Abstract
Understanding potential carbon cycle climate feedbacks is essential, however future simulations are extremely uncertain. Coupled climate-carbon cycle models project an additional rise in CO₂ by year 2100 of between 20 to 200 parts per million (ppm) due to carbon cycle feedbacks. The higher end of this range could have significant detrimental impacts on global climate. We demonstrate methods to improve these models by evaluating based on an indispensable parts per million (ppm) due to carbon cycle feedbacks. The higher end of this range could have significant additional impacts on global climate. We demonstrate methods to improve these models by evaluating based on an indispensable parts per million (ppm) due to carbon cycle feedbacks. The higher end of this range could have significant additional impacts on global climate.

EVALUATION OF THE CARBON CYCLE IN THE CMIP5 EARTH SYSTEM MODEL ESM2G

M. LEONARD1,2, L. BRUHWILER1, J. DUNNE3, E. SHEVLIAKOVA3
1 NOAA BOULDER ERL/NOAA BOULDER, CO, UNITED STATES, 2 SCIENCE AND TECHNOLOGY CORPORATION, BOULDER, CO, UNITED STATES, 3 PRINCETON UNIVERSITY, PROGRAM IN ATMOSPHERIC AND OCEANIC SCIENCES, PRINCETON, NJ, UNITED STATES

CarbonTracker is a state-of-the-art data assimilation system constrained by multiple diverse observational networks and capable of calculating atmospheric CO₂ mole fractions across the globe. It is developed using a combination of CO₂ surface exchange models and an atmospheric transport model (TMS) driven by meteorological fields. Observations include a record of net CO₂ exchange from the multiple inventories, geographic areas, and time collected by NOAA ESRL. In addition, carbon exchange is monitored by a worldwide collection of surface fixed carbon and Global Fire Emissions Database (GFED) fire exchanges and adjustable biophysical and oceanic fluxes.

ESM2G NOAA’s first Earth System Model ESM2G is designed to study the impact of climate change on ecosystems, ecosystem changes on climate and human activities on ecosystems. ESM2G is constructed by NOAA’s Geophysical Fluid Dynamics Laboratory (GFDL) with collaborative efforts by Princeton University. Department of Interior, and other institutes. It is a physical climate model designed to advance our understanding of the how the Earth’s biogeochemical cycles, including human actions, interact with the climate system. ESM2G is coupled with both atmospheric and oceanic circulation using simulation time tool derived to represent land, sea ice and atmosphere dynamics. In addition, this model incorporates biogeochemistry and biogeosciences. Earth System Model ESM2G has a near standard seasonal cycle that represents climate and ecosystem interactions and their potential natural and anthropogenic changes. There is an abundance list of photosynthesis and variables included in the atmospheric and oceanic components mentioned in Dunne et al., 2012. ESM2G allows us to understand the sensitivity of a coupled climatecarbon cycle system over time to our improving knowledge of our land and ocean carbon exchanges.

Results

The terrestrial and oceanic biophere is divided into 22 distinctive regions as well as geographical locations as shown from the TransCom inversion study (e.g. Gurney et al., 2002).

CarbonTracker gives a global view of the carbon cycle in the atmosphere and ocean. The transport model (TEMS) is constrained by observations, and the latter is constrained by a space-based estimate of its performance. Such models will help improve coupled climate-carbon cycle models by improving their ability to simulate the recent past. We investigate global and regional scaled comparisons of the coupled climate-carbon cycle models of CMIP5 and CCSM3, which are purely predictive. We identify and discuss in detail global region scaled fire, terrestrial and oceanic carbon flux comparisons between models. We determine that ESM2G is capable of representing carbon fluxes in a global scale with annual resolution, however regional scales and shorter temporal resolution engenders bias and other parametrized problems. This includes an early growth in atmospheric carbon, an inverse annual cycle around the Indian Ocean and Southern Ocean, and an overestimation of gross primary production (GPP) in regions near the Inter Tropical Convergence Zone. We present ideas for improving future versions of GFDL ESM2O applied for other coupled climate-carbon cycle models.

The terrestrial biosphere is divided into 19 ecosystem types as well as geographical locations. Using these regions can further allocate the source of variances between model fluxes at across different latitudinal regions. ESM2G has an earlier terrestrial growing season in northern boreal and temperate regions and an unwidly large seasonal cycle across the entire southern hemisphere, compared to other models. This may be attributed to an error of vegetation in shortwave radiation during precipitable cloud events and greater Inter Tropical Convergence Zone (ITCZ). ESM2G has a reversed seasonal cycle in the tropical Indian and Southern ocean. In addition, it’s ocean flux produces slightly larger seasonal cycle in the South and Northern Pacific than data-interpreted ocean models.

Summary
Tropics Contains largest flux discrepancy with ESM2G, particularly with tropical NPP due to location of ITCZ.

Higher Northern Latitudes Models have a small phase shift difference in both GPP and Respiration. ESM2G overestimated forests to compensate for sea-ice melting.

Southern Hemisphere ESM2G contains annual cycles in GPP and contains large bias in Amazonian Respiration.

Oceans ESM2G has slight bias of 0.5 Pg yr⁻¹ in southern hemisphere oceans. In addition, Southern Ocean is a half phase shifted annual cycle with respect to Takahashi and OIF.