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SUPPLEMENTARY INFORMATION
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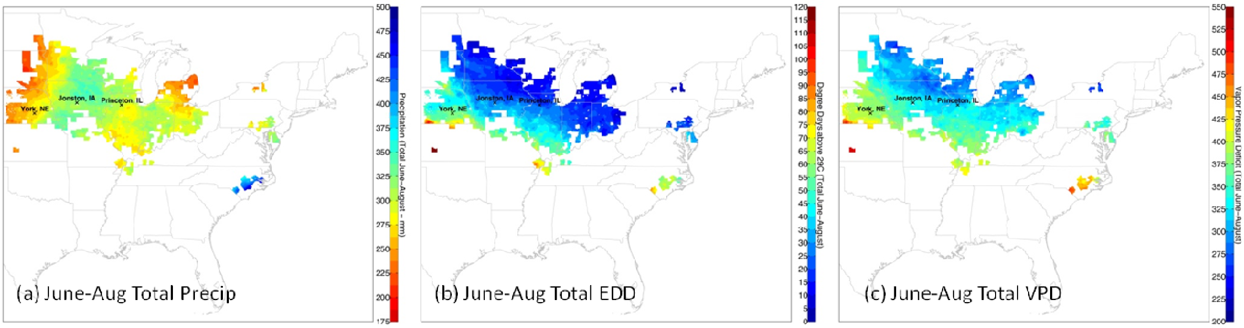
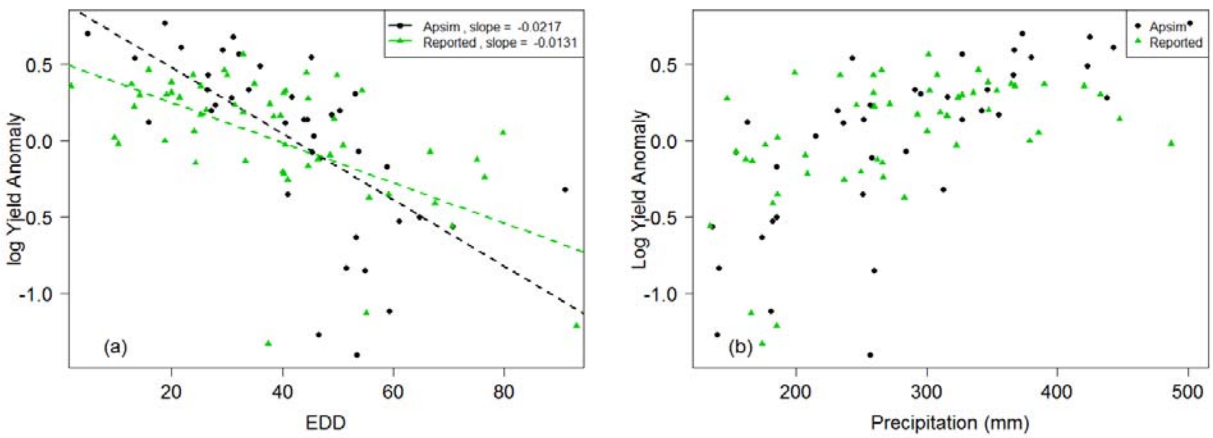
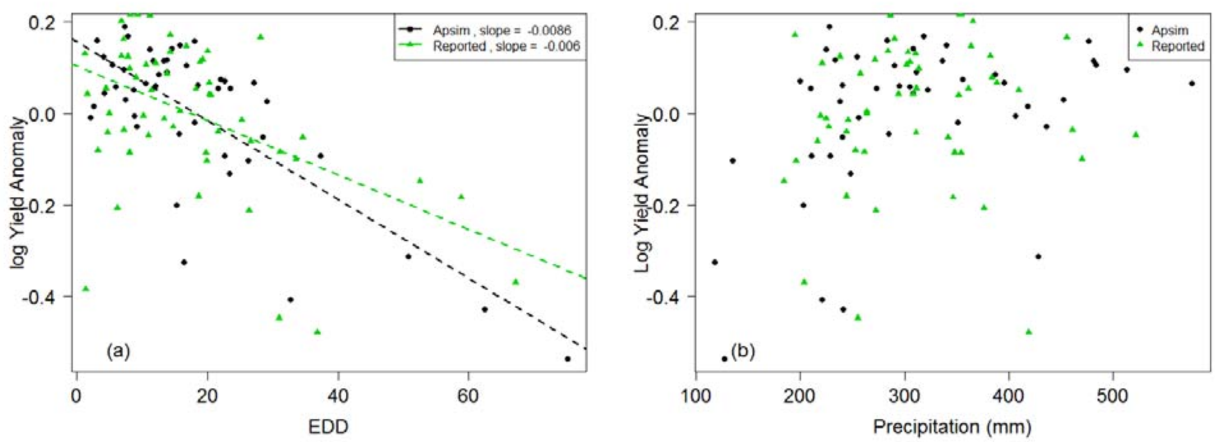
THE CRITICAL ROLE OF EXTREME HEAT FOR MAIZE PRODUCTION IN THE UNITED STATES



