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

Activity Report 2020

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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 **MONARCH** (former NMMB/Dust-BSC) 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.

Upgrade of the MONARCH operational Forecast

An upgrade version of the MONARCH model is in operation since December 2020.

The complete deployment protocol has included the following phases:

- Benchmark
- Installation
- Pre-operational
- Operational

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

1https://dust.aemet.es

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

2. Model integration

The MONARCH 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.

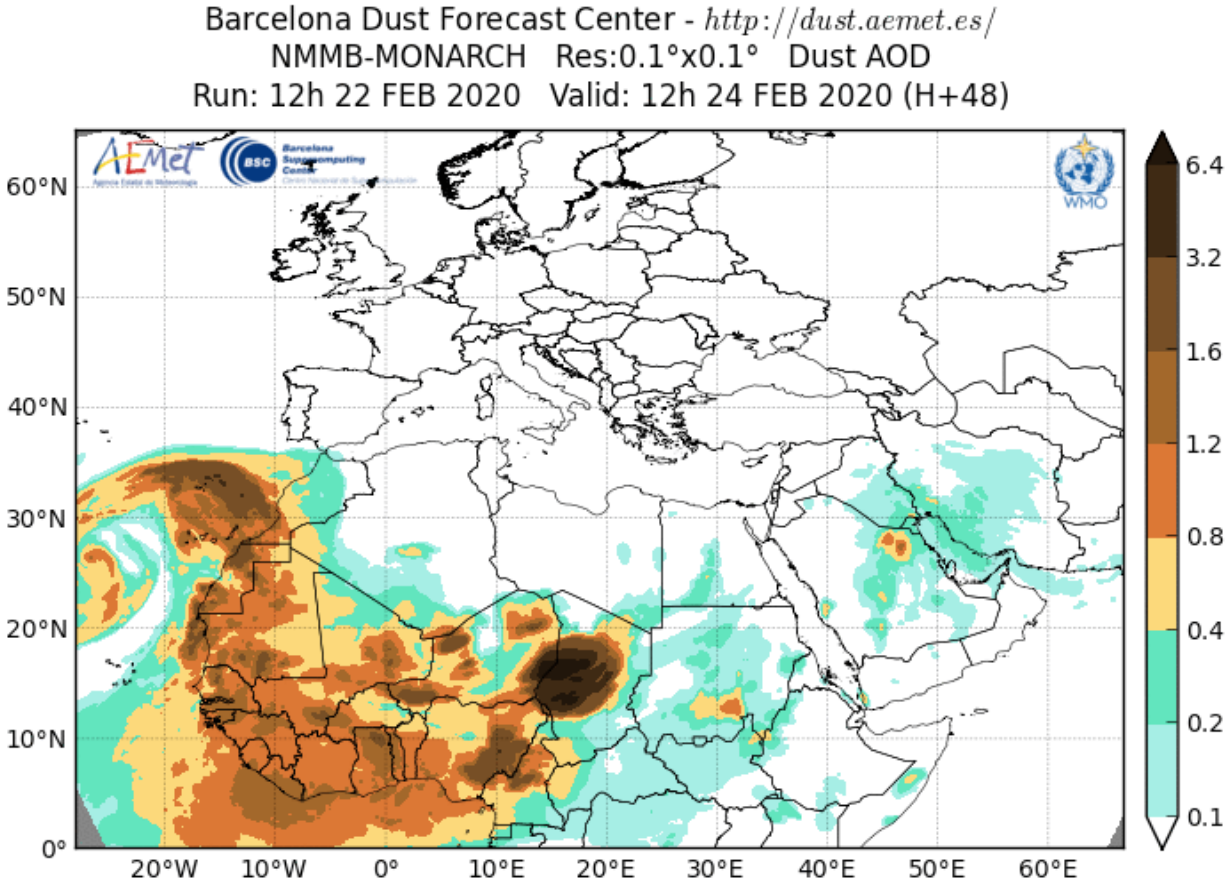

Figure 1: 48-hour forecast of dust optical depth at 550 nm valid for 24 Feb 2020 at 12 UTC

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,

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

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.

