Temperature Forecast Analysis for Winter 2020

February 2021

A report assessing the forecast accuracy of AEMO's operational weather providers in the National Electricity Market from 1 May 2020 to 30 September 2020

Important notice

PURPOSE

This report has been prepared to:

- Give the weather providers used by operational forecasting an insight into their comparative temperature forecast performance in the NEM during the 2020 winter period.
- Give any intending weather providers information to assess the relative performance of their forecasts.
- Contribute to ongoing discussion and improvement within AEMO and the energy industry.

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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 vs. precision	Accuracy refers to the closeness of an actual temperature measurement 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. 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 temperature forecast accuracy of AEMO's three current weather service providers in the National Electricity Market (NEM) from 1 May 2020 to 30 September 2020. AEMO published a temperature forecast analysis for summer 2019-20 and winter 2019. This report aims to highlight the differences in forecasting performance between winter 2019[1] and 2020, while also drawing new insights from winter 2020 performance.

The weather stations analysed in this report are Archerfield (Queensland), Bankstown (New South Wales), Penrith (New South Wales), Melbourne Airport (Victoria), Melbourne Olympic Park (Victoria), Adelaide West Terrace (South Australia)[2], Adelaide Kent Town (South Australia), and Hobart Airport (Tasmania). These weather stations represent the largest electricity load centres in each region of the NEM.

The key findings from the analysis were:

- Overall forecasting performance has improved since last winter. Providers B and C delivered the strongest overall performance.
- Provider C saw the lowest overall improvement, due to a decline in 24 hour-ahead (HA) accuracy.
- Penrith had the lowest forecast precision among providers B and C, and the second lowest for provider A. Each provider had large under- and over-forecasting errors at this station.
- Providers B and C had better forecast performance at West Terrace compared to Kent Town across all time horizons. AEMO is now using West Terrace as the primary weather station to forecast demand in South Australia.
- Provider A had ongoing forecast performance challenges at Hobart Airport, where overall forecast performance and accuracy remained poor, with a median under-forecast error of 2.5°C.
- Comparing intraday performance reveals that:
  - Overall, there was an improvement in intraday forecast performance across all providers compared to winter 2019. Midday, afternoon and early evening temperatures continued to be forecast with greater accuracy, supporting the winter 2019 analysis.
  - All providers tended to have the largest errors overnight and in the early morning.
  - All providers experienced some reductions in peak forecast error, with the most significant reductions occurring during the late afternoon/early evening period.
- A case study analysis of forecasting performance in New South Wales on 9 August 2020 showcased a day where temperature forecasts were inaccurate across all providers. It also highlighted how inaccurate temperature forecasts, as well as other factors such as rainfall and rooftop photovoltaic (PV), can impact overall accuracy in AEMO's demand forecasts.

This analysis will be used by AEMO to aid operational decision-making and will be shared with weather providers to draw attention to potential areas of improvement. AEMO will continue to work with the weather forecasting industry on the key challenged identified in this report.

[1] AEMO's published weather forecast analysis reports are under *Weather Forecasting* at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/operational-forecasting/load-forecasting-in-pre-dispatch-and-stpasa.

[2] Adelaide West Terrace was not included in previous reports. AEMO has now introduced analysis at Adelaide West Terrace in place of Kent Town, due to the decommissioning of Kent Town by the Bureau of Meteorology on 31 July 2020.

Contents

Figures

1. Introduction

This report examines the temperature forecast accuracy of AEMO's three weather service providers in the National Electricity Market (NEM) from 1 May 2020 to 30 September 2020[3]. AEMO publishes a temperature forecast analysis for summer and winter each year [4]. This report aims to highlight the differences in forecasting performance between winter 2019 and 2020, while also drawing new insight from winter 2020 performance.

This report is intended as a resource for weather service providers so they can benchmark their forecast performance against other providers, and as a discussion and ongoing improvement piece within AEMO and the energy industry. It also includes a case study to highlight how temperature forecasts are linked to the operational challenges AEMO faced during the winter 2020 period.

2. Winter forecast performance

This section contains a selection of insights into hourly temperature forecasting performance for winter 2020 in the NEM. Results supporting major comparisons between winter 2019 and 2020 are included in the main report, and a full set of results is in appendices A1 and A2.

This report studies temperature forecast performance at the 72-, 24-, and 4-hour ahead (HA) rolling forecast horizons.

Many of the results in this section and in Appendix A1 are displayed as error density plots, which 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 less than the actual temperature).
- The y-axis shows error density. This reflects the relative rate of occurrence of a forecast error. For each forecast error, the error density will be between 0 and 1, and the area under each curve equates to 1.
- In general, the height of the error density peak captures the level of forecast precision, and the positioning of the peak with respect to a forecast error of zero captures the forecast accuracy. The higher the peak, the greater the precision and the smaller the expected deviation from the average level of error. The further the peak is from zero error, the lower the accuracy, and the larger the tendency for over- or under-forecasting on average.

Appendix A2 contains intraday mean absolute error (MAE) profiles for every studied weather station by provider. Forecasts are provided for each hour of the day.

2.1 The importance of forecast accuracy

As the weather plays a significant role in determining electricity demand, AEMO relies on accurate temperature forecasts when producing its demand forecasts. Historically, accurate temperature forecasts were more critically relied on during summer heatwave periods to accurately forecast maximum electricity demands, ensure a reliable supply of energy, and to keep the power system in a secure and safe operating

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

[4] Previously published reports under *Weather Forecasting* at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/operational-forecasting/load-forecasting-in-pre-dispatch-and-stpasa.

state. In recent years, accurate temperature forecasts have become increasingly important to AEMO during mild and cold conditions, typical of the shoulder and winter seasons. Mild temperatures and clear skies result in a combination of low weather-responsive demand and high levels of rooftop photovoltaic (PV) generation. Both factors can result in periods of low operational demand in the NEM and create challenging operational conditions for AEMO and network service providers.

Winter 2020 saw new winter minimum operational demand records in Queensland, South Australia and Victoria, as well as a new coincident winter minimum operational demand record for the NEM. Unseasonably mild weather, increased penetration of behind-the-meter rooftop PV, and a reduction in economic activity attributable to COVID-19 were all factors contributing to these new minimums. It is also worth noting that South Australia set a record maximum winter operational demand record of 2576MW on 7 August 2020.

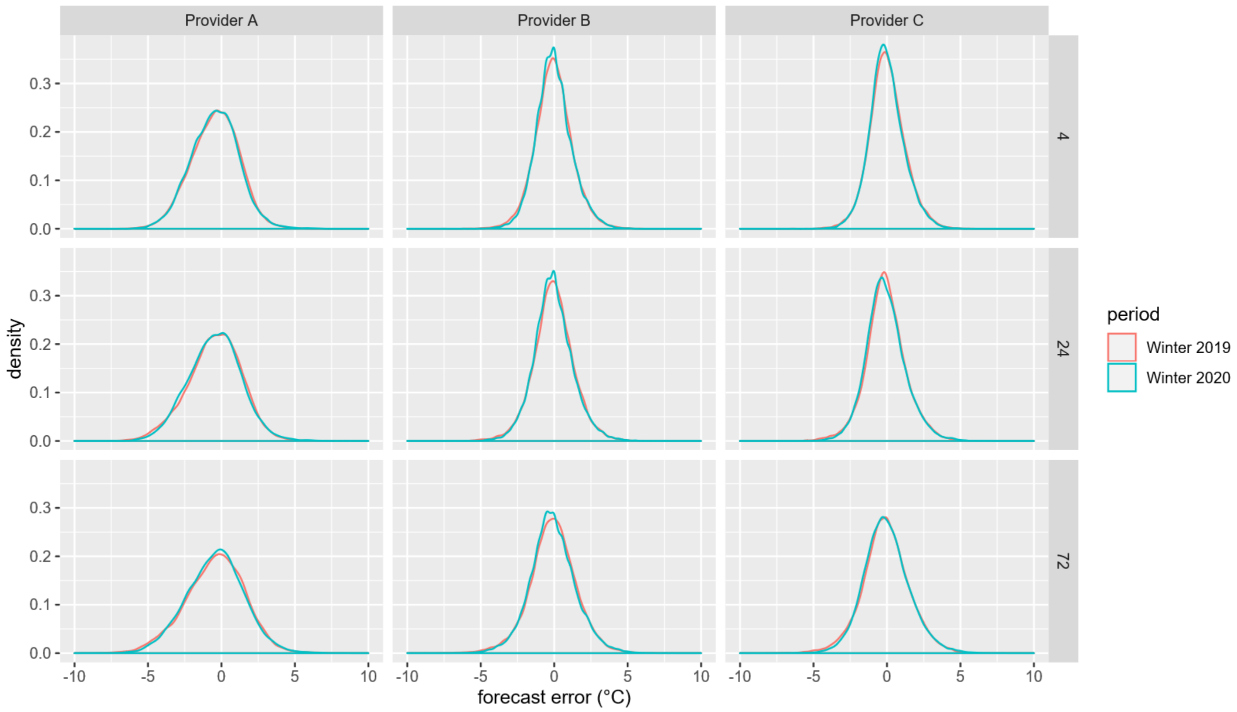
2.2 Overall insights into forecast performance

Overall forecasting performance has improved since last winter

Winter 2020 was Australia's sixth hottest winter on record, with mean temperatures 1.15°C above average[5]. Despite experiencing above average mean temperatures, Victoria and South Australia also experienced some lower than average minimum temperatures.

Figure 1 compares winter 2019 and 2020, showing the 4-HA, 24-HA and 72-HA error distributions for each provider across all studied weather stations. At a high level this shows that forecasting performance either improved or remained consistent across most horizons. One exception to this was Provider C's 24-HA performance, which showed decreased performance in 2020.

Figure 1 Winter performance comparison (2019 and 2020), all providers, all weather stations, 4-, 24- and 72-HA horizons



[5] Bureau of Meteorology. Australia in winter 2020, available at http://www.bom.gov.au/climate/current/season/aus/archive/202008.summary.shtml

2.3 Insights by weather station

Forecast accuracy saw minor improvements in 2020, despite some weather stations regressing

Forecast improvement was observed at several stations this year, primarily due to increased precision. Average forecast biases and large under- or over-forecasting were still observed, and at some stations were larger than winter 2019. These biases or errors at some stations resulted in decreased performance in comparison to winter 2019.

Performance results were mixed:

- Both Melbourne weather stations, Olympic Park and Melbourne Airport, had the best performing forecasts over winter 2020.
- Archerfield and Hobart were the only stations that either improved or had consistent performance across all forecast horizons and vendors.
- Forecast performance improved at Bankstown and Penrith for all except for provider C's 24-HA horizon forecasts.
- Forecast performance at Bankstown had the most significant improvement across all vendors and time horizons.
- Forecast performance declined at Melbourne Olympic Park, Kent Town and Adelaide West Terrace compared to winter 2019.
- On average, 4-HA and 72-HA performance improved more than 24-HA for all stations.

Figure 2 shows the performance improvements between winter 2019 and 2020 at Bankstown, which saw the most significant improvements. Figure 3 shows that despite being one of the best performing weather stations, Melbourne Olympic Park saw decreased performance in winter 2020.

Figure 2 Bankstown Airport, all providers, winter 2019 and 2020 comparison, 4-, 24-, and 72-HA horizons

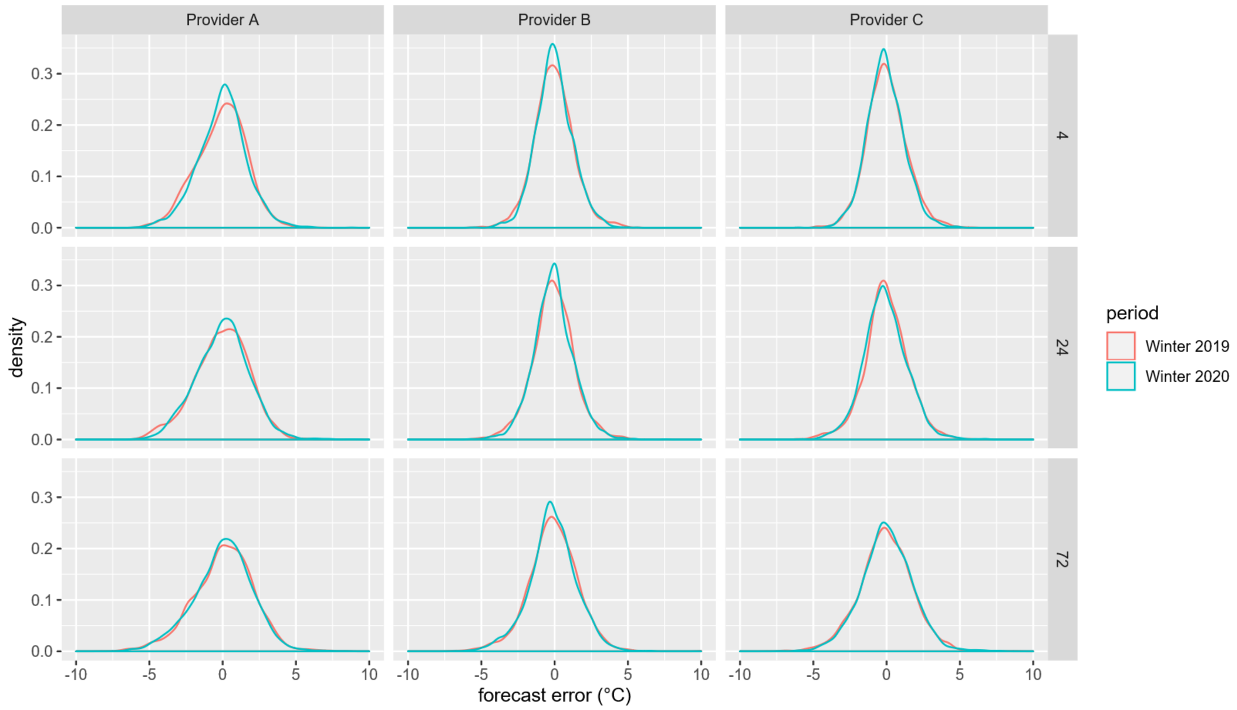
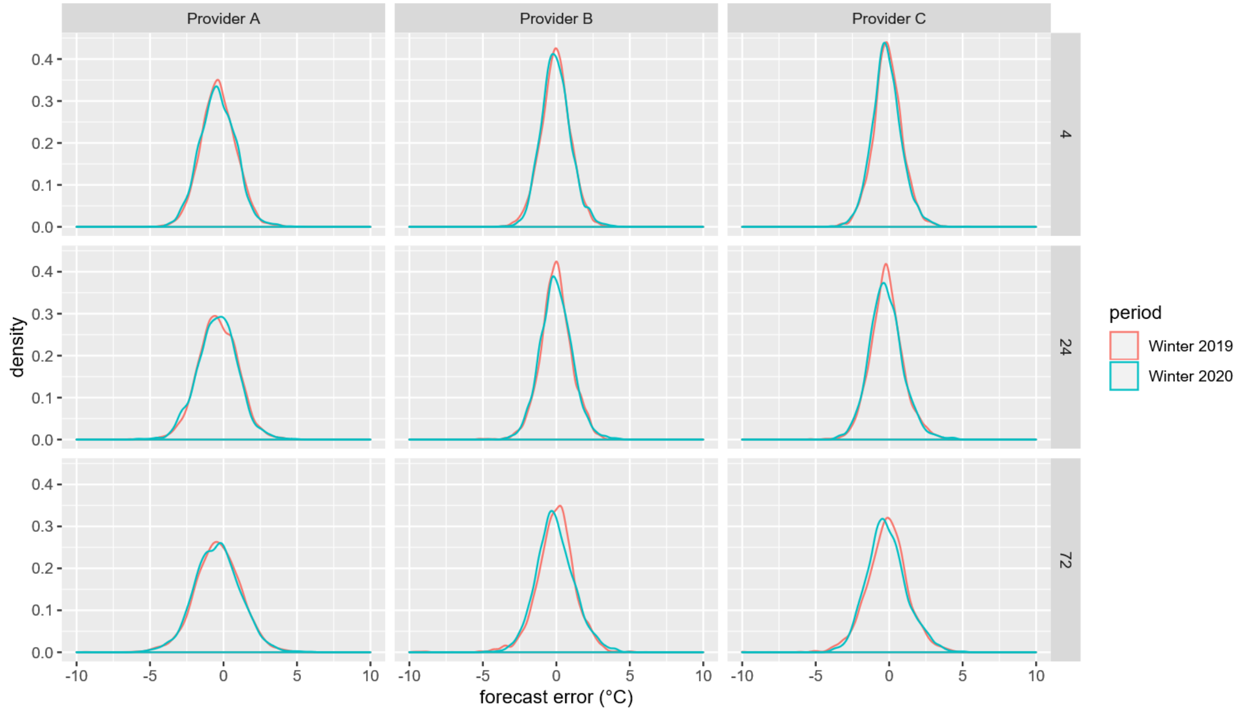


