

Over Half of the Negative Crop Yield Variability Explained by Anthropogenic Indicators

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Introduction

This supporting information provides additional figures to support the findings of the main text.

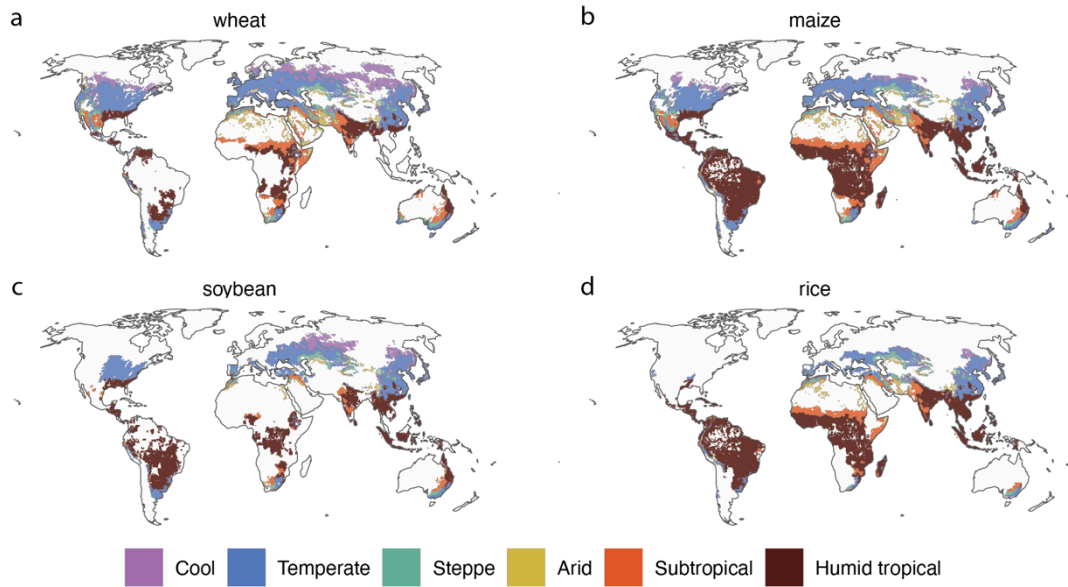


Fig. S1 Holdridge areas intersected with crop growing areas for a. wheat, b. maize, c. soybean and d. rice.

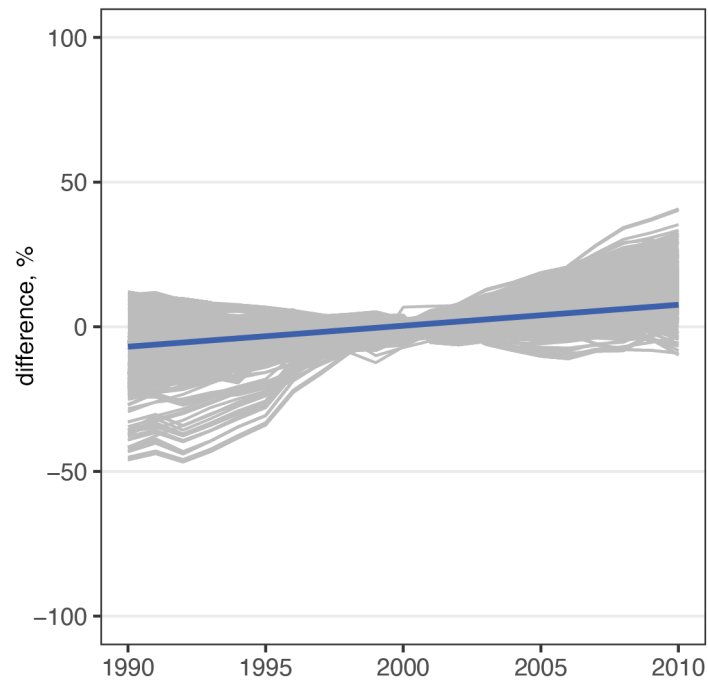


Fig. S2 Difference of subnational Human Development Index (HDI) values (1990-2010) compared to the mean of 1995-2005. We sampled 5000 grid cells from the subnational HDI raster and plotted the timeseries for HDI values for each grid point. Grey lines portray values for the grid cells and blue line depicts linear trend for all the sampled grid cells.

