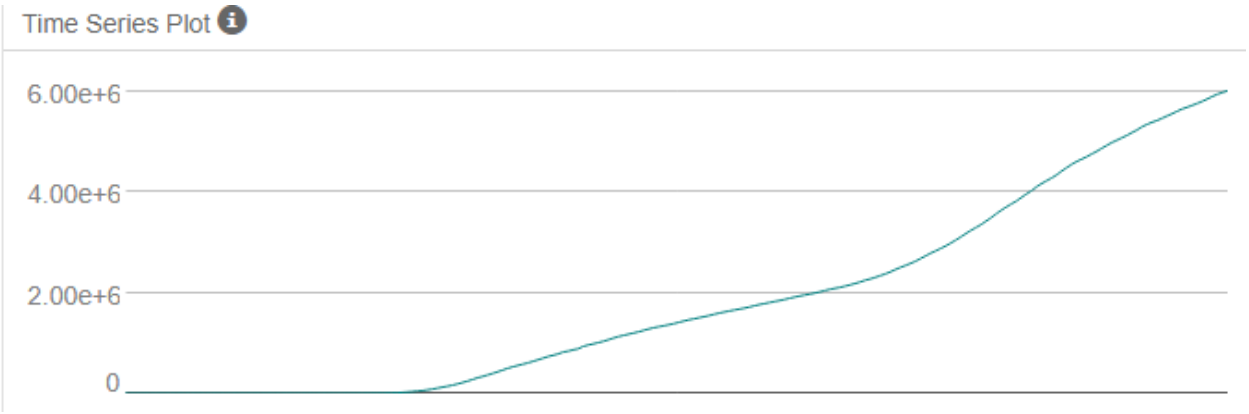
The goal is to find a model to forecast the next 30 days of total COVID cases. We will do so for the United States. I will compare between ETS and ARIMA models.

The characteristics of a time series dataset consists of:

- Continuous data over a long period of time
- The data is in sequential order
- Every consecutive pair of points are one day apart from each other
- There is at most one value per date listed.

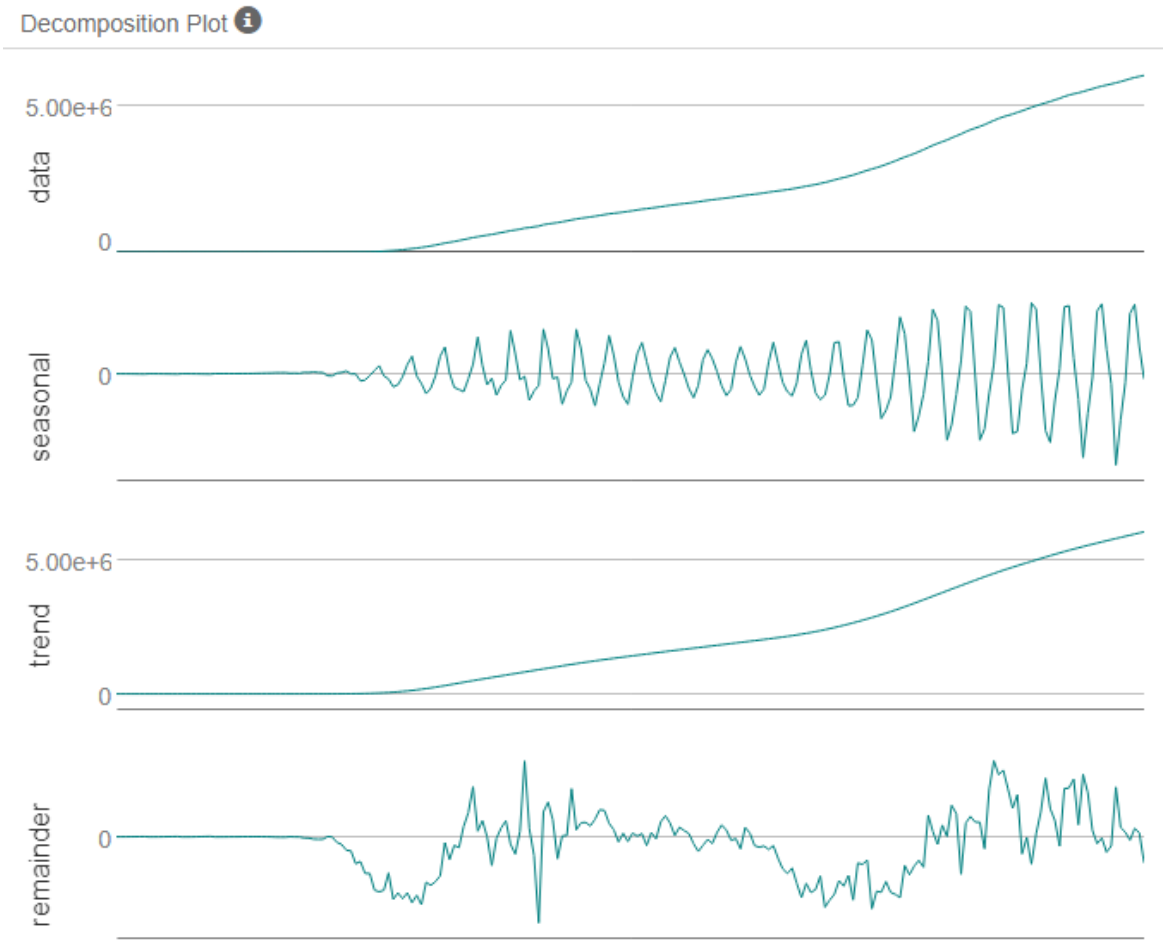
We are also attempting to provide a forecast for the following 30 days; hence we will hold out the last samples.

