Invited Lecture 1

Best practices on the application of climate information in the agricultural sector.

Dr Roger Stone and Dr Holger Meinke. Queensland Government; the University of Southern Queensland.

International Workshop on the Applications of Advanced Climate Information in the Asia-Pacific Region

Outline of presentation:

•The problem faced by agricultural systems.

•<u>The need to link to decision making and management</u>.

•The need to understand value chains in agricultural production.

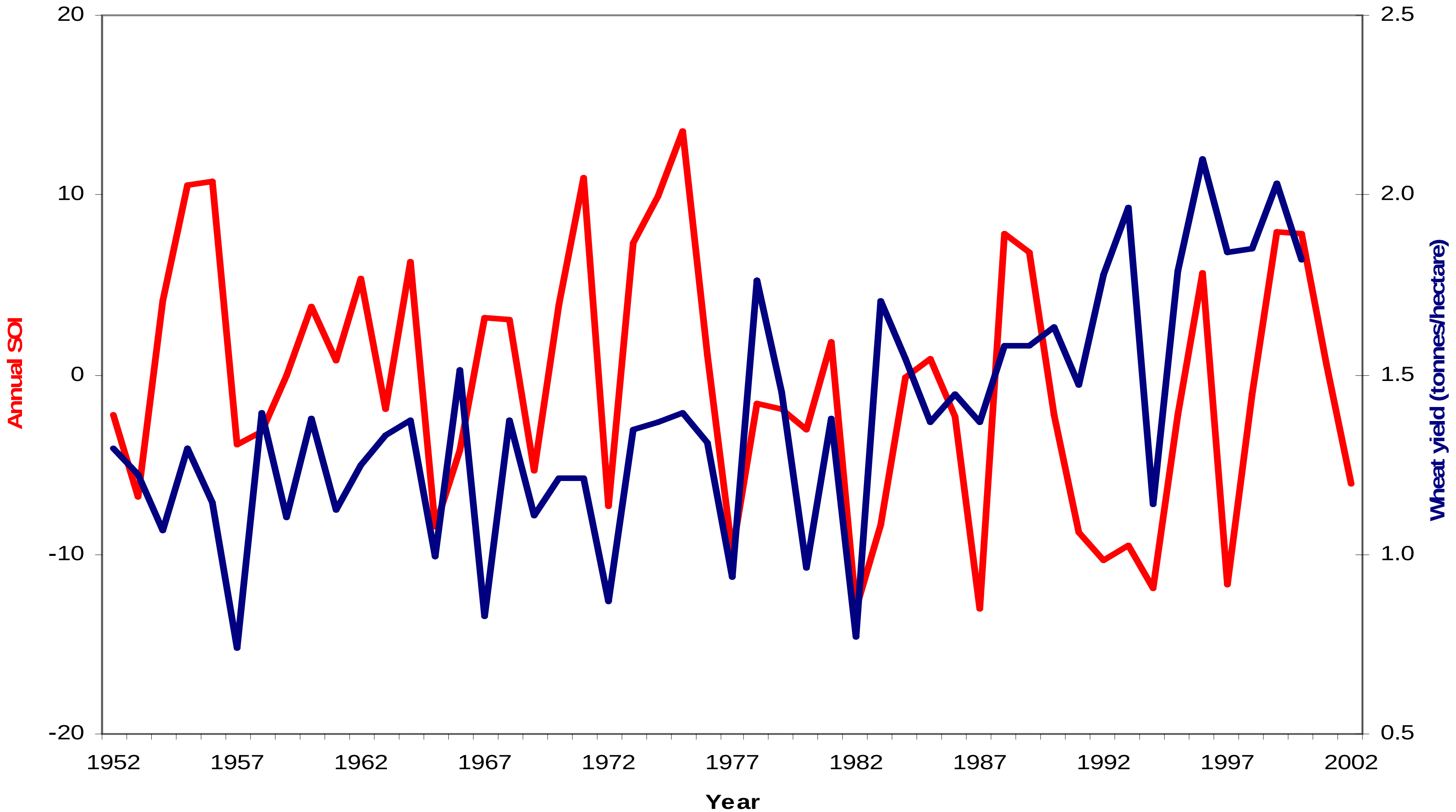
•The need for simulation modelling to provide scenarios.

•How to apply seasonal forecast systems to achieve the best results – use of integrated systems – process models, ‘agroclimatic’ system, farm-scale production, shire-scale forecasts.

•Participative approaches and interdisciplinary approaches.

•Climate change issues?

•Conclusions



Climate impacts: relationship between annual variation in the SOI and annual Australian wheat yield (N Nicholls).
*To achieve best practice need to modify actions ahead of likely impacts.

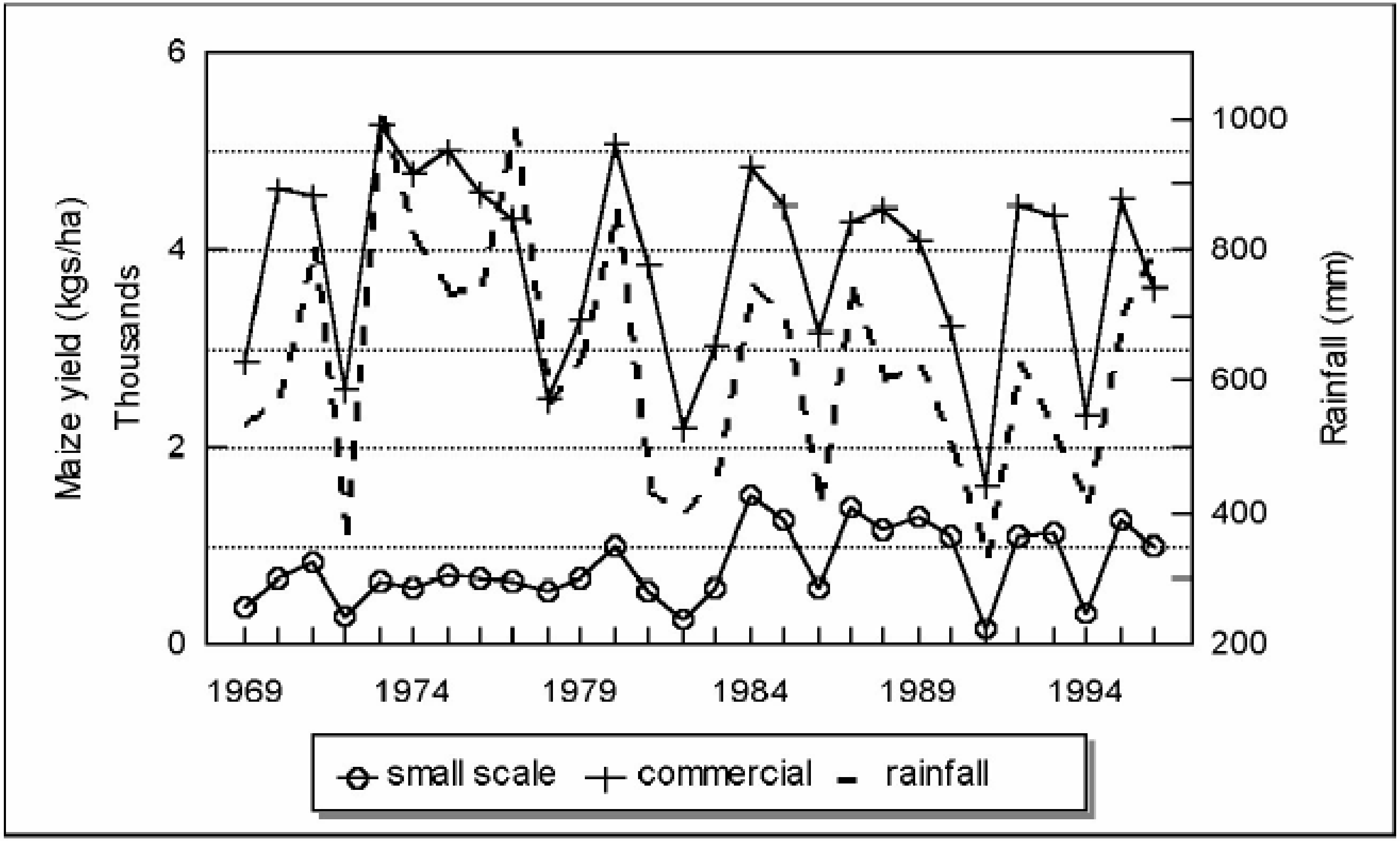
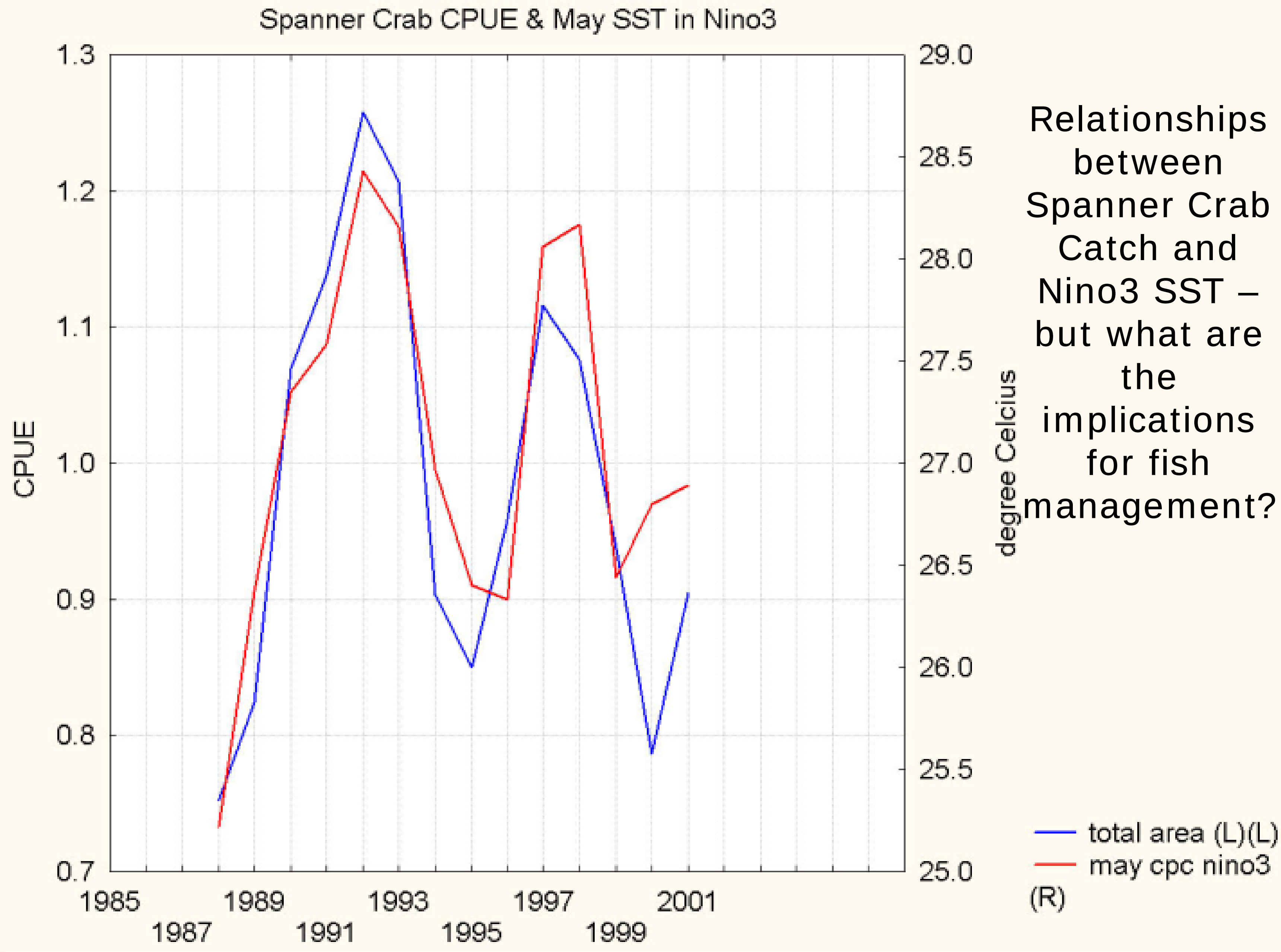


Figure 1. *Time series of average maize yield in the smallholder and commercial farming sectors in Zimbabwe. The national average rainfall is superimposed.*

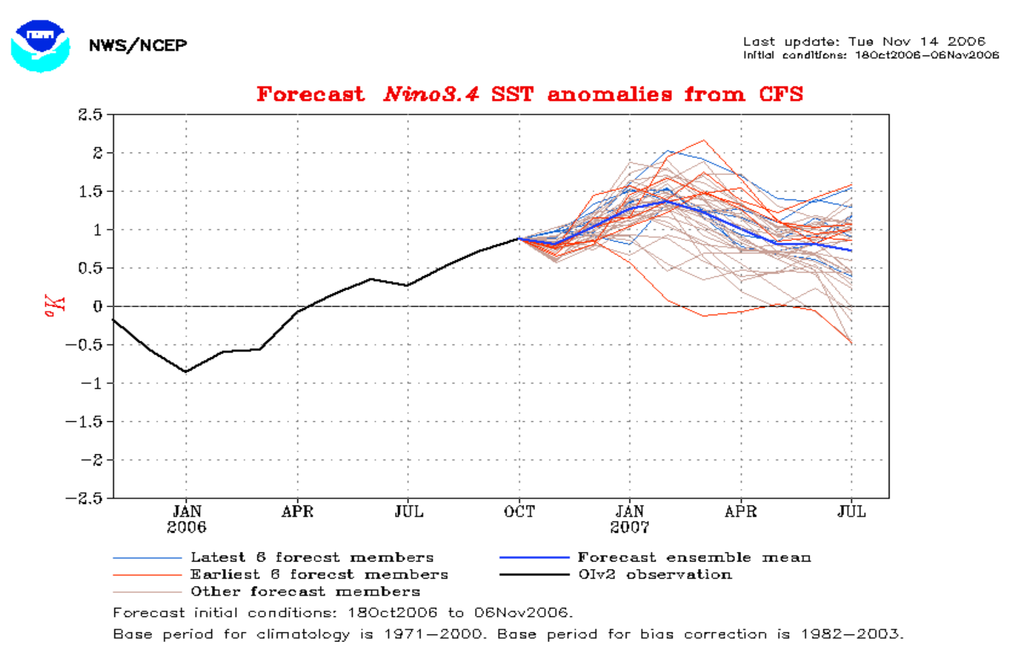
To have value climate information needs to link to management decisions