Region	MB	RMSE	r	FGE	NData
Sahel / Sahara	0.1	0.41	0.65	0.56	5140
Middle East	-0.04	0.36	0.22	0.58	510
Mediterranean	-0.02	0.17	0.61	0.87	1847
TOTAL	**0.06**	**0.37**	**0.66**	**0.64**	**7497**

Table 1: Annual evaluation scores for the forecasts released by the BDFC in 2020 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,

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/

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.

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.

7 http://uneplive.unep.org/region/index/af#data_tab
8 http://uneplive.unep.org/region/index/WS#data_tab

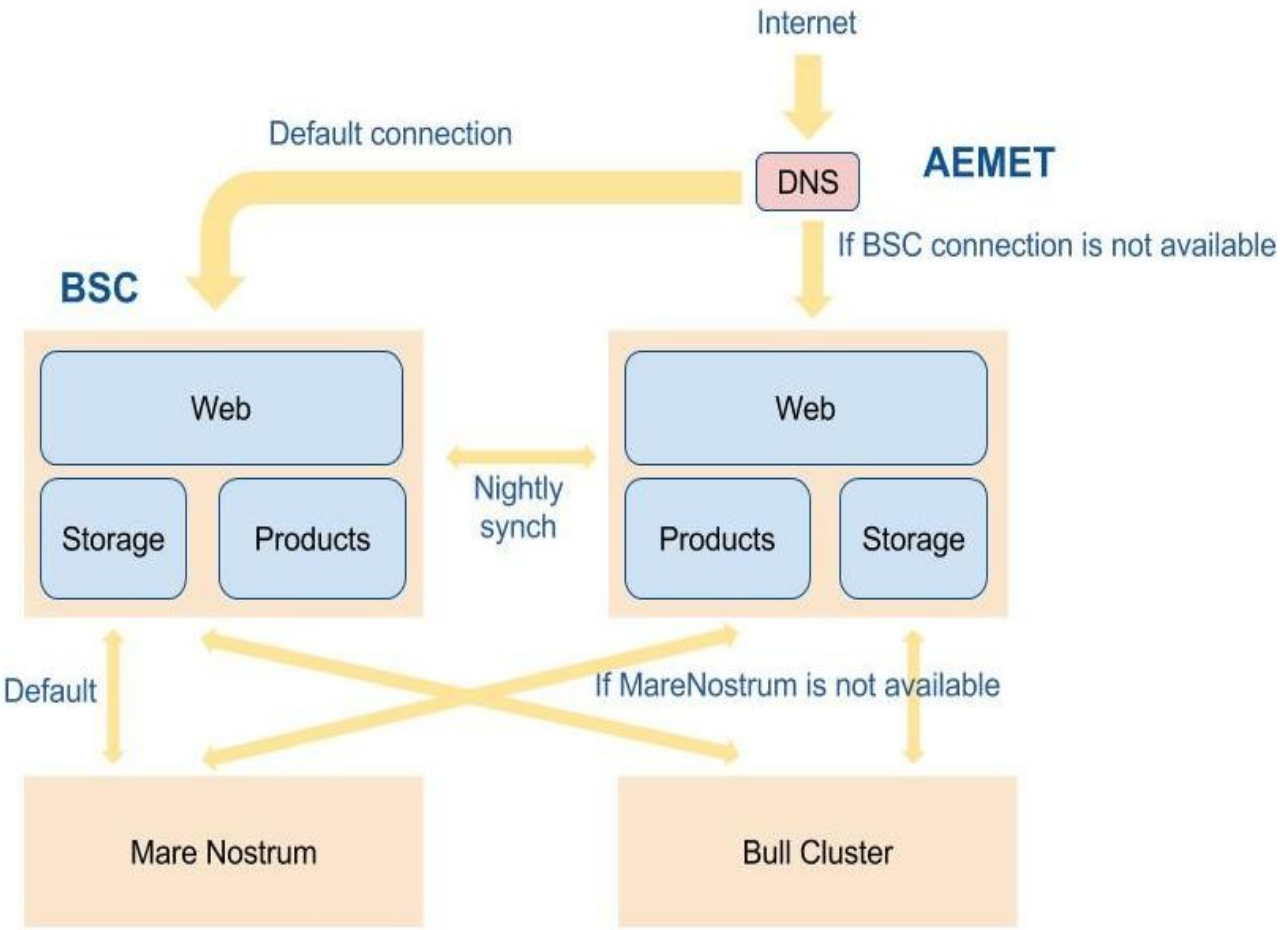

Figure 2: Configuration of the BDFC systems

6. Capacity building

TITLE	**InDust Training School on Dust Products**
TIME	27-29 January 2020
PLACE	Sofia, Bulgaria

This training school was hosted by the National Institute of Meteorology and Hydrology of Bulgaria and organised in the framework of the inDust Cost Action (International Network to Encourage the Use of Monitoring and Forecasting Dust Products, CA16202) and the WMO SDS-WAS NAMEE Regional Center. It was supported by EUMESAT.

It was attended by around 25-30 participants from Turkey, Greece, Bulgaria, Unite Kingdom. Most of them weather forecasters and climatologists from National Meteorological Services and a representative of Rolls-Royce motors company.

Background
Desert dust transport is a global phenomenon. For countries located in and downwind of arid regions, such as Europe, airborne dust presents serious risks to the environment, property and human health. inDust is encouraging the use of monitoring and forecasting dust products to mitigate its harmful effects.

Objective
The main objective of this training school is to build the capacity of participants to use products of dust observation and modelling products and give some insights on impact assessment of dust on air quality and health. The event is targeted to operational and research meteorologists as well as to early career scientists with interest in Earth system sciences.

Agenda and presentations of the training course are available at:
https://earth.bsc.es/indust/lib/exe/fetch.php?media=public:20200127_29_training_school_sofia_bulgaria_ppt.zip

