Prognostic Land Use and Land Cover Change for a Coupled Climate-Biogeochemistry Model

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Objective

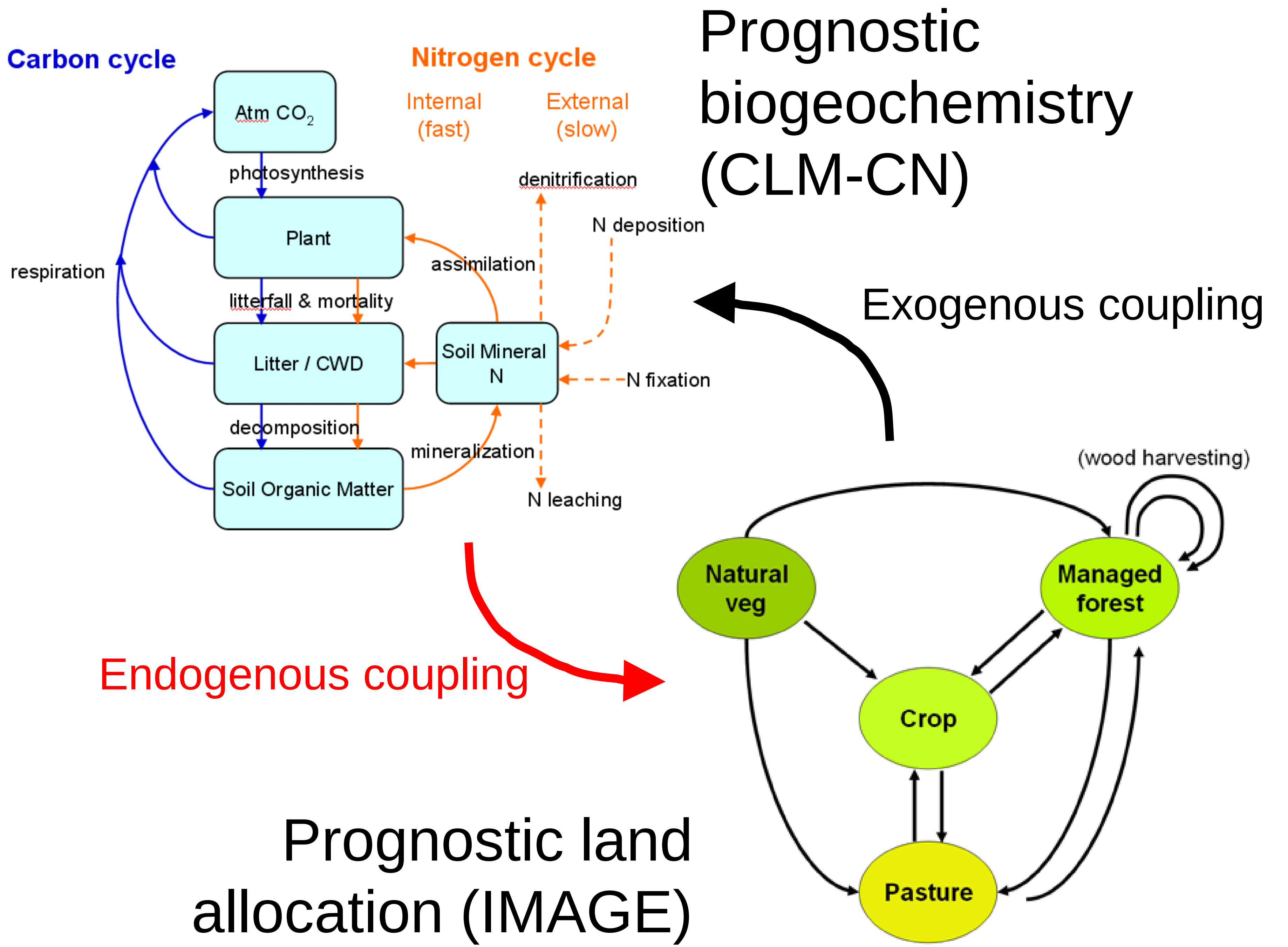
Improve knowledge of controls on future greenhouse gas concentrations and climate-biosphere feedbacks…

by introducing predictions of human land use and land-cover change within a global climate-biogeochemistry model.

