Temperature Forecast Analysis for Summer 2018-19

October 2019

A report exploring the forecast accuracy of AEMO's operational weather providers in the National Electricity Market through the 2018-19 summer period

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 across the 2018-19 summer period.

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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 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 – Actual temperature
Mean Absolute Percentage Error (MAPE)	Measures the size of the error in percentage terms. It is calculated as the average of the unsigned percentage error.
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 explores the temperature forecast accuracy of three weather providers used by operational forecasting across the period 1 December 2018 through 1 April 2019[1].

This analysis has assessed dry-bulb temperature in isolation of other weather metrics as a first step in qualifying accuracy between providers. Temperature is the largest driver of electricity demand and is the most important weather concept used in AEMO's Demand Forecasting System (DFS). The assessment of other weather metrics – such as humidity, precipitation, and wind speed – may be included in future analysis.

The weather stations analysed in this report are Archerfield (Queensland), Bankstown (New South Wales), Hobart Airport (Tasmania), Kent Town (South Australia), Melbourne Airport (Victoria), Melbourne Olympic Park (Victoria) and Penrith (New South Wales). These are identified as the weather stations representing the largest electricity load centres in each region of the National Electricity Market (NEM).

Western Australian weather stations are not included in this report, because only one weather provider is used operationally, therefore a like-for-like comparison with NEM stations is not possible. Assessment of temperature forecast performance in Western Australia may be prepared as a separate analysis paper.

Assessment of forecast performance on 25 January 2019 in Victoria indicated that extreme morning temperatures and the timing of the rapid cool change were not captured well by all providers.

Analysis of performance across all hourly intervals across the analysis period, including analysis of each provider's performance at major weather stations at the 72, 24, and 4-hour ahead (HA) rolling forecast horizons, provided the following insights:

- There was little difference between the performance of Provider B and Provider C at 24 HA at most weather stations.
- Provider B and Provider C outperformed Provider A at all weather stations and forecast horizons.
- Provider B's forecast performance at Melbourne Olympic Park was considerably better than the performance of Provider C.
- Forecast accuracy was generally lowest in the early morning for all weather providers. Additionally, Provider A had large errors in the late afternoon at many weather stations.

Assessment of performance forecasting the top 5% of temperature intervals at each weather station provided the following insights:

- There was a tendency to under-forecast at high temperatures, particularly at the 72 HA and 24 HA horizons. Provider B had the largest tendency to under-forecast outcomes.
- Provider A under-forecast the least and tended to become more accurate as the forecast horizon decreased.
- All providers performed best at Archerfield. Forecast performance was arguably next best at Kent Town.
- Forecast performance at Melbourne Airport was poor for all weather providers, and forecast performance at Melbourne Olympic park was only slightly better.

Following this analysis, anonymised performance assessments will be provided to each weather provider to draw their attention to improvement areas. AEMO will continue to work with the weather forecast industry on the key challenges identified in this report, especially those identified above.

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

Contents

Figures

1. Introduction

Weather forecasts are the most important operational input used by AEMO to forecast electricity demand. Because weather is the primary driver of heating and cooling electricity demand, it is important that the forecasts used by AEMO are as accurate as possible.

While the forecast accuracy of daily maximum and minimum temperatures is important, there are other factors which influence electricity demand. Forecasting events such as overnight temperatures, afternoon temperature ramping, and cool change timing are just as critical to the behavior of electricity consumption.

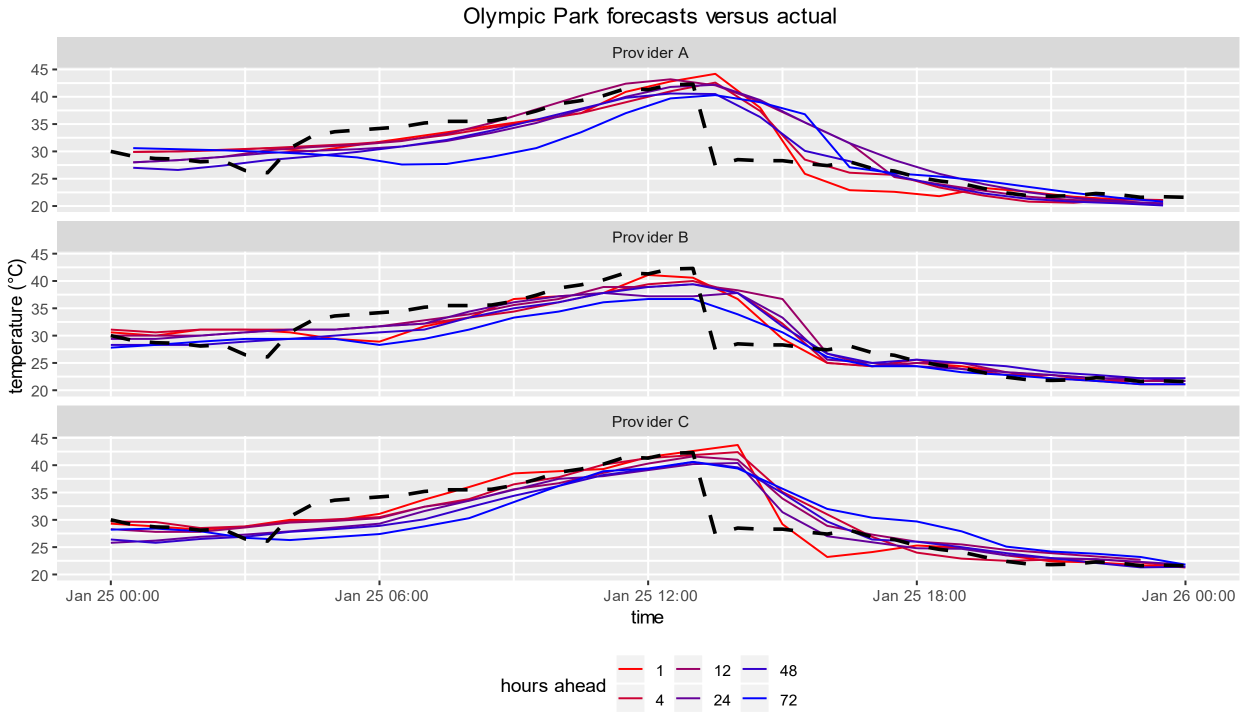
As well as day-ahead and intra-day forecasts, there is a growing requirement for AEMO to assess weather forecasts at extended horizons to advise operational decisions. The accuracy of forecasts produced up to three days ahead is becoming increasingly critical, particularly on peak days for the network.

This report aims to provide AEMO's weather providers an insight into their relative forecast performance between 1 December 2018 and 1 April 2019, referred to as the summer 2018-19 period, by exploring forecast performance at major weather stations at the 72, 24, and 4-hour ahead (HA) rolling forecast horizon.

Case study: Victorian load shedding – 25 January 2019[2]

Temperature forecast accuracy is most important during critical operational periods, particularly when extreme heat exerts stress on the electricity grid. Such an event occurred in Victoria on 25 January 2019, where intense heat combined with unplanned generator outages resulted in involuntary load shedding[2]. The temperature profile observed at Melbourne Olympic Park (OP) on this day is shown in Figure 1.

Figure 1 Forecast temperature profiles against actual temperature observations for different providers against actual observations, Victoria, 25 January 2019, at Melbourne Olympic Park.



[2] AEMO, Load Shedding in Victoria on 24 and 25 January 2019, published 16 April 2019, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2019/Load-Shedding-in-VIC-on-24-and-25-January-2019.pdf.

This profile contains several drivers for high electricity demand, including extreme overnight temperatures, steep ramping to an extreme peak temperature, and a cool change resulting in rapid temperature decline. The forecast temperature profiles for Providers A, B, and C are also shown, with the blue to red transition indicating decreasing forecast time horizon.

Figure 1 shows that as the time horizon decreased from 72 HA to 1 HA, the forecast accuracy increased. This was most apparent between 6:00 am and 12:00 pm, where each provider's successive forecast aligned closer with the actual observations. The progressive accuracy improvement during this period resulted in each provider, particularly Providers A and C, forecasting peak temperature relatively well.

Early morning temperatures, between 4:00 am and 9:00 am, were not forecast well by all providers. During this period, temperatures ramped quickly, which drove high demand through the early morning.

The time and extent of the abrupt cool change at 1:00 pm, which brought a 14°C decrease, was not forecast well by all providers. At the 24 HA horizon, Provider C forecast temperature to climb close to 45°C before falling steadily between 2:00 pm and 4:00 pm. Their peak temperature and rate of decline was revised in subsequent forecasts however the timing of the change remained constant. Provider B projected a gradual decline in temperature from 12:00 pm before an 8°C drop between 3:00 pm and 4:00 pm. Similarly, Provider A forecast a gradual temperature decline from 1:00 pm but failed to capture the steep rate of the change. Analysing the forecast performance on 25 January 2019 highlights the challenges shared by all providers during extreme, volatile days.

1.1 Summer forecast performance for all intervals

This section will explore the forecast performance across all one-hour intervals during the summer period and aims to identify the areas of strength and weakness for each provider. The forecast statistics at Melbourne OP are presented to aid commentary of performance across the rolling forecast horizons 72, 24, and 4 HA. Commentary will also be made for other major weather stations, whose charts are provided in Appendices A.1 through A.3, to explore the trends and differences between providers.

Figure 2 Forecast error distributions for all one-hour intervals during summer 2018-19 at Melbourne Olympic Park at 4 HA, 24 HA, and 72 HA horizons

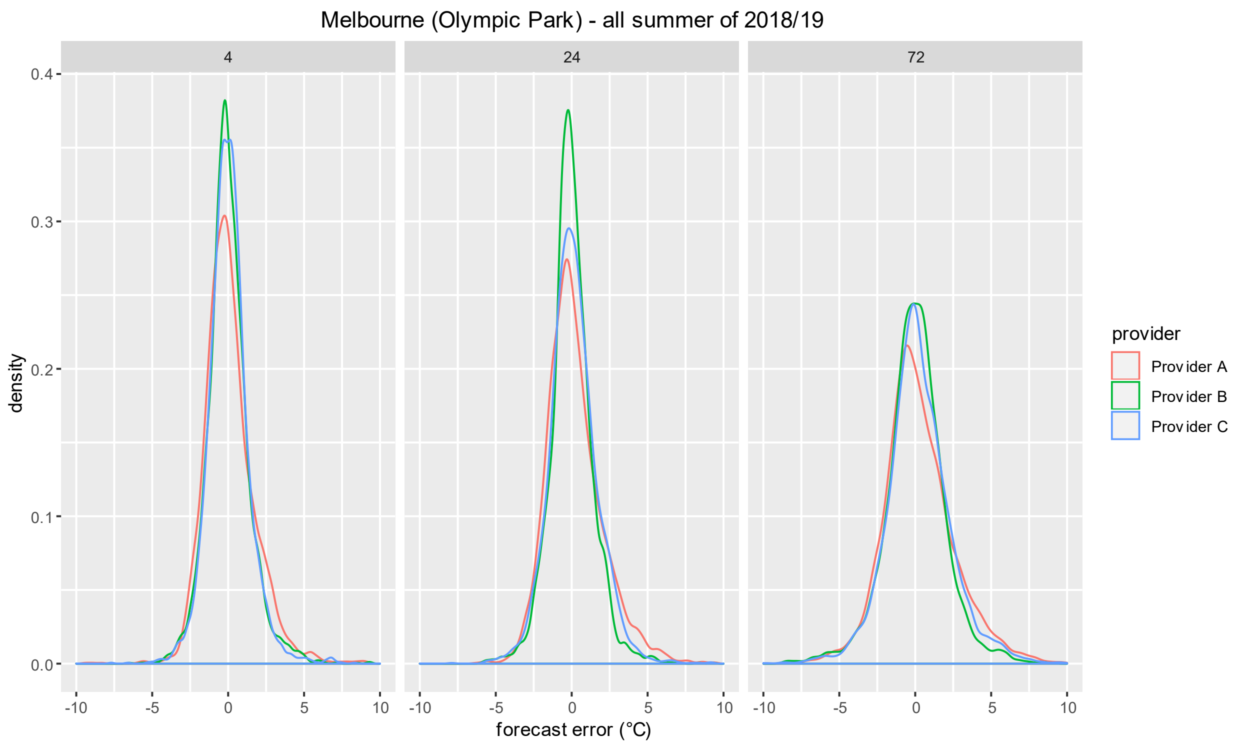


Figure 2 shows the distribution of forecast deviations of each weather provider for each studied horizon at Melbourne OP during the summer 2018-19 period.

There was a trend for each provider's forecast to improve as the horizon decreased, indicated by the tightening of density around zero and reduction of outliers.

Provider B and C performed similarly at the 72 HA horizon, each with a centred distribution around zero.

While no significant deviation bias was observed between providers at the 24 HA horizon, Provider B performed best, with comparatively higher precision and accuracy. The precision of Providers A and C improved steadily with the decreasing forecast horizon. Conversely, the rate of improvement of Provider B was less pronounced, particularly between 24 HA and 4 HA, however, it was the best performing provider at this station overall.

Section A.1.1 shows similar density plots at Archerfield (Queensland), Bankstown (New South Wales), Hobart Airport (Tasmania), Kent Town (South Australia), Melbourne Airport (Victoria), and Penrith (New South Wales). The main observations at these stations were:

- At each weather station, the precision and accuracy of Providers B and C was comparable at the 72 HA forecast horizon. Provider A tended to be less precise at this horizon.
- The improvement in performance from 24 HA to 4 HA was steady for Providers B and C. The improvement of Provider A was more gradual, and in the case of Bankstown did not improve.
- There was little difference between the performance of Providers B and C at the 24 HA horizon. There were two exceptions, at Melbourne OP and Kent Town, where Provider B performed better.
- At the 4 HA horizon, Provider C performed best at Archerfield, Melbourne Airport (AP), and Penrith. Provider B performed best at Melbourne OP at this horizon. The performance of Providers B and C at Bankstown and Kent Town was practically indistinguishable.
- Provider A was outperformed at all weather stations and forecast horizons by Providers B and C.

Section A.1.3 provides the relative forecast performance at each weather station for the 24 HA horizon. Illustrating that:

- All providers forecast Archerfield better than all other stations, shown by its tighter forecast error density around zero. This could be explained by the relatively stable temperatures and fewer heatwaves observed in Queensland during the summer compared to the southern states.
- Kent Town was the least accurate station forecast by Provider A, seen by its much wider error distribution than other stations. Similarly, Kent Town was arguably the least accurate station forecast by Providers B and C. South Australia was subjected to more extreme temperatures during summer compared to other regions. The difficulty in forecasting these conditions is captured in this analysis.
- The forecast performance of Provider B was significantly better at Melbourne OP than other stations, and considerably better than the performance of Provider C. This large variance in forecast performance introduced uncertainty in decision-making for operational forecasting during the summer.
- Provider A had a very large tendency to under-forecast at Hobart Airport, which was a clear outlier compared to its performance at other stations. Conversely, the performance of Providers B and C at Hobart Airport was comparable to other stations. Electricity consumption peaks during the summer period in the mainland regions due to the responsiveness to high temperatures. In comparison, Tasmania sees electricity consumption peak in the winter period and is much less responsive to temperature. Therefore, while the performance of Provider A at Hobart Airport should be investigated, the impact of forecast inaccuracies on load forecasts is less critical compared to mainland regions.

Analysis of intraday forecast errors for all summer intervals

This section will explore the intraday forecast accuracy of each provider to identify the periods of the day where forecast errors were largest.

Figure 3 shows the Mean Absolute Percentage Error (MAPE) for each hourly interval across the summer 2018-19 period at Melbourne OP. Section A.2.1 has intraday MAPE profiles for other major weather stations. MAPE calculations have been utilised in this section of the report in order to maintain consistency with AEMO's demand forecast accuracy statistics.

Figure 3 Hourly MAPE for each provider at Melbourne Olympic Park at 4 HA, 24 HA, and 72 HA horizons

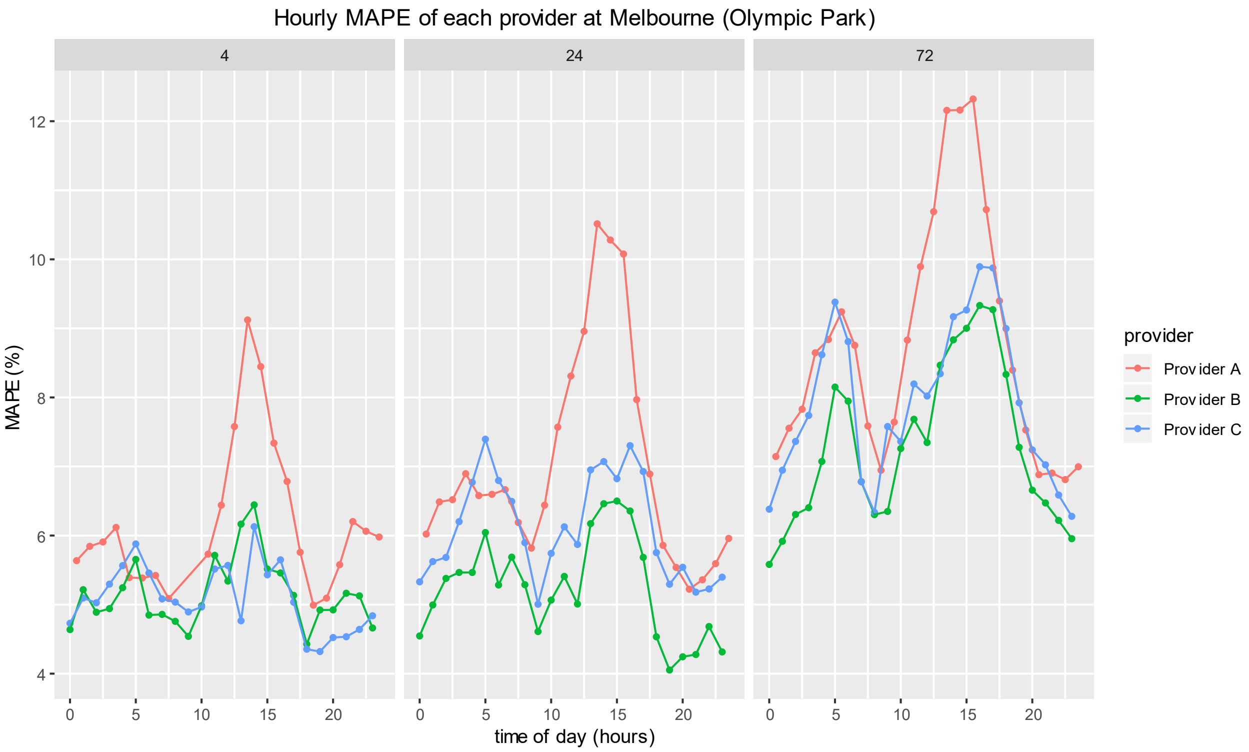


Figure 3 shows that as the forecast horizon decreased from 72 HA to 4 HA, the MAPE of each hourly interval decreased, and the shape of the profiles remained relatively constant. At the 72 HA horizon, each provider's MAPE profile had two peaks – a morning peak at 5:00 am and a late afternoon peak at 3:00-4:00 pm.

