TEMPERATURE CHANGE FORECAST

BY Kirk Lackey and Irene Izere

Introduction

The Food and Agriculture Organization of the United Nations is a specialized agency of the United Nations that leads international efforts to defeat hunger and improve nutrition and food security.

Increases in surface air temperature associated with rising greenhouse gas concentrations threaten plant growth and yield, putting millions of farmers and communities at risk throughout the world.

Together with changes in precipitation and increases in extreme events such as flooding and droughts, climate change threatens countries' food security, and their ability to eradicate poverty and achieve sustainable development.

Problem statement

This project will focus on building a Time series model that will predict and forecast the Temperature change for the next 15 years using a dataset from FAOSTAT on temperature change .

This model will shows the trends and will allow an understanding of impacts of climate change challenges on Agriculture.

Data collection

The dataset is a combination of a dataset of temperature change from Kaggle (https://www.kaggle.com/sevgisarac/temperature-change)

and a dataset of countries with regional codes from (https://github.com/lukes/ISO-3166-Countries-with-Regional-Codes/blob/master/all/all.csv).

Number of countries/areas covered: In 2019: 190 countries and 37 other territorial entities.

Time coverage: 1961-2020

Periodicity: Monthly, Seasonal, Yearly

Base period: 1951-1980

Unit of Measure: Celsius degrees °C

Data Cleaning

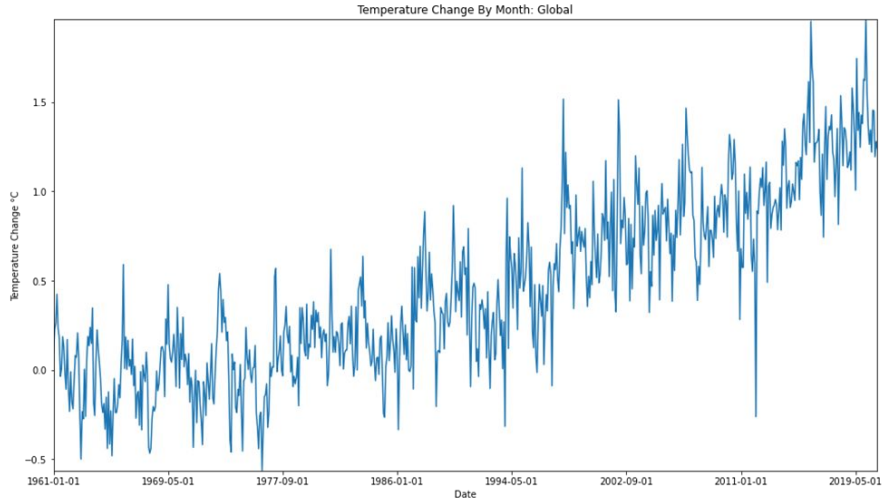
- Removing missing values
- Removing the seasonal and meteorological data
- Combining the month and year features to create a date feature

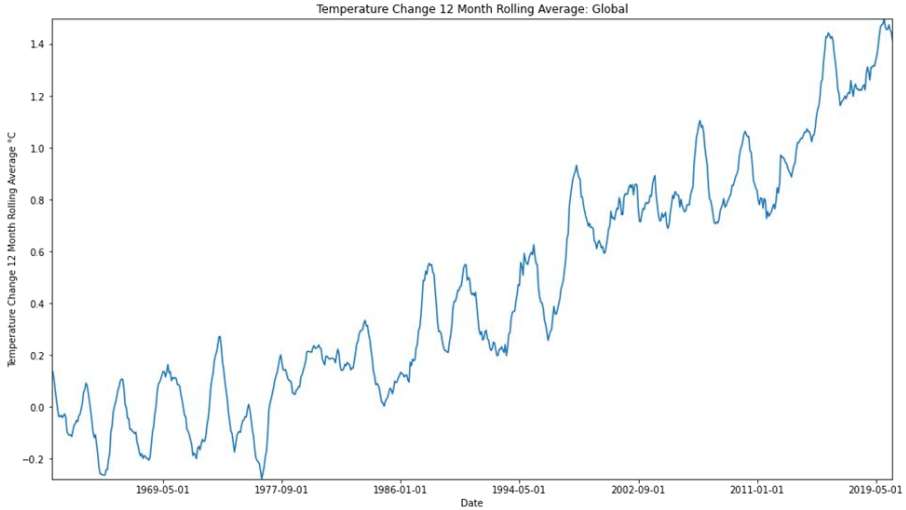
Exploratory Data Analysis

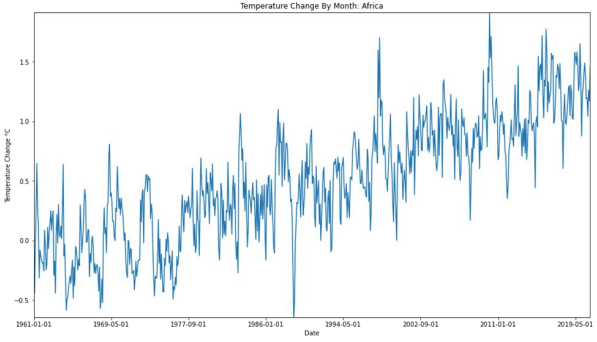
For better understanding we look at the data globally but also we group them by regions.
Africa,Americas,Asia,Europe,Oceania and Antartica

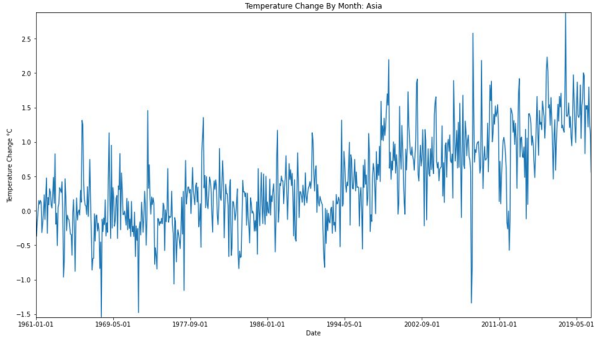
For a clear view we smooth the data by doing a rolling average of 12 months.

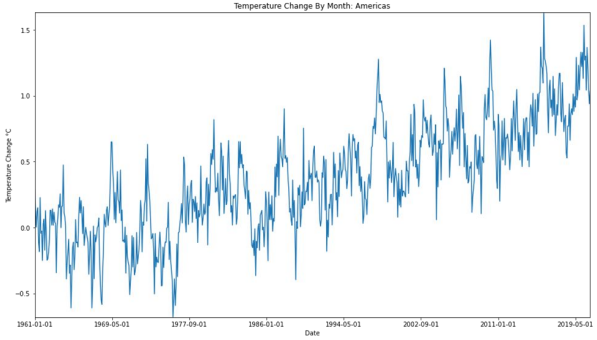
There is an increasing trend and seasonality for all the regions. The Antartica data are more random than the others regions.

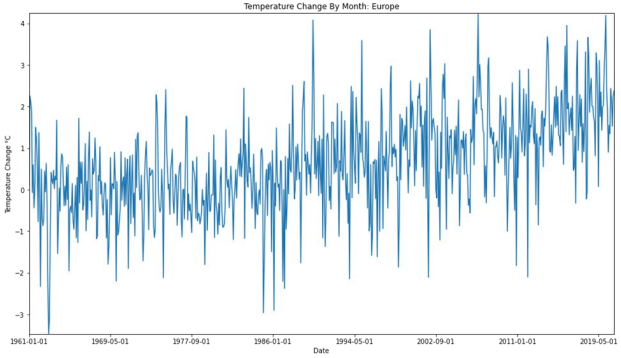


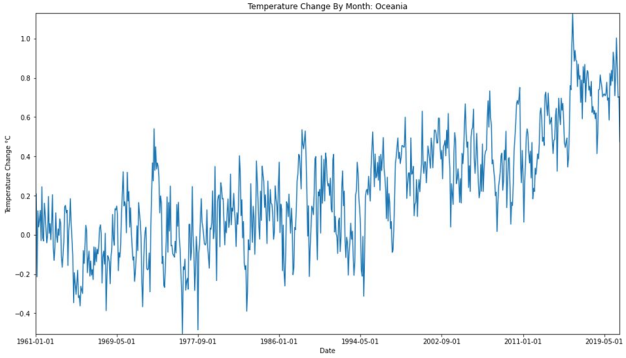


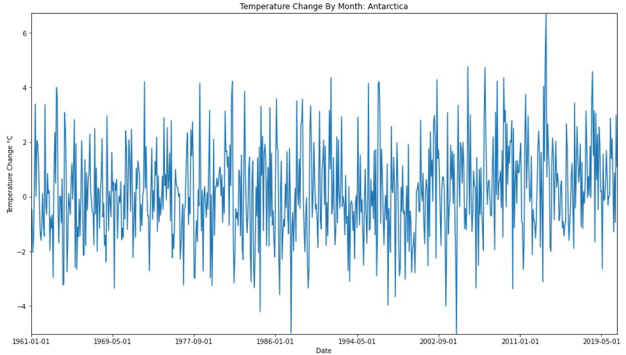

Temperature Change By Month: Africa
Temperature Change °C
1.5
1.0
0.5
0.0
−0.5
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

