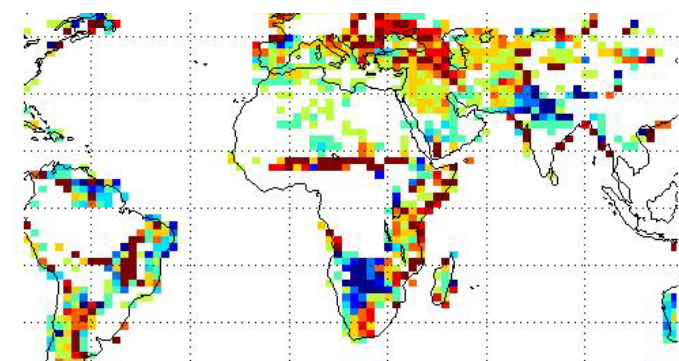
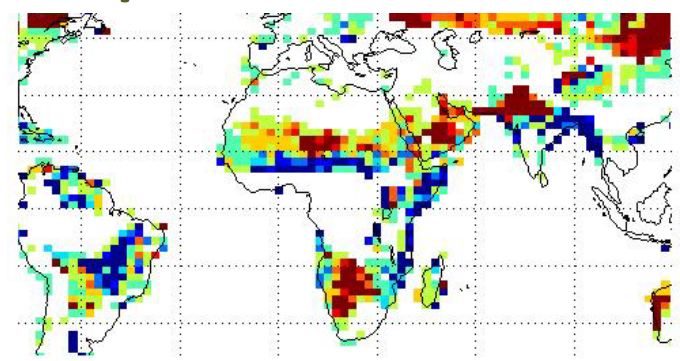


21st century North Africa as simulated in the CCSM4/CESM1



Sam Levis

Terrestrial Sciences Section
CGD/NESL/NCAR
Boulder, Colorado, USA



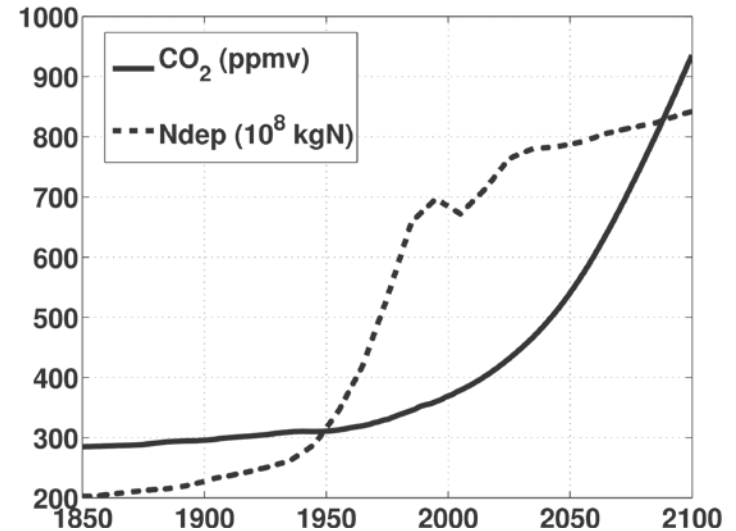
Outline/Summary

- 21st c. North Africa progressively wetter/greener
- Photosynth. less limited by soil moisture due to
 - increased water use efficiency and
 - increased wet season precip
- The increase in veg. cover decreases the albedo

CAVEATS

1. Shortage of N delays vegetation response
2. DGVM feedbacks NOT included in what I show

The simulations

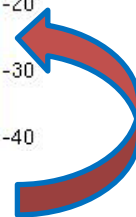
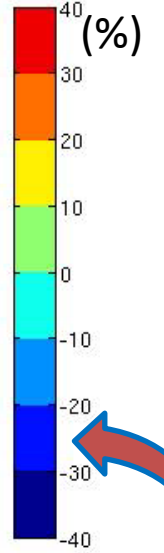
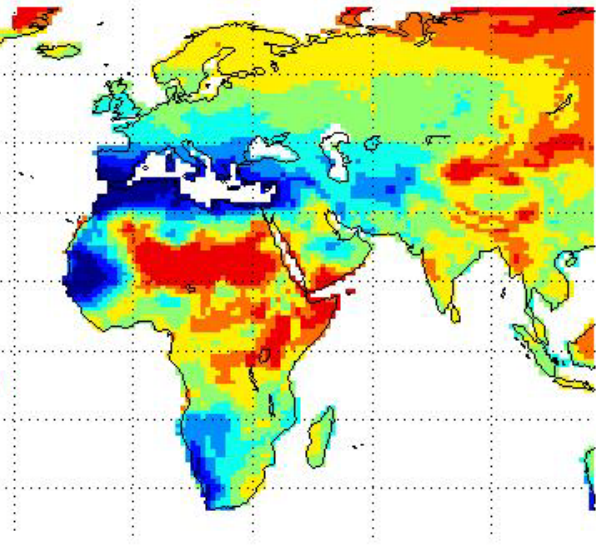
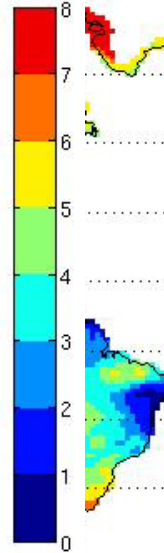
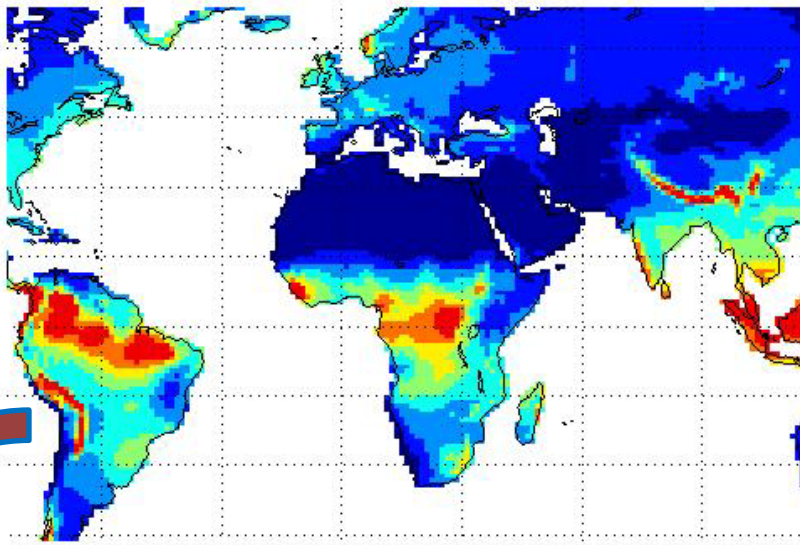


1. Transient **CCSM4CN** simulations
 - A. 1850 to 2005
 - B. 2006 to 2100 (RCP8.5)
2. Transient **CLM4CNDV** (BUT NO land use + wood harvest)
driven with met data simulated in 1A and 1B

Pre-Industr.

ANN PRECIP (mm d⁻¹ OR %)

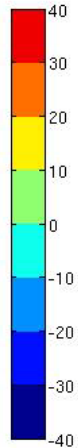
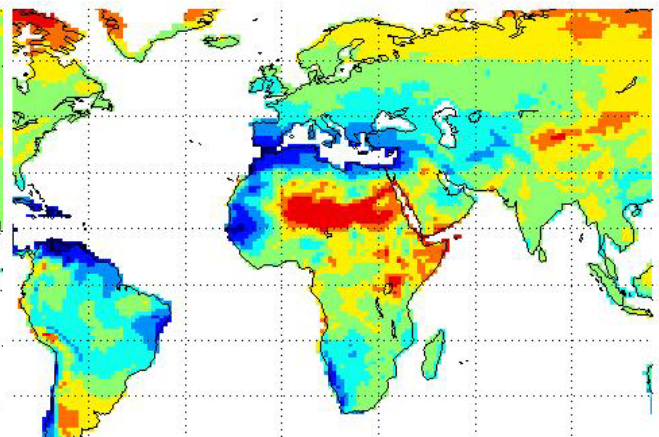
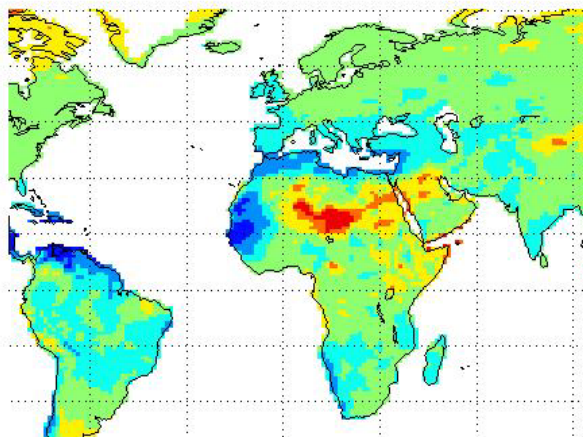
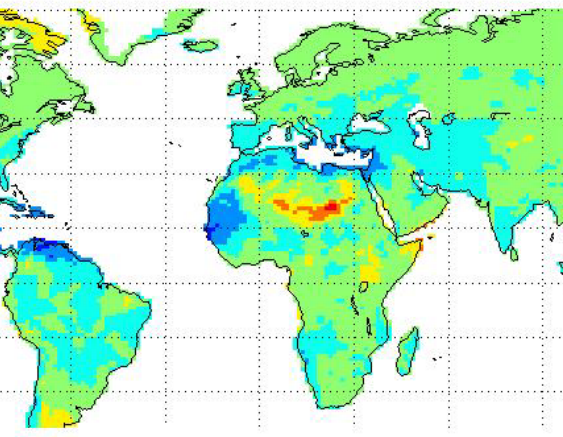
2080 to 2099 - PI



1986 to 2005 - PI

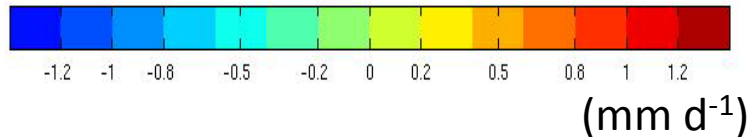
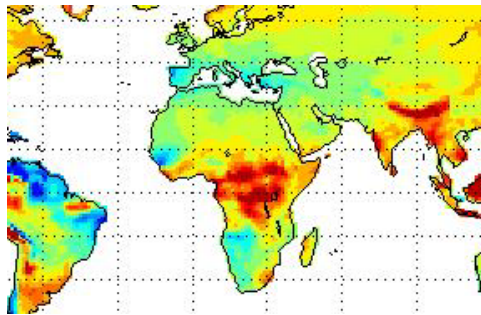
2011 to 2030 - PI

2046 to 2065 - PI

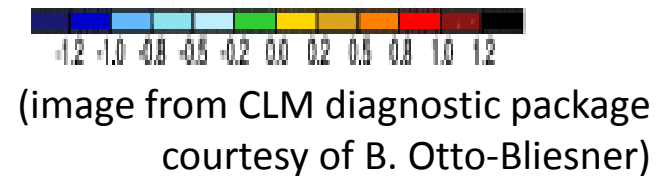
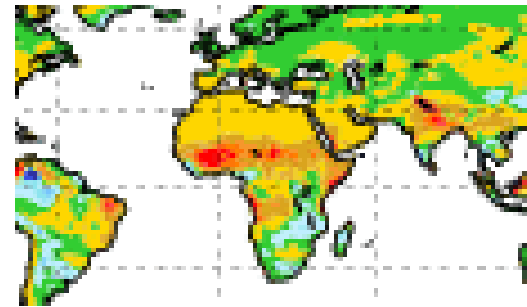


ANN PRECIPITATION (mm d⁻¹)

2080 to 2099 – PI



6 ka BP - PI



Examples of simulations with increased future precip:

ECHAM5 (A1B) used in Scheiter and Higgins (2009)

CLIMBER-2 (1%) Claussen *et al.* (2003)

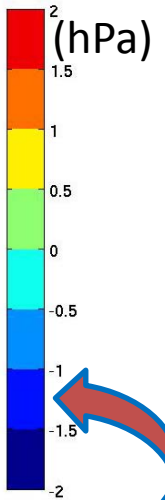
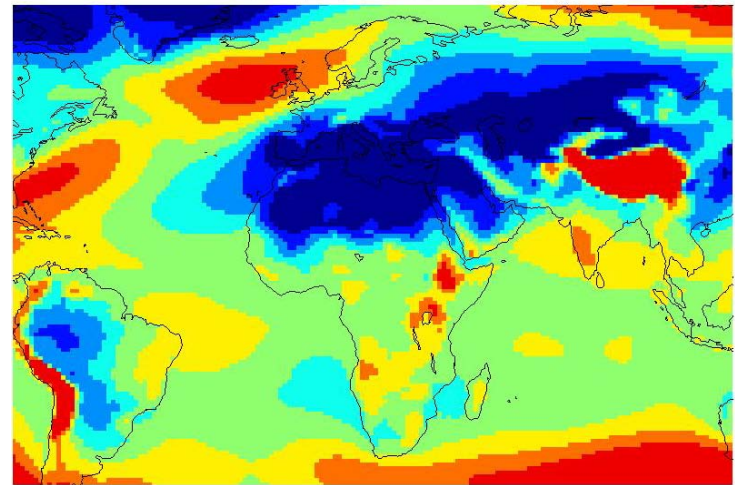
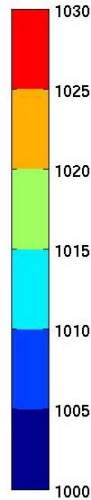
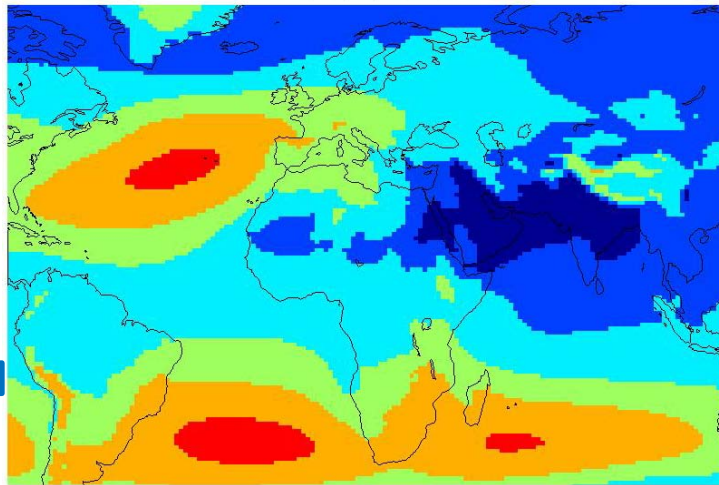
-SSTs lag the land in warming; this enhances monsoon circulation; temporary?

