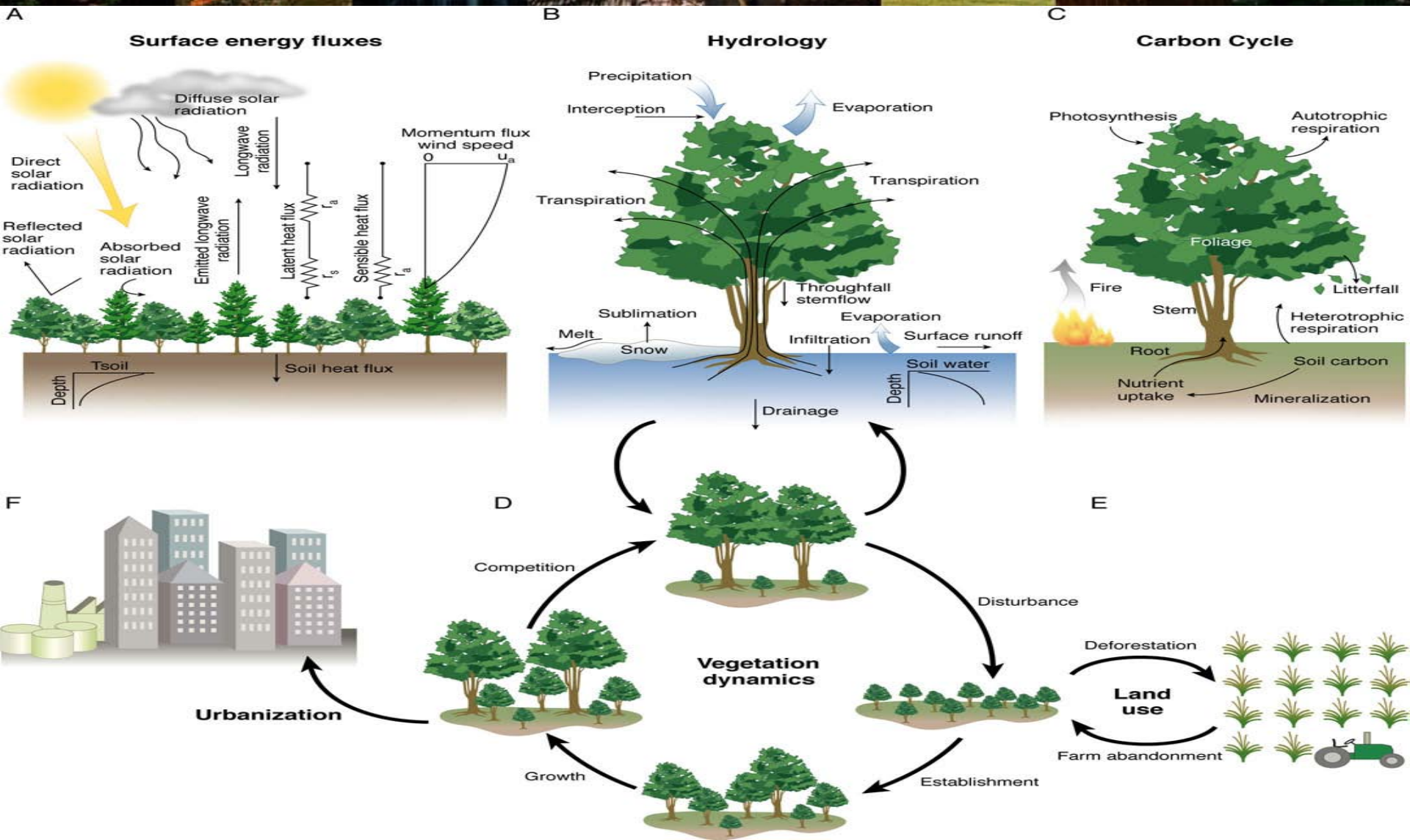
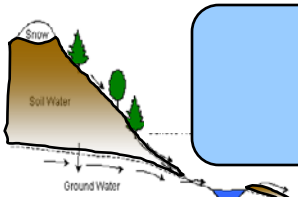
The State of CLM4 (and CCSM4)



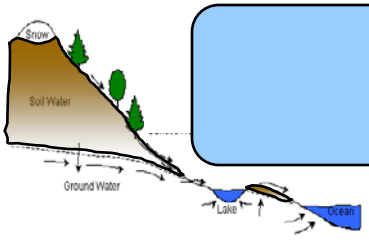
- Change to freezing temperature constant
- forcing height at atm plus z0+d on each tile
- Effective porosity divide by zero fix
- X. Zeng sparse/dense canopy aerodynamic parameters
- Stability formulations
- ground/snow emissivity
- organic soil
- init h2osoi=0.3
- snow compaction fix
- snow T profile 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



LMWG progress towards CLM4

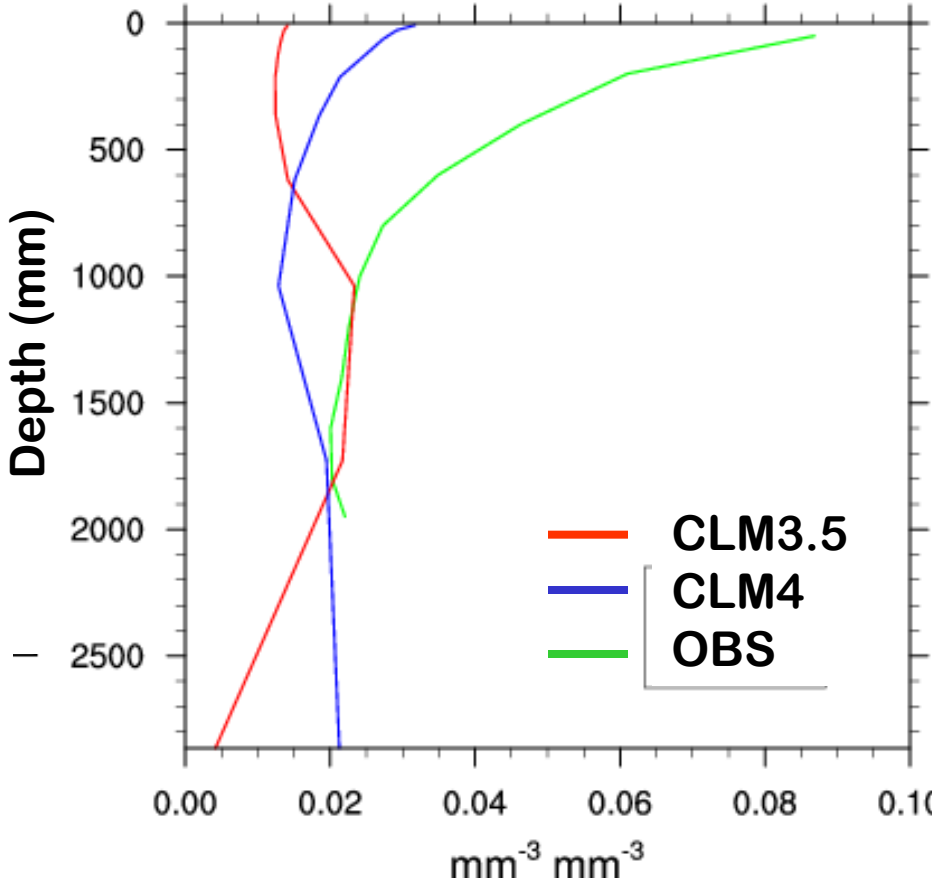
- **Soil hydrology – since Breckenridge 2008** (Sakaguchi, Zeng, Swenson, Oleson, Lawrence, Niu, Yang)
  - litter resistance
  - under canopy turbulent stability
  - modified Richard's equation – maintains steady state
  - tuning R_{submax} and surface runoff decay factor
  - 1-step soil moisture and qcharge solution

