COST
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

# TECHNICAL ANNEX

# 1 S&T EXCELLENCE

## 1.1 SOUNDNESS OF THE CHALLENGE

### 1.1.1 DESCRIPTION OF THE STATE-OF-THE-ART

Suspended wind-blown dust is everywhere and it plays a major role in affecting our health, environment, climate and society. Dust can originate from natural and anthropogenic sources and have impacts both in the vicinity and further away from the source. For example, air quality warnings and health protection actions are needed for severe dust events occurring frequently in several parts of Europe. On a local scale, dust from agricultural fields or road dust have been both linked to respiratory illnesses. **The definitions of the dust types included in this DUSTer-Action are:**

- **CCHLD:** Cold Climate and High Latitude Dust; suspended or re-suspended dust particles either originating from top soil of cold climate areas or from high latitudes (defined as areas ≥ 50 °N and ≥ 40 °S); includes deposited re-mobilized resuspended ash, but excludes direct emissions of volcanic eruptions.
- **AD:** Agriculture Dust; can originate from practices that break-up, or pulverize, the top soil leaving bare ground susceptible to wind erosion. When these dust particles become airborne, by the friction of tires moving on unpaved dirt roads and dust-covered paved roads (RD) or, by wind action (AD) they are referred to as road dust and agriculture dust, respectively.
- **RD:** Road Dust; resuspended road dust, consists of solid particles that are generated by any mechanical processing of materials, including crushing, grinding, rapid impact, handling, detonation, and decrepitation of organic and inorganic materials such as rock, ore, and metal. Exhaust particulates are excluded in this DUSTer-Action, as exhaust emissions are already well-monitored, researched and controlled through air quality legislation, especially in Europe.

Anthropogenic and natural dust are the major constituent of air pollution and affect a wide range of geophysical, biochemical and biological processes on Earth including soil formation, ice melt-rates, lake and marine productivity, climate, as well as air quality. Reduced air quality, and sand or dust storms, affect both health and economy.

**A. COLD CLIMATE DUST**

The natural cold climate and high latitude dust (CCHLD) sources cover over 500 000 $km^2$ and produce tremendous amounts of particulate matter (about 100 Tg/yr). It has been recognized as a powerful source of air pollution of regional and global significance [1]. Moreover, the **World Meteorological Organization WMO Sand and Dust Storm Warning Advisory and Assessment System SDS-WAS**, previously focusing only on low latitude desert dust (mainly Sahara), has very recently recognized the European and international significance of Icelandic high-latitude dust sources, which are now included in the SDS-WAS approaches (modeling test-phase for Icelandic dust sources ongoing in Aug/Sept 2019). General lack of both observational and modelling studies has resulted in poor CCHLD monitoring and prediction. Natural dust is often associated with hot, subtropical deserts, but a mostly forgotten source of dust originating from cold climate and high latitudes has recently started to receive more and more attention. Major CCHLD sources which have been identified in the Northern Hemisphere include Iceland, Greenland, Svalbard, Alaska, and Canada, and Southern sources of Antarctica, New Zealand, and Patagonia, for example (Figure 1).

**The modelling studies show that Europe's and Greenland's dust production and main transport pathways are clearly affecting both the High Arctic and the European mainland** [2]. The largest desert in Europe is located at high latitudes in Iceland and it is also the largest desert in the northern polar region with the size of Denmark or Slovakia. The resuspension of Icelandic volcanic ash and dust transport over the North Atlantic was first described in [3]. Icelandic dust was identified in Svalbard, Serbia and Ireland, able to travel over 3000 km distance from the Icelandic dust hot spots [4,5,6].

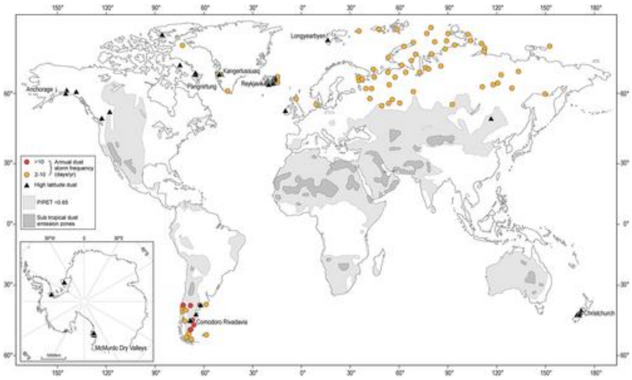

*Figure 1. Global observations of high-latitude dust, where filled circles indicate dust storm frequency based on visibility data, and black triangles indicate georeferenced published observations of dust storms. Areas with potential evapotranspiration ratio <0.65 (aridity index) [United Nations Environment Programme, 1997] are indicated with light grey and subtropical dust emission zones with dark grey. From [1].*

Several studies have shown that CCHLD has different physical, chemical and optical properties compared to crustal dust as known from the Sahara or American deserts. The highly light absorbing CCHLD aerosol particles, even up to as black as black carbon by their spectral reflectance properties [7], can induce significant direct and indirect effects on solar radiation fluxes and snow optical characteristics, strongly impacting Arctic amplification via radiative feedbacks. It has been shown that temperatures in fragile areas, such as the pristine polar regions, have been increasing at twice the global average, causing an accelerated melting of the glaciers. Consequently, potential CCHLD sources such as glacial sediments are increasing. When dust is blown to the glacier surface, ice albedo decreases and influences glacier melt rates via the positive feedback mechanism. The European high latitude areas also include active volcanoes which produce large amounts of volcanic material. Some of this eruptive material is transported over long distances, but much is deposited locally and then resuspended to form dust plumes. Also deposited resuspended ash has been shown to be an important dust source after the original eruption. Attempts have been made to quantify the expanse, characteristics or dynamics of CCHLD sources at regional scales for Iceland, Greenland, Alaska, Canada, Antarctica, New Zealand, and Patagonia. A review on CCHLD is available in [1]. For example, Icelandic dust is of volcanic origin, it is dark, extremely fine (often submicron particles) and consists of higher proportions of heavy metals than crustal dust, and it is also linked with the cryosphere. For the European Arctic, several important sources were not included and long-term research studies from European research groups maintaining aerosol stations in Europe's high latitude were not discussed. Both the land area of CCHLD sources and the contribution of CCHLD sources to global dust budget are predicted to increase under future climate change scenarios. The important fact is that Europe's largest desert is located at HL, in Iceland in the vicinity of glaciers. The long-term evidence on dust days from Iceland shows a frequency of about 135 days/year. The scarcity of year-round observations and limitations of satellite remote sensing data are an important scientific issue to be discussed and improved. First modelling studies have estimated the amounts of Europe's and Greenland's dust production and **main transport pathways are clearly affecting both the High Arctic and the European mainland**. Several studies have shown that **CCHLD has different physical, chemical and optical properties compared to crustal dust as known from Sahara or American deserts. CCHLD therefore has different effects on climate and human health.**

## B. RE-SUSPENDED ROAD DUST

By definition, Road dust (RD) consists of solid particles that are generated by any mechanical processing of materials, including crushing, grinding, rapid impact, handling, detonation, and decrepitation of organic and inorganic materials such as rock, ore, and metal [8]. It is not necessary to include exhaust particulate in the Action, only re-suspended road dust, as exhaust emissions are already well-monitored, researched and controlled through AQ legislation, especially in Europe.

