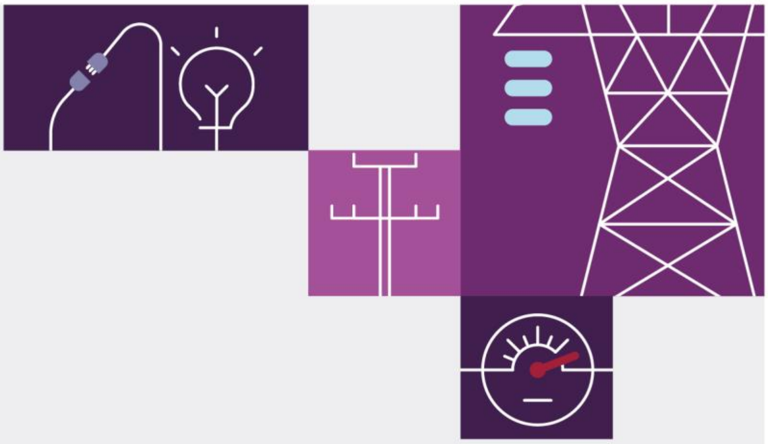
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Temperature Forecast Analysis for Summer 2022-23

June 2023

A report assessing the forecast precision and accuracy of AEMO's operational weather providers in the National Electricity Market from 1 December 2022 to 31 March 2023



Important notice

Purpose

This report has been prepared to:

- Give the weather providers used by AEMO an insight into their comparative temperature forecast performance in the National Electricity Market during the 2022-23 summer period.
- Give any intending weather providers information to assess the relative performance of their forecasts.
- Facilitate industry discussion and ongoing improvement of temperature forecast accuracy.

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Glossary

Term	Description
Dry-bulb temperature	The temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture.
Electricity demand (operational demand)	The sum of scheduled, semi-scheduled, and significant non-scheduled generation connected to the National Electricity Market.
Rolling forecast horizon	A forecast that is always created X hours ahead of the actual observation. For example, for a 4 hour ahead rolling forecast horizon, the observation at 12:00 pm was forecast at 8:00 am, and the observation at 4:00 pm was forecast at 12:00 pm.
Forecast error (°C)	Forecast temperature minus actual temperature
Mean Absolute Error (MAE)	The calculated average of the absolute (unsigned) forecast error. Mean absolute error is only used in reference to temperature forecast error (°C) in this paper.
Accuracy versus precision	Accuracy refers to how close an actual temperature measurement is to the forecast value. Precision is the frequency at which a forecast error is reproduced. Therefore, a set of forecast outcomes could be precise in that its errors fall within a narrow range, and a set of forecast outcomes are both accurate and precise when that small range of errors are close to the actual measurement.

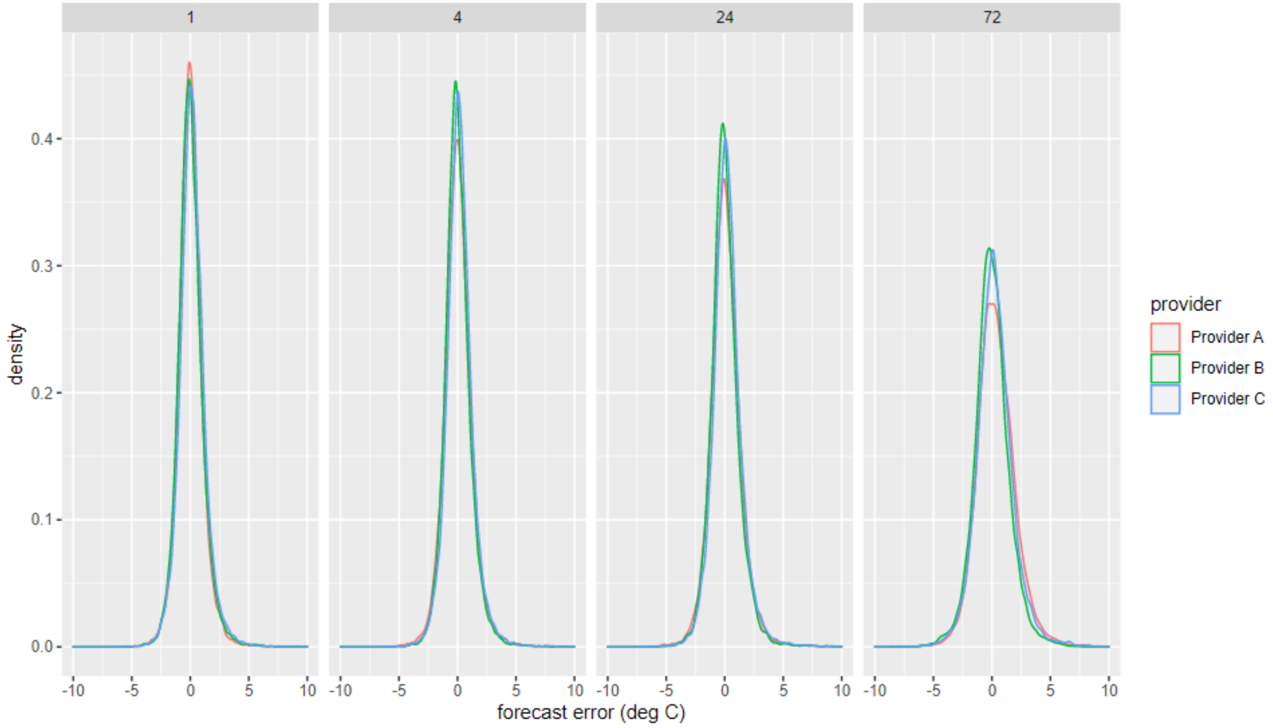
Executive summary

This report examines the hourly temperature forecast performance of AEMO's weather service providers in the National Electricity Market (NEM) from 1 December 2022 to 31 March 2023. The report studies temperature forecast accuracy and precision at the 1, 4, 24, and 72 hours ahead (HA) rolling forecast horizons. It has been prepared as a resource for weather providers to benchmark their performance, and to facilitate discussion and ongoing improvement of temperature forecast accuracy to support system operation and the broader energy industry.

Key findings from summer 2022-23 performance analysis of AEMO's three weather forecast providers (Figure 1) are:

- **Provider A** increased in accuracy for the top 10% of temperatures with no overall significant improvements for all temperatures compared to summer 2021-22. Provider A had the lowest overall performance for the 4, 24, and 72 HA horizon, with accuracy improvements made at half of the weather stations offset by performance degradation at the other half making overall performance improvements negligible.
- **Provider B** increased in forecast performance with significant improvements at Archerfield Airport and Melbourne Olympic Park. For the top 10% of temperatures Provider B had varied performance compared to summer 2021-22. Provider B was the most precise at the 24 HA forecast horizon for the top 10% of temperatures, with a tendency to under-forecast.
- **Provider C** had marginal overall improvements with significant improvements in areas such as the top 10% of temperatures at the 4 and 24 HA forecast horizon. Overall, Provider C was the most accurate for all temperatures at the 24 HA horizon.

Figure 1 Summer 2022-23 performance across all major weather stations and temperatures



This report also includes a case study to discuss the impact of late summer heat on forecast performance in New South Wales and Queensland in March.

AEMO will use this report to aid operational decision-making and draw attention to potential areas of improvement in the weather forecasting industry. This will support existing initiatives between AEMO and the weather forecasting industry, including:

- Redevelopment of AEMO's Projected Assessment of System Adequacy (PASA) to be probabilistic and include weather uncertainty margins in reserve calculations.
- Establishment of new weather observation stations located with renewable energy zones (REZs) near remote variable renewable energy (VRE) generators and in metropolitan heat islands to support weather forecasting.
- Accessing a range of probabilistic weather forecasts from providers to improve situational awareness and better represent extreme weather risk and operational envelopes in demand forecasts.

Contents

Figures

1 Introduction

This report examines the hourly temperature forecast performance of AEMO's three weather service providers in the National Electricity Market (NEM) from 1 December 2022 to 31 March 2023[1]. It aims to highlight the differences in forecasting performance between summer 2021-22 and 2022-23, while also drawing new performance insights from the summer 2022-23 period. It is part of a series of biannual *Temperature Forecast Analysis* reports available on AEMO's website for summer and winter periods since 2018[2].

This report has been prepared as a resource for weather service providers to benchmark their forecast performance, and to facilitate discussion and ongoing improvement of temperature forecast performance to support power system operation in the NEM and the broader energy industry. It includes a case study to discuss the impact of late summer heat on temperature forecast performance in March in Queensland and New South Wales.

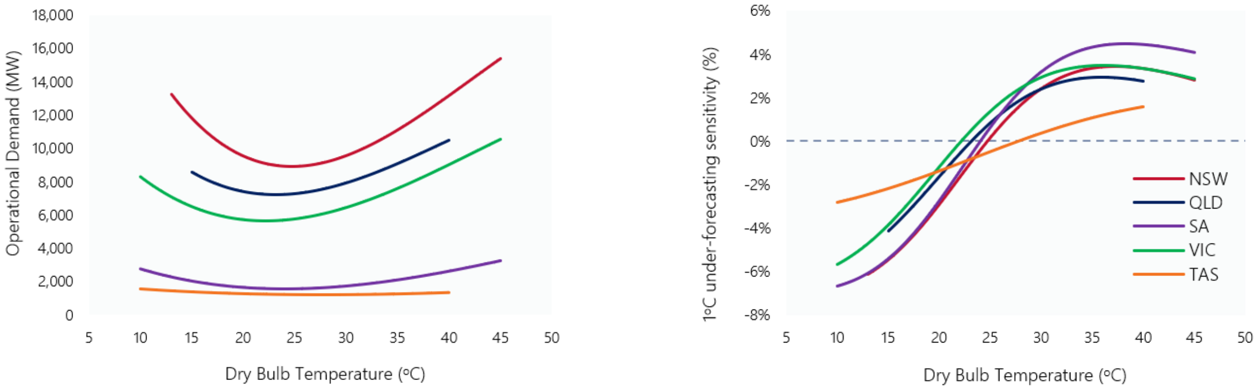
The weather stations analysed in this report are Adelaide West Terrace (WT) (South Australia), Archerfield Airport (AP) (Queensland), Bankstown AP (New South Wales), Hobart AP (Tasmania), Melbourne AP (Victoria), Melbourne Olympic Park (OP) (Victoria), Penrith Lakes (New South Wales) and Sydney AP (New South Wales). These are the main weather stations used by the NEM Demand Forecasting System (DFS) and as such they have the largest influence on demand forecasts for their respective NEM regions.

Within the DFS, the New South Wales, Victoria and South Australia regions are each forecast as a single area. The Queensland region forecast is an aggregate of forecasts for the Northern, Central and Southern areas. The Tasmania region forecast is an aggregate of the Northern and Southern areas.

Sensitivity of electricity demand to temperature

Figure 2 shows the absolute and proportional change in operational demand with reference to temperature for each NEM region, to provide context to the results in this report[3].

Figure 2 Weekday maximum daily operational demand against maximum dry bulb temperature (left) and the percentage change in operational demand for a 1°C under-forecasting error (right) for each NEM region



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[1] All analysis refers to time in Australian Eastern Standard Time (AEST).

[2] Previous reports available at https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/operational-forecasting/load-forecasting-in-pre-dispatch-and-stpasa.

[3] This analysis shows the relationship of maximum daily dry bulb temperature and maximum daily operational demand on weekdays between 1 January 2018 and 31 March 2023. The temperature readings were taken from the primary weather station for demand forecasting in each region (New South Wales – Bankstown AP, Queensland – Archerfield AP, Victoria – Melbourne OP, South Australia – Adelaide WT, Tasmania – Hobart AP).

The performance of a temperature forecast must be understood with reference to its operational impact on electricity demand. The performance of temperature forecasts is most critical for operational demand forecasting when demand is high, generation reserves are low, or when a small change in temperature results in a large change in demand. These conditions are often encountered on hot summer and cold winter days, meaning it is important for weather providers to produce accurate and precise temperature forecasts on these days.

Electricity demand has different temperature sensitivity in each NEM region due to factors such as climate and the mix of residential, commercial, and industrial load. In addition, the same demand forecast error will have different operational impacts for different regions. Since each region has limited local generation and interconnector capacity, percentage changes in demand must be understood in conjunction with absolute demand changes.

Load growth in the NEM

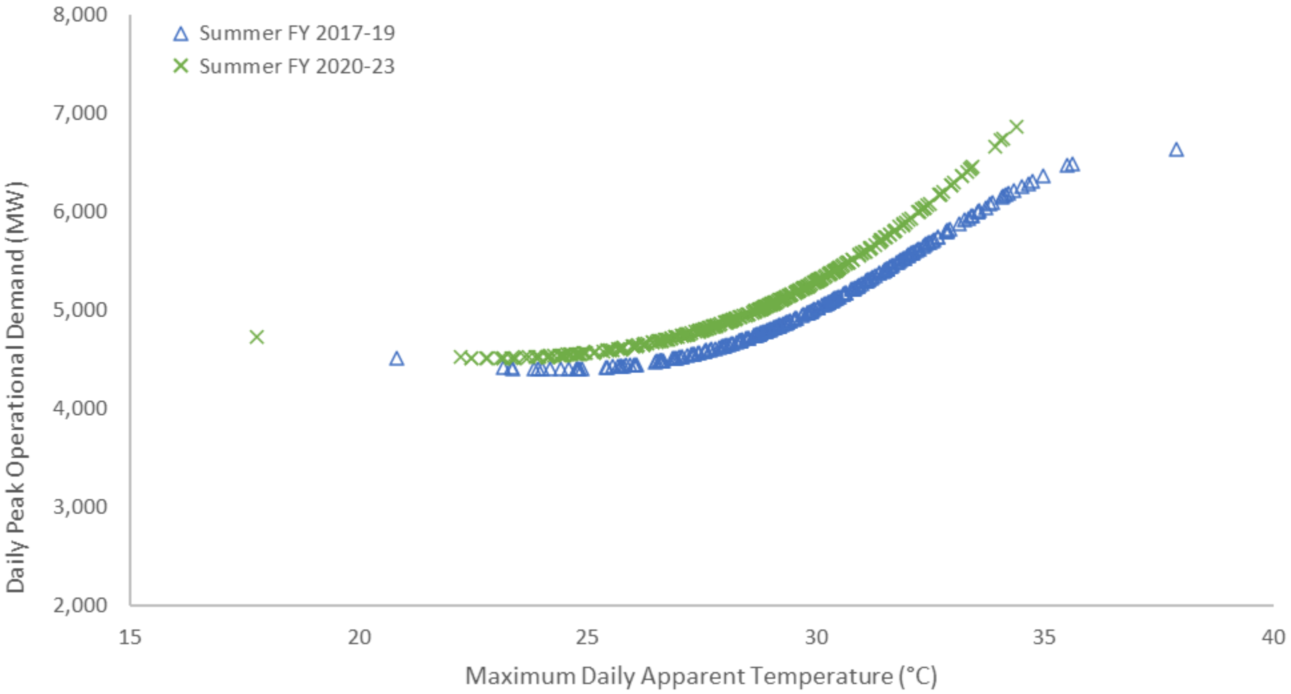
Over the past couple of years, there has been an increase in the proportion of people working from home. This in turn has elevated residential load and increased the temperature sensitivity of demand overall, particularly at extreme temperatures when there are significant heating and cooling loads.

In addition to increased temperature sensitivity, underlying load growth in select NEM regions has become apparent. Figure 3 demonstrates this for southern Queensland by showing daily maximum demand for weekdays in summer between 2017 and 2023 for different maximum daily apparent temperatures averaged across the weather stations used in the DFS.

Compared to days between 2017-19, there is an apparent increase in demand for all temperatures during the 2020-23 summers, with a greater magnitude, or flex, at higher temperatures. Northern Queensland also showed an increase in demand, but it was only material at higher temperatures.

Analysis was performed for other NEM regions, but no underlying load growth was identified outside of extreme temperature flex.

Figure 3 Summer weekday maximum daily operational demand against maximum daily apparent temperature for southern Queensland



Humidity impact on summer electricity demand

Humidity's impact on electricity demand is felt most when it is combined with high dry bulb temperatures. In warm, humid weather, moisture in the air can impede the body's ability to cool down, making people feel hotter for longer. This in turn drives demand for electricity demand through air-conditioning. Also, when humidity levels are high, it negatively affects the cooling efficiency of air-conditioning units, meaning they consume more electricity.

The weather concept that best describes this relationship between humidity and the need for cooling is the dew point, which is the temperature to which air must be cooled to produce condensation (dew). Dew point is related to the quantity of moisture, while relative humidity expresses how close the air is to saturation. Because of its direct relationship to fluctuating temperature, relative humidity doesn't provide suitable guidance on how much moisture is available at a specific location.

The conditions someone is accustomed to, as well as their metabolism, vary the way dew point is experienced. For those living in Brisbane, a dew point above 20˚C would start to feel muggy and uncomfortable, but the same dew point would feel considerably more oppressive in Melbourne, where people are less acclimatised to this type of weather[4].

The accuracy of humidity forecasts is most critical for operational demand forecasting when temperatures are high and therefore so is demand. These conditions are typically only encountered on hot summer days in the northern states such as Queensland, although specific weather patterns can push high humidity into the southern parts of Australia.

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[4] The weather concept of dew point provides a gauge of the impact of the combination of temperature and humidity and helps infer what the conditions may feel like. For more information on dew point, see https://media.bom.gov.au/social/blog/1324/feeling-hot-and-bothered-its-notthe-humidity-its-the-dew-point/.

The last three summers in Australia have been under the influence of La Niña, which typically corresponds to greater moisture in the atmosphere and hence an average increase in humidity. The recent summer humidity was a major driver in demands for the past three summers. The Bureau of Meteorology is currently forecasting a 70% chance of El Niño this year, which typically corresponds to a warmer and drier summer[5].

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[5] Climate Driver Update http://www.bom.gov.au/climate/enso/

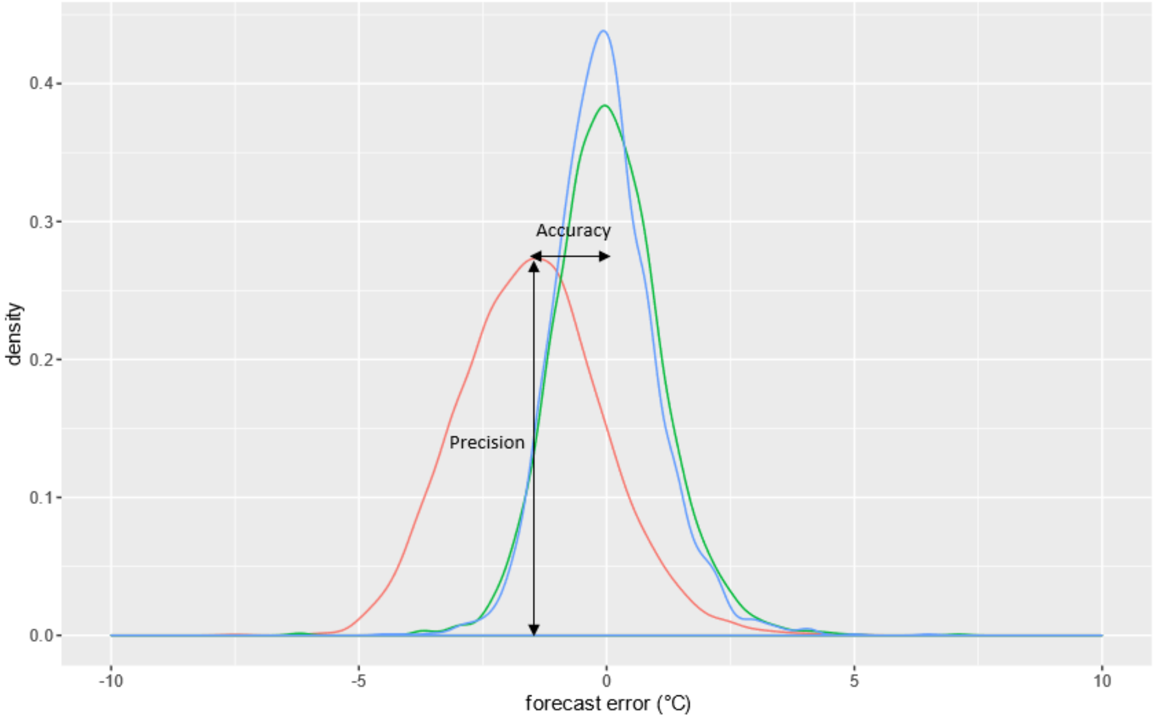
2 Summer forecast performance

This section contains a selection of temperature forecasting performance insights for summer 2022-23 in the NEM. Results supporting major insights are included in this section, with additional results in the appendices. This report studies temperature forecast performance at the 1, 4, 24, and 72 HA rolling forecast horizons.

