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Analysis of changes in peak temperature impact on energy demand in South Australia

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Abstract: South Australia has experienced significant increases in temperature extremes over the past few decades, posing growing challenges for managing energy demand. In particular, changes in peak temperature events have direct implications for electricity consumption, most noticeably through increased demand for cooling during extended heat-waves and extreme summer temperature. Understanding the nature and frequency of these temperature extremes is crucial for the farming industry, planning energy infrastructure, developing climate adaptation strategies, and ensuring long-term energy sustainability in the region.

Keywords: *maximum and minimum temperature, BTLG model, peak temperature, energy*

This study examines temporal variations in daily maximum and minimum temperature extremes at 3 locations, which are 2 main agricultural regions in the Murray Mallee and Upper Eyre Peninsula regions: Cummins, Murray Bridge, and Mount Gambier, the main town in the South East region. The study covers the period 1950 to 2025. A change point analysis was conducted to assess potential shifts in temperature patterns, identifying a statistically significant change around 1985, consistent with regional warming trends attributed to climate change.

Using bivariate distribution models, particularly the Bivariate Truncated Logistic-Geometric (BTLG) model (Biondi et al., 2008), temperature episodes were examined jointly in terms of duration (the number of consecutive days above the threshold) and peak temperature. The threshold for defining heat episodes was set at 35°C for daily maximum temperatures and 23°C for daily minimum temperatures in Summer, and 20°C for maximum and 10°C for minimum in winter, which aligns with thresholds relevant for public health and energy demand alerts. The bivariate model enables us to examine the joint probability of the intensity of heat events and factors most strongly correlated with energy consumption.

The results show an increase in the frequency and intensity of short-duration, high-temperature episodes since the mid-1980s. From 1950 to 1985, heatwaves were characterised by longer durations and more moderate peaks. In contrast, from 1986 to 2025, data shows that peak temperatures have increased, while durations have decreased, indicating a shift toward more intense and abrupt heating events. This is reflected in increasing values of the peak parameter (β) and decreasing values for duration probability (p), suggesting that although events may not last as long, they are reaching more extreme levels.

From an energy concept, these results may be critical. Cooling demand is highly sensitive to daily peak temperatures, particularly when these temperatures are sustained over multiple days. The shift toward higher maximum temperatures, even if for shorter durations, increases the risk of grid overload and reduces the effectiveness of passive cooling systems in buildings.

Furthermore, analysis of seasonal trends reveals that summer episodes contribute extremely to increased energy demand, primarily due to elevated daytime maxima and higher overnight minima, which reduce natural nighttime cooling. Winter data show relatively stable durations and peaks, suggesting less volatility in heating demand.

Cummins showed relatively milder extremes compared to Murray Bridge, which consistently recorded higher peak temperatures and more frequent heat episodes from 1986 to 2025 in summer and winter. This spatial differentiation is important for localised energy infrastructure planning in the near future**.**

By considering bivariate analysis into the study of temperature extremes, this study offers a better understanding of how both the duration and peak intensity of heat events interact to influence, particularly for the farming sector, by investigating whether higher winter temperatures are arriving earlier, affecting flower pollination patterns and also planning in the context of future climate change and energy consumption patterns in SA.

REFERENCES

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