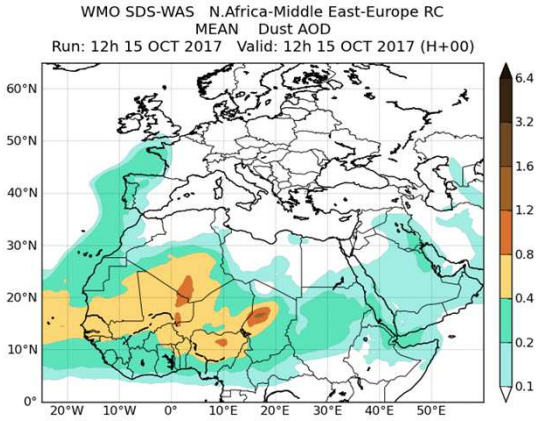
CENTRALITY: median - mean

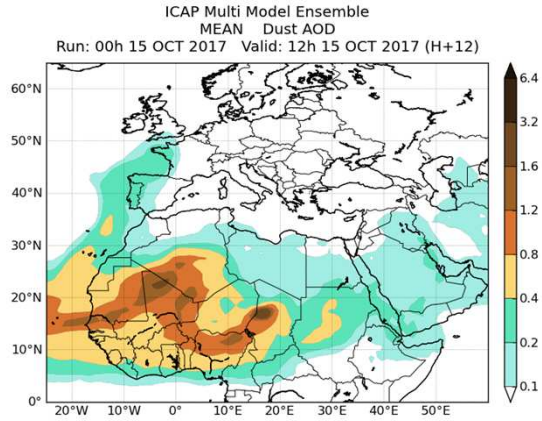
SPREAD: standard deviation – range of variation

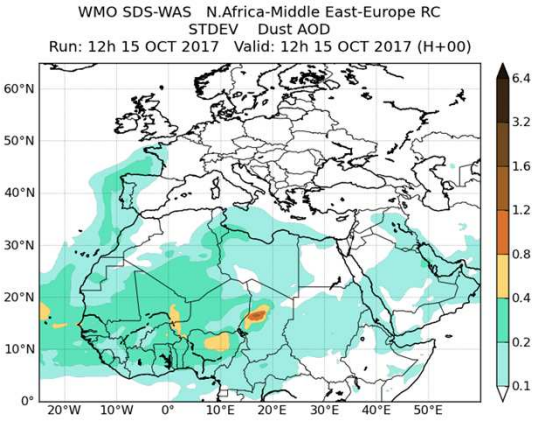
SDS-WAS NAMEE: Multi-model - ICAP

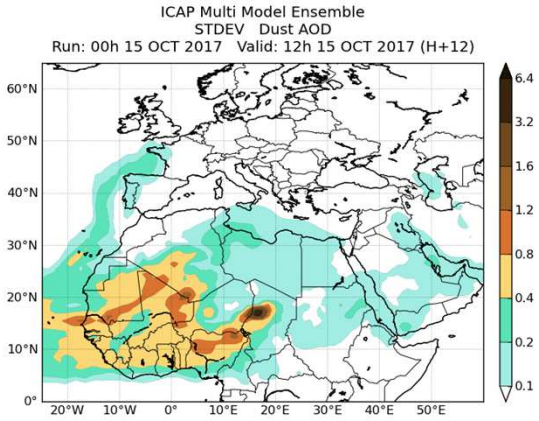
Only global models!

Dust AOD at 550nm
from 15-Oct-2017 12:00 to 18-Oct-2017 00:00





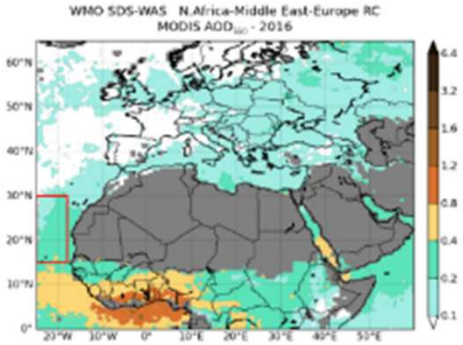




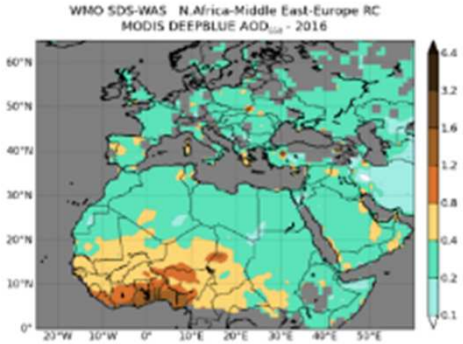
SDS-WAS NAMEE: DOD Model Evaluation

- **Evaluation with AERONET data**
  - Graphical NRT Evaluation by site
  - Evaluation scores monthly/seasonal/annual and sites

- **Evaluation with MODIS data onto the Atlantic**
  - Evaluation scores monthly/seasonal/annual

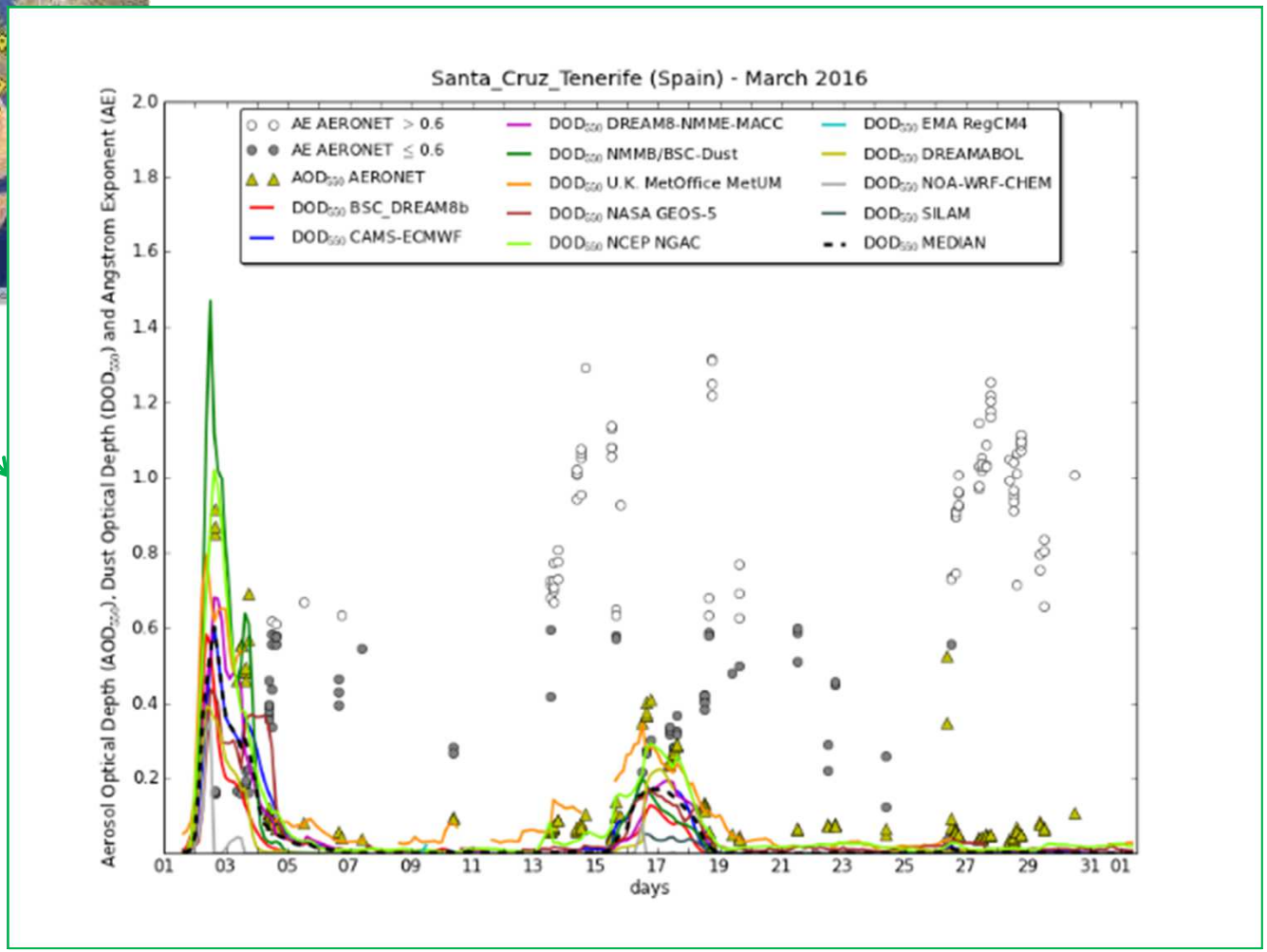


- **Evaluation of dust models with MODIS Deep Blue retrievals**
  - Evaluation scores monthly/seasonal/annual



http://sds-was.aemet.es/forecast-products/forecast-evaluation

SDS-WAS NAMEE: DOD AERONET Evaluation



SDS-WAS NAMEE: DOD AERONET Evaluation

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***

Date: - Select Year - ▼

Jan 2016 - Dec 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	SILAM	MEDIAN
Sahel/Sahara show stations	-0.30	-0.17	-0.20	-0.11	-0.16	-0.20	-0.06	0.03	-0.13	-0.13	-0.06	-0.18
Middle East show stations	-0.12	-0.10	-0.05	-0.17	-0.12	-0.16	-0.11	1.13	0.06	-0.14	0.01	-0.13
Mediterranean show stations	-0.16	-0.12	-0.12	-0.15	-0.10	-0.14	-0.05	-0.02	-0.09	-0.12	-0.10	-0.13
TOTAL	-0.24	-0.14	-0.16	-0.13	-0.14	-0.18	-0.06	0.08	-0.10	-0.13	-0.07	-0.16

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	SILAM	MEDIAN
Sahel/Sahara show stations	0.51	0.42	0.45	0.43	0.44	0.42	0.39	0.64	0.48	0.44	0.82	0.42
Middle East show stations	0.35	0.25	0.28	0.44	0.27	0.31	0.29	11.39	0.34	0.32	0.62	0.28
Mediterranean show stations	0.30	0.29	0.30	0.29	0.27	0.29	0.27	0.40	0.30	0.31	0.44	0.28
TOTAL	0.44	0.37	0.39	0.39	0.38	0.38	0.35	2.86	0.42	0.39	0.71	0.37

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	SILAM	MEDIAN

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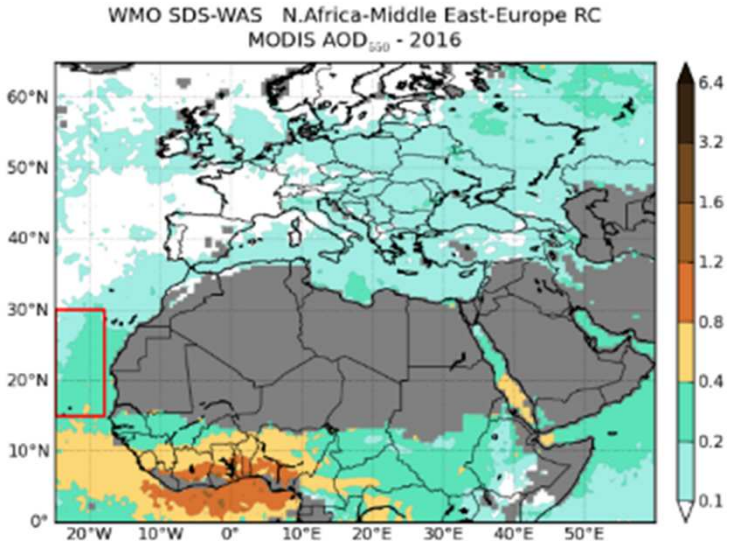
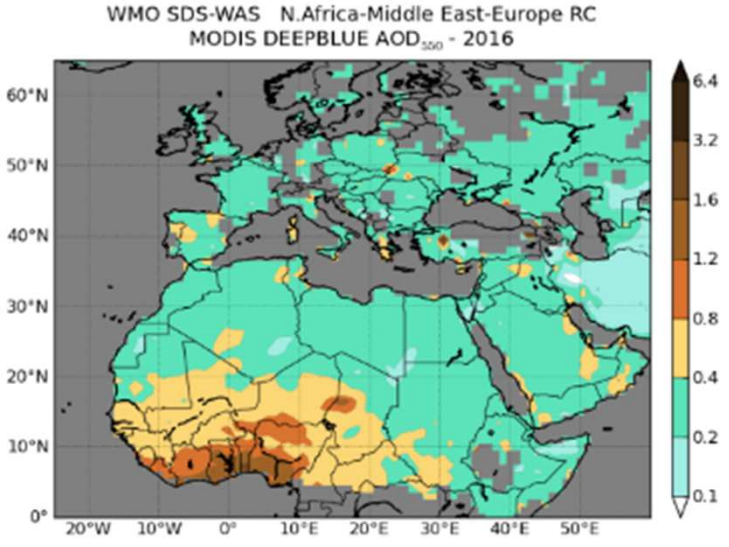
SDS-WAS NAMEE: DOD MODIS Evaluation





	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.16	0.26	0.70	0.97	18493
NMMB/BSC-Dust	-0.11	0.22	0.72	0.83	18293
NCEP NGAC	0.08	0.21	0.79	0.51	18465
EMA RegCM4	0.03	0.35	0.34	1.11	8039
DREAMABOL	-0.06	0.27	0.51	0.84	17834
NOA-WRF-CHEM	-0.00	0.18	0.79	0.71	18141
SILAM	0.03	0.48	0.45	0.93	12302

	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.16	0.32	0.40	0.76	189314
NMMB/BSC-Dust	-0.10	0.29	0.66	0.82	188183
NCEP NGAC	-0.03	0.27	0.52	0.55	189348
EMA RegCM4	0.25	1.51	0.07	0.82	94099
DREAMABOL	-0.01	0.36	0.24	0.70	181446
NOA-WRF-CHEM	-0.04	0.25	0.61	0.59	186946
SILAM	0.10	0.79	0.27	0.93	142429

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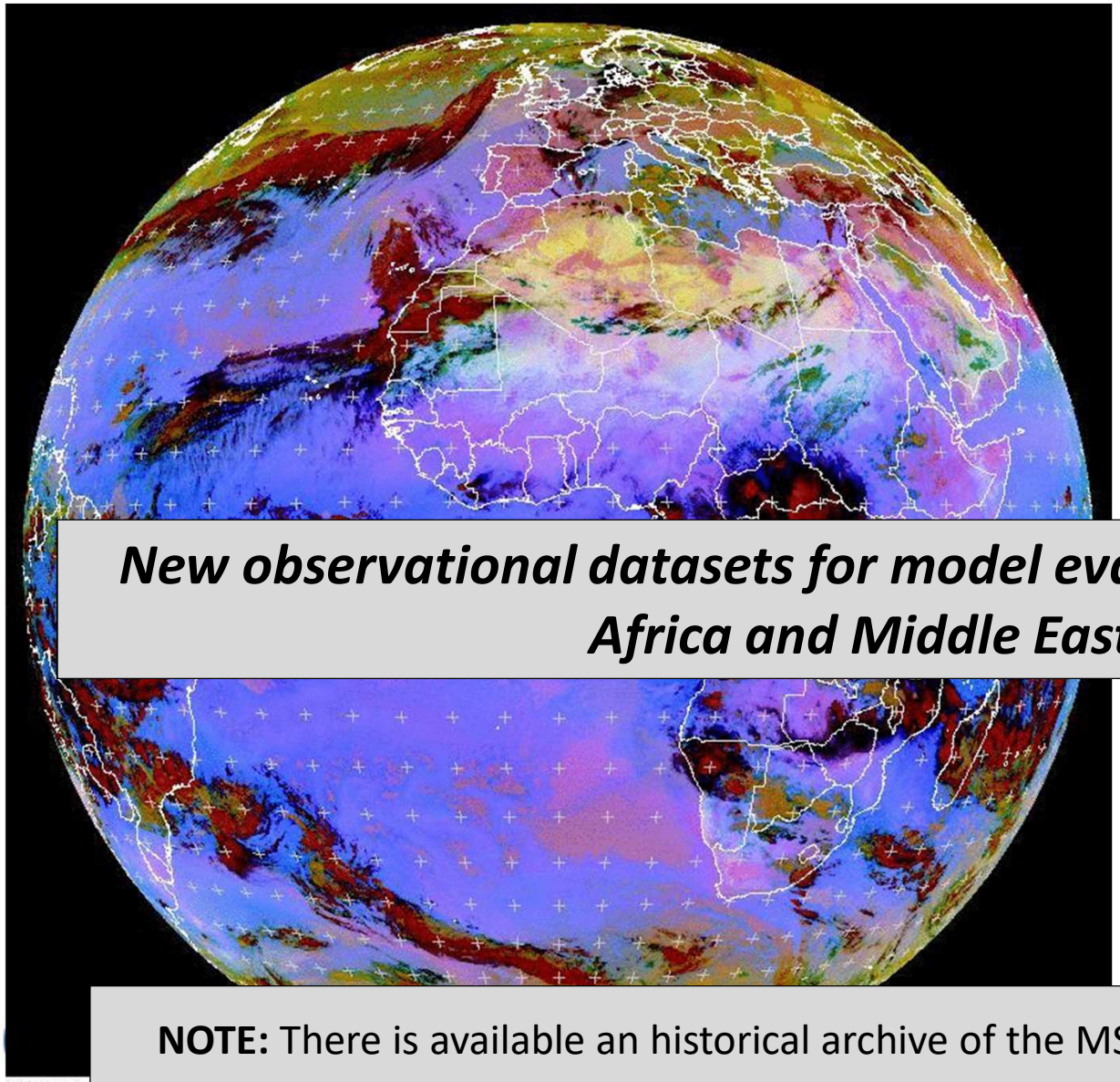
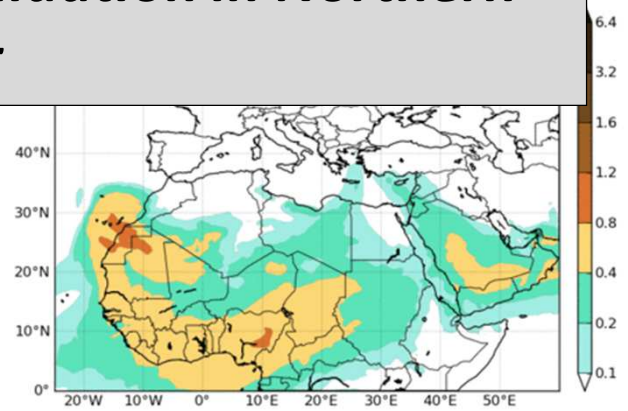
SDS-WAS NAMEE: Model Evaluation



EUMETSAT

7 March 2015

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

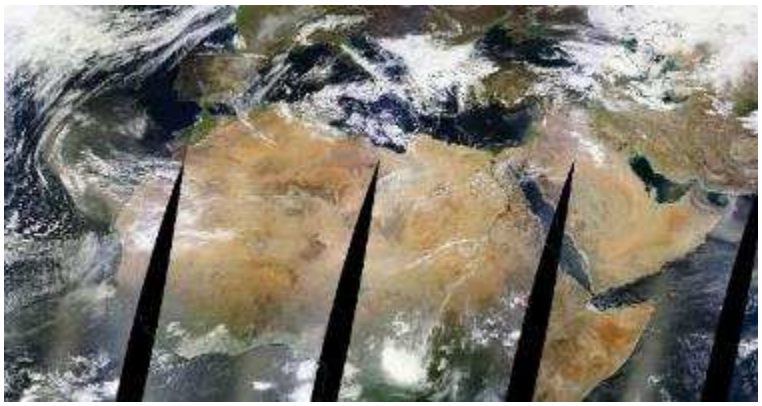


NOTE: There is available an historical archive of the MSG RBG dust products.

