TECHNICAL ANNEX

International Network to encourage the use of Dust Monitoring and Forecasting products (InDust)

1. S&T EXCELLENCE

1.1. Challenge

1.1.1. Description of the Challenge (Main Aim)

When winds are strong, large amounts of sand and dust are lifted from bare, dry soils into the atmosphere. Through this process of deflation, dust particles are transported downwind, affecting regions hundreds to thousands of kilometres away. The most important dust source areas are located in the Northern Hemisphere in an area called "dust belt" (i.e. North Africa, Middle East, East Asia and North America), while other minor sources are in Australia, South America, and South Africa. The North African and Arabian deserts are the most important dust sources in the world and dust from these sources is frequently driven to America, Asia and Europe. Wind-blown mineral dust aerosol accounts for one-third to one-half of the mass of the total aerosol burden. It is estimated that between 1000 and 3000 Tg of mineral dust is uplifted into the atmosphere annually with Saharan desert being the largest global contributor. Also, human activities, such as improper agricultural and grazing practices, may contribute up to 20-50% of the atmospheric loadings. Inadequate water management, agricultural and grazing practices have increased/contributed to the desertification of land throughout the globe. The estimated burden of mineral dust is, therefore, likely to increase due to the predicted increase in human activities as well as the expansion of arid regions due to global warming.

Due to its multi- and trans-disciplinary effects at local, regional and global scales, dust includes impacts to the environment (including climate), human health and specific economic sectors (as agriculture, solar energy and transportation). Over the last few years, numerical prediction of dust concentration and observational products from ground- and satellite platforms have become prominent at several research and operational weather centres due to growing interest from diverse stakeholders, such as agriculture, solar power plant managers, health professionals, aviation authorities and policymakers. However, the coordination between measurement and modelling groups as well as between scientific research and user communities is difficult. On the one hand, measurement products lack harmonised quality indicators, data formats and measurement schedules. On the other hand, current attempts to transfer tailored products to end-users are not coordinated, and the same technological and social obstacles are tackled individually by different groups, a process that makes the use of data slow and expensive. The flow of information and knowledge between measurement, models, and society requires translation across disciplinary and cultural boundaries. The result is that current data-model-user cooperation becomes increasingly fractured and a potentially immense benefit for Europe's end users remains unexplored.

The overall objective of the proposed Action is to establish a network involving research institutions, commercial service providers and potential end users of information on airborne dust. The network will be a forum for discussion to establish common protocols to data exchange between the different scientific and user communities at international level. By this, the Action will coordinate the current research activities as well as enhance the availability of appropriate products to assist the diverse socio-economic sectors affected by the presence of high concentrations of airborne mineral dust. This information will enable mitigation of the negative impacts of this atmospheric component and adaptation.

1.1.2. Relevance and timeliness

Atmospheric dust strongly interacts with the Earth system through direct and indirect impacts (IPCC, 2013). Mineral dust influences the Earth's direct radiative budget by affecting the processes of absorption and scattering at solar and infrared wavelengths. Indirect effects include changes in the number of cloud condensation nuclei and ice nuclei (Nickovic et al., 2016), which in turn affect the optical properties and the lifetime of clouds. In this sense, the prescription of an improved dust climatology or, more accurately, the use of online models to predict airborne dust quantities for radiation calculations and cloud formation in numerical weather prediction models is being increasingly recognized as important to improve the accuracy of short-range weather forecasts (Baklanov et al., 2014) and, consequently, air quality forecasts. Dust particles also have effects on atmospheric chemistry (Krueger et al. 2004), acting as a sink for condensable gases and thus facilitating the formation of secondary aerosols, which in turn contribute to PM concentrations. Dust sedimentation and deposition at the surface causes changes in the biogeochemical processes of terrestrial and marine ecosystems through the delivery of primary nutrients (Jickells et al., 2005). It has been demonstrated that the Amazon rainforest is fertilised significantly by Saharan dust (Yu et al., 2015). Sand and dust storms have many negative impacts on the agricultural sector (Stefanski and Sivakumar, 2009). Human exposure to airborne mineral dust may adversely affect human health, causing or aggravating allergies, respiratory diseases and eyes infections (Gyan et al., 2005; Griffin, 2007; Mallone et al., 2011). Dust events strongly affect the air quality conditions in Asia, where the background situation is often already heavy (e.g. Wang et al., 2014). Desert dust outbreaks over southern Europe frequently exceed daily and annual safety thresholds of particulate matter (PM) set by the European Union directive on ambient air quality and cleaner air (e.g. Basart et al., 2012; Pey et al., 2013). High dust concentrations significantly reduce visibility through increased light extinction and may affect aircraft operations and ground transportation. They also can deteriorate the aircraft engines. Also, airborne dust is a serious problem for solar energy power plants (Schroedter-Homscheidt et al. 2012). The need for precise dust observation and prediction products is particularly important for plants built in desert areas of Northern Africa (e.g. Morocco) and the Middle East, where European companies have designed ambitious projects. Substantial impacts of dust on climate and environment have increased needs to understand better and predict the atmospheric dust cycle.

