



Impact of Heat Stress Events on Wheat Yields

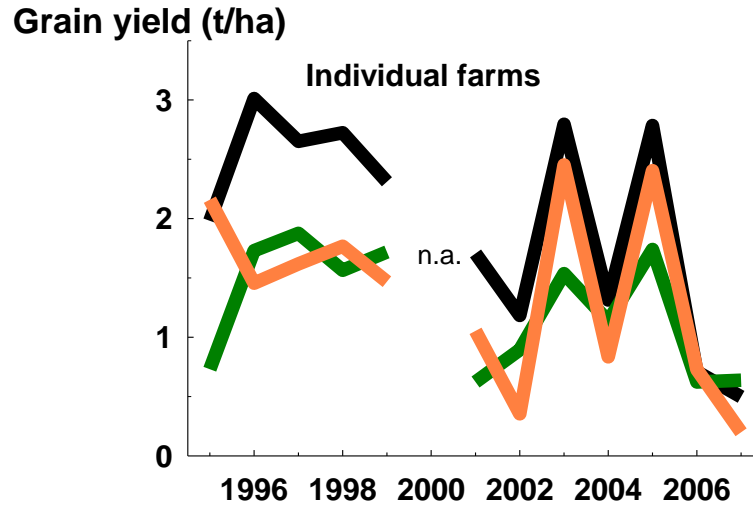
Senthold Asseng

Ian Foster & Neil C. Turner

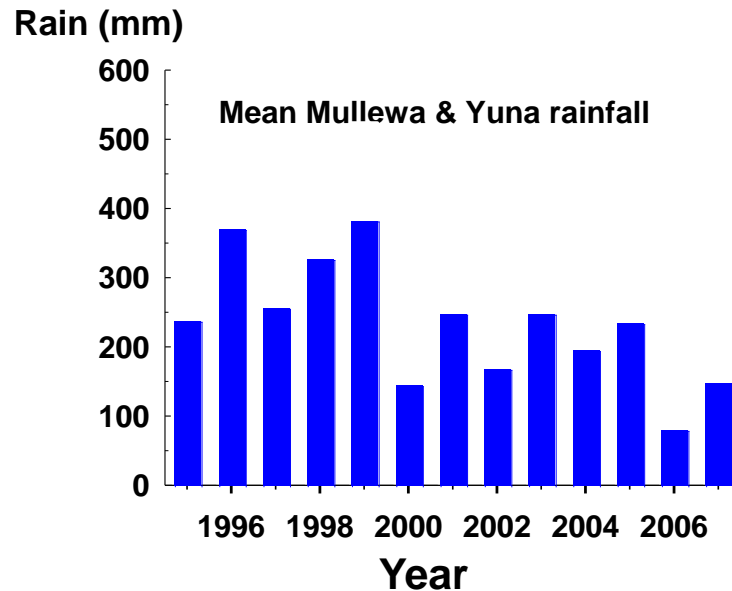
Outline

- 1. Yield variability**
- 2. Global wheat & temperature**
- 3. Climate data to systems impact (Model)**
- 4. Simulation experiment: temperature impact**
- 5. Conclusions**

Yield variability



Source: C Weeks, PlanFarm



What about temperature impact?

What about temperature impact?



South Australia crop yields slashed by extreme weather

Posted Wed Dec 9, 2009 8:11am AEDT

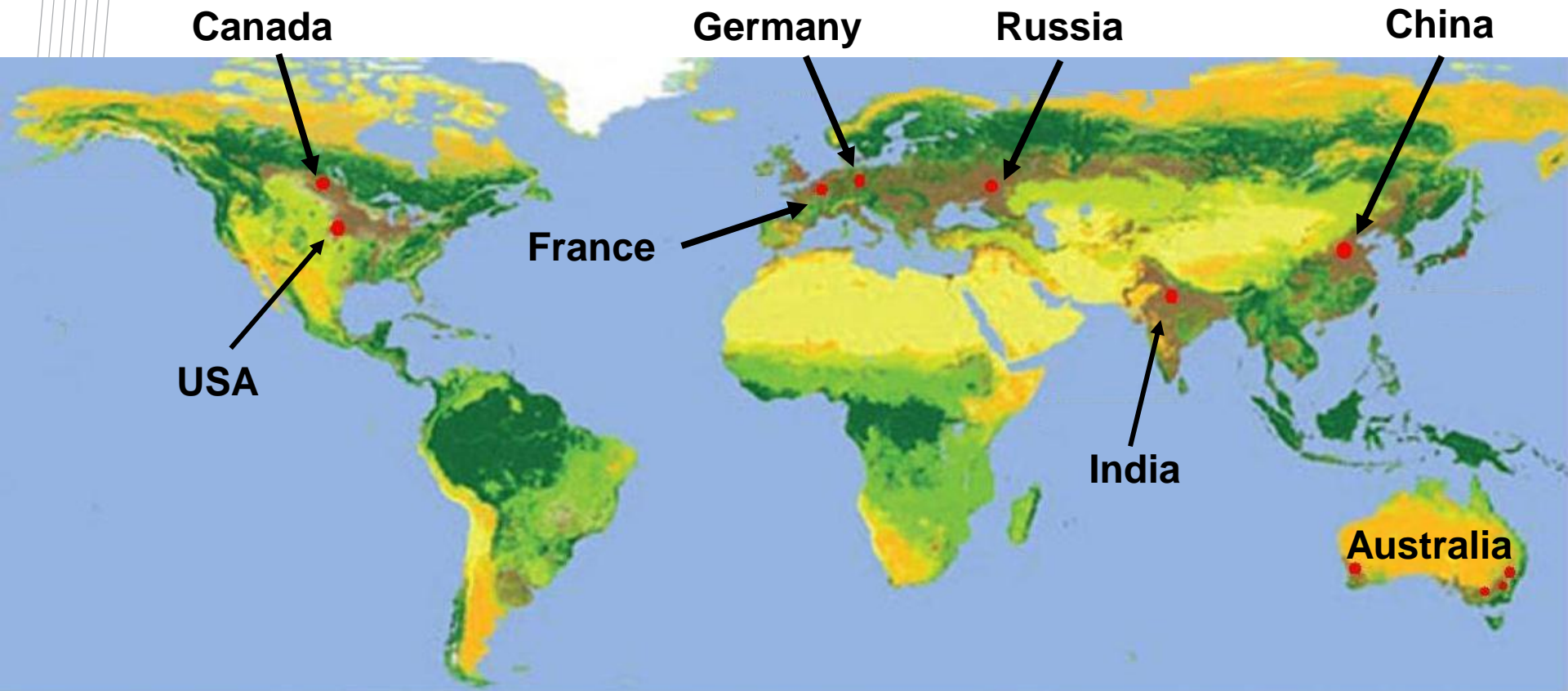
Crops ruined by extreme weather in November

Extreme weather back in November has cut the expected crop yields of some South Australian farms by half.

A record heatwave for the month wiped off between 40 and 60 per cent of yields in areas including the state's south-east and mid-north.

