On Australian Heat Waves:
Time Series Analysis of Extreme Temperature Events in Australia, 1950 - 2005

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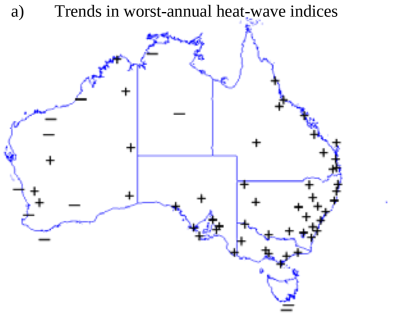
EXTENDED ABSTRACT

The occurrences of extreme weather, particularly heat-waves can often result in significant costs in terms of human health, damage to infrastructure, increased stress of natural ecosystems and reduced economic activity. In Australia, temperature extremes, producing intermittent heat-waves silently kill almost as many people as do any other natural disasters (Granger and Berechree 2005). While there appears to be no official definition, a heat-wave may be considered as a prolonged period of excessively hot conditions that usually lasts more than three consecutive days. This definition, which includes the combined effect of high temperatures and humidity is based on Stedman's (1979) approach and allows us to compute the relevant heat wave index to assess the severity of heat-related events.

This paper presents a statistical analysis of daily maximum temperatures and humidity records for selected Australian cities and rural stations, with a focus on the trends of Australian heat waves since 1950. The two datasets were used to extract the time series of "maximum apparent body temperatures" (also referred to as the yearly-worst heat wave indices) in order to quantify the trends, spatial distribution and statistical significance over the continent. The Mann-Kendall's (MK) non-parametric test and Sen's slope estimation techniques were used to quantify the overall statistical significance of the results.

Figure 1(a) shows the trends in occurrence (number of) worst-annual-3-day heat wave indices between the period 1950-2005, with + sign showing increasing and – signs showing decreasing trends. Overall, results show that there is increasing trend of three-day worst-annual heat index over the entire period. The trend is most pronounced over eastern Australia, where most of the time-series shows a monotonic increase. Results also suggest that western and northern Australia experienced a decreasing trend of worst annual heat wave incidences over the study period.

a) Trends in worst-annual heat-wave indices



b) Significance of trends at 95% Mann-Kendall's Test

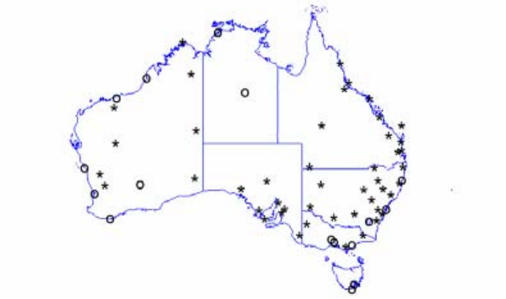


Figure 1 a): Trends of worst annual heat indices, b): statistical significance of trends at 95% confidence interval using Mann-Kendall's test.
\+ increasing trend - decreasing trend
0 insignificant * significant

Figure 1(b) plots the spatial patterns of statistically significant/insignificant regions, tested at the 95% confidence interval using MK statistical procedure. Results confirm spatially coherent patterns of statically significant increases in the severity of heat waves. These were mostly confined to the eastern and southwestern regions. Hence we conclude that heat wave occurrences have become statistically more significant in eastern Australia and South Australia since the 1950s.

1.0 INTRODUCTION

Human activities, leading to an increase in the atmospheric concentrations of CO_2 and land use and land cover change pressures are producing a net radiative forcing of $\approx 1.66 \pm 0.17$ Wm^{-2} (*IPCC* 2007) on our natural climate system. This is impacting the globally averaged land surface temperatures, which have increased markedly over the last century. According to 4th Assessment Report (*AR*) of IPCC, the recent updated 100-yr (1906-2005) temperature trend shows an average warming of 0.74°C ± 0.18°C compared to 0.6°C ± 0.2°C warming trend over the period 1901–2000 in the 3rd *AR*. This significant increase in warming is particularly attributable to the contributions of additional warm years over the last five-ten years. For the Australian continent, anthropogenically driven warming is expected to increase surface temperature between 0.4-2ºC by 2030 and 1-6ºC by 2070 (National Biodiversity and Climate Change Action Plan, 2004). This warming, coupled with enhanced rainfall deficiencies over the continent is likely to increase the frequency of extreme weather all across Australia (Alexander et al. 2006).

