GFDL Land Model LM4

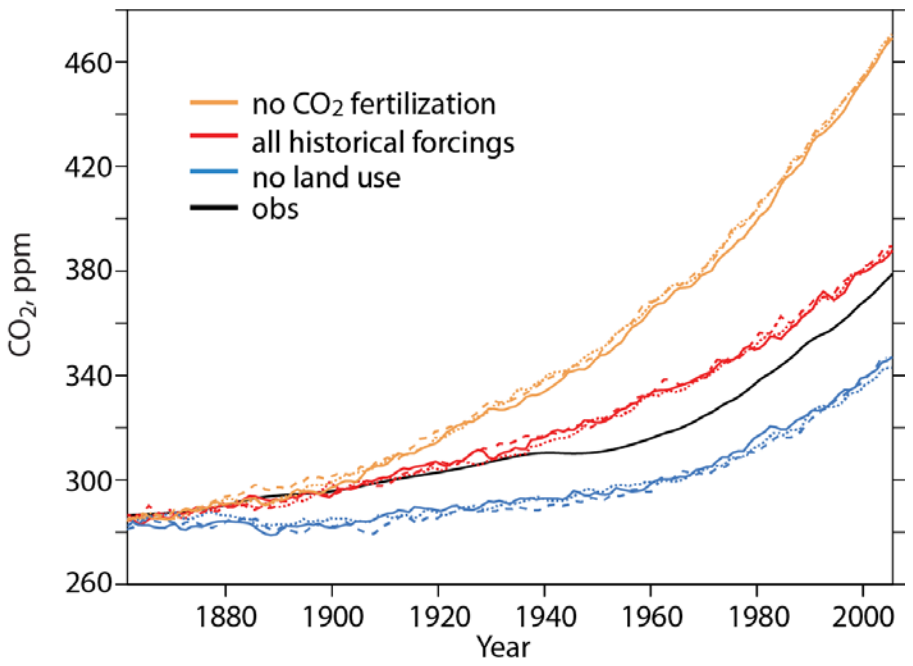
Elena Shevliakova

P.C.D. Milly, S. Malyshev, B. Sulman, D. Ward, N. Chaney, I. Martinez Cano, M. Lee, P. Gauthier, D. Li, P. Phillips, M. H. van Huijgevoort, S. Evans, S. Smolander, P. Ginoux, S. Pacala, and others

Geophysical Fluid Dynamics Laboratory Fall Science Symposium

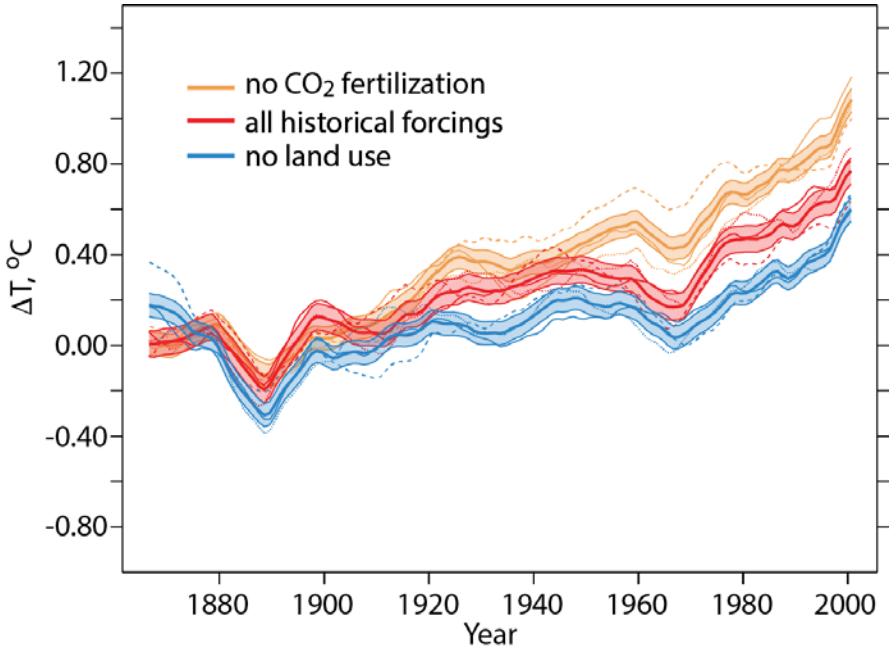
November 2, 2017

LM3 is component of CM3 , ESM2M, and ESM2G prognostic atmospheric CO_2 and climate



