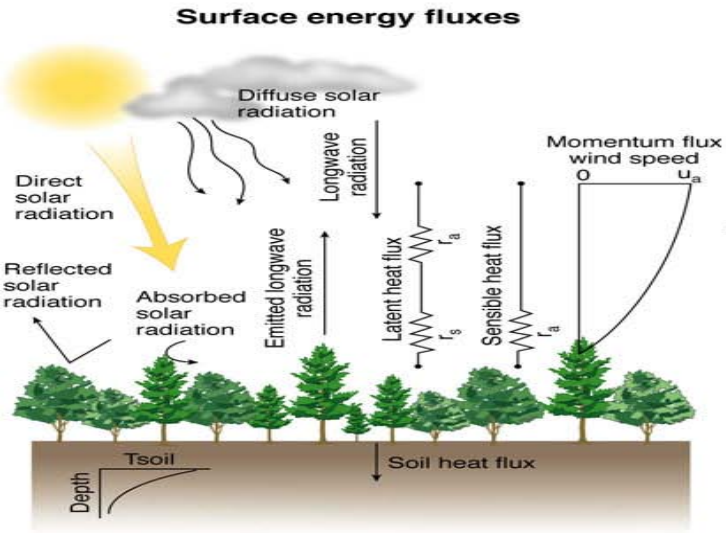
The State of CLM4

A



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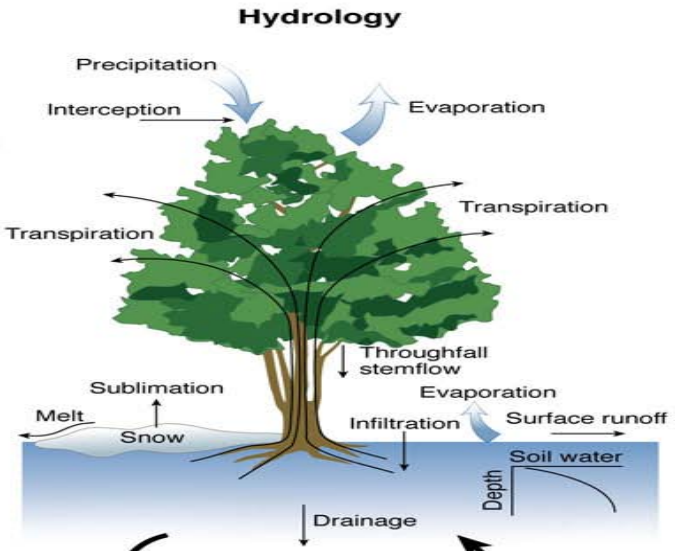

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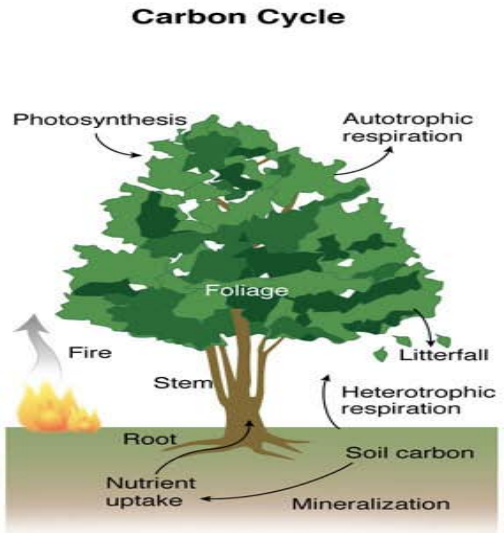
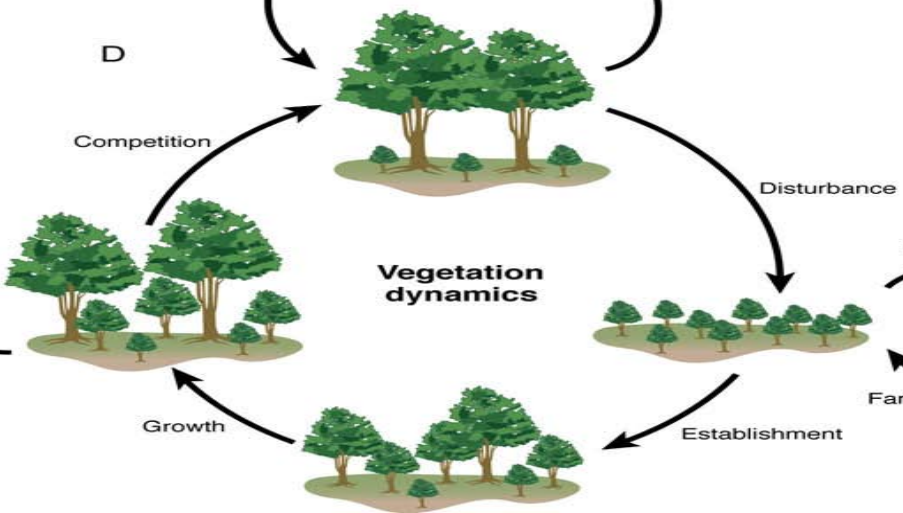


F

D



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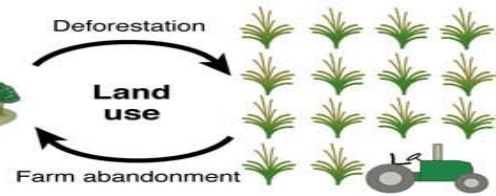
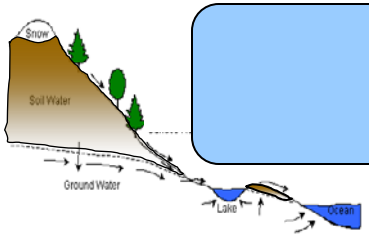
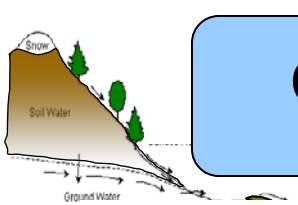




What's new for CLM4

CLM3.5 → CLM4 : Carbon and Nitrogen cycling



Carbon cycle

Nitrogen cycle

Internal (fast)

External (slow)

Atm CO_2

photosynthesis

Plant

respiration

litterfall & mortality

Litter / CWD

decomposition

Soil Organic Matter

assimilation

denitrification

N deposition

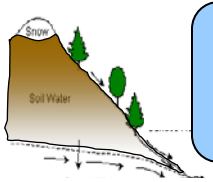
Soil Mineral N

N fixation

mineralization

N leaching

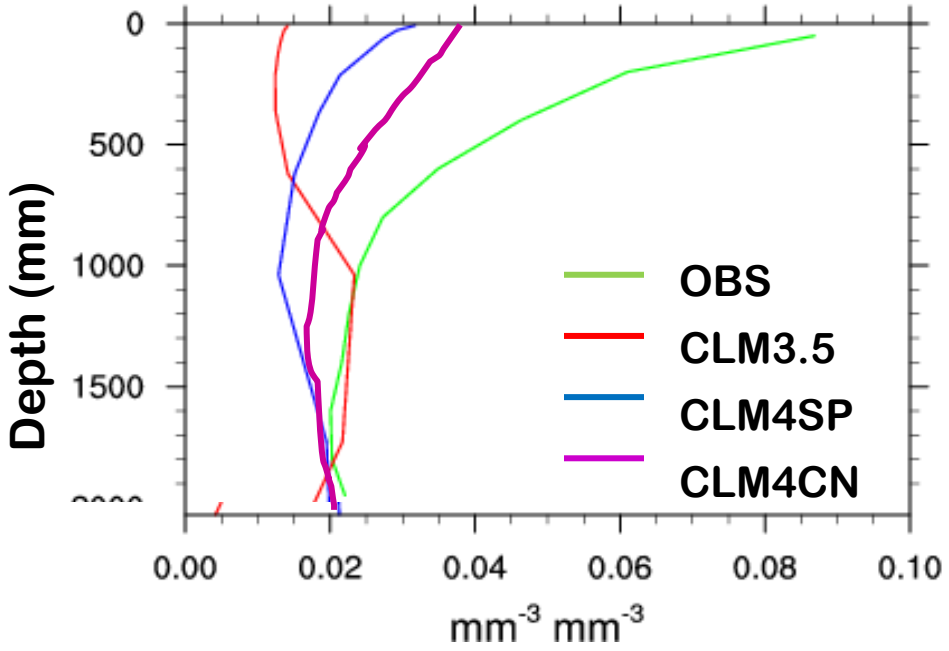
Based on Biome-BGC, Thornton et al., 2009

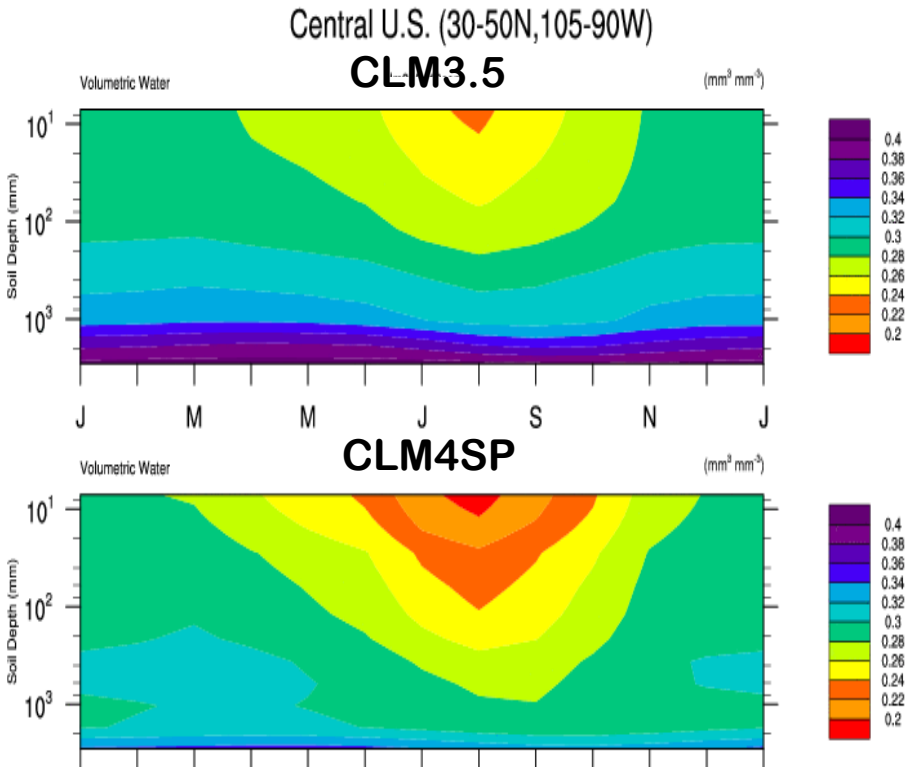


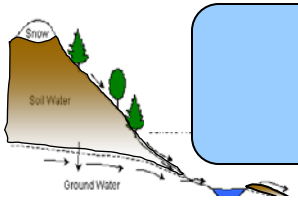
CLM3.5 → CLM4: Soil Hydrology (Sakaguchi, Zeng, Decker, Swenson, Oleson, Lawrence, Niu, Yang)

- Replaced soil evap resistance term with so-called β formation
- litter resistance
- under canopy turbulent stability
- modified Richard's equation – maintains steady state
- simplified bottom boundary condition for soil water equations

Standard deviation of Vol. Soil Water







CLM3.5 → CLM4

– **Snow model** (Flanner, Zender, Niu, Yang, Lawrence, Zeng)

- snow density dependent snow cover fraction parameterization
- snow burial fraction for short vegetation

~ +0.1° C to CCSM4 climate sensitivity

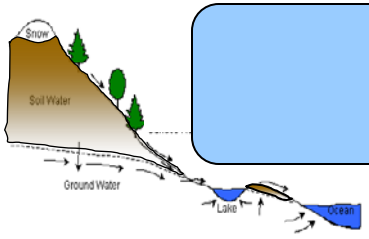
- adopt SNICAR

  snow age

  vertically resolved heating in snowpack (snowdp > 0.1m)

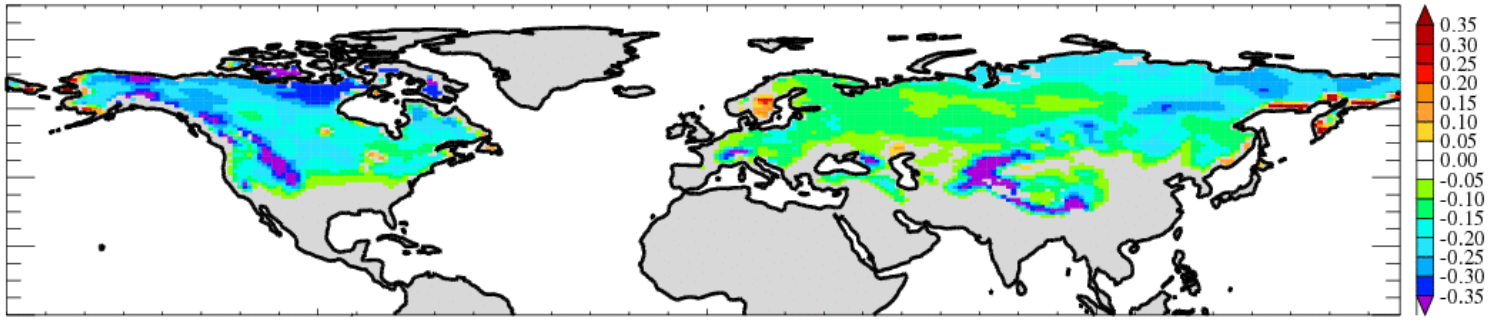
  aerosol deposition (dust, black carbon, organic carbon) – works with bulk or modal aerosols

- snow compaction
- snow layer splitting
- (bug) – energy not conserved during snow layer combination

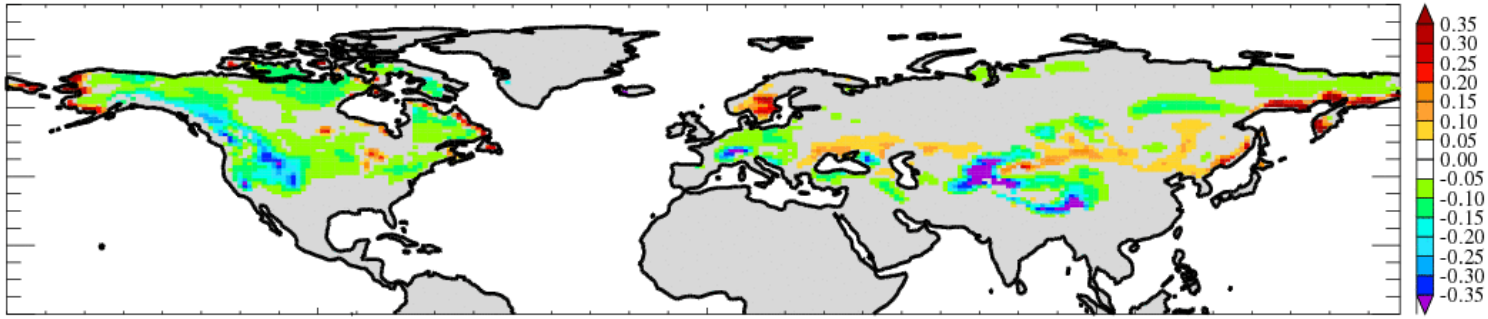


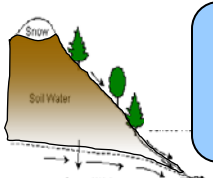
Snow cover fraction

Snow cover fraction: CLM3.5 – Obs



Snow cover fraction: CLM4SP – Obs

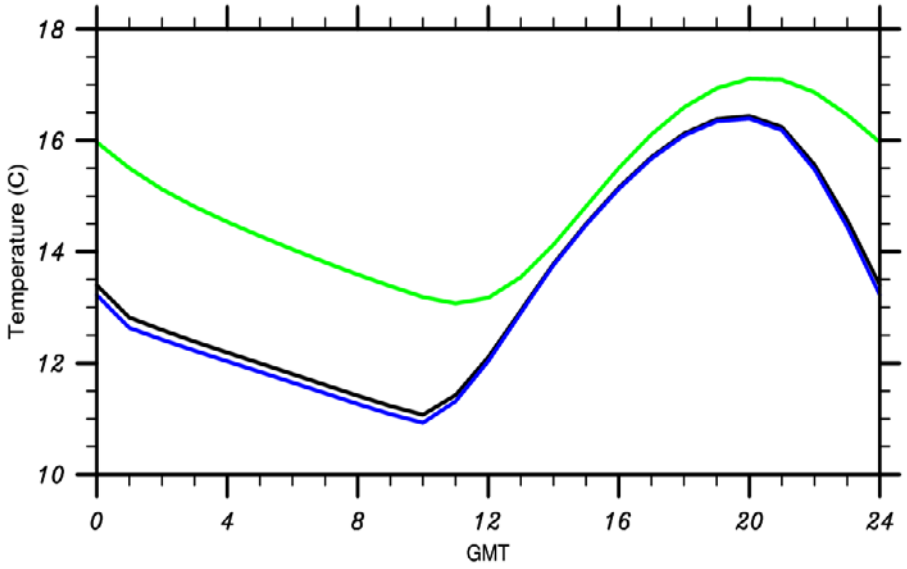




CLM3.5 → CLM4

- **Urban model** (Oleson, Feddema, Bonan)
  - Impact on climate is very small, represent heat island
  - Heating/AC/wasteheat flux: +0.03 to 0.05 W m^{-2} over land

