Forecasting Public Transport Usage

Import data

```
td <- read_csv("publicTransport_part.csv")
```

```
## Rows: 1323 Columns: 3

## -- Column specification ----------------------------------------------------
## Delimiter: ","
## chr  (1): DATE
## dbl  (1): DEMAND
## time (1): TIME

##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
#View(td)
```

The time series runs from 1st March 2005 at 06:30 to 21st March at 22:00. There are 63 time periods per day and 1,323 time periods across the total time series to give us a total of 21 days of data. There is no data for the period between 22:00 and 06:30 as the bus terminal is probably closed during this period.

Convert to ts and plot

```
td.ts <- ts(td$DEMAND, frequency = 63) # create a ts based on observations
autoplot(td.ts,
         xlab="Days",
         ylab="Number of Passengers Arriving at the Terminal",
         color="royalblue") +
  theme(text = element_text(size = 14))
```
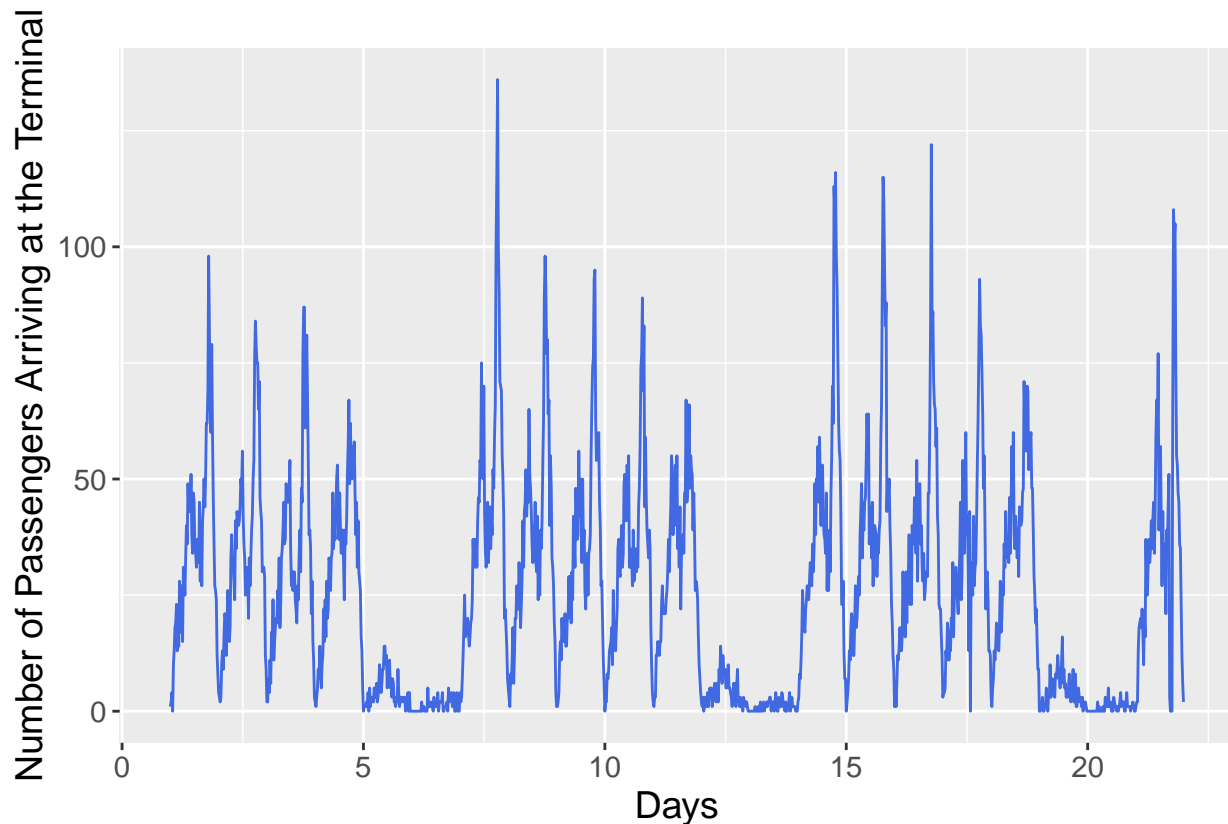
Overview of the data

Looking at the data we can see that it has a clear seasonality to it, with the data looking like it starts on a Tuesday, where there is lots of usage for weekdays and usage then drops off for two weekend days. Each day seems to have two peaks, morning usage and evening usage, with the latter being much higher. Taking a Monday to Friday view there seems to be a drop in numbers as the week progresses, with Mondays having highest usage and Fridays least usage, but this isn't completely consistent. There doesn't appear to be a trend to the data, although we only have three weeks of data available. Given we have three weeks of data, it would be best divided into three parts with the first two used for training and the final part used for validation. With a frequency of 63 for the number of data points per day, this doesn't give us many data points to help with forecasting but as there doesn't seem to be a trend and the patterns seems to hold fairly consistently a reasonable forecast is still possible.

Decompose the data into three components

```
# Components: Seasonal, trend, remainder

td.ts.dec <- stl(td.ts, s.window = "periodic")
autoplot(td.ts.dec,
         main = "Seasonal component, the trend and the remainder in the data") +
  theme(text = element_text(size = 14))
```

Seasonal component, the trend and the remainder in t
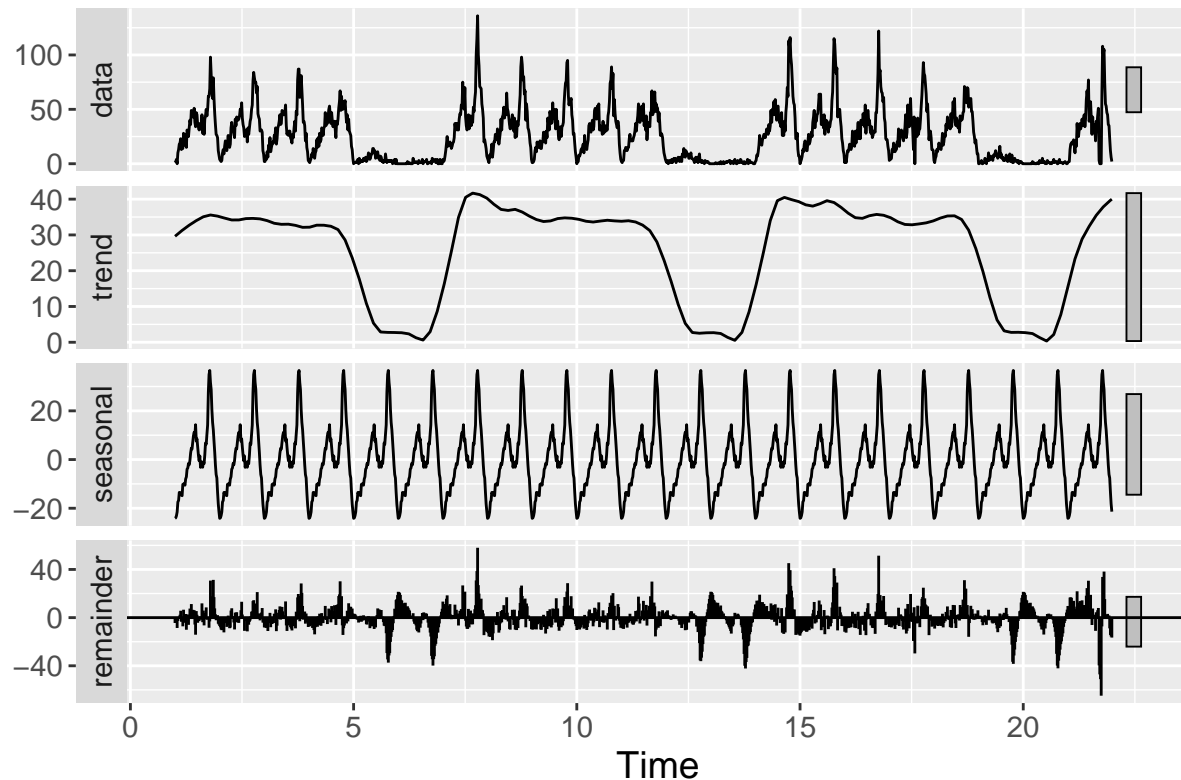
Msts for object class

From the data presented it seems like multi-seasonal time series (msts) would be the best class of object for this dataset as there is seasonality on a daily and weekly basis. With a multi-seasonal time series we can account for a frequency of 63 (a daily seasonality) and a frequency of 441 (a weekly seasonality). This msts object allows for the multi-seasonal periods that the normal ts object can't take into consideration.

ARIMA model

```
td.msts <- msts(td$DEMAND[1:1323], seasonal.periods = c(63, 441)) # daily and weekly seasonality
train.msts <- msts(td$DEMAND[1:882], seasonal.periods = c(63, 441)) # two weeks of training
valid.msts <- msts(td$DEMAND[883:1323], seasonal.periods = c(63, 441)) # one week of validation

arima.mod <- auto.arima(train.msts,
                        xreg = fourier(train.msts, K = c(20, 40)))

arima.pred <- forecast(arima.mod, xreg = fourier(valid.msts, K = c(20, 40)))
accuracy(arima.pred, td.msts)
```

```
##                       ME       RMSE      MAE MPE MAPE      MASE        ACF1
## Training set -0.001670793  5.111612 3.706197 NaN  Inf 0.7257695 0.007079521
## Test set      0.123312144 10.112429 5.356592 NaN  Inf 1.0489596 0.536574105
##              Theil's U
## Training set        NA
## Test set           NaN
```

```
checkresiduals(arima.pred)
```

