WMO SECRETARIAT

WMO SAND AND DUST STORM WARNING ADVISORY AND ASSESSMENT SYSTEM (SDS-WAS)

SCIENCE AND IMPLEMENTATION PLAN 2011-2015

March 2011

Research Department

Atmospheric Research and Environment Branch

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Foreword

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 awayA dust storm or sandstorm is a meteorological phenomenon common in arid and semi-arid regions and arises when a gust front passes or when the wind force exceeds the threshold value where loose sand and dust are 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 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 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 that is 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. Thus, there is a need for international coordination of a diverse community dealing with the societal impacts of sand and dust storms.

The World Meteorological Organization (WMO) has taken the lead with international partners to develop and implement a Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS). This document describes the motivation for such a system and offers an operational structure for dealing with a very diverse community anchored by a well established WMO system of research, observations, numerical weather and climate prediction and service delivery. The community of practice for sand and dust storms observations, forecasts and analyses is very diverse requiring the development of interfaces with users through careful assessments. WMO has a long history in jointly organizing research assessments like those of the IPCC for climate which it co-sponsors with UNEP or the highly successful environmental conventions, such as the Vienna Convention on the Protection of the Ozone Layer or the UN-ECE Convention on Long Range Transboundary Transport. Moreover, as the authoritative international body for weather, climate and water, WMO has coordinated the international provision of weather and climate services and warnings for over a century.

The history of the WMO SDS-WAS development is as follows. On the 12 to 14 September 2004, an International Symposium on Sand and Dust Storms was held in Beijing at the China Meteorological Agency followed by a WMO Experts Workshop on Sand and Dust Storms. The recommendations of that workshop led to a proposal to create a WMO Sand and Dust Storm Project coordinated jointly with the WMO Global Atmosphere Watch (GAW). This was approved by the steering body of the WMO World Weather Research Programme (WWRP) in 2005. Responding to a WMO survey conducted in 2005, more than forty WMO Member countries expressed interest in participating in activities to improve capacities for more reliable sand and dust storm monitoring, forecasting and assessment. In 2006, the steering committee of the Sand and Dust Storm Project proposed the development and implementation of a Sand and Dust Storm Warning

Advisory and Assessment System (SDS-WAS). The WMO Secretariat in Geneva formed an Ad-hoc Internal Group on SDS-WAS consisting of scientific officers representing WMO research, observations, operational prediction, service delivery and applications programmes such as aviation and agriculture.

In May 2007, the 14th WMO Congress endorsed the launching of the SDS-WAS. It also welcomed the strong support of Spain to host a regional centre for the Northern Africa-Middle East-Europe (NA-ME-E) node of SDS-WAS and to play a lead role in implementation. In August 2007, the Korean Meteorological Administration hosted the 2nd International Workshop on Sand and Dust Storms highlighting Korean SDS-WAS activities as well as these of Asian regional partners. From 7 to 9 November 2007, Spain hosted the WMO/GEO Expert Meeting on SDS-WAS at the Barcelona Supercomputing Center. This consultation meeting brought one hundred international experts together from research, observations, forecasting and user countries especially in Africa and the Middle East to discuss the way forward in SDS-WAS implementation. In June 2008, the 60th Executive Council of WMO (EC-LXI, 2008) welcomed the initiatives towards the development of SDS-WAS, to assist Members to gain better access to services related to sand and dust storms prediction and warning advisories through capacity building and improved operational arrangements. It also welcomed the establishment of the two SDS-WAS regional centres in China and Spain in support of the corresponding SDS-WAS nodes. From the time of the SDS-WAS launching, the Spanish Meteorological Agency substantially supported the SDS-WAS activities, including establishment of several ground aerosol measurements in Northern Africa and co-sponsoring several SDS-WAS meetings. In November 2008, first meetings of Regional Steering Groups (RSG) for the two SDS nodes were held in Beijing (China) and Tunis-Carthage (Tunisia).

