The relationship between temperature and bombing in WW2

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Abstract:

Historically speaking, the weather has played a vital role during war. To this day, it still holds its place in strategic planning of attacks. The recent war between Ukraine and Russia has also relied heavily on temperature with several news articles suggesting that sudden cold temperatures in the region of Ukraine had been detrimental to Russia's launching of attacks.

The above made me start to think about how vital temperature and weather conditions are during war and how intelligence of several countries incorporates it into their operations. This was the entire inspiration of the project and thus it made sense for me to perform exploratory data analysis into the matter and make temperature predictions that could help determine the severity of attacks.

From the context of predicting the severity of airstrikes/attacks in a region, current Machine Learning initiatives focus more on incorporating features such as Financial transactions,travel patterns, activities of possible suspects into the model. However, by incorporating an additional feature that is: weather conditions (eg: fog, rain, snow and general temperatures) it becomes possible to formulate a more concrete and intelligent ML Solution. The current ML solutions in different areas of war strategy are usually for target detection, cybersecurity, weaponry etc. However, vulnerable countries can now predict the damage they could face, in a better fashion by incorporating temperature and weather conditions.

This could have helpful implications for a country/region that is vulnerable and is under attack. The primary goal of such a country's stance would be to protect their citizens. Forecasting temperature and weather conditions in this way can help curb the loss of human life by facilitating the following:
(i)evacuation routes in advance,

(ii)devise more optimal safety protocols, and

(iii)build a more solid overall logistic plan.

Big Picture Summary:

The goal of the project boils down to performing temperature forecasting under the informed consideration (& via a thorough research) that temperature and weather conditions play a vital role during war and in particular- in the number of airstrikes. The aim of the project was to help vulnerable countries (such as Ukraine; Note-no political biases are involved) help navigate the timeline and severity of airstrikes in order to devise escape routes and safety plans in advance for their citizens.

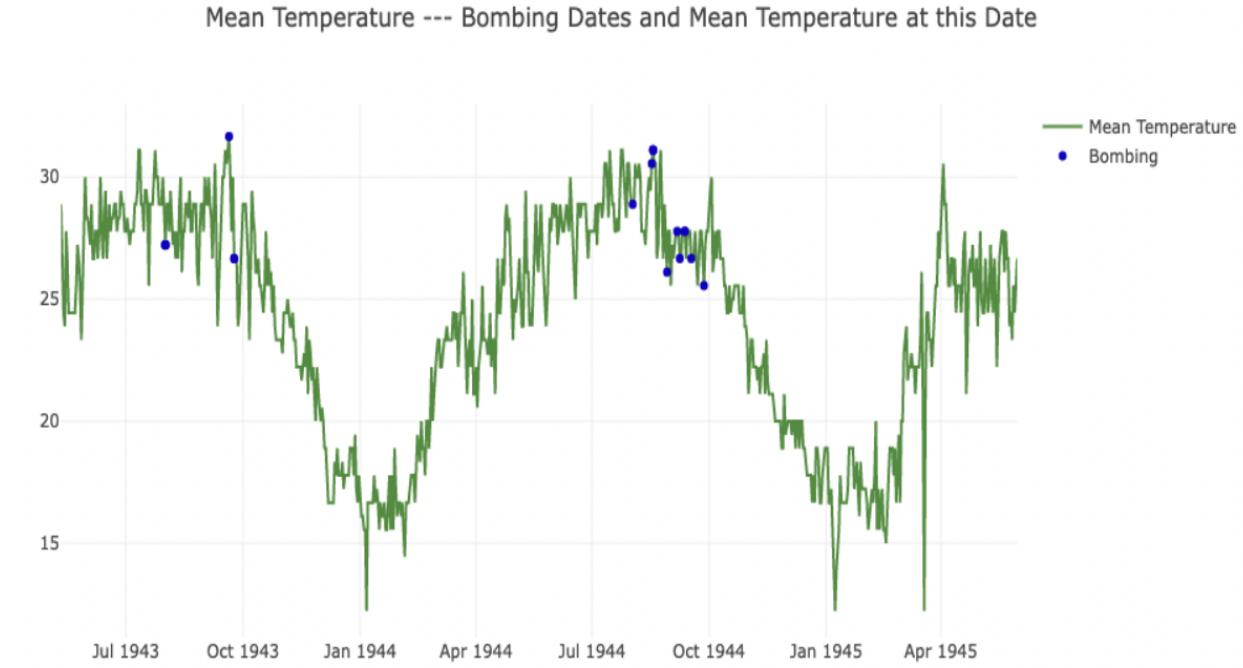
Class project problem:

