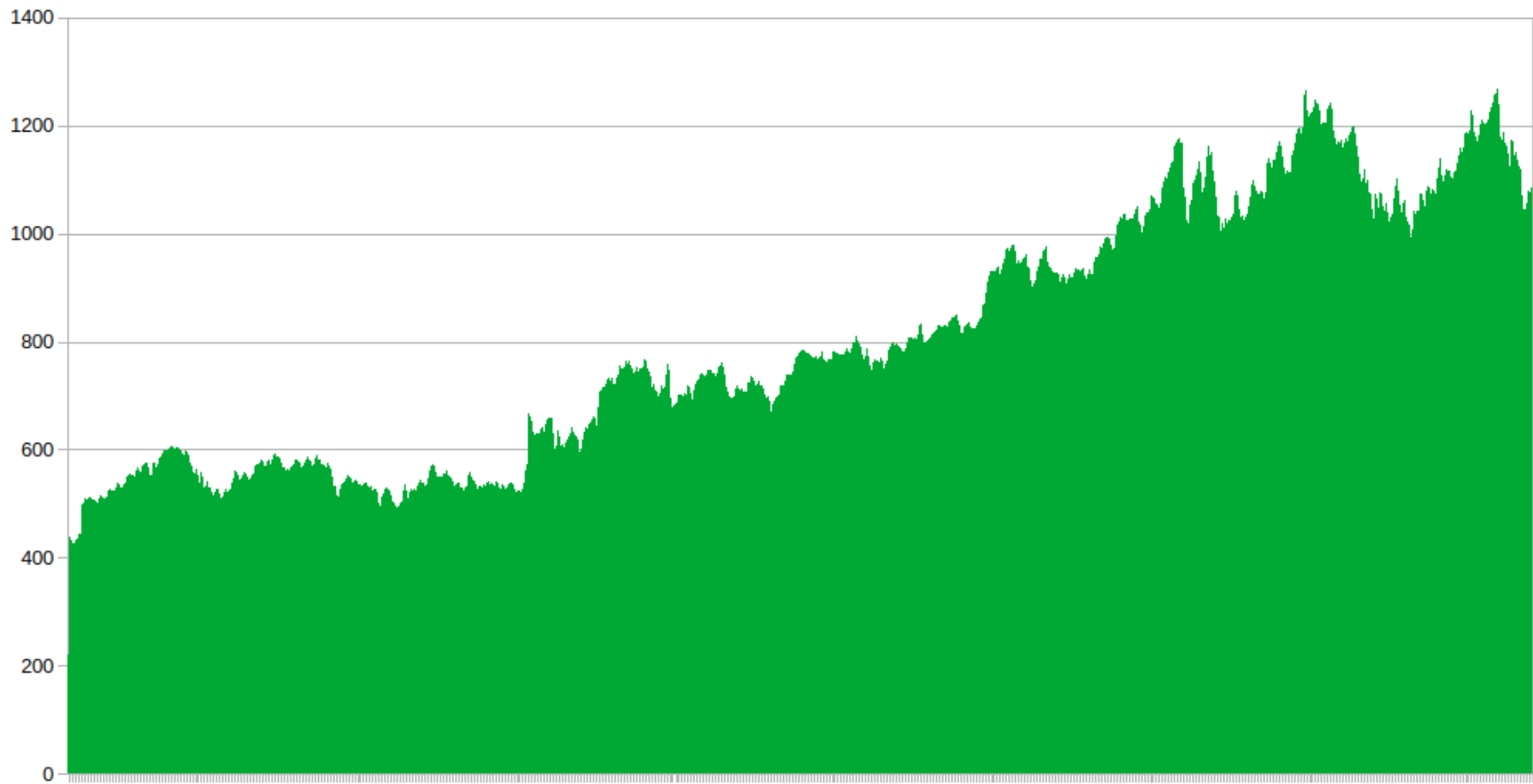


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Sammamish, WA

Monday 11:00 AM

Cloudy



61 °F | °C

Precipitation: 0%

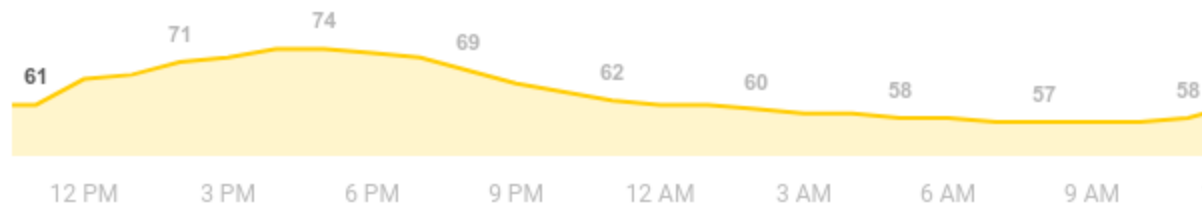
Humidity: 79%

Wind: 5 mph

Temperature

Precipitation

Wind

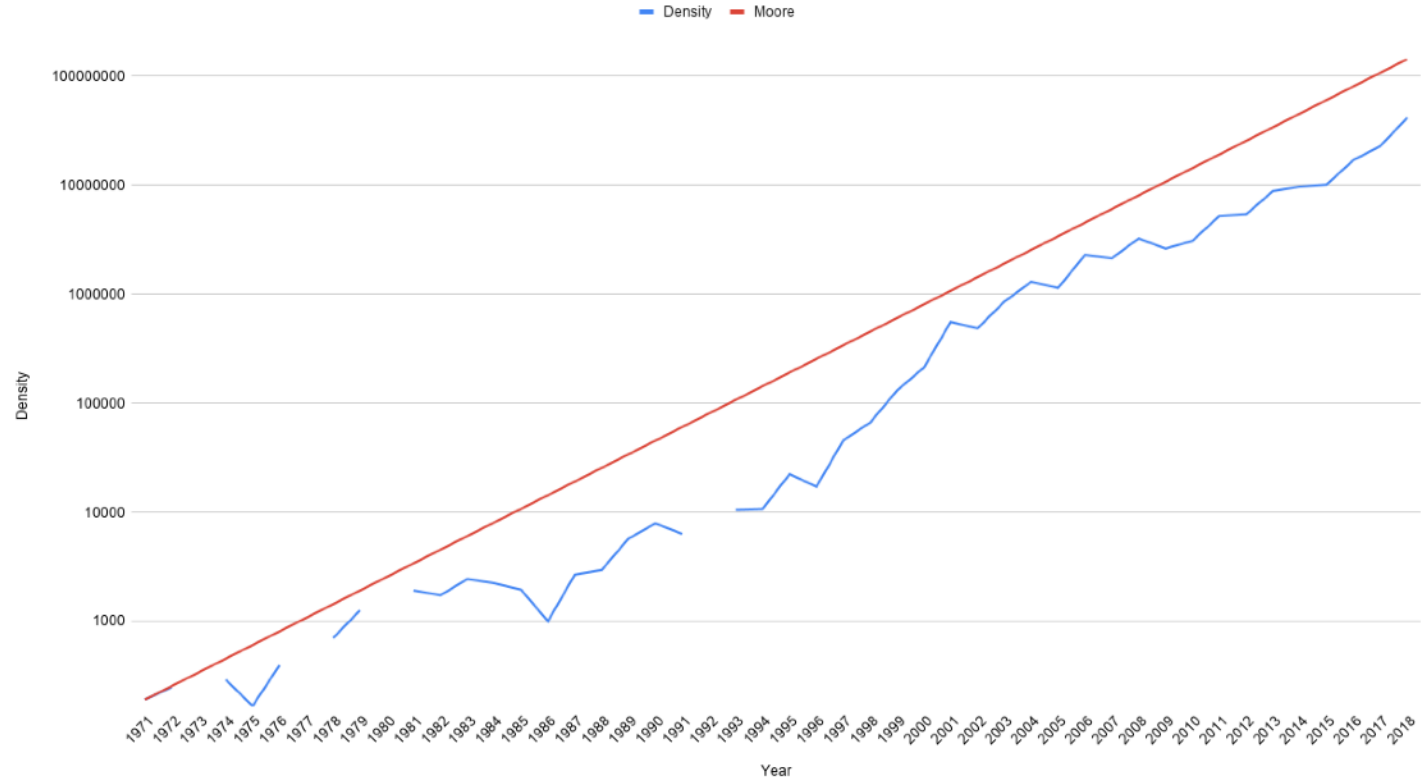


Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
75° 56°	67° 51°	64° 50°	66° 51°	73° 53°	72° 53°	65° 53°	65° 53°

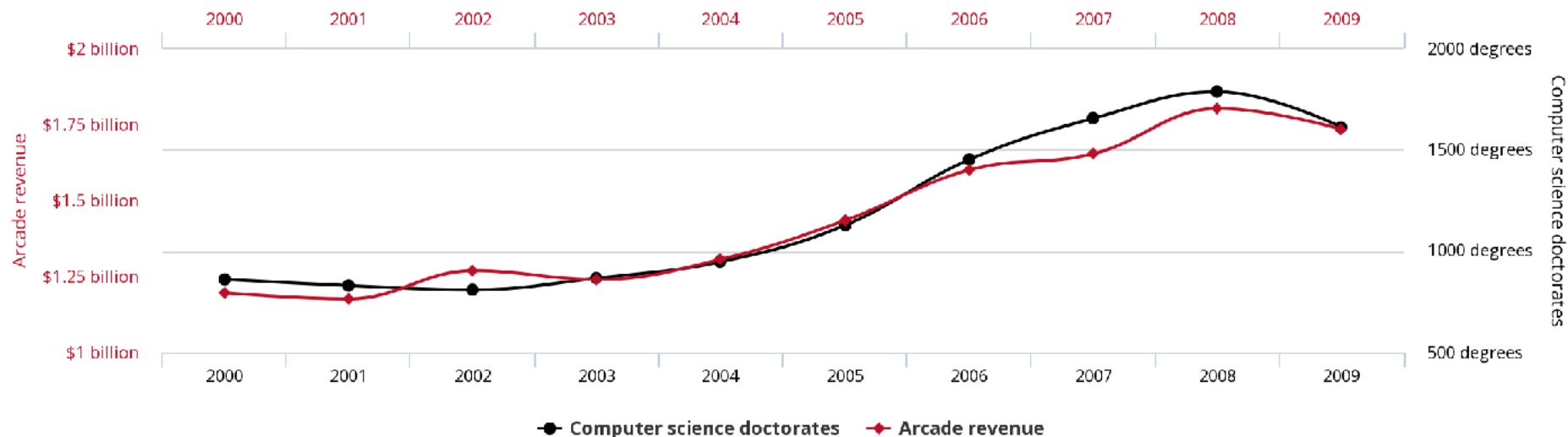
[More on weather.com](#)

[Feedback](#)

Density vs. Year

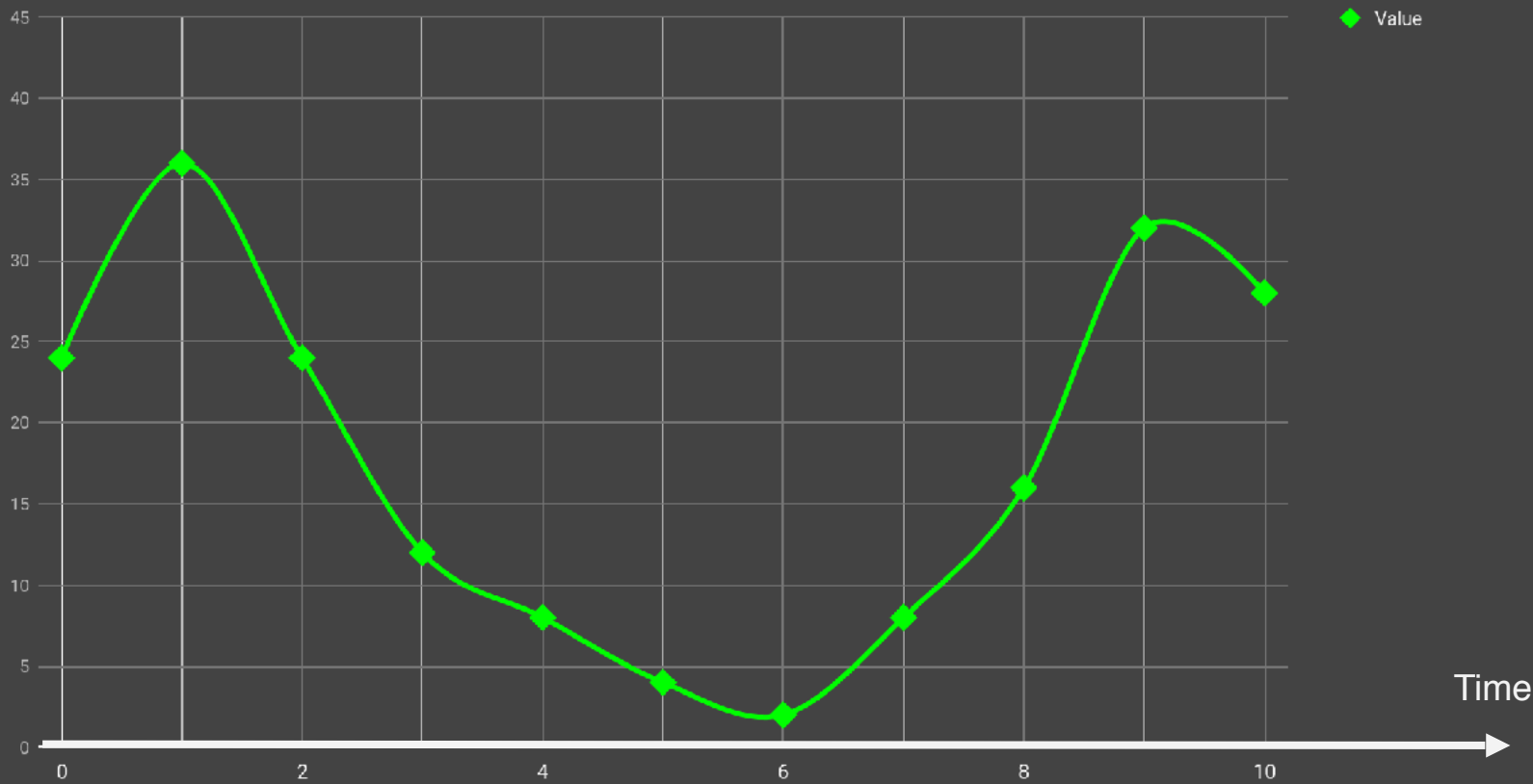


Total revenue generated by arcades
correlates with
Computer science doctorates awarded in the US

