Multi-model regional comparison of carbon dioxide uptake between forward and inverse models over the U.S. Mountain West

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Background

An essential objective of the North American Carbon Program (NACP) has been to constrain carbon cycle sources and sinks in particular through land surface model intercomparison. A significant obstacle to resolving the location and relative magnitude of carbon sinks within the terrestrial biosphere has been the strong influence of elevation across complex terrain [6, 7, 2]. Using the U.S. Mountain West region (MWR) as a testbed domain, we compared differences in NEE between one inverse and two forward models.

Forward models estimate NEE relative to observed changes in processes governing photosynthesis and respiration. Alternatively, inverse models retrieve CO_2 fluxes by optimizing prior flux estimates using *in situ* CO_2 mole fraction observations. Before comparing differences in NEE it is important to explore *how* and *why* such models differ over this difficult-to-model MWR. This is not however a perfect comparison between models due to several caveats including differences between model surface elevations, and grid resolutions over which fluxes were computed, both of which are important to simulating carbon exchange across highly variable topography.

Table 1. Model details. Analyses were done using 60 monthly mean NEE time points representing 2000-2004.

Model	Type	Grid size
CarbonTracker-2008 [4]	Inverse	1°x1°
SiB 3.0 [1]	Forward	1°x1°
CLM-CASA Q_{10}=2.0 [5]	Forward	1.9°x2.5°
CLM-CASA Q_{10}=1.5 [5]	Forward	1.9°x2.5°