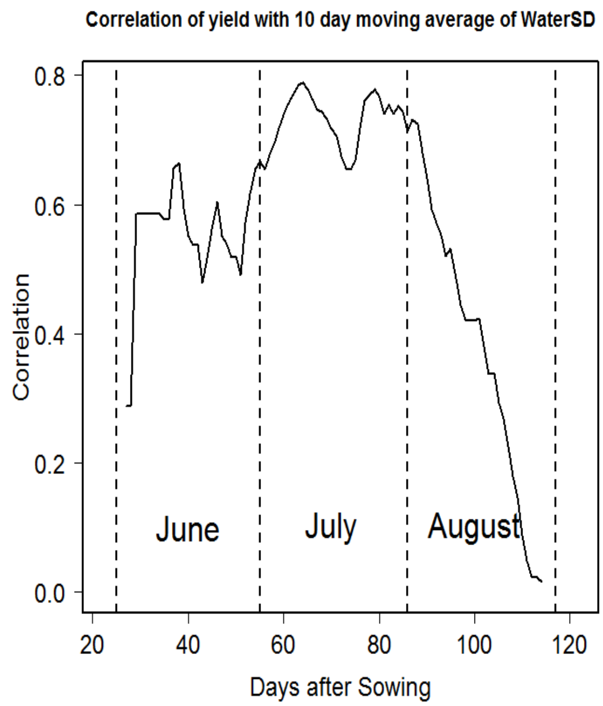
Supplemental figure 1. Three sites used in Hammer et al.[1] and in this study, with total June-August (a) rainfall (b) degree days above 30 °C and (c) vapor pressure deficit for 1954-2004. Only cropped areas within counties that produce at least 0.05% of national maize production are shown. Johnston and Princeton are representative of much of the Corn Belt. June-August mean rainfall is 268 mm in York, 326 mm in Johnston, and 308 mm in Princeton. June-August mean temperature is 23.8 °C in York, 22.6 °C in Johnston, and 22.5 °C in Princeton. June-August mean EDD is 45 degree-days in York, 19 degree-days in Johnston, and 18 degree-days in Princeton



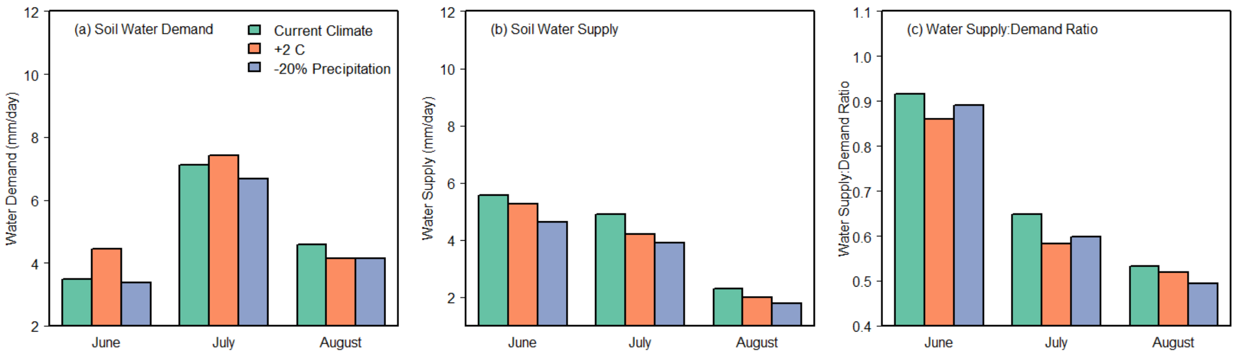
Supplemental figure 2. Comparison of simulated and observed relationships between EDD and yield and precipitation and yield for York, NE (dry site). Same as Figure 1 in main paper for Johnston, IA. For York, some years had simulated yields at or near zero because of severe water stress. These points were omitted from comparison with the county level data, which averages over many fields.



