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	……2024…….……
Project Title:	Exploit observations to constrain land cover, vegetation and hydrology processes for improved near-term climate predictions over land
Computer Project Account:	…… spitales ……..……
Principal Investigator(s):	…… Andrea Alessandri (Fransje van Oorschot, Emanuele Di Carlo, Annalisa Cherchi, Vincenzo Senigalliesi, Marco Possega, Franco Catalano, Etienne Tourigny, Pablo Ortega)
Affiliation:	…… ISAC-CNR ……..……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	G. Balsamo, S. Boussetta, T. Stockdale and M. Balmaseda
Start date of the project:	……2022……..……
Expected end date:	……2024……

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)	5000000	4174909,78	6000000	1686451
Data storage capacity	(Gbytes)	55000	10055	70000	17268

Summary of project objectives (10 lines max)

The objective of this special project is to exploit the latest available observational data over land to improve the representation of processes related to land cover, vegetation and hydrology that can positively contribute to skillful near-term climate predictions. Parameter-fitting and/or inverse modelling techniques will be employed to better constrain the land surface parameterizations to the available observations, followed by careful verification that will be first conducted off-line through ERA-5 forced land-only simulations. Finally, a set of decadal predictions with enhanced representation of land cover, vegetation and hydrology processes will be performed to assess the improvement of the predictions.

Summary of problems encountered (10 lines max)

With the migration of the ECMWF HPC system from Cray cca in Reading to the new Atos HPC2020 in Bologna, several libraries and packages were updated to more recent versions while the old versions, not being supported anymore, were removed. Consequently, we encountered several porting issues in particular related to the update to Python3 and the discontinued support to Python2, which required considerable effort in adapting and reconfiguring the Offline Surface Model (OSM) of EC-Earth. This caused some delays in the execution of the planned land-only simulations. However, the porting is now accomplished together with a preliminary set of ongoing simulations.

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

In the remaining of this special project, we will complete the historical simulations with a post-CMIP6 configuration of EC-Earth3 that includes the dynamics of vegetation (LPJGuess). To preliminarily investigate the feasibility of actual forecasts with initialized vegetation, the residual resources will be used to attempt one case study where the vegetation state in the historical simulation is replaced with the "initialized" vegetation from an off-line simulation (forced by ERA5 boundary fluxes at the land-atmosphere interface).

List of publications/reports from the project with complete references

Di Carlo, E., Alessandri, A, van Oorschot, F., Catalano, F., Cherchi, A., and co-authors.: Effects of the realistic vegetation cover on predictions at decadal time scale. In preparation.

van Oorschot, F., van der Ent, R. J., Hrachowitz, M., Di Carlo, E., Catalano, F., Boussetta, S., Balsamo, G., and Alessandri, A., 2023: Interannual land cover and vegetation variability based on remote sensing data in the HTESSEL land surface model: implementation and effects on simulated water dynamics, Earth Syst. Dynam., 14, 1239–1259, https://doi.org/10.5194/esd-14-1239-2023

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.

1. Porting of EC-Earth3 on HPC2020

We consider here a post-CMIP6 version of the model where IFS and NEMO are the same as in CMIP6 version (Doscher et al 2022), but where changes and specific updates are considered for the other components. In particular, an updated version of the LPJGuess dynamic vegetation model has been included. LPJGuess is used in its version 4 (Nord et al 2021): model updates include new shrub and high arctic plant functional types (PFTs); an improved wildfire model, SIMFIRE-BLAZE; high-latitude peatland vegetation and methane emissions; improved soil temperature calculations and permafrost; speciated BVOC emissions; improved managed forest representations; nitrogen transformations and trace gas emissions.
The porting started in 2023 with some test experiments (mostly pre-industrial control) even if the full model has been available only at the beginning of 2024. A specific need has been to have initial state for the historical simulation from a long pre-industrial control experiment and with a spin up also for the vegetation computed with LPJGuess offline and made available from colleagues at Lund University.

1.1 Off-line land-only configuration and test simulations forced by ERA5

An adaptation and reconfiguration of the Offline Surface Model (OSM) of EC-Earth has been required because several libraries and packages were updated to more recent versions and not supported anymore in the new HPC2020 machine. In particular, Atos HPC2020 no longer supports Python2, and only Python3 is available now.
In fact, several packages, scripts and configuration procedures used in the OSM of EC-Earth were originally written in Python2. Specifically, the following configurations needed to be adapted to run using Python3:
- Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land (HTESSEL) stand-alone,
- Lund-Potsdam-Jena General Ecosystem Simulator (LPJGuess) stand-alone,
- HTESSEL coupled to LPJGuess via OASIS (Craig et al., 2017).

In all the three configurations above, the scripts for generating the atmospheric forcing for the OSM from Observations/Reanalysis (or a previous IFS simulation) have been rewritten using Python3 new syntax and package features. Similarly, porting the scripts to convert files from NetCDF to Grib and handle Gaussian-reduced grids required a complete rewrite to ensure full compliance with Python3.

