Managing Climate Risks in Cotton Systems – Beyond El Niño

Holger Meinke, Roger Stone, Peter deVoil, Brendan Power and Alexis Donald
Department of Primary Industries and Fisheries, PO Box 102, Toowoomba, Qld, 4350
Tel: 07 - 4688 1378, Holger.Meinke@dpi.qld.gov.au

Abstract

Cotton growers need to make weather or climate related management decision all the time. Although we have some scientific basis to forecast the season ahead, most cotton growers make only limited use of our current understanding of climate variability, seasonal predictability and projected future climate trends. Primary producers in Queensland and NSW are familiar with ENSO (El Niño – Southern Oscillation) based seasonal climate forecasts. Close interaction with the cotton industry has revealed that frequently the key issue is not the question 'how reliable are these forecasts?' but rather 'how can I use this information to improve overall risk management and hence my economic and environmental performance?' This important distinction highlights that the bottleneck for climate risk management is not necessarily our understanding of climatic phenomena and their degree of predictability, but rather a lack of knowledge and understanding about how to transform this information into 'actionable climate knowledge'.

Nevertheless, SOI-based seasonal forecasts are issued routinely by various agencies and used by growers in their management. Particularly in conjunction with knowledge about the current and potential amounts of stored soil moisture, SOI-based forecasts now help to determine planting times, area planted, target yields for resource allocation and on-farm water management. Although ENSO is the single most important factor influencing our climate, it is not the only driver of climate variability.

For instance, recent advances in forecasting timing and impact of the Madden-Julian Oscillation (MJO, colloquially know as '40 day wave') as well as new knowledge and understanding of climate change impacts can further improve tactical and strategic decision-making in our highly variable climates. This new knowledge supplements the already existing seasonal forecasting capabilities based on the SOI and the ENSO phenomenon.

Introduction

Rainfall variability is one of the most important factors determining variability in agricultural systems performance, including cotton-based cropping systems. This variability can result in substantial economic losses, but also in considerable environmental degradation particularly when combined with inappropriate management strategies (Hammer et al., 2000; Allan, 2000; Meinke et al., 2003). Understanding rainfall variability is therefore essential for appropriate agricultural risk management. Climate science can provide insights into climatic processes while agricultural systems

science can translate these insights into management options and quantify the likely outcomes of alternative decisions. To ensure optimal societal benefits, this approach must simultaneously influence policy formulation and operational risk management (Meinke and Stone, 2004).

Research and experience over recent decades has shown that the El Niño - Southern Oscillation phenomenon (ENSO) plays a critical role in partially explaining rainfall variability in many countries, including Australia. However, ENSO is not the only source of rainfall variability - climate variability occurs over a wide range of temporal scales and impacts differs from region to region. In addition to ENSO and an inherently unpredictable chaotic component there are a range of other climate phenomena varying at a wide range of time scales that determine what manifests itself as 'climate variability'. In Australia, effort is being directed towards investigating high frequency phenomena such as the Madden-Julian Oscillation (MJO; 30-60 days; Madden and Julian, 1972), to ENSO related information (eg. SOI or SST based forecasting systems; 2.5-8 years) and to low frequency phenomena such as decadal and multidecadal climate variability and climate change (eg. Howden et al., 2002; Meinke and Stone, 2004; Meinke et al., 2004). Our increasing understanding of the underlaying mechanisms means that some of that variability is now predictable.

At the highest frequency, the MJO involves variations in wind, sea surface temperature, cloudiness and rainfall that occur regularly every 30 to 50 days. Although the MJO is a strictly tropical phenomenon (Madden and Julian, 1972), it can, via *teleconnections*[1], influence rain events over large parts of Australia, India and the Maritime Continent. The MJO consists of cloud clusters that originate in the Indian Ocean and move eastward with speeds of 5 to 10 ms^{-1}.

