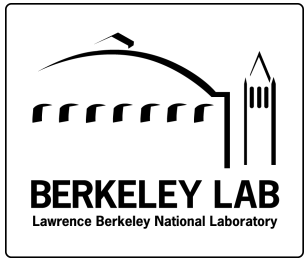


Soil BGC developments in CLM4

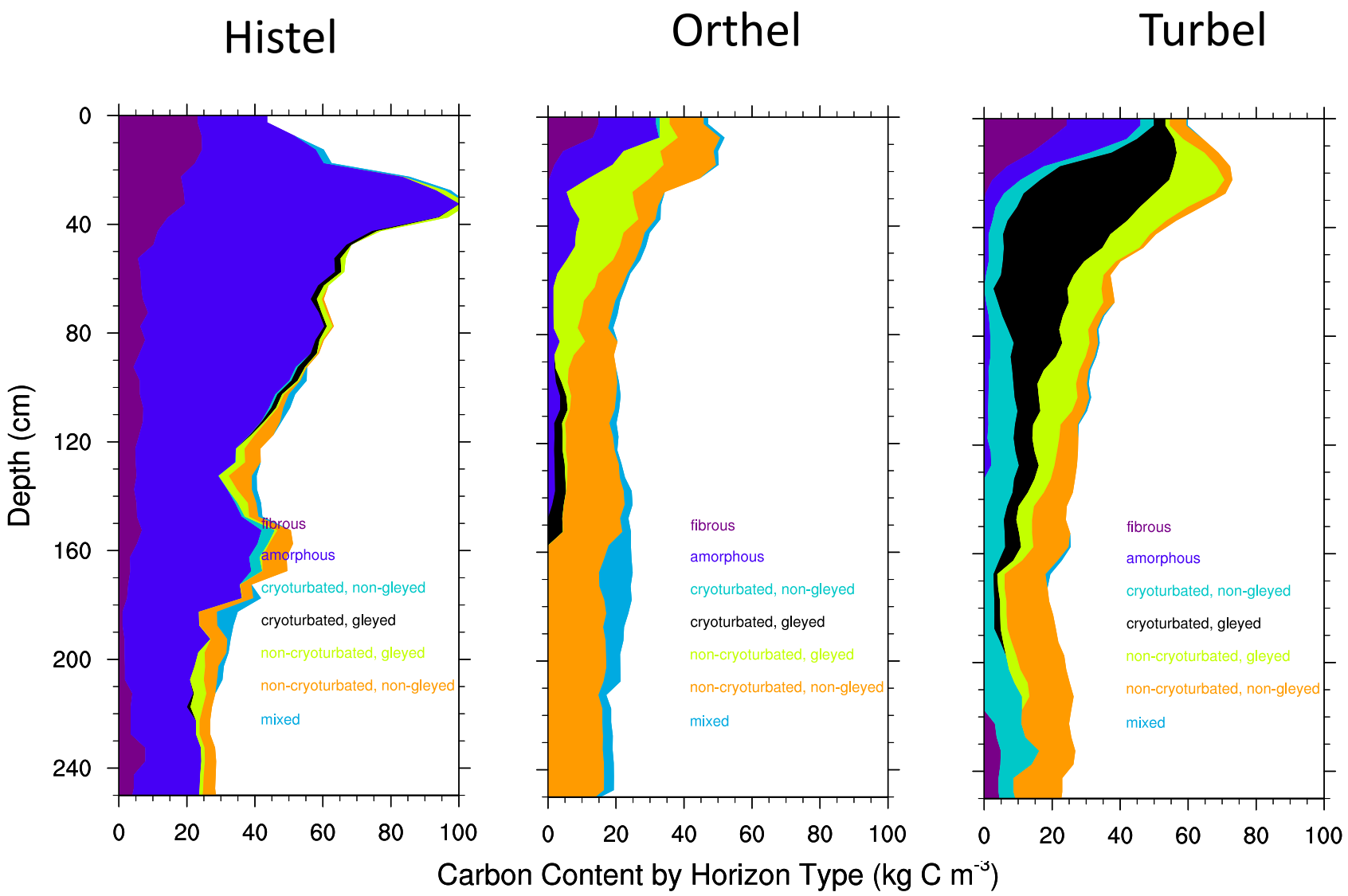
Charlie Koven

William Riley, Margaret Torn, Zack Subin, Jinyun Tang, David Lawrence, Gordon Bonan, Sean Swenson

