Ecosystem structure and seasonal variation in California annual grasslands in CLM-FATES

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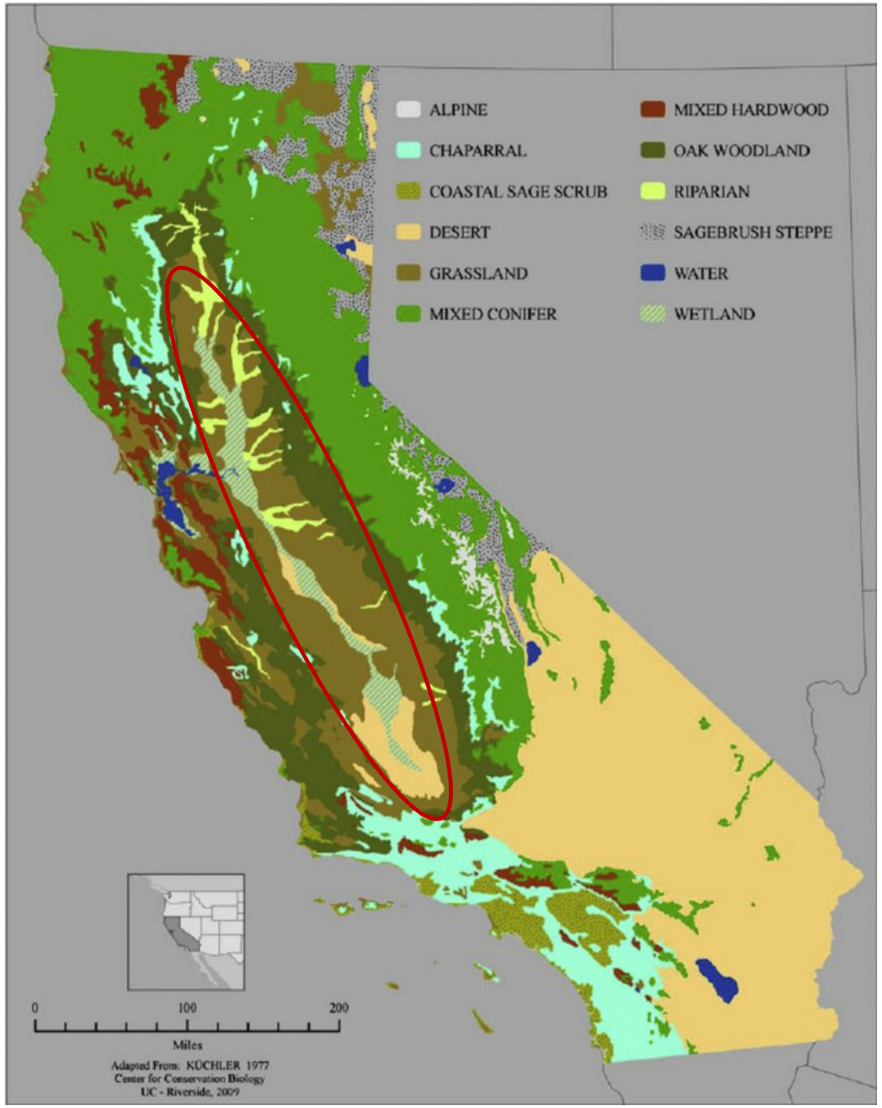
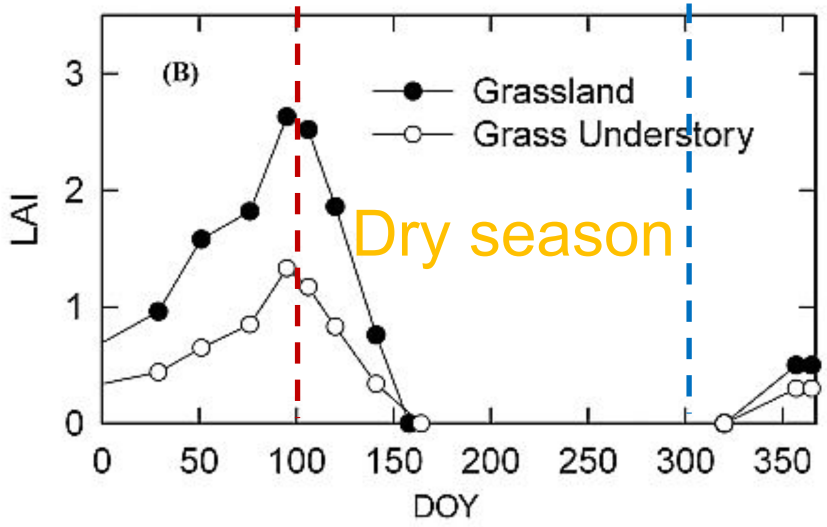
California annual grassland and its phenology



