Evergreen Tropical forest photosynthesis + Stomatal conductance parameters

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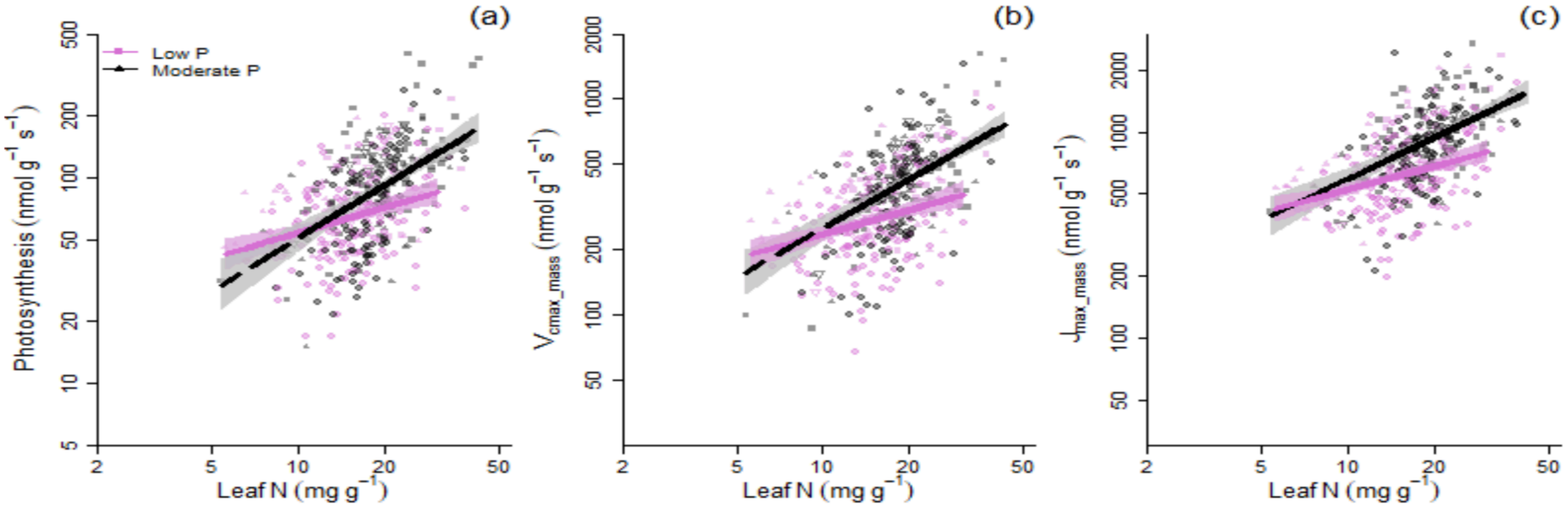
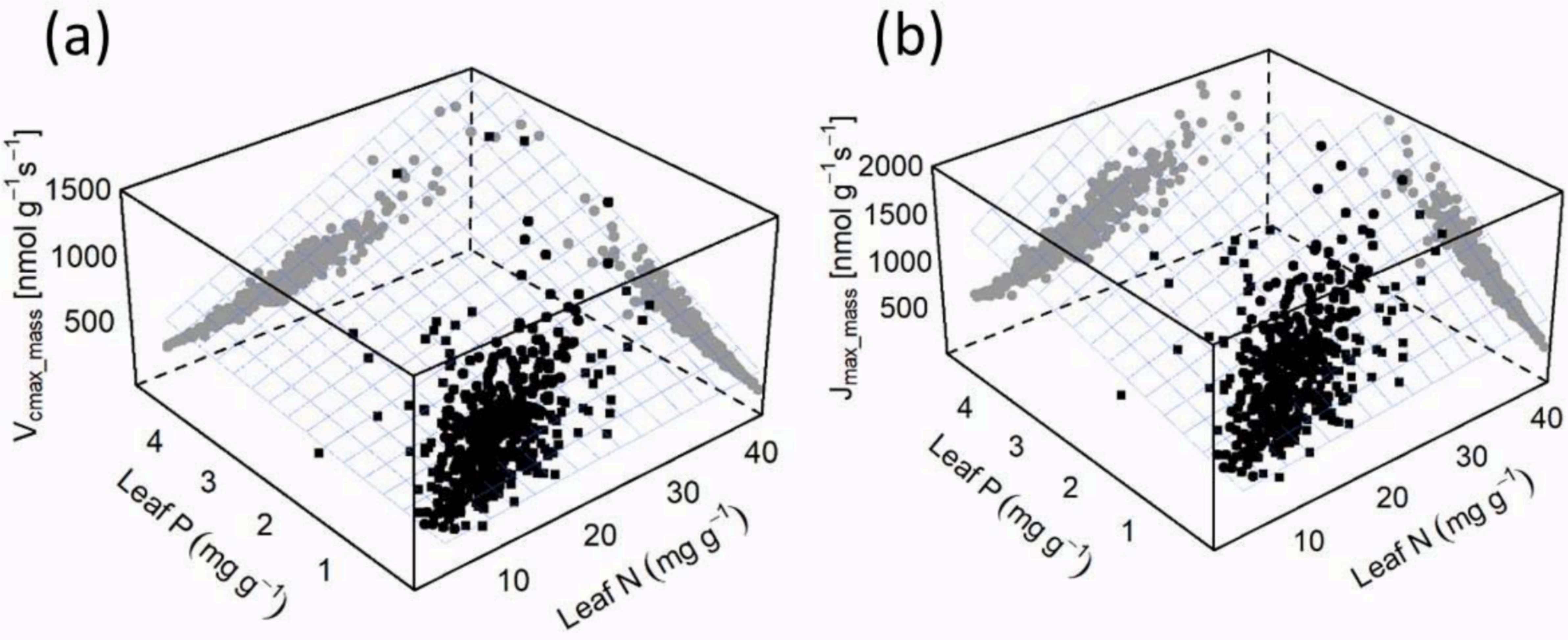
Impact of leaf phosphorus on Ph rates

