Soils, Roots, Water Stress in Amazonia

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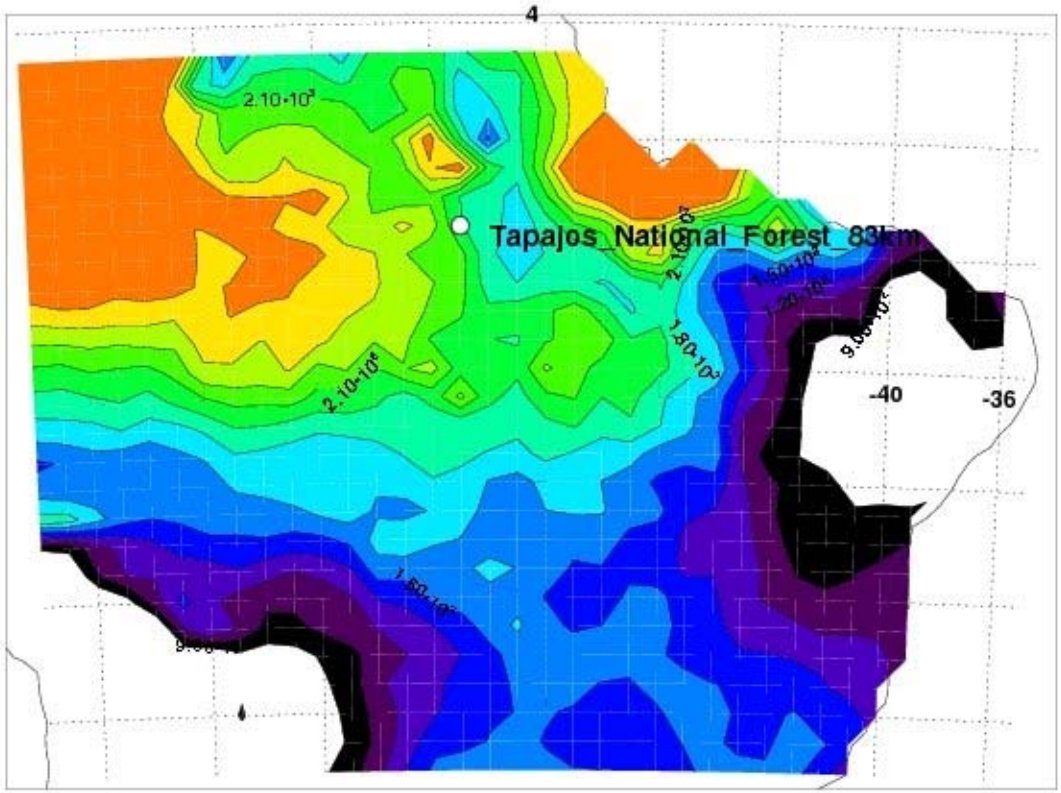
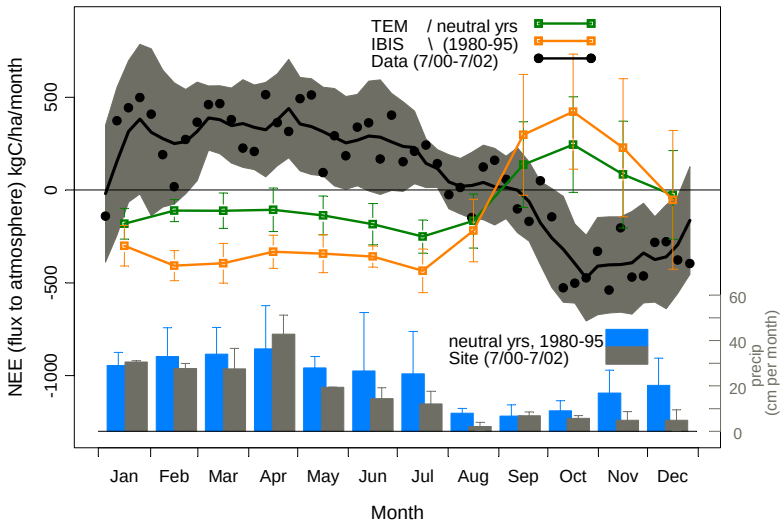
Amazonia: Site location

