Convocatoria 2015
Proyectos de I+D+I para jóvenes investigadores sin vinculación o con vinculación temporal
Dirección General de Investigación Científica y Técnica
Subdirección General de Proyectos de Investigación

AVISO IMPORTANTE

En virtud del artículo 11 de la convocatoria **NO SE ACEPTARÁN NI SERÁN SUBSANABLES MEMORIAS CIENTÍFICO-TÉCNICAS** que no se presenten en este formato.

La parte C de la memoria no podrá exceder de 20 páginas.

Lea detenidamente las instrucciones para rellenar correctamente esta memoria, disponibles en la web de la convocatoria, en el apartado "Documentos explicativos"

Parte A: RESUMEN DE LA PROPUESTA/SUMMARY OF THE PROPOSAL

INVESTIGADOR PRINCIPAL (Nombre y apellidos)**:**

Sara Basart Alpuente

INVESTIGADOR TUTOR (Nombre y apellidos)**:**

Oriol Jorba Casellas

TÍTULO DEL PROYECTO: Estudio de la formación de tormentas de polvo mineral asociadas a procesos meteorológicos convectivos utilizando simulaciones de alta resolución del modelo NMMB/BSC-Dust

ACRÓNIMO: BSC-DustStorms

RESUMEN Máximo 3500 caracteres (incluyendo espacios en blanco):

El polvo mineral es uno de los aerosoles más importantes en los estudios del sistema terrestre debido a sus impactos sobre la calidad del aire, la salud humana, las actividades socio-económicas, y los ecosistemas; así como en la meteorología y el clima. En la mayoría de los casos, las tormentas de polvo son el resultado de vientos turbulentos, asociados a frentes y procesos convectivos, que levantan grandes cantidades de polvo mineral sobre los desiertos. La emisión juega un papel crítico en la simulación del ciclo de vida del polvo mineral. Las emisiones de polvo responden de una manera no lineal a una variedad de factores ambientales, tales como el contenido de humedad del suelo, el tipo de cobertura de la superficie, las condiciones atmosféricas o la turbulencia. El estudio de la emisión de polvo mineral en los desiertos es particularmente difícil debido a la compleja meteorología y una red de observación muy escasa. Los modelos numéricos son esenciales para complementar las observaciones, entender los procesos asociados al ciclo del polvo y predecir su contribución en la atmósfera así como entender interacción en el sistema climático-meteorológico, complementar las observaciones de redes terrestres y satélites. El papel de los procesos atmosféricos convectivos en la emisión del polvo mineral, y en consecuencia en el ciclo global de polvo, es uno de los retos más críticos que deben ser abordados en la actualidad.

El Departamento de Ciencias de la Tierra del Centro Nacional de Supercomputación (BSC-CNS) desarrolla y mantiene el modelo NMMB/BSC-Chemical Transport Model (NMMB/BSC-CTM; https://www.bsc.es/earth-sciences/nmmbbsc-project). Se trata de un modelo meteorológico y de calidad del aire para aplicaciones globales y regionales. Resuelve el ciclo de vida de los aerosoles y la química troposférica siguiendo una programación online.

Actualmente, el sistema se emplea para generar predicciones de transporte de polvo mineral al Centro Regional Norte de África, Oriente Medio y Europa de la Organización Meteorológica Mundial (OMM) para el Sistema de Avisos y Evaluación de Tormentas de Polvo y Arena. El Centro regional está gestionado por el consorcio AEMET y BSC-CNS. Además, el modelo NMMB/BSC-Dust (el módulo de polvo mineral del modelo NMMB/BSC-CTM) se ha seleccionado como el sistema de modelización de referencia para el centro meteorológico regional especializado en predicciones de polvo, recientemente creado por la OMM, denominado Barcelona Dust Forecast Center. Adicionalmente, resultados de simulaciones globales se están proporcionando a la iniciativa International Cooperative for Aerosol Prediction (ICAP).

El principal objetivo de la presente propuesta es estudiar el papel de los procesos meteorológicos convectivos en el ciclo del polvo usando simulaciones de alta resolución espacial basadas en el modelo NMMB/BSC-Dust. El presente proyecto profundizará en cómo los modelos numéricos reproducen los procesos meteorológicos convectivos de pequeña escala. Los resultados obtenidos supondrán una mejora de la descripción del ciclo de polvo (variaciones geográficas, estructura vertical, estacionalidad y ciclo diurno), así como mejorará las previsiones a corto plazo de tormentas de polvo y de calidad del aire. Estos resultados no sólo ayudarán a la comunidad científica en los estudios sobre el clima, sino también para prevenir eventos severos de tormentas de polvo en regiones desérticas donde el polvo se considera un riesgo ambiental.

PALABRAS CLAVE: polvo mineral, meteorología, modelos numéricos, calidad del aire, clima, aeriosoles

TITLE OF THE PROJECT: Understanding of desert dust storm formation associated to atmospheric convective processes using high-resolution simulations of the NMMB/BSC-Dust model

ACRONYM: BSC-DustStorms

SUMMARY Maximum 3500 characters (including spaces):

Atmospheric mineral dust has recently become an important research field in Earth system science because of its impacts on radiation, clouds, atmospheric dynamics and chemistry, air quality, and biogeochemical cycles. Dust storms are in most cases the result of turbulent winds, including fronts and convective haboobs, which raise large quantities of dust from desert surfaces. Dust emission plays a critical role on the simulation of the dust life cycle. Dust emissions respond in a non-linear way to a variety of environmental factors, such as soil moisture content, the type of surface cover, surface atmospheric conditions or turbulence. Studying dust emission over deserts is particularly challenging because of the complex meteorology and a very sparse observational network. Dust modelling is essential not only to have a powerful tool to predict the global or regional dust budget and its interaction in the climate-weather system, but also to complement remote sensing and in-situ observations and to understand the processes involved in dust emissions. The role of the convective atmospheric processes on the dust emission, and consequently on global dust cycle, is one of the most critical challenges that should be addressed because they are substantially associated with the representation of peaks winds.

The Earth Sciences Department of the Barcelona Supercomputing Center–Centro Nacional de Supercomputación (BSC-CNS) develops and maintains a state-of-the-art environmental model, the NMMB/BSC-Chemical Transport Model (NMMB/BSC-CTM; https://www.bsc.es/earth-sciences/nmmbbsc-project). It is a fully online unified global/regional meteorological-air quality model. It solves the fate of global relevant aerosols and the atmospheric chemistry following an online approach. The model has been selected as the reference mineral dust model for the recently created First World Meteorological

Organization (WMO) Regional Meteorological Center specialized on Atmospheric Sand and Dust Forecast, the Barcelona Dust Forecast Center (BDFC). Currently the model provides mineral dust forecasts to the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Northern Africa-Middle East-Europe (NA-ME-E) Regional Center that is managed by a consortium between AEMET and BSC-CNS. Additionally, global aerosol forecasts are provided to the International Cooperative for Aerosol Prediction (ICAP) initiative.

The main objective of the present research is to study the role of convective meteorological processes on the dust cycle using high-resolution simulations based on the NMMB/BSC-Dust model which is the dust module of the NMMB/BSC-CTM model. This proposal research will lead the way to a more physical representation of smaller-scale meteorological processes that will ultimately improve geographical variations, vertical structure, seasonality, and the diurnal cycle of the dust distribution in models as well as short-term forecasts of dust hazards and air quality. These help not just for the scientific community for climate-weather studies but also the end-user communities to prevent severe events over desert source regions where dust is considered to be a harmful air pollutant, and consequently, an environmental risk.

KEY WORDS: mineral dust, meteorology, numerical modelling, air quality, climate, aerosols

Parte B: INFORMACIÓN ESPECÍFICA DEL INVESTIGADOR TUTOR

FINANCIACIÓN PÚBLICA Y PRIVADA (PROYECTOS Y/O CONTRATOS DE I+D+I) DEL INVESTIGADOR TUTOR (repita la secuencia tantas veces como se precise hasta un máximo de 10 proyectos y/o contratos).

Referencia del proyecto: CGL2013-46736-R,
Título: PREDICCION DE AEROSOLES Y EVALUACION DEL FORZAMIENTO RADIATIVO PARA APLICACIONES METEOROLOGICAS Y CLIMATICAS CON EL MODELO ON-LINE NMMB/BSC-CTM
Investigador principal (nombre y apellidos): Dr. Oriol Jorba Casellas / Dr.José Mª Baldasano Recio
Entidad financiadora: Ministerio de Economia y Competitividad
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 2013 - 2015
Financiación recibida (en euros): 141.000 €
Tipo de participación en el proyecto/contrato: IP
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: CGL2010-19652 (subprograma CLI)
Título: ACOPLAMIENTO ON-LINE DE UN MODULO COMPLETO DE AEROSOLES MULTICOMPONENTE AL MODELO ATMOSFERICO GLOBAL REGIONAL NMMB
Investigador principal (nombre y apellidos): Dr.José Mª Baldasano Recio
Entidad financiadora: Ministerio de Economia y Competitividad
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 2010-2012
Financiación recibida (en euros): 100.430 €
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: Exp. 157/PC08/3-12.0
Título: CALIOPE (2008) Sistema de Pronóstico de la Calidad del Aire para España, en colaboración con el CIEMAT, CEAM, y IJA-CSIC
Investigador principal (nombre y apellidos): Dr.José Mª Baldasano Recio
Entidad financiadora: Ministerio de Medio Ambiente
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 2008-2009
Financiación recibida (en euros): 533.214 €]
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está algo relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: CONSOLIDER
Título: Supercomputación y e-Ciencia
Investigador principal (nombre y apellidos): Dr. M. Valero
Entidad financiadora: Ministerio de Ciencia e Innovación,
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 2007-2010
Financiación recibida (en euros): 5.000.000€
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: sin relación
Estado del proyecto o contrato: concedido

