**Title:** Unusually cold and dry winters increase mortality in Australia

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## ABSTRACT

Seasonal patterns in mortality have been recognised for decades, with a marked excess of deaths in winter, yet our understanding of the causes of this phenomenon is not yet complete. Research has shown that low and high temperatures are associated with increased mortality independently of season; however, the impact of unseasonal weather on mortality has been less studied. In this study, we aimed to determine if unseasonal patterns in weather were associated with unseasonal patterns in mortality. We obtained daily temperature, humidity and mortality data from 1988 to 2009 for five major Australian cities with a range of climates. We split the seasonal patterns in temperature, humidity and mortality into their stationary and non-stationary parts. A stationary seasonal pattern is consistent from year-to-year, and a non-stationary pattern varies from year-to-year. We used Poisson regression to investigate associations between unseasonal weather and an unusual number of deaths. We found that deaths rates in Australia were 20–30% higher in winter than summer. The seasonal pattern of mortality was non-stationary, with much larger peaks in some winters. Winters that were colder or drier than a typical winter had significantly increased death risks in most cities. Conversely summers that were warmer or more humid than average showed no increase in death risks. Better understanding the occurrence and cause of seasonal variations in mortality will help with disease prevention and save lives.



**Keywords:** Season, Temperature, Humidity, Climate change, Mortality

**Highlights**

- Research has shown extreme weather increases mortality independently of season.
- The impact of unseasonal weather on mortality has been less studied.
- This research examined the pattern of deaths on a monthly time-scale.
- Colder and drier winters increased mortality across various climates in Australia.
- Unseasonal differences in summer weather did not increase mortality.

## INTRODUCTION

Many studies have highlighted seasonal patterns in mortality, with high death rates in winter and low rates in summer (Gemmell et al., 2000; Kalkstein, 2013). A number of causes for the winter excess deaths have been suggested, including seasonal changes in environmental exposures (e.g., temperature, humidity, ultraviolet light, air pollution), diet, behaviour, infectious agents and light–dark cycles (Hales et al., 2012; Healy, 2003; Huang and Barnett, 2014). Understanding more clearly what factors influence seasonal patterns in mortality has implications for public health planning, as a better knowledge could be used to guide prevention programs (Lawlor, 2004; Naumova, 2006).

Epidemiological research has shown increased risks of death in cold and hot weather. Initial studies of temperature and mortality examined the temperature effects for individual cities. More recent large multi-city studies have provided evidence of temperature–mortality associations across a range of climates (Analitis et al., 2008; Anderson and Bell, 2009; Baccini et al., 2008; Barnett et al., 2012; McMichael et al., 2008). Humidity can also affect health through a variety of mechanisms, and mortality is usually highest on extremely hot and humid days (Davis et al., 2004). However, the effects of humidity on health have received less attention than the effects of temperature (Barreca, 2012; Schwartz et al., 2004).

Previous studies on weather and health are usually based on time-series designs that compare day-to-day changes in mortality with day-to-day changes in temperature while controlling for other time-varying risk factors such as season. The methods used have varied considerably, and estimates of the magnitude of temperature effects on mortality have differed substantially by location (Basu et al., 2005; O'Neill and Ebi, 2009). These differences may reflect actual differences in the effects of temperature on mortality due to variations in climate, but also the estimated effects of temperature could be confounded by seasonal patterns (Bhaskaran et al., 2013; Gasparrini and Armstrong, 2010; Welty and Zeger, 2005).

In this study, we examined the seasonal patterns in death for five major cities in Australia and explored associations between mortality, season and weather. We did not examine the day-to-day changes in mortality and weather, but instead examined the pattern on a time-scale of months. We split the seasonal patterns in temperature, humidity and mortality into their stationary (seasonal) and non-stationary (unseasonal) parts. A stationary seasonal pattern is consistent from year-to-year, and a non-stationary pattern varies from year-to-year. We aimed to determine how unseasonal patterns in temperature and humidity in winter and summer were associated with unseasonal patterns in death.

## METHODS

The cities studied were Sydney, Melbourne, Brisbane, Perth and Adelaide (in order of population size); five major capital cities in Australia. The study period was from 1988 to 2009. Winter was from June to August and summer from December to February.

We obtained daily mortality data from 1 January 1988 to 31 December 2009 for each city from the Australian Bureau of Statistics. Accidental deaths and deaths of individuals who were not residents of the city were excluded. We examined deaths in all ages.

