Historical trends in rainfall and temperature in Queensland's mixed farming zone

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Abstract
In this study an analysis of historical long-term (1910-2010) trends in rainfall and temperature parameters impacting on crop and pasture productivity was undertaken for 15 regional centres in Queensland's mixed farming zone. The climate parameters analysed were; mean annual rainfall, seasonal rainfall (summer, autumn, winter, spring), daily rainfall with 40 mm or more (relating to likely damaging rainfall events), mean maximum temperature, daily maximum temperature 35°C or higher (relating to likely heat stress events), mean minimum temperature, daily minimum temperature 3°C or less (relating to likely frost events). The mean annual rainfall showed a decreasing trend at 4 centres, and remaining centres recorded either no change (7 centres) or increases in rainfall (4 centres). Seasonal rainfall analysis indicated that the majority of centres have a decreasing rainfall trend in autumn and winter, but increasing trend for spring rainfall. In particular, the centres in the south west part of the region (Goondiwindi, Meandarra, St George and Roma) showed increases in rainfall during summer and spring with decreasing number of heat stress days. In contrast, centres in the southeast (Gatton, Toowoomba, Pittsworth, Dalby) and central (Rockhampton) parts of the region showed an increasing number of heat stress days. The mean minimum temperature has been generally increased at all centres. This was further reflected in a reduction in the number of days with daily minimum temperature 3°C or below (at most centres). Implications for crop and pasture production are discussed.

Key words: Historical climate trend, rainfall, temperature, Queensland mixed farming zone

Introduction

The mixed farming production systems (crop/pasture/livestock) are likely to be under pressure due to the current changes and future projections of climate change in Australia and Queensland as highlighted through various reports and publications (Howden et al. 2008; Crimp et al. 2010; Howden et al. 2010). Modelling of various scenarios with elevated CO_2 has resulted in projections of increased temperature, enhanced evaporation, frequent drying and reductions in rainfall in Australia and Queensland (CSIRO and BOM various reports). Future projections of temperature increases (Queensland: 1.0-2.2 °C by 2050) anticipate 'likely' to 'very likely' decreases in crop/pasture/livestock production due to frequent extreme temperatures and severe drought events.

It is now the top priority at various levels involving individuals, agencies and governments to assess, develop and educate various adaption strategies while considering likely adverse impact of climate change on crop/pasture/livestock production systems in Queensland's mixed farming (QMF) zone. Many reports have been published and workshops conducted to educate primary producers in Queensland regarding the adverse impact of future climate change and likely adaptation strategies. However, there has been reluctance among primary producers to accept the looming scenarios of adverse impacts on their production systems. Furthermore, many producers claim that suggested adaptation strategies for future 'climate change' as published in many reports and deliberated in workshops are not new as they have already been using these strategies to combat short- to medium-term 'climate variability'. Producers also claim that they have experienced many cycles of droughts and floods and heat stress and cold shocks over the last few decades. Producers' reluctance and claims warranted a close examination of current and past climate variability/change and likely impact on the production systems in the future.

Methods

In this study we looked firstly at the long-term (1910-2010) changes in annual and seasonal rainfall, and maximum and minimum temperatures from weather data available from SILO (DERM, Longpaddock). The long-term trend of these parameter were analysed while using 15 years moving average for 15 regional

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centres in the QMF zone, involving southeast region (Gatton, Toowoomba, Pittsworth, Dalby, Condamine and Miles), southwest region (Goondiwindi, Meandarra, St George, Roma and Taroom), and central region (Emerald, Biloela, Clermont and Rockhampton). Secondly, the long-term weather data were also used to examine the pattern of extreme temperatures (causing likely heat stress or frost) and episodic rainfall events at these regional centres. Heat shocks from temperatures 35°C or above, and cold shocks and/or frosts from temperatures 3°C or below can adversely impact the crop/pasture growth and yield. Similarly, the daily rainfall event with 40 mm or more would likely to increase the runoff and soil erosion and could be significantly damaging to the standing crops, particularly at the time of harvesting. The number of extreme events was calculated from long-term weather data by using 'R' and 'APSIM' modelling capability.

Results

The long-term trends (15 years moving average over 1910-2010) in annual rainfall, number of days with daily rainfall > 40 mm (episodic rainfall events), number of days with max temp > 35 °C (heat stress), and number of days with min temp <3 (frost or cold shock) are given for Roma (representing southwest region), Dalby (representing southeast region) and Emerald (representing central region) in the Figures 1-3. Summary of these parameters for all the 15 regional centres are presented in the Table 1 and 2.