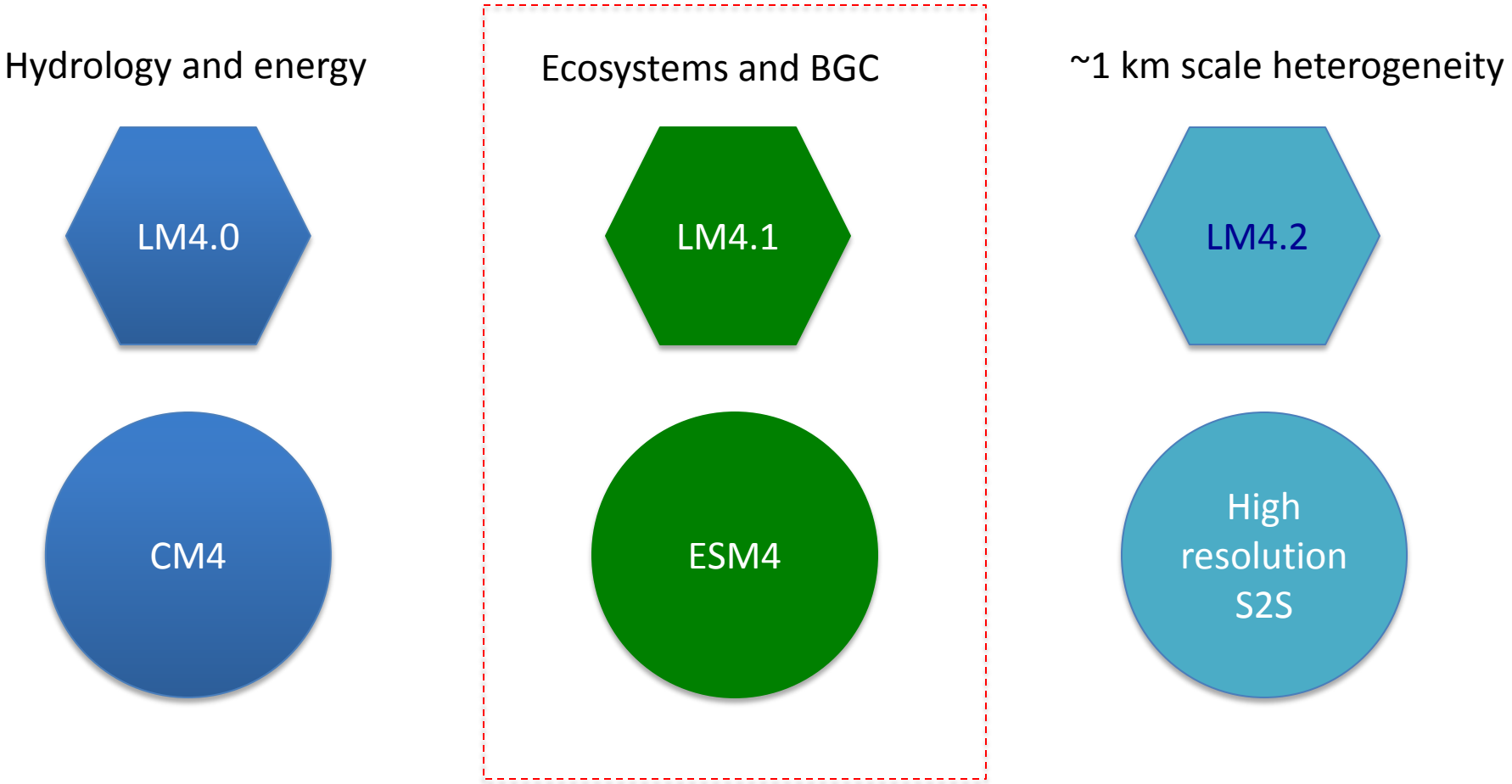
- Land use emissions contributed ~30 ppm to the current atmospheric CO_2 and increased surface temperature by 0.17±0.06°C;

- Without enhanced vegetation growth :
  - Atmospheric CO_2 would be 85 ppm higher;
  - Global surface temperature would be 0.31±0.06°C higher;



