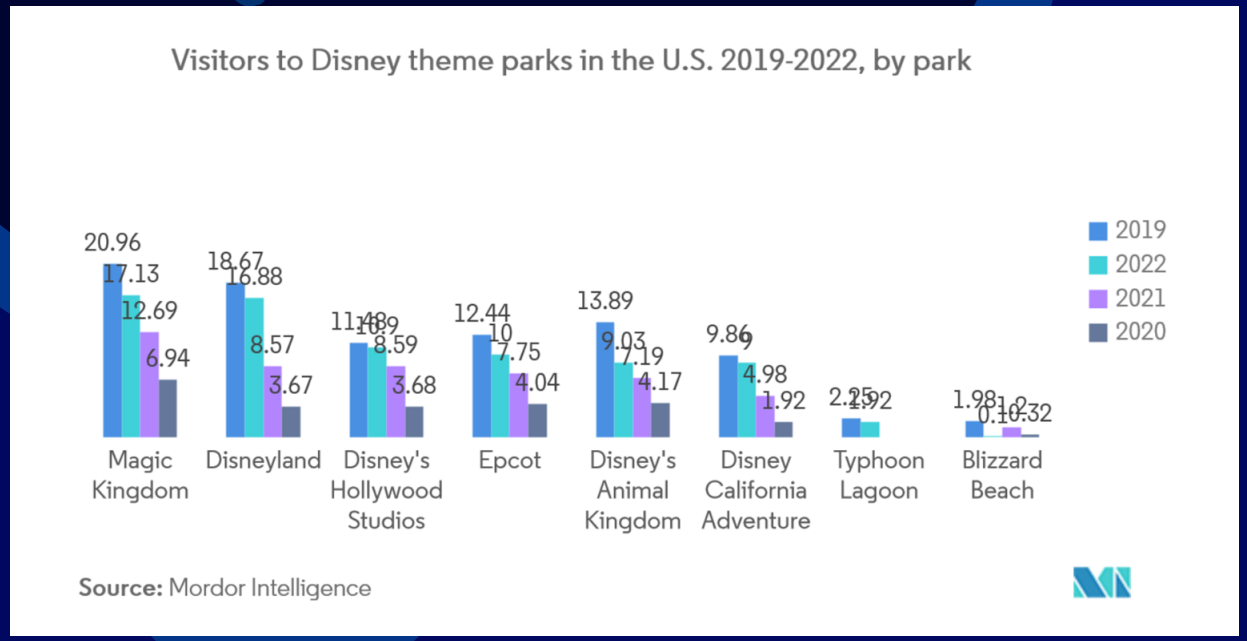

Wait Times
Time Series Analysis
Broghan O’Connor, Coton Bassford, Kristina Lynch

The Disney Problem

- Disney Stock has steadily declined over the past few years.
- Theme parks attendance has not recovered Covid-19



