

# Potential Improvements to Soil Carbon Modeling in CLM4CN



**David Lawrence**

**Sean Swenson**

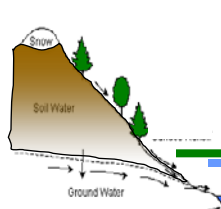
**NCAR Earth System  
Laboratory  
Boulder, CO**



NCAR is sponsored by the National Science Foundation

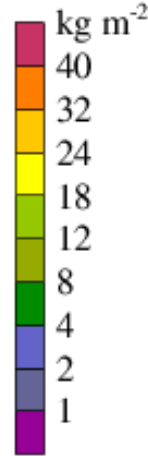
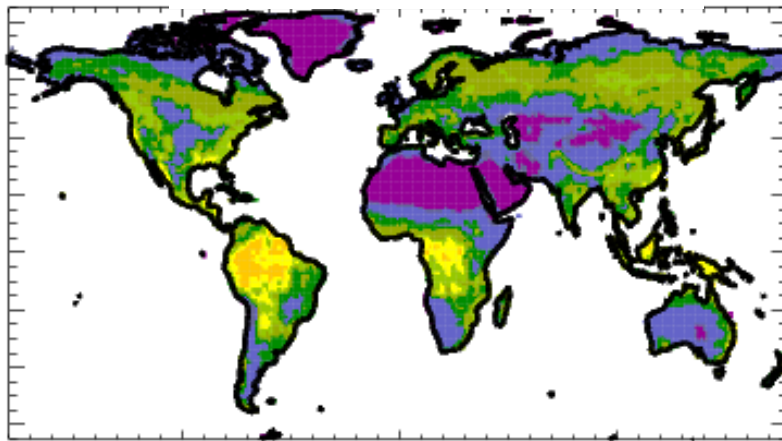


# Land carbon stock biases (Carbon fluxes simulated better than stocks)



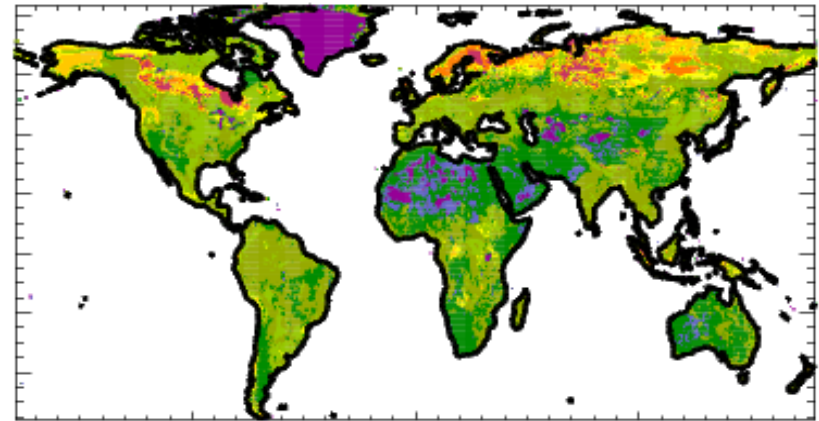
Vegetation Carbon

Olson (obs, high est.)

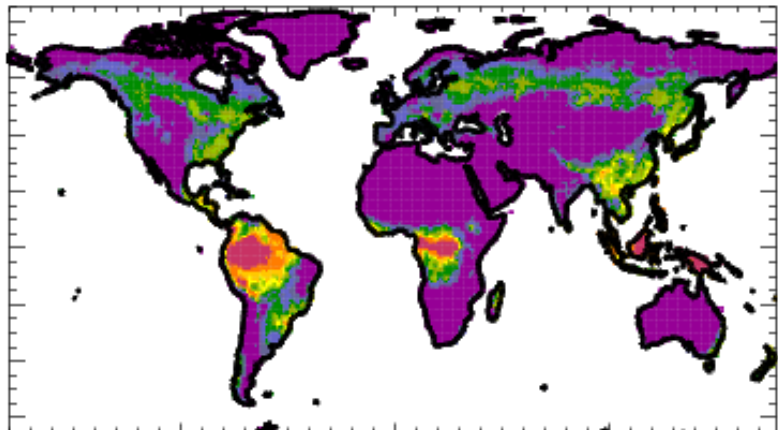


Soil Carbon

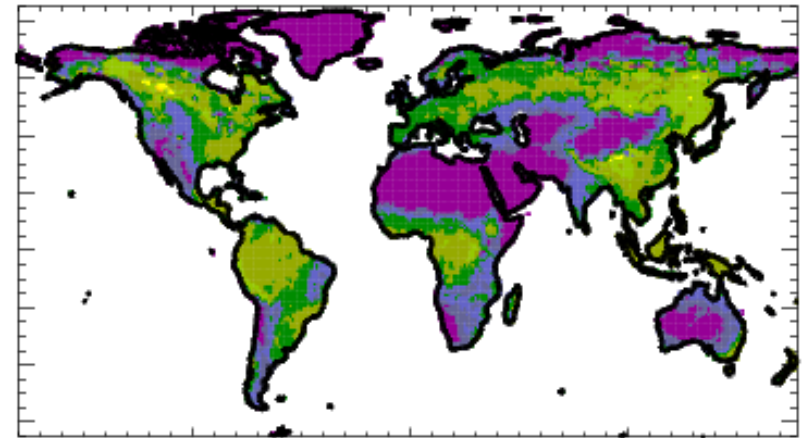
IGBP Soil carbon content (0-1m)