Referencia del proyecto: FP7-SPACE-2009-1, Contract No. 242284
Título: Fluxes, Interactions and Environment at the Land-Ocean Boundary. Downscaling, Assimilation and Coupling
Investigador principal (nombre y apellidos): Dr. Agustín Sánchez-Arcilla
Entidad financiadora: Unión Europea
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/2010-12/2013
Financiación recibida (en euros): 200.037 €

Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está algo relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: FP7-INFRA-2010-1.1.16 Grant Agreement No 262254
Título: ACTRIS Aerosols, Clouds, and Trace gases Research Infrastructure Network
Investigador principal (nombre y apellidos): Dr. Gesolmina Pappalardo
Entidad financiadora: Unión Europea
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 04/2011-04/2015
Financiación recibida (en euros): 43.972,03 €
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está algo relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: FP7-PEOPLE-2013-IEF
Título: "Effects of Mediterranean desert dust outbreaks on radiation, atmospheric dynamics and forecasting accuracy of a numerical mesoscale model
Investigador principal (nombre y apellidos): Dr. José Ma Baldasano Recio
Entidad financiadora: Unión Europea
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/2014-12/2015
Financiación recibida (en euros):117.000€
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: SEV-2011-00067
Título: BSC-CNS Severo Ochoa Center of Excellence
Investigador principal (nombre y apellidos): Dr. mateo Valero Cortés
Entidad financiadora: MICINN
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/2012-12/2015
Financiación recibida (en euros): 4.000.000 €
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: ENV2012.6.5-4
Título: APPRAISAL: Air Pollution Policies foR Assesement of Integrated Strategies At regional and Local scales
Investigador principal (nombre y apellidos): Dr. Marialuisa Voltaue
Entidad financiadora:
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/2012-12/2014
Financiación recibida (en euros): 999.989 €
Tipo de participación en el proyecto/contrato: investigador equipo
Relación con el proyecto que se presenta: está algo relacionado
Estado del proyecto o contrato: concedido

Referencia del proyecto: FP7-PEOPLE-2013-IEF
Título: Aerosol modelling and data assimilation
Investigador principal (nombre y apellidos): Dr. Oriol Jorba Casellas
Entidad financiadora: Unión Europea
Duración (fecha inicio - fecha fin, en formato DD/MM/AAAA): 01/2014-12/2015
Financiación recibida (en euros): 117.000€
Tipo de participación en el proyecto/contrato: IP
Relación con el proyecto que se presenta: está muy relacionado
Estado del proyecto o contrato: concedido

Parte C: DOCUMENTO CIENTÍFICO

C.1. PROPUESTA CIENTÍFICA

1. Antecedents and state-of-the-art

While dust distribution and dust effects are important at global scales, they strongly depend on dust emission, which is a threshold, sporadic and spatially heterogeneous phenomenon, locally controlled by small spatial and temporal scale processes (Shao et al., 2011; 2013). The most important desert dust source regions over the world (as the Sahara or Arabian Peninsula) have a sparse observational network. Given the highly non-linear dependence of emitted dust mass on peak wind speeds, a better understanding of the meteorological processes involved is crucially to successfully model the global dust budget and its climatic impact (Huneeus et al., 2011). Recent fieldwork on different continents, together with significant advances in dust remote sensing and dust modelling, has improved our understanding of the role of the multiscale meteorological processes involved in dust emission and transport as well as their relative importance. However, uncertainty associated with the parameterization of dust emission processes remains very high, resulting from incomplete physics coupled with a lack of critical land surface information (Ginoux et al., 2012; Knippertz and Tood, 2012).

Dust emission occurs from multiple sources around the globe, when the near-surface wind exceeds the emission threshold determined by the local soil conditions. This threshold is strongly influenced by factors as rainfall, soil moisture or vegetation. Combined soil and wind related factors create strong regional, seasonal, interannual and long-term variations in dust emissions. Across the many dust source regions on Earth a number of generic meteorological phenomena associated with dust emission can be identified and classified: (1) *large-scale monsoon-type flows* associated with an acceleration towards a continental heat low, predominantly in late-spring and early summer (e.g. Engelstaedter and Washigton, 2007; Knippertz et al., 2009); (2) *mobile synoptic-scale systems* such as anticyclones, cyclones and their cold fronts, typically in late winter and spring (e.g. Bou Karam et al., 2010); (3) *gust fronts* generated by outflow from moist convective storms, most common during the beginning of the summer rainy season (e.g. Heinhold et al., 2013; Marsham et al., 2013) and; (4) *intense dry convection in the daytime planetary boundary layer* (PBL) particularly during summer, leading to the generation of dust devils and dusty plumes (e.g. Ansmann et al., 2009). These processes can locally be modified by topographic effects and are usually characterised by marked diurnal cycles (Engelstaedter and Washigton, 2007).

The degradation of air quality and the negative impact on human health as well as the potential impact of dust on transportation and energy production (Schroedter-Homscheidt et al., 2012) have motivated the development of operational forecasting capabilities to predict the occurrence of dust events. The dust models (regional and global) are capable to reproduce synoptic-scale (above 1000 km) dust storms. On the mesoscale (from 10 to several hundred km), convective dust storms are found in many dust regions, particularly during the pre-monsoon season in West Africa and India/Pakistan and in the vicinity of orographic triggers (e.g. Atlas in Morocco). An accurate representation of these storms requires explicitly resolving moist convection and its organisation into squall lines, which is beyond the computational limits for most of the current models, creating a fundamental bias over convectively active regions like summertime in West Asia. On even smaller scales, dry convection in the diurnal PBL can create dusty plumes or dust devils, whose contribution to the global dust cycle is unknown and which are typically not represented in dust models. The role of convective atmospheric processes on the dust emission, and consequently on global dust cycle, is one of the most critical challenges that should be addressed because they are substantially associated with the representation of peak winds (Shao et al., 2011; Knippertz and Todd, 2012). Improvements on the understanding and model representation of moist convection and PBL processes will further improve our capabilities of simulating dust storms and their interactions with the weather and climate.

Koch and Renno (2006) suggested that convections developed by small-scale dry convective processes occur frequently in several desert areas, and could contribute by up to 35% to the global dust emissions. The spatial extend of these convective systems ranges from few to several hundred meters and are characterized by intense density currents associated with strong pressure gradients. Under these conditions, the non-hydrostatical components of forcing are very important. Miller et al. (2008) analysed the haboob activity in West Asia in summertime, by using an idealized model of haboob dust production, and concluded that haboobs could be responsible for a significant component of the total regional-scale of dust production (up to 30% over Arabia). Recently, Redl et al. (2015) estimated on the order of 6 cold-pool events per month from May to September in and south of the Atlas Mountains in Morocco and Algeria when the Saharan Heat Low is in its northernmost position. In order to explicitly resolve these convective processes, it is required a model with a horizontal spatial resolution lower than 10 km (Marsham et al., 2011) but this is not still feasible for most of the global models. For this reason, some advanced non-hydrostatic NWP are widely used in order to increase the spatio-temporal resolution (down to less than 1 km) in dust models such as WRF and NMM.

According to the results of previous studies where regional models simulation at high resolutions (> 10 km) were used, it is highlighted the importance of small-scale meteorological processes (e.g. deep convection and planetary boundary layer processes) in the dust emission. Uno et al. (2005) used the RAMS /CFORS model with a spatial resolution of 9 km in order to analyse the characteristics of dust transport in the Taklimakan desert. The model was able to reproduce the complex flow patterns which produce dust storms in the Tarim Basin and in particular the strong down slope wind from the Tianshan Mountains and the strong easterly flow from Hexi Corridor. Also, convective cold pools and the breakdown of Nocturnal Low-Level jets (NLLJs) are key meteorological drivers of dust emission over West Africa in summer as shown by Heinold et al. (2013) who used the UK Met office United Model (UM) with a nominal spatial resolution of 4 km. This study permitted the reproduction of a large number of dust drivers. However, it also revealed the need for a better representation of the moist convection and stable nighttime conditions. Reinfried et al. (2009) and Solomos et al. (2012) studied a number of convective phenomena over the Atlas region (NW of Africa) between May and June 2006 by the implementation of LM-MUSCAT and RAMS/ICLAMS respectively. In both studies, the horizontal model grid resolution was decreased from 24 km to 0.8 km and the main and common conclusion was that the most realistic representations were obtained when at the grid resolution was lower than 4 km. Kalenderski et al. (2013) applied WRF-CHEM model at 10 km horizontal resolution to reproduce typical winter-time dust events over the Arabian Peninsula and the Red Sea. The main finding was that the dust spatial distributions were consistent with the corresponding ones of dust emissions. Vukovic et al. (2014) performed an analysis for a single severe dust storm over the southwest US by the implementation of a regional dust model (NMME-DREAM) with a spatial resolution of 3.5 km. The model succeed to predict the position of the front but there was a time delay (about 1 hour) in its arrival to Phoenix revealing the lack of precision of these severe dust events by the atmospheric core. However, the dust model predicted satisfactorily the rapid uptake of dust and the high dust concentrations during this dust storm. According to the aforementioned studies, the description of low-level scale dust phenomena (such as haboobs) by the model can be improved when the horizontal resolution is lower than 4km.