Hourly measurements of daily ambient temperature and dewpoint temperature (humidity) for the years 1988–2009 were obtained from the Australian Bureau of Meteorology. We used data from airport weather stations for all cities. Daily mean temperature and humidity were calculated as the average of the daily maximum and daily minimum values.

We aimed to separate the strong seasonal patterns in death and weather into their stationary and non-stationary parts. A stationary seasonal pattern is that which is consistent from year-to-year, and a non-stationary pattern is that which varies from year-to-year but is still recognizably seasonal.

To find the stationary seasonal pattern in deaths, we modelled the daily number of deaths in each city using Poisson regression:

$$death_t \sim Poisson\ (\mu_t), \quad t = 1, \dots, n,$$
$$\log(\mu_t) = \alpha + \mathrm{M}_t \boldsymbol{\gamma} + \mathrm{D}_t \boldsymbol{\beta} + s(t, 3),$$

where $\alpha$ is the intercept, $\mathrm{M}_t$ is an $n$×11 matrix of zeros and ones that corresponds to month (with a reference month of January) and $\boldsymbol{\gamma}$ is a vector of parameter estimates for the stationary seasonal pattern, $\mathrm{D}_t$ is an $n$×6 matrix of zeros and ones that corresponds to the day of the week (with a reference day of Monday) and $\boldsymbol{\beta}$ is a vector of parameter estimates for day of the week. The long-term trend in deaths was modelled by $s(t,3)$ which is a natural spline with 3 degrees of freedom.

We examined the deviance residuals of the model to look for patterns in deaths that were not explained by a stationary season. A positive residual means there were more deaths than predicted, and a negative residual means there were fewer deaths than predicted. We examined the deviance residuals for deaths rather than the raw residuals as they are more symmetric (when using Poisson regression) and are therefore more useful for diagnostic purposes (Dobson and Barnett, 2008).

We used the same process to examine temperature and humidity by fitting similar regression models. As temperature and humidity are continuous we used a Gaussian model and the raw residuals. We averaged the daily residuals into months as we are primarily interested in longer-term associations between weather and mortality. For temperature a positive temperature residual means an unusually warm month, and a negative residual means an unusually cold month. For humidity a positive residual means a wetter than average month, and a negative residual is a drier than average month. In order to look for long-term patterns in the residuals we smoothed them using local polynomial regression with a span of 0.5, and then plotted the smoothed residuals over time (Cleveland et al., 1992). We plotted the smoothed monthly temperature and humidity residuals next to the smoothed monthly death residuals to visually look for long-term associations between periods of unusual temperatures and periods of unusual deaths.

To look for statistical associations between unseasonal weather and an unusual number of deaths, we used the following Poisson regression model with the monthly number of deaths as the dependent variable:

$$death_m \sim Poisson\ (\mu_m), \quad m = 1, \ldots, N,$$
$$\log(\mu_m) = \alpha + \log(o_m/30) + \mathrm{M}_m\boldsymbol{\gamma} + s(m, 3) + \mathrm{S}_m\bar{t}_m\boldsymbol{\delta} + \mathrm{S}_m\bar{h}_m\boldsymbol{\beta},$$

where $o_m$ is an offset of the number of days in month *m* divided by 30, which adjusts for differences in month lengths (e.g., February being shorter) and standardizes the results to a common month of 30 days. As in the previous model, $\alpha$ is the intercept, the vector $\boldsymbol{\gamma}$ captures the stationary seasonal pattern, and the spline *s*() captures the long-term trend using three degrees of freedom. The residual effect of temperature is estimated by the mean temperature residuals in each month ($\bar{t}_m$), where a warmer than average month has a positive residual. The effect of unusually low or high temperatures should be different in winter and summer. For example, lower than average winter temperatures are likely to increase the risk of death, whereas lower than average summer temperatures are likely to decrease risk. To capture this difference, $\mathrm{S}_m$ is an $N\times4$ matrix of zeros and ones that corresponds to each season, so that $\boldsymbol{\delta}$ is a vector of parameter estimates that models an unusually warm or cold month for each of the four seasons. The vector of parameters **β** models the effect of humidity.

We presented results on an absolute scale by calculating the estimated mean number of deaths for seasons that were not unusual ($\bar{t}_m = 0$ and $\bar{h}_m = 0$). We then examined the difference in absolute death numbers for: a winter that was 1 ºC colder ($\bar{t}_m = -1$) and a winter with a 1 ºC decrease in humidity ($\bar{h}_m = -1$), a summer that was 1 ºC warmer ($\bar{t}_m = 1$) and summer with a 1 ºC increase in humidity ($\bar{h}_m = 1$). Our linear interaction means that we also test the effects of warmer or wetter winters and colder or drier summers, but we presented the results for the most plausible *a priori* scenarios. All results were presented as means with 95% confidence intervals (CIs). The R software (version 3.0.2) (R Development Core Team, Austria) was used for all analyses.

