

Ecosystem Dynamics and Fire

Next-generation modeling with vegetation demography using the
Functionally Assembled Ecosystem Simulator (FATES)

Charlie Koven, Rosie Fisher, Ryan Knox, Jacquelyn Shuman, Adrianna Foster,
and FATES team



NGEE-TROPICS
NEXT-GENERATION ECOSYSTEM EXPERIMENTS-TROPICS

Jacquelyn Shuman,

Climate and Global Dynamics, Project Scientist

CESM Tutorial
August 10, 2022



Active fire counts

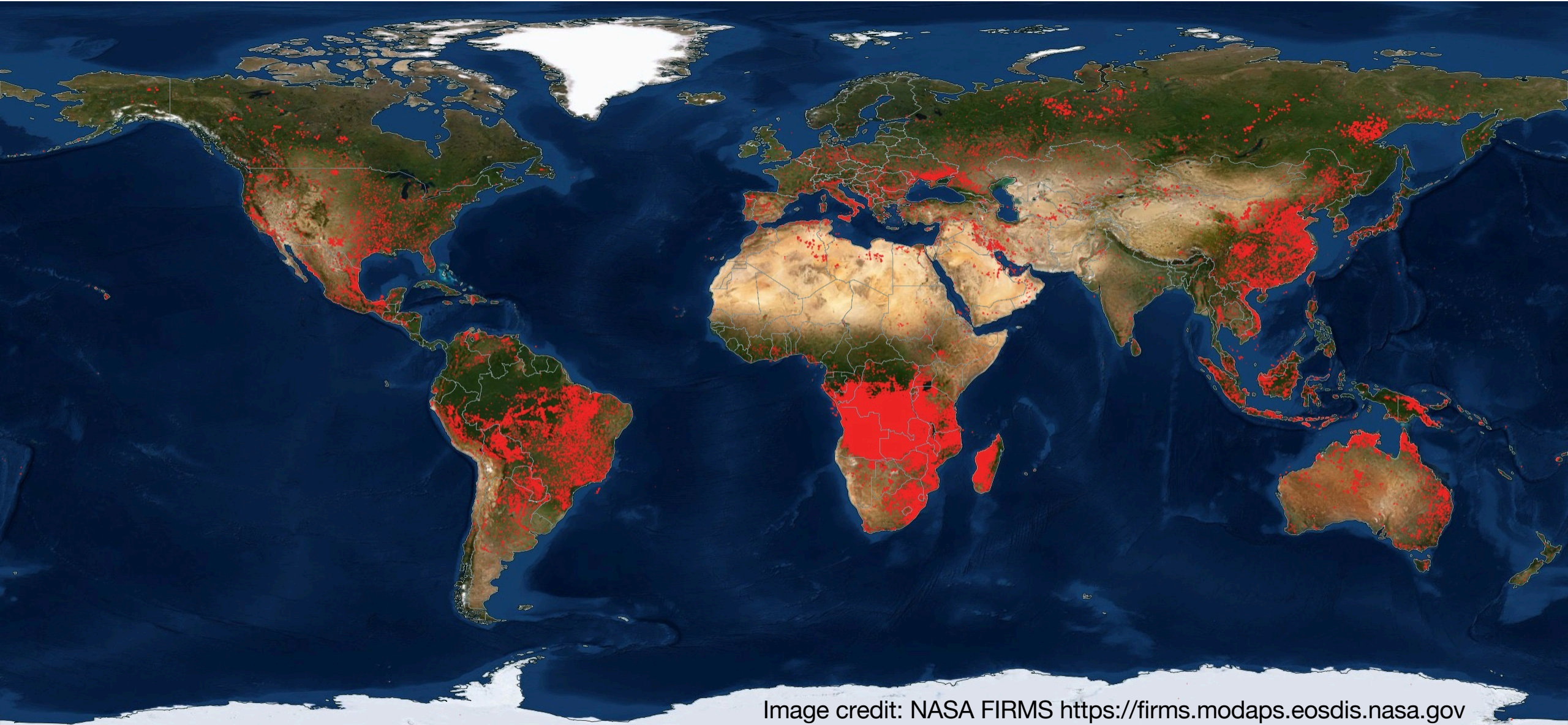
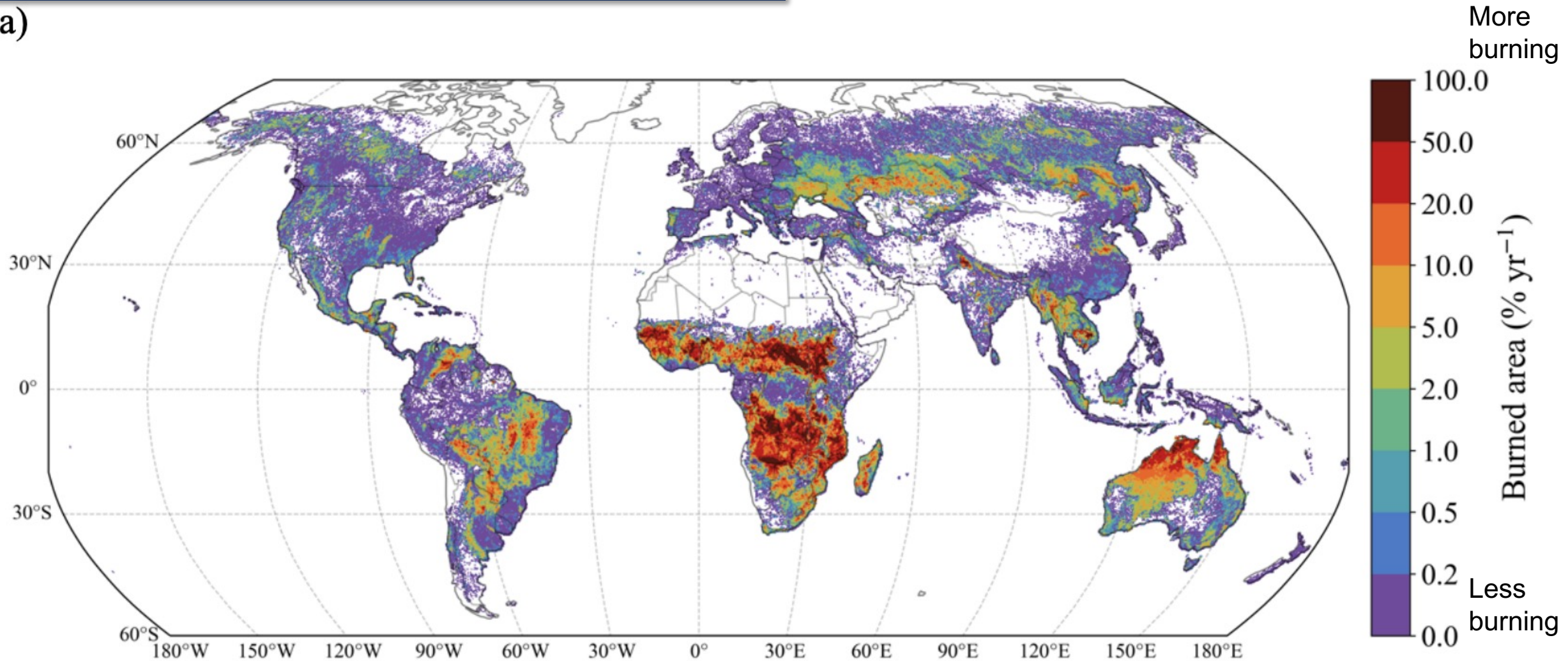


Image credit: NASA FIRMS <https://firms.modaps.eosdis.nasa.gov>

Fires: Jul 20 2022 - Aug 09 2022
Tue Aug 09 2022 15:37:58 GMT-0500 (Mountain Daylight Time)

Global burned area (2002-2019)

(a)

