Above-Belowground Vegetation Carbon Allocation in CMIP5 Earth System Models

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Introduction
The above-belowground vegetation carbon allocation is an important factor to determine how ecosystem carbon sequestration respond to climate change. Model representation of carbon allocation algorithm significantly influence the simulated terrestrial carbon stock and land-atmosphere interaction within Earth System Models (ESMs). Few previous studies, however, have investigated and evaluated the above-belowground carbon allocation in ESMs. In this study, we analyzed carbon density in belowground (root), total vegetation (above + belowground), and root:total vegetation carbon (R/T) ratios of nine ESMs from the Coupled Model Inter-comparison Project Phase 5 (CMIP5), which were used for the latest IPCC Assessment Report (AR5). Previous datasets ranging from site-level, biome-level, to global scale were compiled to compared with CMIP5 model outputs during 1995-2005 based on historical simulations.

Background

Biome-Level Model Evaluation of CMIP5 Output

Spatial Evaluation of CMIP5 Output

Earth System Models
Nine ESMs were used in this study including CCSM4, CESM1-BGC, CESM1-CAM5, GFDL-ESM2M, IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, NorESM1-ME, NorESM1-M.

Definition of Climate Zones and Vegetation Biomes

Comparisons in Three Climate Zones

ESMs are not consistent with observational data; both the root and total vegetation carbon density are underestimated in tropical/subtropical and temperate regions, while overestimated in arctic/subarctic regions. The R/T ratios are underestimated in all three climate zones.

Summary

A few conclusions have been reached in this research
1) ESMs underestimated belowground and total vegetation carbon density in tropical/subtropical and temperate regions, while overestimated in arctic/subarctic regions
2) ESMs underestimated the R/T ratio across the majority of the globe
3) Model-model differences are large in simulating carbon density and R/T ratio
4) The carbon allocation algorithms in current ESMs need to be improved, particularly the R/T ratio.