SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2023
Project Title:	Sensitivity of regional climate models to improved soil thermo-hydrodynamics and land-air interactions: impacts on future climate and renewable energy resources over the EURO CORDEX domain.
Computer Project Account:	spesgarc
Principal Investigator(s):	Elena García Bustamante
Affiliation:	CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	01/01/2023
Expected end date:	Dec 2023

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			9.500.000	223.006
Data storage capacity	(Gbytes)			1500	

Summary of project objectives (10 lines max)

The general objective of this project is to challenge the realism of climate model responses because of improved soil components (depth, configuration, and physics) an RCM. We aim at exploring how sensitive the RCM response is in past and future scenarios to changes in the soil physics paying special attention to critical areas in a consistent fashion as in the parent ESM realm; we will also assess the impact of incorporating external natural and anthropogenic forcings on long-term trends and extreme variability of key atmospheric and soil variables, as well as of solar-wind energy resources over the EURO CORDEX domain. This will be accomplished by performing historical and scenario high-resolution (~9 km) long (30 yr.) simulations (assumable with CPU resources) using the own WRFdeep model version. To our knowledge historical and scenario ESM-RCM downscaled simulations with consistently improved land model components are scarce.

Summary of problems encountered (10 lines max)

The WRF version we are using to perform dedicated simulations to explore impact the land use/land cover changes for the EURO CORDEX community LUCAS (Flagship Pilot Study of WCRP CORDEX) has shown several problems that needed time and effort from the community to be fixed. In particular, it has been detected a surface temperature cold bias over some west France and Russia. Additionally, the rain fraction and excess of low clouds that need to be understood prevent from launching the final production runs we committed to generate in the proposal and to contribute with to the CORDEX experiments.

Summary of plans for the continuation of the project (10 lines max)

Nonetheless, we have performed different tests to prepare the production runs and we have several simulations set up ready to be launched at the time the “bugs” detected are solved. By the end of the year, we plan to have produced at the pool of simulations we projected, including the CMIP6 downscaling experiments with radiative forcings and a deeper land module with WRF. In doing so we will consume the computational capacity we requested for the year 2023. Also, we positively will be sort of capacity and we aim at requesting an extension of resource for the next year given the amount of simulations planned within our special project.

List of publications/reports from the project with complete references

Rojas-Labanda C**., J. F. González-Rouco, E. García-Bustamante, J. Navarro,** E. E. Lucio-Eceiza, et al., 2022: “Surface wind over Europe…” Int. J. Climatol. 43(1), 134-156.

Melo-Aguilar C, **J. F. González-Rouco**, N. J. Steinert, H. Beltrami, F. J. Cuesta-Valero, A. García-García, F. García-Pereira, **E. García-Bustamante,** P. J. Roldán-Gómez, and T. Schmid: " Near-surface soil thermal regime and land-air temperature coupling: a case study over Spain". Int. J. Climatol., **42(15)**, 7516-7534, DOI: 10.1002/joc.7662.

Greciano-Zamorano, E. “Evaluation of the precipitation variability over the Sierra de Guadarrama”. Master Thesis, supervised by **González-Rouco, J. F., E. García Bustamante and J. Navarro**, J. Universidad Complutense de Madrid, 2023.

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The team has been able of successfully install the WRF code at the ECMFWF and we have performed several tests to ensure that results accommodate well with what we would expect if simulations would be run at our own facilities.

We have additionally designed the experiments that include external radiative forcings (greenhouse gases, natural and anthropogenic aerosols and solar variability and they are prepared to be launched) and we have produced a model version with a deeper soil component. Arrangements to couple WRF with the CMIP6 global model, the MPI-ESM$_{deep}$ version have also been discussed and the coupling does successfully run. Therefore, we are devoted to the fixing on the recently found bugs to launch our production runs in historical and scenario modes with this refined own version of the regional model WRF.

In addition, we have performed km-scale sensitivity simulations in a smaller domain to explore the adequacy of the microphysics and cumulus/convection parametrizations that better serve for the purpose of selecting the most suitable model set up to be run at very high resolution (1 km) within a smaller domain. The sensitivity experiments are described in Table 1, where we show the reference configuration and the combinations of microphysics and cumulus in the tested cases.

PARAMETERIZATIONS						
	WRF1		**WRF2**		**WRF3**	
	Microphysics	Cumulus	Microphysics	Cumulus	Microphysics	Cumulus
Reference	Thompson	New Tiedtke	Thompson	New Tiedtke	Thompson	New Tiedtke
Simulation 1	NSSL2	New Tiedtke	NSSL2	New Tiedtke	NSSL2	New Tiedtke
Simulation 2	Thompson	Kain-Fritsch	Thompson	Kain-Fritsch	Thompson	Kain-Fritsch
Simulation 3	Thompson	Grell-Freitas	Thompson	Grell-Freitas	Thompson	Grell-Freitas
Simulation 4	Thompson	New Tiedtke	Thompson	New Tiedtke	Thompson	-
Simulation 5	Thompson	Kain-Fritsch	Thompson	Kain-Fritsch	Thompson	-
Simulation 6	Thompson	Grell-Freitas	Thompson	Grell-Freitas	Thompson	-

Table 1. Sensitivity experiments designed to test the ability of different cumulus and microphysics parametrizations in the three nested domains reaching 1 km of horizontal resolution (WRF3)

Results evidence that no combination of physics scheme outperforms and a tendency of the simulation precipitation to overestimate the number of wet days from observations has been detected, although to some extent Kain-Fritsch and Grell-Freitas parametrizations tend to overestimate in a less degree compared to New Tiedke cumulus parametrization. The latter is shown in Figures 1 and 2 where the percentage of wet days from the reference simulations and the variants explored and the total accumulated precipitation from observations and simulations are represented, respectively.

