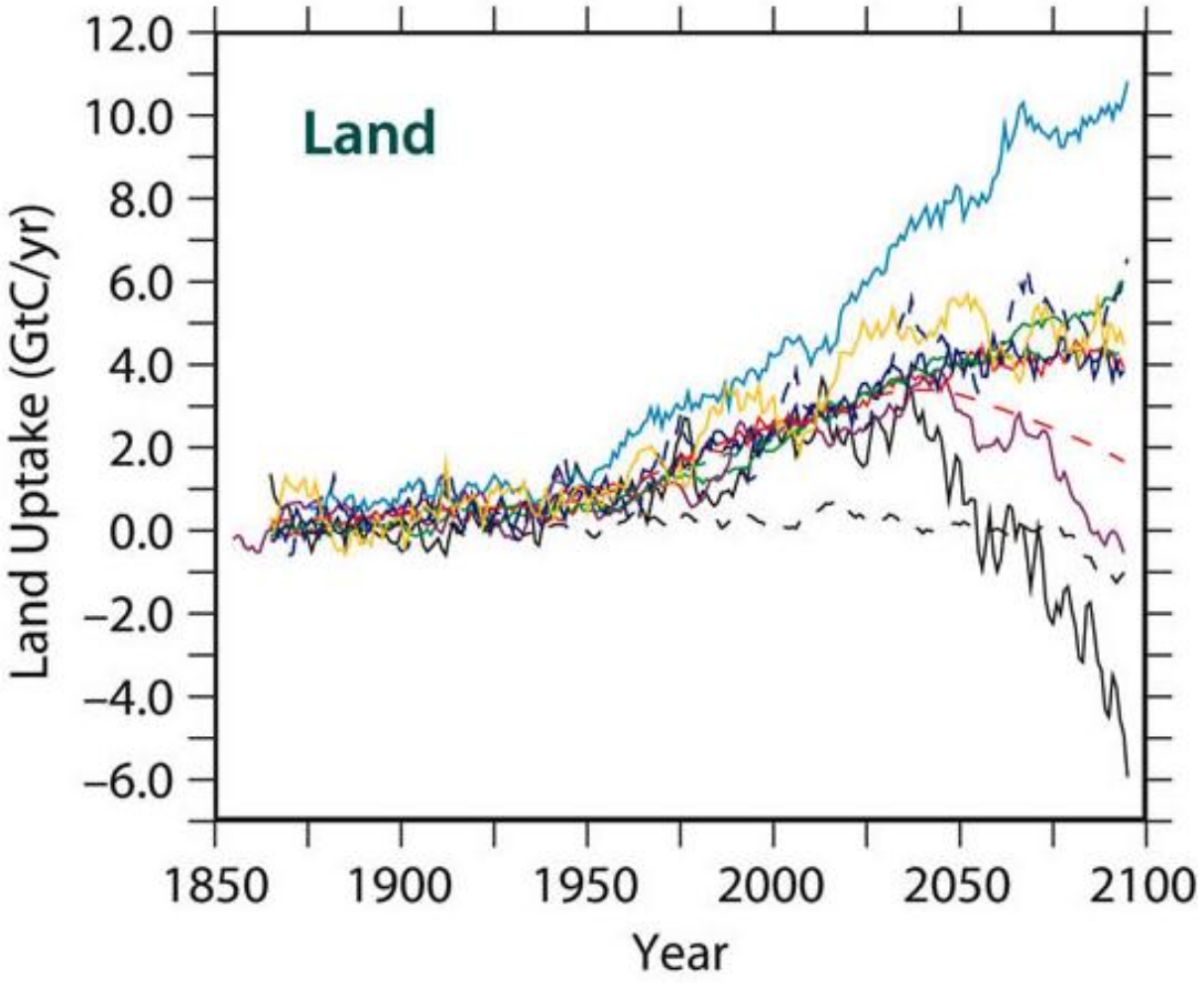
Improved estimates of vegetation carbon cycle components

Thomas Hilker

Forrest Hall

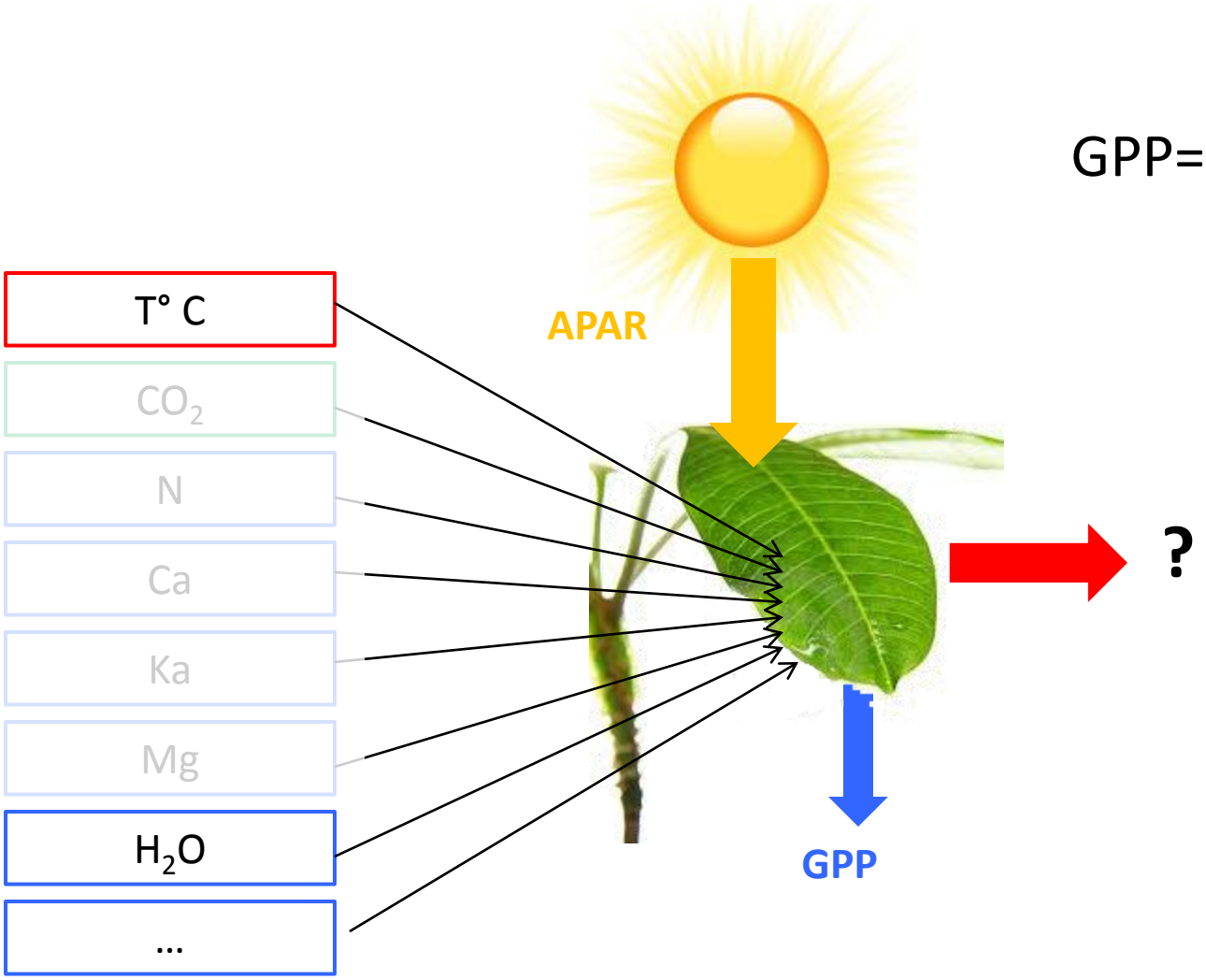
Objective:



