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ABSTRACT BOOK

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The projected increase in global population suggests that, among a range of measures, an increase in food production will likely be necessary to achieve food security. A great deal of effort has been focused on the so-called "yield gap", the difference between actual and potential yields. The closing of this yield gap would bring about massive increases in production. Intensification actions such as irrigation, fertilisation, and better farming practices can bring the actual yield closer to the potential yield, although such actions may not be practical everywhere. Yet climate change greatly complicates this picture; crops are sensitive to their growing environment, and it is therefore inevitable that climate change will impact upon potential crop yields, changing the target for which intensification measures are aiming, and meaning that significant intensification may be required just to hold actual yields constant. Global crop models give some insight into such changes, but huge uncertainties in their process representations make even the direction of future change uncertain. We demonstrate a complementary data-driven approach, based on observations of current potential yield and climate analogues, to assess the vulnerability of yields of the three major cereal crops, wheat, maize and rice, to climate change. We find that huge swathes of current cropland show strong reductions in their potential yields of major cereal crops by the mid 21st century, indicating a large vulnerability of crop production in these areas to climate change, and greatly reducing the capacity for intensification of yields. These reductions are predominately in tropical or arid areas, and include current high-productivity areas like the North American corn-belt. Conversely, however, we also find large areas where potential yields increase substantially under climate change. These areas are most prominent in the northern temperate zone, and include areas not currently under cropland. Our approach is independent of the crop modelling methodologies previously used for future yield projections, however we find our results to be consistent with those from an ensemble of process-based global crop models, providing an important additional constraint on projections of future yield under climate change. Adaptation measures based on intensification of yields must consider the change in productive potential due to climate change.

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Biophysical modeling of climate change impacts on crop yields in Europe by 2030-2050 and socio-economic implications

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An impact assessment of climate change scenarios on agriculture was run covering the EU-28 region and focusing on 2030 and 2050 time horizons. To assess the impact of model uncertainties, three model realizations of the Intergovernmental Panel on Climate Change (IPCC) climate scenarios were used as the input of the analysis, based upon the Representative Concentration Pathway (RCP) 8.5 from the runs of global circulation models (GCM) HADGEM2-ES, IPSL-CM5A-LR and MIROC-ESM-CHEM, all bias-corrected at 0.5°x0.5° resolution.

The WOFOST (World Food Studies) model has been used within the BioMA (Biophysical Model Application) platform to simulate the impacts of climate change on crop yields at EU-level. The crop yield simulations were performed at 25x25 km resolution using the soil and crop parametrization of the MARS Crop Yield Forecasting System (MCYFS) that provides the European Commission operational seasonal forecasts of crop yields in Europe. The crops covered by this study were wheat, maize, barley, rye, rice, field beans, rapeseed, sunflower, sugar beet and potato. For each of these ten crops, simulations were performed under water limited (rainfed) and potential (fully irrigated) conditions. Uncertainties are associated with the effect of CO2 on plant growth which were assessed by simulations considering or not the CO2 fertilization effect. The simulated yields were aggregated at regional, national and EU28 levels, using regional statistics on crop areas.

The crop growth simulations show in most of the cases a stagnation or a moderate increase in the potential yields of most of the crops with the notable exception of maize, sunflower and at a lesser extent potato. Under water limited conditions the picture is slightly different with more pronounced negative effects for maize and sunflower. The greatest decreases in the water limited yields occur with HADGEM2-ES GCM that simulates a drier future climate than the two other GCMs. The actual crop yields, estimated by a weighted average of potential and water limited yields using data on European irrigation shares (EUROSTAT), show an overall moderate increase for the three climate models under RCP 8.5 scenario when the CO2 effect is taken into account but a decrease when it is not.

The spatial distribution of the yield changes is crop specific with for instance an overall increase in winter wheat yields for most of the EU 28 regions and an overall decrease of maize (summer crop) yields, with in both cases a reversed result for northern Europe.

Focusing on the year 2030, a bio-economic approach was proposed to jointly assess biophysical and socio-economic effects of climate change on agriculture, providing both global level analysis as well as regionalised for the EU. The global agro-economic model CAPRI (Common Agricultural Policy Regionalised Impact) has been used to assess the effects of climate induced yield changes on agricultural production and prices. The future quantitative societal developments were introduces in the model by means of an intermediate Shared Socioeconomic Pathway (SSP2).