Forecast performance until 10:00 am was similar for Providers A and C. After this time, however, Provider A's forecast errors diverged and became significantly larger, peaking above 12% at 3:00 pm. The MAPE profiles flattened for Providers B and C as the forecast horizon decreased, however, the afternoon peak remained prominent for Provider A.

Provider A had substantial and persistent peak errors at other weather stations – observed either early morning, late afternoon, or during both periods. This observation was largest at Hobart Airport, where the errors of Provider A were significantly larger than the other providers.

At Kent Town, all providers had large morning errors for each forecast horizon. Errors decreased for Providers B and C from 7:00 am and were reasonable across remaining intervals. In comparison, Provider A also contained an afternoon error peak at each forecast horizon, consistent with the analysis at Melbourne OP.

Observations were similar at Archerfield, Melbourne AP, and Penrith. Providers B and C commonly had large errors in the early morning, particularly at larger forecast horizons, and moderate errors for the remainder of the day. In comparison, Provider A consistently had two distinct error peaks.

The shape and extent of evening electricity demand is heavily influenced by the development of temperature through the morning and afternoon. It is therefore important that these periods are forecast to a reasonable degree of accuracy.

This analysis identified the following areas of potential improvement when basing performance on summer 2018-19 observations:

- All providers in forecasting morning temperatures, particularly at Archerfield, Kent Town, and Melbourne AP.
- Provider A in forecasting afternoon temperatures, particularly around 3:00 pm. There is a clear difference in accuracy during this period between Provider A and the other two providers.
- Provider A in forecasting Hobart Airport, which had very large errors overnight and early morning.

1.2 Summer forecast performance for high temperatures

Temperature is the main driver of electricity demand and it is important that weather providers forecast periods of elevated temperature with reasonable confidence. This section will assess each provider's accuracy in forecasting the top 5% of observed temperatures at each weather station during the summer period. The forecast statistics at Melbourne OP are presented to aid commentary of forecast performance. Additional commentary for other major weather stations is provided in Appendices A.1 through A.3 to explore the trends and differences between providers at high temperatures.

Figure 4 Forecast error density plots for the top 5% of temperatures during Summer 2018-19, Melbourne Olympic Park at 4 HA, 24 HA, and 72 HA horizons

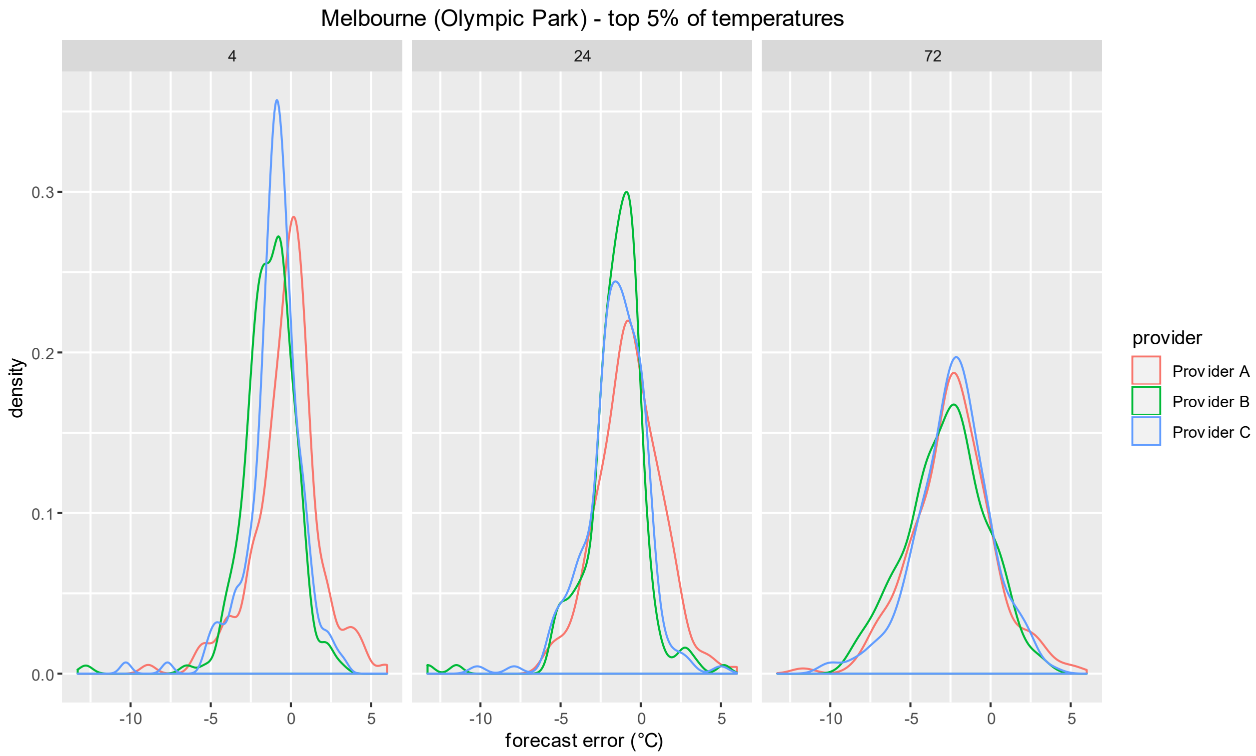


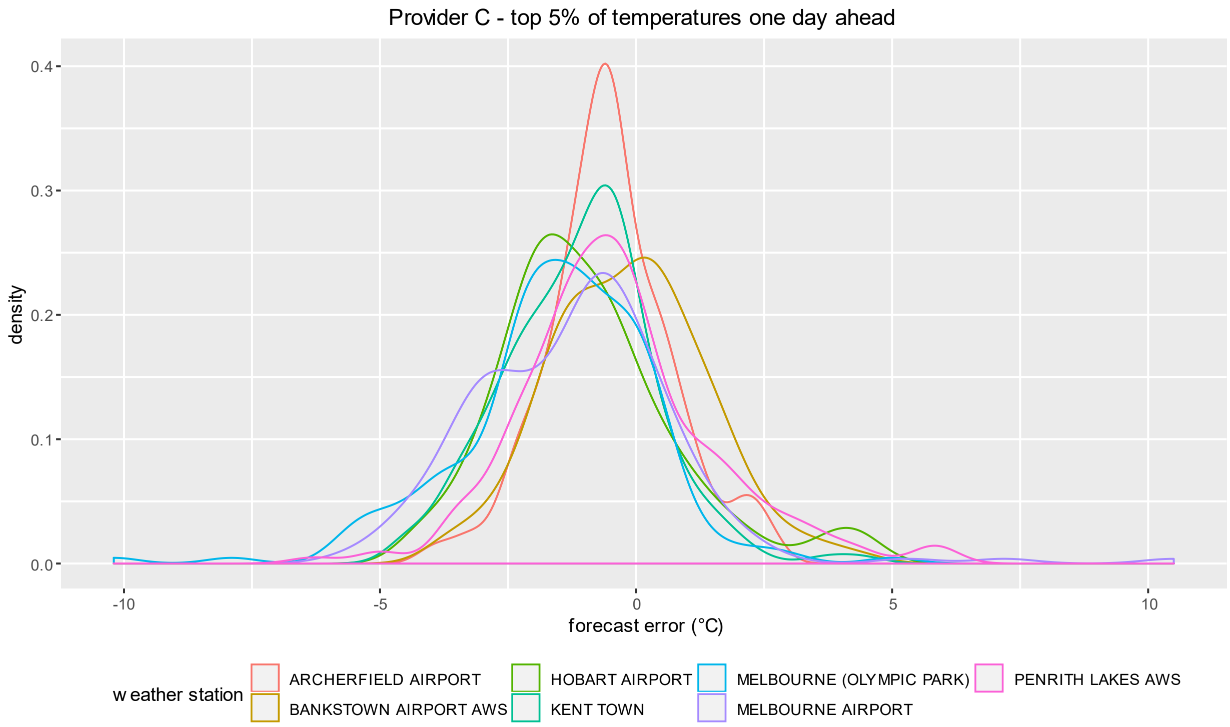
Figure 4 shows that forecast performance for each provider was lower at high temperatures. At the 72 HA horizon, there was no discernible difference between Providers A and C, while the error distribution of Provider B was slightly wider. A bias toward negative forecast errors was common for all providers, indicating an increased tendency to under-forecast high temperatures. Provider C improved steadily in subsequent forecasts, and while its tendency to under-forecast remained, its error spread tightened more than other providers. The progressive increase in precision of Provider A was not as pronounced as Provider C, however, its accuracy increased significantly compared to the other providers. Provider B improved more than other providers between 72 HA and 24 HA, however its forecast accuracy degraded between 24 HA and 4 HA.

The observations from other weather stations, provided in Section A.1.2, can be summarised as follows:

- The tendency to under-forecast was a characteristic at all weather stations, particularly at the 72 HA horizon. Provider B had the greatest tendency to under-forecast at 72 HA and 24 HA horizons – seen at Bankstown, Kent Town, Melbourne AP, and Penrith.
- While Provider C tended to under-forecast, its precision noticeably improved with the decreasing horizon. This was clearest at Archerfield, Melbourne OP, Melbourne AP, and Penrith.
- The precision of Provider B decreased from 24 HA and 4 HA horizons for all stations except Melbourne AP and Penrith. Overall, the forecast precision of Provider B ranks much higher between providers at 24 HA than 4 HA.
- Provider A under-forecast the least among providers and tended to become more accurate as forecast horizon decreased. An exception to this was Hobart Airport, where under-forecasting was prominent.

Figure 5 shows the forecast performance of Provider C at each weather station for the 24 HA horizon for the top 5% of temperatures. Corresponding charts for Providers A and B are provided in Section A.1.4.

Figure 5 Provider C forecast performance at each weather station at the 24 HA horizon



Consistent with the analysis of all forecast intervals, Archerfield was best forecast by all providers at high temperatures. This was clearest for Provider C, where Archerfield error distribution was much tighter than other stations. Provider B was the most accurate provider at Archerfield, with Provider A over-forecasting and Provider C under-forecasting outcomes.

While average temperatures at Kent Town were higher than other stations, overall forecast performance here was arguably the best after Archerfield at high temperatures. Provider A most accurately forecast Kent Town, and while it tended to under-forecast, its density around zero was higher than other providers. Kent Town was the second-best station forecast by Provider C – its accuracy here matched that at Archerfield, but its spread of errors at Kent Town was larger. Provider B tended to under-forecast at Kent Town more than other providers, however, its precision at this station was highest after Archerfield.

The forecast performance at the Melbourne weather stations, particularly Melbourne AP, was among the lowest at high temperatures. Providers A and C were least precise at Melbourne AP, where error spread and tendency to under-forecast were large. Provider B also had low performance at Melbourne AP and had the highest tendency to under-forecast here.

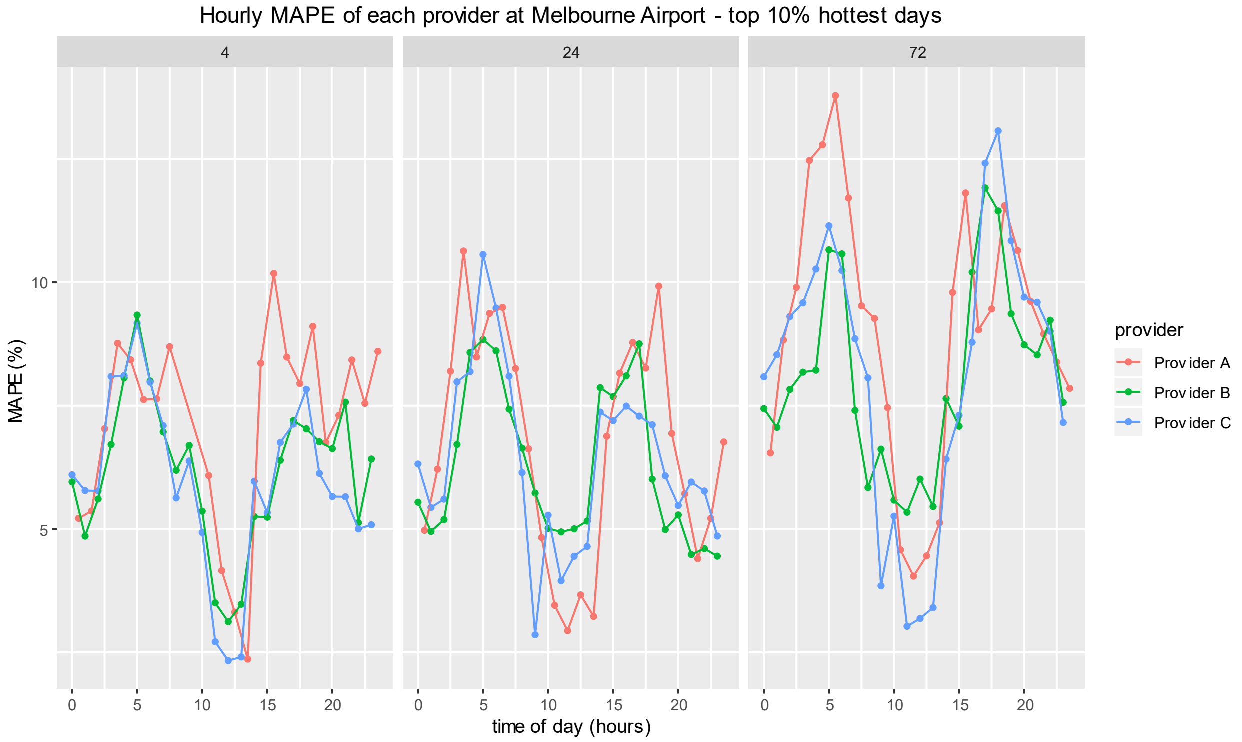
Compared to Melbourne AP, the forecast performance at Melbourne OP was marginally better for Providers A and C, and reasonably better for Provider B. The large bias to under-forecast high temperature outcomes at Melbourne weather stations at the 24 HA horizon introduced uncertainty for operational forecasting during the summer period. This should be looked at as an area of improvement for all providers.

Analysis of intraday forecast errors for the top 10% hottest days in summer

The previous section analysed the top 5% of hourly temperature intervals at each station. The following analysis, however, includes all intervals within the top 10% of hot days at each station, determined by daily average temperature.

Figure 6 shows the intraday MAPE profiles for the hottest 10% of days at Melbourne AP during summer 2018-19. Section A.2.2 contains the intraday MAPE profiles for other major weather stations.

Figure 6 Hourly MAPE for each provider for top 10% of hottest days at Melbourne Olympic Park at 4 HA, 24 HA, and 72 HA horizons



The shape of the MAPE profiles at Melbourne AP were similar for all providers – containing a morning peak at 5:00 am, evening peak at 5:00 pm, and a minimum at 12:00 pm. The intraday errors between providers were comparable at all forecast horizons, with small exceptions in Provider A's elevated morning peak at the 72 HA horizon and evening peak at the 4 HA horizon.

Peak errors decreased significantly between 72 HA and 24 HA horizons, however the decrease from 24 HA and 4 HA was not as pronounced. This revealed that temperature forecast uncertainty existed for all providers, during critical times, even at shorter horizons.

The intraday forecast performance between providers at each horizon was reasonably comparable at other stations – and most apparent at Bankstown, Kent Town, Melbourne OP, and Melbourne AP. An exception to this was at Archerfield, where Provider A had persistently large errors in the morning and afternoon which diverged from the other providers as the horizon decreased.

The MAPE profiles at Kent Town did not contain an afternoon peak, however, MAPE did trend up during the evening from 8:00 pm, leading to a prominent morning peak for all providers.

This analysis identified two areas for potential improvement when basing performance on high temperature days in summer 2018-19:

- Forecast performance in the short-term horizons. The decrease in intraday MAPE values were not pronounced from 24 HA to 4 HA, and in some cases from 72 HA to 4 HA.
- Forecast performance in the morning (5:00 am peak) and early evening (5:00 pm peak) – large errors at one or both times were common for all providers, at all stations and forecast horizon.

1.3 Conclusions and recommendations

Following this analysis, anonymised performance assessments will be provided to each weather provider to draw their attention to improvement areas.

Operational forecasting will continue to work with the weather forecast industry on the key challenges identified in this report, namely:

- Overall forecast accuracy at weather stations in the southern NEM states.
- The tendency to under-forecast at elevated temperatures, particularly at the one-to-three-day horizon.
- Accuracy in forecasting the top 5% of temperatures at Melbourne weather stations.
- Intraday errors in the morning and afternoon, especially in the near-term (4 HA) horizon of hot days.

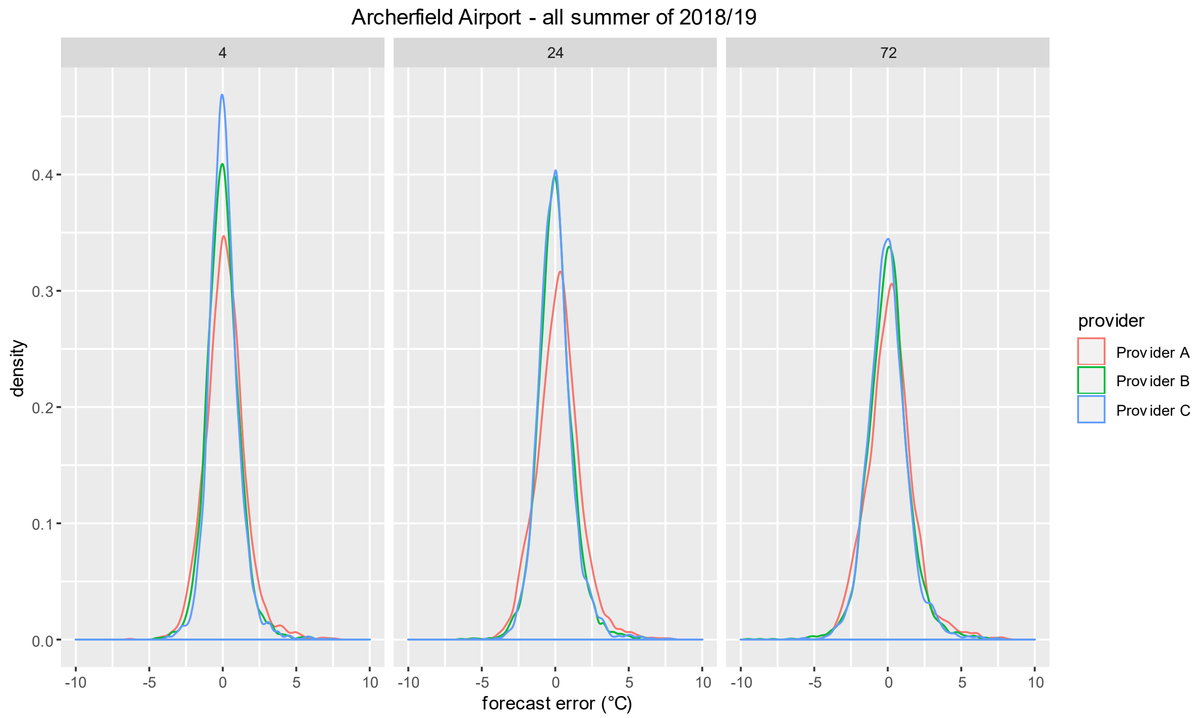
This report, as well as ongoing analysis, will be used by AEMO to inform operational forecasting and assist in operational decision-making.

