Identifying future threats: impact on wheat

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Rothamsted Research

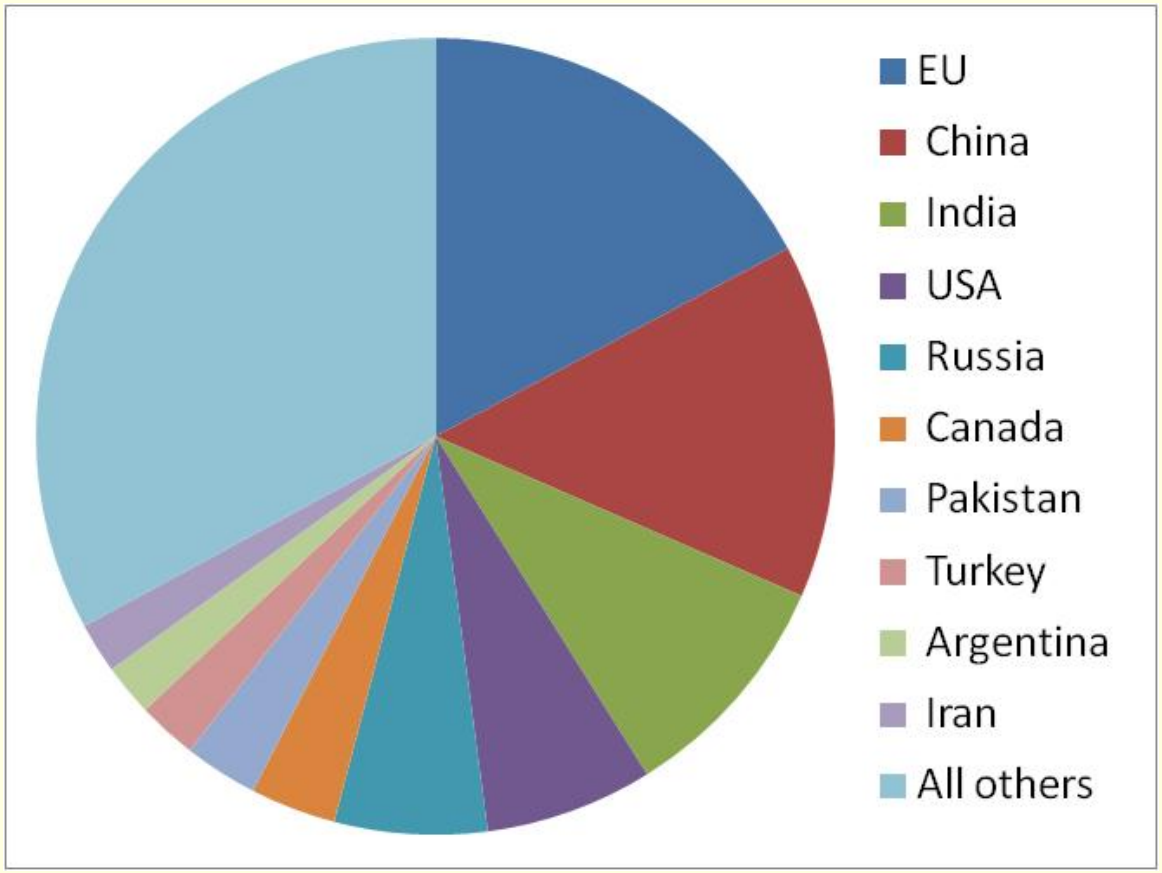