The term "extreme conditions" refers to the infrequent events at the very high or the very low end of the range of values of a particular climate variable. A small change in the average value can produce a much larger impact on the frequency and intensity of climate extremes (Katz and Brown 1992; Hennessy and Pittock 1995). Such changes are likely to have detrimental impacts, particularly on the biosphere and society. Historical records show that extremely high temperatures in eastern Australia between 1st-22nd February 2004 triggered the "most significant medical emergency on record" producing a large burden on the health sector (Canberra Times 24th February 2004). McMichael et al. (2003) reported that, on average, about 1100 heat-related deaths/year occur in Australian cities alone. Of particular concern are long-lasting extreme conditions with prolonged periods of very low rainfall and high temperatures persisting consecutively for many days, leading to heat waves, imposing increased physiological stress on plants, animals and on the sick, babies and elderly human populations.

Daily surface temperatures are regionally confined and spatially variant, therefore it is very difficult to associate a single definition to a heat wave (Meehl and Tebaldi 2004). Based on the observed historical episodes worldwide (e.g. July 1995 Chicago heatwave, or the August 2003 Paris heatwave), unrelenting heat persisting for at least three consecutive days above the 90th percentile threshold, is classified as a heatwave (Karl and Knight 1997). Alternatively, a common approach of characterising a heatwave is to consider any prolonged period of excessively hot conditions accompanied by high atmospheric humidity persisting for at least three consecutive days. This definition can utilize the non-linear algorithm developed by Steadman (1979), which converts temperatures and humidity into a heat index (or apparent body temperature, T_a). Because T_a is the combined influence of air temperature and humidity, it becomes a very useful tool in evaluating heat-related stresses on ecosystems and the human population. The accepted critical thresholds for heat indices are: T_a = 32-40°C, which could cause heat cramps or exhaustion; T_a = 41-54°C, causing heat cramps, exhaustion or heat stroke; and T_a = 54°C or higher, during which heat stroke or brain haemorrhage is very likely (Granger and Berechree 2005). See the Table A1 for the details of the thresholds of T_a.

Statistical analysis of daily temperature time-series may be employed to detect trends in heat-related extreme conditions. Tucker (1975) found that the change in annual mean temperature over the period 1967-1973 varied by some 3°C, from > +2°C in Western Australia to < -0.5°C in Queensland. A 30-year (1946-1975) trend calculated by Coughlan (1979) showed increase in the mean maximum temperatures throughout southern Australia but a decrease by a similar amount over tropical regions. Torok and Nicholls (1996) showed increasing/decreasing trends in annual maximum temperatures, ranging from > +0.15°C/decade in parts of Western Australia to < -0.15°C/decade in the New South Wales. Jones (2004) used surface maximum and minimum temperature records for the period 1950 to 1994 to show presence of secular warming trends. In a review, Nicholls (2006) showed that the mean daytime maximum temperatures over most of Australia have increased, with cooling over the northwest and along the south coast of Western Australia. In a related study, but for the southwest Pacific, Salinger et al. (1995) demonstrated a steady warming in southwest of the South Pacific Convergence Zone.

The above studies, which have only focussed on mean climate conditions, together with those investigating specifically the extreme conditions, e.g. Alexander et al. (2007, Alexander et al. (2006), Collins et al. (2000) raise the following questions: *how has the spatial distribution of heat wave indices changed over the last 50 years for the Australian continent? what are the areas of significant increase and decrease and how large are these?*

In this paper we present results from the analysis of historical daily maximum (screen) air temperatures and humidity across selected urban and rural stations for the period 1950-2005. The

Mann-Kendall statistics was used to detect and verify trends in heat indices time series, their spatial distribution and significance at 95% confidence interval. The magnitudes of increases or decreases were assessed using the Sen's slope technique (Theil 1950 and Sen 1968).

2.0 METHODOLOGY

2.1 The climate data

Our analysis utilized the Bureau of Meteorology temperature and relative humidity datasets. All data had been quality-checked by the Bureau prior to making them publicly available so that gross single-day errors were eliminated and data checked for inhomogeneities. Rather than adjusting the inhomogeneities in mean temperatures, daily temperature records were actually adjusted for discontinuities at the 5, 10…,90, 95 percentile levels. This ensured that the data was particularly useful for examining changes in the occurrence of extreme events. Although data were available for 99 non-urban and 4 urban stations, only a subset of 61 stations was selected. This precaution was taken to avoid significant discontinuities in the series at data-sparse stations. Datasets with greater than thirty years of record were chosen, so that enough information could be extracted for at least three decades, allowing trend detection from time series analysis, as required by the Mann-Kendall procedure. The distribution of Australian stations is biased in that there is a large cluster of stations along the eastern seaboard and few stations in central/northern Australia (Fig. 1). For more information on stations altitudes, etc, please refer to Table A2.

