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Climate change forecasts, long-term spatio-temporal prediction and the resilience of dry ecosystems

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Primary production is an important indicator to climatic changes in drylands, while reduction in productivity has many consequences on ecosystem functioning. We suggest that the response of dry ecosystems to climate change should lead to a change in spatial patterns of grasses without a substantial change in ecosystem resilience. We used field data and a recently published spatio-temporally explicit model to study factors affecting long-term variation in primary production in two dry ecosystems: semi-arid (SAE) and Mediterranean (DME) dominated by annual vegetation. The model was operated in both patch and landscape scales and was executed along 30 years (1979-2008) at SAE and along 21 years (1986-1990; 1993-2008) at DME. Model predictions were validated against samples that were harvested in each site at the end of the growing season, over 15 seasons (1994-2008) at SAE ($0.63<R^2<0.85$; $p<0.0001$) and 6 seasons (2003-2008) at DME ($0.53<R^2<0.66$; $p<0.001$). The long-term prediction has contributed to the delineation of production boundaries under different weather conditions. The model provided random simulations, based on the following 6 climate change scenarios: 1) Rainfall amount reduction; 2) Increase of 10% in annual evaporation rate and 5% in annual temperature; 3) Increase in the magnitude of rainfall events accompanied by reduction in their frequency and variation; 4) Postponement of the beginning of the growing season; 5) Large dry-spell at the mid-growing season; 6) Early ending of the growing season. The results show that: a) The reduction in rainfall amount (5-35%) did not affect the DME, but drastic reduction in rainfall amount (25-35%) showed spatial patterns change at the SAE. b) Similar results were found when temperature and evaporation increased at 5ºC and 10%, respectively; and when the magnitude of rainfall events increased while the frequency of rainfall events decreased and during a large dry spell at the mid season. c) Changes at temporal distribution especially at the beginning of the season showed at both environments the largest ANPP reduction followed by a change in the spatial patterns. d) Long-term data that was gathered during the last 3 decades indicated that both environments demonstrated high resilience under highly fluctuating annual weather conditions. These results imply that ecosystems in drylands respond to climate change scenarios mainly by spatial patterns changes while its resilience is expected to change only under severe scenarios than those predicted.