Around half of dust emissions worldwide originate from the Sahel and Sahara regions, of which a major but uncertain fraction is caused by convectively-generated dust storms (haboobs). In these storms, evaporation-driven downdrafts form cold pools that quickly propagate and create near-surface wind gusts. Current (global and regional) models do not capture such storms, because their convection schemes do not allow effective formation of such cold pools. The present research project bases on the necessity to understand role of convective meteorological processes on the dust cycle at regional and global scales through high-resolution numerical model simulations.

Previous results of the research team and relation with other research groups

The Earth Sciences Department of the Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-ES) research group has strong expertise in air quality, atmospheric modelling, mineral dust, and climate modelling. Several studies have been conducted over Barcelona, Spain, Europe and at global scale (e.g., Toll and Baldasano, 2000; Soriano et al., 2001; Pineda et al., 2004; Jorba et al., 2008; Jiménez-Guerrero et al., 2008; Pérez et al., 2011; Jorba et al., 2012; Spada et al., 2013). The group has developed several emission inventory models for anthropogenic and biogenic emissions (Parra et al., 2004, 2006; Baldasano et al., 2008; Guevara et al., 2013). The group coordinated a national initiative that aimed to develop an air-quality forecasting system for SPAIN under the umbrella of the CALIOPE project (Baldasano et al., 2008; Pay et al., 2010; Baldasano et al., 2011; Pay et al., 2012; Basart et al., 2012). CALIOPE system is nowadays providing air quality forecasts for Europe at 12km, Spain at 4 km, and Andalucia, Catalunya and Madrid domains at 1km. Furthermore, the group has also significant experience in the applications of lidar techniques (e.g., Soriano et al., 2001; Bösenberg et al., 2003; Pérez et al., 2003, 2004; Sicard et al., 2006; Sicard et al., 2011), participating in the European project EARLINET (Bösenberg et al., 2003). Furthermore, works of the group (Nickovic et al., 2004; Pérez et al., 2006ab; Basart et al., 2009; Haustein et al., 2009; Basart et al., 2012) have focused on the evaluation of mineral dust models with lidar observations, sun-photometer data and satellite imagery, and further improvements with the inclusion of dust radiative effect have shown a way to improve numerical weather prediction results through feedbacks between aerosol concentration and meteorology (Pérez et al., 2006a).

Since 2008, the group has been developing a new online chemical weather prediction system, the model NMMB/BSC-CTM (Pérez et al., 2011; Haustein et al., 2012; Jorba et al., 2012; Spada et al., 2013; Spada et al., 2014; Badia and Jorba, 2015). The model is a new fully on-line chemical weather prediction system for meso to global scale applications, and it is the main modelling framework of the present project. The NMMB/BSC-CTM model is developed under the umbrella of several national projects of the Ministry of Economy and Competiveness:

- “Improvement of the Dust REgional Atmospheric Model (DREAM) for prediction of Saharan dust events in the Mediterranean and the Canary Islands” (CGL2006-11879/CLI): in this project a mineral dust module was developed and implemented into the NMMB atmospheric global/regional model developed by the National Centers for Environmental Prediction (NCEP). The NMMB/BSC-Dust model was thus developed to study the life cycle of dust in the atmosphere.

- “Coupling of a Fully Online Chemical Mechanism Within the Atmospheric Global-Regional UMO/DREAM Model” (CGL2008-02818/CLI): the main objective was to implement a gas-phase chemistry module into the NMMB/BSC-Dust atmospheric global/regional model. Thus, the NMMB/BSC-CTM model allows simulating the most relevant gas-phase chemistry of the troposphere and the life cycle of mineral dust within a common framework.

- “Coupling of a fully online multi-component aerosol module within the atmospheric global-regional NMMB model” (CGL2010-19652): this project started in 2011 and the main objective is the development and implementation of a global multicomponent aerosol module into NMMB/BSC-CTM. The project focuses on the primary aerosols relevant at global scale (e.g., dust, sea-salt, black carbon, organic carbon, and sulphate). Secondary aerosols are not treated in this project.

- “Aerosol forecasting and assessment of radiative forcing on weather and climate applications with the online NMMB/BSC-CTM model" (CGL2013-46736): this project started this year (2014) and the main objective in the development and implementation of the aerosol-radiation interactions (ARI) into NMMB/BSC-CTM. The project focuses understanding of the aerosol radiative forcing and the effects of

ARI upon meteorology. Moreover, this project includes improvements related to mineral dust forecasts that can contribute on the development of the present project research.

- "Supercomputación y e-Ciencia" (Consolider CSD2007-0050): in this project the model computational performance was analysed with PARAVER trace analysis tool developed at BSC and the analysis results contributed with some improvements in the communication part of the system. The mineral dust module evaluation was finalized, and the evaluations of the gas-phase module were performed at global scale.

- Severo-Ochoa Program (SEV-2011-00067): in this project a high-resolution configuration of the model at global scale is under development. The system will be coupled with an ocean model for climate projections and a data assimilation system to produce mineral dust analysis. An exascale application of the model is designed to prepare the system for future exascale supercomputers. Improvement on the parallelization of the system for future supercomputer architectures is conducted applying COMPSs and ompSs technologies developed at BSC.

Established international collaborations

The group has established several collaborations with national research teams: AEMET, CIEMAT, CSIC-IDAEA, CSIC-ICM, CEAM, Technical University of Catalonia, University of Granada and University of Murcia. On an international level regular collaborations are established with: University of Aveiro, National Observatory of Athens, National Meteorological Agency of Turkey, National Centers for Environmental Predictions (NCEP; USA), NASA Goddard Institute for Space Studies (GISS, USA), NASA Geophysical Fluid Dinamics Laboratory (GFDL, USA), Finnish Meteorological Institute (FMI, Finland), International Research Institute for climate and Society (IRI, USA), University of California Irvine (UCI; USA). It is believed that such collaborations will benefit the progress of the scientific projects undertaken by the BSC-ES related with the developments of the model NMMB/BSC-CTM.

Specifically, to achieve the objectives described in the proposal, the following researchers from international institutions will participate in the proposed project contributing with their expertise:

Dr. Carlos Pérez (NASA-GISS, USA) is an expert on airborne mineral dust. He conceived and led the initial developments of the NMMB/BSC-CTM model, a global and regional atmospheric model including interactive atmospheric aerosols and chemistry that helps creating bridges between the North American operational weather forecasting community and the rich air quality research ecosystem that has developed recently in Europe. Currently, he is focusing his research in the field of dust effects upon climate. He is responsible for a collaborative project funded by the Department of Energy between NASA GISS, Columbia University and Cornell University that intends to understand and constrain the deposition of the soluble iron from dust and anthropogenic aerosols to oceans waters. Also he col-lead projects recently funded by NASA and NOAA that aim at quantifying the contribution to radiative forcing, climate and air quality by anthropogenic sources of dust aerosol, which are related to human activities like cultivation and grazing.

Dr. Zavisa Janjic (NCEP, USA) is a recognize researcher that contributes to the advancement of theory and practice of atmospheric modelling and numerical weather prediction, in particular, for the development of generations of atmospherics models based on his innovative numerical and parameterization schemes. Professor Janjic also took a leading scientific role in the development of the Hydrometeorological Institute and Belgrade University (HIBU) model, the NCEP Eta model, the Weather Research and Forecasting Nonhydrostatic Mesoscale Model (WRF NMM) and the new, unified, multiscale NMMB. He has been awarded with the 57th WMO International Meteorological Organization (IMO) Prize.

Dr. Kerstin Schepanski (Leibniz Institute for Tropospheric Research, TROPOS, Germany) focuses her investigation on the large-scale transport of Saharan dust, including its sources and sinks, carrying out computer simulations with the regional transport model COSMO-MUSCAT. Also she is an expertise in the analysis of ground-based remote sensing, satellite data, and in-situ measurements and participated in experimental campaigns, as SALTRACE and SAMUM, which allow continuously improve the parametrization for dust mobilization.

Dr. Peter Knippertz and **Dr. Florian Pantillon** (Karlsruher Institut für Technologie, KIT, Germany) are experts on meteorological processes associated to dust emission. Currently they are working on the development of a parameterization of convective dust storms for large-scale atmospheric models within the ERC project Desert Storms, in collaboration with Dr. John Marsham at the University of Leeds.

Dr. Slodoban Nickovic (Institute of Physics of Belgrade-University of Arizona) is an expert on airborne mineral dust. He is developed the Dust REgional Atmospheric Model (DREAM). He is focusing his research in the field of dust effects upon climate and health. Currently, he is the chair of the SDS-WAS NAMME Regional Node.

2. General objectives

Emissions of dust in arid and semi-arid regions represent an important natural source of atmospheric particulate matter. Dust storms are in most cases the result of turbulent winds which raise large quantities of dust from desert surfaces and can transport particulate material over thousands of kilometres from source regions. Dust storms play an important role in the Earth system with important impacts on radiation (IPCC, 2013), clouds (Karyampudi and Pierce, 2002), atmospheric chemistry, biogeochemical cycles (Jickells et al., 2005; Schulz et al., 2012) and human health (Díaz et al., 2012; Pérez García-Pando et al., 2014). Currently, one of the most critical challenges in the study of the dust cycle is the role of smaller-scale meteorological processes on the dust emission. Dust modelling is essential not only to have a powerful tool to predict the global or regional dust budget and its interaction in the climate-weather system, but also to complement remote sensing and in-situ observations and to understand the processes involved in dust emissions.

