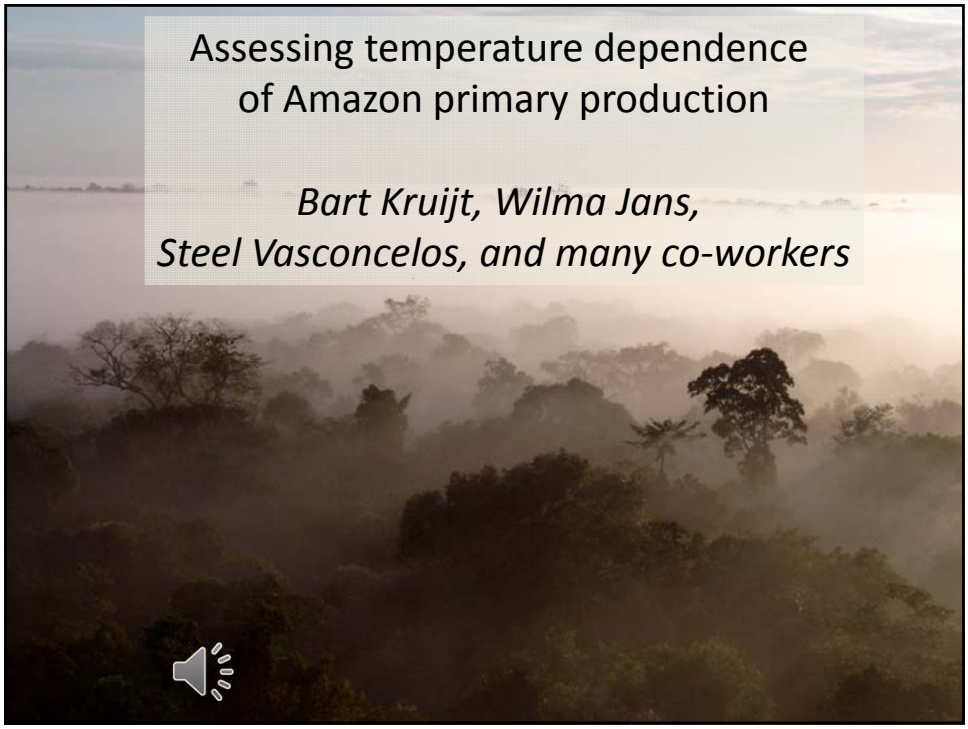
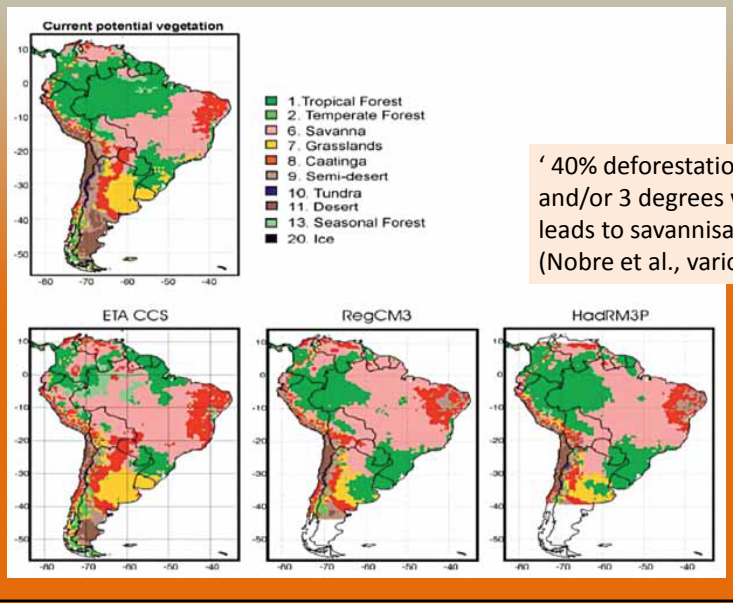

Assessing temperature dependence
of Amazon primary production
Bart Kruijt, Wilma Jans,
Steel Vasconcelos, and many co-workers


AMAZALERT
AMAZALERT
WAGENINGEN UR
LBA
SEVENTH FRAMEWORK
PROGRAMME
Coordinator: Bart Kruijt
Co-coordinator: Carlos Nobre

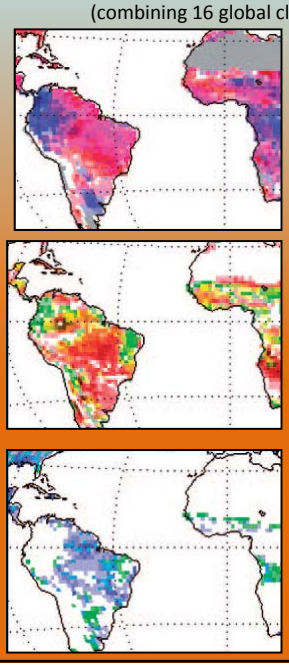
Forecast climate-induced changes to the Amazon till 2100



' 40% deforestation and/or 3 degrees warming leads to savannisation' (Nobre et al., various)

Consequences of climate change: 2080 compared with 1980

(combining 16 global climate models: temperature increase >3° C)