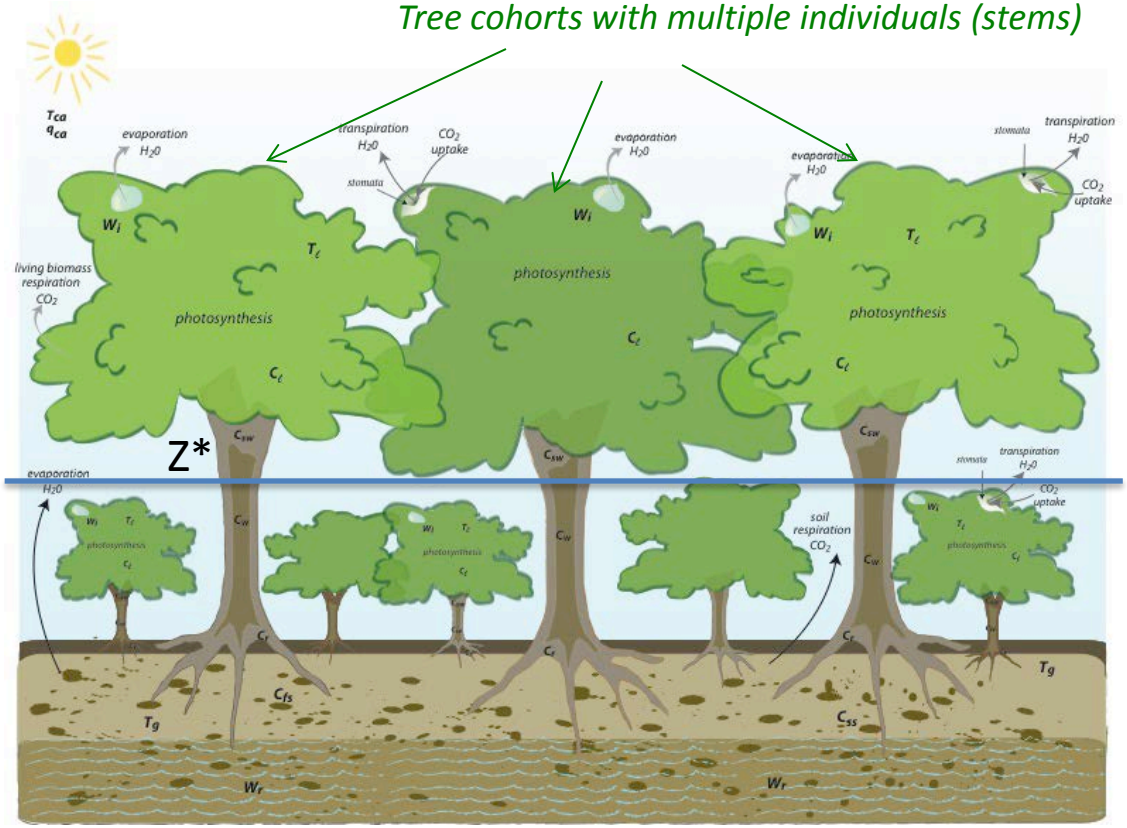
Shevliakova et al, 2013

Improved land modeling capabilities

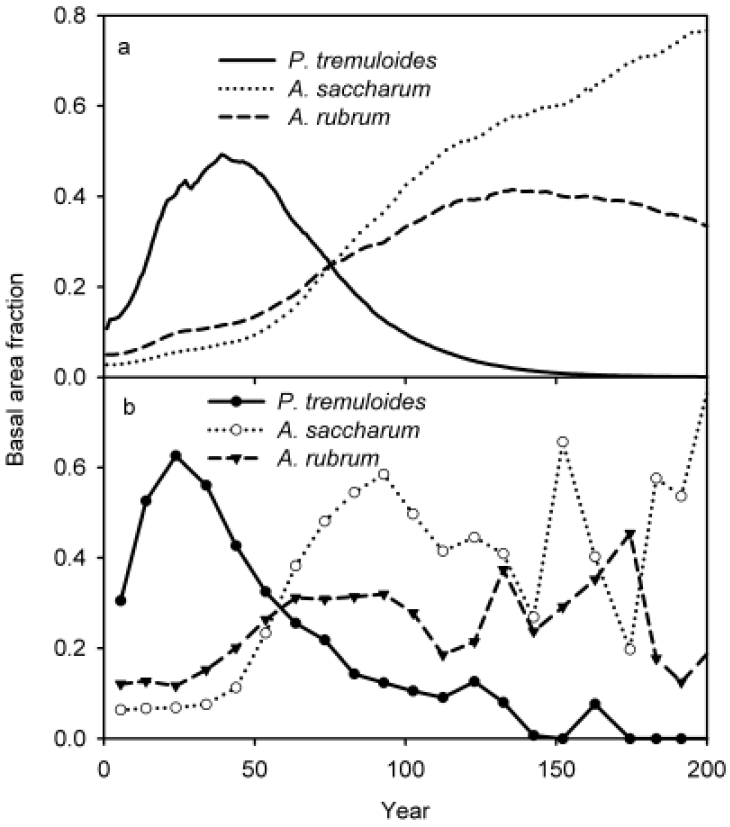


Perfect Plasticity Approximation (PPA) Vegetation Dynamics: we can see forests and the trees in LM4

Tree cohorts with multiple individuals (stems)



Willow Creek, WI



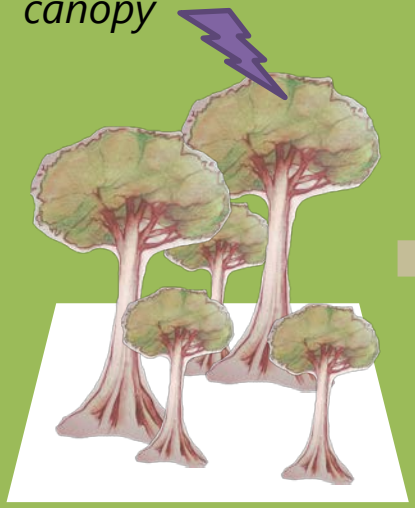
- *Challenges for global PPA*
  - *capturing plant diversity*
  - *phenology and mortality*
  - *evaluating succession*

