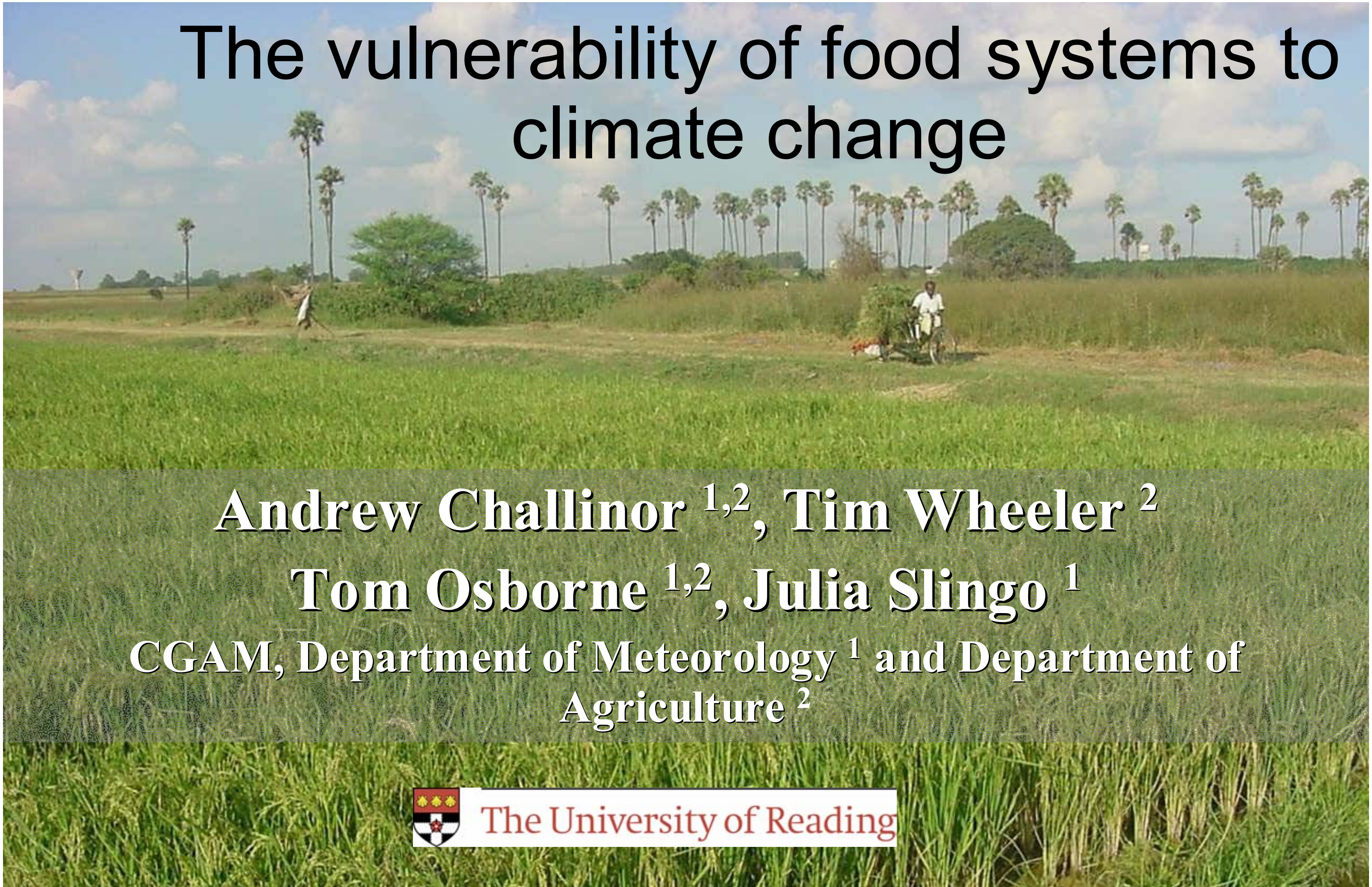
The vulnerability of food systems to climate change



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Key issues for agricultural impacts assessments

1. What constitutes dangerous climate change for food crops?
2. How accurately can we simulate crop yield in future climates?

