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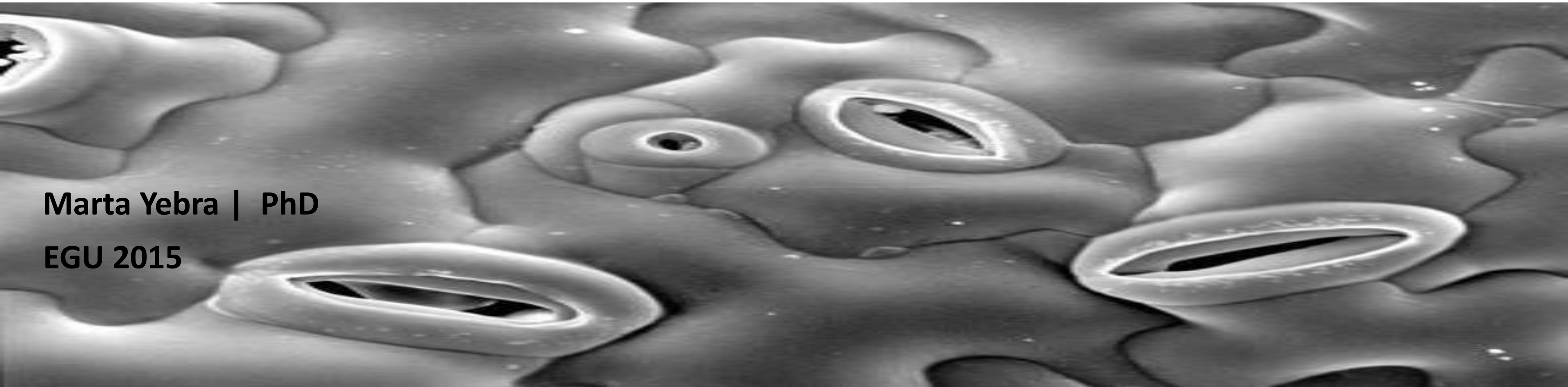
Coupling gross primary production and transpiration for a consistent estimate of canopy water use efficiency

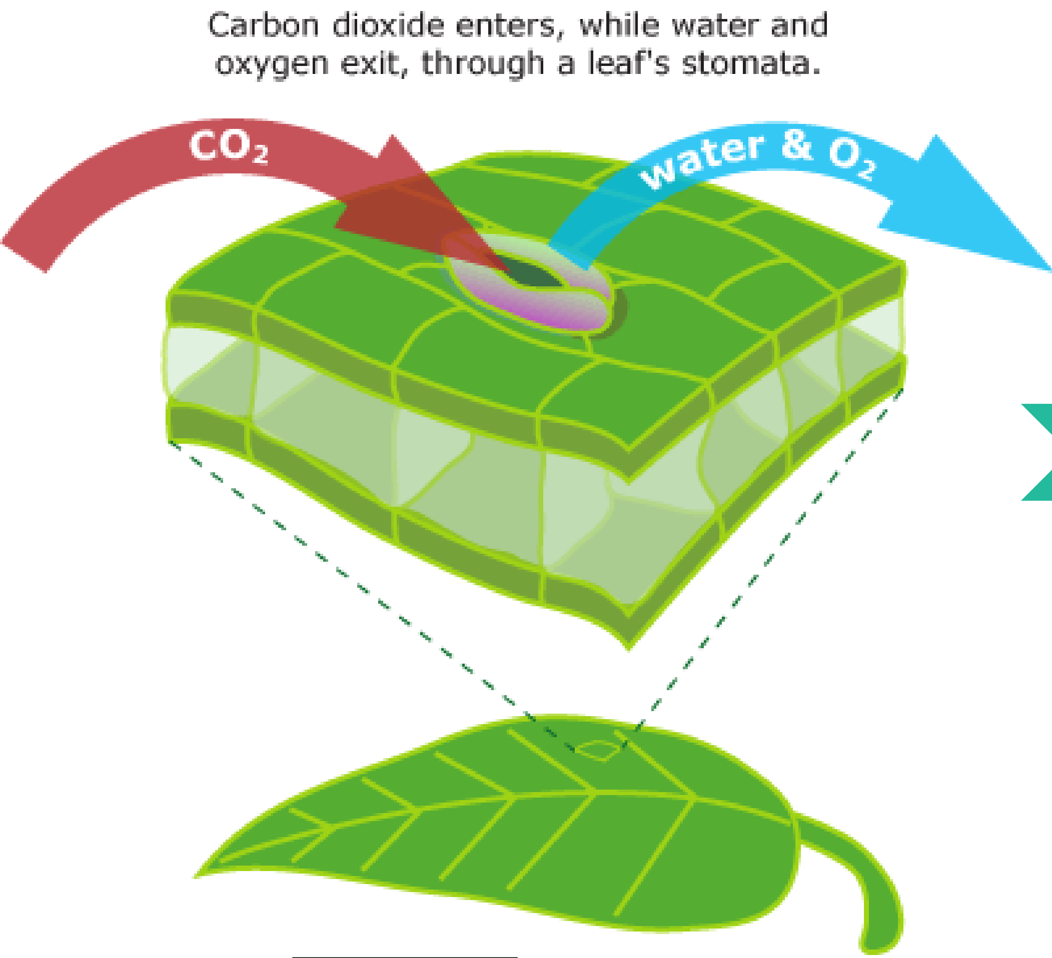
Marta Yebra, Albert Van Dijk, Ray Leuning and Juan Pablo Guerschman



