LATE REQUEST FOR A SPECIAL PROJECT 2019–2021

MEMBER STATE: NETHERLANDS

Principal Investigator[1]**:** Dim Coumou

Affiliation: VU Amsterdam

Address: Institute for Environmental Studies
De Boelelaan 1087
W&N Building, room C-515

Other researchers:
Andrea Allessandri (KNMI, De Bilt, Netherlands)
Iris Manola (VU Amsterdam)

Project Title:
Land Management for Climate Mitigation and Adaptation (LAMACLIMA)

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 the years: (To make changes to an existing project please submit an amended version of the original form.)		**2019**	**2020**	**2021**
High Performance Computing Facility	(SBU)		9.0 million	
Accumulated data storage (total archive volume)[2]	(GB)		20000	

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.
[2] 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.

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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.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages).

Following submission by the relevant Member State the Special Project requests the evaluation will be 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.

All accepted project requests will be published on the ECMWF website.

VU Amsterdam is partner in the new **JPI-Climate/AXIS** funded project **LAMACLIMA** that aims at advancing the scientific and public understanding of the coupled climate effects of land cover and land management (LCLM) options. The project aims at elaborating sustainable land-based adaptation and mitigation measures.

The Royal Netherlands Meteorological Institute (KNMI) is chairing the Land and Vegetation Working Group in the frame of EC-Earth, aiming among other activities to achieving improved Earth system predictions and projections on multiple time scales by filling the gap between the models used for short-term prediction (verification-based) and the latest developments in the Earth System Models (process-based).

There is now strong evidence that anthropogenic changes in LCLM are substantially affecting climate through the release of carbon to the atmosphere (biogeochemical effects), the alteration of local energy and water fluxes at the land surface, and their interaction with large-scale atmospheric dynamics (biogeophysical effects). Accounting for coupled LCLM-climate effects is thus very relevant for future climate mitigation and adaptation efforts. However, the coupled nature of these effects overall receives limited consideration in land use decision making processes. LAMACLIMA will investigate the local and remote biogeophysical and biogeochemical effects of three key changes in LCLM (**re/afforestation**, **irrigation** and **wood harvest**) on climate and their implications for several sectors (agriculture, water availability, forestry and economic productivity). This will be achieved by comparing the results of coordinated sensitivity experiments with three Earth System Models (ESMs) including EC-Earth coupled to LPJ-GUESS. For the EC-Earth-LPJ-GUESS simulation runs we would like to request compute time at the ECMWF's HPC.

State of the art

The scientific analysis of the consequences of global land use changes largely rely on integrated assessments, which have traditionally regarded the influence of climate on land as a unidirectional process, without explicitly accounting for the feedback of changes in LCLM on climate. There is now solid evidence however that this feedback is significant, not only for carbon dioxide concentrations (Erb et al. 2017; Quéré et al. 2018), but also for the energy and water fluxes locally (De Noblet-Ducoudré 2012; Thiery et al. 2017; Lejeune et al. 2018), as well as remotely (Vrese et al. 2016; Winckler 2018). The regional climate effects of projected future changes in LCLM are indeed comparable with those of a global mean temperature increase of 0.5°C (Schleussner et al. 2017; Hirsch et al. 2018). Given the importance of 0.5°C global warming increments and associated impacts in the context of the Paris Agreement, and the substantial changes in LCLM expected under scenarios compatible with it (Seneviratne et al. 2018b), an integrated multi-model intercomparison of LCLM-climate feedbacks in ESMs is of high scientific and policy relevance (Seneviratne et al. 2018a). The effects on energy and water fluxes, if regarded at all, are however usually seen as unintended side effects of land use decisions that focus on carbon stocks. Nevertheless, it has been recognized that these fluxes should be included in a comprehensive assessment of the coupled land use-climate system.