EC-LXI further requested the Commission of Basic Systems (CBS) to collaborate with the Commission for Atmospheric Science (CAS) to develop and establish operational procedures to determine the future role of the centres with the appropriate operational and research capabilities. At the fourteenth session of the Commission for Basic System (CBS), March 2009, the Commission requested appropriate experts in CBS to review the draft SDS-WAS Implementation Plan "to clarify the future of the SDS-WAS centres (and nodes) in the context of the WMO Global Data-Processing and Forecasting System (GDPFS) and Regional Specialized Meteorological Centre (RSMC) structures" (from EC-LX, 2008), and recommended using its RSMC designation process for the establishment of the SDS-WAS centres, to ensure operational sustainability.

This Science and Implementation Plan formulated scientific objectives of the SDS-WAS and defines phases of actions that will be performed in the period 2011-2015 in order to implement the activities that lead to more accurate warnings and assessments of sand and dust storms. It identifies the major challenges for SDS-WAS in the mid-term and proposes an architecture and information exchange for the SDS-WAS that will secure efficient and balanced cooperation and participation of the major components of the SDS-WAS system: research, prediction, observations and service delivery. It is a truly cross-cutting activity within WMO programmes as well as involving a substantive partnership outside the National Hydrological and Meteorological Services, particularly in research. [1]

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[1] The Science and Implementation Plan was drafted by the writing team : William Sprigg (USA; Chair) Jose Baldasano (Spain), Leonard Barrie (WMO), Peter Chen (WMO), Emilio Cuevas (Spain), Menas Kaftos (USA), Slobodan Nickovic (WMO), David Parsons (WMO), Carlos Pérez (Spain), Herbert Puempel (WMO), Robert Stefanski (WMO)

Rationale

In its mission as a world leader in weather, climate, water, and related environmental issues, the World Meteorological Organization (WMO) contributes to the safety and well-being of people throughout the world, and to the societal and economic benefit of all nations. Sand and dust storms are recognized by WMO as serious events that can affect climate, weather, environment and health over much of the world. The WMO therefore is taking a lead with international partners to establish the Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) to develop, refine and provide products to the global community useful in reducing the adverse impacts of sand and dust storms and to assess impacts of the SDS process on society and nature.

Mineral aerosols, mobilized during Sand and Dust Storms (SDS) in arid and semi-arid continental regions, are the dominant component of the atmospheric aerosol over large areas of the Earth (Figure 1).

Figure 1. In the center: a best estimate of the global distribution of annual average tropospheric aerosol optical depth (AOD) with combined data from six satellites operating for limited periods between 1979 and 2004 (courtesy of S. Kinne MPI, Hamburg, Germany). Mineral dust is mainly found in the Northern Hemisphere, in the broad “dust belt” that extends from the eastern subtropical Atlantic eastwards through the Sahara Desert to Arabia and southwest Asia. On the outside of the Figure: Example of sand and dust models performing daily forecasts at different research and/or operational institutes. Regional nodes (big blue dots) in Asia and in Northern Africa - Middle East -Europe.

Although the main source regions include the Sahara desert and the Sahelian region in North Africa, the Arabian Peninsula, Gobi and Taklamakan deserts in Asia, and the Australian and South American deserts SDS events can also occur seasonally on a local sub-regional basis in many other parts of the world. Dust plumes often cover large areas of the Atlantic, Pacific, and Indian oceans downwind of sources in arid regions Estimates of the amount of dust exported annually range from 1000 to 3000 Tg $year^{-1}$ with the largest contributions emitted from the North African (50-70%) and Asian deserts (10-25%). A major fraction of this is of natural origin but indirectly through land surface modification and climate change a significant fraction can be linked to human activities.

Today, a number of organizations (~ 15) around the world (Fig. 1) provide sand and dust storm research forecasts through freely available websites. Some are operated by research and/or operations sections of the National Meteorological and Hydrometeorological Services (NMHSs) of the World Meteorological Organization (WMO) and some are in separate research institutions. Sand and dust storm models are useful tools in providing services that can be used to substantially reduce risk of various impacts. For instance, by predicting dust concentration for several days in advance to NMHSs or by providing a retrospective analysis of past dust events, users could use such information to avoid or reduce adverse effects of sand and dust. Numerical weather prediction systems or their analysis products that drive these Earth System models use complex parameterizations and assimilation of satellite, and surface-based observations to predict winds, clouds, precipitation and dust mobilization, transport, and removal from the atmosphere. Observations of sand and dust are made by many agencies and are being coordinated globally through the Global Atmosphere Watch (GAW) programme as part of a WMO Integrated Global Observing System.