-Increased humidity increases moist static energy and precipitation

Pre-Industrial

JAS SLP (hPa)

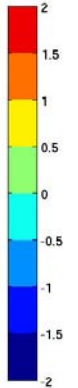
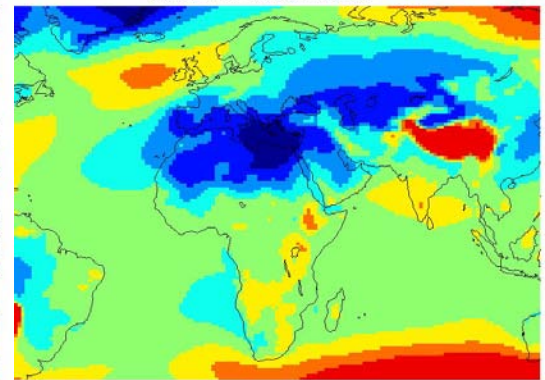
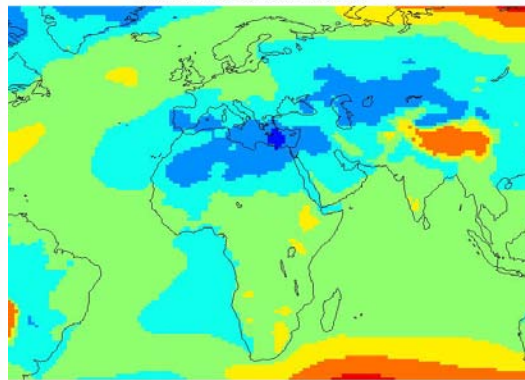
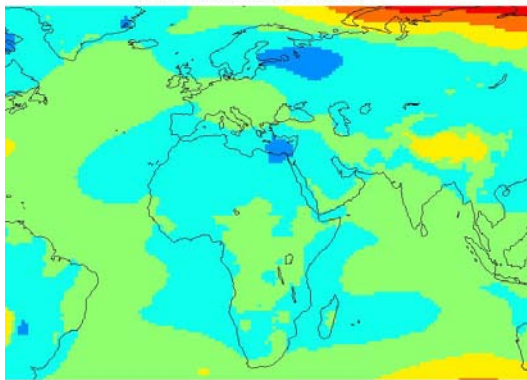
2080 to 2099 - PI



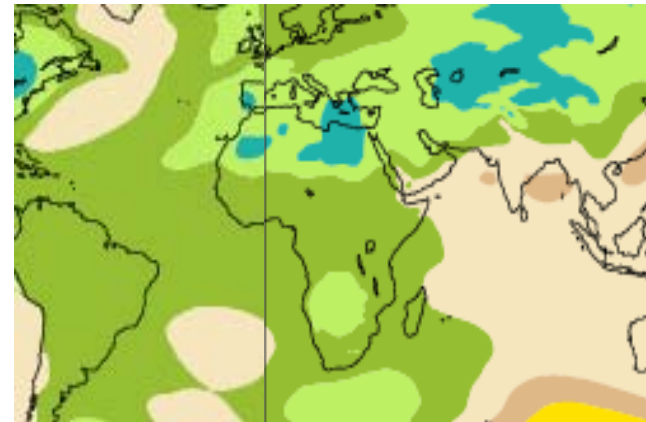
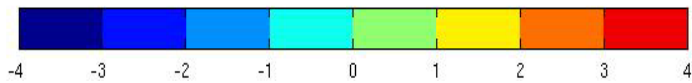
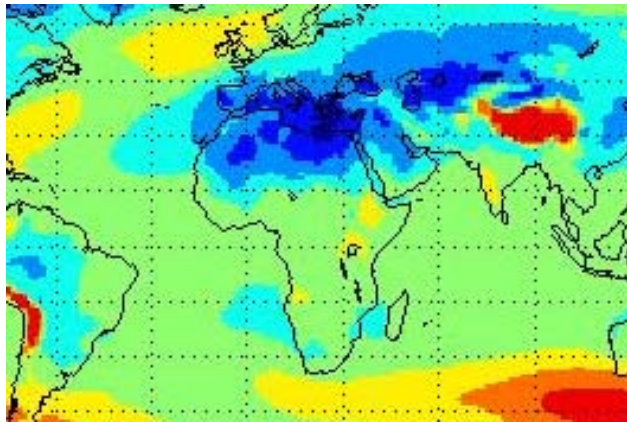
1986 to 2005 - PI

2011 to 2030 - PI

2046 to 2065 - PI



JAS sea-level pressure (hPa) JJA
2080 to 2099 – PI 6 ka BP - PI



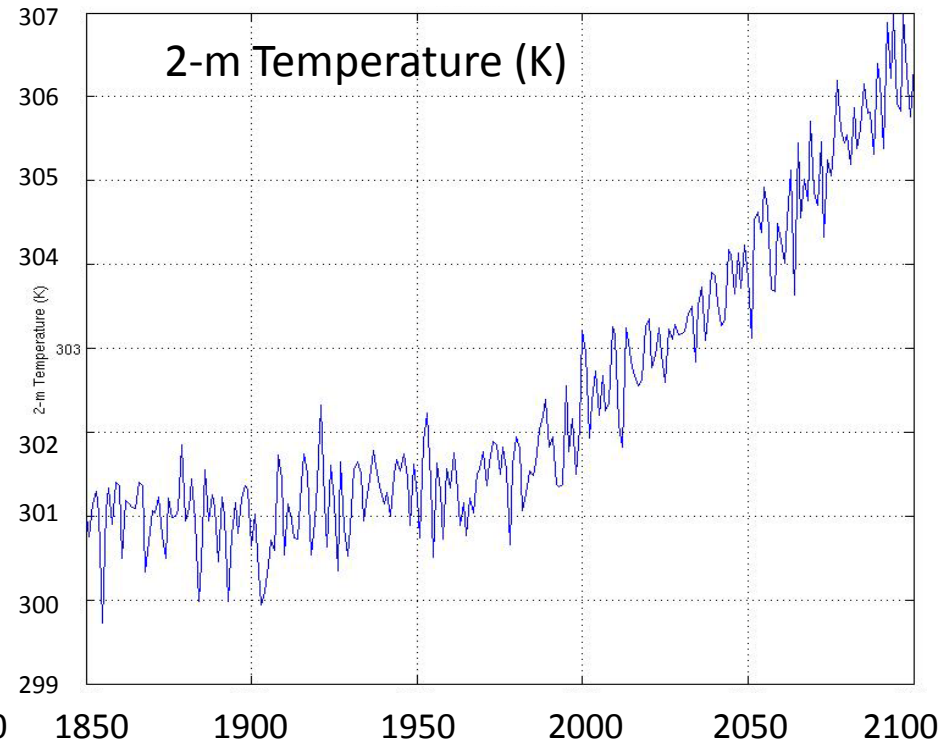
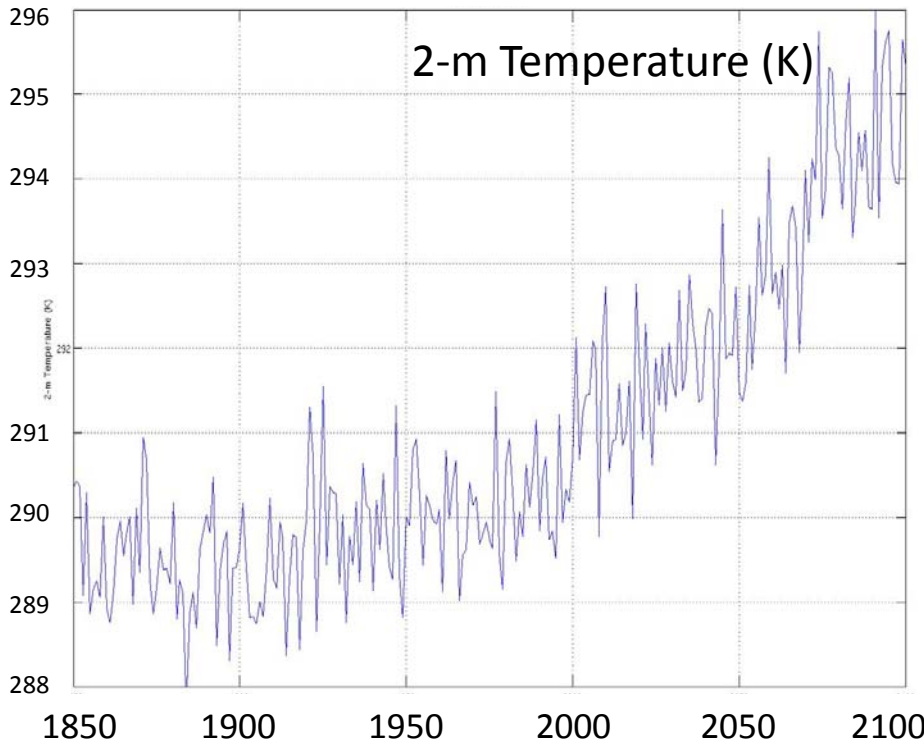
(hPa) (image from CAM diagnostic package
courtesy of B. Otto-Bliesner)

0-30°N 20°W-60°E

JANUARY

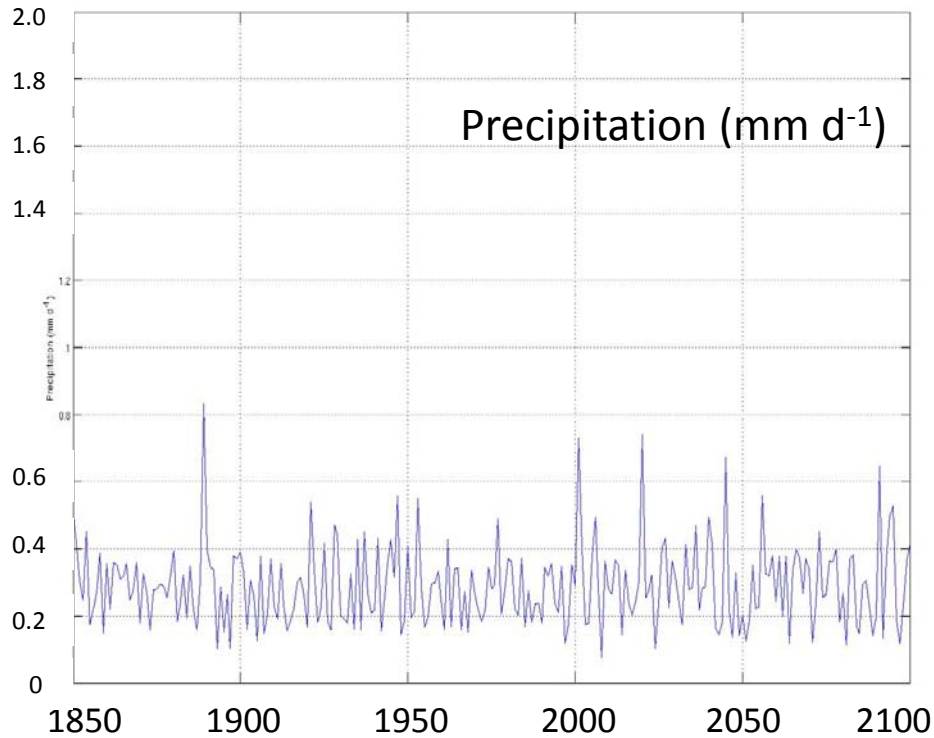
warmer...