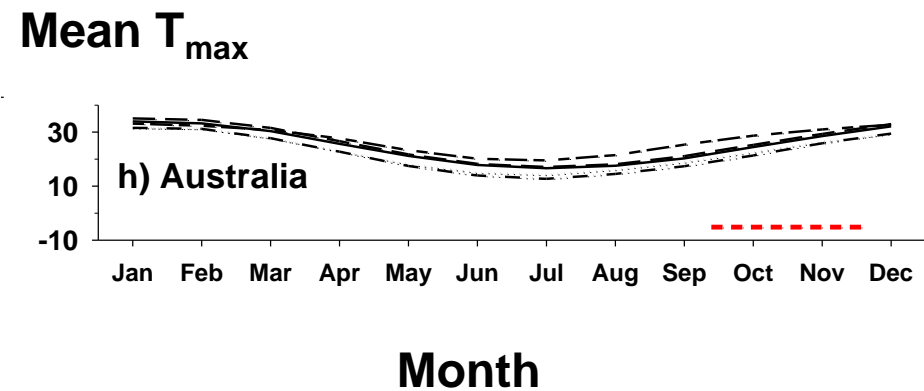


Study locations: Top 8 wheat producer



 Wheat cropping area

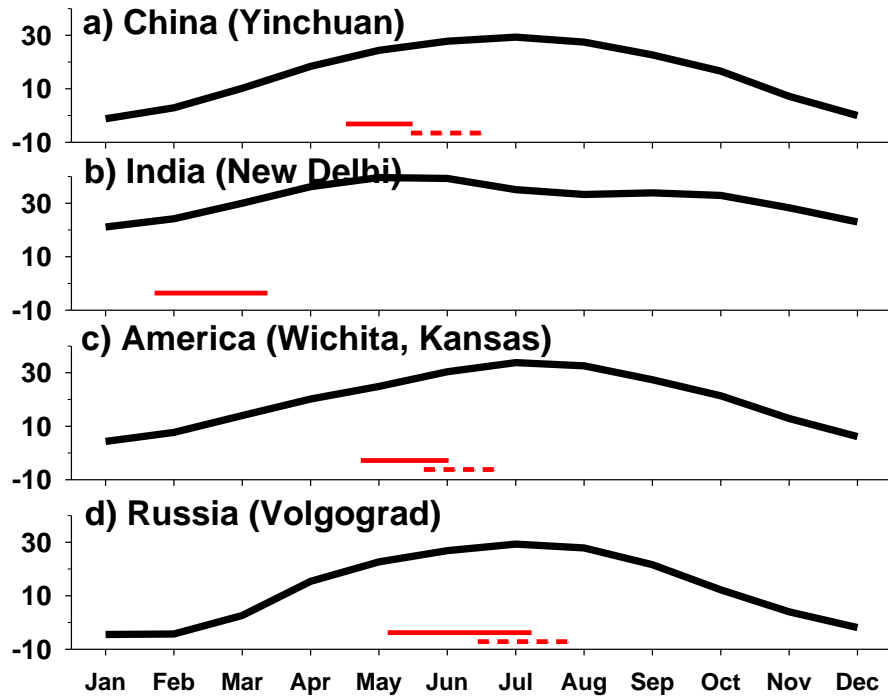
Grain filling into hottest months of year




