BARCELONA DUST REGIONAL CENTER: ACTIVITY REPORT 2021

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TECHNICAL REPORT

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Barcelona Dust Forecasting Center (BDFC)

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Summary

This report summarizes new technical information about the operational model, products availability, products dissemination and capacity building activities carried out in 2021 by the Barcelona Dust Regional Center. Besides, information about the number of users who accessed the Regional Center website is also provided.

Contents

1. Introduction

The **Barcelona Dust Forecast Center** (BDFC) 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), 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.

An upgrade version of the MONARCH model is in operation since December 2020. Some of the new features are:

- Implementation of a new high-resolution mapping of dust sources based on high-resolution MODIS Collection (Ginoux et al., 2012) within the model.
- In addition to the standard emission scheme in MONARCH based on a variation of Marticorena and Bergametti (1995), six additional emission schemes are now available in the model: the GOCART scheme from Ginoux et al. (2001), four schemes that represent dust emission through saltation bombardment and aggregate disintegration (Shao, 2001; Shao, 2004; Shao et al., 2011, Kok et al., 2014) and one scheme represents aerodynamic dust entrainment (Klose et al., 2014).

The new features and each of the mentioned phases of the deployment protocol are described in detail in the technical report of the model upgrade that can be found on this link: https://dust.aemet.es/about-us/monarch_upgrade_2020/view

Furthermore, a completely new version of the Regional Center website was released on the 20th January 2022. This website gather all the information and products developed by the WMO Barcelona Dust Regional Center (BDRC) which manages and coordinates the research activities and operations of WMO related to sand and dust storms in the region of Northern Africa, Middle East and Europe. The forecast products of our operational model MONARCH can be found in this new website here: https://dust.aemet.es/products/daily-dust-products

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.

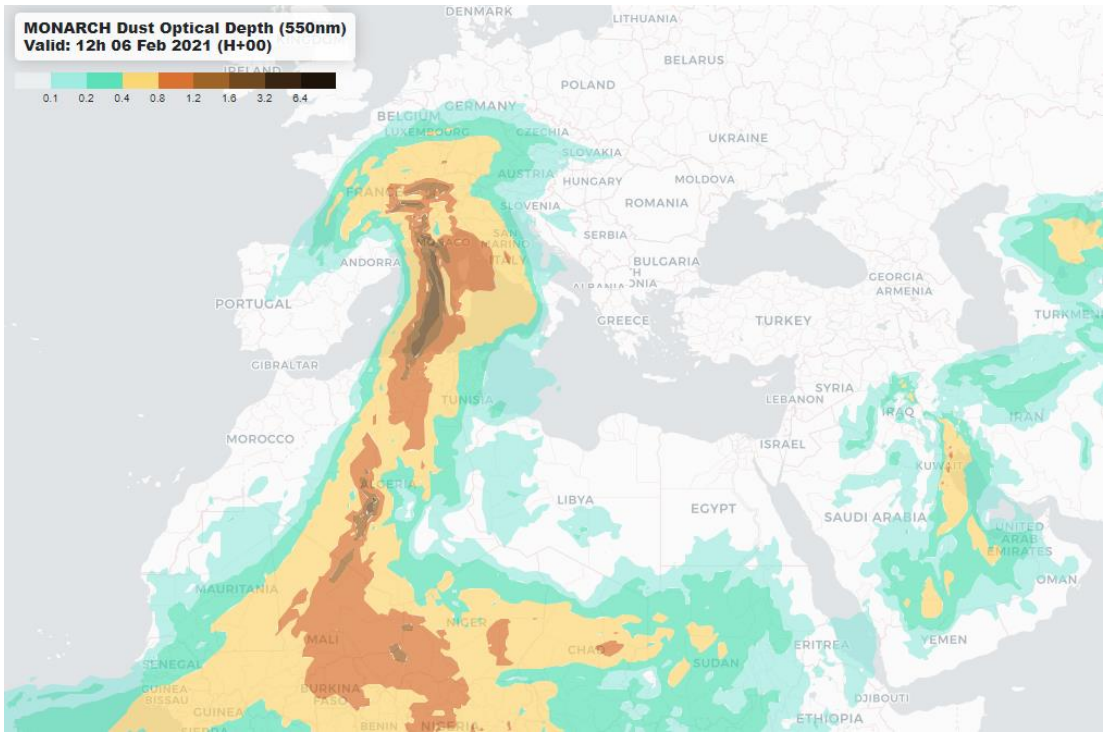

Figure 1: 12-hour forecast of dust optical depth at 550 nm valid for 06 Feb 2021 at 00 UTC

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); 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 2020re 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 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.