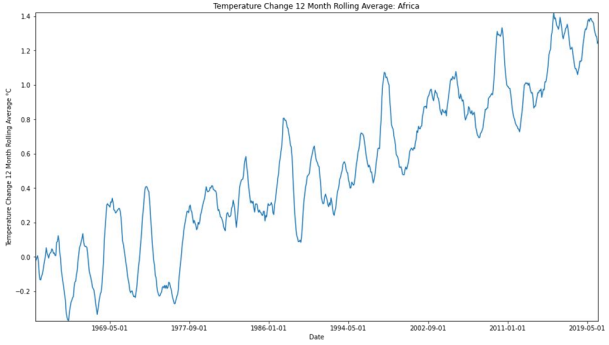

Temperature Change By Month: Asia
Temperature Change °C
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

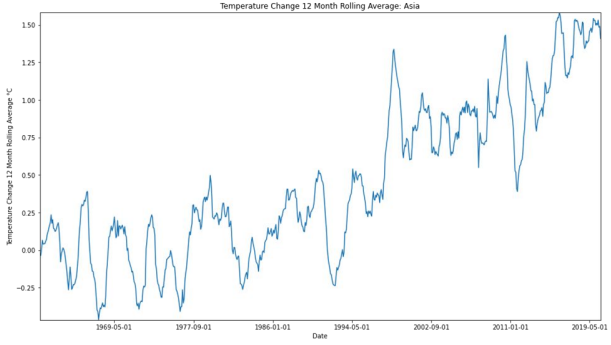

Temperature Change By Month: Americas
Temperature Change °C
1.5
1.0
0.5
0.0
−0.5
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

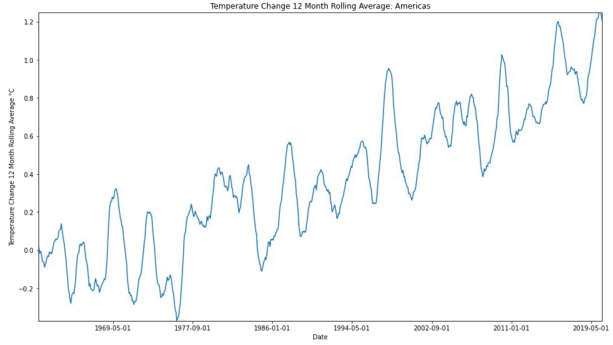

Temperature Change By Month: Europe
Temperature Change °C
4
3
2
1
0
−1
−2
−3
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

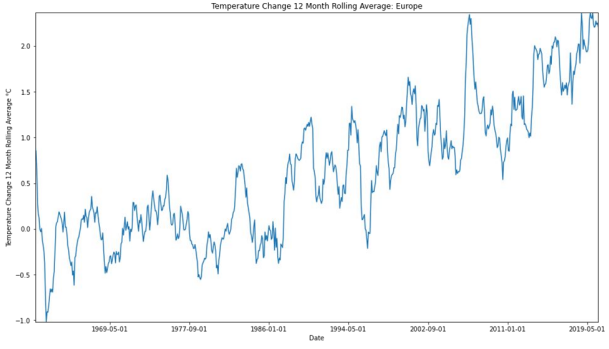

Temperature Change By Month: Oceania
Temperature Change °C
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

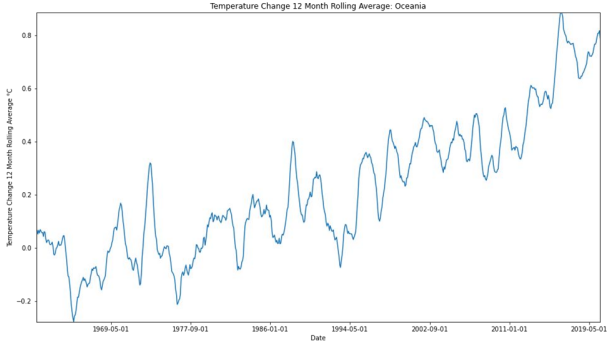

Temperature Change By Month: Antarctica
Temperature Change °C
6
4
2
0
−2
−4
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

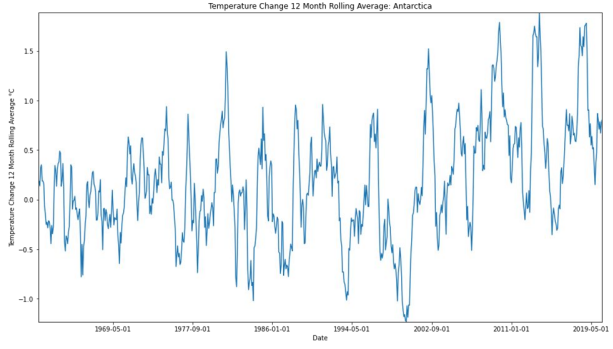

Temperature Change 12 Month Rolling Average: Africa
Temperature Change 12 Month Rolling Average °C
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date


Temperature Change 12 Month Rolling Average: Asia
Temperature Change 12 Month Rolling Average °C
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date


Temperature Change 12 Month Rolling Average: Americas
Temperature Change 12 Month Rolling Average °C
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date


Temperature Change 12 Month Rolling Average: Europe
Temperature Change 12 Month Rolling Average °C
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

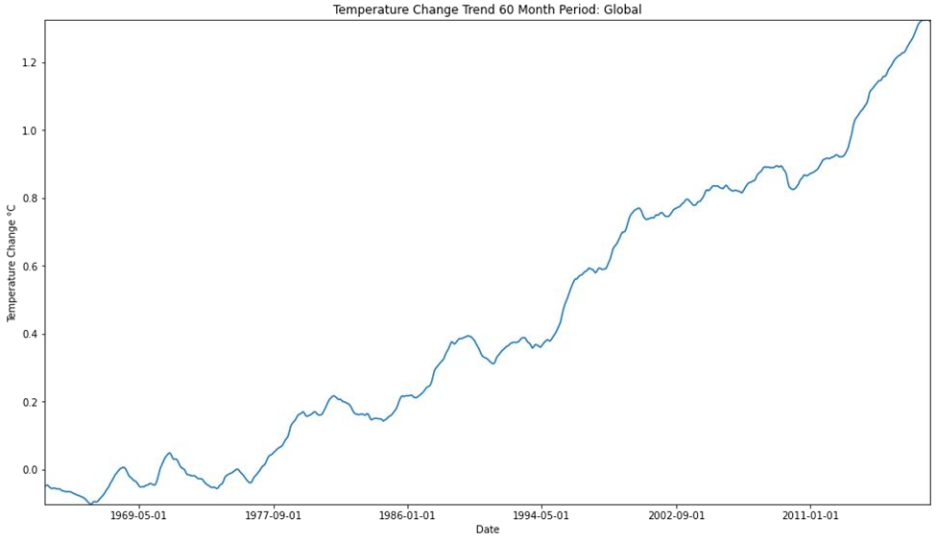

Temperature Change 12 Month Rolling Average: Oceania
Temperature Change 12 Month Rolling Average °C
0.8
0.6
0.4
0.2
0.0
−0.2
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

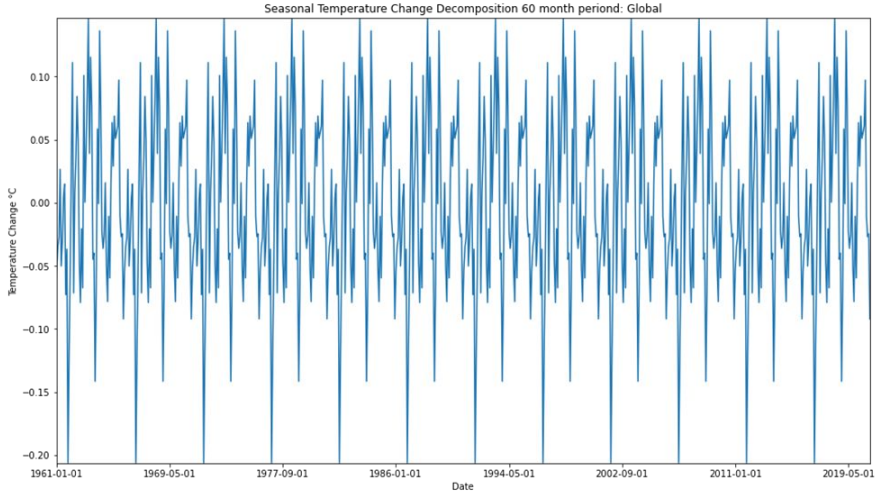

Temperature Change 12 Month Rolling Average: Antarctica
Temperature Change 12 Month Rolling Average °C
1.5
1.0
0.5
0.0
−0.5
−1.0
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01
Date