Dangerous climate change for crops

- Changes in rainfall amounts and distribution
- Higher mean temperatures
- Extreme weather: droughts, floods, heat stress
- Increased CO_2 increases yield

Response of wheat to climate change: observations

CO_2 and mean temperature

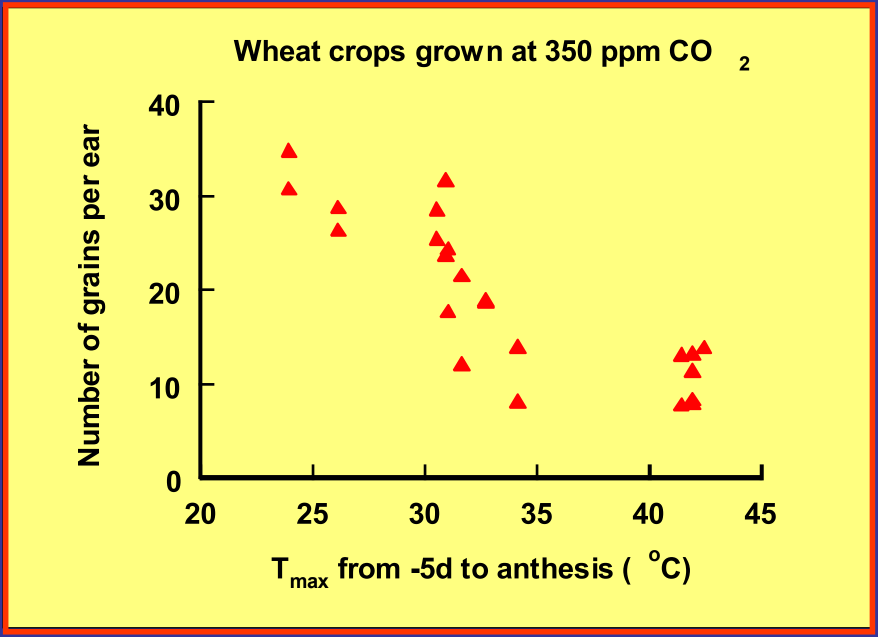
- Grain yields increase by 7 - 11% per 100 ppm rise in CO_2 under well-watered and fertilised conditions.
- Grain yields decrease by 6% per 1^{o}C increase in mean seasonal temperature.

Temperature stress

- Grain yields reduced when maximum daily temperatures exceed 31^{o}C close to the time of anthesis.

Climate thresholds: temperature stress

Grain set reduction at T>31 °C in wheat



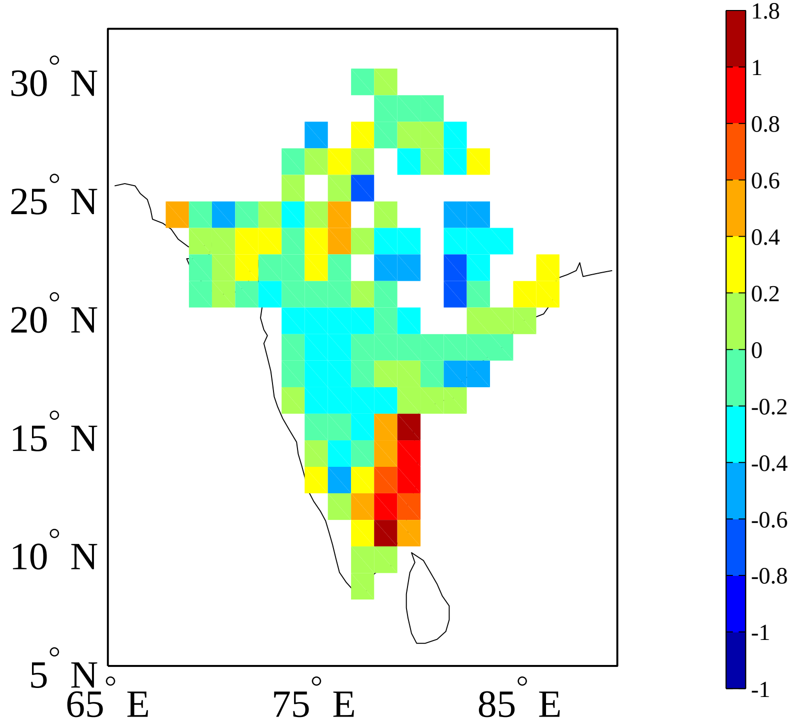
Wheeler et al. (2000)