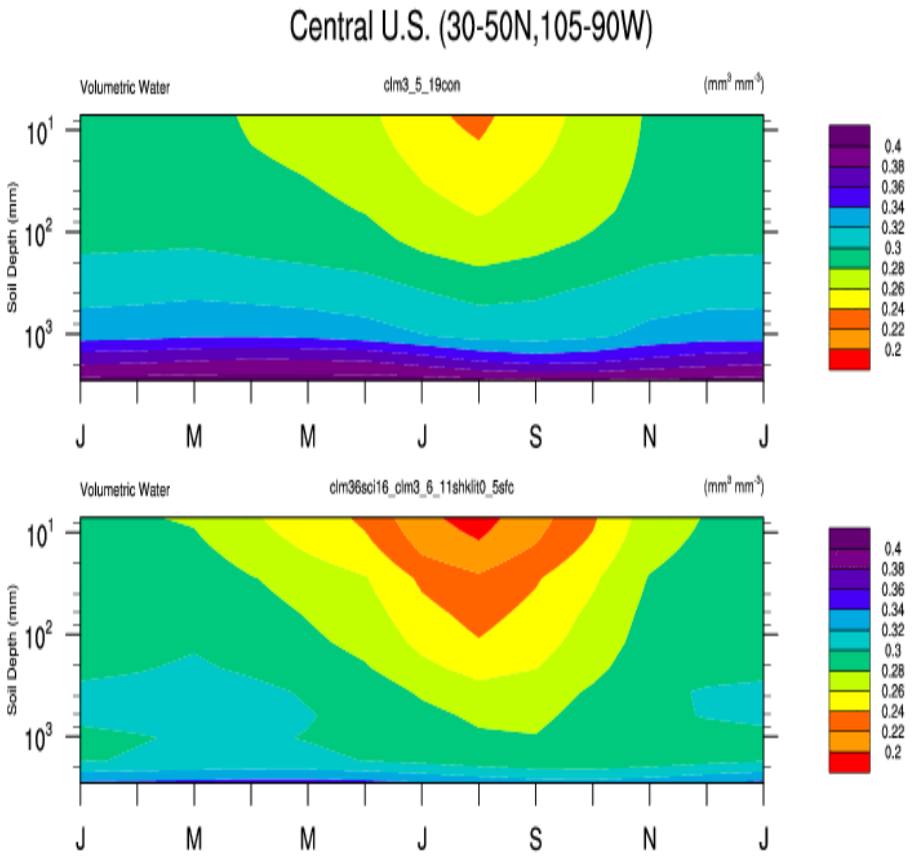
  - Slightly improved soil moisture variability, surface fluxes, soil moisture stress, partitioning of ET into its components, deeper water table