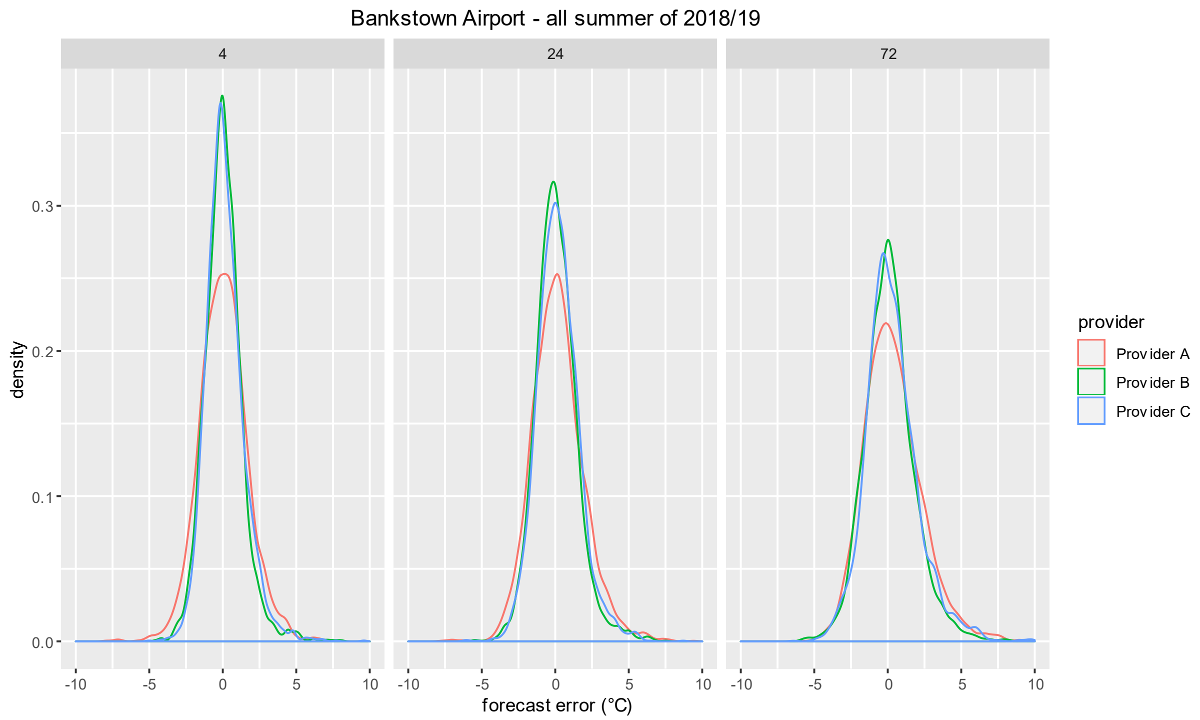
The analysis of dry-bulb temperature in this report is considered a first step in qualifying accuracy between providers. The assessment of other weather metrics – such as humidity, precipitation, and wind speed – may be included in the later stages.

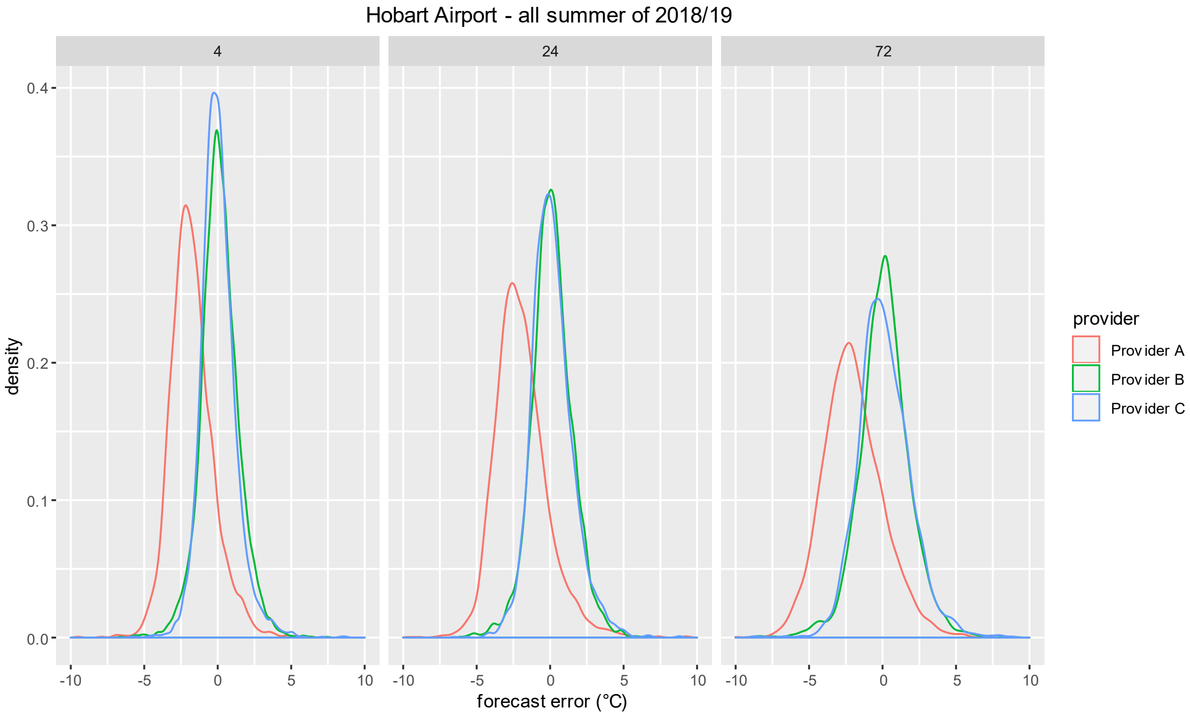
Operational forecasting will also look to analyse weather forecast performance in Western Australia for a holistic assessment across both the NEM and Western Australia's Wholesale Electricity Market (WEM).

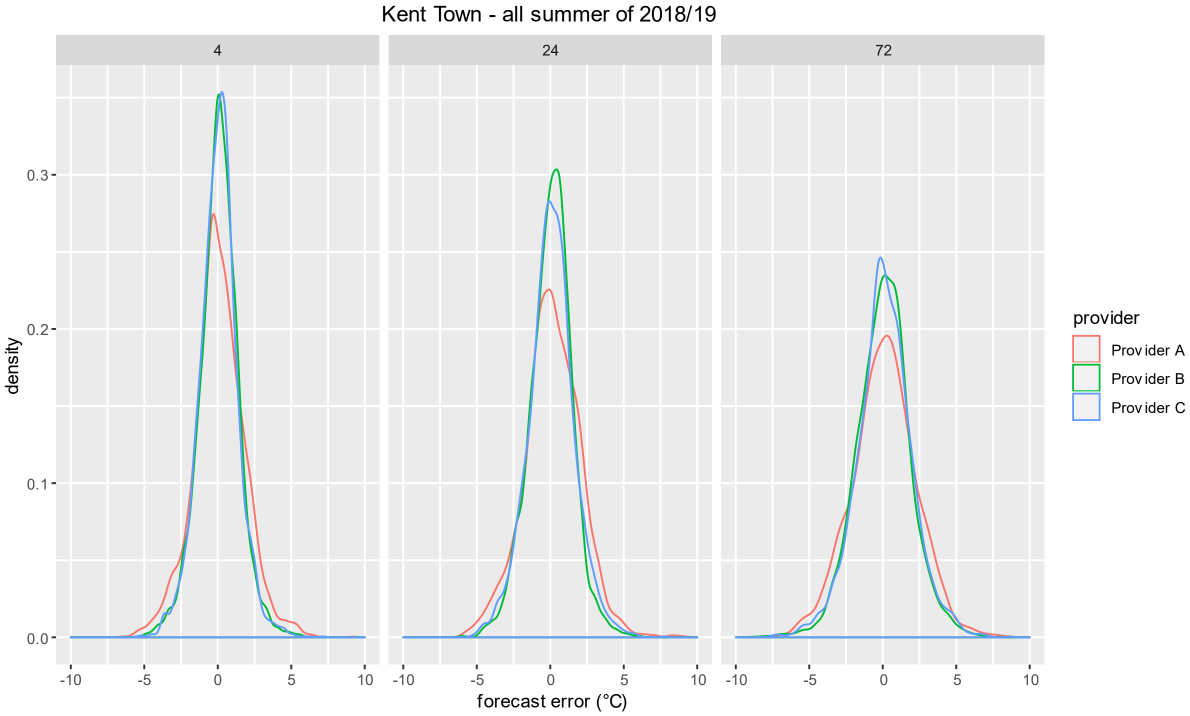
A1. Density plots

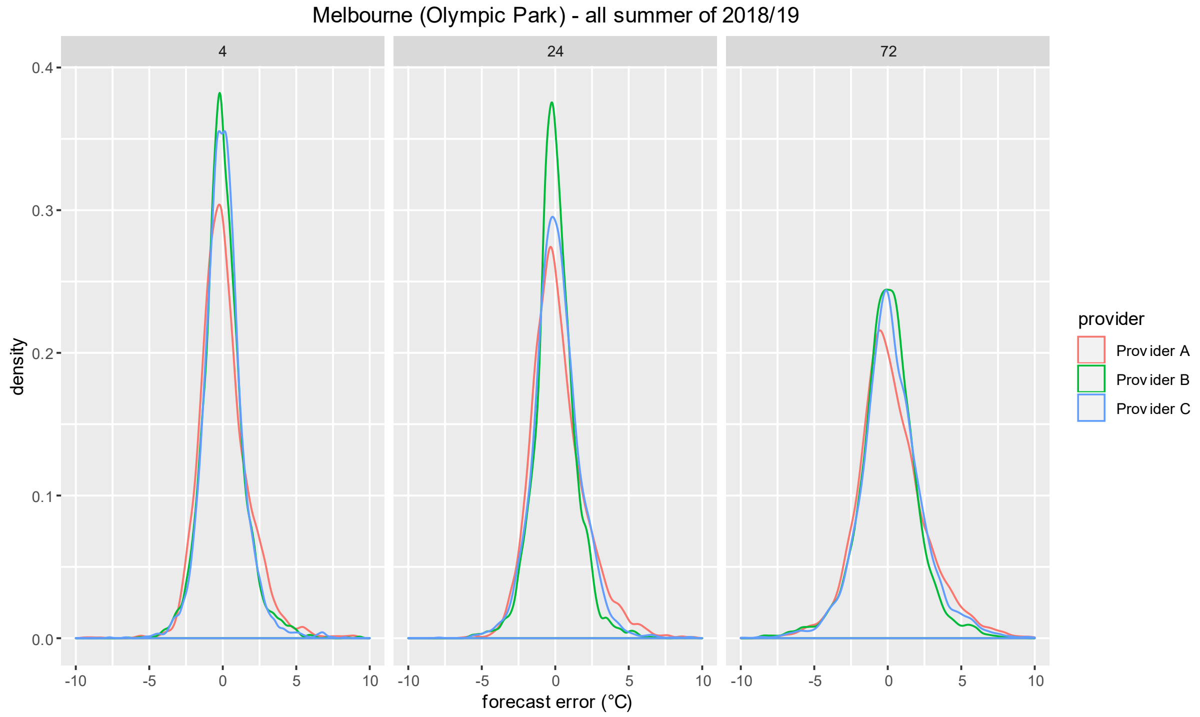
A1.1 All summer intervals – 72 HA, 24 HA, and 4 HA forecast horizons



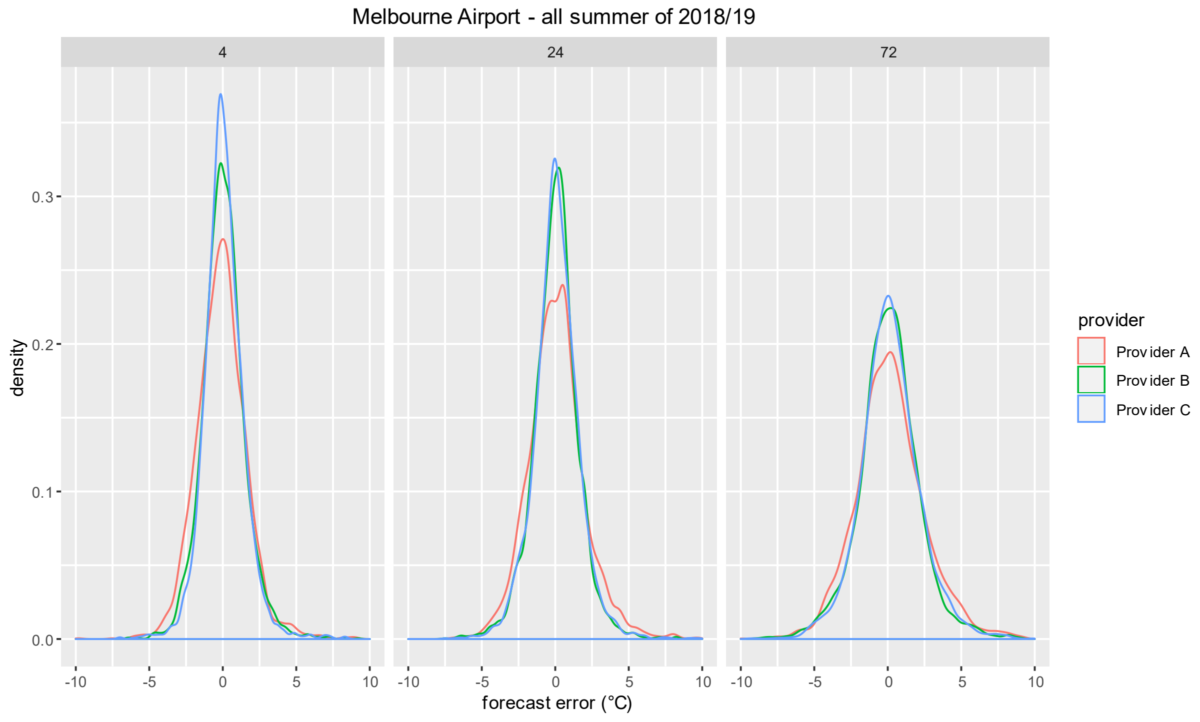



Hobart Airport - all summer of 2018/19
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C

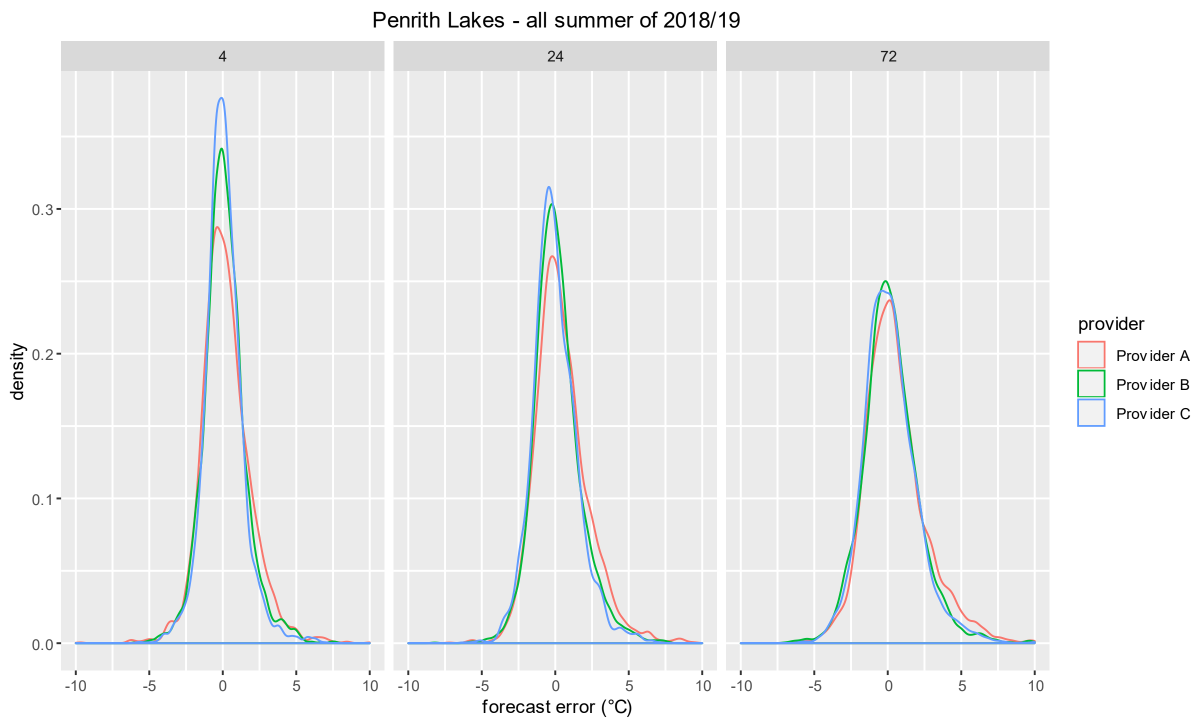

Kent Town - all summer of 2018/19
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C