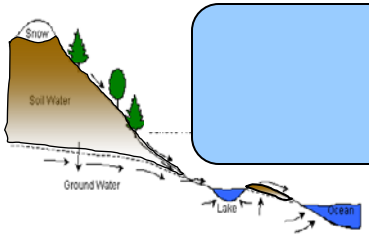
1980-1999 Average Annual Diurnal Cycle (40.7N, 287.5E)



Urban

Grid Average

Rural



CLM3.5 → CLM4

- **New surface dataset -** revised assumptions about how to treat herbaceous understory when assigning PFTs from MODIS (Lawrence, P)

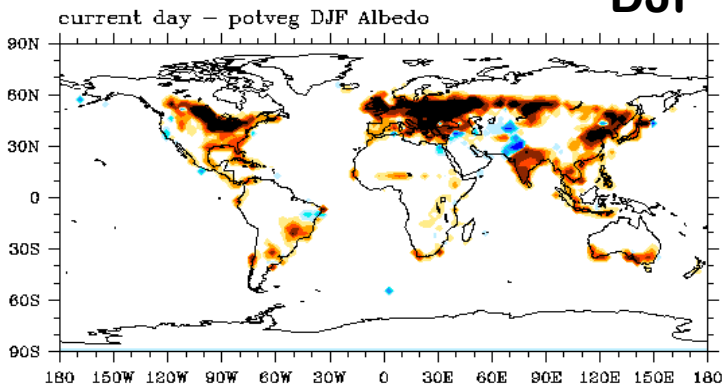
- **New grass optical properties** (Lawrence, D)

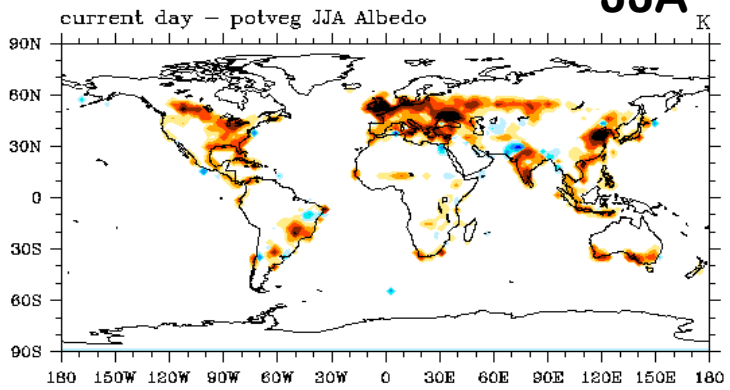
Land cover change impact on albedo

DJF

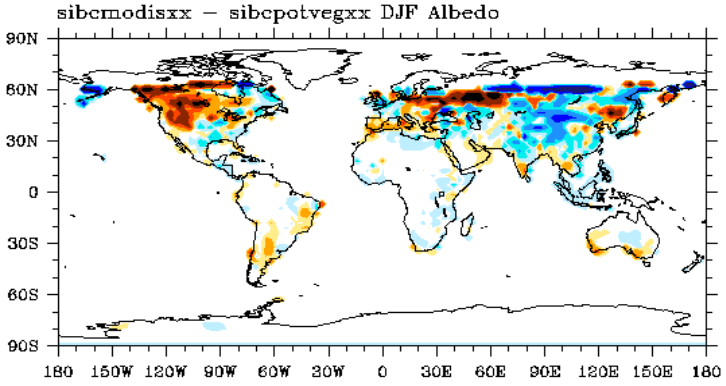
JJA

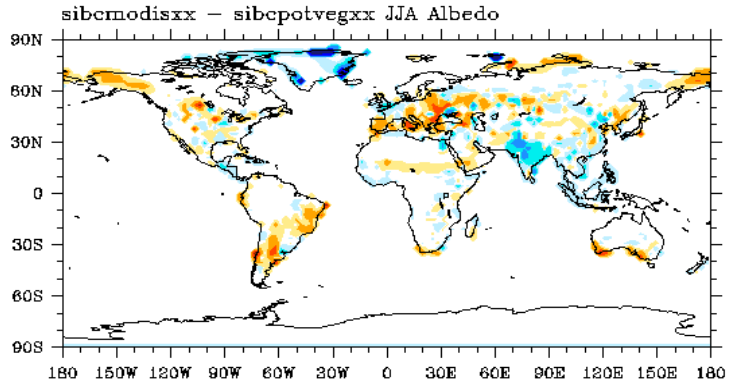
OBS



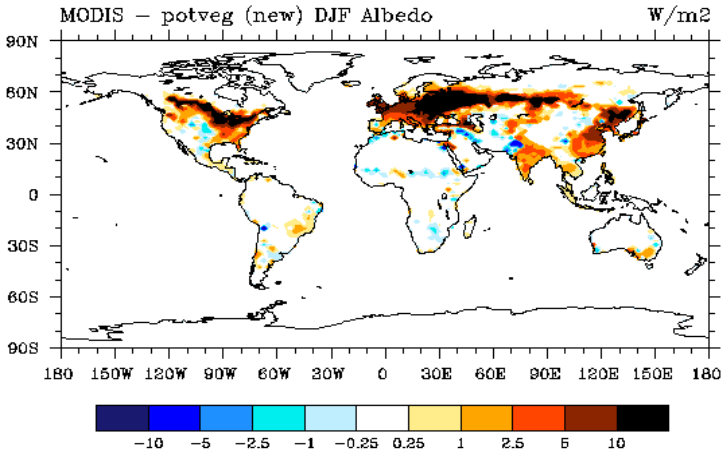


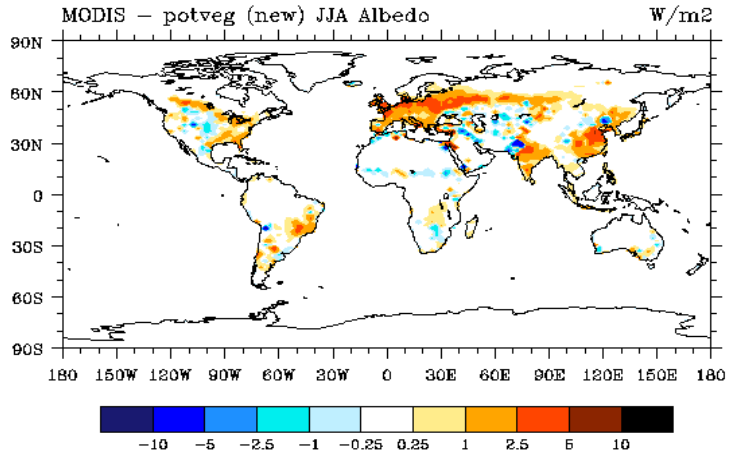
CLM3.5 dataset

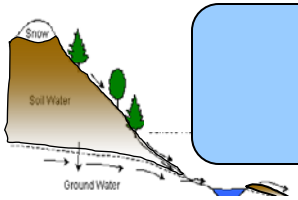




CLM4 dataset

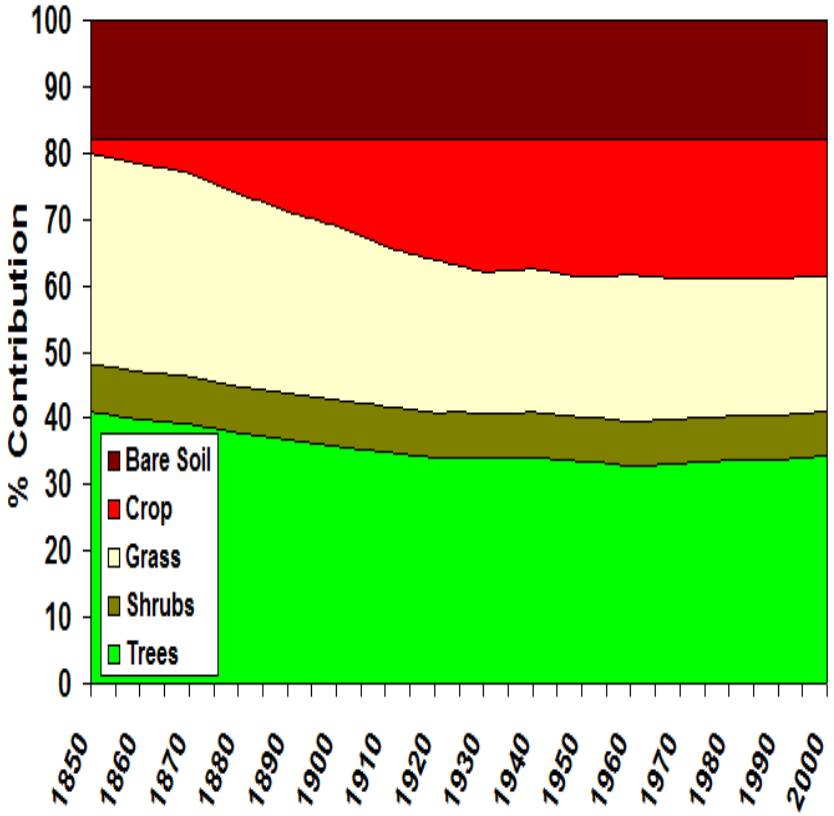




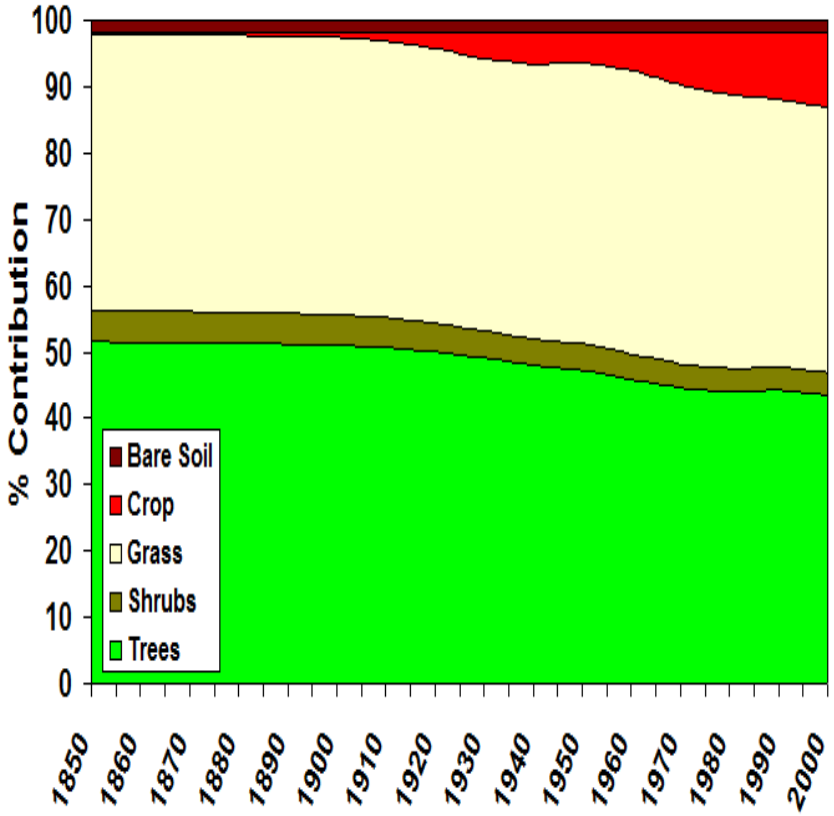


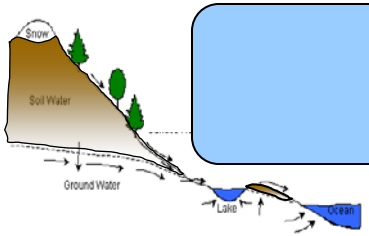
CLM3.5 → CLM4: Transient land cover/land use change

a) Western North America Transient PFTs



b) Eastern South America Transient PFTs

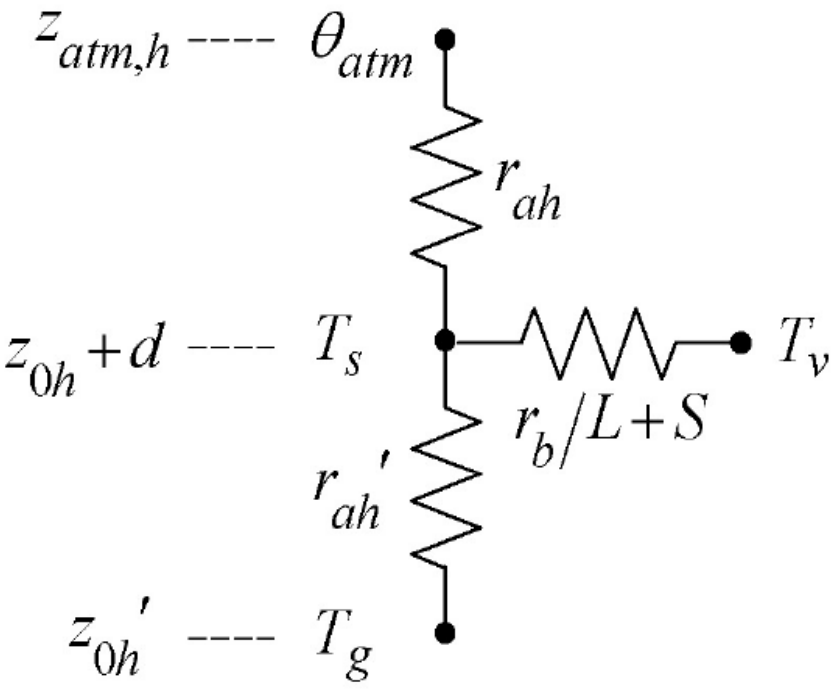


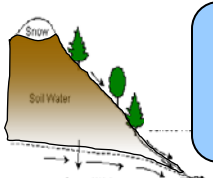


CLM3.5 → CLM4

- **Reference height** (Oleson, Svennson)

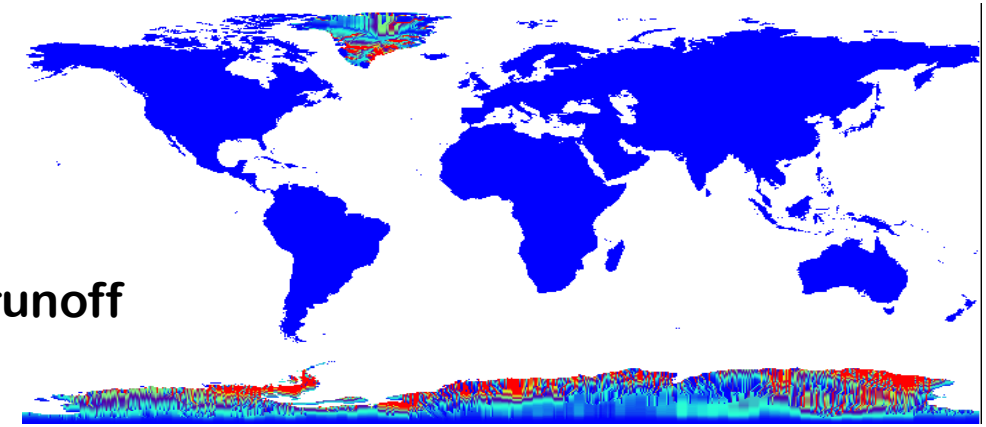
  Distance between reference height (z_0+d) and lowest atmospheric level is same for all land tiles



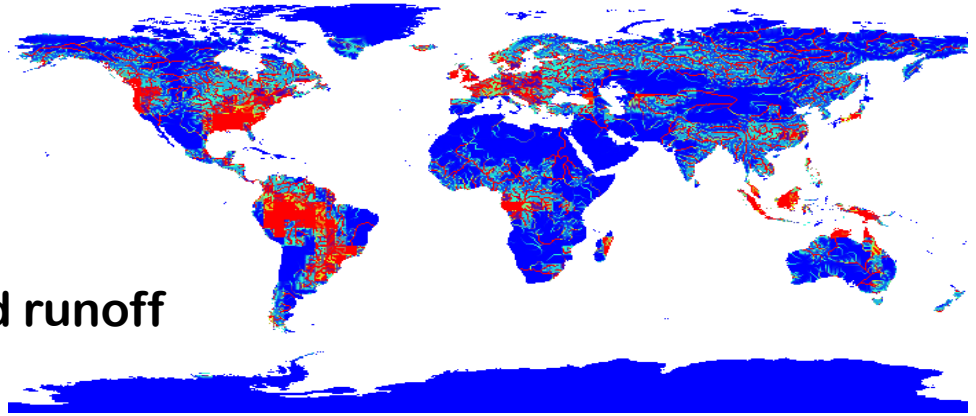


CLM3.5 → CLM4

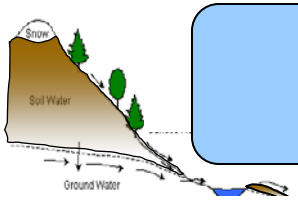
- **Ice stream in River Transport Model (Lawrence, Craig)**
  - For snow capped regions send excess water to ice stream (poor man's ice sheet calving)
  - Reduces CCSM energy imbalance by ~0.15-0.2 W/m^2
  - Unrealistic high sea-ice thickness in semi-closed bays