River runoff – water availability

- increase
- Mix of increase and decrease
- decrease

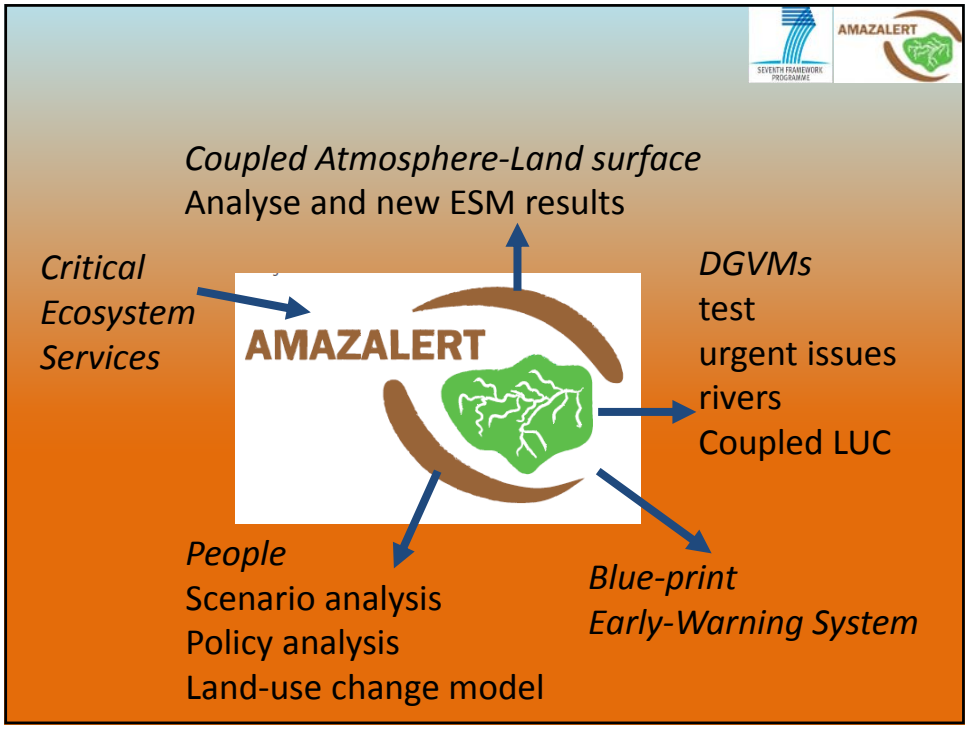
Fires

- increase
- Mix of increase and decrease
- decrease

Stable forests

- increase
- Mix of increase and decrease
- decrease

Nobre and Borma, 2009; Scholze et al, 2006



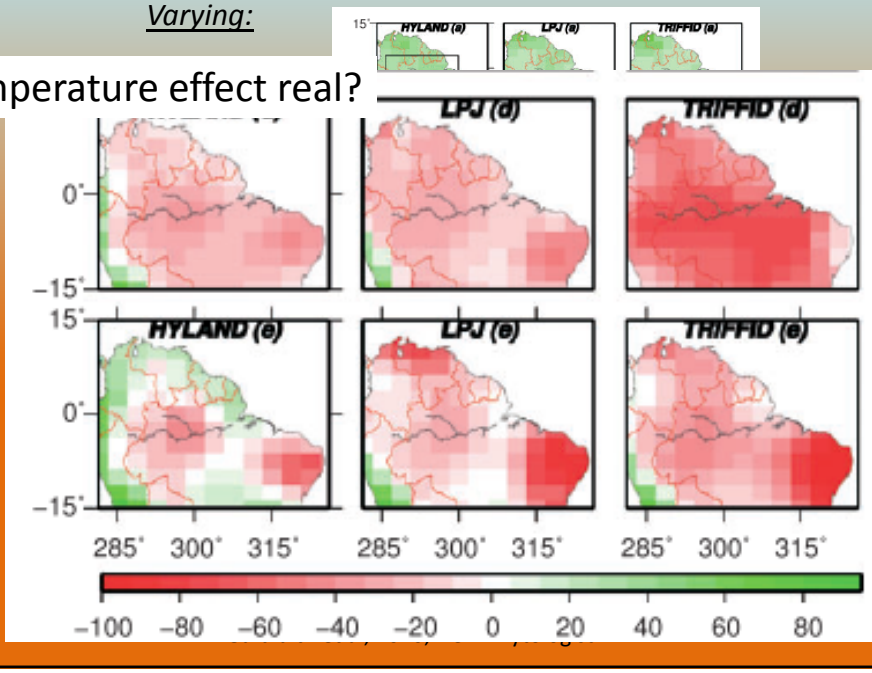
Issues in our knowledge and models

- *Do the forests acclimate to higher temperatures?*
- *How long does it take before forests suffer from drought? Will there be a shift in species?*
- *Under which conditions do different trees die?*
- *How can fire effects be estimated and how do they relate to deforestation?*
- *How do forests respond to high CO_2 and what is the role of nutrients (e.g phosphorus)?*

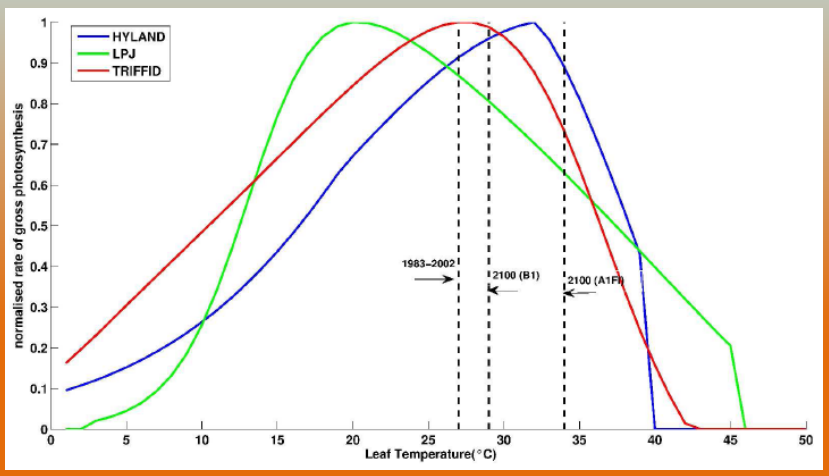
Vegetation model sensitivity

Varying:

Temperature effect real?



Dynamic vegetation models: temperature effects?



Temperature optimum for photosynthesis?

Galbraith et al. 2010

Our limited focus (for now)

Temperature dependence of other processes

- Stomatal conductance! / transpiration
- Autotrophic respiration
- Heterotrophic resp
- allocation?
- Mortality
- ...?