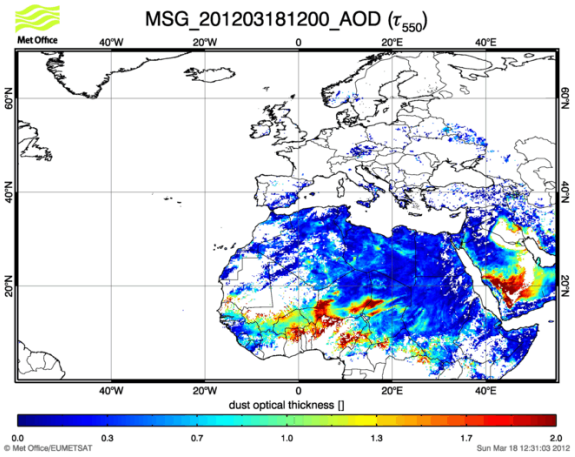
SDS-WAS NAMEE: Model Evaluation

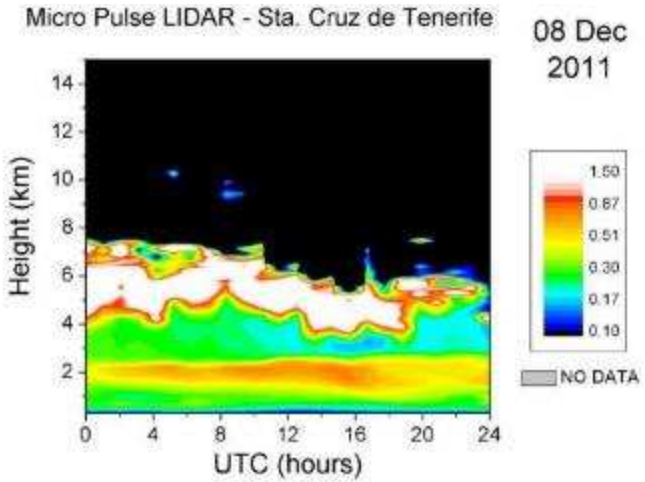
New observational datasets for model evaluation in Northern Africa and Middle East

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



MODIS composite 8th March 2015 from EOSDIS World Viewer





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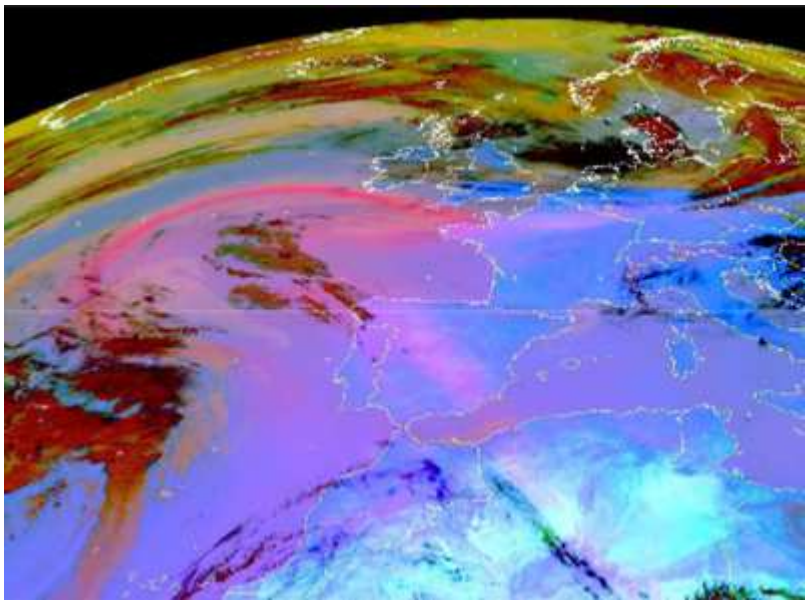
SDS-WAS NAMEE: Studies

Model Intercomparison: European dust outbreak on April 2011



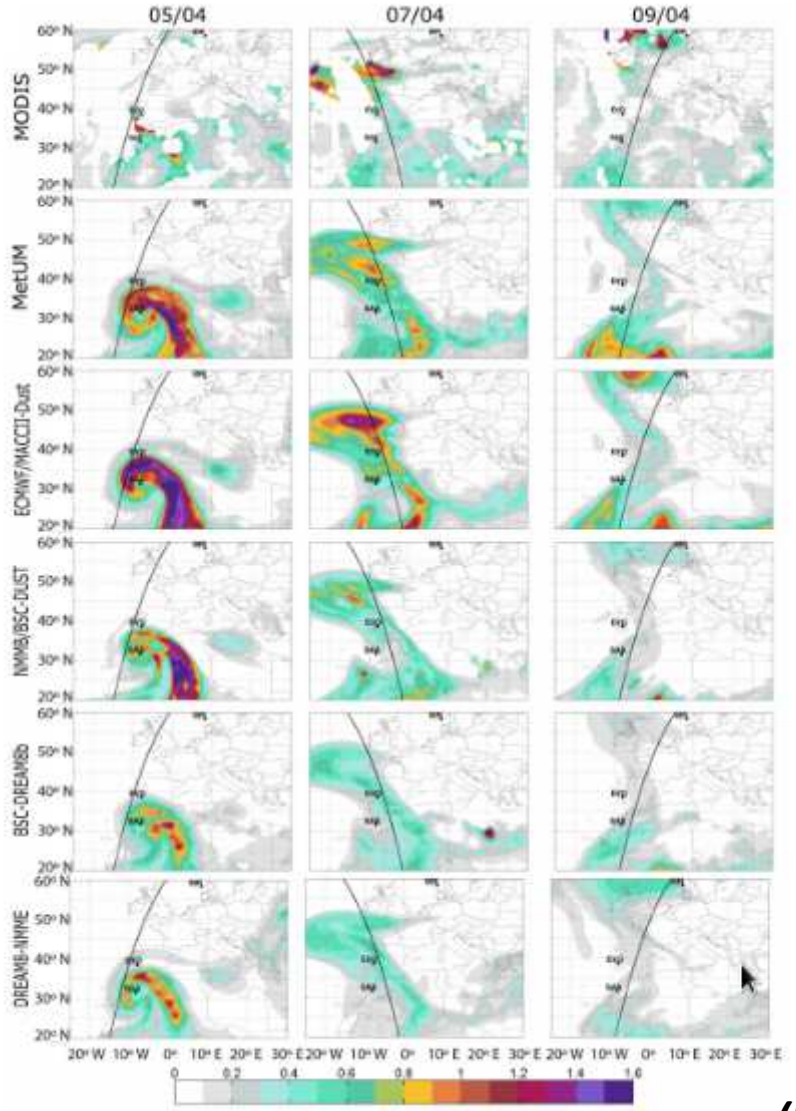
MSG/SEVIRI RGB product 7 April
Courtesy of EUMETSAT

- 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: Studies

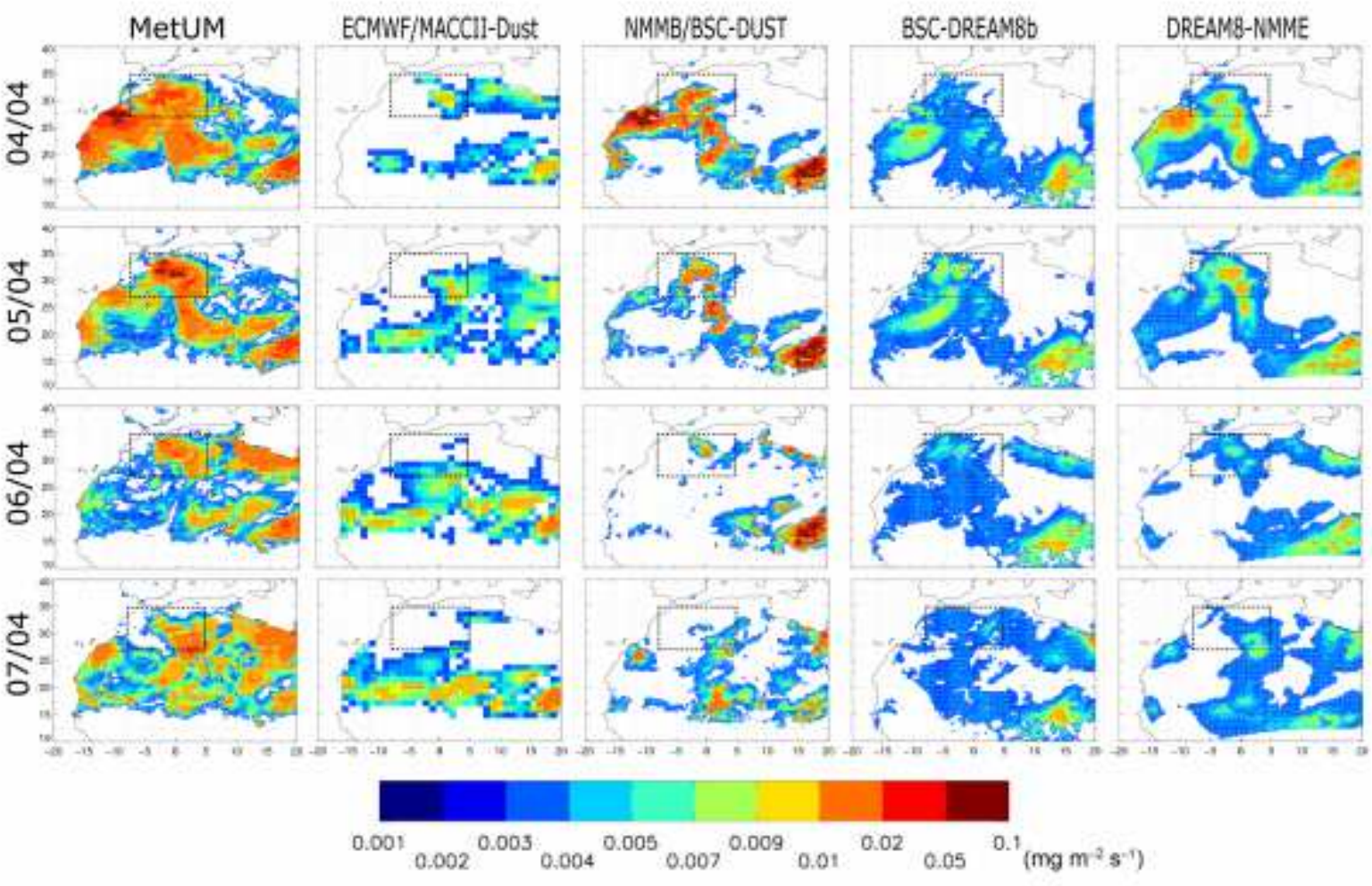
Model Intercomparison: European dust outbreak on April 2011 – DOD



(Huneeus et al., ACP, 2016)

SDS-WAS NAMEE: Studies

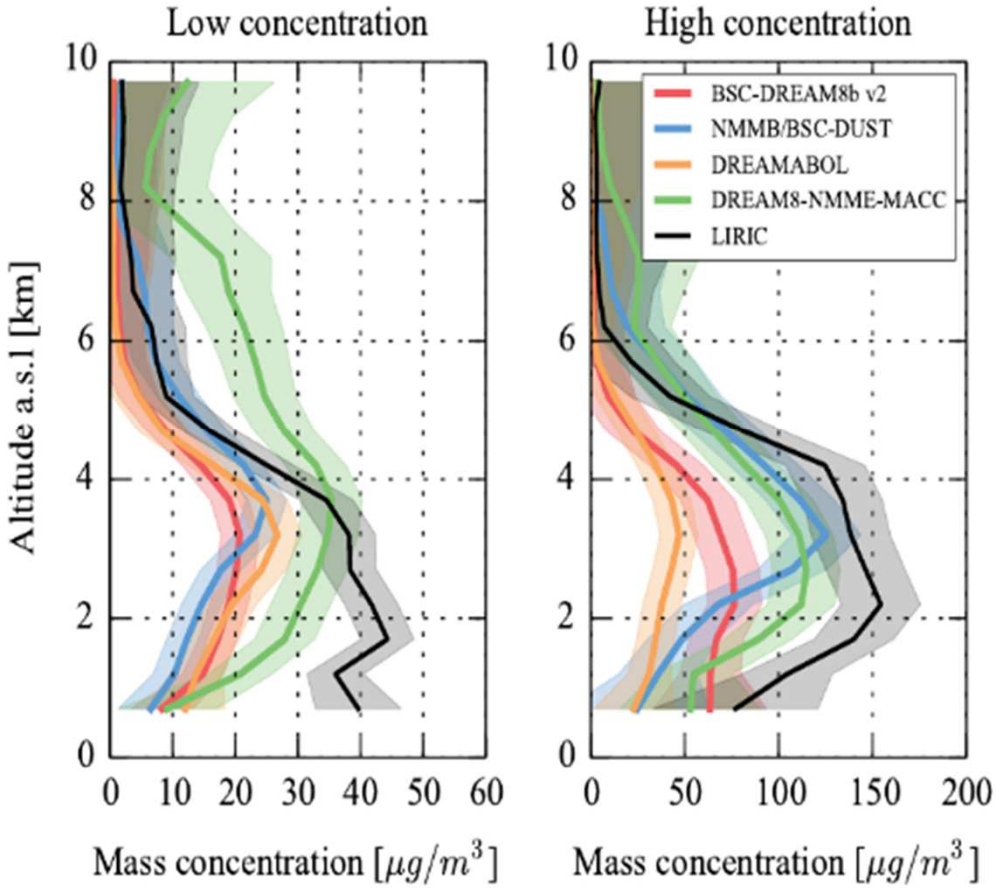
Model Intercomparison: European dust outbreak on April 2011 - Emissions



(Huneeus et al., ACP, 2016)

SDS-WAS NAMEE: Studies

Model Intercomparison: EU-EARLINET vertical dust profiles: 2011-2013



(Binietoglou et al., ATM, 2015)

SDS-WAS NAMEE: Studies

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

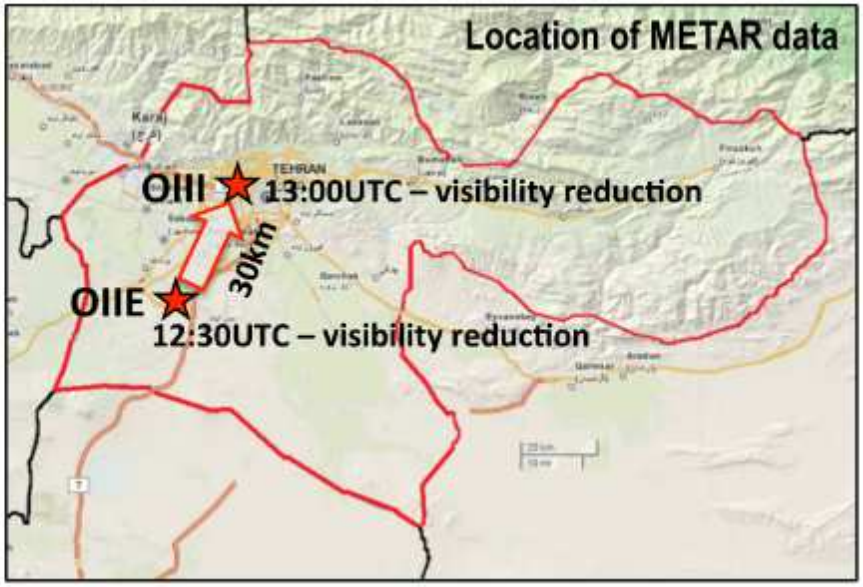
Based on public news, the dust storm caused several deaths, reduction of visibility to several tenths meters in the city, and adverse disturbance of the public traffic. The blowing wind reached 110 km/h.

