



# LUND UNIVERSITY

## State-of-the-art capabilities in LPJ-GUESS

Eckes-Shephard, Annemarie; Nieradzik, Lars; Pugh, Thomas; Gustafson, Adrian; Lindeskog, Mats; Wårlind, David; Smith, Benjamin; Olin, Stefan; Papastefanou, Phillip; Pongrácz, Alexandra

2022

*Document Version:*  
Other version

[Link to publication](#)

*Citation for published version (APA):*

Eckes-Shephard, A., Nieradzik, L., Pugh, T., Gustafson, A., Lindeskog, M., Wårlind, D., Smith, B., Olin, S., Papastefanou, P., & Pongrácz, A. (2022). *State-of-the-art capabilities in LPJ-GUESS*.

*Total number of authors:*  
10

*Creative Commons License:*  
CC BY-NC

### General rights

Unless other specific re-use rights are stated the following general rights apply: Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117  
221 00 Lund  
+46 46-222 00 00



LUND UNIVERSITY

# State-of-the-art capabilities in LPJ-GUESS



ANNEMARIE H. ECKES-SHEPHARD, ADRIAN GUSTAFSON, MATS LINDESKOG, PAUL A. MILLER, LARS NIERADZIK, STEFAN OLIN, PHILLIP PAPAŞTEFANOU, ALEXANDRA PONGRACZ, THOMAS A. M. PUGH, BEN SMITH, JING TANG, DAVID WÄRLIND AND THE LPJ-GUESS DEVELOPMENT CONSORTIUM

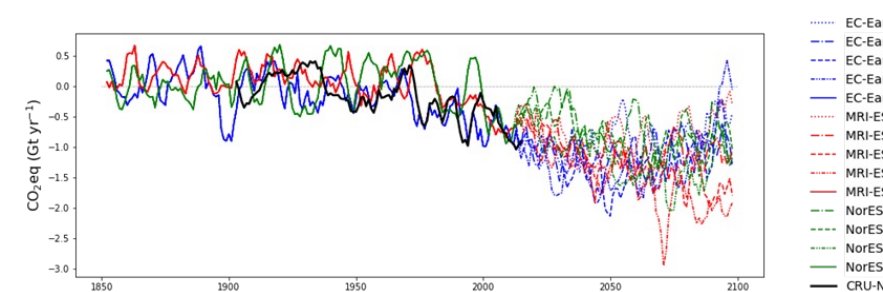
Department of Physical Geography and Ecosystem Science Lund University, 223 62 Lund, Sweden

## Overview

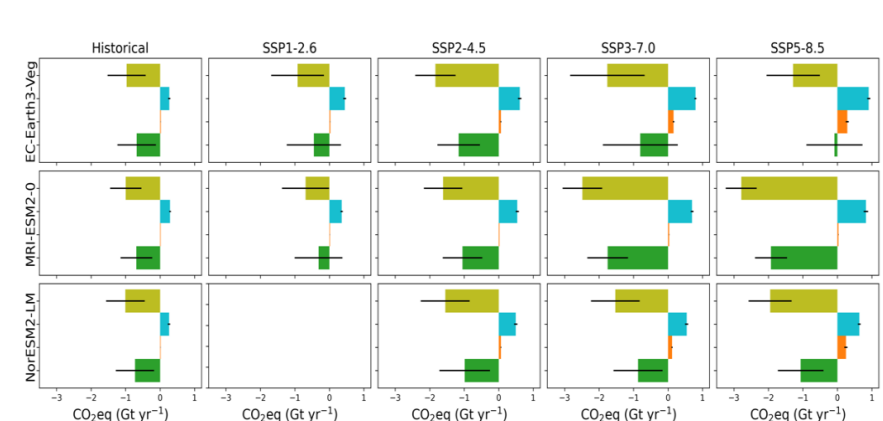
LPJ-GUESS is an advanced DGVM including detailed forest demography and management, croplands, wetlands, specialised arctic processes, emissions of non-CO<sub>2</sub> GHGs and a highly flexible land-use change scheme which tracks transitions between different land-uses. It is the vegetation component of the EC-Earth CMIP6 ESM, the RCA-GUESS regional ESM, and also has a European mode operating at tree species level.

## Dedicated high-latitude features

- High-latitude shrub and tundra PFTs
- Peatland PFTs and biogeochemistry, incl. CH<sub>4</sub>
- Improved soil physics and biogeochemistry, including permafrost, wetland hydrology, soil N<sub>2</sub>O emissions



Simulated annual CO<sub>2</sub>-eq indicate an increased sink for a domain containing land points north of 60°N, from 1850-2100. Forcing from three bias-corrected CMIP6 ESMs and CRU-NCEP for reference.