**C. AGRICULTURE DUST**

Agriculture dust (AD), instead, can originate from practices that break-up, or pulverize, the top soil leaving bare ground susceptible to wind erosion [9]. When these dusts becomes airborne, by the friction of tires moving on unpaved dirt roads and dust-covered paved roads (RD) or, by wind action (AD) they are referred to as road dust and agriculture dust, respectively [8,9]. Both RD and AD have been found to induce adverse health effects on the respiratory system [8,10]. RD, in particular, has been found to exert a complex systemic action in the presence of lead, zinc, vanadium and chromium compounds, while it can induce respiratory allergies and asthma in the presence of aluminum. Soils in agricultural production often contain pesticides, herbicides, bacteria, fungi, and other organic constituents that can create health problems in both humans and animals. On the other hand, the presence of quartz and aluminum silicates in AD has been related to the onset of pneumoconiosis and pulmonary fibrosis in farmworkers employed in plant/fruit harvesting [11]. **Europe has lately experienced dust storms from agricultural fields as reported in Germany, Poland, Czech Republic, Hungary, Romania and Cyprus. Some of them reached over 300 km distance, reduced drastically visibility and resulted in hundreds of car accidents and fatalities. Additionally, the loss of fertile agricultural soils can reach up to tents of cm after one storm** [12].

### 1.1.2 DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The relevance of DUSTer Action is explained here, and the time lines are given in 4.1.4 GANTT Diagram. **The aim of "Cold Climate, Agriculture and Road *DUST* User Network" (DUSTer) is to strengthen, develop, coordinate and promote interdisciplinary cooperation between European dust scientists for the benefit of human health, environment and society by**:

1. **IMPROVING THE FLOW OF KNOWLEDGE AND INFORMATION** between observers, modelers, and end users, stakeholders, train the next generation of scientists, on the latest instruments and methods for dust observations, modeling, and big data use, promote cooperation with society and economical sector to increase awareness with respect dust issues and challenges in Europe and abroad.
2. **COLLECTING AND MANAGING DUST DATA** (observations and methods).
3. **EVALUATING DUST IMPACTS** on health, economy, climate, and environment, by providing estimates on deaths,economic costs due to loss of animals, impact on flights, etc.

**Suspended and resuspended dust except mid-latitude mineral desert dust includes** most of all cold climate and high-latitude dust (**CCHLD**; polar dust, ice-dust, cold-desert-dust), agricultural dust (**AD**, wind-blown top soil), and road dust (**RD**, resuspended dust from brake-wear, tyre-wear, road surface ablation, etc., excluding vehicle exhausts). **Currently or previously there is no European or international level coordinated Action for these dust types.**

**Despite the different sources, these dust types we are interested to investigate have in common**: a) **to effect all Europe**, b) **being suspended wind-blown microparticles**, c) **being detectable using the same techniques**. Though they have in common the three general features mentioned above, CCHLD, AD and RD can be very different as for the composition and, especially, for the distribution and/or diffusion around the source areas. In fact RD and AD are mostly to be intended as localized air pollutants while CCHLD is frequently involved in long range transport to remote countries and very different environments. On national level, several aerosol monitoring stations have been established and run successfully in European stations, and investigated under European projects. CCHLD has, however, never been investigated or focused on EU or EU Arctic level. This makes the difference in the tools and targets of the research. Namely, the tools of CCHLD range from emission to transport and weather forecast models while those of RD and AD mostly involve the treatment of data and analytical results through epidemiological and toxicological approaches. The targets are also very different because AD and RD are mostly considered for their effects on humans and animals, whereas CCHLD has a much wider influence on geography, weather, climate, and, last but not least, on health. All the tools and targets, however, are to be applied and finalized starting from a thorough physico-chemical characterization of each dust. Data collection and management is, therefore, a basic point in the study of dust and its influence in the environment.

To achieve our targets and address the challenges, the network will cover and work across many fields (air quality, environmental sciences, agriculture, engineering, meteorology, hydrology, physics and chemistry) and will co-operate actively with social and economic stakeholders (e.g., tourism, transportation and public health). DUSTer will consist of 4 working groups (WGs). The first 3 will aim to address knowledge gaps and needs related to data collection, usage and management with respect to dust sources (WG1), observations methodologies (WG2), models, big data and Artificial Intelligence, AI (WG3). WG4 will be devoted to identify interdisciplinary knowledge gaps and coordinate WGs activities. DUSTer will coordinate the current multi-disciplinary research of diverse groups to enhance the scientific understanding of CCHLD, AD and RD (including geology, biology, ecology, glaciology, hydrology, meteorology, climate, as well as remote and in-situ observations) and to assess impacts on diverse socio-economic sectors including tourism, transportation and public health. The coordinated efforts and networking will improve dust forecasting methods and warnings through weather services, municipalities, road administration or environmental agencies to the general public on expected dust storms, not sufficiently available at the moment. The Action ensures that the best practices and quality of the measurements on the European level can be adapted.

**<u>Dust in general is an essential and relevant environmental variable with multiple effects</u>: Firstly, dust plays an important role for socio-economical effects such as air quality and public health**. It can negatively affect daily societal activities in both densely inhibited regions as well as remote communities, such as in Iceland or Greenland. Air quality and dust warnings are on-going activities in several meteorological services of relevance to CCHLD, AD and RD as well. In desert countries over 80 % of total air pollution mortalities are caused by suspended dust. Several hundred thousand mortalities are caused annually due to air pollution in Europe [13], but more research is needed on health impacts of natural CCHLD. **Secondly, dust is an important weather and climate variable, and a risk to the human health, to the environment, and to the climate.** CCHLD has similiar properties as anthropogenic aerosols and can be as absorbing as black carbon. Radiative feedbacks can therefore contribute to Arctic amplification. Also, **Arctic and Antarctic climate change** both lead to dust production and are enhanced by dust via feedbacks. For example, changes in dust emission patterns can be expected due to changing Arctic conditions, like retreating glaciers, but also extension of vegetated areas in Greenland. Moreover, **historical dust (palaeodust**) is not only a contributor to climate change but also forms a record of previous dust and climate conditions. The fundamental processes controlling aeolian dust emissions in high latitudes are essentially the same as in temperate regions, but there are additional specific factors influencing the processes in cold regions. These factors include low temperatures and low humidity, strong winds, permafrost and niveo-aeolian processes, all of which can affect the efficiency of CCHLD emission and distribution. CCHLD has different physical and chemical properties than crustal dust with strong implications on health, environment and climate. Mineral and organic matter deposited on glaciers, including natural and anthropogenic dust, can form cryoconite granules. Granules, dust and ice algae can reduce surface albedo and accelerate the melting of the glaciers. Consequently, **glacier melting** constitutes an important natural hazard as a main contributor to sea level rise. Also, glacier surface water run-off can be a potential source for pathogens, black carbon, persistent organic pollutants and antibiotic resistance bacteria, which were deposited on the glacier together with dust. **Dust deposition can provide nutrients to marine ecosystems** by contributing specifically iron. This is particularly relevant in regions such as the NE Pacific and Southern Ocean, both known to be high in nutrients but low productivity because Fe deficience which can be be supplied by high latitude dust.