Ice runoff



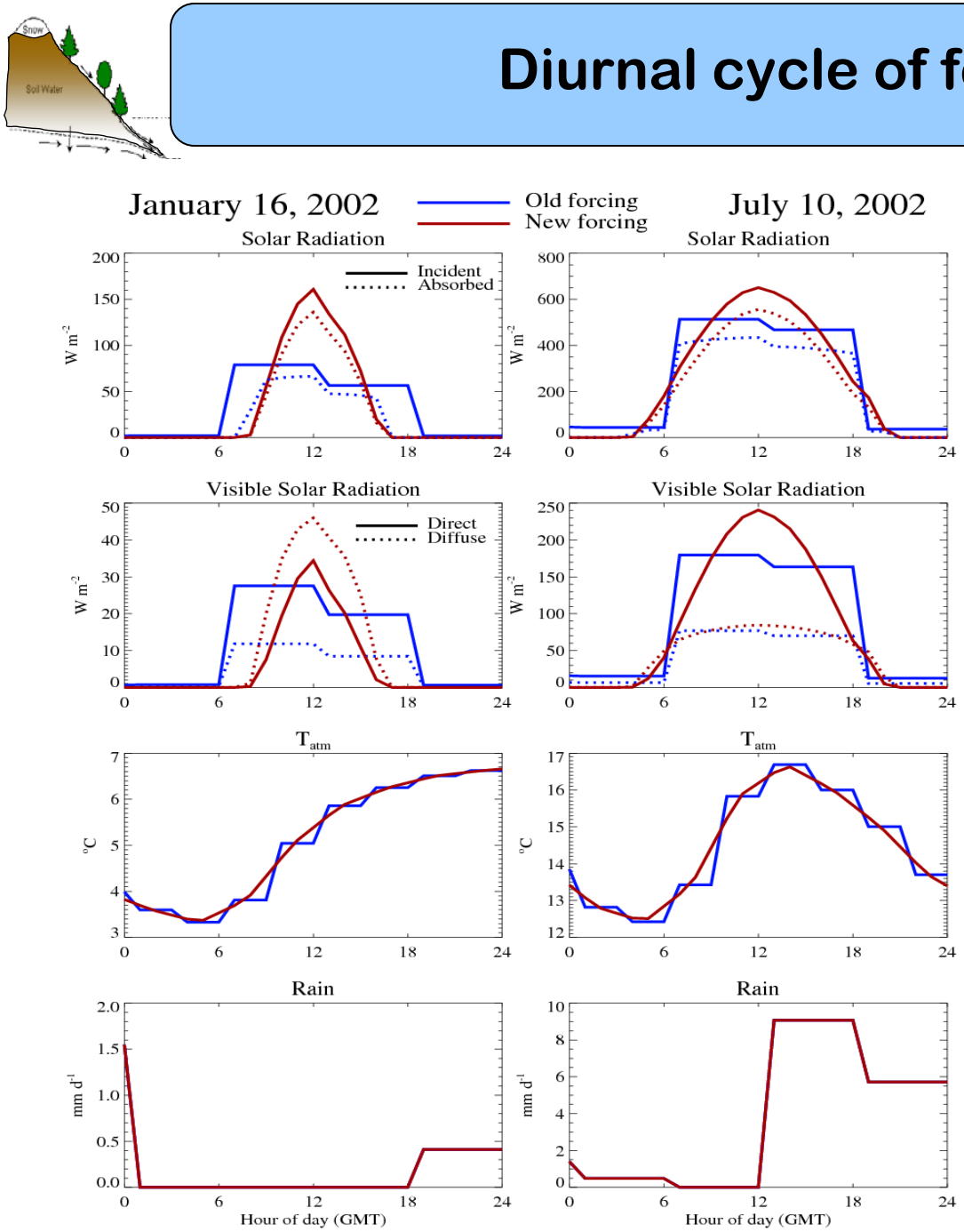
Liquid runoff

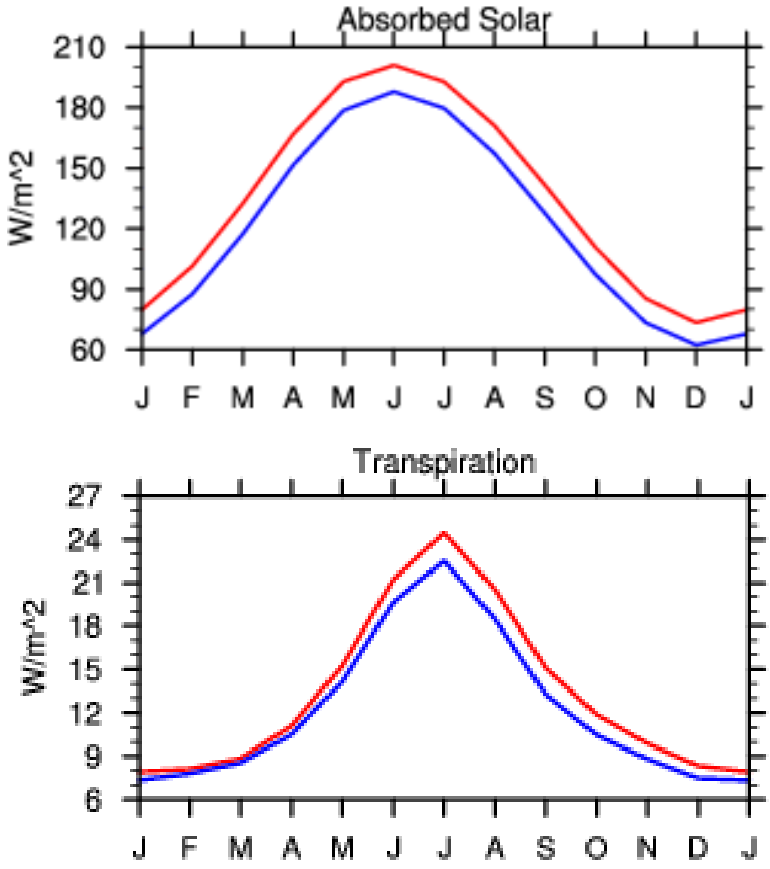


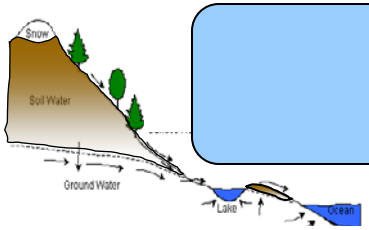
CLM3.5 → CLM4

- Organic soil – thermal and hydrologic properties (Lawrence, Slater)
- Deeper soil column (~50 m, 15 soil levels, layers 11-15 are bedrock) (Lawrence, Slater)
- Integration of CN and DGVM (CNDV)
- New VOC model (MEGAN model) (Heald, Levis)
- Fixed diurnal cycle of solar radiation (offline) (Kluzek, Oleson, Swenson)
- Partitioning of direct vs diffuse radiation (offline) (Lawrence)

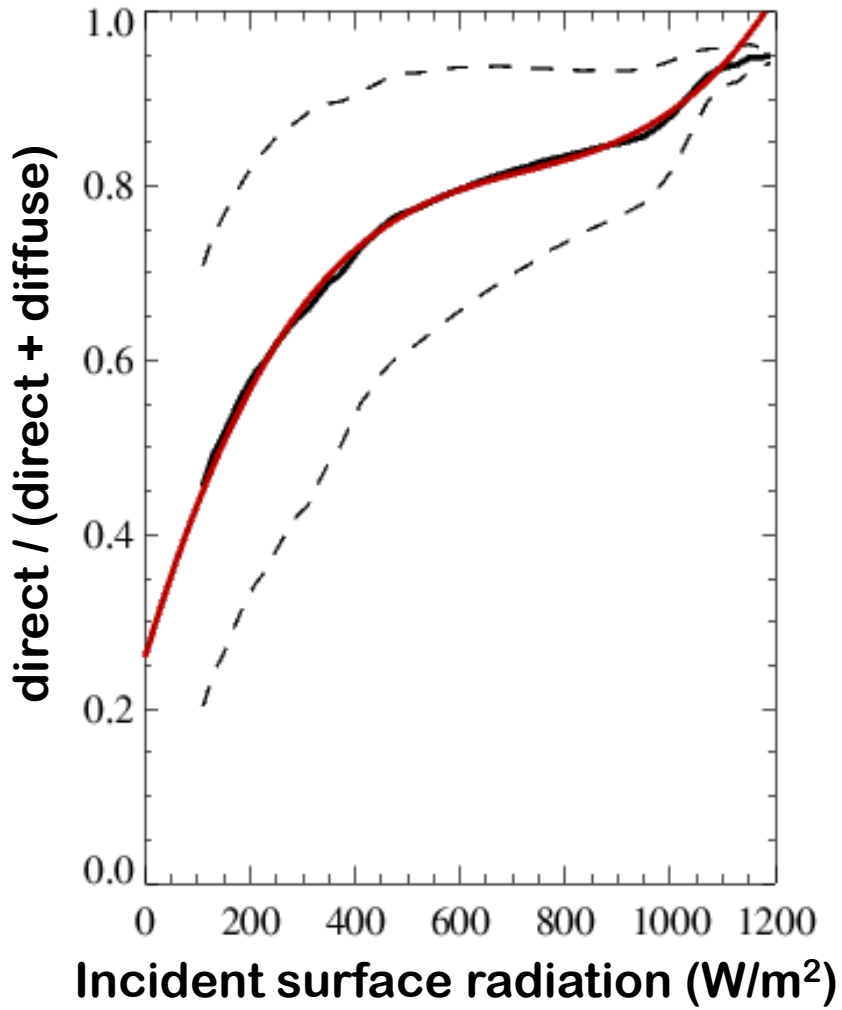
Diurnal cycle of forcing (offline)







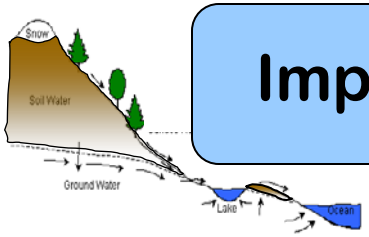
Direct vs diffuse radiation (offline)



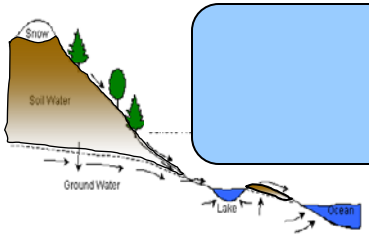
Relationship derived from CAM3.5 hourly data

Separate relationships for visible and near infrared

Affects photosynthesis and increases consistency between online (CAM/CLM) and offlin (CLM only) simulations

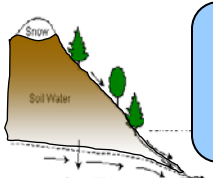


Impact of integrated changes on offline simulations

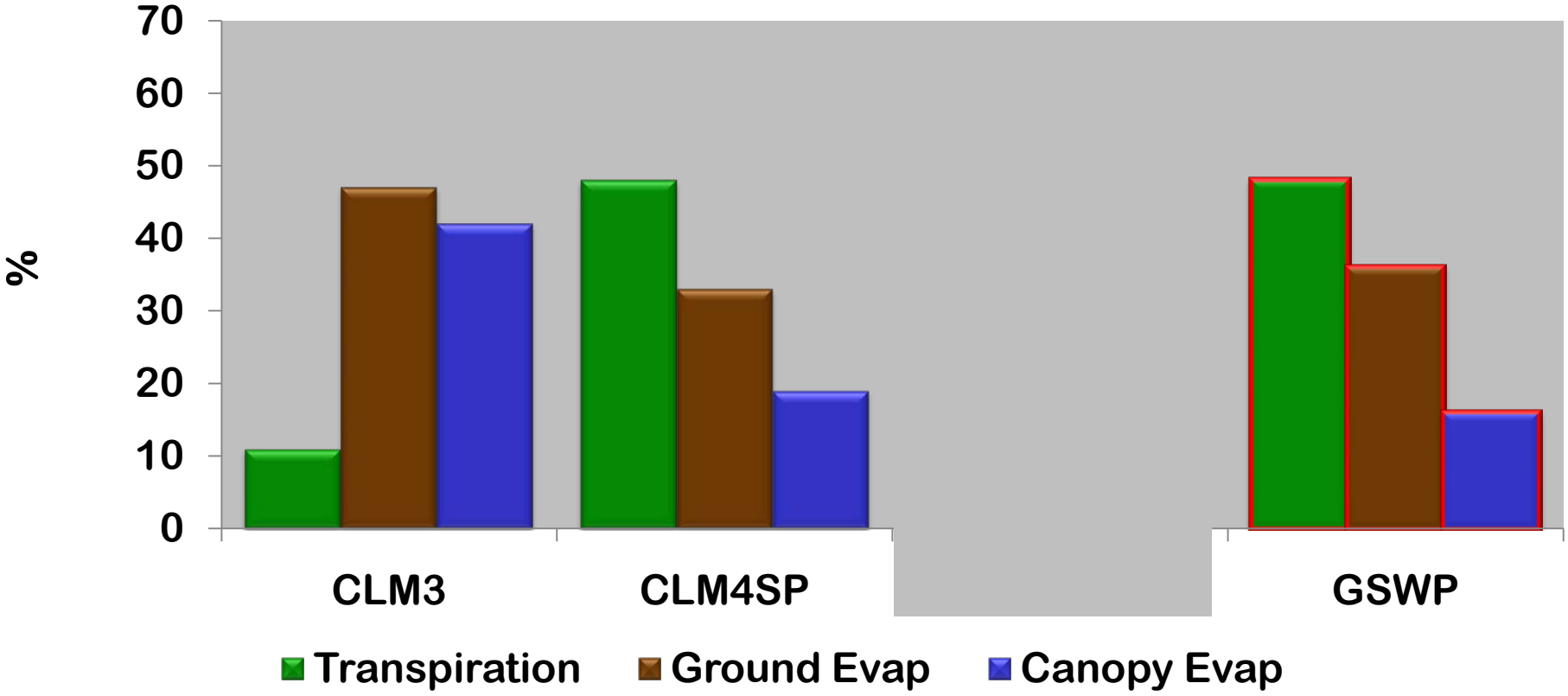


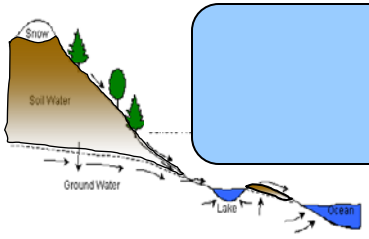
Proposed naming conventions

- CLM3: model released with CCSM3
- CLM3.5: interim version
- CLM4: model released with CCSM4
  - CLM4SP: satellite phenology
  - CLM4CN: carbon-nitrogen cycle phenology



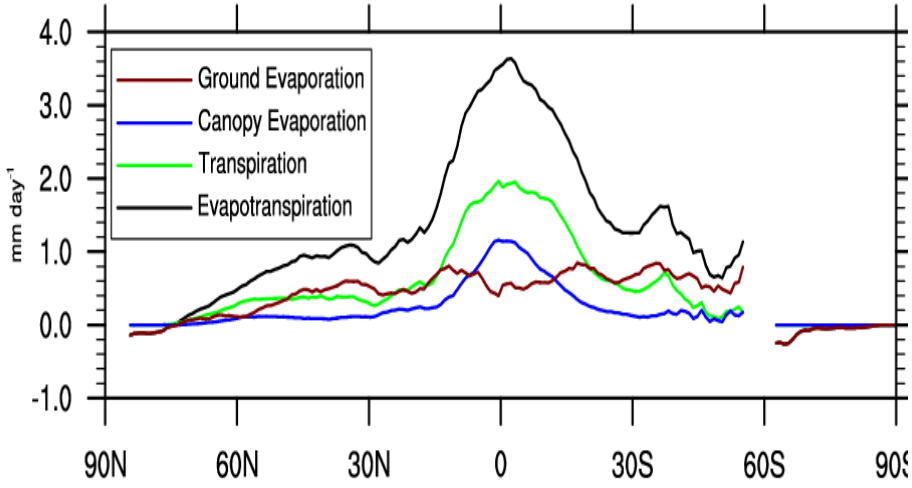
Global Partitioning of Evapotranspiration