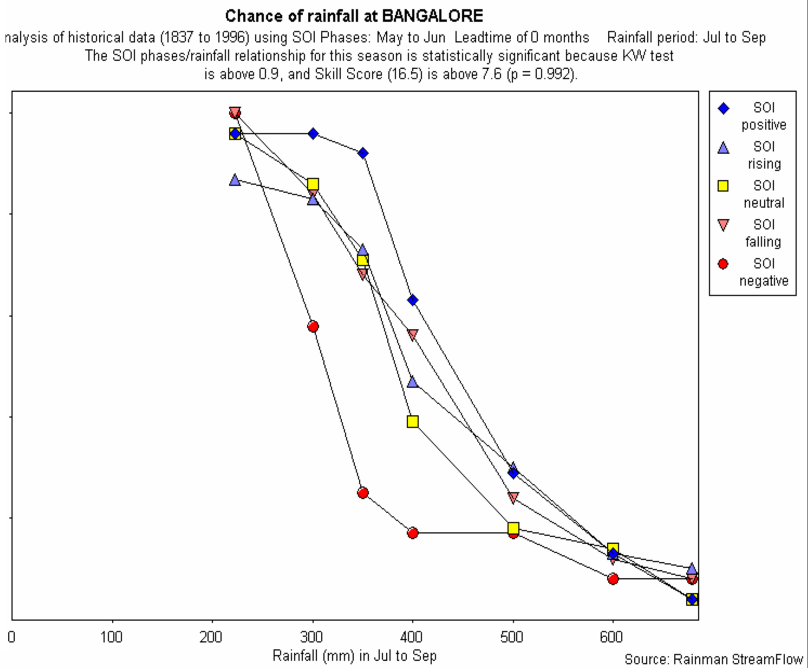


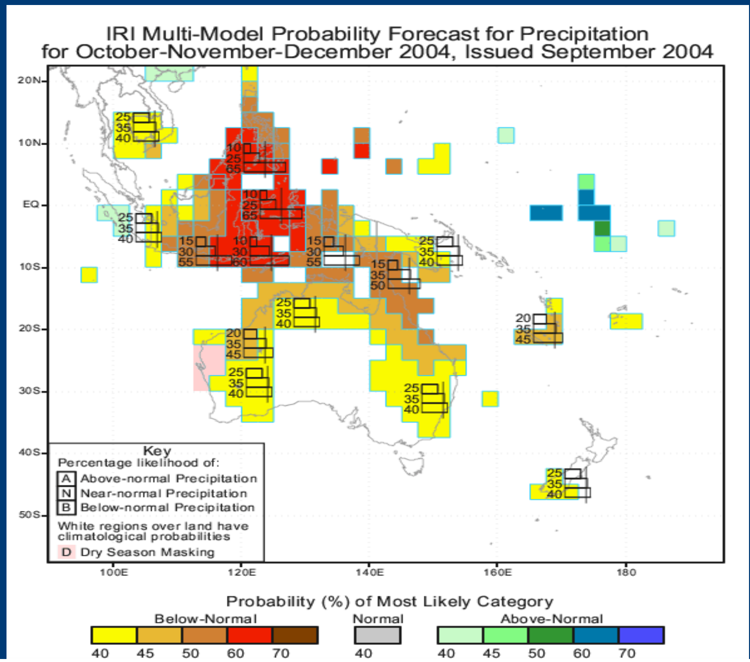
Relationships between Spanner Crab Catch and Nino3 SST – but what are the implications for fish management?

The Complexity of Agricultural Systems, Climate Variability, and Management Decisions

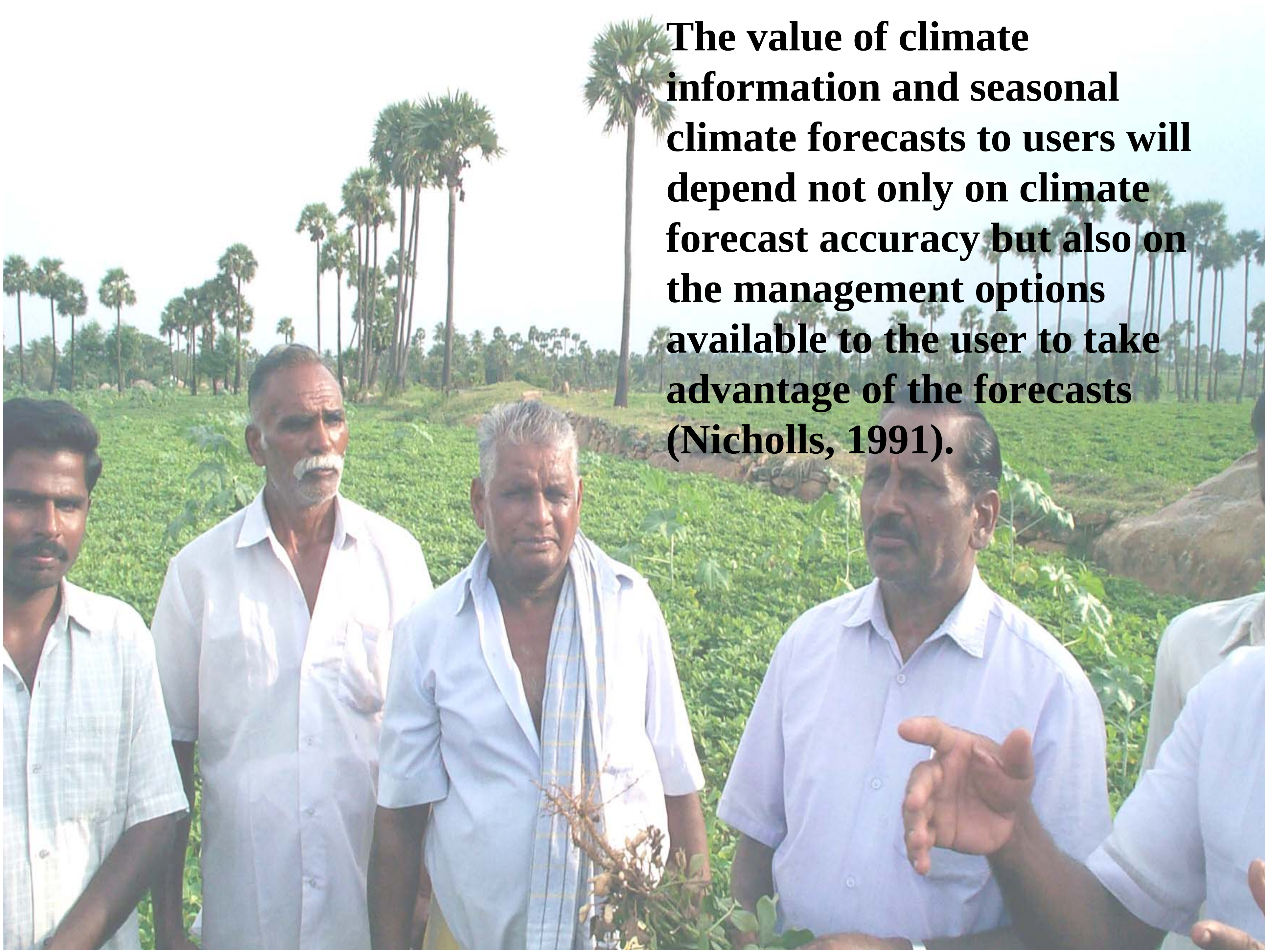
Decision Type (eg. only)	*Frequency (years)*
Logistics (eg. scheduling of planting / harvest operations)	Intraseasonal (> 0.2)
Tactical crop management (eg. fertiliser / pesticide use)	Intraseasonal (0.2 – 0.5)
Crop type (eg. wheat or chickpeas)	Seasonal (0.5 – 1.0)
Crop sequence (eg. long or short fallows)	Interannual (0.5 – 2.0)
Crop rotations (eg. winter or summer crops)	Annual / biennial (1 – 2)
Crop industry (eg. grain or cotton, phase farming)	Decadal (~ 10)
Agricultural industry (eg. crops or pastures)	Interdecadal (10 – 20)
Landuse (eg. agriculture or natural systems)	Multidecadal (20 +)
Landuse and adaptation of current systems	Climate change







General climate forecast outputs: prepared in a variety of ways

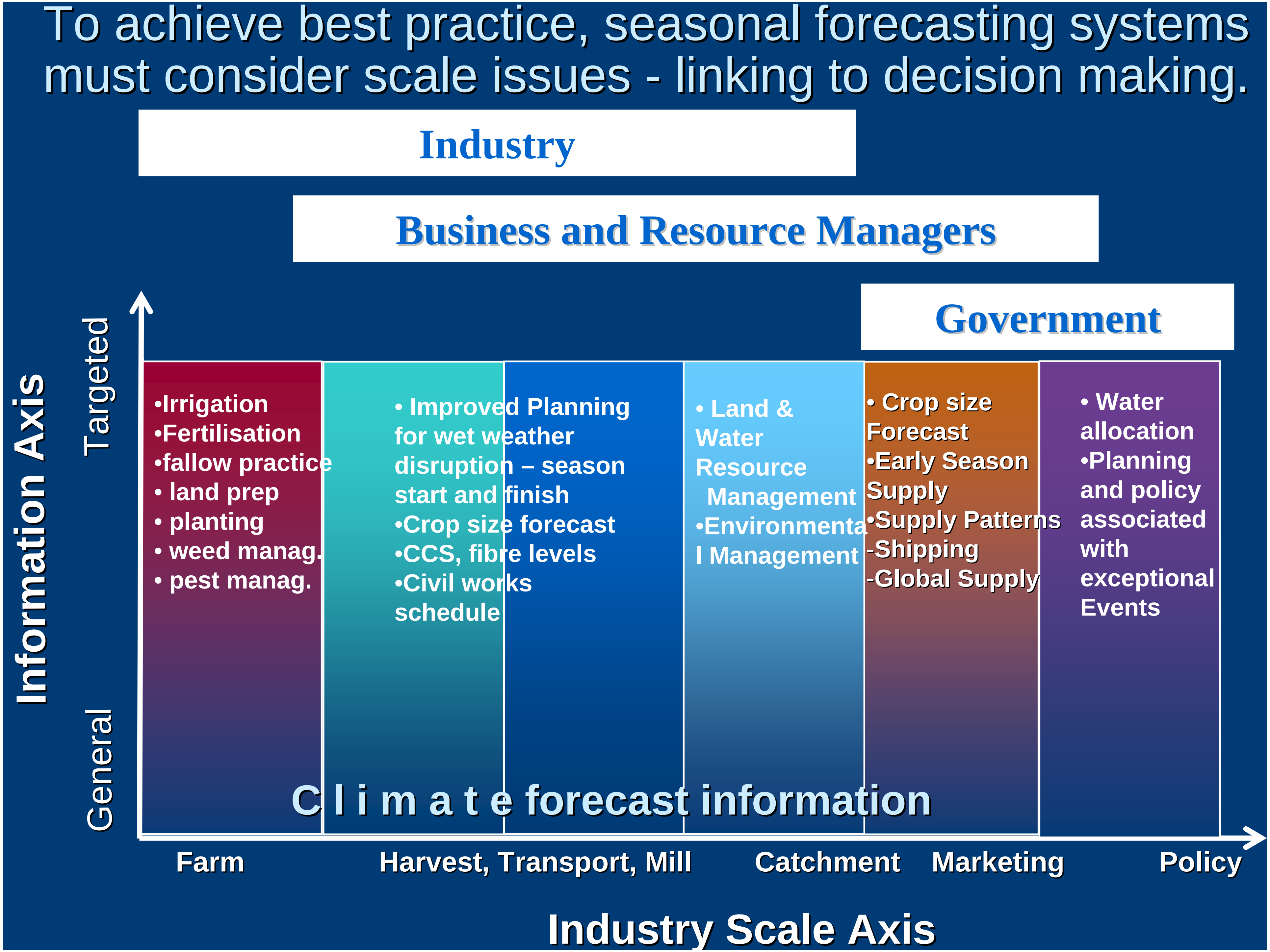


The value of climate information and seasonal climate forecasts to users will depend not only on climate forecast accuracy but also on the management options available to the user to take advantage of the forecasts (Nicholls, 1991).

To achieve best practice, seasonal forecasting must be able to be linked to key management decisions

How much Nitrogen to apply given current low soil moisture levels and low probability of sufficient in-crop rainfall?

Which variety to plant given low rainfall probability values and high risk of damaging frost and anthesis?


To achieve best practice, seasonal forecasting systems must consider scale issues - linking to decision making.
Industry
Business and Resource Managers
Government
Information Axis
Targeted
General
•Irrigation
•Fertilisation
•fallow practice
• land prep
• planting
• weed manag.
• pest manag.
• Improved Planning for wet weather disruption – season start and finish
•Crop size forecast
•CCS, fibre levels
•Civil works schedule
• Land & Water Resource Management
•Environmental Management
• Crop size Forecast
•Early Season Supply
•Supply Patterns
-Shipping
-Global Supply
• Water allocation
•Planning and policy associated with exceptional Events
C l i m a t e forecast information
Farm
Harvest, Transport, Mill
Catchment
Marketing
Policy
Industry Scale Axis

To achieve best practice there is need to consider the whole value chain in agricultural production

Understanding issues across the whole value chain

The Cane Plant → Sugarcane Production → Harvest & Transport → Raw Sugar Milling → Marketing & Shipping

The Cane Plant / Sugarcane Production

- Best use of scarce/costly water resources
- Better decisions on farm operations

Harvest & Transport

- Improved planning for wet weather disruption
- Best cane supply arrangements
  - crush start and finish times

Raw Sugar Milling

- Better scheduling of mill operations
  - crop estimates
  - early season cane supply

Marketing & Shipping

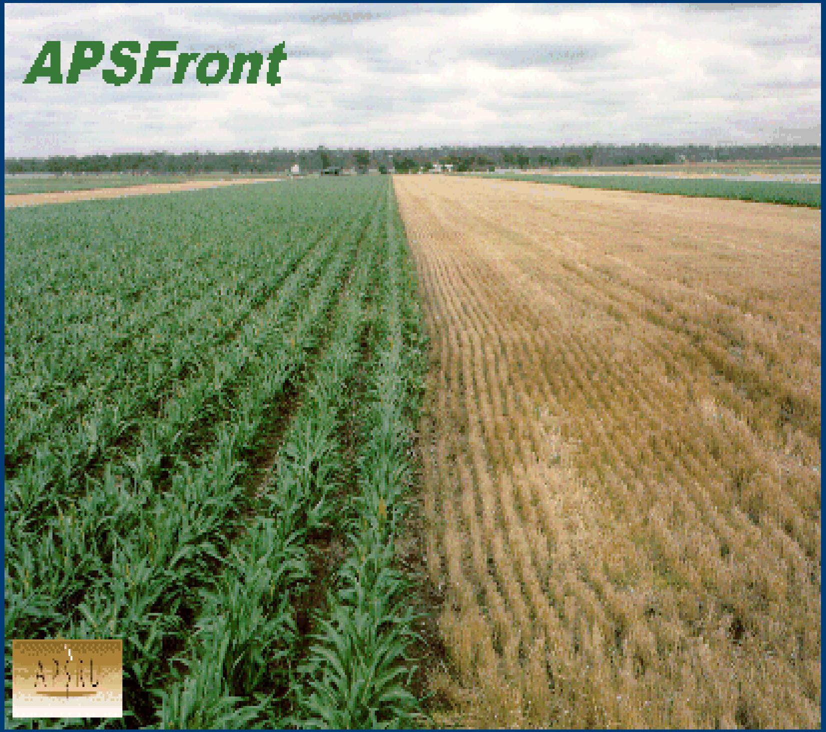
- Better marketing decisions based on likely sugar quality
- More effective forward selling based on likely crop size
- Improved efficiency of sugar shipments based on supply pattern during harvest season

