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

Activity Report 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.

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

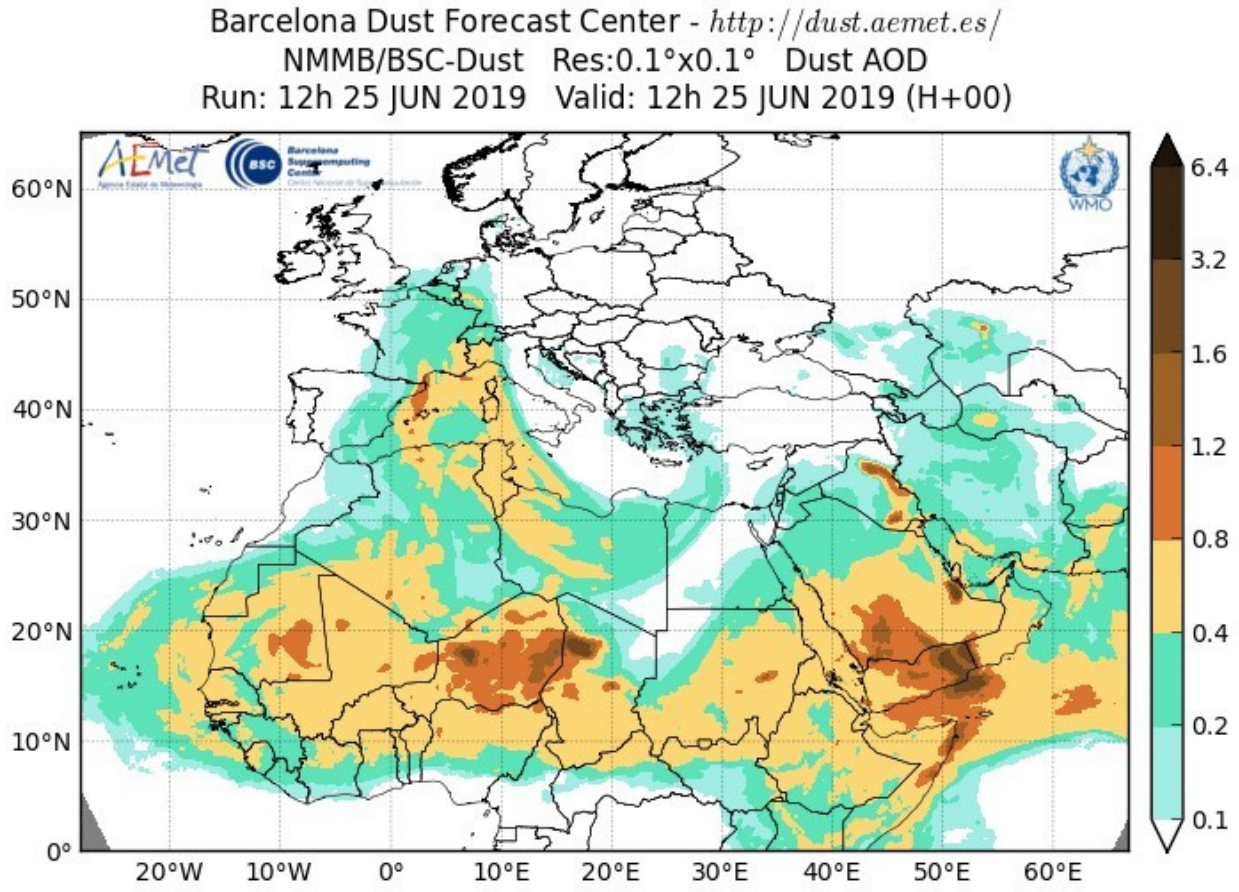

Figure 1: 12-hour forecast of dust optical depth at 550 nm valid for 25 Jun 2019 at 00 UTC

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 2019 are summarized in Table 1.