Some goals/questions with soil biogeochemistry

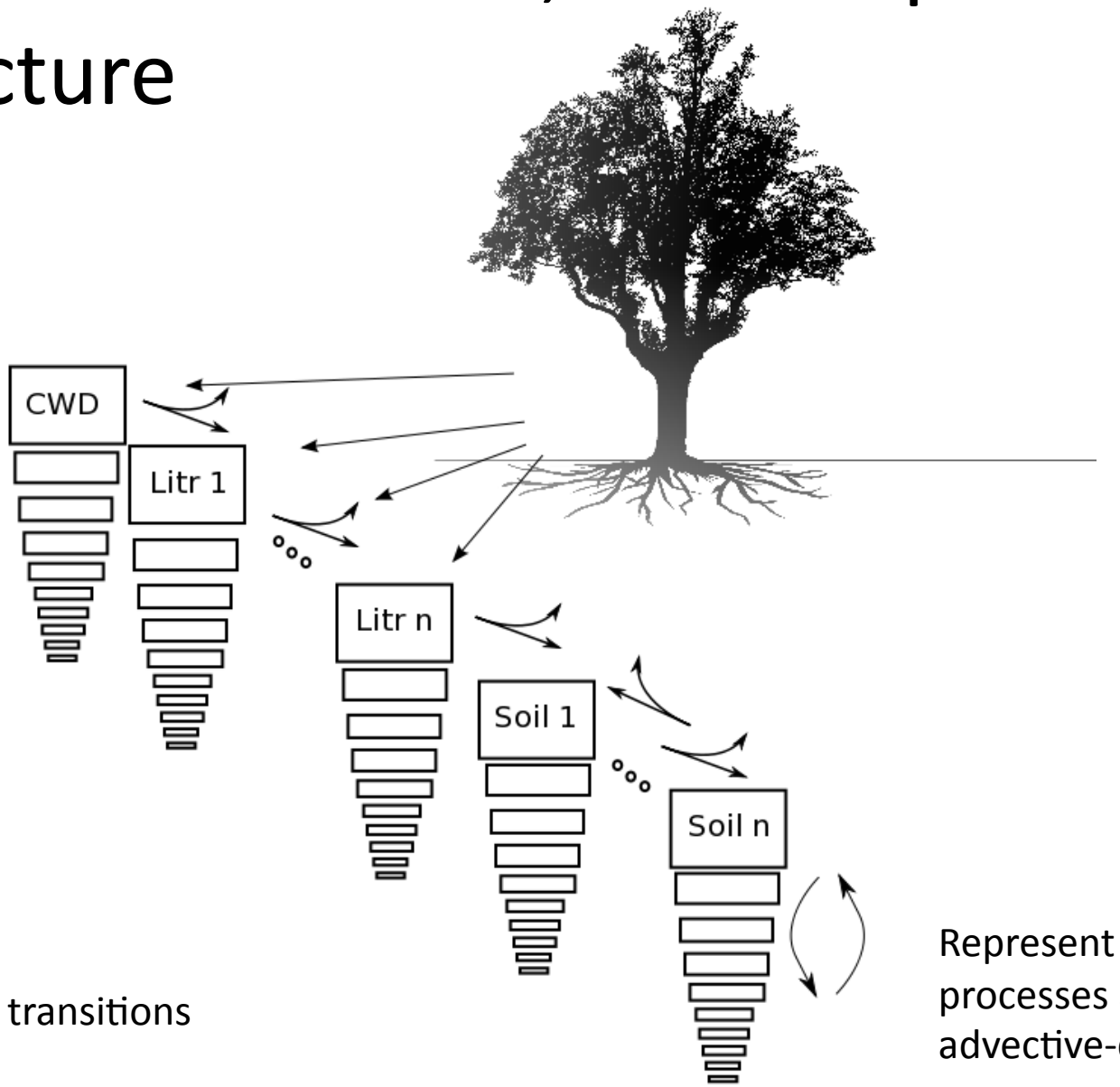
- Vertically-resolved soil BGC:
  - How can we make CLM include the high latitude soil C pool?
  - How can we include deeper soil C more generally?
- How can we use soil ^{14}C ages to constrain turnover times, mixing, depth distributions?
- How does more mechanistic representation of mineral N cycle affect C cycle, and coupling between two?
- Efficient spinup to be able to carry out experiments

Permafrost C profiles by depth and horizon type



Harden et al., *in prep*

Vertical Dimension, Flexible pool Structure



n pools
m cascade transitions
i levels

Represent mixing processes as advective-diffusive process

Spinup Modification: Need to avoid aliasing turnover times with seasonal and diurnal cycles

Pool Name	τ at 25C (yr)	AD (base)	AD (mod.)
CN			
CWD	2.7	1	1
Litter 1	.0023	1	1
Litter 2	.038	1	1
Litter 3	.19	1	1
Soil 1	.038	20	1
Soil 2	.19	20	1
Soil 3	2.0	20	5
Soil 4	27	20	70
CENTURY-like			
CWD	4.1	-	1
Litter 1	.066	-	1
Litter 2	.25	-	1
Litter 3	.25	-	1
Soil 1	.17	-	1
Soil 2	6.1	-	15
Soil 3	270	-	675