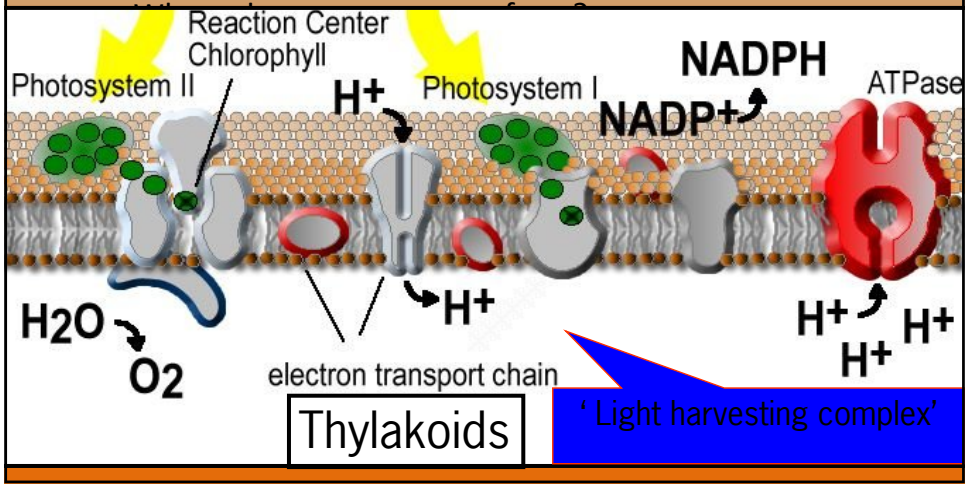
IGNORED HERE!

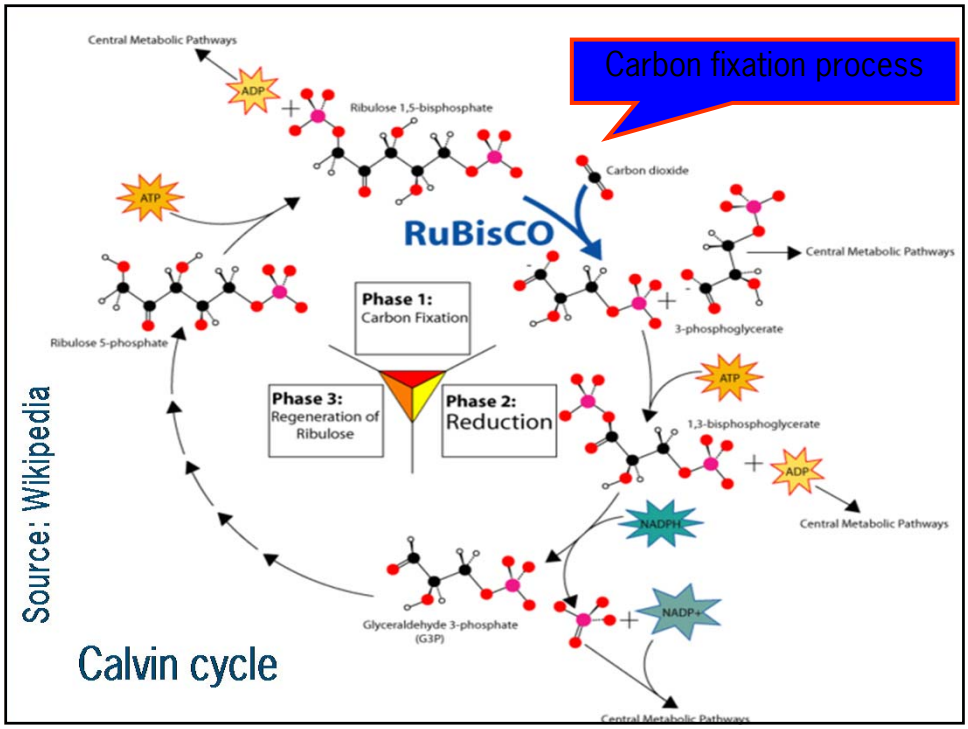
Approach

- Photosynthesis depends on enzymatic processes AND on leaf CO_2 conductance
- Temperature dependence of photosynthesis itself or of underlying processes/parameters..?
- In the end we need Agross/netMAX (photosynthesis at ambient CO2, light and high gs)
- We go for model parameters: underlying parameters

Photosynthesis

- $CO_2 + H_2O + hv \rightarrow CH_2O + O_2$

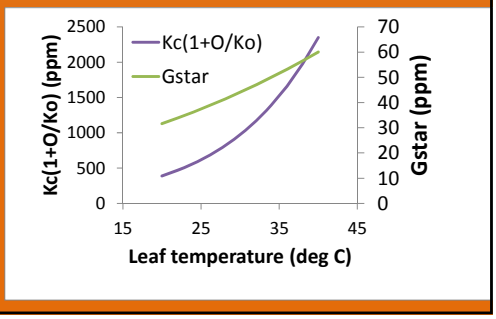




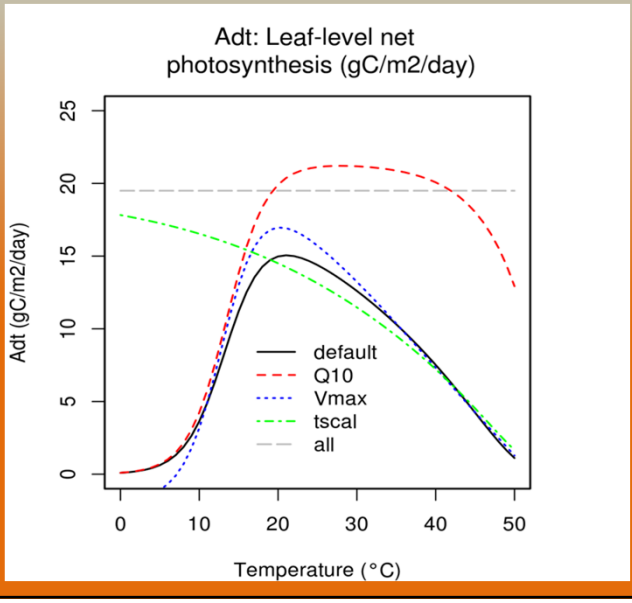
T dependence of Vcmax and Jmax?

$$A_n, \max = \min\left\{\begin{array}{c} J_e = J_{\max}\dfrac{C_i - \Gamma^*}{C_i + 2\Gamma^*} \\ J_c = V_{\max}\dfrac{C_i - \Gamma^*}{C_i + K_c\left(1 + O_a / K_o\right)} \end{array}\right\} - R_d$$

