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

Activity Report 2016

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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., 2015a) available at ([2]), the BDFC daily releases regional forecast fields using the **NMMB/BSC-Dust** model (Pérez et al., 2011; Haustein et al., 2012) 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.

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

2. Model integration

The NMMB/BSC-Dust model is daily integrated at a horizontal resolution of 0.1° longitude per 0.1° latitude with 40 σ-vertical levels on the MareNostrum supercomputer using dedicated resources. MareNostrum III is the core facility of the BSC. A backup integration is daily performed at a horizontal resolution of 0.33° longitude per 0.33° latitude with 24 σ-vertical levels on a dedicated server.

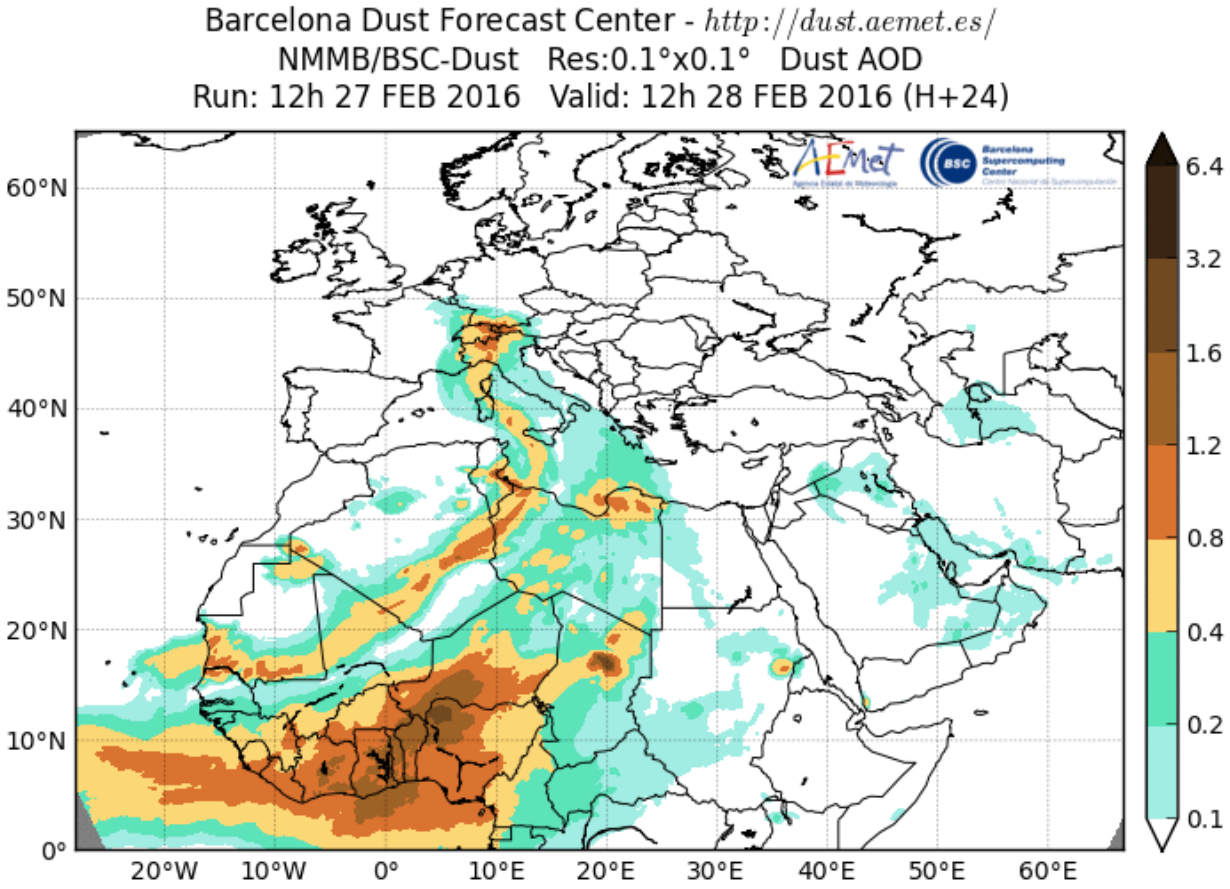

Figure 1: 24-hour forecast of dust optical depth at 550 nm valid for 28 feb 2016 at 12 UTC

Both model configurations use initial meteorological conditions 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.