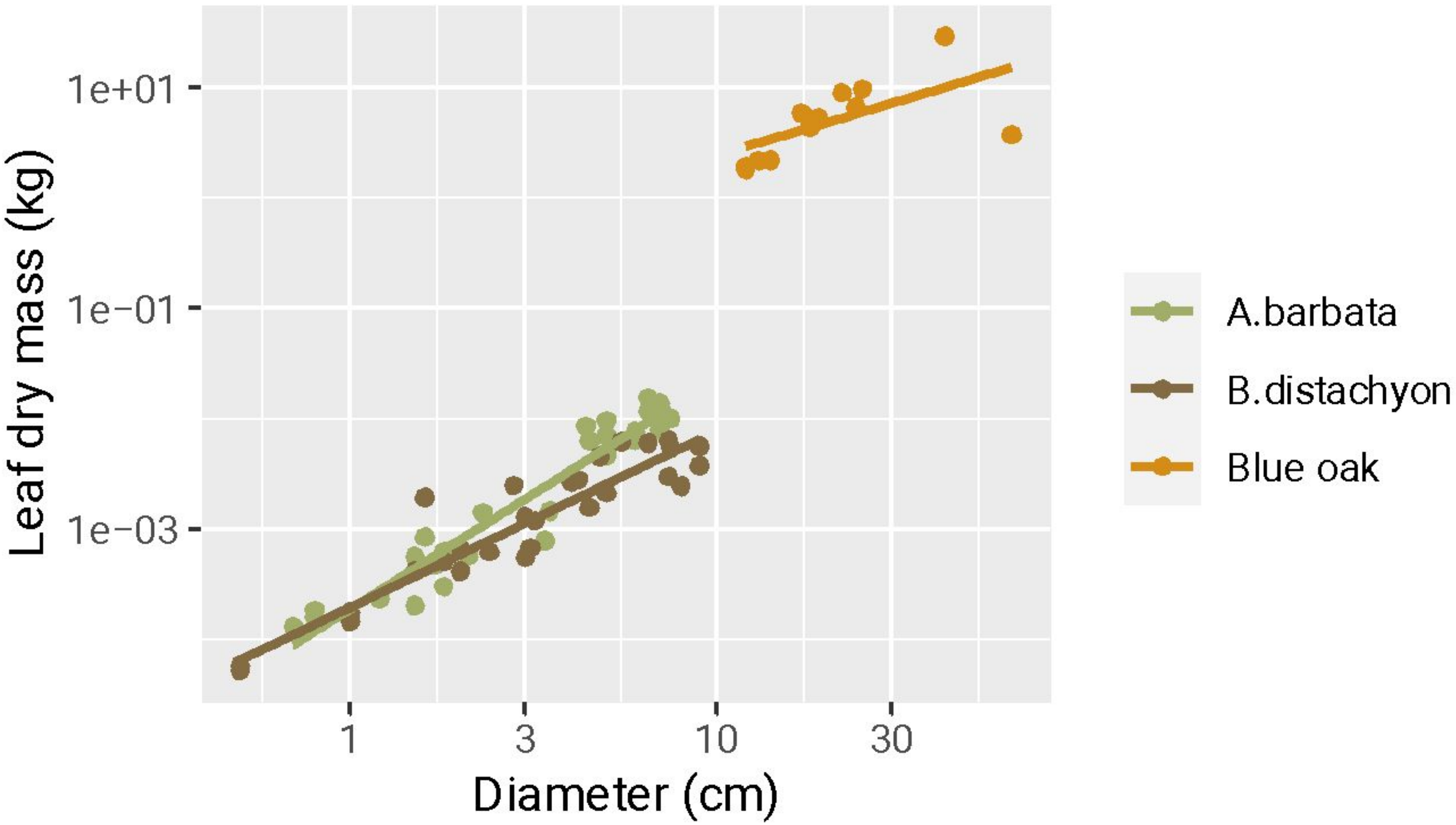
Fenn et al. 2010

nonflammable flammable



Xu et al. 2004

The divergent tree and grass allometry

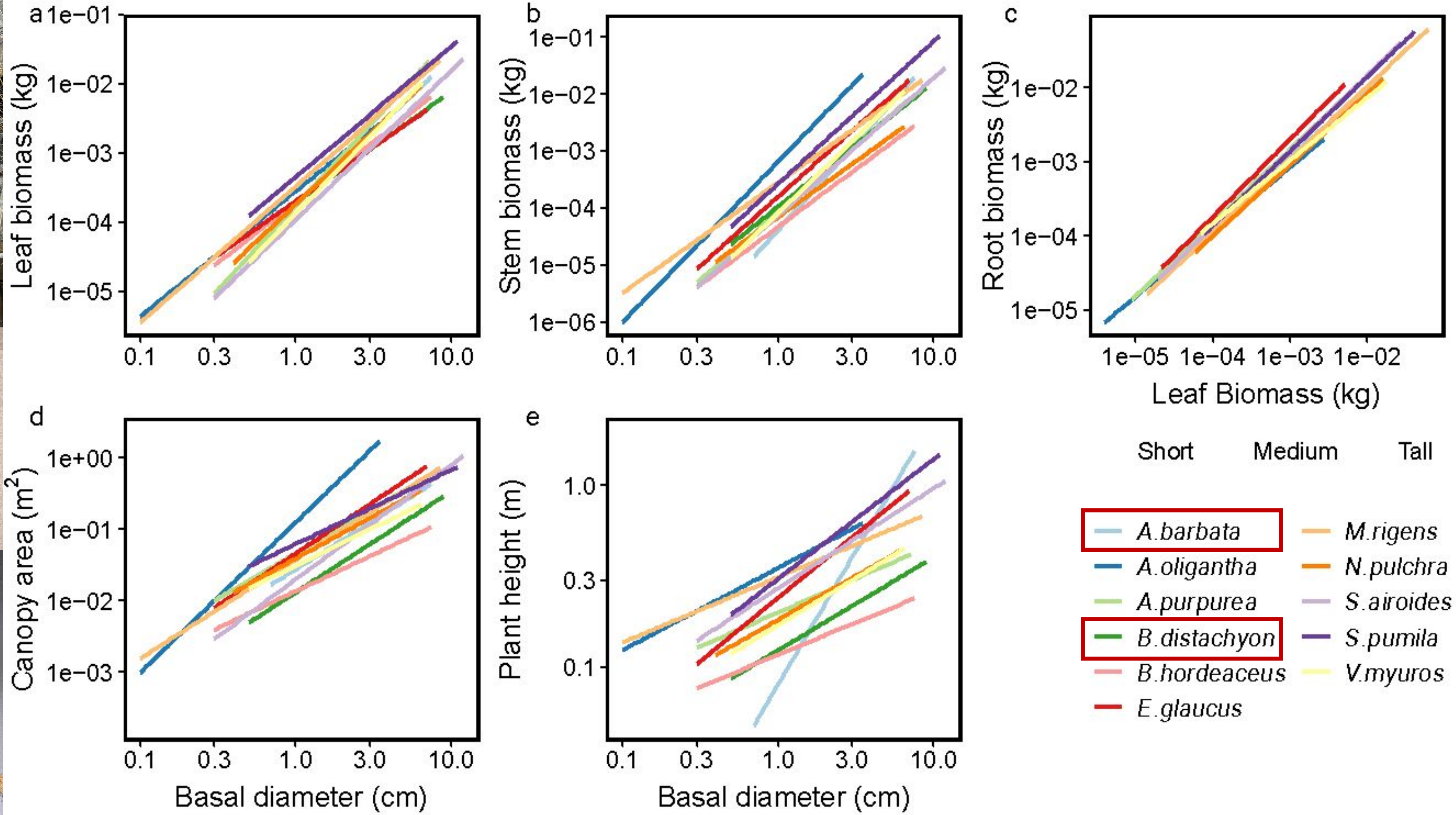


Blue oak data: Karlik and Chojnacky, 2014

Project objectives and goals

- Examine model sensitivity to grass biophysical traits and allometry
- Determine the most influential parameters for grass fire
- Generate parameter sets that can reconstruct site structure and seasonal variation in matter and energy fluxes
- Assess model performance in simulating regional GPP, LAI, and burned fraction with site-derived parameters

The greenhouse experiment and new grass allometry



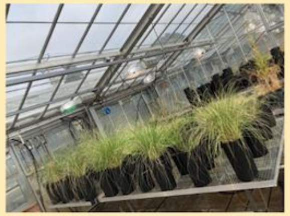
Model parameter settings

	Parameter	Min	Max	Source
Leaf traits	Leaf diameter (m)	0.01	0.04	Experience
	Leaf turnover (yr^{-1})	0.02	0.32	TRY
	SLA ($m2.gC^{-1}$)	0.015	0.072	TRY
	Vcmax (umol CO2.m^{-2}.s^{-1})	35.6	91.6	Griffith et al. 2020; Maire et al. 2012
	Stomatal intercept (umol H2O.m^{-2}.s^{-1})	10000	2030000	Miner et al. 2016
	Stomatal slope (unitless)	5.25	17	Miner et al. 2016
	Leaf N content (leaf gN.leaf gC^{-1})	0.01	0.06	TRY
Allocation	Reproduction DBH threshold (cm)	1.5	4	Gao et al. 2023 (unpublished yet)
	Seed allocation (mature, fraction)	0.1	1	Experience
	Recruitment min. height (m)	0.1	0.5	Experience
	Storage allocation (fraction)	1	1.5	Experience
Phenology Mortality	Drought deciduous SWC% (m^3.m^{-3})	0.1	0.23	Baldocchi et al. 2004
	smpsc (mm H_2O)	-200000	-60000	Experience
	smpso (mm H_2O)	-60000	-33000	Experience
	Rooting depth parameter a (unitless)	5	13	Rooting depth no deeper than 1m
	Rooting depth parameter b (unitless)	3	10	Rooting depth no deeper than 1m
	Soil moisture (drought mort begin, unitless)	0.25	0.9	Experience
	Hydraulic mortality scalar (yr^{-1})	3	20	Experience
	Carbon starvation mortality scalar (yr^{-1})	1	6	Experience
	Growth respiration (unitless)	0.1	0.5	Experience
Fire	Fuel bulk density (dead, kg.m^{-3})	4	22	Prior et al. 2016 Snell 1979
	Fuel bulk density (live, kg.m^{-3})	1	4	Snell 1979
	Ignition density (strikes.km^2.yr^{-1})	0.01	1	Keeley and Syphard 2018
	Fuel drying ratio (unitless)	66	66000	Experience
	Fuel energy (kJ.kg^{-1})	6450	14300	Simpson et al. 2015
	Max. litter fragmentation rate ($g.g^{-1}$.yr^{-1})	0.8	1.6	Zhang et al. 2018

Study region and model experiments set up

Site simulations

Greenhouse allometry data



AVBA: *Avena barbata*
BRDI: *Brachypodium distachyon*
GENL: generalized grass allometry

Turn fire off

Allometry AVBA → Params set 1, 2..N
Allometry BRDI → Params set 1, 2..N
Allometry GENL → Params set 1, 2..N

Ensembles with reasonable GPP, LAI, AGB, and energy flux compared to site data

Turn fire on

Fire params set 1, 2..M

Regional simulations

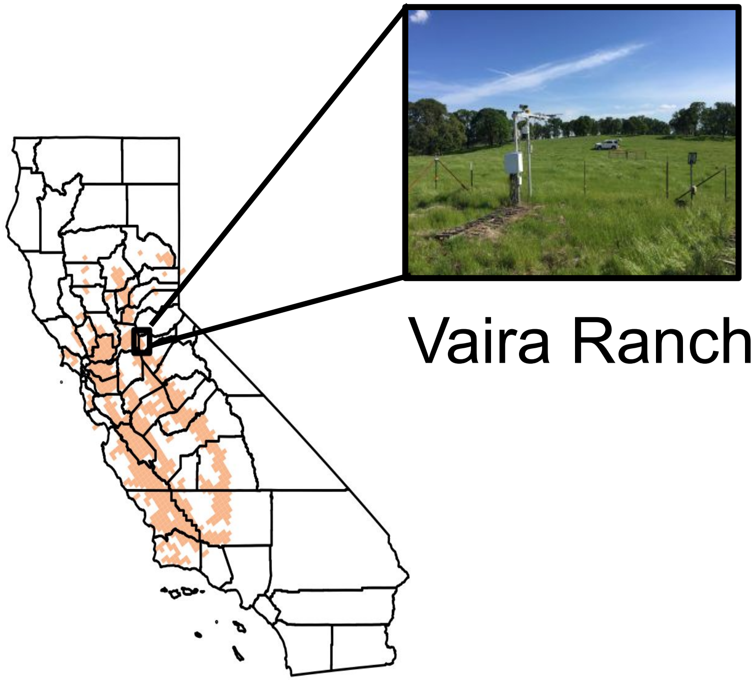
Parameter sets with fire regime that can represent observational range from FRAP