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.

Iranian Haboob: Teheran 2nd June 2014

Information from reports

- reached city at 5.30 p.m. local time;
- passing of the sand storm over the fixed site lasted about 15min;
- storm duration less than 2h;
- reduction of visibility to ~10m; wind velocity reached 110 km/h;
- temperature dropped from 33 to 18ºC in several min;
- at least 5 deaths, 82 injured; multiple vehicle collision;



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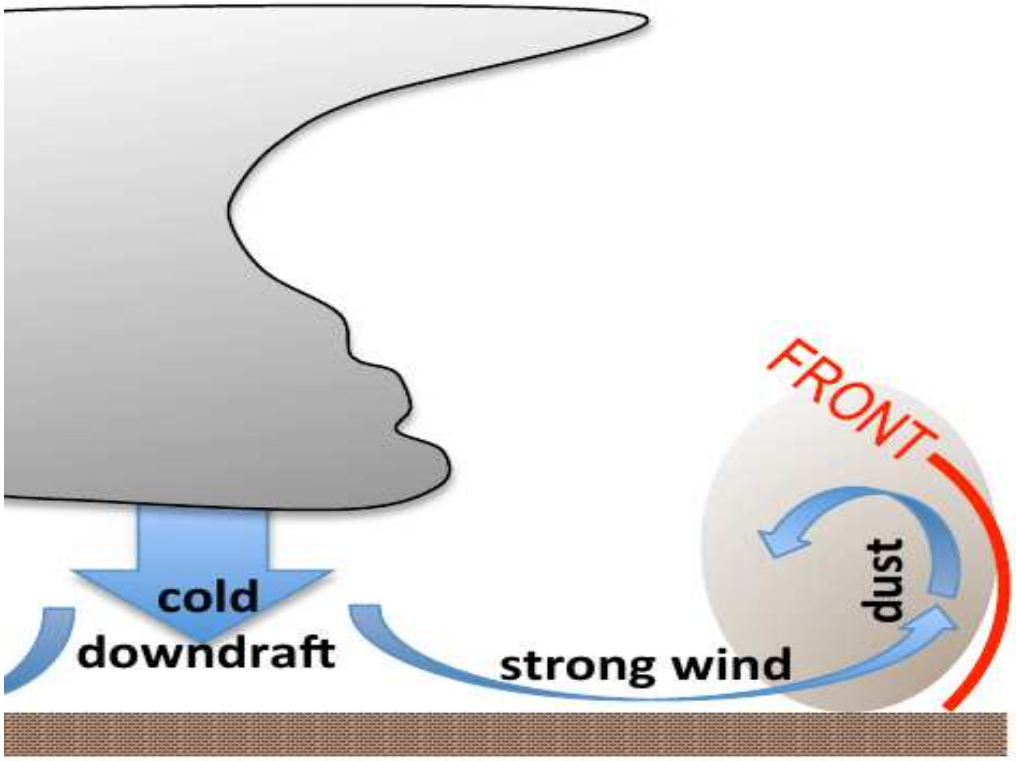
(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

Intensive cold downbursts from convective cells produced high velocity surface wind, creating cold front which was lifting, mixing and pushing dust towards the city;



Expected: high wind speed, drop in temperature, rise in humidity, rise in pressure, reduction of visibility.

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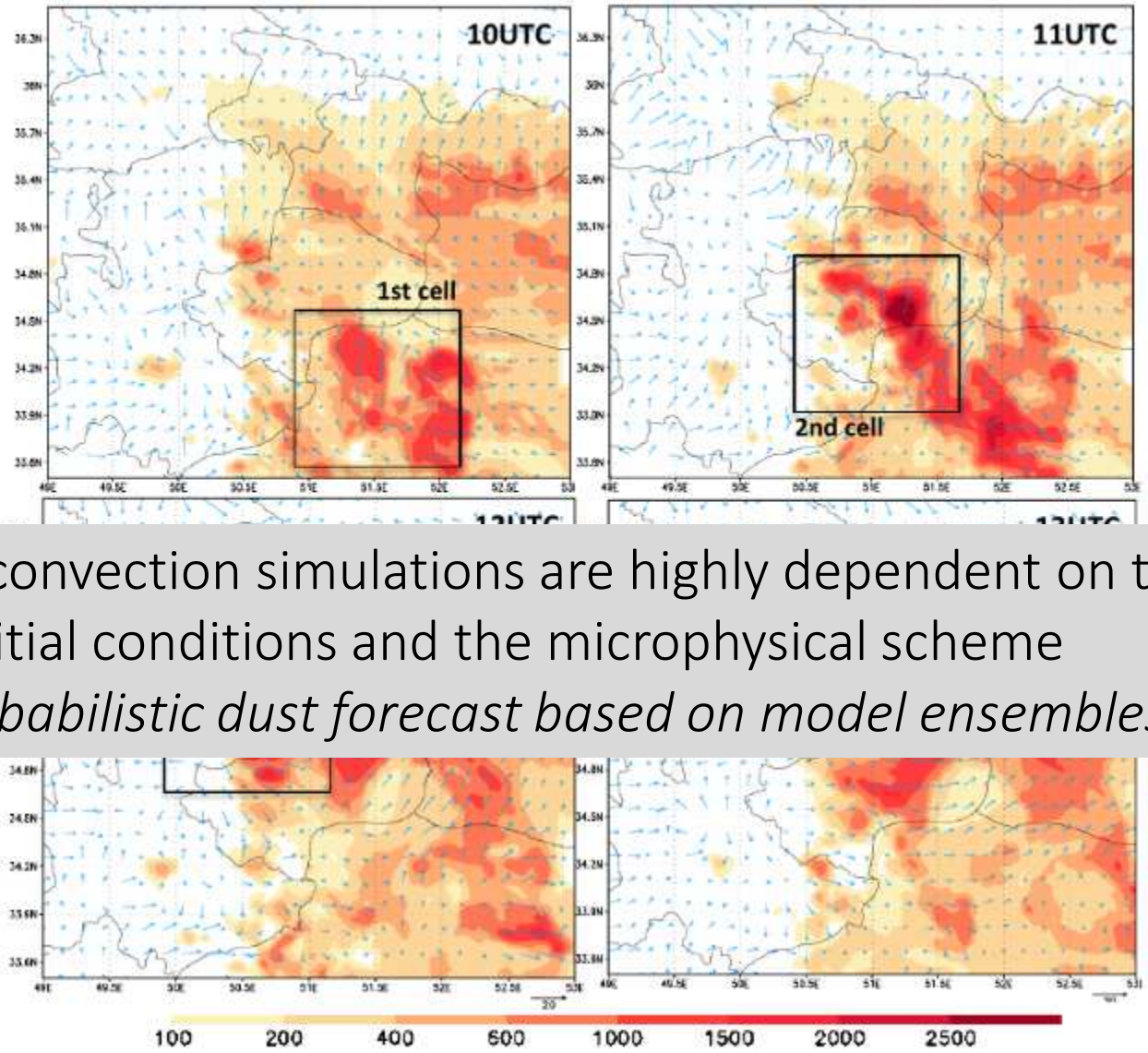
(Vukovic et al., in preparation)

Iranian Haboob: Teheran 2nd June 2014

DNC
(surface)
Dust Number
Concentration
number of dust particles in cm^3

Dust uplift and transport controlled with three main cells.



Explicit convection simulations are highly dependent on the initial conditions and the microphysical scheme

→ *Probabilistic dust forecast based on model ensembles*

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(Vukovic et al., in preparation)

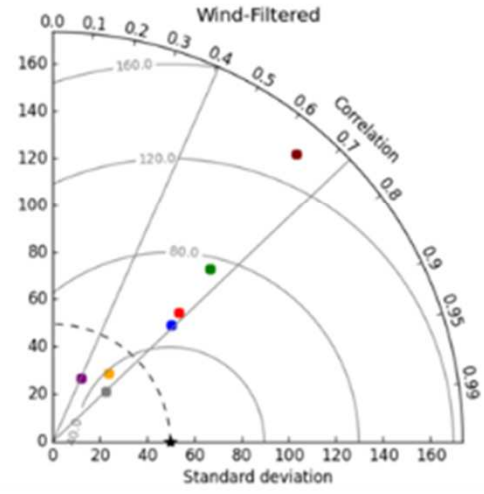
SDS-WAS NAMEE: PM10 Evaluation

AMMA network: PM10 in Sahel for the year 2013

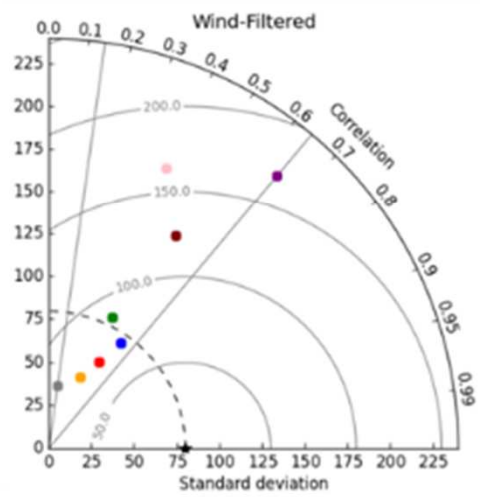
Not all PM10 is dust: *Local and biomass burning from Savannah fires.*

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

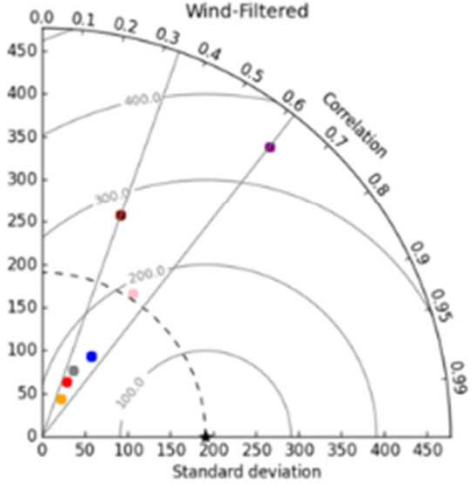
M'Bour-Senegal

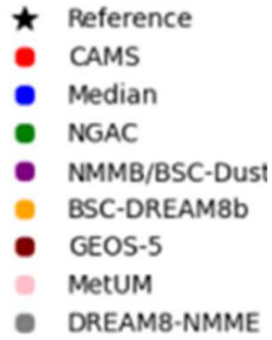


Cinzana-Mali



Banizoumbou-Niger





AMMA (Marticorena et al., 2010)

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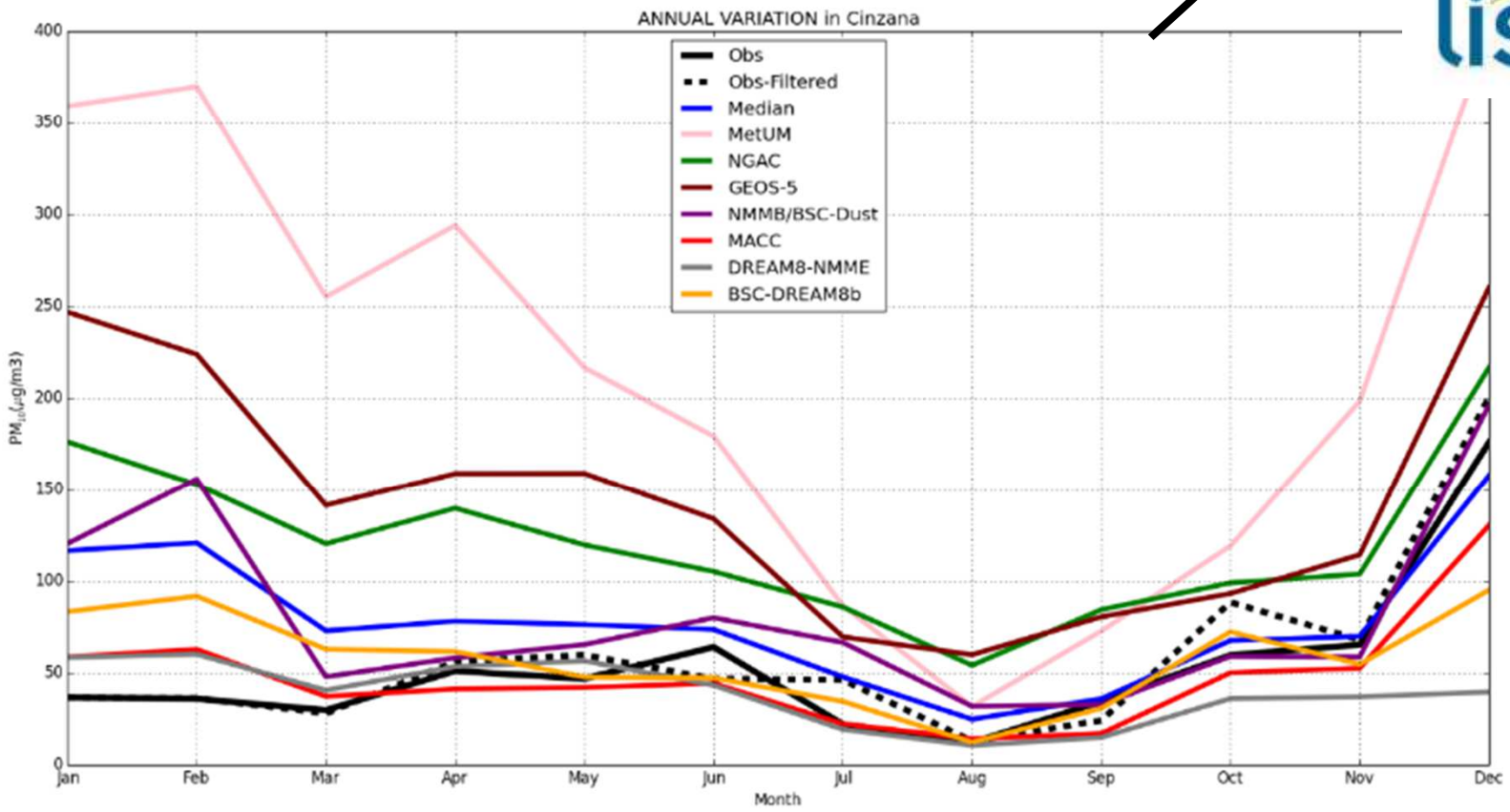
SDS-WAS NAMEE: PM10 Evaluation

AMMA network: PM10 in Sahel for the year 2013



lisa

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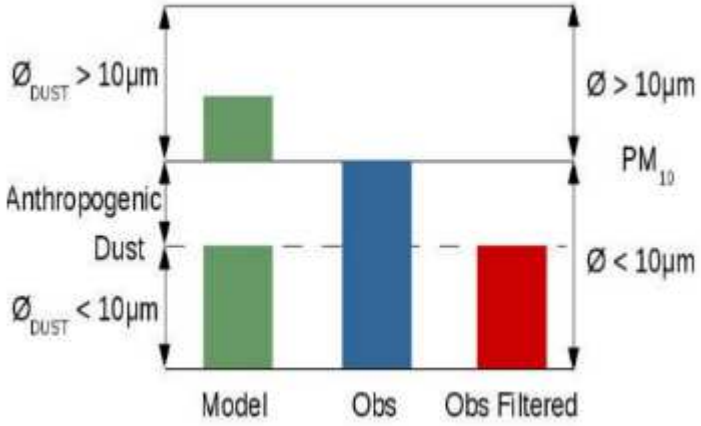
SDS-WAS NAMEE: PM10 Evaluation

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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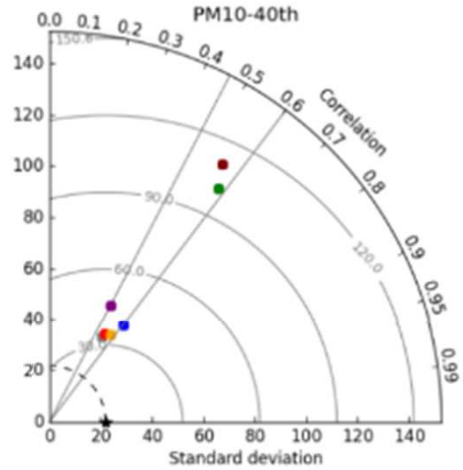
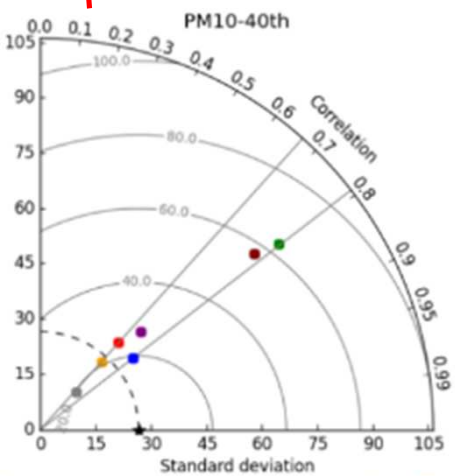
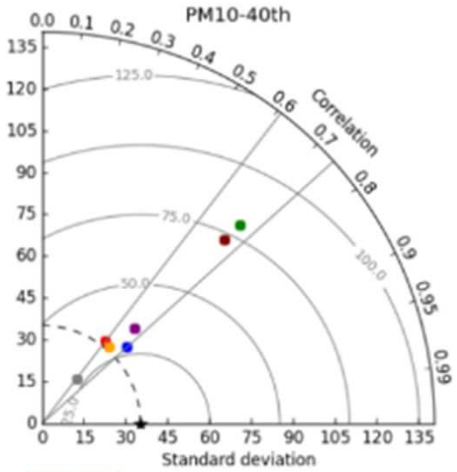
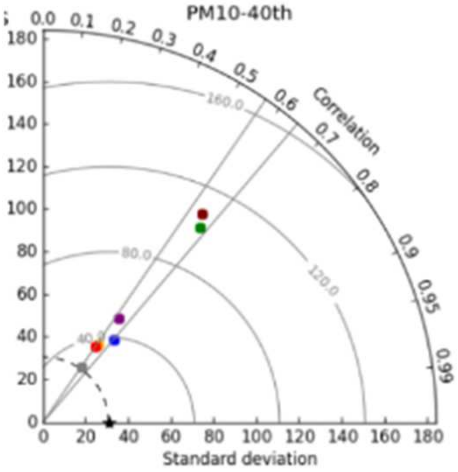
SDS-WAS NAMEE: PM10 Evaluation