Everingham *et al*, 2002

The Key Linking Role of Modelling

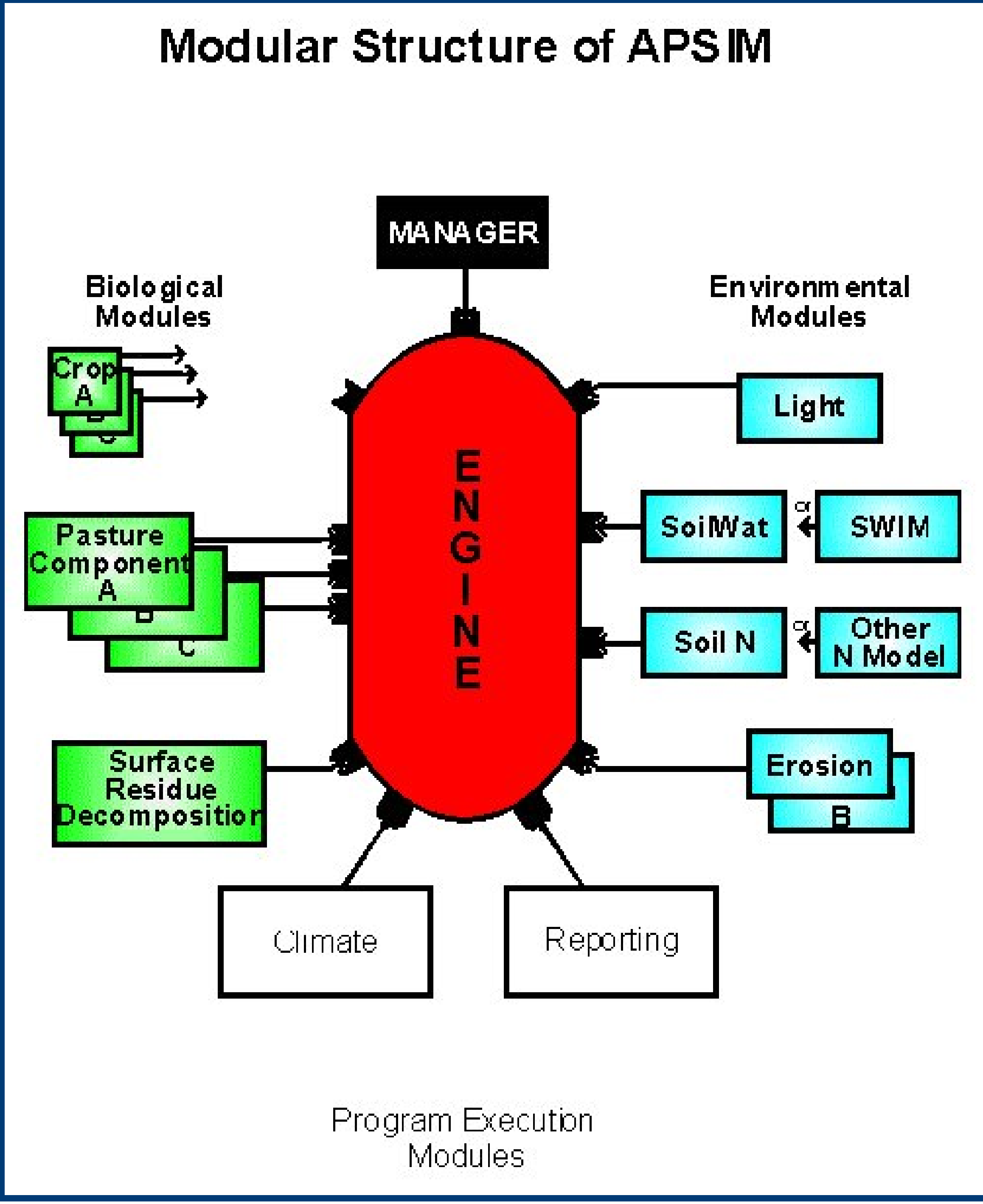
- Simulate management scenarios using analogue years
- Evaluate outcomes/risks relevant to decisions

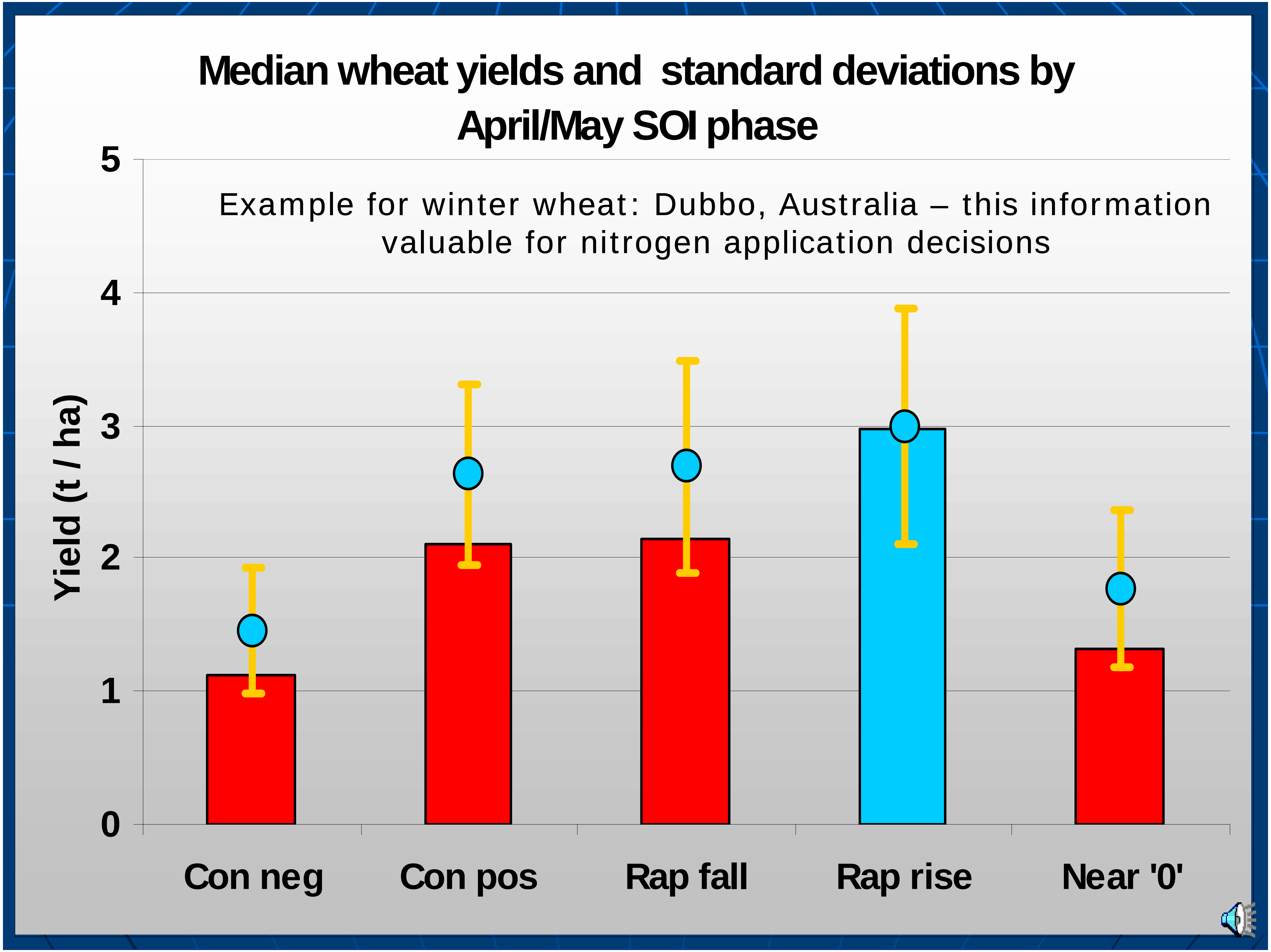
Agricultural Production Systems Simulator (APSIM) simulates

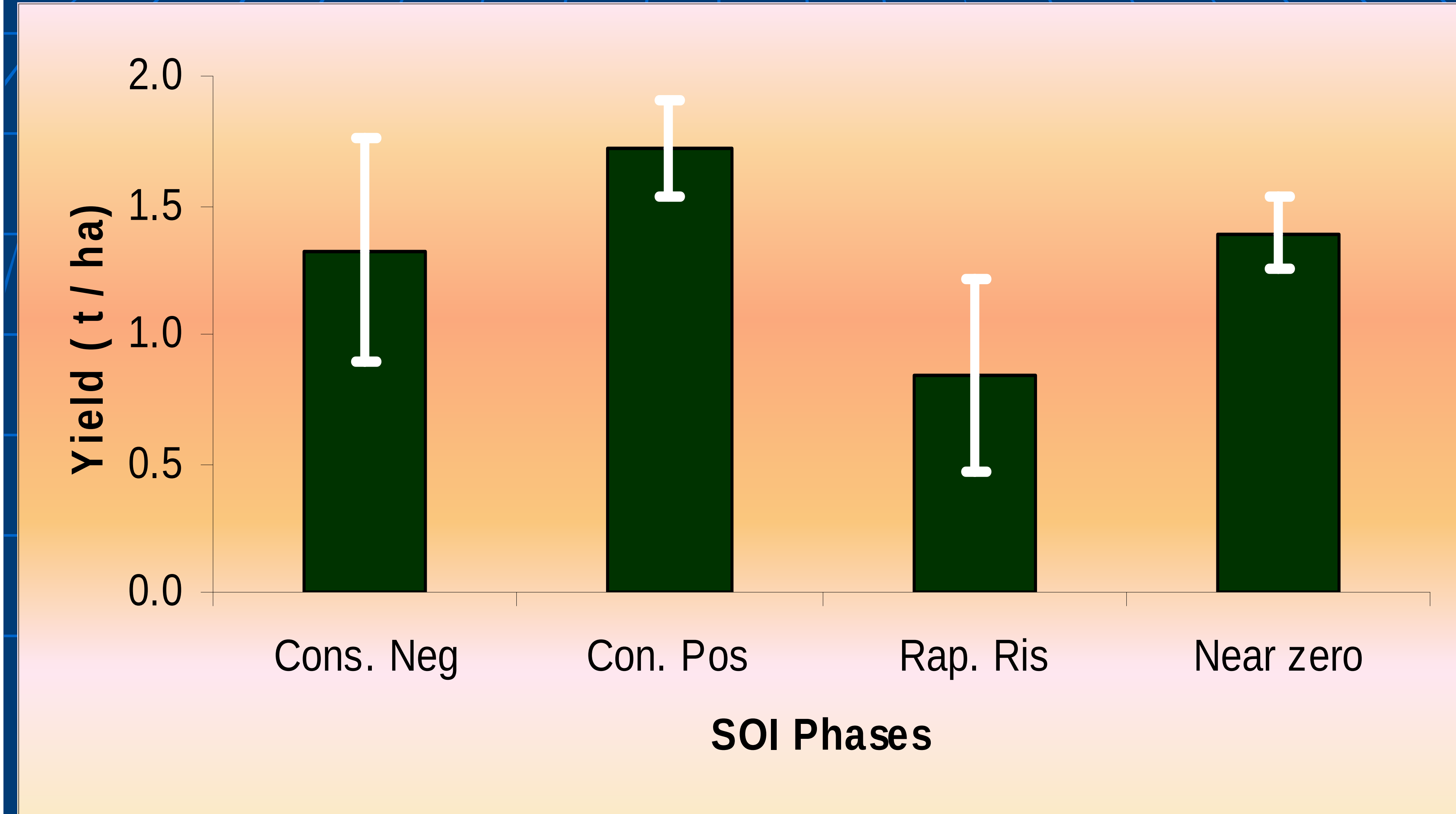


- yield of crops and pastures
- key soil processes (water, N, carbon)
- surface residue dynamics & erosion
- range of management options
- crop rotations + fallowing
- short or long term effects

APSIM: precise daily time step model that mathematically reproduces the physical processes taking place in a cropping system

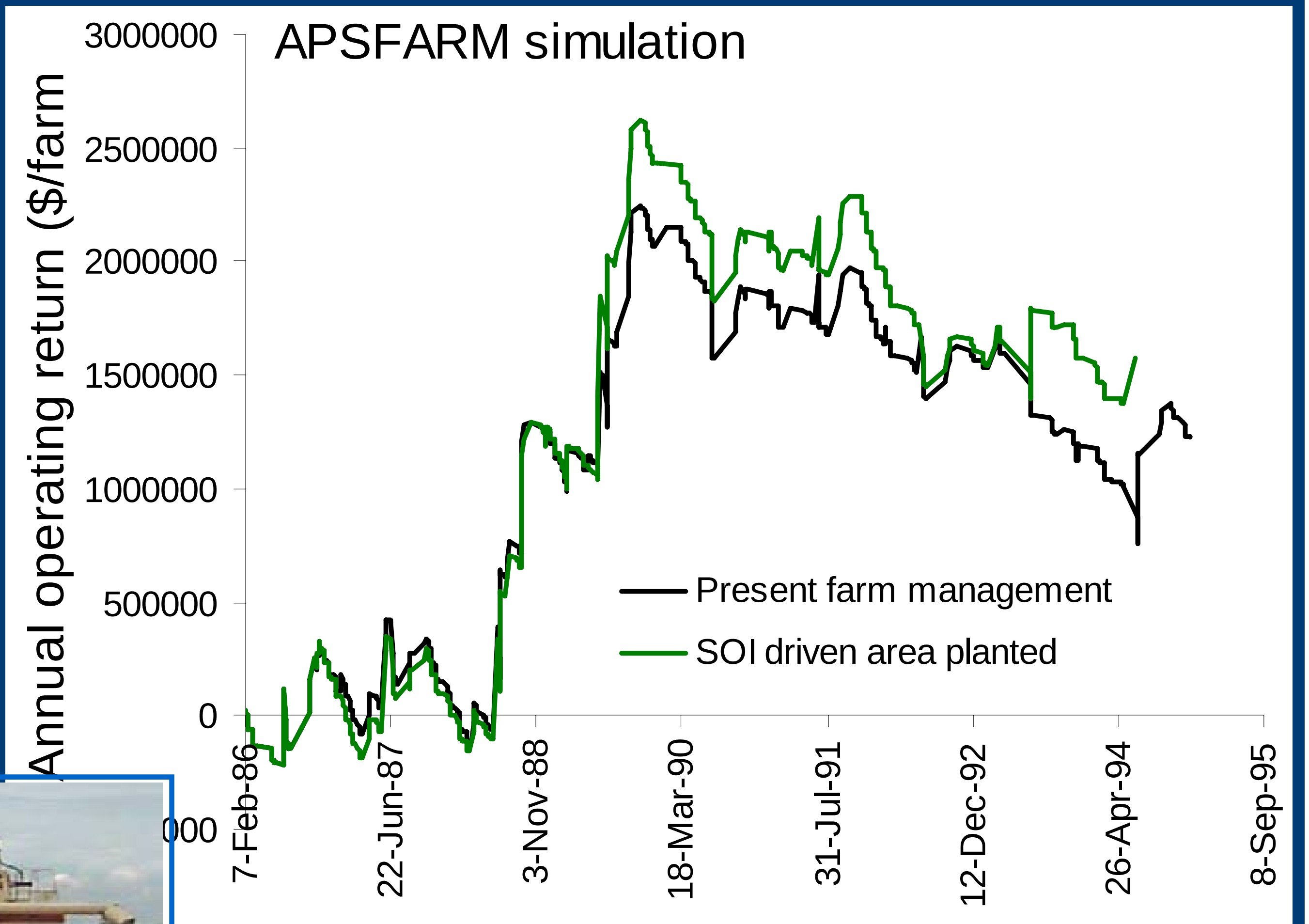



Median wheat yields and standard deviations by April/May SOI phase
Example for winter wheat: Dubbo, Australia – this information valuable for nitrogen application decisions
Yield (t / ha)
5
4
3
2
1
0
Con neg
Con pos
Rap fall
Rap rise
Near '0'