Yield estimates to date

2 x CO_2 N. America	Wheat	-100 to +234%	Reilly and Schimmelpfennig, 1999
2 x CO_2 Africa	Maize Millet	-98 to +16% -79 to -14%	Reilly and Schimmelpfennig, 1999
2080s Africa	Cereals	-10 to +3%	Parry et al., 1999

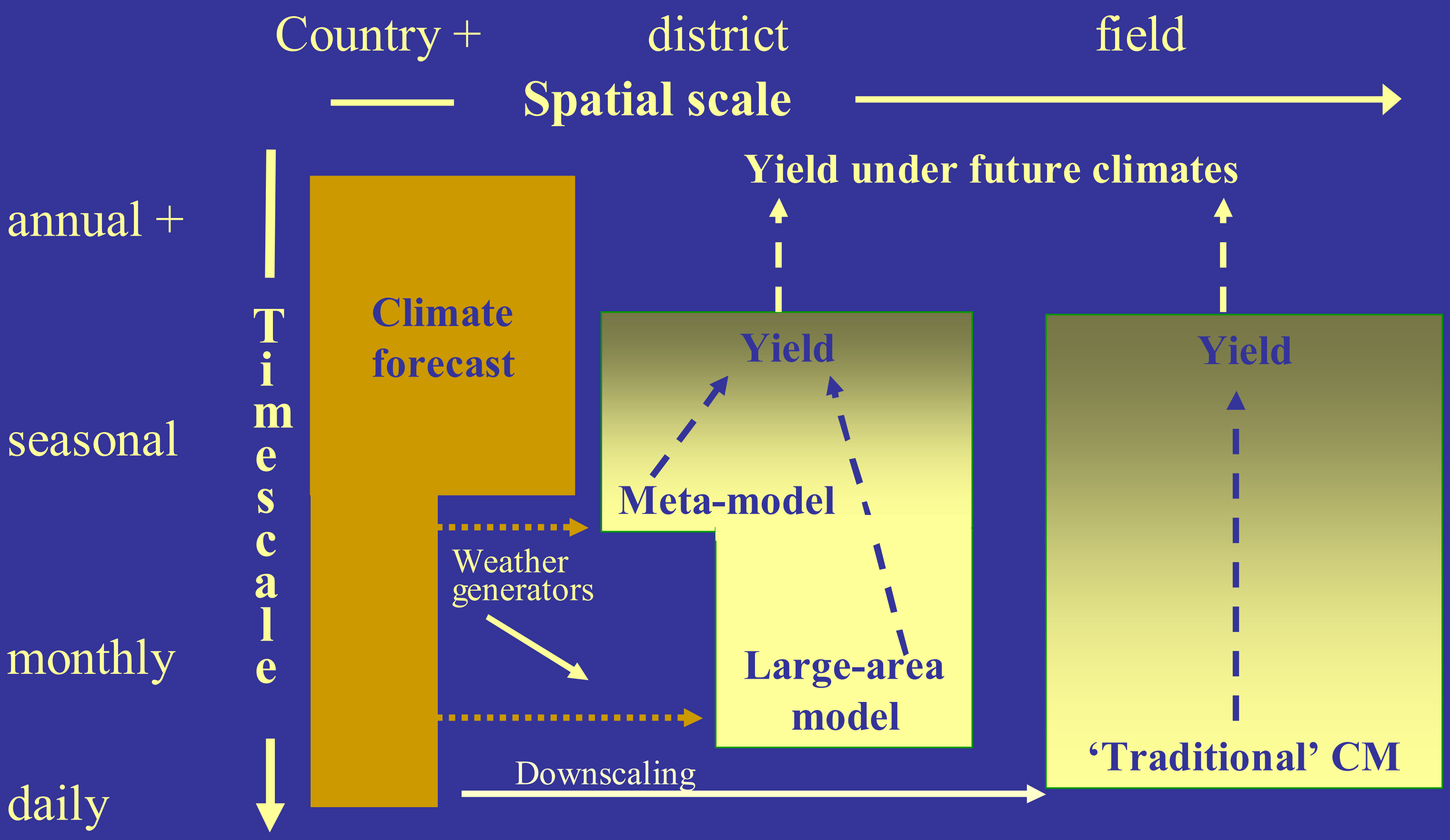
Uncertainty due to choice of crop model

- Empirical fit to crop model often used
- Regress seasonal mean weather onto crop yield in this case
- Results in a 20 - 40% difference in simulated yields in Gujarat

