European ERA4CS Joint Call for Transnational Collaborative Research Projects 2016

Topic B - Researching and Advancing Climate Service Development by Institutional integration

PROPOSAL APPLICATION FORM 2016

1. Project title
Dust Storms Assessment for the development of user-oriented **Clim**ate Services in Northern Africa, Middle East and Europe

2. Project acronym (max. 30 characters)
DustClim

3. Sub-topic(s)
• Development of new methods and tools • Impacts studies and models

4. Duration
36 Months

5. Publishable abstract (Maximum 2000 characters; includes spaces)

Sand and dust storms (SDS) are an important threat to life, health, property, environment and economy in many countries, and play a significant role in different aspects of weather, climate and atmospheric chemistry. There is an increasing need for SDS accurate information and predictions to support early warning systems, and preparedness and mitigation plans. In alignment with the mission of the WMO Sand and Dust Storm Warning Advisory and Assessment System, DustClim will make a major step forward in the way SDS affects society by producing and delivering an advanced **dust regional model reanalysis** for Northern Africa, Middle East and Europe covering the satellite era of quantitative aerosol information, and by developing **dust-related services tailored to specific socio-economic sectors**. The novelties of the DustClim reanalysis include its unprecedented high-resolution, the assimilation of satellite products over dust source regions with specific dust observational constraints, and a thorough evaluation using a wide variety of observations and data from experimental campaigns. There is currently a very limited integration of dust information into practice and policy. In this context, DustClim will not only provide reliable information on SDS trends and current conditions, but will also develop dust impact assessment pilot studies for three key economic sectors (**air quality, aviation and solar energy**). Since the beginning of the project, there will be a continuous exchange between the scientific teams and the main user communities. This collaboration is fundamental for better defining the dust parameters to be investigated and to design and optimise the future provision of dust services.

6. Key words (at least 3 and up to 10)

Climate; climate-variability; aerosols; dust; reanalysis; impacts; air-quality; health; solar-energy; aviation

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8. Executive Summary (Maximum 2 pages)

Over the past decade, there has been a growing recognition of the crucial role of **sand and dust storms (SDS)** on weather, climate and ecosystems, along with their substantial **adverse impacts upon life, health, property, economy** and other strategic sectors. Reacting to the concerns about SDS by its most affected member states, the World Meteorological Organization (WMO) endorsed the launch of the SDS Warning Advisory and Assessment System (SDS-WAS), and more recently of the first Regional Specialized Meteorological Center for Northern Africa, Middle East and Europe with activity specialization on Atmospheric Sand and Dust Forecast. The SDS-WAS mission is to enhance the delivery of timely and quality SDS forecasts, observations, information and knowledge to users through an international partnership of research and operational communities.

Understanding, managing and mitigating SDS risks requires fundamental and cross-disciplinary knowledge underpinned by state-of-the-art scientific research, the availability of **reliable information on SDS past trends and current conditions**, the provision of skilful forecasts and projections tailored to a diversity of users, and the capacity to use the information effectively. At present, all these requirements are confronted by **major challenges**. These challenges include the **lack of reliable dust information in many countries affected by SDS** and the very **limited integration of dust information and forecasts into practice and policy**.

A major obstacle to reconstructing comprehensive dust information of the past is the scarcity of historical and routine in-situ dust observations, particularly in the countries most affected by SDS. Model simulations can be used to “fill in the blanks” and overcome the sparse coverage, low temporal resolution and partial information provided by measurements. By objectively combining model simulations with satellite observations, **DustClim will produce an advanced and thoroughly evaluated decadal high-resolution dust reanalysis for Northern Africa, Middle East and Europe**. The proposed dust regional reanalysis will be built on three pillars: 1) a state-of-art dust model and data assimilation system, 2) quality observations and understanding of their respective uncertainties, and 3) flow-dependent uncertainties reflected by the ensemble simulations. So far reanalyses have been thought for the global domain (missing dust processes associated to finer spatiotemporal scales) and are based on the assimilation of total aerosol optical properties (lacking observational constraints on the model individual aerosol components). The novelty of DustClim will be the generation of a dataset at an unprecedented high resolution spanning the satellite era of quantitative aerosol observations, the assimilation of satellite products over source regions with specific observational constraints for dust, and a thorough evaluation with a wide variety of observations. **This first objective is relevant to topic B1 in the ERA4CS call as it develops new methods and tools by combining the latest advances in dust modelling, observations and data assimilation to create a unique dust regional reanalysis.**

SDS can severely disrupt communications, as well as ground and air transportation. Even moderate dust concentrations affect solar radiation production systems, damage croplands, and compromise air quality and human health. The high-resolution dust reanalysis will describe with accuracy the dust variability and trends, and provide extensive information for the socio-economic evaluation of major events, and their short (direct) and long-term (induced) impacts on society. It will also allow the assessment of the efficiency of countermeasures for particular sectors. In this context, our second objective is to **develop dust-related climate services for user communities focusing on aviation, solar energy and air quality sectors.** In this process, we will enhance the understanding of the precise role of SDS upon these key sectors, while increasing awareness, knowledge and capacities to use this information. This objective is relevant to **topic B2 of the ERA4CS call as it intends to develop dust-related applications in different socio-economic sectors taking into account specific user needs.**

The project is structured along four interconnected lines of work:

- Treatment and provision of accurate and consistent dust observations over the reanalysis period, suitable for assimilation or evaluation;
- Generation and evaluation of a high-resolution regional dust model simulation with dust-specific observational constraints;
- Design of a portfolio of pilot services for key socio-economic sectors affected by SDS (i.e. aviation, solar energy and air quality);
- Dissemination of dust reanalysis-based services to end users, and facilitation of their sustainability.

DustClim aims at making a significant step forward in the way SDS affect society. The design of better early-warning systems along with more adequate air quality policies over regions in Northern Africa, Middle East and Europe should allow better preparedness and a reduction of health expenses. Products tailored to specific sectors are expected to improve the management of resources or activities that are affected by SDS. The reanalysis dataset will become a valuable resource for numerous users to drive or diagnose their models and applications. The wider community will benefit from derived studies on the impact of dust on weather, climate, atmospheric chemistry, ecosystems human health and socio-economic activities.

DustClim will provide scientific expertise and leadership within the atmospheric dust research community by promoting the development of the most suitable end user products for the identified application areas. It will also provide continuity and guidance in overcoming knowledge and capacity gaps; and guidance and training on services and products relevant to public administrations and companies. The project gathers a European transnational and multidisciplinary group of experts on aerosol measurements, regional aerosol modelling, air quality management, and socio-economic analysis. The consortium is composed by partners from southern (Spain, Italy), central (France) and northern (Finland) Europe and by a combination of research institutions (BSC, CNR-DTA and CNRS) and National Meteorological and Hydrological Services (AEMET and FMI).

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9. Project description (Maximum 11 pages)

9.1 State-of-the-art

9.1.1 Sand and dust storms and their impacts

Sand and Dust Storms (SDS) are meteorological phenomena common in arid and semi-arid regions that generate disproportionate amounts of airborne mineral dust particles. Once ejected, dust particles reduce visibility to near zero in source regions and are regularly carried over distances of thousands of kilometres before being deposited to land and ocean waters. Dust is one of the major contributors to the global aerosol mass load (e.g., Textor et al., 2006) and is the dominating component of atmospheric aerosol over large areas of the Earth (Figure 9.1). The major sources of contemporary dust are found in the Northern Hemisphere, in the so-called “dust belt”, extending from the Sahara Desert to Arabia and south-west Asia, and to a lesser degree in the Australian, American and South African deserts (Prospero et al., 2002). Dust plays a significant role in different aspects of weather (e.g., Pérez at al., 2006), climate (e.g., Miller et al., 2014), atmospheric chemistry (e.g., Bauer and Koch, 2005), and ocean biogeochemistry (Jickells et al., 2005).

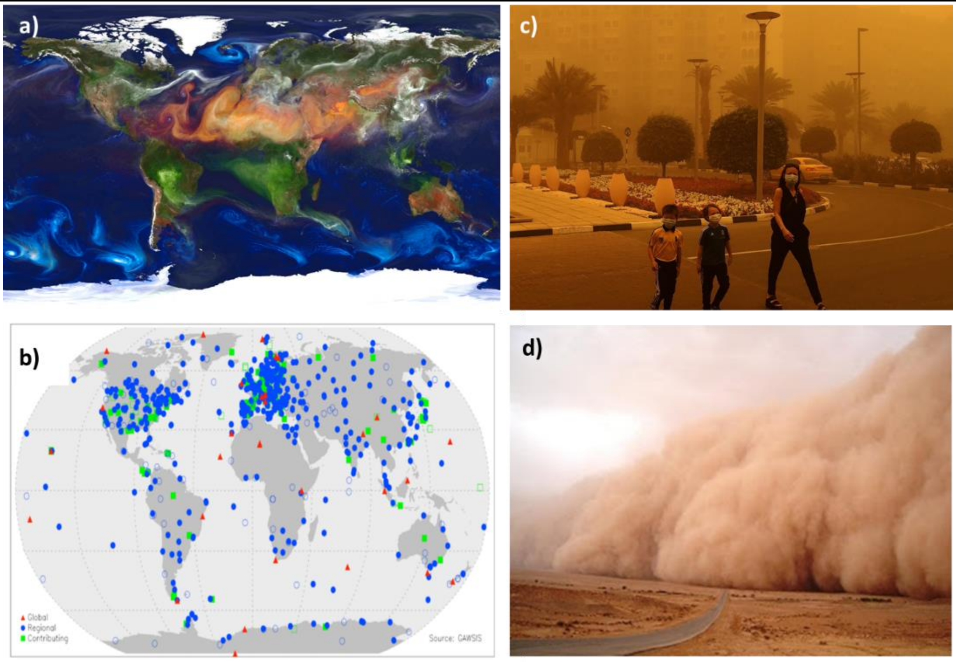

Figure 9.1 a) Global distribution of different aerosol types. Dust is shown in orange (Courtesy of NASA). b) Map of GAW-WMO aerosol observatories showing the dearth of observations over the main desert dust sources. c) A family walks amid a heavy dust storm in Riad (Saudi Arabia, Middle East). d) A dust storm affecting Central Australia and disrupting road traffic.

In addition to the climate effects of dust particles, SDS represent a serious **hazard for life, health, property, environment and economy** in many countries, particularly in the Middle East and North Africa (Figure 9.1). SDS severely compromise air quality, affecting human health (e.g., Mallone et al., 2011; Morman and Plumlee, 2013); and have been associated with deadly epidemics of meningococcal meningitis in the African Sahel (Pérez García-Pando et al., 2014). North African dust outbreaks affecting southern Europe frequently exceed daily and annual safety thresholds for particulate matter (PM) set by the European Union directive on ambient air quality and cleaner air (e.g., Rodríguez et al., 2001; Basart et al., 2012a; Pey et al., 2013). Intense outbreaks can force the closing of roads and airports due to poor visibility, strongly affect commercial solar energy production systems by reducing solar insolation (e.g., Schroedter-Homscheidt et al., 2013), and can deteriorate aircraft engines. Agricultural impacts of SDS include losses of crop and livestock (Stefanski and Sivakumar, 2009).