**RESULTS**

For the 22-year period, there were over 1.5 million deaths in the five major cities of Australia (Table 1). There was a strong seasonal pattern of mortality in every city, with far more deaths in winter (Figure 1). The seasonal pattern was non-stationary, with much larger peaks in some winters.

Death rates were 20–30% higher in a winter than a summer (Figure 2). Sydney had the largest seasonal pattern, and Melbourne the smallest. In Sydney there were 2,353 deaths (95% CI: 2,339–2,367 deaths) in a typical winter month compared with 1,817 deaths (95% CI: 1,805–1,829 deaths) in a typical summer month, an increase in winter of 536 deaths per month (Table 2).

We compared the residual patterns in deaths to the residual patterns in temperature and humidity. There was a striking similarity in the death residuals for Sydney, Melbourne, Brisbane and Perth (Figure 3). So when deaths were unusually high (or low) in one of these cities they were also unusually high (or low) in the other cities. This may indicate a common driver of death rates in four cities.

Unseasonal weather in winter was generally associated with more deaths in all cities. The monthly estimates of death in the five cities for different winter and summer scenarios are in Table 2. In most cities a colder than average winter was associated with a higher than average number of deaths. The largest increase was in Brisbane with 59 more deaths per month (95% CI: 45–73 deaths) for a 1 ºC decrease in mean winter temperature, and the smallest in Adelaide with 14 more deaths per month (95% CI: 4–24 deaths). Conversely, a warmer than average summer was not associated more deaths in any city.

A drier winter was also associated with a higher number of deaths in most cities. The largest increase was in Melbourne with 45 more deaths per month (95% CI: 30–61 deaths) for a 1 ºC decrease in dewpoint temperature in winter, and the smallest in Adelaide with 8 more deaths per month (95% CI: 0–17 deaths). A more humid summer did not increase death rates in any city.

## DISCUSSION

The winter increase in mortality is a recurring phenomenon in Australia. This seasonal pattern is consistent across much of the world, and many countries suffer 10% to 30% excess deaths in winter (Falagas et al., 2009; Healy, 2003). Excess winter deaths have a significant impact on health systems. Extra demands are placed on doctors, hospitals and emergency departments in winter months, especially for cardiovascular and respiratory diseases (Barnett et al., 2008). The specific causes of the seasonality are complex and range from the high incidence of cardio-respiratory and infectious diseases in the winter, to the direct impact of low temperatures, and beyond (Hales et al., 2012; Kalkstein, 2013). Since the winter increases in mortality are predictable, prevention programs may be able to reduce the future burden of disease. Public health measures such as influenza vaccinations and insulating homes, especially for vulnerable groups, might be worthwhile (Healy, 2003; Phu Pin et al., 2012).

In Australian cities, intra-annual mortality exhibits a pronounced winter peak but with a large variability from year to year (Figure 1). These non-stationary seasonal patterns of mortality can partly be explained by lower than average winter temperatures (Table 1). Exposure to cold weather triggers an increase in blood pressure and viscosity. These increases can cause deaths or hospitalisations, especially in people with already high cardiovascular risk factors (Barnett et al., 2008; Huynen et al., 2001; O'Neill and Ebi, 2009). Another contributor could be influenza, and in temperate regions influenza epidemics display a characteristic seasonal pattern with peak incidence occurring in winter months (von Klot et al., 2012). The association between annual influenza peak and winter weather has led to the hypothesis that weather variability may impact on influenza and pneumonia mortality (Davis et al., 2012).

Our results clearly show that the relationship between colder winters and increased mortality influences seasonal patterns of deaths in Australia. This finding is consistent with most previous evidence in this field, which shows that the colder the winter the worse the impact on health (Analitis et al., 2008; Revich and Shaposhnikov, 2008). Therefore, we would expect more deaths and hospital admissions during more severe winters in the future.

The strength of the winter–health association could also be a result of the population being unable to protect themselves adequately from the effects of temperature. The strongest increase in deaths for a colder winter was in Brisbane, the city with the warmest climate, which reflects the greater vulnerability of Brisbane residents to cold despite Brisbane having the mildest winter of any of the five cities (Table 2). This is in line with previous literature showing that warmer climates have stronger associations between cold and health than cooler climates (Anderson and Bell, 2009; Curriero et al., 2002). In Brisbane, we believe this is because most homes are designed to lose heat in summer, which also allows cold outdoor air to get inside homes during winter.