Many of the results in this section and in A1 are displayed as error density plots like Figure 4 below. These figures can be interpreted as follows:

- The **x-axis shows forecast error**. Positive values indicate over-forecasting (the forecast temperature exceeded the actual temperature), and negative values indicate under-forecasting (the forecast temperature was lower than the actual temperature).
- The **y-axis shows error density**. This reflects the relative rate of a forecast error occurring. For each forecast error, the error density will be between 0 and 1, and the area under each curve equals 1.
- The **height of the error density peak captures the level of forecast precision**. The higher the peak, the greater the forecast precision and the smaller the expected deviation from the level of error. In Figure 4, the forecast distribution (blue) has the highest precision, and the forecast distribution (red) has the lowest precision.
- The **position of the peak captures the forecast accuracy** with respect to a forecast error of zero. The further the peak is from zero error, the lower the accuracy, and the larger the tendency for over- or under-forecasting on average. In Figure 4, the forecast distribution in red is less accurate than the forecast distributions in green and blue.

Figure 4 Accuracy and precision in the error density plot



A2 contains intraday mean absolute error (MAE) profiles for major weather stations, where forecasts are provided for each hour of the day and for each provider.

2.1 Overall performance

Weather conditions in summer 2022-23

During summer 2022-23, national mean temperatures were 0.07˚C above the long-term average, with daytime temperature above average for parts of the NEM. The national mean minimum temperature was 0.09°C above average. Daytime temperatures were below or very much below average across much of Queensland away from the south, New South Wales, and most of the Northern Territory. Daytime temperatures were above to well above average for western to central Western Australia, Tasmania, south Victoria, and parts of pastoral South Australia[6].

Summer rainfall was 27% above the long-term average for Australia. Summer rainfall was above average for most of northern Australia, however large areas in Tasmania, Victoria, eastern and northern New South Wales, and southeast Queensland had a drier than average summer. With the well above average rainfall large areas of northern Australia experienced significant flooding, and flooding continued to affect parts of the Murray and Darling rivers in western New South Wales and South Australia continuing from flooding during spring.

While maximum temperatures were above average for parts of the NEM, extreme temperatures at NEM capitals did not reach record levels. A small number of coastal weather stations in Queensland observed their coolest summer daily maximum on record. The NEM experienced a run of heat in March, with average March maximum temperature days 1.11˚C above average[7]. The March heat resulted in record breaking demand levels, with Queensland reaching a new all-time operational demand record of 10,070 megawatts (MW) on Friday 17 March, and the two highest March operational demand records were set in New South Wales (see case study, Section 3).

Overall summer 2022-23 performance insights

Figure 5 and Figure 6 below show the performance comparison of 2021-22 and 2022-23 summer periods across all studied weather stations for Providers A, B, and C.

Key insights include:

- **Provider A increased in accuracy for the top 10% of temperatures with no overall significant improvements** for all temperatures compared to summer 2021-22. Provider A had the lowest overall performance, with accuracy improvements made at half of the weather stations offset by performance degradation at the other half.
- **Provider B had increased in forecast performance** with significant improvements at Archerfield AP and Melbourne OP. For the top 10% of temperatures Provider B had varied performance compared to summer 2021-22. Provider B was the most precise at the 24 HA forecast horizon for the top 10% of temperatures, with a tendency to under-forecast.
- **Provider C had marginal overall improvements with significant improvements in areas** such as the 10% of temperatures at the 4 and 24 HA forecast horizon. Provider C was the most accurate for all temperatures at the 24 HA horizon.

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[6] Australia in Summer 2022-23, Bureau of Meteorology, at http://www.bom.gov.au/clim_data/IDCKGC2AR0/202302.summary.shtml.

[7] Australia in March 2023, Bureau of Meteorology, at http://www.bom.gov.au/clim_data/IDCKGC1AR0/202303.summary.shtml.

Figure 5 Summer 2021-22 and 2022-23 performance comparison across major weather stations, all temperatures

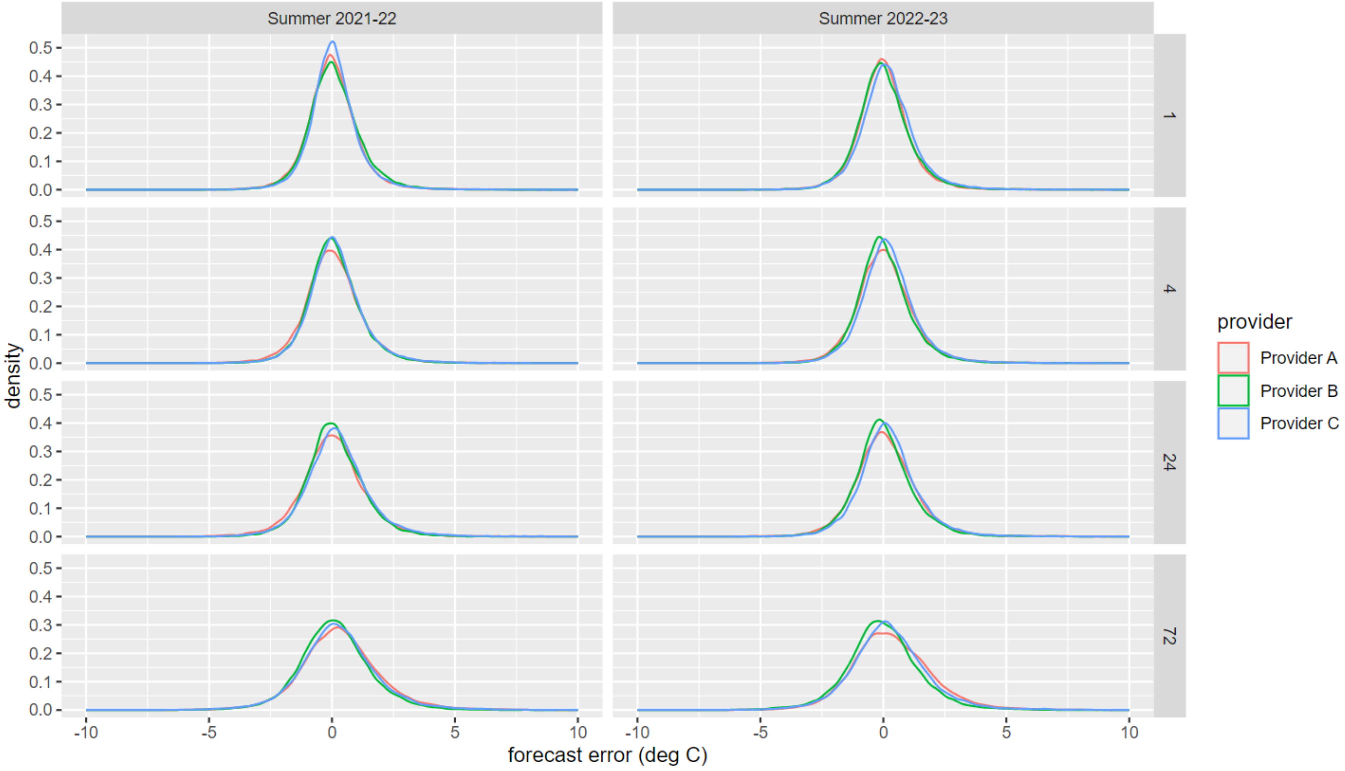
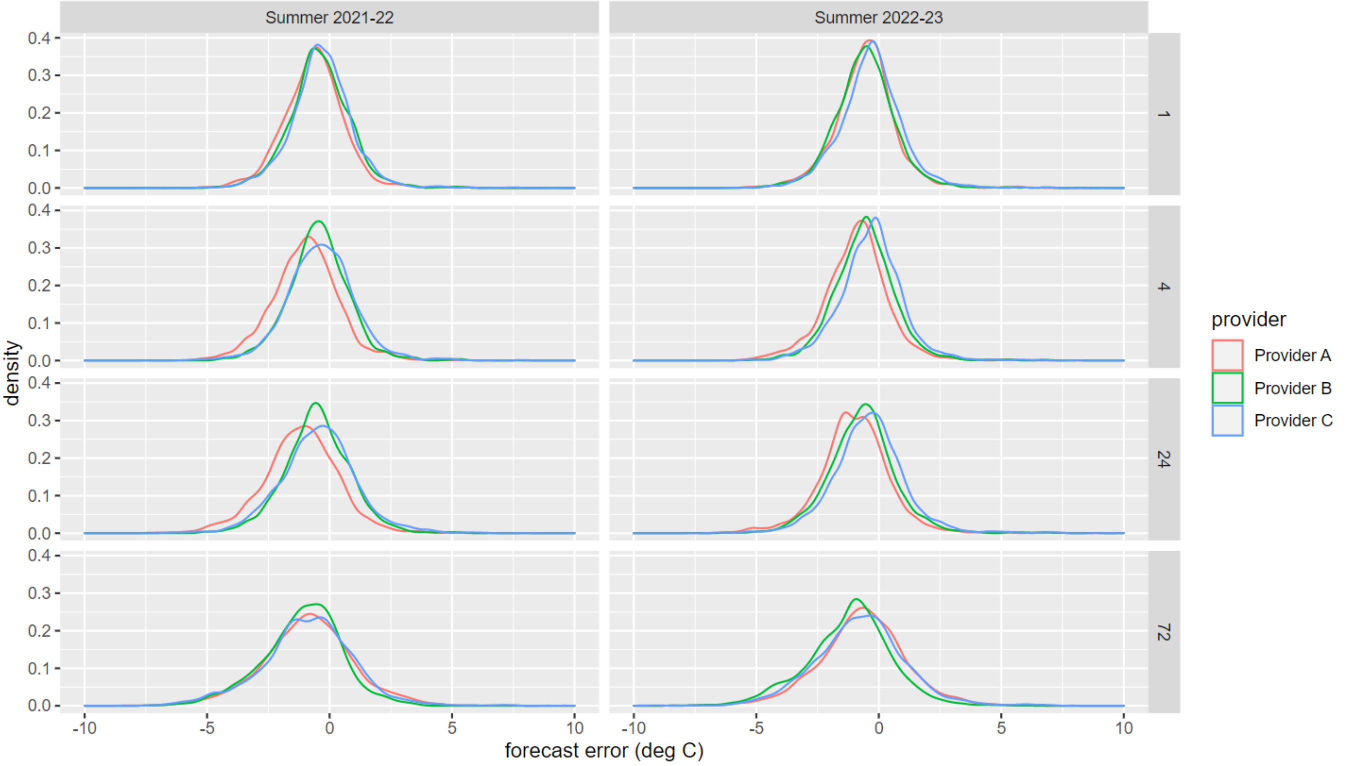


Figure 6 Summer 2021-22 and 2022-23 performance comparison across major weather stations, top 10% of temperatures



2.2 Provider A forecast performance

Provider A had no overall improvements in accuracy and precision across all summer conditions, but an improvement at forecasting the top 10% of temperatures.

Provider A did not exhibit any overall improvement or reduction at the 24 HA forecast horizon, but improved for the top 10% of temperatures, especially at the 1 and 4 HA horizon when compared to summer 2021-22. Major improvements were seen at Melbourne OP and AP, as well as minor improvements at Archerfield AP and Sydney AP, with minor decreases in performance at the other weather stations, seen in Figure 7.

When examining the top 10% of temperatures at the 24 HA forecast horizon, Provider A demonstrated a forecast improvement across all weather stations except Archerfield, seen in Figure 24 (in Appendix A1.2). There was significant improvement at Sydney AP, Bankstown AP and Adelaide AP, as shown in Figure 8.

Compared to other providers, Provider A performed lowest overall in summer 2022-23 in terms of accuracy across the 4, 24 and 72 HA rolling forecast horizons, but performed best at the 1 HA horizon, as shown in Figure 9. This lower performance was observed across all stations at the 4 and 24 HA forecast horizons, and across the 72 HA except for Hobart AP. The intraday MAE profiles in appendix A2 show accuracy issues during the middle of day and evening at the 4, 24, and 72 HA horizons at Adelaide WT and Sydney AP, and 72 HA horizon at Bankstown AP and Melbourne AP.

Figure 7 Major weather stations, Provider A, all summer temperatures 2021-22 and 2022-23, 24 HA

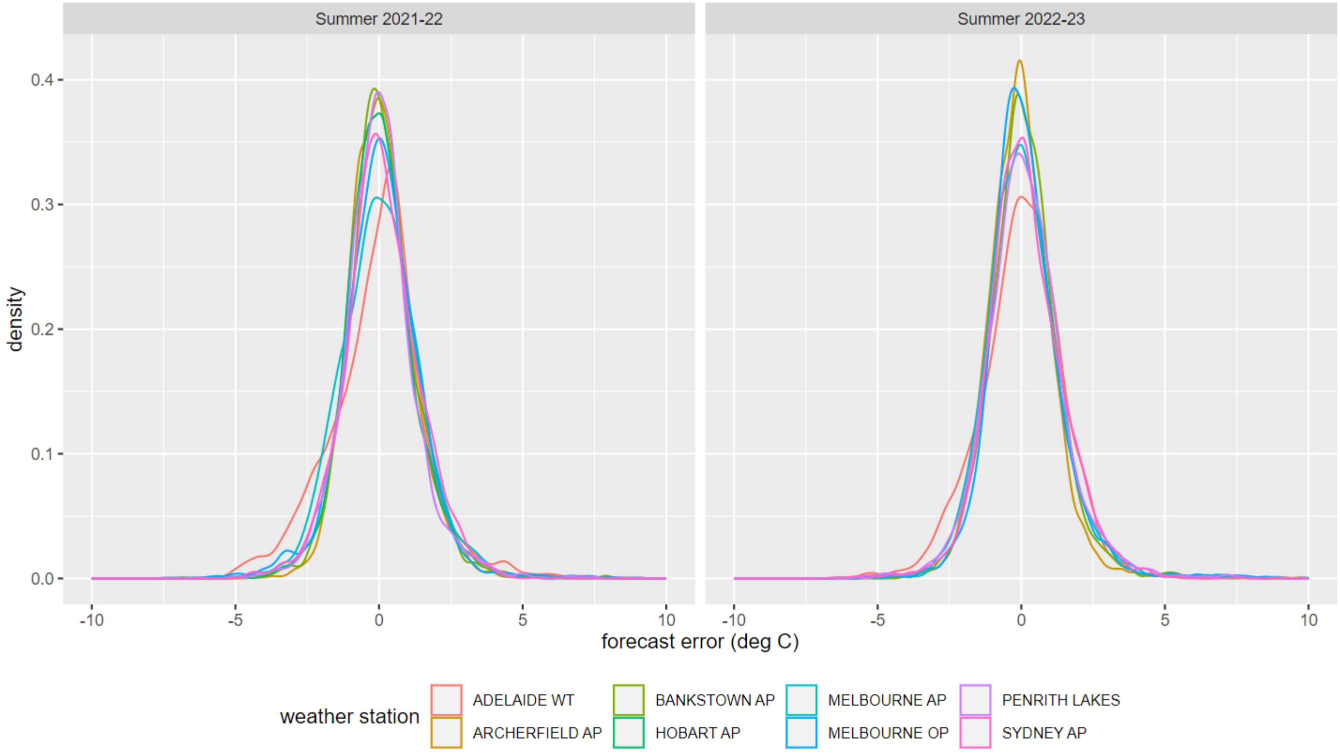


Figure 8 Major weather stations, Provider A, top 10% summer temperatures 2021-22 and 2022-23, 24 HA

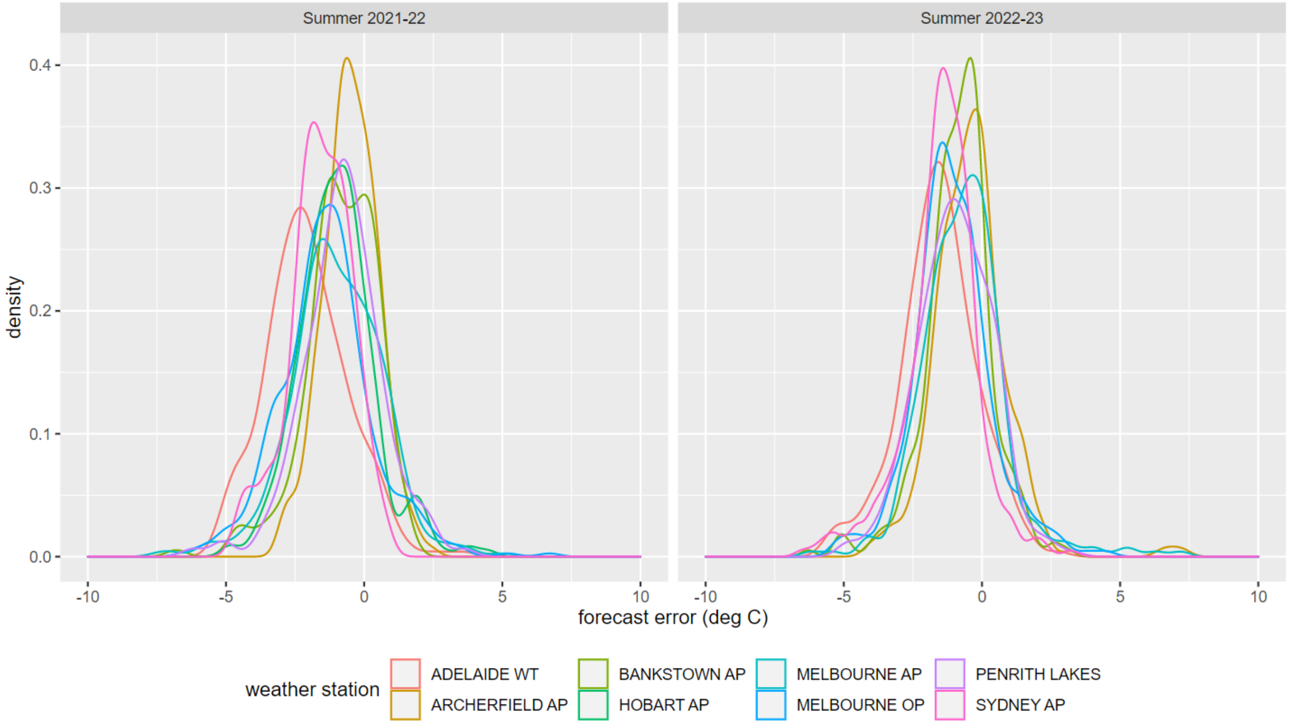
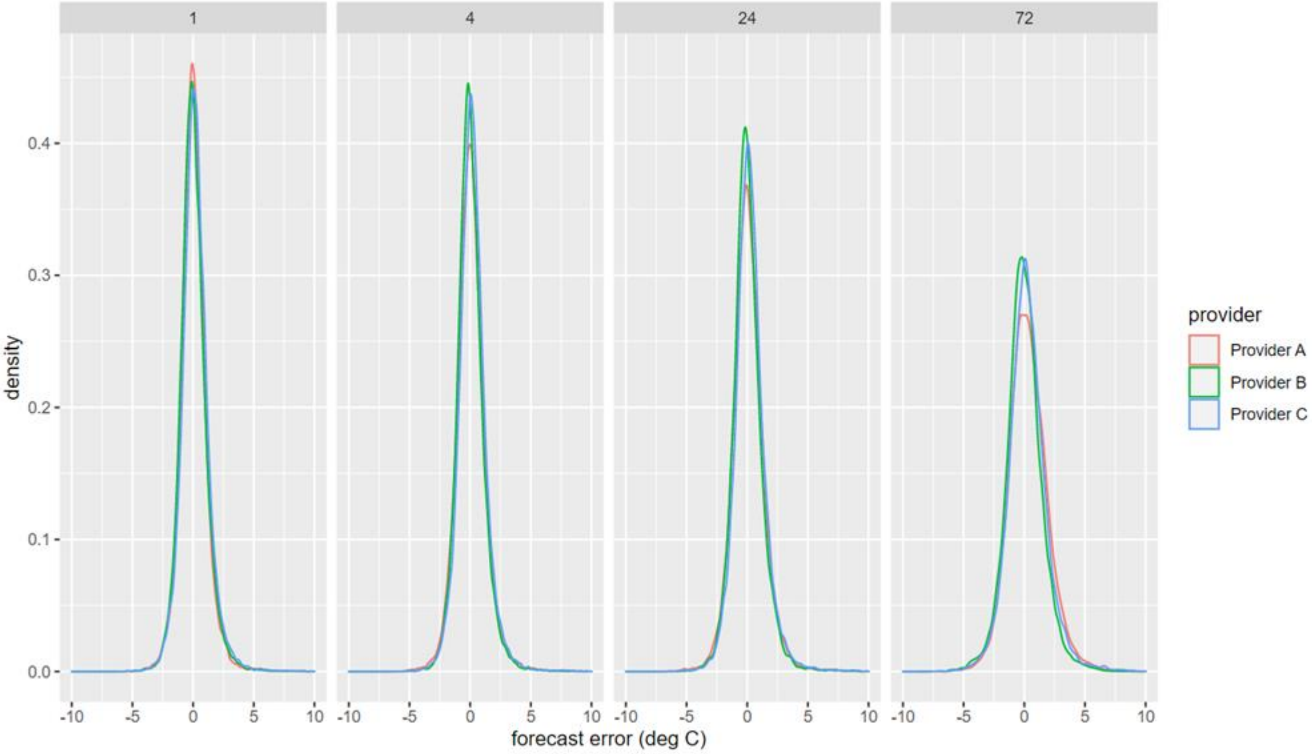


Figure 9 Summer 2022-23 Performance comparison across major weather stations, all providers, all temperatures



2.3 Provider B forecast performance

Provider B had forecast performance improvements compared to summer 2022-23.