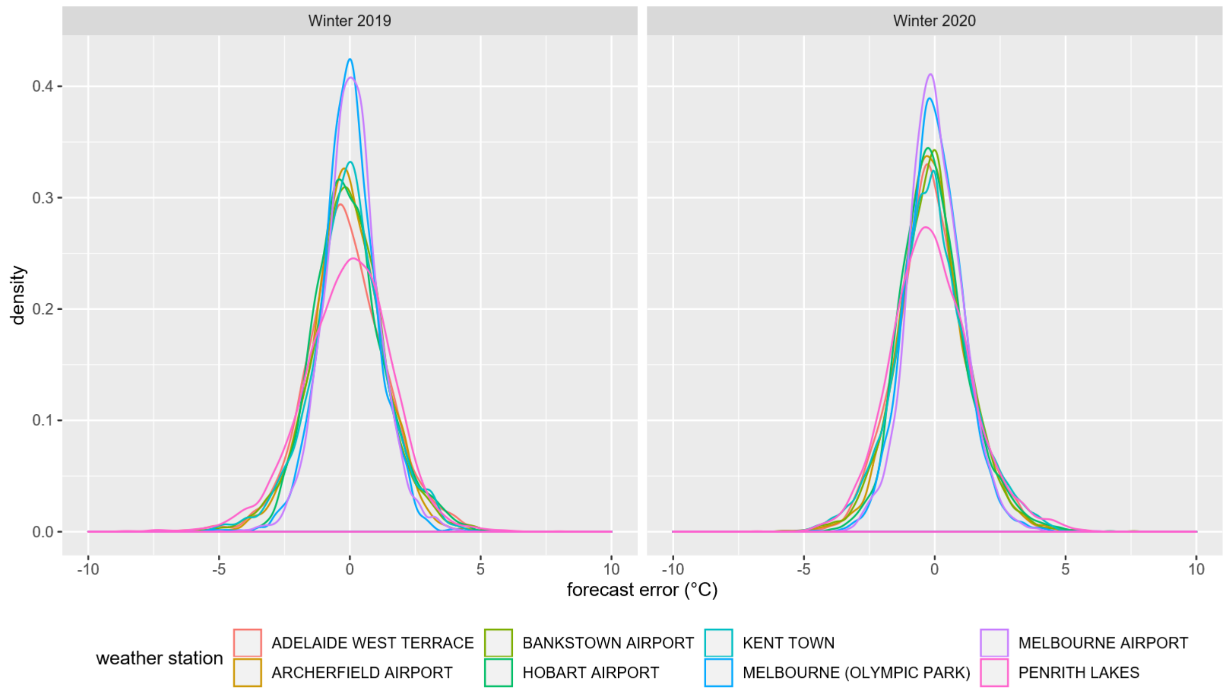
Figure 3 Melbourne Olympic Park, all providers, winter 2019 and 2020 comparison, 4-, 24-, and 72-HA



Penrith continues to be the most difficult weather station to forecast in winter

Penrith was forecast with the lowest precision by providers B and C, and second lowest for Provider A. This is demonstrated in Figure 4, which shows the error distribution for all weather stations for Provider B. This comparison is similar for Providers A and C, and shows Penrith performance marred by large under- and over-forecasting errors.

Figure 4 All weather stations, Provider B, winter 2019 and 2020 comparison, 24-HA horizon



Performance at West Terrace was better than Kent Town, an opposite finding to the 2019-20 summer comparison report

Forecast accuracy and precision at West Terrace was better than at Kent Town in winter 2020, as Figure 5 and Figure 6 show. This was primarily due to precision improvements by Providers B and C. Provider A performed worse at West Terrace across all horizons; accuracy showed limited improvement as lead time decreased.

Figure 5 West Terrace, all providers, winter 2020, 4-, 24-, and 72-HA time horizons

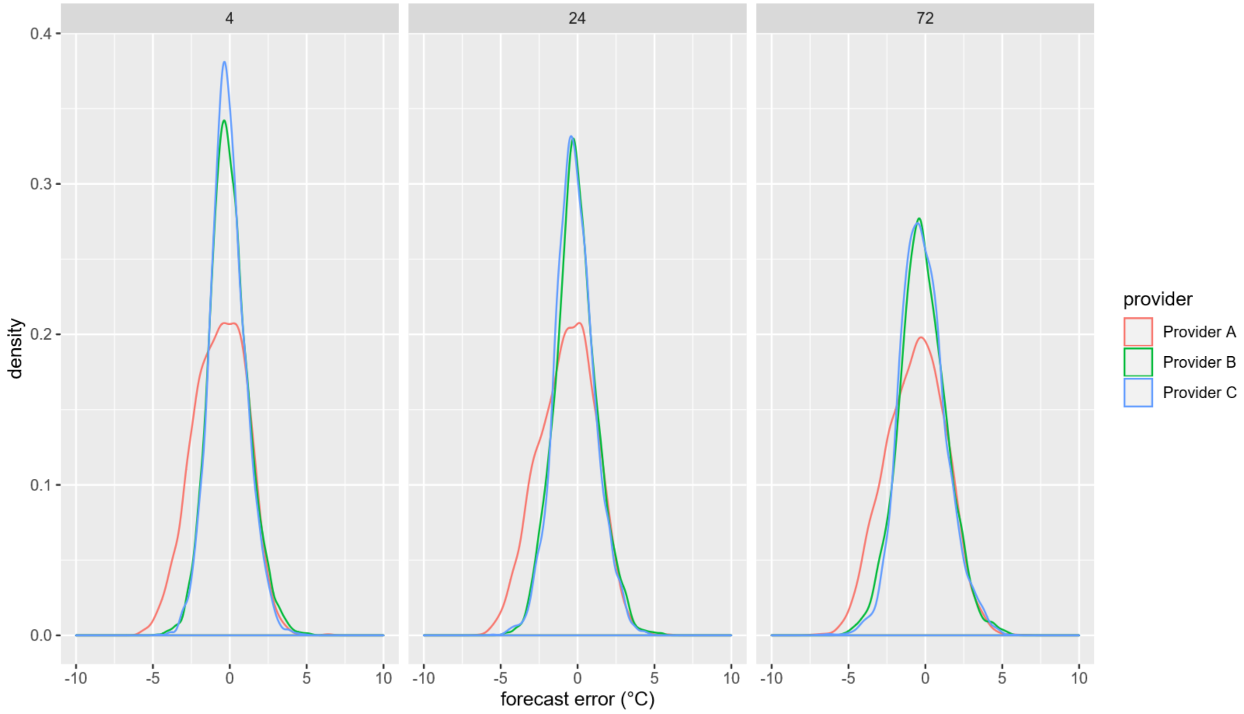
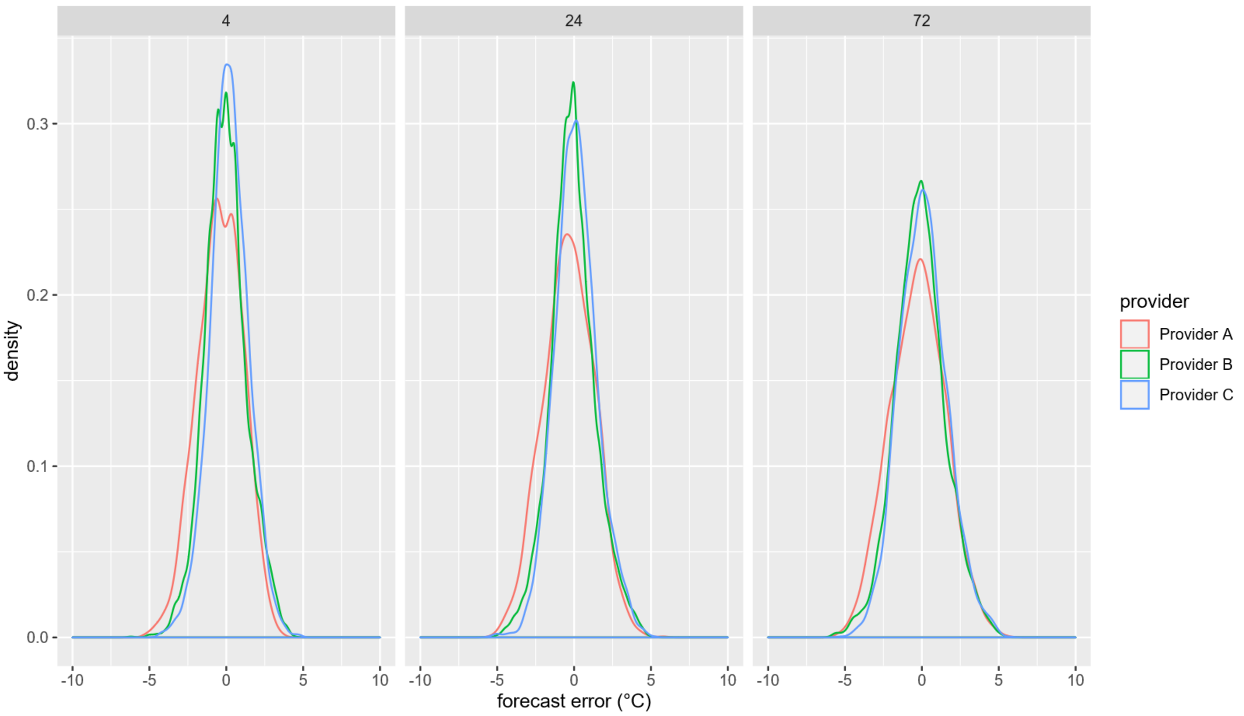


Figure 6 Kent Town, all providers, winter 2020, 4-, 24-, and 72-HA time horizons



On 31 July 2020, Kent Town weather station was decommissioned. AEMO is now using West Terrace as the primary weather station to forecast demand in South Australia. Ongoing performance improvements at West Terrace are particularly important given the high temperature sensitivity of South Australian demand, as explored in the *Temperature Forecast Analysis for Summer 2019-20*[6]. AEMO notes the improved forecast performance at this station by two of the three forecast providers is promising, as it will have translated to improved demand forecast performance during winter 2020.

2.4 Insights by provider

Overall performance improved for each provider in comparison to winter 2019

Overall forecast performance improved in winter 2020 across all providers. Performance improvements were mainly due to increased precision, with some biases still visible.

Performance improvements were positive for all providers:

- No provider had performance improvements at every station. Each provider had one or more stations where accuracy decreased.
- Providers A and B displayed the strongest overall improvements across all stations and forecast horizons.
- Provider C saw the lowest overall improvement, due to a decline in 24-HA accuracy. This can be seen in Figure 1 in the previous section.
- Provider B displayed the strongest performance at 24-HA and 72-HA forecasts; Provider C provided the most accurate 4-HA forecast.
- All providers displayed a bias to under-forecast. Provider A displayed the strongest biases. This can be seen in the error density plots in Appendix A1.

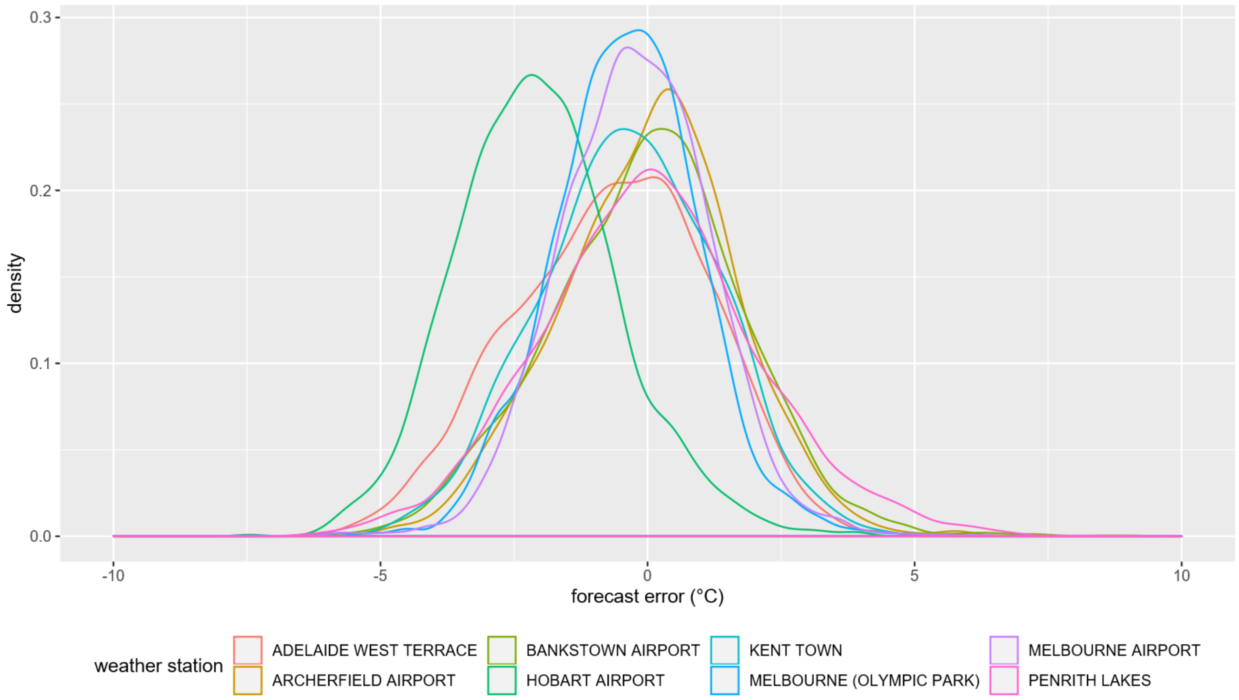
Provider A significantly under-forecast at Hobart Airport

Provider A under-forecast by an average of approximately 2.5°C at Hobart Airport. Smaller, but still notable, under-and over-forecasting was also observed at other stations.

