A model intercomparison project to study the role of plant functional diversity in the response of tropical forests to drought

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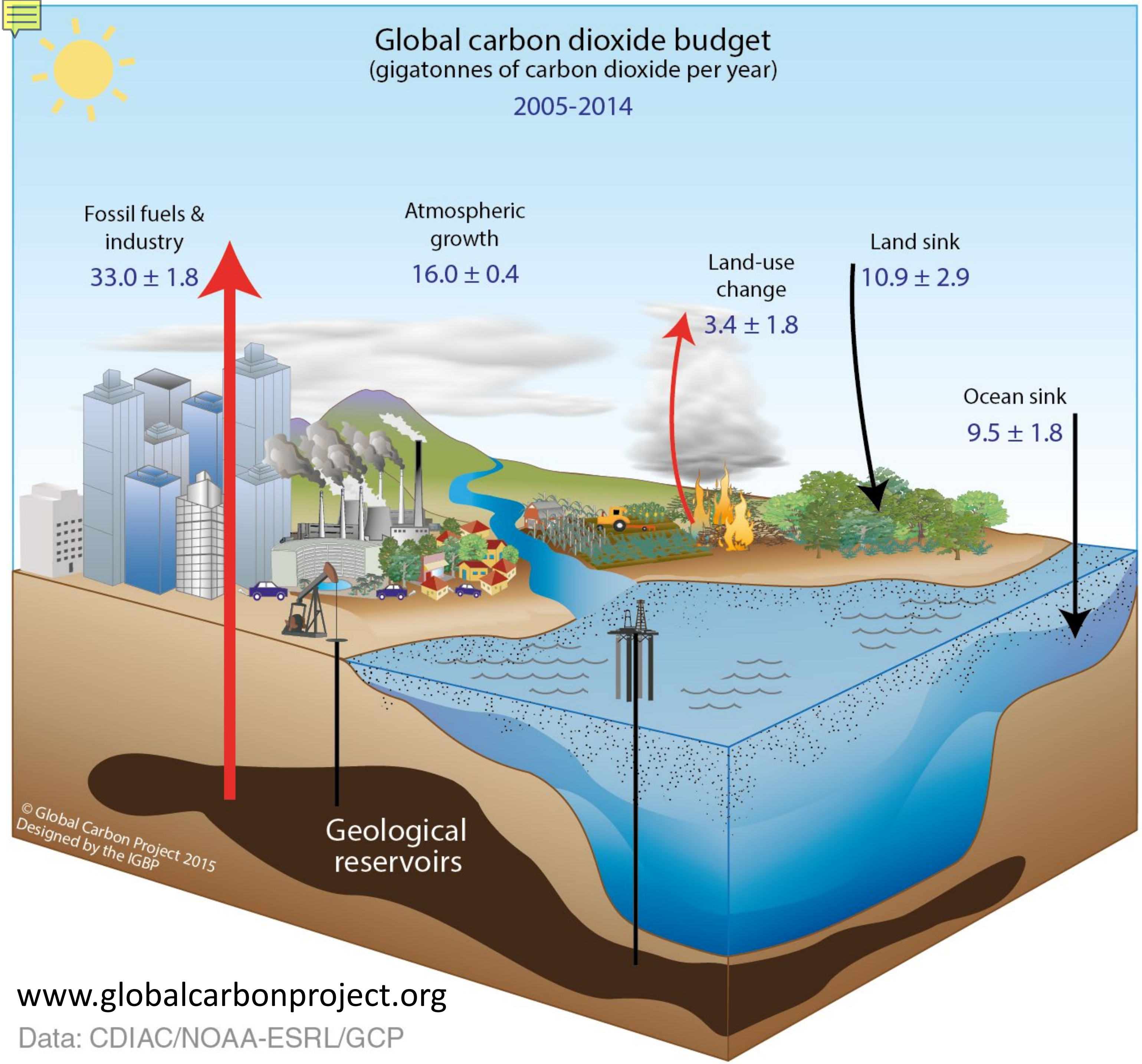
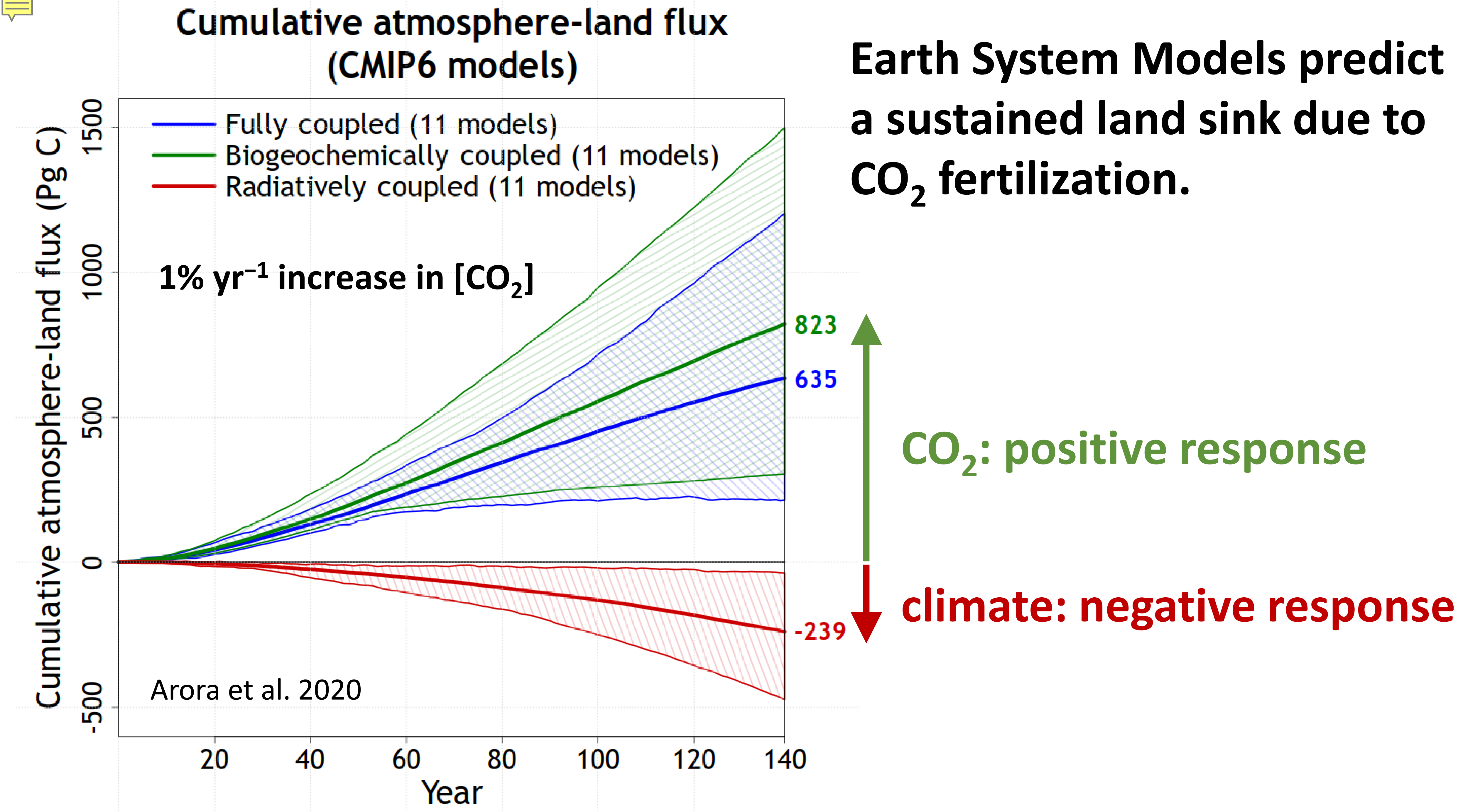