Weng et al. , 2015
Strigul et al. 2008

PPA represents age since disturbance

New tiles are created after disturbance

- *Several layers*
- *Mortality in the canopy*

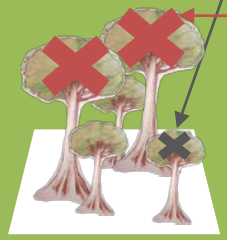


Undisturbed tile

$1 - f(A)$

Mortality in the Understory

Disturbed tile



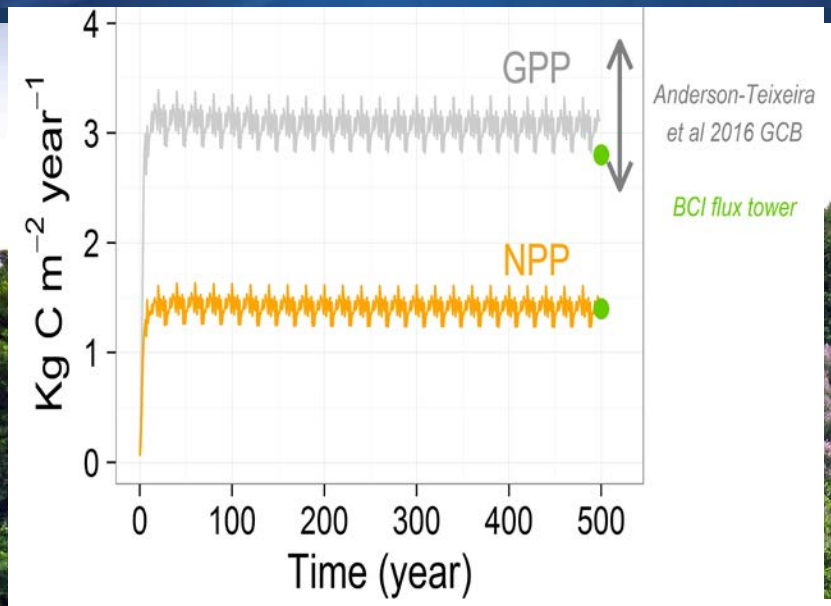
$f(A)$

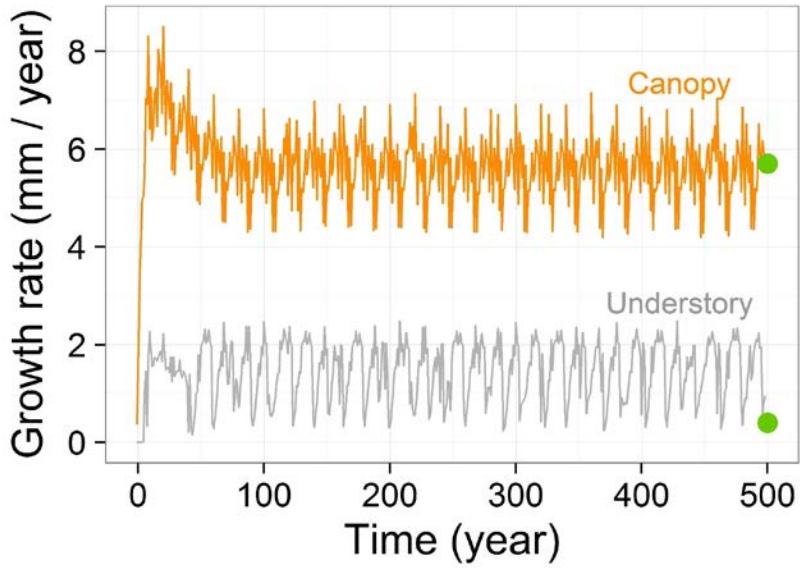
Mortality in the Canopy

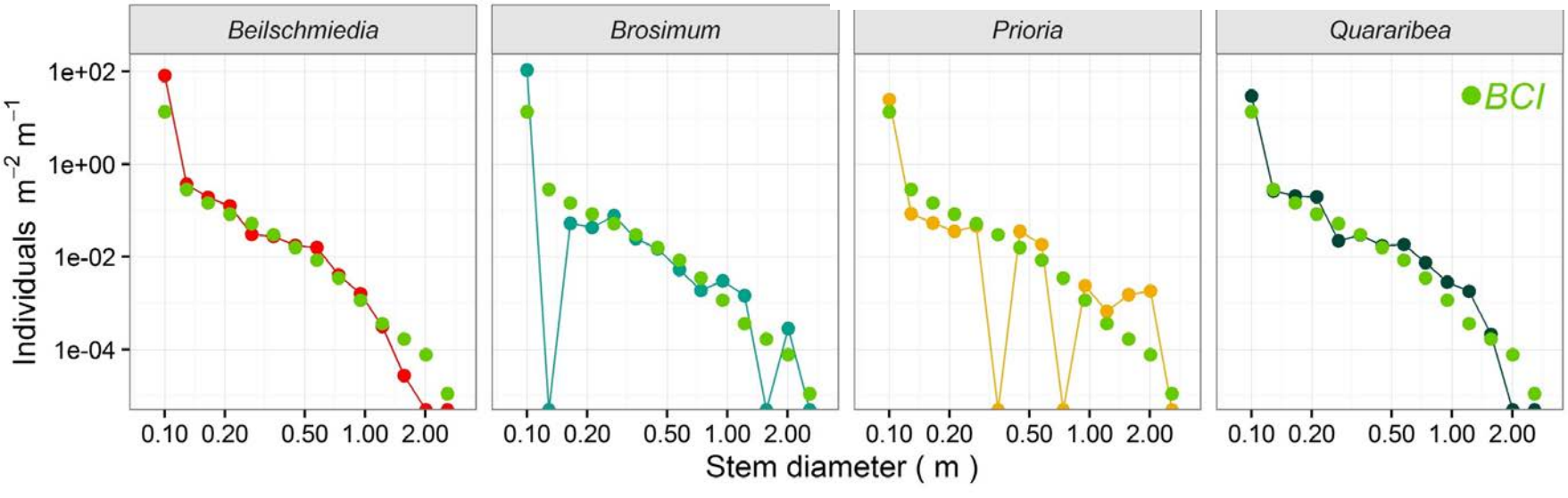
PPA (relayering)