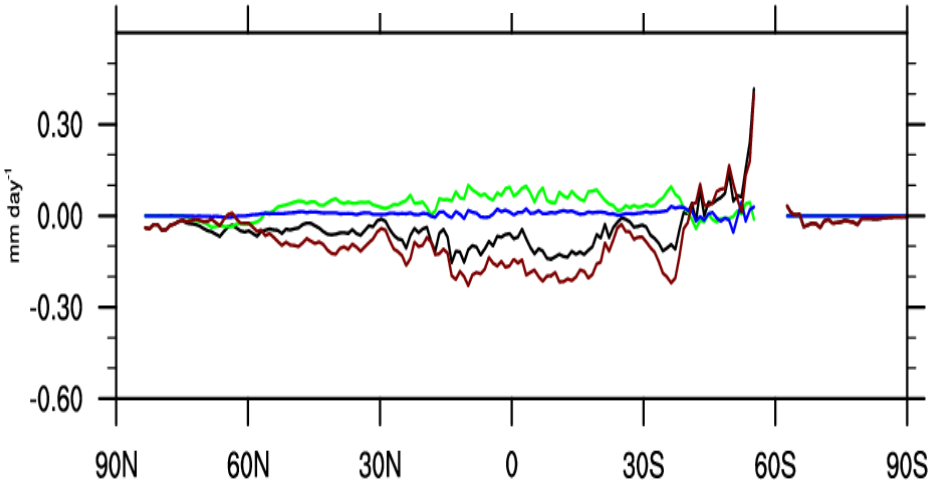


Zonal Mean ET Partitioning

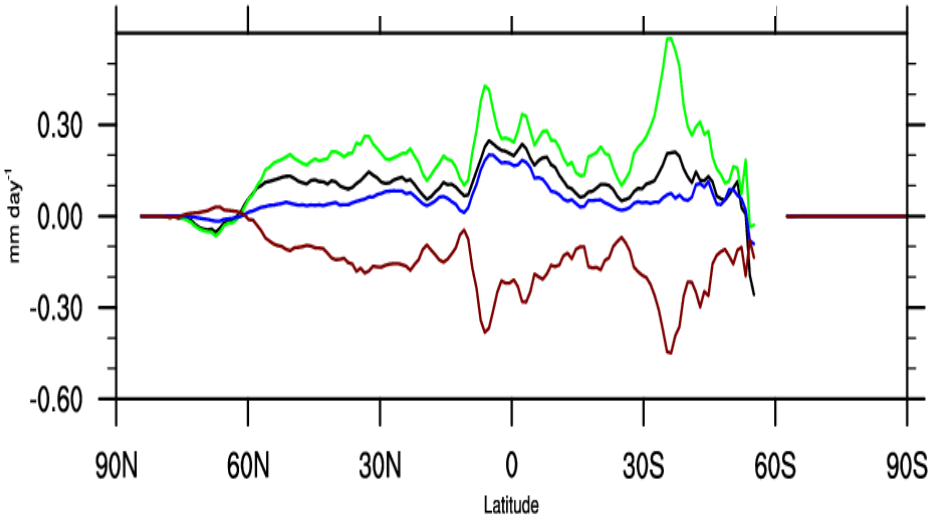
CLM4SP

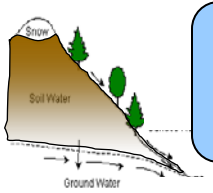


CLM4SP – CLM3.5

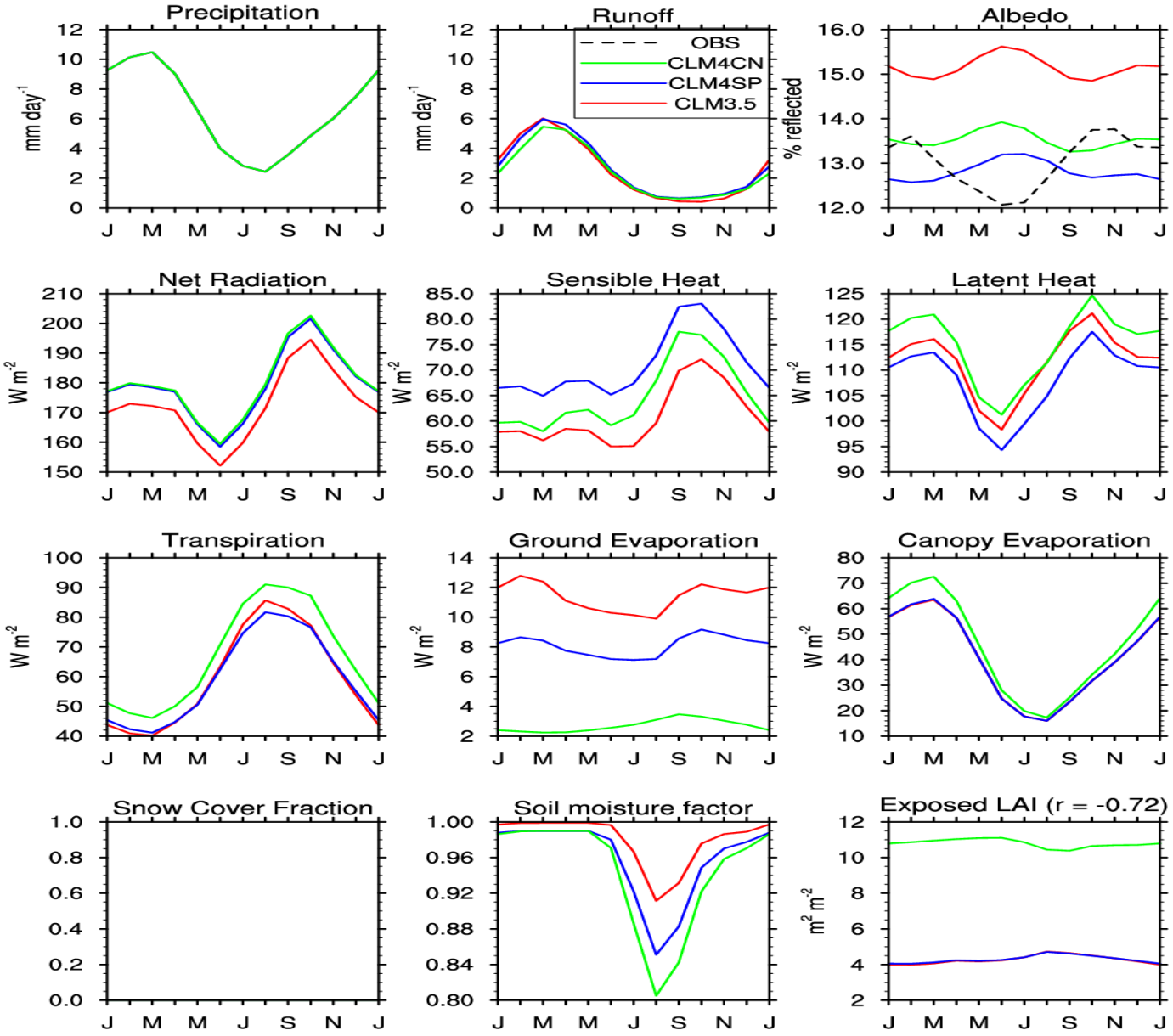


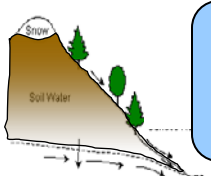
CLM4CN - CLM4SP



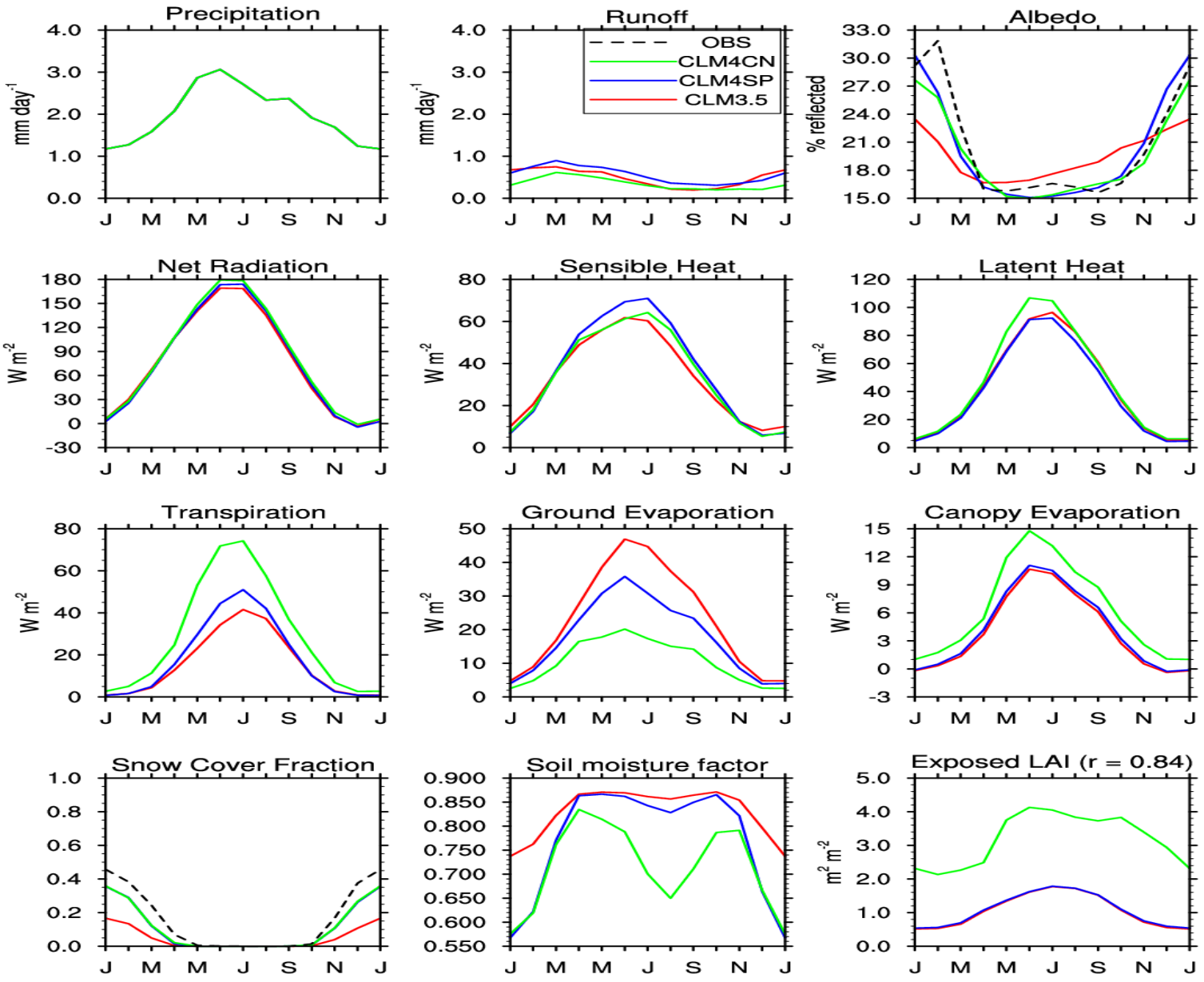


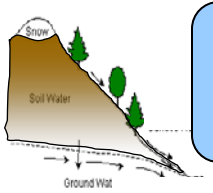
Climatological annual cycle: Amazonia



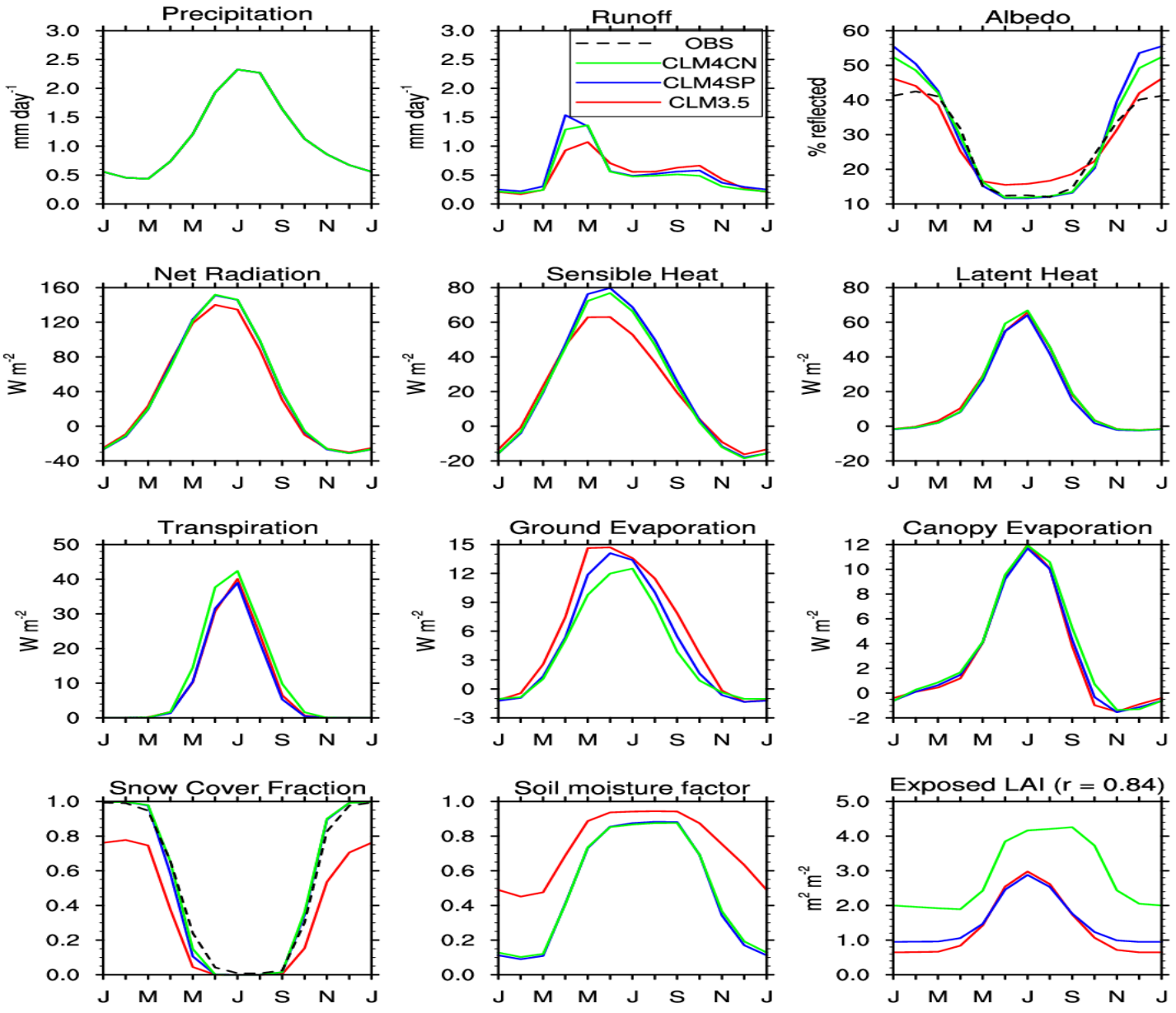


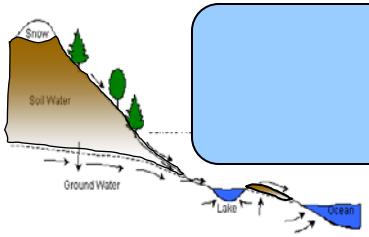
Climatological annual cycle: Central US





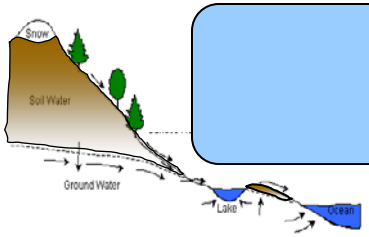
Climatological annual cycle: Siberia





Tower flux statistics (15 sites, hourly)

	Latent Heat Flux		Sensible Heat Flux	
	r	RMSE (W/m^2)	r	RMSE (W/m^2)
CLM3	0.54	72	0.73	91
CLM3.5	0.80	50	0.79	65
CLM4SP	0.80	48	0.84	58

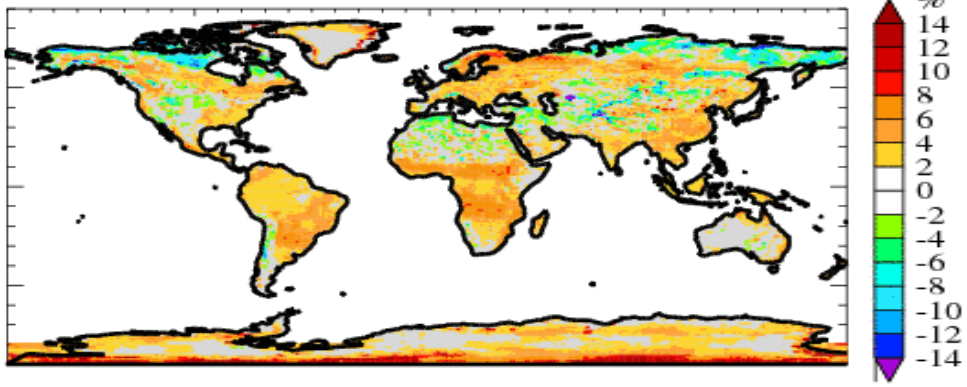


Tower flux statistics (15 sites, monthly)

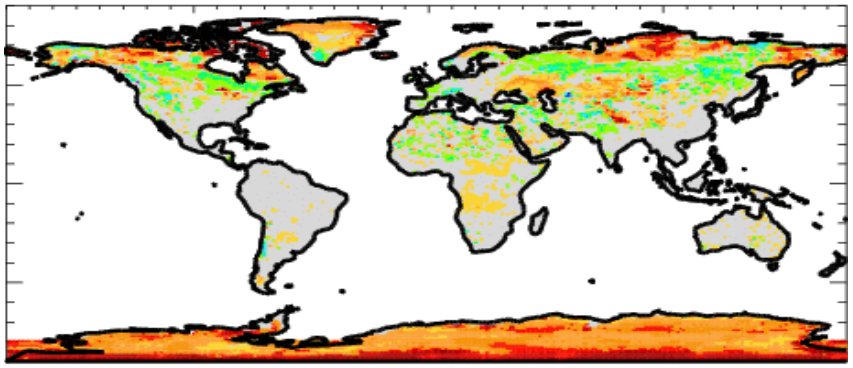
	Latent Heat Flux		Sensible Heat Flux	
	r	RMSE (W/m^2)	r	RMSE (W/m^2)
CLM3	0.58	33	0.73	40
CLM3.5	0.83	22	0.67	29
CLM4SP	0.82	23	0.69	26