For this project, I worked with 2 datasets. One contained Weather information that reported the existing weather conditions during WW2. Due to the sensitivity of the topic- for my second dataset, I chose to work with Aerial Bombing during WW2 War data that was freely available from Kaggle. This dataset was made available by Lt Col Jenns Robertson of the US Air Force.

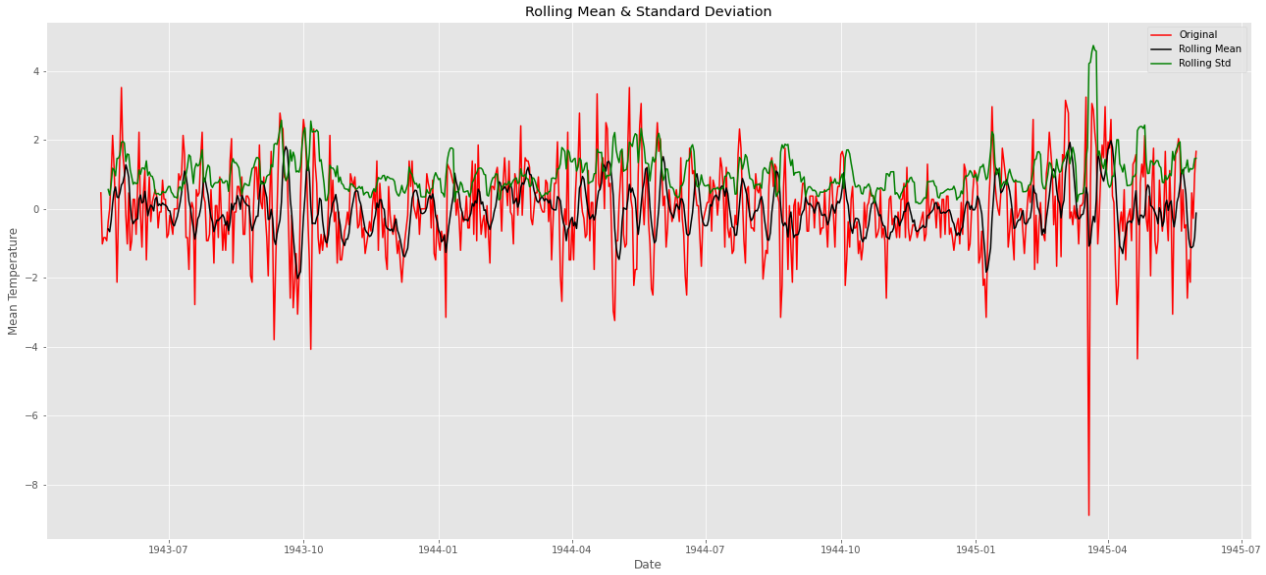
The datasets were first loaded and cleaned. Cleaning involved dropping of unused features, and dropping on NaN values from the columns target latitude, longitude and lastly, dropping countries that were NaN entries. The weather conditions data didn't need any cleaning. This was validated by using the weather.describe(), weather.info() and weather.isnull() functions to first get the dataset information, its values such as mean, median of various features and to check for the presence of any null values.

Firstly, preliminary data visualizations were performed in order to gain more insights. The top attacking and target countries were visualized via countplots. Additionally, the top aircraft series that were used during this WW2 timeline was also obtained. Next, in order to visualize the countries' take off bases, the locations of the weather stations and also bombing routes, the plotly's 'scattergeo' type was invoked. The results for all this are displayed in the Key Results section. The scattergeo plot mapped the latitudes and longitudes respectively.

I chose to focus on the warring between the USA and Burma, that spanned over the timeline of 1942- 1945. The weather station closest to this war was Bindukuri. The mean temperatures and the bombing was recorded on a single plot. This plot validated my hypothesis that airstrikes usually took place in optimal temperature conditions.