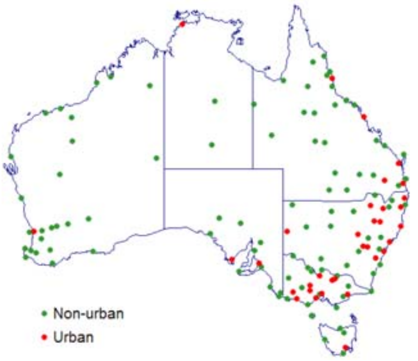


Figure 1: Spatial distribution of Australian stations.

2.2 Calculation of heat indices

The analyses of heat waves followed the approach used by Meehl and Tebaldi (2004). We first considered time series of daily maximum temperatures during the extended warm period in Austral summer (November to April). The daily maximum temperatures and relative humidities were converted to daily heat wave indices (or "apparent body temperature" T_a) using the approximated version of non-linear expression in Appendix 1 for selected Australian stations.

Considering these daily values of T_a for each year, we computed the three-day running mean (moving averages) and saved the highest of those means. This value was labelled as the "worst annual three-day annual event" or heat index during that year. This procedure was repeated for all years over the study period to obtain a time series of T_a for individual stations (Note that the relative humidity records for all years at some stations were either incomplete or not available, so the time series of heat indices reported here for those stations are shorter than the others).

2.3 Trend analysis and significance testing

The time series of heat wave indices was subjected to an univariate, Mann-Kendall (MK) test in order to detect monotonic trends (Hirsch and Slack *1984)*. This procedure has been widely used since its initial formulation by Mann (1945) and Kendall (1975) and later modified by Sneyers (1990). The MK test is a rank-based non parametric procedure widely used for time series data analysis in areas of environmental science, atmospheric and oceanic studies. This is a simple but robust approach that accounts for missing values, serial correlation and numbers below a detection limit that commonly confound trend detection procedures in time series analysis (Hirsch and Slack 1984). In general, the MK-test is expected to be less affected by outliers because its statistic is based on the sign of differences, and not directly on the values of the random variable (Onnz and Bayazit 2003).

The probability (p) of the MK statistic (z) taken over a sample data is estimated by

$$p = 0.5 - \Phi(|Z|)$$

$$\left(\Phi(|Z|) = \frac{1}{\sqrt{2\pi}} \int_0^{|Z|} e^{-t^2/2} dt \right)$$

If the p-value is small, a trend is quite unlikely to be caused by random sampling. The significance level, α, is the probability of rejecting the null hypothesis when it is true. Trends are indicated by the sign of the z-value. A positive z-value shows an upward (or an increasing trend) and a negative z-value corresponds a downward (or a decreasing) trend. In this paper, the α-value was set to 0.05. If the p-value < 0.05, a statistically significant trend exists while a p-value > 0.05 confirms an insignificant trend. For samples that are trend-free, the z value is close to zero and p-value is close to 0.5 (see Yue and Hashino 2003). Note that the MK-test requires at least four values in the time series, so our dataset was sufficiently large to be valid for significance testing.