If we look at the time series plot below, we can see how there is an upward trend occurring. We cannot see if there is seasonal pattern from the plot below, but we will look more into this in the decomposition plot. There does not appear to be any cyclical pattern occurring in the data.



Below, the decomposition plot confirms the upward trend. There also appears to be a seasonal pattern within the graph. Given our seasonal findings when using an ARIMA model we should find the seasonal difference. When using an ETS model, we can see that the magnitude changes for the seasonal component, hence I will consider using a multiplicative method, but will still compare to the additive method.

Finally, when looking at the error plot, the error does not stay consistent throughout the time series plot. It would be best to apply error with a multiplicative method when using the ETS model but will still compare to the additive method.



ETS MODEL

Earlier we mentioned how we were considering multiplicative methods for error and seasonality with an additive method for the trend. We end up with an extremely high error, so I compared to model with all additive methods.

This results in an ETS(A, A, A) model.

In-sample error measures:

ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
845.1577094	4226.7124632	3019.3326037	-539.9949482	3598.8302744	0.0178349	0.1416546

Information criteria:

AIC	AICc	BIC
4193.6229	4195.3856	4232.5872

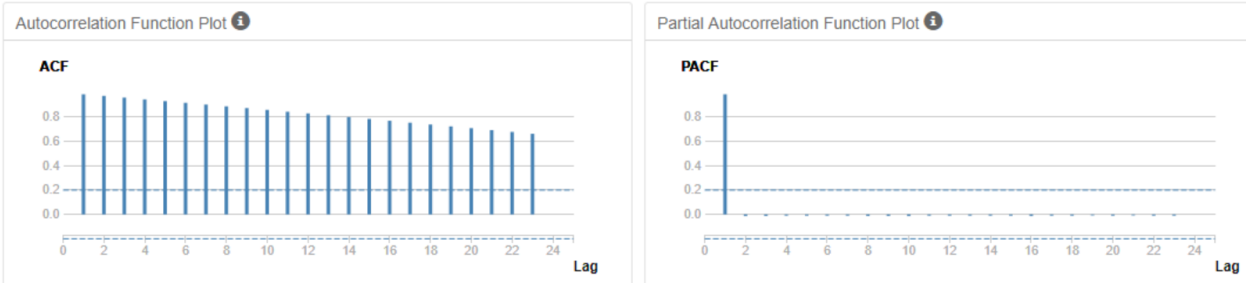
The model results with a RMSE value of 4,227 units around the mean. The MAE is 3,019 units around the mean. We can also see the values for the AIC and BIC are 4194 and 4233, respectively.