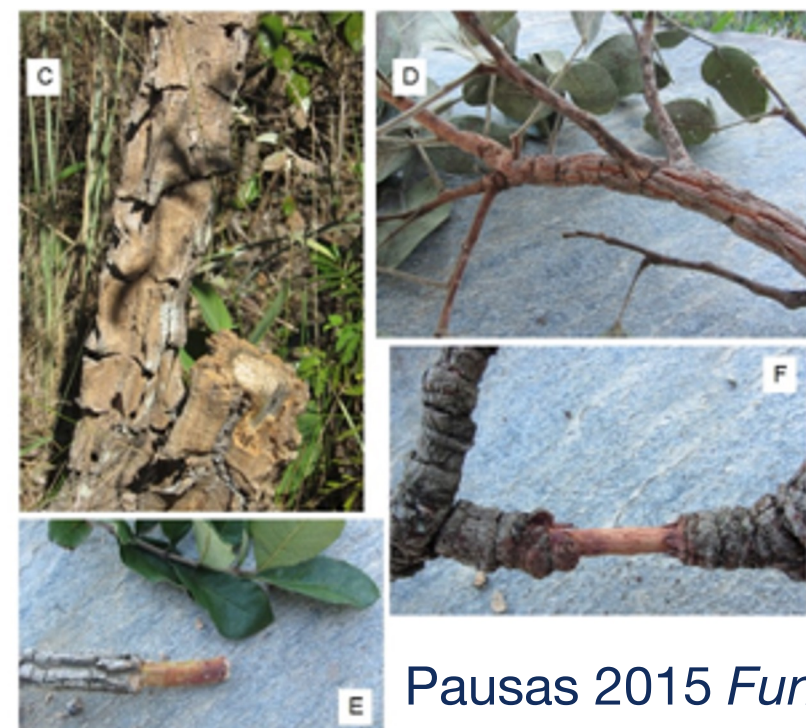


van Wees *et al.* preprint *Geoscientific Model Development*

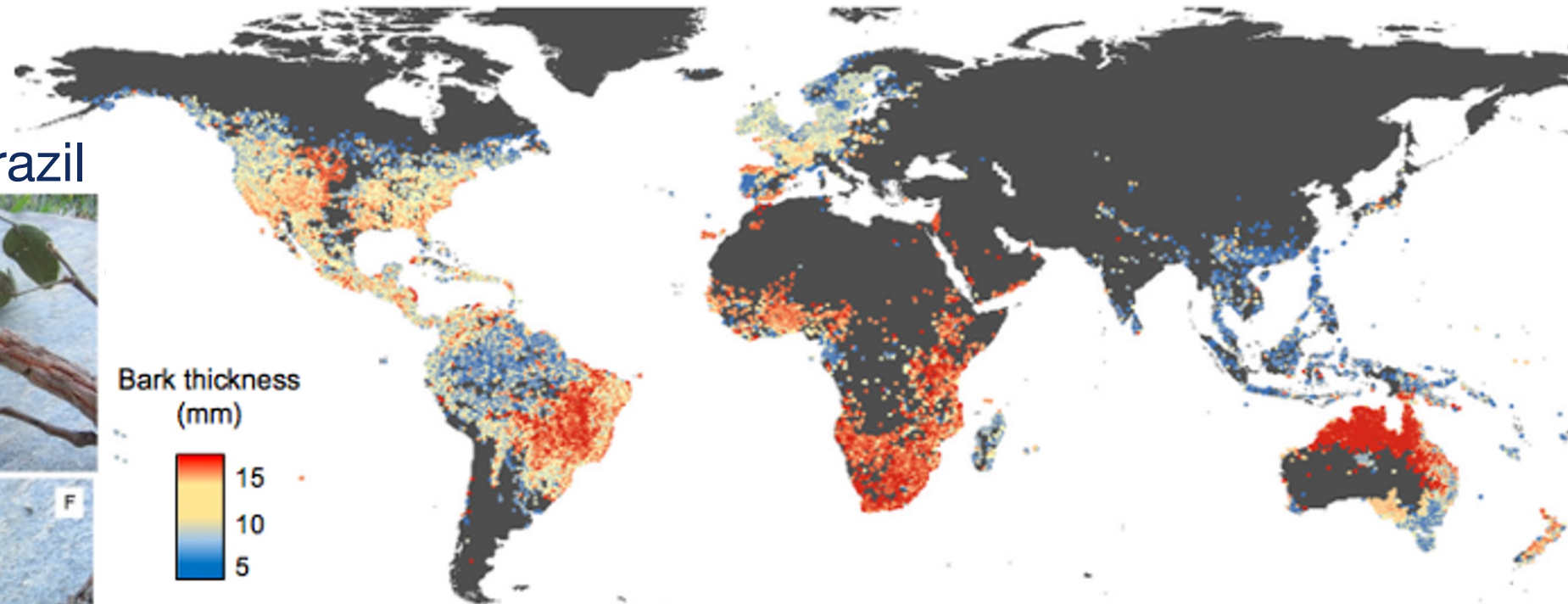
Biogeography shaped by vegetation traits and fire

Thick-barked trees dominate in high fire areas

Thick-barked trees of Brazil



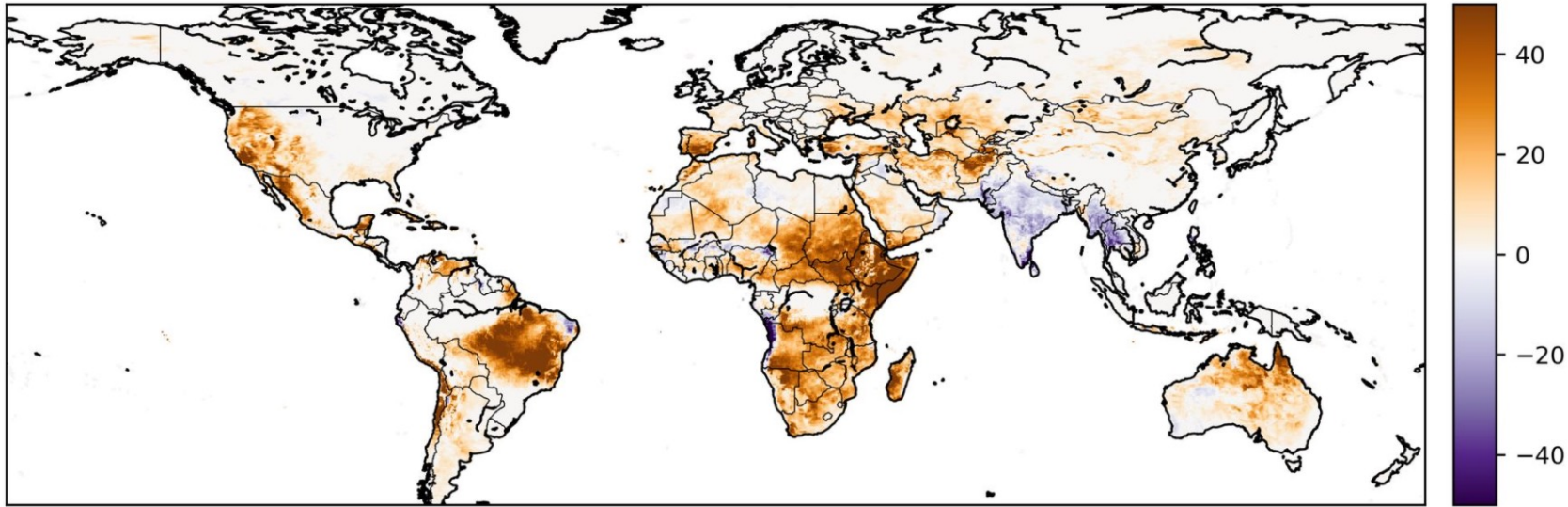
Pausas 2015 *Functional Ecology* FigS2



Pellegrini *et al.* 2017 *Ecology Letters*

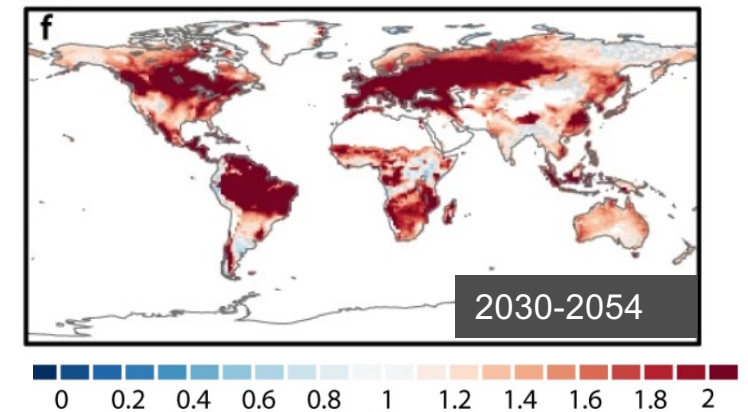
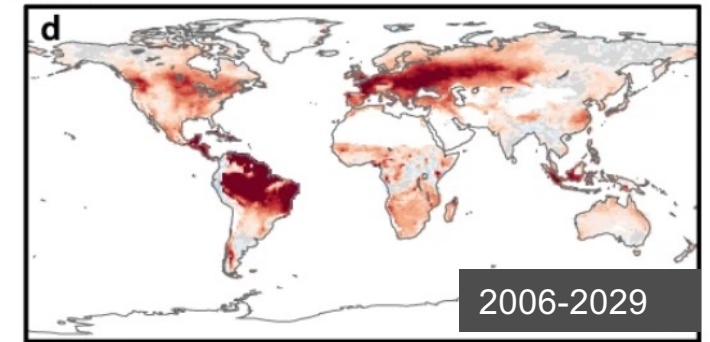
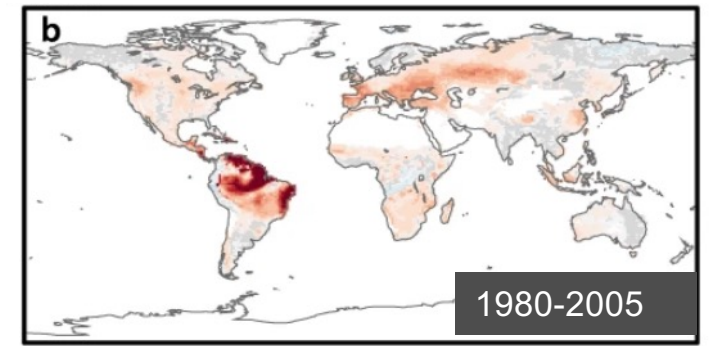
Increasing Fire danger

Change in the length of the fire weather season (1979-2019: days per year)



© Jones & Abatzoglou @ScienceBrief

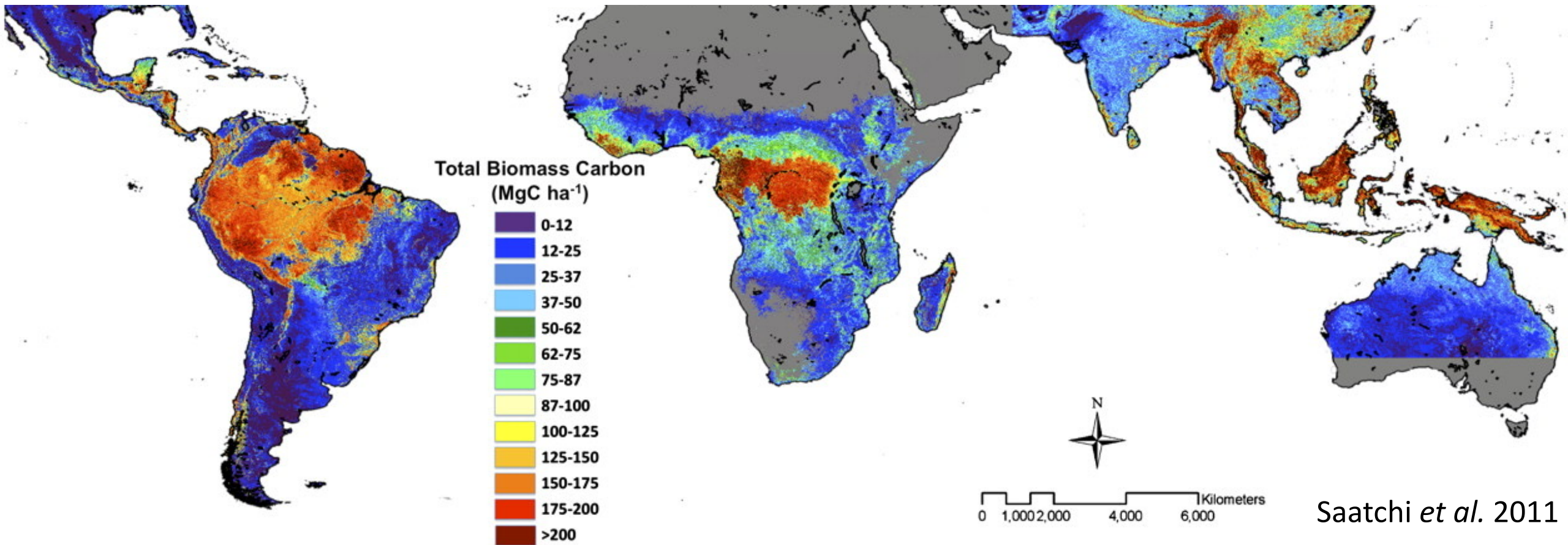
Change in the length of the fire weather season between 1979–2019 as seen in meteorological data (figure produced by M. Jones and J. Abatzoglou following Jolly et al. (2015); data from Vitolo et al., 2020, using the ERA5 dataset)



