BARCELONA DUST FORECAST CENTER
(WMO Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast)

Activity Report 2018

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Barcelona, September 2019

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1. Introduction

The **Barcelona Dust Forecast Center** (BDFC, [1]) was created in February 2014 by the **State Meteorological Agency** of Spain (AEMET) and the **Barcelona Supercomputing Center** (BSC) to fulfil the commitment acquired with **World Meteorological Organization** (WMO) to host the first Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast (RSMC-ASDF). The Center operationally generates and distributes dust predictions for Northern Africa (north of equator), Middle East and Europe.

As described in its Activity Report 2014 (Terradellas et al., 2015) available at ([2]), the BDFC daily releases regional forecast fields using the **NMMB/BSC-Dust** model (the mineral dust module of the online and multiscale NMMB-MONARCH model (Pérez et al., 2011; Haustein et al., 2012; Jorba et al., 2012; Spada et al., 2013; Badia et al., 2017; Di Tomaso et al., 2017) over a domain covering Northern Africa, Middle East and Europe (25°W - 65°E, 0° - 65°N, Figure 1). BDFC predictions include dust load, dust surface concentration, dust optical depth (DOD) at 550 nm, dust surface extinction at 550 nm and 3-hour accumulated dry and wet deposition from the starting time (12 UTC) up to a lead time of 72 hours. Monthly averages of dust surface concentration and dust load are computed for long-term monitoring.

2. Model integration

The NMMB/BSC-Dust model is daily executed at a horizontal resolution of 0.1° longitude per 0.1° latitude with 40 σ-vertical layers over the domain of interest in HPC infrastructures. The primary run is executed at the BSC MareNostrum IV supercomputer using dedicated resources (288 cores). A backup integration is daily performed with the same configuration at Nimbus, the AEMET supercomputing facility.

Both model runs use initial meteorological conditions (at 12UTC) from the U. S. National Centers for Environmental Prediction (NCEP) global analysis at a 0.5° latitude x 0.5° longitude horizontal resolution and 6-hourly boundary meteorological conditions from the NCEP Global Forecast System at the same resolution.

