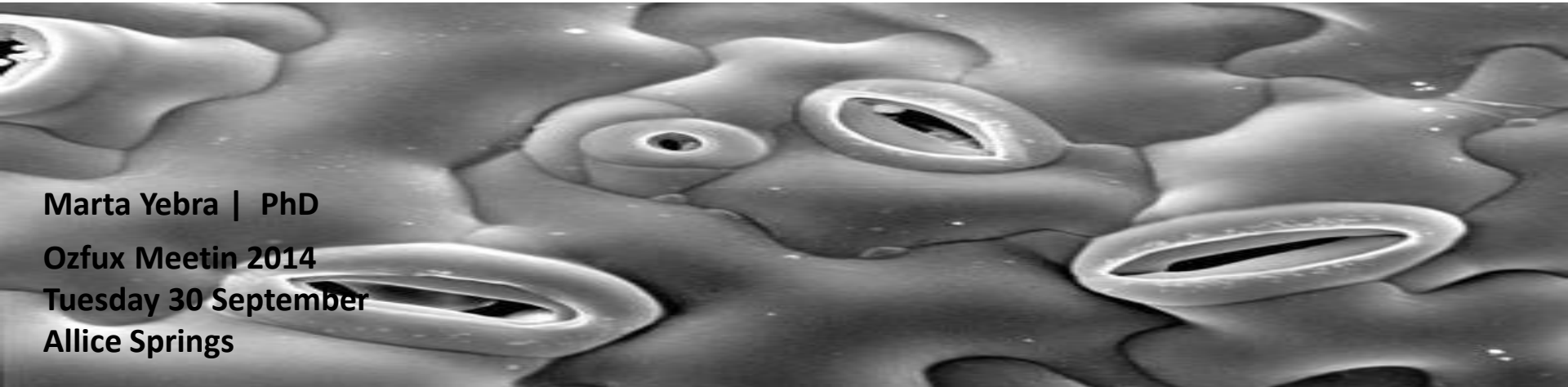
Global gross primary production estimation using satellite-derived canopy conductance

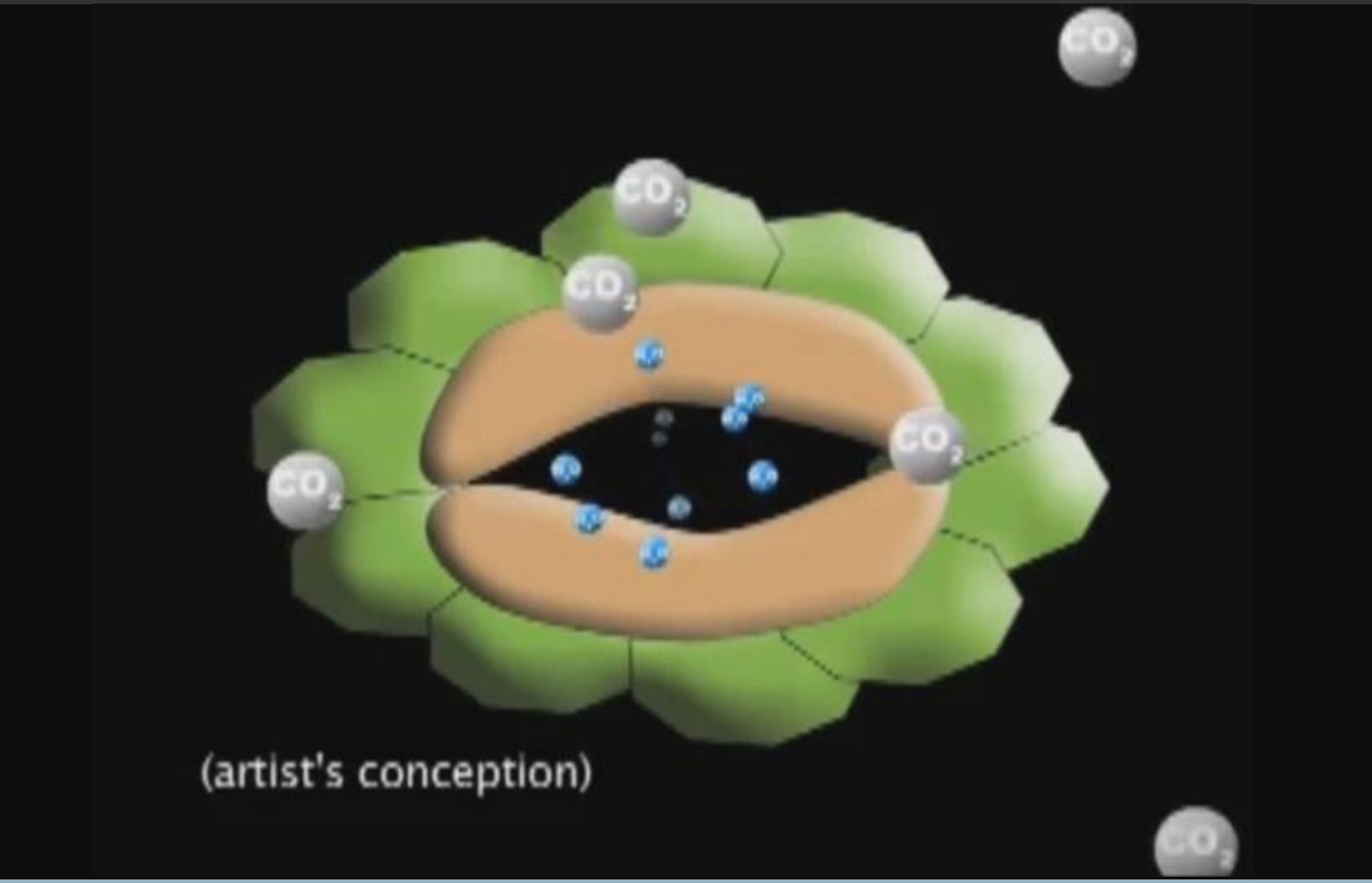
Marta Yebra, Albert Van Dijk, Ray Leuning and Juan Pablo Guerschman



Marta Yebra | PhD

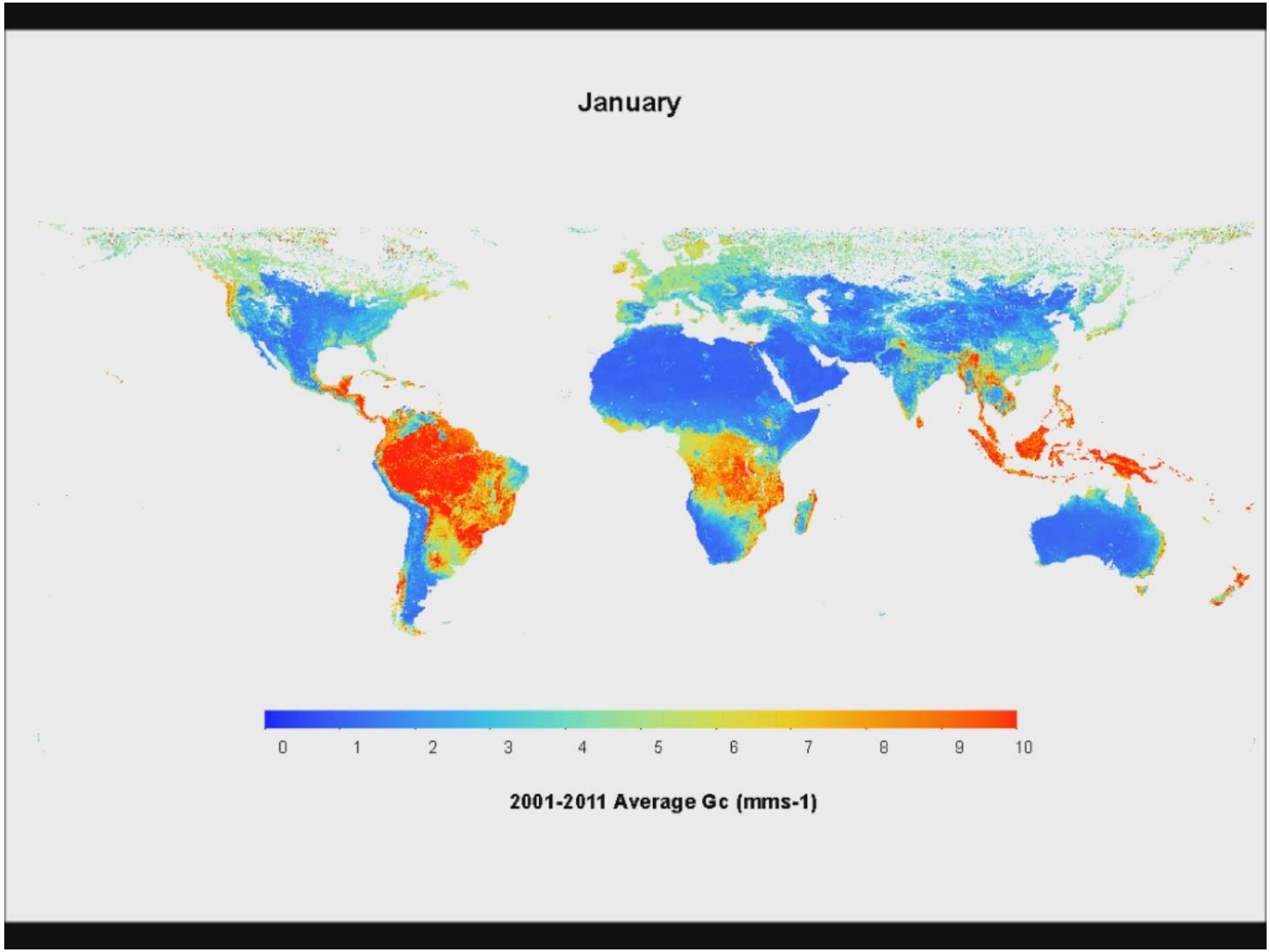
Ozfux Meetin 2014
Tuesday 30 September
Allice Springs

