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Contribution to CR Special 31 'Modelling climate change impacts for food security'

INTRODUCTION

Modelling climate change impacts on crop production for food security

M. Bindi^{1,*}, T. Palosuo², M. Trnka^{3,4}, M. Semenov⁵

¹University of Florence, 50144 Florence, Italy

²Natural Resources Institute Finland (Luke), 00790 Helsinki, Finland

³Institute of Agrosystems and Bioclimatology, Mendel University in Brno, Brno 613 00, Czech Republic

⁴Global Change Research Centre AS CR,v.v.i., 603 00 Brno, Czech Republic

⁵Rothamsted Research, Harpenden, Herts AL5 2JQ, UK

ABSTRACT: Process-based crop models that synthesise the latest scientific understanding of biophysical processes are currently the primary scientific tools available to assess potential impacts of climate change on crop production. Important obstacles are still present, however, and must be overcome for improving crop modelling application in integrated assessments of risk, of sustainability and of crop-production resilience in the face of climate change (e.g. uncertainty analysis, model integration, etc.). The research networks MACSUR and AGMIP organised the CropM International Symposium and Workshop in Oslo, on 10–12 February 2014, and present this CR Special, discussing the state-of-the-art—as well as future perspectives—of crop modelling applications in climate change risk assessment, including the challenges of integrated assessments for the agricultural sector.

KEY WORDS: Crop production · Climate change impact and adaptation assessments · Upscaling · Model ensembles

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1. Crop modelling applications for the assessment of climate change impacts

Agricultural land pressure (e.g. land shortage and degradation), food security risks and the necessity to adapt to climate change increasingly require the modelling of future agro-ecosystems for the purpose of planning and decision making. Process-based crop simulation models are at the core of any climate impact assessment for the agricultural sector. However, neither the modelling approaches nor the crop simulation tools are at present fully up to the task (Knutti 2010, Rosenzweig & Wilbanks 2010, Rötter et al. 2011). For example, most crop simulation models do not account for crop-specific abiotic and biotic stresses (e.g. climate extreme events, pests, and diseases). Moreover, their application for large-area assessments has been done without properly considering time and

spatial up-scaling issues. These and other deficiencies lead to uncertainties, which are often not quantified.

The crop modelling (CropM) component of the FACCE JPI knowledge hub MACSUR (www.macsur.eu) and other agricultural research projects and networks (e.g. AgMIP and CCAFS) are designed to improve the prediction of climate impacts on agriculture. The last international symposium on crop model capabilities, along with the gaps and challenges associated with this, was held more than 10 years ago. Responding for this need for more up-to-date information and analysis, the CropM International Symposium and Workshop was held in Oslo on 10–12 February 2014 to discuss the state-of-the-art—along with future perspectives—of crop modelling and approaches for climate change risk assessment, including the challenges of integrated assessments for the agricultural sector.

*Corresponding author: marco.bindi@unifi.it

2. Contributions to this CR Special

The contributions to this CR Special focus on:

(1) Improvement of tools and applications in climate change assessments (Ferrise et al. 2015, Tao et al. 2015).

(2) Assessment of uncertainty in the modelling of impacts in agriculture, e.g. in upscaling, and in climate and crop model ensembles (Baranowski et al. 2015, Hoffmann et al. 2015, Persson et al. 2015, Pirttioja et al. 2015, Salack et al. 2015, Semenov & Stratonovitch 2015, Zhao et al. 2015).

(3) Assessment of impacts and adaptation strategies (Gabaldón-Leal et al. 2015, Hlavinka et al. 2015, Karunaratne et al. 2015, Mitter et al. 2015, Palosuo et al. 2015).

3. Principal messages

Most early crop simulation models were not primarily developed for the study of climate change impacts, but crop-modelling studies for climate impact research have more recently been substantially elaborated on. Explicit attention has been given to ways of improving descriptions of different adaptations (e.g. use of improved crop cultivars, soil and crop management) and abiotic and biotic stresses. In addition, methods assessing and reducing uncertainties related to model applications, such as multi-model ensemble simulation and upscaling studies, have been further developed (Ewert et al. 2015).

This CR Special highlights potential uses of crop models, for example in combination with seasonal climate forecasts and long-term climate scenarios for climate change impact assessments. Climate and crop model ensembles and upscaling applications can improve accuracy, as well as the analysis of uncertainties, in crop responses. Finally, in studies on adaptation strategies, the use of crop models within integrated modelling frameworks (e.g. statistical climate change models, crop rotation models, biophysical process models, and economic bottom-up land use optimization models) was demonstrated and further developed.

The contributions this CR Special further highlight the importance of accuracy in process descriptions and model calibrations for simulated results. For adaptation studies in particular, the responses of models to changes in soil and crop management were shown to be essential. Finally, the availability of high-quality data for model calibration and testing was seen as a major limiting factor to model improvement.

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