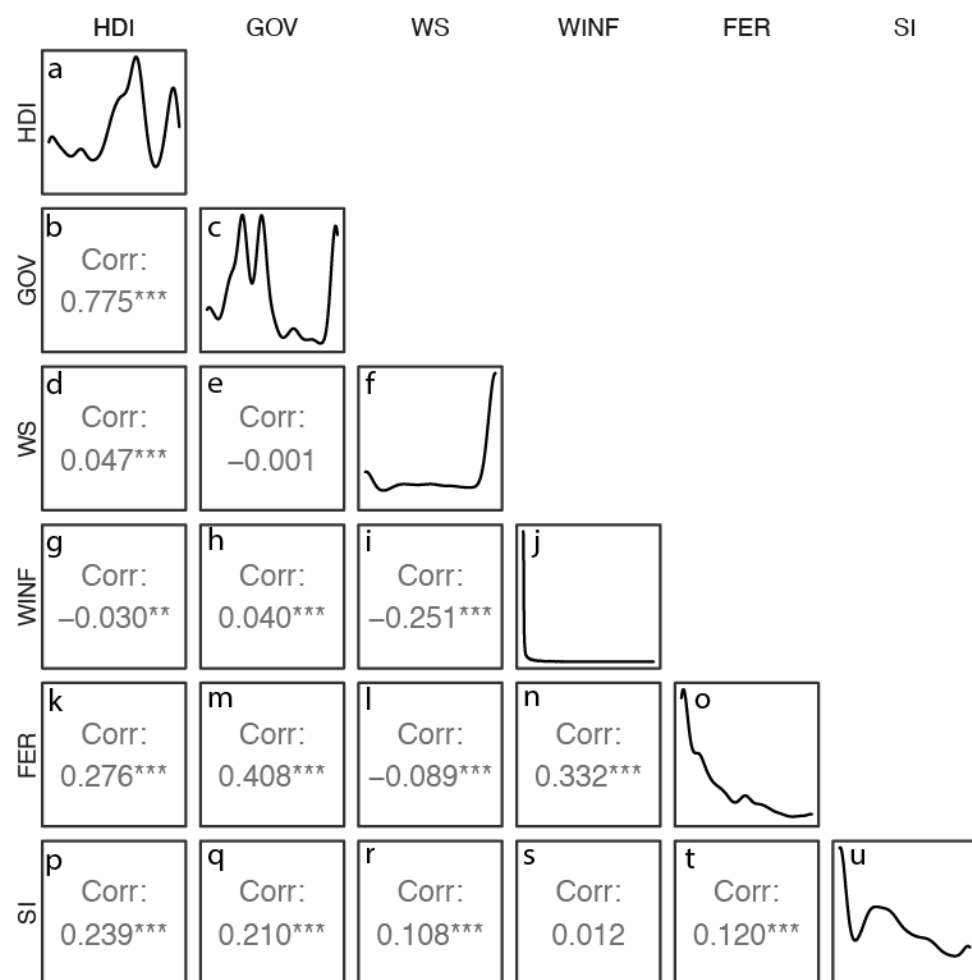


Fig. S3 Distributions (diagonal) and variable correlations for the anthropogenic indicators.

