“Climate forecasting information has no value unless it changes a management decision”
Australia has the world’s highest levels of year-to-year rainfall variability

Variability of Annual rainfall

(100 years of data for Australia and generally also for the other countries)

Country

Australia, S. Africa, Germany, France, NZ, India, UK, Canada, China, USA, Russia

(Love, 2005)
Seasonal and longer term climate variation - relationship between annual variation in the SOI and annual Moree Plains wheat yield (Stone and Donald, 2007) – the key is the need to modify actions ahead of impacts.
More detailed climate indicator/yield relationships: Mean /std production levels associated with ENSO – example for sorghum and wheat /Australia (Hansen and Stone, 2012)
Mean/std Corn production RSA and Palm Kernels associated with ENSO (Hansen and Stone, 2012)
Forecasts: capability to provide probabilistic information (across many continents) based on core ENSO indicators (Stone et al., *Nature*, 1996)
Global seasonal forecasts have high value for major commodity trading decisions, price fixing, likely production shortages (ECMWF).
Key agricultural users may seek forecasts on extremes in order to make major decisions – (probability of precipitation being in the ‘upper quintile’.NDJ 2010/11. courtesy ECMWF).
New generation model assessment:

UK Met Office

The value of forecast verification forecasts for NE Australia (Oct-Nov-Dec) – capability to forecast well in upper or lower terciles (courtesy UKMO).
"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).
Climate forecast information has no value unless it changes a management decision - Utilising climate forecasts in decision making.

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

Deciding, which variety to plant given low rainfall probability values and high risk of damaging frost and anthesis?”
What are the decisions? Linking climate information to user decisions – complex issues of scale – example for the sugar industry

**Industry Scale Axis**

- **Farm**
  - Irrigation
  - Fertilisation
  - Fallow practice
  - Land prep
  - Planting
  - Weed manag.
  - Pest manag.

- **Harvest, Transport, Mill**
  - Improved Planning for wet weather disruption – season start and finish
  - Crop size forecast
  - CCS, fibre levels
  - Civil works schedule

- **Catchment**
  - Land & Water Resource
  - Management
  - Environmental Management
  - Water allocation

- **Marketing**
  - Crop size
  - Forecast
  - Early Season Supply
  - Supply patterns
  - Shipping
  - Global Supply

- **Policy**
  - Water allocation
  - Planning and policy associated with exceptional events

**Targeted**

- **Business and Resource Managers**

- **Government**

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**Climate forecast information**
Decisions across the value chain – ‘climate forecasting has no value unless it changes a management decision’

Understanding climate related issues across the whole value chain

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

- Sugarcane Production

- 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

Recognise the issue of scales - Agricultural Management Decisions occur at many time scales + there are climate systems operating at many time scales! (Meinke and Stone, 2005).

<table>
<thead>
<tr>
<th>Decision type (eg. only)</th>
<th>Climate system (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics (eg. scheduling of planting / harvest operations)</td>
<td>Intraseasonal (&gt;0.2)</td>
</tr>
<tr>
<td>Tactical crop management (eg. fertiliser/pesticide use)</td>
<td>Intraseasonal (0.2-0.5)</td>
</tr>
<tr>
<td>Crop type (eg. wheat or chickpeas)</td>
<td>Seasonal (0.5-1.0)</td>
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<tr>
<td>Crop sequence (eg. long or short fallows)</td>
<td>Interannual (0.5-2.0)</td>
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<tr>
<td>Crop rotation (eg. winter or summer crop)</td>
<td>Annual/biennial (1-2)</td>
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<tr>
<td>Agricultural industry (eg. crop or pasture)</td>
<td>Decadal (~10)</td>
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<tr>
<td>Landuse (eg. Agriculture or natural system)</td>
<td>Interdecadal (10-20)</td>
</tr>
<tr>
<td>Landuse and adaptation of current systems</td>
<td>Multidecadal (20+)</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
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</tbody>
</table>
To assist in the decision process, the linking role of modelling in the application of climate information for agricultural production is to simulate management scenarios and evaluate outcomes and risks relevant to decisions.

- Simulate management scenarios
- **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
Farm-level decisions - Australia - Utilising seasonal climate forecasts in management and adaptation – eg of forecasts of potential sorghum yields associated with varying climate regimes (example for a ‘consistently negative SOI phase’) – varying management decisions (sowing dates): example for Miles, Australia.