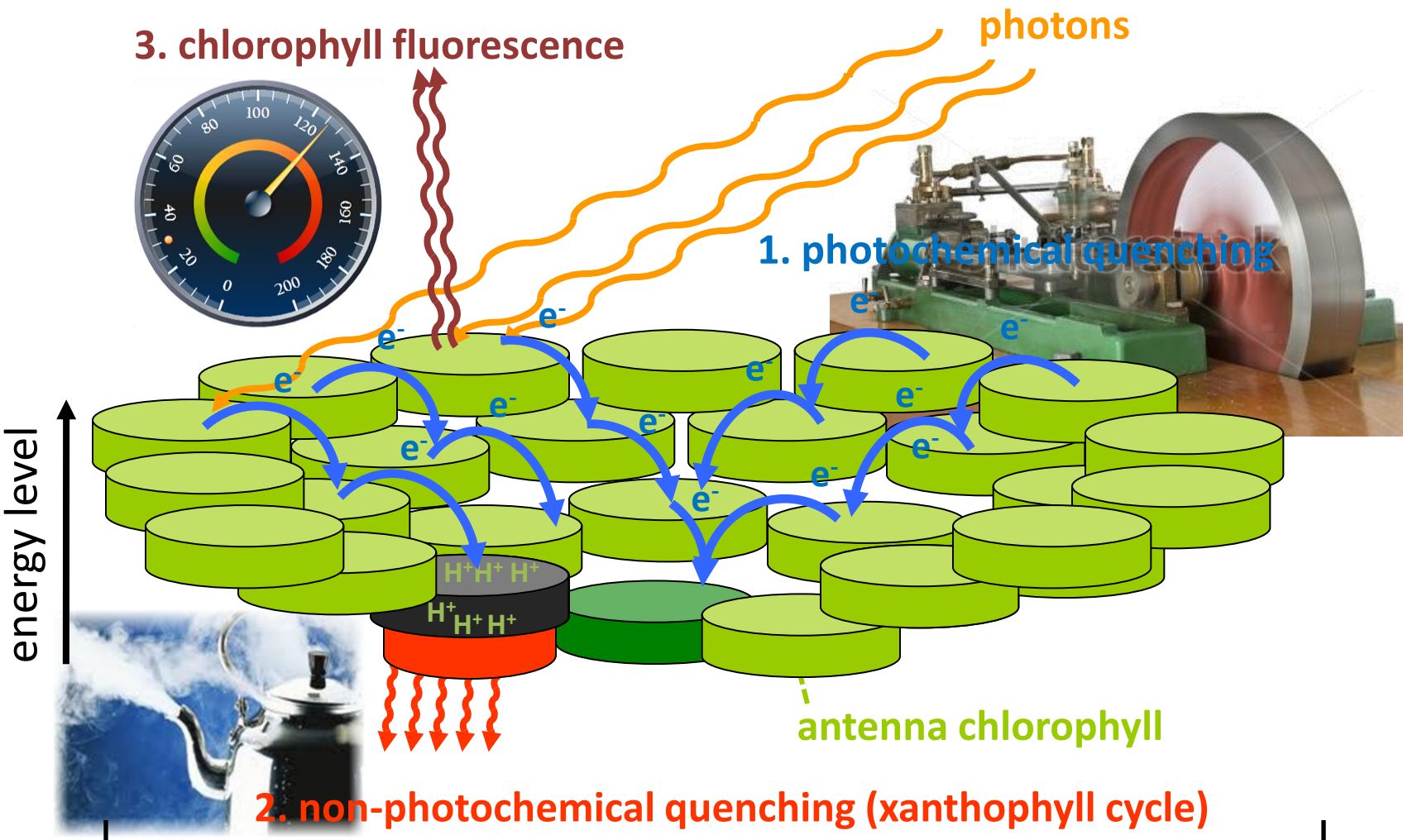
Friedlingstein et al. 2006)

‘Conventional’ GPP model

GPP=APAR*ε



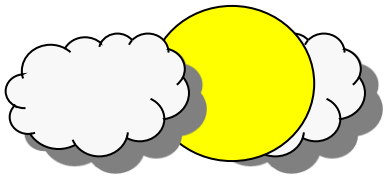
Photosynthetic Energy Pathways

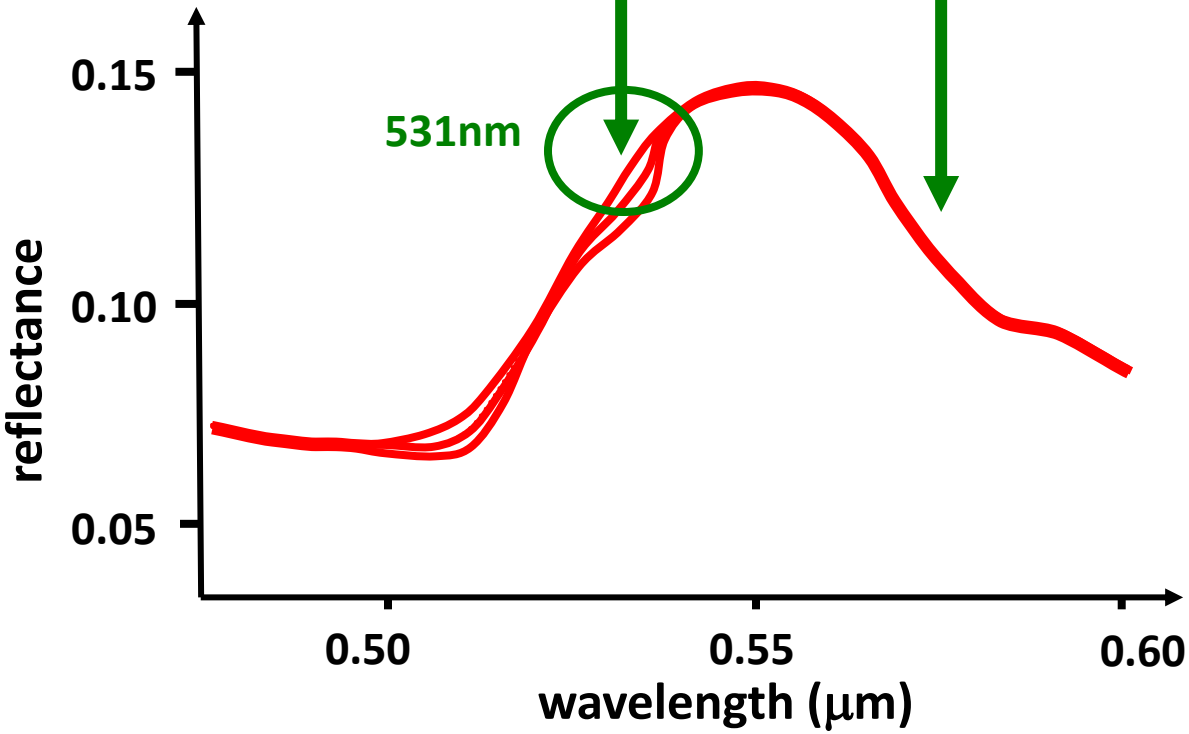


Hilker et al., Science of the Total Environment (2008)