BBSRC bioscience for the future

ROTHAMSTED RESEARCH

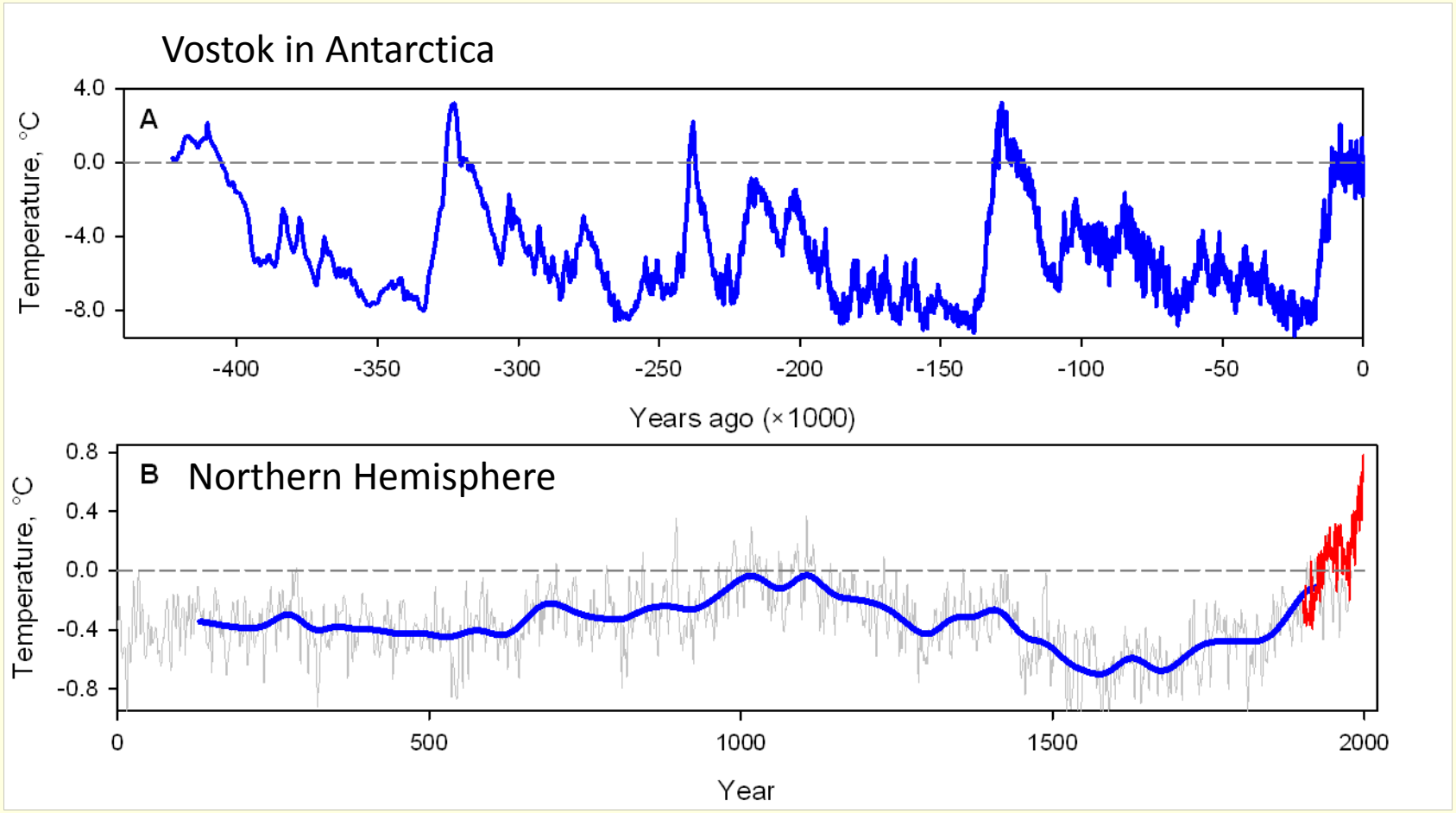
Food security and climate change