9.1.2 Current SDS services and initiatives for North Africa, Middle East and Europe

In a survey conducted by the World Meteorological Organization (WMO) in 2005, more than forty WMO member states formally expressed their concerns about SDS and their interest on building capacities for SDS warning advisory and assessment. In 2007, WMO officially endorsed the launch of the **Sand and Dust Storm Warning Advisory and Assessment System** (SDS-WAS), whose mission is to enhance the ability of countries to deliver timely and quality SDS forecasts, observations, information and knowledge to users through an international partnership of research and operational communities. The Barcelona Supercomputing Center (BSC) and the Spanish Meteorological Agency (AEMET) were designated to host the WMO SDS-WAS Regional Center for Northern Africa, Middle East and Europe (http://sds-was.aemet.es/), which consists of a network of dust research and operational partners (http://sds-was.aemet.es/partners/). Among other activities, the Regional Center delivers routine (non-operational) dust forecasts and multi-model products with 12 modelling systems (BSC-DREAM8b, CAMS-ECMWF, DREAMABOL, GEOS5, LOTOS-EUROS, MetUM, NGAC, NMMB/BSC-Dust, NMME-DREAM8, RegCM4, SILAM and WRF-Chem).

There have been (and currently are) other European and international research initiatives and projects on dust (and/or aerosol in general) involving some of the partners of the Regional

Center that cover modelling and forecasting (e.g., MACC and MACC-II-III, AEROCOM, ICAP and EuMetChem), observations (e.g., EMEP, AMMA, ACTRIS and ACTRIS-2; EARLINET, CARAGA, LALINET, GAW, GALION, AERONET, CV-Project, AEROSAT, AEROSOL-CCI and GEO-CRADLE), airborne hazards (EUNADICS-AV), effects on air quality (EC Life+ DIAPASON, EC Life+ AIRUSE), health (EC Life+ MEDparticles), solar energy (DNIcast, WASCOP, IE SHC and SolarPACES) and aviation (Daedalus).

More recently, in view of the demand of many national meteorological services and the achievements of the SDS-WAS Regional Center, the 65th Session of the WMO Executive Council designated the same consortium, formed by BSC and AEMET, to create in Barcelona the first Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast, known as the **Barcelona Dust Forecast Center** (BDFC). The Center was created in February 2014 (http://dust.aemet.es/) and its mandate is to generate and distribute **operational dust forecasts** 365 days a year. The NMMB/BSC-Dust model runs operationally at the BDFC with a horizontal resolution of 10 km for the same region. Another key operational initiative is Copernicus (http://www.copernicus.eu/), a European Union (EU) programme that aims at developing European system for monitoring the Earth which collects data from multiple sources (i.e. earth observation satellites and in situ sensors). It processes these data and provides users with reliable and up-to-date information through a set of services related to environmental and security issues.

9.1.3 A dust reanalysis for dust-related climate services

While short- and medium-range dust forecasts are available nowadays, there is a complete lack of capabilities to predict dust at longer lead times (e.g., sub-seasonal, seasonal), which could enable a better preparation for the risks presented by SDS. Also, managing and mitigating SDS impacts not only requires the provision of skilful forecasts and predictions, but also the availability of relevant dust information on past trends and current conditions, tailoring the information to a diversity of users, and building capacity to use the information effectively. One of the challenges is the paucity of historical and routine dust observations, particularly in the countries most affected by SDS. The coverage of weather-observing sites in Africa is sub-optimal with only 1/8th of what is considered as minimum coverage, and many historical climatic datasets are still on perishable media. These sites offer operational visibility observations that only provide qualitative and uncertain estimates of dust. In general, there is a dearth of in-situ quantitative observations and limited information on aerosol speciation, which is essential to distinguish dust from other aerosol types (Figure 9.1). Satellites typically provide column-integrated aerosol measurements, but estimates of surface dust concentration and deposition are needed to establish detailed assessments for different socio-economic sectors. In this context, model simulations with data assimilation can complement remote sensing and in-situ observations and help address deficiencies in the observing system. To address this challenge **we propose to produce an advanced and thoroughly evaluated high-resolution regional dust reanalysis for Northern Africa, Middle East and Europe** that will contribute to the formulation of management and/or mitigation plans for different socio-economic sectors.

So far, aerosol reanalysis including dust have been produced for the global domain at low resolutions, ranging from 1 degree (NAAPS reanalysis; Lynch et al., 2016) or 78 km (MACC-II reanalysis; Cuevas et al., 2015; Inness et al., 2013) to half a degree (NASA MERRAero; Buchard et al., 2015; Buchard et al., 2016). Such resolutions do not necessarily meet the requirements of interested stakeholders or policymakers in the energy, health and aviation sectors. A dynamically downscaled regional reanalysis has less prohibitive computational costs for finer spatial resolutions. Furthermore, current reanalysis datasets are based on the assimilation of total aerosol optical properties and lack observational constraints on the model individual aerosol components. These reanalyses rely on the model background to distribute assimilation increments among the different aerosol species, which can produce wrong analysis corrections due to incorrect aerosol attribution. All the existing reanalyses make use of data from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on-board the NASA Aqua and Terra satellites due to their good temporal and spatial coverage and retrieval quality, and, in some cases, of the additional assimilation of data from the Multiangle Imaging Spectroradiometer (MISR) sensor on board of NASA Terra satellite in order to fill in areas where glint precludes MODIS optical depth retrievals. MISR, however, provides low data volume compared to MODIS due to a narrower viewing swath (360 km compared to 2,330 km). The MODIS retrievals used by existing reanalyses are mostly based on the Dark Target algorithm, which does not provide information over very bright reflective surfaces, including the arid regions (with the exception of MERRAero, which assimilates MODIS reflectances without a specific limitation on surface type).

The recent development of algorithms retrieving dust properties from satellite reflectances in the blue range of the visible spectrum (Deep Blue algorithm) has led to a further extension of quantitative dust information to the source regions that are often characterised by bright surfaces and potentially the most useful for dust applications (i.e. Di Tomaso et al., 2016; Escribano et al., 2016). Our team has recently shown that the assimilation of MODIS Deep Blue retrievals from Collection 6 has a positive impact on the model analysis and forecasts downwind from the strongest dust sources of Sahara and in the Arabian peninsula compared to the assimilation of Dark Target retrievals only (Di Tomaso et al., 2016). A combined MODIS Deep Blue and Dark Target-based dust analysis was produced at BSC by coupling the NMMB/BSC-Dust model with a Local Ensemble Transform Kalman Filter (LETKF) scheme (Figure 9.2). **The DustClim project will produce an unprecedented high-resolution regional dust reanalysis using the state-of-art NMMB/BSC-Dust model and its advanced data assimilation capabilities**. The NMMB/BSC-Dust model is operational at the WMO BDFC. It is the dust module of the NMMB/BSC Chemical Transport Model (Pérez et al., 2011; Haustein et al., 2012; Jorba et al., 2012; Spada et al., 2013; Badia and Jorba, 2016), which is an online multi-scale atmospheric model designed and developed at BSC in collaboration with NOAA/NCEP and the NASA Goddard Institute for Space Studies. The model includes an assimilation scheme based on LETKF (Hunt et al., 2007; Miyoshi and Yamane, 2007). LETKF is a development of the ensemble-based transform Kalman filter (ETKF, Bishop et al., 2001) and the local ensemble Kalman filter (LEKF, Ott et al., 2004). It is particularly suited for the assimilation of aerosol information since it has been observed that aerosol fields have limited spatial correlations (~100km) (Anderson et al., 2003; Shinozuka and Redemann, 2011; Schutgens et al., 2013). Within MACC-II, the NMMB/BSC-Dust model was already used to produce a 30-year regional long-term dust simulation (without data assimilation), which was crucial to study the seasonal incidence of meningitis in Niger (Pérez García-Pando et al., 2014).

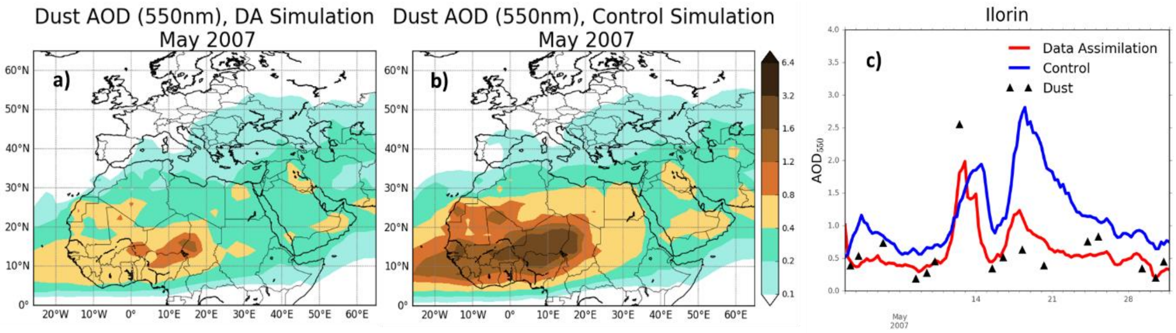

Figure 9.2 a) Monthly average of dust optical depth at 550 nm for May 2007 with the assimilation of MODIS Deep Blue and Dark Target. b) Same as in a), but without data assimilation. c) Comparison between the model simulations in a) (with data assimilation in red) and b) (without data assimilation in blue) and AERONET observations (black triangles) in Ilorin (Niger). Simulations are based on the NMMB/BSC-Dust model. Extracted from Di Tomaso et al. (2016).

9.1.2 Services: air quality, aviation and solar energy

The delivery of accurate information on past trends, current analysis and forecasts is a prerequisite for developing dust services. Other key impediments include a lack of understanding of the precise role of SDS upon certain sectors; the lack of products tailored to specific applications; the lack of awareness, understanding, capacity or structures in place to use the information, and the challenge of or reluctance to incorporating uncertain or new information into management practices. **The second objective of the project is to develop dust-related climate services based on the dust reanalysis and available forecasts for user communities focusing on health (air quality), transport (aviation) and energy (solar energy) sectors.**

National governments and international institutions need to know the precise causes of air quality degradation, epidemic outbreaks or crop damages. Other communities, such as the public health community, need spatially and temporally resolved dust data to attribute the effects of dust particles upon a range of aliments. Similarly, for aviation traffic flow coordination, better preparedness for SDS could reduce disturbances and related impacts. For example, EUROCONTROL is already assessing how climate change may affect future air traffic and is welcoming an extension towards SDS effects.

The output of strategic and operational downscaled SDS products can feed into the risk management systems of the considered sectors and organizations, which is eventually expressed in terms of expected annual extra cost or lost revenue for a given regime, a given level of infrastructure endowment (spare capacity, degree of flexibility, physical vulnerability, etc.), and a given level of annual or seasonal capacity utilization. The significance of predictability and preparedness of SDS also depends on the extent to which other risks matter. **The combination of observation products and model simulations is expected to provide reliable climatological reference values describing the spatial and temporal (daily, 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 for future early-warning systems. Moreover, the governmental stakeholders (environmental agencies) require the means for an appropriate assessment of the contributions of dust to ambient PM10 and PM2.5 levels over Europe and other affected areas during dust outbreaks. Within the EC-LIFE+ DIAPASON Project, an automatic, user-friendly software was developed to quantify the daily dust contribution to ambient PM10 over Italy (Barnaba et al., 2016). **The project will provide to European member States a tool for harmonised assessments of the desert dust contribution to the air quality metrics regulated by the relevant European Directive 2008/50/EC.**

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. In power system management, unplanned non-availability is a common type of indicator that can be translated into extra cost by assessing the marginal production cost in the system by season. **For aviation, specifically designed end user dust products could be used for air traffic management** (pre-flight planning done by pilots/airlines and in-flight plan adjustment). For both aviation and solar power production unplanned non-availability can be regarded as a key indicator to which dust is contributing. In transport systems impacts on capacity are typically initially expressed in terms of aggregate delay, delay % beyond a benchmark level (e.g., Perrels et al., 2014).