On the other hand, climate change is already impacting on our production systems with profound consequences on the strategic management of farming enterprises, including production and sustainability issues. None of these climate phenomena are totally independent of ENSO and on-going research is trying to unravel any connections. We already know that although the MJO is most active and predictable during summer, most of our winter rain, particularly in El Niño years, is associated with the active phase of the MJO. Likewise, climate change is already with us (and has been for many years), with concerns that this might lead to a more 'El Niño-like mean state' of our climate system.

While ENSO-based climate information has proven useful for growers to prepare for the season ahead, some tactical crop management decisions such as planting, spraying and harvesting require better temporal resolutions, while some of the more strategic investment decisions such as major infrastructure developments require assessments of climatic conditions for the next few decades.

---

[1] *Teleconnection* is the term used for energy transfer within the broad ocean/atmosphere system. It is a 'communication mechanism' by which usually independent weather and climate phenomena can influence each other.

The challenge is to use this climate knowledge operationally to achieve two key outcomes:

1) risk management strategies at the farm level that increase profits and efficiencies, reduce vulnerability of rural businesses and minimise negative environmental impacts
2) well-informed rural policy making that supports multi-goal objectives resulting in rapid and substantial societal benefits.

Tactical risk management and the Madden-Julian Oscillation (MJO)

The MJO is a large-scale, tropical atmospheric anomaly that originates in the Indian Ocean, propagating eastward at intervals between 30 to 60 days (Madden and Julian, 1972; Wheeler and Weickmann, 2001). The MJO sits at the interface between synoptic weather forecasting (up to 10 days but with less skill after 5 days) and seasonal, ENSO-based climate forecasting (3-monthly or seasonal forecasting). MJO events are often associated with rainfall events and low maximum temperatures in many parts of Australia. They also influence the onset and break activity of the Asian–Australian monsoon system. Recently, we have shown that the MJO's indirect impact extends well into subtropical and even temperate regions via yet to be quantified teleconnections, as evident in large-scale, causally linked synoptic patterns. For instance, the first passage of the MJO in 2004 (early February) was associated with substantial, 'drought-breaking' rain and negative maximum temperature anomalies to most of Queensland and parts of Northern NSW (Fig. 1). Occasionally, the 'ripple effects' of these events appear to reach as far south as Tasmania.

The ability to forecast such events at sub-seasonal timescale would significantly improve tactical climate risk management by influencing decisions in relation to (eg.) sowing opportunity prediction, pest and disease management, harvest scheduling, irrigation scheduling, product quality management and marketing. Forecasting the timing of MJO events and associated weather impacts across Australia would allow better planning of key tactical decisions for a wide range of agricultural industries. Specifically within cotton systems there are several key decisions where knowledge of the next passage of the MJO could be critically important: MJO events are not only characterised by an increased likelihood of rain, but also by associated low maximum temperature anomalies. Given cotton's sensitivity to low temperatures shortly after emergence this appears to be a phenomenon that should be taken into account when deciding when to plant how much. Further, given the regularity of the event particularly during the summer months, crop management decisions such as spraying and harvesting can be affected by this type of information. GRDC/CRDC funded research has established the basis for such a capability that now needs to be operationalised.