Important – but challenging

- Land use and land-cover change is the second-most important human source of CO_2 emissions (behind fossil fuel burning).
- Large uncertainty for *historical* emissions from land cover change (6%-40% of total radiative forcing from CO_2).
- Leads to large uncertainty in empirical estimates of land carbon sink.

Overview of coupling strategy


Prognostic biogeochemistry (CLM-CN)
Carbon cycle
Nitrogen cycle
Internal (fast)
External (slow)
Atm CO2
photosynthesis
Plant
respiration
litterfall & mortality
Litter / CWD
decomposition
Soil Organic Matter
assimilation
Soil Mineral N
mineralization
denitrification
N deposition
N fixation
N leaching
Exogenous coupling
Endogenous coupling
(wood harvesting)
Natural veg
Managed forest
Crop
Pasture
Prognostic land allocation (IMAGE)

Project Summary

- Add prognostic land use / land cover change algorithms to CLM4
- Explore the interactions of carbon, water, nutrient, and energy components of the climate system with natural and anthropogenic changes in land cover and land use.
- Pragmatic step toward representing human dimensions in an Earth System Model.

Science Questions:

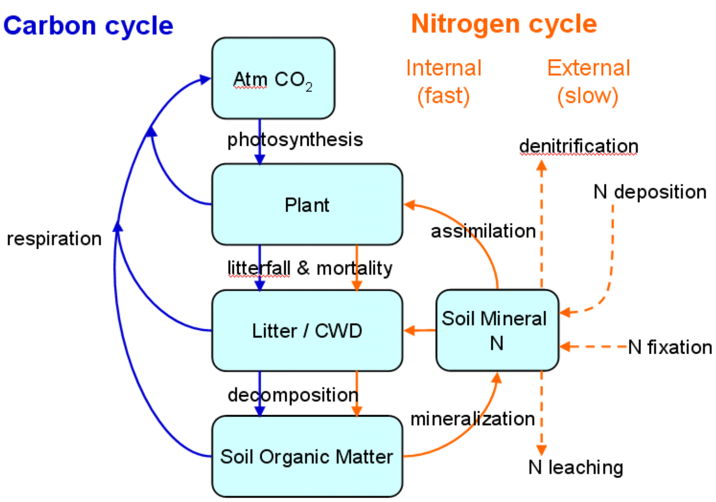
1. How do changes in land use and land cover influence feedbacks between the terrestrial biosphere and the global coupled climate system?
2. How sensitive are modeled climate-carbon cycle feedbacks to on-line vs. off-line representations of land use and land cover change?

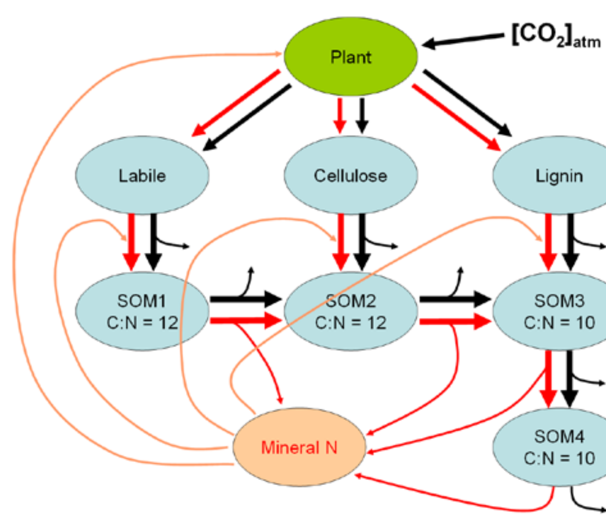
Rationale (Why CLM and IMAGE?)

- Individual models are well-regarded in their respective communities.
- Complementary logical structures.
- Easily identified coupling points.
- Technical coupling issues are manageable in a two-year project.
- Enthusiastic collaboration.