Grain filling period

Grain filling into hottest months of year

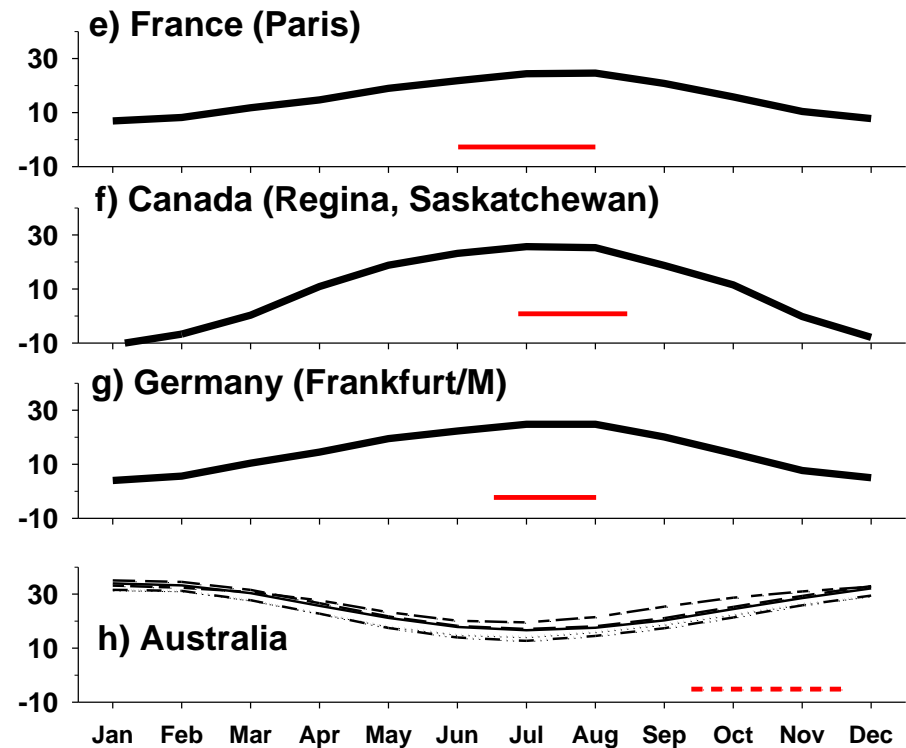
Mean T_{max}



Month

Grain filling period

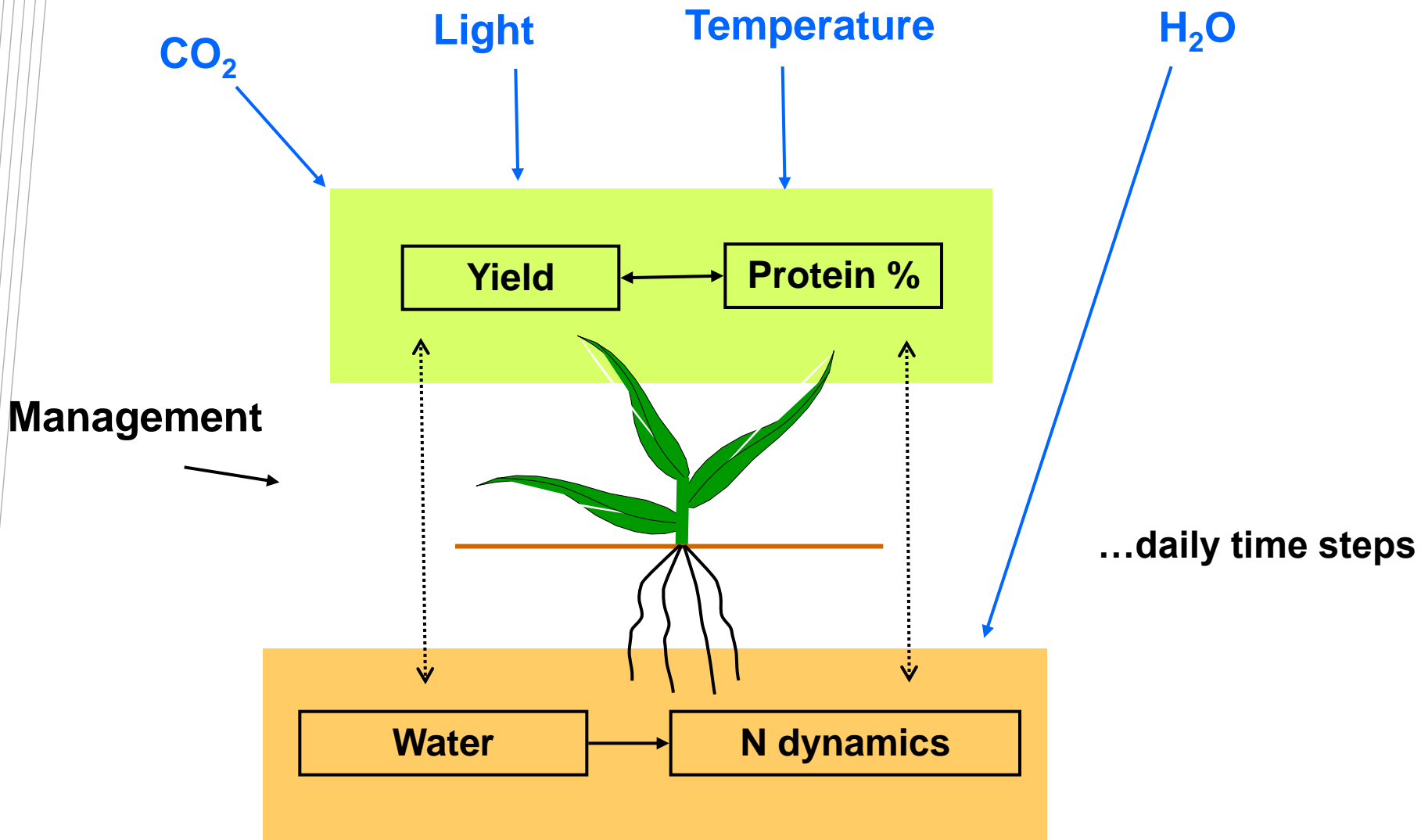
Mean T_{max}



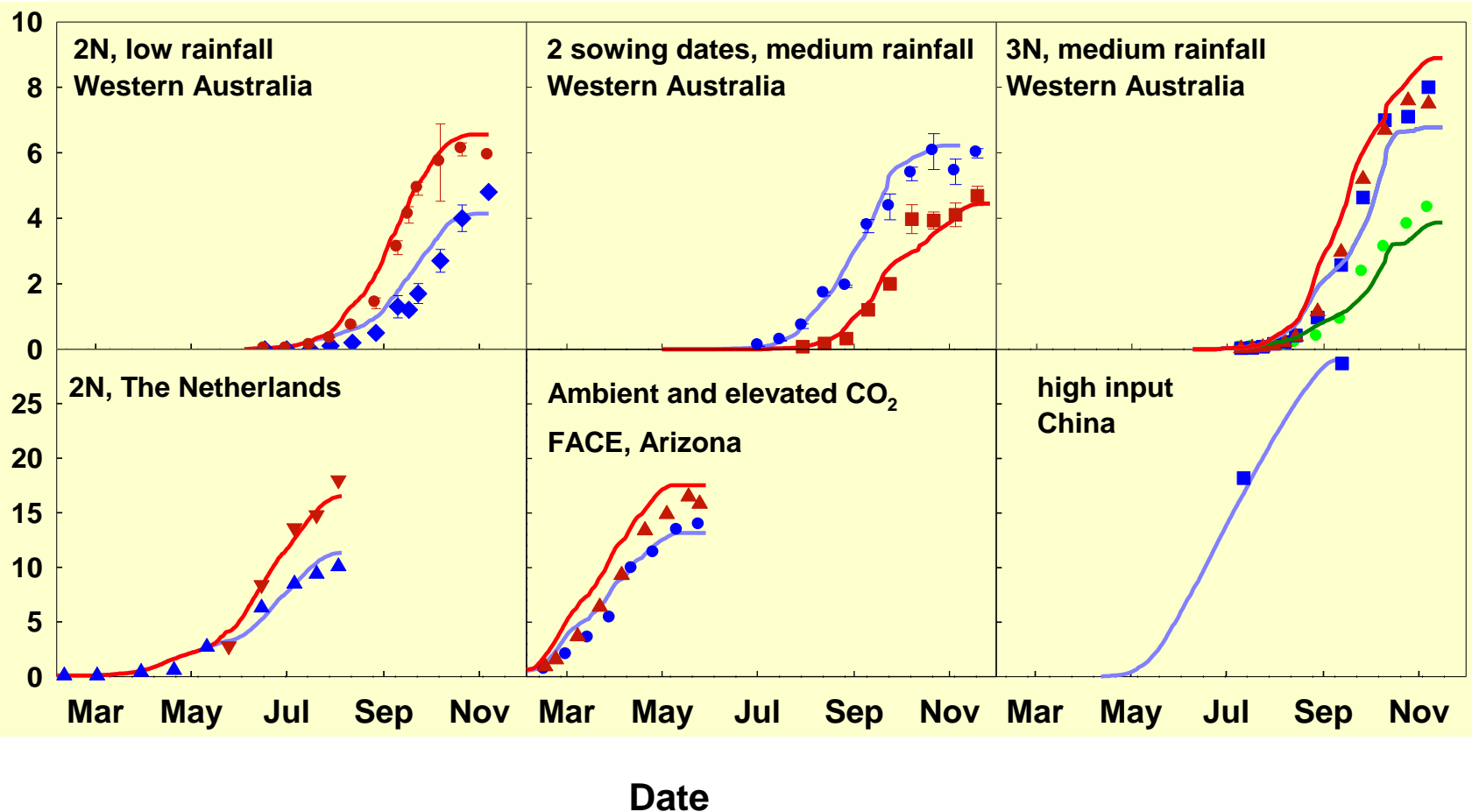
Month

Translating climate data into systems impact

Crop model APSIM-NWheat



APSIM-Nwheat model testing



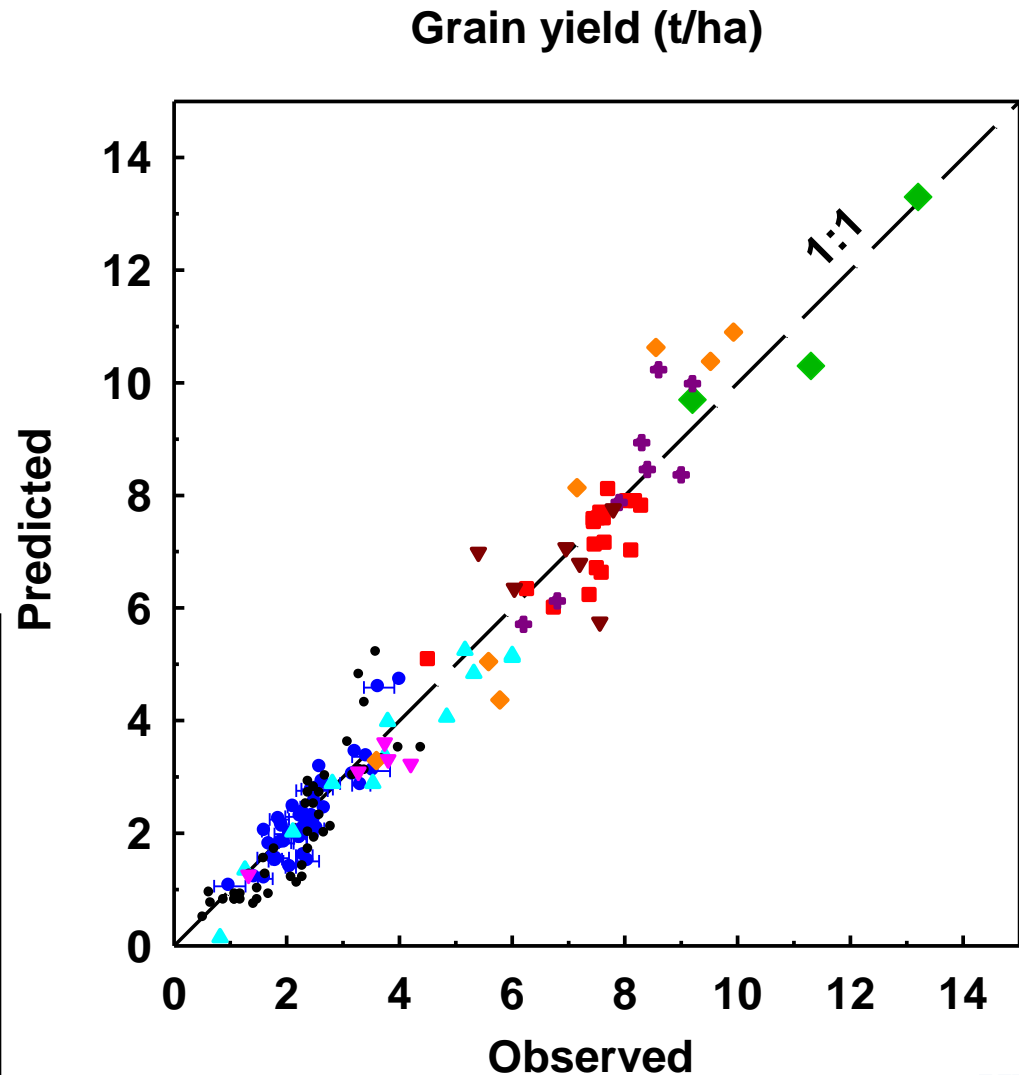
Total above-Ground Biomass (t/ha)

Observed = symbols

simulated = lines

After Asseng et al. 1998; 2000, 2002; 2004

APSIM-Nwheat model testing

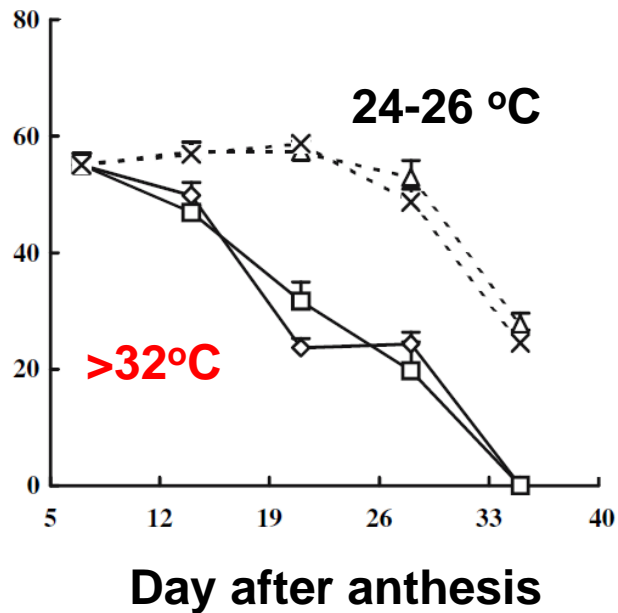