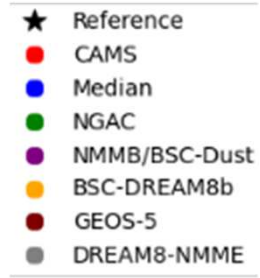
AQ network: Canary Islands 2013-2014











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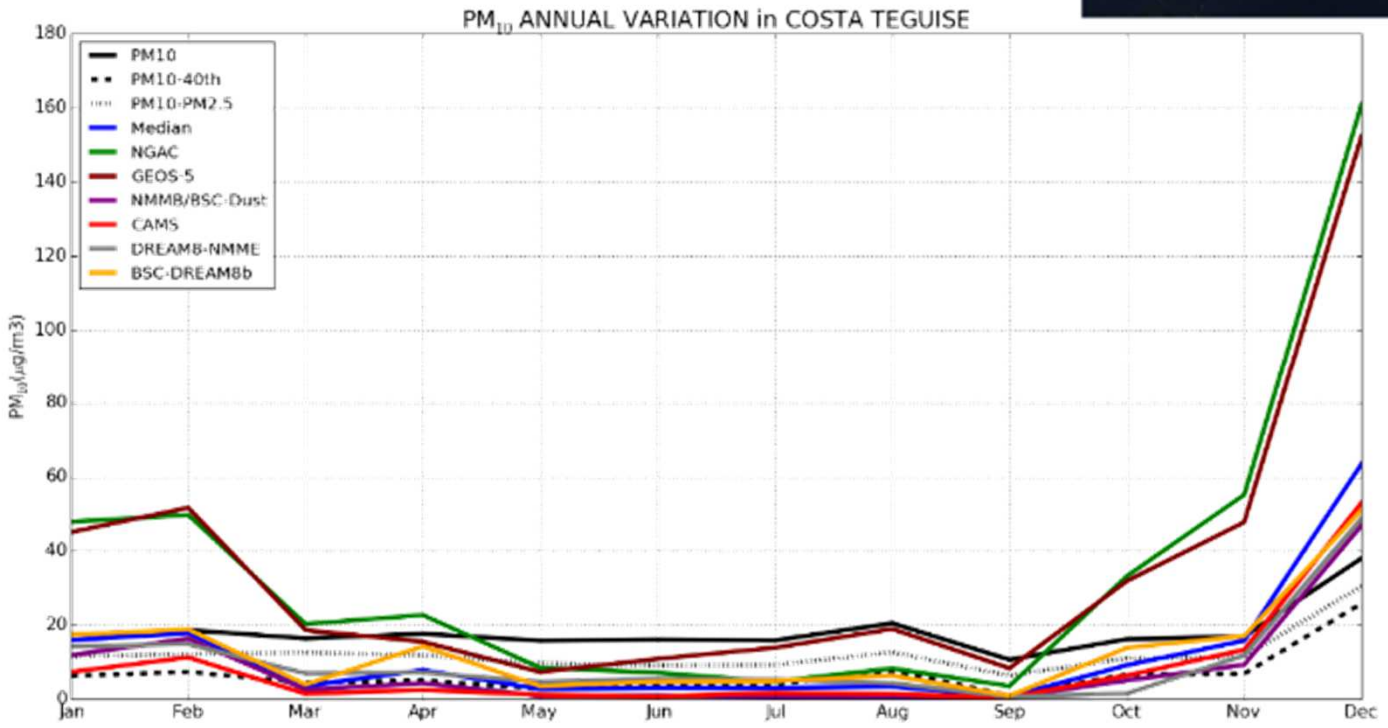
SDS-WAS NAMEE: PM10 Evaluation

AQ network: Canary Islands 2013-2014



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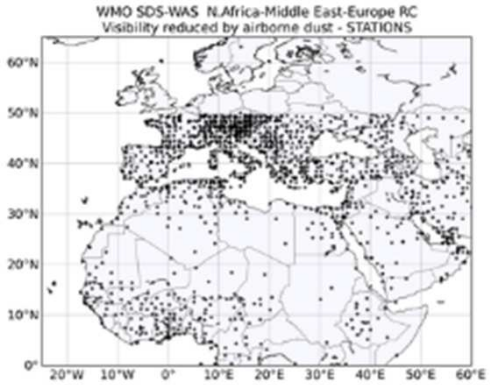
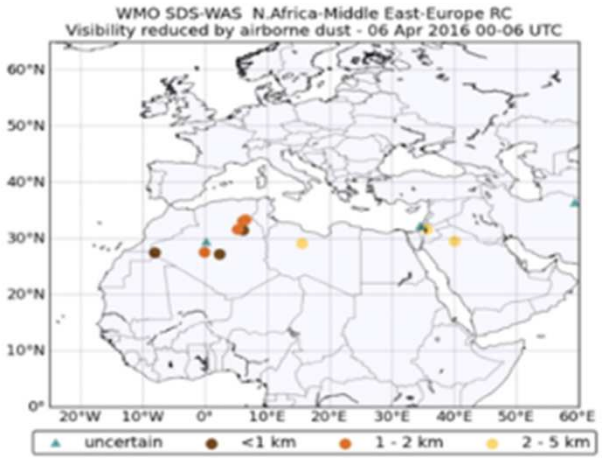
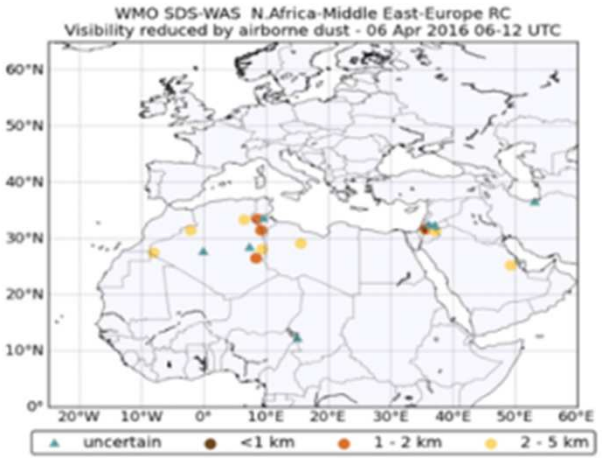
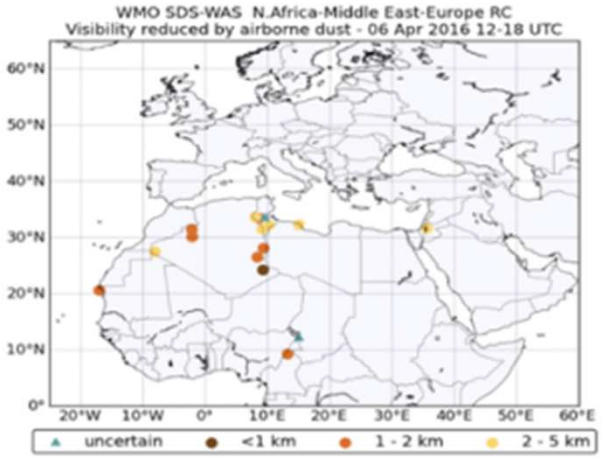
SDS-WAS NAMEE: Visibility vs Surf. Conc.

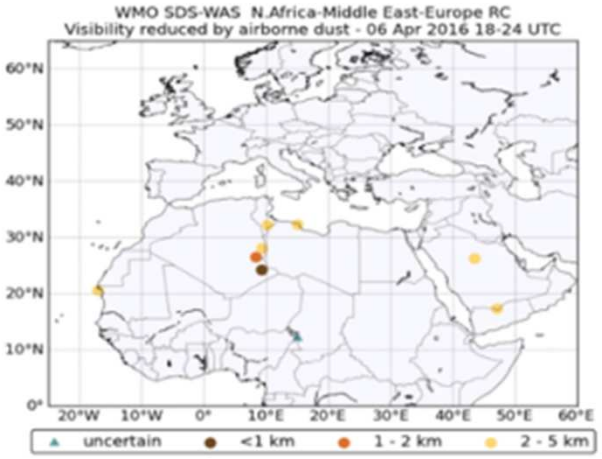
NRT visibility evaluation: 6th April 2016 0-12UTC











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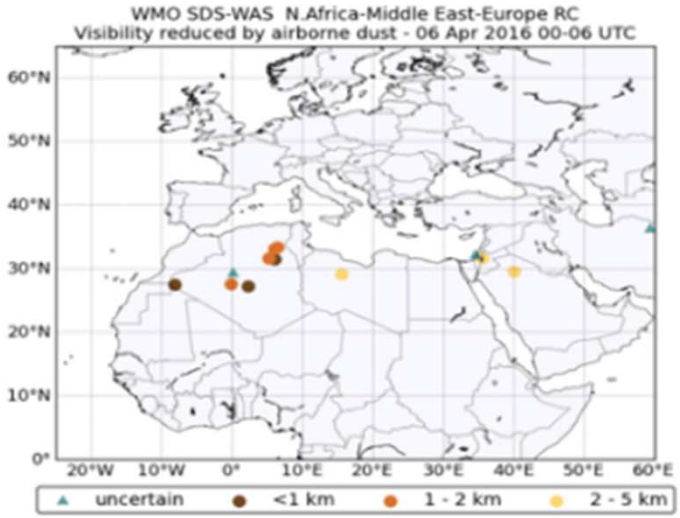
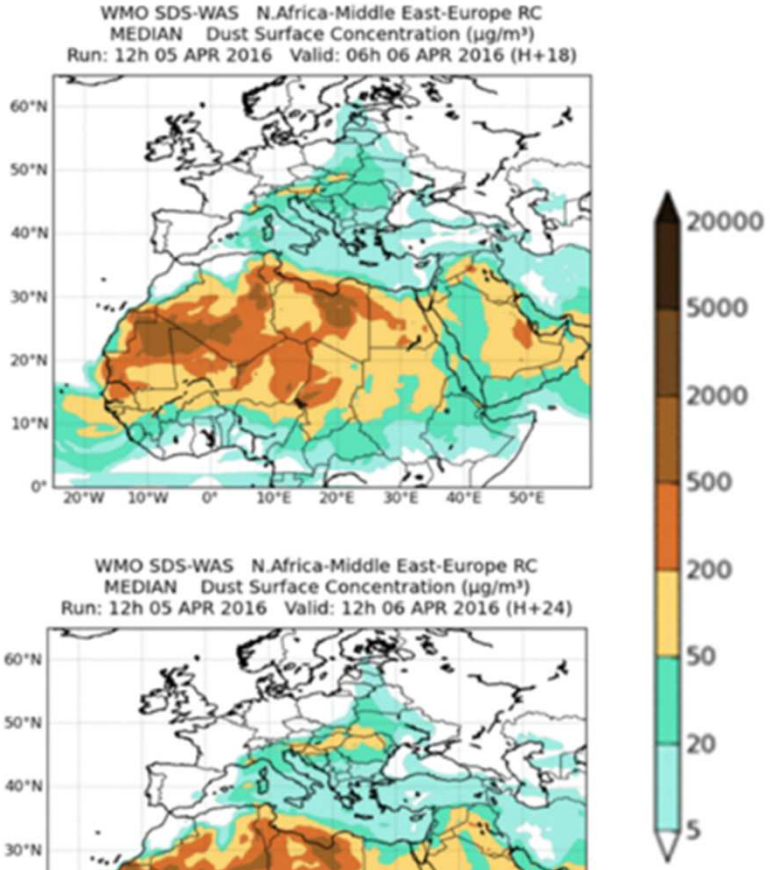
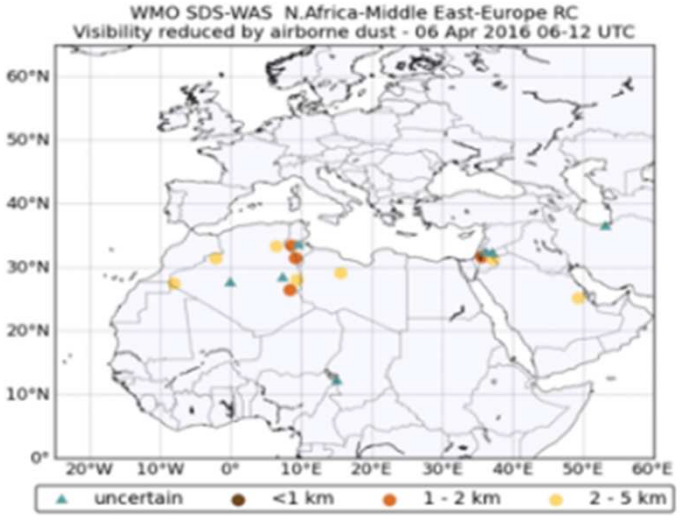
SDS-WAS NAMEE: Visibility vs Surf. Conc.

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







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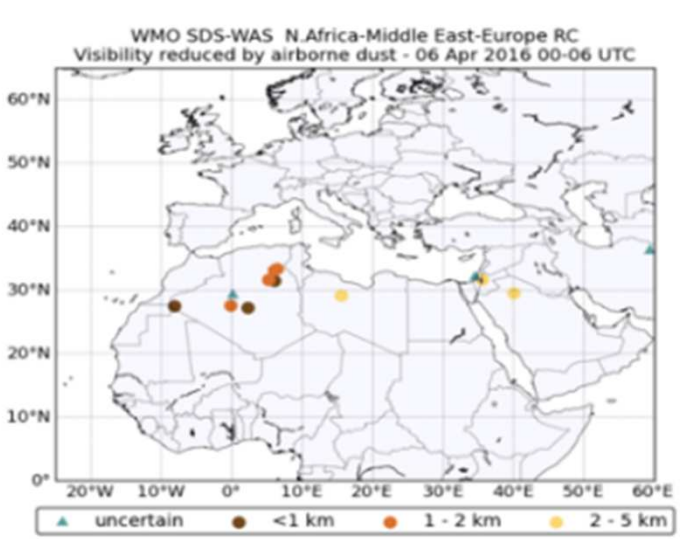
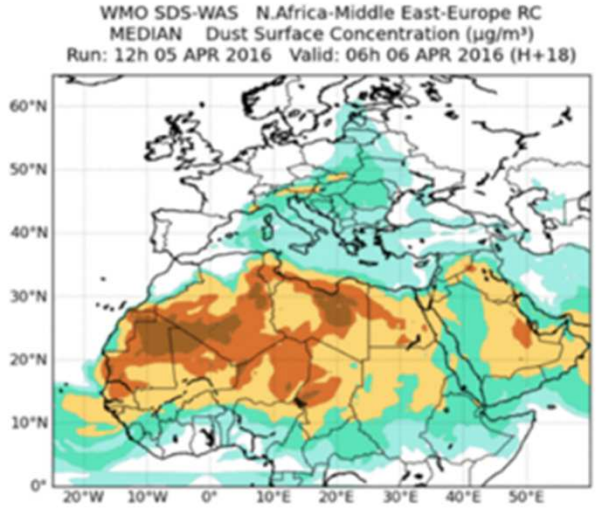
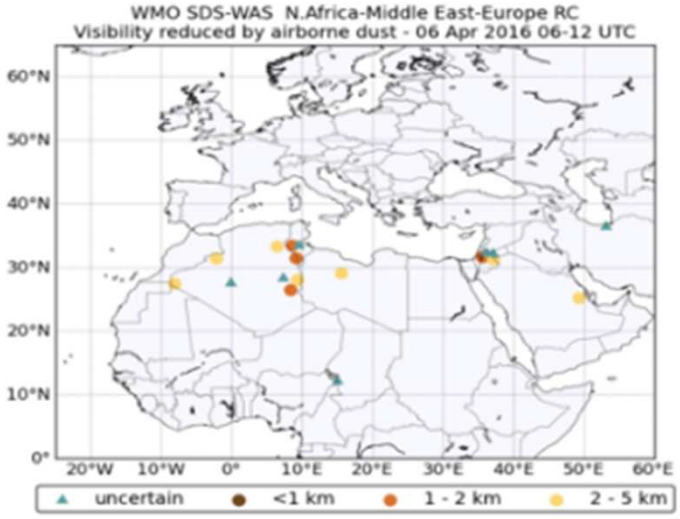
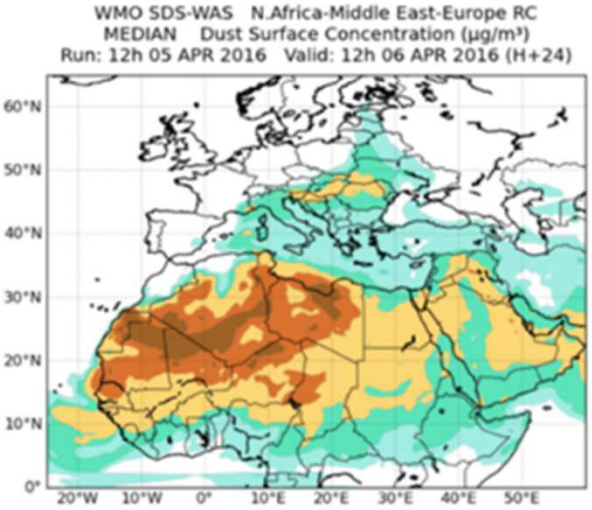
SDS-WAS NAMEE: Visibility vs Surf. Conc.