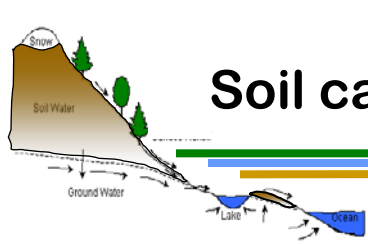


CLM4CN



CLM4CN

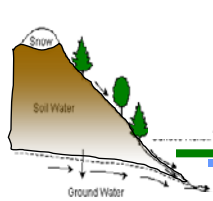




# Soil carbon: Issues from perspective of northern high latitudes

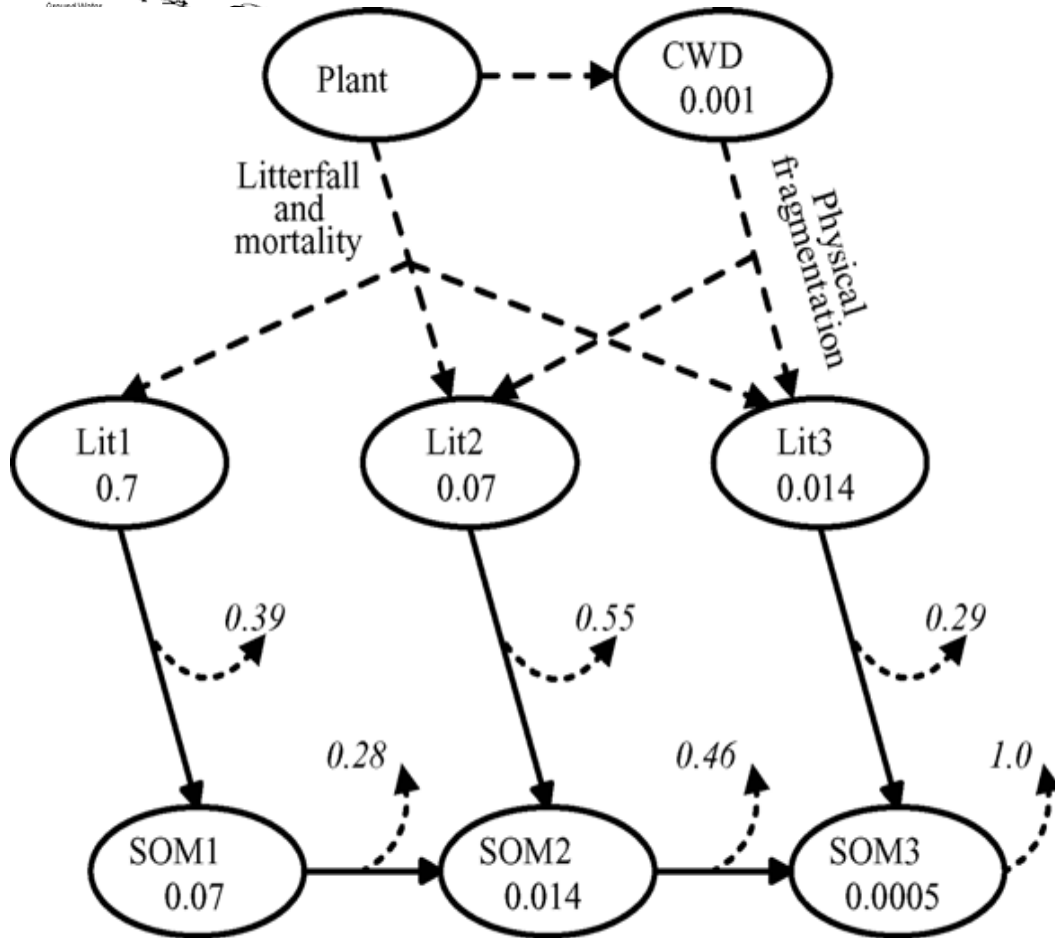
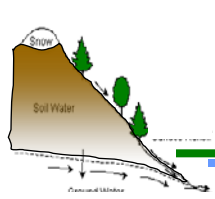
- Soil decomposition rates
  - No limits in CN due to anoxia at high water levels
  - Location of soil carbon is 'virtual' within top 5 model levels
- In tundra zones, very low vegetation growth CLM4CN
  - at least partly due to hydrology problem
- Large carbon stores result of thousands of years of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

# Proposed modifications



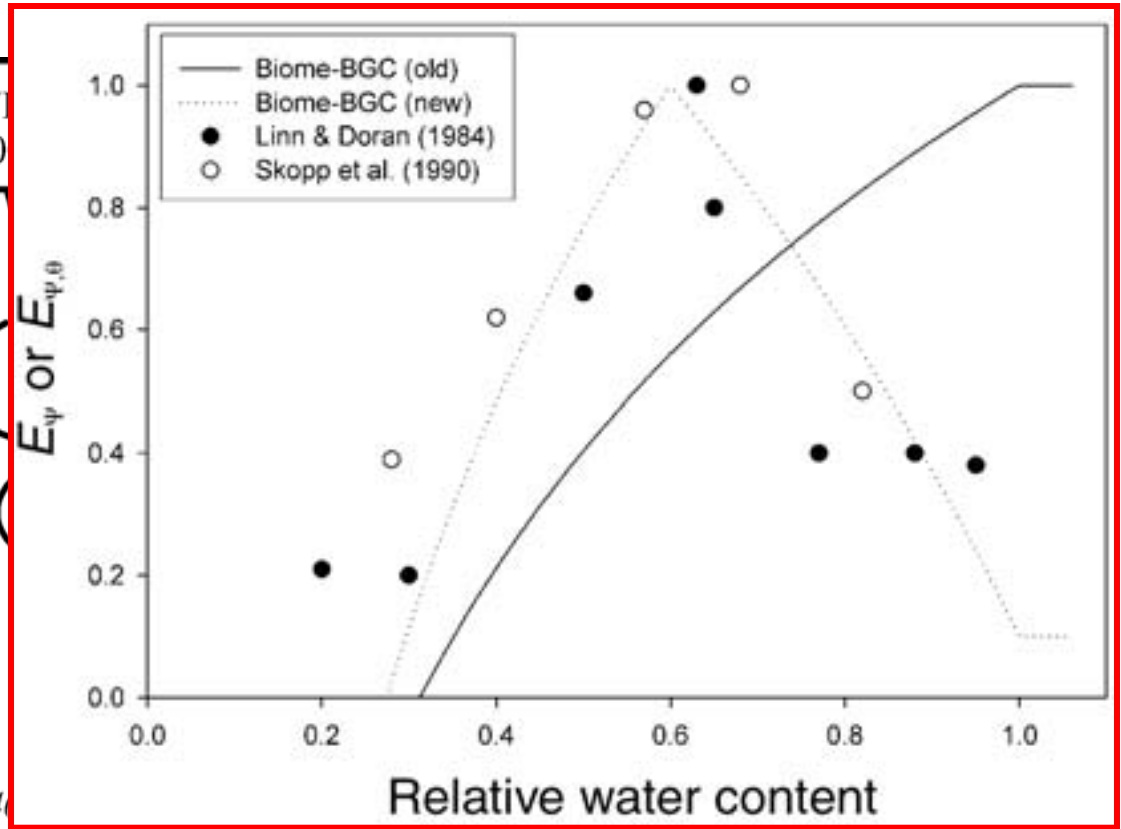
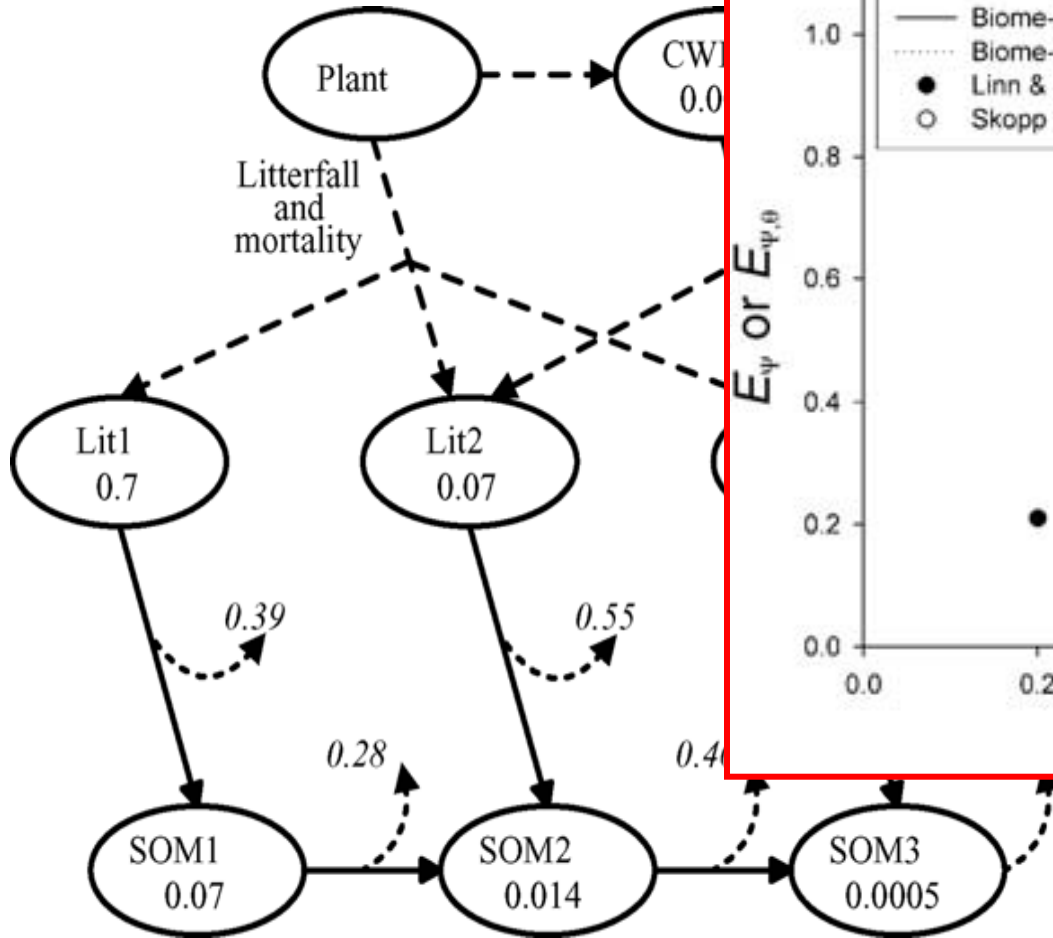
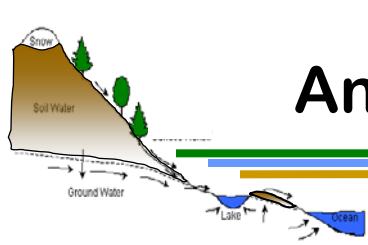
- Cold region hydrology modifications from Sean Swenson
- Incorporate anoxia limitation on decomposition rates
- Connect organic soil thermal and hydrologic properties (Lawrence and Slater, 2008) with prognostic CN soil carbon
  - Account for vertical distribution of soil carbon on decomposition rates
  - 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