Competition

Political Tensions

Underperforming Movies

hulu

Costly Acquisitions

Disney Financials

82.7 billion in revenue

40% comes from theme parks

Need to get attendance back up

Forecast wait times: if it exceeds 45 minutes open virtual queue

Allow time for more fun

Data Acquisition

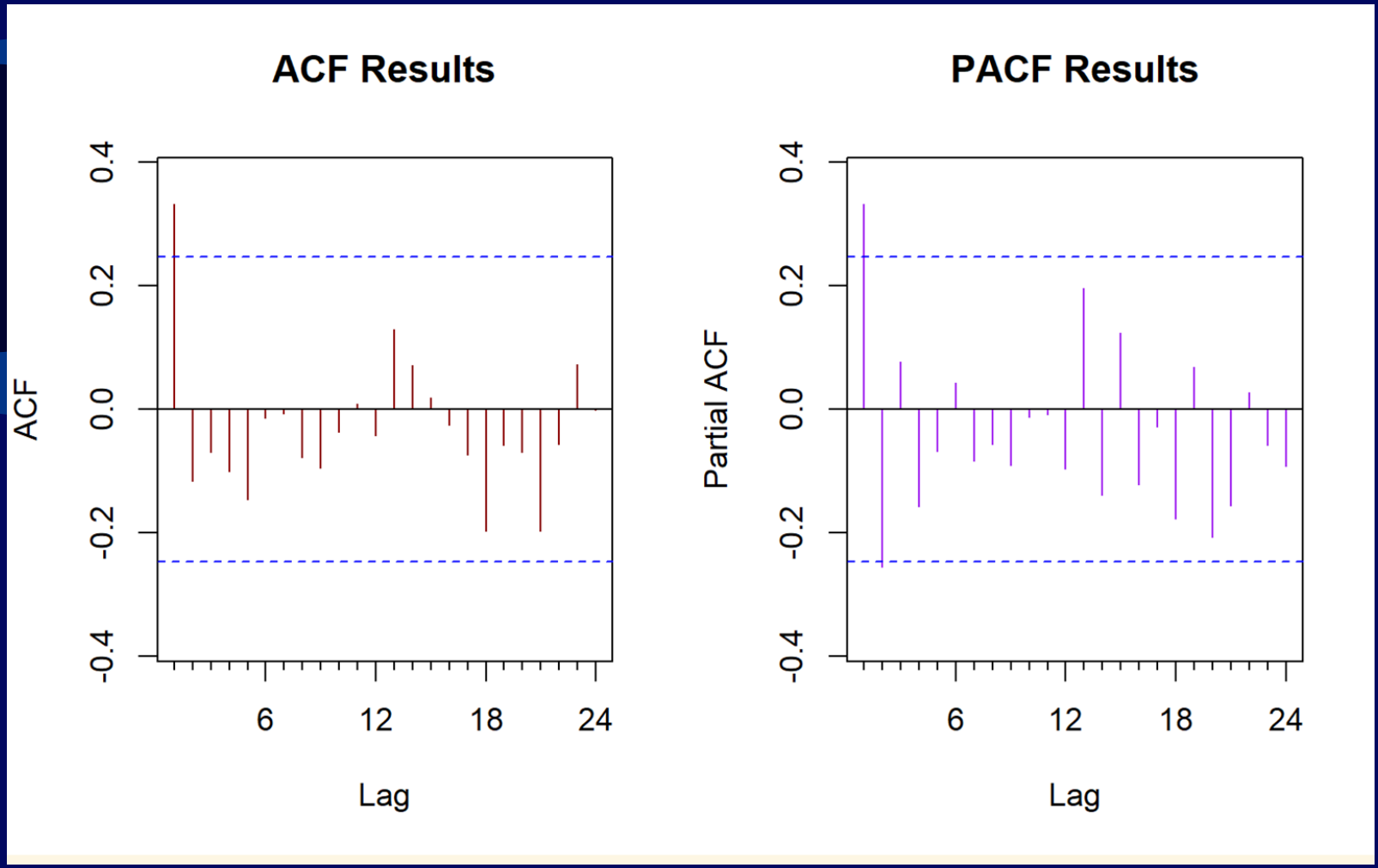
- Combined 32 datasets tracking wait times for each ride at Walt Disney World's Magic Kingdom collected every 6 mins
- Over 6 million rows of data
- Created groupings based on day and month
- Combined data together to give wholistic view
- When implemented each ride will be separated