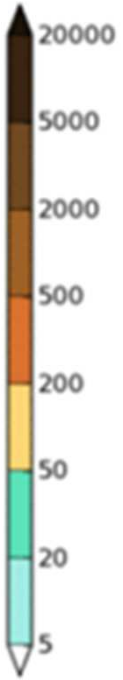
NRT visibility evaluation: 6th April 2016 0-12UTC











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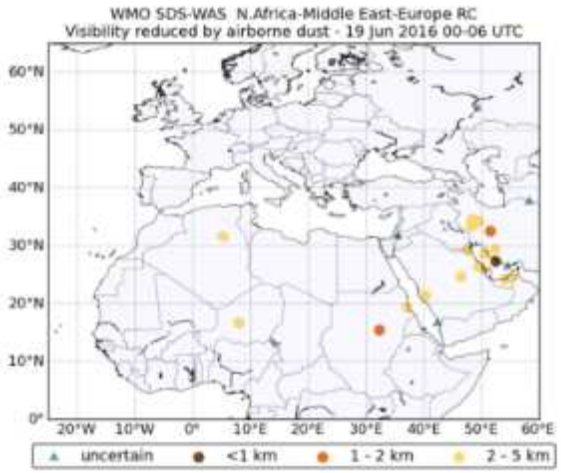
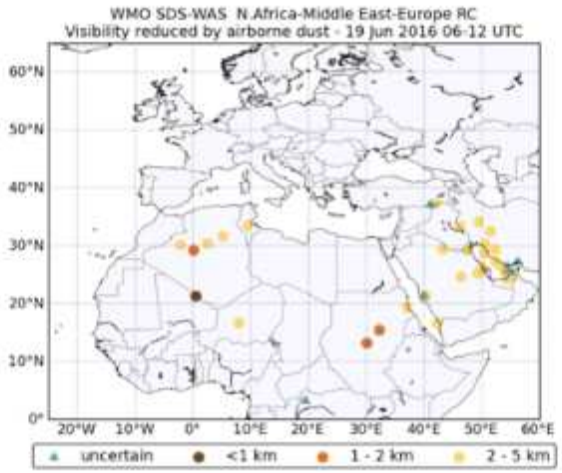
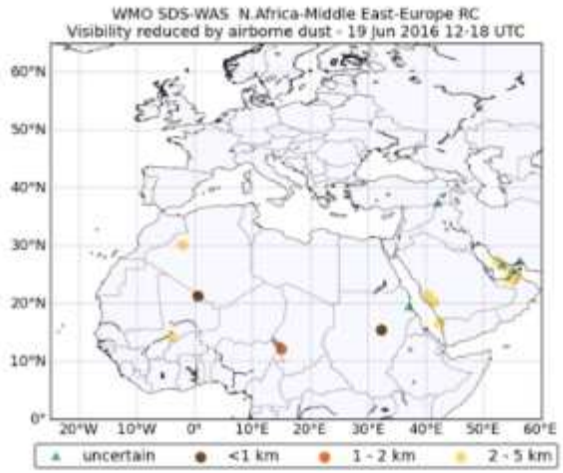
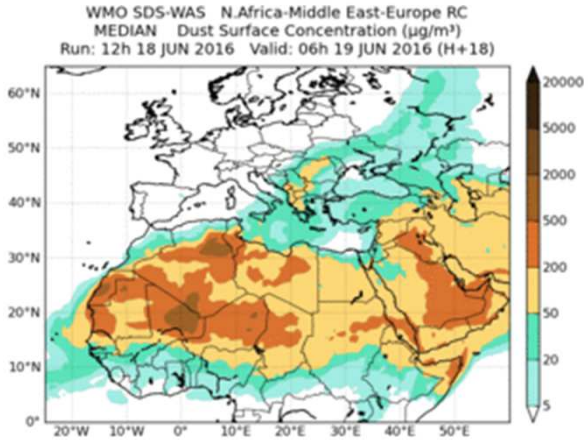
SDS-WAS NAMEE: Visibility vs Surf. Conc.

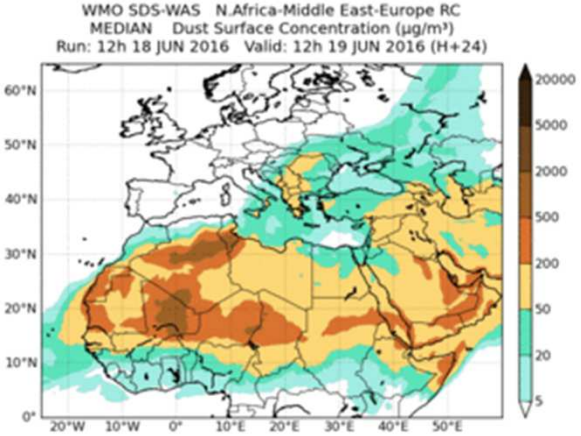
NRT visibility evaluation: 19th june 2016

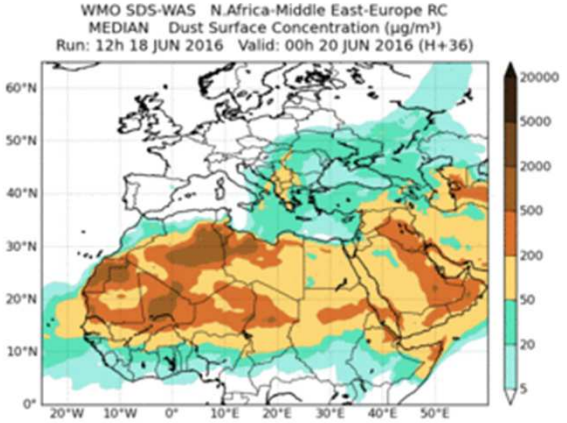












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AEMet Agencia Estatal de Meteorología

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

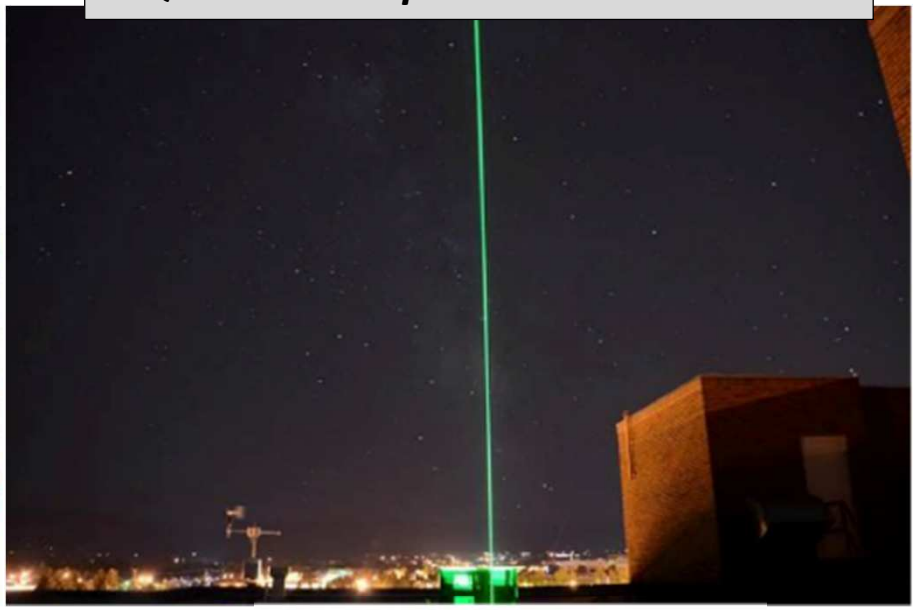
SDS-WAS NAMEE: Dust Profiles Evaluation

Ceilometers
Tenerife, Granada and Montsec (Spain)

+ High density of stations
- Qualitative products

Lidar
M'Bour (Senegal)

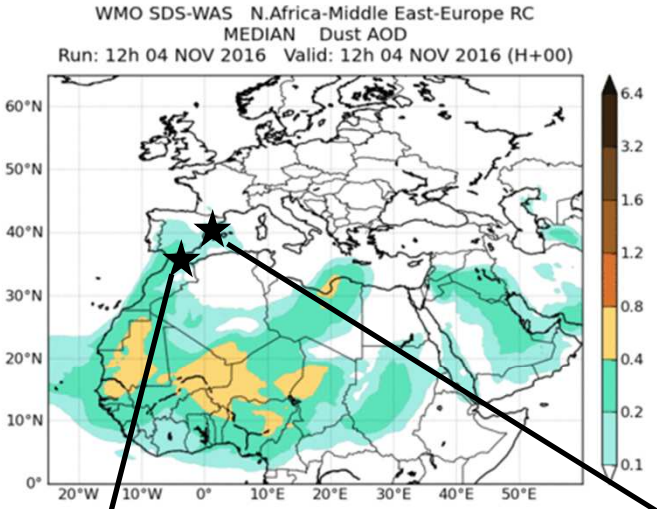
- Low number of stations
+ Quantitative products



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

SDS-WAS NAMEE: Dust Profiles Evaluation

W. Mediterranean dust event: 2 - 5 November 2016



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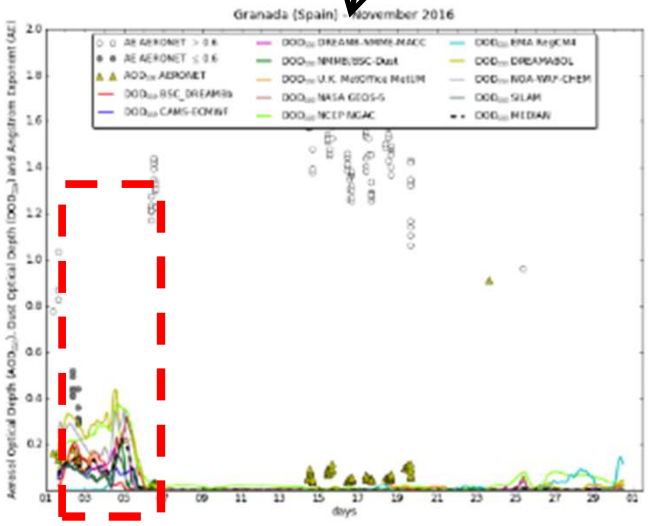
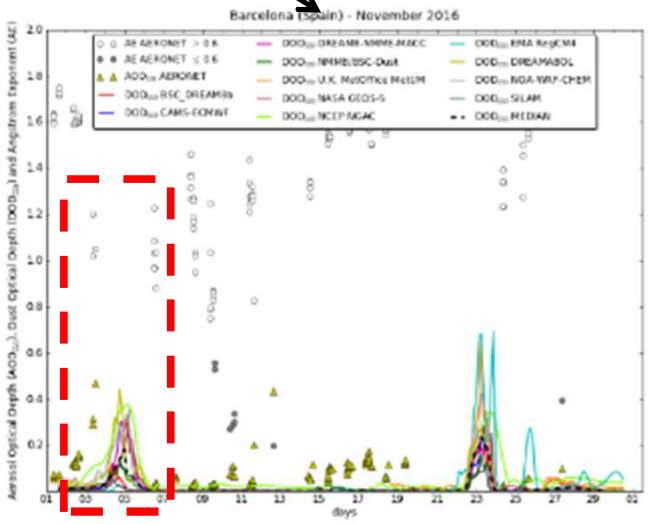
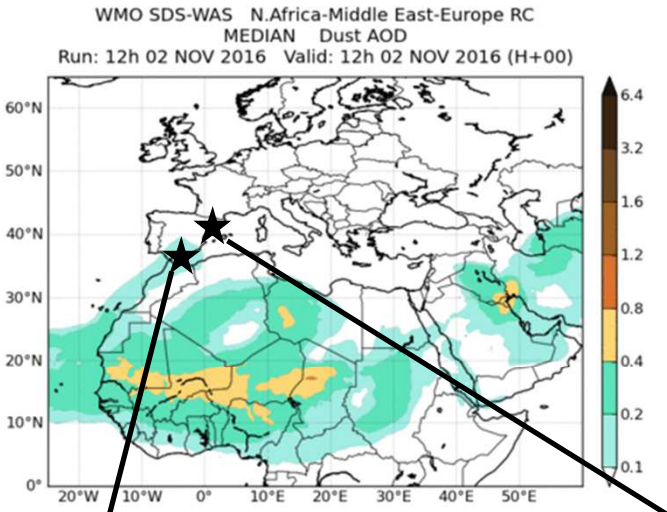
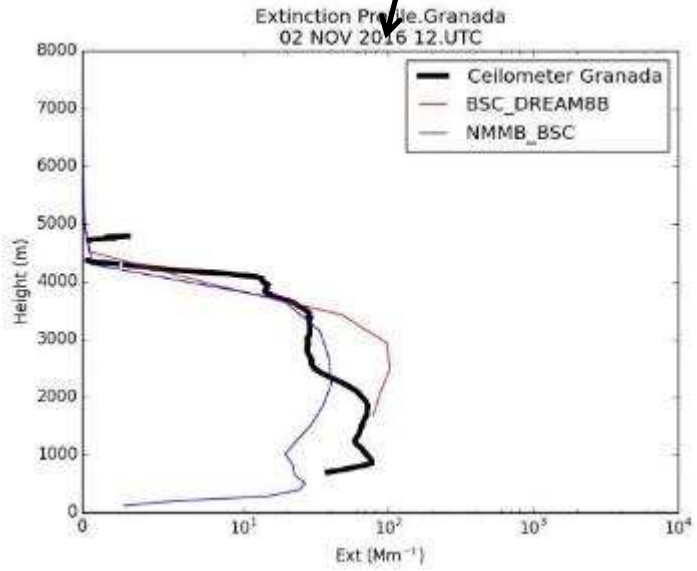