Although today the relevance of mineral dust particles in all these fields is clear and there are several national and international scientific initiatives for studying the dust-related problems, tailored products for the user communities are not yet available. Dust observations and models have nowadays reached a level of maturity to be ready for the translation into user-oriented products. For example, easy-to-use prediction of direct and diffuse solar radiation can help the industry to optimise the installation of photovoltaic and thermal solar systems. However, this translation is delayed by the rapid increase of available observations, modelling approaches and potential user communities. If no action is taken to harmonise data and coordinate the information exchange between the involved communities, the benefit of EU-funded research to users and society as a whole will remain largely unexploited. This Action is, therefore, timely and will increase the impact of dust research on policy makers, public decision makers and the private sector, and will contribute to the strengthening of European research and innovation capabilities in an international context.

1.2. Objectives

1.2.1. Research Coordination Objectives

The overall objective of the proposed Action is to establish a network involving research institutions, service providers, and end users of information on airborne dust. The network shall coordinate and harmonise the process of transferring dust observation and prediction data into user-oriented products. The Action will coordinate the current research activities and enhance the availability of appropriate products to assist the diverse socio-economic sectors affected by the presence of airborne mineral dust. This will be achieved through a) identification of the needs of different end-user groups and b) coordination of existing and new scientific and technical services to achieve a routine delivery of tailored products. As shown in Figure 1.2.1 the aim of this Action is to enhance cooperation between the various dust scientific communities involved in R&D and to connect them to user groups. For example, an archive of dust products could be used to investigate the relationship of sand and dust storms with disease outbreaks; or to develop improved models of soil erosion and land degradation.

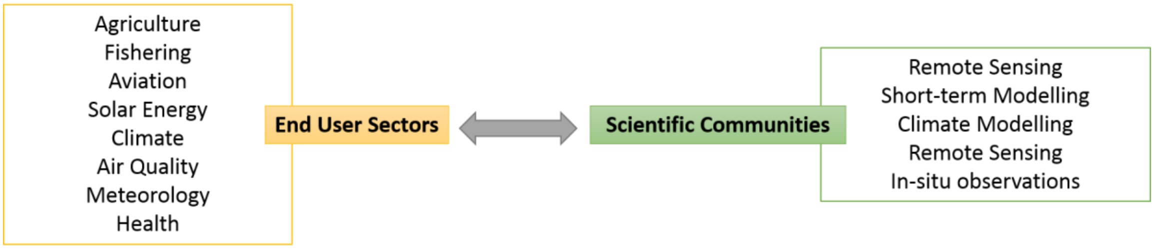

Figure 1.2.1. Schematic plot of the links between scientific and user communities.

Major components of this core objective are to:

- Identify existing and potential user groups (research and commercial organisations) from each participating country that could benefit from specific dust products.
- Identify and exploit dust monitoring observations (from both ground-based and satellite platforms) and forecast products best suited to be transferred/tailored to the needs of end-users.
- Coordinate collaboration between data producers and users.
- Build capacity of end-users to promote the use of the delivered products.
- Involve North Africa and the Middle East in the European-driven climate change science and mitigation/adaptation strategies.

1.2.2. Capacity-building Objectives

The training of policy-makers, managers and technicians from the different socio-economic sectors affected by airborne dust is essential. First, they must gain awareness of the negative impacts of airborne dust and better understand the mechanisms associated with them. Then, they should be trained to properly use the available observational and forecast products to design and implement preparedness and mitigation measures. These objectives shall be achieved through high-level

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

teaching (through seminars and workshops as well as printed and online training material) and will require the involvement of the stakeholders.

Observational networks perform systematic aerosol measurements with high spatial density in developed countries (as EMEP and Airbase networks at European level) but very sparse, discontinuous and rarely near-real-time measurements are available close to the desert dust sources. Conversely, availability of observational data from dust source regions is fundamental to both dust monitoring and forecasting. Nevertheless, the location of the main dust sources in remote and unpopulated areas, often in developing countries with political instability, complicates the establishment of adequate observing networks. Some monitoring stations have been set in Africa and the Middle East by European institutions (as the French network AMMA in Sahel). However, attendance and basic maintenance must often be in charge of local institutions. Furthermore, there is not any protocol for routine international exchange of air quality data, so their use is often limited to the national level. Thus, building the capacity of countries and training technical staff are among the primary objectives of the Action. Cooperation with institutions from near-neighbouring and international partner countries in Northern Africa and the Middle East will be essential and of mutual benefit, because dust concentrations are much higher and the adverse effects more severe near the sources than far downwind. Moreover, the participation in the Action of South African, American and importantly Asian partners brings the possibility of extending the application of the developed products, protocols and tools well beyond the European borders, including areas like Asian regions where dust particles play a significant role in the air quality and meteorological processes.