Extreme Fire Risk Ratio

Critical high biomass regions

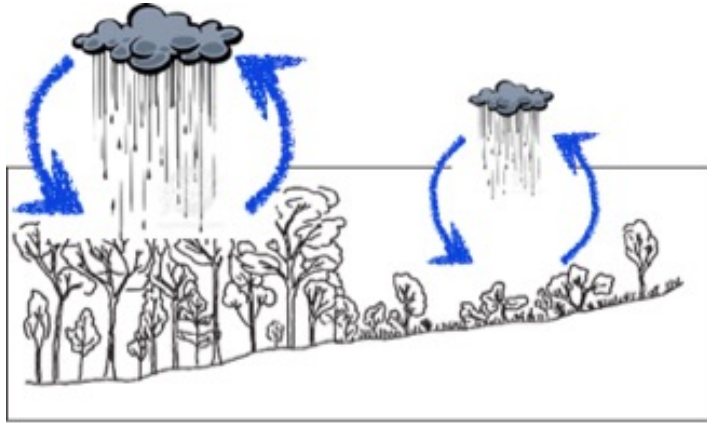
- Shift in fire regime may alter vegetation and C stores



Tropical forests hold 193 Gt carbon aboveground



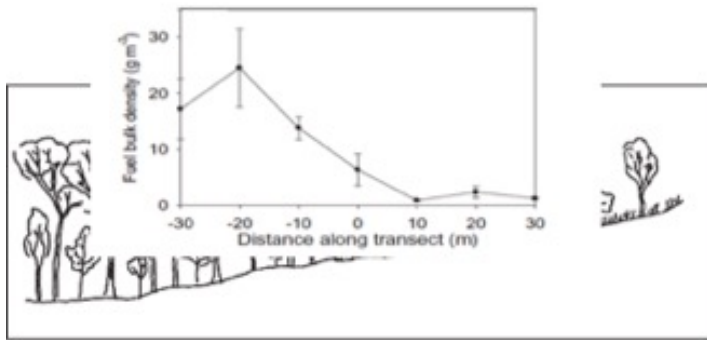
Fire is interactive in CLM, CLM-FATES



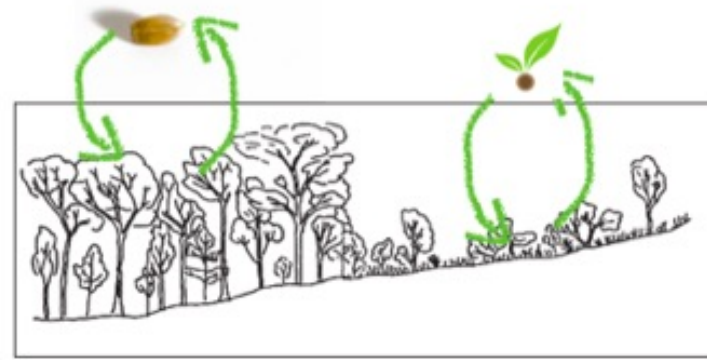
Land-atmosphere feedback



Wind speed feedback



Flammability feedback



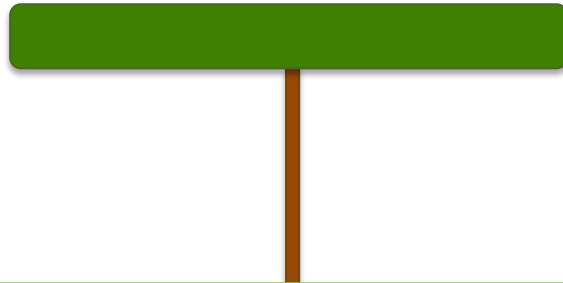
Demographic feedback

- Adaptation of SPITFIRE (Thonicke et al 2010) into FATES (Fisher et al 2018)

Ecological processes in land surface models

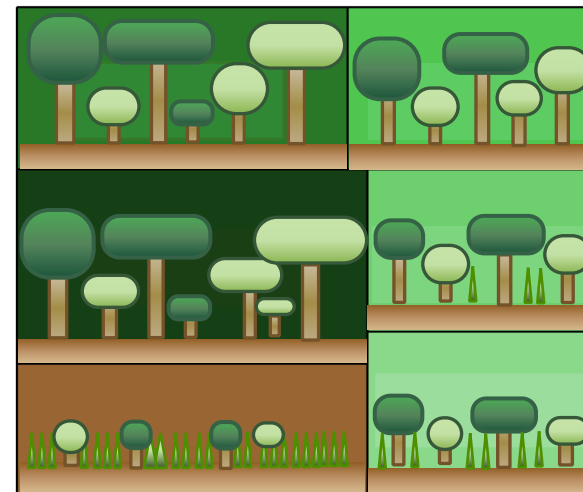
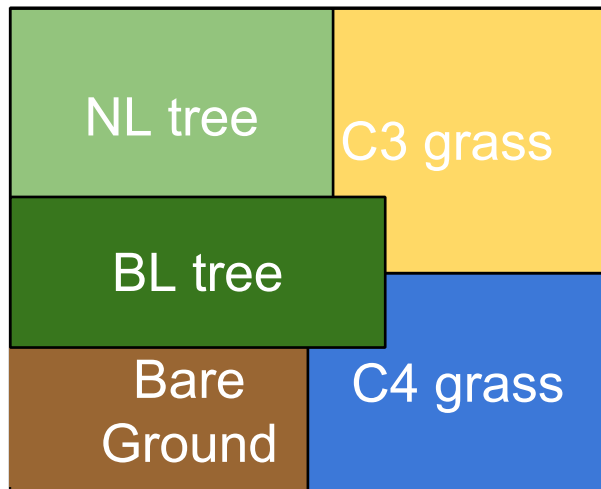
CLM

