Collaborative Research: WSC-Category 3 - Toward Sustainability of the High Plains Aquifer Region: Coupled Landscape, Atmosphere, and Socioeconomic Systems (CLASS)

Project Summary

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The High Plains region hosts some of the most productive irrigated agricultural land in the United States, made possible by one of the largest contiguous aquifer systems in the world, the Ogallala-High Plains aquifer complex (henceforth, HPA). Much of the HPA is on a fundamentally unsustainable path, having been drawn down by over 300 km^3 since the 1930s. Portions of the aquifer are already substantially depleted, necessitating large-scale conversions to dryland farming and disrupting physical and social systems in those areas. What the future holds for this region is highly uncertain, as it will be dictated by a patchwork of state laws and regulations, complex economic drivers, variable soil productivity and saturated thicknesses, and a changing climate that is forecast to increase the severity of existing regional precipitation and evapotranspiration gradients. This collaborative research project will focus on the range of possibilities the future holds for this critically important agricultural region by exploiting the great wealth of data and modeling results from decades of intense study to revolutionize the understanding of feedbacks among climate, hydrology, and agroecosystems. Our interdisciplinary team proposes to simulate the coupled landscape, atmospheric and socioeconomic systems (CLASS) associated with the HPA. We will link process-based climate, hydrology, dynamic vegetation, and econometrics models to explore historical changes and develop fundamental insights into system interactions and feedbacks. Our unprecedented modeling suite will provide a powerful tool to quantify the impacts of a range of possible future social, economic, climate, agroengineering, and land-management conditions on the sustainability of the region's hydrology and economy.

Intellectual Merit: This interdisciplinary effort, with state-of-the-art models describing the social, economic, engineering, biological, hydrologic, and climatic aspects of agricultural production, is unprecedented in scope. The linked models will allow us to better understand and quantify interactions among landscape, atmospheric, agroengineering, and socioeconomic systems over the HPA that will be relevant to irrigated agricultural systems worldwide. Our proposed approach will quantify different levels of sustainability for the region's agricultural practices in the face of increasing demand for agricultural products from an expanding world population, highly variable energy prices, and climate change. The models will simulate diurnal processes over seasonal to century timescales, allowing us to investigate the likely impacts of short-term perturbations and long-term trends. We propose to simulate the entire region at approximately 1 km^2 resolution, providing policy makers and managers with local information within a regional context. This experienced interdisciplinary research team has deep familiarity with the High Plains region, and mastery of the informatics and computational tools required to understand processes and systems at the proposed spatial and temporal scales.

Broader Impacts: The proposed research will provide a powerful modeling system that can inform better management of regional water usage, yields, nutrients applications, and soil carbon sequestration, and offer transformative insights into the sustainability of one of the world's most important agricultural regions. This research will also help raise public awareness of critical links between climate change and biophysical, agroengineering, and socioeconomic systems. Results will be presented to policy makers, planners, and the public directly and via already effective web sites to inform policies that can improve the sustainability of the HPA and other aquifer systems. Students working on the project team will be embedded in science at the interface between disciplines, providing them with in-depth knowledge in their fields along with an ability to work in broad interdisciplinary physical and social science teams. The models and linkages used here can be applied to agricultural systems worldwide and will be made freely available to the research community.