1.3. Progress beyond the state-of-the-art and Innovation Potential

1.3.1. Description of the state-of-the-art

Aerosol particles are emitted from Earth's surface both naturally (e.g., dust, sea-salt, biogenic emissions), and as a result of human activities. Key aerosol species include sulphates, organic carbon, black carbon, nitrates, mineral dust, and sea salt. In the atmosphere, these aerosols rarely occur as individual species, but rather clumped together to form complex mixtures. It is common, for example, particles of black carbon from soot or smoke to mix with nitrates and sulphates, or to coat the surface of dust, creating hybrid particles. The bulk of aerosols—about 90 percent by mass at global scale—have natural origins. Sea salt and dust are two of the most abundant aerosols. Mineral aerosols are highly variable in space and time. Much of the desert dust mass transported in the atmosphere occurs during a few events. Globally averaged, mineral aerosols have varied by a factor of 2–3 between glacial and interglacial time periods (Mahowald et al., 2006), and on the regional and decadal time scale can change by a factor of 2–4 depending on climate variability and/or anthropogenic land use change (Ginoux et al., 2012).

Various ground-based observational systems have been established to monitor aerosols over Europe (e.g., EMEP, Airbase, AERONET, CARAGA, EARLINET). Satellite remote sensing is the most convenient tool for providing spatial and temporal distribution of aerosols. In last years, some new advanced sensors (like SEVIRI, AIRS, IASI, CALIOP and MODIS) have been launched allowing dust detection (e.g. Klüser et al., 2015). Despite the number of available observations, there are still some gaps, especially in the early phase of dust transport or in the proximity of desert sources. Dust modelling partly fills gaps in observations, and, more importantly, can predict (potential) dust episodes and thus facilitate the preparation of dust management's measures. Since the early 1990s, models have significantly improved their skills to predict the major features of the dust cycle. Some dust forecast systems have been developed in Europe, such as the global model for atmospheric composition of the Copernicus project, MetUM™, BSC-DREAM8b, Skiron, NMME-DREAM8 and NMMB/BSC-Dust. While the meteorological community has developed protocols and near real-time observing systems to support forecasting, the aerosol community is only beginning to organise in this direction. An international forum would be necessary for bringing together atmospheric dust forecast centres and remote sensing data providers, and for leading data systems developers to share best practices and discuss pressing issues facing the operational dust community. On the other hand, despite the relevance of desert dust particles in climate, weather, energy, transport, air quality, health and agriculture, several national and international scientific initiatives for studying the dust-related problems, there is no specific 'dust-product' tailored to the potential user communities available yet. Knowledge and technology transfer, via tailored services, is essential to bridge the gap between science and its end users.

1.3.2. Progress beyond the state-of-the-art

The present Action will create a synergy among communities that provide dust prediction/observation data, and those, which should use these products in their professional routines, turning the initially scattered groups into one transnational and multi-disciplinary team.

Observational and forecast products that can eventually be transferred to end users are diverse and often not easily intelligible to users lacking specific training. The search and identification of the most suitable products for this process will require an effort to generate a comprehensive catalogue of products. Throughout the Action, it is also expected to reach agreements, establish protocols and define formats for the near-real-time (NRT) exchange of products as well as develop catalogues of dust-related products for long-term/climatic studies. It is also expected to build the capacity of potential users. The availability of suitable products and training of managers and technicians in their use will facilitate mitigation of the adverse impacts of airborne dust and exploitation of positive effects of dust deposition, leading to a notable progress in those socio-economic sectors affected by the presence of airborne dust.

The ultimate goal is to provide to European Member States the tools for a harmonised assessment of desert dust contribution to the air quality metrics regulated by the relevant European Directive 2008/50/EC. As an example, the Action could set up the platform for providing to the governmental stakeholders (Environmental Agencies) the means for an appropriate assessment of the contributions of desert dust to ambient PM10 and PM2.5 levels over Europe and other affected areas during dust outbreaks following the results of the EC-LIFE+ DIAPASON Project. The solar energy community could benefit from specifically designed end-user dust products to improve solar resource assessment and plant operation especially in arid regions where soiling and ageing of plant components and solar radiation attenuation due to dust is an issue. For aviation, specifically designed end user dust products can be used for air traffic management (pre-flight planning done by pilots/airlines and in-flight plan adjustment) or for investigating how the dust exposure can affect the aircraft engines.

Moreover, the combination of observation products and model simulations is expected to provide reliable climatological reference values describing the spatial and temporal (monthly, seasonal and annual) distribution of airborne dust both near the Earth's surface and in upper levels. These reference values will constitute an element of long-term planning in areas affected by dust. At the same time, they will facilitate the definition of thresholds r future early-warning systems.