These statistics can be found on the webpage here:
https://dust.aemet.es/products/daily-dust-products?tab=evaluation&section=statistics

In order to better evaluate the model, new regions have been defined based on how they are affected by dust outbreaks. Now we have four regions: Europe, Mediterranean, Middle East and northern Africa.

The statistic values for these regions are different from the previous ones but the total values are could be used to evolution. On the website can be found which stations are now included in each region and also the individual AERONET stations that are used for the calculation of the statistics.

Region	MB	RMSE	r	FGE	Total Cases
Europe	-0.10	0.17	0.72	1.47	1906
Mediterranean	0.01	0.21	0.69	0.75	6359
Middle East	0.02	0.24	0.55	0.48	2618
Northern Africa	0.09	0.38	0.46	0.66	6398
TOTAL	**0.03**	**0.28**	**0.57**	**0.75**	**17521**

Table 1: Annual evaluation scores for the forecasts released by the BDFC in 2021 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, on the WMO **Global Telecommunications System** (GTS) and on **EUMETCast**, which is a dissemination system based on commercial telecommunication geostationary satellites that uses digital video broadcast standards. It is managed by EUMETSAT.

4.1. 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

In 2021 the Nimbus (Bull) cluster was replaced by a Cirrus (ATOS) cluster. Final clusters will be installed in 2023-2025 (https://aemetblog.es/2021/04/27/cirrus-el-nuevo-sistema-de-supercomputacion-de-aemet/)

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.

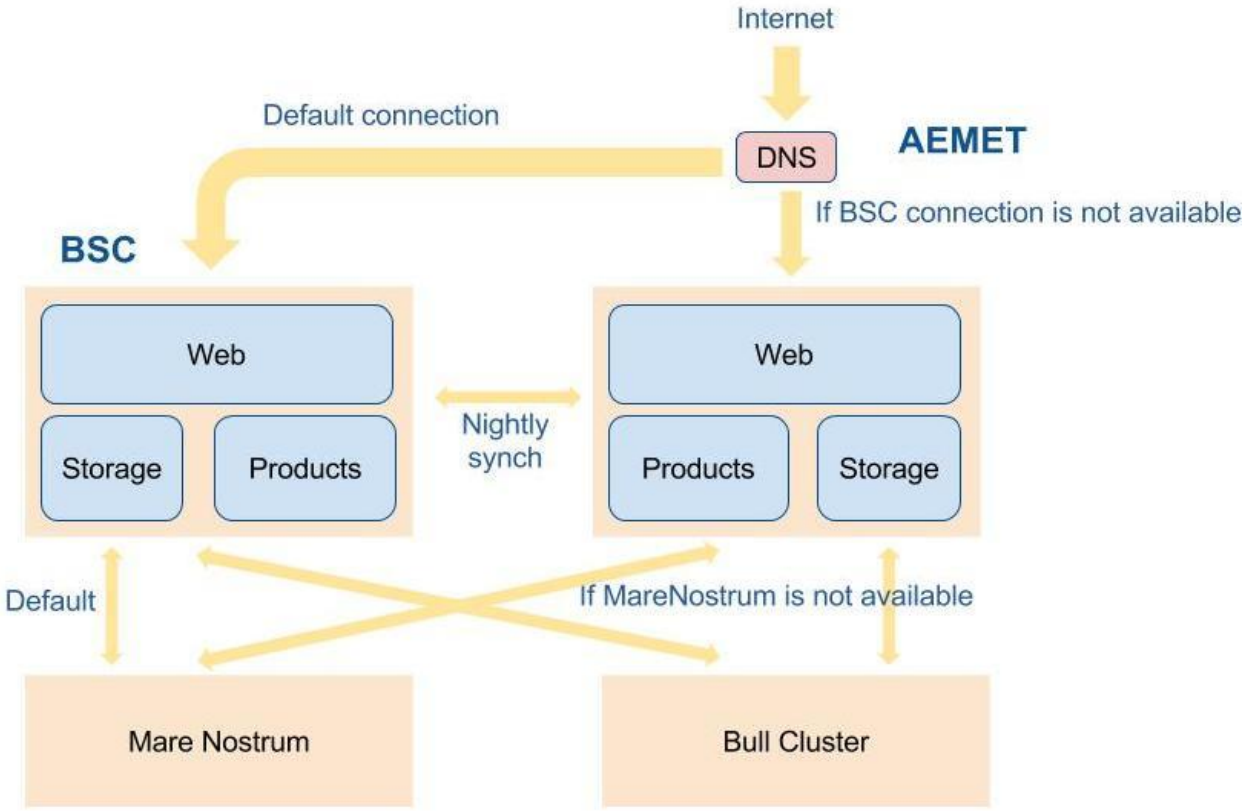

Figure 2: Configuration of the BDFC systems

6. Capacity building

Due to travel restrictions, training activities during 2021 have been online. Thanks to the improvement of the videoconference tools they have been very successful. All of them can be found on our website (https://dust.aemet.es/resources) and most of them were recorded and both recording and presentation can be downloaded.