ARIMA MODEL

From our previous analysis we will use an ARIMA(p, d, q)(P, D, Q)S model to forecast.

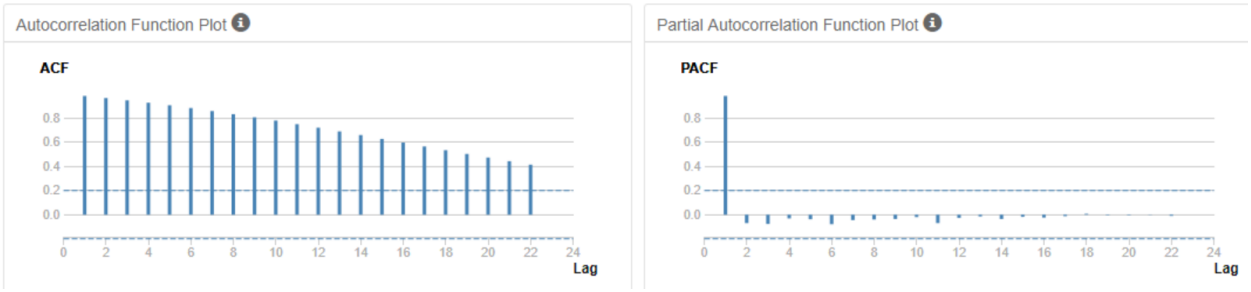
Time Series ACF and PACF:

From the ACF we can see how the data is decreasing the more we proceed. It would be wise to the seasonal difference in the series.



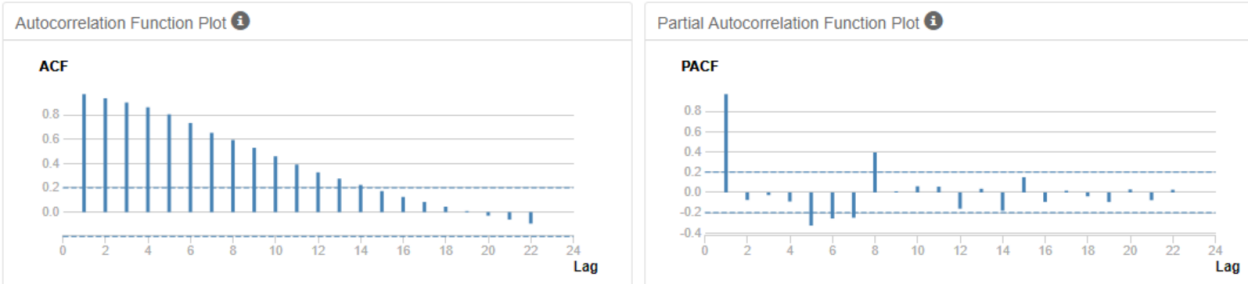
Seasonal Difference ACF and PACF:

We can see similar results to the ACF and PACF from the initial plots without differencing. The only difference is that the correlation decreased. We will take another difference to remove correlation.