JULY

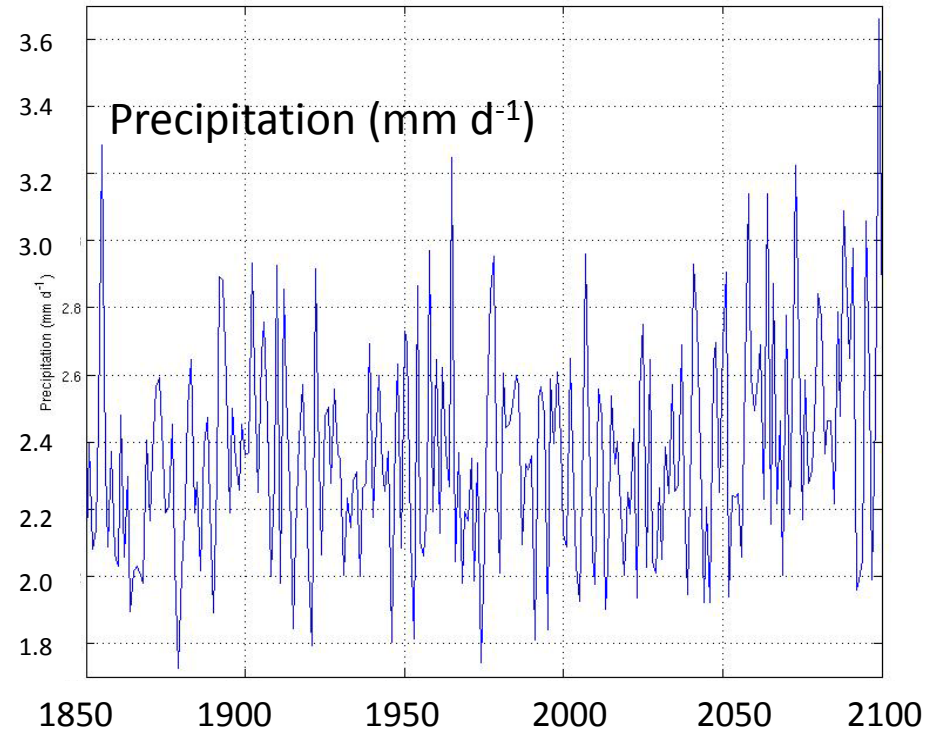


0-30°N 20°W-60°E

JANUARY



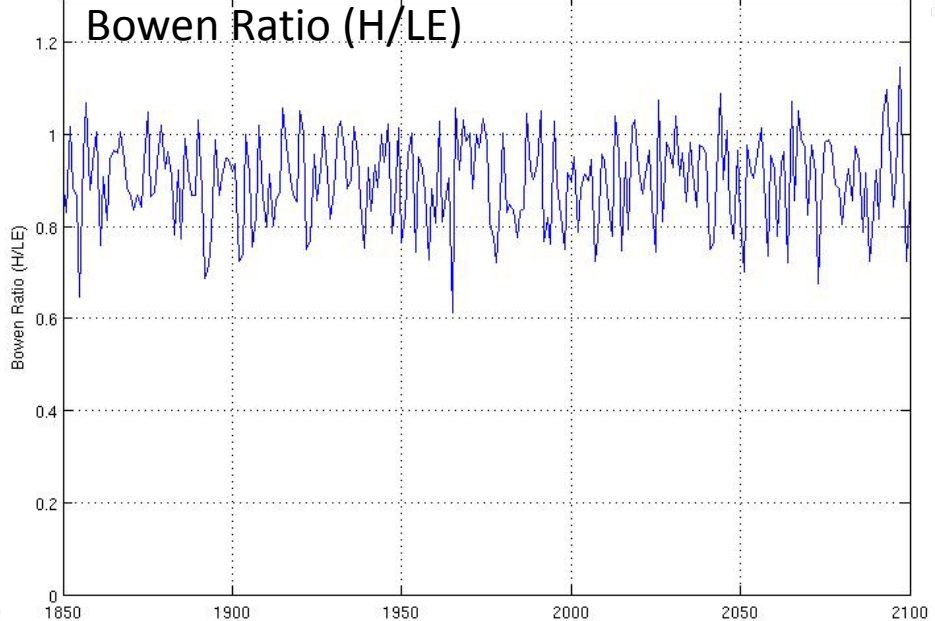
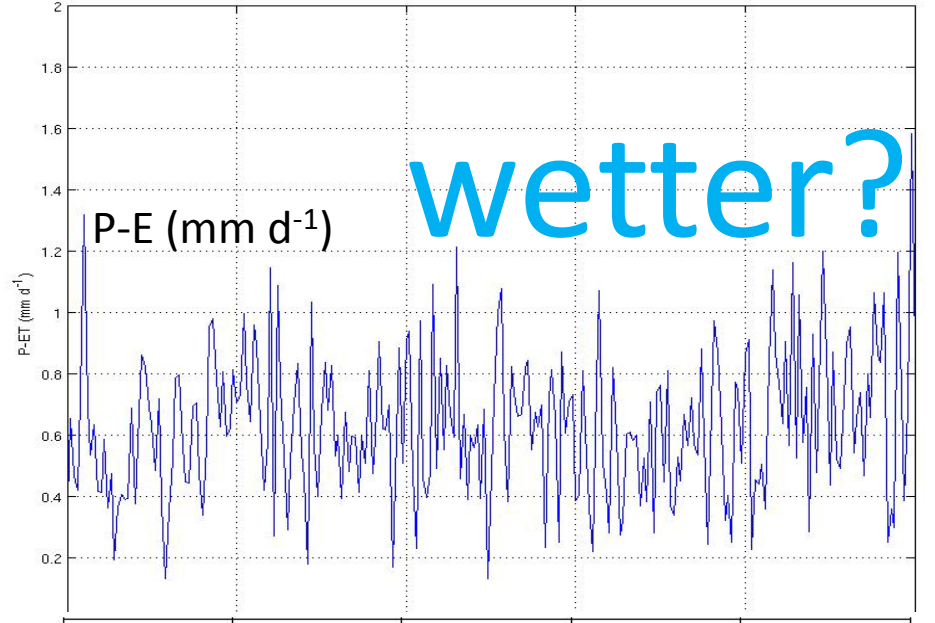
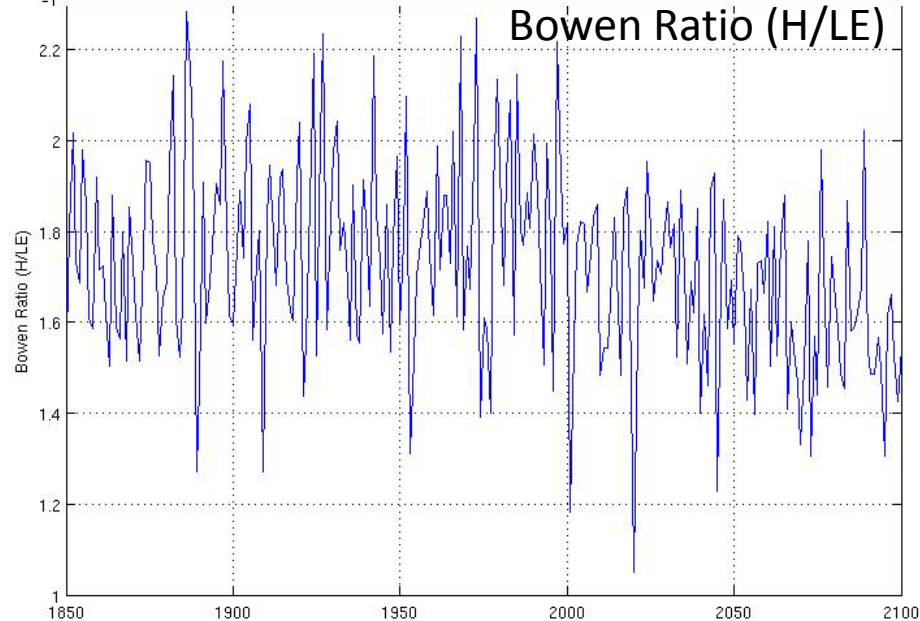
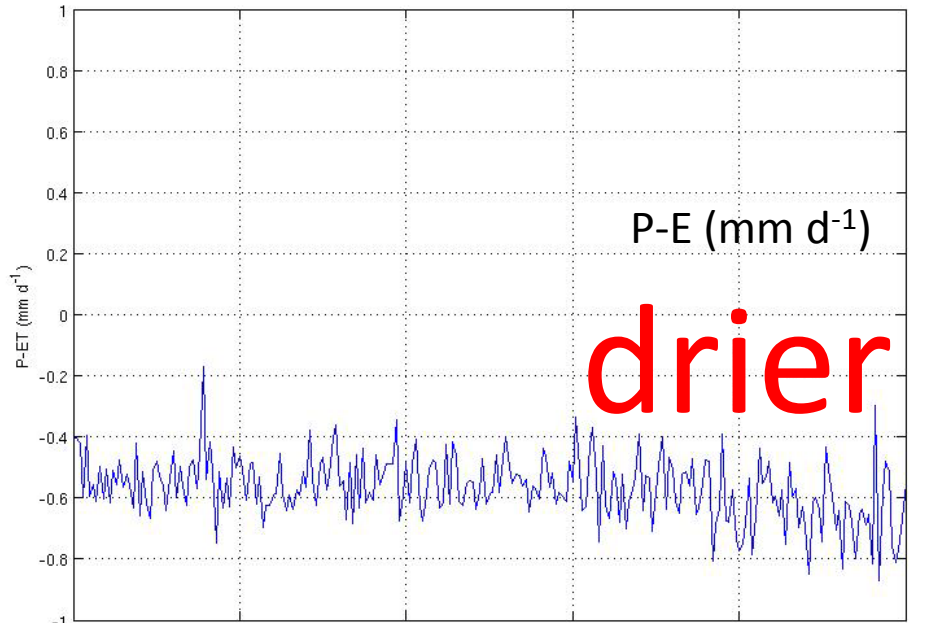
JULY **wetter**



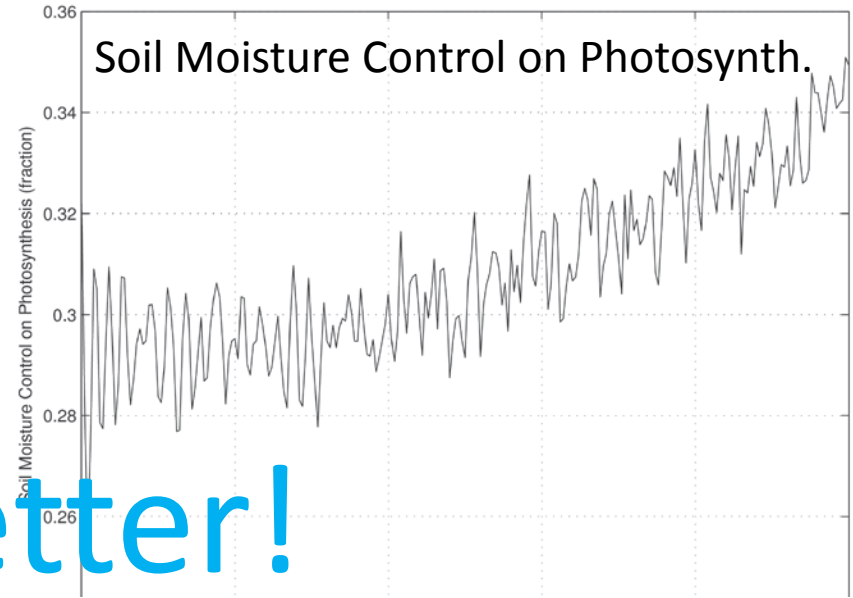
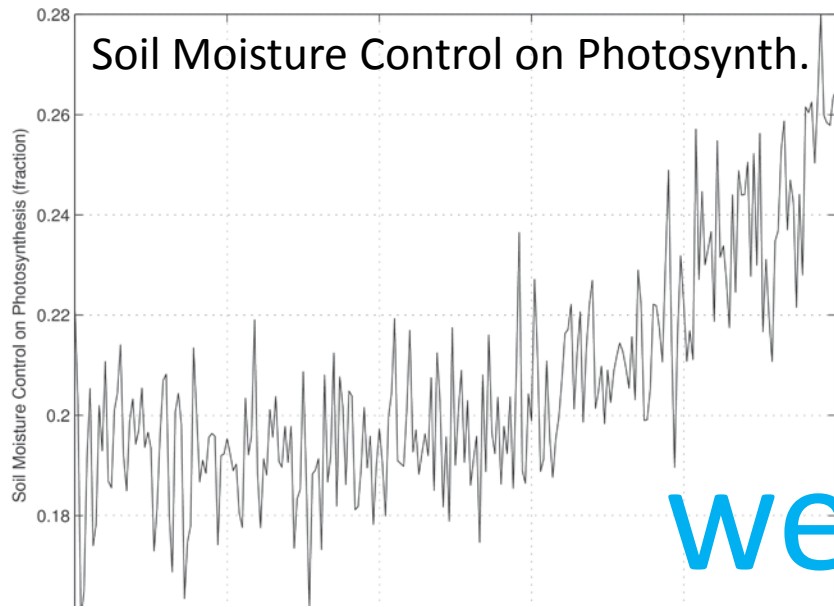
JANUARY

