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Extreme weather conditions reduce the CO_2 fertilization effect in temperate C3 grasslands

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The increase in atmospheric greenhouse gas concentrations from anthropogenic activities is the major driver of global climate change. The rising atmospheric carbon dioxide (CO_2) concentrations may stimulate plant photosynthesis and, thus, cause a net sink effect in the global carbon cycle. As a consequence of an enhanced photosynthesis, an increase in the net primary productivity (NPP) of C3 plants (termed CO_2 fertilization) is widely assumed. This process is associated with a reduced stomatal conductance of leaves as the carbon demand of photosynthesis is met earlier. This causes a higher water-use efficiency and, hence, may reduce water stress in plants exposed to elevated CO_2 concentrations ([eCO_2]). However, the magnitude and persistence of the CO_2 fertilization effect under a future climate including more frequent weather extremes are controversial. To test the CO_2 fertilization effect for Central European grasslands, a data set comprising 16 years of biomass samples and environmental variables such as local weather and soil conditions was analysed by means of a novel approach. The data set was recorded on a “Free Air Carbon dioxide Enrichment” (FACE) experimental site which allows to quantify the CO_2 fertilization effect under naturally occurring climate variations. The results indicate that the CO_2 fertilization effect on the aboveground biomass is strongest under local average environmental conditions. Such intermediate regimes were defined by the mean +/- 1 standard deviation of the long-term average in the respective variable three months before harvest. The observed CO_2 fertilization effect was reduced or vanished under drier, wetter and hotter conditions when the respective variable exceeded the bounds of the intermediate regimes. Comparable conditions, characterized by a higher frequency of more extreme weather conditions, are predicted for the future by climate projections. Consequently, biogeochemical models may overestimate the future NPP sink capacity of temperate C3 grasslands. Because temperate grasslands represent an important part of the Earth’s terrestrial surface and therefore the global carbon cycle, atmospheric CO_2 concentrations [CO_2] might increase faster than currently expected.