Also, speed up ^{14}C radioactive decay and vertical transport by same factors

Spinup performance

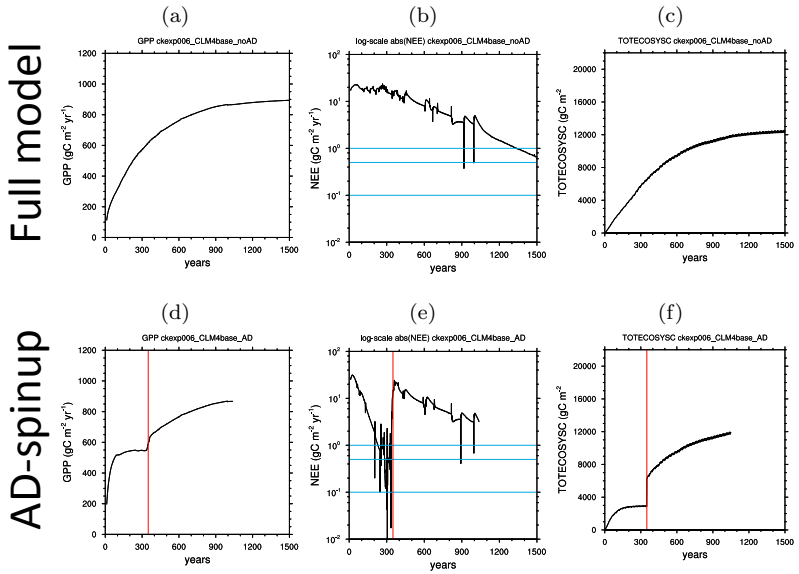
CLM4.0

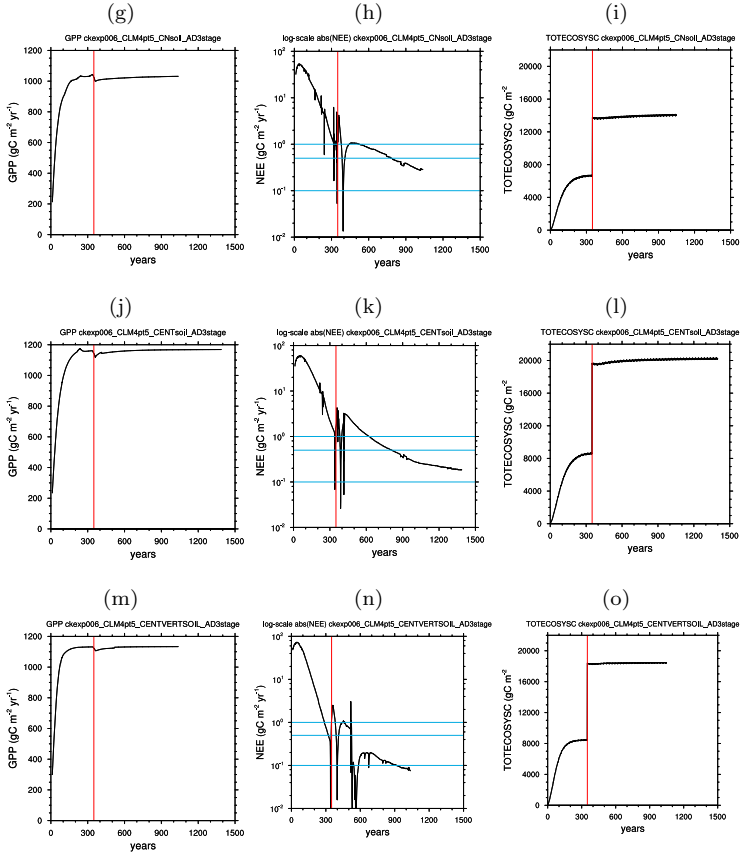
Modified Soil BGC

GPP log(NEE) totC

Full model

AD-spinup



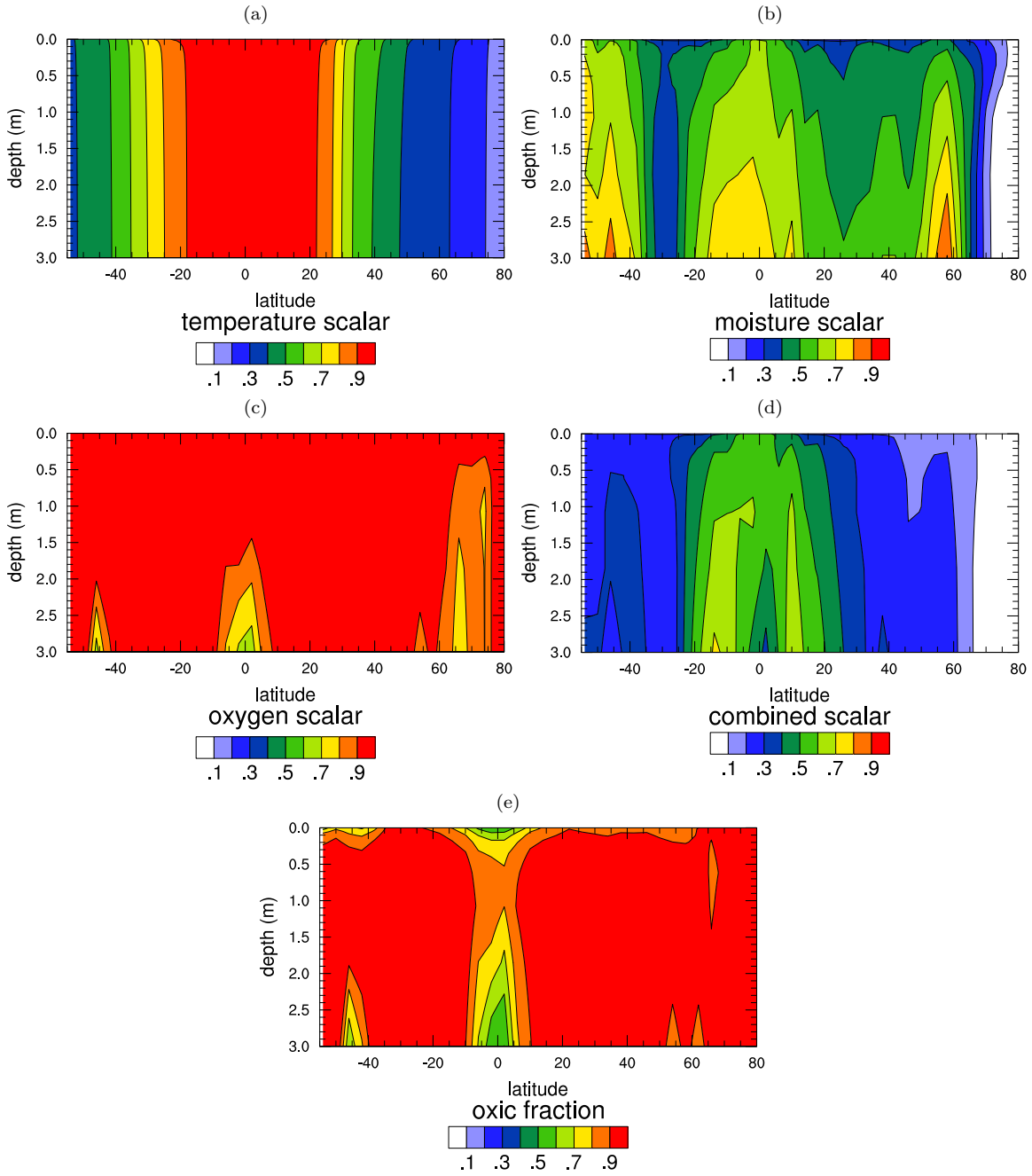


CN

1-lev Cent.