Big Leaf

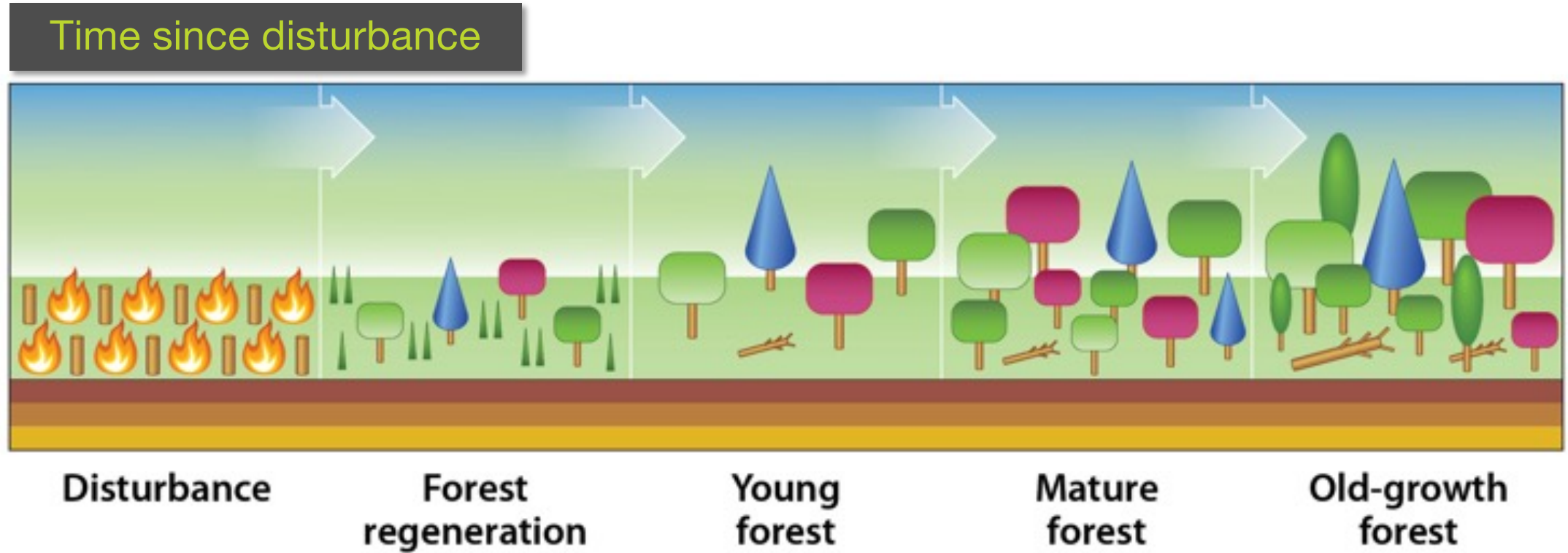


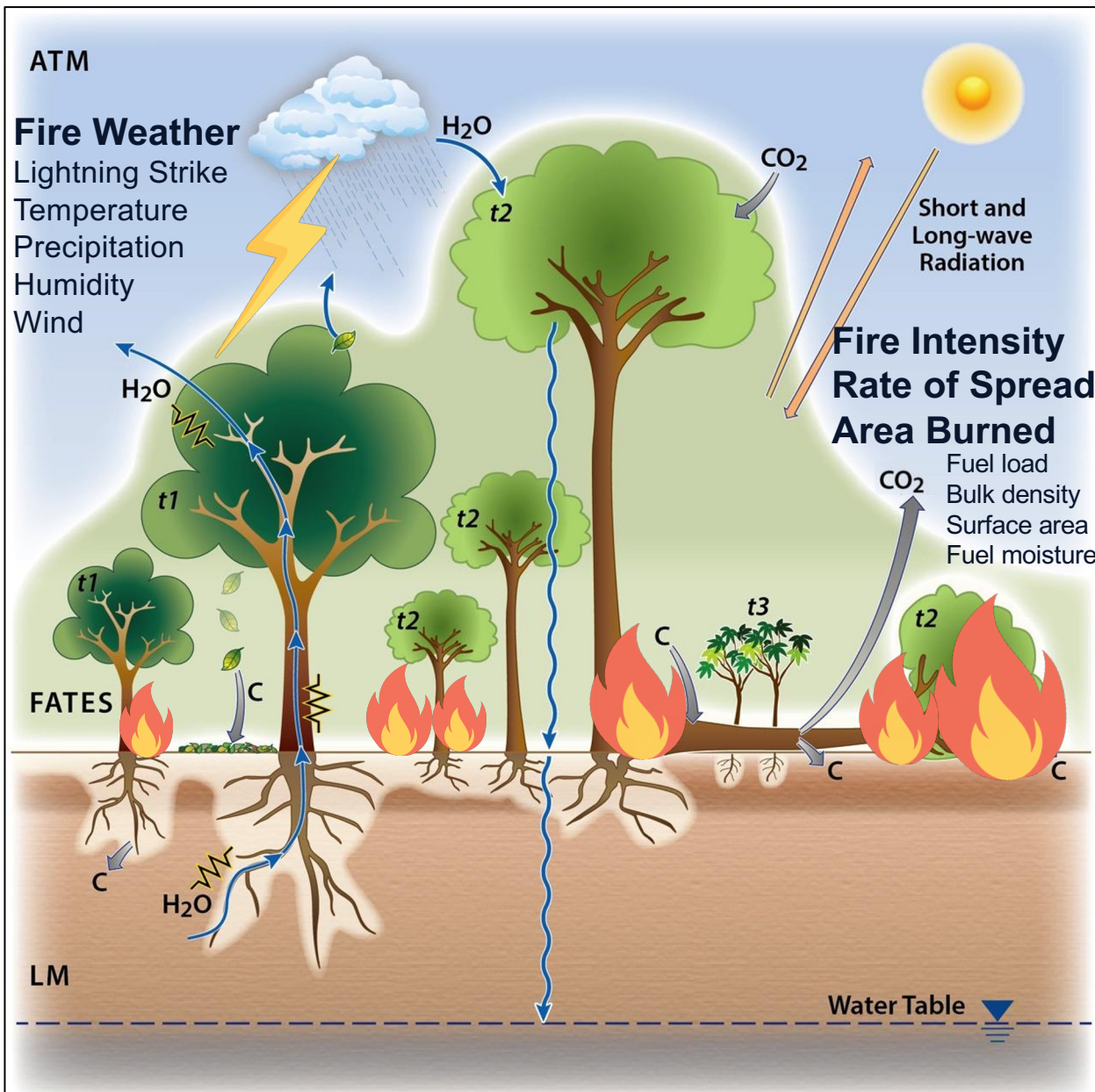
FATES

Cohort Model



FATES has variability





CLM-FATES

- Simulates plant cohort growth, death, and regeneration at sub-daily to daily time steps

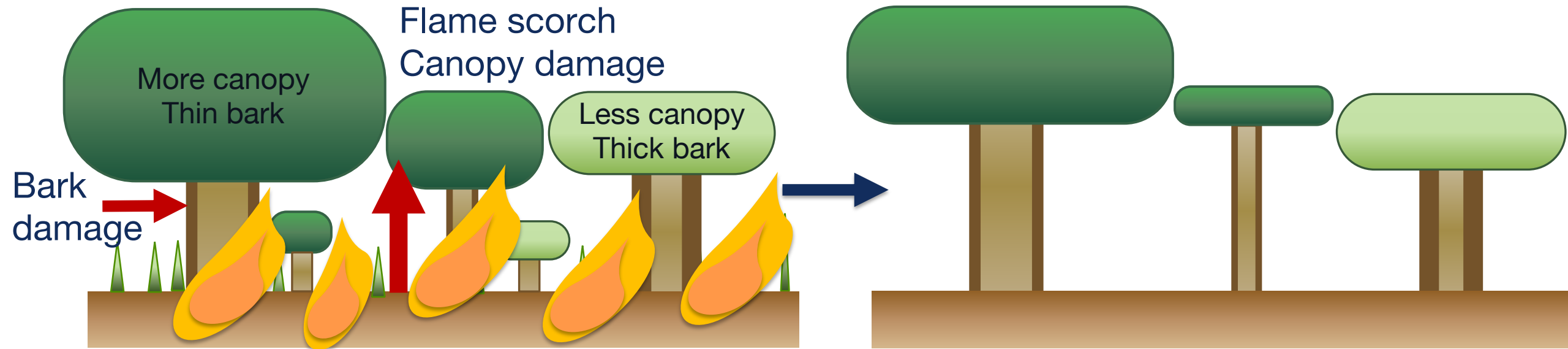
SPITFIRE

- daily process-based fire behavior and effects
- six litter & fuel classes
- flame scorch height, crown damage, bark damage
- size-based tree mortality

FATES-SPITFIRE: vegetation traits and structure



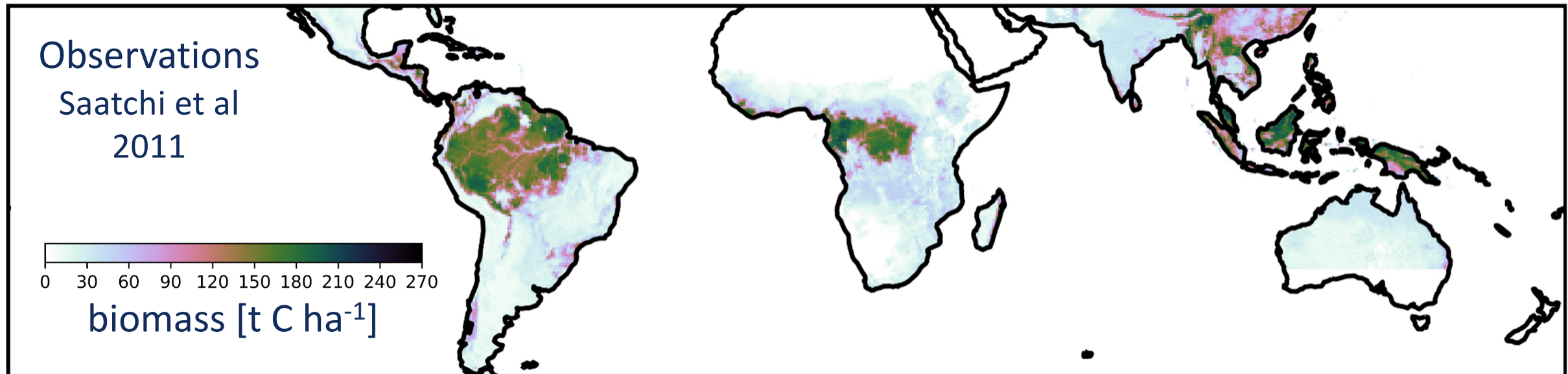
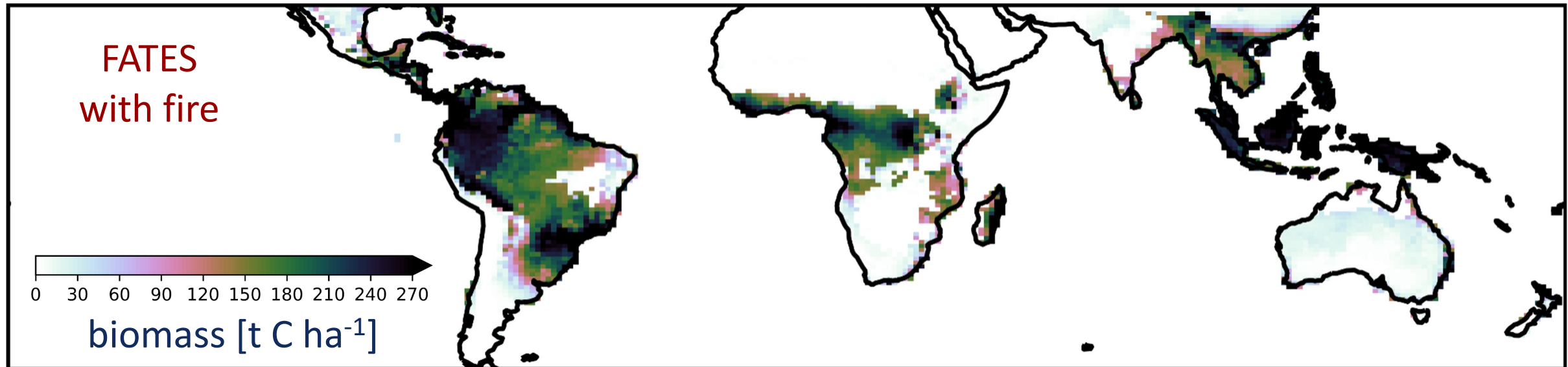
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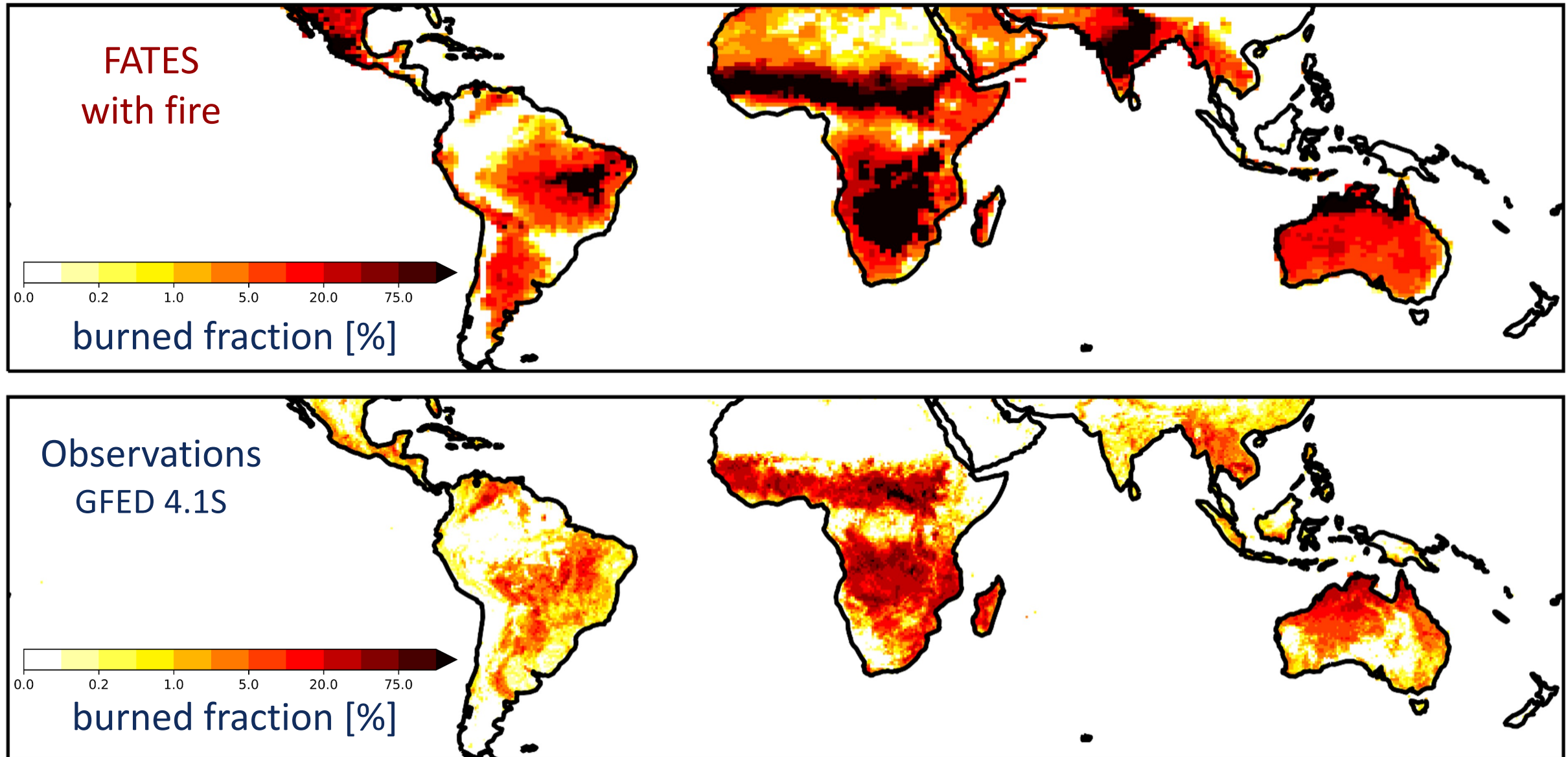
Trees: Trait- and height-level protection from fire

