

Hydrologic Cycle Alterations to Different Climate Change Scenarios in a Tallgrass Prairie: A Modeling Analysis

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To compare the interaction of global climate change factors on individual ecohydrological processes in a terrestrial ecosystem, model simulations were run through a mechanistic ecosystem model. In this study, we used a terrestrial ecosystem (TECO) model to examine effects of climate warming, elevated CO₂, and altered precipitation on plant production, water relations, and soil moisture in a North American tallgrass prairie. We examined 75 scenarios from single and double-factor combinations with 5 levels of climate warming, 5 levels of CO₂ concentration from ambient and 5 levels of precipitation. There were also triple-factor simulations of extreme atmospheric climate change scenarios to show possible ecohydrological interactions. Our modeling results show that runoff, evaporation, transpiration, and rooting zone soil moisture (RZSM) strongly responded to changes in temperature and precipitation. Runoff decreased by 50% with a 10 °C increase in temperature and increased by 250% with doubled precipitation. ANPP was additively affected by dual combinations of temperature, CO₂, and precipitation and optimized approximately at 5 °C of warming, doubled precipitation and doubled CO₂ concentration. Rain-use efficiency (RUE) increased with CO₂, decreased with precipitation, and optimized at 4-6 °C of warming. In contrast, plant-level water-use efficiency (WUE) was highest at doubled CO₂, doubled precipitation, and ambient temperature. The diverse responses of RUE and WUE signify that processes at different scales responded uniquely to climate change. In particular, the fact that runoff, a major component to replenishing freshwater, changed in a distinct fashion in response to different climate change scenarios has implications in regional policy issues.

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