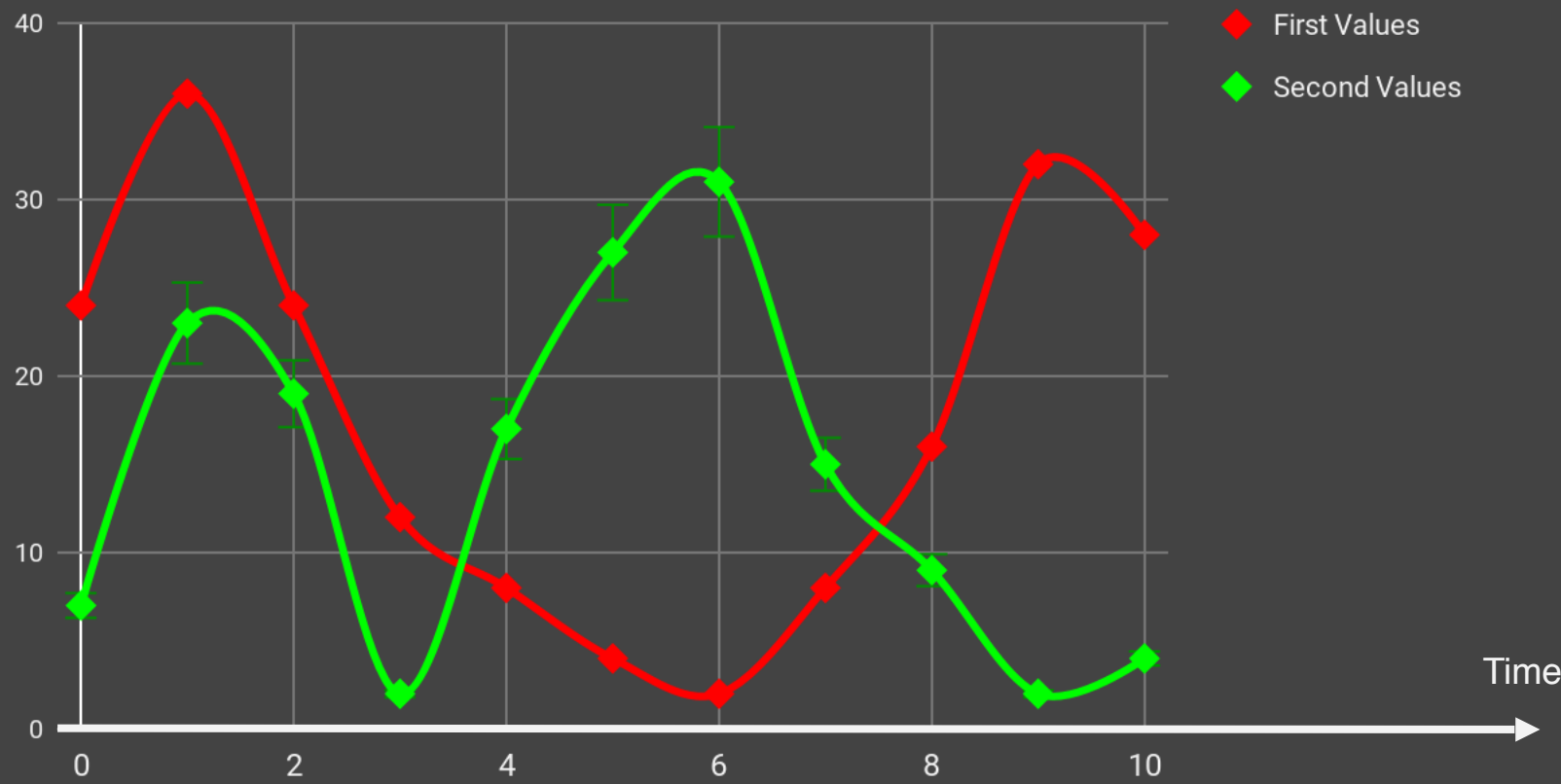


tylervigen.com

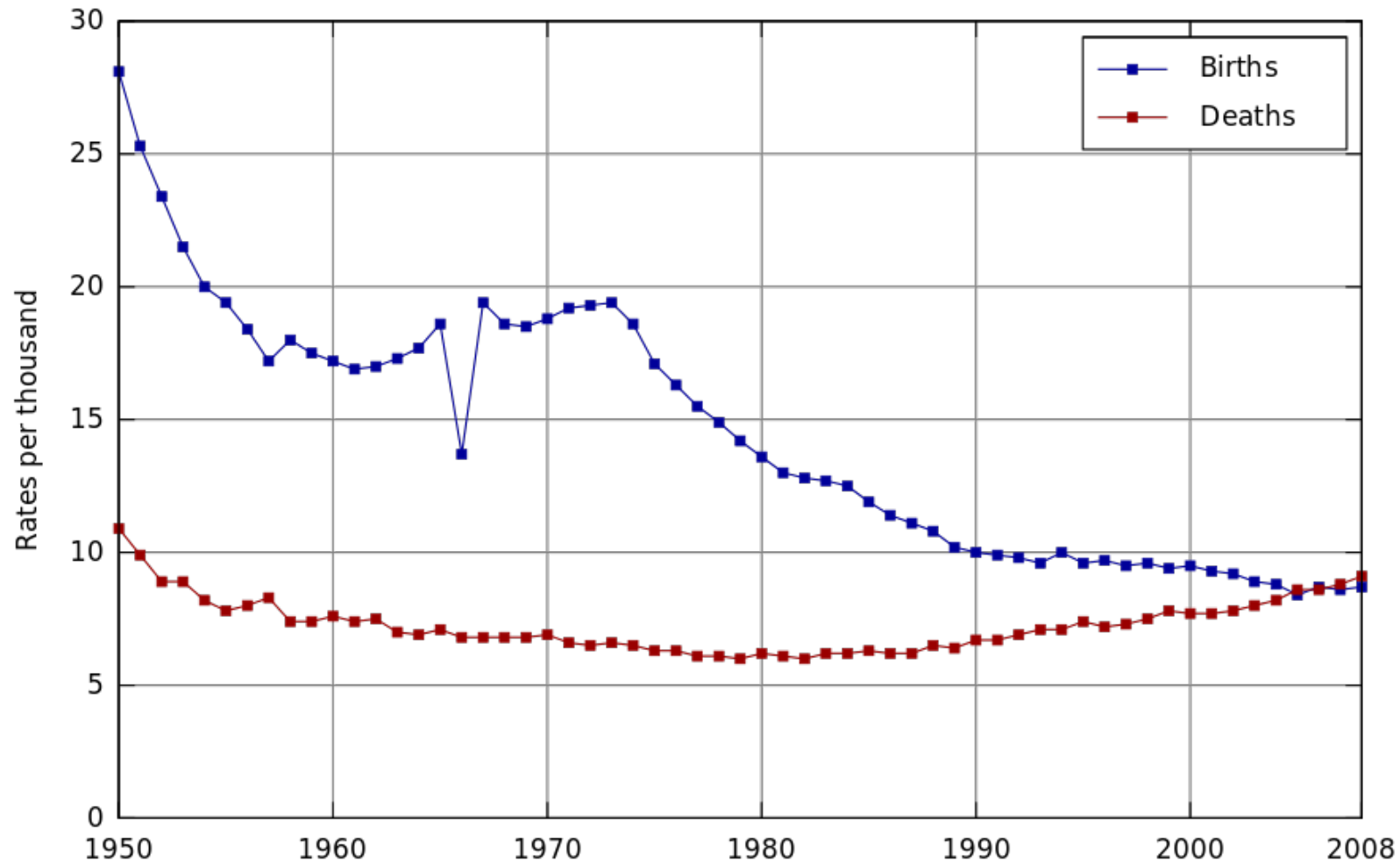
Univariate Time Series

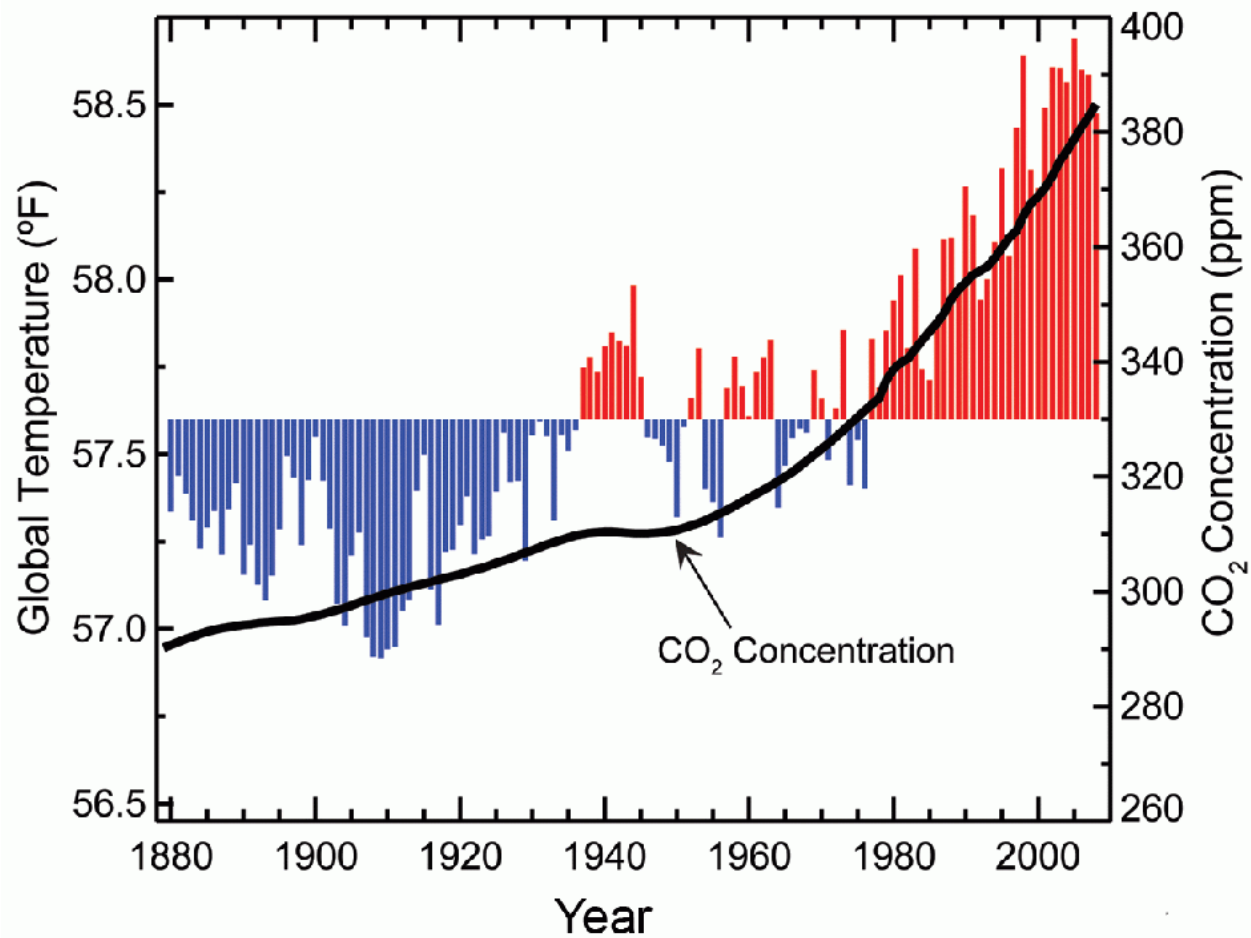


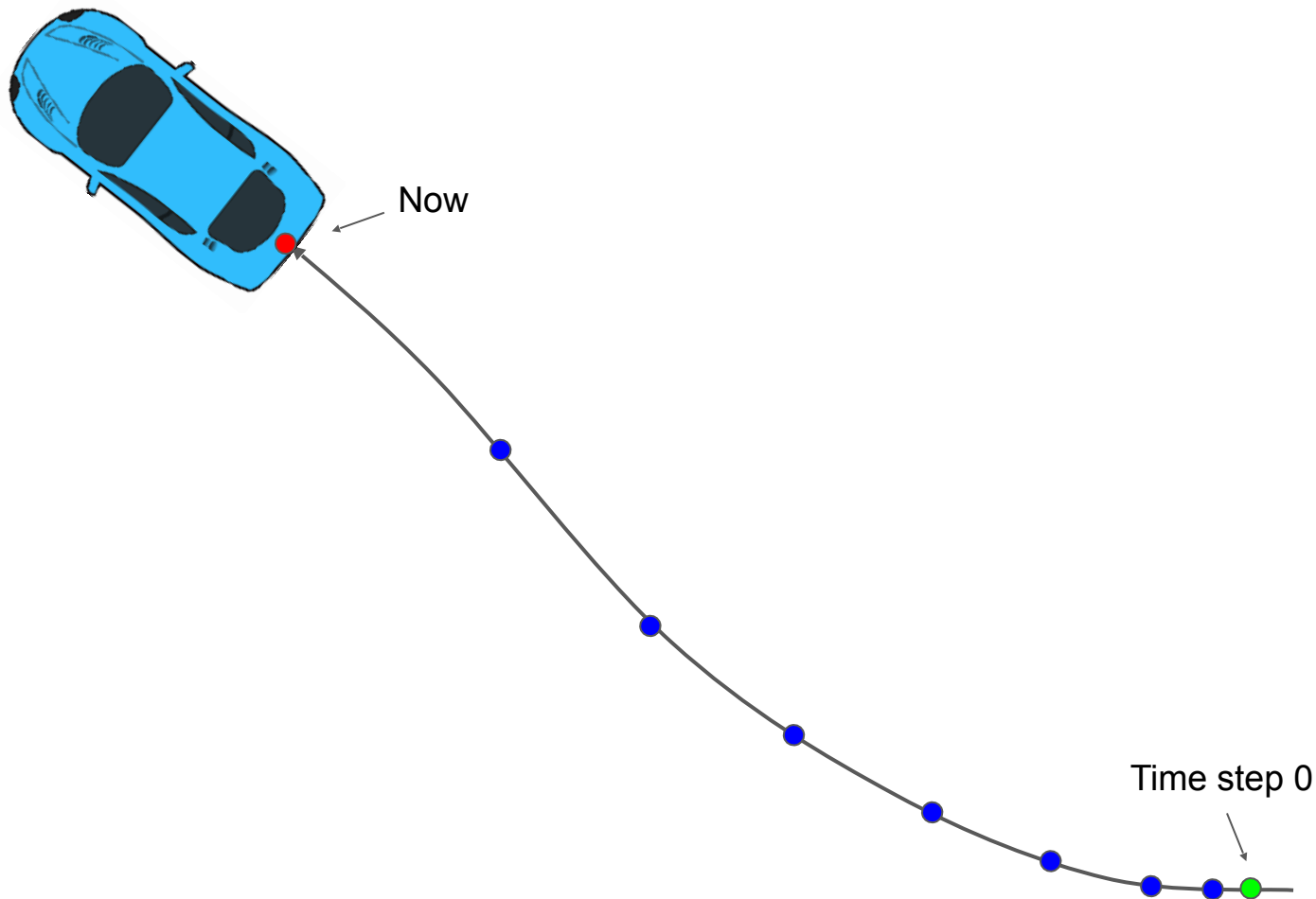
Multivariate Time Series



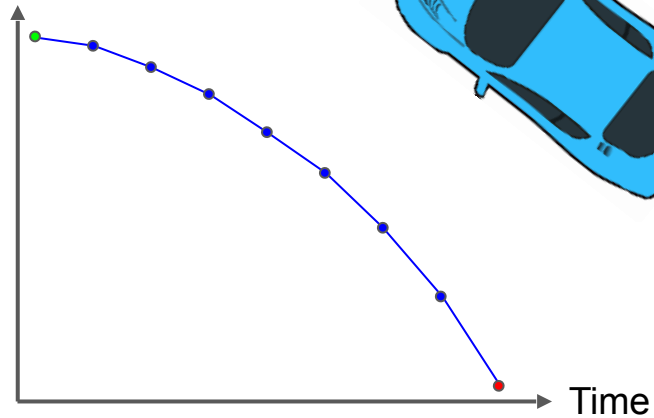
Birth and Death Rate in Japan



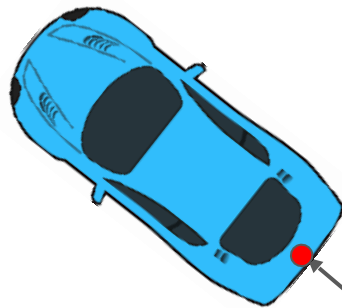
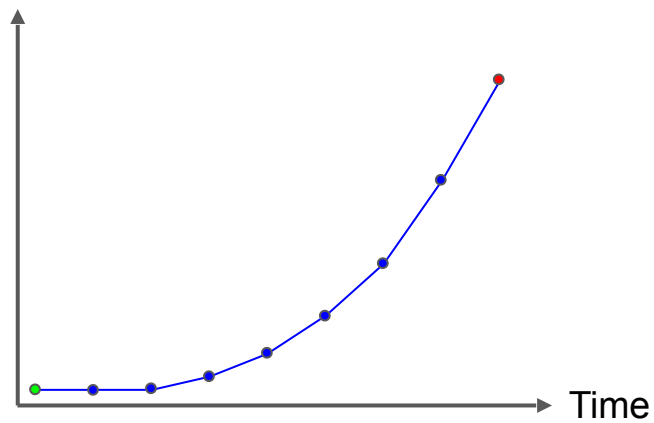