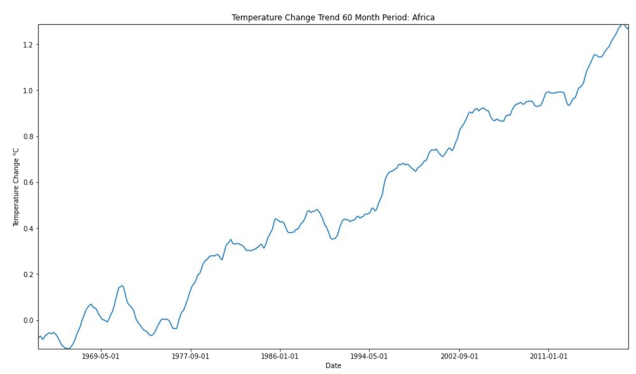
Trend and Seasonality

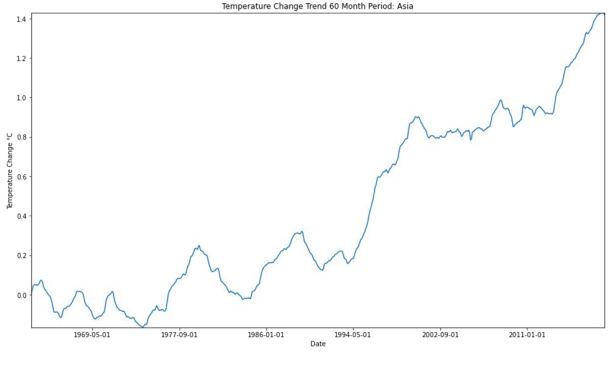
We use a Decomposition method to look separately on the Trend and Seasonality Globally and For every region.

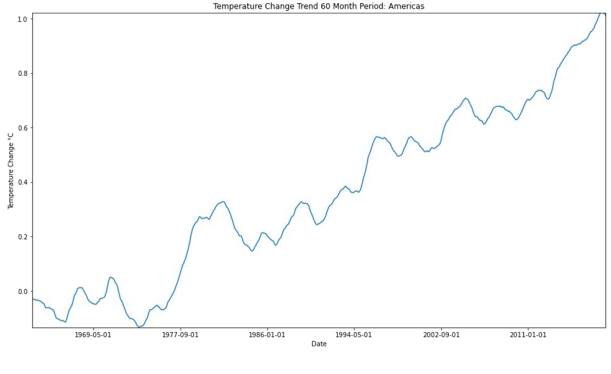
Overall the trend is increasing and there is seasonality.

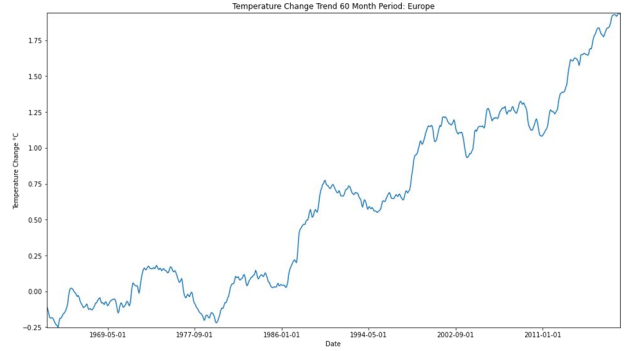


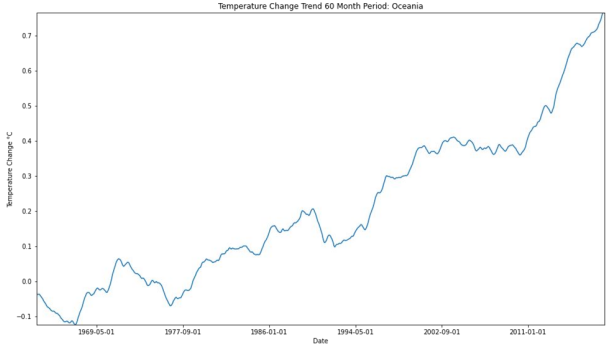


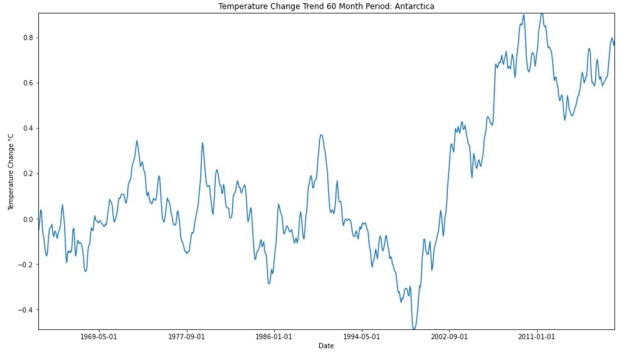

Temperature Change Trend 60 Month Period: Africa
Temperature Change °C
Date
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01

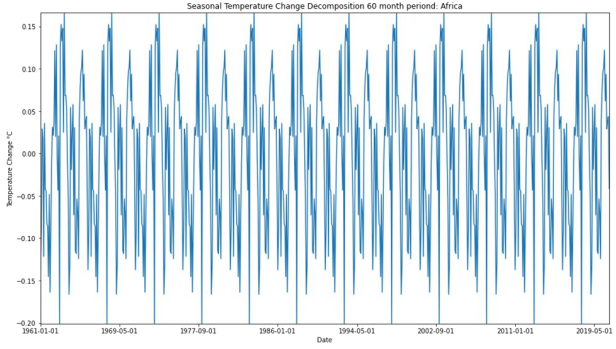

Temperature Change Trend 60 Month Period: Asia
Temperature Change °C
Date
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01

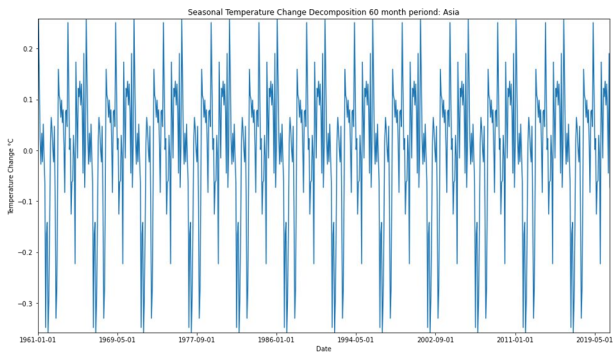

Temperature Change Trend 60 Month Period: Americas
Temperature Change °C
Date
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01

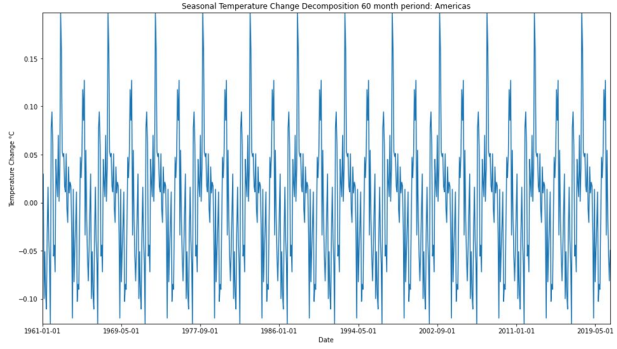

Temperature Change Trend 60 Month Period: Europe
Temperature Change °C
Date
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01

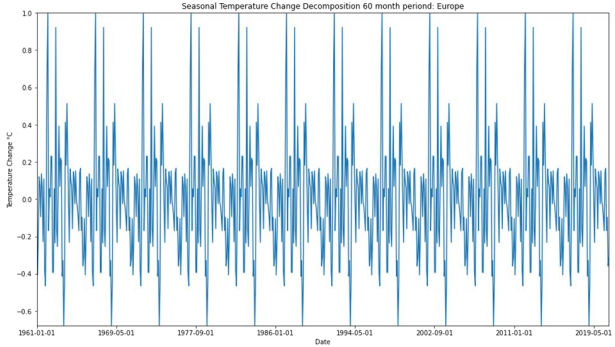

Temperature Change Trend 60 Month Period: Oceania
Temperature Change °C
Date
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01

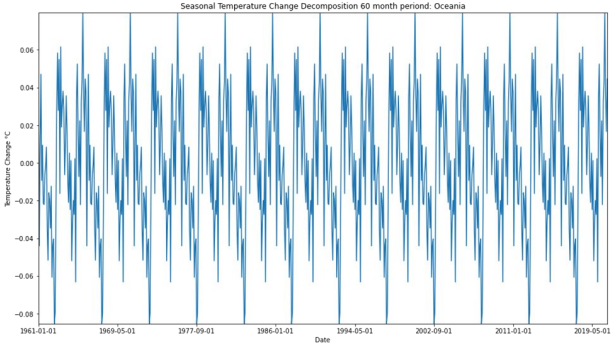

Temperature Change Trend 60 Month Period: Antarctica
Temperature Change °C
Date
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01