www.globalcarbonproject.org

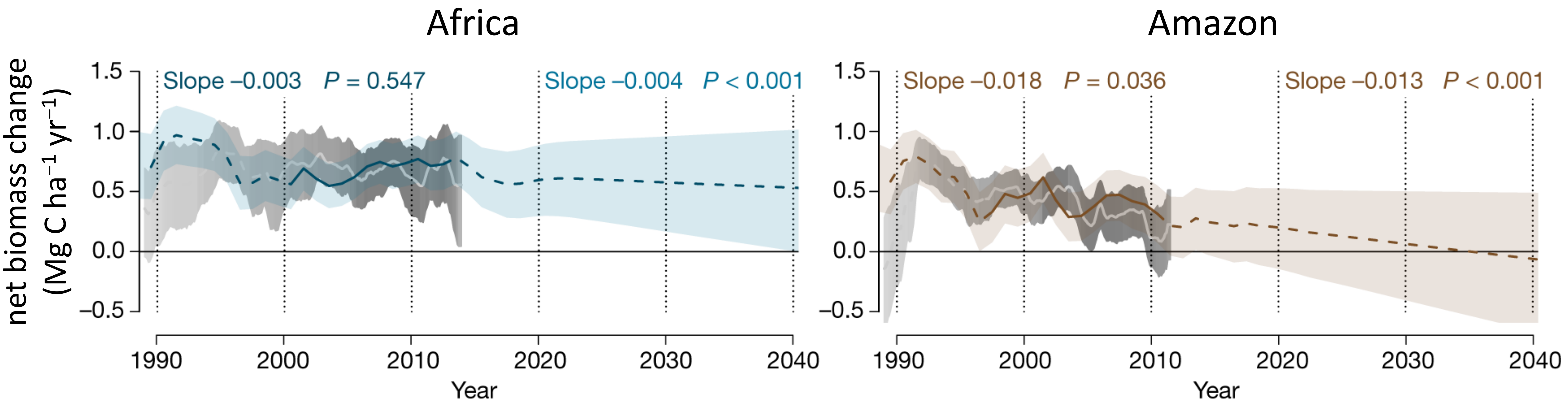
Data: CDIAC/NOAA-ESRL/GCP

- 'Land' = plants, soil, inland water bodies.
- Without land and ocean sinks, atmospheric CO_2 would be rising twice as fast.
- Sinks caused by disequilibrium of the Earth system.
- Land sink probably due to multiple mechanisms:
    - sediments of inland water bodies
    - forest regrowth
    - CO_2 fertilization

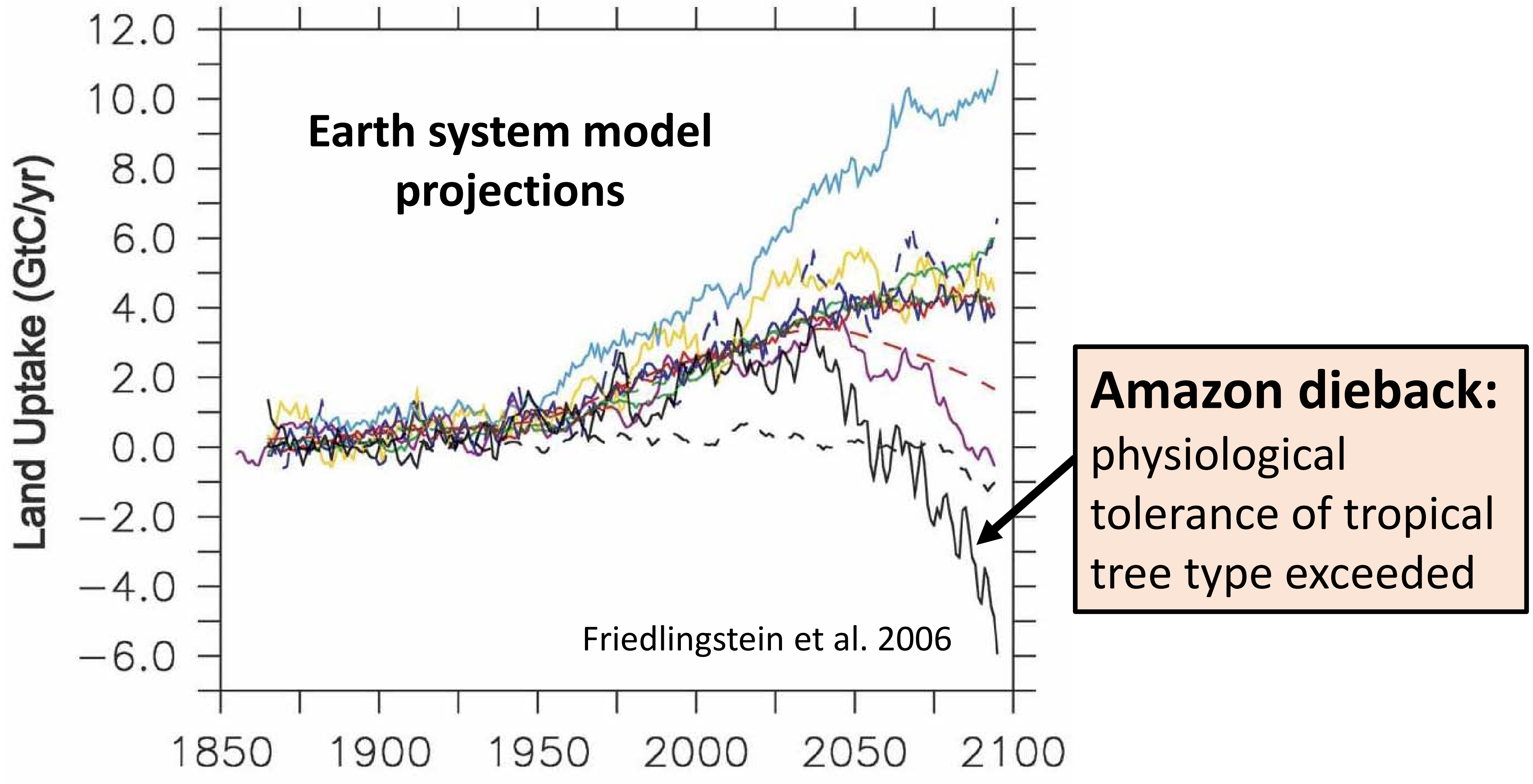


Earth System Models predict a sustained land sink due to CO_2 fertilization.