Provider B showed an overall improvement in forecasting performance at the 24 HA horizon compared to summer 2021-22. Provider B was the most precise provider at the 24 HA horizon for all temperatures and the top 10% but tended to under-forecast, shown in Appendix A1.1. Significant accuracy improvements were observed at Archerfield AP, Melbourne OP, and Sydney AP, shown below in Figure 10.

For the top 10% of temperatures, Provider B had varied performance overall compared to last summer with a continued trend to under-forecast at all forecast horizons and a lower accuracy at 72 HA, seen in Figure 24 (in Appendix A1.2). For the top 10% of temperatures, Provider B had improved precision at select weather stations and decreased at others, particularly Archerfield AP, Bankstown AP, and Sydney AP, averaging total performance improvements to be insignificant, shown below in Figure 11.

The intraday MAE profiles in Appendix A2 show Provider B was the highest performer for almost all forecast horizons at Adelaide WT and improved at Archerfield AP at the 24 and 72 HA horizons. For the other weather stations Provider B had similar performance to the other providers.

Figure 10 Major weather stations, Provider B, all summer temperatures 2021-22 and 2022-23, 24 HA

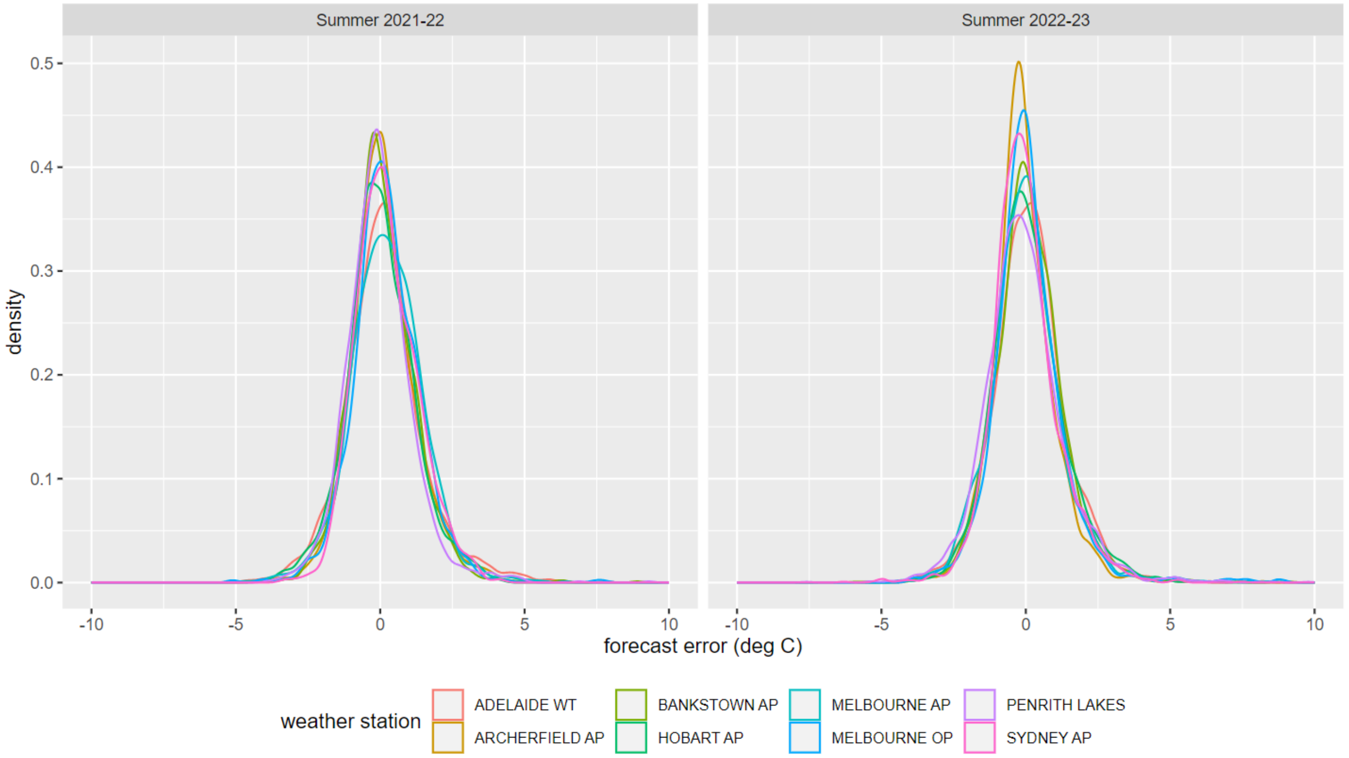
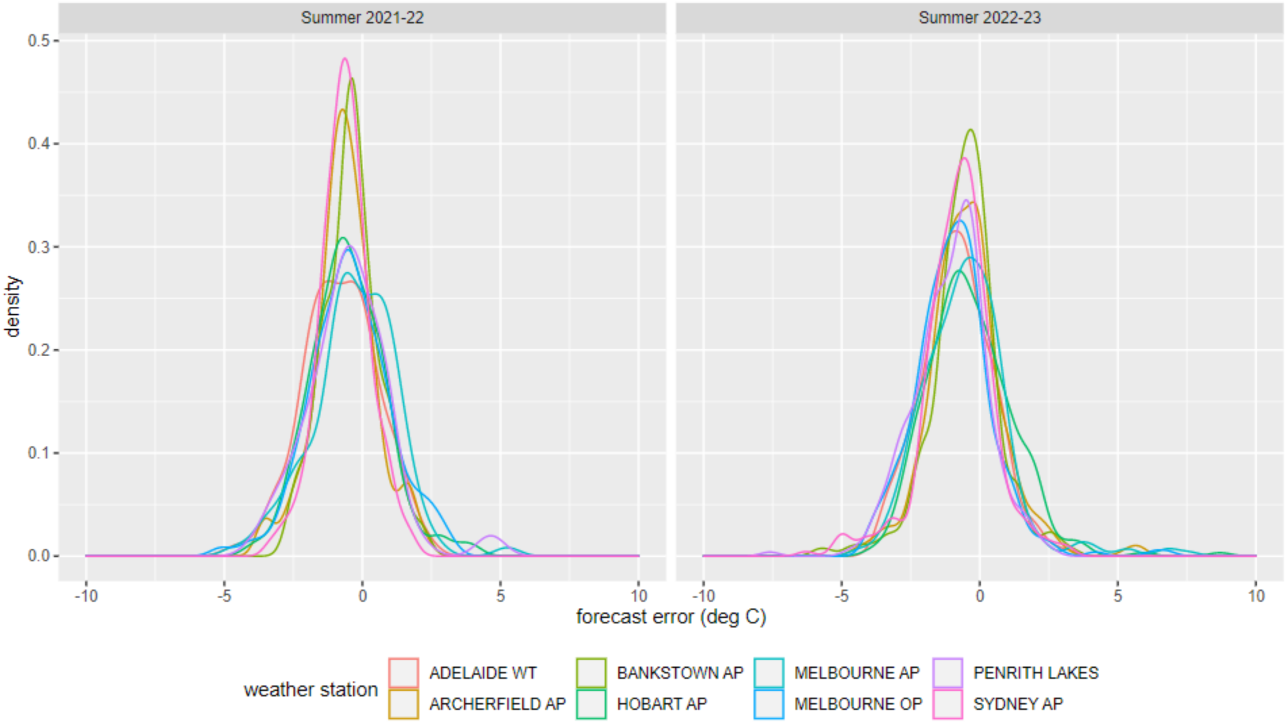


Figure 11 Major weather stations, Provider B, top 10% summer temperatures 2021-22 and 2022-23, 24 HA



2.4 Provider C forecast performance

Provider C had marginal overall forecast improvement, with increased accuracy in some areas.

Provider C increased in forecast accuracy at the 24 HA horizon for all temperatures and significantly improved accuracy for the top 10% of temperatures especially at the 4 and 24 HA horizon compared to summer 2021-22. At individual stations, Provider C vastly improved at Archerfield AP, Sydney AP and Melbourne OP for the 24 HA forecast horizon, shown below in Figure 12. For the top 10% of temperatures, Provider C decreased in accuracy at Archerfield AP and improved significantly at Sydney AP and Melbourne OP, shown in Figure 13.

Compared to summer 2021-22, Provider C decreased in accuracy at the 1 HA forecast horizon for all temperatures but increased in accuracy for all forecast horizons for the top 10% of temperatures, seen in Figure 23 and Figure 24 (in Appendix A1.2). Provider C was the most accurate provider at 24 HA for Sydney AP and 4 HA for Archerfield AP.

The MAE profiles in Appendix A2 show Provider C reduced in forecasting performance during the early morning hours at Adelaide WT.

Figure 12 Major weather stations, Provider C, all summer temperatures 2021-22 and 2022-23, 24 HA

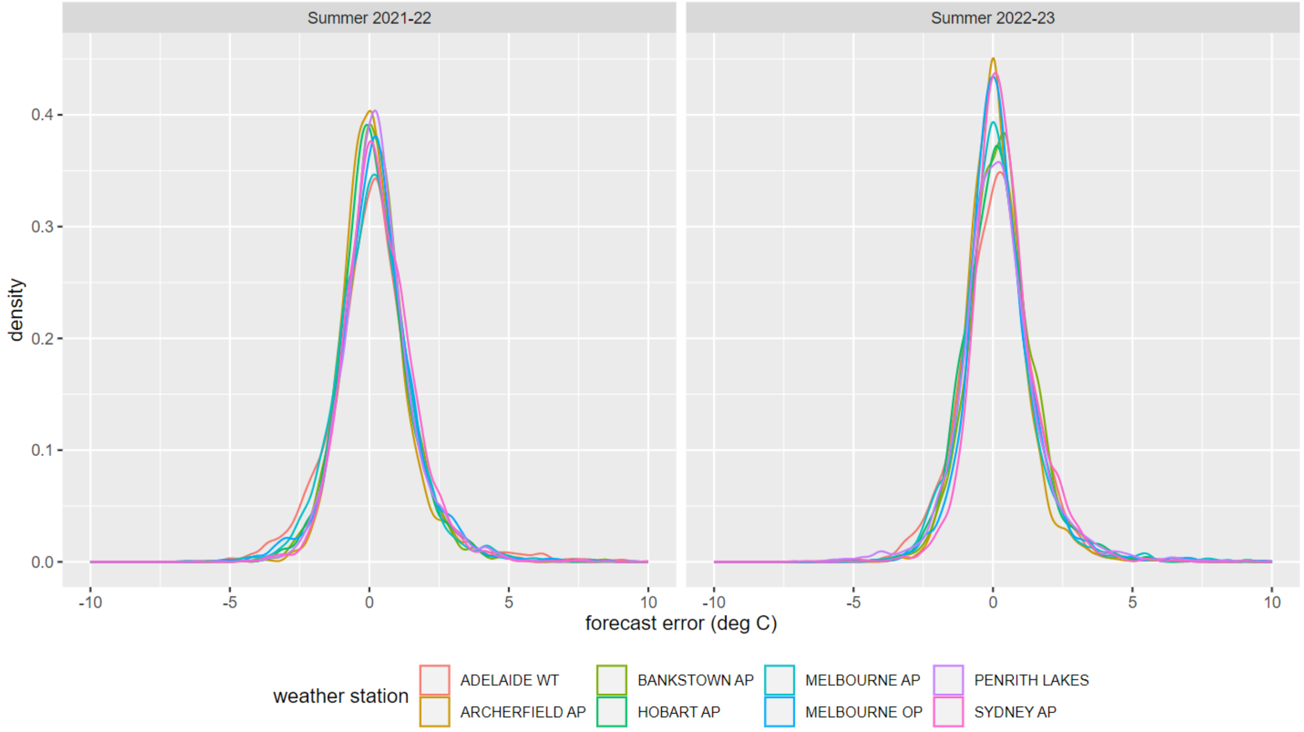
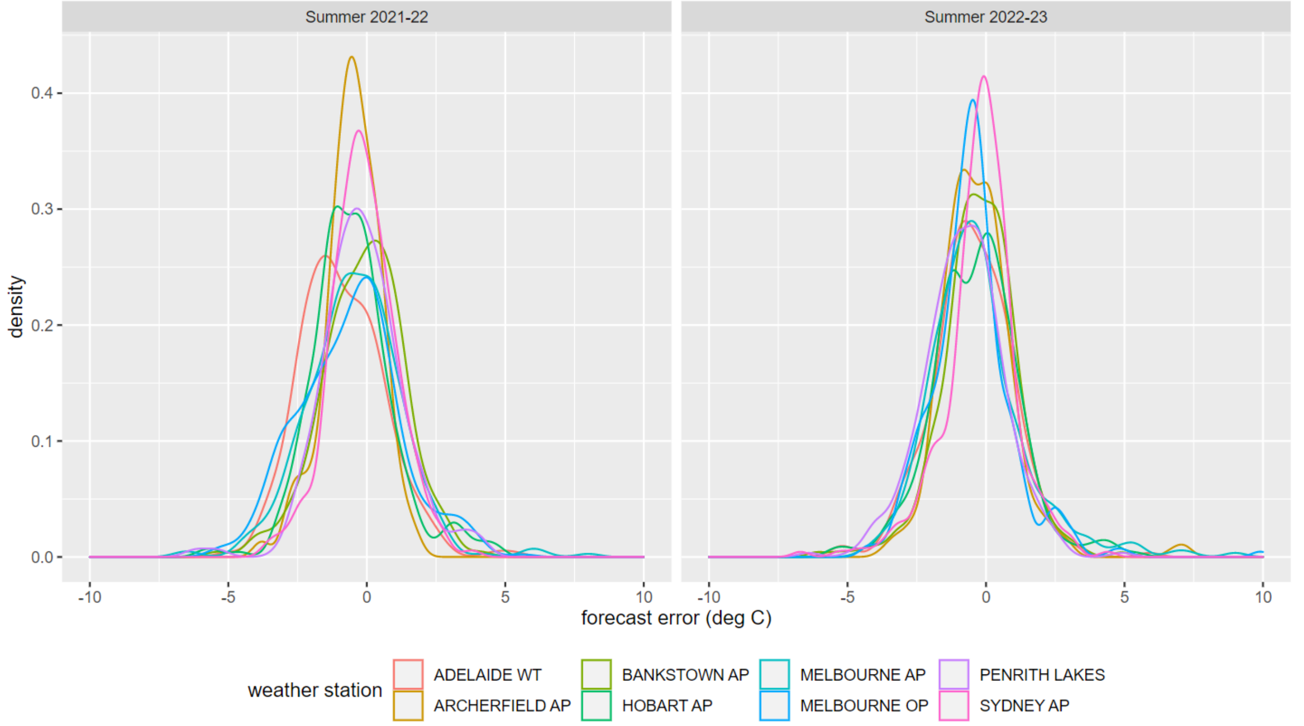


Figure 13 Summer 2022-23 performance comparison across major weather stations, top 10% temperatures



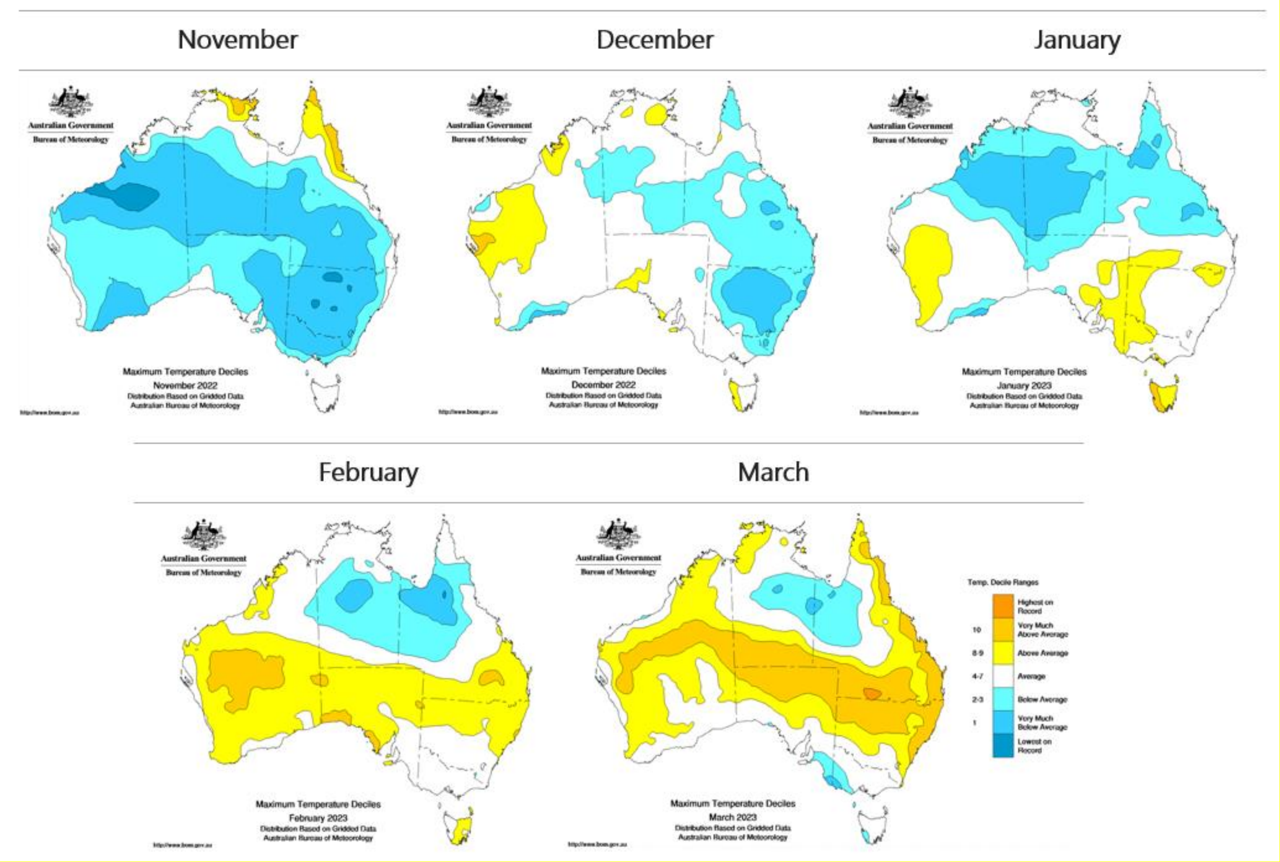
3 Case study: March heat along the east coast

This case study explores the temperature forecasts of a series of hotter than average March maximum temperature days, specifically focusing on New South Wales and Queensland, and the subsequent impacts this had on electricity demand forecasting.

Temperature forecasts and outcomes

In March 2023, the mean temperature across Australia was 1.11°C above the 1961-90 average, marking the tenth hottest March on record[8]. This extreme heat resulted in majority of states, especially on the east coast, experiencing heatwaves and seasonal record levels of daily maximum temperatures. These conditions were somewhat unexpected and sudden, especially after Australia had just experienced three La Niña cycles in succession, which brought cooler conditions and above average rainfall throughout much of the previous months in summer 2022-23. Figure 14 shows the change in weather patterns and the heat brought to the country.

Figure 14 Australian maximum temperature deciles, November 2022 to March 2023



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[8] See http://www.bom.gov.au/clim_data/IDCKGC1AR0/202303.summary.shtml

New South Wales

On Monday 6 March 2023, New South Wales experienced an extreme heat day, due to a trough dragging a hot airmass into the state. Maximum dry bulb temperature forecasts for 6 March 2023 were 37.9°C at Bankstown AP at 1400 hrs, and 37°C at Sydney AP and 38.3°C at Penrith Lakes, at 1500 hrs. It is important to note that the dew point and humidity levels were at average levels for March; if they had been higher this would have created a perception of higher temperatures, increasing operational demand.