Physiological nexus GPP-ET



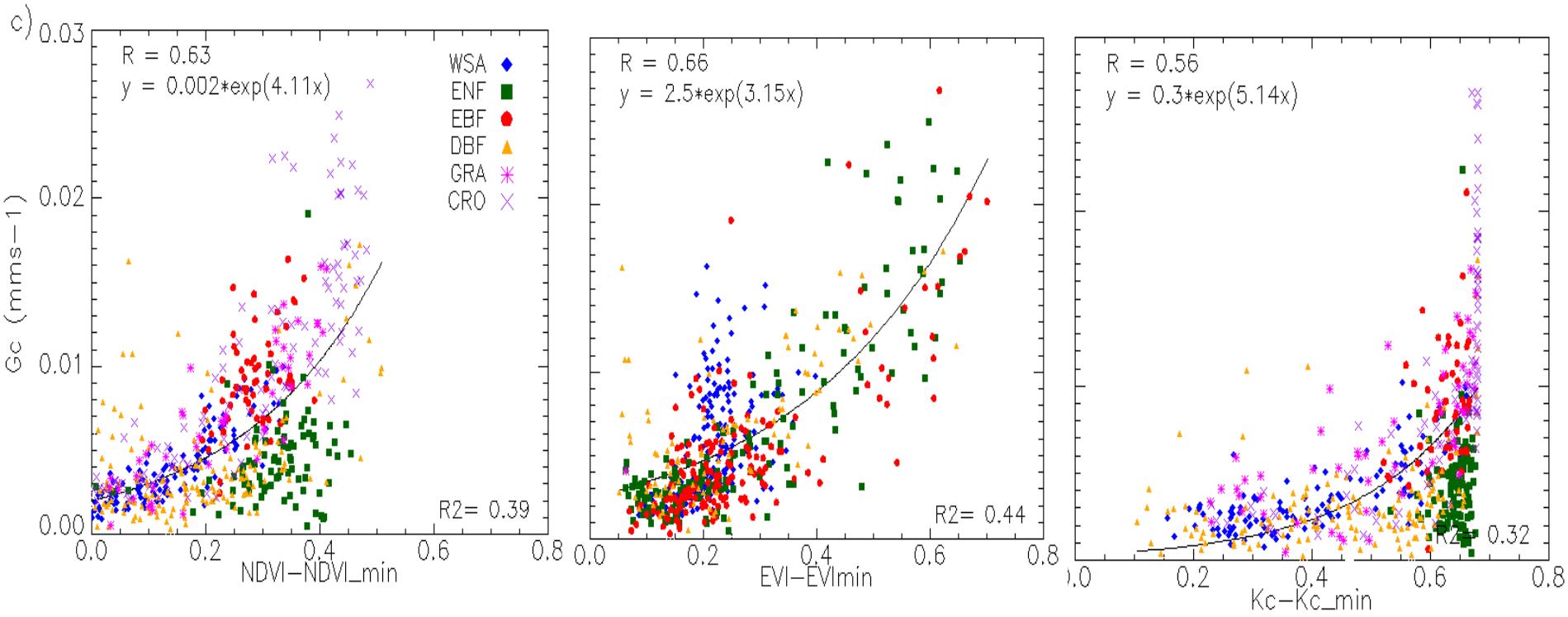
Animation from Joe Berry

Global G_c (2001-2011)



Yebra, M., Van Dijk, A., Leuning, R., Huete, A., Guerschman, J.P., 2013. Evaluation of optical remote sensing to estimate actual evapotranspiration and canopy conductance. Remote Sensing of Environment. 129, 250-261.

Global G_c model



Inverted Penman-Monteith (PM) Equation

$$G_s = \frac{\lambda E G_a}{\varepsilon A - (\varepsilon + 1)\lambda E + \rho c_p D / \gamma}$$ (Monteith 1964)

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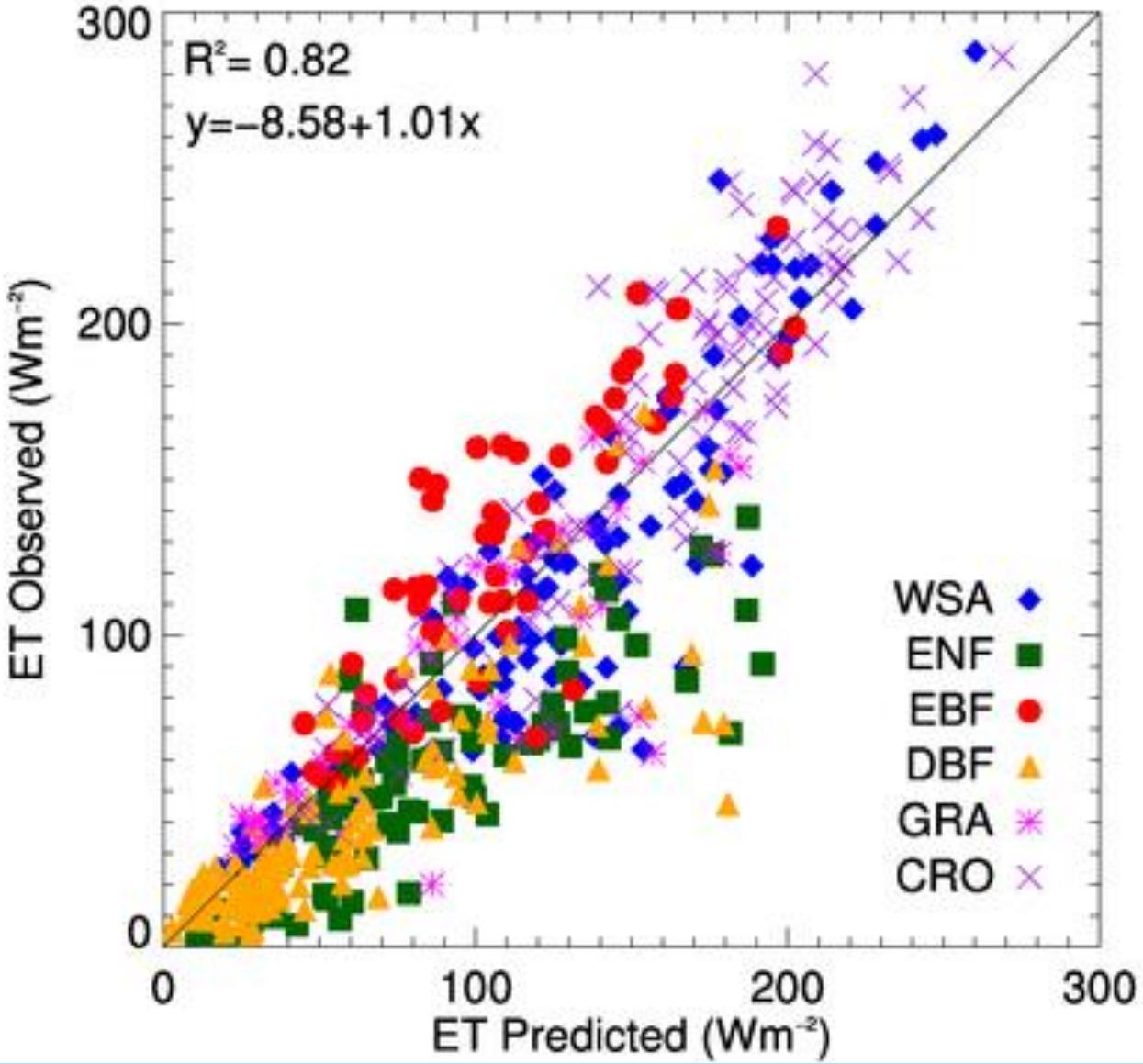
Evaluation against tower ET



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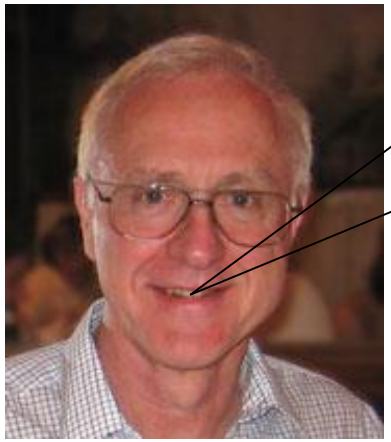
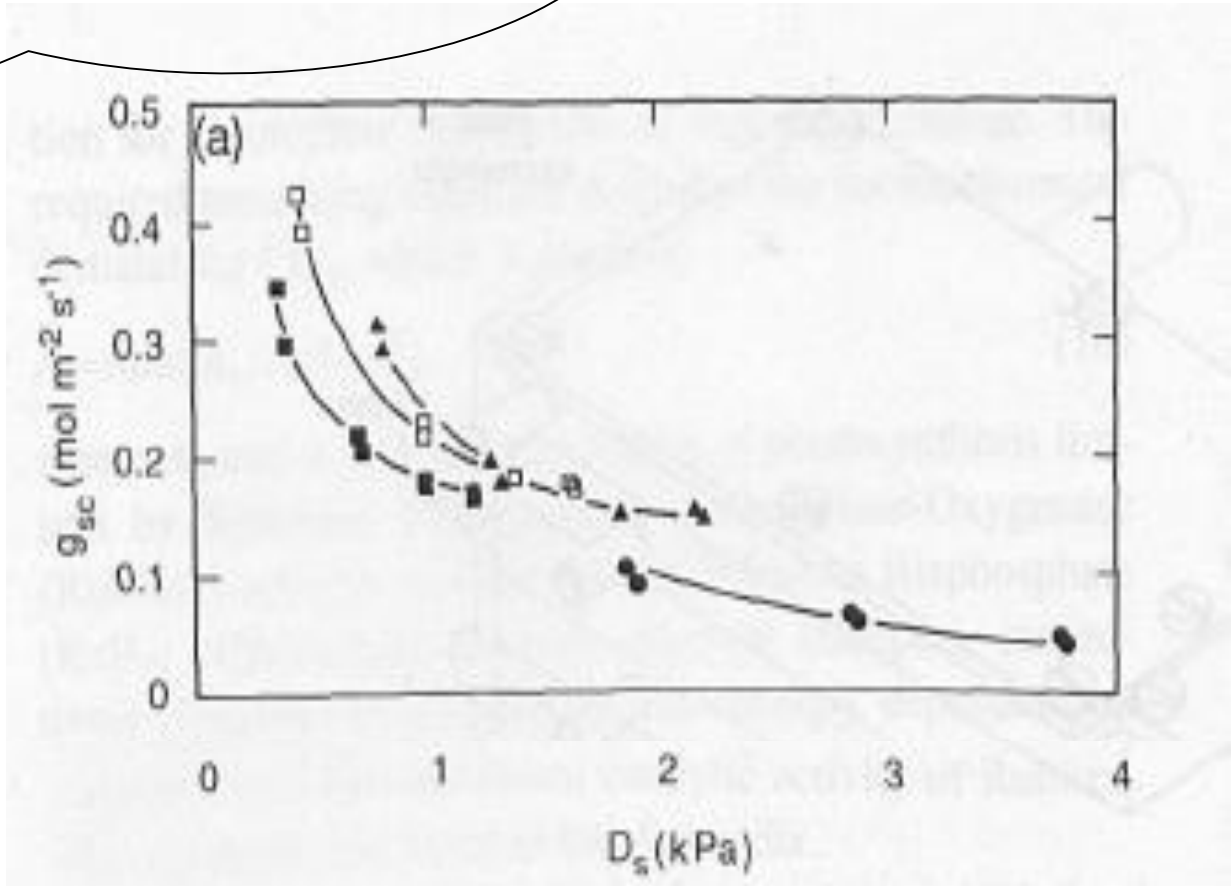
G_c vs D_a has a hyperbolic form