## 1.2 PROGRESS BEYOND THE STATE-OF-THE-ART

### 1.2.1 APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE-OF-THE-ART

**DUSTer will develop novel research approaches/techniques, will be active inapply state-of-the-art data-mining and machine-learning techniques to mine the new and existing data, and will develop together a new method to provide observations of these specific CCHLD, AD, and RD dust sources. DUSTer will discuss evaluate the capacity of and decide whether pre-existing current monitoring networks and sites should be complemented with propose new sitesstations if necessary. COST Action DUSTer Network will be the first European level initiative on suspended CCHLD, RD and AG.**

The DUSTer Dust User Network work will contribute significantly beyond the state-of-art by: characterizing the various dust types of CCHLD, AG and RD with its focus on collecting and providing information on the geographical distribution of dust-productive soils.

*Figure 2. The suspended dust types of CCHLD, AD and RD are included in DUSTer Action.*

**DUSTer is a network connecting all the CCHLD, AD and RD researchers in EU and elsewhere with the main goal to create a synergy among researchers from different scientific fields,** including also aerosol researchers from other research fields, including measurement, modelling and remote sensing of atmosphere, cryosphere, hydrosphere and biosphere. Aerosol researchers of different fields are using different methods to quantify their aerosol or dust inputs. Some researchers are not aware of large dust sources in the European Arctic at all. DUSTer-Action will give guidelines to the outside-Europe CCHLD, AD and RD researches, but it will also build research cooperation on dust among the aerosol research community in Europe generally. DUSTer is determined to foster the knowledge transfer between the academic bodies, the European directive, Arctic protection institutions, national stakeholders, municipalities, tourist boards and other interested stakeholders.

Currently CCHLD, AD and RD are not, nor has previously been, investigated or focused on EU level. **DUSTer 's objectives are aligned and complemented to the mineral dust forecast platform of the World Meteorological Organization Sand and Dust Storm Advisory and Assessment System (WMO WAS-SDS) which is operating for the dust sources outside Europe (Sahara and Middle-East), and the related recently granted COST action International Network to Encourage the Use of Monitoring and Forecasting Dust Products (InDust, CA16202), and with the European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases ACTRIS, and the International Convention for the Safety of Life at Sea SOLAS.**

### 1.2.2 OBJECTIVES

#### 1.2.2.1 Research Coordination Objectives

Overall research coordination objectives: Establish a first European-wide and international integrative and multidisciplinary science network for CCHLD, AD and RD aerosols to create an understanding and quantification on dust impacts. To achieve this, the Action will on **encourage of a) extensive use of current and new CCHLD, AD and RD observations from ground-based and satellite platforms, and b) development and/or implementation CCHLD, AD and RD models**. Observations and model products should be transferred and tailored to needs of end users, coordinate collaboration between data producers and users, build capacity of end-users to promote the use of delivered products.

**Specified scientific and operational objectives:**

1. **Establish a first European-wide integrative and multidisciplinary user network on CCHLD, AD and RD measurements and modelling, and optimum use of corresponding products in applications by direct inclusion and interaction across disciplines.**
2. **Connection between the large number of groups:** DUSTer will provide an actively working connection and free change of information between the large number of dust user groups via its activities of workshops, data collections, STSM activities, and webpages where all the inputs of the network participants will be collected. It will assure the exploitation and dissemination of the results and knowledge.
3. **Aspects regarding the observations and modeling:**
    - DUSTer will Assess and harmonize practices, standards and retrieval algorithms applied to ground, airborne and space-borne dust measurements and foster for their acceptance by key CCHLD, AD and RD network operators at an international level. Temperate regions are used for testing and inter-comparisons of new methods and measurement techniques. Networking of project partners with expertise in numerical dust modelling is encouraged to implement their forecasting and climate models to HL regions.

- Advance the application of CCHLD, AD and RD data assimilation in European weather, climate and hydrological models and show its benefit for weather forecasting and climate and Earth system modelling to improve, air quality warnings as well as other applications.
- Numerical representation of different components of the CCHLD, AD and RD atmospheric process critical for numerical modelling, such as: emission, particle size distribution, using the existing dust particle data basis, turbulent mixing, long-term transport, and wet and dry deposition.
- Develop a rationale and long-term strategy for CCHLD, AD and RD-related measurements and modelling products as inputs to soils, oceans and cryosphere, including their dissemination and archiving.
- Establish a validation strategy for weather, hydrological and climate models and remote sensing approaches using dust observations.

4. **Citizen science initiative:** Global dust mobile app has been introduced in August 2019 and a dust warning app has been developed in USA. DUSTer will contribute to harmonize, advertise, boost the usage of existing apps and designing relevant CCHLD, AD and RD apps to test and modify with the general public. Especially to give alerts on specific types of dust that might have health impacts for vulnerable groups (e.g., fungi, pollen).
5. **Involve outside Europe** CCHLD, AD and RD areas such as South America, Antarctica, Canada, USA, and Russia in the European-driven network and practices to lead the world top research on this topic and introduce innovations in dust monitoring and forecasting/warning.
6. **Maintain and expand a network** of experts, researchers, early career investigators, and University students that allows the achievement of the previous objectives. European region research including atmosphere and cryosphere observations gather many young researchers from the ITC (Inclusiveness Target Countries) which will be emphasized in our network, including Czech Republic, Poland, Hungary, Serbia, and other.
7. **Disseminate** knowledge to policy makers and climate policy bodies according to the implementation of the work plan (GANTT diagram 4.1.4).

