WORLD METEOROLOGICAL ORGANIZATION

REGIONAL CENTER FOR NORTHERN AFRICA, MIDDLE EAST AND EUROPE OF THE WMO SAND AND DUST STORM WARNING ADVISORY AND ASSESSMENT SYSTEM

Activity Report 2010-2012

Enric Terradellas (AEMET), José M. Baldasano (BSC-CNS) and Emilio Cuevas (AEMET)

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Regional Center for Northern Africa, Middle East and Europe of the WMO SDS-WAS
Website: sds-was.aemet.es
Email: sdswas@aemet.es
Postal address: Jordi Girona, 31; 08034 BARCELONA, Spain
Tel: (+34) 934137612

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Foreword

The Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) research project, jointly coordinated by the WMO Global Atmosphere Watch (GAW) Programme and the WMO World Weather Research Programme (WWRP), was initiated in mid 2000s as a response to the need expressed by a number of WMO Members to more accurately monitor and predict the atmospheric dust storm process, and to better understand its impacts to weather and climate.

The Regional Center for Northern Africa, Middle East and Europe (NA-ME-E) was established in 2007 to coordinate SDS-WAS activities within this region. The Center, as a consortium of the Spanish State Meteorological Agency (AEMET) and the Barcelona Supercomputing Center – National Supercomputing Center (BSC-CNS), soon evolved into a structure that hosted international and interdisciplinary research cooperation between numerous organizations in the region and beyond, including national meteorological services, environmental agencies, research groups and international organizations. The Center's web portal became a place where visitors could find the latest dust-related observations and the most up-to-date experimental dust forecasts.

The Center's activities include the provision of online comparisons and intercomparisons between various centers' models and model against observations, and daily ensemble experimental forecasts. The Center further coordinated WMO SDS-WAS participation in several scientific studies: together with the World Health Organization (WHO), assessing dust impacts on health; together with The Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP), investigating a role of mineral dust in marine bioproduction; within WMO Precipitation Chemistry programme, contributing to a related global assessment. The potential usefulness of the experimental dust forecasting was recognised, resulting in a recent proposal to nominate the consortium of BSC-CNS and AEMET to host the first CBS Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast (RSMC-ASDF).

This report presents the Center's activities in the 2010-2012 period. It reports on its efforts to build capacity in the region and to develop user services to reduction of adverse impacts of dust in countries heavily impacted by dust storms. There remain important SDS-WAS research issues to be considered and it is hoped that the Center will continue to play a coordinating role in addressing these. These research topics include the assimilation of observations in numerical dust prediction models; role of dust chemical/mineral composition on health and environment; direct and indirect interactions of dust and the atmosphere; introduction of new generation of measurements (e.g. ceilometers) to better monitor dust process.

1. BACKGROUND

When winds are strong, large amounts of sand and dust can be lifted from bare, dry soils into the atmosphere and transported downwind affecting regions hundreds to thousands of kilometres away. A dust storm, or sandstorm, is a meteorological hazard common in arid and semi-arid regions (Fig. 1). It arises when a gust front passes or when the wind force exceeds the threshold value for the loose sand and dust to be removed from the dry surface. In desert areas dust and sand storms are most commonly caused by either thunderstorm outflows, or by strong pressure gradients which cause an increase in wind velocity over a wide area. Drought and wind contribute to the emergence of dust storms, as do poor farming and grazing practices or inadequate water management by exposing the dust and sand to the wind.

For countries in and downwind of arid regions, airborne sand and dust presents serious risks to the environment, property and human health. Impacts on health include respiratory and cardio-vascular problems, eye infections and in some regions, diseases such as meningitis and valley fever. Dust can carry irritating spores, bacteria, viruses and persistent organic pollutants. It can also transport nutrients to parts of the world oceans and positively affect marine biomass production. Other impacts include negative effects on the ground transport, aviation, agriculture and visibility. The Inter-governmental Panel on Climate Change (IPCC) recognizes dust as a major component of atmospheric aerosol, an essential climate variable. More and more, dust particles are considered by atmospheric researchers to have important effects on weather through feedback on atmospheric dynamics, clouds and precipitation formation. For all these reasons, there is a need for international coordination of a diverse community dealing with sand and dust storms and their societal impacts.

Figure 1 - Incoming sand storm at Abéché airport, Chad, in the afternoon of 24 June 2005

2. SDS-WAS HISTORY

On 12-14 September 2004, an International Symposium on Sand and Dust Storms was held in Beijing, China, hosted by the China Meteorological Agency (CMA). It was followed by a World Meteorological Organization (WMO) Experts Workshop, whose recommendations led to a proposal to create a WMO Sand and Dust Storm Project jointly coordinated by the WMO Global Atmosphere Watch (GAW) Programme and the WMO World Weather Research Programme (WWRP). The proposal was approved by the steering body of the WWRP in 2005. More than forty member countries expressed interest in participating in activities to improve capacities for more reliable sand and dust storm monitoring, forecasting and assessment. A Steering committee for the Sand and Dust Storm Project was formed and in 2006, in a meeting in Shanghai, China, it proposed the development and implementation of a Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS).

In May 2007, the 14th Congress of the WMO approved the launching of the SDS-WAS system 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. The SDS-WAS system, as an international framework linking institutions involved in sand and dust research, operations and delivery of services, addresses the following objectives:

- Provide user communities access to forecasts, observations and information of sand and dust storms through regional centers connected to the WMO Information System (WIS) and the World Wide Web
- Identify and improve sand and dust products through consultation with the operational and user communities
- Enhance operational sand and dust forecasts through technology transfer from research to application
- Improve forecasting and observation technology through coordinated international research and assessment
- Build capacity of countries to utilize sand and dust observations, forecasts and analysis products for meeting societal needs
- Build bridges with other communities conducting aerosol related studies (air quality, biomass burning, etc.)

The Congress also welcomed the strong support of Spain to host the Regional Center for Northern Africa, Middle East and Europe (NA-ME-E) and to play a lead role in implementation of SDS-WAS. This support had been expressed in a letter of the permanent Representative of Spain with WMO dated 1 March 2007.

In November 2007, Spain hosted the WMO/GEO Expert Meeting on SDS-WAS (Fig. 2) at the Barcelona Supercomputing Center – National Supercomputing Center (BSC-CNS). This consultation meeting brought about one hundred international experts together from research, observations, forecasting and user communities to discuss the way forward to the SDS-WAS implementation. In November 2008, the first meeting of the Regional Steering Group (RSG) for NA-ME-E was held in Tunis-Carthage (Tunisia). Finally, on 26 April 2010, the Spanish State Meteorological Agency (AEMET) and the BSC-CNS signed the agreement to create the Regional Center, which started operations on 2 May of that year.

Figure 2 - WMO/GEO Expert Meeting on SDS-WAS held at the Barcelona Supercomputing Center – National Supercomputing Center (BSC-CNS) 7-9 November 2007

3. SDS-WAS: STRUCTURE

The SDS-WAS system works as an international network of research institutes, operational centres and users, organized through regional nodes and coordinated by the SDS-WAS Steering Committee.

At the regional level of nodes, SDS-WAS is structured as a federation of partners. The term federation implies an organized structure following minimum global standards and rules of practice. A federated approach allows flexibility, growth and evolution, while preserving the autonomy of individual institutions. Activities within each node are led by a SDS-WAS Regional Steering Group (RSG) and coordinated by a Regional Center (Fig. 3).

Two nodes were in operation on 31st December 2012:

- Regional Node for Asia, coordinated by a Regional Center in Beijing, China, that is hosted by the CMA
- Regional Node for Northern Africa, Middle East and Europe, coordinated by a Regional Center in Barcelona, Spain, hosted by AEMET and the BSC-CNS

The composition of the RSG for NA-ME-E as at 31st December 2012 is listed in Table 1.

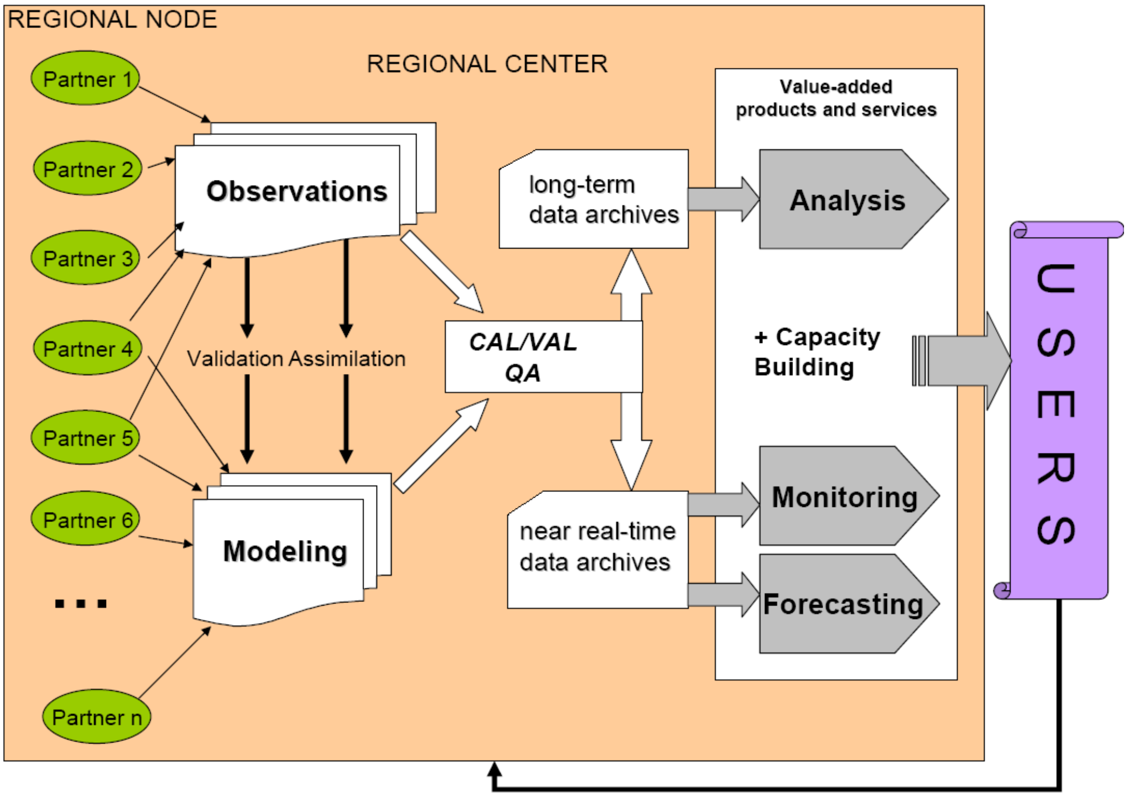

Figure 3 - Flow of information between various SDS-WAS regional components

Table 1 - Composition of the SDS-WAS Regional Steering Group for NA-ME-E as at 31st December 2012

Member	Institution
Michael SCHULZ (Chair)	Norwegian Meteorological Institute (NMI), Norway
José María BALDASANO (Regional Center)	Barcelona Supercomputing Center – National Supercomputing Center (BSC-CNS), Spain
Emilio CUEVAS-AGULLO (Regional Center)	Spanish State Meteorological Agency (AEMET), Spain
Humaid ALBADI	Oman Meteorological Department (OMD), Oman
Olivier BOUCHER	Laboratory of Dynamic Meteorology (LMD), France
George KALLOS	University of Athens, Greece
Benjamin LAMPTEY	Regional Maritime University (RMU), Ghana
Jean-Jacques MORCRETTE	European Centre for Medium-Range Weather Forecasts (ECMWF)
Goran PEJANOVIC	Republic Hydrometeorological Service of Serbia (RHSS), Serbia
Ina TEGEN	Leibniz Institute for Tropospheric Research (LITR), Germany
David WALTERS	U. K. Met Office (UKMO), U. K.
Liisa JALKANEN	World Meteorological Organization (WMO)
Tetsuo NAKAZAWA	World Meteorological Organization (WMO)
Slobodan NICKOVIC	World Meteorological Organization (WMO)

The following sections describe the most relevant activities carried out by the Regional Center for NA-ME-E since it was established until the end of 2012.