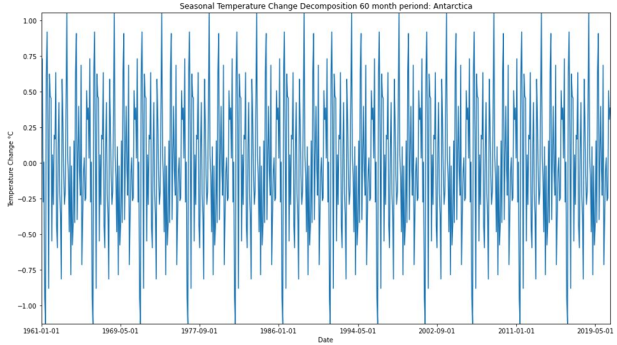

Seasonal Temperature Change Decomposition 60 month periond: Africa
Temperature Change °C
Date
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01


Seasonal Temperature Change Decomposition 60 month periond: Asia
Temperature Change °C
Date
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01


Seasonal Temperature Change Decomposition 60 month periond: Americas
Temperature Change °C
Date
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01

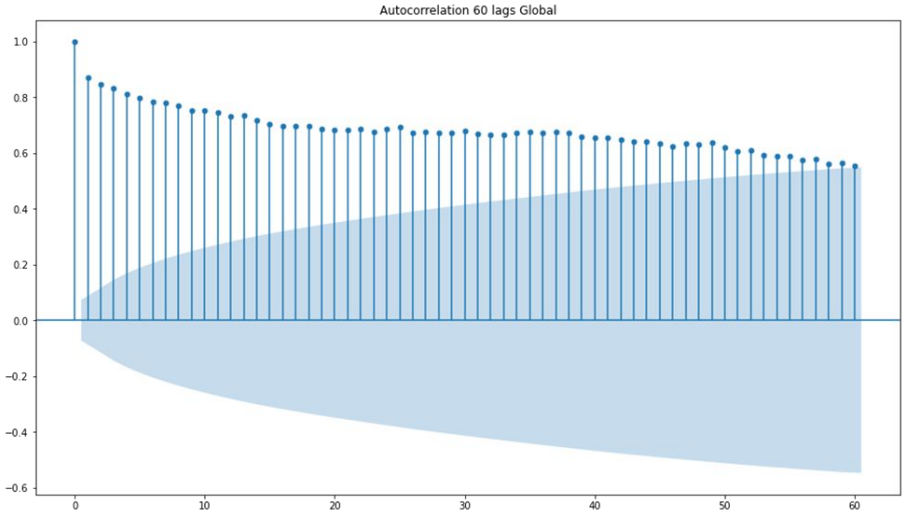

Seasonal Temperature Change Decomposition 60 month periond: Europe
Temperature Change °C
Date
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01

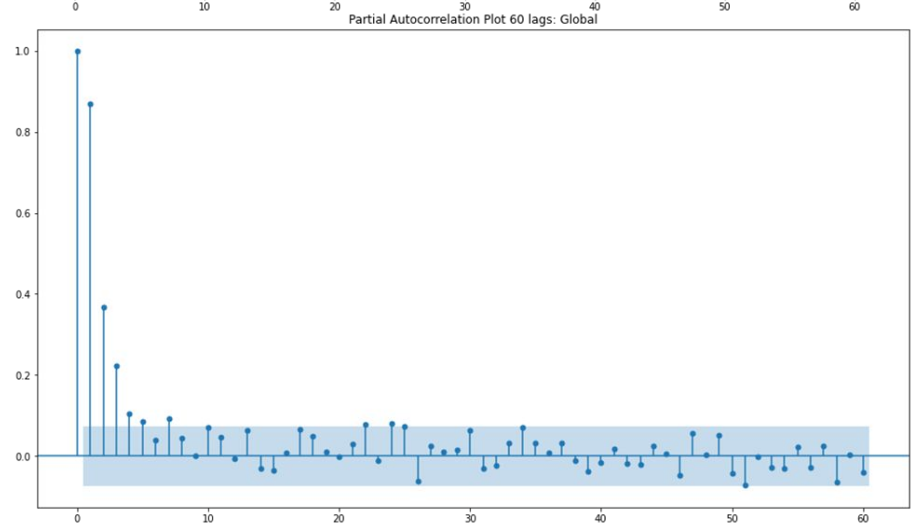

Seasonal Temperature Change Decomposition 60 month periond: Oceania
Temperature Change °C
Date
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01

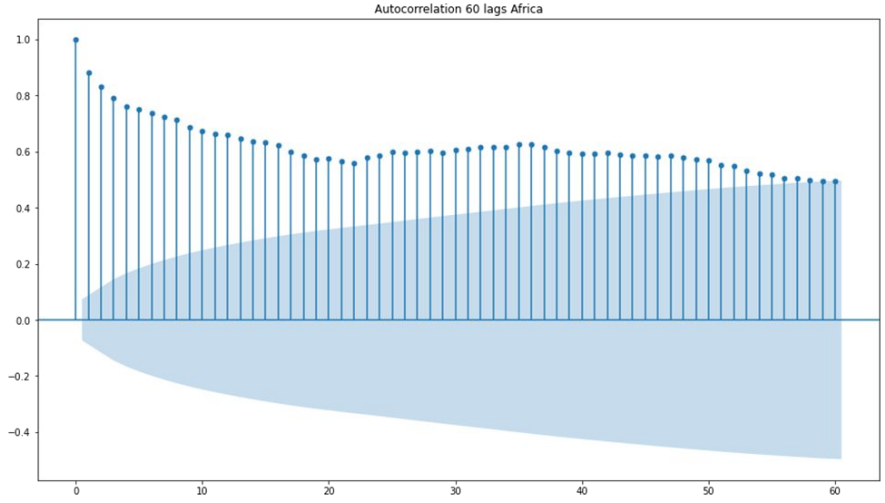

Seasonal Temperature Change Decomposition 60 month periond: Antarctica
Temperature Change °C
Date
1961-01-01
1969-05-01
1977-09-01
1986-01-01
1994-05-01
2002-09-01
2011-01-01
2019-05-01

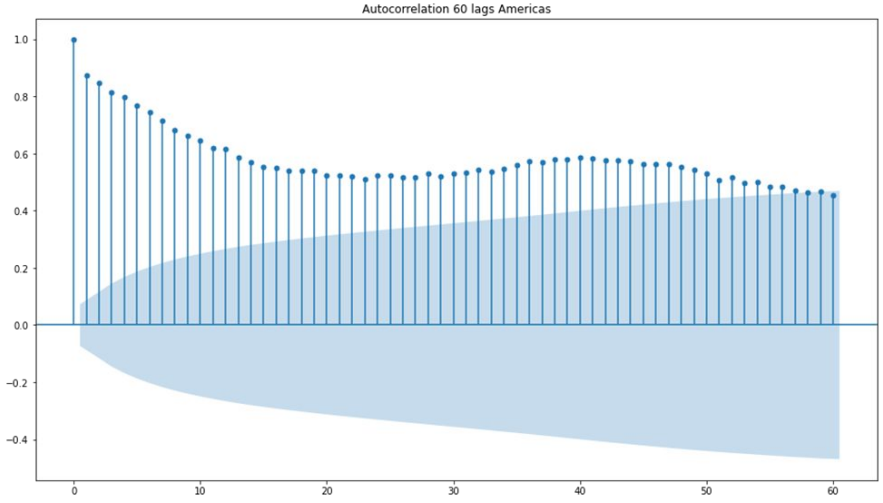
Autocorrelation and Partial-Autocorrelation

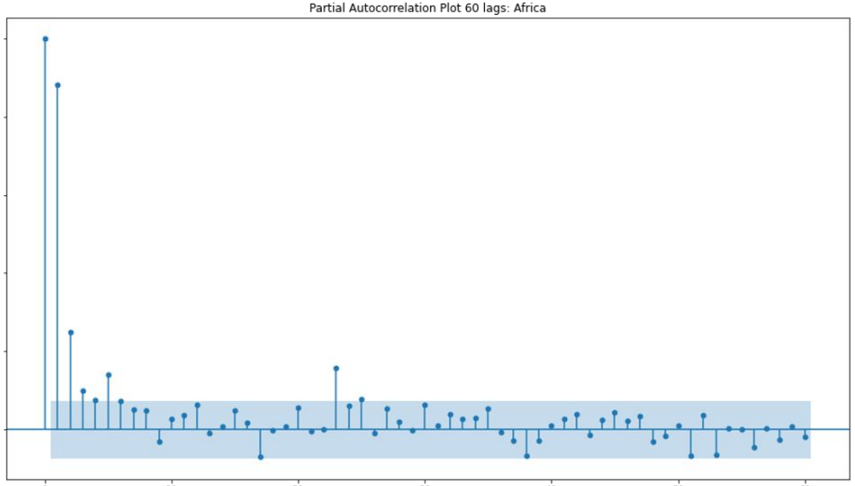
Autocorrelation and partial autocorrelation are measures of association between current and past series values and indicate which past series values are most useful in predicting future values

