The effect of temperature on canopy physiology, carbon cycling, and seasonality of carbon usage in tropical forests

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Are mountain passes higher in the tropics?

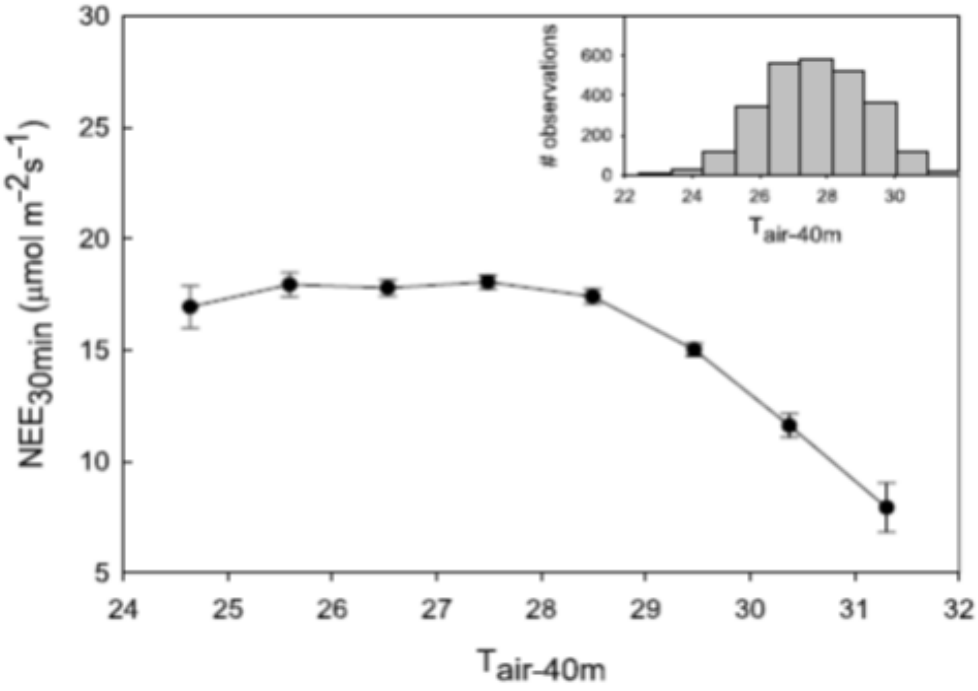
Tropical forests experience small diurnal and seasonal temperature changes compared to temperate forests.

Species can migrate to new climate zones in the mountains.

But what will happen to lowland tropical forests with increased global temperatures?

Temperature thresholds in the Tapajos, Brazil

Eddy covariance from the km 83 eddy covariance tower shows a strong sensitivity to temperature.



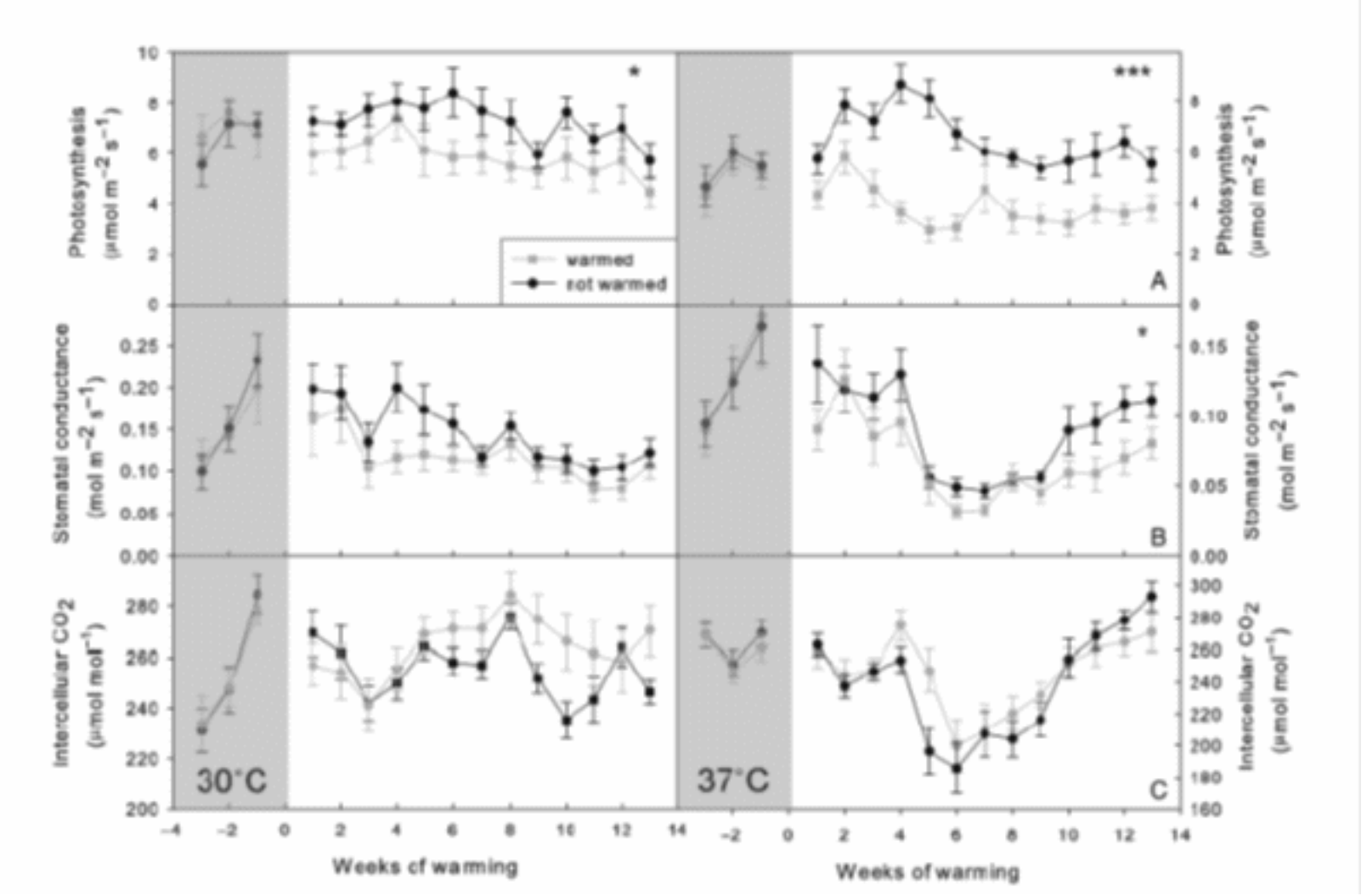
Doughty et al 2008

Do tropical forest trees acclimate to higher temperatures?

We used three canopy access towers to warm indivdual leaves of 9 species by ~2C in the Tapajos Natinal park in Para, Brazil.

We used two heating methods: passive and active.

Effect of warming experiment



There was a significant decrease in maximum photosynthetic capacity in the warmed leaves but not the control group.