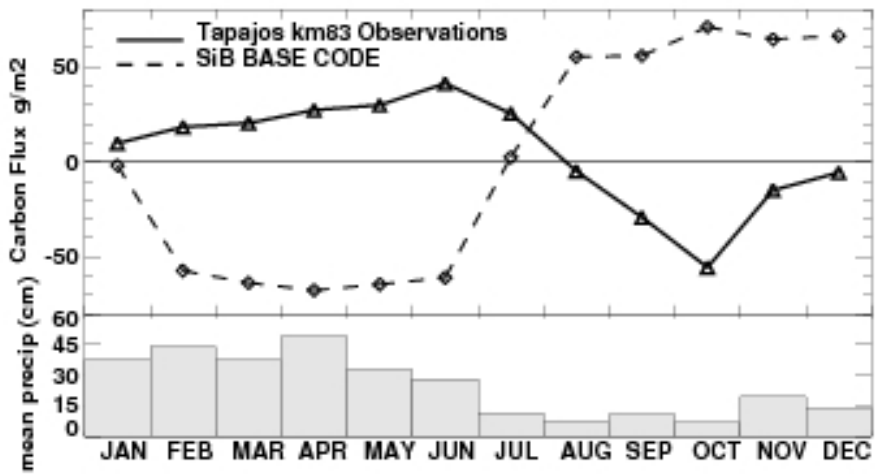


- Evergreen broadleaf (closed canopy)
- ~1600 mm precip annually

How well do the models do?



Model output is mean of 4 gridpoints: -54.5 > longitude > -55.5, -2.5 > latitude > -3.5, for neutral years 1980-81,1984-85,1990, & 1993-95.
Data is from Tapajos, km67 site (2.85 S, 55 W, from 10-Apr-01 to 08-May-02) & km83 site (3.05 S, 55 W, from 1-Jul-00 to 1-Jul-01).



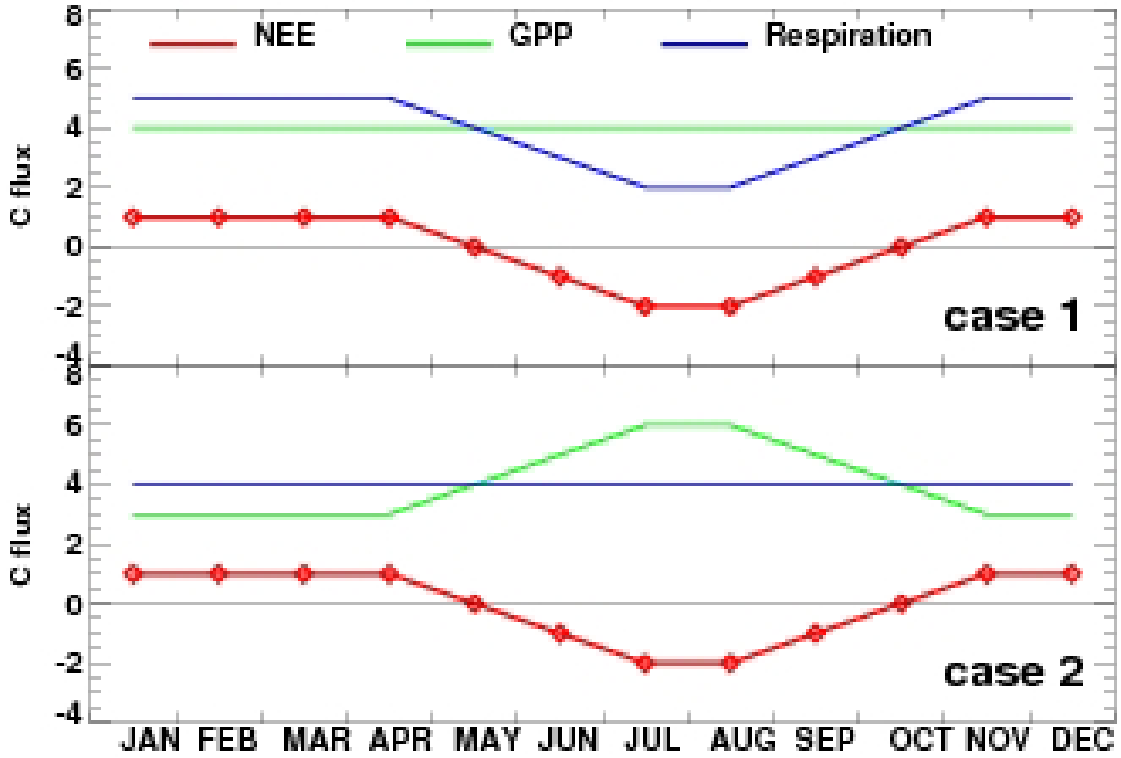
Saleska et al., 2003

SiB3

What mechanisms has the forest evolved to enable survival through annual drought?

