Improving treatments of uncertainty in climate and its impacts

Andy Challinor
Issues in climate change uncertainty

• (How) can we develop quantitative estimate of climate change that take full account of uncertainty?

• Multiplicity of sources of climate information causes problems - are they all to be treated as equally plausible?

• Relationship between spatial scale and uncertainty causes problems for models of impacts and for users
The diversity of techniques used to estimate ranges of future crop yield produce a broad spectrum of results (see e.g. Challinor et al., 2007)

⇒ Systematic quantification of uncertainty and/or

⇒ Focus on decision-making
EQUIP: End-to-end Quantification of Uncertainty for Impacts Prediction

- Edinburgh, Newcastle, Liverpool
- NERC directed research
- EQUIP network (external users and academics) is a core part of our research
End-to-end analyses across decadal timescales

Signal to noise ratio for decadal mean surface air temperature predictions

What would these curves look like for impacts?
- Marine ecosystems
- Crops
- Droughts
- Heatwaves

Design, implementation, and evaluation of forecast systems need to include user needs and the relevant climate impacts, from the start.

Hawkins and Sutton (2009)
Objectives

- Develop **advances in methodology for risk-based prediction, quantification of uncertainty** and identification of **information content** that will be used widely by the scientific community.

- Demonstrate the **utility of climate prediction for some specific decisions**, through engagement with users.
  - e.g. ‘breeding crops for 2030’

- **Contribute significantly to coordinated assessment work on climate change**, including that of the IPCC and UKCIP, through improved quantification of uncertainty across climate and its impacts.
  - In particular future droughts, heat-waves, crop production and marine ecosystems.

- Inform policy through **improved predictions of near-term climate change and its impacts**, including information on the relevance and applicability of the predictions.
EQUIP: an impacts perspective

- Increased climate skill
- Higher resolution for impacts
- Less quantification of uncertainty

Challinor et al. (2009b)
End-to-end quantification of uncertainty for crop prediction (the ensembles route)

Accounts for uncertainty in both crop and climate models, but:

- Will total uncertainty be lower when examining decadal timescales?
- Will initialised simulations result in improved predictability?
- Importance of subgrid processes

Challinor et al. (2010)
The resolution route

Frequency distributions of daily maximum temperature for two grid cells in India

Challinor et al. (2007b)
Improving treatments of uncertainty in crop models
Systematic exploration of crop parameter space

**Single-parameter and Multi-parameter**

**Quantised values, parameters varied one at a time**

**Multi-parameter**

(The same) quantised values, 0-100% (average ~18%) parameters varied

All values (min to max) equally likely
Quantifying and reducing crop model uncertainty

Sources of unc:
1. Lack of process understanding at T>\(T_{opt}\)
2. Models developed and evaluated at different spatial scales and in different environments

Challinor and Wheeler (2008b)
Cross-cutting themes and foci in IPCC AR5

Importance of quantification of uncertainty across physical/natural/social systems and across model chains:

• ID high-confidence findings, using analysis of basic mechanisms and multiple lines of evidence

• Support for good decisions under uncertainty

⇒ links across WGI and WGII are key

⇒ As are links with user community
In conclusion

EQUIP = Quantifying uncertainty & Decadal timescales & Utility of models - ‘end to end’

Impacts / utility perspective
Trade off between resolution and ensemble size
Information content vs ‘real world inside a computer’
Need an end-to-end understanding of processes across spatial scales (e.g. T>34oC)
=> Focus on robust processes; use data and models to increase understanding
=> Systematic exploration of uncertainty in impacts models
⇒ Impacts models of appropriate complexity and spatial scale

Ongoing work in EQUIP:
• Review existing methods
• Extract decision-relevant information
• Evaluate predictions
• Work on specific impacts
• Developing network of scientists and users
Some recent initiatives in uncertainty analysis and climate prediction

- Royal Society meeting, March 2010
- LWEC / DECC meeting ‘Responding to climate change’, July 2010
  - Follow-on workshop on risk-analysis across scales
  - Follow-on workshop on integrated assessment modelling
- NSF-funded report “Best practice approaches for ... Uncertainty in climate decision making,” 2009
  - Meaning of qualitative language (‘likely’ etc) varies across people/contexts
- IAC review of IPCC
  - SPM and TS to use ‘qualitative level-of-understanding’* scale for uncertainty
  - Quantitative probabilities “only when there is sufficient evidence.”
- IPCC good practice guide for multi-model analysis
- IPCC guidance on uncertainty, and WGII supplement
User meeting April 2010

Representatives from:
- Munich Re
- UK Met Office
- Environment Agency
- UK Department of Health
- Consultative Group on International Agricultural Research
- UK Climate Impacts Programme

Collaborative case studies initiated on:
- Case study on Heat and cold waves and links to health
- Crops for 2030
Issues emerging from first user meeting

*How the end to end analyses are carried out:* Various options, e.g.
- Climate diagnostics or response surfaces sent to user
- Full end-to-end analysis using model chains, with summarised outputs
- Which approach is taken depends on the aim, e.g. specific decision or learning process (‘storylines’).

*Treatments of uncertainty can help or hinder decision-making.*
- *Amplifying cascades of uncertainty* need to be decomposed or condensed in order to affect a decision
- Choice of language is important: uncertainty vs robustness vs risk

*The multiplicity of sources of climate information* causes problems, e.g. are they all to be treated as equally plausible?

*Only sustained and informed engagement with users are likely to improve the utility of climate information.*