MEETINGS

Examining Uncertainties in Representations of the Carbon Cycle in Earth System Models

Key Uncertainties in the Global Carbon-Cycle: Perspectives Across Terrestrial and Ocean Ecosystems; Boulder, Colorado, 6–10 August 2013

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Terrestrial and ocean scientists gathered to pursue intellectual fertilization across the traditional land-ocean disciplinary split in carbon cycle science. The goal was to examine the processes driving uncertainties in representations of the carbon cycle in Earth System Models (ESMs). Ecosystem processes with land and ocean parallels were explored through talks, posters, and breakout sessions on four themes: disturbance, remineralization/decomposition, individual organisms/trophic interactions, and nutrient limitation. Data-model synthesis and observational constraints on ESM behavior were a common thread among themes. Key data resources were summarized, and many of these have now been posted at https://climatedataguide.ucar.edu.

Participants discussed how episodic and localized carbon loss occurring within a background of large-scale biomass accumulation is a challenge in both systems. Uncertainties associated with modeling rare events, for example tree mortality on land and episodic aggregation and sinking events in the ocean, have similarities that might be addressed through new mean field approaches. Effects of mortality on land due to windthrow or insect outbreaks are beginning to be explicitly included in ESMs. Similar approaches for modeling the dynamics of these biotic and physical agents can be applied to many different systems and warrant further exploration.

Meeting participants explored how model representations of carbon transformations due to remineralization in the ocean and decomposition on land may benefit from coordinated efforts across systems, especially because the reactions driving transformations are largely common and subject to mediation by similar processes: recalcitrance, aggregate formation, temperature response, and mixing.

Discussions revealed that both the terrestrial and ocean research communities are seeking more accurate depictions of individual physiology to improve mechanistic representation of ecological function. It was evident that both communities require better observational constraints on resource allocation to improve parameterizing of individual optimization strategies. Implementation of new schemes requires balancing ecological complexity with spatial resolution, constrained by computational resources.

Finally, participants found the state of understanding and representation of nutrient limitation to be a key point of contrast between land and ocean systems. In the ocean, there are relatively well developed constraints and robust paradigms, such as new production. In contrast, the representation of nutrient limitation on land is in its infancy due to the complexities of a heterogeneous environment, the path dependency of ecosystem succession, and observational challenges. Further work needs to be done in both systems to understand and represent the physiological controls on nutrient demand, acquisition, and allocation.

This workshop was part of the National Center for Atmospheric Research Advanced Studies Program Graduate Student Colloquium on Carbon-Climate Connections in the Earth System. Over the first 3 weeks of August 2013, 25 graduate students pursued a deeper understanding of the carbon cycle and the climate system through lectures, hands-on modeling tutorials, and analysis of Coupled Model Intercomparison Project Phase 5 (CMIP5) models.

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—R. Quinn Thomas, Virginia Polytechnic Institute and State University, Blacksburg; email: rqthomas@vt.edu; Galen A. McKinley, University of Wisconsin–Madison; and Matthew C. Long, National Center for Atmospheric Research, Boulder, Colo.