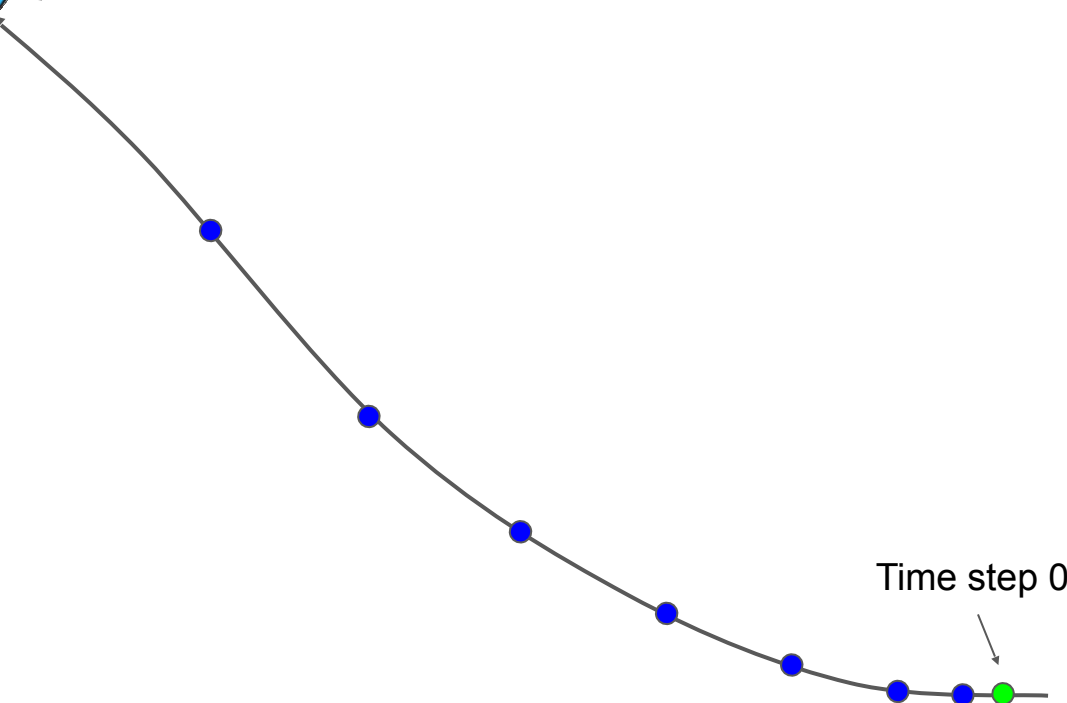
Longitude



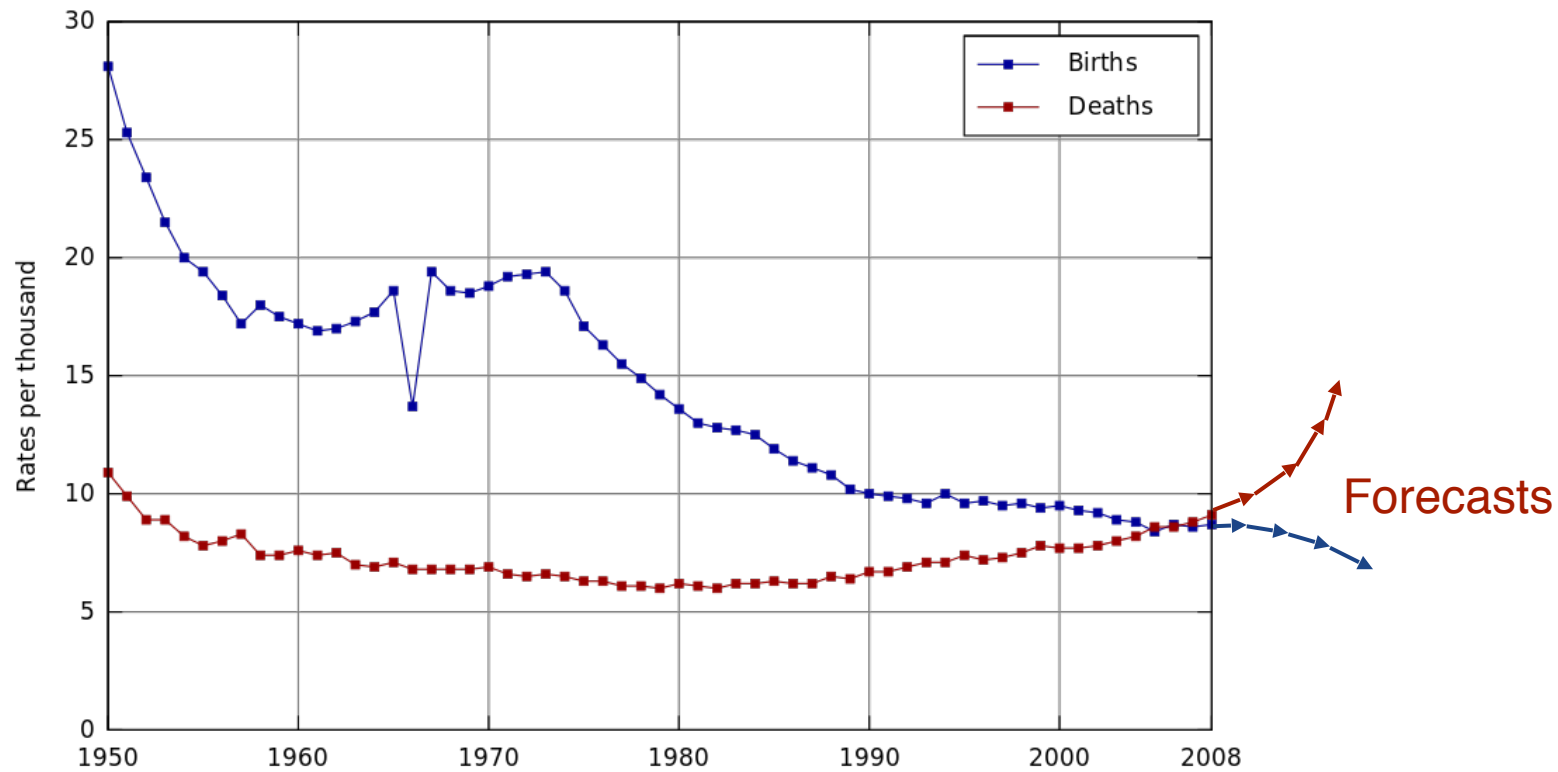
Latitude

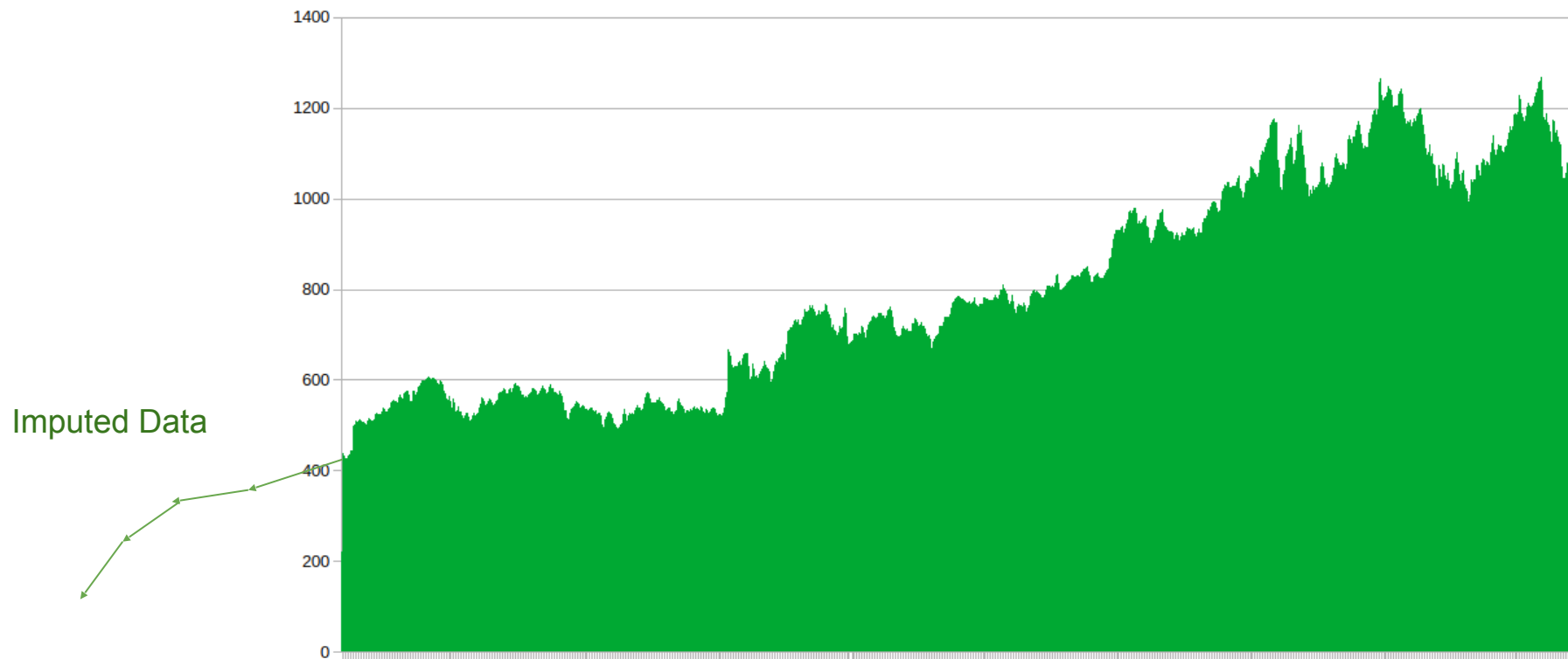


Now

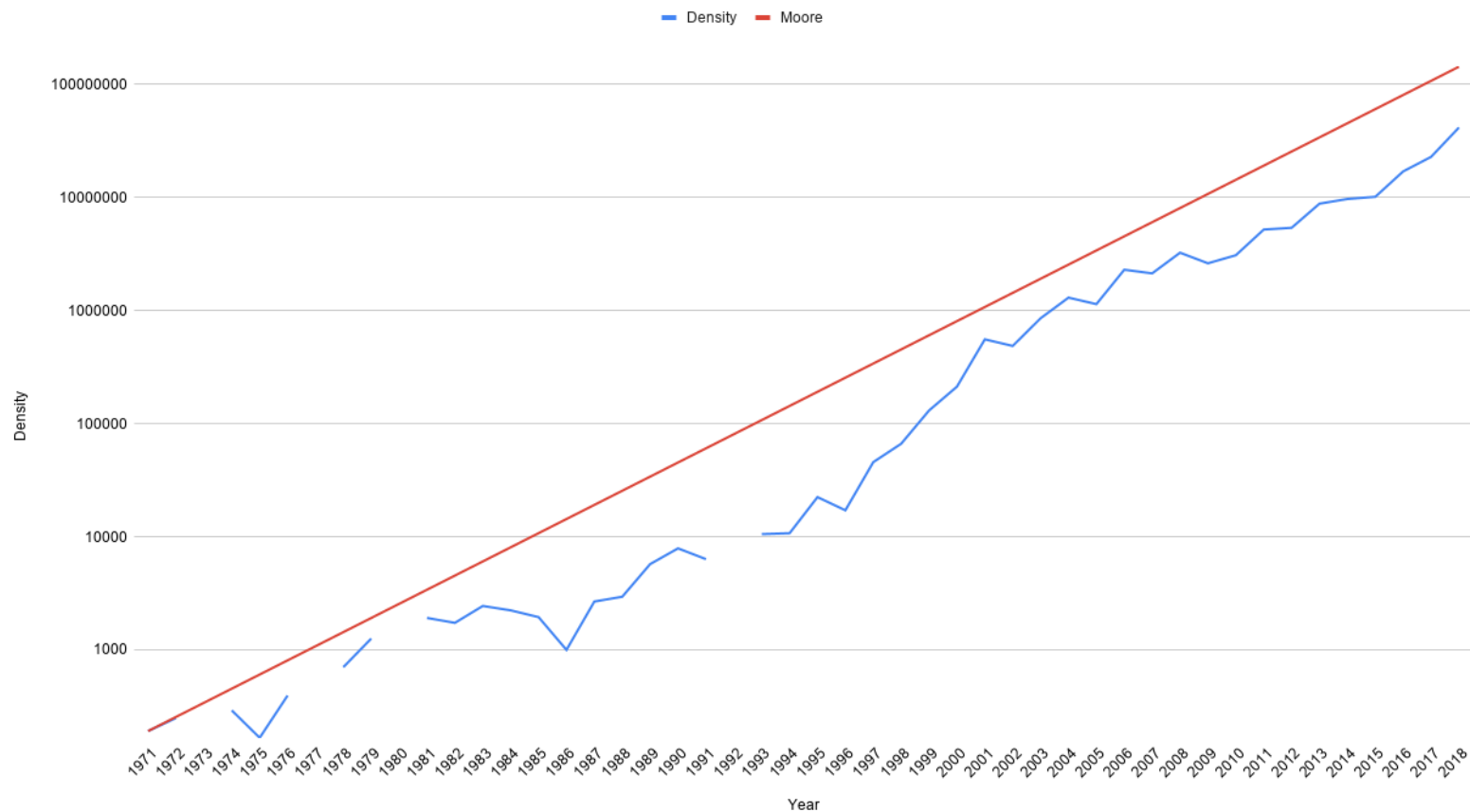


Birth and Death Rate in Japan

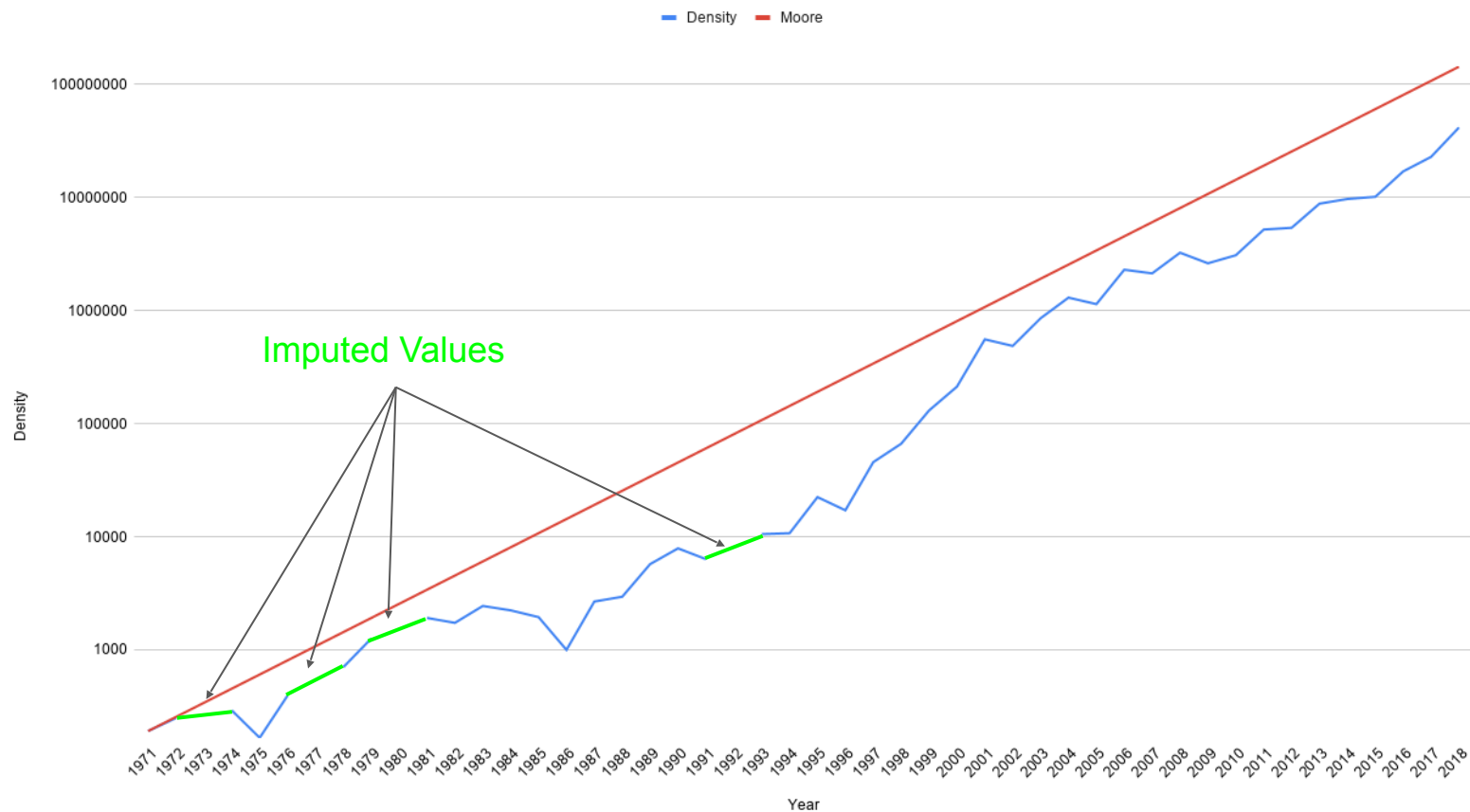




Density vs. Year

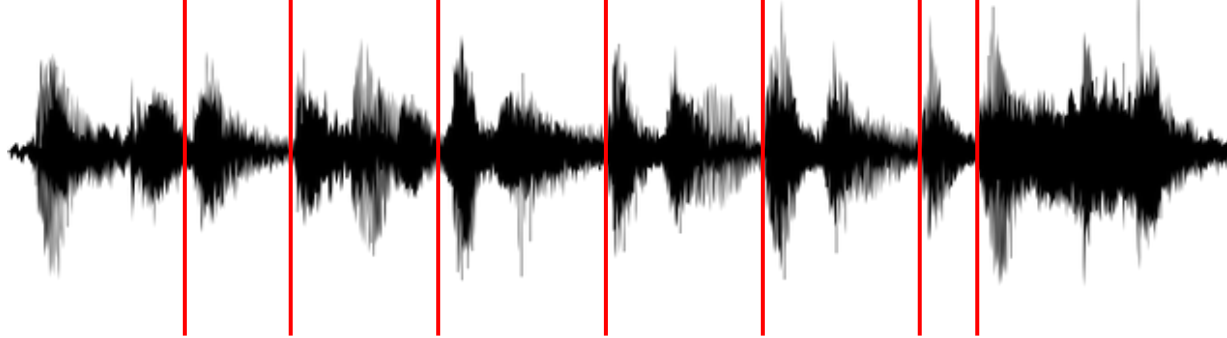


Density vs. Year

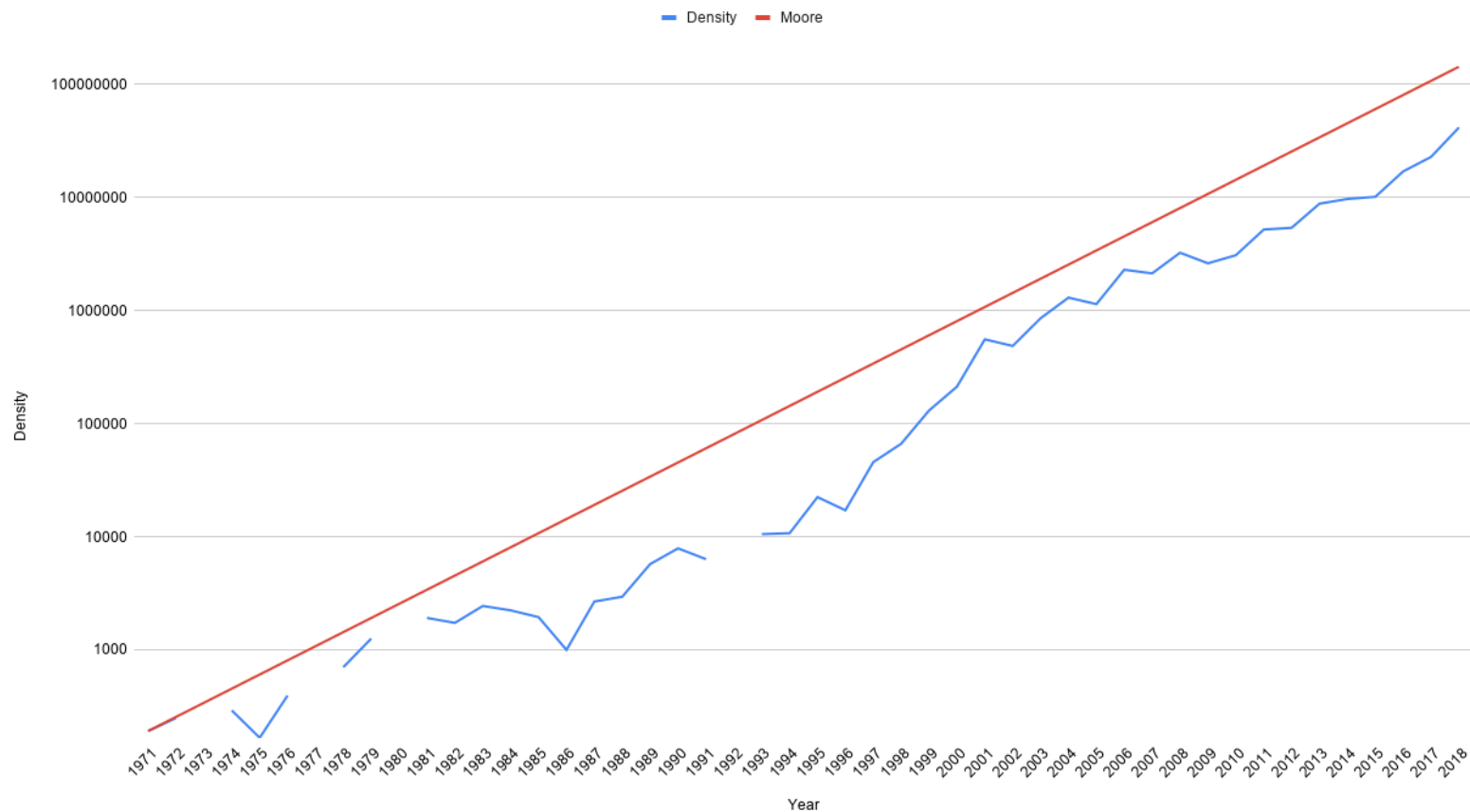


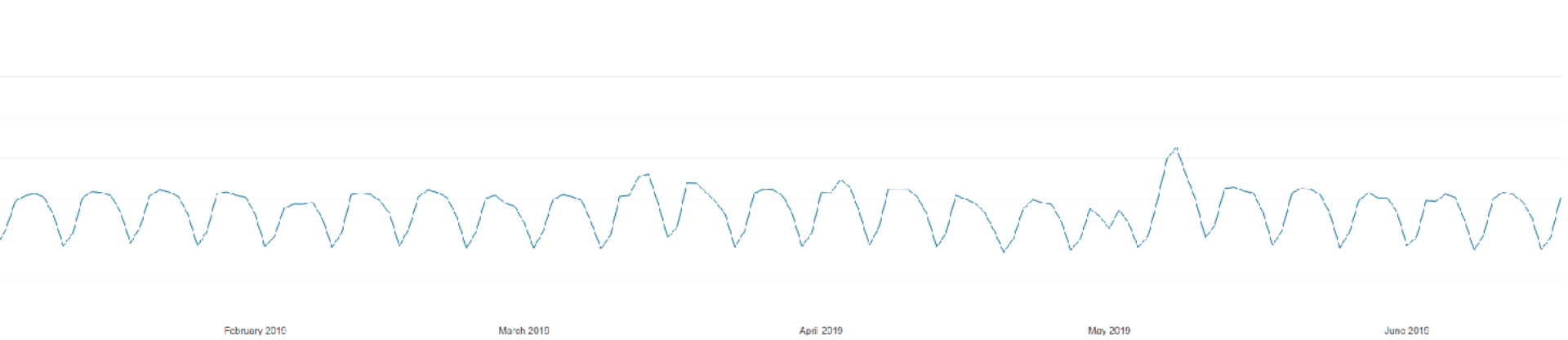


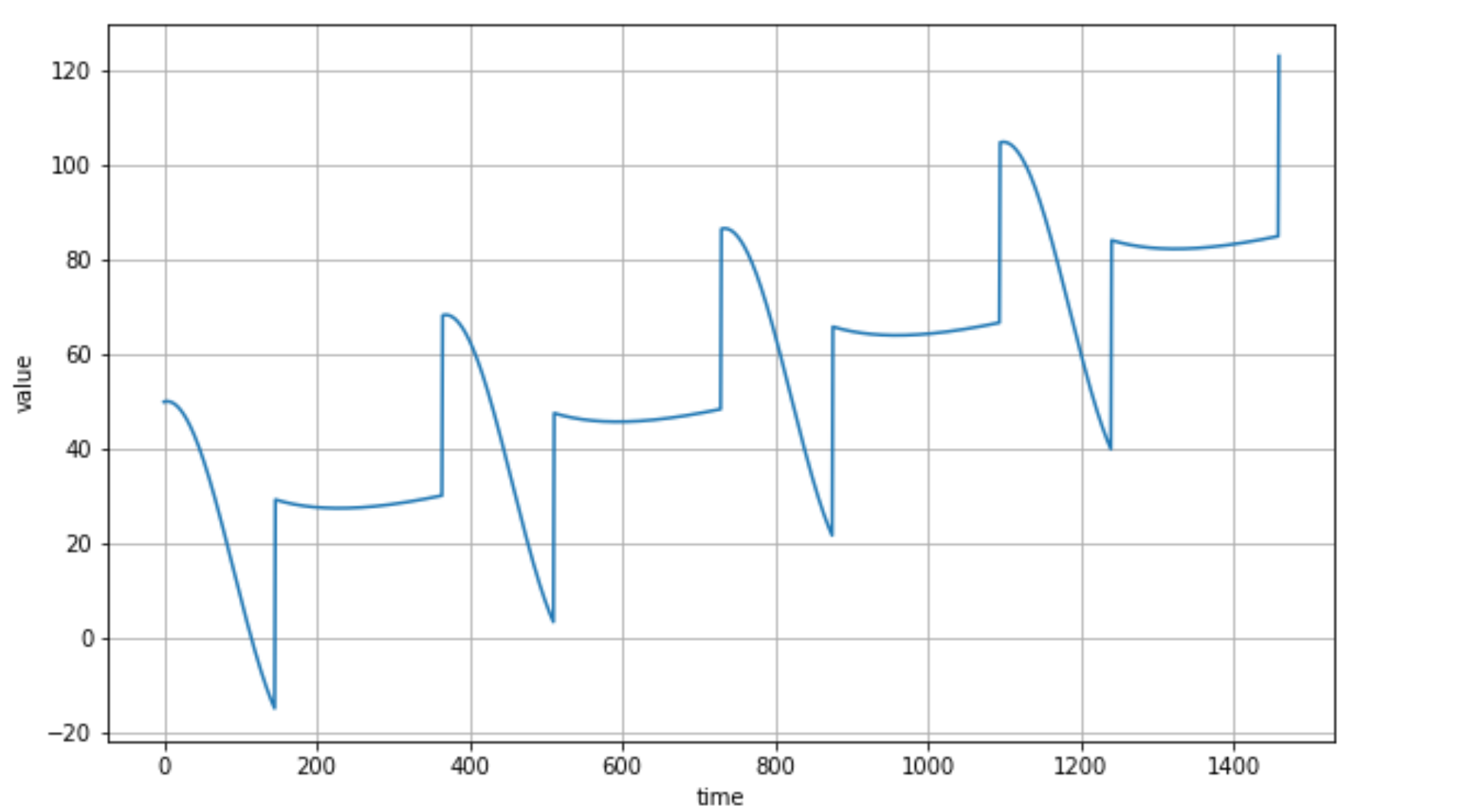
Today we're teaching coding neural layers in Tensorflow