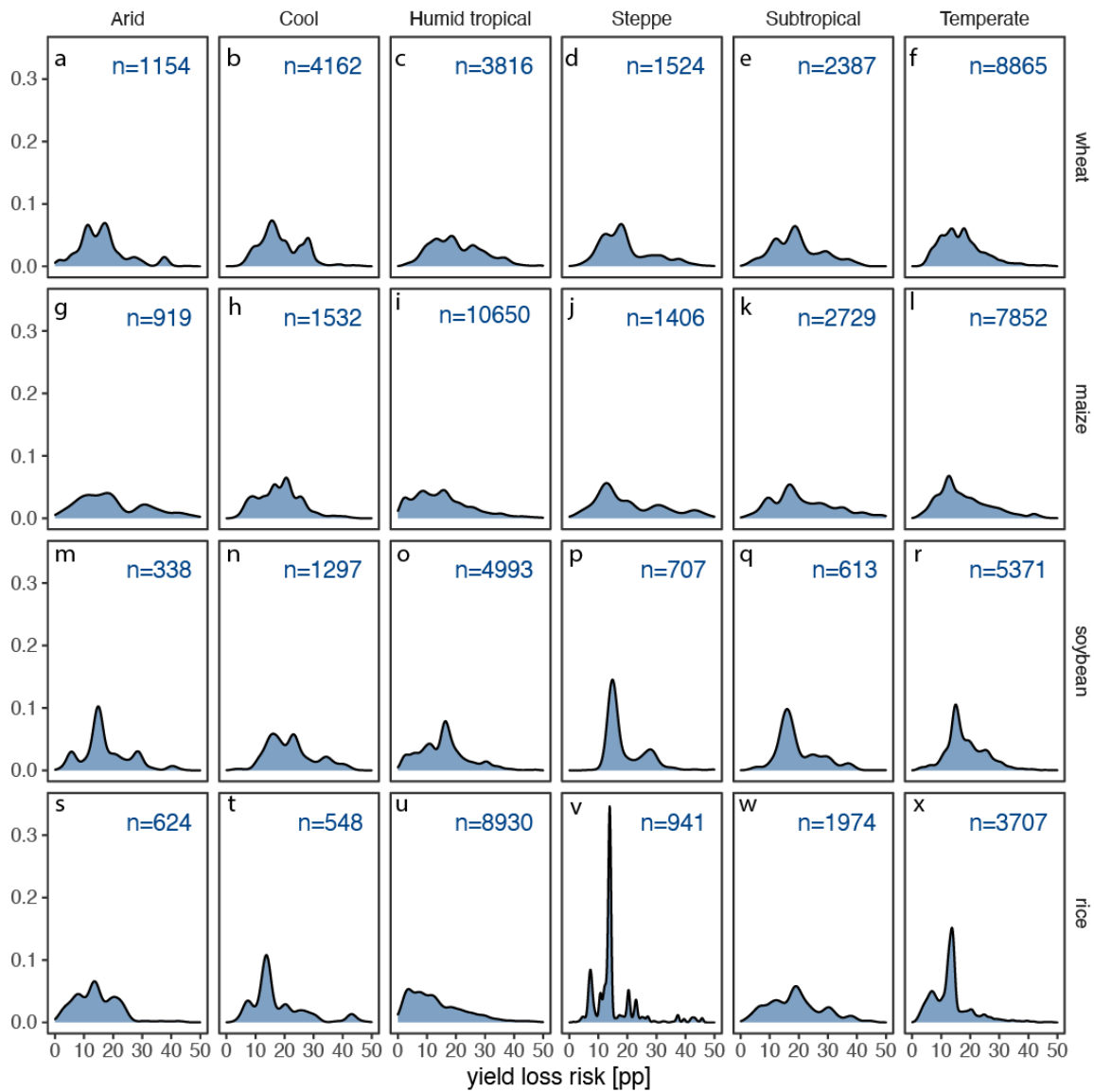


Fig. S4 Distributions and sample sizes (number of cells) used to train the models in the yield loss risk - case. Higher yield loss risk indicates that a grid cell has larger spread in negative yield anomalies (yields lower than running 5-year average) during the study period.