- Mediterranean-type WA I
- Mediterranean-type WA II
- ◆ NSW_{NO}
- Temperate
- ◆ Subtropical (Keating)
- ◆ High altitude, China
- + FACE (Kimball et al.)
- ◆ Rainout shelter NZ (Jamieson)
- ◆ Mexico (Sayre)

Modelling temperature & heat impact

Model: T & heat impact

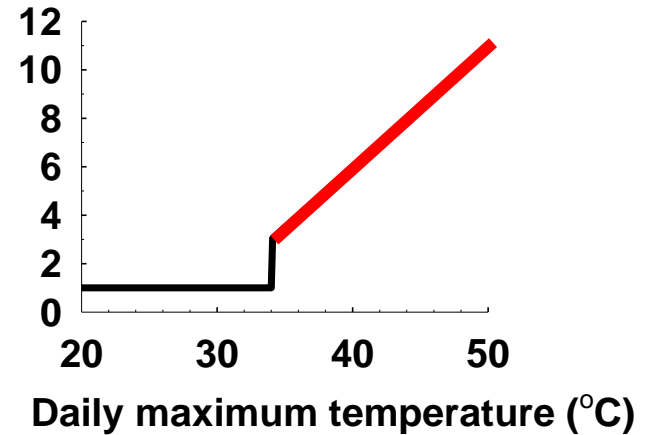
SPAD Value/leaf area



Zhao et al. 2007

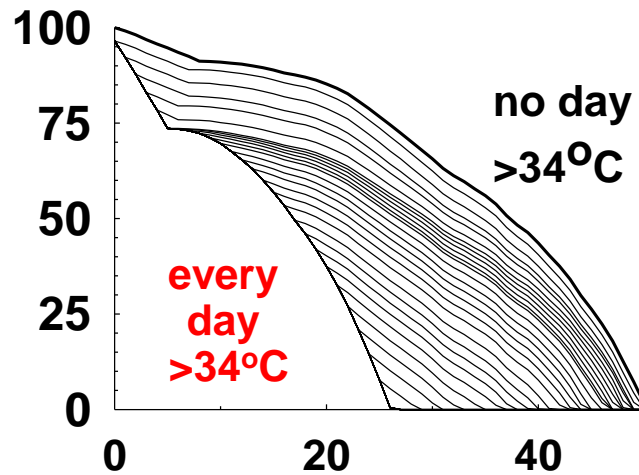
Model

Factor to eccellerate canopy senecence (-)

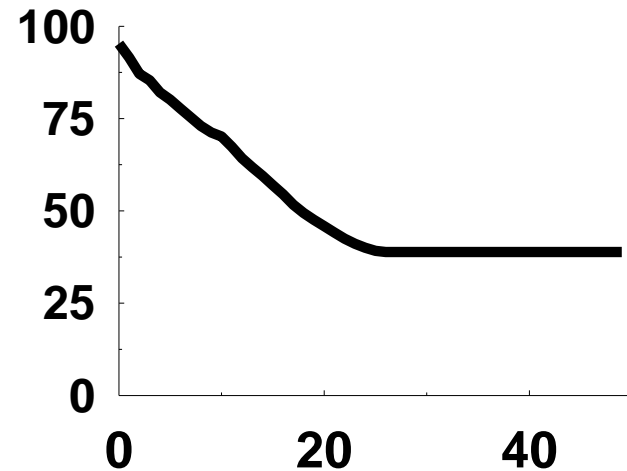


Model: leaf & yield sensitivity to $>34^{\circ}\text{C}$

Relative LAI (%)