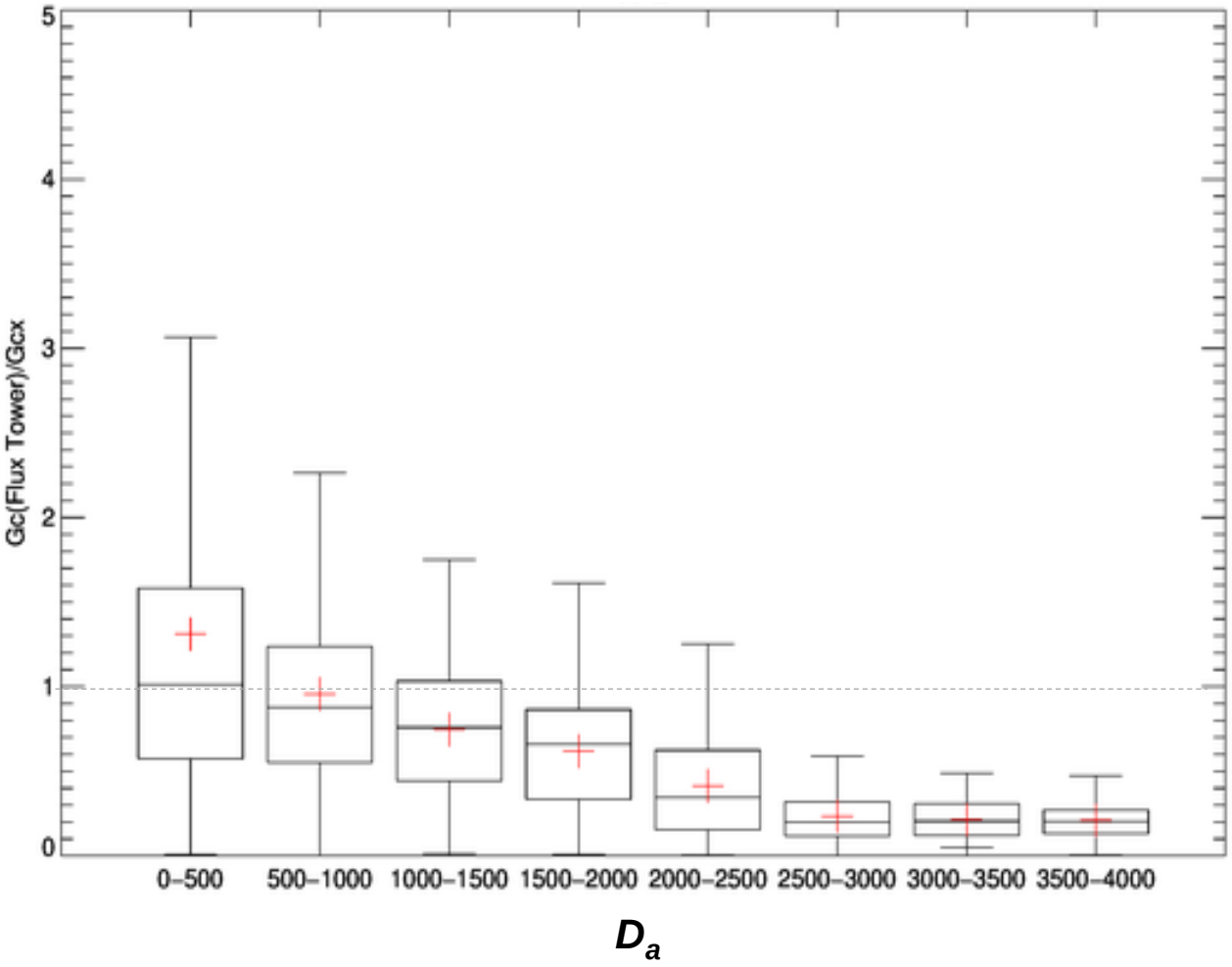


Your satellite G_c estimates do not consider the effect of VPD!!!!!!



(Leuning 1995)

Improved global G_c model



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

Lohammar et al (1980)

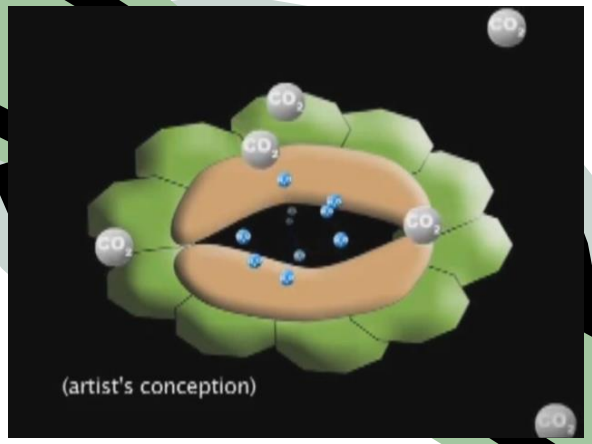
Two parameters model

D_{50}=0.70 kPa
C_0=1.94

Yebra et al, In preparation

Objective

GPP



ET

- **Couple GPP to ET** though remotely-based estimates of G_c
- **Simple** model formulations
- **Small** number of **'free' parameters**
- **Global** scale
- **No-land cover** dependant

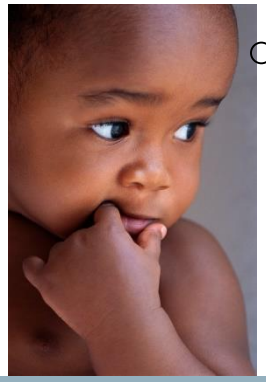
Light use efficiency models

- Primary drivers of GPP (*F*) are vegetation cover and radiation

- Simplest approach to estimate *F*

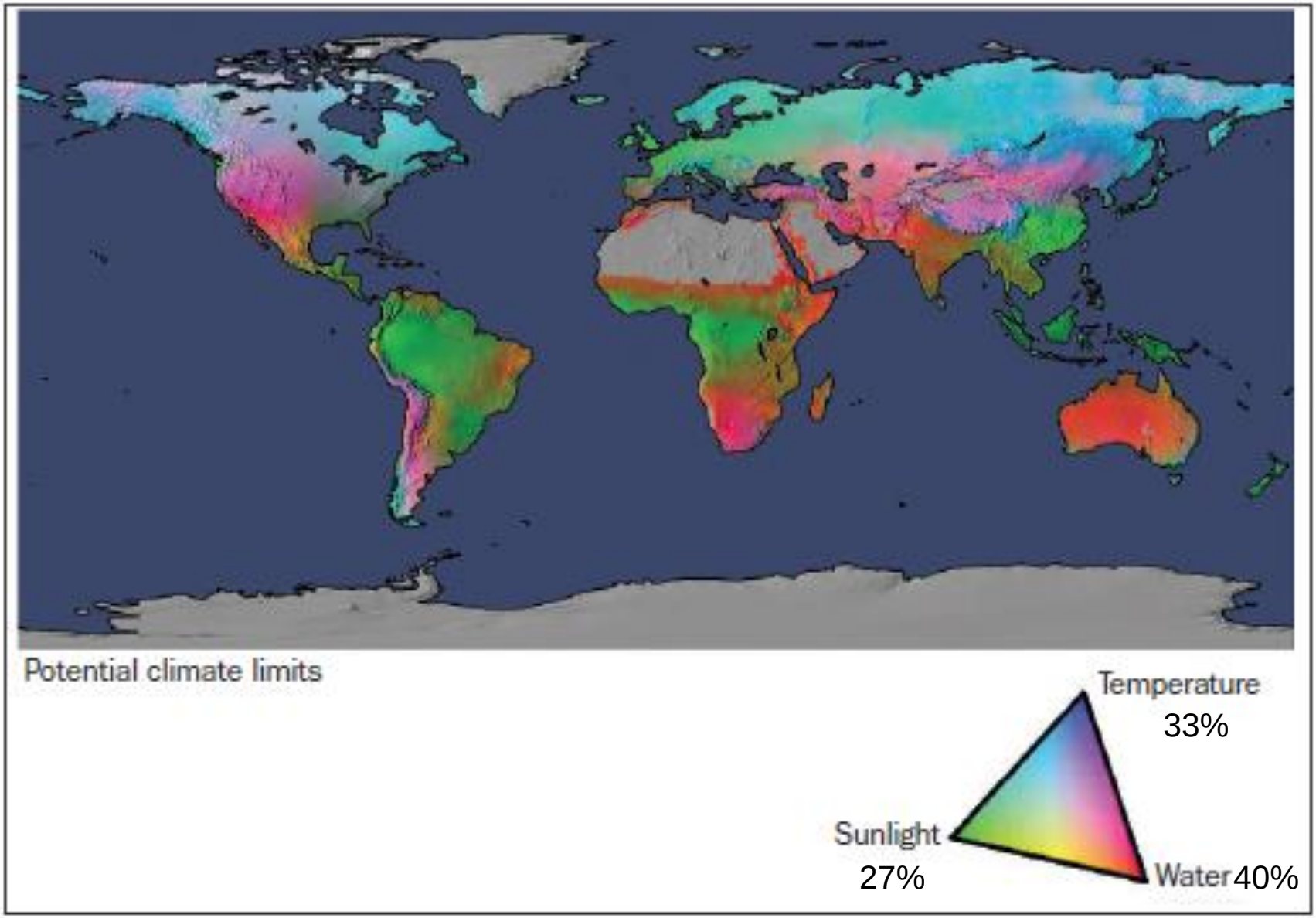
$$F = \varepsilon \, f_{PAR} Q$$

(Sims et al 2008; Running et al 1999; Sjostrom et al 2011 and more and more)



What happens where other environmental conditions limit photosynthesis?

Climatic controls on GPP



Running et al 2004, Bioscience

Our two parameter-model

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

Radiation limited

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

$\varepsilon = \varepsilon_{max}$ *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

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

c_g conversion coefficient

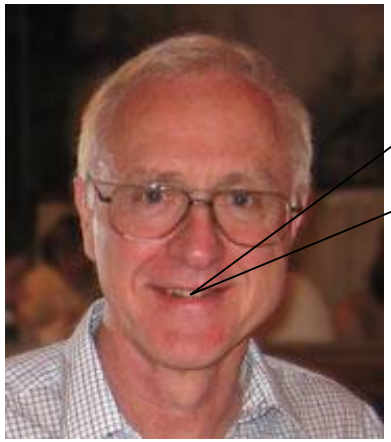
G_{cw} (m s^{-1}) canopy conductance to water vapour