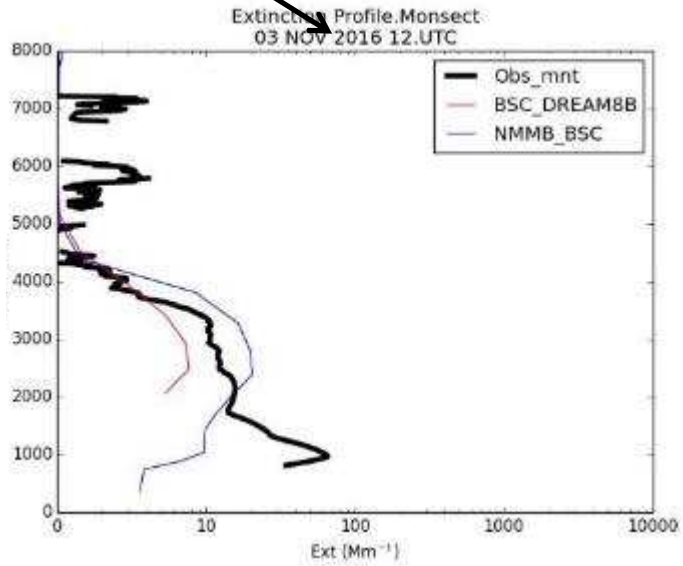


SDS-WAS NAMEE: Dust Profiles Evaluation

Atlantic dust event: 2 - 5 November 2016

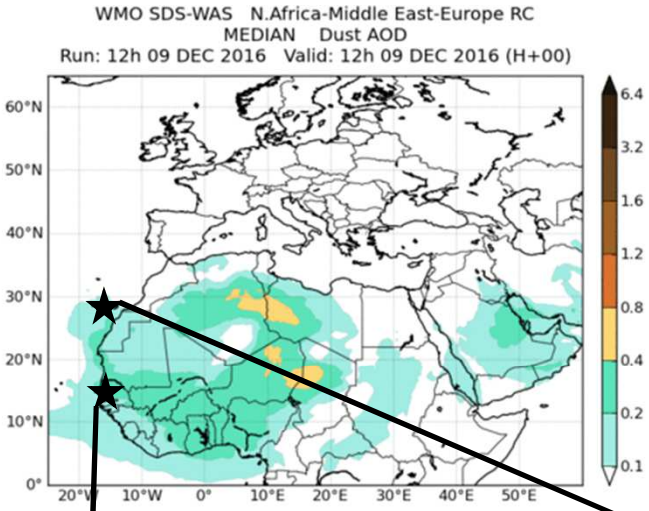






SDS-WAS NAMEE: Dust Profiles Evaluation

Atlantic dust event: 9 - 12 December 2016



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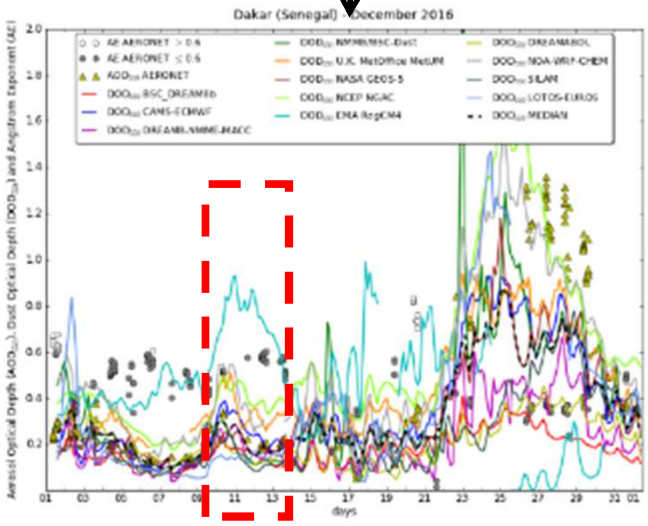
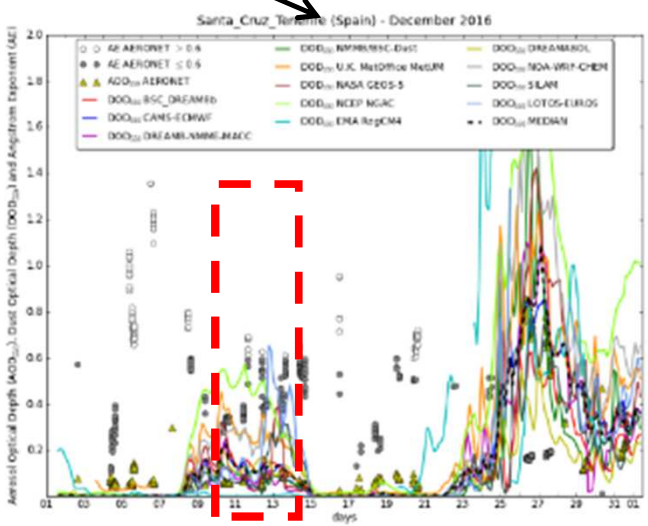
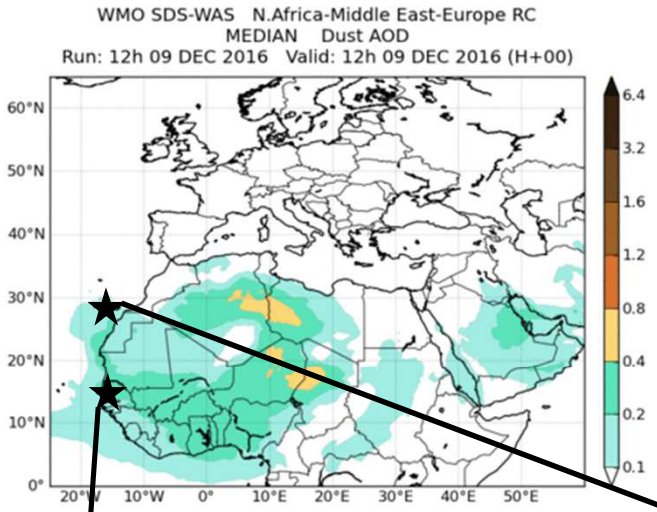
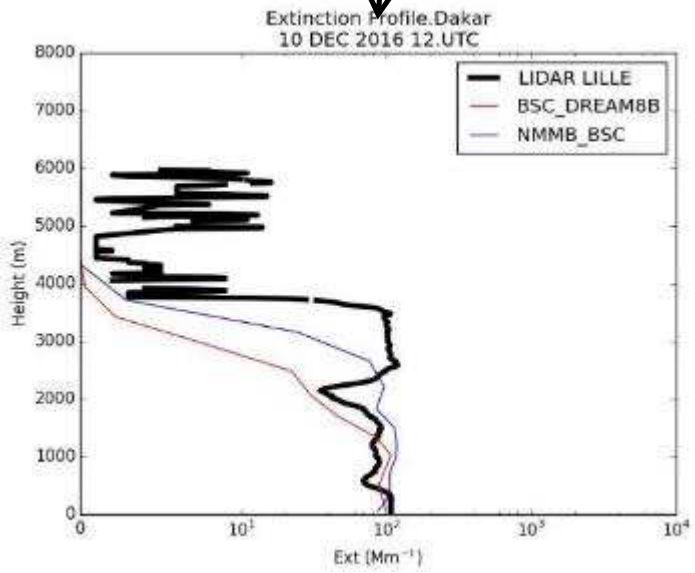


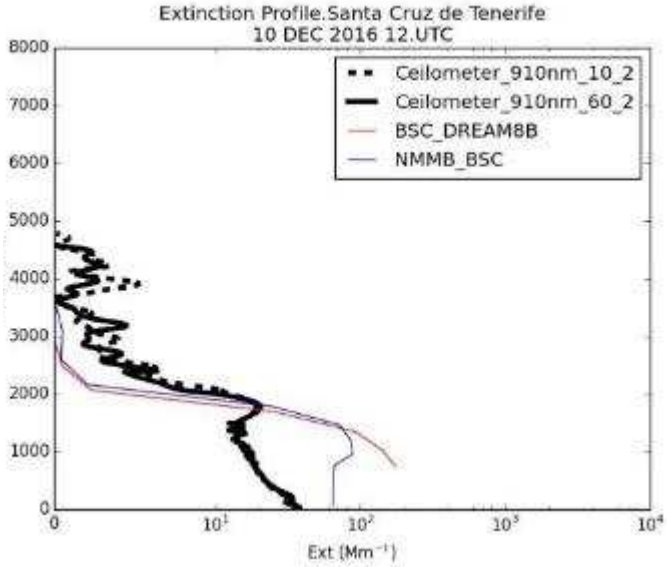


SDS-WAS NAMEE: Dust Profiles Evaluation

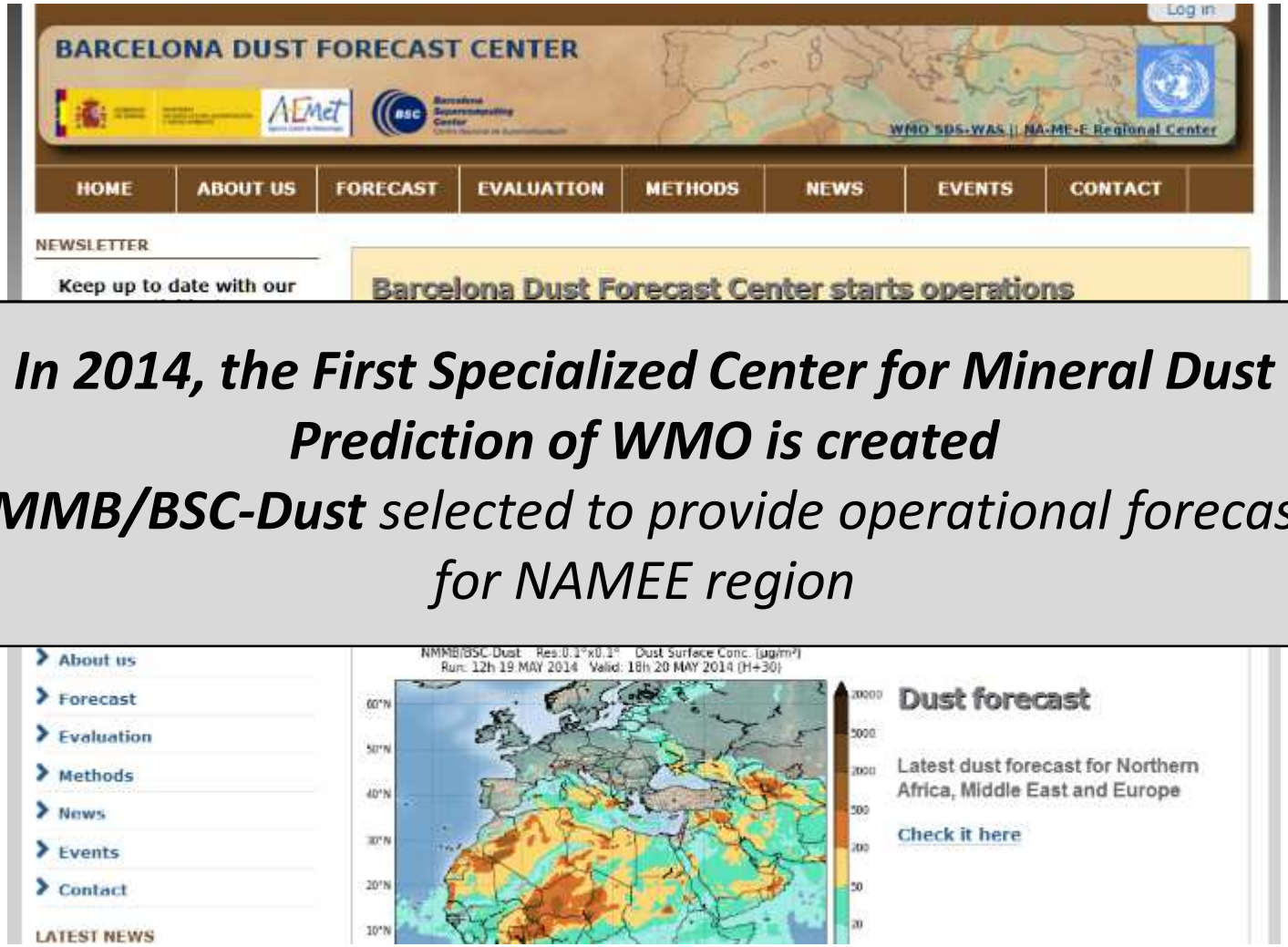
Atlantic dust event: 9 - 12 December 2016







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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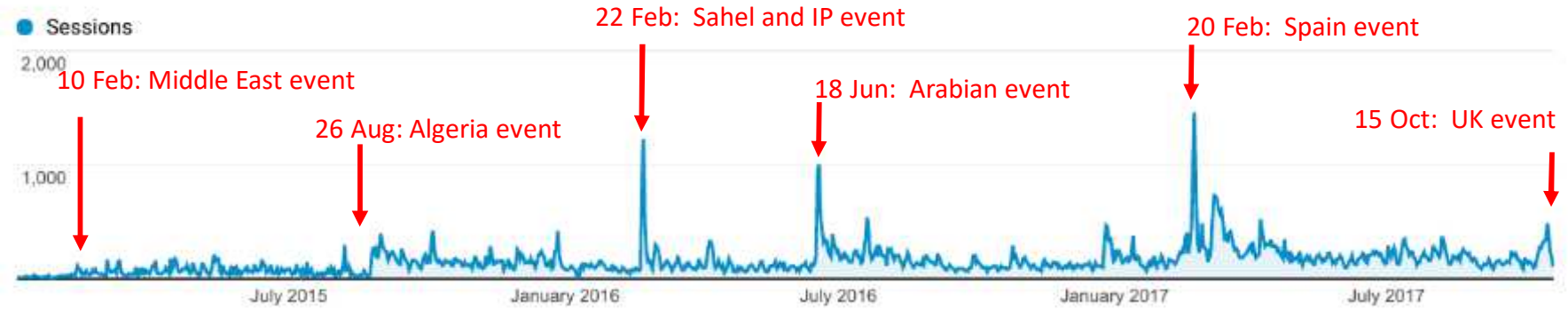
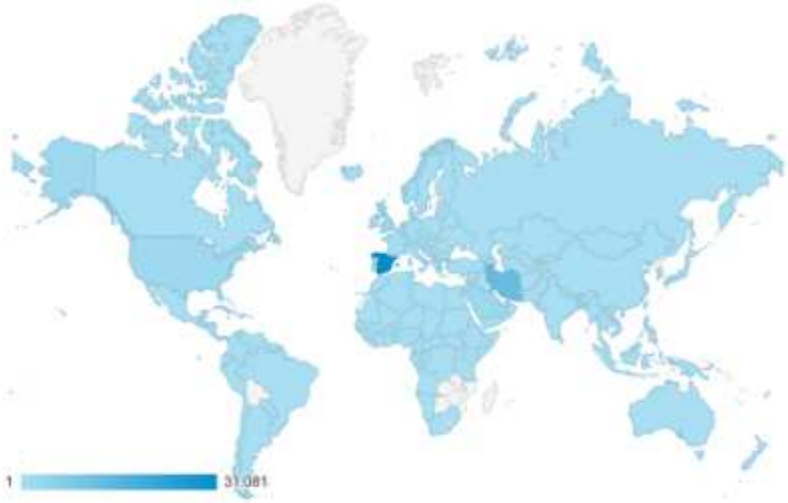
http://dust.aemet.es/

Barcelona Dust Forecasting Center

Website visits: 1 January 2015 – 20 October 2017 ***http://dust.aemet.es/***





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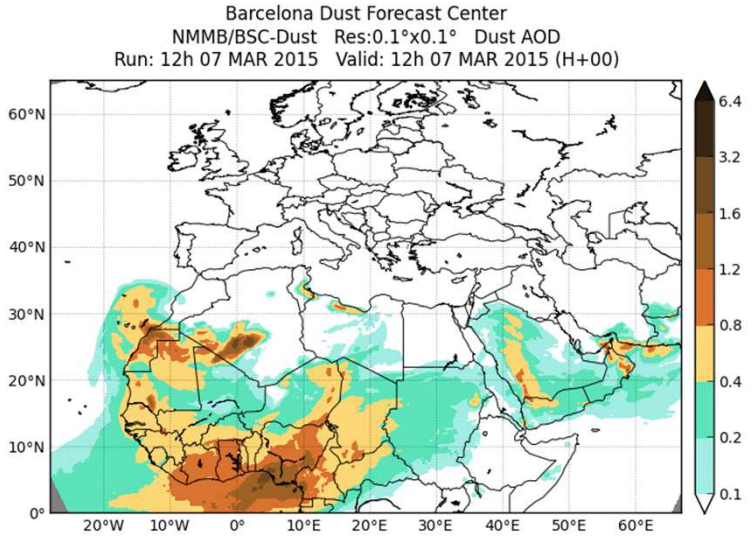
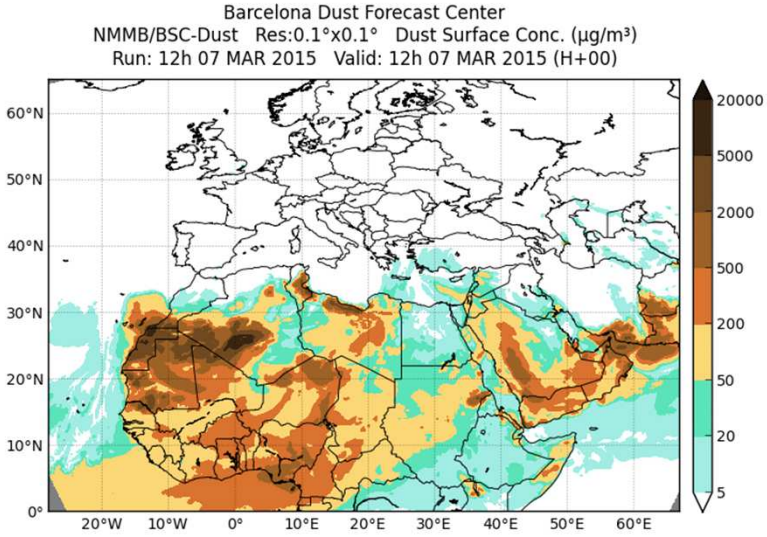
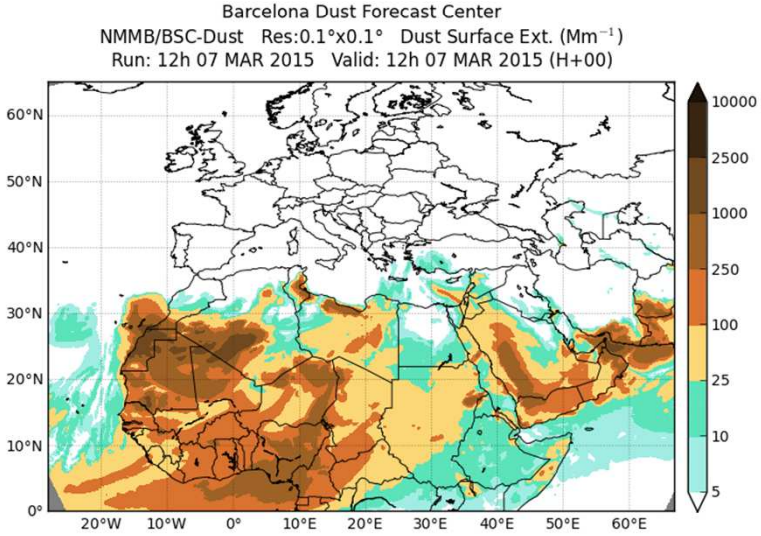
Agencia Estatal de Meteorología

