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Importance of carbon-nitrogen interactions on the feedbacks between climate and the terrestrial carbon cycle

D. Kicklighter (1), A. Sokolov (2), J. Melillo (1), B. Felzer (1), C. Schlosser (2) and T. Cronin (1)

1. Marine Biological Laboratory, Massachusetts, USA, (2) Massachusetts Institute of Technology, Massachusetts, USA (dkick@mbl.edu / Fax: +1 508 457-1548

The influence of nitrogen availability on terrestrial carbon sequestration is not considered in most earth system models used in climate-change assessments including IPCC. Here, we explore how carbon-nitrogen interactions in terrestrial ecosystems affect feedbacks to the climate system using the MIT Integrated Global Systems Model (IGSM) with two different versions of its terrestrial ecosystems sub-model, the Terrestrial Ecosystems Model (TEM). One version considers carbon-nitrogen interactions (CN-TEM) and the other considers only carbon dynamics (C-TEM). Nitrogen constraints on carbon dioxide fertilization cause the terrestrial biosphere simulated by the CN-TEM to take up less atmospheric carbon than that simulated by C-TEM, resulting in a larger increase in atmospheric carbon dioxide concentration and warmer temperatures for a given amount of anthropogenic carbon emitted. Furthermore, consideration of carbon-nitrogen interactions also changes the sign of the carbon feedback with climate change. In the simulations with C-TEM, surface warming significantly reduces carbon sequestration in both vegetation and soil, leading to a positive carbon-cycle feedback to the climate system similar to that found by other earth system models. However, in simulations with CN-TEM, the increased decomposition of soil organic matter with higher temperatures releases soil nitrogen to stimulate plant growth and carbon storage in the vegetation that is greater than the carbon lost from soil. As a result, sequestration of carbon in terrestrial ecosystems increases, in comparison to the fixed climate case, and the carbon cycle feedback to the climate system becomes

negative for much of the next three centuries. Consideration of carbon-nitrogen interactions should be included in future assessments of climate-change impacts.