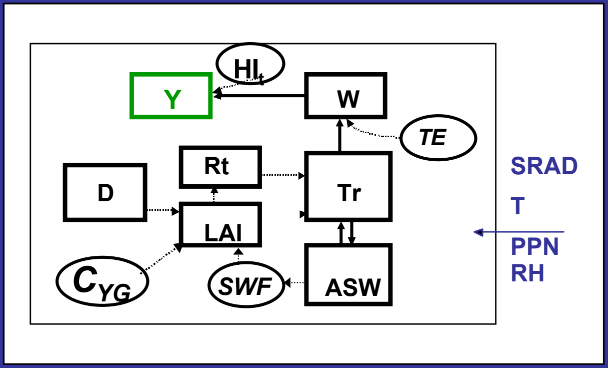


Mean fractional difference (24 years) between GLAM yield and empirical fit to GLAM

Bridging the scale gap



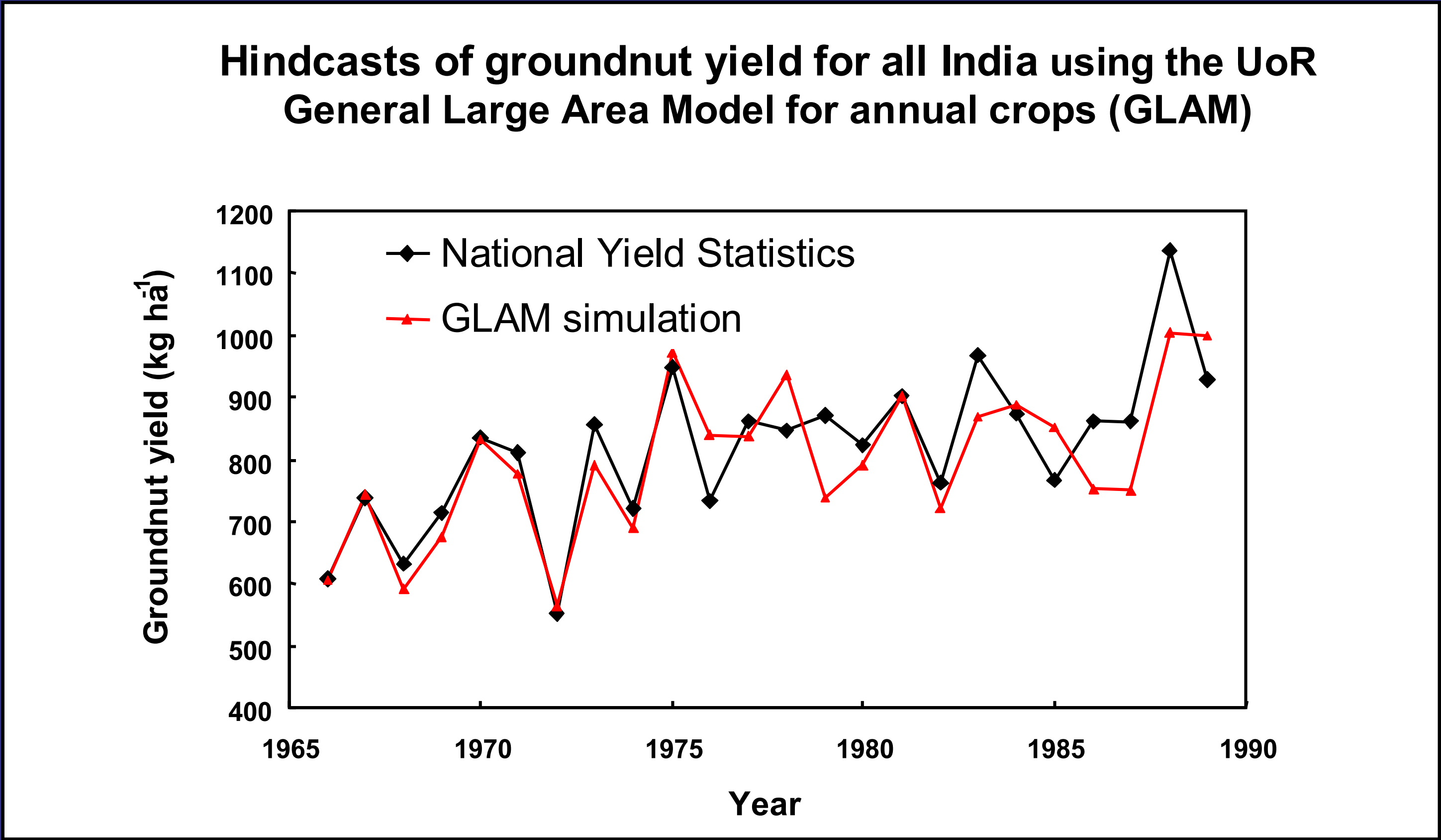
General Large Area Model for Annual Crops (GLAM)



