Alicia Ngoc Phan

# BSTA 477 – Winter 2021

Tutorial 4 - March 14th, 2021



Data used: Bike sharing data

Alicia Ngoc Phan

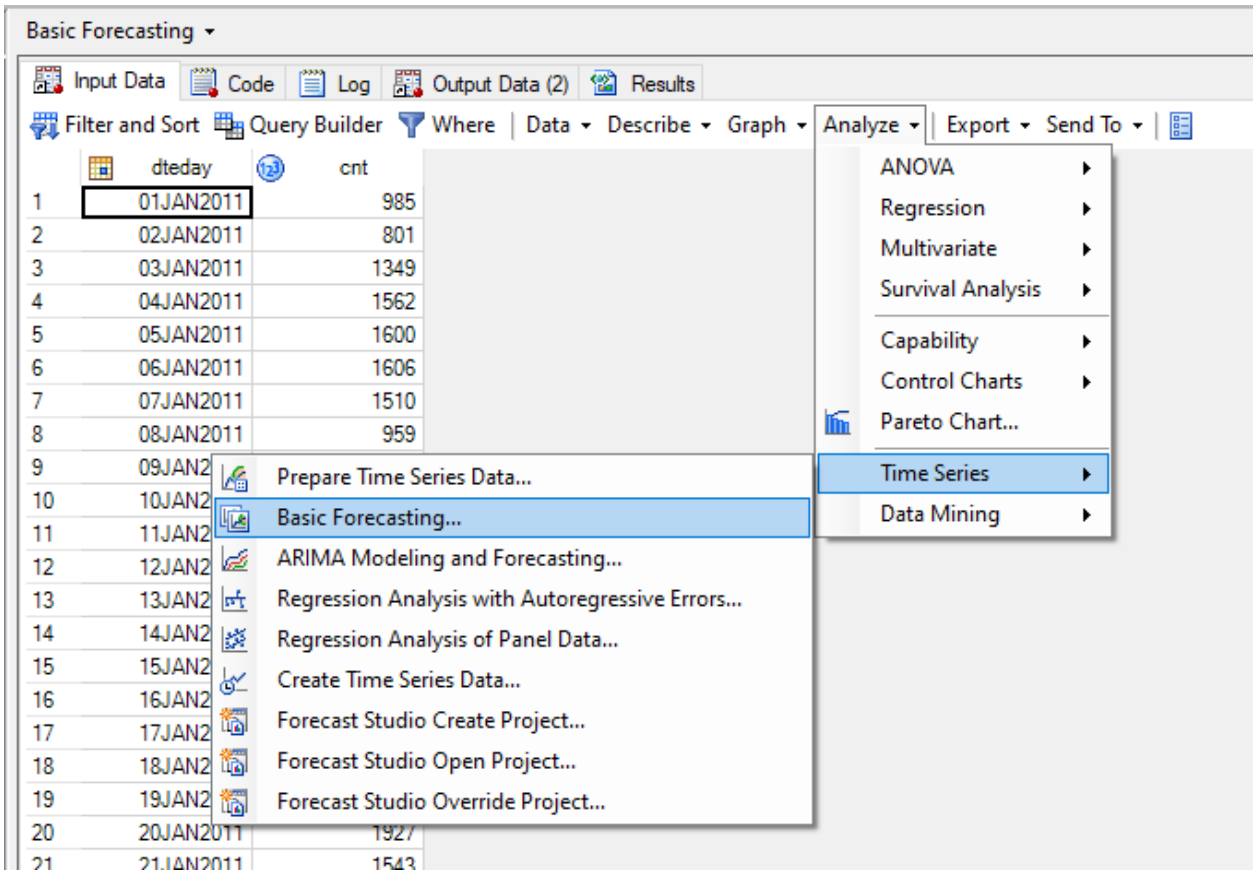
# Exponential Smoothing

The Exponential Smoothing method only takes in observations of the dependent variable and creates forecasts based on the weighted average of previous observations. The general steps in applying Exponential Smoothing in SAS:

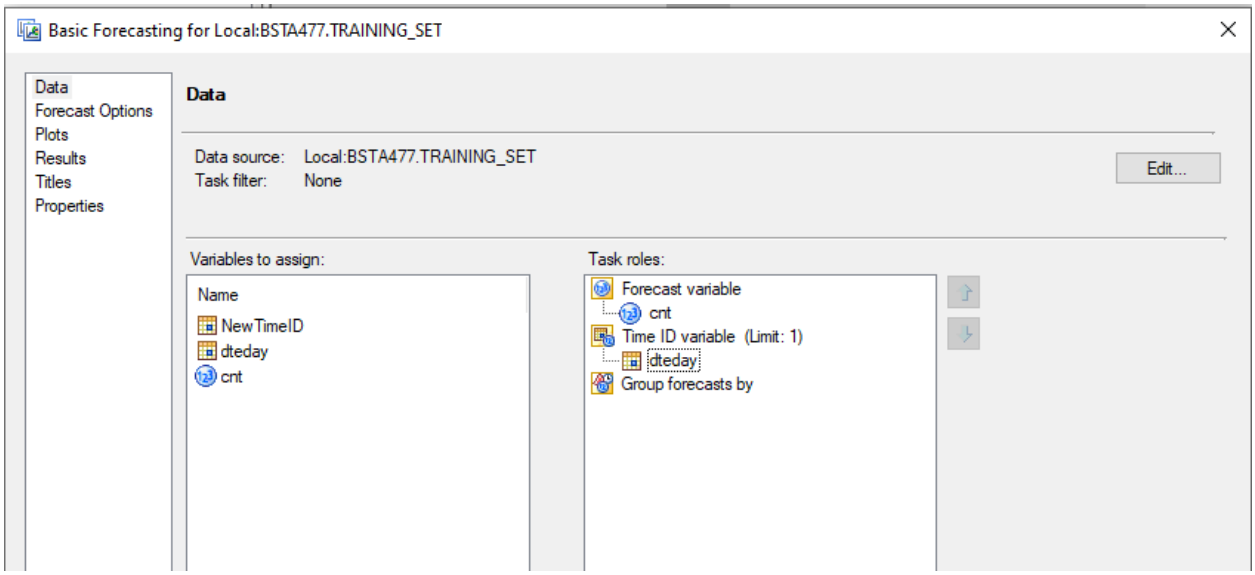
1. Partition the data into training and validation set
2. Use SAS to apply Exponential smoothing methods on training sets.
3. Code the forecast observations to select only validation set observations.
4. Evaluate the performance of the method.