4. DESIGN AND IMPLEMENTATION OF THE WEB PORTAL

The web portal of the Regional Center (http://sds-was.aemet.es) has been designed to allow the user access to observational and forecast products, as well as to sources of basic information. In particular, the portal provides National Meteorological and Hydrological Services (NMHSs) with the necessary information to issue operational predictions and warning advisories related to the dust content in the atmosphere. The site was first released in November 2009 and became fully operational in early 2010. The content is managed using the software Plone 4.x.

Efforts have been aimed to progressively increase the amount and quality of the content published, with special emphasis on observational and forecast products.

4.1 Observational data

A global observational network is crucial to any forecast and early warning system for real-time monitoring, validation and evaluation of forecast products, and possible data assimilation systems. The main data sources in SDS-WAS are in-situ aerosol measurements performed at air quality monitoring stations, visibility and present weather from meteorological stations and ground-based (lidar and photometers) and satellite remote-sensing products.

4.1.1 In-situ measurements

For the purpose of SDS-WAS, air-quality monitoring stations give mass concentration of total suspended particles (TSP) or particulate matter with aerodynamical diameter less than 10 or 2.5 µm (PM10, PM2.5). This information is very helpful to monitor dust events. However, it should be taken into account that these networks measure the mass of all types of particles, not just dust. That is why it is so important to note the location of the stations, often set in (or near) large cities, industrial complexes or roads, where the abundance of anthropogenic aerosol can mask the presence of mineral dust.

The filter-based gravimetric sampling technique is the European reference method to measure particle concentration. Its results take days or weeks to be available and reflect the average conditions over a specific time period, usually 24 hours. Automated devices can continuously estimate the particle concentration, but require application of correction factors to the data so that the results are comparable.

The web portal provides access to monthly plots with hourly data recorded by the 16 air quality monitoring stations listed in Table 2: http://sds-was.aemet.es/forecast-products/dust-observations/in-situ-measurements. Most of these stations have been selected for their rural location, away from important sources of anthropogenic pollution, as well as for their spatial representativeness. Access to archived plots is also available online. Figure 4 displays data recorded in Granadilla (Canary Islands, Spain) in August 2012 and clearly shows the occurrence of successive dust events.

Table 2 - Air-quality monitoring stations whose data are routinely plotted on the Regional Center web portal

Site name	Longitude	Latitude	Country
Granadilla	16.58ºW	28.11ºN	Spain
Costa Teguise	13.52ºW	28.99ºN	Spain
O Saviñao	7.70ºW	42.63ºN	Spain
Peñausende	5.90ºW	41.24ºN	Spain
Campisábalos	3.14ºW	41.28ºN	Spain
La Tardière	0.75ºW	46.65ºN	France
Zarra	1.1ºE	39.1ºN	Spain
Bellver de Cerdanya	1.78ºE	42.37ºN	Spain
Payerne	6.94ºE	46.81ºN	Switzerland
Magadino Cadenazzo	8.93ºE	46.16ºN	Switzerland
Claut – Località P. Pinedo	12.47ºE	46.26ºN	Italy
Gharb	14.19ºE	36.07ºN	Malta
Morska Sobota	16.19ºE	46.66ºN	Slovenia
K-puszta	19.55ºE	46.97ºN	Hungary
Ayia Marina	33.06ºE	35.04ºN	Cyprus

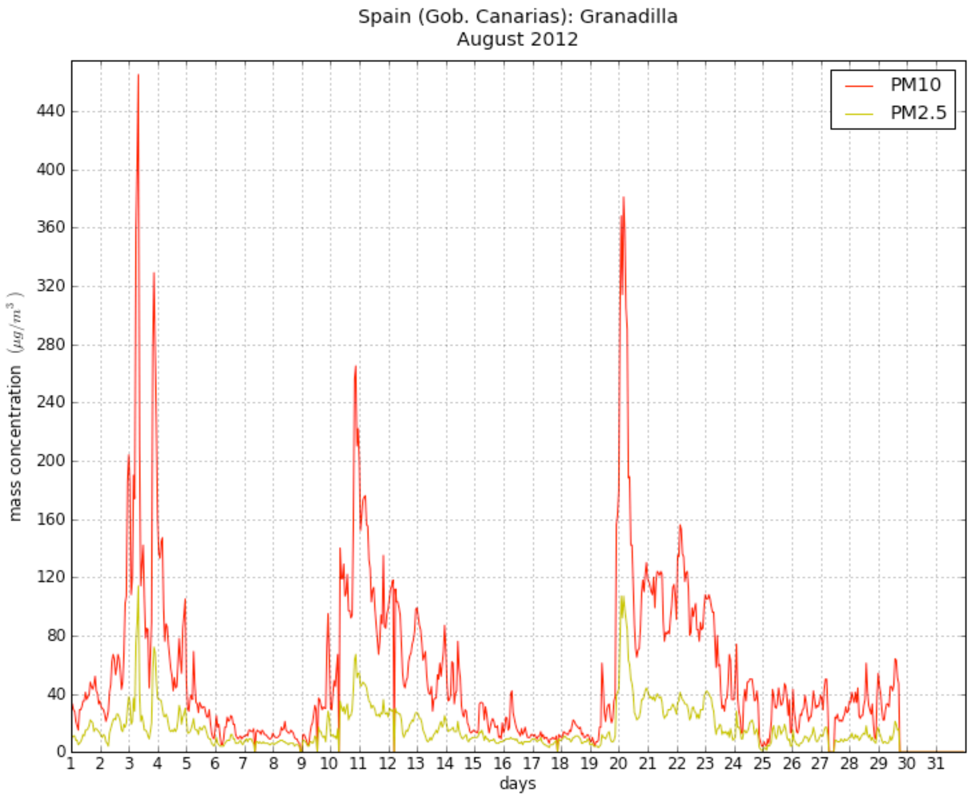

Figure 4 - PM10 and PM2.5 records from Granadilla (Canary Islands, Spain) for August 2012

Information from air quality monitoring stations is complemented with back-trajectories, which allow investigating the origin of the air mass present over a particular site. They are computed using the 'Hybrid Single Particle Lagrangian Integrated Trajectory' (HYSPLIT) model, developed by the U. S. National Oceanic and Atmospheric Administration - Air Resources Laboratory (NOAA - ARL). 60-hour back trajectories ending at 12 UTC at 0, 500 and 1000 m above each station are daily presented at http://sds-was.aemet.es/forecast-products/dust-observations/in-situ-measurements, where there is also access to archived plots. The back-trajectories are computed using the most recent integration of the U. S. National Centers for Environmental Prediction (NCEP)'s Global Forecast System (GFS).

4.1.2 Visibility observations

In-situ measurements of particulate matter concentration are systematic and with high spatial density in Europe, but very sparse, discontinuous and rarely near-real-time available close of the main source regions. Since the data sets of weather records have an excellent spatial and temporal coverage, visibility data included in meteorological observations can be used as an alternative way to monitor dust concentration. Visibility is mainly affected by the presence of aerosol and water in the atmosphere. Therefore, the use of visibility data has to be complemented with information on present weather to flag those cases where visibility is reduced by the presence of hydrometeors (fog, rain, etc.). A 'Google Maps'-based tool (Fig. 5) has been developed to display visibility and present weather from METAR aviation weather reports. It provides real-time information from a large number of airports in Southern Europe, Northern Africa and Middle East: http://sds-was.aemet.es/forecast-products/dust-observations/visibility

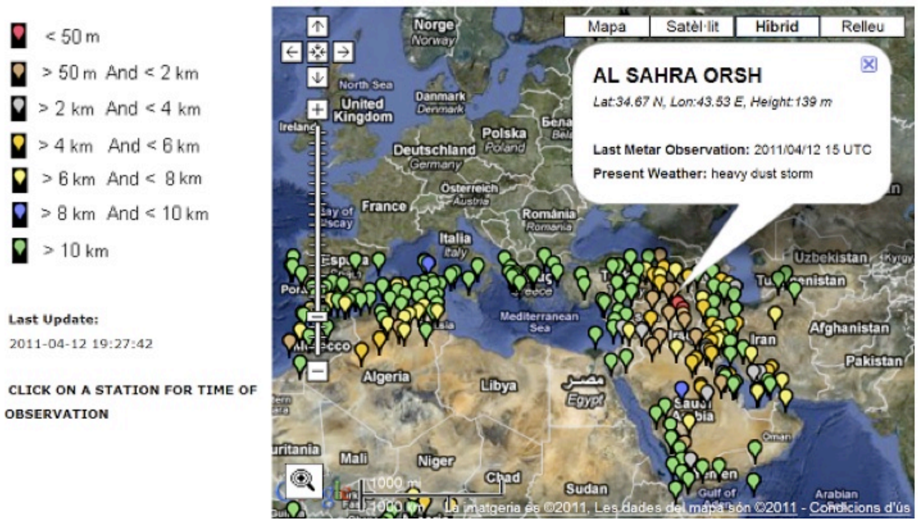

Figure 5 - Low visibility observed during the dust event of 12 April 2011 in the Middle East

4.1.3 Sun-photometric measurements

Direct-sun photometric measurements are a powerful tool for remote sensing of the atmosphere allowing retrieval of column-integrated aerosol microphysical and optical properties, very useful for dust monitoring. In particular, the Aerosol Robotic Network (AERONET) is a comprehensive set of continental and coastal sites complemented with several sparsely-distributed oceanic stations that provides large and refined datasets in near-real-time (NRT). Properties such as aerosol optical depth (AOD) that integrate the contribution of different aerosol types are complemented with spectral information that allows a crude speciation. A major shortcoming of these measurements is their unavailability under cloudy skies and during nighttime. The web portal includes a description of the AERONET network and a link to its data: http://sds-was.aemet.es/forecast-products/dust-observations/aeronet. Figure 6 shows a case when progressive increase of the AOD and decrease of the Ångström exponent (AE) indicate a dust outbreak over Cape Roca, in Portugal.