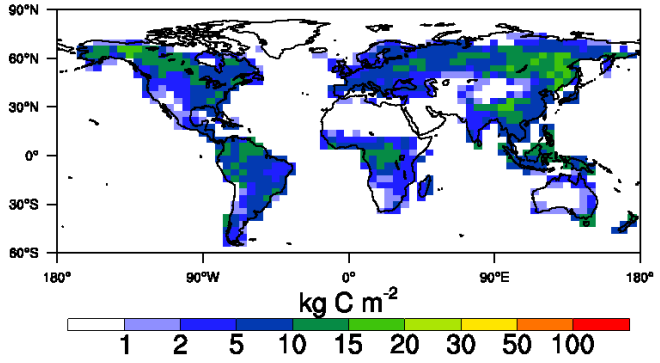
Multi-lev Cent.

Depth effects on soil turnover

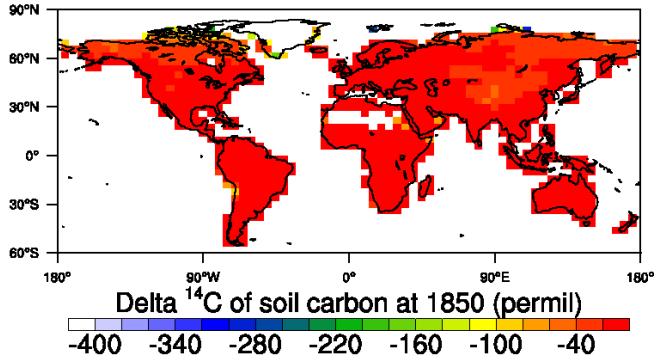


Effect on soil C and ^{14}C

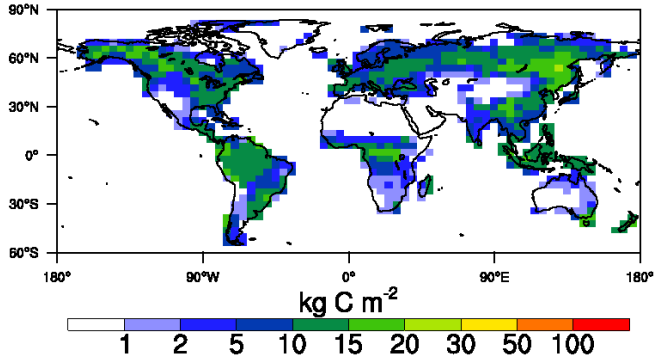
(c) CLM4 base soil C



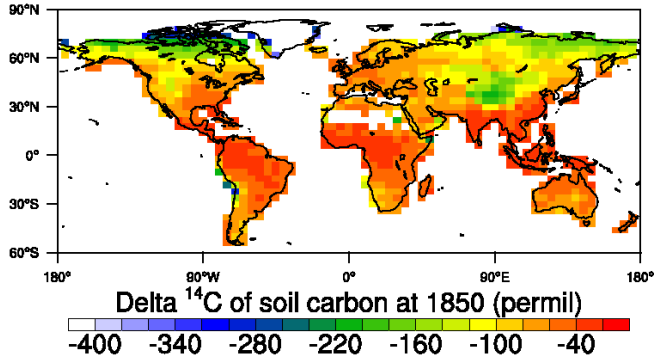
(d) CLM4 base soil $\Delta^{14}C$



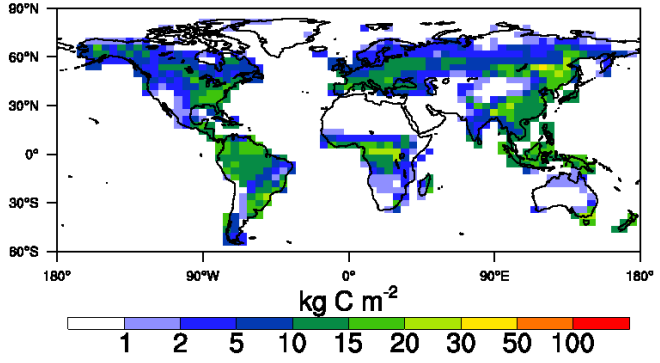
(e) Single-level CENT decomp. soil C



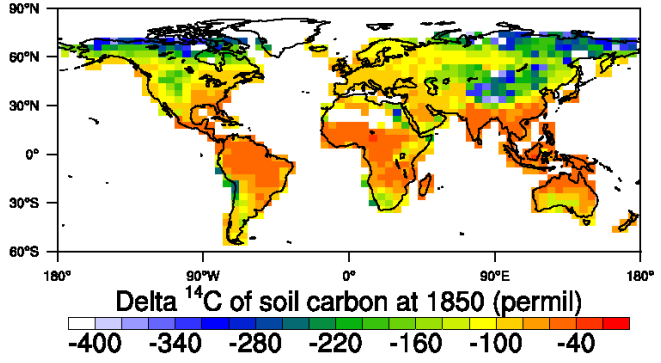
(f) Single-level CENT decomp. soil $\Delta^{14}C$