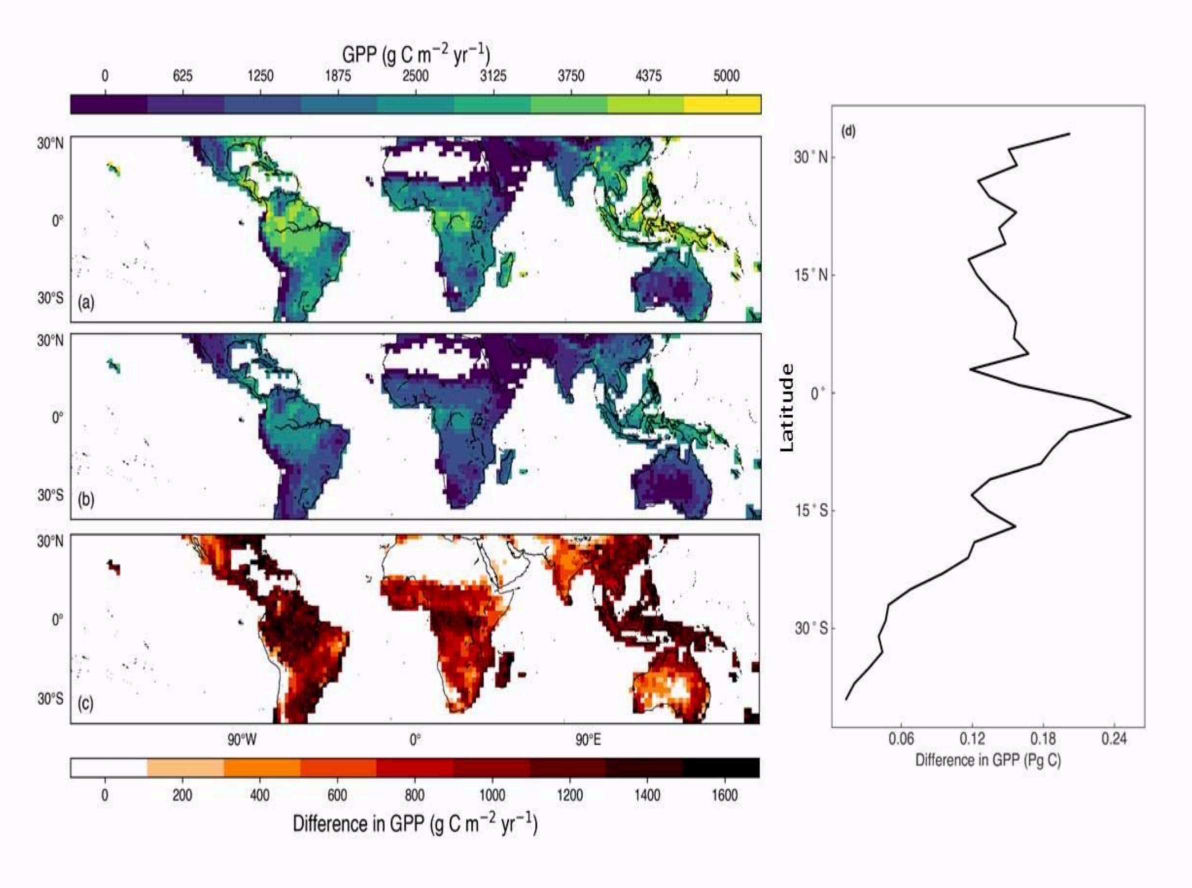
Ellsworth et al. in prep.
> 19,000 data points for controlled photosynthetic responses to [CO_2] for a set of pan-tropical sites involving published and unpublished raw data