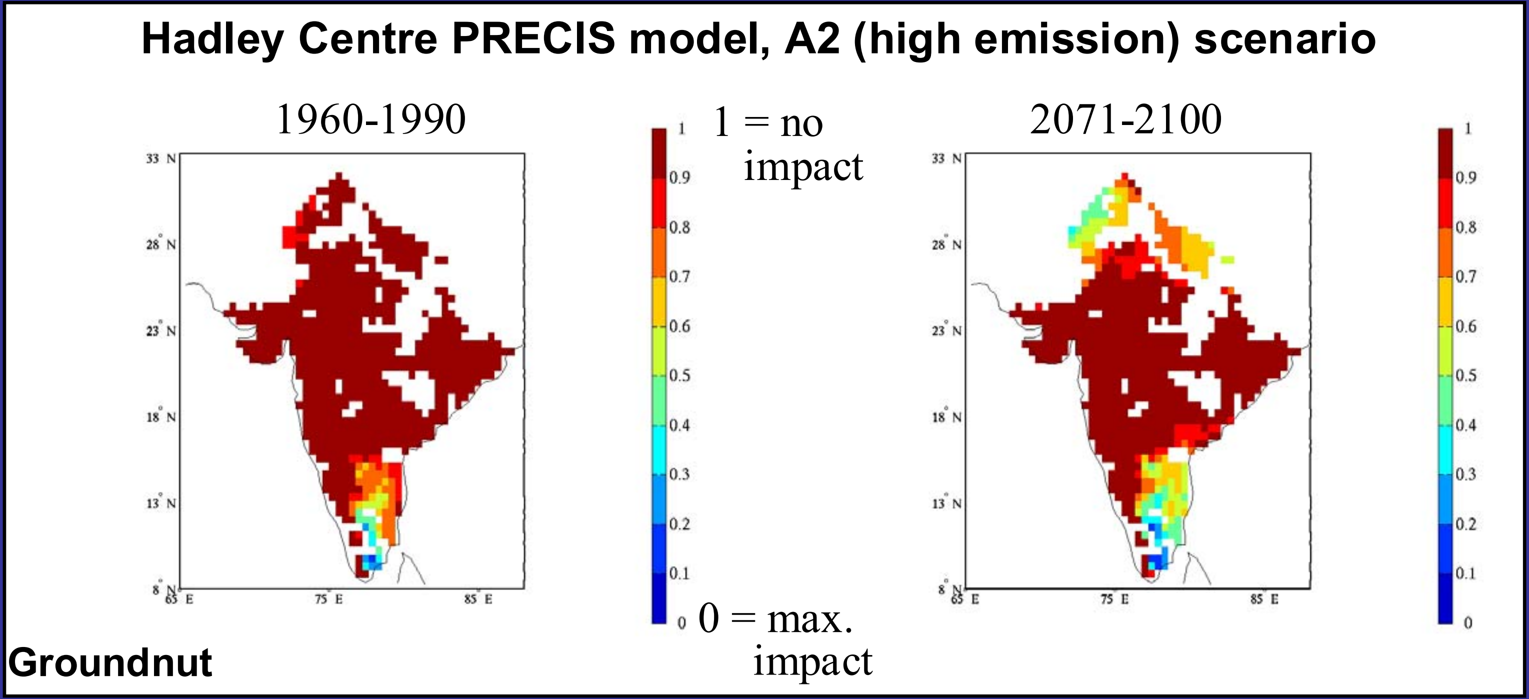
- Aims to combine:
  - the benefits of more empirical approaches (low input data requirements, validity over large spatial scales) ***with***
  - the benefits of the process-based approach (e.g. the potential to capture intra-seasonal variability, and so cope with changing climates)