Figure 7 shows the comparative performance of Provider A at all stations in winter 2020.

[6] See Section 2 of AEMO's Temperature Forecast Analysis for Summer 2019-20, at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/load-forecasting/temperature-forecast-analysis-for-summer-2019-20.pdf?la=en&hash=22FCBA6C05875DF81207B63D3C925D9B

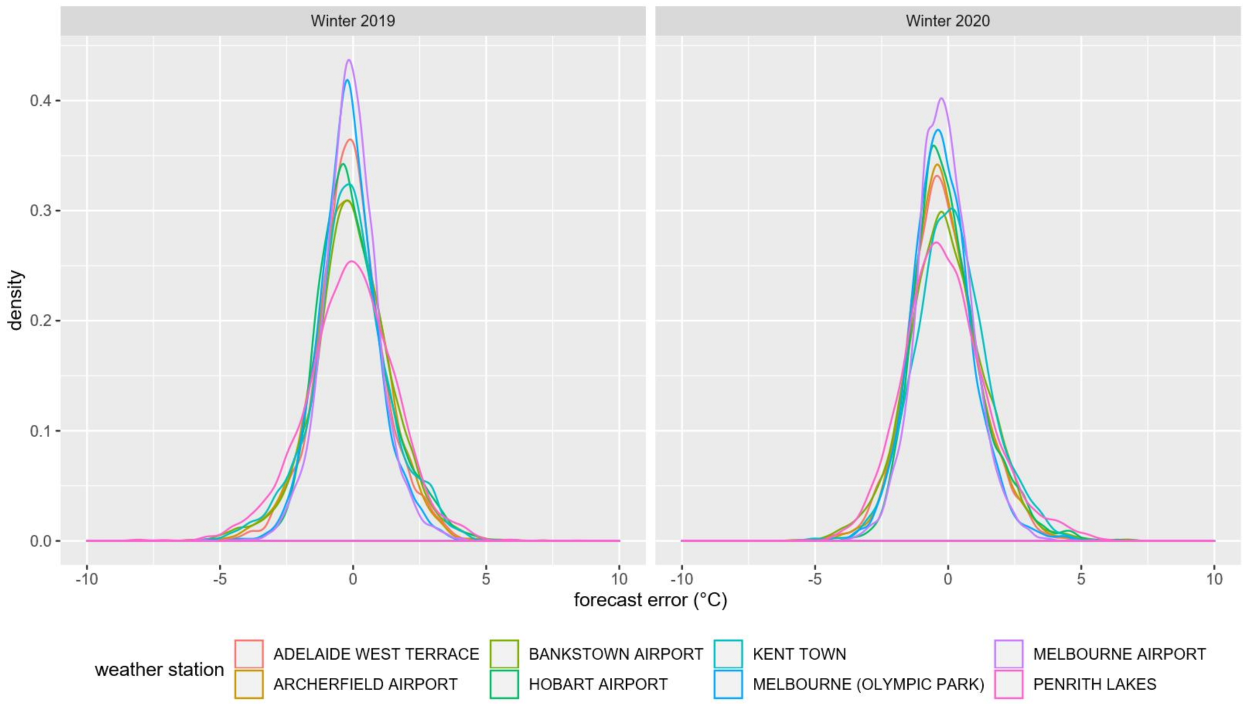
Figure 7 All weather stations, Provider A, winter 2020, 24-HA horizon



Provider C had an overall improvement in forecast performance, but decreased performance for 24-HA forecast since winter 2019

In the 2019 winter report, Provider C had the strongest performance for the 24-HA horizon. This winter, Provider C's 24-HA performance declined for most weather stations, primarily due to reduced precision.

Figure 8 All weather stations, Provider C, winter 2019 and 2020 comparison, 24-HA horizon



Provider B and C provided the most accurate forecasts, but forecast accuracy varied over time horizons

There were small differences in performance between Provider B and C over the three different horizons. The reduction in 24-HA accuracy for Provider C described in the above section resulted in Provider B having the strongest 4-HA and 24-HA performance in winter 2020. Provider C maintained the strongest performing 72-HA forecasts. Forecast performance at Melbourne Airport was the best for both providers. Figure 9, Figure 10 and Figure 11 display these changes in accuracy.

Figure 9 Melbourne Airport, all providers, winter 2019 and 2020 comparison, 4-HA horizon

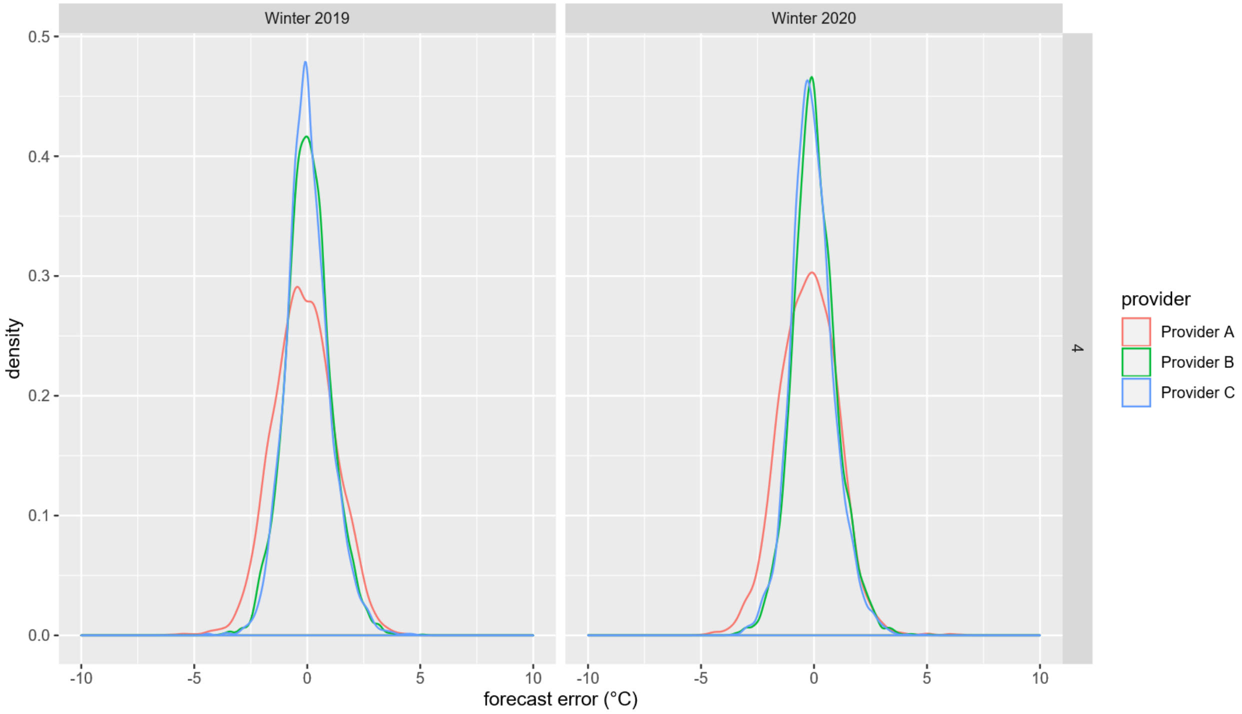


Figure 10 Melbourne Airport, all providers, winter 2019 and 2020 comparison, 24-HA horizon

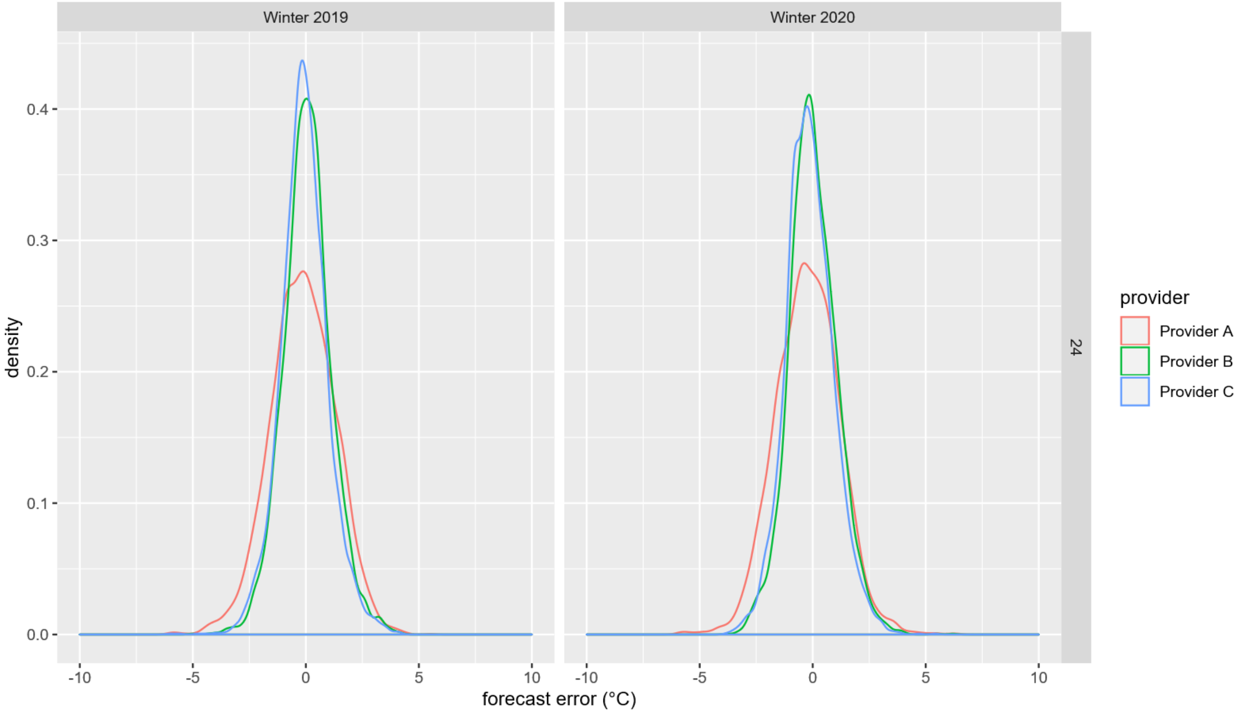
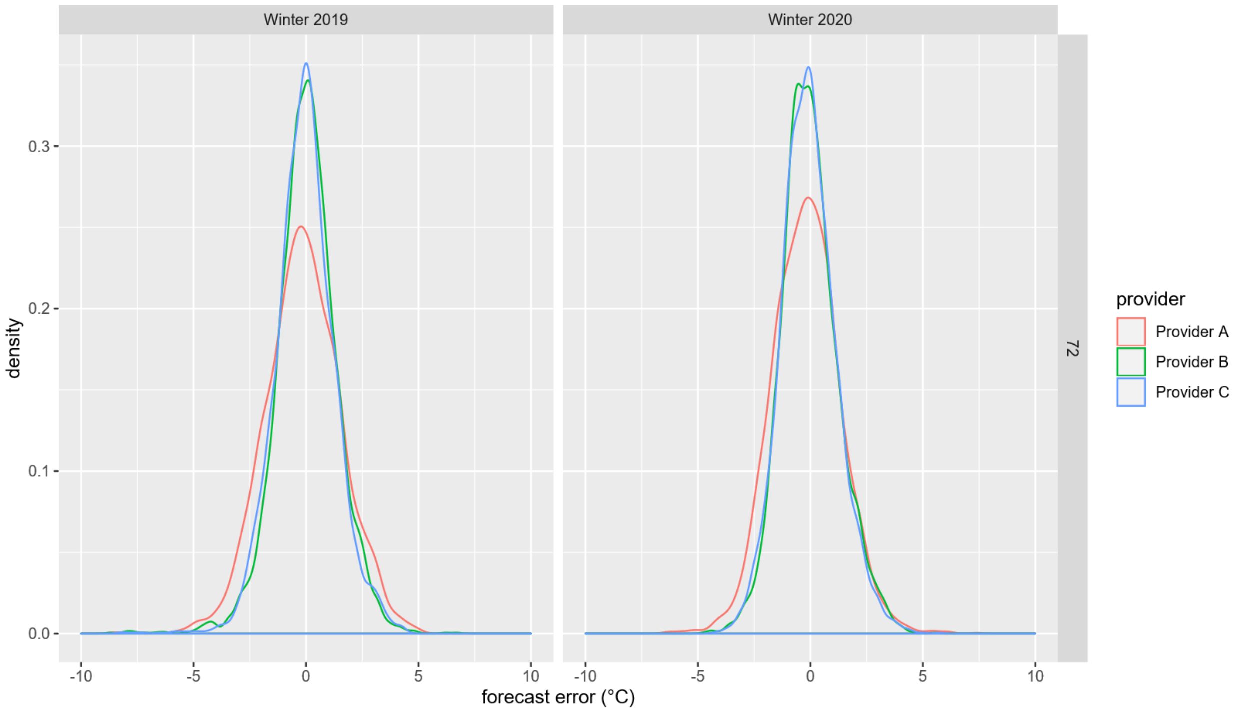


Figure 11 Melbourne Airport, all providers, winter 2019 and 2020 comparison, 72-HA horizon



2.5 Intraday insights

Overall, there was an improvement in intraday forecast performance

In summary:

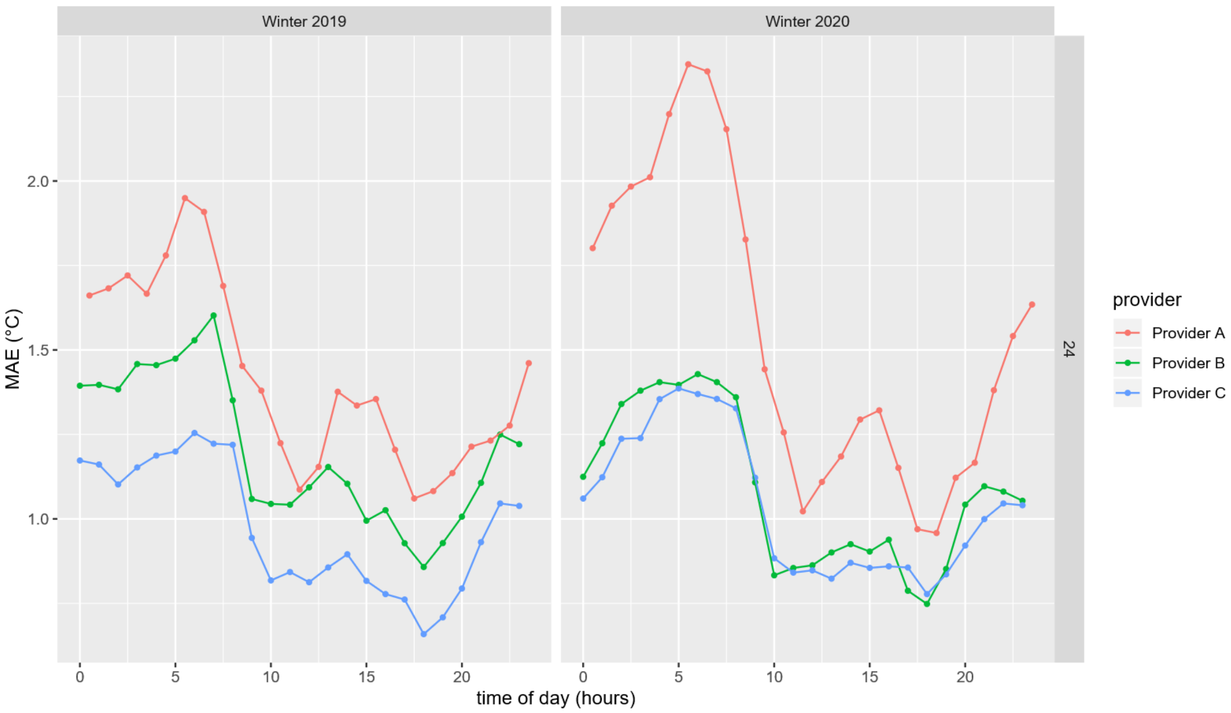
- Midday, afternoon and early evening temperatures continued to be forecast with greater accuracy, supporting the winter 2019 analysis.
- All providers tended to have the largest errors overnight and in the early morning. In winter, this usually aligns with the lowest daily minimum temperatures seen in a calendar year.
- All providers experienced some peak error reductions, with the most significant peak reductions occurring during the late afternoon/evening period.