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

1.3.3. Innovation in tackling the challenge

The Action will work with an interdisciplinary approach to knowledge and technology transfer. It will facilitate the cross-fertilization of scientific research and efforts to advance sustainable development in key sectors such as energy, transport and air quality. The overall aim is to demonstrate the value of airborne dust research to society and economy. End-users will remain at the centre of the Action to ensure that outcomes are both useful and usable through the following main ideas:

- Advance and guide state-of-the-art research on mineral dust.
- Ensure fast availability of products.
- Develop platforms to tailor and disseminate knowledge, products and technology with emphasis to deliver end-user products in remote areas afflicted by dust events (e.g. via mobile phone apps).
- Bring innovation to both institutions and commercial organisations to improve the efficiency of work processes (e.g. air traffic management, aircraft maintenance issues, power plants operation and air quality assessment).
- Assess the user and societal benefits to evaluate the service value, by establishing engagement, co-production and feedback from users to providers.

1.4. Added value of networking

1.4.1. In relation to the Challenge

The process of transferring dust observation and prediction information via user-oriented products cannot be performed without a constant dialogue between producers and users. The planning of the process, the study of the impacts, the transfer of products and knowledge, and the evaluation of the results are not possible without the participation of the stakeholders. Networking will likely benefit all parties. Besides the link with users, it is, however, important to highlight here the scientific progress expected from this multidisciplinary network. The Action will put together different scientific communities looking at different aspects of research on desert dust. The envisaged benefits on the user side are as follows:

- For stakeholder: to better understand the dust impact on human health, especially on pulmonary and cardiovascular diseases. Availability of tailored monitoring and forecast products shall enable optimising health care services and alert the population during the most serious episodes.
- For meteorological and climate services: to better understand the dust-cloud-radiation interaction allowing improved radiation and clouds parameterizations in NWP and climate models.
- For aviation operators: to have access to precise forecasts of visibility reduction by dust particles, which can improve air traffic management and safety; dust is also an issue for aircraft (engines and airframe) maintenance scheduling.
- For the solar power generation sector: to better plan and assess investments in new infrastructures, predict the impact of reduced radiation on the output from operational plants and to plan maintenance and clean-up tasks.
- For fishery industry and agriculture: to receive estimates of deposited dust as nutrient responsible for increasing marine productivity in specific areas.

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- For air quality assessment and management agencies, to better estimate the contribution of natural dust to the overall aerosol concentration, and during pollution episodes in particular, and formulate ad hoc mitigation/adaptation strategies.

The envisaged benefits on the data/model producers' side are:

- Better knowledge of end-users' real needs, optimisation of the data definition for each observation type and harmonisation with the other platforms.
- The exchange of expertise and communication inside the Action will permit identification of critical gaps in current observational networks and model developments.
- Acceleration in model and data-product improvements focused especially on the derivation of new user-oriented products.
- Coordinated work is also expected to lead to better understanding of the interactions between aerosols and atmospheric processes and thus contribute to reduce the uncertainties in modelling the chemical composition of atmosphere and in the quantification of the direct and indirect radiative forcing attributed to natural aerosols. Such advances will contribute to the definition of mitigation and adaptation measures to face the challenges posed by climate change.

1.4.2. Description of the Action in relation to existing efforts at European and/or international level

Different research collaborative European and international initiatives and projects have been set to understand better, monitor and predict the dust (and/or aerosol in general) cycle. These programmes cover specific aspects:

- Models: WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS WAS), MACC and MACC-II-III, AEROCOM, ICAP and EuMetChem
- Observations: EMEP, ACTRIS and ACTRIS2; EARLINET, LALINET, AERONET, AERO-SAT, AEROSOL-CCI and GEO-CRADLE
- Dust effects on air quality (EU Life+ DIAPASON, EU Life+ AIRUSE), health (EU Life+ MED-particles), solar energy (DNIcast, WASCOP, IE SHC and SolarPACES) and aviation (Daedalus)

Additionally to these research activities, some other initiatives are focused on providing products to end-users:

- The Barcelona Dust Forecast Center (**BDFC**, http://dust.aemet.es/) is designated by the WMO as the first Regional Specialized Meteorological Centre with activity specialisation on Atmospheric Sand and Dust Forecast. It generates and distributes operational dust forecasts for Northern Africa (north of the Equator), Middle East and Europe.
- **Copernicus** (http://www.copernicus.eu/ is a European Union (EU) programme aimed at developing European information services based on satellite and ground Earth observation and data analysis.

Even if some examples of interactions occurred, there is not yet a common platform for addressing dust related issues. The current Action is designed as a cross-sector platform that could act as a link among these pre-existing projects promoting important synergies of different communities and it is expected to provide innovative and affordable technologies to environmental agencies for assessing the contribution of African dust to air quality levels in Europe following a similar scheme

COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

as EMEP, DIAPASON, MED-Particles and ACTRIS-2. For example, ACTRIS is chosen to be in the ESFRI roadmap (see http://www.actris.eu/Projects/ACTRISonESFRIroadmap.aspx). It will be very important if this Action could provide guidance and input on the needed data formats and measurement schedules, in a way that it is useful to modellers and users. This will help ACTRIS for the transition to operations.