The general objective of the present research is *to study the role of convective meteorological processes on the dust cycle using high-resolution simulations based on the NMMB/BSC-Dust model* which is the dust module of the modelling system NMMB/BSC Chemical Transport Model (NMMB/BSC-CTM; Pérez et al., 2011; Haustein et al., 2012; Jorba et al., 2012; Spada et al., 2013; Spada et al., 2014; Badia and Jorba, 2015; http://www.bsc.es/earth-sciences/nmmbbsc-project). The more specific objectives that will achieve from the present project research are:

- a more complete description and understanding of the multiscale meteorological processes responsible of dust emissions
- a deeper knowledge of the strengths and key limitations of models in representing atmospheric convective processes at smaller spatial scales through an accurate model evaluation
- an improved quantitative representation of the 4-D structure of desert dust outbreaks over North Africa, Middle East and Europe

The results will lead a more complete description and understanding of the multiscale meteorological processes responsible of dust emissions and consequently on the desert dust transport and deposition. Additionally, the evaluation of the model results will help to determine the strengths and key limitations of models in representing these smaller-scale meteorological processes that will ultimately improve short and mid-term forecasts of dust hazards and air quality. Thus, the results of the project will strongly benefit several economic and social sectors. Specifically:

- for aviation operators, where precise forecasts of visibility reduction by dust particles may improve air traffic management and safety,
- for solar power generation sector, by predicting reduced radiation at the surface impacting the final electric production from solar power plants,

- for fishery industry, by estimating deposited dust as nutrient responsible for marine productivity,
- for health stakeholders, by predicting impacts of particulate matter on pulmonary and cardiovascular diseases, planning and optimizing health care services and alerting the population about the most serious episodes,
- for public environmental administrations, by helping to a better management of the air quality networks. Air pollution is the environmental factors with the greatest impact on health in Europe. The current European directive (2008/50/EC) on ambient air quality and cleaner air for Europe highlight the necessity of having modelling tools to address air quality problems.

The achievement of such objectives will significantly contribute to a better mineral dust forecast for the World Meteorological Organization (WMO) Barcelona Dust Forescat Center (BDCF) and the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Northern Africa-Middle East-Europe (NA-ME-E) Regional Center managed by the consortium of AEMET and BSC-CNS.

The BSC-DustStorms project is in agreement with the general objectives of several national plans and programs. The project contributes to the objectives defined by the "Estrategia Española de Ciencia y Tecnología y de Innovación 2013-2020" promoting the formation of new research personnel and the stabilization of the staff of BSC-ES. In the last 10 years the group has contribute to the formation of 19 PhD candidates, now working in national and international research centres and universities. The present project aims to continue this important task of formation and will stimulate the collaboration among national and international institutions. The promotion of the excellence in the research group is one of the key goals defined by BSC. It is worth mentioning that BSC has been selected as one of the Severo-Ochoa awarded centres, by the Ministry of Economy and Competiveness, recognizing its contribution to the excellence in the scientific work developed by the centre. The work performed on atmospheric modelling strongly contributes to the development of cutting-edge technologies.

Furthermore, the topic of the present proposals covers the fifth societal challenges identified by the Spanish research strategy about Climate Change. A better understanding about the interactions between aerosols and atmospheric processes will contribute to reduce the uncertainties on the quantification of the radiative forcing attributed to anthropogenic and natural aerosols. Such advances will contribute in the definition of future mitigation and adaptation measures to face the challenges that Climate Change is creating. The goals defined in the HORIZON 2020 on climate change and air quality modelling is in agreement with the strategy defined by the Spanish Government. In this sense, the improvement and evaluation of air quality modelling system (and in particular mineral dust models) are enhancing the climate change are key areas of research at the European level. An example is the "Desert Storms" project at the University of Leeds (lead Peter Knippertz, KIT/Leed University) which is funded by the European Research Council (ERC) and run until September 2015.

Additionally, the objectives of the present proposal are in agreement with the research lines defined by the "Plan Nacional de Calidad del Aire y Protección de la Atmósfera 2013-2016" of the Ministry of Environment. The Plan identifies the aerosols as one of the critical pollutants to monitor and over which further modelling activities are required. In this sense, the modelling tools under development in the present project will provide valuable information about the contribution of mineral dust in the global aerosol budget. Concerning the actions to promote the research, the Plan identifies air quality modelling as a key topic where the Spanish research community has to further increase its expertise. Models need to be improved and evaluated under different conditions. The present proposal has as first objective the improvement of aerosol forecast. Improved air quality forecasts will provide to the administration the required information to activate information actions or mitigation strategies to improve the air quality of our urban and rural areas.

3. Objectives and specific aims

The specific objectives that will achieve from the present project research are:

1. Enhancement of emission dust scheme of the NMMB/BSC-Dust model
    a. Synthesis of existing information about the state-of-the-art emission flux parameterizations
    b. Assessment the uncertainties of desert dust source mask on dust emissions in high-resolution simulations
2. Assessment the role of convective meteorological processes responsible of dust emission through high-resolution simulations of the NMMB/BSC-Dust model
    a. Extensive sensitivity studies with regional simulations to explore effects of spatial resolution and model physics
    b. Extensive sensitivity studies of the model initialization on dust forecast
    c. Assessment the impact of novel parameterizations on the dust emission scheme of the model
3. Determining the impact of small-scale dust storms at regional and global scales
    a. Comprehensive comparison between simulations from a wide range of global and regional scales and observations

The achievement of such objectives will significantly contribute to a better mineral dust forecast for the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Northern Africa-Middle East-Europe (NA-ME-E) Regional Center managed by the consortium of AEMET and BSC-CNS. The project would constitute an important scientific and technical improvement in the performance of regional dust models for operational predictions and research activities over the regions around the Sahara (as Europe and the North Atlantic regions) and to more accurate assessment of aerosol influence on air quality, natural environment and climate.

These will help not only the scientific community of climate-weather research but also the end-user communities to prevent the impact of severe events over desert source regions where dust is considered to be a harmful air pollutant, and consequently, a natural hazard associated to atmospheric phenomena. Moreover, the better understanding of the role of the convective meteorological processes on the dust cycle will provide valuable information to constrain the uncertainties associated to mineral dust, one of the most important contributors to the global aerosol budget.

4. Methodology

The NMMB/BSC-Dust model (Pérez et al., 2011; Haustein et al., 2012) is one of the operational dust model in the ES-BSC, and the dust module of the NMMB/BSC-Chemical Transport Model (NMMB/BSC-CTM; Pérez et al., 2011; Jorba et al., 2012; Spada et al., 2013; Spada et al., 2014; Badia and Jorba, 2015; https://www.bsc.es/earth-sciences/nmmbbsc-project). It has been developed at the Earth Sciences Department of the Barcelona Supercomputing Center (BSC-ES) in collaboration with NOAA/National Centers for Environmental Prediction (NCEP), NASA Goddard Institute for Space Studies and the International Research Institute for Climate and Society (IRI).

At present, the model provides operational dust forecast over North Africa-Middle East-Europe and global regions which are daily published (http://www.bsc.es/projects/earthscience/nmmb-bsc-dust/). Its most relevant characteristic is its on-line coupling with a state-of-the-art global/regional meteorological model with non-hydrostatic dynamics. This provides a unique framework to simulate/predict air quality and weather in a wide range of scales from mesoscale to global applications, and allows interactions among dust-chemistry-meteorology processes. The BSC-ES strongly contributes to the success of the present project research with its contribution to the scientific and technological advancement in air quality modelling and mineral dust forecast. In this sense, the excellent results of the group in the field of mineral dust transport have contributed to the creation of the First WMO Regional Meteorological Center specialized on Atmospheric Sand and Dust Forecast, the Barcelona Dust Forecast Center (BDFC; http://dust.aemet.es/) which includes the operational daily products of the NMMB/BSC-Dust model. The experience acquired with the management, in coordination with the Spanish Weather Agency (AEMET), of the WMO SDS-WAS Northern Africa-Middle East-Europe Regional Center (http://sds-was.aemet.es/) will significantly contribute to the production of excellent research and creation of specialized products for the end-users. Furthermore, BSC-CNS hosts MareNostrum, one of the most powerful supercomputers in Europe which is also part of the PRACE Research Infrastructure as one of the 6 Tier-0 Systems currently available for European scientists. Marenostrum will be used as main computing facility for the executions required by the project.

In order to achieve the proposed objective the following activities are defined and described in detail below.

Activity 1: Project management and monitoring of the project progress

Management of the project will be based mainly in communicating and reporting to the Ministry. Reports have been established periodically one by year. Monitoring of the project is needed for assuring its correct development. Corrective actions will be applied, if required, to reduce deviations from the original plan. Achievement of milestones will provide information on the proper development of the project.

Task 1.1: Project management

- To manage and coordinate protocols and resources to deliver the actions as scheduled to achieve the project objectives.
- To report on technical and financial progress to the Ministry.

Task 1.2: Monitoring of the project progress

- To revise the progress of the project according to the approved work plan.
- To evaluate the costs according to the budget every six months.
- To identify and apply corrective actions when required.

Participants: The PI of the project will lead this Activity.

