WARNING ADVISORY SYSTEM FOR SAND AND DUST STORM IN BURKINA FASO

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TECHNICAL REPORT

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Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Regional Center for Northern Africa-Middle East-Europe (NAMEE)

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Summary

This document describes the design and implementation of a Warning Advisory System (WAS) for sand and dust storm for the thirteen regions in which Burkina Faso is administratively divided. The warning advisory levels are based on the multi-model median forecast produced by the SDS-WAS Regional Center for Northern Africa, Middle East and Europe (https://sds-was.aemet.es/forecast-products/dust-forecasts/ensemble-forecast).

The system has been designed and is operated by State Meteorological Spanish Agency (AEMET) and the Barcelona Supercomputing Center (BSC) in collaboration with the Burkina Faso National Meteorological Agency (ANAM).

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1. Background

Airborne dust presents serious risks for human health. Particles larger than 10 μm are not breathable, thus can only damage external organs – mostly causing skin and eye irritation, conjunctivitis and enhanced susceptibility to ocular infection. However, inhalable particles, those smaller than 10 μm, often get trapped in the nose, mouth and upper respiratory tract, thus can be associated with respiratory disorders such as asthma, tracheitis, pneumonia, allergic rhinitis and silicosis. Moreover, finer particles may penetrate the lower respiratory tract and enter the bloodstream, where they can affect all internal organs and be responsible for cardiovascular disorders.

Some infectious diseases have also been associated with airborne dust. Meningococcal meningitis, a bacterial infection of the thin tissue layer that surrounds the brain and spinal cord, can result in brain damage and, if untreated, death in 50% of cases. Outbreaks occur worldwide, yet the highest incidence is found in the “meningitis belt”, a part of sub-Saharan Africa extending from Senegal to Ethiopia and including the entire territory of Burkina Faso. These outbreaks have a strong seasonal pattern – many studies have linked environmental conditions, such as low humidity and dusty conditions, to the time and place of infections. Researchers believe that inhalation of dust particles in hot dry weather may damage nose and throat mucosa creating favourable conditions for bacterial infection.

Airborne dust has also many negative impacts on agriculture, including reducing crop yields by burying seedlings, causing loss of plant tissue, reducing photosynthetic activity and increasing soil erosion. Indirect dust deposit impacts include filling irrigation canals, covering transportation routes and affecting river and stream water quality.

The Sahara is the major source on Earth of mineral dust, accounting for about half of the 1000-3000 Tg.yr-1 of dust particles emitted globally into the atmosphere. Especially in winter and spring, a large amount of such particles is transported southwards by trade winds, known as Harmattan, affecting mainly the Sahel, but sometimes also regions bordering the Gulf of Guinea.

In 2007, owing the societal needs for monitoring and forecasting dust events, and for assessing and mitigating their negative impacts, World Meteorological Organization (WMO) launched the Sand and Dust Storm - Warning Advisory and Assessment System (SDS-WAS, http://www.wmo.int/sdswas) 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.

In 2013, in view of the demand of many national meteorological services and the good results obtained by the SDS-WAS, which prove the feasibility and the need to begin developing operational services beyond the scope of R&D, the WMO Executive Council designated the consortium formed by the State Meteorological Agency of Spain (AEMET) and the Barcelona Supercomputing Center (BSC) to create in Barcelona the first Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast

(RSMC-ASDF). The Center began operating in February 2014 with the name of Barcelona Dust Forecast Center (https://dust.aemet.es). It generates and distributes dust predictions for Northern Africa (north of equator), Middle East and Europe.

Early Warning Systems (EWS) are well recognized as a critical life-saving tool for floods, droughts, storms, bush-fires, and other hazards. The recorded economic losses linked to extreme hydro-meteorological events have increased nearly 50 times over the past five decades, but the global loss of life has decreased significantly, by a factor of about 10, thus saving millions of lives over this period. This has been attributed to better monitoring and forecasting of hydro-meteorological hazards and more effective emergency preparedness. However, despite the availability of tools for monitoring and prediction, EWS for airborne dust are practically non-existent.

This document describes the design and implementation of a Warning Advisory System (WAS) for sand and dust storm for the thirteen regions in which Burkina Faso is administratively divided.

2. Burkina Faso

Burkina Faso is a landlocked country of West Africa, divided into 13 administrative regions (in red on Figure 1). It lies mostly between latitudes 9° and 15°N and longitudes 6°W and 3°E, covering an area of 274,200 square kilometres. Its population is estimated at over 17.5 million. Agriculture employs the vast majority of the work force and accounts for an estimated 30 percent of Gross Domestic Product. Cotton is the main crop, accounting for about half of total exports. Cereals, with increasing importance in recent years, have become the other pillar of the country's agricultural production.