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

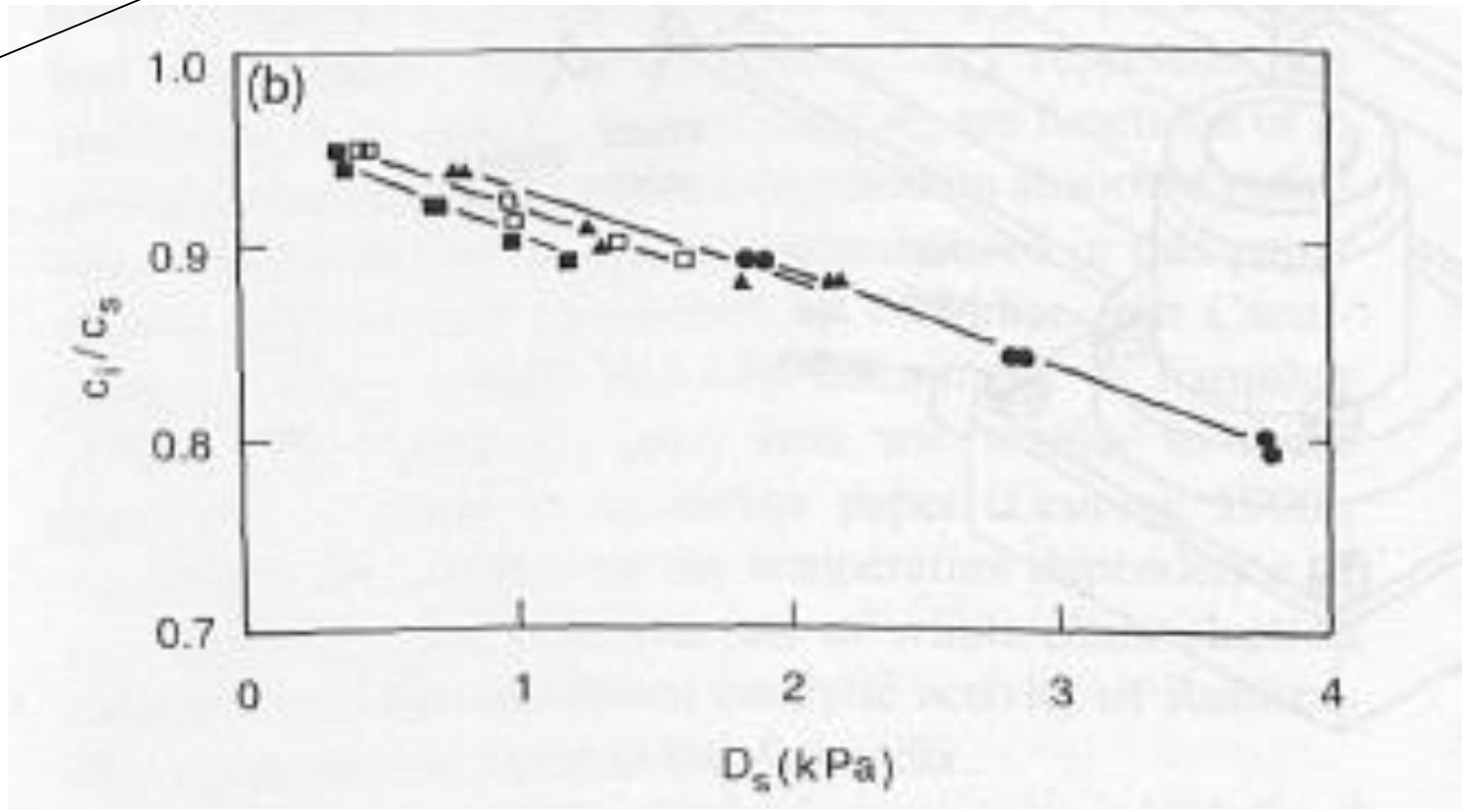
C_i internal [CO_2]
C_a external [CO_2]

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

R_0 decreases linearly with D_a

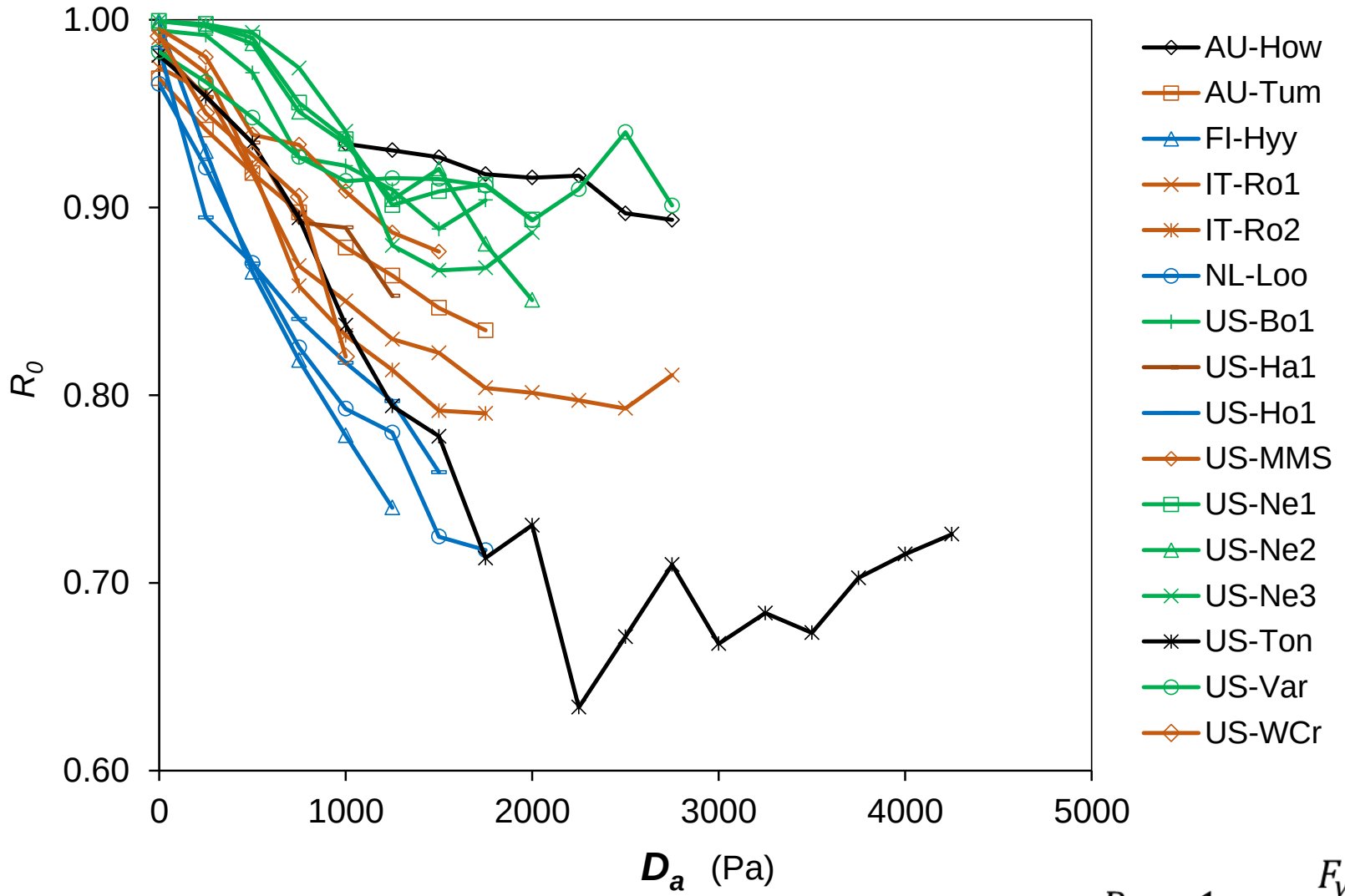


Are you assuming R_0 is constant?!!!!!



(Leuning 1995)

R_0 decreases linearly with D_a



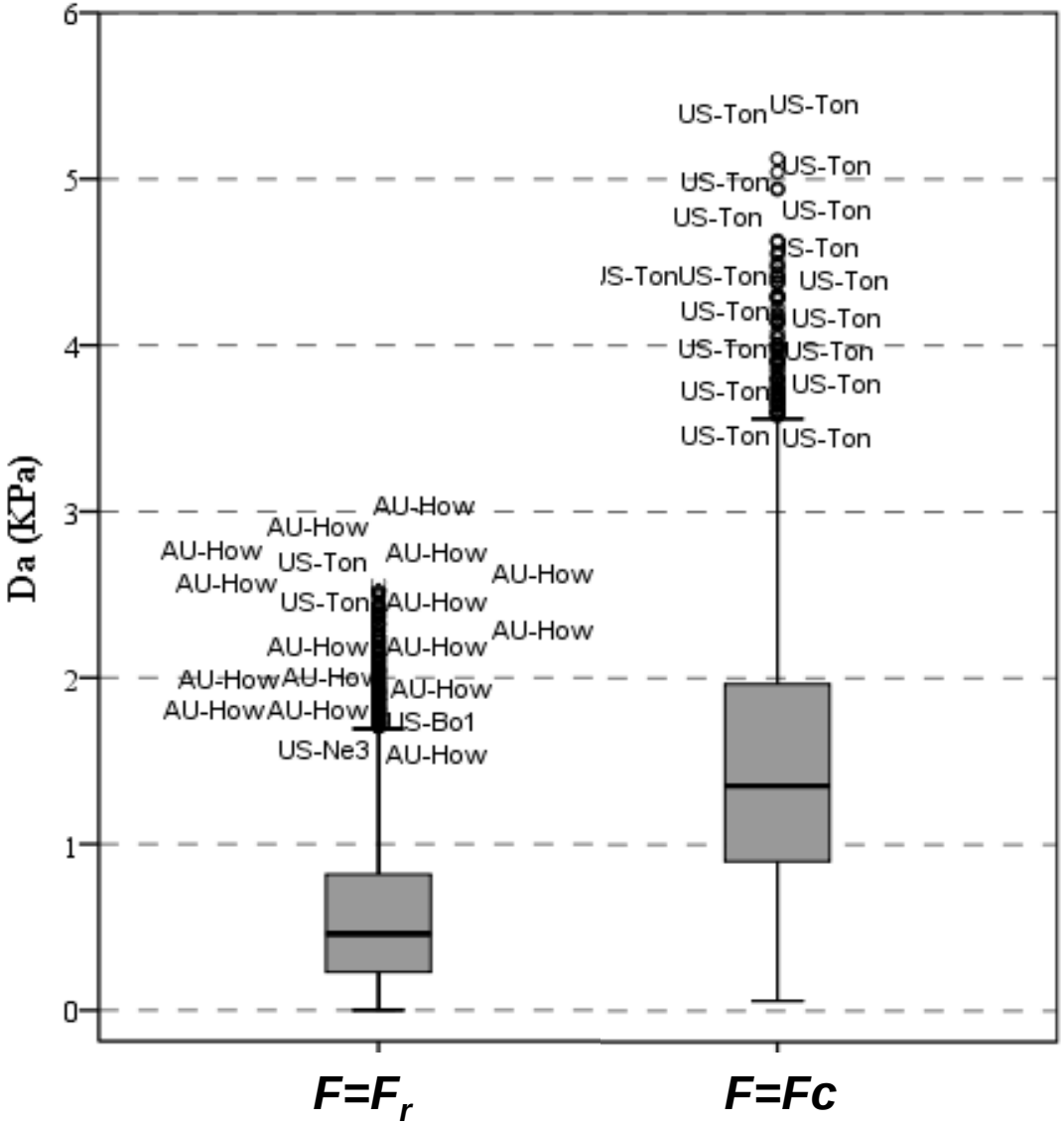
Optim R_0=0

ENF, DBF/EBF, CRO/GRA, WSA

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

Yebra et al, In preparation

D_a for Periods when $F=F_r$ and $F=F_c$



Other factors to explain GPP

- **Optimum temperature;** most enzyme-mediate reactions have a
- **D_a** may have additional influence **on ε or [CO_2]**
- At **High radiations** photosynthesis becomes limited by biochemical capacity (light-saturated)
- **Diffuse/direct radiation; ε** has been observed to be greater under **cloudy conditions**