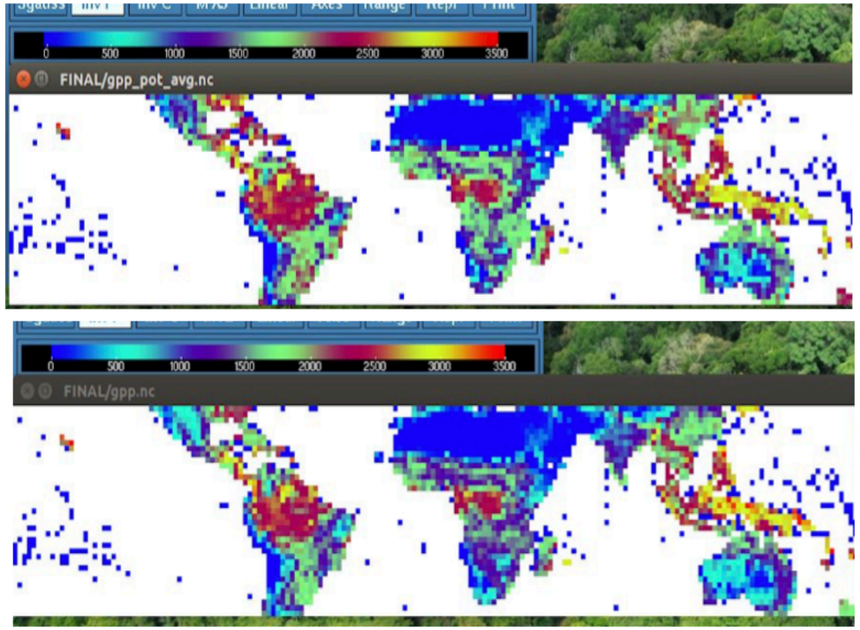


Low defined as P < 0.92 mg g^{-1} and moderate, given as P ≥ 0.92 mg g^{-1}


(a)
V_{cmax_mass} [nmol g^{-1} s^{-1}]
1500
1000
500
Leaf P (mg g^{-1})
4
3
2
1
Leaf N (mg g^{-1})
10
20
30
40
(b)
J_{max_mass} [nmol g^{-1} s^{-1}]
2000
1500
1000
500
Leaf P (mg g^{-1})
4
3
2
1
Leaf N (mg g^{-1})
10
20
30
40

Impact : reduction of GPP in the tropics





NP ratios (observed and model adjusted)

Simulations with ORCHIDEE CNP adjusted for N&P co-limited Ph rate constants

Phenology and photosynthesis of evergreen tropical forests

Leaf development and demography explain photosynthetic seasonality in Amazon evergreen forests

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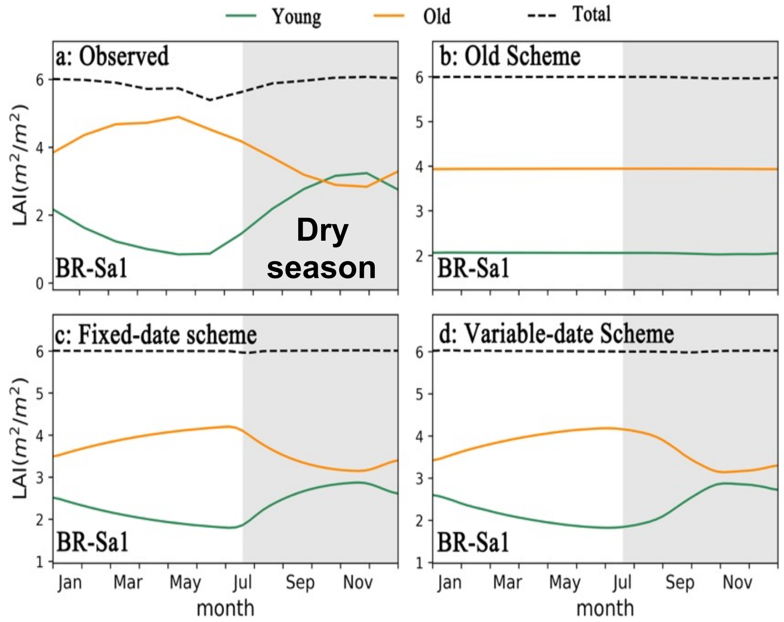
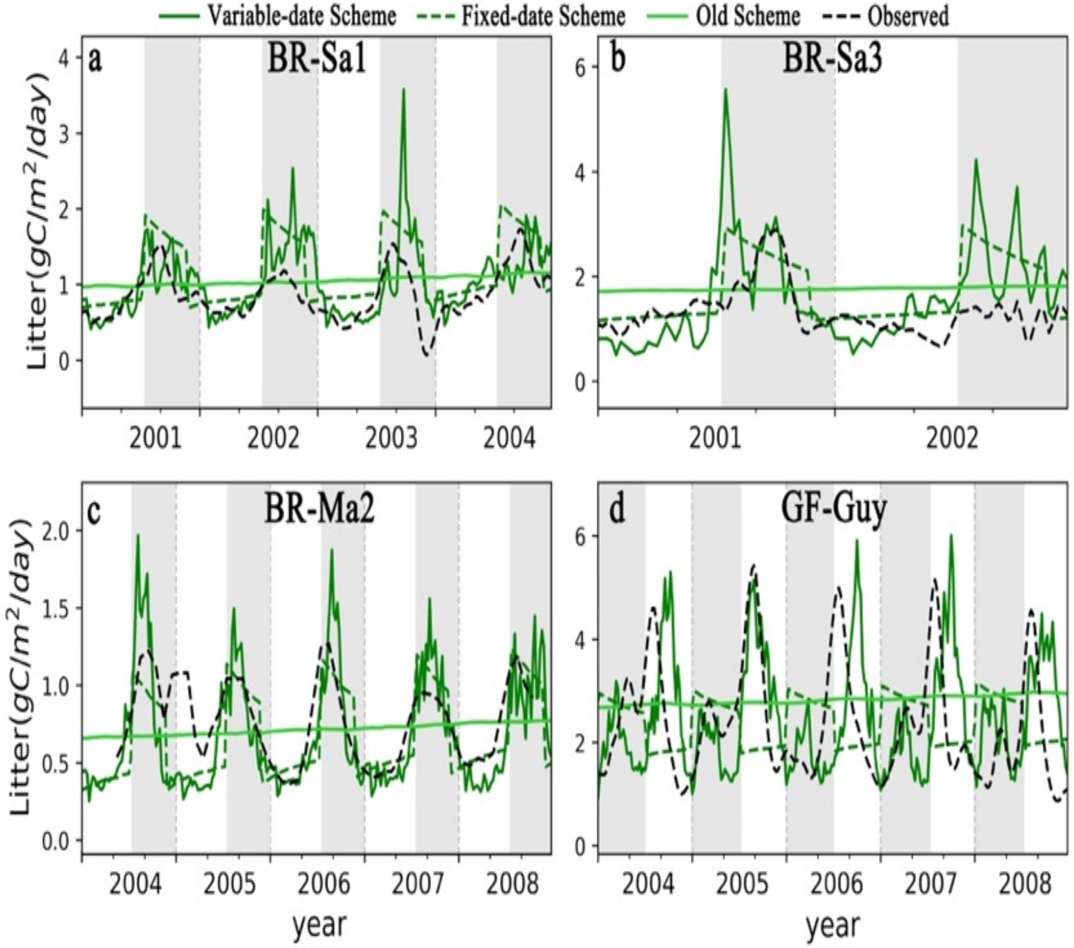
In evergreen tropical forests, the extent, magnitude, and controls on photosynthetic seasonality are poorly resolved and inadequately represented in Earth system models. Combining camera observations with ecosystem carbon dioxide fluxes at forests across rainfall gradients in Amazônia, we show that aggregate canopy phenology, not seasonality of climate drivers, is the primary cause of photosynthetic seasonality in these forests. Specifically, synchronization of new leaf growth with dry season litterfall shifts canopy composition toward younger, more light-use efficient leaves, explaining large seasonal increases (~27%) in ecosystem photosynthesis. Coordinated leaf development and demography thus reconcile seemingly disparate observations at different scales and indicate that accounting for leaf-level phenology is critical for accurately simulating ecosystem-scale responses to climate change.