Wheat production in 2007 was 725 million ton

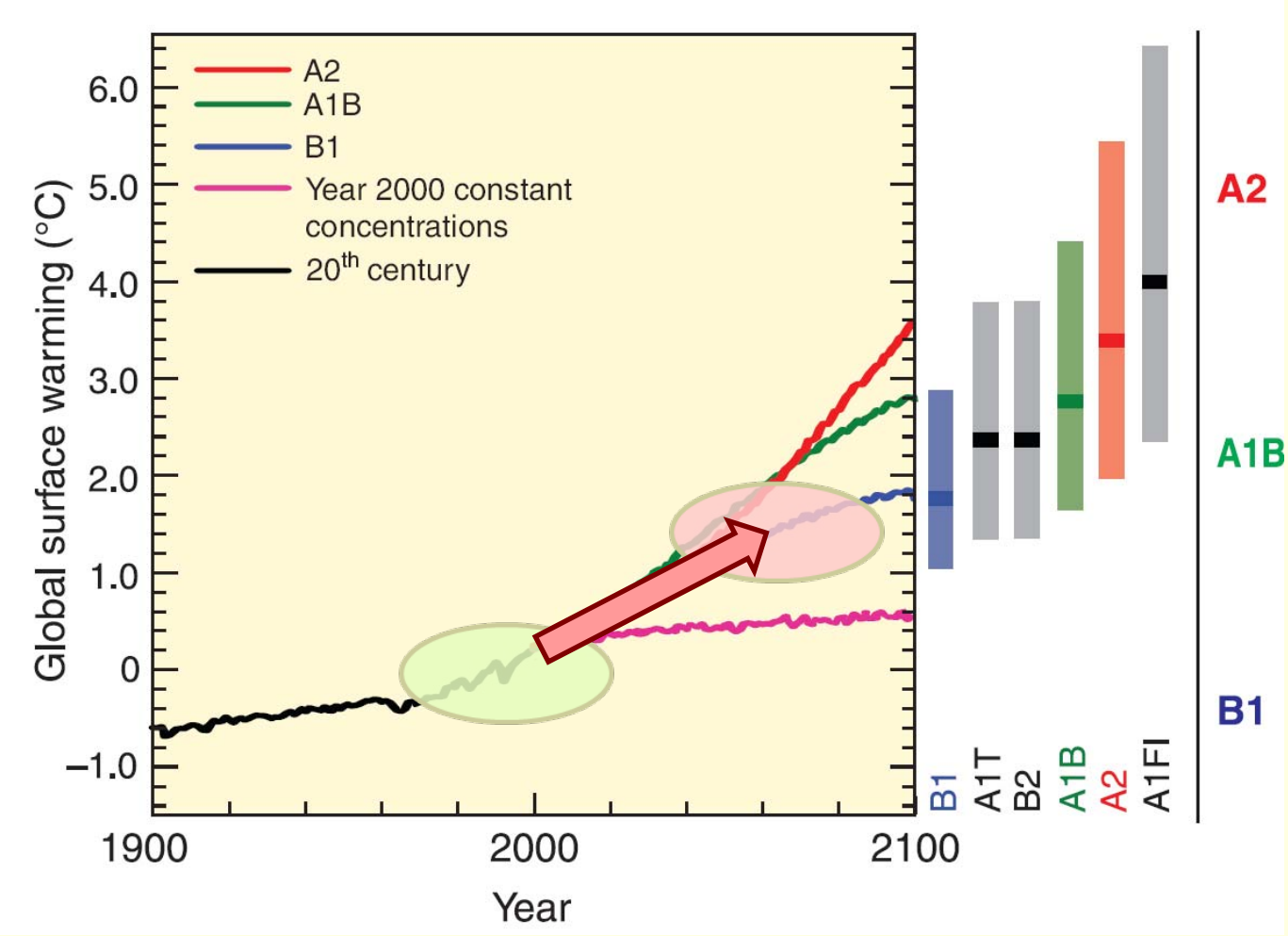
(wheat is the third most-produced cereal after maize and rice, FAO)



