Dryland feedbacks to future climate: Strong interactions among climate, biota, carbon cycling, and energy balance

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Like all ecosystems, drylands are made up of multiple classes of biota with varied physiologies, survival strategies, and life history traits. A factor that binds dryland organisms together is the harshness of their environment, and that these ecosystems that are characterized by high temperature and aridity are also predicted to become hotter and drier still. Here we present data from a variety of timescales that show how different climate drivers (e.g., increased temperature and multiple altered precipitation treatments) affect the community composition, carbon cycling, and energy balance of a dryland on the Colorado Plateau, USA. Using automated CO_2 flux data from climate manipulation plots, we show substantial exchange of CO_2 between biological soil crusts and the atmosphere. Our recent data highlight how these biocrust CO_2 fluxes are partitioned into net primary productivity and respiration, how these discrete fluxes are differentially affected by increased temperature, and how they are temporally decoupled from the fluxes of vascular plants. This new insight allows us to create dryland biogeochemical models that explicitly include biocrusts, and to test hypotheses about how future climate will affect dryland carbon cycling, both via changes to existing communities and through shifts in community composition. Interestingly, such community shifts not only affect the cycling of carbon and nutrients, but also have strong effects on surface albedo. We have combined our results with global biocrust distribution datasets to estimate radiative forcing effects of predicted climate-induced changes to biocrust communities, and have found incredibly strong negative forcing potential under future climate scenarios. In addition, we have discovered strong patterns between interannual variability in climate and climate manipulation treatments. For example, while the cover, phenology, and physiology of vascular plant species are significantly affected by experimental warming, the interannual variation in climatic extremes has a stronger overall effect on the vegetation community than warming treatments alone. Our results suggest background rates and magnitudes of climate change will interact with extreme climate events to shape future vegetation community structure and ecology. Taken together, these data represent a significant step forward in our understanding of and capacity to forecast how different dryland organisms, biogeochemical cycles, and energy fluxes will respond to a range of future climates.