LATE REQUEST FOR A SPECIAL PROJECT 2024–2026

MEMBER STATE: Spain

Principal Investigator[1]**:** María Gonçalves Ageitos

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Project Title: Mineral dust radiative forcing with observationally constrained emissions since the pre-industrial era

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ………….	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2024	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☐

Computer resources required for project year:		**2024**	**2025**	**2026**
High Performance Computing Facility	[SBU]	45 Million		
Accumulated data storage (total archive volume)[2]	[GB]	--		

EWC resources required for project year:		**2024**	**2025**	**2026**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

Continue overleaf.

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[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.

[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

[3] The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

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Extended abstract

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF and its Scientific Advisory Committee. The requests are evaluated based on their scientific and technical quality, and the justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests exceeding 10,000,000 SBU should be more detailed (3-5 pages).

Atmospheric aerosols have a cooling effect on climate, hence partially offsetting the warming induced by well mixed greenhouse gasses. However, the magnitude and spatio-temporal variability of this effect is uncertain, yet relevant to predict how future climate will respond to both climate and air quality mitigation strategies [1]. The effective radiative forcing (ERF), which accounts for the immediate radiative effect and the adjustments of the climate system after an imposed perturbation, is a fundamental metric to assess the contribution of different drivers to climate change. The negative ERF of aerosols since the pre-industrial time is attributed to their interaction with radiation (ERFari) and, to a larger extent, to their interaction with warm and cold clouds (ERFaci), being the latter more uncertain [1].

One key component contributing to that uncertainty is mineral dust [2,3], the most abundant atmospheric aerosol in mass. Dust interacts with longwave and shortwave radiation and contributes to the formation of warm and cold clouds. Furthermore, dust intervenes in atmospheric chemistry and holds micro-nutrients that upon deposition influence terrestrial and oceanic ecosystems, further affecting the Earth System and climate. These processes are sensitive to the dust mineralogical composition, an aspect often neglected in the state-of-the-art Earth System Models (ESM) used for climate assessments [4,5,6,7].

Historical changes in dust sources and their strength depend on climate (e.g., through precipitation, drought, or wind speed), land-use and vegetation changes, both natural and anthropogenically induced. A recent reconstruction of dust loading indicates that dust has increased by 55 ± 30 % since pre-industrial times [3]. In contrast, the Coupled Model Intercomparison Project Phase 6 (CMIP6) ESMs simulate an approximately constant dust loading over the historical period, suggesting that they are not able to capture the evolution and/or effect of the dust emission drivers.

This project aims to quantify the ERF of dust since the pre-industrial times considering our best knowledge of the dust sources evolution during the historical period [3] and the spatially resolved mineralogy of the dust sources [4]. We will specifically tackle the quantification of the ERF through the impact of dust on radiation and clouds. This endeavour will be undertaken with an updated version of the EC-Earth3-AerChem model [7,8], and it will be part of the DURF AEROCOM ensemble.

The Tier 1 experiments of the DURF include 3 atmosphere-chemistry experiments for the period 1850-2000 (150 years) with prescribed sea surface temperature (SST) and sea ice concentration. The simulations will follow the CMIP6 AerChemMIP [9] hist-SST experiment protocol (https://shorturl.at/gpDI7), but with varying dust fields. The variations in the dust and anthropogenic aerosols fields target specifically the impact on ERF of dust increases during the historical period [3,10,11], and the relevance of its interaction with anthropogenic aerosols and precursor gasses. This will be achieved through a baseline simulation with the current version of the model, and two additional experiments that globally scale dust emission according to the dust reconstruction, but with pre-industrial or transient CMIP6 anthropogenic emissions.

EC-Earth3 is a state-of-the-art ESM developed by European research centers from 10 different countries, including BSC [12]. EC-Earth3 integrates the atmospheric model IFS Cy36r4 of the ECMWF coupled with the ocean circulation model NEMO3.6 [13]. TM5 allows for interactive simulation of atmospheric chemistry and transport of aerosols and reactive gas species [8]. Here, we will use an updated version of the EC-Earth3-AerChem [7,14,15], which includes an explicit representation of dust minerals, its impact on dust optical properties, and their role as ice nucleating particles, along with other improvements The experiments will be run with prescribed sea surface temperature and sea ice concentrations read in through the AMIP interface. We will rely on the standard model configuration that sets a spatial resolution of ~0.75º for IFS (T255L91) and 3ºx2º for TM5.

The model has been previously run in HPC2020 with similar configurations, and we estimate a performance of ≈1.3 simulated years per day (SYPD) using 2 nodes (256 cpu), which will be equivalent to approximately 95000 SBU per year of simulation for the atmosphere-chemistry experiments, which for the 3 experiments completion (450 years) would be 42.5 MSBU. Considering a safety margin of around 5%, we request then for the completion of the project 45 MSBU.

References:

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4. Gonçalves, M. et al., Atm. Chem. Phys. 2023.
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