A UK climate-crop modelling capability for impact assessments on food security: plans and progress

Pete Falloon[1], Andy Challinor[2], Marcelo Galdos[2], Mike Rivington[3], Robin Matthews[3], Mikhail Semenov[4], Brendan Freeman[5], Ed Pope[1]

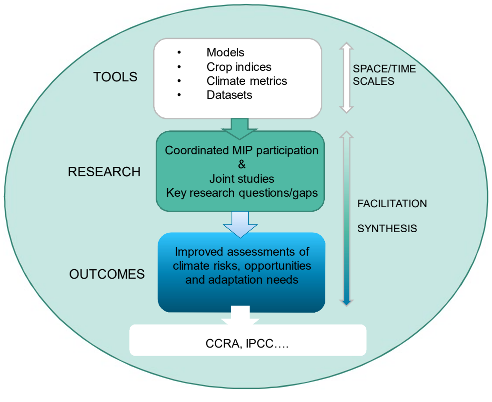
[1]Met Office Hadley Centre, Fitzroy Road, Exeter, UK; [2]School of Earth and Environment, University of Leeds, Leeds, UK
[3]Information and Computational Sciences, The James Hutton Institute, Craigiebuckler, Aberdeen, Scotland, UK; [4]Plant Sciences, Rothamsted Research, Harpenden, UK;
[5]Committee on Climate Change, 7 Holbein Place, London, UK.

Summary

We propose the development of a UK climate-crop modelling and impact assessment capability that will:

- *bring together key expertise in crop-climate modelling (including a range of approaches such as models, crop indices and climate metrics) and required data across space and time scales in the UK;*
- *facilitate coordinated participation in relevant MIP projects, and*
- *deliver robust assessments of climate impacts on UK food security.*

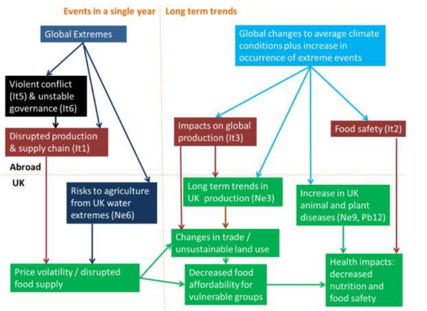
Activities under this capability will help to deliver improved assessments of climate-related risks, opportunities and adaptation needs for crops, both in the present-day and in the future. Outcomes from the new capability will deliver key, coordinated contributions to the Climate Change Risk Assessment, IPCC Assessment Reports and related assessments. Additional benefits will be realised through an improved understanding of crop-climate interactions, associated model development, and ultimately pull-through from these findings to benefit the representation of agriculture in earth system models in the longer-term.



Assessing climate impacts on UK food security needs national and international perspectives

Climate change could affect UK food security through both national impacts such as direct effects on crop yields and agricultural practices, and international dimensions such as changing productivity and trade overseas. Given that the UK produces 60% of its food (Defra, 2017), risks to both domestic and international food production and trade were noted as a key priority in the recent UK's Climate Change Risk Assessment (CCC, 2012). There is also a large variation in self-sufficiency across food sectors, for example 100% for indigenous cereals and 10% for indigenous fresh fruit (Barling et al. 2008, using FAO data). UK food security is therefore dependent both on domestic and international production (Figure 1), so robust assessments will require both perspectives, as noted by the CCRA (CCC, 2016). This implies that modelling approaches are needed both at the global scale (to assess international dimensions) and local to national scale (to assess domestic risks and identify adaptation options).

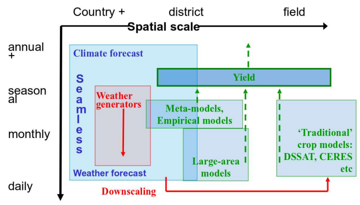
Figure 1: Risks to UK food systems derived from an analysis of international ("It") and domestic dimensions of climate change. Domestic dimensions arise from risks to natural environment and natural assets ("Ne") and people and the built environment ("Pb"). Blue indicates climate change; green shows impacts on UK food systems and society; brown shows international food system risks that are transmitted to the UK; black indicates factors that compound international food system risks. Full details, together with the other enumerated lists, are contained in Challinor et al. (2016), Brown et al. (2016) and Kovats et al. (2016), and via interactive web resources at UK Committee on Climate Change (2016). See also Challinor et al. (2017).