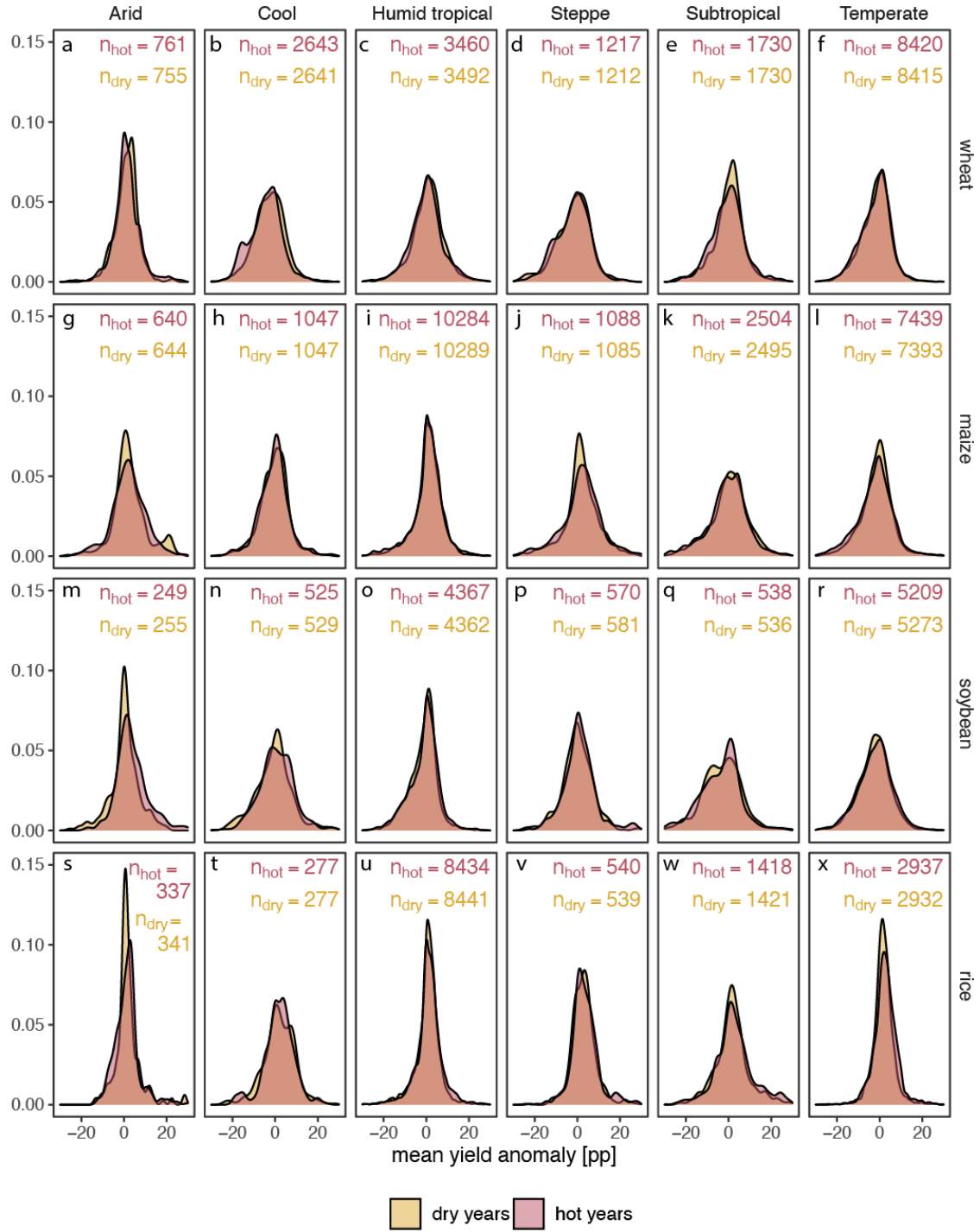


Fig. S5 Distributions and sample sizes (number of cells) used to train the models in the shock factor - cases. Dry years are those when soil moisture deficit is in the >90th percentile is more than 1 standard deviation from the long-term mean (as the number of days). Hot years indicate that the number of days when air temperature is in the 90-100% percentile is more than 1 standard deviation from the long-term mean.