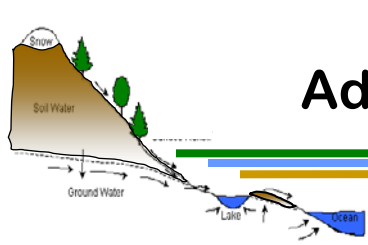
**Base decomposition rates for each SOM pool are modified by functions of water and temperature**

# Anoxia limitation on soil carbon decomposition



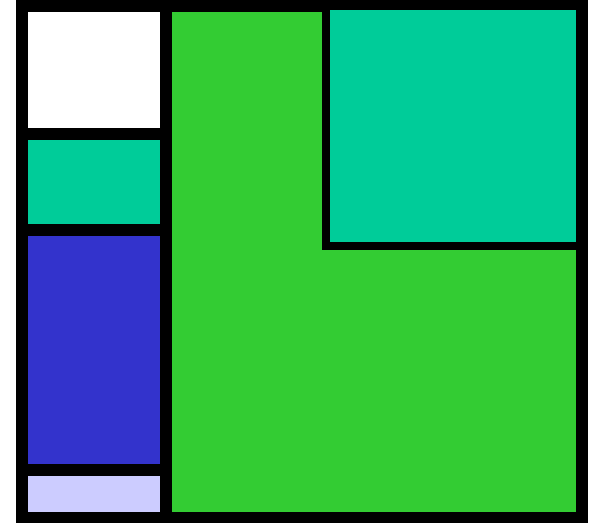
Bond-Lamberty et al., 2007

# Additional proposed revisions – wetland carbon cycling

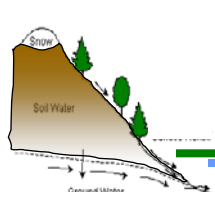


At each time step:

- 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

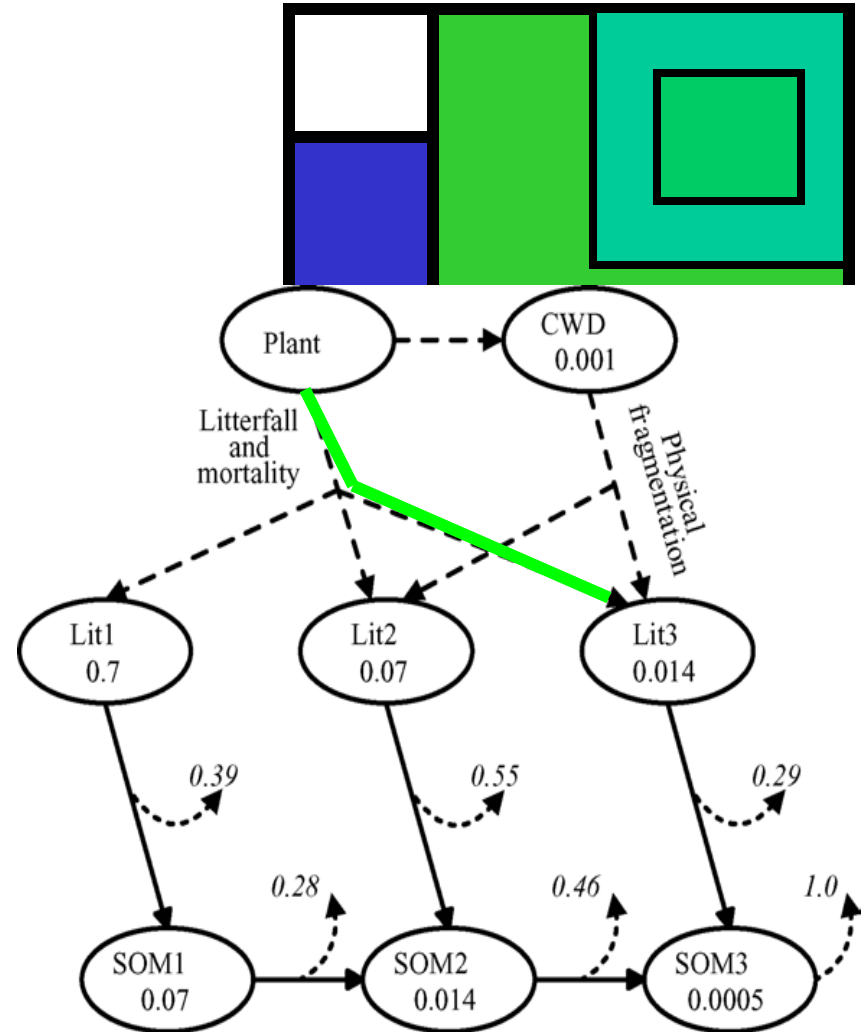


# What about wetland vegetation?



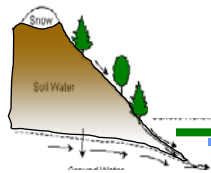
Ideally, need a new 'moss-like' PFT

- 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

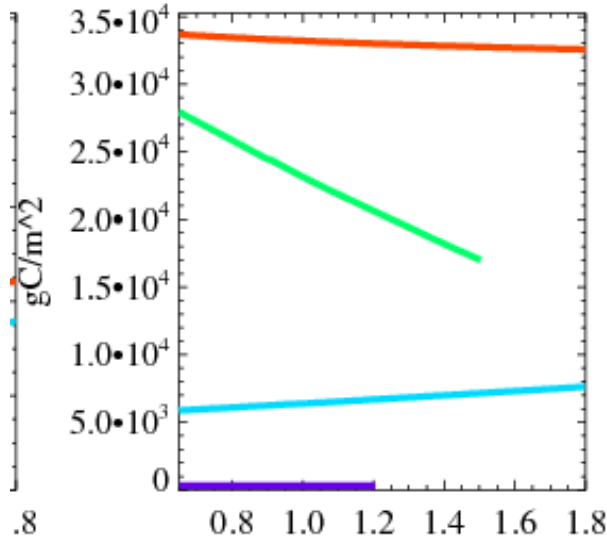




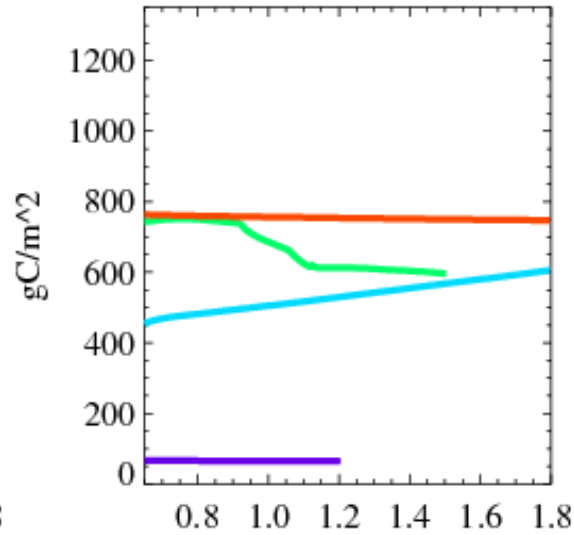
# Arbitrarily selected point in Alaska Arctic