Marta Yebra | PhD

EGU 2015

Nexus between GPP and T



10^{-4} m

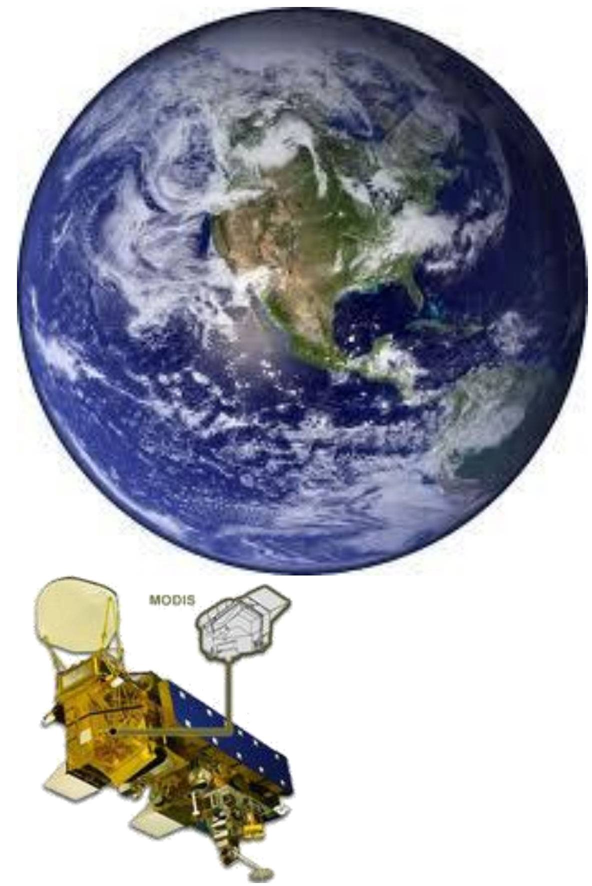
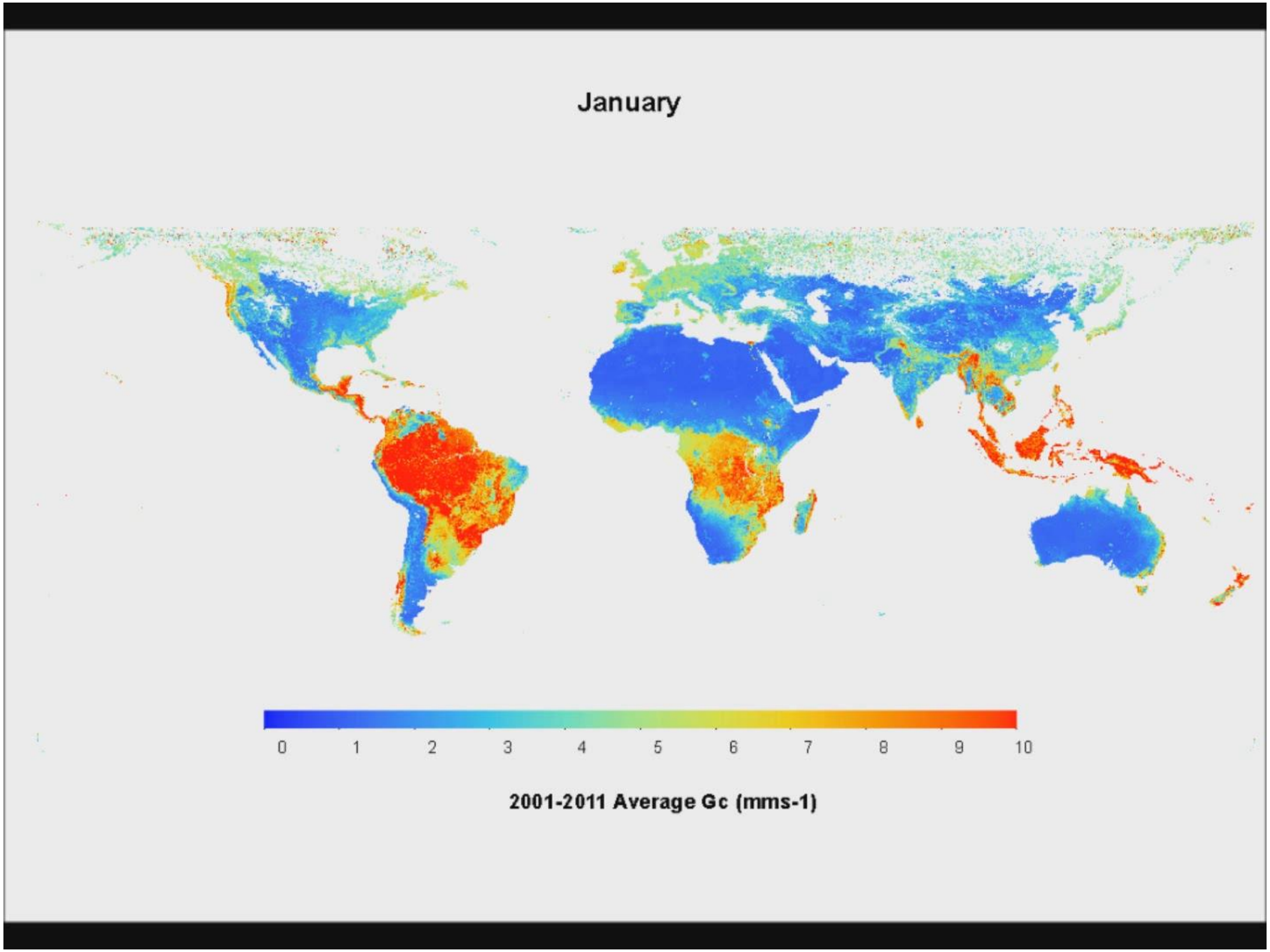