Residuals from Regression with ARIMA(0,0,3) errors
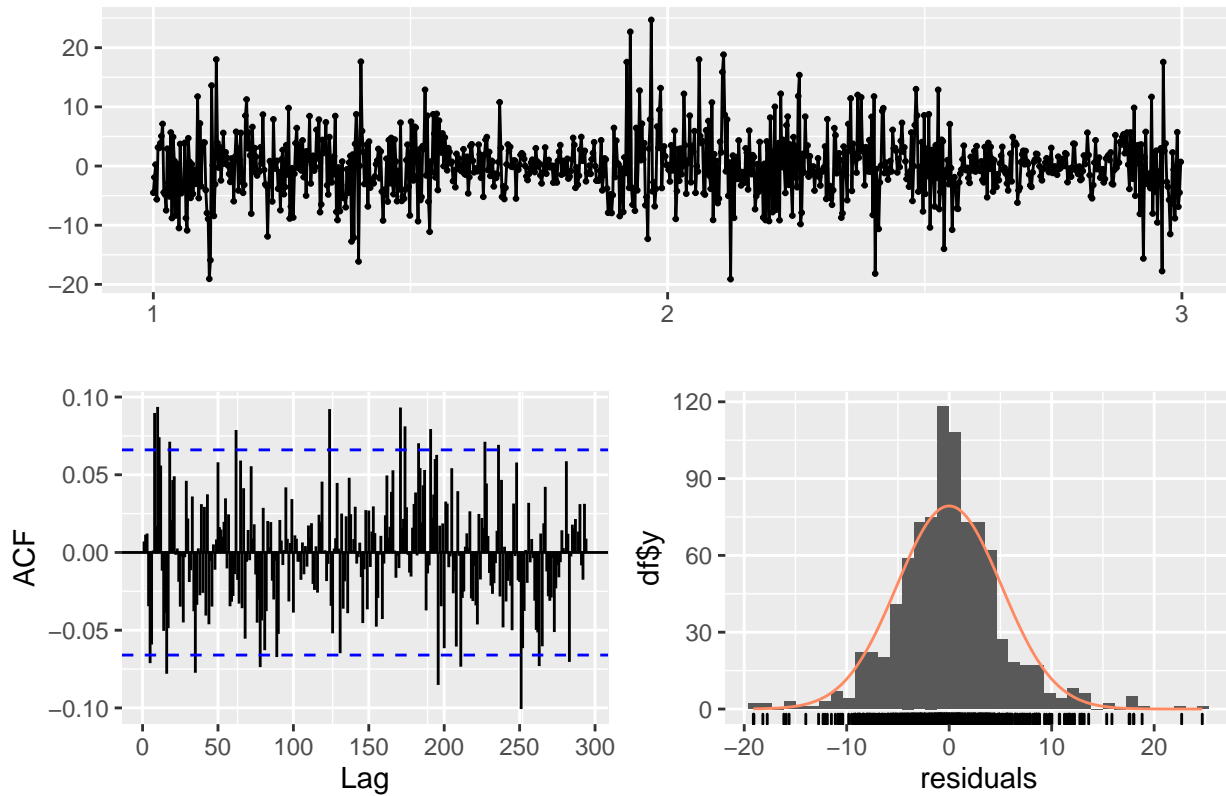

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(0,0,3) errors
## Q* = 211.87, df = 62, p-value < 2.2e-16
##
## Model df: 114.   Total lags used: 176
```

```
clrs <- c("red", "royalblue")
autoplot(arima.pred, series ="ARIMA") +
        ggtitle("Terminal Usage and Predicted Usage") +
        xlab("Weeks") +
        ylab("Number of Passengers Arriving at the Terminal") +
  autolayer(td.msts, series = "True Values") +
  autolayer(arima.pred, series ="ARIMA Validation") +
  guides(colour=guide_legend(title="Time Series")) +
  scale_color_manual(values=clrs) +
  theme(text = element_text(size = 14))
```

Terminal Usage and Predicted Usage
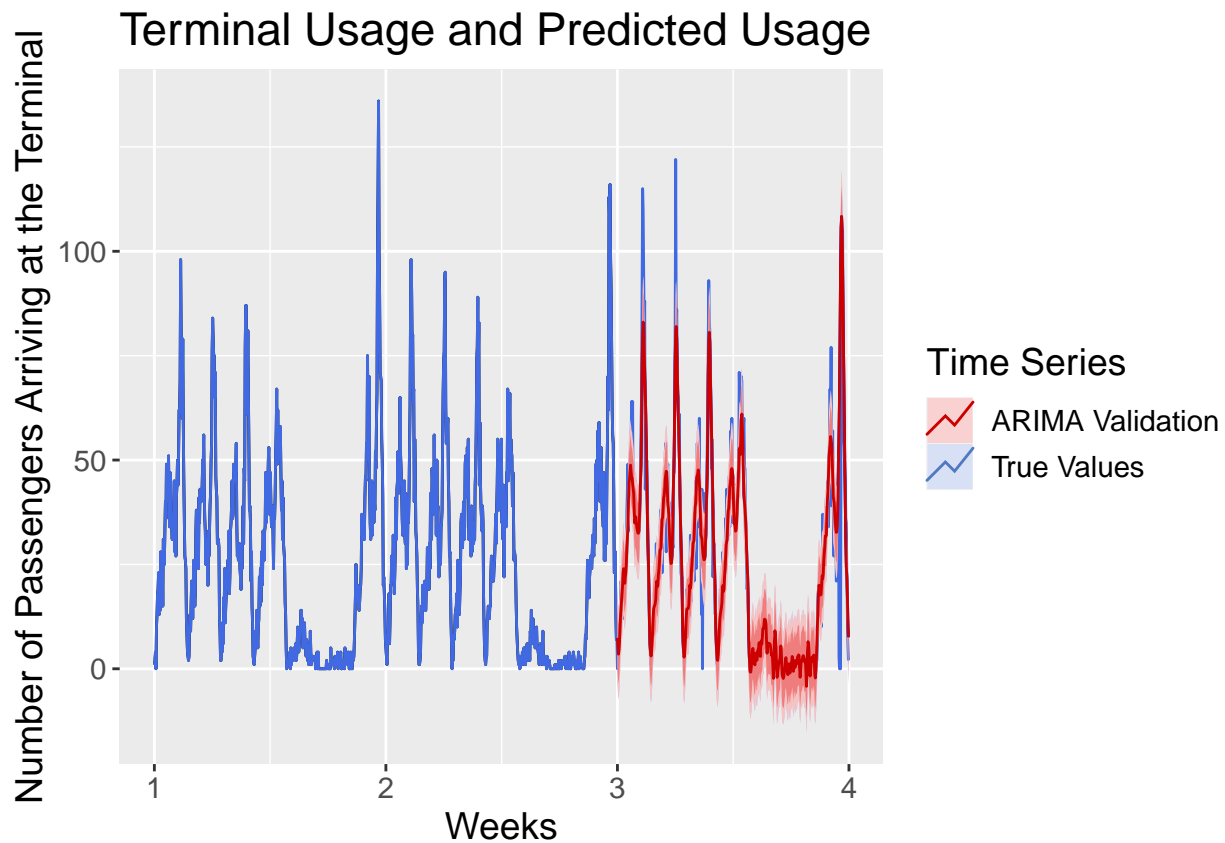
This does reasonably well at forecasting the both daily highs, and also approximates the weekend drop in demand quite well, although Sunday's prediction seems a little off. K of 20, 40 took about 90 seconds to complete. Higher K values can produce better results but place additional demands on computer resources (K should not exceed half of the frequency).

As an alternative I'll try using a linear model with trend and seasonality as predictors.

```
lmts.mod <- tslm(train.msts ~ trend + season, lambda = "auto")

lmts.pred <- forecast(lmts.mod, h = 441)

accuracy(lmts.pred, td.msts)
```

```
##                          ME       RMSE      MAE  MPE MAPE      MASE       ACF1
## Training set  1.388723e-16   3.754652 2.562389  NaN  Inf 0.5017822 0.1342548
## Test set     -7.029478e-02  10.396808 5.560137 -Inf  Inf 1.0888190 0.4373040
##                    Theil's U
## Training set              NA
## Test set                   0
```

```
checkresiduals(lmts.pred)
```

Residuals from Linear regression model
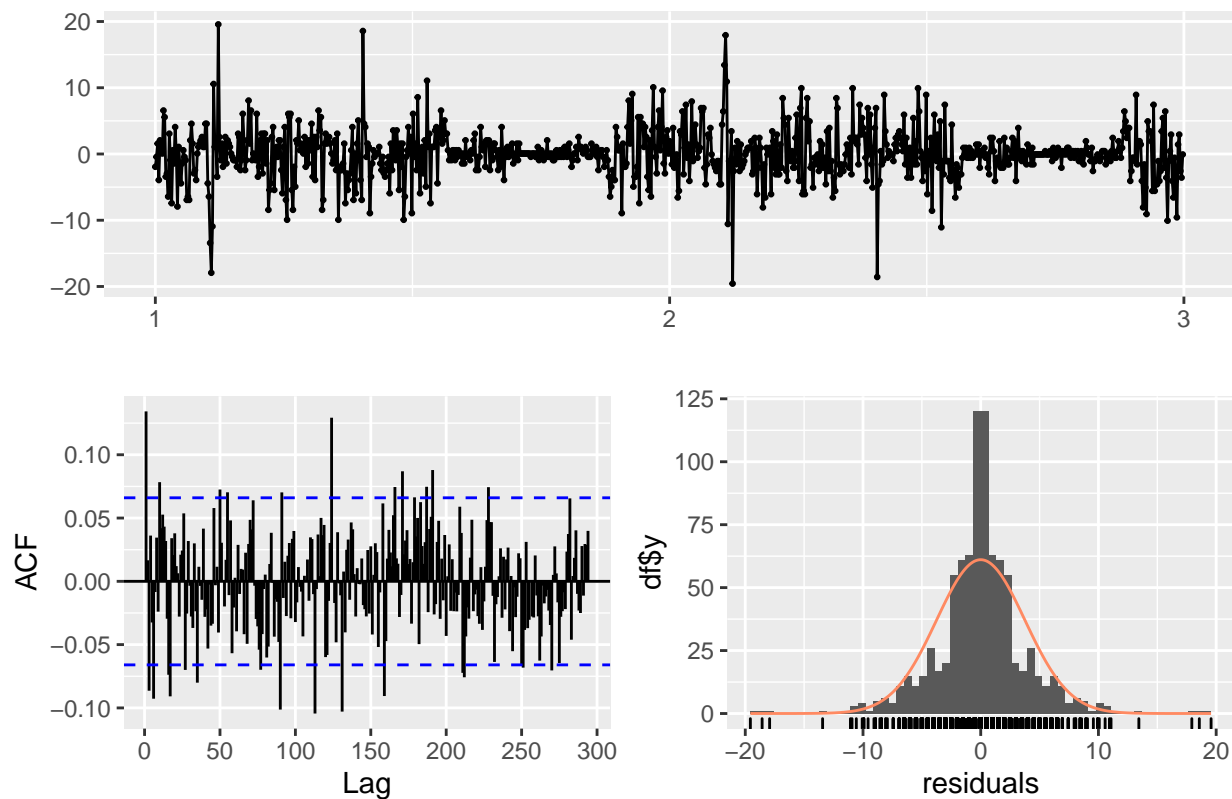

```
## 
##  Ljung-Box test
## 
## data:  Residuals from Linear regression model
## Q* = 1145.8, df = 3, p-value < 2.2e-16
## 
## Model df: 442.    Total lags used: 445
```

