REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: FRANCE

Principal Investigator[1]: Robert Vautard

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Nikolay Kadygrov (IPSL)

Project Title:

Production of regional climate model projections for Europe in the framework of Copernicus C3S project PRINCIPLES

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.)	2020	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2020-2022:
(To make changes to an existing project please submit an amended version of the original form.)

		2020	**2021**	**2022**
High Performance Computing Facility	(SBU)	30,000,000	30,000,000	
Accumulated data storage (total archive volume)[2]	(GB)	350,000	350,000	

Continue overleaf

1The 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.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

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.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific Advisory Committee. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and 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 asking for 1,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more might receive a detailed review by members of the Scientific Advisory Committee.

Production of regional climate model projections for Europe in the framework of Copernicus C3S project PRINCIPLES .

The aim of the special project is to perform high-resolution runs of the regional climate model (RCM) downscaling different CMIP5 and CMIP6 Global Climate Models (GCMs) under different future scenarios (RCPs).

The work is part of the C3S_34b_Lot2 (PRINCIPLES) collaborative project involving nine nine partners: the Swedish Meteorological and Hydrological Institute (SMHI), the Danish Meteorological Institute (DMI), the Royal Netherlands Meteorological Institute (KNMI), Centre National de la Recherche Scientifique (CNRS) through the Institut Pierre-Simon Laplace (IPSL), ETH Zürich (ETH), Météo-France (METEO-FRANCE), the U K Met Office (MOHC), the Climate Service Center Germany (HZG-GERICS) and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS).

Members of the partner teams have been among those initiating and developing CORDEX (Coordinated Regional climate Downscaling Experiment) that is now the prime source of regional climate information at high resolution in Europe. The partnership involves the majority of regional climate models (RCMs) employed to produce regional climate projections for Europe.

Along with experimental design, IPSL is contributing with production of RCM projections, evaluating and synthesizing the outcome. This special project aims at contributing to PRINCIPLES by producing two of the simulations with the WRF model version 3.8.1 (labelled WRF381P in the cordex ensemble). It complements simulations done using national HPC facilities.

Project objective and goals:

Despite the relatively large set of projections completed under the EURO-CORDEX framework, the matrix of available GCM-RCM simulations is far from sufficient to satisfactorily cover the entire dimensions of model spread let alone overall uncertainty in current projections, especially for the higher resolution of 0.11° (see Table 1). In addition, as an all voluntarily based effort the EURO-CORDEX matrix so far has not been populated based on objective criteria to optimally cover the different uncertainty dimensions (RCP/GCM/RCM). The overarching goal of the PRINCIPLES project is to produce a further well-coordinated set of RCM simulations for the European domain at high horizontal resolution (0.11°, 12.5 km) as an input to the CDS (Copernicus Climate Data Store). This set of simulations will expand the set currently available from EURO-CORDEX, to provide an optimal matrix that better characterizes the sources of spread

in variability in climate projections over the European region. The simulation strategy is defined in the PRINCIPLES project. A main focus is to have a core set of simulations achieving a full matrix for RCP8.5, and using the ECEARTH, HADGEM, CNRM, NORESM and MPI models. Then other scenarios are also requested such as RCP2.6.

GCM/RCM	CCLM	RACMO	RCA	HIRHAM	REMO	WRF361H	WRF381P	ALADIN	REGCM
ECEARTHr12									
ECEARTHr1									
ECEARTHr3									
MPIr1									
MPIr2									
HadGEMr1									
CNRMr1									
IPSLr1									
NORESMr1									
CANESMr1									
MIROCr1									

Table 1: EURO-CORDEX simulations achieved as of January 2019 (in orange). Rows represent GCMs downscaled and columns RCMs. The column IPSL is filling is the WRF381P column. Since January NORESM has been downscaled. In this project we plan to downscale ECEARTHr12 for RCP8.5 and another simulation, based on the strategy that will be decided in September 2019 at the PRINCIPLES general assembly.

The IPSL team is involved in PRINCIPLES with WRF RCM model, focusing on producing simulations of the ECVs (Essential Climate Variables) for the EURO-CORDEX domain at high horizontal resolution, i.e. 0.11° (c. 12.5 km grid spacing) covering the full period 1951-2100.

Several runs of the WRF RCM are now performed at CEA super computer Center. Given the number of the GCM models and several scenarios to be run, this special project aims to take advantage of ECMWF's HPC to perform more simulations and achieve the project's goal.