Figure 2. **Planet**

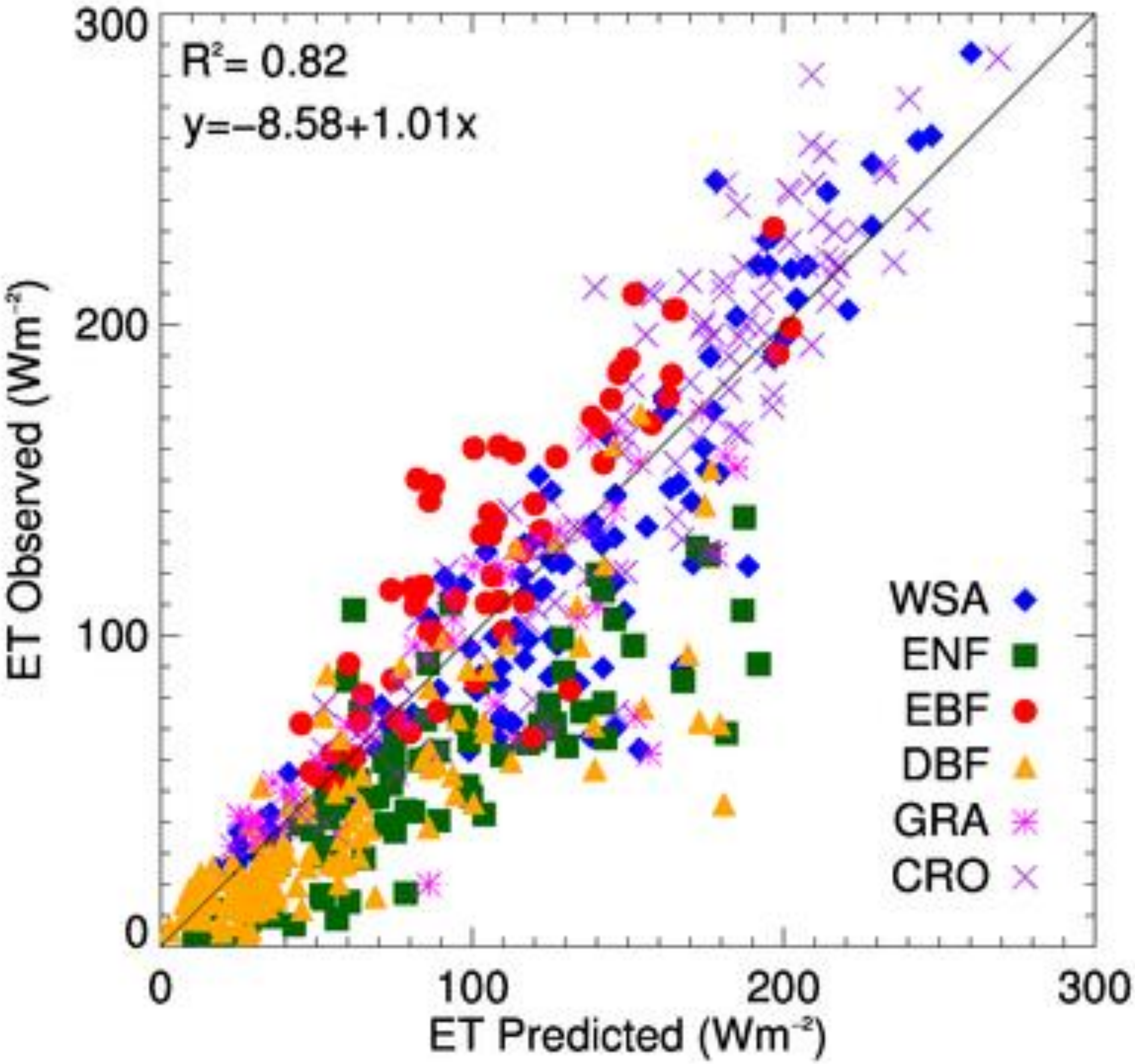
10^{7} m

Global canopy conductance



Data available here: http://www.wenfo.org/wald/data-software/

Evaluation against tower ET



$$\lambda E = \frac{\varepsilon A + (\rho C_\rho / \gamma) D G_a}{\varepsilon + 1 + G_a / G_s}$$

(Monteith 1964)

Process-based canopy GPP model

$$F = \min\{F_r, F_c\}$$

Radiation limited (F_r)

$$F_r = \varepsilon \, fPAR \, Q$$

$\varepsilon = \varepsilon_{max}$ *EVI (Light use efficiency)*

fPAR Linear ramp function between ($NDVI_{min}$,0) and ($NDVI_{max}$,0.95) (*Donohue et al. 2008)*

Q incident PAR (mol photons)

Conductance limited (F_c)

$$F_c = c_g \, G_{cw} \, (1 - R_0) \, C_a$$

c_g conversion coefficient

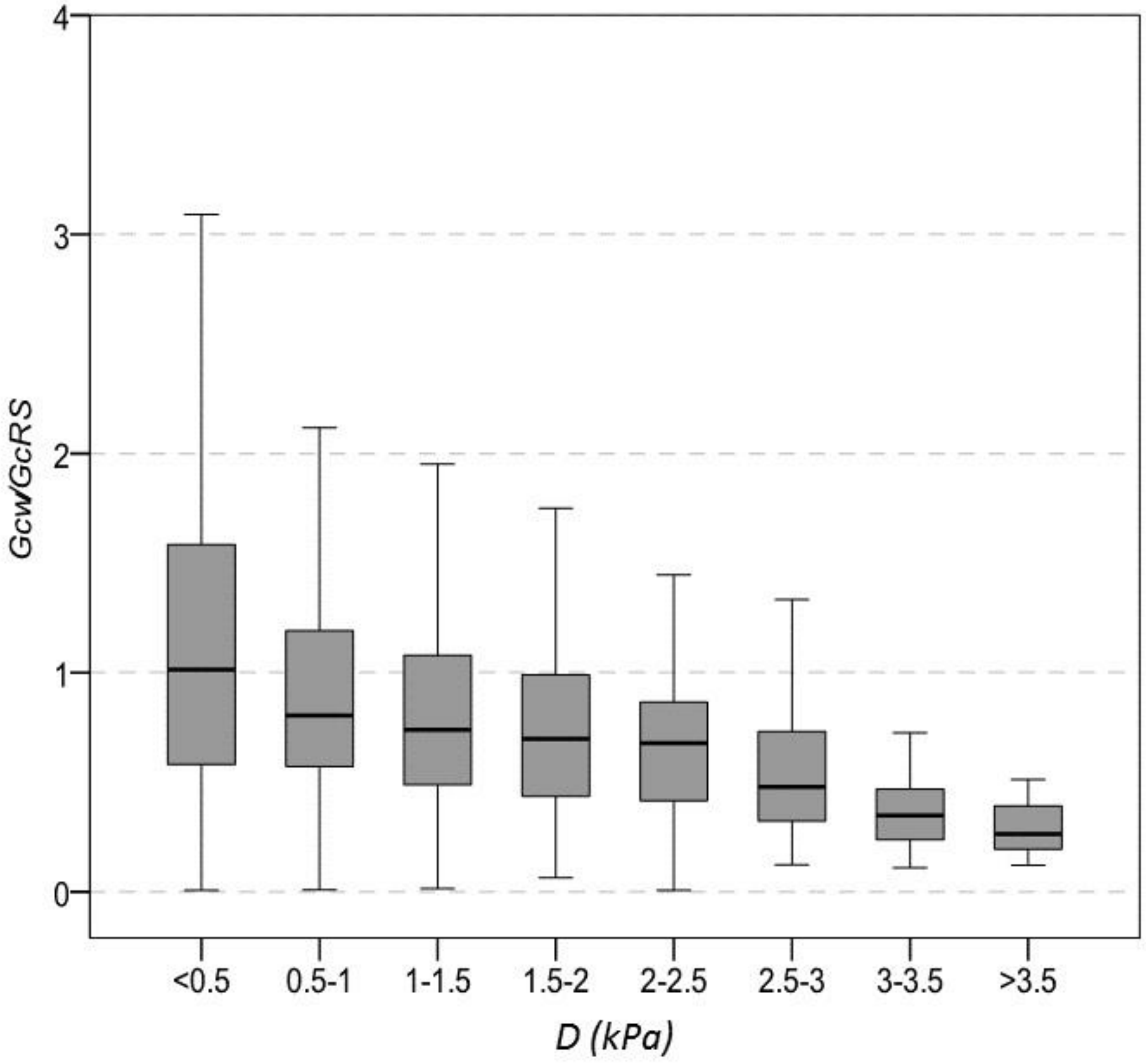
G_{cw} ($m \, s^{-1}$) canopy conductance to water vapour