Intraday MAE profiles show that temperature forecasting performance between late morning and late evening continued to be superior to forecast performance at other times. These periods coincide with the evening electricity demand peak, and the period leading into the peak. Temperatures in the hours leading up to evening peak demand have a significant impact on residential heating loads in winter and cooling loads in summer.

All providers tended to have the poorest performance during the overnight hours and the early morning. Given that morning demand peaks occur more frequently than evening demand peaks in winter, the outcome that overnight and morning temperatures were forecast with lower performance should be considered an improvement area for providers. Given the impact on demand, performance improvement during these periods will greatly assist AEMO.

Figure 12 shows the comparison of intraday forecasting errors at Adelaide West Terrace for winter 2019 and winter 2020 at the 24-HA horizon. For the midday to early evening period (normally the time of peak electricity demand), Provider B showed a significant improvement, Provider A displayed slight improvement, and Provider C had no improvement (see Section 2.4 for commentary on Provider C's reduction in 24-HA accuracy).

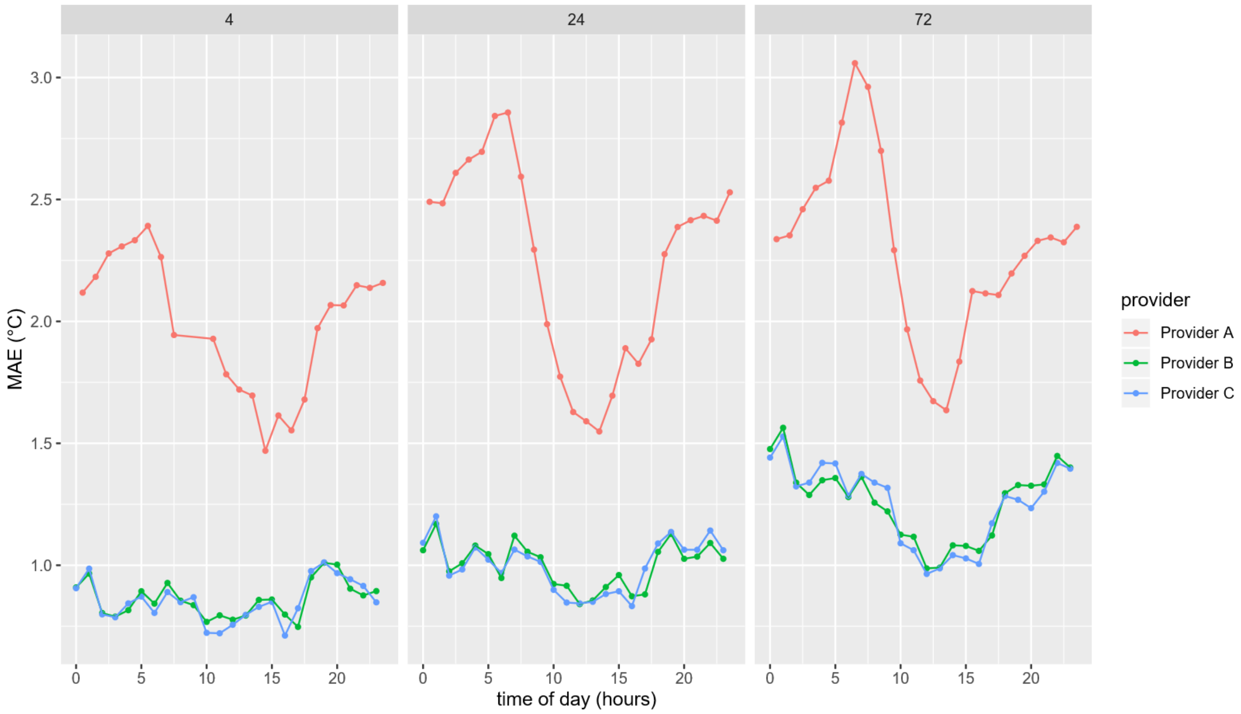
Figure 12 Adelaide West Terrace, all providers, MAE intraday profiles, winter 2019 and 2020 comparison, 24-HA horizon



Provider A's forecasts produced large MAEs relative to the other providers at Hobart Airport, a finding similar to the 2019-20 summer analysis

There was a large spread between providers at Hobart Airport, with Providers B and C producing significantly lower MAEs. Provider A's largest errors came overnight and in the early morning, with the lowest around the late afternoon. Figure 13 shows this separation between the providers.

Figure 13 Hobart Airport, all providers, MAE intraday profiles, winter 2020, all horizons



3. Case study: New South Wales, 9 August 2020

3.1 Temperature forecasting

This section examines an instance of extreme temperature under-forecasting at Bankstown Airport and Penrith Lakes weather stations on Sunday, 9 August 2020.

AEMO's regional forecast models take temperature forecast feeds from multiple weather stations across a region, and weight these feeds according to their relative value in predicting demand for electricity. For context, Penrith and Bankstown are the most heavily weighted weather stations in the New South Wales region due to their close proximity to major load centres, as observations at both these weather stations are highly indicative of New South Wales demand. Accurate temperature forecasts, particularly at these stations, will tend to increase the accuracy of AEMO's demand forecasts.

New South Wales demand on 9 August 2020 was under-forecast by up to 1,334 megawatts (MW) compared to forecasts made 24 hours prior. A significant proportion of the region's demand forecast error on this day can be attributed to the temperature over-forecasting observed at Bankstown and Penrith. The remainder of the forecast error was due to a combination of weather forecast error at other stations, deviation of rooftop PV generation from forecasts, and residual 'model' error inherent in the demand forecast model.

Observations from Figure 14 and 15 are:

- The actual temperature profile (dashed black line) was accurately forecast at both stations by all providers from the 72-HA forecast onwards from midnight through to mid-morning. This coincided with New South Wales demand forecasts, which closely aligned with the observed actual demand during this period
- Actual temperatures dropped significantly at Bankstown at approximately 1100 hrs and Penrith at 1200 hrs, and remained lower than forecast until the evening. This drop in temperature was not captured at the 72-HA forecast, with all providers forecasting a gradual increase in temperature through to approximately 1400 hrs before a gradual decline leading into the evening. Forecast accuracy gradually improved for Providers B and C as the forecast horizon shortened, yet both providers still over-forecast even at the 1-HA timeframe. Forecast accuracy for Provider A did not significantly improve between the 72- and 4-HA time horizons, with a moderate improvement at the 1-HA timeframe.

Figure 14 Forecast temperatures against actual temperature observations (black dashed line) for each provider in New South Wales, 9 August 2020 at Bankstown Airport

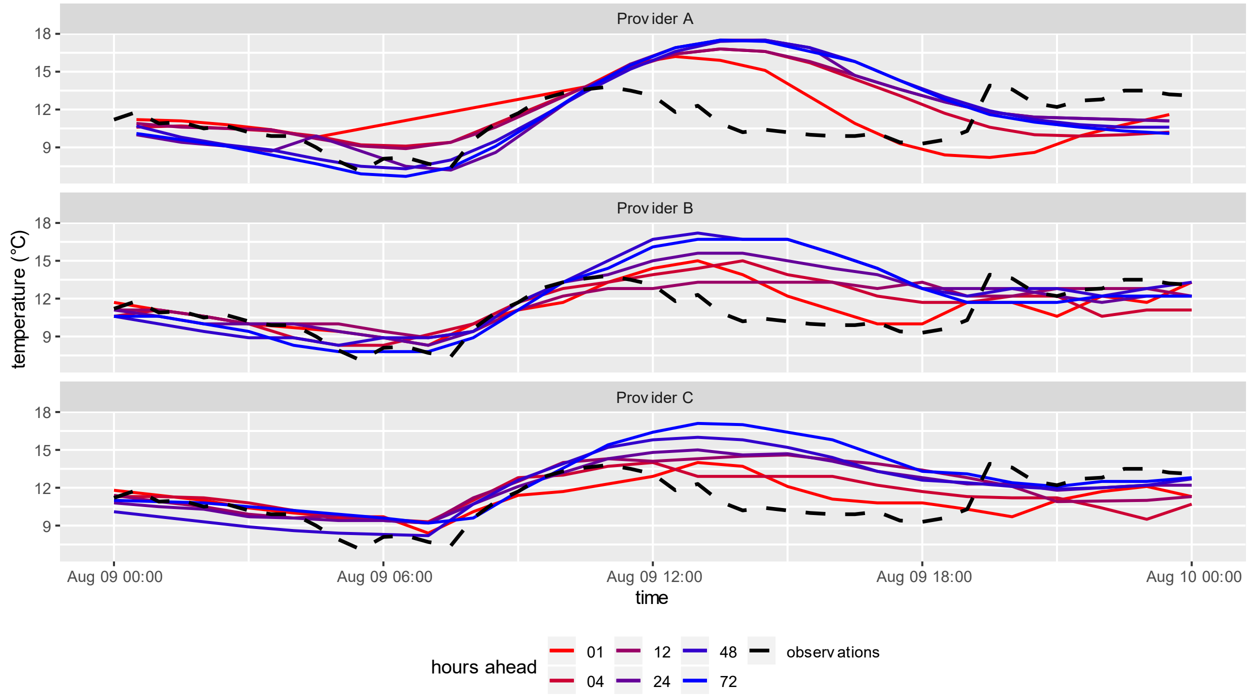
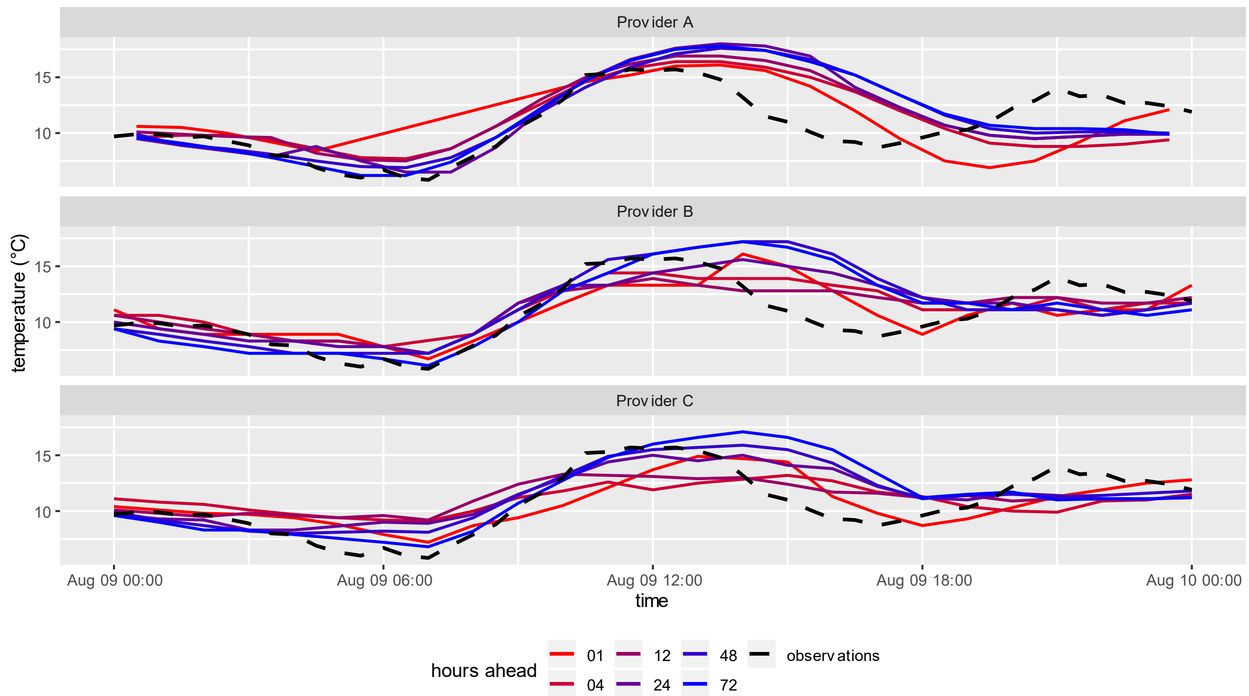


Figure 15 Forecast temperatures against actual temperature observations (black dashed line) for each provider in New South Wales, 9 August 2020 at Penrith Lakes