9.2 Research plan

9.2.1 Goals

The aim of **DustClim** is to make a leap forward in the development and use of dust-related climate services for key socio-economic sectors. The two specific goals are to:

1. **Produce and deliver an advanced and thoroughly evaluated high-resolution dust reanalysis for Northern Africa, Middle East and Europe**. The novelty with respect to current aerosol reanalysis datasets will be its unprecedented high-resolution, the

assimilation of satellite products over source regions with specific observational constraints for dust, and a thorough evaluation using a wide variety of observations. A key legacy will be the establishment of operational dust reanalysis updates (complementing current analysis and forecasts capabilities) beyond the lifetime of the project, which will be ensured by the WMO SDS-WAS Regional Center. **This goal is relevant to topic B1 in the ERA4CS call as it seeks to advance the development of new methods and tools.**

2. **Develop dust-related climate services for user communities focusing on air quality, aviation and solar energy sectors.** The developed dust reanalysis will be used in pilot studies to assess dust impacts upon these three key sectors. Since the beginning of the project, there will be a continuous collaboration between the scientific teams and the main user communities. This linkage will be fundamental for better defining the dust parameters to be investigated and to desing and optimise the future provision of services. **This goal is relevant to topic B2 of the ERA4CS call as it intends to develop dust-related applications in different socio-economic sectors taking into account specific user needs.**

9.2.2 Project Overview

The proposal is structured along five work-packages, including a work-package for **project management (WP5)**. The inter-relations among the work-packages are depicted in Figure 9.3. Besides the project management (WP5), the rest of WP activities span across the whole project creating synergies between them. **WP1 (Review, compilation and treatment of dust observations)** will tackle the dust observational part of the project by providing a comprehensive review of available dust observations (Task 1.1) that will support the development of dust observation catalogues for both data assimilation (Task 1.2) and model evaluation (Task 1.3). Overall, WP1 will feed WP2, WP3 and WP4. **WP2 (Generation of the high-resolution dust reanalysis)** involves the model configuration (Task 2.1), the data assimilation tuning phase and the generation of the reanalysis using the LETKF scheme (Task 2.2), and the reanalysis evaluation (Task 2.3). **WP3 (Development of dust-related products and services)** will develop products for aviation (Task 3.1), solar energy (Task 3.2) and air quality (Task 3.3), along with visualisation capabilities (Task 3.4). During the whole project duration, **WP4 (User involvement and dissemination)** will be devoted to stakeholder engagement (Task 4.1) and the promotion of products and services (Task 4.2).

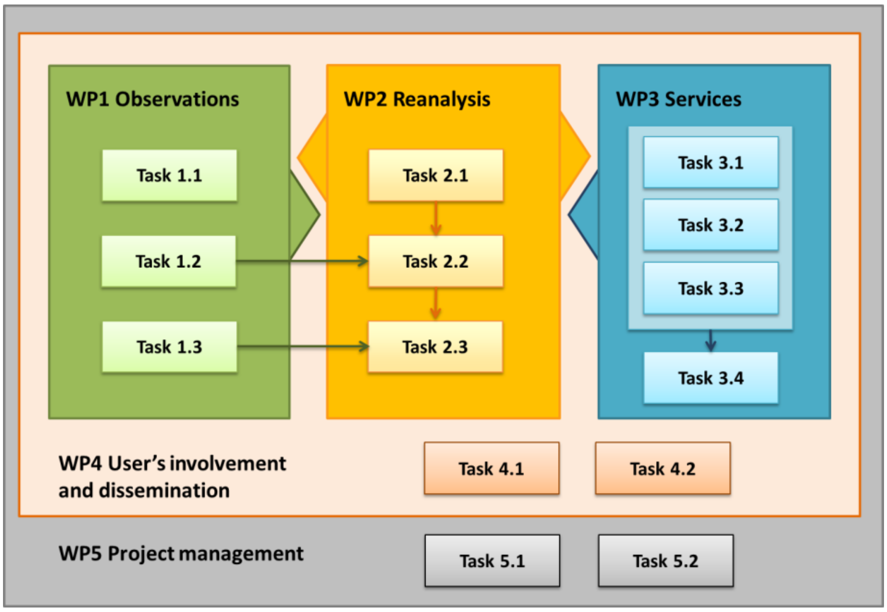

Figure 9.3 DustClim work breakdown structure.

WP1: Review, compilation and treatment of dust observations (Leader: CNR-DTA,

Contributors: CNRS, BSC) (M1-M24)

The objective of this WP is the identification of the aerosol and dust products best suited for both model data assimilation and evaluation. Satellite remote sensing remains the most convenient tool for data assimilation, while ground-based observational systems and experimental campaigns are more appropriate for model evaluation. Members of the DustClim consortium are involved in well-known observational networks (e.g., EMEP, AERONET, CARAGA, EARLINET), and have organised several experimental campaigns targeting dust in the region of interest. The main outcome of this activity will be a catalogue of ground-based and satellite observations suitable for data assimilation and model evaluation.

Task 1.1 Overview on dust-related data (Leader: CNR-DTA, Contributors: CNRS, BSC) (M1-M6). Dust datasets are highly heterogeneous regarding geographical and temporal coverage, resolution (time and space), accuracy, observed parameter, data format, and data policy. This task will provide a detailed account of what is nowadays available regarding dust observations for both data assimilation (Task 1.2) and evaluation purposes (Task 1.3).

Task 1.2 Dust observations for data assimilation (Leader: CNR-DTA, Contributors: CNRS) (M1-M16). Based on the outcomes of Task 1.1, this Task will identify, screen and filter the most appropriate datasets for assimilation by the model (Task 2.2). We will mostly consider observations from the MODIS sensor on-board of the NASA polar-orbiting satellites Terra (from 2000) and Aqua (from 2002), which provide high spatial coverage and good quality retrievals. In particular, we plan to use filtered and spatially aggregated Level 2 MODIS Dark Target retrievals (Remer et al., 2008; Levy et al., 2007a,b) as described in Zhang and Reid (2006), Hyer et al. (2011) and Shi et al. (2011). Close to the source region, the MODIS Deep Blue Level 2 quality assured retrievals at 0.1ºx0.1º resolution from Collection 6 (Sayer et al. 2014) are potentially the most useful for mineral dust applications, as shown in a recent work by members of our team (e.g. Di Tomaso et al., 2016). Both products include characterization of retrieval errors. In the same region, the detailed classification of MISR observations into spherical and non-spherical particles (Kalashnikova and Kahn, 2008) are potentially a powerful dataset for assimilation following the dust reanalysis needs (i.e., dust component information and its uncertainty). Aerosol absorption measurements from TOMS/OMI (Total Ozone Mapping Spectrometer/Ozone Monitoring Instrument; Torres et al., 1998, 2007) also provide a long record of information on the dust component.

Task 1.3 Dust observations for model evaluation (Leader: CNRS, Contributors: CNR-DTA) (M9-M24). Task 1.3 will focus on selecting and preparing the datasets for the dust reanalysis evaluation in WP2 (Task 2.3). (Note that WP3 will guide the evaluation by identifying the relevant application-specific parameters and timescales to be evaluated.**)** Independent observational datasets (not involved in the assimilation) will be used to evaluate the reanalysis performance. In addition to ground-based and in-situ observations from ground networks (e.g., AERONET, EMEP, EARLINET, AMMA, CARAGA) and intensive experimental campaigns (e.g., FENNEC, CV-PROJECT, SAMMUM, Charmex), a number of new dust products from advanced sensors (e.g., SEVIRI, AIRS, IASI, POLDER or CALIOP) are becoming available (e.g., Amiridis et al., 2015; Klüser et al., 2015). In addition to column-integrated measurements (e.g., AERONET), it is critical to evaluate dust surface concentration, dust deposition and dust vertical profiles. Air quality monitoring stations (i.e. EMEP and AMMA) are the main source of data for the evaluation of surface concentration in our region of interest. However, they are concentrated in populated and industrialised areas around the Mediterranean and the Sahel. In regions devoid of air quality stations (as Saharan and Arabian deserts) modelled dust surface concentrations will also be evaluated using METAR-weather stations by assuming an empirical relationship between visibility and dust surface concentration (Camino et al., 2015). To assess the potential impact of dust over photovoltaic panels, it is imperative to quantify the radiative and deposition fluxes with high spatial and temporal variability. Currently, deposition fluxes simulated by the 3D models of the atmospheric cycle of desert aerosols are not properly constrained, mainly due to the lack of observations. CRNS-LISA is implementing continuous measurements of deposition fluxes that meet the episodic character of the deposition of desert aerosols in Europe (CARAGA) and the Sahel (AMMA). With respect to dust vertical profiles, high-quality aerosol extinction profiles provided at European scale by EARLINET since 2000 (Pappalardo et al., 2015) have proved to be important for dust model evaluation (Mona et al., 2014; Binietoglou et al., 2015), and since 2006 CALIOP is providing global aerosol profiling giving insights on the dust vertical distribution (Amiridis et al., 2015; Papagiannopoulos et al., 2016; Yu et al., 2015). Observational data will be screened and dust-filtered applying specific methodologies to each particular dataset (i.e. when or where dust dominates the aerosol composition). Data will be prepared for comparison with the model outputs from WP2.

Deliverables

D1.1. Report on the available aerosol observations assessing their suitability for assimilation and evaluation. (Responsible: CNR-DTA) (M6)

D1.2. Catalogue of dust-related observations for data assimilation. (Responsible: CNR-DTA) (M16)

D1.3. Catalogue of dust-related observations for model evaluation. (Responsible: CNRS) (M24)

Milestones

M1.1. Compilation of aerosol observations for data assimilation. (Responsible: CNR-DTA) (M4)

M1.2. Dust-filtered observations for data assimilation. (Responsible: CNR-DTA) (M12)

M1.3. Compilation of aerosol observations for model evaluation. (Responsible: CNRS) (M12)

M1.4. Dust-filtered observations for model evaluation. (Responsible: CNR-DTA) (M20)

WP2: Generation of the high-resolution dust reanalysis (Leader: BSC, Contributors: CNR-DTA, CNRS, FMI) (M4-M24)

WP2 will generate and evaluate the decadal dust reanalysis using the NMMB/BSC-Dust model coupled with an LETKF assimilation scheme (Pérez et al., 2011; Di Tomaso et al., 2016). Model simulations will be run during the Earth Observation System satellite era from 2002 to 2016 when two polar-orbiting MODIS sensors can provide a good spatial and temporal coverage (globally two daily samples) and retrieval quality. Additionally, the production of shorter datasets will be considered for more recent periods that are particularly rich in dust observations. The validation of the reanalysis product will provide uncertainty estimates and identify whether spurious variability and trends are introduced by biases in observations and model, or by changes of observation availability.

