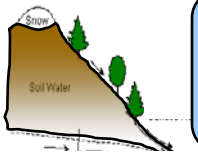


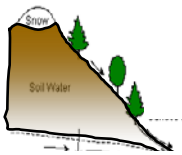
LMWG progress towards CLM4

- **Soil hydrology**
  - Since CLM3.5, numerous updates and tuning
  - Improved soil moisture variability, surface fluxes, soil moisture stress partitioning of ET into its components
- **Snow model**
  - snow density dependent snow cover fraction parameterization (Niu and Yang, 2006)
  - snow burial fraction for short vegetation (Zeng et al., 2008)
  - adopt SNICAR (Flanner et al., 2004, 2005, 2006)

    snow age

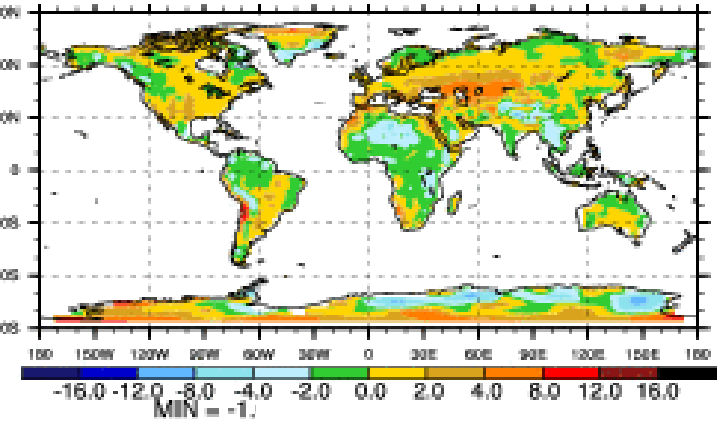
    vertically resolved heating in snowpack (snowdp > 0.1m)

    aerosol deposition (dust, black carbon, organic carbon from modal aerosol scheme)
  - snow compaction, snow layer splitting

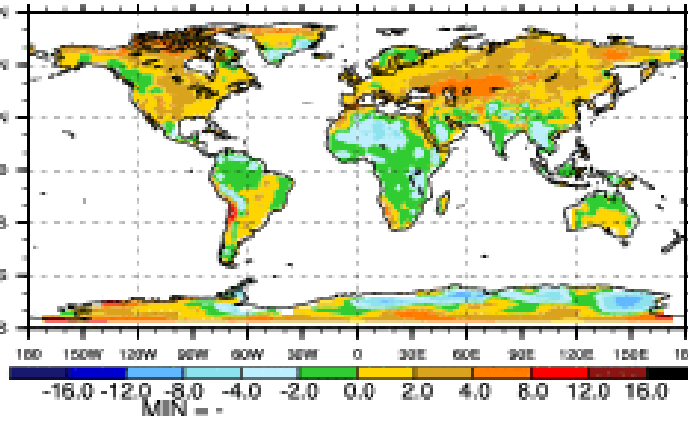


Results from Community Snow Project: Surface air temperature (ANN)