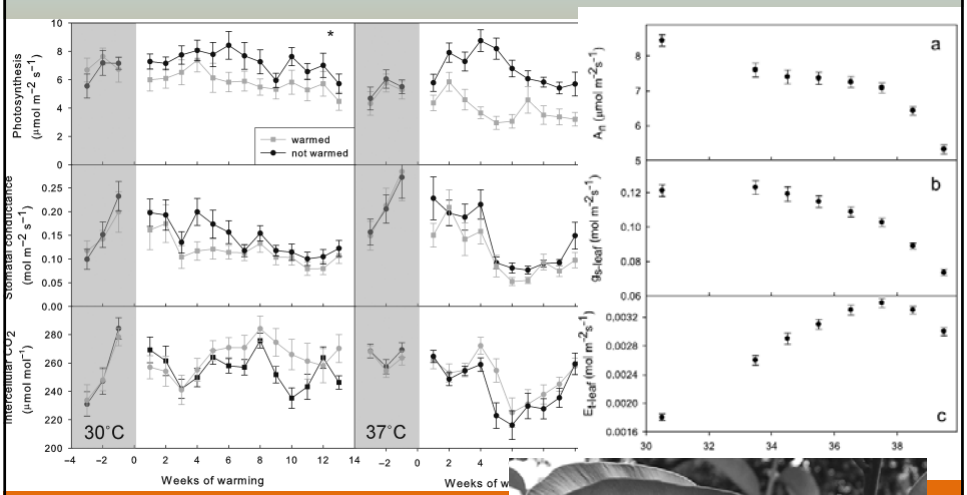
- Assume Gamma-star, Kc, Oa, Ko as given
  - We cannot determine them anyway!



LPJ (Seiler analysis)



Previous work (Doughty et al, 2008,2010)

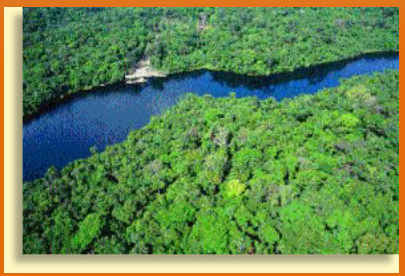


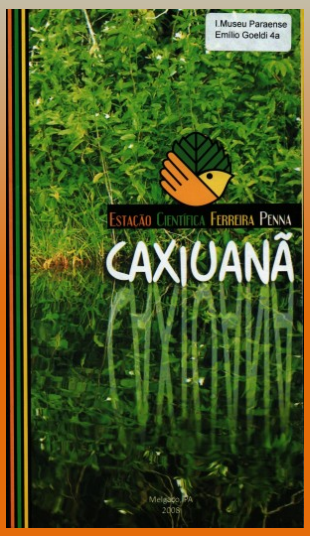
Only response of in situ, ambient Photosynthesis


The Crew

Estação cientifica Ferreira Penna

Caxiuana





Caxiuana Fieldstation

Caxiuana Fieldstation

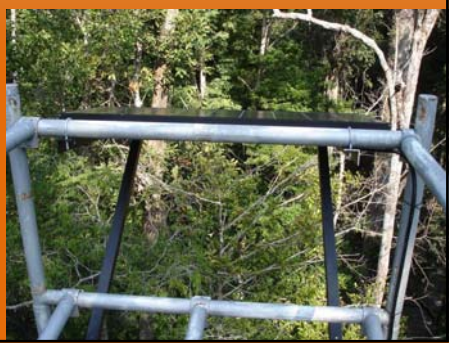
Experimental site

Drought experiment

Since 2002 50% rainfall excluded

1 hectare

Experimental site



Our activities

- *Set up a 'leaf warming' experiment*
- *Light and CO_2 response curves at different leaf temperatures*

Leaf warming experiment

Long term effect of increased leaf temperature on photosynthetic parameters.

Leaf warming experiment




Leaf warming experiment




Photosynthesis

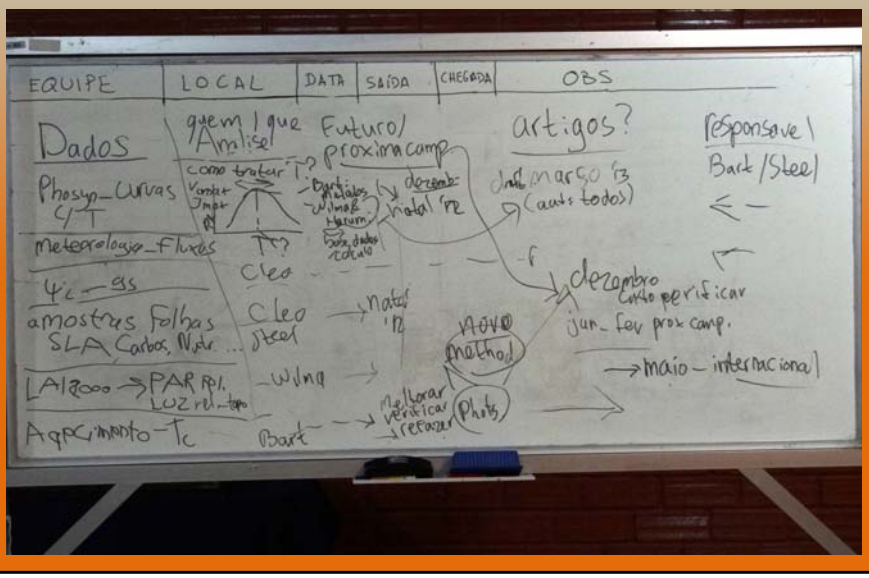
Photosynthesis curves

- Light response curves. Effect of light on photosynthesis (CO_2 and temperature constant)
- CO_2 response curves. Effect of CO_2 on photosynthesis (light and temperature constant)
- 4 temperatures 4 X
- Drought and wet plot 2 X
- Different species 3 X, 2 X
- Sun exposed and shaded leaves 2 X
- Heated, zero and control 3 X
- Three campaigns 3 X
- So.....