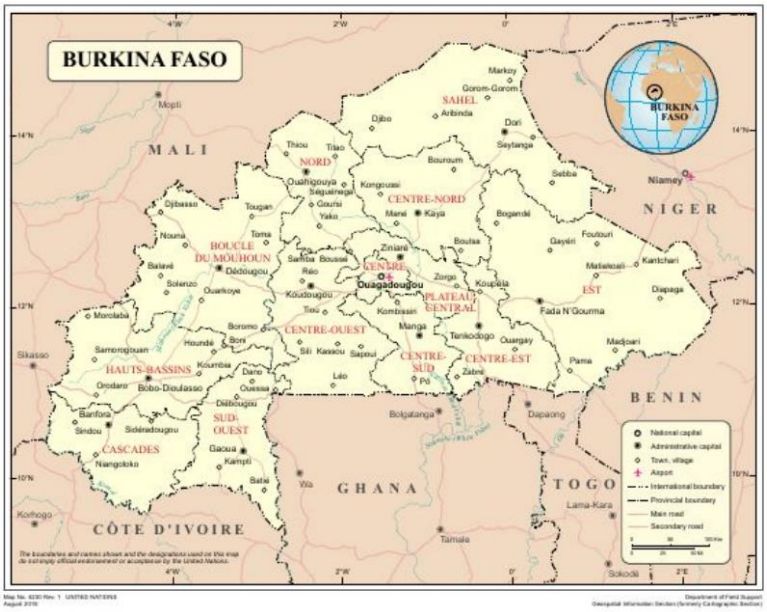

Figure 1: Map of Burkina Faso

Burkina Faso, located in the transition zone between the Saharan desert and the humid equatorial region of Africa, has a primarily tropical climate with a rainy season from May/June through September, a little shorter in the northern part of the country, and a dry season, when a hot dry wind called Harmattan blows from the Sahara. Three climatic zones can be identified:

- The Sahel, north of 13.5°N, typically receives less than 600 mm of rainfall and temperatures are high.
- The Sudan-Sahel, a tropical savannah extending between 11.5 and 13.5°N, receives 600-900 mm of rainfall
- The Sudan-Guinea, south of 11.5°N, receives more than 900 mm of rainfall and has cooler average temperatures.

3. Warning Advisory System for airborne dust in Burkina Faso

The core of the Warning Advisory System (WAS) is a universally understood system based on colour-coded maps. Every day, the Regional Center for Northern Africa, the Middle East and Europe of the WMO Sand and dust Storm – Warning Advisory and Assessment System (SDS-WAS, https://sds-was.aemet.es) is producing two maps with the warning levels for the next two days (D+1 and D+2) in the country's thirteen regions. This clear, concise information is expected to help planning any activity vulnerable to airborne dust or activate services and procedures aimed at the mitigation of damages caused in agriculture, public health or any other vulnerable sector.

The warning advisory levels are based on the multi-model median forecast produced by the SDS-WAS Regional Center for Northern Africa, Middle East and Europe (https://sds-was.aemet.es/forecast-products/dust-forecasts/ensemble-forecast) that is described in the next section of this document. The warning level for each region is set according to the highest concentration value expected for the day at any model grid-point within the region.

The warning advisory thresholds have been set based on a percentile-based approach, so that they may be higher for the northern regions, prone to high dust concentrations, than for the southern ones, where heavy dust events are not so common. First, the daily series of maximum concentration (considering all the grid points in the corresponding province) predicted by the SDS-WAS multi-model median for each province between 2013 and 2017 was built. This time series is used to define the corresponding thresholds for high (80^{th} percentile), very high (90^{th} percentile) and extremely high (97.5^{th} percentile) concentrations of airborne dust (see values at table 1). As a result, each region in Burkina Faso is colour-coded on the map to represent one out of four levels of warning advisory:

- red to indicate extremely high concentration of airborne dust,
- orange to indicate very high concentration,
- yellow to indicate high concentration,
- green, indicating that dusty weather is not expected.

Table 1. Thresholds for warning advisory levels and number of grid-points at the different regions used to determine the warning advisory level.

Region	Yellow (80th percentile)	Orange (90th percentile)	Red (97.5th percentile)	Number of grid-points
Boucle du Mouhoun	235	306	438	10
Cascades	157	212	321	5
Centre-Est	218	286	419	4
Centre-Nord	259	329	468	7
Centre-Ouest	217	277	396	8
Centre-Sud	216	277	401	5
Centre	210	278	392	1
Est	277	355	511	17
Haut-Bassins	193	255	364	9
Nord	263	333	502	6
Plateau Central	215	287	393	1
Sahel	360	463	702	11
Sud-Ouest	172	228	342	6

Maps showing the warning advisory levels for D+1 and D+2 (Figure 2) are daily available at https://sds-was.aemet.es/forecast-products/burkina-faso-dust-alert since 0 UTC of D+1. Maps released the previous days are also available on the website in order to facilitate evaluation of the WAS performance.

