Effects of Land Use On Climate and Water Resources: Application of a Land Surface Model for Land Use Management

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Personnel Supported:

Dr. Keith Oleson, Associate Scientist (NCAR) - 100%
Dr. Charles Zender (UC-Irvine) - 2 months

Goal: Study natural and human changes in land cover and ecosystem functions and their effects on climate, water resources, and biogeochemistry

Land Cover Land Use Change Program Goals

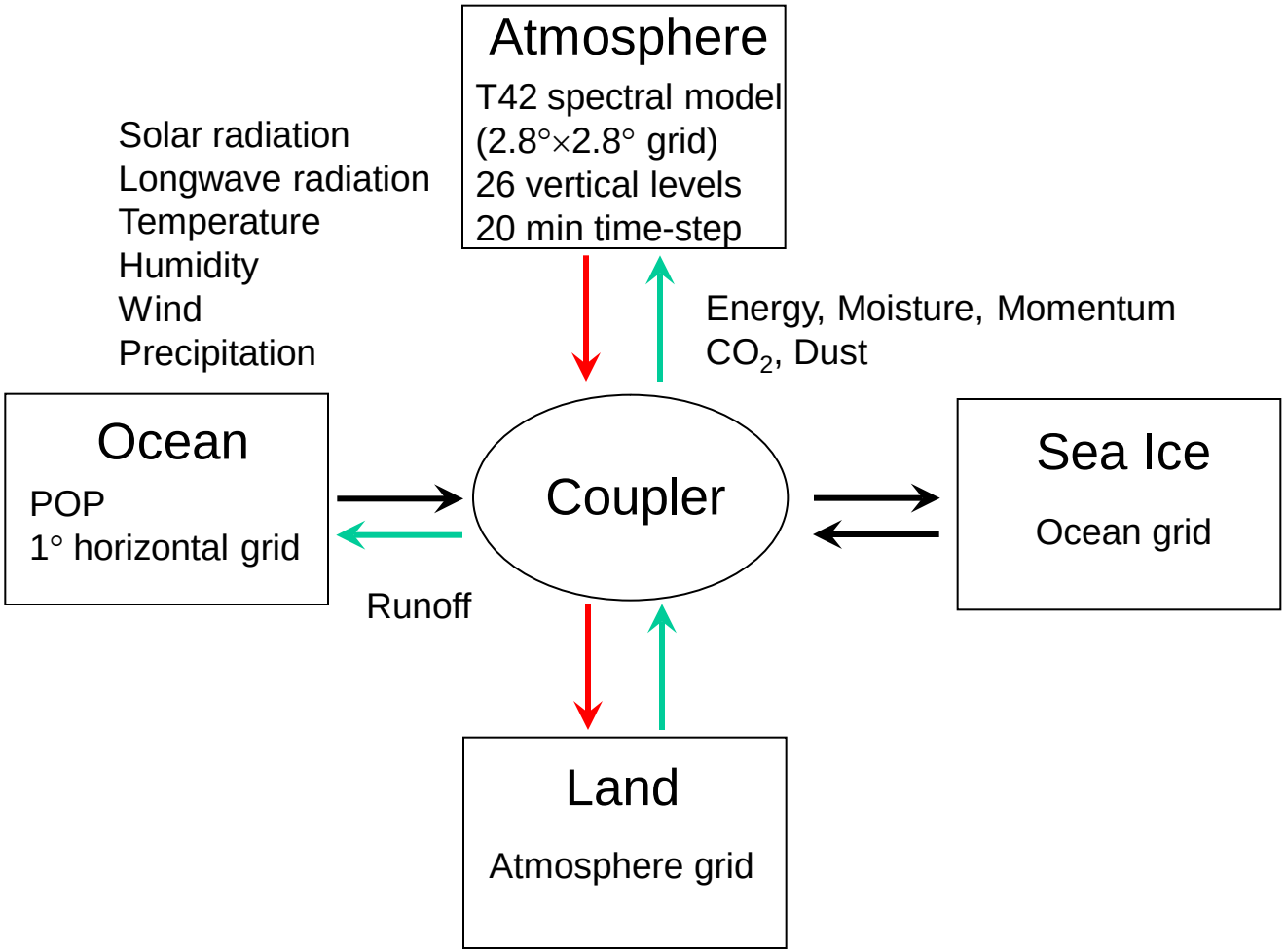
(1) Capability to perform global inventories of land use and land cover from space

(2) Develop scientific understanding and models to simulate processes

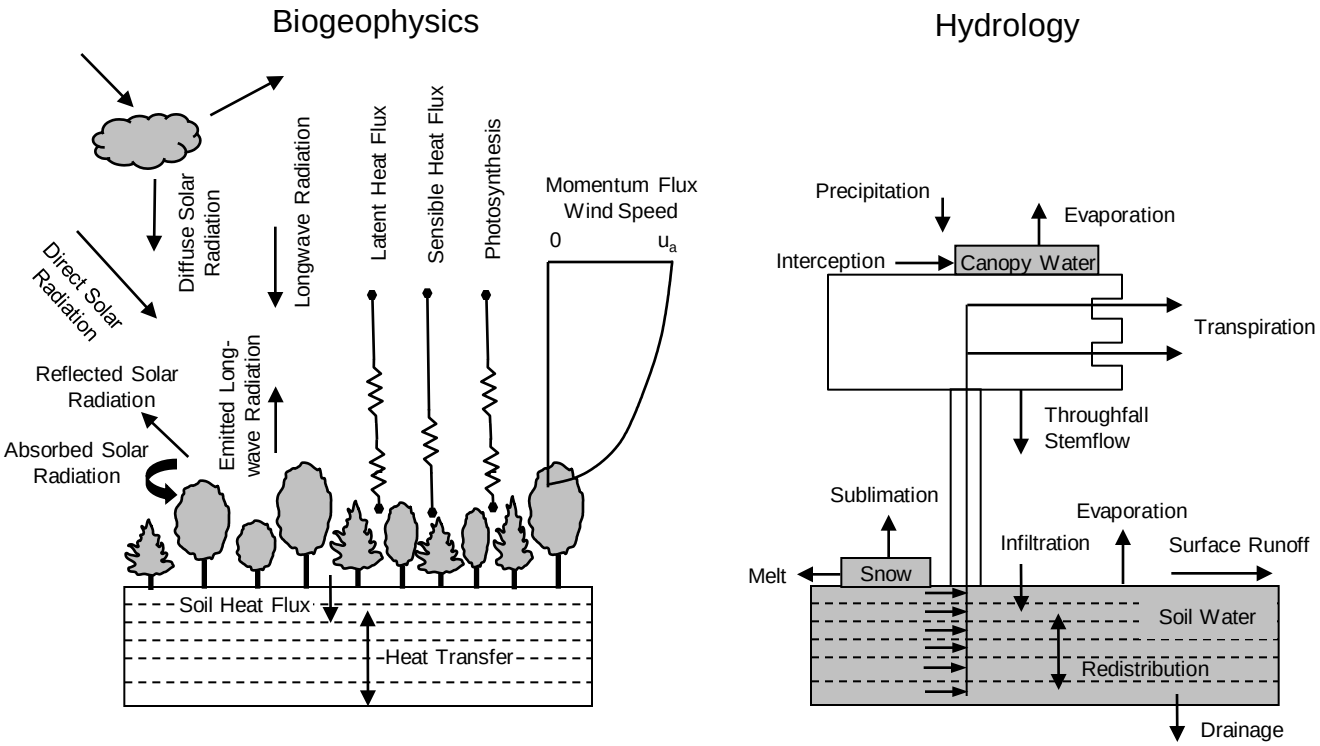
(3) Evaluate the consequences of observed and predicted change
- Environmental goods and services
- Carbon and water cycles
- Management of natural resources

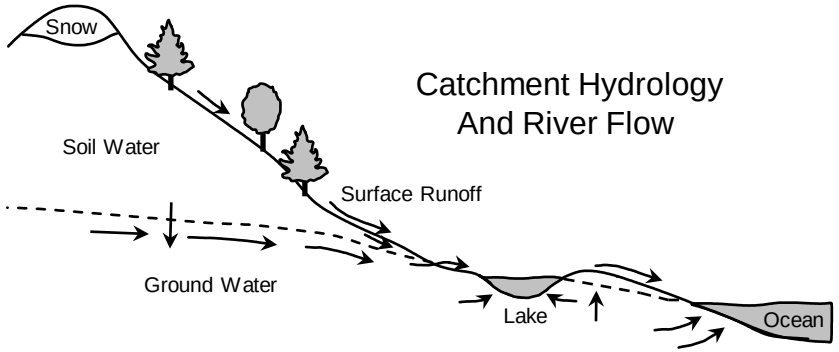
(4) Understand human interaction with the environment - sustainability, vulnerability, and resilience of land systems and their use