0-30°N 20°W-60°E

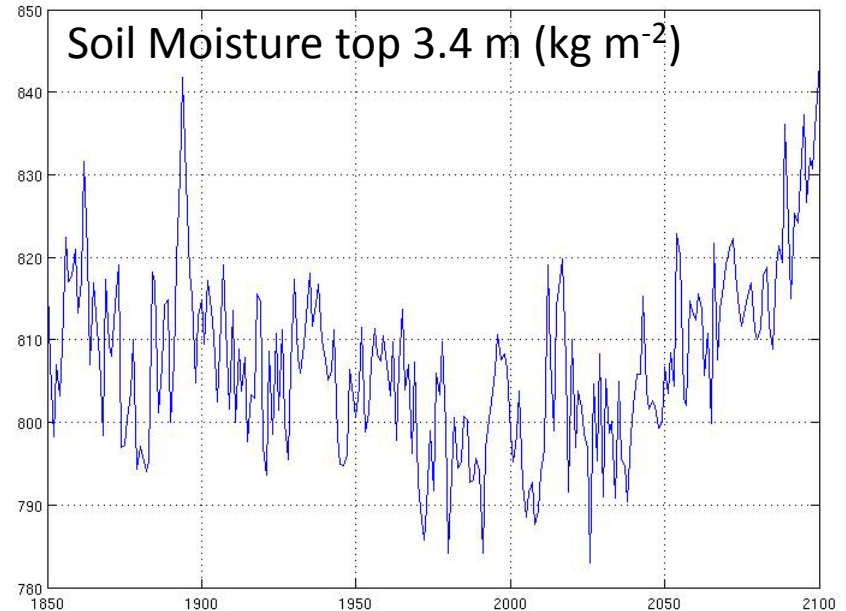
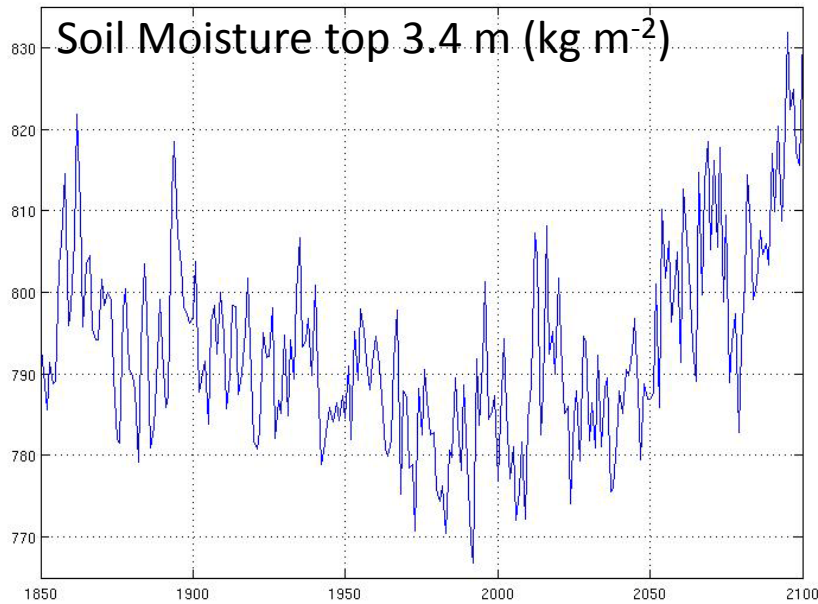
JULY



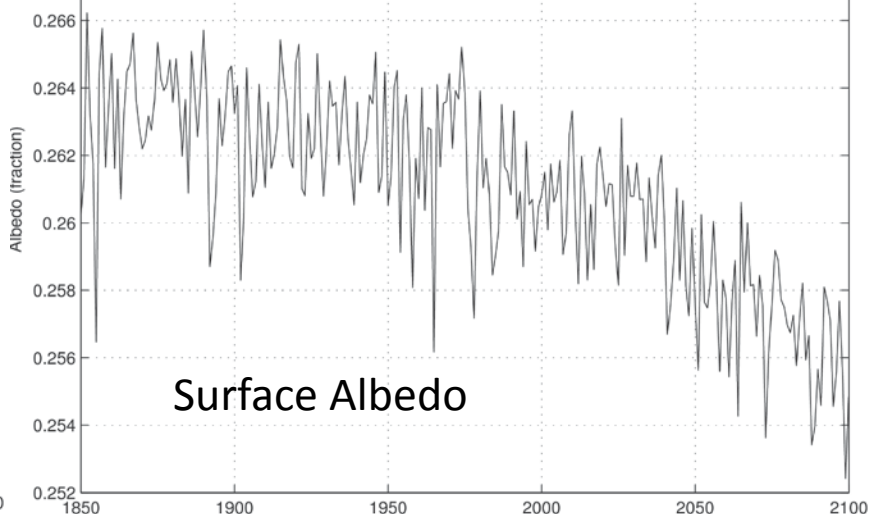
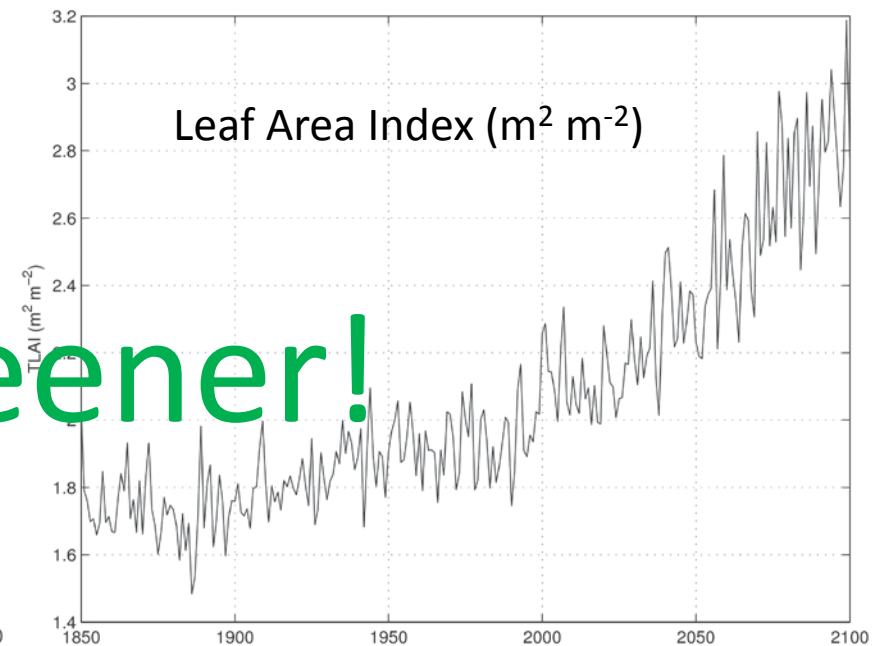
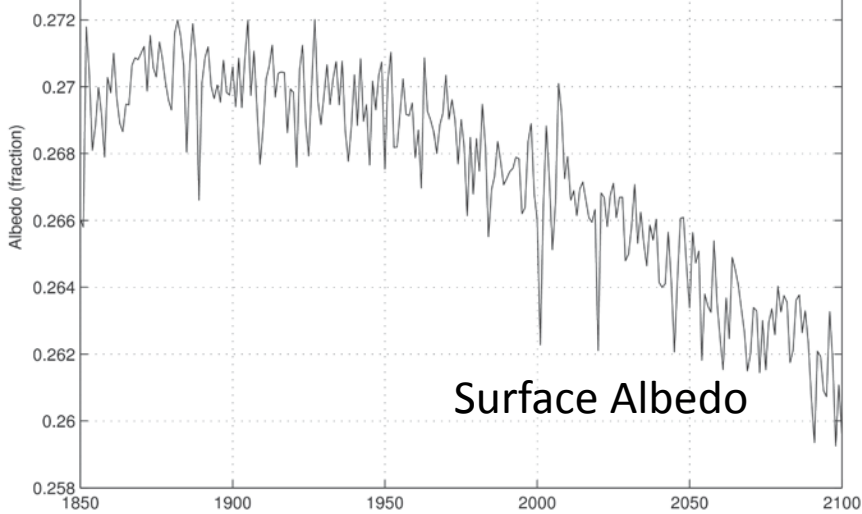
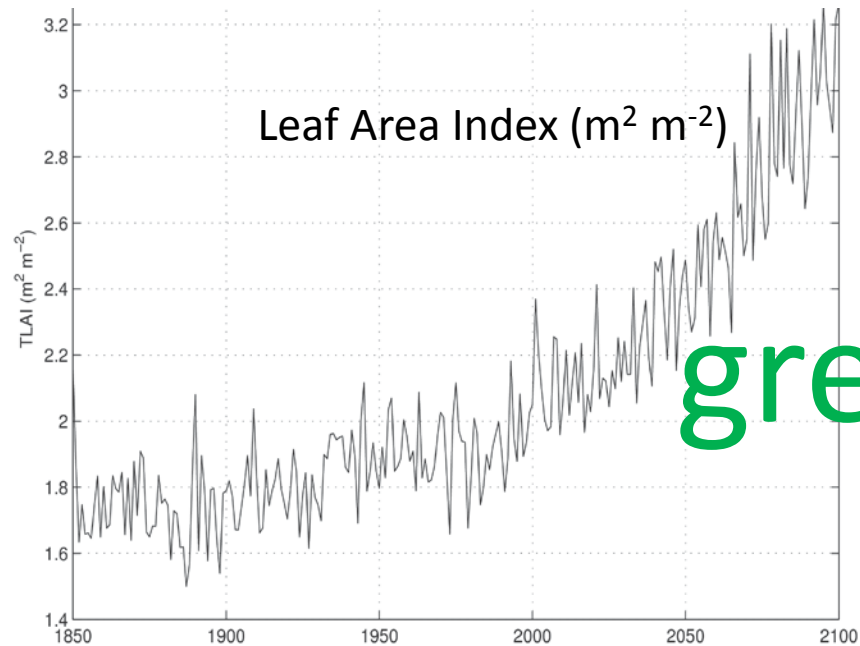
JANUARY 0-30°N 20°W-60°E JULY



wetter!



JANUARY 0-30°N 20°W-60°E JULY

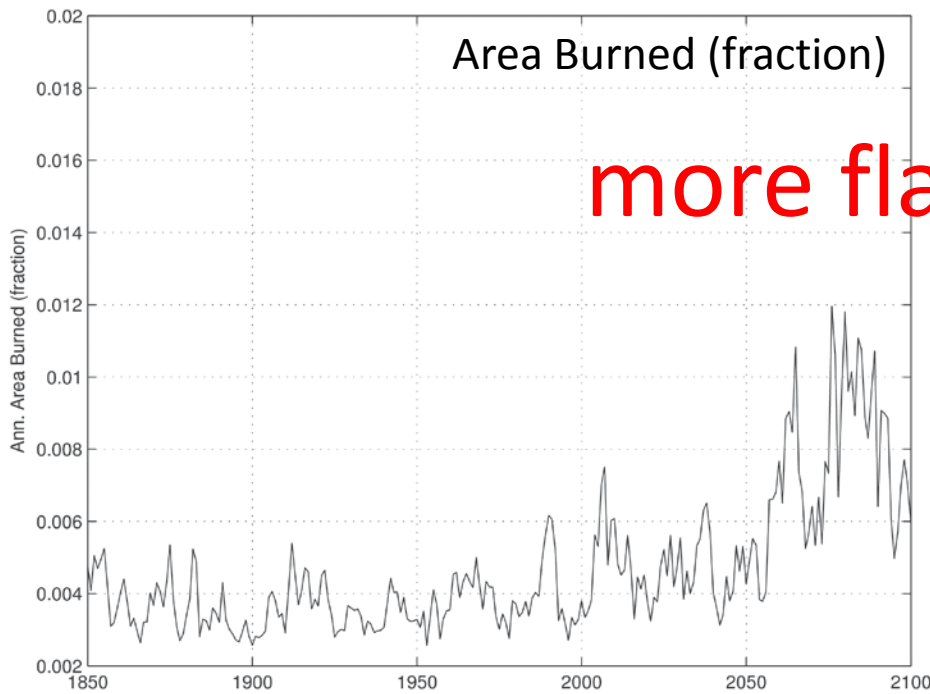


greener!