(g) Vert. CENT decomp; CN nitrif/denitrif soil C to 1m

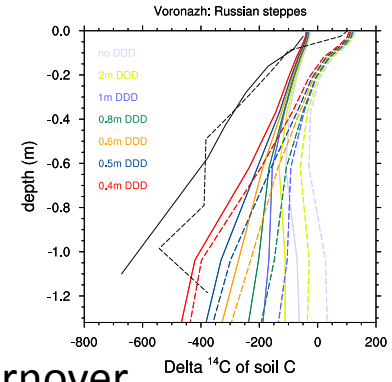


(h) Vert. CENT decomp; CN nitrif/denitrif soil $\Delta^{14}C$

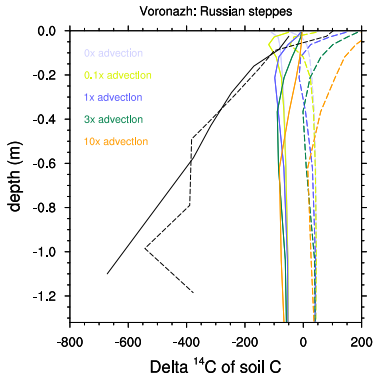


Parameter Sensitivity on ^{14}C profiles for grassland site

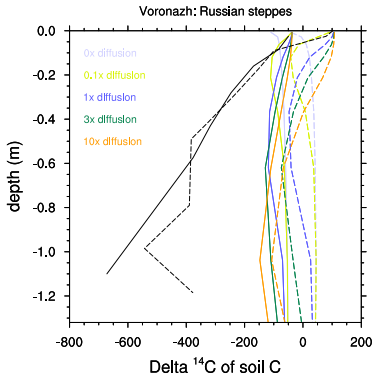
(a) Varied vertical profiles of turnover time



