Deliverable 2

Dataset: Climate Change: Earth Surface Temperature Data
Source: https://www.kaggle.com/datasets/berkeleyearth/climate-change-earth-surface-temperature-data

Libraries used:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
from statsmodels.tsa.stattools import adfuller
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from sklearn.metrics import mean_squared_error
from math import sqrt
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline
```

Understanding the data:

```
cities = pd.read_csv(s3_csv_path)
cities.head()
```

	dt	AverageTemperature	AverageTemperatureUncertainty	City	Country	Latitude	Longitude
0	1743-11-01	6.068	1.737	Århus	Denmark	57.05N	10.33E
1	1743-12-01	NaN	NaN	Århus	Denmark	57.05N	10.33E
2	1744-01-01	NaN	NaN	Århus	Denmark	57.05N	10.33E
3	1744-02-01	NaN	NaN	Århus	Denmark	57.05N	10.33E
4	1744-03-01	NaN	NaN	Århus	Denmark	57.05N	10.33E

```
cities.shape
```

```
(8599212, 7)
```

```
cities.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8599212 entries, 0 to 8599211
Data columns (total 7 columns):
 #   Column                         Dtype
---  ------                         -----
 0   dt                             object
 1   AverageTemperature             float64
 2   AverageTemperatureUncertainty  float64
 3   City                           object
 4   Country                        object
 5   Latitude                       object
 6   Longitude                      object
dtypes: float64(2), object(5)
memory usage: 459.2+ MB
```

The data set has 8599212 rows and 7 columns. The datatype of these columns are displayed above.

```
cities.describe
```

```
<bound method NDFrame.describe of                 dt  AverageTemperature  AverageTemperatureUncertainty  \
0        1743-11-01            6.068000                        1.737000
1        1743-12-01           16.727433                        1.028575
2        1744-01-01           16.727433                        1.028575
3        1744-02-01           16.727433                        1.028575
4        1744-03-01           16.727433                        1.028575
...             ...                 ...                             ...
8599207  2013-05-01           11.464000                        0.236000
8599208  2013-06-01           15.043000                        0.261000
8599209  2013-07-01           18.775000                        0.193000
8599210  2013-08-01           18.025000                        0.298000
8599211  2013-09-01           16.727433                        1.028575

           City      Country Latitude Longitude
0         Århus      Denmark   57.05N    10.33E
1         Århus      Denmark   57.05N    10.33E
2         Århus      Denmark   57.05N    10.33E
3         Århus      Denmark   57.05N    10.33E
4         Århus      Denmark   57.05N    10.33E
...         ...          ...      ...       ...
8599207  Zwolle  Netherlands   52.24N     5.26E
8599208  Zwolle  Netherlands   52.24N     5.26E
8599209  Zwolle  Netherlands   52.24N     5.26E
8599210  Zwolle  Netherlands   52.24N     5.26E
8599211  Zwolle  Netherlands   52.24N     5.26E

[8599212 rows x 7 columns]>
```

Checking for null values:

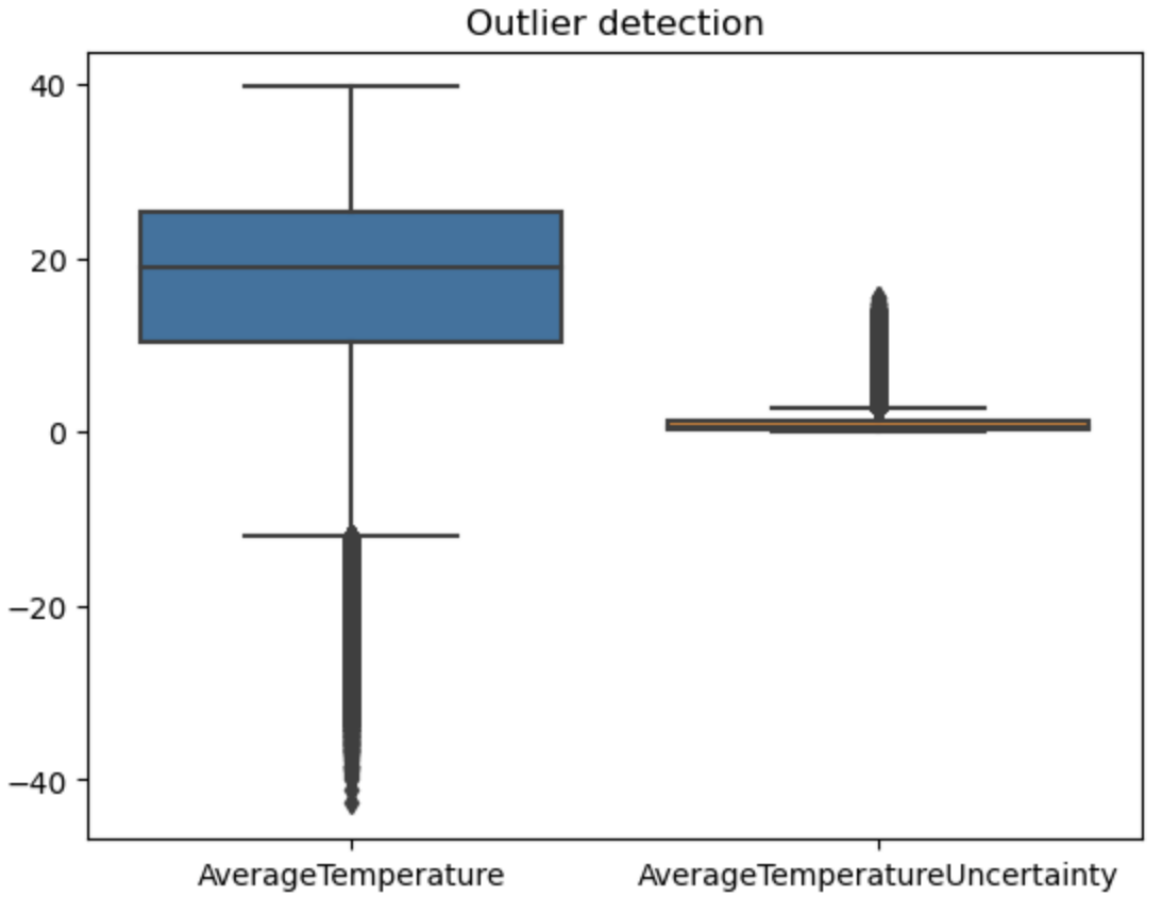
```
cities.isnull().sum()
```

