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Modeling Nutrient-Limited Plants Migration In High Latitudes

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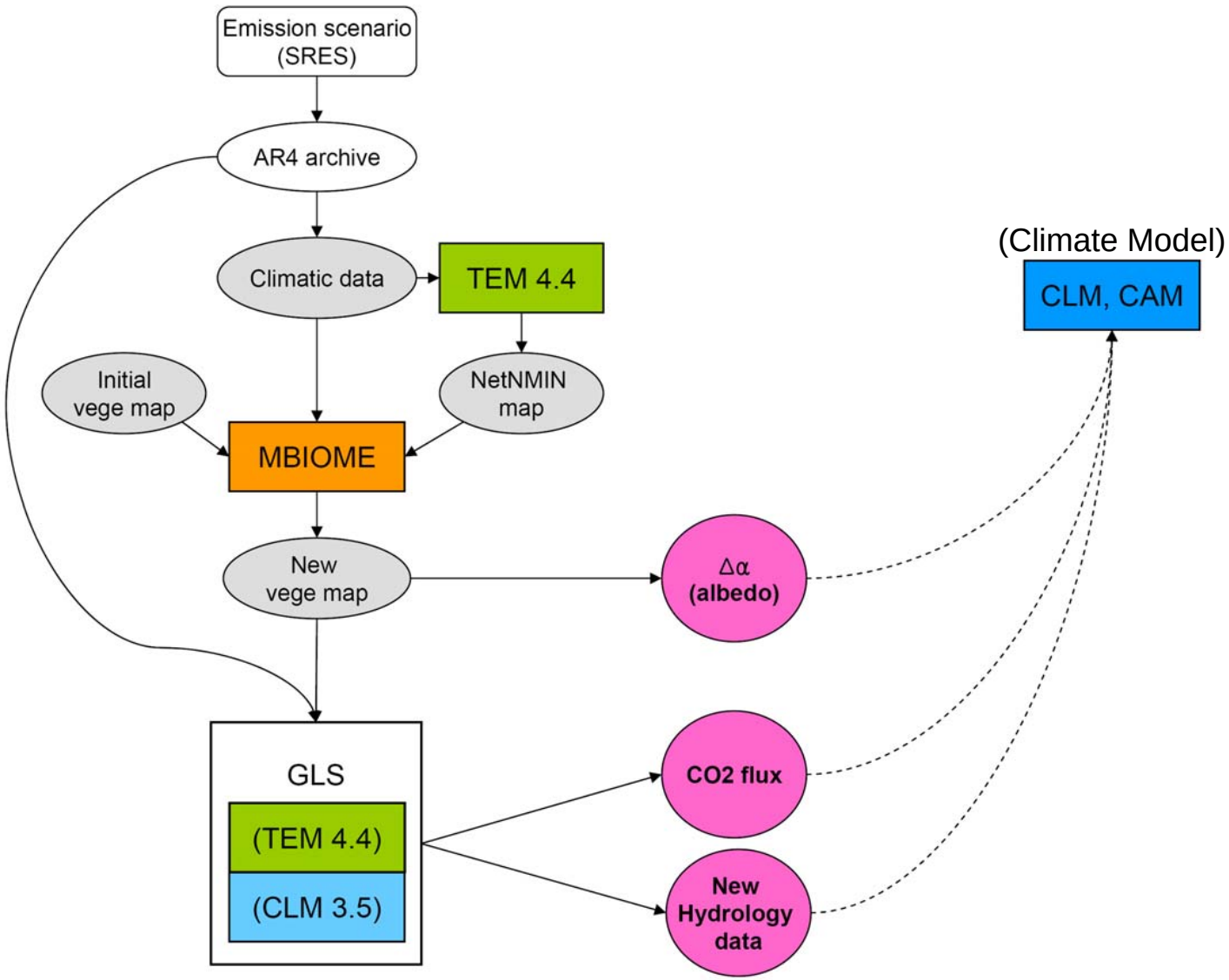
Motivations & Goal

- High latitude lands: Nitrogen-limited
- Expected vegetation change associated with anticipated warming climate
- Better atmosphere-land CO_2 flux estimation in the high latitude lands


Emission scenario (SRES)
AR4 archive
Climatic data
TEM 4.4
Initial vege map
NetNMIN map
MBIOME
New vege map
GLS
(TEM 4.4)
(CLM 3.5)
Δα (albedo)
CO2 flux
New Hydrology data
(Climate Model)
CLM, CAM