1https://dust.aemet.es

2https://dust.aemet.es/about-us/report-2014

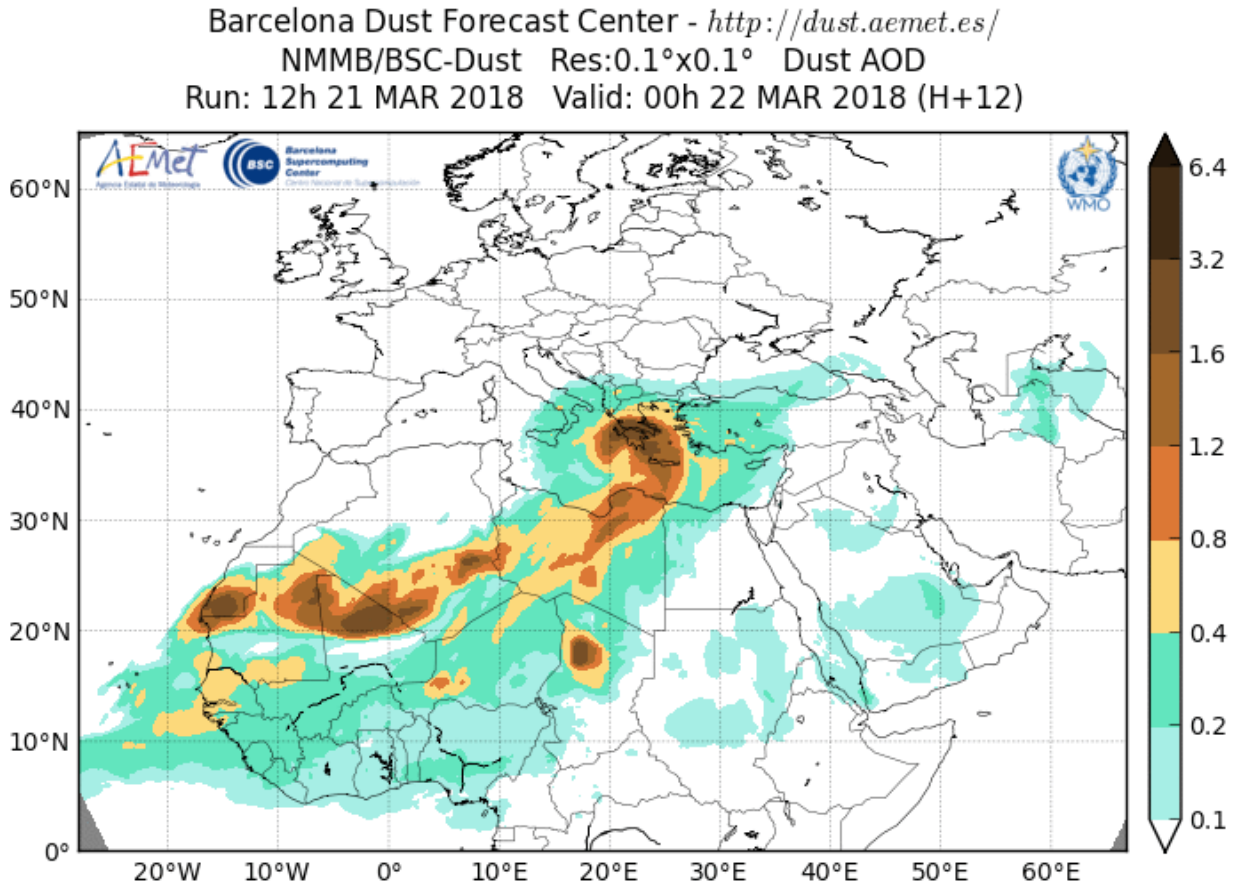

Figure 1: 12-hour forecast of dust optical depth at 550 nm valid for 22 Mar 2018 at 00 UTC

3. Forecast evaluation

The BDFC conducts regular evaluation of the predicted DOD. In the Near-Real-Time (NRT) evaluation, forecasts of DOD at 550 nm with lead times from 0 to 24 hours are compared with total aerosol optical depth (AOD) provided by the **AErosol RObotic NETwork** (AERONET, [3]); Holben et al., 1998; Dubovik and King, 2000) for 40 selected dust-prone stations (Figure 2). Then, evaluation scores are computed on a monthly, seasonal and annual basis by site and considering particular regions (i.e. Sahara/Sahel, Mediterranean and Middle East). To minimize the sources of error, it is intended to restrict the comparison to situations in which mineral dust is the dominant aerosol type. Threshold discrimination is made by discarding observations with an Ångström exponent 440-870 nm higher than 0.6. However, other particles are always present in the atmosphere (anthropogenic aerosol, products from biomass burning, etc.) and therefore a negative bias can be expected. The annual evaluation scores for 2018 are summarized in Table 1.

3http://aeronet.gsfc.nasa.gov/

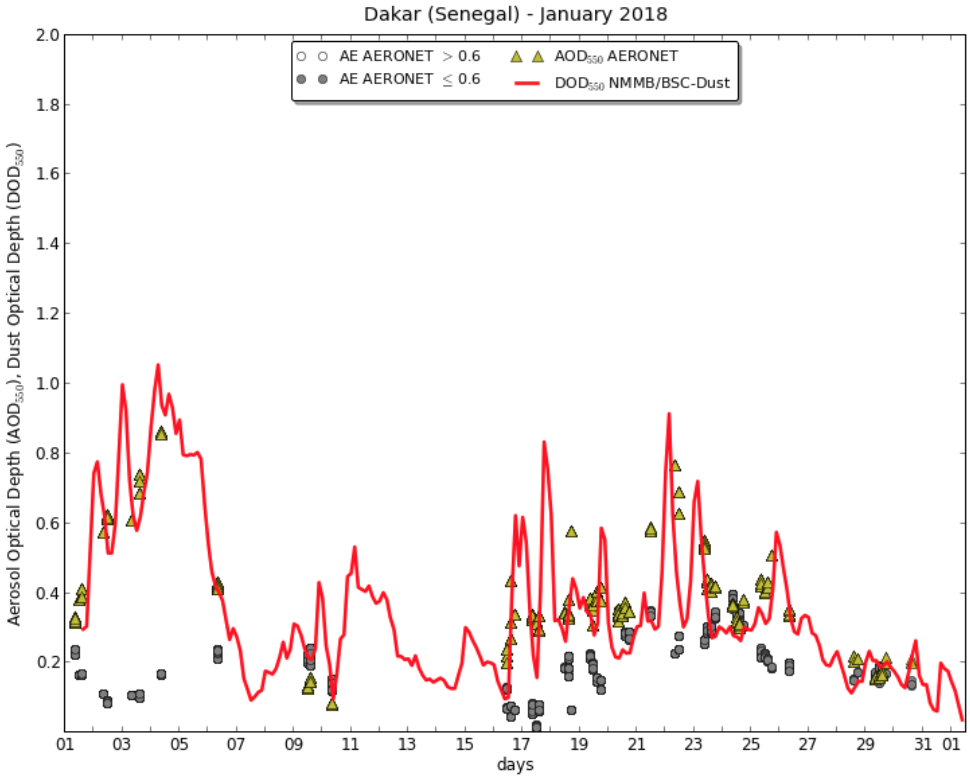

Figure 2: Evaluation of dust optical depth for January 2018 in Dakar, Senegal. Yellow triangles show the AERONET retrievals of total AOD, Black and white dots show the Ångström exponent