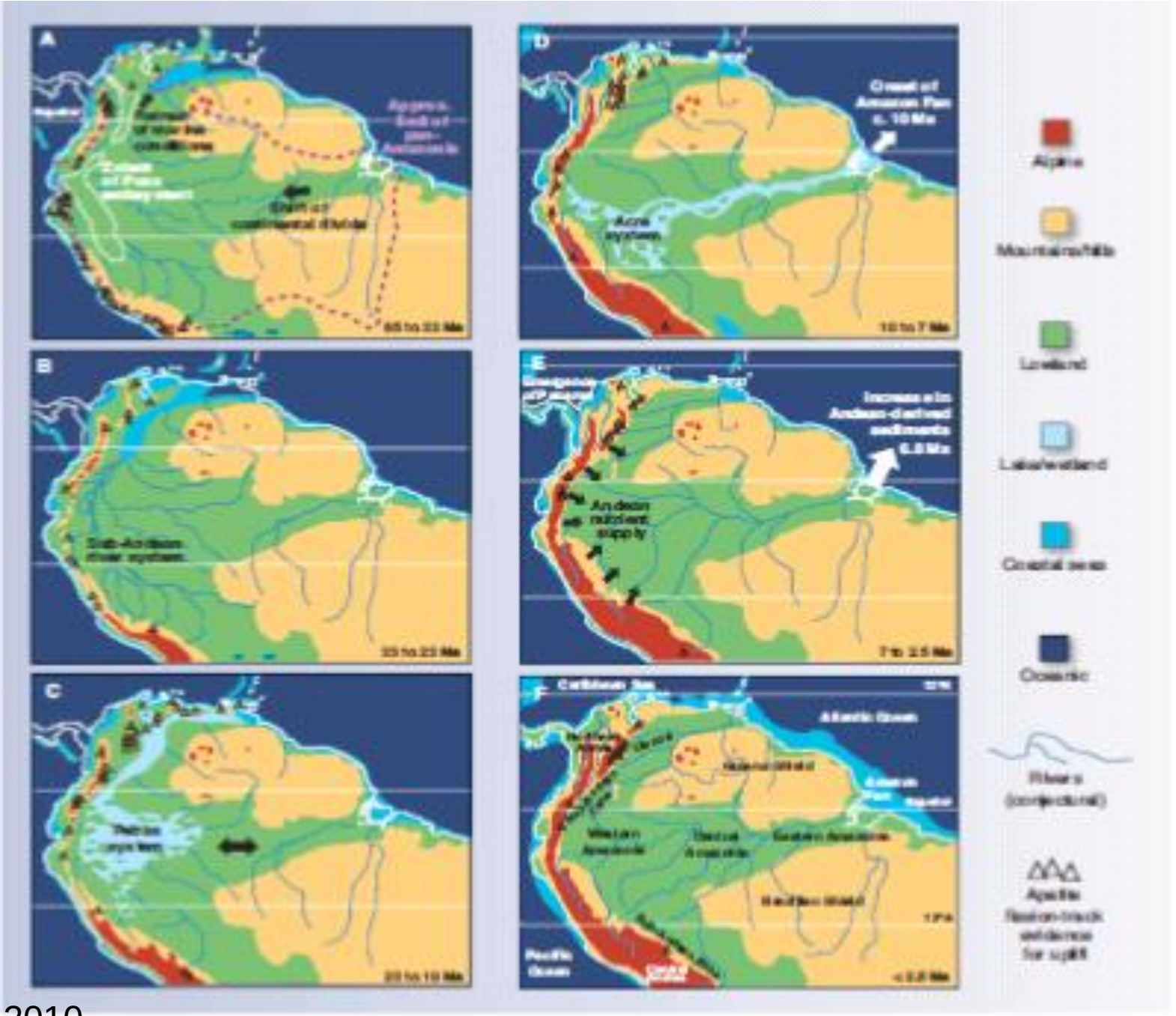
Doughty et al 2011

How can we understand whether lowland tropical forests will acclimate to higher temperatures?

Large scale warming experiment.

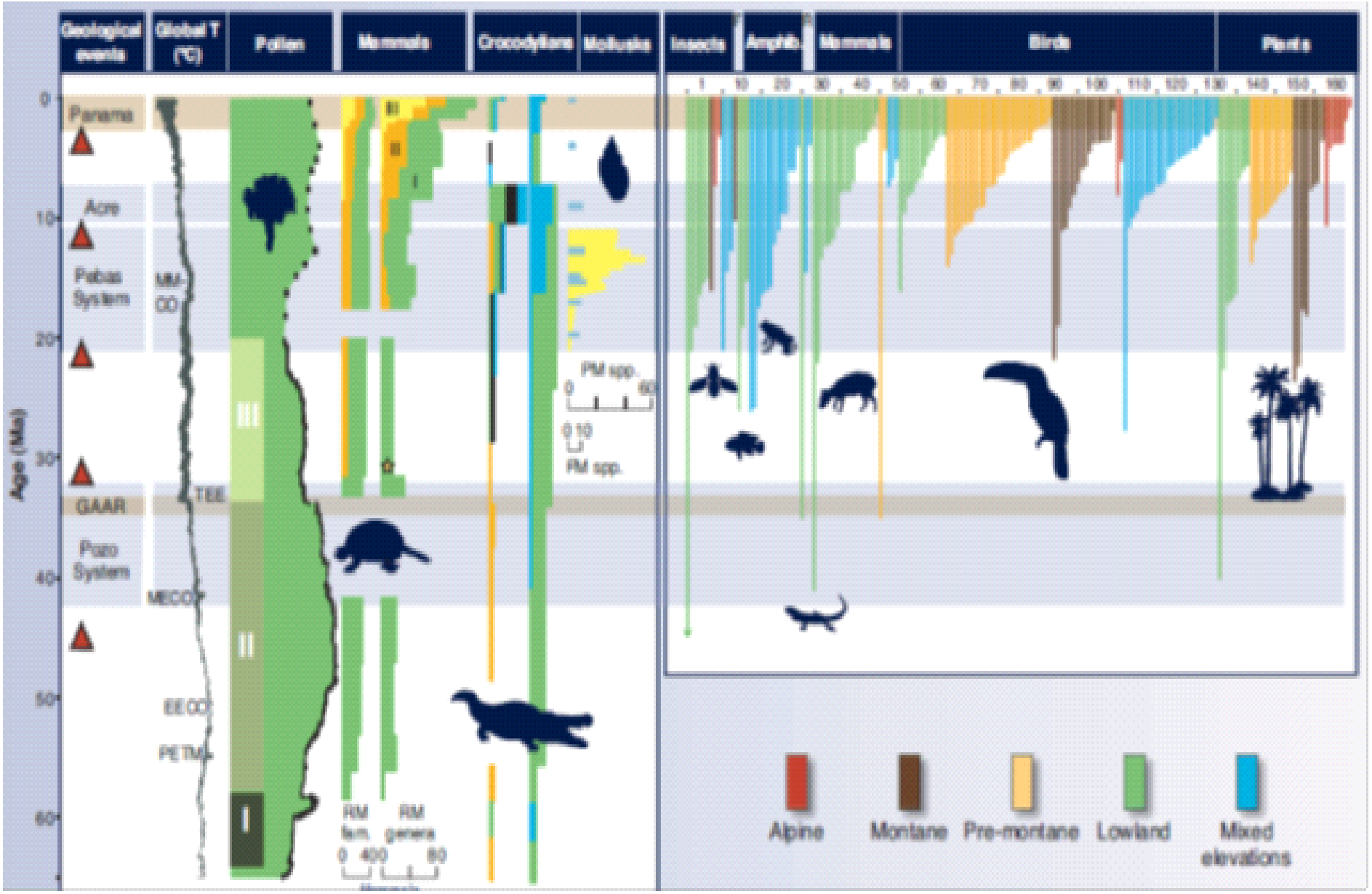
Understand the evolutionary history of the Amazon trees.

Amazon basin through time

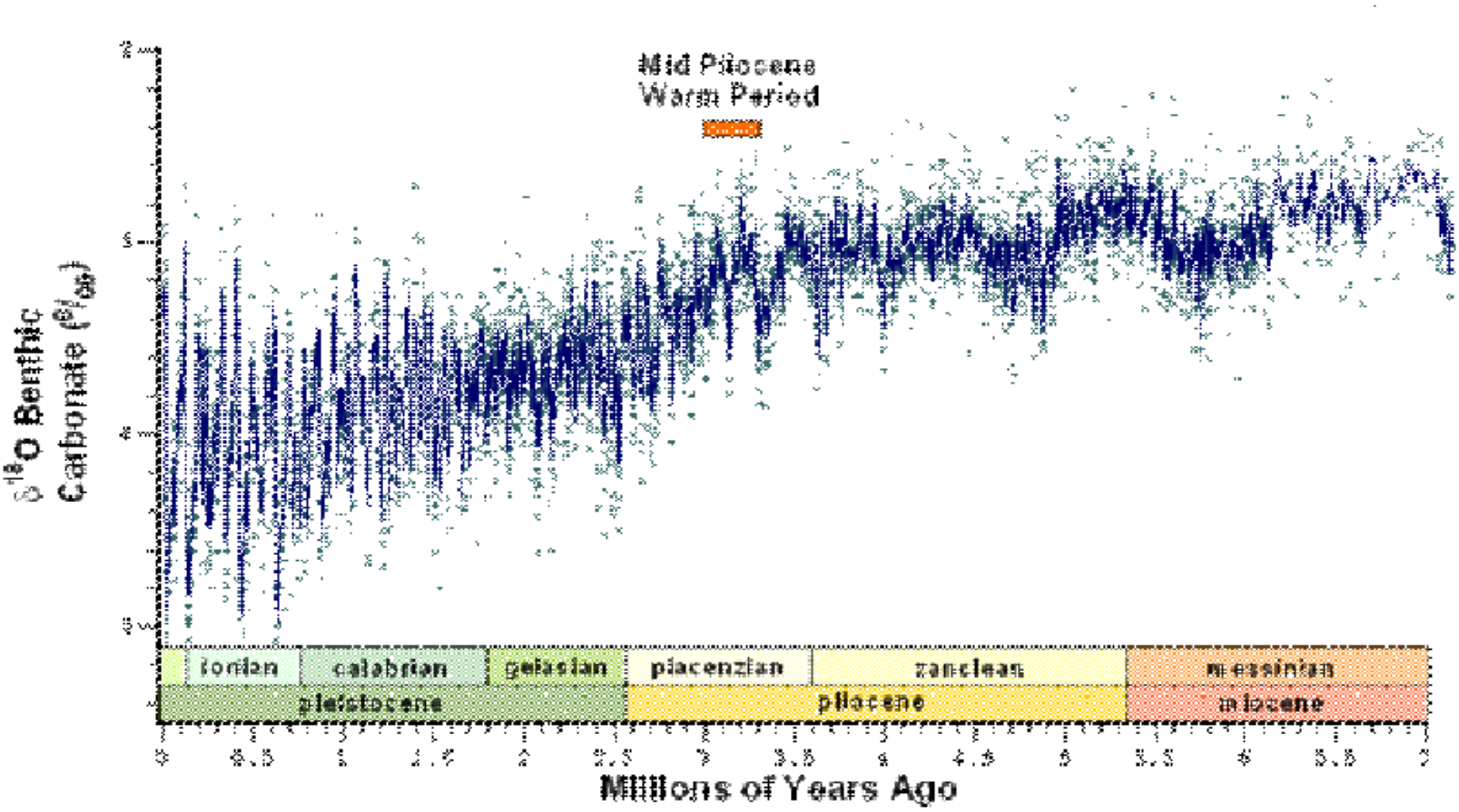


Hoorne et al. 2010

When did tropical forest tree species evolve?