Validate regional burned fraction

Step1: biophysical parameter perturbations at site level

Step2: fire parameter perturbations at site level

Step3: assess model performance at regional level with site-derived parameters

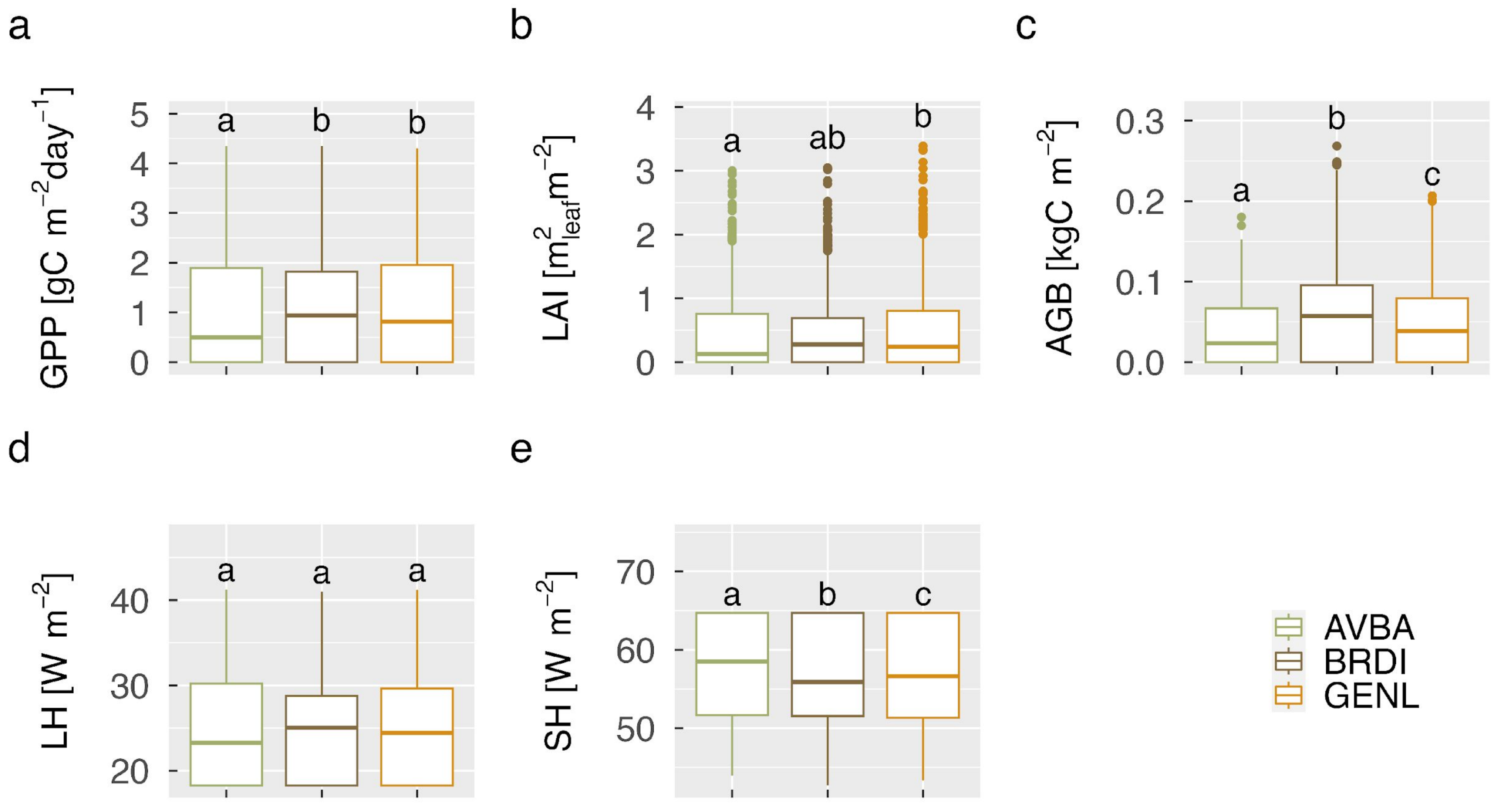


Vaira Ranch

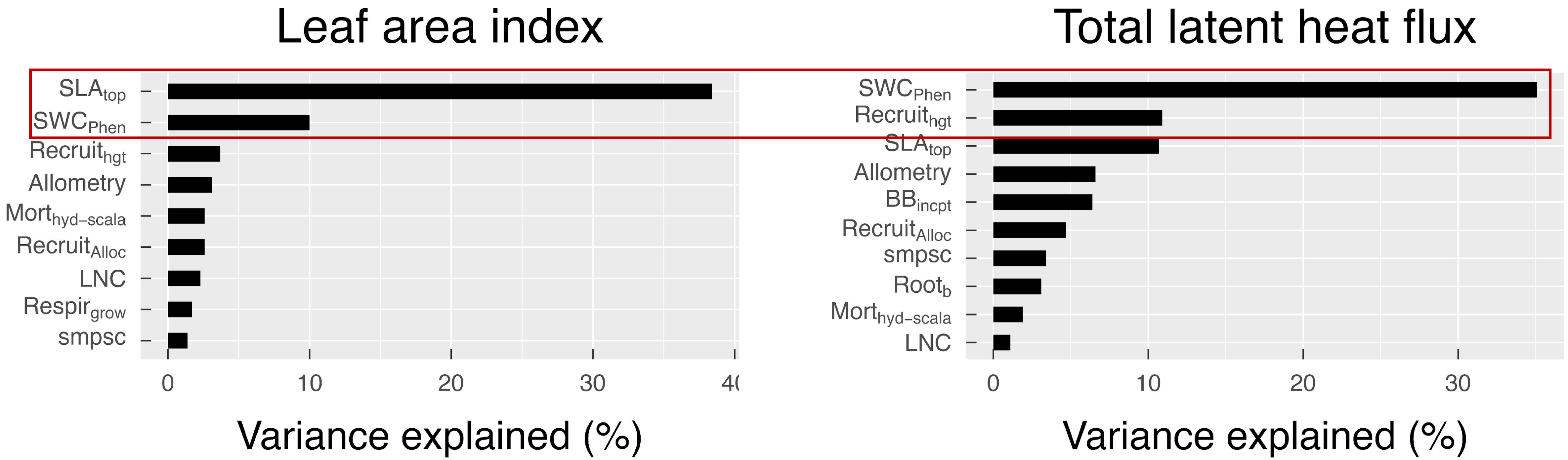
BRDI

AVBA

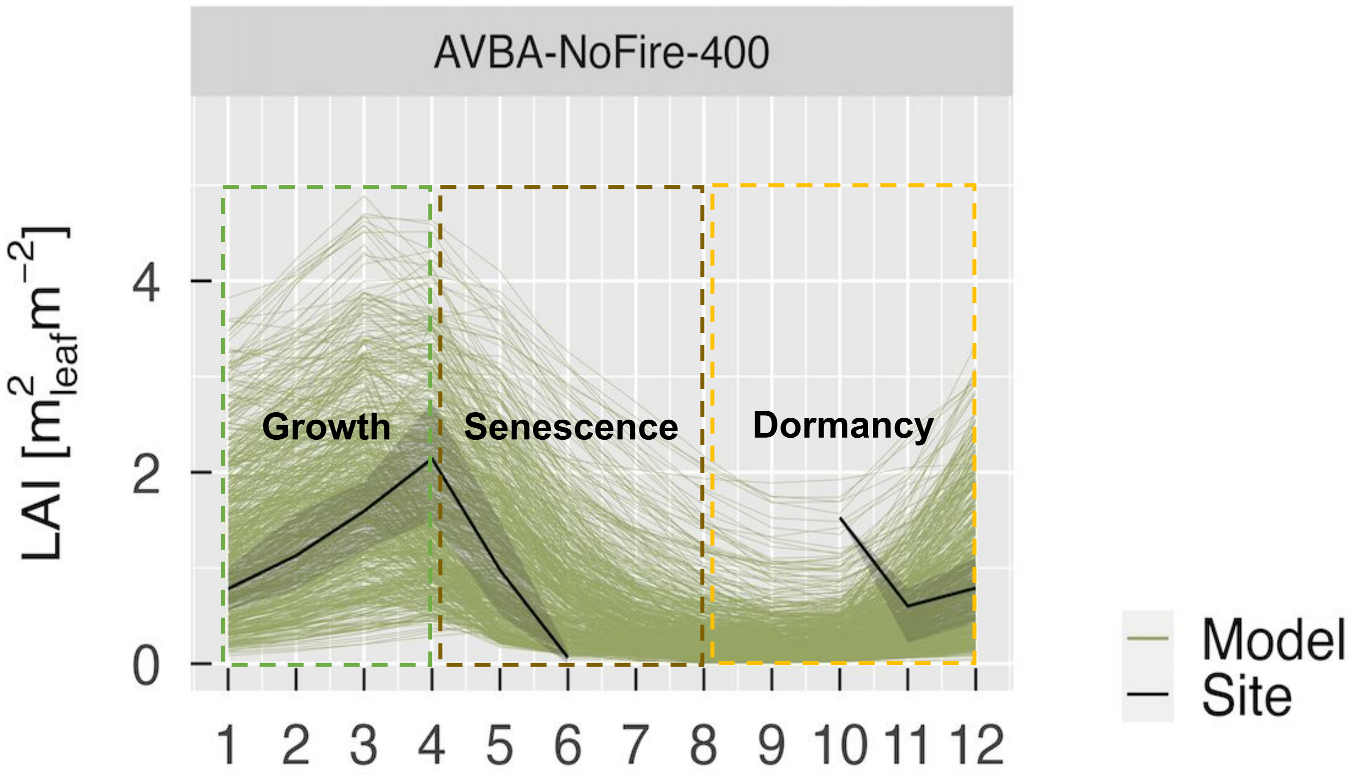
Grass allometry influenced model simulations of water, carbon, and energy fluxes