Tropical forest carbon sinks are weakening

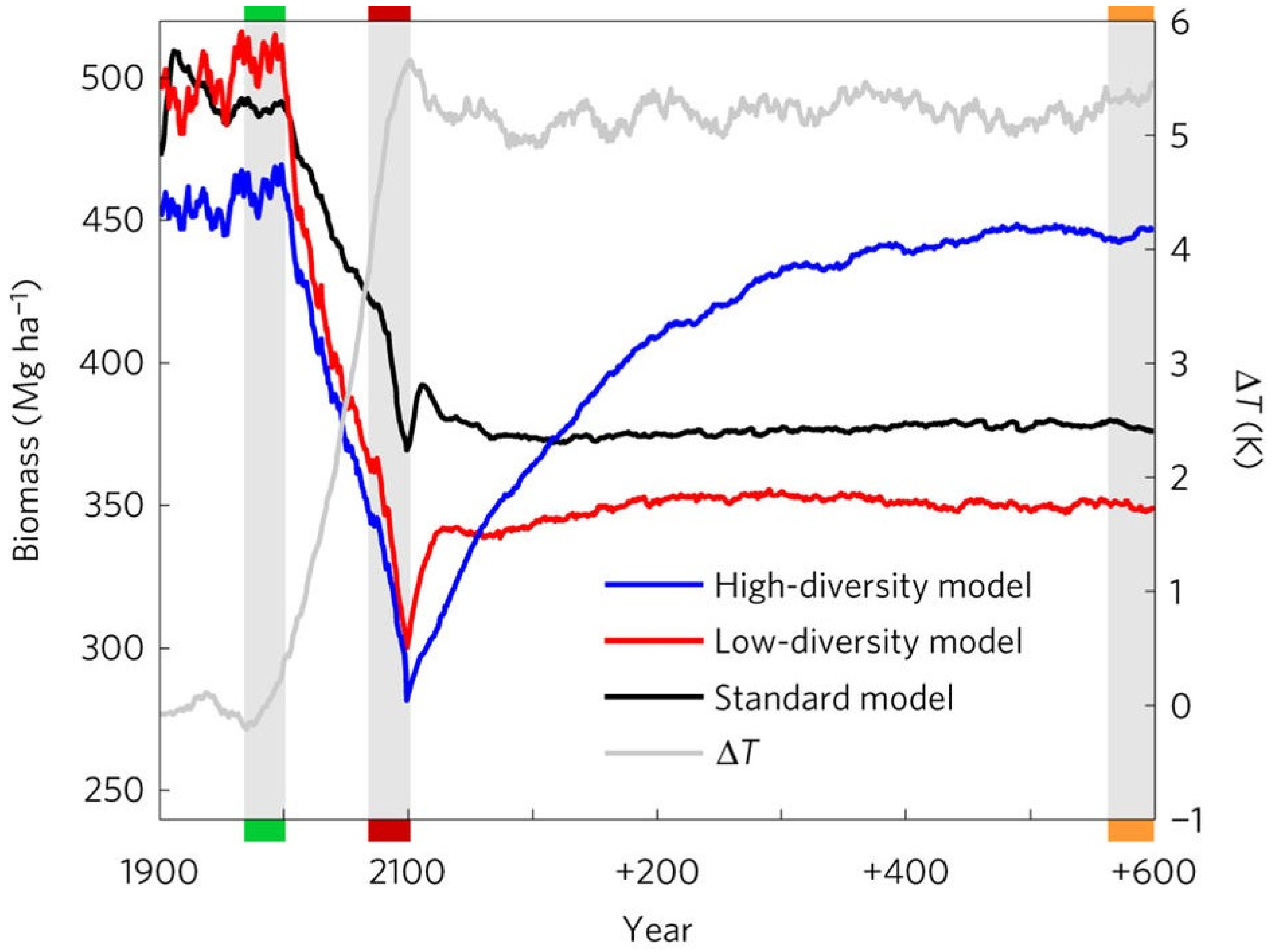


Hubau et al. 2020



Scheiter et al. (2013): "In reality, one might expect that phenotypic plasticity, local adaptation, and shifts … to more drought-tolerant forest tree types may buffer the impacts of decreasing precipitation and thereby avoid a catastrophic dieback of the Amazon rainforest."

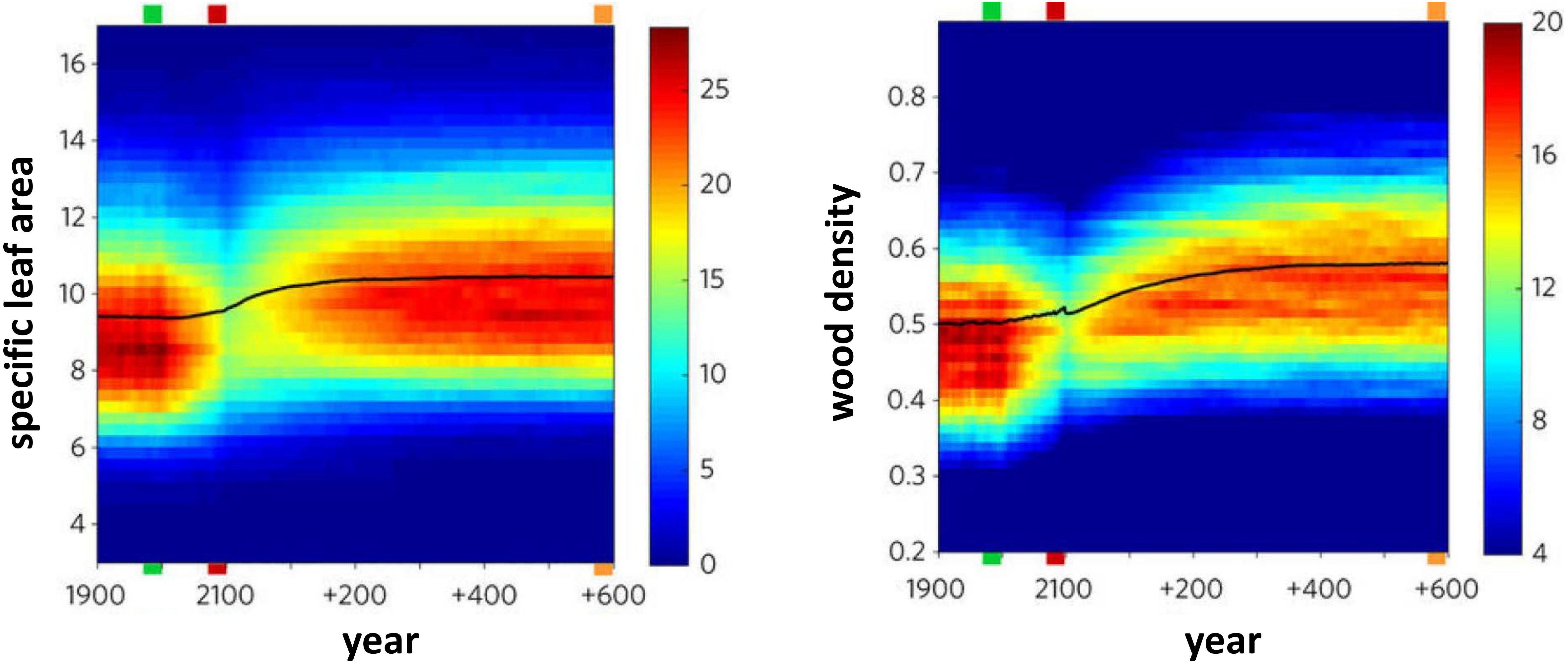
Resilience of Amazon forests emerges from plant trait diversity



Experiments with a process-based vegetation model suggest that plant trait **diversity increases ecosystem resilience** to climate change.