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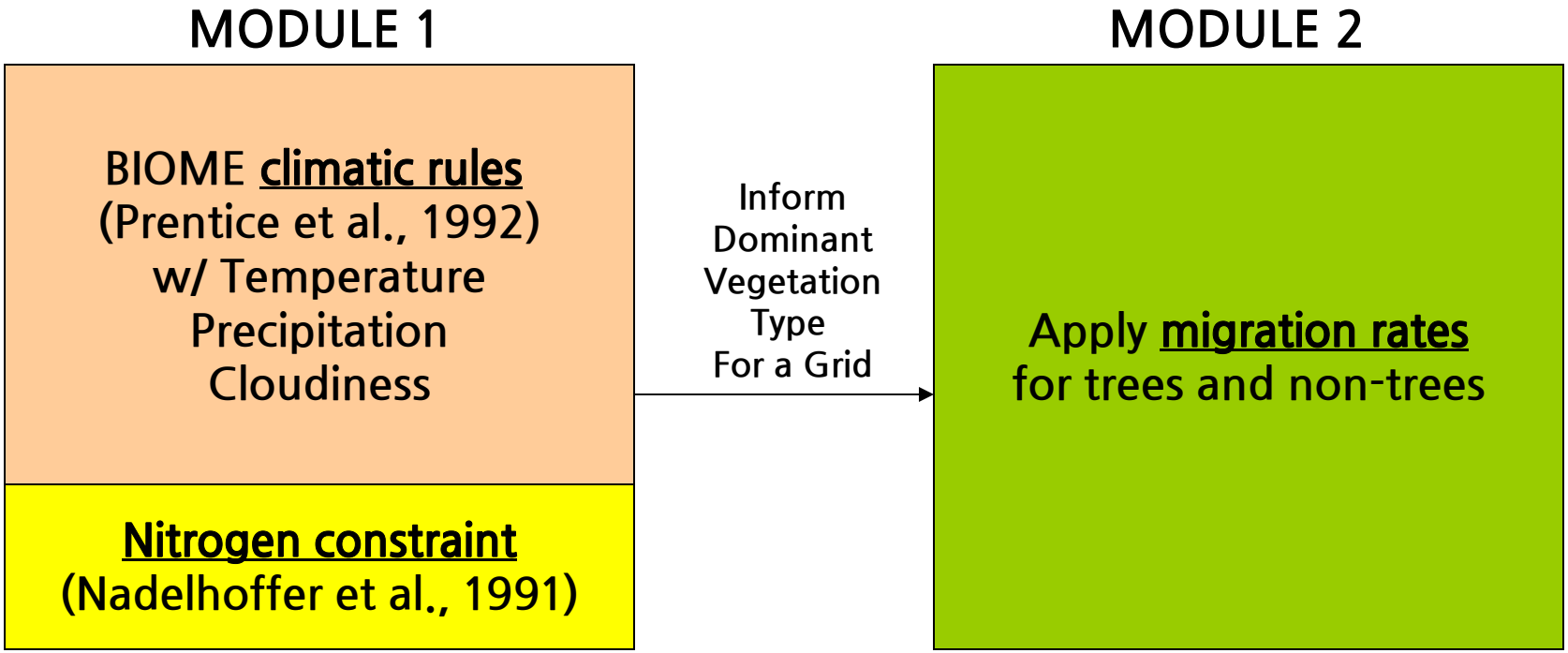
Modeling Vegetation in High latitude lands

- Seven land cover types
  - Ice and Polar desert
  - Moist Tundra
  - Boreal Forest
  - Evergreen Temperate Forest
  - Deciduous Temperate Forest
  - Grasslands
  - Arid Shrub
- 0.5°x0.5°, decadal time step
- Covering High Latitude Land (52°N and above)

Plants Migration Model

Module 1) Select the optimal vegetation type for a grid
Module 2) Apply migration rates of vegetations



Plants Migration Model

Module 1) Select the optimal vegetation type for a grid

Module 2) Apply migration rates of vegetations

MODULE 1

BIOME climatic rules
(Prentice et al., 1992)
w/ Temperature
Precipitation
Cloudiness

Vegetation Type	Mean Temp of the coldest month (Tc)	Growing Degree Days	AET/PET (α)
Moist Tundra		GDD00 ≧ 100	α ≧ 0.33
Boreal Forest	-35°C ≦ Tc ≦ -2°C or Tc ≧ 5°C	GDD05 ≧ 350	α ≧ 0.75 or α ≧ 0.65
Evergreen Temperate Forest	-19°C ≦ Tc ≦ 5°C	GDD05 ≧ 900	α ≧ 0.65
Deciduous Temperate Forest	-15°C≦Tc≦15.5°C	GDD05≧1200	α ≧ 0.65
Grasslands		GDD05 ≧ 500	α ≧ 0.33
Arid Shrub		GDD00 ≧ 100	

