What does the Paris Agreement mean for crop-climate modelling?

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The Paris Agreement achieved at COP21 has reignited scientific interest sub-two degree global mean temperature targets and prompted a need for risk assessments that can differentiate between 1.5 and 2 degrees of global warming. Risks can be defined narrowly as the potential for reduced food production, or broadly as the risk to the food systems that deliver – or fail to deliver – food security. This talk focusses on the role of crop-climate modelling within each of these types of assessment.

Assessments of risk to crop productivity have a relatively long history, and tend to be based on crop-climate modelling (e.g. Challinor *et al.*, 2009). Detecting systematic differences in crops yields at 1.5 vs 2 degrees of warming is difficult because the range of model results is large (Fig. 1). The frameworks used to conceptualise uncertainty underpin the potential for crop-climate modelling to distinguish risks. A critical assessment of these frameworks reveals a number of characteristics that tend to improve risk assessments:

a. Use of a range of observed data and outputs from crop models, as opposed to only yield (Challinor *et al.*, 2014a, Wesselink *et al.*, 2014).
b. Data analysis to determine when particular changes will occur, rather than what will occur at any particular time (Vermeulen *et al.*, 2013).
c. Use of crop-climate models as part of broader assessments of risk (e.g. Ewert *et al.*, 2015). The concept of 'food system shocks' has recently been used to capture the impact of major extreme events on global food systema (Lloyds, 2015).

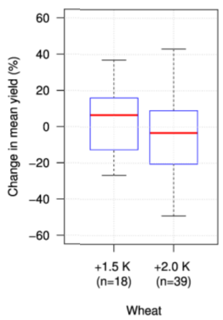

*Figure 1***.** Difference in modelled wheat yields from across the globe for 1.5 and 2 K of global warming. Source: ref. (Challinor *et al.*, 2014b) re-analysed by Julian Ramirez Villegas.

Risk assessment methods such as those outlined above can be used to evaluate the implications of the Paris Agreement. A number of technical challenges will need to be addressed when quantifying future impacts in a way that aligns with policy targets:

- **Understanding the spatial distribution of climate and its impacts for a given change in global mean temperature.** For any given change in global mean temperature there are a range of possible global spatial configurations of temperature change. These interact with land use patterns, which are themselves a source of uncertainty in determining yield responses (Challinor *et al.*, 2015).
- **Detailed understanding of the risk of food system shocks** (Lloyds, 2015) and their implications will require very long (1000+ years) climate model runs in order to capture the statistics adequately.
- **Global-scale impacts and adaptation options need to be assessed alongside global agricultural mitigation options.** Work at the adaptation/mitigation interface (e.g. climate-smart agriculture) is often conducted at relative small scales. The strong mitigation targets presented by the Agreement make global- and regional- scale assessments of this sort particularly important.

Addressing these and other associated challenges will require a plurality of approaches. Critical analysis of the modelling tools available to achieve these technical challenges demonstrates that there is no single approach that can be expected to produce the most robust results. Hence, in order to assess risk and provide societally relevant information we are increasingly required to conduct impacts modelling in novel and diverse ways. Targeted analyses of this sort could profitably focus on identifying which decisions it can affect (Hulme, 2016), perhaps following a similar methodology to the global framework for climate services the might fall under the climate services umbrella (Hewitt *et al.*, 2012).

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