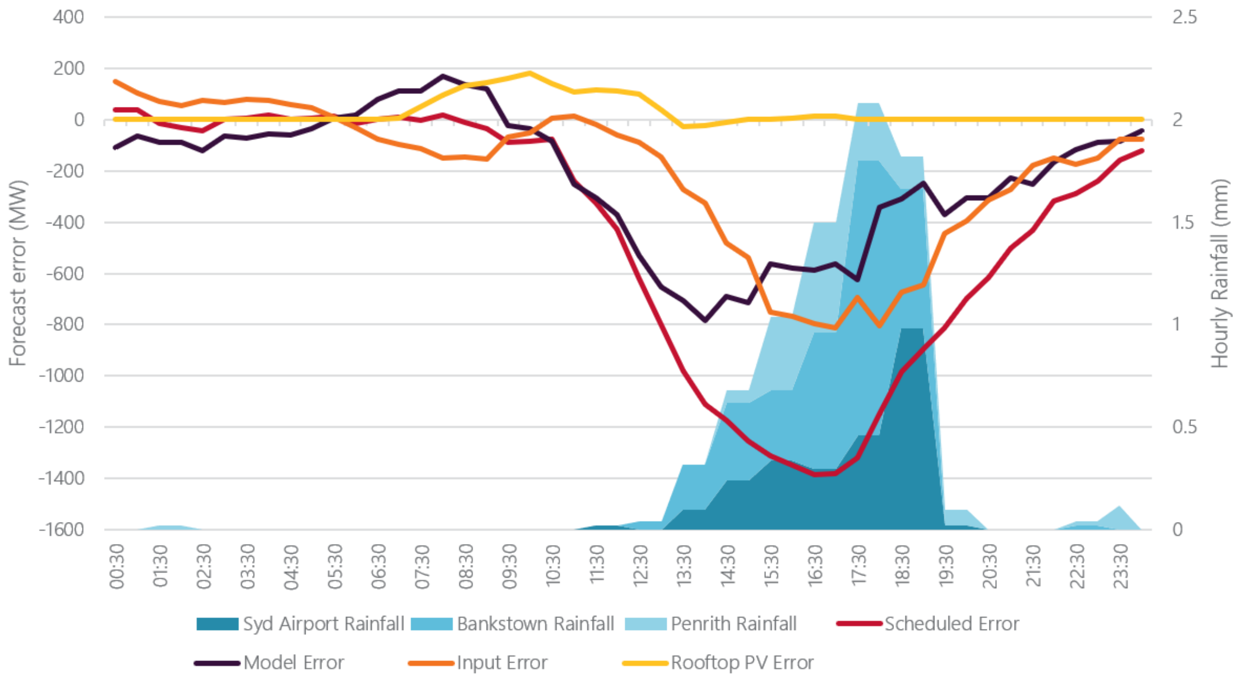


3.2 Demand forecasting

Using the same day and region as above (9 August 2020, New South Wales), this section illustrates how inaccurate weather forecasts may impact the accuracy of AEMO's demand forecasts. Figure 16 below shows how different types of demand forecast error contributed to the large scheduled error observed on this day:

- It compares the actual demand observations to the forecasts published at 1230 hrs on the previous trading day, in line with the publishing of the pre-dispatch schedule as outlined in the Spot Market Operations Timetable[7].
- There are four types of error included in this chart:
  - Scheduled – the total deviation of observed demand from forecast.
  - Input – the deviation of demand from forecast attributable to the deviation of forecast inputs (temperature, humidity etc).
  - Model – the deviation of demand from forecast attributable to inherent deviations in demand not captured by the demand forecast model.
  - Rooftop PV – the deviation of demand attributable to deviation of estimated actual rooftop PV generation from forecast.
- Errors are calculated as the difference between the forecast and observed actual, with a negative number indicating under-forecasting. The under-forecasting of rooftop PV has been flipped in the chart to reflect that it contributes to over-forecasting of demand.
- Rainfall may impact rooftop PV generation and temperatures in ways not captured by PV and temperature forecasts. This can contribute to PV and temperature error in the demand forecast. The behavioural impacts of rainfall on demand are considered model error.

Figure 16 Rainfall at Sydney weather stations and New South Wales 1230 hrs pre-dispatch demand forecast error, 9 August 2020



7 At 1230 hrs, the pre-dispatch (PD) schedule is extended to include an extra trading day in accordance with the Spot Market Operations Timetable, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Dispatch/Spot-Market-Operations-Timetable.pdf.

Three key observations from Figure 16 are:

- From 0700-0900 hrs, there was persistent positive model error which coincided with a similarly sized persistent negative input error. These two errors had the effect of largely negating each other, resulting in negligible scheduled error during this period. It is important to understand how different types of error contribute to the overall scheduled error.
- Between 0700 hrs and 1230 hrs, rooftop PV generation on this day was under-forecast by up to 180 MW. This has the effect of reducing operational demand and helped reduce the over-forecasting observed during this period.
- From 1030-1630 hrs, overall forecast performance deteriorated significantly. Unlike the period earlier in the day, both model and input contributed to the significant under-forecast. These errors impacted the demand forecast in the following ways:
  - Cooler than forecast temperatures have the effect of increasing heating loads and therefore increased operational demand. This contributes to model and input error.
  - Rainfall, as observed during this period, has the effect of increasing the use of appliances as individuals choose to stay indoors. This contributes to model error.
  - There has been increased sensitivity to cold temperatures this winter. This sensitivity has been more apparent on cold days coinciding with rainfall, as well as on weekends. This has been attributed to a greater number of people staying at home this year due to COVID-19, further increasing heating load and use of appliances. This contributes to model error.

  This relationship between lower temperatures and higher operational demand is typical of most major load centres in the NEM during winter. This relationship tends to be reversed in summer, where cooler temperatures tend to decrease air-conditioning load rather than increase heating load.

  Temperature error was largest during the early afternoon at Bankstown (4°C at 1400 hrs) and mid-afternoon at Penrith (5°C at 1600 hrs). The largest input error, in megawatt terms, was observed later in the afternoon at 1700 hrs, despite slightly smaller temperature errors observed at Bankstown and Penrith at this time. This illustrates the lagged effect temperature has on demand, as spaces which have been cooled over the day require more energy to be heated up again during the evening. Therefore, if temperature was over-forecast during the daytime, it can be expected that evening heating loads will be under-forecast.

  These findings are consistent with the findings outlined in the *Temperature forecast Analysis for Winter 2019* report and highlight AEMO's need for accurate temperature forecasts.

4. Conclusions

The results presented in this report supplement the findings of AEMO's previous temperature forecast analysis, and AEMO will use them to aid operational forecasting and decision-making. This analysis will be shared with AEMO's current weather service providers to draw attention to areas of improvement, and will provide information to intending weather service providers. The report also aims to contribute to ongoing discussion and improvement within AEMO and the energy industry.

The key findings from the analysis were:

- Overall forecasting performance has improved since last winter.
- Both Melbourne weather stations had the best performing forecasts for all providers.
- Despite being one of the most improved weather stations, Penrith continued to have the lowest forecasting precision over winter.
- Forecast performance at Penrith and Bankstown saw the strongest improvement since last winter.
- Forecast performance at West Terrace was better than Kent Town, a positive finding given AEMO now uses West Terrace for measurements in Adelaide.
- Provider A had ongoing performance issues at Hobart Airport.
- All providers improved their forecasts over each forecast horizon, with the exception of Provider C, which had lower 24-HA accuracy than in winter 2019.

In 2021, AEMO is continuing to work with the weather forecasting industry to ensure weather forecast tools are developed for the purposes of energy forecasting. In addition, AEMO is:

- Continuing to work with Solcast on the ARENA-funded Nowcasting project, to test improvements to near-term weather forecasts in the 0-6 hour ahead horizon[8].
- Working with the renewable energy industry to improve the management of intermittent generation de-rating and cut-out during extreme weather conditions[9]. AEMO updated its generator reference temperature procedure ahead of summer 2020-21 to better capture the risk of de-rating and cut-out events.
- Working with the meteorology industry on the continuous improvement of current weather prediction models, as these provide key weather inputs into variable renewable generation (VRE) forecasts.

8 See AEMO's media release on the ARENA funded Nowcasting project at https://aemo.com.au/news/solcast-nowcasting-project.

9 See Section 9.2.3 of AEMO's Summer Operations Review Report, at https://aemo.com.au/-/media/files/electricity/nem/system-operations/winter-operations/2020/winter-2020-nem-operations-review.pdf?la=en.

A1. Error density plots

A1.1 Station comparison by provider

Figure 17 All weather stations, Provider A, winter 2020, 24-HA horizon

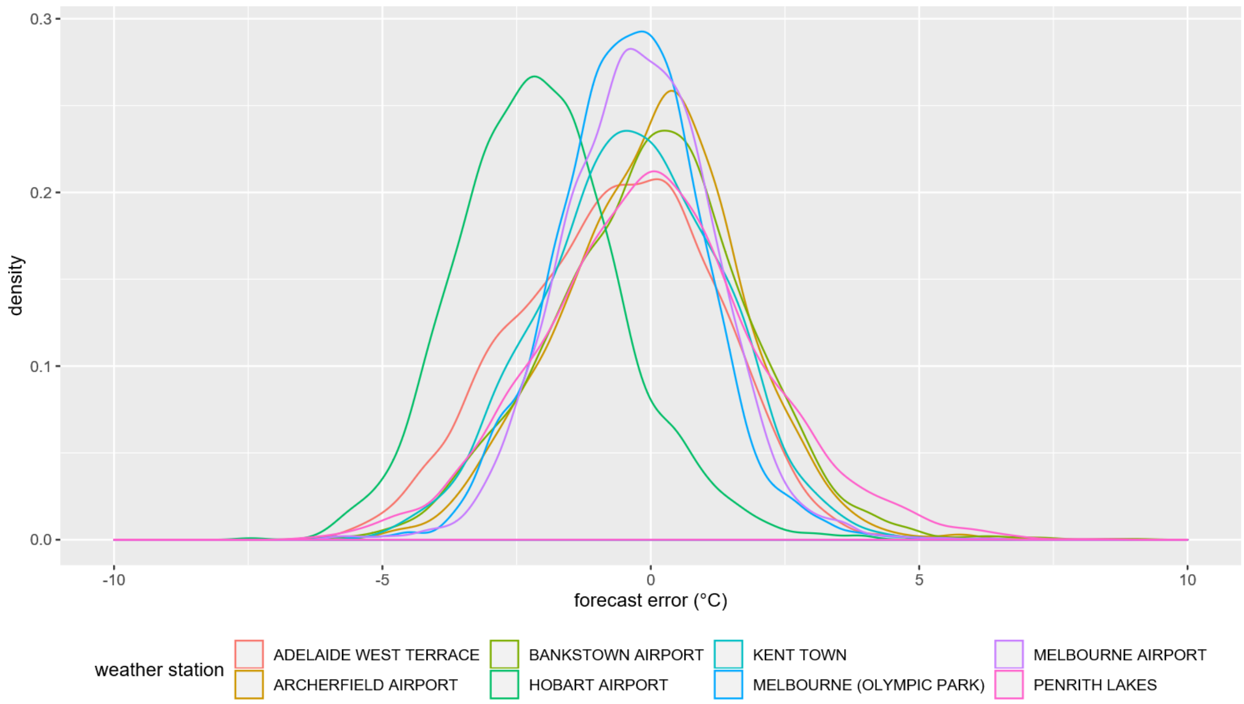


Figure 18 All weather stations, Provider B, winter 2020, 24-HA horizon

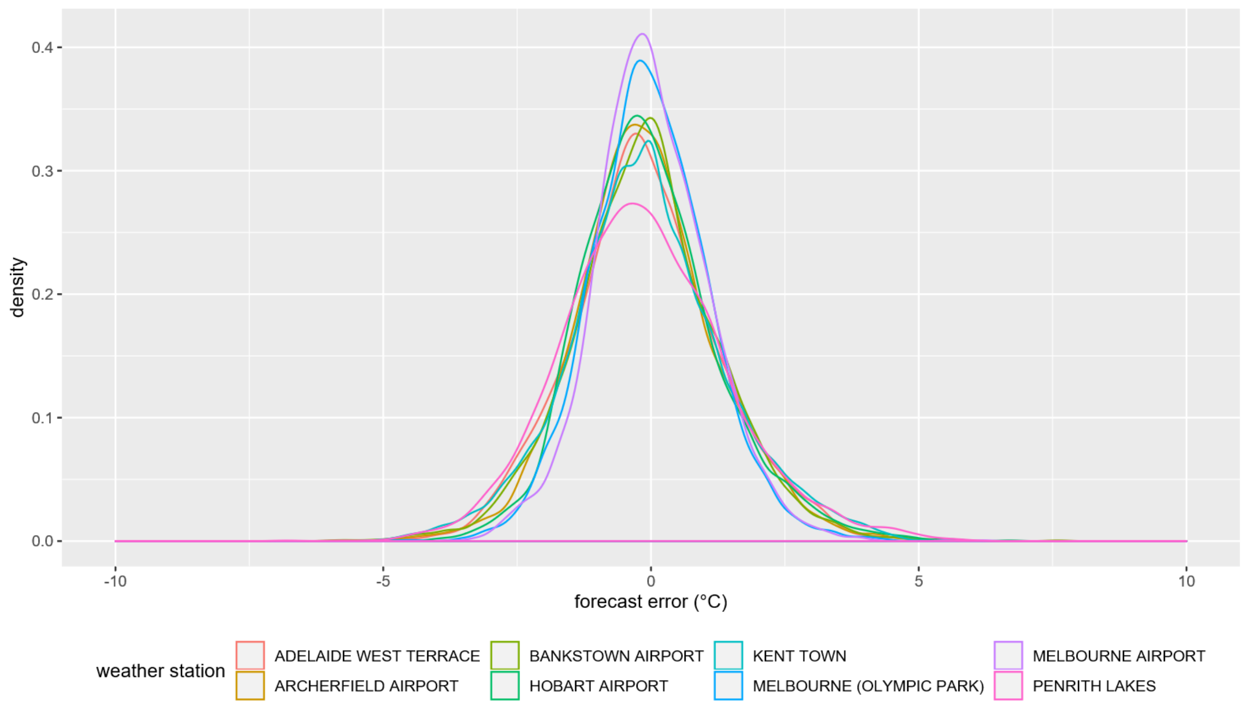
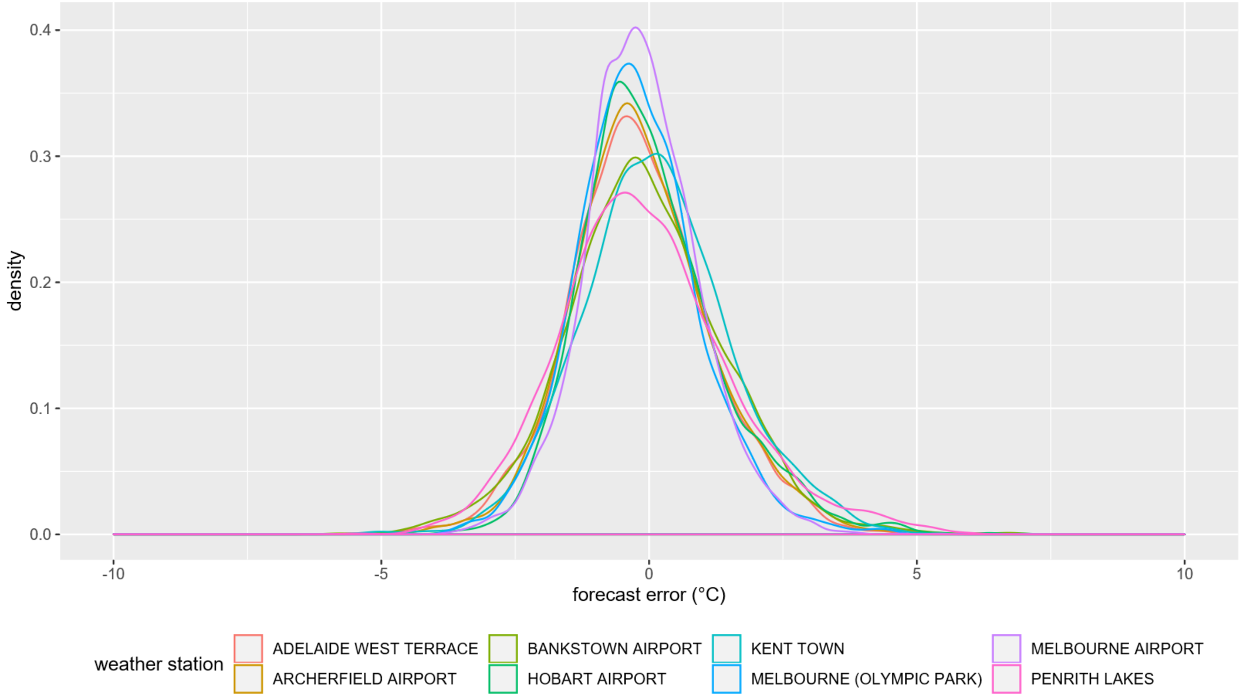