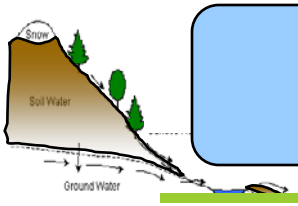


Soil moisture variability

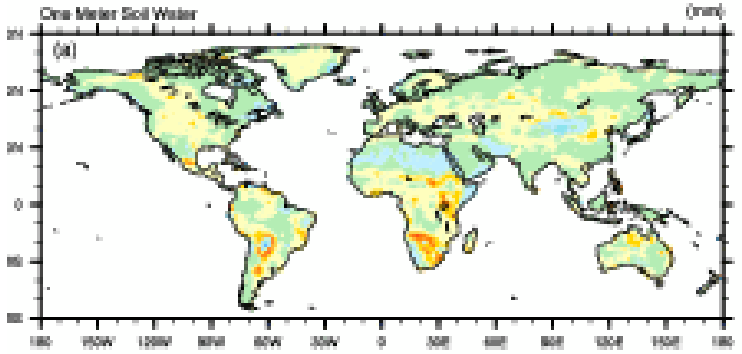
- Standard deviation of Vol. Soil Water

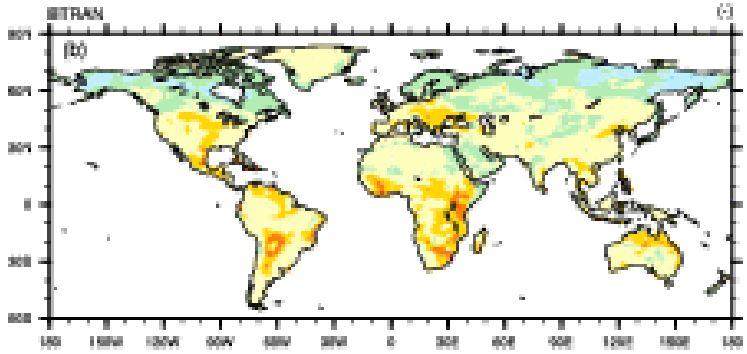


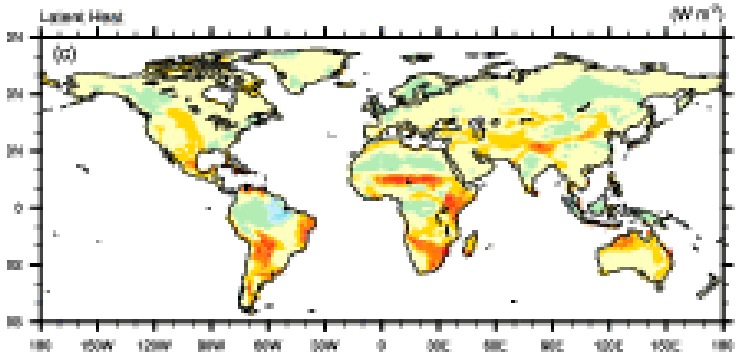


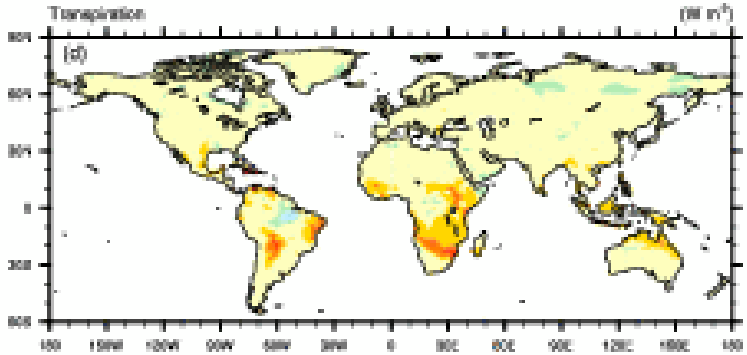


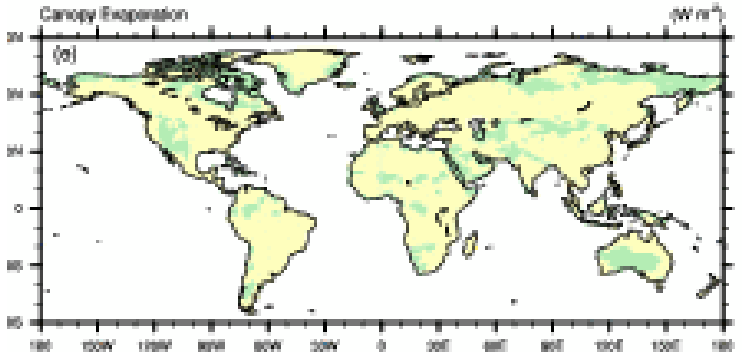
U_HYD-U_CON Standard Deviation, Annual Cycle Removed (1984-2004)

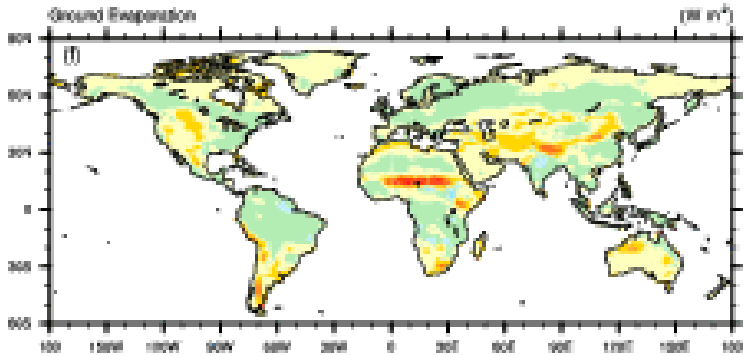


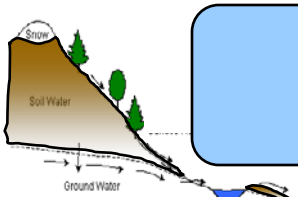












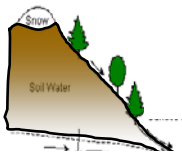
LMWG progress towards CLM4

- **Snow model**
  - snow density dependent snow cover fraction parameterization
  - snow burial fraction for short vegetation
  - adopt SNICAR

    snow age

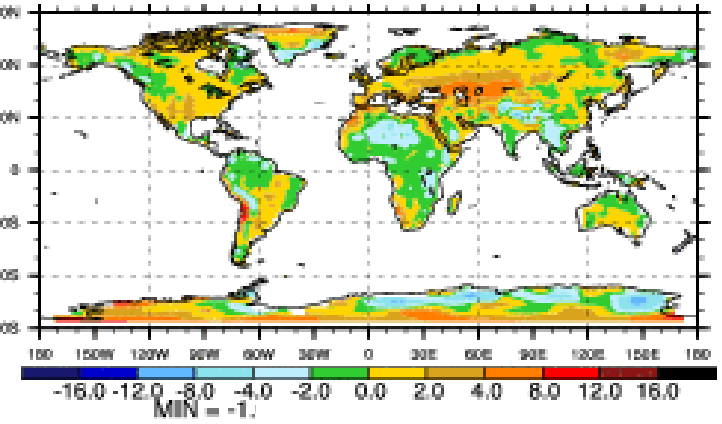
    vertically resolved heating in snowpack (snowdp > 0.1m)

    aerosol deposition (dust, black carbon, organic carbon) – works with bulk or modal aerosols
  - snow compaction
  - snow layer splitting

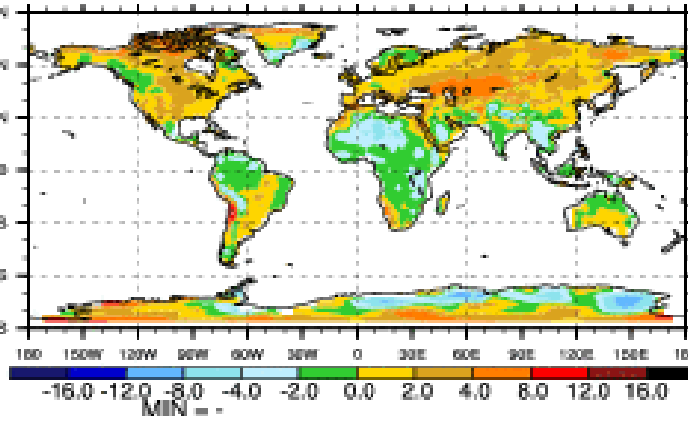


Results from Community Snow Project: Surface air temperature (ANN)