Cano et al, in prep

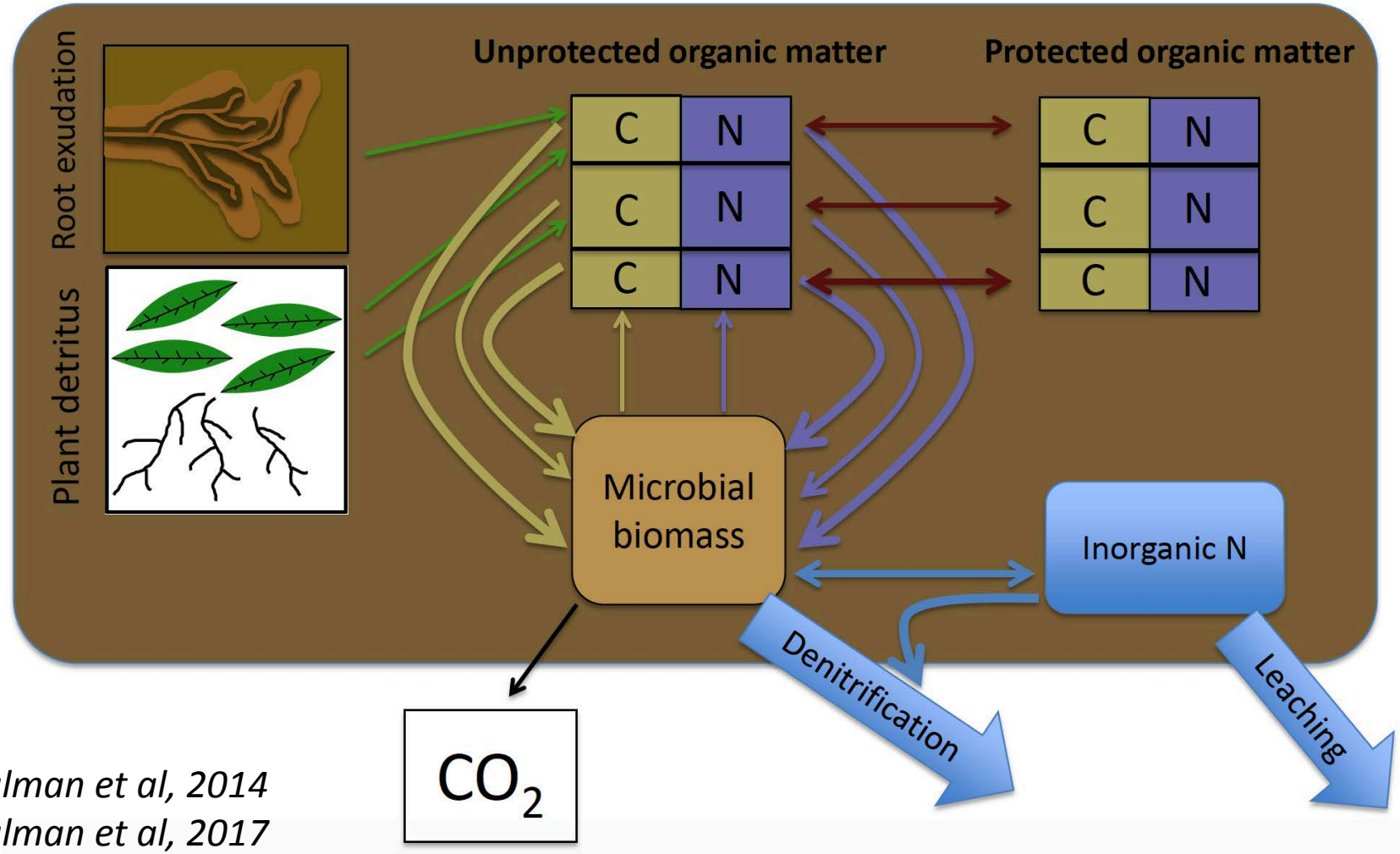
PPA tropical tree simulations capture key patterns