Plants Migration Model

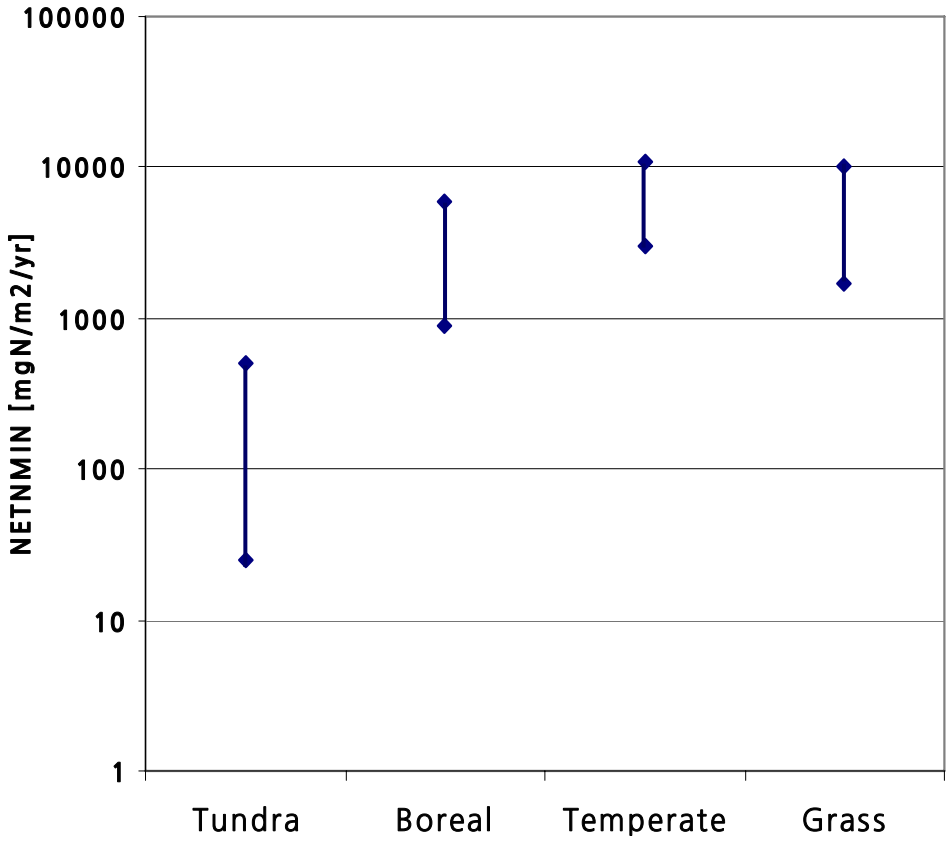
Module 1) Select the optimal vegetation type for a grid

Module 2) Apply migration rates of vegetations

MODULE 1

BIOME climatic rules
(Prentice et al., 1992)
w/ Temperature
Precipitation
Cloudiness

Nitrogen constraint
(Nadelhoffer et al., 1991)



Plants Migration Model
(in progress)

Module 1) Select the optimal vegetation type for a grid

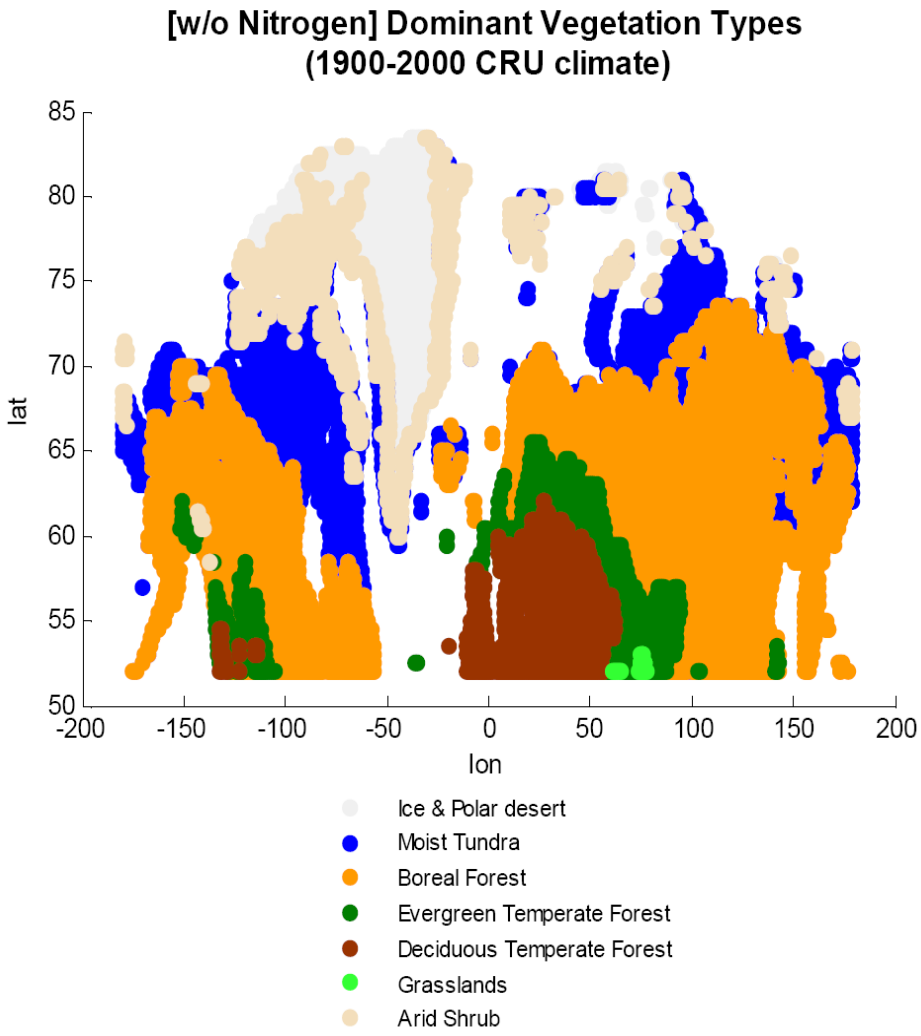
Module 2) Apply migration rates of vegetations