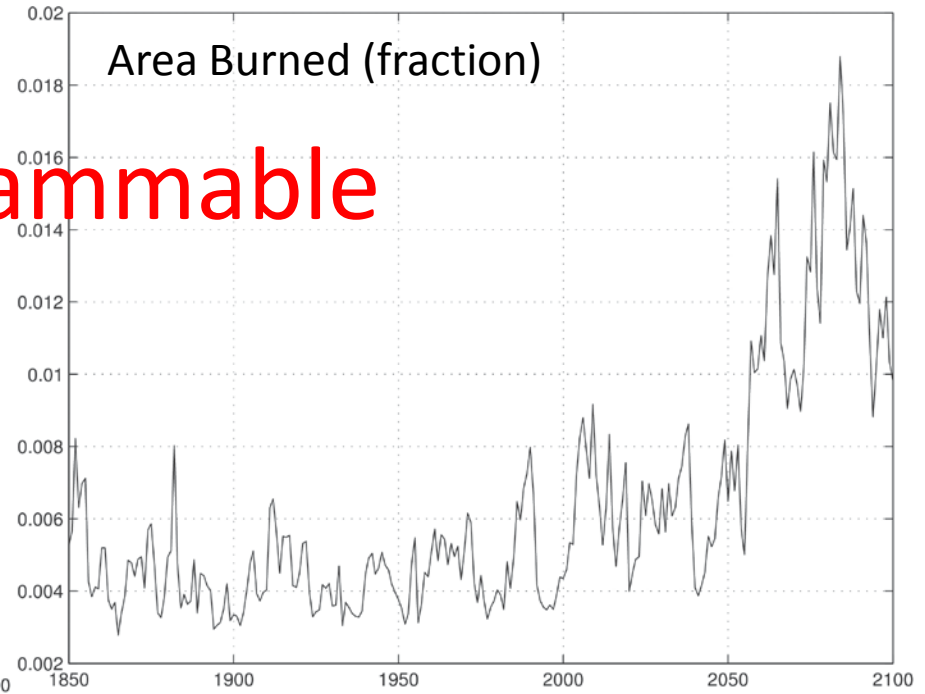
0-30°N 20°W-60°E

JANUARY

JULY



more flammable



The talk so far...

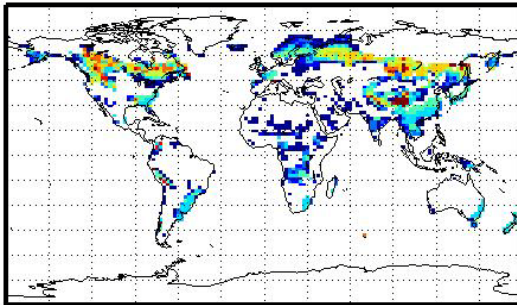
- 21st c. North Africa progressively wetter/greener
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CAVEATS

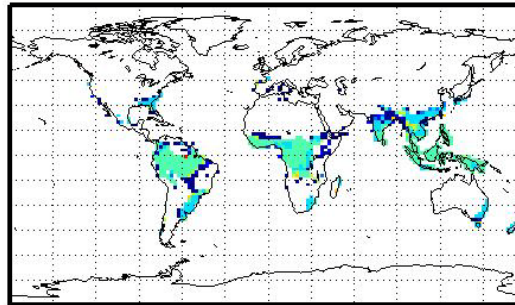
1. Shortage of N delays vegetation response
2. DGVM feedbacks NOT included in what I show

Pre-Industrial PFT cover (%)

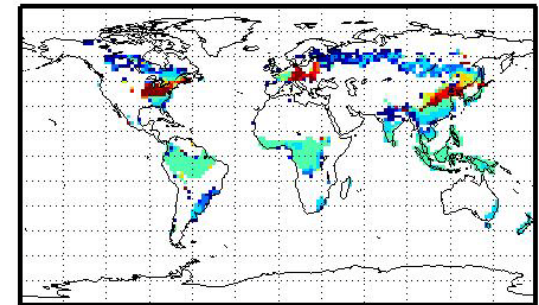
NEEDLELEAF EVERGREEN TREES



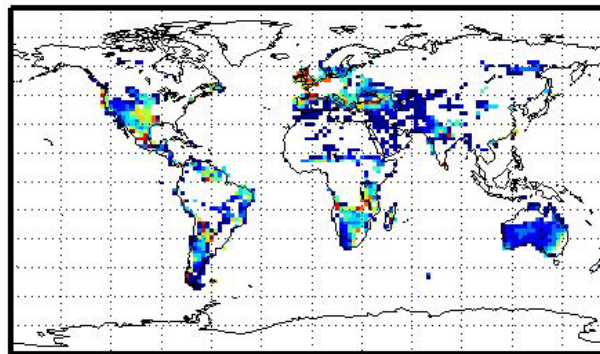
BROADLEAF EVERGREEN TREES



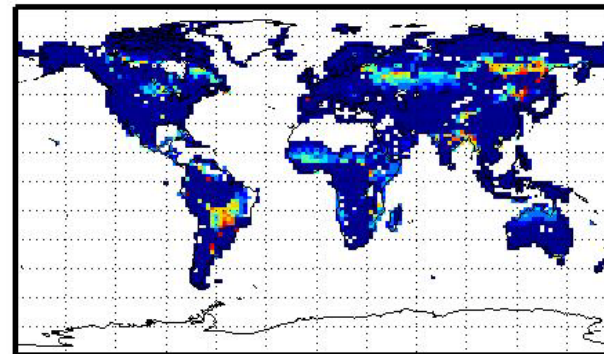
DECIDUOUS TREES



SHRUBS



GRASSES

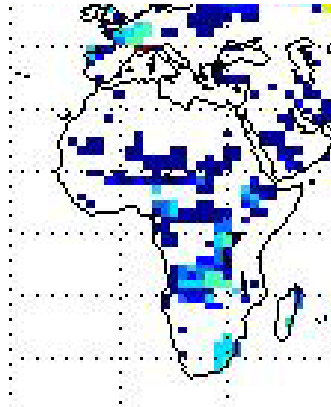


20-year avg veg cover from year 1881 to year 1900

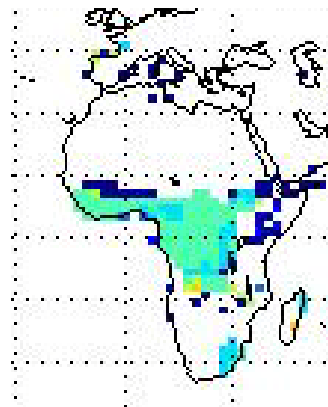


Pre-Industrial PFT cover (%)

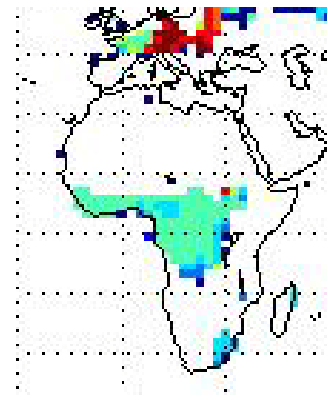
NEEDLELEAF EVERGREEN TREES



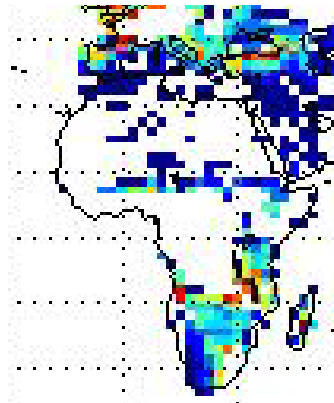
BROADLEAF EVERGREEN TREES



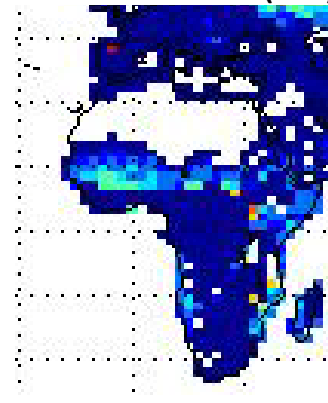
DECIDUOUS TREES



SHRUBS



GRASSES (C4)

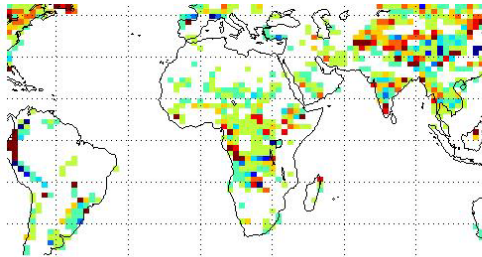


20-year avg veg cover from year 1881 to year 1900

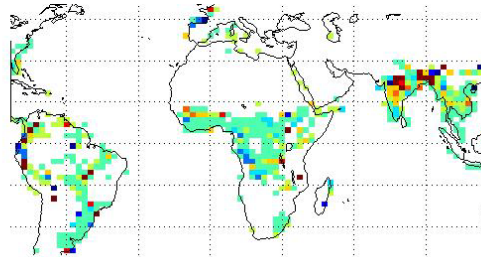


1986 to 2005 - PI

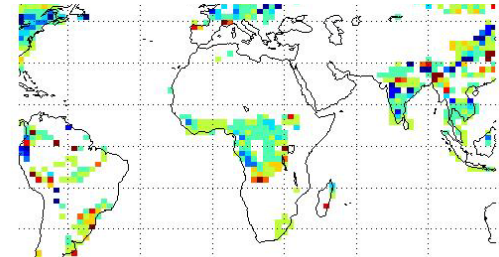
NEEDLELEAF EVERGREEN TREES



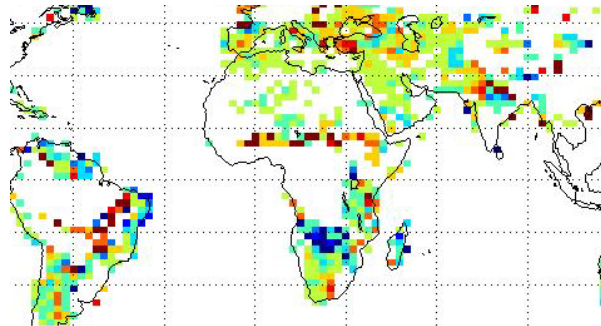
BROADLEAF EVERGREEN TREES



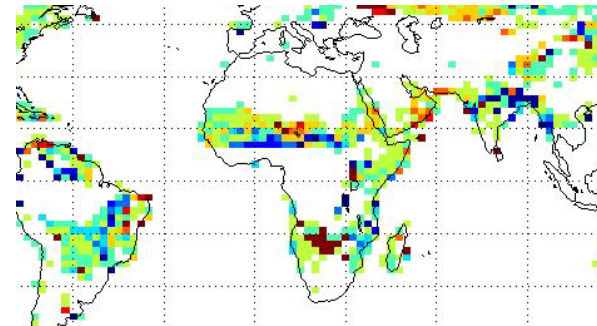
DECIDUOUS TREES



SHRUBS

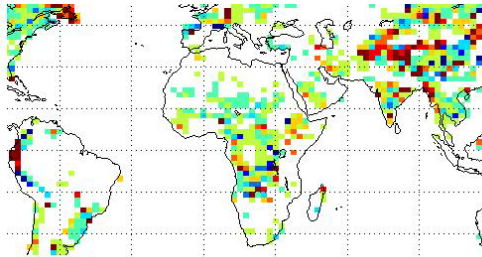


GRASSES

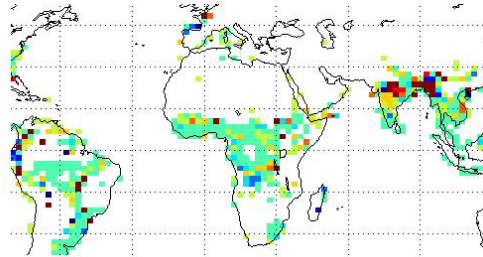


2011 to 2030 - PI

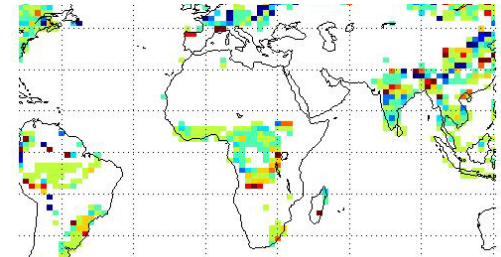
NEEDLELEAF EVERGREEN TREES



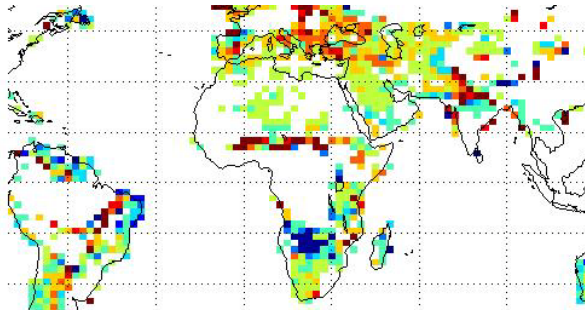
BROADLEAF EVERGREEN TREES



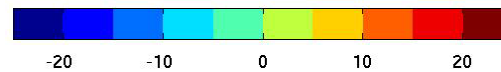
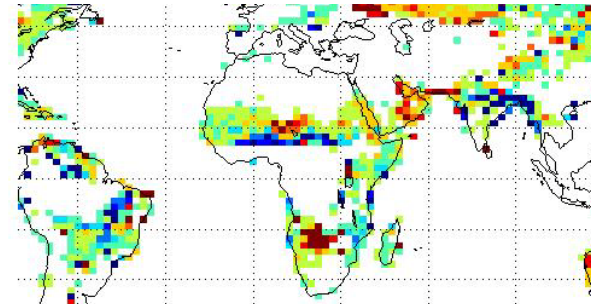
DECIDUOUS TREES