```r
# plot(lmts.pred)
# lines(td.msts)

autoplot(lmts.pred, x=td$DATE, colour=TRUE,
         main="Terminal Usage and Predicted Usage",
         xlab="Weeks",
         ylab="Number of Passengers Arriving at the Terminal",
         color="royalblue") +
  autolayer(td.msts, series = "True Values") +
  autolayer(lmts.pred, series ="Linear Validation") +
  guides(colour=guide_legend(title="Time Series")) +
  scale_color_manual(values=clrs) +
  theme(text = element_text(size = 14))
```

Terminal Usage and Predicted Usage
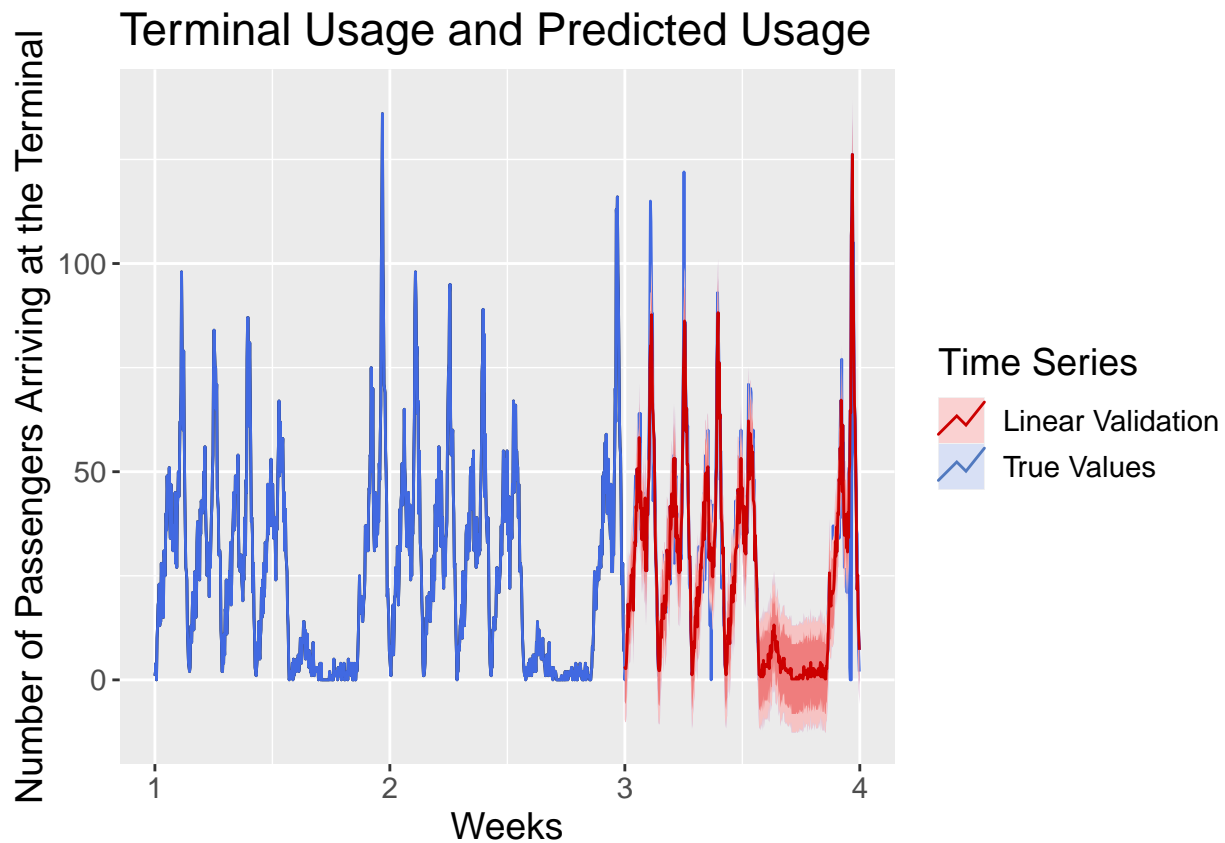
This model performs well and is computationally less intensive as it only took seconds to run although we do have coefficients for each 15-minute period and an intercept, which amounts to 442 in total. Although this has produced a good results I must be concerned with overfitting.

Next let's try a seasonal naive method

```
summary(lmts.mod)
```

```
##
## Call:
## tslm(formula = train.msts ~ trend + season, lambda = "auto")
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -19.568  -1.568   0.000   1.568  19.568
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.932e+00  3.763e+00   0.513 0.607998
## trend        3.085e-04  8.118e-04   0.380 0.704093
## season2     -5.003e-01  5.316e+00  -0.094 0.925060
## season3     -5.006e-01  5.316e+00  -0.094 0.925014
## season4      9.991e-01  5.316e+00   0.188 0.851010
## season5      4.999e+00  5.316e+00   0.940 0.347559
## season6      8.998e+00  5.316e+00   1.693 0.091213 .
## season7      1.500e+01  5.316e+00   2.821 0.004998 **
## season8      9.498e+00  5.316e+00   1.787 0.074677 .
## season9      1.450e+01  5.316e+00   2.727 0.006643 **
## season10     1.350e+01  5.316e+00   2.539 0.011460 *
```

```
## season11       1.400e+01  5.316e+00    2.633 0.008761 **
## season12       1.750e+01  5.316e+00    3.291 0.001077 **
## season13       2.200e+01  5.316e+00    4.138 4.20e-05 ***
## season14       1.800e+01  5.316e+00    3.385 0.000775 ***
## season15       2.150e+01  5.316e+00    4.044 6.21e-05 ***
## season16       2.350e+01  5.316e+00    4.420 1.25e-05 ***
## season17       1.350e+01  5.316e+00    2.539 0.011473 *
## season18       2.399e+01  5.316e+00    4.514 8.19e-06 ***
## season19       2.599e+01  5.316e+00    4.890 1.42e-06 ***
## season20       2.999e+01  5.316e+00    5.642 3.01e-08 ***
## season21       2.899e+01  5.316e+00    5.454 8.22e-08 ***
## season22       3.849e+01  5.316e+00    7.241 2.00e-12 ***
## season23       3.749e+01  5.316e+00    7.053 6.83e-12 ***
## season24       4.749e+01  5.316e+00    8.934  < 2e-16 ***
## season25       3.949e+01  5.316e+00    7.429 5.73e-13 ***
## season26       4.449e+01  5.316e+00    8.370 7.76e-16 ***
## season27       4.099e+01  5.316e+00    7.711 8.40e-14 ***
## season28       5.499e+01  5.316e+00   10.345  < 2e-16 ***
## season29       4.149e+01  5.316e+00    7.805 4.38e-14 ***
## season30       3.799e+01  5.316e+00    7.147 3.72e-12 ***
## season31       4.199e+01  5.316e+00    7.899 2.27e-14 ***
## season32       3.749e+01  5.316e+00    7.052 6.86e-12 ***
## season33       3.049e+01  5.316e+00    5.736 1.81e-08 ***
## season34       3.399e+01  5.316e+00    6.394 4.13e-10 ***
## season35       3.049e+01  5.316e+00    5.735 1.81e-08 ***
## season36       3.799e+01  5.316e+00    7.146 3.73e-12 ***
## season37       2.899e+01  5.316e+00    5.453 8.27e-08 ***
## season38       2.799e+01  5.316e+00    5.265 2.20e-07 ***
## season39       4.049e+01  5.316e+00    7.616 1.61e-13 ***
## season40       2.299e+01  5.316e+00    4.324 1.89e-05 ***
## season41       3.449e+01  5.316e+00    6.488 2.35e-10 ***
## season42       2.299e+01  5.316e+00    4.324 1.90e-05 ***
## season43       3.699e+01  5.316e+00    6.958 1.26e-11 ***
## season44       3.649e+01  5.316e+00    6.864 2.29e-11 ***
## season45       4.249e+01  5.316e+00    7.992 1.18e-14 ***
## season46       4.549e+01  5.316e+00    8.556  < 2e-16 ***
## season47       5.349e+01  5.316e+00   10.061  < 2e-16 ***
## season48       7.249e+01  5.316e+00   13.635  < 2e-16 ***
## season49       7.699e+01  5.316e+00   14.482  < 2e-16 ***
## season50       7.698e+01  5.316e+00   14.482  < 2e-16 ***
## season51       8.448e+01  5.316e+00   15.892  < 2e-16 ***
## season52       7.798e+01  5.316e+00   14.670  < 2e-16 ***
## season53       6.198e+01  5.316e+00   11.660  < 2e-16 ***
## season54       6.048e+01  5.316e+00   11.377  < 2e-16 ***
## season55       5.648e+01  5.316e+00   10.625  < 2e-16 ***
## season56       5.448e+01  5.316e+00   10.249  < 2e-16 ***
## season57       4.398e+01  5.316e+00    8.273 1.56e-15 ***
## season58       3.148e+01  5.316e+00    5.922 6.41e-09 ***
## season59       2.598e+01  5.316e+00    4.887 1.43e-06 ***
## season60       2.348e+01  5.316e+00    4.417 1.26e-05 ***
## season61       1.848e+01  5.316e+00    3.476 0.000558 ***
## season62       1.048e+01  5.316e+00    1.972 0.049284 *
## season63       2.981e+00  5.316e+00    0.561 0.575274
## season64      -5.194e-01  5.316e+00   -0.098 0.922208
```

