

An aerial photograph of a vast, dense tropical rainforest. A dark, winding river flows through the center of the forest, reflecting the sky. The forest canopy is a rich, textured green, extending to the horizon under a cloudy sky.

The Land Surface: Recent Research and Applications to MMF

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Colorado State University
Atmospheric Science Department

A satellite image of Earth's ocean surface, showing a large cyclone or storm system in the upper left quadrant. The image displays intricate cloud patterns and ocean surface features, including a prominent spiral structure. The text "CMMAP Research So Far..." is overlaid on the right side of the image.

CMMAP Research So Far...

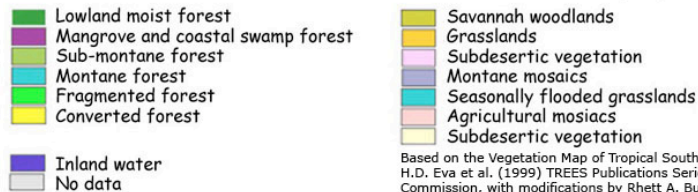
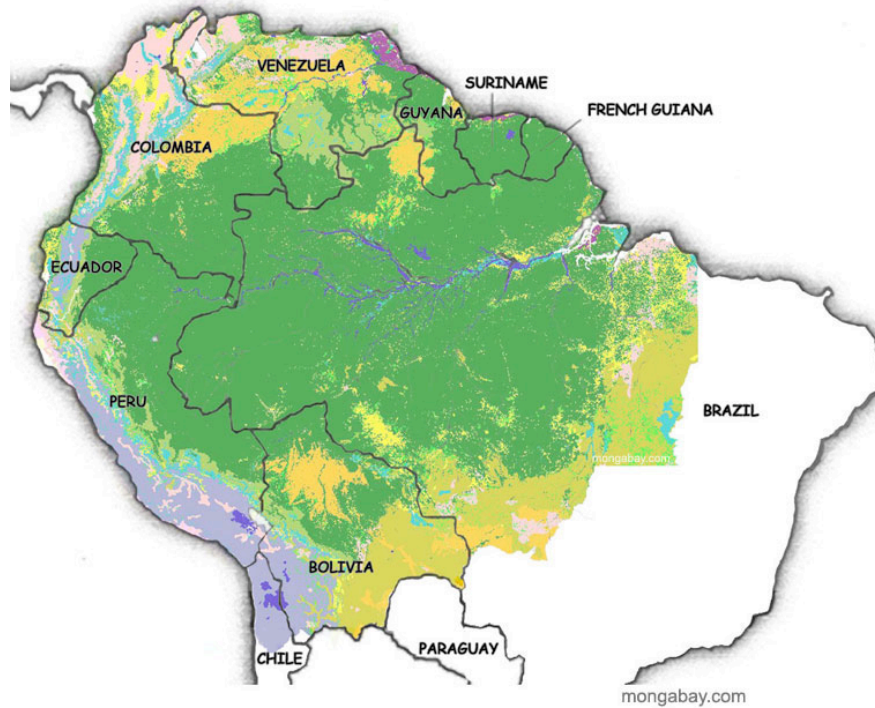
- Emphasis in CMMAP has been on Marine Systems
- Surface Fraction
- Heterogeneous

An aerial photograph of a dense tropical rainforest. A dark, winding river flows through the center of the forest, reflecting the sky. The forest is a vibrant green, with varying shades indicating different tree species and canopy heights. The overall scene is lush and expansive.

Why Do We Care About the Surface?

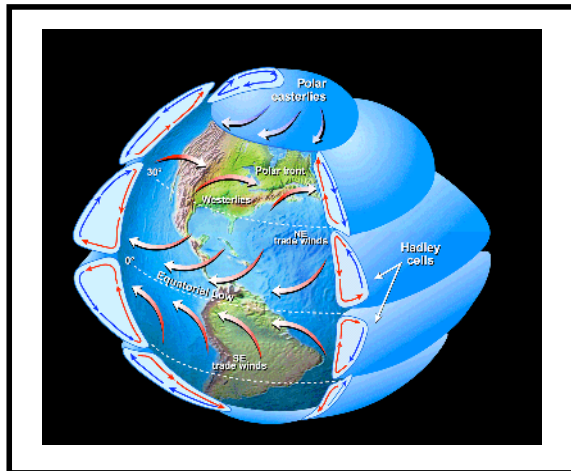
- Land: Lower Boundary for 25% of the global atmosphere
- Land has greater than 25% contribution
 - Irregular distribution
 - Circulation (topography)
 - Carbon
 - Heterogeneity

Tropics: Amazon Basin



Based on the Vegetation Map of Tropical South America,
H.D. Eva et al. (1999) TREES Publications Series, European
Commission, with modifications by Rhett A. Butler / mongabay.com

- Hadley Cell/Energy Transport
- Forest Conversion?
- Light Limited/Water Limited?
- Do we know?

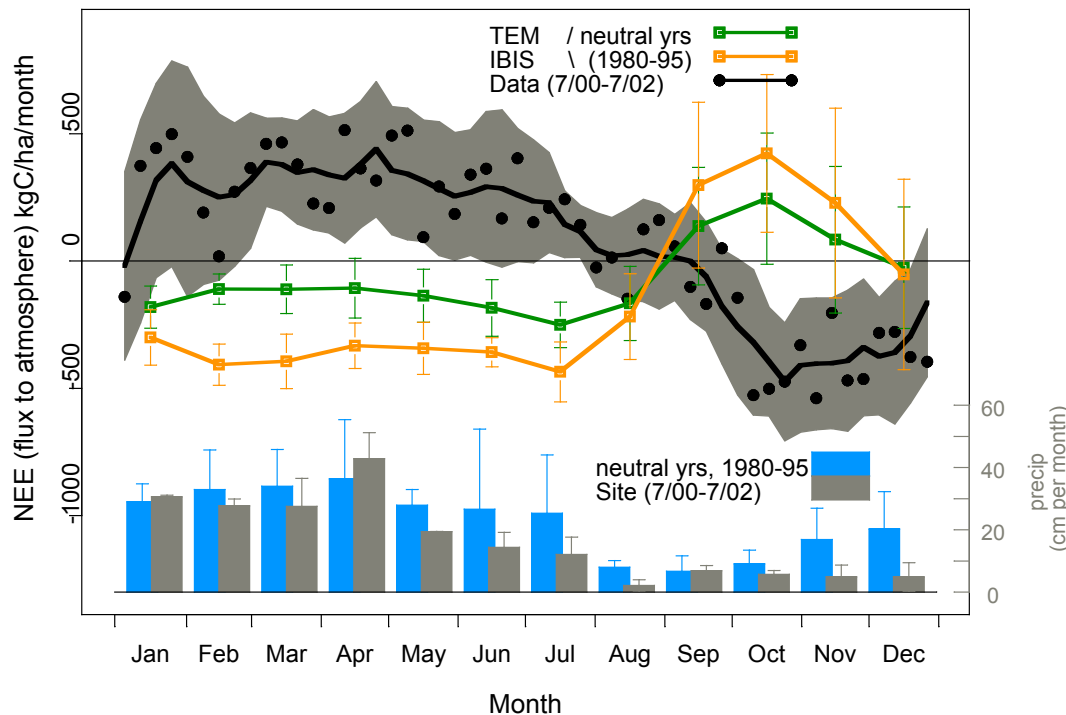


Amazon Basin: Seasonality



- temperature variability: minimal
- seasonality in precipitation
 - ITCZ
- Dense Vegetation: couples energy budget to canopy

Do our Models Reproduce Observed Seasonality?

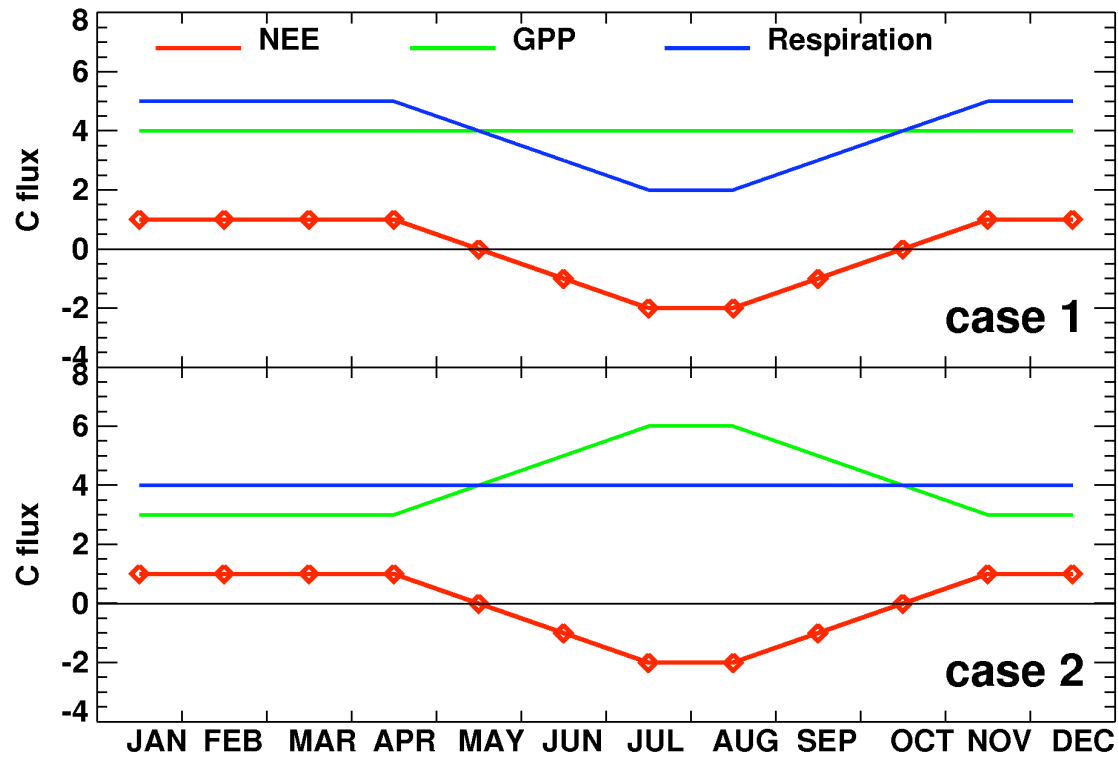


Model output is mean of 4 gridpoints: $-54.5 > \text{longitude} > -55.5$, $-2.5 > \text{latitude} > -3.5$, for neutral years 1980-81, 1984-85, 1990, & 1993-95. Data is from Tapajos, km67 site (2.85 S, 55 W, from 10-Apr-01 to 08-May-02) & km83 site (3.05 S, 55 W, from 1-Jul-00 to 1-Jul-01).

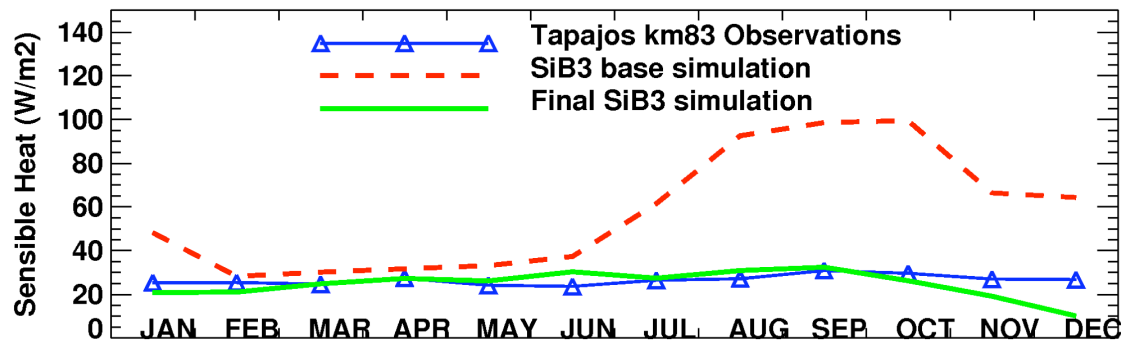
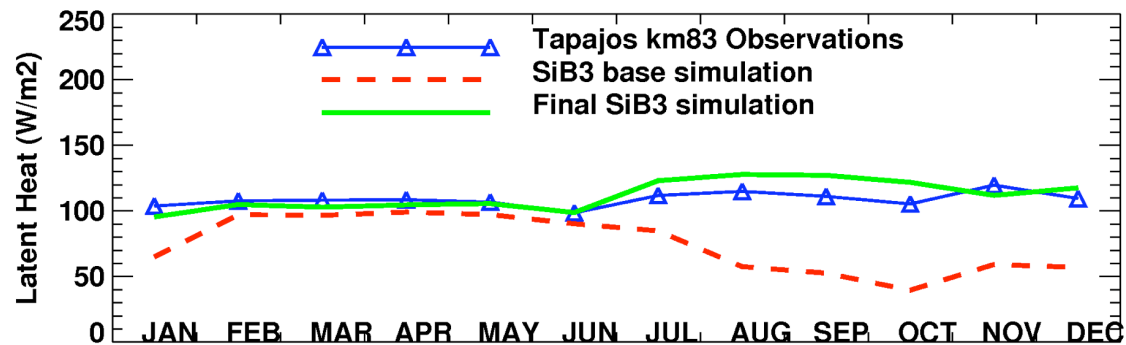
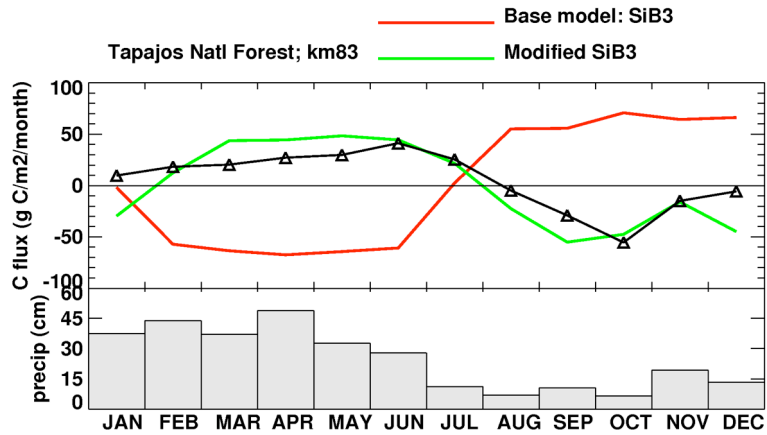
- Carbon Flux?
Not Really...
- Remember: Tight coupling between vegetation and Energy Fluxes
- Mechanisms?