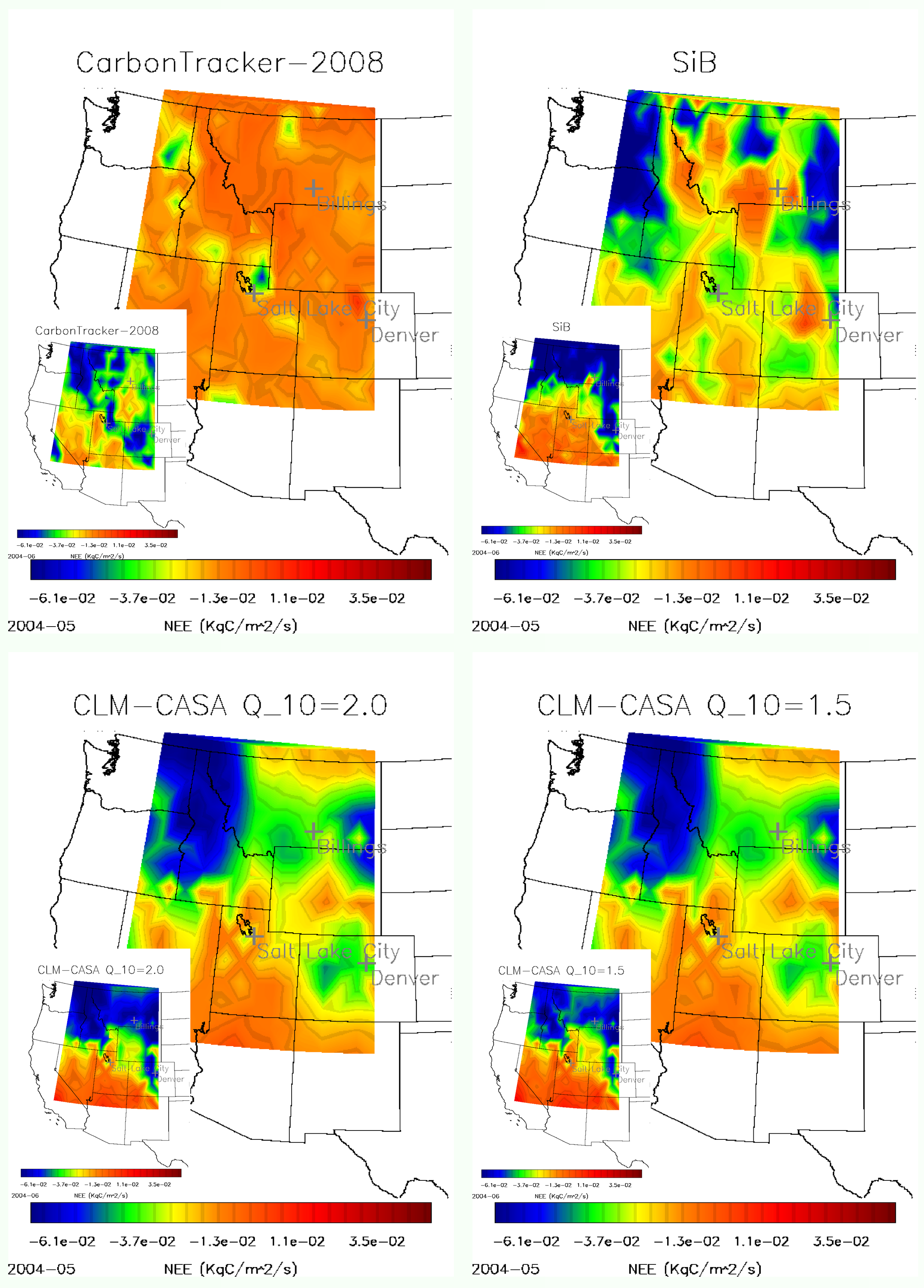
Statistical Correlations

Table 2. r^2 correlations between domain averaged monthly mean NEE (15x16, 1° grid cells covering 60 months) show agreement between models (e.g. CLM-CASA with Q_{10}=2.0 and SiB), while CarbonTracker inversions seem to agree only slightly with SiB.

	CT	SiB	CLM-Q2.0	CLM-Q1.5
CarbonTracker	–	0.57	0.34	0.01
SiB 2.5	–	–	0.84	0.40
CLM-CASAQ2.0	–	–	–	0.71

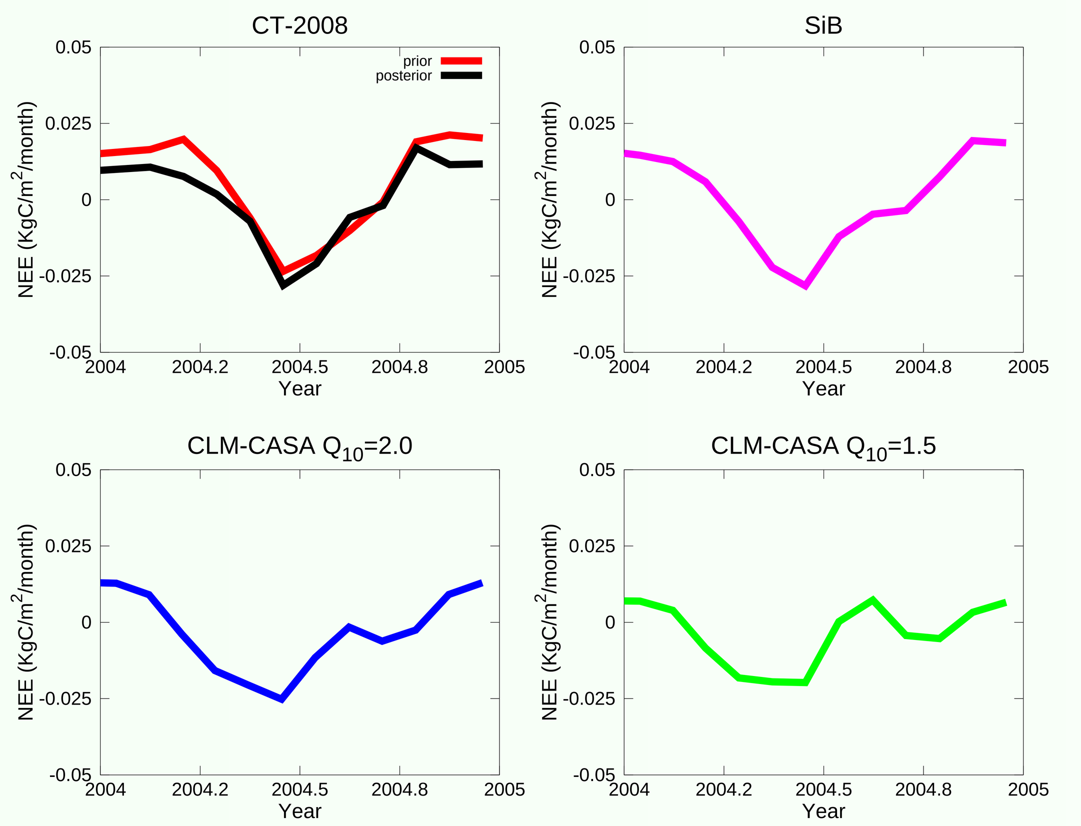
Timing NEE Peak Uptake

Fig. 1. Monthly mean NEE maps for May 2004 (inset figures represent June) indicate general agreement among forward models in the timing of peak carbon uptake (typically June). CT inversion estimates suggest Mountain West growing season in condensed by 1-2 months (see also Fig. 2).