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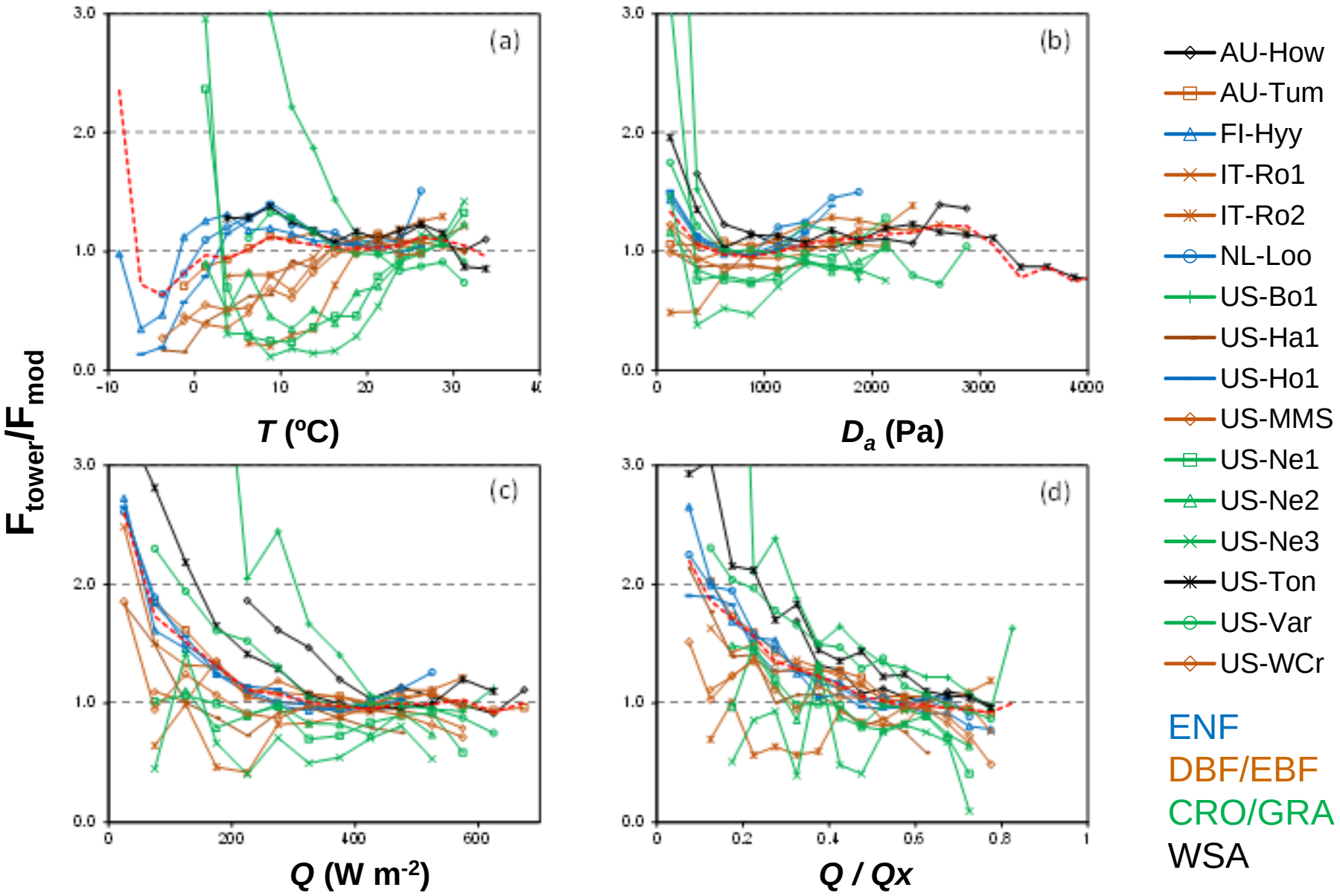
Other factors explain the residuals



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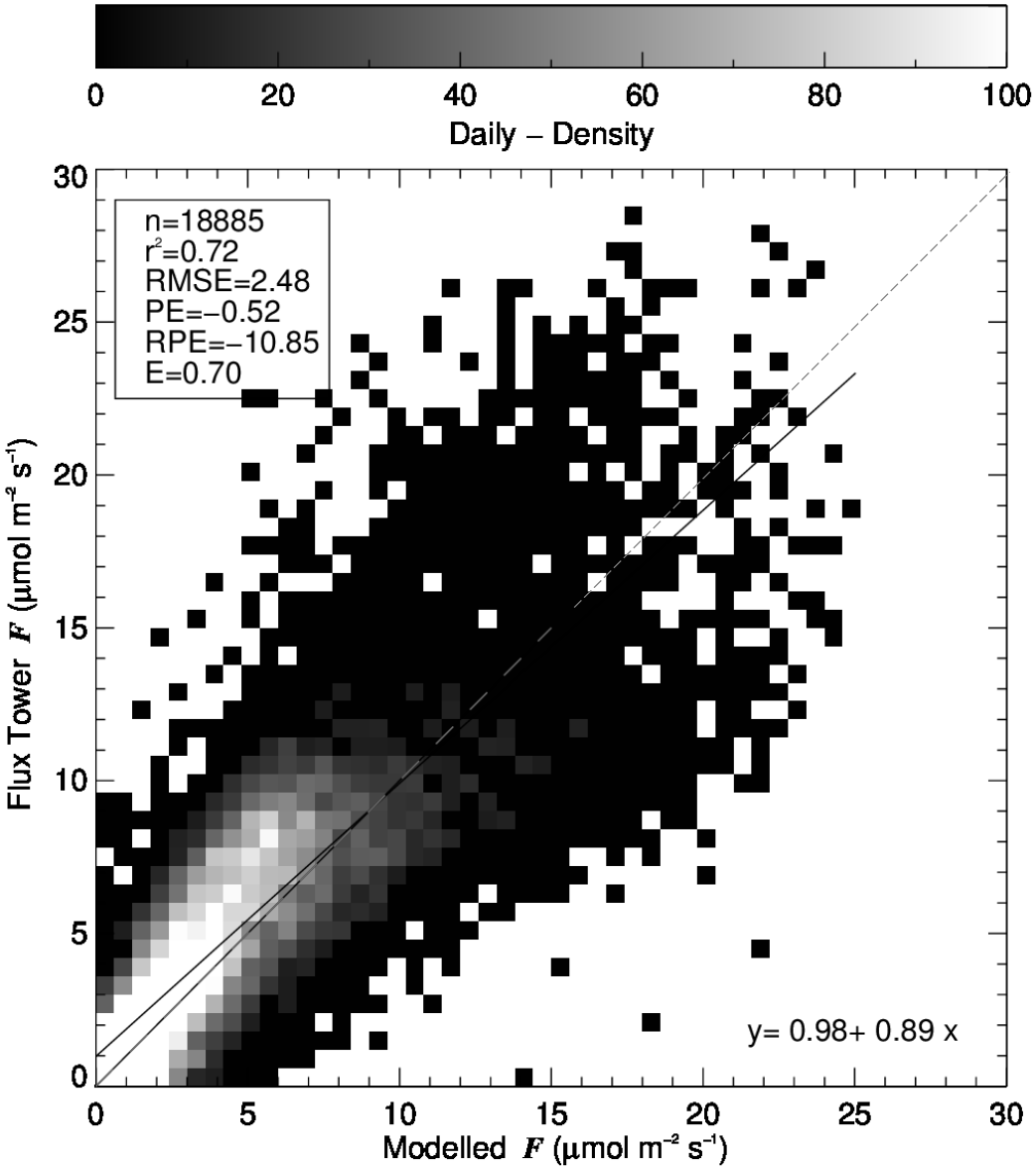
Evaluation against flux tower data



$$E = \frac{\sigma^2_{tower} - \sigma^2_{res}}{\sigma^2_{tower}}$$ Nash-Sutcliffe

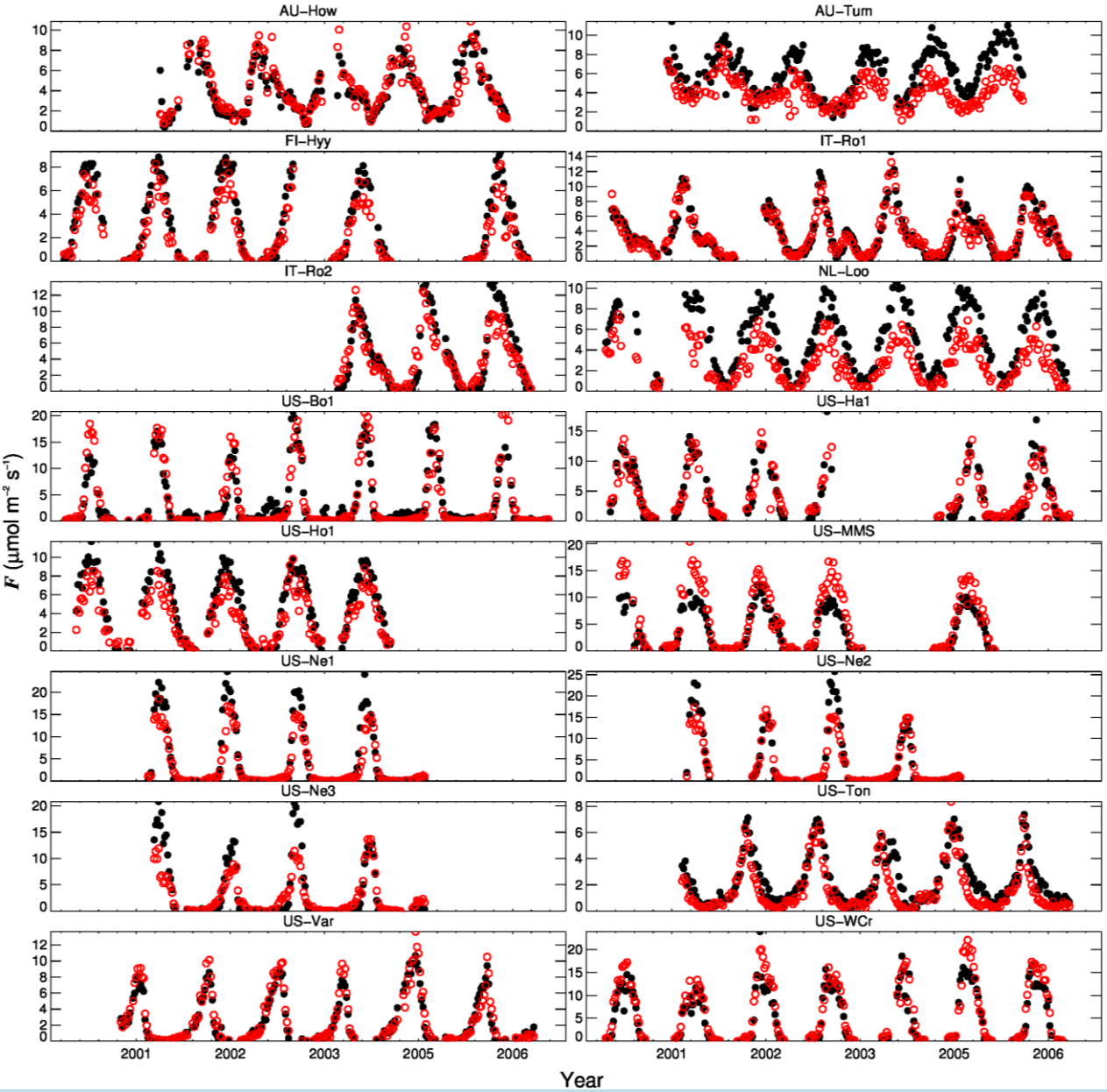
$$PE = \overline{F_{tower}} - \overline{F_{mod}}$$

$$RPE = \frac{\overline{F_{tower}} - \overline{F_{mod}}}{\overline{F_{tower}}}$$

G_c tower and local meteorology
(R_0=0.76 and ε_{max}=0.045)