```
## season65    -1.020e+00  5.316e+00   -0.192 0.847972
## season66    -1.020e+00  5.316e+00   -0.192 0.847927
## season67     4.796e-01  5.316e+00    0.090 0.928152
## season68     7.979e+00  5.316e+00    1.501 0.134086
## season69     1.098e+01  5.316e+00    2.065 0.039489 *
## season70     6.979e+00  5.316e+00    1.313 0.189960
## season71     1.498e+01  5.316e+00    2.817 0.005058 **
## season72     1.498e+01  5.316e+00    2.817 0.005059 **
## season73     1.448e+01  5.316e+00    2.723 0.006720 **
## season74     1.148e+01  5.316e+00    2.159 0.031394 *
## season75     1.698e+01  5.316e+00    3.193 0.001507 **
## season76     1.698e+01  5.316e+00    3.193 0.001507 **
## season77     1.298e+01  5.316e+00    2.441 0.015043 *
## season78     1.448e+01  5.316e+00    2.723 0.006726 **
## season79     1.598e+01  5.316e+00    3.005 0.002807 **
## season80     2.798e+01  5.316e+00    5.262 2.23e-07 ***
## season81     2.698e+01  5.316e+00    5.074 5.75e-07 ***
## season82     2.748e+01  5.316e+00    5.168 3.60e-07 ***
## season83     2.247e+01  5.316e+00    4.227 2.88e-05 ***
## season84     2.597e+01  5.316e+00    4.886 1.45e-06 ***
## season85     2.097e+01  5.316e+00    3.945 9.28e-05 ***
## season86     3.847e+01  5.316e+00    7.237 2.06e-12 ***
## season87     3.297e+01  5.316e+00    6.202 1.28e-09 ***
## season88     3.397e+01  5.316e+00    6.390 4.22e-10 ***
## season89     4.147e+01  5.316e+00    7.801 4.51e-14 ***
## season90     3.897e+01  5.316e+00    7.331 1.11e-12 ***
## season91     3.597e+01  5.316e+00    6.766 4.23e-11 ***
## season92     3.797e+01  5.316e+00    7.142 3.82e-12 ***
## season93     4.997e+01  5.316e+00    9.399  < 2e-16 ***
## season94     4.197e+01  5.316e+00    7.895 2.34e-14 ***
## season95     4.997e+01  5.316e+00    9.399  < 2e-16 ***
## season96     4.047e+01  5.316e+00    7.612 1.66e-13 ***
## season97     3.097e+01  5.316e+00    5.825 1.10e-08 ***
## season98     3.847e+01  5.316e+00    7.236 2.07e-12 ***
## season99     2.747e+01  5.317e+00    5.167 3.62e-07 ***
## season100    3.147e+01  5.317e+00    5.919 6.52e-09 ***
## season101    2.547e+01  5.317e+00    4.791 2.28e-06 ***
## season102    2.297e+01  5.317e+00    4.320 1.93e-05 ***
## season103    2.247e+01  5.317e+00    4.226 2.89e-05 ***
## season104    3.047e+01  5.317e+00    5.731 1.86e-08 ***
## season105    2.297e+01  5.317e+00    4.320 1.93e-05 ***
## season106    3.047e+01  5.317e+00    5.731 1.86e-08 ***
## season107    3.397e+01  5.317e+00    6.389 4.26e-10 ***
## season108    3.697e+01  5.317e+00    6.953 1.30e-11 ***
## season109    4.947e+01  5.317e+00    9.304  < 2e-16 ***
## season110    5.697e+01  5.317e+00   10.715  < 2e-16 ***
## season111    7.197e+01  5.317e+00   13.536  < 2e-16 ***
## season112    7.697e+01  5.317e+00   14.476  < 2e-16 ***
## season113    8.297e+01  5.317e+00   15.605  < 2e-16 ***
## season114    8.197e+01  5.317e+00   15.417  < 2e-16 ***
## season115    6.596e+01  5.317e+00   12.407  < 2e-16 ***
## season116    5.646e+01  5.317e+00   10.620  < 2e-16 ***
## season117    6.196e+01  5.317e+00   11.655  < 2e-16 ***
## season118    4.846e+01  5.317e+00    9.115  < 2e-16 ***
```

```
## season119     4.846e+01  5.317e+00    9.115  < 2e-16 ***
## season120     3.996e+01  5.317e+00    7.516 3.18e-13 ***
## season121     3.196e+01  5.317e+00    6.012 3.86e-09 ***
## season122     2.596e+01  5.317e+00    4.883 1.46e-06 ***
## season123     2.646e+01  5.317e+00    4.977 9.28e-07 ***
## season124     2.096e+01  5.317e+00    3.943 9.38e-05 ***
## season125     8.462e+00  5.317e+00    1.591 0.112217
## season126     4.461e+00  5.317e+00    0.839 0.401864
## season127    -2.039e+00  5.317e+00   -0.383 0.701556
## season128    -1.039e+00  5.317e+00   -0.195 0.845132
## season129     1.461e+00  5.317e+00    0.275 0.783683
## season130     2.960e+00  5.317e+00    0.557 0.577982
## season131     5.960e+00  5.317e+00    1.121 0.262933
## season132     4.460e+00  5.317e+00    0.839 0.402068
## season133     1.196e+01  5.317e+00    2.249 0.024990 *
## season134     1.146e+01  5.317e+00    2.155 0.031692 *
## season135     1.646e+01  5.317e+00    3.095 0.002091 **
## season136     1.146e+01  5.317e+00    2.155 0.031702 *
## season137     9.458e+00  5.317e+00    1.779 0.075961 .
## season138     1.896e+01  5.317e+00    3.565 0.000403 ***
## season139     1.446e+01  5.317e+00    2.719 0.006806 **
## season140     1.496e+01  5.317e+00    2.813 0.005128 **
## season141     1.646e+01  5.317e+00    3.095 0.002093 **
## season142     1.846e+01  5.317e+00    3.471 0.000569 ***
## season143     2.446e+01  5.317e+00    4.599 5.55e-06 ***
## season144     2.346e+01  5.317e+00    4.411 1.29e-05 ***
## season145     2.696e+01  5.317e+00    5.070 5.89e-07 ***
## season146     2.846e+01  5.317e+00    5.352 1.41e-07 ***
## season147     2.895e+01  5.317e+00    5.445 8.61e-08 ***
## season148     3.445e+01  5.317e+00    6.480 2.47e-10 ***
## season149     3.945e+01  5.317e+00    7.420 6.09e-13 ***
## season150     3.045e+01  5.317e+00    5.727 1.89e-08 ***
## season151     3.245e+01  5.317e+00    6.103 2.28e-09 ***
## season152     4.595e+01  5.317e+00    8.642  < 2e-16 ***
## season153     4.645e+01  5.317e+00    8.736  < 2e-16 ***
## season154     4.295e+01  5.317e+00    8.078 6.40e-15 ***
## season155     3.995e+01  5.317e+00    7.514 3.24e-13 ***
## season156     4.745e+01  5.317e+00    8.924  < 2e-16 ***
## season157     4.795e+01  5.317e+00    9.018  < 2e-16 ***
## season158     4.195e+01  5.317e+00    7.889 2.43e-14 ***
## season159     2.595e+01  5.317e+00    4.880 1.48e-06 ***
## season160     2.945e+01  5.317e+00    5.539 5.26e-08 ***
## season161     2.545e+01  5.317e+00    4.786 2.32e-06 ***
## season162     2.845e+01  5.318e+00    5.350 1.42e-07 ***
## season163     2.545e+01  5.318e+00    4.786 2.33e-06 ***
## season164     2.845e+01  5.318e+00    5.350 1.42e-07 ***
## season165     2.195e+01  5.318e+00    4.128 4.38e-05 ***
## season166     2.145e+01  5.318e+00    4.034 6.48e-05 ***
## season167     2.795e+01  5.318e+00    5.256 2.30e-07 ***
## season168     2.395e+01  5.318e+00    4.504 8.57e-06 ***
## season169     2.945e+01  5.318e+00    5.538 5.28e-08 ***
## season170     3.195e+01  5.318e+00    6.008 3.94e-09 ***
## season171     3.395e+01  5.318e+00    6.384 4.39e-10 ***
## season172     4.495e+01  5.318e+00    8.452 4.23e-16 ***
```

```
## season173     4.795e+01  5.318e+00    9.016  < 2e-16 ***
## season174     7.245e+01  5.318e+00   13.624  < 2e-16 ***
## season175     7.895e+01  5.318e+00   14.846  < 2e-16 ***
## season176     8.495e+01  5.318e+00   15.974  < 2e-16 ***
## season177     6.195e+01  5.318e+00   11.649  < 2e-16 ***
## season178     7.295e+01  5.318e+00   13.717  < 2e-16 ***
## season179     5.945e+01  5.318e+00   11.178  < 2e-16 ***
## season180     6.044e+01  5.318e+00   11.366  < 2e-16 ***
## season181     4.694e+01  5.318e+00    8.828  < 2e-16 ***
## season182     3.544e+01  5.318e+00    6.665 7.94e-11 ***
## season183     3.444e+01  5.318e+00    6.477 2.51e-10 ***
## season184     3.094e+01  5.318e+00    5.819 1.14e-08 ***
## season185     2.694e+01  5.318e+00    5.066 5.98e-07 ***
## season186     2.844e+01  5.318e+00    5.348 1.43e-07 ***
## season187     1.344e+01  5.318e+00    2.528 0.011829 *
## season188     7.442e+00  5.318e+00    1.399 0.162387
## season189     4.420e-01  5.318e+00    0.083 0.933800
## season190    -1.058e+00  5.318e+00   -0.199 0.842354
## season191    -2.059e+00  5.318e+00   -0.387 0.698875
## season192    -5.893e-02  5.318e+00   -0.011 0.991165
## season193     9.408e-01  5.318e+00    0.177 0.859672
## season194     7.440e+00  5.318e+00    1.399 0.162502
## season195     6.440e+00  5.318e+00    1.211 0.226563
## season196     1.144e+01  5.318e+00    2.151 0.032016 *
## season197     7.940e+00  5.318e+00    1.493 0.136187
## season198     5.439e+00  5.318e+00    1.023 0.306996
## season199     9.439e+00  5.318e+00    1.775 0.076625 .
## season200     1.044e+01  5.318e+00    1.963 0.050305 .
## season201     1.944e+01  5.318e+00    3.655 0.000288 ***
## season202     1.794e+01  5.318e+00    3.373 0.000810 ***
## season203     1.944e+01  5.318e+00    3.655 0.000288 ***
## season204     1.544e+01  5.318e+00    2.903 0.003887 **
## season205     2.144e+01  5.318e+00    4.031 6.55e-05 ***
## season206     1.744e+01  5.319e+00    3.279 0.001126 **
## season207     1.994e+01  5.319e+00    3.748 0.000202 ***
## season208     2.644e+01  5.319e+00    4.971 9.58e-07 ***
## season209     2.794e+01  5.319e+00    5.252 2.34e-07 ***
## season210     2.844e+01  5.319e+00    5.346 1.44e-07 ***
## season211     2.844e+01  5.319e+00    5.346 1.44e-07 ***
## season212     3.293e+01  5.319e+00    6.192 1.36e-09 ***
## season213     4.243e+01  5.319e+00    7.978 1.30e-14 ***
## season214     4.193e+01  5.319e+00    7.884 2.52e-14 ***
## season215     4.243e+01  5.319e+00    7.978 1.30e-14 ***
## season216     3.443e+01  5.319e+00    6.474 2.55e-10 ***
## season217     3.943e+01  5.319e+00    7.414 6.35e-13 ***
## season218     4.293e+01  5.319e+00    8.072 6.67e-15 ***
## season219     4.993e+01  5.319e+00    9.388  < 2e-16 ***
## season220     3.943e+01  5.319e+00    7.414 6.36e-13 ***
## season221     4.293e+01  5.319e+00    8.072 6.69e-15 ***
## season222     3.793e+01  5.319e+00    7.131 4.11e-12 ***
## season223     3.643e+01  5.319e+00    6.849 2.51e-11 ***
## season224     2.943e+01  5.319e+00    5.533 5.41e-08 ***
## season225     3.843e+01  5.319e+00    7.225 2.22e-12 ***
## season226     2.743e+01  5.319e+00    5.157 3.80e-07 ***
```