Albedo

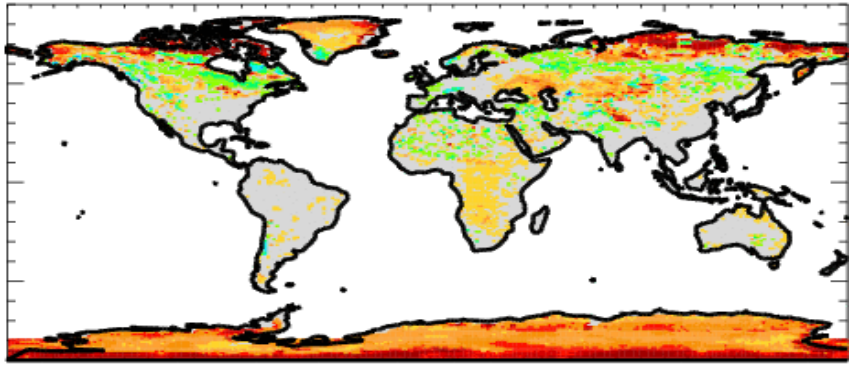
CLM3.5 – Obs



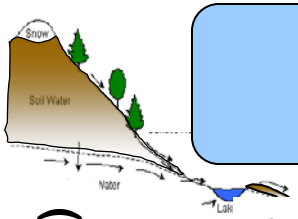
CLM4SP – Obs



CLM4CN – Obs

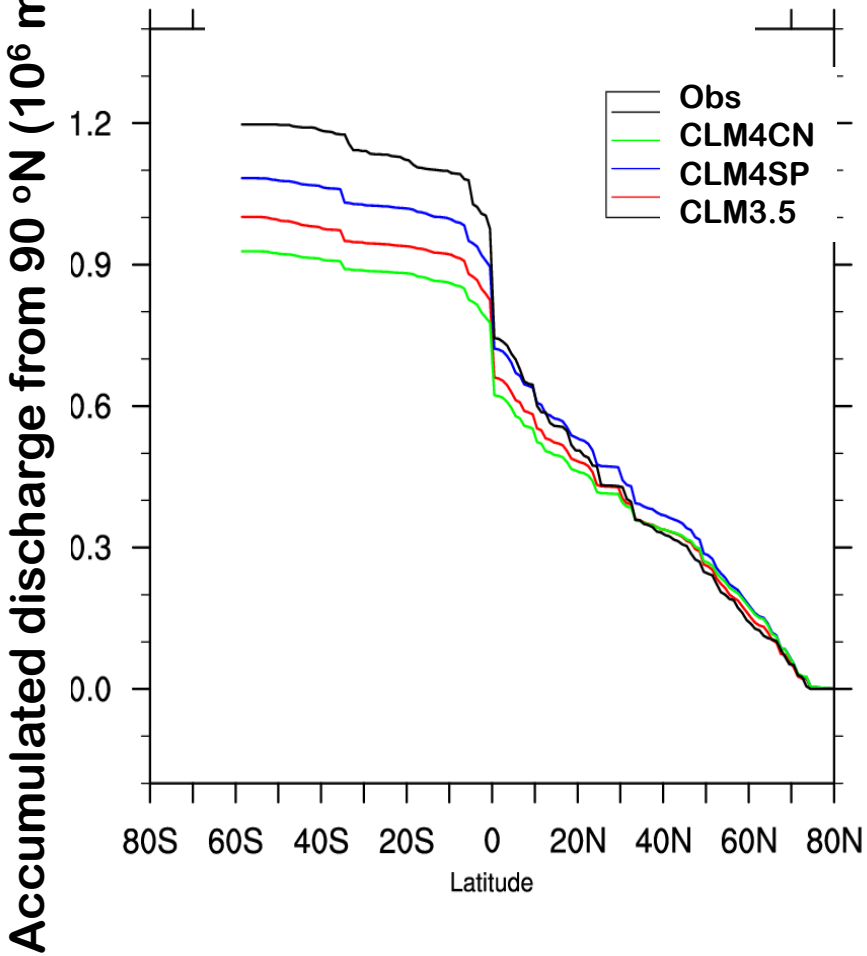


	Bias (%)		RMSE (%)	
Model	**Snow-free**	**Snow depth> 0.2m**	**Snow-free**	**Snow depth > 0.2m**
CLM3.5	**2.7**	**-5.0**	**4.1**	**11.9**
CLM4SP	**0.4**	**2.9**	**2.0**	**13.2**
CLM4CN	**0.7**	**1.3**	**2.2**	**13.9**

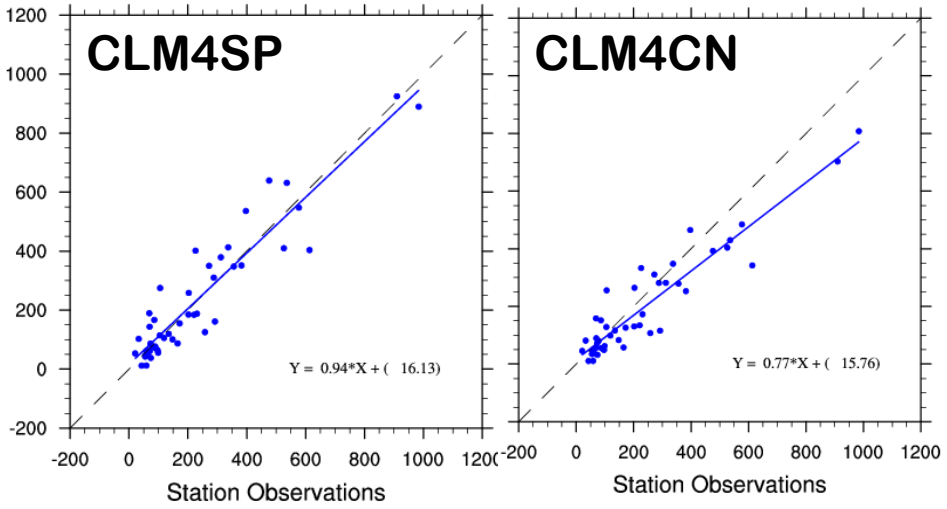


River Discharge

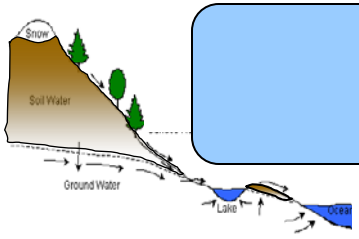
Annual discharge into Global ocean



River flow at outlet Top 50 rivers ($km^3\ yr^{-1}$)



CLM3: r = 0.86
CLM3.5: r = 0.87
CLM4SP: r = 0.94
CLM4CN: r = 0.77



Permafrost

Near-Surface Permafrost Extent and Active Layer Thickness

CLM3.5

8.2 million km²

CLM4SP

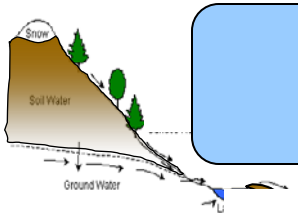
14.2 million km²

m
2.30
1.38
0.83
0.49
0.29
0.17
0.09

11.3 – 14.3 million km²

Observations

Isol.
Spor.
Disc.
Cont.

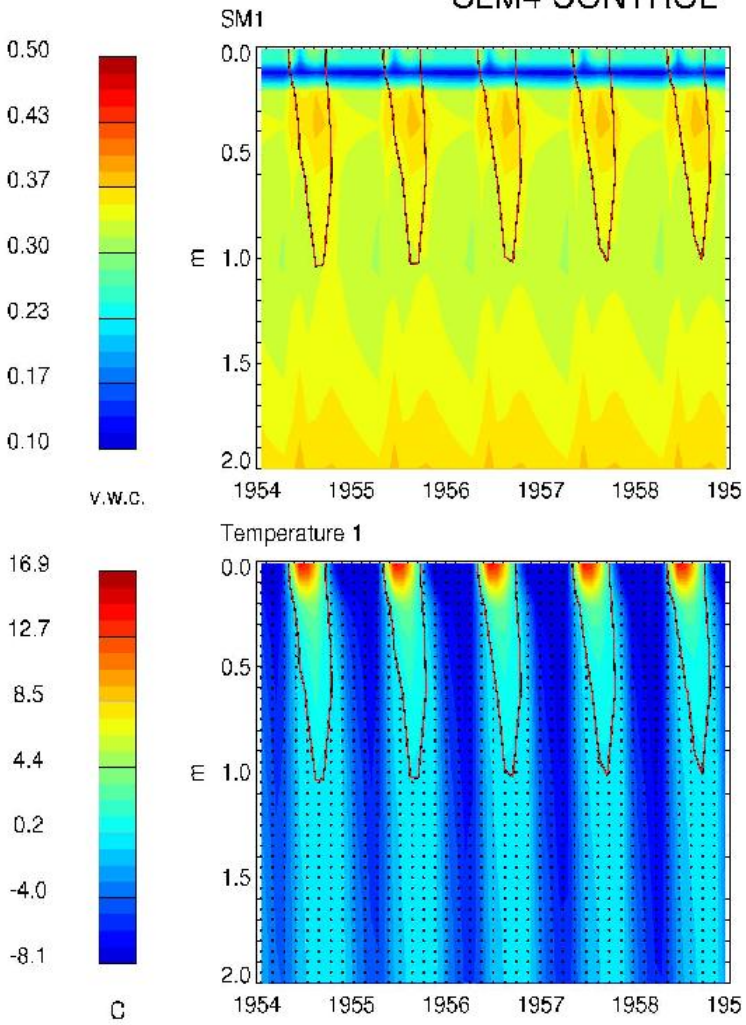


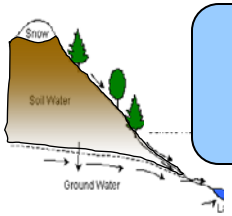
Cold region hydrology problem

Yukon stevens point

VWC (top) and Temperature (bottom)

CLM4 CONTROL

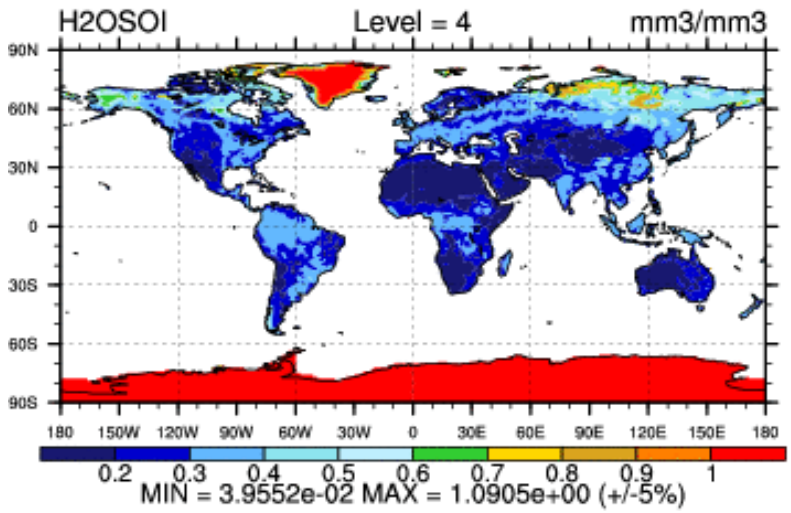




Soil Moisture

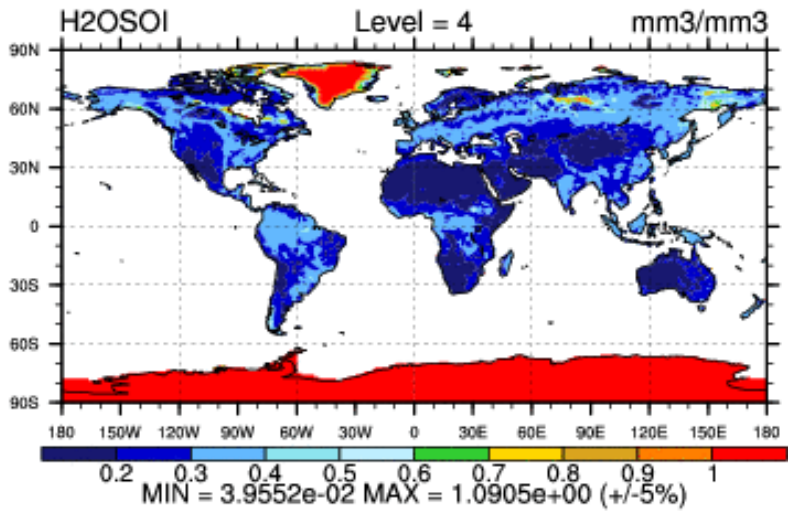
ANN

DRAINAGE (yrs 1979-2003)



MIN = 3.9552e-02 MAX = 1.0905e+00 (+/-5%)

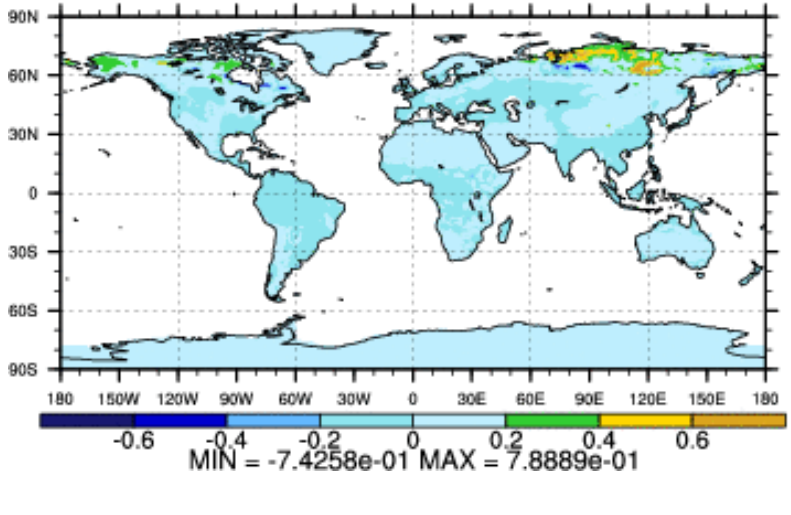
CONTROL (yrs 1979-2003)



MIN = 3.9552e-02 MAX = 1.0905e+00 (+/-5%)

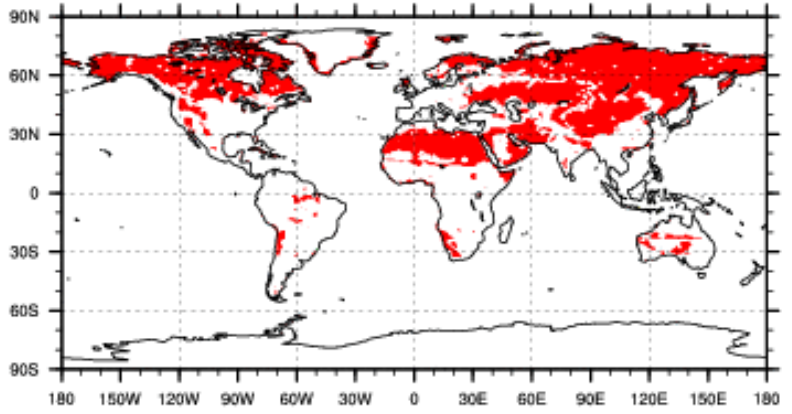
T-Test of two Case means at each grid point

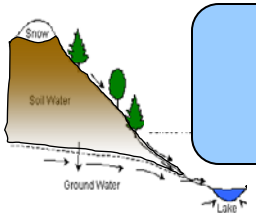
Case 1 - Case 2



MIN = -7.4258e-01 MAX = 7.8889e-01

Cells are significant at 0.1 level

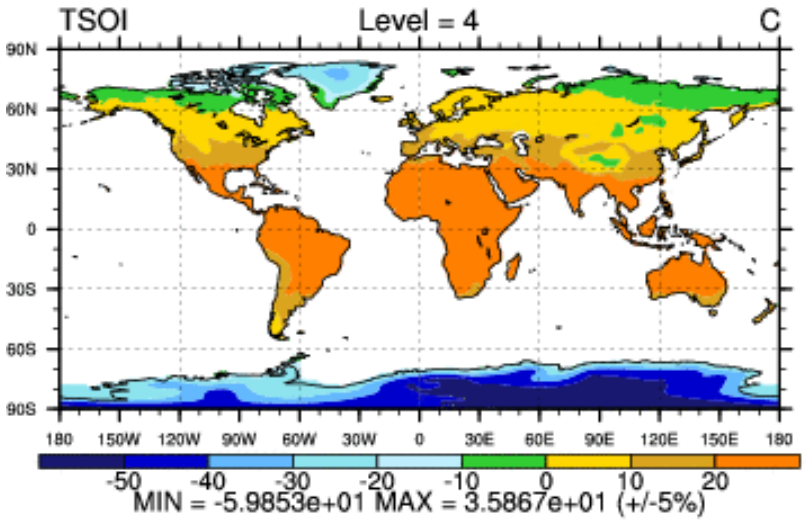




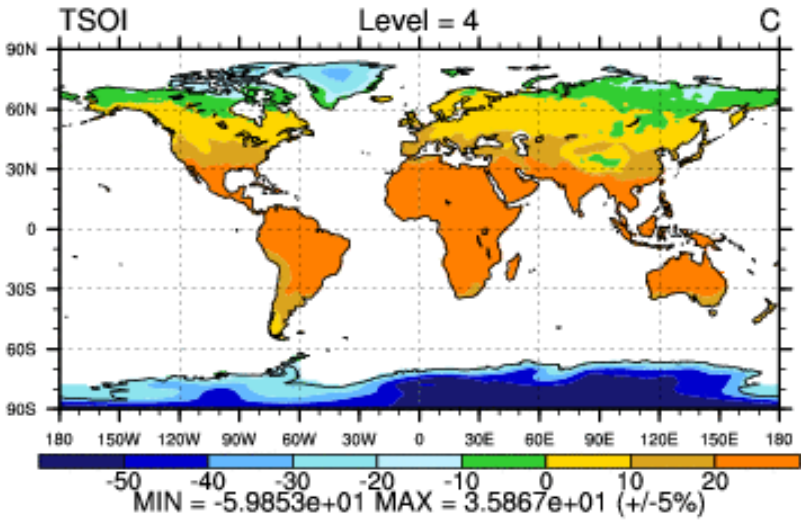
Soil Temperature

ANN

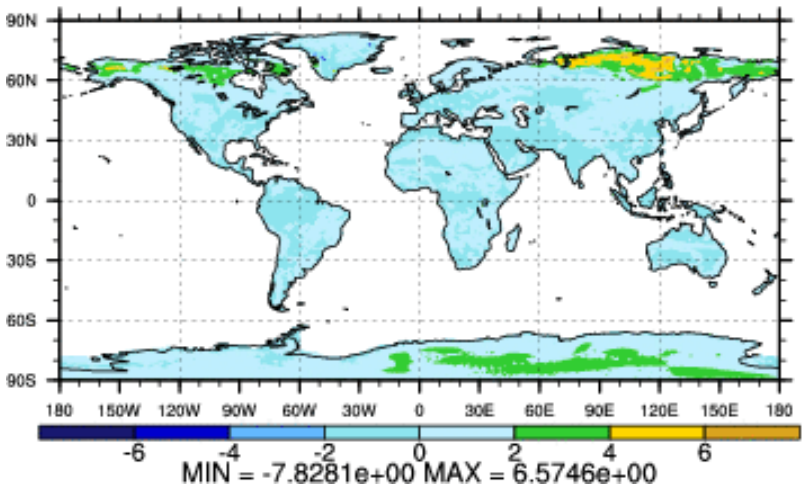
DRAINAGE (yrs 1979-2003)