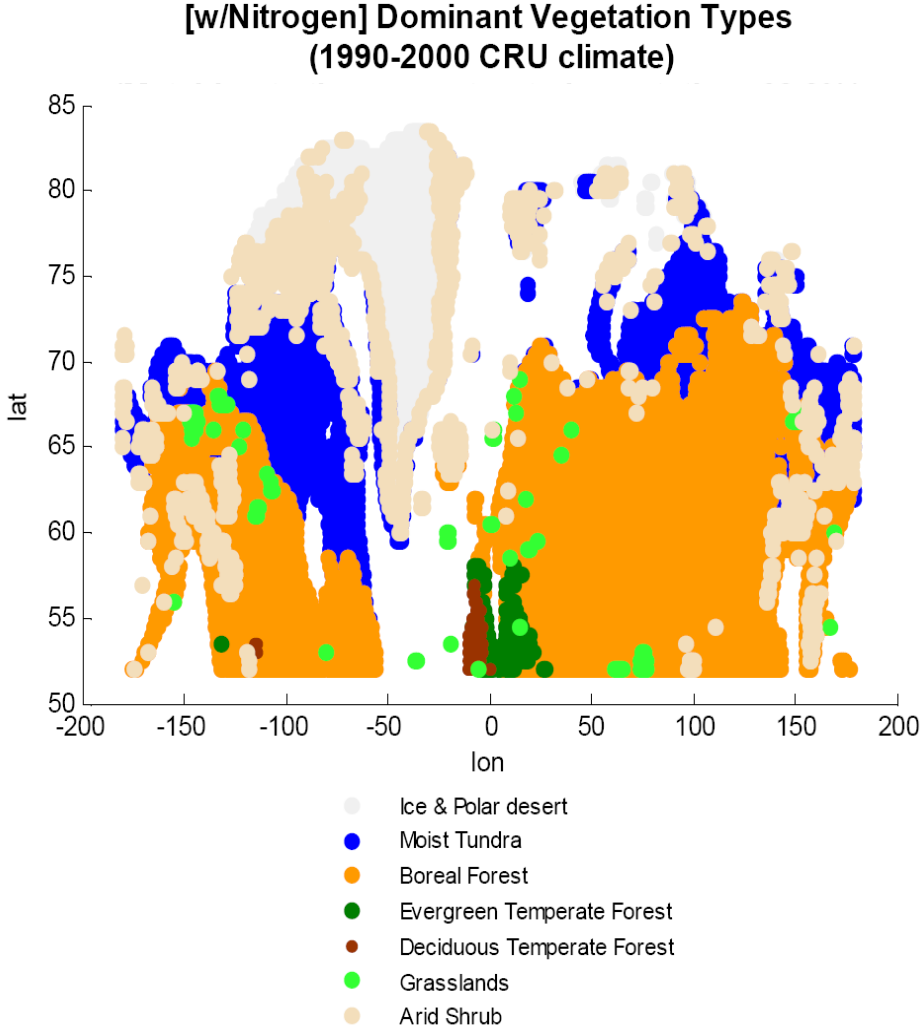
Vegetation Type		Delayed time	Migration rate
Non-trees	Tundra, grass, shrub	Zero or less than 10yrs (Immediate migration)	100%
Trees	Boreal	30 yrs	6%
	Evergreen temperate	40yrs	6%
	Deciduous temperate	40 yrs	4%