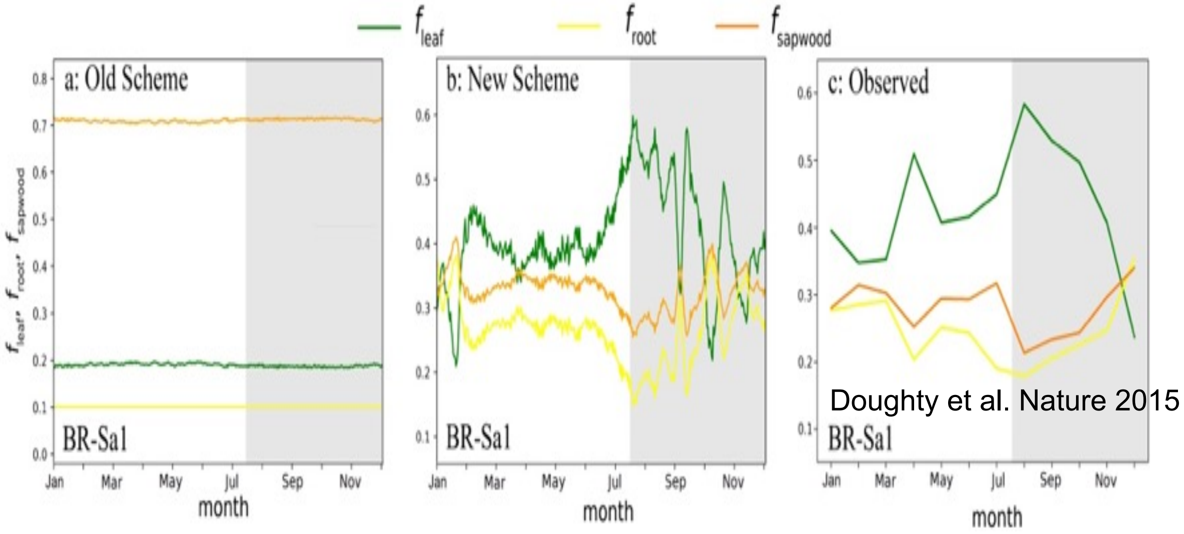
Changes in ORCHIDEE :

- Redefine leaf cohorts aging & Vcmax =f(age_{leaf})
- Time of leaf shed triggered by fixed date / seasonal change of VPD or SWD (before dry season)
- Priority of NPP allocation to leaves after shedding from SW
- Track LAI age cohorts
- Effect is to increase canopy LUE during dry season