### 1.2.2.2 Capacity-building Objectives

DUSTer will focus on harmonizing monitoring, modelling, field and remote sensing, and this will be achieved through **networking, with different types of participation and building critical mass** to drive scientific progress (ref. Action plan in 2.2.1). The STSMs from PhD students, ECI and participants from Inclusiveness Target Countries will have priority, and the Action focuses on preserving gender balance (responding to the general gender imbalance in physical/natural sciences). **DUSTer emphasizes capacity building via its objectives to**:

- Foster knowledge exchange between separated research units on CCHLD, AD and RD. Scientists and groups dealing with CCHLD, AD and RD, such as the physical characteristics of aerosol particles, dust monitoring and measurements, CCHLD, AD and RD representation in models, CCHLD, AD and RD mineralogy and its impact to the environment and health (including, e.g., iron (Fe) effects) and biological processes on glaciers affected by dust, are often working separately in individual institutes, projects and countries. Therefore, this Action will build a linkage between the various issues from local-scale characteristics to remote-sensed broad areas, from micro-scale modelling to climatic and hydrological parameters and from instrumental capabilities to data assimilation (DA). This is likely to boost these communities towards advances in solving some of the multidisciplinary scientific and application issues.
- Train new generations of young scientists and existing experts (STSM, ECI, training schools, laboratory staff exchange), with focus on researchers from the ITC countries encouraging them to present their work at topical conferences.
- Engage trainees and give guidelines for the policy makers and educational institutions. Engage national stakeholders: Governmental stakeholders (National and/or Regional, e.g. National weather services, Environmental Agencies, National Parks and UNESCO Heritages, WMO SDS-WAS dust programme, and in general EU policy makers and decision-making bodies at national and/or regional levels, health institutions), and Non-governmental organisations (NGOs) in the sector (municipalities, tourist boards, aviation authorities, road administrations, farmers, ski areas).
- Encourage Citizen-Science projects, as dust and resuspended ash transported to municipalities or regions elsewhere is difficult to recognize by naked eye, people need to be educated and informed by the municipalities to distinguish when they should take measures to

protect their health, e.g. volunteers to collect pictures and videos of the CCHLD, AD and RD events (dust storms, dirty glaciers) and create a catalogue of such reports using standardised quality controls; Promotion to media (newspapers, radios, television).

- Transfer of knowledge to the CCHLD, AD and RD community globally, including to stakeholders such as policy-makers, regulators, and giving input for future commercial applications, including co-operation with private enterprises.
- Workshops and presentations in primary and high schools.
- Collect and disseminate research results of the project partners, including best measurement and modelling practises and new climate change connections together with mitigation/adaptation strategies, to the general public and stakeholders.

The Action will involve and liaise with major coordinating and implementing agencies such as the World Meteorological Organization WMO and its relevant Commissions and projects (especially WMO Sand and Dust Storm Warning Advisory and Assessment System - SDS-WAS and WMO SAG-Aerosols and the GAW programme) for taking stock of the Action's achievements with respect to measurement and model prediction practices and parameters recommendations, the European space bodies (ESA and EUMETSAT) regarding the production and application of space-borne dust data.

Training and harmonizing the methods will be achieved by **training schools, workshops and meetings**. Students and experts from the different scientific fields must be linked together and must perfectly communicate together in order to get the overall understanding of such complicated phenomenon such as CCHLD and its effects on climate, and characteristics related to CCHLD, AD and RD. The newest findings from the following scientific topics will be assessed, harmonized, checked for quality and improved during capacity-building events: Geochemical, mineralogical and morphological analyses of dust particles; field collection of the samples and instrumentation in harsh conditions; remote sensing; modelling and dust forecasting; climate adaptation/mitigation, understanding the atmosphere-cryosphere interactions and climate effects.

# 2 NETWORKING EXCELLENCE

## 2.1 ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

### 2.1.1 ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

**This DUSTer Action, as a user network, will co-operate with the international efforts and established networks related to its topic and will be open for all participants to join. As a first European level initiative on CCHLD, AD and RD, it will widen the perspective of the existing efforts** of, for example, World Meteorological Organization WMO SDS WAS (WMO has always favourably considered COST Actions and is observer in the ESSEM DC), WMO GAW, ESA, EUMETSAT, NOAA, AMAP (Arctic Monitoring and Assessment Program) and SCAR (Scientific Committee on Antarctic Research). DUSTer will be open for all participants to join its activities of workshops, conferences, training schools, short-term scientific missions (STSMs) and dissemination, and it will aim at participation, coordination, collaboration, and planning of future initiatives in its field of science. DUSTer will implement suitable tools and results, evaluate existing tools for CCHLD, AD and RD, improve or create new tools so existing efforts will clearly benefit from this.

DUSTer will focus on characteristics of CCHLD, AD and RD, and their contribution to the global dust load. The network will focus on harmonizing monitoring, modelling, field and remote sensing of CCHLD, AD and RD aerosols in air and cryosphere for climate change and historical dust, threats to aviation, operational responses to dust events, optical properties of dust, air quality; assessment of high-latitude dust including sources and mineral and physical features of CCHLD, AD and RD particles, and modelling of atmospheric dust life-cycle.

**This will be achieved through networking, including inter-comparison work, workshops, short-term scientific missions, exchange and training, and linking them to activities in international agencies and global networks. All parties of the network will benefit from the cooperation – the observers provide source data to modellers as well as to remote sensing experts. Modellers and forecasters can provide products to stakeholders. Stakeholders are needed to participate on the evaluation of the products during the progress as well as express their needs to be implemented in the products. The main goal is the awareness of general public about this**

**specific phenomenon from all points of view – health, property protection, preparedness and awareness, as achieved through the dissemination of the Action.** Scientific network will bring innovative break-through results, which can be further investigated from the various scientific disciplines point of view. Natural habitat is what the Europe should be protecting the most. To gain this, first step is the scientific understanding of the inner mechanisms in such environments, to be able to provide the best protection of such environments and people living in their vicinity. The scientific core of this action will provide such needed information. The EU air quality monitoring will get new aerosol information from our Action, and climate assessments will gain reduction in uncertainties on factors related to Arctic Amplification. Special attention in this Action will be given to the remote sensing techniques at high latitudes with limited amount of daylight in winter.

## 2.2 ADDED VALUE OF NETWORKING IN IMPACT

### 2.2.1 SECURING THE CRITICAL MASS AND EXPERTISE

The Network includes **55** proposers from **29** COST countries and **2** International Organisations, with **12** ECIs (**22** %). In addition, atmospheric and cryosphere experts from the Non-COST countries will be involved as International Partner Countries (**5** – Argentina, Canada, India, New Zealand, South Korea; more CCHLD experts from the Australia, South Africa, and Russia are expected as representatives of the Antarctic, Greenland, Alaska and Patagonian CCHLD sources). Each IPC have a specific role in the DUSTer network: For example, Canada has been an active in High Latitude and Cold Climate Dust investigations, it has many dust sources and expertise in source dynamics; South Korea is an expert in cryosphere and organisms in dust and cryoconite; at the proposal stage this network is with smaller amount of the COST countries that it is expected to have at the end of the Action. The EU CCHLD, AD and RD network is the core of the worldwide effort to understand, monitor and create protection strategies for the dusty areas of our planet. Gender balance is **54** % males and **46** % females at the moment of submission with a resolution to equalize these numbers during the progress of the Action. The main proposer is a female while the main candidates on the working group leaders (to be voted at the Kick-off meeting) are females and leading experts on CCHLD, AD and RD as well. The Core Expertise is in the Earth and Environmental Sciences (**73** %) with specialists in environmental engineering (**9** %), physical, biological and chemical sciences (**12** %), and other (~**7** %). **74** % of proposers represent higher education and associated organizations, **22** % governmental organizations, **2** % standard organizations and **2** % private. NGOs, Business enterprises and Standard Organisations are **4** % of the proposers. The CCHLD, AD and RD-Network proposers are on average **15** years after their PhD graduation, showing the dedication and top-level scientific experience in this young and novel research topic. A significant number of DUSTer's COST Member Countries are COST Inclusiveness Target Countries. The work and inputs of the user network members allow the Action to meet the objectives, foremost the establishment of the first EU-wide multidisciplinary science network on the EU level. The composition of the Action Management Committee (MC) is not defined at the proposal stage. MC members will be nominated by the COST countries and can join the Action anytime during its lifetime. The participation of WG members and ad hoc participants will be decided by the MC. WG and management structure may be changed by the MC at a later stage in compliance with COST rules. The Action is based on four Working Groups (WG). Management Committee (MC) meetings will be carried out once a year with the WG meetings, and additional WG meetings will be arranged to implement the work plan. Open discussion and planning is the most important to maximise the Action's success. At least one of the key leadership positions in the Action management (e.g. Action Chair, Vice-Chair, Working Group Leader, Grant Holder, STSM Coordinator) shall be reserved to a representative of a COST Inclusiveness Target Country. **Summarizing all above, this guarantees the capability of the Network to achieve the Action objectives.**