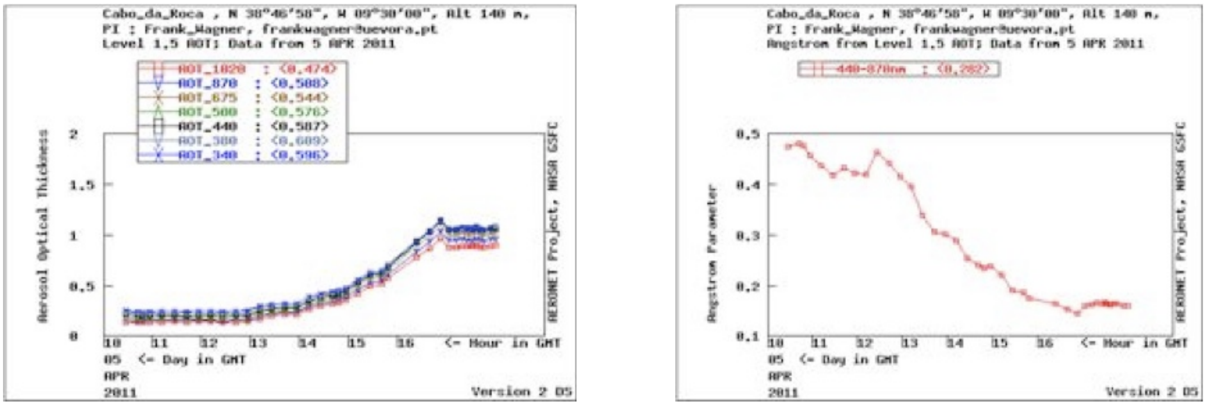

Figure 6 - Progressive increase of the AOD and decrease of the 440-870 nm-Angström exponent (AE) indicating a dust outbreak over Cape Roca, Portugal, on 5 April 2011

4.1.4 Lidar

LIDAR (LIght Detection And Ranging) is a remote sensing system that illuminates a target with an ultraviolet, visible or near-infrared beam and analyzes the reflected light. Very short laser pulses of light are sent into the atmosphere and partially scattered back to the lidar by gases and aerosols in the air. The position, concentration and some information on the properties of the scatters are determined from the measured backscattered energy and the time delay between the signal emission and reception. The aerosol lidar systems estimate vertical profiles of particulate matter from the backscatter profiles.

Comparison of backscatter at different wavelengths provides some indication of particle size. Finally, if polarized light is used, the non-spherical character of particles can be determined: since dust particles are usually less spherical than other aerosol types, the method allows distinction between mineral dust and other pollutants.

The portal provides access to different lidar resources through the page http://sds-was.aemet.es/forecast-products/dust-observations/lidars

- EARLINET quicklooks. The European Aerosol Research Lidar Network (EARLINET) is an aerosol network with almost 30 lidar stations in Europe
- MPLNET data. The NASA Micro-Pulse Lidar Network (MPLNET) is a federated network of micro-pulse lidar systems designed to measure aerosol and cloud vertical structure continuously, day and night, over long time periods
- CALIPSO products. CALIPSO is an environment satellite that flies a 3-channel lidar with a suite of passive instruments designed to assess the radiative effects of aerosol and clouds.

4.1.5 Satellite products

The satellite products have the advantage of a large spatial coverage and a regular and quick availability. However, satellite measurements are highly integrated both over the atmospheric column and over all aerosol components. Moreover, in the visible and near-infrared region of the electromagnetic spectrum, dust has a limited detectability over bright surfaces such as deserts, which are the main sources.

The EUMETSAT RGB-dust product is generated through a combination of three different infrared channels of the SEVIRI radiometer travelling onboard the Meteosat Second Generation satellites. It is designed to follow day and night evolution of the dust plumes both over land and ocean. It makes use of the differential emissivity of the atmospheric dust and the desert surface over the infrared band of the spectrum. Daytime, it also exploits the temperature difference between the hot desert surface and the colder dust cloud. Dust appears pinkish or magenta in colour, whereas the dry land surface (desert) does light bluish in the daytime and light greenish at night (Fig. 7). The web portal presents hourly images and 24-hour animations, as well as access to archived products: http://sds-was.aemet.es/forecast-products/dust-observations/msg-2013-eumetsat. The temporal resolution and the quick availability of this product make it ideal for dust monitoring.

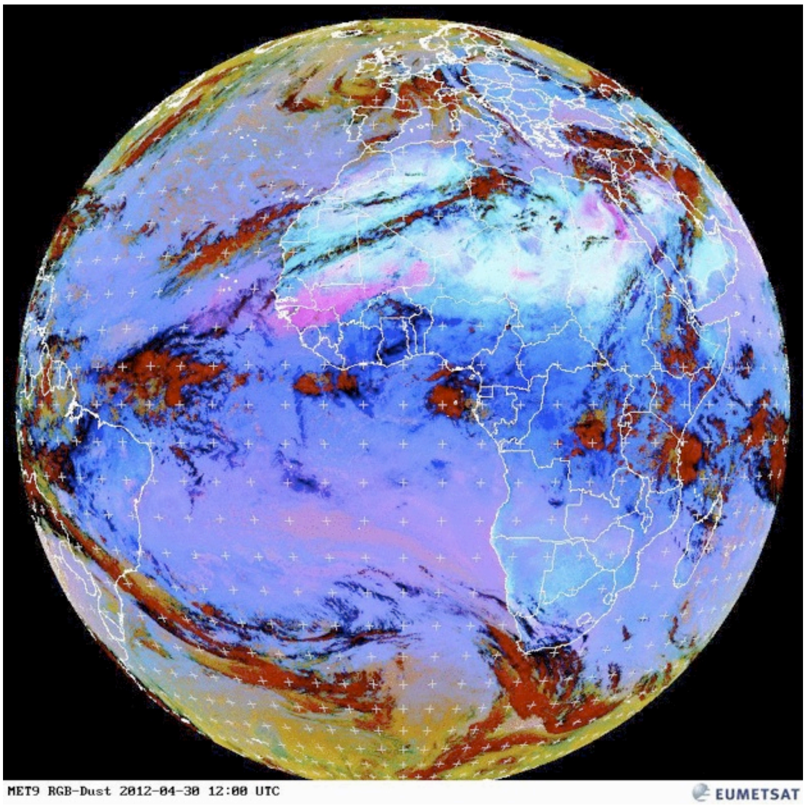

Figure 7 - The EUMETSAT RGB-dust product from 30 April 2012 at 12:00 shows a dust cloud extending from Central Sahara to the Eastern tropical Atlantic. Other dust clouds are visible in Chad, around the Bodélé depression and in Egypt

The U. K. Met Office produces a quantitative retrieval of dust optical depth (DOD) over land from SEVIRI (Figure 8). It is based on empirical relationships between the radiance measured by the SEVIRI infrared channels and the DOD at 550 nm. The web portal presents hourly images and 24-hour animations as well as access to archived images at: http://sds-was.aemet.es/forecast-products/dust-observations/msg-2013-u.k.-met-office

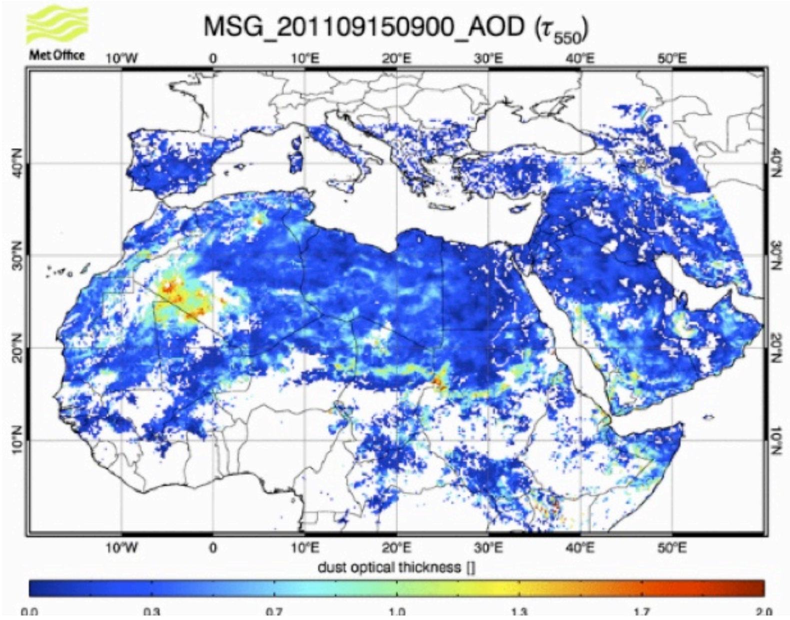

Figure 8 - The U. K. Met Office dust product for 15 September 2011 at 09:00 shows a dust cloud over southern Algeria and Northern Mali

The portal also offers links to different products from polar-orbiting satellites that can be useful for dust monitoring:

- The OMI instrument on board Aura satellite provides an aerosol index, which is an estimation of the aerosol contents retrieved from the measurement of the backscattered ultraviolet radiation and its comparison with that of a purely molecular atmosphere. The product is available at http://sds-was.aemet.es/forecast-products/dust-observations/omi with a 2-day delay.
- The Moderate resolution Imaging Spectrometer (MODIS) flies aboard Aqua and Terra satellites performing measurements in 36 channels of the solar to thermal infrared spectral region, between 0.41 and 14.2µm, with high spatial resolution (up to 250m at nadir). The true colour composites (Fig. 9) are available from http://sds-was.aemet.es/forecast-products/dust-observations/modis
- PARASOL is a research satellite that carries a wide-field imaging radiometer/polarimeter called POLDER, which is designed to improve our knowledge of the radiative and microphysical properties of clouds and aerosols. POLDER-based products are available at http://sds-was.aemet.es/forecast-products/dust-observations/parasol

