Project: **891**
Project title: **Forest management in the Earth system**
Principal investigator: **Julia Pongratz**
Report period: **2025-11-01 to 2026-10-31**

| | Allocated for 2026 | Consumed (26. Oct 2026) | Projection of consumption by end of 2026 |
|---|---|---|---|
| Computing time [node hours] | 41082 | 30563 (including 3650 expired) | 41082 |
| Levante storage [TiB] | 603 | 466 | 600 |
| Archive project [TiB] | 232 | 20 | 50 |
| Long term archive [TiB] | 56 | 0 | 0 |

The scientific work under bm0891 during the reporting period focused on a more profound understanding and better quantification of land-related carbon fluxes, applying and developing process-based (JSBACH) and bookkeeping models (BLUE), and assessing Earth system consequences.

**BLUE**

In 2026, we contributed to GCB2026 (Friedlingstein et al., 2026, under review), we finished the development of new datasets of (1) spatially explicit carbon stocks and (2) enhanced Plant Functional Types (PFTs), including their implementation in BLUE. The corresponding manuscripts (1) Ganzenmüller et al. (under review) and (2) Jäschke et al. (2026, under review) were submitted to peer-reviewed journals. Work on obtaining comparable CO2 removal estimates through re-/afforestation from bookkeeping models and national GHG inventories began. To this end we adjusted the temporal accounting scheme in BLUE, making it spatially explicit, and ran first simulations with it. In parallel, we continued restructuring the BLUE code base, focusing on optimization, flexibilization, improved computational efficiency and better use of the DKRZ HPC system resulting in an updated model version BLUEv2. A new methodology based on flexible vegetation recovery curves has been introduced in BLUE to improve the representation of post-disturbance carbon recovery. Various Earth-observation-based vegetation recovery datasets were collected and evaluated, and suitable datasets were pre-processed to support the implementation of more realistic and flexible recovery curves in BLUE. In addition, we conducted BLUE simulations using future LUH3 land-use scenarios to assess how different land-use pathways influence future carbon emissions and removals associated with land-use change and management activities.

**TRENDY**

For participation in GCB2026, simulations with JSBACH3.2 (extended by PFT-level output) were conducted following the TRENDY protocol. Updated data for land use and wood harvest from LUH2-GCB2026, population density, climate and CO2 were transferred to Levante and remapped to T63 resolution. A model spin-up of 5000 years was necessary to reach the specified target accuracy of the equilibrium state. Differently to previous years, three additional experiments had to be run this year. Reason for that was the adjustment of the calculation of the land carbon sink to not account for forest that was already deforested historically anymore. Therefore, in total seven experiments (7x225 years) were conducted branching off the spin-up. Jupyterhub was used to monitor and visualize the progress of the model integrations and results. Aside of the inclusion into GCB2026, our results will be made available to the wider scientific community as part of TRENDYv15 and are also included into the most recent inter-comparison and benchmarking of land surface models at a global and regional scale (ILAMB; link to last year's TRENDY v14). Four spin-off studies including last year's JSBACH3.2 TRENDY v14 data are already in review (Chen et al., Huang et al., Rosan et al., Zhang et al.), while three spin-off studies using JSBACH3.2 TRENDY v13 data were published in 2026 (Dong et al., 2026; Endsley et al., 2026; O'Sullivan et al., 2026).

**WETSCAPES2.0**

In 2026, we developed a peatland implementation in JSBACH3.2 focusing on the representation of typical vegetation, hydrological and soil processes in rewetted peatlands. Mainly, we implemented (1) a new plant functional type representing typical vegetation on rewetted fens based on common reed, (2) a new reed phenology logic more accurately describing reed growth throughout the year and (3) a simple waterlogging scheme allowing simulations under water-saturated conditions. We ran test simulations in

standalone JSBACH3.2 for the domain of Mecklenburg-Vorpommern during model development as well as some longer simulations used for comparison to observational data. A technical paper to describe the implementation and behavior of the new peatland module is planned (Raberg et al, in prep.).