Maximum temperatures at Bankstown AP reached 38.7°C at 1500 hrs, 40.1°C at Sydney AP at 1500 hrs and 39.1°C at Penrith Lakes at 1300 hrs. All providers were able to forecast the conditions reasonably well on this day at Bankstown AP and Penrith Lakes, due to low dew point and humidity levels, however all slightly under-forecast for most of the day. Figure 15 and Figure 16 show the temperature forecast from each provider against actual temperature conditions at Bankstown AP and Penrith Lakes respectively. At Sydney AP all forecast providers significantly under-forecast the maximum temperature at the 24 and 72 HA horizon, with Provider A and Provider C able to adjust their forecasts more accurately at the 1 and 4 HA horizon shown below in Figure 17.

Figure 15 Forecast temperatures at various horizons against actual temperature observations for each provider at Bankstown AP on 6 March 2023

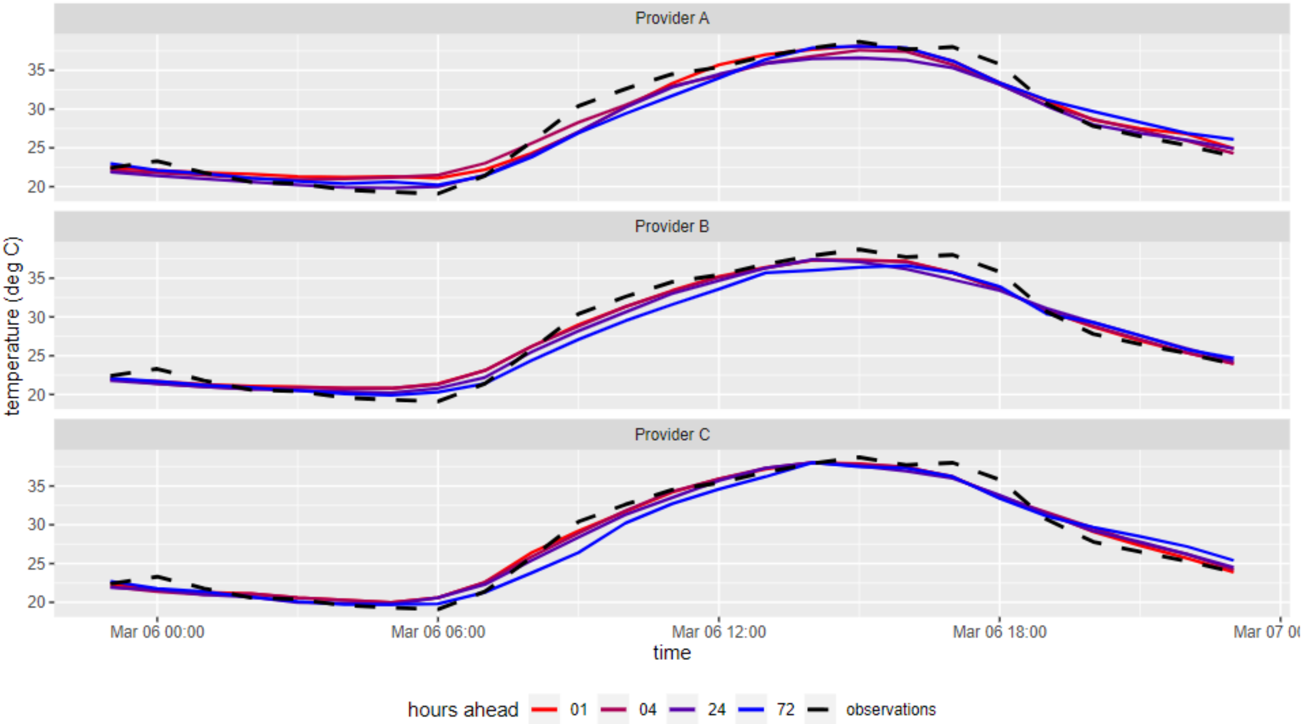


Figure 16 Forecast temperatures at various horizons against actual temperature observations for each provider at Penrith Lakes on 6 March 2023

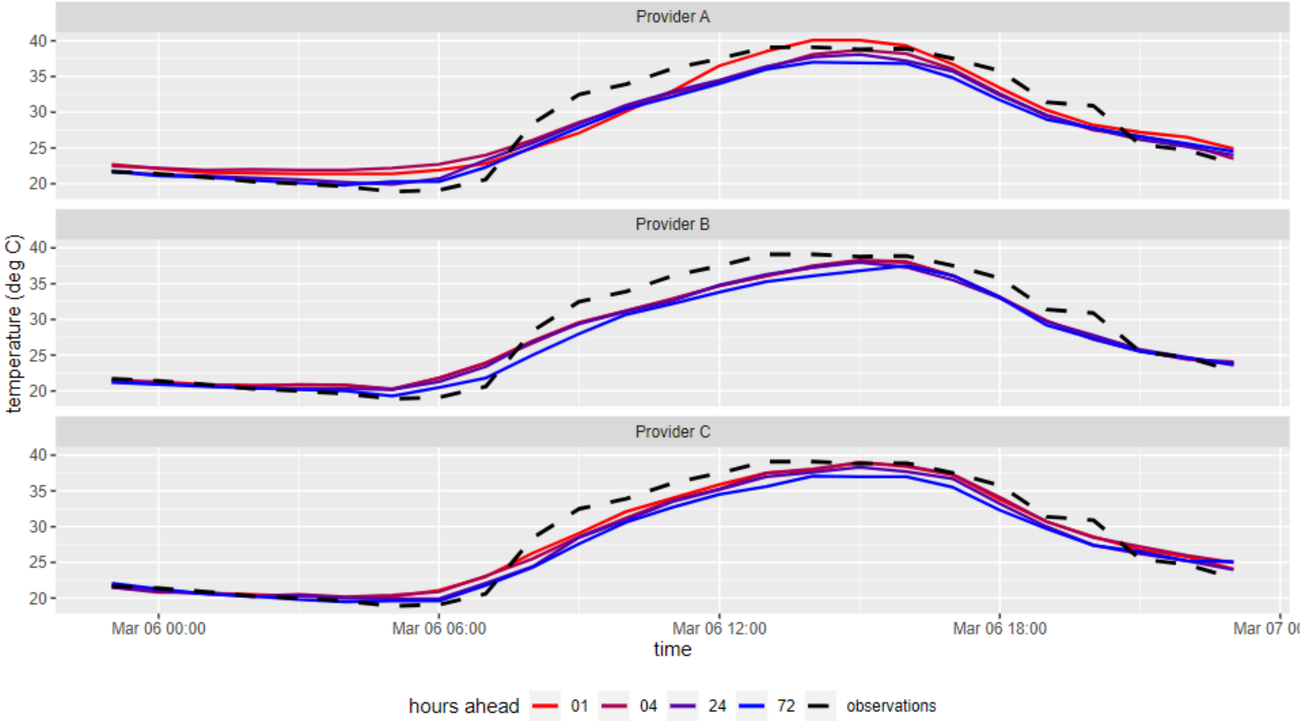
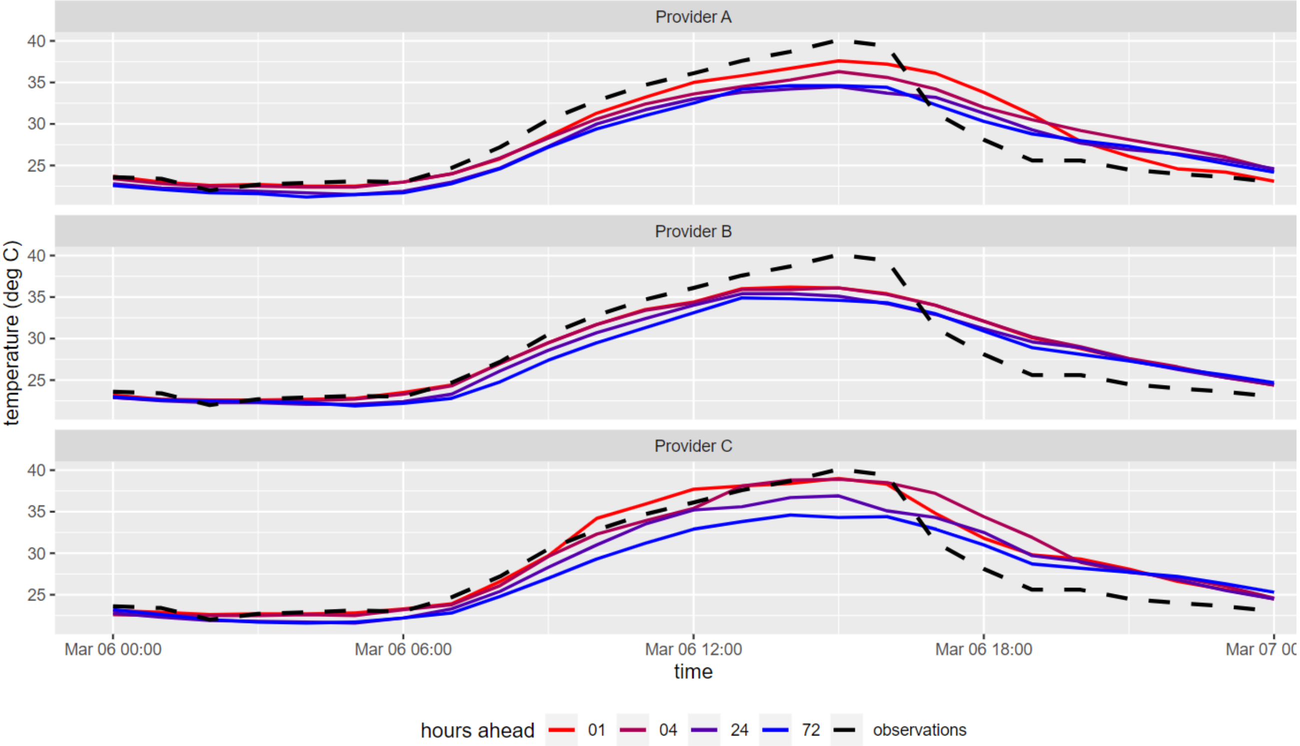


Figure 17 Forecast temperatures at various horizons against actual temperature observations for each provider at Sydney AP on 6 March 2023

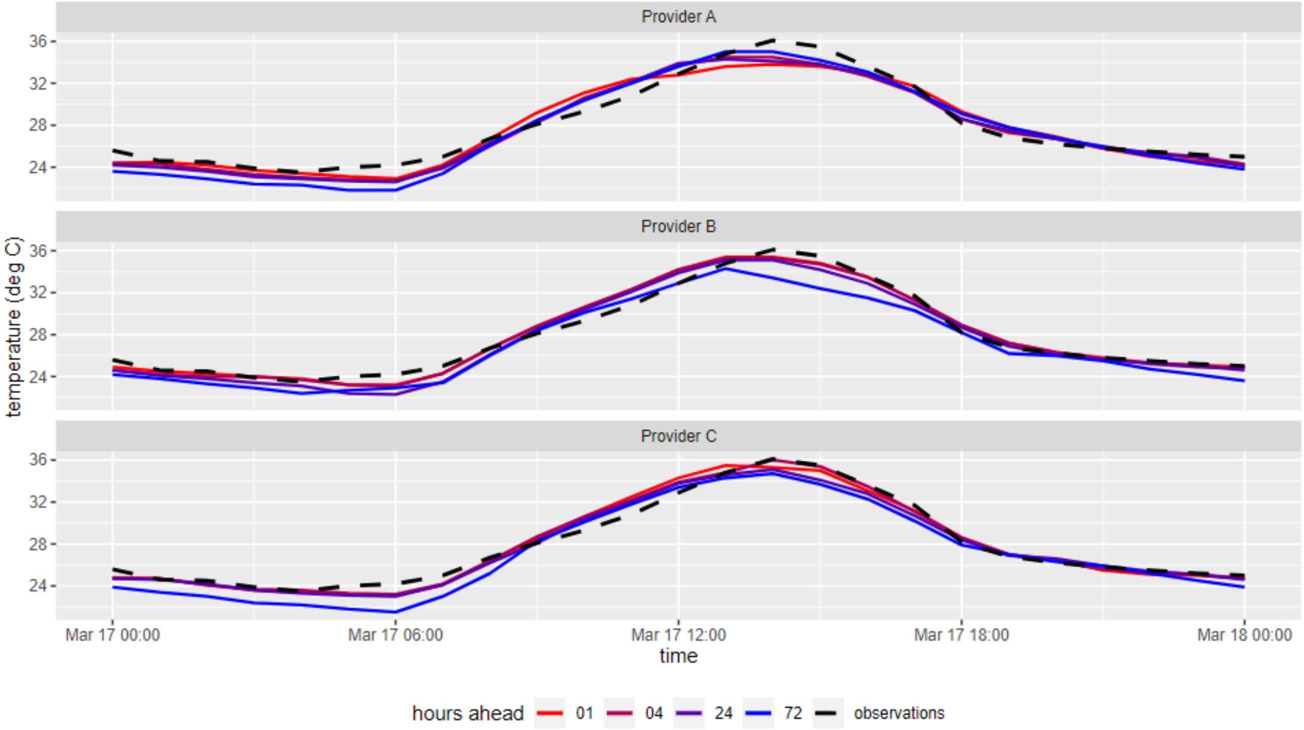


Queensland

Queensland encountered an intense heat and muggy day on Friday 17 March 2023. High dry bulb temperatures were combined with a high dew point resulting from a hot airmass moving around the state and a high-pressure ridge bringing wind and showers. A maximum dry bulb temperature of 35.1°C was forecast at Archerfield AP and the 1500 hrs dew point forecast was above average at 21.7°C.

The actual maximum dry bulb temperature was 36.1°C at 1500 hrs, with an accompanying dew point of 23°C. Despite these challenging forecast conditions, all weather providers provided reasonable temperature forecasts, each slightly under-forecasting the minimum and maximum day temperatures at Archerfield AP, as shown in Figure 18.

Figure 18 Forecast temperatures at various horizons against actual temperature observations for each provider at Archerfield AP on 17 March 2023



Demand forecasts and outcomes

The heat events during March 2023 resulted in record March demand levels observed in New South Wales, and all-time peak demand records for Queensland.

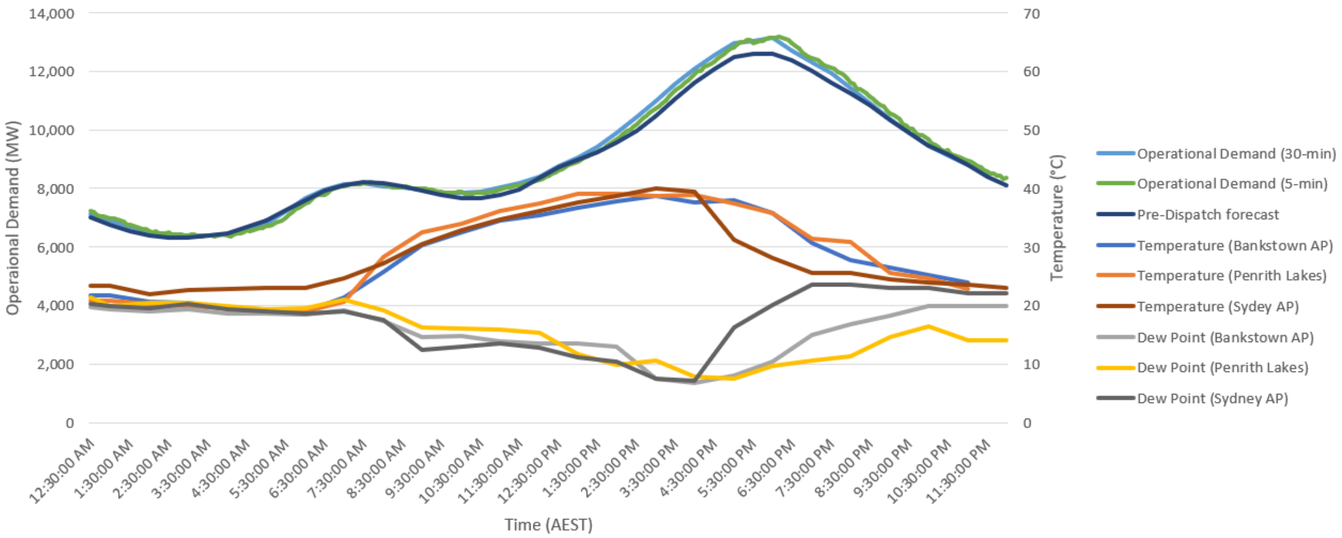
New South Wales

On Monday 6 March 2023, demand in New South Wales peaked at 13,136 MW and was almost 1,000 MW higher than the previous March record of 12,173 MW on 9 March 2016. It did not, however, exceed the all-time New South Wales peak operational demand of 14,744 MW, set on 1 February 2011.

Figure 19 shows the deviation between the operational demand recorded on the demand and the day-ahead (pre-dispatch) operational demand forecast. The forecast temperatures were below the observed temperatures, which contributed to a maximum error between pre-dispatch forecast and 30-minute operational demand of

531 MW at 1800 hrs, the time of peak demand on that day. It is important to note that the largest temperature forecast deviation was seen at Sydney AP, which unusually had a higher maximum temperature than Bankstown AP and Penrith Lakes, leading to challenging summer forecast conditions.

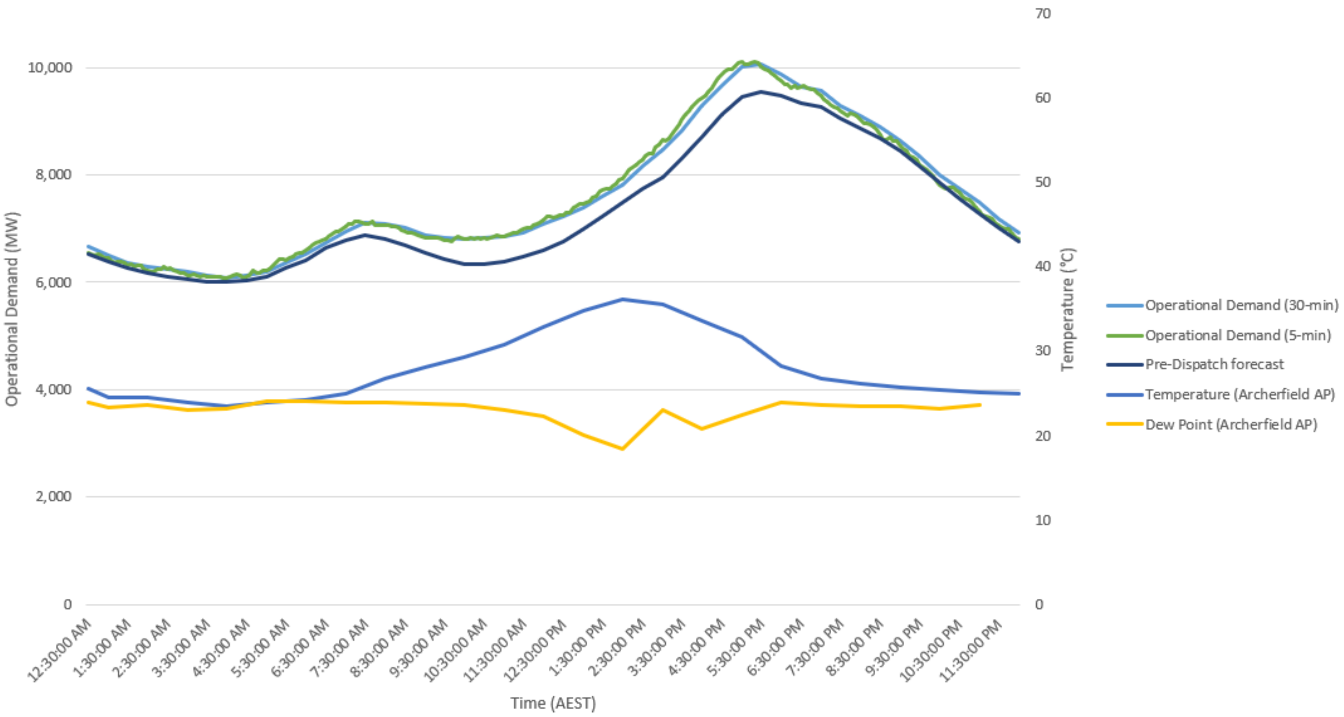
Figure 19 Operational demand, pre-dispatch forecast, temperature, and humidity in New South Wales on Monday 6 March 2023



Queensland

Queensland had its maximum operational demand record surpassed on Friday 17 March, with demand peaking at 10,070 MW. This replaced the previous record of 10,058 MW set on 8 March 2022 and was the third time operational demand in the state exceeded 10,000 MW. Figure 20 shows the deviation between the operational demand recorded on the demand and the day-ahead operational demand forecast for Queensland. The major impact of this event was experienced in southern Queensland.