Deliverable 1 - First year annual report
Deliverable 2 - Second year annual report
Deliverable 3 - Final year annual report

Activity 2. Enhancement of emission dust scheme of the NMMB/BSC-Dust model

Dust emission schemes require land surface information at the temporal and spatial scales associated to dust emission processes. Particular aspects associated to the desert dust source description and emission dust flux have to be revised and further developed in the dust emission scheme before performing high-resolution simulations (horizontal resolutions > 10 km).

Task 2.1 Review and select of the state-of-the-art emission flux parameterizations

The computation of a realistic distribution of dust emission fluxes is a central part of the model-based description of the dust aerosol cycle, as the emissions depend on both surface properties and surface wind speeds, and cannot be prescribed externally as, for example, many anthropogenic emissions. Parameterization of dust emission in transport models must take into account that dust emission processes are highly variable in space and time and can occur at small local scales that may not be resolvable in the regional- or global-scale dust models.

- A critical overview of the state-of-the-art emission flux parameterizations will be conducted doing a focus on those that are more adequate for high-resolution simulation (> 10 km)

Task 2.2 Assess the uncertainties of desert dust source mask on dust emissions in high-resolution simulations

Crucial to understanding all of the roles of dust at global and regional scales is the identification of dust sources. In fact, not all surfaces in deserts or semi-deserts are effective sources of dust aerosol particles. Due to the difficulties in determining the location of dust sources in particular for the Saharan and Arabian deserts, satellite retrievals from polar-orbiting satellite instruments (including MODIS, MISR and OMI) or instruments on geostationary satellites (e.g. SEVIRI) are often used to identify dust source areas (Schepanski et al. 2007; Draxler et al. 2010). Alternatively to determining dust source areas from such remote sensing products by assigning high frequencies of large dust loadings to potential source regions, they can also be derived by tracking observed individual dust plumes back to their source location. The spatial distribution of such dust source areas derived by the different methods can differ considerably (Schepanski et al. 2012).

This may be partly due to problems of quantifying the dust signal above bright land surfaces by remote sensing. As an example the Saharan dust source activation frequency computed with the model of Tegen et al. (2004) that uses topographic depressions as preferential dust sources is compared to the activation frequencies derived by the backtracking from Meteosat satellite data (Schepanski et al. 2007). The evident differences in the simulated source regions compared to the satellite-derived product may be due either to a misrepresentation of dust source areas or meteorology in the model or also to a smaller extent due to limitations of the satellite product (Brindley et al. 2012). Dust emission can only occur when the soil surface is bare or only sparsely vegetated. Not only the vegetation cover but also the type of vegetation determines its capacity to protect soil surfaces, particularly in semi-arid areas at desert fringes. Non-forest biomes can be potential dust sources, that is, dust emissions can occur when other criteria (including sparse vegetation cover, soil dryness and absence of snow cover) are satisfied.

- Detailed analysis and collection of observations including station data, measurements from recent and future field campaigns, analysis data and satellite products
- Implementation of a high-resolution desert source mask (> 5 km) in the model.

Participants: This activity will done with the participation of Dr. Pérez García-Pando and Dr. Kerstin Schepanski. Dr. Pérez García-Pando is an expert on dust emission models and he will contribute to the successful of Task 2.1 and Dr. Kerstin Schepanski will participated on the development of Task 2.2.

Milestone 1 - Evaluation report of the review of the state-of-the-art emission flux parameterizations
Milestone 2 - Implementation of a new high-resolution source mask in the model

Deliverable 4 - Report on the review of the state-of-the-art emission flux parameterizations
Deliverable 5 - Report on uncertainties of desert dust source mask in high-resolution simulations

Activity 3. Assessment the role of convective meteorological processes responsible of dust emission by means high-resolution simulations of the NMMB/BSC-Dust model

Around half of dust emissions worldwide originate from the Sahel and Sahara regions, of which a major but uncertain fraction is caused by convectively-generated dust storms (haboobs). In these storms, evaporation-driven downdrafts form cold pools that quickly propagate and create near-surface wind gusts. Current global models do not capture such storms, because their convection schemes do not allow effective formation of such cold pools. This activity aims to study the convective meteorological processes responsible of dust emission (as nocturnal low level jets and cold fronts) through the implementation of novel meteorological parametrizations. All model developments proposed in this Activity will be implemented and evaluated with observations and compared with other previous model simulations.

Task 3.1 Extensive sensitivity studies of the model initialization on dust forecast

The initial and boundary conditions required to initialize the model and to update its boundary conditions introduce uncertainties too. Here, we will quantify the impact of the initial concentration dust fields used (e.g. using a dust initial field obtained from assimilation of satellite observations), soil moisture and meteorological data (as NCEP, ECMWF and NASA) used and its sensitivity upon the dust emission scheme at different spatial resolutions.

- Simulations to evaluate the impact of soil moisture and meteorological data used as initial conditions (i.e. NCEP, ECMWF and NASA) in the simulated dust fields over Norther Africa, Middle East and Europe.

Task 3.2 Extensive sensitivity studies with regional simulations to explore effects of spatial resolution and model physics

The NMMBSC/BSC-CTM model allows a wide range of spatial resolution configurations, from 100 km to 1 km of horizontal grid-cell space, and implements detailed parameterizations for the small scale processes such as the viscous sub-layer, turbulence in the PBL, atmosphere-land interaction processes, among others. The objective of the present task is to analyse the sensitivity of the model to different spatial resolutions to better understand the strengths and limitations of the current modelling system to the reproduction of the smaller-scale meteorological processes. The results of this task will contribute to discuss the limitations of the different horizontal-resolution simulations and provide a detail evaluation of the uncertainties in the simulation of the dust cycle as well as to define the optimum configuration for the high-resolution experiments (> 10 km).

- Detailed analysis of observations including station data, measurements from recent and future field campaigns, analysis data and satellite products over North Africa and Middle East. A set of dust and meteorological observations will be collected and prepared for model comparison for particular study cases used to perform the rest of the experiments in the present project. These observational datasets includes ground-based (e.g. AERONET, EARLINET, EMEP, METAR and radiosoundings) and satellite aerosol products (SEVIRI, MODIS, OMI, MIRS and CALIPSO) as well as measurements from experimental campaigns (e.g. SAMUM, FENNEC and CV-Project).

- Sensitivity of the model to spatial grid resolutions. Different model configurations with different spatial resolutions (from 100 to 1km in the horizontal) will be designed and evaluated to study the relevance of the model grid resolution on the ability to solve small-scale turbulent and convective processes associated to dust emission for selected study cases associated to haboobs (i.e. convectively-generated dust storms). In this sense, it is worthy to mention that the NMMBSC/BSC-Dust model uses the same numerical parameterizations for their wide range of spatial resolutions. Therefore, we will also analyse the validity range of their implemented approaches for a selected study cases.

Task 3.3 Effect of a novel cold pools parameterization on dust emissions

The main goal of the ERC project Desert Storms (lead Peter Knippertz, KIT/Leed University) is to better understand weather processes for emission of mineral dust over West Africa. The different works developed in the framework of this European project include an ideal set of simulations for developing an offline parameterization of convective dust storms designed for a large-scale models. As a result, a new parameterization of near-surface wind gusts and dust emissions generated by cold pools, based on the downdraft mass flux from the convection scheme has been introduced (Pantillon et al., 2015). This new parameterization assumes the horizontal dispersion of all downdrafts into cold pools and the unknown geometry of the cold pools results in one free parameter.

- Implementation of the offline parameterization of convective dust storms from Pantillon et al. (2015) in the NMMB/BSC-Dust model.

- Analysis of the results of the inclusion of the offline parameterization of convective dust storms for large-scale simulations (~25km). The results obtained from this new parameterization will be compared with observations and the simulations obtained with current model configuration done it in Task 3.2.

Task 3.4 Effect of Large-Eddy Model on dust emissions

On the other hand, the nocturnal low level jet (LLJ) governs the diurnal cycle of low-level and surface winds, and hence is a key mechanism for dust emission and transport across large parts of the Sahara, the largest source for mineral dust on Earth (Fiedler et al., 2013). However, such processes are likely also relevant for other Saharan regions. Heinhold et al. (2014) performed idealised large-eddy simulations of the nocturnal LLJ using the UK Met Office Large-Eddy Model (LEM). According to the model-based climatology by Fiedler et al. (2013), 15% of the North African dust emissions on annual and spatial average are related to the nocturnal LLJ phenomenon, with a contribution of up to 60% to the total dust uplift over specific areas such as the Bodélé Depression. Large-eddy simulations (LESs) can be used to model the nocturnal stable boundary layer (SBL) and LLJ formation provided the grid resolution is high enough to resolve the characteristic flow features. Still, LES modelling of the SBL is challenging (e.g., Beare and MacVean, 2004; Holtslag, 2006; Beare, 2006), and most studies have focused on idealised homogeneous cases with only weakly or moderately stable conditions because of computational constraints (Zhou and Chow et al., 2011).

The main research theme of the Atmospheric modelling department at TROPOS is the development and application of complex models that describe the interactions of aerosol chemistry, aerosol and cloud micro-physics, radiative processes involving aerosols and the distribution of aerosol optical properties as well as transport processes. The department holds expertise in the atmosphere all-scale model ASAM (All Scale Atmospheric Model) applied at Large Eddy Scales (LES) for e.g. urban scale simulations and investigations of the "island effect".