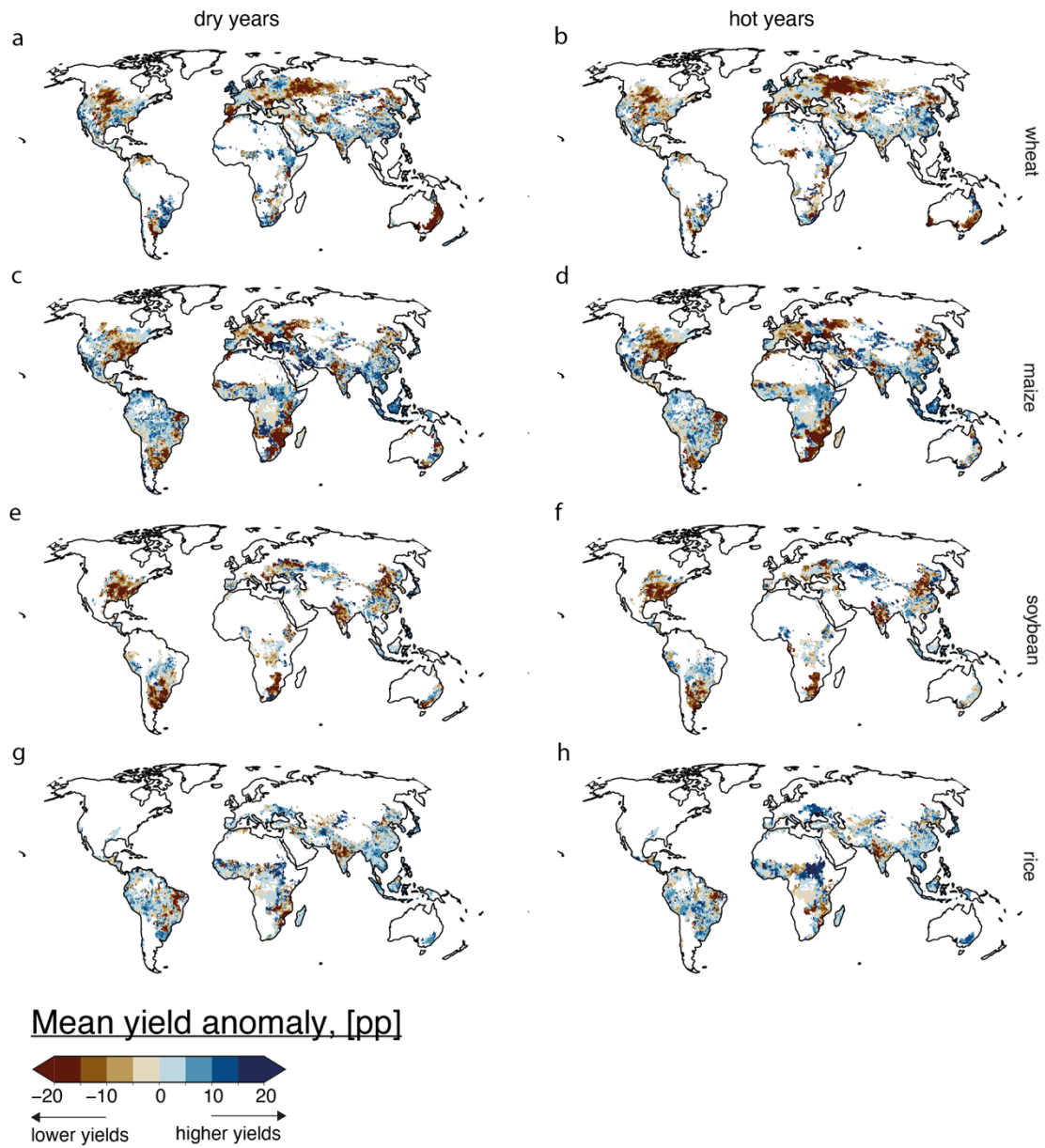


Fig. S6 Mean yield anomalies during shock years. The sign of the yield anomaly indicates whether the mean yields for shock years are higher (positive values; blue) or lower (negative values; brown) than the running 5-year mean yield. Dry years are those when number of days with soil moisture deficit in the >90th percentile is more than 1 standard deviations from the long-term mean. Hot years indicate that the number of days when number of days with air temperature in the >90th percentile is more than 1 standard deviation from the long-term mean.