Sakschewski et al. 2016

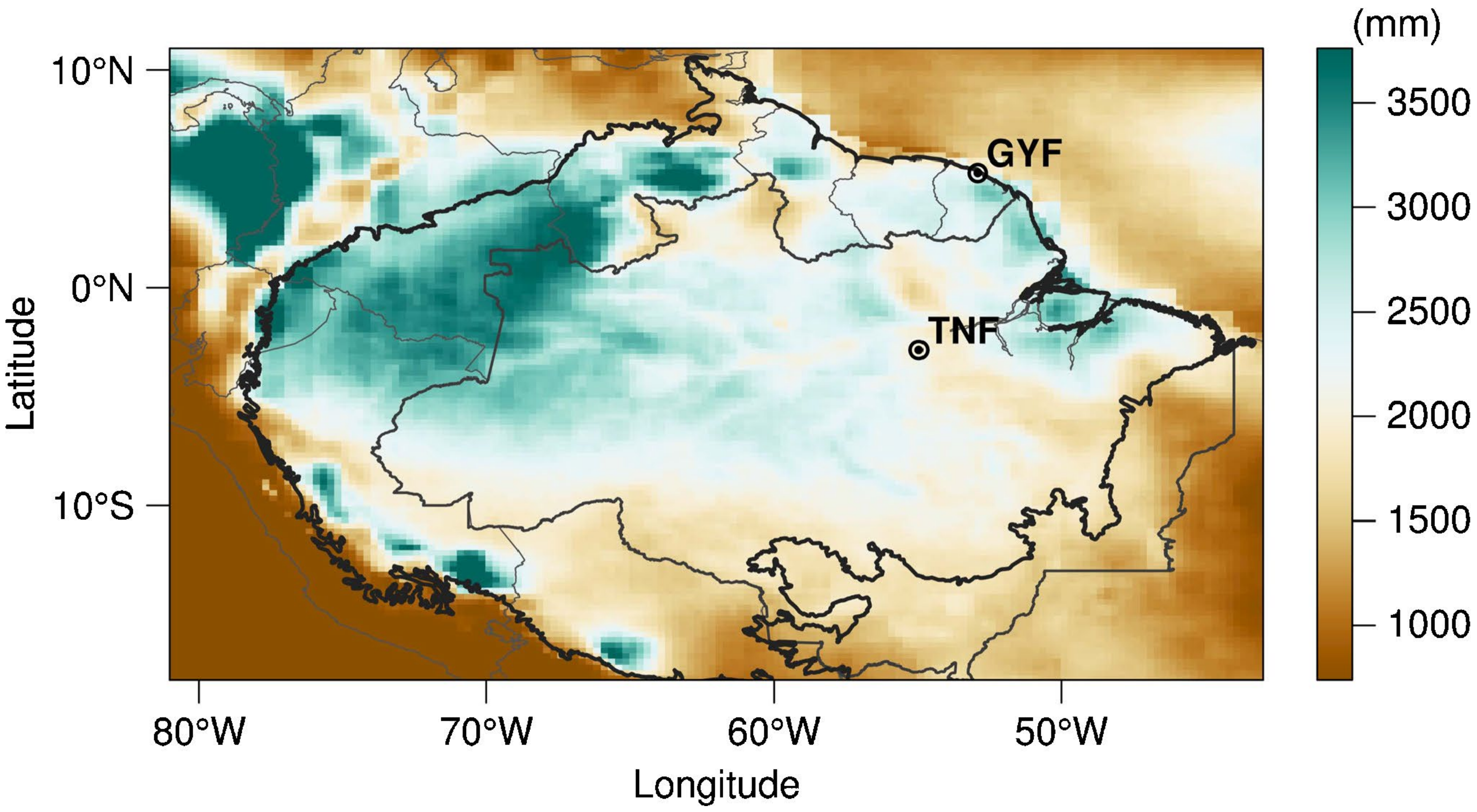
Biodiversity provides the raw material for shifting trait distributions



Sakschewski et al. 2016

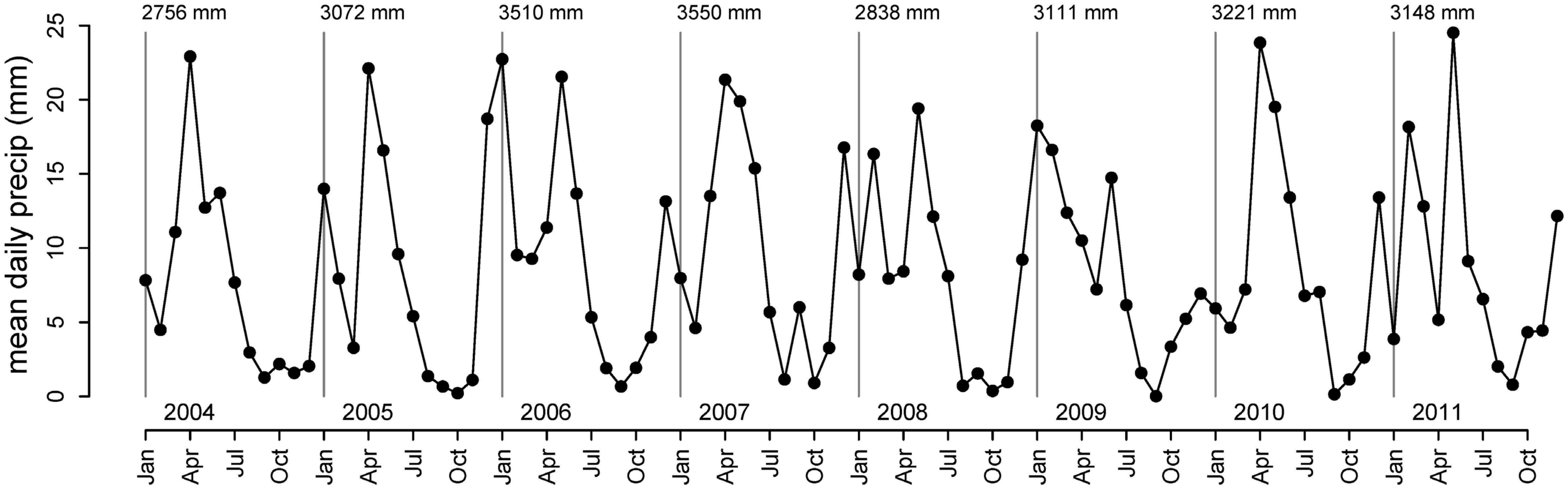
Drought-MIP: A model intercomparison project to study the role of plant functional diversity in the response of tropical forests to drought

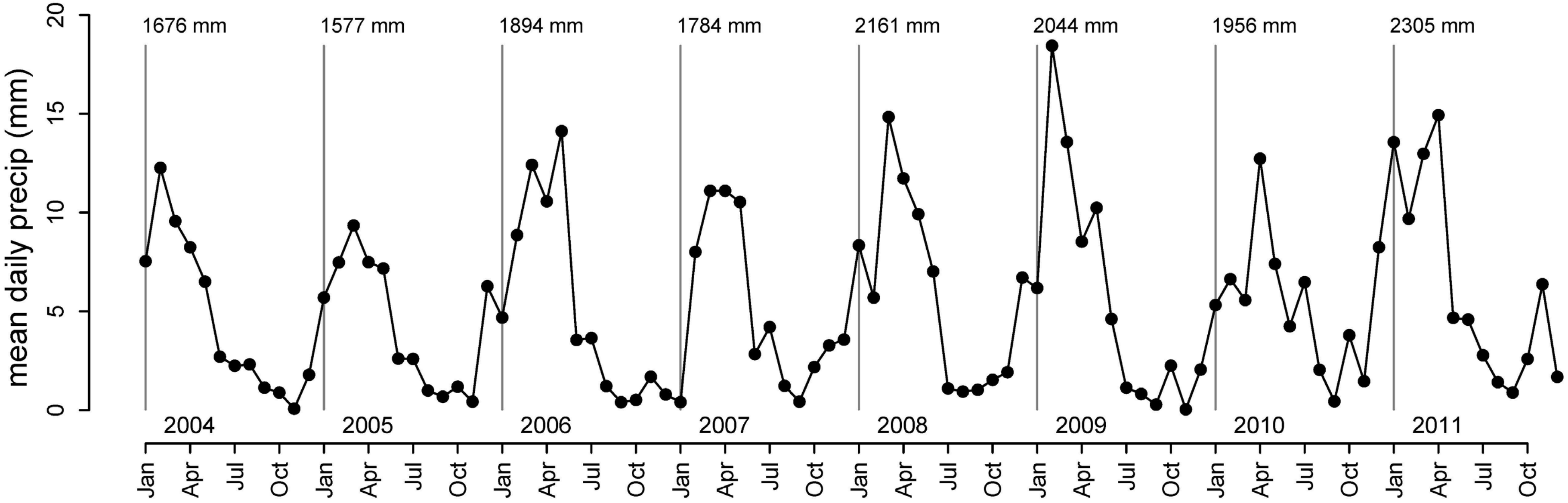
- Models that allow for shifts in trait distributions over time as an emergent outcome of diversity, individual-level competition, and demography.
  - **Dynamic global vegetation models:** aDGVM2, aDGVM-BT, LPJ-GUESS-NTD, LPJmL-FIT
  - **Earth system model components:** ED2, FATES, GFDL-LM4
  - **Forest dynamics models:** FORMIND, TROLL
  - Interested? Contact jlichstein@ufl.edu
- Wet site (GYF): GuyaFlux tower at Paracou Field Station, French Guiana
- Dry site (TNF): Santarém-Km67 tower at Tapajós National Forest, Brazil