- Review of the atmosphere all-scale model ASAM (All Scale Atmospheric Model; Jähn et al., 2015) applied at Large Eddy Scales (LES) for the representation of the nocturnal low-level jets.
- Implementation of the ASAM model in the NMMB/BSC-Dust model.
- Simulations with ASAM over Northwestern Africa using NMMB/BSC-Dust models. Two approaches will be tested: considering the implementation of the ASAM model in the model or taking the meso-scale output files as initialization files for the ASAM model.

- Analysis of the results of the inclusion of the Large-Eddy Model for the representation of the nocturnal low-level jets. The results obtained from this new parameterization will be compared with observations and the simulations obtained with current model configuration done it in Task 3.2.

Task 3.5 Assessment of the model performance

- The performance of the dust forecast system for different spatial resolutions (from 100 to 1km in the horizontal) will be analysed. Trace analysis of an execution in the supercomputer MareNostrum will be analysed with performance tools like PARAVER, DIMEMAS developed by the Computer Sciences Department of BSC. Any improvement on the model performance will have an important effect on the overall forecast time of the forecasting system that is fundamental for the present project because the computational resources needed for high-resolution simulations.

Participants: The PI will monitor the full activity. The present task will be developed in collaboration with Dr. Peter Knippertz and Dr. Florian Pantillon from KIT (Task 3.3) as well as Dr. Schepanski from TROPOS (Task 3.4). For this Activity 3 and particularly Task 3.5, the participation of a hired informatics engineer is foreseen. The support of Computer Earth Science Group will be useful for optimization of the codes in the model.

Milestone 3 - Model runs Task 3.1
Milestone 4 - Model runs Task 3.2
Milestone 5 - Implementation of offline parameterizations to explicitly solve convection processes
Milestone 6 - Implementation of a Large-Eddy Model (LEM)
Milestone 7 - Model runs Task 3.3
Milestone 8 - Model runs Task 3.4

Deliverable 6 - Report on the sensitivity of the model initialization on dust forecast
Deliverable 7 - Report on the sensitivity studies with regional simulations to explore effects of spatial resolution and model physics
Deliverable 8 - Report on the implementation of offline parameterizations to explicitly solve convection processes.
Deliverable 9 - Report on the implementation OF a Large-Eddy Model (LEM) for the representation of the nocturnal low-level jets.
Deliverable 10 - Report on the assessment of the model performance

Activity 4. Analyse the impact of convective dust storms at regional and global scales using the NMMB/BSC-Dust model

Recent observations and models suggest about 50% of the summertime dust uplift over West Africa (Knippertz and Todd, 2012). This mineral dust contribution is missing in global models which do not resolve convection. The NMMB/BSC-Dust model provides an unique framework for dust modelling studies because its unified non-hydrostatic dynamical core allows the increase of the grid resolution from global to regional scales (from 100 to 1km) maintain the same physics and dynamics. This activity aims to quantify the contribution of convective dust storms (i.e. haboobs) at regional and global scales using the NMMB/BSC-Dust model.

Task 4.1 Comprehensive comparison between simulations from a wide range of global and regional scales and observations

A set of annual model simulations (from ~100 to 1km horizontal resolutions) will be evaluated and compared with selected dust and meteorological observations from ground-based (e.g. AERONET, EARLINET, EMEP, METAR and radiosoundings) and satellite aerosol products (MSG/SEVIRI, MODIS, OMI, MIRS and CALIPSO) as well as measurements from experimental campaigns (e.g. SAMUM, FENNEC and CV-Project) to quantify the impact of convective dust storms over North Africa and Middle East at regional and global scales.

- Quantification of the impact of haboobs on dust budget at regional scale through a one-way nesting simulation for a selected study case from Activity 2. The regional-parent domain will include North Africa, Middle East and Europe (~25km) and the nesting domain will include a high-resolution simulation (<5km) over Algeria/Morocco solving explicitly convection in the model. The results of Activities 2 and 3 will be used to define the model configuration applied.
- Quantification of the impact of haboobs on dust budget at global scale through an annual two-way nesting simulation defining a high-resolution domain (<5km) over North Africa (i.e. solving explicitly convection) that will be connected to the global domain (~100km). The results of Activities 2 and 3 will be used to define the model configuration applied.
- Analyses of the impact of haboobs on dust budget at global/regional scale for an annual cycle.

Task 4.2 Assessment of the model performance

- The performance of the dust forecast system for different spatial resolutions (from 100 to 1km in the horizontal) will be analysed. Trace analysis of an execution in the supercomputer MareNostrum will be analysed with performance tools like PARAVER, DIMEMAS developed by the Computer Sciences Department of BSC. Any improvement on the model performance will have an important effect on the overall forecast time of the forecasting system that is fundamental for the present project because the computational resources needed for high-resolution simulations.

Participants: The PI will monitor the full activity. The present task will be developed in collaboration with Dr. Slodoban Nickovic as well as Dr. Florian Pantillon (Task 4.1). For this Activity 4 and particularly Task 4.2, the participation of a hired informatics engineer is foreseen. The support of Computer Earth Science Group will be useful for optimization of the codes in the model

Milestone 9 - Model runs Task 4.1

Deliverable 11 - Report of the impact of convective dust storms at regional and global scales
Deliverable 12 - Report on the assessment of the model performance

Activity 5. Diffusion of the project results

Finally, the last activity of the present proposal research will be the reporting of the results and their exploitations, compiling all the research made and the conclusions obtained. Both during the project duration and after completion, the results suitable for dissemination will be published in refereed international journals and/or presented in lectures and conferences.

Task 5.1 Update of the model forecasts web pages

- Update and maintenance of BSC dust forecasts web page. The improvements of the forecast system will be detailed in the web page of the model forecasts. The present version of the web is available at: http://www.bsc.es/earthsciences/mineral-dust/nmmbbsc-dust-forecast/. Moreover, summary of all the developments will also be posted on the web site of the NMMB/BSC-CTM project (http://www.bsc.es/earth-sciences/nmmbbsc-project).

- Update and maintenance of Barcelona Dust Center (BDFC) dust forecasts web page. The improvements of the forecast system will be detailed in the web page of the model forecasts. The present version of the web is available at: http://dust.aemet.es/
- Update the most insights results in the WMO SDS-WAS NA-ME-E Regional Center (http://sdswas.aemet.es/) which seeks to document differences of dust component modules and to deep in the uncertainties associated to smaller-scale meteorological processes on dust emission processes.

Task 5.2 Dissemination of the project results in international journals, conferences and workshops

- Participation in international conferences, symposia, and other scientifically related activities to present the ongoing work of the project and discuss with the scientific community about its impact. It is estimated the participation in two congresses per year.
- Publication of the results of the project in international scientific journals. It is estimated 5 publications from Activities 2, 3 and 4.
- Participation in model intercomparison exercises in the framework of the WMO SDS-WAS NA-ME-E Regional Center

Participants: The PI of the project will lead this Activity.

Deliverable 13 - Report of the publications and conference participations during the first year of the project.
Deliverable 14 - Report of the publications and conference participations during the second year of the project.
Deliverable 15 - Report of the publications and conference participations during the last year of the project.

5. Tools

The project application will be run at the MareNostrum Supercomputer. The Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS) hosts MareNostrum, the most powerful supercomputer in Spain. In March 2004 the Spanish government and IBM signed an agreement to build one of the fastest computer in Europe. With the last upgrade (2012-2013), MareNostrum has a peak performance of 1,1Petaflops, with 48,896 Intel Sandy Bridge processors in 3,056 nodes, and 84 Xeon Phi 5110P in 42 nodes, with more than 100.8 TB of main memory and 2 PB of GPFS disk storage. In June 2013, MareNostrum was positioned at the 29th place in the TOP500 list of fastest supercomputers in the world. Marenostrum is also part of the PRACE Research Infrastructure as one of the 6 Tier-0 Systems currently available for European scientists. Marenostrum will be used as main computing facility for the executions required by the project.

Complementing the standard computing resources of Marenosturm, the project will also have access to a specific queue on Marenostrum supercomputer which provides access on 42 heterogeneous compute nodes. Each of them is constituted by two Intel Sandybridge E5-2670 8-core processors and two Xeon Phi 5110P coprocessors. There are totally 84 Xeon Phi 5110P coprocessors which theoretically can provide 84 TFlops. The advantage of this technology concerning the GPUs, is that the required computation optimizations apply also for the Xeon processors which are used on Marenostrum. Moreover the required time to port an application on Intel Xeon Phi is less than GPUs.

To run the model, atmospheric analyses are required as initial conditions and as boundary conditions. In this sense, the NCEP/GFS analysis and 72h forecasts will be used for the project. Such analysis will provide a valuable framework with which meteorological model results at global scale will be compared (the prediction against the analysis). The reanalysis simulations form NCEP, NASA and ECWMF will be used for the sensitivity studies of the model initialization on dust forecast. Additionally, meteorological observations from METAR, SYNOP, and radiosounding networks will be used to evaluate the meteorological variables. On the other hand, different ground-based and satellite observations will be included in the evaluation of the model simulations. Aerosol optical properties in the entire atmospheric column are routinely observed within the Aerosol Robotic NETwork (AERONET; http://aeronet.gsfc.nasa.gov/) which provides spectral aerosol optical depth (AOD) observations at global scale. Aerosol vertical distribution observations from NASA Micro-Pulse Lidar Network (MPLNET; http://mplnet.gsfc.nasa.gov/) will be also included. Finally, aerosol satellite products from SEVIRI, MODIS, OMI, MISR and CALIOP sensors will complement the observational dataset used to evaluate the model and study the optical properties of the aerosols.