Region	MB	RMSE	r	FGE	NData
Sahel / Sahara	-0.15	0.46	0.51	0.73	6943
Middle East	-0.19	0.82	0.21	0.85	683
Mediterranean	-0.14	0.32	0.38	1.20	3829
TOTAL	**-0.15**	**0.45**	**0.48**	**0.89**	**11455**

Table 1: Annual evaluation scores for the forecasts released by the BDFC in 2018: mean bias (MB), Root Mean Square Error (RMSE), correlation coefficient (r), Fractional Gross Error (FGE) and the number of observations considered for verification (NData).

4. Product dissemination

Operational forecasts are made available 12 hours after the starting forecast time on the Center's web portal ([4]), on the WMO **Global Telecommunications System** (GTS) and on **EUMETCast** ([5]), which is a dissemination system based on commercial telecommunication geostationary satellites that uses digital video broadcast standards. It is managed by EUMETSAT.

4 https://dust.aemet.es/forecast

5 http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast

A selection of daily forecasts are also available on the WMO website ([6]) and on UNEPLive, a UN system-wide open platform of environmental information designed for global, regional and national data sharing and assessment ([7]), ([8]) .

Dissemination of dust forecasts in numerical form

Since 8 November 2018 the dust forecast released by the Barcelona Dust Forecast Center is available through EUMETCast in numerical form. The daily dust prediction is delivered in netCDF format.

The filename convention is the following:

<DATETIME>_3H_SDSWAS_NMMB-BSC-v2_EUMETCAST.nc where <DATETIME> = model run in YYYYMMDDHH UTC. Example: 2018110412_3H_SDSWAS_NMMB-BSC-v2_EUMETCAST.nc

The datafiles are distributed as follows:

EUMETCast Europe:
Channel: EUMETSAT Data Channel 12
Multicast address: 224.223.222.35
PID: 301

EUMETCast Africa:
Channel: A1C-TPC-6
Multicast address: 224.223.225.4
PID: 100

5. High availability of products

In previous years the system had been operating over 98% of the time. However, a plan was designed to reduce disruptions and ensure higher availability of products. The plan is based on adding redundancy and eliminating single points of failure. Its main elements are:

- Duplication of the Center's webserver at AEMET headquarters (Madrid, Spain).
- Duplication of the model run on the Nimbus (Bull) cluster, also at AEMET headquarters

The system architecture is represented in Figure 3. The AEMET Domain Name System (DNS) by default directs the web requests to the main BDFC server. However, in case of connection failure, it transfers the request to the secondary server. The two web servers are daily synchronize at 1 UTC, after receiving the forecast files.

6 https://www.wmo.int/pages/prog/arep/sdswas/
7 http://uneplive.unep.org/region/index/af#data_tab
8 http://uneplive.unep.org/region/index/WS#data_tab

Regarding the model forecasts, both runs are done in a totally independent way. Then, once each integration is completed, output files are loaded into both servers.