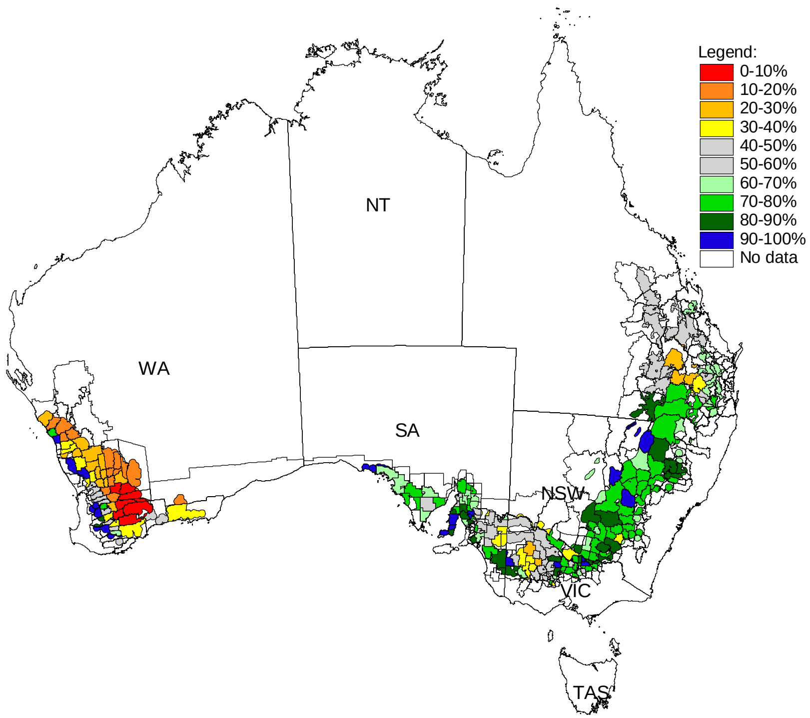
APSIM Model output used to establish better cropping systems: Example for the farmers in Pakistan in a given climate. Simulated wheat yields based on June/July SOI phase

The value of a whole-farm systems approach

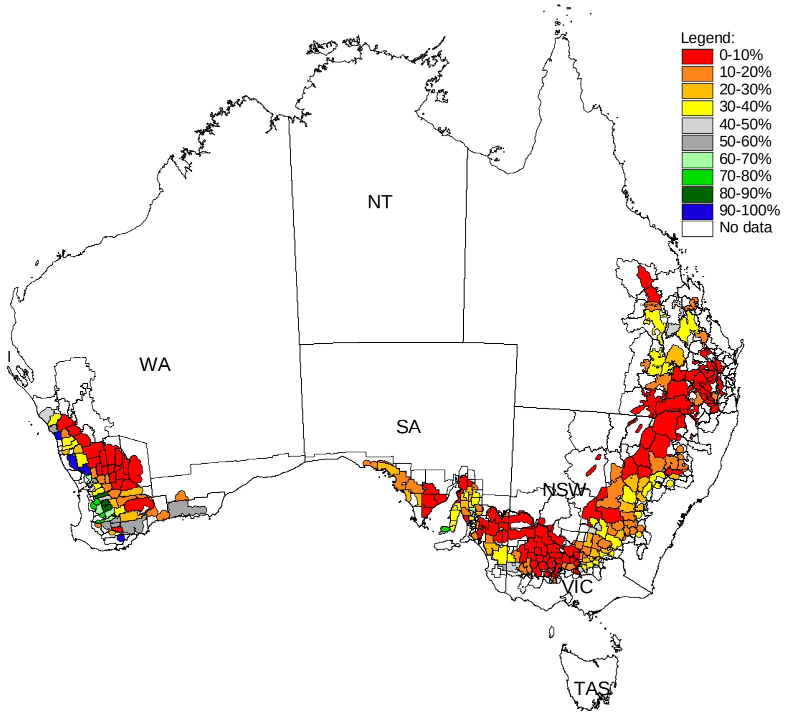


Rodriguez et al., 2006

July 2001



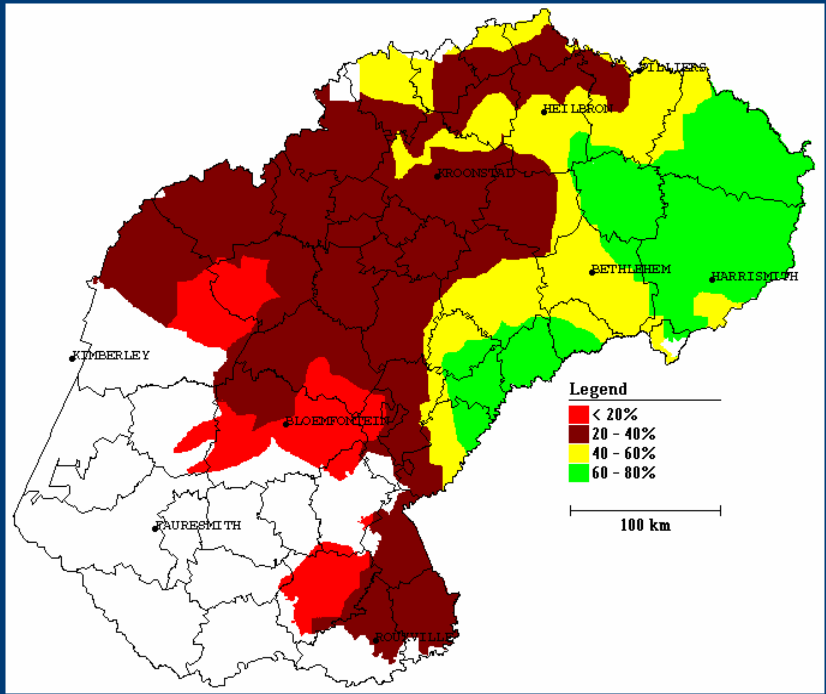
July 2002



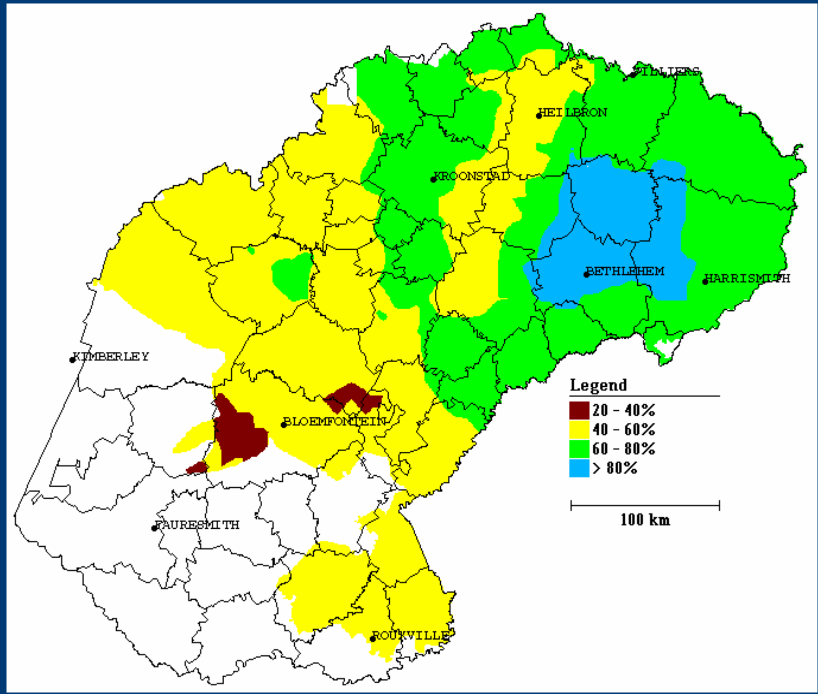
Forecasting agricultural commodities: Probabilities of exceeding long-term median wheat yields for every wheat producing shire (= district) - example for Australia issued in July 2001 and July 2002, respectively. (Grain trading issues).

Case study example from RSA: An integrated climate-farming/cropping systems forecast

Probability (%) of exceeding maize yields of 2.5 t/ha



Planting date: 1 November (Cons –ve SOI phase)



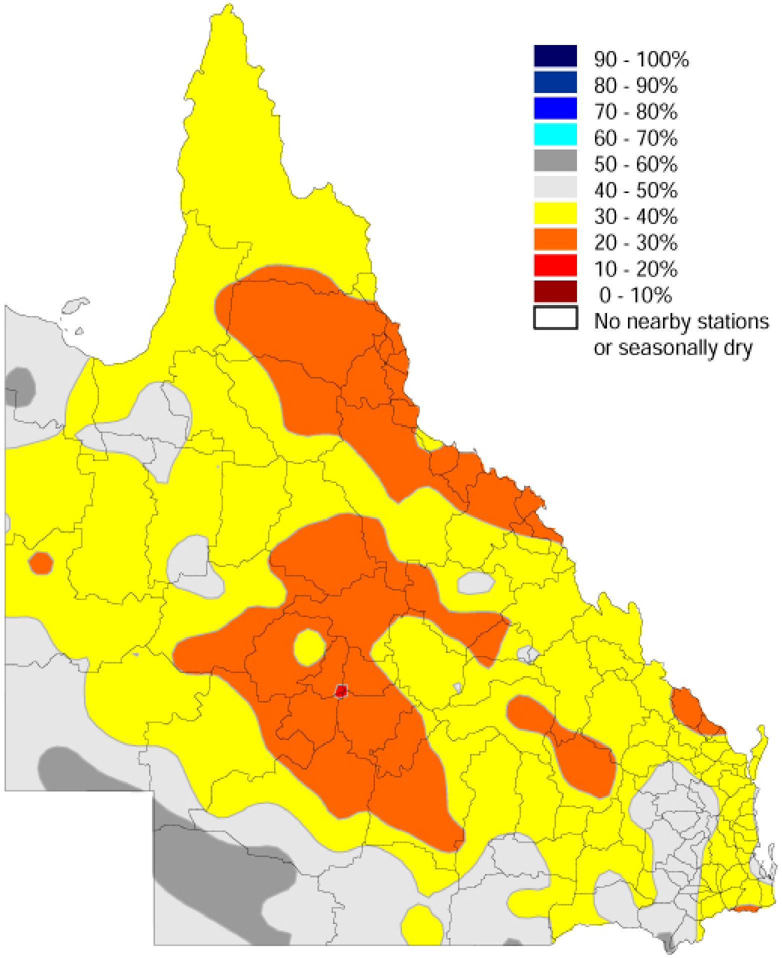
Planting date: 1 November (Cons +ve SOI phase)

(Potgieter, 1999)

Probability of exceeding Median Rainfall

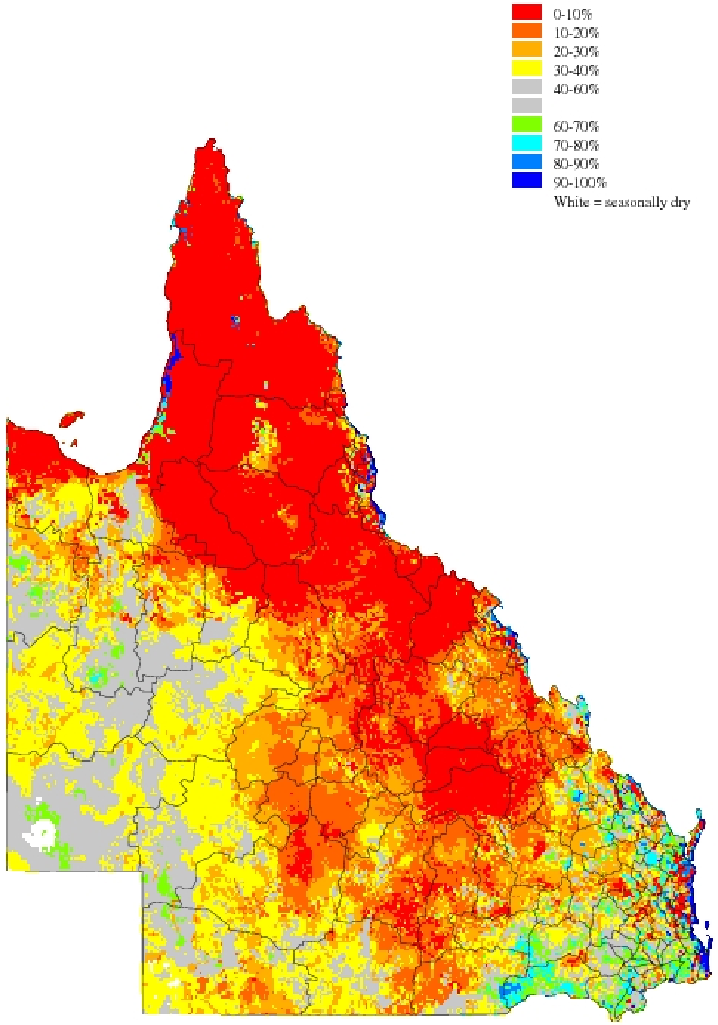
for January / March
based on consistently negative phase
during November / December

