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Ecosystem Response to Monsoon Rainfall Variability in Southwestern North America

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Due to its marked plant phenology driven by precipitation, the North American Monsoon System (NAMS) can serve to reveal ecological responses to climate variability and change in water-controlled regions. This study attempts to elucidate the effects of monsoon rainfall variability on vegetation dynamics over the North American Monsoon Experiment (NAME) tier I domain (20°-35° N, 105°-115° W). To this end, we analyze long-term dynamics (1982-2004) in seasonal precipitation (Pr), net primary production (NPP) and rain-use efficiency (RUE) based on phenological and biophysical memory metrics from NOAA CPC daily 1° gridded precipitation data and satellite GIMMS semi-monthly NDVI images at 8-km resolution. We focus our analysis on six diverse ecosystems spanning from semi-arid and desert environments to tropical deciduous forests to investigate: 1) the spatially averaged NPP/RUE profiles along the regional Pr gradient, 2) the linkage between NPP and Pr inter-annual variations and 3) the long-term trends of Pr, NPP and RUE. All the biomes show an increase (decrease) in mean NPP (RUE) along the mean seasonal precipitation gradient ranging from 100 to 900 mm. Variations in NPP/RUE profiles differ strongly across ecosystems and show threshold behaviors likely resulting from different physiological responses to climate effects and landscape features. Statistical analysis suggests that the inter-annual variability in NPP is significantly related to the temporal variability in precipitation. In particular, we found that forest biomes are more sensitive to inter-annual variations in precipitation regimes. Semi-arid ecosystems appear to be more resilient, probably because they are more exposed to extreme conditions and consequently better adapted to greater inter and intra-annual climate variability. The long-term positive signal in RUE imposed on its inter-annual variability, which results from a constant NPP under negative long-term trends of Pr, indicates an improved capacity of vegetation to exploit water resources.