2.4 Magnitudes of trends

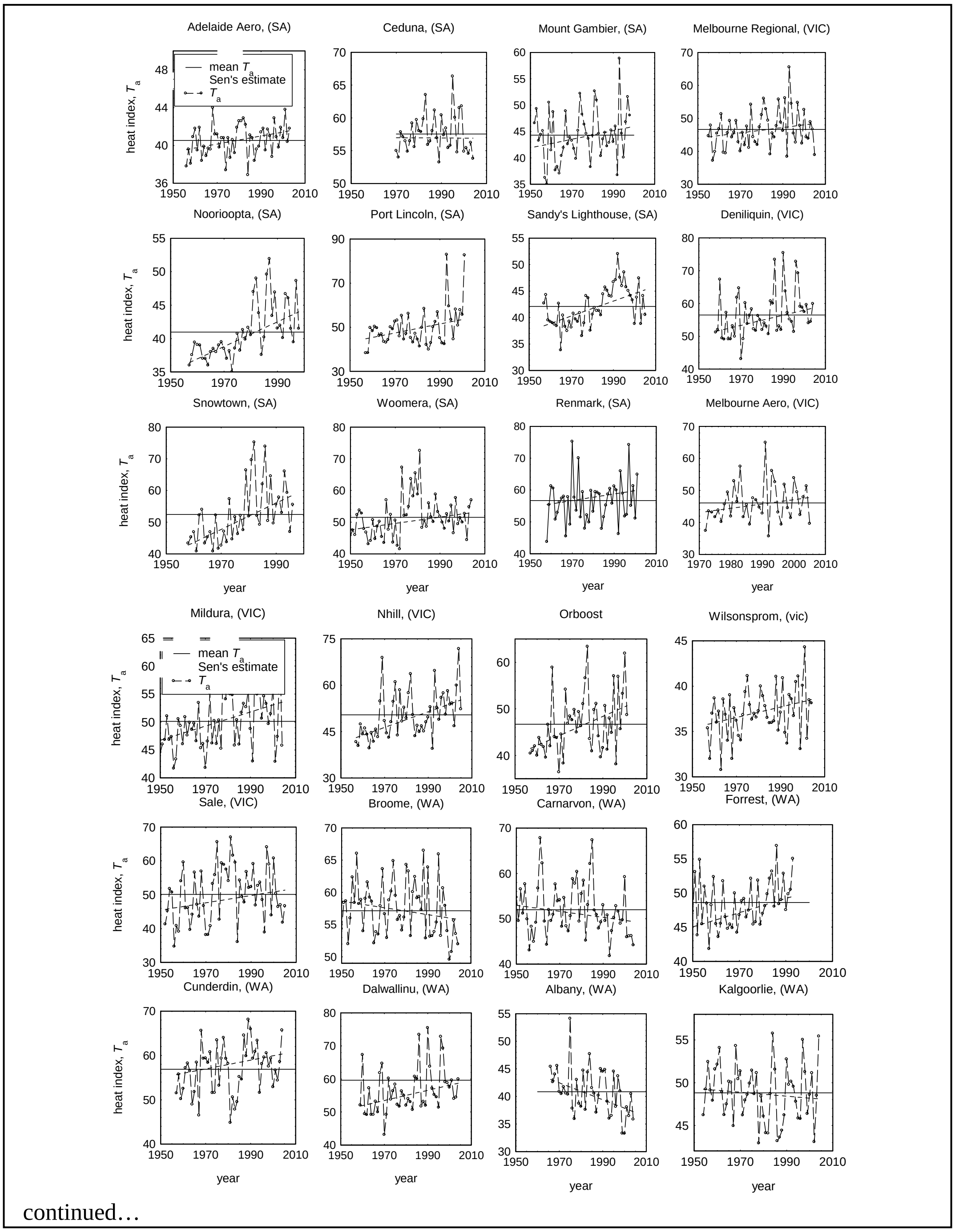
The non-parametric method proposed jointly by Theil (1950) and Sen (1968) was used to estimate the magnitude of trends. This approach uses the Sen's slope estimation method by assuming the trend to be linear, such that $f(t) = Q(t) + B$, where Q is the gradient of the linear trend and B is the constant.

The Sen's slope is a nonparametric alternative method for estimating the slope for univariate time series, in this case, the heat wave indices. This approach involves computing slopes for all the pairs of ordinal time points and then using the median of these slopes as an estimate of the overall slope.

To compute the Sen's slope b, we first calculated the slopes of all data value pairs using

$$b = median\left(\frac{Xj - Xi}{j - i}\right), \forall \text{ j > i}$$

where b is an estimate of the slope of a trend and X_j is the j-th and X_i is the i-th observation record. Note that b, the slope of the trend in the time series, is a robust measure of the magnitude of a monotonically increasing trend and essentially computes the median of all pair wise slopes in the