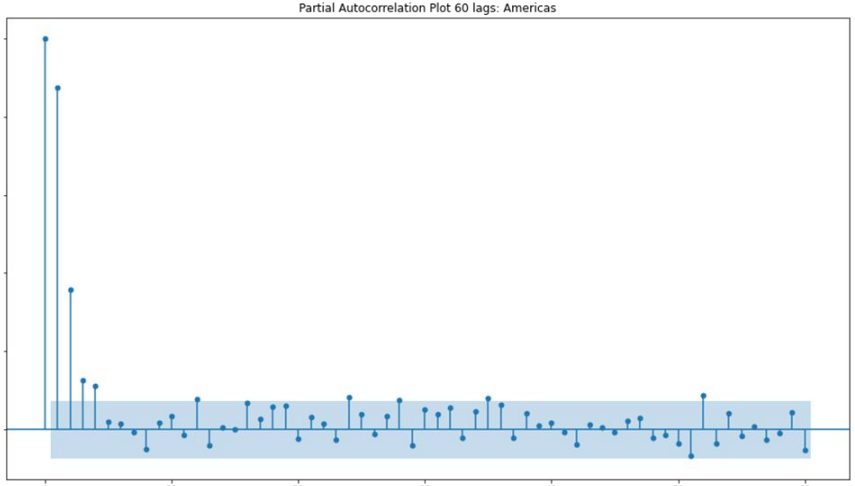


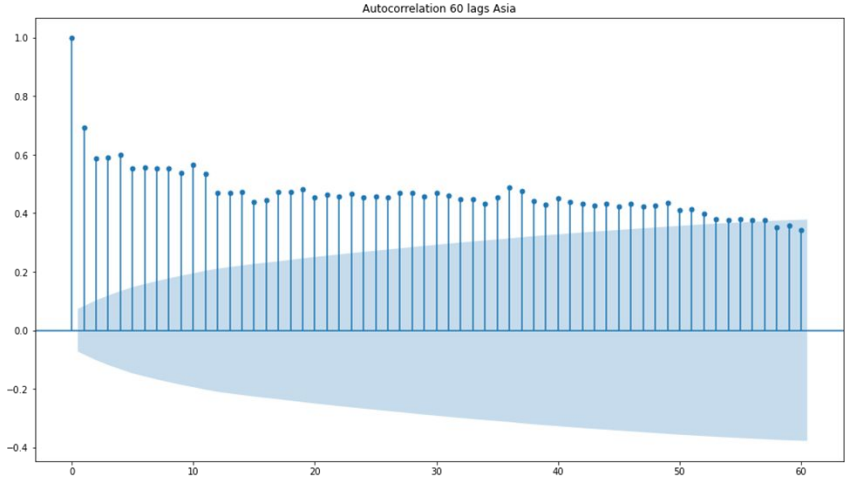


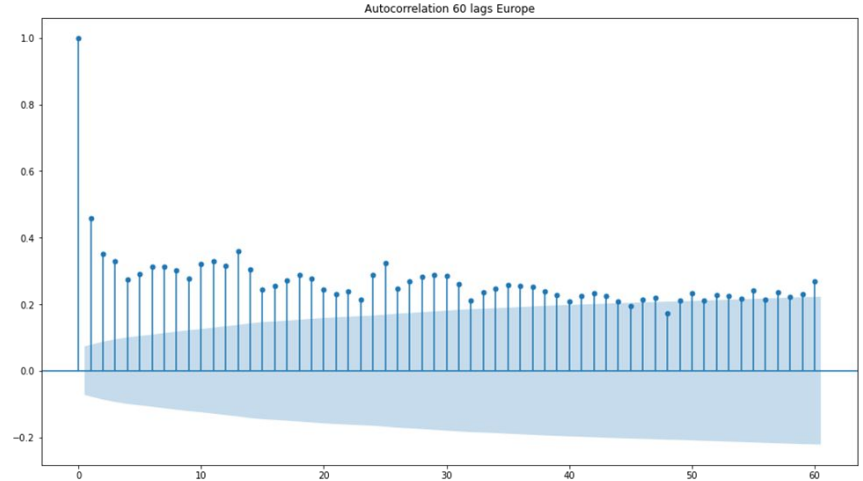

Autocorrelation 60 lags Africa

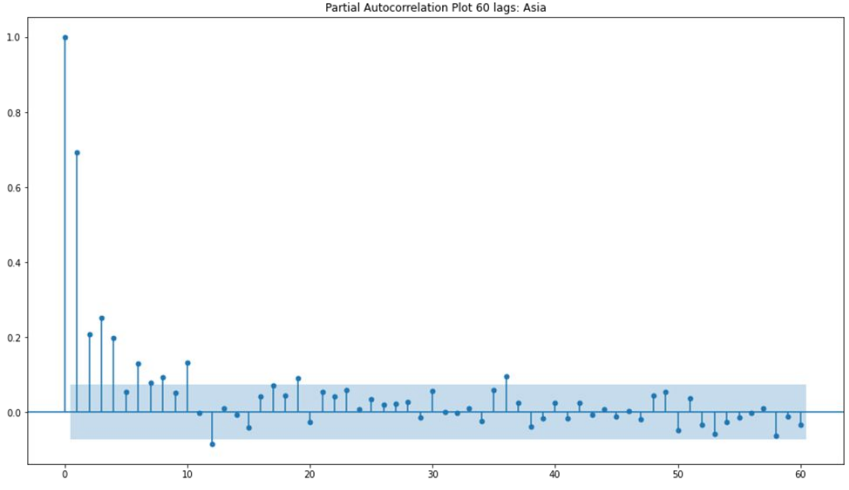

Autocorrelation 60 lags Americas

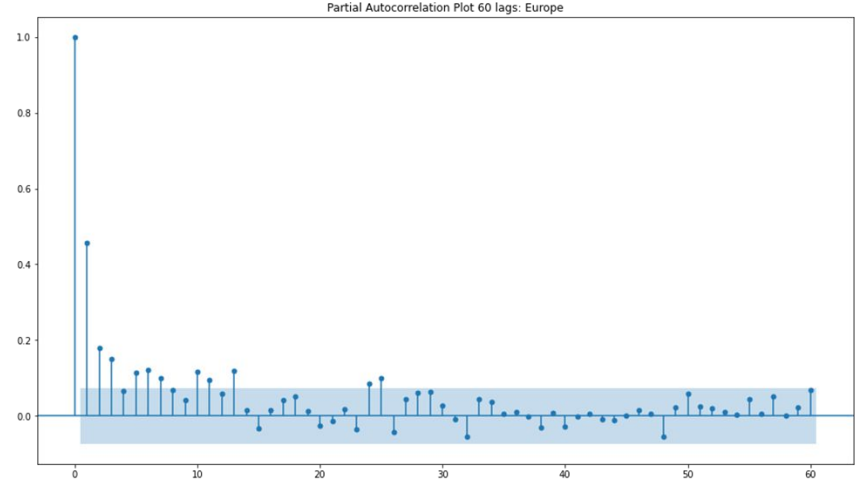

Partial Autocorrelation Plot 60 lags: Africa

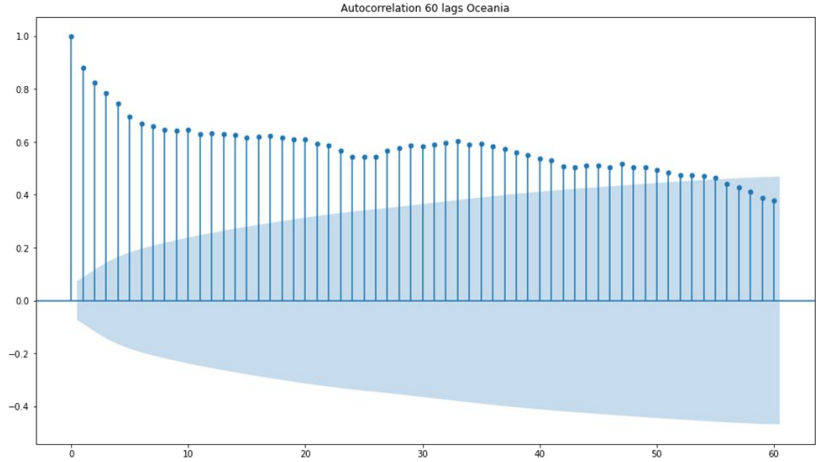

Partial Autocorrelation Plot 60 lags: Americas

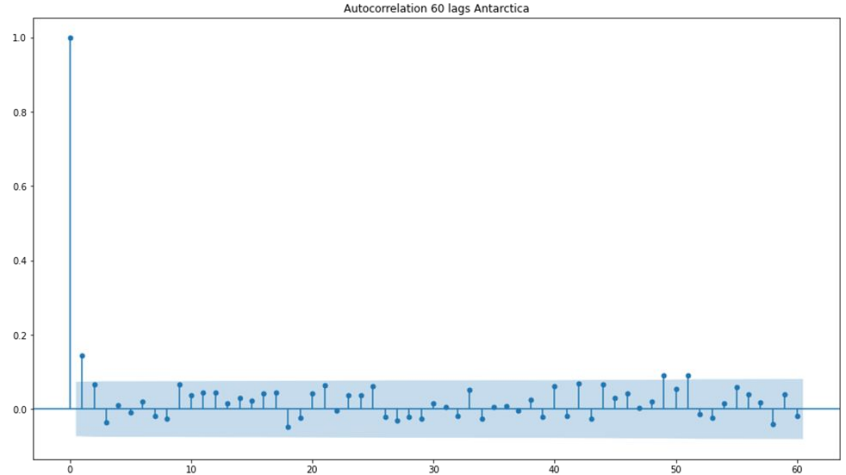

Autocorrelation 60 lags Asia

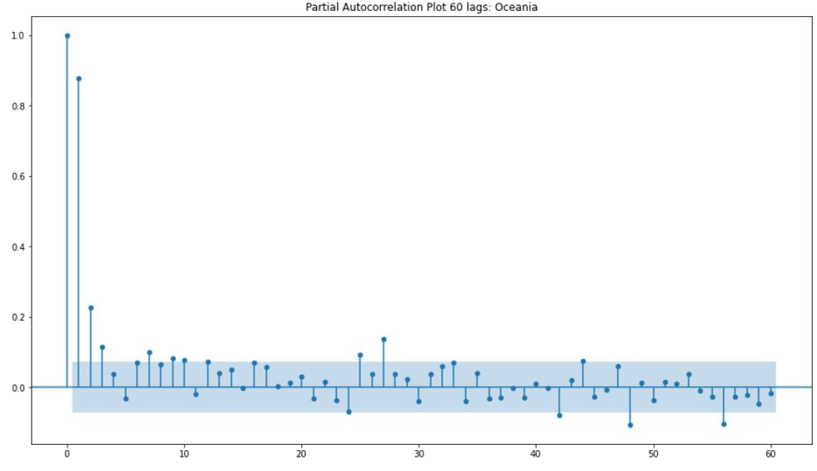

Autocorrelation 60 lags Europe

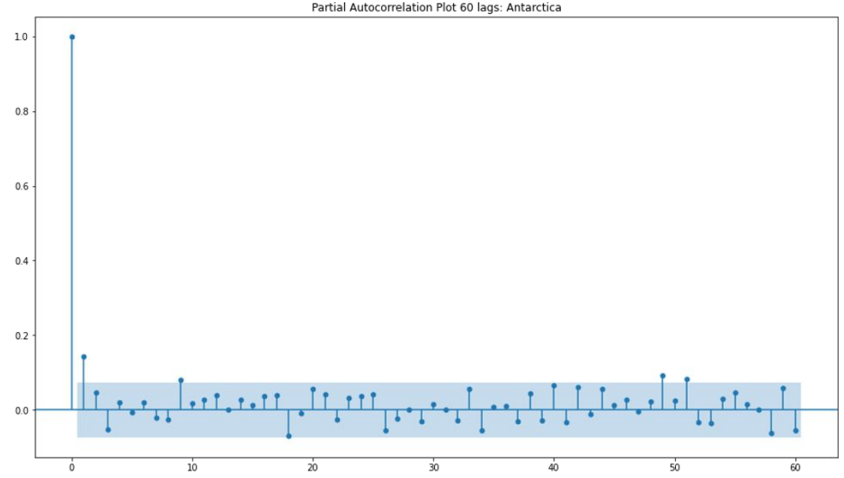

Partial Autocorrelation Plot 60 lags: Asia


Partial Autocorrelation Plot 60 lags: Europe


Autocorrelation 60 lags Oceania


Autocorrelation 60 lags Antarctica


Partial Autocorrelation Plot 60 lags: Oceania