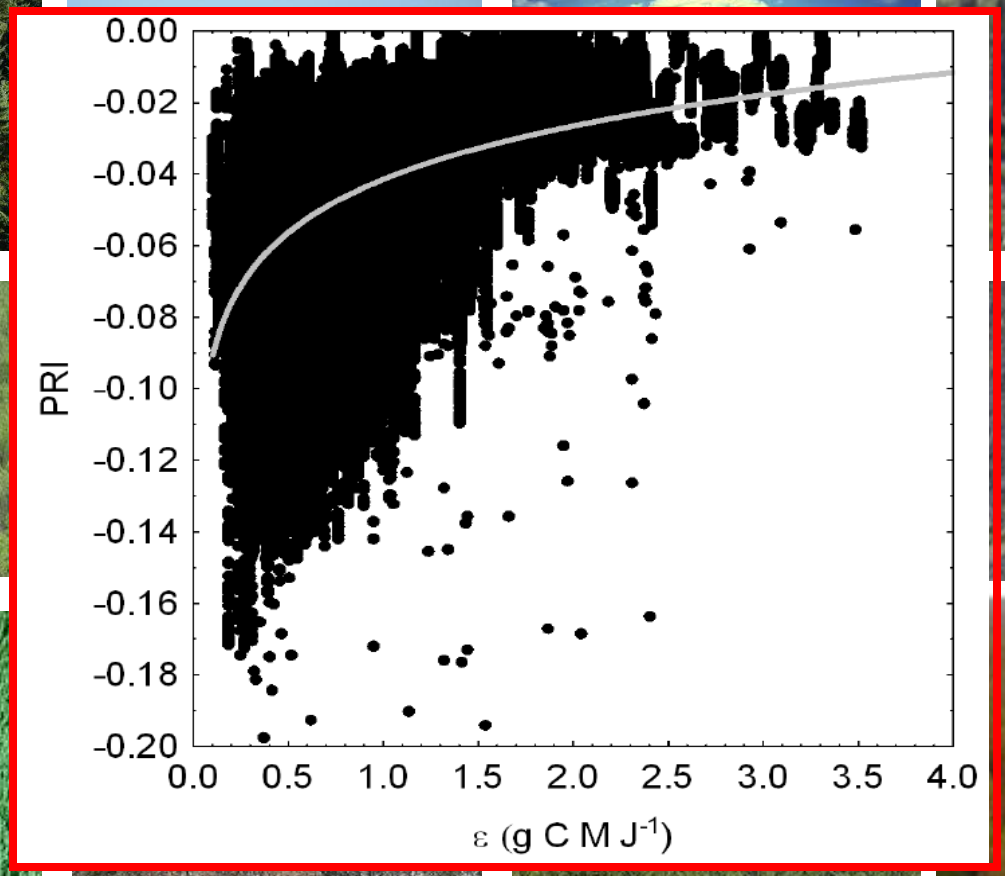
Associated changes in reflectance

$$PRI = \frac{\rho_{570} - \rho_{531}}{\rho_{570} + \rho_{531}}$$

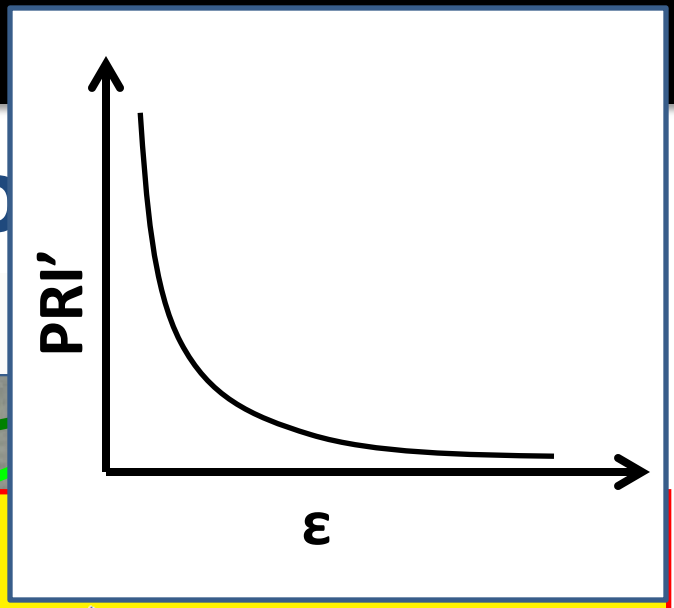




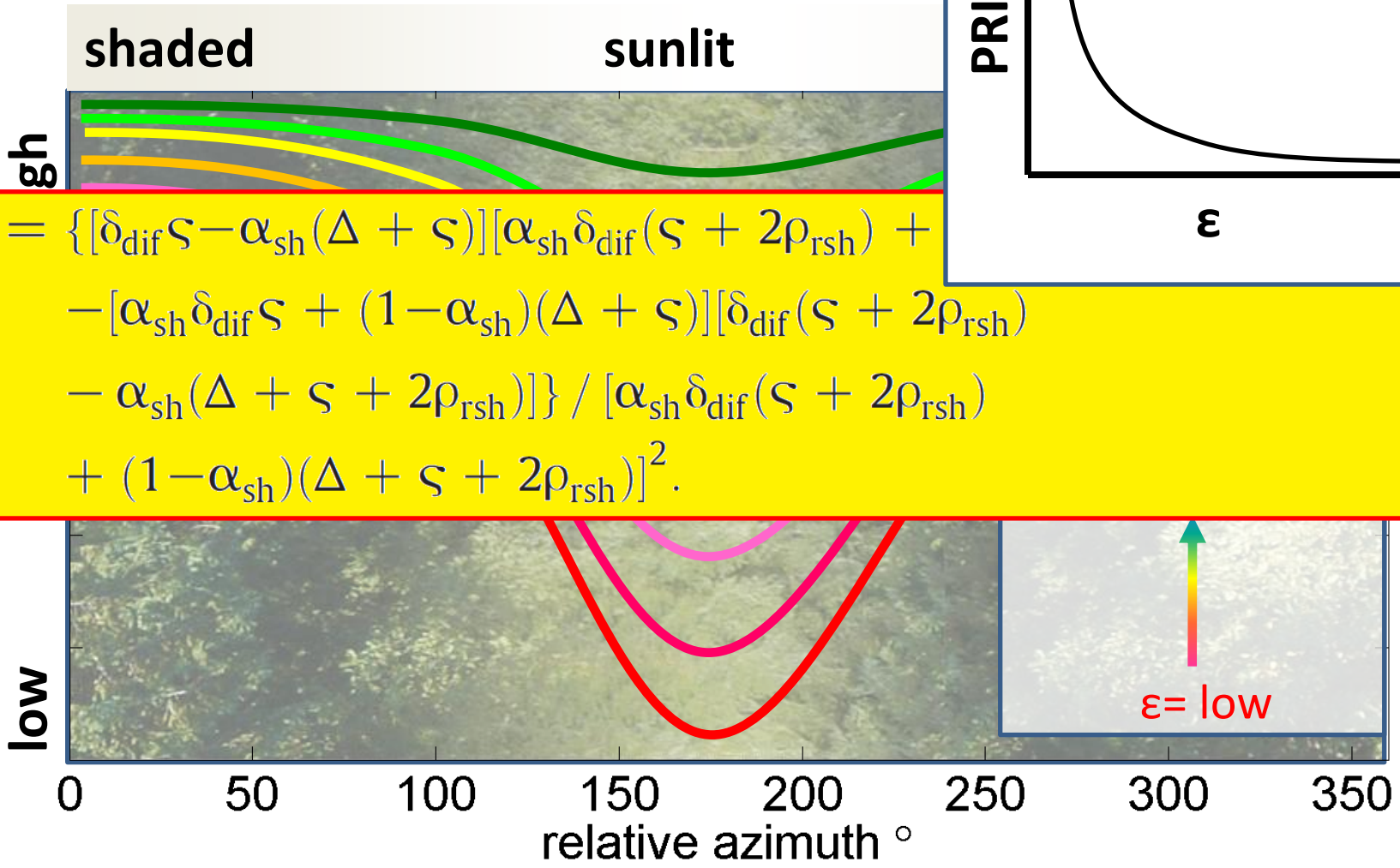
Why multi-angular?



Effects of Function c

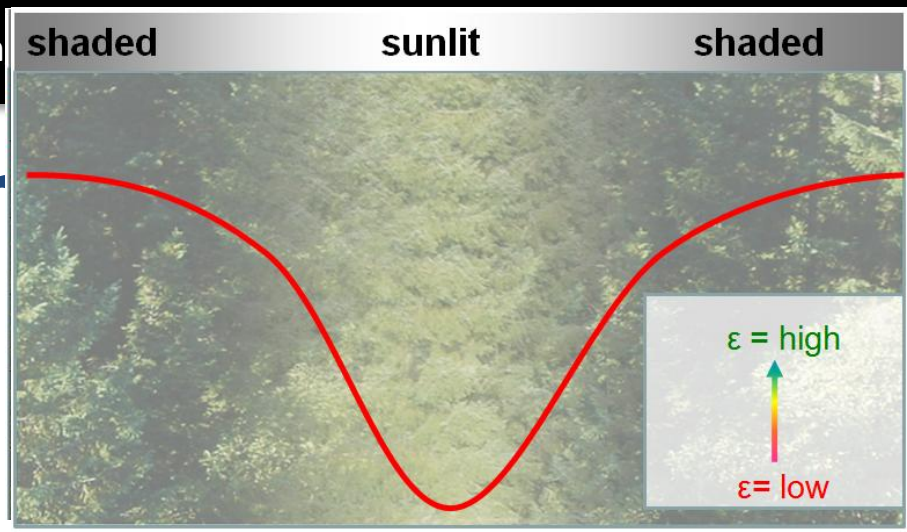


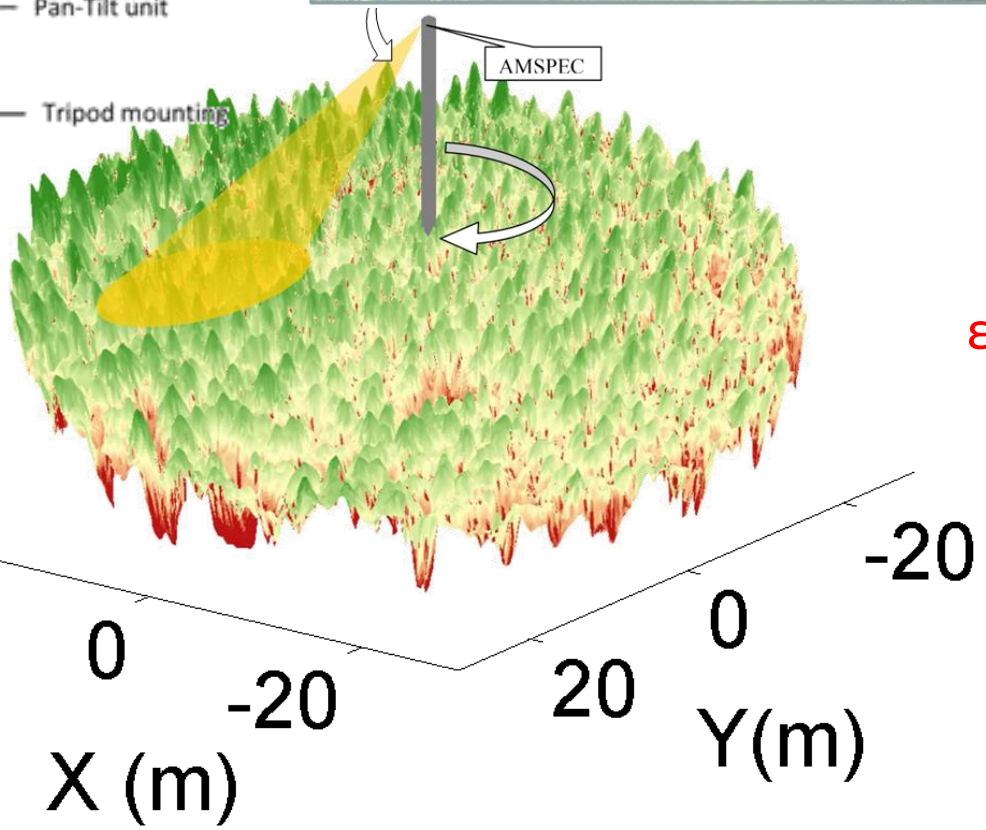
$$PRI' = \{[\delta_{dif}\varsigma - \alpha_{sh}(\Delta + \varsigma)][\alpha_{sh}\delta_{dif}(\varsigma + 2\rho_{rsh}) +$$
$$-[\alpha_{sh}\delta_{dif}\varsigma + (1-\alpha_{sh})(\Delta + \varsigma)][\delta_{dif}(\varsigma + 2\rho_{rsh})$$
$$-\alpha_{sh}(\Delta + \varsigma + 2\rho_{rsh})]\} / [\alpha_{sh}\delta_{dif}(\varsigma + 2\rho_{rsh})$$
$$+ (1-\alpha_{sh})(\Delta + \varsigma + 2\rho_{rsh})]^2.$$