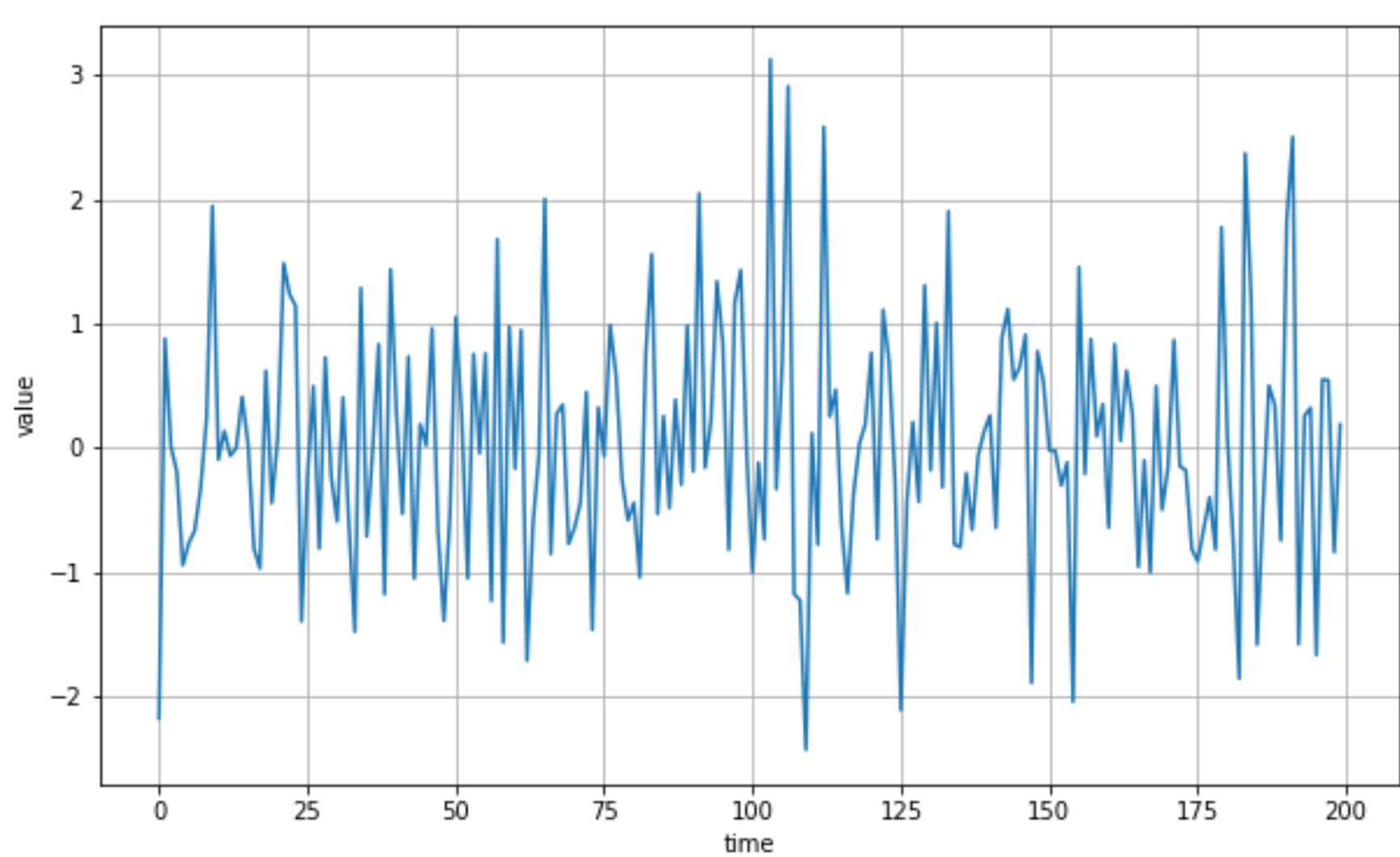


Density vs. Year

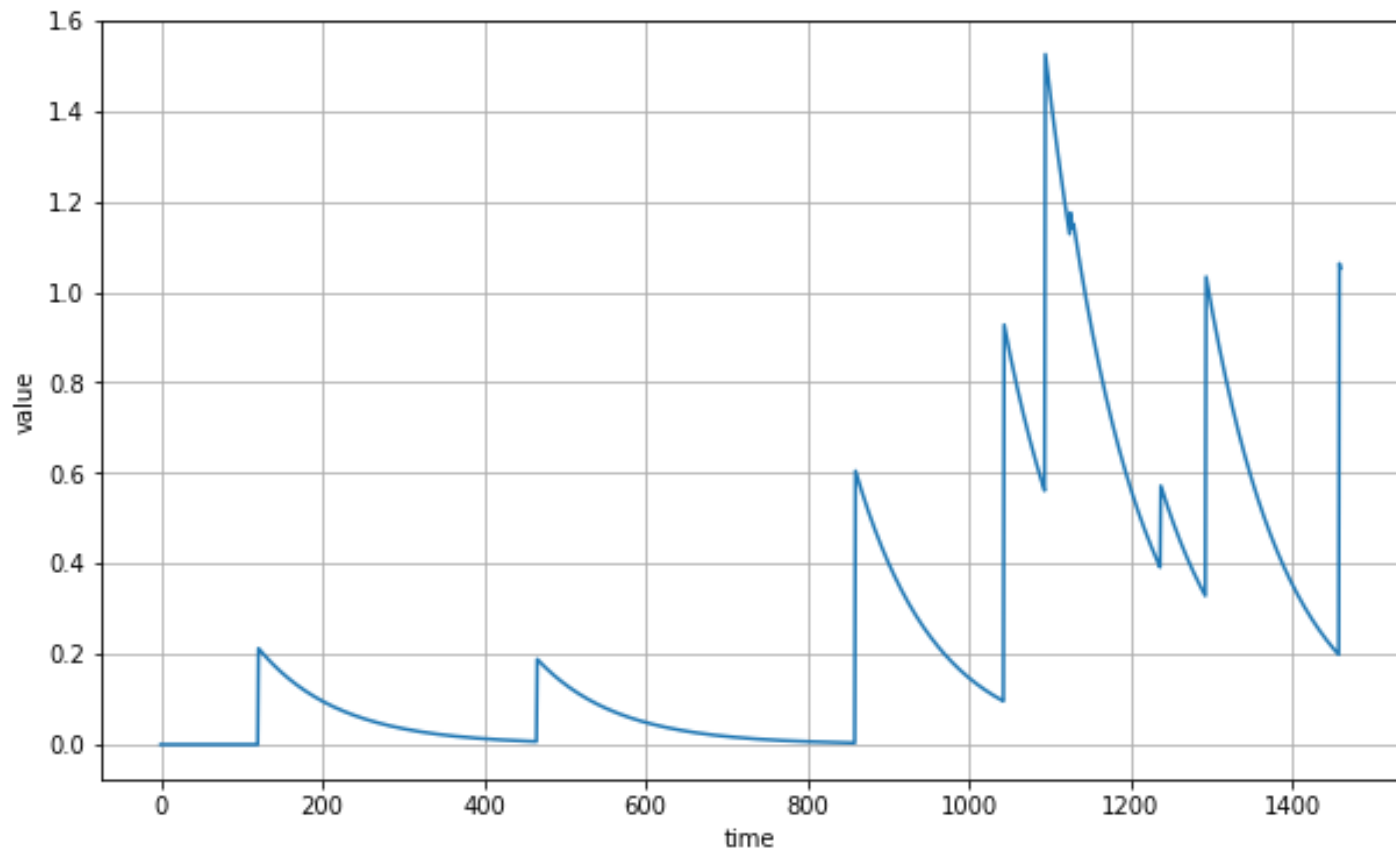




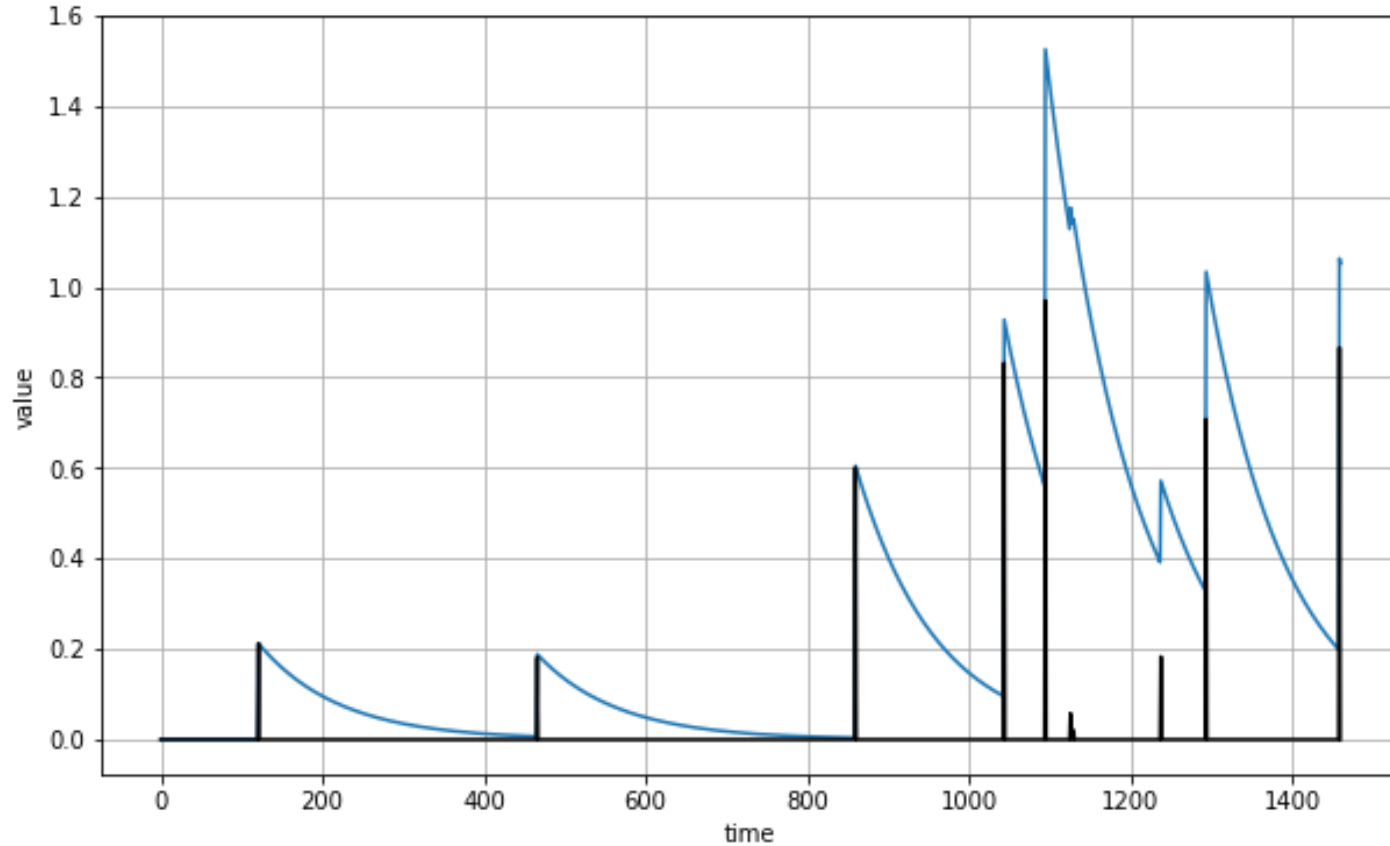




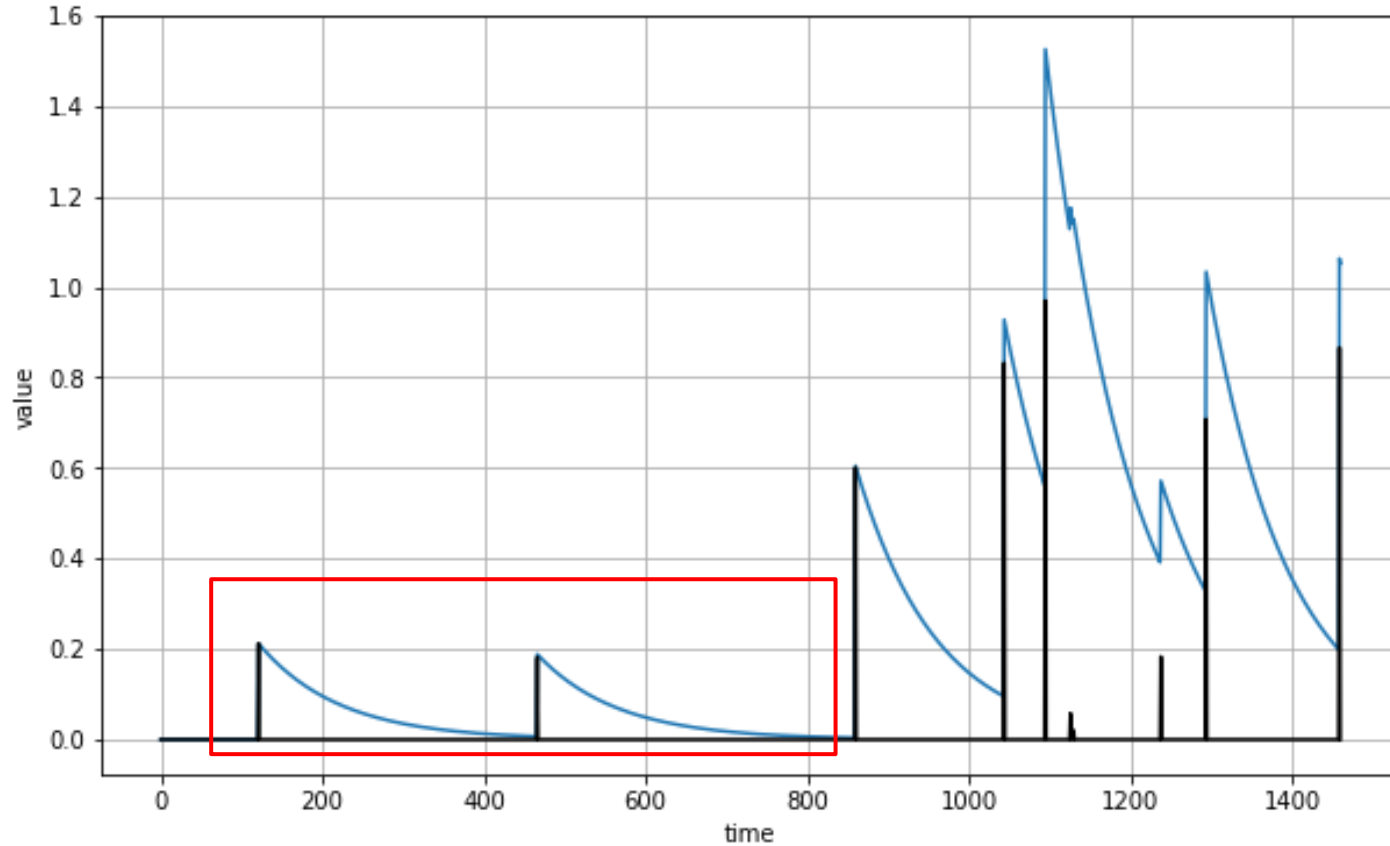
Autocorrelation



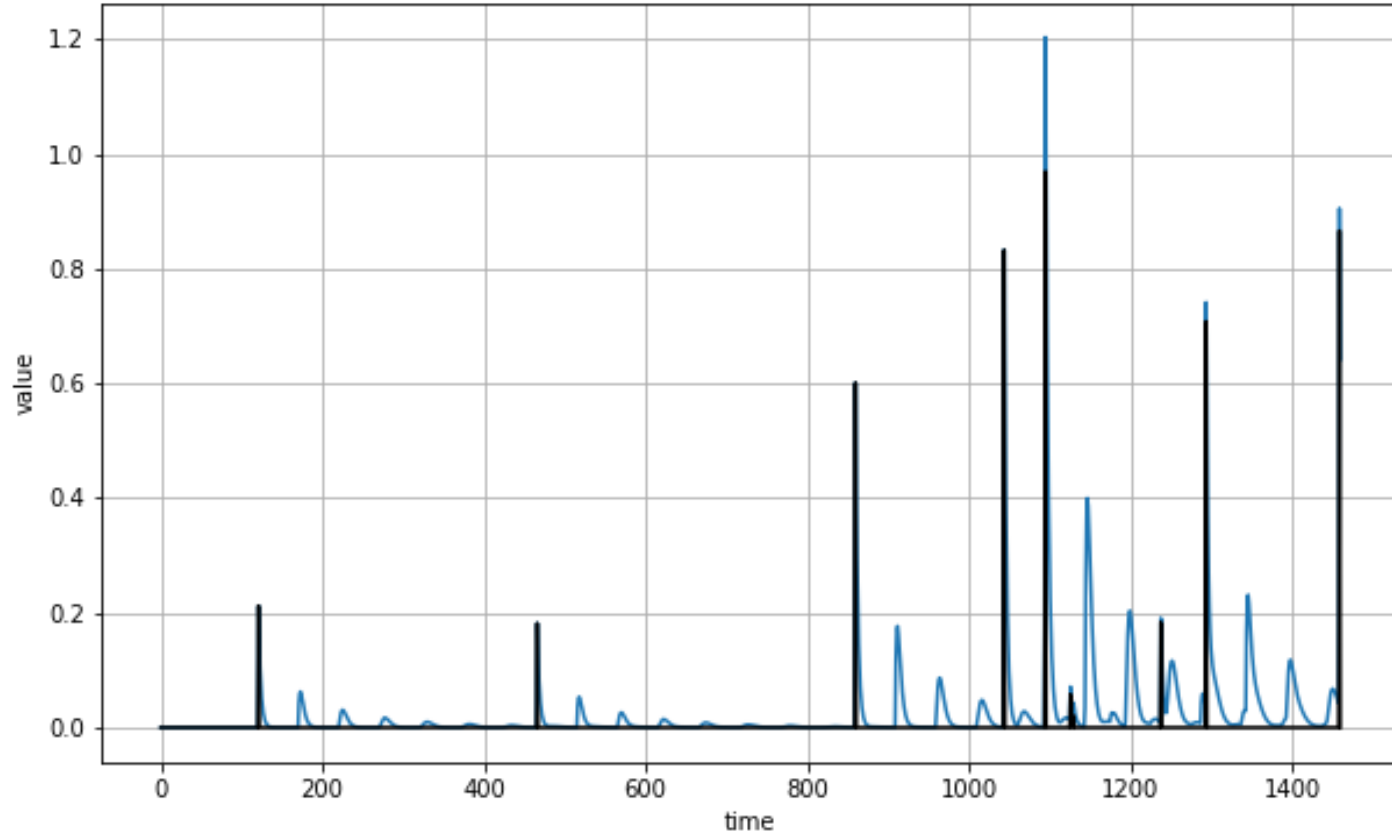
$$v(t) = 0.99 \times v(t-1) + \text{occasional spike}$$



