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The effects of vegetation parameter uncertainty on the magnitude of future terrestrial carbon sinks

Zavareh Kothavala and Damon Matthews
Concordia University, Montreal, Canada (zkothava@alcor.concordia.ca)

In this study, we examine the role of the terrestrial carbon cycle in a changing climate at the centennial scale using an intermediate complexity Earth system climate model which includes the effects of dynamic vegetation and the global carbon cycle. We present a series of ensemble simulations to evaluate the sensitivity of simulated terrestrial carbon sinks to three key model parameters: (a) the temperature dependence of soil carbon decomposition, (b) the upper temperature limits on the rate of photosynthesis, and (c) the nitrogen limitation of the maximum rate of carboxylation of Rubisco. We integrated the model in fully coupled mode for a 1200-year spin-up period, followed by a 300-year transient simulation starting at year 1800. Ensemble simulations were conducted varying each parameter individually and in combination with other variables.

The results of the transient simulations show that terrestrial carbon uptake is very sensitive to the choice of model parameters. Changes in net primary productivity were most sensitive to the upper temperature limit on the rate of photosynthesis, which also had a dominant effect on overall land carbon trends; this is consistent with previous research which has shown the importance of climatic suppression of photosynthesis as a driver of carbon-climate feedbacks. Soil carbon generally decreased with increasing temperature, though the magnitude of this trend depends on both the net primary productivity changes and the temperature dependence of soil carbon decomposition. Vegetation carbon increased in some simulations, but this was not consistent across all configurations of model parameters. Comparing to global carbon budget observations, we indentify the subset of model parameters which are consistent with observed carbon sinks; this serves to narrow considerably the future model projections of terrestrial carbon sink changes in comparison with the full model ensemble.