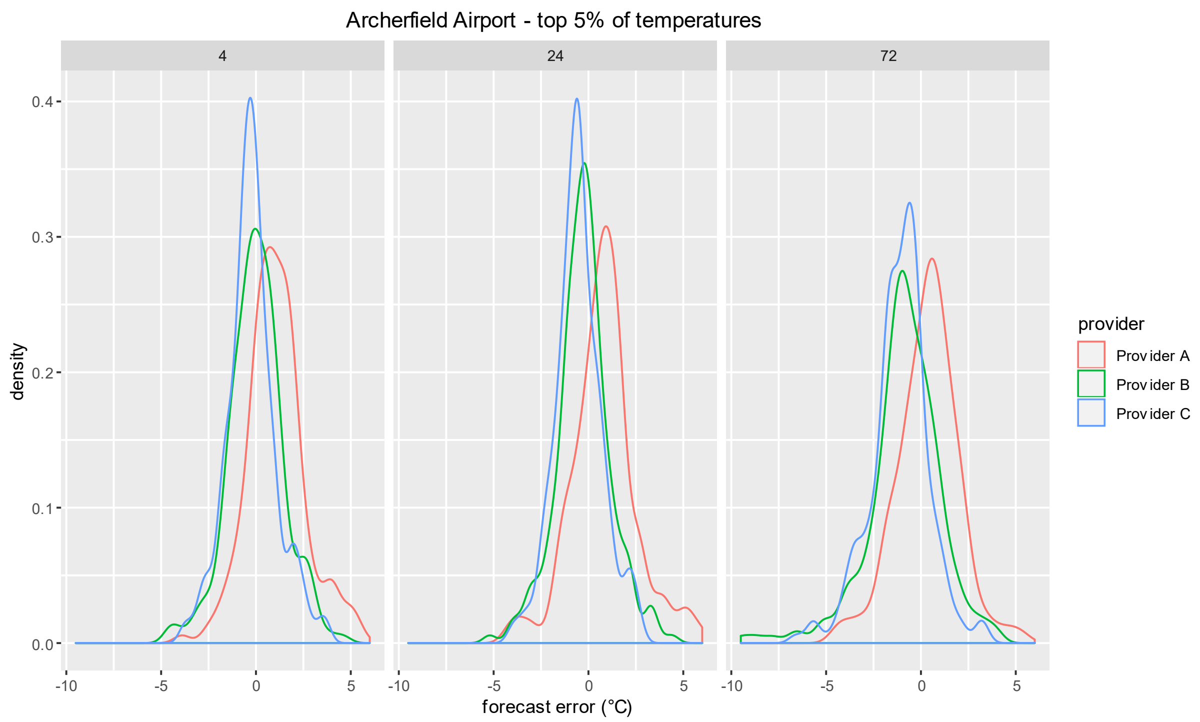
Melbourne (Olympic Park) - all summer of 2018/19
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C

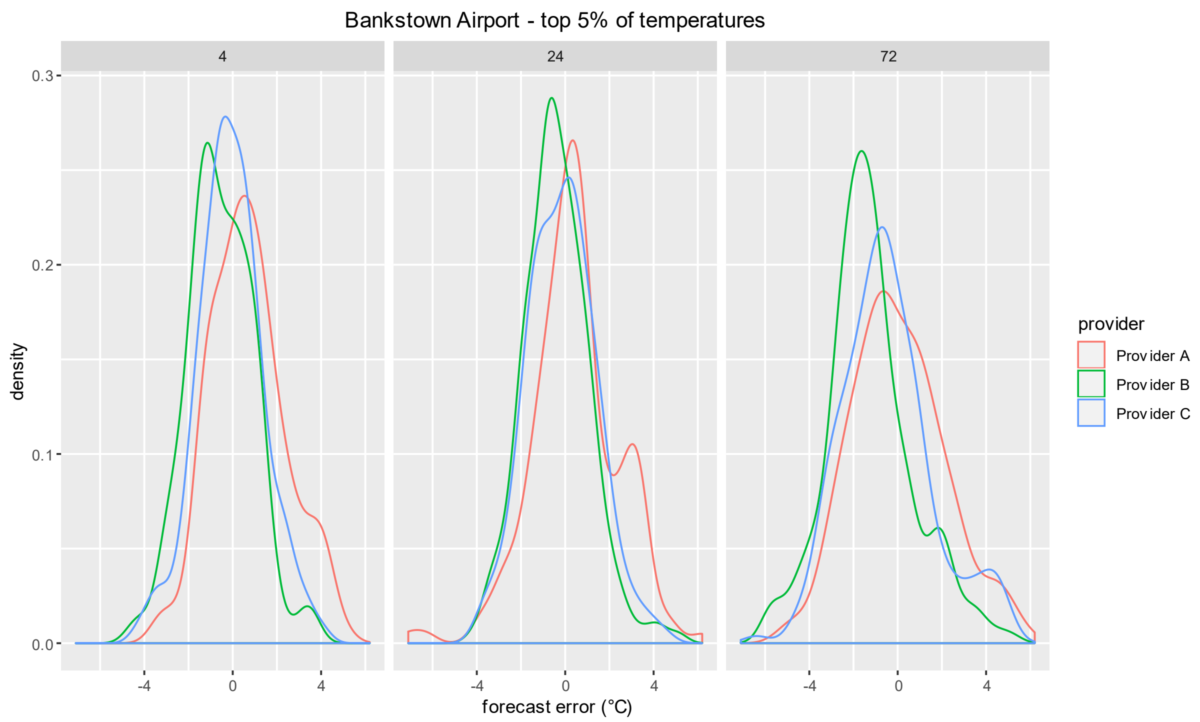


Melbourne Airport - all summer of 2018/19
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C

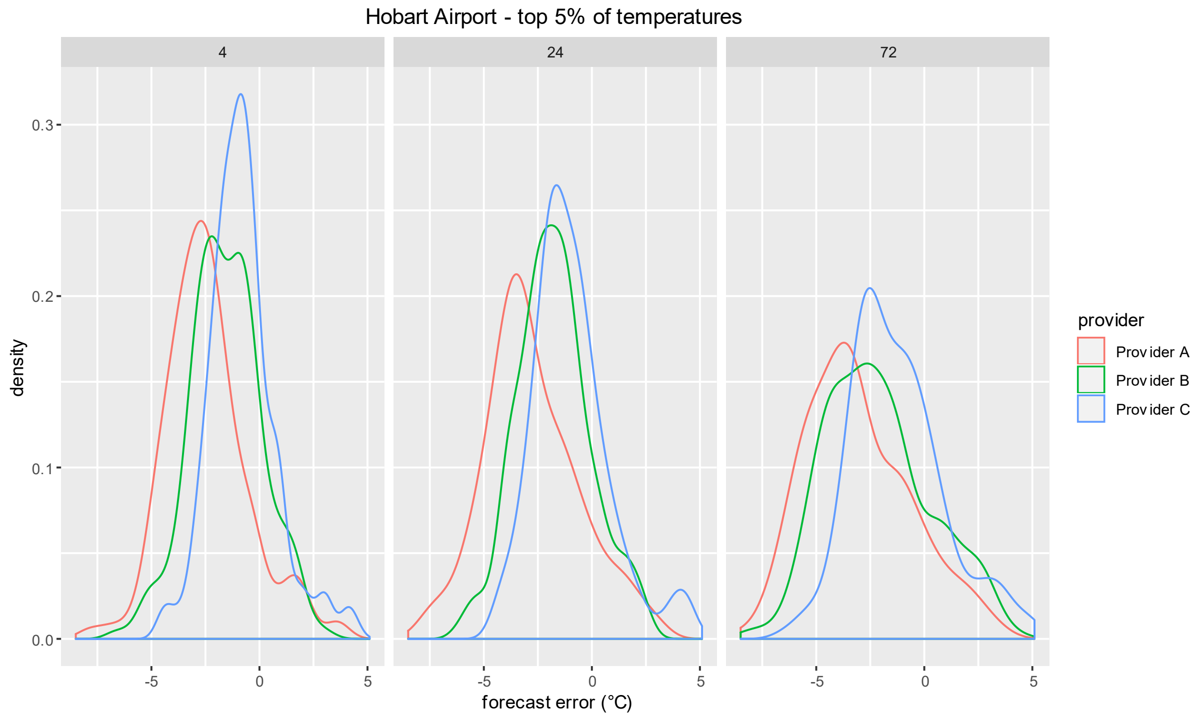


A1.2 Top 5% of temperatures – 72 HA, 24 HA, and 4 HA forecast horizons

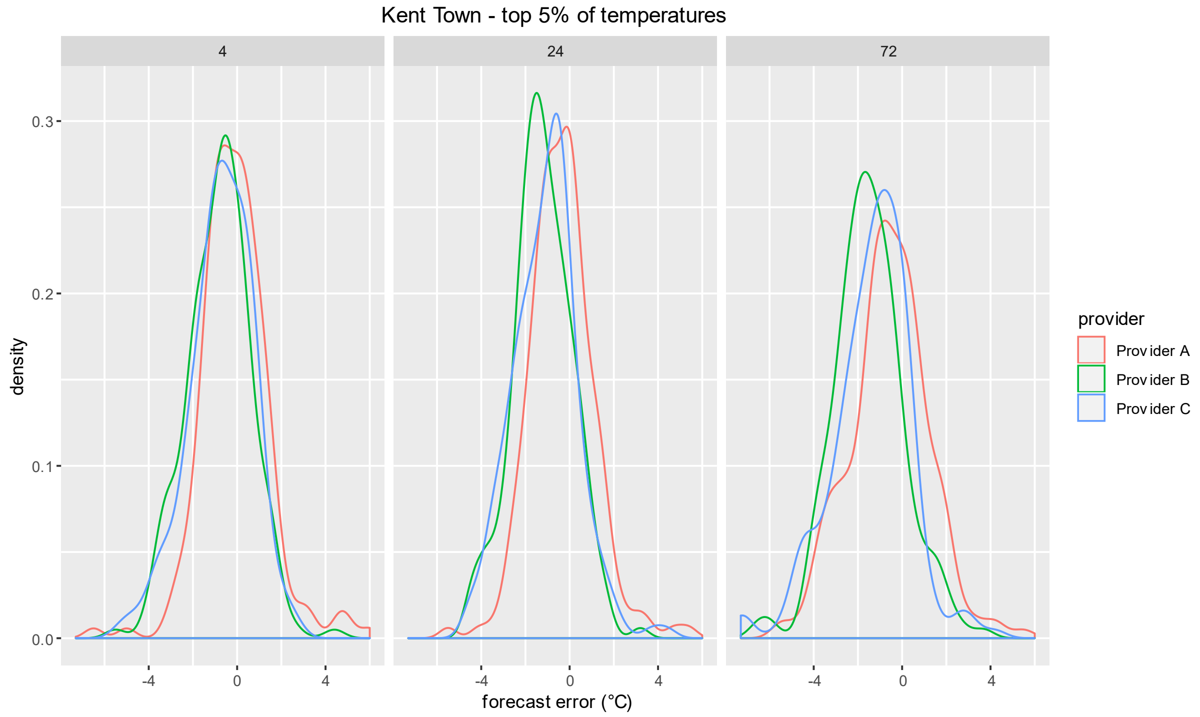


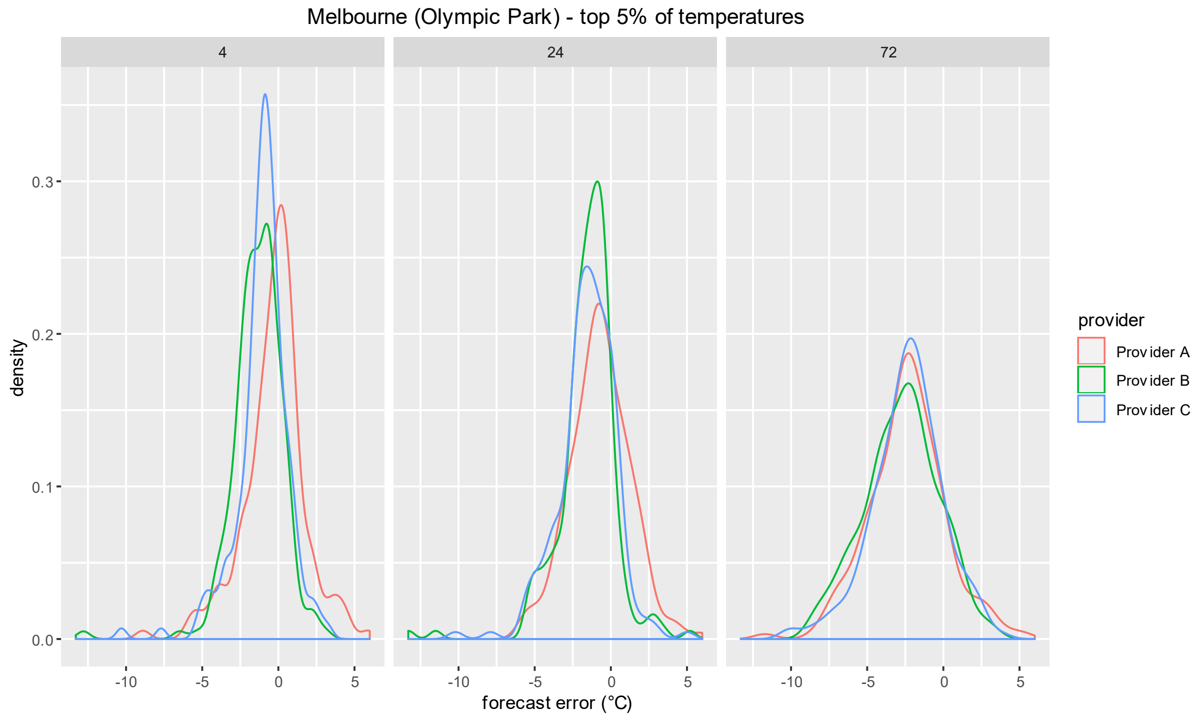


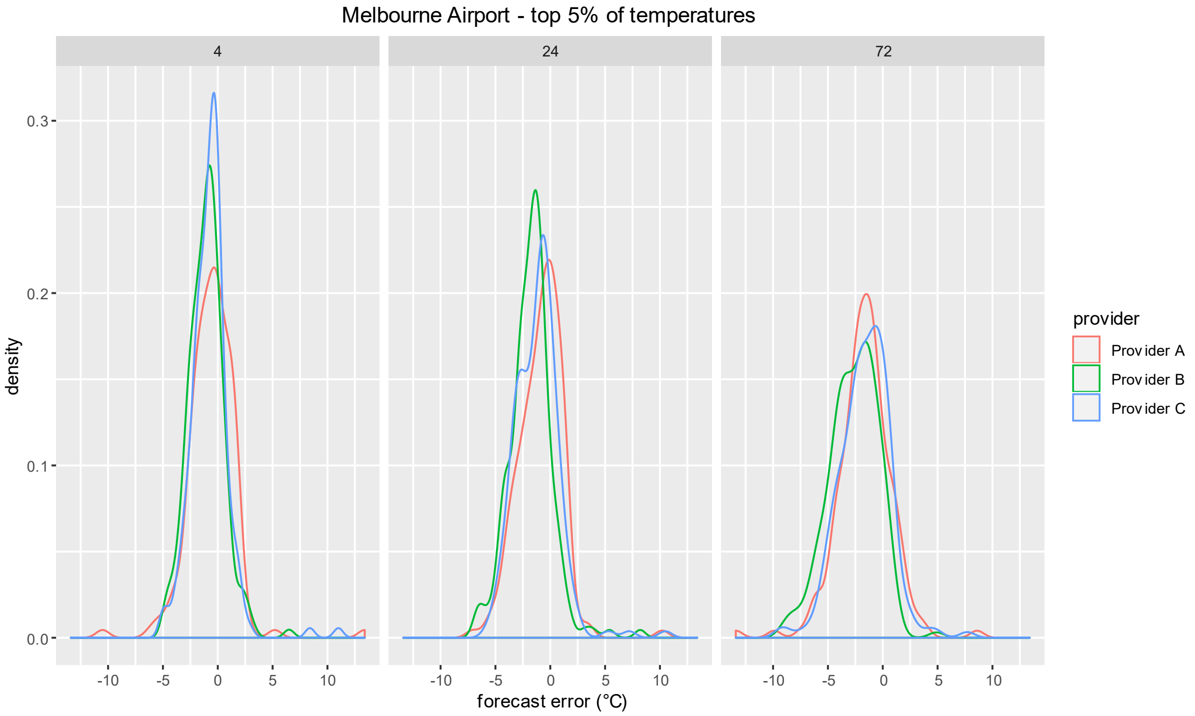
Bankstown Airport - top 5% of temperatures
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C

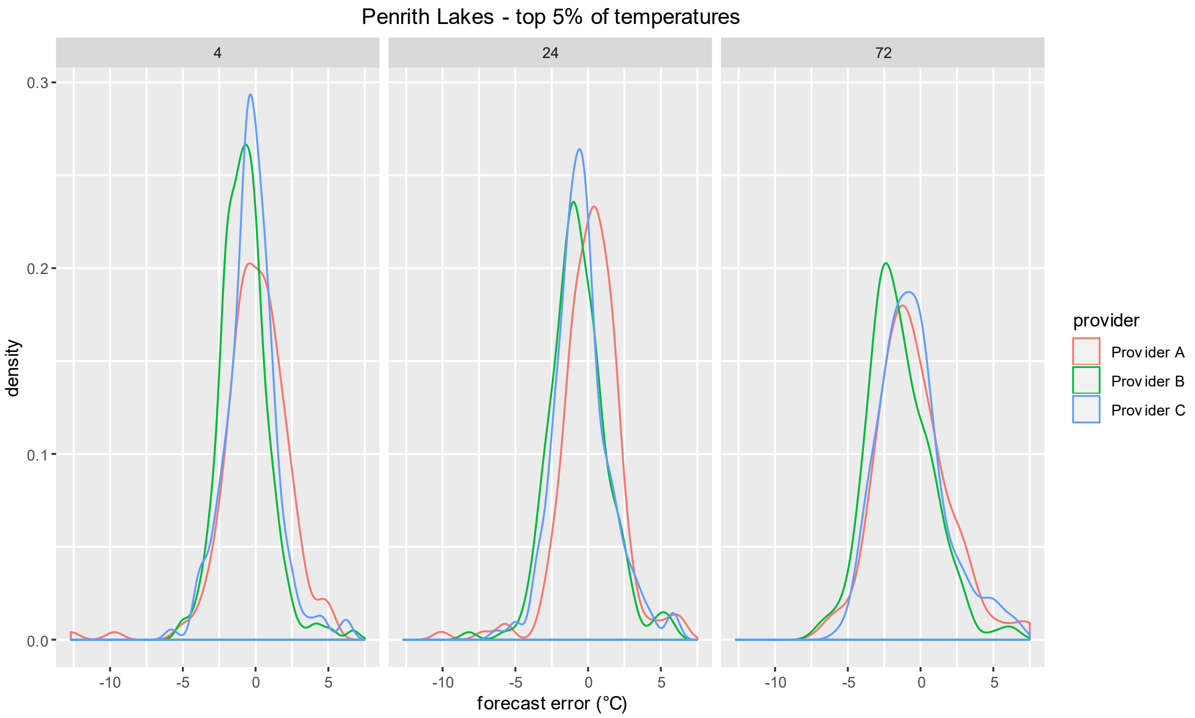


Hobart Airport - top 5% of temperatures
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C