From Saleska *et al*, 2003, *Science*

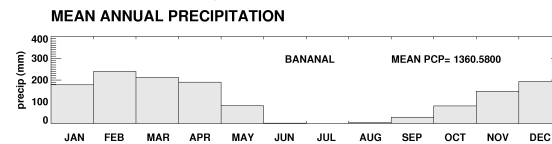
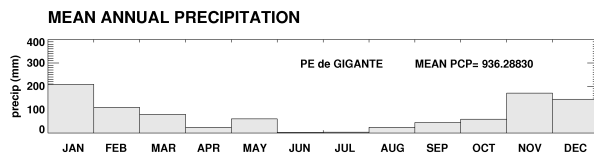
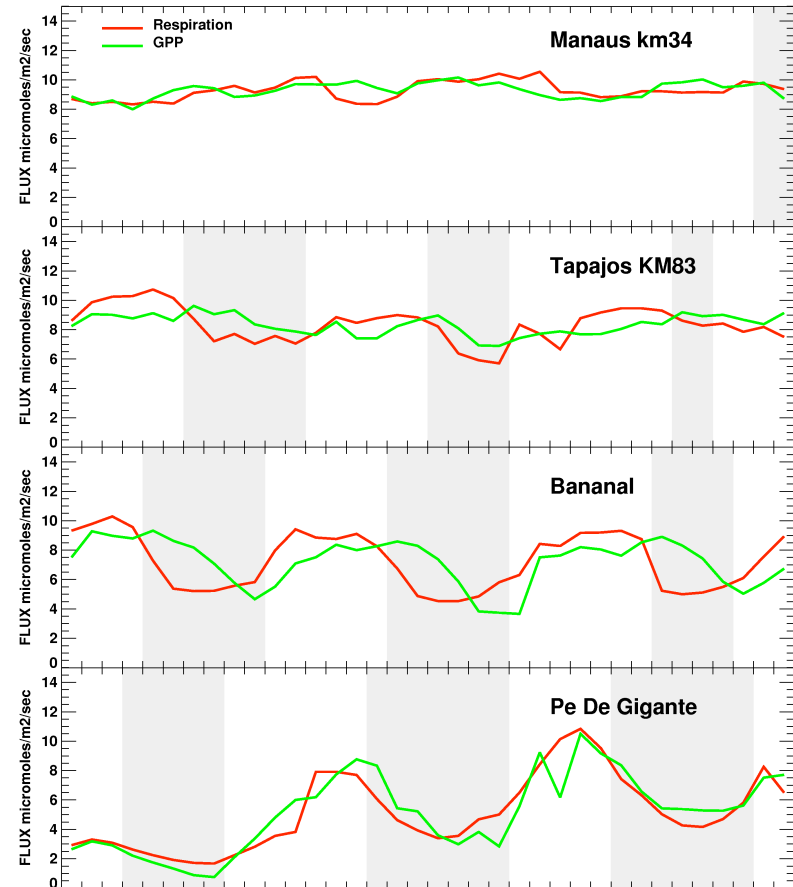
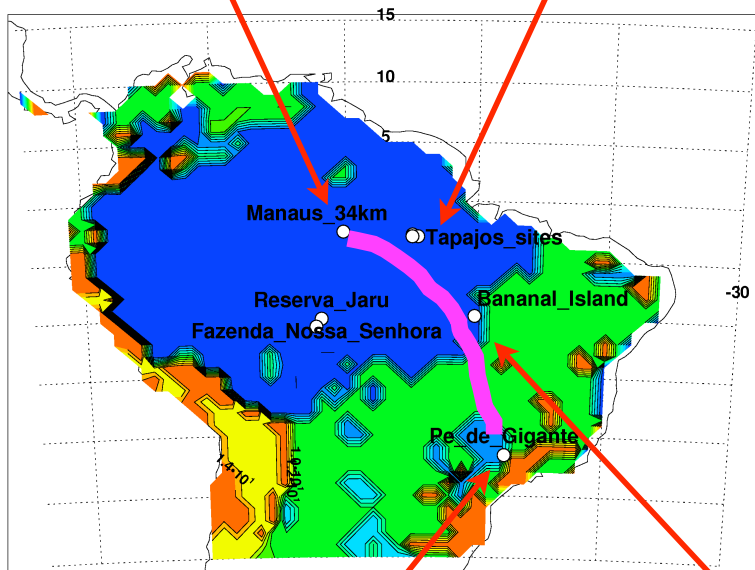
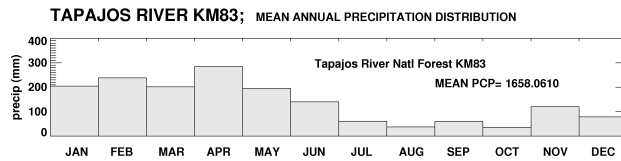
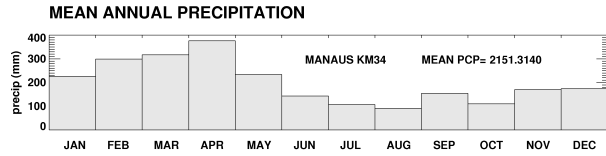
Process Equifinality



What We've Learned...



Regional Behavior

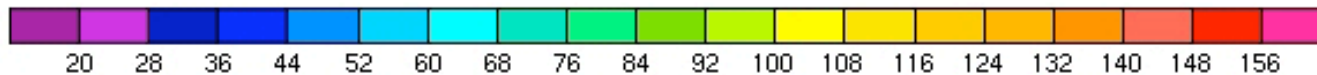
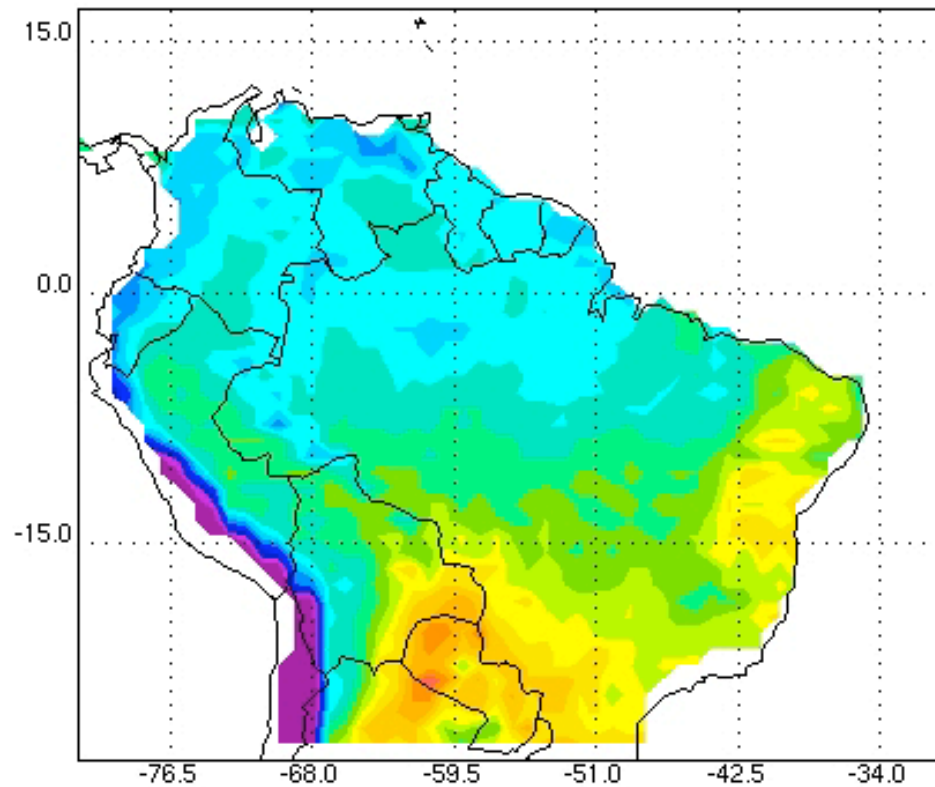


Region: Latent Heat

Oct 17, 2008

LE January

Area Mean = 77.08

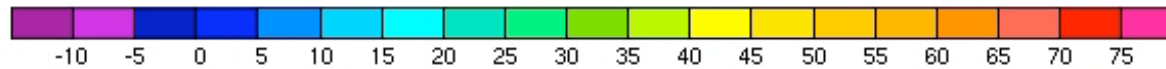
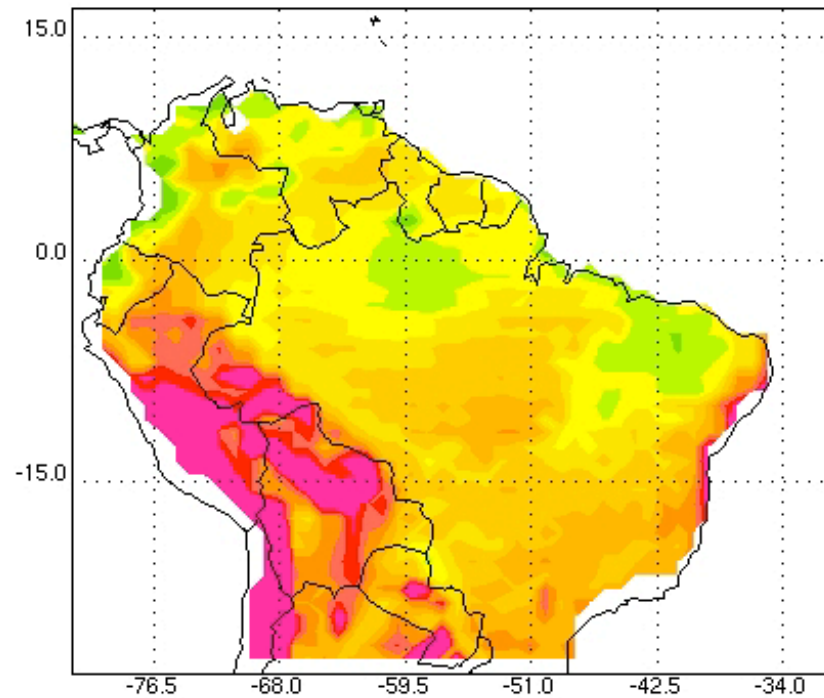


