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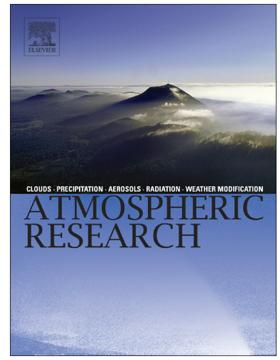

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Skilful Rainfall Forecasts from Artificial Neural Networks with Long Duration Series and Single-Month Optimization

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Abstract

General circulation models, which forecast by first modelling actual conditions in the atmosphere and ocean, are used extensively for monthly rainfall forecasting. We show how more skilful monthly and seasonal rainfall forecasts can be achieved through the mining of historical climate data using artificial neural networks (ANNs). This technique is demonstrated for two agricultural regions of Australia: the wheat belt of Western Australia and the sugar growing region of coastal Queensland. The most skilful monthly rainfall forecasts measured in terms of Ideal Point Error (IPE), and a score relative to climatology, are consistently achieved through the use of ANNs optimized for each month individually, and also by choosing to input longer historical series of climate indices. Using the longer series restricts the number of climate indices that can be used.

1. Introduction

Two very different approaches exist for medium-term rainfall forecasting: general circulation modelling (GCMs) (Hawthorne et al, 2013; Schepen et al, 2014) and statistical modelling (Fawcett and Stone, 2010) – including with artificial neural networks (ANNs). Statistical models typically use a set of lagged-input variables, and of particular importance are climate indices (Risbey, 2009). These are provided as input, together with historical temperature and rainfall data to compute a desired output - in this study monthly rainfall at 3 and 12 month lead-times for two important agricultural regions of Australia with very different rainfall patterns.

Wheat is a major crop in Western Australia, with 11–13 million hectares planted annually, approximately 40% of this in south-west Western Australia. Aside from soil fertility and other agronomic considerations, the major constraints on production are meteorological and climatological (Anderson et al., 2005; Anderson, 2010; Sharma et al., 2008; Zhang et al., 2010). Soil moisture profile at the time of planting influences crop success (French and Schultz, 1984), which in turn is influenced by rainfall during the summer-autumn fallow period. Water availability during the growing period is the most critical factor affecting crop yields (French and Schultz, 1984). The timing of the arrival of adequate autumn rains for sowing is a key factor in the crop establishment phase (Pook et al, 2009). In particular, the timing of rainfall events in relation to crop requirements is regarded as more important than the total rainfall received during the crop life-cycle (Pook et al., 2012; Pook et al., 2009).

Sugarcane is an important agricultural crop on the east coast of Australia, cultivated in a coastal region extending from northern Queensland into northern New South Wales. The timing and amount of rainfall is critical in determining both the yield of sugar, and scheduling of harvesting operations (Skocaj and Everingham, 2014; Du et al., 2010; Valade et al., 2014). In Australia, water stress is estimated to cost the sugar industry AUS$260 million per annum in lost production (Inman-Bamber et al., 2012). Skocaj and Everingham (2014) investigated the impact of variables on sugar yields for the Tully region in the wet tropics of Queensland, reporting that spring and summer rainfall were the most important determinants. The optimal time of cane harvesting to achieve maximum yield is influenced