(b) Varied advection rate

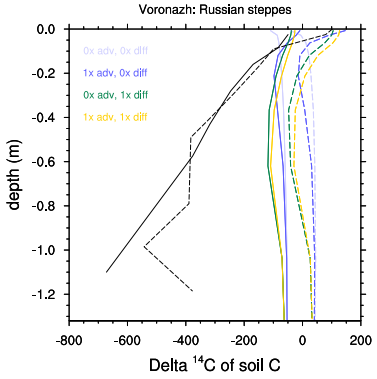


(c) Varied diffusion rate

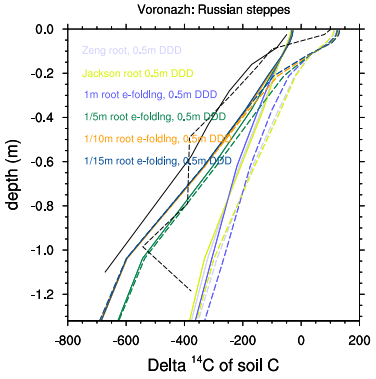


Requires turnover to slow with depth

(d) Varied combined advection and diffusion rates

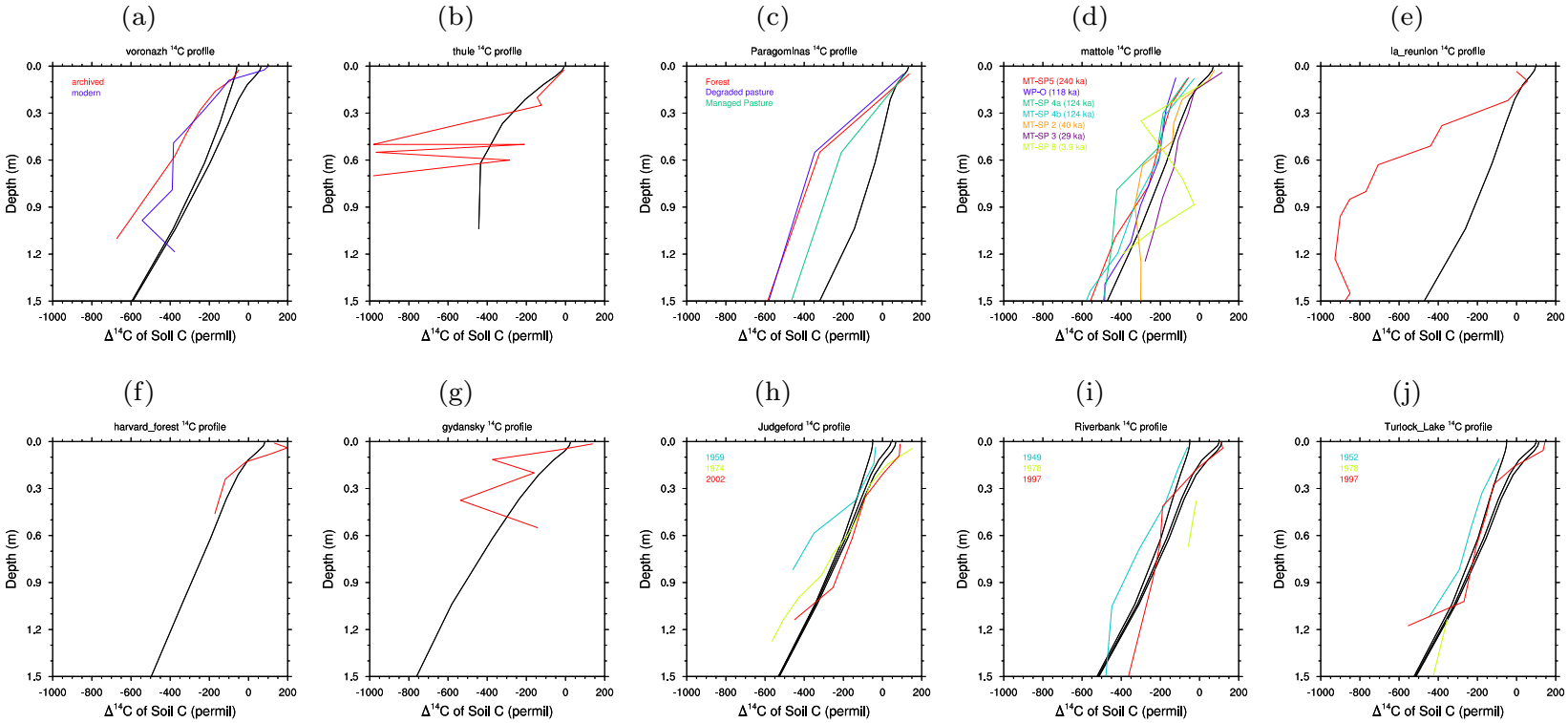


(e) Varied rooting profile



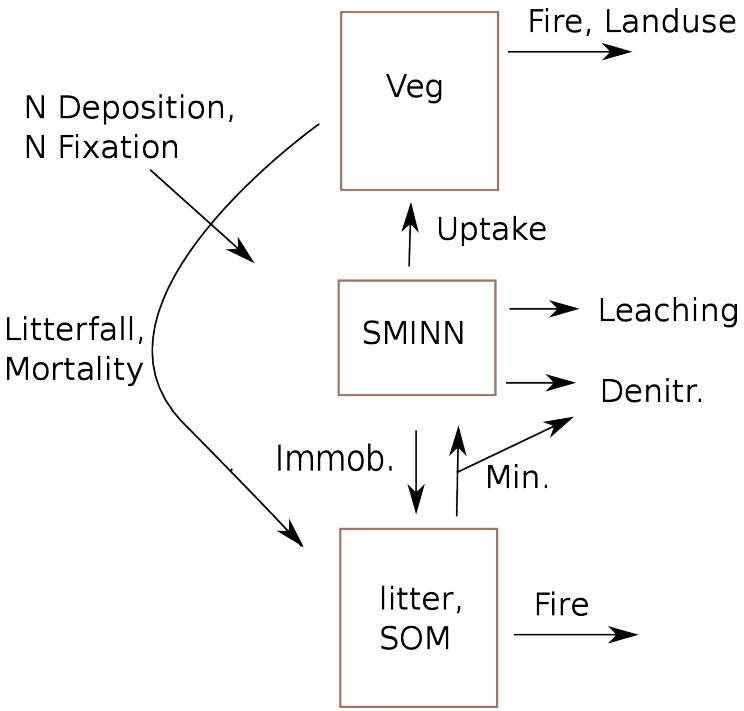
CLM root distributions too deep for this grassland ecosystem