From 2019 the AERONET Version 3 (V3) algorithm is operational. In Version 2 (V2) of the AERONET database, the near real-time AOD was semi-automatically quality controlled utilizing mainly cloud screening methodology, while additional AOD data contaminated by clouds or affected by instrument anomalies were removed manually before attaining quality assured status (Level 2.0). The large growth in the number of AERONET sites over

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

the past 25 years resulted in significant burden to manually quality control millions of measurements in a consistent manner. The AERONET Version 3 (V3) algorithm provides fully automatic cloud screening and instrument anomaly quality controls. All of these new algorithm updates apply to near real-time data as well as post-field deployment processed data, and AERONET reprocessed the database in 2018. A full algorithm redevelopment provided the opportunity to improve data inputs and corrections such as unique filter specific temperature characterizations for all visible and near-infrared wavelengths, updated gaseous and water vapor absorption coefficients, and ancillary data sets.

Due to this improvement in the algorithm and the new filters, fewer observations were available in 2019, in particular in Middle East region (fig 2). Hence, scores for this region (table 1) are not as significant as in previous years.

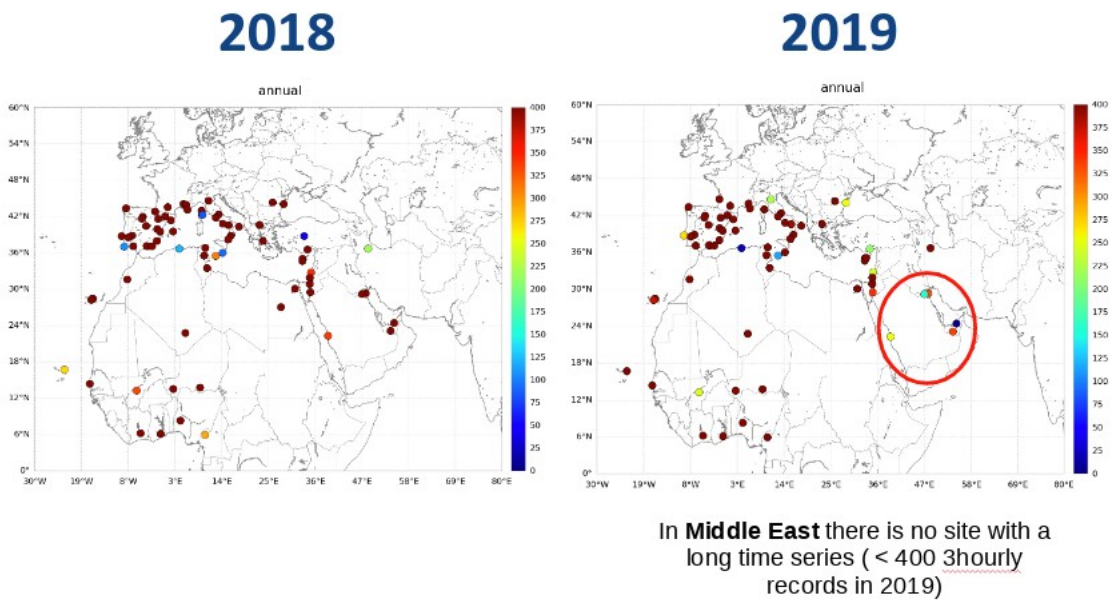

Figure 2: Available 3 hourly observations direct sun V3-lev1.5 (2018 versus 2019) Source: BSC-CNS

Region	MB	RMSE	r	FGE	NData
Sahel / Sahara	-0.04	0.32	0.63	0.63	5617
Middle East	*-0.09*	*0.34*	*0.04*	*0.95*	*88*
Mediterranean	-0.06	0.21	0.57	0.9	1786
TOTAL	**-0.04**	**0.29**	**0.63**	**0.7**	**7491**

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.

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

4 https://dust.aemet.es/forecast
5 http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast
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

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.

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.