Networking is expected to strongly cooperate with the **WMO SDS-WAS** and to lead to improvements in the products delivered by the **Barcelona Dust Forecast Center**, which is the Centre designated by the WMO to generate and distribute operational dust forecasts to the National Meteorological and Hydrological Services of the NA-ME-E region. Similarly, it will likely improve the dust component of the products delivered by the future Copernicus services. Within Copernicus, the Copernicus Atmospheric Monitoring Services (CAMS) is delivering near-real-time forecasts of atmospheric composition, which includes dust. The first users of **Copernicus** services are policymakers and public authorities, who need the information to develop environmental legislation and policies or to take critical decisions in the event of an emergency, such as a natural disaster or a humanitarian crisis. Other users are private companies (i.e. solar power industry) who need the products for planning investments and managing operations.

2. IMPACT

2.1. Expected Impact

2.1.1. Short-term and long-term scientific, technological, and/or socioeconomic impacts

As a short-term impact, the Action will contribute to establishing a network for coordinating the exchange of available information through the definition of common protocols as well as for supporting the process of transferring dust products to end-users, where health, aviation, solar power generation sectors and fishery industry will benefit from the outset. Additionally, the Action will work on the development of high-quality training material to promote the use of dust products and to address the risks associated with airborne dust. In the long term, the open observers/users cooperation and discussion platform will be the backbone for a continuous exchange of ideas and information leading to the design of more efficient tailored tools and to strengthen the resilience to the dust impacts. On the other side, tailored tools will help the users in exploiting the positive impacts of dust presence (e.g. nutrients provision to the ecosystems can be beneficial for fishery industry and agriculture). The Action output concerning the impact of dust on solar plants could foster strategies for improving their efficiency. This will have both social (improved quality of life) and economical (decrease of production expenses) impacts.

It is expected that the Network created in the framework of the present Action (in which researchers and users are involved) will continue beyond the present Action. This will favour further collaborations creating new synergies that can contribute to a more accurate assessment of dust (and other aerosols) influence on air quality, natural environment and climate, and consequently help to formulate adequate policies, strategies and measures to mitigate the negative impacts caused by desert dust particles.

2.1.2. Plan for involving the most relevant stakeholders

The Action will be open to all potential stakeholders. The Scientific Committee will invite a list of stakeholders to join the first technical meeting of the Action. The link between the consortium and ongoing projects and initiatives at national, regional and global level provides a good opportunity to reach the most relevant stakeholders. To reach and involve stakeholders, a call will be published on the dedicated web page to suggest/request participation of potential users. Also, a selection of the Action objectives and plans will be prepared and presented on the website and at international conferences and national/international meetings.

The results of the Action will be shared within the WMO Global Atmosphere Watch (GAW) Programme, as an international body. Among others, one of the proposed actions will be the identification of government stakeholders in regions affected by dust outbreaks (mainly Northern Africa, Middle East and Europe) and professional associations (energy engineers, healthcare professionals).

2.1.3. Dissemination and/or Exploitation Plan

To reach the expected impact of the Network, the dissemination activities must reach the four main target audiences:

- The scientific community (members participating in this Action and other scientific communities and research bodies interested in dust and its atmospheric impacts/feedbacks).
- Governmental stakeholders (National and/or Regional, e.g. National weather services, Environmental Agencies, and in general EU policy makers and decision-making bodies at national and/or regional levels).
- Industrial stakeholders (technical non-academic professionals of diverse sectors such as health, aviation, solar energy and fishery industries)
- Non-governmental organisations (NGOs) in the sector.

The communication measures will be adapted to the target audience:

- Scientific results will be published in refereed international journals and/or presented in lectures and conferences.
- The Action outcomes that could be exploited by stakeholders (e.g. access to dust observations and predictions, tailored products/services developed by consortium partners, etc.) will be made available on the project website, which will be built upon the already existing SDS-WAS website. This will ensure the open access to the network's outcomes during and after the Action's lifetime.
- Multimedia and printed material (videos, factsheets, brochures, etc.) will be tailored to the information needs of the different industrial sectors and governmental stakeholders. A multimedia approach will be taken ensuring the use of multiple platforms and formats to enhance the Action's dissemination among stakeholders. This will also be linked to training activities.
- The mailing list will be used to disseminate material or invite to participate different end users in an eDiscussions.
- Social networks will inform the general public through the Facebook and Twitter accounts. Mainstream press releases will be prepared and circulated into general and specialised media.

The list of activities will be defined in the "Dissemination and exploitation strategy document" that will be a constantly in progress document revised and adapted according to the evolution of the network. Where possible and appropriate, the Action may use the additional dissemination channels of the various projects and initiatives the proposers are part of to disseminate results and outcomes of this Action and raise awareness of its presence. All activities will be evaluated afterwards with quantitative indicators to assess the direct impact on the target audiences and improve them in the future. Furthermore, it is worth emphasising that the Action will collect and improve open-source tools that will help users to access, read, and visually inspect the results. This will be important e.g. for start-ups and other small and medium-sized enterprises (SMEs).