Region: Sensible Heat

Jan 4, 2009

Sensible Heat Flux
January

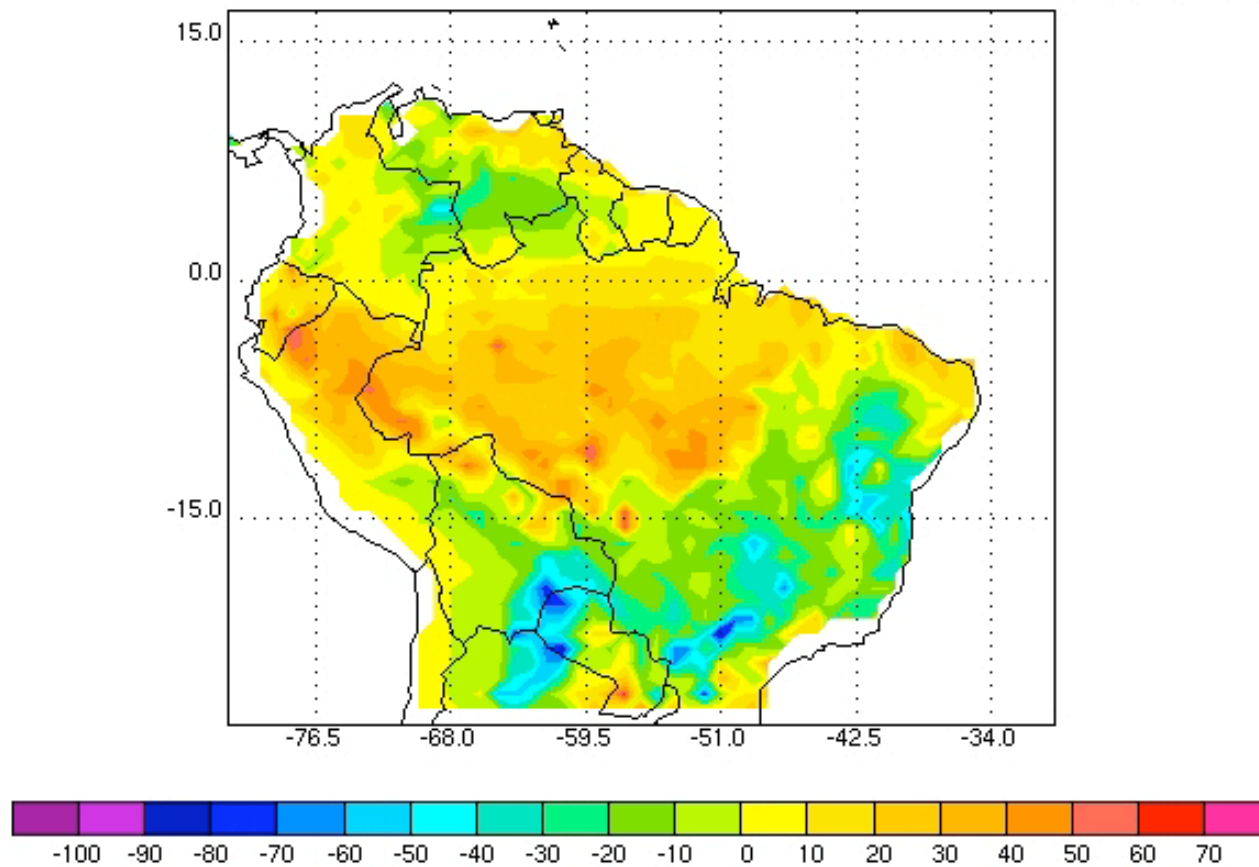
Area Mean = 55.32



Region: Carbon Exchange

NEE January

Area Mean = 2.92





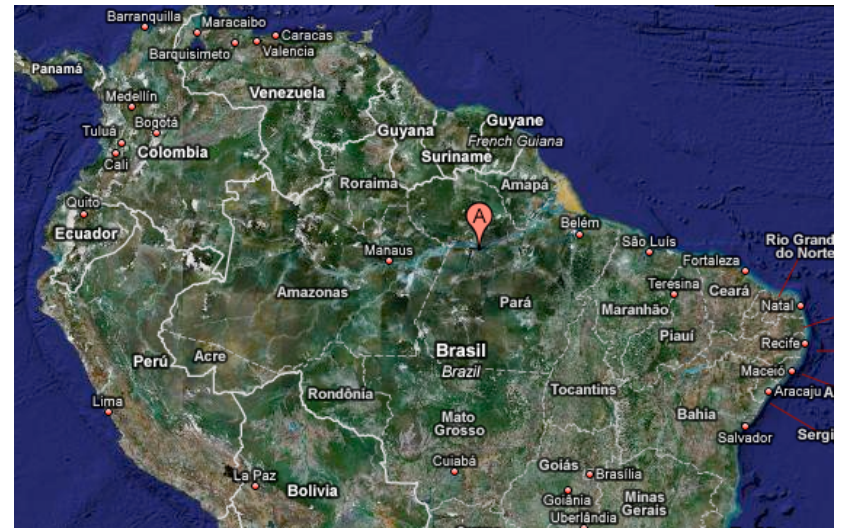
What Do We Learn
When We Couple Our
New Land Features to
the Atmosphere?

What is the affect of land?

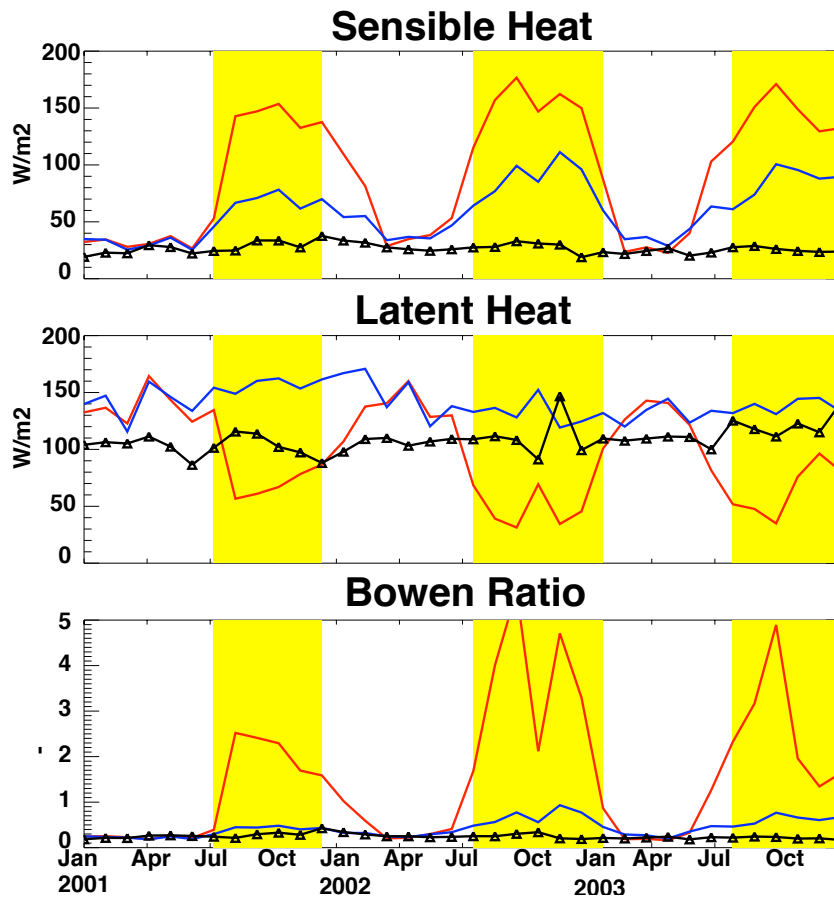
- Improve surface biophysics - what is the effect on the climate?
- “SiB3 Stressed”: The control run - tropical forests are unable transpire through the dry season.
- “SiB3 Unstressed”: Allow deep roots to access soil moisture in tropical forests.

Single Column Model

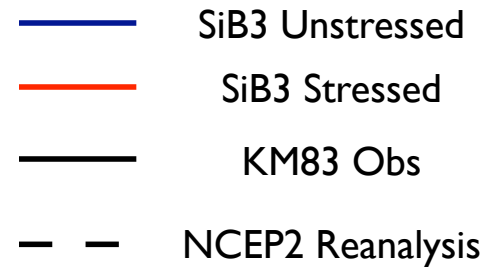
- Simulates the atmosphere of one grid cell centered at 3S, 55W
- Location of flux tower with half-hourly observations from 2000-2004
- Run model 2001-2003
- Same code as global model except a 17 layer atmosphere
- Lateral boundary conditions set w/ “relaxation forcing” using NCEP2 reanalysis



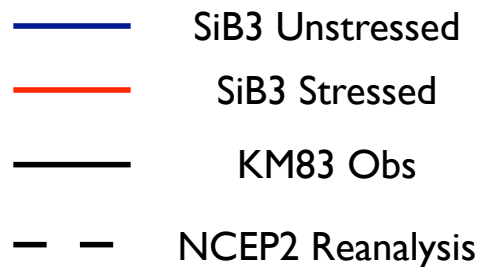
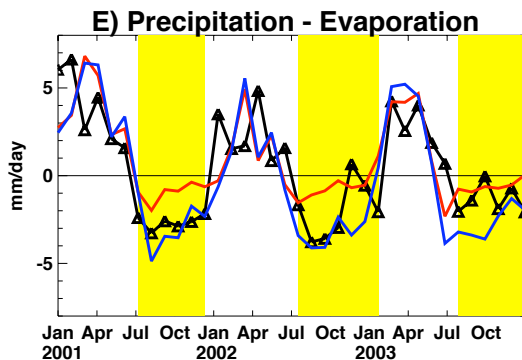
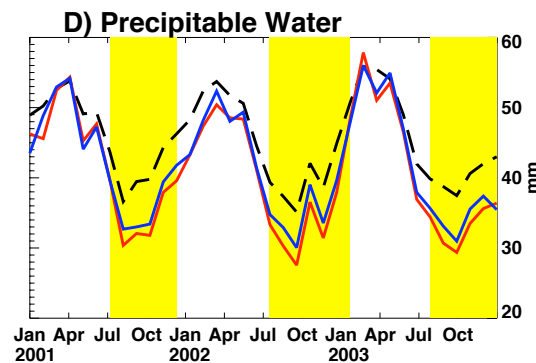
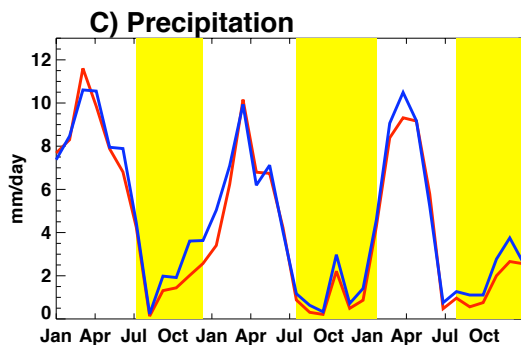
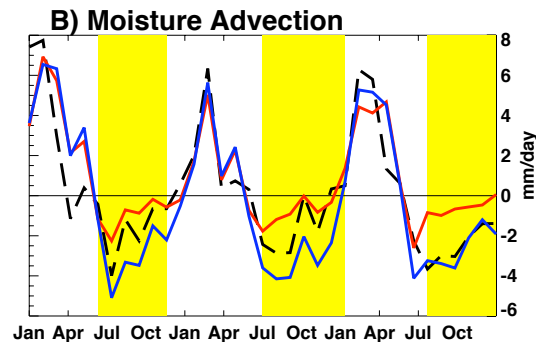
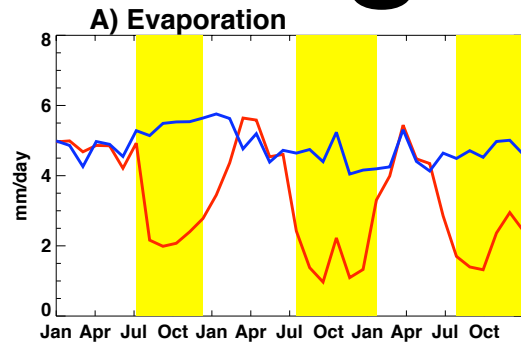
Single Column Model



- It works!
- Improved seasonal cycle



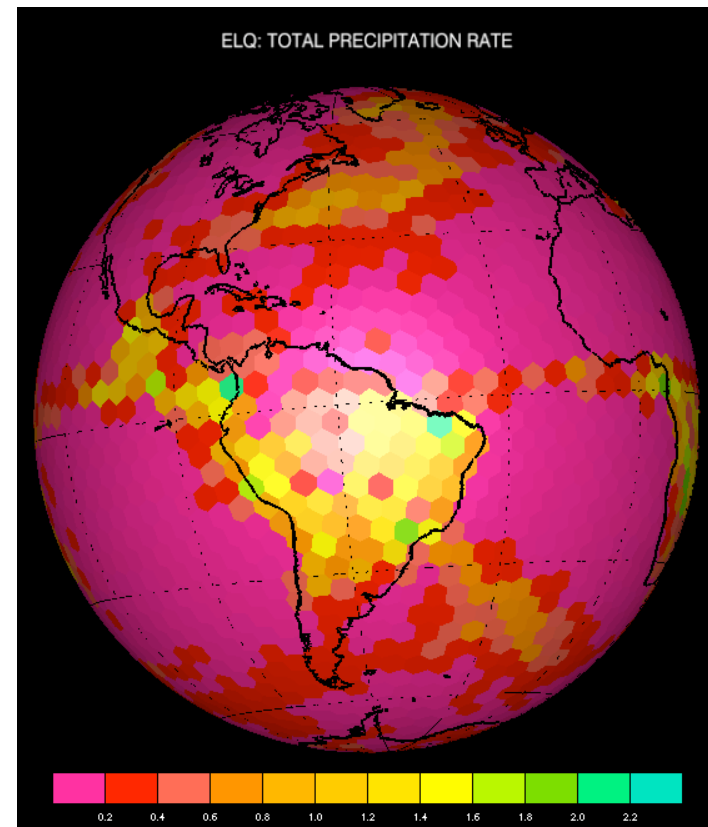
Single Column Model



- Increased hydrologic cycle
- What affects will this have in the full model?