**RESCUE**

Within RESCUE, we ran emission-driven MPI-ESM1.2-LR simulations with interactive carbon dioxide removal (CDR) for the four RESCUE Tier-1 scenarios: two pairs (500 and 1150 $GtCO_2$) of a non-overshoot and an overshoot pathway (500os, 1150os) reaching the same carbon budget and global mean temperature by 2100. For each scenario, four members with all CDR options (BECCS, afforestation and ocean alkalinity enhancement simulated interactively, DACCS prescribed) and four without CDR were run for 2015–2100, branching from four emission-driven historical runs; one member per scenario was extended to 2300 (Fig. 1). Concentration-driven no-CDR runs prescribed with the $CO_2$ of the CDR runs, started in October 2026, will separate $CO_2$-mediated from direct effects of CDR (Schwinger et al., 2026). First analyses compare daily heat extremes between overshoot and non-overshoot pathways at matched warming, together with CMCC-ESM2 and FOCI (Gupta et al., in prep.). There are also several multimodel intercomparison analysis currently underway, e.g., on BECCS uncertainty quantification (Bernardello et al., in prep.), response of carbon and nitrogen cycle components to overshoot (Cardeli et al., in prep.), biodiversity impacts (Bauer et al., in prep.).

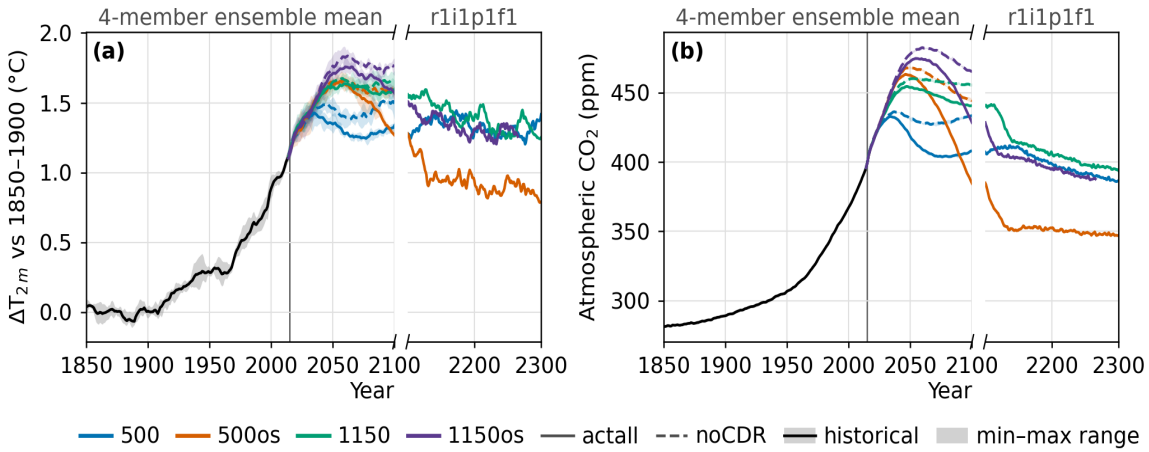



*Figure 1: Global-mean (a) 2 m temperature anomaly w.r.t. 1850–1900 and (b) atmospheric CO2; ensemble mean and min–max of four members, after 2100 one member; solid: with CDR, dashed: without CDR.*

**ForestNavigator**

In the first half of 2026, analysis focused on pre-existing data sets, so little computing time was needed. After that, setting up and debugging the limited are model (LAM) configuration for the coupled ICON/JSBACH4 simulations took longer than expected. The coupled, resource-intensive simulations are therefore only starting now. Therefore, the remaining resources from the current allocation period are expected to be used by the end of the year.

**LabForest**

In 2026, we emulated forests with the dynamic vegetation model FORMIND, testing different forests management and climate forcing from REMO2009. Analyzing the results allowed to see different drought sensitivity depending on the considered forest management. The end of the year will be used to implement new equations in the model, aiming at representing the impact of deadwood retention on water dynamics. We are currently preparing a paper which has two goals: The first is to describe the implementation of deadwood water dynamics in FORMIND, and the second is to quantify the impact of deadwood water retention and advance regeneration on drought resilience (Bechon et al., in prep).

**LUMIP**

In 2026, we pre-processed and analysed CMIP6 model outputs to assess the impact of land-use change on the Atlantic Meridional Overturning Circulation and extended our analysis to the impact on atmospheric circulation as well. Two manuscripts (Amali et al., *in prep*) evolved from these analyses, one currently in draft and the other in preparation for submission.