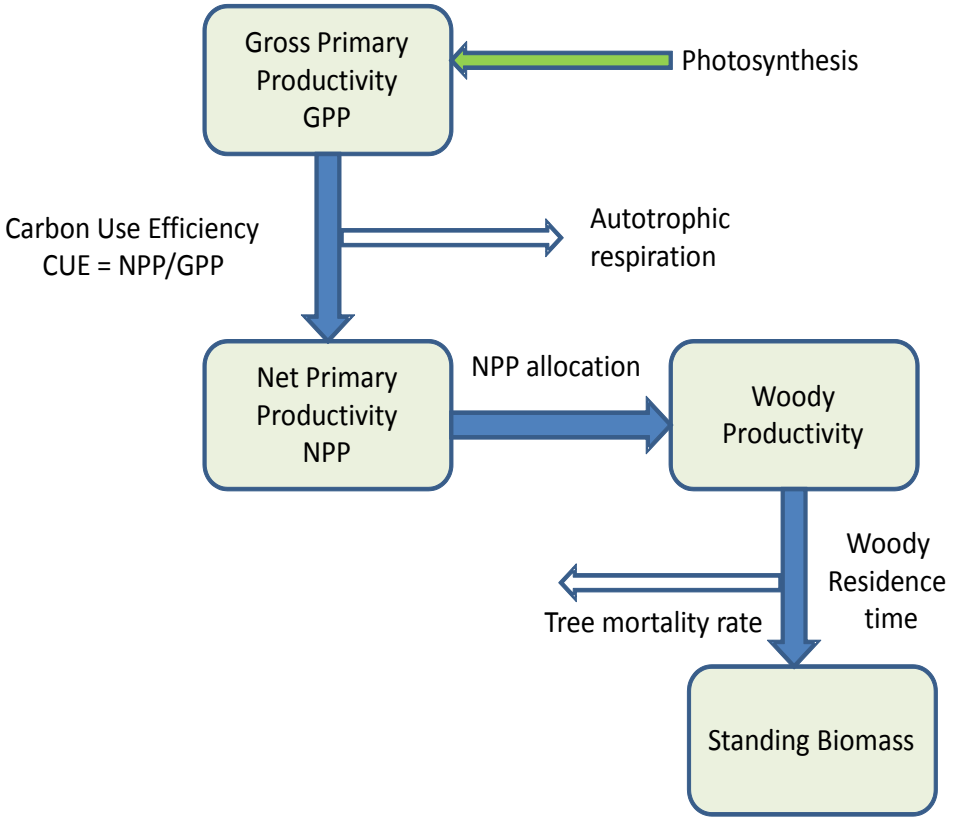


What were temperatures like during this period?



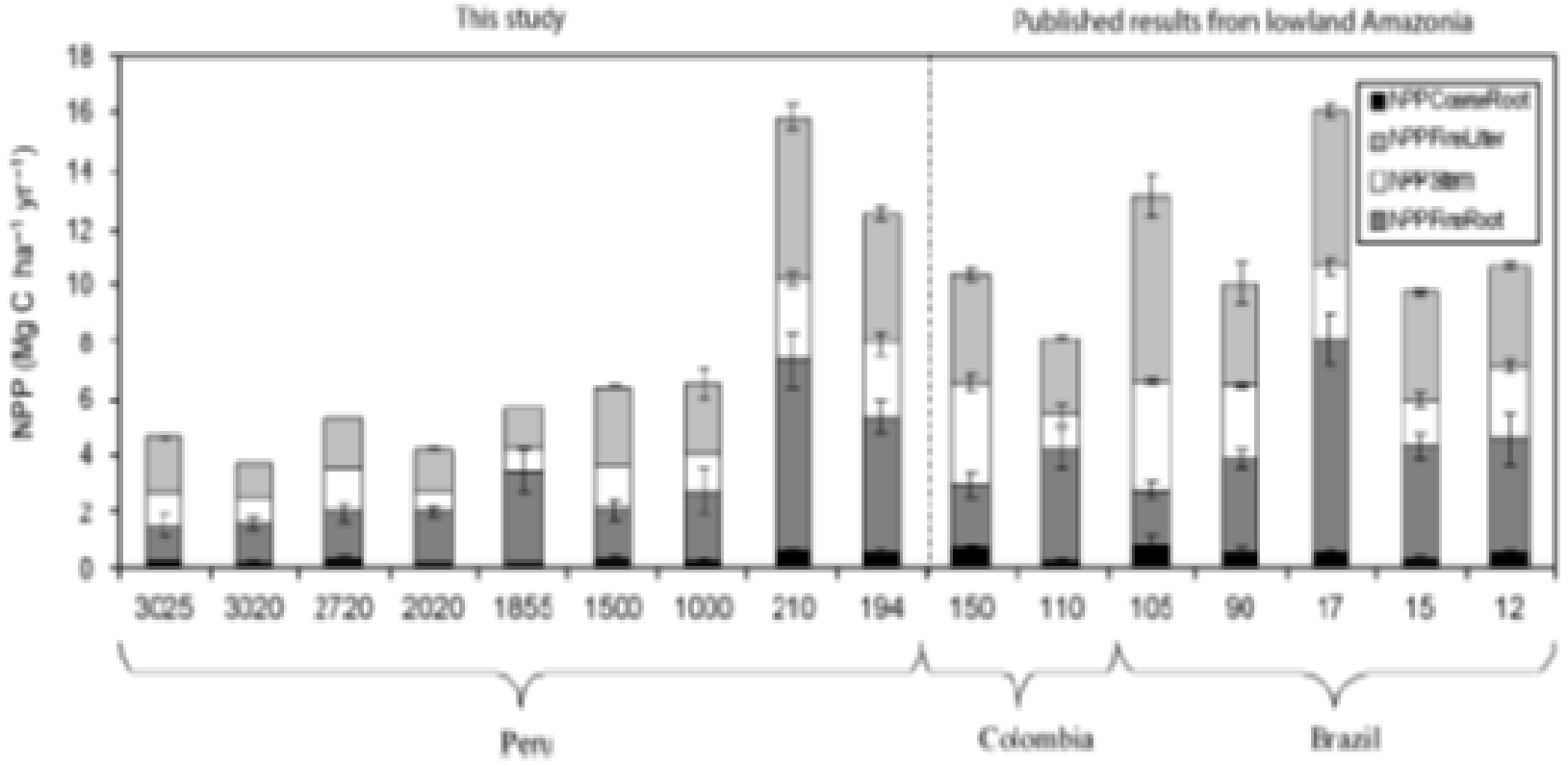
Other things impact the carbon budget...

Changes in carbon use efficiency or allocation can impact global carbon budgets and climate