Queensland Government
Department of Primary Industries



Chance of Exceeding Median Growth

January to March 2005

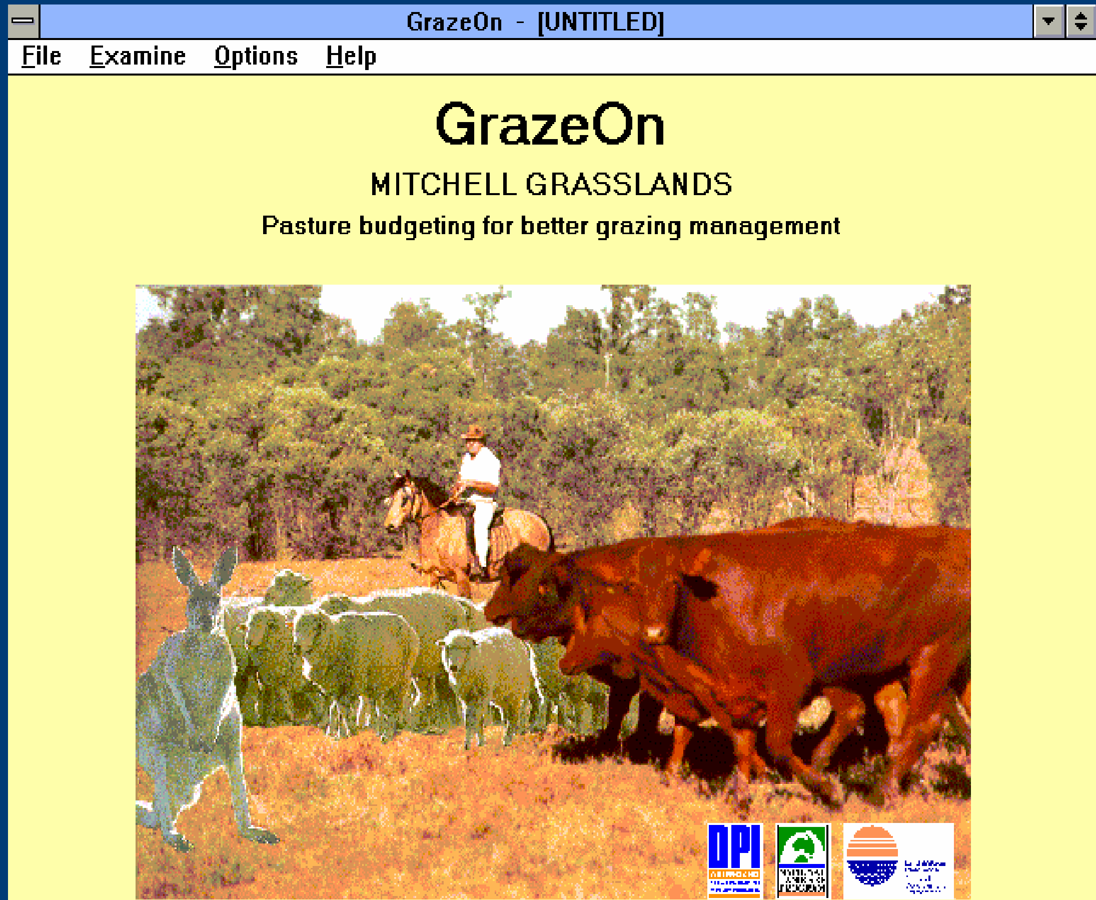


www.LongPaddock.qld.gov.au

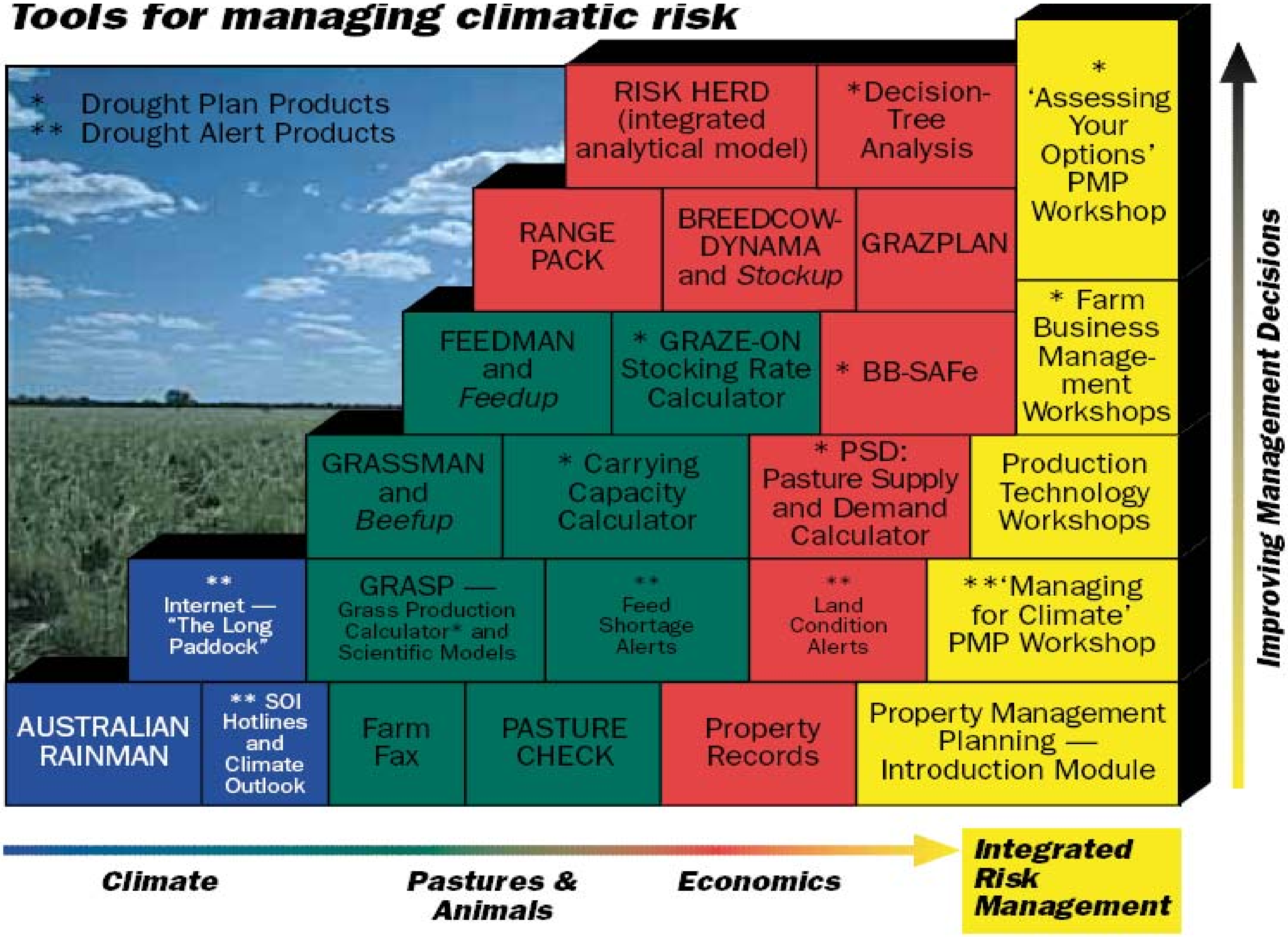
Best practice for graziers – use of pasture growth models.

Use of decision-support systems –'example of GrazeOn' to help pastoralists with best practice risk management measures

- estimating stocking rate
- pasture budgeting
- monitoring
- total grazing pressure
- drought preparation



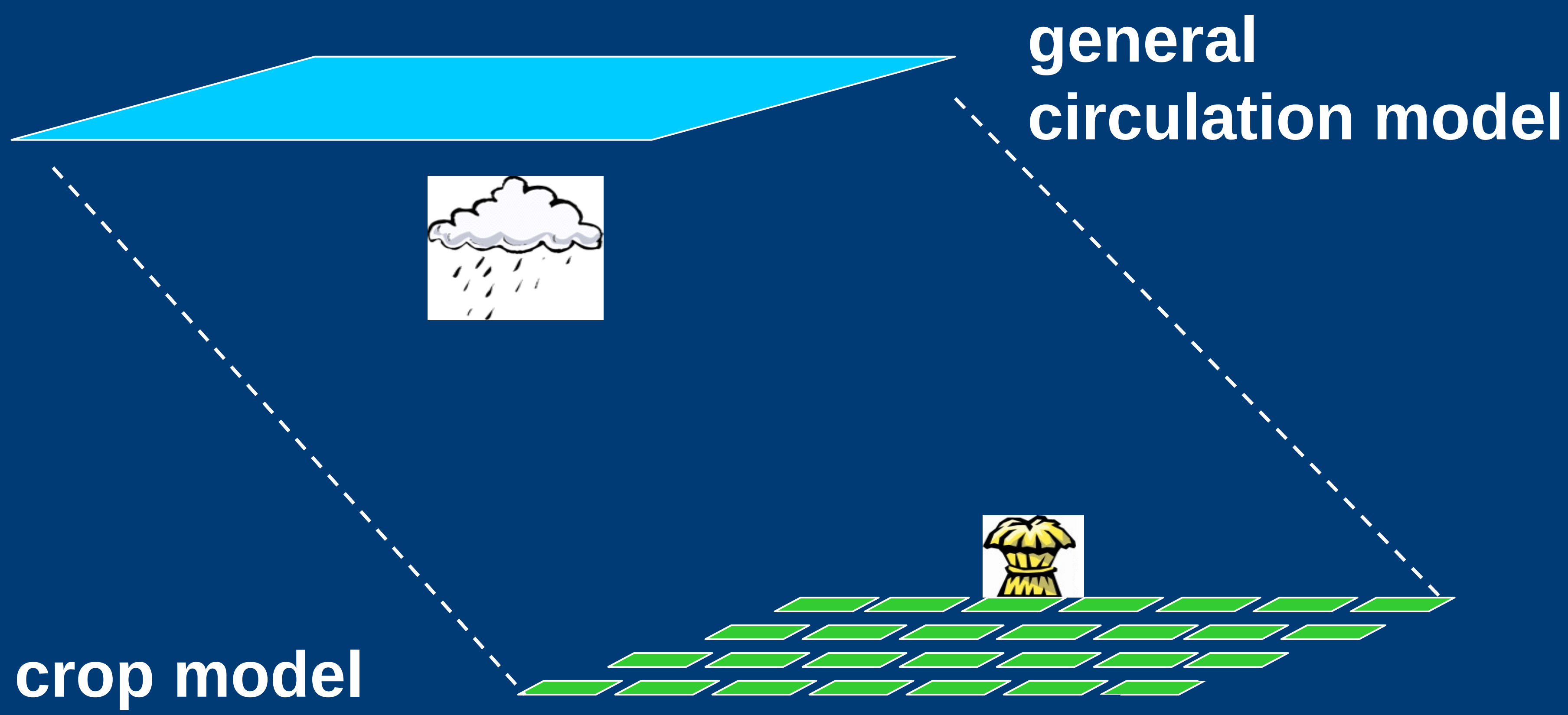
- **Climate forecasting and pasture growth models enable forward budgeting of pasture**
- **Need to assist preparedness and contingency planning for drought and reduce risk by forward budgeting of pasture (for up to 2 years)**



The danger of having too many decision-support tools?

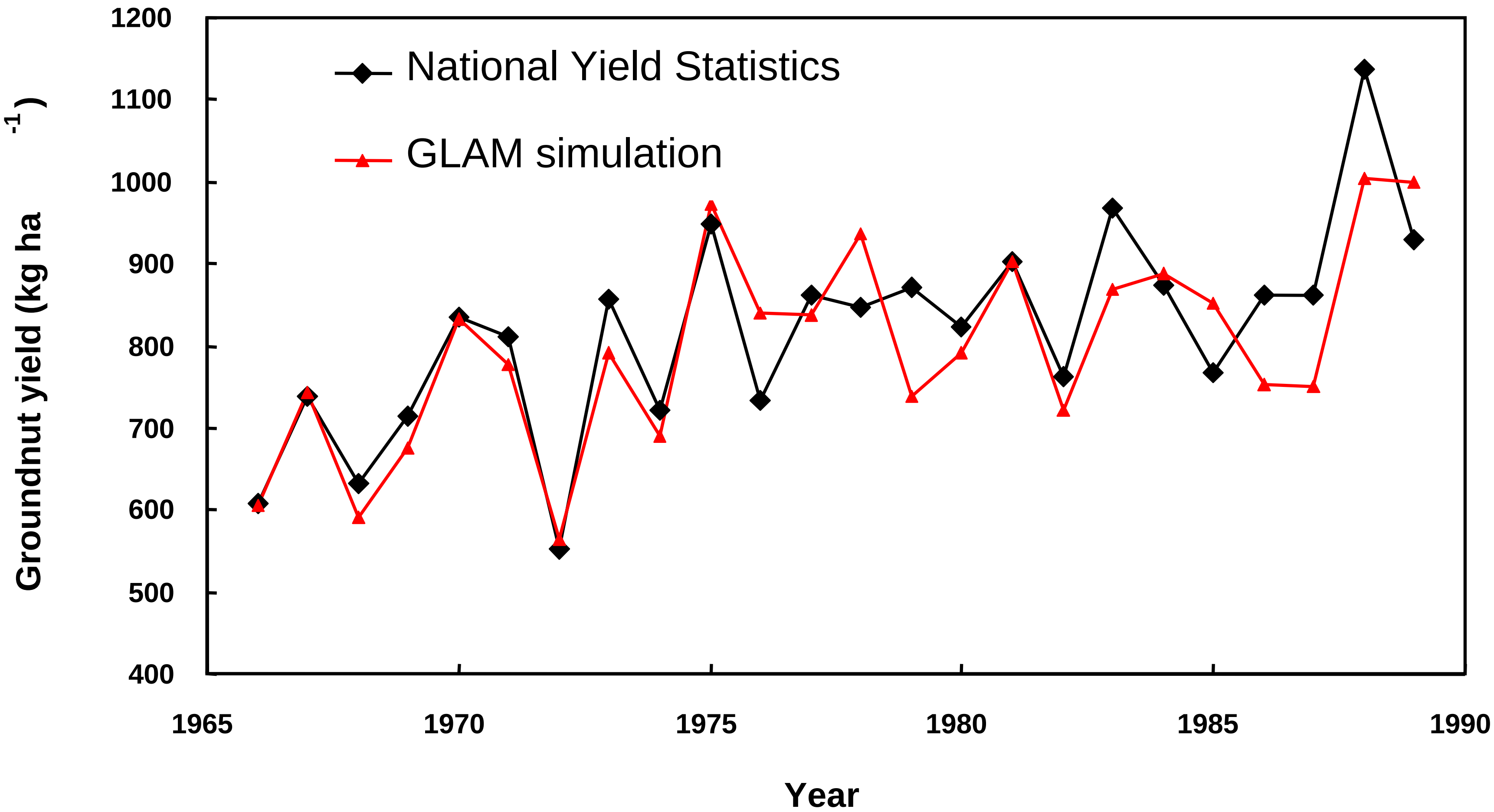
Best practice in the delivery of seasonal forecasting systems. Important aspect of co-learning with end-users - ‘Participative R&D in action’. Tully Consultative Group sugar/climate project (Russell Muchow; Yvette Everingham, Roger Stone; CSIRO/JCU/DPI&F/USQ)

The next steps - linking new generation of general circulation models to agricultural models (Challinor et al)