Hall et al. Rem. Sens. Environ. (2008,2012)

Multi-angle Rer

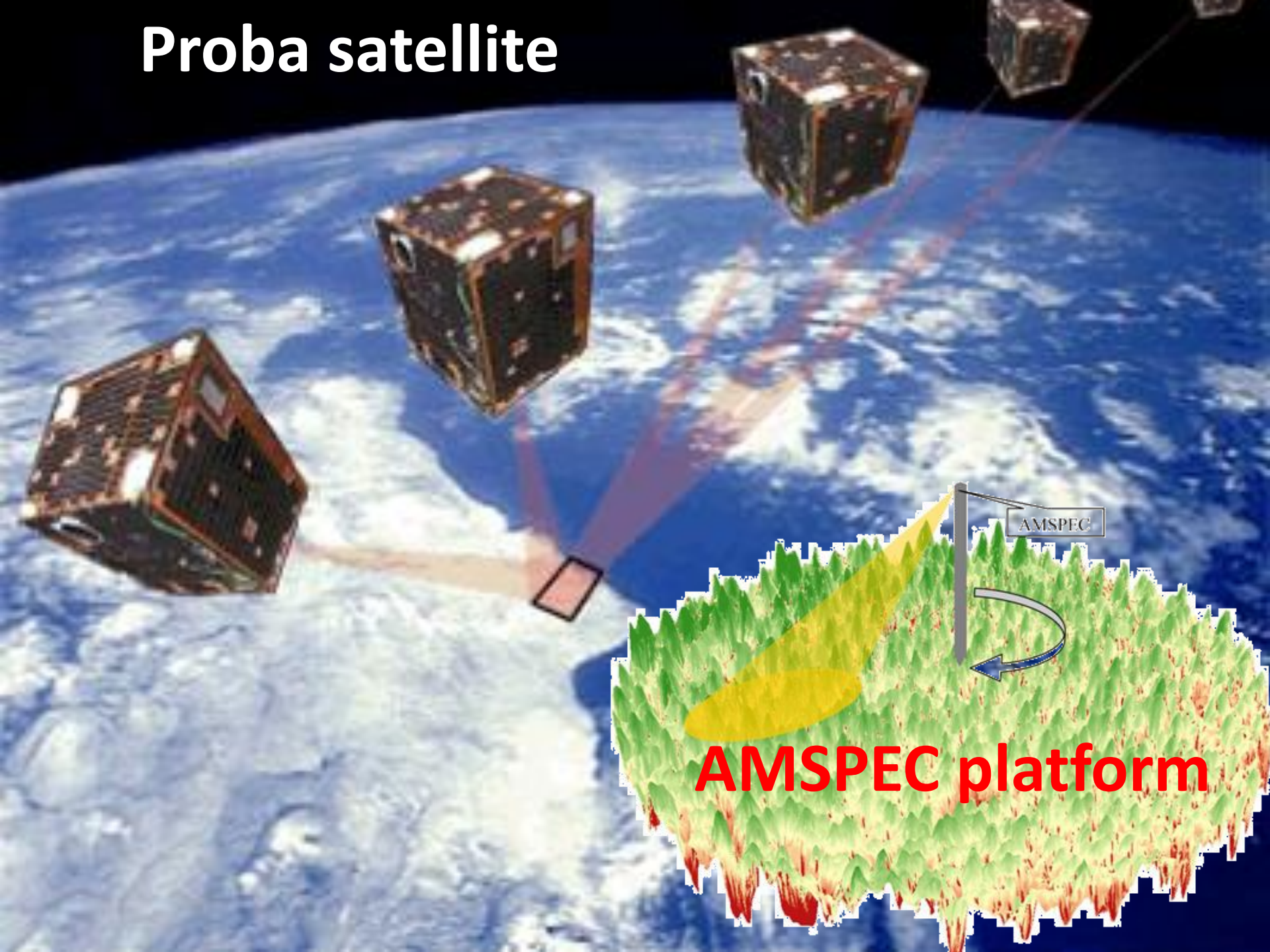




ε= low

Hilker et al., Remote Sensing of Environment (2010)

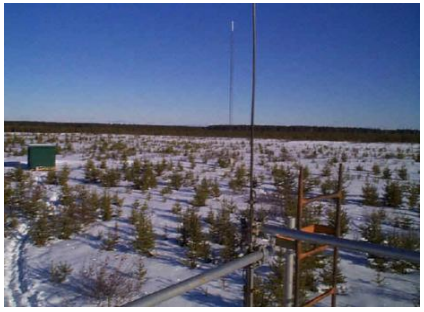
Proba satellite



Sites





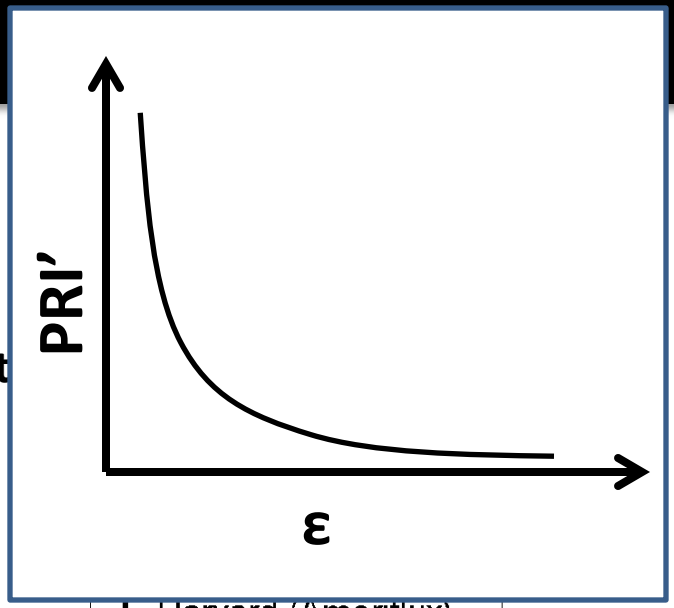





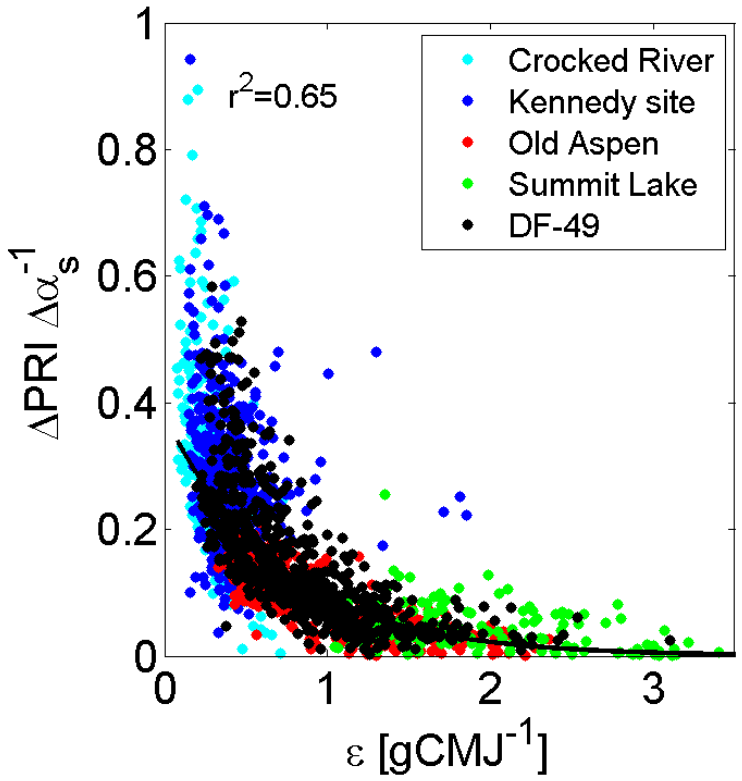


Hilker et al. JGR (2011)

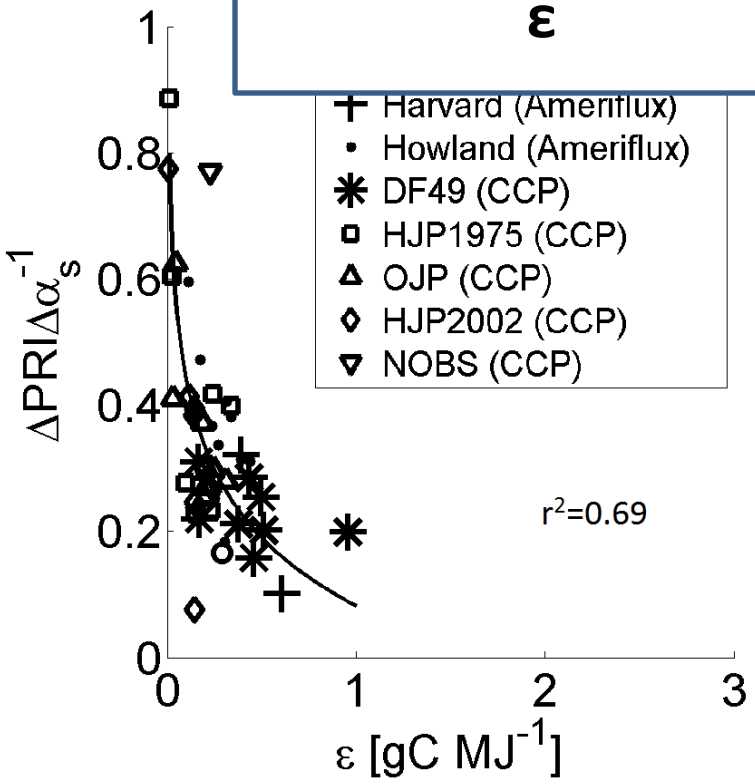
Results



Stand level (AMSPEC)