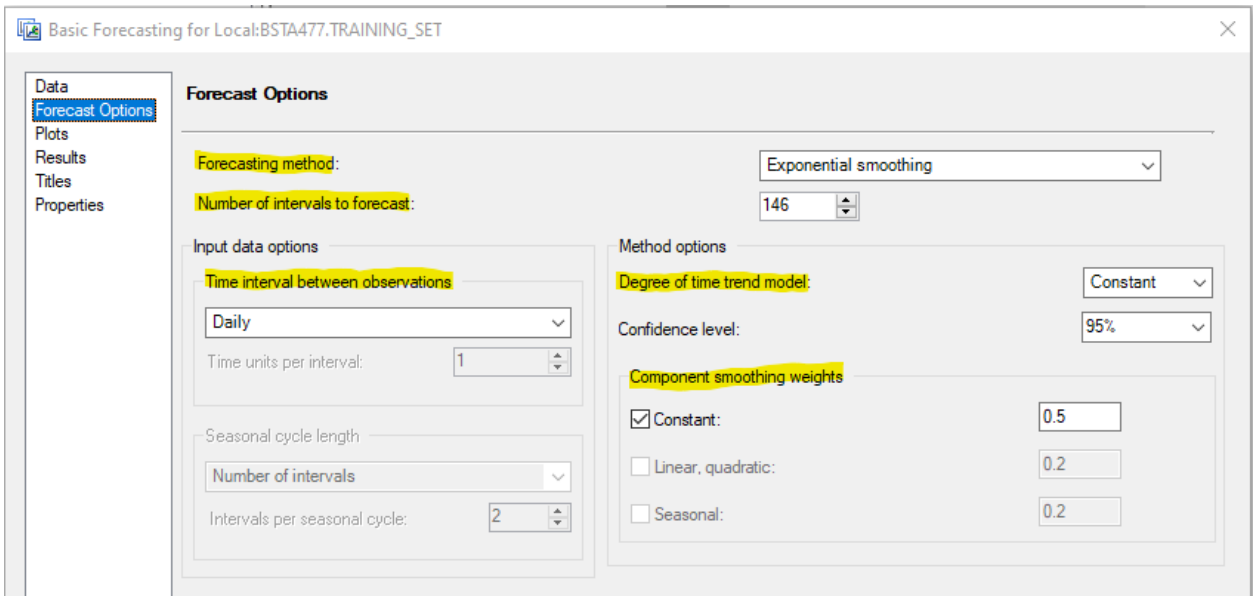
## Simple exponential smoothing

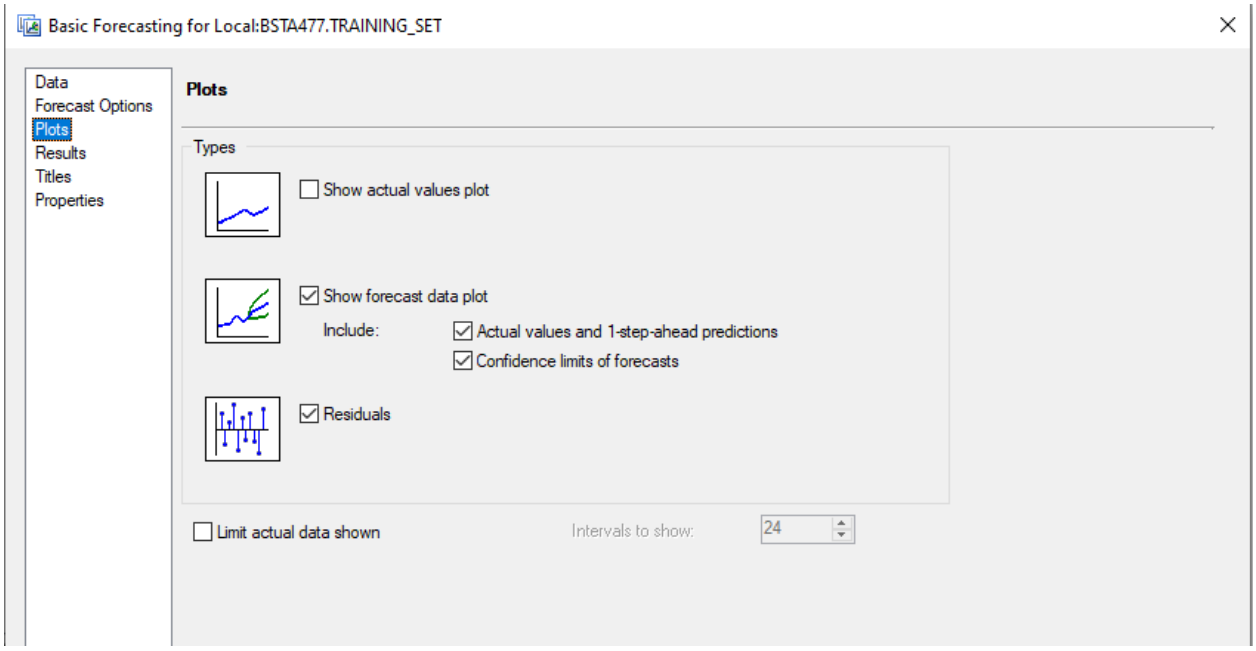
1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
2. Apply simple exponential smoothing on the training set.

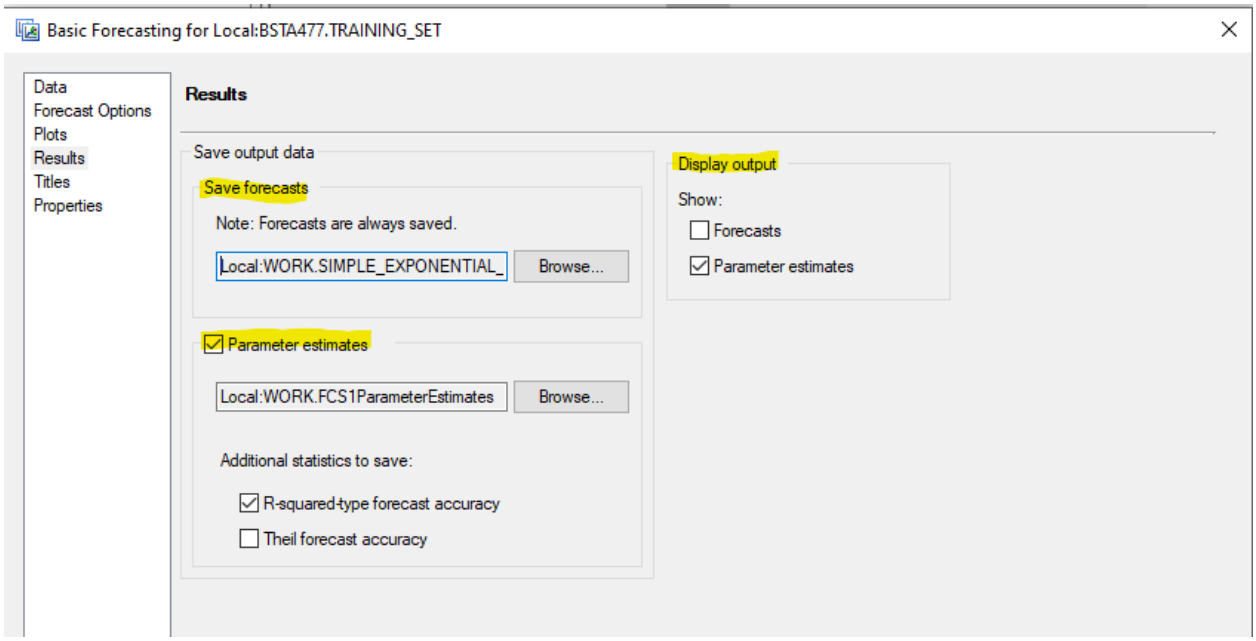


Alicia Ngoc Phan






3. Output the forecasts: Filter the forecasts of validation set observations and merge with the original validation set to calculate the residuals and error terms

```
data simple_exponential_forecast;
set work.simple_exponential_smoothing;
where _type_='FORECAST' and dteday >= '08AUG2012'd;
rename cnt=forecast_cnt;
run;
```

```
data simple_exponential_merged;
merge work.simple_exponential_forecast bsta477.validation_set;
by dteday;
residual = cnt - forecast_cnt;
abs = abs(residual);
square = residual**2;
proportion = residual/cnt;
abs_proportion = abs/cnt;
run;
```