Relative Grain Yield (%)

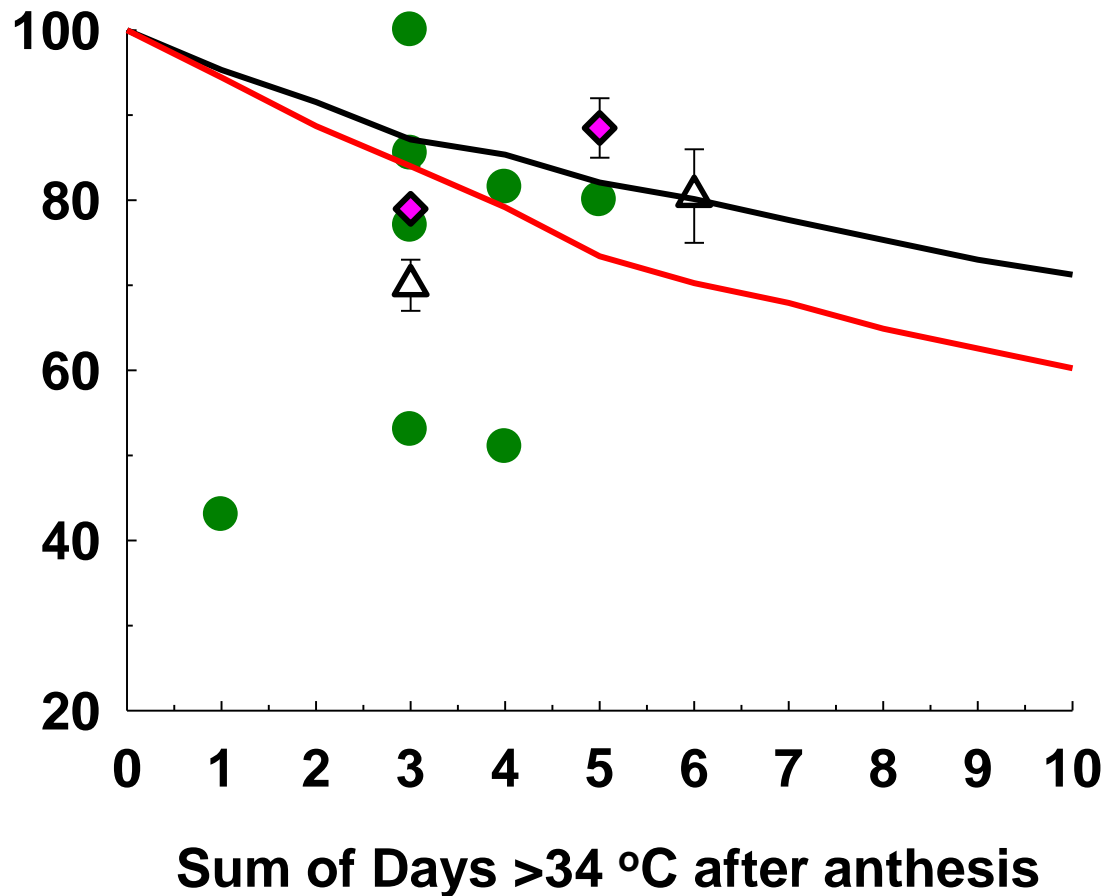


Sum of days after anthesis with $>34^{\circ}\text{C}$

Observed & simulated high temperature & heat impact after anthesis

Observed & simulated impact of heat shock

% grain yield (or kernel weight)



Published observations:

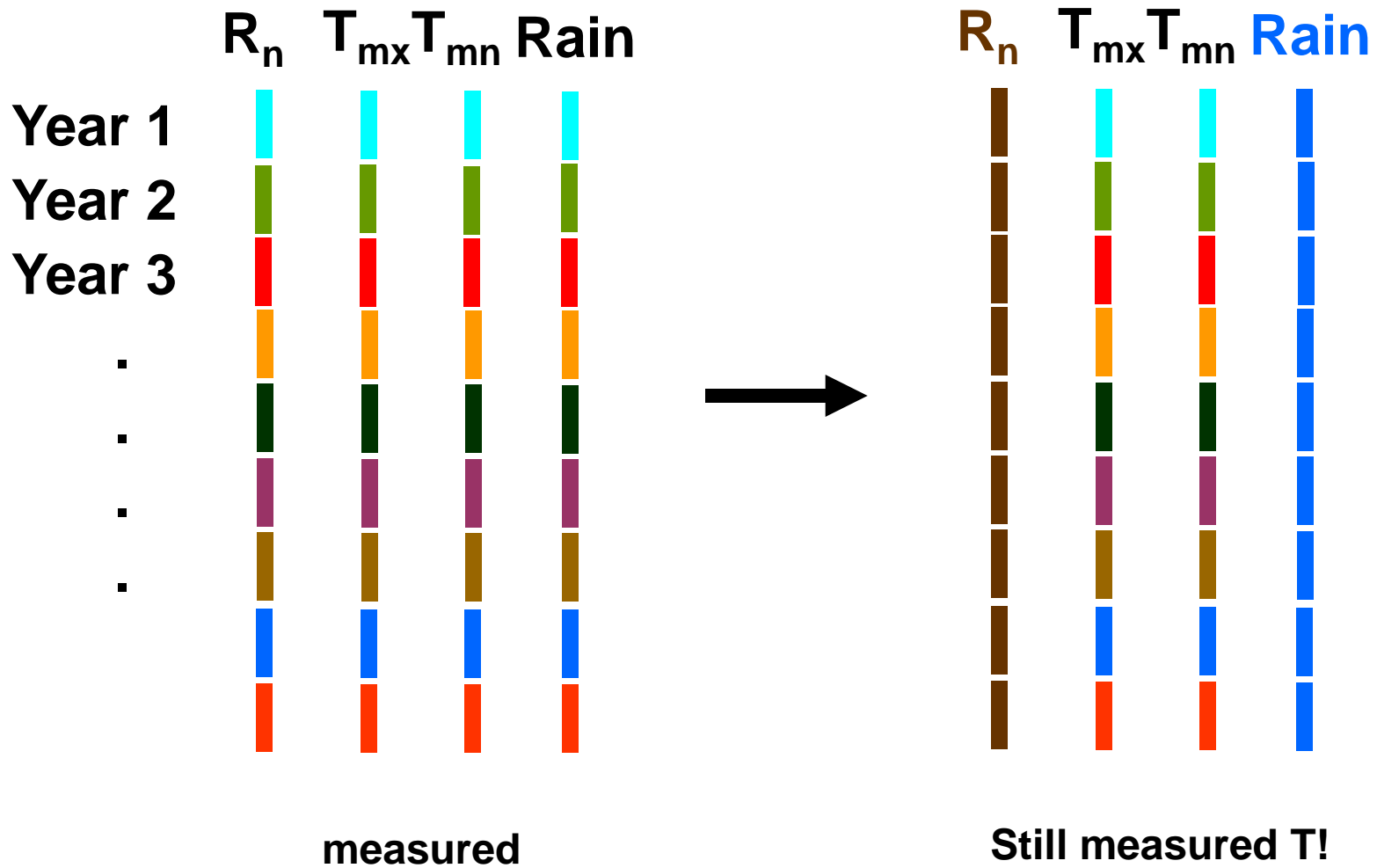
- Pot
- △ Field
- ◆ Regional

Simulated Days at 34.1 °C

Simulated Days at 38 °C

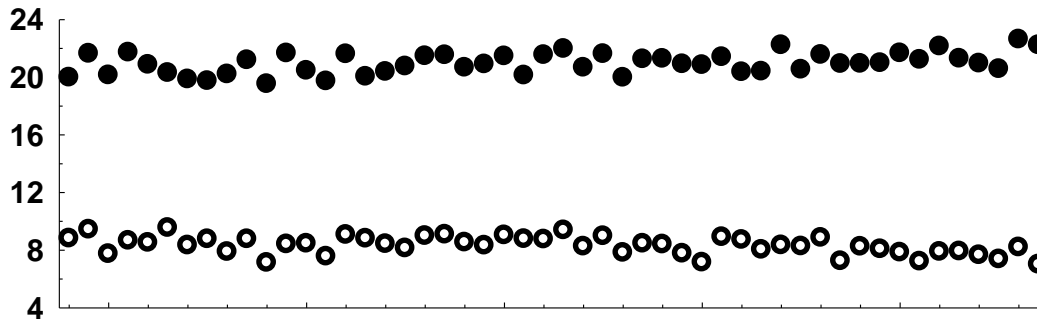
Simulation experiment on impact of high temperature & heat during grain filling

Isolation of temperature effect



Separated temperature impact on yield

Maximum and minimum temperature (°C)

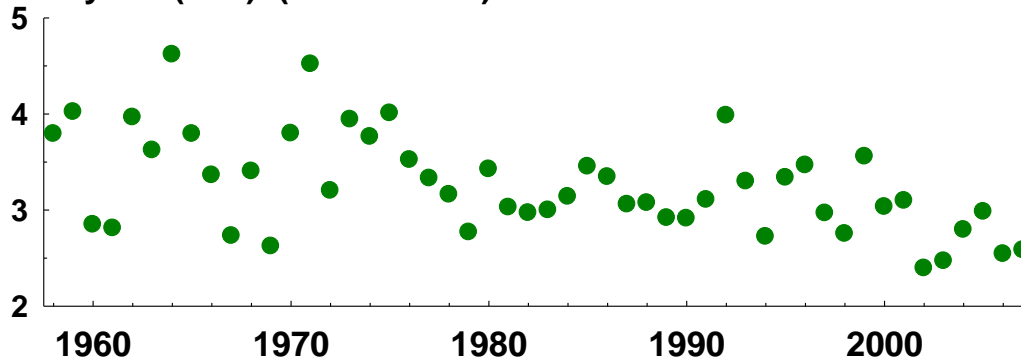


T_{max}

Western
Australia

T_{min}

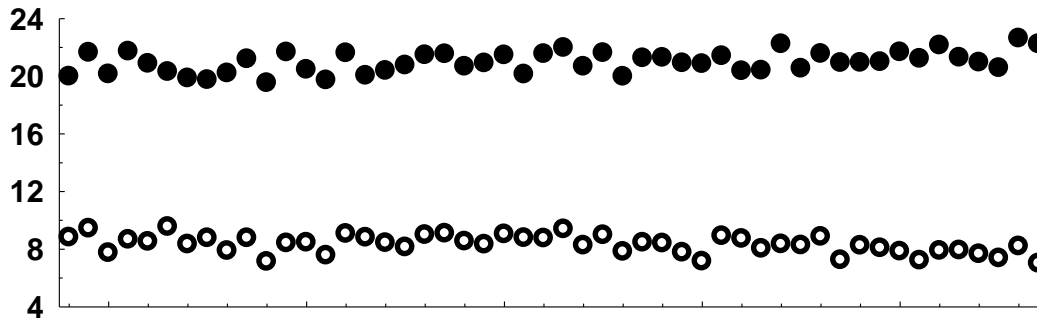
Wheat yield (t/ha) (Wet season)



Grain yield

Separated temperature impact on yield

Maximum and minimum temperature (°C)

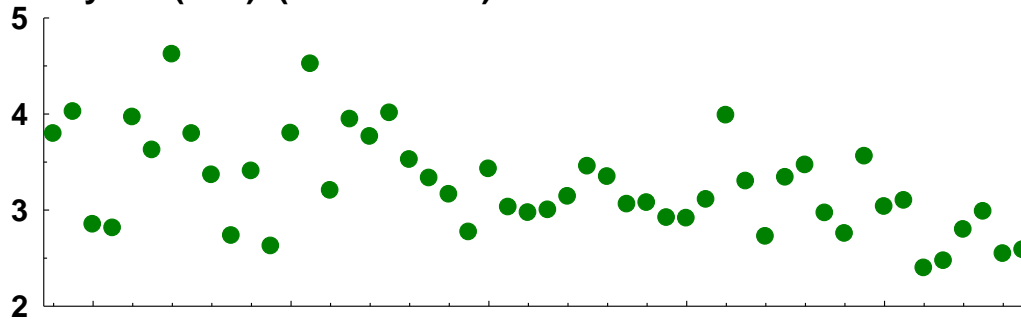


T_{max}

Western
Australia

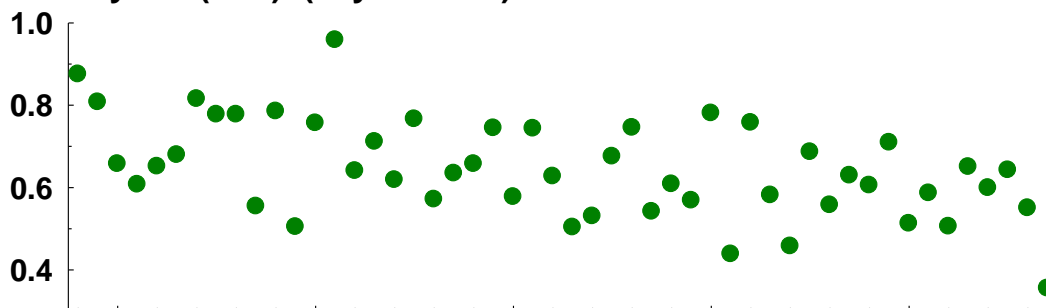
T_{min}

Wheat yield (t/ha) (Wet season)



Grain yield

Wheat yield (t/ha) (Dry season)