Grasses: no protection and burn with all fires.

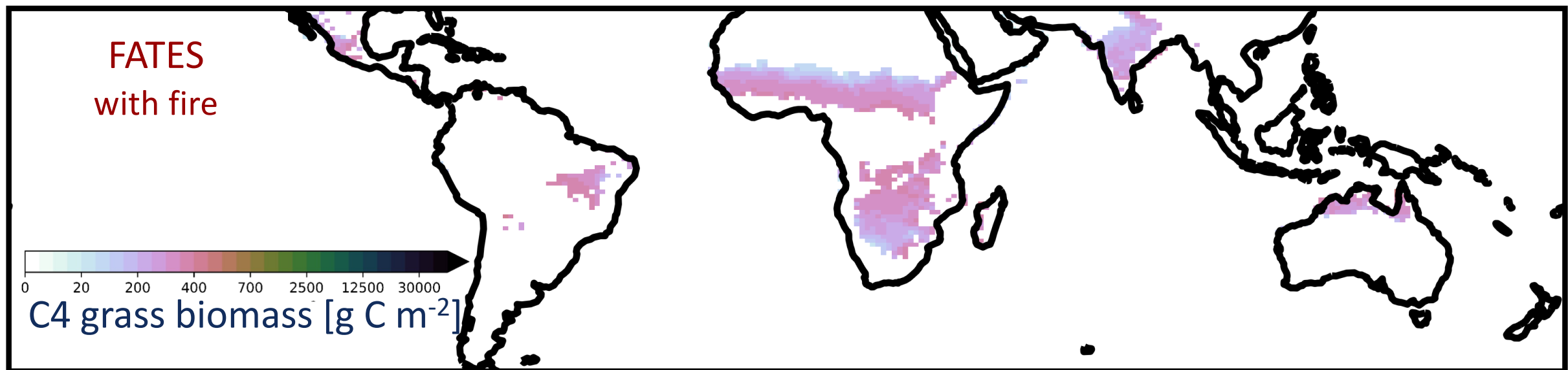
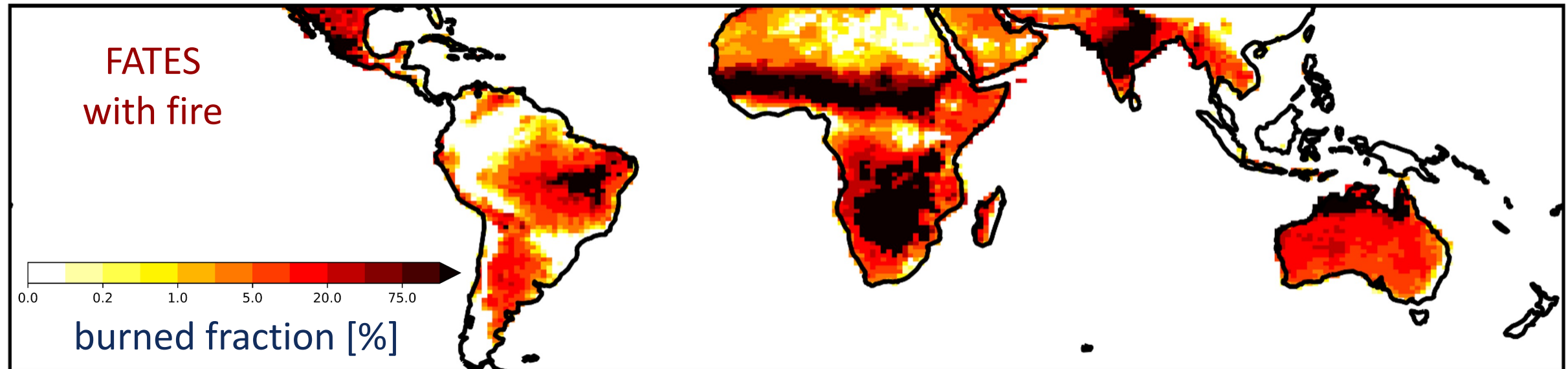
FATES captures biomass accumulation



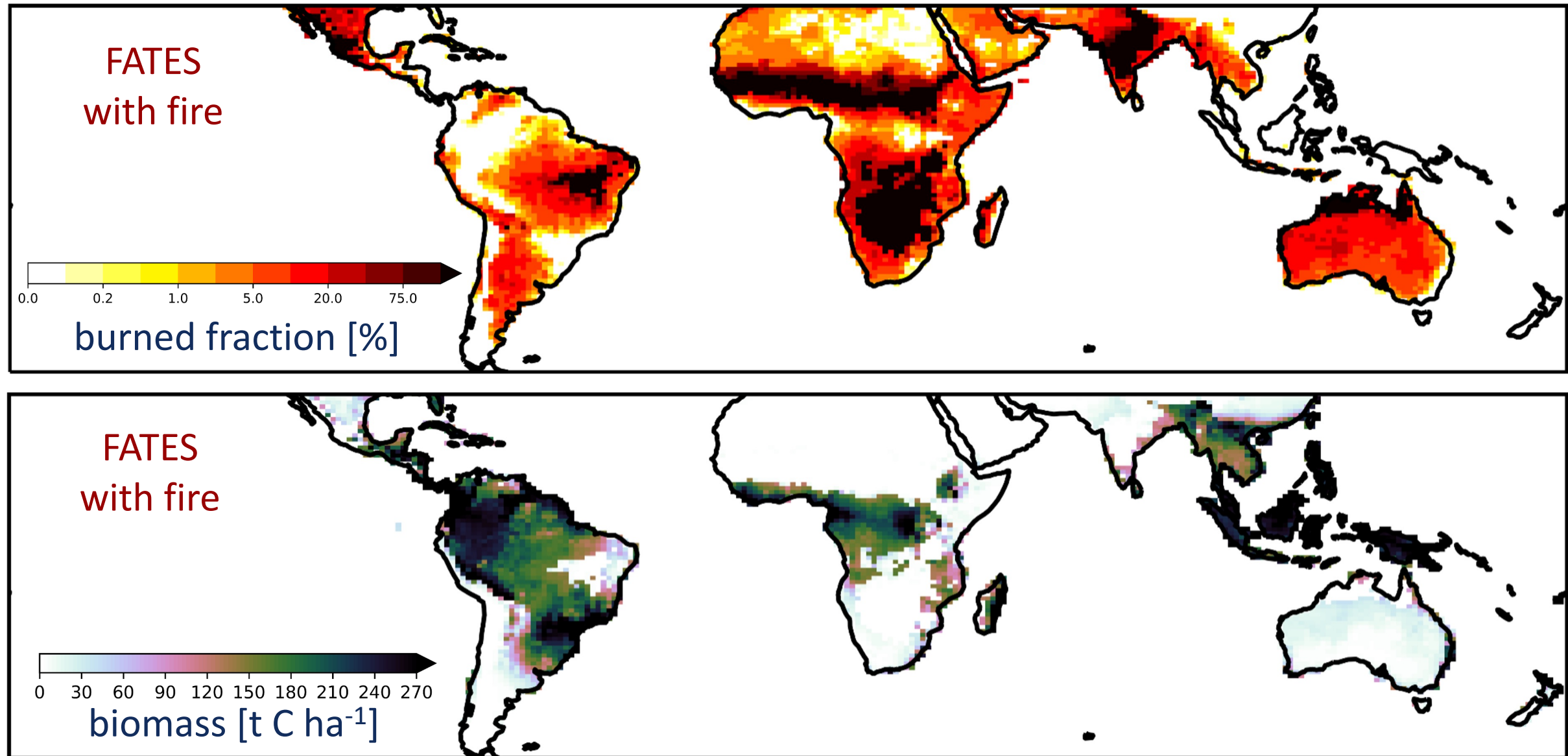
FATES captures broad spatial burn pattern