$R_0 = C_i / C_a$ *(minimum)*

C_i internal [CO_2]
C_a external [CO_2]

Only 2 Parameters! R_0=0.76 and ε_{max}=0.045

Improved global G_c algorithm



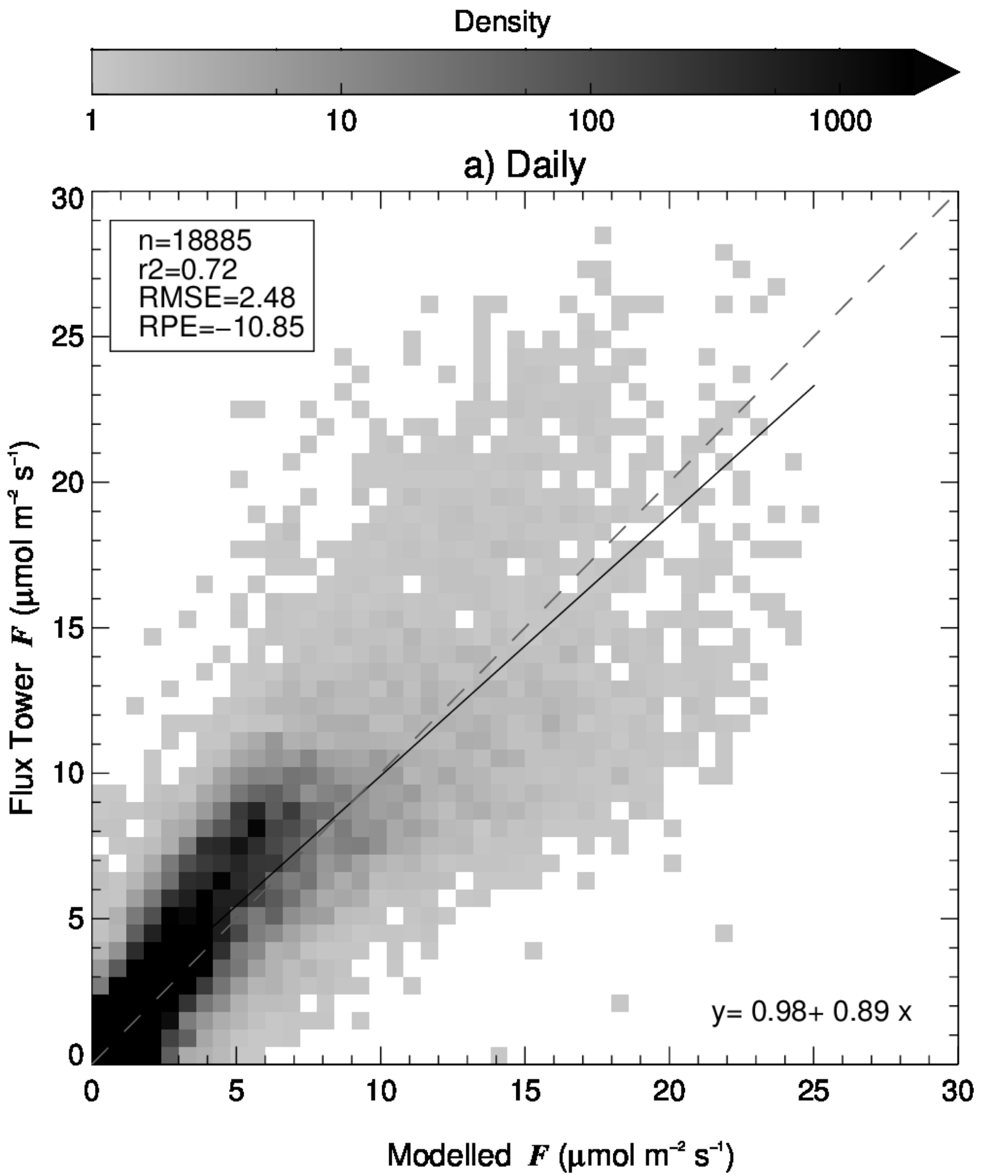
$$\frac{G_c}{G_{cRS}} = \frac{C_0}{1+{D}/{D_{50}}}$$

Lohammar et al (1980)

Two parameters model

D_{50}=0.70 kPa
C_0=1.94

Evaluation against flux tower data



Yebra, M., et al 2015. Remote Sensing of Environment. In press.

