Aerodynamic & stomatal resistance

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Aerodynamic coupling with atmosphere

$$\Omega = \frac{1+\epsilon}{1+\epsilon+\frac{G_a}{G_s}},$$

Coupling with atmosphere

Ga << Gs	=> Ω = 1	fully aerodynamically decoupled
Ga >> Gs	=> Ω = 0	fully aerodynamically coupled

At flux towers:

$$G_s = \frac{G_a \gamma \lambda E}{s(R_n - G) - (s+\gamma)\lambda E + G_a M_a c_p D},$$

Measured ET

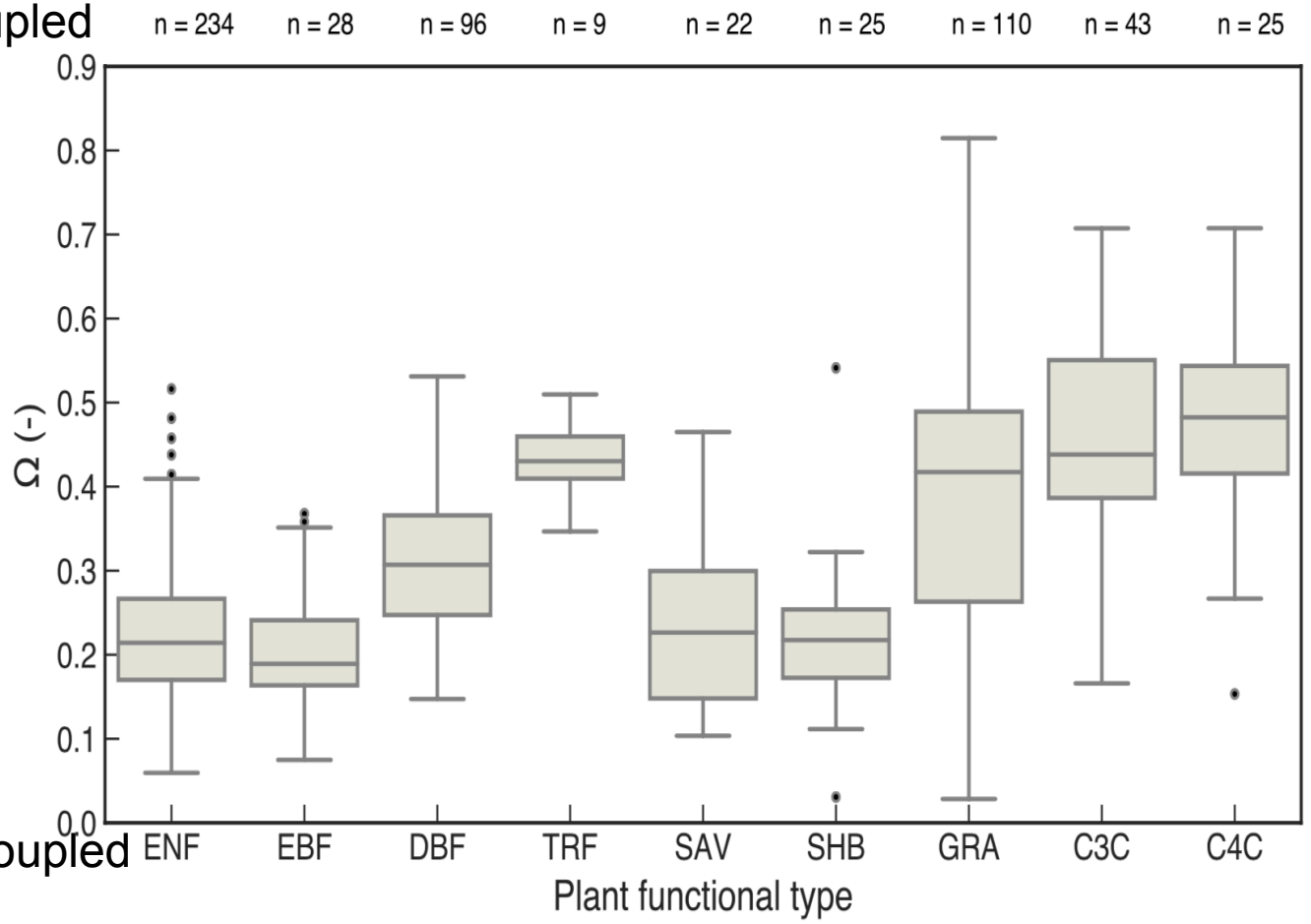
VPD

Ground heat storage

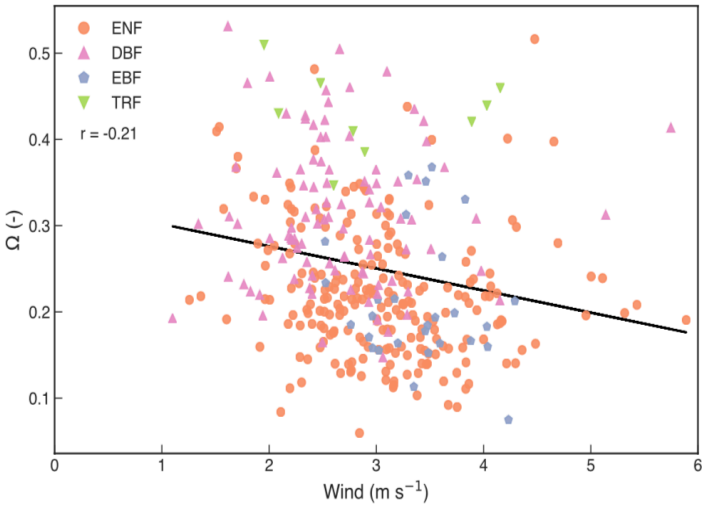
$$G_a = \frac{c}{\frac{u}{u_*^2} + 6.2 u_*^{-\frac{2}{3}}}$$

Ω diagnostic from flux towers

decoupled



Fully coupled



Ideas and perspectives: how coupled is the vegetation to the boundary layer?