So far, WRF simulations have downscaled three GCMs: IPSL-CM5-MR (RCP4.5 and RCP8.5), HadGEM-ES (RCP8.5) and NORESM (RCP8.5). A plan to downscale CNRM-CM5 RCP8.5 is made on CEA computer. However more simulations are necessary. So far the priorities have been to have a core set of RCP8.5 and historical scenarios, but a second priority will be to also have 2-degree warming scenarios such as RCP2.6, as well as RCP4.5, and possibly to add CMIP6 models downscaling. The strategy will be defined at the next PRINCIPLES general assembly in September 2019.

The goal of this special project is to complete the runs required by C3S-PRINCIPLES, by two simulations of 150 years of WRF, downscaling 2 GCMs. IPSL is also in charge of the evaluation of these simulations and the inter-comparisons among models. A particular effort will be put to identify the source of biases and check whether these biases come rather from GCMs or RCMs. A clear dependence on GCMs can be seen for instance in Figure 1 for the current simulations.

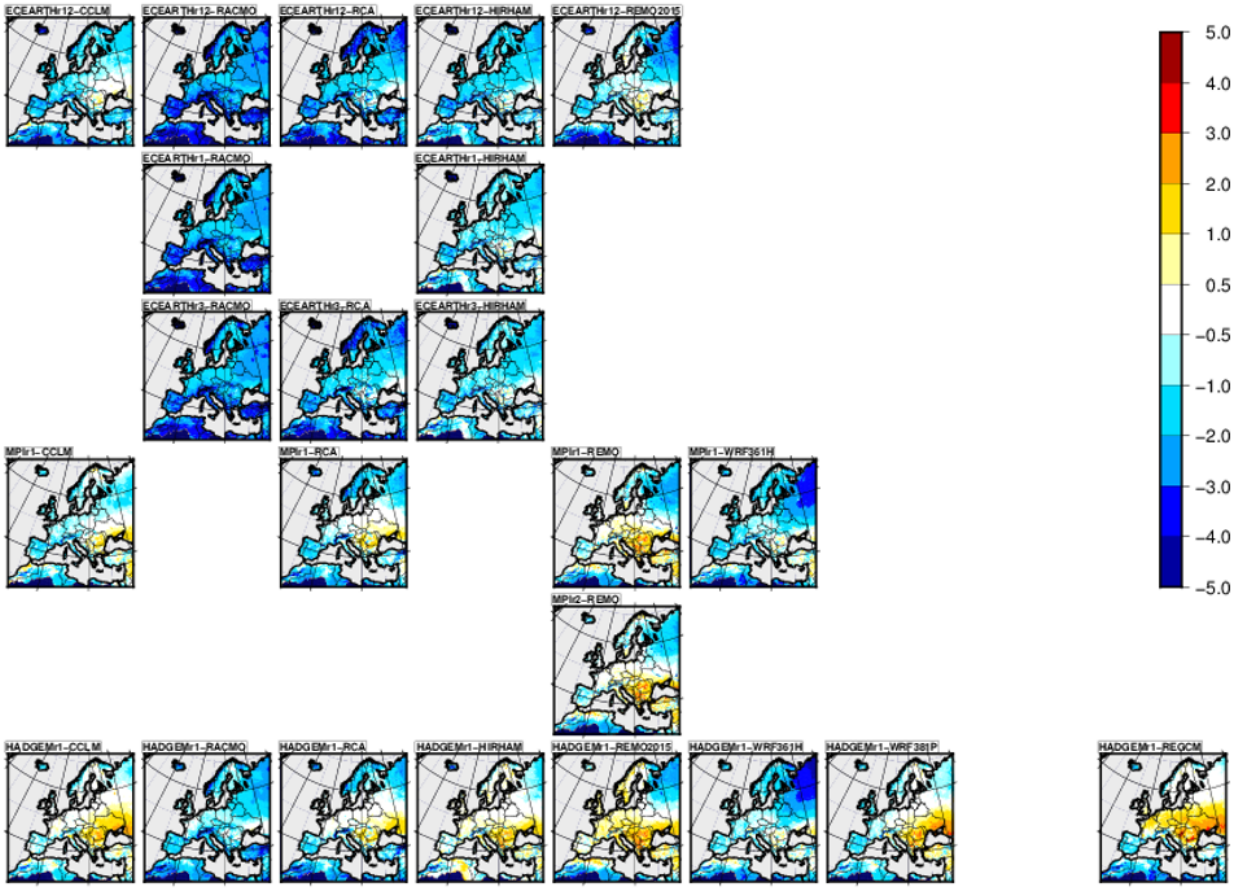

Figure 1: example of the output of the evaluation analysis: 2m-temperature biases of the GCM-RCM models (rows represent GCMs and columns RCMs.