Historical temperature variation



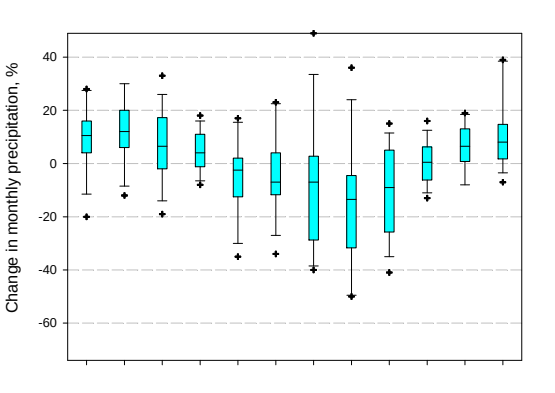
Breading for climate change



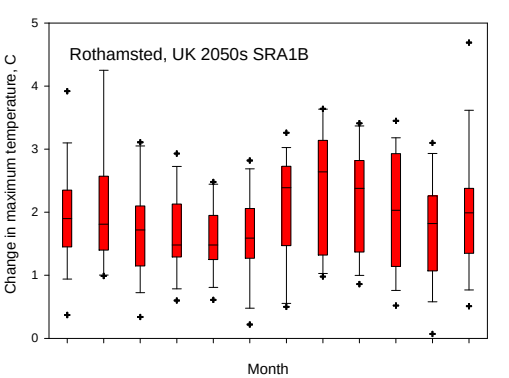
Identifying future threats

IPCC AR4 predictions for the 2050s

Drier summers



Hotter summers



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Breeding cultivars for drought or heat stress?