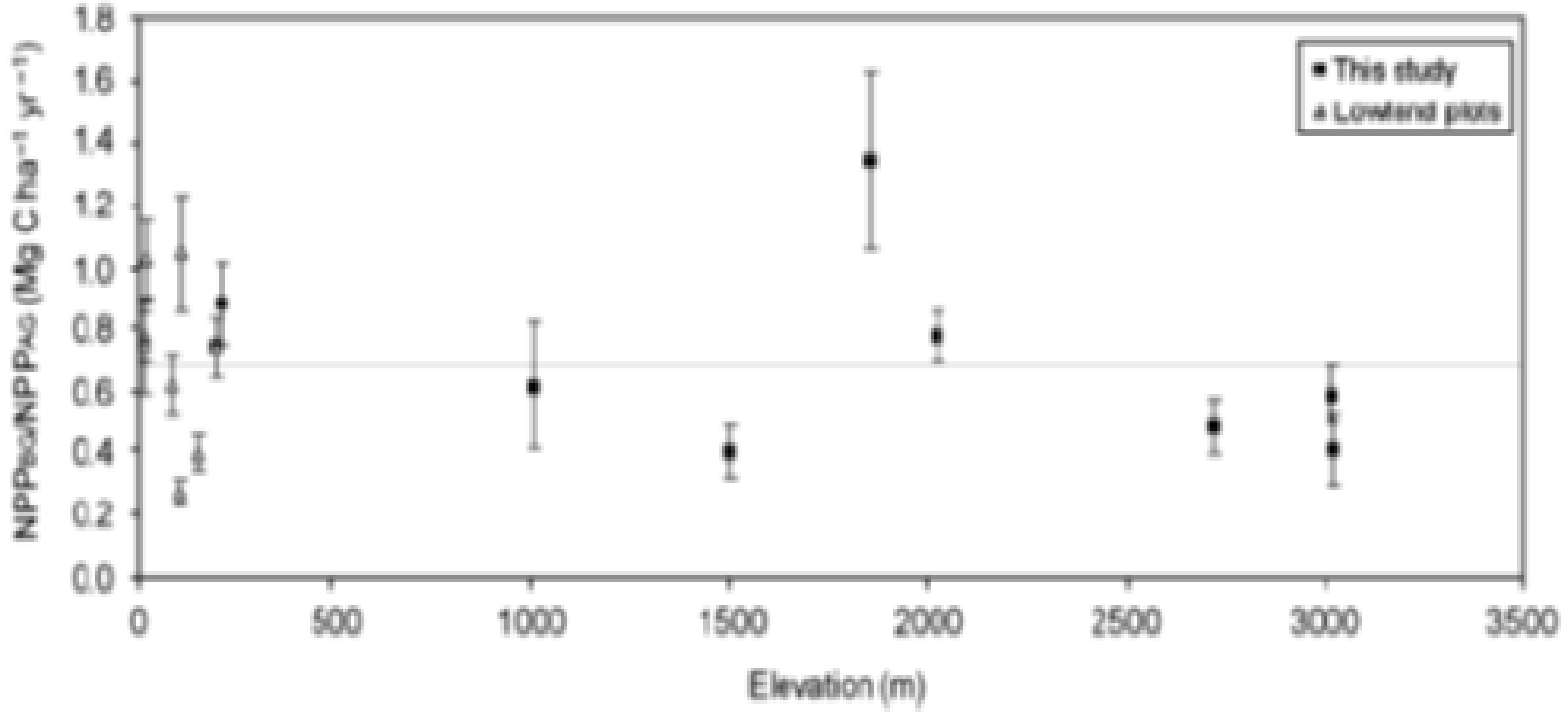
Malhi et al. in press

How does NPP change between sites?



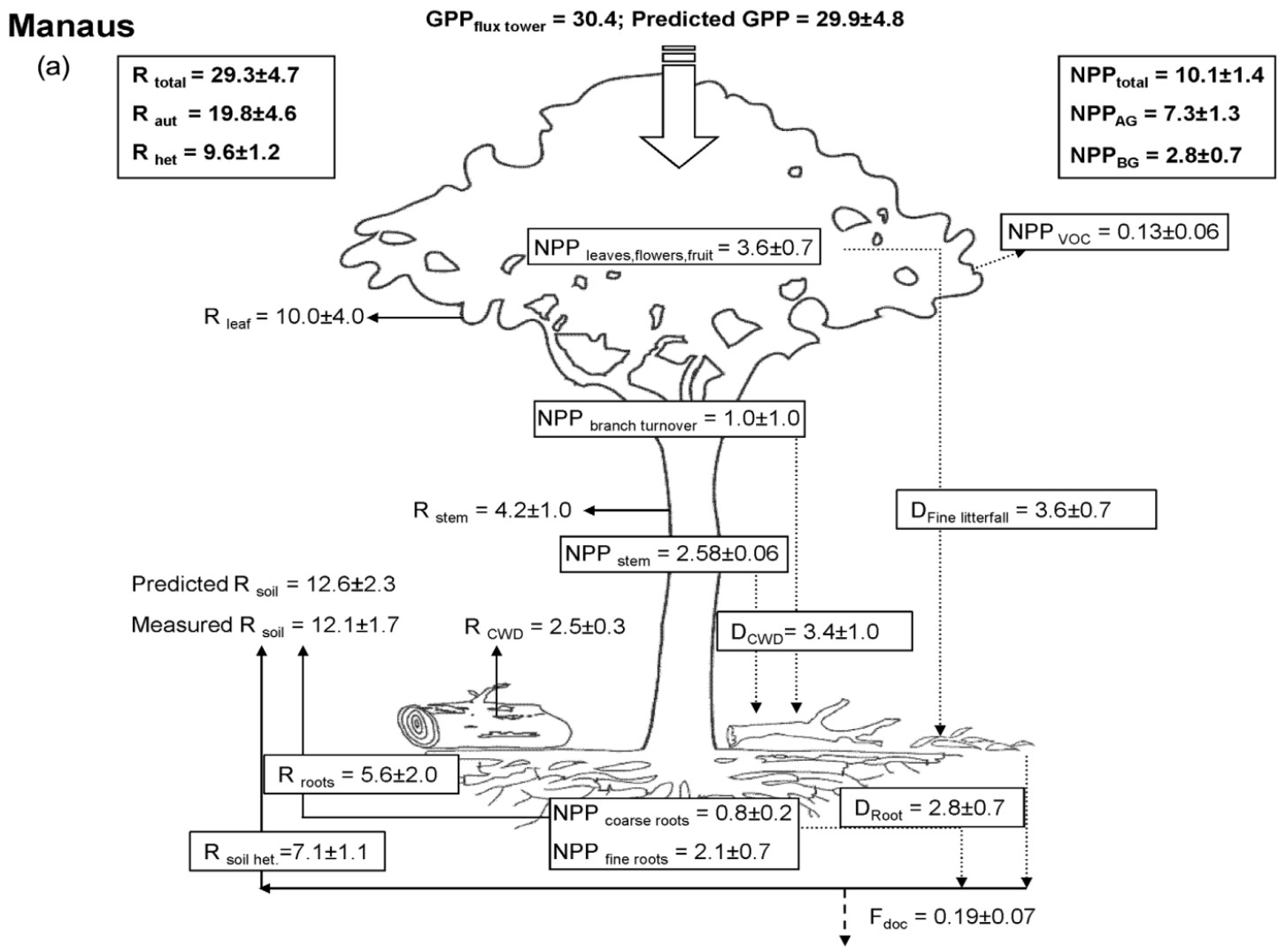
Girardin et al. (2010) shows total NPP decreases with temperature.

Is there a shift to below ground NPP?



No change in allocation of carbon to below ground with elevation.