Effect of sowing date on sorghum yield 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 (WhopperCropper)}
Utilising seasonal climate forecasts - forecasts of potential wheat yields associated with varying climate regimes (SOI patterns or phases): Example for a location in Pakistan – potential yields based on June/July SOI phase (APSIM output).
Decisions being made by grain exporting authority: forecasting agricultural commodities – Use of the larger spatial scale model – ‘OzWheat’ – to produce probabilistic of exceeding long-term median wheat yields for every wheat producing district in Australia issued in July 2001 and July 2002, respectively – 2002 was an ‘El Niño year’ (Potgieter, 2010).
commodity trading
Probabilities of exceeding long-term median maize yields for Free State, RSA, associated with a consistently negative SOI phase and a consistently positive SOI phase – output provides the 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)
A core challenge
Challinor et al 2003

Spatial scale

Country + district field

Timescale

annual + seasonal monthly daily

GCM
Crop models
Key – to effectively link the new generation of general circulation models in climate prediction to agricultural models (Challinor et al)

At what scale should information pass between models?
Multiple Gridded ECMWF/POAMA Realizations

- Biomass Accumulation
- Radiation
- Rainfall
- Minimum Temperature

Distributions of Station Climate Data

- Maximum Temperature
- Radiation
- Rainfall

Agronomic Simulations

Sucrose Accumulation

CCS Accumulation

AGRONOMIC PRODUCTION SIMULATOR
Example for Europe - Wheat yields – Use of multi-model ensemble prediction through statistical downscaling to directly forecast wheat yields – examples for Germany, France, Denmark, and Greece (Palmer et al, 2004)
Assisting decision processes? – developing decision-support systems that link climate information, agricultural models and user decisions – are they really valuable? …

Decisions related to estimation of future stocking rates

Decisions related to pasture budgeting monitoring

Decisions related to total grazing pressure

Decisions related to drought preparation
are ‘discussion-support systems’ more appropriate? – the use of participatory approaches - also assists in the cooperation between service providers and users……

The value of a participatory approach with users – a ‘discussion-support’ system
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).
- **Summary:** A systematic approach in applying climate forecasts to agricultural decision-making to achieve best practice (after Hammer, 2000)

- **Understand the agricultural system and its management:** it is essential to understand the system dynamics and opportunities for management intervention i.e. *identify those decisions* that could influence desired systems behaviour or performance;

- **Understand the impact of climate variability/climate change:** it is important to understand *where in the ag-system climate is an issue*;

- **Determine the opportunities** for tactical/strategic management in response to the forecasts. If forecasts are now available, what possible options are there at relevant decision-points? How might agricultural decisions be changed in response to forecasts? What nature of forecast would be most useful? and - What lead-time is required for management responses?
• Evaluate the worth of tactical or strategic decision options: the quantification and clear communication of the likely outcomes e.g. economic or environmental, and associated risks of a changing an agricultural management practice are key to achieving adoption of the technology.

• Implement participative implementation and evaluation: working with agricultural managers/decision makers generates valuable insights and learning throughout the entire process: i.e. identifying relevant questions/problems and devising suitable technologies and tools.

• Provide feedback to climate forecasting research in the NMHS or university: rather than just accepting a given climate forecast, consider what specific improvements would be of greatest value in the agricultural system. This can provide some direction for the style of delivery of forecasts and for climate research of value for the agricultural sector.

• “Climate information doesn’t have to be perfect to be useful; it just needs to support a decision” (Hammer, 2000; Hammer et al., 2001; Stone and Meinke, 2007; Rodriguez, 2010).
Conclusions...

• Climate forecast information has reached a mature stage but care must be taken in relation to scale issues – spatial but especially temporal (e.g., 3 month seasonal or intra-seasonal?)
• Useful to provide information on forecast skill to users but the key aspect will always be whether the SCF can fit the management options available to the user... if we miss this point the entire system can be seen by the user to fail..
• Seek out as many key decision-points as possible for a particular agricultural enterprise – ('keep going back for more') and aim to meet these points with completely relevant information...
• Decision-support systems (DSS) and tools are useful but often more valuable to the scientist than to the agriculturalist: the best application of DSS seems to be as a tool to be used within a broad discussion environment (small or large groups – workshops – even electronic media).
• Feed as much information as possible back to the climate/ocean modellers/forecast agencies (also good to have them all working together)
• Aim to give as much ‘ownership’ as possible of the climate forecast system to the user – create a sense of empowerment!
THANK YOU!
‘Climate pattern in transitional stage so I keep a watchful eye on the climate updates’

‘I take special interest in the sea surface temperatures (SST) particularly in the Niño 3 region’.

‘There is currently (2002) some indications of warming in the Niño 3 region which hints at a possible El Niño pattern’…..

- Decisions: Sugar-cane replant would be kept to a minimum
- Harvest drier areas earlier, even if CCS may be effected.

“We don’t run the farm based solely on climate information and forecasts, it’s just another tool to consider when making decisions”.
Probability of exceeding Median Rainfall

August / October based on consistently negative phase during June / July