Satellit



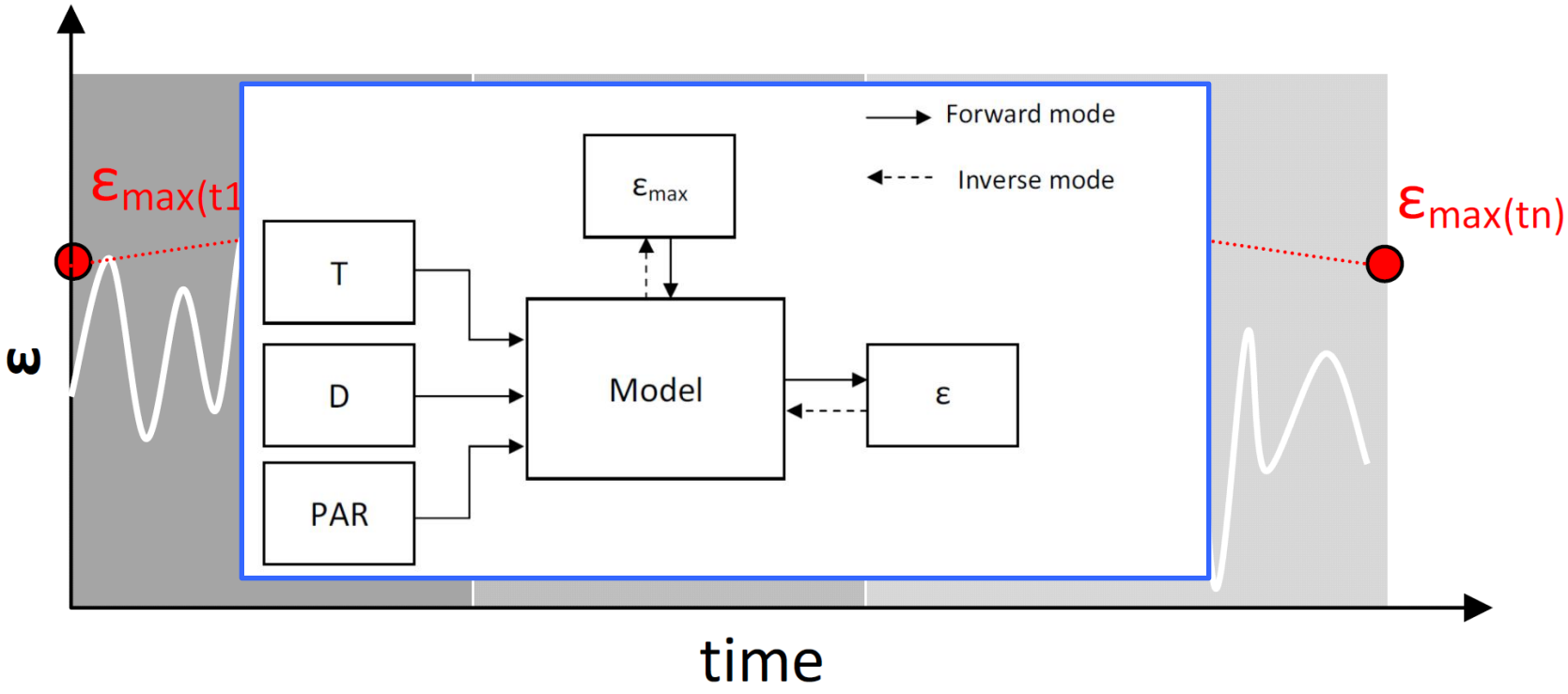
Hilker et al. JGR (2011), Ag and For Met(in review)

How do we use this information to improve our models?

- Temporally discrete
- Spatially discrete

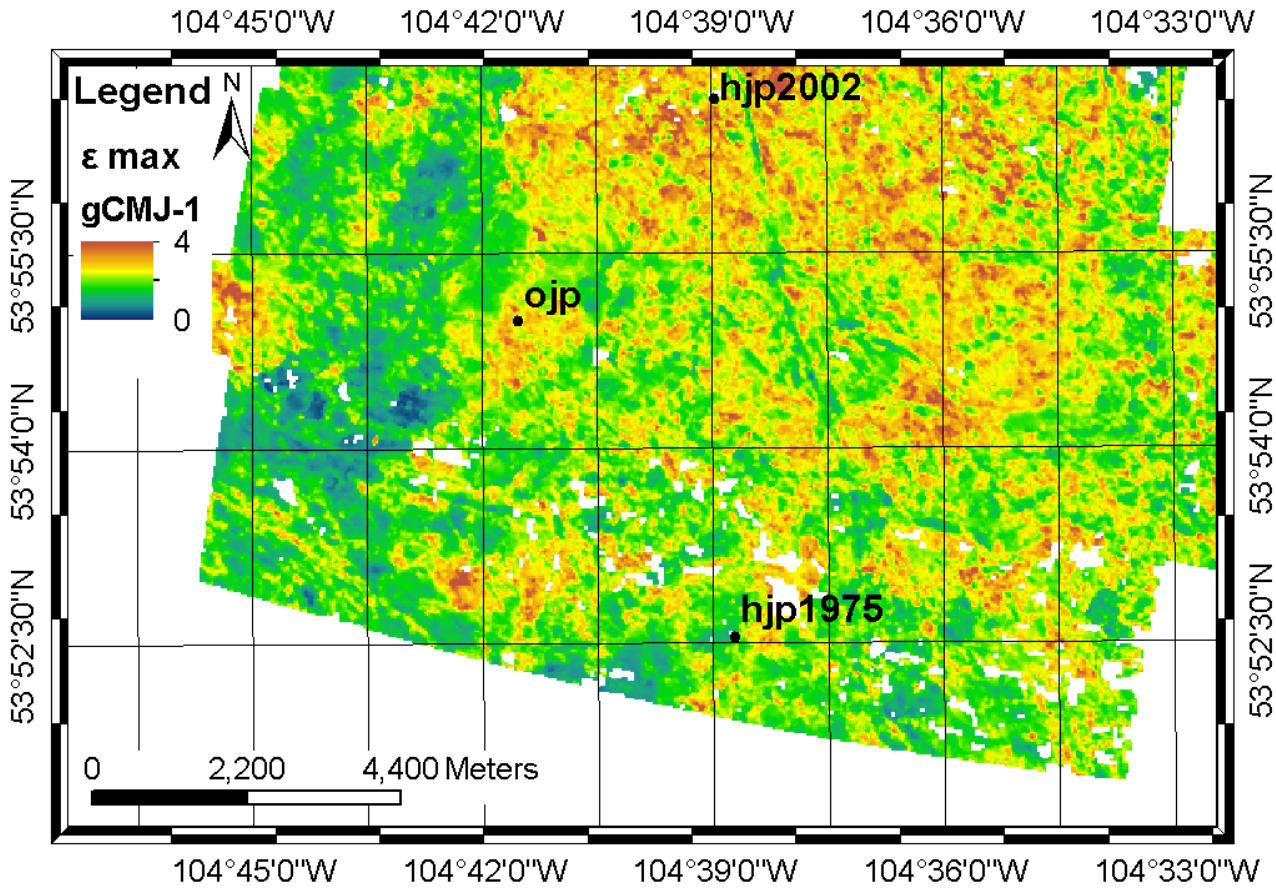
Temporal Scaling of GPP

Data assimilation



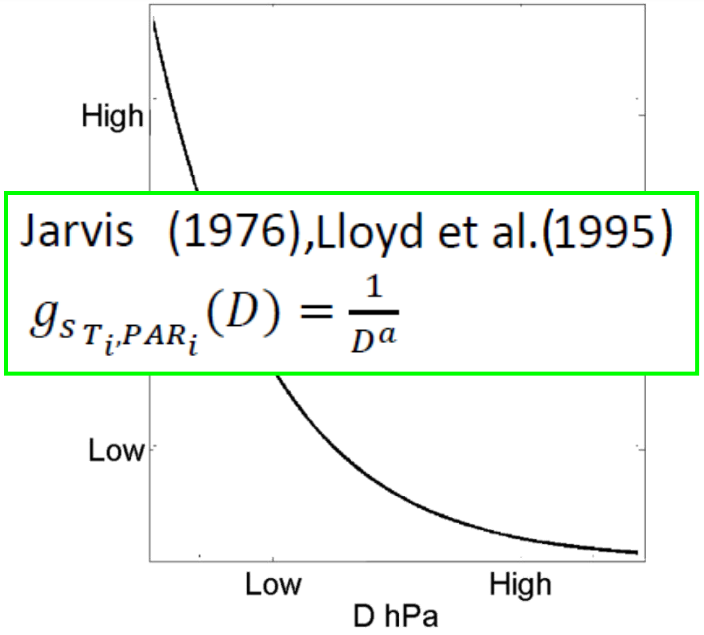
Hall et al., Rem. Sens. Environ. (2012)