Grasses drive high burned area



High biomass in areas of low disturbance

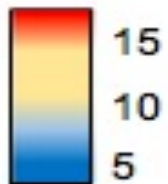


Fire is essential to plant distribution

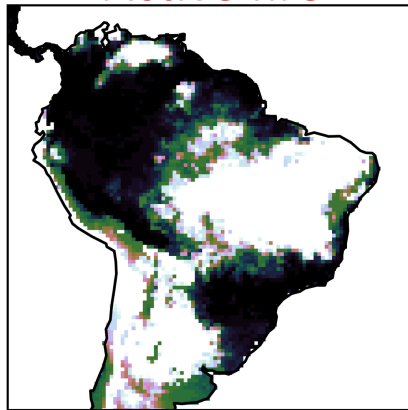
Observations
Pellegrini et al 2017



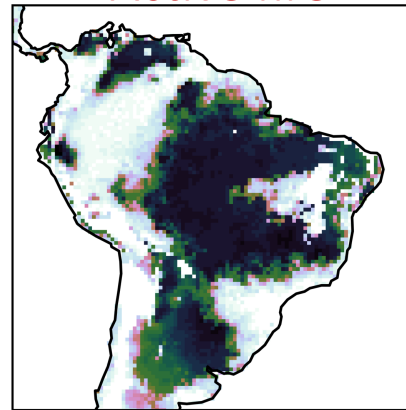
Bark thickness
(mm)



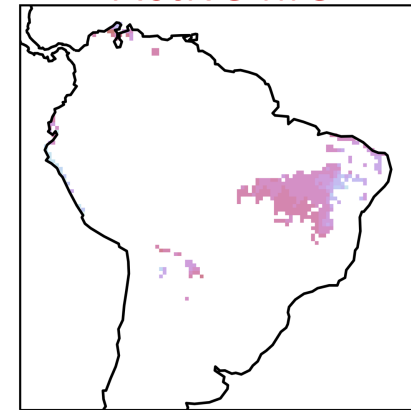
Thin bark tree
Active fire



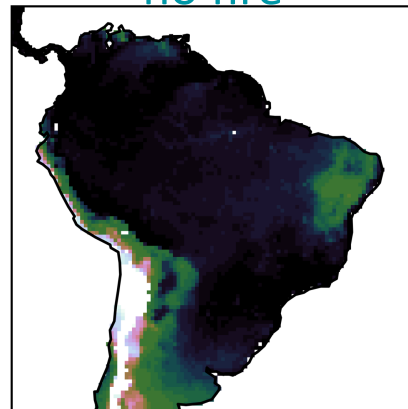
Thick bark tree
Active fire



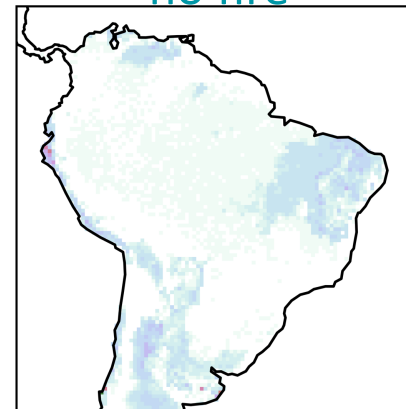
C4 grass
Active fire



Thin bark tree
no fire



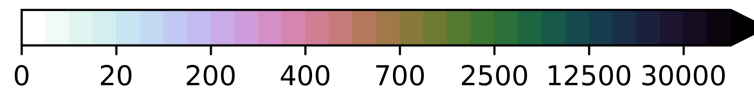
Thick bark tree
no fire



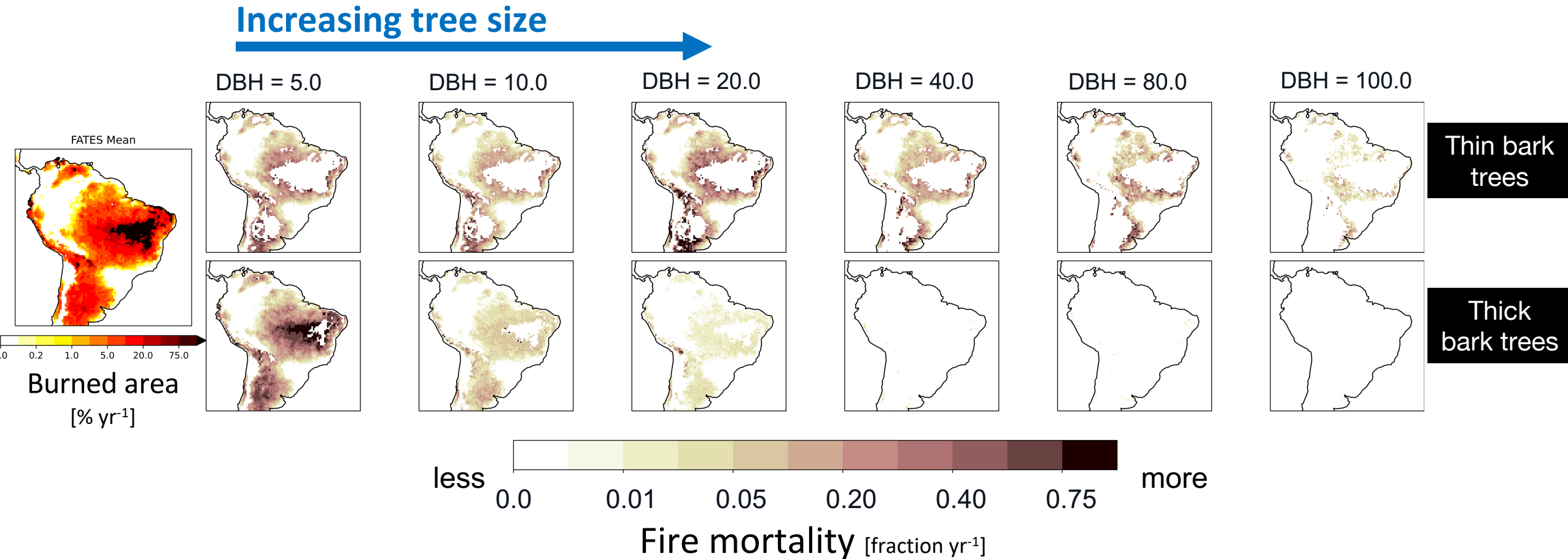
C4 grass
no fire



Biomass [g C m⁻²]

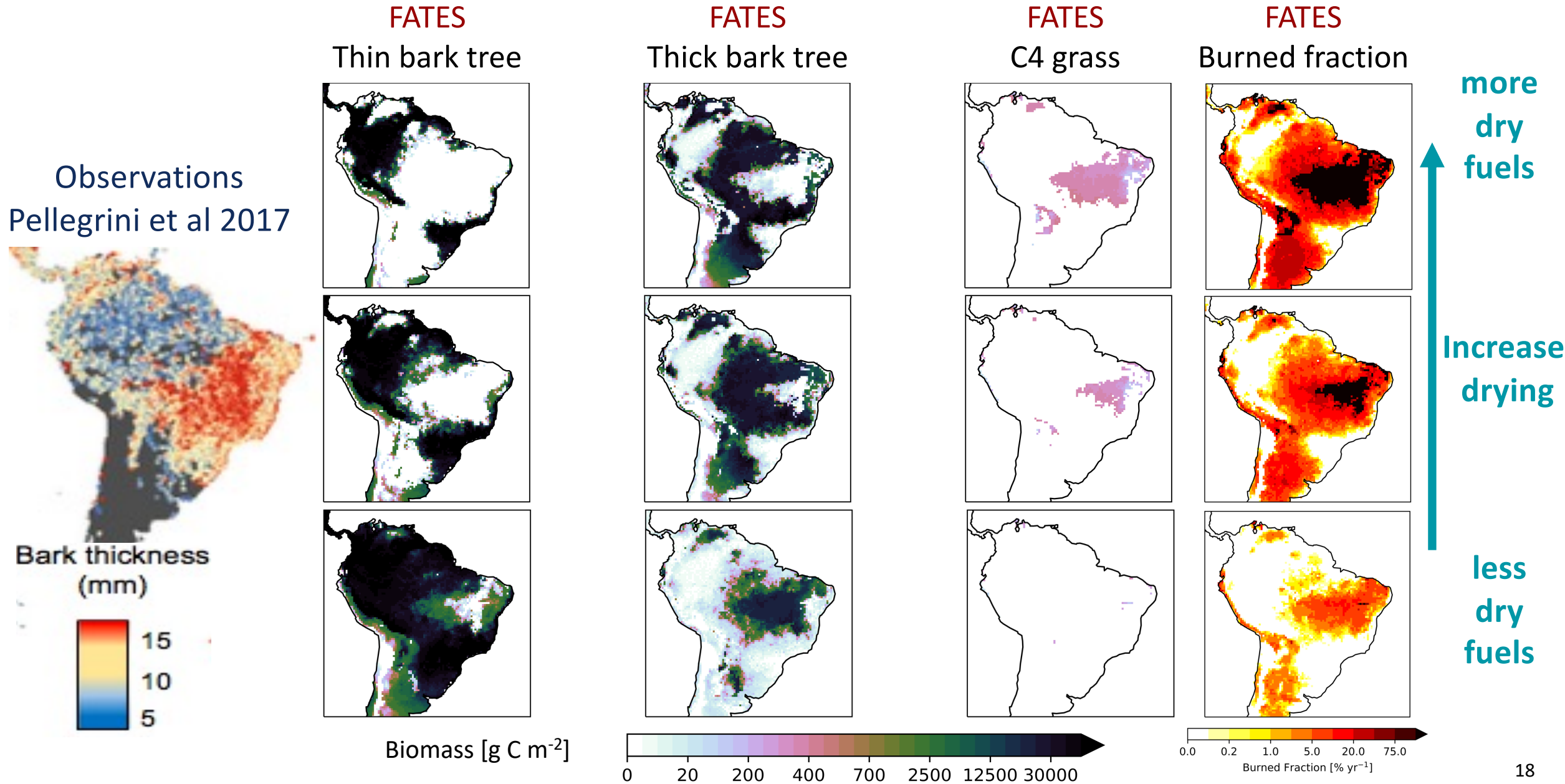


Size- and trait-based mortality impacts survival



Vulnerability/resistance is a function of feedbacks between traits and fire regime