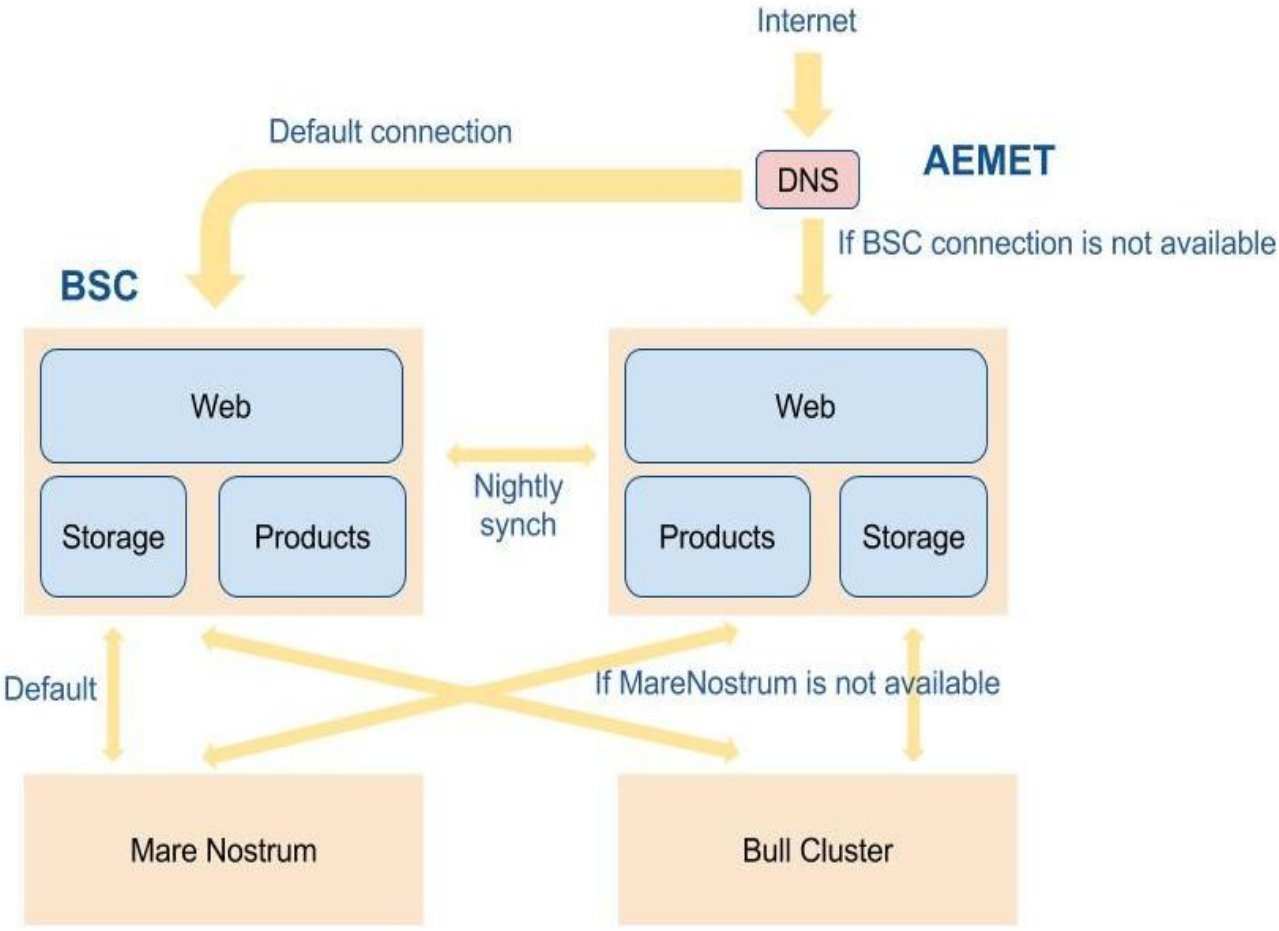

Figure 3: Configuration of the BDFC systems

6. Capacity building

The 7**th Training Course on WMO SDS-WAS Products** (Satellite and Ground Observation and Modelling of Atmospheric Dust) was held in Ahvaz, Iran, on 10-14 November 2018. It was organized by the Iran Meteorological Organization (IRIMO), World Meteorological Organization (WMO) and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), Atmospheric Science & Meterological Research Center (ASMERC) with cooperation of the State Meteorological Agency of Spain (AEMET) and the Barcelona Supercomputing Center (BSC). It was attended by 40 meteorologists and technicians from Iran, Iraq and Niger.

TIME	10-14 Nov 2018
PLACE	Ahvaz, Iran

TITLE	7th Training Course on WMO SDS-WAS Products

Background

When strong or very turbulent winds blow over dry, unvegetated soils, loose particles are lifted from the Earth's surface into the atmosphere, where the finer fraction may be transported over long distances, even across continents. For countries in and downwind of arid regions, this airborne dust poses a major challenge to sustainable development. Impacts on health mainly include respiratory, cardio-vascular problems and infectious diseases. On the other hand, especially once deposited back to the Earth's surface, dust has positive environmental impacts, since it provides nutrients to terrestrial and oceanic ecosystems, boosting primary productivity. Socio-economic impacts may include negative effects on ground transport, aviation, agriculture and generation of solar energy. Finally, dust particles are considered by atmospheric researchers to have important effects on weather and climate through feedback on the atmospheric radiative budget, clouds and precipitation formation.