Temporally discrete ε_{opt}



Hilker et al. RSE (2012)

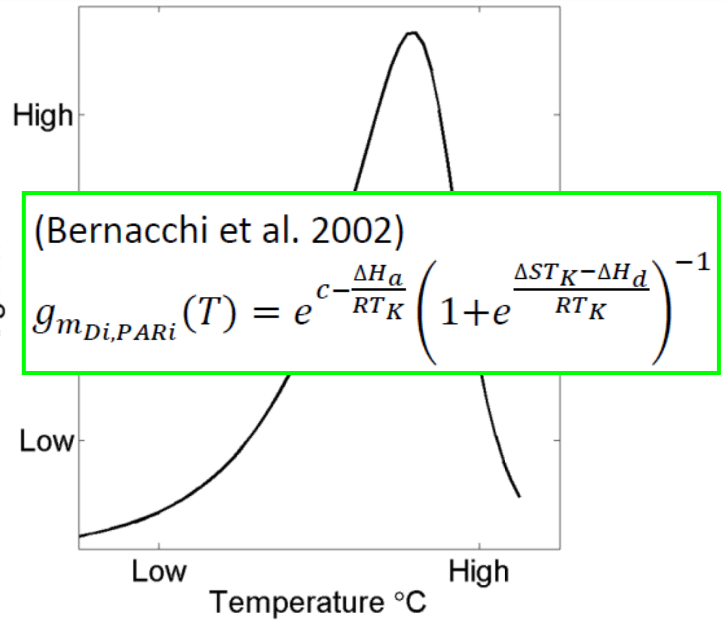
Response functions



Jarvis (1976),Lloyd et al.(1995)

$$g_{s_{T_i,PAR_i}}(D) = \frac{1}{D^a}$$

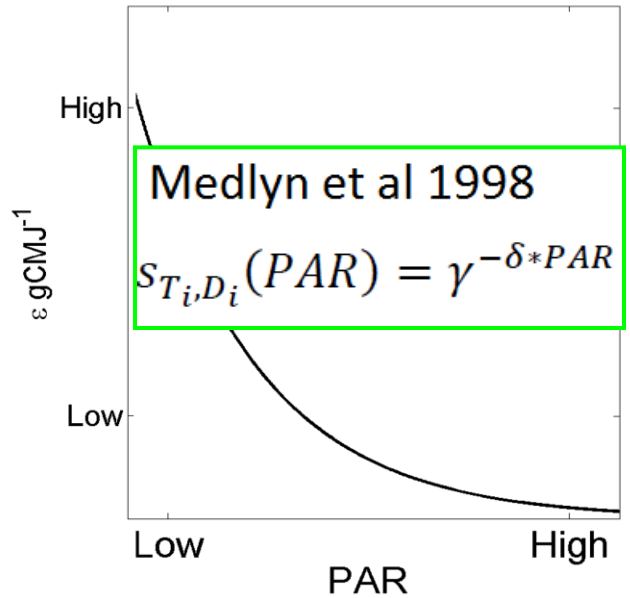
C



(Bernacchi et al. 2002)

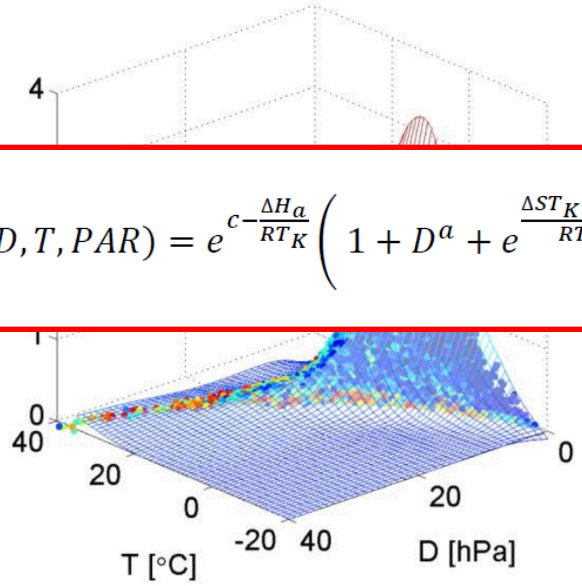
$$g_{m_{Di,PARi}}(T) = e^{c-\frac{\Delta H_a}{RT_K}}\left(1+e^{\frac{\Delta ST_K-\Delta H_d}{RT_K}}\right)^{-1}$$

D



Medlyn et al 1998

$$s_{T_i,D_i}(PAR) = \gamma^{-\delta * PAR}$$

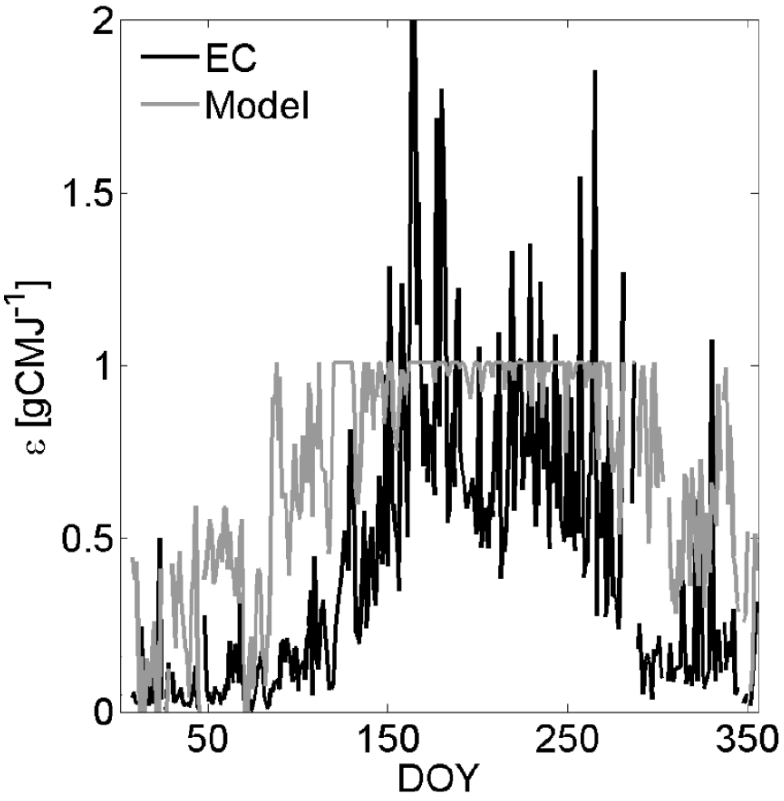


$$f(D,T,PAR) = e^{c-\frac{\Delta H_a}{RT_K}}\left(1+D^a+e^{\frac{\Delta ST_K-\Delta H_d}{RT_K}}\right)^{-1}\gamma^{-\delta * PAR}$$

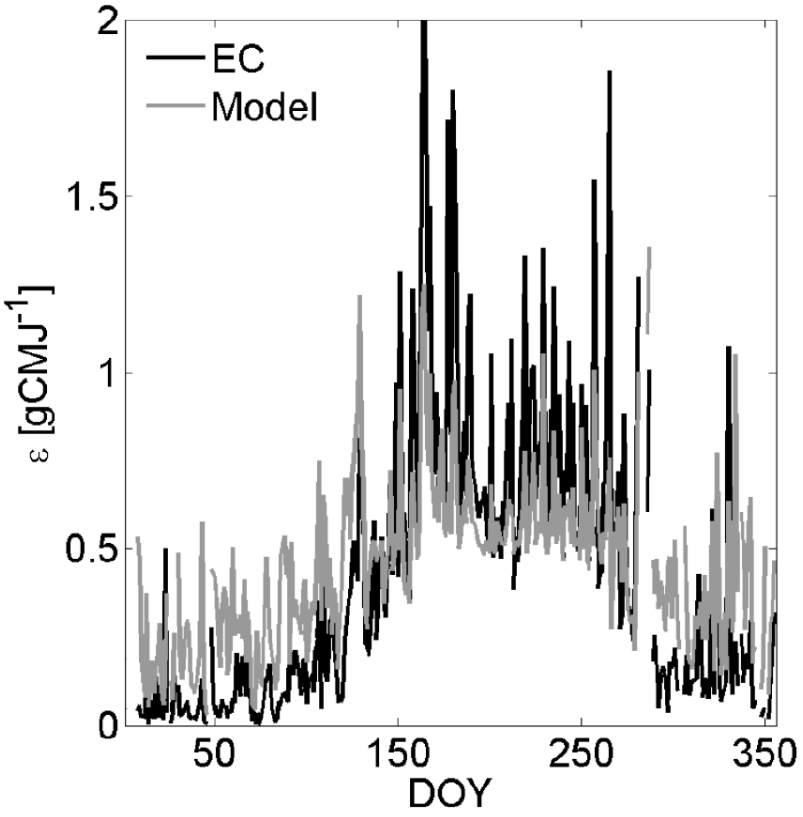
Hall et al. RSE (2012)