Airborne sand and dust aerosol is a serious hazard with numerous adverse impacts. There are many known social, economic and environmental consequences and most are negative. The SDS-WAS should help reduce those that are not wanted, such as human exposure to unhealthy levels of dust, and take greater advantage of those that are positive, such as nutrient deposition in ocean primary productivity zones. Below are listed a few impacts and anticipated benefits from international collaboration in the SDS-WAS.

<u>Human Health and Air Quality</u>

When inhaled, airborne particulate matter of various sizes are known factors in cardiovascular, respiratory and lung disease. The result of this is that many countries around the world have adopted air quality standards for airborne particulate matter (PM) in various size ranges; for instance for PM less than 10 and 2.5 micrometre diameter (PM10 and PM2.5, respectively). Forecasts of the time and place where PM will exceed air quality standards for human health allow information to be delivered that assists those impacted to avoid exposure or to understand serious events that have happened.

An important application of dust forecasting to air quality management is found in southern Europe. Elevated SDS PM in air masses transported from North Africa to countries of Southern Europe often exceeds the PM10 limits established for air pollution by the European Directive to be exceeded. This has important implications for many constituencies in a country ranging from the public to industry. For example, in Spain, Italy and some other countries, methodologies have been implemented to quantitatively evaluate the African dust load contribution to exceedances of the European PM10 daily limit value using a combination of observations and dust forecasting. This research will eventually replace an assessment methodology based on a low-resolution PM10 air monitoring network. SDS-WAS forecasts should help to routinely interpret PM records from ground stations distinguishing between dust and other aerosols.

Human Health and Disease

Bacteria, spores, chemical wastes and other potentially harmful materials mingle with mineral dust, riding along air currents to reach destinations from one to thousands of kilometres away. Predicting SDS can help to better understand and unravel the "hypothesized" role of mineral dust and dry hot air in outbreaks of meningitis across the Sahel's "meningitis belt." WHO, WMO and GEO through the "Meningitis Environmental Risk Information Technologies" (MERIT) are supporting an international research including many African countries to further investigating this issue. SDS-WAS has been recognized as potentially very useful information source to predict possible Sahel regions with higher seasonal risk for meningitis outbreaks.

Valley Fever is another illness caused by a soil-dwelling fungus endemic to the central valley of California and the desert southwest of the United States, Mexico, and locations in Central and South America. During dust storms, fungi are launched into the air and dispersed by air currents and upon inhalation, cause valley fever in humans and animals with sometimes fatal results. Forecasts of dust could assist public health services in improving operational disease surveillance and early detection.

Transportation

Air and highway safety are threatened by sudden and severe dust storms and may be improved using the appropriate SDS-WAS forecast and services. Visibility reducing dust storms are common in desert regions and a hazard to highway safety. With a fully-functioning SDS-WAS, traffic safety officers and accident emergency measures can help the public avoid costly accidents, could reduce injuries and highway fatalities, and facilitate trucking and transport of goods. Air traffic control can alert pilots to conditions that should be avoided, such as dust storms that can interfere with visibility, radar and laser guidance systems and equipment function.

Marine Productivity

When deposited to oceans limited in nutrients, dust rich in iron, phosphate or nitrate can stimulate marine productivity with impacts on fisheries. Understanding when, where and how much mineral nutrient is being deposited may result in more efficient practices to sustain fisheries as well as to provide guidance to marine researchers in understanding complex processes of the marine environment. From 2007, World Meteorological Organization (WMO) and Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) cooperate in studying the atmospheric chemical input into the ocean, focusing on nutrient aspect of the (dust) aerosol deposition.

Agriculture

Sand and dust storms erode soil, smother cropland by moving dunes, damage crops and injure livestock. They are a risk to food and water security. They are part of a feedback loop that begins with natural or human related land degradation leading to desertification, then to more dust and then back to land degradation closing the feedback. Sand and dust storm warning advisories and assessments will allow mitigating action to be taken, such as harvesting maturing crops and sheltering livestock, along with adaptive action, such as changing the time of planting, strengthening infrastructure, and construction of windbreaks and shelterbelts. With appropriate user consultation, tools and products of SDS-WAS could be developed to: (i) better assess crop yield; (ii) research plant and animal pathogen movement; (iii) understand the relationship between elevated dust levels and disease outbreaks and (iv) to develop soil erosion and land degradation models.