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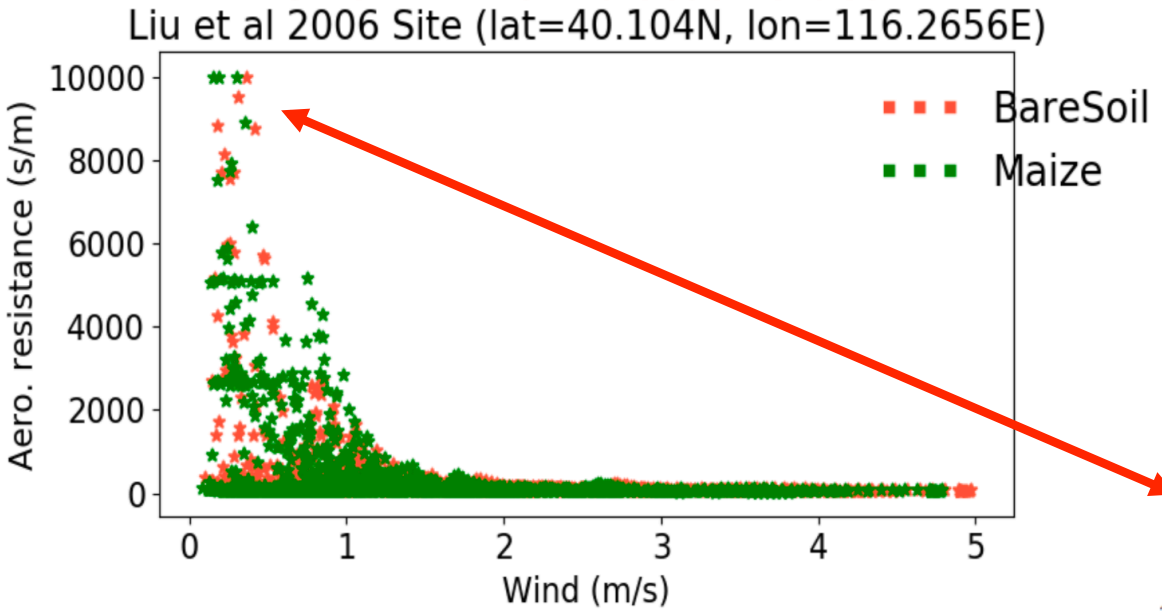
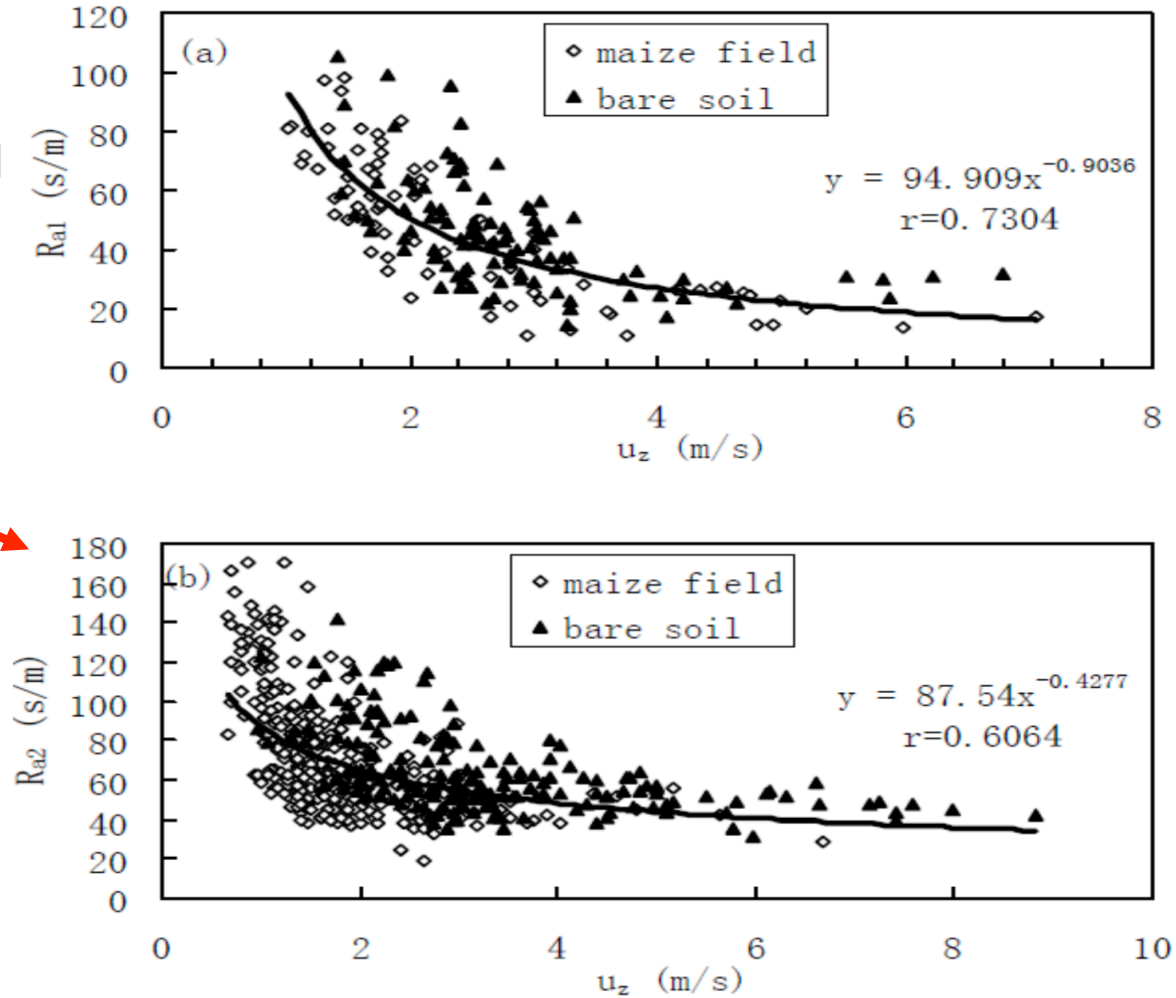
3 month peak growing season averages
Quality filtered data
Daylight hours (8:00 to 16:00)
Only 48 - ½ hours after rain events

Ra vs Wind Speed

ORCHIDEE simulated values



Liu et al 2006, Observational estimates



- Smaller wind speeds leading to sharp increase in *ra*
- Whether Baresoil or Maize field, *ra* variation trend is same

- ORCHIDEE *ra* variation curve is consistent with observational estimates

Stomatal conductance per PFT

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

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:

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

<=>

$$g_s = 1.6 \left(1 + \frac{g_1}{\sqrt{D}}\right) \frac{A}{C_a}$$

Yin & Struijk 2009 as used in ORCHIDEE

Medlyn et al.

