Potential Improvements to Soil Carbon Modeling in CLM4CN

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Land carbon stock biases
(Carbon fluxes simulated better than stocks)

Vegetation Carbon
Olson (obs, high est.)

Soil Carbon

IGBP Soil carbon content (0-1m)
Soil carbon: Issues from perspective of northern high latitudes

- Soil decomposition rates
  - No limits in CN due to anoxia at high water levels
  - Location of soil carbon is ‘virtual’ within top 5 model levels
- In tundra zones, very low vegetation growth CLM4CN
  - at least partly due to hydrology problem
- Large carbon stores result of thousands of years of accumulation (with differing initiation dates) in peatlands or similar systems
- The model does not represent unique biogeochemistry of peatlands
Proposed modifications

• Cold region hydrology modifications from Sean Swenson
• Incorporate anoxia limitation on decomposition rates
• Connect organic soil thermal and hydrologic properties (Lawrence and Slater, 2008) with prognostic CN soil carbon
  – Account for vertical distribution of soil carbon on decomposition rates
  – Represent vertical decrease in hyd. conductivity from fabric to sapric peat - wetter soil in organic rich regions
• Adjust Q10 back from 1.5 to 2 or ???
• Assume that Arctic C3 grass more like moss – grows in nutrient-limited environs; leaf C/N ratios
• Initialize model with ‘observed’ soil carbon and slowly turn on carbon pool transfers
Heterotrophic soil respiration in CLM-CN

Base decomposition rates for each SOM pool are modified by functions of water and temperature

Thornton and Zimmerman, 2005
Anoxia limitation on soil carbon decomposition

Thornton and Zimmerman, 2005

Bond-Lamberty et al., 2007

Thornton and Zimmerman, 2005
At each time step:

- Calculate inundated fraction of vegetated portion of grid cell (Sean’s work)
- For unsaturated fraction of grid cell, soil respiration calculated as above
- For saturated fraction of grid cell, soil respiration at 10% of temperature regulated base rate
What about wetland vegetation?

Ideally, need a new ‘moss-like’ PFT

- Assume that moss preferentially inhabits the saturated fraction of grid cell
- Dead moss goes to recalcitrant litter pool
- Short cut: skip moss PFT and simply assume that litter from grass growing in saturated zone goes to recalcitrant litter pool
Arbitrarily selected point in Alaska Arctic

Diagram showing various measurements over time:
- TOTSOMC: gC/m²
- TOTVEGC: gC/m²
- TOTLITC: gC/m²
- TLAI: gC m² yr⁻¹
- GPP: gC m² yr⁻¹
- NPP: gC m² yr⁻¹
- NEE: gC m² yr⁻¹
Initial results from global runs

Alaskan Arctic

- **CLM4CN w/ mods**
- **w/ mods + $f_{\text{sat}} = 25\%$**
Initial results from global runs

Global

- TOTSOMC: 2062
- TOTVEGC: 487-996
- TOTLITC

ClM4CN
w/ mods
w/ mods + $f_{\text{sat}} = 25\%$
Soil carbon pool turnover timescales

Thornton and Zimmerman, 2005
Results from global runs

Alaskan Arctic

Amazonia

TOTSOMC: 31

TOTSOMC: 14

TOTVEGC: 2-4

TOTVEGC: 11-23

TOTLITC

TOTLITC

kgC m⁻²

kgC m⁻²

kgC m⁻²

kgC m⁻²

yr

yr

yr

yr

CLM4CN

w/ mods

w/ mods + SOM5
Results from global runs

Global

- TOT SOMC: 2062
- TOT VEGC: 487-996
- TOT LITC

Graphs show changes in Pg C over time for different models:
- CLM4CN
- w/ mods
- w/ mods + SOM5
Some results from global tests

Polar (60-90N, -180W-180E)

- CLM4CN
- w/ mods

Graphs showing:
- Net Ecosystem Exchange
- GPP
- NPP
- Autotrophic Respiration
- Heterotrophic Respiration
- Ecosystem Respiration
Vertical distribution of carbon and impact on decomposition rates

Siberia peatland

Organic Matter Profile

Soil Temperature

Tropical Africa

Organic Matter Profile

Soil Temperature

T_{sc} = 0.45

T_{sc} = 0.40

T_{sc} = 1.12

T_{sc} = 1.13
CN Soil carbon compared to Global Soil Data Task obs

Obs

i1850cnNewNdep

clm3_6_45.CN10r

clm3_6_45.CN10r – Obs