Weather Prediction

Airborne dust affects precipitation processes and the atmosphere's energy and radiation budget. Advanced weather forecast models are increasingly taking into account the effects of dust and other aerosol types on direct radiative heating, on cloud radiative properties, cloud coverage and on the formation of rain and snow. There are many journal publications showing the improvement in atmospheric dynamics of forecast models that result from adding aerosols as active "weather variables" in numerical weather prediction models. This will no doubt play a role in reducing model uncertainty and accelerate progress toward extending weather forecasts from one week to two weeks. There are hypotheses that Saharan dust over the Atlantic affects the development of hurricanes reaching the Americas. In addition, there is modelling evidence that dust and pollution aerosol in India could affect the Indian Monsoon. SDS-WAS will promote this type of weather model research and development.

Climate Prediction

The Intergovernmental Panel on Climate Change in its 4th Assessment Report recommends research to reduce important uncertainties in the effect of aerosols on the Earth's radiation budget and climate. Products of the research component of SDS-WAS will improve estimates of the contributions to global airborne particulates from natural and anthropogenic sources and the land-atmosphere processes that produce them. These will be essential for improving the accuracy in predicting seasonal to inter-annual climate and providing users with estimates of SDS in future climate scenarios.

Mission

The SDS-WAS mission is 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.

Research Objectives

The SDS-WAS, as an international framework linking institutions involved in SDS research, operations and delivery of services, will address the following objectives:

- Provide user communities access to forecasts, observations and information of the SDS through regional nodes to be connected to the WMO Information System (WIS) and the World Wide Web.
- Support research leading to better understanding and modelling the atmospheric dust process
- Identify and improve SDS products to be delivered to user communities
- Enhance operational SDS forecasts through technology transfer from research
- Improve forecasting and observation technology through coordinated international research and assessment
- Build capacity of relevant countries to be trained to utilize SDS observations products for meeting societal needs
- Build bridges between SDS-WAS and other communities conducting aerosol related studies (air quality, biomass burning, etc.)

- (to be completed if needed)

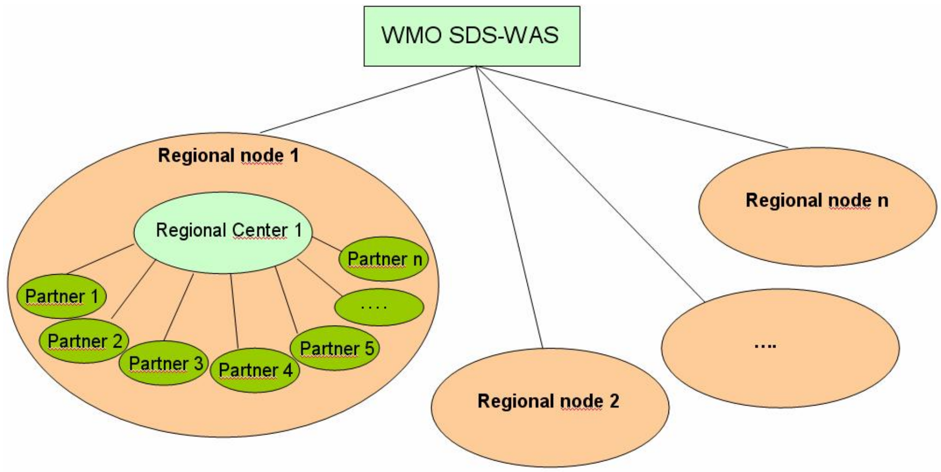

Figure 2. The international network of SDS-WAS comprised of federated nodes assisted by regional centres

Structure and Federation

SDS-WAS is an international network of research, national operational centres and users organized through regional nodes assisted by SDS-WAS regional centres (Fig 2). It is coordinated by the SDS-WAS Steering Committee supported by the WMO Secretariat and reporting to CAS through the WWRP and GAW programmes.

