CHANGES IN CLIMATE EXTREMES IN AUSTRALIA, ASIA-PACIFIC AND THE SOUTHERN HEMISPHERE

Dean Collins*, Michael Coughlan, David Jones and Blair Trewin
Bureau of Meteorology, Melbourne, Australia

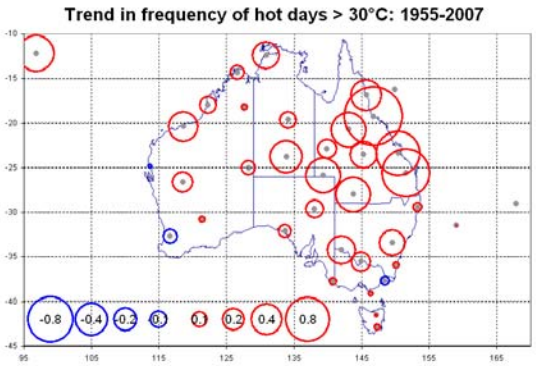
1. INTRODUCTION

Impacts from more frequent or intense climate extremes provide the potential "sting in the tail" of anthropogenic climate change. Consequently, the monitoring of climate extremes has increased dramatically over the past decade. Significant effort has been undertaken to define standard indices of extreme climate and rehabilitate historical datasets to the standard required for the analysis of reliable trends in extremes.

2. CHANGES IN AUSTRALIA

2.1 Daily temperature extremes

In Australia, changes in the frequency and intensity of extreme temperature events have tended to reflect the general warming observed through most of Australia since the mid-20th Century. The frequency of hot days has mostly increased (Fig. 1, top), with the strongest increases in the northeast. The frequency of warm nights has increased across the north (Fig. 1, bottom), while changes in frost frequency (nights below 0°C) across the south are weak and mixed (Fig. 2).



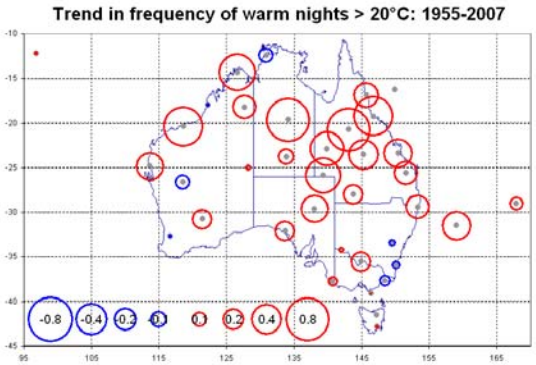


Figure 1. 1955-2007 trends (per year) in annual frequency of (top) hot days (maximum temperature > 35°C) and (bottom) warm nights (minimum temperature > 20°C).

* *Corresponding author address:* Dean Collins, Bureau of Meteorology, GPO Box 1289, Melbourne, VIC 3001, Australia; e-mail: D.Collins@bom.gov.au

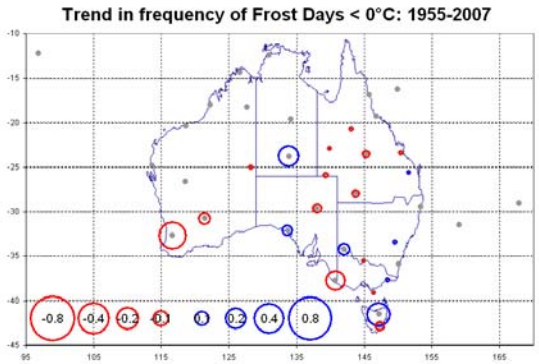


Figure 2. 1955-2007 trends (per year) in annual frequency of frost days (minimum temperature < 0°C).

Most regions show increases in the highest and lowest daytime and night-time temperatures of the year since the mid-1950s, with the rise in the lowest daytime temperature being most coherent (Fig 3). Most regions also show an increase in the duration of warm spells and a decline in the duration of cold spells.