### 2.2.2 INVOLVEMENT OF STAKEHOLDERS

**Plan for involving the most relevant stakeholders:**

**Potential stakeholders are identified and will be contacted** face-to-face, by arranging events and inviting the stakeholders there, via press releases, via DUSTer webpages, and in social media using #DUSTer, and DUSTer-Twitter account will be created for the Action. DUSTer will prepare a video of the work included in the DUSTer network and to be available in the internet, and all this will be advertised in webpages, meetings, conferences, in the social media. The WG members will be provided with all the material and links and will advertise DUSTer in their own networks to include more stakeholders. Organising a session at EGU aims to introduce the Action and build a network efficiently, engaging many potential stakeholders, including commercial partners to specify user-tailored products. DUSTer plan for involving the most relevant stakeholders includes the following:

- **Aviation** is especially vulnerable to CCHLD events. CAO and IATA will be contacted and invited as an expert for DUSTer meeting, for face-to-face discussion for involving them closely to DUSTer activities.
- **Health:** WHO is the most important stakeholder for protecting health
- **Tourism industry**: UNWTO is a key partner with regards tourism impacts.
- **Socioeconomic impacts**: the World Bank. They will be invited to be involved in preparing DUSTer reports on environmental issues.
- **National Weather Services:** to incorporate CCHLD, AD and RD, agri and road dust in NWP models and to validate these models against dust observations from corresponding networks; training of operators how to use dust model products.
- **Hydrological Services**: to assimilate and calibrate hydrological models using improved dust observations as well as for guidance in hydrological observations related to dust effects.
- **National environmental and health authorities and policy makers on a national, EU-wide and international level:** to have better, sounder and more representative information on dust sources, particle variability and impacts on air quality, health, cryosphere, aviation, etc.
- **Climate modelling groups in Europe, North America, Asia, and within the IPCC**: to use improved dust observations for evaluating and developing models that produce climate change scenarios.
- **The next generation of scientists:** student training to attract more researchers into this specific field, and to create a problem-awareness, to promote Arctic and Antarctic high latitude dust research at universities.
- **Entities responsible for dust warnings**: to enhance their monitoring and warning capacities.
- **Instrument manufacturers and practitioners**: to have access to state-of the art scientific information about dust physical properties and the usage of measurement data.
- **European remote-sensing community** via ESA and EUMETSAT: to harmonise ground-based and space-borne observation techniques on dust and their application.
- **International organisations (WMO, EUMETNET, AMAP):** to set improved harmonised guidelines in a coordinated manner.
- **Science community and commercial partners:** DUSTer EGU session will be arranged.

### 2.2.3 MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

Internationally, the European CCHLD, AD and RD dust sources are important for environmental, health, societal (e.g., transport and tourism) and climatic impacts in Europe, and outside Europe [14]. Similarly, outside Europe originating dust is important to Europe, too. Therefore, there is a high international mutual benefit for all the network members. **Air pollution is a shared problem by all countries.** Cold climate and high-latitude dust (also called as polar dust, ice-dust and cold desert-dust), agricultural dust and road dust are all included in this Action. For example, in the Alaska, during the summer, road dust is a recurrent problem. This is exarcebated by the frequent glacier silt blowouts from deposits along several rivers (Copper, Tanana, Yukon rivers). The Alaska department of environment has dedicated several studies on the subject of road dust affecting in-land villages, citing several respiratory in the local communities in the elderly and children populations.

Representatives of international partner countries and organisations, bodies and associations involved in environmental protection issues will be represented and have already expressed their interest in participating in the current Action. The current network consist of minority of involved countries while experts from the past European initiatives are ready to transfer the knowledge and legacy to proposed DUSTer network and disseminate to increasing number of researchers and students from Europe and abroad.

# 3 IMPACT

## 3.1 IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAK-THROUGHS

### 3.1.1 SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

**Scientific, technological, and/or socioeconomic impacts are recognized. Scientific impacts are:**
**Short term:** Establishing a network and ensuring collaboration; Contribution to dust forecasts, dust monitoring control, Arctic protection, transport control (road and aviation), health community, tourist boards, environmental and air quality agencies; understanding and quantifying the effects of CCHLD, AD and RD on health, transport, climate and climate change; climate change mitigation; Coordination and harmonization of current CCHLD, AD and RD methods and research and sustainability in top-level science for the benefit of measurements, remote sensing, modelling and forecasts and warnings and distributing to stakeholders.
**Long term:** The Network created in the framework of the present Action will continue beyond the present Action. In short, all the EU states and partners from abroad should together monitor, provide observed data, predict the future behaviours, assess risk and mitigation plan. To attract the next generation of scientists via student training and to create a problem-awareness to promote CCHLD, AD and RD research at universities.
**Technological:** Harmonization and development of the measurement methods and technologies. **Socioeconomic**: the aviation, remote sensing community, forecasts, assessments, health/dust warnings and tourism will benefit from the DUSTer results directly.

**Potential for scientific, technological and/or socioeconomic innovation breakthroughs:**
***A. Scientific and technological innovation breakthroughs*** include most of all:
1. **International data base** of characterization of various dust types of cold climate dust, road dust and agricultural dust, and
2. **New information rising from data mining of the big data**, **where new technologies and artificial intelligence can be applied for services and commercial products,** including, e.g., dust warnings and mobile apps. For example, a dust warning mobile app to protect people with respiratory illnesses, for elderly people and children who are more sensitive to air pollution, and for tourism and outside workers, Also,for determining sources, using **big data and mining strategies can provide estimates which are not constrained by predetermined hypotheses**. **Data mining of satellite images and webcams can be coupled with meteorological data to improve dust source appointing**.
3. **Identification of new CCHLD aerosol types with high impacts** and understanding their role in **climate change** and **European air quality** including health and socioeconomical impacts; predicting ice surface melting affected by dust, discovering feedback mechanisms between Arctic biota and dust including phytoplankton fertilization effects, new knowledge to climate change modeling, Earth system **modeling**, European dust **warnings**, Arctic protection, AMAP and IPCC.
***B. Socioeconomic innovation breakthrougs include:*** Awareness-raising, innovative research; protection in tourist areas and ski areas, aviation and road administration protection when utilizing the scientific and technological innovations, where source specific risks have been identified and risk communication will be targeted at vulnerable groups, thus improving their mitigation strategies and avoiding morbidity and ensuing costs to society.
***The overall breakthrough***: Establishing Europe as the science excellence leader in European dust monitoring and protection and DUSTer dust data usage for the benefit of the European society. The potential of DUSTer for innovation is high compared to risks identified in 4.1.3.