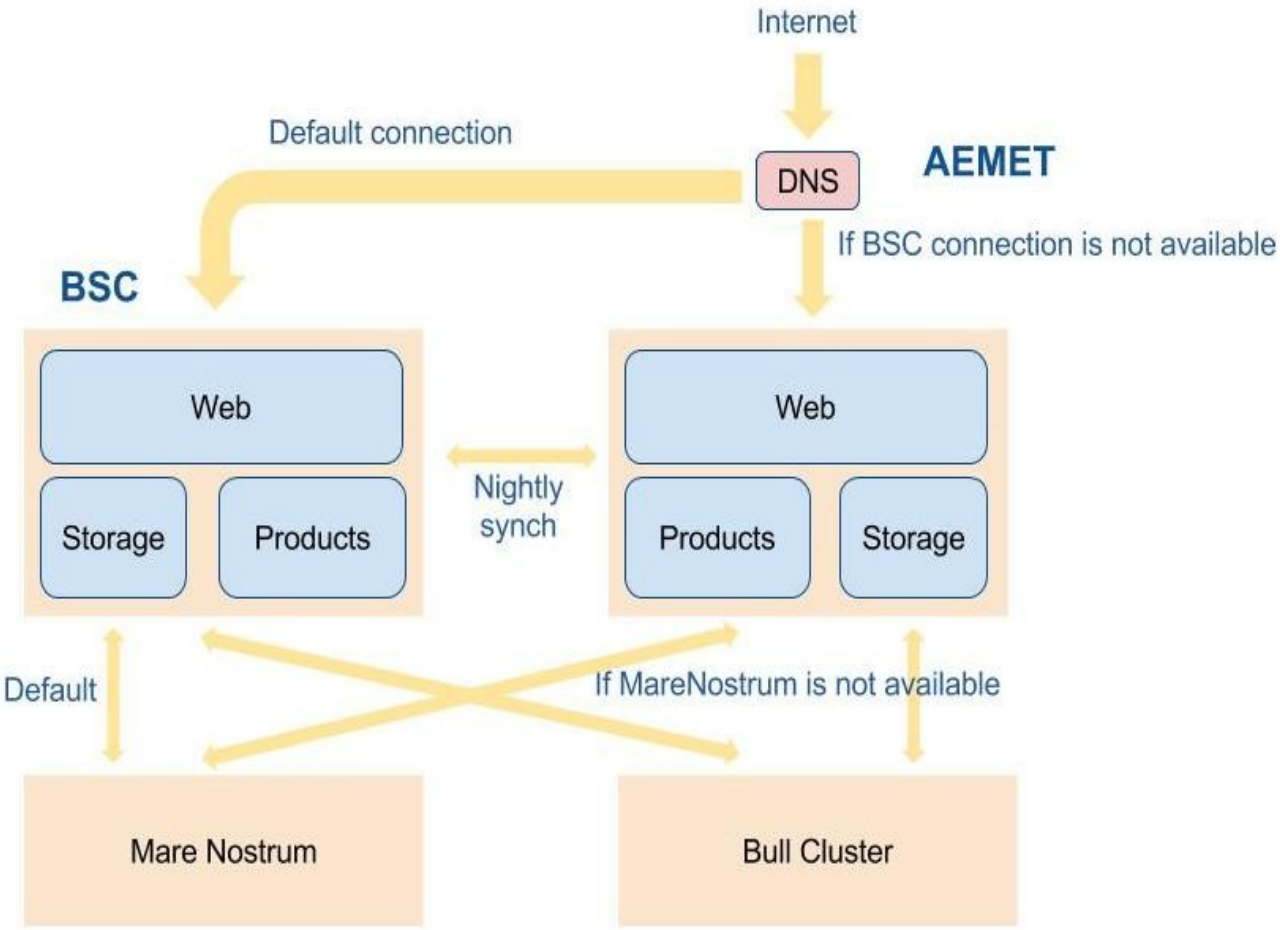

Figure 3: Configuration of the BDFC systems

6. Capacity building

The 8th Training Course on WMO SDS-WAS Products was held in Dakar, Senegal from 9th to 11th December 2019 organized by AEMET in collaboration with the WMO (world Meteorological Organization), BSC-CNS (Barcelona Supercomputing Center), EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) and CSIC (Spanish National Research Council). This workshop was aimed at western and northern African countries and focused on mineral airborne dust forecast and observational products.