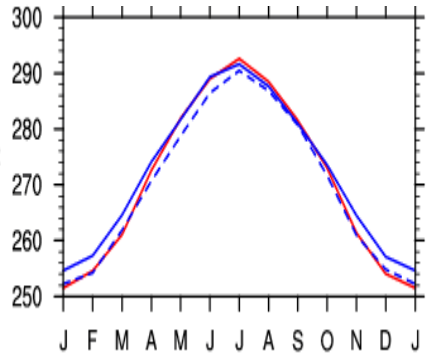
Community Snow - Obs



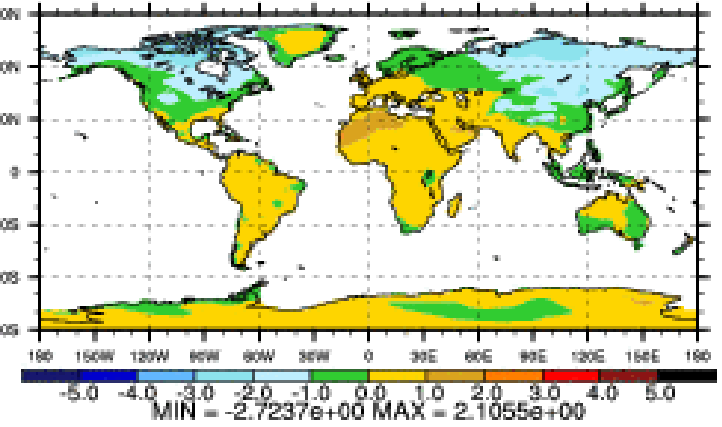
Control - Obs



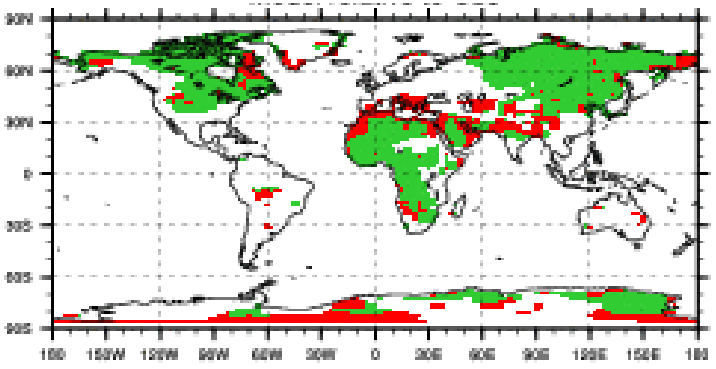
Western Siberia



Community Snow - Control



Reduced or Increased Bias

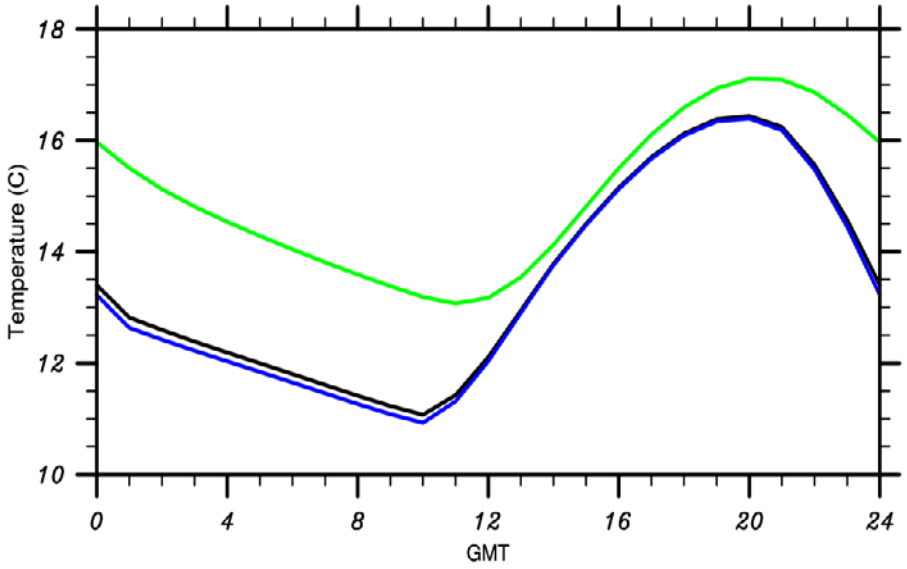


T_{air}(land): RMSE 2.78°C → 2.56°C, Bias 0.59°C → 0.43°C
Climate sensitivity: +0.2 to +0.3°C

LMWG progress towards CLM4

- **Urban model**
  - **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)



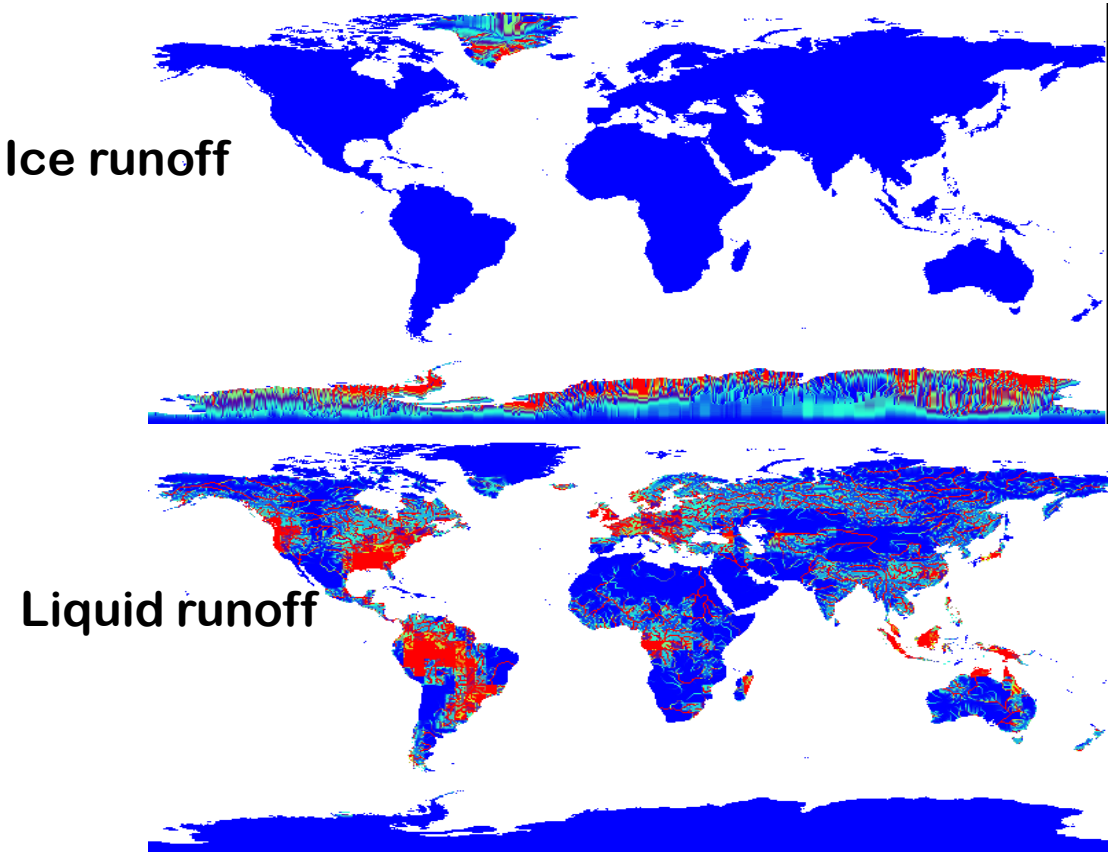
Urban

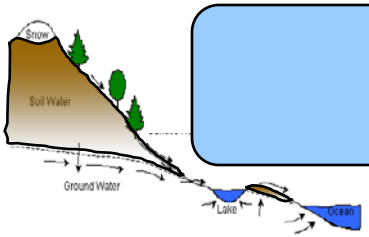
Grid Average

Rural

LMWG progress towards CLM4

- **Ice stream in River Transport Model**
  - 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