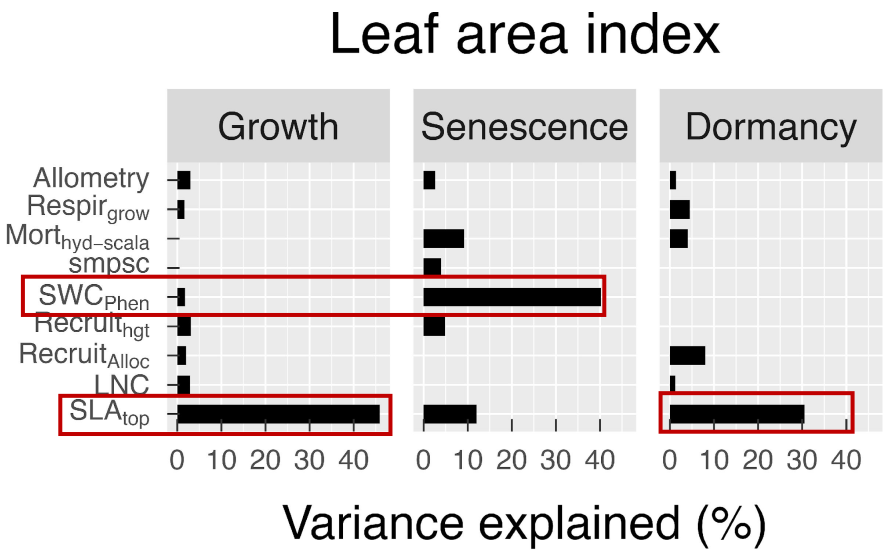


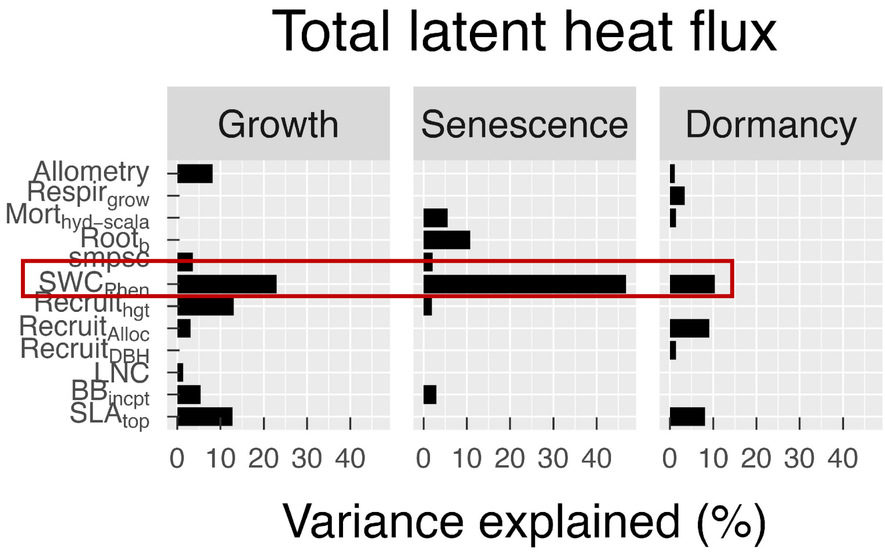
Soil water content triggering drought-deciduous phenology shapes the seasonal dynamic



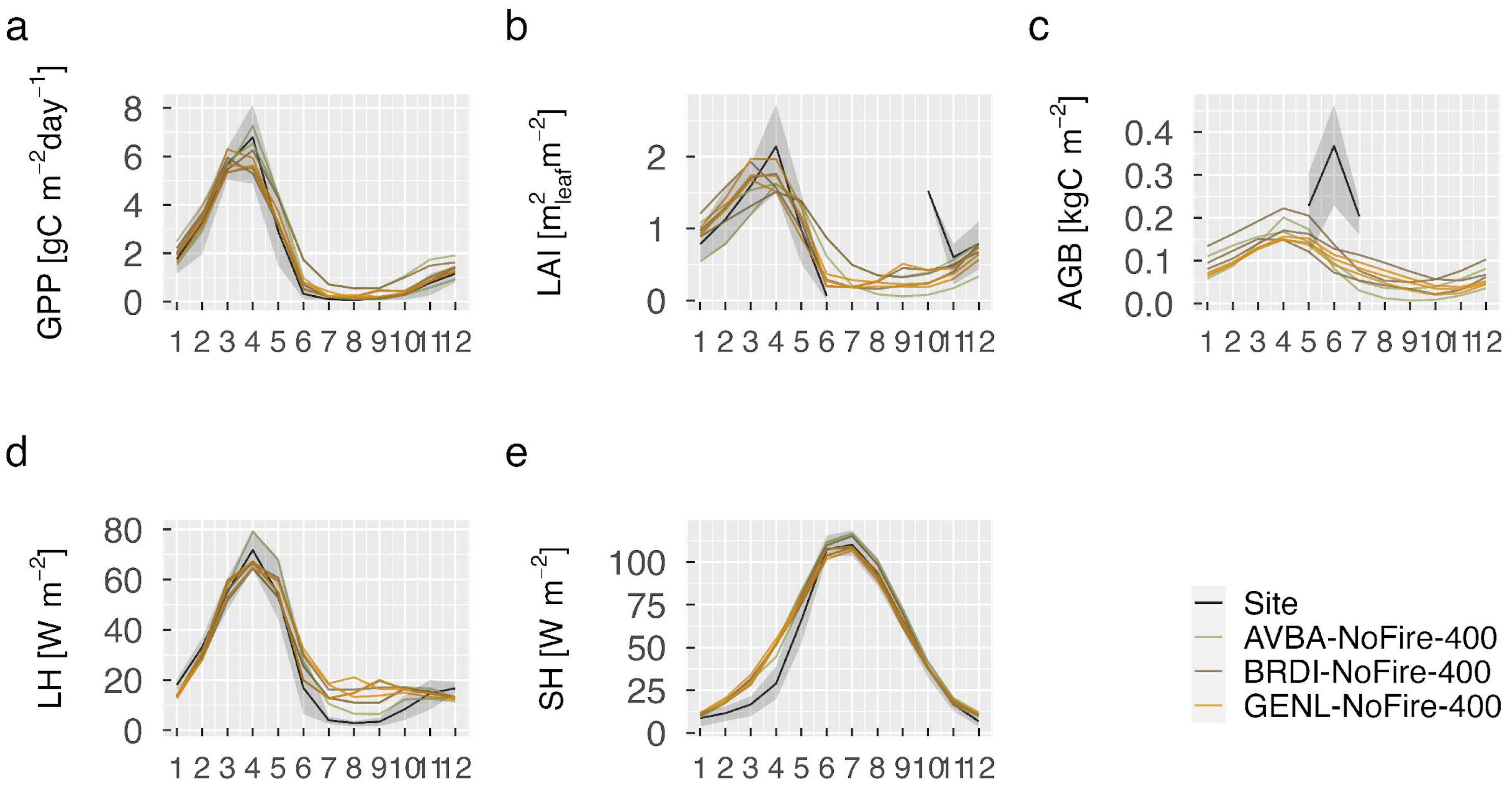
Importance of model parameters also has a seasonal pattern that depends on the phenology of the PFT