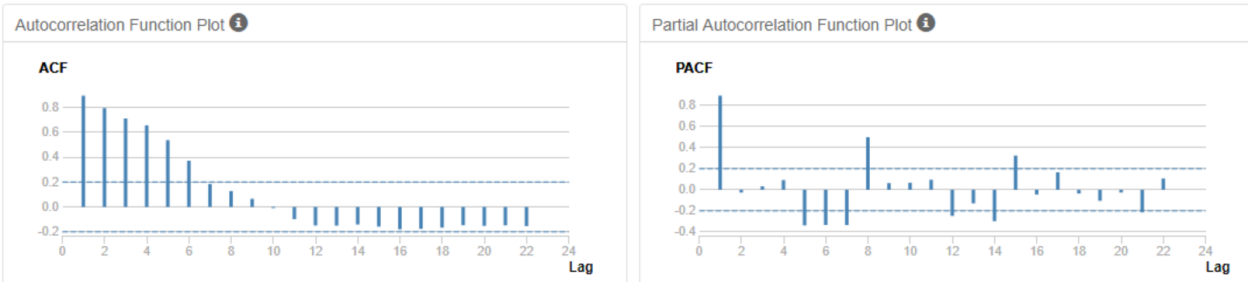
Seasonal First Difference ACF and PACF:

We can see that the results for the ACF and PACF decreased a lot more and its actually decaying towards 0. We will take another difference.



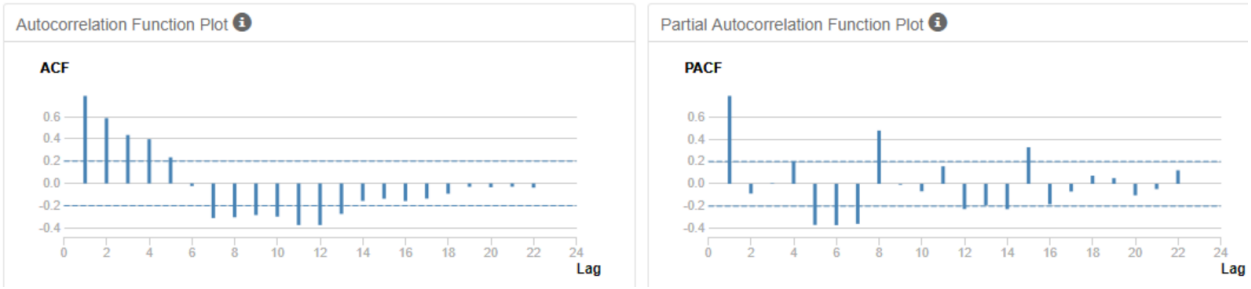
Seasonal Second Difference ACF and PACF:

The correlation continues to decay more, hence taking another difference would be wise.



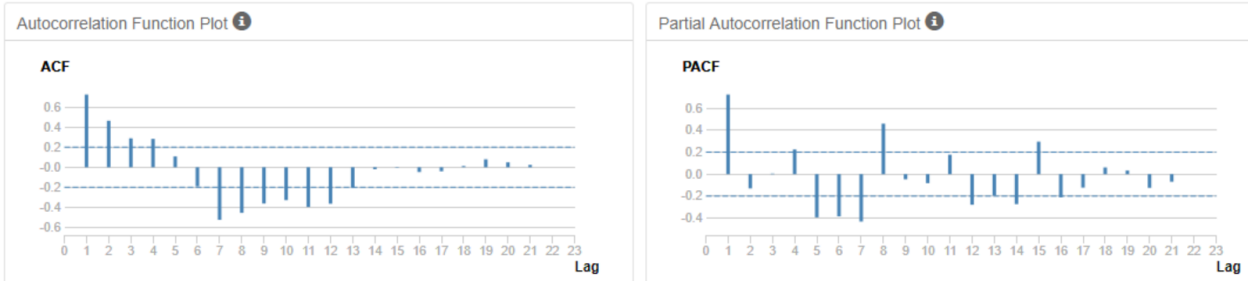
Seasonal Third Difference ACF and PACF:

The correlation continues to decay; hence I will consider taking one more difference.



Seasonal Fourth Difference ACF and PACF:

Although the correlation was decreasing, we can see how it also started increasing again towards the center of the ACF plot.



Given that we could not ultimately decide what terms to use for the ARIMA model, I went ahead and allowed the program to decide what parameters to use. This resulted in: ARIMA(0, 2, 1)(0, 0, 4)[7]

Now we will look at the in-sample errors to provide a closer look at the model accuracy.