This Plan calls for close collaboration with operational forecasting and service delivery programmes reporting to the WMO Commission for Basic Systems. At the regional level of nodes, SDS-WAS is structured as a federation of partners. The regional nodes as an aggregate structure comprise the SDS-WAS federation. What the term federation implies is 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. It allows a variety of participants (such as regional centres-serving as hosts, university research centres - serving as partners, WMO designated operational forecasting centres, meteorological operational services, health organizations, etc.) to cooperate and benefit without requiring changes to their own internal structures and existing arrangements. The regional node and its partners will adopt minimum regional standards to operate and will be open to new members to join. The structure is scalable and allows for adaptability to changing research and operational environments.

The flow of information between various SDS-WAS regional components and the role of an SDS-WAS regional centre is shown in Figure 3. The Scientific Committee of SDS-WAS takes into account flow of information between system components (Fig 3) and the interaction of research and operations, as well as ensuring minimum global standards when appropriate.

Figure 3 Flow of information between SDS-WAS system components for a regional node consisting of a consortium of partners supported by the Regional Steering Group and Regional Centre

SDS-WAS Steering Committee

The SDS-WAS Steering Committee (SDS-WAS SC) coordinates activities at the global scale. Its role is to ensure the fulfillment of SDS-WAS objectives. It will manage the SDS-WAS according to this implementation plan which in turn supports detailed plans developed by the regional nodes assisted by the SDS-WAS Regional Centre (role defined below).

The terms of reference of SDS-WAS SC are:

- To periodically review the SDS-WAS objectives
- To identify value-added global activities in research, assessment and operations and promote their implementation
- To identify gaps in SDS-WAS global coverage and to recommend solutions
- To promote communication between regional nodes
- To provide guidance on standardization between regional nodes
- To represent at a global level SDS-WAS activities through a membership comprised of operational and research representatives, chairs of RSGs, and selected experts to fill programmatic and geographic gaps. It will meet every two years.
- To promote extra-budgetary contributions to a WMO Trust fund for SDS-WAS
- To report routinely to the appropriate bodies or expert groups of CAS as appropriate

SDS-WAS Regional Node and Regional Steering Group

For regions mostly affected by dust process, SDS-WAS regional collaboration nodes are established. The node is organized on federated principles. Activities within each node are harmonized by a SDS-WAS Regional Steering Group (RSG) and assisted by the WMO Secretariat. For each node, a Regional Centre (RC) is nominated with a mandate to implement the following tasks agreed by a corresponding RSG.

- To provide a web-based portal agreed between regional partners for user access to regional research and forecast activities and services [2]
- To support efficient observation data sharing providing neutral ground for SDS-WAS data exchange
- To assist partners on implementing agreed research and forecast activities at a regional level
- To cooperate with existing operational service delivery mechanisms, recognizing that warnings related to SDS-WAS are generally the responsibility of the National Meteorological and Hydrological Services (NMHSs) and that SDS-WAS products provide input to NMHSs.
- To report on implementation progress to the WWRP JSC and to the SDS-WAS Steering Committee
- To cooperate with existing operational service delivery mechanisms, recognizing that warnings related to SDS-WAS are generally the responsibility of the National Meteorological and Hydrological Services (NMHSs), so that SDS-WAS products represent input to NMHSs.
- To support research among partners of a regional node and to help implementing operational SDS-WAS forecasts at the NMHSs
- To guide RC on implementing agreed research and forecast activities at a regional level
- To organize training workshops on use of the SDS-WAS products
- To convene symposia, conferences, workshops and other meetings as necessary to advance research SDS activities;
- To assist, when necessary, in the resource mobilization through trust funding contributions

Membership in SC and RSG

Chair of the SC is appointed by the CAS President upon recommendation of the WWRP JSC Chair and the WMO Secretariat. Chairs of the RSGs are appointed by the Chair of the WWRP JSC Chair upon recommendation of the WMO Secretariat.

Members of SC are appointed by the WWRP JSC Chair upon recommendation of the WMO Secretariat. Members of RSG are appointed by the WWRP JSC Chair upon the recommendation of the WMO Secretariat. The term of SG and RSG members is four years with possible extension for another four years.