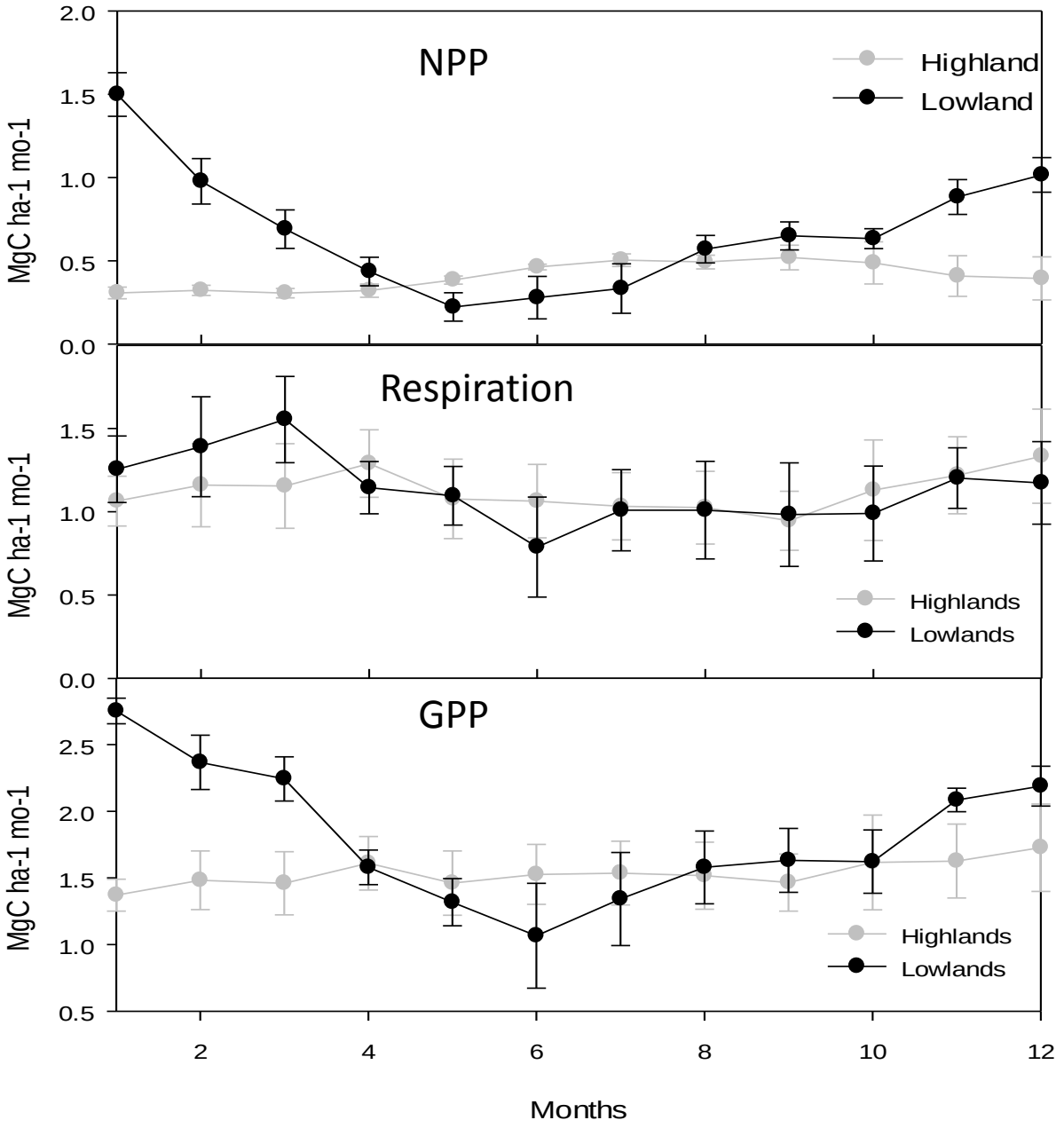
Intensive carbon cycling sites



Malhi et al. 2009

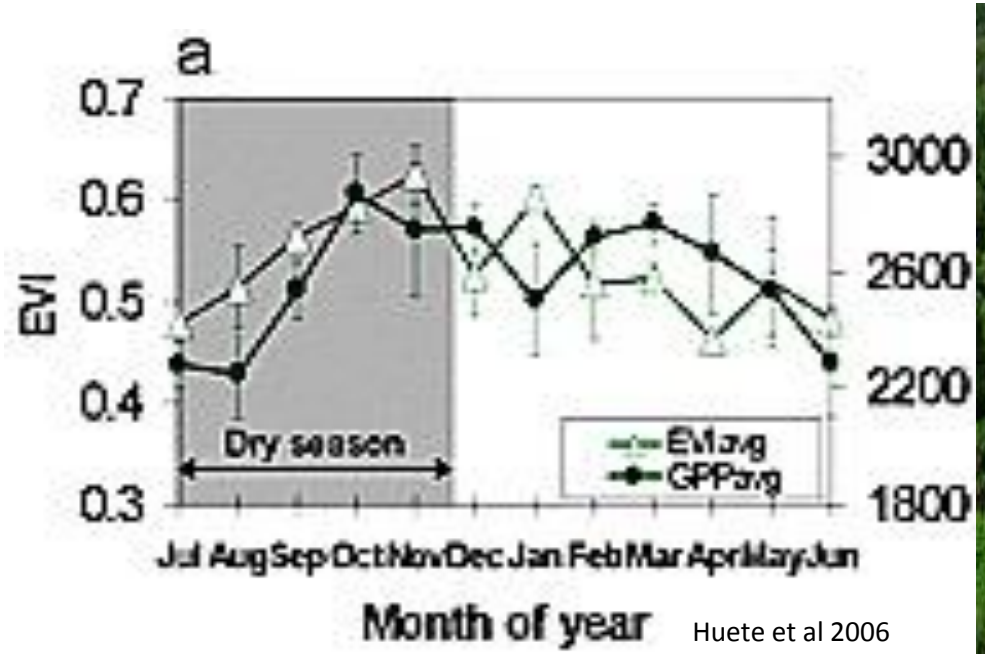
Rainfor network

- **Caxiuanã, Brazil** (4 plots, 1 on Oxisol soil, 1 on a Terra Preta Anthrosol soil, and 2 plots constituting the Drought experiment and Control both on Oxisol soils).
- **Tambopata, Peru** (2 plots, 1 each on Ultisol and Oxisol soils).
- **Kosñipata Valley, Peru** (4 plots, 2 each at 3000m and 1500m altitude).
- **Tanguro, Brazil** (2 plots, 1 burnt every three years, 1 undisturbed).
- **Kenia, Bolivia** (2 plots) This site occurs at the dry ecotone between forest and savanna.
- **Allpahuayo, Peru** (2 plots, 1 each on white sand and Ultisol soil).

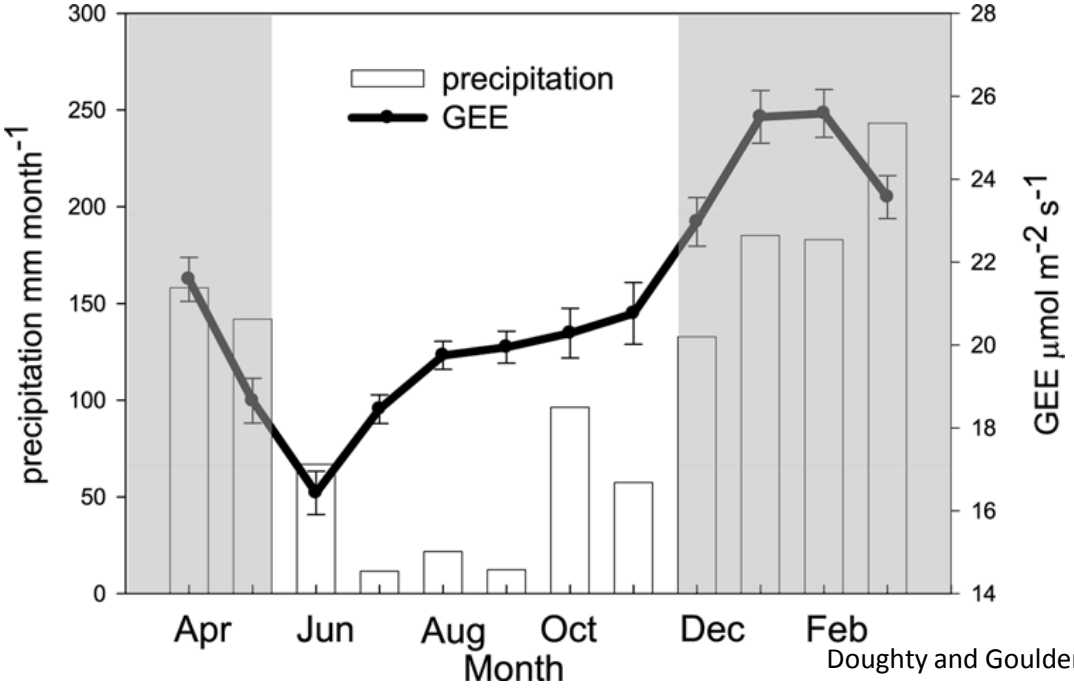

NPP
Highland
Lowland
MgC ha-1 mo-1
2.0
1.5
1.0
0.5
0.0
Respiration
Highlands
Lowlands
MgC ha-1 mo-1
1.5
1.0
0.5
0.0
GPP
Highlands
Lowlands
MgC ha-1 mo-1
2.5
2.0
1.5
1.0
0.5
2
4
6
8
10
12
Months

Compare bottom up GPP to eddy covariance tower GPP

- How does GPP vary in tropical forests?
- The Tapajos region shows a seasonal cycle in total photosynthesis and photosynthetic capacity.



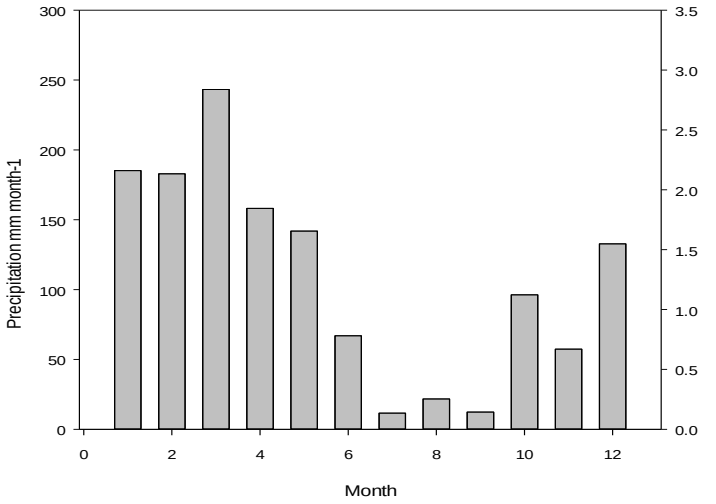
Huete et al 2006

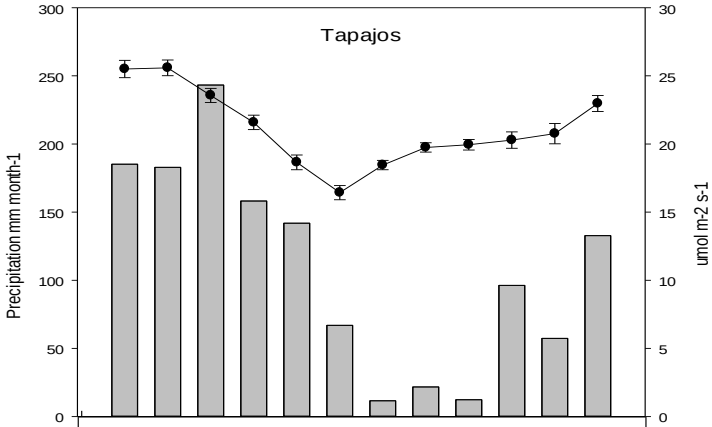


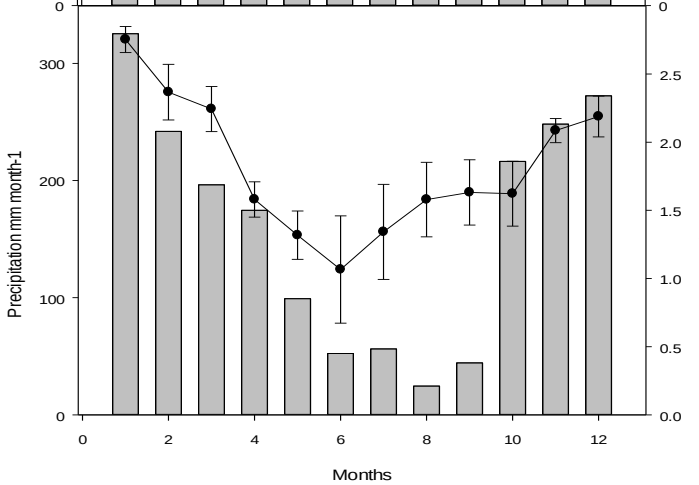
Doughty and Goulden 2008

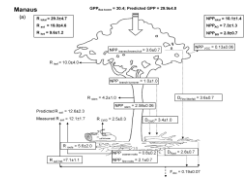
Compare bottom up GPP to eddy covariance tower GPP