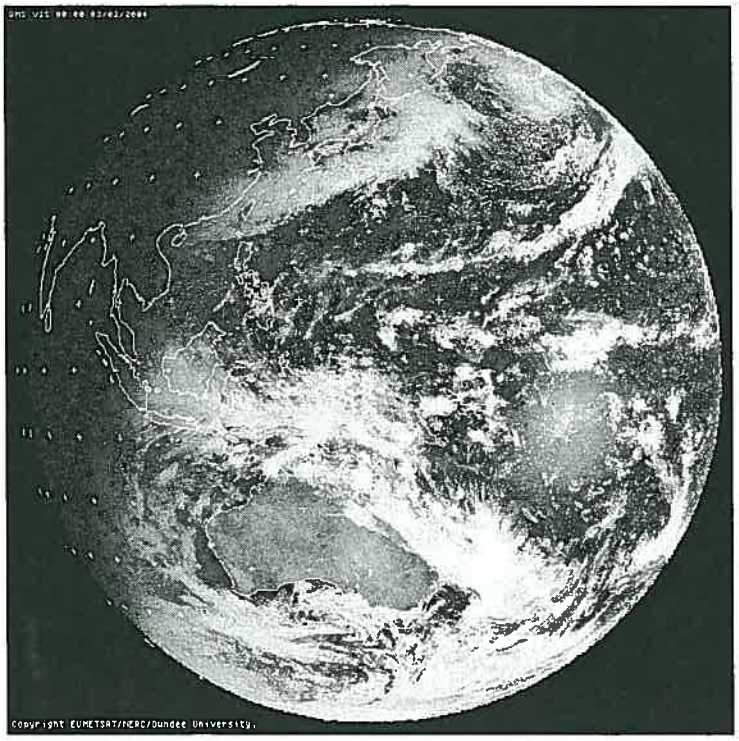

Figure 1. Satellite image (taken on 2 February 2004) of MJO-associated convection in the tropics and associated higher latitude instability over Eastern Australia. This event brought substantial, 'drought-breaking' rain to Queensland and Northern NSW.

Climate Variability and Climate Change

At the other end of the temporal spectrum, research clearly shows that long-term climate change is already impacting on our production systems (eg. Howden et al., 2003). A full systems analysis of likely climate change impacts for cotton growers has, to our knowledge, not yet been conducted. The most compelling evidence of climate change impacts are increases in minimum winter temperatures across many parts of the world. However, there is increasing evidence of broader climate change impacts, with some studies indicating more El Niño-like conditions occurring with subsequent impacts on rainfall and hence production. In some parts of Australia increases in minimum temperatures have already significantly reduced the frost risk for wheat (Howden et al., 2003). Here we show the consequences of the undisputed changes in minimum temperatures mean for the wheat industry in 3 different Queensland locations (Fig. 2).