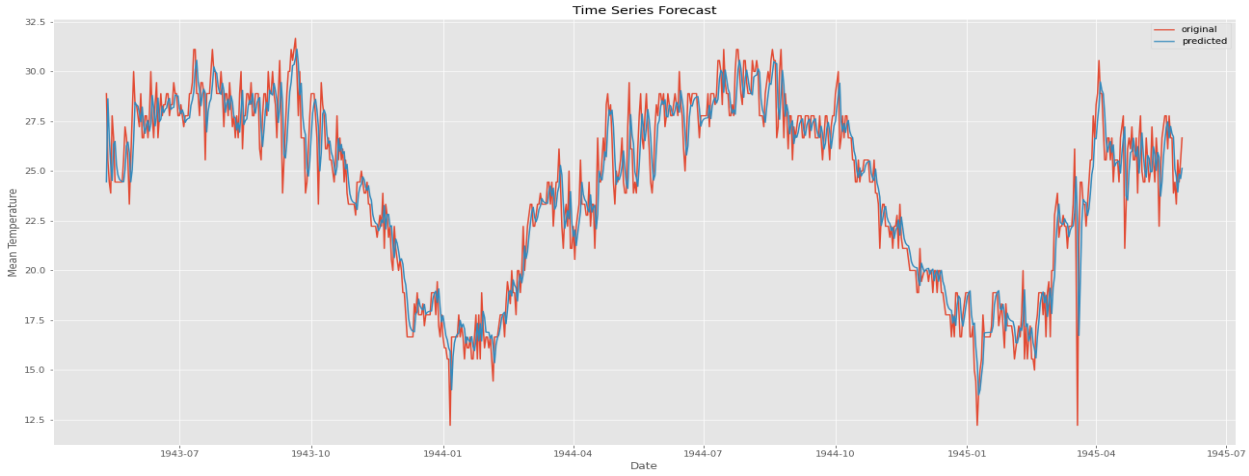
The final step was to predict future temperatures in the region and thereby deduce whether bombing would take place. For the sake of making predictions, the ARIMA model was used. The temperature plot showed seasonality and the rolling mean and std.deviation plots also showed non-stationary data. Since ARIMA required stationary data, the data was made stationary by performing moving average differencing from the time series.



Time Series after converting to stationary data

The data was validated for stationarity using the ADF-test and plotting rolling statistics. In order to choose the p,d,q parameters for the ARIMA model, the ACF and PACF plots were generated. In both cases, the lag values where it crossed the upper confidence interval for the first time was p=q=1. Since, first order differencing was taken, d was set to 0.

Finally, the temperature predictions were made over the timeline of the USA and Burma War. The model performed very well and this was validated by the low **Mean Squared Error of 1.862**.



Literature Review:

1. **How Ukraine's Weather and Geography could influence Russian Invasion**

   Citation:
   https://www.washingtonpost.com/world/interactive/2022/ukraine-russia-invasion-geography-weather/

   https://www.theguardian.com/world/2015/oct/05/perfect-weather-for-airstrikes-russian-tv-forecast-sets-sights-on-syria

   This article by the Washington Post speaks about how the weather and terrain of Ukraine had restricted Russia's attacks over it. Temperature conditions and radioactivity of the soil were factors that were shaping Russia's next moves. Although now due to state of the art weaponry, aircrafts etc, the impact of weather has not been as high-Historically speaking. However, to this day, it still has considerable influence over the war situation. Kirill Mikhailov, an analyst of the independent Russian Intelligence Team said in a conversation with journalists that it was inconvenient to carry out attacks in the Spring due to the thawing of ravines to creeks and subsequently into rivers. He mentions waiting for optimal temperature conditions to carry out offensive attacks. In another such Russian news correspondence experts said with regards to the Syrian bombing in 2015, that October was a good month for airstikes in Syria noting that warm and sunny conditions posed average wind speeds of only 2.4 meters per second and rain falls once every ten days. Although there are 13 overcast days on average, this shouldn't pose a severe hurdle to the operation because clouds are typically 4 to 6 kilometers above the ground and will not impair weapon aiming systems.