Lin et al. 2015

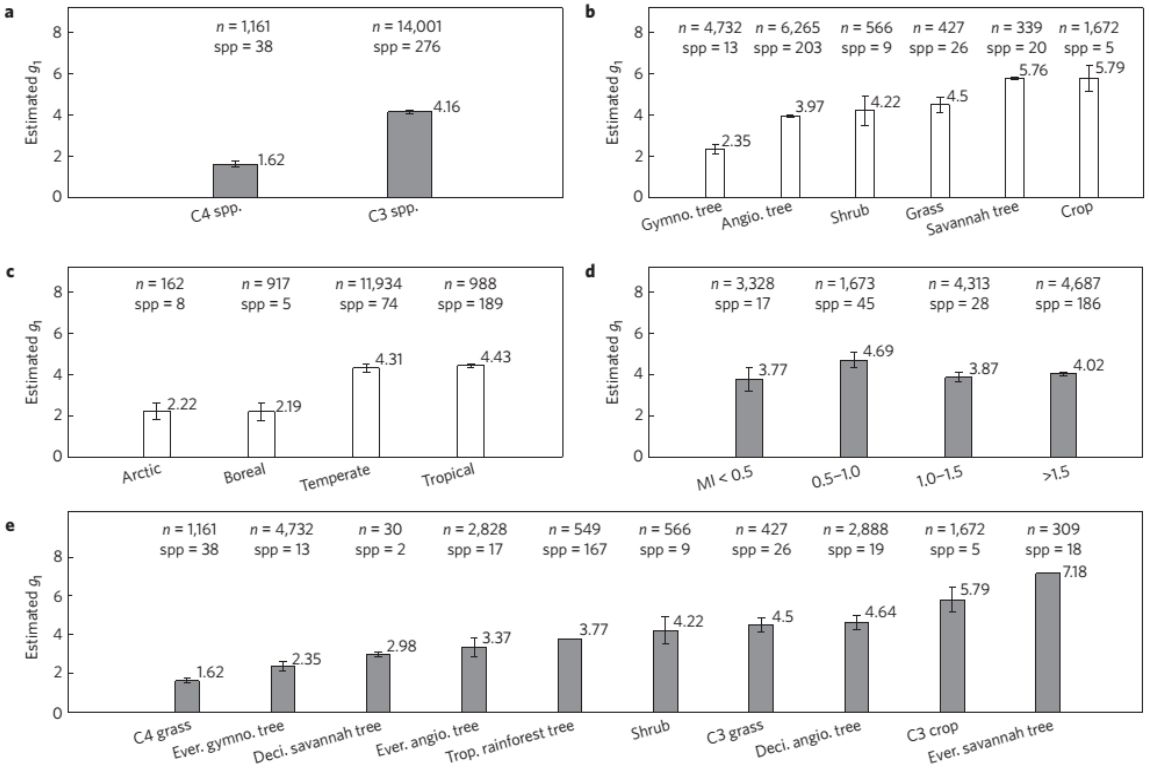


Figure 2 | Mean g_1 values for plant functional types defined by different classification schemes. Each bar represents the mean values ± 1SE of g_1 from the stomatal model fitted using a nonlinear mixed-effects model assuming species as a random effect. The sample sizes (n) are the number of measurements. 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.

$$g_s = 1.6\left(1+\frac{g_1}{\sqrt{D}}\right)\frac{A}{C_a}$$

Medlyn et al.

ORCHIDEE

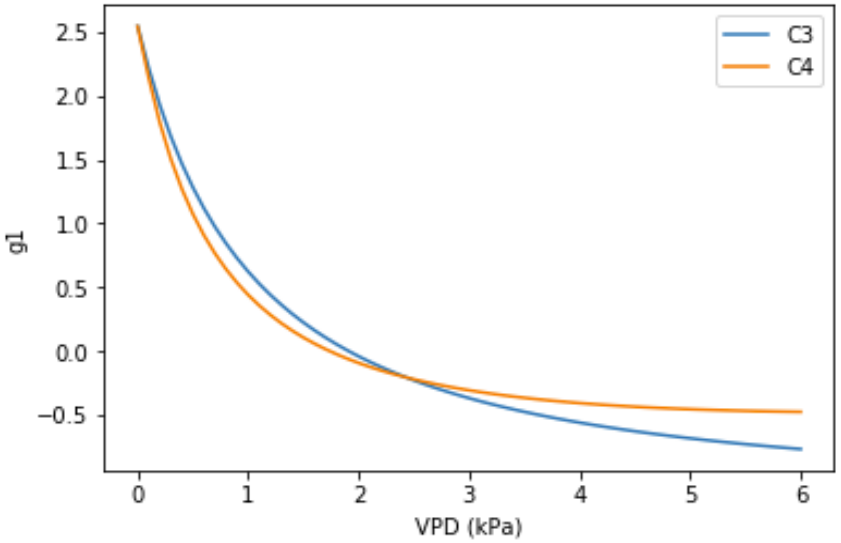
Ca = 360 #ubar, from Yin&Struik, 2009
Anet = 15 # umol/m2/s, from Yin&Struik, 2009