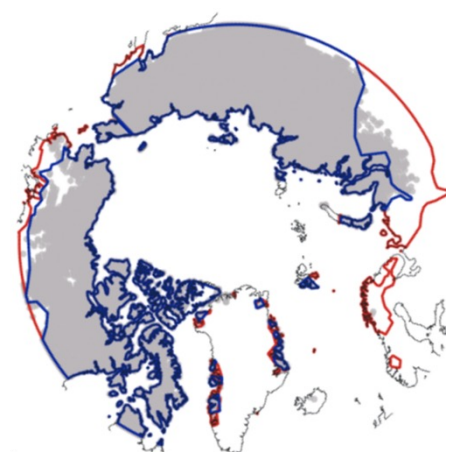


Decadal-averaged CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O and net CO<sub>2</sub>-eq for the historical and end-of-century periods, showing that the net emissions are both ESM and SSP-dependent but uptake is greater in the warmer scenarios (Gustafson et al. in prep.)

- Annual CO<sub>2</sub>-eq estimates indicate an increased sink, with increased CO<sub>2</sub> uptake (treeline advance, increased tree and shrub growth) only partially counteracted by greater respiration and CH<sub>4</sub> and N<sub>2</sub>O emissions

Arctic cold-season focus:

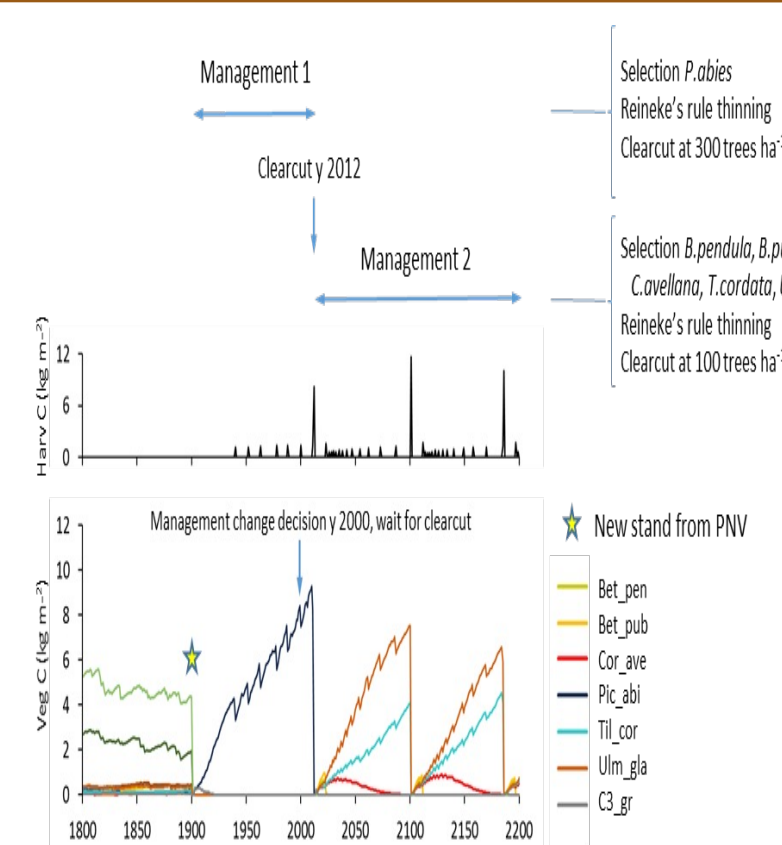
- Dynamic, multi-layer snow scheme
- Improved permafrost extent
- Improved near-surface soil temperature



Simulated and literature-estimated permafrost extent.