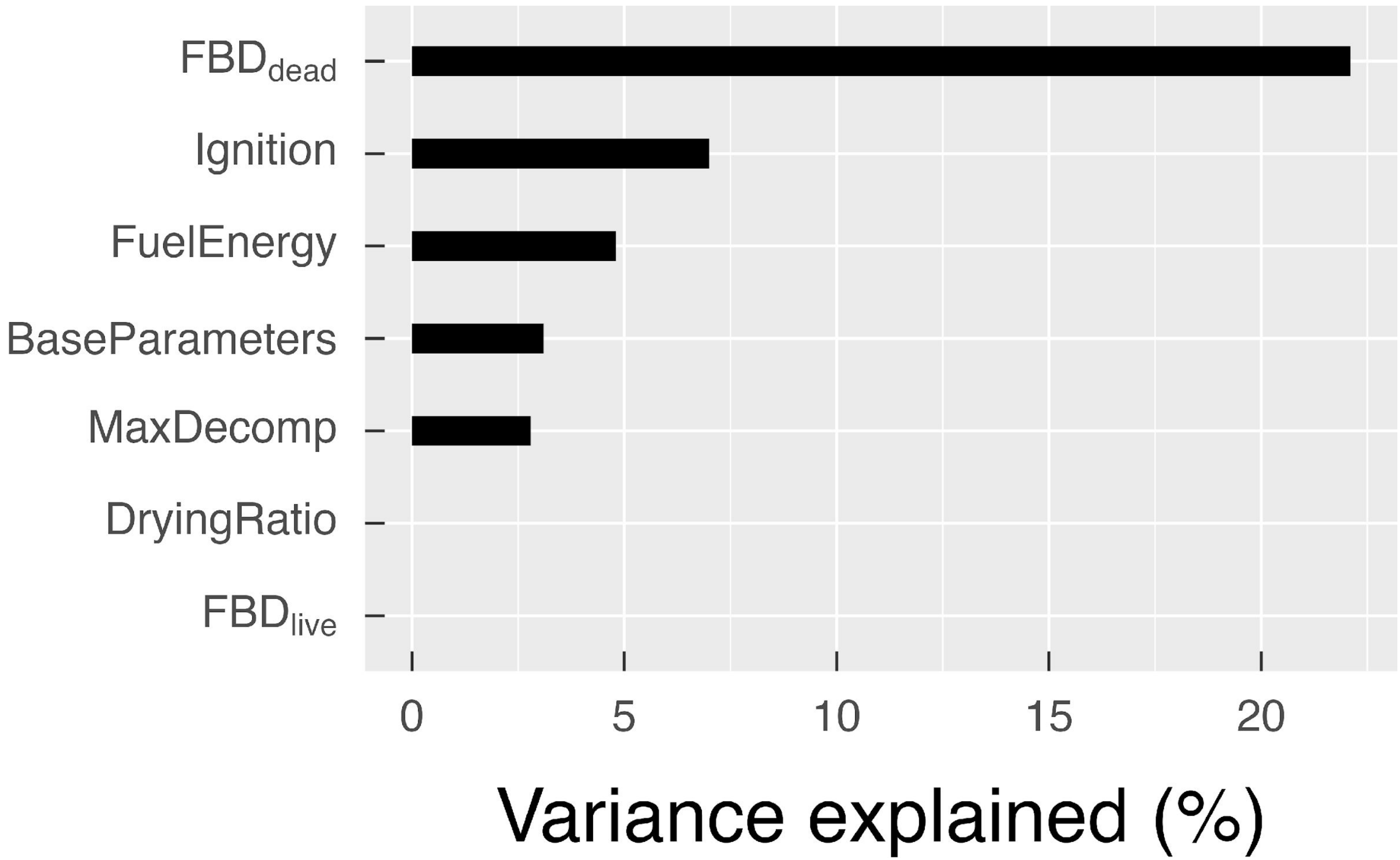




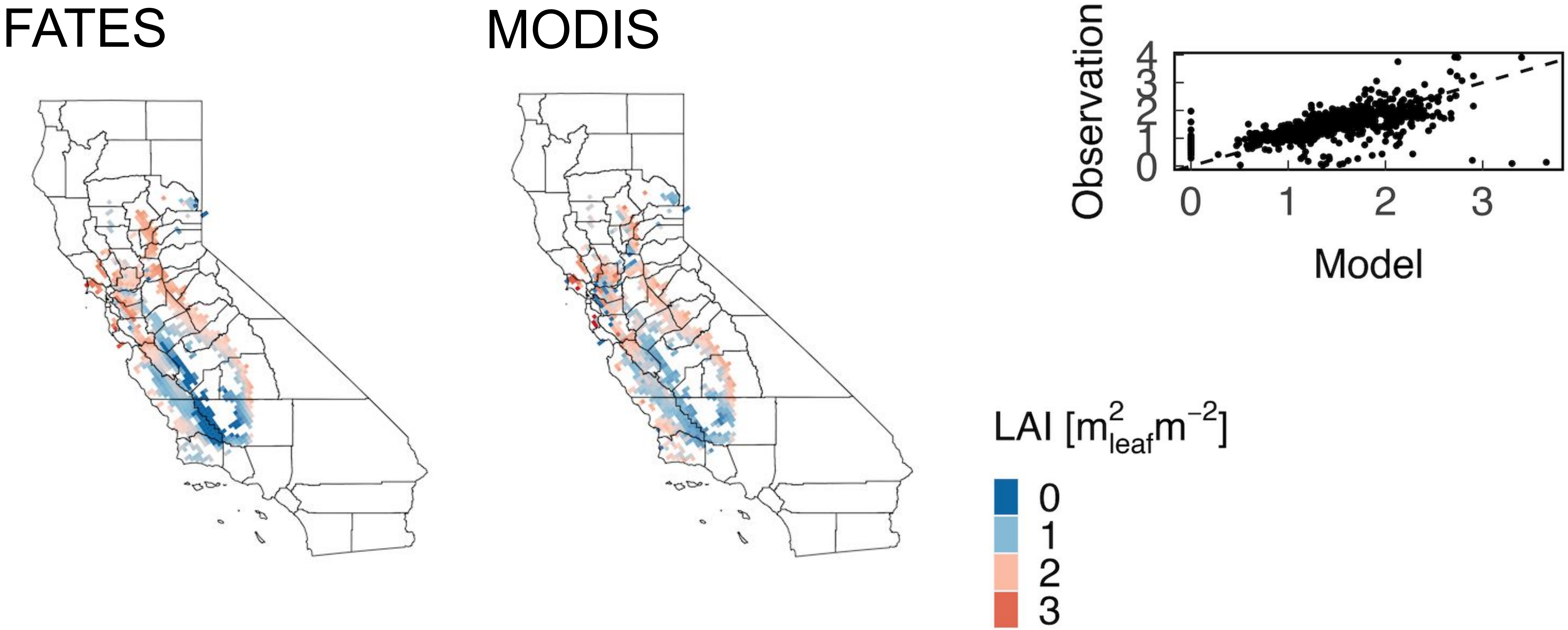
Selected best parameter sets can well represent site characteristic and seasonal dynamic



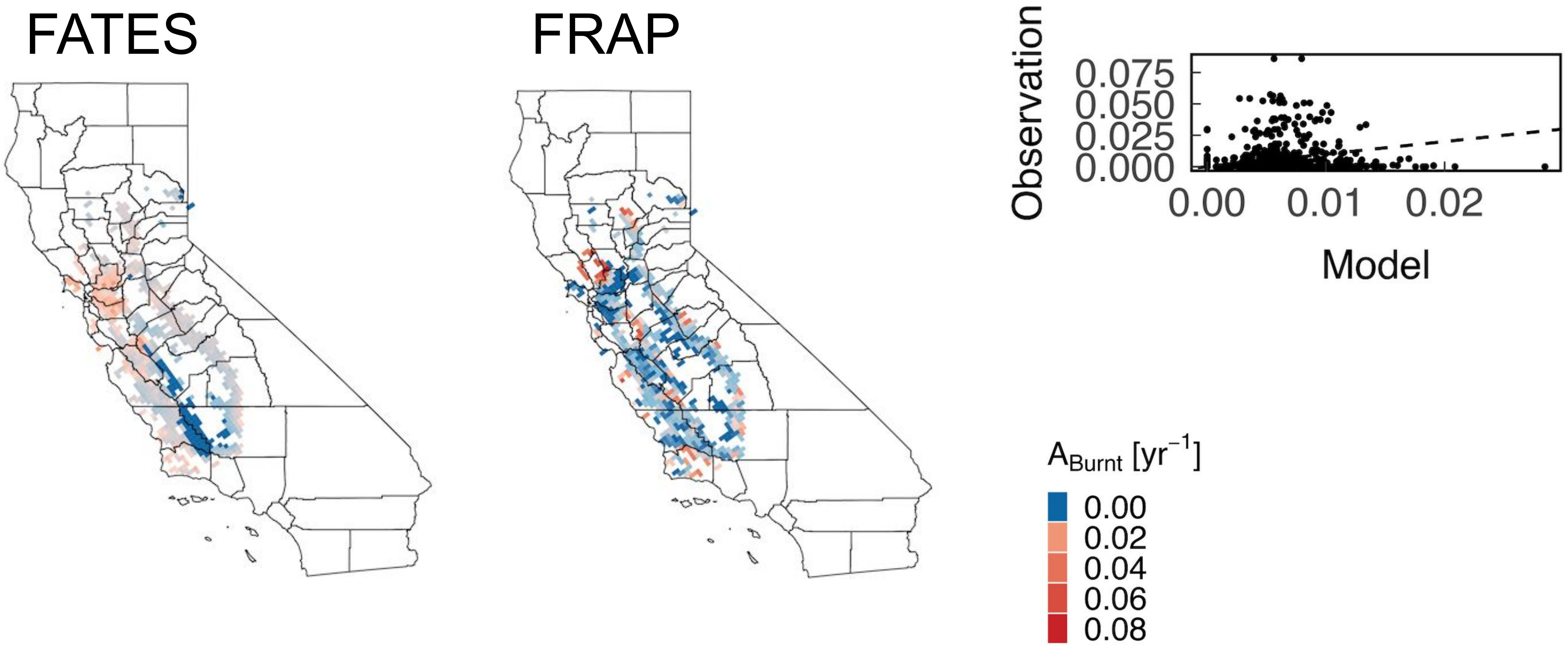
Burned fraction in FATES is largely determined by fuel bulk density