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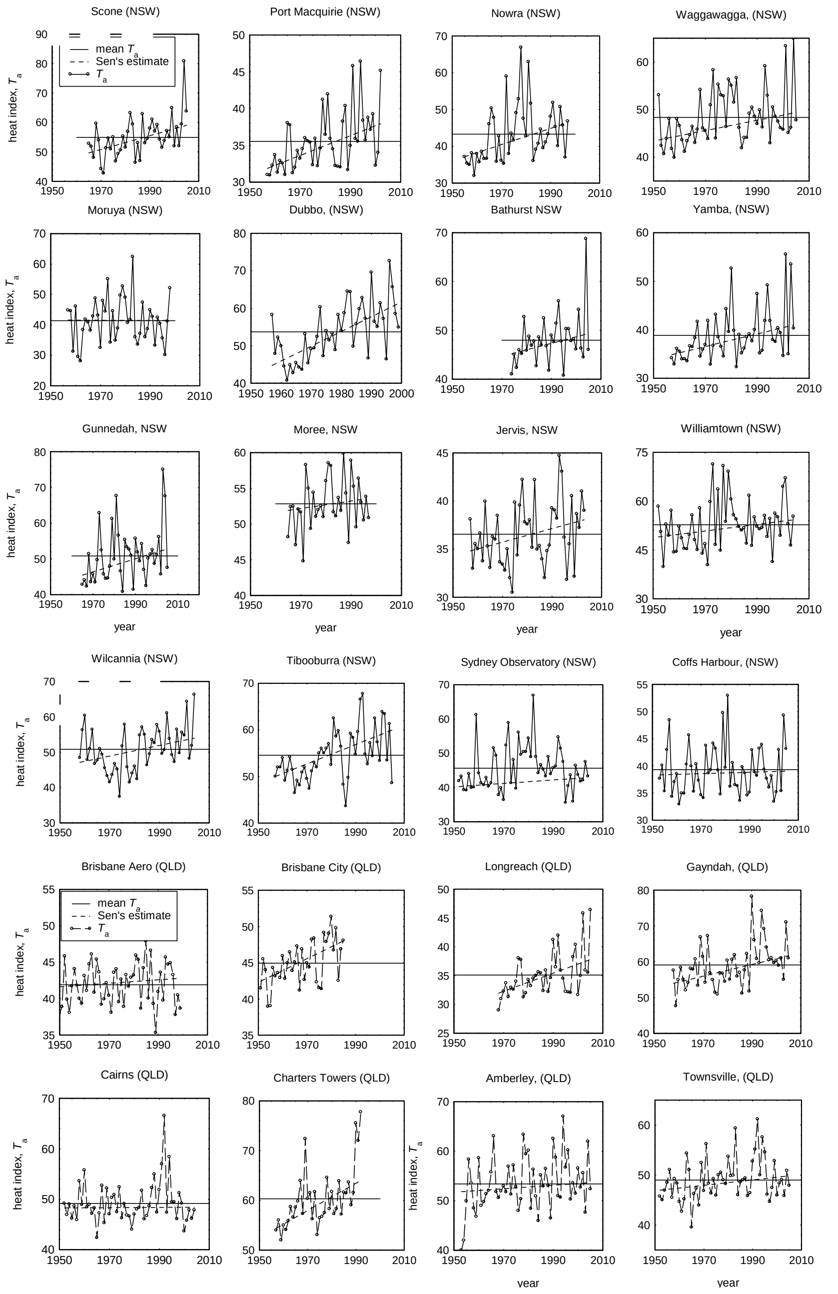


Figure 2: Time series of the three-day worst-annual heat wave indices (T_a) for the 61 stations across Australia. The mean T_a and Sen's slope estimates are also shown.

particular time series.

This technique has been used widely to verify the magnitudes of trends, e.g. Hirsch et al. (1982), Gan (1998), Zhang et al. (2000), Yue and Hashino (2003). Since the Sen's slope is insensitive to outliers or missing data, it is more rigorous than the usual regression slopes and thus provides us a realistic measure of the trends in the data series.

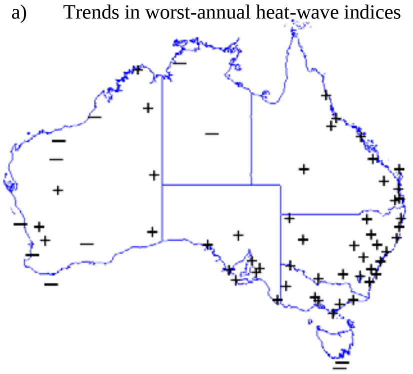
3.0 RESULTS AND DISCUSSION

The time series of worst annual-3-day heat-events across 61 urban and regional stations are shown in Fig. 2. There was strong evidence that heat indices have increased at almost all measurement sites across eastern Australia since the 1950s. However, much weaker signal was found in western and northern regions, with Western Australia stations Albany, Broome, Carnarvon, Port Headland and Geraldton and Northern Territory stations, Darwin and Kalumburu, having very weak but monotonic decreases in heat wave severity.

The results of the assessment of the trends in heat indices using MK's non-parametric test is shown in Table A2. Figure 3a plots the spatial distribution of those trend results. In eastern Australia, all z-values, except for one station, were positive, confirming an existence of monotonically increasing trends at these stations. Conversely, in

Western Australia and Northern Territory, the test revealed decreasing trends at almost 50% of the total number of stations.

a) Trends in worst-annual heat-wave indices



b) Significance of trends at 95% Mann-Kendall's Test

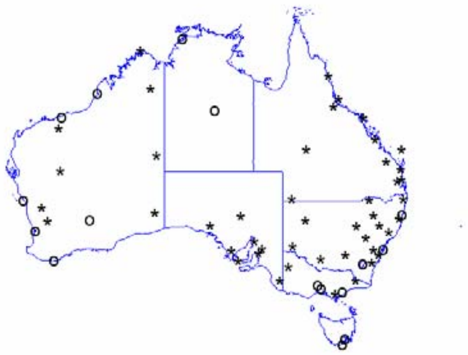


Figure 3: a) Spatial distribution of the trends of three-day worst-annual heat wave indices, and b) the statistical significance of the trends at 95% confidence interval using Mann-Kendall's test.