To complement the lack of observations over desert dust sources, several field campaigns have been designed aiming to the full description of aerosols physical and optical properties. Some of the most important experimental campaigns that they will included in the present research project are: 1) the Saharan Mineral Dust Experiment (SAMUM-1/-2) (Heintzenberg et al., 2009; Ansmann et al., 2011), 2) the Fennec project (Washington et al., 2013) and 3) the CV-Dust Project (Pio et al., 2014).

The storage at the MareNostrum supercomputer to each user is 1Tb. The set of model simulations proposed in the framework of the present work is estimated on 10Tb. For that reason the acquisition of a Fat Node and external disks is foreseen in the budget.

6. Work plan

Table 1 shows the chronogram of the BSC-DustStorms project along the 36 months. Deliverables (D) and Milestones (M) are indicated related to the objectives associated to each Activity.

Table 1. Work schedule and estimated duration of proposed tasks.

Activities	Year 1				Year 2				Year 3			
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
Activity 1: Project management and monitoring of the project progress												
Task 1.1: Project management				D1				D2				D3
Task 1.2: Monitoring of the project progress												
Activity 2. Enhancement of emission dust scheme of the NMMB/BSC-Dust model												
Task 2.1: Review and selection of the state-of-the-art emission flux parameterizations							M1	D4				
Task 2.2: Assessment the uncertainties of desert dust source mask on dust emissions in high-resolution simulations					M2			D5				
Activity 3. Assessment the role of convective meteorological processes responsible of dust emission by means high-resolution simulations of the NMMB/BSC-Dust model												
Task 3.1: Extensive sensitivity studies of the model initialization on dust forecast							M4					D6
Task 3.2: Extensive sensitivity studies with regional simulations to explore effects of spatial resolution and model physics.					M3				M5			D7
Task 3.3: Implementation and analysis *of novel parameterizations that link grid-scale quantities with probabilities of winds exceeding a given threshold within the grid-box*								M6				D8
Task 3.4: Assessment of the model performance												D9
Activity 4. Analyse the impact of convective dust storms at regional and global scales using the NMMB/BSC-Dust model												
Task 4.1: Comprehensive comparison between simulations from a wide range of global and regional scales and observations												D10
Activity 5. Diffusion and exploitation of the results												
Task 5.1: Update of the model forecasts web pages												
Task 5.2: Dissemination: conferences, meetings and publications				D11				D12				D13

7. Hiring of personnel

The budget of the project comprises the activities described above for the three years (36 months) of the project. Apart from that BSC-CNS will provide free access to MareNostrum supercomputer for all the model simulations.

The present project proposal does not include the hiring of personnel. However, the computer support will be in kind provided by BSC-ES. Furthermore, there is a request budget for short stages in collaborative institutes (i.e. KIT and TROPOS). This is needed to the achievement of the objectives proposed in the present project as it is scheduled in Section 6.

8. References

Ansmann, A., Tesche, M., Knippertz, P., Bierwirth, E., Althausen, D., Müller, D., and Schulz, O. Vertical profiling of convective dust plumes in southern Morocco during SAMUM. Tellus B, 61(1), 340-353, 2009.

Badia, A., and Jorba, O. Gas-phase evaluation of the online NMMB/BSC-CTM model over Europe for 2010 in the framework of the AQMEII-Phase2 project. Atmospheric Environment, 2015.

Beare, RJ, MacVean, MK. 2004. Resolution Sensitivity and Scaling of Large-Eddy Simulations of the Stable Boundary Layer, Boundary-Layer Meteorol. 112: 257-281.

Beare RJ, MacVean MK, Holtslag AAM, Cuxart J, Esau I, Golaz JC, Jimenez MA, Khairoutdinov M, Kosovic B, Lewellen D, Lund TS, Lundquist JK, McCabe A, Moene AF, Noh Y, Raasch S, Sullivan, P. 2006. An intercomparison of large-eddy simulations of the stable boundary layer. Boundary-Layer Meteorol. 118(2): 247-272. DOI: 10.1007/s10546- 004-2820-6.

Bou Karam, D., Flamant, C., Cuesta, J., Pelon, J., & Williams, E.. Dust emission and transport associated with a Saharan depression: February 2007 case. J. Geophys. Res., 115(D4), 2010.

Brindley H, Knippertz P, Ryder C, Ashpole I (2012) A critical evaluation of the ability of the Spinning Enhanced Visible and Infrared Imager (SEVIRI) thermal infrared red-greenblue rendering to identify dust events: theoretical analysis. J Geophys Res 117, D07201. doi:10.1029/2011JD017326.

Díaz, J., Tobías, A., and Linares, C.: Saharan dust and association between particulate matter and case-specific mortality: a case-crossover analysis in Madrid (Spain), Environ. Health, 11(11), 2012.

Draxler RR, Ginoux P, Stein AF (2010) An empirically derived emission algorithm for wind-blown dust. J Geophys Res 115, D16212. doi:10.1029/2009JD013167.

Engelstaedter, S., and Washington, R.: Atmospheric controls on the annual cycle of North African dust, J. Geophys. Res, 112, D03103, 2007.

Fiedler, S Schepanski, K, Heinold, B, Knippertz, P, Tegen, I. 2013. Climatology of nocturnal low-level jets over North Africa and implications for modeling mineral dust emission. J. Geophys. Res. Atmos. 118(12): 6100-6121. DOI: 10.1002/jgrd.50394.

Ginoux, P., Prospero, J. M., Gill, T. E., Hsu, N. C., and Zhao, M.: Global scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products, Reviews of Geophysics, 50, doi: 10.1029/2012RG000388, 2012.

Haustein, K., Pérez, C., Baldasano, J. M., Jorba, O., Basart, S., Miller, R. L., Janjic, Z., Black, T., Nickovic, S., Todd, M. C., Washington, R., Müller, D., Tesche, M., Weinzierl, B., Esselborn, M., and Schladitz, A.: Atmospheric dust modeling from meso to global scales with the online NMMB/BSC-Dust model – Part 2: Experimental campaigns in Northern Africa, Atmos. Chem. Phys., 12, 2933-2958, doi:10.5194/acp-12-2933-2012, 2012.

Heinold, B., Knippertz, P., Marsham, J. H., Fiedler, S., Dixon, N. S., Schepanski, K., Laurent, B. and Tegen, I. The role of deep convection and nocturnal low-level jets for dust emission in summertime West Africa: Estimates from convection-permitting simulations. J. Geophys. Res., 118(10), 4385-4400, 2013.

Heinhold, B., Knippertz, P., Beare, R.J. Idealised large-eddy simulations of nocturnal low-level jets over subtropical desert regions and implications for dustgenerating winds, Quarterly Journal of the Royal Meteorological Society, accepted.

Holtslag, AAM. 2006. GEWEX Atmospheric Boundary-Layer Study (GABLS) on stable boundary layers. Boundary-Layer Meteorol. 118: 243–246. DOI: 10.1007/s10546-005-9008-6.

Huneeus, N., Schulz, M., Balkanski, Y., Griesfeller, J., Prospero, J., Kinne, S., Bauer, S., Boucher, O., Chin, M., Dentener, F., Diehl, T., Easter, R., Fillmore, D., Ghan, S., Ginoux, P., Grini, A., Horowitz, L., Koch, D., Krol, M. C., Landing, W., Liu, X., Mahowald, N., Miller, R., Morcrette, J. J., Myhre, G., Penner, J., Perlwitz, J., Stier, P., Takemura, T., and Zender, C. S.: Global dust model intercomparison in AeroCom phase I, Atmos. Chem. Phys., 11, 7781-7816, 2011.

IPCC: Intergovernmental Panel on Climate Change. Climate change 2013: the physical science basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2013.

Jähn, M., Knoth, O., König, M., and Vogelsberg, U.: ASAM v2.7: a compressible atmospheric model with a Cartesian cut cell approach, Geosci. Model Dev., 8, 317-340, doi:10.5194/gmd-8-317-2015, 2015.

Jickells et al., Global iron connections between desert dust, ocean biogeochemistry, and climate, Science, 308, 67-71, 2005.

Jorba, O., Dabdub, D., Blaszczak-Boxe, C., Pérez, C., Janjic, Z., Baldasano, J. M., Spada, M., Badia, A., and Gonçalves, M.: Potential significance of photoexcited NO2 on global air quality with the NMMB/BSC chemical transport model, J. Geophys. Res., doi:10.1029/2012JD017730, 2012.

Kalenderski, S., Stenchikov, G., and Zhao, C., 2013. Modeling a typical winter-time dust event over the Arabian Peninsula and the Red Sea. Atmos. Chem. Phys., 13, 1999–2014, doi: 10.5194/acp-13-1999-2013.

Karyampudi, V. M., and H.F. Pierce: Synoptic-scale influence of the Saharan air layer on tropical cyclogenesis over the Eastern Atlantic. Mon. Wea. Rev., 130, 3100-3128, 2002.

Knippertz, P., and Todd, M. C.: Mineral dust aerosols over the Sahara: Meteorological controls on emission and transport and implications for modeling, Reviews of Geophysics, 50, doi: 10.1029/2011RG000362, 2012.

Knippertz, P., Trentmann, J., and Seifert, A.: High resolution simulations of convective cold pools over the northwestern Sahara, Journal of Geophysical Research, 114, D08110, 2009.