- Tapajos km 67 GPP
- Tapajos km 83 NEE
- GPP from Tambopata, Peru and Kenia, Bolivia

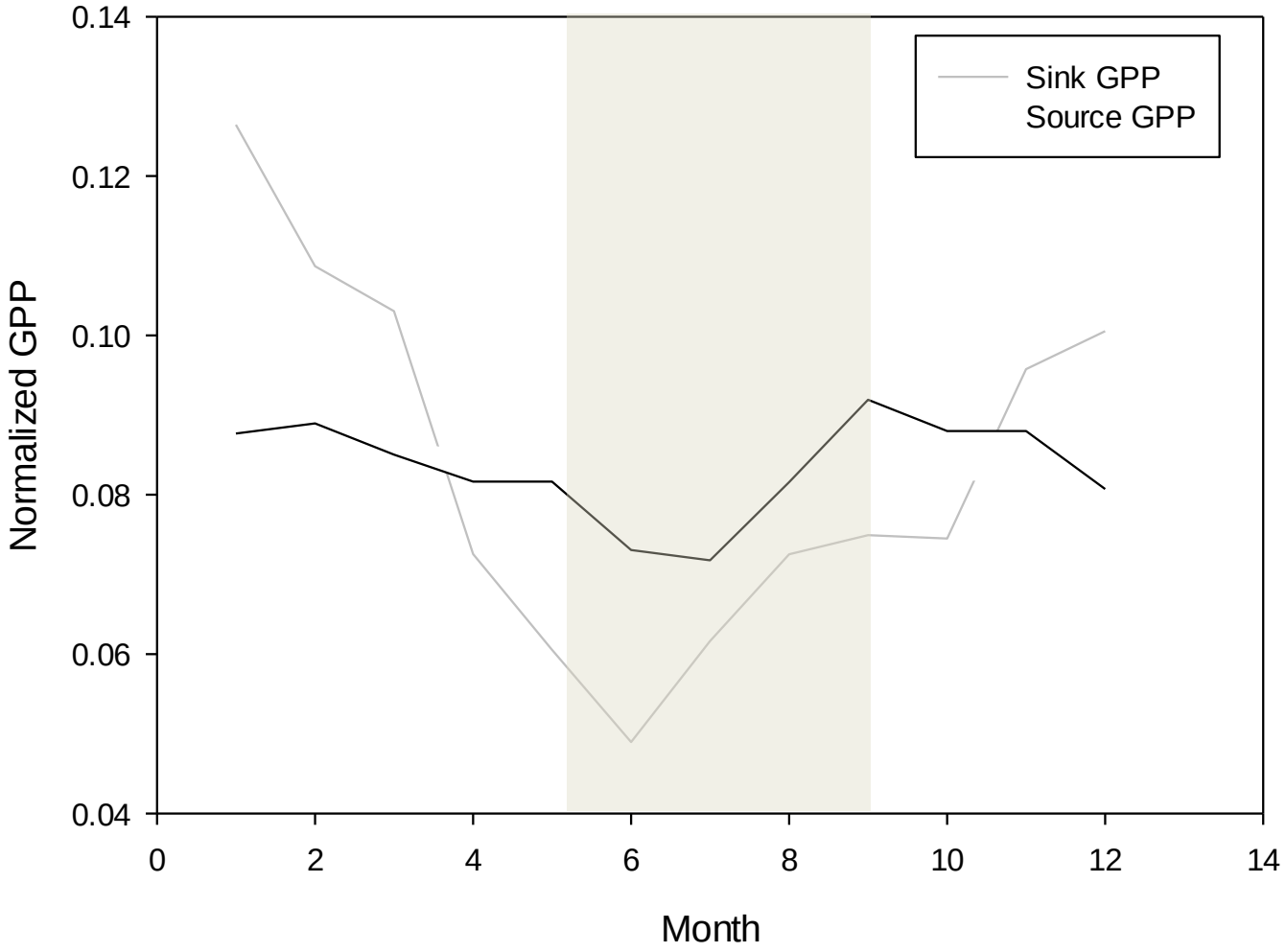


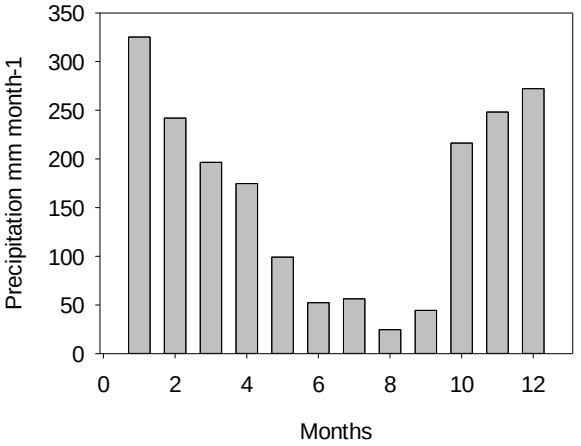






Compare bottom up GPP to eddy covariance calculated GPP





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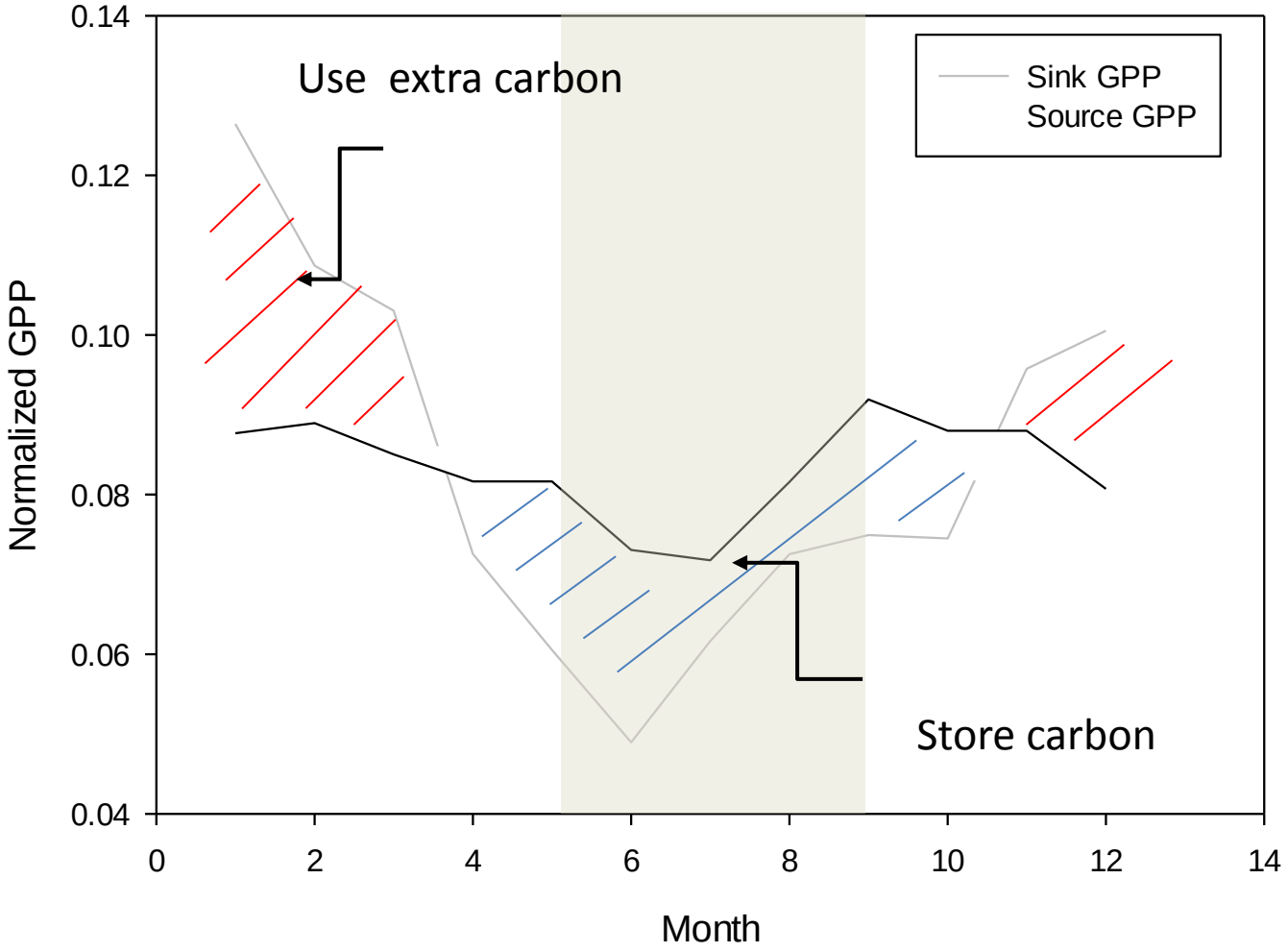
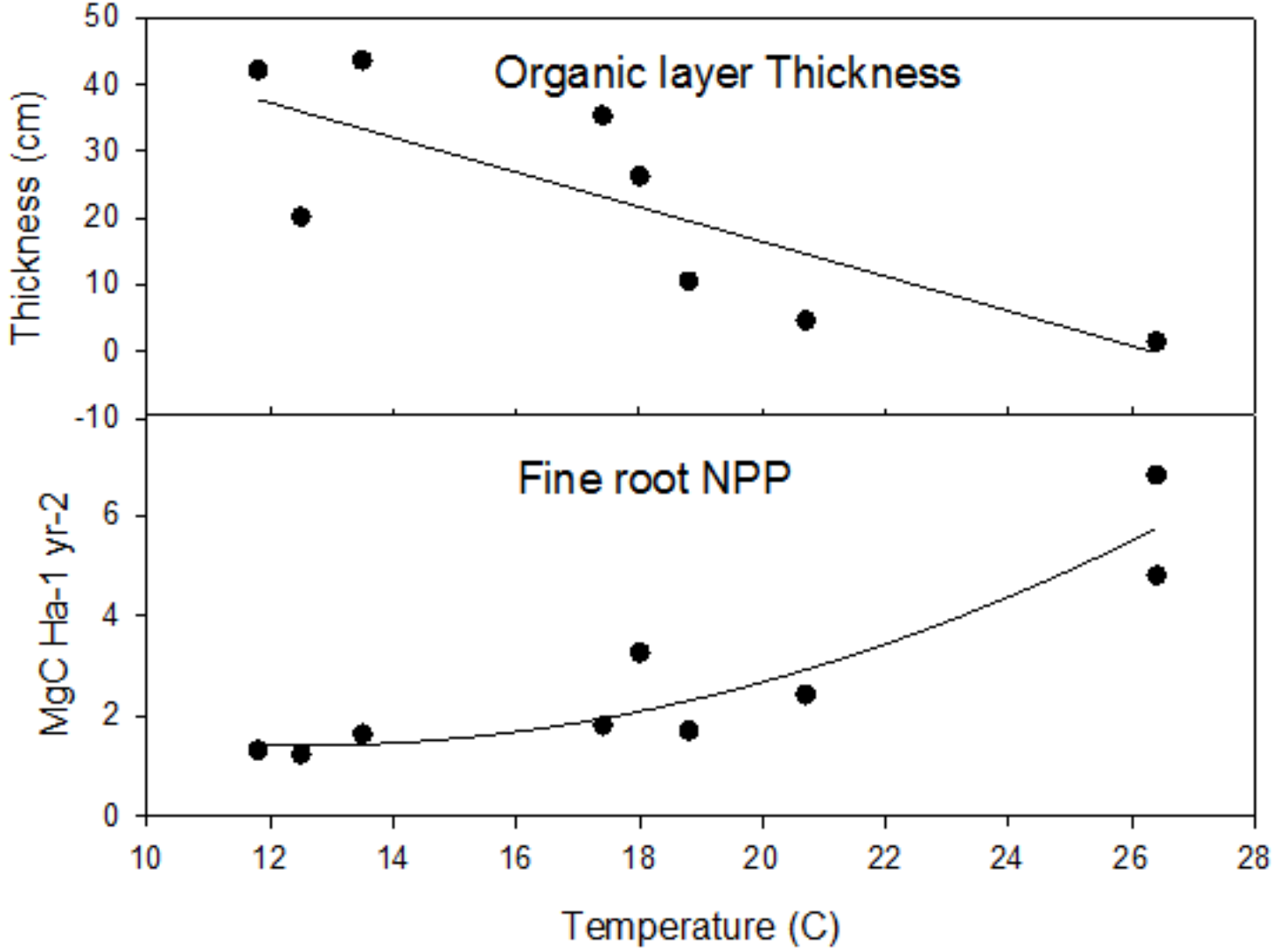


How else can we use the data from the elevation transect

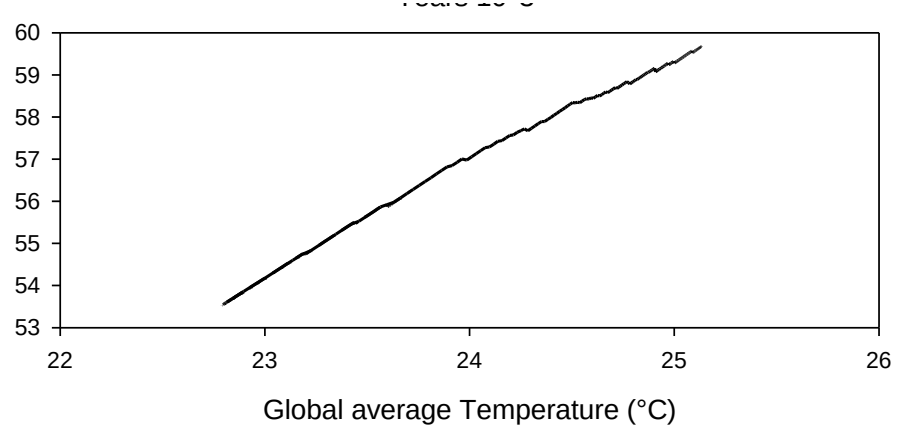