Community Climate System Model



Community Land Model

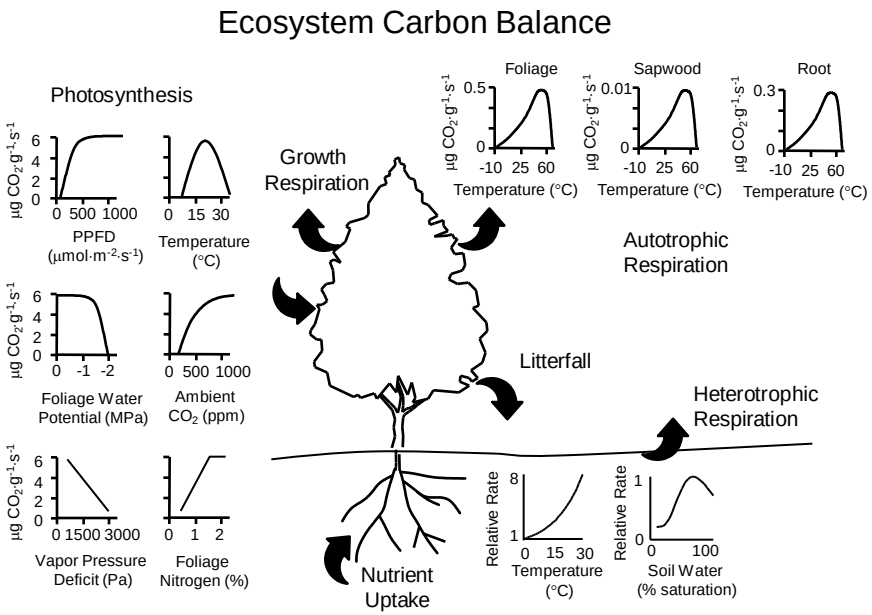


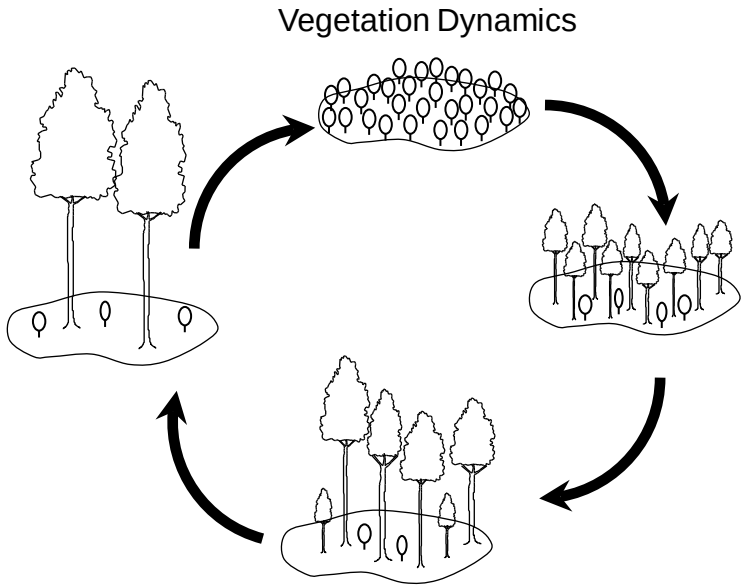


Catchment Hydrology
And River Flow

Community Land Model

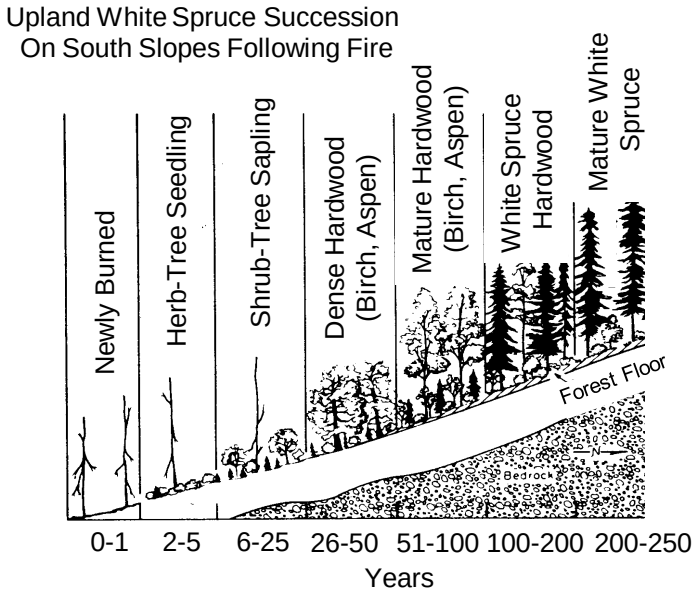
Interactive Vegetation

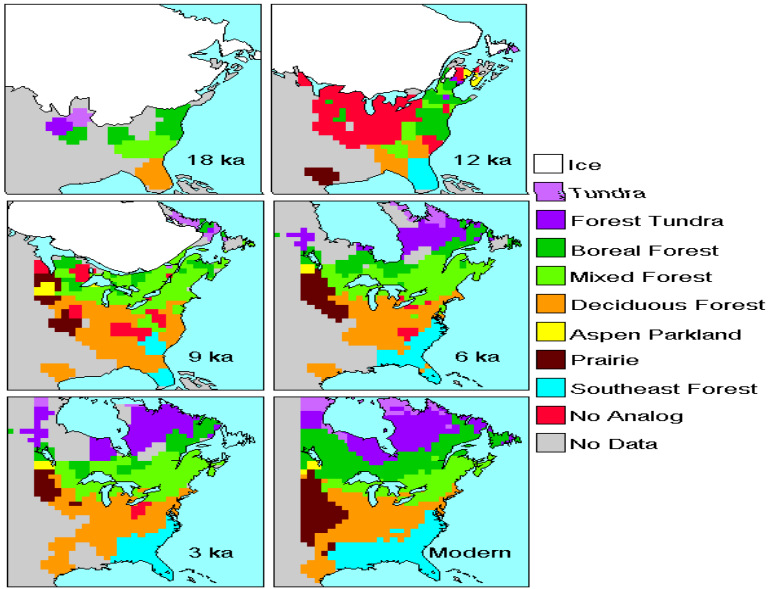




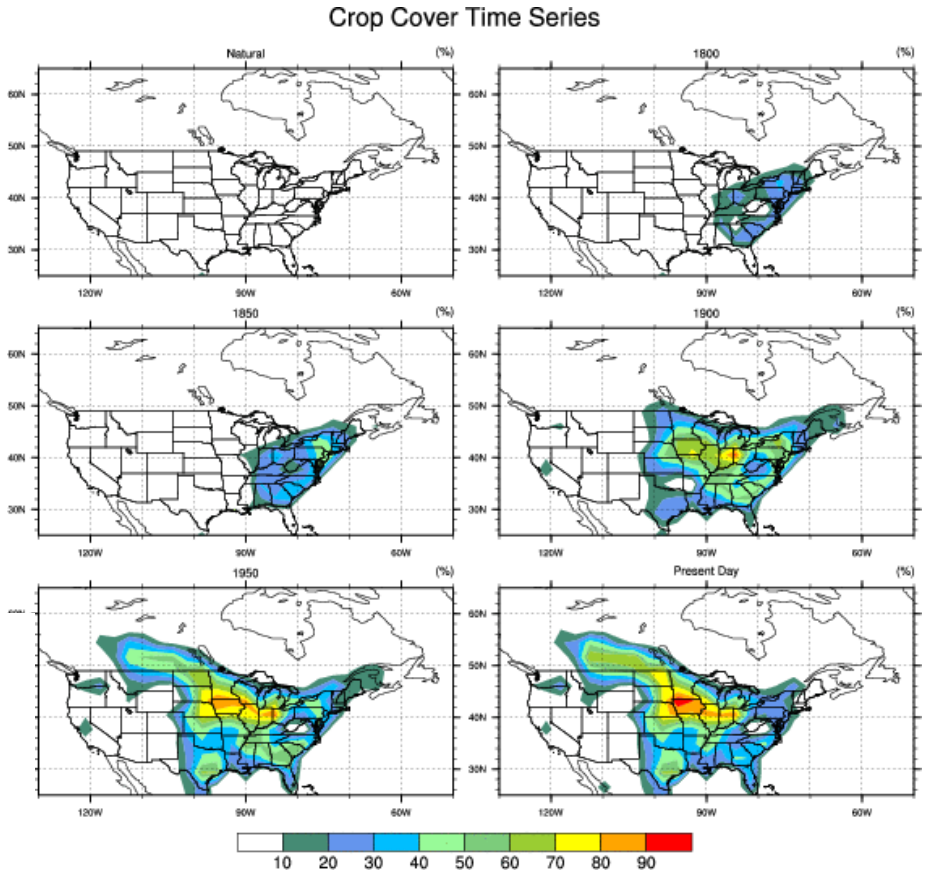
Land Cover and Land Use Change

Vegetation Dynamics





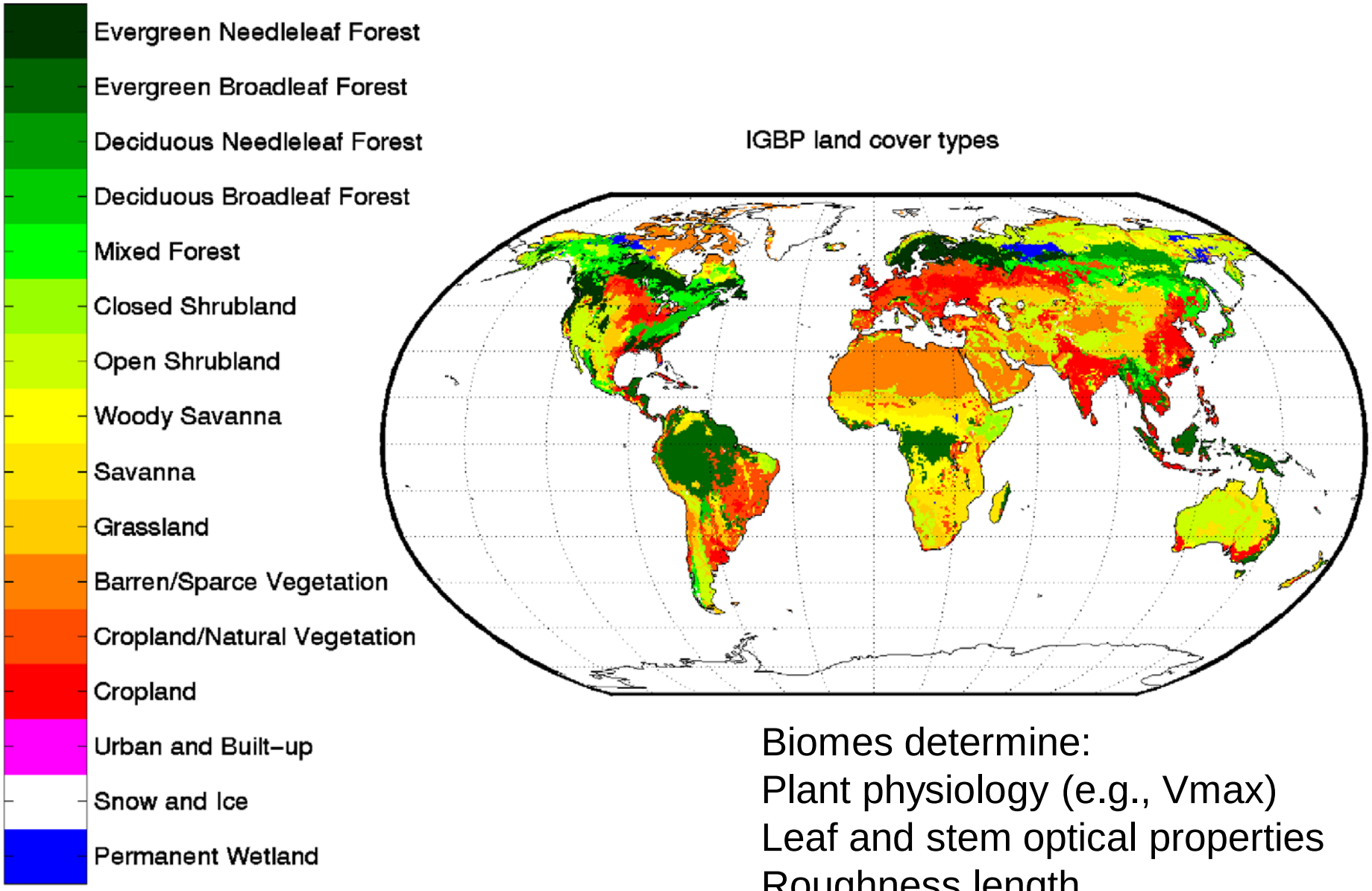
Land Use



- Surface energy fluxes (albedo, H,λE)
- Hydrologic cycle
- Atmospheric CO_2 (carbon storage)
- Dust

Tasks	Status
* • Implement subgrid land cover	• Done
* • New biogeophysics and hydrology	• Done
* • Implement river routing model	• Done
• Implement dust emission model	• In progress
• Add urban land cover	• In progress
* • U.S. agroecosystem experiments	• In progress
* • Implement dynamic vegetation model	• In progress

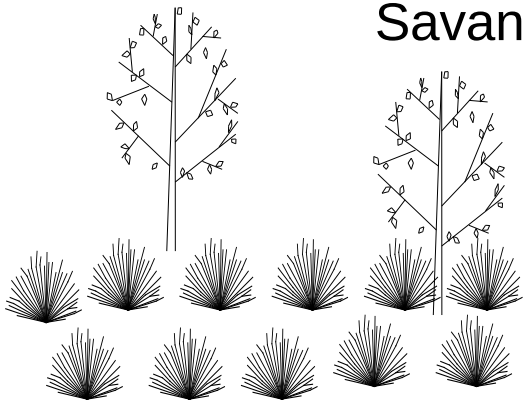