Longo et al. 2018

Meteorological reconstruction (1972-2021)





Marcos Longo

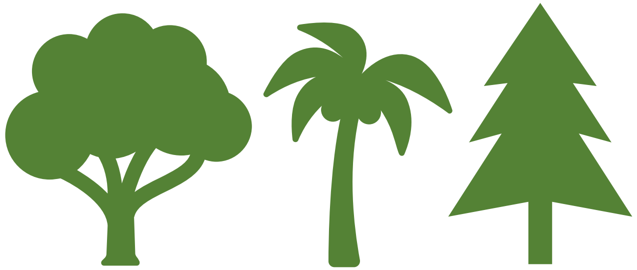
Wet site
- historical: 3421 mm
- obs. dry: 2534 mm
- novel dry: 1708 mm

Dry site
- historical: 1915 mm
- obs. dry: 1131 mm
- novel dry: 950 mm

Experimental design

2 sites × 2 climate scenarios × 2 diversity scenarios

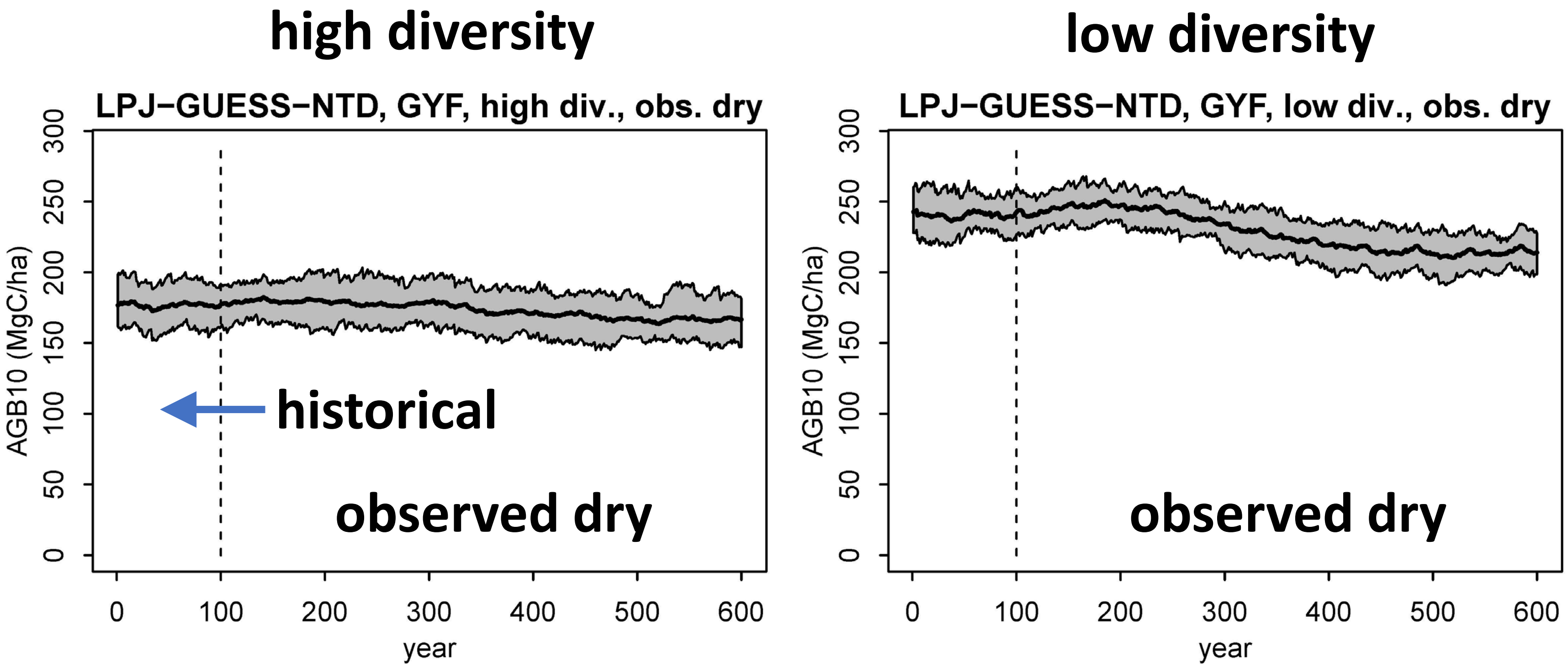
2 sites	2 climate scenarios	2 diversity scenarios
wet	historical → observed dry	high
dry	historical → novel dry	
		low