MODULE 2

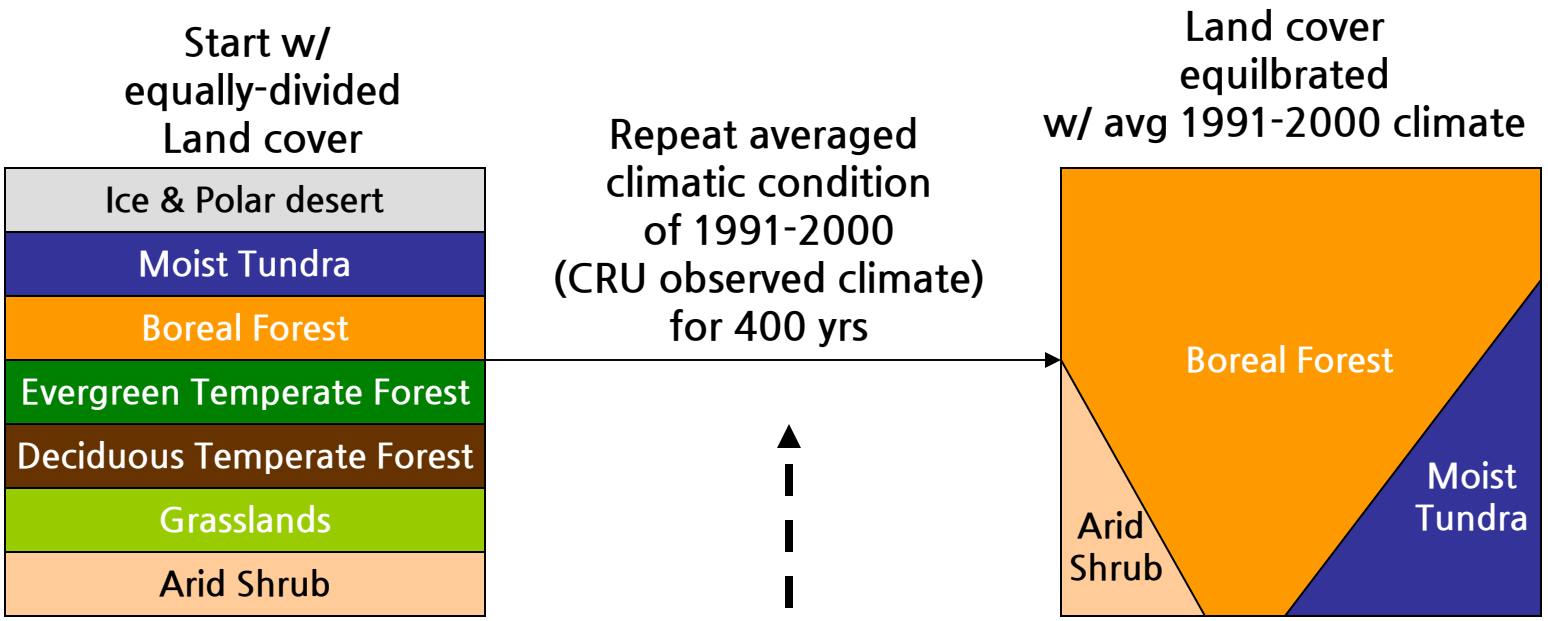
Apply migration rates for trees and non-trees

Evaluate Module 1 @ Eq





Model land mosaics @ Eq



Module 1	Module 2
Climatic rules only	Immediate migration
Climatic rules + Nitrogen constraints	Immediate migration
Climatic rules only	Delayed migration
Climatic rules + Nitrogen constraints	Delayed migration

4 land mosaics

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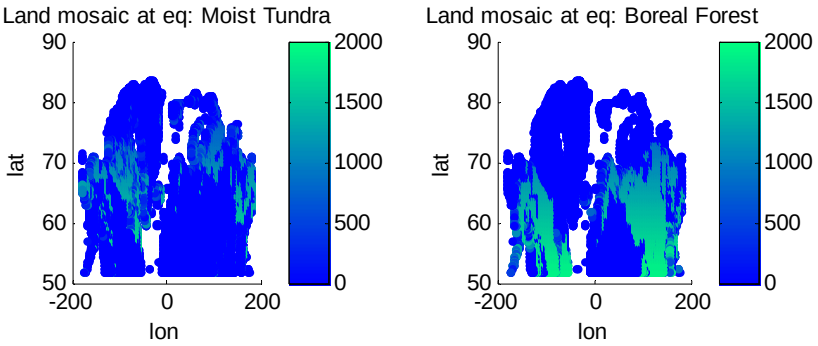
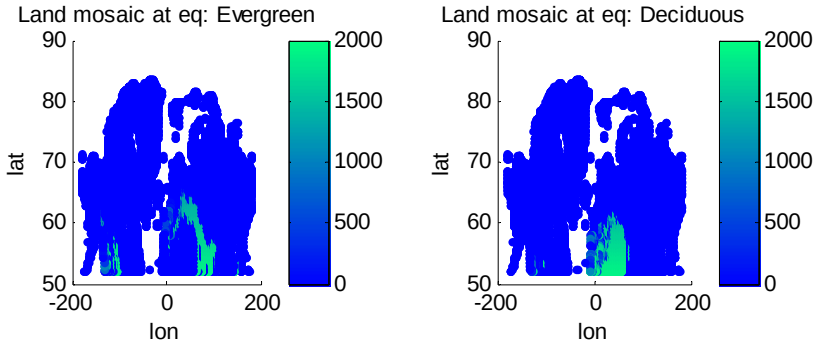
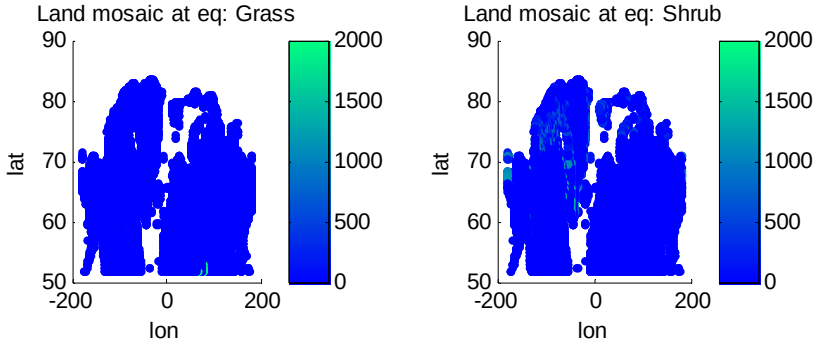
Land Mosaics @ Eq