Initial Model

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  25.567762   1.175093  21.758  < 2e-16 ***
trend         0.440611   0.065857   6.690 2.41e-08 ***
I(trend^2)   -0.004718   0.001001  -4.715 2.19e-05 ***
season2       1.174479   1.257644   0.934  0.35514
season3       3.751798   1.257924   2.983  0.00452 **
season4      -0.546891   1.328229  -0.412  0.68240
season5      -3.417371   1.329300  -2.571  0.01337 *
season6      -0.195023   1.330248  -0.147  0.88407
season7       0.379200   1.330936   0.285  0.77696
season8      -3.013888   1.331273  -2.264  0.02824 *
season9     -11.407749   1.331229  -8.569 3.65e-11 ***
season10     -6.932628   1.330839  -5.209 4.13e-06 ***
season11     -2.909546   1.330197  -2.187  0.03373 *
season12     -0.386844   1.329444  -0.291  0.77235
cyc1          0.958239   0.418208   2.291  0.02647 *
cyc2         -0.684854   0.397600  -1.722  0.09156 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.178 on 47 degrees of freedom
Multiple R-squared:  0.8559,    Adjusted R-squared:   0.81
F-statistic: 18.62 on 15 and 47 DF,  p-value: 7.21e-15
```

- Important Stats: R^2 of 0.8559
- Takeaway: Good initial detrending of the data, but there will still be noise present

Initial Model

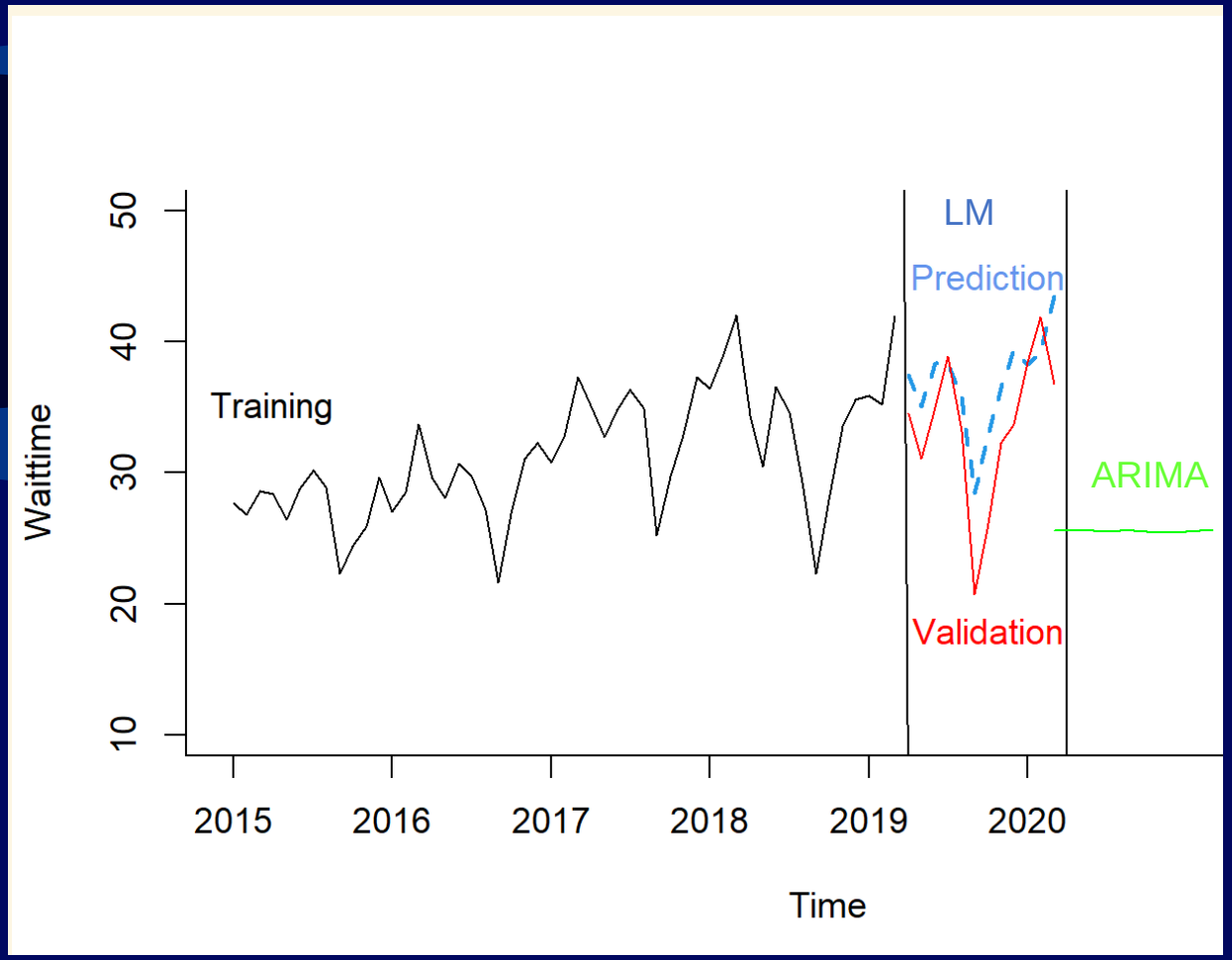


- Important Stats: AR(1) and MA(1) present
- Takeaway: We must account for these components

ARIMA Models

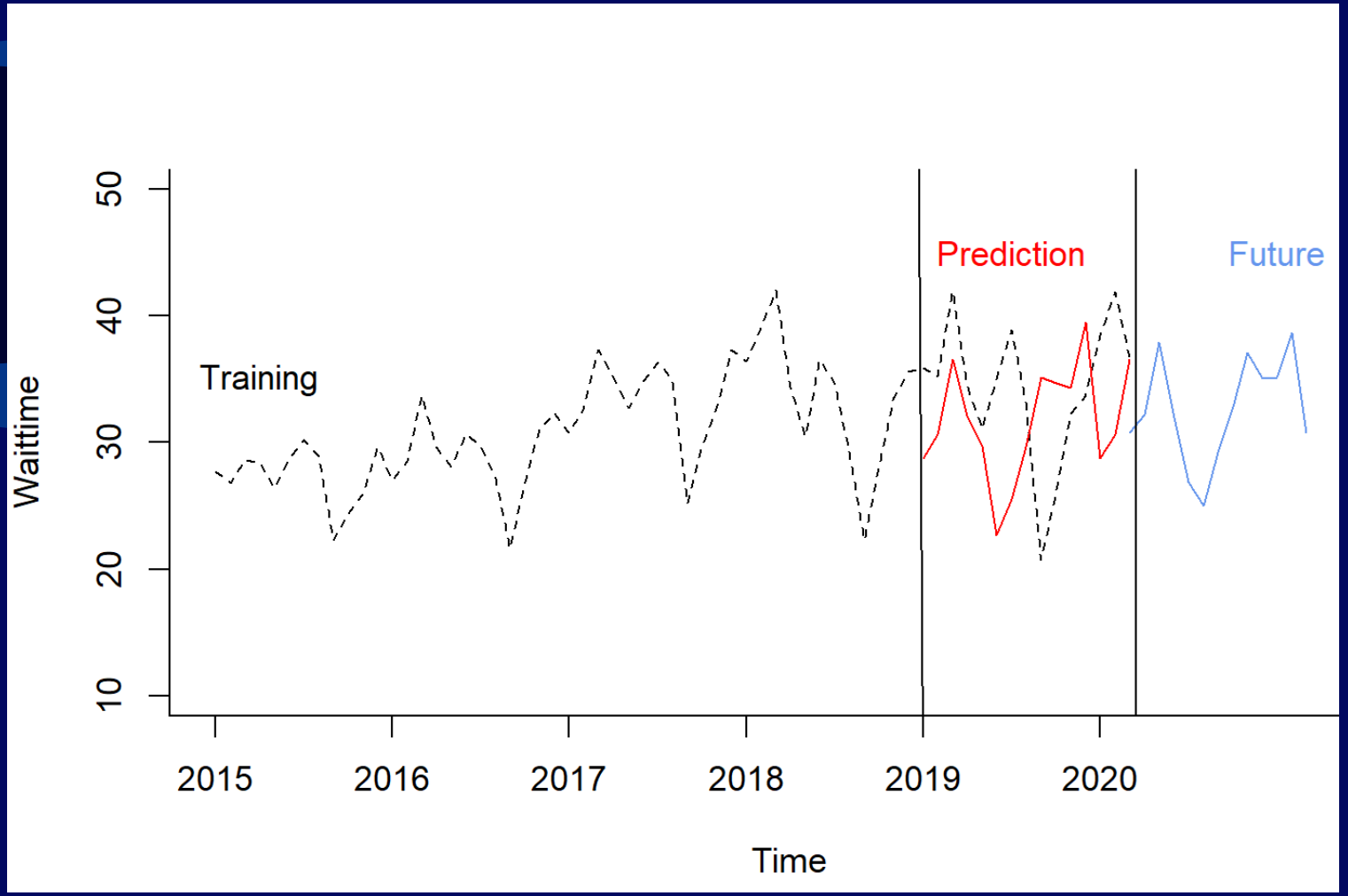
```
ARIMA(1,0,0) with non-zero mean