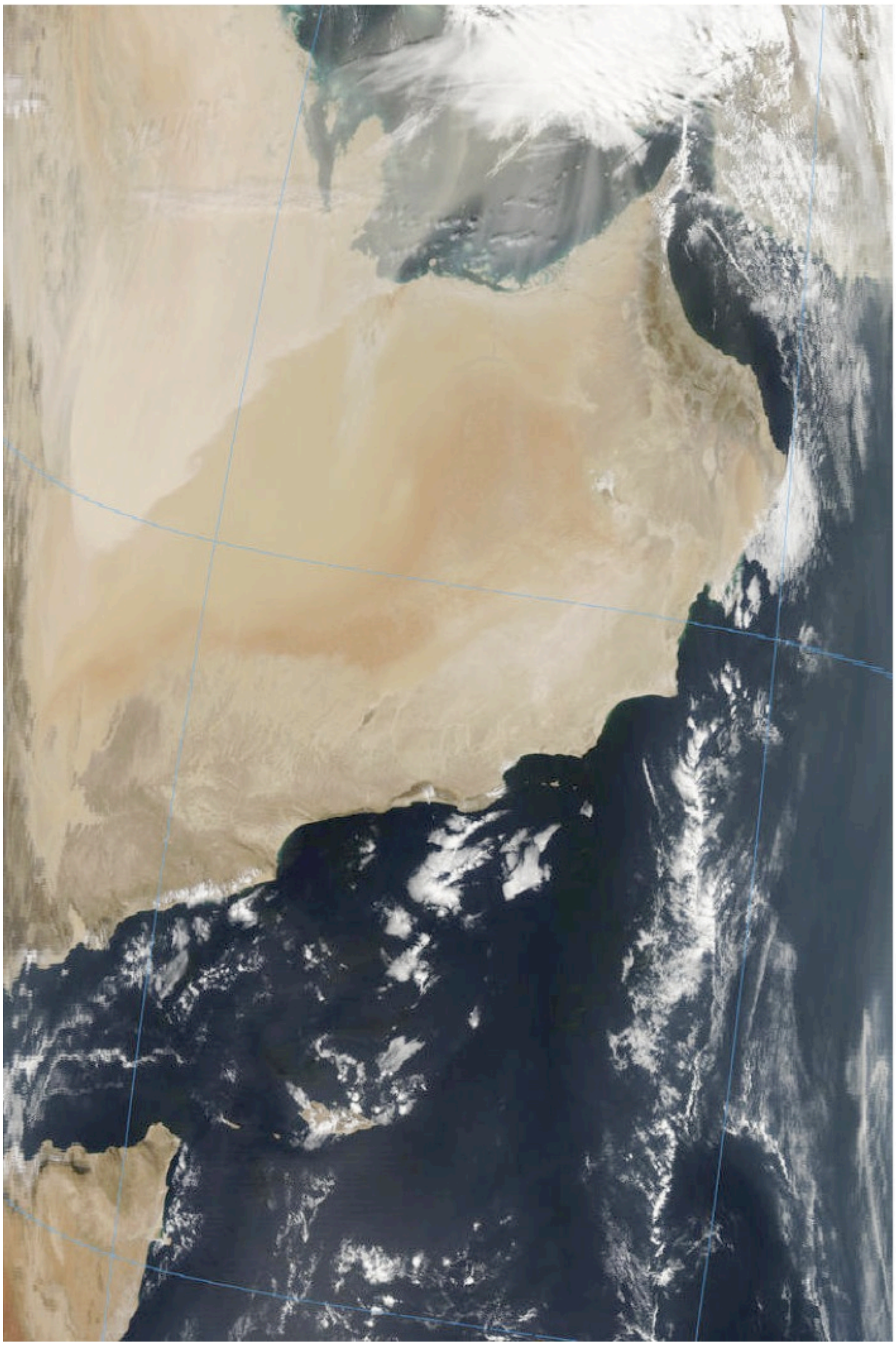

Figure 9 - The Aqua/MODIS true-colour picture of 2 February 2012 at 09:45 shows a dust event over the Arabian Peninsula and Persian Gulf

4.2 Forecast products

DREAM was the first regional dust model, in which dust concentration was built as a prognostic variable in the equations of the atmospheric driver. In 1995, it was run during several months by the Tunisian Meteorological Service. Quasi-operational and operational forecasts have since then become available from a number of numerical weather prediction and research centres around the world.

The page http://sds-was.aemet.es/forecast-products/dust-forecasts provides links to dust forecasts issued by different numerical models. These models may have very different characteristics (global or regional coverage, horizontal and vertical resolutions, dust emission and deposition parameterizations, presence or absence of data assimilation, feedback to the meteorological model, etc.). Information on the characteristics and configurations of the models can be found on their respective websites. The list of models is specified on Table 3.

Table 3 - Models whose predictions are accessible from the Regional Center web portal

Model	Institution
BSC-DREAM8b	Barcelona Supercomputing Center – National Supercomputing Center (BSC-CNS)
MACC	European Center for Medium-Range Weather Forecast (ECMWF)
LMDzt-INCA	French Climate and Environment Sciences Laboratory (LSCE)
PREV'AIR (MOCAGE, CHIMERE)	Météo-France
CHIMERE	French Laboratory of Dynamical Meteorology (LMD)
SKIRON	University of Athens
TAU-DREAM-8b	Tel-Aviv University
NAAPS	U. S. Naval Research Laboratory
DREAM8-NMME-MACC	South Eastern European Virtual Climate Change Center (SEEVCCC)
MetUM	U. K. Met Office
TSMS/BSC-DREAM8b	Turkish State Meteorological Service (TSMS)
GEOS-5	U. S. National Aeronautics and Space Administration (NASA)
NMMB-BSC/Dust	Barcelona Supercomputing Center – National Supercomputing Center (BSC-CNS)
NGAC	National Centers for Environmental Prediction (NCEP)

The products described in Section 5, generated by the SDS-WAS Joint Visualization and Evaluation of Dust Models initiative, can also be accessed from the above mentioned page. In particular, the page on compared dust forecasts http://sds-was.aemet.es/forecast-products/dust-forecasts/compared-dust-forecasts daily offers side-by-side 48-hour predictions released by different forecast systems.

Besides forecast products, dust models can provide information on the average dust distribution over specific time periods. In particular, the Regional Center generates monthly averages of surface concentration and column-integrated dust load (Fig. 10). These products have been especially designed for the African Center of Meteorological Application for Development (ACMAD), an institution with that there is close collaboration, and that regularly releases the time-averaged products in its climate and health bulletins.

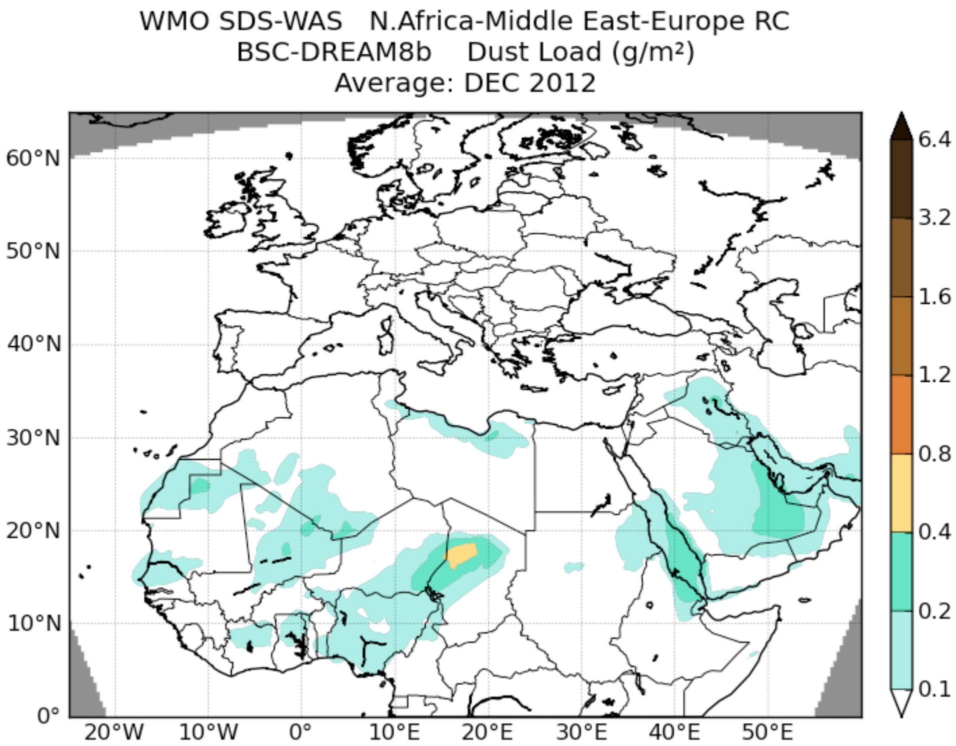

Figure 10 - Average column-integrated dust load in December 2012 computed from the BSC-DREAM_v2 forecasts

4.3 Miscellaneous information

In addition to observational and forecast products, the web portal offers miscellaneous information on actions carried out within the framework of the WMO SDS-WAS as well as on resources, news and events that are related to its subject.

The home page of the web portal has been designed to facilitate access to the most outstanding content, to the latest news and to information on upcoming events. Furthermore, a Newsletter service has been created to periodically release information on ongoing actions and latest news. The five mailing lists are mentioned in Table 4.

Table 4 - Mailing lists for distribution of newsletters

Newsletter services
Steering Group
Partners
Students
Modellers
Public Newsletter

5. JOINT VISUALIZATION AND EVALUATION OF NUMERICAL DUST MODELS

The exchange of forecast model products is recognized as a core part of the Implementation Plan of the WMO SDS-WAS and as a basis for the joint visualization and evaluation initiative.

The exchange is done for the 'Reference Area', which extends from 25°W to 60°E in longitude and from 0° to 65°N in latitude. It is intended to cover the main source areas in Northern Africa and Middle East, as well as the main transport routes and deposition zones from the equator to the Scandinavian Peninsula. The action will consider forecasts of up to 72 h with a 3-hour frequency, involving the following variables:

- Dust concentration at surface
- DOD at 550 nm

NetCDF Format is used for data exchange. This format allows compression of data fields while preserving characteristics of numerical values that have a very large dynamical range.

At the end of 2012, seven models (Table 5) were involved in the initiative by providing daily files with numerical output. Two other models have also participated in it during specific periods (Table 6).

Table 5 - Models contributing to the joint visualization and evaluation of dust models at the end of 2012

Model	Institution
BSC-DREAM8b_v2	BSC-CNS
MACC	ECMWF
DREAM8-NMME-MACC	SEEVCCC
NMMB/BSC-Dust	BSC-CNS
MetUM	U. K. Met Office
GEOS-5	NASA
NGAC	NCEP

Table 6 - Models that have contributed to the joint visualization and evaluation of dust models over specific time periods

Model	Institution
LMDzt-INCA	LSCE
CHIMERE	LMD

5.1 Joint visualization of model output

The values of dust surface concentration and DOD provided by each model are daily plotted side-by-side for the reference area using a common colour palette (Fig. 11). The palette has been built by combining brownish and greenish colours. The brownish tones highlight the areas with the highest contents of mineral dust whereas the greenish tones allow emphasizing the thresholds set by European Union directives on air quality.

The plots are routinely generated and made available at the end of each day using the results of the simulations starting the same day either at 00 or at 12 UTC. In this manner, forecasts released by the models are available for a common period of up to 48 hours, thus making the product a powerful tool to issue short-term predictions and early warning notices. The product is then completed at the end of the next day incorporating the model outputs that have not been collected on time. The latest forecasts, as well as historical plots, are available at: http://sds-was.aemet.es/forecast-products/compared-dust-forecasts