dominant species/type from high-diversity scenario

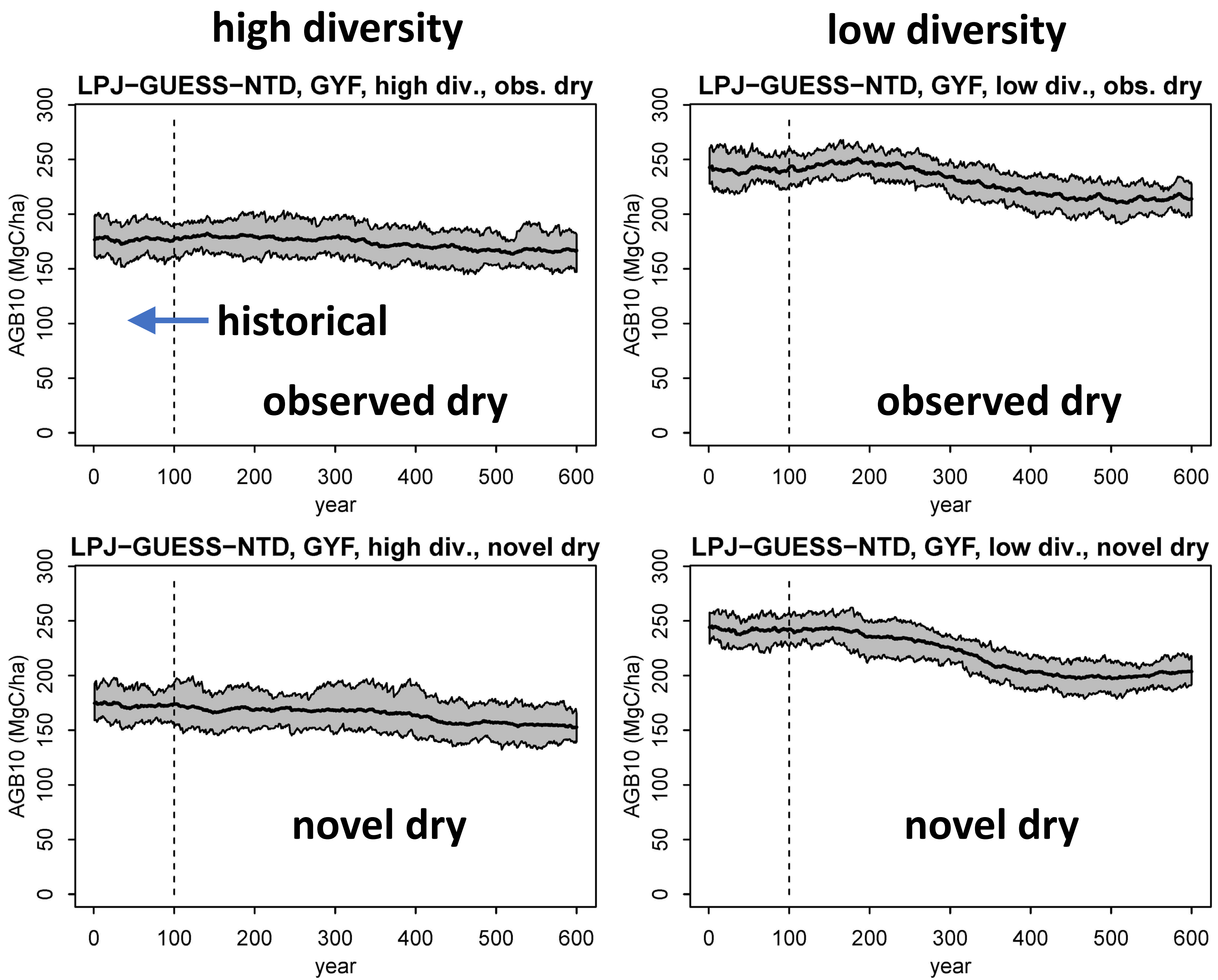
Wet site

LPJ-GUESS-NTD model



Wet site

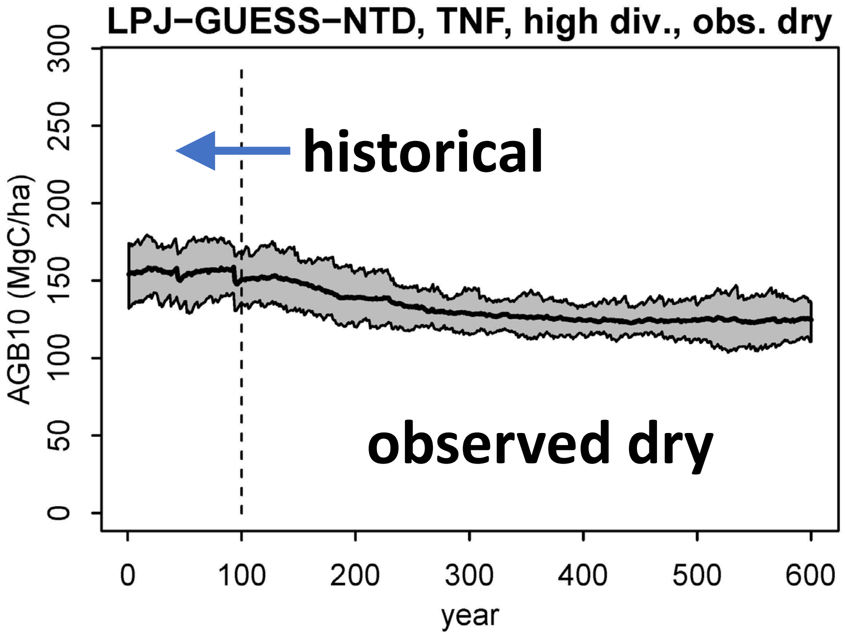
LPJ-GUESS-NTD model



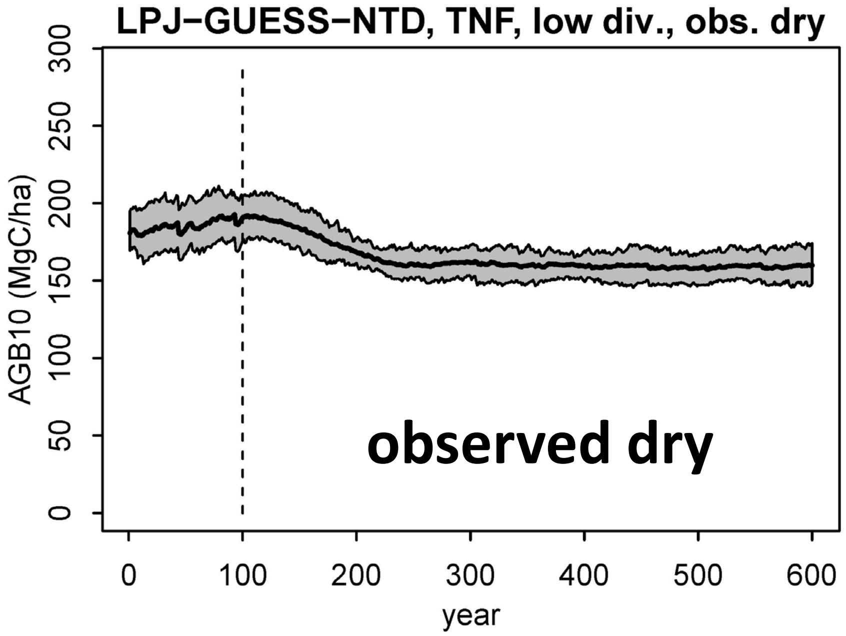
Dry site

LPJ-GUESS-NTD model

high diversity

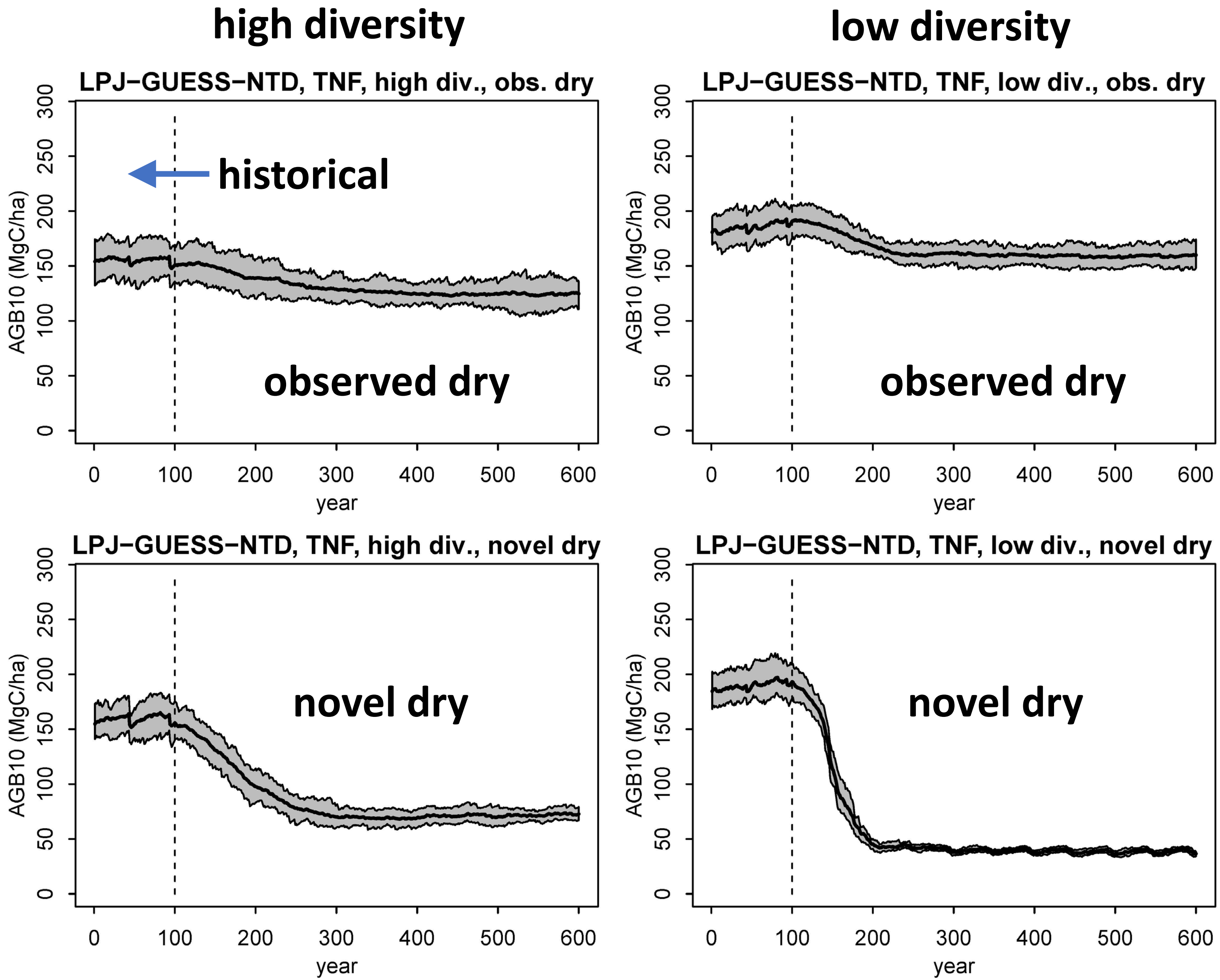


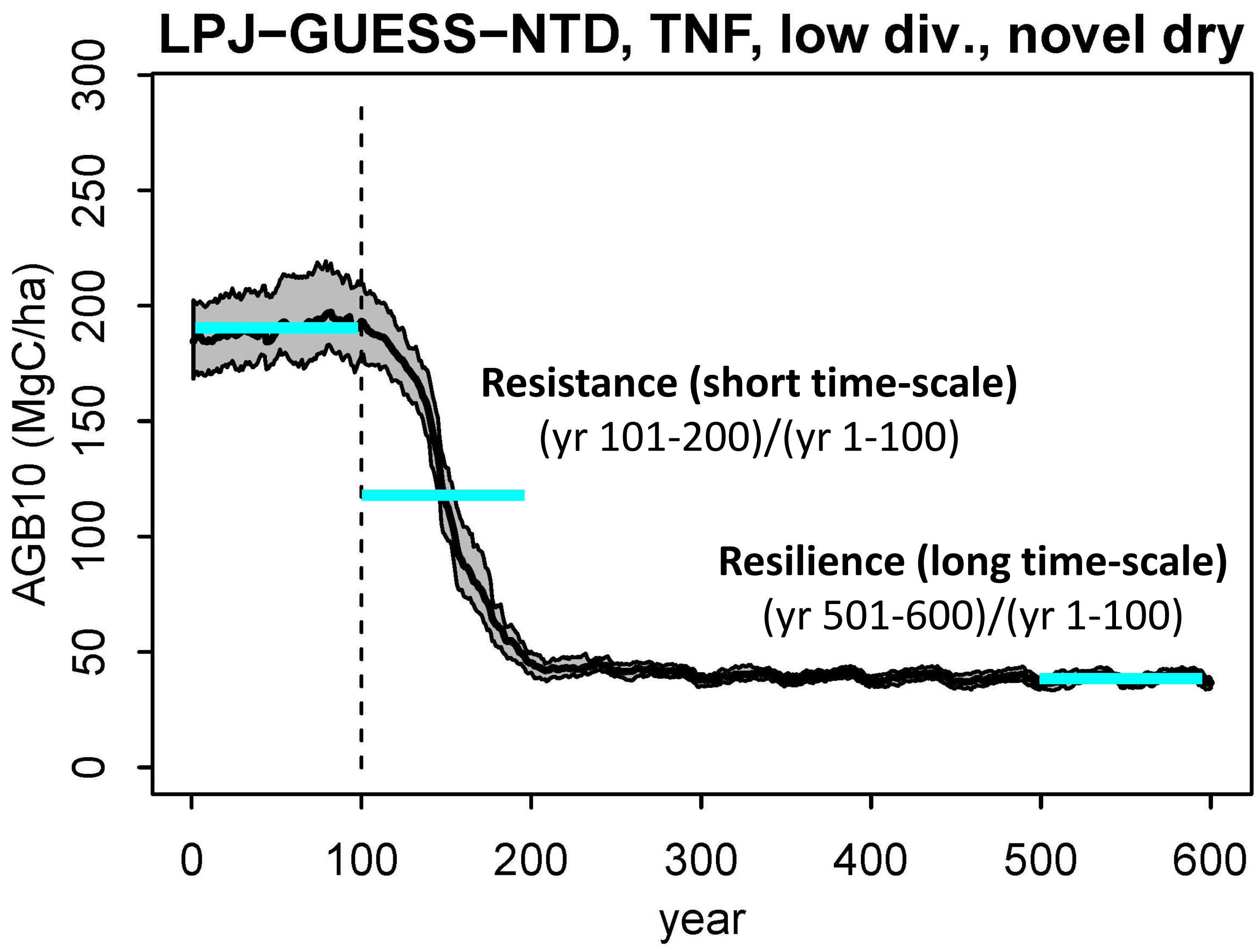
low diversity



Dry site

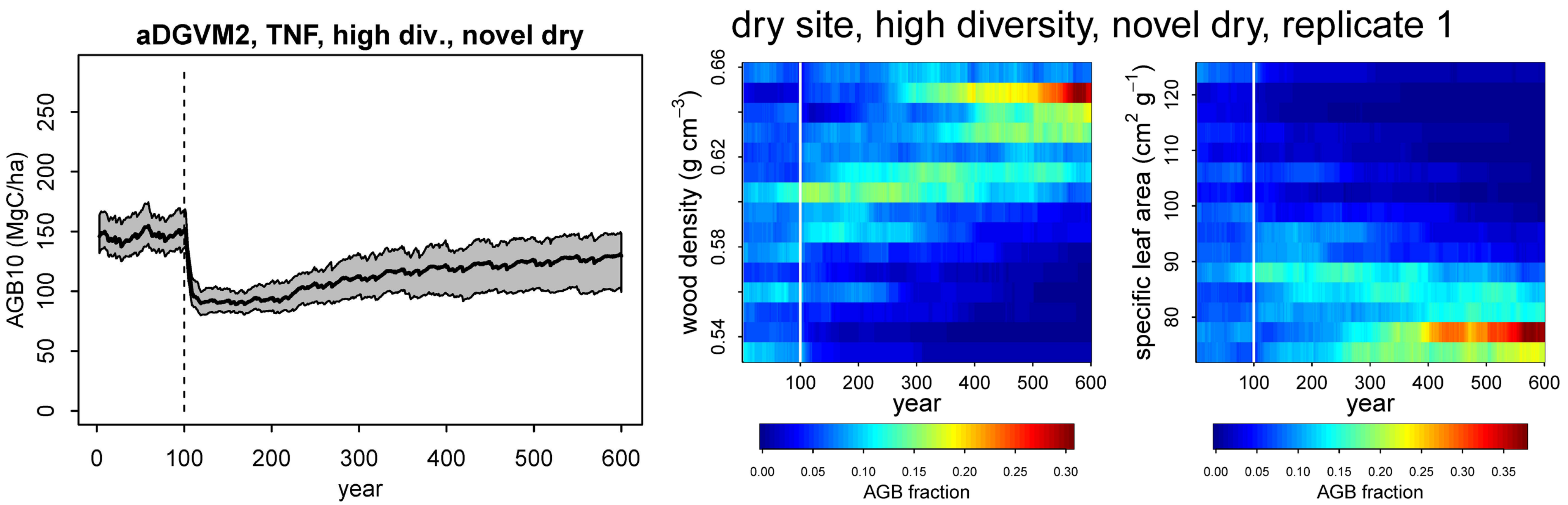
LPJ-GUESS-NTD model



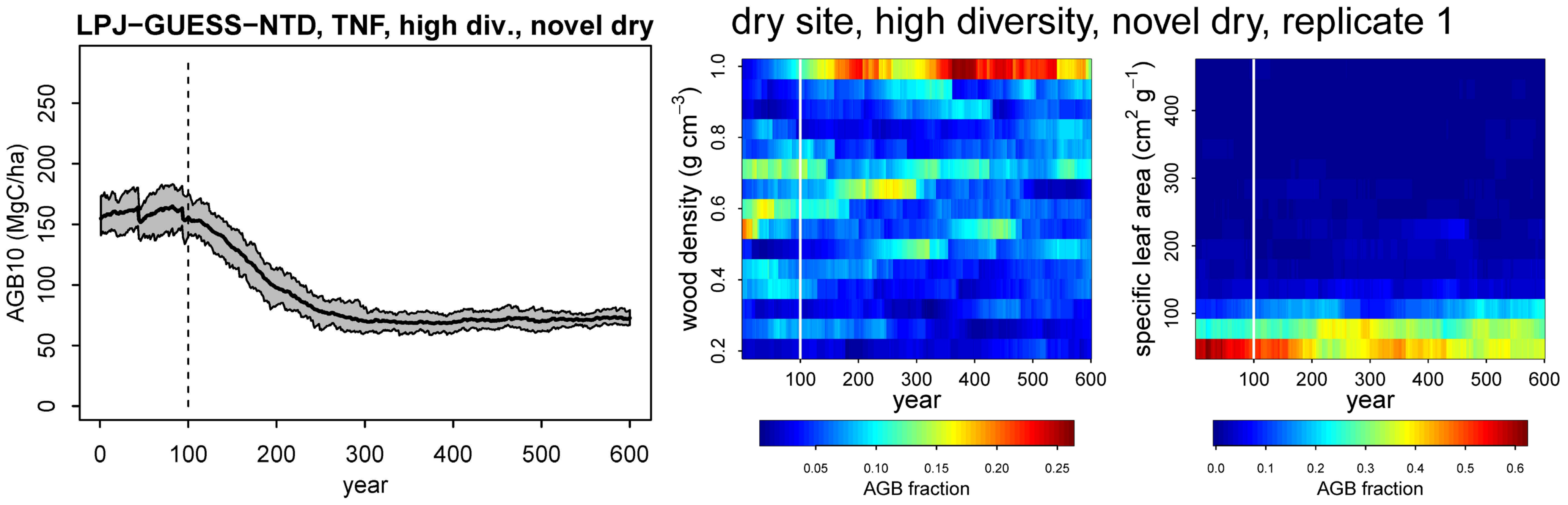