With site-derived parameters, FATES can capture regional pattern of LAI



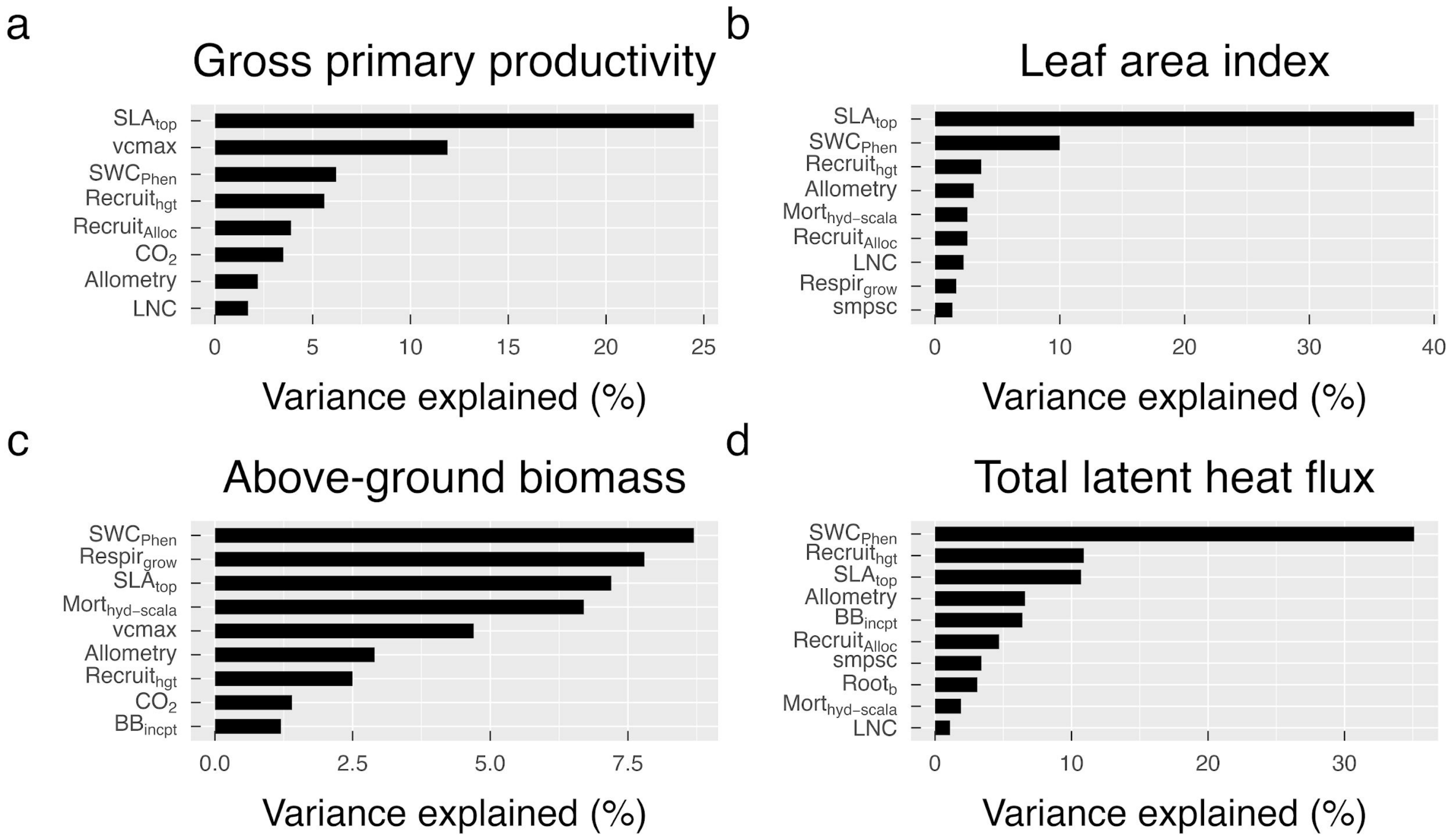
FATES tended to overestimate burned fraction in most area



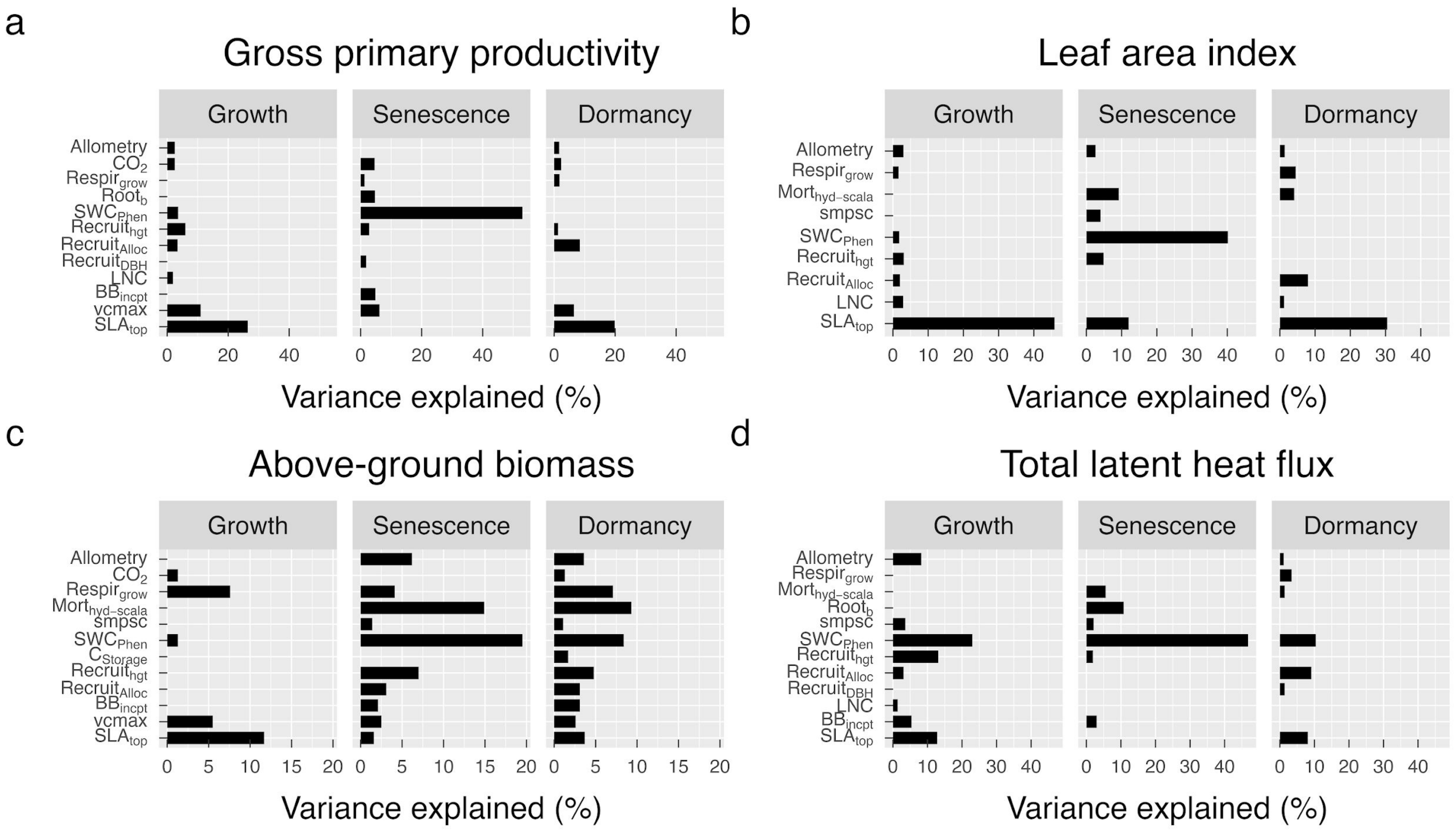
Take-homes and future work

- Grass allometry is important; soil water content as a trigger for drought deciduous phenology shape the seasonal variation in water, carbon, and energy fluxes in California annual grasslands; with site-derived parameters, FATES is able to capture the spatial pattern in LAI but not burned fraction.
- This study provides better understanding of grass PFT in FATES, also the first step toward understanding the fire-mediated tree-grass coexistence in California oak savannas.
- Next step: oak-C_3 grass competition and coexistence in the transition zone in CA and how these grassy ecosystem responses to future changes.