Humans are sensitive to humidity and its changes. High humidity can reduce the body's efficiency of transporting away metabolic heat through evaporative cooling (sweating) and heat conduction, while low humidity may lead to dehydration and promote the spread of airborne diseases (Barreca, 2012). Despite these known physiological mechanisms, the effects of humidity on health have not been well established in the epidemiological literature (Schwartz et al., 2004). Here we found that low humidity conditions in winter are particularly dangerous. This association may be explained by an increase in influenza outbreaks. Recent studies indicate that the transmission and survival of influenza virus, as well as the onset of increased wintertime influenza-related mortality, are strongly associated with low humidity levels (Shaman et al., 2011).

We did not find an association between unseasonal summers and increased mortality, either for temperature or humidity. Although we know that heat waves do kill people in the short-term (Hajat et al., 2010; Huang et al., 2012a; Knowlton et al., 2009; Le Tertre et al., 2006;

Peng et al., 2011), longer-term seasonal differences in summer weather may not increase mortality. Summer weather in Australia is generally more variable than winter weather (Supplementary Figure 1) and Australians may be more prepared for unseasonal summers because of the predominant housing design geared towards cooling, wide availability of air conditioning and better awareness of heat risks (Davis et al., 2003).

The short-term effects of weather on mortality have been widely researched worldwide, with most studies reporting that both low and high temperatures increase mortality. However, human responses to temperature exposure vary considerably. Extreme heat events often result in large, abrupt increases in mortality, while the effect of cold is generally longer lasting, making a direct weather–health relationship between cold and mortality more difficult to detect (Sheridan and Kalkstein, 2010). There are also potentially long lag times between temperature exposure and death, especially for cold weather where deaths may occur weeks later (Analitis et al., 2008; Anderson and Bell, 2009; Huang et al., 2012b). Examining lagged effects can highlight mortality displacement, where extreme temperatures trigger deaths in already frail persons (Bhaskaran et al., 2013; Saha et al., 2013).

Previous studies are usually based on a time-series design comparing daily counts of mortality with daily weather. Time-series analysis has the advantage of controlling for multiple confounding factors, as the same population is examined repeatedly under varying exposure conditions but with constant (or slowly varying) confounders. Time trends and seasonal patterns in exposures and deaths are potential confounders, and are therefore controlled for by modelling. Season has been adjusted for in various ways, including splitting the year into winter and summer seasons, or using smoothed functions of date (e.g., splines) to capture seasonal patterns and long-term trends (Bhaskaran et al., 2013; Zeger et al., 2006).

However, questions remain as to whether time-series regression models have completely controlled for the confounding effects of season (Gasparrini and Armstrong, 2010; Welty and Zeger, 2005).

In this study we did not examine the day-to-day changes in mortality, but instead examined the pattern of deaths on a time-scale of month. We split the strong seasonal pattern in mortality into its stationary and non-stationary parts. We attempted to separate out normal (stationary) seasonal variations from unusual (non-stationary) seasonal variations, and then examined the mortality effects of the temperature anomalies. This approach takes a broader view of the seasonal patterns in death compared with previous research that investigated daily time-series data of death and temperature. Also, examining the longer-term association between temperature and death largely avoids the issue of short-term mortality displacement occurring within weeks.

Many recent studies of temperature and mortality have controlled for ambient air pollutants. However, this practice may not always be appropriate. Buckley et al. (2014) illustrated potential relationships among temperature, air pollution and mortality on a short-term basis using directed acyclic graphs. They suggested that adjustment for temperature is warranted when assessing the effects of air pollution on mortality, but not vice versa. Therefore, we did not include air pollution in this analysis.

Climate change is expected to amplify weather extremes because a more energetic atmosphere generates greater variability, making the weather less predictable (Coumou and Rahmstorf, 2012; Moberg et al., 2005). Human adaptation to climate change and extreme weather may occur over time, through changes in people’s physiology and through socioeconomic, cultural and behavioural changes (Huang et al., 2013). These changes have been used to explain the declining mortality from heat and cold events in historic registers (Åström et al., 2013; Davis et al., 2003). However, adaptation to extreme daily temperatures may not be predictive of people's ability to adapt to seasonal changes, particularly for those unusually cold or dry winters.