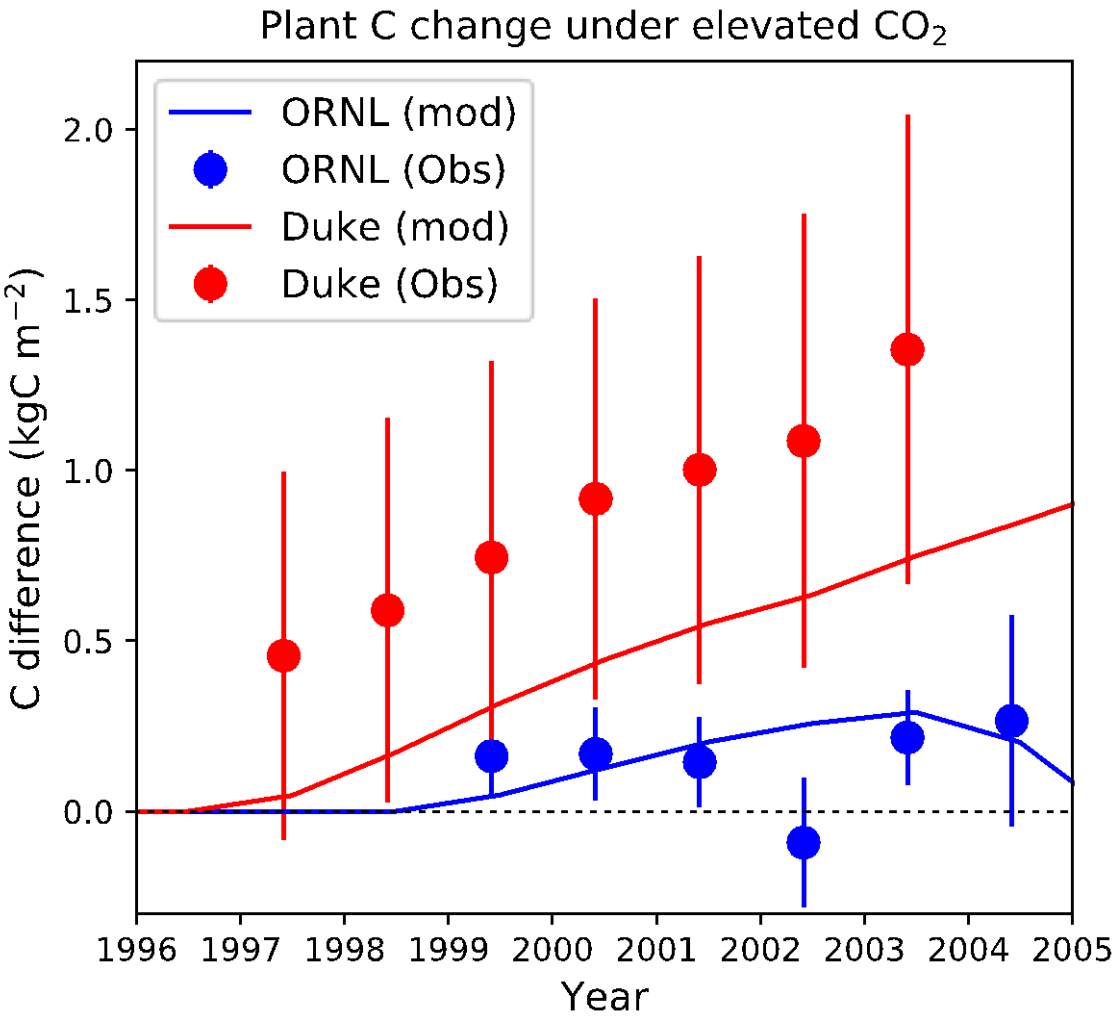


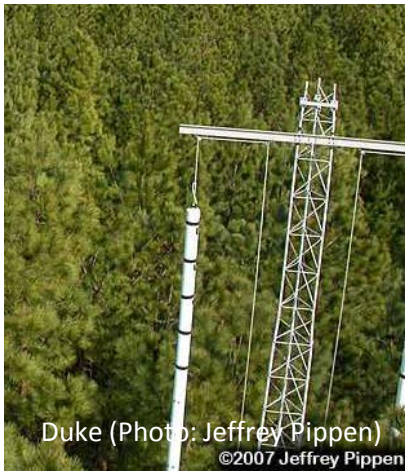
New soil Carbon and Nitrogen model



Sulman et al, 2014
Sulman et al, 2017

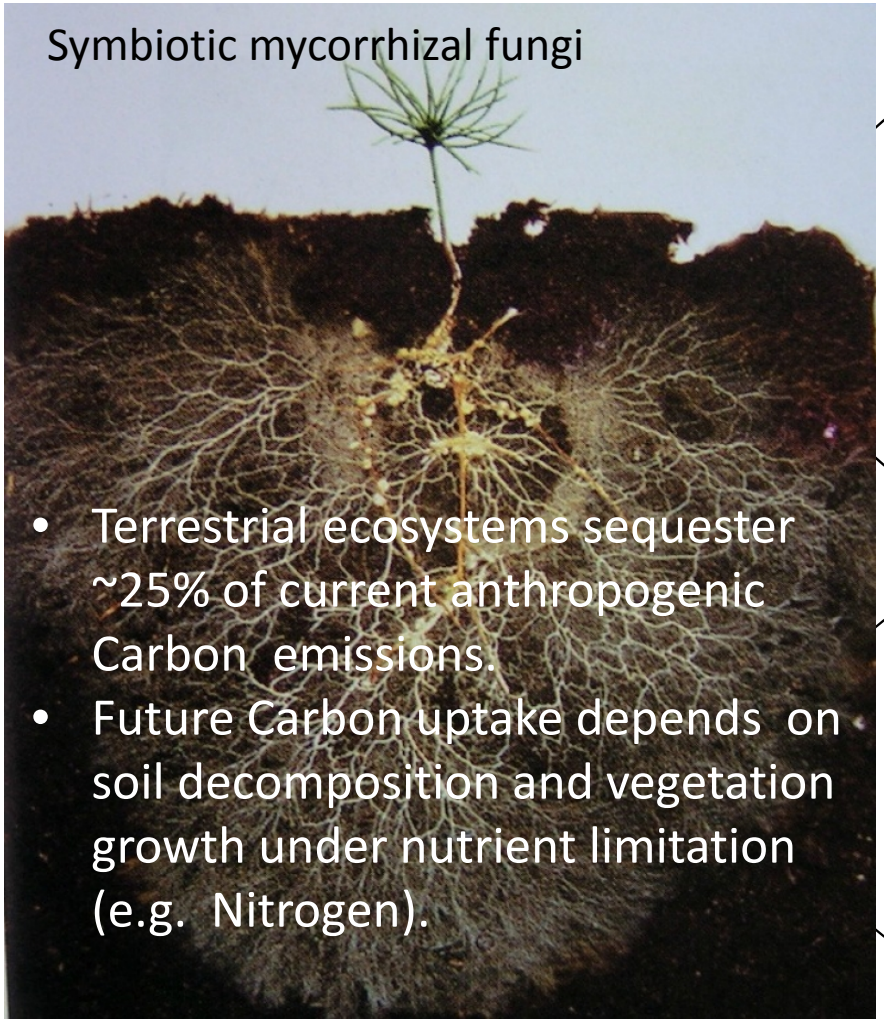
Plant-soil-microbial interactions in GFDL land model explained contrasting trends at DOE FACE elevated CO_2 sites