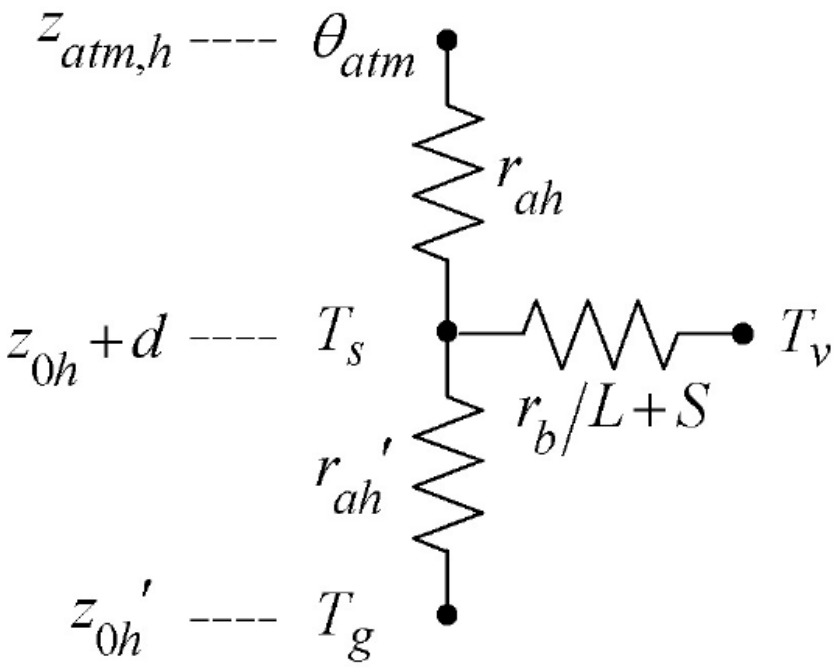


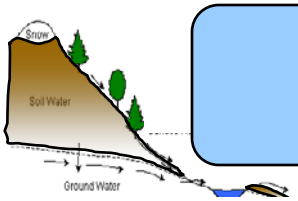


LMWG progress towards CLM4

- **Reference height**

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



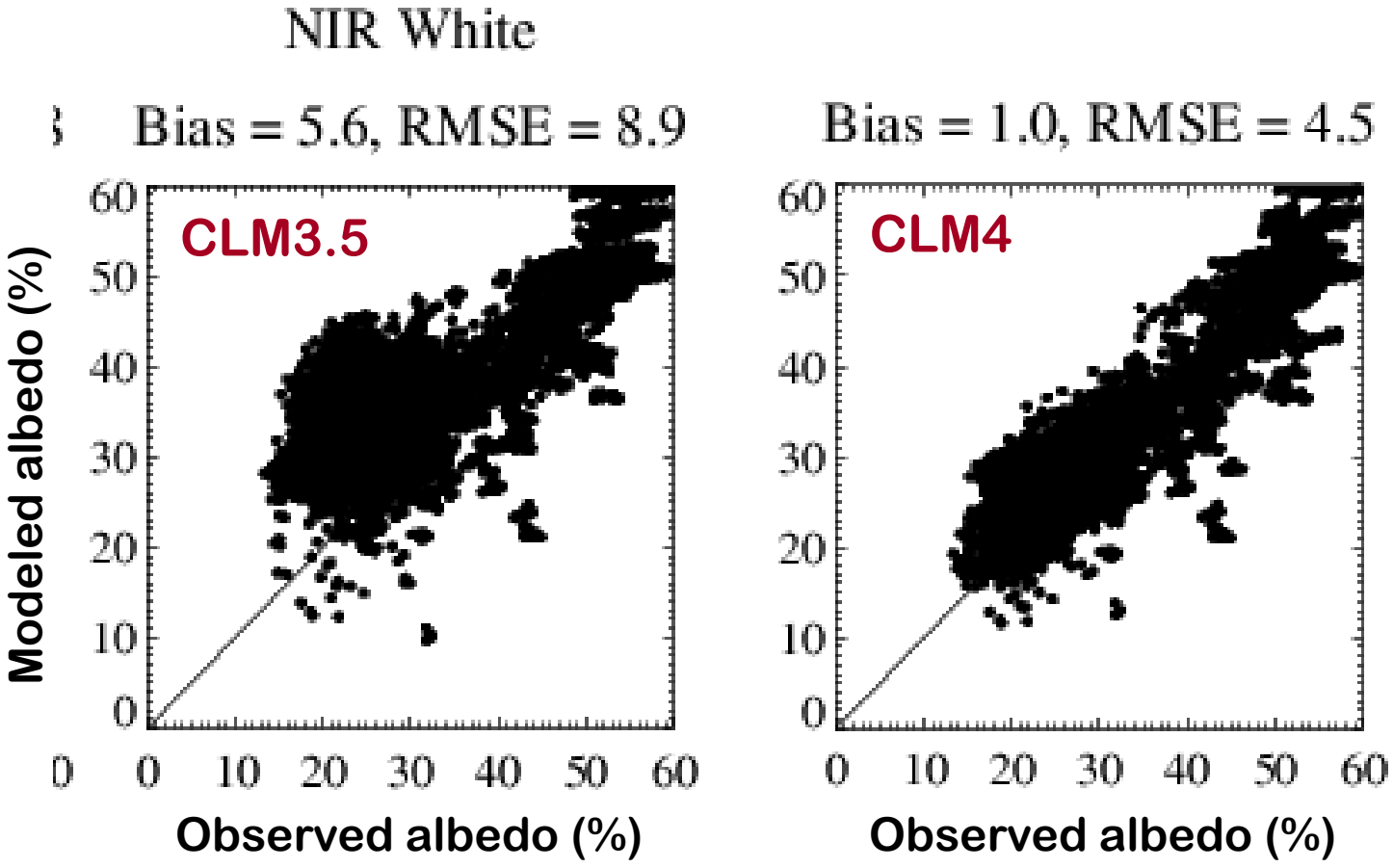


LMWG progress towards CLM4

- Revised surface dataset
- New grass optical properties
- Organic soil – physical properties
- Deeper soil column (~50 m, 15 soil levels, layers 11-15 are bedrock)
- Fixed diurnal cycle of solar radiation (offline)
- Partitioning of direct vs diffuse radiation (offline)
- New VOC model (MEGAN model)

LMWG progress towards CLM4

- **New surface dataset -** revised assumptions about how to treat herbaceous understory when assigning PFTs from MODIS
- **New grass optical properties**