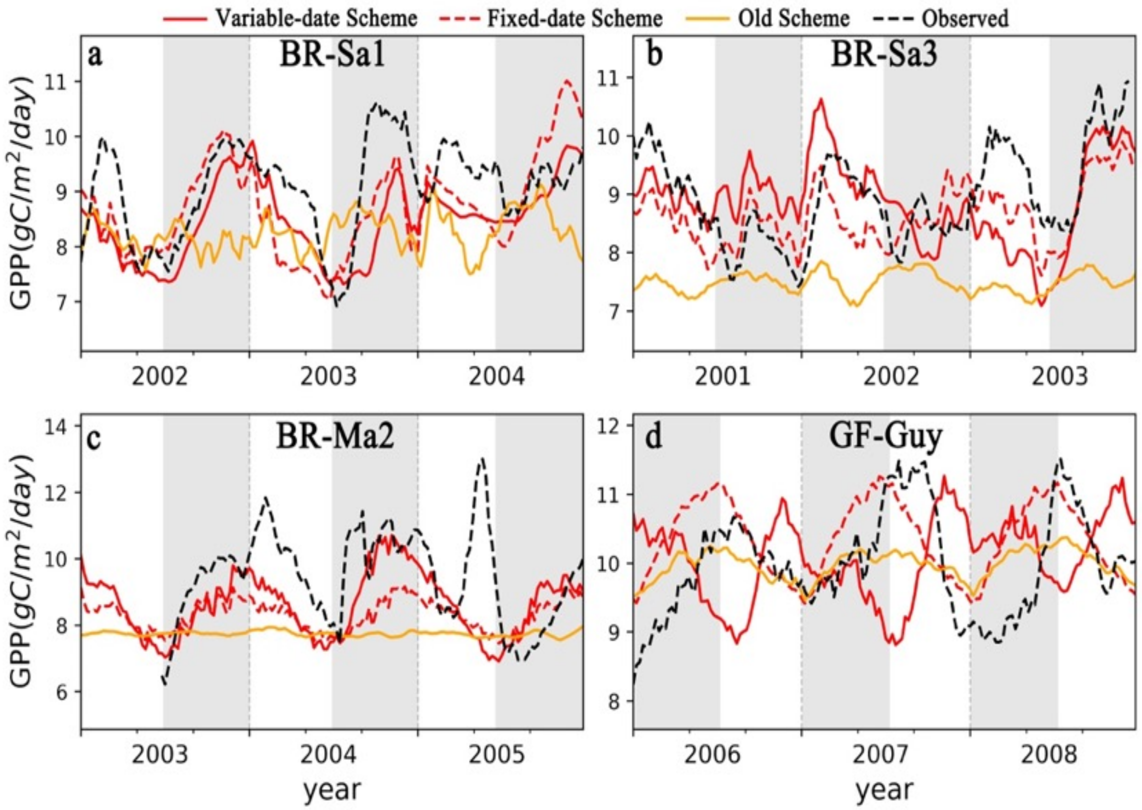
Improved litterfall seasonality



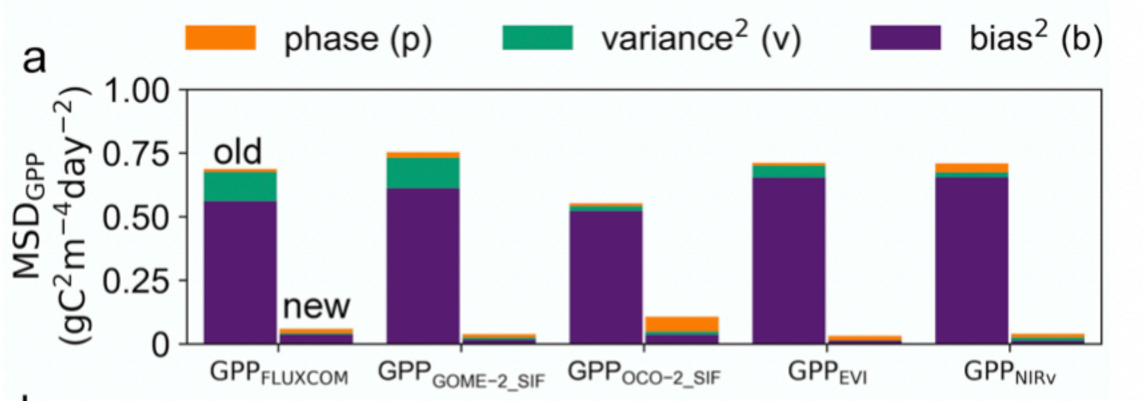


Improved C allocation seasonalit

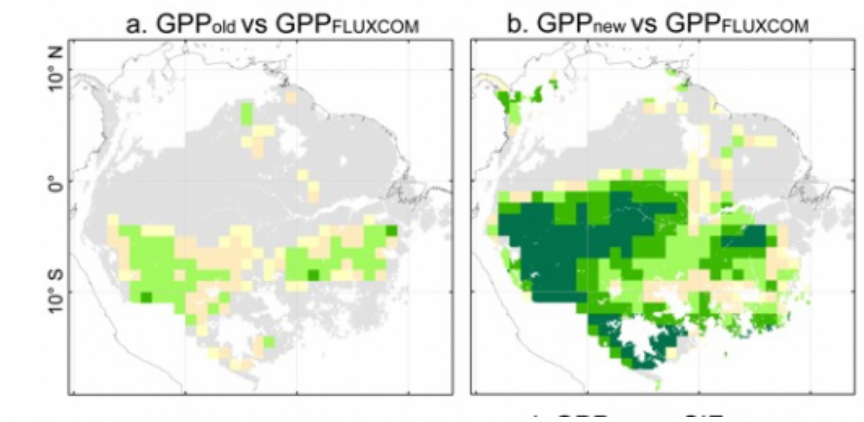
Impacts on GPP



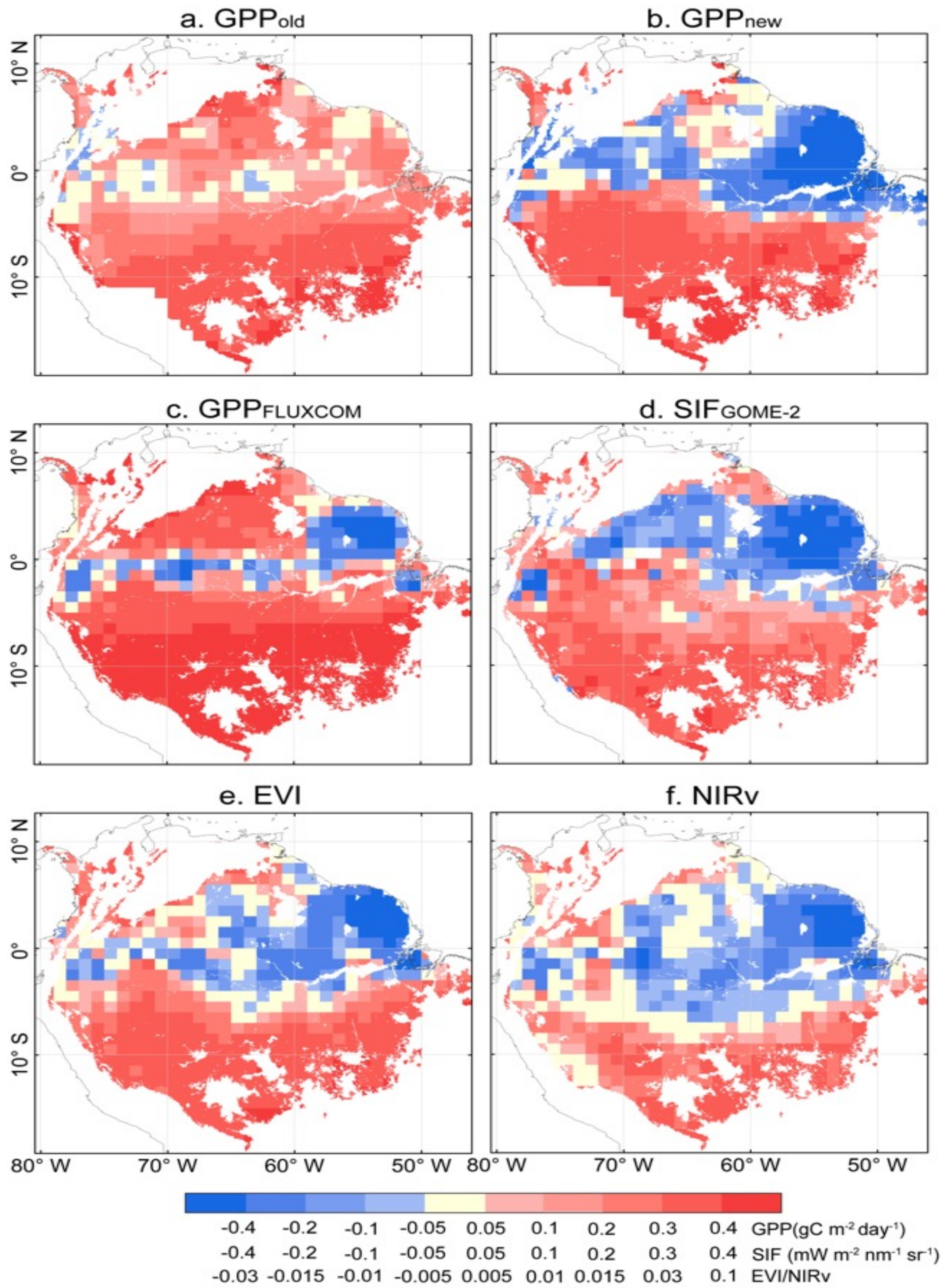
Sites



Amazon basin



NSE map across Amazon against FLUXCOM observation based model



Difference between Dry and Wet season GPP

Positive where MAP > 2000 mm y-1 negative if MAP < 2000 mm y-

Stomatal conductance per PFT

$$g_s = g_0 + \frac{A + R_d}{C_i - C_{i*}} f_{vpd} \tag{15}$$

where g_0 is the residual stomatal conductance if the irradiance approaches zero, C_{i*} is the C_i-based CO_2 compensation point in the absence of R_d (by definition $C_{i*} = \Gamma_* - R_d/g_m$), and f_{vpd} is the function for the effect of leaf-to-air vapour pressure difference (VPD), which is not yet understood sufficiently and may be described empirically as:

$$f_{vpd} = \frac{1}{[1/(a_1 - b_1 \mathrm{VPD}) - 1]} \tag{15a}$$

Lin et al. 2015

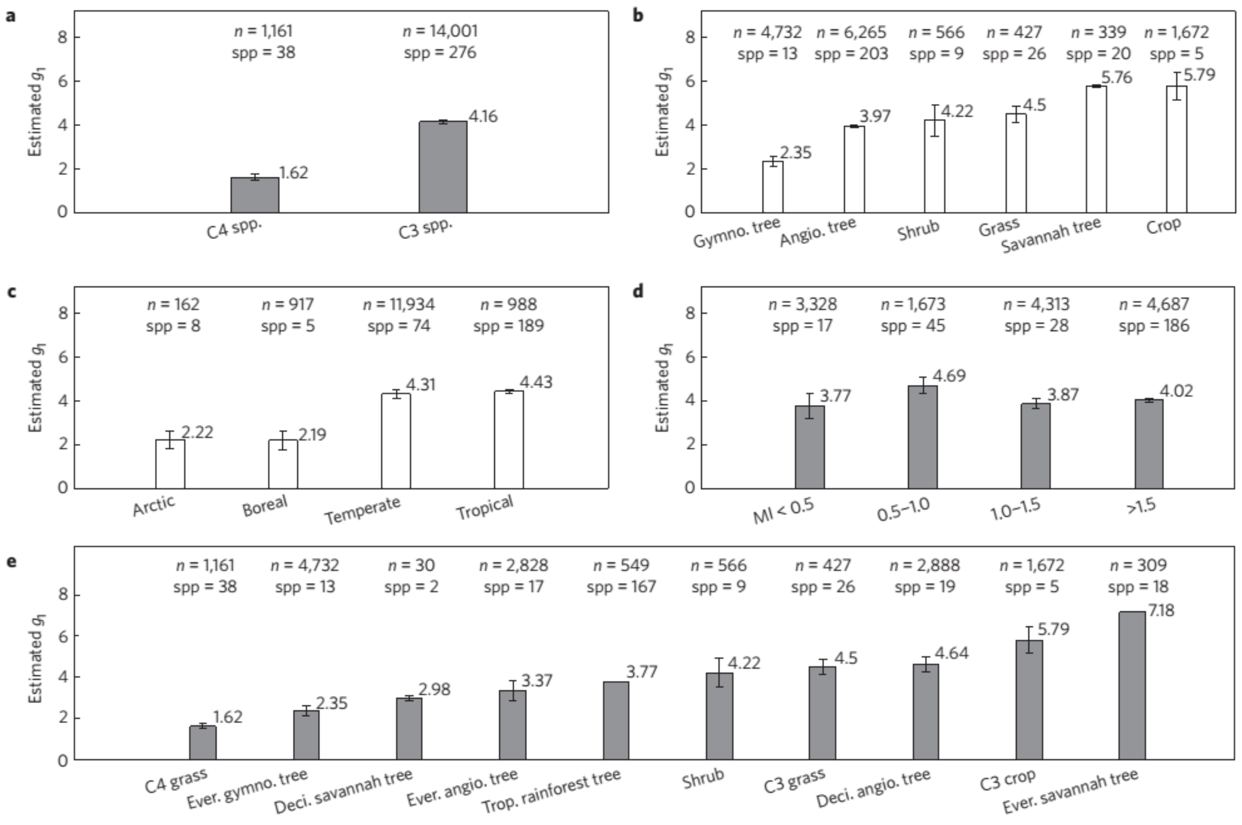


Figure 2 | Mean g_1 values for plant functional types defined by different classification schemes. Each bar represents the mean values ± 1SE of g_1 from the stomatal model fitted using a nonlinear mixed-effects model assuming species as a random effect. The sample sizes (*n*) are the number of measurements. In the case of diurnal measurements, measurements might be done on the same leaf but under different environmental conditions. Species number (spp) indicates the number of the species in each group. Panels **b–d** include C_3 species data only.

ORCHIDEE

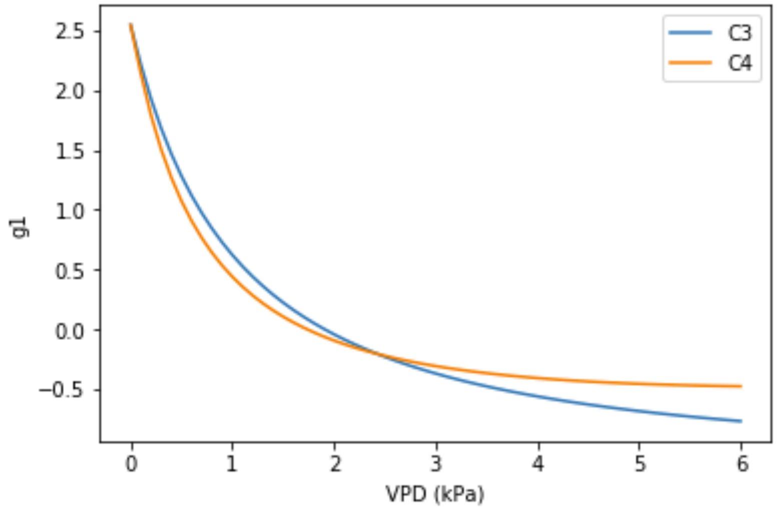
Ca = 360 #ubar, from Yin&Struik, 2009
Anet = 15 # umol/m2/s, from Yin&Struik, 2009

