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Negative extreme events in gross primary productivity and their drivers in China during the past three decades

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Climate extremes have remarkable impacts on ecosystems and are expected to increase with future global warming. However, only few studies have focused on the extreme ecological events and their drivers in China. We therefore carried out an analysis of negative extreme events in gross primary productivity (GPP) in China and the sub-regions during 1982-2015, using monthly GPP simulated by 12 process-based models (TRENDYv6) and an observation-based model (Yao-GPP). Extremes were defined as the negative 5th percentile of GPP anomalies, which were further merged into individual extreme events using a three-dimensional contiguous algorithm. Spatio-temporal patterns of negative GPP anomalies were analyzed by taking the 1000 largest extreme events into consideration. Results showed that the effects of extreme events decreased annual GPP by 2.8% in TRENDY models and 2.3% in Yao-GPP. Hotspots of extreme GPP deficits were mainly observed in North China (-53 gC m^{-2} $year^{-1}$) in TRENDY models and Northeast China (-42 gC m^{-2} $year^{-1}$) in Yao-GPP. For China as a whole, attribution analyses suggested that extreme low precipitation was associated with $\sim$28% of extreme negative GPP events. Most events in northern and western China could be explained by meteorological droughts (i.e. low precipitation) while GPP in southern China was also vulnerable to temperature extremes, such as cold spells in South China. Power law exponent values for sizes of drought-induced extreme events were significantly smaller than wet related events, implying that drought events are more likely to result in large GPP negative anomalies than wet events. Combined with projected changes in climate extremes in China, GPP deficits caused by drought events in northern China and by temperature extremes in southern China might be more prominent in the future.