Partial Autocorrelation Plot 60 lags: Antarctica

Modeling and Forecasting

In this part we built a SARIMAX model to predict and forecast The Temperature change for the next 15 years. We choose to use SARIMAX because the model take into account the seasonality of our dataset.

SARIMA models include extra parameters related to the seasonal part.Therefore, a SARIMA(p,d,q)(P,D,Q,S) model have (p,d,q) that are non-seasonal parameters and P,D,Q,S that are the seasonal parameters.

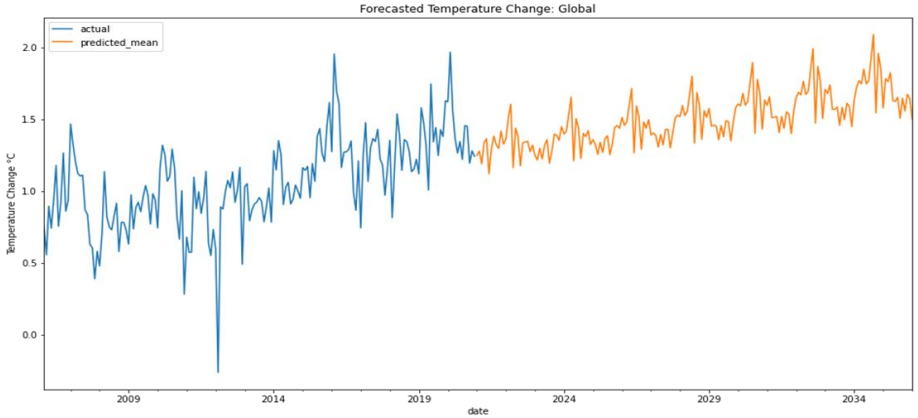
We used **AIC (Akaike information criterion)** metric to find the best value of *p* and *q.*

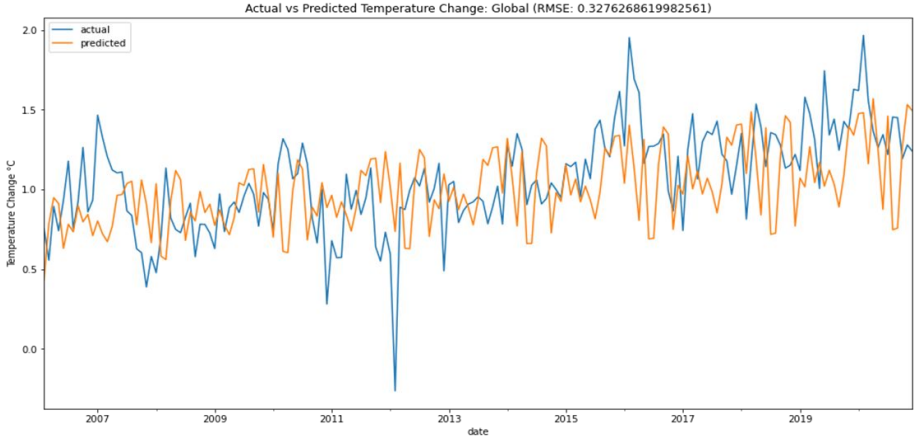
We also checked if our data is stationary by using the an **Augmentated Dickey-Fuller** test.

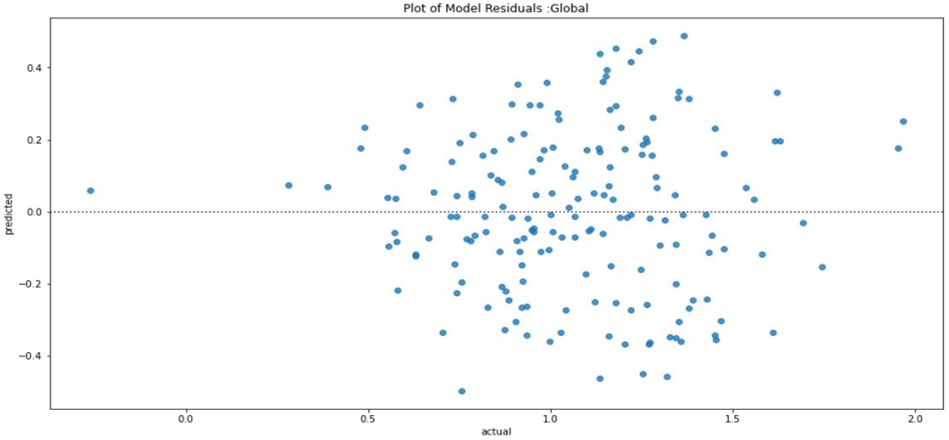
We looked at the PCF and ACF to determine the Seasonal parameters.