Biome Representation Of Land Cover

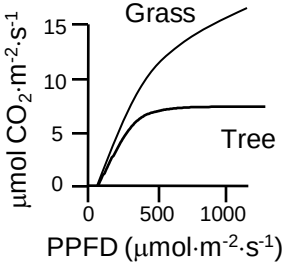


Biomes determine:
Plant physiology (e.g., Vmax)
Leaf and stem optical properties
Roughness length
Leaf and stem area index

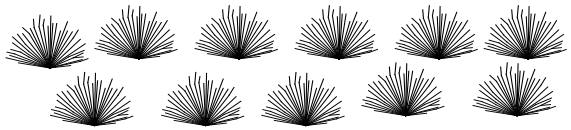
Mixed Life-Form Biomes

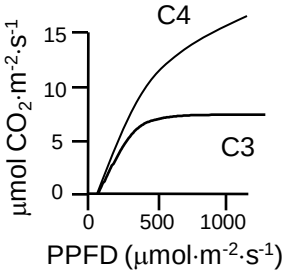
Savanna



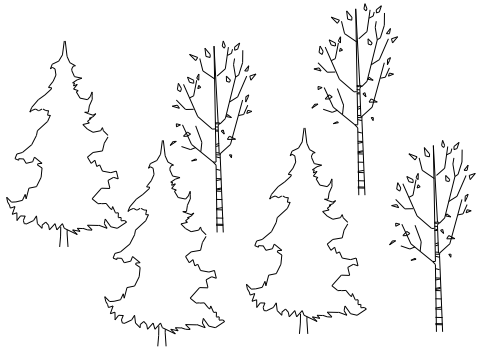


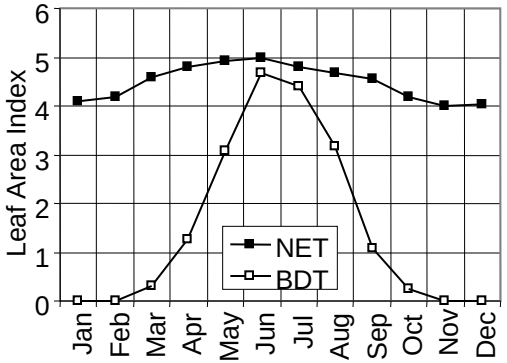
Grassland



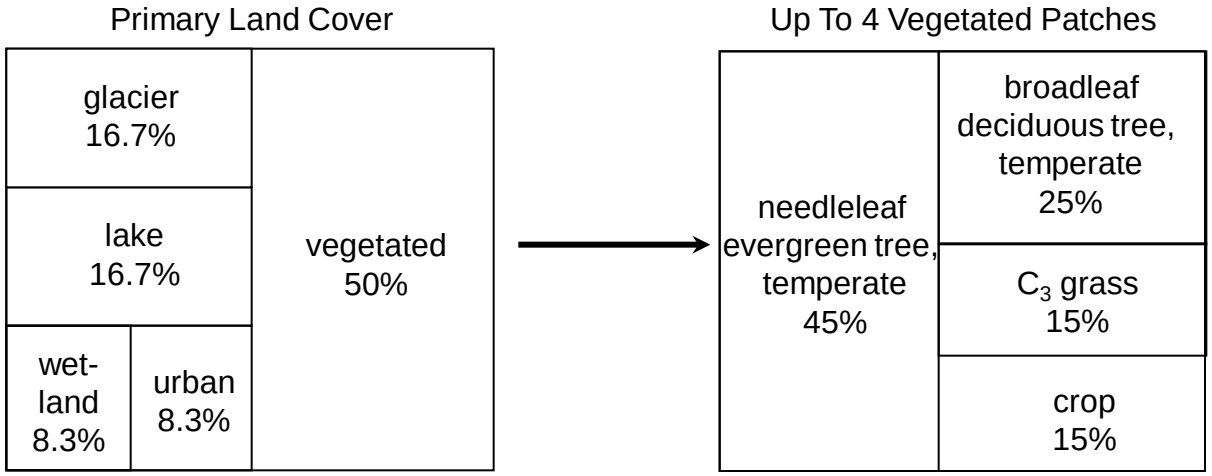


Mixed Forest





Subgrid Land Cover and Plant Functional Types



Each subgrid land cover type is separate column for energy,water, and carbon

<u>Each patch has own</u>:

- PFT abundance
- leaf area
- height

Datasets provided on ½° grid and then aggregated to T42 grid

Oleson and Bonan (2000) The effects of remotely-sensed plant functional type and leaf area index on simulations of boreal forest surface fluxes by the NCAR land surface model. Journal of Hydrometeorology 1:431-446.

