Quantification and Reduction of Critical Uncertainties Associated with Carbon Cycle-Climate System

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PROJECT DESCRIPTION

Carbon cycle climate feedback uncertainties play a large role in defining the overall uncertainty envelope for predictions of future greenhouse gas concentration, terrestrial ecosystem structure and function, and associated climate changes. The processes thought to dominate the sign and magnitude of carbon-climate feedbacks vary across latitudinal zones, and integrated prediction of the global-scale feedbacks depends on detailed understanding of regional and zonal mechanisms connecting the terrestrial cycles of carbon and nutrients with the climate system.

The team's approach is: 1) to quantify critical uncertainties in global-scale climate predictions associated with carbon-climate feedbacks; 2) to improve our understanding and model representation of processes controlling these feedbacks through zonally-specific model-data evaluation exercises; and 3) to extend our data-based evaluation to quantification of carbon-climate feedback responses and uncertainties in a large population of global-scale carbon-climate models. An integrating theme across these three regional focus areas is the use of observations and experimental results to evaluate model performance. This effort will result in an improved model evaluation framework, building on the success of the existing Carbon-Land Model Intercomparison Project (C-LAMP). We will add new observations and metrics to C-LAMP and use this system to test hypotheses related to the causes of variation among carbon-climate models.

SIGNIFICANCE

There is broad agreement in the scientific community that changes in climate over the next several centuries will depend in part on anthropogenic emissions of carbon dioxide and other greenhouse gases due to the direct influence of GHG concentrations on atmospheric radiative forcing. It is also well-understood that prediction of anthropogenically-forced climate change is complicated by the existence of multiple climate system feedback loops connecting atmospheric GHG levels to physical and biological processes on land and in the oceans. We have prioritized our efforts to focus on three of the most significant terrestrial ecosystem types, in terms of their contributions to the global carbon cycle, categorized by latitudinal zones: 1) tropical upland and lowland forests, with a focus on carbon-nutrient interactions, 2) forests of the temperate zone, with a focus on the consequences of land use modification and age-class dynamics over the past several centuries, and 3) high-latitude forest, shrub, and tundra ecosystems, with a focus on permafrost dynamics and related changes. In each of these zones and ecosystem types, the CMIP5 model representations of carbon cycle-climate interactions, as well as interactions with water and nutrient cycles, are limited at present by an incomplete understanding of the relevant processes and inadequate comparison with available observations and experiments. Our project aims to overcome these limitations to deliver model predictions with reduced carbon-climate feedback uncertainties, as well as to provide an improved framework for evaluating the performance of carbon-climate models participating in CMIP5. Our goal is to reduce the range of climate prediction uncertainty by improving the representation of key terrestrial ecosystem processes that regulate feedbacks and by identifying model predictions that are inconsistent with available observations and experimental results.