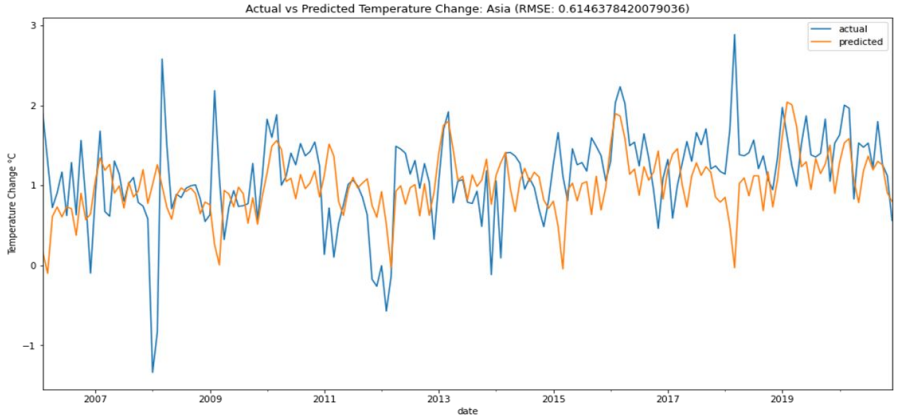
Evaluating

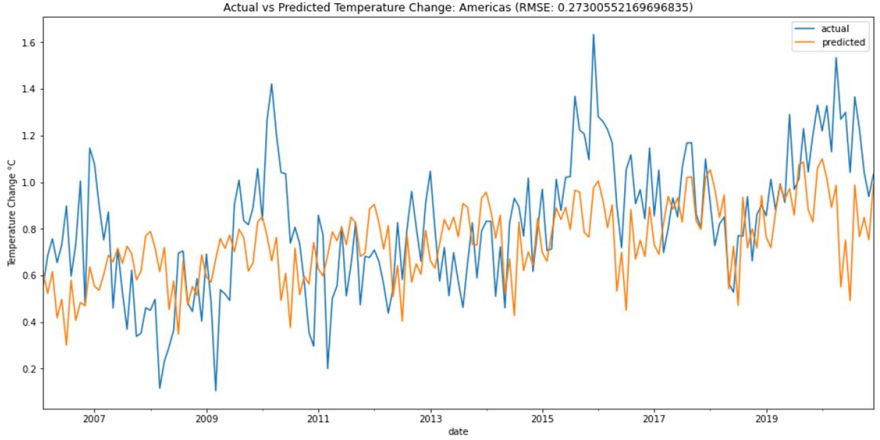
The model is doing the prediction with RMSE =0.32 for the global data.
For the forecasting , it is picking up the increasing trend and seasonality of the data.

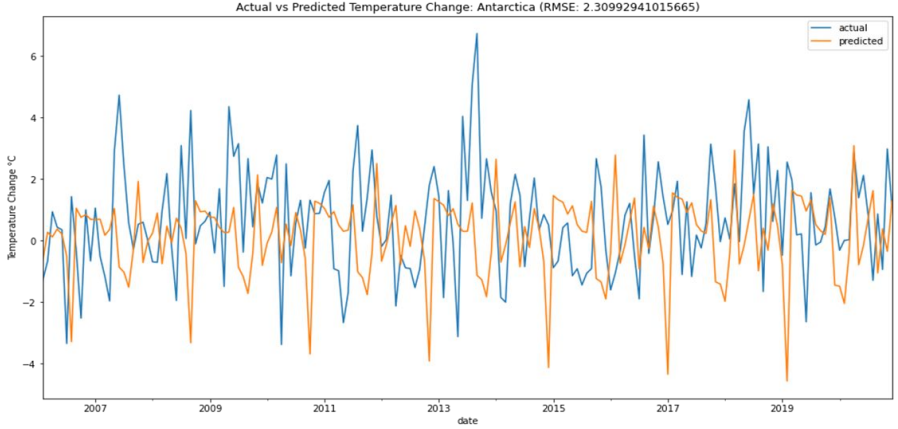


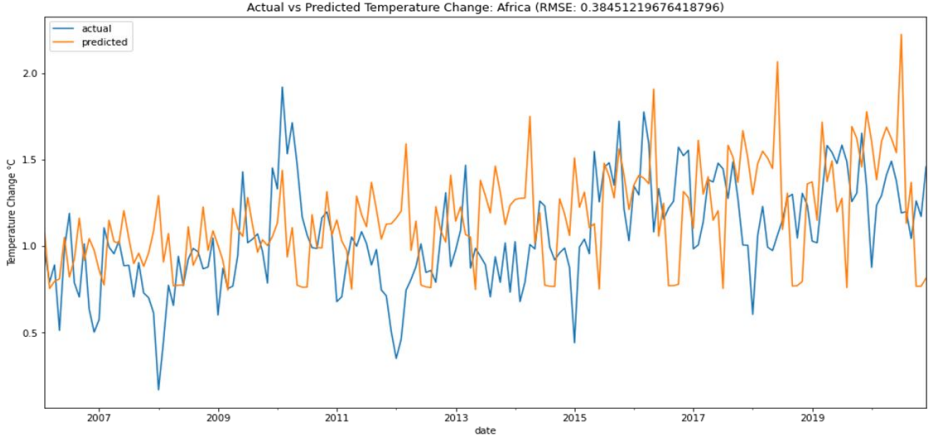


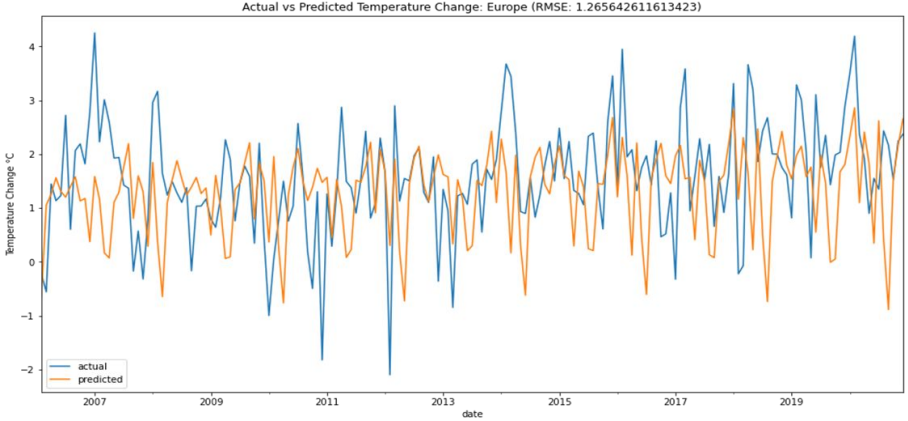


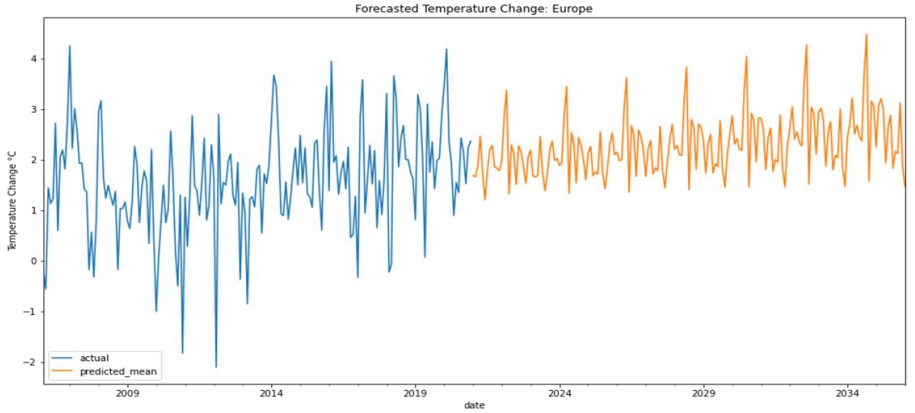

Actual vs Predicted Temperature Change: Asia (RMSE: 0.6146378420079036)
actual
predicted
Temperature Change °C
date