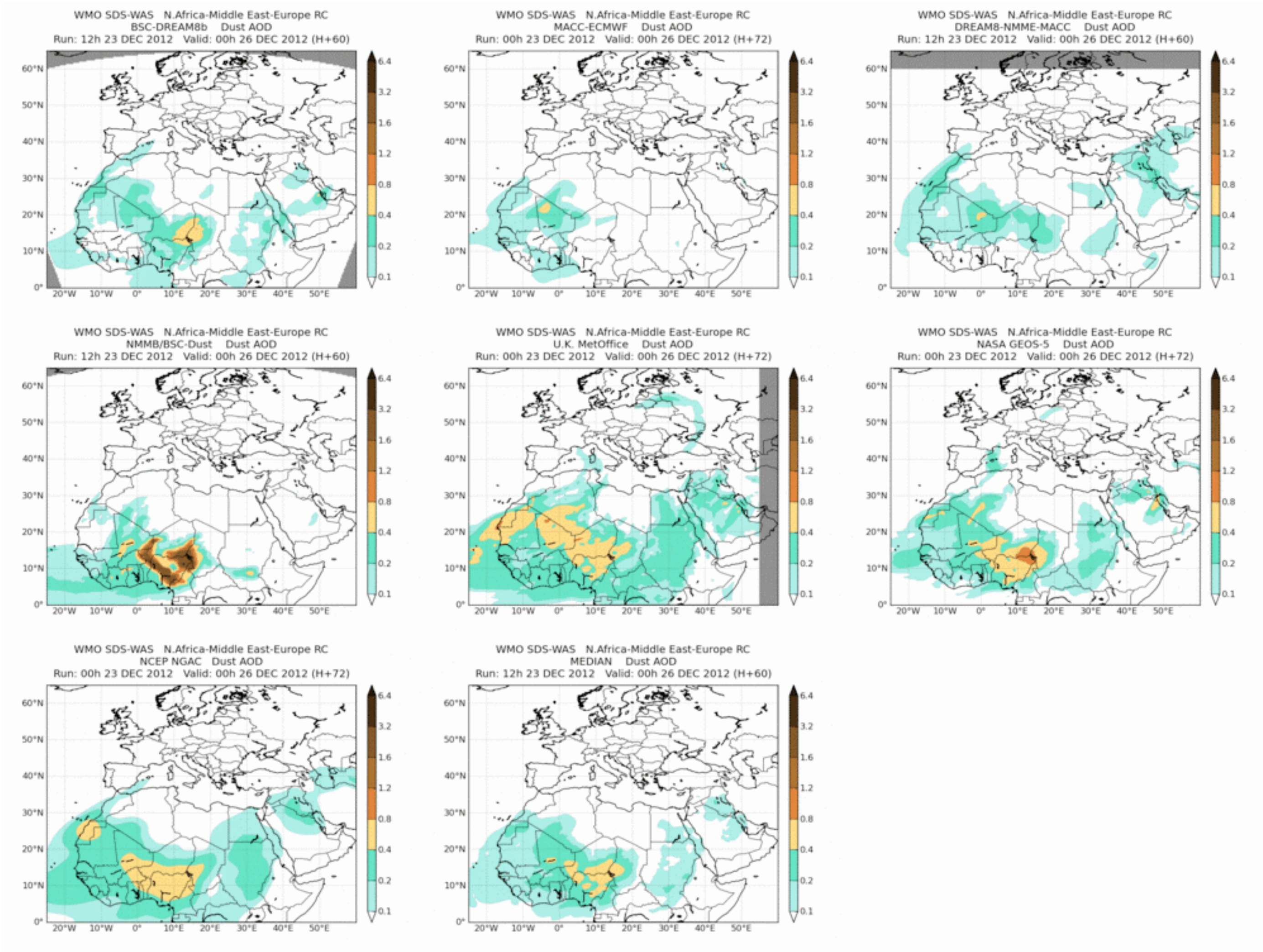

Figure 11 - DOD forecasts released by different models for 00 UTC 26 December 2012

5.2 Multi-model products

Ensemble prediction is a form of Monte-Carlo analysis aimed to describe the future state of the atmosphere from a probabilistic point of view. Multiple simulations are run to account either for the uncertainty of the initial state or for the inaccuracy of the model and the mathematical methods used to solve its equations. In particular, multi-model forecasting intends to alleviate the shortcomings of any individual model through the combined use of several of them.

The Regional Center daily generates multi-model products for its region of interest using for this purpose the results of the models previously mentioned. On the one hand, it yields products describing centrality (multi-model median and mean) aimed at improving the forecast skill of a single model-based approach concerning the different variables. On the other hand, it generates products describing the models spread (standard deviation and range of variation), which show the dispersion of the variables for specific time steps in the future (Fig. 12). When ensemble spread is small and the forecast solutions are consistent within multiple models, more confidence in the forecast can be perceived.

The generation of multi-model ensemble products requires a preliminary interpolation of the various models outputs to a common grid mesh. To perform this step, the fields are bi-linearly interpolated to a common grid of 0.5º latitude x 0.5º longitude.

The daily multi-model products as well as historical plots are available at http://sds-was.aemet.es/forecast-products/dust-forecasts/multimodel-products. Furthermore, the multi-model median forecasts of dust surface concentration and DOD are plotted along with their corresponding single-model elements, as shown in Figure 11.

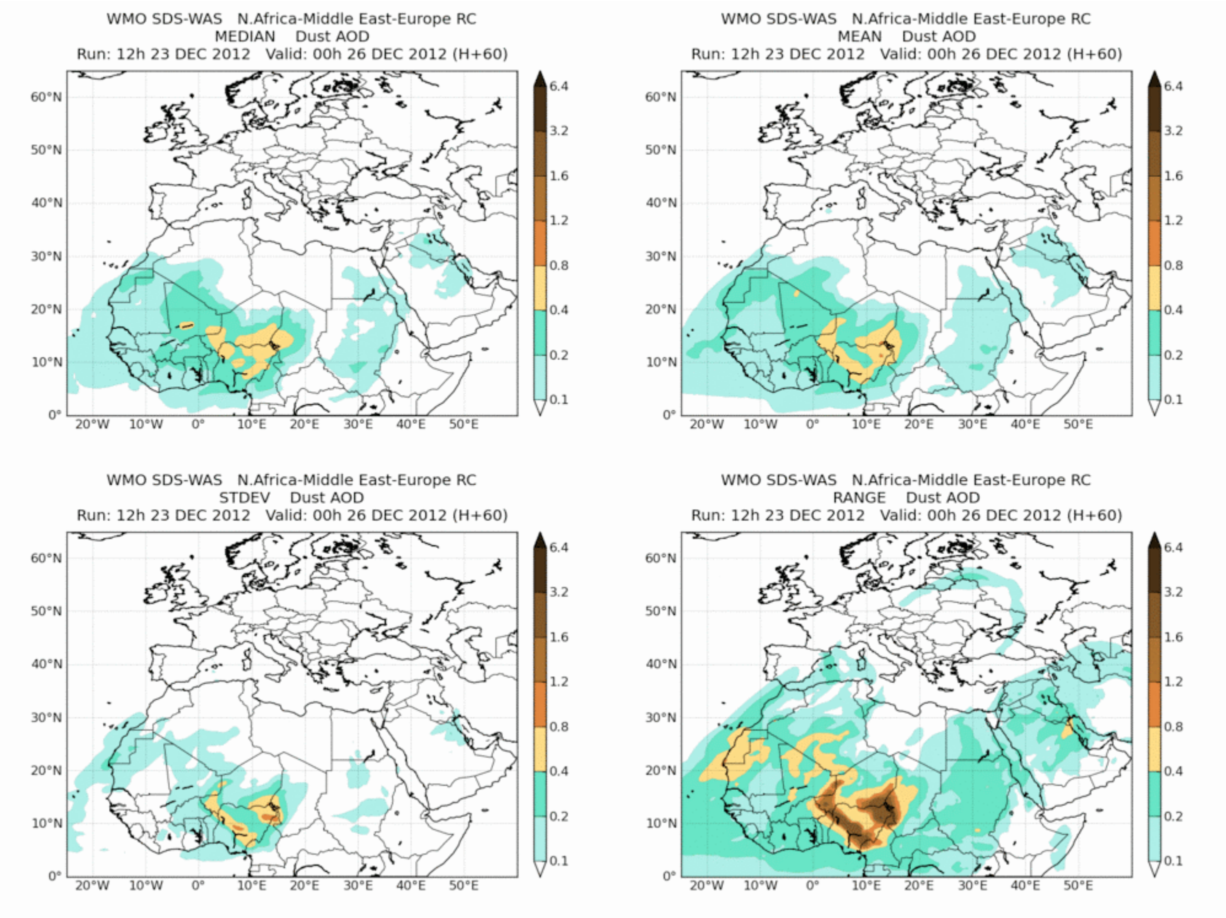

Figure 12 - Multi-model products of DOD for 00 UTC 26 December 2012: median (top left), mean (top right), standard deviation (bottom left) and range of variation (bottom right)

5.3 Common model evaluation

An important stage of any forecasting system is the evaluation of the outcoming products. The main goal of the common evaluation is to assess whether the modelling systems successfully simulate the temporal and spatial evolution of the dust-related parameters. Besides, it helps understanding the models capabilities, limitations, and appropriateness for the purpose, for which they were designed, and provides guidance for the models improvement.

The evaluation is performed by comparing the models and multi-model forecasts with observational data. The DOD at 550 nm forecast by the models and multi-model median is first drawn together with the AERONET observations of AOD in monthly plots for 40 selected dust-prone stations (Fig. 13, Table 7). Monthly plots (Fig. 14) are daily updated and automatically archived: http://sds-was.aemet.es/forecast-products/forecast-evaluation. These plots, typically implemented for NRT monitoring, are very valuable to detect outliers and to identify jumps in performance.

Figure 13 - AERONET stations where the forecast evaluation is performed

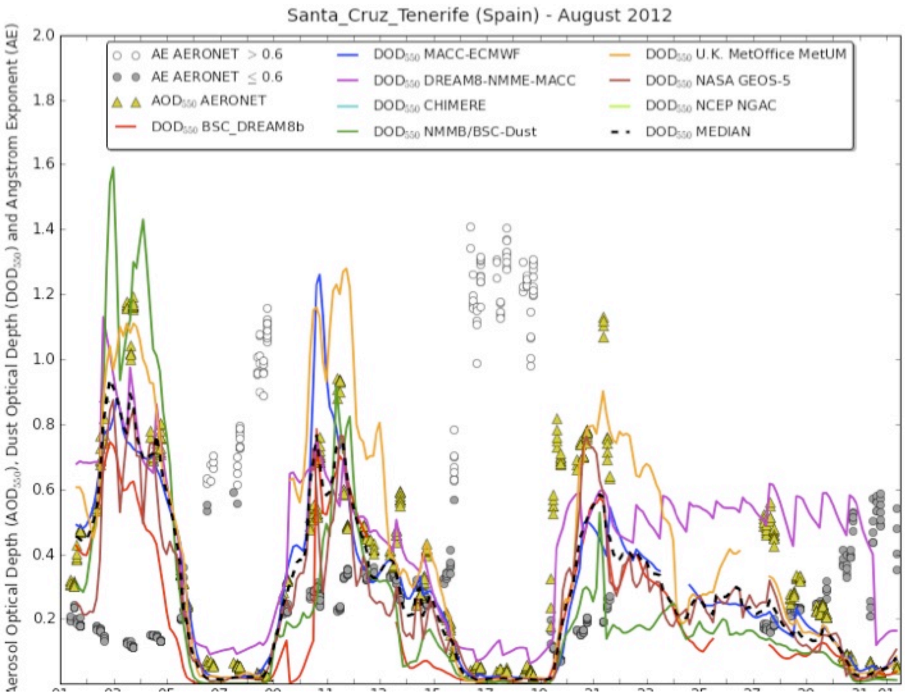

Figure 14 - DOD forecast by different models (full lines) and multi-model median (dashed black line) compared with AOD (yellow triangles) from the AERONET station of Santa Cruz de Tenerife (Canary Islands, Spain) in August 2012. Black and white circles show the values of the Ängstrom exponent