Task 2.1 Model configuration (Leader: BSC) (M4-M9). The dust model set-up will be defined in this task. In addition to the definition of the domain, period, spatial and temporal resolution, the performance of the dust forecast will be analysed by means of a trace analysis. The user products requirements gathered within WP3 will be considered for the definition of the model configuration and post-processing. The baseline model configuration will follow the settings of the operational run of the Barcelona Dust Forecast Center, with a horizontal resolution of 0.1ºx0.1º, and a vertical resolution of 40 hybrid sigma-pressure layers. The model domain will cover Northern Africa, Middle East, Europe, and the North Atlantic up to about 50ºW (this will ensure that Atlantic arch episodes affecting Europe in spring are captured in our reanalysis). The meteorological fields will be downscaled from ERA-Interim reanalysis. Depending on the release date, the new ERA5 reanalysis could be the best option, as it would offer the possibility for dust reanalysis updates continuing forward in time for a longer period. The dust model has been recently updated with high-resolution source identification from MODIS Deep Blue, and improvements in the emission scheme and size distribution. A series of tuning experiments will be carried out with the model to iteratively adjust, on a regional basis, source and sink parameters. Different assimilation parameters need to be adjusted to the model's resolution and updates. A test period is planned in Task 2.2 for assimilation simulations to make these adjustments.

Task 2.2 Dust reanalysis (Leader: BSC) (M9-M24). The goal is to produce a dust reanalysis over more than one decade for Northern Africa, Middle East and Europe. Model execution will include the model configuration resulting from Task 2.1 and the observations resulting from Task 1.2. Some short experiments will be run to choose a close-to-optimal configuration for representativeness error (to be added to the instrument error component), observation density, covariance localisation and background error statistics. For aggregated aerosol satellite retrievals, following the approach in Zhang et al. (2008), we will use the representativeness errors estimated by spatial sample variance of the original retrievals and assume uncorrelated observation errors. For fields containing smaller scale features, like over dust source regions, and for denser observations, representativeness error can be larger and correlated. For observations at the original retrieval resolution (Level 2), methods such as variance inflation (Hilton et al., 2009, Whitaker et al., 2008) will be tested to account for these errors and unrepresented correlation structure. With a higher resolution model, generally, a smaller radius of influence of the observations is required to reduce the effect of spurious long-range covariances. This limits the use of observations that have large-scale information. Methods have been developed for applying different localisation scales (Zhang et al., 2009; Miyoshi and Kondo, 2013). We will use a different localisation radius of influence for different groups of observations. The method for generating the ensemble is also crucial, since the ensemble represents the uncertainty in the model background. Previous studies have demonstrated the skill of source perturbations (Schutgens et al., 2010a,b), while source plus meteorology ensembles have been shown important mainly for long range Atlantic transport (Rubin et al., 2016). Compared to our previous data assimilation simulations, we will consider a new approach based on spatially varying perturbations of the emission flux. Calibration of model and observation error parameters will be guided by internal assimilation diagnostics: statistics on first-guess and analysis departures, comparison between the analysis root mean square error and ensemble spread, ensemble rank histograms (Anderson, 1996). Once the system configuration is selected, longer simulations will be run and validated in Task 2.3. We will use a 24-hour assimilation window, where observations are subset (limited to satellite overpasses) to 6-hour slices centred on the nominal valid time of the analysis (at 0, 6, 12, and 18 UTC). We will use the LETKF implementation with a four-dimensional extension as described in Hunt et al. (2007).

Task 2.3 Model evaluation (Leader: CNR-DTA, Contributors: BSC, CNRS, FMI) (M12-M28). The dust observations prepared in Task 1.3 will be used to evaluate the reanalysis from Task 2.2. The main objective of Task 2.3 is to provide information on the quality and uncertainty of the dust reanalysis. The activity of this task is however planned to start well before the end of the reanalysis simulations as we will develop an evaluation interface and we will constantly be evaluating the model tests before the final model reanalysis execution. The interface will build upon existing tools and the experience of the DustClim partners in model evaluation for AOD (Basart et al., 2012b), surface concentration (Camino et al., 2015; Cuevas et al., 2015), deposition (Laurent et al., 2015) and dust vertical structure (Mona et al., 2012; Binietoglou et al., 2015). A set of parameters (i.e. dust load, surface concentration, deposition and dust vertical profiles) will be identified for scoring the model performances. The results of the evaluation will be delivered together with the reanalysis dataset and will include a specific discussion on the potential impact of the uncertainty in each of the considered socio-economic sectors in WP3. Dust climatologies (e.g., interannual variations and monthly, seasonal, annual means of concentrations, emission and deposition maps, SDS frequency), maps of model scores, and the processed observational datasets used in the evaluation (resulting from Task 1.3) will also be made available through the project portal.

Deliverables

D2.1. Report on the reanalysis configuration. (Responsible: BSC) (M12)
D2.2. Dust reanalysis. (Responsible: BSC) (M24)
D2.3. Dust Climatology. (Responsible: CNR-DTA) (M28).
D2.4. Report on reanalysis evaluation results and associated uncertainties oriented to user requirements. (Responsible: CNR-DTA) (M28)

Milestones

M2.1. Model configuration. (Responsible: BSC) (M8)
M2.2. Data assimilation configuration. (Responsible: BSC) (M12)
M2.3. Finalisation of reanalysis simulation. (Responsible: BSC) (M24)

WP3: Development of dust-related products and services (Leader: FMI, Contributors: ALL) (M4-M36)

This working group will develop products (direct impacts) for three different application areas (aviation, solar energy and air quality). This WP will constantly be interacting with WP2 to tailor model outputs to the requirements of dust-related service products and with WP4, which will work on engaging stakeholders.

Task 3.1. Aviation (Leader: FMI, Contributors: BSC, CNR-DTA) (M4-M32). The duration, type, and intensity of SDS derived from the dust reanalysis (WP2) will be used to assess the impact of adverse events on the European aviation network. This task will first identify the different critical thresholds (for different use purposes) regarding the spatial-temporal resolution of simulated dust following the methodologies of the FP7 ToPDAd project. ToPDAd aims to provide a set of best-practice climate-change-strategies for regional stakeholders and decision makers in the energy, tourism and transport sectors. These strategies are developed and supported by a state-of-the-art toolset of methodologies and models for an integrated assessment. For DustClim, the default will be the ToPDAd's 25km EU grid to which a simplified aviation network of hubs and spokes is added using georeferenced information system (GIS) software. The GIS software is important to connect causes and effects, but decision makers at the end of the chain (i.e. air traffic decision makers) will translate localised effects back into system relevant figures. Subsequently, for several resolution combinations potential avoided costs per typical event, per season and per year (for Europe as a whole) will be assessed for selected operational and strategic response options (as cancellation, diversion, dynamic air corridors, delay, technical protection measures; Perrels et al., 2014; Campanelli et al., 2014). The resulting benefit estimates provide an indication of the allowable cost of the actual service to be developed. Liaison partner EUROCONTROL will cooperate in this task to assess network response effects. Assessment of the impact of flight delay risk potential in Europe related to dust and of societal benefits of mitigation strategies will be performed using an aviation-oriented GIS dataset.

Task 3.2. Solar energy (Leader: FMI, Contributors: BSC, CNR-DTA) (M4-M32). Maps of dust storm occurrence and density, and dust deposition derived from the reanalysis (WP2) will be translated into % loss in received solar radiation. This development will be based on earlier work conducted in the FP7 ToPDAd project, in which a hybrid socioeconomic impact GIS dataset was developed by downscaling 0.5-degree climate projections to a 25km vector grid. Typical solar panel soiling loss functions and parameters are obtained from earlier studies (Maghami et al., 2016; Lopez-García et al., 2016; Sayyah et al., 2014). Benefits of optimised management for both photovoltaic and thermal panels will be the main outcome of the present task. Similar to and in conjunction with the critical spatial-temporal resolutions for aviation, the solar energy sector will be consulted on critical warning times on protective measures and production planning, and electricity market pricing. Assessment of the impact of production loss potential of solar energy systems related to dust in the Mediterranean and of societal benefits of mitigation strategies will be performed using a solar energy oriented GIS dataset.

Task 3.3. Air quality (Leader: CNR-DTA, Contributors: BSC) (M4-M32). This task aims at translating the dust reanalysis generated by WP2 into customised products relating the model-estimated dust loads to the expected impact on the relevant air quality metrics (e.g., the contribution of desert dust to PM10 and PM2.5 levels legislated in Europe by the EU Directive 2008/50). This Task will make use of PM air quality data from the catalogue produced by WP1 (e.g. Barnaba et al., 2016). Expected outcomes include 1) the design of an early warning system for expected detrimental desert-dust impacts on air-quality/health, 2) region-tailored recommendations (for Northern Africa, Middle East and Europe) for adaptation/mitigation strategies in relation to air quality.

Task 3.4. Visualisation (Leader: BSC, Contributors: ALL) (M12-M36). We will adapt the graphical framework used for forecast products in the SDS-WAS Regional Center to provide visualisations of the reanalysis products. We will tailor the visualisation to the requirements of the air quality/health, aviation, and solar energy communities.

Deliverables

D3.1. Impact assessment on aviation and solar energy. (Responsible: FMI) (M24)

D3.2. Assessment of societal benefits of dust oriented climate services for aviation and solar energy. (Responsible: FMI) (M32)

D3.3. Impact assessment of desert dust on EU-regulated PM metrics and design of an early warning system for those dust events heavily impacting air quality in populated regions over North Africa, Middle East and Europe. (Responsible: CNR-DTA) (M28)

D3.4. Report containing region-specific recommendations to adapt to and mitigate desert dust impacts on Air Quality. (Responsible: CNR-DTA) (M32).

D3.5. Graphical interface for the provided services. (Responsible: BSC) (M36)

Milestones

M3.1. Assembly of user-specific preliminary information (end user needs, thresholds, and guidelines) compiled by interacting with aviation liaisons. (Responsible: FMI) (M9)

M3.2. Assembly of user-specific preliminary information (end user needs, thresholds, and guidelines) compiled by interacting with solar energy liaisons. (Responsible: FMI) (M9)

M3.3. Requirements for the design of an early warning system for dust events. (Responsible: CNR-DTA) (M11)

WP4: User involvement and dissemination (Leader: AEMET, Contributors: ALL) (M1-M36)

This WP will work on the engagement of potential users during the whole project duration. WP4 will also be responsible for a wide range of dissemination activities and will use communication strategies adapted to the different target audiences detailed in Section 11. The engagement and dissemination actions will be performed in close coordination with the SDS-WAS Regional Center for Northern Africa, Middle East and Europe.

Task 4.1. Stakeholder engagement (Leader: AEMET, Contributors: ALL) (M1-M36). Through this task, we will identify potential user communities, understand their perspectives and interests, and analyse and classify their needs. We will prioritise interaction with the most relevant stakeholders according to the expected benefit from the use of delivered products and services. We will keep constant exchange with this community for the definition and testing of services in WP3. In the framework of the SDS-WAS Regional Center, AEMET is periodically organising and participating in user meetings. Through the SDS-WAS dissemination and capacity building activities, DustClim will be able to disseminate its advances and available products.

Task 4.2. Promotion of products and services (Leader: AEMET, Contributors: ALL) (M1-M36). We will provide guidance and training for the optimal use of products and services, increase the international visibility of the products, and establish feedback mechanisms to evaluate their value to society and economy. We will build on the experience gathered within the SDS-WAS Regional Center and the BDFC, which have coordinated a series of training courses and seminars mainly targeted to operational meteorologists from National Meteorological and Hydrological Services from Northern Africa and the Middle East. The complete list is available in the SDS-WAS Regional Center website (http://sds-was.aemet.es/materials).