Figure 20 Operational demand, pre-dispatch forecast, temperature, and humidity in Queensland on Friday 17 March 2023



The maximum deviation between the pre-dispatch forecast and 30-minute operational demand was 576 MW at 1600 hrs, before the evening peak. Adjustments to the forecast were made on the day to increase the evening forecast by up to 300 MW. The forecast deviations between pre-dispatch and operational demand can be attributed to:

1. Overnight temperatures were warmer than forecast, contributing to a build-up of heat in houses and buildings.
2. Afternoon temperatures were warmer than forecast, leading to more cooling load in residential and commercial buildings.
3. Elevated dew points, >18°C, increased the discomfort people were experiencing in the extreme heat and increased the cooling load. Elevated dew points also decreased the efficiency of air conditioners hence increasing the amount of energy they used.

4 Conclusions

The results and insights presented in this report supplement the findings of previous *Temperature Forecast Analysis* reports and will continue to aid operational forecasting and decision-making at AEMO. This report is to be shared with current and potential weather service providers to draw attention to areas of improvement and help assist in baselining performance. AEMO is continuing to work with the weather forecasting industry on developing weather forecast products tailored for the energy industry as well as addressing the key challenges identified in this report.

The key findings of this report are:

- Provider A and Provider C improved in accuracy for the top 10% of temperatures, and all providers marginally improved overall for the 24 HA forecast horizon.
- Provider B was the most precise provider for the 4, 24 and 72 HA forecast horizon but tended to under-forecast. Provider C had the most accurate forecasts overall for the 4, 24 and 72 HA forecast horizons. Provider A had the most accurate forecasts overall for the 1 HA forecast horizon.
- Improvements were made by all providers at Archerfield AP, Melbourne OP and Sydney AP for all temperatures at the 24 HA horizon.
- The intraday MAE profiles show Provider A and C had lower performance during the early morning hours at Adelaide WT. Provider A also showed significant deviations compared to the other providers during the day at Sydney AP and Melbourne AP.

In 2023, AEMO is continuing to work with the weather forecasting industry to ensure weather forecast tools are developed for the purposes of energy forecasting. Initiatives include:

- Redevelopment of AEMO's Projected Assessment of System Adequacy (PASA) to be probabilistic and include weather uncertainty margins in reserve calculations.
- Establishment of new weather observation stations located with renewable energy zones (REZs) near remote variable renewable energy (VRE) generators and in metropolitan heat islands to support weather forecasting.
- Accessing a range of probabilistic weather forecasts from providers to improve situational awareness and better represent extreme weather risk and operational envelopes in demand forecasts.

The next *Temperature Forecast Analysis* report, focusing on winter 2023, is to be published later this year.

A1. Error density plots

A1.1 2022-23 summer performance

Figure 21 **Summer 2022-23 performance comparison across all weather stations, all temperatures**

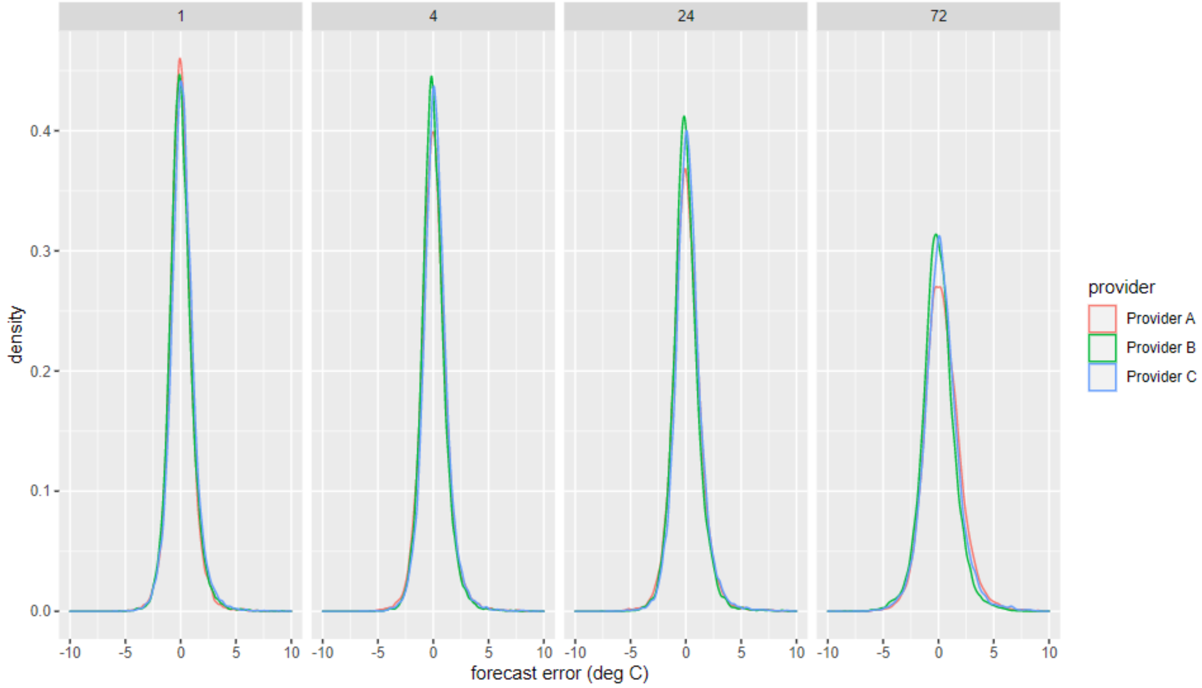
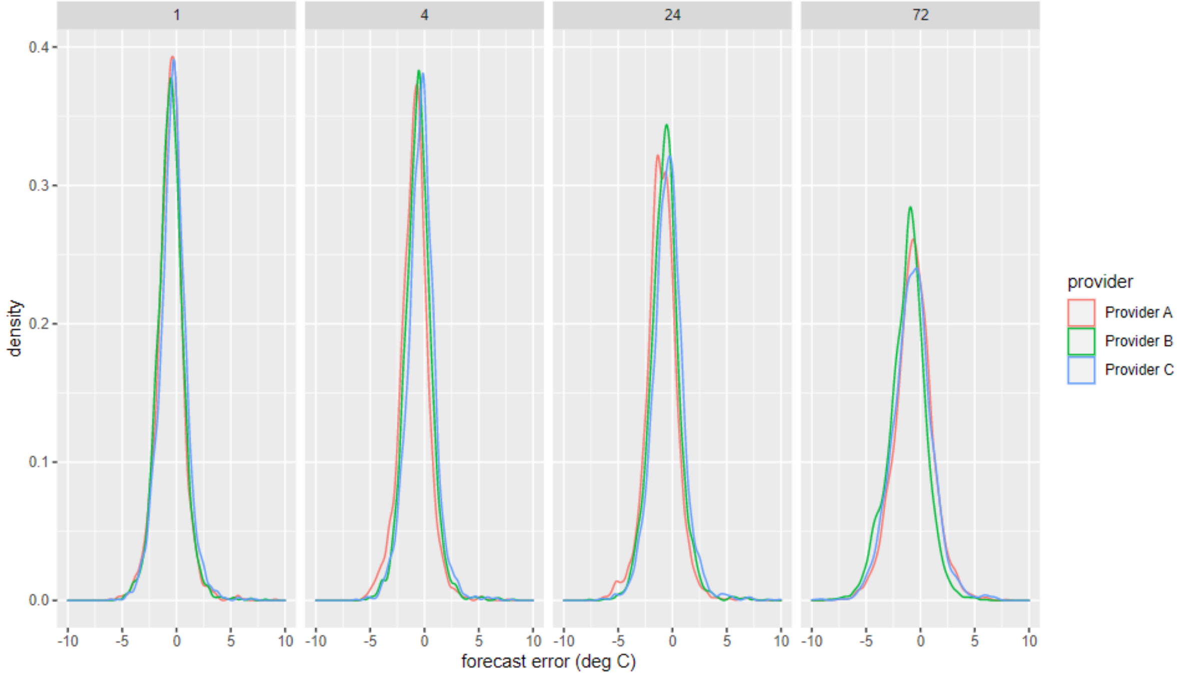


Figure 22 **Summer 2022-23 performance comparison across all weather stations, top 10% of temperatures**



A1.2 Summer performance comparison across all weather stations

Figure 23 Summer performance comparison across all weather stations (2021-22 and 2022-23), all temperatures

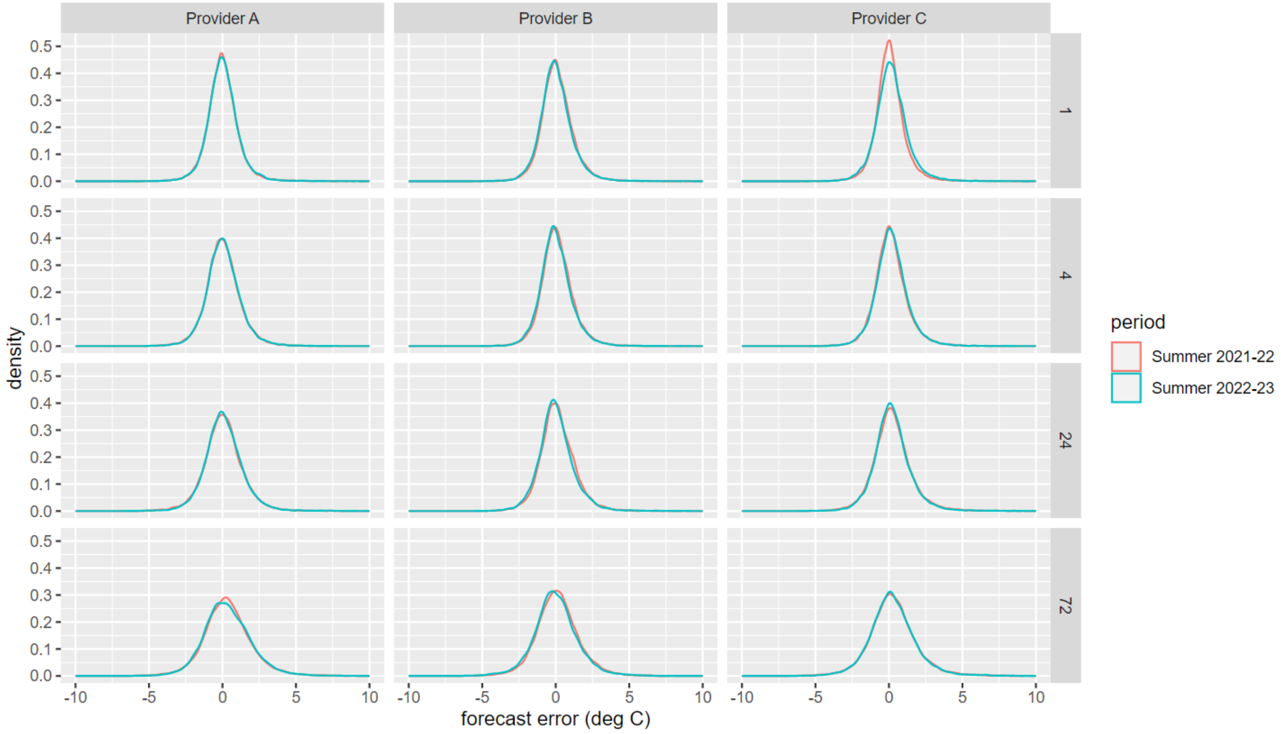
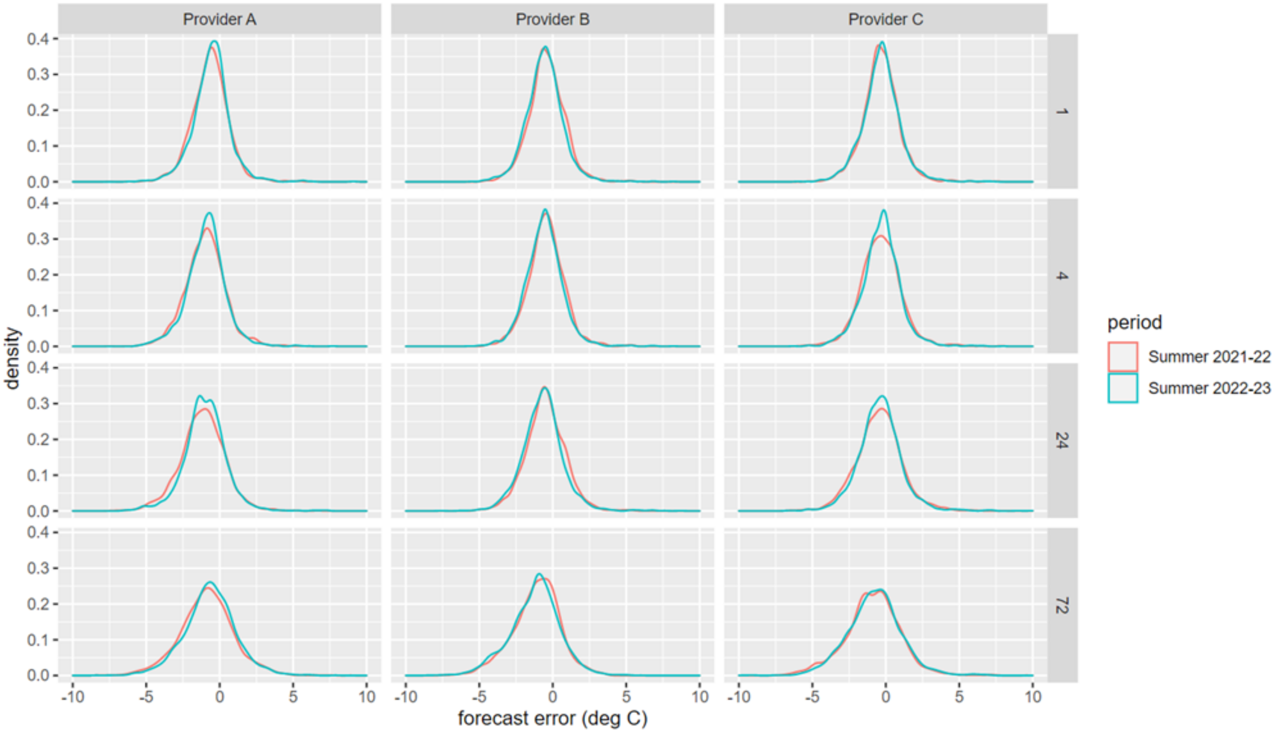


Figure 24 Summer performance comparison across all weather stations (2021-22 and 2022-23), top 10% temperatures



A1.3 Station comparison by provider

Figure 25 Major weather stations, Provider A, all summer temperatures 2021-22 and 2022-23, 24 HA

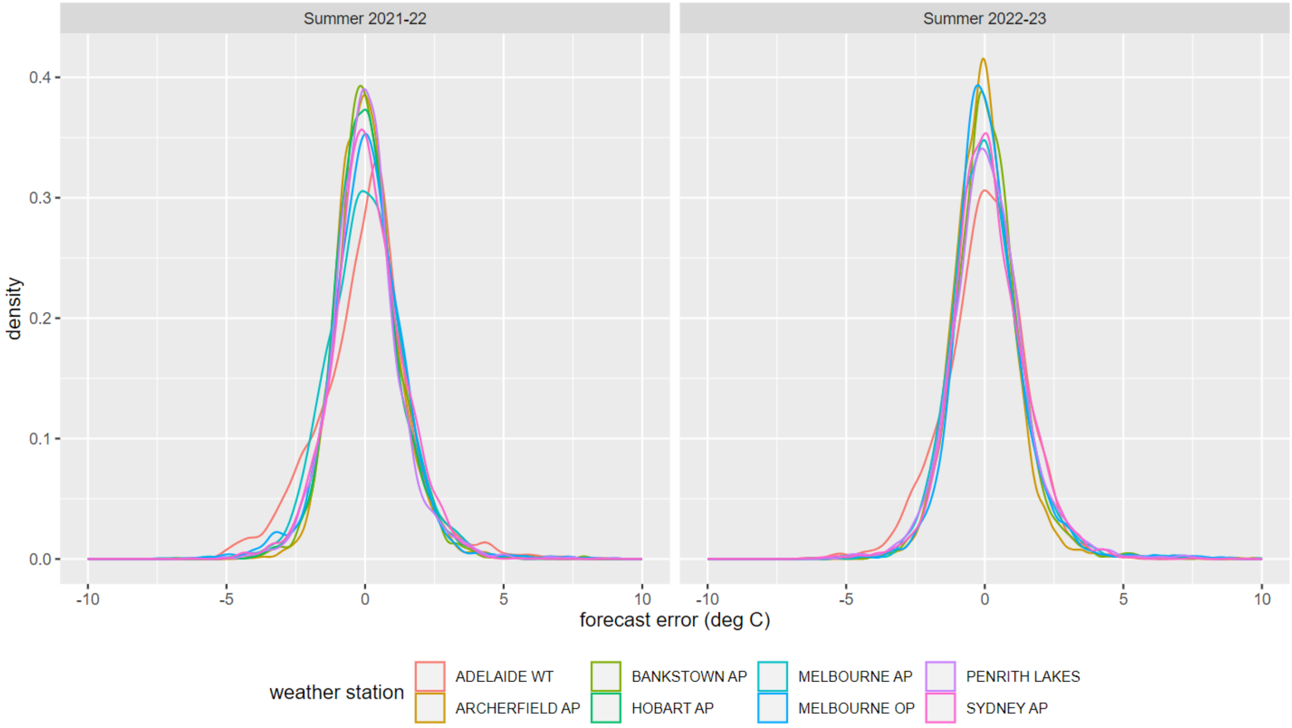


Figure 26 Major weather stations, Provider A, top 10% summer temperatures 2021-22 and 2022-23, 24 HA

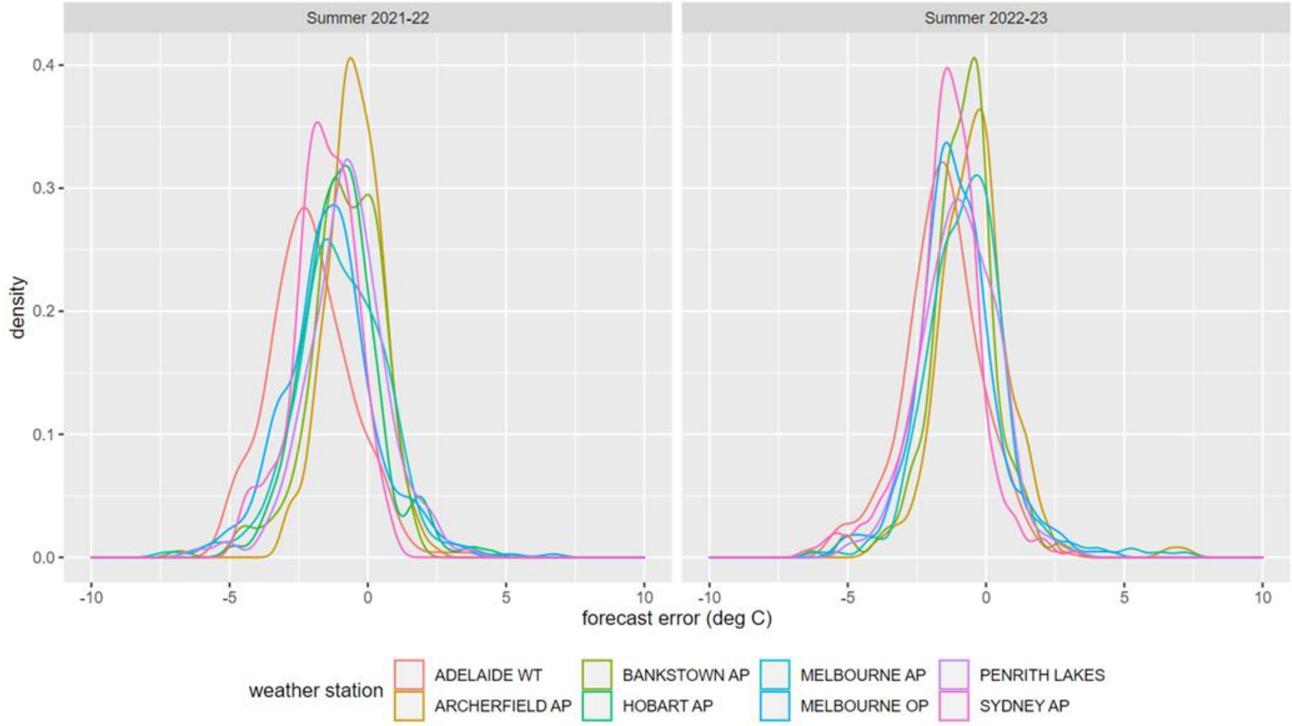


Figure 27 Major weather stations, Provider B, all summer temperatures 2021-22 and 2022-23, 24 HA