2. **The North Atlantic Weather War**

   Citation: https://en.wikipedia.org/wiki/North_Atlantic_weather_war

   This link spoke about how during World War II, there was a weather war in the North Atlantic. In the North Atlantic and Arctic waters, the Allies (particularly Britain) and Germany attempted to obtain a monopoly on weather data. Meteorological intelligence was crucial because it influenced military strategy and ship and convoy routing. Visibility was required in some situations (photographic reconnaissance and bombing strikes), but hiding was required in others (keeping ship movements secret or suppressing enemy air activity). Weather forecasts had a significant impact on D-day planning; it was postponed by one day in the hopes that a storm would pass and sea conditions would be acceptable. Ships at sea and weather stations at Valentia Observatory and Blacksod Point, both in neutral Ireland, were used by the British; the Germans used ships at sea and weather stations at Valentia Observatory and Blacksod Point, both in neutral Ireland. Because of inclement weather, bombers and other aircraft may be grounded, or their targets may be disguised by fog or clouds. Land offensives relied on weather forecasts as well, while at sea, convoys carrying essential supplies required accurate forecasts to deliver their cargoes. It highlighted how the Germans decided to send

weather ships into North Atlantic waters, allegedly "fishing" trawlers capable of avoiding Allied discovery while still providing important meteorological data.

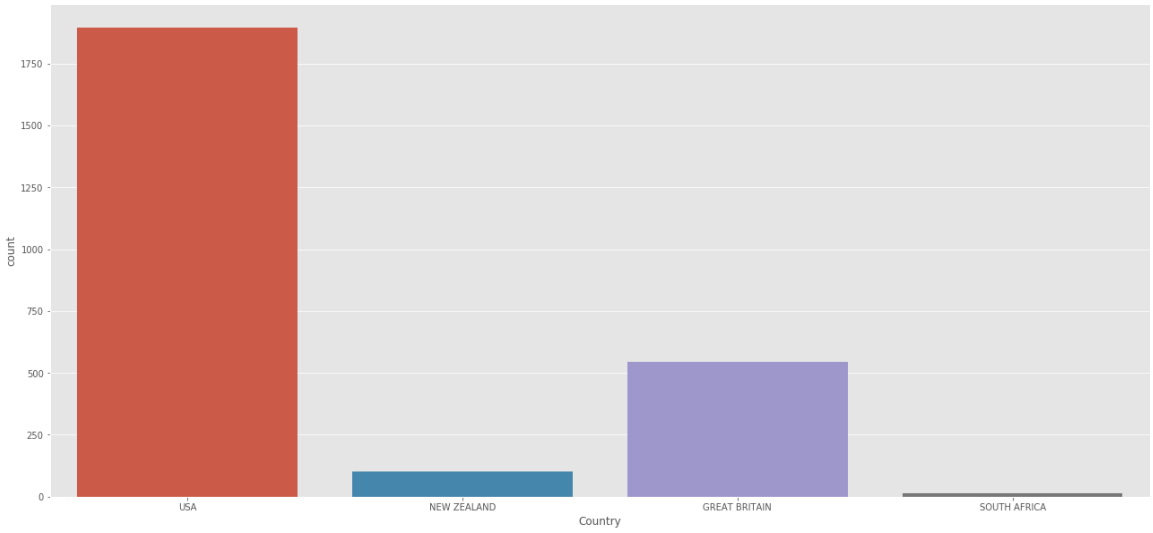
3. **Weather Modification Technology in Warfare**

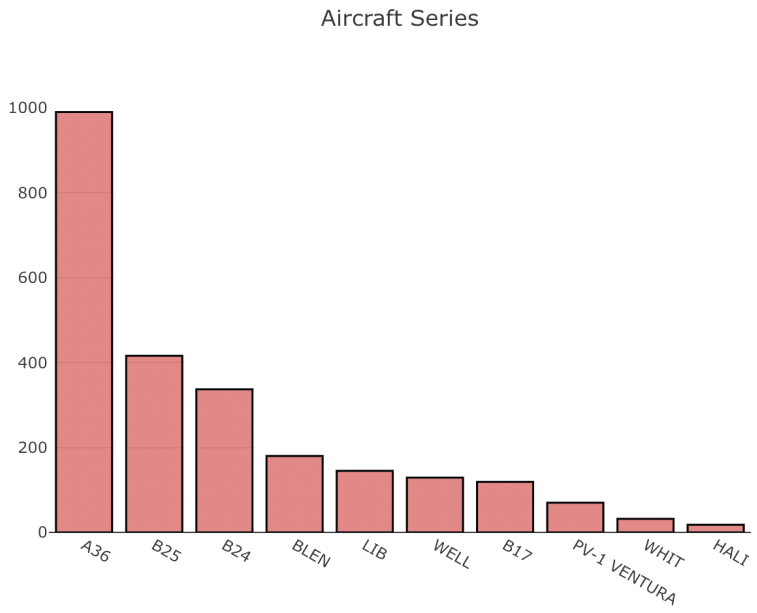
   Citation:
   https://www.unrevealedfiles.com/weather-warfare-weather-modification-technology-in-warfare/#:~:text=Weather%20modification%20can%20be%20used,weather%20control%20programs%20are%20similar.