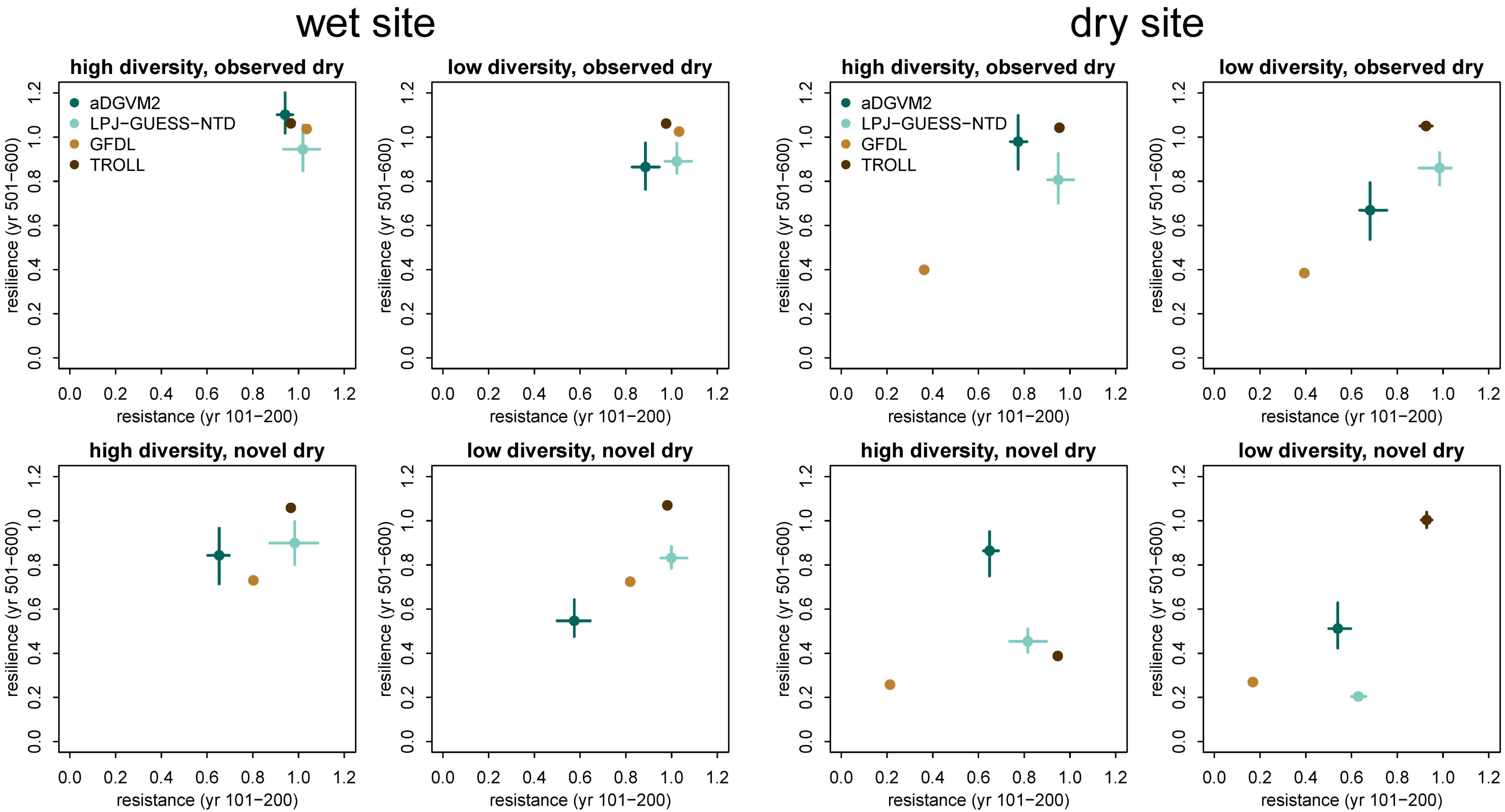
LPJ−GUESS−NTD, TNF, low div., novel dry
AGB10 (MgC/ha)
0
50
100
150
200
250
300
0
100
200
300
400
500
600
year
Resistance (short time-scale)
(yr 101-200)/(yr 1-100)
Resilience (long time-scale)
(yr 501-600)/(yr 1-100)

low resistance
high resilience



low resistance
low resilience




wet site
dry site
high diversity, observed dry
low diversity, observed dry
high diversity, novel dry
low diversity, novel dry
aDGVM2
LPJ−GUESS−NTD
GFDL
TROLL
resilience (yr 501−600)
resistance (yr 101−200)
0.0
0.2
0.4
0.6
0.8
1.0
1.2

Conclusions

- Results differ among models.
- Diversity has only moderate simulated effects on resistance and resilience to drought.
- Need to understand how diversity effects relate to coexistence mechanisms:
  - Sampling from regional species pool (metacommunity processes).
  - Niche partitioning (local stability).
- Results are preliminary:
  - Waiting for results from some collaborators.
  - New collaborators welcome (contact jlichstein@ufl.edu).