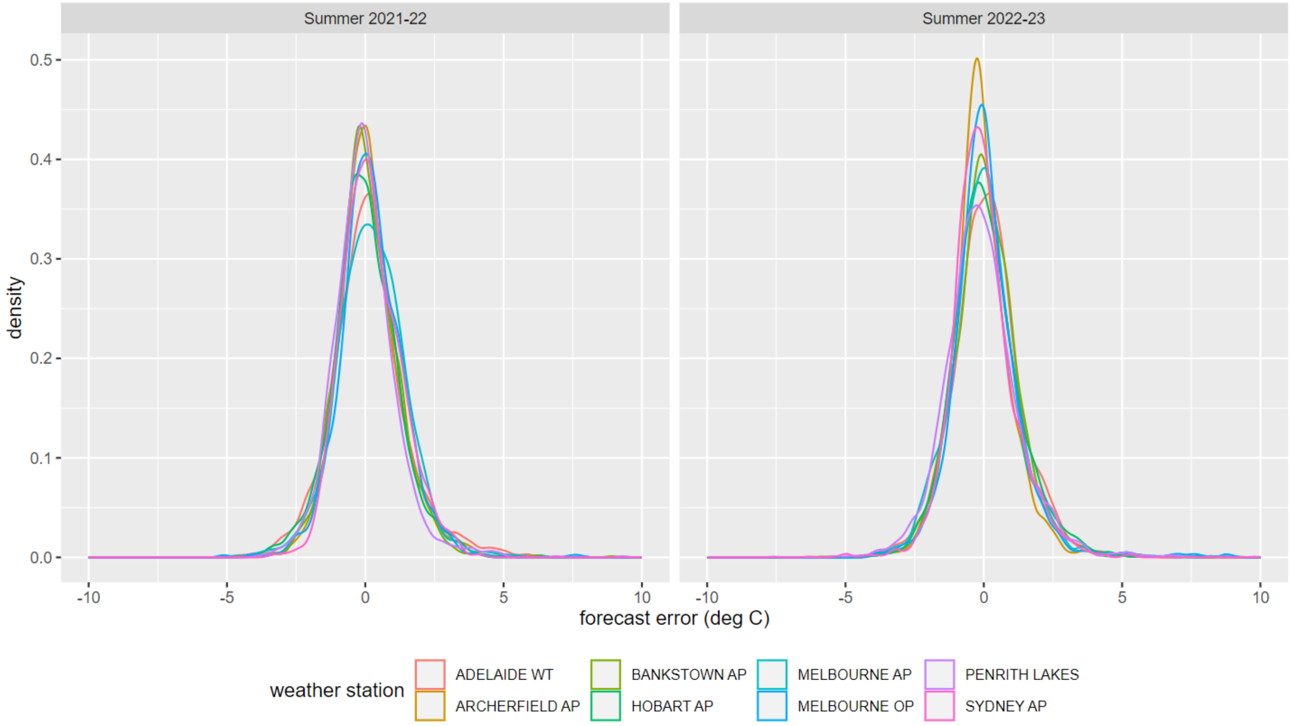


Figure 28 Major weather stations, Provider B, top 10% summer temperatures 2021-22 and 2022-23, 24 HA

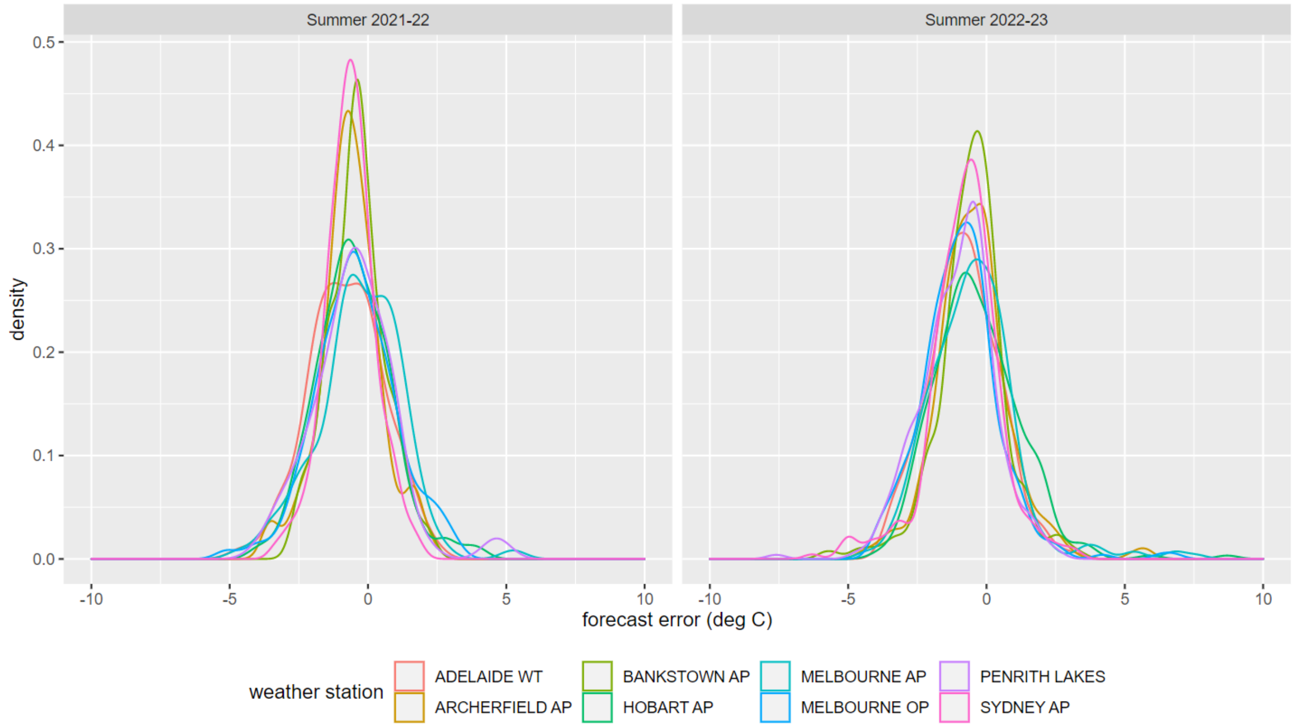


Figure 29 Major weather stations, Provider C, all summer temperatures 2021-22 and 2022-23, 24 HA

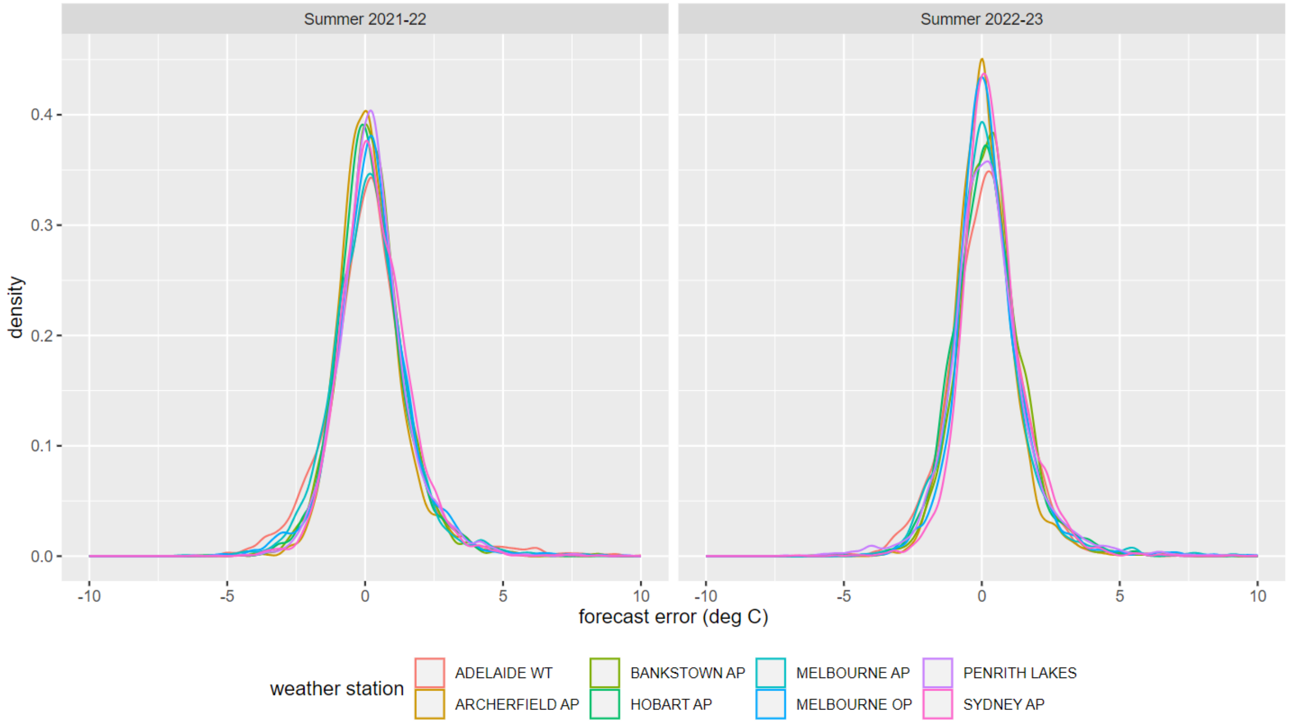
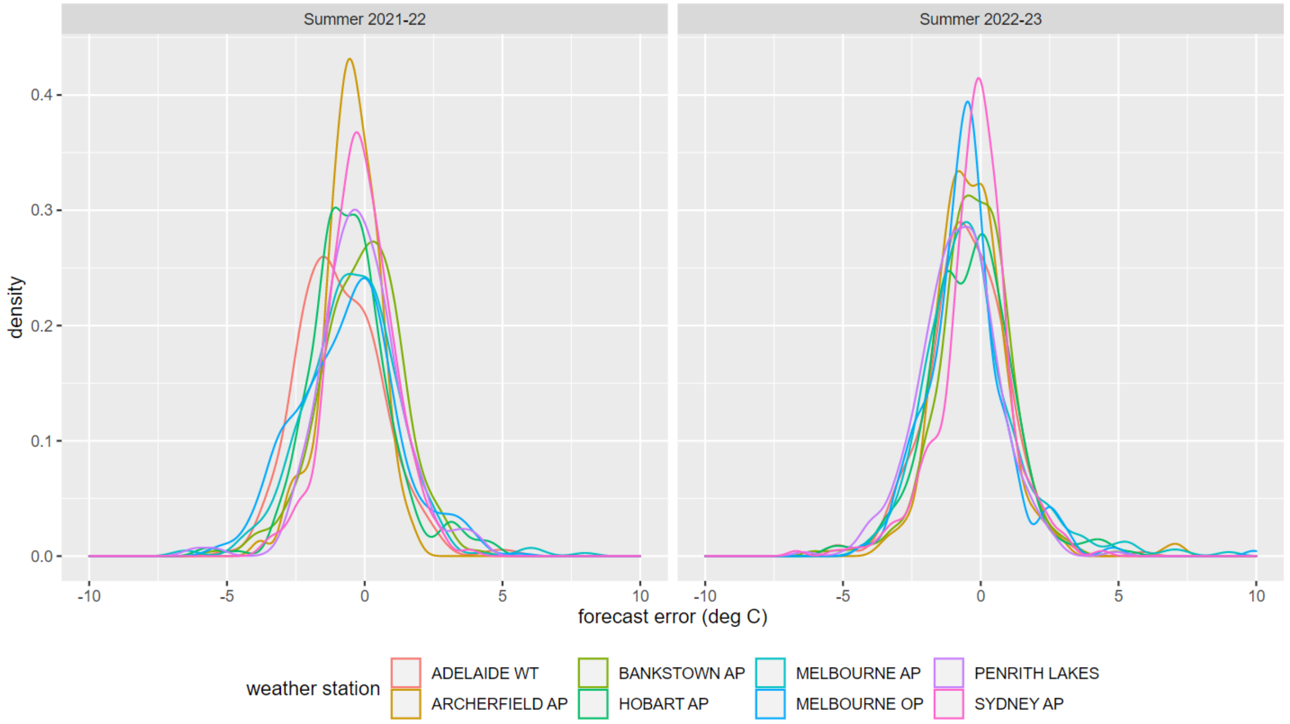


Figure 30 Major weather stations, Provider C, top 10% summer temperatures 2021-22 and 2022-23, 24 HA



A1.4 Provider comparison by weather station

Figure 31 Adelaide WT, all summer temperatures 2021-22 and 2022-23, all time horizons

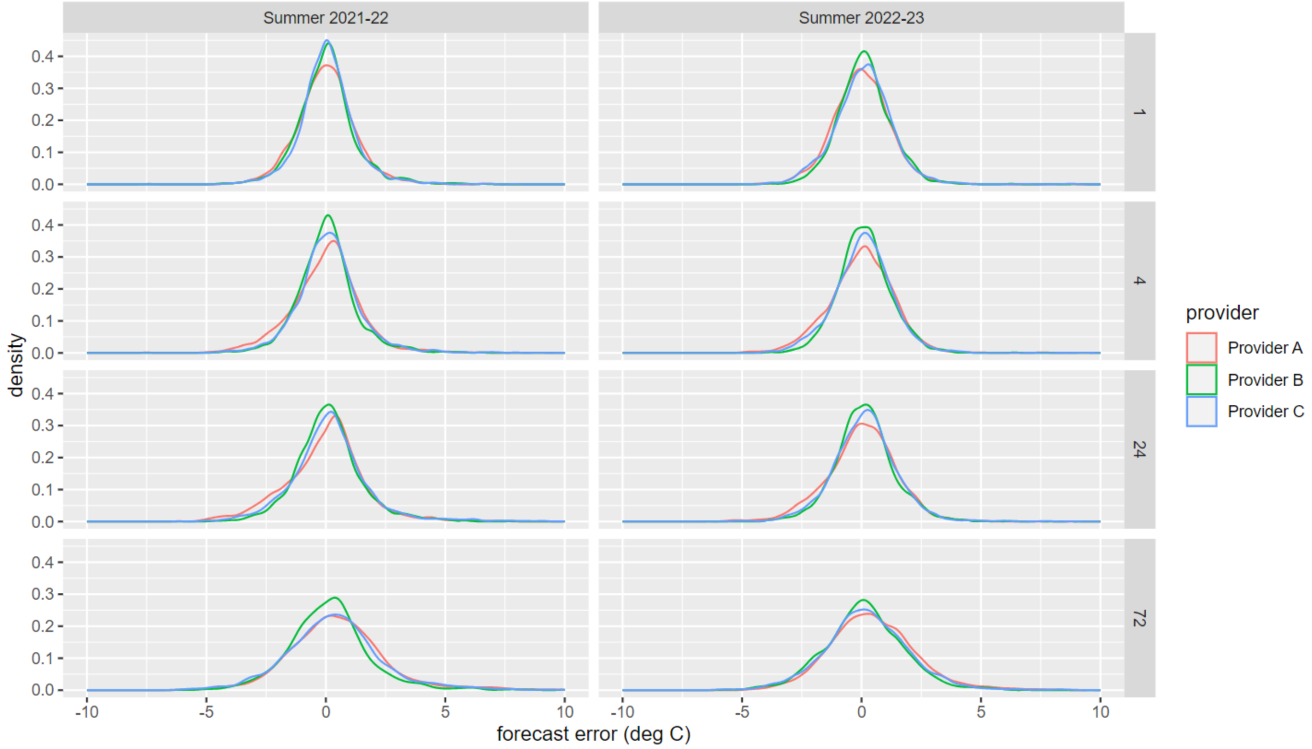


Figure 32 Archerfield AP, all summer temperatures 2021-22 and 2022-23, all time horizons

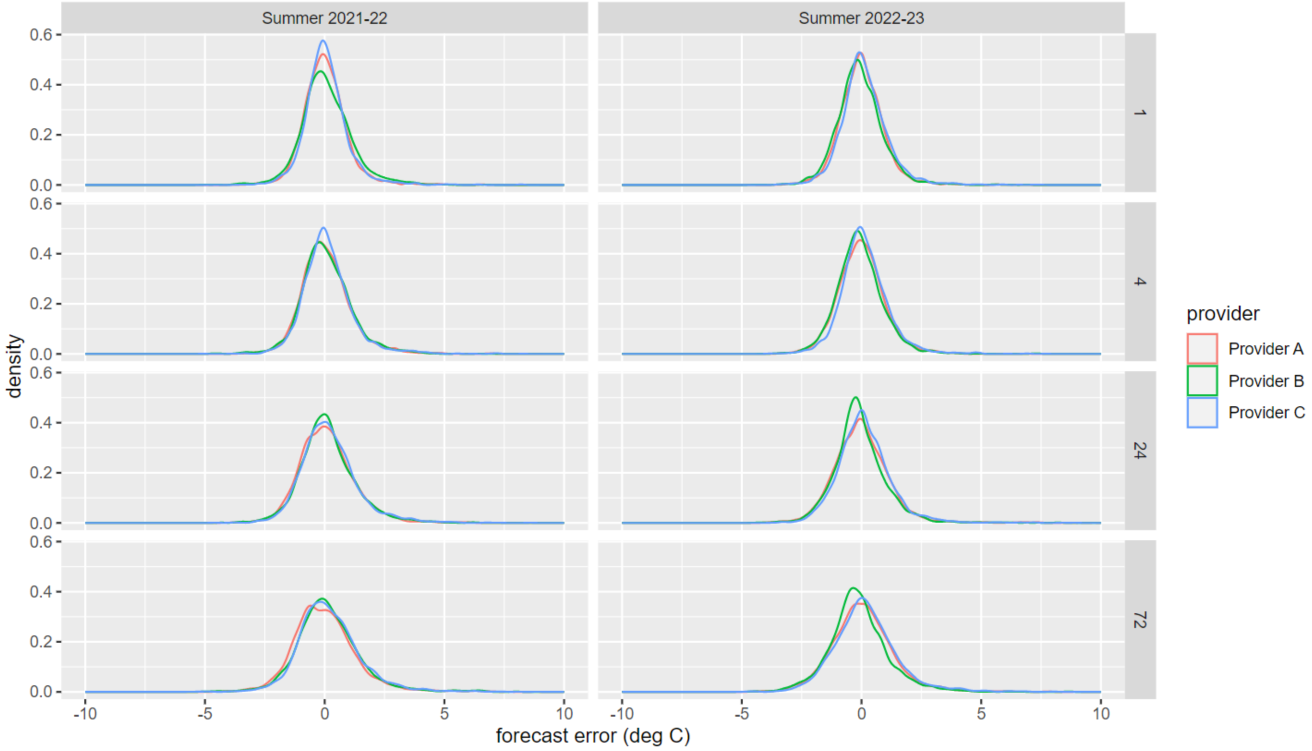


Figure 33 Bankstown AP, all summer temperatures 2021-22 and 2022-23, all time horizons

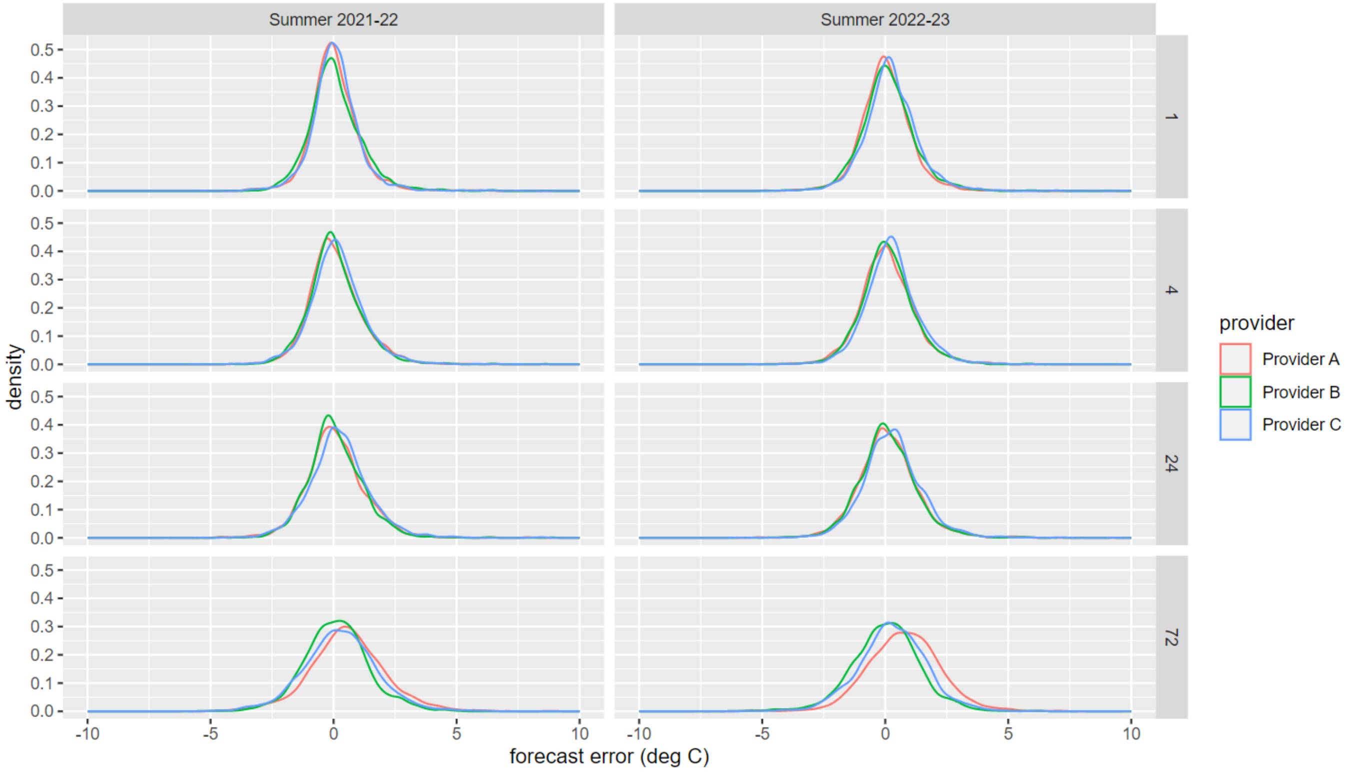


Figure 34 Hobart AP, all summer temperatures 2021-22 and 2022-23, all time horizons