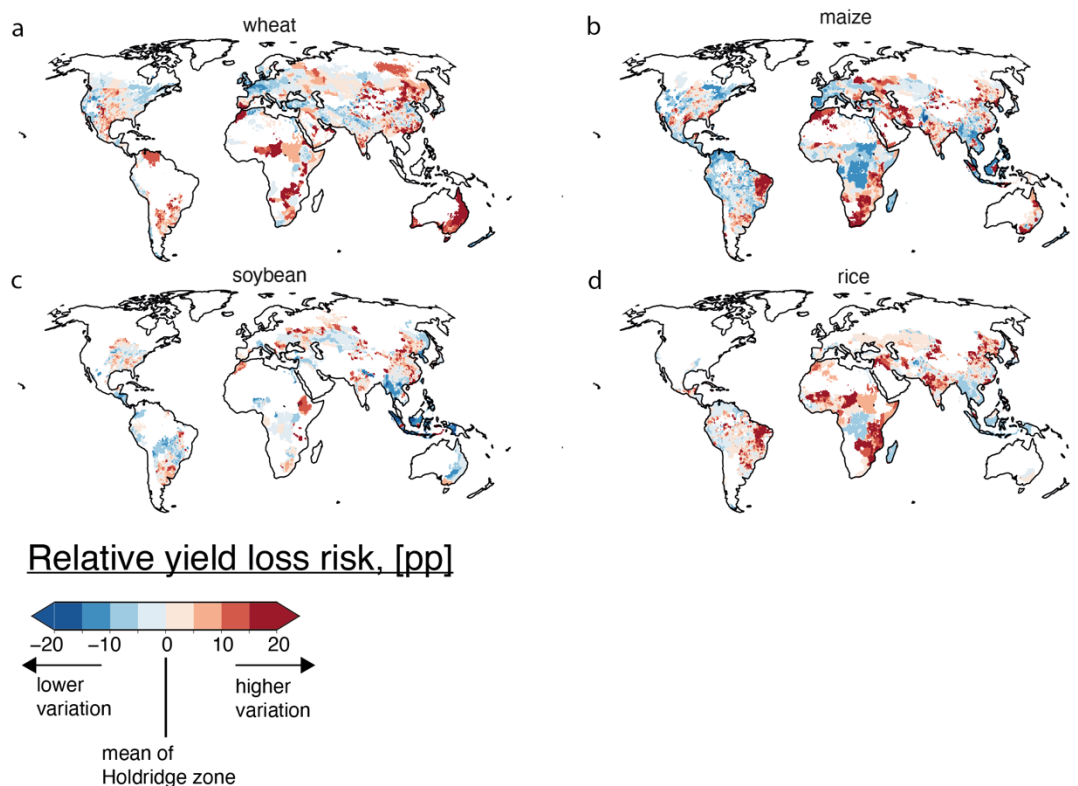


Fig. S7 Difference (as percentage points) between yield loss risk (standard deviation of negative yield anomalies) compared to the mean yield loss risk weighted by mean harvested area for a Holdridge zone for **a. wheat**, **b. maize**, **c. soybean**, and **d. rice**. Increasing yield loss risk (in red) indicates that a grid cell has larger spread in negative yield anomalies (yields lower than running 5-year average) during the study period compared to the mean yield loss risk of the respective Holdridge zone. Decreasing yield loss risk in (blue) indicates smaller variation in negative yield anomalies compared to the weighted mean of the respective Holdridge zone. Values close to zero indicate that the yields align the Holdridge zone's mean yields over 1981-2009, and white areas indicate no production of the crop in question.