Global Results

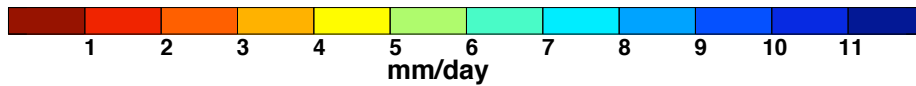
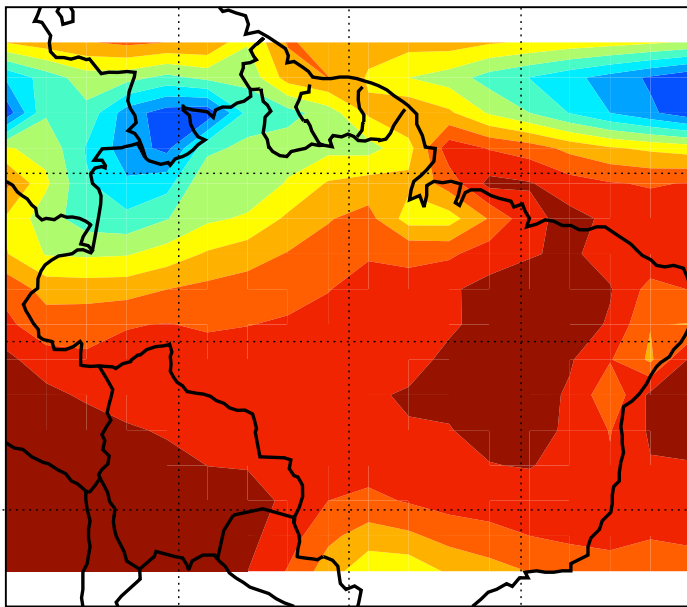
- First run: 2562 resolution (~480 km)
- 3 years to overlap with obs. (2001-2003)
- Climatological SST's



Jan. 2003

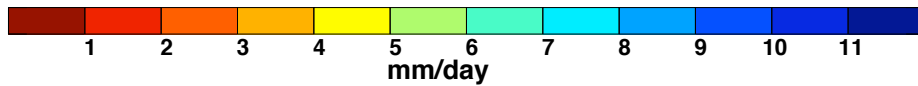
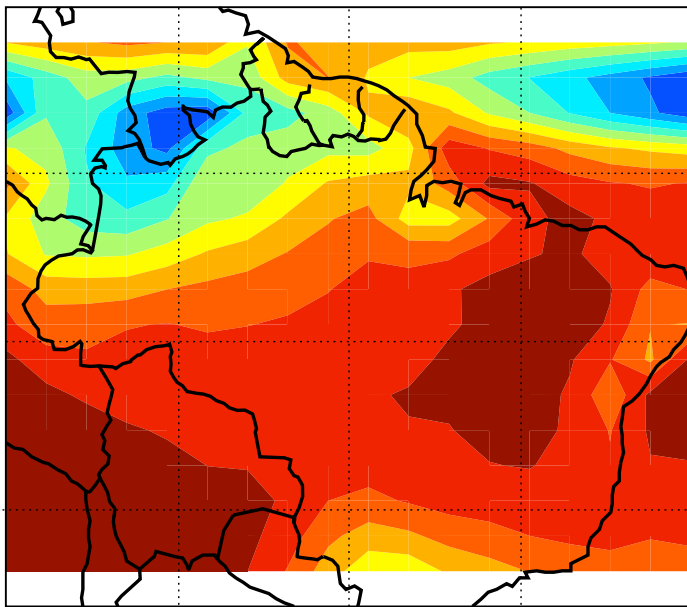
dry season precipitation

GPCP
1979-2007



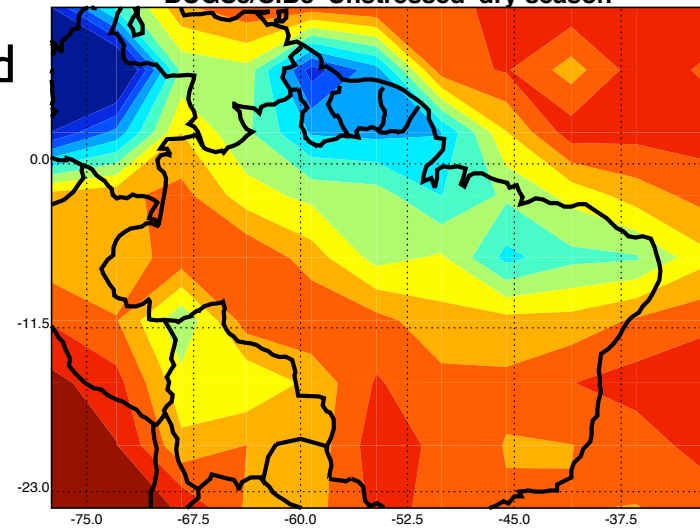
dry season precipitation

GPCP
1979-2007



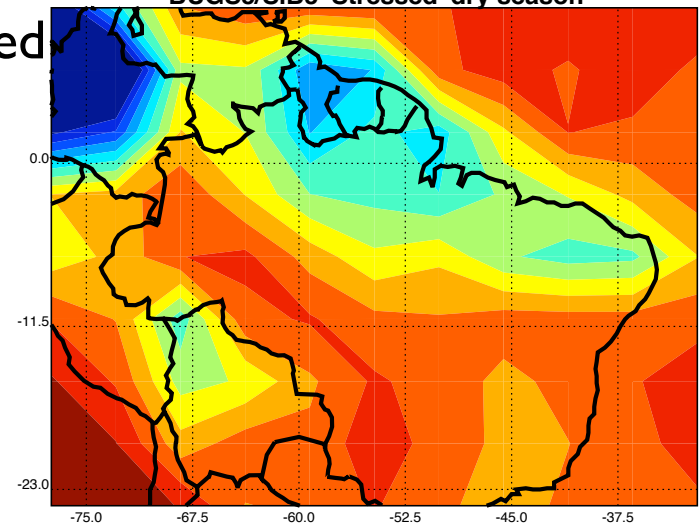
SiB3 Stressed

BUGS5/SiB3 'Unstressed' dry season



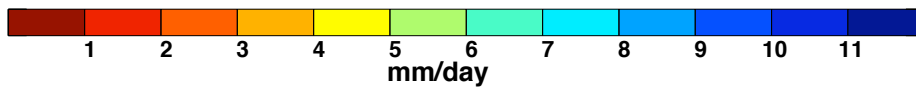
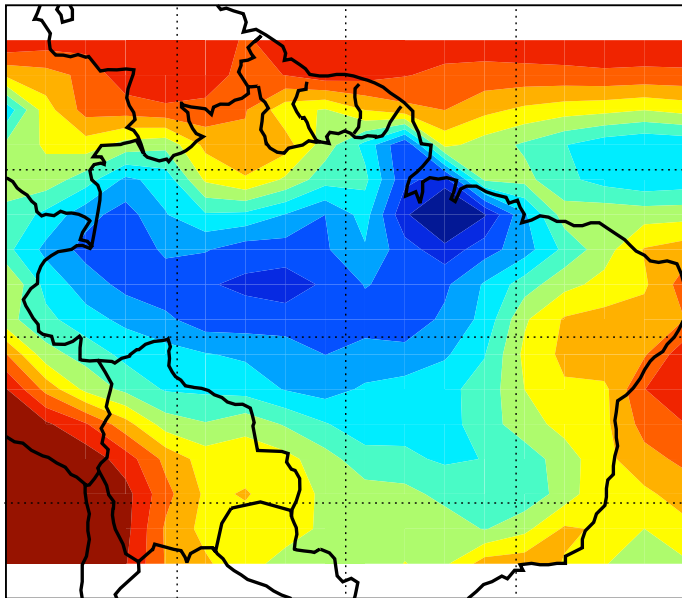
SiB3 Unstressed

BUGS5/SiB3 'Stressed' dry season



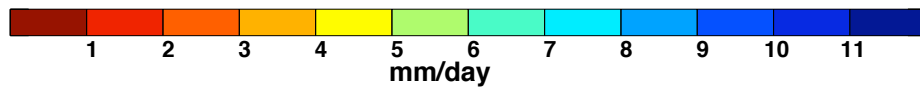
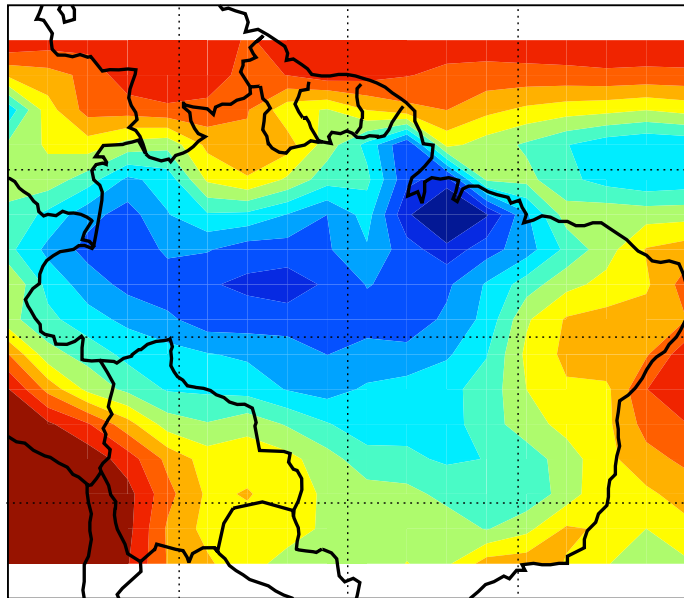
wet season precipitation