CONTROL (yrs 1979-2003)

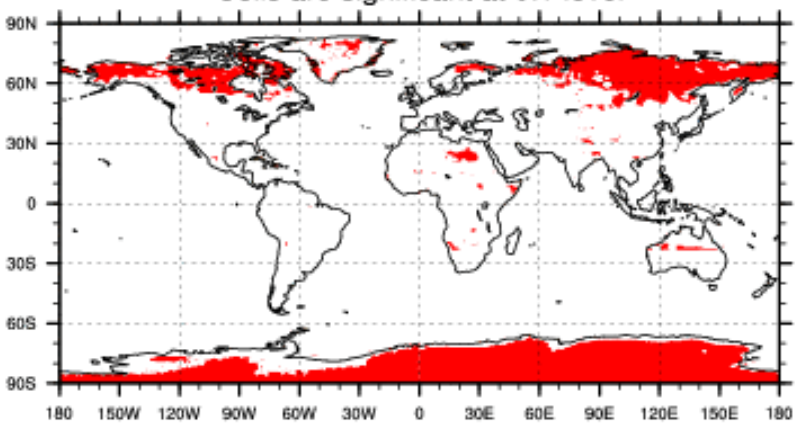


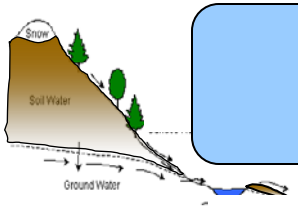
Case 1 - Case 2



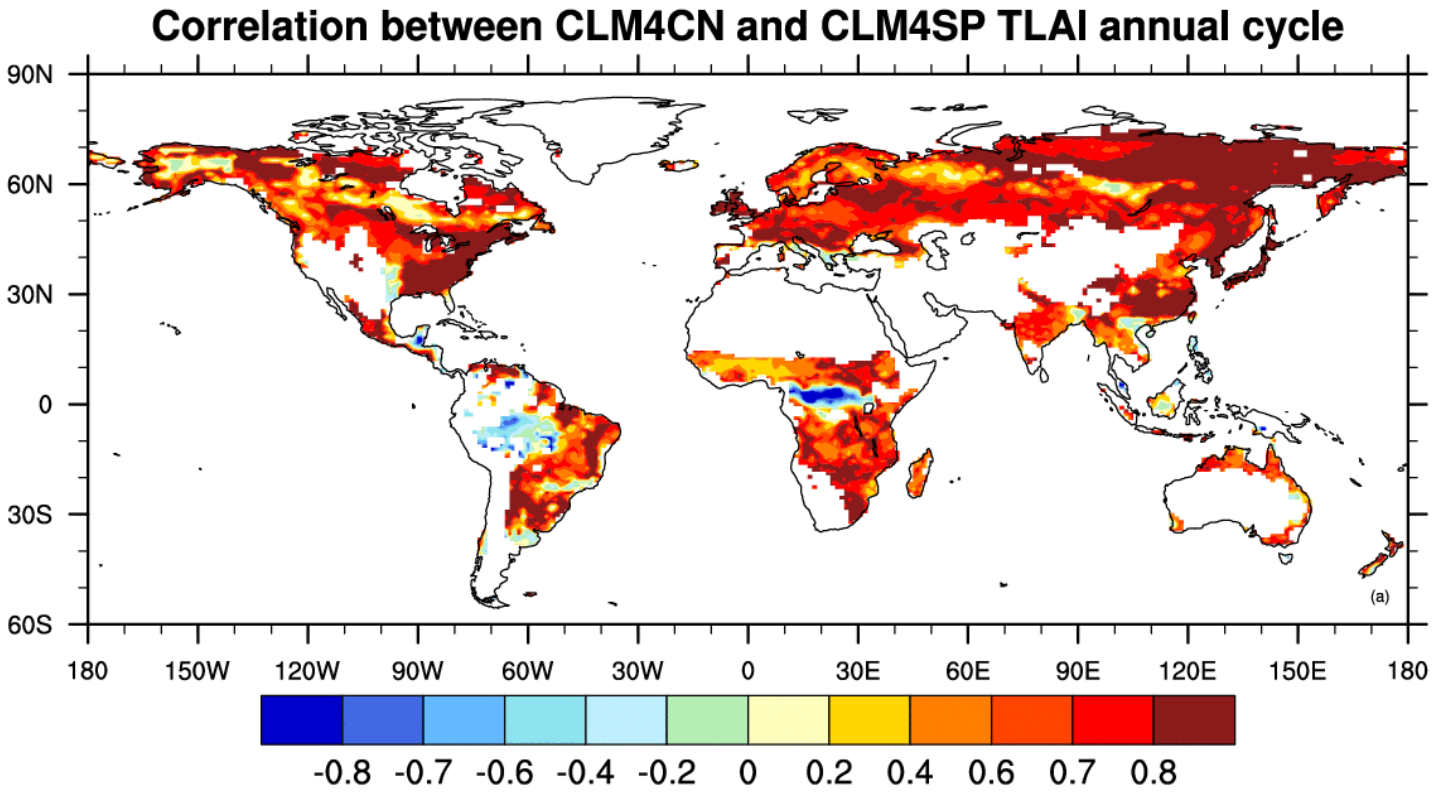
T-Test of two Case means at each grid point

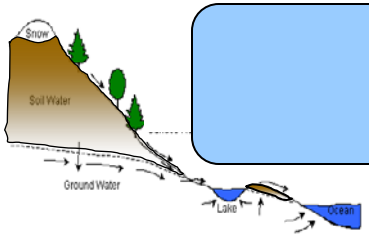
Cells are significant at 0.1 level





Correlation for LAI (CLM4CN vs CLM4SP)

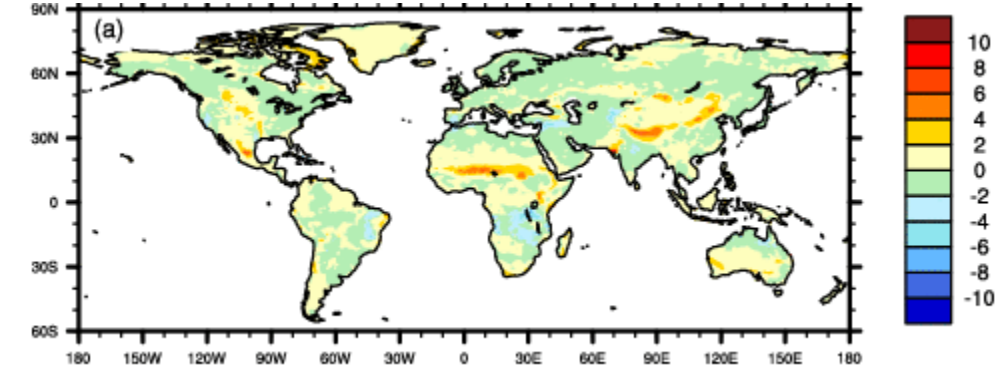




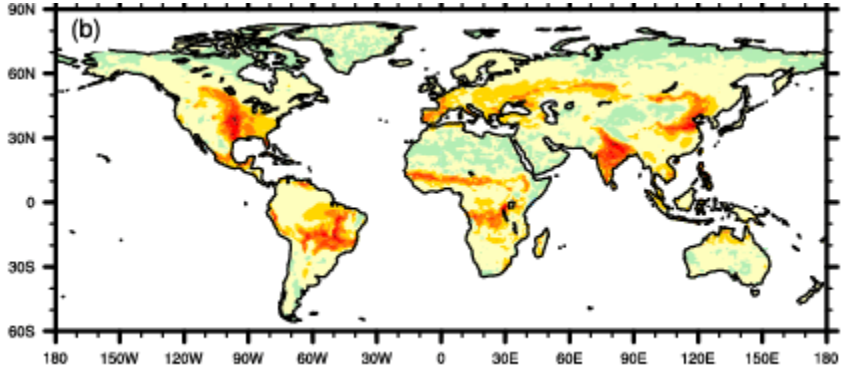
Interannual variability (JJA)

$\sigma_2 - \sigma_1$

CLM4SP – CLM3.5

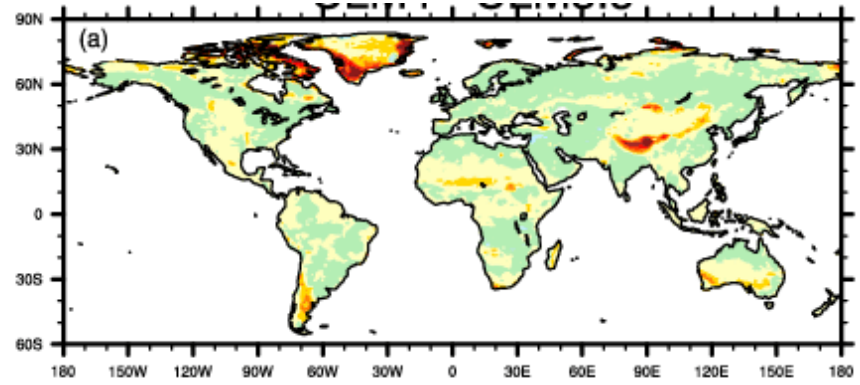


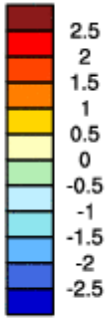
CLM4CN – CLM4SP



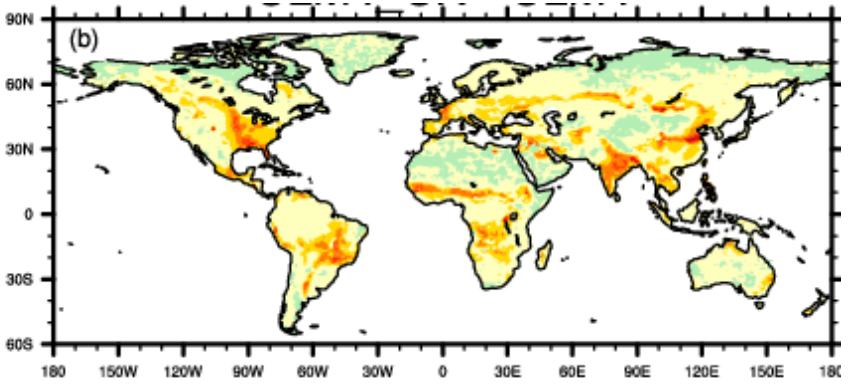
$(\sigma_2 - \sigma_1)/\sigma_1$

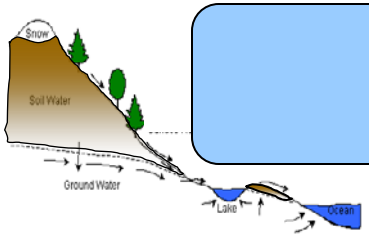
CLM4SP – CLM3.5





CLM4CN – CLM4SP

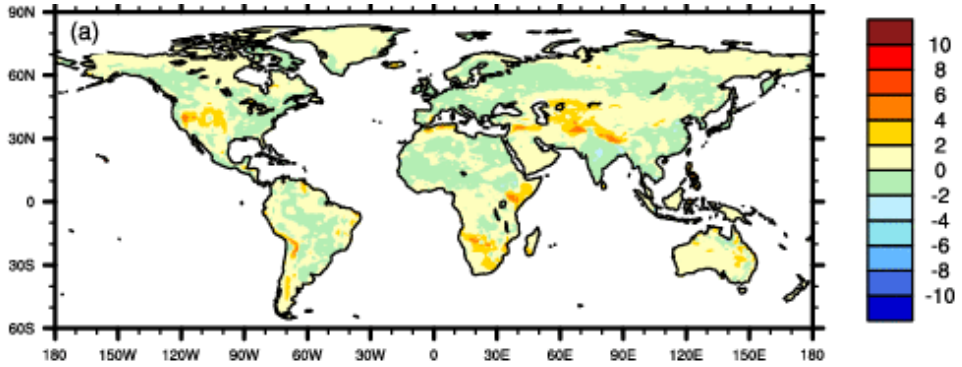




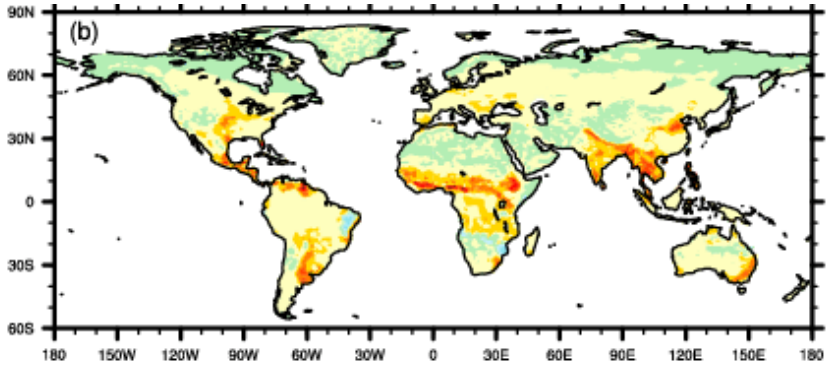
Interannual variability (MAM)