Project description and workflow

The PRINCIPLES project is organized in four work packages:

WP1: Formulation of a method to define the 3-D matrix

WP1 defines a method for how to best define and fill the 3-D matrix of regional climate change projections (RCP/GCM/RCM), including the formulation of a rationale for defining as realistic as possible a representation of spread of the modelled climate over Europe as it is determined by existing GCM simulations, along with considerations of GCM performance over the European region.

WP2: Production of regional climate projections

WP2 holds the production part as all climate simulations will be performed here. Another key goal is the production and collection of model documentation for the involved RCMs.

WP3: Evaluation of possibility to integrate CMIP6-based RCM scenarios

WP3 will look at the availability of CMIP6 scenarios at the onset of the second phase of the project to investigate which, if any, of these may be downscaled to better fill the 3-D RCP/GCM/RCM matrix according to the formulation of the filling process.

WP4: Synthesis and Demonstration

WP4 monitors the advancement by regular verifications of the progressive fulfilment of the spread requirements; (ii) perform, over a few key metrics the evaluation of existing and new simulations allowing a

scientific “health check” of all simulations as they are produced, and (iii) provide regular syntheses and demonstrations.

IPSL is mostly involved in WP2 (production) and IPSL leads WP4. The simulations done on the ECMWF computer will be a WP2 contribution.

Working plan:

The workplan for this special project includes 3 phases:

1. Until FEB 2020: Transfering and testing the WRF381P code: The model works on the IRENE machine of CEA which is a ~9 petaflop machine and is part of the PRACE program. On this machine WRF381P has a performance of 10000 hour.cores per simulated year, which has been optimized on 288 parallel cores. The scalability is high and remains good even if twice more cores are taken. Until February 2020, the code will be tested and the configuration will be optimized for the ECMWF computer. Results will be compared to results obtained on IRENE, through the simulation of a test year.
2. MAR-JUN 2020: First simulation production: During this period one simulation will be done, downscaling the MPI model. This will be done in two phases: a first phase of 10 years until the end of march. Then a number of verifications and 10-year climatologies will be done in order to make sure that the simulation has realistic climatological values. Then the simulation will be pursued or corrected and restarted. This phase covers the simulation from 1951 to 1960. Te full historical period will then be simulated (1951-2005) then the RCP8.5 period (2006-2100) will be carried out. The simulation is done in time slices of 30-year periods with a 2-year overlap as it would take too long otherwise. The 2-year overlap is necessary in order to have the soil variables well initialized.
3. JUN-SEP 2020: An analysis of the performance of the simulation will be carried out using the criteria of the WP4 of the project. This includes biases for temperature, winds, precipitation, radiation, extremes and trends analysis. The analysis will be reported in the WP4 synthesis report in FEB 2021. A preliminary analysis, which may cover a non-full period, will also be reported to ECMWF in June 2020.
4. OCT2020-SEP2021: the same procedure will be done but for the downscaling of another GCM simulation. This simulation will be defined based on the PRINCIPLES strategy which will be defined in September 2019 at the general assembly.

The WRF381P model configuration:
WRF is a well known Regional weather and climate model. It has been used in a number of studies, and is already part of the EUROCORDEX ensemble. It uses a number of physical parameterizations such as

- The NOAH land-surface scheme
- The RRTMG radiation scheme
- A Mellor-Yamada Planetary boundary layer scheme
- The simplified Arakawa-Schubert scheme
- The Thompson microphysics scheme
- …

It runs over an extended 0.11° rotated grid including the EURO-CORDEX domain (412x424 grid points), with 31 vertical levels.

The expected performance on the ECMWF computer will be tested and all calculations are made here based on equivalent performances with the IRENE computer. We counted that one 150 year simulation would require about 30 million SBU and 350Tb storage. This count is made on the assumption of an elapsed time of 10000 hour.core per simulated year and 150 year per simulation, and an overhead for overlaps and testing.