20th Century Carbon budgets in CLM4.0 and CLM4.5

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Differences between model versions

• CLM4.0CN -> CLM4.5CN
  – Updated physics: photosynthesis, hydrology, fire, many others

• CLM4.5CN -> CLM4.5BGC
  – Updated soil biogeochemistry: changed soil/litter decomposition rates; vertical resolution to soil C an N cycling; revised mineral N dynamics
Latitude profiles of GPP

Fluxnet curve from Beer et al., 2010 dataset
Latitude profiles of C pools

Vegetation

Litter + CWD

Soil Organic Matter
Late 20th century terrestrial C budget and comparison to Global Carbon Project reconstructed budget

2-degree Qian forcing

1-degree CRUNCEP forcing

GCP curve: sum of land-use change and land sink from Le Quere et al., 2013
GCP Land error assumptions here assumes interannual errors are uncorrelated
Integrated changes of GPP, NPP
Where is GPP increasing: latitude/time fields for each run

CLM4.0CN

CLM4.5CN

CLM4.5BGC
Relative changes to C flux terms

GPP

AR

H

Time

CLM4.0CN
CLM4.5CN
CLM4.5BGC

Time

CLM4.0CN
CLM4.5CN
CLM4.5BGC

Time

CLM4.0CN
CLM4.5CN
CLM4.5BGC
N downregulation factors

CLM4.0-CN (Bonan and Levis, 2010)
CLM4.5-BGC
Comparison of N effects on GPP: mean instantaneous N downregulation (FPG)
Where is the carbon going?

Largest change in carbon between model runs is in the biomass pools.
Latitude profiles of $\Delta C$ pools

Vegetation

Litter + CWD

Soil Organic Matter
Modes of C vs. N limitation

- Trend is to shift from highly N-limited to less so
  - CLM4CN -> CLM4.5CN: reduced intrinsic GPP requires less N downregulation
  - CLM4.5CN -> CLM4.5BGC: reduced denitrification leads to less N downregulation

- This leads to higher land uptake over 20th century

- Possible that nutrient limitation may be too weak in CLM4.5BGC; but why is CLM prediction of global C budget so sensitive to poorly-resolved processes like denitrification?

- Future development: shift from nutrient presence limitation to nutrient availability limits?