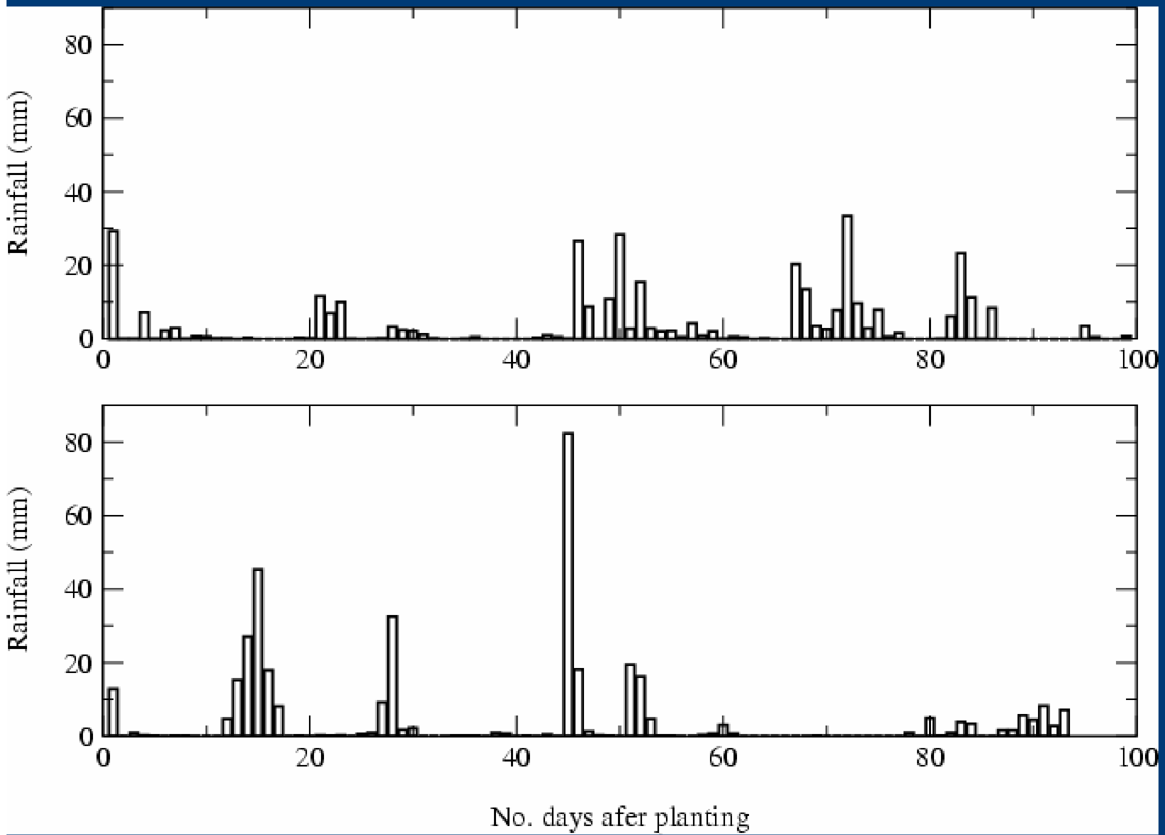


At what scale should information pass between crop and climate models?

Hindcasts of groundnut yield for all India using GLAM



The need to capture the effects of intra-seasonal variability

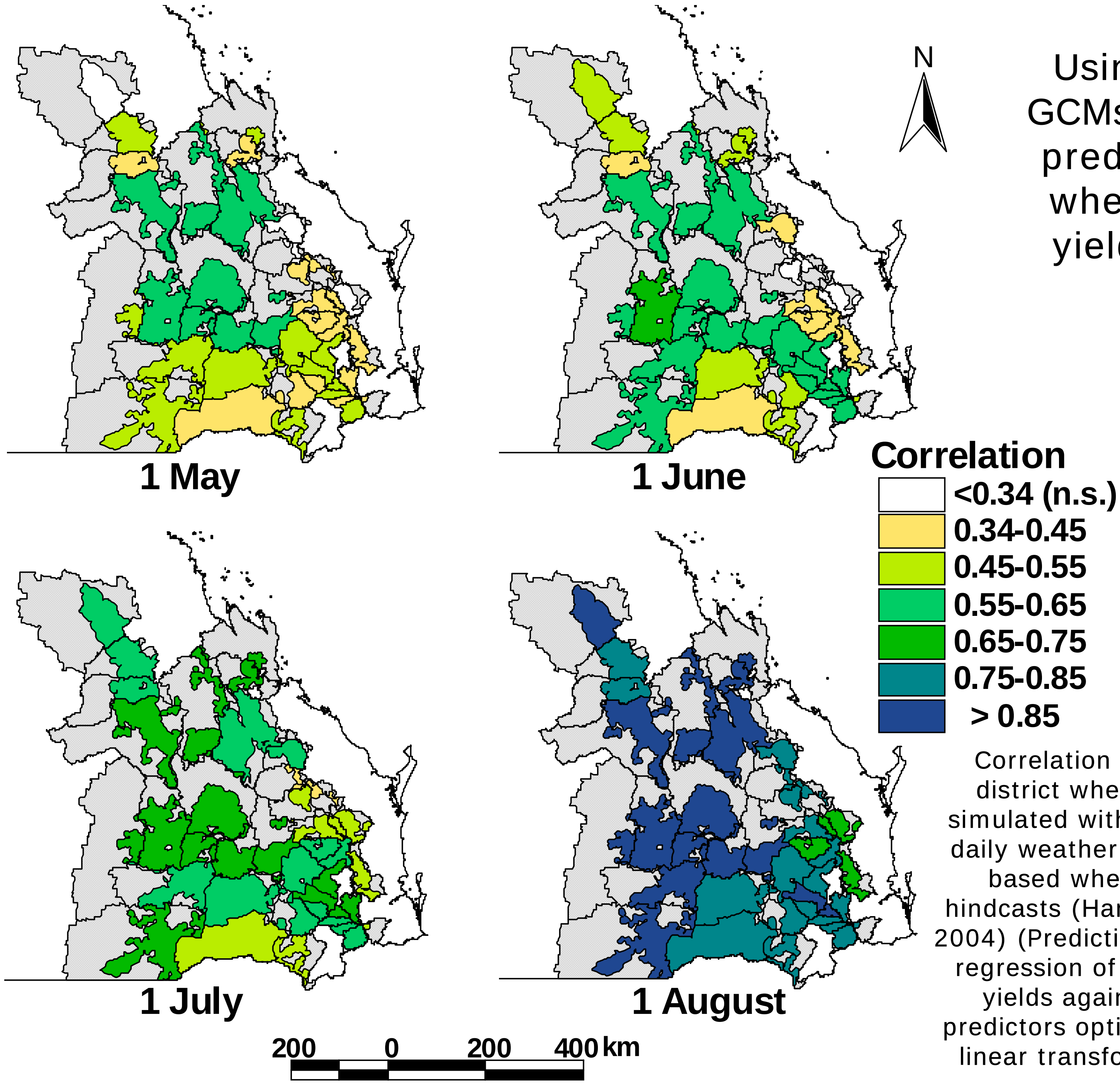


1975
Total rainfall: 394mm
Model: 1059 kg/ha
Obs: 1360 kg/ha

1981
Total rainfall 389mm
Model: 844 kg/ha
Obs: 901 kg/ha

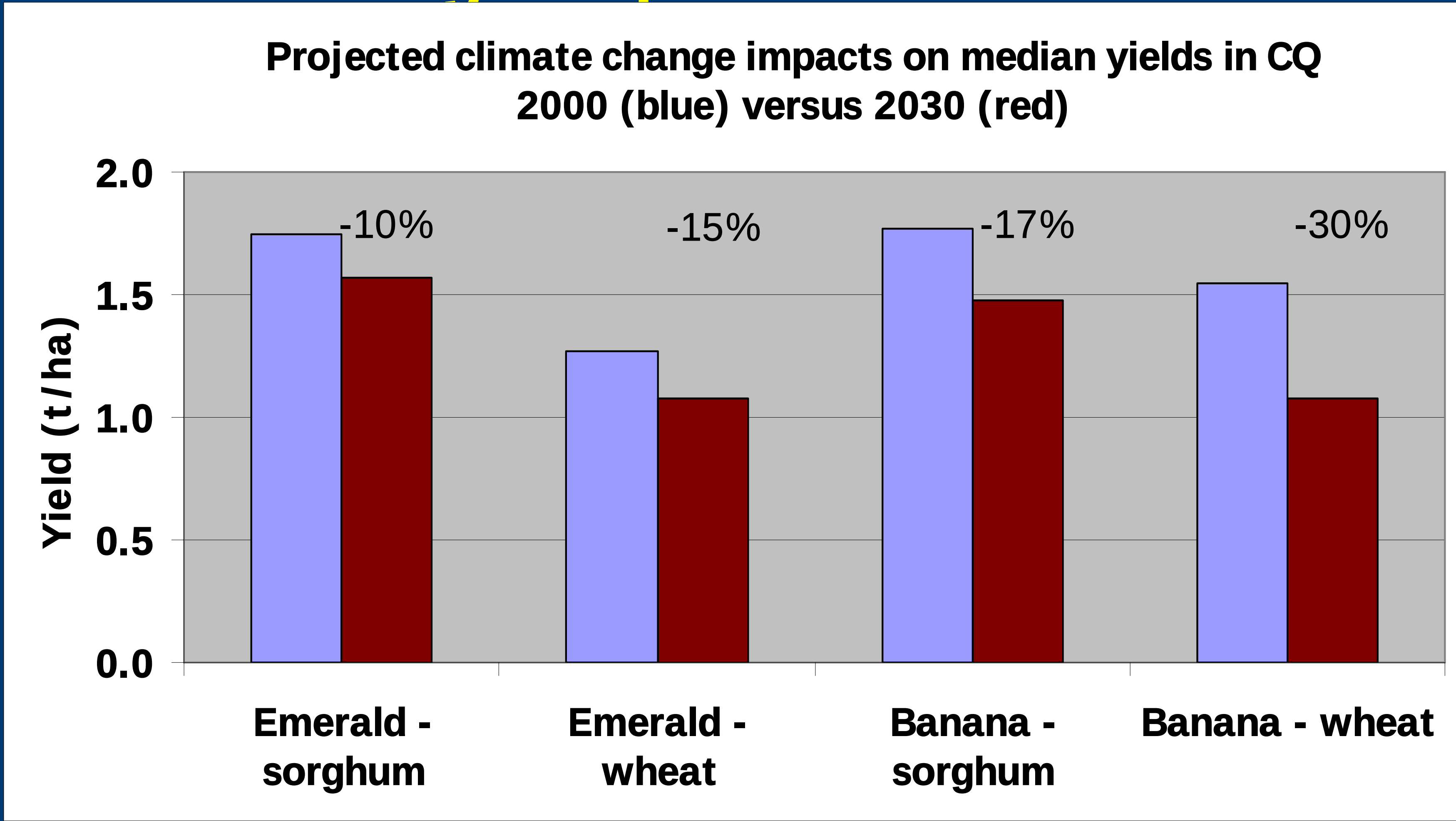
"While these models provide probabilistic predictions of the seasonal mean climate they also produce daily time series of the evolution of the weather and therefore provide information on the statistics of the weather during the crop growing season. Of prime importance is that these daily time series can be used to drive crop simulation models" (Challinor et al. 2003).

Using GCMs to predict wheat yields



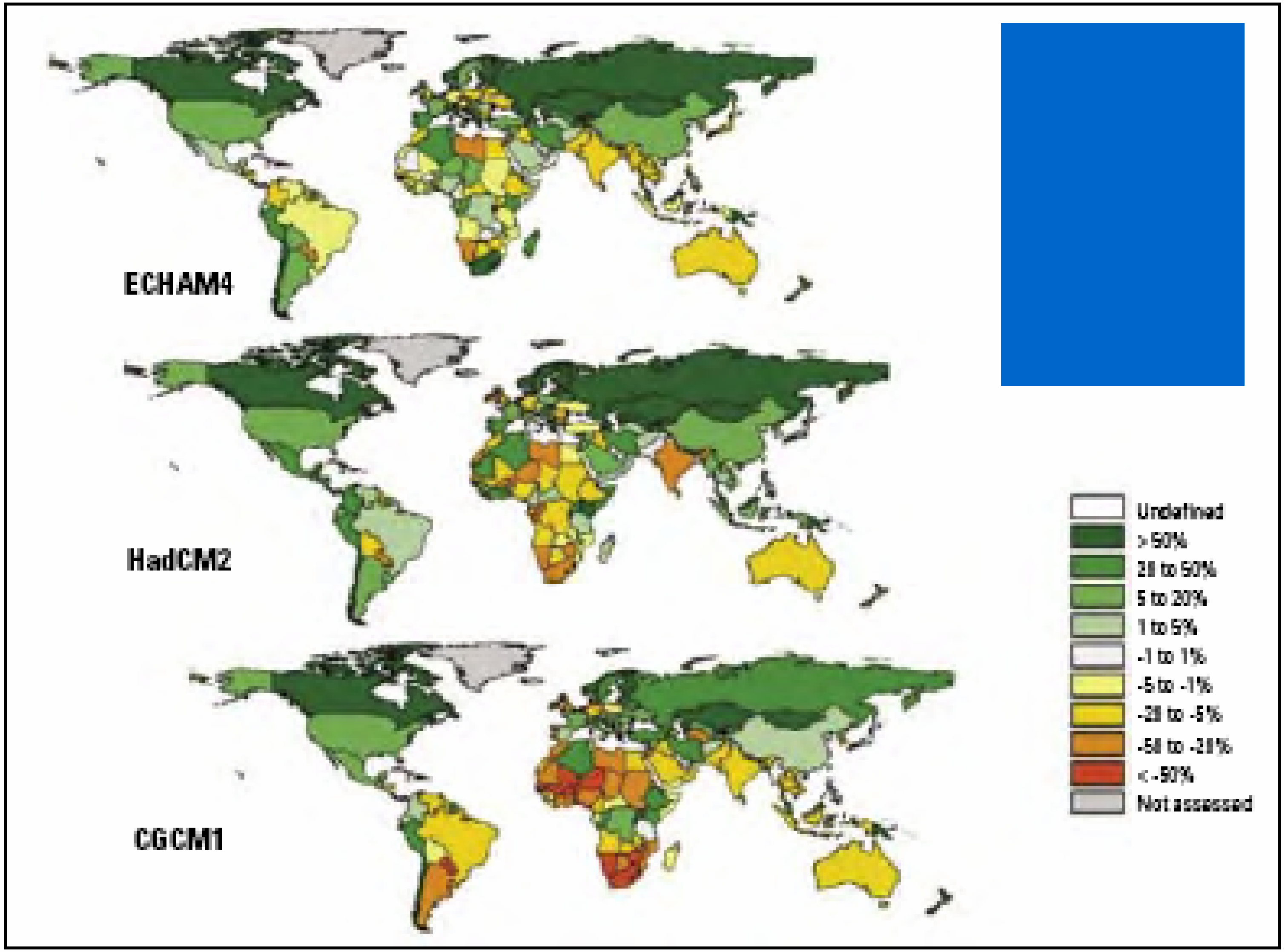
Correlation between district wheat yields simulated with observed daily weather and GCM-based wheat yield hindcasts (Hansen *et al.*, 2004) (Prediction by linear regression of simulated yields against GCM predictors optimized by a linear transformation).