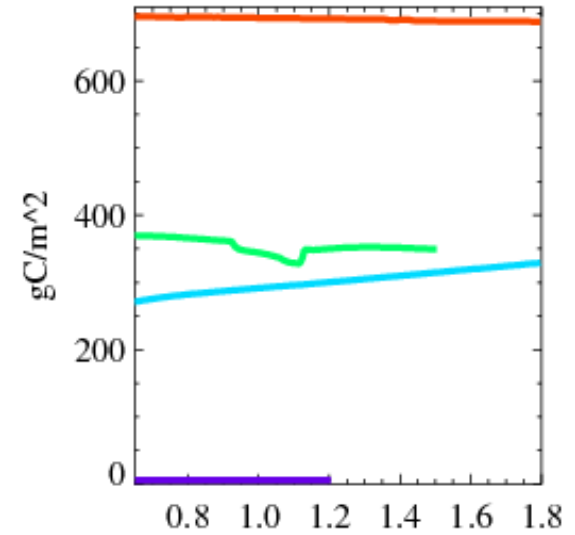
TOTSOMC



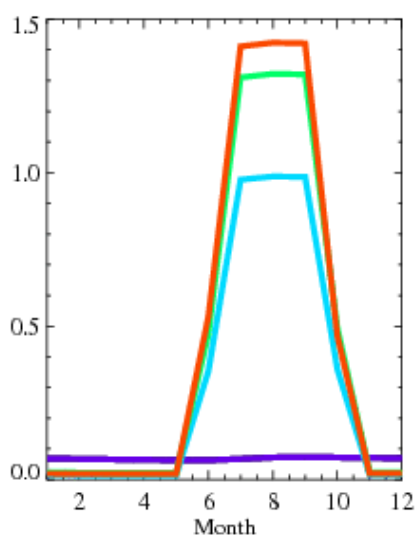
TOTVEGC



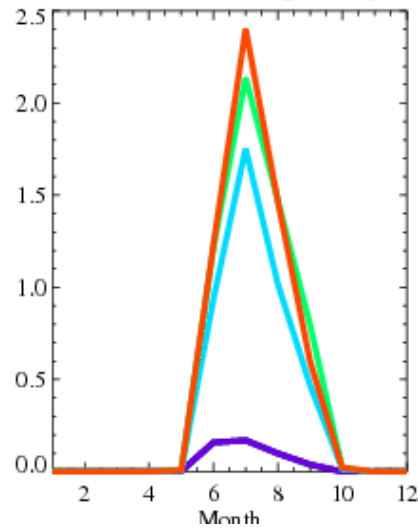
TOTLITC



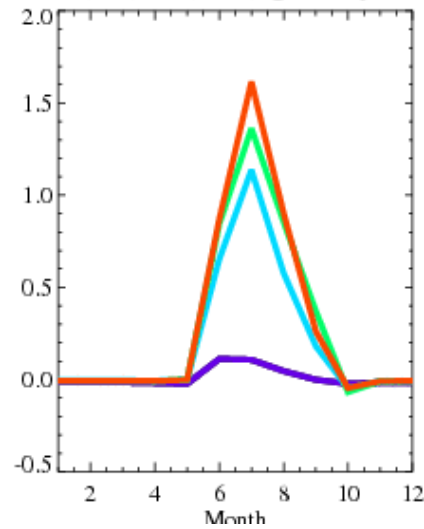
TLAI



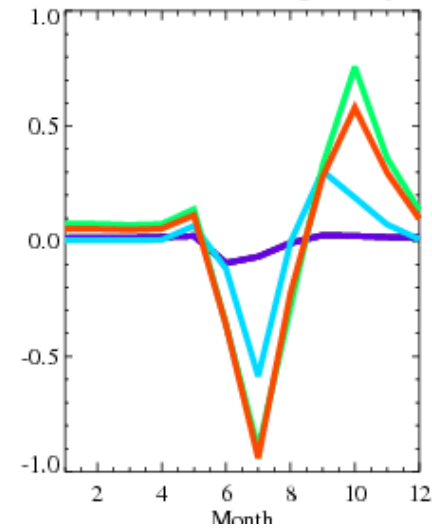
GPP  
14, 128, 172, 174, gC m<sup>-2</sup> yr<sup>-1</sup>



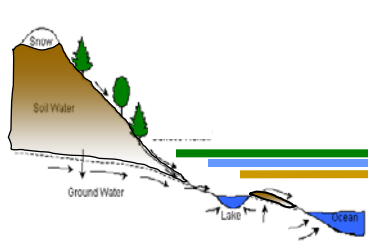
NPP  
4, 75, 101, 108, gC m<sup>-2</sup> yr<sup>-1</sup>



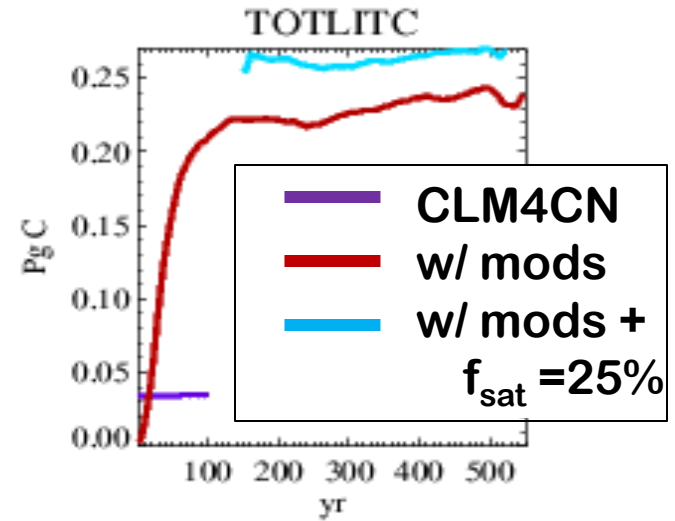
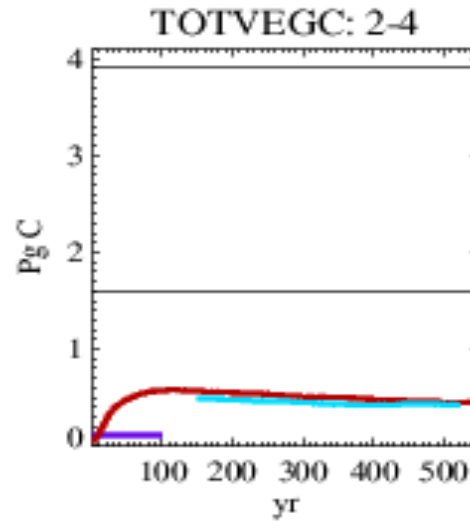
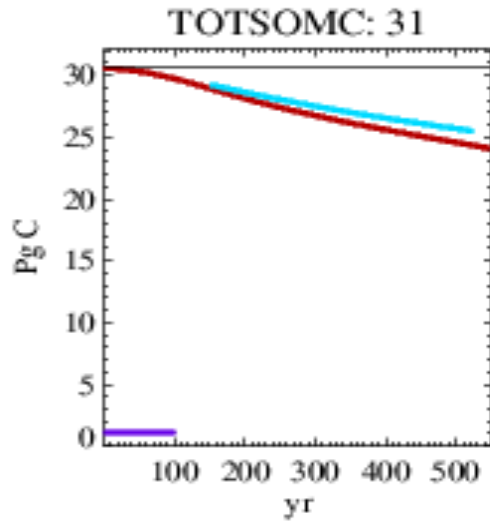
NEE  
0.0, -1.5, 14.2, 1.5, gC m<sup>-2</sup> yr<sup>-1</sup>