Lecturers:
Emilia Georgieva, National Institute of Meteorology and Hydrology of Bulgaria (NIMH)
Anastasiya Stoycheva, National Institute of Meteorology and Hydrology of Bulgaria (NIMH)
Viktoria Klestanova, National Institute of Meteorology and Hydrology of Bulgaria (NIMH)
Dimitar Stoyanov and Ivan Nedkov, Bulgarian Academy of Sciences (BAS)
M. Dimitrova , Bulgarian Academy of Sciences (BAS)
Ernest WERNER, State Meteorological Agency of Spain (AEMET)
Sara BASART, Barcelona Supercomputing Center (BSC)
José PRIETO, European Organization for Explotation of Meteorological Satellites (EUMETSAT)
Aurelio TOBÍAS, Spanish Council for Scientific Research (CSIC), Spain
Jorge Pey, Spanish Council for Scientific Research (CSIC), Spain
Athanasios Votsis, Finnish Meteorological Institute (FMI)
Goran Pejanovic, Republic Hydrometeorological Service of Serbia, (RHMS)

7. Staff

Ernest Werner, technical director
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 2019 – Feb 2020	34,819	59.535
Mar – May 2020	26.778	44.588
Jun – Aug 2020	21.884	34.503
Sep – Nov 2020	15.473	25.220

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

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

The top five countries ranked by number of visitors are Spain, United States, Slovenia Germany and Iran. A peak of 2,678 users on 24th February was recorded when a dust intrusion affected Europe with significant dust deposition on Pyrenes and Alps and affecting central Europe where strong dust intrusion are more episodic. Thanks to the number of dust intrusion over Europe and the number of sessions and page views have increased. Besides, the Atlantic dust plume that reached the United States has helped to gather interest from America.

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 BDFC carries out. During 2020 we added around 500 new followers to our account (current followers in July 2021 are 3277)

Furthermore, we are about to finish the process of redesigning and improvement of 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 model forecast and evaluation products. The new website are expected to be fully operational in September 2021.

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