Figure 19 All weather stations, Provider C, winter 2020, 24-HA horizon



A1.2 Provider comparison by station

Figure 20 Adelaide West Terrace, all providers, winter 2020, 4-, 24-, and 72-HA horizons

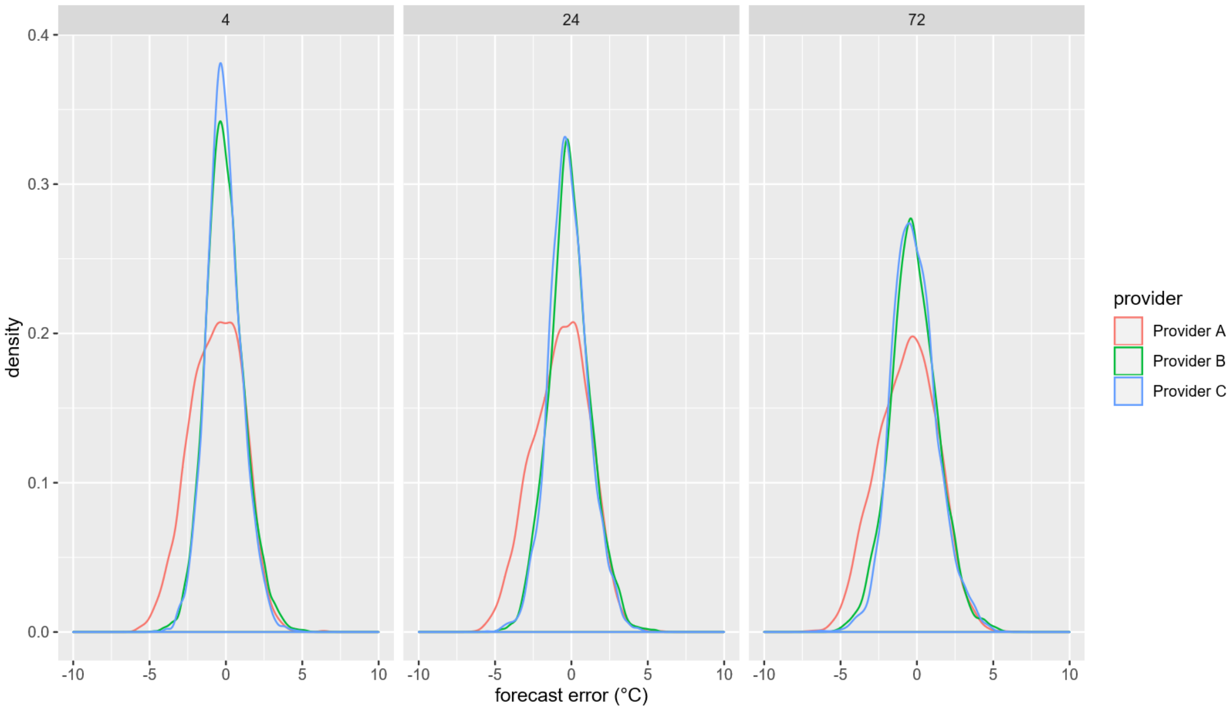


Figure 21 Archerfield, all providers, winter 2020, 4-, 24-, and 72-HA horizons

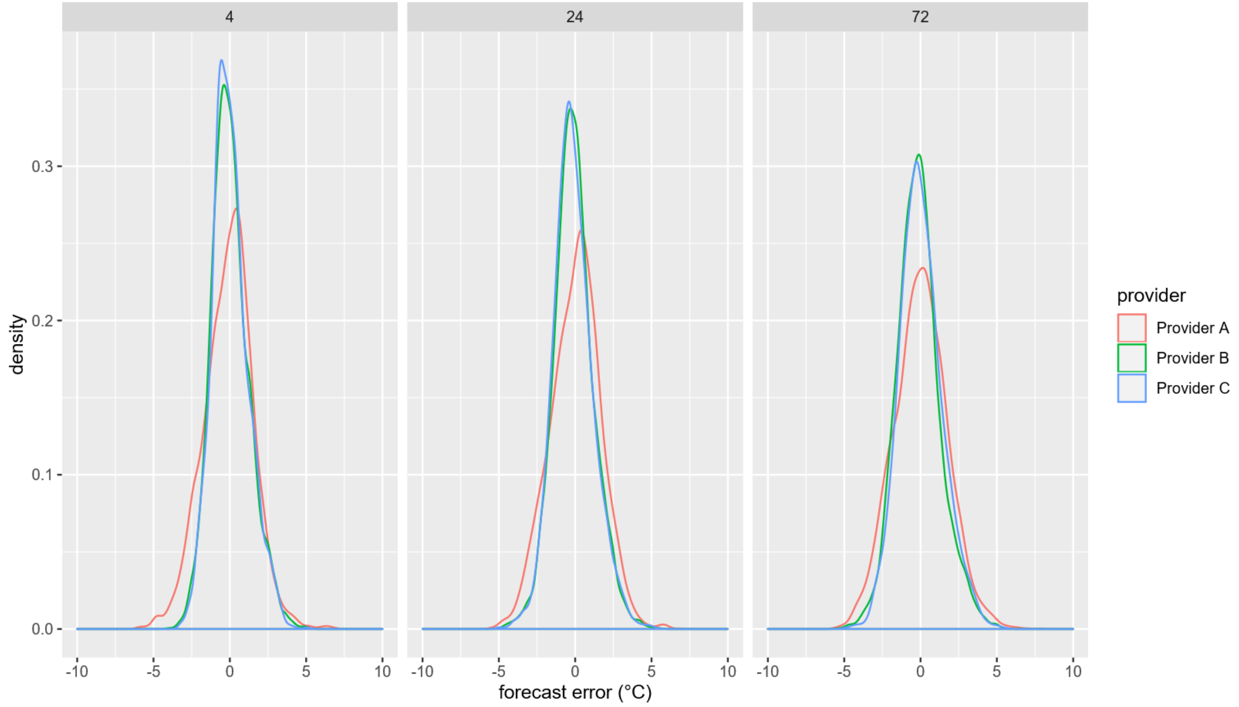


Figure 22 Bankstown Airport, all providers, winter 2020, 4-, 24-, and 72-HA horizons

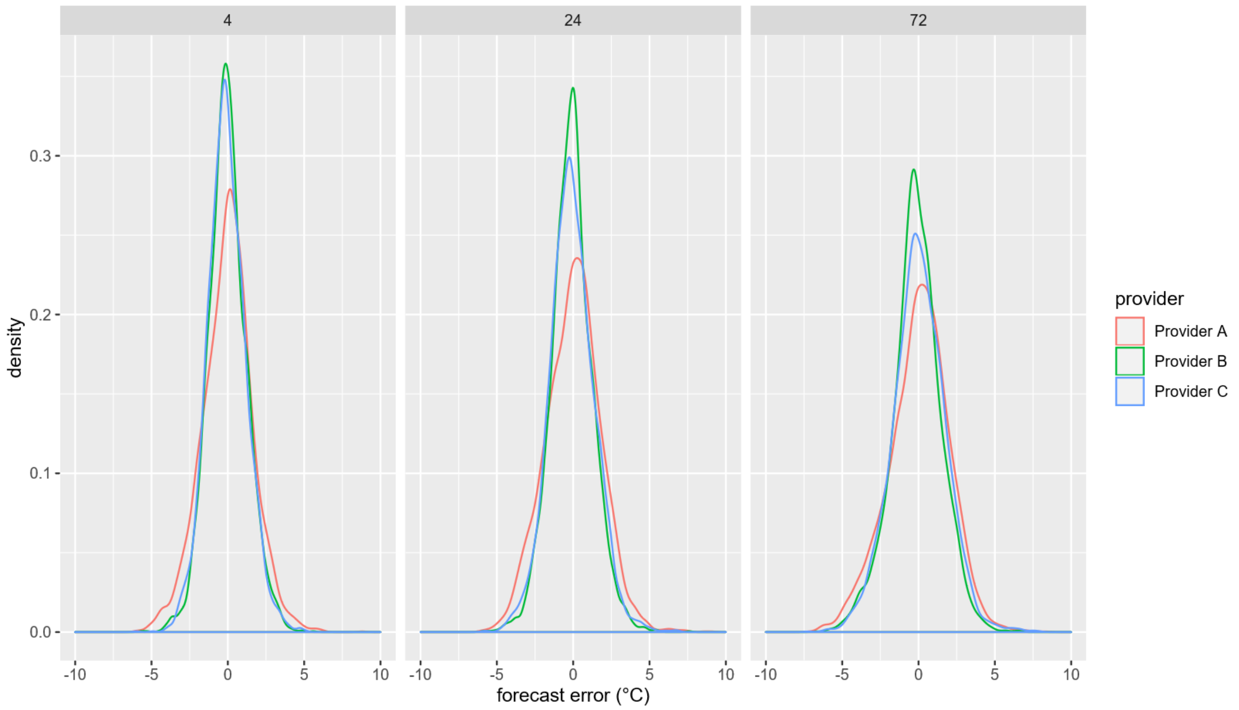


Figure 23 Hobart Airport, all providers, winter 2020, 4-, 24-, and 72-HA horizons

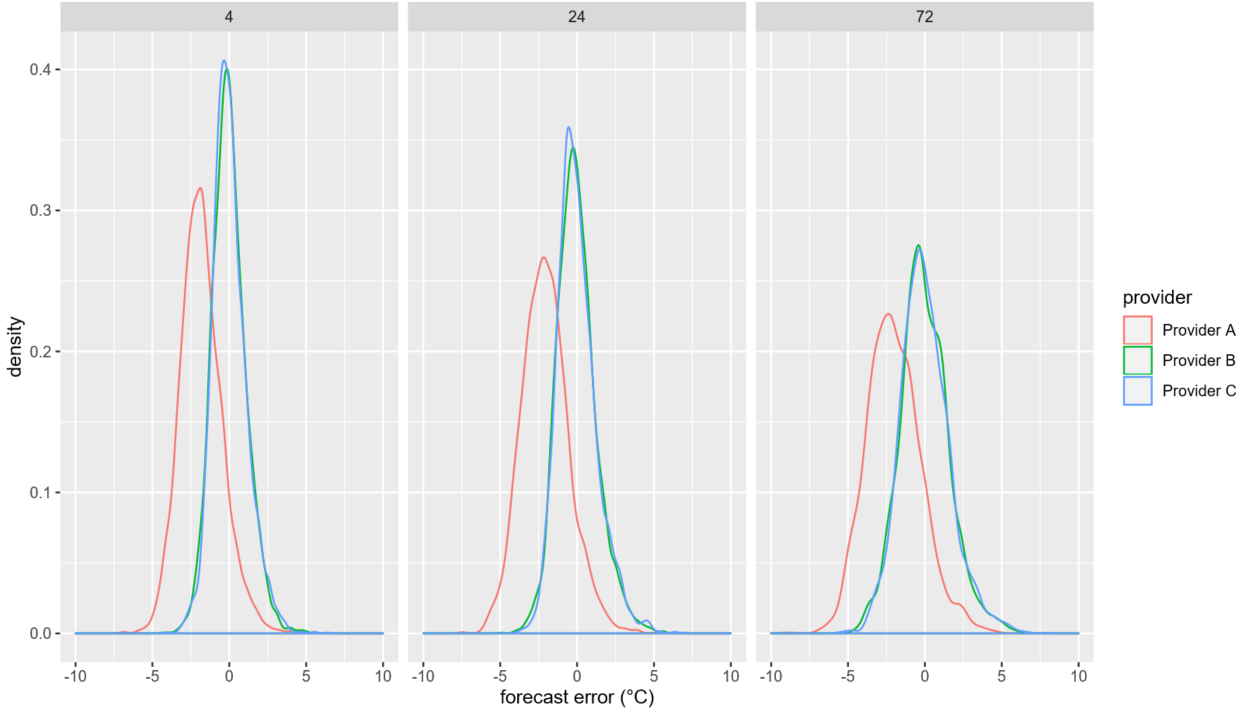


Figure 24 Kent Town, all providers, winter 2020, 4-, 24-, and 72-HA horizons

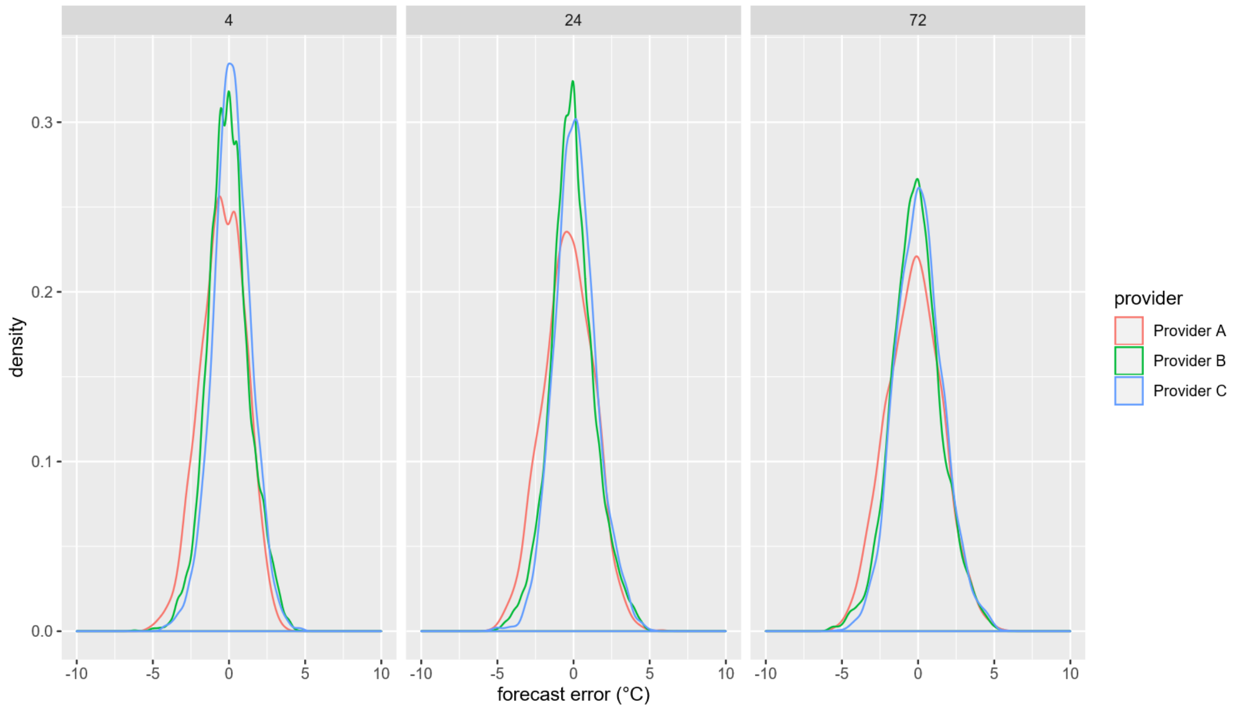


Figure 25 Melbourne Olympic Park, all providers, winter 2020, 4-, 24-, and 72-HA horizons