The results suggest that agriculture markets projections to 2030 are sensitive to changes in crop productivity and, therefore, to the uncertainties linked to climate change. They show as well that market forces can reverse the effects of climate induced yield changes with a decrease (increase) in production when yields increase (decrease). The price changes will induce adjustments both on the intensity of production and on crop areas. A sectorial analysis indicates that the regional variability in prices and areas is greater for oilseeds than for cereals. Overall the modelling exercise estimates a moderate decrease of the EU agricultural income for all the scenarios with the CO2 fertilization effect simulated and a moderate increase when the CO2 fertilization effect is ignored. The limitations of these conclusions will be explored.

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Interactions of Mean Climate Change and Climate Variability on Food Security Extremes

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The Coordinated Climate-Crop Modeling Project (C3MP) has conducted a common set of sensitivity tests on more than 1100 simulation sets representing different farm systems in more than 50 countries, with carbon dioxide, temperature, and precipitation change sensitivities gauged for ~20 crop species and ~20 crop models. Here we present an analysis of C3MP results indicating how mean climate changes are likely to affect variability and extreme events within future time periods.

Recognizing that climate change will affect agricultural systems both through mean changes and through shifts in climate variability and associated extreme events, C3MP can elucidate several aspects of these changes. First, mean climate changes can affect yields across an entire time period. Second, extreme events (when they do occur) may be more sensitive to climate changes than a year with normal climate. Third, mean climate changes can alter the likelihood of climate extremes exceeding critical biophysical thresholds, leading to more food security extremes. Finally, shifts in climate variability can result in an increase or reduction of mean yield, as extreme climate events tend to have lower yield than years with normal climate. This presentation will demonstrate each of these effects and illustrate the potential implications for future food production and associated agricultural economies under climate change.

P-2223-19

Past and future changes in climate of rice-wheat cropping zone in Punjab, Pakistan

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Agriculture is ranked Pakistan's top among economic sectors vulnerable to the potential impacts of climate change. The agricultural production system is directly affected by weather inputs (temperature, solar radiation, and rainfall) that are projected to change in the future (following increases in carbon dioxide and other greenhouse gases). Climatic extremes such as drought, floods and heat waves, are expected to increase with detrimental consequences for agriculture and livestock production, but changes in mean climates also pose challenges to sustainable development. This study presents climate change results for five districts within the major rice-wheat productivity zone of Punjab province in Pakistan. The results are focused on RCP8.5 mid century (2040-2069) scenarios derived from five global climate models (GCMs) output and the Kharif (June-October) and Rabi (November-April) seasons. Analysis of recent historical weather data of Sialkot and Sheikhupura districts shows an increase in minimum temperatures and maximum temperatures and a large variation in rainfall. This temperature change and variability in rainfall is expected to enhance further as we approach the 2050s. Mean maximum temperature is projected to increase by 2-2.5°C during rice growing (Kharif) season and 2.4-2.7°C during the wheat growing (Rabi) season. Rainfall during rice growing season is more uncertain, with projections indicating an increase of 25%-35 % in the study region, while a minimal change is expected during the Rabi season. The projected increase in monsoon intensity corresponds with the climax of the rice season, leaving no doubt about the crop water demand satisfaction. However, simultaneous increase in day and night temperature may affect the growth and development at some critical phenological stages.

P-2223-20

Economic Impact of climate change and benefits of adaptation in maize production in Southern Africa: Case study from South Africa, Namibia and Botswana