   This article was extremely interesting as it spoke about the possibility of modifying weather as a part of war strategy. The importance of weather for military intelligence is so critical that research efforts are being made into weather modification as it serves as a tactical weapon or an incendiary way to weaken the enemy state. The removal of warm and supercooled fog, modifying cloud cover, boosting precipitation (rain or snow), controlling lightning, and dealing with hurricanes and other severe storms have all been studied. Injecting pollutants into the atmosphere, spreading lampblack on ice, releasing frozen carbon dioxide into the clouds to cause snowstorms, and depleting ozone have all had negative consequences. All have been subjected to tests and calculations.Many governments throughout the world are still conducting drills and experiments to learn how to alter the weather and utilize it in combat. The Russians, for example, have long been active in weather manipulation as a means of managing hail. Cloud seeding has also been used in China to bring rain.

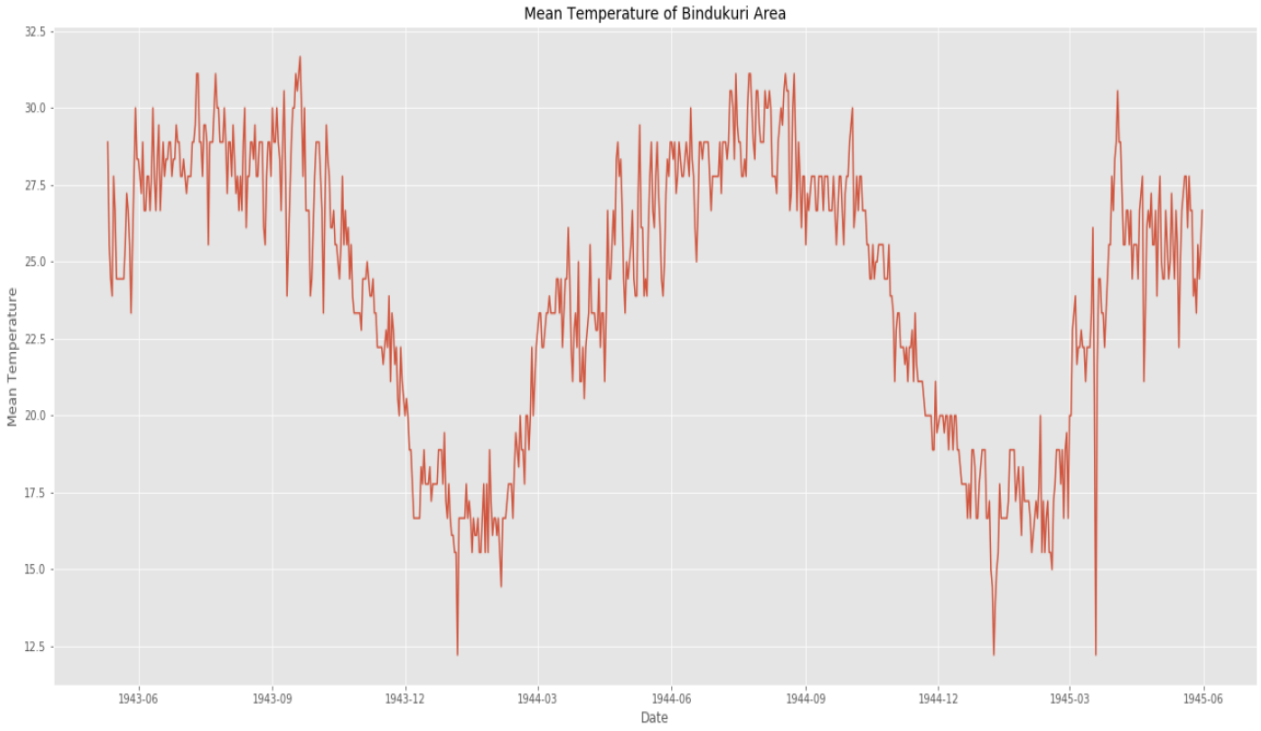
Key Results:

1. Most used aircraft series and top attacking countries:



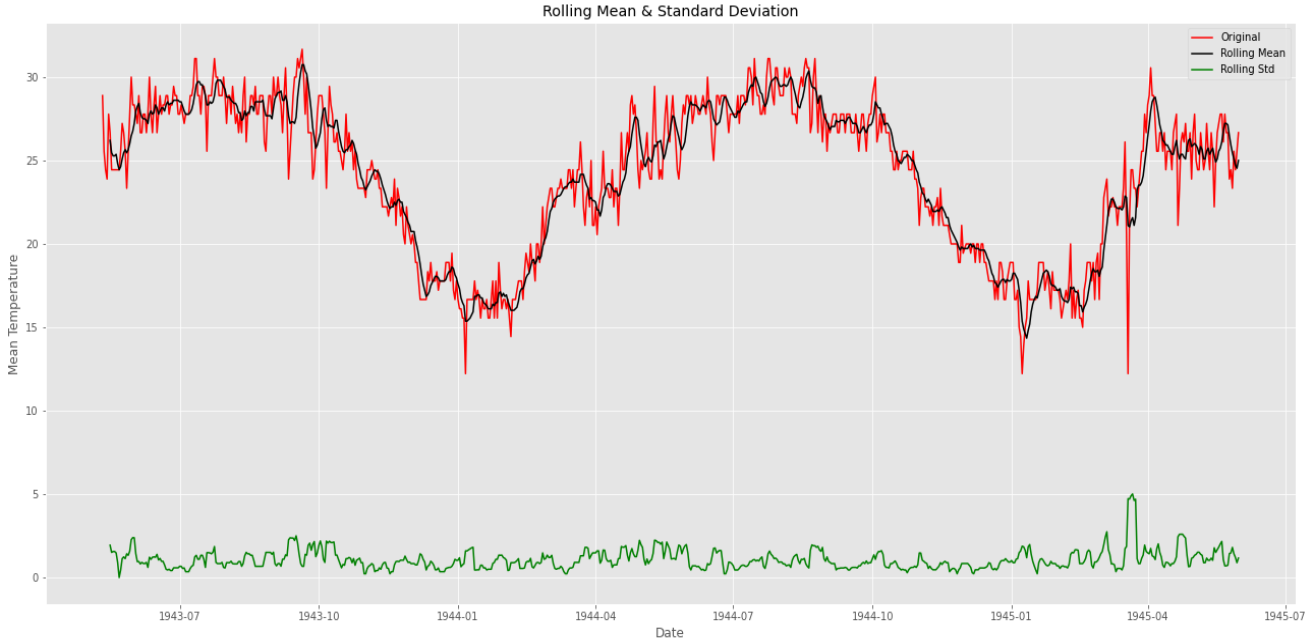


2. To initially check for the **presence of seasonality** in the time series:



The winter months see lower mean temperatures and vice versa in the summer months.

3. **Rolling mean and Std.Dev** before transforming the data to become stationary:



Time Series before converting to stationary data

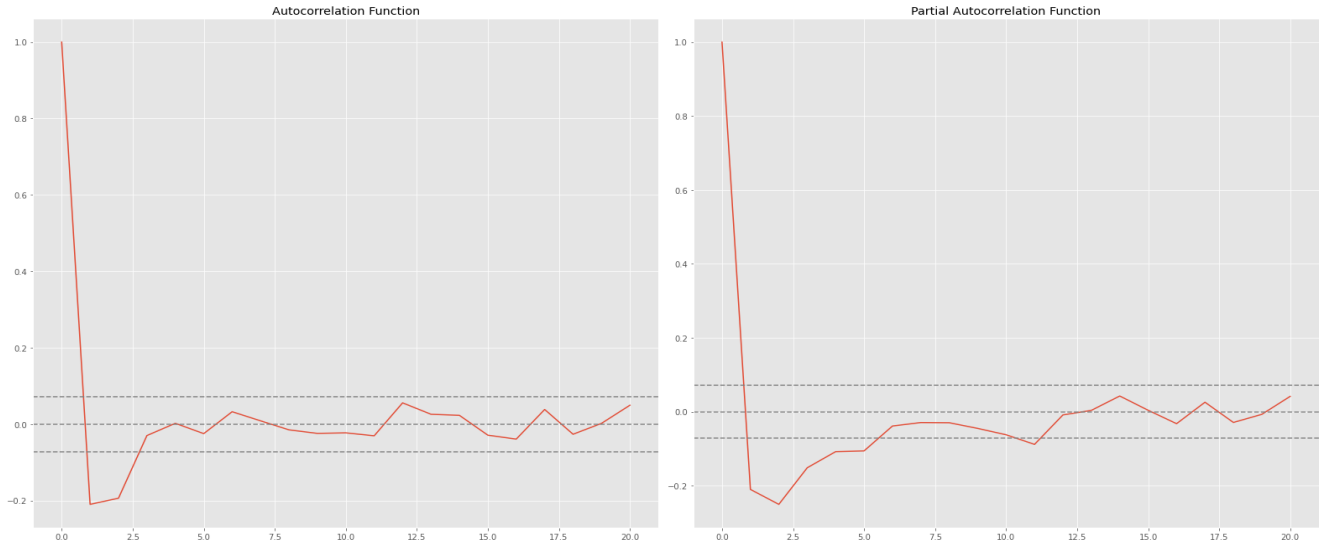
The **test statistics** after converting data to stationary (**the plot of which is present in the Class Project Problem**) were obtained as follows:

```
Test statistic:  -11.138514335138474

p-value:  3.150868563164652e-20
Critical Values: {'1%': -3.4392539652094154, '5%':

-2.86546960465041, '10%': -2.5688625527782327}
```

We can clearly see how the test stat is lower than all critical values at all confidence intervals:

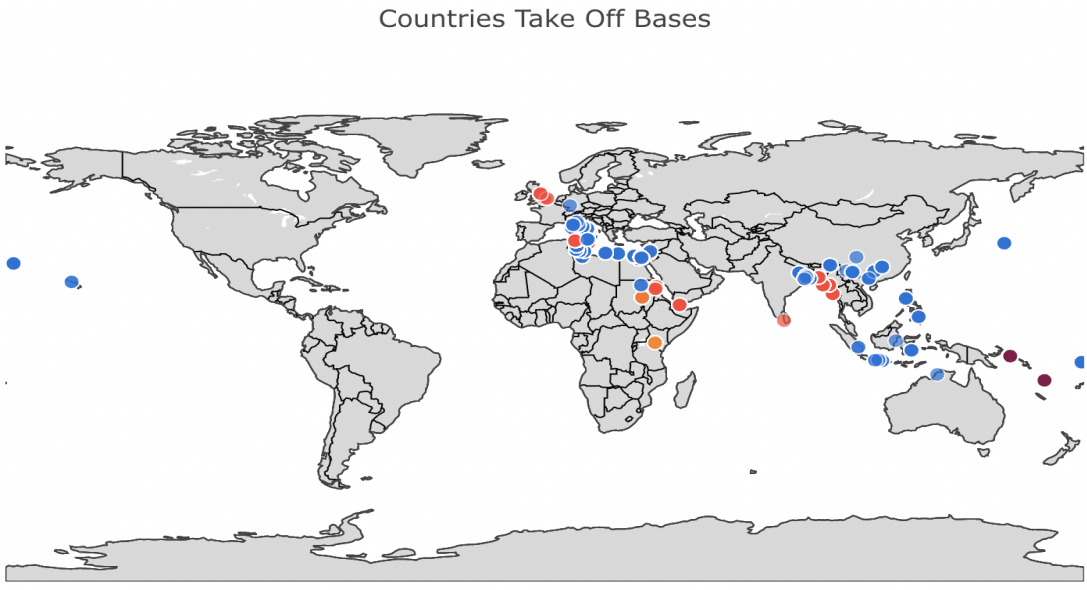
suggesting stationarity.