In conclusion, there were many more deaths in winter than summer in all five Australian cities studied. Unseasonal weather, particular colder and drier winters, were associated with an increased mortality across various climates. Understanding the main drivers of seasonal mortality is important, as it will assist in improving disease prevention and ultimately saving lives.

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## FIGURE LEGENDS

**Figure 1.** Time series of monthly total deaths in five Australian cities (1988–2009). Numbers adjusted to a common month length of 30 days. Excluding accidental deaths. The grey vertical bars show winter.

**Figure 2.** Stationary seasonal patterns of mortality in five Australian cities (1988–2009). January is the reference month.

**Figure 3.** Smoothed monthly residuals over time for death, temperature and humidity in five Australian cities (1988–2009). Residuals after removing trend and season. Using a loess smoother with a span of 0.5.

For mortality a positive residual means there are more deaths than predicted by the model, and a negative residual means there are fewer deaths. For temperature a positive residual means a warmer than average month, and a negative residual is a colder than average month. For humidity a positive residual means a wetter than average month, and a negative residual is a drier than average month.

**Table 1.** Summary statistics on daily temperature, humidity (dew-point temperature) and deaths by city and season (1988–2009)

| | Daily average temperature (ºC) | | | Daily dewpoint temperature (ºC) | | | Daily deaths | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | 5% | 95% | Mean | 5% | 95% | Mean | 5% | 95% | Total |
| **Sydney** | **18.1** | **11.6** | **24.2** | **11.7** | **2.6** | **19.2** | **68.7** | **50** | **92** | **552,460** |
| Winter | 13.3 | 10.4 | 17.1 | 6.6 | 0.6 | 12.4 | 79.9 | 62 | 99 | |
| Summer | 22.2 | 18.6 | 25.7 | 16.3 | 10.6 | 20.4 | 61.7 | 46 | 79 | |
| **Melbourne** | **15.8** | **8.9** | **26.3** | **7.7** | **2.5** | **14.2** | **57.7** | **43** | **73** | **463,351** |
| Winter | 10.7 | 7.6 | 14.2 | 5.6 | 2.2 | 9.3 | 63.0 | 48 | 78 | |
| Summer | 20.9 | 14.7 | 30.3 | 10.0 | 4.2 | 16.4 | 53.6 | 40 | 67 | |
| **Brisbane** | **21.9** | **15.7** | **27.4** | **14.3** | **3.5** | **21.6** | **25.2** | **15** | **36** | **202,156** |
| Winter | 17.3 | 14.0 | 20.2 | 9.2 | 0.0 | 15.9 | 28.9 | 19 | 40 | |
| Summer | 25.8 | 22.7 | 28.6 | 18.9 | 14.3 | 23.0 | 23.2 | 14 | 33 | |
| **Perth** | **20.4** | **12.9** | **30.4** | **9.9** | **3.8** | **16.0** | **20.2** | **12** | **29** | **162,614** |
| Winter | 14.7 | 11.5 | 18.1 | 8.5 | 3.3 | 13.3 | 22.7 | 14 | 31 | |
| Summer | 26.2 | 20.3 | 33.2 | 11.3 | 4.3 | 17.2 | 18.4 | 11 | 27 | |
| **Adelaide** | **18.1** | **11.1** | **29.0** | **8.5** | **3.0** | **14.2** | **22.1** | **14** | **31** | **177,728** |
| Winter | 12.8 | 10.0 | 16.5 | 7.2 | 2.8 | 11.2 | 24.8 | 17 | 33 | |
| Summer | 23.2 | 17.3 | 32.6 | 10.1 | 4.0 | 16.2 | 20.0 | 13 | 28 | |

