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

@AndyChallinor
“Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C”

UNFCCC has requested an IPCC Special report 2018 on impacts at 1.5°C

“UNFCCC's invitation raises the issue of whether the IPCC is in a position to deliver such a report in 2018, and if so, whether its assessment would be useful and robust” (Hulme, Nature Climate Change 6, 222–224 2016)

=> Focus instead on decision-centred research
Simulated outcomes

1. Risk of reduced yields
2. Risks to the food systems that deliver – or fail to deliver – food security

All possible outcomes

Unpleasant outcomes

Simulated outcomes
1.5 vs 2 degree
temperature impacts

How can crop-climate modelling contribute to:

1. Assessments of food production
2. Food systems
5. Better decision-making

Source: Julian Ramirez / IPCC CH7 data
1. Risks to crop yields

Challinor et al. (2014), Nature Climate Change, doi:10.1038/nclimate2153

Estimates of uncertainty can be too broad or too narrow
Work is needed to determine appropriate error bars for mean yield analyses

Uncertainty metrics:

1. The full spread of data => Simulated uncertainty has increased
2. Bootstrapped regressions => uncertainty about the same, but the answer has changed
   • So, the “AR4” uncertainty estimate must have been too small; and probably the “All data” too

Simulated outcomes

Unpleasant outcomes

All possible outcomes

Simulated outcomes

Improve overlap through:

- Good practice in modelling
  - Models applied at spatial scales different to those intended
  - Lack of model evaluation / testing
  - No attempt to quantify uncertainty
  - Often unclear which processes have been simulated within a given ag. impacts study

- Using a range of obs data and models (and not just for yields)
- Looking for systematic differences within uncertainty ranges

White et al. (2011) Field Crops Res. 124 (3), 357-368
Wesselink et al. (2014) Climatic Change DOI 10.1007/s10584-014-1213-1
Looking for systematic differences according to method


“Niche effect”

And: models tend to be more skilful for higher cropped area

See Watson et al. (2014), Comparing the effects of calibration and climate errors on a statistical crop model and a process-based crop model, Climatic Change, 1-17
How do weather and climate influence cropping area and intensity?

Toshichika Iizumi, Navin Ramankutty

doi: 10.1016/j.gfs.2014.11.003

Cropping frequency and area response to climate variability can exceed yield response

Avery S. Cohn, Leah K. VanWey, Stephanie A. Spera and John F. Mustard
2. Risks to food systems
1 & 2. Food shocks and means yields at 1.5 vs 2 deg.

3. Agriculture needs to be part of the solution
1 & 2. Food shocks and means yields at 1.5 vs 2 deg.

3. Agriculture needs to be part of the solution

4. Demand-side issues
5. Information for decision-making

Reframing uncertainty:

Time of Emergence (ToE) of the signal

Graph taken from Mahlstein et al. (2011) Environ. Res. Lett. 6 034009
Recent research:

Crop breeding is not keeping pace with climate change

Challinor et al. (Nature Climate Change, forthcoming)
climate change and agriculture

J. Vermeulen, Louis Parker, den

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The diagram illustrates the extent of transformation (%) of bananas, cassava, and yams from 2020 to 2080 under different climate change scenarios.

The maps show the predicted distributions of pearl millet, sorghum, yam, and maize across Africa, with color coding indicating varying adaptation levels.
Approaches to risk assessment in crop-climate modelling include:

- Continued model intercomparison and improvement
- ToE analysis
- Targeted analyses that employ a range of linked methods (indices, crop models, niche models,...)
  - Maize studies used ToE, crop yield and niche models, and indices
  - Food shocks analysis using analogues and crop models

In summary
Moss et al. (2010)
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