Model comparison: GPP

MODIS GPP model:
Tower f_{PAR}, PAR, MODIS ε

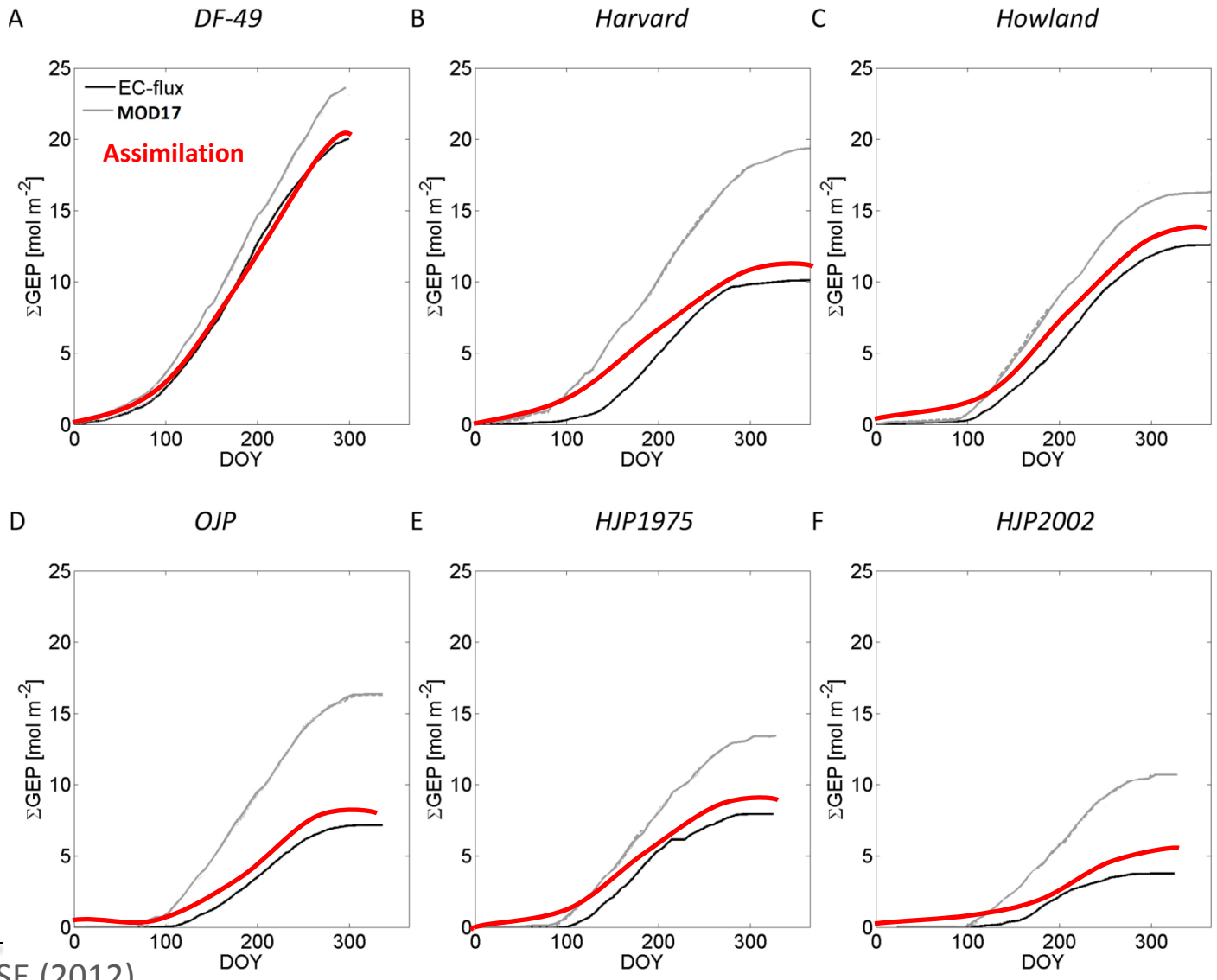


Data assimilation model:
Tower f_{PAR}, PAR, assimilated ε



Hilker et al. RSE (2012)

Comparing Results



Hilker et al. RSE (2012)

Energy balance

H	λE
$H = \frac{\rho c_p (T_c - T_A)}{r_a}$	$\lambda E = \frac{\rho c_p \partial_e}{\gamma (r_c + r_a)}$

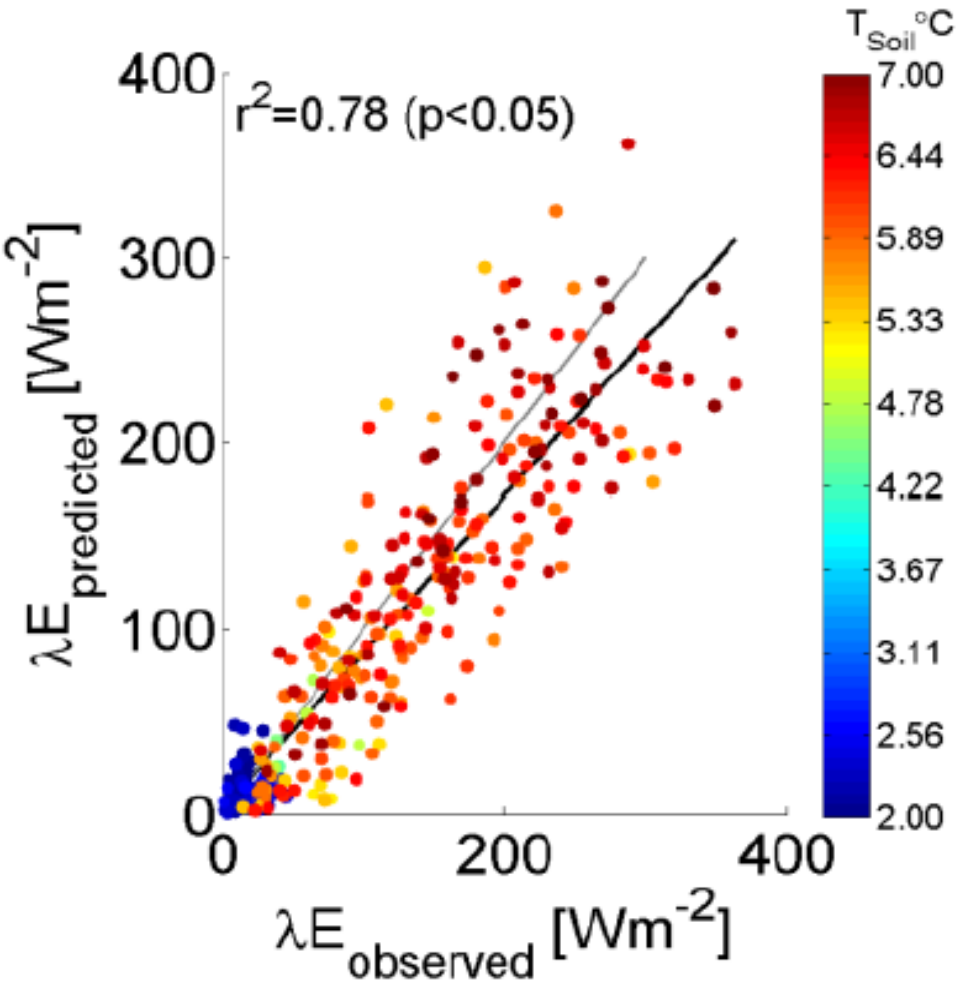
Energy balance

- Stomatal conductance is linked to GPP (A)

$$g_s = m\frac{Ah_s}{c_s} + b$$

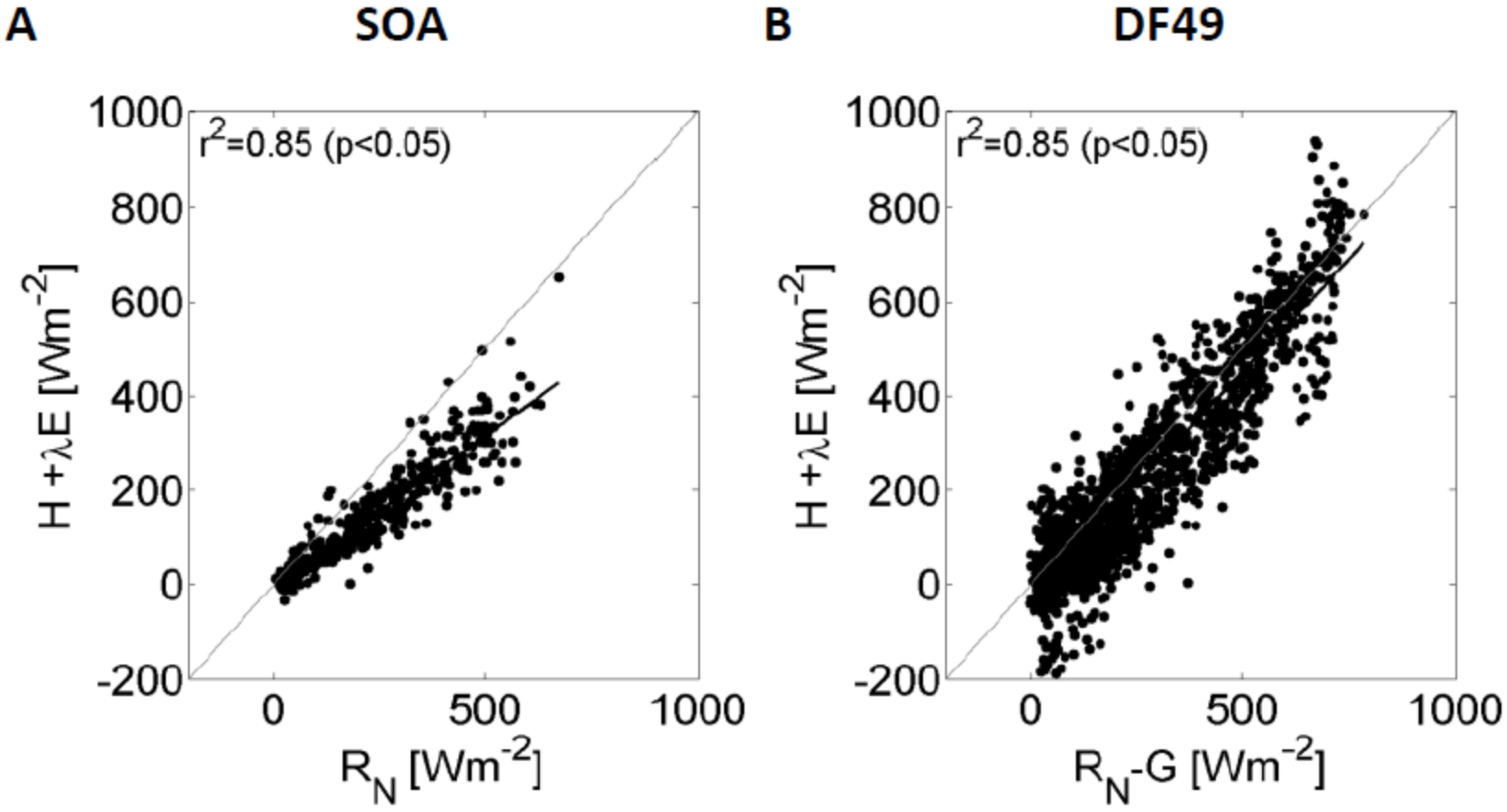
(Ball Berry Collatz relationship)