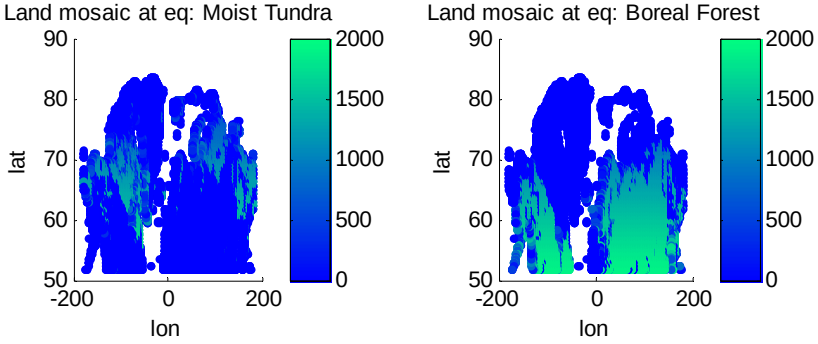
No nitrogen - immediate

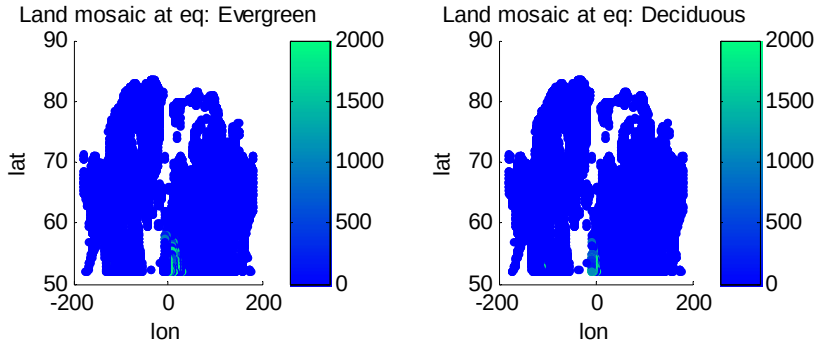


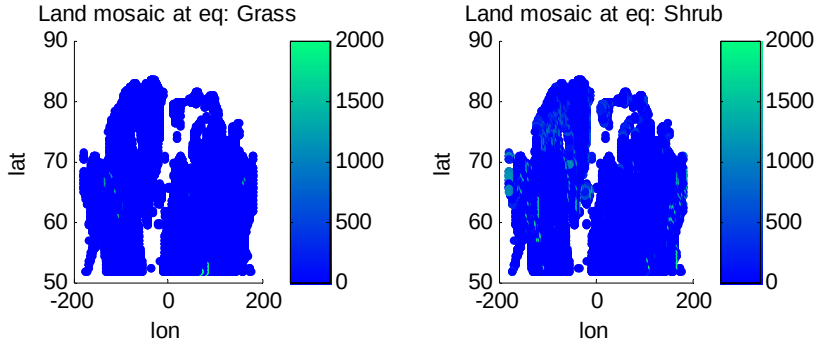




w/ nitrogen - immediate







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Runs w/ model future climate

- SRESA1B scenario
  - 720ppm stabilization
  - 2001-2100

- Use of different GCM results from IPCC AR4 archive to drive the model
  - NCAR CCSM 3.0
  - GFDL CM 2.0

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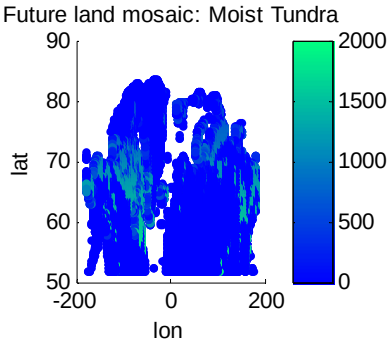
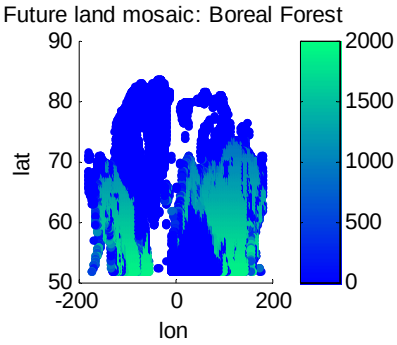
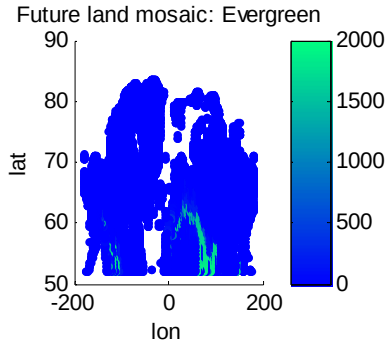
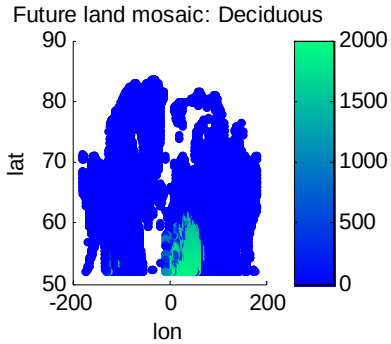
Future Land Mosaics