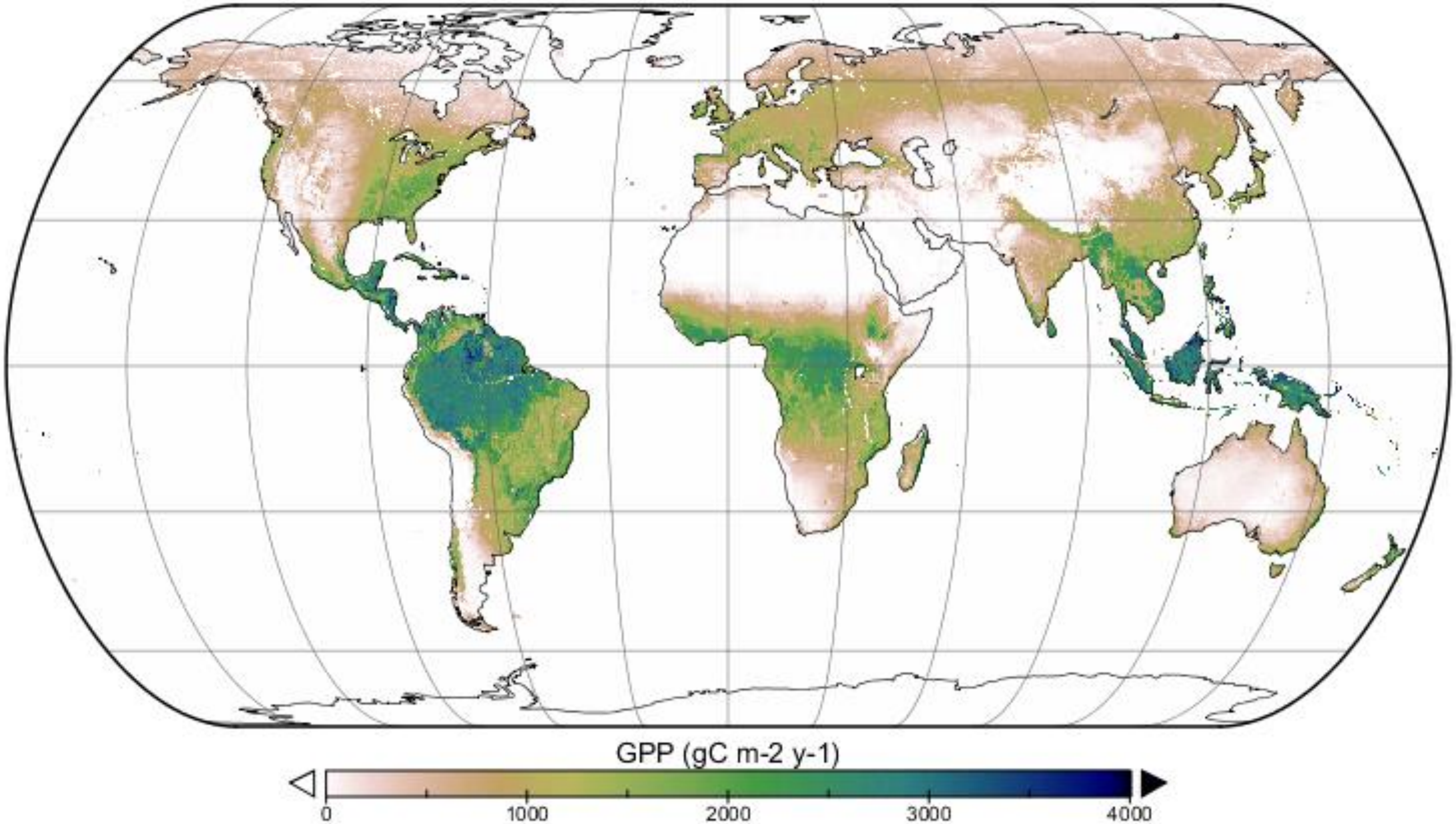
Global estimates

- Global daily meteorological data 2000-2011 (Sheffield et al. 2006), (1º).
  - Solar radiation
  - Specific humidity and air pressure → G_c (improved Yebra et al 2013's algorithm)
- MODIS data 2000-2011, 8-day (0.05º)
  - Reflectance (MOD42) → fPAR, EVI, G_c

2000–2011 annual GPP average

107 $PgCy^{-1}$

4%< MOD17 (112 $PgC\ y^{-1}$)
14% < MPI (122 $PgC\ y^{-1}$)



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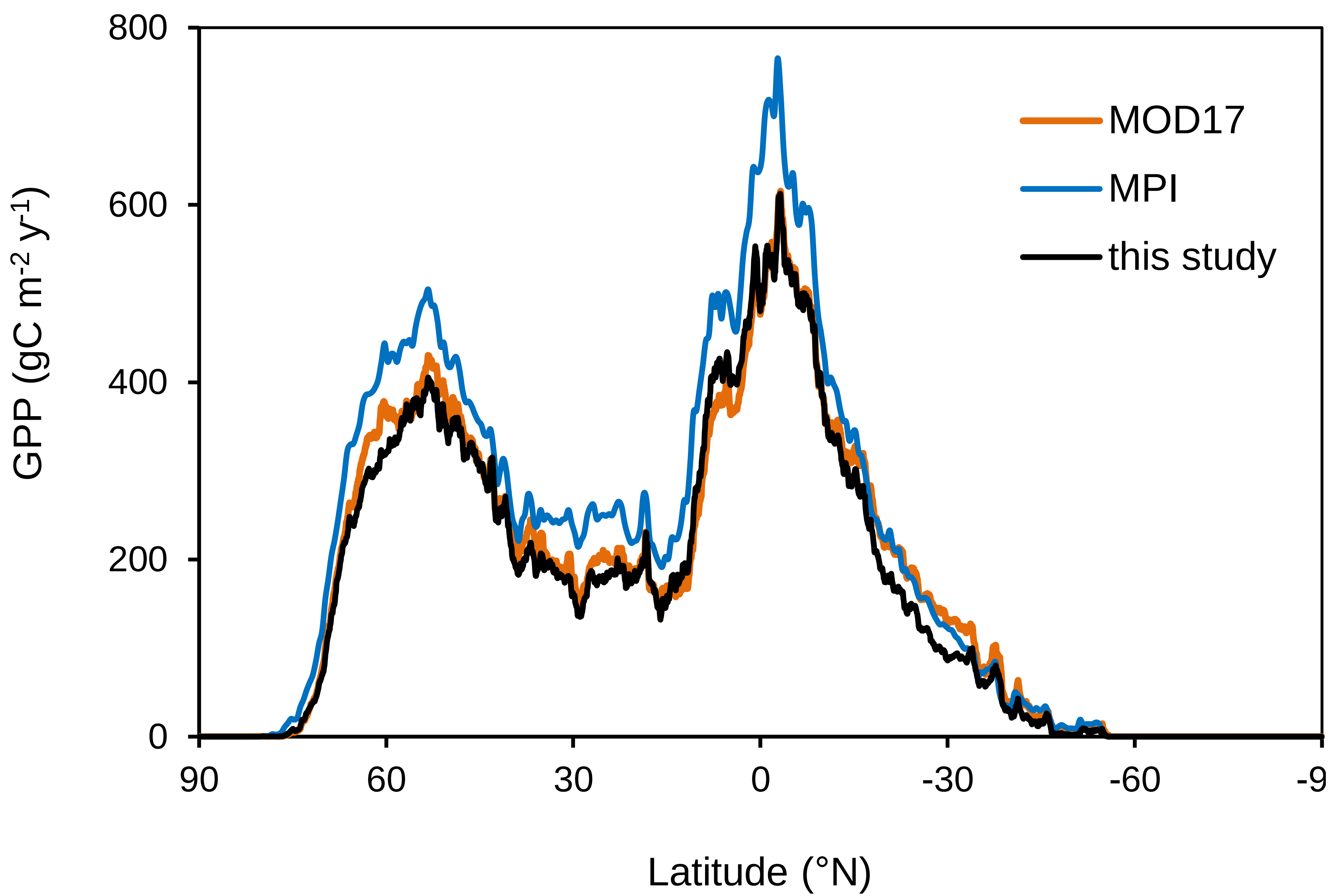
GPP per different latitudes