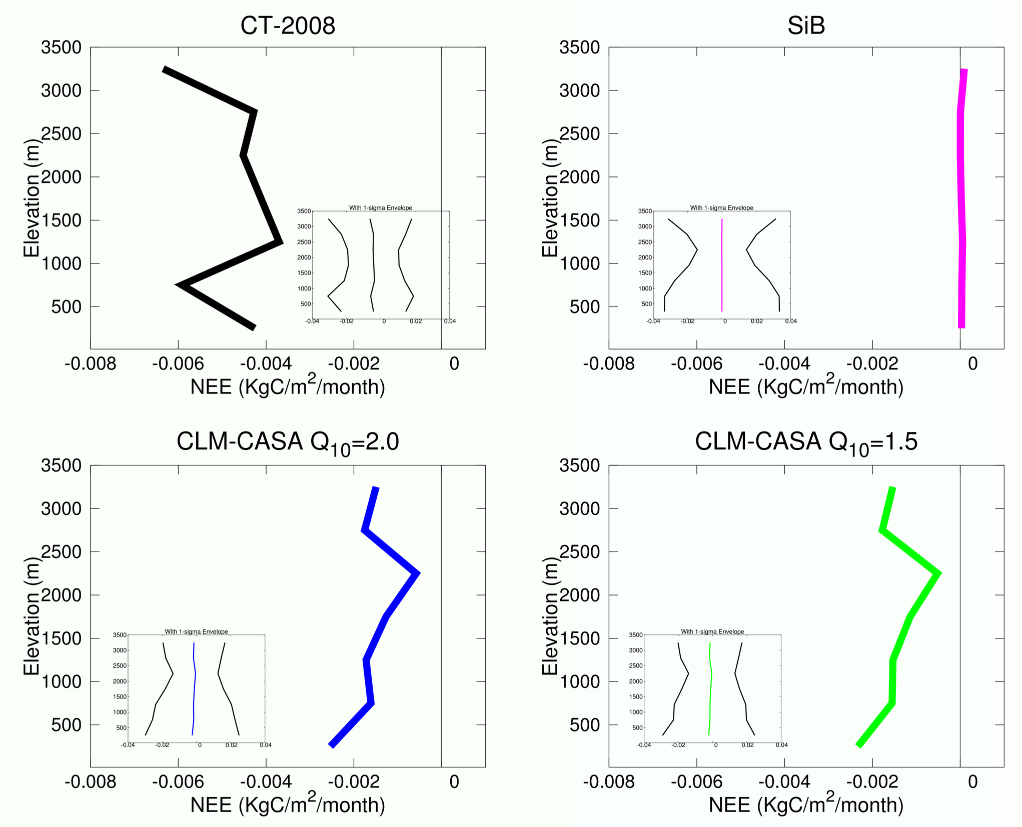
map animations: http://flux.aos.wisc.edu/~bjorn/2010_agu/

Fig. 2. 2004 MWR domain averaged (15°x16°) time series comparing timing of peak carbon uptake.