In-sample error measures:

ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
374.8027962	4080.6107486	2541.8565526	1.2508879	3.548399	0.0150145	0.0011973

Information Criteria:

AIC	AICc	BIC
3676.28	3676.7441	3695.6987

The model results with a RMSE value of 4,081 units around the mean. The MAE is 2,541 units around the mean. We can also see the values for the AIC and BIC are 3676 and 3696, respectively.

MODEL COMPARISON:

Referring to our in-sample errors we can see how the RMSE, MAE, AIC, and BIC values are all smaller for the ARIMA model. Below we can further compare and find the same results where the error is smaller for the ARIMA model.

Accuracy Measures:

Model	ME	RMSE	MAE	MPE	MAPE	MASE
ETS_Covid_cases	-194628.3	237357.8	194628.3	-3.4445	3.4445	7.9613
ARIMA	-145686.6	174955.7	145686.6	-2.5847	2.5847	5.9593

Therefore, we will use the ARIMA model for the forecasting.

FORECAST

Below we have our forecasted values for the next 30 days.

date	forecasts	forecasts_high_95	forecasts_high_80	forecasts_low_80	forecasts_low_95
9/2/2020	6068387.33	6076754.08	6073858.05	6062916.61	6060020.58
9/3/2020	6107255.49	6121644.41	6116663.90	6097847.07	6092866.56
9/4/2020	6147072.66	6167891.45	6160685.33	6133459.99	6126253.88
9/5/2020	6190981.58	6218756.57	6209142.67	6172820.49	6163206.59
9/6/2020	6230906.46	6266168.79	6253963.26	6207849.65	6195644.12
9/7/2020	6267100.21	6310363.06	6295388.27	6238812.15	6223837.36
9/8/2020	6302579.84	6354333.89	6336420.00	6268739.69	6250825.79
9/9/2020	6339508.48	6401638.29	6380132.98	6298883.98	6277378.67
9/10/2020	6378247.62	6451478.82	6426130.93	6330364.31	6305016.42
9/11/2020	6416843.43	6501844.06	6472422.35	6361264.51	6331842.81
9/12/2020	6458610.50	6556004.26	6522292.86	6394928.14	6361216.73
9/13/2020	6497512.54	6607887.66	6569682.95	6425342.13	6387137.42
9/14/2020	6533102.98	6657018.31	6614126.86	6452079.10	6409187.65
9/15/2020	6568101.94	6706091.48	6658328.45	6477875.43	6430112.40
9/16/2020	6605127.36	6758965.84	6705716.94	6504537.78	6451288.88
9/17/2020	6642551.43	6813071.42	6754048.46	6531054.40	6472031.44
9/18/2020	6680655.43	6868631.68	6803566.49	6557744.36	6492679.18

9/19/2020	6719336.66	6925496.52	6854137.34	6584535.98	6513176.81
9/20/2020	6757640.92	6982672.26	6904781.01	6610500.84	6532609.59
9/21/2020	6793426.43	7037983.82	6953333.91	6633518.94	6548869.04
9/22/2020	6829562.63	7094272.14	7002646.87	6656478.39	6564853.12
9/23/2020	6866261.00	7152703.07	7053555.40	6678966.60	6579818.93
9/24/2020	6903258.97	7212307.86	7105335.18	6701182.76	6594210.08
9/25/2020	6940843.43	7273325.42	7158241.72	6723445.15	6608361.45
9/26/2020	6978580.41	7335280.40	7211814.00	6745346.83	6621880.43
9/27/2020	7016089.49	7397756.50	7265648.14	6766530.84	6634422.47
9/28/2020	7052685.83	7460037.56	7319038.81	6786332.84	6645334.09
9/29/2020	7089006.66	7522733.21	7372605.21	6805408.12	6655280.12
9/30/2020	7125793.83	7587075.94	7427409.99	6824177.67	6664511.72
10/1/2020	7162580.99	7652227.21	7482743.44	6842418.54	6672934.78