Table 7 - List of AERONET stations where the forecast evaluation is performed

Site name	Longitude	Latitude	Country	Region
Avignon	4.88ºE	43.93ºN	France	Mediterranean
Banizoumbou	2.66ºE	13.54ºN	Niger	Sahel/Sahara
Barcelona	2.12ºE	41.39ºN	Spain	Mediterranean
Cabo_da_Roca	9.50ºW	38.78ºN	Portugal	Mediterranean
Caceres	6.34ºW	39.48ºN	Spain	Mediterranean
Cairo_EMA_2	31.29ºE	30.08ºN	Egypt	Mediterranean
Capo_Verde	22.93ºW	16.73ºN	Cape Verde	Sahel/Sahara
CUT-TEPAK	33.04ºE	34.67ºN	Cyprus	Mediterranean
Dakar	16.96ºW	14.39ºN	Sénégal	Sahel/Sahara
Eilat	34.92ºE	29.50ºN	Israel	Mediterranean
Ersa	9.36ºE	43.00ºN	France	Mediterranean
ETNA	15.02ºE	37.61ºN	Italy	Mediterranean
Evora	7.91ºW	38.57ºN	Portugal	Mediterranean
FORTH_CRETE	25.28ºE	35.33ºN	Greece	Mediterranean
Granada	3.60ºW	37.16ºN	Spain	Mediterranean
IASBS	48.51ºE	36.70ºN	Iran	Middle East
IER_Cinzana	5.93ºW	13.28ºN	Mali	Sahel/Sahara
Ilorin	4.34 ºE	8.32ºN	Nigeria	Sahel/Sahara
IMAA_Potenza	15.72ºE	40.60ºN	Italy	Mediterranean
IMS-METU-ERDEMLI	34.26ºE	36.56ºN	Turkey	Mediterranean
KAUST_Campus	39.10 ºE	22.30ºN	S. Arabia	Middle East
Kuwait University	47.97 ºE	29.33ºN	Kuwait	Middle East
Lampedusa	12.63ºE	35.52ºN	Italy	Mediterranean
Lecce_University	18.11ºE	40.33ºN	Italy	Mediterranean
Oujda	1.90ºW	34.65ºN	Morocco	Mediterranean
Ouarzazate	6.91ºW	30.93ºN	Morocco	Sahel/Sahara
Palma_de_Mallorca	2.62ºE	39.55ºN	Spain	Mediterranean
Porquerolles	6.16ºE	43.00ºN	France	Mediterranean
Rome_Tor_Vergata	12.65ºE	41.84ºN	Italy	Mediterranean
Saada	8.16ºW	31.62ºN	Morocco	Sahel/Sahara
Santa_Cruz_Tenerife	16.25ºW	28.47ºN	Spain	Sahel/Sahara
SEDE_BOKER	34.78ºE	30.85ºN	Israel	Mediterranean
Seysses	1.26ºE	43.50ºN	France	Mediterranean
Solar_Village	46.40ºE	24.91ºN	S. Arabia	Middle East
Tabernas_PSA-DLR	2.36ºW	37.09ºN	Spain	Mediterranean
Tamanrasset_INM	5.53ºE	22.79ºN	Algeria	Sahel/Sahara
Villefranche	7.33ºE	43.68ºN	France	Mediterranean
Xanthi	24.92ºE	41.15ºN	Greece	Mediterranean
Zinder_Airport	8.99ºE	13.78ºN	Niger	Sahel/Sahara
Zouerate-Fennec	12.48ºW	22.75ºN	Mauritania	Sahel/Sahara

Version 2 Level 1.5 of AERONET products are used for the evaluation. Level 1.5 data are automatically cloud screened, but do not have final calibration applied and, thus, they are not quality assured. Since AERONET sun photometers do not yield AOD at 550 nm, this variable is

calculated from AOD at 440, 675 and 870 nm using the Ångström law. Rather than time-interpolated, observations are assigned to the nearest multiple-of-3 hour. In case more than one observation is assigned to the same hour, only the closest-in-time is considered.

The AERONET retrievals of AOD integrate the contribution of the different types of atmospheric particles. To minimize the sources of error, it is intended to restrict the comparison to situations, in which mineral dust is the dominant aerosol type. A threshold discrimination is made by discarding observations with an AE 440-870 higher than 0.6.

The comparison is applied to forecast values ranging from the initial day of the simulation (D) at 15:00 UTC to the following day (D+1) at 12:00 UTC. It means that the lead times of the evaluated forecasts range from 15 to 36 hours for model runs starting at 00 UTC, but from 3 to 24 hours for model runs starting at 12 UTC.

In addition to this NRT evaluation, a system to quantitatively assess the performance of the different models has been set. The system yields evaluation scores computed from the comparison of the simulated DOD and the AERONET retrievals of AOD. The metrics that are used to quantify the departure between modelled (c_i) and observed (o_i) quantities are described below and summarized in Table 8.

- The mean bias error (BE) captures the average deviations between two datasets. It has the same units as the variable.
- The root mean square error (RMSE) combines both the bias and the standard deviation. It also has the same units as the variable. It is strongly dominated by the largest values, due to the squaring operation. Especially in cases where prominent outliers occur, the usefulness of RMSE is questionable and its interpretation becomes difficult.
- The correlation coefficient (r) indicates the extent to which patterns in the model match those in the observations. It is a dimensionless statistic.
- The fractional gross error (FGE) is a measure of the overall model error. It ranges between 0 and 2 and behaves symmetrically with respect to under- and over-estimation, without overemphasizing outliers.

Table 8 - Summary of the evaluation scores that are routinely computed; c_i and o_i refer respectively to model outputs and observed values and n to the number of cases

Statistic Parameter	Formula	Range	Perfect score
Mean Bias Error (BE)	$BE = \frac{1}{n}\sum_{i=1}^{n}(c_i - o_i)$	−∞ to +∞	0
Root Mean Square Error (RMSE)	$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(c_i - o_i)^2}$	0 to +∞	0
Correlation coefficient (r)	$r = \frac{\sum_{i=1}^{n}(c_i - \bar{c})(o_i - \bar{o})}{\sqrt{\sum_{i=1}^{n}(c_i - \bar{c})^2} \cdot \sqrt{\sum_{i=1}^{N}(o_i - \bar{o})^2}}$	-1 to 1	1
Fractional Gross Error (FGE)	$FGE = \frac{2}{n}\sum_{i=1}^{n}\left\lvert\frac{c_i - o_i}{c_i + o_i}\right\rvert$	0 to 2	0

The scores of each model and multi-model median are computed on a monthly, seasonal and annual basis for each AERONET site, for three selected regions (Sahel/Sahara, Middle East and Mediterranean) as well as globally, considering all sites. It should be noted that scores for individual sites can be little significant for being calculated from a small number of data.

Monthly evaluation scores are available at http://sds-was.aemet.es/forecast-products/forecast-evaluation/model-evaluation-metrics, seasonal scores at http://sds-was.aemet.es/forecast-products/forecast-evaluation/model-evaluation-metrics-seasonal and, finally, annual scores at http://sds-was.aemet.es/forecast-products/forecast-evaluation/model-evaluation-metrics-annual.

6. SDS-AFRICA

In 2008, AEMET, in collaboration with the WMO, launched the project 'Sand and Dust Strom Early Warning System in the Magreb Region' (SDS-Africa) aimed to reinforce the observational capacity for mineral dust in Northern Africa. The main goal of the project, financed by the Spanish Agency for International Development Cooperation (AECID), was to establish a ground-based network of sun photometers in selected locations of Northern Africa (Morocco, Algeria, Tunis and Egypt) for detecting and monitoring dust storms. They would also be useful for NRT satellite sensor validation and calibration, and for the evaluation of dust models.

The first instrument was set in the GAW observatory of Tamanrasset, Algeria, a strategic site in the core of the Sahara. The photometric station, jointly managed by AEMET and the Algerian National Meteorological Office (ONM), was incorporated into the AERONET network.

Upon creation, the Regional Center for NA-ME-E took on the project and installed a second sun-photometer in Cairo, Egypt. The importance of Cairo lies in the fact that it is a strategic place for the monitoring and study of the mineral dust during transport from the Sahara towards the Mediterranean, as well as of the abundant and varied anthropic aerosols generated in one of the largest mega-cities in the world. The station, also incorporated into the AERONET network, is managed by AEMET and the Egyptian Meteorological Authority (EMA).

In 2012, a third instrument was set in Ouarzazate, Morocco (Fig. 15), a small city on the Southeastern slopes of the Atlas range, on the edge of the Sahara desert. The station, already part of the AERONET network, is managed by AEMET and the Moroccan Direction of the National Meteorology (DMN)

Figure 15 - Sun-photometric station set in Ouarzazate, Morocco

Finally, it is expected to install a new instrument in Tunisia in the coming months. Data from the three stations currently in operation are routinely used in the SDS-WAS joint evaluation of dust models described in Section 5 (see Fig. 16).

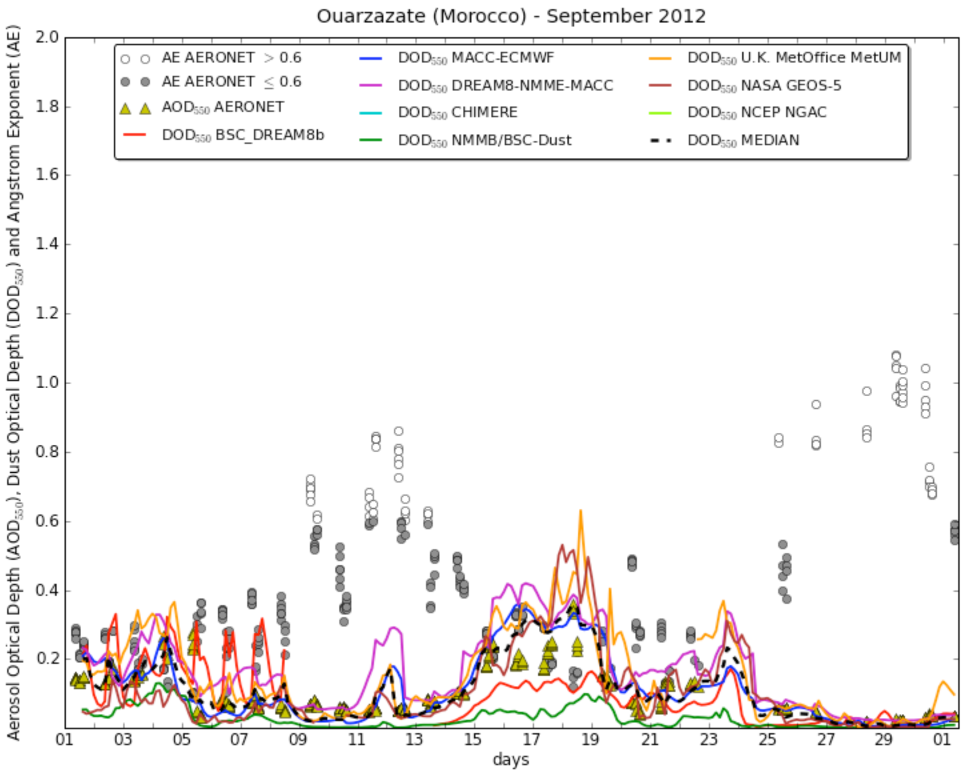

Figure 16 - DOD forecast by different models (full lines) and multi-model median (dashed black line) compared with AOD (yellow triangles) retrieved from the AERONET station of Ouarzazate, Morocco, in September 2012

7. CAPACITY BUILDING ACTIVITIES

The Regional Center coordinates with partners and NMHSs in the region different actions aimed to strengthen the capacity of countries to use the observational and forecast products distributed in the framework of the WMO SDS-WAS.