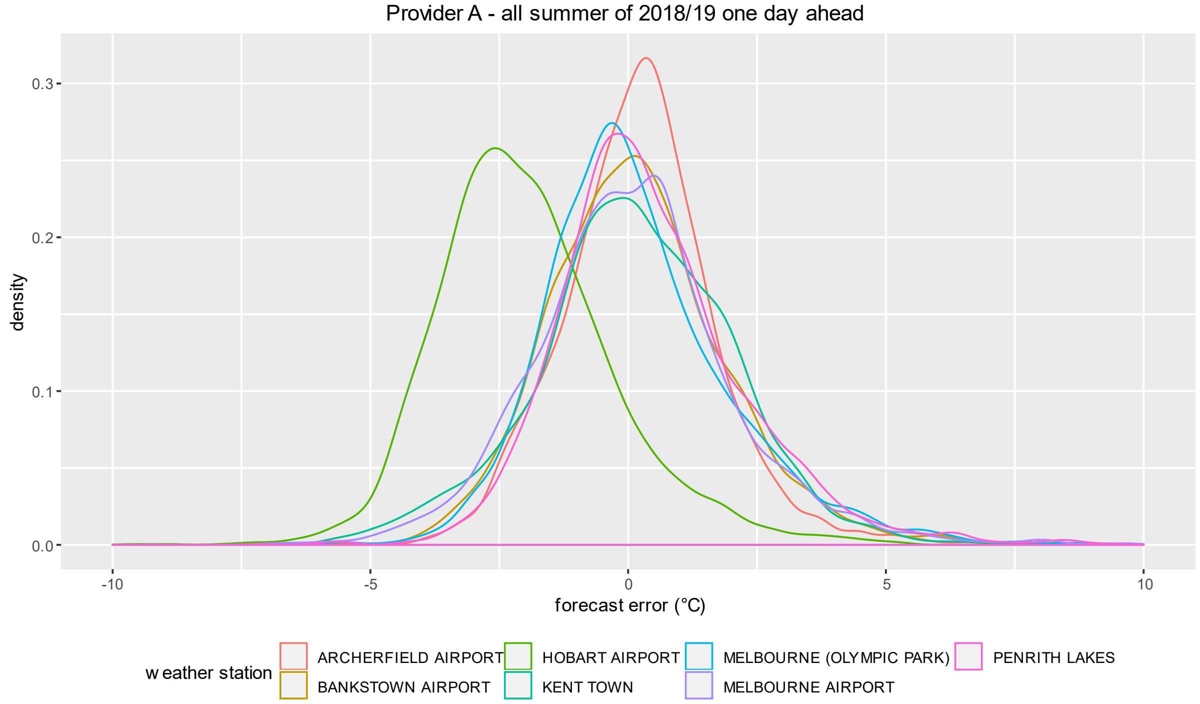

Kent Town - top 5% of temperatures
4
24
72
density
0.0
0.1
0.2
0.3
-4
0
4
forecast error (°C)
provider
Provider A
Provider B
Provider C

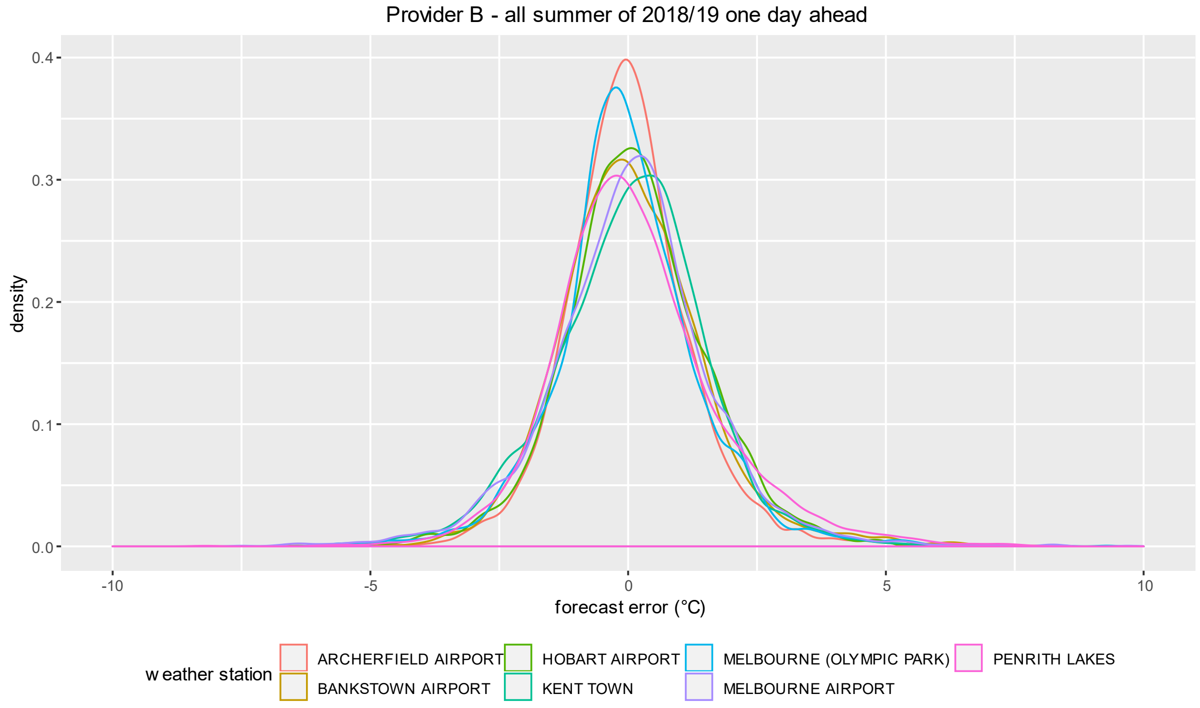

Melbourne (Olympic Park) - top 5% of temperatures
4
24
72
density
0.0
0.1
0.2
0.3
-10
-5
0
5
forecast error (°C)
provider
Provider A
Provider B
Provider C

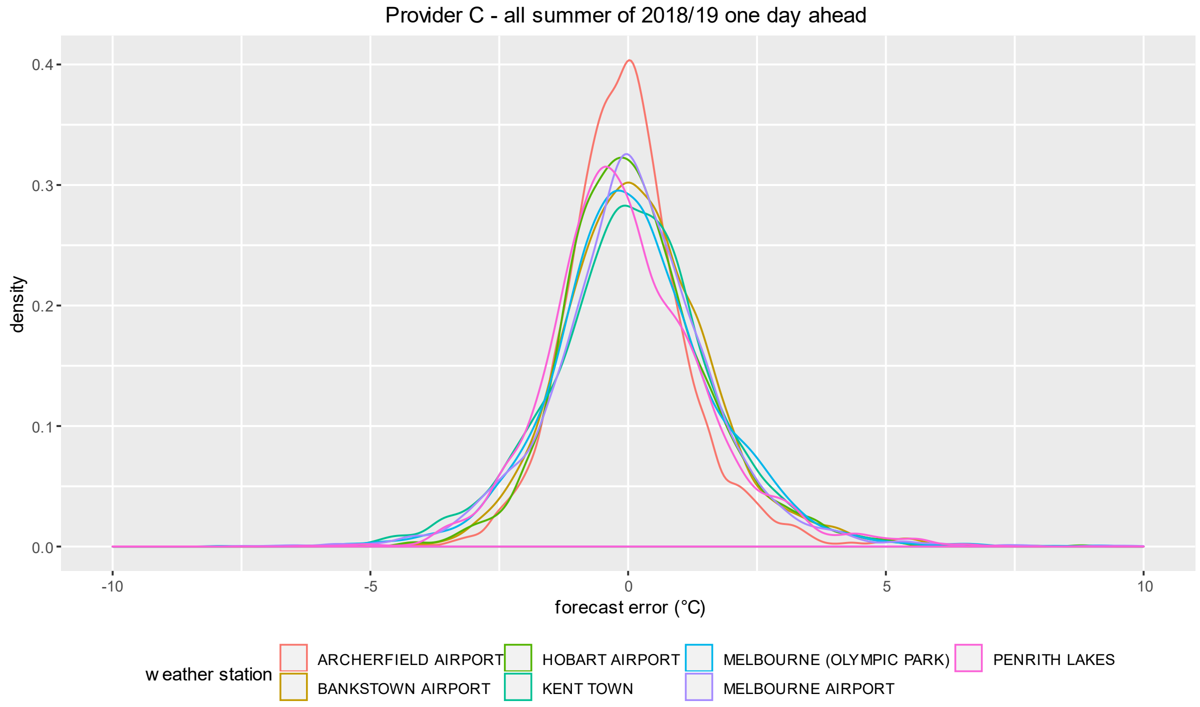

Melbourne Airport - top 5% of temperatures
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C


Penrith Lakes - top 5% of temperatures
4
24
72
density
forecast error (°C)
provider
Provider A
Provider B
Provider C

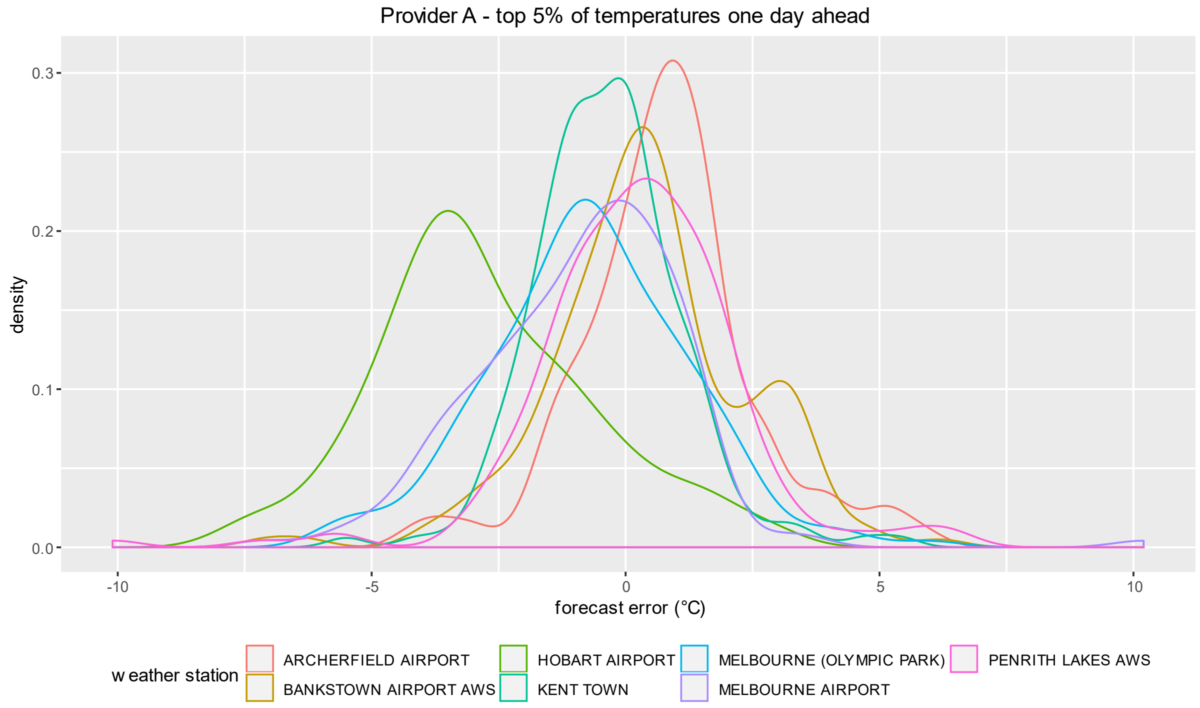
A1.3 Weather station comparison, all summer intervals – 24 HA forecast horizon