Challinor et. al. (2004)

Results for current climate



Dangerous climate change: impact of water and temperature stress at anthesis



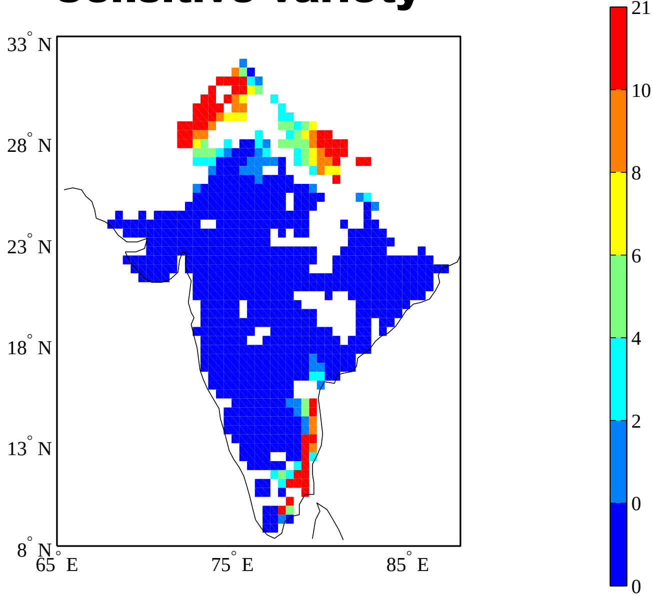
• Current risk is dominated by water stress; in the future climate run temperature stress dominates in the north.

Impact of temperature stress alone

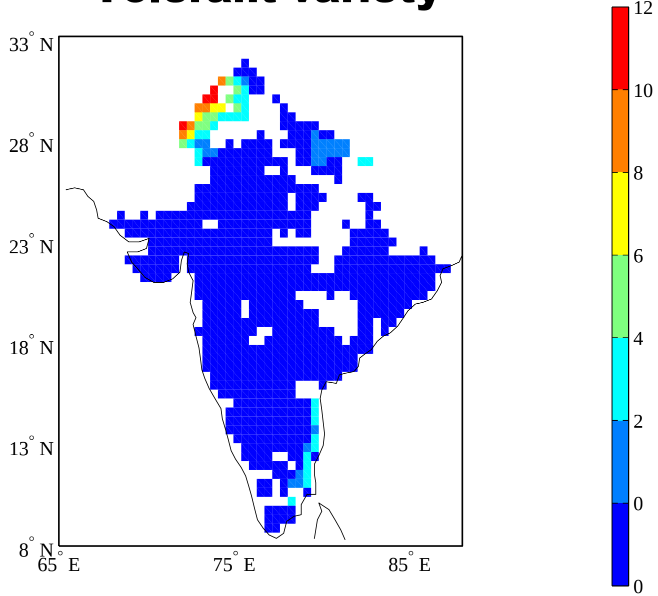
Hadley Centre PRECIS model, A2 (high emission) scenario 2071-2100

Number of years when the total number of pods setting is below 50%.

Sensitive variety



Tolerant variety



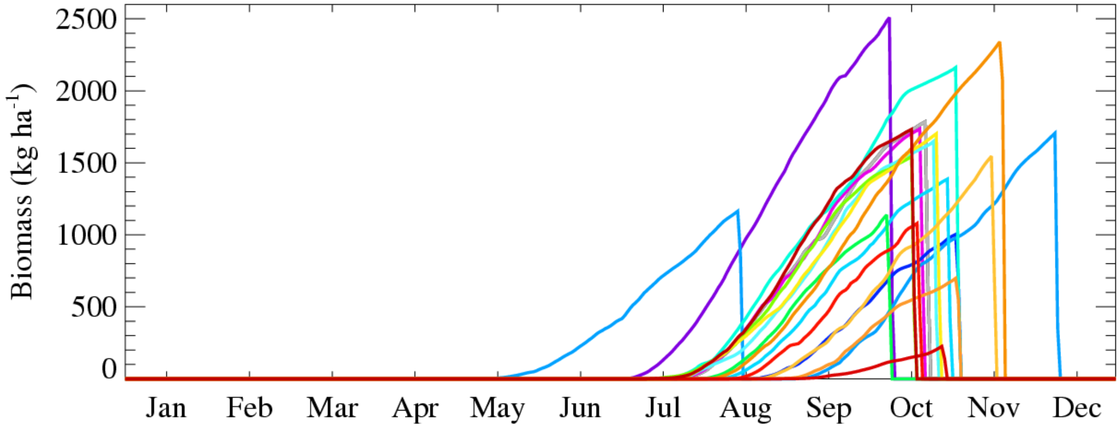
An integrated approach to impact assessments