Note:

+ increasing trend - decreasing trend
o not significant * significant

To deduce spatial distribution of statistically significant regions of increasing/decreasing trends at the 95% confidence interval, the computed *p*-values are included in Table A2 in Appendix 2. Most stations showed statistically significant increasing trends at $\alpha = 0.05$. A statistically insignificant trend ($p>0.05$) was found at Moruya (NSW). It is interesting to note that although heat wave indices at Coffs Harbour and Sydney Observatory were increasing (*z*-value > 0), the trends were not statistically significant at $\alpha = 0.05$. Particularly strong increasing trends occurred at Scone, Port Macquarie, Nowra, Dubbo, Yamba and Tibooburra, with *p*-values close to zero. These increasing trends were significant even at $\alpha = 0.005$. For QLD, VIC and SA stations, statistically significant increases in heat wave indices occurred at all stations, except Townville, Amberley, Mount Gambier, Sale and the regional Melbourne station. Similar to NSW, most sites in these three states show increasing trends which were highly significant at $\alpha = 0.005$, confirming that the strongly persisting dryness in inland and coastal eastern regions were accompanied by heat wave events.

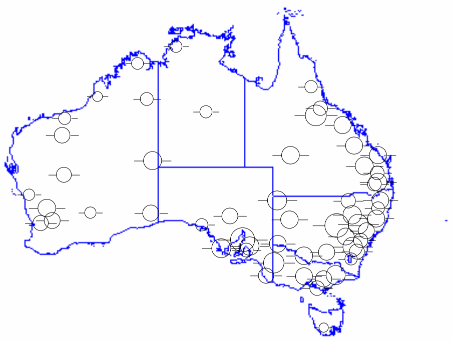


Figure 4: The spatial distribution of the magnitudes of trends in three-day worst-annual heat wave indices derived from the Sen's slopes. Note the size of symbols indicates the magnitude.

The distribution of the increases/decreases in heat wave indices using Sen's slope approach (Table A2) is plotted in Figure 4. Results show that all sites in NSW except five stations (Moruya, Jervis, Coffs Harbour and Sydney Observatory) had Sen's slope values between 0.101°Cyr^{-1} and 0.394°Cyr^{-1}, thus showing strong increases in heat wave severity over the last fifty years. Likewise, the QLD station Rockhampton has a Sen's slope of 0.139°Cyr^{-} and Charters Towers of 0.274°Cyr^{-1}. In Victoria, six out of seven stations show average increases in heat indices between 0.108°Cyr^{-1} to 0.253 °Cyr^{-1} and in South Australia, six out of eight stations had increases in heat wave indices between 0.104°Cyr^{-1} to 0.204°Cyr^{-1}. Unlike eastern and south-eastern regions, only three out of thirteen stations in Western Australia had positive Sen's slope, of values ranging between 0.105°Cyr^{1} minimum to a maximum of 0.165°Cyr^{1}. In this region, six stations had decreasing slopes, although they are statistically insignificant. In general, stations in northern Australia did not have positive slopes; therefore did not experience statistically significant increases in heat waves.

The reported trends in heat wave indices are consistent with media reports of extreme heat events striking eastern and south-eastern Australia in recent decades. For example, weather records at Bureau of Meteorology showed that the township of Renmark, Snowtown, Leigh Creek and Port Augusta recorded four-day and three-day running maximum temperatures greater than 40°C in December 2002 (Media Release 2002). The heat wave indices calculated are useful for assessing the extent of physiological stress to people associated with any outdoor activities during heatwaves. For comparison, the thresholds of the Steadman heat indices, showing the ranges of T_a values which could cause potential health risks, are summarised in Appendix 1.

The minimum threshold of apparent body temperature that would initiate physiological stress, causing heat cramps or heat exhaustion is about T_a = 32°C. Our calculation of worst-annual heat indices over the period 1950-2005 shows that the mean value of T_a was mostly higher than this minimum threshold. Rather, most stations have mean T_a between the next higher thresholds of 41-54°C, which is the range at which a heat stroke is possible if the person is exposed to outdoor environment for a prolonged period. The results therefore indicate that possible increase in the incidences of heat waves is posing serious threat to human health across much of Australia. This is evident from recent events in southeast Queensland, where a severe heat wave between 19th and 21st January 2000 reportedly killed 22 people, most of the victims being elderly residents of Brisbane, who were living alone behind closed doors (Granger and Berechree 2005).