```
## season227    2.993e+01  5.319e+00    5.627 3.27e-08 ***
## season228    2.693e+01  5.319e+00    5.063 6.08e-07 ***
## season229    3.543e+01  5.319e+00    6.661 8.15e-11 ***
## season230    3.193e+01  5.319e+00    6.003 4.06e-09 ***
## season231    4.093e+01  5.319e+00    7.695 9.41e-14 ***
## season232    4.593e+01  5.319e+00    8.634  < 2e-16 ***
## season233    5.893e+01  5.319e+00   11.078  < 2e-16 ***
## season234    5.293e+01  5.319e+00    9.950  < 2e-16 ***
## season235    4.493e+01  5.319e+00    8.446 4.42e-16 ***
## season236    5.593e+01  5.319e+00   10.514  < 2e-16 ***
## season237    5.543e+01  5.319e+00   10.420  < 2e-16 ***
## season238    4.593e+01  5.319e+00    8.634  < 2e-16 ***
## season239    5.293e+01  5.319e+00    9.950  < 2e-16 ***
## season240    4.993e+01  5.319e+00    9.386  < 2e-16 ***
## season241    5.143e+01  5.319e+00    9.667  < 2e-16 ***
## season242    3.993e+01  5.320e+00    7.506 3.42e-13 ***
## season243    3.943e+01  5.320e+00    7.411 6.46e-13 ***
## season244    3.843e+01  5.320e+00    7.223 2.25e-12 ***
## season245    2.542e+01  5.320e+00    4.779 2.40e-06 ***
## season246    3.142e+01  5.320e+00    5.907 6.97e-09 ***
## season247    2.542e+01  5.320e+00    4.779 2.40e-06 ***
## season248    2.292e+01  5.320e+00    4.309 2.02e-05 ***
## season249    1.792e+01  5.320e+00    3.369 0.000820 ***
## season250    9.923e+00  5.320e+00    1.865 0.062798 .
## season251    6.923e+00  5.320e+00    1.301 0.193821
## season252    1.423e+00  5.320e+00    0.267 0.789280
## season253   -2.078e+00  5.320e+00   -0.391 0.696308
## season254   -2.078e+00  5.320e+00   -0.391 0.696267
## season255   -1.078e+00  5.320e+00   -0.203 0.839461
## season256   -2.579e+00  5.320e+00   -0.485 0.628118
## season257   -1.579e+00  5.320e+00   -0.297 0.766758
## season258   -1.079e+00  5.320e+00   -0.203 0.839328
## season259    4.204e-01  5.320e+00    0.079 0.937050
## season260   -2.580e+00  5.320e+00   -0.485 0.627961
## season261    1.420e+00  5.320e+00    0.267 0.789693
## season262   -2.081e+00  5.320e+00   -0.391 0.695938
## season263   -8.083e-02  5.320e+00   -0.015 0.987885
## season264    4.189e-01  5.320e+00    0.079 0.937283
## season265   -8.145e-02  5.320e+00   -0.015 0.987793
## season266    4.182e-01  5.320e+00    0.079 0.937376
## season267   -8.206e-02  5.320e+00   -0.015 0.987700
## season268    4.176e-01  5.320e+00    0.078 0.937469
## season269   -8.268e-02  5.320e+00   -0.016 0.987608
## season270    2.917e+00  5.320e+00    0.548 0.583785
## season271   -8.330e-02  5.320e+00   -0.016 0.987516
## season272   -5.836e-01  5.320e+00   -0.110 0.912704
## season273    2.916e+00  5.320e+00    0.548 0.583911
## season274    4.916e+00  5.321e+00    0.924 0.356031
## season275    1.915e+00  5.321e+00    0.360 0.719011
## season276    3.415e+00  5.321e+00    0.642 0.521288
## season277    3.415e+00  5.321e+00    0.642 0.521329
## season278    8.415e+00  5.321e+00    1.581 0.114486
## season279    6.414e+00  5.321e+00    1.206 0.228649
## season280    6.914e+00  5.321e+00    1.299 0.194477
```