Deliverables

D4.1 Dissemination and engagement document plan. (Responsible: AEMET) (M6)

D4.2 Year 1 periodic report including the dust training. (Responsible: AEMET) (M12)

D4.3 Year 2 periodic report including the dust training. (Responsible: AEMET) (M24)

D4.4 Final periodic report including the dust training. (Responsible: AEMET) (M36)

Milestones

M4.1 Launch of a DustClim section in the SDS-WAS website. (Responsible: AEMET) (M4)

M4.2. Year 1 training on dust. (Responsible: AEMET) (M9)

M4.3. Year 2 training on dust. (Responsible: AEMET) (M21)
M4.4. Announcement of the completed reanalysis. (Responsible: AEMET) (M28)
M4.5. Year 3 training on dust. (Responsible: AEMET) (M33)
M4.6. Announcement of the launch of services on aviation, solar energy and air quality. (Responsible: AEMET) (M36)

WP5: Project management (Leader: BSC) (M1-M36)
This work package will deal with the overall project management. The high-level Management Structure, as well as management procedures and tools, are described in Section 10.

Task 5.1: Administrative and financial management (M1-M36) (Leader: BSC). Led by the project manager, this task will establish the corresponding procedures, tools and methodologies to enable a correct project management. It will also coordinate the timely production of deliverables, organise the kick-off, mid-term and final meetings and reviews, and organise and manage audits requested by the commission. The high-level principles guiding these management procedures will be agreed to at the start of the project (at the kick-off meeting). On an annual basis, the project coordinator will monitor the resource usage and will report on the conclusions of the kick-off, mid-term and final meetings.

Task 5.2: Technical coordination (M1-M36) (Leader: BSC, Contributors: ALL). Led by the technical manager, this task will perform the technical coordination of the project, using monitoring the progress of the work packages, technical coordination of the meetings, appointing reviewers to assess the quality of the deliverables, and solving technical conflicts.

Deliverables
D5.1. Year 1 periodic report. (Responsible: BSC) (M12)
D5.2. Year 2 periodic report. (Responsible: BSC) (M24)
D5.3. Year 3 periodic report. (Responsible: BSC) (M36)

Milestones
M5.1. Project meeting report (kick-off meeting minutes). (Responsible: BSC) (M1)
M5.2. Project meeting report (mid-term meeting minutes). (Responsible: BSC) (M19)
M5.3. Project meeting report (final project meeting minutes). (Responsible: BSC) (M36)

(*Details for section 8, 9, 10, 11, 12, 13 and 14 will need to be uploaded in the form of a pdf document*)

10. Management Plan (Maximum 5 pages)

10.1 Consortium as a whole
Our research activities are designed to make available scientifically sound information on the environmental, social, and economic risks and impacts of atmospheric dust. Understanding, managing and mitigating SDS risks and effects require fundamental and cross-disciplinary knowledge. The DustClim consortium is formed by a multidisciplinary group of international scientific experts on aerosol measurements (CNR-DTA/IMAA-ISAC, CNRS-LISA), aerosol modelling (BSC, CNR-DTA/ISAC), and dust impacts and services (AEMET, FMI, CNR-DTA/ISAC).

AEMET represents Spain in international meteorological organisations, such as WMO, EUMETSAT and ECMWF. AEMET is involved in development cooperation programs worldwide, although its activity has focused mainly in Latin America, West Africa and the Mediterranean region (Afrimet, HEALTHMET, METAGRI, MARINEMET, GAW-Twinning, MedCOF, SDS-WAS and BDFC). The development networks created by AEMET have promoted an institutional strengthening of National Meteorological and Hydrological Services in the region, capacity building and service delivery. WMO identifies the Spanish cooperation within the SDS-WAS as an example of good practice. AEMET will lead the user engagement and dissemination activities of the DustClim project.

BSC is the Spanish National Supercomputing facility and a hosting member of the PRACE distributed supercomputing infrastructure. BSC houses MareNostrum, one of the most powerful supercomputers in Europe. The BSC also hosts other HPC systems such as MinoTauro, one of the most energy-efficient supercomputers in the world. The mission of BSC is to research, develop and manage information technologies to facilitate scientific and societal progress. The Earth Sciences Department at BSC has developed into a reference institution in Europe in the field of climate predictions, air quality and atmospheric composition modelling. A core activity of the group is sand and dust storm modelling and forecasting from regional to global scales, and as a result of its excellence, the BSC hosts both the WMO SDS-WAS Regional Center and BDFC, in close collaboration with AEMET. BSC will coordinate the overall project and will develop the dust reanalysis using the in-house NMMB/BSC-Dust model.

CNR-DTA has as main objective the support and coordination of research on environmental sciences within the National Research Council of Italy. In the DustClim consortium, two institutes of CNR-DTA are involved: Institute of Methodologies for Environmental Analysis (IMAA) and Institute of Atmospheric Sciences and Climate (ISAC). IMAA has internationally-recognized experience on remote sensing techniques (e.g., EARLINET) and is coordinating the H2020 ACTRIS-2 project. ISAC conducts pure and applied research in atmospheric sciences and the climate system and produces results directly transferable to the society. Among other activities, ISAC develops and maintains a non-assimilated dust operational regional dust model (i.e. DREAMABOL). CNR-DTA will coordinate the dust observational work package and the model evaluation, taking advantage of its leading role in the field of ground-based observations and its links to European and extra-European observational groups and projects. The expertise gained by ISAC during the EC-Life+ DIAPASON project in analysing dust observations for air quality issues will be important to translate the dust reanalysis in air quality services.

CNRS-LISA has an internationally-recognized experience on the mineral dust cycle and its impact on atmospheric radiation and biogeochemistry. The CNRS-LISA has obtained funding from European, international and national institutions to participate in all the major field campaigns dedicated to mineral dust which have been taken place in the last 15 years (AMMA-EU, DODO, GERBILS and FENNEC). The group has developed novel, internationally-recognized tools for the modelling and observation of mineral dust that will be included in the DustClim project giving feedback on the correct use of the dust-filtered observations generated during the activity.

FMI is designated by the Finnish government as national air quality expert with a mandate to produce information and forecasts on the state of the atmosphere and its characteristics, as well as contributing to scientific ends. FMI is involved in leading positions within numerous international research and application efforts (FP7, Copernicus, ESA, EUMETSAT, NMR, Academy of Finland, TEKES); it participates in work of IPCC, UN/ECE EMEP and IM, HELCOM, WMO/GAW, AMAP, GEOSS, etc. Within the FMI Climate Service Centre, the group Climate & Society deals with climate change impact analysis, hazard economics, and cost-benefit analysis of weather and climate services. FMI will lead and coordinate the generation of new socio-economic dust products.

Figure 10.1 shows the distribution of the tasks among the consortium members. The composition of the consortium is well balanced around the objectives of DustClim. The gender distribution includes a 40% of females. Three out of five PIs are female, and the roles of Technical Manager and Project Manager are also covered by women.

Acronym	DustClim					
Duration:	3 years					
	BSC	AEMET	CNR-DTA	CNRS	FMI	TOTAL
WP1: Dust observations	**3**		**47**	**30**		**80**
Task 1.1	1		8	6		
Task 1.2	1		37			
Task 1.3	1		2	24		
WP2: Dust reanalysis	**43**		**18**	**5**	**2.5**	**68.5**
Task 2.1	15				0.5	
Task 2.2	25					
Task 2.3	3		18	5	2	
WP3: Services	**2**		**16**		**13**	**31**
Task 3.1					6	
Task 3.2					6	
Task 3.3			15			
Task 3.4	2		1		1	
WP4: Dissemination	**9**	**18**	**3**	**6**	**2.5**	**38.5**
Task 4.1	3	9	1	3	1	
Task 4.2	6	9	2	3	1.5	
WP5: Management	**33**					**33**
Task 5.1	13					
Task 5.2	20					
TOTAL	**90**	**18**	**84**	**41**	**18**	**251**

Figure 10.1 Distribution of the tasks among the consortium members.

10.2 Overall coordination, monitoring and evaluation of the project

The management structure for the project evolves from successful models used by the partners in previous H2020 projects, taking into account the specific needs of a project that aims to deploy a complex integrated system in a short timeframe as well as the contractual restrictions of the Horizon 2020 Framework Programme. The Consortium is constituted by **5 partners** with different organisational cultures (National Meteorological and Hydrological Services, research centres, supercomputing facilities) that contribute to the project with complementary expertise. It is important to note that partners have been working together in previous European and National Projects: SDS-WAS, ACTRIS and ACTRIS-2 (in which CNR-DTA is the main coordinator) and Copernicus. Additionally, BSC and AEMET were designated to manage the WMO SDS-WAS and BDFC Regional Centers. The management structure for the project is designed to provide an appropriate level of professional management to mediate efficiently between the different interests and cultures of the partners, and it is based on well-known best practice methodologies. The main purposes of the management structure are: (1) to define procedures that ensure timely completion of quality project deliverables, (2) to provide an efficient organizational structure that ensures the involvement of all partners, and (3) to provide mechanisms for the management of knowledge and intellectual property and the resolution of conflicts. The Consortium Agreement to be signed at the beginning of the project will set out the high-level operational rules for this project, including the distribution of the tasks, human and financial resources and deliverables, as well as intellectual properties rights. The project organisational structure is shown in Figure 10.2 and includes the following key components:

- **Coordinator**: BSC will coordinate the DustClim project. BSC is a large organisation that performs research and provides computing and training services with expertise in climate, atmospheric composition and computational research. The coordination role is a responsibility shared between the Principal Investigator, acting as Technical Manager (TM), Dr Sara Basart, and the Project Manager (PM), Ms Dorota Chmielewska. The role of the TM is to ensure that the scientific and technical objectives of the project are met. Moreover, the TM organises technical presentations of project progress to external parties and ensures the appropriate involvement and visibility of the members of the project. The TM is supported by the PM, who is responsible for the day-to-day execution of the project.
- **Work Package Leaders** (WPL): They are responsible for meeting the objectives of their WPs. They also ensure communication within the WP, present the WP results in project meetings and report on the WP progress to the Coordinator. They are also responsible for keeping project deliverables in time and doing the initial quality control on WP deliverables.

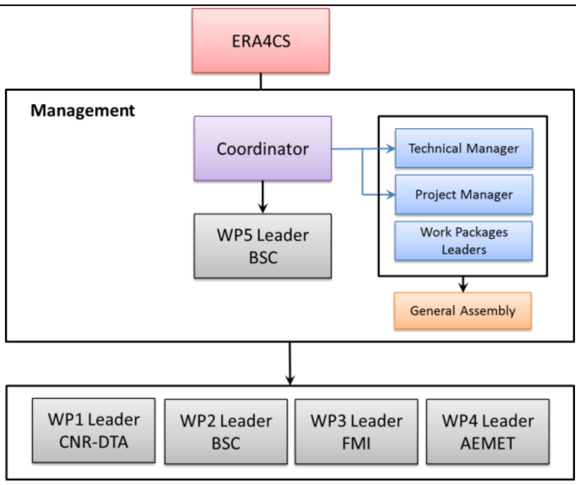

Figure 10.2 DustClim project management structure.

Activities requiring cooperation amongst members and technical decisions will be decided by the General Assembly (GA) which is composed by one representative person from each partner, as well as by the Coordinator and WPL. The next section describes the general organisational and decision-making structure in addition to the most important management procedures.

