Project: **1202**

Project title: **Modelling the impact of global change on the terrestrial biosphere with LPJ-GUESS**

Principal investigator: **Matthew Forrest**

Report period: **2025-11-01 to 2026-10-31**

*Maximum of 2 pages including figures. 9 pt minimum font size.*

## ISIMIP Simulations

The main ISIMIP 3a and 3b simulations planned for this year were, unfortunately, delayed due to a holdup on the main LPJ-GUESS trunk version. A new input module, which includes much of the functionality required for implementing the ISIMIP protocol, was expected much earlier but was only finally integrated into the trunk LPJ-GUESS version in mid-September. We are currently pulling together other key enhancements from the LPJ-GUESS community including: a revised snow scheme which improves high latitude temperatures (essential for the permafrost sector) which has been well-validated and published (Pongracz et al. 2021) but not yet merged into the model trunk; recalibration of the SIMFIRE-BLAZE fire model; and adjustments to the irrigation scheme required for the agricultural sector. Additional outputs will also need to be added, but a small group LPJ-GUESS members has been actively cooperating on this. So whilst it is regrettable that these simulations were not performed with last year's computing time, the pieces are in place to do them in the upcoming period. As detailed below and in the request, we believe they will be widely used, and so the scientific case is still strong and they remain a worthwhile endeavour.

## ISIMIP Fire Sector Future Burnt Area Analysis

Currently the ISIMIP fire sector is working on the first consistent multi-model assessment of future burnt area under climate change. This analysis is led by PI Forrest, preliminary plots are shown in Fig 1. These simulations only include changing climate forcing, with socioeconomic forcings held constant. Despite this, the ensemble spread is large, this is particularly surprising in temperate and boreal zones where would expect a strong response to climate warming. LPJ-GUESS-SIMFIRE-BLAZE, which is one of the better validated fire-veg models, is missing from the ensemble but would be a valuable addition. There is therefore high motivation to perform the corresponding ISIMIP3a historical (required for the model skill weighting) and 3b (the future scenarios) simulations to expand the ensemble for this important analysis. This publication is targeted for the IPCC AR7 WG I report, so these simulations are time sensitive and high priority.

## Other ISIMIP3 Analyses

There are many other analyses planned and ongoing in the biome, fire and permafrost sectors to which LPJ-GUESS-SIMFIRE-BLAZE simulations can contribute. In particular there is a cross-sectoral project from PIK about biosphere integrity and planetary boundaries for LPJ-GUESS-SIMFIRE-BLAZE has been identified as particularly valuable. Other ongoing activities include: global and regional permafrost evaluation; biome model evaluation; carbon-nutrient interactions during permafrost thaws; examination of the effects of N-cycling; and future fire regimes which fully transient direct human forcing.

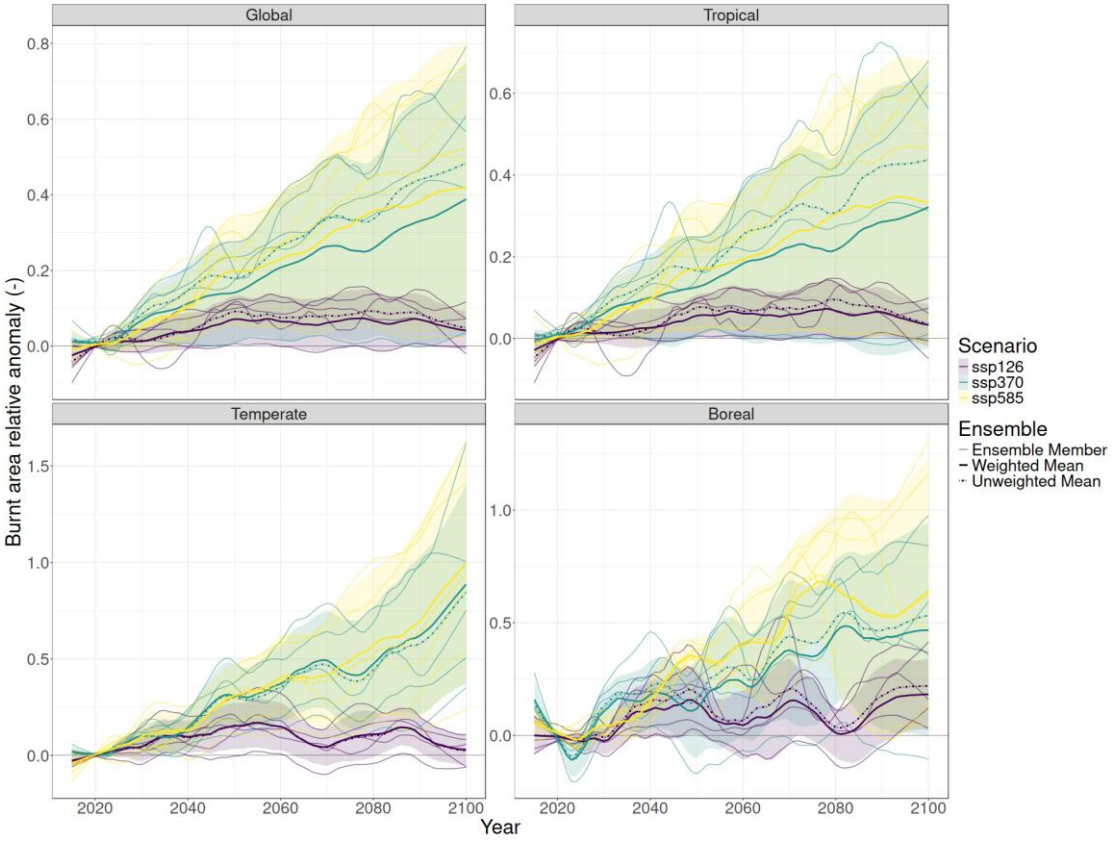



Fig 1. Ensemble means and individual members of a five-member fire-vegetation model ensemble. Direct human forcings are held constant, so changes are only due to climate forcing.

## Additional – implementing Eco-Evolutionary Optimality into LPJ-GUESS

Some of the year's compute resources were used for the finalising the implementation of an optimality-based photosynthesis scheme (the P-model) into LPJ-GUESS. The implementation improves the representation of photosynthesis against both FLUXNET and remotely-sensed GPP, reduces runtime, and removes reliance on poorly-constrained model parameters. The resulting paper has now been accepted in GMD (Forrest et al. 2026).

## References

Forrest, Matthew, Mateus Dantas de Paula, Filipe Gomes de Almeida, Sandy P. Harrison, I. Colin Prentice, and Thomas Hickler. 2026. 'Leveraging Leaf-Level Optimality Processes with Explicit Acclimation Improves Global GPP Representation in an Individual-Based DGVM (LPJ-GUESS v4.1.1)'. *Geoscientific Model Development* (accepted):1–57. doi:10.5194/egusphere-2026-3273.

Pongracz, Alexandra, David Wårlind, Paul A. Miller, and Frans-Jan W. Parmentier. 2021. 'Model Simulations of Arctic Biogeochemistry and Permafrost Extent Are Highly Sensitive to the Implemented Snow Scheme in LPJ-GUESS'. *Biogeosciences* 18(20):5767–87. doi:10.5194/bg-18-5767-2021.