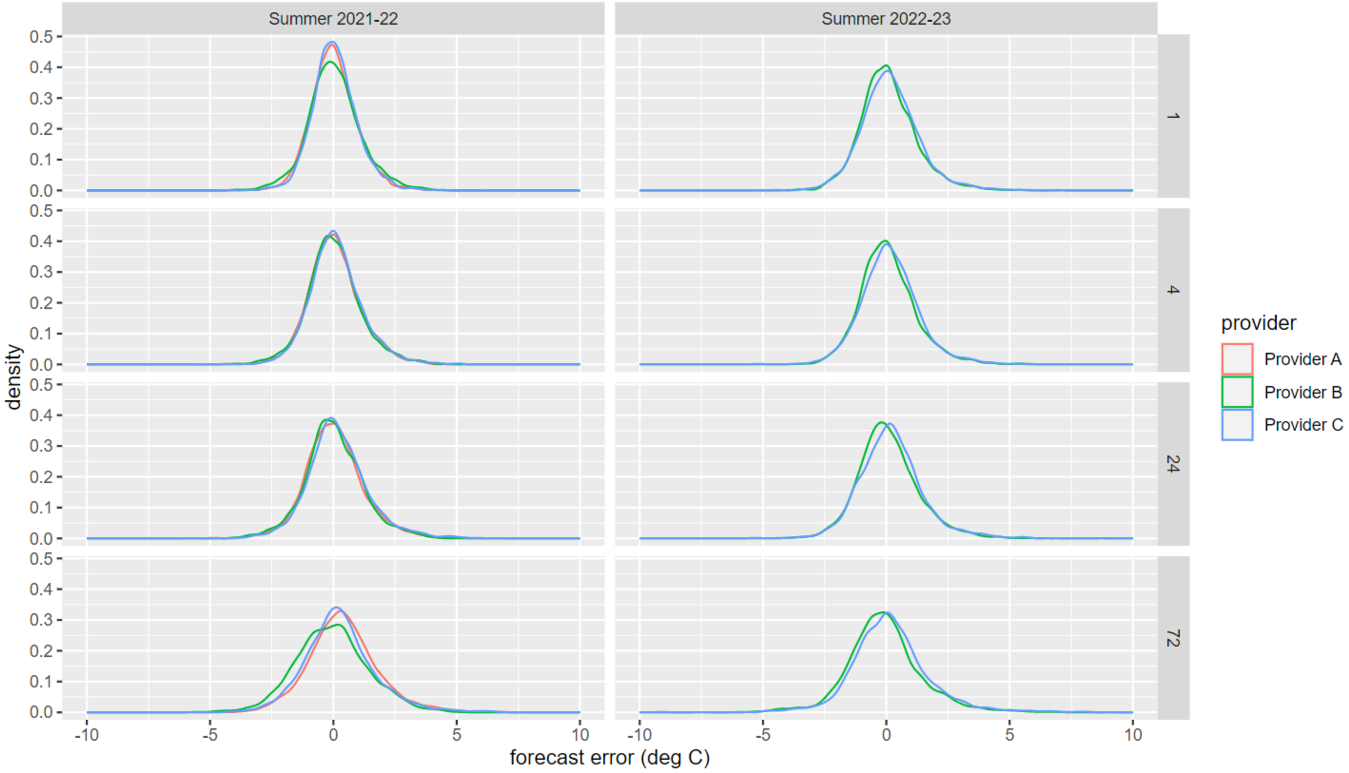


Figure 35 Melbourne AP, all summer temperatures 2021-22 and 2022-23, all time horizons

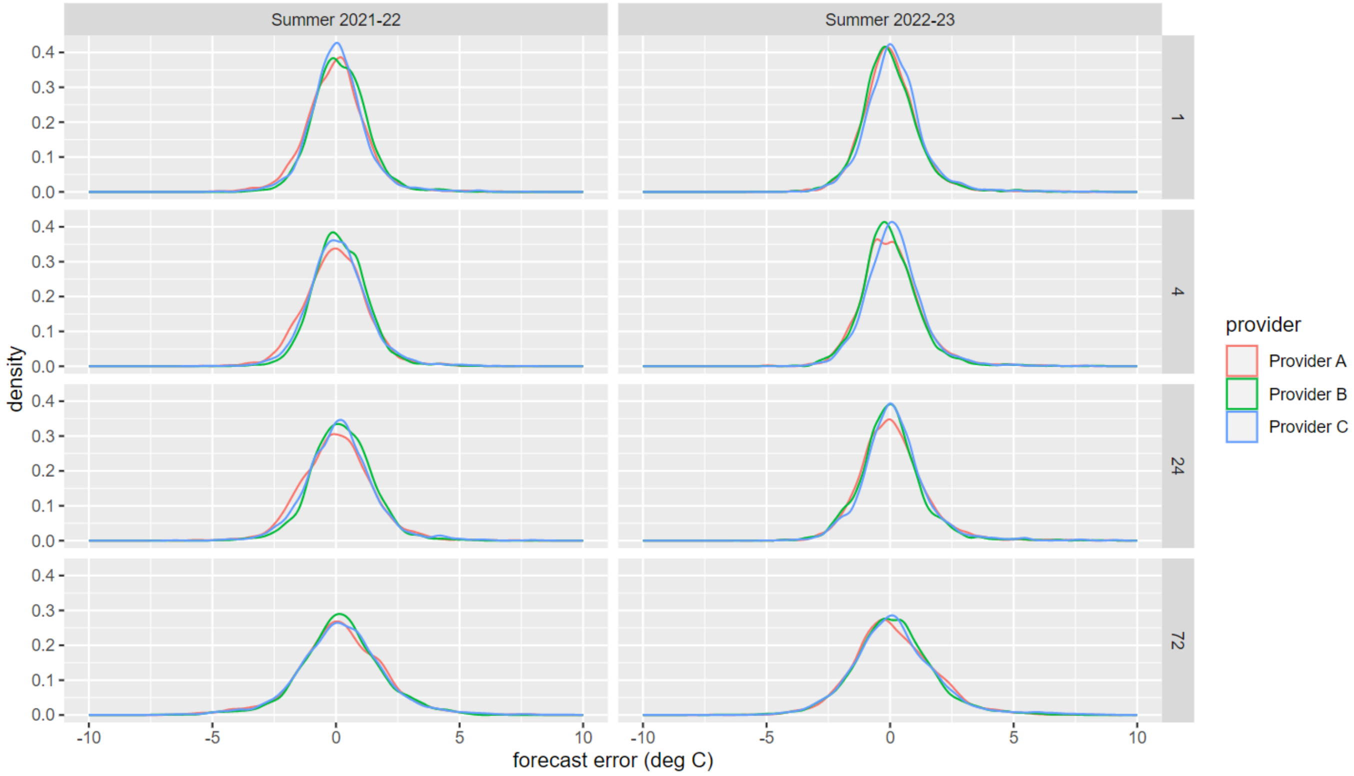


Figure 36 Melbourne OP, all summer temperatures 2021-22 and 2022-23, all time horizons

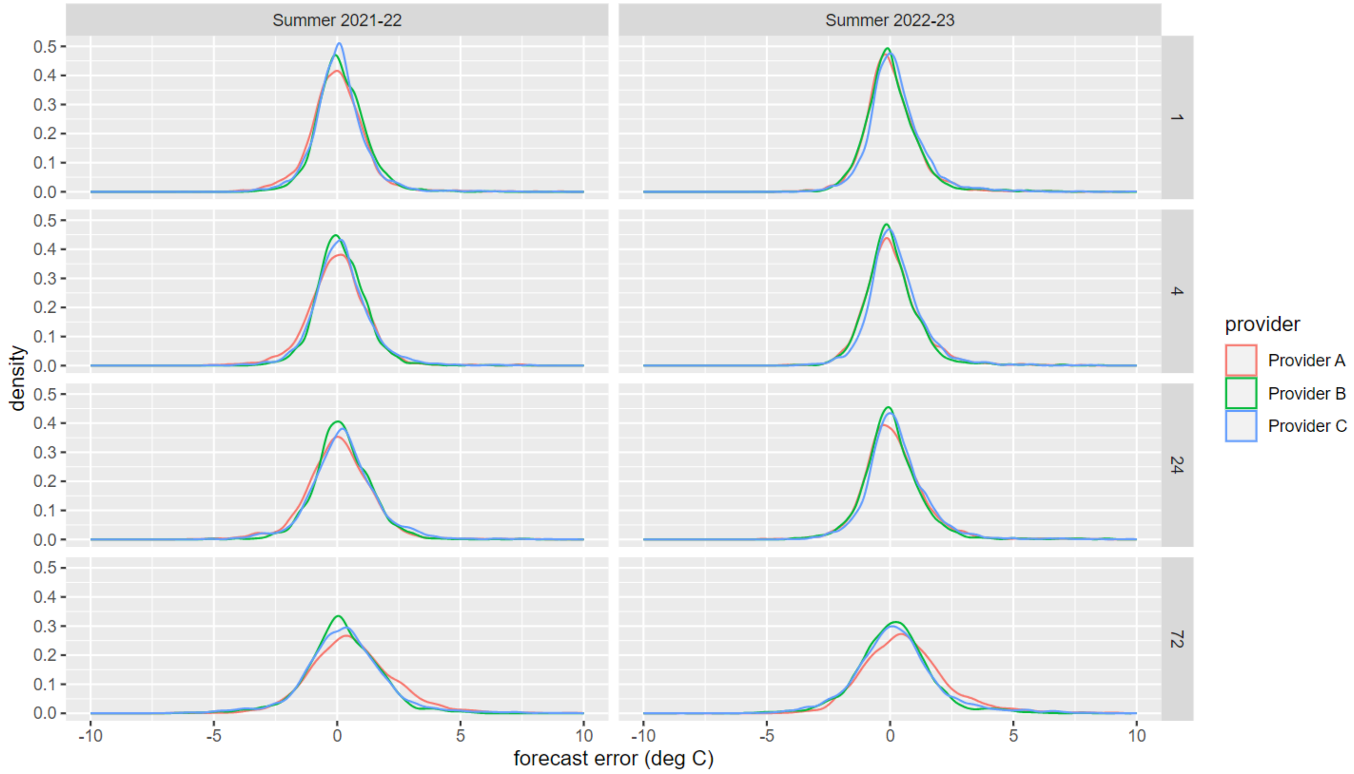


Figure 37 Penrith Lakes, all summer temperatures 2021-22 and 2022-23, all time horizons

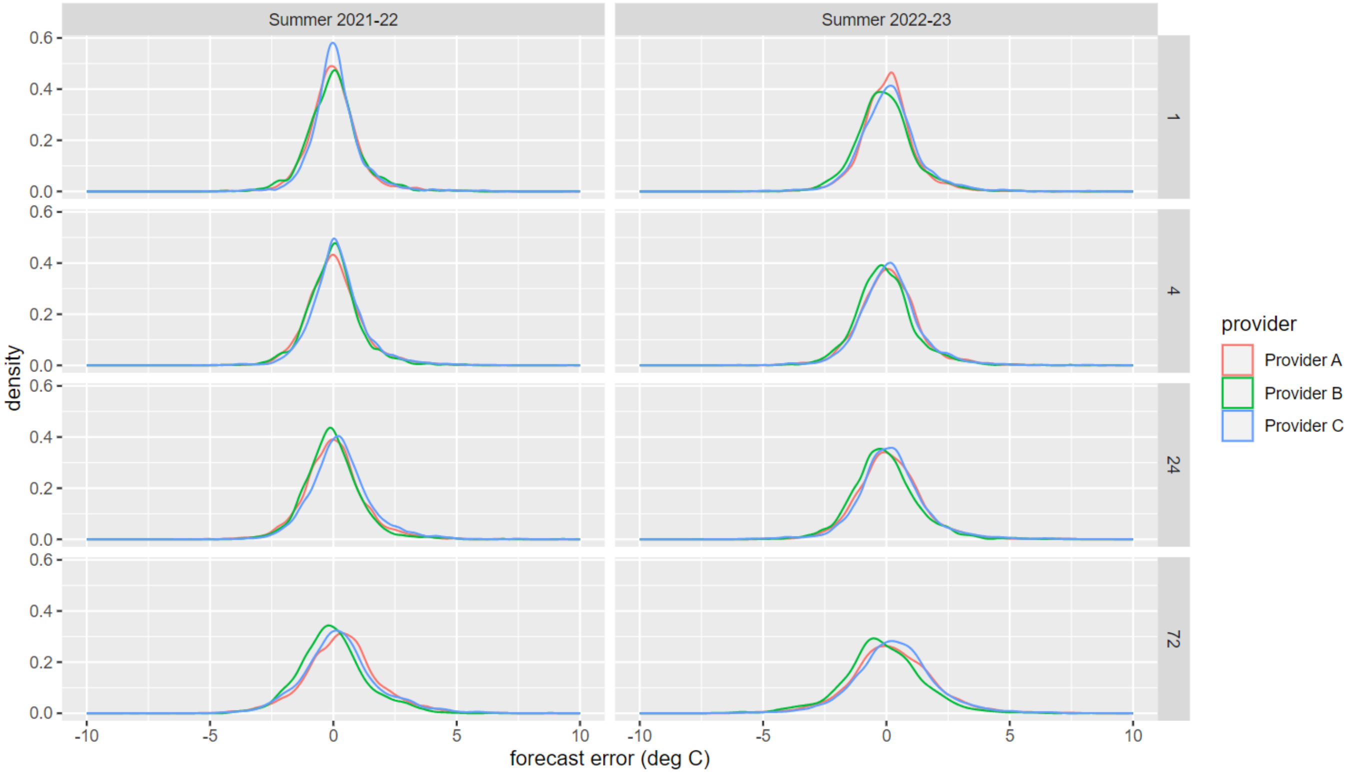
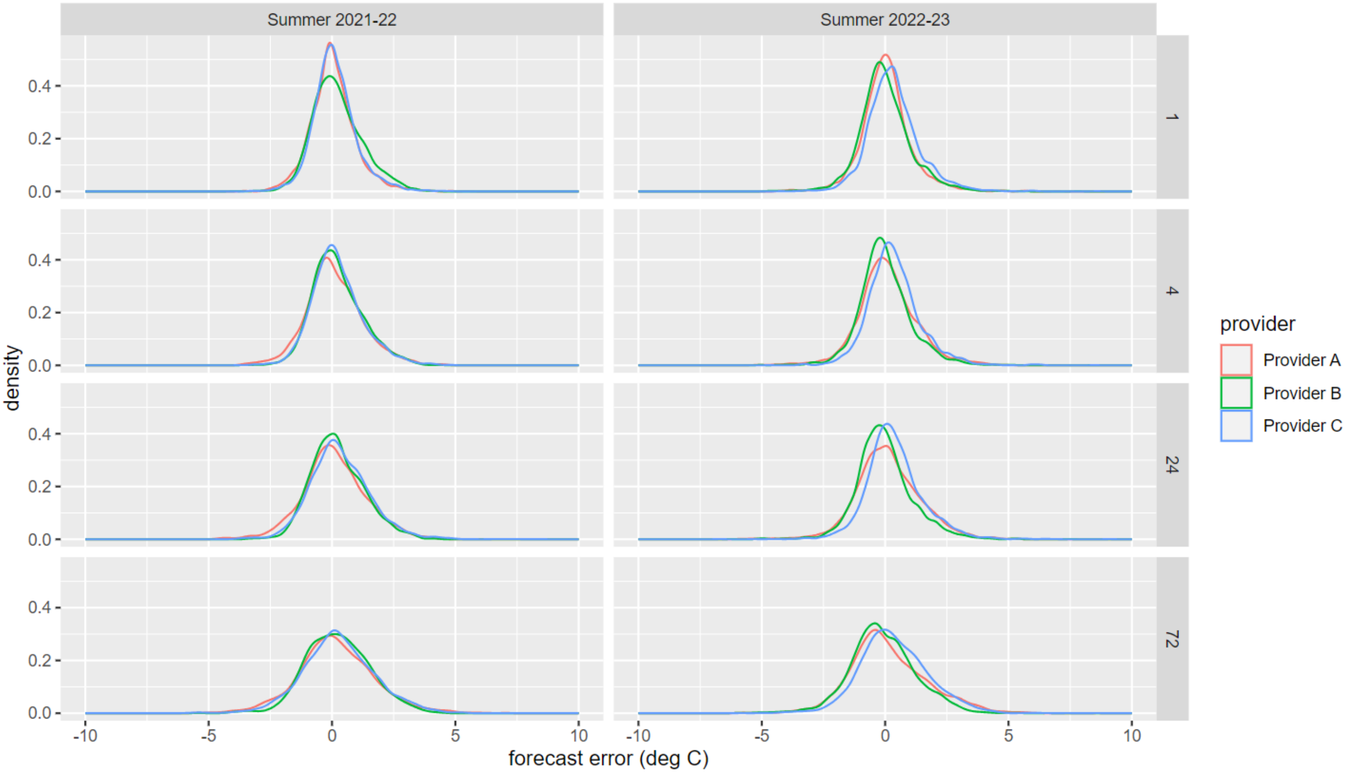


Figure 38 Sydney AP, all summer temperatures 2021-22 and 2022-23, all time horizons