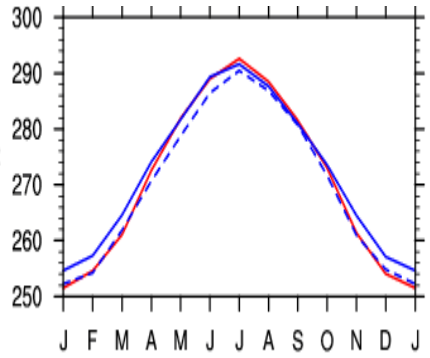
Community Snow - Obs



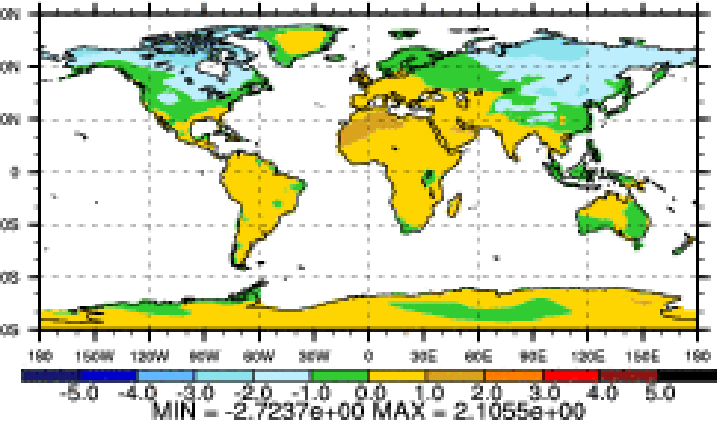
Control - Obs



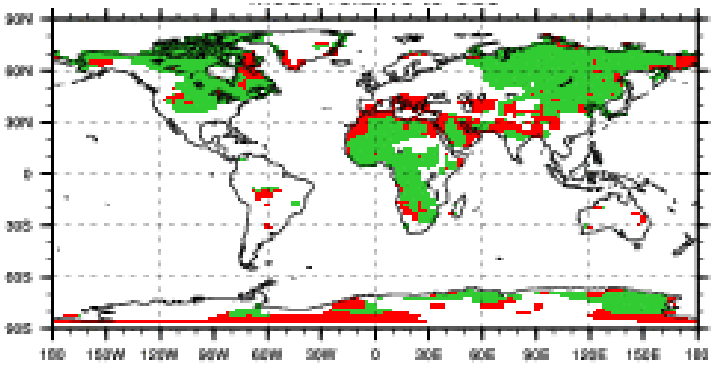
Western Siberia



Community Snow - Control



Reduced or Increased Bias

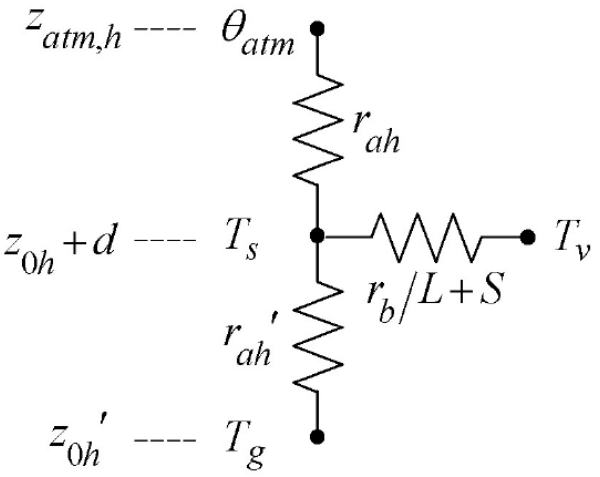


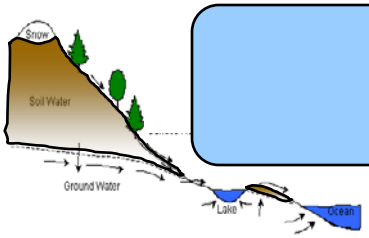
T_{air}(land): RMSE 2.78°C → 2.56°C, Bias 0.59°C → 0.43°C
Climate sensitivity: +0.2 to +0.3°C

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
- **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
- **Revised surface dataset and grass optical properties**
- **Reference height**