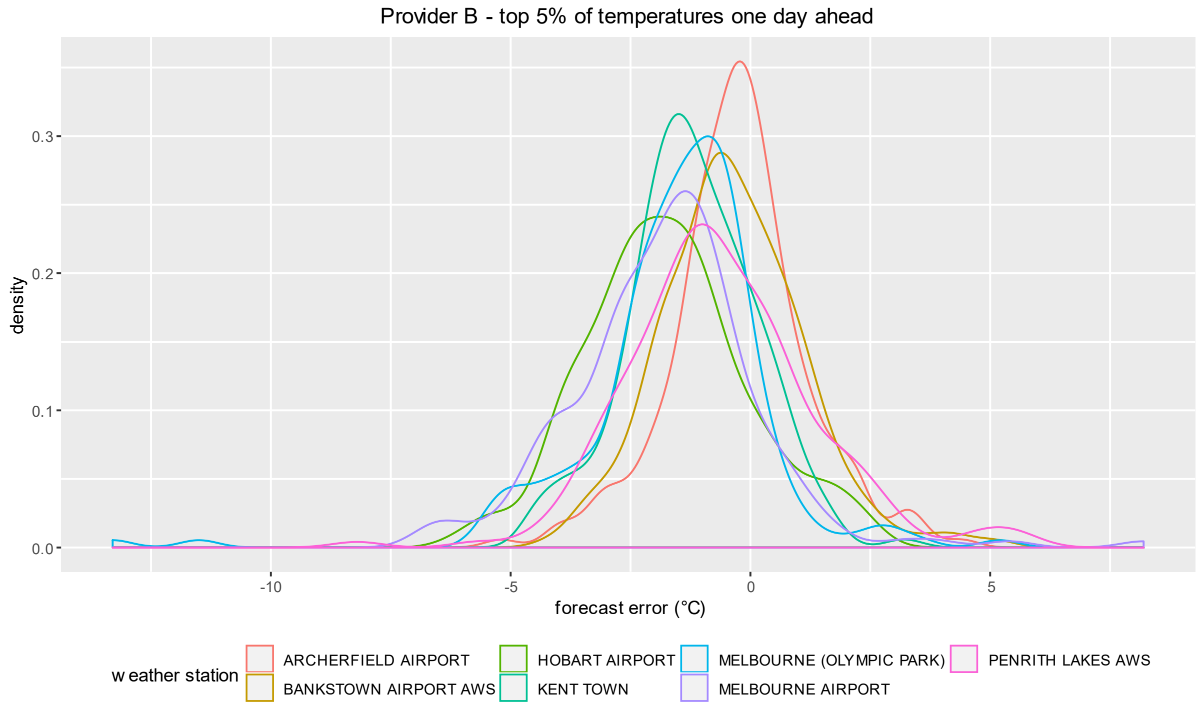


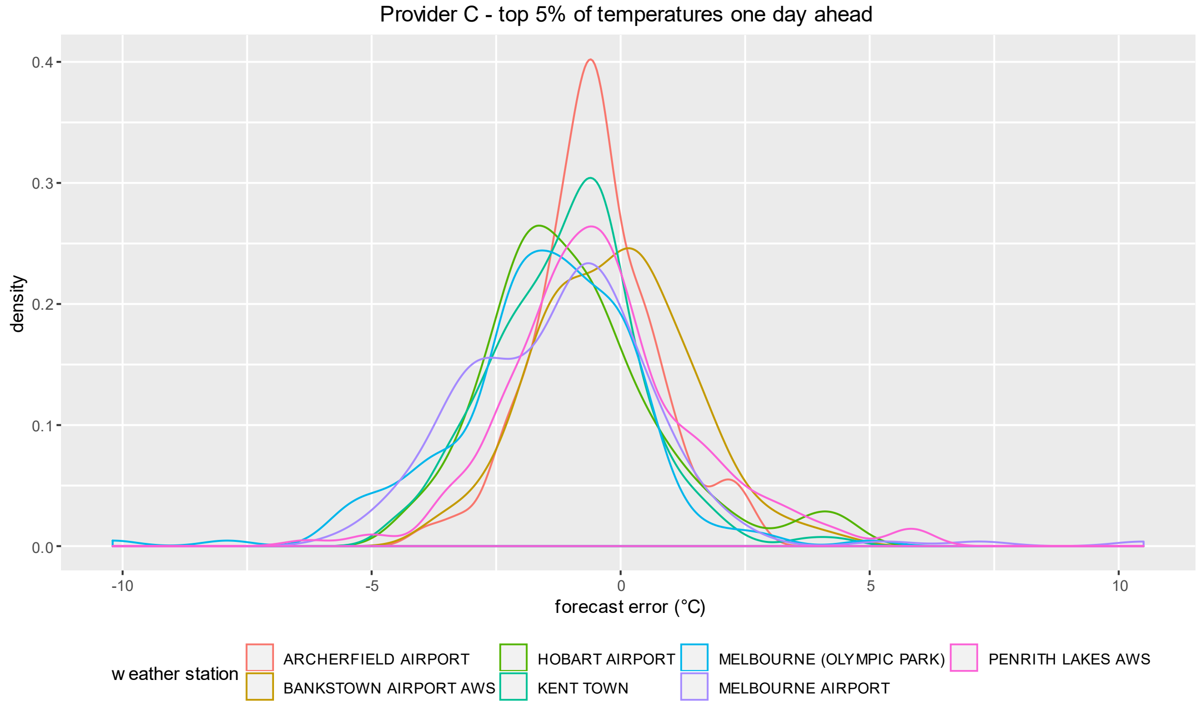




A1.4 Weather station comparison, top 5% of temperatures – 24 HA forecast horizon

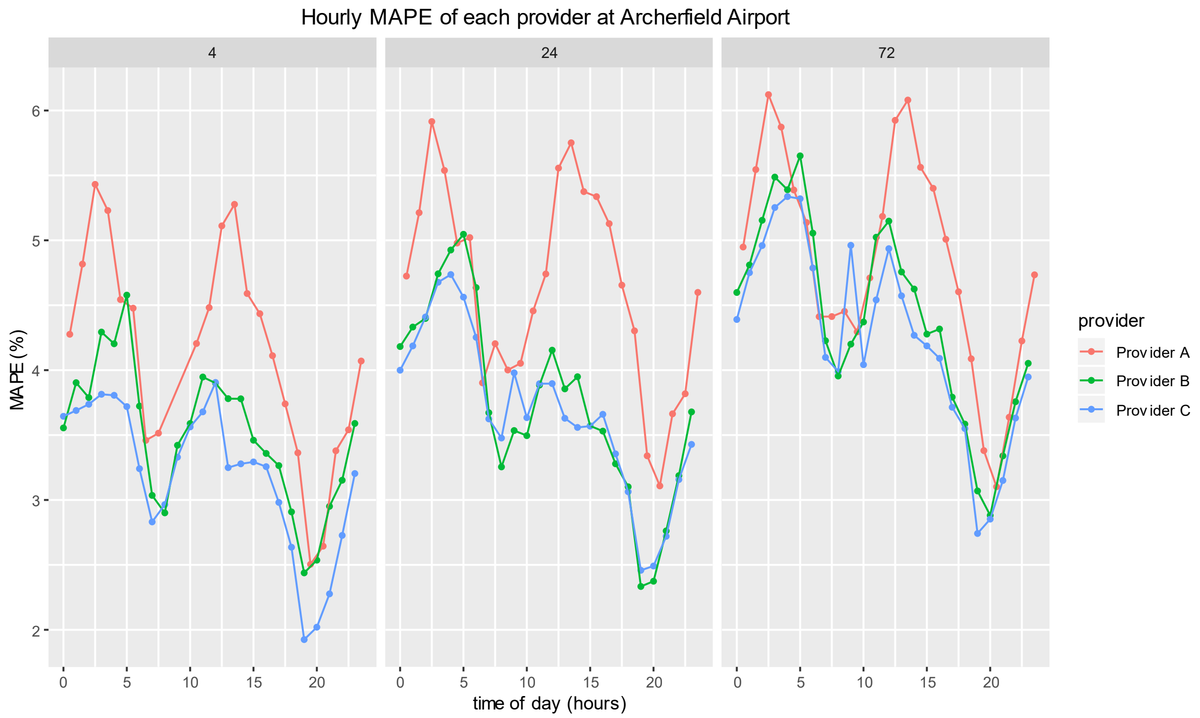


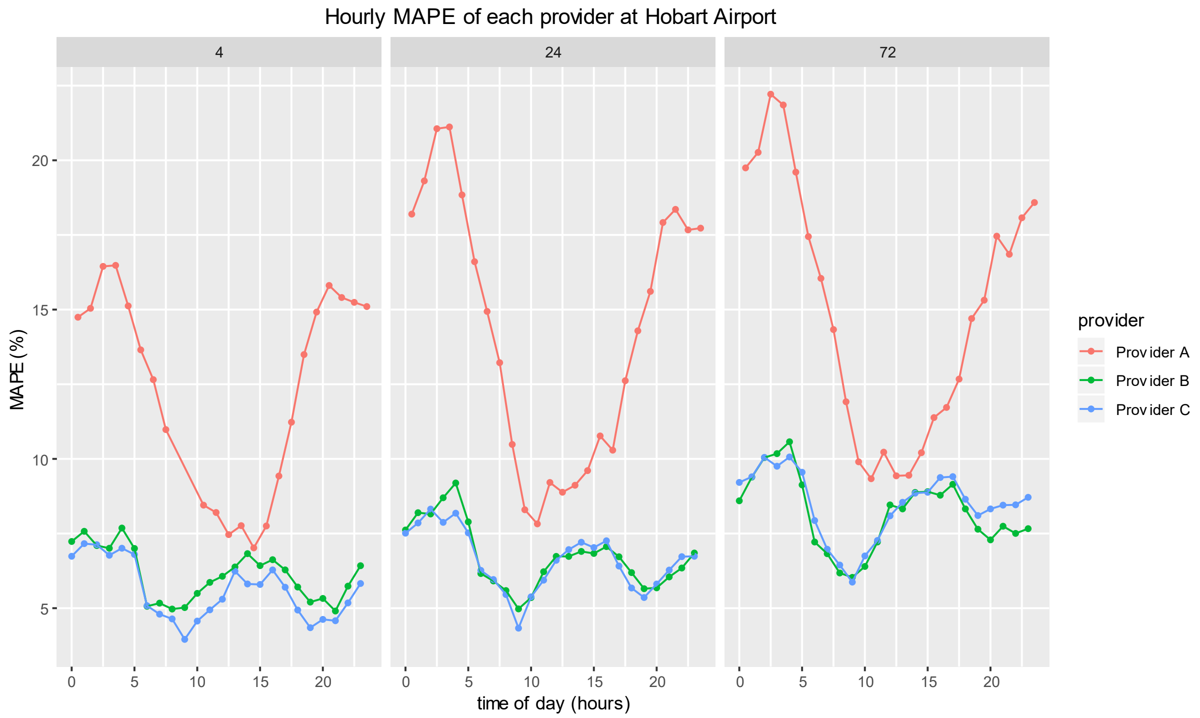

Provider B - top 5% of temperatures one day ahead
density
0.3
0.2
0.1
0.0
-10
-5
0
5
forecast error (°C)
weather station
ARCHERFIELD AIRPORT
BANKSTOWN AIRPORT AWS
HOBART AIRPORT
KENT TOWN
MELBOURNE (OLYMPIC PARK)
MELBOURNE AIRPORT
PENRITH LAKES AWS

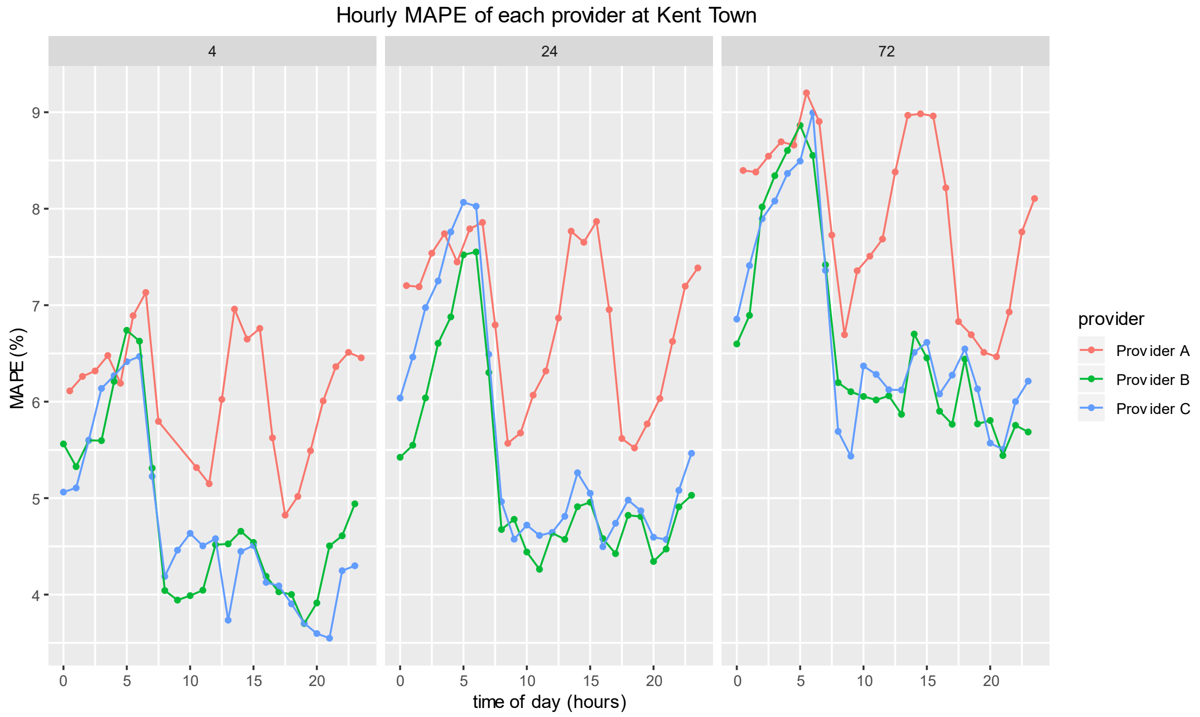

Provider C - top 5% of temperatures one day ahead
density
0.4
0.3
0.2
0.1
0.0
-10
-5
0
5
10
forecast error (°C)
weather station
ARCHERFIELD AIRPORT
BANKSTOWN AIRPORT AWS
HOBART AIRPORT
KENT TOWN
MELBOURNE (OLYMPIC PARK)
MELBOURNE AIRPORT
PENRITH LAKES AWS

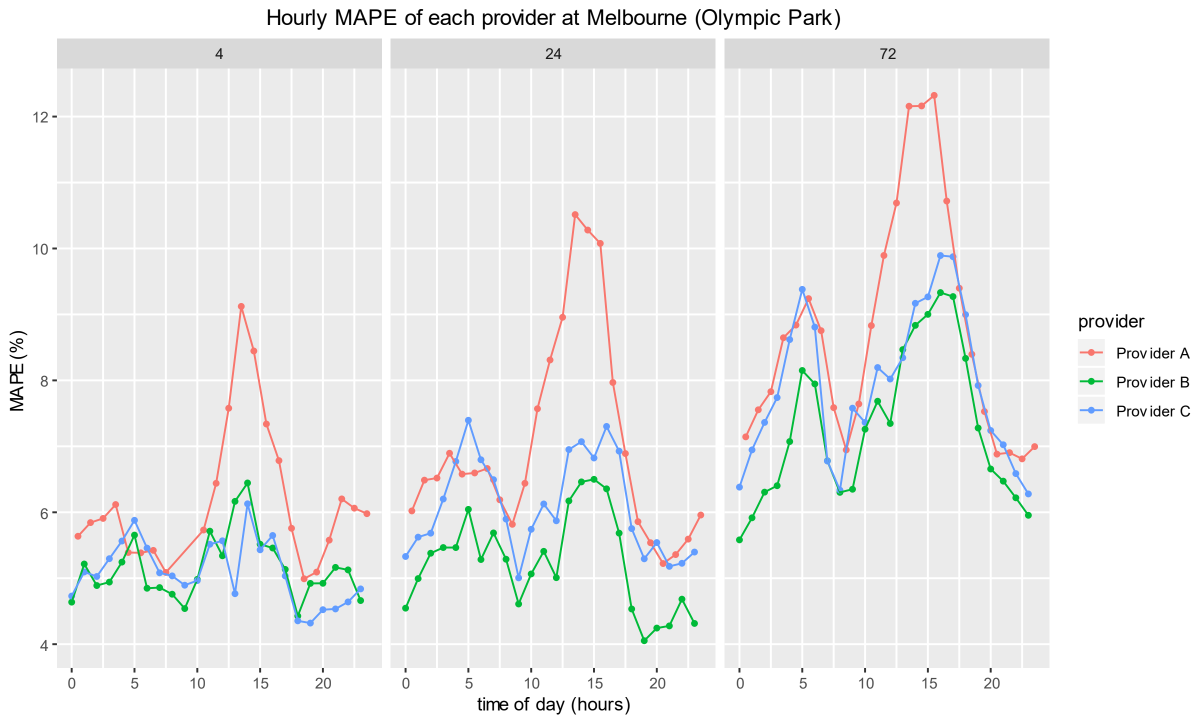
A2. Intraday MAPE profiles

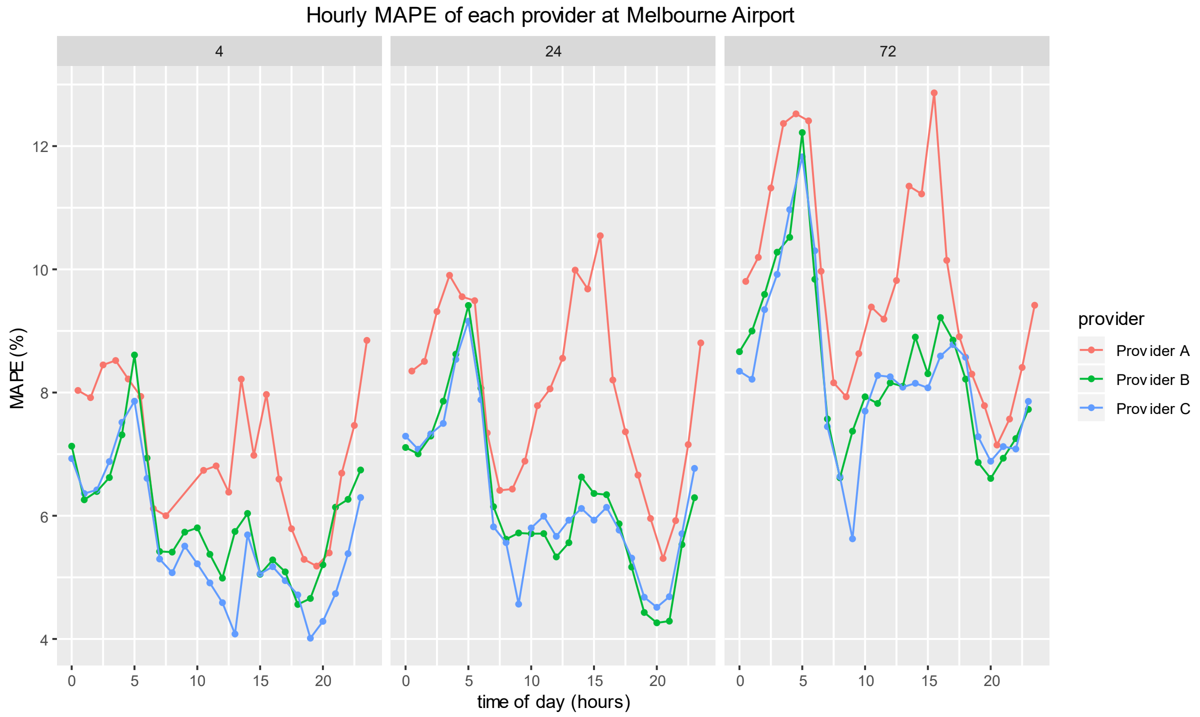
A2.1 All summer intervals – 72 HA, 24 HA, and 4 HA forecast horizons

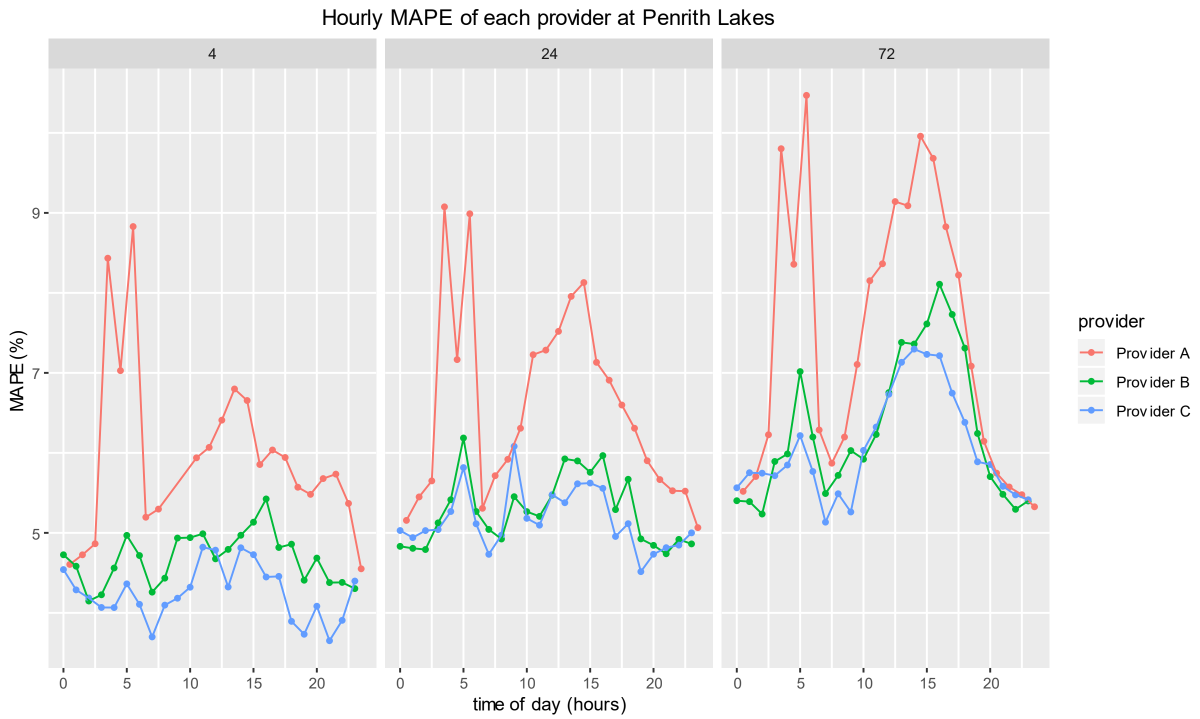




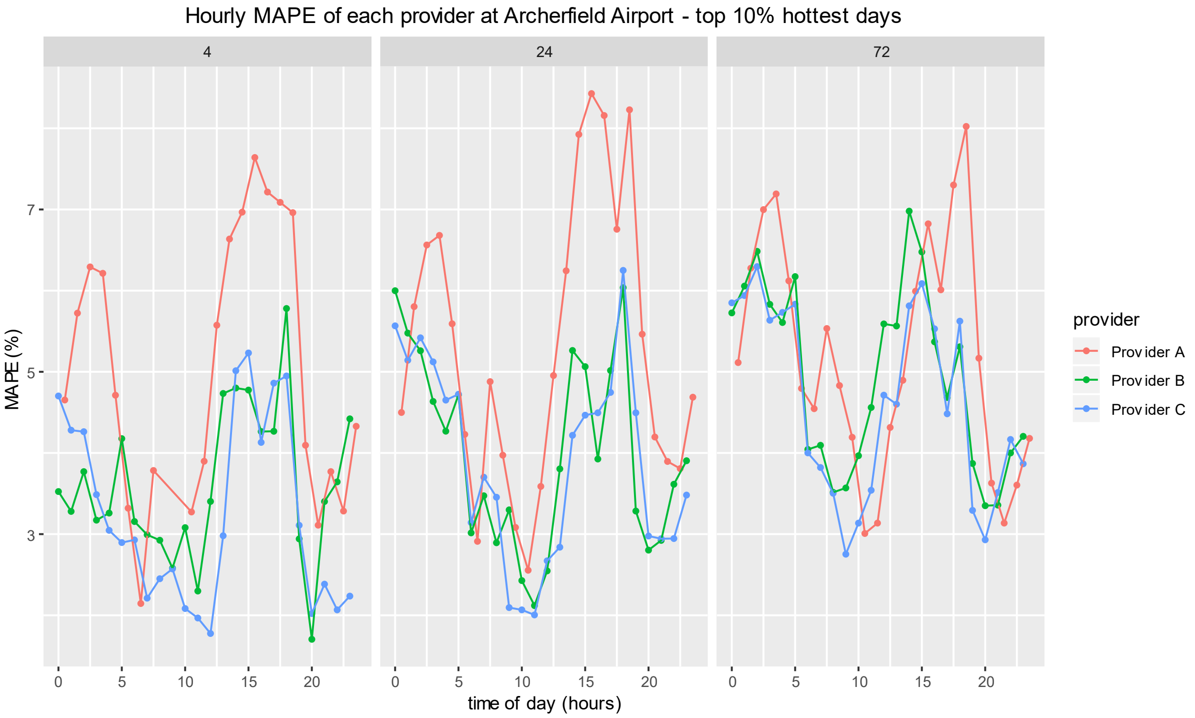

Hourly MAPE of each provider at Kent Town
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C