GPCP
1979-2007



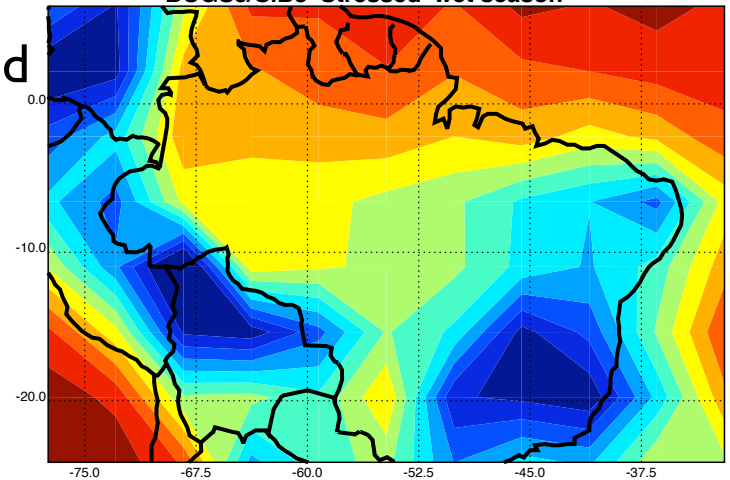
wet season precipitation

GPCP
1979-2007



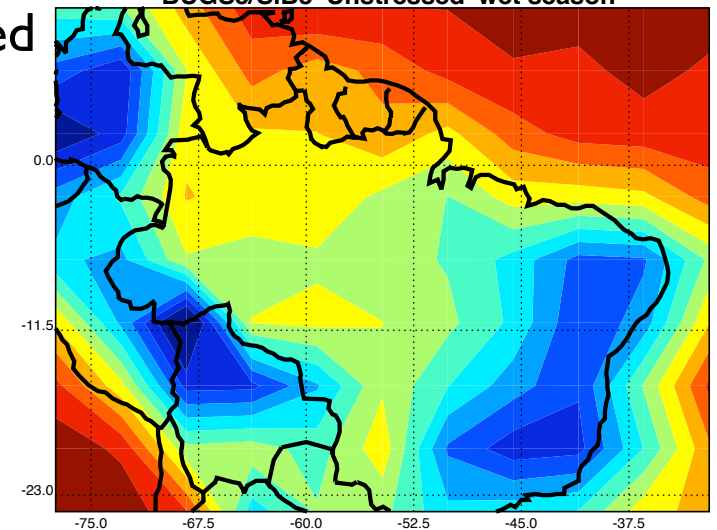
SiB3 Stressed

BUGS5/SiB3 'Stressed' wet season



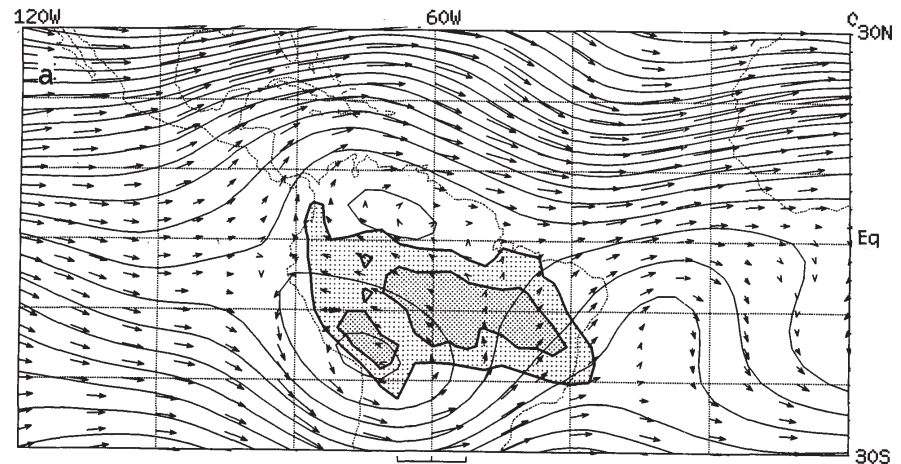
SiB3 Unstressed

BUGS5/SiB3 'Unstressed' wet season



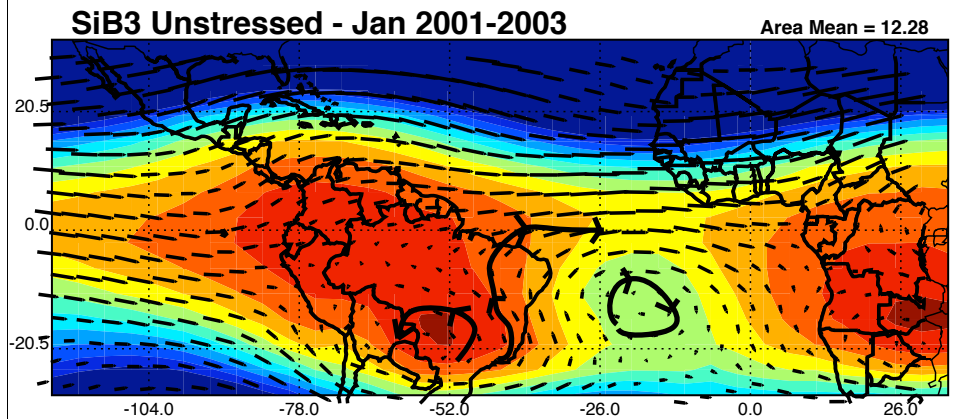
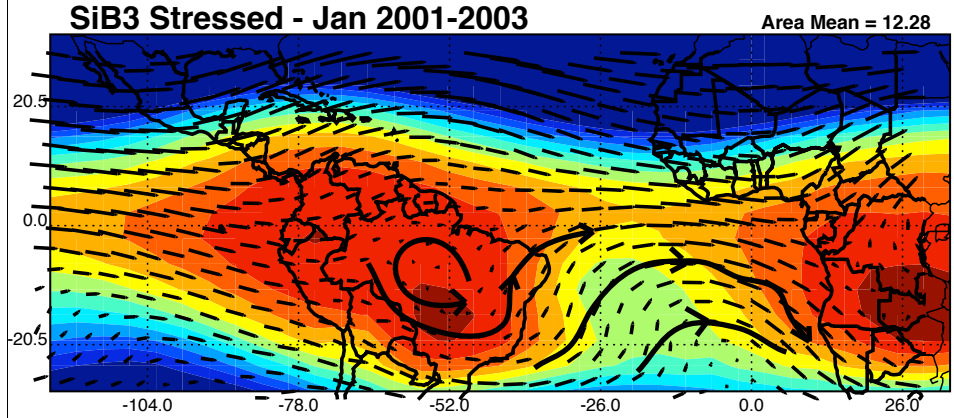
Upper Tropospheric Circulation

Interplay between
Bolivian high and
Amazonian
precipitation - develops
post wet season onset.

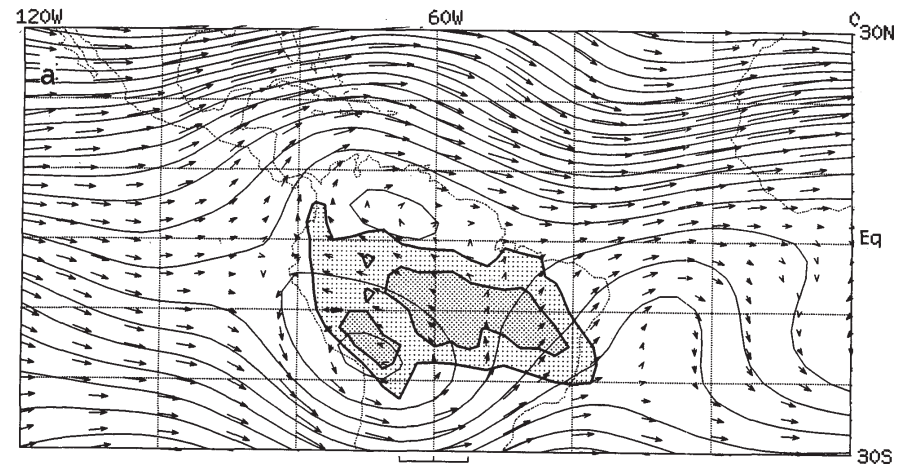
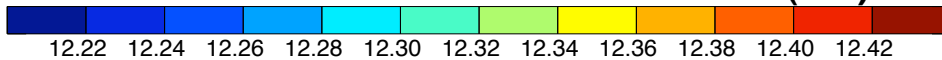


Obs from Horel et al. 1989: Jan 1-5,
1980-1987. 200mb geopotential height,
wind vectors, & OLR

Upper Tropospheric Circulation

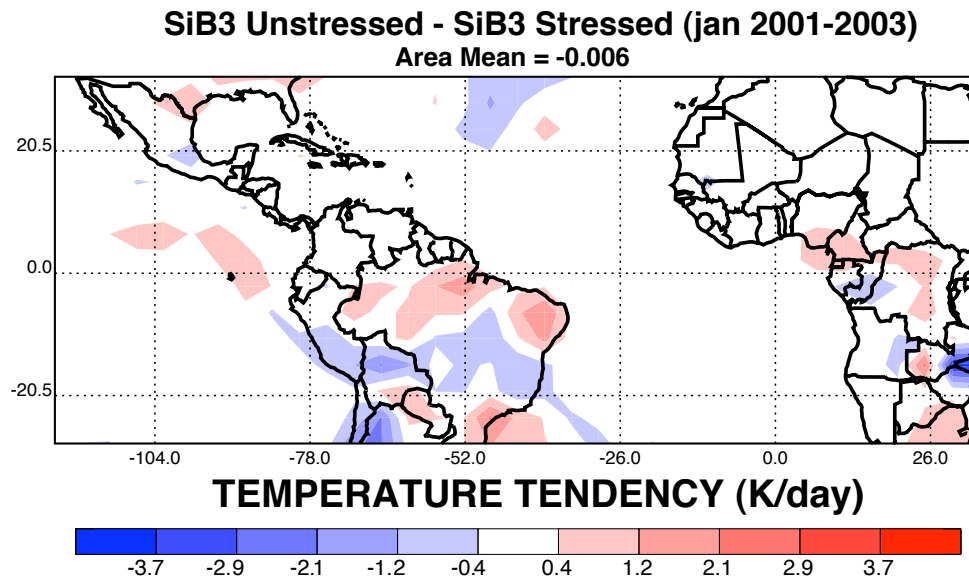


GEOPOTENTIAL HEIGHT at 200 mb (km)



Obs from Horel et al. 1989: Jan 1-5,
1980-1987. 200mb geopotential height,
wind vectors, & OLR

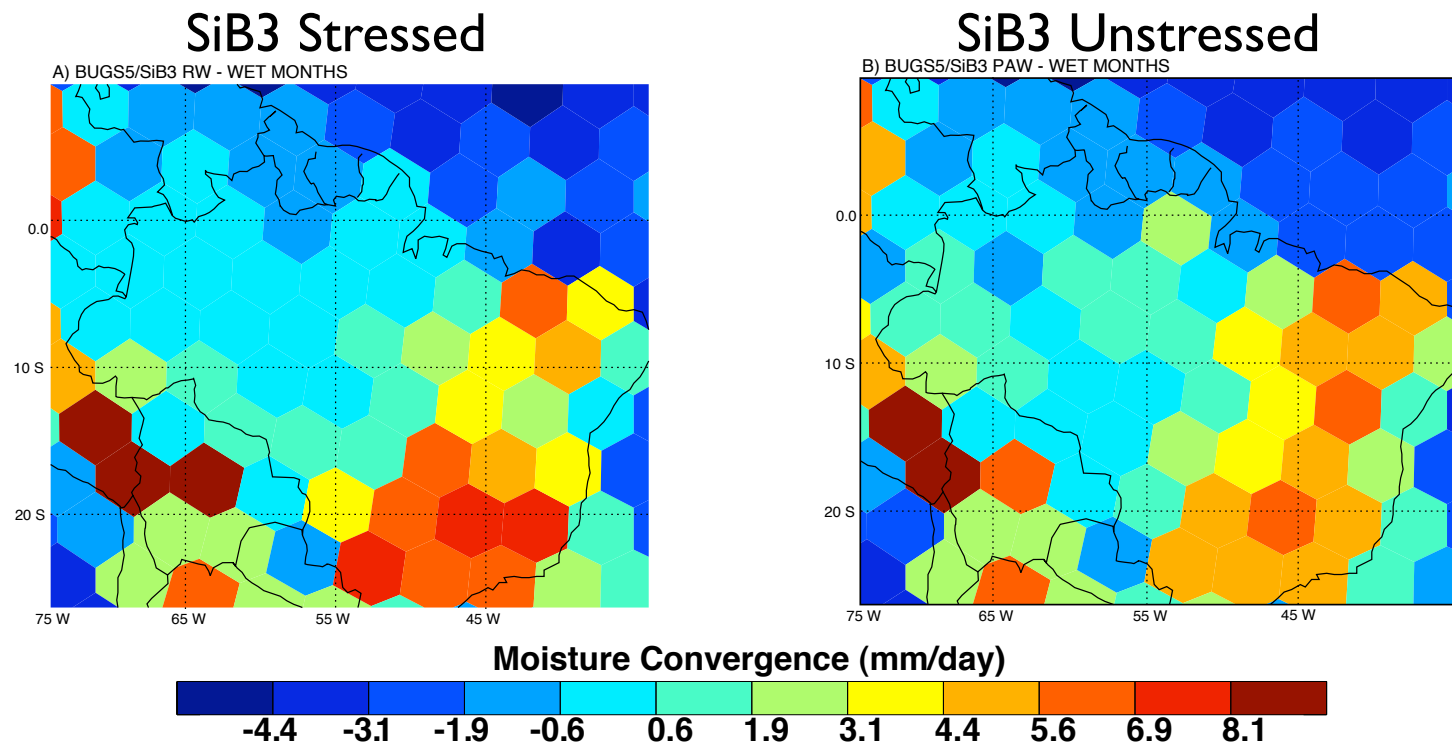
Upper Tropospheric Circulation



- strong convection = strong atmospheric heating
- condensation above Amazon basin influences position of Bolivian high
- circulation around Nordeste low influenced by precipitation in Amazon, SACZ, & Africa

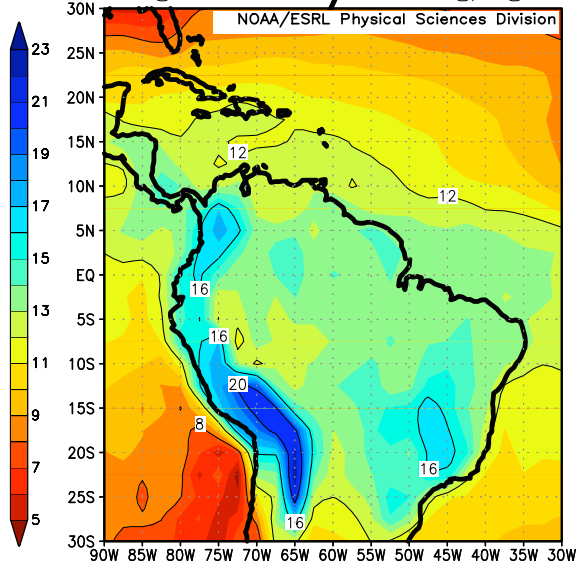
Lenters and Cook 1997; Silva Dias et al. 1983

wet season moisture convergence



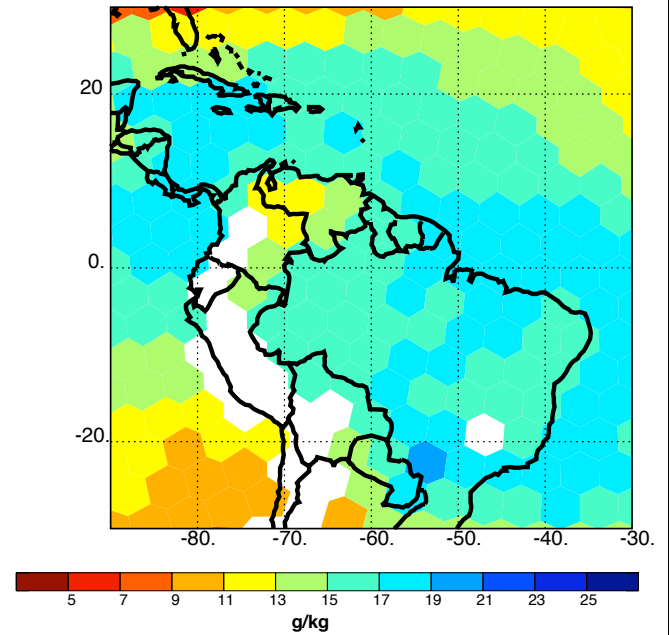
why is wet season precip misplaced?

