LATE REQUEST FOR A SPECIAL PROJECT 2025–2027

MEMBER STATE: ……GREECE……..…

Principal Investigator[1]: ……ELENI KATRAGKOU……..……

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Other researchers: …VASILEIOS PAVLIDIS , STERGIOS KARTSIOS, SOFIA PASCHOU …….

Project Title: …EURO-CORDEX SIMULATIONS INCLUDING LAND USE CHANGES

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.)	2025	
Would you accept support for 1 year only, if necessary?	YES X	NO ☐

Computer resources required for project year:		**2025**	**2026**	**2027**
High Performance Computing Facility	[SBU]	40.000.000		
Accumulated data storage (total archive volume)[2]	[GB]	50		

EWC resources required for project year:		**2025**	**2026**	**2027**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

[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).

Abstract

The project will produce a set of hindcast simulations within the framework of the EURO-CORDEX initiative (Jabob et al., 2020). The first evaluation simulation with be forced by ERA-interim including the European domain in 0.11 with static land use following the specifications of the CMIP6/EURO-CORDEX protocol (Katragkou et al, 2024), hereafter the **control simulation**. The second evaluation simulation will be identical but will include transient land use changes as provided by Hoffmann et al., 2023 the official land use change product, endorsed by the WCRP-CORDEX Flagship Pilot Study (FPS) – LUCAS (Land Use and Climate across scales) (hereafter, **LUC simulation**). Comparison of the two evaluation simulations will provide insights to the impact of land use changes on regional climate, which has been characterized as of great importance and high-uncertainty (IPCC, 2019). The envisaged simulations will be publicly available through publication into the ESGF, as EURO-CORDEX ensemble members. The deployed model will be WRF, which has been established within the EURO-CORDEX community as a plausible regional climate model (Katragkou et al., 2015). Both control and LUC simulations will cover the time-period from 1980 to 2020, including two years for spin off.

Introduction

Climate change has become one of the most urgent challenges for today's society. Climate scientists using state-of-the-art climate models and scenarios of future emissions trajectories of anthropogenic sources, provide updated assessments on the evolution of climate. The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change, with the objective to provide governments at all levels with scientific information that can be used for the development of climate policies. IPCC's Assessments Reports (ARs) are the most comprehensive scientific reports about climate change produced worldwide, with voluntary contributions from different organizations and academic institutions worldwide. The urgency for drastic and coordinated climate action has led the European Commission (EC) to formulate a set of targeted strategic policy initiatives, with the goal to achieve climate neutrality by 2050, within the European Union (EU) states. This set of rules and regulations are expressed in the European Green Deal (EGD). The underlying physical science on which EGD is based on, depends on the robustness of the modeling tools developed and operated by the climate modeling scientific community.

The climate modeling scientific community is a major IPCC contributor. Climate modelers over the world are self-organized in communities with the aim to produce coherent climate datasets, that are of much greater value as a whole, than the sporadic and stand-alone research efforts of individual researchers. In this way, the Global Climate Model (GCM) community works under the framework of the Couple Model Intercomparison Projects (CMIPs). The CMIPs design of synergistic experiments are updated for every new cycle of IPCC reports. Recently, the CMIP6 simulations and scientific achievements supported the IPCC Sixth Assessment Report (AR6). Understanding the importance of this effort, the World Climate Research Program (WCRP) recognized CMIP and, thus, the latter became part of the WCRP structure. Similarly, the Regional Climate Modeling (RCM) community evolved around the Coordinated Regional Downscaling Experiment CORDEX (Gutowski et al 2016), which also operates under the auspices of the WCRP. Moreover, CORDEX has become a diagnostic model intercomparison project (MIP) within CMIP6 and has established itself as a leading community in the field of regional climate. The regional climate models of CORDEX dynamically downscale the global fields produced by the CMIPs, thus allowing for a better representation of regional and local climate, which is relevant for climate impact assessments.

In this work, we use one established EURO-CORDEX model, namely WRF, to assess the impacts of land use and the urban environment on regional climate. All the proposed simulations are within the CORDEX framework, and namely part of WCRP-CORDEX-Flagship Pilot Studies, which occupy a great number of European, Asian and American scientists. The simulations are part of a larger European ensemble member, which will, after completion, will be open to the scientific community.

Scientific plan

The main scientific question to be answered is the following:

Q1: How well does the WRF model without any transient land use forcing describe the regional European climate?

Q2: How land use changes affect regional European climate?

To answer those questions two "evaluation" type of simulations will be performed with the WRF model driven by ERA5 reanalysis boundary conditions with 0.11^{o} spatial resolution, covering Europe. The first simulation (control) will follow the standard production runs as established by the EURO-CORDEX community, without any land use forcing. The control simulation will be assessed against a variety of observational and satellite datasets providing an answer to scientific question Q1. Moreover, one additional evaluation simulation will be conducted with transient land use changes (LUC). Comparison of the LUC simulation with the control run, will provide answers to the scientific question Q2 respectively.

The methodology of adopting the land use change into regional climate simulations are provided here (Davin et al., 2020).

Essential Climate Variables that will be analyzed include: temperature at 2 m, precipitation, net SW and LW radiation budget at the surface, Planetary Boundary Layer Height and soil moisture. The post processing of variables will take place on-site, ensuring the minimization of data transfer. Additional variables will be stored, as identified in the EURO-CORDEX official simulations protocol.

The time plan of the simulations is as follows:

Month1: Benchmarking of the WRF model in the ECMWF HPC system

Month2-10: Completion of the WRF control evaluation simulation

Month4-12: Completion of the of the WRF-LUC evaluation simulation

Month4-12: Post processing and data transfer

Justification of computer resources

Computer resources

Overall, two evaluation simulations are planned. The **control** simulation and the **LUC** simulation will both cover a 43-year period: 1980-2020 including at least two extra years of spin-off. Based on our experience in other HPC systems we plan on using 256 cores for each simulation and expect the time required for each simulated month to be around 9-10 hours. For a total of 43years (516 months) the required time is 5160hours (18.576.000 sec). With the use of 256 cores for each simulation we expect around 1.300.000 core hours ($4.7x10^{9}$ core secs). Therefore, the expected SBUs for the completion of each 43year simulation is around 20.000.000 SBUs. We intend to complete these two simulations within the one year of the project thus, we request 40.000.000 SBUs for year 2025.

Storage required

The WRF model output in the proposed climate simulations is considerable. One simulated year requires around 3.7TB of space, therefore the entire 43 year period would require around 160TB for only one simulation. However, we intend to post process the model output data on-site to drastically reduce the space requirements. We calculate that one year of post-processed data requires around 40-45GB thus the post-processed data for the 43year period for both simulations are expected to require around 40TB. The required space for the driving data is around 3-5TB. Therefore, we expect that a of request 50TB of space will be sufficient for the proposed project.

Technical characteristics of code to be used

We on plan on using the WRF climate model with the ARW core, specifically v4.5.1 for all the planned simulations. The WRF-ARW code is written in Fortran with some supplementary programs that are written in C to perform file parsing

and file construction. The necessary libraries are netCDF, MPICH, JasPer, Libpng, and Zlib. We have more than ten years of experience with the WRF model and have compiled and used various versions of the model in different HPC environments.

References

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