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Using model reduction to predict the soil-surface $C^{18}OO$ flux: an example of representing complex biogeochemical dynamics in a computationally efficient manner

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Abstract. Earth system models (ESMs) must calculate large-scale interactions between the land and atmosphere while accurately characterizing fine-scale spatial heterogeneity in water, carbon, and other nutrient dynamics. We present here a high-dimension model representation (HDMR) approach that allows detailed process representation of a coupled carbon and water tracer (the $\delta^{18}O$ value of the soil-surface CO_2 flux (δF_s)) in a computationally tractable manner. δF_s depends on the $\delta^{18}O$ value of soil water, soil moisture and temperature, and soil CO_2 production (all of which are depth dependent), and the $\delta^{18}O$ value of above-surface CO_2. We tested the HDMR approach over a growing season in a C_4-dominated pasture using two vertical soil discretizations. The difference between the HDMR approach and the full model solution in the three-month integrated isoflux was less than 0.2% (0.5 mol m^{-2} ‰), and the approach is up to 100 times faster than the full numerical solution. This type of model reduction approach allows representation of complex coupled biogeochemical processes in regional and global climate models and can be extended to characterize subgrid-scale spatial heterogeneity.

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