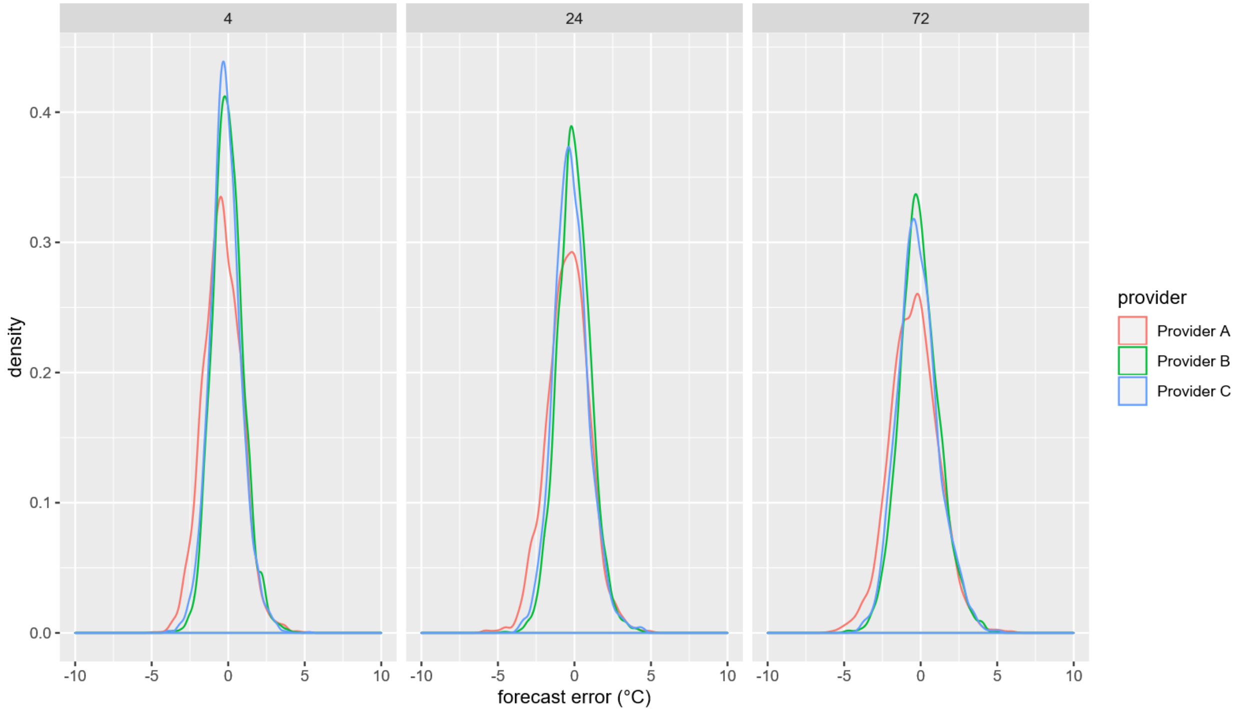


Figure 26 Melbourne Airport, all providers, winter 2020, 4-, 24-, and 72-HA horizons

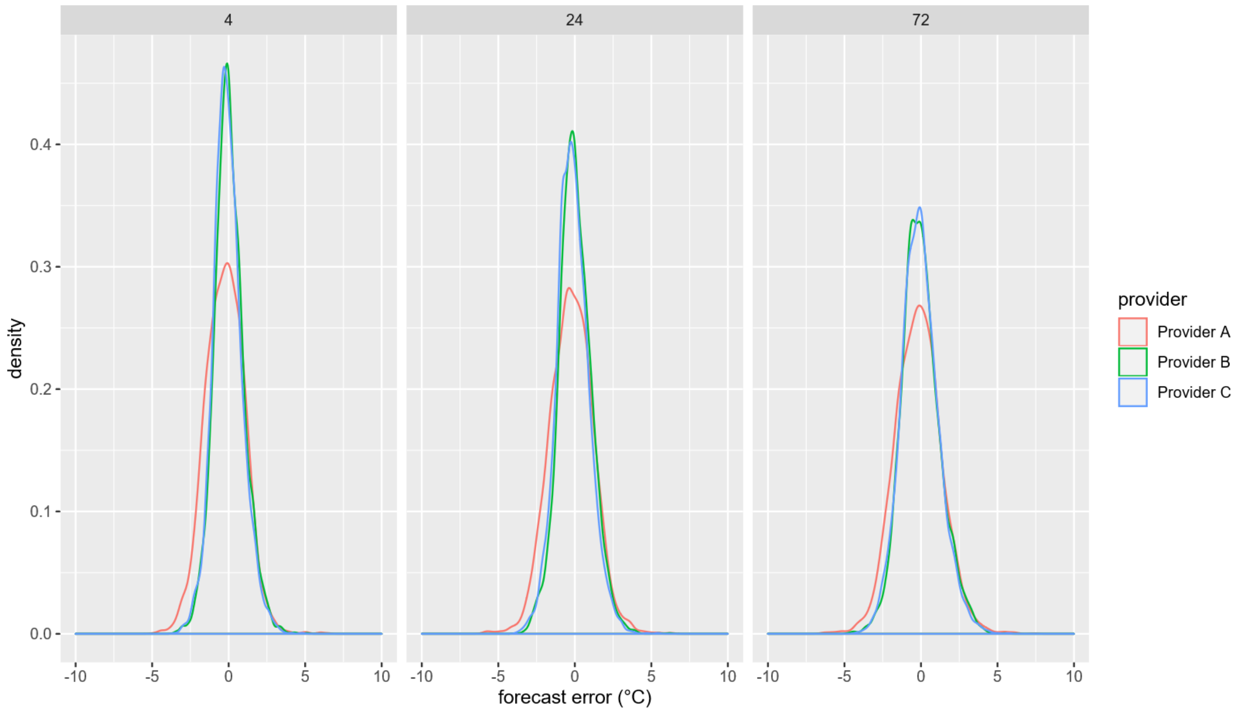
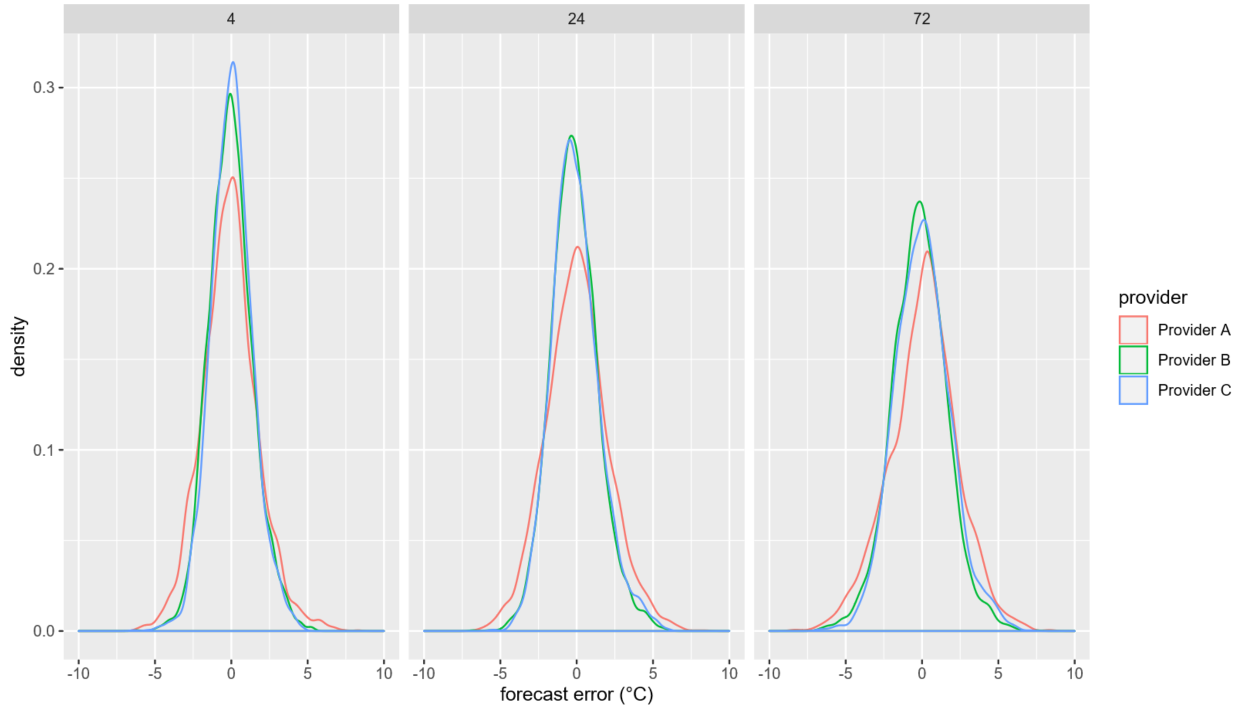


Figure 27 Penrith Lakes, all providers, winter 2020, 4-, 24-, and 72-HA horizons



A2. Intraday MAE profiles

Figure 28 Adelaide West Terrace, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