4. Calculate error terms

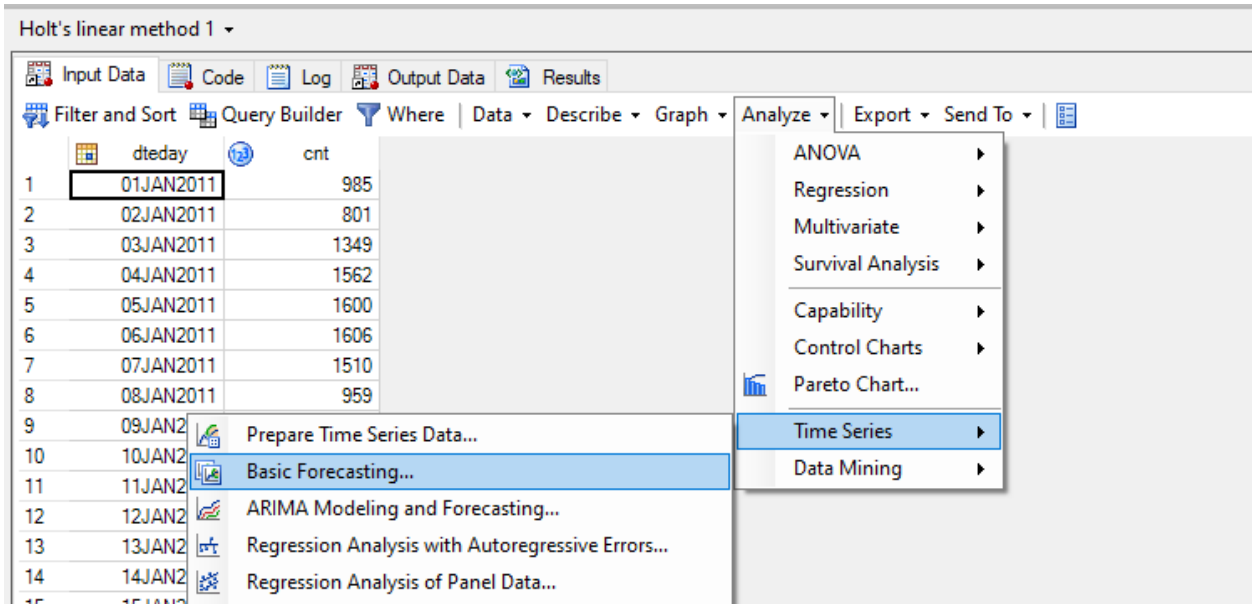
```
proc means data= simple_exponential_merged;
var abs square proportion abs_proportion;
output out=work.simple_exponential_result
Mean(abs)=MAE
Mean(square)=MSE
Mean(proportion) = MPE
Mean(abs_proportion) = MAPE;
run;
```