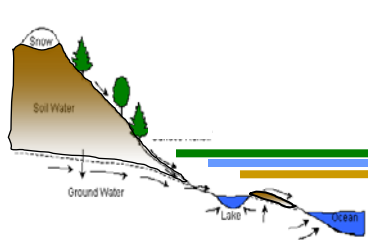
# Initial results from global runs



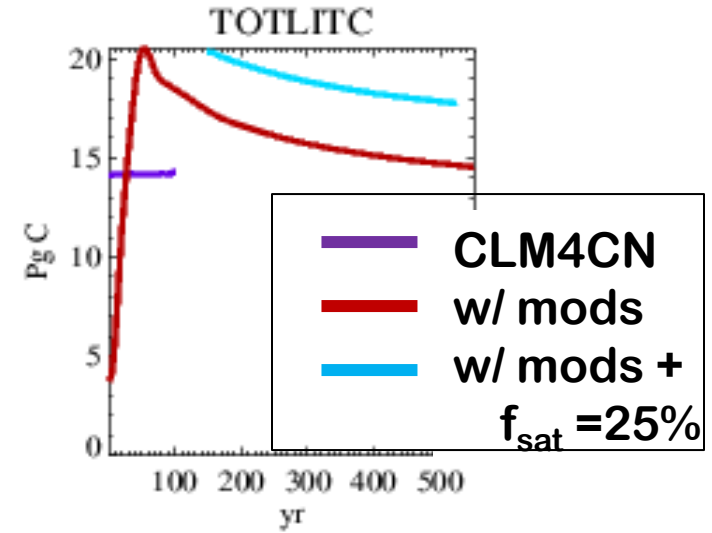
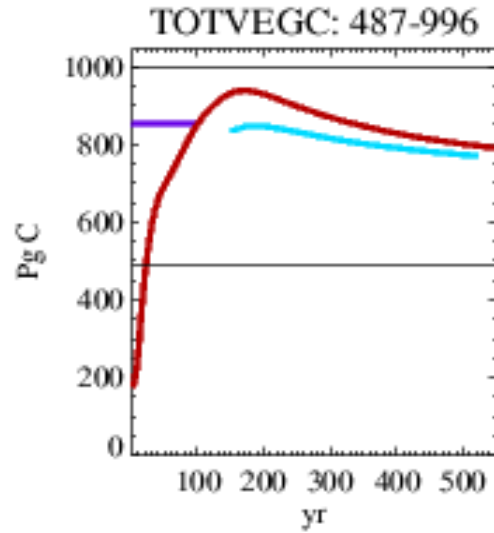
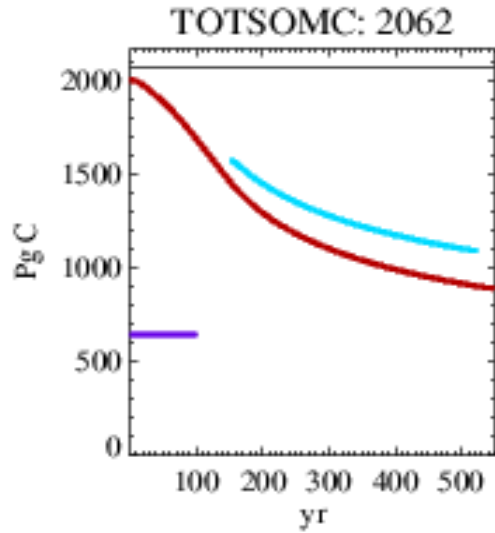
## Alaskan Arctic



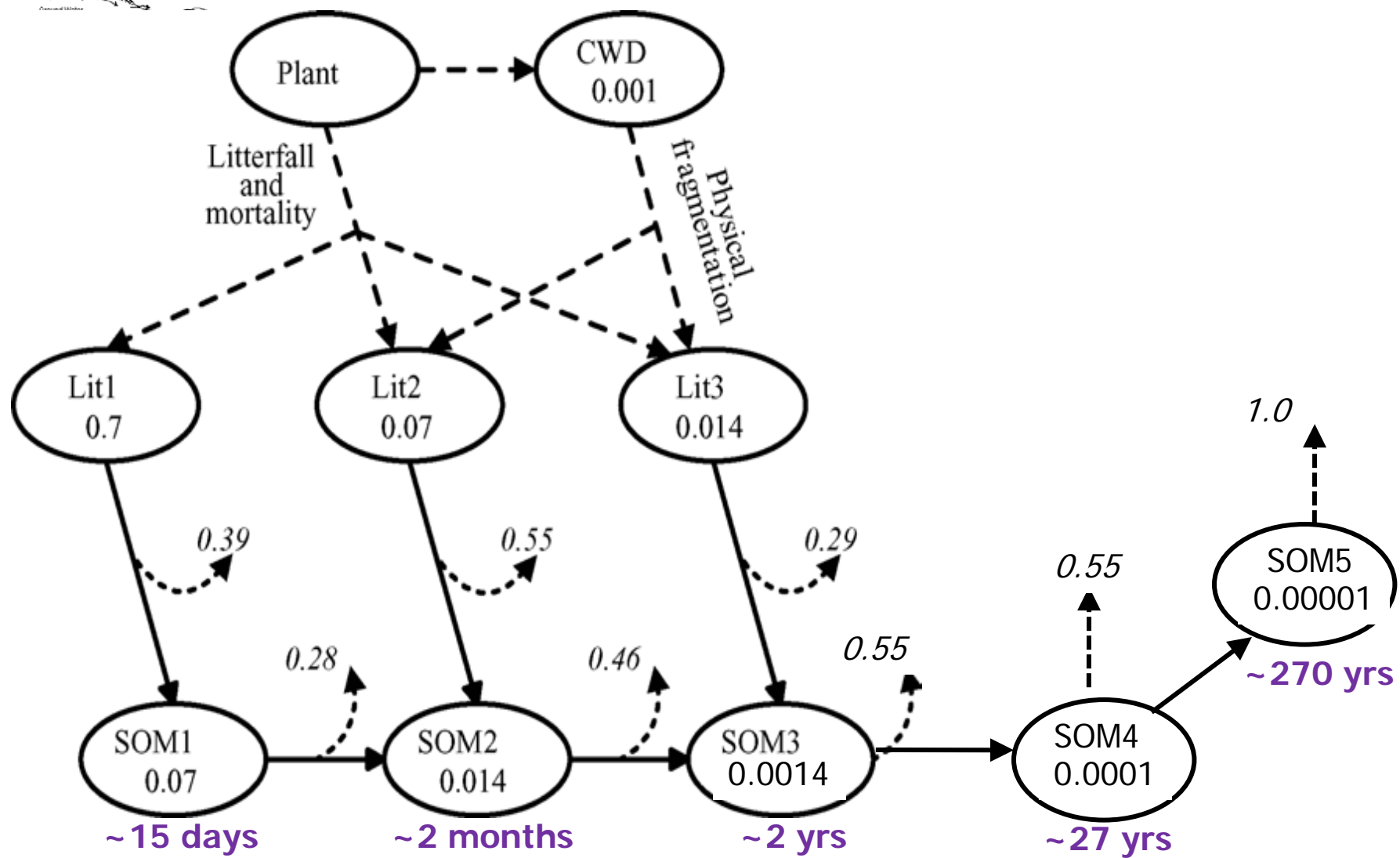
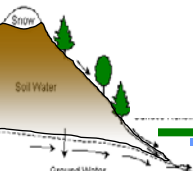
# Initial results from global runs