In 2010, the Regional Center organized two training courses and a technical seminar:

Training Week on Satellite Meteorology

The 'Training Week on Satellite Meteorology' (Fig. 17) was held in Barcelona, 8-12 November 2010. It was jointly organized and financed by AEMET, BSC-CNS, EUMETSAT and the WMO. It was not a monographic course on mineral dust, but there were several lectures on satellite detection of dust. 14 meteorologists from African NMHS (Algeria, Benin, Burkina Faso, Cape Verde, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Mali, Mauritania, Morocco, Niger and Senegal) and one from ACMAD attended the course, which included a technical visit to the AEMET Center in Barcelona

Figure 17 - Participants in the Training Week on Satellite Meteorology

Training Week on WMO SDS-WAS Products

The 'Training Week on WMO SDS-WAS Products' (Fig. 18) was held in Barcelona 15-19 November 2010. It was also jointly organized and financed by AEMET, BSC-CNS, EUMETSAT and the WMO. 14 meteorologists from African and Middle-Eastern NMHS (Algeria, Burkina Faso, Iraq, Iran, Mali, Mauritania, Morocco, Niger, Nigeria, Oman, Saudi Arabia and Turkey), one from ACMAD, and a researcher from the University of Milan attended the course. In addition to lectures and practical sessions, there were technical visits to:

- Raman lidar at the Catalonia Technical University (UPC)
- AERONET station at the UPC
- Air quality monitoring station and analysis laboratory at the Spanish Scientific Research Council (CSIC)
- MareNostrum supercomputer at the BSC-CNS

Figure 18 - Participants in the Training Week on WMO SDS-WAS Products

Lectures on Atmospheric Mineral Dust and its Impact on Human Health, Environment and Economy

'Lectures on Atmospheric Mineral Dust and its Impact on Human Health, Environment and Economy' (Fig. 19) was a technical seminar organized by the Regional Center and jointly financed by AEMET, BSC-CNS, EUMETSAT and the WMO. It was held in Barcelona on 13 November 2010. The lecturers were Dr Leonard Barrie (WMO), Mr José Prieto (EUMETSAT), Dr Emilio Cuevas (AEMET), Dr Michael Schulz (Norwegian Met. Institute: NMI, chair of the WMO SDS-WAS Regional Steering Group for NA-ME-E), Dr José M. Baldasano (BSC-CNS), Dr Benjamin Lamptey (Regional Maritime University, RMU, Ghana) and Dr Xavier Querol (CSIC).

Figure 19 - Opening of Lectures on Atmospheric Mineral Dust and its Impact on Human Health, Environment and Economy

In 2011, the Regional Center participated in training courses held in Turkey and Iran, and coordinated the '2^{nd} Training Course on WMO SDS-WAS Products', conducted in Turkey.

Meteorological Services, Sand and Dust Storm (SDS), Forecasting and Early Warning System

The 'Meteorological Services, Sand and Dust Storm (SDS), Forecasting and Early Warning System' was held in Istanbul, 22-26 February 2011 (Fig. 20). It was organized and financed by the Turkish State Meteorological Service (TSMS) in the framework of the Action Plan for Regional Cooperation on Environment and Meteorology signed between Turkey, Iraq, Iran, Syria and Qatar. The course was conducted in English, Turkish and Arabic, with simultaneous translation. It run in parallel with another course, entitled 'Erosion Preventing Techniques and Controlling Methods and Forestry', with several common lectures. Attendees came from seven Middle-Eastern countries: Iran, Iraq, Jordan, Lebanon, Saudi Arabia, Syria and Turkey.

Figure 20 - Participants in the training course on Meteorological Services, Sand and Dust Storm (SDS), Forecasting and Early Warning System

2^{nd} Training Course on WMO SDS-WAS (Satellite Observation and Modelling of Atmospheric Dust)

The 2^{nd} Training course on WMO SDS-WAS (satellite and ground observation and modelling of atmospheric dust)' (http://sds-was.aemet.es/materials/2nd-training-course) was held in Antalya, Turkey, 21-25 November 2011 (Fig. 21). It was organized and funded by the TSMS, EUMETSAT and the WMO, with collaboration of AEMET and BSC-CNS, and coordinated by the Regional Center. There were 23 participants from 16 different countries: Algeria, Burkina Faso, Cape Verde, Chad, Egypt, Ethiopia, Iraq, Jordan, Kuwait, Morocco, Saudi Arabia, Senegal, Sudan, Tunisia, Turkey, and Yemen.

Figure 21 - Participants in the 2nd Training Course on WMO SDS-WAS

Training Course on Sand and Dust Storms

The 'Training Course on Sand and Dust Storms' was held in Tehran, Iran, 10-13 October 2011 (Fig. 22), organized by the Islamic Republic of Iran Meteorological Organization (IRIMO) with the support of other Iranian institutions and international organizations, particularly the WMO, the United Nations Convention on Combating Drought (UNCCD) and the United Nations Environment Programme (UNEP).

The overall objective of this course was to enhance the capabilities of national and regional institutions in sand and dust monitoring and prediction, and specifically to:

- Increase awareness of sand and dust storms in general, and in the region in particular
- Identify and assess gaps in sand and dust storm observation coverage in the region
- Build capacity for modelling and forecasting sand and dust storms
- Identify ways to mitigate current and future impact of sand and dust storms at national and regional level
- Propose ways to develop, access and use regional SDS-WAS products through collaboration with existing SDS-WAS Regional nodes

Figure 22 - Lecturers of the Training course on Sand and Dust Storms held in Tehran, Iran

In 2012, the Regional Center participated in two training courses and organized and coordinated the 'II Lectures on Atmospheric Mineral Dust'.

II Lectures on Atmospheric Mineral Dust

Figure 23 - Banner of the II Lectures on Atmospheric Mineral Dust

The 'II Lectures on Atmospheric Mineral Dust' (http://sds-was.aemet.es/materials/training/ii-lectures-on-atmospheric-mineral-dust) was held in Barcelona, 5-9 November 2012 (Fig. 23 and 24). It was jointly organized by AEMET, BSC-CNS, EUMETSAT, UPC and WMO, and coordinated by the Regional Center. The event was targeted to operational meteorologists as well as to early career scientists (advanced students, PhD candidates and postdoctoral researchers) with a background in the Earth system sciences. The attendees had the opportunity to participate in technical visits to:

- Raman lidar at the UPC
- AERONET station at the UPC
- Air quality monitoring station and analysis laboratory at the CSIC

The course was attended by 19 participants from Germany, Morocco, Niger, Spain, The Gambia and Tunisia.

Figure 24 - Participants in the II Lectures on Atmospheric Mineral Dust

Cours sur L'utilisation des Produits Satellitaires aux Applications Agrometeorologiques

The 'Cours sur l'utilisation des produits satellitaires aux applications agrometeorologiques' (Course on the use of satellite products for agrometeorological applications) was held at the Agriculture, Hydrology, Meteorology (AGRHYMET) Regional Center of Niamey, Níger, 19-23 November 2012 (Fig. 25), organized by AGRHYMET with technical and financial support of EUMETSAT and WMO. The AGRHYMET Center was established in 1974 as a specialized institute of the 'Permanent Interstate Committee for Drought Control in the Sahel' (CILSS, http://www.cilss.bf), which is supported by nine member countries: Burkina Faso, Cape Verde, Chad, The Gambia, Guinea Bissau, Mali, Mauritania, Niger and Senegal.

The event, conducted in French, was attended by experts from Burkina Faso, Chad, Guinea, Guinea Bissau, Ivory Coast, Mali, Mauritania, Niger, Senegal and Togo.

Figure 25 - Participants in the 'Cours sur l'utilisation des produits satellitaires aux applications agrometeorologiques'

Workshop on Meteorology, Sand and Dust Storm (SDS), Combating Desertification and Erosion

The 'Workshop on Meteorology, Sand and Dust Storm (SDS), Combating Desertification and Erosion' was held in Ankara, Turkey, 26-28 November 2012 (Fig. 26). It was jointly organized by three Turkish institutions: TSMS, General Directorate of Combating Desertification and Erosion and General Directorate of Forestry. It was attended by experts from Algeria, Azerbaijan, Bahrain, Egypt, Iran, Iraq, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Libya, Mauritania, Morocco, Northern Cyprus, Oman, Palestinian Territories, Qatar, Saudi Arabia, Sudan, Tajikistan, Tunisia, Turkmenistan, United Arab Emirates, Uzbekistan and Yemen.

Figure 26 - Participants in the sessions on meteorology of the Workshop on Meteorology, Sand and Dust Storm (SDS), Combating Desertification and Erosion

8. PARTICIPATION IN WMO MEETINGS

The Regional Center participated in some outstanding WMO meetings. The following can be highlighted:

- XVI WMO Congress: Side event on 'Sand and Dust Storm Research'
- Meeting of the WMO SDS-WAS Regional Steering Group for NA-ME-E
- Meeting of the WMO SDS-WAS Regional Steering Group for Asia
- Fifteenth Session of the Commission for Basic Systems (CBS-15)

XVI WMO Congress: Side Event on 'Sand and Dust Storm Research'

A side event on 'Sand and Dust Storm Research' was held in Geneva, Switzerland on 25 May 2011 in the framework of the Sixteen World Meteorological Congress.

The event was intended to publicize the SDS-WAS research activities to the different NMHSs and to show the undertaken efforts aimed to better understand and predict the release, transport and deposition of mineral dust. The programme was:

- Nickovic, S.: Sand and Dust Storm Research. Global Overview.
- Zhang, X., S.-U. Park and Y. Chun: Review of SDS Activities in Asia
- Terradellas, E., J. M. Baldasano and E. Cuevas: WMO SDS-WAS programme. Regional Center for NA-ME-E

Meeting of the WMO SDS-WAS Regional Steering Group for NA-ME-E

A meeting of the Regional Steering Group was held in Antalya, Turkey, 25-26 November 2011, hosted by the TSMS (Fig. 27).

Figure 27 - Meeting of the WMO SDS-WAS Regional Steering Group for NA-ME-E

First, the most important actions carried out at the Regional Center and by the different partners were reviewed. Then, the action plan for the coming years was updated. The minutes and the presentations delivered during the meeting are available at http://sds-was.aemet.es/materials/Nov-2011-meeting-of-the-regional-steering-group.

Meeting of the WMO SDS-WAS Regional Steering Group for Asia

The Regional Center attended the meeting of the WMO SDS-WAS Regional Steering Group for Asia as a guest. The meeting was held in Tsukuba, Japan, 7-8 March 2012, hosted by the Japan Meteorological Agency (Fig. 28). A presentation with the main activities and future plans of the Regional Node for NA-ME-E was delivered.

Figure 28 - Participants in the meeting of the WMO SDS-WAS Regional Steering Group for Asia

15^TH Session of the Commission for Basic Systems (CBS-15)

The Regional Center took part in the 15th Session of the Commission for Basic Systems of the WMO (CBS-15) (https://sites.google.com/a/wmo.int/cbs-15/) held in Jakarta, Indonesia, 10-15 September 2012 (Fig. 29). The meeting discussed issues that are critical to the future of the SDS-WAS.