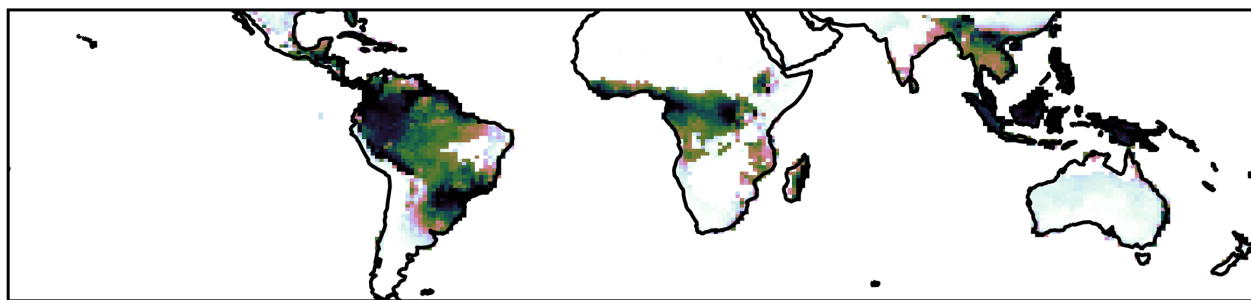
Shift in fire regime shifts biogeography



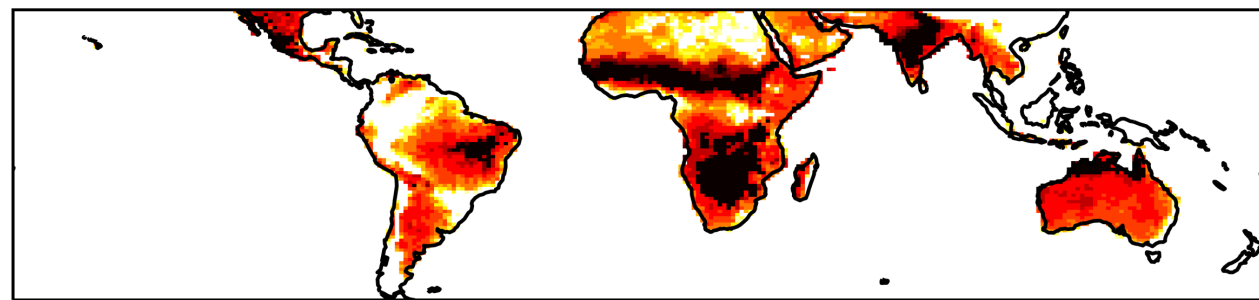
Conclusions

- FATES captures dynamic biogeography and biomass
- Fire feedbacks determine plant survival
- Critical for tropical simulation

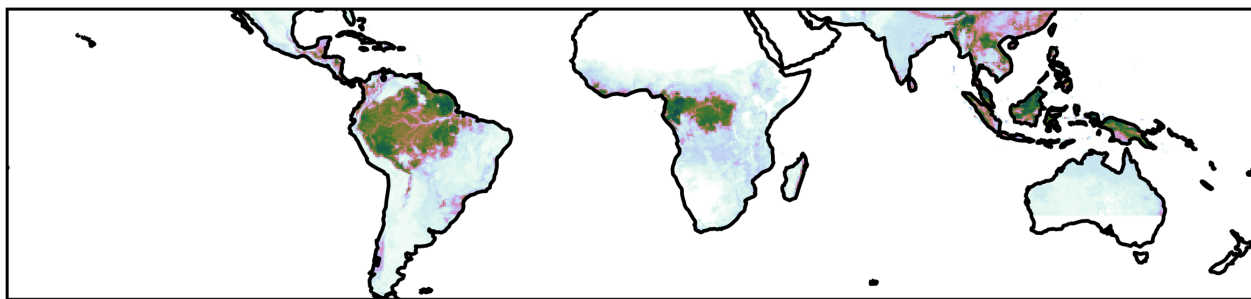
FATES Active fire



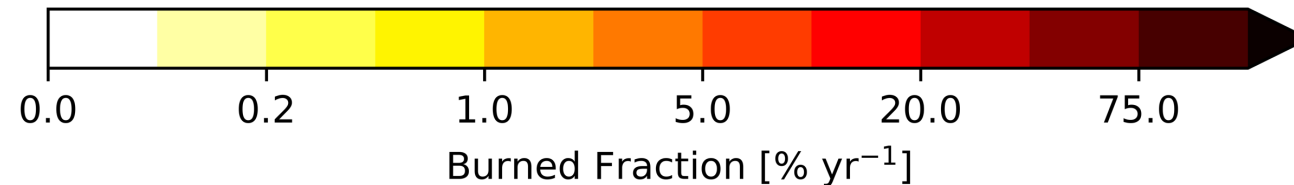
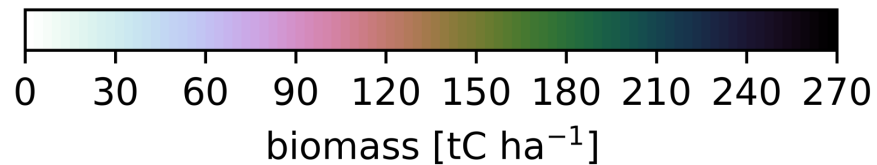
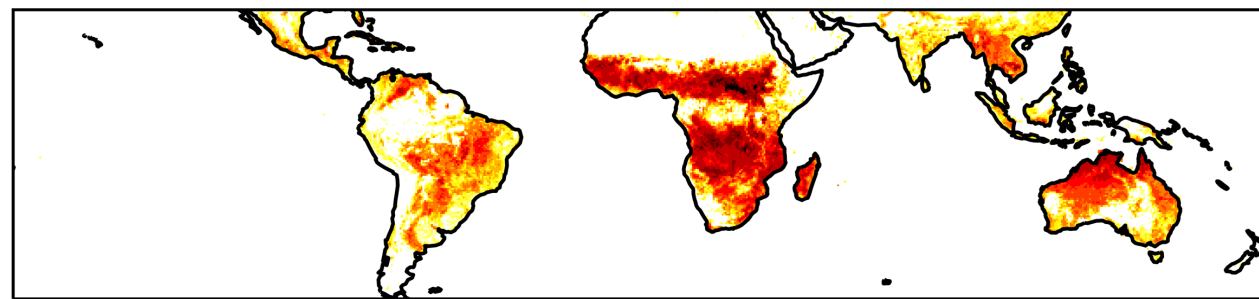
FATES Active fire

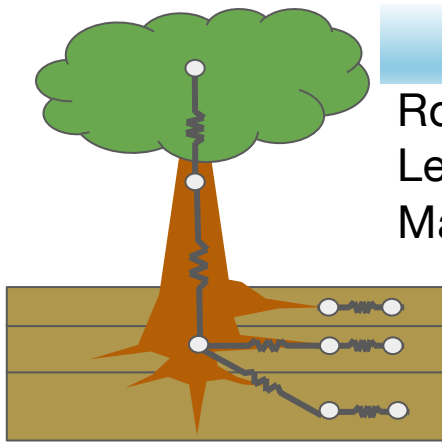


Observations Saatchi et al 2011



Observations GFED4.1s





Plant Hydraulics

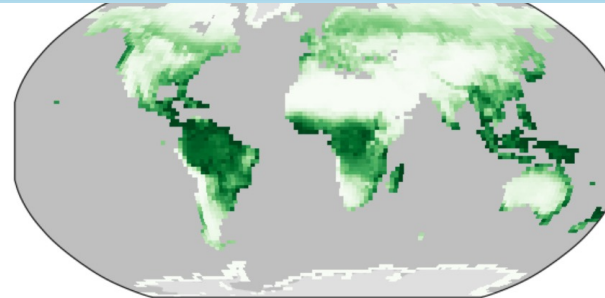
Root layers and plant-size root depth
Leaf humidity, stomata set transpiration
Mass balance at root nodes