Climate-crop modelling tools for food security assessments

There is a wide range of tools for assessing climate impacts on crops across time and space scales, including detailed process models, indices and indicators, and large scale crop models (Figure 2). The UK has a broad and diverse pool of expertise relevant to climate change and crop modelling, but it is fragmented and lacks coordination. This has led to omissions in key climate impact assessments. For example, the 2012 CCRA (CCC, 2012) used a simple regression between temperature and wheat yield to assess future risks (Knox et al. 2012) but this was criticised (Semenov et al. 2012) for failing to account for key factors which more comprehensive models could address (genetic improvement, pest/disease management, fertiliser use, water limitations, CO_2 fertilisation and climate extremes), although the authors noted the limitations were made explicit, and the approach taken was chosen to enable consistency with a wider range of impacts being assessed (Knox & Wade, 2012).

Figure 2. Schematic representation of methods used to combine crop and climate models. Solid arrows show climate information; dashed arrows and lightly shaded boxes show crop growth simulation. Solid boxes show numerical models; boxes with dotted outlines show model output. Areas where boxes overlap indicate models that operate on commensurate spatial and temporal scales. From Challinor et al. (2009)

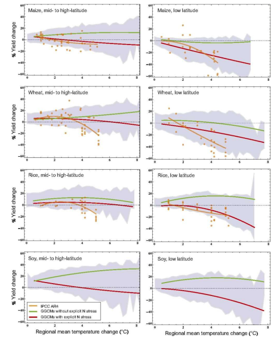


Crop models and MIPs: the challenges of communication

Climate impact assessments of food security often rely on crop models and are increasingly being delivered through coordinated model inter-comparison projects (MIPs) such as AgMIP[1] and ISI-MIP[2], which can help produce robust assessments, understand uncertainties and provide roadmaps for future model development. However, results from MIPs can be difficult to communicate given they often produce wide spreads in impacts probabilities that may be difficult to interpret due to differences in model formulations and experimental design (Figure 3). In addition, such MIPs are largely conducted at the global scale, which is relevant to international dimensions of food security, but lacks the detail required for local to national adaptation planning such as informing future crop breeding programmes.

"There is considerable variation in response with mid- and high-latitude crop yields spanning both positive and negative responses.." - Rosenzweig et al. 2014

Figure 3: Mean relative yield change (%) from reference period (1980–2010) compared to local mean temperature change (°C) in 20 top food-producing regions for each crop and latitudinal band. Results shown for the 7 GGCMs (6 for rice) for all GCM combinations of RCP8.5 compared to results from IPCC AR4 (represented as orange dots and quadratic fit). The 15–85% range of all models for each ¼°C band is represented in grey. Limits of local temperature changes reflect differences in projected warming in current areas of cultivation. From Rosenzweig et al. 2014

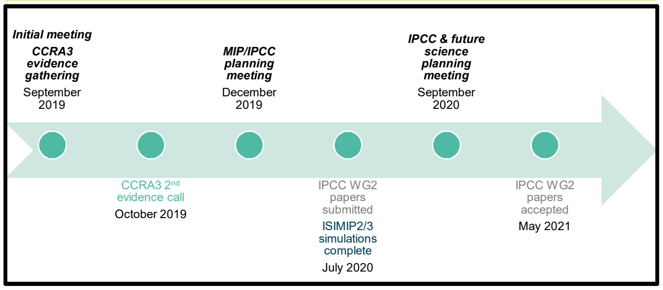


1: AgMIP - the Agricultural Model Inter-comparison Project

2: ISI-MIP – the Intersectoral Impacts Model Inter-comparison Project

Plans and activities

Key timelines for IPCC, CCRA and ISI-MIP are given below. We are proposing meetings to coordinate inputs, write joint papers, and set key science questions as follows.



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Met Office Hadley Centre, FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: +44 1392 885680 Fax: +44 1392 885681
Email: pete.falloon@metoffice.gov.uk