**Table 2.** Monthly death estimates in five Australian cities for various winter and summer scenarios (1988–2009)

| City | Scenario | Mean | 95% CI |
|---|---|---|---|
| **Sydney** | **Typical winter (deaths)** | **2353** | **2339, 2367** |
| ([§]Population | Cold winter (change in deaths) | 58* | 38, 78 |
| = 4.12 million) | Dry winter (change in deaths) | 19* | 8, 29 |
| | **Typical summer (deaths)** | **1817** | **1805, 1829** |
| | Warm summer (change in deaths) | –6 | –20, 9 |
| | Humid summer (change in deaths) | –4 | –16, 8 |
| **Melbourne** | **Typical winter (deaths)** | **1857** | **1845, 1870** |
| ([§]Population | Cold winter (change in deaths) | 20* | 4, 36 |
| = 3.59 million) | Dry winter (change in deaths) | 45* | 30, 61 |
| | **Typical summer (deaths)** | **1580** | **1569, 1592** |
| | Warm summer (change in deaths) | –6 | –13, 1 |
| | Humid summer (change in deaths) | –2 | –9, 5 |
| **Brisbane** | **Typical winter (deaths)** | **854** | **846, 863** |
| ([§]Population | Cold winter (change in deaths) | 59* | 45, 73 |
| = 1.76 million) | Dry winter (change in deaths) | –4 | –9, 1 |
| | **Typical summer (deaths)** | **687** | **680, 695** |
| | Warm summer (change in deaths) | 1 | –10, 13 |
| | Humid summer (change in deaths) | –6 | –15, 2 |
| **Perth** | **Typical winter (deaths)** | **679** | **672, 687** |
| ([§]Population | Cold winter (change in deaths) | –6 | –18, 5 |
| = 1.45 million) | Dry winter (change in deaths) | 12* | 5, 18 |
| | **Typical summer (deaths)** | **552** | **545, 558** |
| | Warm summer (change in deaths) | –4 | –9, 0 |
| | Humid summer (change in deaths) | 1 | –4, 5 |
| **Adelaide** | **Typical winter (deaths)** | **745** | **737, 753** |
| ([§]Population | Cold winter (change in deaths) | 14* | 4, 24 |
| = 1.11 million) | Dry winter (change in deaths) | 8* | 0, 17 |
| | **Typical summer (deaths)** | **602** | **595, 609** |
| | Warm summer (change in deaths) | –2 | –6, 2 |
| | Humid summer (change in deaths) | 1 | –4, 6 |

The table shows the monthly number of deaths per typical winter and summer, and the change in deaths for variable seasons. Cold winter = 1 ºC decrease in mean winter temperature. Dry winter = 1 ºC decrease in mean dew-point temperature in winter. Warm summer = 1 ºC increase in mean summer temperature. Humid summer = 1 ºC increase in mean dew-point temperature in summer.

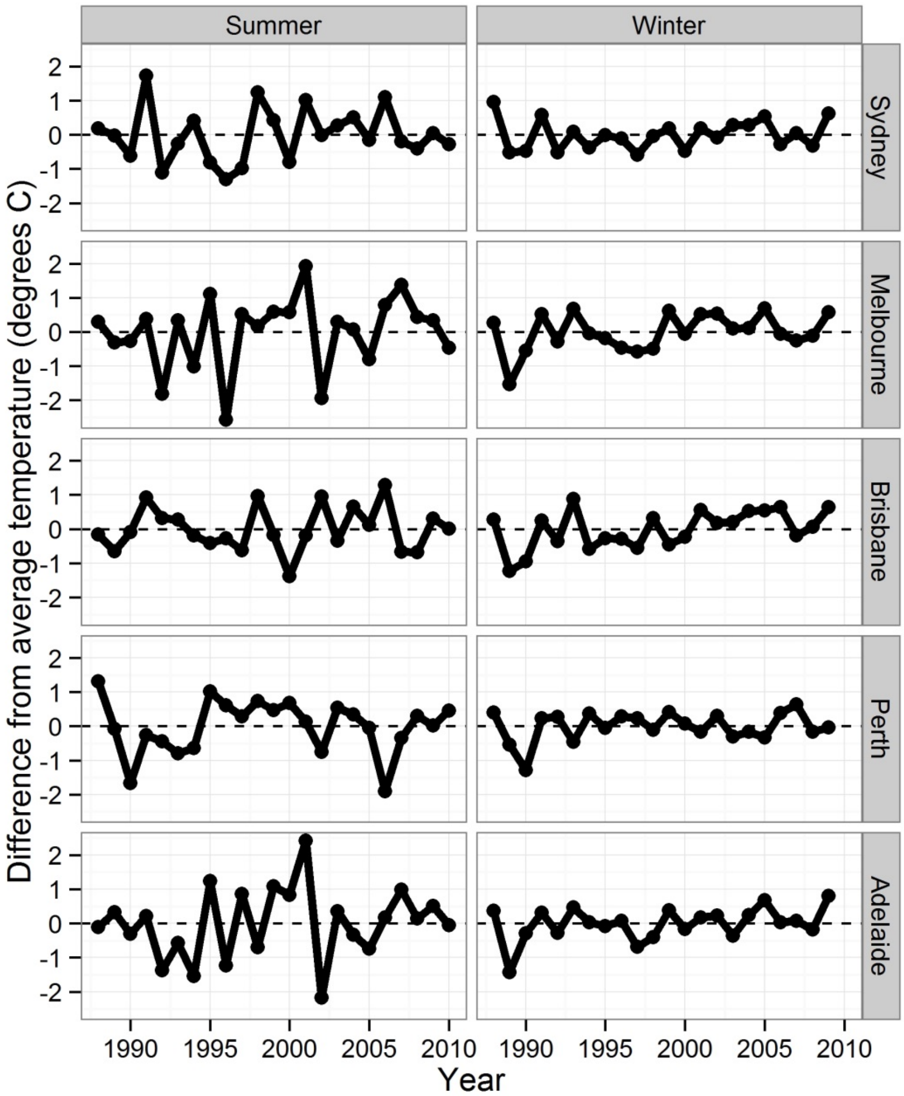
[§] Data from the 2006 Census of Population & Housing conducted by the Australian Bureau of Statistics.

