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Global contribution of climate variability and trends to maize yield change in observations and crop models during 1980-2010

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Understanding historical crop yield response to climate change is critical for projecting future climate change impacts on yields. Previous assessments rely on statistical or process-based crop models, but each has its own strength and weakness. A comprehensive comparison of climate impacts on yield between the two approaches allows for evaluation of the uncertainties in future yield projections. Here we assess the impacts of historical climate change on global maize yield for the period 1980-2010 using both statistical and process-based models, with a focus on comparing the performances between the two approaches. To allow for reasonable comparability, we develop an emulator which shares the same structure with the statistical model to mimic the behaviors of process-based models. Results show that the simulated maize yields in most of the top 10 producing countries are overestimated, when compared against FAO observations. Overall, GEPIC, EPIC-IIASA and EPIC-Boku show better performance than other models in reproducing the observed yield variations at the global scale. Climate variability explains 42.00% of yield variations in observation-based statistical model, while large discrepancy is found in crop models. Regionally, climate variability is associated with 55.0% and 52.20% of yield variations in Argentina and USA, respectively. Further analysis based on process-based model emulator shows that climate change has led to a yield loss by 1.51%-3.80% during the period 1980-1990, consistent with the estimations using the observation-based statistical model. As for the period 1991-2000, however, the observed yield loss induced by climate change is only captured by GEPIC and pDSSAT. In contrast to the observed positive climate impact for the period 2001-2010, CLM-Crop, EPIC-IIASA, GEPIC, pAPSIM, pDSSAT and PEGASUS simulated negative climate effects. The results point to the discrepancy between process-based and statistical crop models in simulating climate change impacts on maize yield, which depends on not only the regions, but also the specific time period. We suggest that more targeted efforts are required for constraining the uncertainties of both statistical and process-based crop models for future yield predictions.