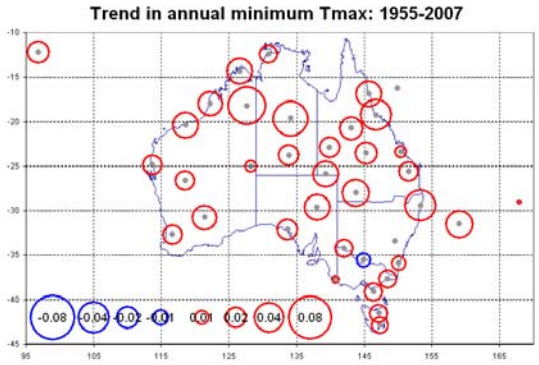


Figure 3. 1955-2007 trends (°C/year) in value of lowest daily maximum temperature of the year.

2.2 Rainfall extremes

Strong declines in total rainfall are evident across southern and eastern Australia over the past half-century, with marked increases in the northwest. Changes in the frequency of very wet days (Fig. 4, top) generally mirror these changes in total rainfall. A simple index of daily intensity (Fig. 4, bottom) also follows this east-west contrast. Overall, extreme rainfall indices tend to provide little evidence that daily rainfall has become more extreme in Australia, except in regions where total rainfall has increased.

In Australia, the dry periods of the 21st century have been accompanied by warmer temperatures than similar periods of rainfall deficiency in the past, suggesting that the impacts of droughts are becoming exacerbated by higher temperatures

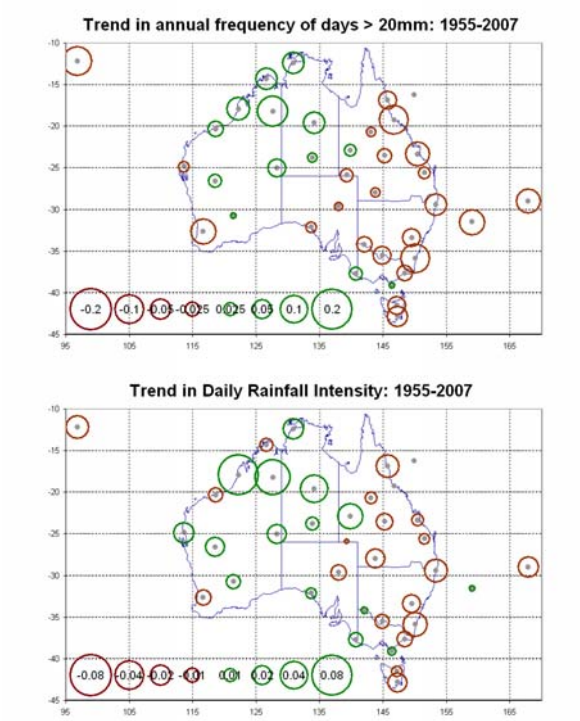


Figure 4. 1955-2007 trends (per year) in (top) annual frequency of heavy rain days (daily total > 20 mm) and (bottom) daily rainfall intensity (total rain / number of rain days).

2.3 Other extremes

The total number of tropical cyclones (TCs) in the Australian region (south of equator; 105-160°E) shows a decline since the early 1970s, with a possible increase in the proportion of severe TCs (minimum central pressure less than 970 hPa) (Fig. 5). However, it is difficult to assess the significance of these trends due to the short period of record, with only very limited satellite and radar coverage prior to 1970, and analyses broadly comparable to current analyses only becoming available from the mid-1980s. The overall decrease may partly be due to improved discrimination between TCs and tropical lows.

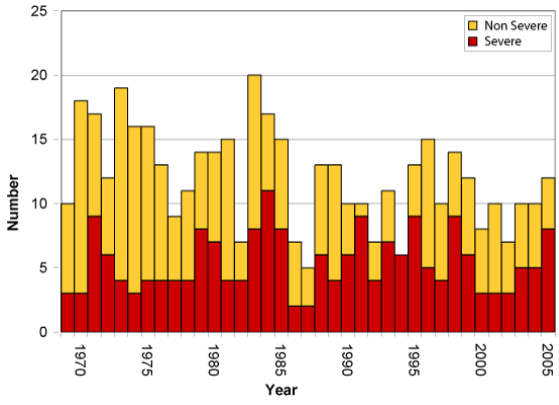


Figure 5. Number of severe and non-severe tropical cyclones in Australian region, 1970-2005. From: http://www.bom.gov.au/weather/cyclone/tc-trends.shtml

The study of changes in other climate extremes has been limited in Australia. There is no evidence to suggest significant trends in such extreme weather events as severe thunderstorms, tornadoes, damaging hail events, and damaging wind gusts. However, studies of long-term changes in such extreme weather phenomena are hampered by the quality and subjectivity of historical records.