NCEP Reanalysis - 925 mb

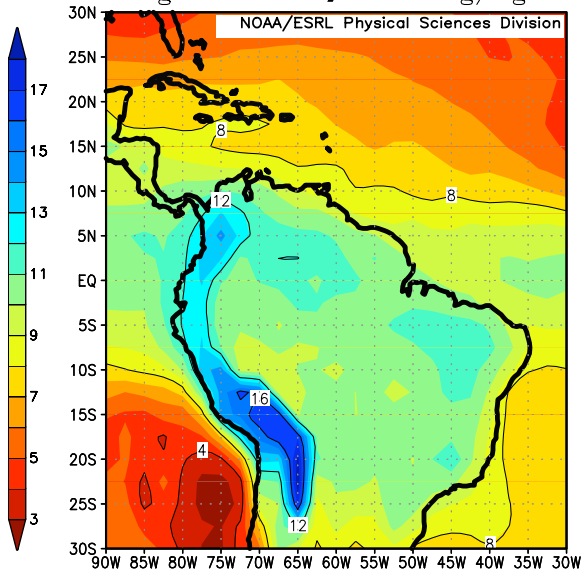


DJF specific humidity

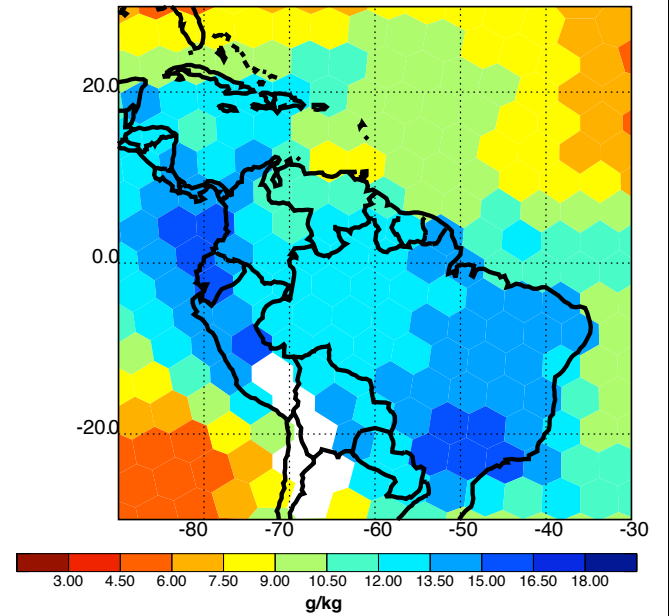
SiB3 Untressed - 925 mb



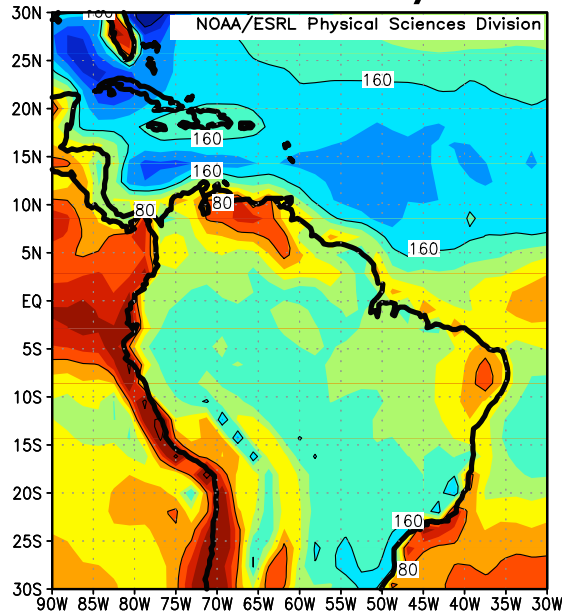
NCEP Reanalysis - 850 mb



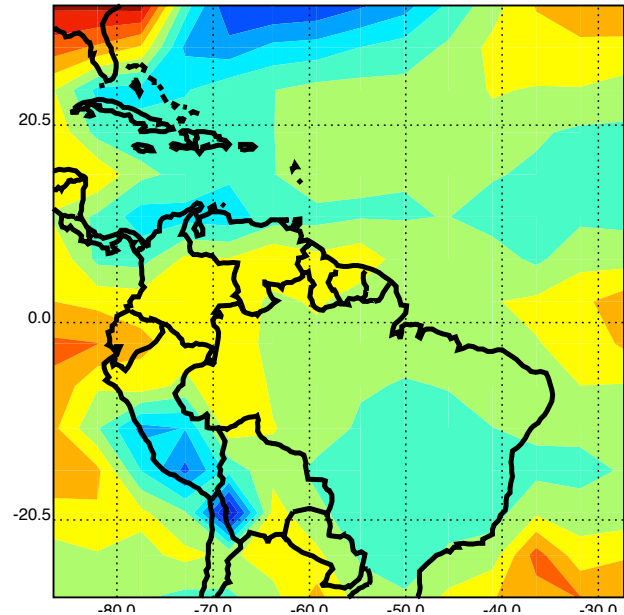
SiB3 Untressed - 850 mb



NCEP Reanalysis



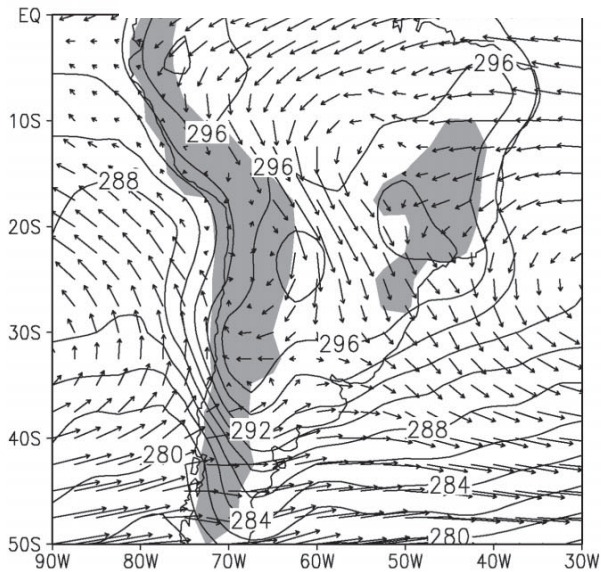
SiB3 Unstressed



DJF
latent
heat

←→

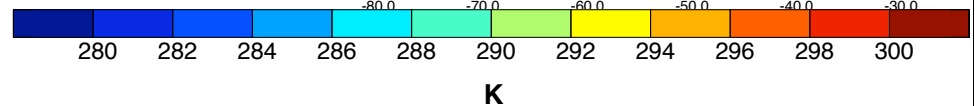
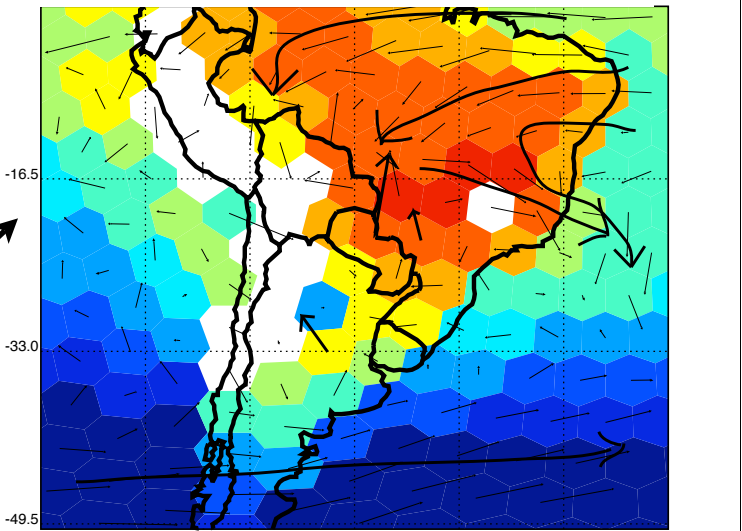
925 hPa temperature & 850 hPa winds



Wang and Fu, 2004

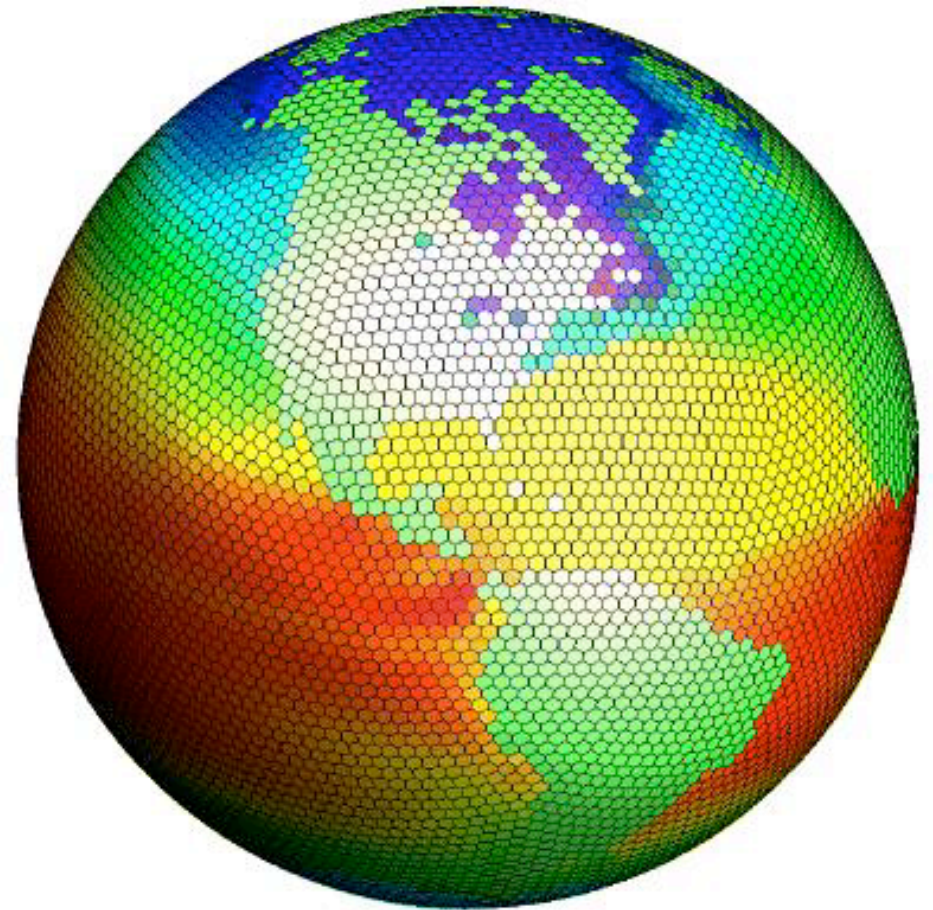
← Jan.

wet
season



Higher Resolution Runs

- Next is 10242: 19 year AMIP style run
- Interannual variability
- Better spin-up, more robust results
- Don Dazlich