10.1.2 Management Procedures and Tools

The management of the project will be carried out using an agile methodology. As each stage needs interactions between the partners, the progress of the tasks will be documented using the Scrum approach, with the definition of tasks managers, owners and customers. The process will be documented using collaborative project management tools, like Trello. In order to support the cooperation among all partners and encourage participation in the decision-making process, a set of internal collaboration tools will be set up. BSC, as the leader of WP5, will be responsible for providing the project with the necessary internal collaborative tools, including shared workspace to facilitate the exchange of critical project documentation and news, an issue tracking system and a set of distribution mailing lists for working sub-groups as appropriate. Progress monitoring will be performed through the set of milestones and deliverables defined in the work plan (Section 9.2 and Table 10.1) as part of the work plan structure and shown in the Gantt diagram in Figure 10.3. There will be three physical meetings (kick-off meeting, mid-term meeting and a final meeting) of the consortium. The meetings will be planned in such a way as to minimise the travelling effort and costs.

Acronym	DustClim								
Duration:	3 years								
		1st year			2nd year			3rd year	
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
WP1: Observations									
Task 1.1		D1.1							
Task 1.2	M1.1		M1.2	D1.2					
Task 1.3			M1.3		M1.4	D1.3			
WP2: Reanalysis									
Task 2.1		M2.1							
Task 2.2			D2.1/M2.2			D2.2/M2.3			
Task 2.3							D2.3/D2.4		
WP3: Services									
Task 3.1			M3.1			D3.1			D3.2
Task 3.2			M3.2						
Task 3.3			M3.3			D3.3			D3.4
Task 3.4									D3.5
WP4: Dissemination			D4.2			D4.3			D4.4
Task 4.1	M4.1	D.4.1					M4.4		M4.6
Task 4.2			M4.2			M4.3			M4.5
WP5: Management									
Task 5.1	M5.1								
Task 5.2			D5.1			D5.2	M5.2		D5.3/M5.3

Figure 10.3. Timing of the work packages and their components.

The Coordinator will ensure that monitoring the work progress and use of resources is done on an annual basis to ensure the detection of errors and deviations as early as possible in the project's lifecycle. Regular teleconferences (as a minimum on a bi-monthly basis) will be planned to monitoring the work progress.

Table 10.1 Deliverables of the DustClim project.

#	Description	Responsible	Due
D1.1	Report on the available aerosol observations	CNR-DTA	M6
D1.2	Catalogue of dust-related observations for data assimilation	CNR-DTA	M16
D1.3	Catalogue of dust-related observations for model evaluation	CNRS	M24
D2.1	Report on the reanalysis configuration	BSC	M12
D2.2	Dust reanalysis	BSC	M24
D2.3	Dust Climatology	CNR-DTA	M28
D2.4	Report on reanalysis evaluation results and associated uncertainties	CNR-DTA	M28
D3.1	Impact assessment on aviation and solar energy	FMI	M24
D3.2	Assessment of societal benefits of services for aviation and solar energy	FMI	M32
D3.3	Impact assessment of desert dust on EU-regulated metrics and design of an early warning system	CNR-DTA	M28
D3.4	Report containing region-specific recommendations to adapt to and mitigate desert dust impacts on Air Quality	CNR-DTA	M32
D3.5	Graphical interface on the provided services	BSC	M36
D4.1	Dissemination and engagement document plan	AEMET	M6
D4.2	Year 1 Periodic report including the dust training	AEMET	M12
D4.3	Year 2 Periodic report including the dust training	AEMET	M24
D4.4	Final Periodic report including the dust training	AEMET	M36
D5.1	Year 1 Periodic report	BSC	M12
D5.2	Year 2 Periodic report	BSC	M24
D5.3	Year 3 Periodic report	BSC	M36

This will enable the consortium to apply systematically corrective actions or contingency plans, if necessary. Any event that may jeopardise the overall completion date of the DustClim project should be reported immediately to the PM. The PM will call an emergency meeting or teleconference as required with the WPL. Each party involved in the issue must present a short document describing their respective understanding of the conflict that includes at least one proposed solution. The GA reviews the conflict documents, each GA's member votes on one of the proposed solutions. The solution receiving the simple majority is implemented with the chairperson casting the tie-breaking vote as necessary. Table 10.2 summarises the identified main risks related to the Work Plan and proposes their corresponding mitigation measures.

Table 10.2 Risk management.

Description of risk	Proposed risk-mitigation measures
Partnership is unable to fulfil the work plan / Delay on deliverables of WP's	Ensure regular contact between all project members. Clear definition of the work plan and work package leaders. Elaborate clearly defined milestones and means of verification to monitor tasks' accomplishment. Use of project website. Monitoring of work plan by the Coordinator. In case a delay is due to lack of readiness from a WP Leader, it will be immediately replaced by the Coordinator. Revision of the Draft Documents that support the discussion by stakeholders. If needed segmentation of the scientific community into smaller areas of interest.
Working problems / Insufficient collaboration between partners and new participants (e.g., end users)	Establish strategies (such as periodical meetings and other events) to 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 work effectively with others, promoting collaboration between partners. General events will reinforce the participation of new potential end users.
Late delivery of the dust-related	Strategy for prioritised delivery of minimum observation datasets to allow to perform

observations for assimilation (M1.1)	the dust reanalysis.
Late delivery of the dust-related observations for evaluation (M1.2)	Strategy for prioritised delivery of minimum observation datasets to allow to perform the model evaluation.
NMMB/BSC-Dust runs have technical problems leading to late delivery of simulations (Task 2.2)	Ensure resource requirements are well understood by the responsible group. Produce outline document of the procedures for obtaining HPC resource, along with the timescales involved, possibly including PRACE.

10.3 Open Knowledge plan

The guidelines on Open Knowledge contribute to increasing research activities' societal impact and credibility by making them more transparent. Following the JPI Climate Guidelines on Open Knowledge, during the execution of the DustClim project we will consider the following:

- **Internal accessibility.** Working documents of general concern will be accessible for all DustClim members and partners through the wiki of the project.
- **Open licensing.** The use of the Creative Commons (CC) "public domain" license (CC0) when publishing any internal document will be prioritised.
- **Open formats.** The use of open formats, i.e. ODF (e.g., *.odt, *.ods, *.odp, *.pdf) for working documents will be encouraged.
- **Open Access publishing.** Research results being funded in the context of DustClim will be published in Open Access journals, books or proceedings. Costs related to Open Access and Open Data will be foreseen in the corresponding budgets of the co-funded projects from the DustClim partners.
- **Open Data.** Research data and meta-data derived from DustClim will be freely available through the WMO SDS-WAS NAMEE Regional Center portal. The publication, storage and preservation strategy will follow the WMO SDS-WAS NAMEE Regional data policy rules.

10.4 Climate-Friendly Research

Following the JPI Climate principles committed to increasing the credibility of climate impact research, the proposed project is willing to apply a constant effort for improving the sustainability principles. The proposed project mainly involves the use of human resources and computer facilities and does not include large construction work producing extensive CO_2 emissions. During the project implementation, to demonstrate how the consortium takes into account sustainability principles in research, the following measures will be taken to reduce its climate footprint.

- An online communication platform (i.e. wiki) will be established at the beginning of the project which will be used for web-based meetings and presentations for all purposes.
- A reduction of air travelling will be accomplished by organising meetings whenever it is mandatory and necessary. Otherwise, green virtual meetings (i.e. teleconferences on a regular basis and upon request) will be largely preferred.
- Public transportation will be preferred to minimise the greenhouse gas emissions and other pollutants released by taxis or rental cars.
- The proposed project will use paperless technology and will emphasise the use of electronic format material for the dissemination of project results.

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11. Impact, Engagement and dissemination plan (Maximum 5 pages)

11.1 Expected impact

The objectives addressed by **DustClim** are envisaged to have an impact on a variety of sectors and communities with benefits both in social (improved quality of life) and economic (improved resource management) aspects. The **DustClim** project aims to create applied products tailored to the needs of specific sectors whose **activities** are highly dependent on SDS. The envisaged benefits on the user side are as follows:

- **For solar power generation sector.** Specifically-designed end user dust products will be beneficial to assess the **solar resource in the phase of planning investments. During this phase, it is also important to consider the need on periodic removal of dust from panels and lenses,** especially in arid regions, where water is a scarce commodity.
- **For air traffic management.** Some airports, in particular in Northern Africa and the Middle East, are often affected by SDS. Moreover, major dust events can indirectly affect air routes worldwide, eventually causing delays or cancellations. The spatial and temporal distribution of SDS that provides a dust climatology will be beneficial to improve air **traffic planning and air traffic safety**.
- **For public health, air quality assessment and management agencies.** The design of better early-warning systems as well as of **an adequate air quality policy** over regions in Northern Africa, Middle East and Europe will produce a benefit regarding preparedness, **mitigation of health risks** and **reduction of health expenses**. This will be particularly relevant close to source regions, where concentrations of dust are often very high, but can be beneficial also in distant areas affected by dust intrusions, as Europe. Preparedness and mitigation actions for SDS will increase social welfare and well-being in particular among the most vulnerable segment of society.

A well-evaluated high-resolution dust dataset can be applied to Earth system studies on the impact of dust on weather, climate and ecosystem, and to weather/chemistry forecast. Such dataset will provide the following envisaged benefits to the scientific community:

- support the evaluation of **dust modelling developments** offering a reference product that is consistent in quality and time,
- support **air quality management** studies in Europe offering dust boundary conditions for air quality hindcasts,
- account for the **climatological average radiative effect** of dust in limited area numerical weather predictions within the regional domain of Northern Africa, Middle East and Europe.

The institutions of the consortium will bring in a variety of complementary expertises (in aerosol measurements, aerosol modelling, air quality management, computational science, and socio-economic analysis) and links to relevant international projects and networks in which they participate (e.g., ACTRIS-2, SDS-WAS, EARLINET and Copernicus). Cooperation throughout the project between them and user communities from public institutions (meteorological services, universities, local authorities) will lead to their increased strength and **enhanced integration in international networks**. DustClim's objectives are very relevant to several projects of WMO's World Weather Research (WWR) and Global Atmospheric Watch (GAW) Programmes (especially to the WMO SDS-WAS project). Moreover, at European level, there is a related big effort in providing aerosol high quality and standardised observations (EMEP, ACTRIS and ACTRIS-2, EARLINET, AERONET-PHOTONS, AERO-SAT, AEROSOL-CCI) and predictions (BDFC and Copernicus) to end users. DustClim aims to advance knowledge of end users' real needs and to work on model and data-product improvements, focused especially on the development of new user-oriented products. Such advances will contribute to the preparedness and the definition of mitigation and adaptation measures to face the challenges posed by climate change.