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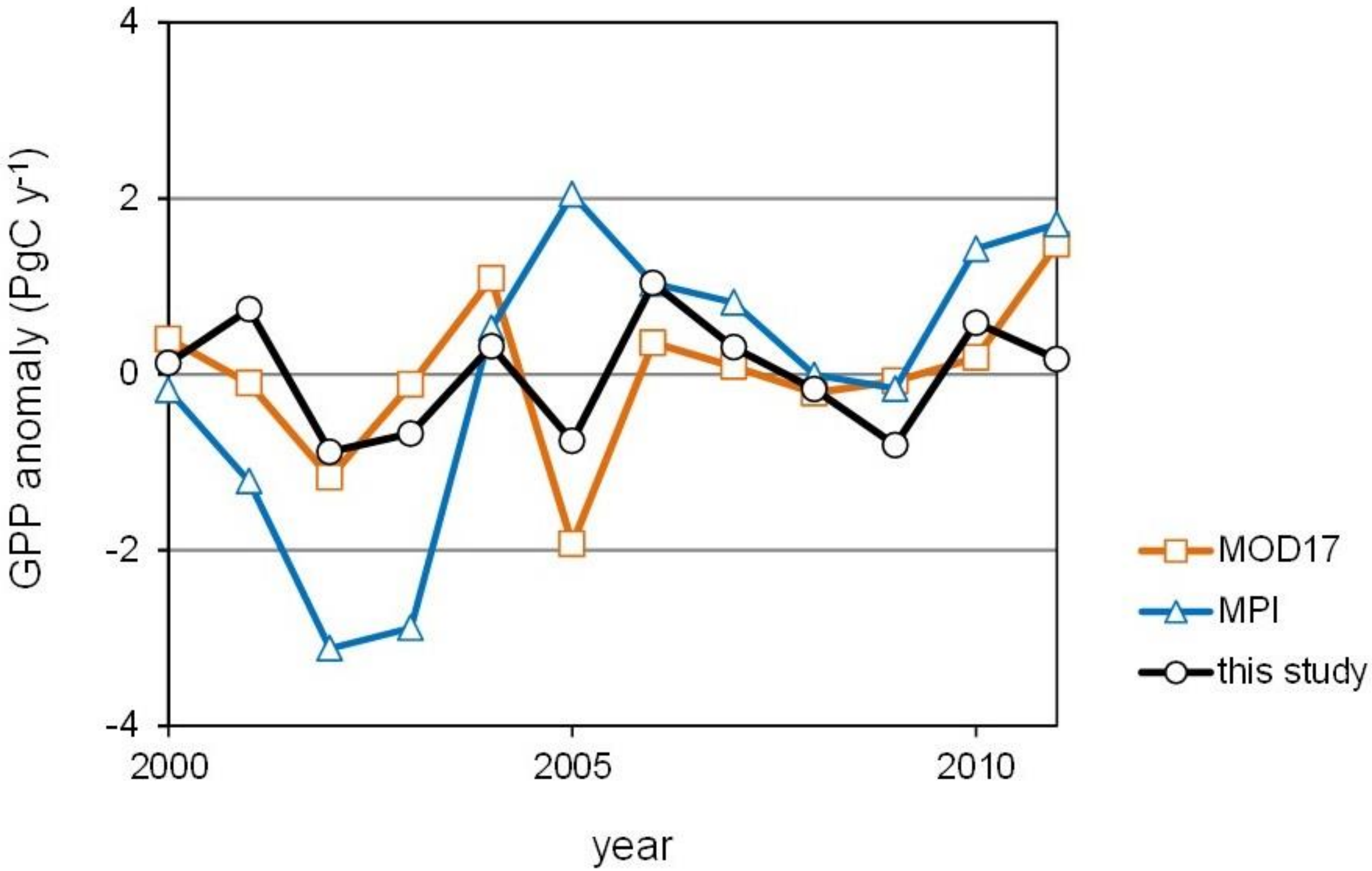
GPP model comparison

Model	RPE	r^2	RMSE
This study	-15.46	0.61	2.65
MPI	-17.95	0.73	2.36
MOD17	-27.57	0.50	3.15