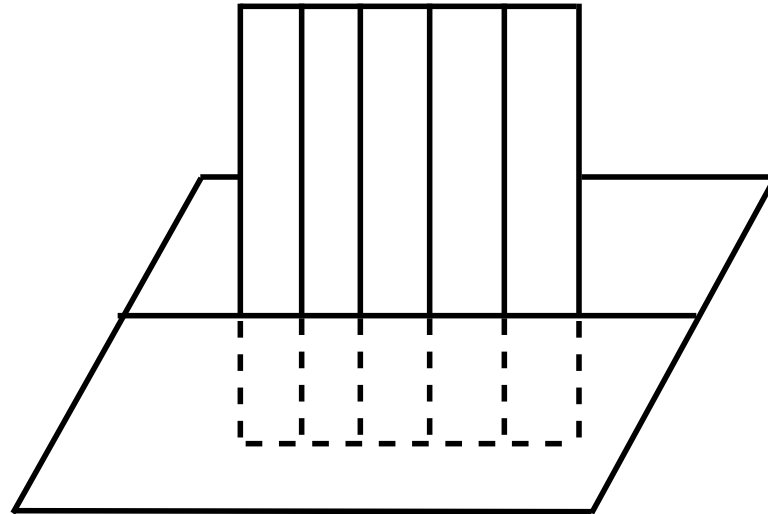




Surface-Atmosphere Interaction in the MMF

- Global Model-2562 gridpoints-1 MONTH ONLY (January)
- 32 columns per GCM gridcell-single 'curtain'
- Surface Parameters constant
 - LAI/fPAR
 - Soil Type
 - Roughness Length
- Variability in Atmospheric Processes
 - Soil moisture
 - Canopy conductance

Surface-Atmosphere Interaction in the MMF



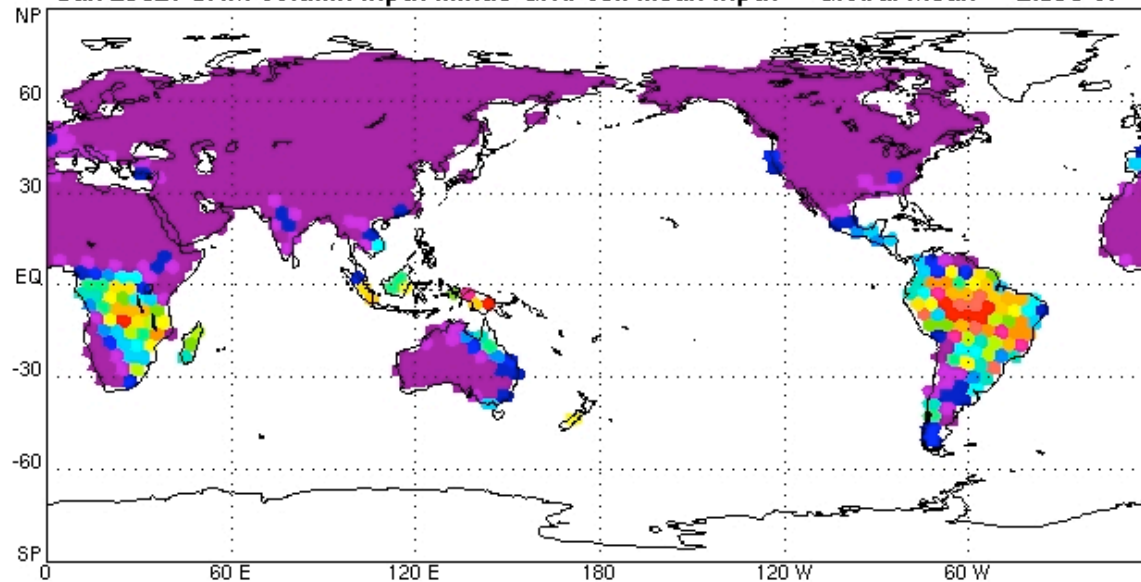
Results-Global

Jan 3, 2009

CANOPY PHOTOSYNTHESIS (Difference)

moles/m²/s

Jan 2562: CRM column input minus Grid-cell mean input Global Mean = -2.35e-07

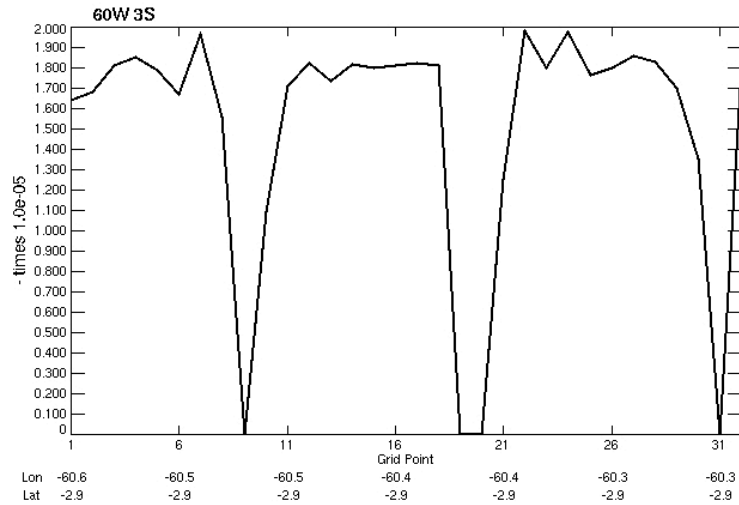


- Latent/Sensible Heat Fluxes Relatively Unchanged
- Reduction in Photosynthesis (mean; 12%)

Jan 4, 2009

CANOPY PHOTOSYNTHESIS

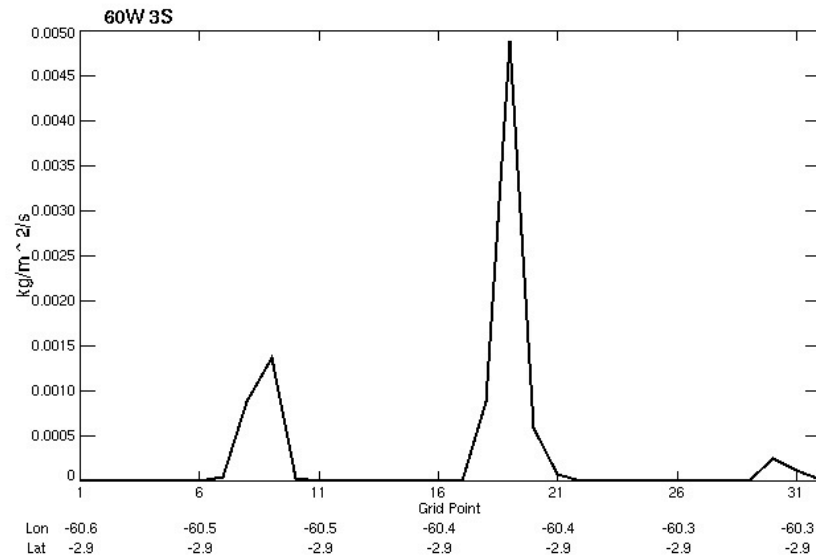
Cross-section at hour 137.000



Jan 5, 2009

PRECIPITATION RATE

Cross-section at hour 137.000

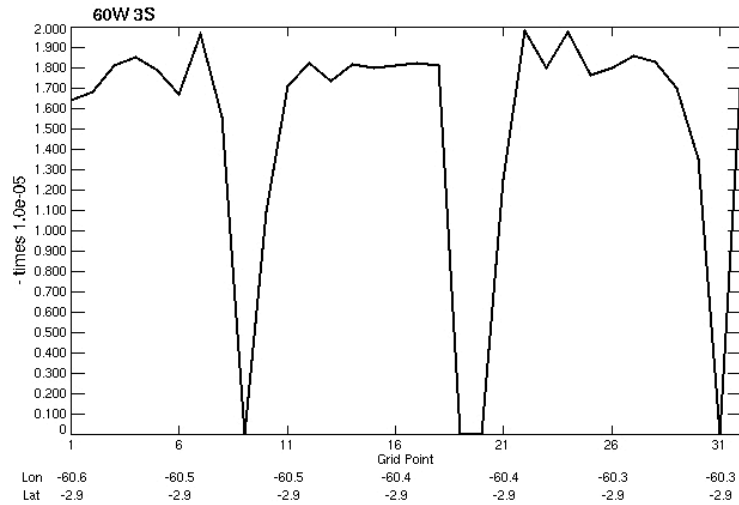


Q: What Happens
When a Cloud Passes
Through?

Jan 4, 2009

CANOPY PHOTOSYNTHESIS

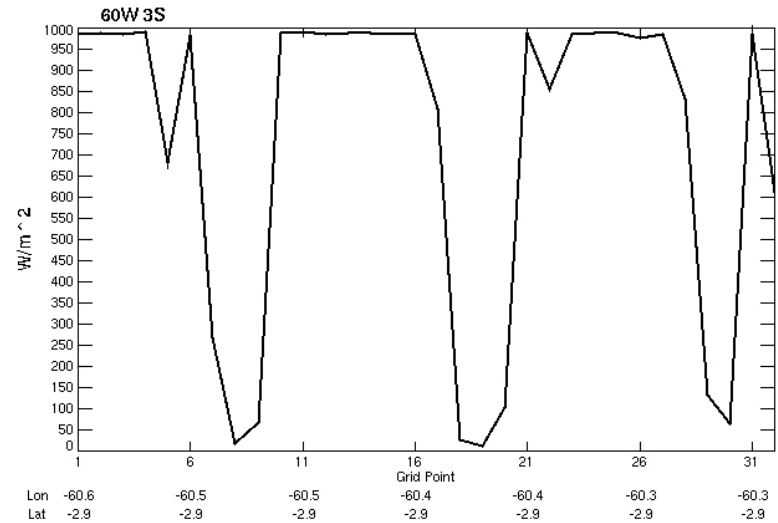
Cross-section at hour 137.000



Jan 4, 2009

SFC INCIDENT SHORTWAVE RADIATION

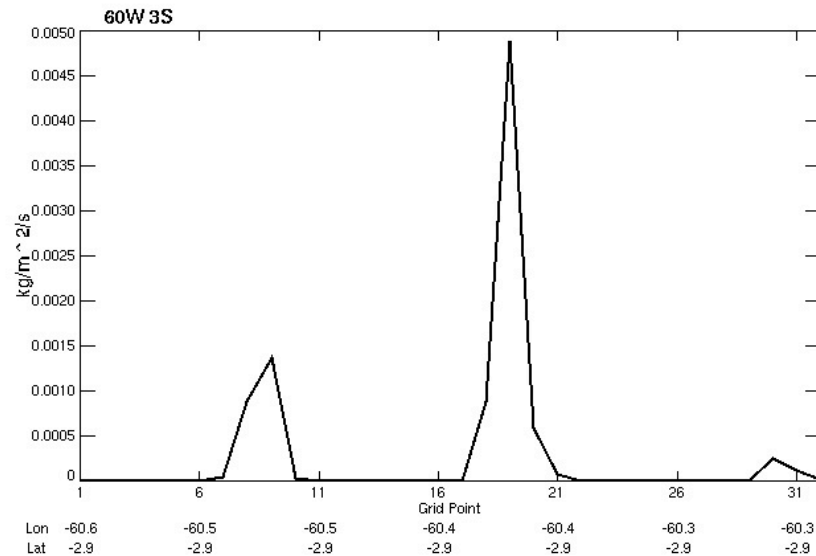
Cross-section at hour 137.000



Jan 5, 2009

PRECIPITATION RATE

Cross-section at hour 137.000



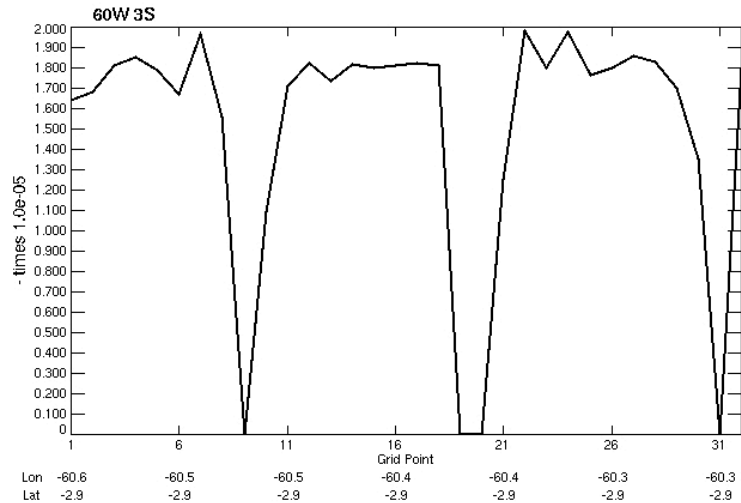
**Q: What Happens
When a Cloud Passes
Through?**