- Over the past few years we have collected very good root NPP and organic layer depth data
- Root weathering can control long term global climate through silicate rock weathering
- If roots grow in the organic layer they do not grow in the mineral layer and they do not weather the rock.

How do root growth and organic layer depth change with temperature?



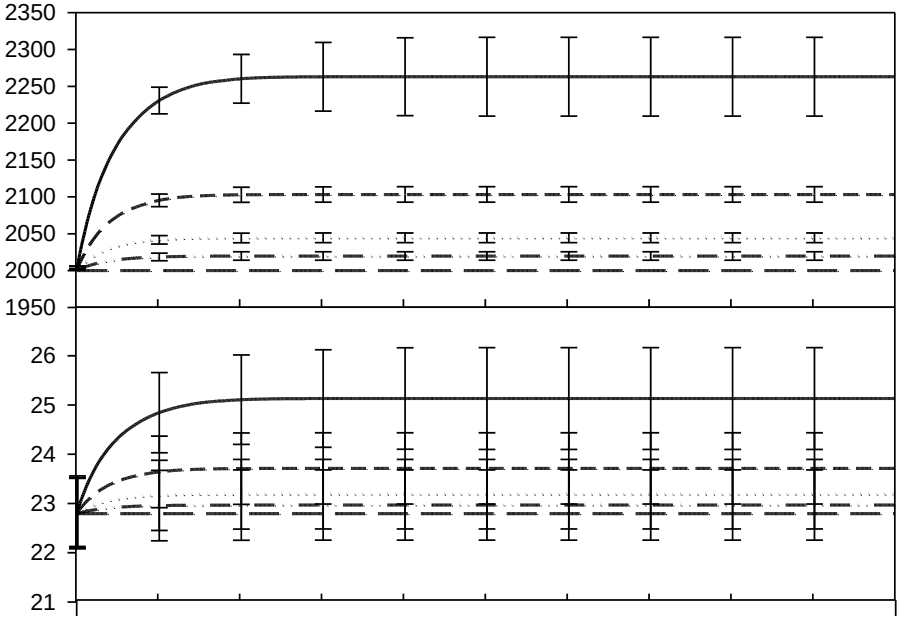
Put these results in a simple climate model.

Weathering rate ppm/1000 years



CO2 (ppm)

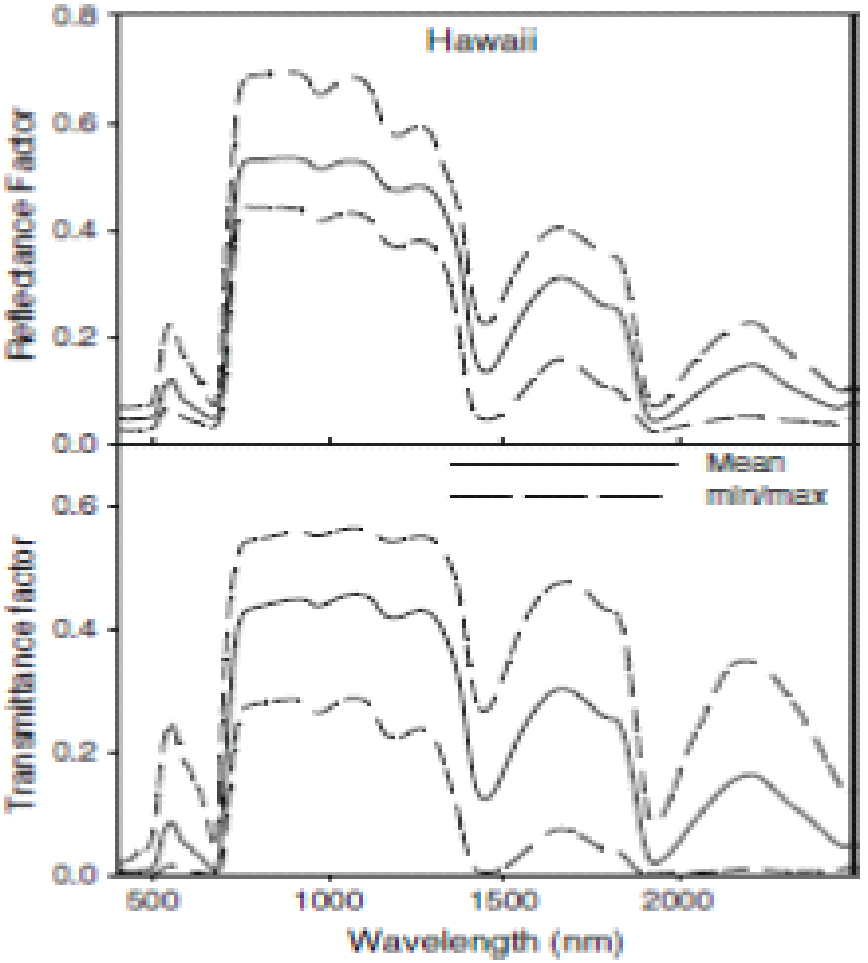
Temp (C)



