Response to Comment on “Climate and Management Contributions to Recent Trends in U.S. Agricultural Yields”

Gu (1) claims that by analyzing a subset of counties, we guaranteed that temperature trends would significantly impact yields. This was not the case. If temperature trends were small, or if nonclimatic contributions to yields were large, then the effect of temperature trends on yields would have been insignificant even if yields were strongly correlated with temperature from year to year. The crucial point is that it is the relative importance of climate and other factors that determine climate’s overall influence on yield trends.

In the simulation presented by Gu, he claims that the numbers are not important because they are only for illustrative purposes. In our opinion, the numbers are crucial. For example, we have rerun the simulation presented by Gu, but with $R_T$ having a range of $(-1,1)$. In this case, after selecting counties with a negative correlation with yield, the squared correlation between yield and temperature trends was only 8%. Varying other parameters had similar effects. Clearly, the actual numbers are important in determining the strength of the relationship between climate and yield trends. Further evidence of this is the fact that precipitation trends were not correlated with yield trends in (2), even though most counties showed positive correlation with yields. Even if we select only counties with a positive correlation with precipitation (rather than temperature), precipitation trends explain less than 5% of yield trends. This does not say that precipitation is not important for yields (clearly, it is), but rather that the observed trends in precipitation did not measurably impact yields.

Gu also expresses concern that by focusing on counties with negative correlations, we cannot extrapolate our findings to the entire nation. We agree with this to the extent that these counties fail to represent the entire United States. However, as we noted in (2), a majority of counties in the United States exhibited a negative correlation with temperature. The reason we selected a subset of counties was not to bias our climate effect, but rather to ensure an unbiased estimate of nonclimatic contributions. As mentioned in (2), there are distinct regions of corn growth in the United States; combining all regions in a single regression will result in a biased estimate of nonclimatic contributions unless the distribution of climate trends is the same in each region (as assumed in Gu’s simulation). The bias introduced by including all regions is clearly seen in the simulation if the probability of $S_T$ equal to 1 varies for $S_T$ positive and negative.

As described in (2), the temperature effect derived from the regression is applicable only to those counties within the subset (that is, Midwest and Southeast). To test potential bias toward management in these regions when computing the nonclimatic gains for the entire United States, we have performed an independent test of temperature contribution to national yield trends based on average national yield and area weighted temperature time series, following (3). First differences of these time series were used to compute the slope of yield response to temperature change; this slope was then multiplied by the temperature trend to estimate the national yield change due to temperature. This analysis estimated a 10% and 20% reduction in corn and soybean yield trends, respectively, when removing the effect of temperature, which is close to the values of 18% and 20% derived in (2). The lower value for corn when using the entire nation likely reflects the suppression of yield gains in Northern states by negative temperature trends. However, the agreement between these two approaches is significant, given the different assumptions necessary in each approach (4–6).

Finally, Gu states that we assumed nonclimate contributions were constant temporally, which is not the case. The parameter $m$ reflects changes in management that were spatially uniform, but the temporal nature of this trend did not impact our analysis. We recognized that spatial covariance of management and temperature trends would impact the apparent effect of temperature; indeed, it is well known that farmers often adjust management in response to climate (7). This can be considered one mechanism by which climate trends affect yield trends. Various other mechanisms potentially play an important role in the temperature–yield relationship, including changes in crop development rates, increased water stress, and increased pest damage (8). Although we did not attempt to discuss causal mechanisms in our brief paper, we clearly did not suggest that direct physiological effects were the only link between temperature and yield trends.

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