The OSM HTESSEL stand-alone configuration forced with ERA5 has been tested successfully in a 20-yr simulation, while tests for the LPJGuess stand-alone configuration and the coupled HTESSEL-LPJGuess configuration are currently underway.

2. Historical simulations with post-CMIP6 configuration of EC-Earth3 and with vegetation dynamics activated (LPJ-Guess) – preliminary results

The historical simulation with post-CMIP6 configuration of EC-Earth3 is produced with the vegetation dynamics activated (LPJGuess). The historical simulation should cover the period 1850-2014, following the CMIP6 protocol (Eyring et al 2016), and it is currently underway. The initialconditions at year 1850 are taken from a pre-industrial simulation of about 500 years produced at SMHI, and the initial conditions for the vegetation have been provided by Lund University and produced with LPJGuess offline and with boundary conditions taken from the pre-industrial control simulation. Some preliminary transient results for the global land integrals of the carbon pools (Figure 1) as well as of the Gross Primary Productivity (GPP), Net Primary Productivity and of the Net Biosphere Production (Figure 2) are provided below, considering the length of the simulation performed so far (1850-1939).

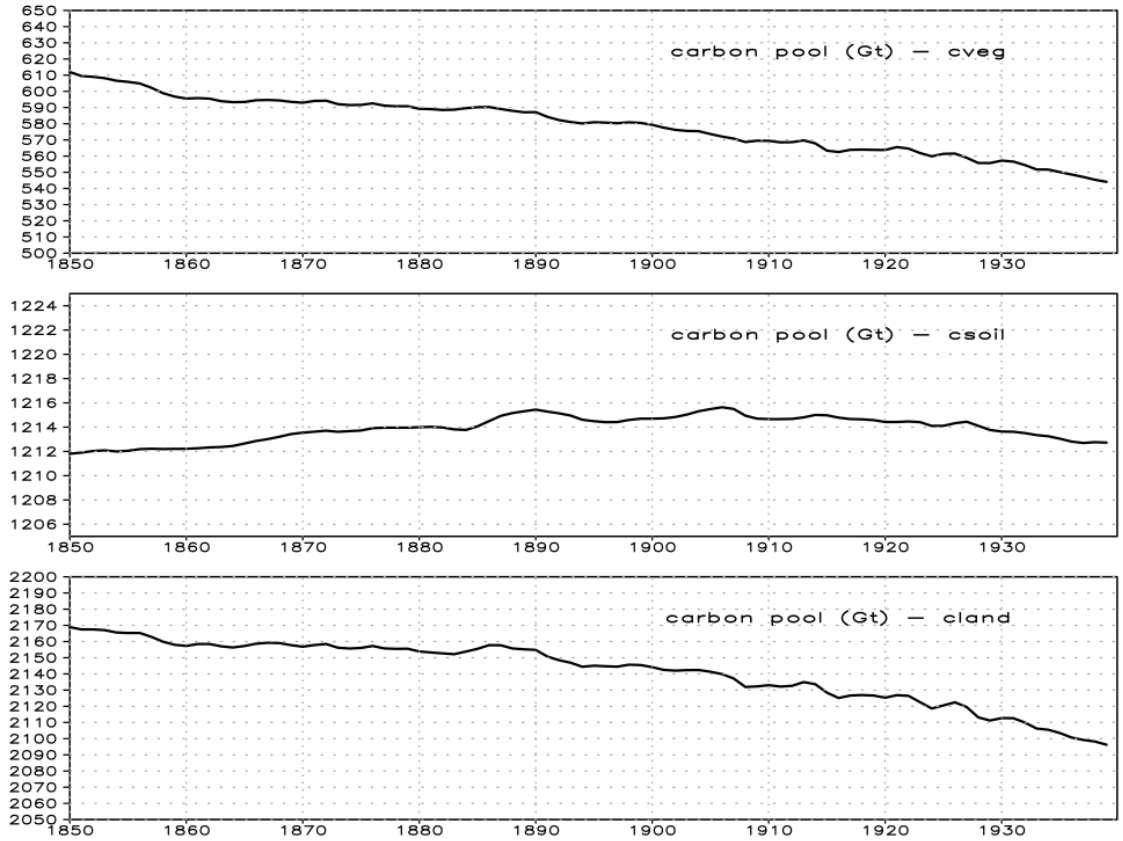

Figure 1: Time series of the total vegetation carbon pool (cveg; upper panel), of the soil carbon pool (csoil; middle panel) and total land carbon (cland=cveg+csoil; lower panel) integrated over global land areas.