Time (years 100,000 years)

Spectranomics

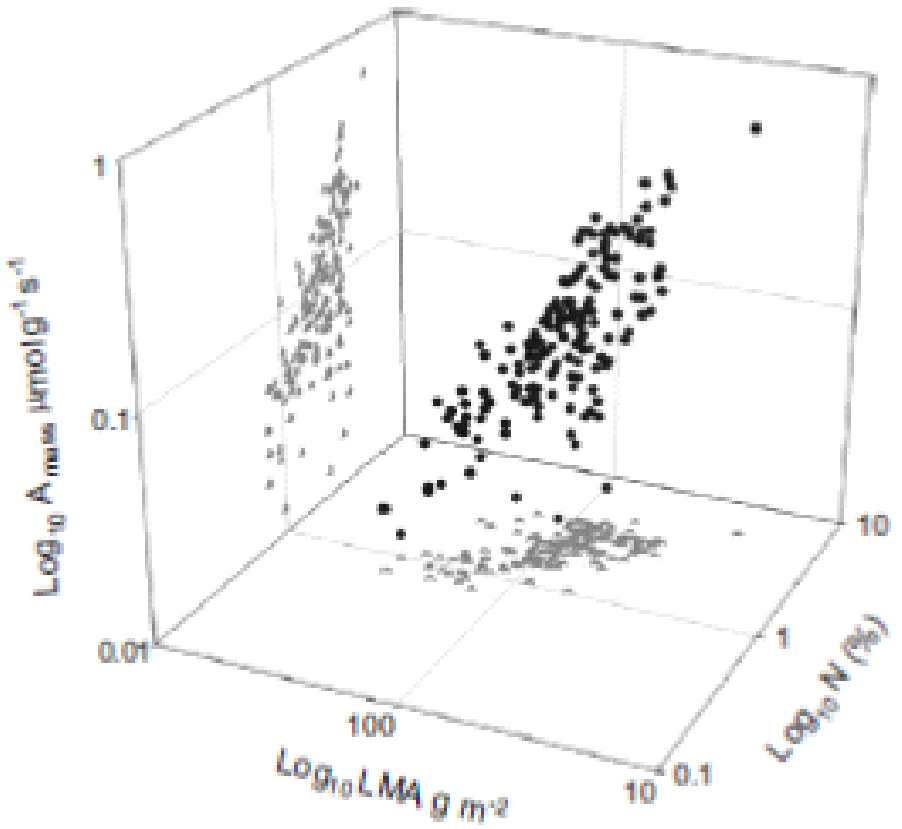
Use the full integrated spectrum to understand canopy chemistry and physiology



Doughty et al 2010

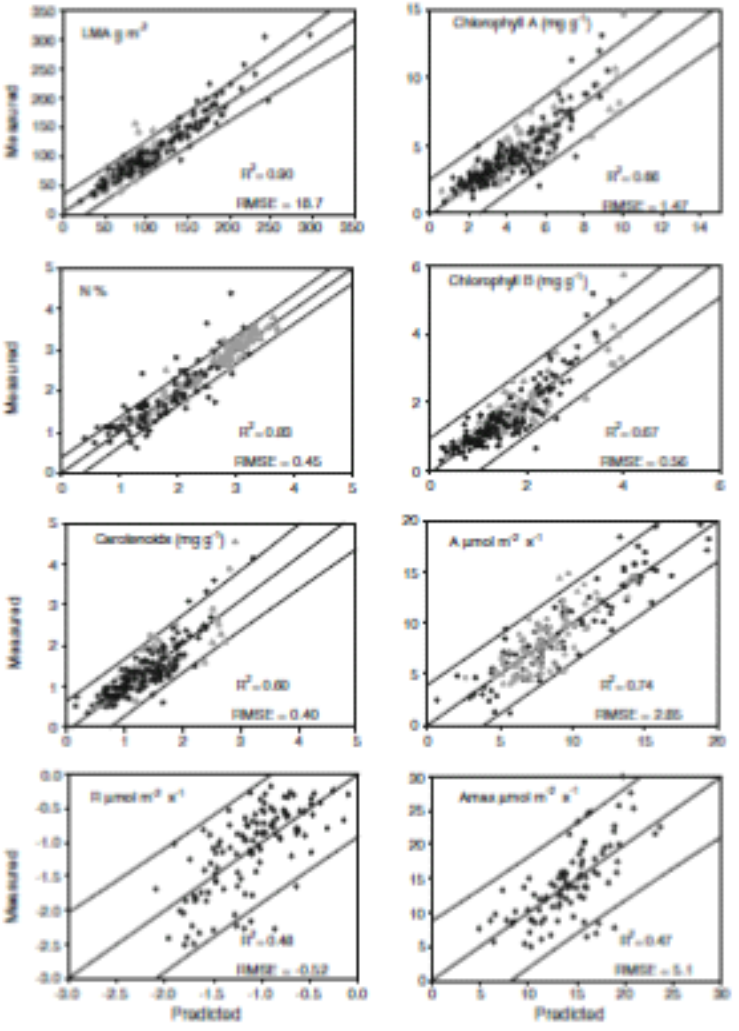
Leaf economics spectrum

LMA and leaf nitrogen can indicate photosynthetic capacity



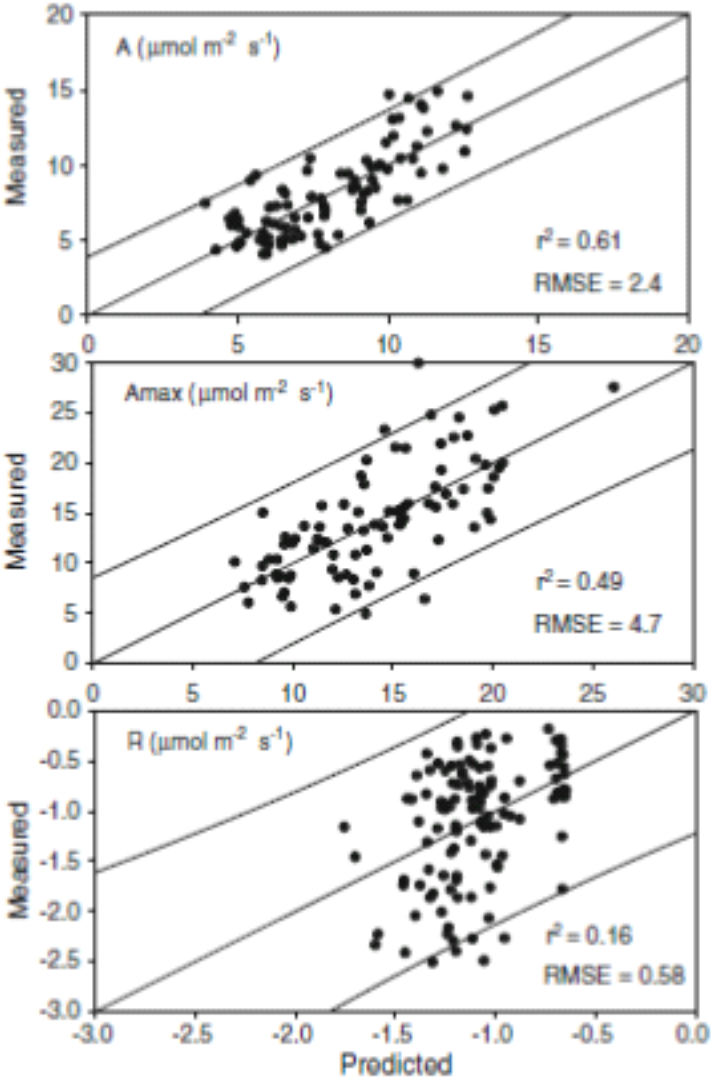
Leaf level regressions

Strong regressions for nutrients and maximum photosynthetic capacity.



Do the relationships work at the canopy level?

Simulated canopy spectra show good correlations for physiology.




Thank you