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Vegetation-Climate-Water coupling in a changing environment

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The directionality of the response of gross primary productivity (GPP) to climate has been shown to vary across the globe. This effect has been hypothesized to be the result of the interaction between multiple bioclimatic factors, including environmental energy (i.e. temperature and radiation) and water availability. This is due to the tight coupling between water and carbon cycling in plants and the fact that temperature often drives plant water demand. Using GPP data extracted from 188 sites of FLUXNET2015 and observation-driven terrestrial biosphere models (TBMs), we disentangled the confounding effects of temperature, precipitation and carbon dioxide on GPP, and examined their long-term effects on productivity across the globe. Based on the FLUXNET2015 data, we observed a decline in the positive effect of temperature on GPP, while the positive effects of precipitation and CO_2 were becoming stronger during 2000–2014. Using data derived from TBMs between 1980 and 2010 we found similar effects globally. The modeled data allowed us to investigate these effects more thoroughly over space and time. In arid regions, the modeled response to precipitation increased since 1950, approximately 30 years earlier than in humid regions. We further observed the negative effects of summer temperature on GPP in arid regions, suggesting greater aridity stress on productivity under global warming. Our results imply that aridity stress, triggered by rising temperatures, has reduced the positive influence of temperature on GPP, while increased precipitation and elevated CO_2 may alleviate negative aridity impacts.