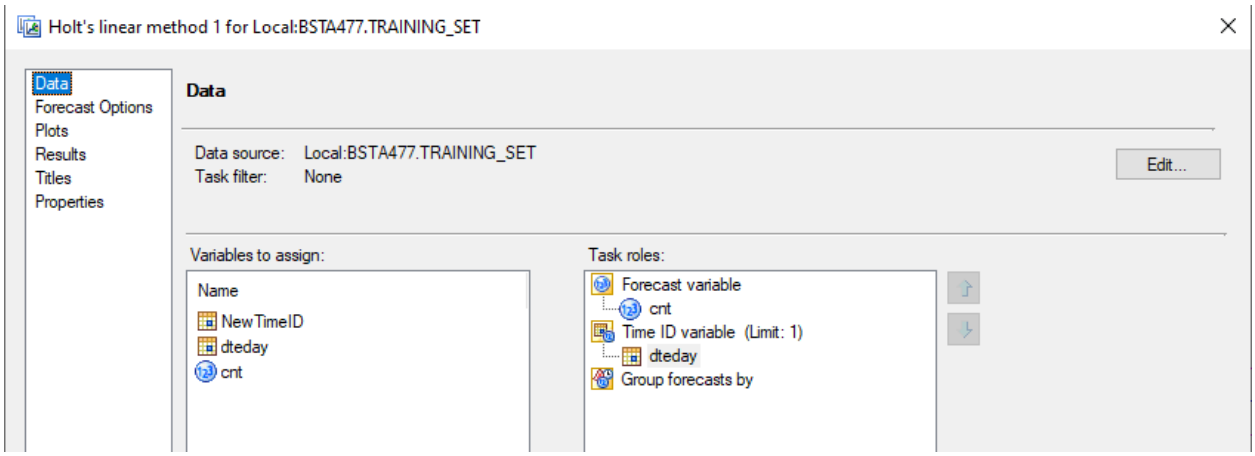
## Holt's linear method

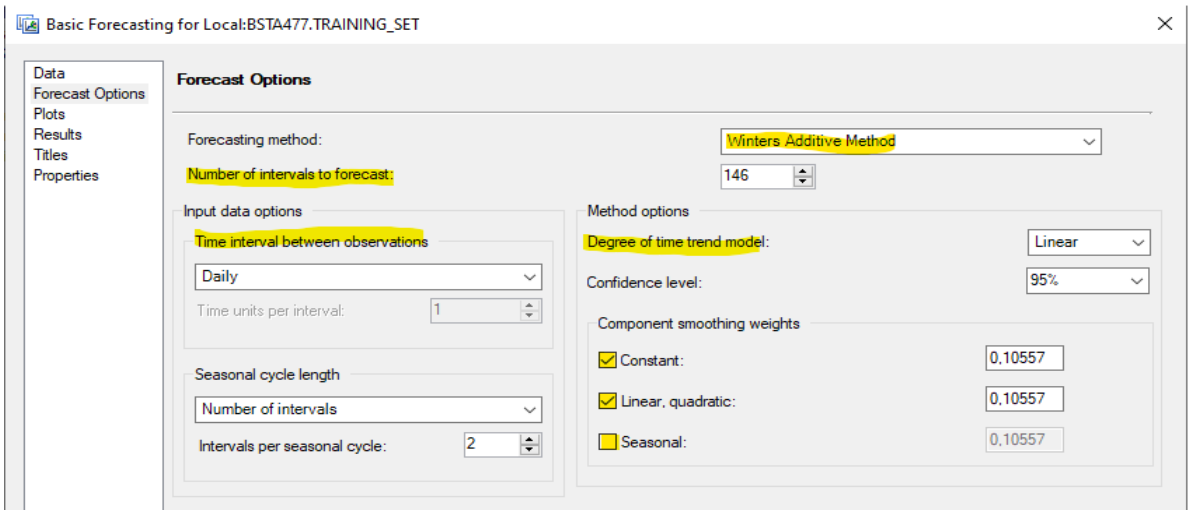
1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.

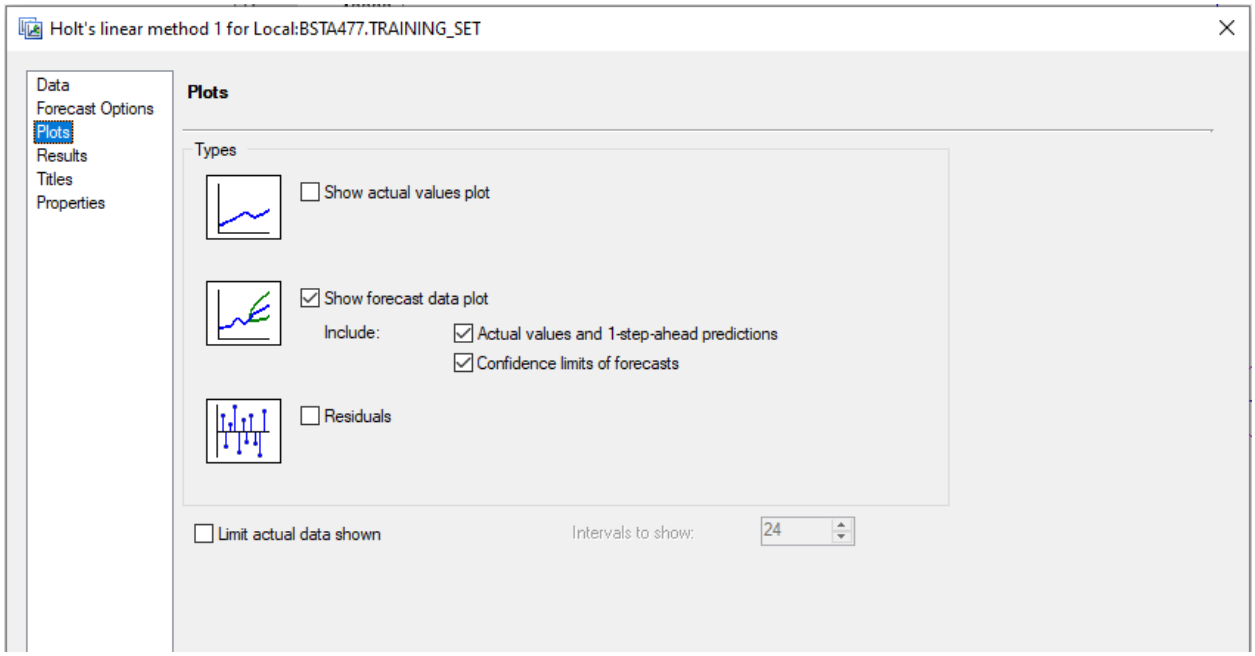
2. Apply Holt's linear method: As SAS does not have a separate option to run Holt's linear method. We can apply Holt's linear method on the training set by applying Holt-Winters (or Winter's in SAS) without selecting the seasonal factor.

