Title: **Global patterns of ecosystem legacy associated with dynamic roots and extended root turnover times in E3SM**

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Project Abstract:

The fine root profile of ecosystems exhibits dynamic behavior in response to external forcing that influence soil moisture and the carbon pools available for root growth. However, in most Earth System Models the fine root profiles are defined by the plant functional type (PFT) and remain static in spite of external forcing. The absence of dynamic roots leads to modeled ecosystems that are unable to take advantage of available resources. However, if root profiles are too responsive to changes in soil moisture then they ultimately lose sensitivity to water and nutrient stress. This can be adjusted by modifying root turnover times such that fast turnover times increase the capacity for root profiles to respond to fleeting resource pools such as shallow water after a rain storm whereas slow turnover times lead to root profiles that have multi-year legacies. Here, we take advantage of a recently developed dynamic root module for the E3SM model to explore both how dynamic roots respond to changes in precipitation and how changes in the root profile influence the interannual legacy in ecosystems. We ran a series of 6 E3SM simulations through the historical period, which (1) either include or exclude dynamics roots, (2) have enhanced or default water sensitivity and (3) have fine root turnover times that are either default or doubled in length. Using this ensemble of simulations, we firstly compare how root profiles of the same PFT and similar mean climate state differ in response to changes in precipitation frequency (i.e. the mean interval between rainfall events). Observational data suggest that ecosystems experiencing large but infrequent rain events are going to develop deeper root profiles whereas locations with frequent small events will favor shallower roots. We will explore how this process emerges at the global scale for all PFTs and how sensitive this is to changing root turnover time. Secondly, we compare the legacy of ecosystems, defined as autocorrelation in gross primary productivity (GPP) anomalies, at seasonal to interannual timescales to assess how the combination of dynamic roots with variable turnover times influence aboveground productivity through changes in access to resources. The model results are compared against legacy assessment of the monthly SatFlux GPP product derived from OCO-2 and MODIS satellites. This work will continue through the development of a more sophisticated routine for defining root turnover times and through new observational data from a network of AmeriFlux sites.