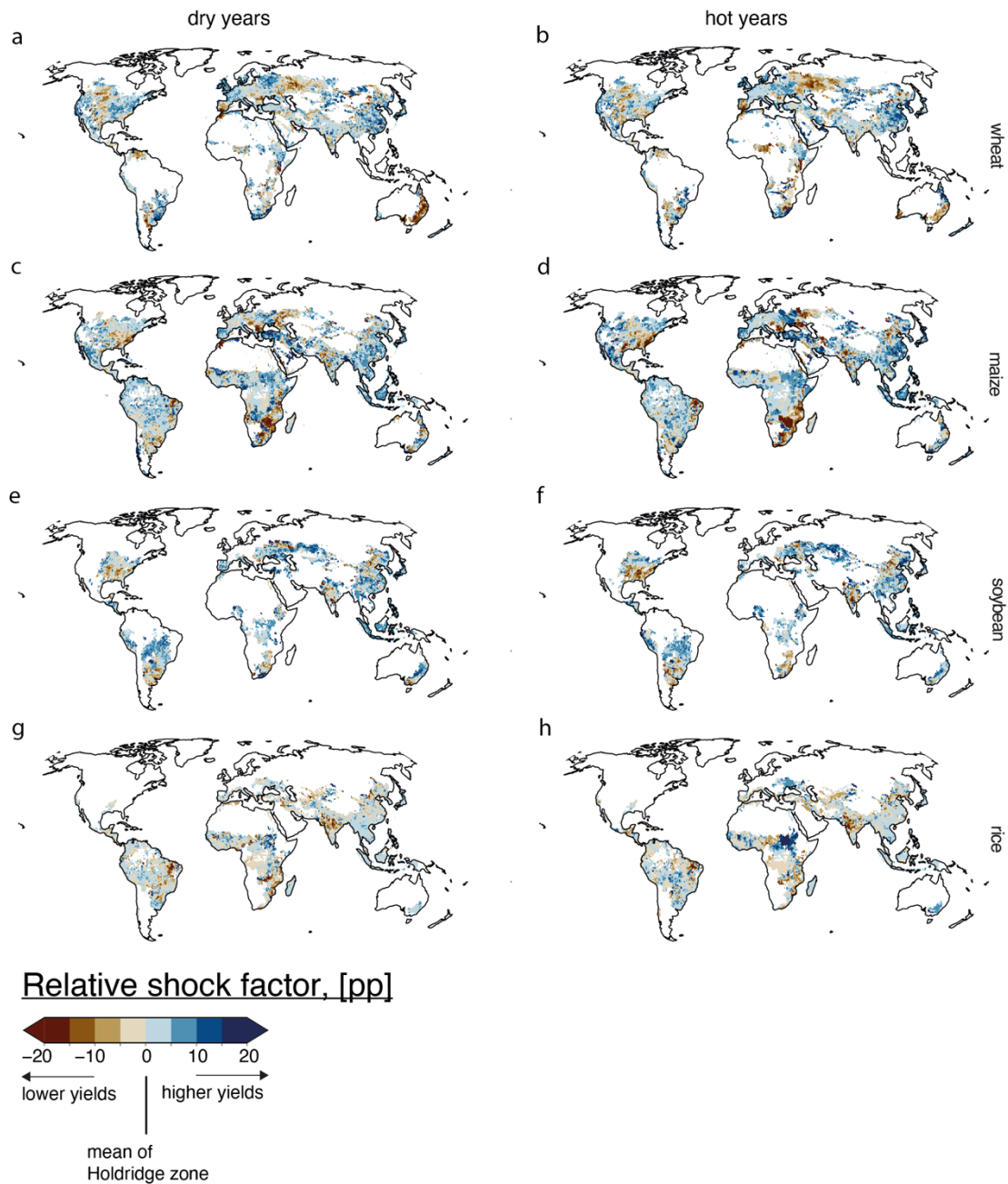


Fig. S8 Difference (as percentage points) in shock factors across shock years. Dry years are those when soil moisture deficit is in the >90th percentile is more than 1 standard deviation from the long-term mean (as the number of days). Hot years indicate that the number of days when air temperature is in the 90-100% percentile is more than 1 standard deviations from the long-term mean. For each grid cell, the mean shock factors are compared to the mean of the whole Holdridge zone. Negative value indicates that the detrended yields normalized by shock sizes are lower than the mean value for a given Holdridge zone. Positive value (blue) indicates that yields during shock years are higher than the mean value for a given Holdridge zone.

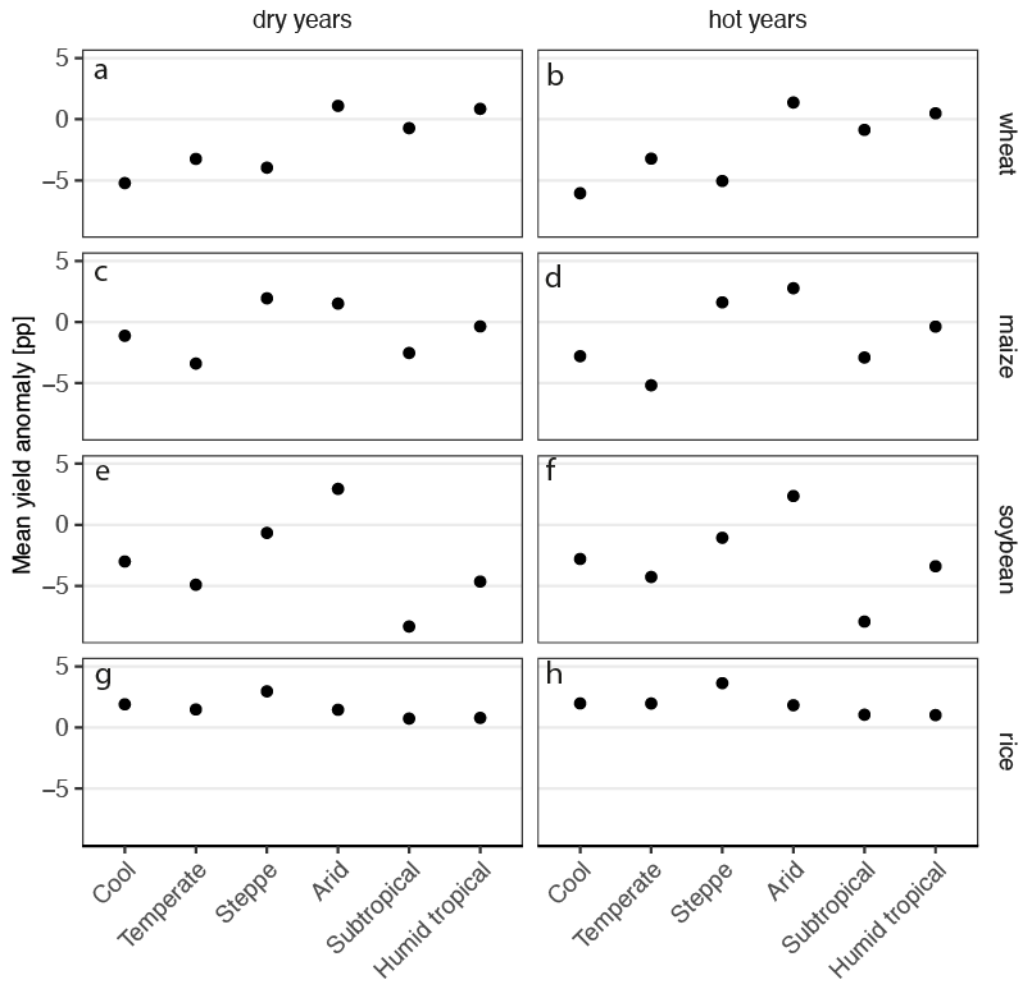


Fig. S9 Mean yield anomalies during temperature ("hot") and soil moisture ("dry") shock years in Holdridge zones. Dry years are those when soil moisture deficit is in the >90th percentile is more than 1 standard deviation from the long-term mean (as the number of days). Hot years indicate that the number of days when air temperature is in the 90-100% percentile is more than 1 standard deviation from the long-term mean.