GPP anomalies



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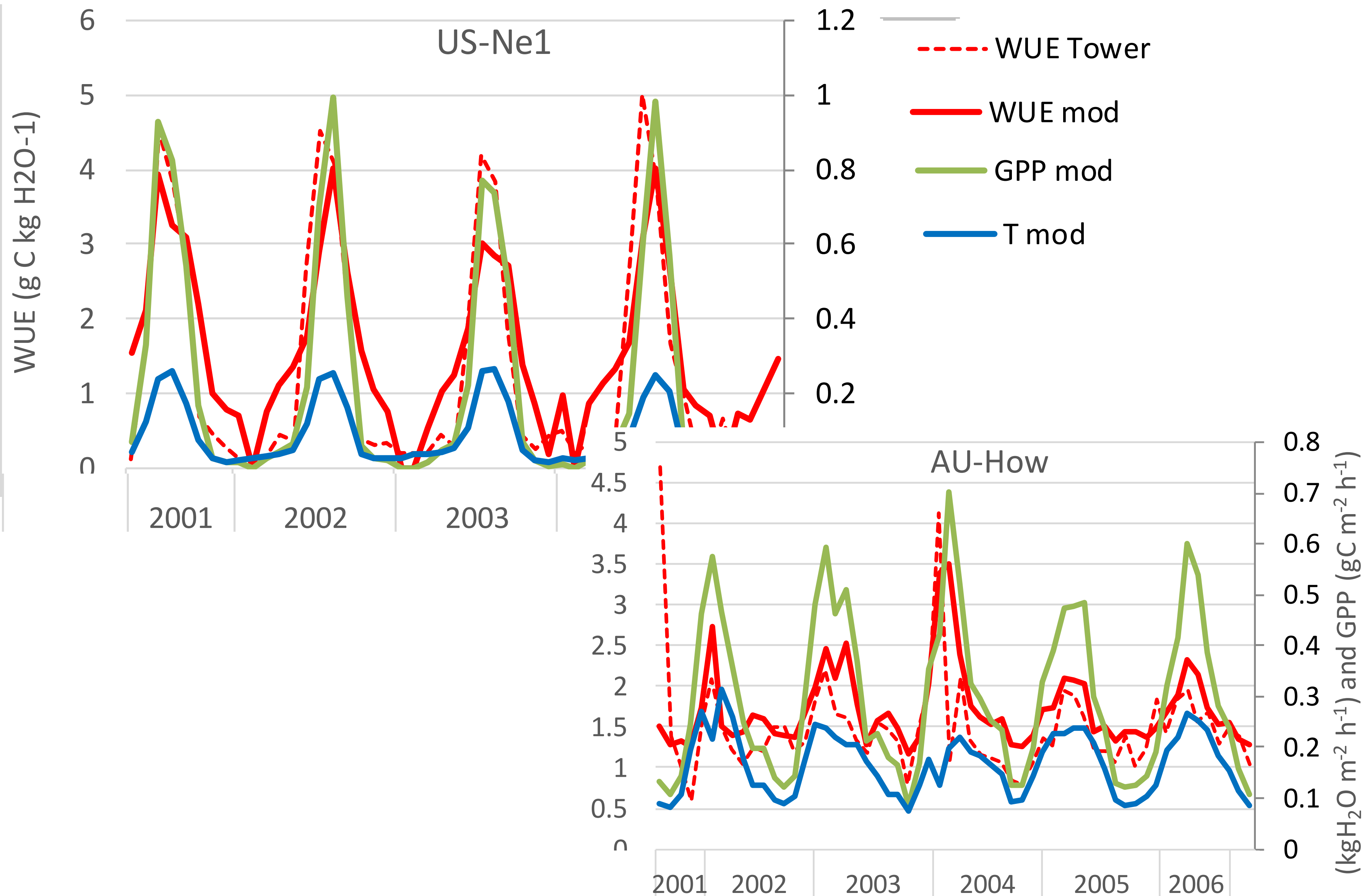
Water use efficiency



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Modelled GPP, T and WUE

	GPP ($gC\ m^{-2}h^{-1}$)	T ($kgH_20\ m^{-2}h^{-1}$)	WUE ($gC\ kg\ H_20^{-1}$)
Crops (CRO) and grasslands (GRA)			
US-Bo1	0.18 (-5%)	56.16 (-26%)	3.2 (+28%)
US-Ne1	0.21 (-35%)	72.36 (-29%)	2.9 (-6%)
US-Ne2	0.22 (-24%)	74.88 (-30%)	3 (+7%)
US-Ne3	0.16 (-31%)	66.60 (-29%)	2.5 (-4%)
US-Var	0.16 (+9%)	50.76 (-4%)	3.1 (+15%)
Deciduous Broadleaf Forest (DBF)			
IT-Ro1	0.21 (+26%)	71.28 (+40%)	2.9 (-10%)
IT-Ro2	0.23 (-3%)	73.44 (+13%)	3.1 (-13%)
US-Ha1	0.23 (+13%)	67.68 (+25%)	3.5 (-8%)
US-MMS	0.39 (+62%)	93.96 (+10%)	4.1 (+46%)
US-WCr	0.34 (+28%)	65.88 (-3%)	5.2 (+30%)
Evergreen Broadleaf Forest (EBF)			
AU-Tum	0.18 (-34%)	65.16 (-24%)	2.8 (-12%)
Evergreen Needle leaf Forest (ENF)			
FI-Hyy	0.14 (-15%)	60.84 (+32%)	2.3 (-36%)
NL-Loo	0.14 (-44%)	57.60 (-5%)	2.4 (-40%)
US-Ho1	0.22 (-13%)	77.40 (+43%)	2.8 (-40%)
Woody Savannas (WSA)			
AU-How	0.14 (-14%)	81.36 (-30%)	1.7 (+21%)
US-Ton	0.08 (-23%)	44.28 (3%)	1.8 (-25%)

2000-2011 average values of modelled GPP, T and WUE and the relative percentage difference between the predicted and the observed

Conclusions

- We produced **mutually consistent** estimates of **GPP** and **T** at 16 Fluxnet sites using satellite derived **canopy conductance** to analyse **WUE**.
- **Satellite-derived WUE** explains variation in average WUE among sites, but evergreen needleleaf forests had higher WUE than predicted.
- Encouraging result, given
  - the **simplicity** of our GPP two-parameter model
  - the **lack of biome-** or land-cover specific parameters
  - the simple but **explicit coupling between ET and GPP**

THANKS!