Bonan, Levis, Kergoat, and Oleson (2002) Landscapes as patches of plant functional types: an integrating concept for climate and ecosystem models. Global Biogeochemical Cycles, in press

Plant Functional Types

Climate Rules

Remote Sensing Data Products	→	Plant Functional Types
Needleleaf evergreen tree		temperate boreal
Needleleaf deciduous tree		boreal
Broadleaf evergreen tree		tropical temperate
Broadleaf deciduous tree		tropical temperate boreal
Shrub		broadleaf evergreen temperate broadleaf deciduous temperate broadleaf deciduous boreal
Grass		C3 C3 arctic C4
Crop		Corn Wheat

Trees

1-km U. Maryland tree cover

- needleleaf, broadleaf
- evergreen, deciduous

Others

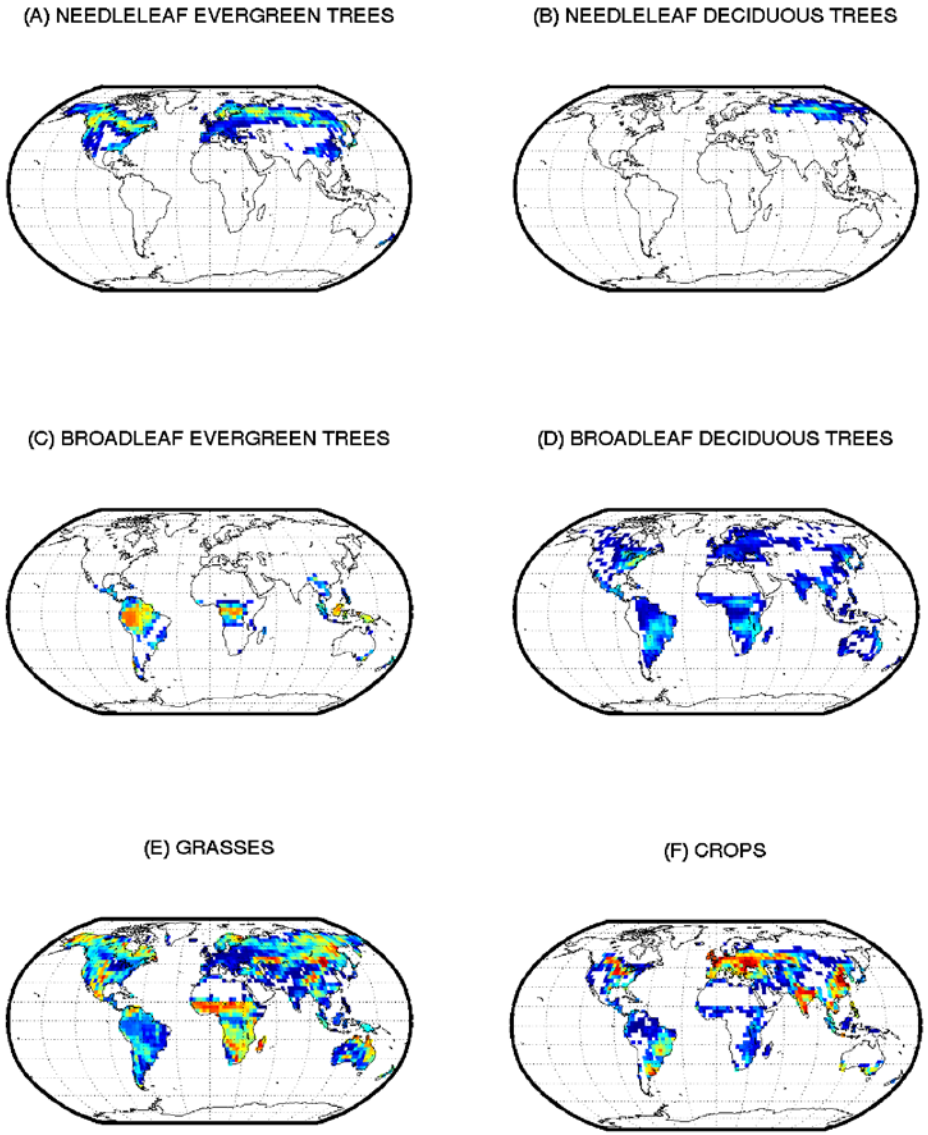
1-km IGBP DISCover

- shrub, grass, crop

Monthly Leaf Area

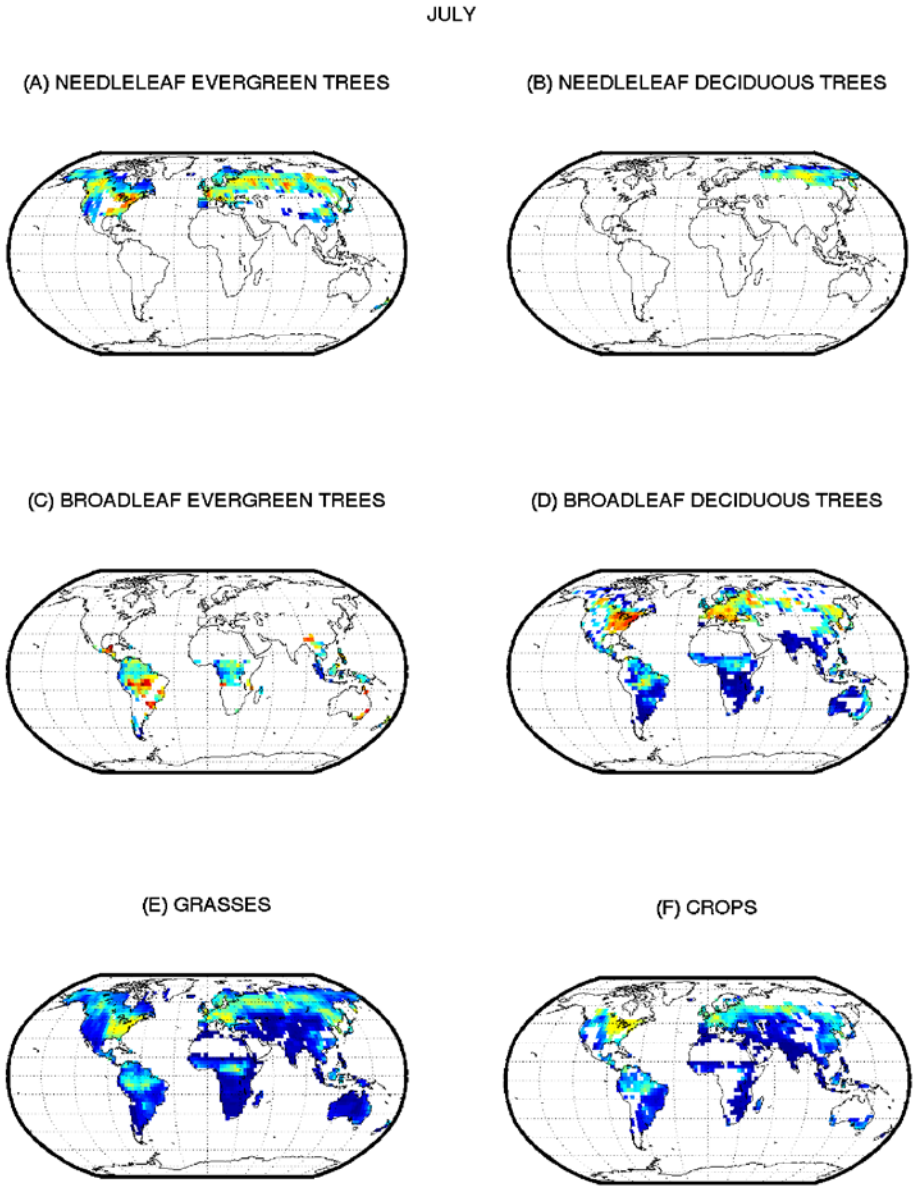
- 1-km AVHRR red and near infrared reflectance
- April 1992 to March 1993
- 'Pure PFT' NDVI for 200 km × 200 km grid
- Average NDVI for each 1-km pixel with PFT > 60%

Plant Functional Type Geography



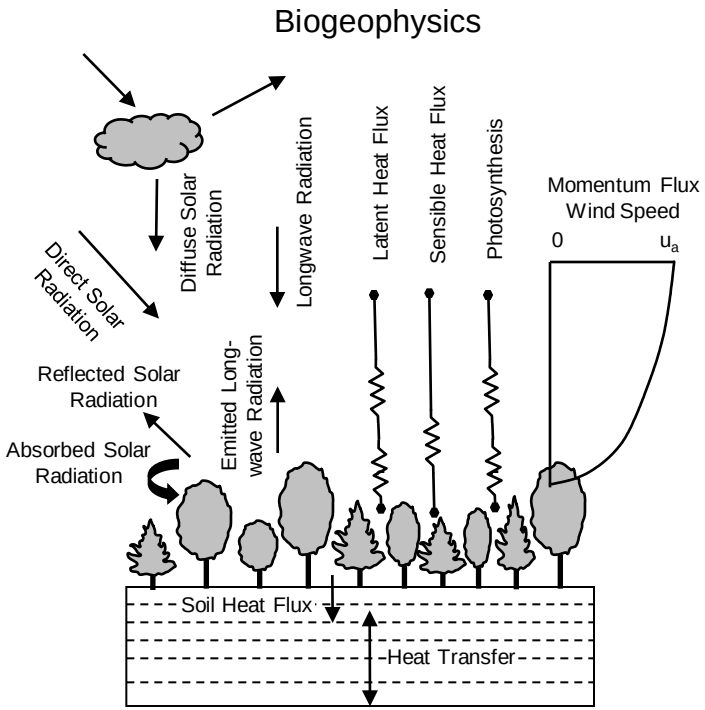
(½º grid)