$\sigma_2 - \sigma_1$

CLM4SP – CLM3.5

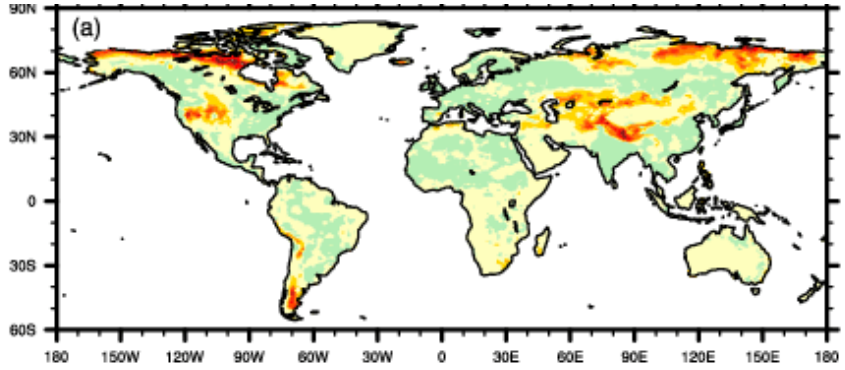


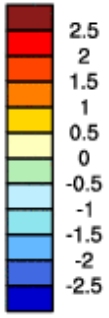
CLM4CN – CLM4SP



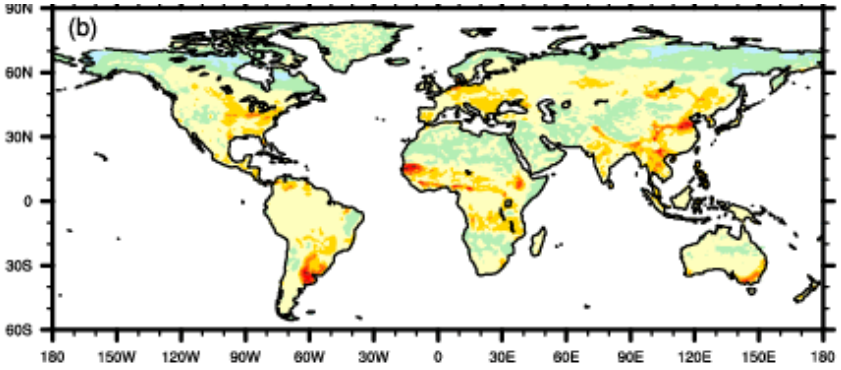
$(\sigma_2 - \sigma_1)/\sigma_1$

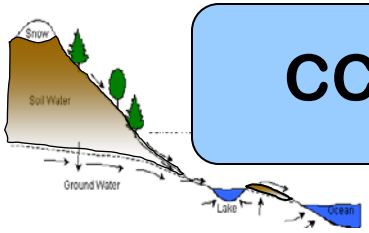
CLM4SP – CLM3.5



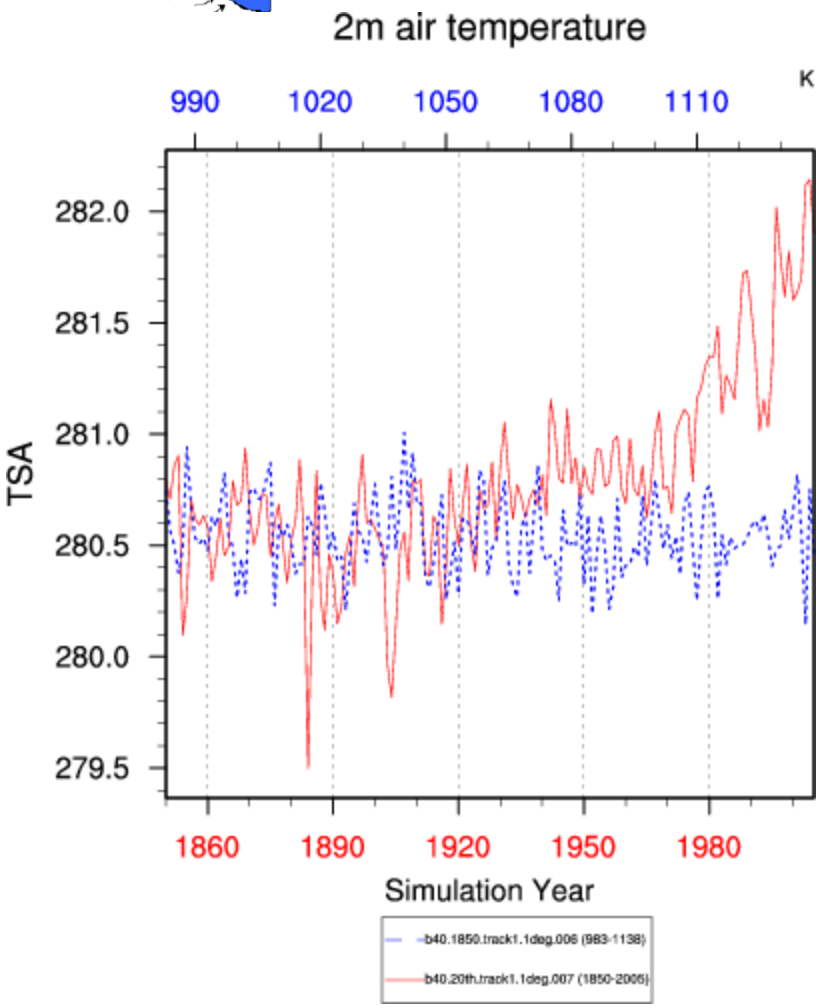


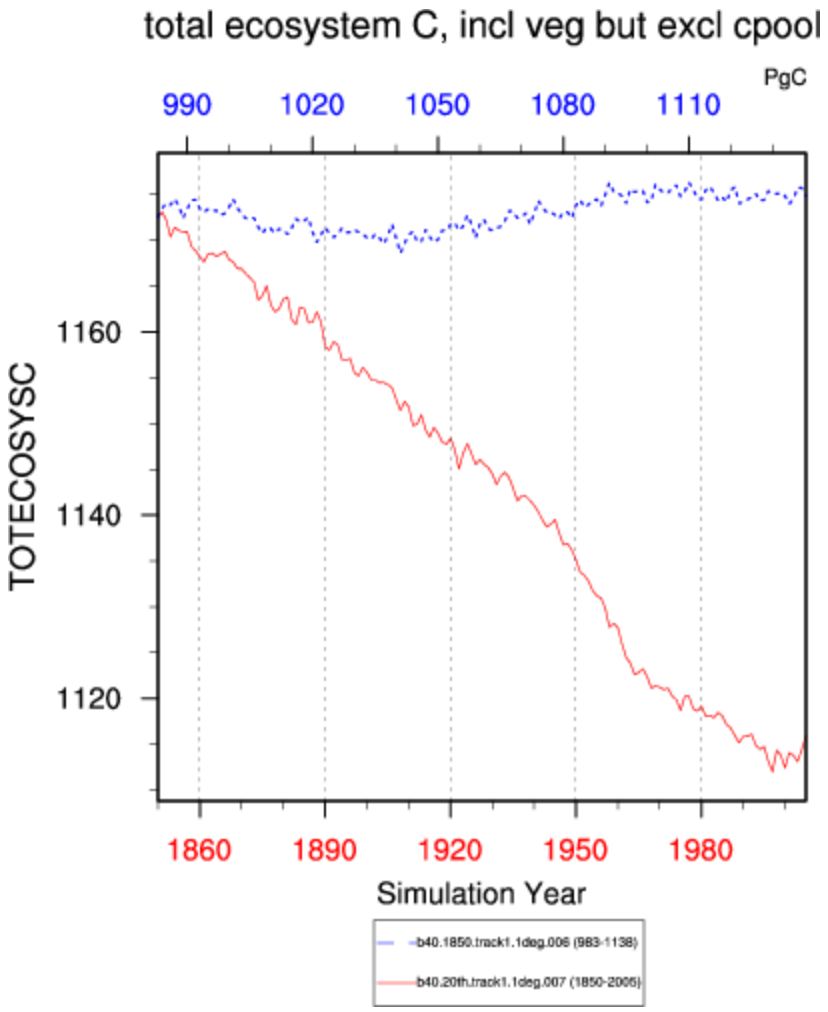
CLM4CN – CLM4SP

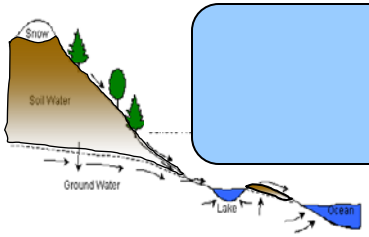




CCSM4 20th century CMIP5 simulations underway



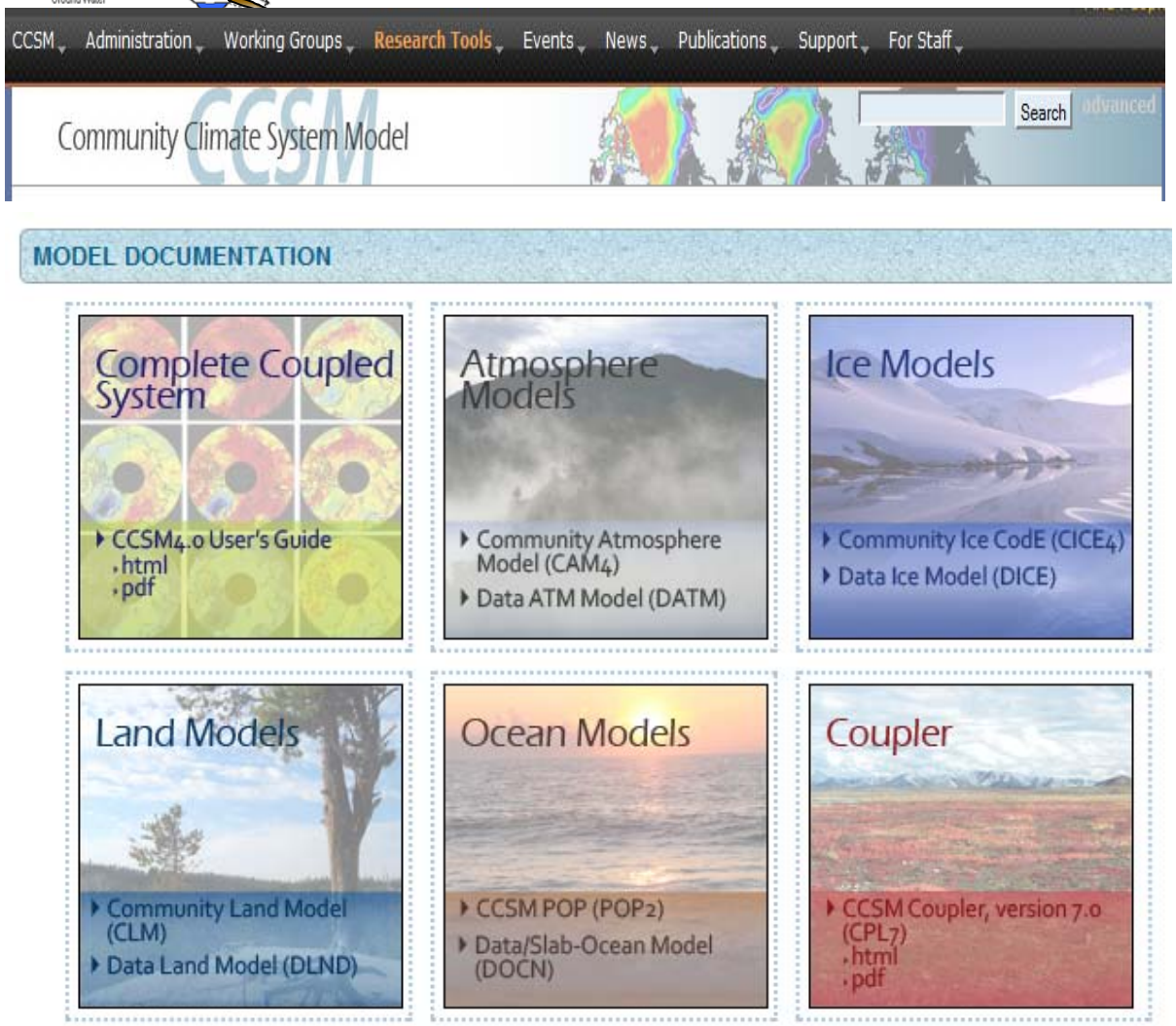




Ongoing and future projects 'beyond' CLM4

- Crop model / irrigation
- Updated lake model / thermokarst lakes
- Cold region hydrology fixes
- Prognostic wetlands
- Methane emission model
- Integration with Integrated Assessment Models
- Spatially variable soil depth
- Insect outbreaks
- Implementing the Ecosystem Demography (ED) model
- Ozone and vegetation
- (Riverine carbon/nutrient fluxes)

Timeline



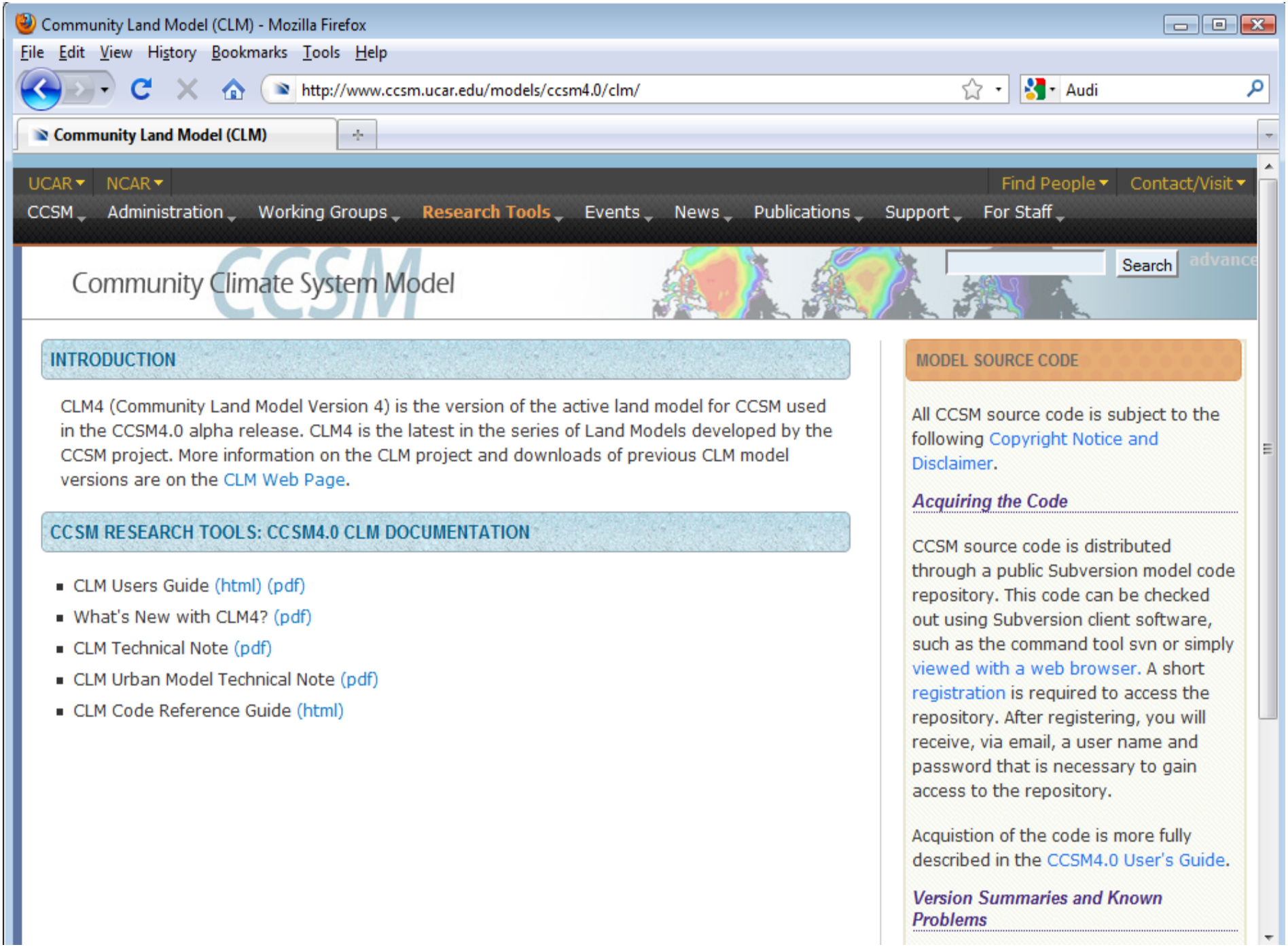
CCSM4 Public Release
April 1

CESM1 Public Release
June

CMIP5 data
Start trickling in by summer?

CCSM meeting Breck
June 28-July 1

CCSM Tutorial NCAR
July 12-16


Community Land Model (CLM) - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.ccsm.ucar.edu/models/ccsm4.0/clm/
Audi
Community Land Model (CLM)
UCAR NCAR
Find People Contact/Visit
CCSM Administration Working Groups Research Tools Events News Publications Support For Staff
Community Climate System Model
Search
advance
INTRODUCTION
CLM4 (Community Land Model Version 4) is the version of the active land model for CCSM used in the CCSM4.0 alpha release. CLM4 is the latest in the series of Land Models developed by the CCSM project. More information on the CLM project and downloads of previous CLM model versions are on the CLM Web Page.
CCSM RESEARCH TOOLS: CCSM4.0 CLM DOCUMENTATION
CLM Users Guide (html) (pdf)
What's New with CLM4? (pdf)
CLM Technical Note (pdf)
CLM Urban Model Technical Note (pdf)
CLM Code Reference Guide (html)
MODEL SOURCE CODE
All CCSM source code is subject to the following Copyright Notice and Disclaimer.
Acquiring the Code
CCSM source code is distributed through a public Subversion model code repository. This code can be checked out using Subversion client software, such as the command tool svn or simply viewed with a web browser. A short registration is required to access the repository. After registering, you will receive, via email, a user name and password that is necessary to gain access to the repository.
Acquistion of the code is more fully described in the CCSM4.0 User's Guide.
Version Summaries and Known Problems

NCAR/TN- +STR
NCAR TECHNICAL NOTE

January 2010

Technical Description of version 4.0 of the Community Land Model (CLM)

DRAFT

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Peter J. Lawrence
Samuel Levis
Sean C. Swenson
Peter E. Thornton

