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Comparing climate change impacts on crops in Belgium based on CMIP3 and EU-ENSEMBLES multi-model ensembles

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Global Circulation Models (GCMs) are sophisticated tools to study the future evolution of the climate. Yet, the coarse scale of GCMs of hundreds of kilometers raises questions about the suitability for agricultural impact assessments. These assessments are often made at field level and require consideration of interactions at sub-GCM grid scale (e.g., elevation-dependent climatic changes). Regional climate models (RCMs) were developed to provide climate projections at a spatial scale of 25-50 km for limited regions, e.g. Europe (Giorgi and Mearns, 1991). Climate projections from GCMs or RCMs are available as multi-model ensembles. These ensembles are based on large data sets of simulations produced by modelling groups worldwide, who performed a set of coordinated climate experiments in which climate models were run for a common set of experiments and various emissions scenarios (Knutti et al., 2010). The use of multi-model ensembles in climate change studies is an important step in quantifying uncertainty in impact predictions, which will underpin more informed decisions for adaptation and mitigation to changing climate (Semenov and Stratonovitch, 2010).

The objective of our study was to evaluate the effect of the spatial scale of climate projections on climate change impacts for cereals in Belgium. Climate scenarios were based on two multi-model ensembles, one comprising 15 GCMs of the Coupled Model Intercomparison Project phase 3 (CMIP3; Meehl et al., 2007) with spatial resolution of 200-300 km, the other comprising 9 RCMs of the EU-ENSEMBLES project (van der Linden and Mitchell, 2009) with spatial resolution of 25 km. To be useful for agricultural impact assessments, the projections of GCMs and RCMs were downscaled to the field level. Long series (240 cropping seasons) of local-scale climate scenarios were generated by the LARS-WG weather generator (Semenov et al., 2010) via statistical inference. Crop growth and development were simulated with the AquaCrop model for maize and the Sirius model for winter wheat.

Our study showed that for maize significantly different yield changes were predicted for future scenarios based on CMIP3 and EU-ENSEMBLES ensembles, respectively. Whereas under CMIP3 scenarios the overall impact on maize yield was mostly negative, there was a positive yield impact under ENSEMBLES scenarios. In contrast, changes in winter wheat yields were very similar for the two ensembles. Our results demonstrated that the use of the EU-ENSEMBLES ensemble allowed further exploration of uncertainties in agricultural impacts in Belgium, and we hypothesize that even more added value from the use of RCMs could be anticipated in European regions with complex topography where projections from GCMs and RCMs would be significantly different.

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