Effects of climate change on corn yield in the U.S. using a parameter optimized crop model with muliple general circulation models

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A detailed analysis was conducted of the effects of climate change and increased carbon dioxide (CO_2) concentrations on corn yield in the United States of America by a crop model using outputs from multiple general circulation models (multi-GCMs). To find the best attainable calibrated model parameters, the automatic multi-objective complex evolution algorithm was applied to the Environmental Policy Integrated Climate model. Corn yield was simulated for 1999–2010, the 2050s (average for 2041–2060), and the 2070s (average for 2061–2080) under representative concentration pathways 4.5 (RCP4.5) and 8.5 (RCP8.5).
Results indicated a shortening of the growing periods (GP), decreased water use efficiency in almost all regions, and increased crop available water and evapotranspiration during GP in almost all regions except for the Southern U.S. Using multi-GCMs, the simulations under both climate scenarios resulted in negative effects of climate change on yield in almost all regions during both future periods. Especially strong negative impacts were reported south of latitude 40°N due to less optimal growing conditions. On the other hand, there were relatively smaller negative impacts in high-latitude regions due to more optimal growing conditions because of larger temperature changes and less water stress compared to low- and mid-latitude regions. However, temperature stress which interferes with corn growth was notably present in almost all regions for the 2070s under RCP8.5. Higher CO_2 concentrations have the potential to increase corn yield. CO_2 effects were approximately 0.04–0.05% increase in yield per 1 ppm increase in CO_2 concentration under both future climate scenarios, but the negative impacts of increased temperatures fully outweighed the CO_2 -fertilization effects. Assessments of climate change impacts using multi-GCMs are essential for synthetic studies of uncertainties in GCMs and not just for considering particular or bounding-case scenarios. Development of an integrated crop model that includes information and mechanisms related to crop physiology, breeding, biotechnology, agronomy, climate change, and resource use efficiency is needed to address more accurately the effects of climate change, CO_2 effects, and technology development and their interactions on crop yield.

Keywords: Climate change impacts, Multi-objective complex evolution, Corn yield, Multiple GCMs

