Adding ^{13}C and ^{14}C to a Global Dynamic Vegetation Model: Can Isotopes Help Us Improve Process-Based Model Fluxes and Atmospheric Inversions?

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Predicting future terrestrial carbon storage is essential to understanding feedbacks on the climate system and informing policies concerning CO_2 emissions and land management. To predict the effect of warmer temperatures and higher CO_2 on vegetation and soils, process-based models need accurate numerical representations of photosynthesis, respiration, below-ground turnover rates, and plant community change. However, calculations of these key processes carry significant uncertainties and differ considerably between models. In addition to model structure differences, models also differ in their consideration of acclimation of plants and microbial respiration to previous temperatures, which has become an emergent trend among newer vegetation models. In this study, we add carbon isotopes to the Lund-Potsdam-Jena (LPJ) dynamic global vegetation model (DGVM), which includes representations of fire, agricultural management, and population dynamics. Simulating carbon isotope fluxes in LPJ can help disentangle the influences of gross primary productivity (GPP) and ecosystem respiration (R_{ECO}) on the seasonal dynamics of net ecosystem exchange (NEE) as well as provide information on plant water use efficiency and carbon turnover rates. We compare modeled total carbon and carbon isotope values of GPP, R_{ECO}, and NEE at daily to monthly scales with different numerical representations of respiration and photosynthesis to measurements at two flux tower sites (Harvard Forest and Niwot Ridge) where researchers have measured carbon isotope ratios (^{13}C) of CO_2 at high temporal frequencies. We also compare predicted below-ground $D^{14}C$ to measured bulk soil $D^{14}C$ to evaluate the accuracy of the modeled below-ground carbon turnover rates. Furthermore, modeled global fluxes of ^{13}C and ^{14}C are used in an atmospheric inversion to represent isotope disequilibrium from the biosphere. Currently, the model is run with only natural vegetation; however, land use and age class subroutines are under development, which will help improve model accuracy in managed lands.

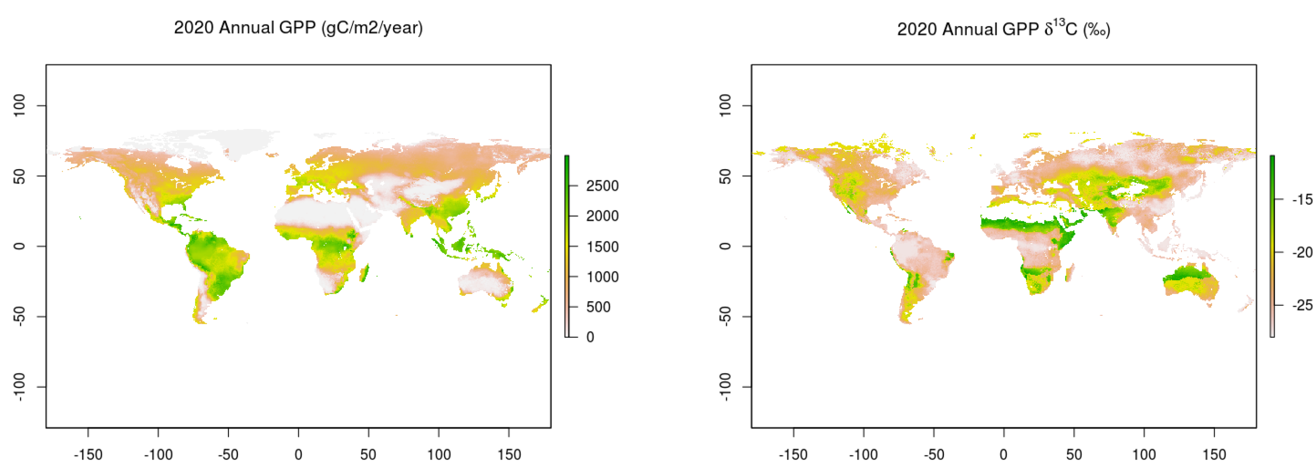

Figure 1. Left: LPJ model simulated annual bulk carbon GPP flux for 2020 in gC/m2/year. Right: LPJ model simulated annual GPP flux carbon isotope ratio (d13C) in permil.