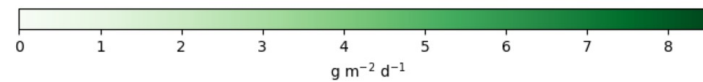
Fire

Live fuel moisture
Crown fire

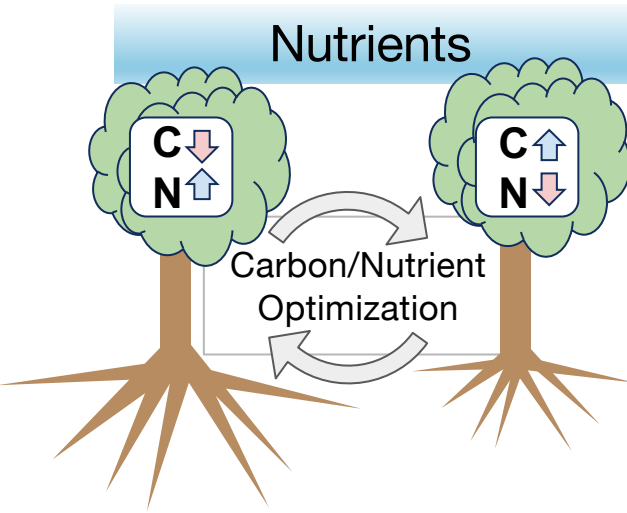
Reduced Complexity modes



FATES-SP mean GPP



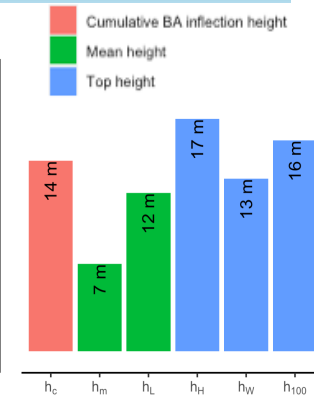
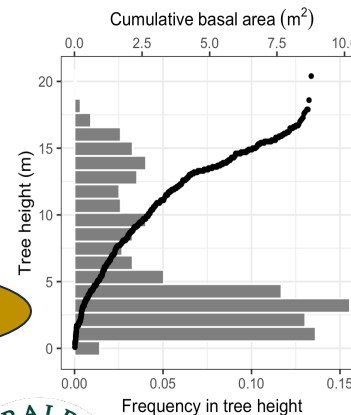
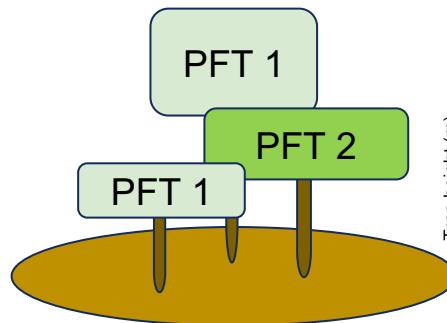
Nutrients



Moss

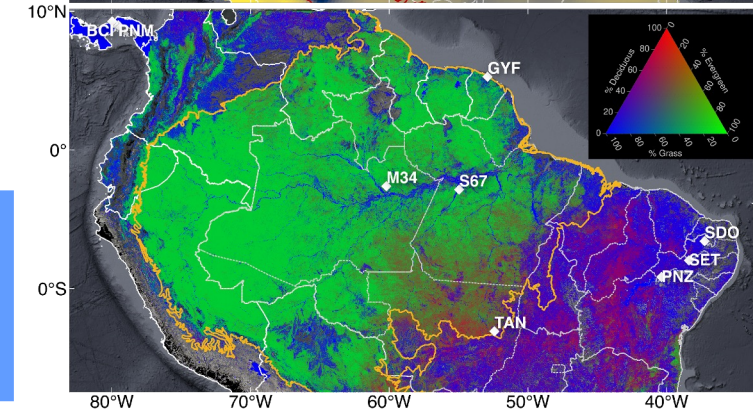
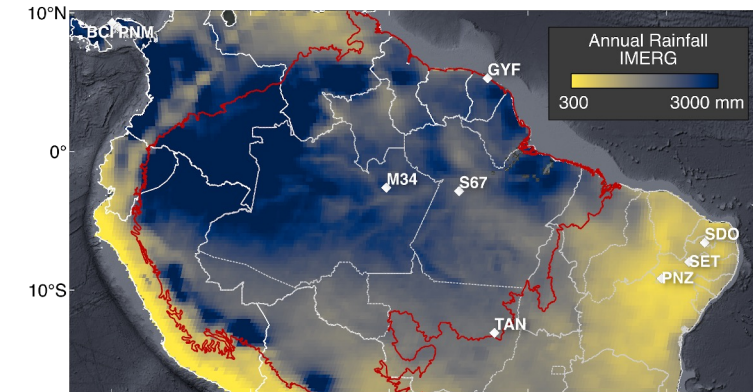


Canopy turbulence for mixed vegetation



Deciduous Phenology

Forest resilience to drought



Data from DeFries et al. (2000) GCB
Figure credit Marcos Longo, LBNL

FATES code and information

<https://github.com/NGEET/fates/wiki>

Home

Gregory Lemieux edited this page on Mar 10 · 24 revisions

The Functionally Assembled Terrestrial Ecosystem Simulator (FATES)

This repository houses the development of the Functionally Assembled Terrestrial Ecosystem Simulator (FATES). FATES is a numerical terrestrial ecosystem model. The funding for this project is supported by Department of Energy's Next Generation Ecosystem Experiment - Tropics (NGEE-T) project. The conceptual design is based off of the original Ecosystem Demography model (ED, Moorcroft et al. 2001, Hurtt et al. 2002, Fisher et al. 2015). This model is designed so that it works as a library that can be called from a selection of driver models including Earth System Models (ESM) such as

Documentation

- FATES technical documentation
- FATES User's Guide

CTSM Mini-tutorial 2022

GETTING STARTED

- Tutorial 0a: CTSM, CESM-Lab, & Git
- Tutorial 0b: CTSM Simulations at NEON Tower Sites

GLOBAL SIMULATION

- Tutorial 1a: Global Simulations
- Tutorial 1b: Global Visualizations

GENERIC SINGLE POINT SIMULATION

Technical Documentation
&
User's Guide

Tutorial materials

Welcome to the 2022 CTSM mini-tutorial

JupyterBook passing

license MIT Made with Jupyter Last commit last saturday Contributors 5

The materials and notebooks in this tutorial is published as a Jupyter book [here](#).

This repository includes materials for the [Community Terrestrial Systems Model \(CTSM\)](#) Spring 2022 mini-tutorial ([link to agenda and resources](#)).

These tutorials are designed as an introduction to running the Community Terrestrial Systems Model (CTSM). We will go through three configurations that include running a:

1. Supported NEON tower site,
2. Global FATES-SP simulation, and
3. Generic single point simulation.

We'll also learn how to:

Acknowledgment

A portion of this research was supported as part of the Next Generation Ecosystem Experiments-Tropics, funded by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research.

Thank You! Questions?

Contact details:

Jacquelyn Shuman jkshuman@ucar.edu

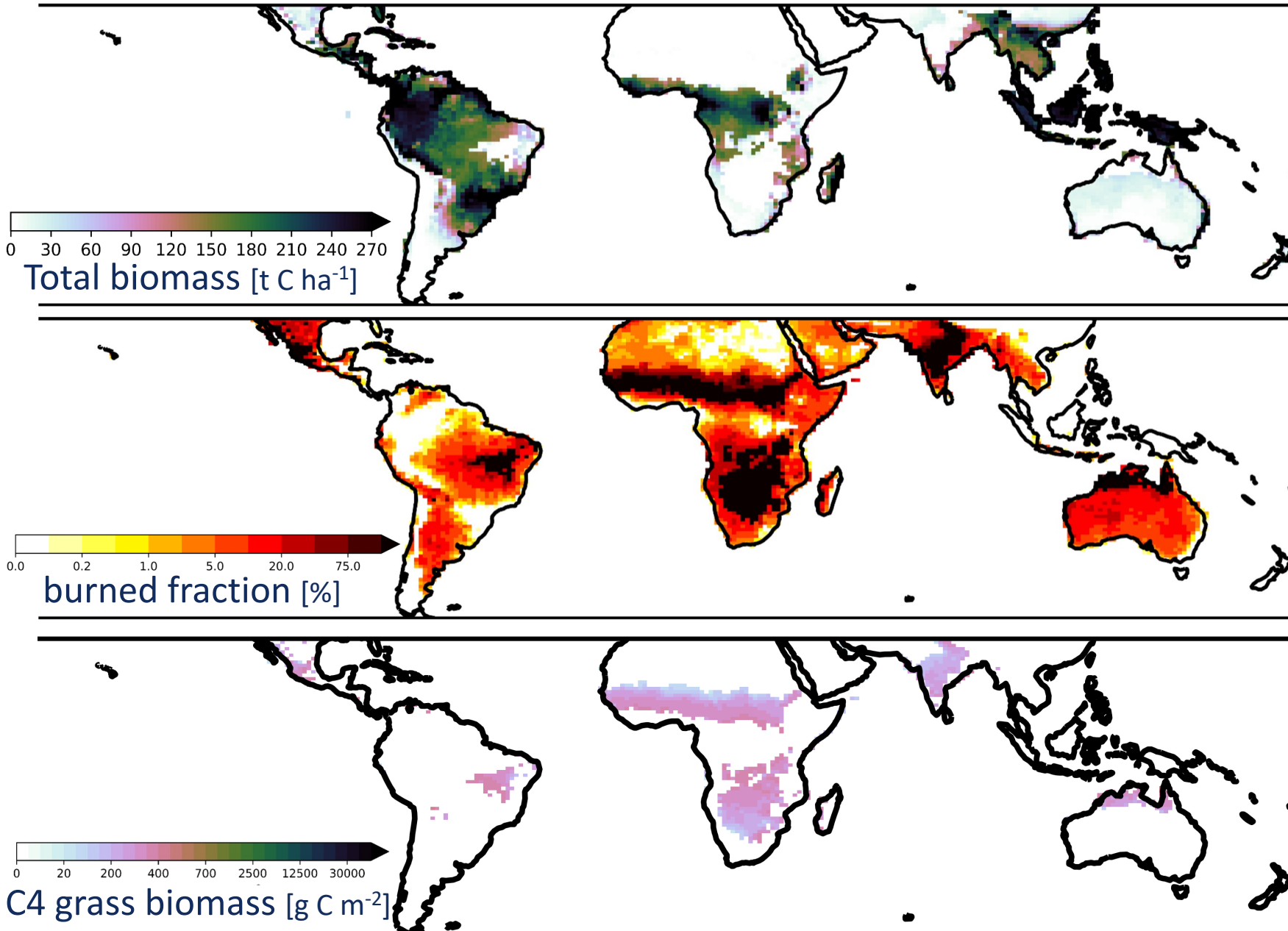


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NEXT-GENERATION ECOSYSTEM EXPERIMENTS-TROPICS





Conclusions



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