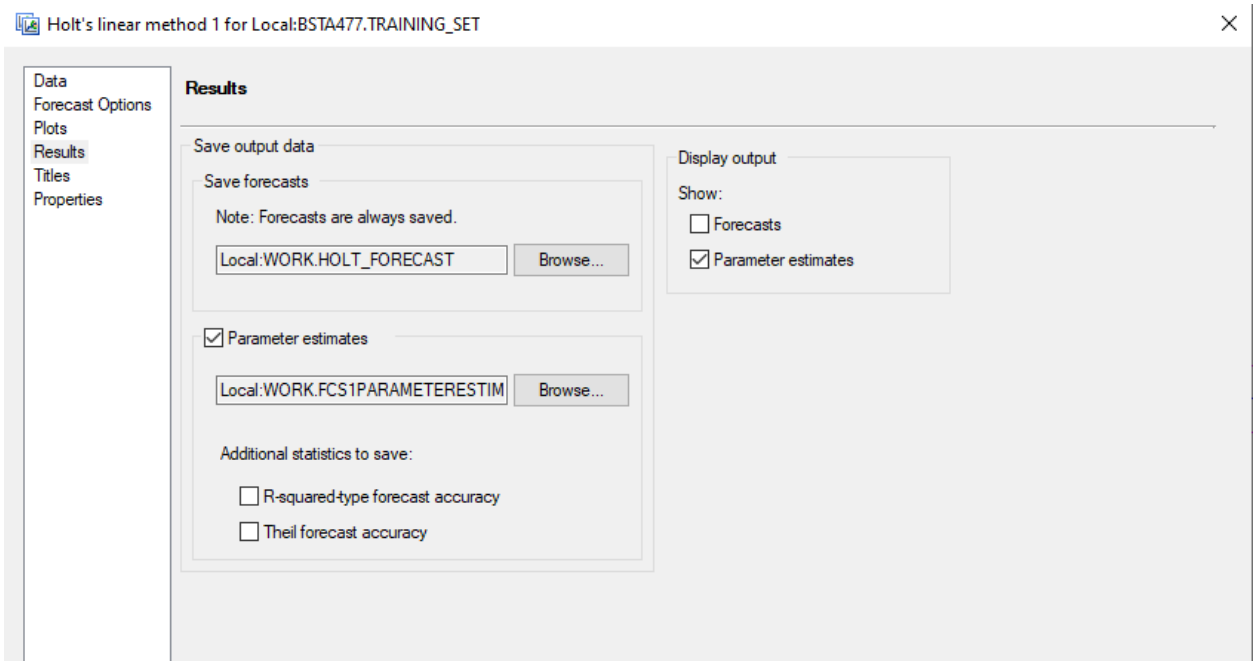
Alicia Ngoc Phan






3. Output the forecasts: Filter the forecasts of validation set observations and merge with the original validation set to calculate the residuals and error terms.

```
data holt_validation_forecast;
set work.holt_forecast;
where _type_='FORECAST' and dteday >= '08AUG2012'd;
rename cnt=forecast_cnt;
run;
```

```
data holt_forecast_merged;
 merge work.holt_validation_forecast bsta477.validation_set;
 by dteday;
 residual = cnt - forecast_cnt;
 abs = abs(residual);
 square = residual**2;
 proportion = residual/cnt;
 abs_proportion = abs/cnt;
 run;
```

4. Calculate error terms

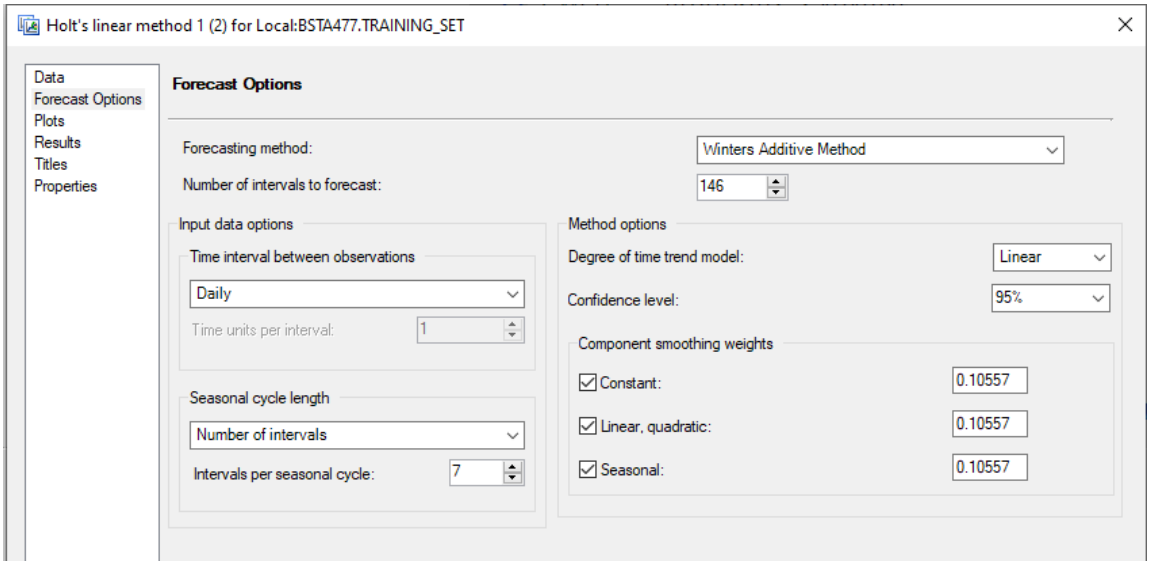
```
proc means data= holt_forecast_merged;
 var abs square proportion abs_proportion;
 output out=work.holt_result
 Mean(abs)=MAE
 Mean(square)=MSE
 Mean(proportion) = MPE
 Mean(abs_proportion) = MAPE;
 run;
```