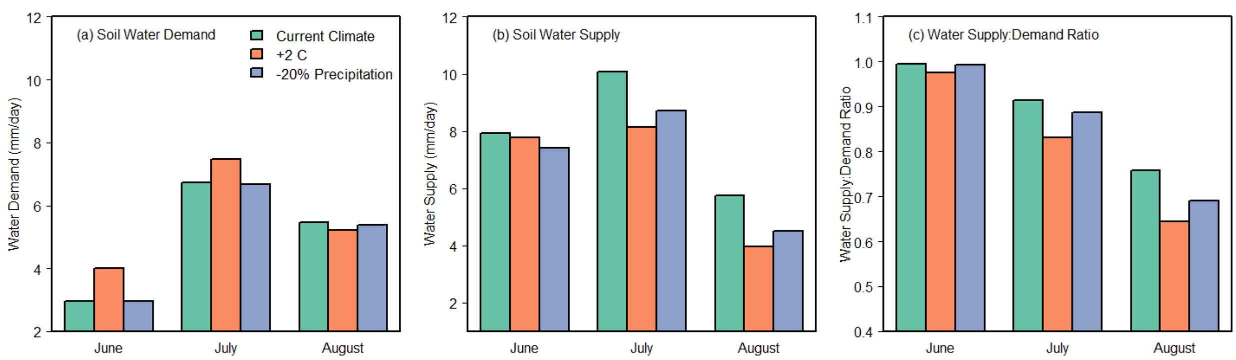
Supplemental figure 3. Comparison of simulated and observed relationships between EDD and yield and precipitation and yield for Princeton, IL (wet site). Same as Figure 1 in main paper for Johnston, IA.



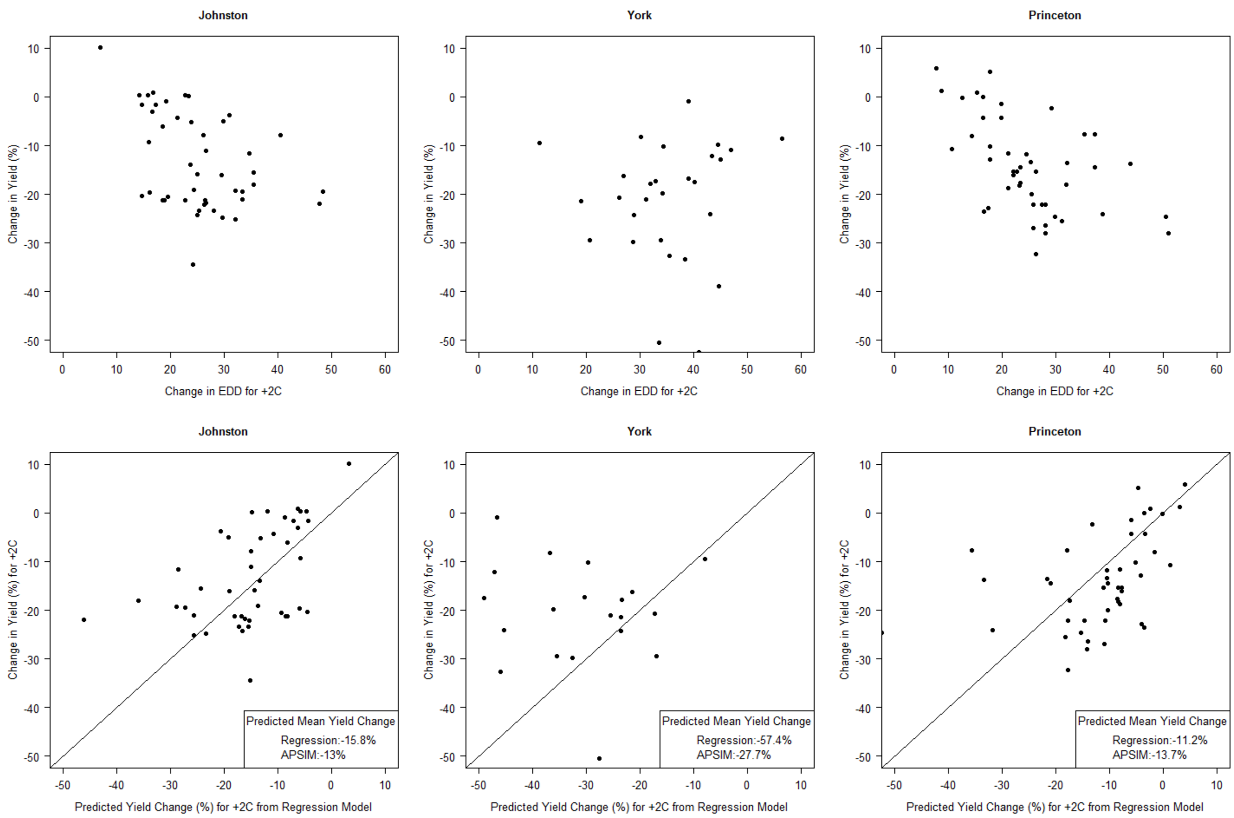
Supplemental figure 4. Correlation between final yields and 10-day moving average of water supply demand ratio throughout the season, for 46 years of simulations in Johnston, IA. July is the key period in which water stress affects yields.