A2. Intraday MAE profiles

Figure 39 Adelaide WT, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

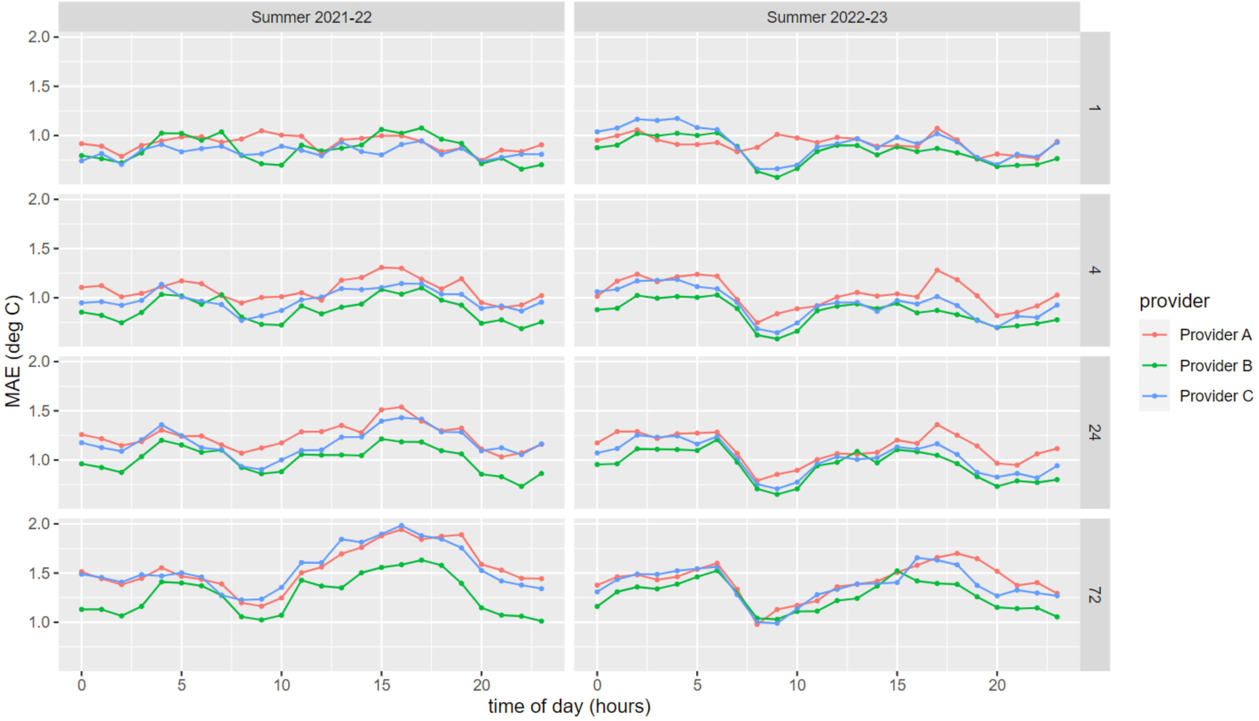


Figure 40 Archerfield AP, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

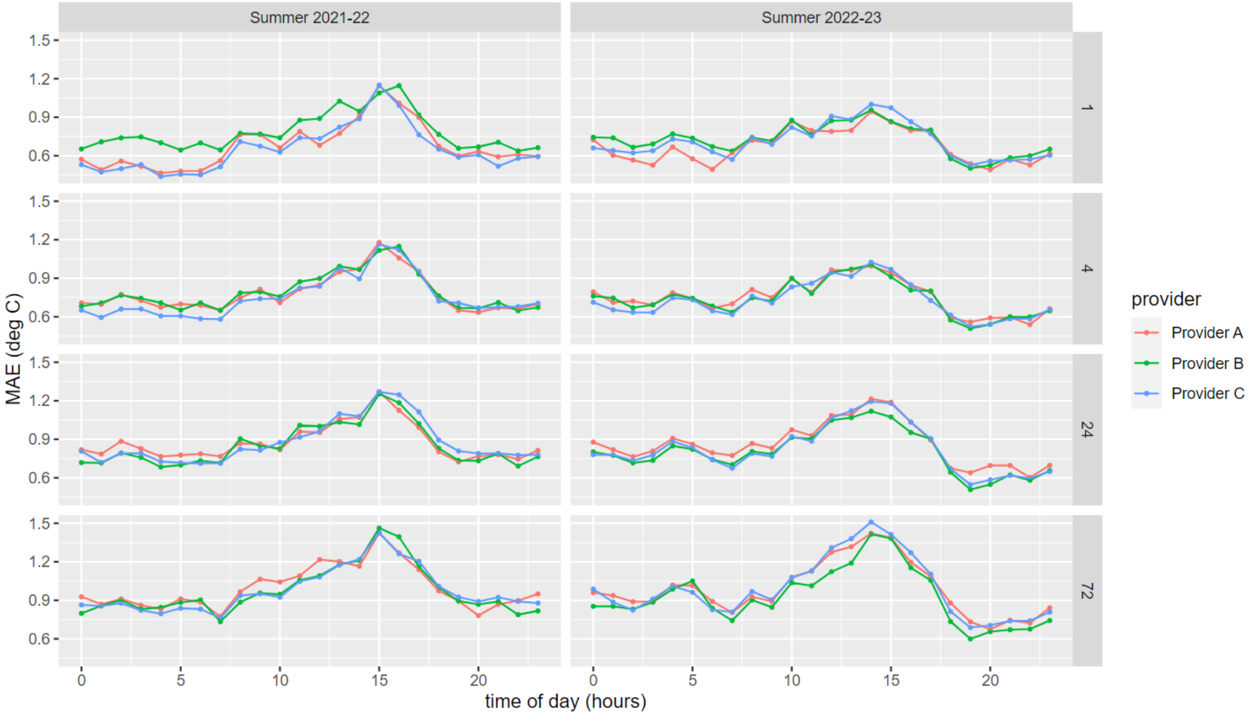


Figure 41 Bankstown AP, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

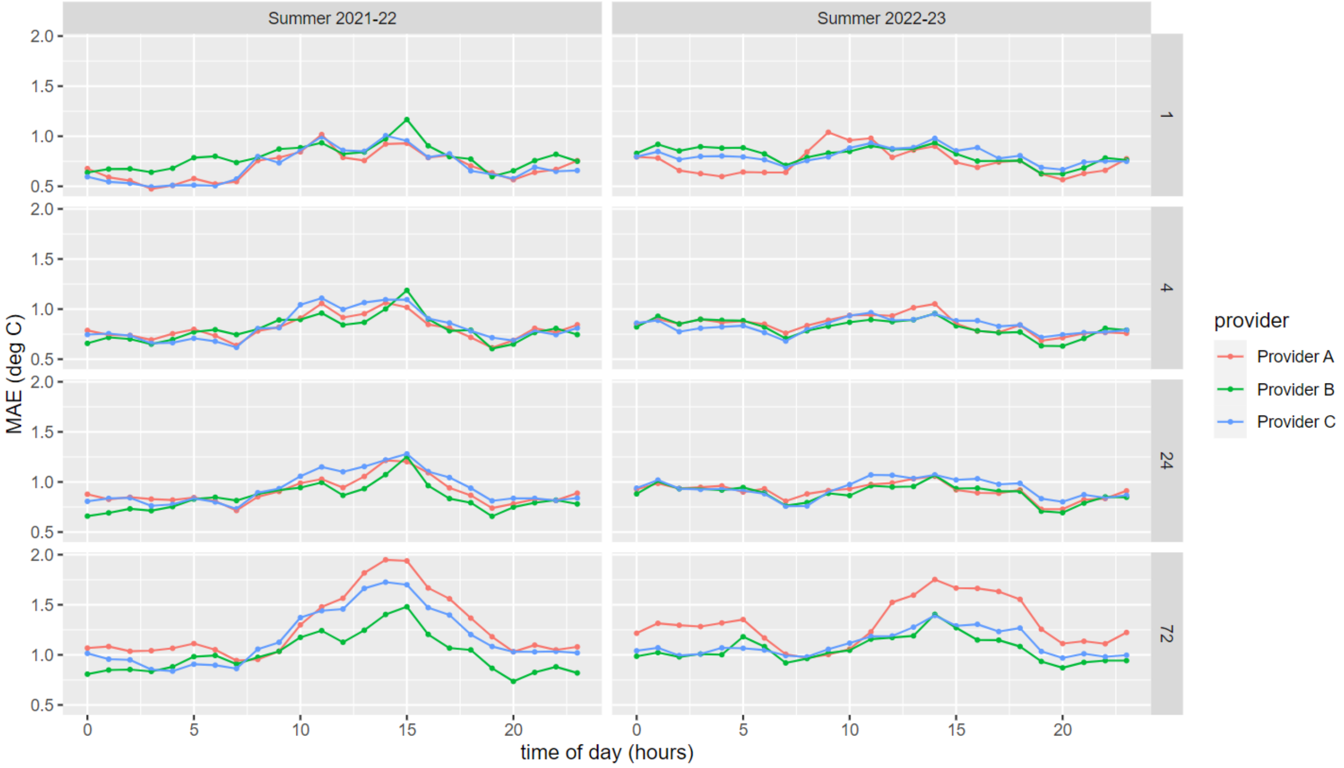


Figure 42 Hobart AP, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

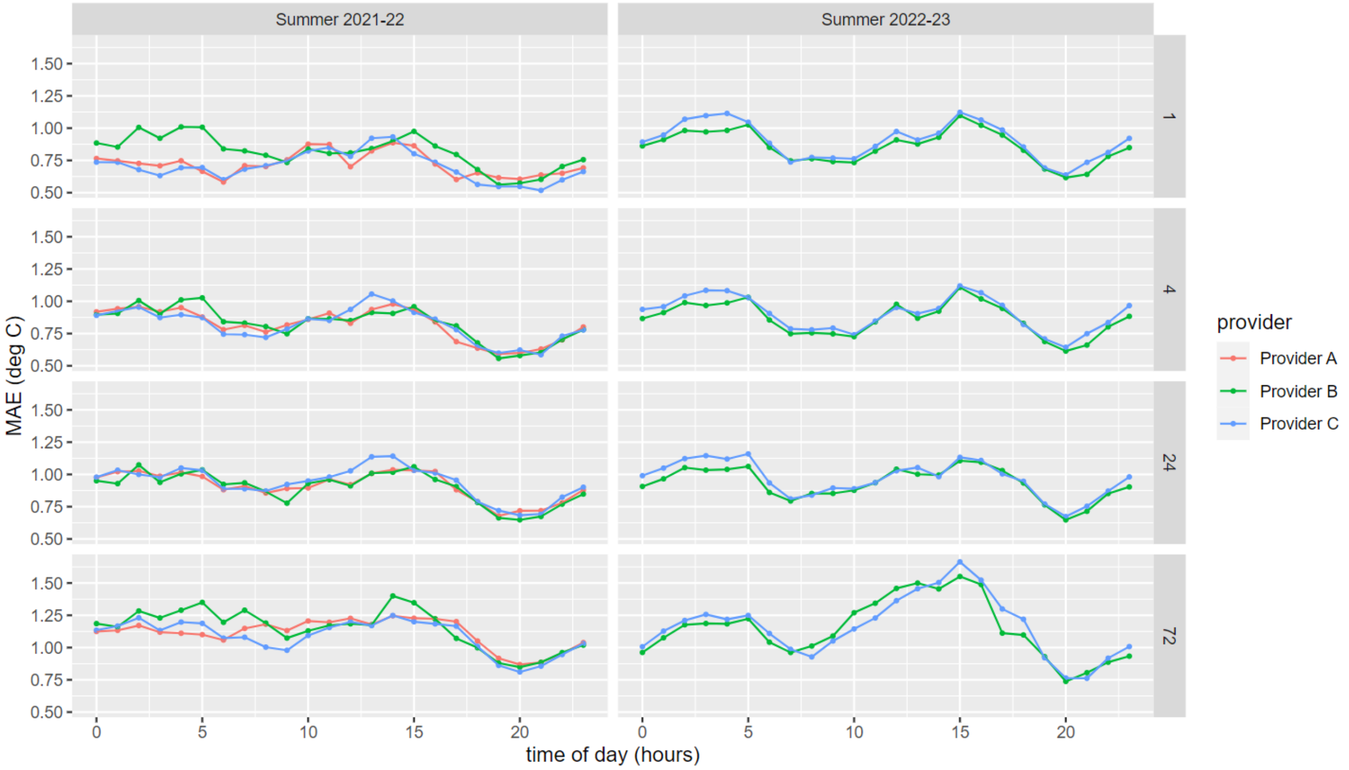


Figure 43 Melbourne OP, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

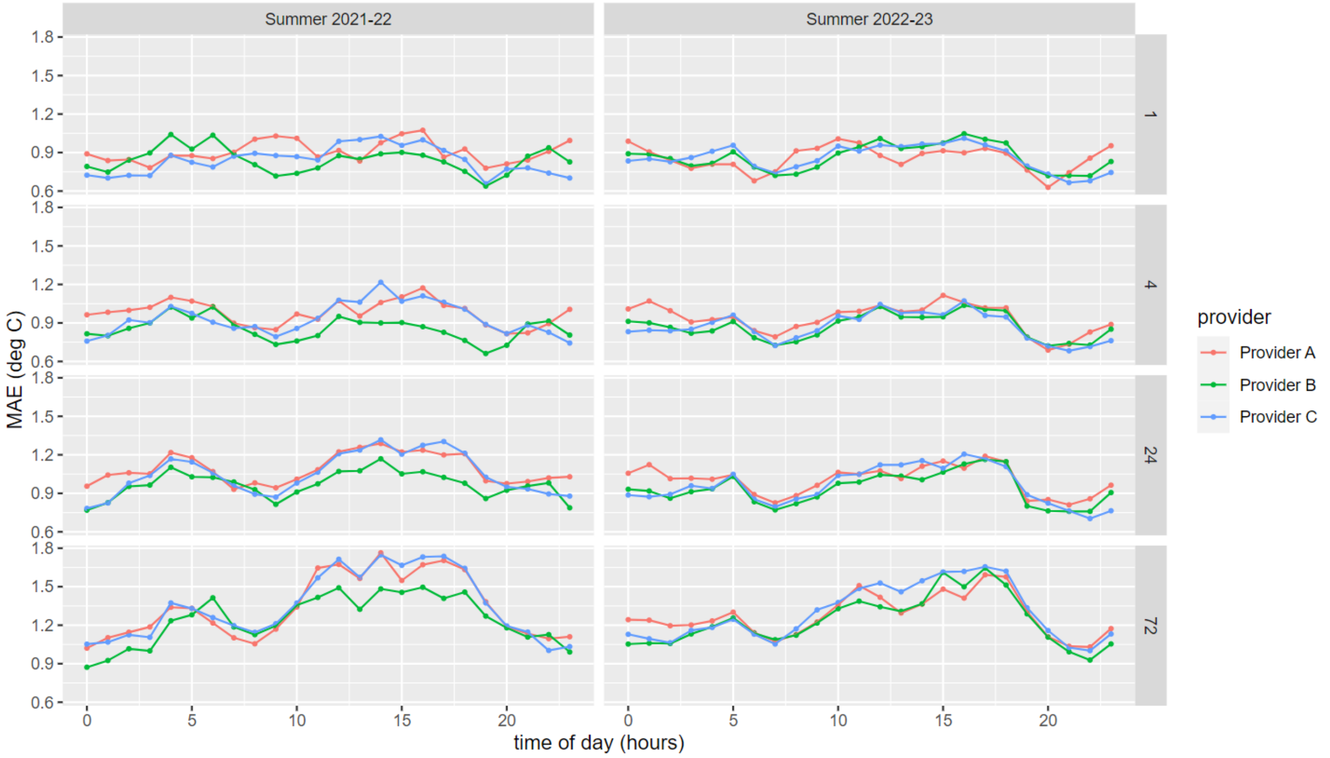


Figure 44 Melbourne AP, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

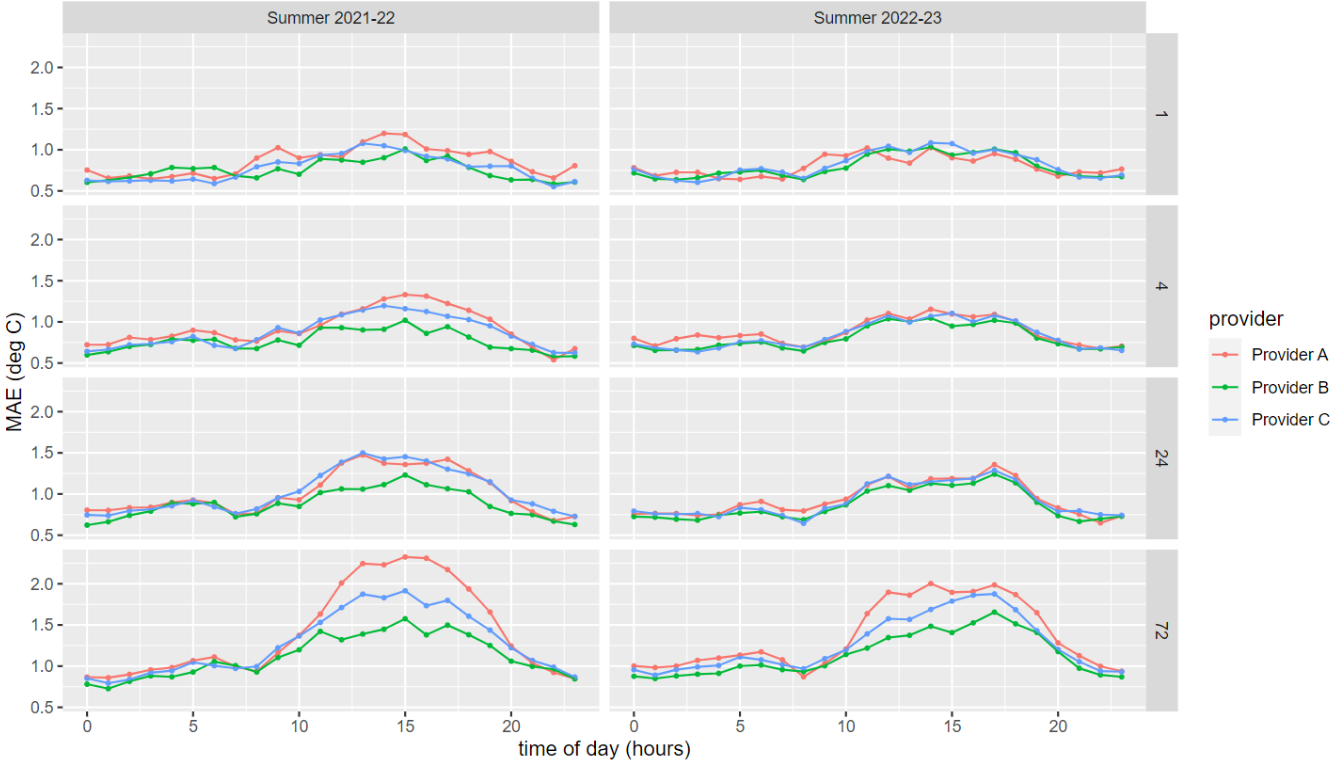


Figure 45 Penrith Lakes, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures

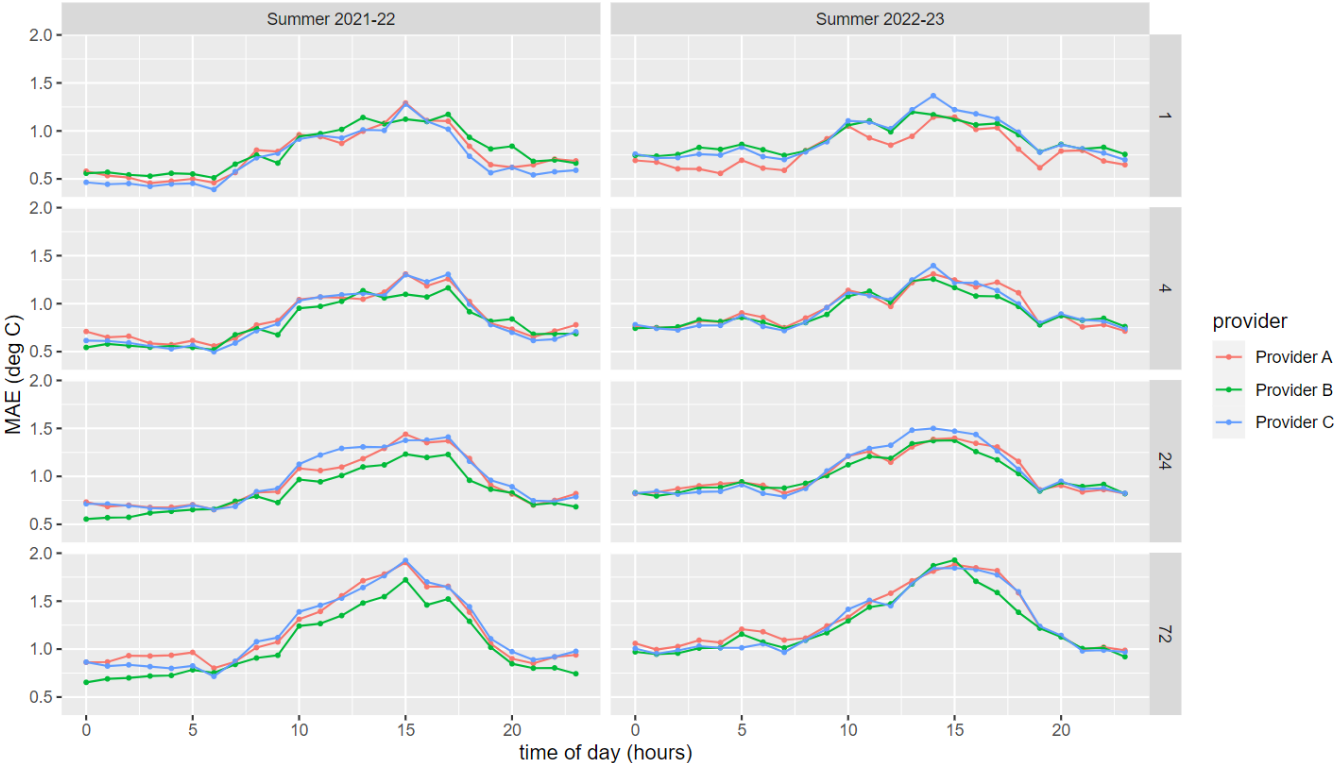


Figure 46 Sydney AP, intraday MAE profile, summer 2021-22 and 2022-23, all time horizons, all temperatures