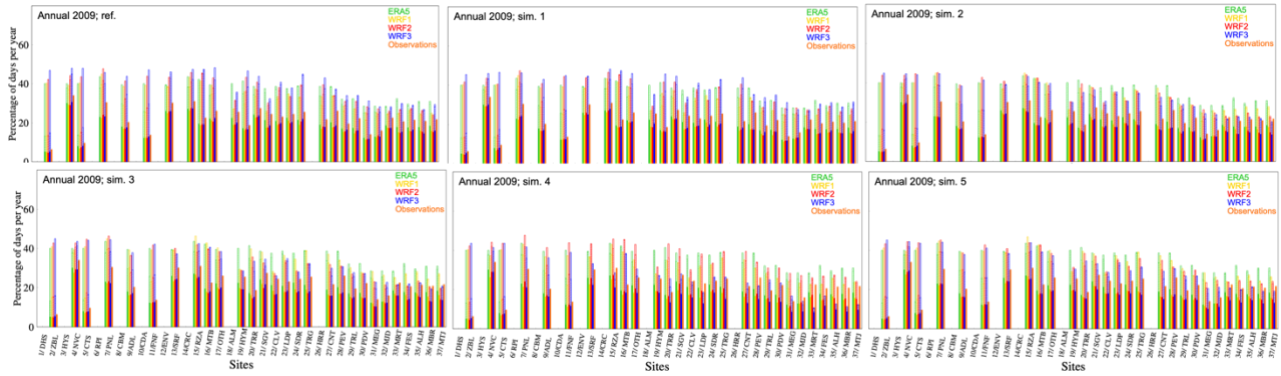

Figure 1. Percentage of wet days from the reference simulation and the set of sensitivity experiments with alternative microphysics and cumulus schemes calculated at three nested domains (9km for WRF1, 3 km for WRF2 and 1 km of horizontal resolution for WRF3) together with the same for the observational data set and the reanalysis ERA5 for comparison).

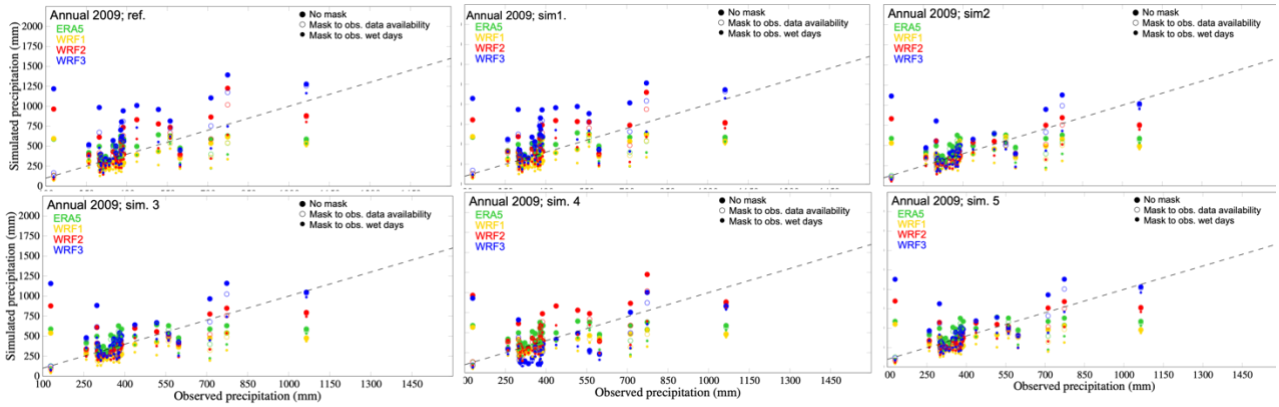

Figure 2. Dispersion diagram showing the precipitation amounts from the observations compared to that from the reference simulation and the set of sensitivity experiments with alternative microphysics and cumulus schemes calculated at three nested domains (9km for WRF1, 3 km for WRF2 and 1 km of horizontal resolution for WRF3) together with the same for the observational data set and the reanalysis ERA5 for comparison).

We have significantly enlarged our knowledge about the configuration of the model (parametrizations set up) and the technical requirements that allow us to produce a more realistic WRF model version, including radiative forcings at the regional scale a deeper land module, allowing for a better distribution of soil temperature and moisture at the subsurface. The historical and production runs need to be launched nevertheless, probably starting in August.

We calculate that we will need more HPC capacity and storage than estimated at the time of the proposal since we have enlarged the number of production runs by including a smaller domain within the EURO CORDEX region reaching 1 km resolution for a very complex terrain area where we have tested the several convection parametrizations.

As a result of our collaboration with the CORDEX community during this year it has been evidenced that our approach to increase the realism of the model is of interest to test the ability of the simulation to reproduce the observations in a context of very high resolution (~1km). Therefore, we are facing the inclusion in our production runs a smaller domain reaching this very high resolution and to have long climatological simulations to discuss the added value of convection permitting schemes with our refined model version.

The latter implies that our calculations to request the amount of HPC and storage capacity is limited if we want to implement the additional extensive experiments exposed. The additional resources we ask for are supposed to be added to what we requested so our total for 2024 would ideally be 9.5000.000 + 6.000.000 = 15.500,000 SBUs and 250.000 + 100.000= 350.000 Gbytes.