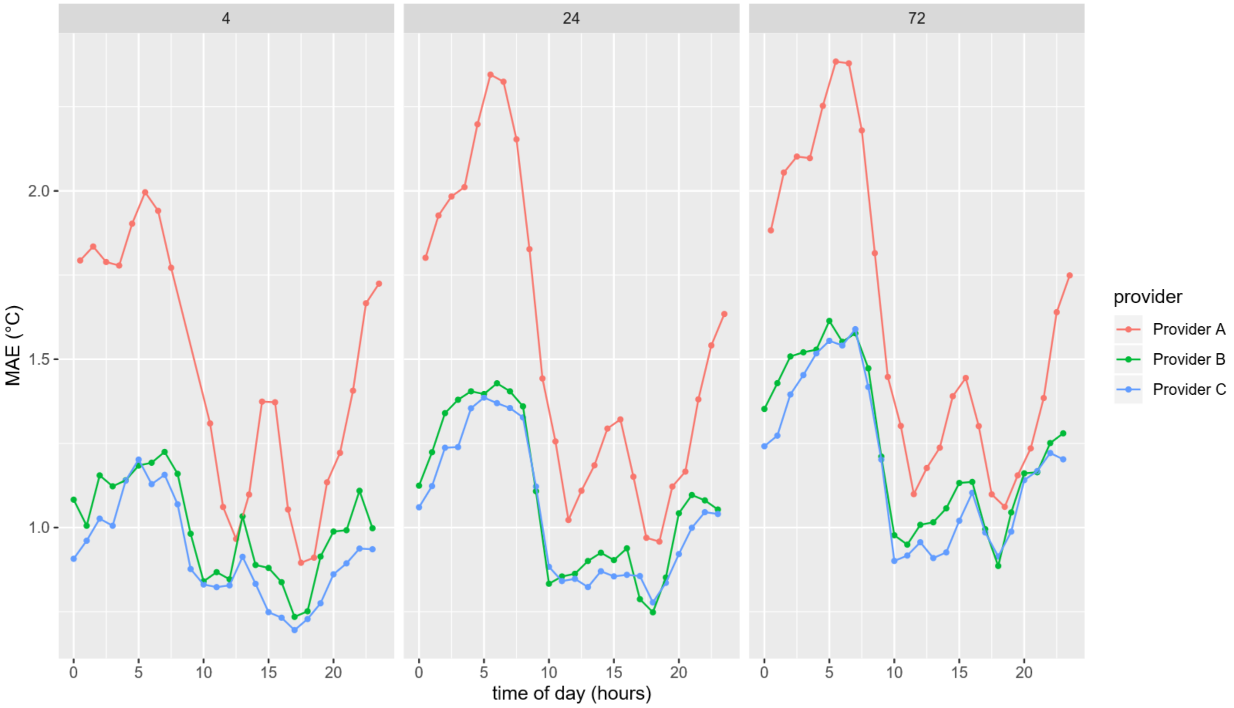


Figure 29 Archerfield, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

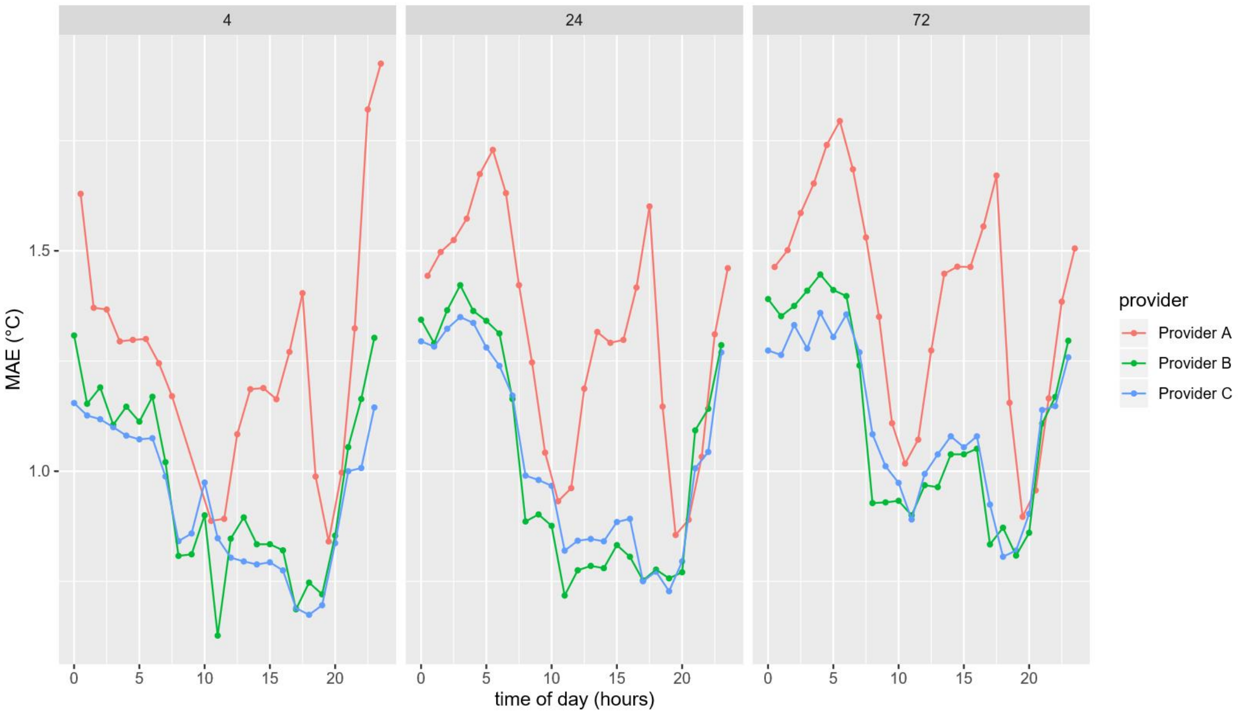


Figure 30 Bankstown, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

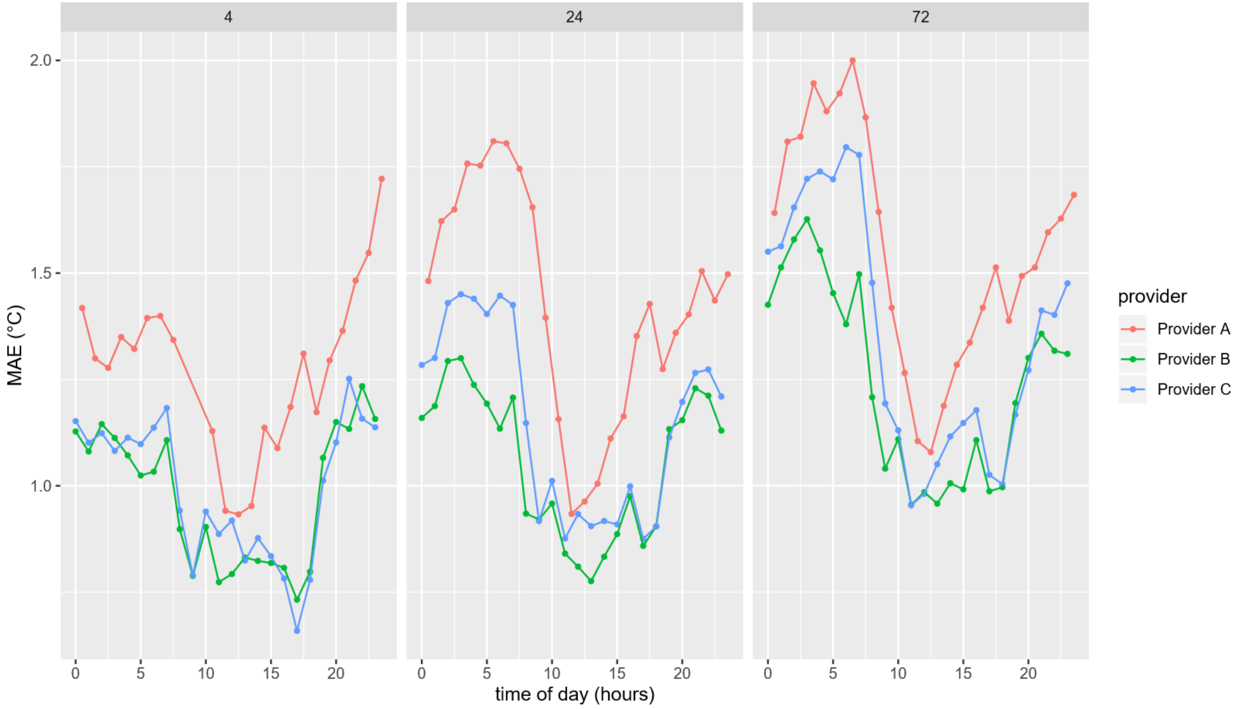


Figure 31 Hobart Airport, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

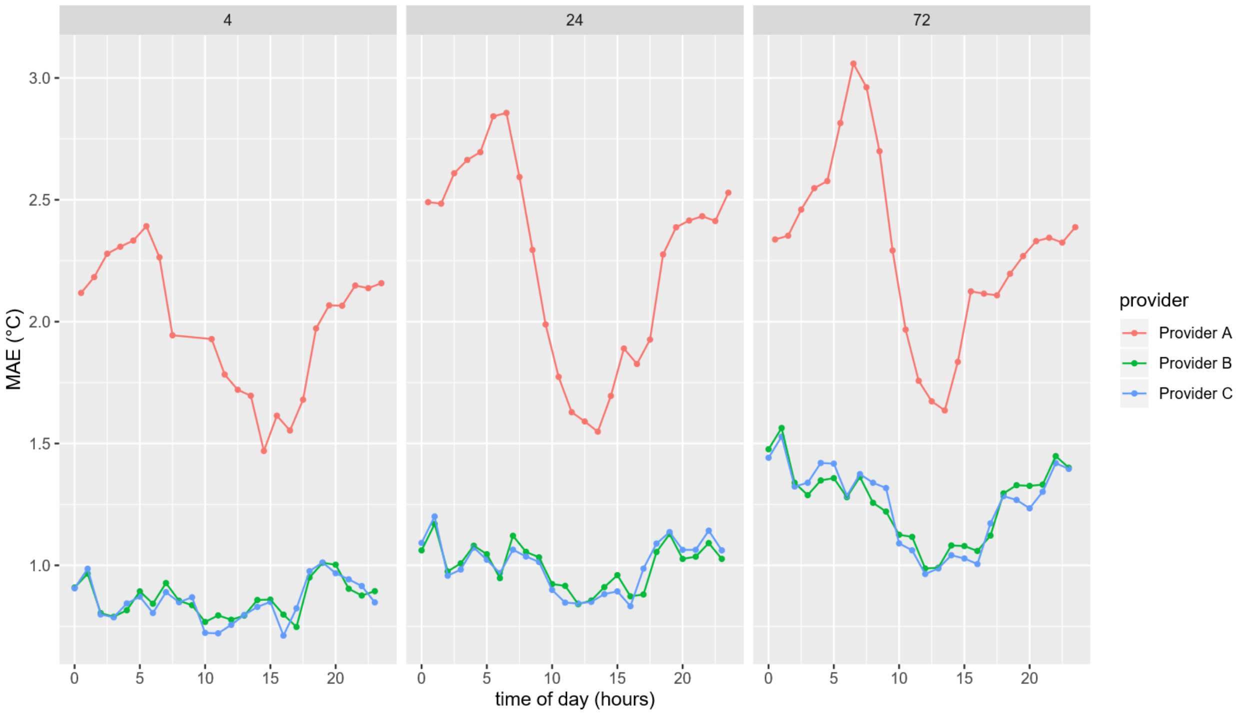


Figure 32 Kent Town, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

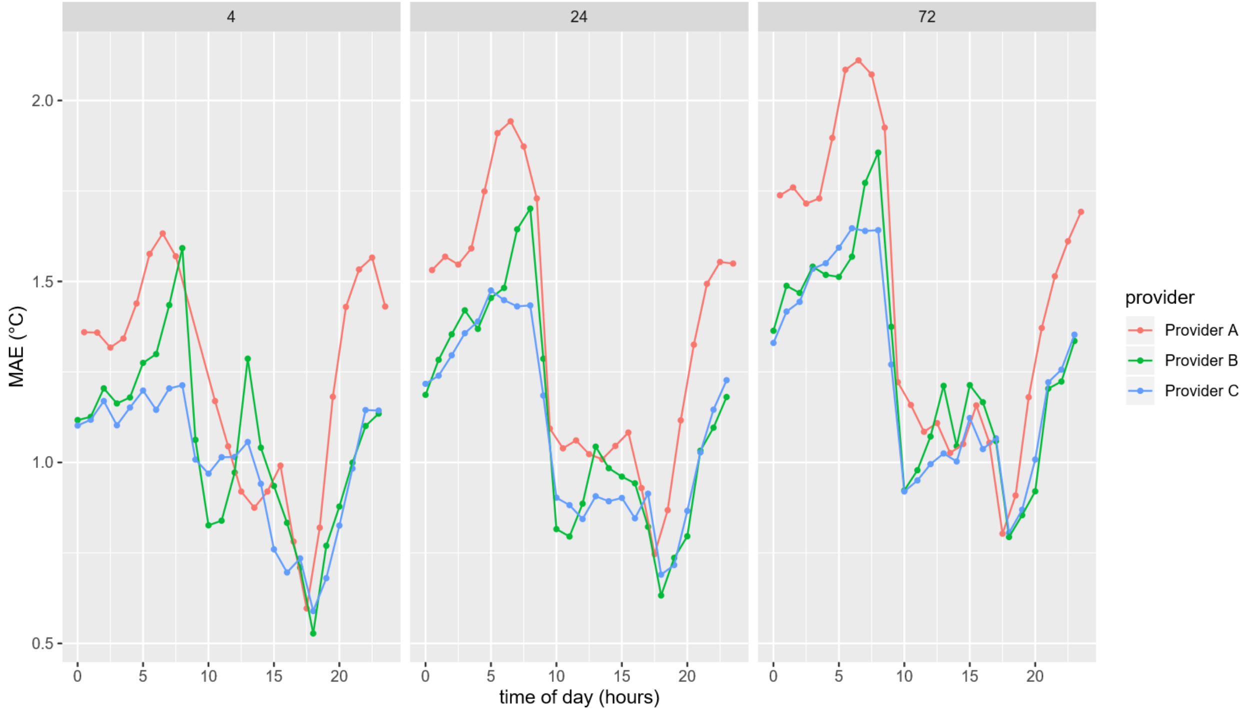


Figure 33 Melbourne Olympic Park, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

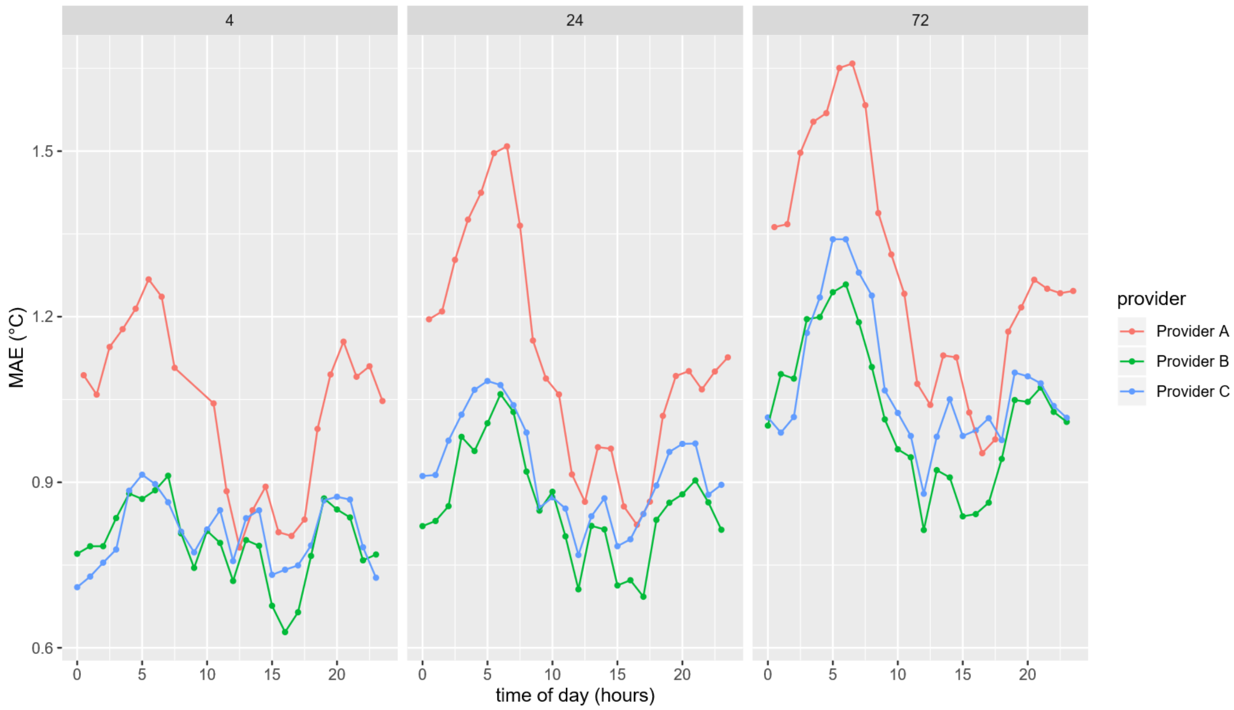


Figure 34 Melbourne Airport, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons

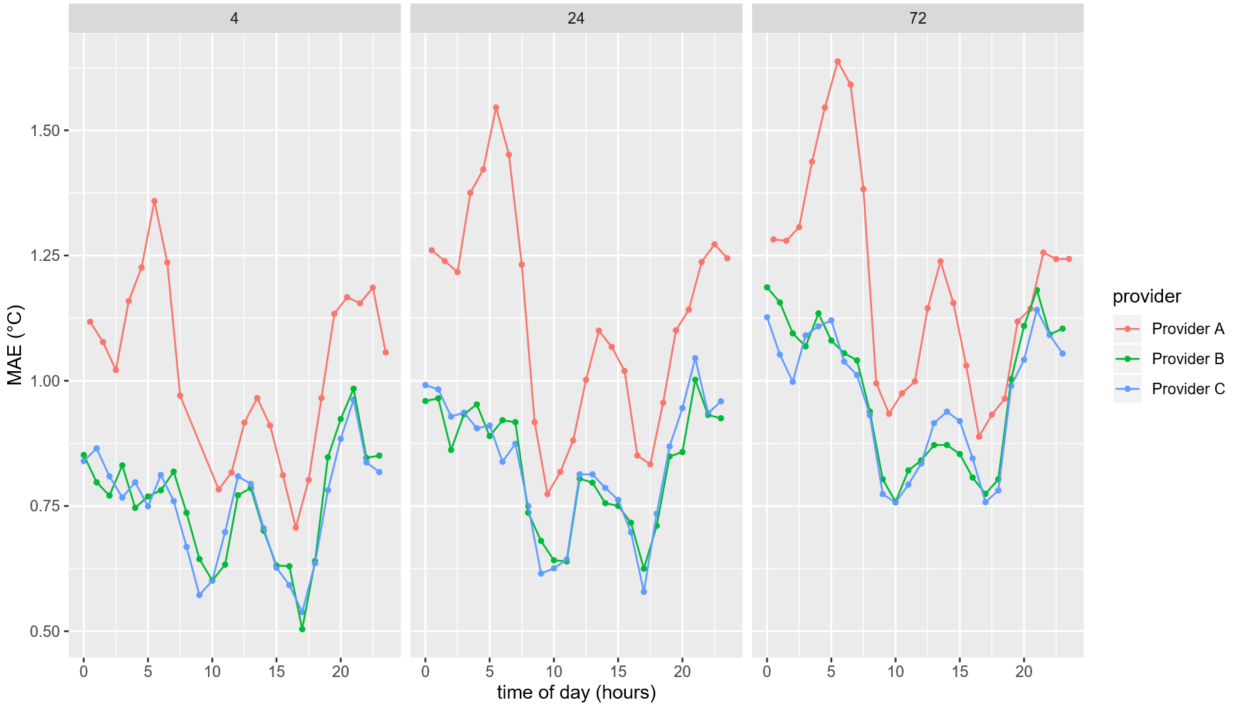


Figure 35 Penrith, intraday MAE profile, all providers, winter 2020, 4-, 24-, and 72-HA horizons