Grain yield

1960

1970

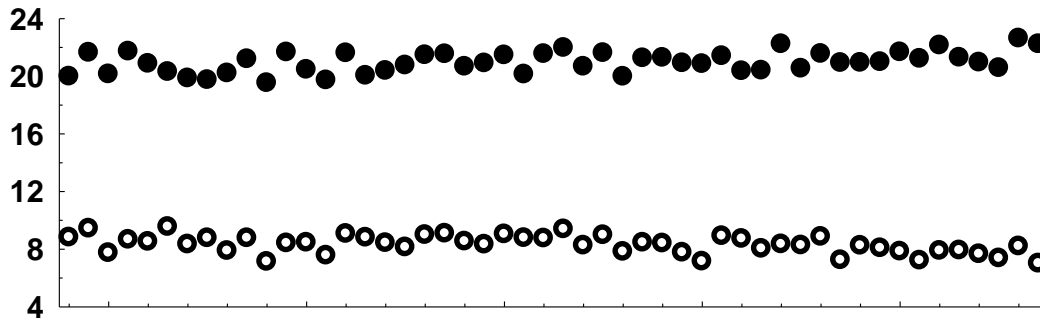
1980

1990

2000

Separated temperature impact on yield

Maximum and minimum temperature (°C)

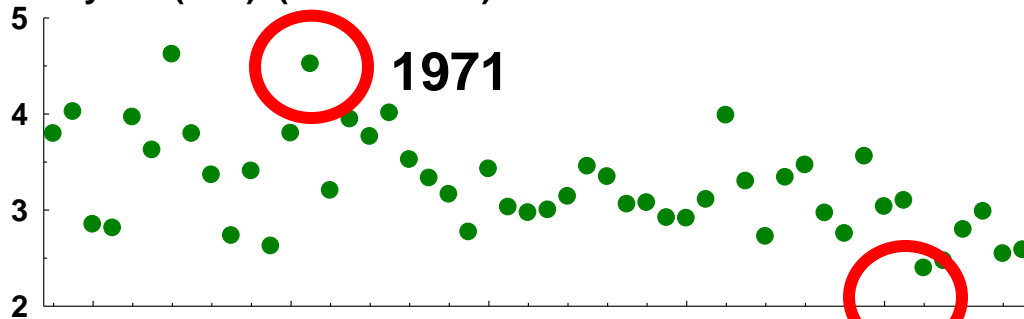


T_{max}

Western
Australia

T_{min}

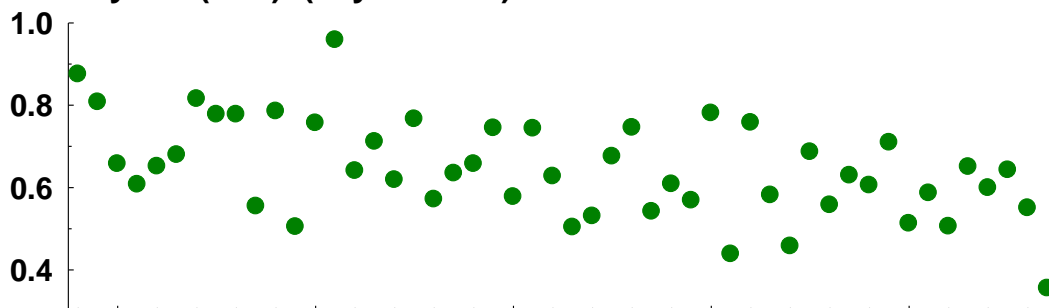
Wheat yield (t/ha) (Wet season)



1971

Grain yield

Wheat yield (t/ha) (Dry season)



2002

Grain yield

1960

1970

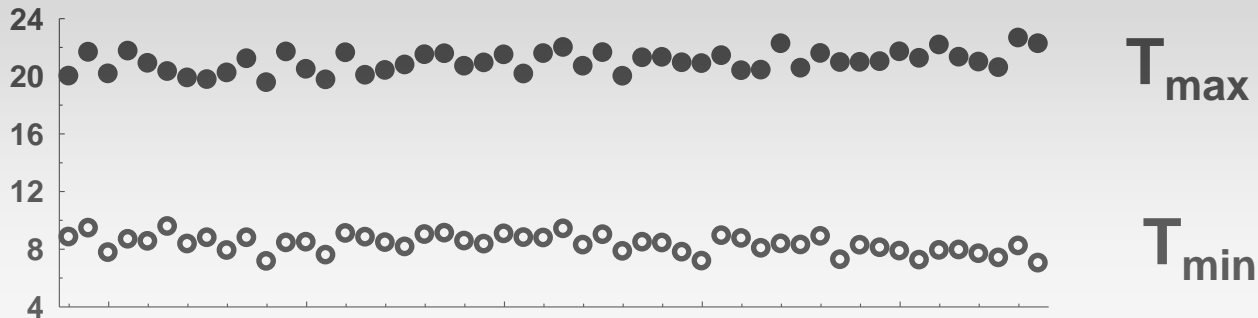
1980

1990

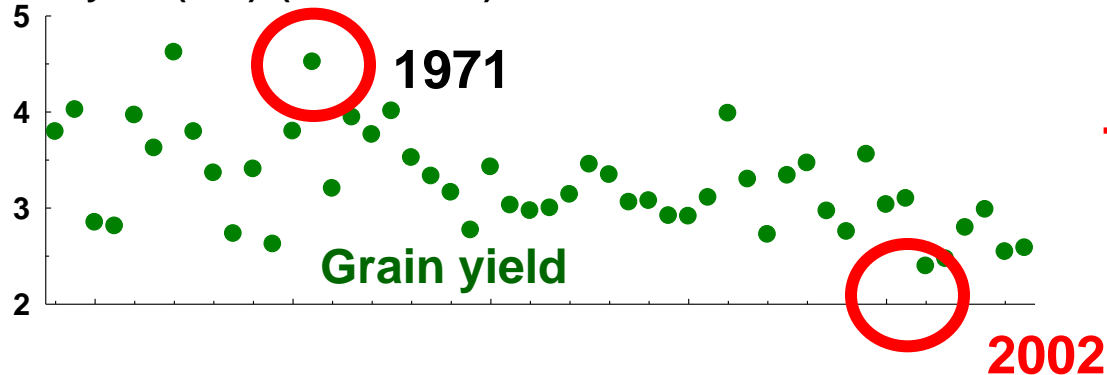
2000

Separated temperature impact on yield

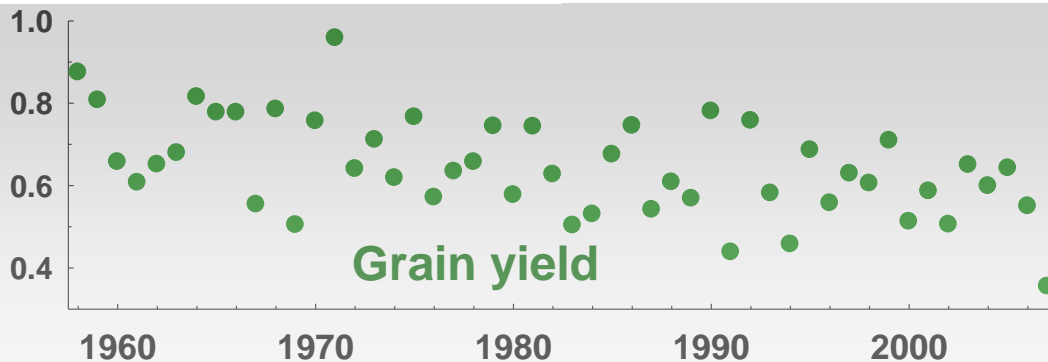
Maximum and minimum temperature (°C)