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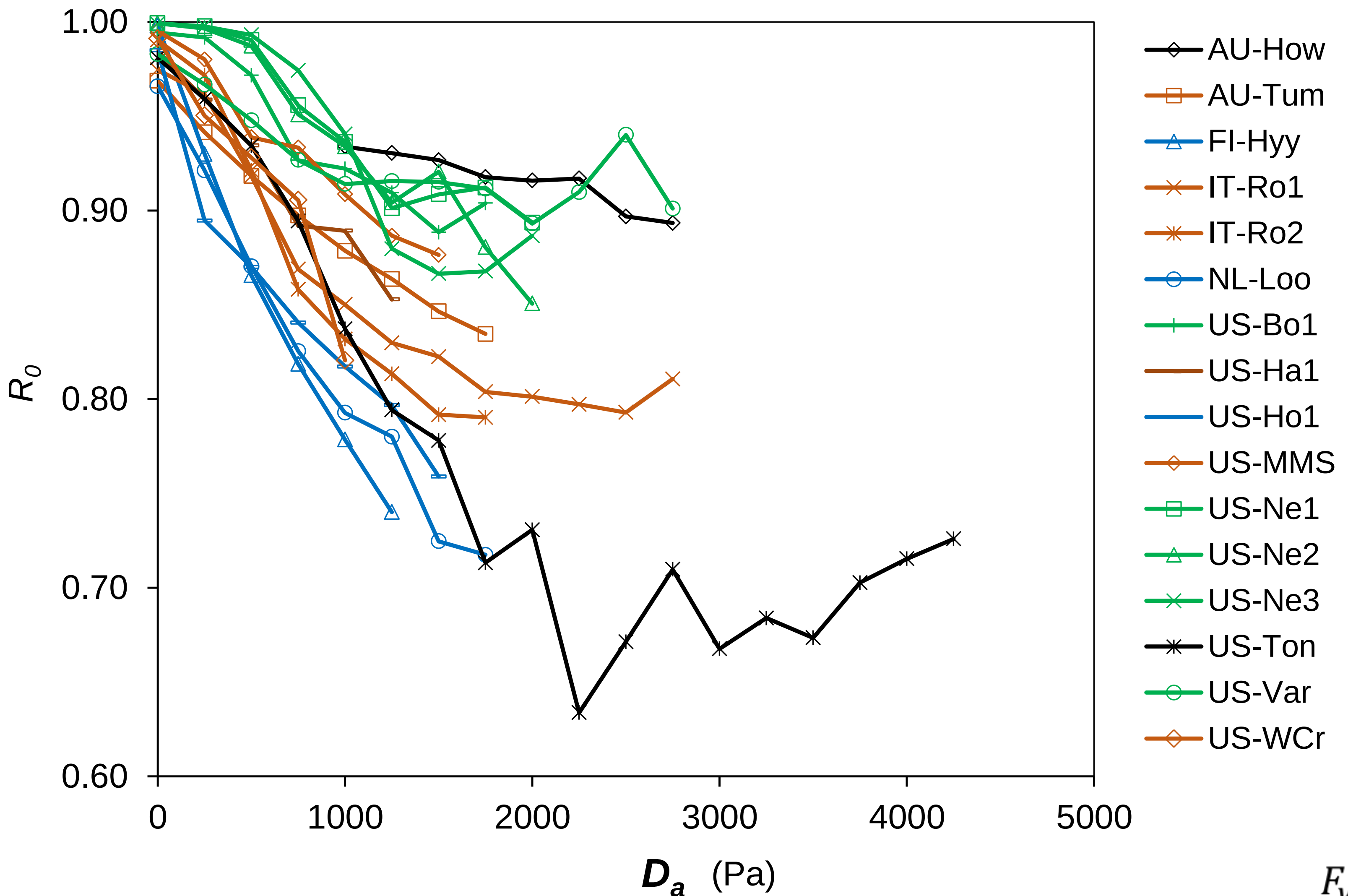
R_0 decreases linearly with D_a

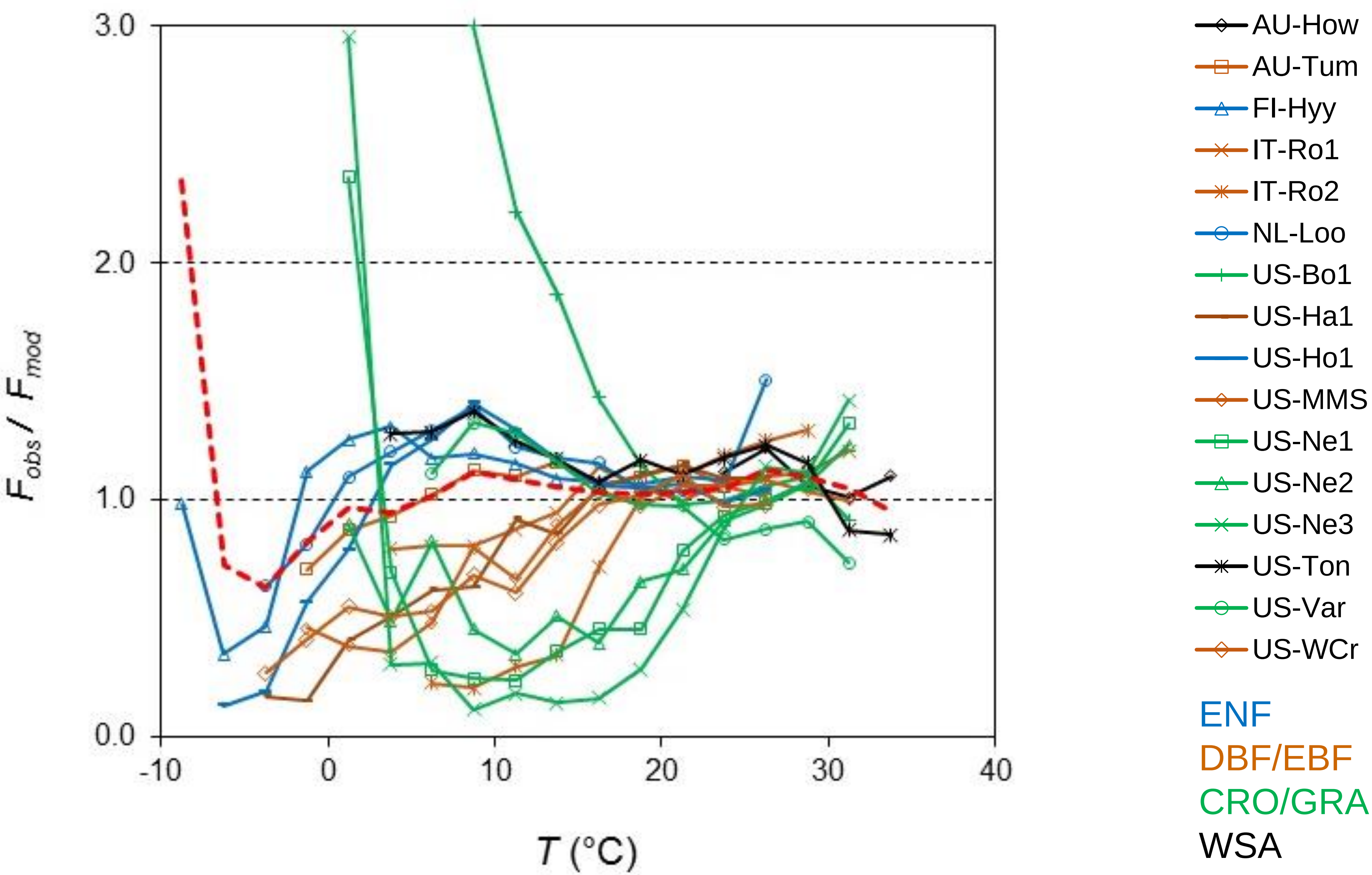
Optim
R_0=0



ENF, DBF/EBF, CRO/GRA, WSA

$$R_0 = 1 - \frac{F_w}{c_g G_{cw} C_a}$$

Other factors to explain GPP



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