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Mathematical Reconstruction of Land Carbon Models From Their Numerical Output: Computing Soil Radiocarbon From 12C Dynamics

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Radiocarbon (^{14}C) is a powerful tracer of the global carbon cycle that is commonly used to assess carbon cycling rates in various Earth system reservoirs and as a benchmark to assess model performance. Therefore, it has been recommended that Earth System Models (ESMs) participating in the Coupled Model Intercomparison Project Phase 6 report predicted radiocarbon values for relevant carbon pools. However, a detailed representation of radiocarbon dynamics may be an impractical burden on model developers. Here, we present an alternative approach to compute radiocarbon values from the numerical output of an ESM that does not explicitly represent these dynamics. The approach requires computed ^{12}C stocks and fluxes among all carbon pools for a particular simulation of the model. From this output, a time‐dependent linear compartmental system is computed with its respective state‐transition matrix. Using transient atmospheric ^{14}C values as inputs, the state‐transition matrix is then applied to compute radiocarbon values for each pool, the average value for the entire system, and component fluxes. We demonstrate the approach with ELMv1‐ECA, the land component of an ESM model that explicitly represents ^{12}C, and ^{14}C in 7 soil pools and 10 vertical layers. Results from our proposed method are highly accurate (relative error <0.01%) compared with the ELMv1‐ECA ^{12}C and ^{14}C predictions, demonstrating the potential to use this approach in CMIP6 and other model simulations that do not explicitly represent ^{14}C.