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Role of the WMO Secretariat

The WMO Secretariat, through the lead of the Department of Research, working closely with Departments of Weather and Disaster Risk Reduction Services and other Departments, will provide support

[2] SDS-WAS partners will communicate using regional web portals accessible through a general WMO SDS-WAS web site. They will contain value-added observational and forecast products as well as links to sources of basic information. They will also contain SDS-WAS description, tasks, upcoming events and background information.

for SDS-WAS under the guidance of CAS and CBS. The Ad-hoc Internal SDS-WAS Group, chaired by the Research Department has the following ToR:

- To assist the appointment and organization of the SC and RSG activities
- To support the SC and RSG meetings
- To establish, in consultation with SC and RSGs a WMO Trust fund for SDS-WAS
- To promote national capacity building for SDS-WAS activities,
- To coordinate SDS activities with other international organizations, in particular with United Nations Convention to Combat Desertification, World Health Organization, International Civil Aviation Organization, Group on Earth Observations and United Nations Environmental Protection
- To assist in development, ongoing review and update of the Science Implementation Plan
- To establish outreach and communication mechanisms, including the maintenance of a web site portal to SDS-WAS

Partners

Participation of organizations in SDS-WAS is on a voluntary basis. An organization establishes its SDS-WAS partnership by notifying the WMO Secretariat about its intention to collaborate with the SDS-WAS community. Organizations may link to one or more of the regional nodes, to the WMO Secretariat, or via an established portal or other SDS-WAS partners. Partner organizations may undertake collaborative research, provide data, test products, develop and provide added value products, improve monitoring and extend outreach.

Research

Research is an essential component of SDS-WAS. In 2008, the immaturity of atmospheric science related to aerosols and their inclusion in weather and climate models meant that a large fraction of activities and partners are research and development oriented. This plan recognizes that for success in the long term, it is important to establish a mix of research and operational activities with a strong dialog and link to capacity building. In the long term, SDS-WAS will be sustained through research assisting the delivery of effective operational services and assessments linked to user needs.

This research component of this plan considers the following scientific fociii as a priority for further development of the SDS-WAS:

- Improved dust source specification and parameterization
- Influence of local and mesoscale atmospheric processes on dust storm generation
- Advanced methods in observing the SDS, including surface-based, aircraft and satellite methods
- 4-D assimilation of dust-related observations
- Studying direct and indirect radiative forcing effects of dust in atmospheric weather and climate models
- The role of dust as ice nuclei affecting storm development and precipitation
- Dust impact on high impact hydrometeorological and environmental phenomena (e.g. monsoons, tropical cyclones, mesoscale convective complexes, flooding and droughts)
- Developing ensemble systems for SDS prediction
- Dust and health issues

- Photochemical effects of dust and its impact on atmospheric ozone and other oxidants
- Impact of dust on marine productivity
- SDS reanalysis studies producing dust climatologies
- SDS model validation and model intercomparisons

Current Nodes

Regional Node for Asia (SDS-WAS RC A).

In order to promote more effectively the science and implementation plan, the Regional Centre for Asia (SDS-WAS RC A) hosted by the Centre for the Atmospheric Watch and Services of the National Satellite Meteorological Centre and National Meteorological Centre of CMA in China supports the regional node in SDS-WAS consisting of a consortium of partners from China, Korea, Japan, Mongolia and other interested countries in the region. The Regional Steering Group recognized the following actions to be performed within the Node partners

Regional Node Northern Africa - Middle East - Europe (SDSWAS RC NA-ME-E)

- This Centre supporting the SDSWAS RC NA-ME-EU Node, hosted by Spain is composed of a consortium that includes: the Meteorological State Agency of Spain (AEMET), the Barcelona Supercomputing Center (BSC-CNS) and the National Research Council (CSIC). Some of the regional node partners will include Meteo-France, LISA, University of Athens, University of Tel Aviv, Egyptian Meteorological Agency, METU and NMHSs in the region.