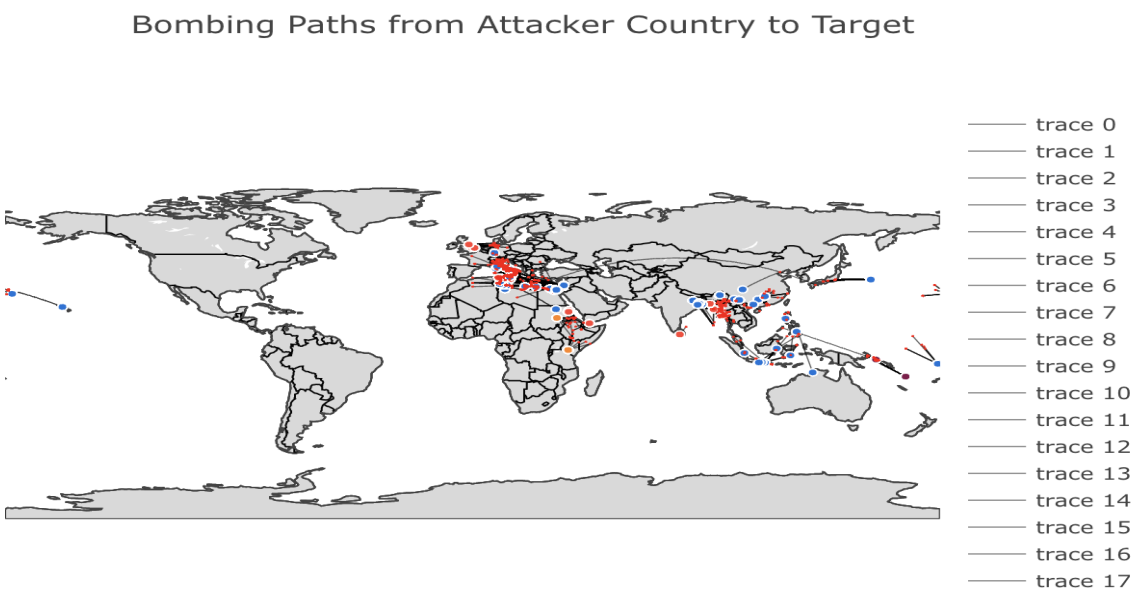
4. ACF and PACF plots to choose p and q parameters:



Hence, I chose p = q = 1.

5. Scattergeo plots: (Top: Countries and their take off bases; Below: Bombing routes adopted by attacking countries)





Looking at the above two plots: The USA (signified by blue dots)had most air force bases set up around different countries, followed by Great Britain(in red), Kenya(in orange) and New Zealand (in purple). Furthermore, the bombing routes show how countries such as the US heavily attacked the Burma, Philippines, Thailand etc. regions. The plots above were meant to provide more insight into how the war took place.

Discussions:

The ARIMA model performed very well with choosing of parameters p,d,q. Differencing was another method that was explored to convert time series to stationary data. However, I chose to stick with Moving Average as it led to a slightly better- that is lower MSE error. The scattergeo plots were added in to give more graphic and informative content about the warring timeline. It was also done inorder to incorporate the new found interest of Geospatial Data Science that I gained from this course.

The Exploratory data analysis suggested that the US was the top attacking country and the most used aircraft was A36. The scattergeo plot revealed how the Asian and Mediterranean regions faced a lot of attacks.

In the bigger picture of things, this model can be used to predict temperature conditions and hence correlate this to the severity of bombing attacks/airstrikes in a region. To be able to correlate features, or add more predictors such as this in already existing Machine Learning solutions would prove to be beneficial to intelligence and also to enhance safety protocols for vulnerable countries under attack. Adding relevant predictors to a model will only make for smarter predictions. So in today's world and situation, further predictors such as fog, rain, snow and Air Quality indices can be incorporated in addition to the temperature. Incorporating Air Quality indices can then also be predicted during post-war situations. This will help vulnerable countries realize the future environmental danger that it could pose to their citizens and hence come up with solutions for the same.