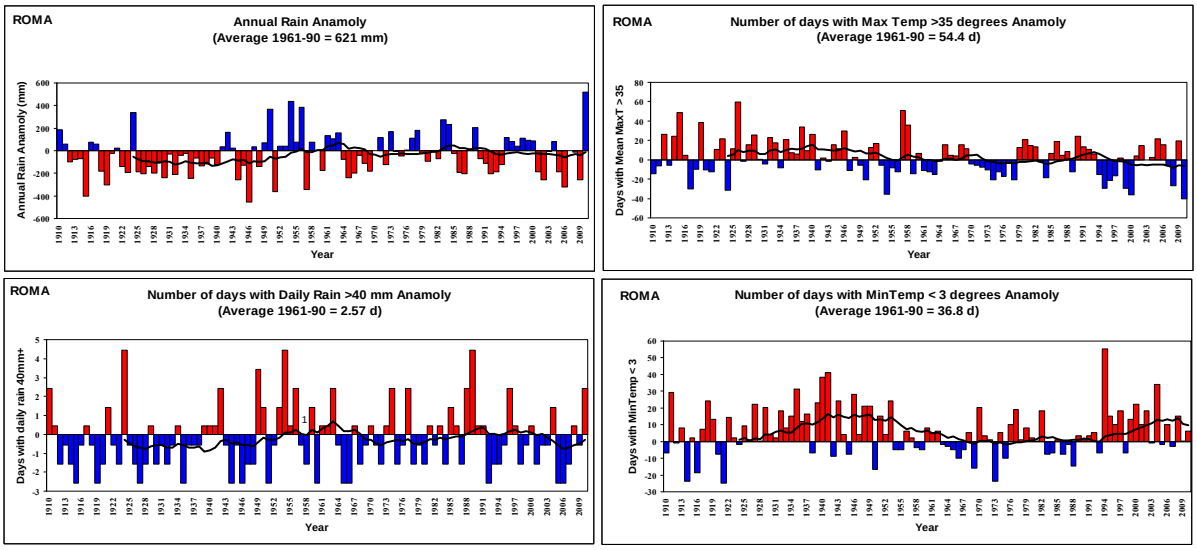

Figure 1. The long-term trends in annual rainfall, days with daily rainfall more than 40mm, and days with maximum temperature more than 35 °C or less than 3 °C for Roma.

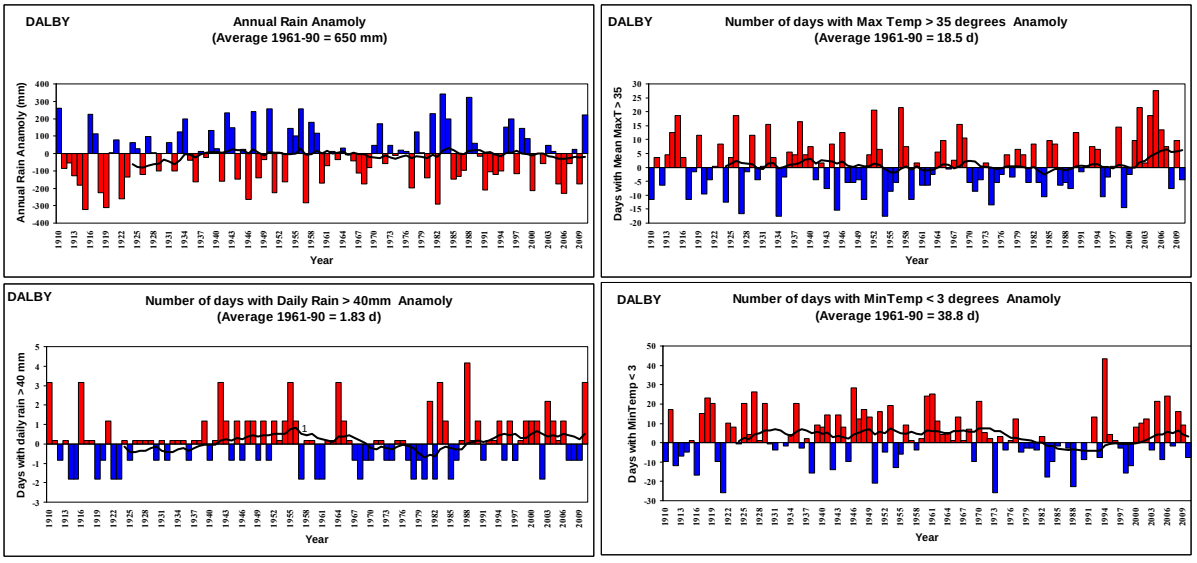

Figure 2. The long-term trends in annual rainfall, days with daily rainfall more than 40mm, and days with maximum temperature more than 35 °C or less than 3 °C for Dalby.