Note:

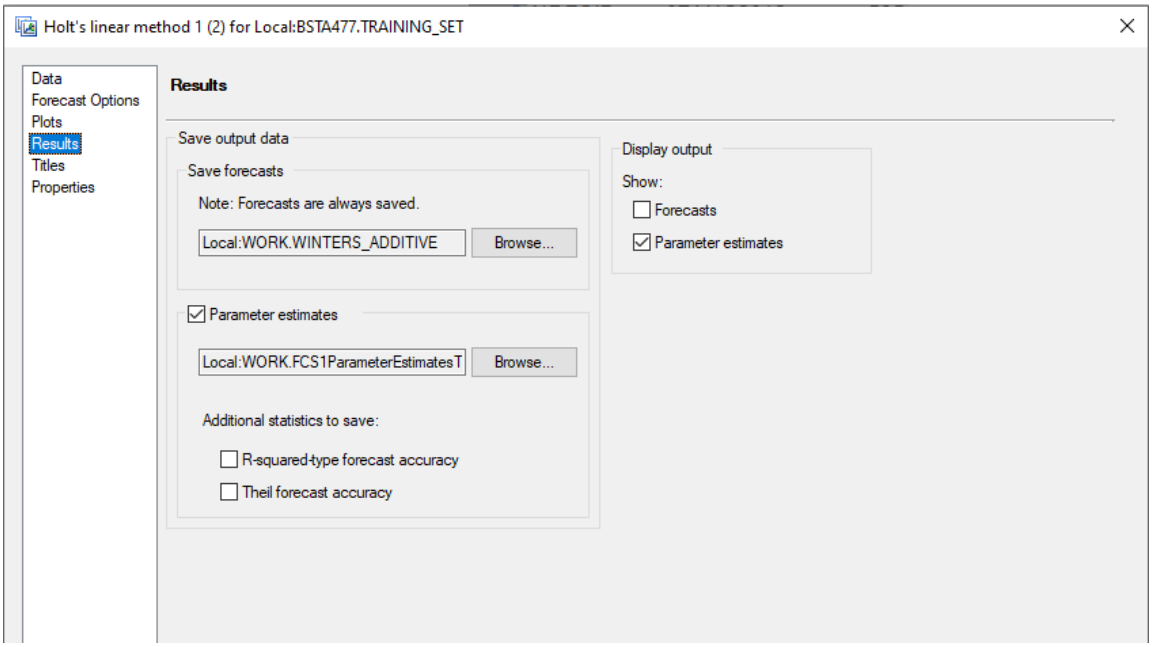
- Choose Winter's Additive method on SAS to appropriately reflect Holt's linear method.

# Holt-Winters method

- Additive Holt- Winter linear method
    1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
    2. Apply Winters additive method on the training set. (Similar options and operations to the above with minor changes)



Note that the seasonal cycle length is based on personal judgement and analysis. Here, intervals per seasonal cycle equals 7 are used due to previous analysis that there is seasonality within the date of the week.




Save the output data to the library intended.

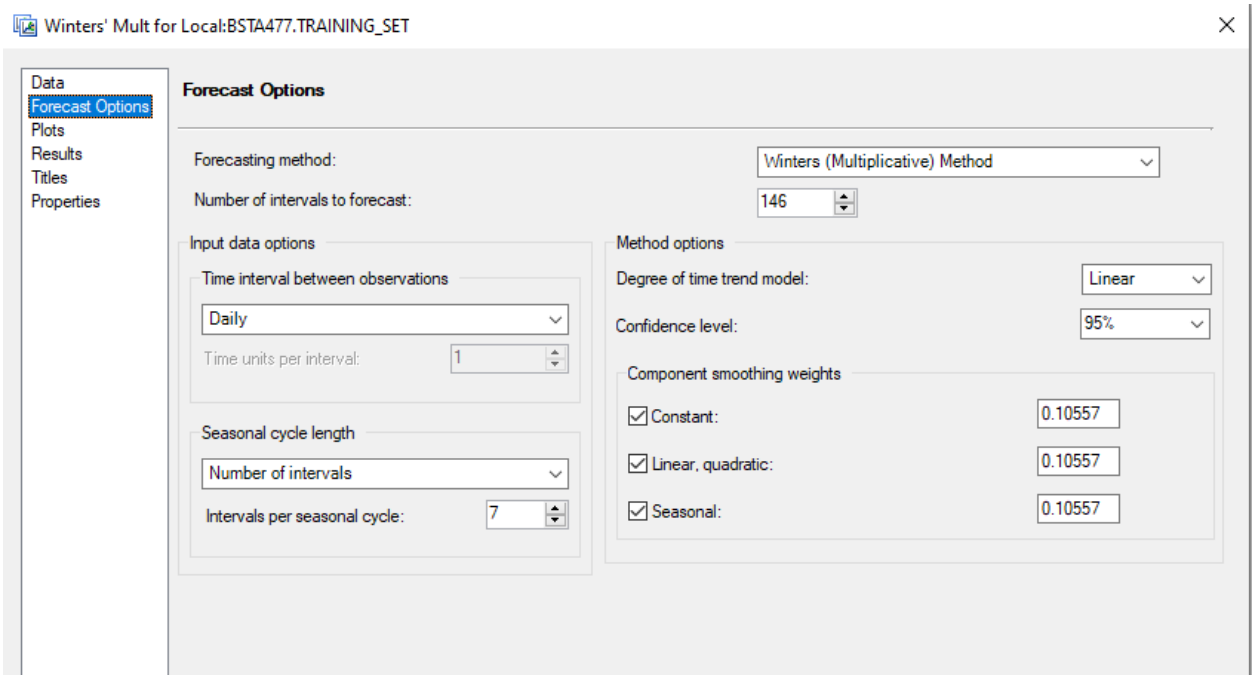
3. Output the forecasts: Filter the forecasts of validation set observations and merge with the original validation set to calculate the residuals and error terms.