Community Land Model with coupled Carbon and Nitrogen cycles (CLM-CN)

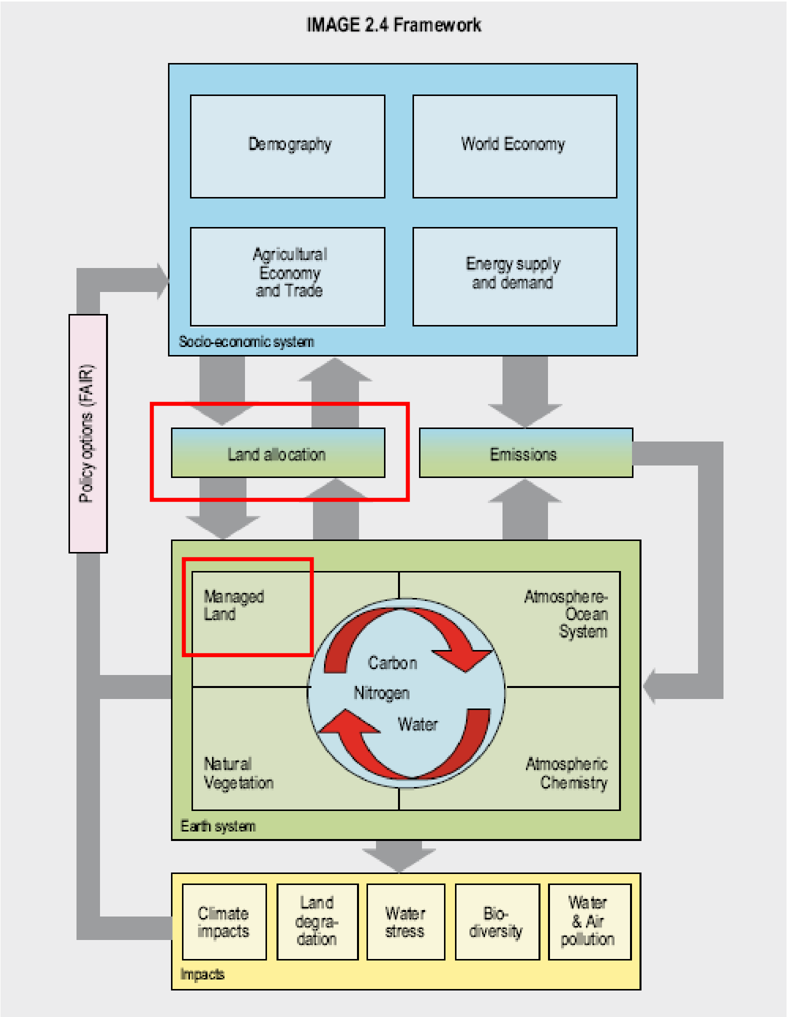
- Fully prognostic carbon and nitrogen cycles.
- Influence of land cover change on carbon, water, and energy budgets.
- Detailed treatment of natural vegetation types.



