Overview:

The US has incurred billions of dollars in damage from extreme weather and climate disasters linked to anthropogenic climate change since 1980s. However, studying modern landscape response to climate change is difficult due to the lag time for clastic sedimentation, and the need for data from warmer climates under a range of pCO_2 levels to improve earth systems models and better understand regional variability. The regional response is especially important in the western US, which is sensitive to climate change due to high topography and sediment yield. For this data, we must look to the past, and the early Eocene carbon cycle perturbations and hyperthermal events provide an excellent analog for the predicted levels of warming and rapid increases in pCO_2. Terrestrial biological effects of these hyperthermals, such as the dwarfing of mammalian species and the northward migration of dry-adapted, tropical plant taxa, are well studied, but the physical landscape response is poorly understood. I propose to generate new terrestrial paleoclimate records from three fluvially dominated basins from the western US: 1) San Juan Basin of New Mexico, 2) Wind River Basin of Wyoming, and 3) Williston Basin of North Dakota. I will use a novel method that integrates datasets from both sandstone channel facies and floodplain paleosols to test the hypothesized connection between hyperthermals and the large sand bodies and thick packages of kaolinite previously identified in these basins. This multi-proxy approach uses bulk geochemistry, mineralogy, stable isotopes ($\delta^{13}C$, $\delta^{18}O$, and Δ_{47}), sedimentology and stratigraphy, sandstone petrography, detrital zircon and $^{40}Ar/^{39}Ar$ geochronology, and magnetostratigraphy to reconstruct the paleoclimate and constrain landscape response to the hyperthermal events both spatially and temporally. I will integrate this dataset into quantitative models to test how rapid pCO_2 increases, global warming, and the resulting hydrologic cycle intensification increase the magnitude of weathering and sediment yield, which cause billions of dollars in damage to infrastructure and ecosystems from soil loss, erosion, and increased flooding.

Intellectual Merit:

The proposed research integrates multiple fields of the earth sciences - paleopedology, sedimentary geology, paleoclimatology, geomorphology, and geochronology - to generate new paleoclimate and pCO_2 records for three understudied basins across a latitudinal gradient in the western US, which will provide new datasets that can be integrated into earth systems models. Modeling results from this study will provide insights into how global warming driven changes in monsoon intensity and extreme rainfall events will affect sediment yield, weathering rates, and fluvial morphology and address a long-standing need in the community to understand the lag times in clastic sedimentary systems associated with climate change by quantifying the amount and duration of sedimentological and geomorphological change. Improved chronostratigraphy from this study will also benefit ongoing paleontological and paleobotanical studies as well as provide new paleoclimate context for early Eocene mammalian and plant evolutionary developments.

Broader Impacts:

This project supports my long-term goals of 1) improving diversity, equity, inclusion in the earth sciences and 2) reconstructing climates throughout earth's history to better understand the context in which organisms evolved and use that knowledge to influence the future of our planet. The proposed project will support an early career female scientist at the University of Houston (UH), which is the second most ethnically diverse R1 research university in the US. This proposal will support the education and training of 1 postdoctoral fellow, 2 PhD students, and >10 undergraduate students at a diverse R1 research university. Fieldwork financial aid, including a field gear stipend, will encourage participation of UH undergraduate students because these experiential learning activities for undergraduates are not possible at UH without the support of grant funding. This project will also support participation of underrepresented minorities and persons with disabilities in field experiences through the creation of a Virtual Field Trip of the San Juan Basin. Petrographic thin sections of sandstones and paleosols, which are difficult to share, will be digitized using the open access UK Virtual Microscope for Earth Sciences allowing any educators to teach a petrography module and providing the first examples of paleosols. Additional open access education modules will be developed using the products generated by this project, including paleoclimate and sedimentological datasets, and published for use by all earth science educators. Outreach activities will focus on novel science communication through art via collaboration with an internationally recognized climate artist to create science-data watercolor paintings. We will also develop a transformative interdisciplinary science data-art curriculum for 3rd to 8th graders from Houston communities historically underrepresented in STEM fields.