new snow scheme  
static snow scheme  
literature estimate

## Forest management



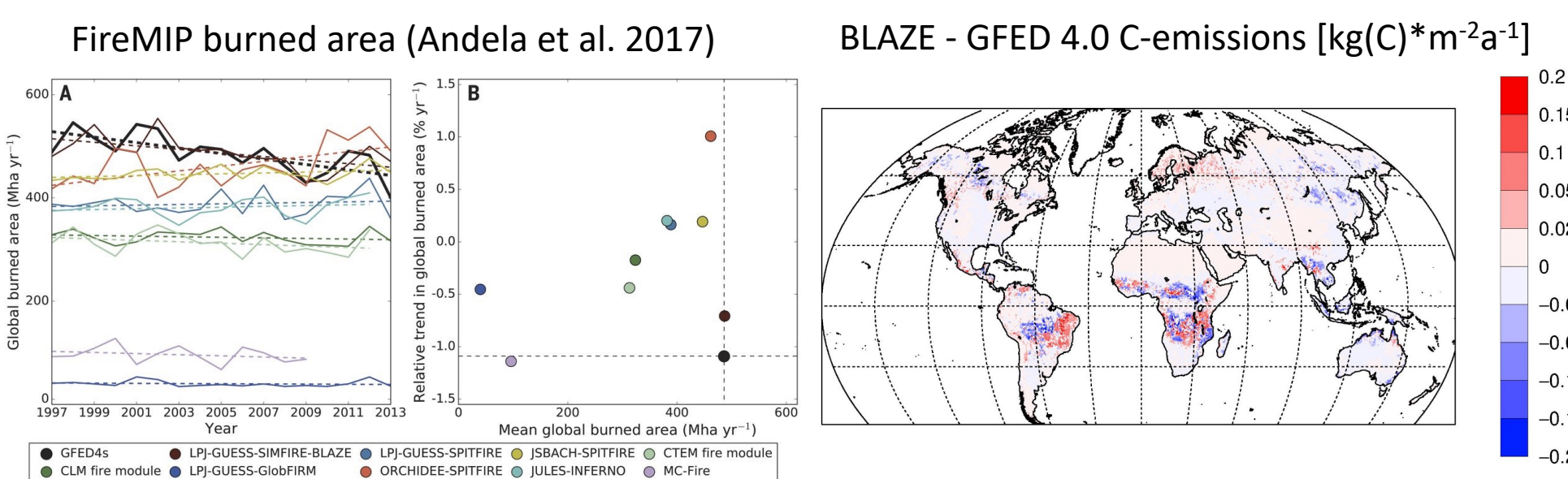
Automated harvest examples and management changes.

- Forest initialization: Land-use history, species & age structure
- Harvest alternatives: Clearcut w. thinnings/ continuous Automated/ fixed (detailed)
- Management change

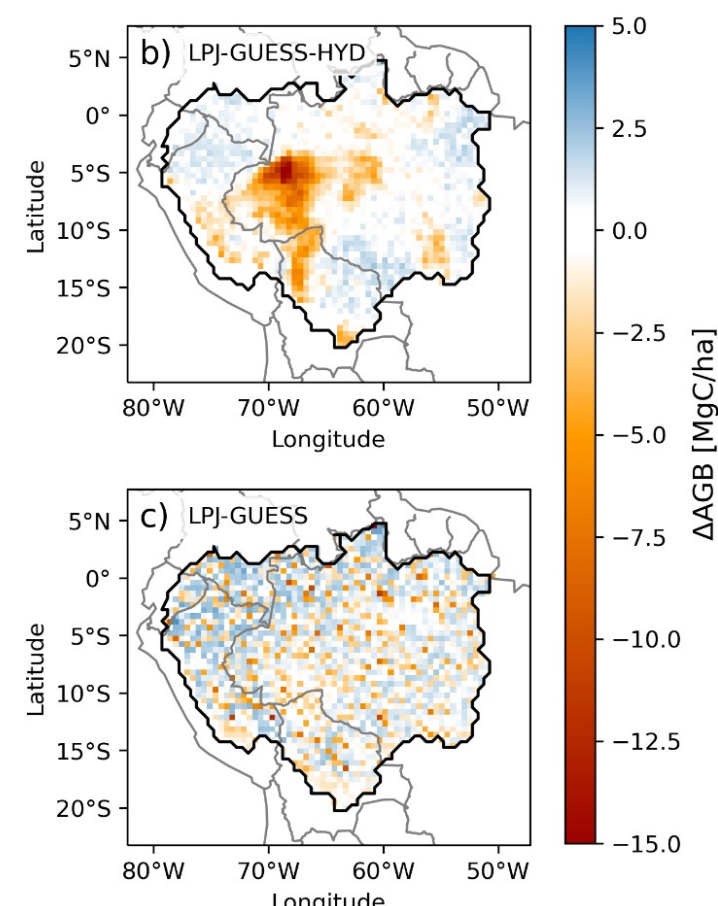
## Fire dynamics

The wildfire model SIMFIRE-BLAZE provides

- Daily burned-area and C,N turnover
- Fire-line Intensity (FLI) based on fuels and fire-weather
- Biome specific tree-mortality based on allometry and FLI
- Combustion completeness depending on FLI