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

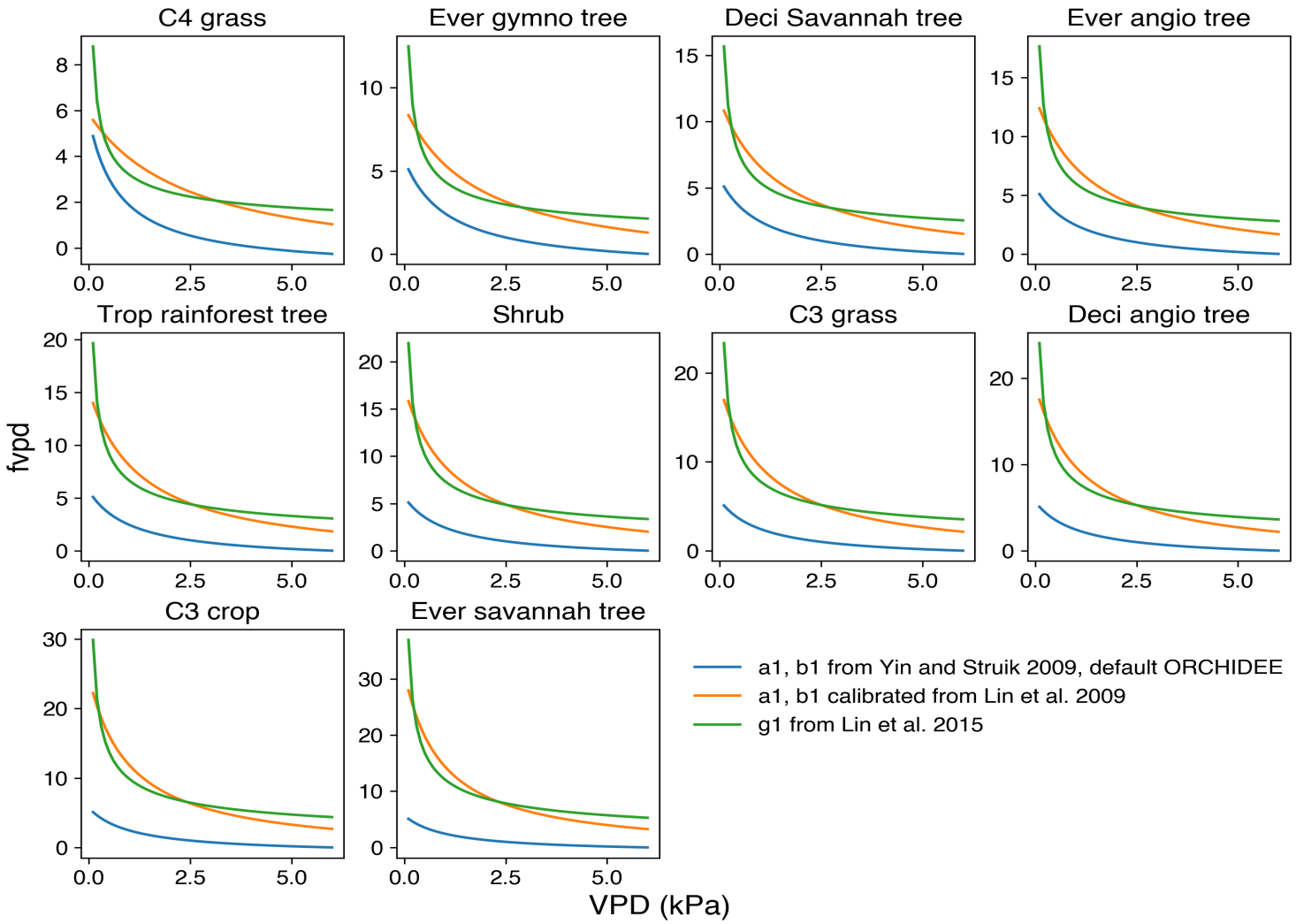
a1, b1 = 0.85, 0.14 # C3, ORCHIDEE, from Yin&Struik, 2009
a1, b1 = 0.85, 0.20 # C4, ORCHIDEE, from Yin&Struik, 2009