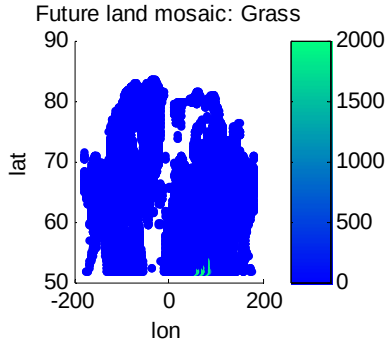
CCSM 3.0 No nitrogen

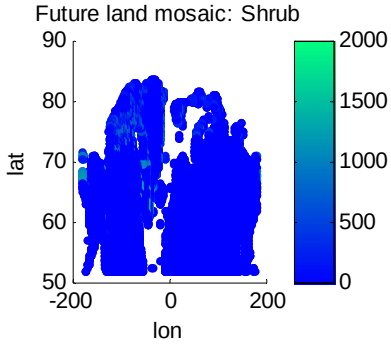




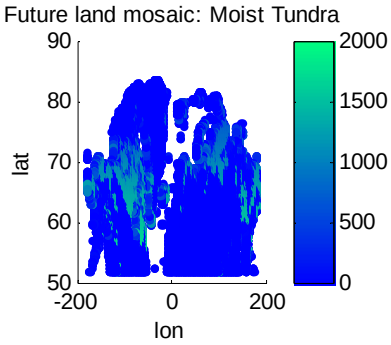


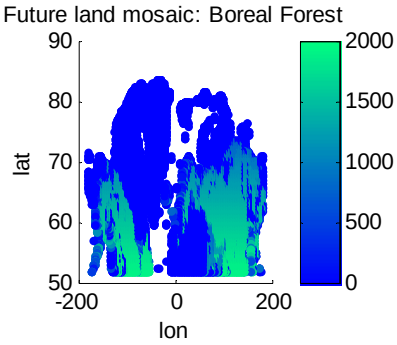


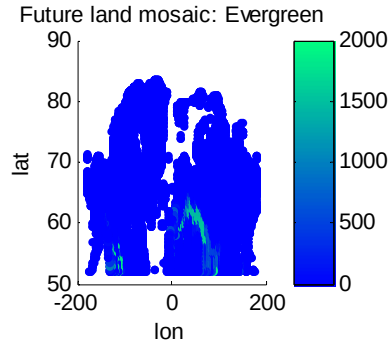


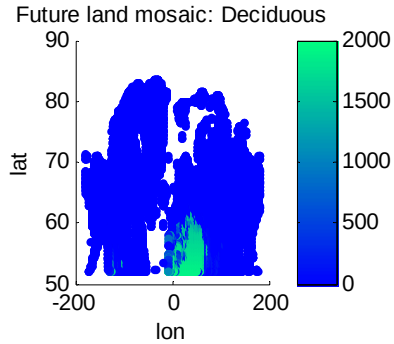


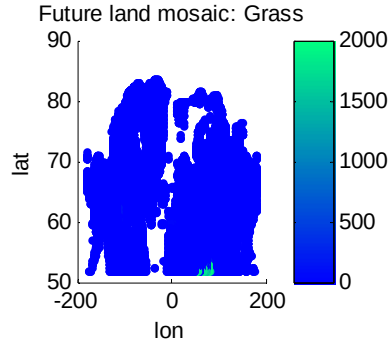
GFDL 2.0 No nitrogen

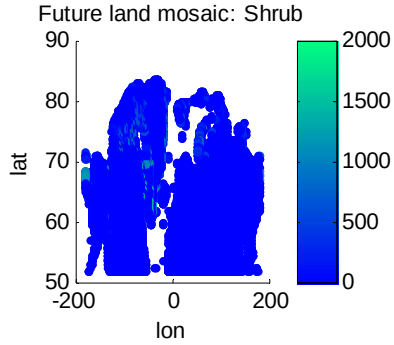












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Future Land Mosaics

