Simulating International Drought Experiment Field Observations Using The Community Land Model

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Anthropogenic climate change will alter regional hydrologic cycles around the world, in part by increasing the frequency or duration of droughts in some areas. The International Drought Experiment (IDE) is investigating the impact of severe drought on terrestrial vegetation by experimentally reducing precipitation at dozens of sites. Here we implement the IDE precipitation reduction protocol using the Community Land Model (CLM). Though many model results suggest that carbon fertilization will outpace drought-caused reduction of terrestrial carbon uptake, uncertainty is large. We therefore configure CLM to consider carbon cycling impacts of reduced moisture availability without intertwining the effects of carbon fertilization or phenological changes. California hosts a number of IDE sites and a wide range of topography, climate, and biomes. CMIP5 predictions suggest 21st century California will experience droughts in excess of the 1000-year climatological record for both frequency and magnitude. CLM suggests that some regions, including much of northern California, may experience a steeper decline in gross primary productivity (GPP) during 21st century severe droughts than during 20th century severe droughts. Vegetation in northern California experiences virtually all of this GPP reduction during the dry season, with little wet season GPP reduction even during severe drought. Southern California vegetation experiences soil moisture GPP limitation at virtually all times, increasing substantially with drought severity. Southern California should experience a more pronounced shift in GPP seasonality and decline in magnitude relative to northern California during droughts. Some parts of every vegetated continent see changes to drought response and seasonality similar to southern California. Our CLM results provide drought impacts that forthcoming IDE field observations may test, can help to spatially upscale site-based IDE observations of drought impact, and provide CLM's prediction of reduced precipitation impacts per unit leaf area index.

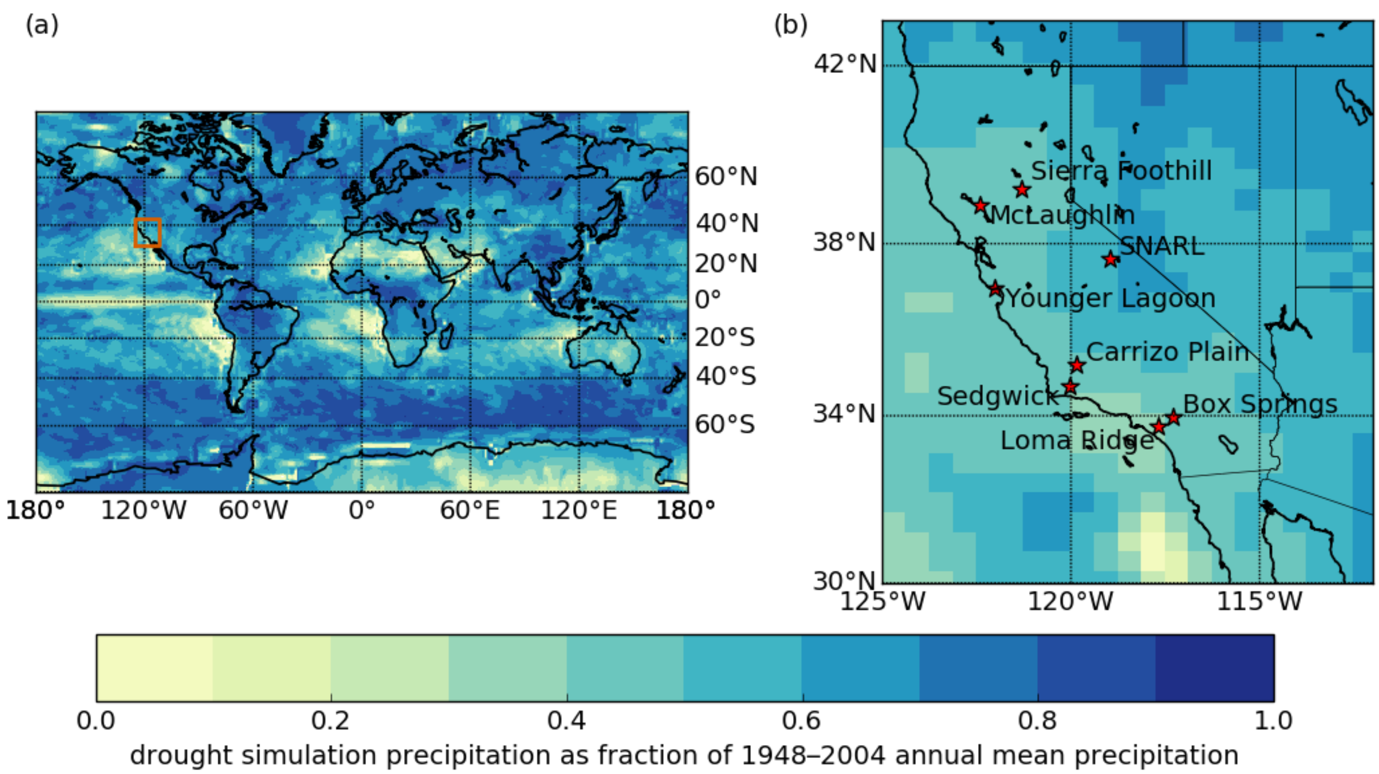

Figure 1. International Drought Experiment (IDE) per-gridcell precipitation reduction. Panel (a): global precipitation reduction as a fraction of the 1948–2004 annual mean total precipitation. Panel (b): same as panel (a), but zoomed to the California, U.S. analysis area [shown in the orange box in panel (a)]. Precipitation reduction fractions are calculated as [(1st percentile)/(50th percentile)] of the 1948–2004 (Qian et al., 2006) annual total precipitation. Red stars on panel (b) denote California analysis sites.