**The innovations/added value of this DUSTer COST Action network are expected to be:**

- **new more accurate models for dust warnings**, for the use of stake holders, such as governmental services, private companies of transportation, tourism. This is done by improving the accuracy and precision of the Eulerian dust models: Chemical/mineralogical features of CCHLD, AD and RD should be a part of source specification. Receptor and Lagrangian/trajectory models will complement the full models. A chemical approach is required to determine exact fingerprints of dusts from their natural emission sources. Also, specific chemical forms of elements originating from emission sources can help following long-range atmospheric transport of dusts. This information in combination with receptor models will help to evaluate the contributions of various natural emissions sources to the global dust load.

- **new DUSTer mobile apps** for the use of European citizens, and private companies in various fields, for dust warnings
- **a new dust atlas** with detailed specification of geographic distribution of potential dust sources and their physical (e.g. particle size distribution, optics) and mineralogical/chemical (mineral fractions, chemical composition, etc) properties. This is the key set of parameters necessary to accurately parameterize potential of dust emission in numerical dust models.
- **new methods**: Developing/implementing numerical dust models specifically designed to predict/simulate CCHLD, AD and RD dust atmospheric processes
- **new services**: Incorporating CCHLD, AD and RD knowledge to existing dust platforms
- **new services**: implementing mineralogy effects of transported dust to marine biochemistry, health and climate to commercial, governmental and various services in the society health sciences included.
- **new assessments for the society**: Assessing climate change and CCHLD, AD and RD, with a particular focus on dust role in: a) modifying snow and ice optical characteristics and impact on seasonal snow melting process, b) radiative feedbacks and influence of dust on glacier melt, and c) climatic effects of dust nutrient depositing to the ocean (e.g. potential reduction of the ocean HL acidification due to dust).
- Detection and control of the specific aerosols of CCHLD, AD and RD in Europe for EU Arctic protection and awareness.
- **New services and methods**: Obtaining and harmonizing missing characterisation for the geological databases, allowing data mining and big data used for artificial intelligence-based new products and services

## 3.2 MEASURES TO MAXIMISE IMPACT

### 3.2.1 KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

**Knowledge Creation and Transfer of Knowledge.** DUSTer will consist of 4 working groups (WG) to address knowledge gaps and needs related to data collection, usage and management, including dust sources (WG1), observations (WG2), models, big data and AI (WG3), and identification of interdisciplinary knowledge gaps and coordination of WG activities (WG4). DUSTer aims to improve the flow of knowledge and information between observers, modelers, and end users, and to train the next generation of scientists, observers and end users on the latest instruments and methods for dust observations, modeling and big data. DUSTer has a specific engagement plan to guarantee the required transfer of knowledge, especially to potential end-users (presented in 2.2.2)

**Career development.** The number of research groups involved in DUSTer Action are all active in promoting personal career development of undergraduate and PhD students. The first point is to **attract** more and more **young students** to the practice of STEM disciplines at university through wide-ranging scientific dissemination projects on global warming and its effects. The second point is to encourage the **participation** of students in **courses, schools and congresses** aimed at stimulating them to a critical, analytical and creative mentality at the same time. A further point is to encourage the **mobility** of PhD students abroad where they conduct studies and researches related to the impact of dust on climate. This is already done in specific organizations, e.g., active in studies in Arctic areas (e.g., SIOS and SSF for Svalbard).

### 3.2.2 PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

To maximise the impact of DUSTer on various sectors, the Action will make the following **identified measures according to the DUSTer Dissemination and/or Exploitation Plan:**

The European CCHLD, AD and RD network of DUSter responds to the needs rising from air quality, health and environmental impact aspects, regarding suspended and re-suspended dust pollution, and **data will be shared** leading to **European database on parameters of CCHLD, AD and RD**. The currently missing parameters will be added for models and dust weather forecasts and geological databases. This will affect and likely change the results of high number of published studies on suspended dust sources. This transfer of the knowledge will be through the representatives of the databases - mainly weather services. **Assessments based on reliable data and dispersion modelling** will be elaborated for the climate scenario projection (currently without CCHLD calculations) in future IPCC (Intergovernmental Panel on Climate Change) reports. **Research results will be disseminated to health authorities to give warnings during extreme events. Health science representatives** will be selected to disseminate the Action's achievements to the community and targeted health institutions. DUSTer generates new knowledge, and a **handbook on the best practices** will be introduced recommending the practices at polar stations and to The European Monitoring and Evaluation Programme (EMEP) and contribute to EBAS database (http://ebas.nilu.no/).

DUSTer benefits and results will be shared with stakeholders including standardization bodies, policy-makers, regulators, existing organizations and associations, AMAP (Arctic Monitoring and Assessment Program) and meteorological institutes. **Rising awareness** is the key to outreach the gained knowledge. DUSTer will coordinate the fragmented research groups under one network to successfully spread the generated innovative results to: a) the public, and to the scientific community (members participating in this Action from different scientific fields) and other scientific communities and research bodies interested in dust and its atmospheric impacts and feedbacks. b) Governmental national and/or regional stakeholders (National weather services, Environmental Agencies, National Parks and UNESCO Heritages, and in general EU policy makers and decision-making bodies at national and/or regional levels, health institutions). c) Non-governmental organisations (NGOs) active in the sector (municipalities, tourist boards, aviation authorities, road administrations, ski areas).