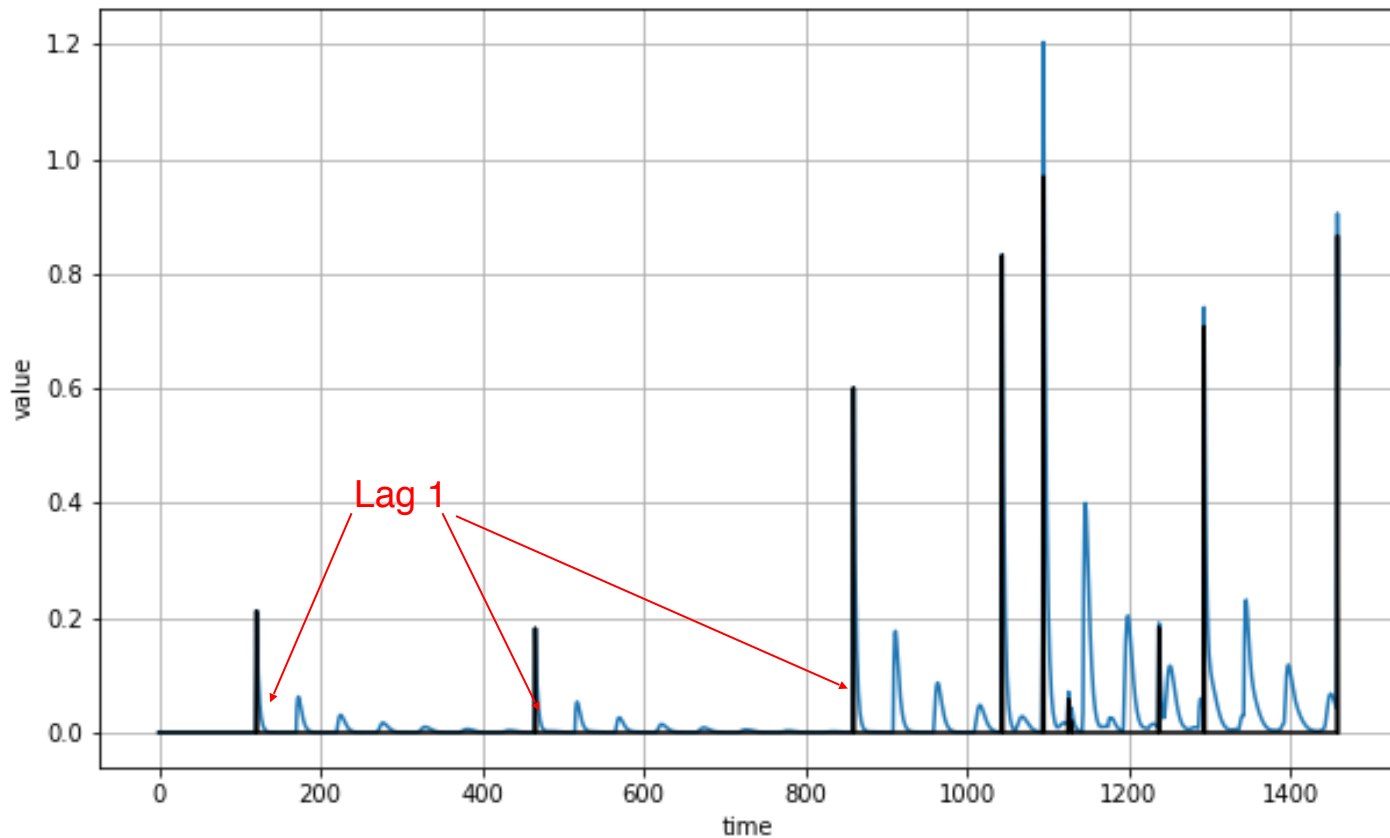
$$v(t) = 0.99 \times v(t-1) + \text{occasional spike}$$



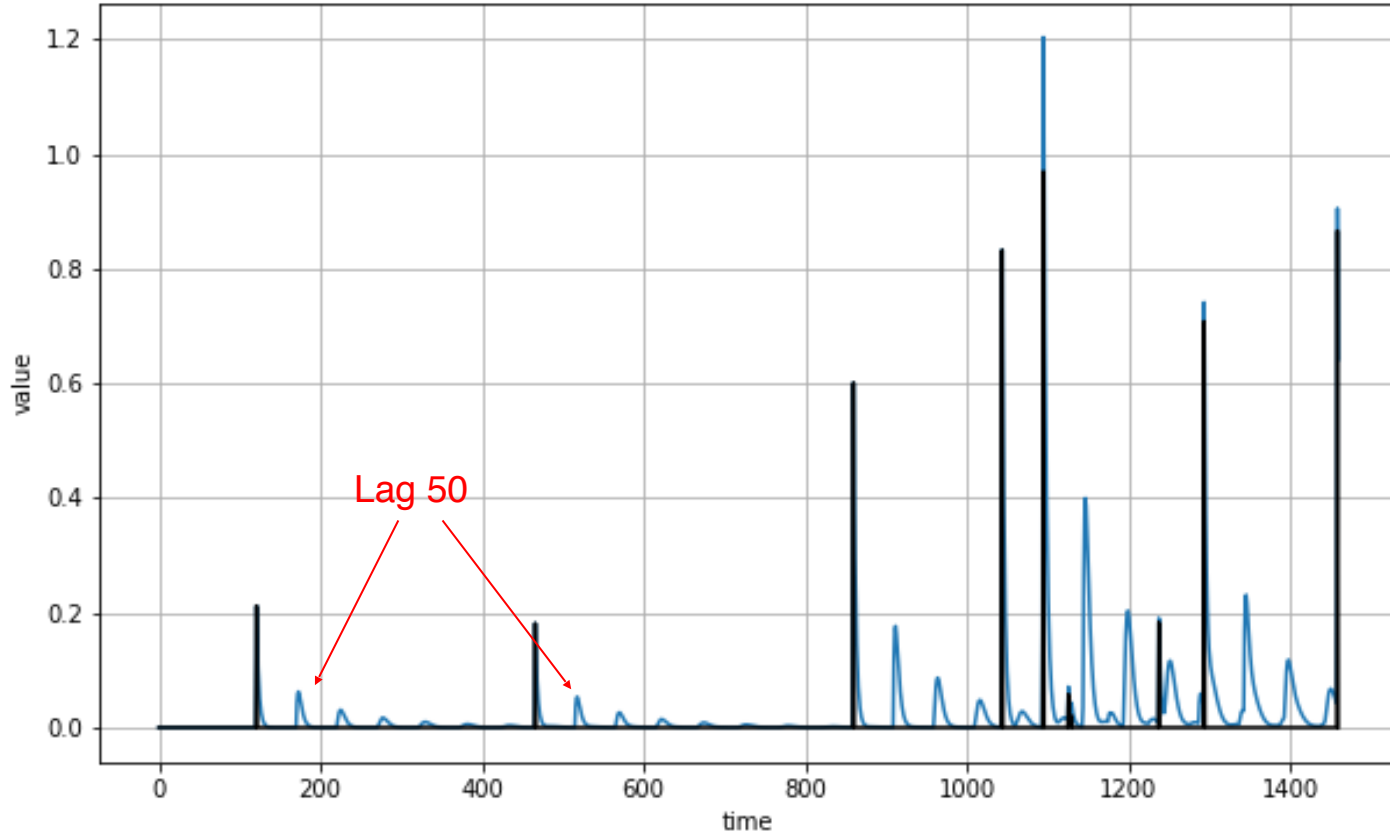
$$v(t) = 0.7 \times v(t-1) + 0.2 \times v(t-50) + \text{occasional spike}$$



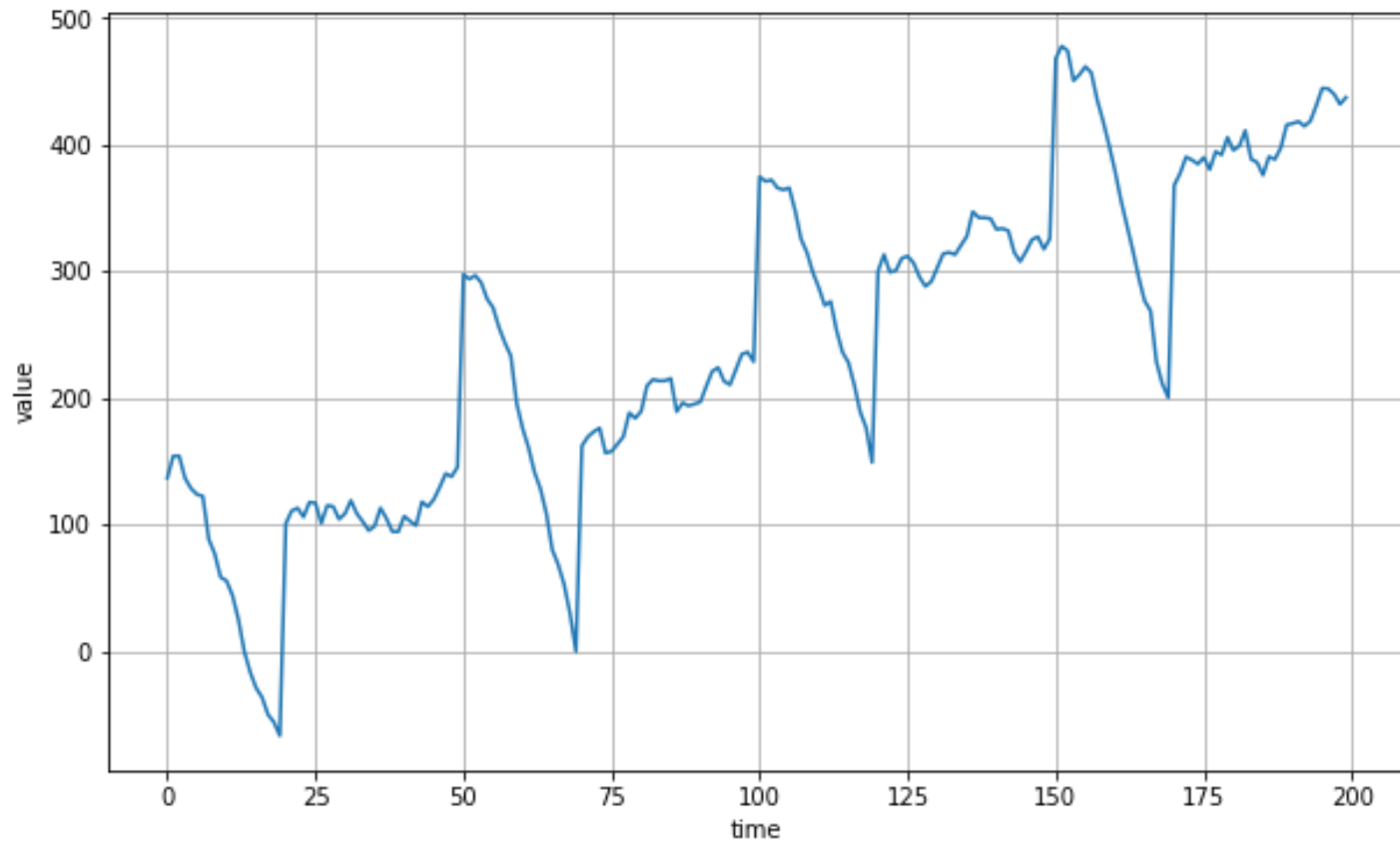
$$v(t) = 0.7 \times v(t-1) + 0.2 \times v(t-50) + \text{occasional spike}$$