```
## season281       9.914e+00   5.321e+00    1.863 0.063101  .
## season282       6.413e+00   5.321e+00    1.205 0.228725
## season283       7.413e+00   5.321e+00    1.393 0.164262
## season284       3.913e+00   5.321e+00    0.735 0.462520
## season285       3.912e+00   5.321e+00    0.735 0.462558
## season286       3.412e+00   5.321e+00    0.641 0.521692
## season287       5.912e+00   5.321e+00    1.111 0.267162
## season288       4.411e+00   5.321e+00    0.829 0.407518
## season289       2.911e+00   5.321e+00    0.547 0.584587
## season290       9.108e-01   5.321e+00    0.171 0.864164
## season291       2.411e+00   5.321e+00    0.453 0.650763
## season292       1.410e+00   5.321e+00    0.265 0.791117
## season293      -1.590e+00   5.321e+00   -0.299 0.765217
## season294      -5.904e-01   5.321e+00   -0.111 0.911706
## season295       4.093e-01   5.321e+00    0.077 0.938724
## season296      -5.910e-01   5.321e+00   -0.111 0.911615
## season297       9.087e-01   5.321e+00    0.171 0.864490
## season298       1.908e+00   5.321e+00    0.359 0.720049
## season299       1.408e+00   5.321e+00    0.265 0.791439
## season300       1.908e+00   5.321e+00    0.359 0.720139
## season301      -5.926e-01   5.321e+00   -0.111 0.911389
## season302      -5.929e-01   5.322e+00   -0.111 0.911343
## season303      -1.093e+00   5.322e+00   -0.205 0.837337
## season304      -5.935e-01   5.322e+00   -0.112 0.911253
## season305      -1.094e+00   5.322e+00   -0.206 0.837248
## season306      -1.094e+00   5.322e+00   -0.206 0.837204
## season307      -1.594e+00   5.322e+00   -0.300 0.764621
## season308      -1.595e+00   5.322e+00   -0.300 0.764578
## season309      -1.595e+00   5.322e+00   -0.300 0.764536
## season310      -1.095e+00   5.322e+00   -0.206 0.837028
## season311      -5.956e-01   5.322e+00   -0.112 0.910935
## season312      -2.096e+00   5.322e+00   -0.394 0.693894
## season313      -5.963e-01   5.322e+00   -0.112 0.910845
## season314      -3.097e+00   5.322e+00   -0.582 0.560969
## season315      -3.097e+00   5.322e+00   -0.582 0.560933
## season316      -3.097e+00   5.322e+00   -0.582 0.560897
## season317      -3.097e+00   5.322e+00   -0.582 0.560861
## season318      -3.098e+00   5.322e+00   -0.582 0.560825
## season319      -3.098e+00   5.322e+00   -0.582 0.560789
## season320      -3.098e+00   5.322e+00   -0.582 0.560753
## season321      -3.099e+00   5.322e+00   -0.582 0.560716
## season322      -3.099e+00   5.322e+00   -0.582 0.560680
## season323      -2.599e+00   5.322e+00   -0.488 0.625521
## season324      -3.100e+00   5.322e+00   -0.582 0.560608
## season325      -3.100e+00   5.322e+00   -0.582 0.560572
## season326      -3.100e+00   5.322e+00   -0.582 0.560536
## season327      -2.601e+00   5.322e+00   -0.489 0.625368
## season328      -3.101e+00   5.323e+00   -0.583 0.560464
## season329      -2.101e+00   5.323e+00   -0.395 0.693204
## season330      -2.102e+00   5.323e+00   -0.395 0.693163
## season331      -2.602e+00   5.323e+00   -0.489 0.625214
## season332      -2.602e+00   5.323e+00   -0.489 0.625176
## season333      -2.602e+00   5.323e+00   -0.489 0.625138
## season334      -2.103e+00   5.323e+00   -0.395 0.693001
```

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```
## season335    -3.103e+00   5.323e+00   -0.583 0.560212
## season336    -2.603e+00   5.323e+00   -0.489 0.625023
## season337    -1.037e-01   5.323e+00   -0.019 0.984471
## season338    -1.604e+00   5.323e+00   -0.301 0.763304
## season339    -2.104e+00   5.323e+00   -0.395 0.692799
## season340    -1.605e+00   5.323e+00   -0.301 0.763220
## season341    -1.105e+00   5.323e+00   -0.208 0.835663
## season342    -1.105e+00   5.323e+00   -0.208 0.835619
## season343    -1.106e+00   5.323e+00   -0.208 0.835575
## season344    -3.106e+00   5.323e+00   -0.583 0.559889
## season345    -6.061e-01   5.323e+00   -0.114 0.909397
## season346    -1.606e+00   5.323e+00   -0.302 0.762966
## season347    -1.607e+00   5.323e+00   -0.302 0.762923
## season348    -2.607e+00   5.323e+00   -0.490 0.624564
## season349    -1.607e+00   5.323e+00   -0.302 0.762839
## season350     8.923e-01   5.323e+00    0.168 0.866958
## season351    -2.608e+00   5.323e+00   -0.490 0.624449
## season352    -2.108e+00   5.324e+00   -0.396 0.692274
## season353    -2.109e+00   5.324e+00   -0.396 0.692234
## season354    -6.089e-01   5.324e+00   -0.114 0.908990
## season355    -1.609e+00   5.324e+00   -0.302 0.762585
## season356    -6.095e-01   5.324e+00   -0.114 0.908900
## season357    -2.610e+00   5.324e+00   -0.490 0.624220
## season358    -1.110e+00   5.324e+00   -0.209 0.834917
## season359    -1.110e+00   5.324e+00   -0.209 0.834873
## season360    -2.111e+00   5.324e+00   -0.396 0.691952
## season361    -2.111e+00   5.324e+00   -0.397 0.691911
## season362    -2.111e+00   5.324e+00   -0.397 0.691871
## season363    -2.112e+00   5.324e+00   -0.397 0.691831
## season364    -6.120e-01   5.324e+00   -0.115 0.908539
## season365    -2.112e+00   5.324e+00   -0.397 0.691750
## season366    -1.113e+00   5.324e+00   -0.209 0.834566
## season367    -6.129e-01   5.324e+00   -0.115 0.908404
## season368     8.868e-01   5.324e+00    0.167 0.867797
## season369    -2.614e+00   5.324e+00   -0.491 0.623764
## season370    -1.114e+00   5.324e+00   -0.209 0.834391
## season371     3.859e-01   5.324e+00    0.072 0.942262
## season372    -2.614e+00   5.324e+00   -0.491 0.623650
## season373    -2.615e+00   5.324e+00   -0.491 0.623612
## season374    -2.615e+00   5.325e+00   -0.491 0.623574
## season375    -6.154e-01   5.325e+00   -0.116 0.908043
## season376    -2.616e+00   5.325e+00   -0.491 0.623498
## season377    -3.116e+00   5.325e+00   -0.585 0.558712
## season378    -3.116e+00   5.325e+00   -0.585 0.558677
## season379    -1.166e-01   5.325e+00   -0.022 0.982537
## season380    -6.169e-01   5.325e+00   -0.116 0.907817
## season381     2.383e+00   5.325e+00    0.447 0.654749
## season382     3.882e+00   5.325e+00    0.729 0.466320
## season383     8.382e+00   5.325e+00    1.574 0.116177
## season384     1.438e+01   5.325e+00    2.701 0.007184 **
## season385     2.238e+01   5.325e+00    4.203 3.19e-05 ***
## season386     1.488e+01   5.325e+00    2.795 0.005424 **
## season387     1.488e+01   5.325e+00    2.794 0.005426 **
## season388     1.438e+01   5.325e+00    2.700 0.007191 **
```

```
## season389     1.788e+01  5.325e+00     3.358 0.000854 ***
## season390     1.738e+01  5.325e+00     3.264 0.001186 **
## season391     1.738e+01  5.325e+00     3.264 0.001186 **
## season392     1.788e+01  5.325e+00     3.357 0.000855 ***
## season393     1.838e+01  5.325e+00     3.451 0.000612 ***
## season394     2.088e+01  5.325e+00     3.921 0.000102 ***
## season395     2.488e+01  5.326e+00     4.672 3.98e-06 ***
## season396     2.988e+01  5.326e+00     5.610 3.58e-08 ***
## season397     2.638e+01  5.326e+00     4.953 1.04e-06 ***
## season398     3.338e+01  5.326e+00     6.267 8.77e-10 ***
## season399     2.738e+01  5.326e+00     5.141 4.13e-07 ***
## season400     3.288e+01  5.326e+00     6.173 1.52e-09 ***
## season401     3.688e+01  5.326e+00     6.924 1.56e-11 ***
## season402     3.638e+01  5.326e+00     6.830 2.83e-11 ***
## season403     4.488e+01  5.326e+00     8.426 5.13e-16 ***
## season404     4.388e+01  5.326e+00     8.238 2.02e-15 ***
## season405     5.238e+01  5.326e+00     9.834  < 2e-16 ***
## season406     4.588e+01  5.326e+00     8.613  < 2e-16 ***
## season407     6.387e+01  5.326e+00    11.993  < 2e-16 ***
## season408     4.937e+01  5.326e+00     9.270  < 2e-16 ***
## season409     4.187e+01  5.326e+00     7.862 2.94e-14 ***
## season410     5.787e+01  5.326e+00    10.866  < 2e-16 ***
## season411     4.487e+01  5.326e+00     8.425 5.17e-16 ***
## season412     3.537e+01  5.326e+00     6.641 9.20e-11 ***
## season413     3.137e+01  5.326e+00     5.890 7.68e-09 ***
## season414     3.187e+01  5.326e+00     5.984 4.52e-09 ***
## season415     3.637e+01  5.327e+00     6.829 2.86e-11 ***
## season416     3.637e+01  5.327e+00     6.828 2.86e-11 ***
## season417     2.837e+01  5.327e+00     5.326 1.60e-07 ***
## season418     3.637e+01  5.327e+00     6.828 2.87e-11 ***
## season419     2.737e+01  5.327e+00     5.138 4.17e-07 ***
## season420     3.687e+01  5.327e+00     6.922 1.58e-11 ***
## season421     3.087e+01  5.327e+00     5.795 1.30e-08 ***
## season422     4.637e+01  5.327e+00     8.705  < 2e-16 ***
## season423     4.837e+01  5.327e+00     9.080  < 2e-16 ***
## season424     6.137e+01  5.327e+00    11.520  < 2e-16 ***
## season425     6.087e+01  5.327e+00    11.426  < 2e-16 ***
## season426     1.034e+02  5.327e+00    19.404  < 2e-16 ***
## season427     1.084e+02  5.327e+00    20.343  < 2e-16 ***
## season428     1.229e+02  5.327e+00    23.064  < 2e-16 ***
## season429     9.587e+01  5.327e+00    17.996  < 2e-16 ***
## season430     8.737e+01  5.327e+00    16.400  < 2e-16 ***
## season431     7.087e+01  5.327e+00    13.303  < 2e-16 ***
## season432     6.287e+01  5.327e+00    11.801  < 2e-16 ***
## season433     5.937e+01  5.327e+00    11.144  < 2e-16 ***
## season434     5.137e+01  5.328e+00     9.642  < 2e-16 ***
## season435     4.287e+01  5.328e+00     8.046 8.02e-15 ***
## season436     2.937e+01  5.328e+00     5.512 6.05e-08 ***
## season437     1.837e+01  5.328e+00     3.447 0.000621 ***
## season438     2.187e+01  5.328e+00     4.104 4.84e-05 ***
## season439     1.236e+01  5.328e+00     2.321 0.020752 *
## season440     7.365e+00  5.328e+00     1.382 0.167587
## season441     3.864e+00  5.328e+00     0.725 0.468662
## ---
```
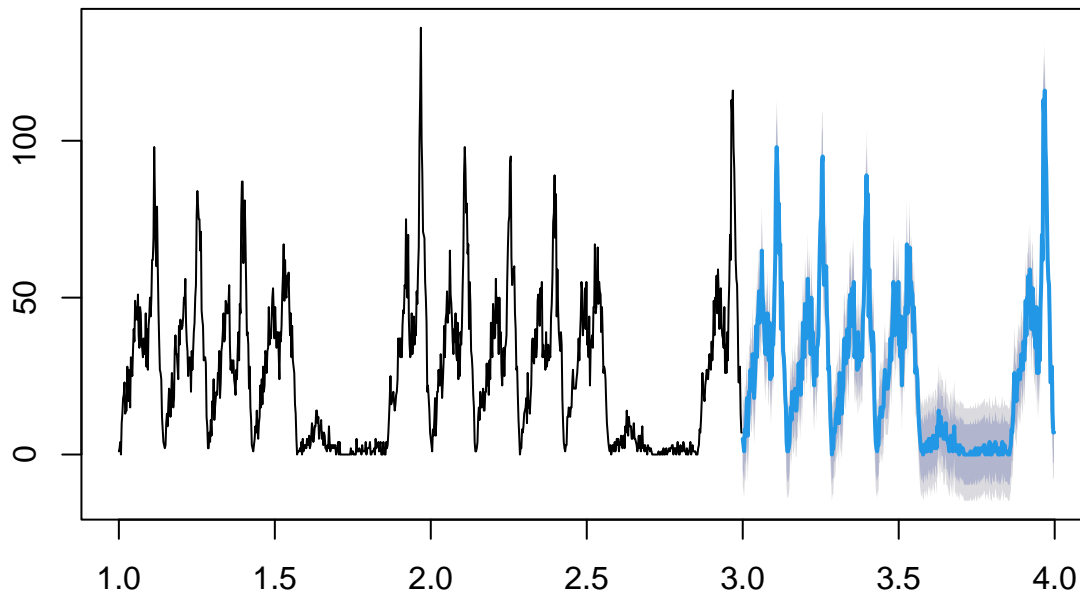
```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.316 on 440 degrees of freedom
## Multiple R-squared:  0.9739, Adjusted R-squared:  0.9478
## F-statistic: 37.29 on 441 and 440 DF,  p-value: < 2.2e-16
```

```r
#accuracy(snaive(train.msts, h = 441), td.msts)
sn.train <- snaive(train.msts, h = 441)
sn.pred <- forecast(sn.train, h=441)

plot(sn.pred)
```

Forecasts from Seasonal naive method


```r
line(td.ts)
```

```
##
## Call:
## line(td.ts)
##
## Coefficients:
## [1]  23.59070  -0.07143
```

```r
accuracy(sn.pred, td.msts)
```

```
##                       ME       RMSE      MAE MPE MAPE     MASE      ACF1
## Training set 0.13605442  7.510537 5.106576 -Inf  Inf 1.000000 0.1342442
## Test set     0.06575964 10.804278 5.970522 -Inf  Inf 1.169183 0.3648308
##              Theil's U
## Training set        NA
## Test set             0
```
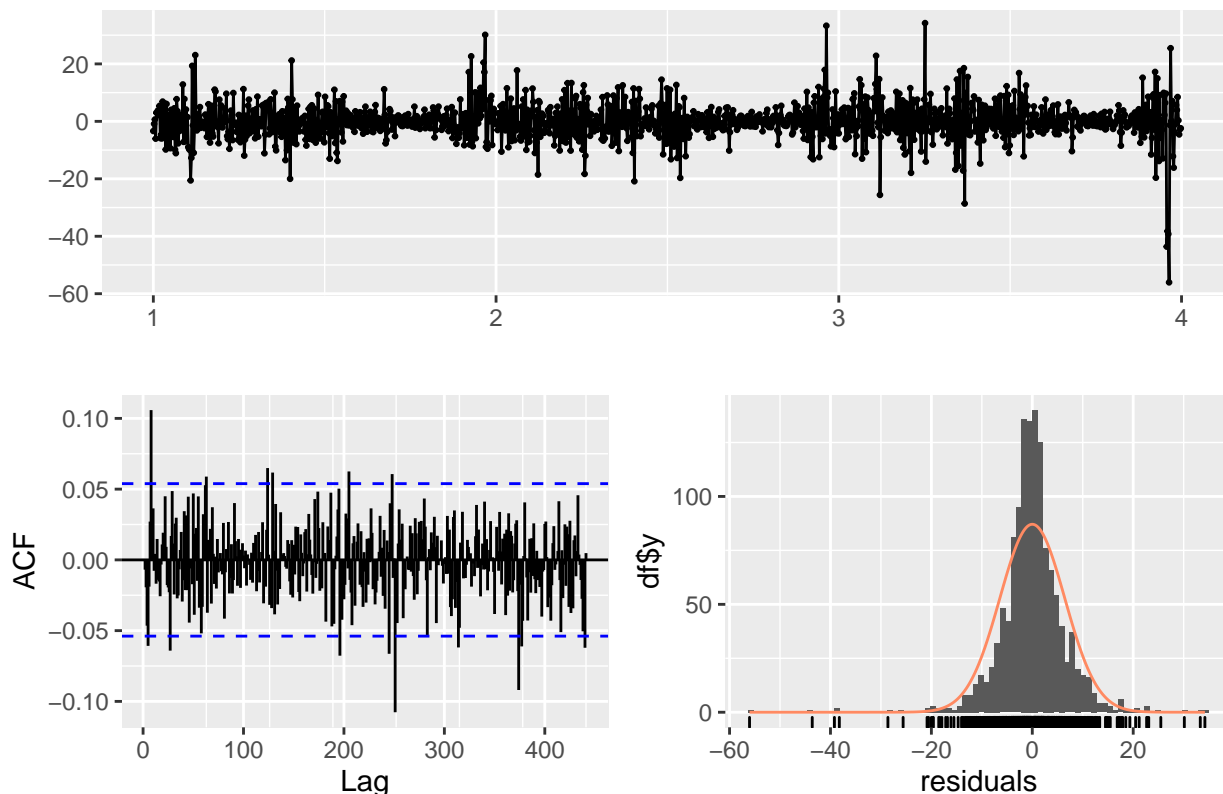
Final Model

