# (42-240329-C) **Exploring Terrestrial $CO_2$, $^{13}CO_2$, and $^{14}CO_2$ Fluxes with the LPJ Dynamic Vegetation Model**

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Predicting future terrestrial carbon storage is essential to understanding feedbacks within the carbon-climate system and informing policies concerning $CO_2$ emissions mitigation and land management. To predict the effect of warmer temperatures and higher $CO_2$ on vegetation and soils, process-based models require accurate numerical representations of key processes, including photosynthesis, respiration, turnover rates of below-ground carbon, and plant community change. However, representations of these processes carry significant uncertainties and differ considerably between models. In this study, we add carbon isotopes ($^{13}C$ and $^{14}C$) to the Lund-Potsdam-Jena (LPJ) dynamic global vegetation model (DGVM), which also includes representations of fire, agricultural management, and vegetation population dynamics. Simulation of carbon isotope fluxes in LPJ provides for the application of additional observational constraints that can help separate the influences of gross primary productivity (GPP) and ecosystem respiration ($R_{ECO}$) on the seasonal dynamics of net ecosystem exchange (NEE) as well as providing additional information on plant water use efficiency and below-ground carbon turnover rates. Here we simulate land fluxes for $CO_2$, $^{13}CO_2$, and $^{14}CO_2$ from 1901-2022 using LPJ in a set of model runs changing parameters related to the temperature response of photosynthesis and respiration, isotope fractionation, age class, permafrost, and land use change. Modeled global land-atmosphere isotope disequilibrium fluxes of $^{13}C$ and $^{14}C$ from 1901-2022 are compared to previous estimates of global isotope disequilibrium fluxes. Simulated fluxes of bulk $CO_2$, $^{13}C$, and $^{14}C$ associated with unique combinations of model parameters and assumptions are then transported using the TM5 atmospheric transport model and evaluated by comparison to observations of all three quantities ($CO_2$, $d^{13}CO_2$, and $D^{14}CO_2$) in measurements obtained from NOAA global monitoring sites around the world.

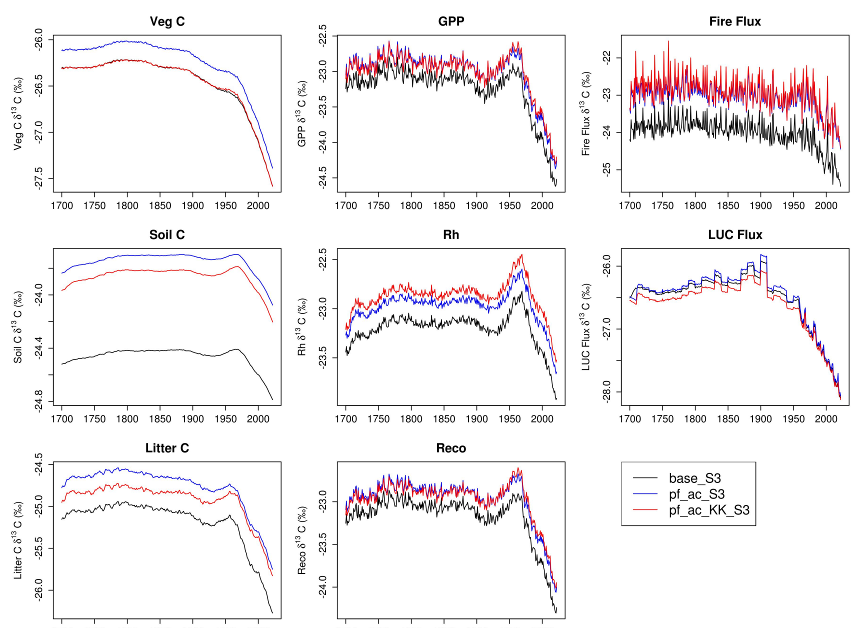


**Figure 1.** Modelled $\delta^{13}C$ values of global carbon pools (vegetation, soil, and litter) and fluxes (gross primary productivity, ecosystem respiration, heterotrophic respiration, fire, and landuse change) for 3 LPJ simulations which test the effects of permafrost (pf), ageclass (ac), and Vcmax temperature scaling (KK) and all using the TRENDY S3 protocol.