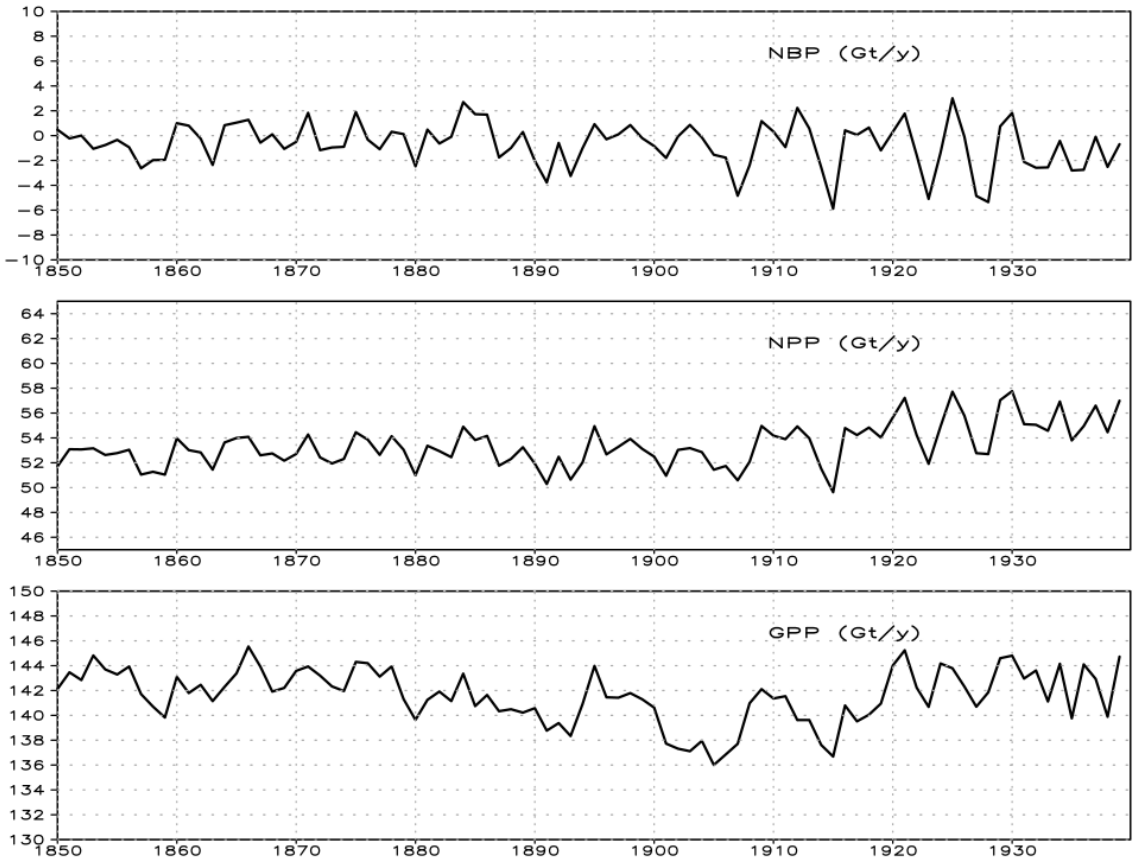

Figure 2: Same as Figure 1 but for Net Biosphere Productivity (NBP; upper panel), Net Primary Productivity (NPP; middle panel) and Gross Primary Productivity (GPP; lower panel).

References:

Craig, A., Valcke, S., and Coquart, L., 2017: Development and performance of a new version of the OASIS coupler, OASIS3- MCT_3. 0. GEOSCI MODEL DEV, 10(9).

Döscher, R., Acosta, M., Alessandri, A., Anthoni, P., Arsouze, T., Bergman, T., Bernardello, R., Boussetta, S., Caron, L.-P., Carver, G., Castrillo, M., Catalano, F., Cvijanovic, I., Davini, P., Dekker, E., Doblas-Reyes, F. J., Docquier, D., Echevarria, P., Fladrich, U., Fuentes-Franco, R., Gröger, M., v. Hardenberg, J., Hieronymus, J., Karami, M. P., Keskinen, J.-P., Koenigk, T., Makkonen, R., Massonnet, F., Ménégoz, M., Miller, P. A., Moreno-Chamarro, E., Nieradzik, L., van Noije, T., Nolan, P., O'Donnell, D., Ollinaho, P., van den Oord, G., Ortega, P., Prims, O. T., Ramos, A., Reerink, T., Rousset, C., Ruprich-Robert, Y., Le Sager, P., Schmith, T., Schrödner, R., Serva, F., Sicardi, V., Sloth Madsen, M., Smith, B., Tian, T., Tourigny, E., Uotila, P., Vancoppenolle, M., Wang, S., Wårlind, D., Willén, U., Wyser, K., Yang, S., Yepes-Arbós, X., and Zhang, Q.(2022) The EC-Earth3 Earth system model for the Coupled Model Intercomparison Project 6, Geosci. Model Dev., 15, 2973–3020, https://doi.org/10.5194/gmd-15-2973-2022

Eyring et al (2016) “Overview of the coupled model intercomparison project phase 6 (CMIP6) experimental design and organization” GMD https://doi.org/10.5194/gmd-9-1937-2016

Nord, J., Anthoni, P., Gregor, K., Gustafson, A., Hantson, S., Lindeskog, M., Meyer, B., Miller, P., Nieradzik, L., Olin, S., Papastefanou, P., Smith, B., Tang, J., Wårlind, D., & and past LPJ-GUESS contributors. (2021). LPJ-GUESS Release v4.1.1 model code (4.1.1). Zenodo. https://doi.org/10.5281/zenodo.8065737