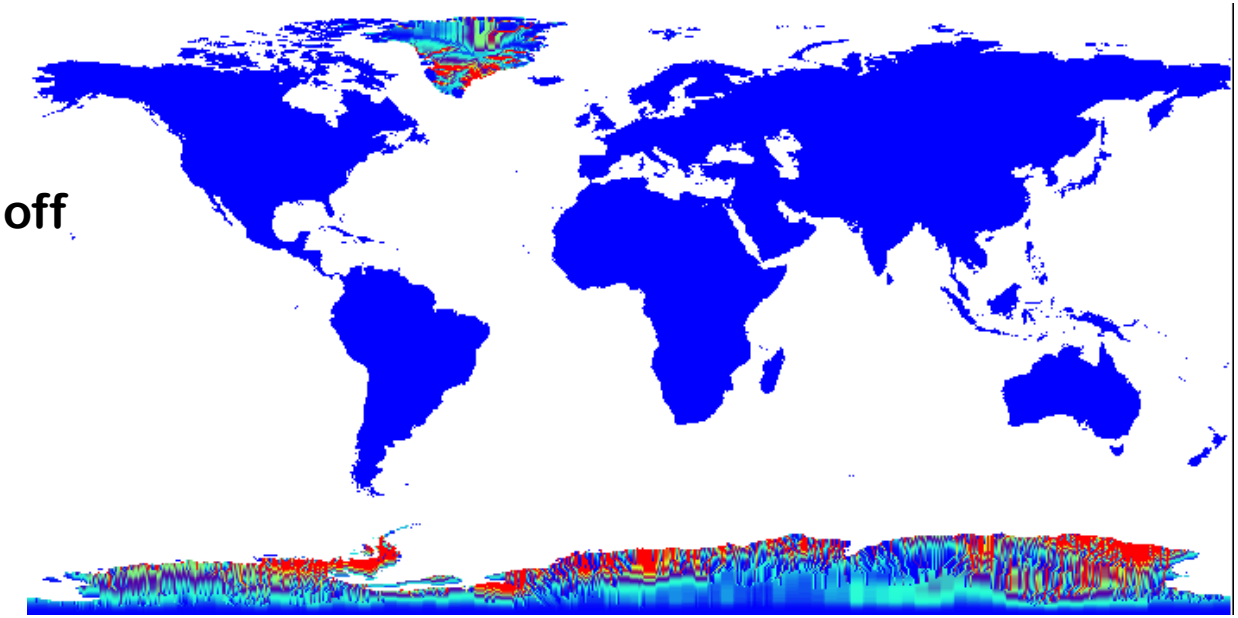
  Distance between reference height and lowest atmospheric level is same for all land tiles