g0 = 0.00625 # C3 ORCHIDEE
g0 = 0.01875 # C4 ORCHIDEE

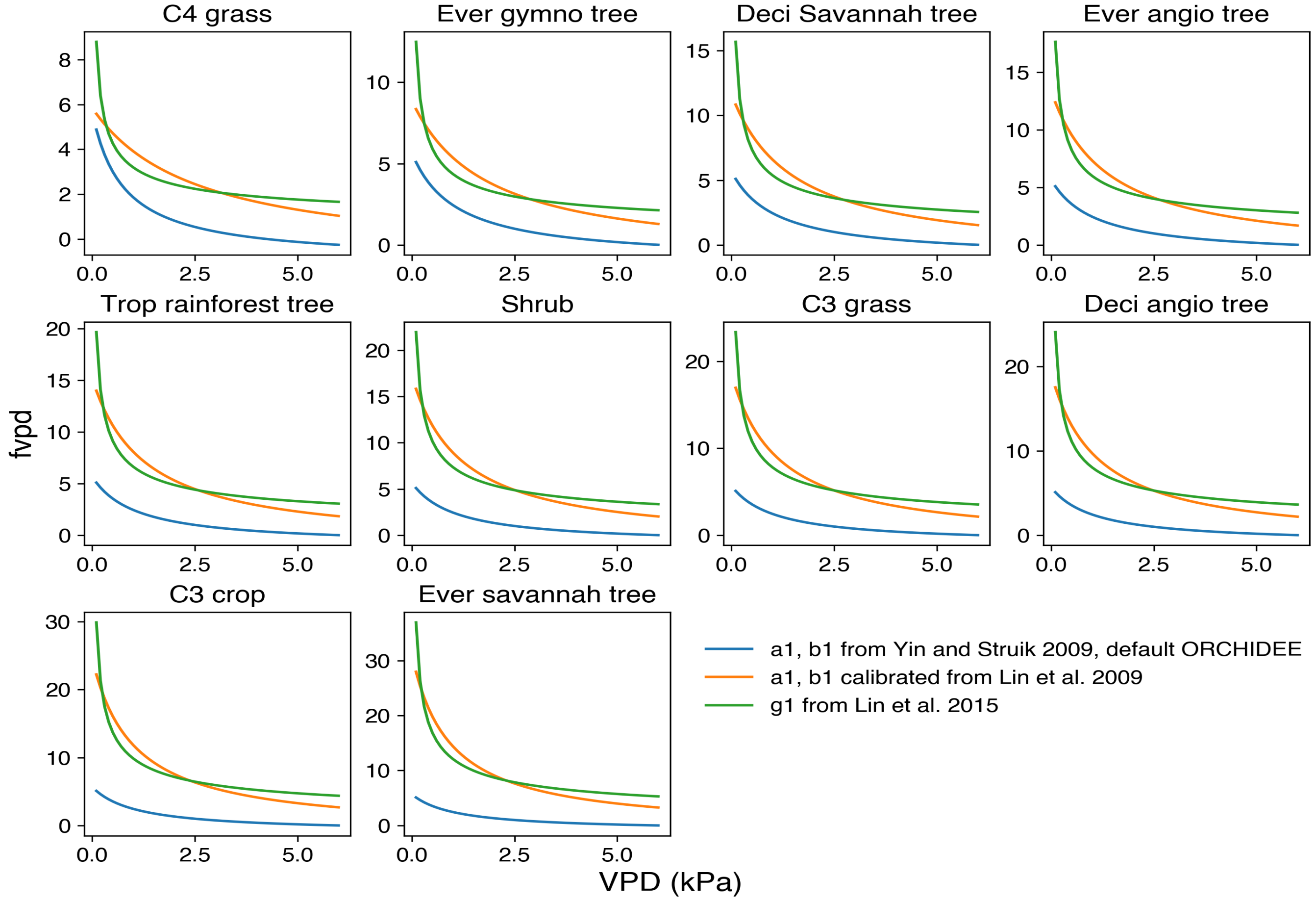
a1, b1 = 0.85, 0.14 # C3, ORCHIDEE, from Yin&Struik, 2009
a1, b1 = 0.85, 0.20 # C4, ORCHIDEE, from Yin&Struik, 2009

vpd = np.arange(0,6.1,0.2)
fvpd = 1 / (1/(a1-b1*vpd) -1)

g1 = g0*Ca*np.sqrt(vpd)/1.6/Anet + fvpd/1.6 – 1



Reparameterized Gs per PFT



	PFT	g1	a1new	b1new	a1old	b1old
0	C4 grass	1.62	0.853906	0.057487	0.85	0.20
1	Ever gymno tree	2.35	0.898666	0.055832	0.85	0.14
2	Deci Savannah tree	2.98	0.920749	0.052675	0.85	0.14
3	Ever angio tree	3.37	0.930372	0.050528	0.85	0.14
4	Trop rainforest tree	3.77	0.938174	0.048335	0.85	0.14
5	Shrub	4.22	0.945162	0.045955	0.85	0.14
6	C3 grass	4.50	0.948789	0.044540	0.85	0.14
7	Deci angio tree	4.64	0.950435	0.043854	0.85	0.14
8	C3 crop	5.79	0.960853	0.038771	0.85	0.14
9	Ever savannah tree	7.18	0.968853	0.033826	0.85	0.14