Continental-Scale Soil Organic Carbon Composition and Vulnerability Regulated by Regional Soil and Environmental Controls

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Processes that control soil organic carbon (C) composition and dynamics over large scales are not well understood. Thus, our understanding of C cycling is incomplete, making it difficult to predict C gains and losses due to changes in climate, land use and management. In this paper, we show that controls on the composition of organic C, the particulate, humus (or mineral associated) and resistant fractions, and the potential vulnerability of C to decomposition across Australia are distinct, scale-dependent and variable. We used machine-learning with 5,721 topsoil measurements to show that, continentally, climate, soil properties such as total nitrogen and pH, and topography are dominant controls. But, such general assessments disregard underlying region-specific controls that affect the distribution of the C fractions and vulnerability, potentially leading to misinterpretations that prejudice our understanding of soil C processes and dynamics. At the regional scale, climate is mediated through interactions with soil properties, mineralogy and topography. In some regions, climate is isn't important. Our results highlight the need for regional assessments of soil C dynamics and more local parameterization of biogeochemical and Earth system models. The analysis propounds the development of region-specific strategies for effective C management and climate change mitigation.