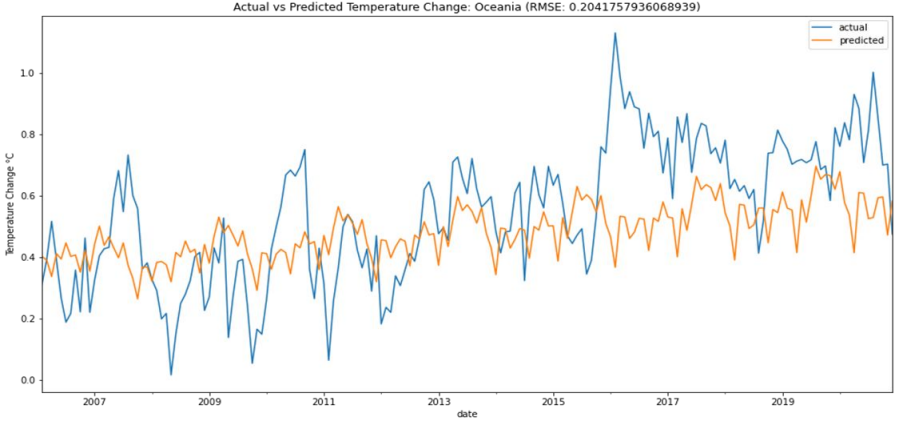

Actual vs Predicted Temperature Change: Americas (RMSE: 0.27300552169696835)
actual
predicted
Temperature Change °C
date

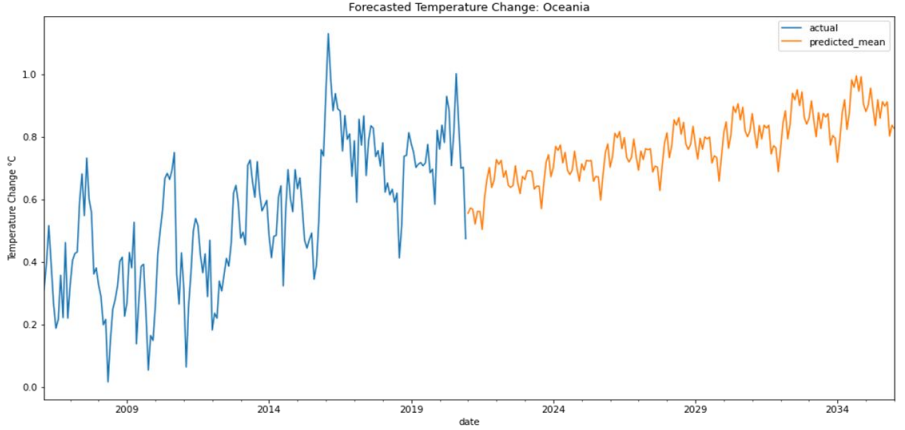

Actual vs Predicted Temperature Change: Antarctica (RMSE: 2.30992941015665)
actual
predicted
Temperature Change °C
date

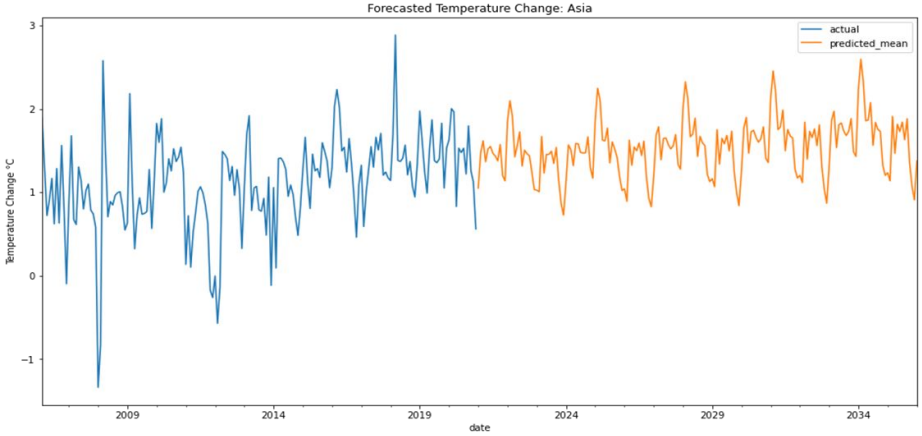

Actual vs Predicted Temperature Change: Africa (RMSE: 0.38451219676418796)
actual
predicted
Temperature Change °C
date

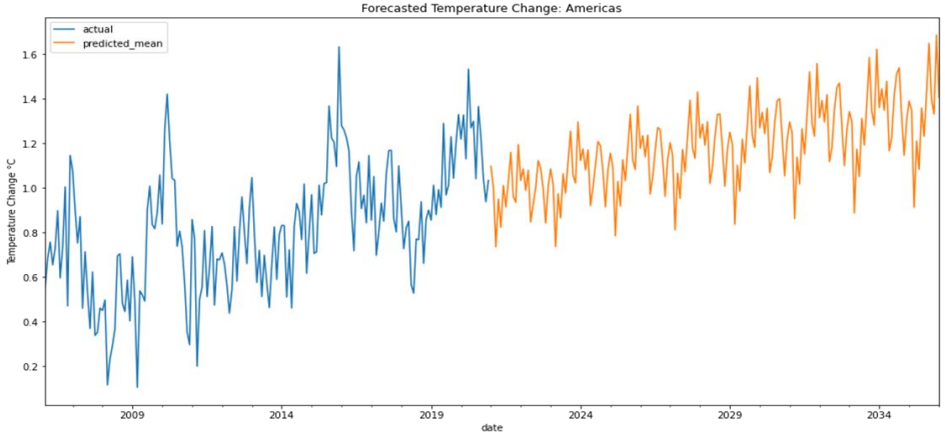

Actual vs Predicted Temperature Change: Europe (RMSE: 1.265642611613423)
Temperature Change °C
date
actual
predicted

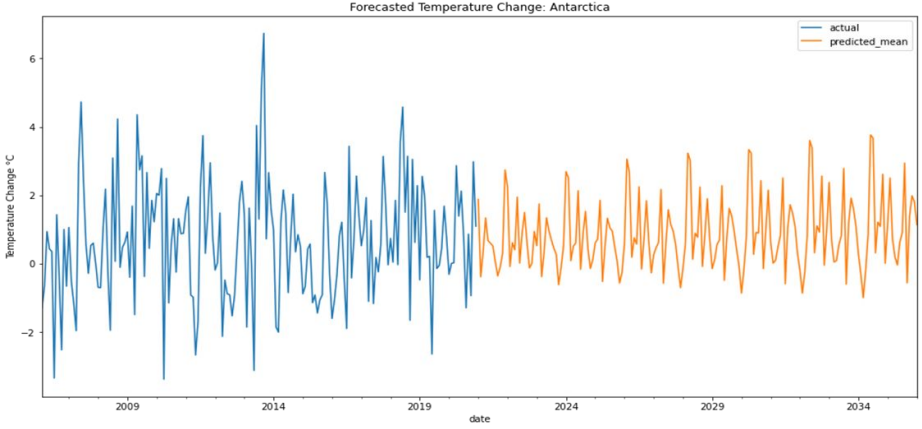

Forecasted Temperature Change: Europe
Temperature Change °C
date
actual
predicted_mean

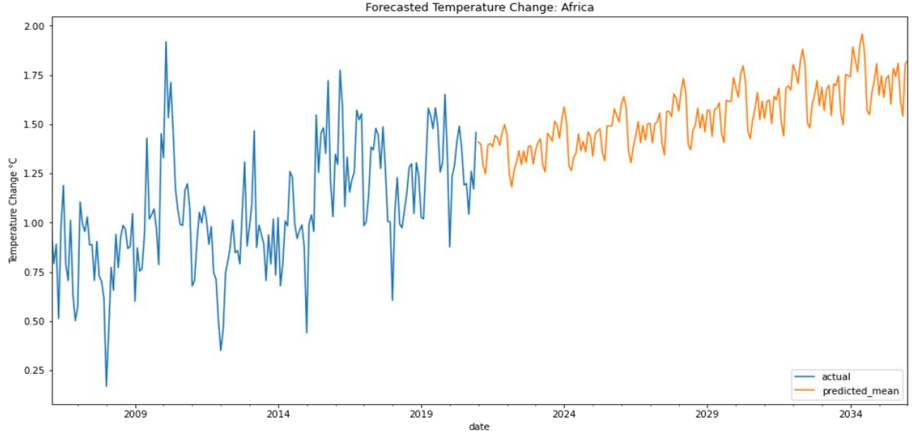

Actual vs Predicted Temperature Change: Oceania (RMSE: 0.2041757936068939)
Temperature Change °C
date
actual
predicted


Forecasted Temperature Change: Oceania
Temperature Change °C
date
actual
predicted_mean


Forecasted Temperature Change: Asia
actual
predicted_mean
Temperature Change °C
date


Forecasted Temperature Change: Americas
actual
predicted_mean
Temperature Change °C
date


Forecasted Temperature Change: Antarctica
actual
predicted_mean
Temperature Change °C
date


Forecasted Temperature Change: Africa
actual
predicted_mean
Temperature Change °C
date

Conclusion and Recommendations

AS conclusion , the SARIMAX model we built is a starting point , It picked up the trend and seasonality in the predictions and forecast.

To improve it we can look more on subregions and those regions with high RMSE for outliers.