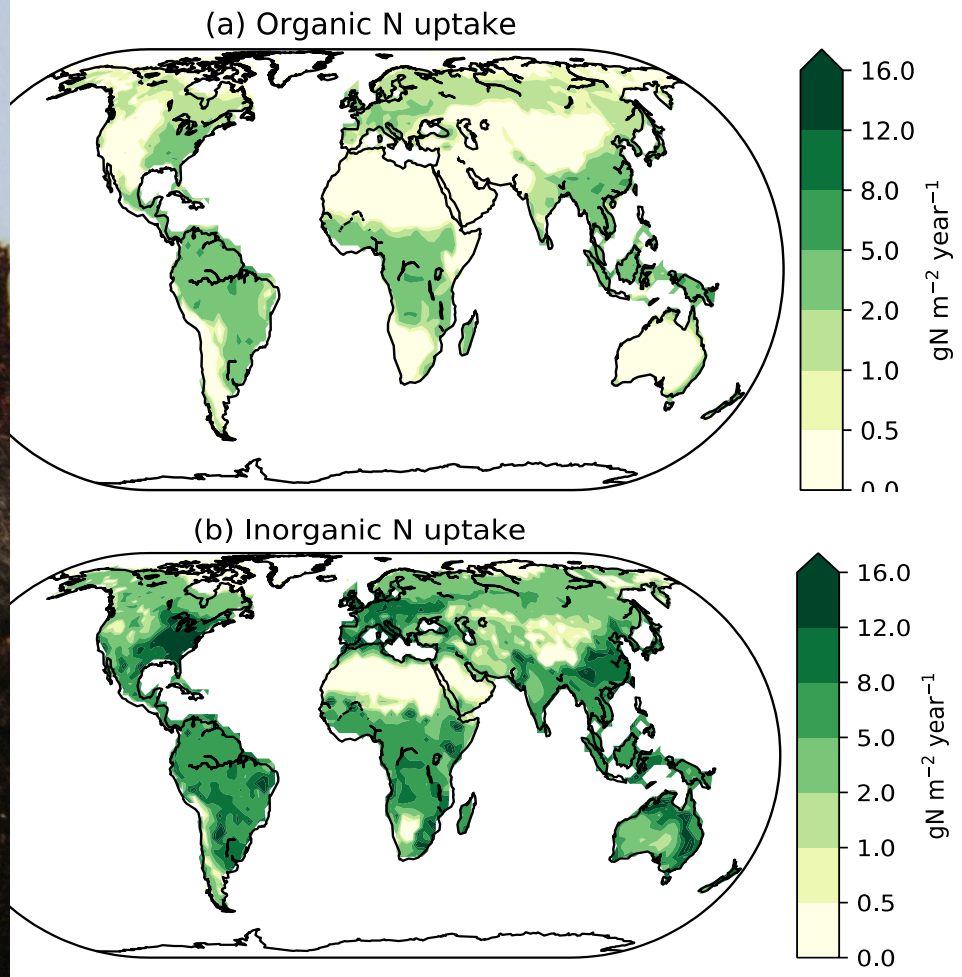


Sulman et al., 2014, 2017

Novel LM4 mechanisms: symbiotic fungi controlling nitrogen acquisition by plants



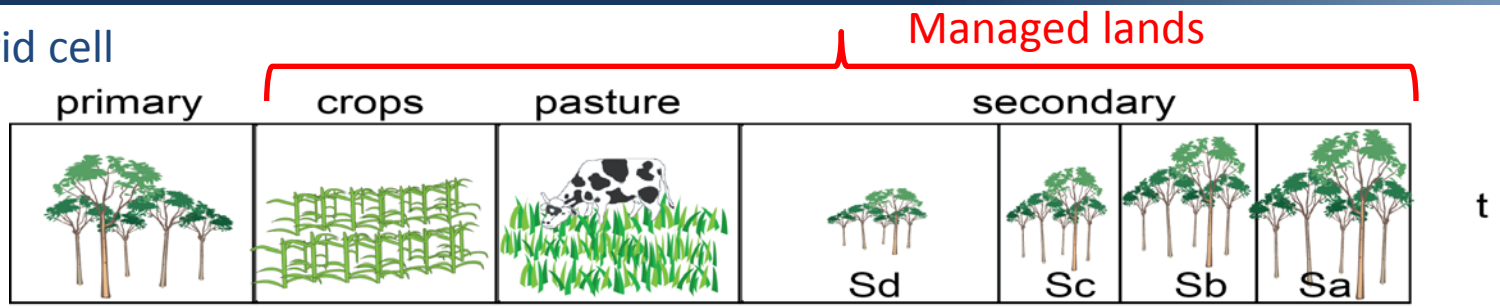
- Terrestrial ecosystems sequester ~25% of current anthropogenic Carbon emissions.
- Future Carbon uptake depends on soil decomposition and vegetation growth under nutrient limitation (e.g. Nitrogen).