BDFC: Operational 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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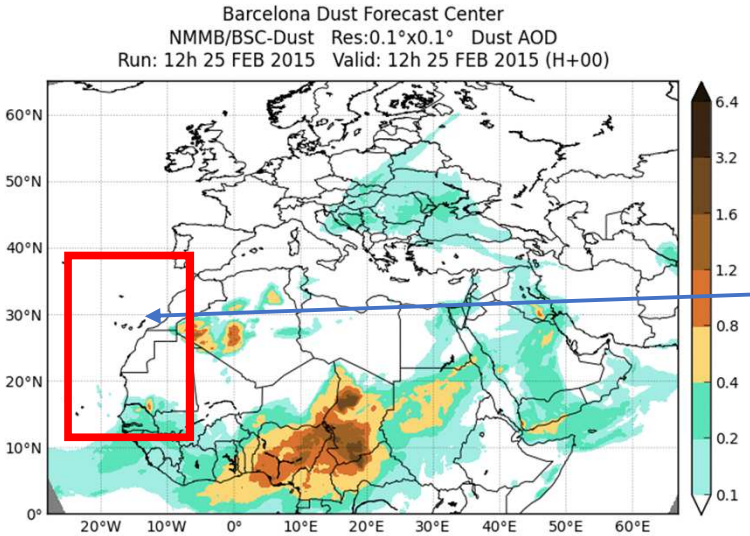
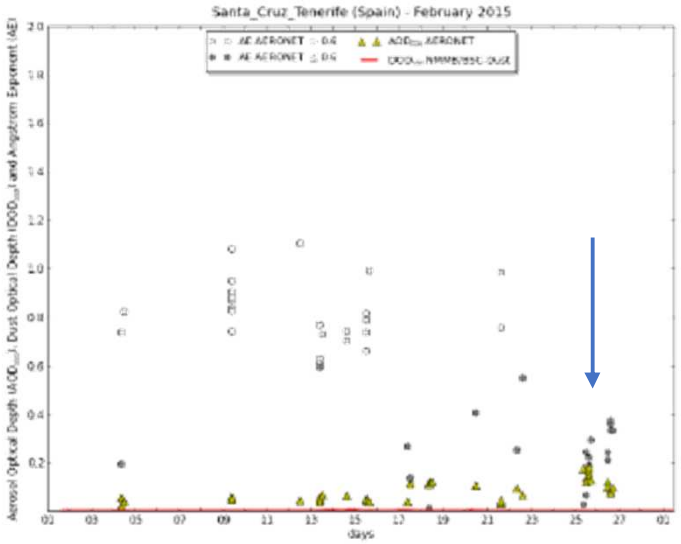
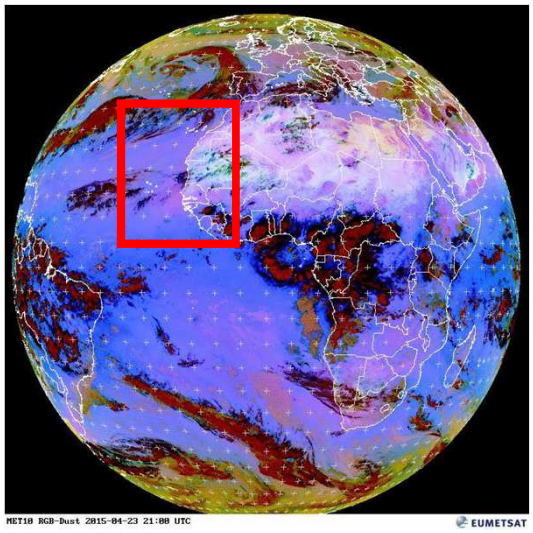
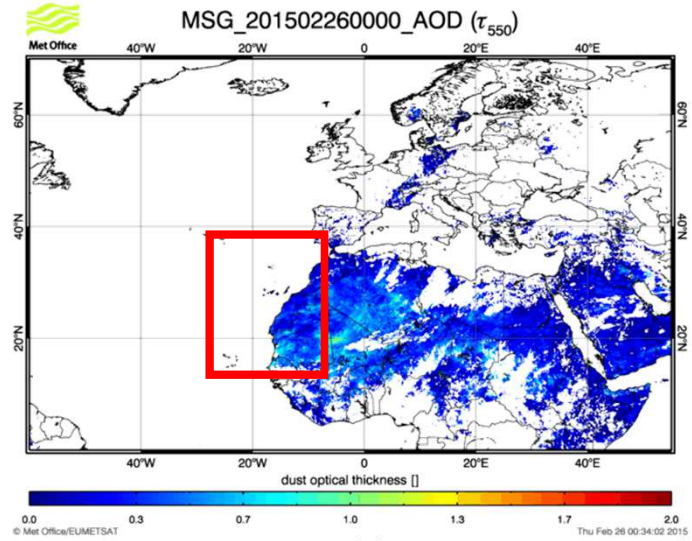
BDFC: Dust event Canary Islands Feb 2015



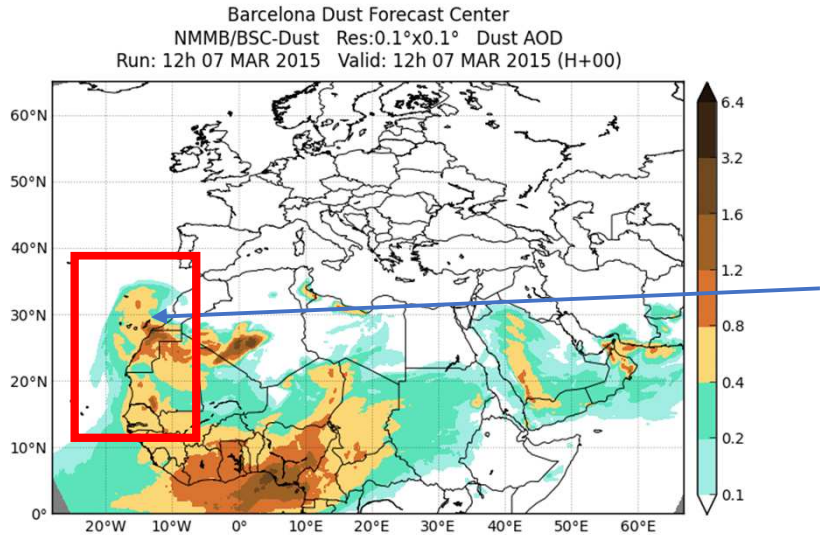


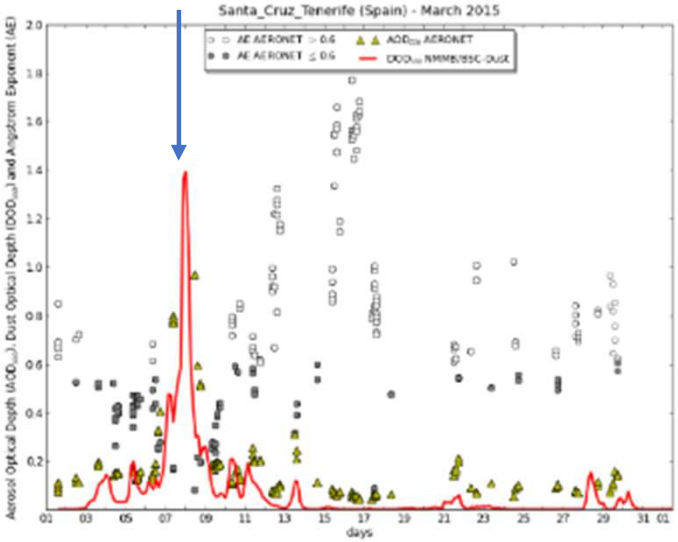


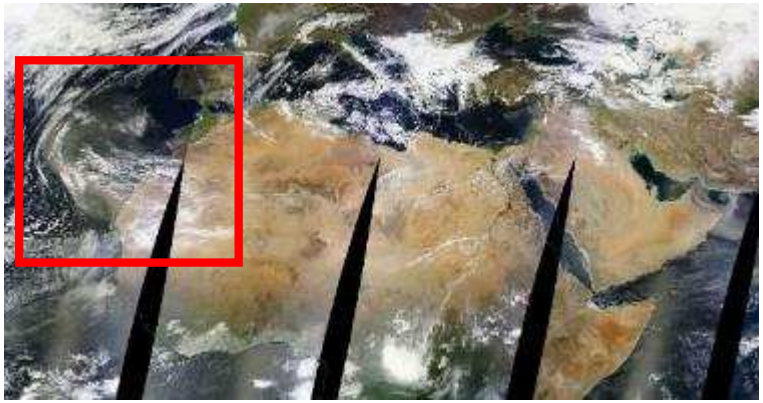


http://dust.aemet.es/

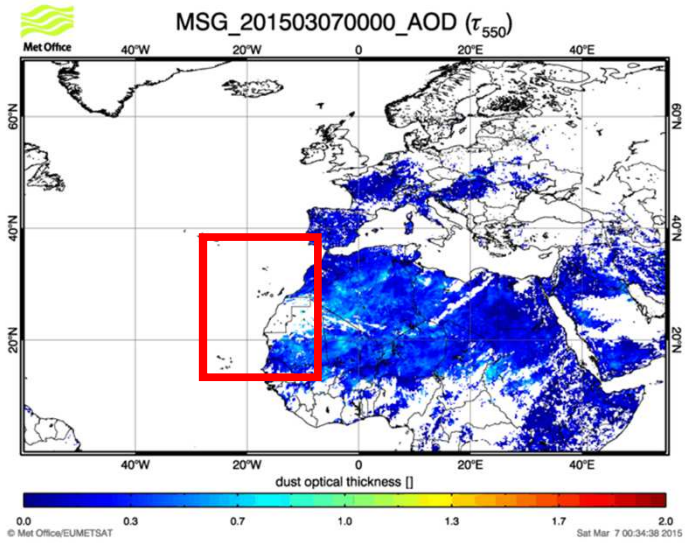
BDFC: Dust event Canary Islands Mar 2015





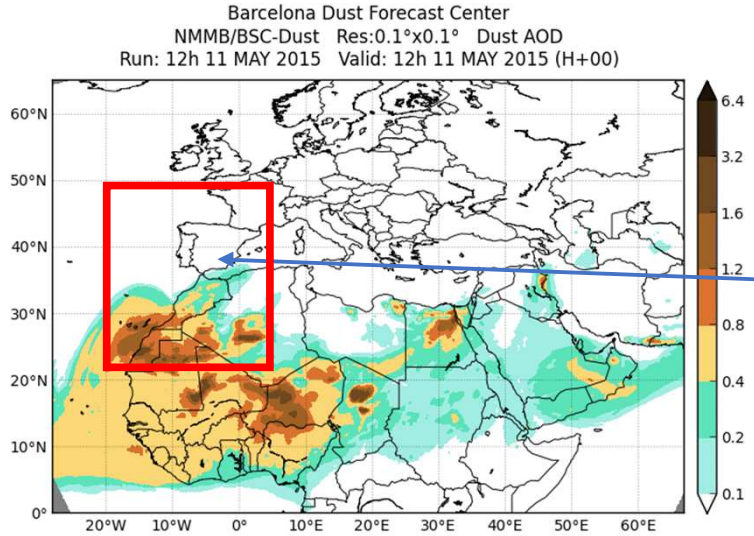


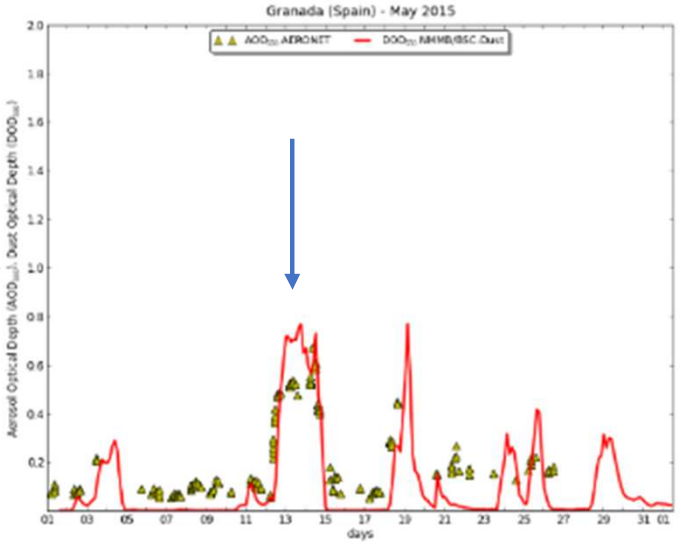
MODIS composite 8th March 2015 from EOSDIS World Viewer