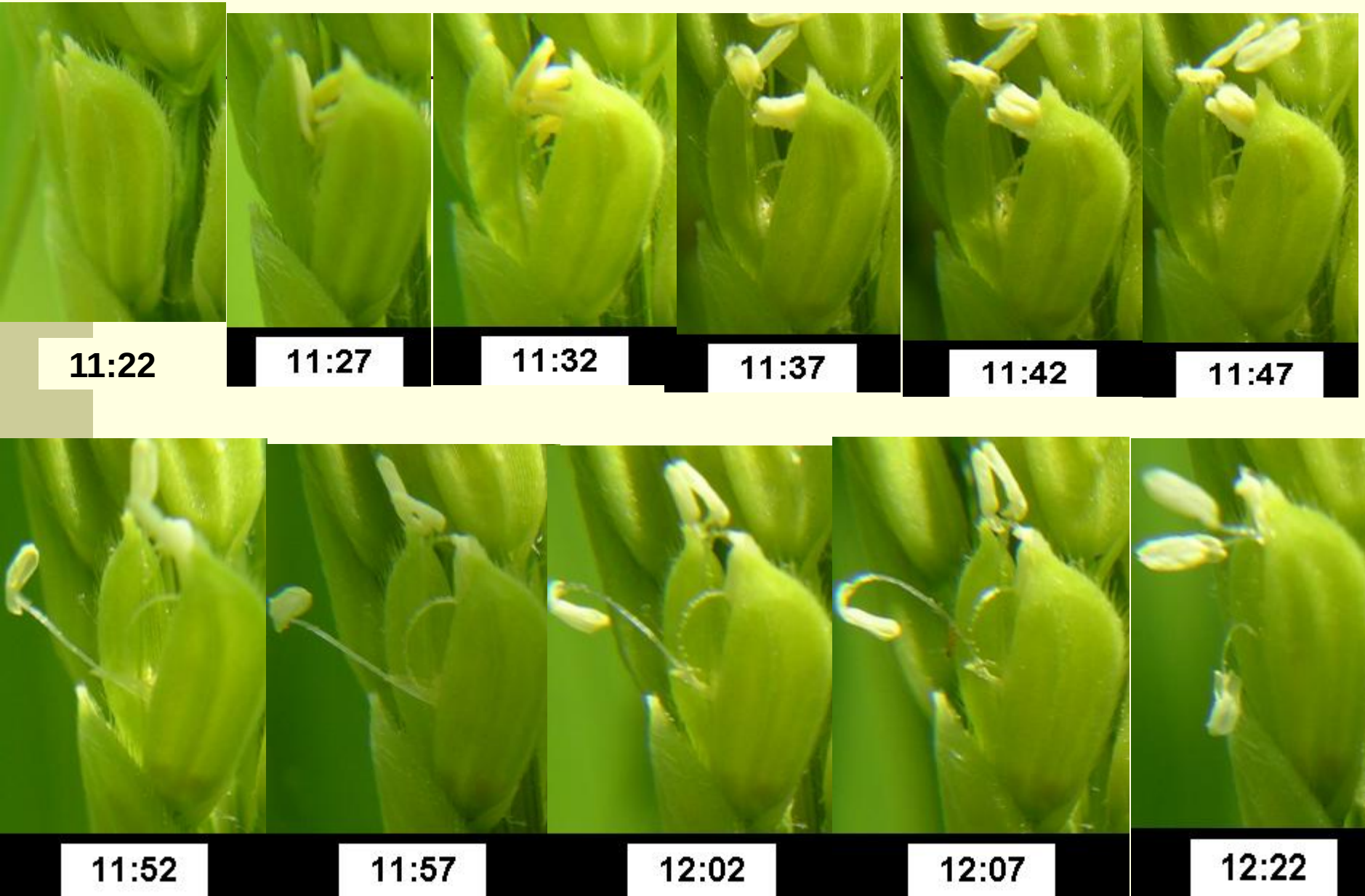
Extreme impact of high temperature

- Heat shock during flowering can result in a high number of sterile grains

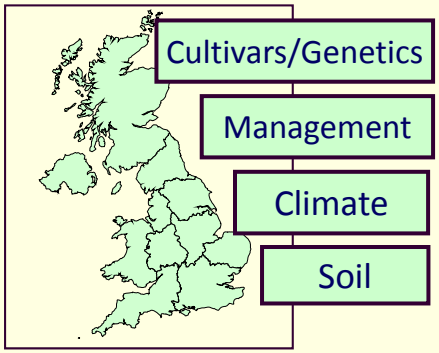
- Heat shock shortly after flowering decrease potential size of grains

Rice flowering

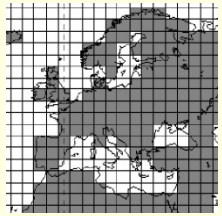
Toshi Hasegawa, National Institute for Agro-Environmental Sciences, Japan



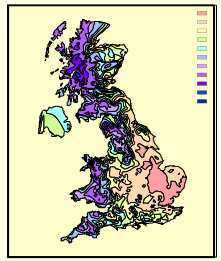
Modelling framework:
testing wheat performance in target environments