**A: It Gets Really, Really
Dark**

Jan 4, 2009

CANOPY PHOTOSYNTHESIS

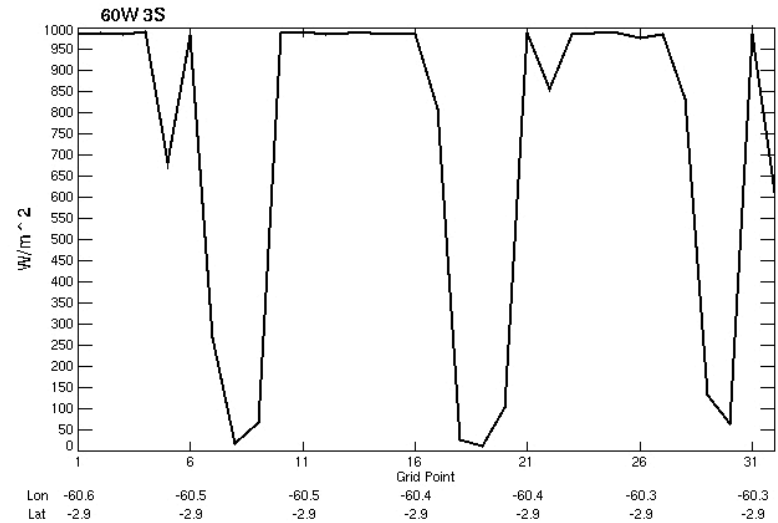
Cross-section at hour 137.000



Jan 4, 2009

SFC INCIDENT SHORTWAVE RADIATION

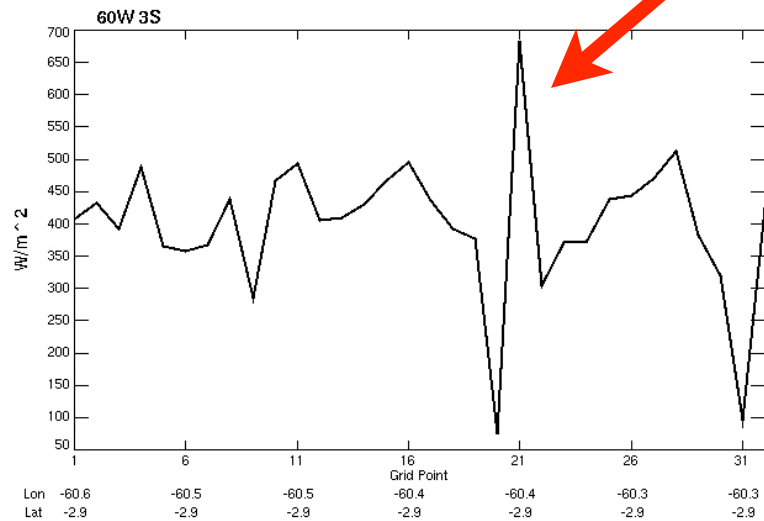
Cross-section at hour 137.000



Jan 4, 2009

SURFACE LATENT HEAT FLUX

Cross-section at hour 137.000

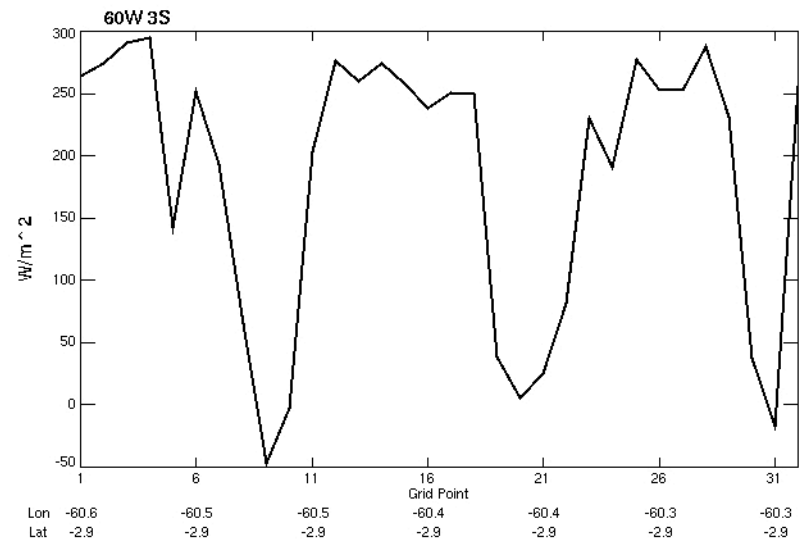


What's this?

Jan 4, 2009

SURFACE SENSIBLE HEAT FLUX

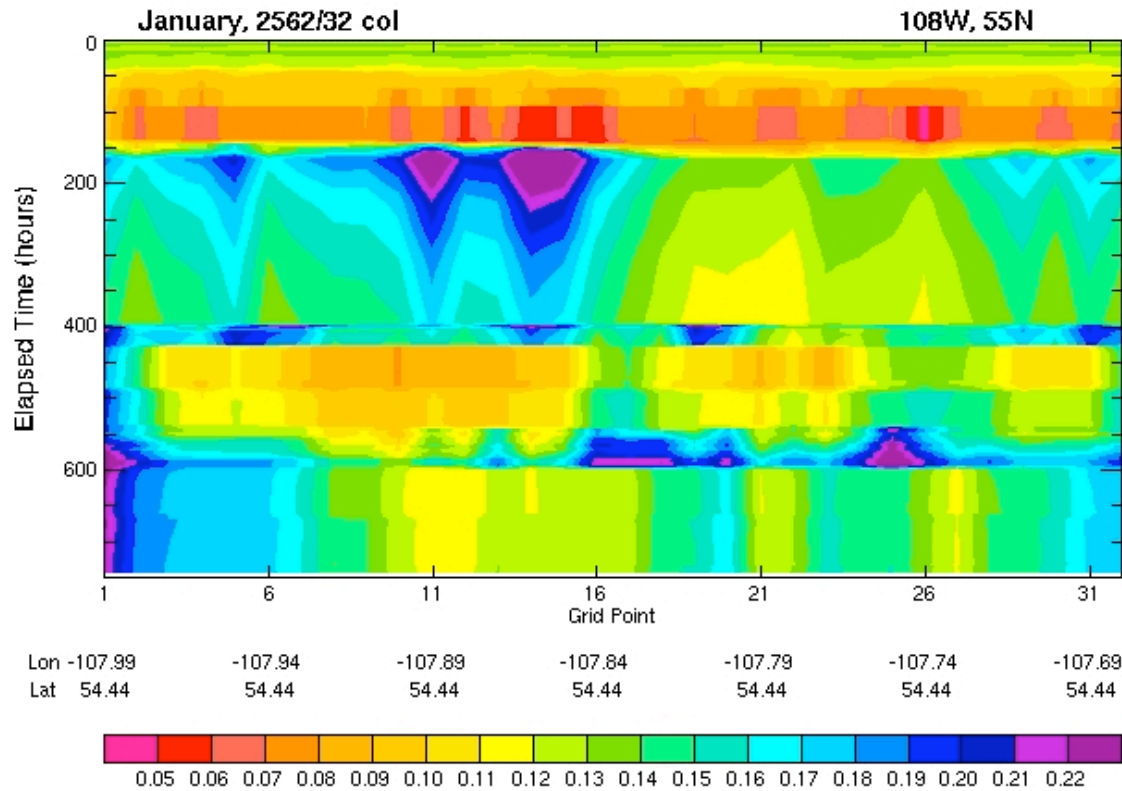
Cross-section at hour 137.000



Results-Gridcell

Jan 4, 2009

SNOW DEPTH
m



Should be
some
interesting
interactions
in the spring!

Surface-Atmosphere Interaction in the MMF

► Issues:

- Cyclic Boundary Conditions
 - [CO₂]
 - Atmospheric State
 - Topography
- I-D Radiative Transfer

An aerial photograph of a vast, dense tropical forest. A dark, winding river flows through the center of the forest, reflecting the sky. The forest canopy is a rich, dark green, with some lighter green patches visible. The sky above is overcast with soft, grey clouds. The overall scene is a lush, natural landscape.

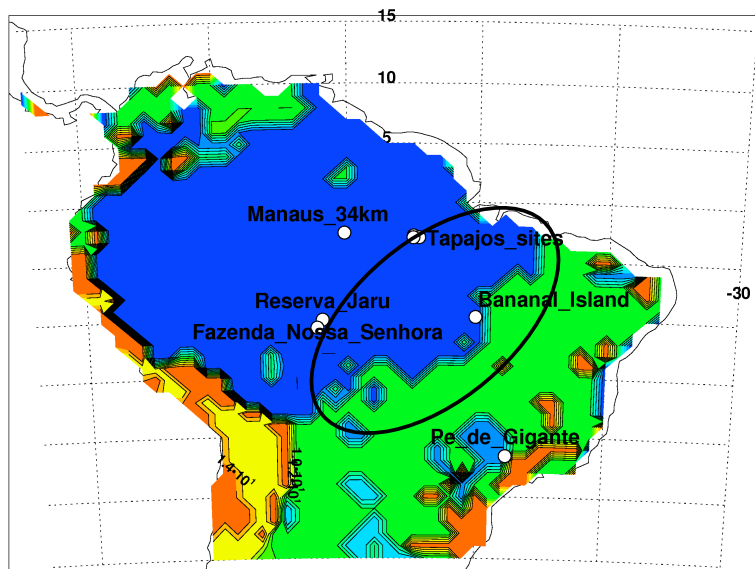
Land Surface: Multiple Areas of Emphasis-What We're Working On

- Basic Landsurface Processes:
 - Tropics
 - Savanna
 - Crops
- Basic Processes, Coupled Back to Atmosphere
- MMF-simple (homogeneous surface, variable atmosphere)
- MMF-complex (heterogeneous surface, variable atmosphere)

Surface-Atmosphere Interaction in the MMF

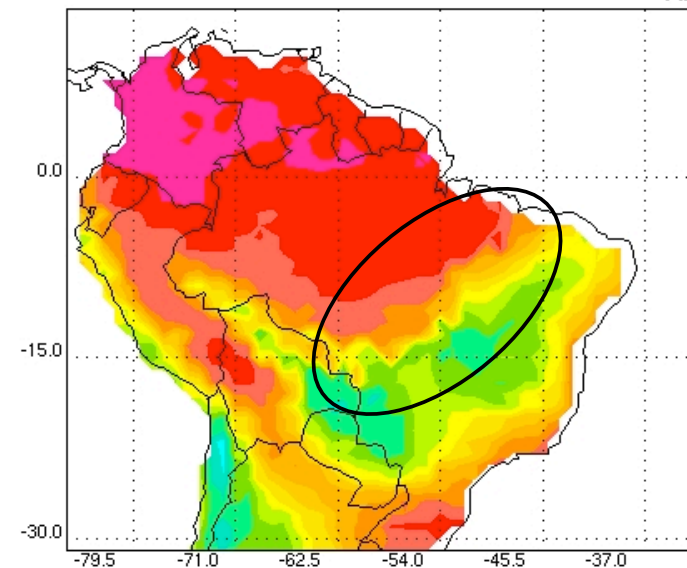
- Tropics: Transition Forest

Jan 4, 2009



HUMIDITY STRESS FACTOR
September 1988

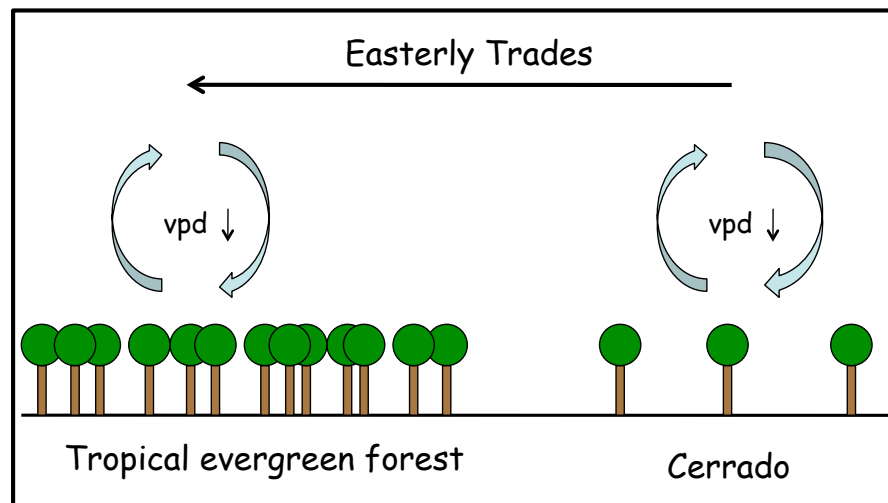
Area Mean = 0



Surface-Atmosphere Interaction in the MMF

- Tropics: Transition Forest

Wet Season



Dry Season