TIME	9-14 Des 2019
PLACE	Dakar, Senegal
TITLE	8th Training Course: Workshop on Sand and Dust Storms in West and Northern Africa

Background
More than 500 million people live in West and Northern Africa, a region stretching from the Gulf of Guinea in the west to the Red Sea in the east and covering areas such as the Sahara desert and the Sahel. The Sahara is the most extensive desert on Earth and the main emission source of mineral dust into the atmosphere. Airborne dust does not only affect the desert itself, but, especially in winter and spring, is dragged to densely populated areas of the Sahel and the Gulf of Guinea, where it causes a deep deterioration of air quality and triggers serious health problems. High concentrations of dust also affect agriculture, aviation, due to the drastic reduction in visibility, and other socio-economic sectors.

Objectives

- Enhance the understanding of the physical processes involved in the dust cycle and the impacts of airborne dust on air quality, health, aviation and diverse socio-economic sectors.

- Enhance the technical capacities of operational meteorologists from West and Northern Africa on the analysis and prediction of sand and dust storms, including the use of ground and satellite observations, as well as available dust predictions.

Participants
It was attended by 24 participants from 23 northern and western African countries. Most of them weather forecasters and climatologists from National Meteorological Services.

Language
The workshop was conducted in English.

Support
This activity was supported by:
- AEMET through the cooperation funds of AFRIMET and ACMAD
- EUMETSAT

Workshop Agenda

Dakar, 9-11 December 2019

	Monday 9th Dec	Tuesday 10th Dec	Wednesday 11th Dec
08:30 - 09:00	Registration		
09:00 - 10:00	Opening Dust Cycle **Ernest Werner**	Dust Modelling of Atmospheric Dust **Sara Basart**	Dust Impacts Overview **Sara Basart** Dust Impacts on Health **Aurelio Tobías**
10:00 - 11:00	Dust Ground Observation **Natalia Prats**	SDS-WAS Operational Products **Sara Basart**	Dust Impacts on Health **Aurelio Tobías**
11:00 - 11:30	Coffee break		
11:30 - 12:30	Dust Ground Observation **Natalia Prats**	SDS-WAS Multimodel Products **Ernest Werner**	Dust Impacts on Health **Aurelio Tobías** Lectures of the participants
11:30 - 13:30	Dust Satellite Observations **José Prieto**	SDS-WAS Warning Systems **Ernest Werner**	Lectures of the participants
13:30 - 15:00	Lunch break		
15:00 - 16:00	Dust Satellite Observations **José Prieto**	SDS-WAS Products practice Session **Ernest Werner/ Sara Basart**	Lectures of the participants
16:00 - 17:00	Dust Satellite Observations **José Prieto**	SDS-WAS Products practice Session **Ernest Werner/ Sara Basart**	Discussion/ Closing

Lecturers:
Ernest WERNER, State Meteorological Agency of Spain (AEMET), Spain
Natalia PRATS, State Meteorological Agency of Spain (AEMET), Spain
Sara BASART, Barcelona Supercomputing Center (BSC), Spain
José PRIETO, European Organization for Explotation of meteorological Satellites (EUMETSAT), Germany
Aurelio TOBÍAS, Consejo Superior de Investigaciones Científicas (CSIC), Spain

7. Staff

Enric Terradellas, technical director (retired March 2019)
Ernest Werner, technical director (since March 2019)
Sara Basart, research and operations
Francesco Benincasa and **Kim Serradell**, technical support
Carlos Pérez García-Pando and **Emilio Cuevas**, scientific advisers

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 2018 – Feb 2019	22,392	38,167
Mar – May 2019	23.486	41.187
Jun – Aug 2019	18.839	31.892
Sep – Nov 2019	20.462	11.734

Table 2: Quarterly overview of web access during 2019.

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
Dec 2018 – Nov 2019	76,451	131,708

Table 3: Evolution of annual web access

The top five countries ranked by number of visitors are Spain, Poland, United States, Iran, Germany and United Kigndom. A peak of 2,129 users on 23th April was recorded when a dust intrusion affected part of Europe reaching Poland. Number of sessions and page views are similar to the last two years.

We are now in the process of redesigning and improvement our web system, both front and back ends, in order to offer a better user experience and a user friendly access to our forecast and evaluation. In particular, the website will have a new visualization tool for our forecast and evaluation products. The new website are expected to be fully operational in September 2021.

9. References

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