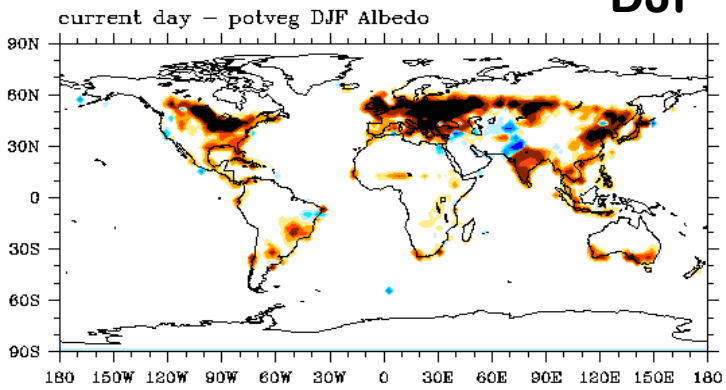


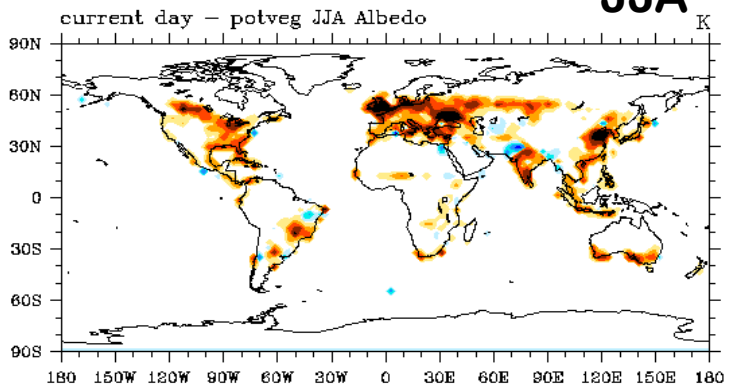
Land cover change impact on albedo

DJF

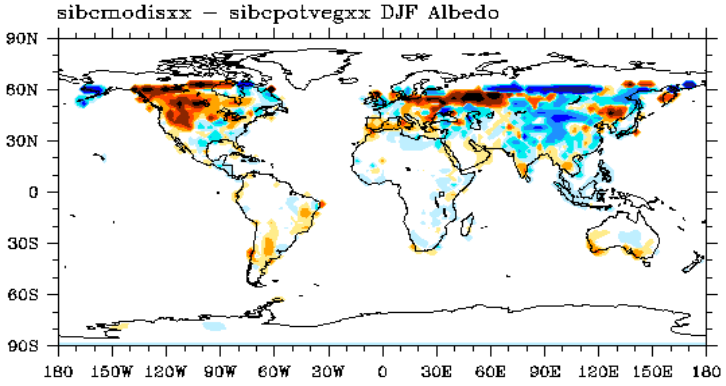
JJA

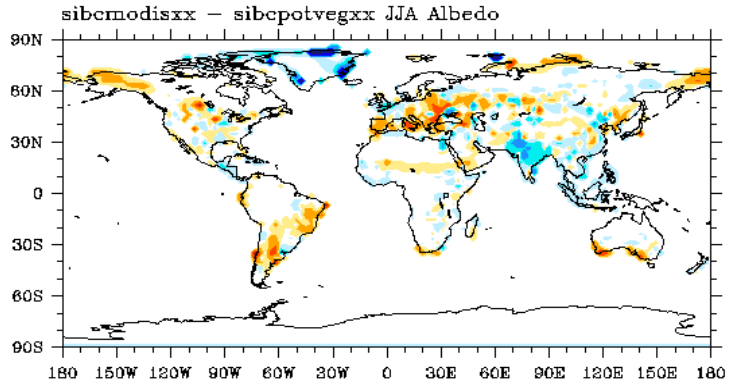
OBS



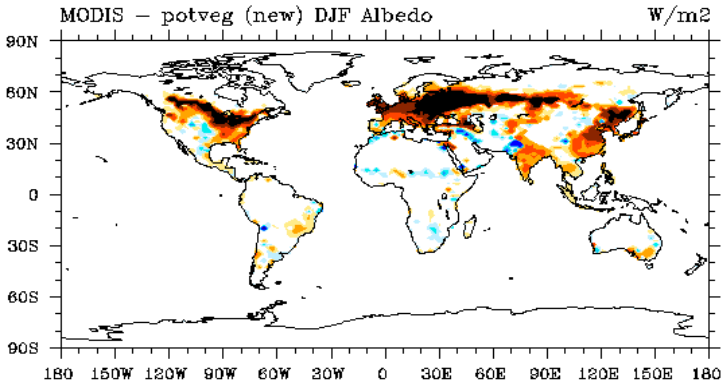


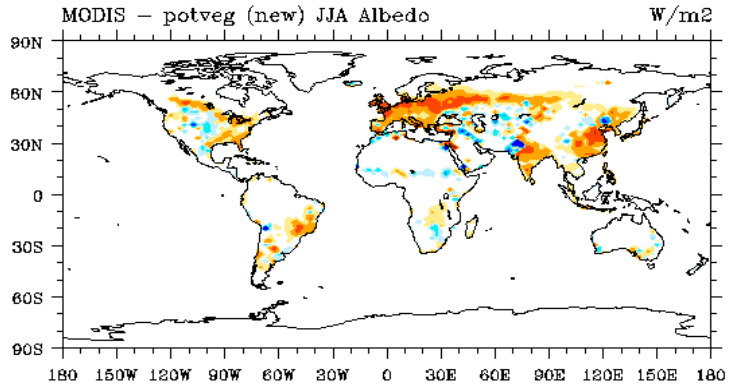
CLM3.5 dataset

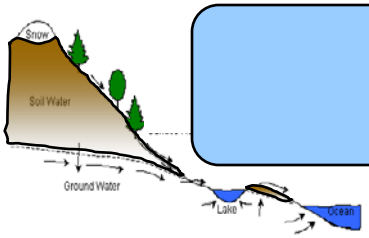




CLM4 dataset







LMWG progress towards CLM4

- Organic soil – physical properties
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- Fixed diurnal cycle of solar radiation (offline)