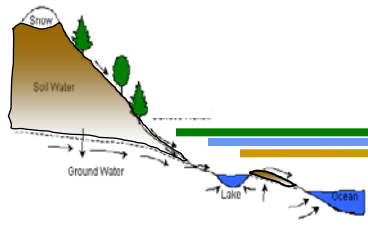
## Global



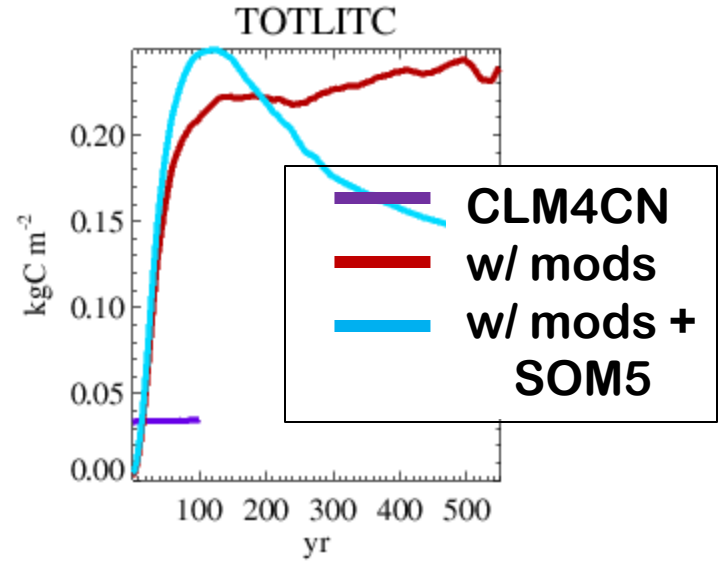
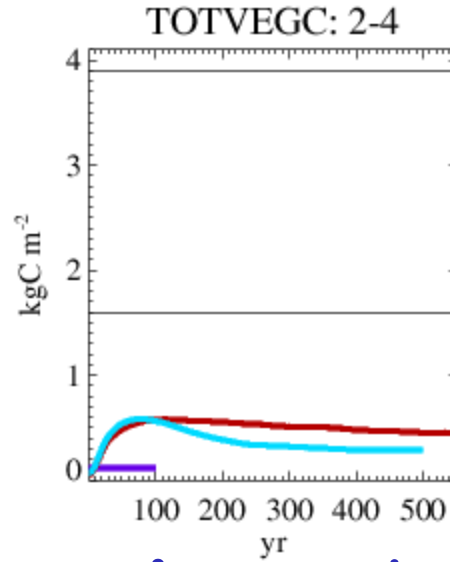
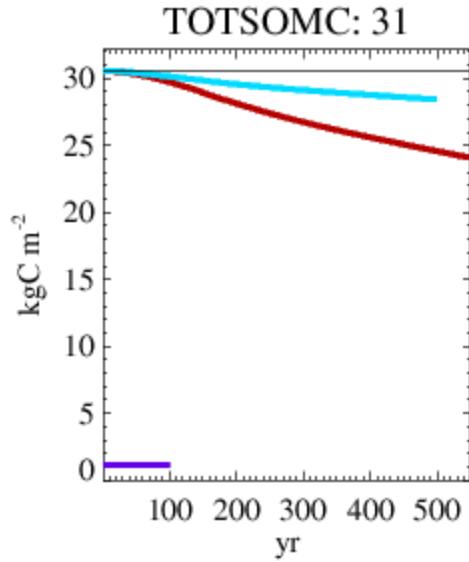
# Soil carbon pool turnover timescales



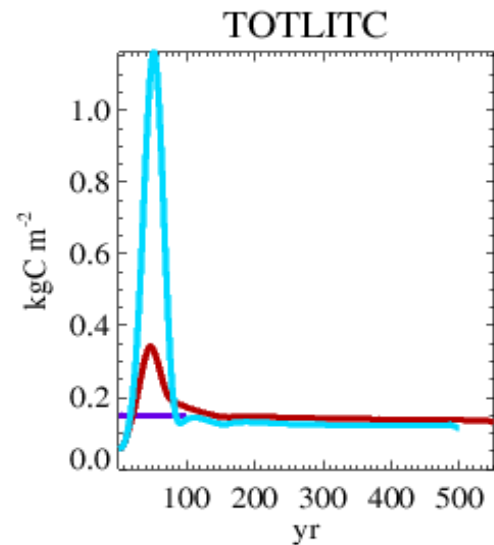
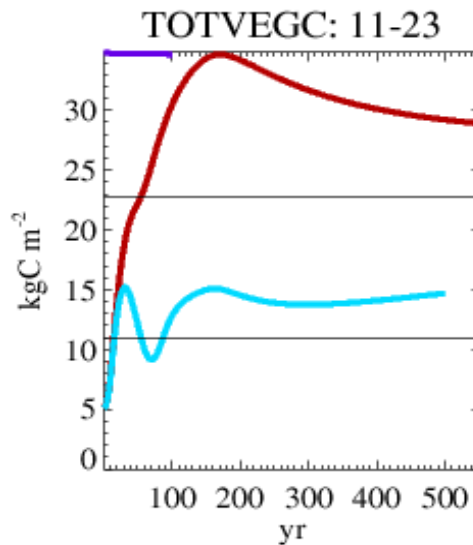
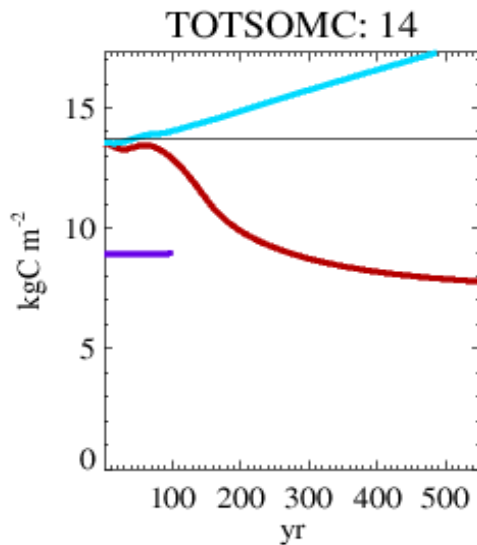
# Results from global runs