Global climate model



Weather Generator



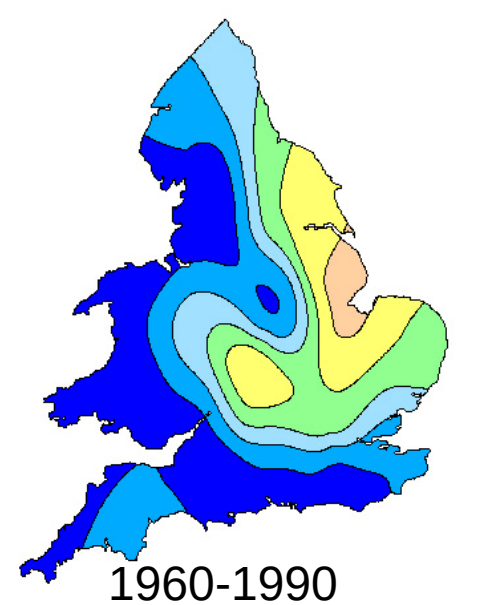
Local-scale scenarios

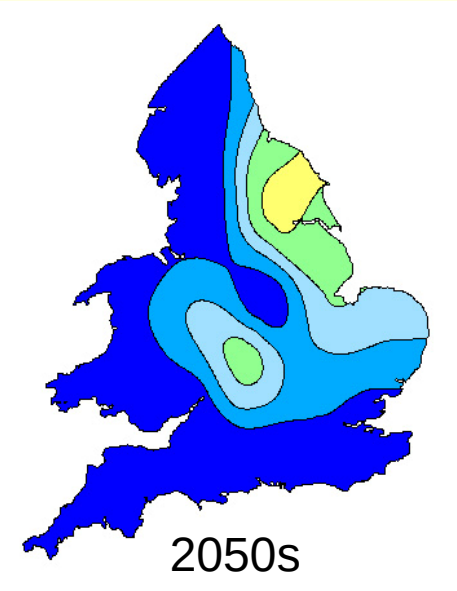
Wheat Model

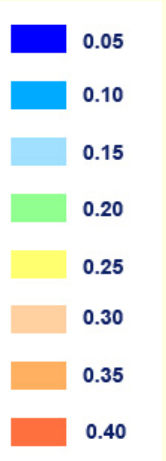
Wheat performance under climate change

Drought stress decreased

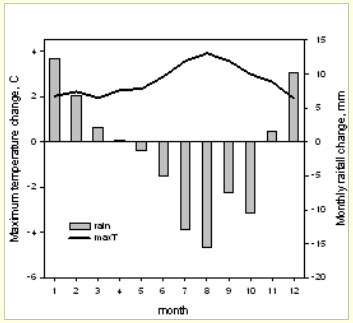
Yield losses due to drought expected on once every 20 years for cv. Avalon