## Plant hydraulics\*



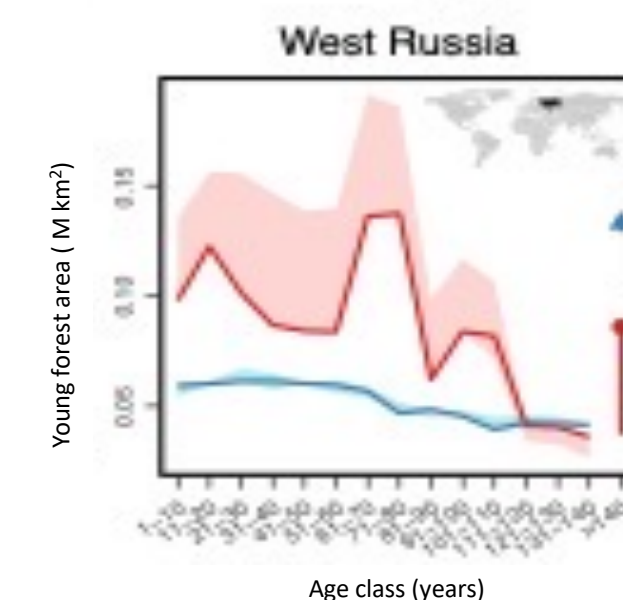
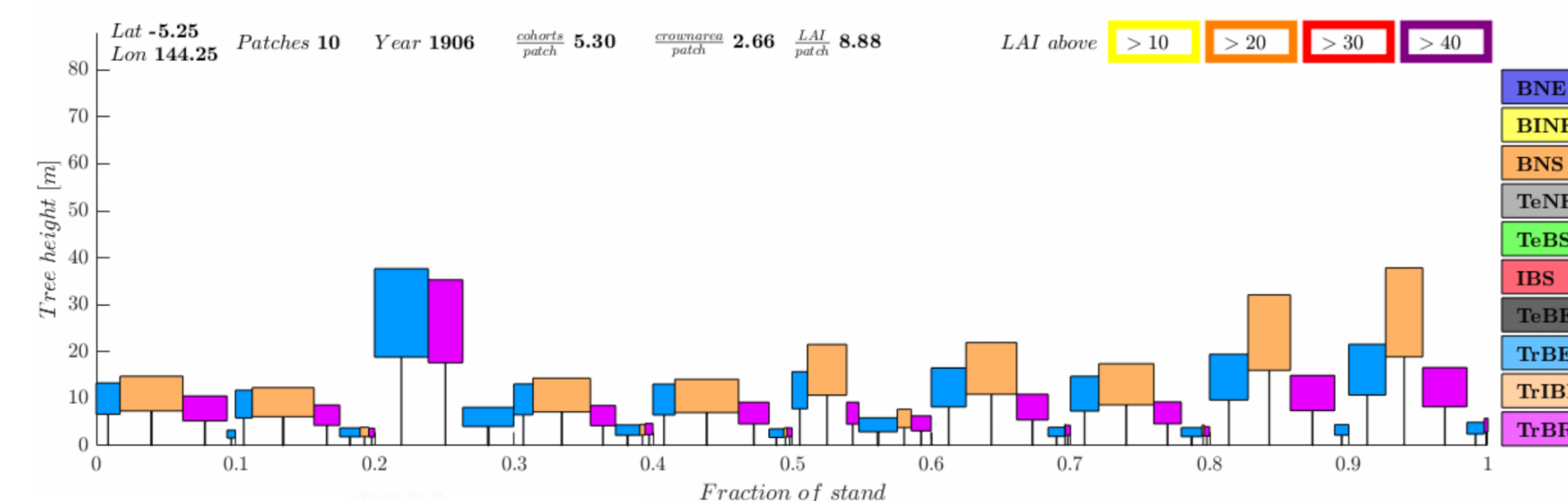
- Based on Darcy's law and the water supply-demand principle
- Simulates different plant hydraulic behavior (e.g., early vs late stomatal closure) under drought stress
- New mechanistic drought induced tree mortality based on hydraulic failure

Impact of the 2005 drought event on the Amazon basin. **Top:** Simulated net change in aboveground biomass of LPJ-GUESS with new hydraulic architecture. **Bottom:** Simulated net change in aboveground biomass of standard LPJ-GUESS

\* Not included in release 4.1.