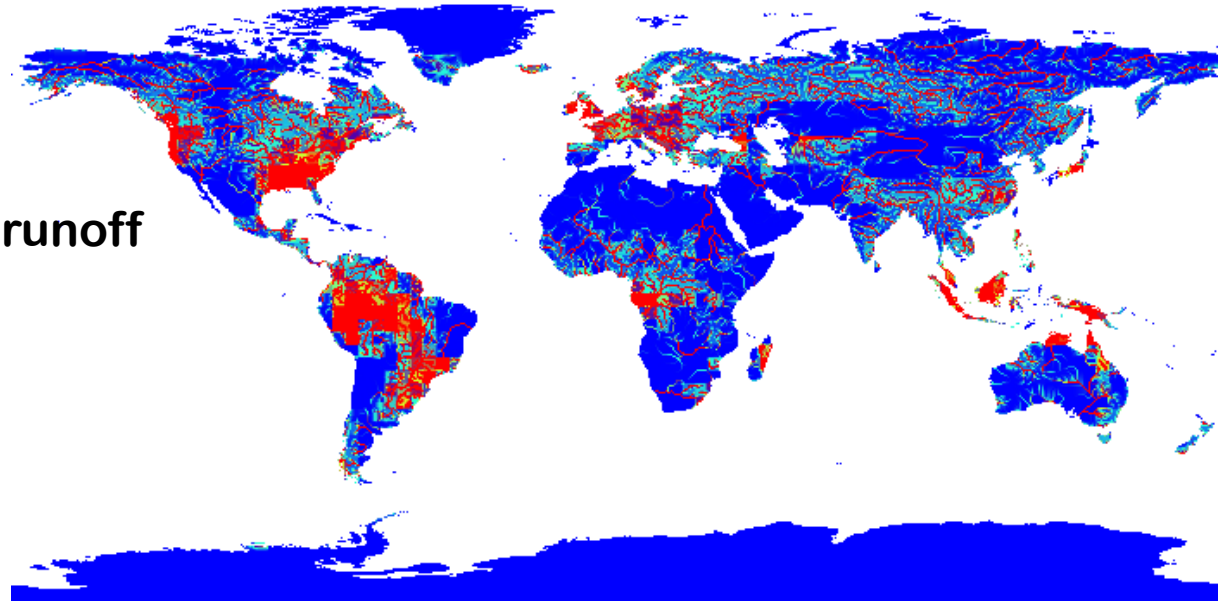


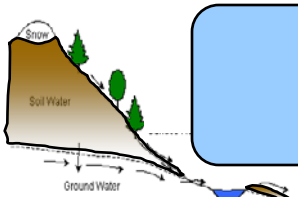
Ice stream in snow capped regions

Ice runoff



Liquid runoff



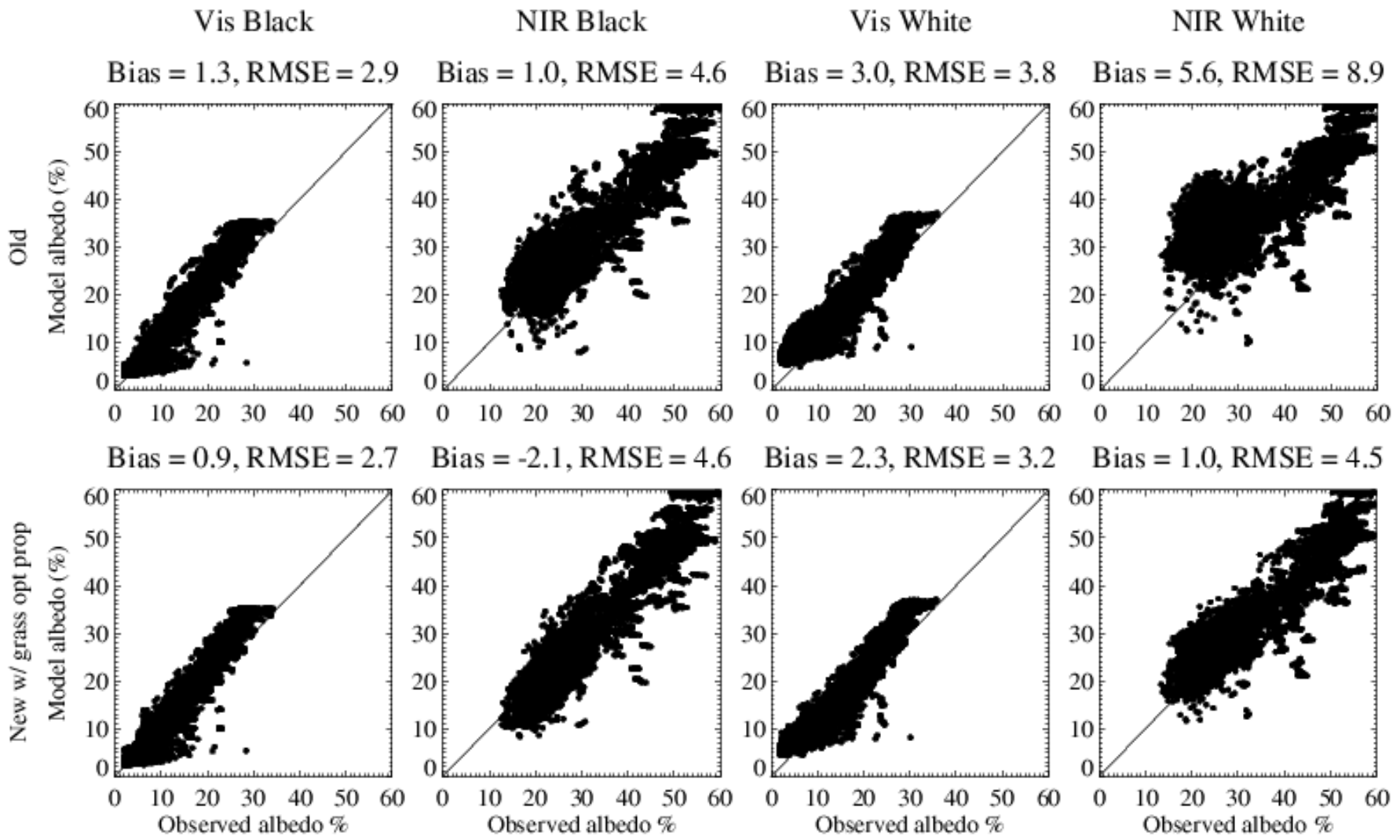


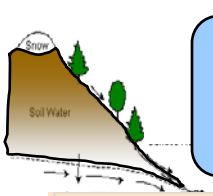
LMWG progress towards CLM4

- **Urban model**
  - Heat island
  - Heating/AC/wasteheat flux: +0.03 to 0.05 W m^{-2} over land
- **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
- **Revised surface dataset and grass optical properties** (Lawrence and Lawrence)
- **Reference height at z0 + d on each tile**
  - Distance between reference height and lowest atmospheric level is same for all land tiles