3. Forecast evaluation

The BDFC conducts regular evaluation of the predicted dust optical depth. 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. 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 higher than 0.6. However, other particles are always present in the

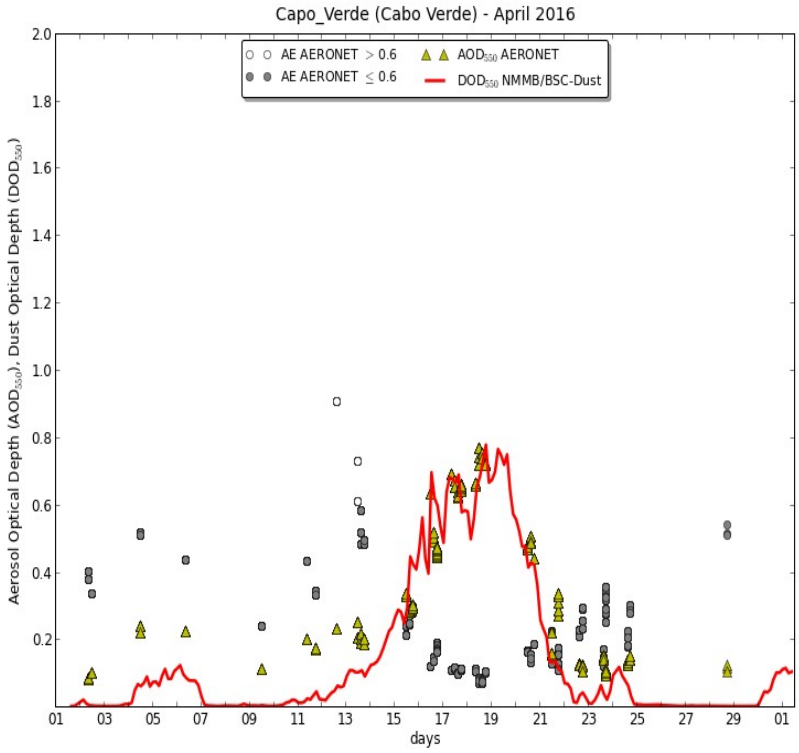

Figure 2: Evaluation of dust optical depth for April 2016 in Cape Verde. Yellow triangles show the AERONET retrievals of total AOD, Black and white dots show the Ångström exponent

atmosphere (anthropogenic aerosol, products from biomass burning, etc.) and therefore a negative bias can be expected.
The annual evaluation scores for 2016 are summarized in Table 1

Area	Mean bias	r.m.s.e.	Correlation coefficient	Fractional Gross Error	Number of cases
Sahel / Sahara	-0.09	0.45	0.53	0.67	8944
Middle East	-0.19	0.43	0.23	0.95	1972
Mediterranean	-0.16	0.30	0.41	1.21	5141
TOTAL	**-0.12**	**0.40**	**0.54**	**0.87**	**15157**

Table 1: Annual evaluation scores for the forecasts released by the BDFC in 2016.

On the other hand, Table 2 shows the evolution of the annual correlation

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

coefficient between model forecasts and AERONET measurements.

Year	Correlation coefficient
2014	0.52
2015	0.53
2016	0.54

Table 2: Annual values of the correlation coefficient between the forecasts released by the BDFC and the AERONET retrievals of aerosol optical depth.

Evaluation of other parameters is waiting for the availability of suitable observational data sets. Some pilot tests conducted in the framework of the WMO **Sand and Dust Storm Warning Advisory and Assessment System** (SDS-WAS) (I. e. Terradellas et al., 2015b; García-Castrillo et al., 2015) are expected to be the starting point to develop and implement future routine evaluation systems.

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, an UN system-wide open platform of environmental information designed for global, regional and national data sharing and assessment ([7]), ([8]) .

5. High availability of products

Several temporary service failures have been reported in the following dates:

- 9-10 January 2016 (server power failure)
- 1-2 August 2016 (scheduled maintenance on the campus)
- 16-18 November 2016 (DNS misconfiguration)

Although the system has been operating over 99% of the time, a plan has been 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:

4 http://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

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

The projected system architecture is represented in Figure 3.

