Title: **Dynamic roots alter the legacy strength of terrestrial ecosystems in an Earth System Model**

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Project Abstract:

The response of terrestrial ecosystems to climate perturbations typically persist longer than the timescale of the forcing, a phenomenon that is broadly referred to as *ecosystem legacy*. Understanding the strength of legacy is critical for predicting ecosystem sensitivity to climate extremes and the extent to which disturbances in land surface-atmosphere exchange might feedback onto the climate, for example, extending drought. Here we focus on the relatively unexplored role that changes in root profiles in response to perturbation (i.e. drought and pluvials) play in altering an ecosystem's recovery time. We use a series of global Earth System Model simulations with the E3SM model that include a dynamic root module where vegetation can forage for water and nutrients by altering their root profiles. As expected, the simulations show that in response to stress events most ecosystems deepen their root profiles. In semi-arid ecosystems, the deeper root profiles lead to a more rapid recovery (i.e. less legacy) than simulations without dynamics roots because access to deeper water pools after the initial event remains favorable. In wetter ecosystems, the development of deeper root profiles slows down the recovery timescale because water stress does not persist and the deeper root profile reduces access to nutrients in the shallower soils (i.e. more legacy). Similarly, in hyperarid systems the recovery is also delayed by deep root foraging due to reduced access to shallow soil water from smaller rain events. The results show that the response of root profiles to external forcing alters the legacy timescale in a direction that is predictable based on the baseline water stress. This dynamic is a critical component of global patterns of legacy that is not typically represented in Earth System Models. We will extend this global analysis to more detailed site scale studies as well as add more complex consideration of root allocation and turnover time schemes for fine root carbon with the E3SM model.