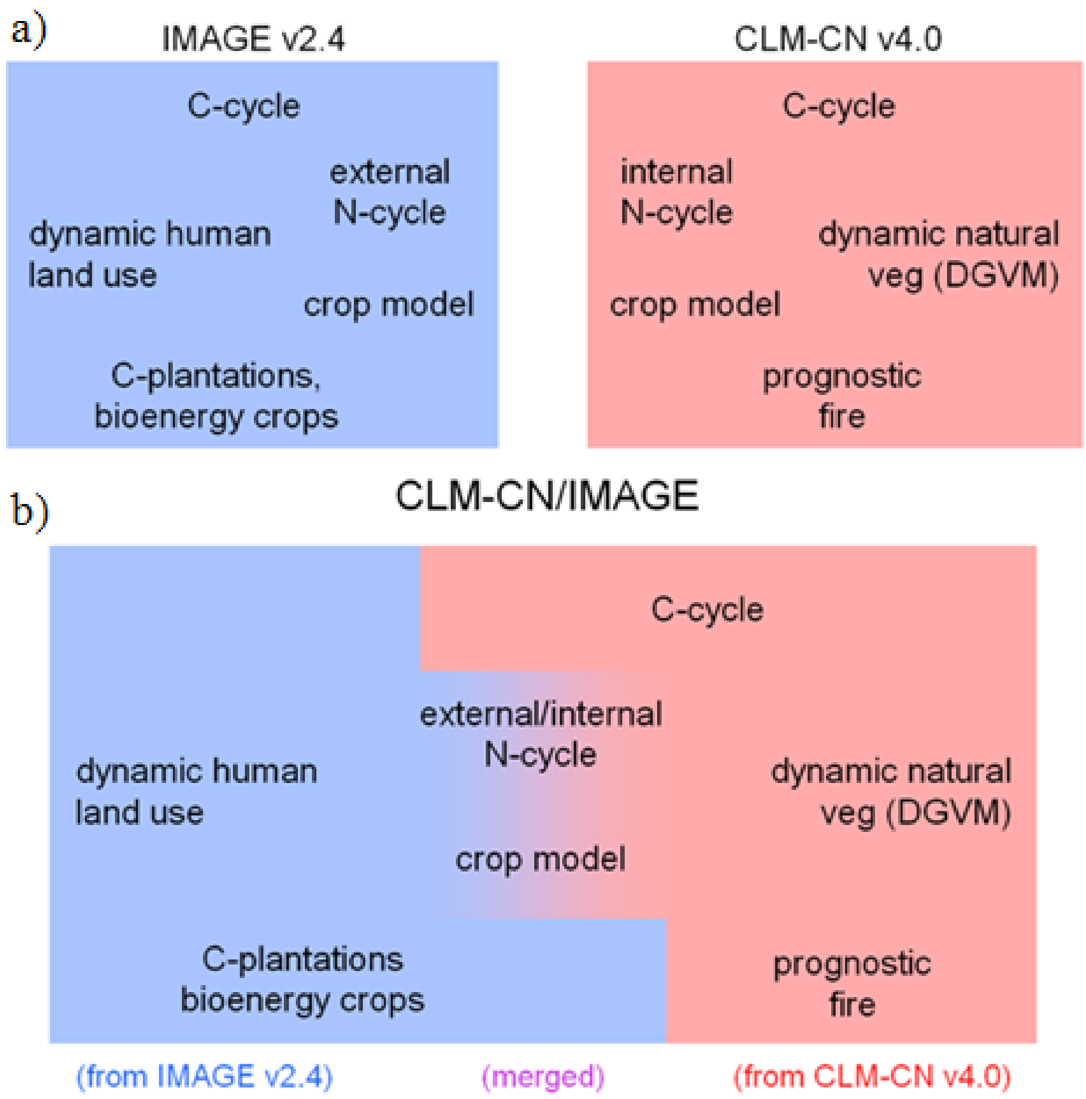


Integrated Model to Assess the Global Environment (IMAGE v2.4)

- Dynamic land allocation algorithm
- Detailed treatment of managed land types
- Crops (7), pasture (2), carbon plantations, bioenergy crops
- External nitrogen cycle
- 0.5 degree grid



Coupling Strategy



Model Development Tasks

1. Bring new plant functional types into CLM-CN (crops, C-plantations, bioenergy crops).
2. Integrate internal N-cycle (CLM-CN) with external N-cycle (IMAGE).
3. Insert IMAGE land allocation as optional switch replacing current dataset drivers in CLM-CN.
4. Integration of historical datasets with expanded CLM-CN vegetation types from Task 1.

Simulation Experiments

- Phase 1: Historical (1500-2000) simulations driven by observed and modeled land use change datasets.
- Phase 2: Future scenario (2000-2100) driven by off-line IMAGE land use change dataset.
- Phase 3: Future scenario (2000-2100) driven by endogenously coupled IMAGE land use change algorithm.

Proposed work…

- Apply the same coupling strategy to another IAM
  - MiniCAM, Proposed collaboration with PNNL / JGCRI (Edmunds, Smith).
- Integrate operational forest management tools into CLM diagnostics and eventually CLM representation of stand dynamics
  - Forest Vegetation Simulator (FVS). Proposed collaboration with Forest Service (Moscow, ID).