SHRUBS

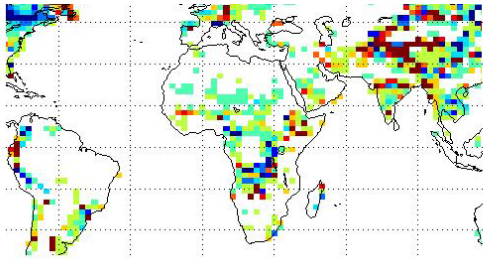


GRASSES

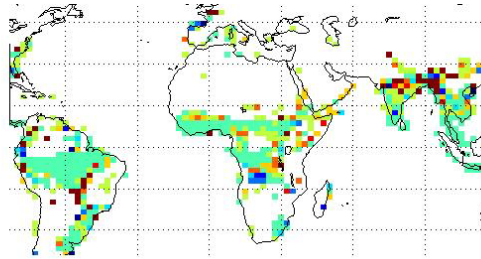


2046 to 2065 - PI

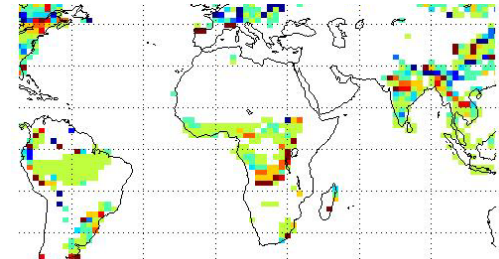
NEEDLELEAF EVERGREEN TREES



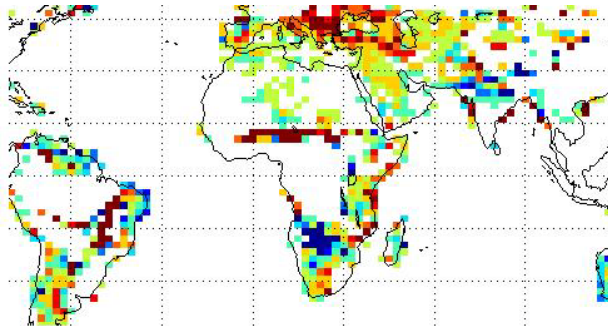
BROADLEAF EVERGREEN TREES



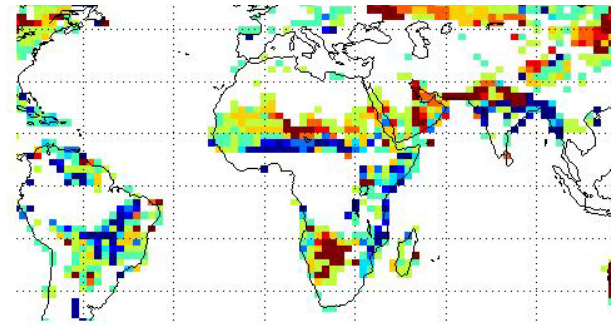
DECIDUOUS TREES



SHRUBS

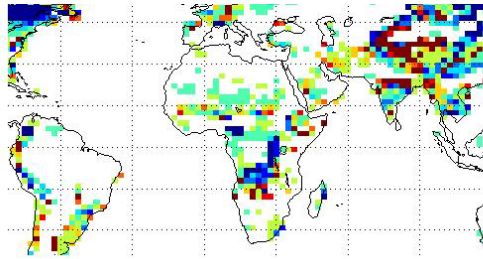


GRASSES

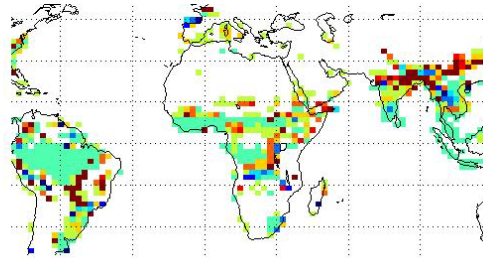


2080 to 2099 - PI

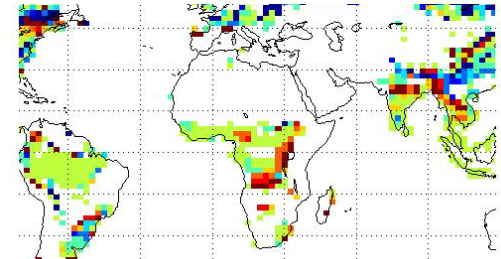
NEEDLELEAF EVERGREEN TREES



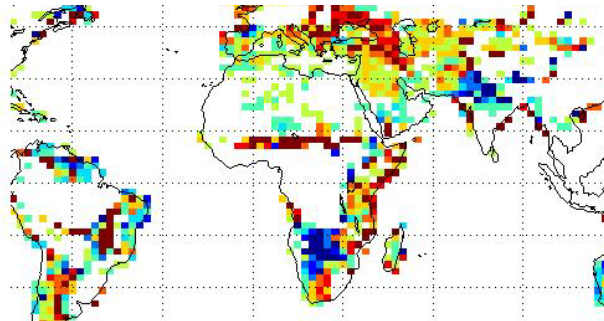
BROADLEAF EVERGREEN TREES



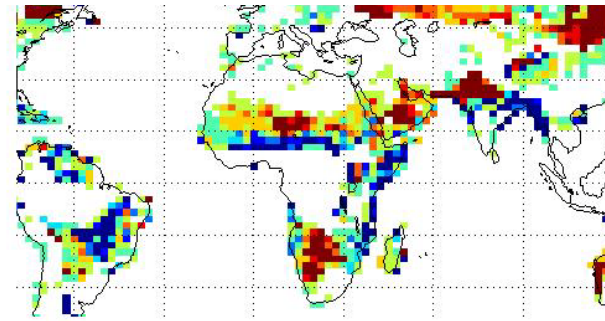
DECIDUOUS TREES



SHRUBS



GRASSES



Potential vegetation feedbacks

- Biogeophysical enhancement of NA Monsoon
 - Albedo
 - Evapotranspiration
- Biogeochemical
 - Net Ecosystem Exchange
 - Dust mobilization

Summary/Outline

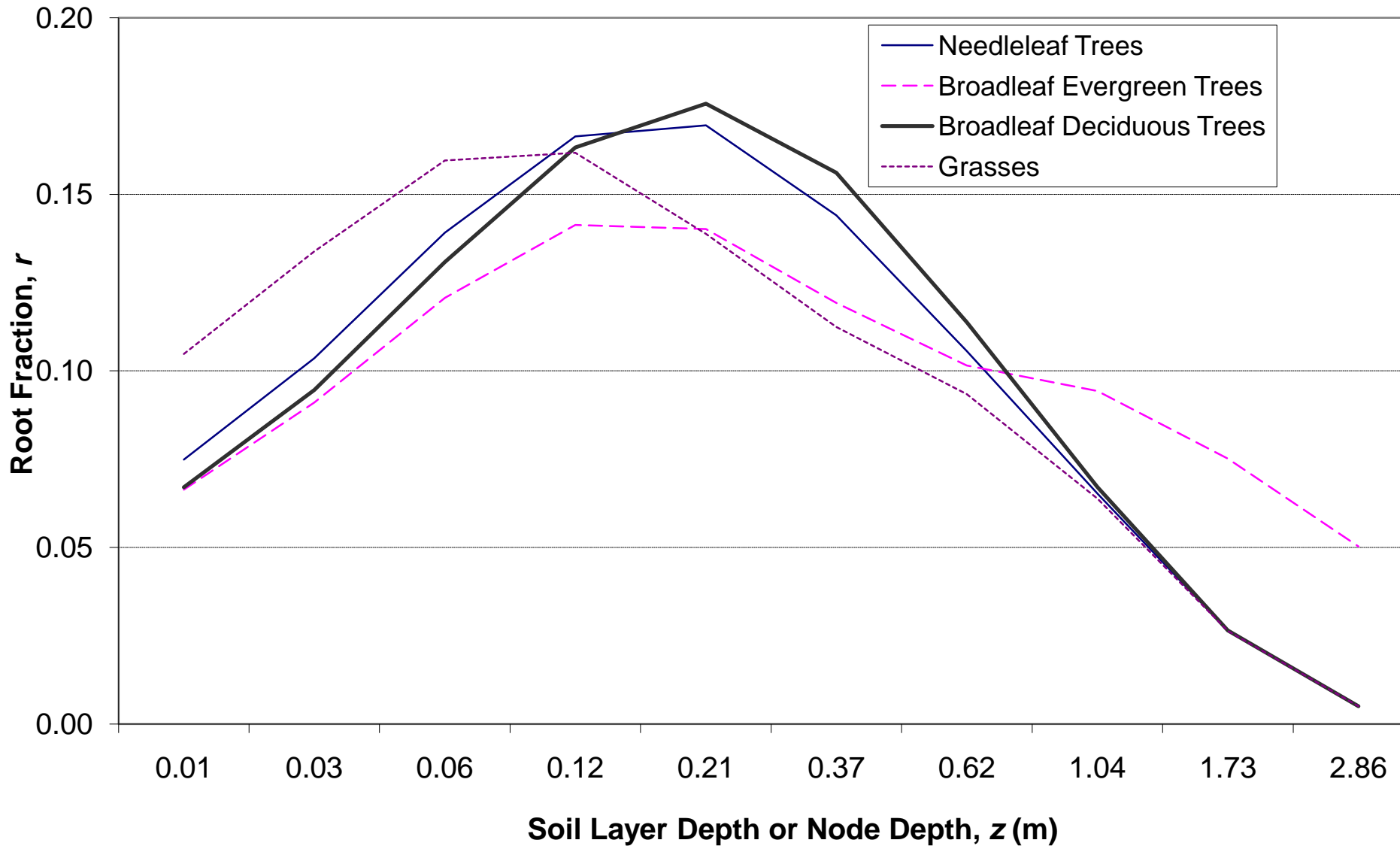
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- Photosynth. less limited by soil moisture due to
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CAVEATS

1. Shortage of N delays veg. response... REALISTIC?
2. DGVM feedbacks NOT included in what I show

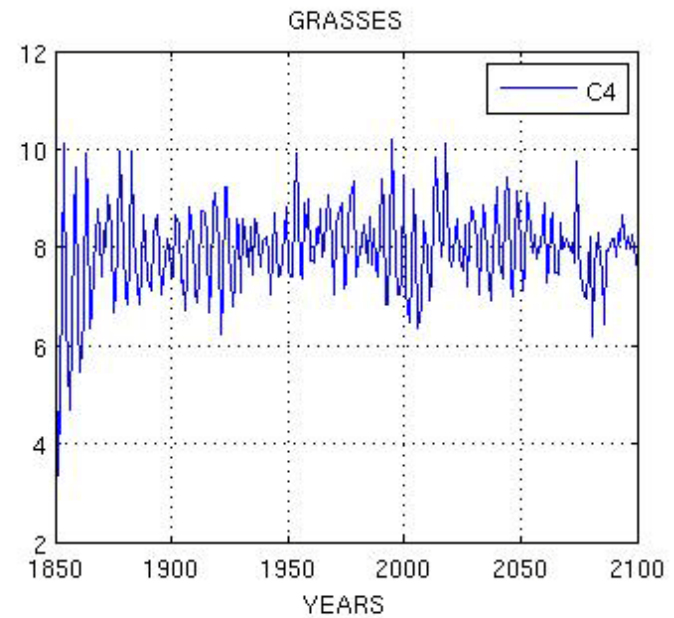
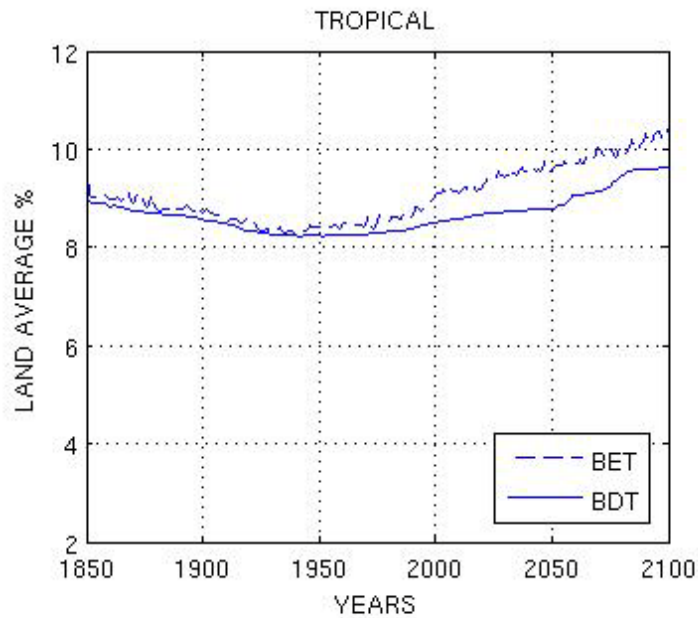
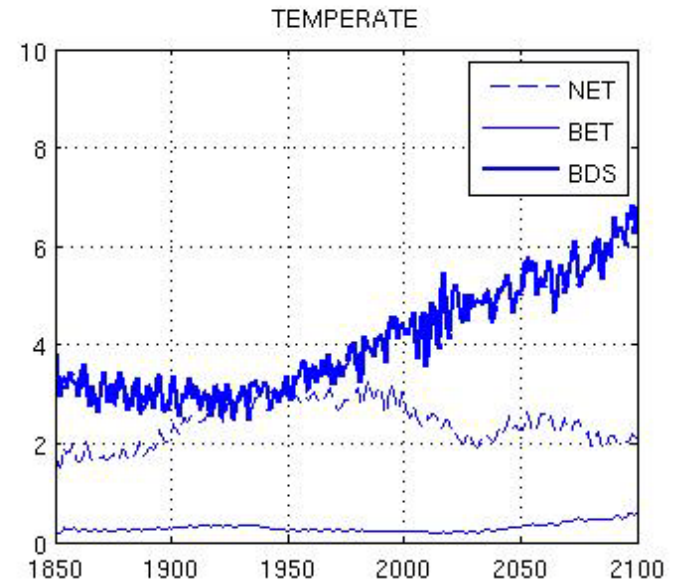
Extra slides...