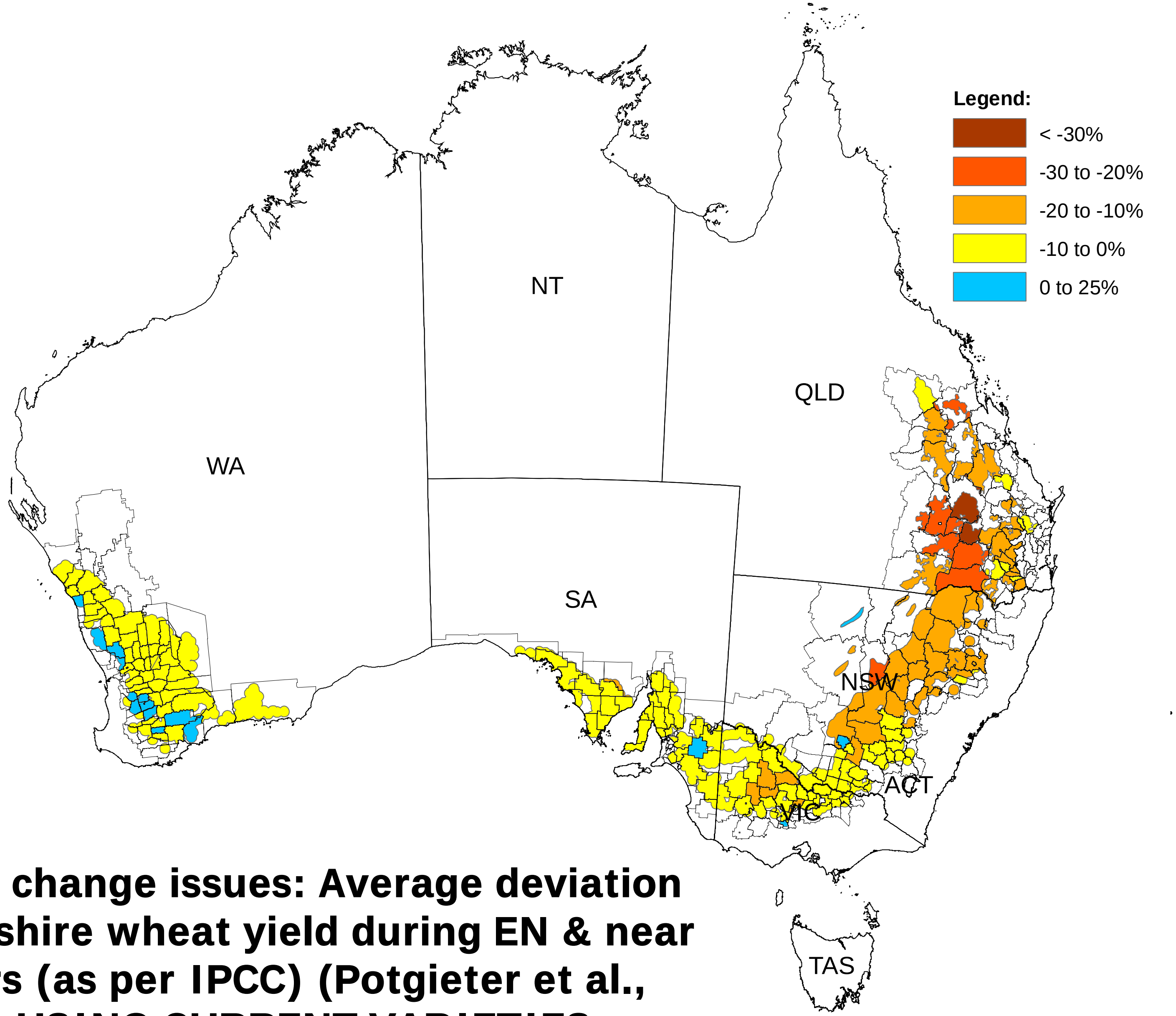
Likely climate change impacts on grain production



Meinke and Howden (2001)

Climate change impacts on cereal production potential by 2050





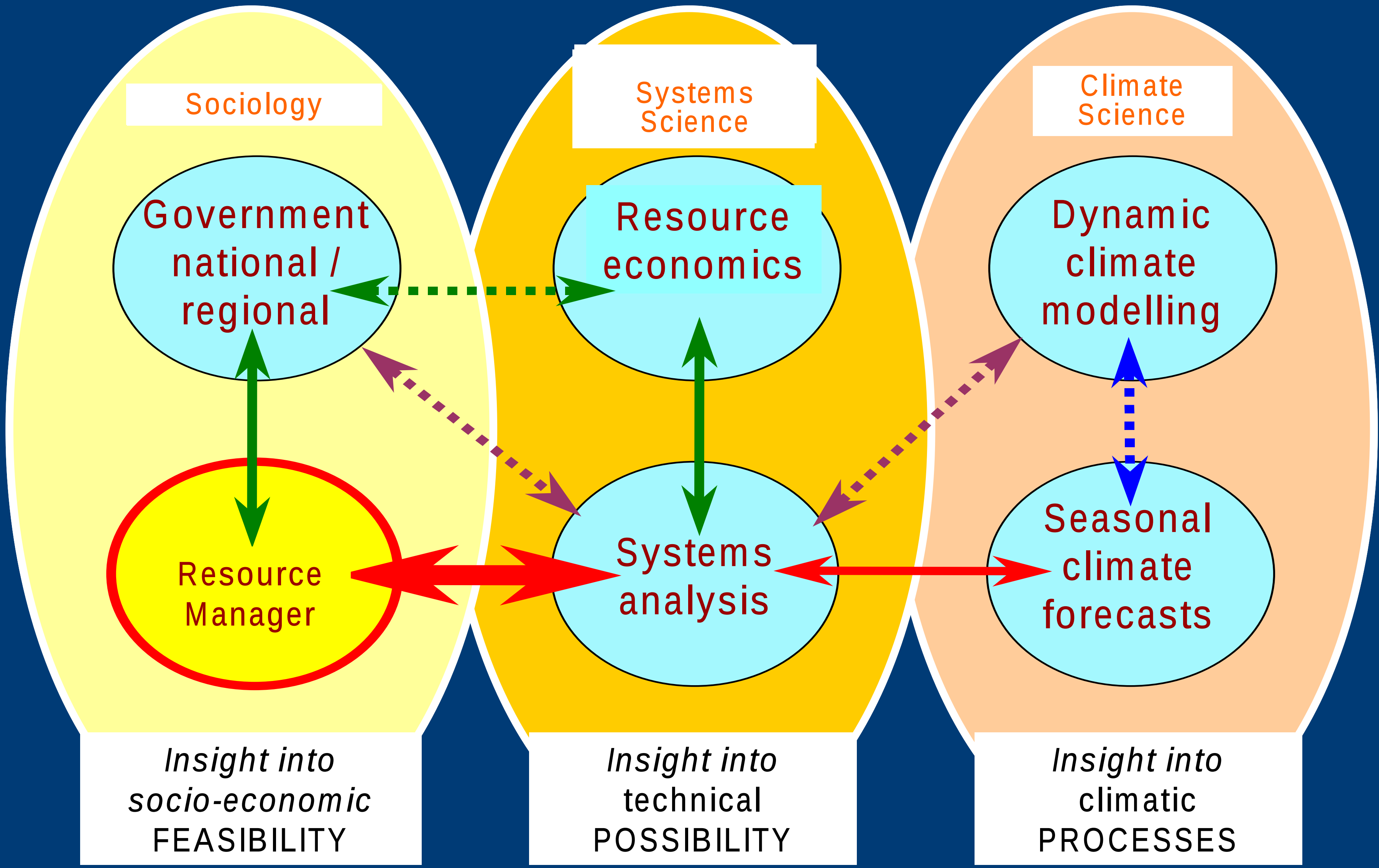
Climate change issues: Average deviation (%) of shire wheat yield during EN & near EN years (as per IPCC) (Potgieter et al., 2006) – USING CURRENT VARIETIES

MANAGING CLIMATE VARIABILITY
R & D PROGRAM

Innovative weather and climate risk management using derivative trading

Roger Stone, Peter Best, Lexie Donald, Queensland Department of Primary Industries and Fisheries

An Australian Government Initiative



Finally, the need for an interdisciplinary approach :The RES AGRICOLA concept (Meinke *et al*., 2001). Aim to convert insights gained into climatic processes via systems analysis and modelling into the socio-economic feasibility of decision options. (after Meinke and Stone, 2005).

Conclusions

- Both empirical and numerical climate forecast systems offer remarkable opportunity to improve best practice in agriculture world-wide through input of forecasting capability.
- Process-based and hybrid ‘agroclimatic’ crop simulation models are capable of providing very useful outputs of likely potential yield before the crop is planted or during crop growth stages.
- A somewhat pragmatic approach so far has led to the development of working systems that use empirical climate forecast models integrated with crop simulation models.

- There is an urgent need to develop integrated systems that combine the new generation of climate forecasting systems with regional and field scale agricultural simulation systems (preferably also including the whole-farm scale and economic models).
- To achieve best practice in the application of climate information for agriculture we strongly suggest a core commitment to an *interdisciplinary approach* in the development of specialist climate systems such as seasonal forecasting systems.
- To achieve best practice there is a strong need to integrate climate forecast systems with key management decisions.

- Use of simulation models, climate and weather forecasts plus DSS all help in the process – although the information suite can become very complex. The use of case studies seems to help users considerably.

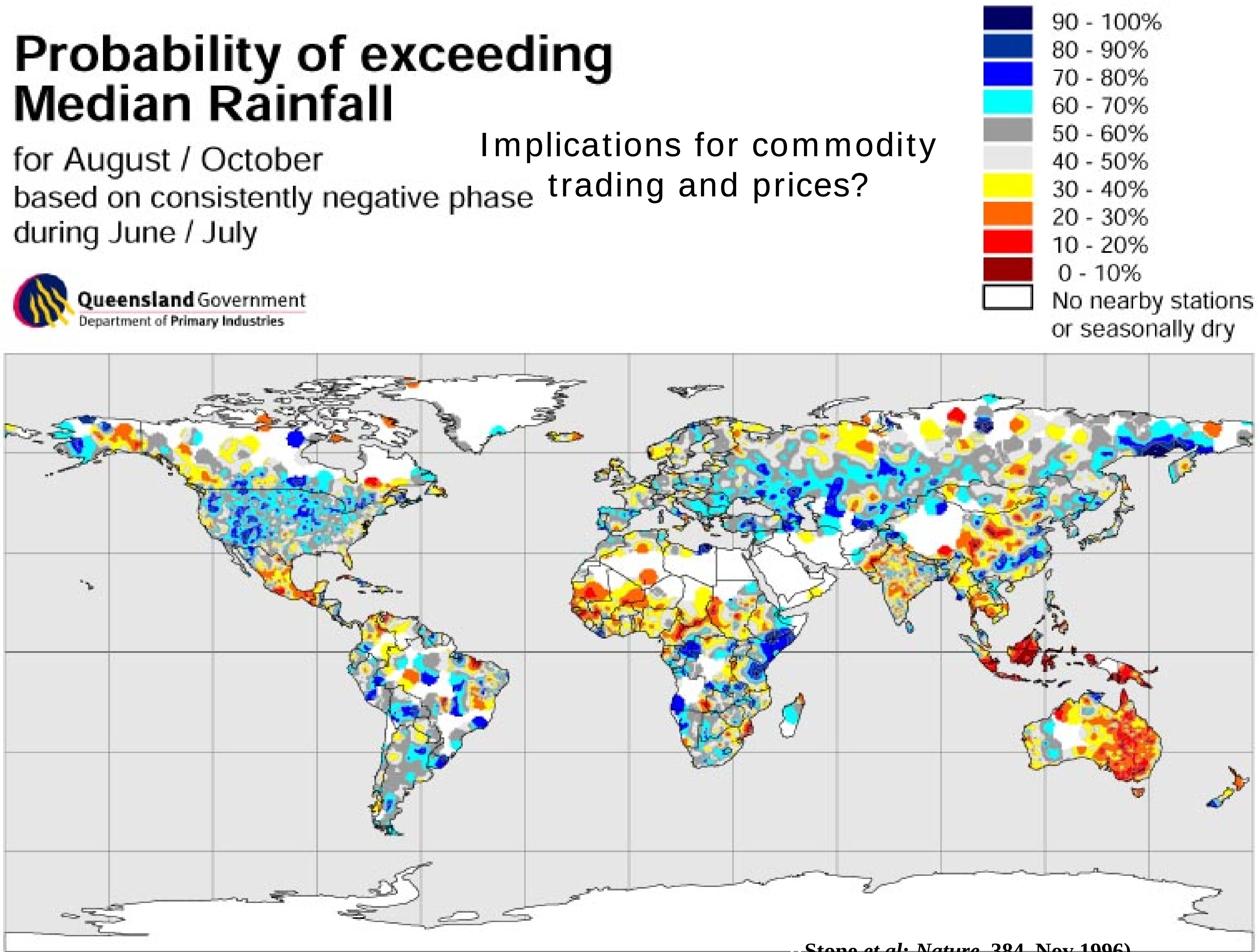
- Farmers will also need to adapt to climate change trends embedded in a very noisy background of natural climatic variability.

- This variability can mask slow trends and delay necessary adaptive responses by government agencies.


