Title: **Droughts and Deluges in Semi-Arid Grassland Ecosystems: Implications of Co-occurring Extremes for C Cycling**

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Project Abstract:

Intensification of the global hydrological cycle is increasing the frequency of extreme climate perturbations including multi-year droughts and deluges (persistent, torrential rain events). Such climate extremes are known to have substantial impacts on ecosystem structure and function, but when these co-occur as compound climate extremes, their impacts are expected to exceed their independent effects. The overall goal of our proposed research is to assess how co-occurring drought and deluge climate extremes will impact key C cycling processes known to be important for carbon-climate feedbacks. We will address this goal via research in the 280,000 km^2 semi-arid shortgrass steppe ecoregion located at the western edge of the US Great Plains. Our research project will test the hypothesis that when a compound climate perturbation of an extreme deluge occurring within the backdrop of extreme drought, a combination of conditions converge (e.g., warm temperatures, abundant soil moisture, and increased soil N availability) to strongly stimulate C cycle processes, potentially resulting in "hot moments" or landscape-level "hot spots" (i.e., increases in biogeochemical processes in time or space that far exceed background levels). To test this hypothesis, we will conduct a field experiment designed to quantify the magnitude of C cycling responses to drought and deluge events (independently and combined) and identify the underlying mechanisms resulting in positive drought-deluge interactions that can lead to hot moments of C cycling. Both above- and belowground C cycle responses to climate extremes will be quantified during this 3-yr experiment. To scale-up from the plot-level experiment to the shortgrass steppe ecoregion, we will use historical climate data to quantify the regional frequency of potential drought-deluge interactions and remote sensing products to estimate C cycling sensitivity to droughts, deluges and their combined effects and to identify hot spots in C cycling regionally. Concurrent with these research activities, we will simulate extreme drought, deluge and drought-deluge perturbations with DOE's E3SM Land Model (ELM). We will explicitly compare the experimental results and remotely

sensed observations of drought-deluge compound climate perturbations to ELM simulations, with the expectation that the process-level understanding gained from our field experiment and remote sensing analyses can be used to constrain process representation and parameterization in ELM, and to improve Earth System projections of ecosystem C-cycling responses to droughts and deluges at the ecoregion scale.