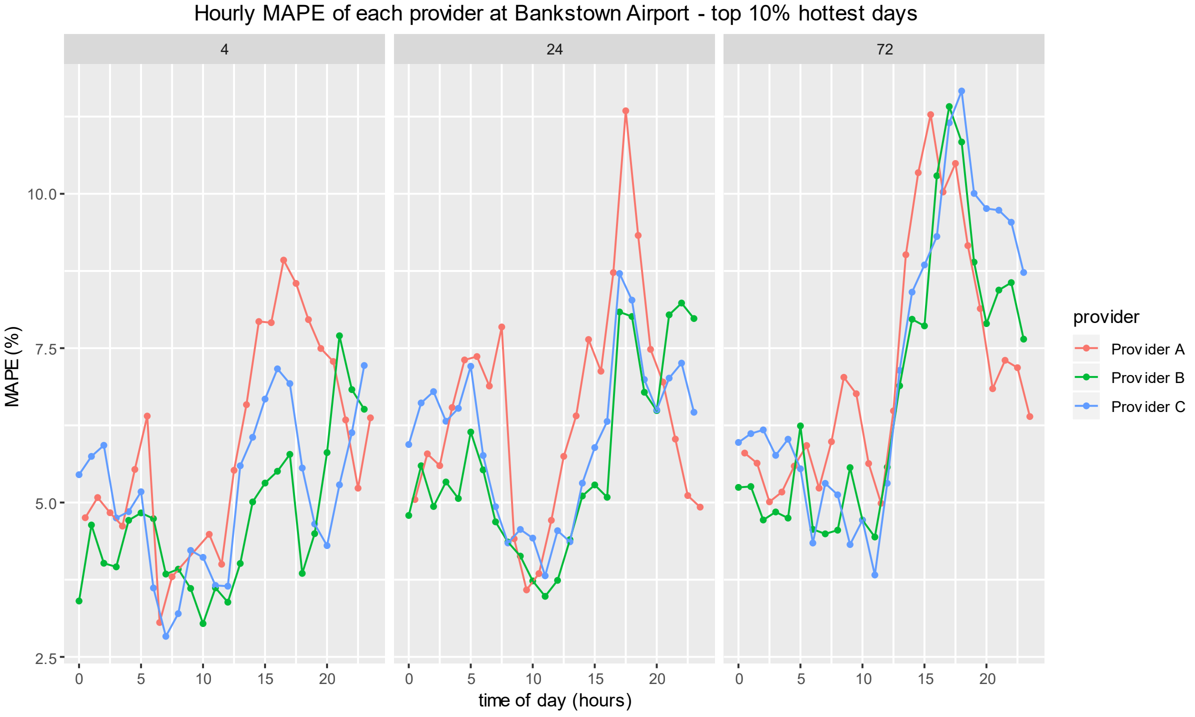

Hourly MAPE of each provider at Melbourne (Olympic Park)
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C

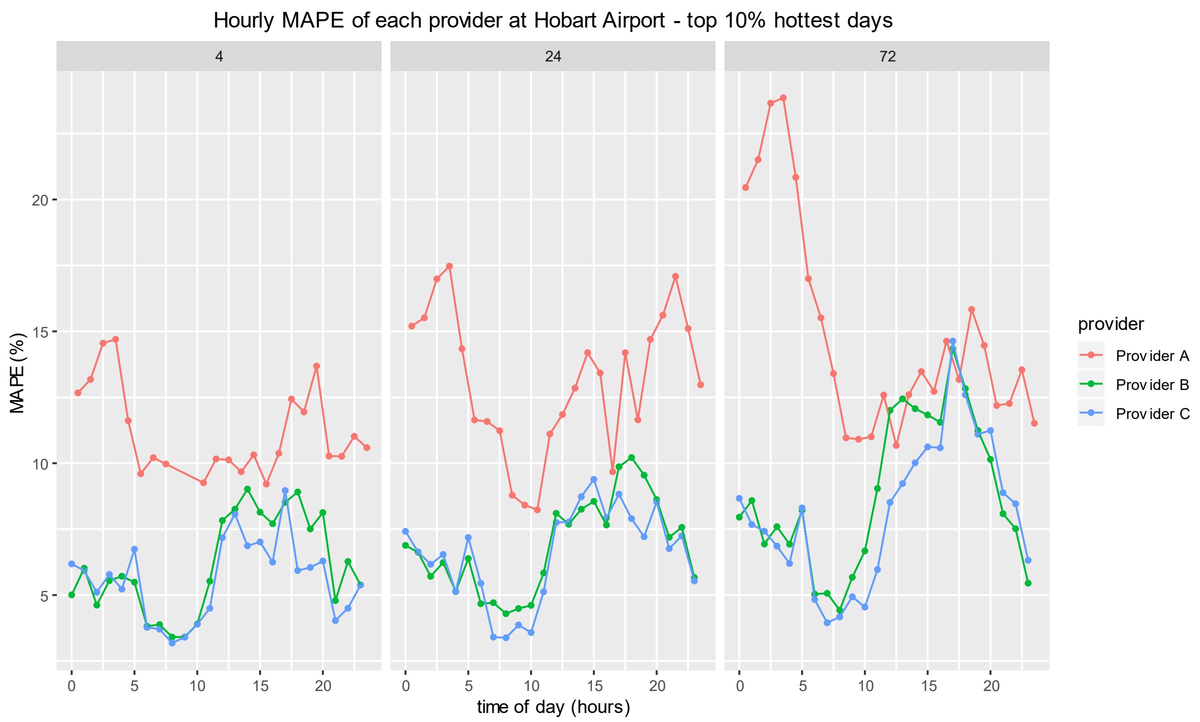

Hourly MAPE of each provider at Melbourne Airport
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C

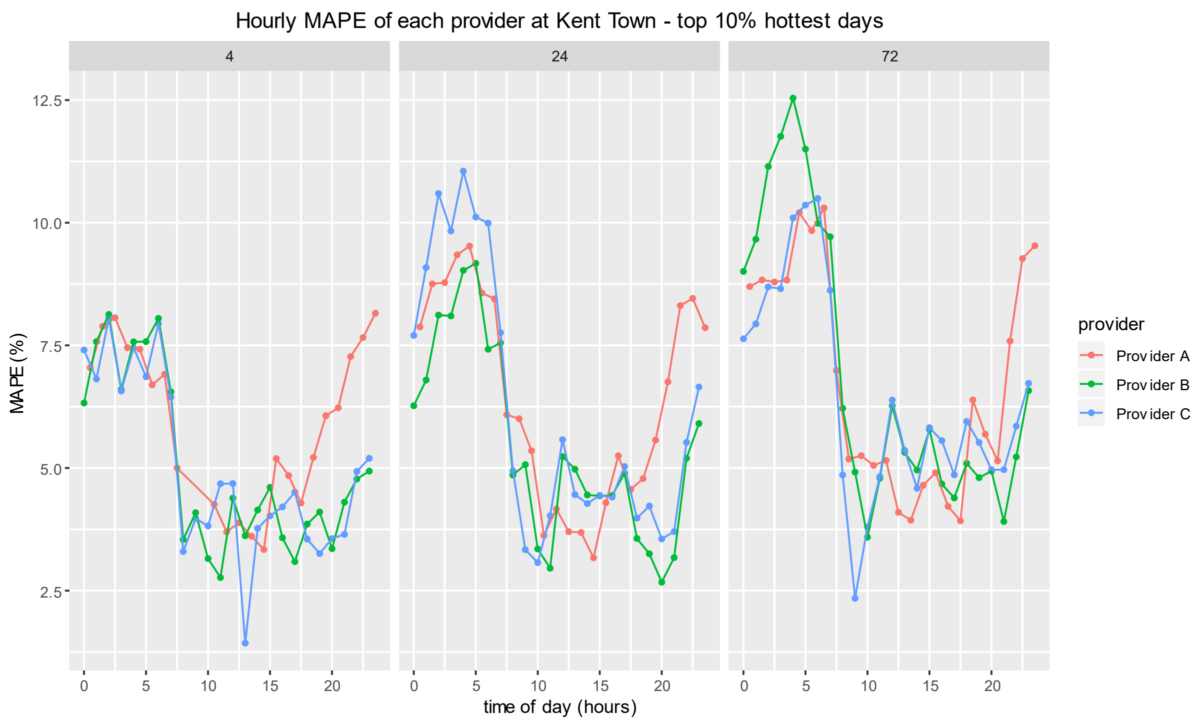

Hourly MAPE of each provider at Penrith Lakes
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C

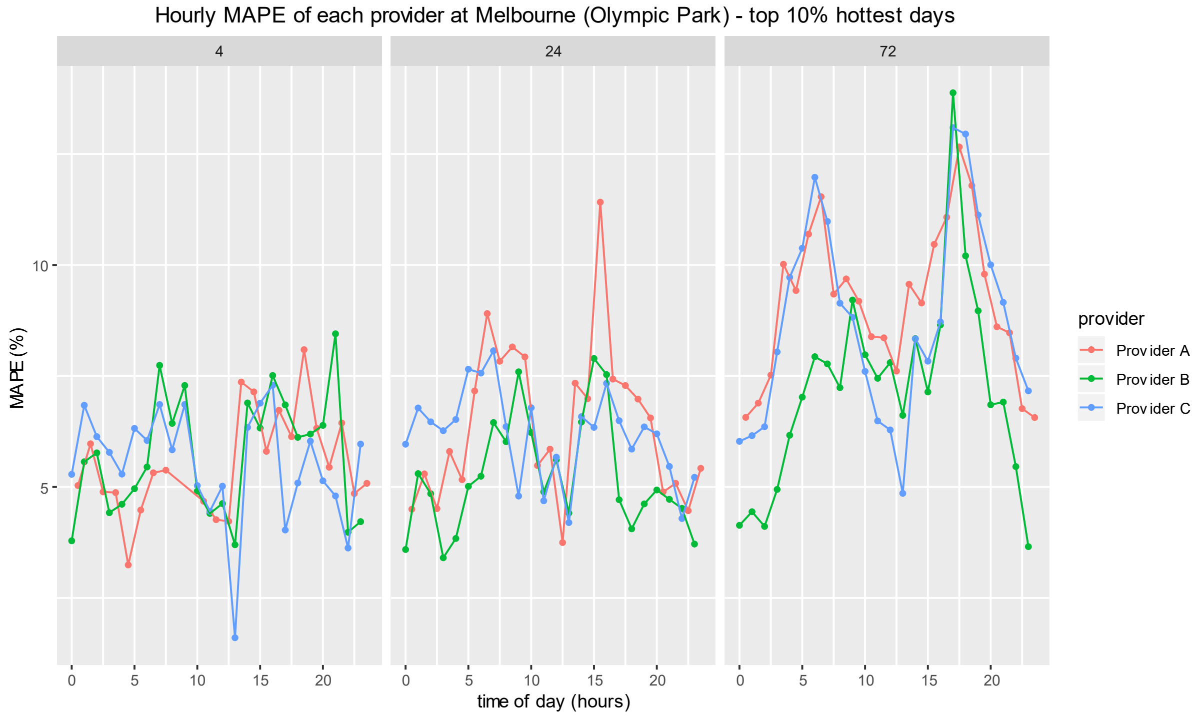
A2.2 Top 10% average temperature days – 72HA, 24HA, and 4HA forecast horizons

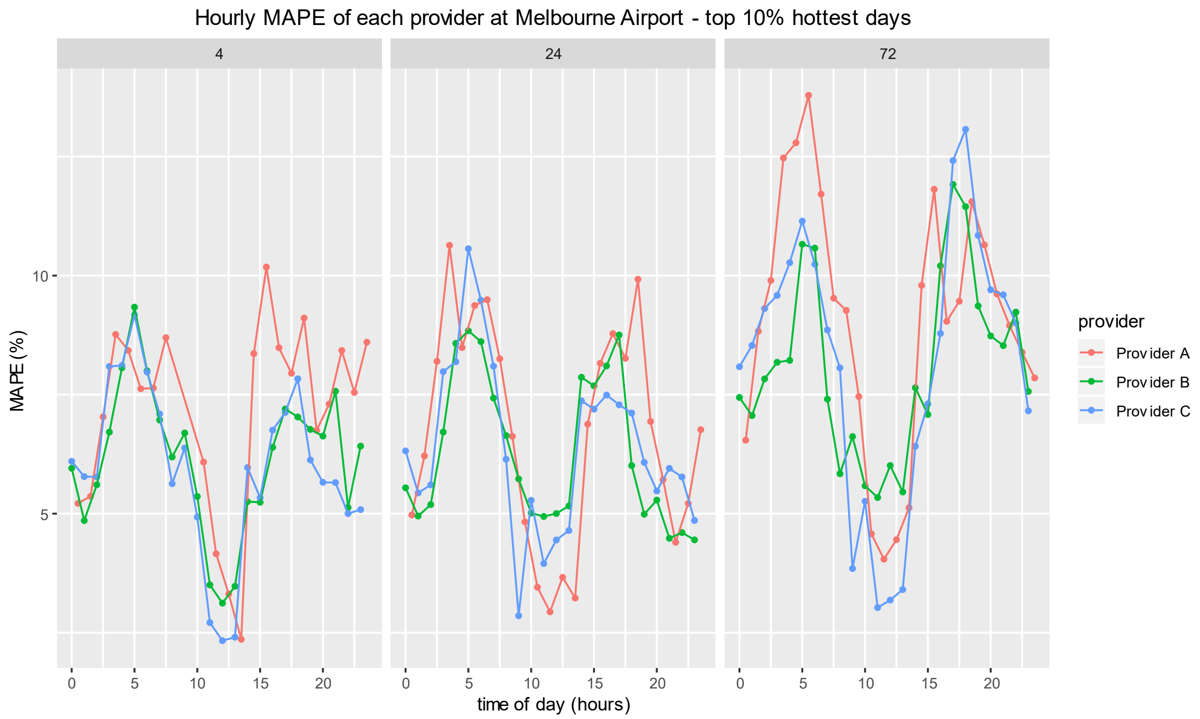


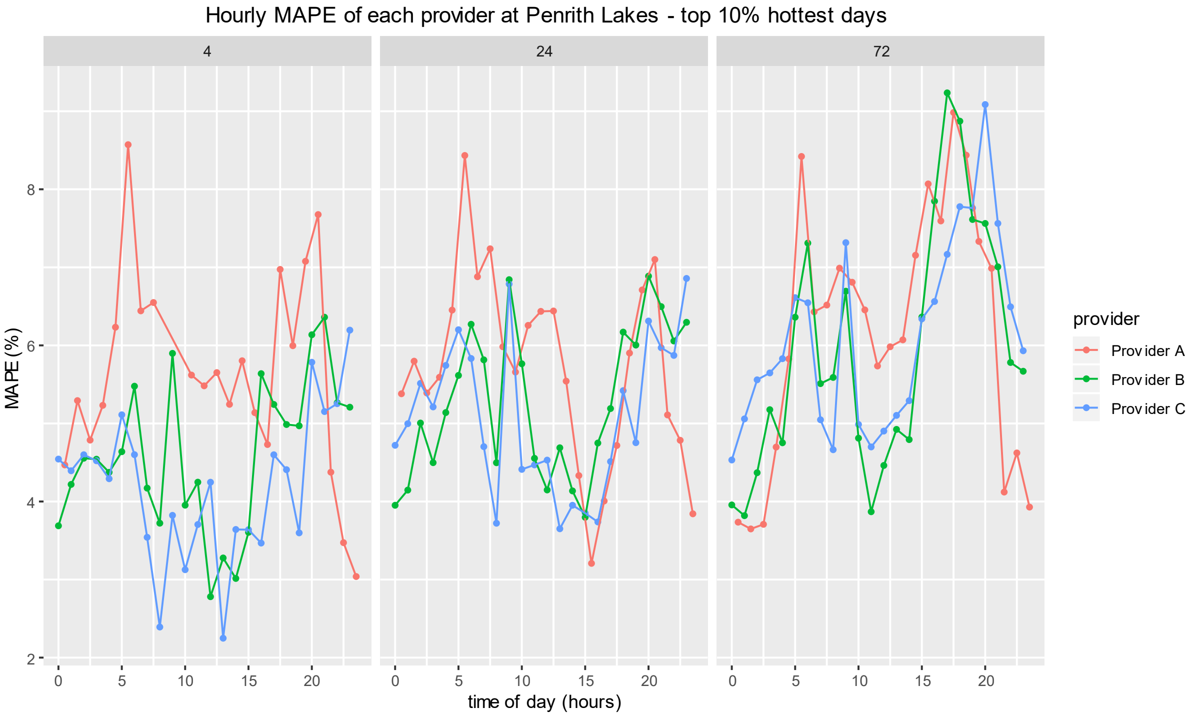



Hourly MAPE of each provider at Hobart Airport - top 10% hottest days
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C


Hourly MAPE of each provider at Kent Town - top 10% hottest days
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C


Hourly MAPE of each provider at Melbourne (Olympic Park) - top 10% hottest days
4
24
72
MAPE (%)
10
5
0
5
10
15
20
time of day (hours)
provider
Provider A
Provider B
Provider C