- Crops can modify their own environment
  - The water cycle and surface temperatures vary according to land use
- Integrate biological and physical modelling
  - By working on common spatial scale
  - By fully coupling the models

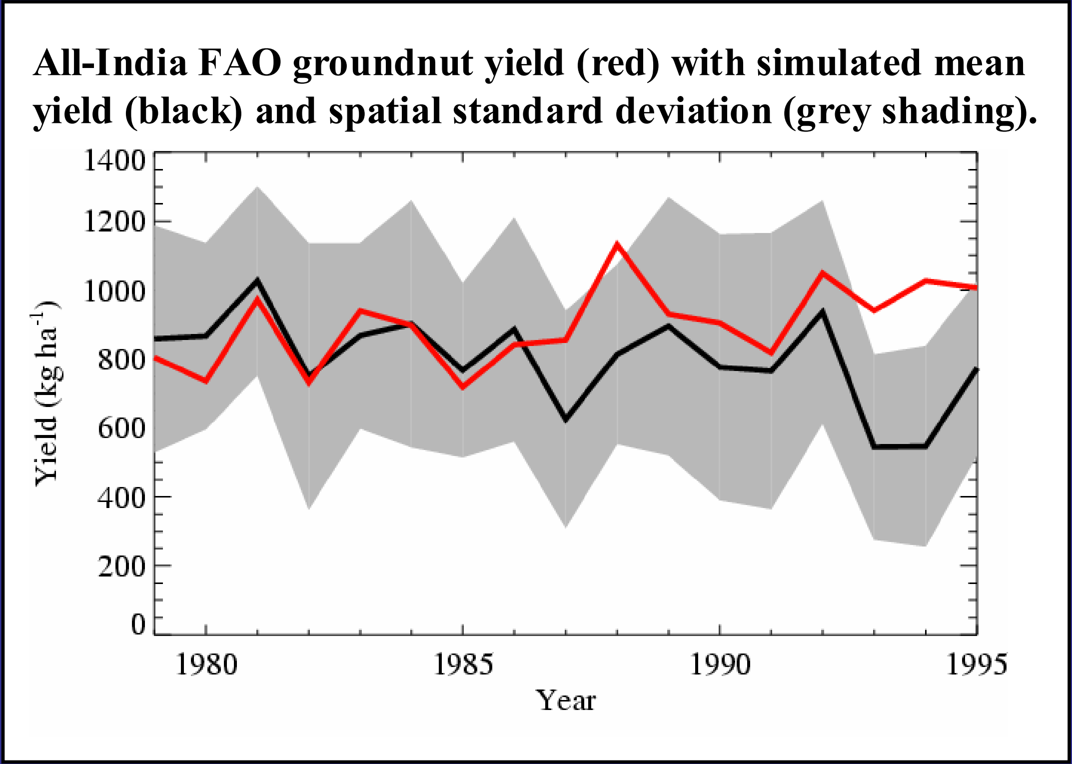
Fully coupled crop-climate simulation

- Resolve diurnal cycle
- Study feedbacks
- Integrate land-use patterns

Crops 'growing' in HadAM3 (NW India)



Fully coupled crop-climate simulation



Conclusions

- **How accurately can we simulate yield in future climates?**
  - There are many possible methods, crops, scenarios and locations
  - Studies to date have sampled a limited set of these possibilities
  - We need to develop our understanding of how these different methods impact yield estimates

Conclusions

- **What constitutes dangerous climate change for a food system?**
  - Depends on the balance between the impact of mean temperature and CO_2 increases
  - Treatment of weather extremes is crucial
  - A process-based approach is needed in order to assess these impacts

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