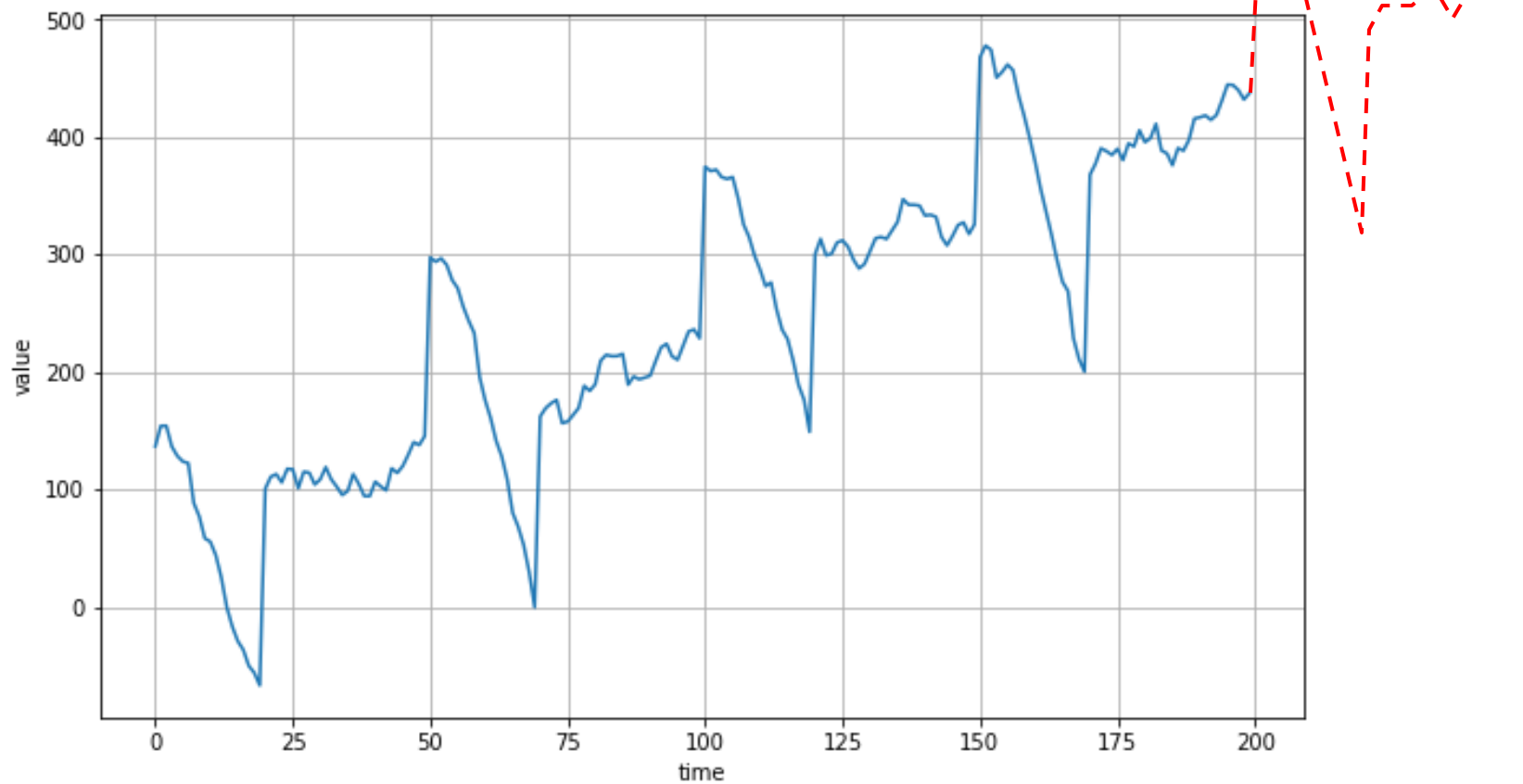
$$v(t) = 0.7 \times v(t-1) + 0.2 \times v(t-50) + \text{occasional spike}$$



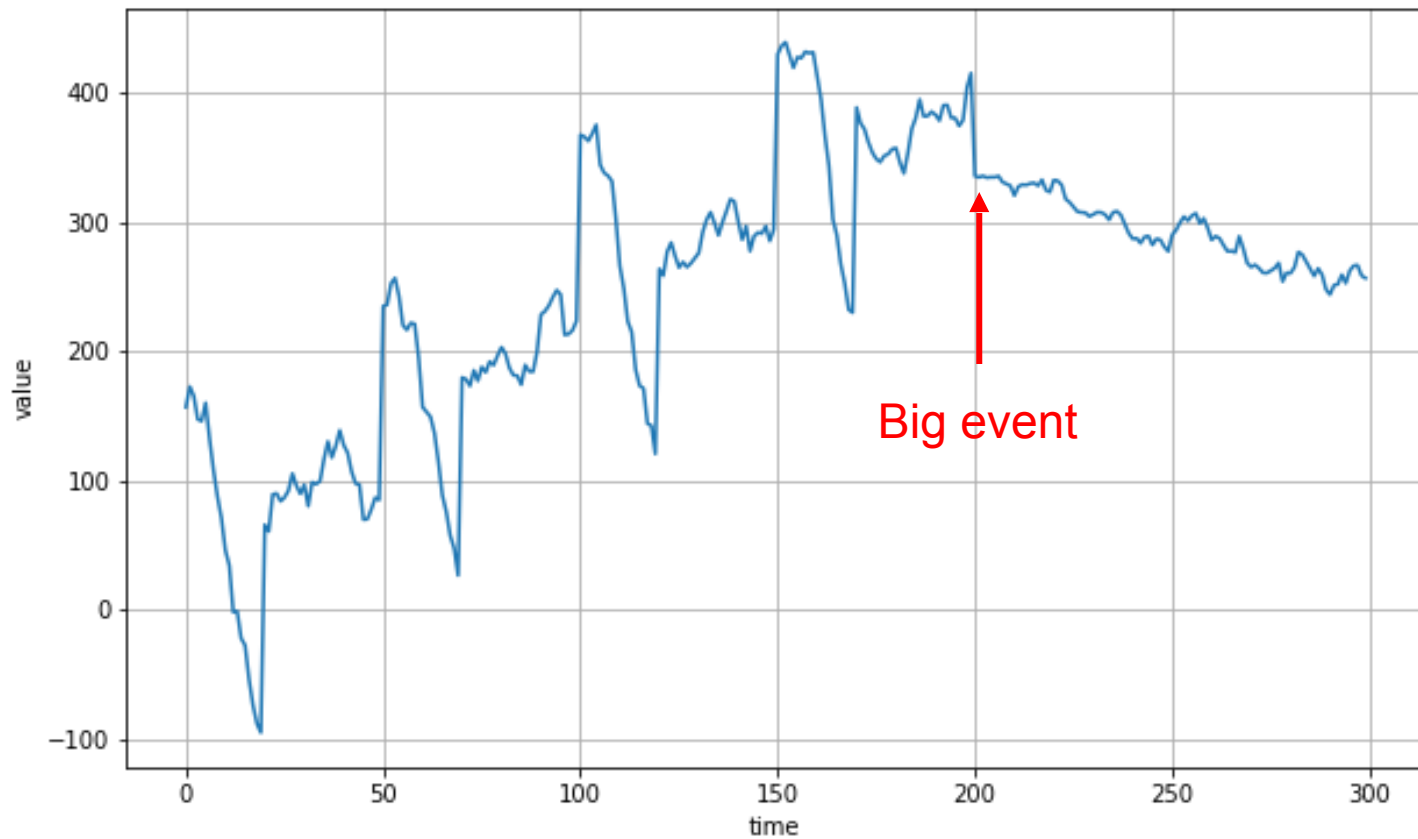
Trend + Seasonality + Autocorrelation + Noise