These training activities have been carried out within the framework of projects such as inDust (Cost Action), DUSTCLIM (ERA4CS) and MAC-CLIMA (Interreg). It is also remarkable the collaboration with EUMETSAT in an online dust training school that included Python Notebooks with basic and advanced scripts to work both models and observation datasets.

List of training activities carried out in 2021:

Workshops and training schools	
EUMETSAT Training School and Workshop on Dust Aerosol Detection and Monitoring	https://dust.aemet.es/news-events/events/training-school-and-workshop-on-dust-aerosol-detection-and-monitoring
MAC-CLIMA Workshop on SDS-WAS West Africa: Senegal	https://dust.aemet.es/news-events/events/mac-clima-workshop-on-sds-was-west-africa-senegal
User Workshop DustClim: Development of dust climate services for solar energy	https://dust.aemet.es/news-events/events/user-workshop-dustclim-development-of-dust-climate-services-for-solar-energy

inDust webinars	
User Workshop on Dust Products for Aviation	https://dust.aemet.es/news-events/events/user-workshop-on-dust-products-for-aviation
Icelandic dust forecasting	https://dust.aemet.es/news-events/events/icelandic-dust-forecasting
EARLINET observations during Saharan dust intrusions	https://dust.aemet.es/news-events/events/earlinet-observations-during-saharan-dust-intrusions
Short-term health effects of desert dust	https://dust.aemet.es/news-events/events/short-term-health-effects-of-desert-dust
Data visualization in user-tailored products	https://dust.aemet.es/news-events/events/data-visualisation-in-user-tailored-products
Impacts of Sand and Dust Storms on Oceans	https://dust.aemet.es/news-events/events/impacts-of-sand-and-dust-storms-on-oceans
Giant dust particles	https://dust.aemet.es/news-events/events/giant-dust-particles
A dust-derived satellite dataset	https://dust.aemet.es/news-events/events/a-dust-derived-satellite-dataset
High-resolution global dust map	https://dust.aemet.es/news-events/events/high-resolution-global-dust-map
Mineral dust and health effects	https://dust.aemet.es/news-events/events/mineral-dust-and-health-effects
Aerosol typing from observations	https://dust.aemet.es/news-events/events/aerosol-typing-from-observations
Dust impacts on aviation	https://dust.aemet.es/news-events/events/dust-impacts-on-aviation
Dust mineralogy and climate	https://dust.aemet.es/news-events/events/dust-mineralogy-and-climate
Physico-chemical desert dust properties	https://dust.aemet.es/news-events/events/physico-chemical-desert-dust-properties
Dust impacts on snow	https://dust.aemet.es/news-events/events/dust-impacts-on-snow
E-PROFILE: Looking at the aerosols' vertical distribution	https://dust.aemet.es/news-events/events/e-profile-looking-at-the-aerosols-vertical-distribution

7. Staff

Ernest Werner, Technical Director

Sara Basart, Lead Scientist

Konstantina Coucha, Scientific Support

Gerardo García-Castrillo, Scientific Support

Francesco Benincasa, Lead Developer

Kim Serradell, Technical Support

Diana Urquiza, Product Designer

Carlos Pérez García-Pando and **Emilio Cuevas**, Scientific Advisors

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 2020 – Feb 2021	26.914	48.267
Mar 2021 – May 2021	32.751	58.374
Jun 2021– Aug 2021	30.344	49.607
Sep 2021– Nov 2021	19.447	32.440

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
Dec 2019 – Nov 2020	98.954	163.846
Dec 2020 – Nov 2021	109.456	188.688

Table 3: Evolution of annual web access (* Google analytics new version)

The top five countries ranked by number of visitors are Spain, France, United States, Germany and Iran. Two peaks exceeding 1000 users were registered on 1st February

(1221) and 6th (1549) February when several dust intrusions affected Europe and Canary Islands. More dust events affected Europe in the next weeks and this was reflected in the number of users during February and March exceeding 700 users in several days.

The BDFC Twitter account (@Dust_Barcelona) has been proven to be a very effective way to disseminate our forecast products and other activities that the BDRC carries out. During 2021 we added around 800 new followers to our account (current followers in September 2022 are 3914)