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



Re-calibrated G_s per PFT



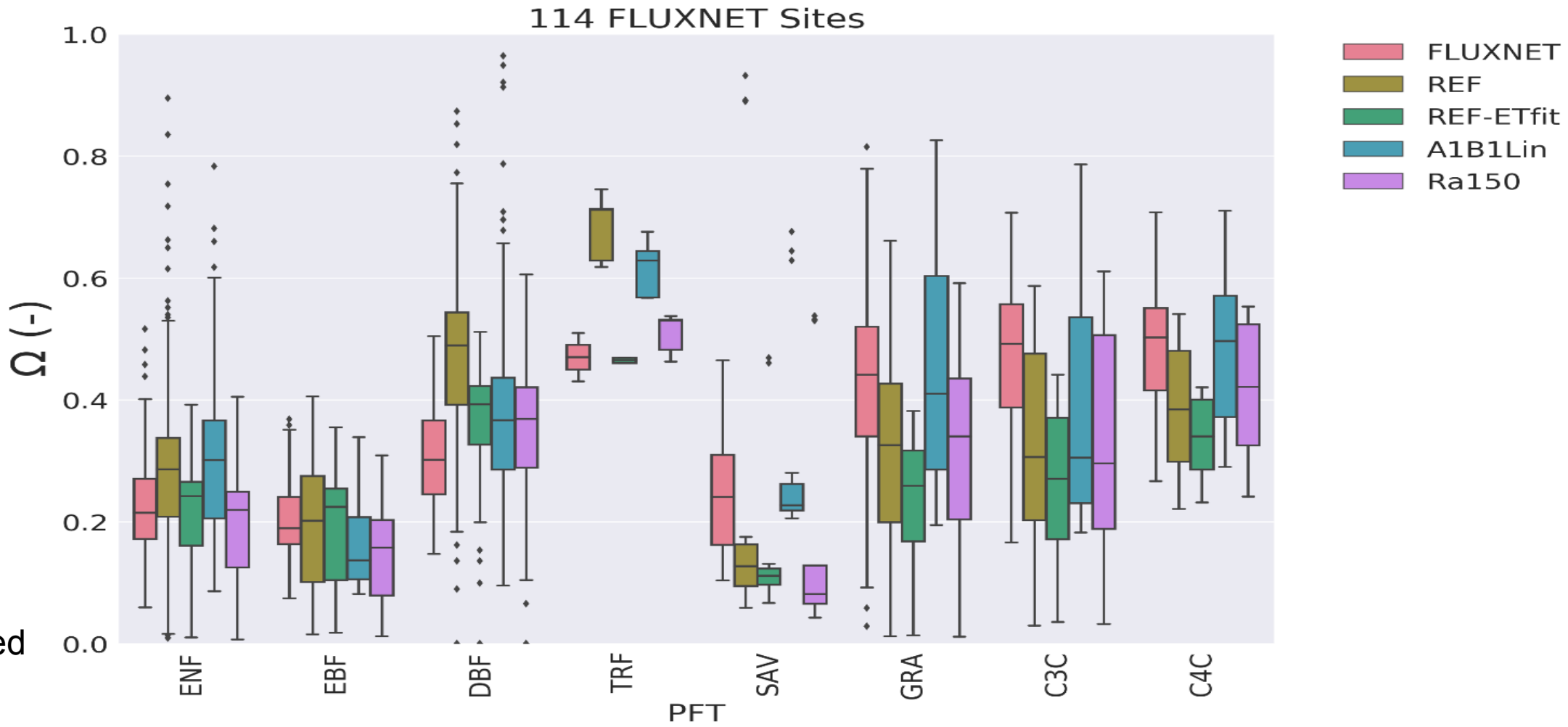
New parameter values

	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

recalibrating a1 and b1 from Lin et al.