Soil water content triggering drought-deciduous phenology and mortality shape the seasonal variation in matter and energy exchange

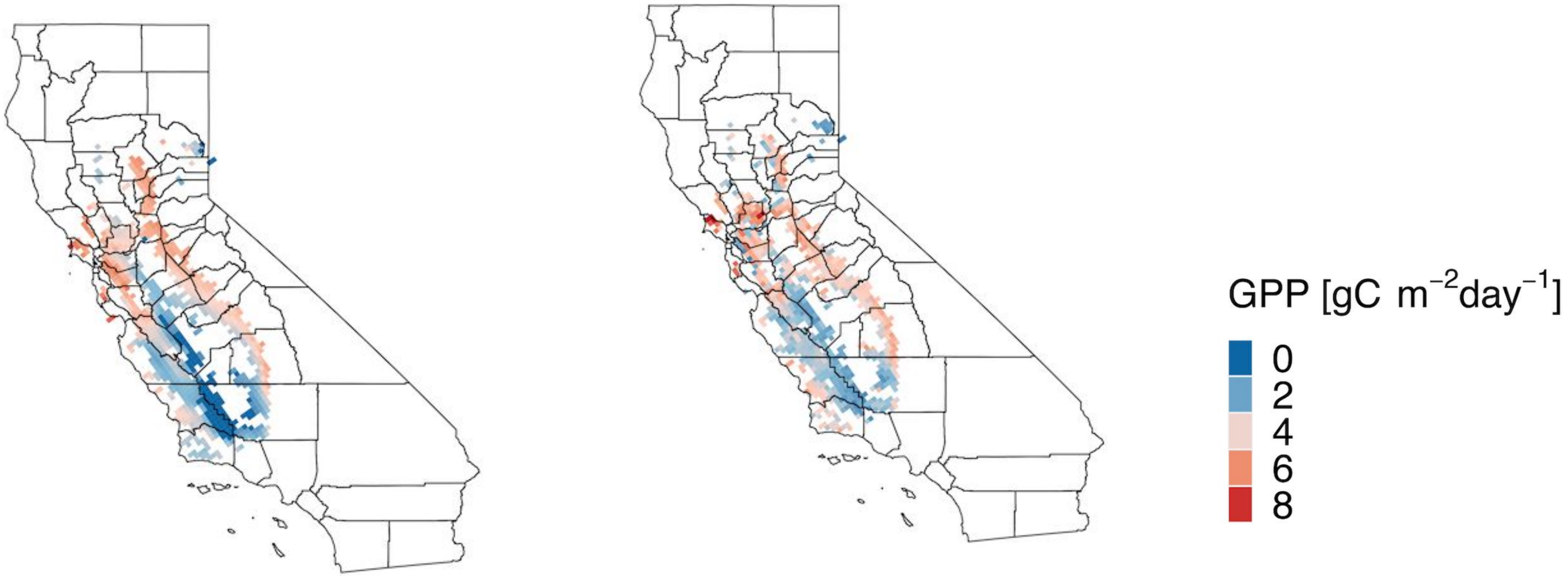


Importance of model parameters also has a seasonal pattern that depends on the phenology of the PFT