4.0 CONCLUSIONS

This study investigated the spatial patterns of long-term trends in worst annual heat wave indices at 61 sites across Australia between 1950 and 2005. The magnitude of the trends was estimated from the Sen's slopes and statistical significance was tested using the Mann-Kendall's test.

Of the 61 sites over the observation period, only one station showed statistically significant decrease in heat wave incidence since 1950. The increases in heat incidences were confined in eastern and South Australia with the magnitudes of increases varying across the continent. Large increases of about 0.415ºCyr^{-1} have occurred at Snowtown (SA) and 0.394ºCyr^{-1} at Dubbo (NSW), while most of the remaining stations in eastern Australia showed smaller increases which were statistically significant at 95% confidence interval.

We conclude that statistically significant increases in the severity of heat wave incidences are occurring mostly in eastern and South Australia although some northern and western regions also experienced increasing trends, although these were statistically insignificant.

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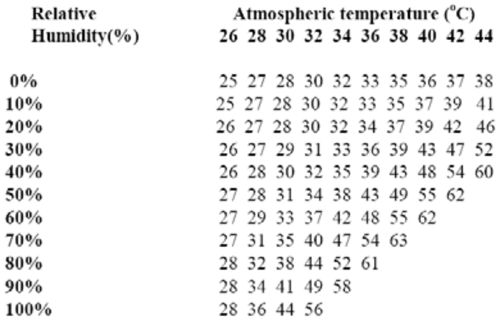
APPENDIX 1

The approximated version of Stedman's (1979) formula to calculate the heat wave indices using relative humidity and air temperatures is

$$T_a\ (°\mathrm{C}) = 5/9\ [(-42.4 + 2.0\times T_{\mathrm{air}} + 10.1\times RH - 0.2\times(T_{\mathrm{air}}\ RH) - 6.8\times10^{-3}\times T^{2}_{\mathrm{air}} - 5.5\times10^{-2} \times RH^{2} + 1.2\times10^{-3} \times (\mathrm{T}_{\mathrm{air}}\ RH)^{2} + 8.5\times10^{-4} \times (T_{\mathrm{air}}\ RH)^{2} - 2.0\times10^{-6} \times (T_{\mathrm{air}}\ RH^{2})) - 32].$$

The range of T_a (apparent body temperature) values for corresponding relative humidity (%) and air temperature (ºC) are shown in Table A1.



Relative Humidity(%)	Atmospheric temperature (°C) 26	28	30	32	34	36	38	40	42	44
0%	25	27	28	30	32	33	35	36	37	38
10%	25	27	28	30	32	33	35	37	39	41
20%	26	27	28	30	32	34	37	39	42	46
30%	26	27	29	31	33	36	39	43	47	52
40%	26	28	30	32	35	39	43	48	54	60
50%	27	28	31	34	38	43	49	55	62	
60%	27	29	33	37	42	48	55	62		
70%	27	31	35	40	47	54	63			
80%	28	32	38	44	52	61				
90%	28	34	41	49	58					
100%	28	36	44	56						

Table A1 The apparent temperature heat index, T_a (based on Steadman 1979 and 1984).

Note that: At an apparent temperature, T_a of:

- **32-40** Heat cramps or heat exhaustion possible
- **41-54** Heat cramps or heat exhaustion likely, heat stroke possible
- **54-more** Heat stroke highly likely

Exposure to full sunshine can increase the heat index value by up to 8ºC (after Granger and Berechree 2005).

APPENDIX 2

Table A2: The list of stations, locations and altitudes of the present study. The Mann-Kendall statistics and *p*-values at 95% confidence level are also shown. Note that + indicates an increasing trend and – indicates a decreasing trend and Sen's slope shows the magnitudes of the trends (°C yr^{-1}). Note that the latitude/longitude is denoted as negative for south/east and positive for north/west.