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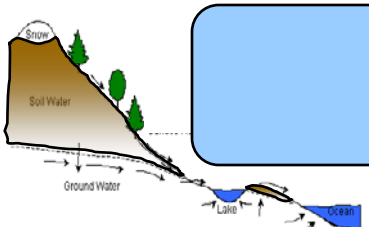
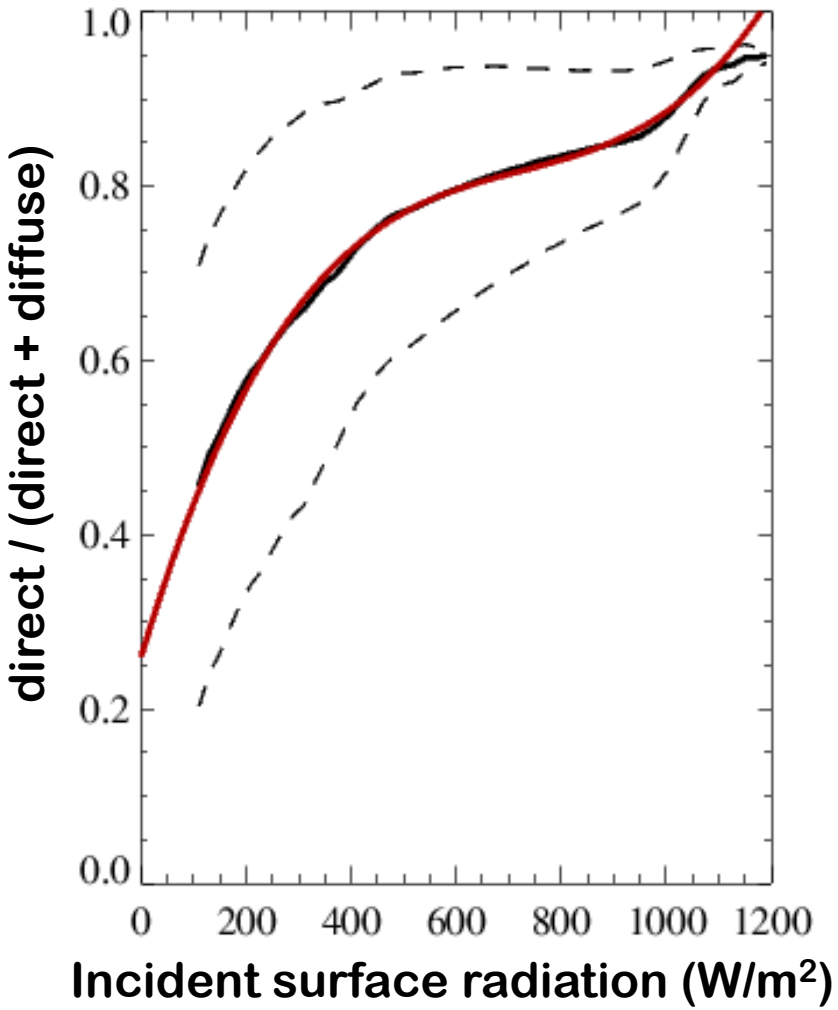
- New VOC model (MEGAN model)

Direct vs diffuse radiation (offline)

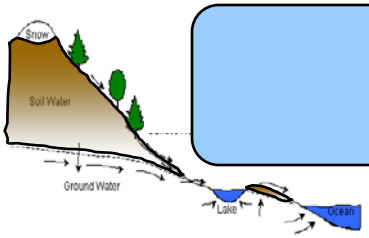




Relationship derived from CAM3.5 hourly data

Separate relationships for visible and near infrared

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



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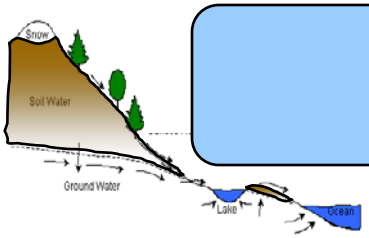
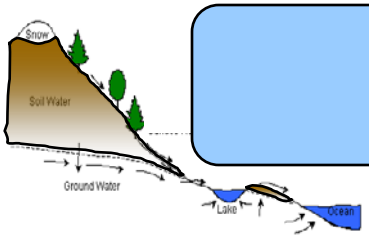
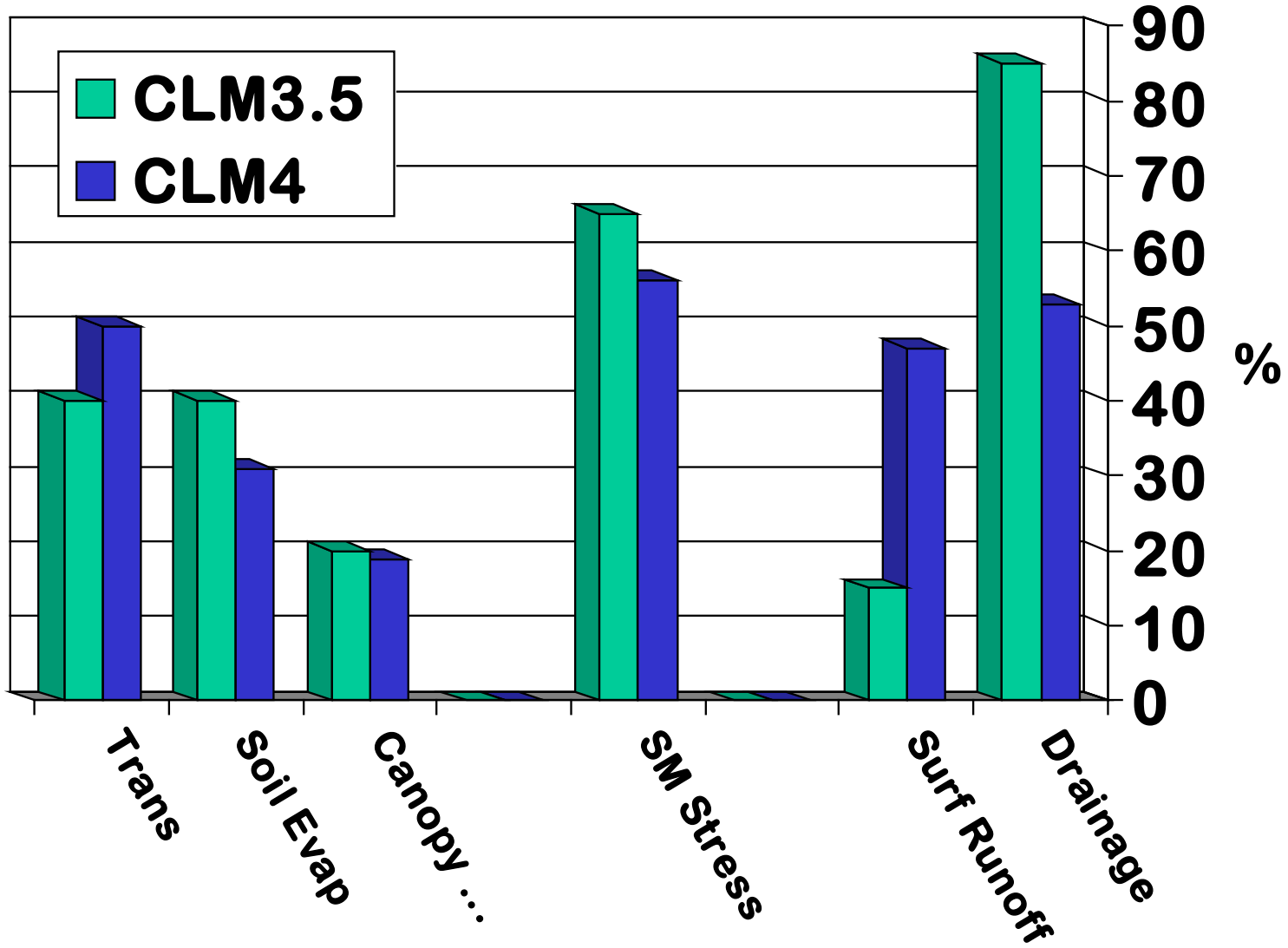


