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Terrestrial carbon cycle feedbacks in the Earth system models

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Anthropogenically emitted CO2, which is partly absorbed by land and ocean ecosystems, produces energy imbalance on the Earth due to its greenhouse effect and leads to global climate change. Changes in atmospheric environment such as global warming and CO2 increase can alter the various processes in the land ecosystems (e.g. photosynthesis, evapo-transpiration, ecosystem respiration, plant growth, and mortality). So far, two processes have been considered to be the major processes of the impact from environmental changes on terrestrial carbon cycle. The first is the climate impact on land ecosystems that is often called ”climate-carbon feedback”. One of the examples of this process is the enhanced ecosystem respiration due to warming, which can accelerate CO2 increase in the atmosphere. The second is the impact of CO2 increase on the land ecosystems. As CO2 has a ”fertilization effect” on plants because elevated CO2 stimulates photosynthesis, plant growth can be promoted and resultant carbon accumulation occurs. This process is sometimes called ”concentration-carbon feedback” and works as a negative feedback against CO2 increase in the atmosphere. The balance of these two processes determines the magnitude of net carbon uptake in terrestrial ecosystems and thus could affect the degree of global warming. In this study, the strength of the carbon cycle feedbacks were evaluated by the Earth system models, which are advanced from climate models by incorporating biogeochemical processes and have been commonly used for long-term climate projections. First, we applied several scenarios to an ESM and found that the response of carbon cycle feedback evaluated by cumulative airborne fraction showed large variation among scenarios, likely due to the different response of concentration-carbon feedback across scenarios. Second, we applied a common scenario to multi-ESMs (this analysis was conducted as a joint research) and found that the strength of concentration-carbon feedback in terrestrial ecosystems showed the largest inter-model variation, largely affecting global carbon budget. This inter-model variation produces uncertain estimates of compatible fossil fuel emission that is the amount of emitted carbon to achieve a given atmospheric CO2 pathway and calculated from the carbon budget estimated by ESMs. From these results, it was suggest that the strength of concentration-carbon feedback in terrestrial ecosystem is a key to reduce the uncertainty of projected climate by ESMs.