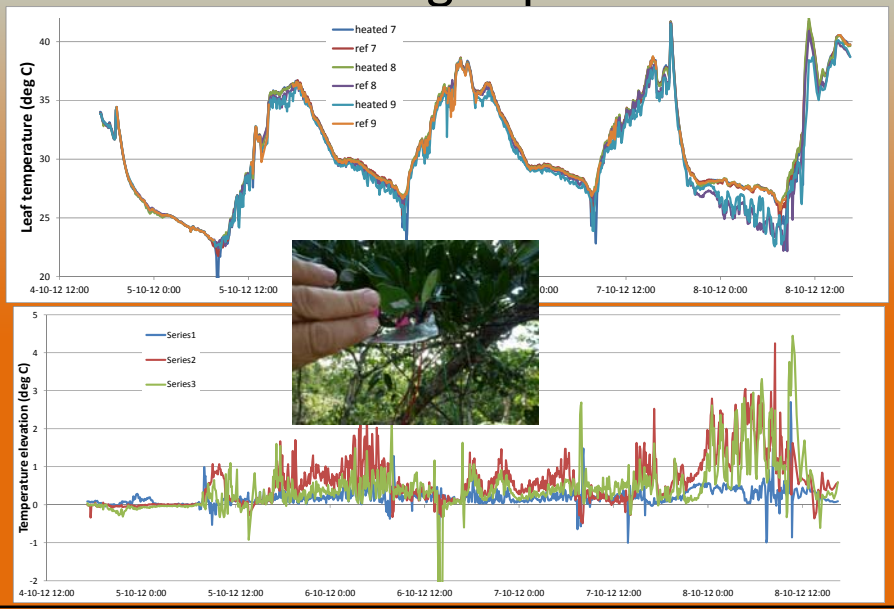
The work is done!



So, what's next?

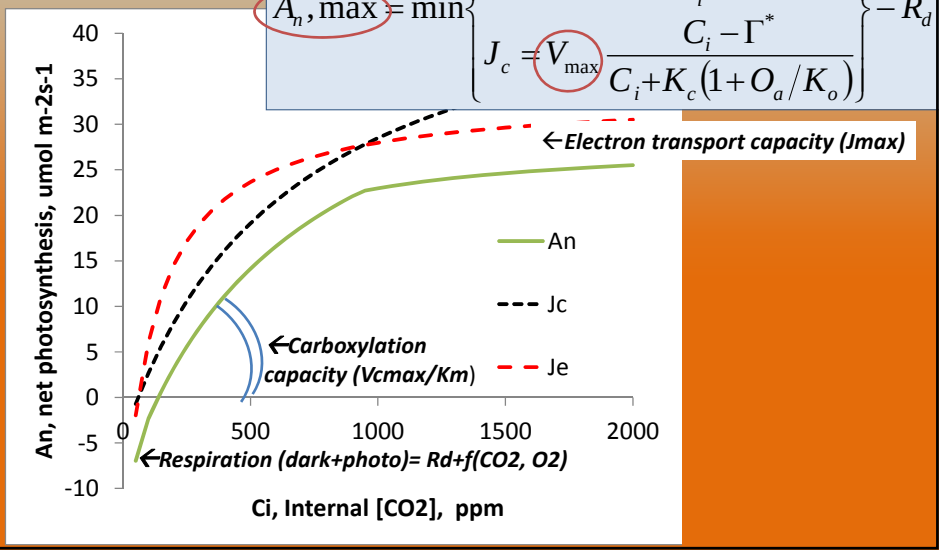


Leaf heating experiment..

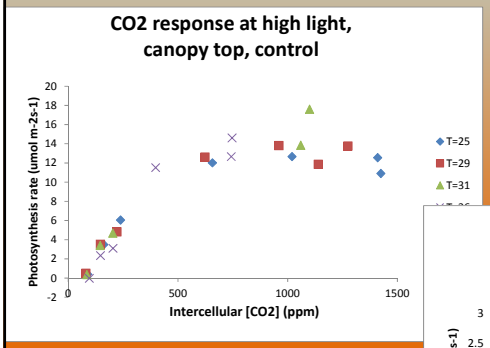


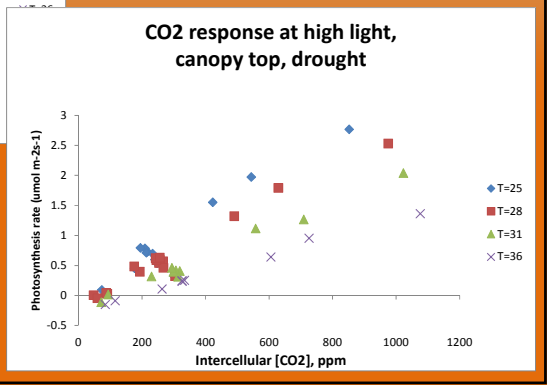
Fitting the Farquhar model of photosynthesis, concept

$$A_n, \max = \min\left\{\begin{array}{l} J_e = J_{\max}\dfrac{C_i - \Gamma^*}{C_i + 2\Gamma^*} \\ J_c = V_{\max}\dfrac{C_i - \Gamma^*}{C_i + K_c\left(1 + O_a/K_o\right)} \end{array}\right\} - R_d$$



Can we see an effect of temperature on photosynthetic CAPACITY?





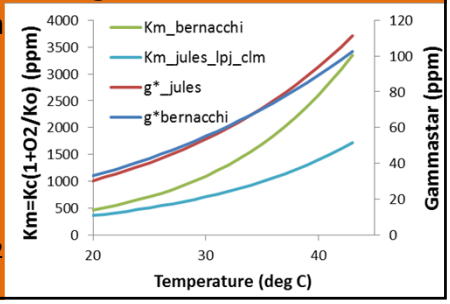
→parameters:
Vcmax (T), Jmax (T), Rd (T)...

Simple calculation of Vcmax and Jmax?

$$A_n, \max = \min\left\{ \begin{array}{l} J_e = J_{\max}\dfrac{C_i - \Gamma^*}{C_i + 2\Gamma^*} \\ J_c = V_{\max}\dfrac{C_i - \Gamma^*}{C_i + K_c\left(1 + O_a / K_o\right)} \end{array} \right\} - R_d$$