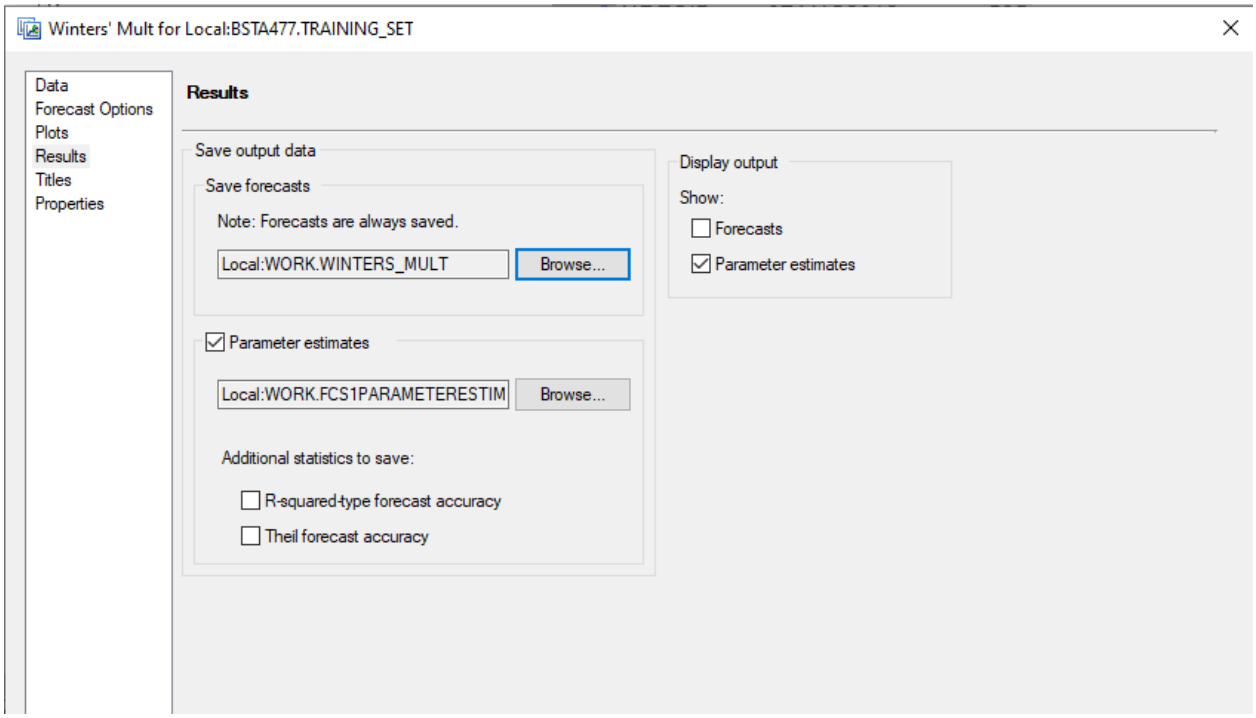
```
data winters_add_forecast;
 set work.winters_additive;
 where _type_='FORECAST' and dteday >= '08AUG2012'd;
 rename cnt=forecast_cnt;
 run;

data Winters_add_merged;
 merge work.winters_add_forecast bsta477.validation_set;
 by dteday;
 residual = cnt - forecast_cnt;
 abs = abs(residual);
 square = residual**2;
 proportion = residual/cnt;
 abs_proportion = abs/cnt;
 run;
```

4. Calculate error terms

```
proc means data= winters_add_merged;
 var abs square proportion abs_proportion;
 output out=work.winters_add_result
 Mean(abs)=MAE
 Mean(square)=MSE
 Mean(proportion) = MPE
 Mean(abs_proportion) = MAPE;
 run;
```

- Multiplicative Holt-Winter linear method
    1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
    2. Apply Winters multiplicative method on the training set. (Similar options and operations to the above with minor changes in Forecast options and Results tab)






3. Like Step 3 from Additive Holt-Winter linear method.
4. Like step 4 from Additive Holt-Winter linear method.

## Evaluation

Each method outputs training and validation error terms. We compare the training set error terms together to determine the goodness of fit of the model. Then, we compare the validation set error terms to determine the forecasting power of the method. Choose the overall best method with lowest error terms in both training and validation, taking into considerations of project priorities as well.