Yebra et al, In preparation

Evaluation against flux tower data



- *F* Tower
- *F* modelled

G_c tower and local meteorology
(R_0=0.76 and ε_{max}=0.045)

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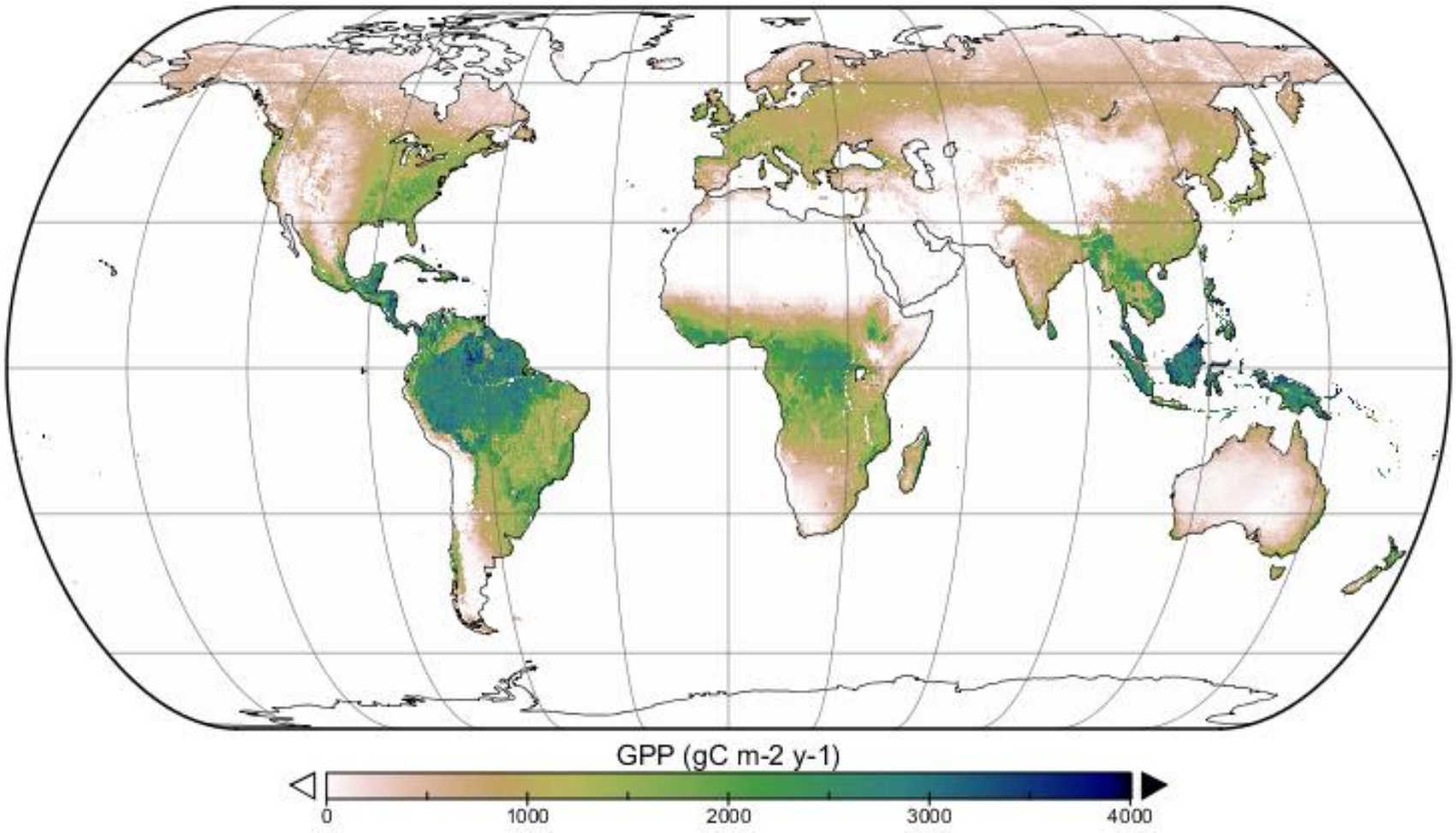
Global estimate

- Global daily meteorological data 2000-2011
  - Daily values of solar radiation, specific humidity and air pressure from Sheffield et al. (2006), (1º)
- MODIS data 2000-2011
  - 8-day/5km (0.05º) MOD42 from Distributed Active Archive Center of NASA→ fPAR, EVI, G_c
- Compared to MOD17 (Zhao and Running 2010) and MPI(Jung et al 2009)

2000–2011 annual average

107 PgCy^{-1}

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



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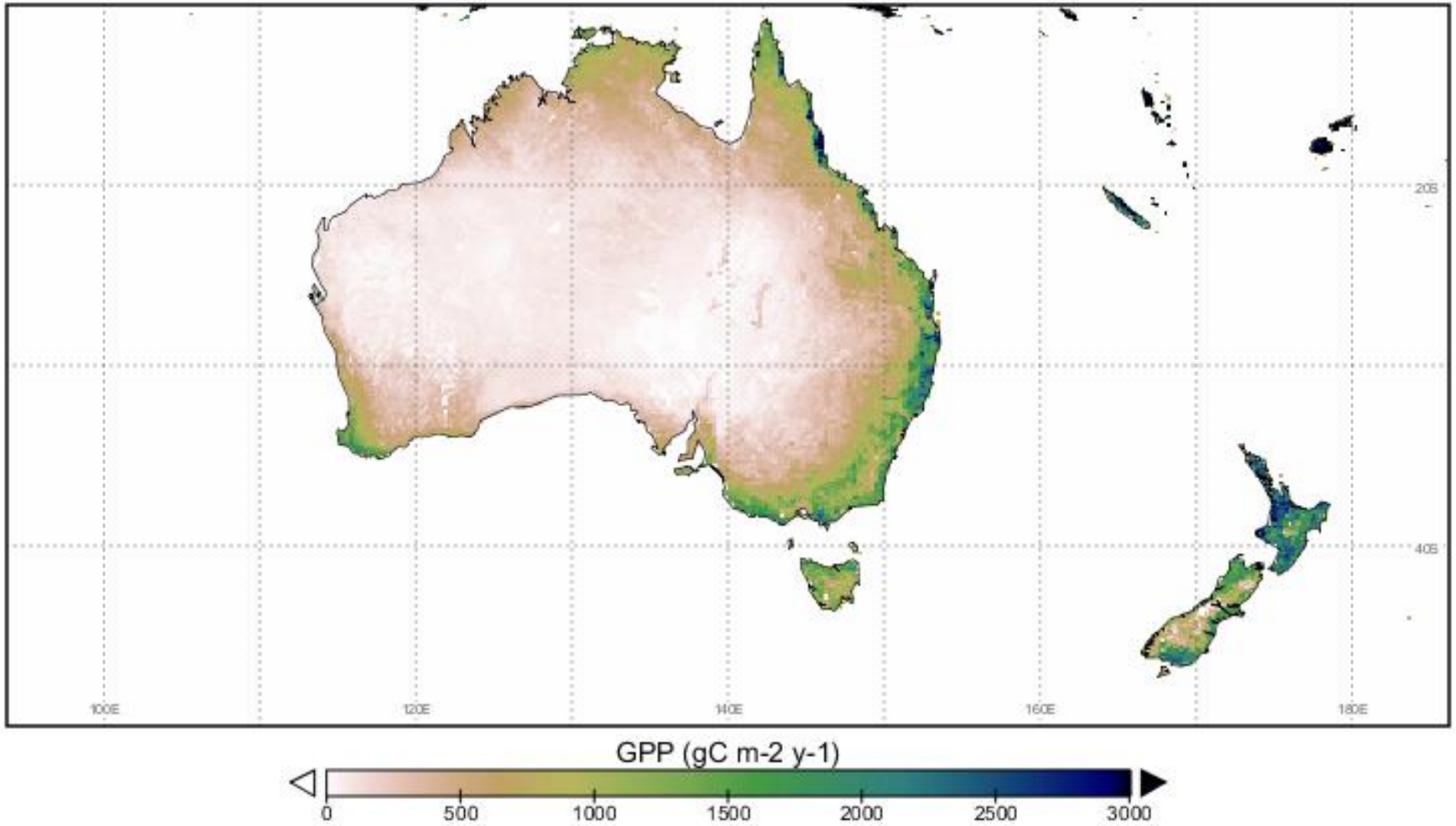
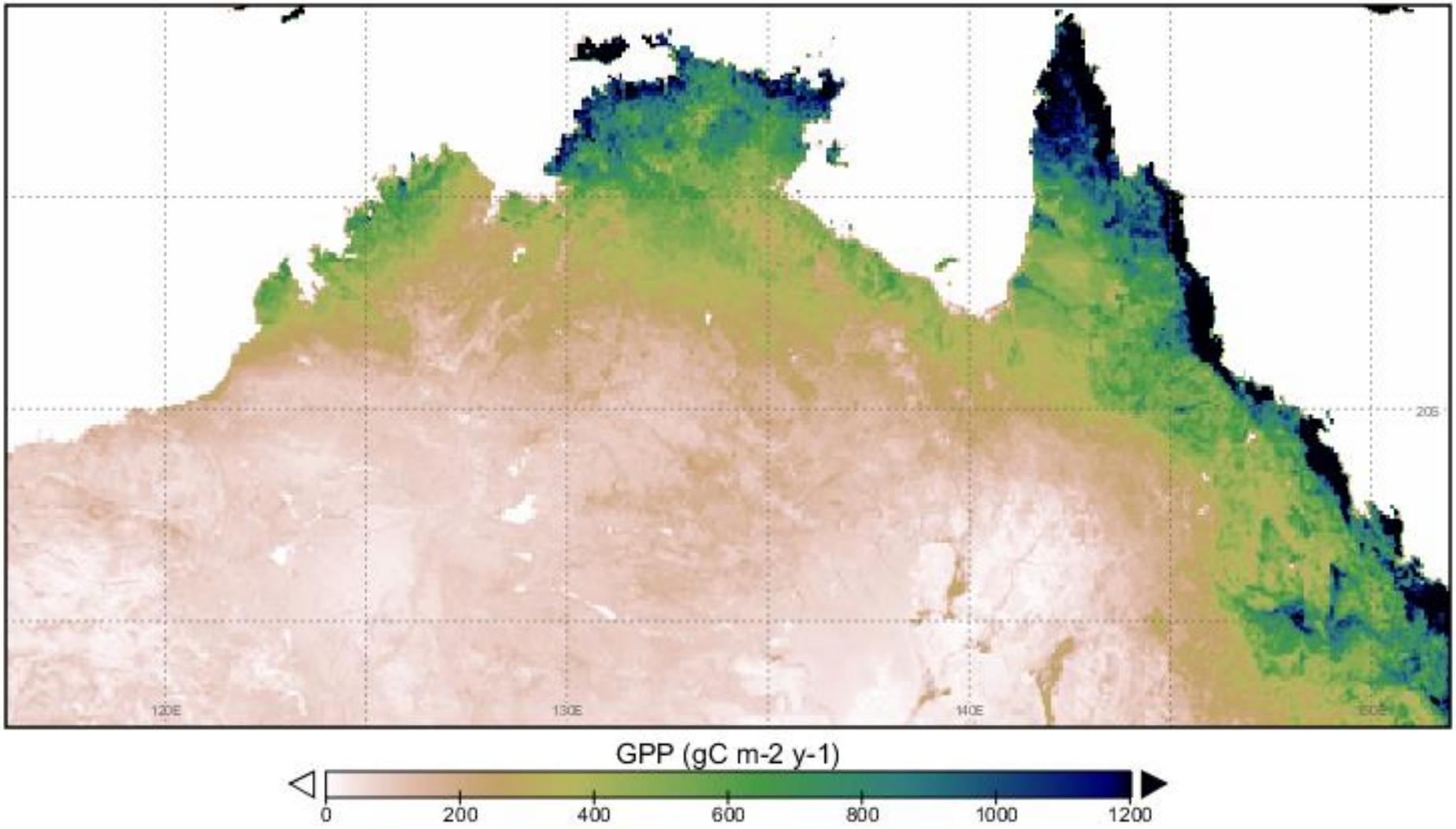
Australian National University