2.2. Potential for Innovation versus Risk Level

2.2.1. Potential for scientific, technological and/or socioeconomic innovation breakthroughs

At present, many socio-economic sectors consider airborne dust as a random hazard that can only be statistically accounted for. Therefore, knowledge of the physical processes, information on the occurrence of individual episodes and more reliable statistical information can lead to improvement in planning and operations. The Action will positively impact the scientific community through a better awareness of the end-users' real needs, an optimisation of the data definition for each observation type and harmonisation with the other platforms. The exchange of expertise and communication inside the Action will also permit the identification of critical gaps in current models and observations. In a long-term perspective, the Action will accelerate work on improving dust models further, focusing especially on promising outcomes related to the derivation of new user-oriented products.

Current efforts to bring together dust observations and modelling communities are mainly focused on climate studies with historical satellite data and climate model runs. Dust forecast models assimilate total aerosol optical depth from satellites, if at all, and mostly no specific dust product. As in recent years, the dust observation capabilities from satellite have significantly improved, the proposed Action has high potential to bridge the gap between the dust modelling communities and the providers of satellite dust observations, steadily improving data quality and ensuring data standards compliance. Consequently, there is a good chance that the Action will facilitate the use of such observation data in dust forecasting as well as communicate the need for timely delivery of satellite dust observations to user communities other than climate researchers. It can be expected that all subsequent user groups of combined tailored dust products and/or dust forecasts will benefit from a stronger link between the model community and the satellite data providers.

One of the most important innovative factors of the Action is the aim to engage the scientific and user communities in a continuous exchange. To this innovative factor corresponds, however, a high-risk level: the user community interest should be kept high. Typically, scientists are more efficient in communicating with other scientists. Problems start already with scientists of different fields, and the situation is definitively worse for a non-scientific audience. As actions for reducing the risk of lack of interest from the users, multimedia informative materials and communication through social network are foreseen. Moreover, a partner from the social scientist-communication field and post-merger integration (PMI) partners with expertise in science-to-users presentations are involved.

3. IMPLEMENTATION

3.1. Description of the Work Plan

3.1.1. Description of Working Groups – Provide for each WG the Objectives, Tasks, Milestones and Deliverables

The scientific program of the Action will be realised through the following working groups (WG):

- WG1: Dust observation
- WG2: Dust modelling and forecast
- WG3: Assessment of user and societal benefits to evaluate the service value
- WG4: Transfer of dust (modelled and observed) products to user-oriented applications and ex-post evaluation of the services value

WG1 shall work on the identification and catalogue of dust (ground-based and satellite) observations best suited to be transferred to modelling groups and end-users. It will review existing quality assurance and communication practices and propose harmonised reporting procedures, following the guidance of the GEO's Quality Assurance for Earth Observation (**QA4EO**) initiative. Additionally, WG1 will identify critical gaps in the current observational capacity (including the availability of observational products in near-real-time) and consider the most appropriate integration of different observation practices and datasets. WG1 will also propose formats and protocols for data harmonisation and NRT data exchange.

Tasks:

Task 1.1. Review, assess and adapt existing techniques, methodologies, and best practices for the quality assurance of dust-related observations.

Task 1.2. Identify and catalogue observation methods and products, and assess their suitability for different users.

Task 1.3. Identify observation gaps in terms of parameters and operational capabilities.

Task 1.4. Adapt or develop data formats and protocols for data harmonisation and NRT exchange. This task will be in coordination with WG2.

Task 1.5. Produce recommendations to document and communicate the quality and maturity level of existing and future products.

Task 1.6. Interact with WG2 on the specific needs of the modelling community: defining joint exercises for models evaluation and inter-comparison for showcasing the potential for data assimilation in dust forecast.

Deliverables:

D1.1. Report on the current needs and future directions for dust observations and applications. **D1.2.** Report on recommended protocols and formats for harmonisation and NRT exchange. **D1.3.** Report on dust observational parameters and operational capabilities. **D1.4.** Report on documentation and communication of quality, validation status and uncertainty in dust observations. **D1.5.** Report on usability and benefits of dust observations in data assimilation experiment (together with WG2). **D1.6.** Update of the dust observations in the website of the project.

Milestones:

M1.1. Catalogue of existing dust-related observational products.

WG2 shall work on the identification of the most suitable model products (forecasts, hindcasts, reanalysis) for the user's communities. It will also deal with the most appropriate way to communicate the models' modelled data accuracy. The WG2 will also propose formats and protocols for data harmonisation and NRT exchange.

Tasks:

Task 2.1. Consolidate state-of-the-art information and identify existing gaps in dust modelling and priorities for the development of next-generation dust models for regional and climatic applications.