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ARIMA(0,0,3)

```
train2.msts <- msts(td$DEMAND[1:1323], seasonal.periods = c(63, 441)) # full period to train on

arima2.mod <- Arima(train2.msts, order = c(0, 0, 3),
                    xreg = fourier(train2.msts, K = c(20, 40)))
# new model trained on full dataset

arima2.pred <- forecast(arima2.mod, xreg = fourier(train2.msts, K = c(20, 40), h=189))
checkresiduals(arima2.pred)
```

Residuals from Regression with ARIMA(0,0,3) errors


```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(0,0,3) errors
## Q* = 278.88, df = 151, p-value = 1.168e-09
##
## Model df: 114.   Total lags used: 265
```

```
# Plot results
clrs2 <- c("green", "royalblue")
autoplot(arima2.pred, series ="ARIMA") +
        ggtitle("Terminal Usage and Forecast") +
        xlab("Weeks") +
        ylab("Number of Passengers Arriving at the Terminal") +
  autolayer(td.msts, series = "True Values") +
  autolayer(arima2.pred, series ="ARIMA Forecast") +
  guides(colour=guide_legend(title="Time Series")) +
```

```
scale_color_manual(values=clrs2) +
theme(text = element_text(size = 14))
```

Terminal Usage and Forecast
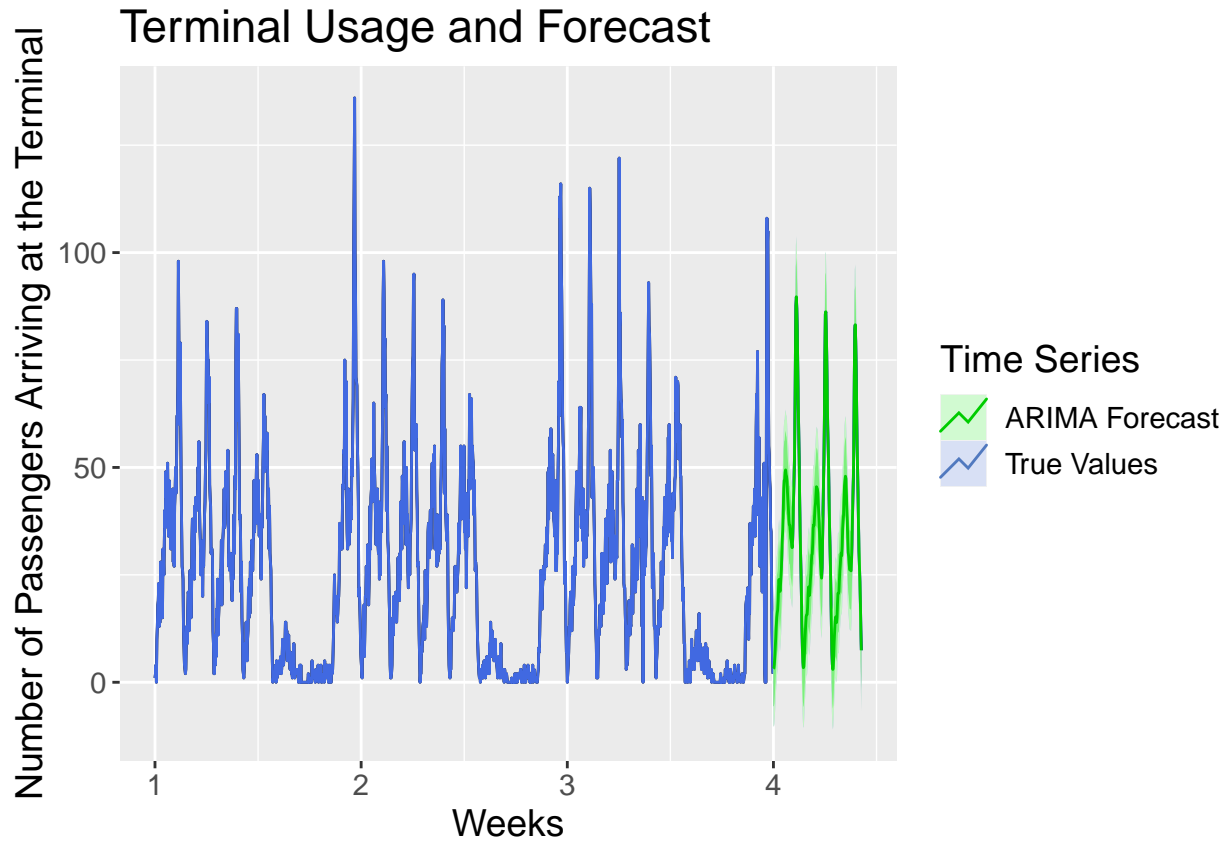

```
arima2.pred
```

```
##            Point Forecast       Lo 80     Hi 80          Lo 95     Hi 95
## 4.000000         3.147802  -5.4740511  11.76965  -10.03818417  16.33379
## 4.002268         3.299259  -5.6207894  12.21931  -10.34277802  16.94130
## 4.004535         4.217660  -4.9031792  13.33850   -9.73146004  18.16678
## 4.006803         6.159160  -2.9669461  15.28527   -7.79801462  20.11633
## 4.009070         8.457134  -0.6689722  17.58324   -5.50004072  22.41431
## 4.011338        10.554903   1.4287968  19.68101   -3.40227177  24.51208
## 4.013605        12.942924   3.8168187  22.06903   -1.01424990  26.90010
## 4.015873        15.082156   5.9560503  24.20826    1.12498175  29.03933
## 4.018141        16.080024   6.9539179  25.20613    2.12284933  30.03720
## 4.020408        16.795741   7.6696353  25.92185    2.83856677  30.75292
## 4.022676        18.932786   9.8066803  28.05889    4.97561169  32.88996
## 4.024943        22.283095  13.1569895  31.40920    8.32592090  36.24027
## 4.027211        23.935027  14.8089211  33.06113    9.97785251  37.89220
## 4.029478        22.466115  13.3400092  31.59222    8.50894065  36.42329
## 4.031746        21.146586  12.0204799  30.27269    7.18941131  35.10376
## 4.034014        22.421420  13.2953147  31.54753    8.46424616  36.37859
## 4.036281        24.302288  15.1761827  33.42839   10.34511410  38.25946
## 4.038549        26.350204  17.2240980  35.47631   12.39302948  40.30738
## 4.040816        30.060591  20.9344855  39.18670   16.10341695  44.01777
## 4.043084        33.404508  24.2784026  42.53061   19.44733399  47.36168
## 4.045351        35.517268  26.3911623  44.64337   21.56009373  49.47444
```

```
## 4.047619      39.793324 30.6672181 48.91943   25.83614956   53.75050
## 4.049887      45.111114 35.9850082 54.23722   31.15393961   59.06829
## 4.052154      46.951811 37.8257048 56.07792   32.99463624   60.90898
## 4.054422      47.191329 38.0652232 56.31743   33.23415464   61.14850
## 4.056689      48.852275 39.7261693 57.97838   34.89510077   62.80945
## 4.058957      49.425975 40.2998695 58.55208   35.46880096   63.38315
## 4.061224      48.335977 39.2098713 57.46208   34.37880277   62.29315
## 4.063492      47.936913 38.8108077 57.06302   33.97973912   61.89409
## 4.065760      46.892637 37.7665315 56.01874   32.93546297   60.84981
## 4.068027      44.223135 35.0970293 53.34924   30.26596072   58.18031
## 4.070295      42.184721 33.0586152 51.31083   28.22754666   56.14190
## 4.072562      40.407118 31.2810121 49.53322   26.44994357   54.36429
## 4.074830      37.852573 28.7264676 46.97868   23.89539898   51.80975
## 4.077098      36.649189 27.5230833 45.77529   22.69201468   50.60636
## 4.079365      36.554993 27.4288873 45.68110   22.59781871   50.51217
## 4.081633      35.109647 25.9835417 44.23575   21.15247308   49.06682
## 4.083900      33.497617 24.3715110 42.62372   19.54044247   47.45479
## 4.086168      33.003755 23.8776491 42.12986   19.04658055   46.96093
## 4.088435      32.081077 22.9549713 41.20718   18.12390269   46.03825
## 4.090703      31.316218 22.1901122 40.44232   17.35904364   45.27339
## 4.092971      33.017867 23.8917615 42.14397   19.06069295   46.97504
## 4.095238      37.255391 28.1292856 46.38150   23.29821699   51.21257
## 4.097506      42.676494 33.5503880 51.80260   28.71931944   56.63367
## 4.099773      47.468401 38.3422950 56.59451   33.51122639   61.42558
## 4.102041      52.085987 42.9598816 61.21209   38.12881302   66.04316
## 4.104308      61.561096 52.4349903 70.68720   47.60392175   75.51827
## 4.106576      76.456438 67.3303318 85.58254   62.49926324   90.41361
## 4.108844      87.652760 78.5266539 96.77887   73.69558537  101.60993
## 4.111111      89.710227 80.5841216 98.83633   75.75305305  103.66740
## 4.113379      86.935428 77.8093220 96.06153   72.97825340  100.89260
## 4.115646      81.825183 72.6990776 90.95129   67.86800907   95.78236
## 4.117914      73.511607 64.3855009 82.63771   59.55443232   87.46878
## 4.120181      65.157958 56.0318518 74.28406   51.20078320   79.11513
## 4.122449      59.091637 49.9655315 68.21774   45.13446290   73.04881
## 4.124717      52.245297 43.1191914 61.37140   38.28812287   66.20247
## 4.126984      43.464544 34.3384380 52.59065   29.50736945   57.42172
## 4.129252      35.727138 26.6010325 44.85324   21.76996395   49.68431
## 4.131519      30.167806 21.0417002 39.29391   16.21063159   44.12498
## 4.133787      25.095960 15.9698539 34.22207   11.13878538   39.05313
## 4.136054      19.113417  9.9873117 28.23952    5.15624315   33.07059
## 4.138322      12.636125  3.5100195 21.76223   -1.32104904   26.59330
## 4.140590       7.533243 -1.5928630 16.65935   -6.42393152   21.49042
## 4.142857       4.694489 -4.4316172 13.82059   -9.26268576   18.65166
## 4.145125       3.383415 -5.7426903 12.50952  -10.57375887   17.34059
## 4.147392       3.664663 -5.4614428 12.79077  -10.29251139   17.62184
## 4.149660       5.839989 -3.2861166 14.96609   -8.11718516   19.79716
## 4.151927       8.603051 -0.5230551 17.72916   -5.35412372   22.56022
## 4.154195      11.043636  1.9175299 20.16974   -2.91353870   25.00081
## 4.156463      13.470600  4.3444942 22.59671   -0.48657437   27.42777
## 4.158730      15.296741  6.1706356 24.42285    1.33956706   29.25392
## 4.160998      15.716152  6.5900458 24.84226    1.75897721   29.67333
## 4.163265      15.768256  6.6421498 24.89436    1.81108120   29.72543
## 4.165533      17.362482  8.2363758 26.48859    3.40530723   31.31966
## 4.167800      20.450607 11.3245011 29.57671    6.49343255   34.40778
```