Planned Simulations

The interactions between LCLM and climate will be quantified by conducting a set of sensitivity experiments using EC-Earth-LPJ-GUESS. The output of these simulations will be analysed for (i) local climate impacts of changes in LCLM through biogeophysical effects such as changes in albedo or evapotranspiration, (ii) remote biogeophysical impacts through atmospheric teleconnections and (iii) biogeochemical impacts on the carbon cycle. Three key LCLM options for climate – i.e. for which strong potential biogeochemical and biogeophysical effects were identified – will be considered: re/afforestation, irrigation and wood harvesting. Furthermore, selected output fields will be used to quantify additional or avoided economic impacts of LCLM.

We will generate simulations with the coupled-model **EC-Earth-LPJ-GUESS** over the period 1976-2010 (**35 years including 5 years of spin-up**). We will use the latest frozen version EC-Earth 3.2 at T255 resolution. We will do four ensembles of each five members: A control ensemble with all major anthropogenic and natural external forcings including present-day LCLM (hereafter referred to as CTL), a second ensemble identical to the first one but with irrigation implemented on all current agricultural lands (hereafter referred to as IRR), a third ensemble with wood harvesting rates prescribed according to SSP3-RCP7.0 projections for 2100 (~1800 MtC yr-1 compared to current ~1000 MtC yr-1; hereafter referred to as HARV), and a final ensemble with re/afforestation prescribed according to SSP1-RCP2.6 (~43 Mkm2 in 2100 compared to current ~37 Mkm2; hereafter referred to as FRST). The **three sensitivity experiments** thereby represent an extreme yet feasible implementation of a single LCLM scenario. All simulations will be greenhouse gas concentration-driven and performed in fully coupled mode, consistent with the Land-Use Model Intercomparison Project (LUMIP) simulation protocol. Simulations will be branched from the CMIP6 historical simulations and each ensemble will contain five unique realisations (i.e. members) in terms of natural variability but with an identical representation of the underlying physical processes. With 4 experiments of each 40 years modelled climate and 5 ensemble members, the **total amount of modelled years will be less than 1000 years**. The CTL ensemble will be evaluated for its ability to represent (i) surface energy balance components using e.g. GEWEX-SRB GLEAM and LandFlux-EVAL, (ii) near-surface climate using e.g. ERA5, CRU and GPCP, and (iii) carbon stocks and fluxes using the ILAMB and/or ESMValTool benchmarking systems. The three LCLM options will be addressed in sequential order. The experiments run will enable us to quantify the impact of the three investigated LCLM options on a series of variables such as air temperature, rainfed and irrigated crop yields, and surface runoff. The derived spatially explicit relationships between LCLM implementation and these variables will be used for further impact and policy relevant analyses.

Computational Requirements

In order to accurately estimate the computational requirements, a set of experiments has been specifically designed and performed using the same codes that will be used in the production phase. The aim is to verify the performance of the codes and determine the better processors configuration. Large scalability is not an issue in our case, since we plan to run different experiments at the same time. Therefore, we limited our tests to a maximum of 384 parallel tasks. The tests also analysed the opportunity to use two threads per physical core. All the tests run for 1 hour wall clock time with the model in coupled (ocean-atmosphere-LPJ-GUESS) configuration. Based on the results we estimate that the configuration uses about 9000 SBU per simulation year. The total number of years to be run (see description of experiment above) will be below 1000 years, giving us a total estimate of 9 million SBU.

All data for the project will be stored on the original grid and in NetCDF4 format (CF compliant). A total of 5 3-Dimensional (3D) and 24 2-Dimensional (2D) variables will be saved for the atmosphere and likewise about 24 2D variables for LPJ-GUESS. The time frequency of the outputs spans from 6-hourly data to daily and monthly averages, depending on the variable considered. A realistic estimate of the storage for one year of simulation gives a total of 20 GB of data to be stored. Therefore, the overall data storage capacity required for the project amounts to 20TB. Also additional storage capacity is available for the LAMACLIMA consortium so we can quickly transfer data to free the ecmwf storage system.

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