CSIRO

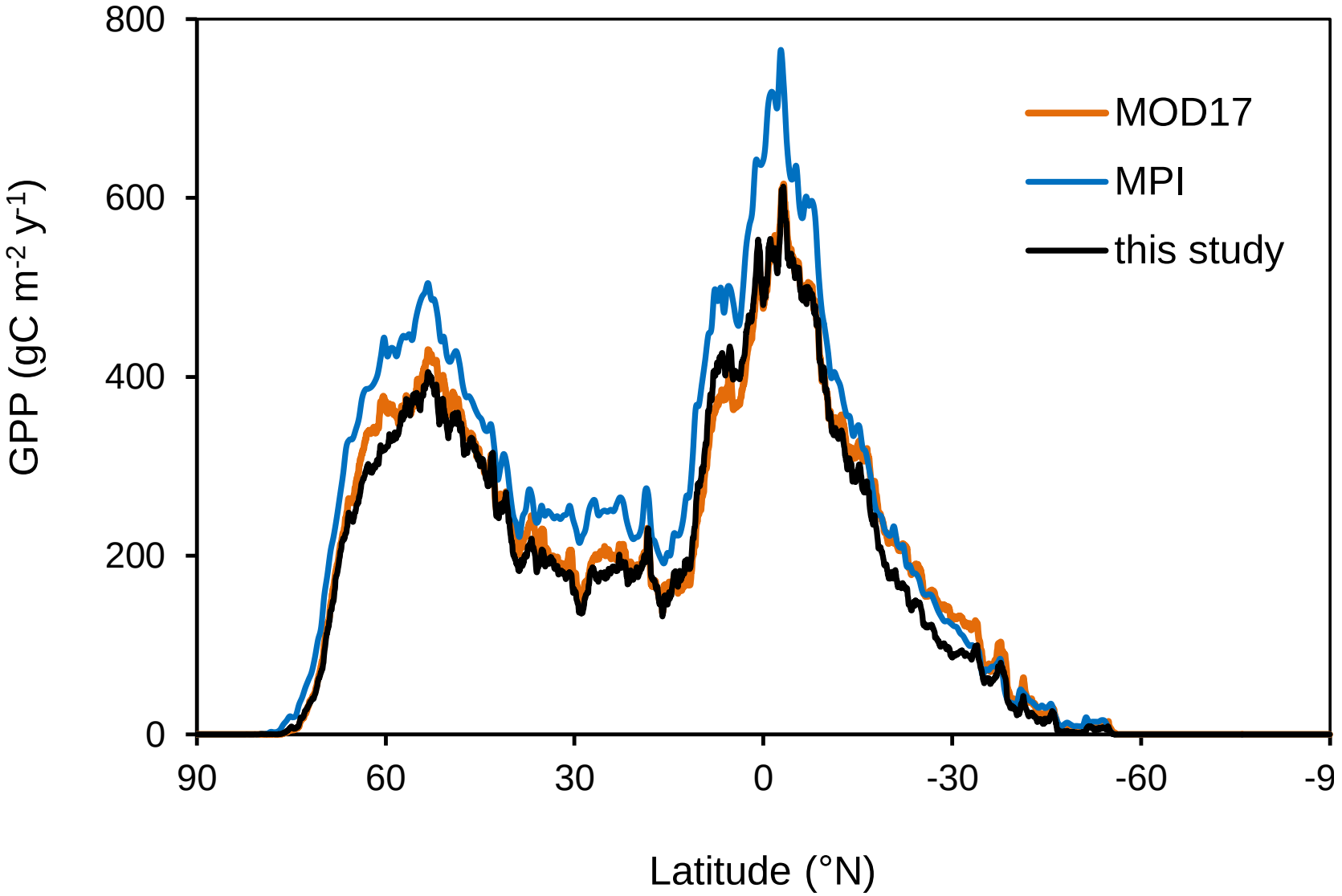
2000–2011 annual average



2000–2011 annual average



GPP per different latitudes



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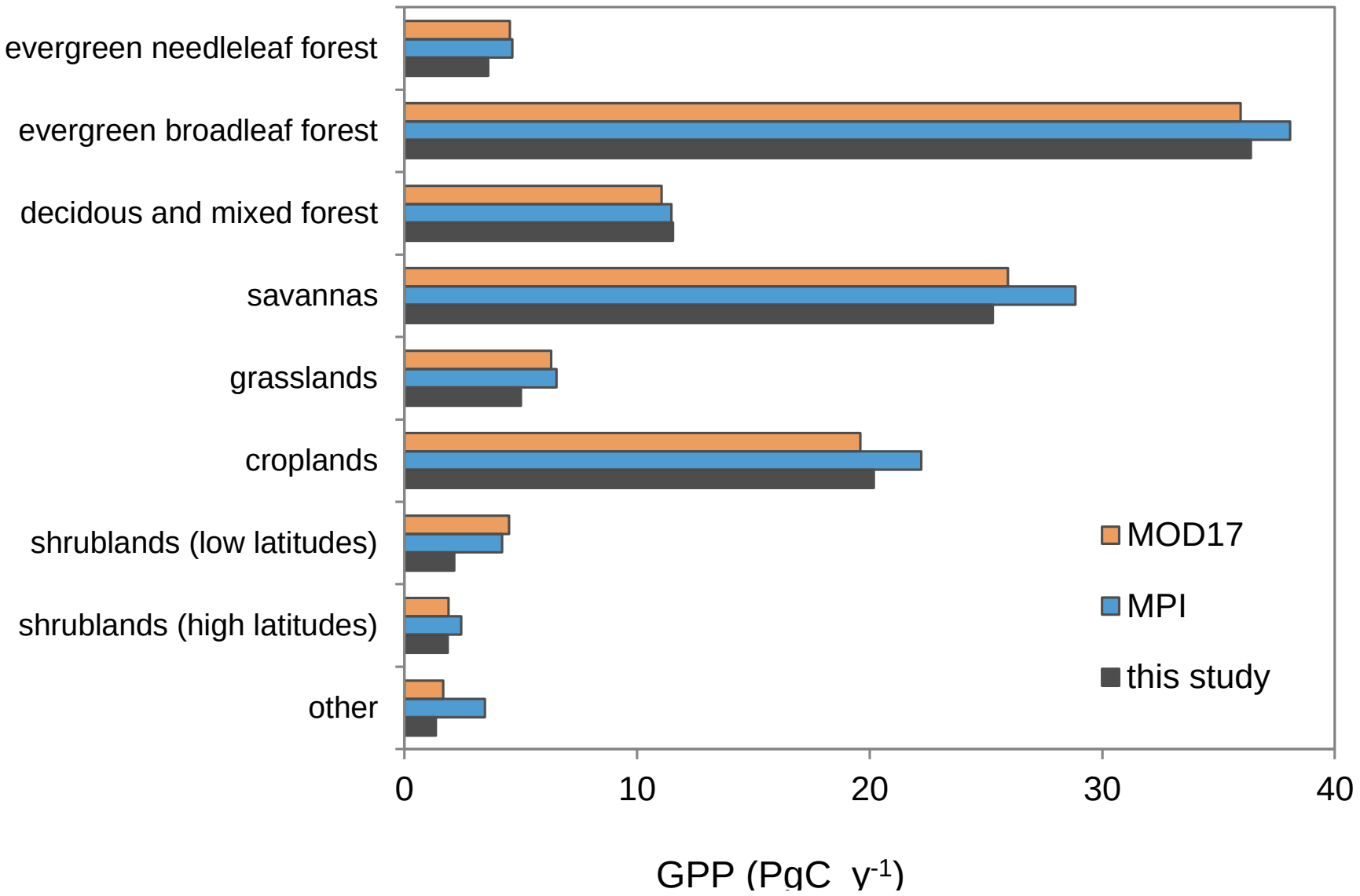
GPP per biome category



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Conclusions and future work

- The spatial and temporal patterns in our GPP estimates compare favourably with other data sets.
- Encouraging result, given
  - the simplicity of our two-parameter model
  - the lack of biome- or land-cover specific parameters
  - the simple but explicit coupling between ET and GPP

- Test model performance fully independently → OZFLUX!!

THANKS!