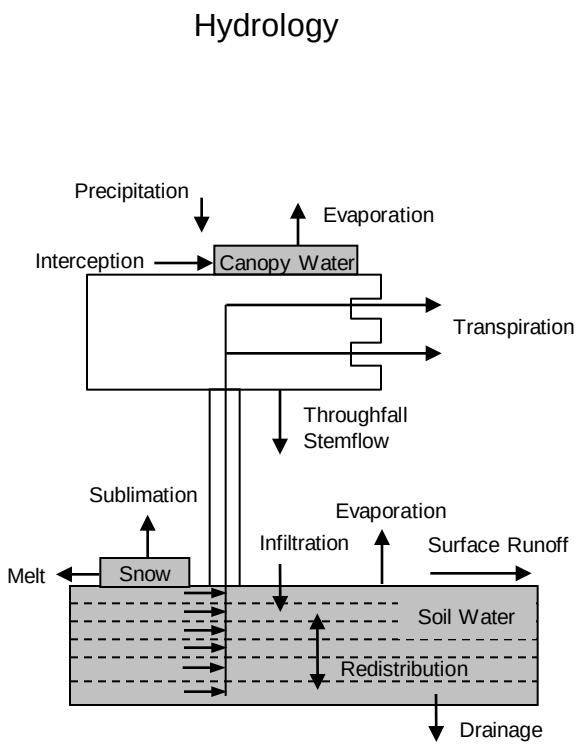
Leaf Area Index



(½° grid)

Improved Biogeophysics and Hydrology





CCSM Land Model Working Group

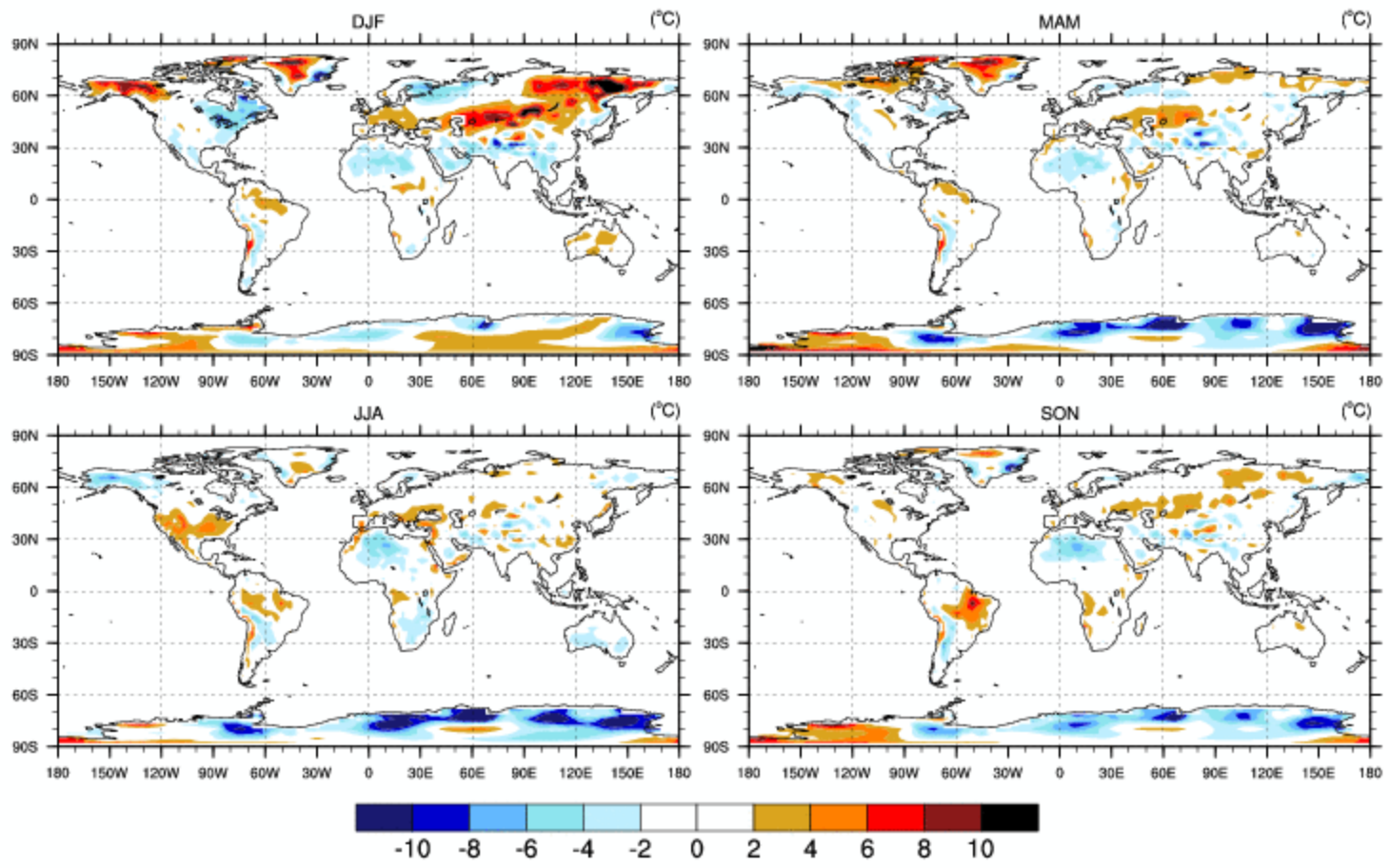
Gordon Bonan (NCAR)

Robert Dickinson (Georgia Tech.)

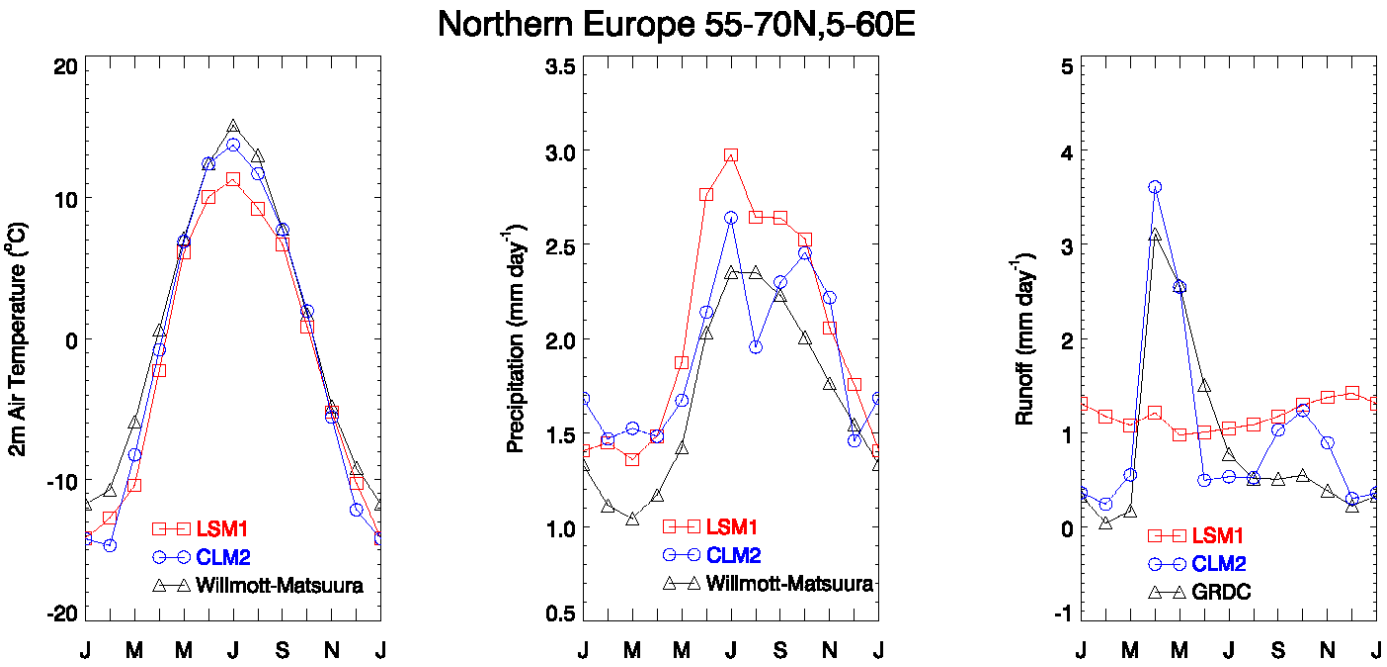
Paul Houser (NASA/GSFC)

Zong-Liang Yang (U. Texas)

Xubin Zeng (U. Arizona)

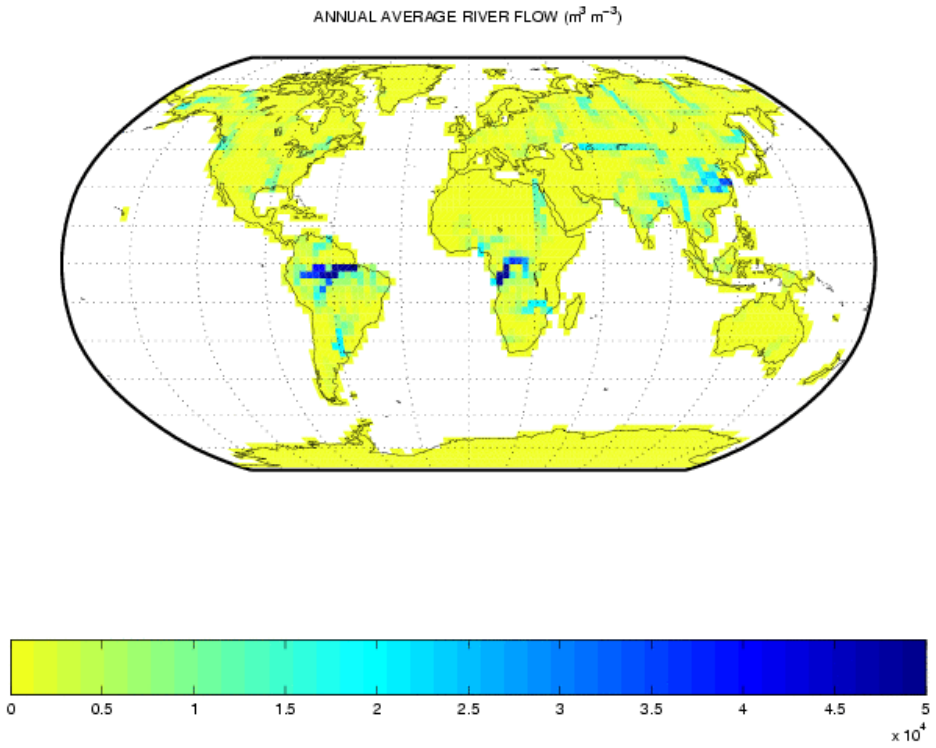

CLM2 - Willmott/Matsuura Surface Air Temperature Difference
DJF
(°C)
MAM
(°C)
JJA
(°C)
SON
(°C)
90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
-10 -8 -6 -4 -2 0 2 4 6 8 10