The CBS noted the results of the working group formed by the CBS itself and the Commission for Atmospheric Sciences (CAS) on the WMO SDS-WAS. It considered that atmospheric sand and dust storm forecasts are of particular importance as dust storms strongly affect socio-economic sectors, including maritime and air transportation. Many countries informed of their capabilities to produce and deliver atmospheric sand and dust storm forecasts, and expressed interest in cooperating with this Regional Center on these issues, including on dust models evaluation. As a consequence, the Commission agreed that there is need to promote the creation of operational forecast services and resolved to incorporate the following items in the current version of the Manual on the Global Data Processing and Forecasting System (MGDPFS, http://www.wmo.int/pages/prog/www/DPFS/documents/485_Vol_I_en_colour.pdf):

- The mandatory functions of future Regional Specialized Meteorological Centers with activity specialization on Atmospheric Sand and Dust Forecast (RSMC-ASDF)
- The criteria for designating the RSMC-ACDF

The Regional Center presented its ongoing activities and the candidacy of Barcelona to host a RSMC-ASDF managed by AEMET and BSC-CNS. The Commission noted that the candidate met the approved mandatory functions and therefore recommended its formal designation as RSMC-ASDF Barcelona and proposed to amend the MGDPFS accordingly.

Figure 29 - Presentation of the activities of the SDS-WAS Regional Center and the candidacy of Barcelona to host a RSMC-ASDF

9. PARTICIPATION IN OTHER OUTSTANDING MEETINGS

The most outstanding meetings with participation of the Regional Center have been:

- GESAMP/SDS-WAS Workshop
- International Conference on Dust and Dust Storms

GESAMP/SDS-WAS Workshop

The Group of Experts on the Scientific Aspects of the Marine Environmental Protection (GESAMP) is an advisory body consisting of specialized experts nominated by the Sponsoring Agencies detailed in Table 9.

Table 9 - Agencies sponsoring GESAMP

GESAMP Sponsoring agencies
International Marine Organization (IMO)
Food and Agriculture Organization (FAO)
Intergovernmental Oceanographic Commission (UNESCO-IOC)
United Nations Industrial Development Organization (UNIDO)
World Meteorological Organization (WMO)
International Atomic Energy Agency (IAEA)
United Nations (UN)
United Nations Environment Programme (UNEP)
United Nations Development Programme (UNDP)

Its principal task is to provide the Sponsoring Agencies with scientific advice concerning the prevention, reduction and control of the degradation of the marine environment.

GESAMP and SDS-WAS organized a joint workshop that was held in Malta, from 7 to 9 March 2011 to deal with the atmospheric input of chemicals to the ocean.

The three topics discussed at the Malta meeting were:

- Improving the quantitative estimates of the geographical distribution of the transport and deposition of mineral matter and its content to the ocean
- Long-term assessment of mineral dust, iron and phosphorus input to the ocean: In-situ observations and marine response utilizing coupled atmospheric transport and ocean biogeochemical modelling and remote sensing
- Specifying test-bed regions for joint studies of the transport and deposition of mineral matter to the ocean utilizing SDS-WAS transport modelling

The conclusions and recommendations have been gathered in the book 'The Atmospheric Input of Chemicals to the Ocean' (GESAMP Reports and Studies No. 84, http://sds-was.aemet.es/events/wmo-sds-was-gesamp-expert-workshop).

International Conference on Dust and Dust Storms

The Regional Center participated in the International Conference on Dust and Dust Storms held in Kuwait from 20 to 22 November 2012 (Fig. 30), organized by the State of Kuwait in collaboration with the Gulf Cooperation Countries (GCC). The UNEP and the WMO conducted a special session on the scientific aspects of a regional sand and dust programme that had been previously drafted. Experts from countries, WMO, regional and international centers endorsed the overall approach and design and gave valuable recommendations on its improvement. The final recommendations of the Conference reflect almost all elements of the SDS-WAS in addition to establishing a dedicated Regional Center and a Fund on Dust Storms.

The concept note for the regional sand and dust programme has been later updated in light of the recommendations of the conference and bi-lateral meetings held with Iraq, Kuwait and Iran: http://sds-was.aemet.es/news/RegionalDustStromConceptNotedraftIII26Dec12.docx
.

Figure 30 - International Conference on Dust and Dust Storms held in Kuwait 20-22 November 2012

10. COOPERATION WITH OTHER INTERNATIONAL PROJECTS

The Regional Center has been cooperating with other international projects, either occasionally or regularly. This section describes some of these collaborations.

MACC and MACC-II

Figure 31 - Logo of the MACC project

Monitoring Atmospheric Composition and Climate (MACC, http://www.gmes-atmosphere.eu/) operates and improves data-analysis and modelling systems for a range of atmospheric constituents that are important for climate, air quality and surface solar radiation. Product lines include data records on atmospheric composition for recent years, data for monitoring present conditions and forecasts of the distribution of key constituents for a few days ahead.

MACC is funded under the 7th Framework Programme of the European Union and provides the pre-operational atmospheric environmental service of the Global Monitoring for Environment and Security (GMES) initiative. This service complements the weather analysis and forecasting services provided by European and national organizations by addressing the composition of the atmosphere.

To provide air quality and atmospheric composition services, MACC-II uses a comprehensive global monitoring and forecasting system that estimates the state of the atmosphere on a daily basis, combining information from models and observations, and it provides a daily 5-day forecast. The global modelling system is also used to provide the boundary conditions for an ensemble of more detailed regional air quality models that are used to zoom in on the European domain and produce 4-day forecasts of air quality.

The collaboration with MACC has enabled SDS-WAS to incorporate the MACC prediction system to the inter-comparison and joint evaluation of dust models described in Section 4. On the other hand, SDS-WAS has provided a valuable external evaluation of the dust component of the MACC prediction system that has led to new ways for improvement.

DIAPASON

Figure 32 - Logo of the DIAPASON project

Desert-Dust Impact on Air Quality trough Model-Predictions and Advanced Sensors Observations (DIAPASON, http://www.diapason-life.eu/index.php?lang=en) is a demonstrative and innovative project in the field of air-quality assessment. It deals with the improvement of the existing tools to assess the desert dust contribution to PM levels. In Southern Europe such contribution can often cause the PM10 concentrations in ambient air to exceed the air quality limit values set by the E. U. Air Quality Directive 2008/50/EC.

The European legislation allows Member States to subtract the contribution of natural sources to PM10 levels by means of specific guidelines. DIAPASON intends to strengthen such EU guidelines by means of innovative and affordable technologies, partly prototyped within the project (Polarization Lidar-Ceilometer, PLC) and by Optical Particle Counters (OPC). PLCs are laser radars capable of detecting and profiling dust clouds from near ground up to 10 km altitude.

SDS-WAS and DIAPASON share the desert dust as the object of study, from a global view in the first case, with a clear focus on applications to air quality in the second. Therefore, there has been a continuous exchange of both modelling and observational data.

COPERNICUS

Figure 33 - Logo of the Copernicus programme

Environmental information is of crucial importance. It helps to understand how our planet and its climate are changing, the role played by human activities in these changes and how these will influence our daily lives.

The well-being and security of future generations are more than ever dependent on everyone's actions and on the decisions being made today on environmental policies. To take the right actions, decision makers, businesses and citizens must be provided with reliable and up-to-date information on how our planet and its climate are changing.

The European Earth observation programme Copernicus (http://copernicus.eu/), previously known as Global Monitoring for Environment and Security (GMES), provides this information.

An article on 'Monitoring and Forecasting Dust Storms' has been included in 'The Growing Use of GMES across Europe's Regions' initiative (http://sds-was.aemet.es/wmo-sds-was-contributes-to-the-global-monitoring-for-environment-and-security), an illustrative and strong collection of regional GMES-uses. The article describes the contribution of WMO SDS-WAS and MACC programmes to health hazard warning and cooperation with Africa.

The publication was launched with a festive evening event and panel debate in the European Parliament on 10 October 2012 in Brussels, Belgium. Politicians, representatives of relevant European institutions and end-user representatives were brought together to debate the impact of GMES-uses on Europe's regions while presenting the GMES-collection.

List of Acronyms

ACMAD	African Center of Meteorological Application for Development
AE	Ängström exponent
AECID	Spanish Agency for International Development Cooperation
AEMET	Spanish State Meteorological Agency
AERONET	Aerosol Robotic Network
AGRHYMET	Agriculture, Hydrology, Meteorology
AOD	Aerosol Optical Depth
ARL	Air Resources Laboratory
BE	Bias Error
BSC-CNS	Barcelona Supercomputing Center – National Supercomputing Center
CAS	Commission for Atmospheric Sciences
CBS	Commission for Basic Systems
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
CMA	China Meteorological Agency
CSIC	Spanish Scientific Research Council
DIAPASON	Desert-Dust Impact on Air Quality trough Model-Predictions and Advanced Sensors Observations
DMN	Direction of the National Meteorology of Morocco
DOD	Dust Optical Depth
DREAM	Dust Regional Atmospheric Model
EARLINET	European Aerosol Research Lidar Network
ECMWF	European Center for Medium-Range Weather Forecast
EMA	Egyptian Meteorological Authority
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization
FGE	Fractional Gross Error
GAW	Global Atmosphere Watch
GCC	Gulf Cooperation Countries
GEOS	Goddard Earth Observing System
GESAMP	Group of Experts on the Scientific Aspects of the Marine Environmental Protection
GFS	Global Forecast System
GMES	Global Monitoring for Environment and Security
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
IAEA	International Atomic Energy Agency
IMO	International Marine Organization
INCA	Interaction of Chemistry and Aerosol
IOC	Intergovernmental Oceanographic Commission
IPCC	Inter-governmental Panel on Climate Change
LIDAR	LIght Detection And Ranging
LITR	Leibniz Institute for Tropospheric Research

LMD	Laboratory of Dynamical Meteorology
LMDzt	Laboratory of Dynamical Meteorology zoom tracers
LSCE	Climate and Environment Sciences Laboratory
MACC	Monitoring Atmospheric Composition and Climate
METAR	Meteorological Aerodrome Report
MGDPFS	Manual on the Global Data Processing and Forecasting System
MOCAGE	Modelo f Atmospheric Chemistry at Large-Scale
MODIS	Moderate resolution Imaging Spectrometer
MPLNET	Micro-Pulse Lidar Netw
NA-ME-E	Northern Africa, Middle East and Europe
NAAPS	Navy aerosol Analysis and Prediction System
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NEMS	National Environmental Modelling System
NGAC	NEMS GFS Aerosol Component
NMHS	National Meteorological and Hydrological Service
NMI	Norwegian Meteorological Institute
NMMB	Non-hydrostatic Multi-Scale Model on the B grid
NOAA	National Oceanic and Atmospheric Administration
NRT	Near-real-time
OMD	Oman Meteorological Department
OMI	Ozone Monitoring Instrument
ONM	Algeria National Meteorological Office
OPC	Optical Particle Counters
PARASOL	Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar
PLC	Polarization Lidar – Ceilometer
PM	Particulate Matter
POLDER	Polarization and Directionality of Earth Reflectances
RGB	Red-Green-Blue
RHSS	Republic Hydrometeorological Service of Serbia
RMSE	Root Mean Square Error
RMU	Regional Maritime University, Ghana
RSG	Regional Steering Group
RSMC-ASDF	Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast
SDS	Sand and Dust Storm
SDS-WAS	Sand and Dust Storm – Warning Advisory and Assessment System
SEEVCCC	South Eastern European Virtual Climate Change Center
SEVIRI	Spinning Enhanced Visible and Infrared Imager
TSMS	Turkish State Meteorological Service
TSP	Total Suspendes Particles
UKMO	United Kingdom Met Office
UNCCD	United Nations Convention on Combating Drought
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UPC	Catalonia Technical University
UTC	Universal Time Coordinated
WIS	WMO Information System
WMO	World Meteorological Organization
WWRP	World Weather Research Programme

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