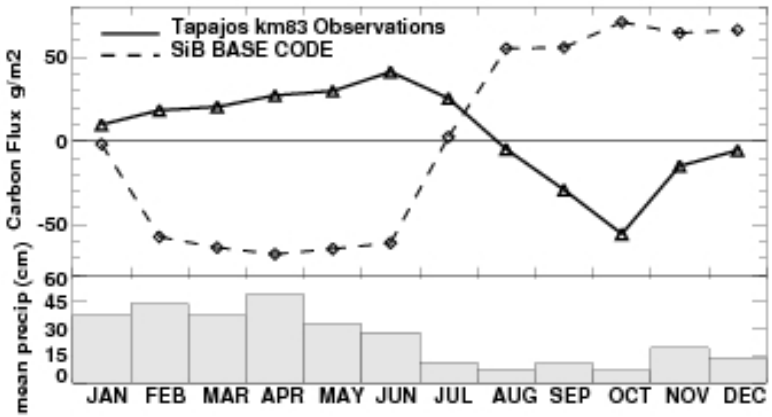
- Deep soil provides large reservoir for water storage
- Deep roots can access stored water
- Hydraulic Redistribution can move water to surface, enhance inflow
- Light response during dry season

Conceptual Model



Model Photosynthesis

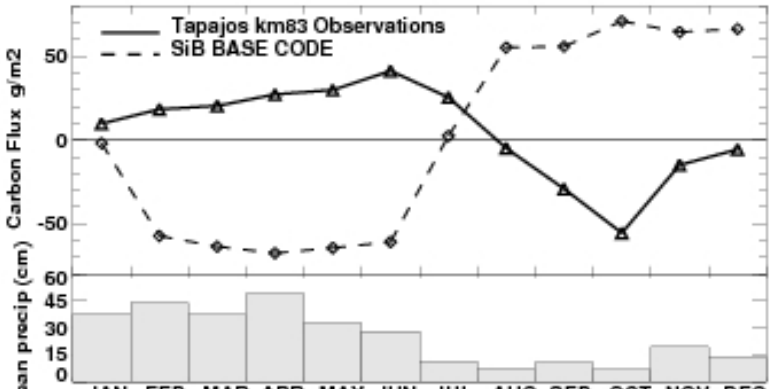
- Initial calculation: soil water stress on PSN
- Subsequent: remove water from soil

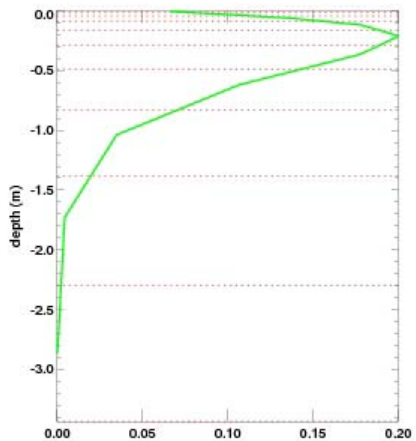


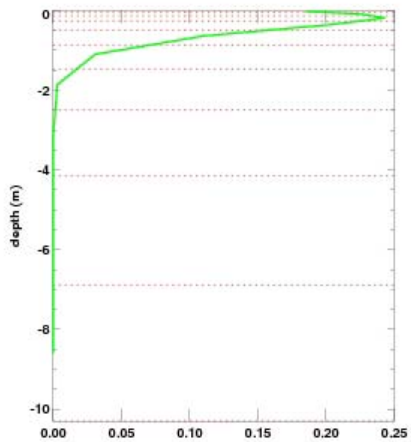
$$stress = \sum_{i=1}^{nsoil} \left(\frac{1 - \frac{\theta_{wp}}{\theta_i}}{1 - \frac{\theta_{wp}}{\theta_{fc}}} \right) (rootf_i)$$

Model Photosynthesis: Deeper Soil?