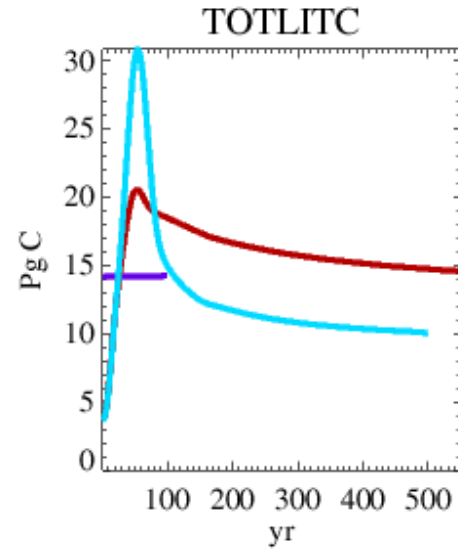
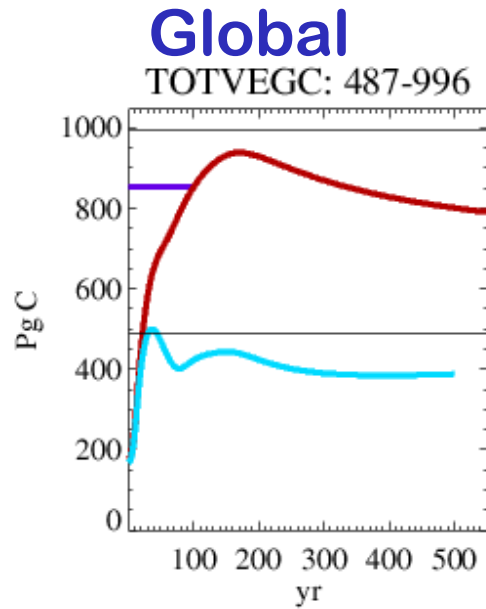
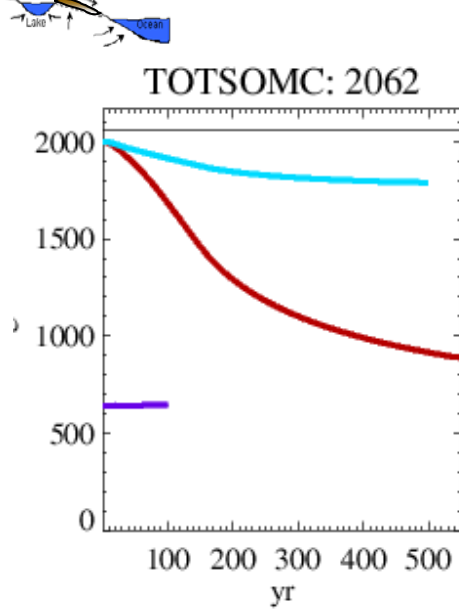
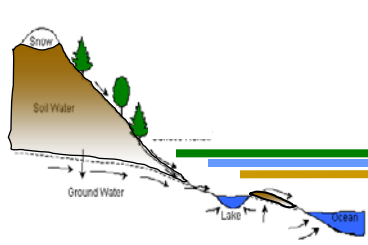
## Alaskan Arctic



## Amazonia

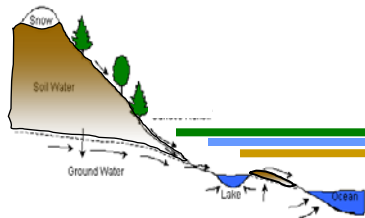


# Results from global runs



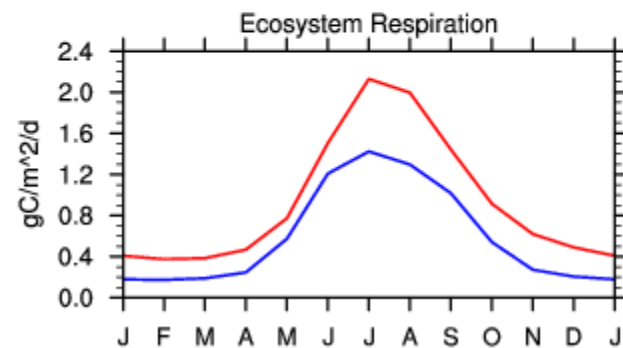
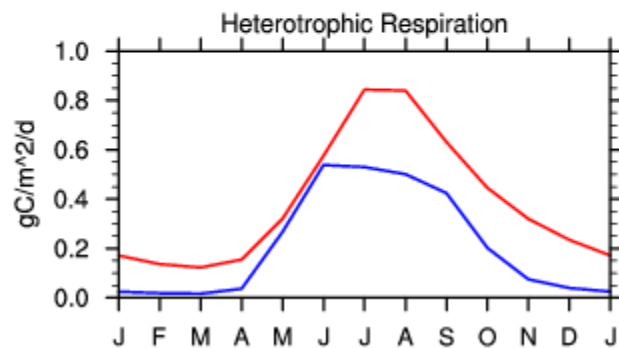
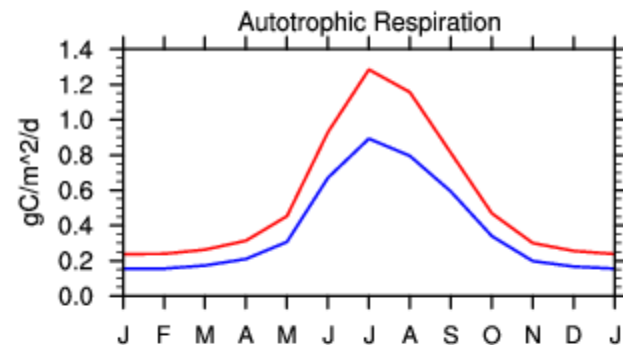
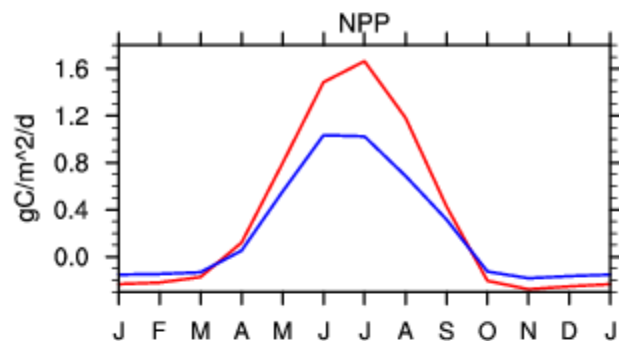
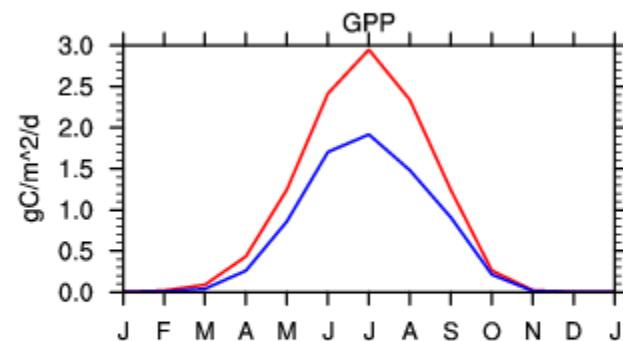
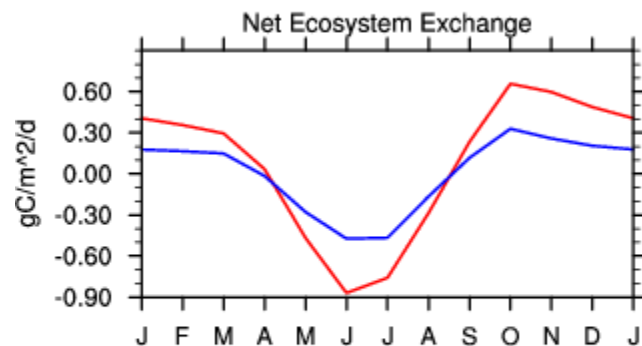
- CLM4CN
- w/ mods
- w/ mods + SOM5

# Some results from global tests

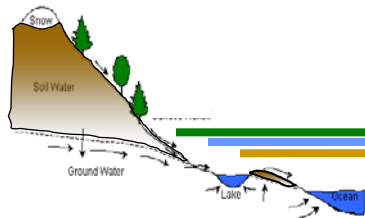


Polar(60-90N,-180W-180E)

CLM4CN  
w/ mods

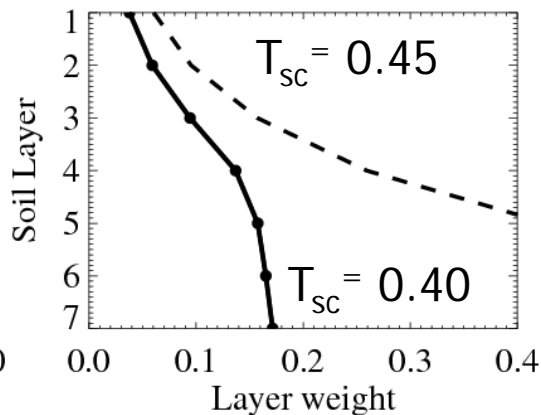
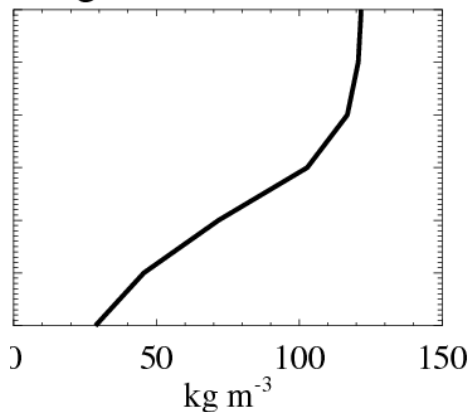