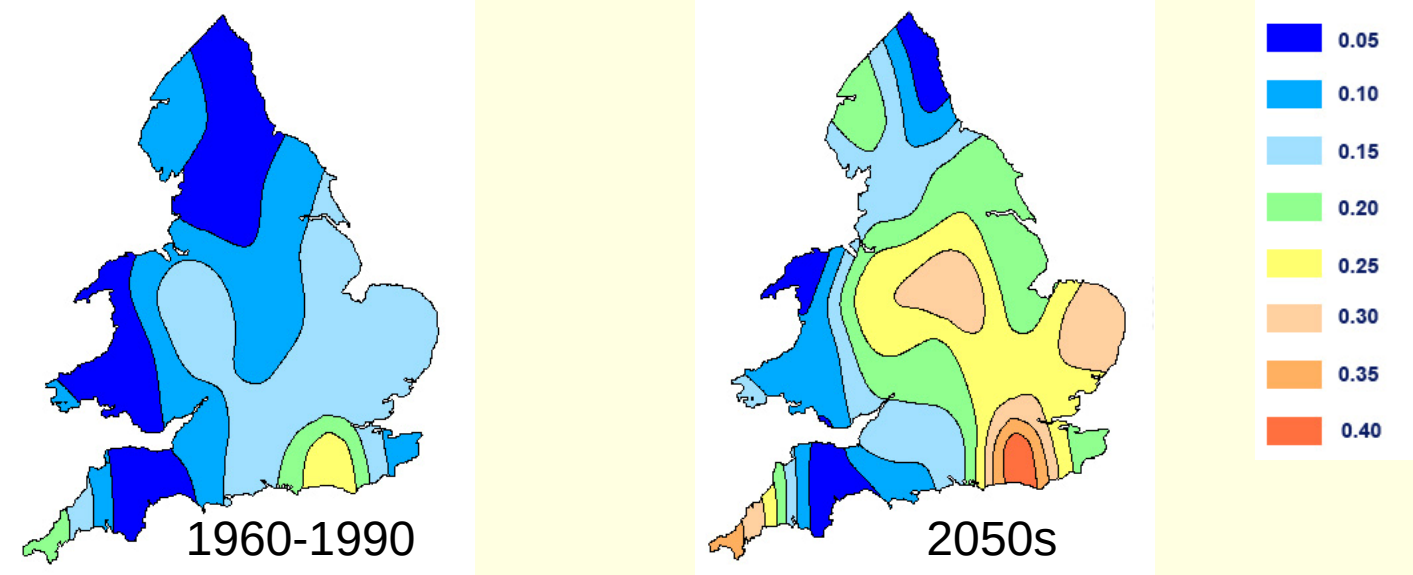


Cultivar		1960-90	2050HI
Avalon	Maturity	8 Aug	18 July



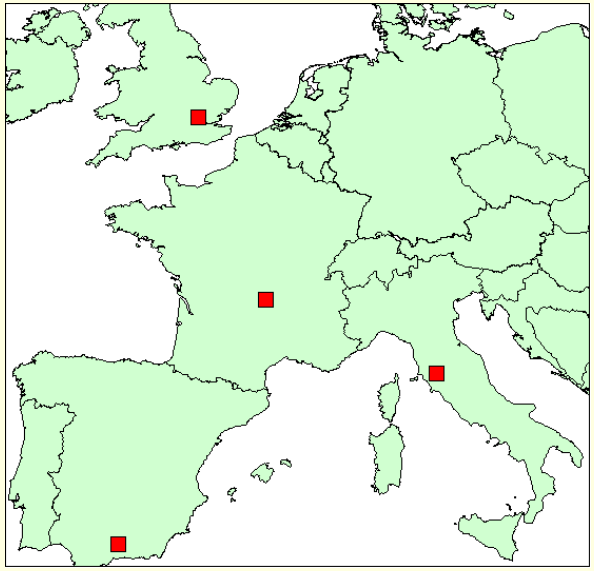
Heat stress at flowering increased

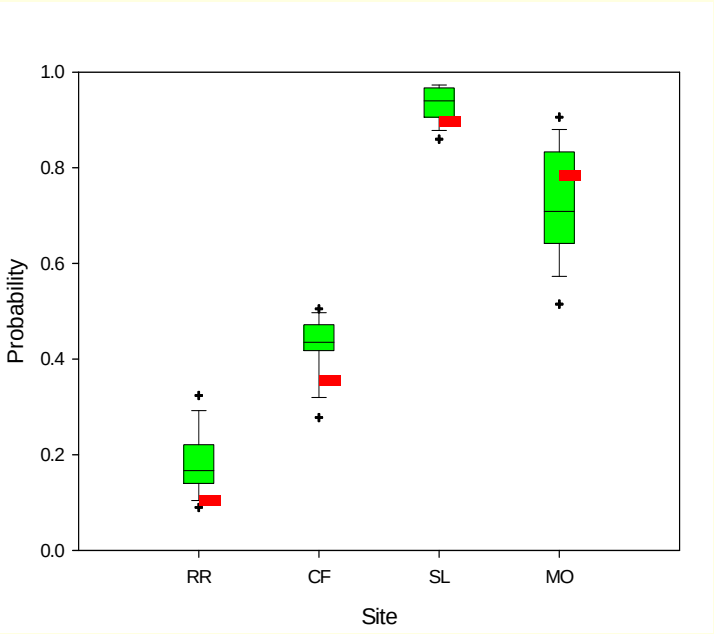
The probability of heat stress at flowering resulting to substantial yield losses for cv. Mercia



Cultivar		1960-90	2050HI
Mercia	Flowering	19 June	5 June
	Tmax at flowering, °C	19.36	20.42
	Tmax at 19 June		21.70