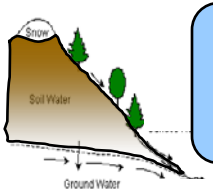
Tower flux statistics (15 sites, hourly)

	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
CLM4	0.80	48	0.84	58

Partitioning of ET, Runoff



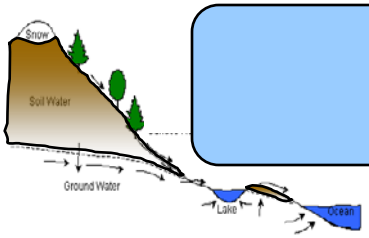




CCSM4

- Track 1
  - CAM3.5; updated surface components (which are chilled)
  - Running beta 1850 and present day simulations now
- Track 5
  - CAM4 with modal aerosols (aerosol indirect effect), UW PBL scheme, Morrison/Gettleman microphysics, updated macrophysics, RRTM
  - similarly updated surface components
- Release of CCSM4
  - autumn 2009???
- A Climate Modeling Primer
  July 27-31st, 2009
  National Center for Atmospheric Research, Boulder, CO

  APPLICATION DEADLINE: 1 May 2009

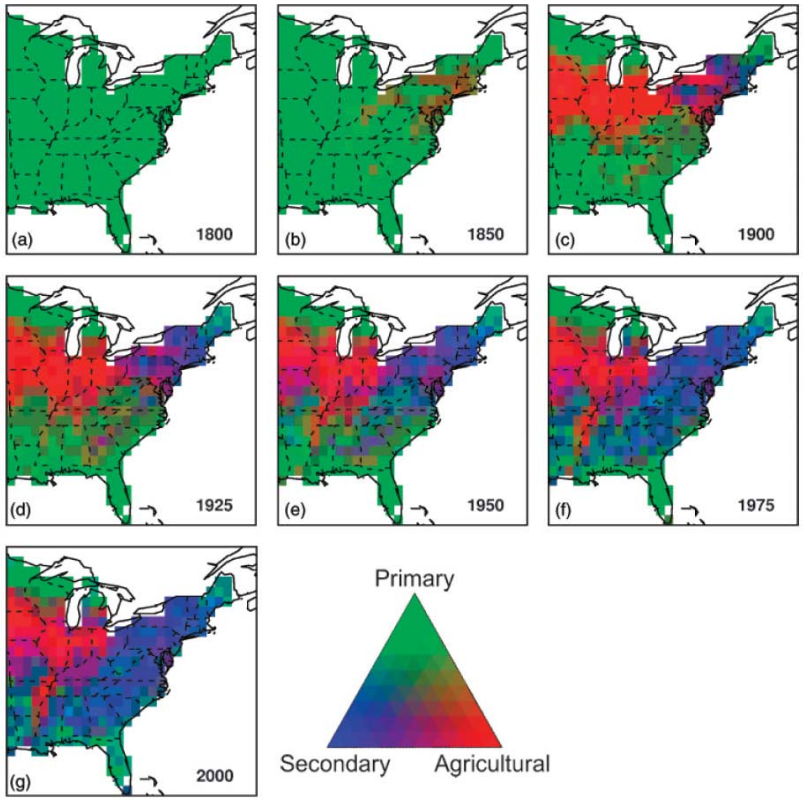


Ongoing and future projects 'beyond' CLM4

- Crop model / irrigation
- Land use / land cover transitions at column / landunit level
- Integration with Integrated Assessment Models
- Spatially variable soil depth
- Soil texture heterogeneity
- (Human managed water systems)
- Dynamic wetlands
- Methane emission model
- Thermokarst / shallow lakes
- Insect outbreaks
- Numerous other carbon, nitrogen, phosphorus cycling projects

Land use

Goal - Represent historical and future changes in land use (crops, pastures, cities) and their effects on energy, water, and biogeochemical fluxes

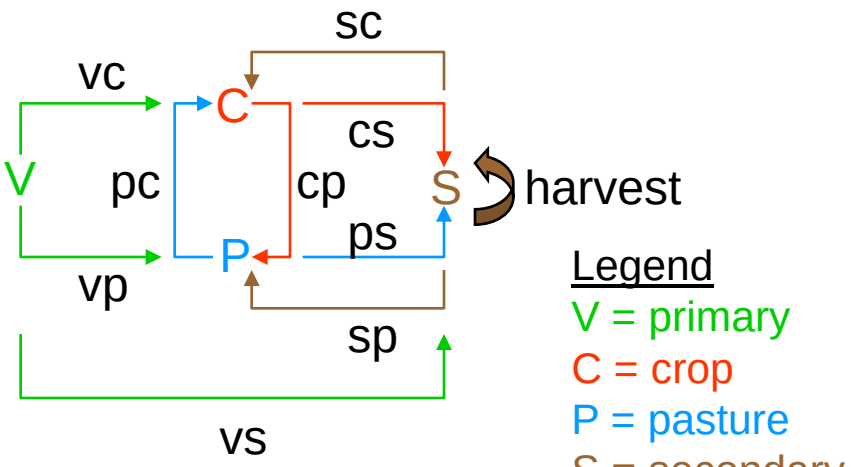


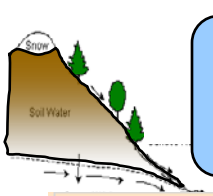
Albani et al. (2006) Global Change Biology 12:2370-2390
Hurtt et al. (2006) Global Change Biology 12:1208-1229

Challenges:

The CN approach is a starting point, but does not provide a framework to include cities or managed systems (crops, pastures) as ecosystems separate from natural ecosystems. It does not recognize specific land cover transitions.

Need a community framework: Johan Feddema (Kansas), George Hurtt (UNH), Natalie Mahowald (Cornell), Jim Randerson (UC-Irvine)





Diagnostics (T, P, albedo, runoff)

TSA	modified	control	Comparison
Model	cam3_5_45sci21a	cam3_5_45cona	Summary
RMSE	2.59	2.74	-0.15
RMSE % Area	21.84	10.67	+11.17
ANN Bias	0.09	0.50	-0.41
ANN Bias % Area	24.06	9.38	+14.68
DJF Bias	-0.38	0.41	-0.79
DJF Bias % Area	14.48	11.89	+2.59
MAM Bias	0.03	0.61	-0.58
MAM Bias % Area	24.75	9.88	+14.87
JJA Bias	0.54	0.37	+0.17
JJA Bias % Area	18.97	25.19	-6.22
SON Bias	0.04	0.43	-0.39
SON Bias % Area	12.79	9.17	+3.62

New grass optical properties

Old values in parentheses, new values based on Asner et al. 1998