Global distribution of ^{14}C profiles with a single set of vertical parameters

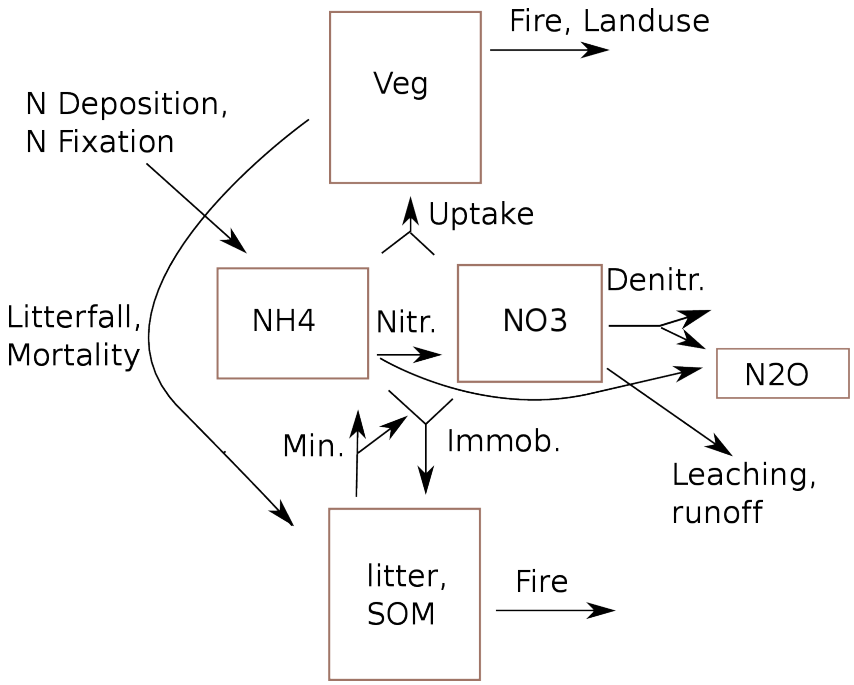


Modified mineral N cycle

CLM4.0

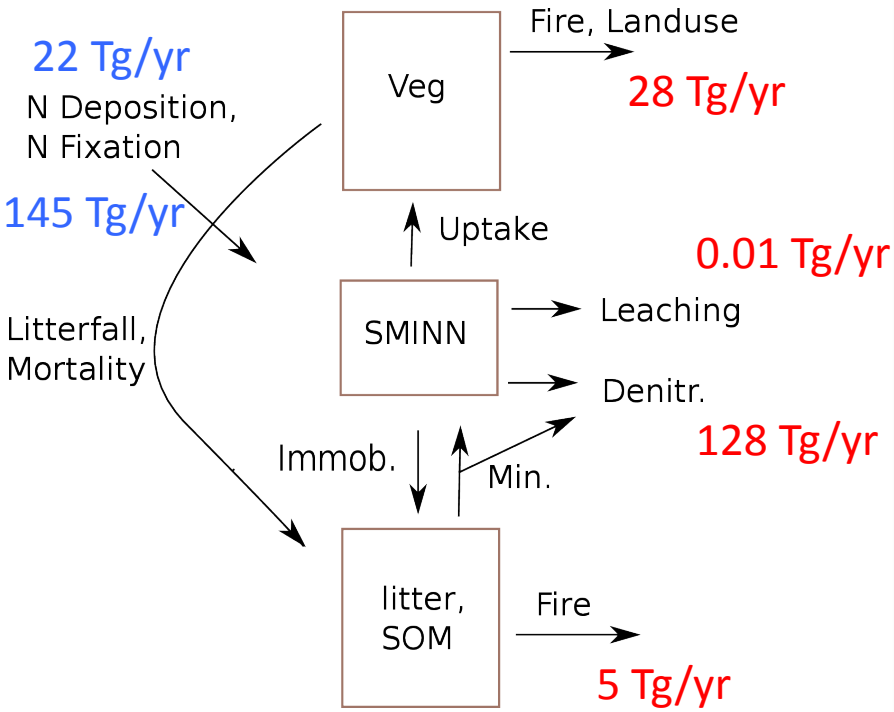


Modified N Cycle

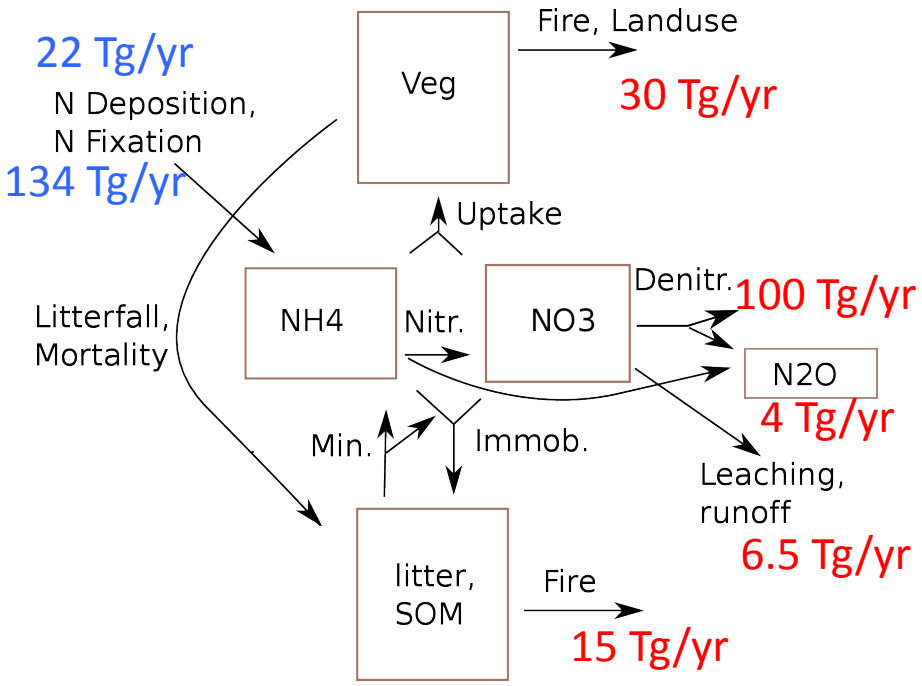


Modified mineral N cycle

CLM4.0

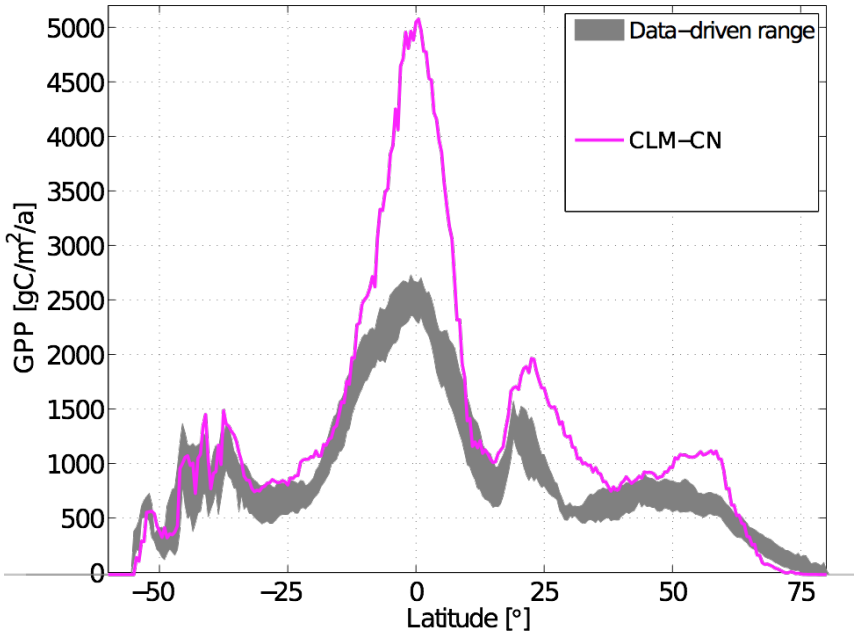


Modified N Cycle



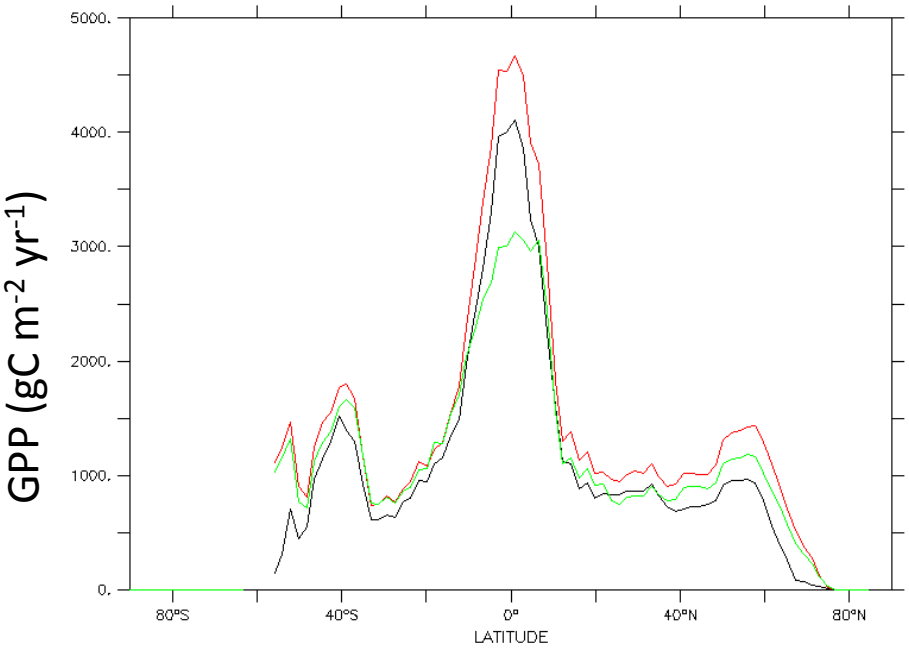
Other changes:
Seasonal N fixation cycle