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```
## 4.170068      22.180586 13.0544798 31.30669    8.22341121  36.13776
## 4.172336      21.067733 11.9416275 30.19384    7.11055893  35.02491
## 4.174603      20.213598 11.0874921 29.33970    6.25642354  34.17077
## 4.176871      21.833962 12.7078561 30.96007    7.87678755  35.79114
## 4.179138      23.713103 14.5869976 32.83921    9.75592907  37.67028
## 4.181406      25.247849 16.1217430 34.37395   11.29067440  39.20502
## 4.183673      27.877637 18.7515314 37.00374   13.92046279  41.83481
## 4.185941      29.644554 20.5184487 38.77066   15.68738012  43.60173
## 4.188209      29.872141 20.7460352 38.99825   15.91496663  43.82932
## 4.190476      32.226199 23.1000934 41.35230   18.26902487  46.18337
## 4.192744      35.890239 26.7641332 45.01634   21.93306459  49.84741
## 4.195011      36.630103 27.5039977 45.75621   22.67292915  50.58728
## 4.197279      36.536807 27.4107016 45.66291   22.57963301  50.49398
## 4.199546      38.741442 29.6153363 47.86755   24.78426771  52.69862
## 4.201814      40.716575 31.5904689 49.84268   26.75940034  54.67375
## 4.204082      41.737372 32.6112666 50.86348   27.78019804  55.69455
## 4.206349      43.896464 34.7703579 53.02257   29.93928929  57.85364
## 4.208617      45.515240 36.3891341 54.64135   31.55806555  59.47241
## 4.210884      45.238399 36.1122931 54.36450   31.28122453  59.19557
## 4.213152      44.971415 35.8453089 54.09752   31.01424030  58.92859
## 4.215420      44.077082 34.9509762 53.20319   30.11990767  58.03426
## 4.217687      41.386363 32.2602572 50.51247   27.42918868  55.34354
## 4.219955      39.064644 29.9385385 48.19075   25.10746992  53.02182
## 4.222222      37.080171 27.9540648 46.20628   23.12299620  51.03734
## 4.224490      33.326126 24.2000207 42.45223   19.36895216  47.28330
## 4.226757      29.421772 20.2956664 38.54788   15.46459778  43.37895
## 4.229025      27.083381 17.9572754 36.20949   13.12620684  41.04056
## 4.231293      25.101733 15.9756275 34.22784   11.14455892  39.05891
## 4.233560      24.232433 15.1063276 33.35854   10.27525903  38.18961
## 4.235828      26.743795 17.6176888 35.86990   12.78662021  40.70097
## 4.238095      32.462083 23.3359770 41.58819   18.50490845  46.41926
## 4.240363      39.644455 30.5183497 48.77056   25.68728117  53.60163
## 4.242630      46.032916 36.9068104 55.15902   32.07574186  59.99009
## 4.244898      51.690866 42.5647605 60.81697   37.73369193  65.64804
## 4.247166      61.409223 52.2831175 70.53533   47.45204897  75.36640
## 4.249433      75.719983 66.5938776 84.84609   61.76280906  89.67716
## 4.251701      85.689368 76.5632618 94.81547   71.73219320  99.64654
## 4.253968      86.228971 77.1028648 95.35508   72.27179619 100.18614
## 4.256236      82.069097 72.9429911 91.19520   68.11192253  96.02627
## 4.258503      76.090445 66.9643389 85.21655   62.13327031  90.04762
## 4.260771      67.669021 58.5429147 76.79513   53.71184617  81.62619
## 4.263039      60.011228 50.8851222 69.13733   46.05405366  73.96840
## 4.265306      55.281890 46.1557845 64.40800   41.32471598  69.23906
## 4.267574      50.096814 40.9707082 59.22292   36.13963958  64.05399
## 4.269841      42.922894 33.7967879 52.04900   28.96571928  56.88007
## 4.272109      36.403518 27.2774119 45.52962   22.44634336  50.36069
## 4.274376      31.472533 22.3464269 40.59864   17.51535832  45.42971
## 4.276644      26.418630 17.2925244 35.54474   12.46145579  40.37580
## 4.278912      19.994759 10.8686531 29.12086    6.03758453  33.95193
## 4.281179      12.880751  3.7546449 22.00686   -1.07642371  26.83792
## 4.283447       7.231986 -1.8941198 16.35809   -6.72518840  21.18916
## 4.285714       4.153735 -4.9723703 13.27984   -9.80343891  18.11091
## 4.287982       2.987965 -6.1381409 12.11407  -10.96920952  16.94514
## 4.290249       3.721118 -5.4049876 12.84722  -10.23605615  17.67829
```

```
## 4.292517      6.453129 -2.6729765 15.57924  -7.50404507 20.41030
## 4.294785      9.626346  0.5002404 18.75245  -4.33082820 23.58352
## 4.297052     12.120600  2.9944942 21.24671  -1.83657434 26.07777
## 4.299320     14.153723  5.0276168 23.27983   0.19654828 28.11090
## 4.301587     15.204871  6.0787651 24.33098   1.24769653 29.16205
## 4.303855     14.677737  5.5516315 23.80384   0.72056295 28.63491
## 4.306122     13.901334  4.7752280 23.02744  -0.05584058 27.85851
## 4.308390     15.061886  5.9357807 24.18799   1.10471216 29.01906
## 4.310658     18.282618  9.1565122 27.40872   4.32544364 32.23979
## 4.312925     20.715728 11.5896227 29.84183   6.75855416 34.67290
## 4.315193     20.703916 11.5778101 29.83002   6.74674150 34.66109
## 4.317460     21.047000 11.9208941 30.17311   7.08982556 35.00417
## 4.319728     23.621919 14.4958133 32.74802   9.66474475 37.57909
## 4.321995     25.945245 16.8191390 35.07135  11.98807046 39.90242
## 4.324263     27.307403 18.1812973 36.43351  13.35022872 41.26458
## 4.326531     29.244842 20.1187365 38.37095  15.28766789 43.20202
## 4.328798     30.078180 20.9520739 39.20429  16.12100535 44.03535
## 4.331066     29.508856 20.3827506 38.63496  15.55168204 43.46603
## 4.333333     31.560502 22.4343959 40.68661  17.60332736 45.51768
## 4.335601     35.633442 26.5073360 44.75955  21.67626747 49.59062
## 4.337868     37.484863 28.3587576 46.61097  23.52768907 51.44204
## 4.340136     38.952113 29.8260068 48.07822  24.99493819 52.90929
## 4.342404     42.722775 33.5966691 51.84888  28.76560056 56.67995
## 4.344671     45.753373 36.6272675 54.87948  31.79619897 59.71055
## 4.346939     46.877951 37.7518456 56.00406  32.92077701 60.83513
## 4.349206     47.958191 38.8320857 57.08430  34.00101713 61.91537
## 4.351474     47.377383 38.2512775 56.50349  33.42020889 61.33456
## 4.353741     44.138732 35.0126265 53.26484  30.18155791 58.09591
## 4.356009     40.723636 31.5975306 49.84974  26.76646207 54.68081
## 4.358277     37.145990 28.0198845 46.27210  23.18881590 51.10316
## 4.360544     32.796271 23.6701648 41.92238  18.83909625 46.75344
## 4.362812     30.162711 21.0366047 39.28882  16.20553618 44.11988
## 4.365079     29.216870 20.0907638 38.34298  15.25969526 43.17404
## 4.367347     27.538179 18.4120730 36.66428  13.58100442 41.49535
## 4.369615     26.201806 17.0756999 35.32791  12.24463138 40.15898
## 4.371882     26.295695 17.1695892 35.42180  12.33852066 40.25287
## 4.374150     26.062105 16.9359995 35.18821  12.10493089 40.01928
## 4.376417     25.924062 16.7979567 35.05017  11.96688814 39.88124
## 4.378685     28.104488 18.9783826 37.23059  14.14731404 42.06166
## 4.380952     32.660268 23.5341625 41.78637  18.70309391 46.61744
## 4.383220     38.268209 29.1421035 47.39432  24.31103492 52.22538
## 4.385488     43.144510 34.0184038 52.27062  29.18733523 57.10168
## 4.387755     47.740458 38.6143522 56.86656  33.78328358 61.69763
## 4.390023     57.042841 47.9167349 66.16895  43.08566631 71.00001
## 4.392290     71.546486 62.4203806 80.67259  57.58931203 85.50366
## 4.394558     82.080210 72.9541039 91.20632  68.12303533 96.03738
## 4.396825     83.211113 74.0850076 92.33722  69.25393904 97.16829
## 4.399093     79.340112 70.2140058 88.46622  65.38293720 93.29729
## 4.401361     73.145673 64.0195673 82.27178  59.18849870 87.10285
## 4.403628     63.995854 54.8697480 73.12196  50.03867947 77.95303
## 4.405896     55.285679 46.1595730 64.41178  41.32850438 69.24285
## 4.408163     49.503463 40.3773571 58.62957  35.54628858 63.46064
## 4.410431     43.618496 34.4923901 52.74460  29.66132149 57.57567
## 4.412698     36.367008 27.2409023 45.49311  22.40983374 50.32418
```

```
## 4.414966        30.490383 21.3642772 39.61649   16.53320863  44.44756
## 4.417234        26.816023 17.6899168 35.94213   12.85884823  40.77320
## 4.419501        23.352498 14.2263926 32.47860    9.39532401  37.30967
## 4.421769        18.483199  9.3570936 27.60931    4.52602501  32.44037
## 4.424036        12.539683  3.4135774 21.66579   -1.41749117  26.49686
## 4.426304         7.452686 -1.6734200 16.57879   -6.50448855  21.40986
```

Final comments

The final forecast used an ARIMA(0, 0, 3) model and looks to have done a good job on the data taking into consideration morning and evening peaks as well as the weekly seasonality.