Building Capacity in the CLM to Better Model Forest Management

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Motivation / Problem Description

- Forest management is minimally represented in the CLM.
- Forest management, broadly defined, is pervasive.
  - 52.5% of forests globally have a management plan\(^1\)
- Forests are a major mitigation tool.
  - 25% of emissions reductions in Paris Accord\(^2\)
- Large operational knowledge base
  - Foresters have many tools to alter productivity

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What CLM Can and Can’t Do

• Can put forest where you want
• Can alter bulk harvest
  • Modify relevant input files
• Can’t isolate treatments to specific PFTs
  • Fertilize one species, you fertilize them all
• Can’t harvest at species (PFT) level
  • Harvest occurs linearly based on total harvest and PFT weight / fractional coverage.
• Can’t harvest realistic rotations
  • Forests harvested with pruning shears
Goals

Ultimately:
• Explore climate impacts of forest management.

Currently *(First Steps)*:
• Column Mod:
  • Isolate individual PFTs on their own columns.
• Preferential Harvest Mod:
  • Make it possible to harvest from select PFTs first.
Technical Modifications: PFT Structure
Technical Modifications: Isolated PFT Columns

• Modify Sub-grid Data Structure

• PFT Logic:
  • Made the PFT conditionals consistent through the code
  • Alter conditionals for new Independent Column PFTs

• PFT Assumptions in Code
  • Remove assumption that vegetated PFTs share a column
  • Add code to give the new PFTs their own column

• Modify Existing Input Files
  • Copy temperate needle-leaf in PFT parameter file
  • Land Surface, Land Use Time Series, Megan
Technical Modifications: Harvest
Technical Modifications: Harvest
Experimental Questions

• Did we break the model?
  • Yes, many times

• Identify changes due to modifications in the model structure

• Are these changes manageable?
  • Are they small compared to anticipated effects?
  • Are there ways to compensate or reduce side effects?
Experimental Design

• CLM5 (recent tag r247)
• 4 x 5 Degree Simulations
• Offline Mode, not coupled to atmosphere
• CRU-NCEP Forcing
• Parallel Spin-ups:
  • 1 spin up for 0%
  • 1 spin up for 100%
• 4 Transient Runs 1850 -2010:
  • Control, column mod, harvest mod, both togeather
• PFT level history file output
• Analyzed effects on Vegetated Land Unit
Results: Subtle at First Glance

- Data set are the same
- Historical period
- No extreme scenarios

3181 Pg Total Eco C

- What did we expect?
- Isn’t no change good?
- Pine isn’t everywhere.

3165 Pg Total Eco C
Relevant Evergreen Regions
Temp. Evergreen C at Equilibrium
Temp. Evergreen C at Equilibrium

![Graph showing the relationship between Column Mod Pine Carbon and Control Pine Carbon. The graph includes data points for the Pacific NW and S.E. USA regions.](image-url)
Temp. Evergreen C at Equilibrium

Column Mod Pine Carbon (Pg C / Grid Cell) vs. Control Pine Carbon (Pg C / Grid Cell) graph showing data points for different regions: E. China, Pacific NW, S.E. USA.
Temp. Evergreen C at Equilibrium
Temp. Evergreen C at Equilibrium
Transient Delta Carbon

Column Mod: -2.15 Pg
Harvest Mod: 5.22 Pg
(3.08 Pg over Column alone)
Soil Carbon at 2010
Pine Carbon: Control

Control Pine Biomass (Pg / gridcell)
Pine Carbon: Control

Control Pine Biomass (Pg / gridcell)
Pine Carbon: Harvest Mod On

Harvest Mod On Pine Biomass (Pg / gridcell)
Pine Carbon: Control

Control Pine Biomass (Pg / gridcell)
Pine Carbon: Column Mod On

Column Mod On Pine Biomass (Pg / gridcell)
Pine Carbon: Both On

Both On Pine Biomass (Pg / gridcell)
Conclusion

• We can now isolate PFTs, in part or in whole, on their own soil columns.
• We can harvest preferentially from a specific PFT.
• Modular & extensible implementation

• In regions where forest management is relevant:
  • Model induced changes are small and consistent
  • We should be able to control for changes in experiments

• Methods paper is in the works
• SVN branch managedforests almost ready to share
Future Directions

• Finish up this work:
  • Higher resolution, better settings (feedback appreciated)

• Column Mod Experiments:
  • Fertilization and Fire Suppression

• Further develop Preferential Harvest Mod:
  • Hierarchical harvest (this PFT then that PFT, etc.)
  • Map RCP harvest types in input files to PFTs

• Other:
  • Loblolly PFT Parameterization
  • Temperate evergreen phenology with greater seasonal variation in LAI
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