The scientific community is aware that a significant part of the dust emission is the consequence of human-induced factors, such as poor agricultural practices or land and water mismanagement. Therefore, reducing the harmful impacts of airborne dust is a multi-disciplinary issue that will require making progress on very diverse fields. In 2007, the World Meteorological Organization endorsed the launching of the Sand and Dust Storm - Warning Advisory and Assessment System (SDS-WAS) with the mission to enhance the ability of countries to deliver timely and quality sand and dust storm forecasts, observations, information and knowledge to users through an international partnership of research and operational communities. Some European initiatives as InDust and DustClim are aligned with the SDS-WAS objectives searching to build a network with potential users and favouring the transfer of knowledge and technology to affected communities.

Objective

The main objective of this training course is to build capacity of participants to use products of observation, analysis and forecast of atmospheric mineral dust.

Scope

The event is targeted to operational and research meteorologists as well as early career scientists (advanced students, PhD candidates and postdoctoral researchers) with interest on the Earth system sciences. It may also be of interest to policy-makers, decision-makers and technicians from air quality, aviation and solar energy sectors. Participants are expected to be proficient in English as a working language.

Lecturers

Enric TERRADELLAS, State Meteorological Agency of Spain (AEMET)
Sara BASART, Barcelona Supercomputing Center (BSC), Spain
Sergio RODRIGUEZ , State Meteorological Agency of Spain (AEMET)
Khan ALAM, University of Peshawar, KPK, Pakistan
Saviz SEHAT, Atmospherıc Science and Meteorological Research center (ASMERC),Tehran, Iran

Agenda

Time	Nov. 10th 2018	Nov. 11th 2018	Nov. 12th 2018	Nov. 13th 2018	Nov. 14th 2018
08:45-09:45	Opening	Monitoring of Dust Optical Characteristics Using Remote Sensing Instruments **Khan ALAM**	Ground observation of airborne dust **Sergio RODRIGUEZ**	Dust prediction **Sara BASART**	Synoptic and Dynamic Aspects of dust genesis **Saviz SEHAT**
09:45-10:45	The dust cycle **Enric TERRADELLAS**	Monitoring of Dust Optical Characteristics Using Remote Sensing Instruments **Khan ALAM**	Ground observation of airborne dust **Sergio RODRIGUEZ**	Dust prediction **Sara BASART**	Lectures of the Participants
10:45-11:00	Break	Break	Break	Break	Break
11:00-12:00	The dust cycle **Enric TERRADELLAS**	Dust prediction **Sara BASART**	Ground observation of airborne dust **Sergio RODRIGUEZ**	SDS-WAS products **Enric TERRADELLAS**	Lectures of the Participants
12:00-13:15	Prayers & Lunch	Prayers & Lunch	Prayers & Lunch	Prayers & Lunch	Prayers & Lunch
13:15-14:15	Study of Mineral Dust using Remote Sensing Techniques **Saviz SEHAT**	Dust prediction **Sara BASART**	Satellite and Ground Aerosol data Retrieval and Validation **Khan ALAM**	Filed Visit	Closure
14:15-14:30	Break	Break	Break		Break
14:30-15:30	Opening Ceremony	The health impact of airborne dust **Sergio RODRIGUEZ**	Satellite and Ground Aerosol data Retrieval and Validation **Khan ALAM**		Khuzestan province Meteorological Office visit & Site seeing

7. Staff

Enric Terradellas, technical director *
Sara Basart, research and operations
Francesco Benincasa and **Kim Serradell**, technical support
Carlos Pérez García-Pando and **Emilio Cuevas**, scientific advisers

* Enric Tarradellas retired in March 2019 when Ernest Werner took up his position as technical director.

8. Users

The BDFC conducts regular monitoring of website access. The results (Table 2) show the number of sessions and page views.

Season	Sessions	Page views
Dec 2017 – Feb 2018	20,223	36,107
Mar – May 2018	26,094	47,647
Jun – Aug 2018	22,851	37,382
Sep – Nov 2018	15,508	26,443

Table 2: Quarterly overview of web access during 2017.

Compared with the previous years, there has been an important and steady increase of web accesses, as shown in table 3

Year	Sessions	Page views
Dec 2014 – Nov 2015	31,578	62,443
Dec 2015 – Nov 2016	55,270	98,378
Dec 2016 – Nov 2017	79,173	146,954
Dec 2017 – Nov 2018	84,676	147,579

Table 3: Evolution of annual web access

The top five countries ranked by number of visitors are Spain, Iran, United States, Italy and France.

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