Improvements to surface albedo

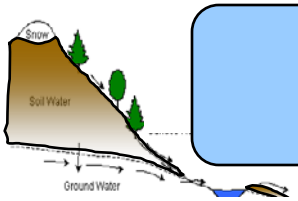
New grass optical properties and revised assumptions about how to treat herbaceous understory when assigning Plant Function Types from MODIS





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

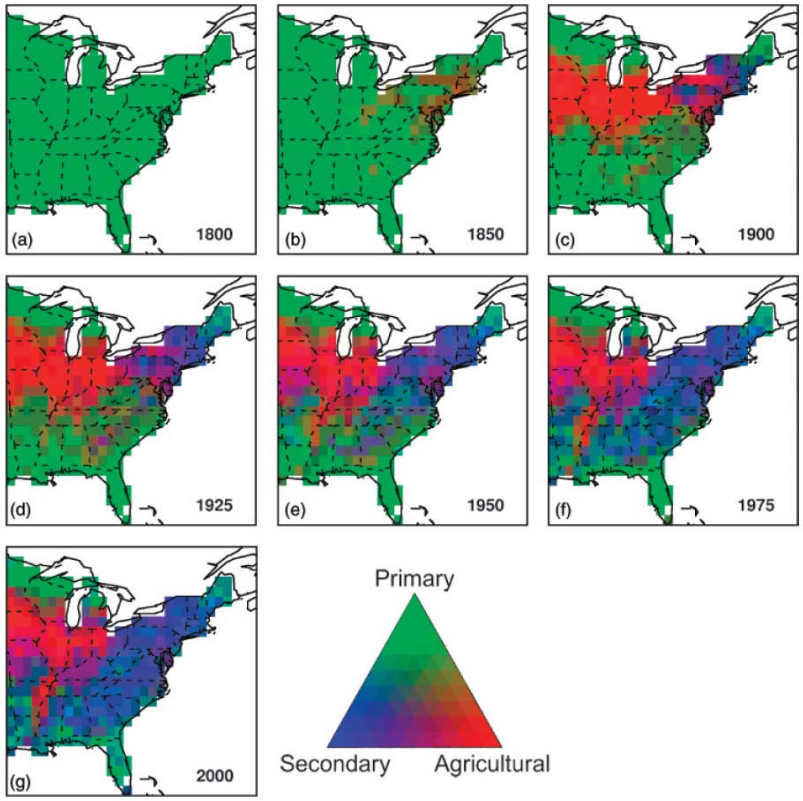


LMWG progress towards CLM4

- Transient land use: transitions between primary veg, secondary veg, crop, pasture, urban (Bonan, Levis, Oleson, Hurtt, Thornton)
  - account for biogeophysical and carbon cycle impacts of historic (1850-2000) and future land use change
- Organic soil – physical properties (Lawrence and Slater, 2008)
- Deeper soil column (~50 m, 15 soil levels, layers 11-15 are bedrock) (Lawrence et al., 2008)
- Fine mesh – downscaling atmospheric forcing to high resolution land
- VOC emissions (MEGAN model)
- Dust emissions
- Methane emissions (not for CLM4)