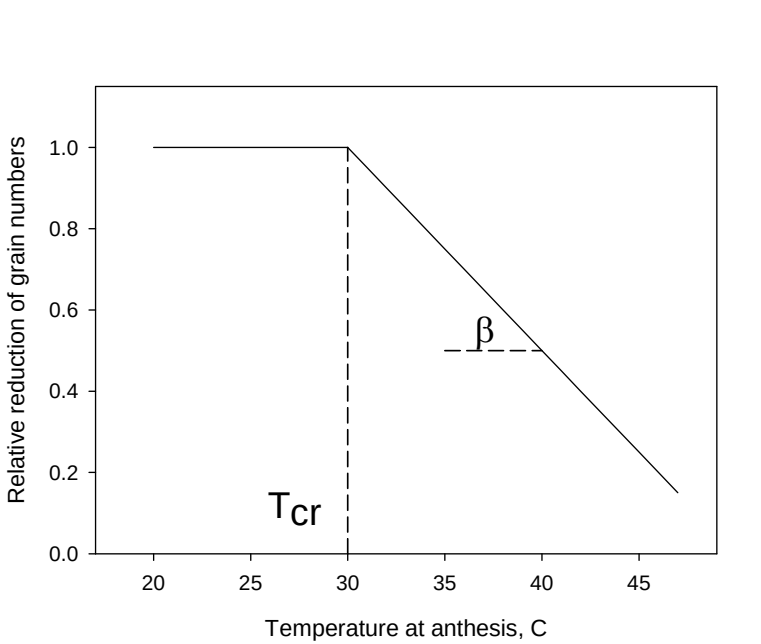
Heat stress in Europe





Simulation results suggest that the need for breeding for wheat varieties tolerant to heat stress around flowering is likely to be more pressing for Northern Europe.

Modelling the effect of heat stress on yield

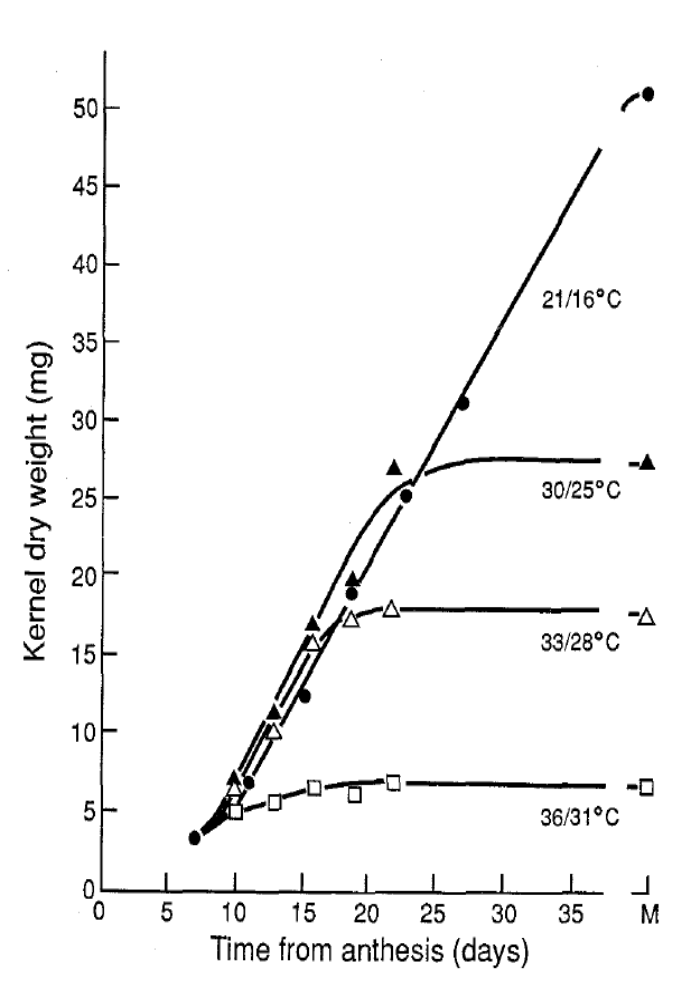


- The number of grain linearly decline, when maximum temperature exceeds a critical value *Tcr* during flowring.

- Wheat can compensate for reduction in grain number by growing larger grains.

(Mitchell et al, 1995; Wheeler et al, 1996)

Post-anthesis heat stress



- However, high temperature shortly after anthesis can substantially limit a potential kernel weight (*hypothesis*)

- Reduction in intercepted radiation due to decrease of grain filling duration for high temperature treatment alone does not explain a decrease in kernel weight

- Tolerance to post-anthesis heat stress is cultivar dependent

(Wardlaw & Moncur, 1995)

Conclusions

- Prediction of climate change impact on wheat could be counterintuitive as a result of non-linear interactions between crop and environment

- Modelling provides a powerful technique for rational design of wheat ideotypes, which can underpin breeding for new wheat cultivars for the rapidly changing environments caused by global warming