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Soil Moisture Control on the Temporal Scaling and Prediction of Soil Respiration

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Understanding the temporal variability and dependencies of carbon fluxes is critical to robustly scaling individual measurements across time and space. In particular, soil respiration (R_S), the soil-to-atmosphere CO_2 flux that originates from both heterotrophic and autotrophic sources, is a key component of the carbon cycle but difficult to predict. R_S at collar- to ecosystem- scales is controlled by a complex cascade of biotic and abiotic processes, and soil moisture has emerged as a key but complex factor: in conjunction with soil structure it regulates soil organic carbon and nutrient bioavailability, driving microbial activities, but its importance varies across temporal and spatial scales. We examined the degree to which R_S at long timescales can be predicted by its flux at mean annual temperature, an idea first advanced by Bahn et al. (2010), and how this relationship varies under different soil moisture regimes and in long-disturbances such as drought. Monthly and annual databases of measured R_S flux are used to test the robustness, accuracy, and bias of the Bahn scaling under different soil moisture (as well as other abiotic and biotic) conditions. These results can also be linked to pore-to-core scale analyses that examine the laboratory sensitivity of heterotrophic respiration to imposed drought and rewetting conditions. Because R_S cannot be measured over large spatial scales, and over continuous temporal scales only to a very limited extent, robust scaling mechanisms are the key to credible gap filling, as well as producing the wall-to-wall data products necessary for global flux assessments and earth system model benchmarking.