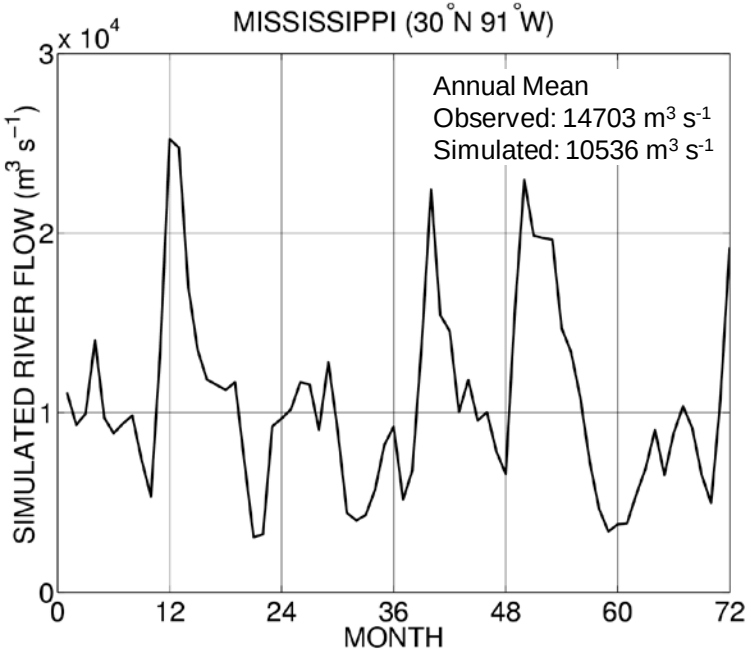
Regional Analyses



- Reduced summer cold bias
- Reduced precipitation
- Improved runoff

River Routing



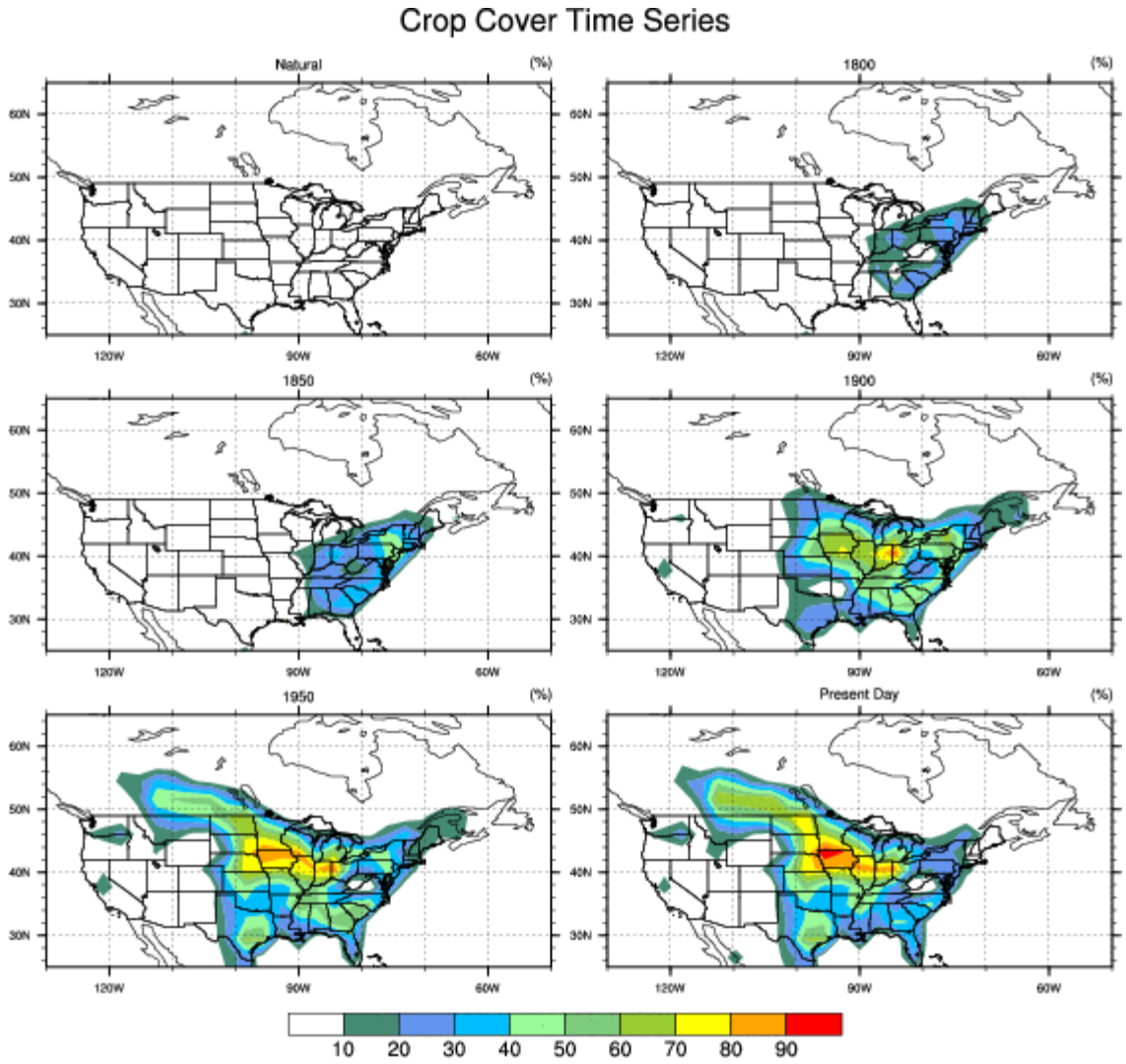


Route Runoff To Oceans

