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Analogues of a historical extreme-impact event and their implication for climate change risk assessment

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Meteorological conditions can affect crop development and yield in multiple and non-linear ways. Many studies have investigated the influence of climate change on crops by simulating crop responses to the most likely mean climatic projections in the future. However, this approach can potentially overlook changes in extreme-impact events, highly relevant for society, due to their low probability of occurrence and to potential different behaviour with respect to the mean conditions. One way of focusing on extreme-impact events is through the use of physical climate storylines. Storylines enable the construction of self-sustained and physically-plausible chain of events that recreate historical events from source to impact. In addition, storylines allow the exploration of future analogues of the historical events under different circumstances to account for externalities, such as climate change. In this experiment, we use physical climate storylines to reconstruct a historical extreme-impact event and to explore potential analogues of the same event under climate change influence. We develop two types of analogues, event-analogues and impact-analogues, and compare how the future manifestation of the historical event depends on the analogue definition. We use soybean production in the US as an example, with the year of 2012 being the historical extreme event. Based on a random forest model, we link the historical event to meteorological variables to identify the conditions associated with the failure event. To quantify the frequency of occurrence of the different analogues under climate change, we apply the trained random forest model to large ensembles of climate projections from the EC-Earth global climate model. We find that the 2012 failure event is linked to low precipitation levels, and high temperature and diurnal temperature range (DTR) levels during July and August. The analogues of the historical event greatly diverge: while event-analogues of the 2012 season are rare and not expected to increase, impact-analogues show a significant increase in occurrence frequency under global warming, but for different combinations of the meteorological drivers than experienced in 2012. The results highlight the importance of considering the impact perspective when investigating future extreme crop yields.