Terrestrial Sciences Section
Climate and Global Dynamics Division

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
BOULDER, COLORADO

CLM4 Tech Note

257 pages

18 chapters

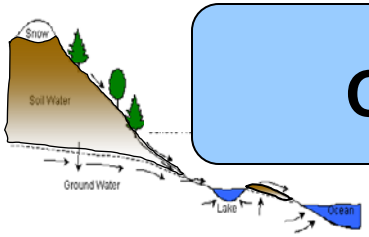
643 equations

Separate Urban and CN Tech Notes

CLM4 paper in preparation, to be submitted to JAMES or GMD

Over 200,000 lines of code in CLM4

Over 1.5 million in CCSM4

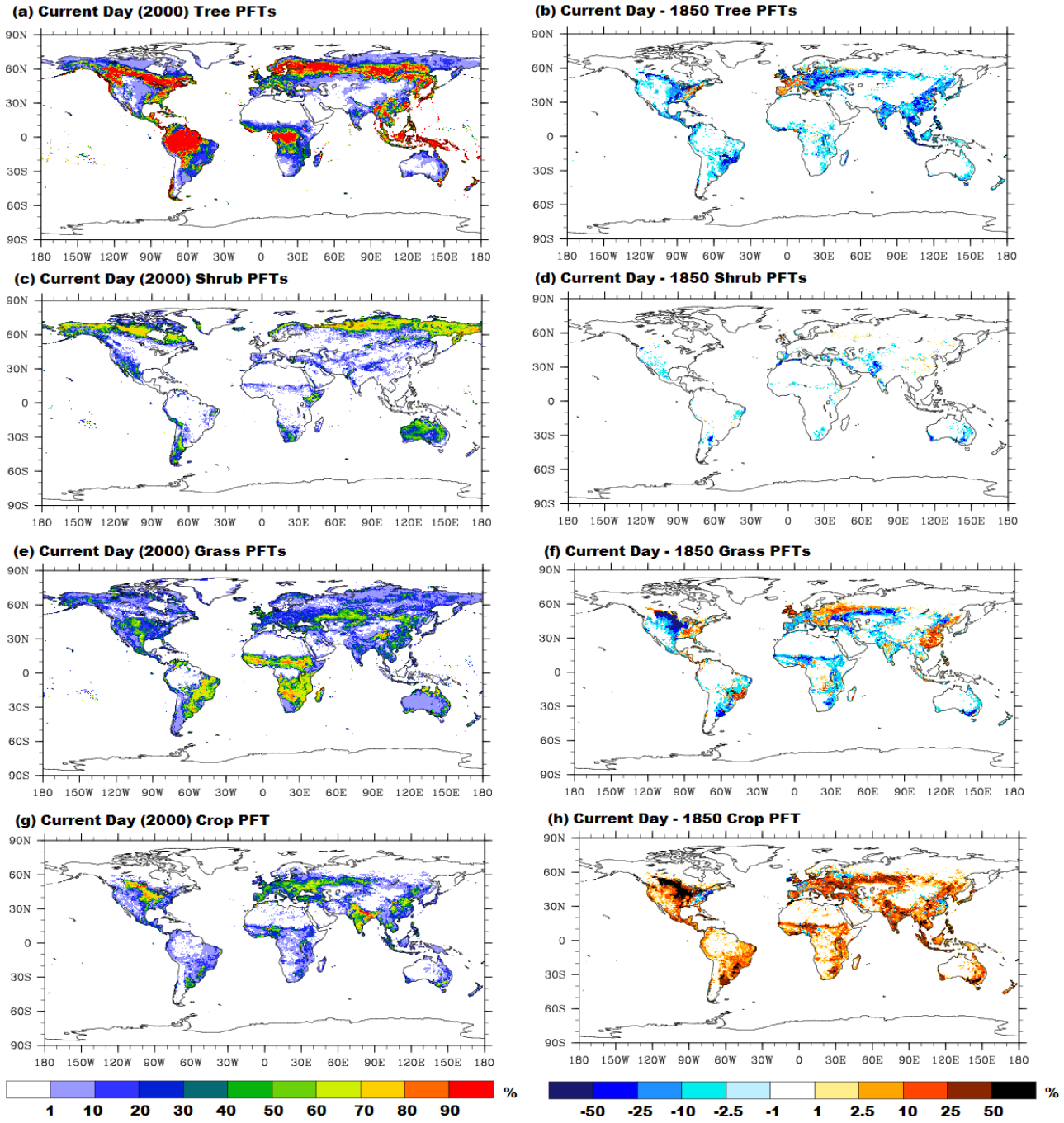


Community Climate System Modeling Tutorial

July 12-16th, 2010

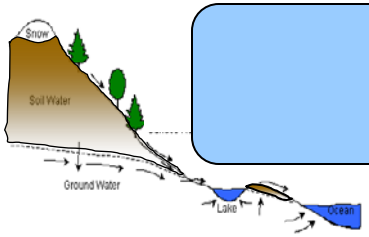
APPLICATION DEADLINE: 15 April 2010

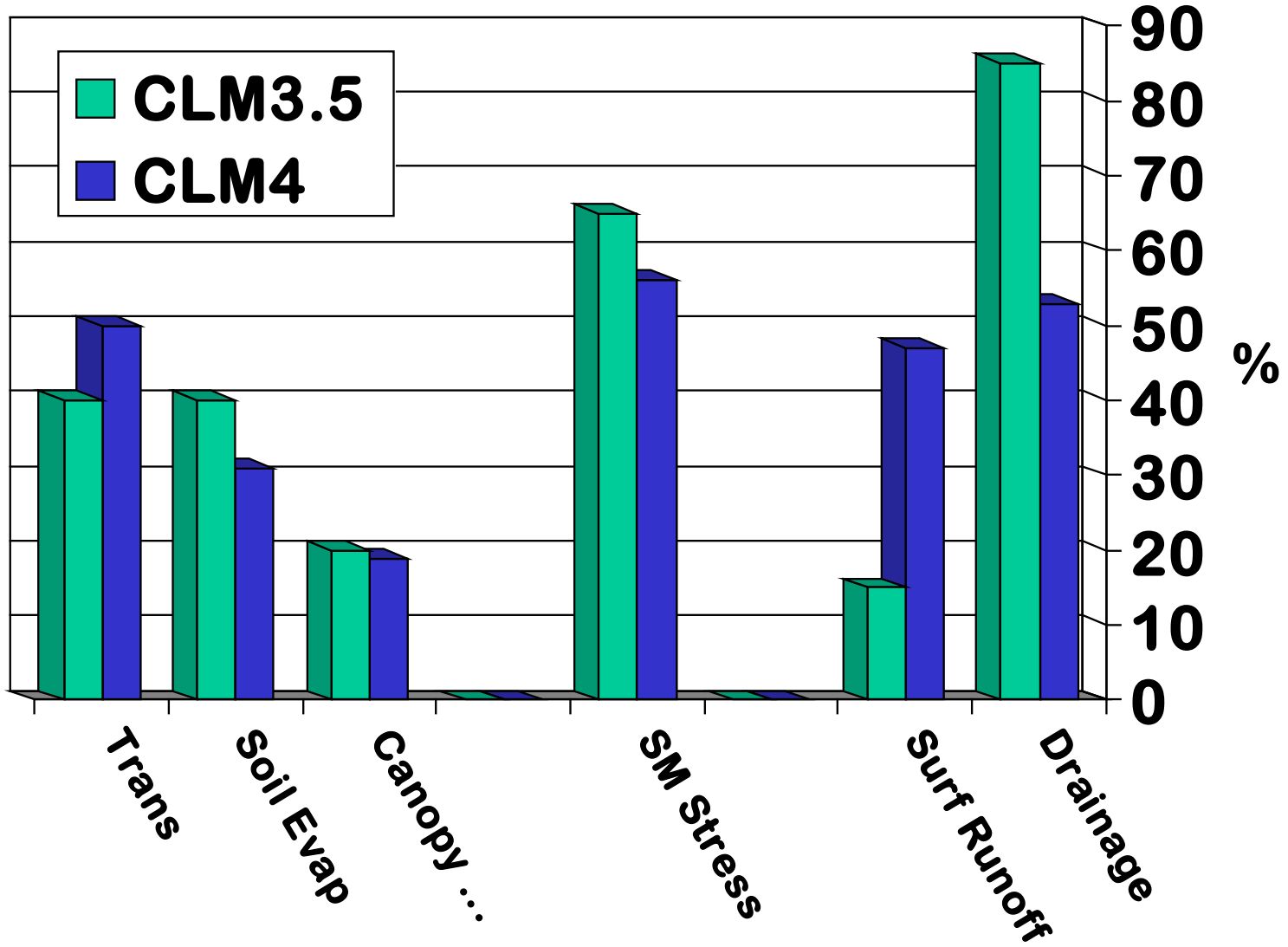
- **Anticipate space for 40 students.**
- **The focus will be on modeling of the coupled climate system and its major components.**
- **The tutorial is targeted at researchers (graduate students, post-docs and beyond) who wish to learn how to understand, run and modify climate models for scientific applications. The focus will be on CCSM specifically.**
- **This is hoped to be an initial version of an annually repeating series.**


(a) Current Day (2000) Tree PFTs
(b) Current Day - 1850 Tree PFTs
(c) Current Day (2000) Shrub PFTs
(d) Current Day - 1850 Shrub PFTs
(e) Current Day (2000) Grass PFTs
(f) Current Day - 1850 Grass PFTs
(g) Current Day (2000) Crop PFT
(h) Current Day - 1850 Crop PFT
90N 60N 30N 0 30S 60S 90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
1 10 20 30 40 50 60 70 80 90 %
-50 -25 -10 -2.5 -1 1 2.5 10 25 50 %

- Change to freezing temperature constant
- forcing height at atm plus z0+d on each tile
- Effective porosity divide by zero fix
- X. Zeng sparse/dense canopy aerodynamic parameters
- Stability formulations
- ground/snow emissivity
- organic soil
- init h2osoi=0.3
- snow compaction fix
- snow T profile during layer splitting fix
- new FGR12 diagnostic
- snow burial fraction
- snow cover fraction
- SNICAR (snow aging, black carbon and dust deposition, vertical distribution of solar energy)
- remove SNOWAGE, no longer used
- deep soil (15 layers), including changes for bed rock
- Koichi ground evap (beta), stability, and litter resistance
- Swenson organic/mineral soil hydraulic conductivity percolation theory
- Zeng/Decker Richards equation modifications
- normalization of frozen fraction of soil formulation
- Swenson one-step solution for soil moisture and qcharge
- changes to rsub_max for drainage and decay factor for surface runoff
- back to old lakes and wetlands datasets
- changes to pft physiology file from CN
- possible changes to surface dataset due to CN?
- new grass optical properties
- new surface dataset from Peter Lawrence assuming no herbaceous understory
- direct versus diffuse radiation offline
- new VOC model (MEGAN)
- modification to solar radiation penetration through snow (no solar to soil if snowdp<0.1m)
- new RTM rdirc file and change to QCHANR definition
- snow-capped runoff goes to ice stream
- dust model always on, LAI threshold parameter change from 0.1 to 0.3
- daylength control on vcmax
- SAI and get_rad_dtime fix

Partitioning of ET, Runoff





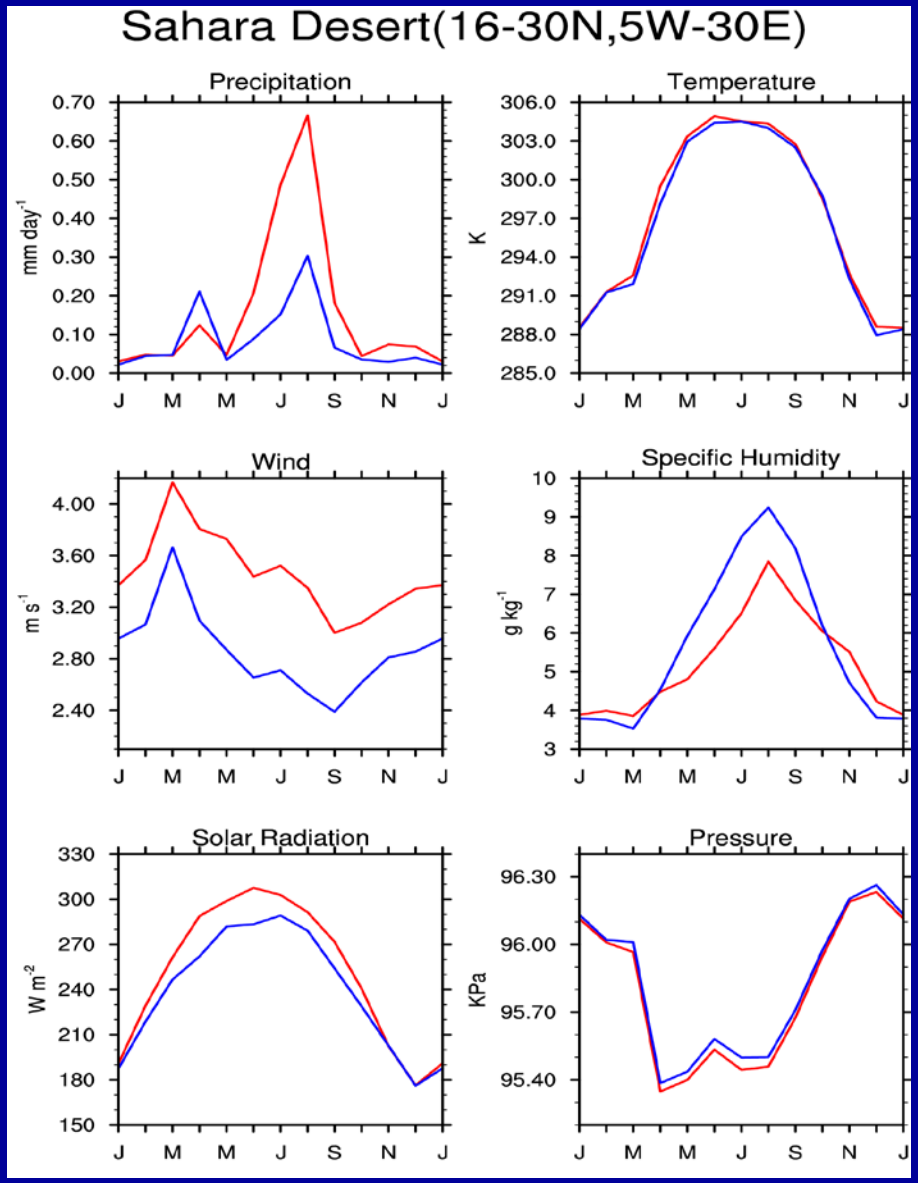
Quick Look at CRUNCEP Atmospheric Forcing Dataset (Viovy, Ciais)

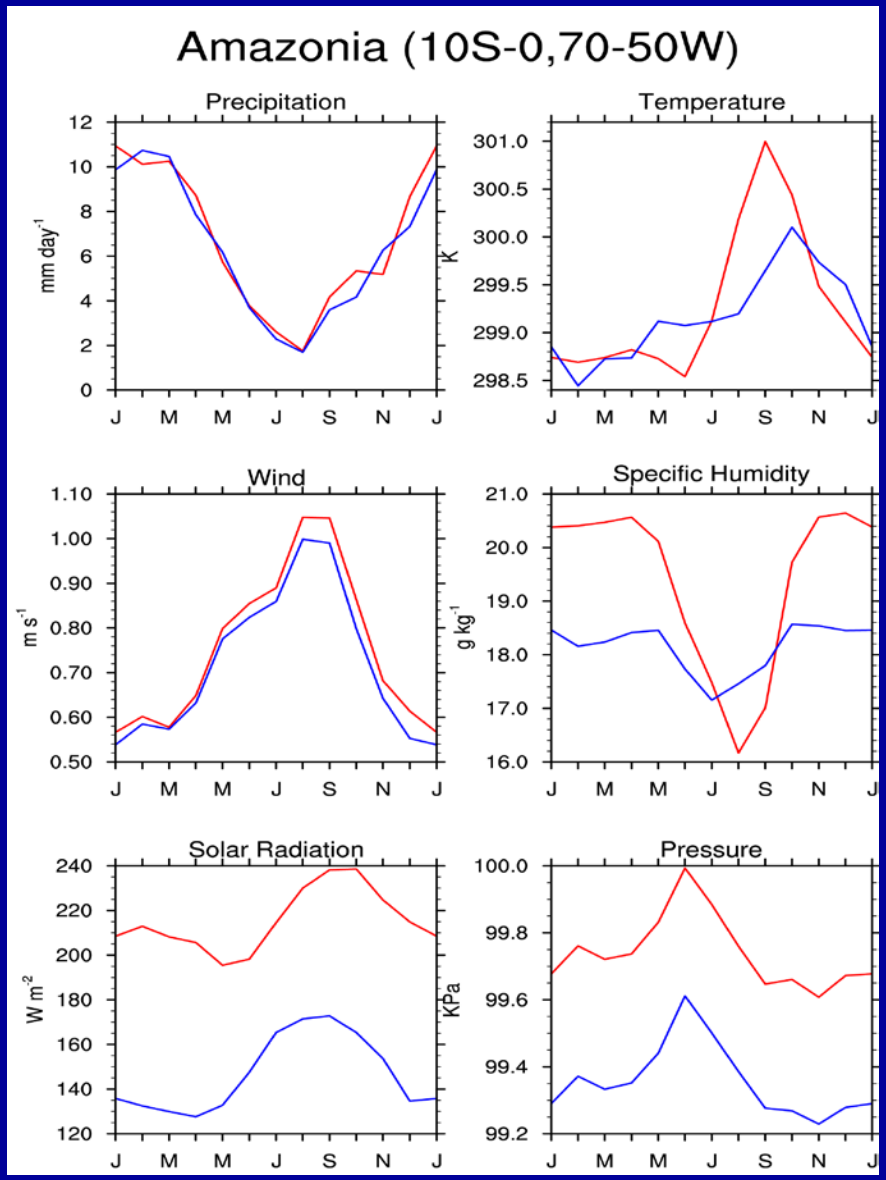
- Combination of CRU TS.2.1 0.5°X0.5° 1901-2002 monthly climatology and NCEP reanalysis 2.5°X2.5° 1948-2008 6-hourly
  - NCEP interpolated to 0.5°X0.5°
  - Precip, cloudiness, rel. hum., temperature from CRU
  - CRU cloudiness converted to shortwave radiation
  - 1901-1947 based on CRU climatology with 1948 NCEP used to generate diurnal and daily variability
  - 1948-2002 based on CRU climatology with NCEP for given year used to generate diurnal and daily variability
  - 2003-2008 based on difference between monthly NCEP for given year and monthly NCEP for 2002.

- 0.5°X0.5° 6-hourly longwave, shortwave, air temperature, u/v winds, precip, specific humidity, pressure
- NetCDF format
- No interannual variability in pressure, longwave, u/v winds before 1948
- No data over Antarctica
- Not global, has it's own land mask
- Fair use data policy

Comparison of CRUNCEP with Qian - 1948

CRUNCEP (Blue), Qian (Red)





Comparison of CRUNCEP with Qian - 1948

CRUNCEP (Blue), Qian (Red)