## Detailed forest demography

- Direct competition between tree cohorts of different sizes and functional type
- Explicit representation of stand age due to disturbance. (fire, wind, beetle) or land-use change



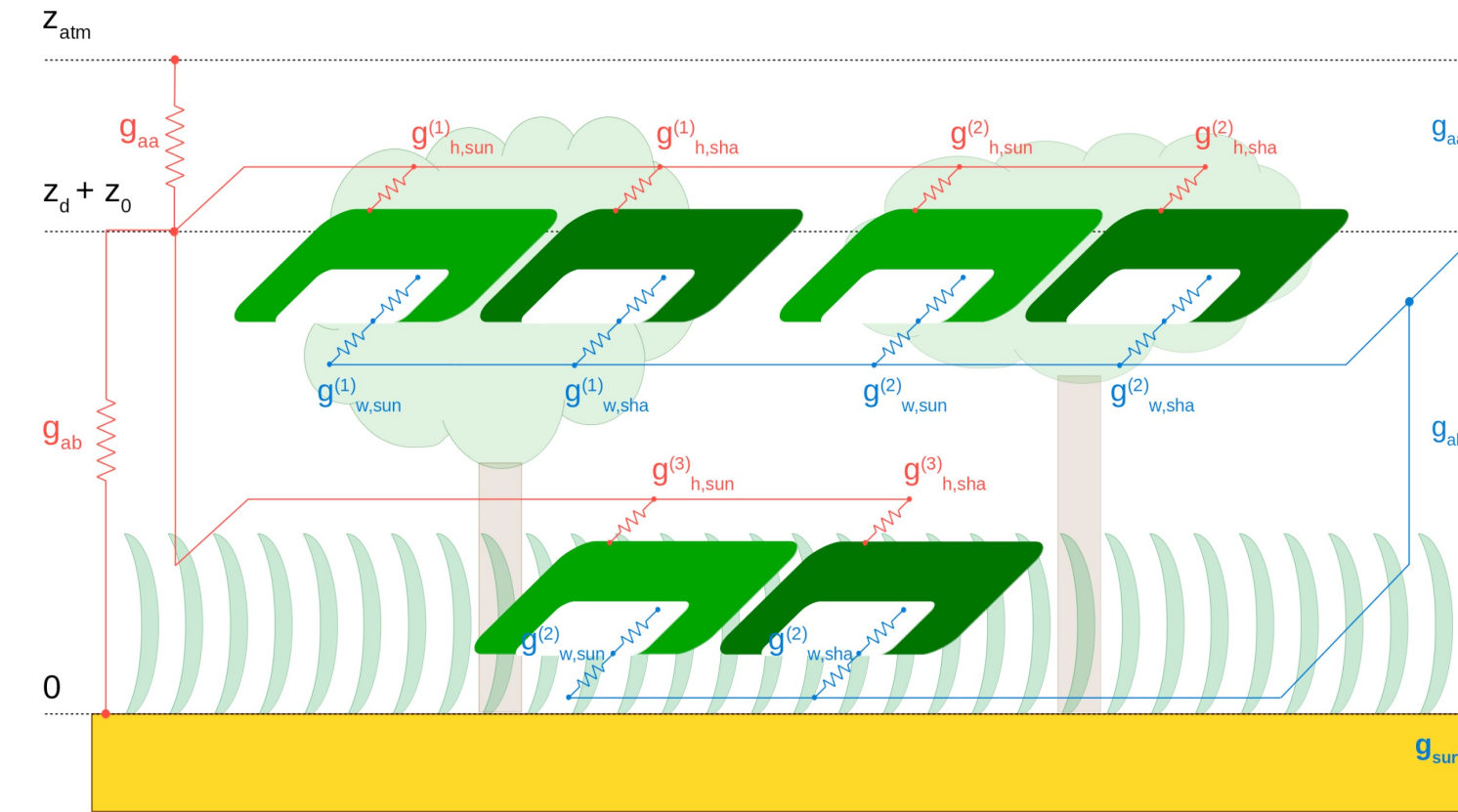
**Above:** Example tree size structure in a simulation with 10 replicate 1000 m<sup>2</sup> patches. Cohorts compete for light, water and nutrients within the same patch.

**Left:** Example forest age structures simulated by LPJ-GUESS with natural disturbances only (blue) and including land-use and management (red). Carbon fluxes follow from the age distribution.

## Energy Balance\*

- New surface energy balance feature allows use as full Land surface model

Networks of sensible (red) and latent (blue) heat exchange between the ground surface, the canopy and the atmosphere in the patch. Light green indicates the sunlit fraction of the cohorts, dark green the shaded fraction.



## Other developments, usage and collaboration

Full Atm-Canopy-Surface energy balance closure, coupling to regional climate model, BVOCs, P cycling, daily plant carbon allocation, flexible multi-layer OM-scheme.

We welcome collaborations for application of features under active development or new feature development. Please contact [lpj-guess@nateko.lu.se](mailto:lpj-guess@nateko.lu.se)



References & Model-access