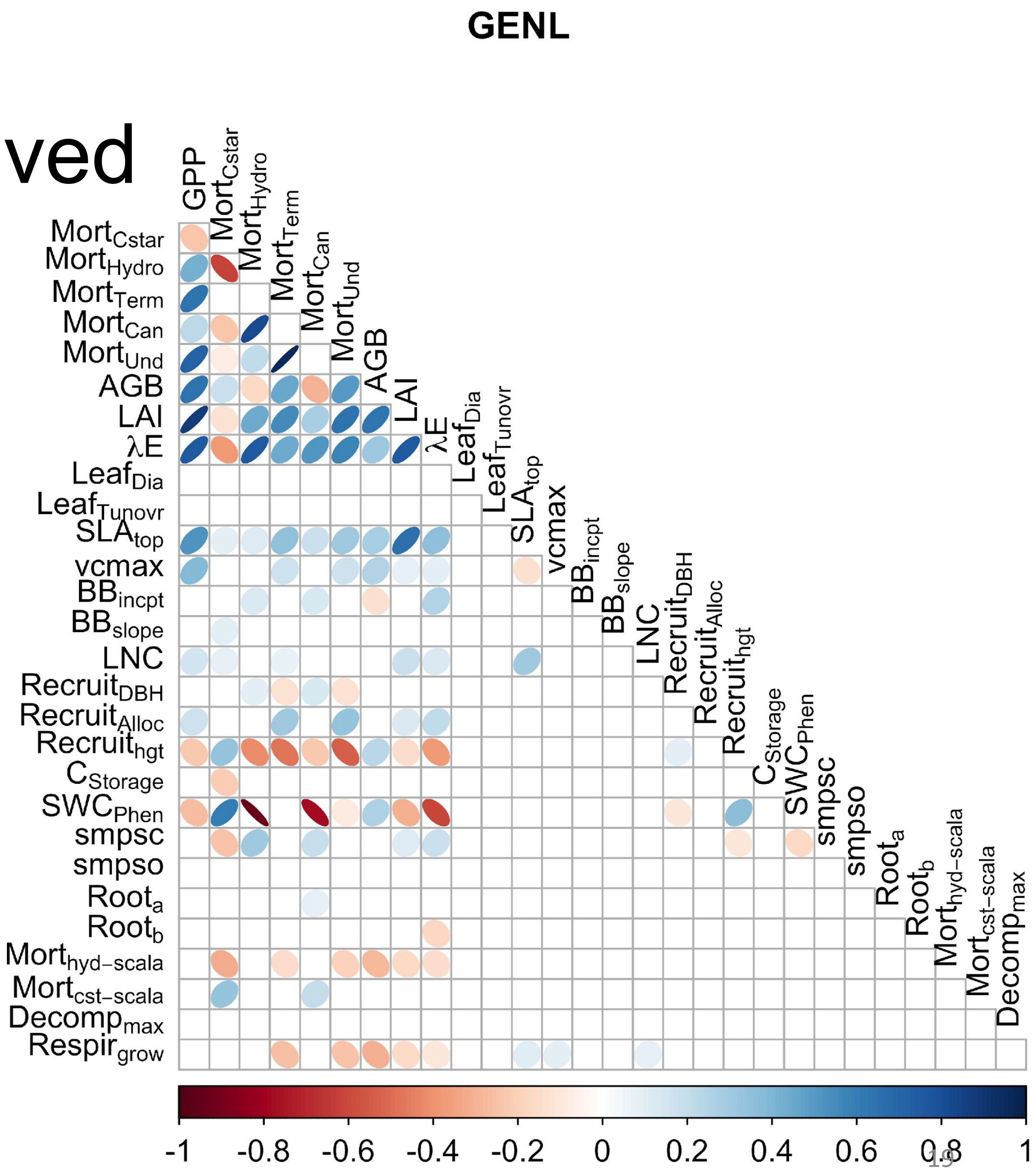


GPP

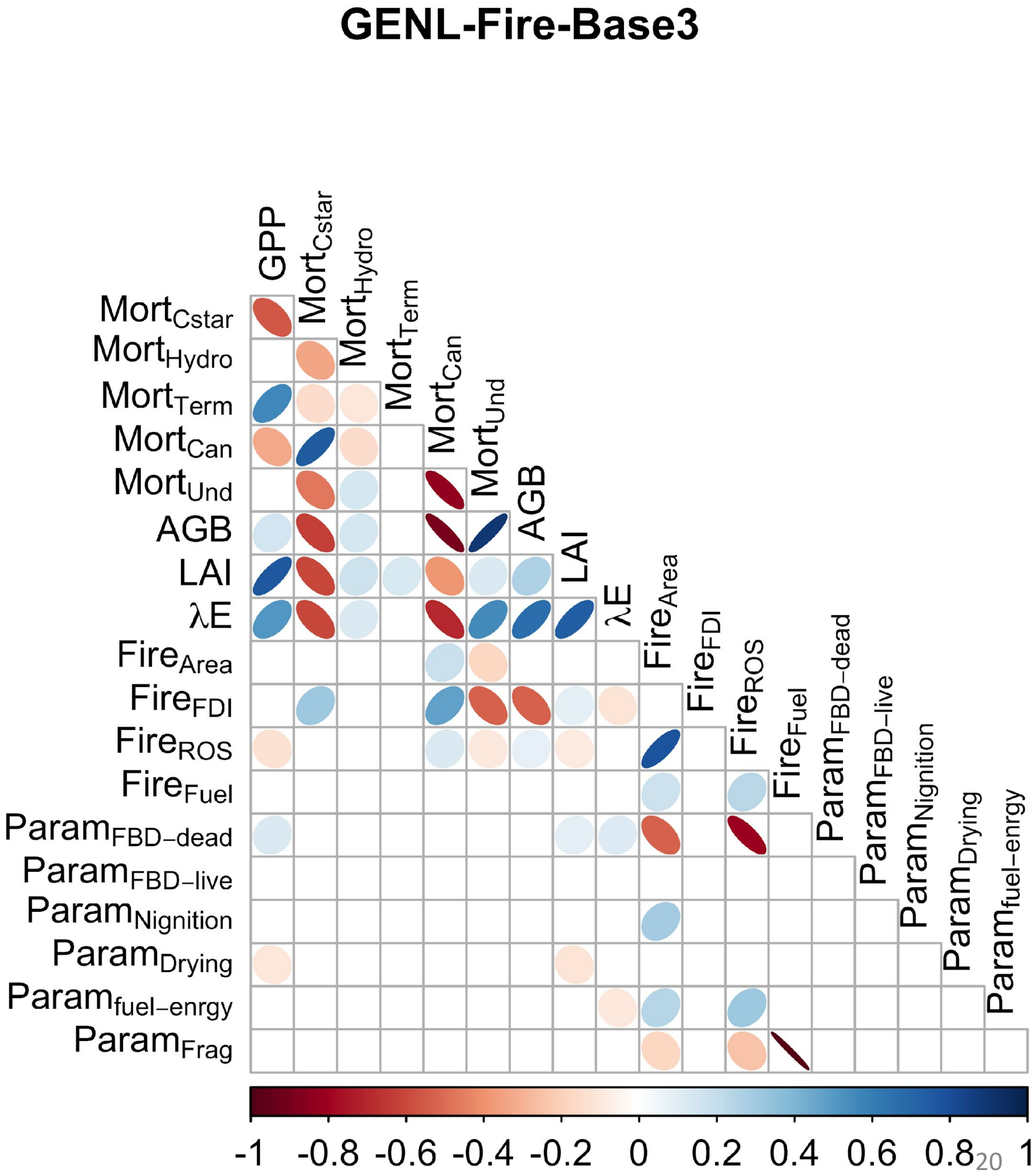
FATES SIF



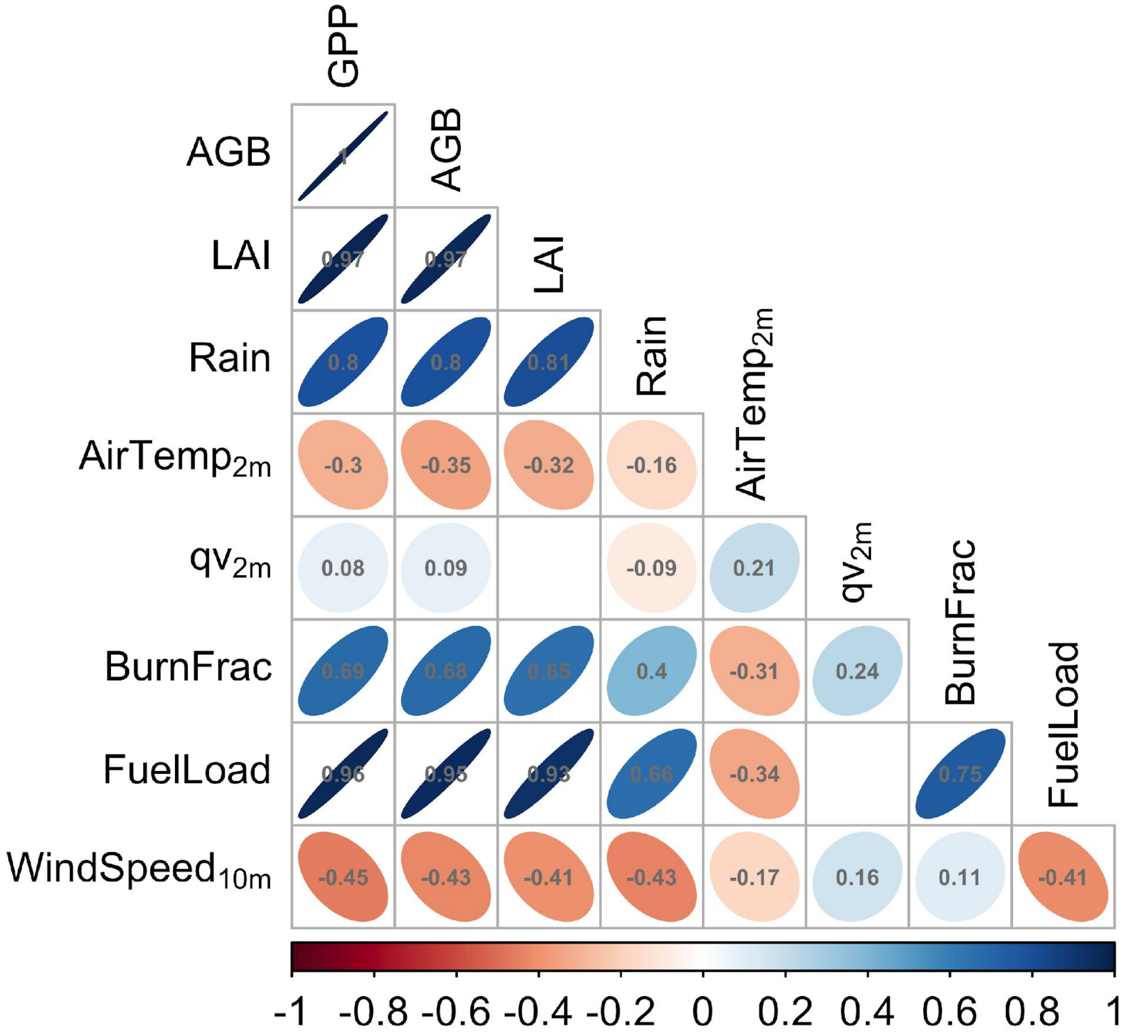
The correlation between model parameters and variables (survived ensembles only)

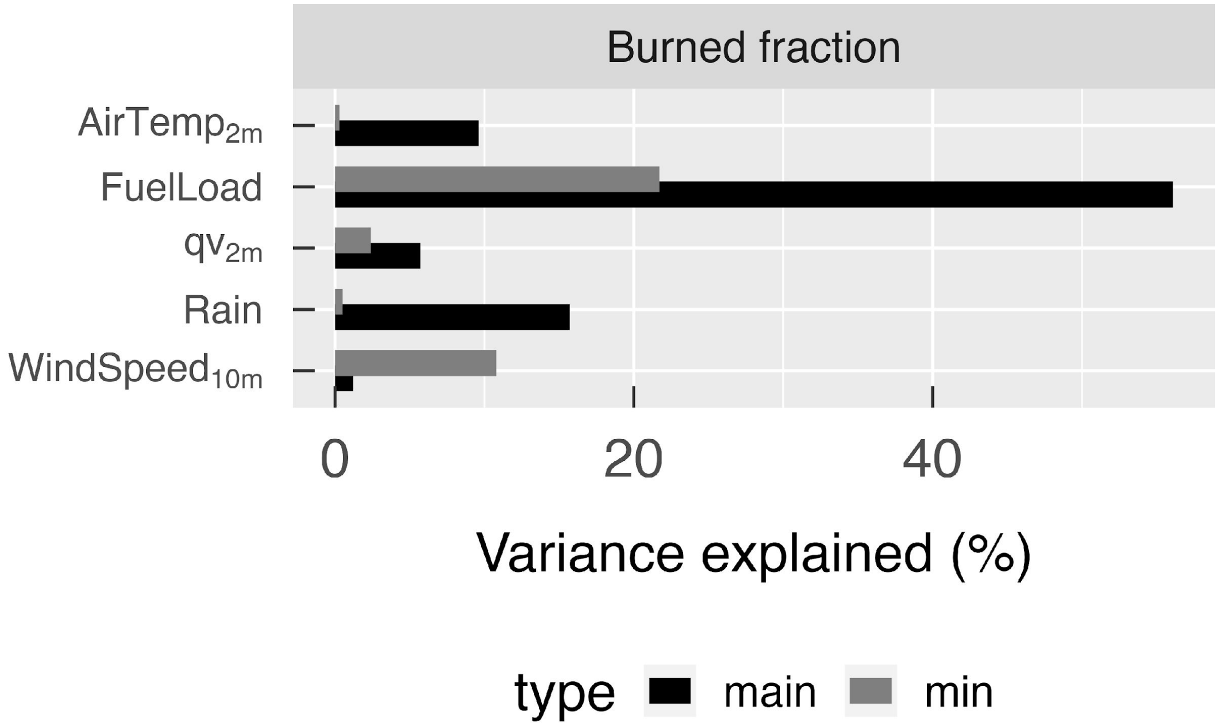


Model fire parameter and fire behavior variables correlation



Variations in forcing variables such as temperature, precipitation, and wind speed contributes to the spatial pattern in model simulated burned fraction





FATES is able to capture the seasonality of burned fraction in California compared to observed lightning-ignited wildfires