DUSTer Action plan comprises all elements required to meet its objectives, covering benefits in establishing a European-wide top-level science network on CCHLD, AD and RD control and improved coordination between existing research bodies to provide opportunities and promote innovation and sustainability of the Network and Standardisation for the best practices through guidelines, training schools and STSM to ensure the preservation strategies for an existing and future CCHLD, AD and RD network, and as measures for career development of current and future dust scientists. The end users will be informed about the generated results as follows: **Scientific communities will be engaged through international conferences (EGU, AGU, DUST), social media, workshops, training schools, and STSMs.** A special effort from the experiences requires to communicate with the NGOs and Governmental stakeholders - the **Action's representatives give an undertaking to disseminate the results personally to selected institutions**, lead a dialog on this issue and implement the information and dust warnings in their action plans. **The public community will be informed via media, social media, popular geographical journals, wikipedia, newsletters and websites of this initiative as well as of aerosol and dust associations.** Awareness-raising and communication between scientists from different science fields, aerosol scientists, outside Europe CCHLD, AD and RD experts and aerosol scientists: Engagement of new generation of **young scientists** already working in CCHLD, AD and RD through **training schools and STSM**; Elaborate the first European joint review **open access publication** on CCHLD, AD and RD as well as a **depository and overview of scientific papers including the main output of the Action regarding both methods and results at a European scale**: A webpage of the Action will be created and kept updated, including a CCHLD, AD and RD publication repository; Actions highlights will be promoted periodically through 'newsroom' at the Action´s website as well as the cost.eu website; online channels (facebook, twitter, blogs, wikipedia); press releases; newsletters to participants and to further distribution. **Presentation of results from the Action to competent European institutions**, such as Environment and the European Environmental Agency, by **inviting them** to one of the Action's meetings or through a specific meeting for this purpose. Contact with the European institutions will be maintained during the course of the Action. The relevant results from the Action will be disseminated in the **media, and in meetings with concerned parties and policy makers at the municipality and regional authorities** level. An important consideration for the project is that its outcomes are sustainable into the future after the project's funding has ceased. Part of the sustainability strategy will be the focus on public body, environmental agency and scientific end-user engagement.

# 4 IMPLEMENTATION

## 4.1 COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

### 4.1.1 DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

The DUSTer working groups are devote to address dust sources (WG1), observation methodologies (WG2), models, big data and AI (WG3), interdisciplinary knowledge gaps, dissemination and coordinating all the DUSTer activities (WG4).

**WG1 DUST SOURCES OF SUSPENDED CCHLD, AD and RD. Task 1.1**. Determine an approach for mapping and classification of actual and potential dust sources of CCHLD, AD and RD. To establish a method for applying the classification at an agreed range of spatial scales to enable mapping of the dominant source type. **Task 1.2.** Constrain dust source dynamics analyzing the geomorphological context for dust sources, seasonal or long-term hydrology-connected sediment exposure due to ephemeral lakes, vegetation cover, and glacier retreat. **Task 1.3.** Develop a standard methodology for characterise dust source persistence at a range of temporal scales. **Task 1.4.** Coordinate approaches for generating data on gridded soil types and mineralogy of dust sources. **Milestones:** (1) Dust sources assessment. (2) Dissemination of D1.1. and 1.2. (see 4.1.2), (3) Open access availability of the data for the stakeholders (modelers, weather services, governmental bodies).

**WG2 DUST OBSERVATIONS ON CCHLD, AD and RD. Task 2.1** Instrument, method and protocol evaluation: inter-comparison of different instrumentation to measure re-suspended dust properties; evaluation of different approaches to separate the dust from other aerosols; review, assess and adapt quality assurance methodologies, and best practices of dust-related observations; identify and catalogue observation methods, protocols and products, and assess their suitability for different users; identify observation gaps in terms of parameters and operational capabilities; adapt or develop data formats and protocols for data harmonisation, in coordination with WG1 and WG3. **Task 2.2** Chemical properties of dust: review and assess used methodologies, including e.g., X-ray diffraction and SEM-EDS (mineral chemistry). **Task 2.3** Physical and optical properties of dust in air and snow: determine typical range of values for many parameters, including albedo, extinction, scattering, absorption, polarisation, spectrum, laser backscattering in laboratory, field, and aerial measurements, and connection with dust morphology and evolution. Two measurement campaigns are planned to provide data to modellers. **Task 2.4** Remote sensing of dust aerosols:review existing space-borne sensors and algorithms applied for retrievals of aerosol dust; assess source of errors at high latitutudes; evaluate improvements arising from new algorithms, including Bayesian Dark Target (BDT). **Task 2.5** Student's training school on CCHLD, AD and RD dust measurements will be organized where achievements will be used to form young researchers. **Milestones**: (1) Two inter-comparison field campaigns, the second linked to one student's training school on CCHLD, AD and RD; (2) Handbook 'How to measure suspended dust of CCHLD, AD and RD - the best practices' (3) Joint assessment based on D2.2, D2.3.1 and D2.3.2.

**WG3 MODELLING, BIG DATA AND AI.** This WG will aim to consolidate a dust model system. **Task 3.1** Numerical modelling of the atmospheric dust life-cycle: improve the representation of the CCHLD, AD and RD life-cycle (dust emission, transport, and deposition processes) in state of the art atmosphere-dust aerosol models, also taking advantage of activities of WG2. **Task 3.2** Climate modelling: improve modelling of dust atmospheric processes at climate time scales (optical properties of dust, effects of absorbing aerosols in snow over land and sea, dust effects on marine biogeochemistry). Attention devoted to both direct and indirect effects. **Task 3.3** Dynamical downscaling for Iceland and for Svalbard – application of Weather research and forecasting model, WRF and DREAM dust model. Optimizing the WRF and DREAM model to indicate spatial and temporal variability of meteorological elements, first for Svalbard archipelago, including testing of boundary layer, microphysics and radiation parameterization schemes and evaluation of their impact on modelling results. Simulations in high resolution will be prepared (3 km x 3 km) in reanalysis mode. **Task 3.4** Modeling long-range transport processes: dust emission parameterizations adjustments (developed for transport modelling approaches), treatment of emissions and optical properties of dust. **Task 3.5** Big data, data mining and AI: Big data usage with data mining and AI techniques will be advanced and promoted inside the DUSTer network and by the DUSTer network stakeholders. To this scope, joint exercises for models evaluation and intercomparisons will be defined starting from specific needs of observation, modelling and stakeholders communities. Recommendations to document and communicate the quality and maturity level of existing and future data and products will be produced. **Milestones:** (1) Inter-comparison of different modelling approaches and parameterizations; (2) Dissemination of D3.1-D3.4 to global forecasting centers, governmental stakeholders (Dissemination twice during the Action = mid-term and end term), including attendance at the EGU special "COST session"; (3) Assessment evaluating dust simulations of severe CCHLD, AD and RD events.