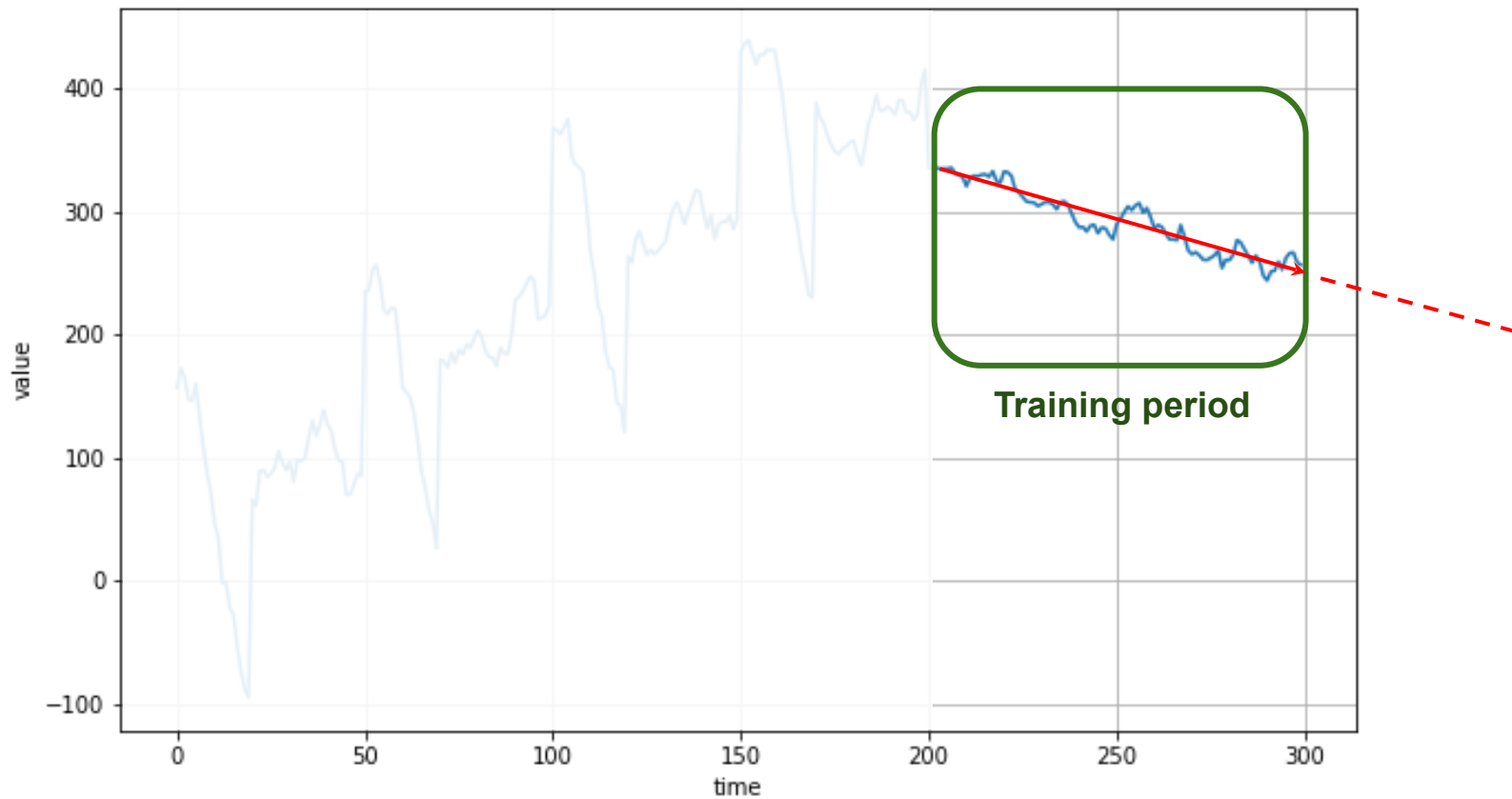
Forecast Learned Patterns



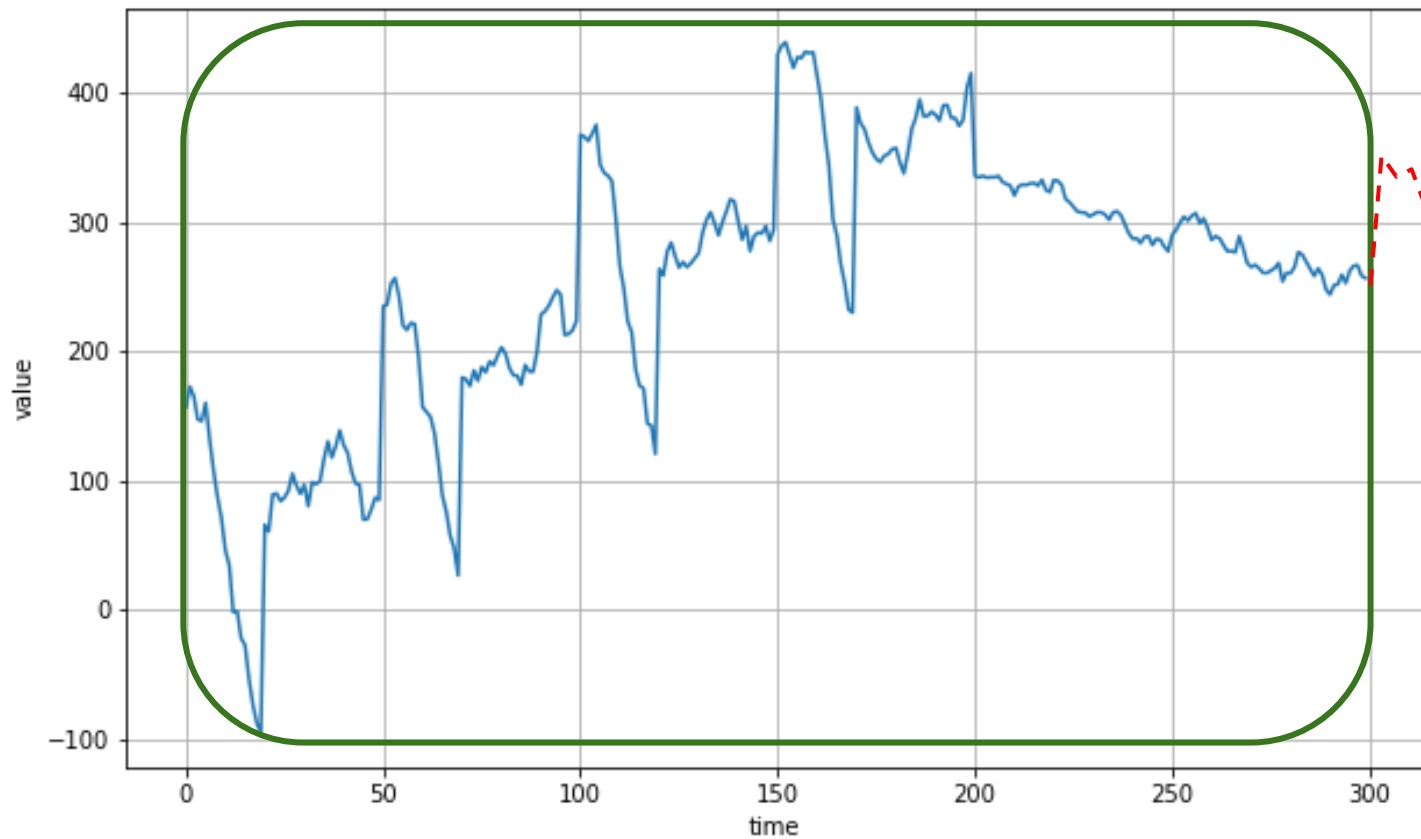
Non-Stationary Time Series



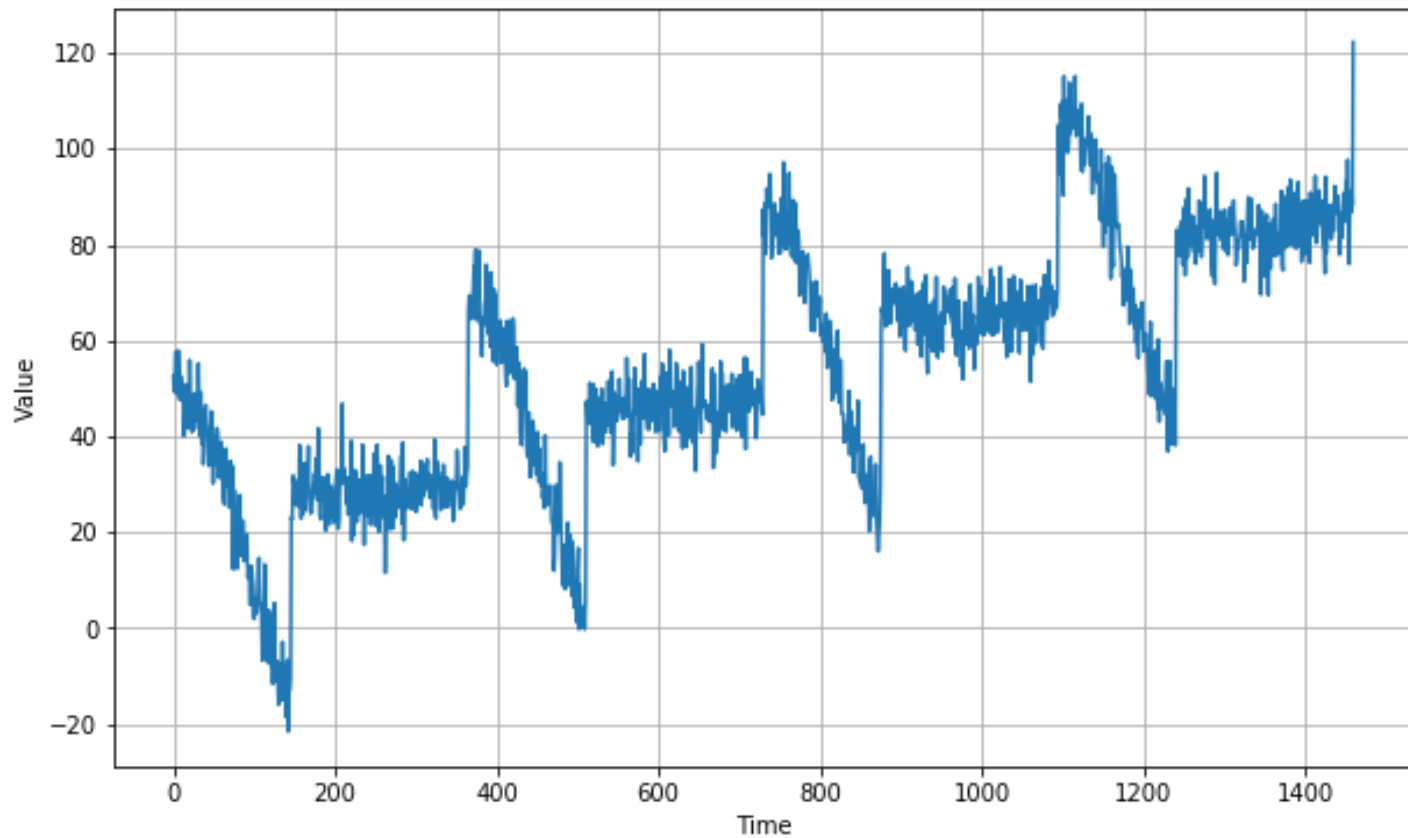
Non-Stationary Time Series



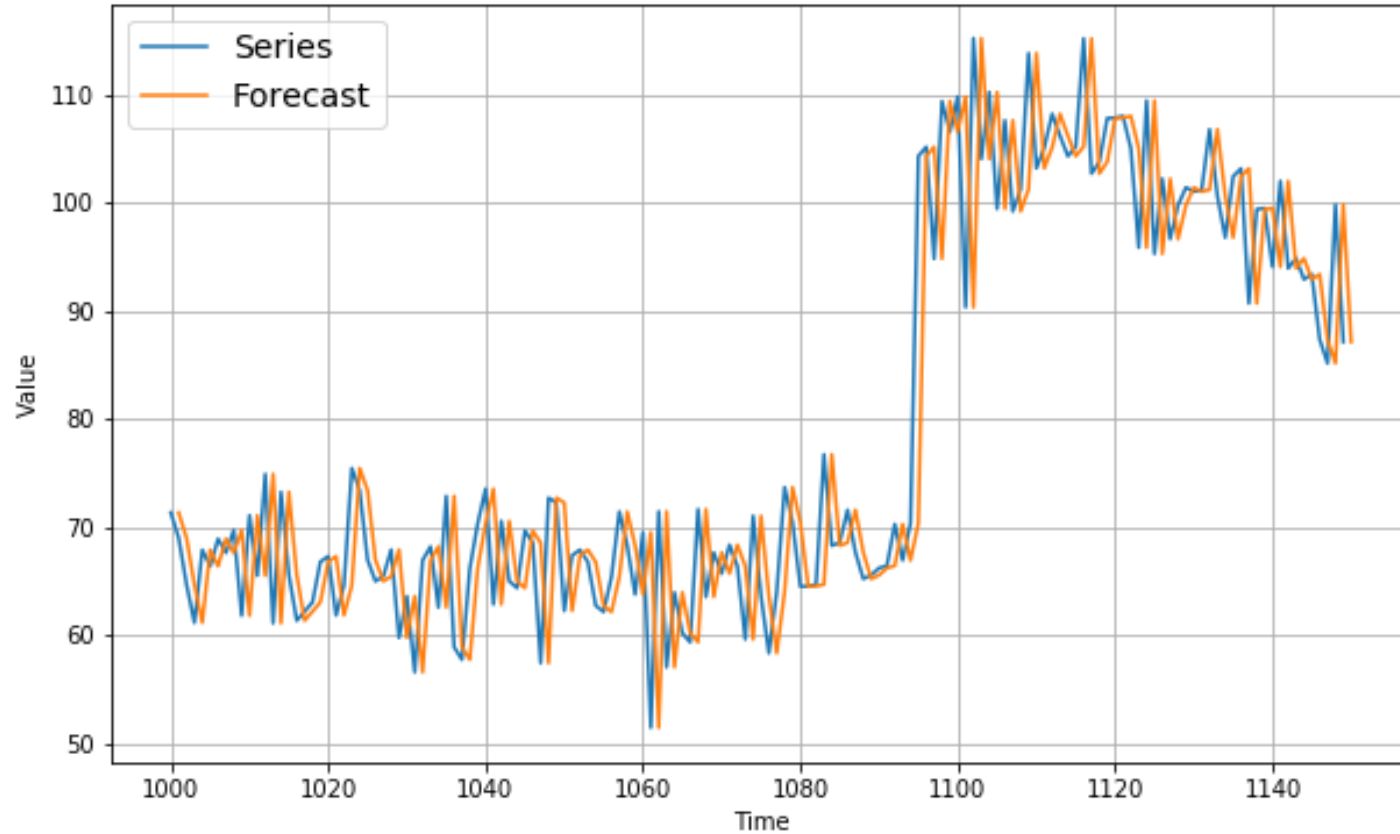
Non-Stationary Time Series



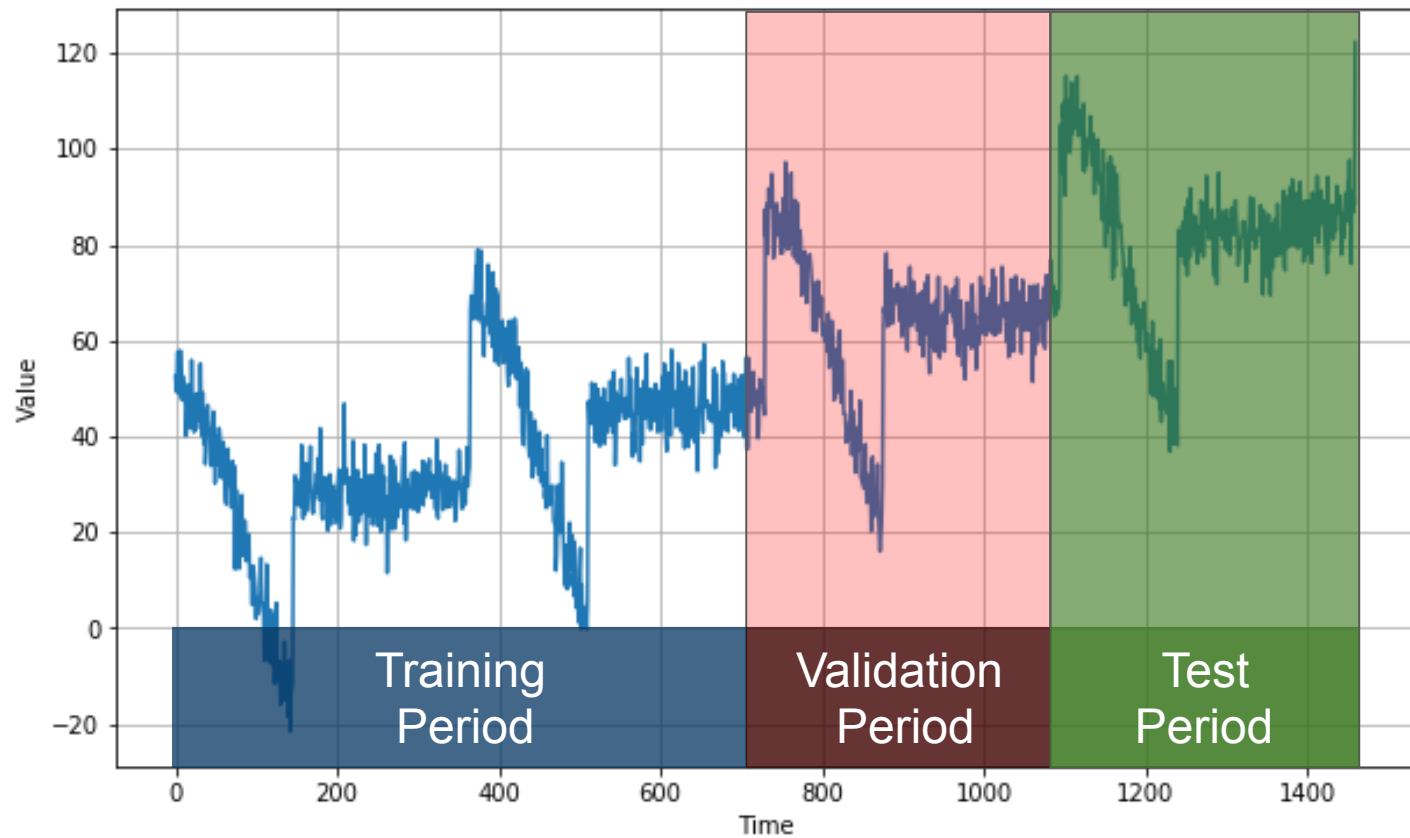
Trend + Seasonality + Noise



Naive Forecasting



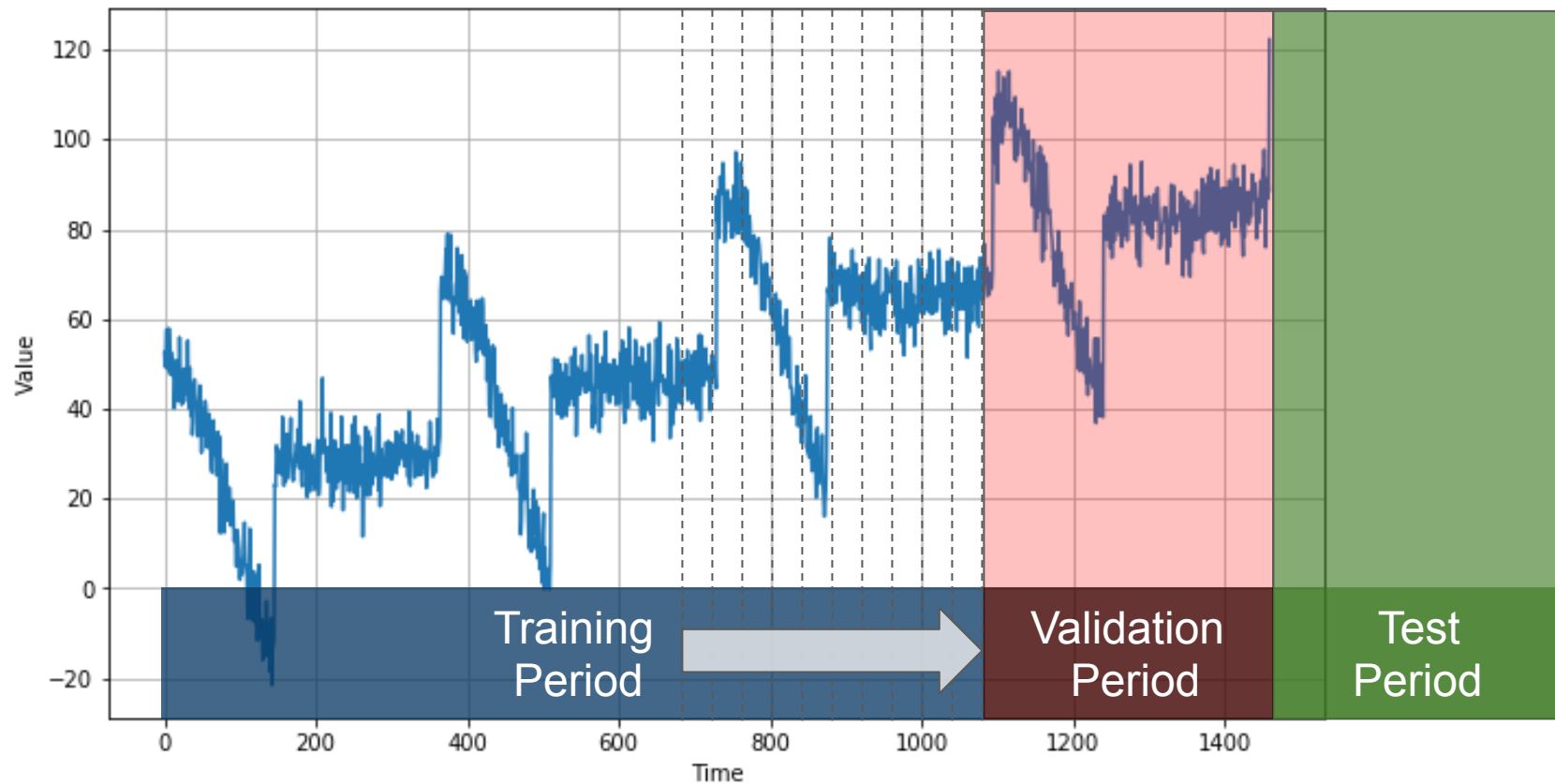
Fixed Partitioning



Fixed Partitioning



Roll-Forward Partitioning



Metrics

```
errors = forecasts - actual
```

```
mse = np.square(errors).mean()
```

```
rmse = np.sqrt(mse)
```

```
mae = np.abs(errors).mean()
```

```
mape = np.abs(errors / x_valid).mean()
```

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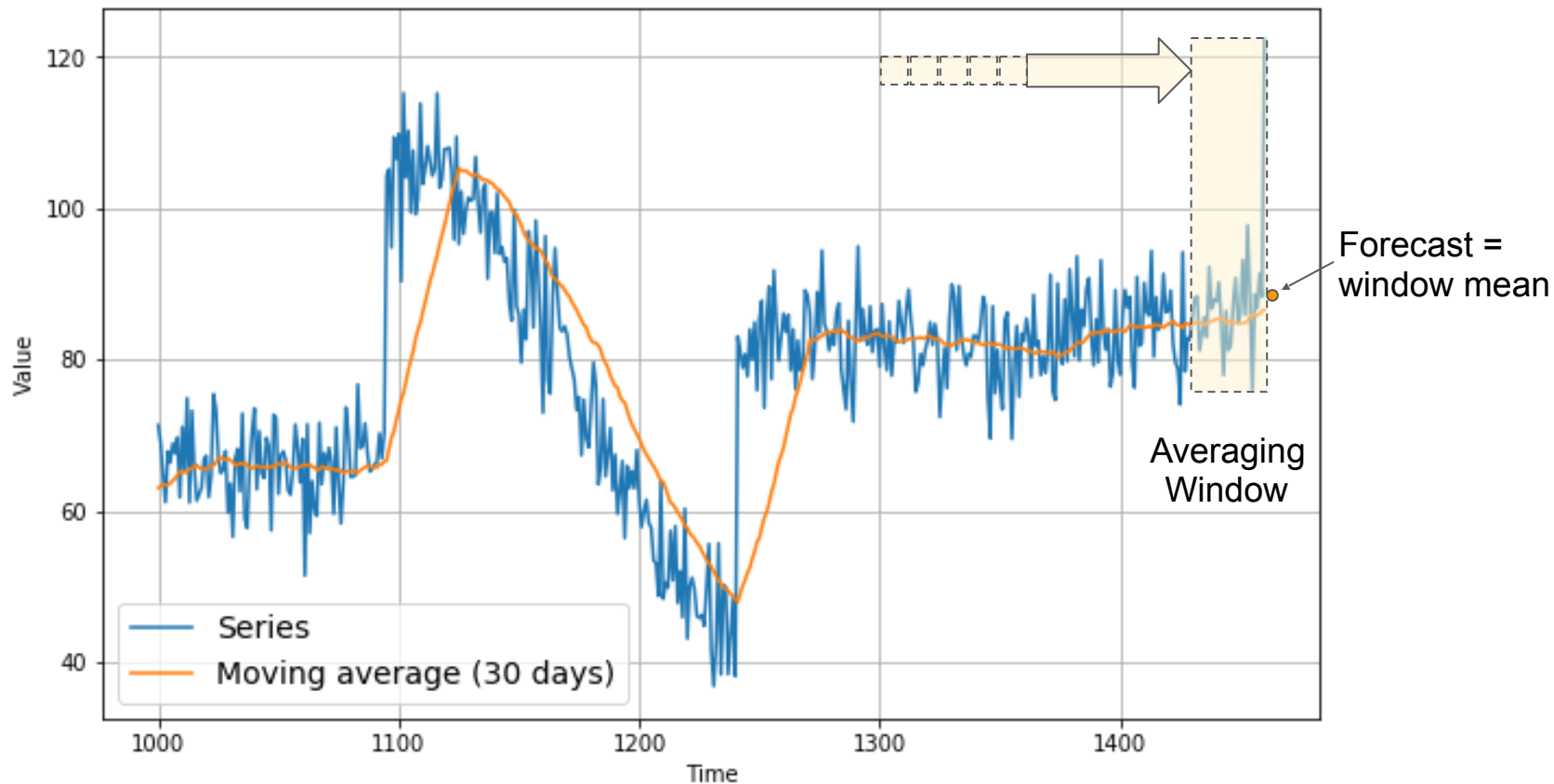
```
mape = np.abs(errors / x_valid).mean()
```