- Using this stress formulation, increasing soil depth from 3.5 to 10 meters has almost no effect







Modifications to SiB

- Relax the link between photosynthesis stress and root fraction: look at a column-total stress amount

$$stress = \frac{(1 + wssp)\frac{w_{column}}{w_{max}}}{wssp + \frac{w_{column}}{w_{max}}}$$

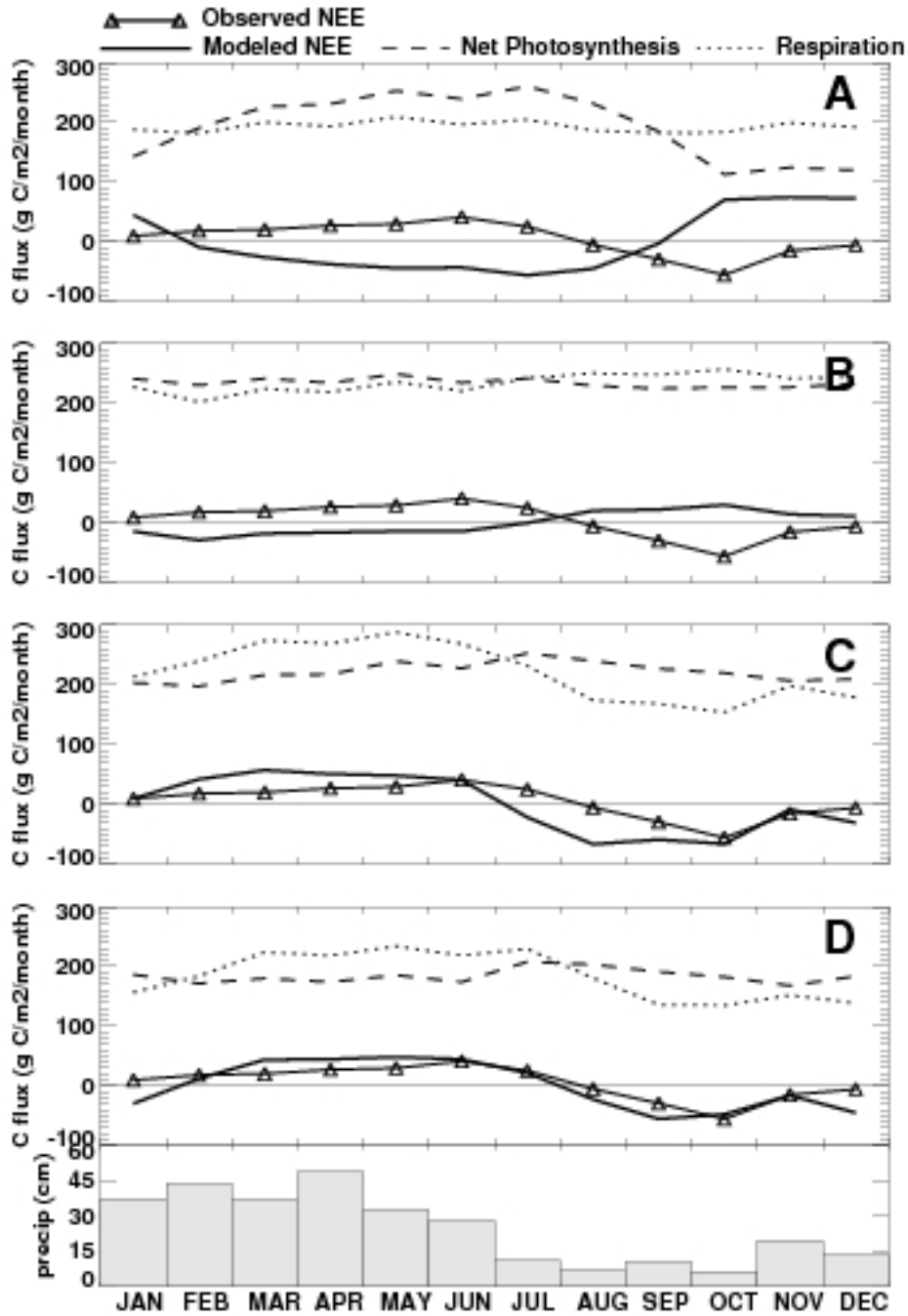
Modifications to SiB

- Adjust root fraction for transpiration removal. Take the water from where it resides

$$rootr_i = \left(\frac{1 - \frac{\theta_{wp}}{\theta_i}}{1 - \frac{\theta_{wp}}{\theta_{fc}}} \right)$$

Sensitivity Studies

1. Relaxed stress calculation
2. Hydraulic Redistribution
3. Deep Soil with Relaxed Stress Calculation
4. Light Response
5. Combination


Observed NEE
Modeled NEE
Net Photosynthesis
Respiration
A
B
C
D
C flux (g C/m2/month)
300
200
100
0
-100
precip (cm)
60
45
30
15
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Conclusions

- Linking stress/transpiration directly to root fraction won’t work, no matter how deep you make the soil
- Relaxed stress calculation won’t work if the soil isn’t deep enough
- Roots need to be able to reach deep into the soil
- Respiration response to soil conditions plays a large role in determining NEE cycle