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Multiyear Precipitation Reduction Strongly Decreases Carbon Uptake over Northern China

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Drought has been a concern in global and regional water, carbon and energy cycles. From 1999-2011, Northern China experienced a multiyear precipitation reduction that significantly decreased water availability as indicated by the Palmer Drought Severity Index and soil moisture measurements. In this study, a light use efficiency model (EC-LUE) and an ecosystem physiological model (IBIS) were used to characterize the impacts of long-term drought on terrestrial carbon fluxes in Northern China. EC-LUE and IBIS models showed that the reduction of averaged GPP of 0.09 and 0.05 Pg C yr-1 during 1999-2011 compared with 1982-1998. Based on the IBIS model, simulated ecosystem respiration underwent an insignificant decrease from 1999-2011. The multiyear precipitation reduction changed the regional carbon uptake of 0.011 Pg C yr-1 from 1982-1998 to a net source of 0.018 Pg C yr-1 from 1999-2011, and the ecosystem during the 13 years (1999 to 2011) released 0.23 Pg C to atmosphere which is 1.31 times that total carbon sink of 17 years prior to 1998 (0.18 Pg C). Moreover, a pronounced decrease in maize yield in almost all provinces in the study region was found from 1999-2011 versus the average of yield from1978-2011. The largest maize yield reduction occurred in Beijing (2499 kg ha-1 yr-1), Jilin (2180 kg ha-1 yr-1), Tianjing (1923 kg ha-1 yr-1) and Heilongjiang (1791 kg ha-1 yr-1), and the maize yield anomaly was significantly correlated with the annual precipitation over the entire study area. Our results revealed that recent climate change, especially drought-induced water stress, is the dominant cause of the reduction in the terrestrial carbon sink over Northern China.