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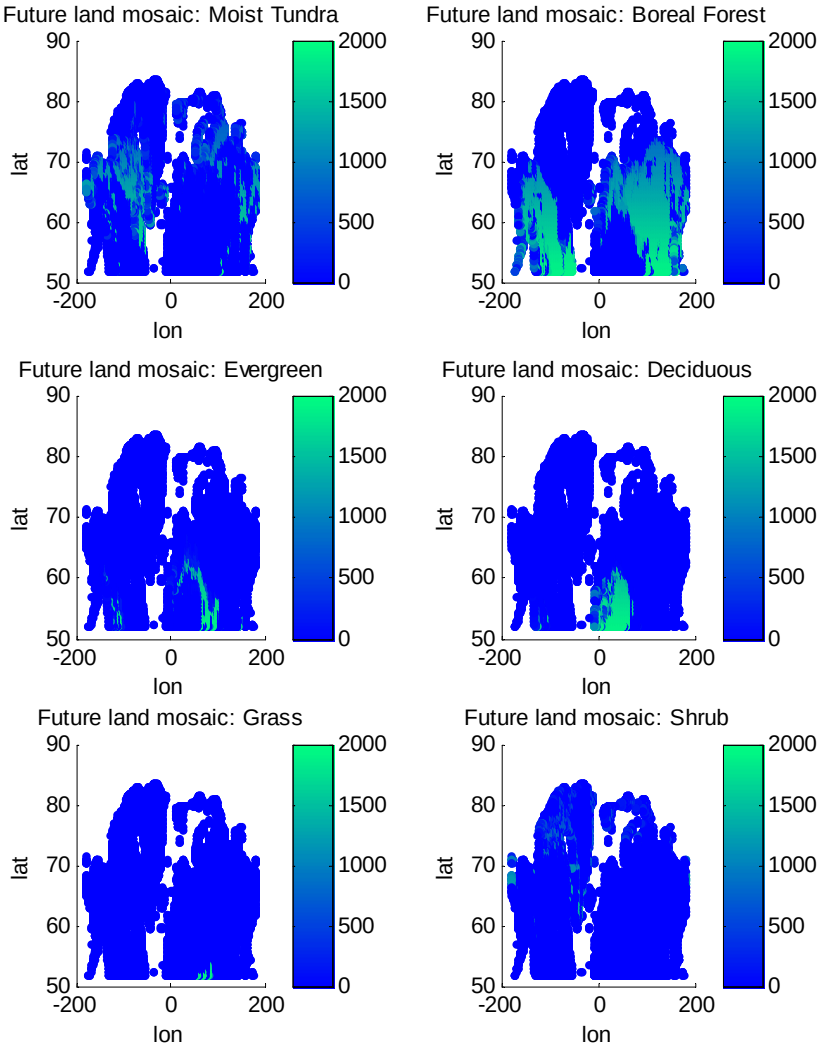
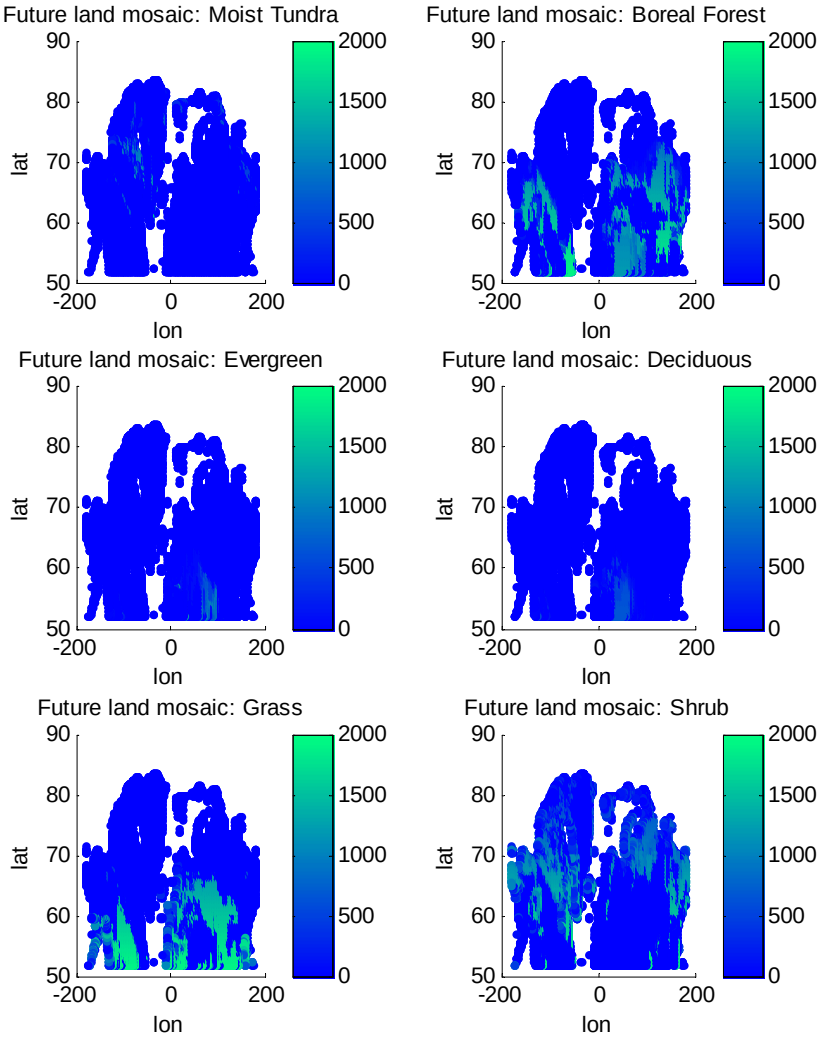


CCSM 3.0 w/ nitrogen



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Future work

- Use CLM output to obtain better input data (e.g. GDD(Growing Degree Days))
- Better hydrology constraints
- Use of NPP-based nitrogen constraints
- Link interactively to CLM (and TEM)
- Estimate future albedo changes, land-atmosphere CO_2 fluxes, and hydrology