Thank you
CANADA
NORTH
UNITED STATES
AMERICA
MEXICO
Tropic of Cancer
MARSHALL
ISLANDS
KIRIBATI
equator
International Date Line
PACIFIC OCEAN
COOK
ISLANDS
(NZ)
FRENCH POLYNESIA
(FR)
Tropic of Capricorn
AUSTRALIA
Antarctic Circle

Requires:

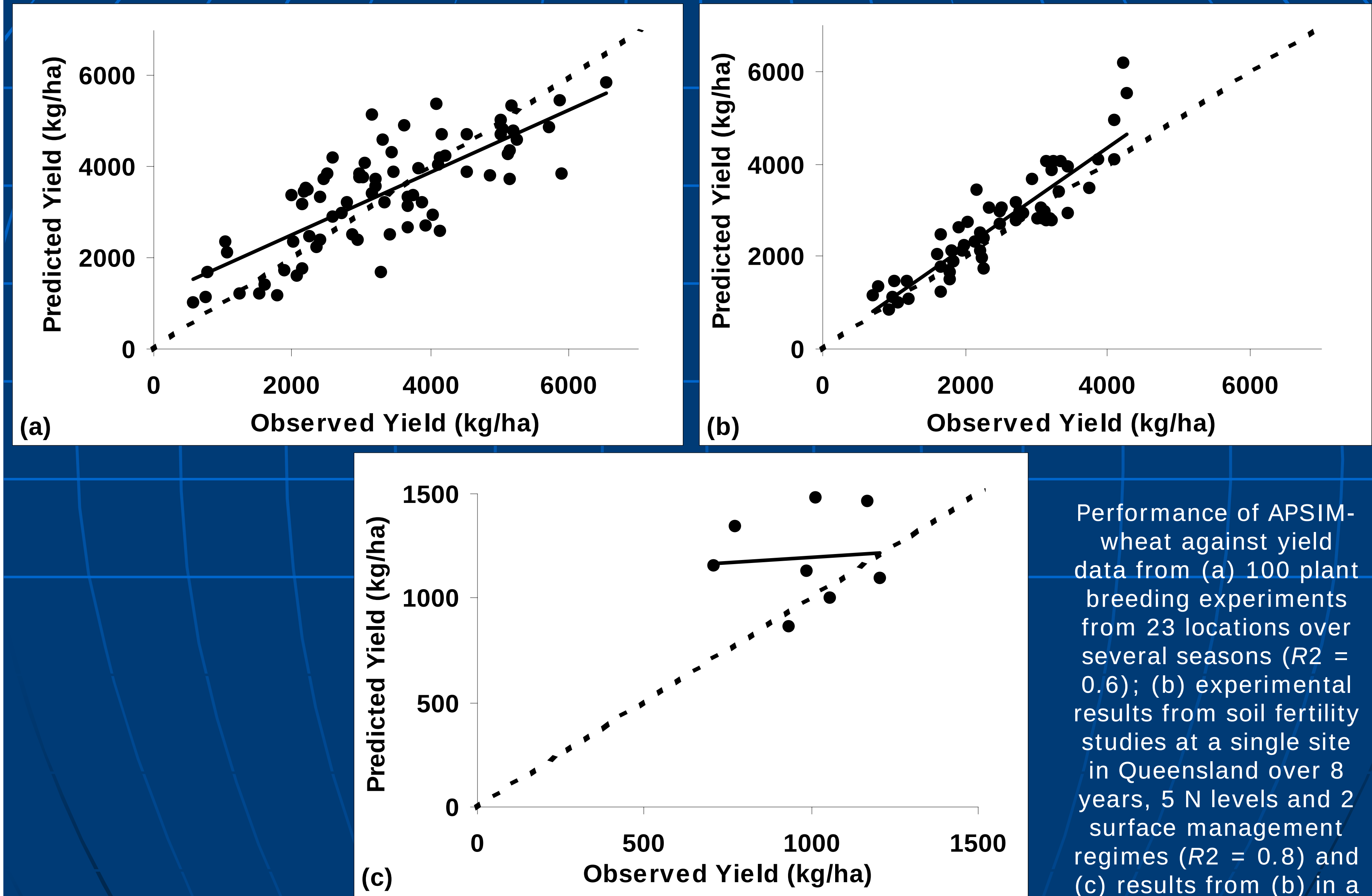
- High quality climate data sets – rigorous station quality adherence.
- Strong relationships between aspects such as crop yield and the climate indicator.
- Restriction of moral hazard.
- Liquid market – may require reinsurance industry involvement.
- ‘Attractive’ premiums (competition from other insurance products.



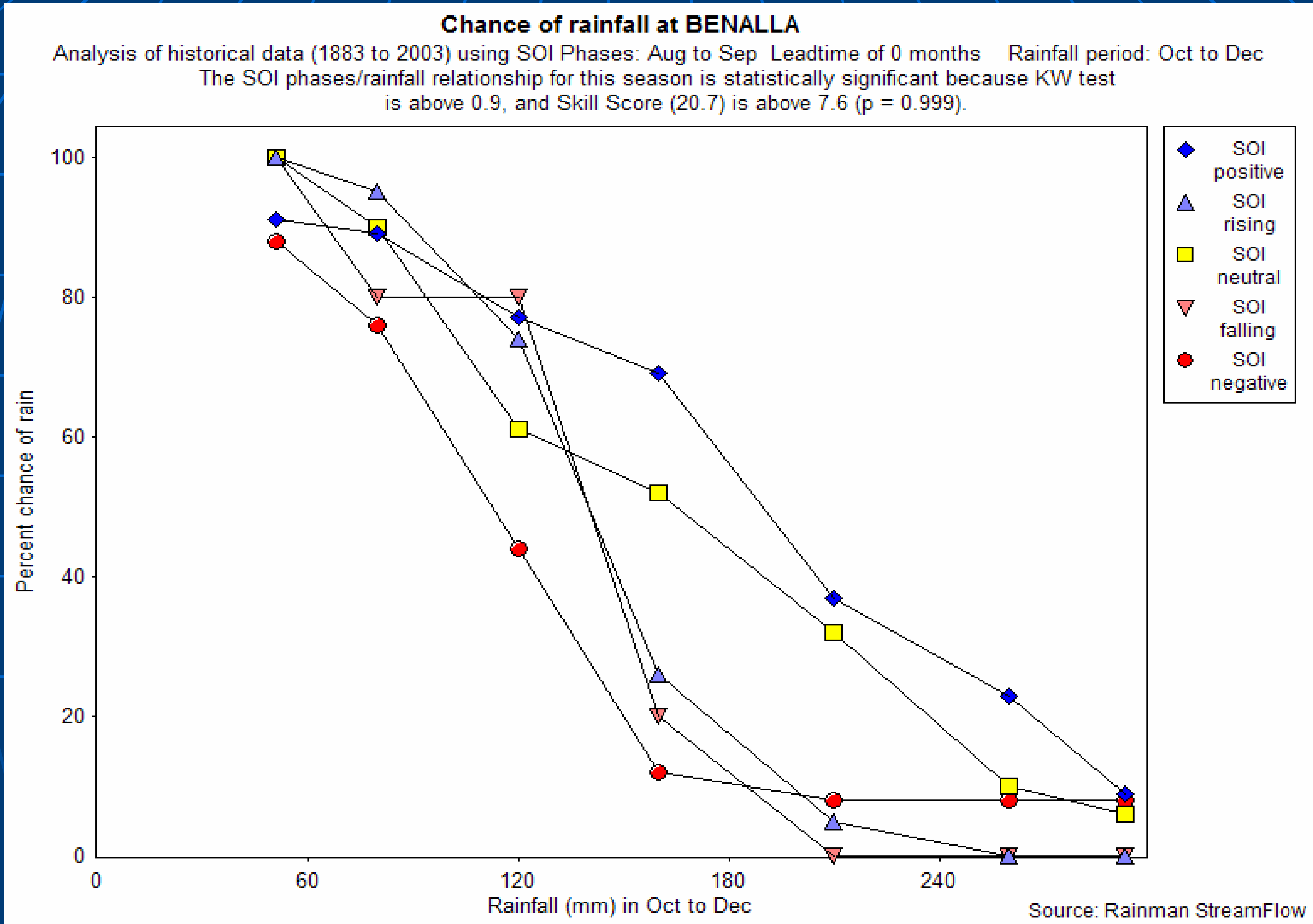
Implications for commodity trading and prices?

Stone *et al*; *Nature* 384, Nov 1996)

The value of crop simulation models (APSIM)

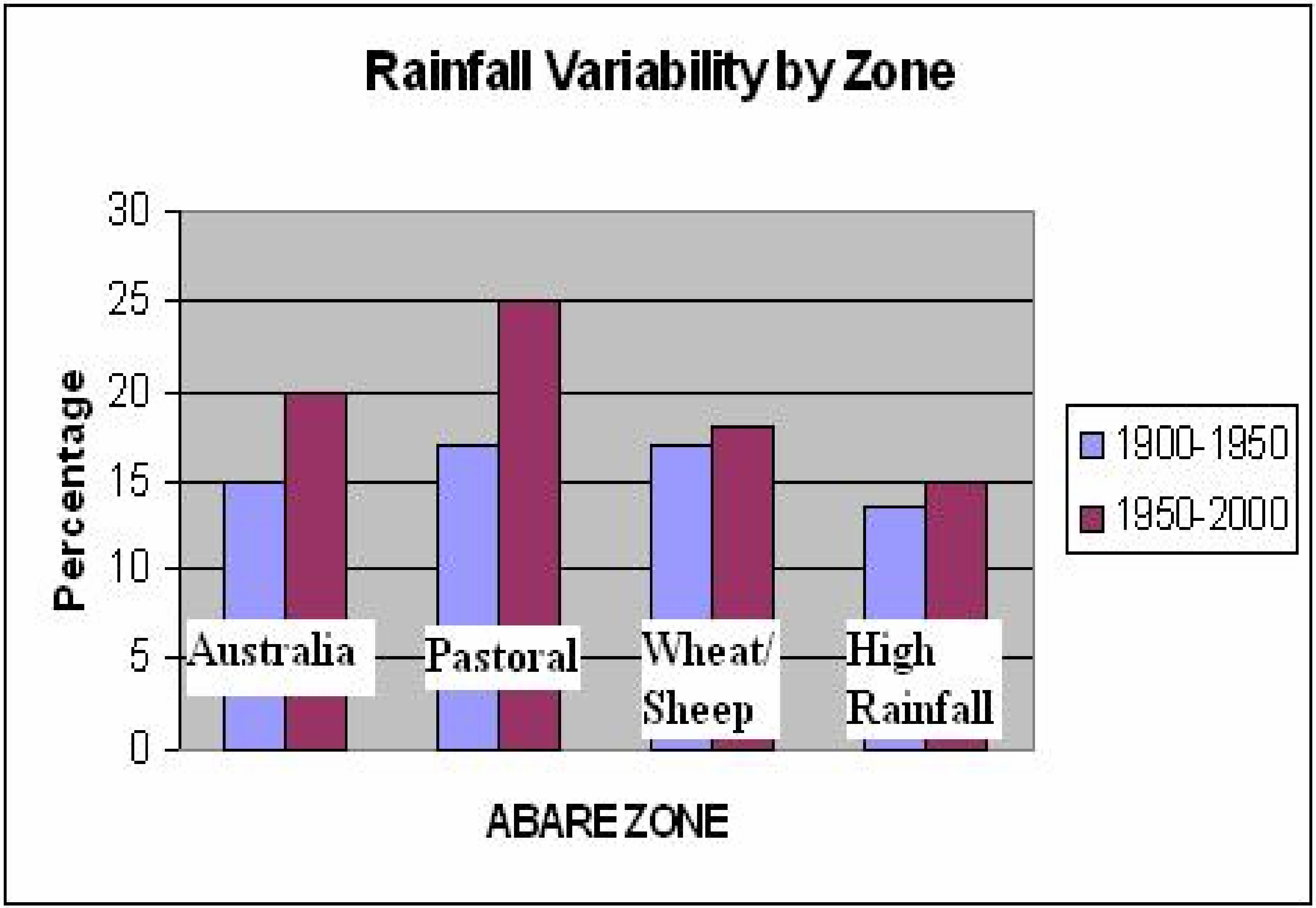


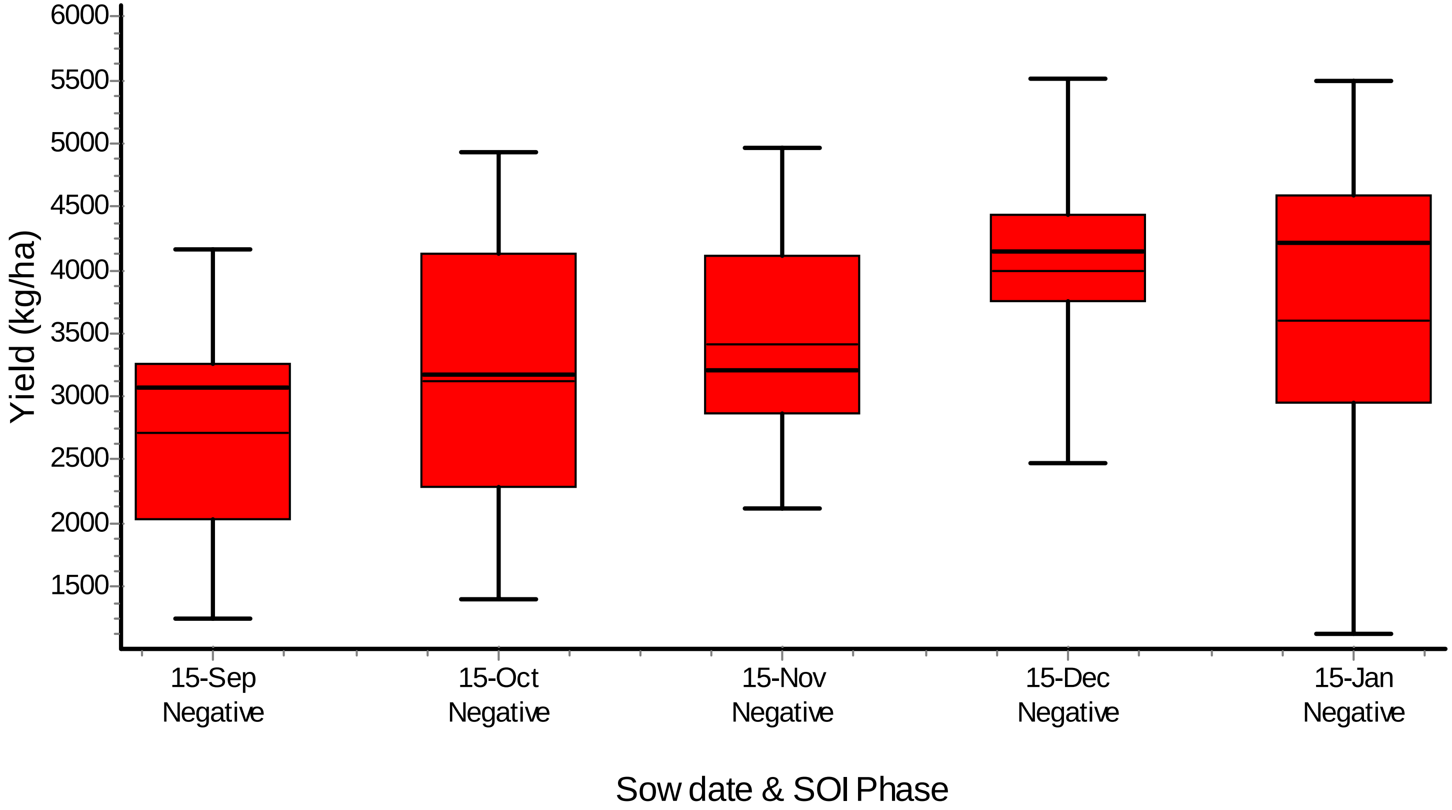
Performance of APSIM-wheat against yield data from (a) 100 plant breeding experiments from 23 locations over several seasons (*R*2 = 0.6); (b) experimental results from soil fertility studies at a single site in Queensland over 8 years, 5 N levels and 2 surface management regimes (*R*2 = 0.8) and (c) results from (b) in a dry year



Climate forecast systems at point scale? : example of general user output….(‘SOI phases’: Stone et al; 1996)

Rainfall variability is increasing (in Australia). Change in rainfall variability between the 1900-1949 half century and 1950 – 2000 (Love 2005).





Climate forecast information has no value unless it can change a decision: <u>When to sow my sorghum crop</u>? Effect of sow date on sorghum yield range at Miles South QLD with a ‘consistently negative’ SOI phase for September/October (Other parameters - 150mm PAWC, 2/3 full at sowing, 6pl/m2, medium maturity. Source; **WhopperCropper**