Task 2.2. Identify and catalogue dust forecast products, and assess their suitability for different users.

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Task 2.3. Define protocols for model evaluation to assess their suitability for different users.

Task 2.4. Define protocols and formats for NRT data exchange. This task will be in coordination with WG1.

Task 2.5. Produce recommendations to document and communicate the quality and maturity level of existing and future products.

Task 2.6. Interact with experimentalists (WG1) on the specific needs of the modelling community and on preparing joint exercises for models evaluation and intercomparison and for showcasing the potential of data assimilation and evaluation in dust forecast.

Deliverables:

D2.1. Report on the current needs and future directions for dust model development and applications. Specific focus will be given on dust/cloud/radiation parameterizations, dust mineralogy, climate models and data assimilation. **D2.2.** Report on recommended protocols and formats for harmonisation and NRT exchange. **D2.3.** Protocol for model evaluation to assess their suitability for different users. **D2.4.** Report on documentation and communication of quality and uncertainty in dust forecasts. **D2.5.** Report on usability and benefits of dust observations in data assimilation experiment (together with WG1). **D2.6.** Update of the dust forecasts in the website of the project.

Milestones:

M2.1. Catalogue of dust simulations (i.e. forecasts, hindcasts and reanalysis).

WG3 shall work on the creation of a network that enables fruitful collaborations between researchers and end-user communities. Therefore, WG3 shall work on guidance and training on provided services to public institutions and private companies as well as to increase the international visibility of services to attract new users and establish feedback mechanisms to evaluate the service value. In particular, the present Action will try to network countries from Northern Africa and the Middle East.

Tasks:

Task 3.1. Identify potential user communities (institutions, private companies, etc.) that can benefit from the use of dust products.

Task 3.2. Build capacity of end-users to promote the use of dust products and to address the risks associated with airborne dust and mainstream them.

Task 3.3. Provide guidance, training and marketing for established services to increase international visibility, and establish feedback mechanisms to evaluate their value to society and the economy.

Task 3.4. Dissemination of the project results for the scientific community.

Task 3.5. Establish a discussion forum between research and user communities to ask for their needs as well as show potential products.

Deliverables:

D3.1. Report on dissemination and exploitation strategy. **D3.2.** Report on the capacity building strategy **D3.3.** Multimedia and printed material (videos, factsheets, brochures, etc.) **D3.4.** Report of the publications and conference participations during the project. **D3.5.** Online user guide on the provided services.

Milestones:

M3.1. List of potential users. **M3.2.** Deployment of the website of the project. **M3.3.** A workshop to build the capacity of scientists, engineers and policy makers to use this information to address the risks associated with airborne dust. **M3.4.** Training School on dust forecast and observations. **M3.5.** Launch of open online discussion platform and tools for communication of scientific, commercial and user communities.

WG4 shall work on proposing the most suitable products for the application areas identified by users involved in the Action and also identified by WG3. WG4 will work closely to WG3.

Tasks:

Task 4.1. Identify specific needs of the users not covered by existing dust products.

Task 4.2. Identify and record end-user current capacities and needs related to data handling formats.

Task 4.3. Design tailored observational and forecast products to cover specific user needs. This task will also work to bridging between research and commercial organisations, to transfer pure research/knowledge/tools to the applied domain.

Deliverables

D4.1. Report on the specific need of the users not covered by existing dust products. **D4.2.** Report with specific needs regarding products, formats, etc. of the end-user community. **D4.3.** Report on recommendations to develop new observational and forecast products to cover specific user needs.

Milestones

M4.1. Survey to user's communities

3.1.2. GANTT Diagram

PROJECT:	International Network to promote the use of Dust Monitoring and Forecasting products (NetDust)											
Duration:	4 years											
	1st year			2nd year			3rd year			4th year		
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
WG1: Dust observations												
Task 1.1				D1.1								
Task 1.2			M1.1									D1.6
Task 1.3								D1.3				
Task 1.4						D1.2						
Task 1.5									D1.4			D1.5
WG2:Dust modelling and forecast												
Task 2.1				D2.1								
Task 2.2			M2.1									D2.6
Task 2.3							D2.3					
Task 2.4					D2.2							
Task 2.5									D2.4			D2.5
WG3: Assessment of user and societal benefits to evaluate the service value												
Task 3.1		M3.1										
Task 3.2				D3.2		M3.3						
Task 3.3			M3.2				D3.3		M3.4			D3.5
Task 3.4												D3.4
Task 3.5							D3.1			M3.5		
WG4: Transfer of dust (modelled and observed) products to user-oriented applications												
Task 4.1			M4.1			D4.1						
Task 4.2									D4.2			
Task 4.3												D4.3

3.1.3. Risk and Contingency Plans

The following table summarises the identified main risks related to the Work Plan and proposes their corresponding mitigation measures.