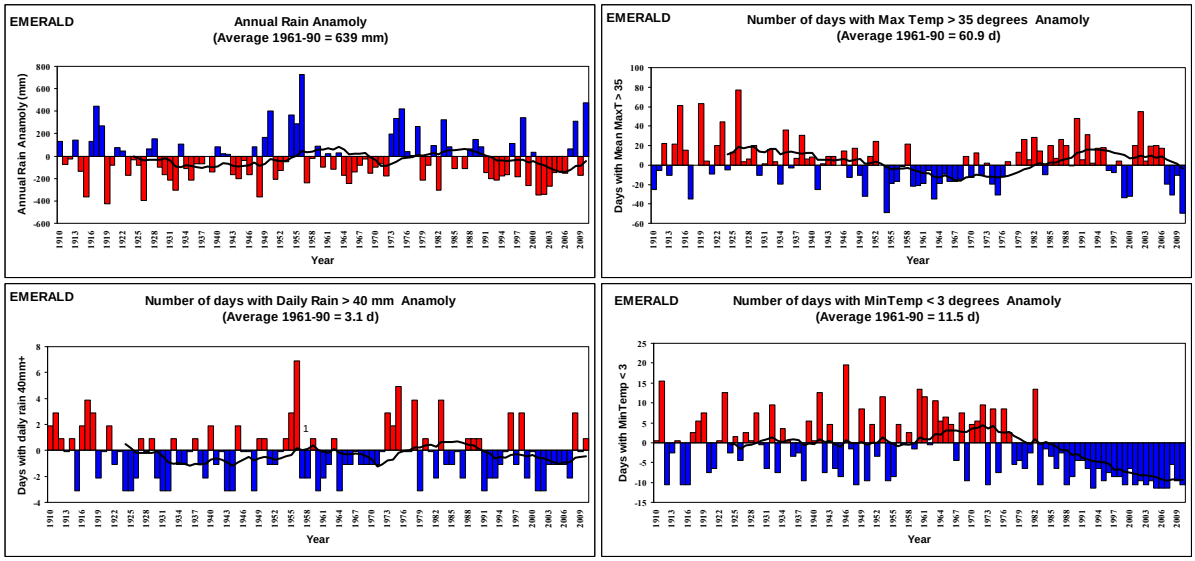

Figure 3. The long-term trends in selected climatic parameters for Emerald

Table 1. Summary of mean annual and seasonal rainfall (averages of 1961-1990). Historical trends based on 15 years of moving averages over 1910-2010 period, whether increasing (I), decreasing (D) or with no change (NC) are also given in the parenthesis.

Regional centres	Annual (mm)	Summer (mm)	Autumn (mm)	Winter (mm)	Spring (mm)
Gatton	864 (NC)	320 (NC)	211 (D)	133 (D)	200 (NC)
Toowoomba	1003 (D)	380 (D)	231 (D)	165 (D)	227 (NC)
Pittsworth	731 (NC)	265 (NC)	159 (NC)	124 (D)	183 (I)
Dalby	650 (NC)	237 (NC)	140 (D)	103 (D)	169 (I)
Miles	668 (NC)	261 (NC)	146 (NC)	108 (D)	152 (NC)
Goondiwindi	606 (I)	202 (I)	145 (NC)	104 (NC)	152 (I)
Meandarra	597 (I)	197 (I)	145 (NC)	101 (D)	153 (I)
St George	543 (I)	190 (I)	137 (D)	89 (NC)	119 (I)
Condamine	693 (NC)	263 (NC)	152 (NC)	112 (D)	165 (NC)
Roma	621 (I)	225 (I)	145 (NC)	106 (NC)	149 (I)
Taroom	679 (NC)	272 (NC)	147 (D)	97 (NC)	163 (NC)
Emerald	639 (NC)	294 (NC)	154 (D)	72 (NC)	117 (NC)
Clermont	656 (D)	306 (D)	165 (D)	70 (D)	115 (I)
Biloela	676 (D)	283 (D)	138 (D)	88 (D)	165 (I)
Rockhampton	621 (D)	368 (D)	219 (D)	98 (D)	151 (I)

Table 2. Summary of mean number of days with ≥ 40 mm rainfall, ≥ 35 °C temperature, and ≤ 3 °C temperature (averages of 1961-1990). Historical trends based on 15 years of moving averages over 1910-2010 period, whether increasing (I), decreasing (D) or with no change (NC) are also given in the parenthesis.