Wheat yield (t/ha) (Wet season)

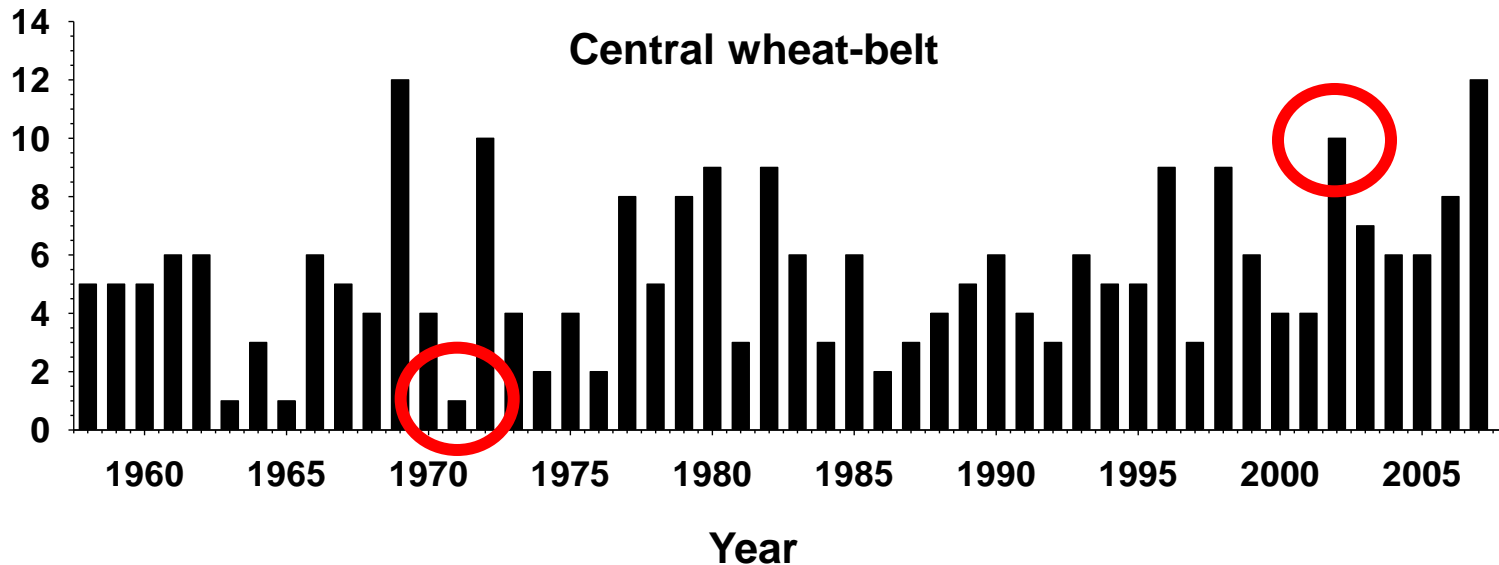


heat stress
+
indirect T
effect via
water stress



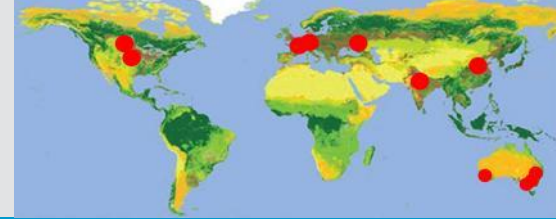
Heat events

Heat stress events (>34 °C)
during grain filling months

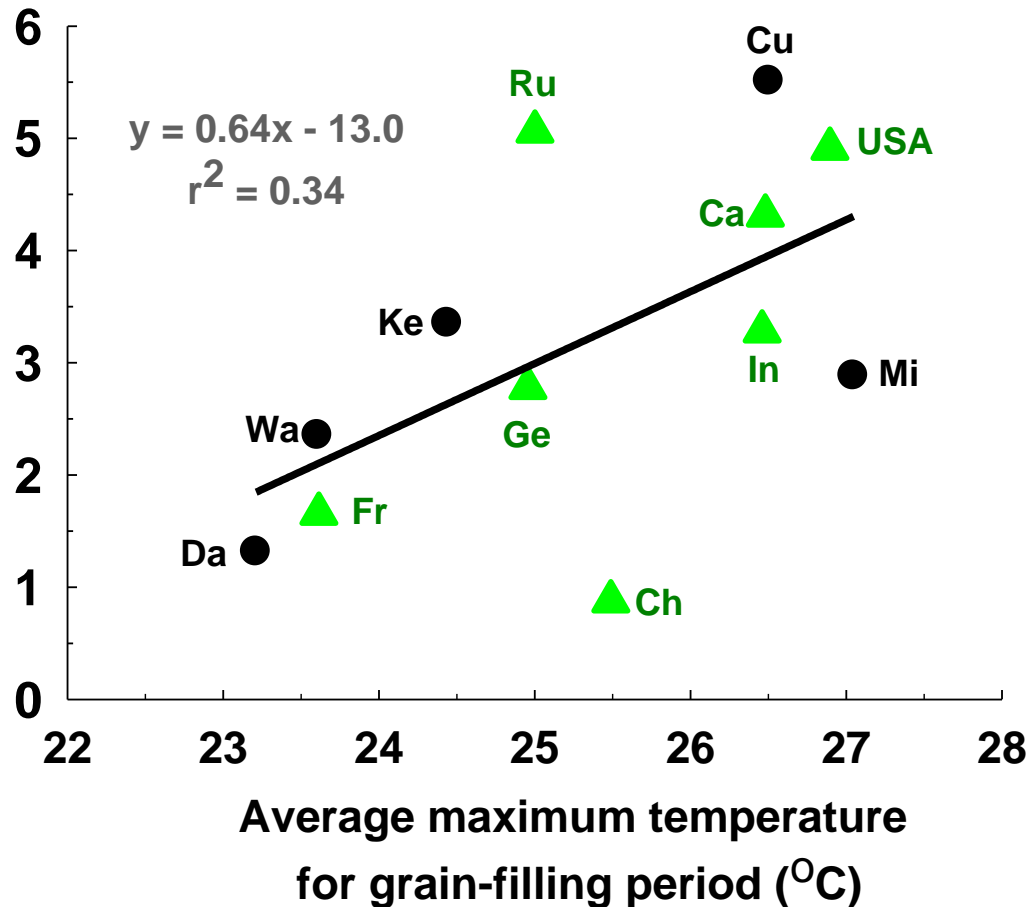


~5% yield loss per heat event!

Australia & the rest of the world



Average number of days > 34°C during grain filling period



Conclusions

- **Inter-seasonal temperature variability & heat events can cause wheat yield reductions of 50%**
- **Future global warming will further increase temperature-effected yield reductions**
- **Temperature is a poorly-recognised threat to Global Food Security.**

Asseng, Foster & Turner 2011 *The impact of temperature variability on wheat yields.* In: Global Change Biology.