Project: 1255

Project Title: ESM2025

Principal Investigator: Tatiana Illyna

Report period: 2023-11-01 to 2024-10-31

1 Resource usage

	Allocated for 2023	Consumed (Oct 2024)	Projection of consumption by end of 2024
Computing time [node-hours]	304680	178788	255208
Temporary storage [TiB]	626	567	626
Storage / arch [TiB]	75	0	15
Long term storage [TiB]	13	0	0

2 Outcomes and experiments

WP2: MPI-BGC moved forward with the integration of QUINCY in ICON-Land (IQ). We conducted ICON-Land standalone simulations for model evaluation using QUINCY in different configurations with (1) only biogeophysical processes and (2) also biogeochemical processes enabled, and compared these simulations to observational-based data and to a JSBACH4 simulation using ILAMB. Preliminary analysis show a good agreement on the global scale (see e.g. Fig.1) but also indicated that further revisions/parameter adjustments are required to conform to ILAMB benchmarks.

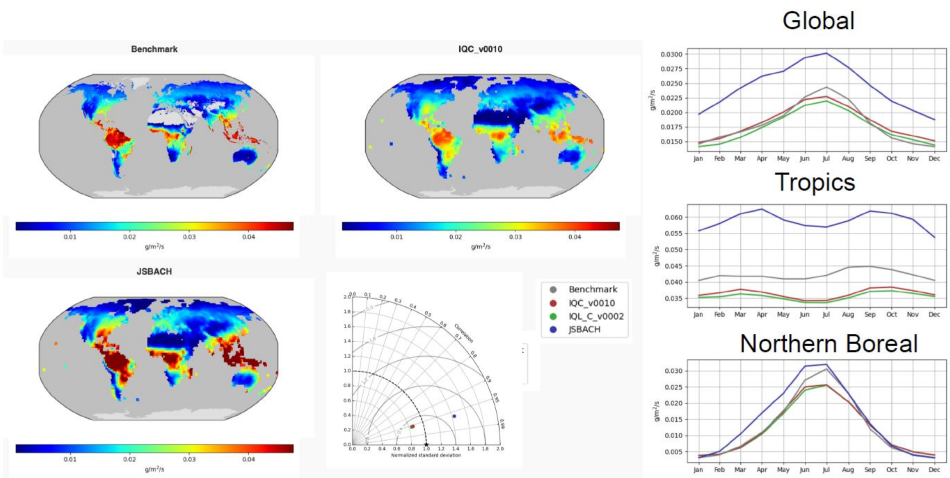

Figure 1: ILAMB comparison for simulated present-day evapotranspiration from TRENDY like simulations using (1) **JSBACH**4, (2) **IQL_C**: QUINCY running with C-cycle model, in which neither nitrogen nor phosphorus limitation is enabled and (3) **IQC**: QUINCY in CANOPY mode, where only biogeophysical processes are enabled.

WP3/WP6: We setup HAMOCC in ICON-XPP and slightly tuned the model in the R2B4/R2B6 and R2B5/R2B6 pi-Control setups. After fixing a few bugs, our first simulations show that HAMOCC results are in good agreement with observations but further tuning is required. Since the postdoc position for ESM2025 could not be filled this year, we mainly used our computation time to further run our high-resolution, 10km simulations. In our 10km ICON-O-HAMOCC simulations, we included the budget terms for advection, diffusion and sources and sinks of obgc tracers (for 30 years) to further distinguish the processes impacting the carbon uptake in the Southern Ocean. The manuscript for these new runs are in preparation. Furthermore, to evaluate the model drift (in the 10km setup), we ran the model for pi-Control conditions for 30 years.

WP4: At MPI-M implemented and tuned the TOPMODEL wetland and WEED ponding schemes as well as ported the natural terrestrial methane module (Fig. 2) from MPI-ESM into ICON-Land. Also we changed the atmospheric ICON version from RUBY (ECHAM physics) to XPP (DWD physics) of the source branch in which we develop the methane module.

As preparation to facilitate an ICON-ESM version with an interactive global methane cycle, we build in estimation of natural terrestrial production and release of trace gases important for the atmospheric lifetime of methane (CO, NO, Isoprene).

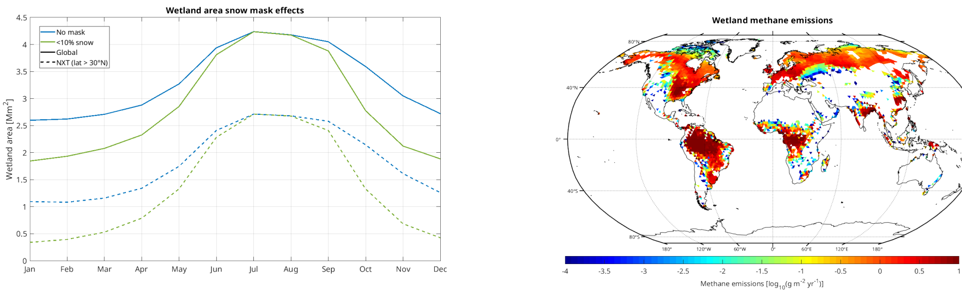

Figure 2: Left: Yearly cycle of wetland extend, in- or excluding snow masking for global and nothern extratropics. Right: Distribution of global methane wetland emissions.

WP10: Our implementation of a 2nd generation bioenergy crop PFT representing Miscanthus was finalized in JSBACH3.2 based on an improved plant-physiological parameter set (Nützel. T, 2024) and was published in Egerer et al. 2024. The new PFT was included in standalone JSBACH simulations to investigate and compare the impact of different land-based carbon dioxide removal (CDR) options on the carbon cycle and the surface energy budget across four land surface models (JSBACH, JULES, CLM, ORCHIDEE). Three spin-ups and historical runs were run as a basis for 24 idealized future experiments where a small land cover fraction of each grid cell was converted to CDR in 2015 and kept constant afterwards (agricultural land to bioenergy crop, agricultural land to re-/afforestation, natural land to bioenergy crop, reference without change; all based on two background climates, SSP1-2.6 and SSP3-7.0 from three ISMIP3b GCMs). Disturbances from fire and wind-throw were switched off in these simulations. The simulation output was transferred to the Spirit servers of our project partners at IPSL. Publications based on these simulations are being prepared.

JSBACH4 standalone simulations within the ICON infrastructure, are conducted at an R2B4 horizontal resolution (around 158 km), using the "maps" land cover change scheme. This approach captures changes in land cover fractions without explicitly modelling transitions between land cover types. In this "maps" option, the fraction of a particular land cover type can sometimes remain unchanged even after a transition and therefore the transitions are ignored, as well as the changes in corbon relocation due to these transitions. These results highlight the necessity of incorporating a more dynamic land use transition scheme into JSBACH4. Conceptual and practical work on implementing the "land use transition" scheme into ICON-LAND within JSBACH4 is underway. The implementation of "Land Use Transition" is designed to support applications that require various Plant Functional Types (PFTs), such as representation of herbaceous biomass plantations (HBPs). This process will also include implementing carbon relocation to account for shifts in land use (Account for active carbon (different tiles and pools) and passive carbon (different tiles, same pool) in the relocation process).

3 Publications and Presentations

Egerer, S., Falk, S., Mayer, D., Nützel, T., Obermeier, W., and Pongratz, J. (2024). How to measure the efficiency of terrestrial carbon dioxide removal methods, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-1451.

Nützel, T. (2024). Calculation of parameter values based on observations for the herbaceous biomass plantation PFT representing Miscanthus in JSBACH3.2 (1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.11193881.