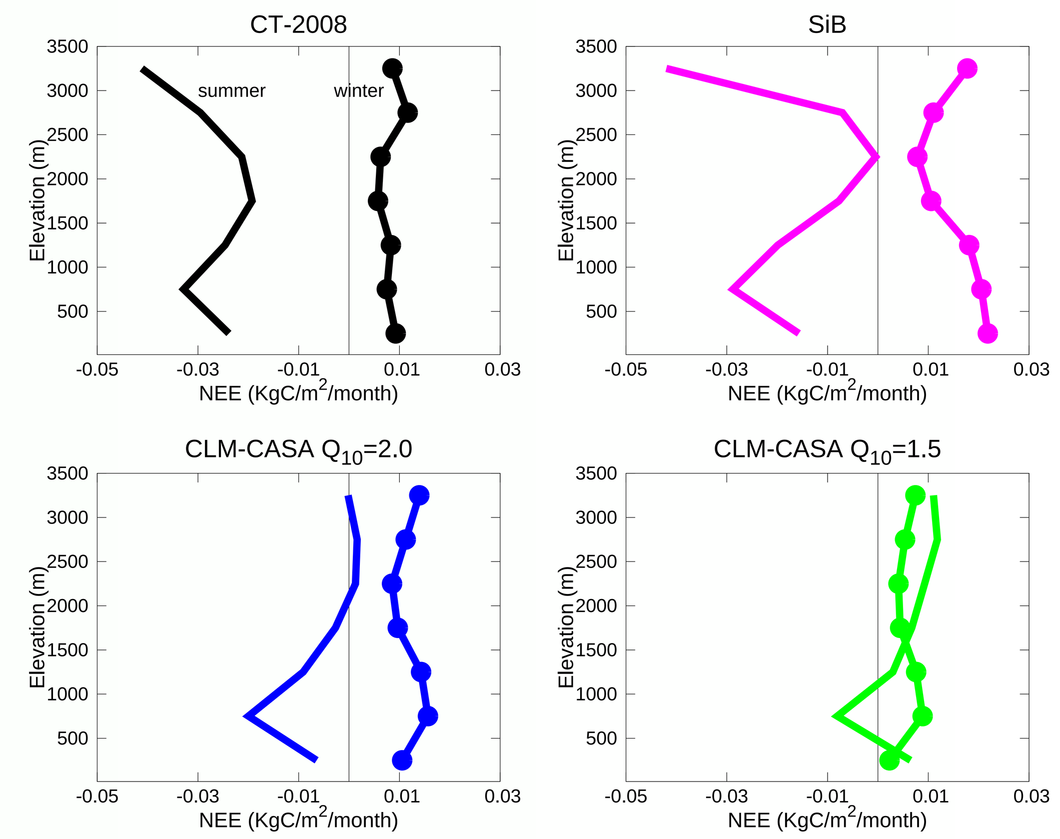
NEE by Elevation

Fig. 3. Differing trends. Mean NEE representing 16,320 1°x1° grid cells from 2000 through 2004. NEE inversion estimates from CarbonTracker show strongest uptake below 1,000 m and above 3,000 m, while forward models show either no change in uptake with elevation or decreasing carbon uptake with increasing elevation.



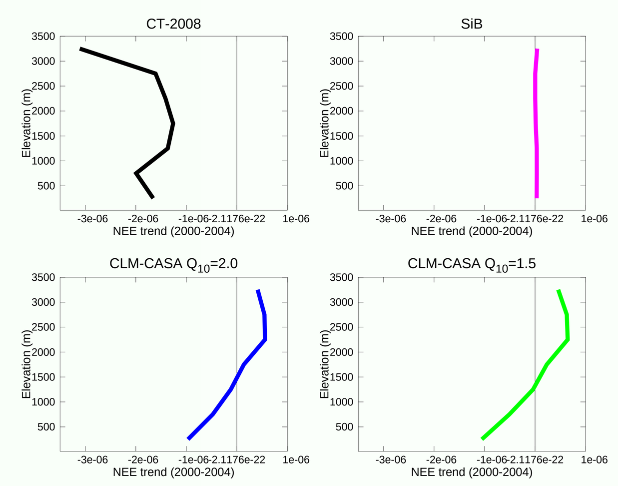
NEE by Elevation and Season

Fig. 5. As in Figure 3 NEE is partitioned by elevation with a further grouping into seasons. CarbonTracker NEE contrasts more strongly between seasons and across elevations than do CLM-CASA forward models, and SiB at most elevations. Peak summer uptake occurs below 1,000 m for CLM-CASA.



5-yr NEE Trend

Fig. 4. 5 year NEE Trend by Elevation. CarbonTracker indicates a stronger trend toward increasing carbon uptake at elevations near 1,000 m and above 2000 m during 2000-2004 model period. CLM-CASA and SiB show either no trend or decreasing uptake with elevation.



Conclusions

1. CarbonTracker indicates a summer growing season that is condensed by 1-2 months as compared to forward models (Fig. 2), which cannot be attributed solely to the assimilated observations (*cf.* prior vs. posterior NEE).
2. CarbonTracker and forward models disagree on which elevations are most responsible for the Mountain West carbon sink. CT indicates peak uptake at lower and higher elevations, while forward models indicate either no, or decreasing uptake with increasing elevation. However, as discussed earlier confounding effects (differing flux grid resolutions and model surface elevations) cannot be ruled out.
3. All models agree that the least variability in uptake occurs at mid elevations between 1,500 and 2,500 meters (see inset figures in Fig. 3).
4. CLM-CASA appears to capture the early and late peak in NEE (Fig. 2). At Niwot Ridge [3] related this to a secondary pulse in precipitation that typically occurs in August. However, to fully explain NEE differences we need to look at monthly precipitation and interannual variability.

Acknowledgments and References

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