Latent heat flux



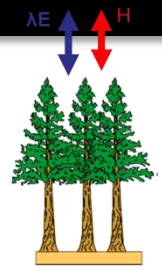
Hilker et al. GBC (in review)

Energy Balance: λE+H

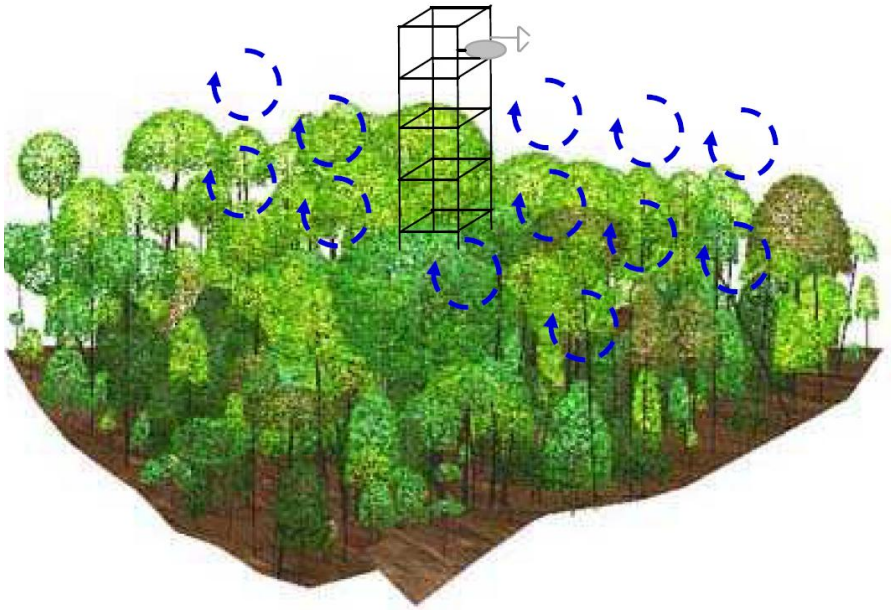


Hilker et al. GBC (in review)

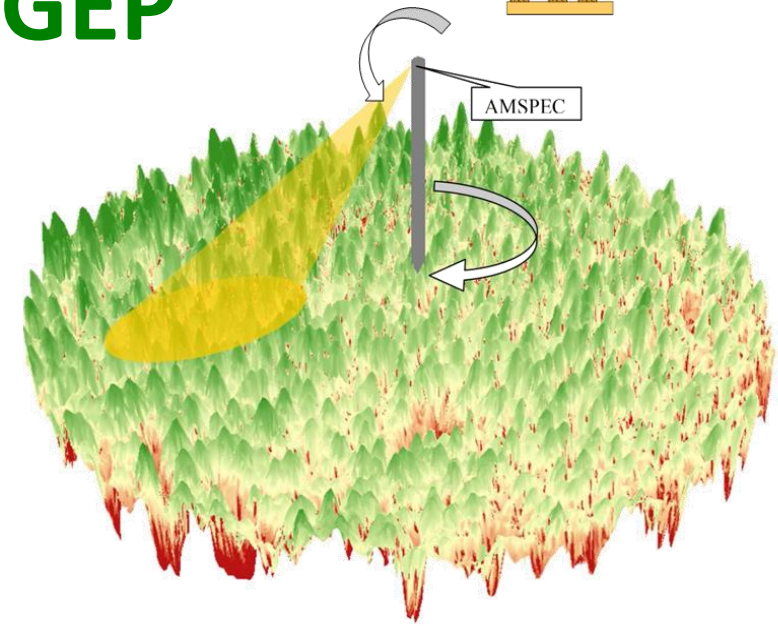
Respiration



NEP



GEP

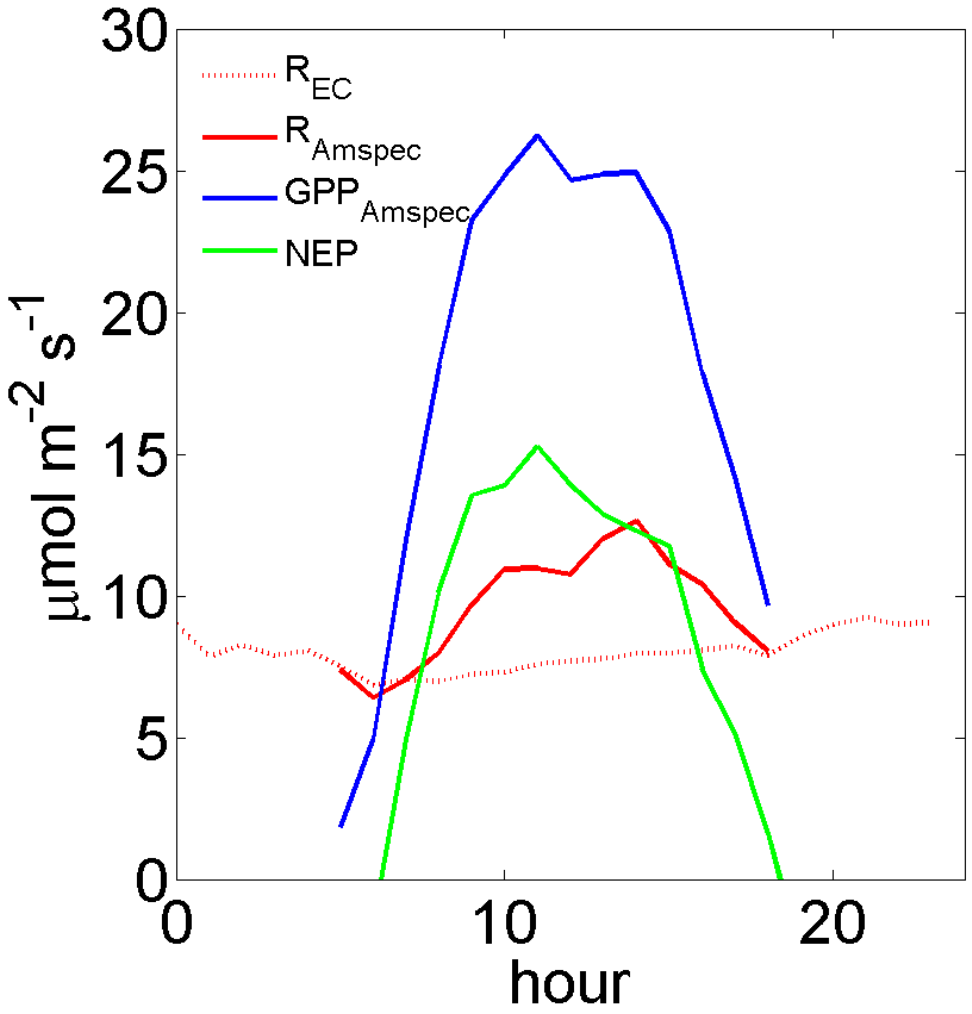


→ GEP=NEP-R

We can determine R independently of T_{Soil}

Hilker et al. Ag and For Met (2012)

Diurnal variability of R



Hilker et al. Ag and For Met (2012)

Conclusions

- This is the first time we can directly infer ε from satellites
- Combined with fluorescence: Onboard validation, two independent measurements!
- This allows us to revisit
  - Respiration independently of T_{Soil}
  - Energy balance
- Method could revolutionize monitoring of terrestrial GPP using data assimilation

Thank you!!
For your attention!
Questions?

Thomas Hilker
Assistant Professor
College of Forestry | Oregon State University
231 Peavy Hall | Corvallis, OR 97331
☎ **541.737.2608** | **301.326.3743** | FAX **541.737.4316**
thomas.hilker@oregonstate.edu