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Forcing climate variability has large impacts on terrestrial carbon storage in a dynamic global vegetation model

Andreas Krause, Katharina Küpfer, and Anja Rammig
TUM School of Life Sciences Weihenstephan, Technical University of Munich, Germany (andy.krause@tum.de)

Terrestrial carbon storage is largely driven by prevailing climate conditions. However, ecosystems are not only affected by mean climate conditions but also by day-to-day climate variability, which is projected to increase in the future. Here we explore the effects of low vs. high climate variability on global terrestrial carbon storage in the dynamic global vegetation model LPJ-GUESS. Low variability corresponds to linear interpolation between monthly means while high variability corresponds to daily means. We conduct three factorial simulations: one driven by low variability for temperature, radiation, and precipitation; one with low temperature and radiation variability but high precipitation variability; and one with high variability for all climatic drivers. All three options are commonly used in existing LPJ-GUESS studies but have so far not been compared to each other in terms of carbon cycle impacts. Surprisingly, the low variability simulation results in the smallest terrestrial carbon stocks globally (1963 Gt C), while low temperature/radiation variability but high precipitation variability simulates the largest carbon storage (2171 Gt C). Differences are most pronounced in high latitudes and deviations from the global trend also occur in some regions. Exploring the underlying processes, we find that differences in carbon stocks are largely driven by differences in ecosystem productivity. In LPJ-GUESS, high precipitation variability increases nitrogen availability via enhanced nitrogen mineralisation and reduced leaching, thereby promoting plant growth. In contrast, high temperature variability decreases productivity as the optimum temperature range for photosynthesis is often exceeded in temperate and boreal regions. Differences in fire mortality and soil water availability across simulations seem to be less important. Our results suggest that future changes in climate variability could impact ecosystem carbon storage via subtle effects on photosynthesis and coupled carbon-nutrient cycling. They also imply that ecosystem modellers need to be aware that changing the temporal resolution of the input climate (e.g. from monthly to daily means) may substantially affect their simulation results.