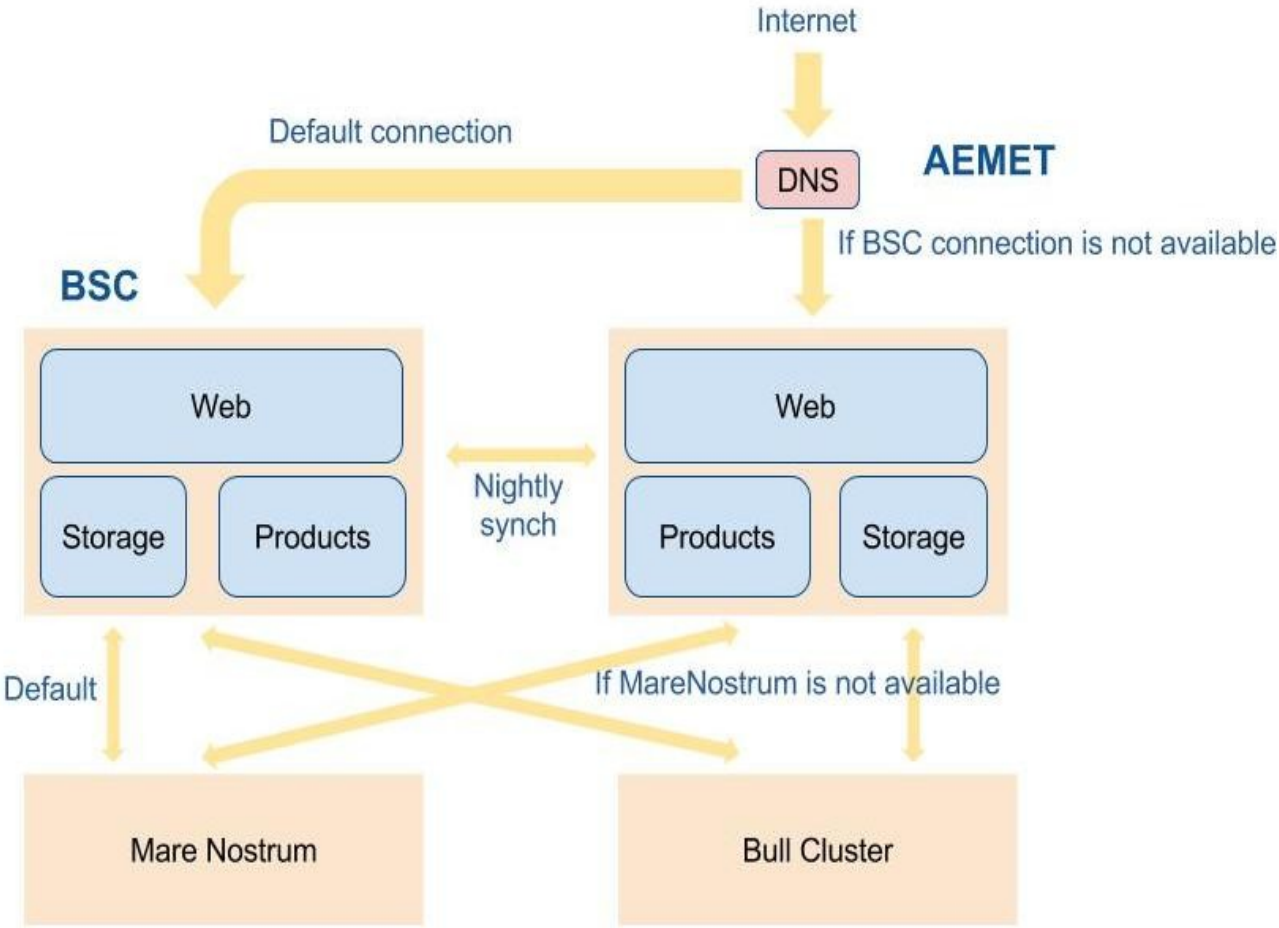

Figure 3: New configuration of the BDFC systems

The AEMET DNS will, by default, direct the web requests to the current BDFC server. However, in case of connection failure, it will transfer the request to the server in AEMET. The two web servers will be daily synchronized after receiving the forecast files.

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

At the end of 2016, the secondary server is already installed and configured, and synchronization tests are being performed. On the other hand, the NMMB/BSC-Dust model is daily run on the AEMET's Nimbus cluster.

The pending steps to have the final configuration fully operational are:

- Completion of servers synchronization
- Restrict the secondary model run to the event of failure or unavailability of the primary one.

6. Capacity building

The **5th Training Course on WMO SDS-WAS Products** (Satellite and Ground Observation and Modelling of Atmospheric Dust) was held at the WMO Training Center of Tehran, Iran, on 5-9 November 2016. It was organized by WMO, EUMETSAT, the Islamic Republic of Iran Meteorological Organization (IRIMO), the Iranian Atmospheric Science and Meteorological Research Center (ASMERC) and the Barcelona Dust Forecast Center. The local organizer of the event was IRIMO and the course coordinator, the Barcelona Dust Forecast Center.

Figure 4: 5th Training Course on WMO SDS-WAS Products

The event was targeted to operational and research meteorologists, although it was also attended by technicians from air quality agencies as well as early career scientists (advanced students, PhD candidates and postdoctoral researchers) with interest on the Earth system sciences.

Materials from the training course are available on the website of the WMO

SDS-WAS Regional Center for Northern Africa, Middle East and Europe ([9]).

7. Conferences and meetings

The activity of the BDFC was presented (Terradellas, 2016a) at the **First International Conference on Dust**, held in Ahvaz, Iran, on 2-4 March 2016. It was the first interdisciplinary scientific conference in Iran covering mineralogical, geochemical, environmental, economic and social aspects of dust storms. Also (Terradellas et al., 2016b), at the **Regional Consultation on Climate Services in the Arab Region**, held in Casablanca, Morocco, on 4-6 October 2016. The workshop was focused on the role of climate data, information products and services in support of decision making in climate sensitive sectors and on the way to develop and apply them in the Arab Region.

8. 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

9. Users

The BDFC conducts regular monitoring of website access. The results (Table 3) show the number of sessions and page views.

Season	Sessions	Page views
Dec 2015 – Feb 2016	13,551	25,075
Mar – May 2016	11,196	20,639
Jun – Aug 2016	19,817	33,350
Sep – Nov 2016	10,716	19,314

Table 3: Quarterly overview of web access

Compared with the previous year, there has been an important 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

Table 4: Evolution of annual web access

The top five countries ranked by number of visitors are Spain, Iran, United

9 http://sds-was.aemet.es/materials/training/5th-training-course-on-wmo-sds-was-products

States, Saudi Arabia and United Kingdom.

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