* $P < 0.05$.

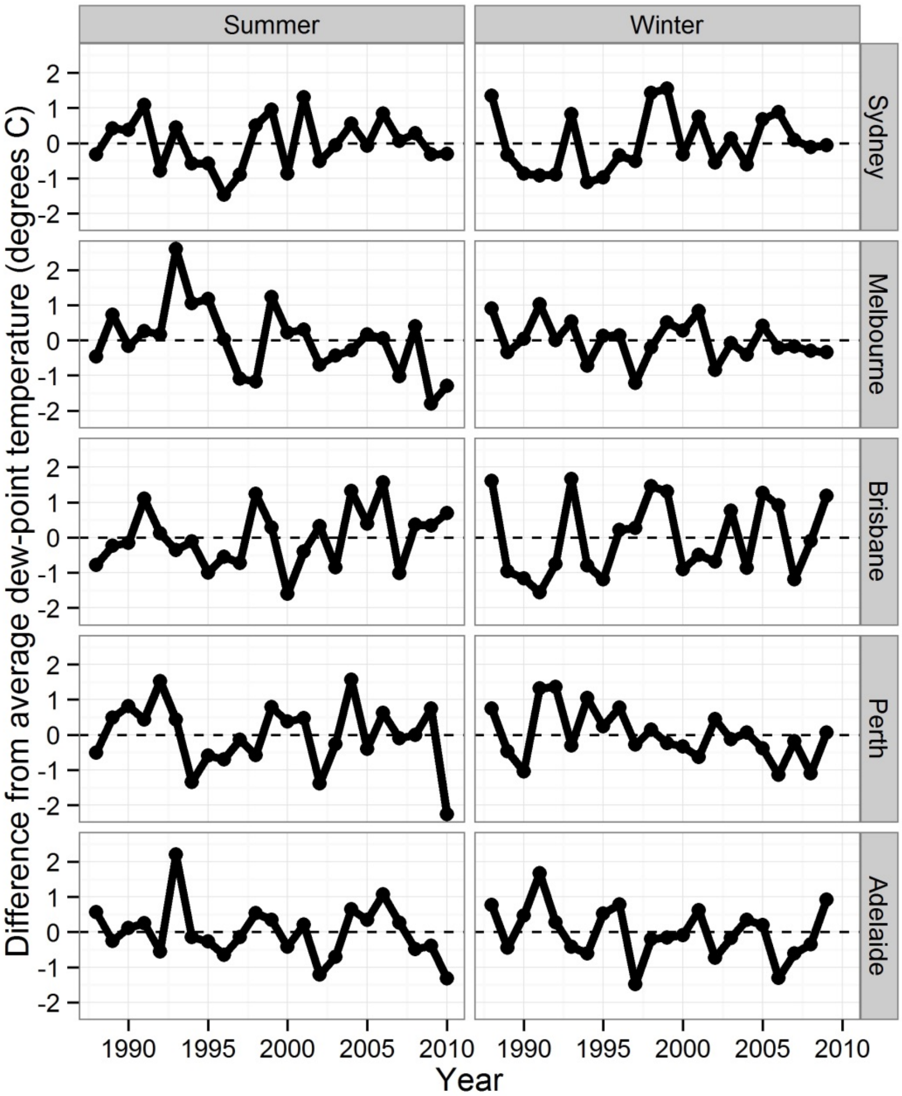
**SUPPLEMENTARY INFORMATION**

**Supplementary Figure 1.** Annual differences from the average seasonal temperature and humidity by summer and winter in five Australian cities (1988–2009).