Land use

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

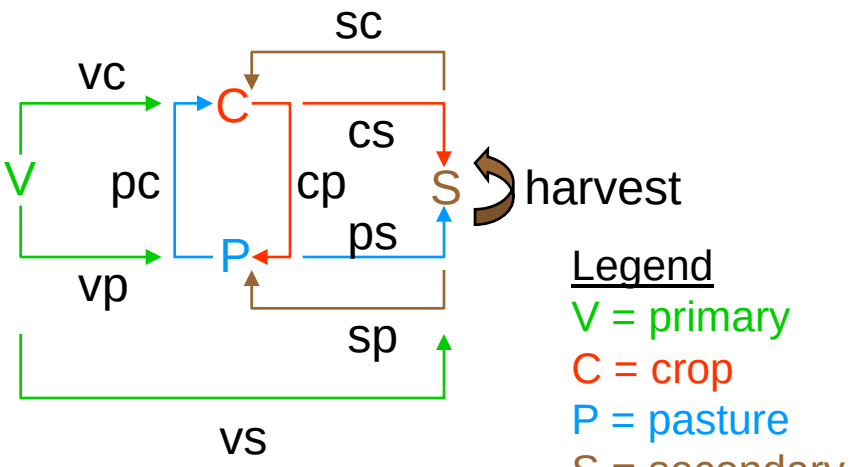


Albani et al. (2006) Global Change Biology 12:2370-2390
Hurtt et al. (2006) Global Change Biology 12:1208-1229

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)