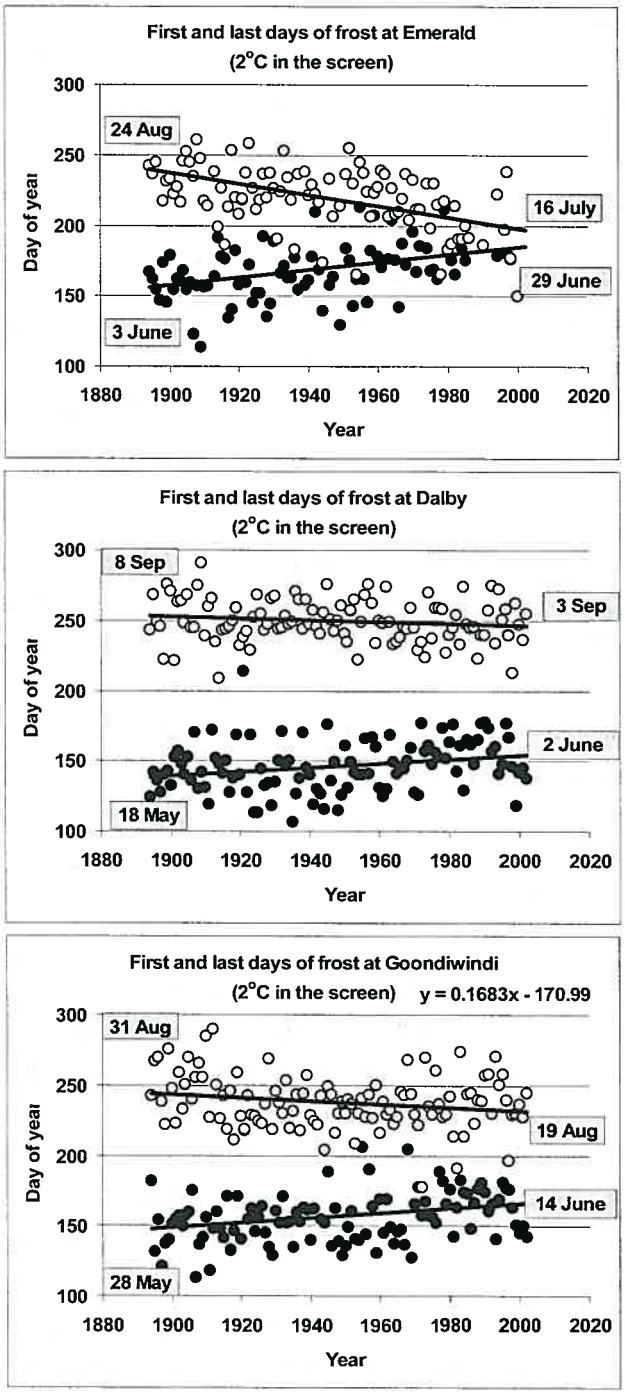

Figure 2. Changes in the dates of first and last frost at Emerald, Dalby and Goondiwindi during the last century (expressed as a screen temperature of 2°C or lower).

In Central Queensland (Emerald) the frost risk period has been reduced from approximately 80 days at the end of the 19th century to about 20 days today. However, the effects are not uniform and

detailed climatic analyses need to be conducted on a regional basis. At Dalby and Goondiwindi, for instance, the trends are similar but much less pronounced than at Emerald (Fig. 2). Generally, wheat is now sown earlier and maturity types have been adapted accordingly, compared to several decades ago. This shows that in some agricultural systems we are already seeing a degree of autonomous adaptation (reactive adaptation) to climate change. Good risk management suggests that this autonomous adaptation needs to be supplemented by planned, proactive adaptation. This requires policy frameworks that encourage and promote such proactive risk management strategies and farm managers who are aware of these impacts and are willing to adapt. Proactive adaptation (eg. initiating selection for varieties suited to future climates and CO_2 levels; changes to cropping systems management etc.) will be necessary to complement climate change mitigation efforts.

References:

Allan, R.J. 2000 In: *El Niño and the Southern Oscillation: Multiscale variability and its impacts on natural ecosystems and society*, (eds Diaz, H.F., Markgraf, V.) Cambridge Univ. Press, Cambridge, UK, pp 3-55.

Hammer, G.L. 2000 In: *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems – The Australian Experience* (eds Hammer, G.L., Nicholls, N., Mitchell) Kluwer Academic, The Netherlands 2000, pp 51-65.

Howden, M. et al. 2002 An overview of the adaptive capacity of the Australian agricultural sector to climate change – options, costs and benefits. Major Report commissioned by the Australian Greenhouse Office (AGO), 157pp.

Howden, S.M., Meinke, H., Power, B. and McKeon, G.M 2003 Risk management of wheat in a non-stationary climate: frost in Central Queensland. Post, D.A. (ed.) Integrative modelling of biophysical, social and economic systems for resource management solutions. Proceedings of the International Congress on Modelling and Simulation, July 2003, Townsville, Australia, pp 17-22.

Madden, R.A. and Julian, P.R. 1972 Description of Global-Scale Circulation Cells in the Tropics with a 40-50 Day Period J. Atmos. Sc. 29, 1109-1123.

Meinke, H. and Stone, R.C. 2004 Seasonal and inter-annual climate forecasting: the new tool for increasing preparedness to climate variability and change in agricultural planning and operations *Climatic Change* in press.

Meinke, H., deVoil, P., Hammer, G.L., Power, S., Allan, R., Stone, R.C., Folland, C. and Potgieter, A. 2004 Rainfall variability at decadal and longer time scales: signal or noise? J. Climate, in press.

Meinke, H., Wright, W., Hayman, P. & Stephens, D. 2003 In: *Principles of field crop production.* (ed Pratley, J.) Fourth Edition. Oxford Univ. Press, Melbourne, Australia, pp 26-77.

Wheeler, M. and Weickmann 2001 Real time monitoring and prediction if modes of coherent synoptic to intra-seasonal tropical variability Monthly Weather Review 129: 2677-2694