**a. Temperature**



**b. Humidity**



Summer
Winter
Sydney
Melbourne
Brisbane
Perth
Adelaide
Difference from average dew-point temperature (degrees C)
2
1
0
-1
-2
1990
1995
2000
2005
2010
Year

**Supplementary Table 1.** Parameter estimates by city, season and variable (temperature/humidity) in all five cities. Means and 95% confidence intervals.

| City | Season | Variable | Mean | Lower 95% CI | Upper 95% CI | P-value |
|---|---|---|---|---|---|---|
| Sydney | Spring | Temperature | 0.0024 | –0.0043 | 0.0090 | 0.486 |
| | Summer | Temperature | –0.0031 | –0.0110 | 0.0047 | 0.436 |
| | Autumn | Temperature | –0.0087 | –0.0186 | 0.0012 | 0.085 |
| | Winter | Temperature | –0.0243 | –0.0326 | –0.0159 | 0.000 |
| | Spring | Humidity | –0.0056 | –0.0097 | –0.0015 | 0.008 |
| | Summer | Humidity | –0.0023 | –0.0089 | 0.0043 | 0.498 |
| | Autumn | Humidity | –0.0044 | –0.0094 | 0.0005 | 0.081 |
| | Winter | Humidity | –0.0080 | –0.0125 | –0.0035 | 0.001 |
| Melbourne | Spring | Temperature | –0.0104 | –0.0163 | –0.0045 | 0.001 |
| | Summer | Temperature | –0.0038 | –0.0080 | 0.0004 | 0.079 |
| | Autumn | Temperature | –0.0011 | –0.0078 | 0.0056 | 0.756 |
| | Winter | Temperature | –0.0106 | –0.0190 | –0.0021 | 0.014 |
| | Spring | Humidity | –0.0048 | –0.0088 | –0.0009 | 0.017 |
| | Summer | Humidity | –0.0014 | –0.0056 | 0.0028 | 0.516 |
| | Autumn | Humidity | –0.0042 | –0.0098 | 0.0014 | 0.139 |
| | Winter | Humidity | –0.0247 | –0.0331 | –0.0164 | 0.000 |
| Brisbane | Spring | Temperature | 0.0064 | –0.0059 | 0.0187 | 0.305 |
| | Summer | Temperature | 0.0021 | –0.0139 | 0.0181 | 0.799 |
| | Autumn | Temperature | –0.0173 | –0.0338 | –0.0008 | 0.040 |
| | Winter | Temperature | –0.0666 | –0.0815 | –0.0518 | 0.000 |
| | Spring | Humidity | –0.0113 | –0.0173 | –0.0053 | 0.000 |
| | Summer | Humidity | 0.0093 | –0.0023 | 0.0209 | 0.114 |
| | Autumn | Humidity | 0.0030 | –0.0050 | 0.0109 | 0.462 |
| | Winter | Humidity | 0.0050 | –0.0007 | 0.0107 | 0.084 |
| Perth | Spring | Temperature | 0.0071 | –0.0036 | 0.0178 | 0.192 |
| | Summer | Temperature | –0.0077 | –0.0160 | 0.0005 | 0.066 |
| | Autumn | Temperature | 0.0020 | –0.0080 | 0.0120 | 0.694 |
| | Winter | Temperature | 0.0095 | –0.0072 | 0.0262 | 0.263 |
| | Spring | Humidity | –0.0152 | –0.0265 | –0.0039 | 0.009 |
| | Summer | Humidity | 0.0011 | –0.0076 | 0.0097 | 0.808 |
| | Autumn | Humidity | –0.0026 | –0.0095 | 0.0042 | 0.456 |
| | Winter | Humidity | –0.0174 | –0.0270 | –0.0078 | 0.000 |
| Adelaide | Spring | Temperature | –0.0192 | –0.0273 | –0.0111 | 0.000 |
| | Summer | Temperature | –0.0029 | –0.0097 | 0.0039 | 0.406 |
| | Autumn | Temperature | –0.0033 | –0.0127 | 0.0061 | 0.495 |
| | Winter | Temperature | –0.0183 | –0.0315 | –0.0051 | 0.007 |
| | Spring | Humidity | –0.0071 | –0.0150 | 0.0008 | 0.076 |
| | Summer | Humidity | 0.0015 | –0.0062 | 0.0093 | 0.697 |
| | Autumn | Humidity | –0.0036 | –0.0125 | 0.0053 | 0.424 |
| | Winter | Humidity | –0.0111 | –0.0225 | –0.0004 | 0.048 |