# Vertical distribution of carbon and impact on decomposition rates

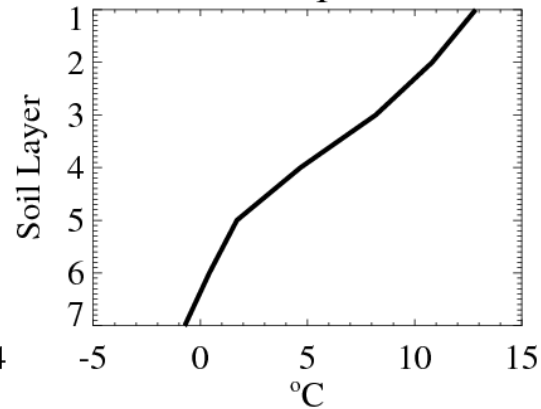


## Siberia peatland

Organic Matter Profile

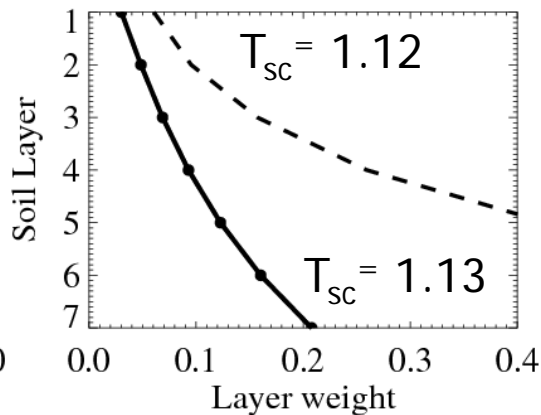
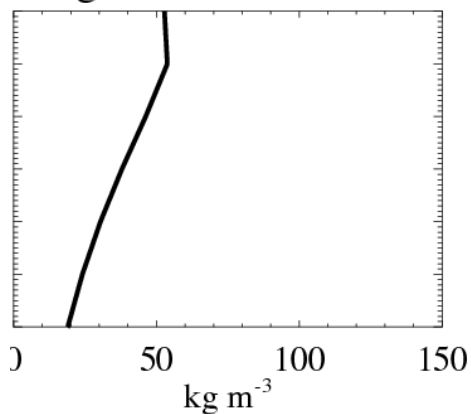


Soil Temperature

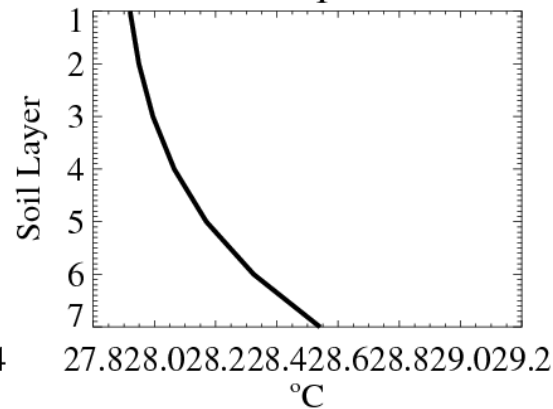


## Tropical Africa

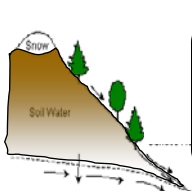
Organic Matter Profile



Soil Temperature

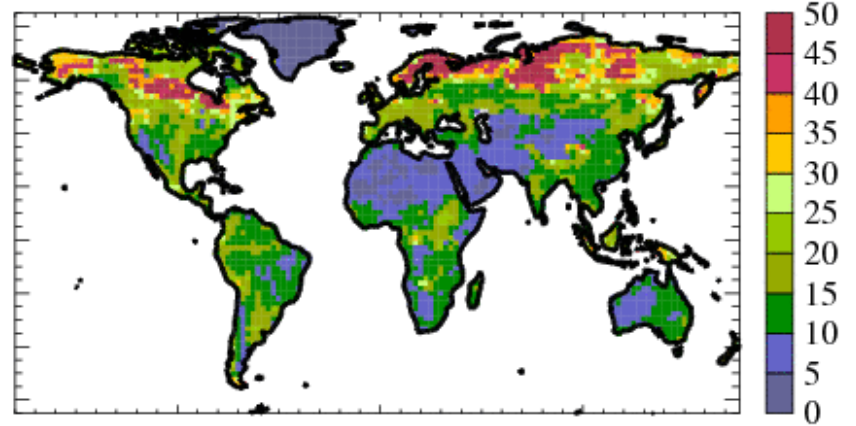




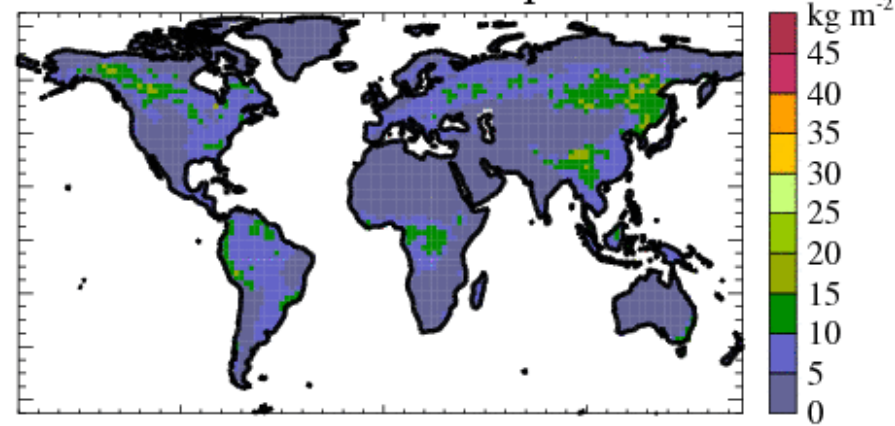


# CN Soil carbon compared to Global Soil Data Task obs

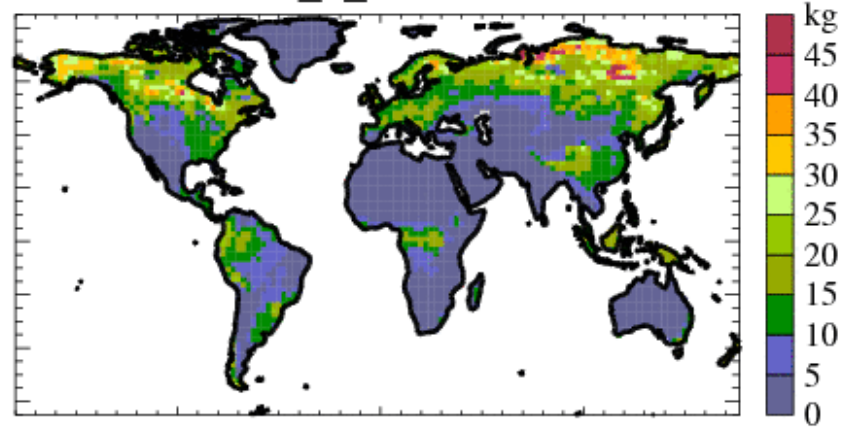
Obs



i1850cnNewNdep



clm3\_6\_45.CN10r



clm3\_6\_45.CN10r - Obs