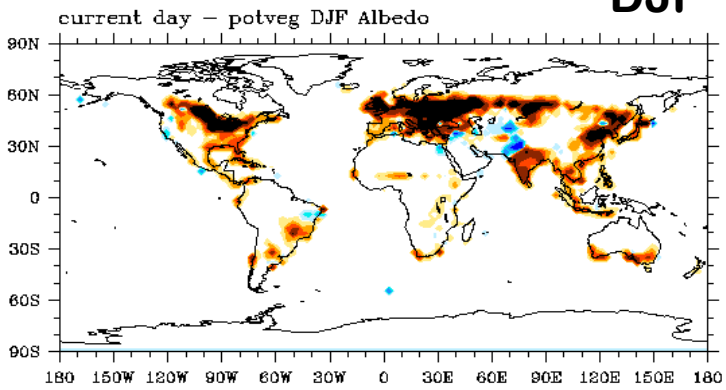


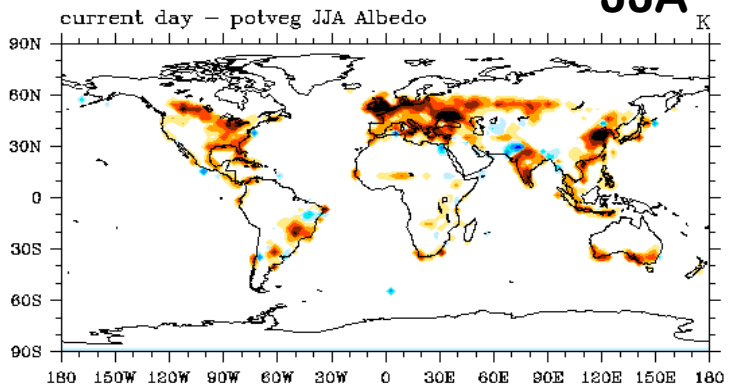
Land cover change impact on albedo

DJF

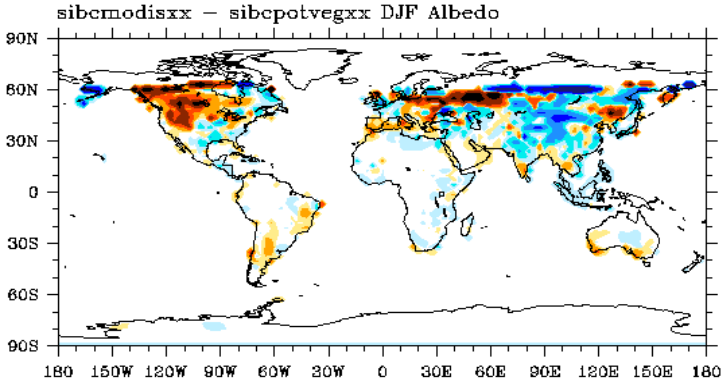
JJA

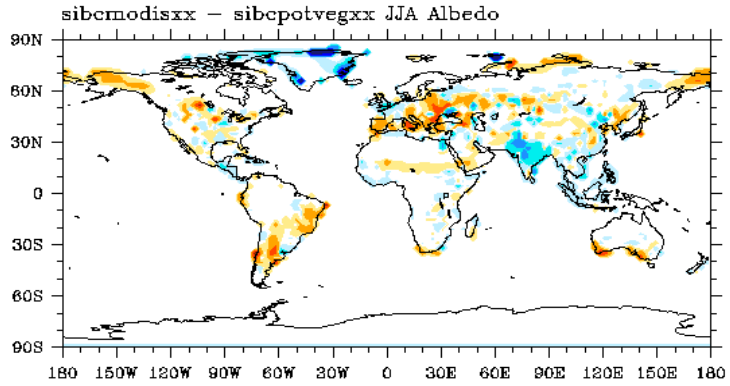
OBS



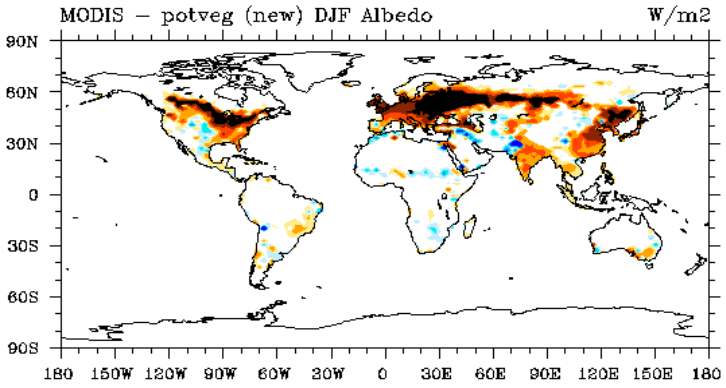


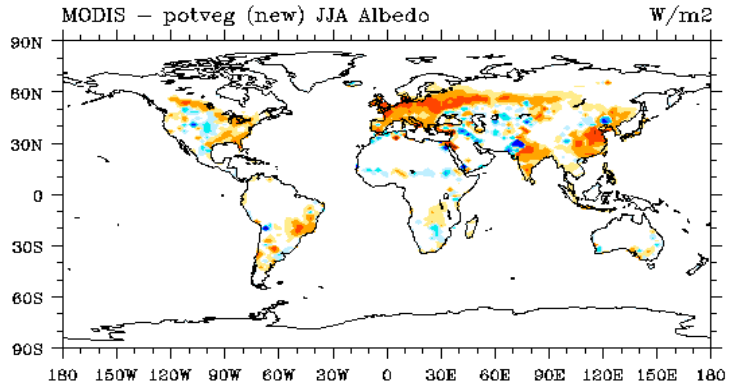
CLM3.5 dataset





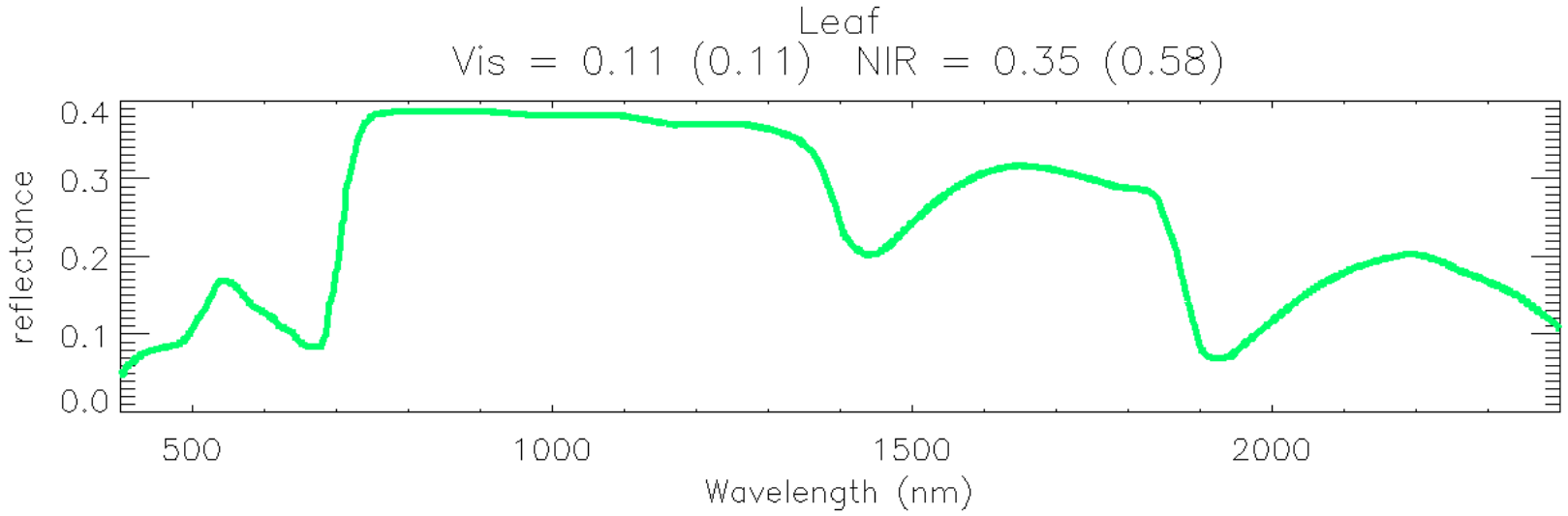
CLM4 dataset

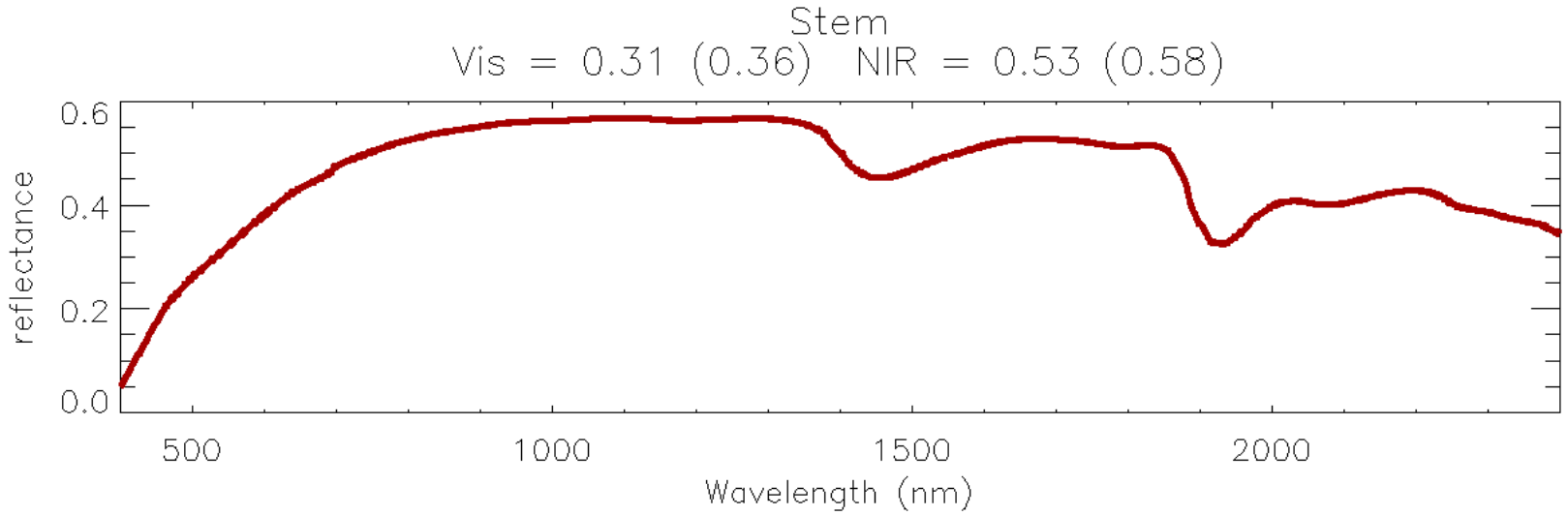


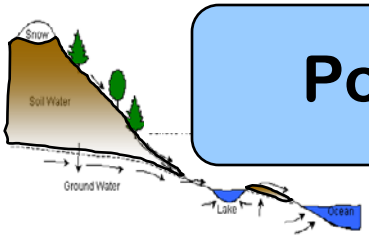


New grass optical properties

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







Polar relevant land changes for CCSM4+ (CLM4)

- **Dynamic wetlands** (Swenson and Lawrence)
- **Methane emission model** (Riley, Lawrence, Mahowald, Hess, Fung)
- **Thermokarst lakes** (Subin, Riley, Lawrence)
- **Insect outbreaks** (Hicke, Lawrence, Thornton)