11.2 Engagement and dissemination

DustClim dissemination actions will be planned in close coordination with the WMO SDS-WAS Regional Center for Northern Africa, Middle East and Europe (http://sds-was.aemet.es/) to reach the end user communities and to disseminate the resulting dust products to the target audiences such as policy and decision-makers on EU and national levels or non-governmental organisations. The goal is to enhance the current research network of the WMO SDS-WAS Regional Center and enable fruitful collaborations between researchers and end user communities while increasing the international visibility of the SDS services to attract new users and new sectors affected by SDS. Since its creation in 2010, the WMO SDS-WAS Regional Center has become a reference for dust products but also a source of data. In 2015, there were more than 15700 downloads of model numerical datafiles. Moreover, the user-oriented products of the project will lead to improvements in the products delivered by the Barcelona Dust Forecast Center (BFDC, http://dust.aemet.es), the Center designated by WMO to generate and distribute operational dust forecasts to the National Meteorological and Hydrological Services of Northern Africa, Middle East and Europe. The synergies with these two WMO-supported centres will ensure that DustClim outcomes are publicly available on-line in a well-established platform that is already a reference for dust information to public and private users in the regions of interest and the integration of the dissemination actions in the frame of a long-term strategy. In this sense, it is worthy to mention that all the DustClim partners contribute to the WMO SDS-WAS Northern Africa, Middle East and Europe Regional Node. One of the most important goals of DustClim is to **promote capacity building, dissemination and public engagement** (WP4). To maximise the impact of DustClim, WP4 will deploy a full dissemination and stakeholder engagement plan that will be carried out from the beginning to the end of the project. The main objectives within WP4 are:

- To disseminate the project ideas, results and products adapting the message or content to each audience ranging from the scientific community involved in weather, climate and atmospheric chemistry to industry stakeholders, government, policy-makers and the general public.
- To engage with all the interested parts, to receive end user feedback and interaction, promote capacity building and project co-design according to the real needs of the sectors affected by SDS.
- To generate public engagement about the potential impacts of SDS.

Dissemination actions will be adapted to different target audiences (scientific community, stakeholders, and society at large). The results suitable for dissemination to the scientific communities will be published in refereed international journals and presented at lectures and conferences. Among other, dissemination activities will include elements such as:

- **Dustclim website section** embedded within the SDS-WAS Northern Africa, Middle East and Europe Regional Center website. On this website, the DustClim project will be introduced with the contact data of its partners and links to individual project websites. The website will be regularly updated in parallel with the project progress. A special section will be meant specifically for stakeholders, showcasing the latest results or tools.
- **DustClim events** to publicize and promote the project in different context as: offering training and education activities, including a training aimed at facilitating the creation of an exchange platform among PhD students, scientists and practitioners in how to improve the science-practice interface, user workshops and stakeholder events organized by other initiatives under H2020 and other programmes such as the European LIFE+ programme, meetings with stakeholders and decision makers, satellite sessions or side events at international conferences (e.g., the European Geosciences Union meeting and the European Meteorological Society general assemblies).
- **DustClim materials** will be created and distributed using different tools. Multimedia and printed material (videos, factsheets, leaflets, brochures, etc.) will be tailored to the information needs of the different industrial sectors and governmental stakeholders. Social networks (the Twitter account of the BDFC that already has 795 followers) will inform the general public. Mainstream press releases will be prepared and circulated into general and specialised media. Papers for peer-reviewed literature, published reports (i.e. all deliverable reports marked public), user guides and training materials on how to make proper and effective use of DustClim results will be also used to engage new end users.

Regarding stakeholders/end users communities, there will be a first task to identify potential users within the three main sectors addressed in DustClim (solar energy, aviation and air quality). The objective is to engage them and to understand their perspectives, interests and needs regarding SDS information and products. After the creation of sector-specific products, there will be an active dissemination and promotion of the products and services developed in DustClim adapted in each sector to the characteristics of the target audience. Some of the activities will involve capacity building and training activities (e.g., workshops, in-house training in public and private institutions), providing guidance (e.g., sectoral reports, online user guide, and additional printed material) and creating feedback mechanisms to evaluate the service value to society and economy. During the last years, the WMO SDS-WAS Regional Center and more recently the BDFC have coordinated a series of training courses and seminars mainly targeted to operational meteorologists from National Meteorological and Hydrological Services from Northern Africa and the Middle East. The events have also been eventually attended by PhD students and post-doctoral researchers interested in atmospheric composition and solar radiation. The syllabuses include the dust cycle and impacts, ground and satellite observation, dust modelling and forecast as well as information on available observational and forecast products. Different institutions have contributed to financing the events: WMO, EUMETSAT, AEMET, BSC, Turkish State Meteorological Service, Catalonia Technical University, Directorate General of Meteorology and Air Navigation of Oman, Sultan Qaboos University, National Meteorology Direction of Morocco and I. R. of Iran Meteorological Organization. Through the SDS-WAS Regional Center, DustClim will be able to disseminate the latest advances to this audience.

11.3 Data management and intellectual property rights

The types of data that the project will generate include dust (observations and reanalysis) catalogues. The DustClim partners will also bring their pre-existing knowledge (e.g., dust observations, model codes). All results (i.e. datasets or methods) generated during the project will be maintained electronically, providing reconcilable audit trails, such as documented proof of ownership, if necessary. Methodologies, product designs and newly generated datasets will be developed in collaboration between the DustClim partners. The methodologies and product designs will be documented in peer-reviewed papers generated by the DustClim consortium. Datasets will be documented with appropriate metadata to capture their provenance and derivation to identify their origin and make them intelligible for any user. Additionally, guidelines for final users will be generated and published on the project's website. Taking advantage from the active data pilot with the objective to move WMO SDS-WAS Regional Center storage to the EUDAT project (http://www.eudat.eu/) services, all data produced will be available for the worldwide community following the main standards, including the creation of PIDs (Persistent IDentifiers) for all datasets, with the aim to make experiments completely reproducible (open science).

Dust observational catalogues resulting from WP1 will be made publicly available through the WMO SDS-WAS Regional Center (http://sds-was.aemet.es/). Simulation runs performed in WP2 will produce a decadal high-resolution simulation with a large volume of primary output data. Secondary data, produced through post processing will be generated consisting of a dust reanalysis, which will include a wide variety of additional data fields describing particular phenomena, such as catalogues of events including SDS frequency and intensity among others, will be made publicly available through the WMO SDS-WAS Regional Center (http://sds-was.aemet.es/). Where primary outputs are sufficiently difficult to regenerate or particularly valuable for further exploitation, these will be retained along with full documentation within the project and will be preserved until ten years after the project's completion. Data standards include CMOR-compliant NetCDF format that will be used for the primary (i.e. the resulting dust reanalysis dataset) and secondary (i.e. derivative products from the dust reanalysis) results of the project. Specifications of the standards used for secondary data will be maintained on the internal project wiki and published externally along with the data. Curation and preservation of the primary and secondary datasets will be the responsibility of individual partners. The datasets will be stored in a long-term archive managed by BSC.

The specific guidelines developed by JPI Climate in combination with the general application of open access rules under H2020 will help long term dissemination and knowledge transfer within DustClim. A general "**open data access**" policy will be followed to ensure the open access of the DustClim results. The protection of the knowledge/intellectual property that the partners bring to the project and the subsequent knowledge generated (i.e., methodologies, datasets, results) will be regulated through the project Consortium Agreement and also in the co-funded project agreement. All published material will be communicated and coordinated by the General Assembly of the DustClim project and will contain an acknowledgement to the research funding from ERA4CS.

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12. Budget justification

12.1 Financial planning approach

The major part of the DustClim budget is dedicated to personnel costs, as the proposal relies on the scientific and technical skills and robust expertise of the partners involved, and computing time, as required by the reanalysis runs. A summary of the staff efforts is presented in Table 12.1. In the next sub-sections, a detailed justification of how the funds requested will be used to fulfil the activities of each partner is reported, together with and the corresponding justification that the requested funds are sufficient to achieve the objectives of DustClim. The total budget is **2,133,640.66€**, of which 1,474,574,974€ correspond to the operating costs of the DustClim consortium, and will be provided as in-kind. The total ERA4CS funding requested is 659,066€ and corresponds to 39% of the total direct costs.

Table 12.1 Summary of the staff efforts and resources.

	BSC	AEMET	CNRS-LISA	CNR-DTA	FMI	Totals
Totals PM	90	18	41	74	18	241
Total Personnel Costs	€ 360,000	€ 80,859	€ 290,833	€ 296,000	€ 126,720	€ 1,154,412
Travel	€ 6,000	€ 12,000		€ 6,000	€ 6,000	€ 30,000
Subcontracting		€ 15,000				€ 15,000
Audit	€ 2,500					€ 2,500
Consumables					€ 2,500	€ 2,500
Equipment	€ 63,000					€ 63,000
Computing Hours/Others Direct Costs	€ 420,000	€ 20,000				€ 440,000
Total Direct Costs	€ 851,500	€ 127,859	€ 290,833	€ 302,000	€ 135,220	€ 1,707,412
Overheads	€ 212,250	€ 31,965	€ 72,708	€ 75,500	€ 33,805	€ 426,228
Total budget	€ 1,063,750	€ 159,824	€ 363,541	€ 377,500	€ 169,025	€ 2,133,640
Funding (39% of Direct Costs)	€ 331,110	€ 44,015	€ 113,425	€ 117,780	€ 52,736	€ 659,066
In-Kind	€ 732,640	€ 115,809	€ 250,116	€ 259,720	€ 116,289	€ 1,474,574

12.1.1 Personnel costs

Personnel costs (1,154,412€) represents 54% of the overall budget. Table 12.1 (and Table 10.1) shows the amount of staff effort broken down by beneficiary and work package. As a coordinator partner, BSC is involved in all the work packages and consequently has the most important effort (90PM). In addition to coordinating, BSC also leads WP2. The assigned PMs for this WP (43PM) will allow BSC to oversee the success of it. CNR-DTA has a large number of PMs (84) due to their substantial involvement in a number of WPs in which they have particular expertise, specifically in WP1 that they are leading. AEMET has concentrated its resources in WP4 where they have 18PM dedicated to user engagement and dissemination. FMI has relatively significant resources in WP3. They are leading WP3 and have contributions in the rest of WPs to ensure the success of WP3. CNRS is leading a task in WP1 where most of their PMs (30) are dedicated to

producing the dust-oriented products used in the dust reanalysis.
WP1 and WP2, which involve the generation and evaluation of the reanalysis dataset, have the largest number of PMs dedicated to the project (~60% which represents 148.5PM)

- ***Resources required for engagement and dissemination activities:*** All partners have been given time within WP4 to allow them to undertake dissemination and communication activities for DustClim. Partners who are leading WPs also have additional time to enable them to work with the Technical Manager to synthesise all the results for dissemination and communication. The Technical Manager has dedicated time available to promote DustClim at scientific events and to engage with other projects and government to maximise impact and exploitation. In addition to this, WP4 has 38.5PMs dedicated specifically to engagement, dissemination and communication with end users.
- ***Management activities:*** 33PM are allocated for the Project Management and Coordination (WP5) of DustClim. These PMs will allow to BSC to fulfil its project management activities.
- ***In-kind contribution for personnel costs***: Among the total amount of human effort (241PM) covering the whole duration of the proposal, it is worth noting that 68.75% of the total effort is allocated to permanent position staff and represent the in-kind part of personnel costs, while 31.25% of the total effort is requested for funding.

12.1.2 Other direct costs
Other direct costs represent 46% of the overall budget. Table 12.1 shows the amount per concept broken down by beneficiary.