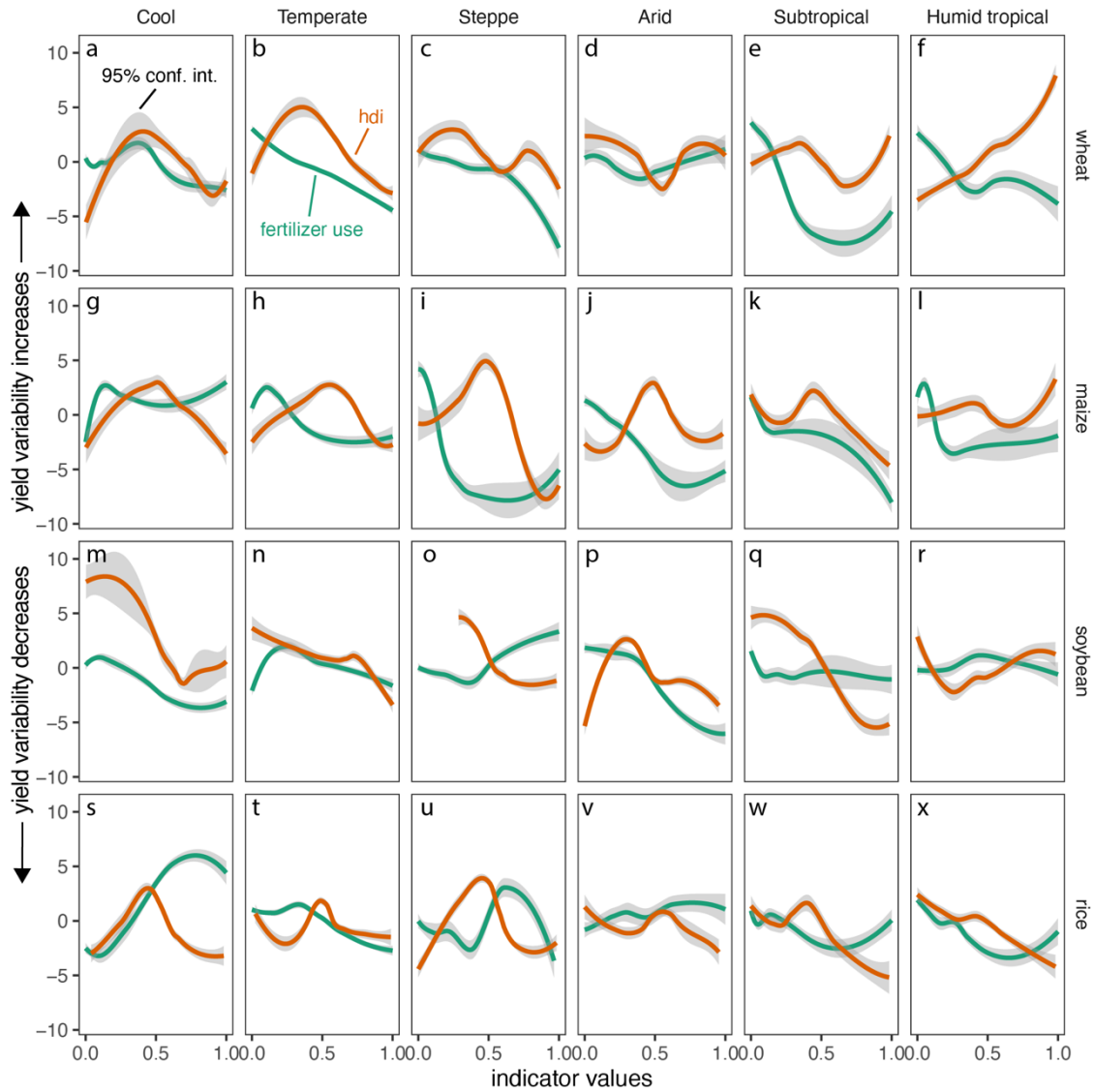


Fig. S10 Main effects for normalized subnational human development index (SHDI) and fertilizer use for assessing the negative crop yield variation at each Holdridge zone from Cool to Humid tropical. The effects are estimated using accumulated local effects -plot (ALE-plot) (Apley & Zhu, 2020) from the 10 models fitted for each crop and Holdridge zone combination aggregated using loess-smoothing. The ALE-plot shows the average marginal effect that the indicator has on the model's outcome variable. The figure shows the magnitude of the effect on yield loss risk (y-axis) with given indicator values (x-axis). The shaded areas indicate 95% confidence intervals.

References

Apley, D. W., & Zhu, J. (2020). Visualizing the effects of predictor variables in black box supervised learning models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 82(4), 1059–1086. <https://doi.org/10.1111/rssb.12377>