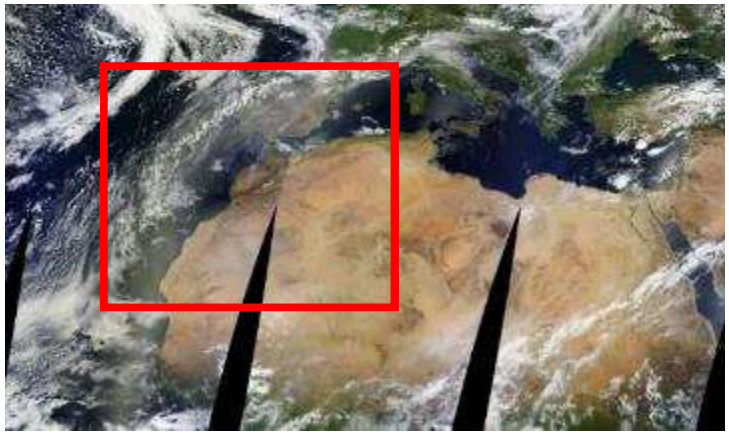


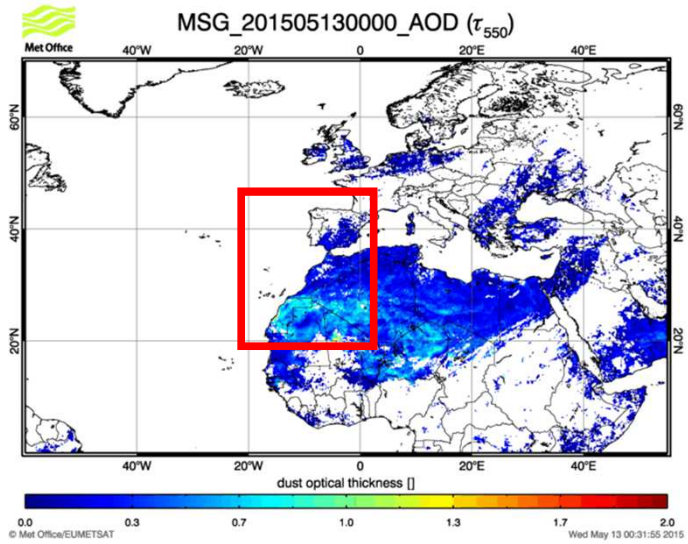
http://dust.aemet.es/

BDFC: Dust event Europe May 2015



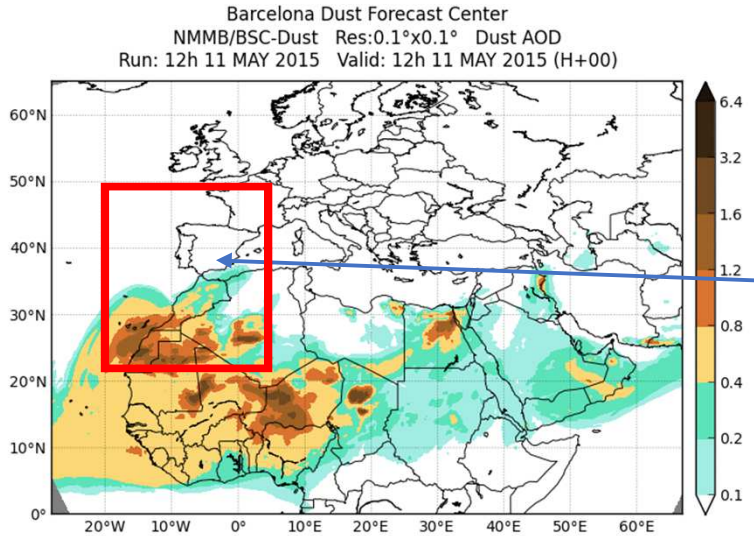


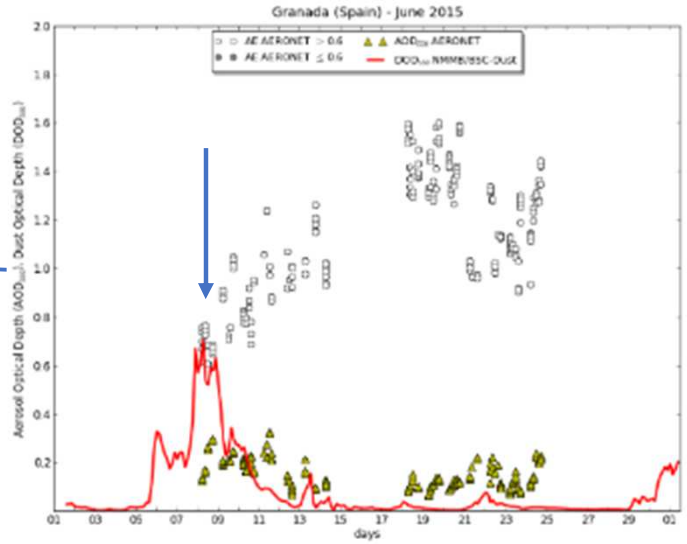


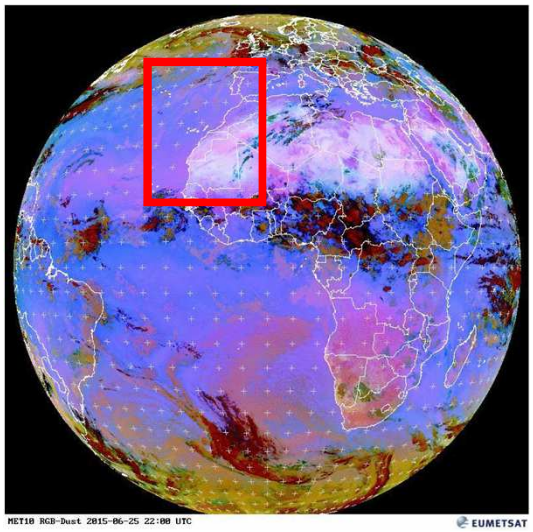


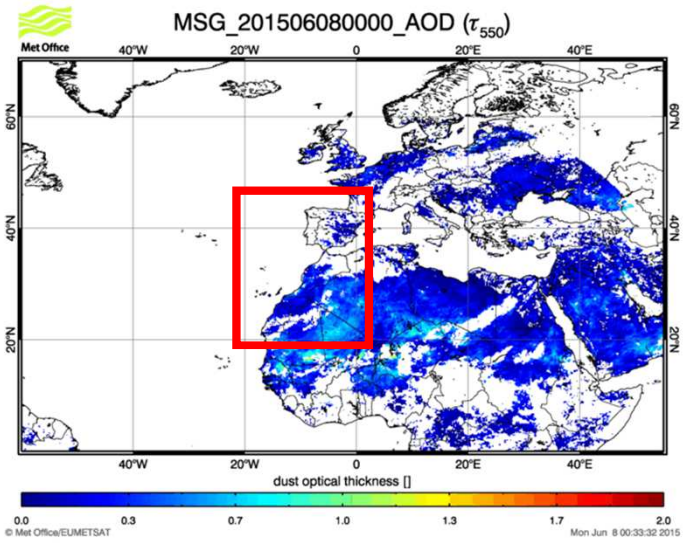
http://dust.aemet.es/

BDFC: Dust event Europe June 2015



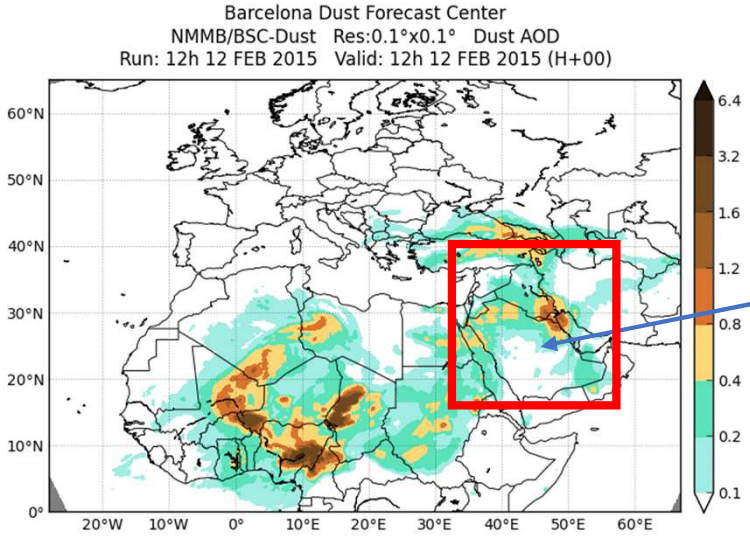


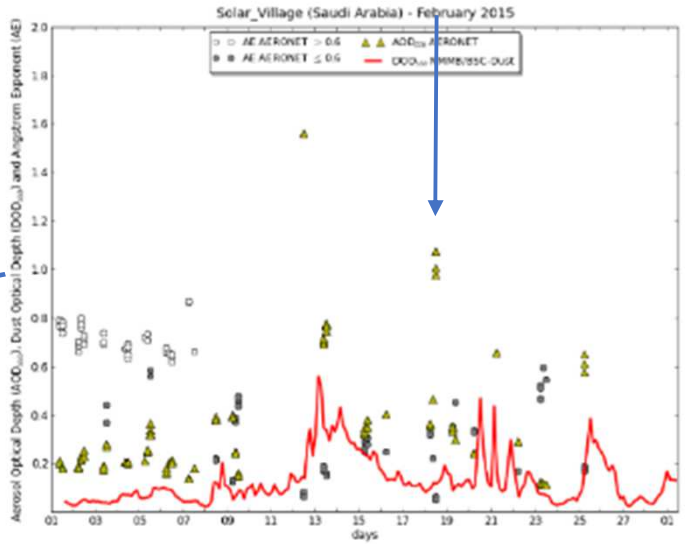


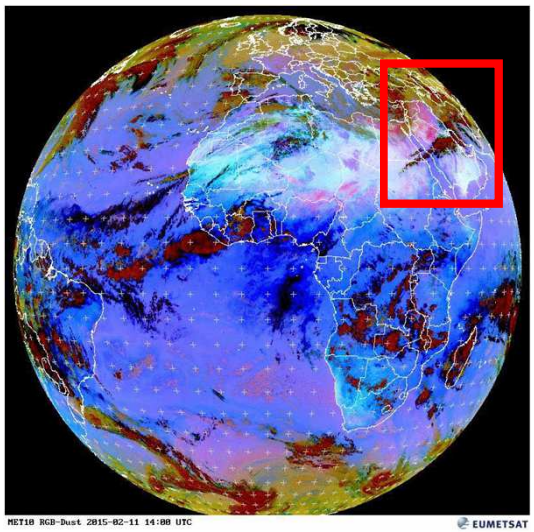


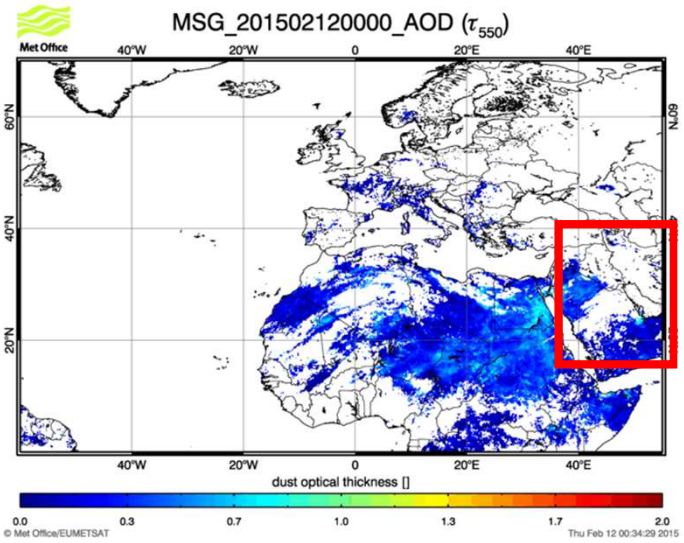
http://dust.aemet.es/

BDFC: Dust event Middle East Feb 2015



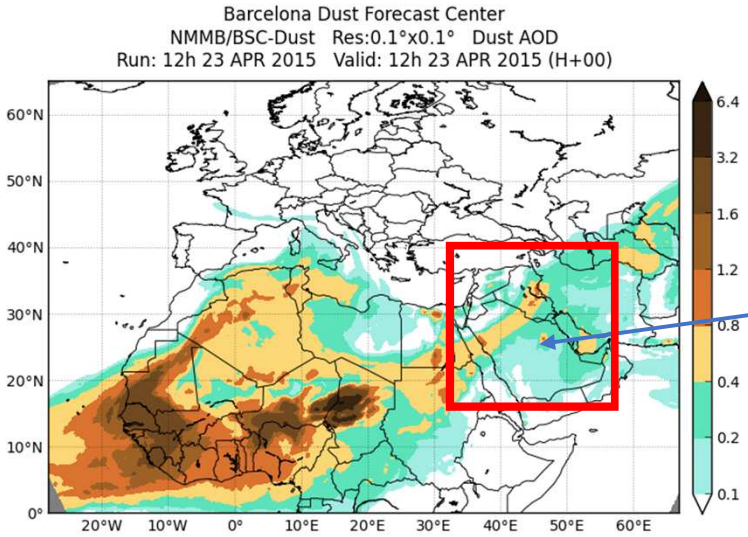


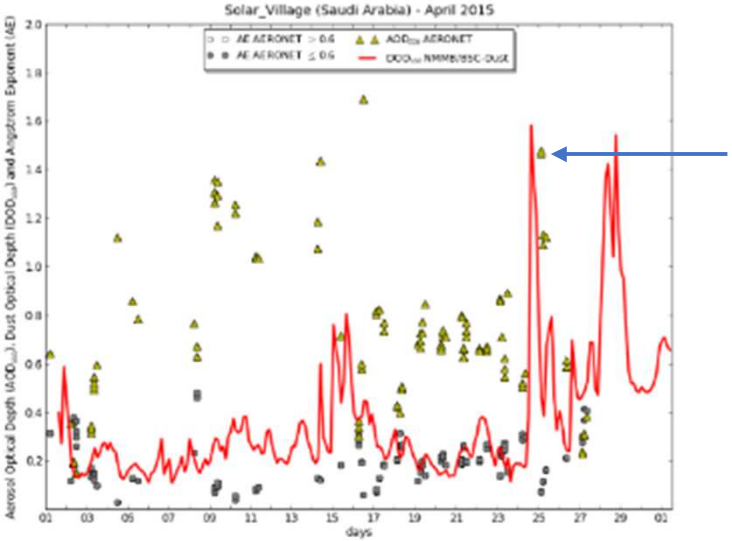


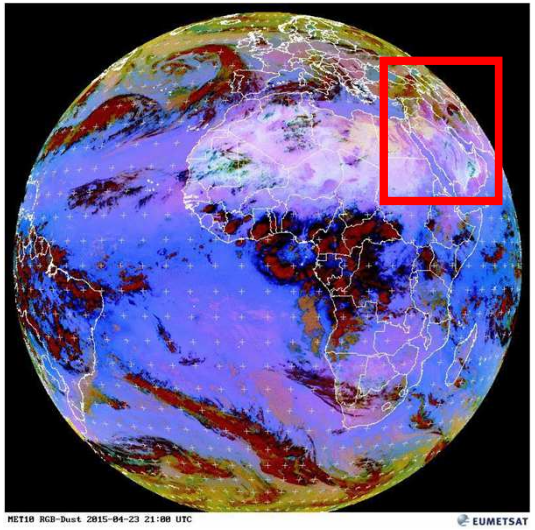


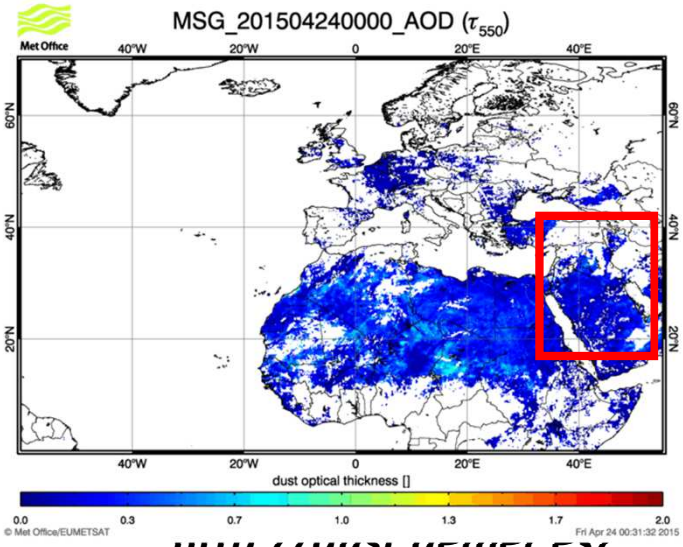
http://dust.aemet.es/

BDFC: Dust event Middle East Apr 2015









http://dust.aemet.es/

COST Action InDust (CA16202)

INTERNATIONAL NETWORK TO ENCOURAGE THE USE OF MONITORING AND FORECASTING DUST PRODUCTS

Chair: Dr Sara Basart (Barcelona Supercomputing Center, Spain)
Vice-chair: Dr Slobodan Nickovic (Republic Hydrometeorological Service of Serbia)

http://www.cost.eu/COST_Actions/ca/CA16202

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

COST InDust - Objectives

- The overall objective of the proposed Action is ***to establish a network*** involving research institutions, service providers and potential end users of information on airborne dust.

- The Action will search to ***coordinate and harmonise*** the process of transferring dust observation and prediction data to users as well as to ***assist the diverse socio-economic sectors*** affected by the presence of high concentrations of airborne mineral dust.

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

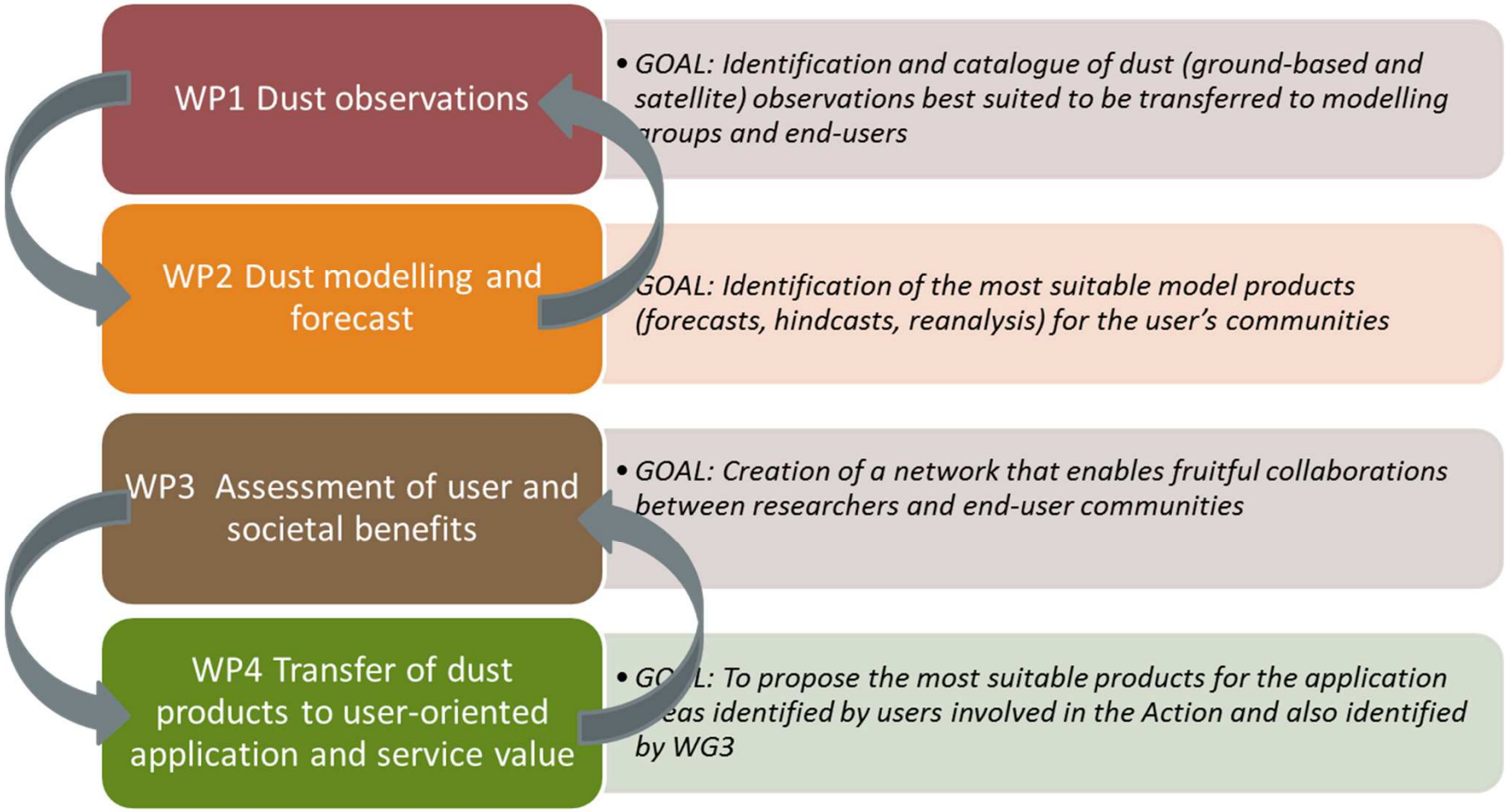
COST Action InDust – Participants

- 28 COST EU members countries signed the MoU:
  - Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Cyprus, Denmark, Finland, France, fYR Macedonia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Spain, Switzerland, Turkey and United Kingdom.
- 3 COST Near-Neighbour Countries:
  - Jordan (University of Jordan), Morocco (Ministry of Health) and Egypt (The Egyptian Meteorological Authority and Cairo University).
- one international organisation:
  - World Meteorological Organization (WMO)

Moreover, InDust also accounts with the participation of a number of researchers from Africa, America and Asia.

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

COST InDust - Structure



COST InDust – Events

1st Joint Working Group meeting in Barcelona on 14-15 March

Nexus II Building. Barcelona

MareNostrum supercomputer

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Ongoing projects to design dust services

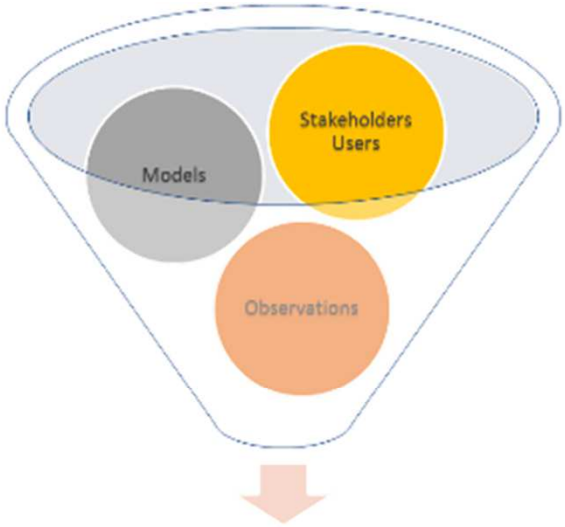
DustClim

ERA4CS European Research Area for Climate Services

Dust Storms Assessment for the development of user-oriented **Clim**ate Services in Northern Africa, Middle East and Europe

- SDS is a serious hazard
- Lack of dust observations, particularly in Africa

GOAL: Develop **dust-related services** to specific socio-economic sectors based on an advanced **dust reanalysis**



Dust-related Climate Services

Next dust events

Updated in the SDS-WAS website: ***http://sds-was.aemet.es/***

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

AXA Research Fund

EXCELENCIA SEVERO OCHOA

GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
AEMet Agencia Estatal de Meteorología

Thank you

Acknowlegde to Carlos Pérez García-Pando, Emilio Cuevas, Slodoban Nickovic, Francesco Benincasa, Gerardo García-Castrillo, Enza DiTomaso, Oriol Jorba, Kim Serradell, Enric Terradellas as well as AERONET, MODIS, U.K. Met Office MSG, MSG Eumetsat and EOSDIS World Viewer principal investigators and scientists for establishing and maintaining data used in the present contribution. Also special thank to all researchers, data providers and collaborators of the WMO SDS-WAS NA-ME-E Regional Node.

sara.basart@bsc.es