Koch, J., and Renno, N. O., 2006. The role of convective plumes and vortices on the global aerosol budget. Geophys. Res. Lett. 32, L18806.

Marsham, J. H., Knippertz, P., Dixon, N. S., Parker, D. J., and Lister, G. M. S., 2011. The importance of the representation of deep convection for modeled dust-generating winds over West Africa during summer, Geophys. Res. Lett., 38, L16803, doi: 10.1029/2011GL048368.

Miller, S. D., Kuciauskas, A. P., Liu, M., Ji, Q., Reid, J. S., Breed, D. W., Walker A. L., and Al Mandoos, A., 2008. Haboob dust storms of the southern Arabian Peninsula, J. Geophys. Res. 113, D01202, doi: 10.1029/2007JD008550.

Marsham, J. H., Dixon, N. S., Garcia-Carreras, L., Lister, G., Parker, D. J., Knippertz, P., and Birch, C. E. The role of moist convection in the West African monsoon system: Insights from continental-scale convection-permitting simulations. Geophysi. Res. Lett., 40(9), 1843-1849, 2013.

Pantillon, F., Knippertz, P., Marsham, J., and Birch, C. A parameterization of convective dust storms for models with mass-flux convection schemes. Journal of the Atmospheric Sciences, 2015.

Pérez, C., Nickovic, S., Baldasano, J. M., Sicard, M., Rocadenbosch, F., and Cachorro, V. E.: A long Saharan dust event over the western Mediterranean: Lidar, Sun photometer observations, and regional dust modeling, J. Geophys. Res., 111, D15214, doi:10.1029/2005JD006579, 2006.

Pérez, C., Haustein, K., Janjic, Z., Jorba, O., Huneeus, N., Baldasano, J. M., Black, T., Basart, S., Nickovic, S., Miller, R. L., Perlwitz, J. P., Schulz, M., and Thomson, M.: Atmospheric dust modeling from meso to global scales with the /BSC-Dust model: 1. Model description, annual simulations and evaluation, Atmos. Chem. Phys., 11, 13001–13027, doi:10.5194/acp-11-13001-2011, 2011.

Pérez García-Pando, C., Thomson, M. C., Stanton, M. C., Diggle, P. J., Hopson, T., Pandya, R., ... and Hugonnet, S. Meningitis and climate: from science to practice. Earth Perspectives, 1(1), 1-15, 2014.

Redl, R., Fink, A. H., and Knippertz, P. An objective detection method for convective cold pool events and its application to northern Africa. Monthly Weather Review, 2015.

Reinfried, F., Tegen, I., Heinold, B., Hellmuth, O., Schepanski, K., Cubasch, U., Huebener, H., and Knippertz, P., 2009. Simulations of convectively-driven density currents in the Atlas region using a regional model: Impacts on dust emission and sensitivity to horizontal resolution and convection schemes, J. Geophys. Res., 114, D08127, doi: 10.1029/2008JD010844.

Rezazadeh, M., Irannejad, P., and Shao, Y.: Climatology of the Middle East dust events, Aeolian Research, 10, 103-109, 2013.

Schepanski, K., Tegen, I., Laurent, B., Heinold, B., and Macke, A., 2007. A new Saharan dust source activation frequency map derived from MSG-SEVIRI IR-channels, Geophys. Res. Lett., 34, L18803, doi: 10.1029/2007GL030168.

Schepanski, K., Tegen, I., & Macke, A. (2012). Comparison of satellite based observations of Saharan dust source areas. Remote Sensing of Environment, 123, 90-97.

Schroedter-Homscheidt, Oumbe A., Benedetti A. and J.-J. Morcrette: Aerosols for concentrating solar electricity production forecasts: requirement quantification and ECMWF/MACC aerosol forecast assessment. Bulletin of the American Meteorological Society, doi: http://dx.doi.org/10.1175/BAMS-D-11-00259, 2012.

Schulz, M., J.M. Prospero, A.R. Baker, F. Dentener, L. Ickes, P.S. Liss, N.M. Mahowald, S. Nickovic, C. Pérez García-Pando, S. Rodríguez, M. Sarin, I.Tegen, R. A. Duce, 2012: The Atmospheric Transport and Deposition of Mineral Dust to the Ocean : Implications for Research Needs. Environ. Sci. Technol., 46, 10390−10404, dx.doi.org/10.1021/es300073u, 2012.

Shao, Y., Wyrwoll, K.-H., Chappell, A., Huang, J., Lin, Z., McTainsh, G. H., Mikami, M., Tanaka, T. Y., Wang, X., and Yoon, S.: Dust cycle: An emerging core theme in Earth system science, Aeolian Research, 2, 181-204, 2011.

Shao, Y., Wyrwoll, K.-H., Chappell, A., Huang, J., Lin, Z., McTainsh, G. H., Mikami, M., Tanaka, T. Y., Wang, X., and Yoon, S.: Dust cycle: An emerging core theme in Earth system science, Aeolian Research, 2, 181-204, 2013.

Solomos, S., Kallos, G., Mavromatidis, E., and Kushta, J., 2012. Density currents as a desert dust mobilization mechanism, Atmos. Chem. Phys., 12, 11199–11211.

Spada, M., Jorba, O., Pérez García-Pando, C., Janjic, Z., and Baldasano, J. M.: Modeling and evaluation of the global sea-salt aerosol distribution: sensitivity to size-resolved and sea-surface temperature dependent emission schemes, Atmos. Chem. Phys., 13, 11735-11755, 2013.

Spada, M., Jorba, O., García-Pando, C. P., Janjic, Z., and Baldasano, J. M.. On the evaluation of global sea-salt aerosol models at coastal/orographic sites. Atmospheric Environment, 101, 41-48, 2015.

Tegen, I., Werner, M., Harrison, S. P., and Kohfeld, K. E.: Relative importance of climate and land use in determining present and future global soil dust emission, Geophys. Res. Lett., 31, doi:10.1029/2003GL019216, 2004.

Uno, I., Harada, K., Satake, S., Hara, Y., Wang, Z., 2005. Meteorological characteristics and dust distribution of the Tarim Basin simulated by the nesting RAMS/CFORS dust model. J. Meteorol. Soc. Jpn. 83A, 219–239.

Vukovic, A., Vujadinovic, M., Pejanovic, G., Andric, J., Kumjian, M. J., Djurdjevic, V., Dacic, M., Prasad, A. K., Paris, B. C., Sprigg, W., and Nickovic, S. Numerical simulation of an American Haboob, submitted to Atmos. Chem. Phys., 2014

Zhou, BW, Chow, FK. 2011. Large-Eddy Simulation of the Stable Boundary Layer with Explicit Filtering and Reconstruction Turbulence Modeling. J. Atmos. Sci., 68(9): 2142-2155. DOI: 10.1175/2011JAS3693.1.

C.2. IMPACTO ESPERADO DE LOS RESULTADOS

One of the greatest environmental impacts on health around the world is associated with air pollution. In Europe, it is responsible for the largest burden of environment-related disease. The last report of the World Health Organization identifies air pollution as a leading environmental cause of cancer deaths. The justification of the present project is based on the efforts directed to improve the air quality, the life quality, health and protection of ecosystems through a more precise scientific knowledge of the physical processes of the atmosphere. Scientifically, state-of-the-art numerical modelling methods and parameterizations will be employed to reduce the uncertainties associated to dust emission, to more accurate assessment of aerosol influence on air quality, natural environment and climate, and consequently help formulating more adequate policies, strategies and measures to mitigate the impacts caused by gases and aerosols. Technologically, the project will contribute with a new global-regional online coupled chemical weather prediction system for research and operational applications.

The results will lead a more complete description and understanding of the multiscale meteorological processes responsible of dust emissions and consequently on the desert dust transport and deposition. Additionally, the evaluation of the model results will help to determine the strengths and key limitations of models in representing these smaller-scale meteorological processes that will ultimately improve short and mid-term forecasts of dust hazards and air quality.

The project will strongly benefit the World Meteorological Organization (WMO) Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Northern Africa-Middle East-Europe Regional Center (NA-ME-E RC) managed by a consortium of AEMET and BSC-CNS, and the Barcelona Dust Forecast Center (BDFC) of the WMO, providing improved mineral dust modelling products with higher accuracy and resolution. The Commission for Atmospheric Sciences of the WMO recognized, during its 17th session, the efforts of Spain to support the SDS-WAS RC activities. In this sense, the present project will reinforce the Spanish efforts on the enhancement of the SDS-WAS products and activities. The group also has an important collaboration with AEMET Izaña Atmospheric Research Center. That group studies the impact of mineral dust over Spain. It is expected that the improved mineral dust forecasts will benefit the work of Izaña group characterizing the events of dust affecting the Canary Islands.

Both during the project duration and after completion, the results suitable for dissemination will be published in refereed international journals and/or presented in lectures and conferences. The new model forecasts developed through the framework of the present project research will be put available to the general public through the forecast websites of the group. Furthermore, the improved products obtained with the NMMB/BSC-Dust mineral dust forecasts will be disseminated through the web site of BSC-ES forecasts, and the new results will be transferred to SDS-WAS NA-ME-E RC and BDFC. For the internalization of the project at BSC, the lessons learn on running high-resolution simulations in supercomputing platforms will be included in the program of the specialized training courses organized by the PRACE Advanced Training Center and the CUDA Center of Excellence in which BSC-ES takes part.

C.3. IMPLICACIONES ÉTICAS Y/O DE BIOSEGURIDAD

None