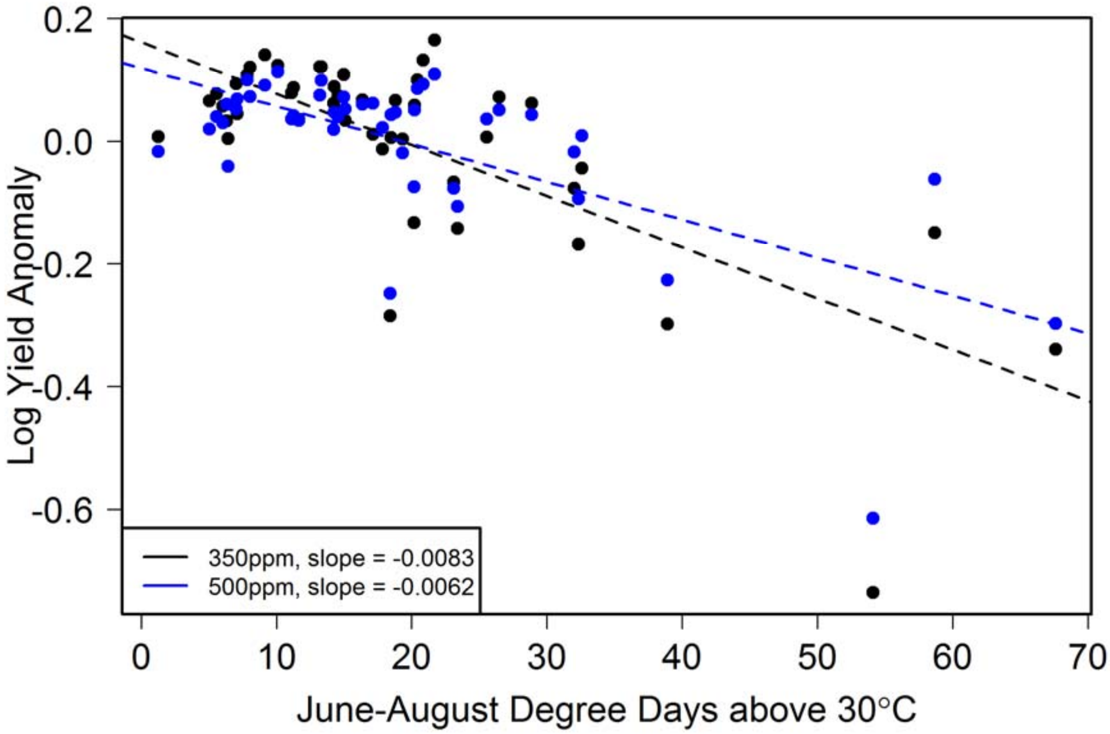
Supplemental figure 5. Response of average monthly water supply, demand, and supply:demand ratio (inversely related to water stress) to +2°C and -20% precipitation for York, NE (dry site). Same as Figure 3 in main paper for Johnston, IA. Water stress in July is increased more by +2°C than -20% precipitation.



Supplemental figure 6. Response of average monthly water supply, demand, and supply:demand ratio (inversely related to water stress) to +2°C and -20% precipitation for Princeton, IL (wet site). Same as Figure 3 in main paper for Johnston, IA. Water stress in July is increased more by +2°C than -20% precipitation.



Supplemental figure 7. (top row) changes in APSIM simulated yields for the scenario with temperatures raised by 2°C, compared to the change in June-August EDD. Each point represents a single year. Yield changes were negatively related to EDD increases in Johnston and Princeton ($p<.05$), but not in the driest site (York), where changes in season length had more important effects because it influenced late-season moisture stress. (bottom row) Comparison of predicted yield changes by APSIM for scenario with temperatures raised by 2°C with predicted yield changes for a statistical model trained on the historical simulations. Statistical model was of the form yield = a+bX, where X included June-August growing degree days (GDD), extreme degree days (EDD), precipitation, and precipitation squared. Solid line shows 1:1 line. Mean yield changes were similar for the two methods at Johnston and Princeton. The statistical model overpredicted yield losses at York because it did not fully capture the benefits of shorter season length at this location.



Supplemental figure 8. Effects of elevated CO_2 on sensitivity to extreme heat. APSIM simulated yields for 46 historical yields using default (350 ppm) or elevated (500 ppm) values of CO_2 concentrations. The slope of the best fit lines (shown as dashed lines) between simulated yield and EDD is roughly 25% smaller under elevated CO_2. The simulations do not include effects of elevated CO_2 on canopy temperatures, which would reduce the benefits of CO_2.

Supplemental References

1 Hammer, G. *et al.* Can changes in canopy and/or root system architecture explain historical maize yield trends in the US corn belt? *Crop Science* **49**, 299-312 (2009).