Current Achievements

From the time of its launching, SDS-WAS made the following achievements in facilitating developments and implementation of its several components:

- Two activity research nodes were established with the supporting centres in China and Spain
- Established node portals for data (observations, forecasts, other information) between regional partners); agreed standardised display of dust-related products (selected parameters, agreed color scale for maps, etc.)
- Several scientific meetings coordinated jointly by WMO and regional partners were organized, including the first WMO/GEO Expert Meeting on SDS-WAS, and the first user training hands-on workshop on use of the SDS-WAS products
- Multi-decadal regional dust model reanalysis was performed, to serve as a information source for regional dust climate studies
- at a regional or global scale several organizations established daily dust forecasts
- building observational capacity through installation of new sun photometers in Northern Africa (framework AERONET), a better utilization of the lidar retrievals of vertical profiles of aerosol (cooperation with EARLINET/GALION), incorporation of PM10 aerosol measurements (EG Spanish air quality network),
- AEMET supporting WMO to ship sun photometers to Morocco and Tunisia.
- WMO and/or its SDS-WAS partners support/participate dust aerosol-related projects, including

- Meningitis Environmental Risk Information Technologies (MERIT) – impact of dusty weather on meningitis outbreaks in Sahel
- GMES and Monitoring Atmospheric Composition and Climate (MACC) EU project – dust and health aspects; chemical weather forecast, including dust aerosol modelling
- "GAW Aerosol Lidar Observation Network" (GALION) – observing vertical profiles of aerosol including dust
- Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) Working Group on the atmospheric chemical input into the ocean
- The Fennec project: Dust processes and the western Sahara 'heat low' (leaded by UK NERC)
- (to be completed if needed)

Capacity Building

Capacity building in SDS-WAS involves technology transfer with self-sustaining capability and long-term partnership in mind. This capacity building will be coordinated through various mechanisms including those very well established in WMO through the Development and Regional Activities Department. Elements of capacity building include: consultation meetings with national users to develop effective and realistic products and tools for their needs; training courses on use of services that are available; research workshops and provision of guidance and outreach material. The SDS-WAS nodes will promote capacity building through regional partnerships.

Depending on available resources, proposed activities include:

- Regular scientific exchange: A scientific workshop or demonstration will accompany every group meeting to discuss recent developments in SDS modelling and forecasting.
- Dedicated training: It will include training on monitoring and modelling methods.

These activities will be carried out through In-house training courses and workshops conducted at an institution within the regional node, at WMO headquarters, and at affiliated institutions. The capacity building component of SDS-WAS will include expert visits to local institutions.

Capacity building, training and demonstrations may be assisted from relevant existing WMO programmes, and from the regional SDS-WAS nodes. Subjects for training and demonstration include satellite data access and analysis, dust storm forecast and simulation model output analysis, targeting user needs through new information products, measuring and monitoring particulate air quality through remote sensing and in-situ air sampling instruments, developing PM monitoring networks for verifying and validating SDS products, and characterizing and mapping sand and dust source regions.

Programs such as the *Sistema Regional Visualización y Monitoreo* (SERVIR) routinely disseminate data and value-added products derived from research and monitoring systems. Users and researchers from throughout the Americas benefit from SERVIR, which is expanding to cover African nations as well. Training and demonstrations in preparing and applying environmental information products provide access to tools and technology generally not available except in the largest laboratories and institutions.

Implementation in the period 2011-2015

The implementation of the SDS-WAS will include.

The emphasis will be

- enhancing NRT effective cooperation between partners in regional nodes, that will include exchanging of agreed observations and model products (2011-2013)
- Developing and implementing a routine verification system. (2012-2014)
- strengthening cooperation with organizations/networks/projects providing SDS-related observations (NASA, ESA, GALION, AEONET, etc. (continuous)
- proposing Trust Fund establishment (2011)
- models inter-comparisons (2012-)
- dust reanalysis (2012-)
- ensemble forecasting (2014-)
- Considering establishing new nodes and/or sub-nodes (Americas, SE Asia, Australia) (2012-)
- Establishing RDP/FDP projects (continuous)
- Supporting field campaigns, to be used for a better understanding of the SDS process, to evaluate of model performance.
- Data assimilation (2011-)
- Establishing user-oriented studies (e.g. case studies of events affecting air/ground transport; studies linking public health and dust, etc.) (continuous)
- Studies on emission process (continuous)
- Mineral dust fractions; impact of deposited dust on environment (continuous)

Milestones

February 2011

- Science and Implementation Plan endorsed by the WWRP JSC. being conditional following recommendations of the JSC

Spring 2011:

- Activated portals in two nodes.