Naive Forecast MAE

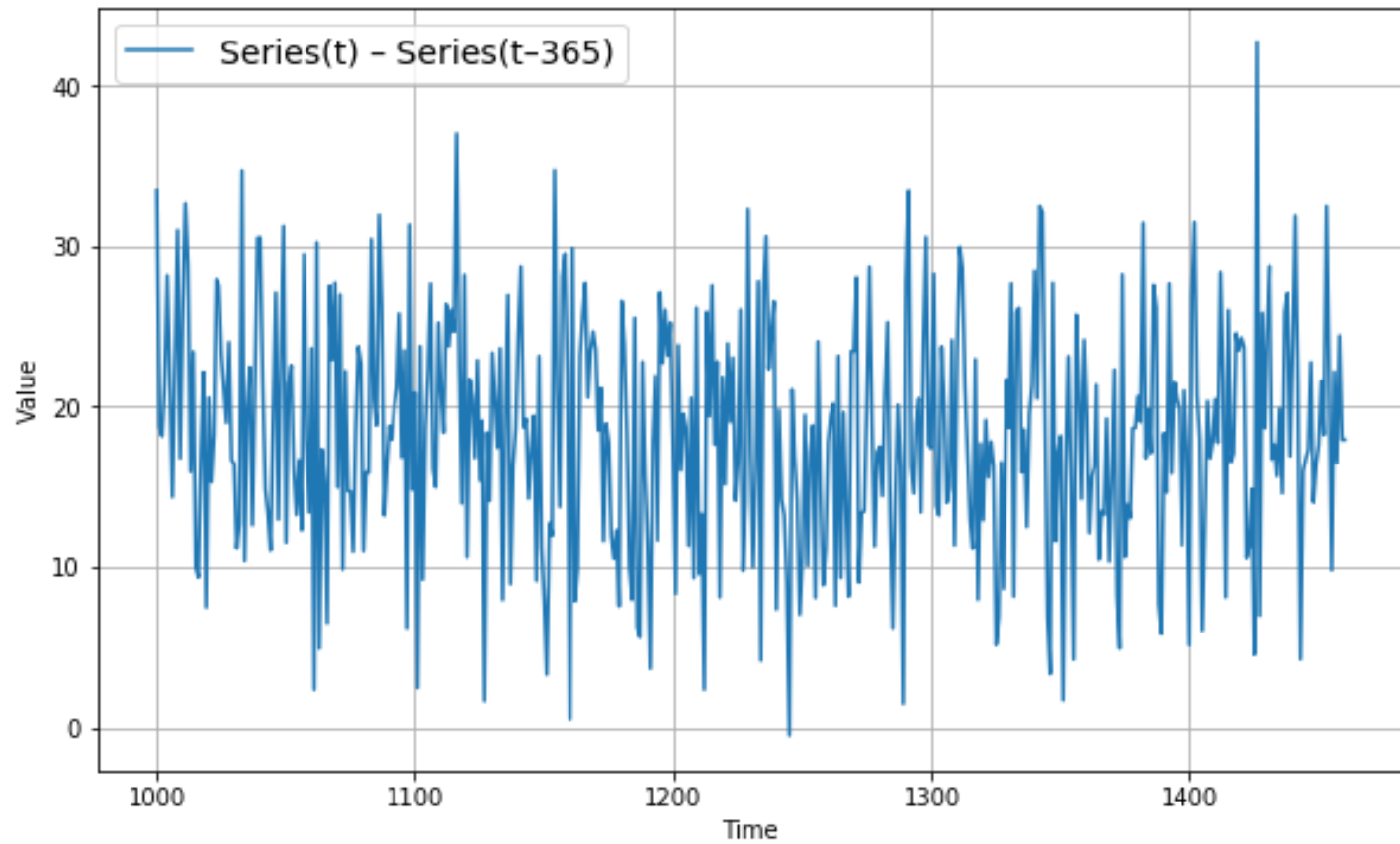
```
keras.metrics.mean_absolute_error(x_valid, naive_forecast).numpy()
```

```
5.937908515321673
```

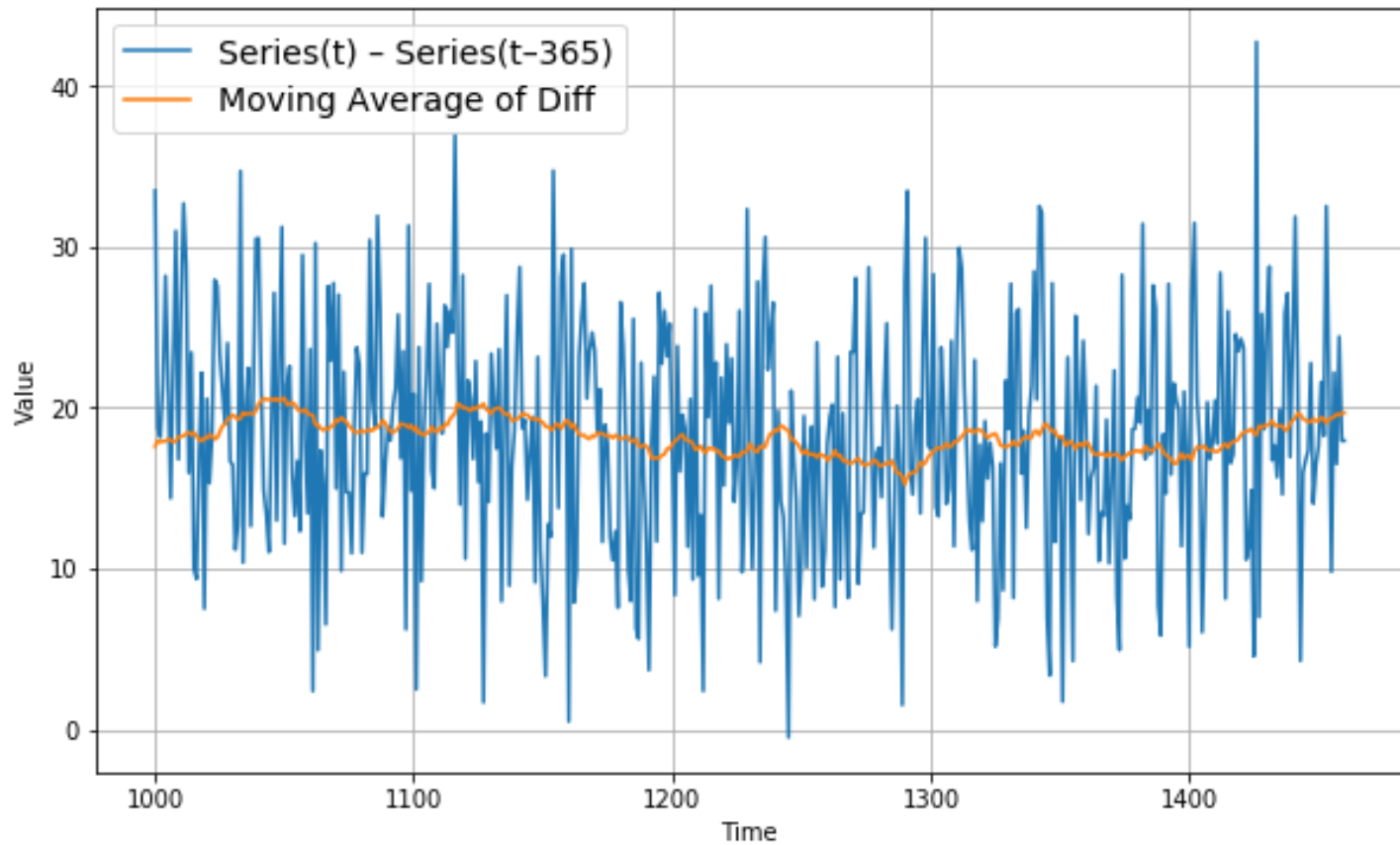
Moving Average



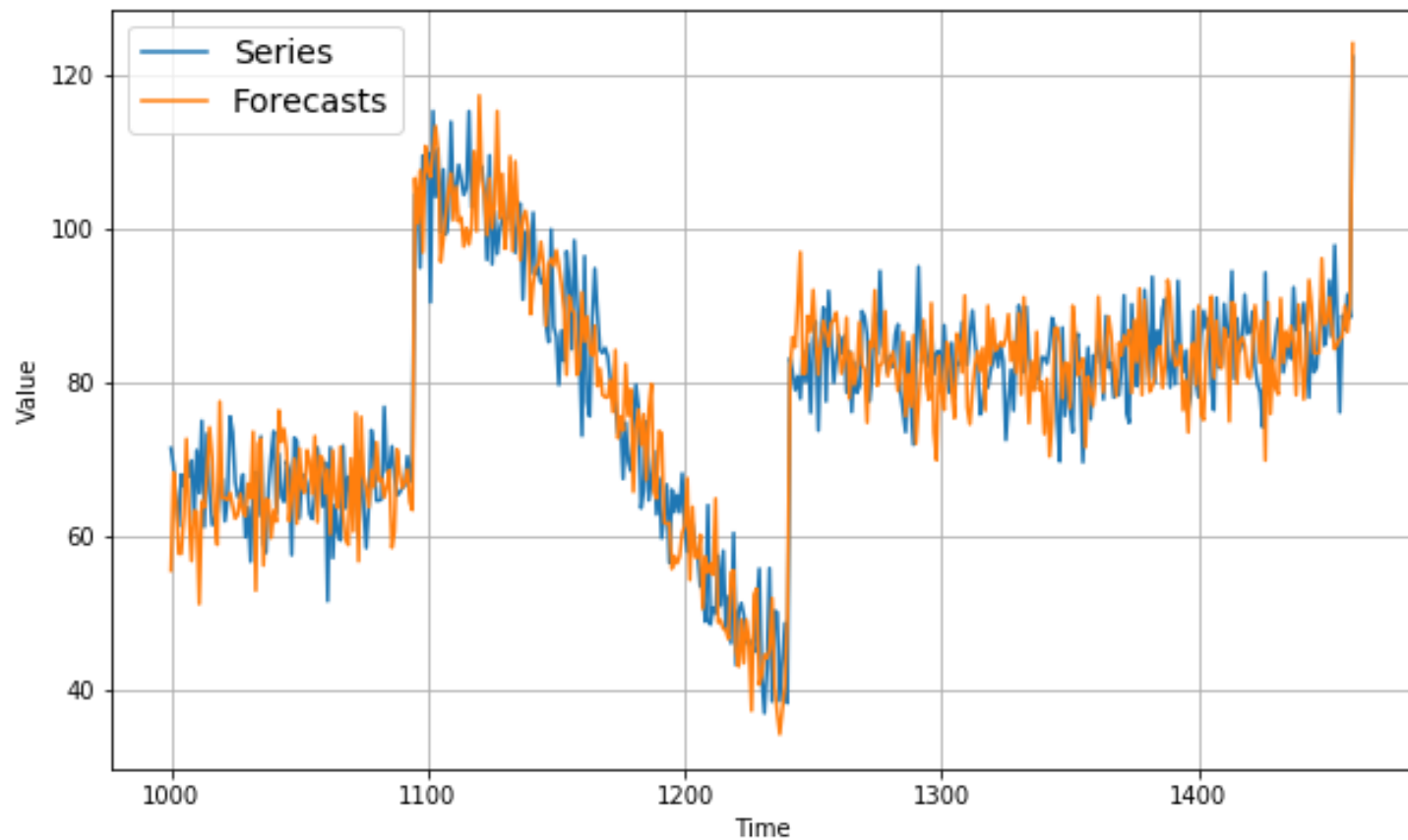
Differencing



Moving Average on Differenced Time Series

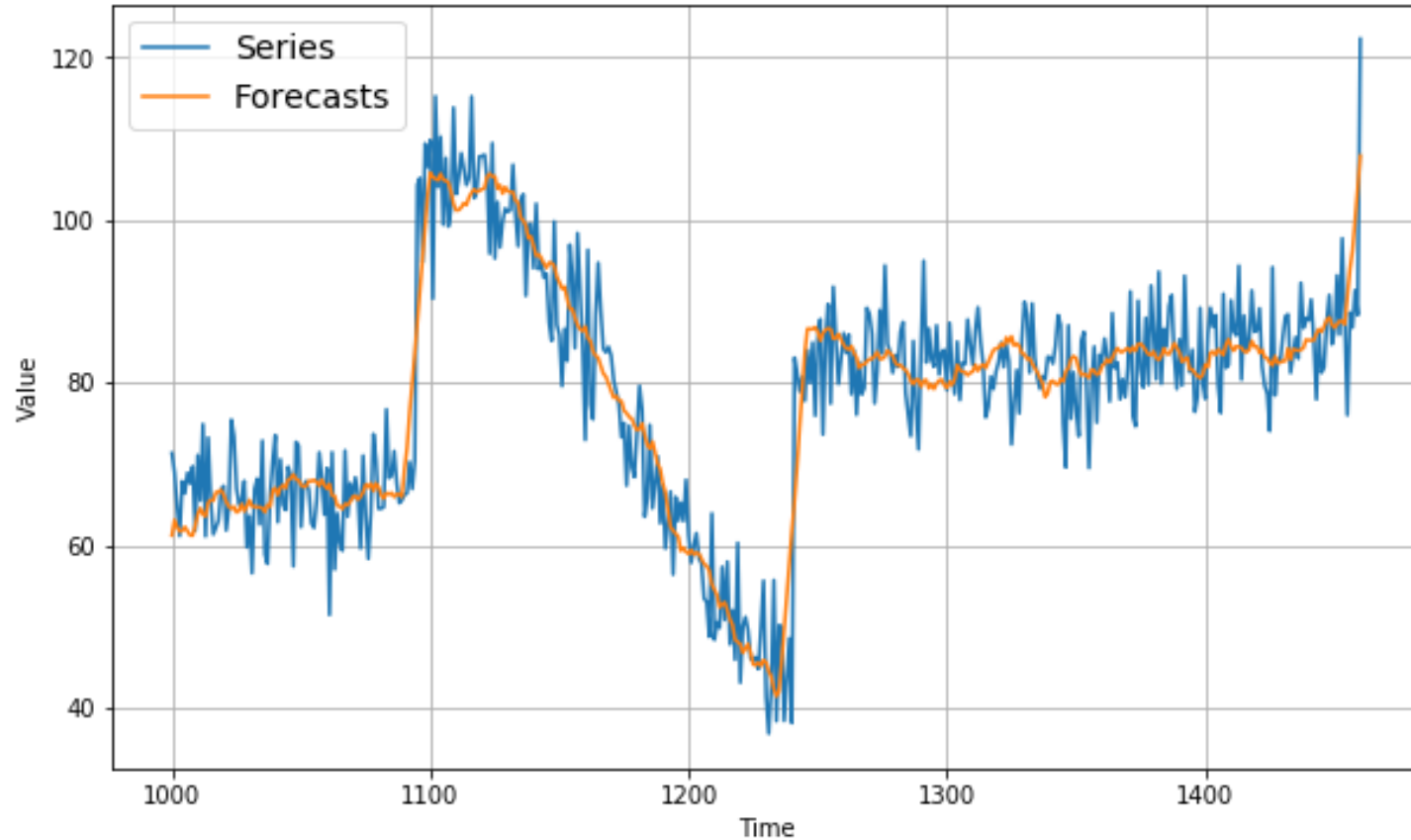


Restoring the Trend and Seasonality



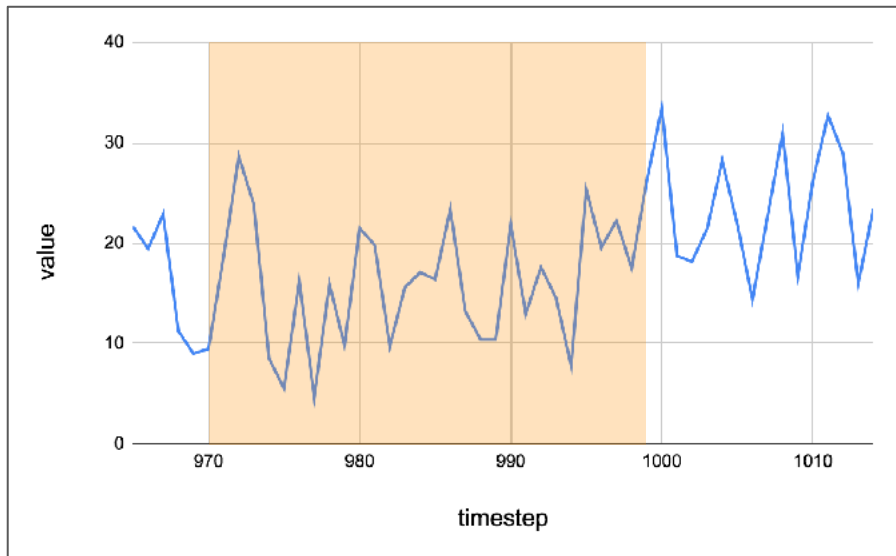
Forecasts = moving average of differenced series + series($t - 365$)

Smoothing Both Past and Present Values

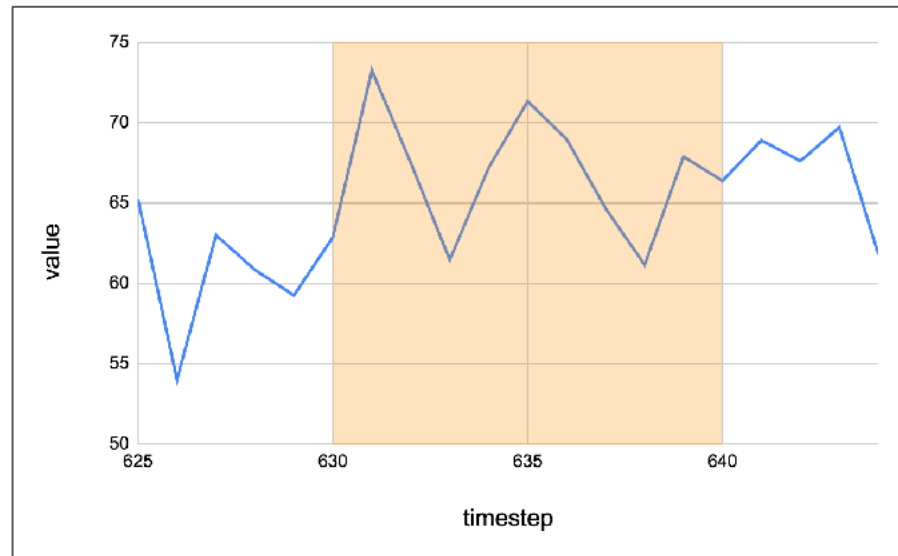


Forecasts = trailing moving average of differenced series + centered moving average of past series ($t - 365$)

Trailing Moving Average of Differenced Series
(zoomed at t_{1000} , window size = 30)



Centered Moving Average of Past Series ($t - 365$)
(zoomed at t_{635} , window size = 11)



$$\text{TMA}_{t_{1000}} = (v_{t_{970}} + v_{t_{971}} + v_{t_{972}} + \dots + v_{t_{999}}) /$$

$$\text{CMA}_{t_{635}} = (v_{t_{630}} + v_{t_{631}} + v_{t_{632}} + \dots + v_{t_{640}}) / 11$$

30

$$\text{forecast at } t_{1000} = \text{TMA}_{t_{1000}} + \text{CMA}_{t_{635}}$$