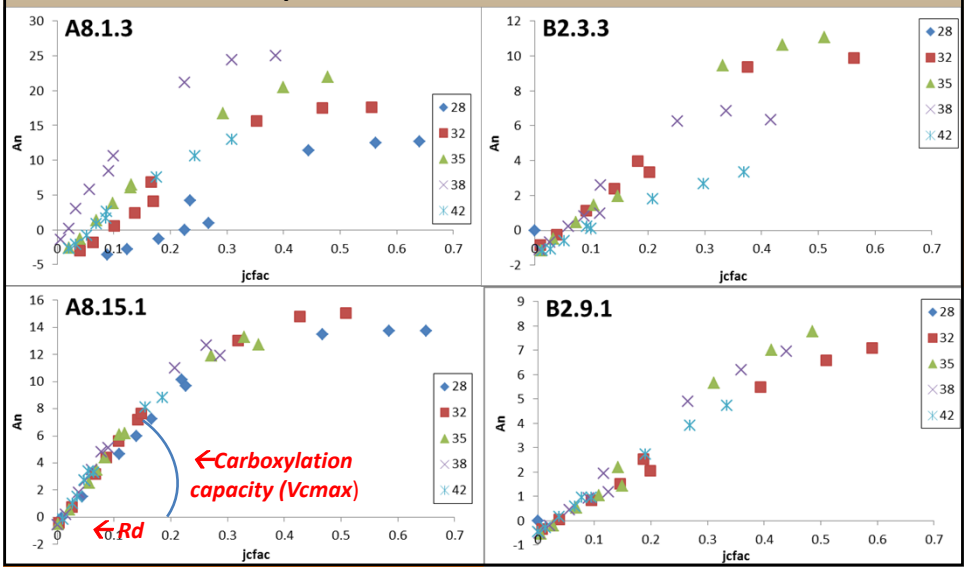
- Assume Gamma-star, Kc, Oa, Ko as given
  - We cannot determine them a

Then regress An against fc(Ci)
- Vm: slope
- Rd: intercept
- Jm=(A_n+Rd)/f_e(C_i) at high CO_2

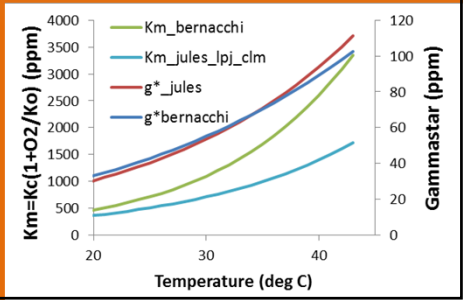


Control plot

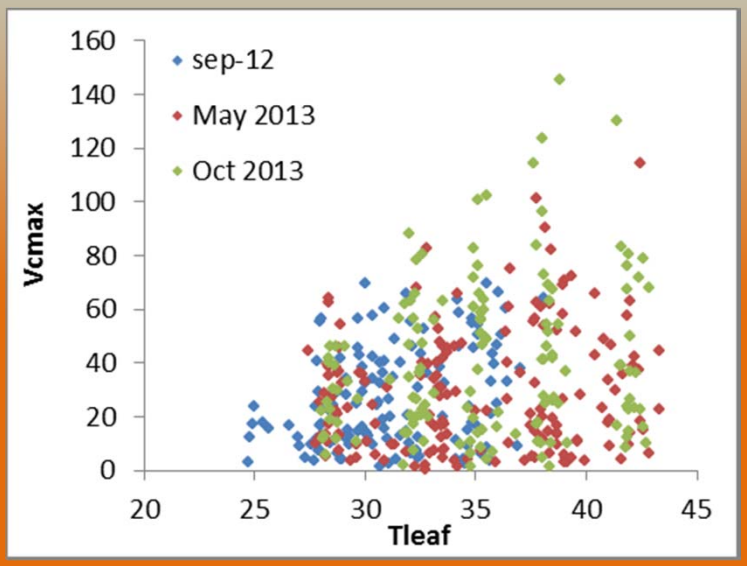
Drought plot



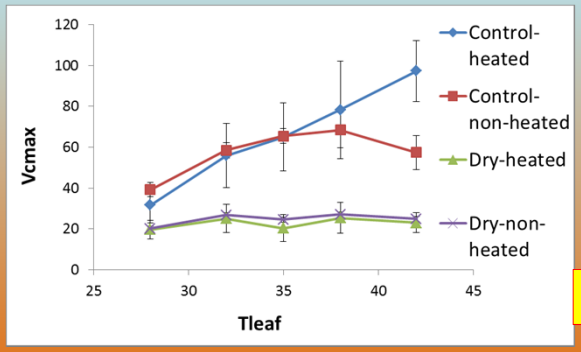
- Various forms of michaelis-menten parameter Temperature dependences...
- This will affect Vcmax and its T dependence
- Our choice: both latest insights and traditional forms as in models



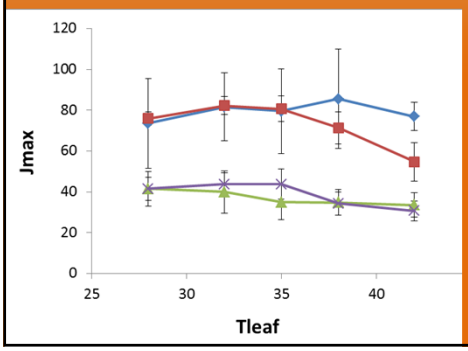
Calculate about 440 Vcmax values..

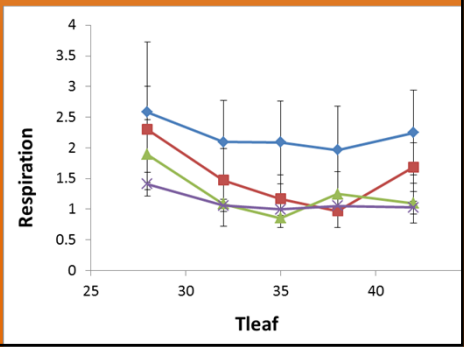


Our results!