CLM root fraction profiles (Zeng 2001)



PFT trends

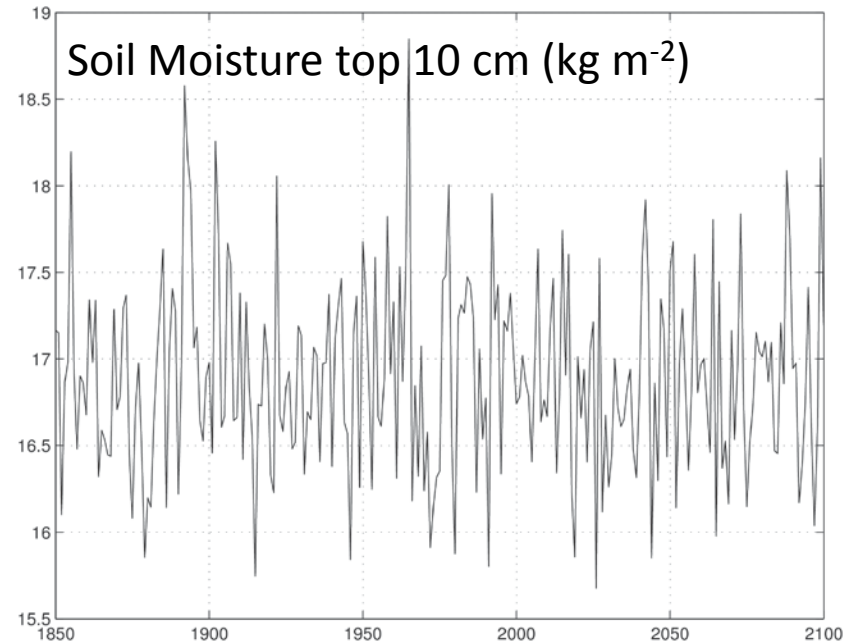
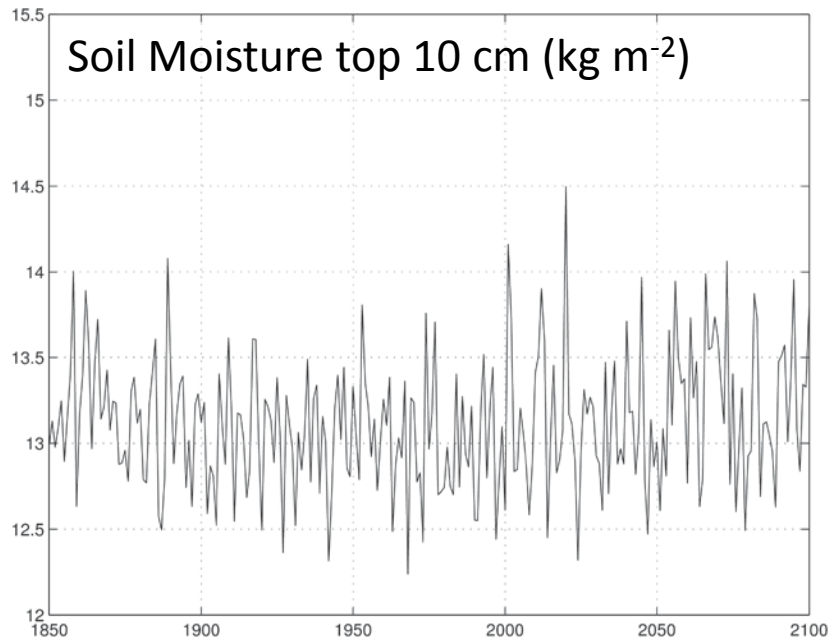
0-30°N 20°W-60°E



0-30°N 20°W-60°E

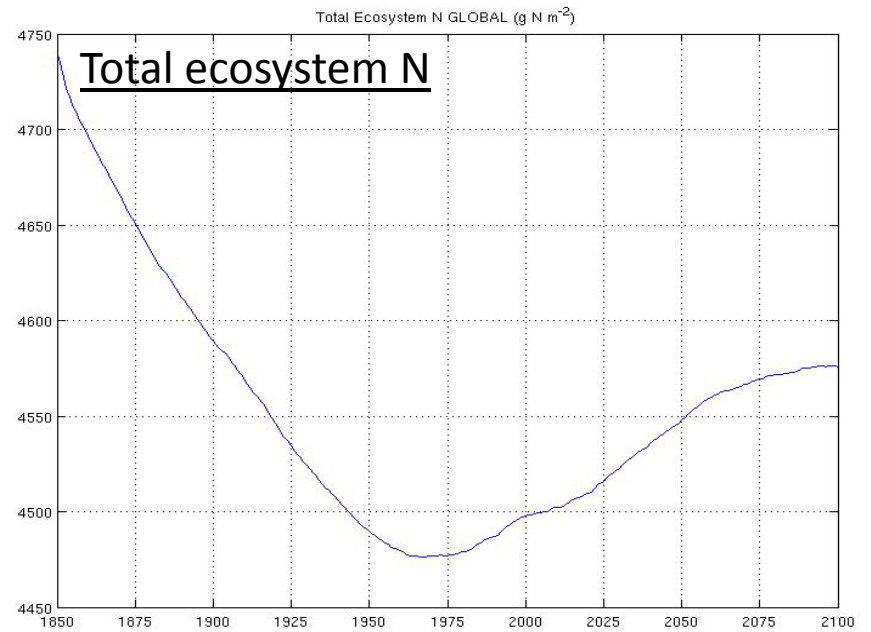
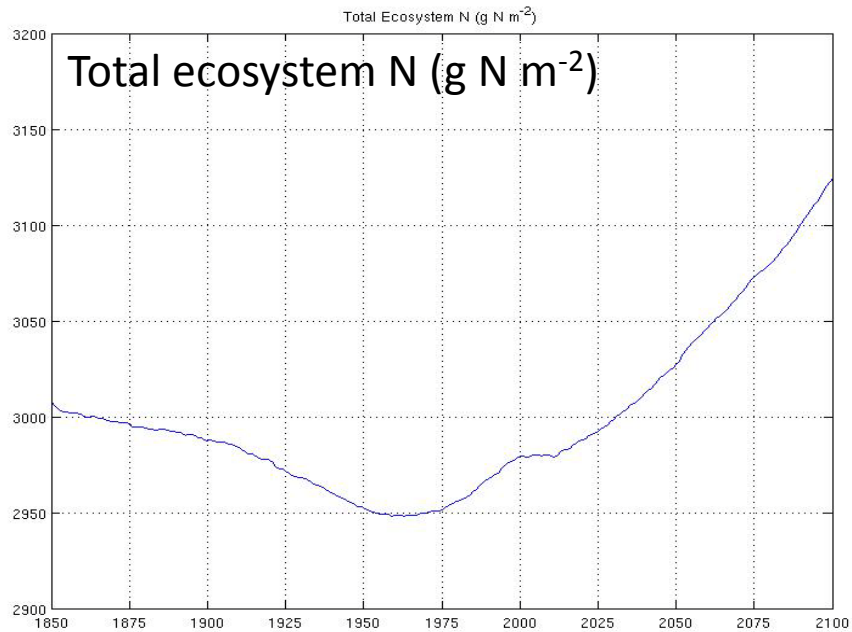
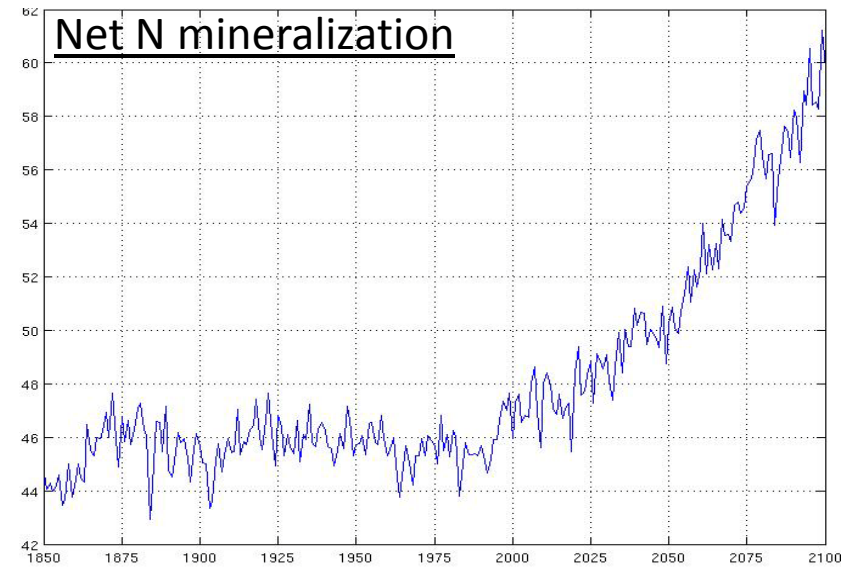
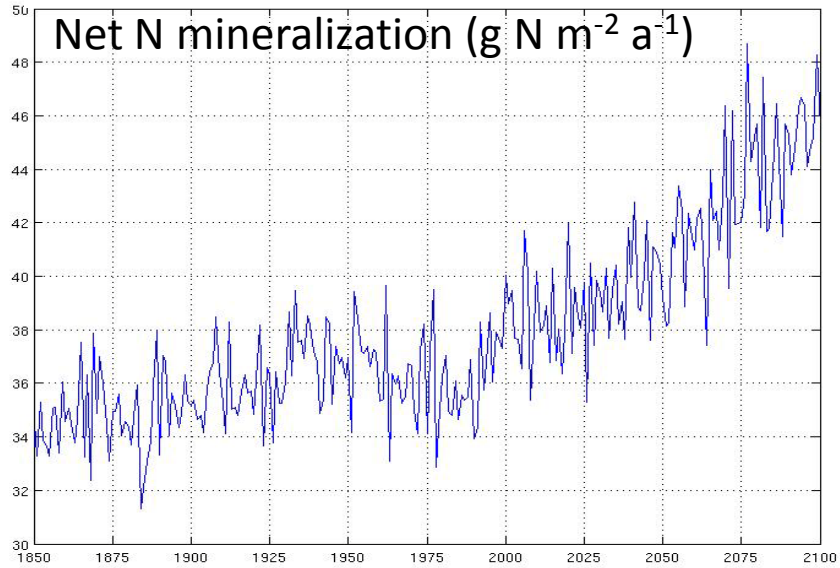
JANUARY