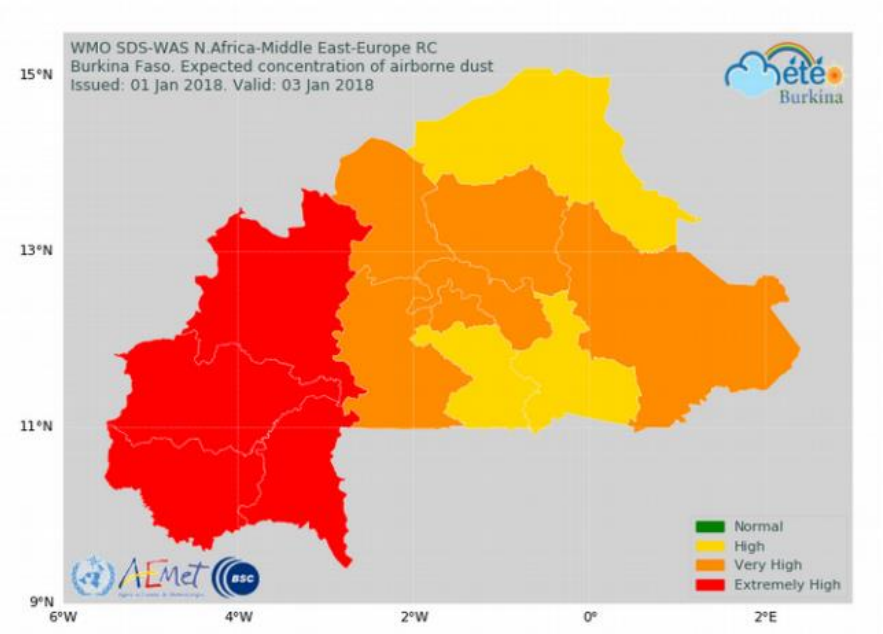

Figure 2: Warning advisory levels issued on 1 Jan 2018 and valid for 3 Jan 2018

The system is complemented with the automatic sending of e-mails to predefined distribution lists.

The WAS has been designed and is operated by State Meteorological Spanish Agency (AEMET) and the Barcelona Supercomputing Center (BSC) in collaboration with the Burkina Faso National Meteorological Agency (ANAM). It is released by the WMO SDS-WAS Regional Center for Northern Africa, Middle East and Europe.

4. SDS-WAS Multi-model median product

The exchange of forecast products released by different national meteorological services and other research or operational institutions is the basis for the generation of the SDS-WAS multi-model ensemble products (https://sds-was.aemet.es/forecast-products/dust-forecasts). The exercise involves forecasts of dust surface concentration, which is the parameter used for the present WAS, and dust optical depth at 550 nm, with lead times from 0 to 72 h, every 3 hours. As seen in Table 2, some contributing models are global and others regional. For all of them, only results in a domain bounded by the following coordinates: 25°W to 60°E of latitude and 0° to 65°N of longitude are considered. This domain is intended to cover the main source areas in Northern Africa and the Middle East, as well as the main transport routes and deposition zones from the equator to the Scandinavian Peninsula.

In order to generate the SDS-WAS multi-model product, the predictions are bi-linearly interpolated to a common grid mesh of 0.5 x 0.5 degrees. Then, two products describing centrality (multi-model median and mean) and two products describing spread (standard deviation and range of variation) are daily computed: https://sds-was.aemet.es/forecast-products/dust-forecasts/ensemble-forecast. In particular, in most regions and time periods, the multi-model median shows better verification scores than any of the contributing models (check the model evaluation results in https://sds-was.aemet.es/forecast-products/forecast-evaluation).

Table 2 Models contributing to the WMO SDS-WAS ensemble prediction

Model	Institution	Domain
BSC-DREAM8b	Barcelona Supercomputing Center	Regional
CAMS	European Center for Medium-range Weather Forecast	Global
DREMA8-NMME-MACC	Republic Hydrometeorological Service of Serbia	Regional
NMMB/BSC-Dust	Barcelona Supercomputing Center	Regional
Met UM	UK Met Office	Global
GEOS-5	US National Aeronautics and space Administration	Global
NGAC	US National Centers for Environmental Prediction	Global
WMA RegCM4	Egyptian Meteorological Authority	Regional
DREAMABOL	Italian National Research Council	Regional
WRF-Chem	National Observatory of Athens	Regional
SILAM	Finnish Meteorological Institute	Regional
LOTOS-EUROS	Netherlands Organisation for Applied scientific Research	Regional