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Limitations of global terrestrial biosphere models used for future climate projections

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Processes in terrestrial ecosystems, to large extent, are controlled by changes in climate and CO_2 concentration. In turn, geographical distribution of ecosystems and plant physiology strongly affect heat, moisture, and momentum fluxes between land surface and atmosphere. These interactions form a feedback loop between terrestrial biosphere and climate which modulates substantially the Earth system dynamics on different time scales. Experiments with coupled atmosphere-vegetation models suggest that these interactions could be strong enough to support multiple steady states in the climate-vegetation system. However, how robust are the models of terrestrial biosphere, and how good are constraints on the terrestrial biosphere processes? Intercomparison of land surface models included into the Earth system models used for future climate and CO_2 projections reveals a remarkable dissimilarity among different models. One of key uncertainties is our limited understanding of the ecosystem response to the increase in the atmospheric CO_2 concentration. The CO_2 fertilization of terrestrial productivity is included into all models; however the availability of nutrients such as nitrogen and phosphate necessary for the biomass buildup is usually neglected. Another example of poorly constrained process is a response of soil organic carbon to elevated temperature, which is especially essential for permafrost regions. A proper representation of the land surface heterogeneity requires running the global models on very high spatial resolution, and this is still beyond the computational capacity of the Earth system models. These and other limitations of current generation of terrestrial biosphere models as well perspectives of the model development will be discussed.