Coefficients:
         ar1    mean
      0.3367  0.0056
s.e.  0.1191  0.3337

sigma^2 = 3.24:  log likelihood = -125.47
AIC=256.93   AICc=257.34   BIC=263.36

Training set error measures:
                     ME     RMSE      MAE       MPE     MAPE      MASE        ACF1
Training set -0.01312189 1.771137 1.40986 143.2815 147.4262 0.6648354 0.09066214
```

Plotting Models



Takeaway: We see that ARIMA's prediction doesn't accurately forecast the data.

Neural Network



Takeaway: The neural network was able to detrend the patterns in the data and give a good prediction on the validation set before predicting future wait times

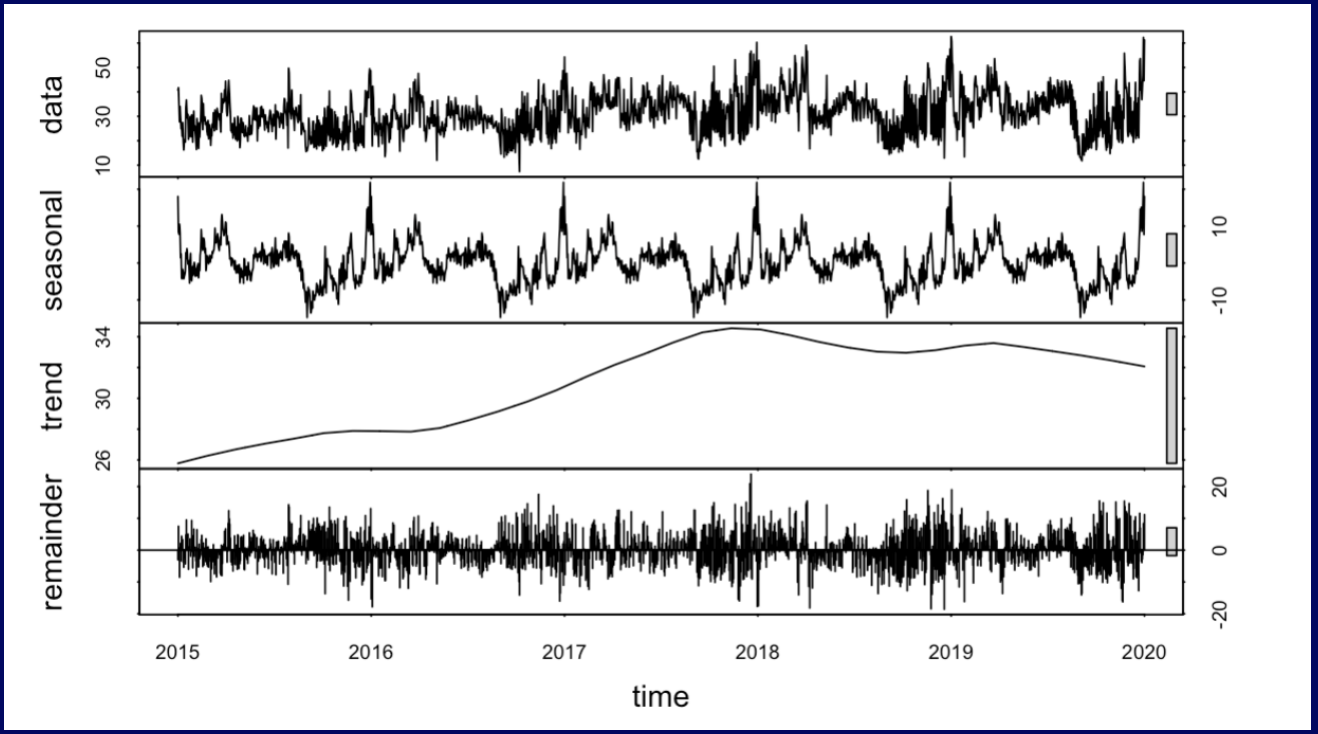
Forecasting using STL combined with ETS

Overview

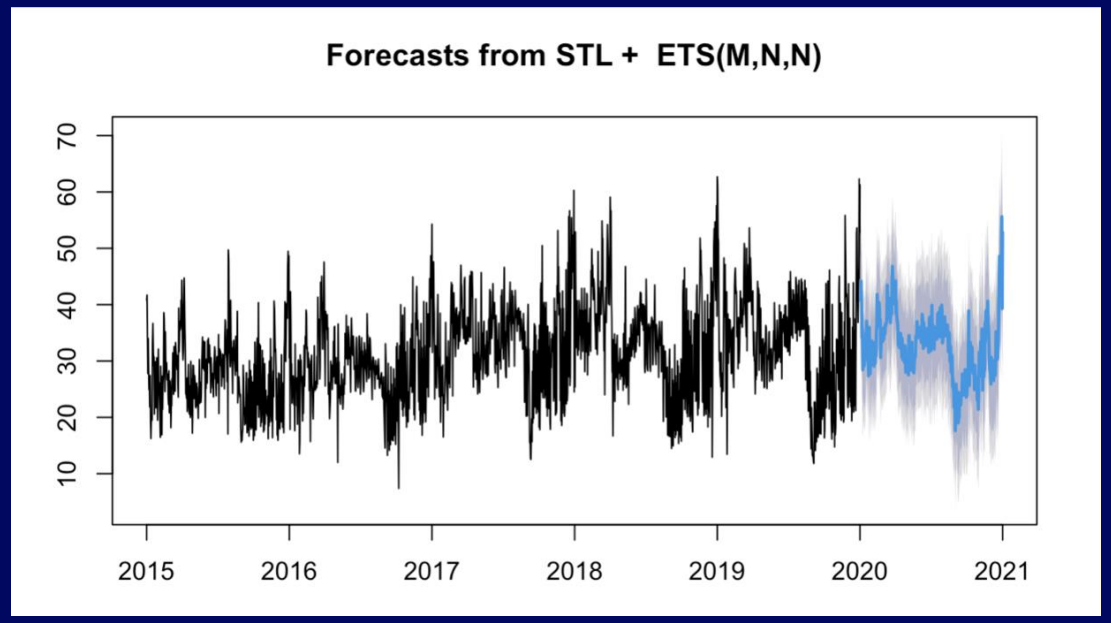
- Decomposes time series into seasonal, trend, and remainder components
- Built in Loess filter (smoothing)

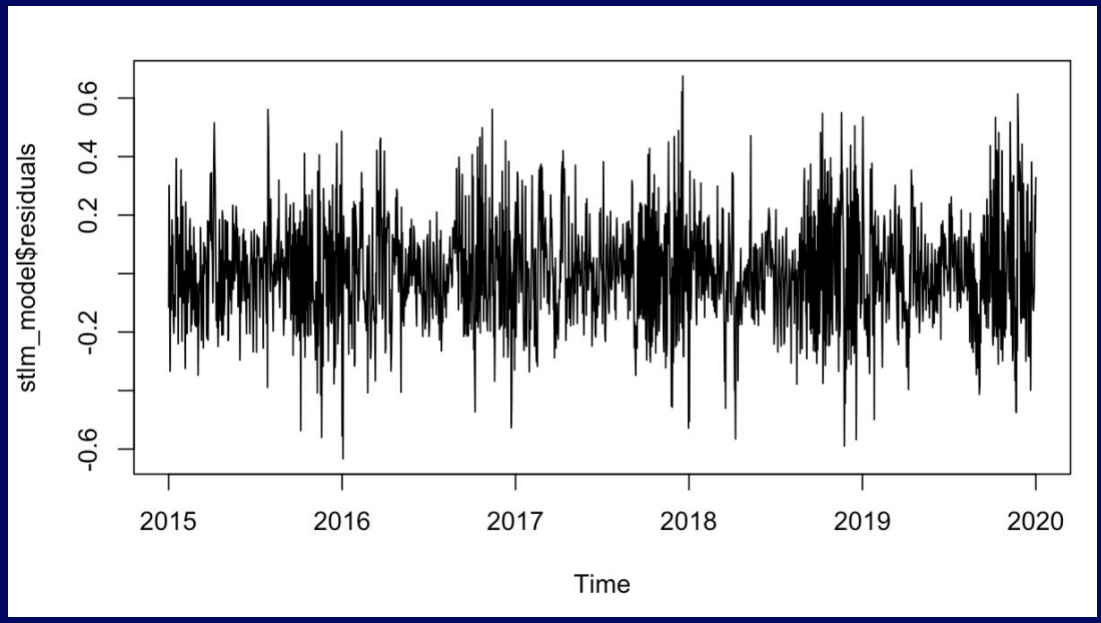
Drawbacks

- Don’t get sense of what was detrended
- Can not put components back into forecast



Results