**WG4 IMPACTS, DISSEMINATION AND COORDINATION**. **Task 4.1** Air quality and health impacts: develop. methods to implement CCHLD, AD and RD Model, observations and laboratory analyses to provide timely warnings to the public. **Task 4.2** Dust and cryosphere interactions: improve evaluations of CCHLD, AD and RD on ice melting processes, assessing the effects of dust/BC/OC aerosols; identify the most endangered glaciers and ice caps by CCHLD, AD and RD; understand the role of and consequences on organisms and pollutants in affected glaciers (cryoconite, algae, pathogens and antibiotic resistance bacteria, persistent organic pollutants). **Task 4.3** Historical record of dust preserved within glaciers: link the data on today dust distribution with past dust variations in the Arctic. The pivot area is in Svalbard and Iceland with dust and other light-absorbing impurity concentrations and deposition in ice cores for the last ca. 300 years. Analytical methods relying on both chemical proxies (linked with Task 2.2) and measurements of the light-absorbance of mineral particles and BC (linked with Task 3.4) will be compared. **Task 4.4** Threats to transportation and aviation: assess the risk of reduced visibility, and in extreme cases engine damage, to provide well characterized and standardized data on dispersion of the airborne CCHLD to Aviation safety authorities. Current airborne dust predictions for aviation safety in Europe include only the dust outbreaks from temperate region deserts (mainly Sahara and Arabian Peninsula) while based on observations from geostationary satellites only. **Task 4.5** Best practices regarding communication and dissemination of the Action´s results: develop a robust scheme for these issues. The Action will elect a DUSTer dissemination director, Health Science representative and Climate impacts dissemination representative at the Kick-off MC meeting, with the aim to coordinate efforts at national level. Typical instruments for communication, website, social media+wikipedia, communication plan with the stakeholders, dissemination plan of main achieved outcomes, 'newsroom', will be developed. CCHLD, AD and RD publication repository will be realized, as main source of information also for COST action products (Handbook, guidelines, impact assessments). Citizen involvement will be promoted also producing suitable guidelines. A coordinate plan to participate workshops and conferences will be elaborate since the beginning. **Milestones**: (1) Deployment of the website of the project and social media profiles. (2) A workshop to build the capacity of scientists, and policymakers to address the risks associated with CCHLD, AD and RD. (3) Training School on CCHLD, AD and RD observations and modelling. (4) Final joint assessment based on the M2.2, M3 and D4.1-5.

The WGs are closely linked and need to share the deliverables between each other. The WG1 “Dust Sources” provides outcome to WG2 “Observations on Dust” and WG3 “Modelling dust”, while WG2 will inform WG1 when new sources are identified through satellite images. WG2 obtained data will be validated and harmonized to support the WG3. WG3 needs to validate outcomes from the WG1 to understand properly the surface processes of CCHLD, AD and RD suspension. Based on systematic task solution of WG1-3, WG4 can elaborate assessments on impacts of CCHLD, AD and RD and aerosol on cryosphere, Arctic region, Europe’s air quality and health impacts to be disseminated to stakeholders. WG4 takes, however, the responsibility of continuous dissemination of partial deliverables of all WGs to the stakeholders and via media and ECI trainees. Additionally, WG meetings, sessions at conferences and STSMs will be organised to improve the networking.

**Managment structure and composition.** The composition of the Action Management Committee (MC) is not defined at the proposal stage. MC members will be nominated by the COST countries and can join the Action anytime during its lifetime. The participation of WG members and ad hoc participants will be decided by the MC. WG and management structure may be changed by the MC at a later stage in compliance with COST rules. The Action is based on four Working Groups (WG). Management Committee (MC) meetings will be carried out once a year with the WG meetings, and additional WG meetings will be arranged to implement the work plan. Open discussion and planning is the most important to maximise the Action’s success. At least one of the key leadership positions in the Action management (e.g. Action Chair, Vice-Chair, Working Group Leader, Grant Holder, STSM Coordinator) shall be reserved to a representative of a COST Inclusiveness Target Country. Grant Holder role: Administering the Action network centered around nationally funded research projects in fields that are of interest to at least seven COST Member States with financial support averages EUR 111 000 per year for a four-year period.

### 4.1.2 DESCRIPTION OF DELIVERABLES AND TIMEFRAME

**The deliverables are as follows: WG1** Deliverable 1.1 A map and classification of the CCHLD sources to be implemented to the global dust source maps. Deliverable 1.2 Harmonized guidelines for dust researchers to identify the dust sources and use the correct classification for the dust sources based on dust source dynamics. **WG2** Deliverable 2.1 Handbook on the best practices for methods and measurements. Deliverable 2.2 Assessment on the chemical properties of CCHLD, AD and RD for the global geochemical databases. Deliverable 2.3 Assessment on morphological properties of CCHLD, AD and RD for mineralogical databases. Deliverable 2.4 Assessment on optical properties of CCHLD, AD and RD using a simplistic optical two-component model to discriminate between the black carbon and dust aerosols. Deliverable 2.5 Assessment on improvements on detecting CCHLD in MODIS including BDT more suitable for HL regions. **WG3** Deliverable 3.1 New modelling parameterizations/schemes through validation against measurement data. Deliverable 3.2 CCHLD, AD and RD in climate models. Deliverable 3.3 CCHLD, AD and RD in hi-res models. Deliverable 3.4 Assessment on the CCHLD, AD and RD feedback mechanisms with environment and future projections. Deliverable 3.5 Big data, data mining and AI, as well as identification of data users who can perform data mining and AI algorithms for DUSTer open data. **WG4** Deliverable 4.1 Air quality and health assessment for EU and governmental stakeholders, weather services, and municipalities. Deliverable 4.2 Assessment dust and cryosphere interaction linked with the D2.4. Deliverable 4.3 Assessment on comparison of historical and current dust environments. Deliverable 4.4 Implementation of new research techniques of CCHLD, AD and RD retrieval to operational aviation safety products and harmonization of the research techniques and standardization of the retrieval products. Deliverable 4.5 Dissemination plan, responsible persons, dissemination reports.

### 4.1.3 RISK ANALYSIS AND CONTINGENCY PLANS

DUSTer excludes volcanic eruptions and focuses on resuspended dust. The risks are: RISK1: Dissemination of the Action's results to National stakeholders and policy makers. CONTINGENCY PLAN1: The dissemination director and country dissemination representatives will utilise Action's dissemination plan and other measures (workshops, short assessments, trainee if needed) to deliver the results to the National stakeholders. RISK2: Low attendance of the MC members for the voting at the MC meetings CONTINGENCY PLAN2: Evaluation of the participants attendance prior the MC meeting by the Action's director. RISK3: Field campaign organization and measurement acquisition CONTINGENCY PLAN3: There is possibility that there will be no aerosol concentration during the field campaign. The laboratory conditions or indoor environment would have to be used instead or include measurements of anthropogenic pollution in the Arctic areas. RISK4: STSM flow - too many or too few applications. CONTINGENCY PLAN4: The STSM coordinator will assure the STSM flow by promoting the Action's benefits and needs with emphasis on experts and ECI. The STSM committee will be elected if there is high number of STSM to select the most beneficial STSMs for the Action's outcome. The risk will be minimized by linking field campaigns, training schools and STSMs. RISK5: Delay in delivery of deliverables or fulfilling milestones on time. CONTINGENCY PLAN5: Identification and mitigation of the causes of the delay, creation of smaller working segments of scientist concentrated on the delayed task. Support in networking of all the COST members (skype meetings to ensure that the responsibility of each part of the deliverable is linked to the selected and most appropriate COST member), and detailed monitoring of tasks progress. RISK6:Ensure high participation of ECI (>current 25%). CONTINGENCY PLAN6: STSM, ITC grants, training school, field campaigns, providing new topics and leadership for theses and publications.

### 4.1.4 GANTT DIAGRAM