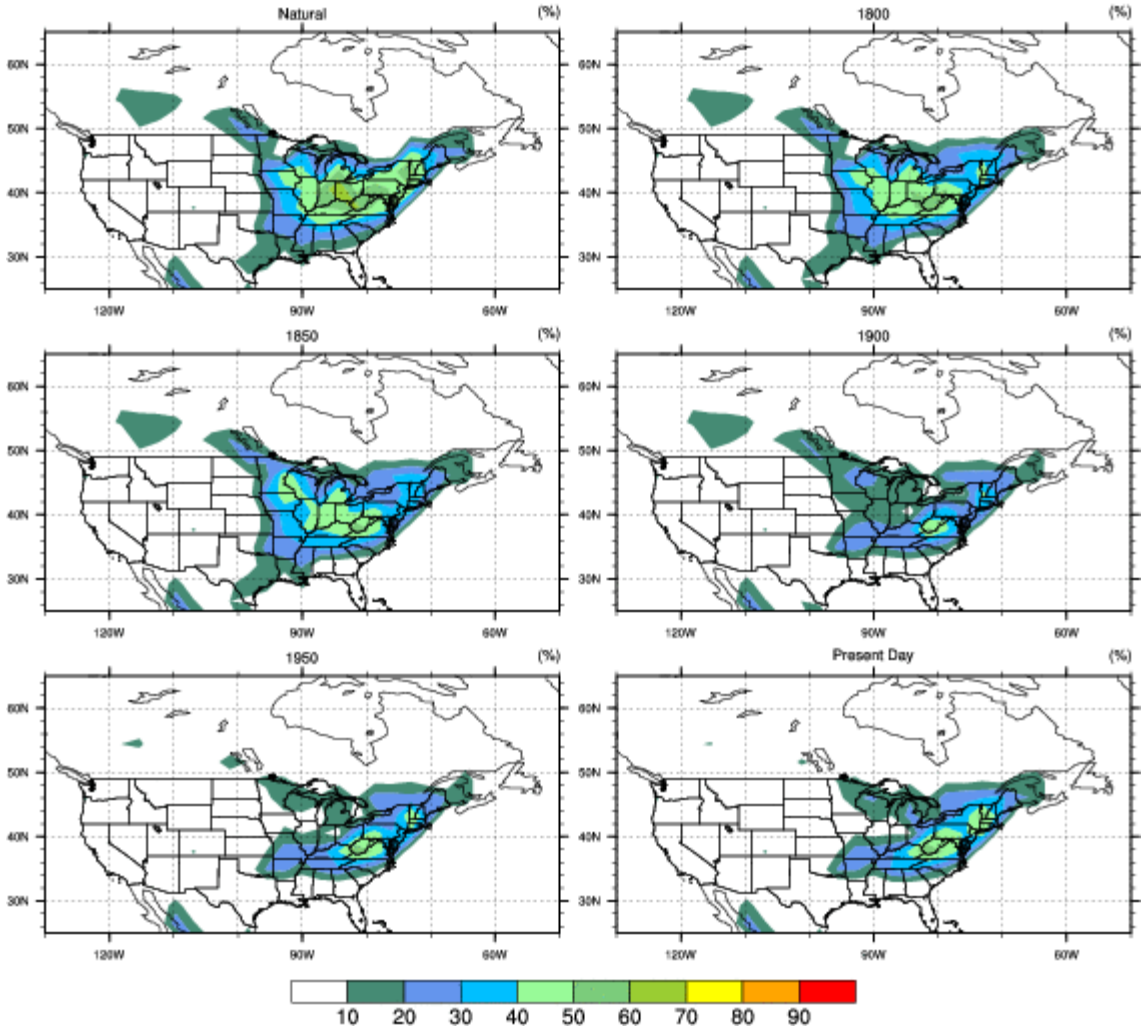
<u>Collaborator</u>

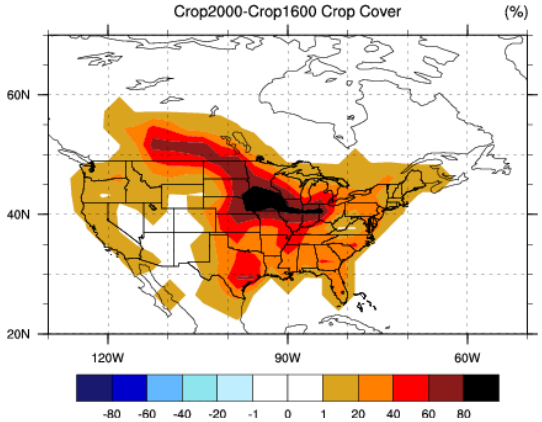
Jay Famiglietti (UC - Irvine)

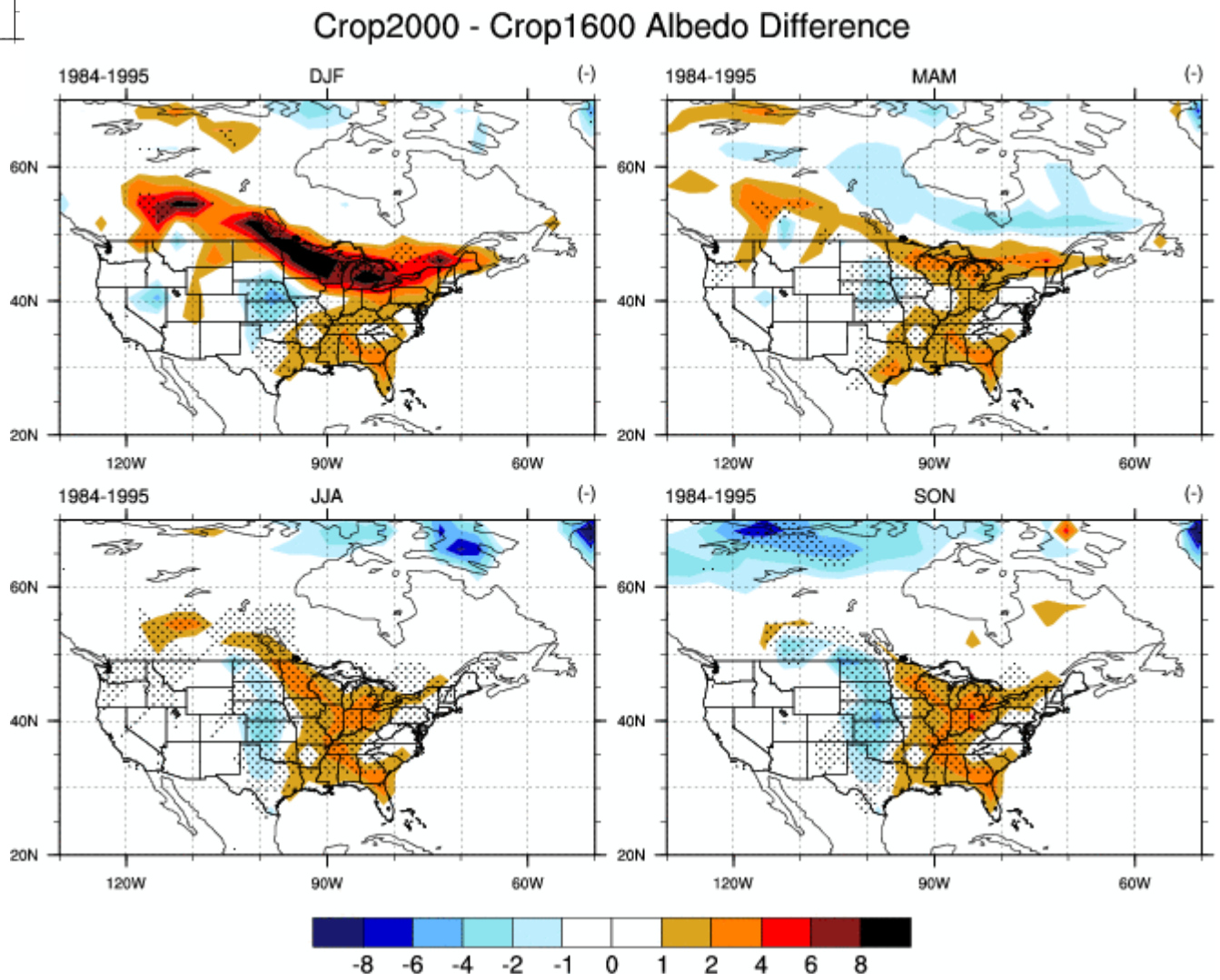
Land Cover and Land Use Change Experiments