Effect of mineral N modifications is to increase turnover time of mineral N pools, increase N availability, reduce N downregulation



Modified from Beer et al., *Science* 2010, fig. S26

Qian-forced CLM (I1850CN)



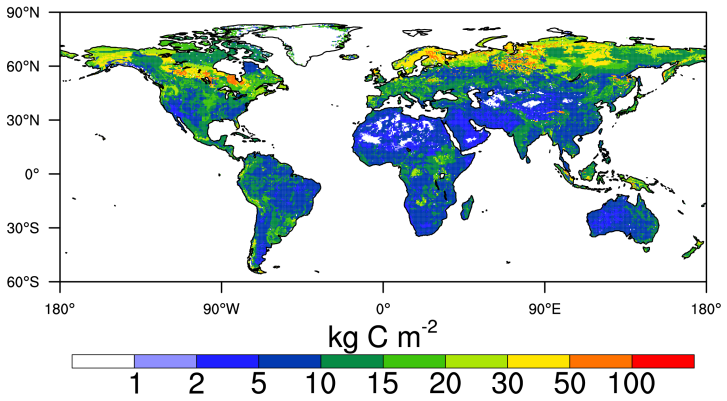
CLM4.0

Modified SOM+N cycle

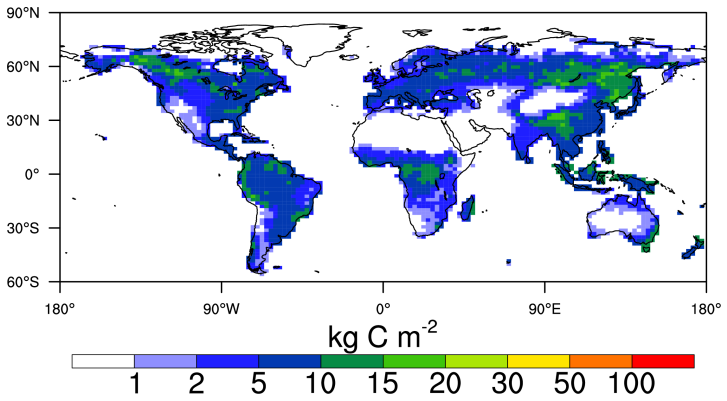
Modified SOM+N cycle + GPP(v1)

Better latitudinal distribution of soil C, but overproductive model now leads to too much soil C

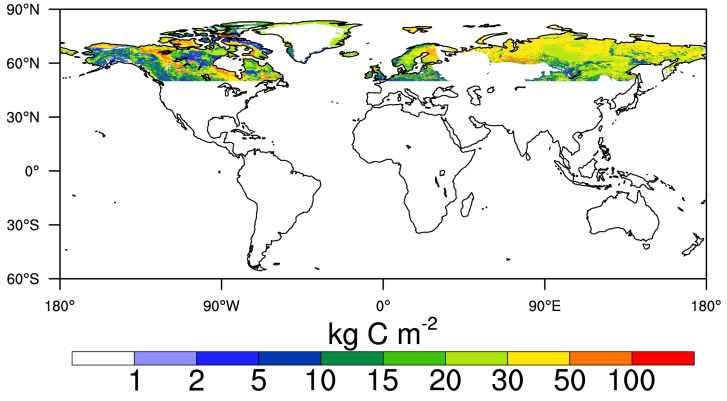
IGBP soil carbon



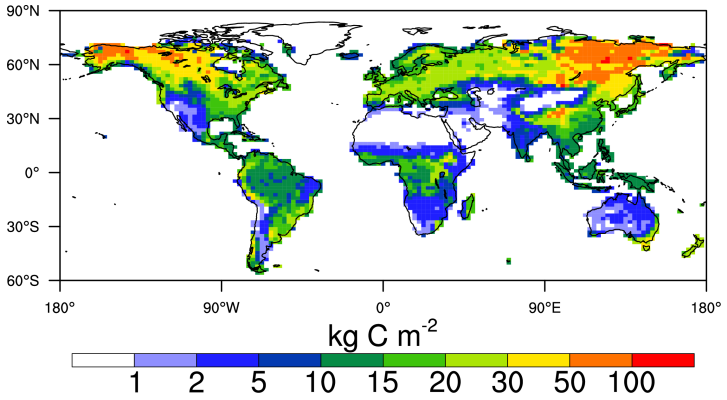
CLM4.0



NCSCD soil carbon



Modified SOM+N cycle



Conclusions/next steps

- CN soil structure incompatible with natural abundance ^{14}C; Century model allows for better match, especially to deeper profiles
- High-latitude biogeochemistry requires some relaxation of N limitation; resolved nitrification-denitrification reactions allows nonzero productivity there
- Relaxed N limitation overall leads to increased (over-) productivity—needs stronger intrinsic C cycle limitations?
- And/or: changes to other components of N cycle: fixation, plant uptake, downregulation?
- How do different SOM model structures lead to different C storage over historical/future time periods?