The Fate of Terrestrial Carbon Under Climate Change: Results from a CCDAS

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Major Questions

What is the impact of the modelled change in climate on the CO2 flux predicted by a terrestrial model?
Can the use of current data help constrain this projection?

Method

- Optimize the parameters in a terrestrial carbon-cycle model following Rayner et al. GBC, 2005 (abbrev. R05).
- Construct climate anomalies for 2000–2050 from the LMD SRES-A2 scenario by

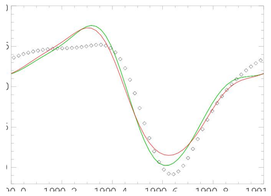
$$x_A(t) = x(t) - \overline{x(t = 1979 - -1999)}$$

- Construct climate forcing by adding anomaly time series to observed climatology for 1979–1999
- Run optimized and unoptimized models with this forcing and compare their carbon fluxes. Forcing includes SRES-A2 CO_2 concentration.
- Also run with constant climate and CO_2.
- Model formulation requires us to construct a prognostic model of the slow pool off-line.

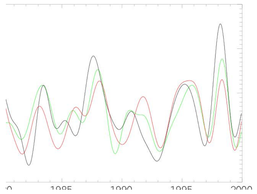
Conclusions

- The new optimization improves on R05.
- The simulated climate change in LMD enhances CO2 uptake in the Bethy model
- The uptake is further enhanced when optimized parameters are used, mainly because of enhanced productivity of the model.

New Optimization



fit of R05 (red) and new optimization (green) to computed seasonal cycle at Barrow Alaska (diamonds). Note the improved estimates for the depth of the summer draw-down.

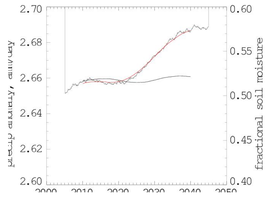


Fit of R05 and new optimization to the interannual variability in global growth rate calculated from 0.25×South Pole + 0.75×Mauna Loa

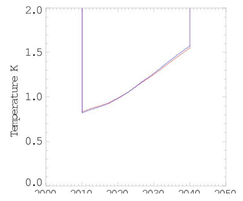
Name	Average (1979–1999) Gt C/y prior	R05	New
GPP	135.70	134.80	144.70
NPP	68.18	40.55	64.92
NEP	-0.11	2.453	2.316

- Weaker prior constraints on photosynthesis parameters allow optimization to increase productivity.
- Improves fit to seasonal cycle of concentration
- Interannual fit unchanged from R05, suggests that missing processes are still missing.
- Greatly increased turn-over time for the fast pool however also increased temperature sensitivity.
- Reduced temperature sensitivity for respiration in the slow pool.

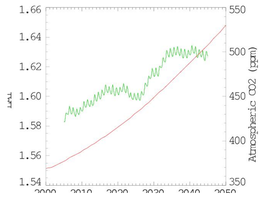
Climate Forcing



Decadal mean globally averaged Precipitation anomaly from LMD (red) and soil moisture output from full bethy model (green).



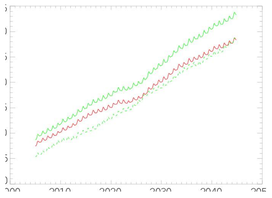
Decadal mean globally averaged maximum and minimum temperature simulated at each surface gridpoint within each month. Both series show the expected increase but there is little change in diurnal amplitude. Note that these averages include ocean points.



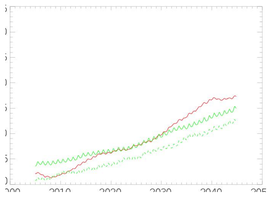
Decadal mean globally averaged CO_2 (red) and leaf area index simulated by full Bethy model (green). The CO_2 is given by the SRES-A2 scenario.

- Climate sensitivity is not unusual.
- There is no dramatic changes in averages of driving fields.
- Global averages could hide many impacts.

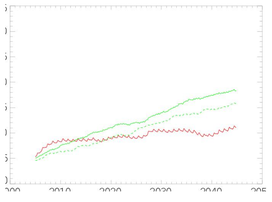
Model response to Climate Forcing



Decadal mean anomalous NPP for the optimized case (solid green) prior (black) and optimized case with no climate change (dashed green). All cases use enhanced CO_2 although note that in the no climate change cases CO_2 was not increased in the full Bethy run.



Decadal mean anomalous Respiration for the optimized case (solid green) prior (black) and optimized case with no climate change (dashed green).



Decadal mean anomalous NEP for the optimized case (solid green) prior (black) and optimized case with no climate change (dashed green).

- Optimized parameters produce enhanced increase in productivity.
- Climate change alone enhances productivity.
- Climate change decreases residence time by 10%.
- Enhanced respiration offsets but does not cancel increased productivity.
- NEP estimates are not sensitive to assumptions about initial pool size.