Spring 2011:

- Consider establishing a node for Americas and a sub-node for the SE Asia

Fall 2011

- Final approval of the Science and Implementation Plan by CAS MG.

Fall 2011:

- SC and RSGs formally established

May 2011:

- Promoting SDS-WAS on Cg-16; organizing a side meeting; delivering a SDS-flyer

Fall 2011

- RSG Nodes meetings

October 2011

- NA-ME-E training workshop

Spring 2012:

- Routine quantitative and qualitative verification systems in RCs

2011-:

- Developing data assimilation techniques

2012-:

- Dust models reanalysis.

2013-:

- Developing ensemble dust forecast systems.

Organizations delivering SDS forecasts

Organization	Web site	Domain coverage	Contact person and e-mail
Laboratoire des Sciences du Climat et de l'Environnement, Gif-sur-Yvette, Paris, France	http://www-lsceinca.cea.fr/cgi-bin/lsce/inca_work_annualrs.pl	Global	Dr Yves Balkanski yves.balkanski@lsce.ipsl.fr
Japan Meteorological Agency	http://www.jma.go.jp/en/kosafcst/kosafcst-c.html	East Asia, Central Pacific	Maki, Takashi maki@met.kishou.go.jp
Met Office, UK	Not publically available	Eastern Africa, Middle East and southern Asia	Dr Damian Wilson Damian.Wilson@metoffice.gov.uk
Spain: Barcelona Supercomputing Centre & the Meteorological State Agency of Spain (AEMET),	http://www.bsc.es/projects/earthscience/DREAM/	North Africa, Middle East, Europe East Asia	Carlos Pérez carlos.perez@bsc.es José Baldasano Jose.baldasano@bsc.es Emilio Cuevas ecuevas@inm.es
Centre for Atmosphere Watch and Services (CAWAS), Chinese Meteorological Agency	http://www.sds.cma.gov.cn/index.php?mid=22	East Asia, Central Pacific	Xiaoye Zhang xiaoye@cams.cma.gov.cn
University of Athens, Greece	http://forecast.uoa.gr/dustindx.php	Middle East, Mediterranean, Europe, North Africa and Atlantic Ocean; Saudi Arabia for Arabian Peninsula, North Africa, Middle East and SW Asia – password protected	George Kallos kallos@mg.uoa.gr
Korean Meteorological Administration, Korea	http://web.kma.go.kr/eng/asi/asi_02_04.jsp	East Asia	Seungbum Kim skim@kma.go.kr
MeteoFrance	Pre-operational	Global	Vincent-Henri Peuch vincent-henri.peuch@meteo.fr
University of Tel Aviv, Israel	http://wind.tau.ac.il/dust8/dust.html	North Africa, Middle East, Europe	Pavel Kishcha pavel@cyclone.tau.ac.il
Naval Research Laboratory, Monterey, USA	http://www.nrlmry.navy.mil/aerosol/index_shortcuts.html	Global	Douglas Westphal douglas.westphal@nrlmry.navy.mil
Research Institute for Applied Mechanics, Kyushu Univ., Japan In cooperation with National Institute for Environmental Studies (NIES)	http://cfors.riam.kyushu-u.ac.jp/~cfors/index.html http://www-cfors.nies.go.jp/~cfors/index.html	East Asia, Central Pacific	Itsushi Uno, iuno@riam.kyushu-u.ac.jp
Laboratoire de Météorologie Dynamique, Paris, France	http://www.lmd.polytechnique.fr/dust/dust-fcst-maps.php	Africa, Europe, Atlantic, Central Asia	Laurent MENUT menut@lmd.polytechnique.fr
ECMWF	http://www.gmes-	Global	Jean-Jacques.Morcrette@ecmwf.int

	atmosphere.eu/d/services/gac/nrt/		
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Turkish State Meteorological Service	http://www.dmi.gov.tr/2006/arastirma/arastirma-etatozmodeli.aspx operational	Regional	Mustafa COSKUN mcoskun@dmi.gov.tr
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