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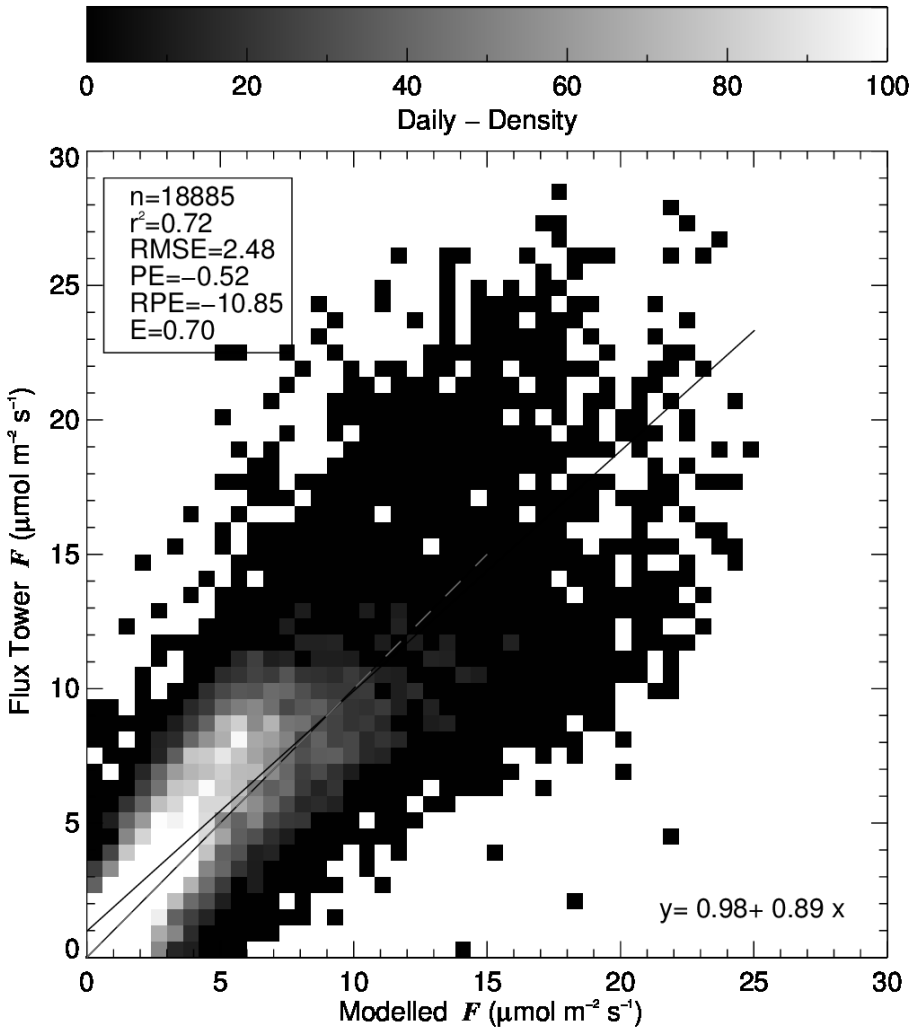
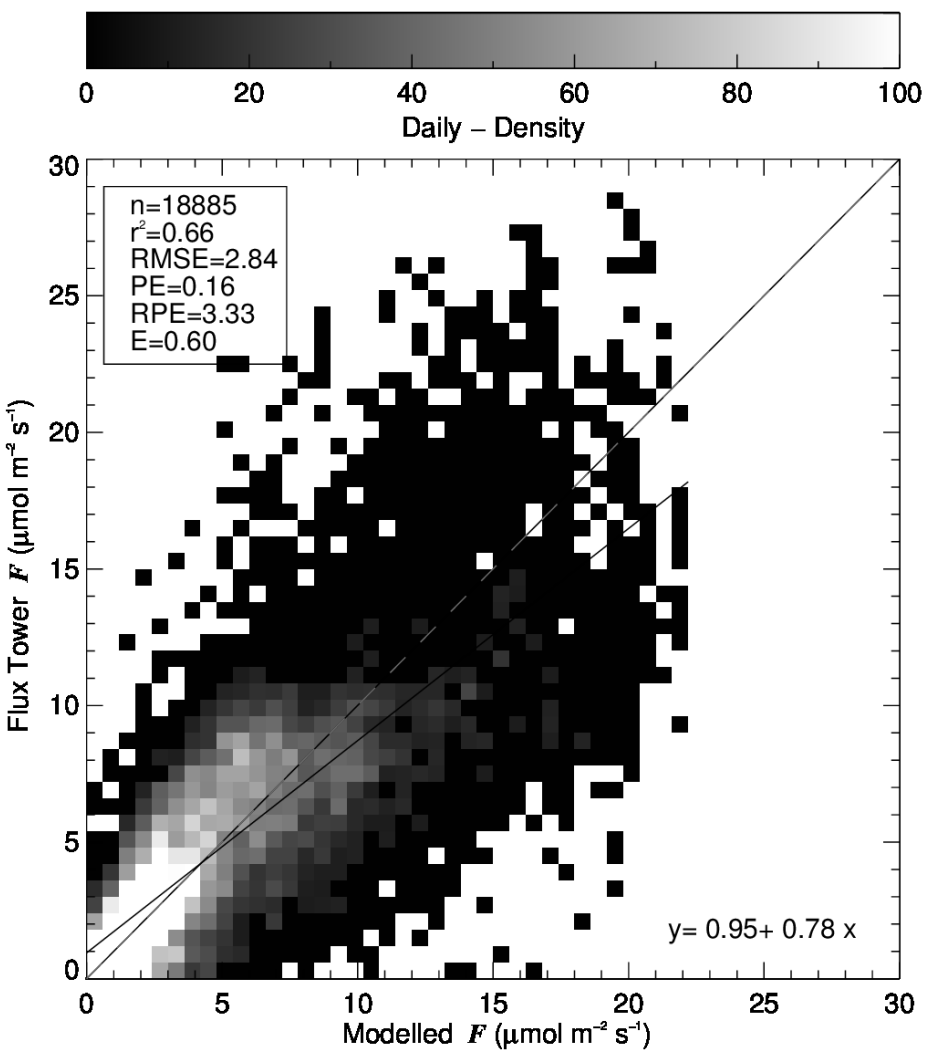
Local vs global inputs

G_c and meteo data from Tower



G_{cRS} and global meteo data



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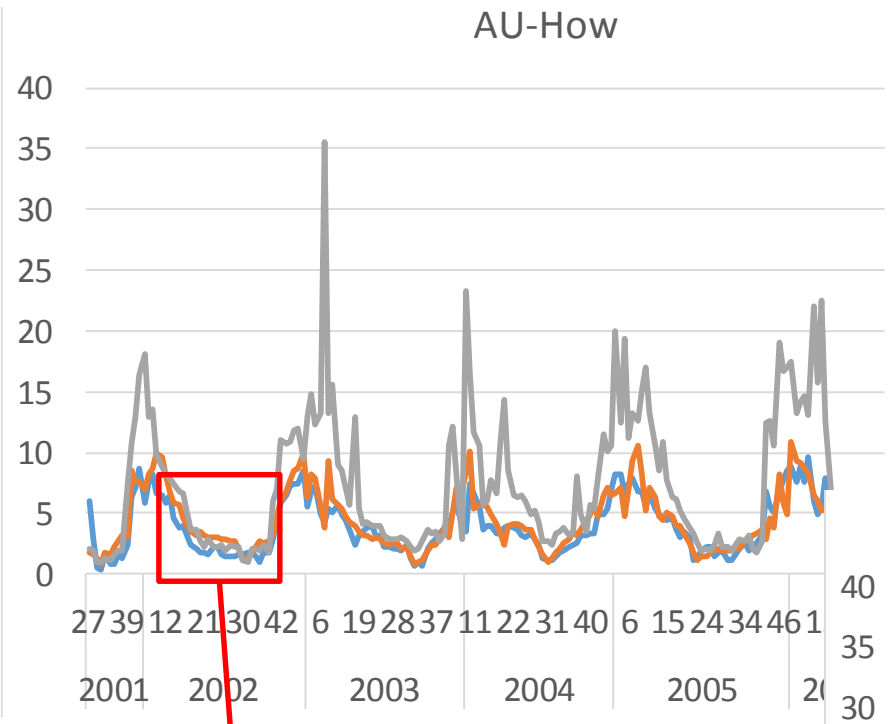
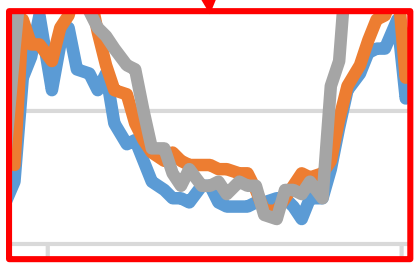
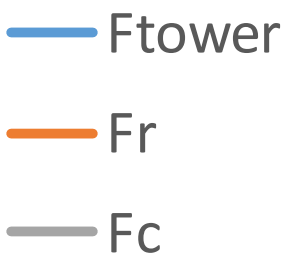
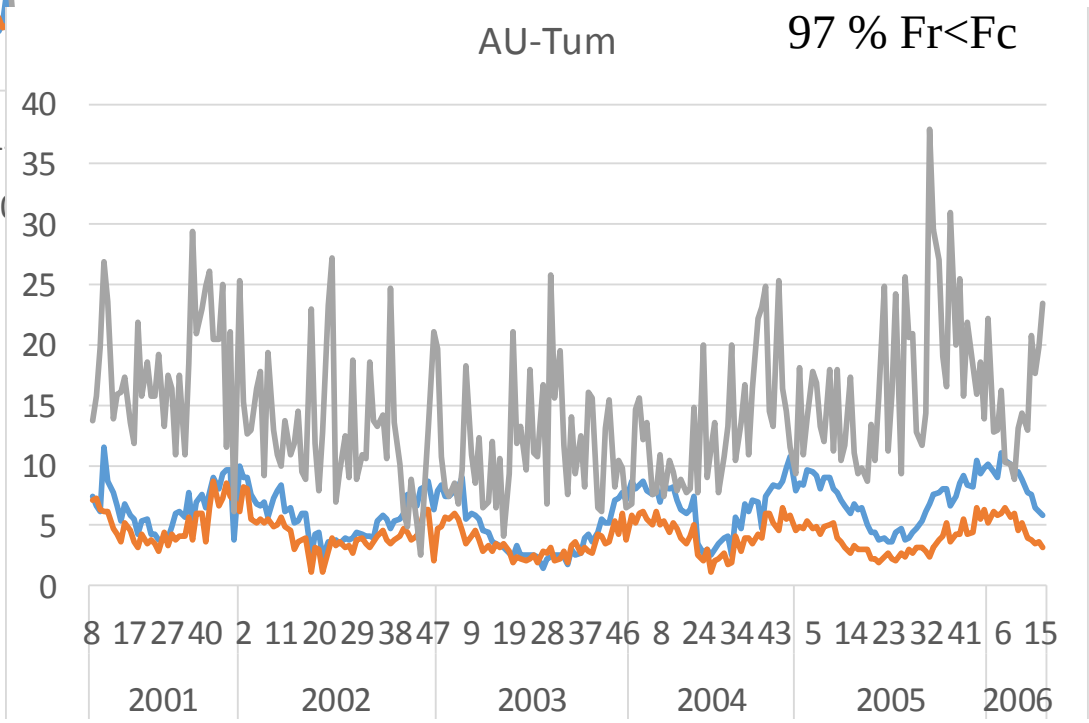


78% Fr<Fc



(R_0=0.76 and ε_{max}=0.045)





97 % Fr<Fc