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The paper applied the Trade-Off Analysis-Multi-Dimensional (TOA-MD) model to evaluate the economic impacts of climate change and benefits of adaptation strategies for maize-based agricultural production systems in Southern Africa. The analysis was based on data collected from three countries, South Africa, Namibia and Botswana. The empirical analyses combined simulated baseline and future simulated yield from the Decision Support Systems for Agro-technology Transfer (DSSAT) crop model, under five different climate scenarios selected from 20 Global Circulation Models (GCMs). The paper focused on analysing three main objectives: (a) the sensitivity of current crop production systems to future climate change, (b) the sensitivity of future crop production systems to future climate change and (c) the benefits of adaptation in the future. The empirical results show that current and future crop production systems in the three study countries are sensitive to future climate change and yields would decline if no adaptation strategies are implemented. The results with the adaptation package show positive gains in yields, farm net returns and marginal reductions in poverty. In addition, the percentage of vulnerable farmers decrease for the scenario with adaptation compared to the other two scenarios without adaptation. Since various assumptions and uncertainties are associated with using the proposed approach, the results should be interpreted with caution. Despite these limitations, the methodology presented in this study shows the potential to yield new insights into the way that realistic adaptation strategies could improve the livelihoods of smallholder farmers.

P-2223-21

Modelling of Climate Change Impact on Maize Yields in Croatia

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Analyzing agricultural systems and modelling the potential impact of climate change on crop production is a very important topic, particularly nowadays as food supplies are becoming scarcer in many parts of the world and the need for all people to have sufficient food. As climate changes of different intensity in various regions were detected, there is a need for researching them at regional and national levels. The main application of the crop models is in climate change impact research on agriculture. Maize, winter wheat and spring barley are very often used for scientific investigations in the central and southeastern Europe using the different crop-weather models. Maize is one of the most important agricultural crops in Croatia and its vegetation period coincides with the warm season, from May to October. Therefore, it was decisive factor in the crop type choice for the research of climatic changes impact on maize yields in Croatia. The meteorological data of the Zagreb-Maksimir station, which is situated in the central Croatia, and pedological data, physiological and morphological data obtained in the field maize experiment in Zagreb have been analyzed. The Decision Support System for the Agrotechnology Transfer (DSSAT) model, as one of the most applied crop model in the world, has been used for the investigation of maize production in the present climate since 1949. The linear trends of model outputs and Mann-Kendall test indicated a significant earlier onset of silking by 1.4 days/10 years and physiological maturity by 4.5 days/10 years in the central Croatia which started in mid-1990s. Moreover, a significant decrease in maize yields by 216 kg/ha in 10 years is also obtained. The yield trend became significant at the beginning of the 21st century. There was a slight decrease in kernel mass (0.01 g/10 years) and aboveground biomass (122 kg/ha in 10 years). A positive trend in evapotranspiration and soil evaporation (around 3 mm/10 years) and in runoff (0.6 mm/10 years) has been noticed during the vegetation period. Thus, significant shortening the vegetation period by 5 days and reduction in maize yield by 2% have been estimated in the present climate. Further investigation involved the generation of synthetic meteorological series representing the changed climate by stochastic weather generator Met&Roll and different climate change scenarios. The climate change scenarios were prepared by the pattern scaling technique using the following global climate models: ECHAM, HadCM and SCIRO. The middle climate sensitivity is a 2.5°C increase in global temperature to equilibrium doubled carbon dioxide. When the three climate change scenarios had been prepared, the stochastic weather generator Met&Roll was applied to generate a 99-years synthetic meteorological series. Using the synthetic meteorological series in the DSSAT model, the indirect effect of increased carbon dioxide on maize yields in the central Croatia has been estimated for different climate change scenarios for years 2050 and 2100. All climate change scenarios for the 21st century projected a shorter growing season and a reduction in maize yields. The maize vegetation period in the central Croatia would be 39 days shorter for ECHAM, 42 days for HadCM and 34 days shorter for CSIRO, which would result in 14%, 25% and 22% smaller yields for maize, respectively, at the end of the 21st century. Both shifting planting date and using hybrids with longer growing season would be beneficial for maize productivity in the changing climate. The experience of farmers and agronomists in the central Croatia shows they have already been adapting maize production to the warmer weather conditions in the last decade. The usual hybrids in the central Croatia were hybrids with a medium growing season, but nowadays hybrids with a longer growing season are increasingly used. In the future, thus, Croatia could belong to the area of decreased maize yields. Some adaptation options like shifting to an earlier sowing date and selecting hybrids with longer growing season and resistant to drought could be an appropriate response to offset the negative effect of an increase in temperature. The present study could help in optimizing and improving agricultural management in order to adapt to changes in