3. CHANGES IN THE ASIA-PACIFIC

International collaboration on the definition of a standard set of indices has allowed ongoing global monitoring of climate extremes. Workshops examining changes in extremes have now been held in several regions of the globe (Peterson and Manton, 2008). Such workshops have greatly improved the understanding of changes in extremes by allowing cross-border exchange of data and analyses based on common definitions, data formats and methodologies.

Results from a series of extremes workshops for the Asia-Pacific region (e.g. Manton et al. 2001, Griffiths et al. 2005) indicate that changes in the frequency of temperature extremes are generally consistent with a warming world. The most recent analyses of percentile-based extreme temperature indices demonstrate that at most locations the frequency of cool nights and days has significantly decreased, while the frequency of warm nights and days (Fig. 6) has increased (Choi et al. 2009).

Changes in indices of extreme rainfall across the Asia-Pacific region are mixed, with few locations showing significant changes in extreme rainfall.

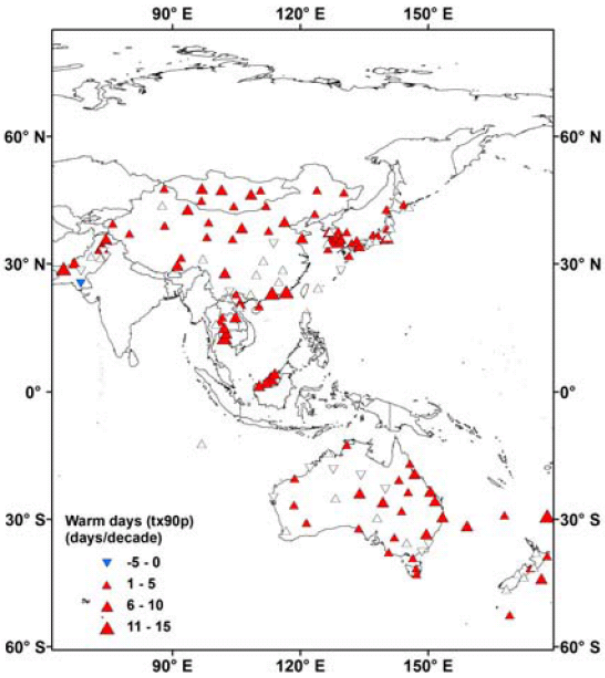


Figure 6. Trends (days/decade) in the frequency of warm days (maximum temperature > 90th percentile), 1955-2007. Filled symbols represent statistically significant trends (95% level) (Choi et al. 2009).

4. CHANGES IN THE SOUTHERN HEMISPHERE

By combining data from several regional studies, Alexander et al. (2006) provided the latest and most comprehensive analysis of global-scale changes in climate extremes. Due to the predominance of oceans and large data voids on all continents, these analyses are not as comprehensive in the Southern Hemisphere as for the Northern Hemisphere (Fig 7).

Where analyses have been possible in the Southern Hemisphere, results are generally similar to those elsewhere. There has been a general increase in the frequency of warm days and nights and a decline in the occurrence of cool days and nights, while changes in extreme rainfall are mixed, with coherent changes only at local and regional scales.

Vast data voids in the Southern Hemisphere highlight the need for improved data collection employing a variety of remote sensing techniques and autonomous observing platforms.

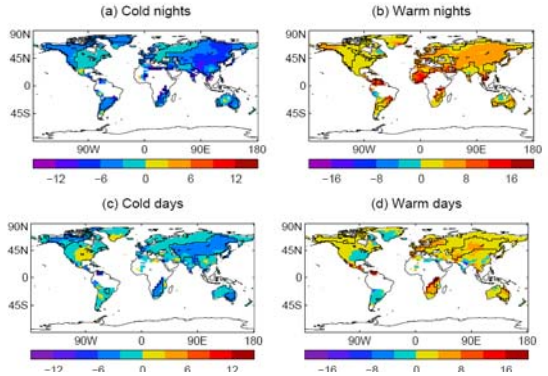


Figure 7. Trends (days/decade) in the frequency of (a) cold nights, (b) warm nights, (c) cold days and (d) warm days, 1951-2003 (Alexander et al. 2006).

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