Regional centres	Number of days with 40 mm or more daily rainfall	Number of days with 35 °C or higher temperature	Number of days with 3 °C or lower temperature
Gatton	3.7 (NC)	15.5 (I)	14.7 (D)
Toowoomba	4.3 (D)	2.7 (I)	23.9 (D)
Pittsworth	2.7 (NC)	5.7 (I)	48.4 (NC)
Dalby	1.8 (I)	18.5 (I)	38.8(NC)
Miles	2.8 (NC)	28.7 (D)	48.1 (D)
Goondiwindi	1.4 (NC)	36.9 (D)	30.5 (NC)
Meandarra	1.9 (I)	37.4 (D)	41.2 (D)
St George	2.0 (NC)	54.9 (D)	20.6 (NC)
Condamine	3.0 (NC)	14.1 (NC)	47.8 (D)
Roma	2.6 (NC)	54.4 (D)	36.8 (NC)
Taroom	3.1 (NC)	40.2 (NC)	32.2 (D)
Emerald	3.1 (NC)	60.9 (D)	11.5 (D)
Clermont	3.5 (D)	52.6 (NC)	15.2 (D)
Biloela	3.2 (NC)	26.8 (NC)	25.5 (D)
Rockhampton	4.4 (D)	15.1 (I)	3.0 (D)

The 15 year moving average visually indicates that the mean annual rainfall in Roma has increased slightly in recent decades (1960-2010) compared with the previous ones (1910-1950) (Fig. 1). This was reflected in the decreasing number of heat stress days while comparing the same decades (Fig. 1). The number of days with minimum temp < 3 °C appears to be increased from 1990 to 2010 compared with 1960 to 1990, indicating more days with likely cold shocks or frost in recent decades for Roma. Dalby, in contrast to Roma, had visually no change in mean annual rainfall, and had increasing number of heat stress days and episodic rainfall events, but with no change in number of frosty days (Fig. 2). Emerald appears to have slight decrease in the mean annual rainfall, decrease in the number of heat stress days, and significantly lesser frosty days in recent decades (Fig. 3). There was no consistency in the pattern of changes in rainfall and temperature stress for these three regional centres. When these visual trends were analysed for all 15 centres, the historical trends over the last 100 years (1910-2010) indicated that most centres (9-10/15) have been experiencing a decreasing rainfall trend during autumn and winter (Table 1). In contrast, rainfall has been increasing during spring for various regional centres (10/15). During summer the trend in rainfall is almost equally distributed with 7 centres showing no change, 4 centres with increases and 4 centres with decreases in rainfall. The southwest region (involving Goondiwindi, Meandarra, St George and Roma) showincreases in rainfall during summer and springwhereas the central region (involving Clermont, Biloela and Rockhampton) has shown decreases in the rainfall during summer. The southeast region involving Gatton, Pittsworth, Dalby and Miles has shown no change in the summer rainfall. On an average, the trend in the mean annual rainfall has been either no change (7 centres) or increases (4 centres) or decreases (4 centres), similar to the trend for the summer rainfall (Table 1). The number of days with daily rainfall 40 mm or more (indicating likely episodic/damaging rainfall event) are between 1.4 (Goondiwindi) and 4.4 (Rockhampton). The trend over the historical period 1910-2010 indicates that this parameter has not changed over the years for the 10 centres, whereas 3 centres indicated a decreasing trend and only 2 centres (Dalby and Meandarra) with an increasing trend. The mean number of days with 35°C or higher temperature (indicating likely heat stress event) varied between 2.7 (Toowoomba) and 60.9 (Emerald). Mostly, the southeast region (Gatton, Toowoomba, Pittsworth, Dalby) and Rockhampton in the central region indicated increasing number of heat stress days. The southwest region (Goondiwindi, Meandarra, St George and Roma) indicates decreasing number of heat stress days. Changes in the mean number of days with 3°C or less minimum temperature indicating increasing frost risk has been wide with 10 centres showing decreases, and 5 centres with no change. Pittsworth, Miles and Condamine have recorded the maximum number of days (around 48) with likelihood of frost, whereas the central region (Emerald, Clermont, Biloela and Rockhampton) have the least number of days with frost, between 3 and 26 days.

Conclusion

Historical trends in various climatic parameters have indicated significant variability from centre to centre in the QMF zone, except that minimum temperature has increased significantly for all centres (data not presented). Southwest centres appear to have minimum adverse impact of current climate change, whereas southwest centres had an increasing number of heat stress days. The risk of cold shocks or frosts has decreased for most centres. The current climate change appears to be favourable to crop and pasture production, and adaptation of current best management practices is the best bet for the QMF zone. In this context, Singh (2010) reported increased cereal crop productivity over the last two decades for Queensland. However, expected further increases in maximum and minimum temperatures and likely reductions in rainfall in future certainly emphasises continued staged investments in development, education and implementation of various adaptation strategies.

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