JULY

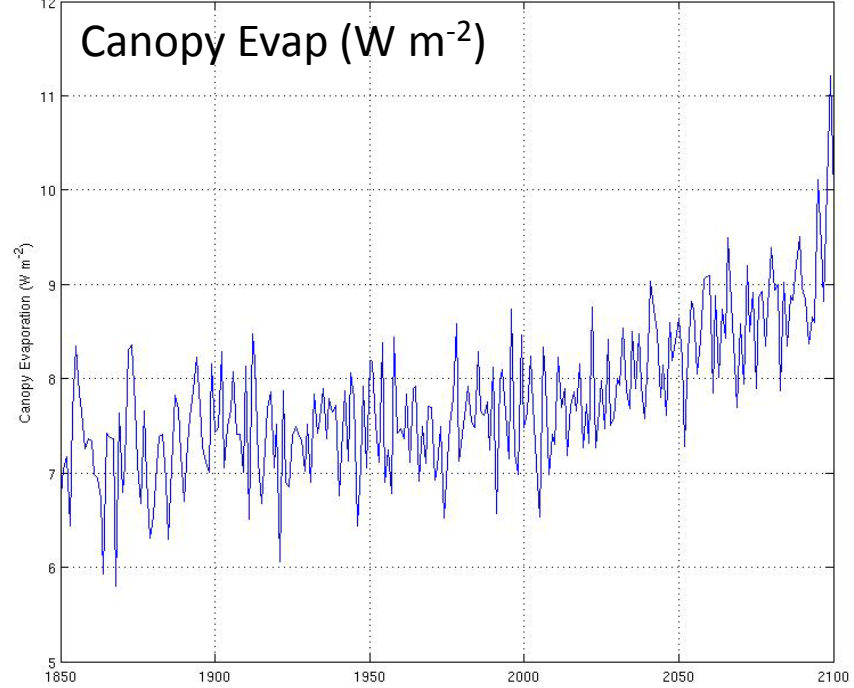
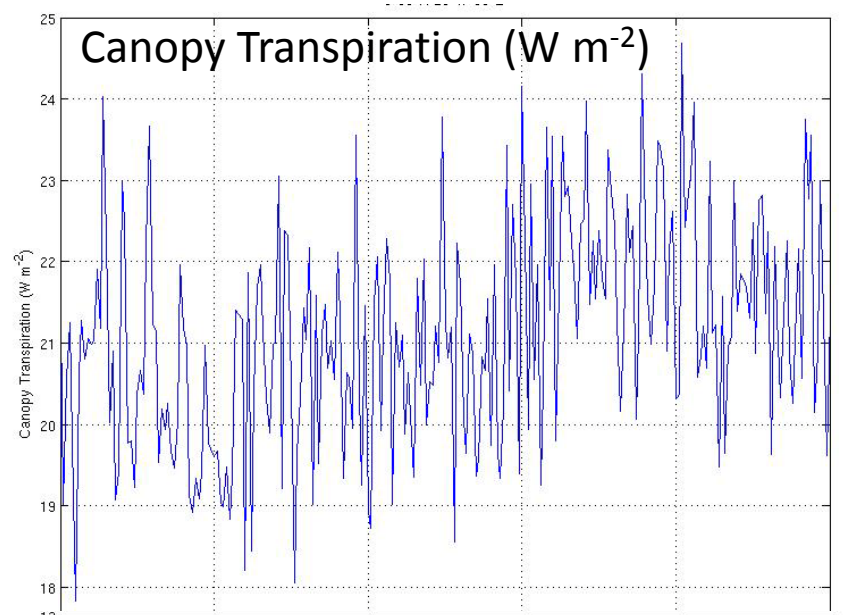
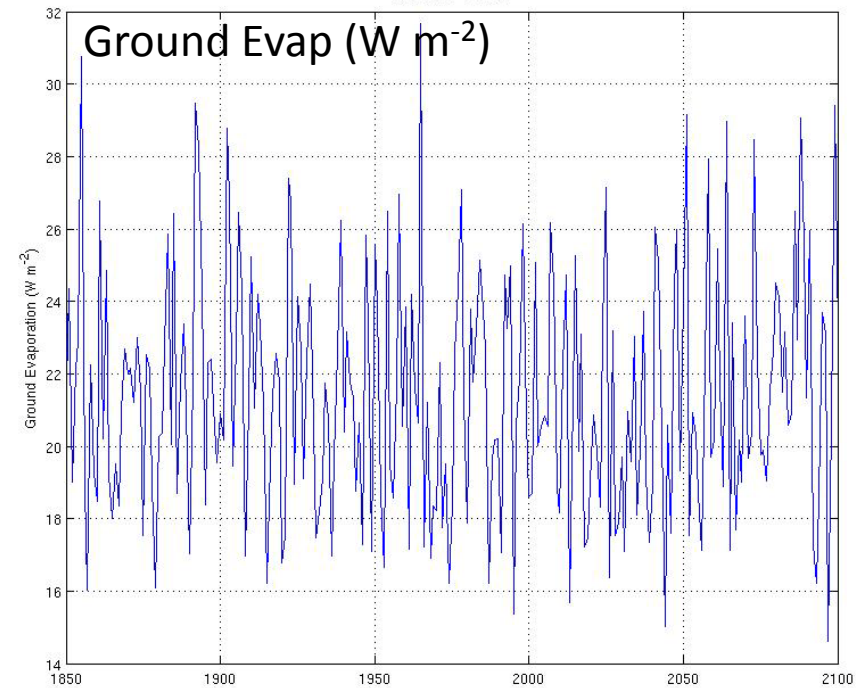
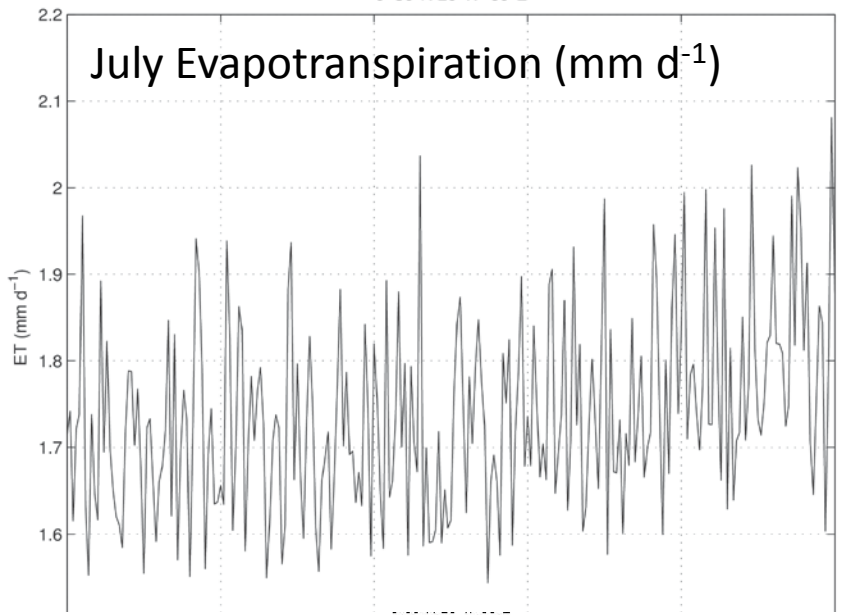


0-30°N 20°W-60°E

GLOBAL



0-30°N 20°W-60°E

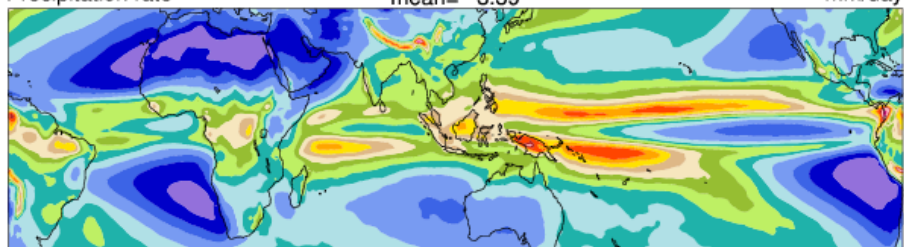


JJA

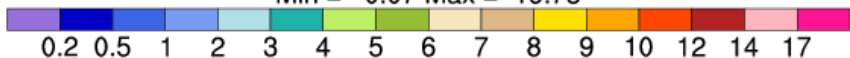
ANN

b40.mh6ka.1deg.003 (yrs 981-1000)

Precipitation rate mean= 3.39 mm/day

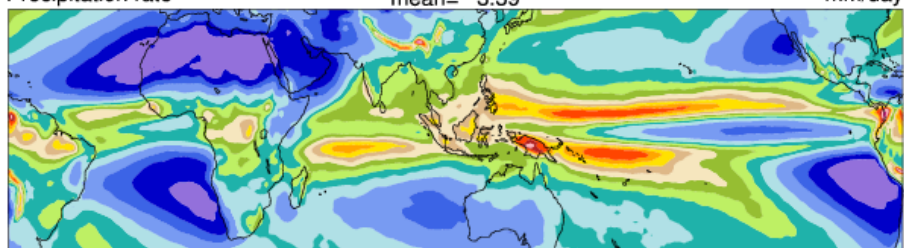


Min = 0.07 Max = 19.75

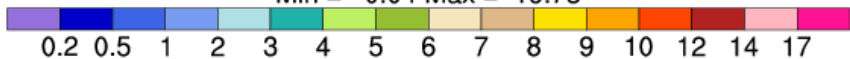


b40.1850.track1.1deg.006 (yrs 981-990)

Precipitation rate mean= 3.39 mm/day

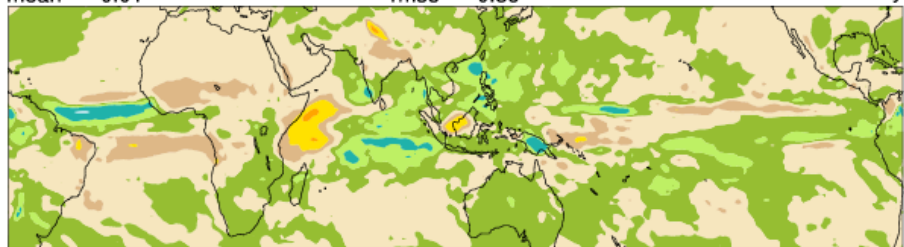


Min = 0.04 Max = 19.73

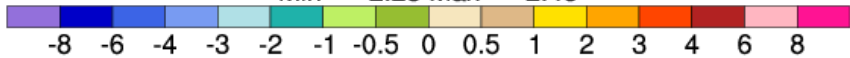


b40.mh6ka.1deg.003 - b40.1850.track1.1deg.006

mean = -0.01 rmse = 0.39 mm/day

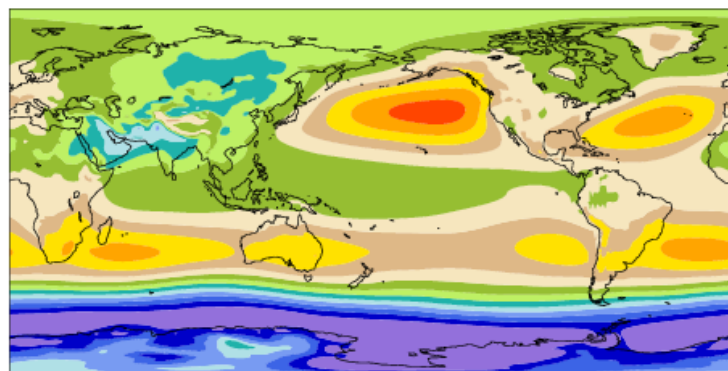


Min = -2.23 Max = 2.48

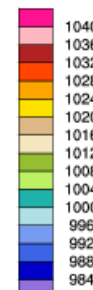


b40.mh6ka.1deg.003 (yrs 981-1000)

Sea-level pressure mean= 1010.95 millibars

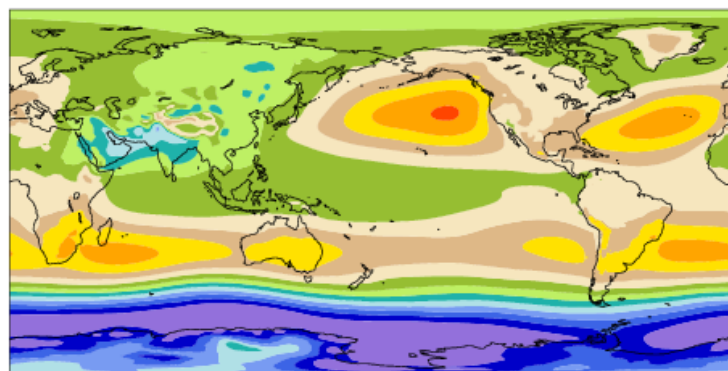


Min = 973.78 Max = 1029.88

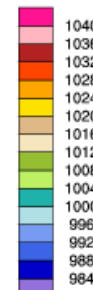


b40.1850.track1.1deg.006 (yrs 981-990)

Sea-level pressure mean= 1010.99 millibars

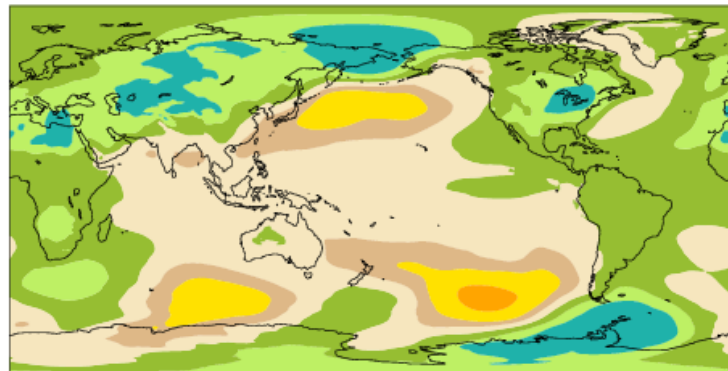


Min = 974.41 Max = 1028.56



b40.mh6ka.1deg.003 - b40.1850.track1.1deg.006

mean = -0.04 rmse = 1.15 millibars



Min = -3.45 Max = 5.13