- ***Travel budget:*** The travel budget was prepared by the Project Manager and then reviewed and agreed by all the partners. The Project Manager has avoided any unnecessary travel and promoted the use of alternative forms of communication wherever practicable. A budget of 30,000€, representing 1.4% of the total project budget has been put aside for travel costs. Face-to-face meetings will be on the same dates than other meetings. A budget of 2,000€ per partner per meeting has been included in the budget. Note that AEMET's budget allocated for travelling (12,000€) is higher because AEMET is responsible for the dissemination and user engagement activities (WP4).
- ***Computing hours:*** The main assimilation cycle for the production of the reanalysis will be executed on the HPC BSC facilities. The needed computational power is directly dependent on the resolution. The computational time estimated for one-year execution of a 24 member ensemble following the BDFC model configuration (at 0.1ºx0.1º and 40 vertical layers) is of 1.15 million CPU hours. DustClim proposes a simulation over more than one decade (a 15-years reanalysis, 2002-2016) that with the necessary set-up experiments will need 20M cpu/hours that have an estimated cost of 420k€. This represents 20% of the total project budget. This represents an in-kind contribution from BSC.
- ***Other direct costs:*** AEMET's budget includes 20,000€ to cover the organisation of one dust training/workshop during the execution of the DustClim activities.
- ***Equipment:*** BSC's budget requires 63,000€ to purchase disks for sharing project output data with partners. Although BSC obtains substantial amounts of competitive computing time, this does not provide associated long-term storage. The space needed for the execution and storage of a 15-years reanalysis following the BDFC model configuration (at 0.1ºx0.1º and 40 vertical layers) is estimated to be 90Tb.
- ***Audit:*** Given its requested funding greater than 325,000€, the coordinator BSC will require external audits (for certification of financial statements) at the end of the project, accounting for 0.12% of the direct cost.
- ***Subcontracts:*** Resources required for engagement and dissemination activities in WP4 (also described in Section 11) will include multimedia and printed material (videos, factsheets, leaflets, brochures, etc.). AEMET requires 15,000€ for this purpose.
- ***Overheads:*** A flat rate of 25% is applied according to financial H2020 financial rules for

all partners.

Details for section 8, 9, 10, 11, 12, 13 and 14 will need to be uploaded in the form of a pdf document)

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(*Details for section 8, 9, 10, 11, 12, 13 and 14 will need to be uploaded in the form of a pdf document*)

14. Suggested International Conferences

Because of the multidisciplinary team involved in DustClim (measures, predictions, impacts and users), the conferences for the mid-term and end-of-term meetings will be chosen between the following list:

AGU - American Geophysical Union Conference (San Francisco, USA - December, Annual)
EGU - European Geophysical Union Conference (Vienna, Austria - April, Annual)
EAC - European Aerosol Conference (Europe, Annual)
EMS - European Meteorological Society (Europe, Annual)
International Workshop on Sand/Duststorms and Associated Dustfall (Europe, Biannual)
Dust conference (Italy - June, Biannual)

15. Budget plan (in K€)[1]

Total budget of the proposal:	2,133,640

BSC		
		Totals
Permanent Position	Time dedicated to this project (# months)	39 months
	Salaries	156,000€
Non permanent position with funding requested	Time dedicated to this project (# months)	51 months
	Salaries	204,000€
Travel and subsistence		6,000€
Other costs (Overheads, Computing costs, Other)		632,250€
Consumables		-€

Equipment	63.000€
Sub-contract	2,500€
Total	1,063,750€

AEMET		
		Totals
Permanent Position	Time dedicated to this project (# months)	18 months
	Salaries	80,859€
Non permanent position with funding requested	Time dedicated to this project (# months)	- months
	Salaries	- €
Travel and subsistence		12,000€
Other costs (Overheads, Computing costs, Other)		51,965€
Consumables		- €
Equipment		- €
Sub-contract		15,000€
Total		159,824 €

CNRS-LISA		
		Totals
Permanent Position	Time dedicated to this project (# months)	41 months
	Salaries	290,833€
Non permanent position with funding requested	Time dedicated to this project (# months)	- months
	Salaries	- €
Travel and subsistence		- €
Other costs (Overheads, Computing costs, Other)		72,708€
Consumables		- €
Equipment		- €
Sub-contract		- €

Total	363,541€

CNR-DTA		
		Totals
Permanent Position	Time dedicated to this project (# months)	65.7 months
	Salaries	262,800€
Non permanent position with funding requested	Time dedicated to this project (# months)	8.3 months
	Salaries	33,200€
Travel and subsistence		6,000€
Other costs (Overheads, Computing costs, Other)		75,500€
Consumables		- €
Equipment		- €
Sub-contract		- €
Total		377,500€

FMI		
		Totals
Permanent Position	Time dedicated to this project (# months)	9.25 months
	Salaries	65,120€
Non permanent position with funding requested	Time dedicated to this project (# months)	8.75 months
	Salaries	61,600€
Travel and subsistence		6,000€
Other costs (Overheads, Computing costs, Other)		33,805€
Consumables		2,500€
Equipment		- €
Sub-contract		- €
Total		169,025 €

16. Potential reviewers to avoid for direct competition reasons or conflict of interest

None.

(*Details for section 17 will need to be uploaded in the form of a pdf document as an annex of the proposal*)

17. Curriculum Vitae

Dr Sara Basart (female) is a researcher in the Barcelona Supercomputing Center- Centro Nacional de Supercomputación (**BSC**). Her main research background covers mineral dust modelling, air quality and aerosols. She is scientist in charge of the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Regional Center for Northern Africa, Middle East and Europe, and the Barcelona Dust Forecast Center (BDFC), hosted in BSC. She also participates in international projects like the International Cooperative on Aerosol Prediction (ICAP) initiative and ACTRIS and ACTRIS-2. She is leading the BSC participation in Copernicus (CAMS-84). She has authored or co-authored more than 30 peer-reviewed publications in international journals and book chapters.

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Dr Paola Formenti (female) is a senior researcher at the Centre National de Recherche National (**CNRS-LISA**). She has a 20-year long experience in the field and airborne observations of aerosol properties, mineral dust in particular. She has developed a novel airborne inlet for the sampling and characterization of coarse particles. She was one of the co-PIs of the EU AMMA (African Monsoon Multidisciplinary Analysis) and the ANR FENNEC (Dust and the Climate System) and ADRIMED (Aerosol Direct Radiation Impact in the Mediterranean). She is the PI of the ANR AEROCLO-sA (Aerosols, Radiation and Clouds in southern Africa) and the Dust-Attack (Aging of African dust during long-range transport: chemical and physical characterization of desert dust particles near their source and at a receptor site in the Caribbean and implication for their effect on the optical and radiative properties). In 2001, Paola Formenti has received the Otto-Hahn medal of the

Max Planck Society. She has authored or co-authored 83 peer-reviewed publications in international journals and two book chapters.

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Dr Lucia Mona (female) is a senior researcher at the Institute of Methodologies for Environmental Analysis of the National Research Council of Italy (**CNR-DTA/IMAA**). She has a researcher profile that combines expertise on developments of lidar systems, instruments integration/combination, analysis methodologies, exploitation of state-of-the-art measurements for different application fields and integrated studies with models. She is responsible for the EARLINET (European Aerosol Research Lidar NETwork) database. She has participated in many international measurement campaigns (such as EAQUATE, LAUNCH-2005, SAMUM, and BAECC) and projects (EARLINET, EARLINET-ASOS, GEOMON, WEZAR, ACTRIS and ACTRIS-2; ENVRIplus, and GAIA-CLIM). She is now leading the EC-ACTS (Earlinet and Cloudnet - Aerosol and Clouds Teams for Sentinel-5P Validation) ESA validation project and AEROSAT (International Satellite Aerosol Science Network) Working Group on Aerosol Typing. She is a member of the Regional Steering Group of the SDS-WAS (Sand and Dust Storm Warning Advisory and Assessment System) of the WMO. She has authored or co-authored more than 50 peer-reviewed publications in international journals and book chapters.

Mona, L., Papagiannopoulos, N., Basart, S., Baldasano, J., Binietoglou, I., Cornacchia, C., and Pappalardo, G.(2014). EARLINET dust observations vs. BSC-DREAM8b modeled profiles: 12-year-long systematic comparison at Potenza, Italy, Atmos. Chem. Phys., 14, 8781-8793, doi:10.5194/acp-14-8781-2014.

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Dr Adriaan Perrels (male) is Research Professor in Finnish Meteorological Institute (**FMI**). He is an economist with a long time experience in climate policy assessment, both in mitigation and adaptation studies. Before FMI he worked for ten years for the Finnish VATT Government Institute for Economic Research, and earlier in the Netherlands for TNO, ECN, and the Free University Amsterdam, especially in energy and transport studies. Among his 150+ publications are over 30 peer-reviewed articles and books. He is leading (multi-partner) socioeconomic evaluation studies regarding climate impact and adaptation and weather services at the national and international level.

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Ms Enric Terradellas (male) has an MSc in Physics with specialisation on Physics of the Earth and the Cosmos from the University of Barcelona. He works for the State Meteorological Agency of Spain (**AEMET**) as a meteorologist since 1980. He has participated in different projects in the fields of the operational weather forecast, climatology, atmospheric composition, micrometeorology, numerical weather prediction, remote sensing and international cooperation. He is the chair of the WMO's Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS). He is also the Technical Director of the SDS-WAS Regional Center for Northern Africa, Middle East and Europe and the Technical Director of the Barcelona Dust Forecast Center (BDFC).

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A complete CVs have been uploaded in the form as an annexe of the DustClim proposal.

(*Details for section 18 will need to be uploaded in the form of a pdf document as an annex of the proposal*)

18. Supporting Letters

The DustClim project receives the support of different international institutions, research institutes and private companies from different socio-economic sectors. They are the following:

- **Deon Terblanche (Director of the Atmospheric Research and Environment Branch Research Department of WMO)**. He emphasises that DustClim project's objectives are very relevant to several WMO's World Weather Research (WWR) and Global Atmospheric Watch (GAW) Programmes' focal areas and cross-cutting activities, especially to its WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Project.
- **Dr Ahmad Base Al-Yousfi (Director of the Regional Center for Environmental Health Action at the Regional Office for the Eastern Mediterranean of the World Health Organization, WHO/CEHA).** He expresses their interest and support in the development

of dust reanalysis which is one of the goals of the DustClim project because of its relevance to health.

- **Paola Michelozzi (as acting Director of the Department of Epidemiology Lazio Regional Service).** She expresses their interest and support in the development of dust reanalysis and air quality services, which is one of the goals of the DustClim project because of their relevance to health.
- **Bertrand Bessagnet (Chief Scientist at the Chronic Risks Division at the Institut National de l'Environnement et des Risques, INERIS).** He expresses their interest and support in the development of air quality services, which is one of the goals of the DustClim project.
- **Domenico Gaudioso (Responsible of the Servizio Monitoraggio e Prevenzione degli Impatti sull'Atmosfera at the Istituto Superiore per la Protezione e la Ricerca Ambiental, ISPRA).** He expresses their interest and support in the development of air quality services, which is one of the goals of the DustClim project.
- **Torsten Marheineke (Director of Energy Markets - Analysis and Evaluation at Energie Baden-Württemberg, EnBW).** He expresses their interest and support in the development of specific solar energy services, which is one of the goals of the DustClim project.
- **Stefan Wilbert (Team Leader on Solar Energy and Meteorology at the Institute of Solar Research of the German Aerospace Center, DLR).** He expresses their interest and support in the development of specific solar energy services, which is one of the goals of the DustClim project.
- **Rachel Burbidge (Head of Unit Support to SES-related Policies at EUROCONTROL).** She expresses their support and collaboration to DustClim project providing air traffic management technical and operational guidance for the development of aviation services, which is one of the goals of the DustClim project.
- **Ulrike Decoene (Head of the AXA Research Fund).** She emphasises the relevance of the DustClim project for the recent support for the creation of the AXA Chair on Sand and Dust Storms at the Barcelona Supercomputing Center, led by AXA Prof. Carlos Pérez García-Pando from October 2016. Dr. Perez will actively participate in and support DustClim.

The original letters have been uploaded in the form as an annexe of the DustClim proposal.