Forecasts from STL + ETS(M,N,N)
10
20
30
40
50
60
70
2015
2016
2017
2018
2019
2020
2021


stlm_model$residuals
-0.6
-0.2
0.2
0.4
0.6
2015
2016
2017
2018
2019
2020
Time

Prophet: Automatic Forecasting Procedure

Overview:

- Non-linear trends fit with yearly, weekly, and daily seasonality, plus holiday effects

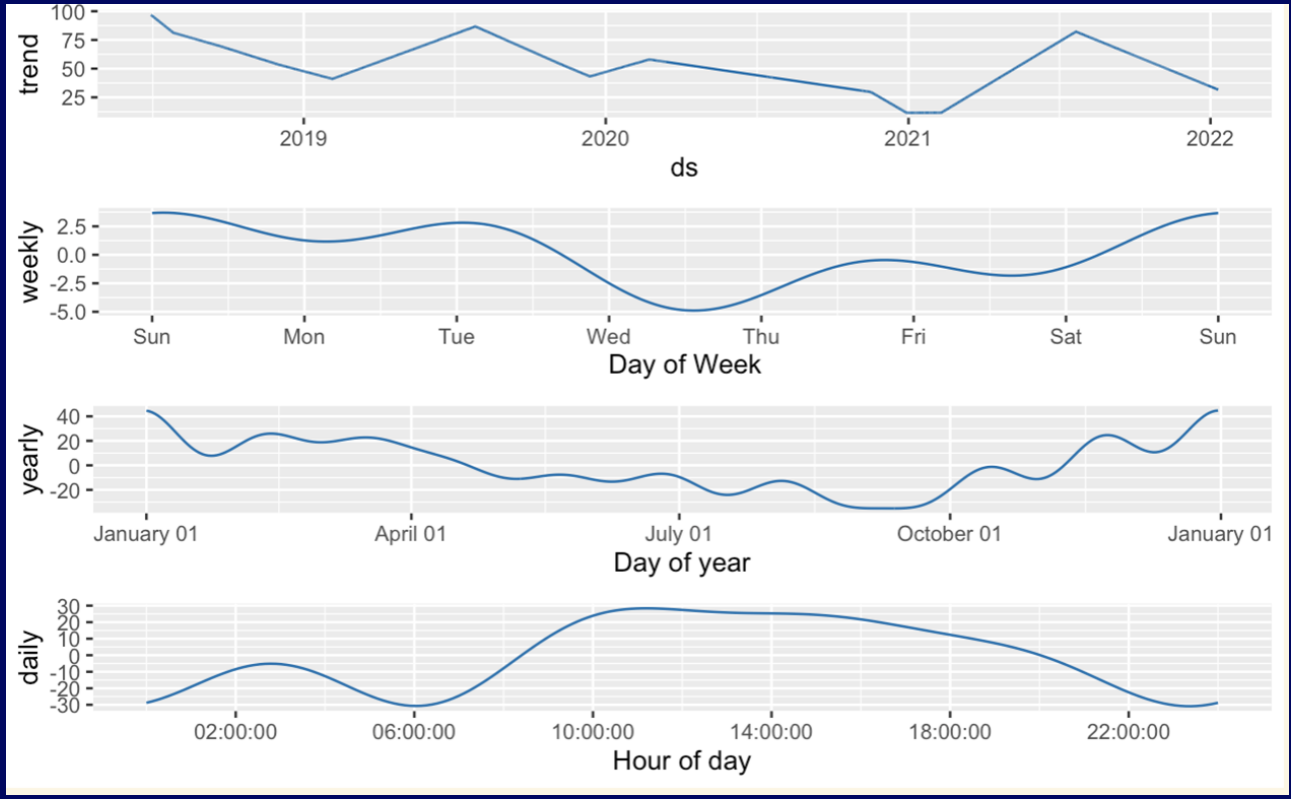
Drawbacks:

- Unpredictable results

Results

Best time to ride Slinky Dog Dash:

Wednesday or Thursday morning at the start of the school year



Thank You!