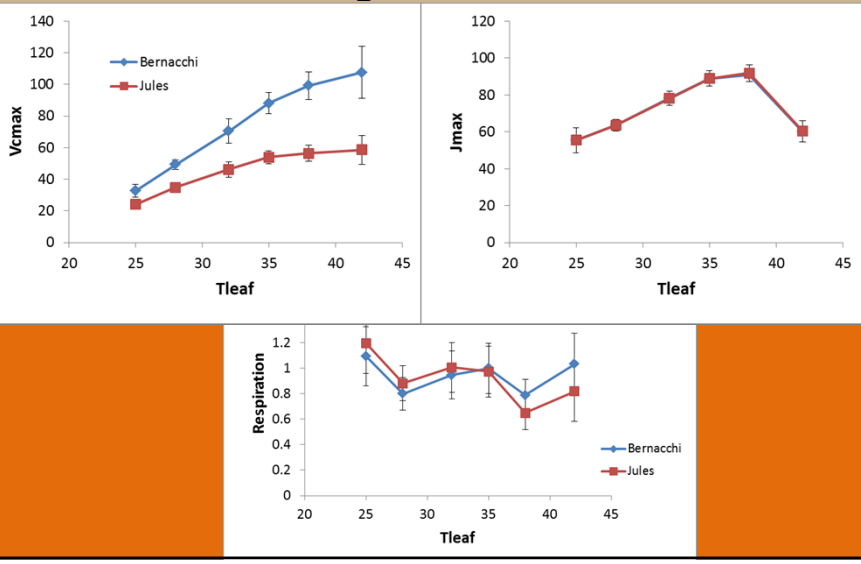


µmol $m^{-2}s^{-1}$

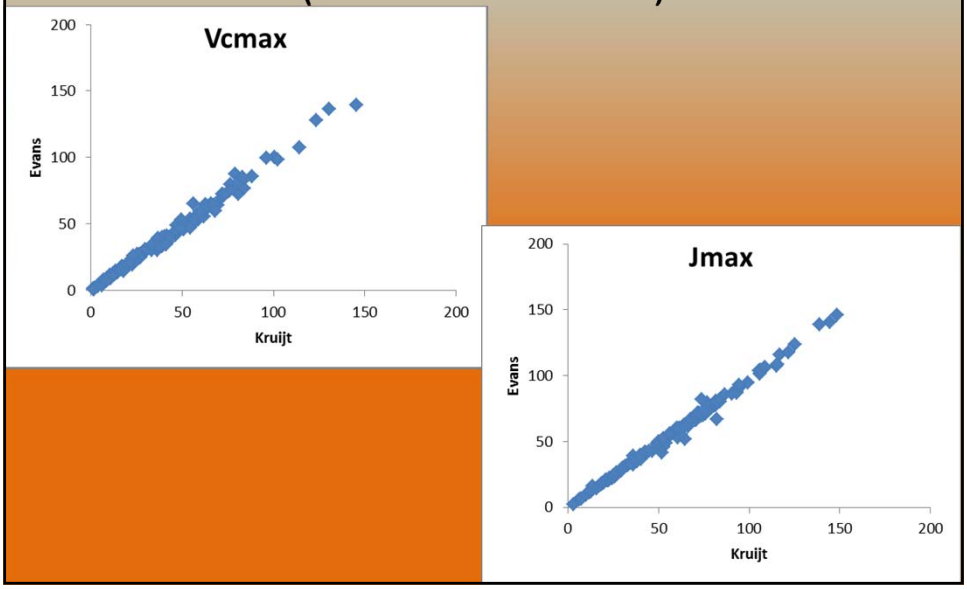




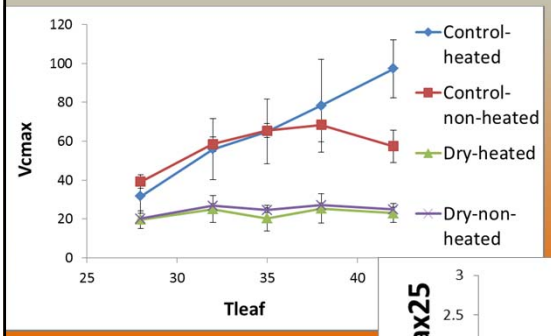
Edgard Tribuzy's data: Several species, Manaus and Tapajos, no warming, using OUR methods

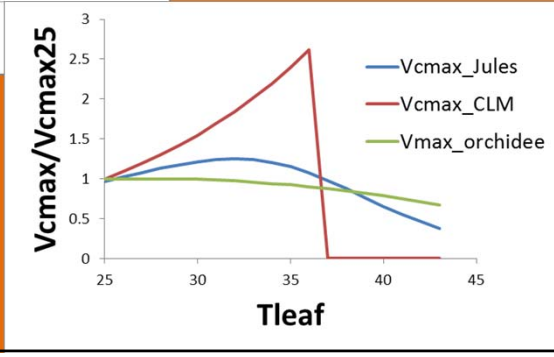


Comparison with full curve fitting methods (court. John Evans)

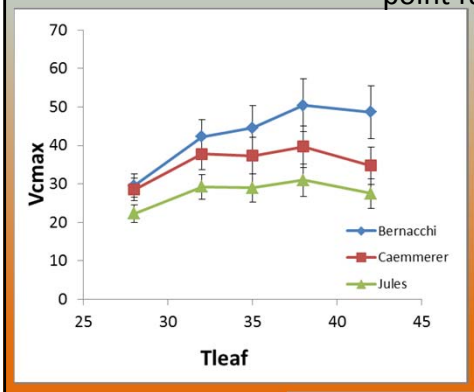


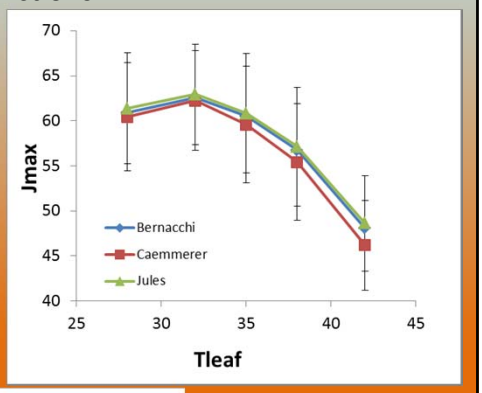
Compare to models

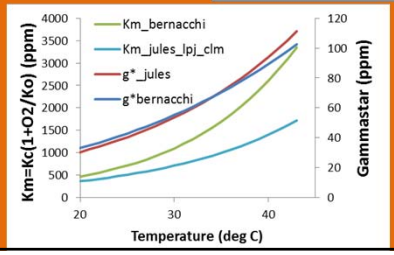




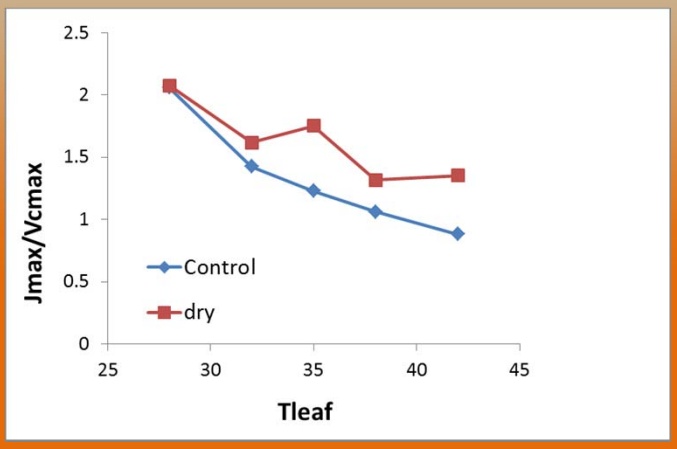
Dependence on underlying Michaelis-Menten and compensation point functions