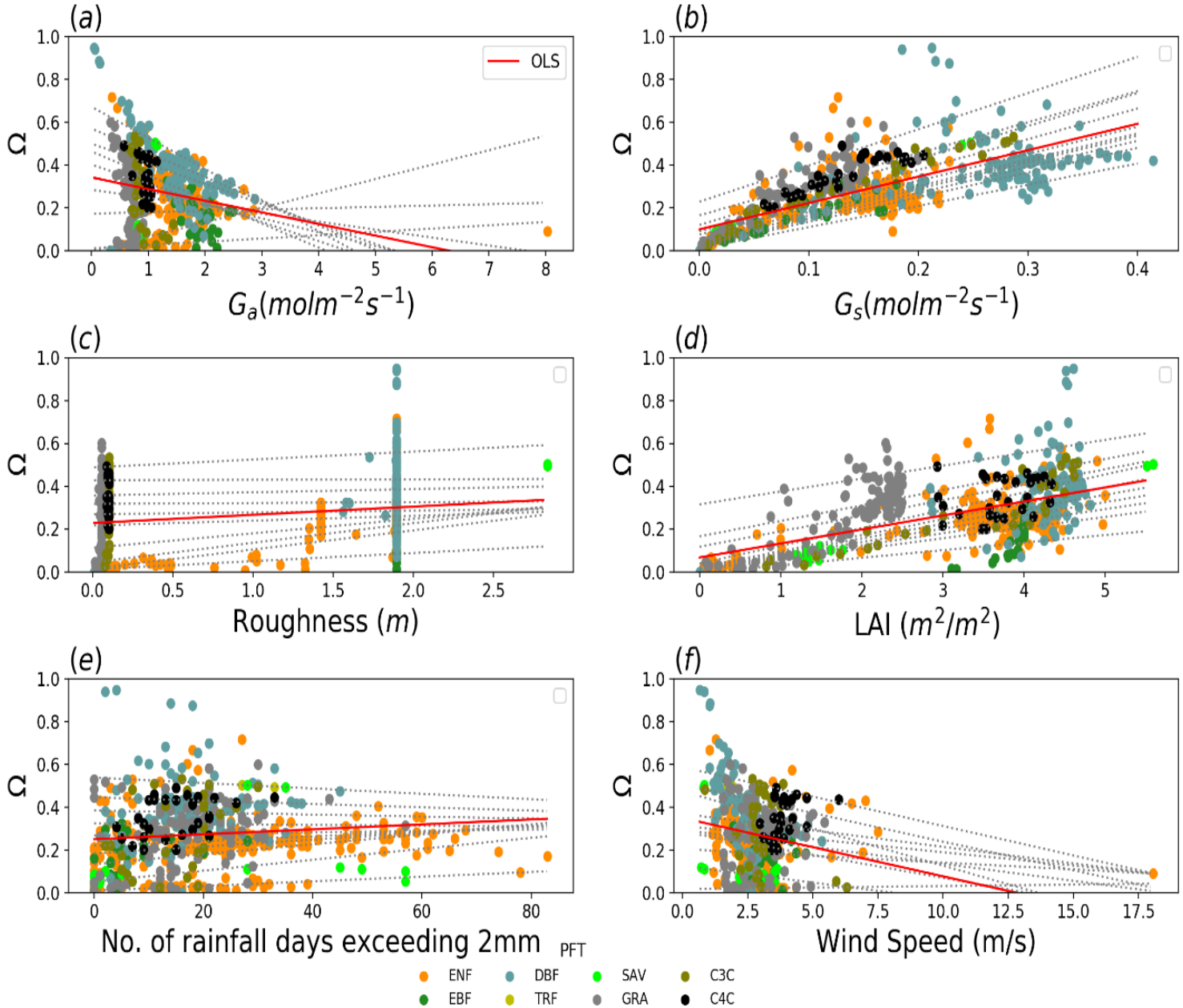
Gs too small in default version
-> too decoupled

Decoupled



Fully coupled

REF = standard version - Omega calculated from Ga and Gs of ORCHIDEE
REF ET fit = standard version – ORCHIDEE ET fitted like done at FLUXNET sites
Ra 150 = capped Ra @ 150 s m-1


(a)
(b)
(c)
(d)
(e)
(f)
Ω
OLS
$G_a(molm^{-2}s^{-1})$
$G_s(molm^{-2}s^{-1})$
Roughness (m)
LAI (m^2/m^2)
No. of rainfall days exceeding 2mm
Wind Speed (m/s)
PFT
ENF
EBF
DBF
TRF
SAV
GRA
C3C
C4C