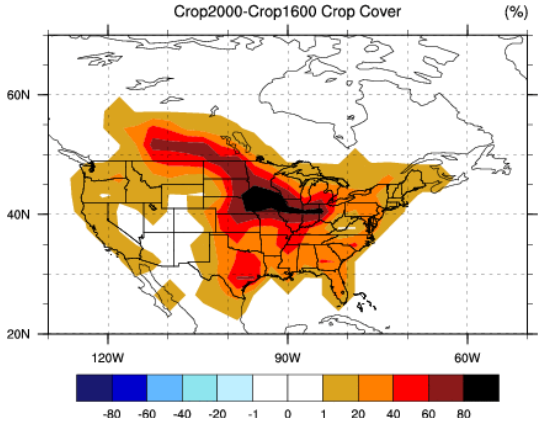


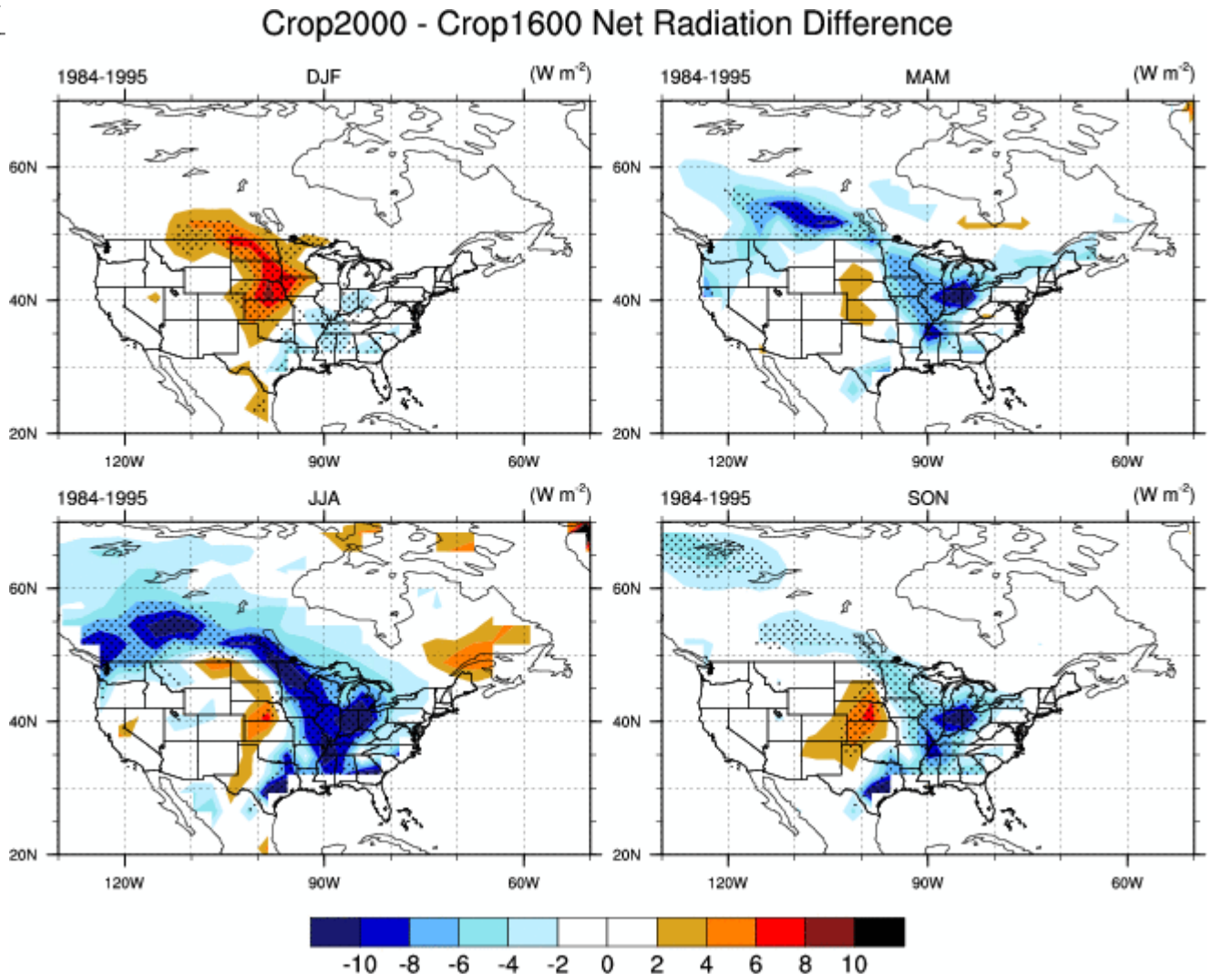
Broadleaf Deciduous Cover Time Series



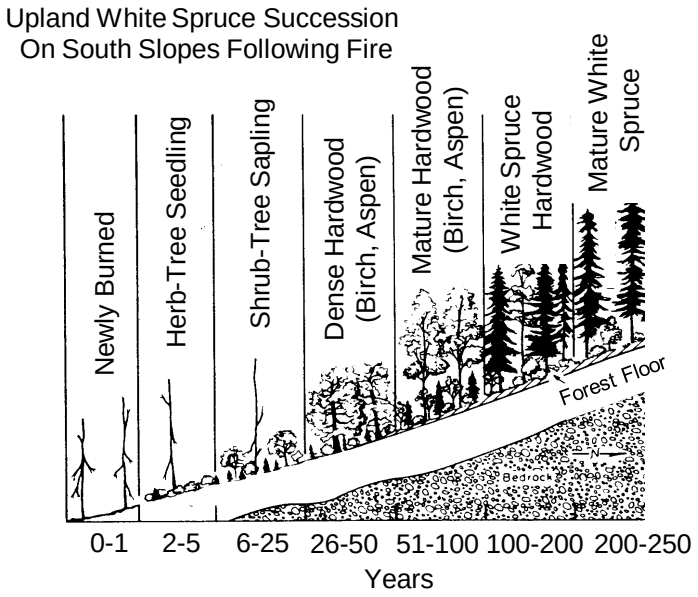

Crop2000-Crop1600 Crop Cover
(%)
60N
40N
20N
120W
90W
60W
-80 -60 -40 -20 -1 0 1 20 40 60 80

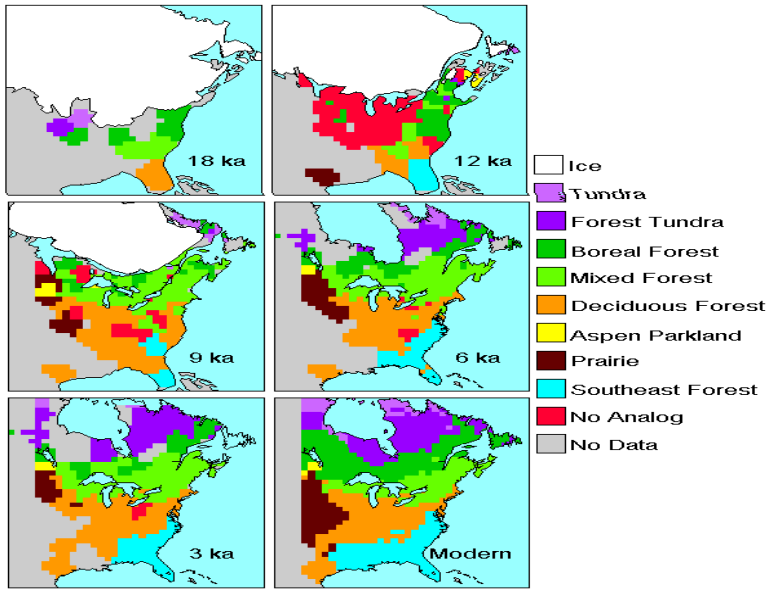

Crop2000 - Crop1600 Albedo Difference
1984-1995
DJF
(-)
MAM
JJA
SON
60N
40N
20N
120W
90W
60W
-8 -6 -4 -2 -1 0 1 2 4 6 8


Crop2000-Crop1600 Crop Cover
(%)
60N
40N
20N
120W
90W
60W
-80 -60 -40 -20 -1 0 1 20 40 60 80


Crop2000 - Crop1600 Net Radiation Difference
1984-1995
DJF
(W m-2)
MAM
JJA
SON
60N
40N
20N
120W
90W
60W
-10 -8 -6 -4 -2 0 2 4 6 8 10

Vegetation Dynamics





<u>Collaborators</u>

CCSM Land Model Working Group

CCSM Biogeochemistry Working Group

Inez Fung (UC-Berkeley)

CCSM Paleoclimate Working Group

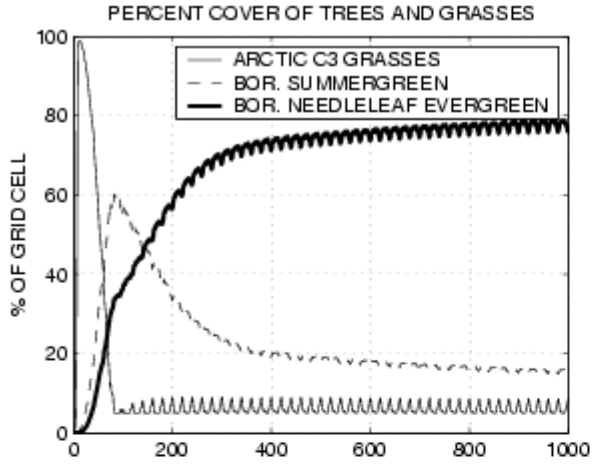
John Kutzbach (U. Wisconsin)

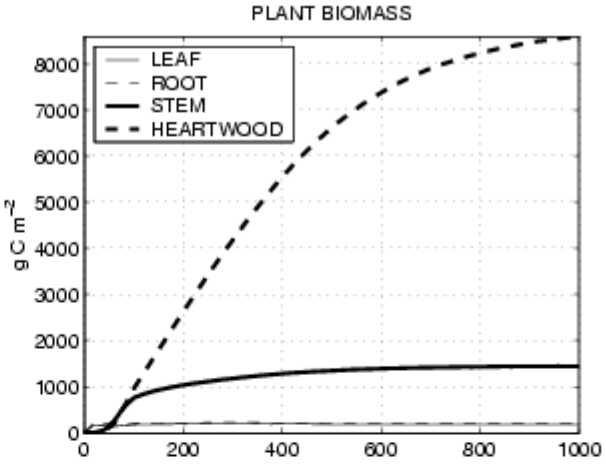
Bob Gallimore (U. Wisconsin)

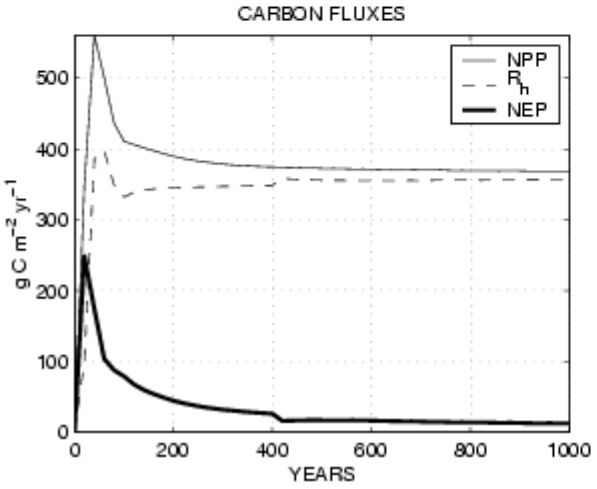
- Grow plants
- Store carbon
- Manage ecosystems

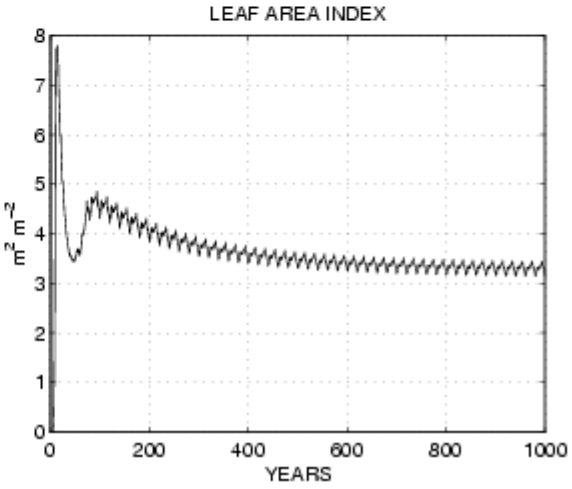
Boreal Forest Succession

Single grid cell in northern Canada









Products/Deliverables

Land surface datasets for CCSM2
Land model (Community Land Model) for CCSM2

Land Cover Land Use Change Program Goals

(1) Global inventories of land use and land cover from space - 0%

(2) Evaluate the consequences of observed and predicted change
- Carbon cycle - 100%
- Water cycle - 100%
- Nutrient cycles - 0%