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COST Association
Avenue Louise 149 I 1050 Brussels, Belgium
t: +32 (0)2 533 3800 I f: +32 (0)2 533 3890
office@cost.eu I www.cost.eu

Description of risk	Proposed risk-mitigation measures
Partnership is unable to fulfil the w ork plan	- Clear definition of the w ork plan and w ork package leaders. - Use of project w ebsite. - In case a delay is due to lack of readiness from a WG Leader, it w ill be immediately replaced by the Executive Committee.
Inability to produce w ork on time	- Monitoring of w ork plan by the Review Committee. - Revision of the Draft Documents that support the discussion by stakeholders. If needed segmentation of the scientific community into smaller areas of interest. - Ensure regular contact betw een all COST members. - Elaborate clearly defined milestones and means of verification to monitor tasks' accomplishment.
Working problems / Insufficient collaboration betw een partners and new participants (e.g. end-users)	- Establish strategies (such as periodical meetings and other COST events). - Ensure all partners know each other and create interpersonal connections. - Establish clear procedures for internal communication and reporting. - Take remedial actions in case a partner is not able to w ork effectively with others, promoting collaboration betw een partners. - Funded COST Action events w ill reinforce the participation of new potential end-users. - Political events affecting training organisation/participation w ill be compensated w ith online materials.
Lack of interest from the users	- Multimedia informative materials and communication through social netw orks. - A partner from the social scientist-communication field and PMI partners w ith expertise in science-to-users presentation are involved.

3.2. Management structures and procedures

The overall Action activity will be managed by the Management Committee (MC), composed of the national delegates. Efficient day-to-day management will be ensured by the Steering Committee (SC), consisting of the MC chair, the vice-chair and the WG leaders. SC will have frequent conference call meetings to secure efficient coordination of the Action. Activities requiring cooperation amongst members will be accomplished mainly through Short-Term Scientific Missions (STSMs), which will be planned and managed by a dedicated member of the MC. The Action will involve specifically or invite to its meeting experts from the United States and countries with relevant scientific production in the area (e.g. China, Japan, and Korea). In particular, the involvement of space agencies (e.g. ESA, EUMETSAT) will be encouraged. Also, scientists and technicians coming from geographic regions containing the main dust sources affecting Europe (North Africa and the Middle East) will have an important contribution.

The SC will be in charge of organising the MC and the WG meetings and workshops. The MC will define the strategic roadmap of the Action and integrate the results of the WGs. The MC will also ensure the promotion of the Action and the dissemination of its results, and secure interactions between data producers and users as partners within the project.

3.3. Network as a whole

Atmospheric dust plays a significant role in different aspects of weather, climate, atmospheric chemistry and ecosystems as well as its impacts on life, health, economy. Understanding, managing and mitigating sand and dust storms risks and effects requires fundamental and cross-disciplinary knowledge.

Desert dust transport is a global phenomenon. For countries located in and downwind of arid regions (e.g. Northern Africa and the Middle East) airborne sand and dust present serious risks to the

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environment, property and human health. In downwind regions (such as Europe), dust outbreaks may greatly increase the ambient air levels of PM recorded in air quality monitoring networks. Due to this international and multi-regional/multi-national character of atmospheric dust transport, the present COST Action involves 26 countries: in Europe (Spain, Portugal, Greece, Italy, Germany, Serbia, Romania, United Kingdom, Belgium, Norway, Finland, Netherlands and France), North Africa (Morocco) and Middle East (Egypt, Turkey, Cyprus, Jordan, Kazakhstan and Saudi Arabia). Furthermore, the Action will involve specifically atmospheric aerosol experts from America (i.e. United States, Chile and Brazil), and from other countries with relevant scientific production in the area (e.g. Japan, Namibia and South Africa). The Action will continue on its expansion to cover all European geographical regions. In addition, representatives of international and European organizations, bodies and associations involved in environmental protection issues will be represented and have already expressed their interest to participate in the current Action.

Research activities are designed to make available scientifically robust information on the environmental, social, and economic risks and impacts of atmospheric dust. Because of the strong interaction atmospheric dust has with the Earth system, a multidisciplinary group of international scientific experts on aerosol measurements and aerosol modelling (from short-term to climatic scales) will be part of the present Action. Moreover, one of the main objectives of the present proposal is to provide scientific expertise and leadership within the atmospheric dust research community for supporting the development of the most suitable products for the application areas identified by users; providing continuity and guidance in overcoming knowledge and capacity gaps; and guidance and training on provided services to public administrations and companies. It is within this framework that a multidisciplinary group of international experts on aerosol measurements, regional aerosol modelling, air quality management experts and social scientists are participating. Moreover, the aim of the Action is to create a network that enables fruitful collaborations between researchers and business by providing a natural platform for them to meet and build mutual trust. It also aims at increasing impact of research in the industrial sector, by promoting the use and development of technologies, as well as the exploitation of COST Action results and outcomes through dedicated dissemination and exploitation activities targeting European small and medium-sized enterprises (SMEs) and companies.

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