

Simulations of the High Plains drought of 2012 using the Super-parameterized Community Earth System Model (SP-CESM)

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Abstract. The impact of changes in the frequency and severity of drought on fresh water sustainability is a great concern for many regions of the world. One such location is the High Plains, where fresh water withdrawals from the Ogallala aquifer accounts for approximately 30% of total irrigation withdrawals from all U.S. aquifers combined. Research has shown a decline in water levels underlying the High Plains since the onset of intensive irrigation practices (~1950), and has focused on sustainable agricultural systems and irrigation techniques for reducing groundwater withdrawals. Studies focusing on the climate and eco-hydrologic feedbacks have been limited and have used conventional General Circulation Models (GCMs) that have grid length scales ranging from one hundred to several hundred kilometers. Additionally, these models utilize crude statistical parameterizations of cloud processes for estimating sub-grid fluxes of heat and moisture and have a poor representation of land surface heterogeneity. To mitigate these problems, we introduced the Colorado State University Multi-scale Modeling Framework (CSU MMF), a super-parameterized GCM (SP-GCM), in which a 64-column 4 km horizontal resolution cloud resolving model (CRM) is embedded within each host GCM grid cell, replacing the traditional parameterizations used in GCMs. Thus, within a single framework, a SP-GCM can represent scales of atmospheric motion (hundreds of km) as well as the mesoscale and cloud scale. For this research, the High Plains drought of 2012 will be simulated using the Super-parameterized Community Earth System Model (SP-CESM), a SP-GCM where each CRM column is coupled to a land surface model (i.e., 64 land surface models within each SP-GCM grid cell as opposed to a single land surface model) allowing for greater land surface heterogeneity. Simulated hydrologic and atmospheric components will be compared to observations as well as those simulated from the Giga-LES, a very fine scale model that explicitly resolves CRM sub-grid scale components such as individual cloud elements and turbulence. It is important for models to simulate past climatic events, such as droughts, in order to better predict them in the future. With the SP-CESM, the improved representation of the slow varying components of the earth system (e.g., soil moisture heterogeneity) and the higher resolution atmospheric response to those components is a very promising tool that will be necessary for future climate simulations over the High Plains.