Station	Lat	Long	Elevation (m)	MK Statistics (Z-value)	Trend	*p*-value	Significant	Sens-Slope (°C yr^{-1})
New South Wales								
Scone	-32.06	150.9	216	3.20	+	0.001	Y	0.235
Port Macquarie	-31.44	152.9	7	3.96	+	0.000	Y	0.135
Nowra	-34.57	150.3	109	3.03	+	0.002	Y	0.219
Mourya	-35.91	150.2	17	-0.01	-	0.991	N	-0.004
Dubbo	-32.21	148.6	275	4.18	+	0.000	Y	0.394
Bathurst	-33.43	149.6	713	1.82	+	0.043	Y	0.133
Gunnedah	-31.03	150.3	307	2.09	+	0.037	Y	0.183
Moree	-29.48	149.8	212.1	1.86	+	0.043	Y	0.053
Jervis	-35.09	150.8	85	1.72	+	0.036	Y	0.070
Waggawagga	-35.16	147.5	212	2.51	+	0.012	Y	0.108
Yamba	-29.43	153.4	29	3.33	+	0.001	Y	0.130
Williamtown	-32.79	151.8	9	1.58	+	0.010	Y	0.101
Wilcannia	-31.56	143.4	75	2.16	+	0.030	Y	0.150
Tibooburra			183	2.16	+	0.000	Y	0.207
Coffs Harbour	-30.31	153.1	5	0.43	+	0.668	N	0.013
Sydney Observ.	-33.86	151.2	39	0.85	+	0.394	N	0.050
Tibooburra	-29.44	142.0		3.96	+	0.000	Y	0.207
Queensland								
Brisbane	-27.42	153.1	4	2.94	+	0.003	Y	0.163
Cairns	-16.87	145.8	3	0.05	+	0.963	N	0.002
Charters Towers	-20.04	146.3	290	4.09	+	0.000	Y	0.274
Gayndah	-25.63	151.6	105.7	3.04	+	0.002	Y	0.164
Longreach,	-24.44	143.5	192.2	3.14	+	0.002	Y	0.158
Mackay	-21.12	149.2	30.2	3.87	+	0.000	Y	0.139
Rockhampton	-23.38	150.5	10	2.89	+	0.004	Y	0.139
Tewantin	-26.39	153	8.3	0.32	+	0.747	N	0.036
Townsville	-19.25	146.8	7.5	1.83	+	0.068	N	0.054
Amberley	-27.63	152.7	27	0.86	+	0.390	N	0.035

…**Table A2**: continued…

South Australia								
Adelaide Aero	-34.92	138.6	48	3.21	+	0.001	Y	0.042
Ceduna	-32.13	133.7	15.3	1.94	+	0.046	Y	-0.002
Mount Gambier	-37.75	140.8	63	2.89	+	0.155	N	0.082
Renmark	-34.10	140.5	20	1.31	+	0.005	Y	0.104
Nuriootpa	-34.48	139	274	4.63	+	0.000	Y	0.185
Port Lincoln	-34.72	135.9	4	2.31	+	0.021	Y	0.204
Sandy L/house	-24.44	153.1	99	3.74	+	0.000	Y	0.142
Snowtown	-33.78	138.2	103	3.82	+	0.000	Y	0.415
Woomera	-31.16	136.8	166.6	3.58	+	0.036	Y	0.100
Western Australia								
Albany	-34.94	117.8	68	-2.82	-	0.005	Y	-0.153
Broome	-17.95	122.2	7	-1.37	-	0.170	N	-0.053
Carnarvon	-43.49	147.1	4	-1.44	-	0.149	N	-0.067
Cunderdin	-31.66	117.3	236	1.99	+	0.046	Y	0.099
Dalwallinu	-30.28	116.7	335	2.63	+	0.008	Y	0.155
Forrest	-30.84	128.1	161	2.33	+	0.020	Y	0.105
Geraldton	-28.8	114.7	33	-0.72	-	0.472	N	-0.024
Giles	-25.04	128.3	618	2.92	+	0.003	Y	0.169
Kalgoorlie	-30.79	121.5	365	-0.89	-	0.376	N	-0.023
Meekatharra	-26.61	118.5	517	1.92	+	0.046	Y	0.074
Perth Reg	-31.93	116		1.55	+	0.121	N	0.079
Port Headland	-20.37	118.6	6.4	-0.09	-	0.925	N	-0.003
Wittenoom	-22.24	118.3	463	0.32	+	0.033	Y	0.093
Northern Territory								
Darwin	-12.42	130.9	30	-0.55	-	0.581	N	-0.011
Hall Creek	-18.23	127.7	422	0.64	+	0.516	N	0.017
Kalumburu	-14.3	126.6	23	-0.55	-	0.580	N	-0.011
Tennant Creek	-19.64	134.2	375.5	-0.03	-	0.977	N	-0.002
Victoria								
Deniliquin	-35.55	145	93	1.93	+	0.044	Y	0.155
Melbourne Aero	-37.81	145		0.99	+	0.321	N	0.135
Mildura	-34.23	142.1	50	2.71	+	0.007	Y	0.127
Nhill	-36.34	141.6	133	3.72	+	0.000	Y	0.253
Orbost	-37.69	148.5	41	1.83	+	0.004	Y	0.209
Sale	-38.11	147.1	4.6	1.47	+	0.142	N	0.108
Wilsons Prom.	-39.13	146.4	88.7	1.88	+	0.038	Y	0.058
Melbourne Reg	-37.47	144.6		1.44	+	0.150	N	0.082

Table A2