Stoiciometry?
Ratio of Jmax/Vcmax
(Electron transport / carboxylation capacity)

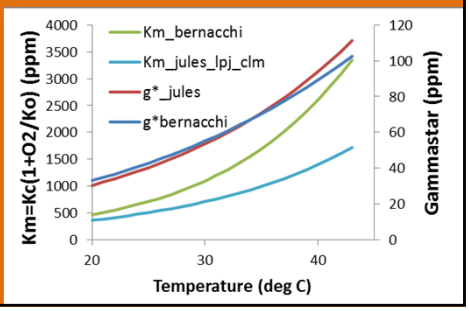


(see also recent work by Mercado et al...)

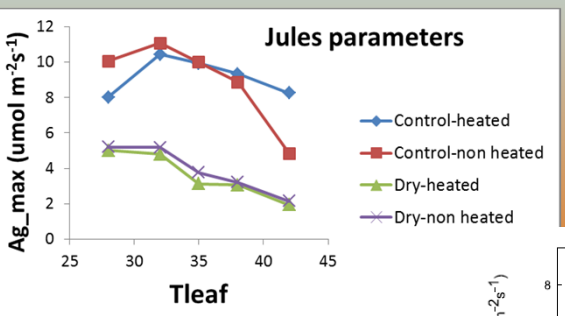
Reconstruct Amax from Vcmax, Jmax and Rd, keeping Ca and Gs constant/high.

$$A_n = \min\left\{\begin{array}{l} J_e = aJQ\dfrac{C_i-\Gamma^*}{C_i+2\Gamma^*} \\ J_c = V_m\dfrac{C_i-\Gamma^*}{C_i+K_c\left(1+O_a/K_o\right)} \end{array}\right\} - R_d$$

Dividing by increasing Km values!

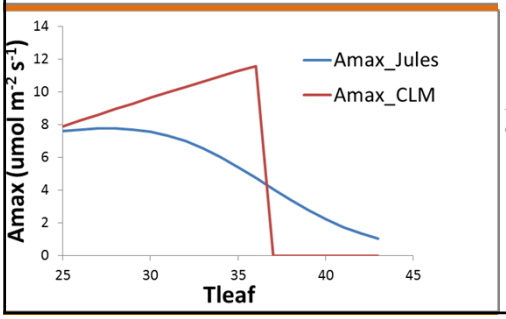


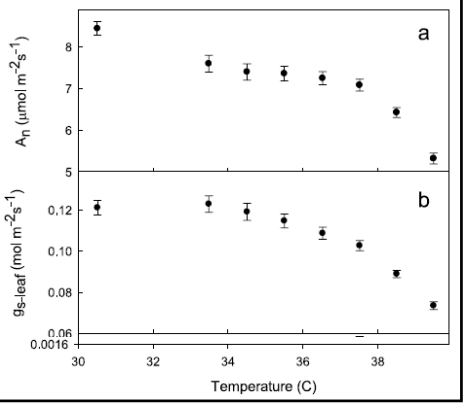
Reconstructed Amax



This study

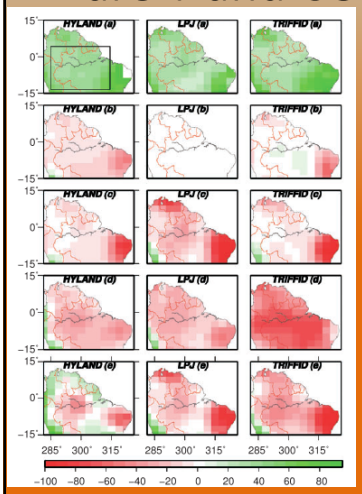
Chris Doughty



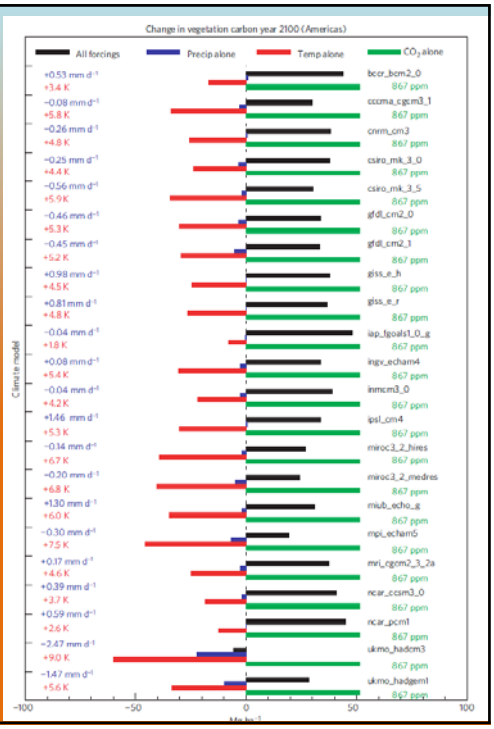


Ecosystem physiology using tower flux data: T response of Vcmax_canopy?

Main uncertainties in Amazon dieback are T and CO_2..



Huntingford et al, 2013



Main uncertainties in Amazon dieback are T and CO_2..

Conclusions/ discussion:

- Will models still predict Amazon dieback with adjusted temperature response?
- Will temperature acclimation prevent Amazon dieback?

- BUT:
  - Need better warming experiments
  - Need to evaluate our methods
  - (Acclimation of) respiration?
  - Stomatal conductance?
  - Mortality/turnover rates?