Assessing the representation of the Australian carbon cycle in global vegetation models

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Australia plays an important role in the global terrestrial carbon cycle on inter-annual timescales. While the Australian continent is included in global assessments of the carbon cycle, the performance of dynamic global vegetation models (DGVMs) over Australia has rarely been evaluated. We assessed simulations of net biome productivity (NBP) and the carbon stored in vegetation between 1901 to 2018 from 13 DGVMs (TRENDY v8 ensemble). The TRENDY models simulated differing magnitudes of NBP on inter-annual timescales, leading to marked differences in carbon accumulation in the vegetation on decadal to centennial timescales. We showed that the
spread in carbon storage resulted from differences in simulated carbon residence time rather than differences in net carbon uptake. Differences in simulated long-term accumulated NBP between models were mostly due to model responses to land-use change. The DGVMs also simulated different sensitivities to atmospheric CO\textsubscript{2} concentration. Notably, models with nutrient cycles did not simulate the smallest response. While our results suggested that changes in the climate forcing do not have a large impact on the carbon cycle on long timescales, the inter-annual variability in precipitation drives the year-to-year variability in NBP. We analysed the impact of key modes of climate variability, including the El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD). While the DGVMs agreed on sign of the response of NBP to El Niño and La Niña, and to positive and negative IOD events, the magnitude of inter-annual variability in NBP differs strongly between models. In addition, we identified simulated phenology and fire as associated with high model uncertainty, indicating differences in simulated vegetation composition and process representation. Model disagreement in simulated vegetation carbon, phenology and carbon residence time imply different types of vegetation cover across Australia between models, whether prescribed or resulting from model assumptions. Our study highlights the need to evaluate parameter assumptions and key processes that drive vegetation dynamics, such as phenology, mortality and fire, in an Australian context to reduce uncertainty across models.