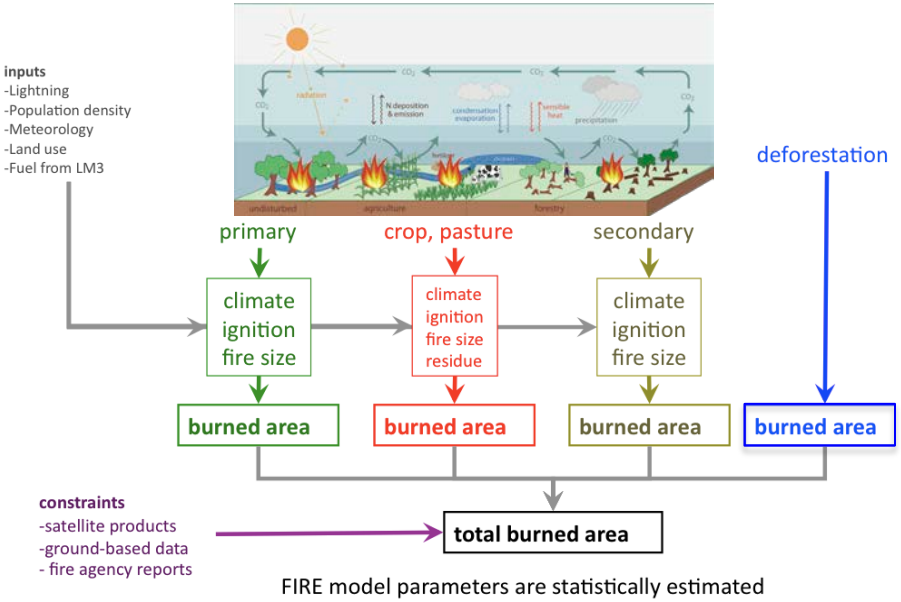


Sulman et al., in prep

LM4: land use, surface heterogeneity, and fire

In each grid cell

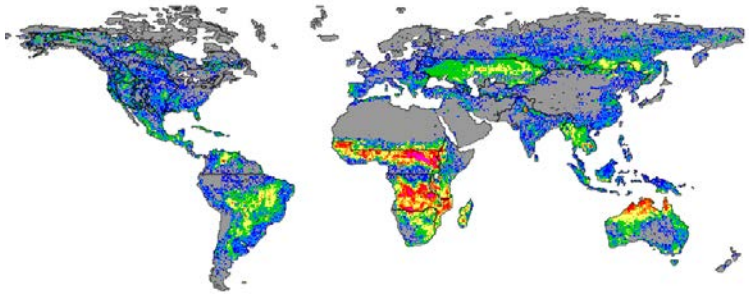




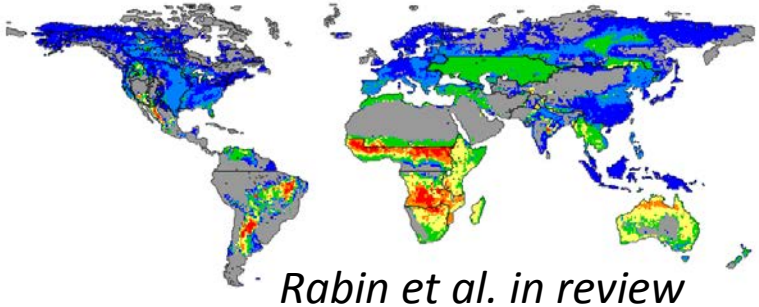
FIRE model parameters are statistically estimated

Land-use specific fire models =>
LU-specific datasets to estimate these parameters , *Magi et al 2011*

Observed area burned, 2003-2008

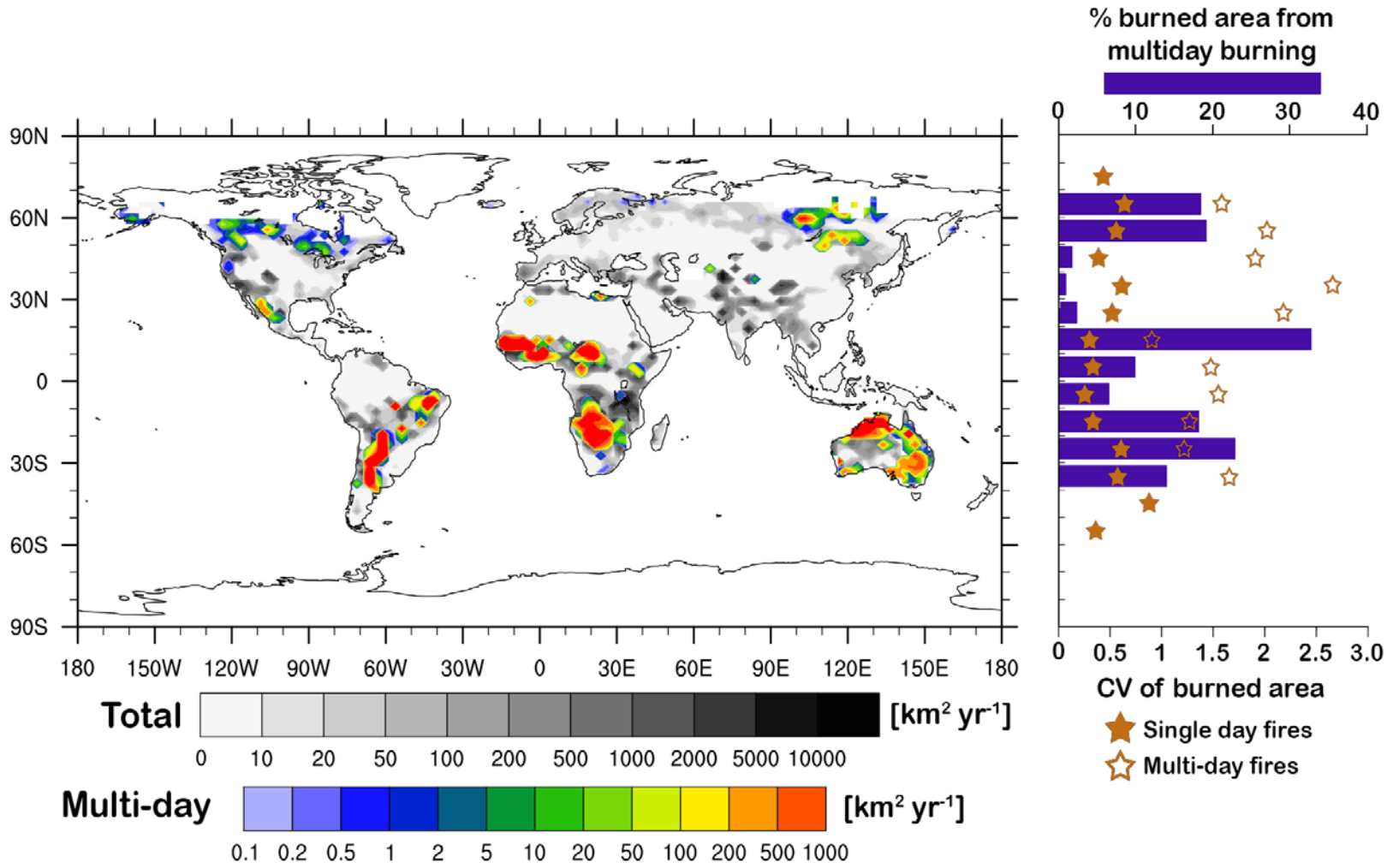


Estimated area burned, 2003-2008



Rabin et al. in review

LM4 simulates multi-day fires



Ward et al, in review

Summary

- LM4 addressed many ecological limitations in current generation of carbon cycle models.
- LM4 captures the response of leaves, plants, forests or the carbon cycle to climate change and rising CO_2 in a mechanistic manner.
- LM4 model includes novel capabilities enabling exploration of key uncertainties about the future carbon cycle and climate, including
  - projected growth and losses of forests and grasslands
  - Nutrient down regulation of C sink
  - Changes in fires and associated emissions
- Ongoing developments of ESM-N, CH_4, interactive biogenic aerosols capabilities based on LM4 .