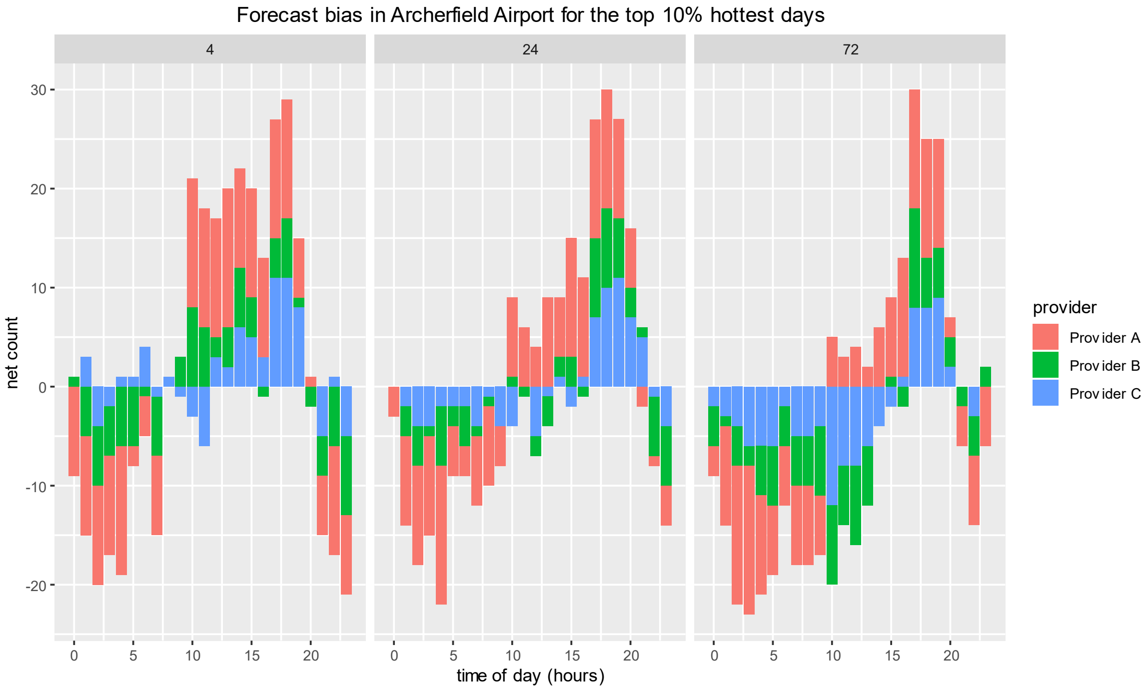

Hourly MAPE of each provider at Melbourne Airport - top 10% hottest days
4
24
72
MAPE (%)
10
5
0
5
10
15
20
time of day (hours)
provider
Provider A
Provider B
Provider C

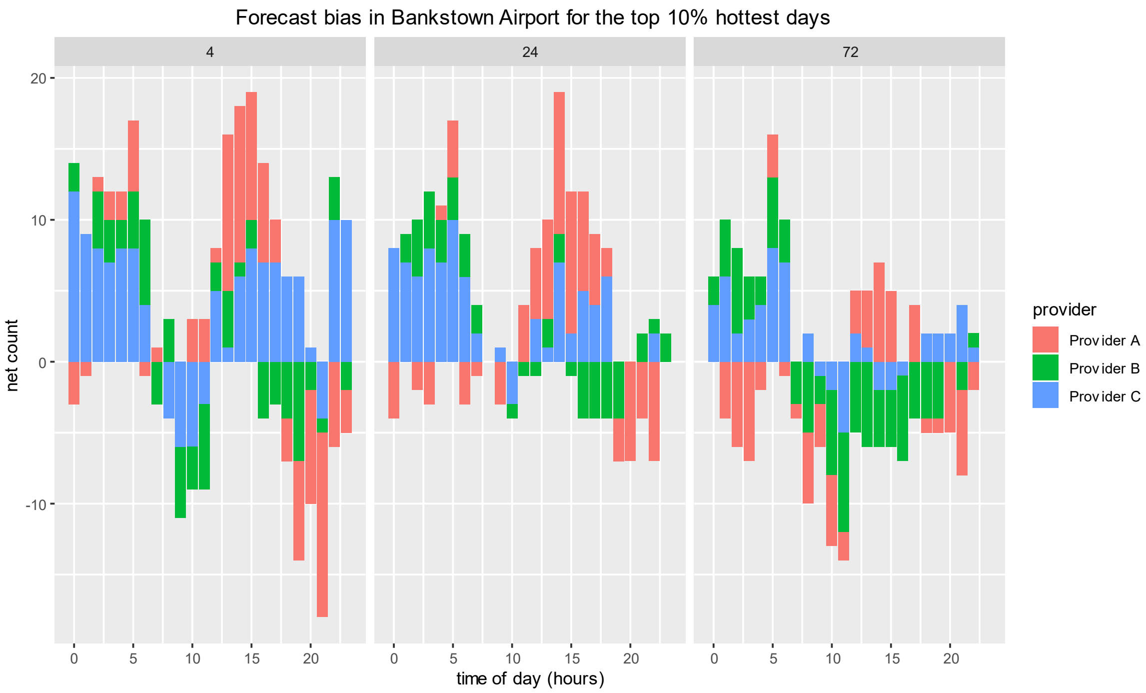


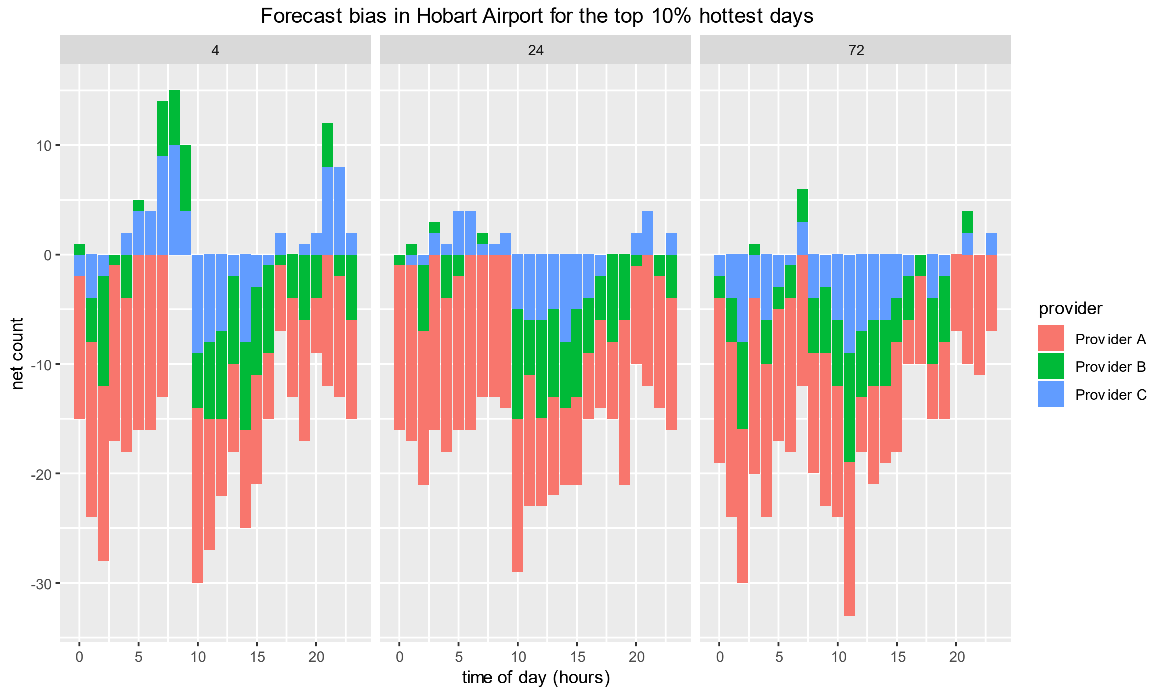
Hourly MAPE of each provider at Penrith Lakes - top 10% hottest days
4
24
72
MAPE (%)
time of day (hours)
provider
Provider A
Provider B
Provider C

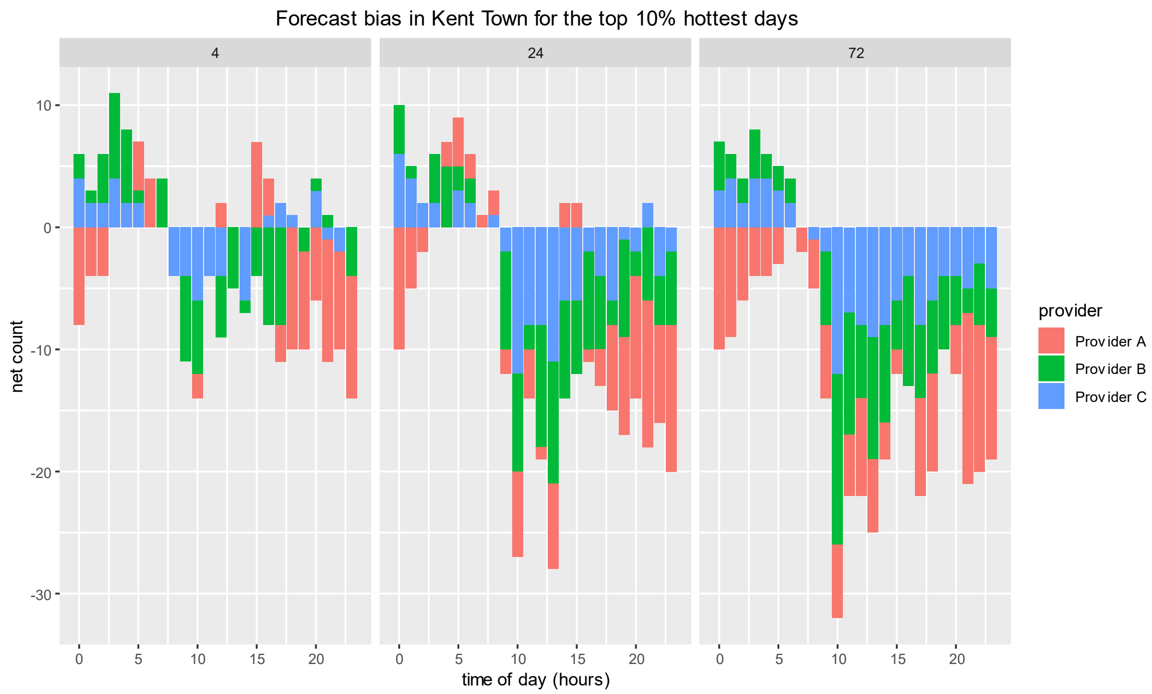
A3. Hourly forecast bias by net count

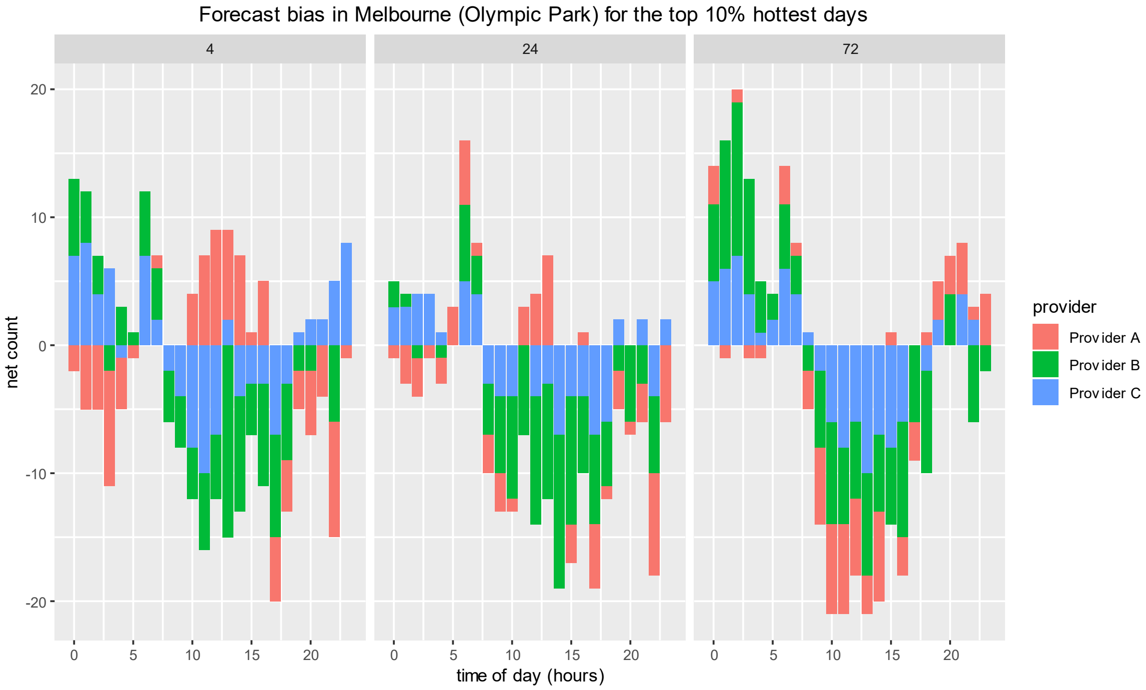
A3.1 Top 10% average temperature days – 72 HA, 24 HA, and 4 HA forecast horizons

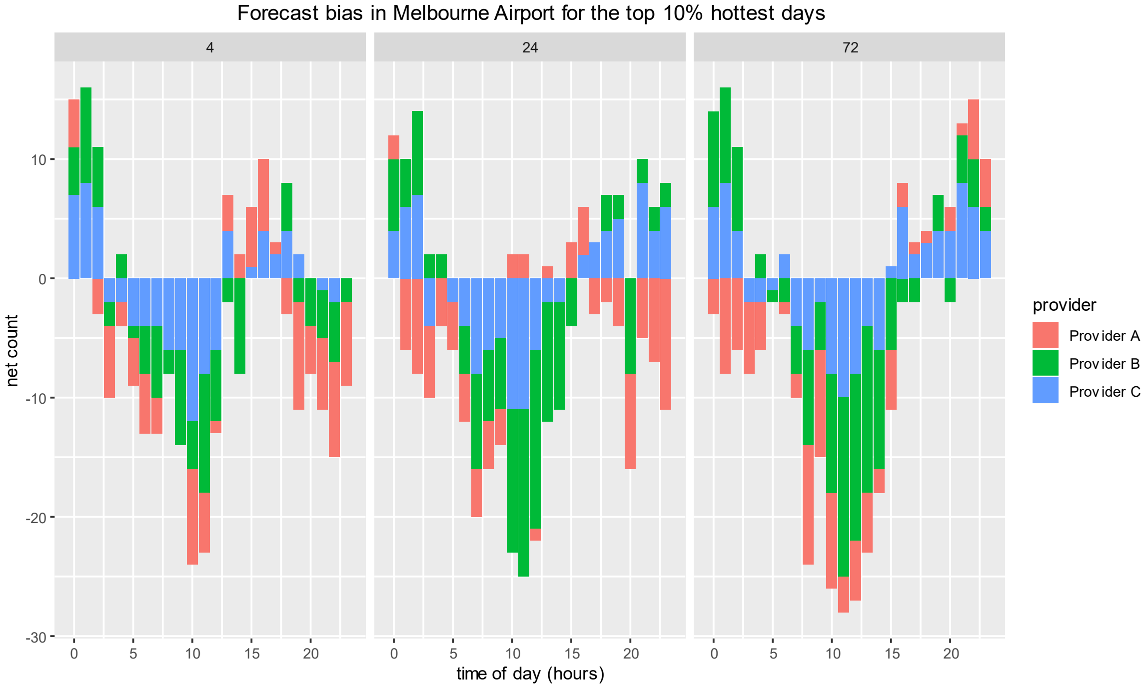


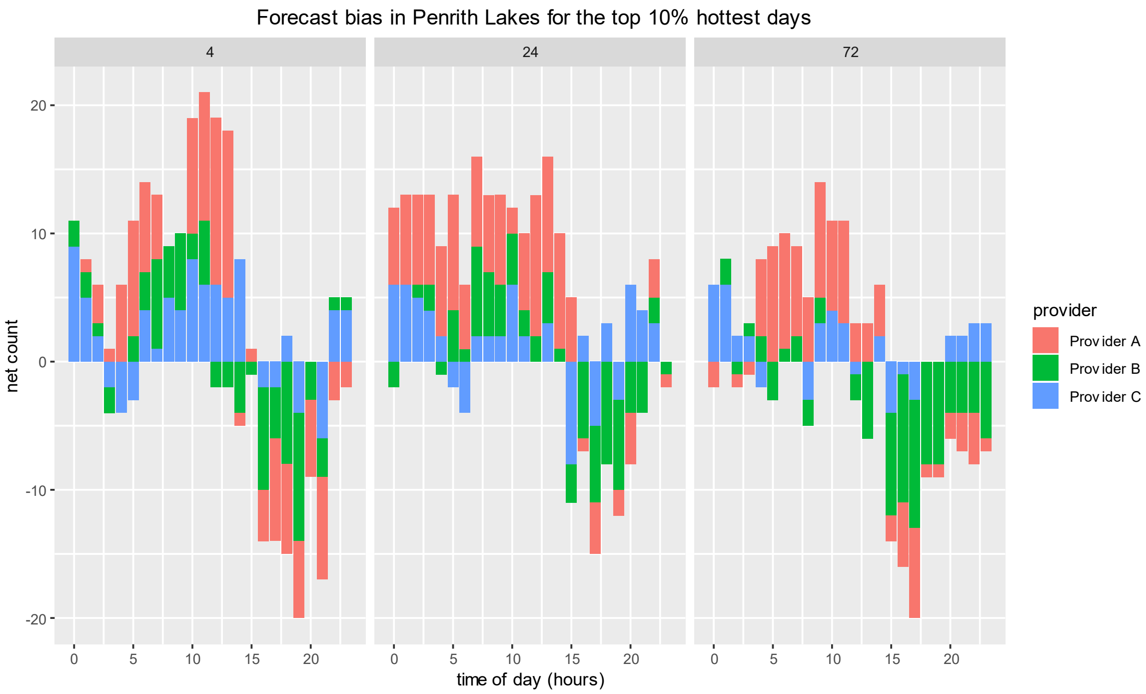



Forecast bias in Hobart Airport for the top 10% hottest days
4
24
72
10
0
-10
-20
-30
net count
0
5
10
15
20
time of day (hours)
provider
Provider A
Provider B
Provider C


Forecast bias in Kent Town for the top 10% hottest days
4
24
72
10
0
-10
-20
-30
net count
0
5
10
15
20
time of day (hours)
provider
Provider A
Provider B
Provider C


Forecast bias in Melbourne (Olympic Park) for the top 10% hottest days
4
24
72
net count
20
10
0
-10
-20
0
5
10
15
20
time of day (hours)
provider
Provider A
Provider B
Provider C


Forecast bias in Melbourne Airport for the top 10% hottest days
4
24
72
net count
10
0
-10
-20
-30
0
5
10
15
20
time of day (hours)
provider
Provider A
Provider B
Provider C


Forecast bias in Penrith Lakes for the top 10% hottest days
4
24
72
net count
time of day (hours)
provider
Provider A
Provider B
Provider C