```
dt                                    0
AverageTemperature               364130
AverageTemperatureUncertainty    364130
City                                  0
Country                               0
Latitude                              0
Longitude                             0
dtype: int64
```

We found some null values which we will address in the data cleaning step.

Checking outliers in the dataset:

```
sns.boxplot(data=cities)
plt.title("Outlier Detection")
plt.show()
```



Data Cleaning:

Handling null values:

```
cities['AverageTemperature'].fillna(cities['AverageTemperature'].mean(), inplace=True)
cities['AverageTemperatureUncertainty'].fillna(cities['AverageTemperatureUncertainty'].mean(), inplace=True)
```

```
cities.isnull().sum()
```

```
dt                             0
AverageTemperature             0
AverageTemperatureUncertainty  0
City                           0
Country                        0
Latitude                       0
Longitude                      0
dtype: int64
```

Checking for duplicate rows:

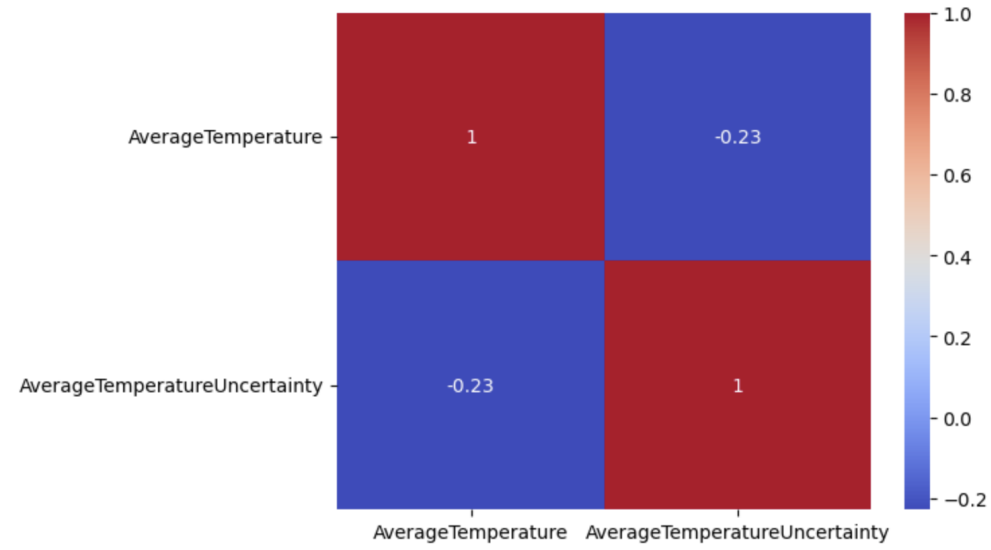
```
duplicate = cities[cities.duplicated()]
print("Duplicate rows:", len(duplicate))
print(duplicate)
```

```
Duplicate rows: 0
Empty DataFrame
Columns: [dt, AverageTemperature, AverageTemperatureUncertainty, City, Country, Latitude, Longitude]
Index: []
```

We found no duplicate rows.

Feature correlations:

```
corr = cities.corr()
sns.heatmap(corr, cmap='coolwarm', annot=True)
plt.show()
```

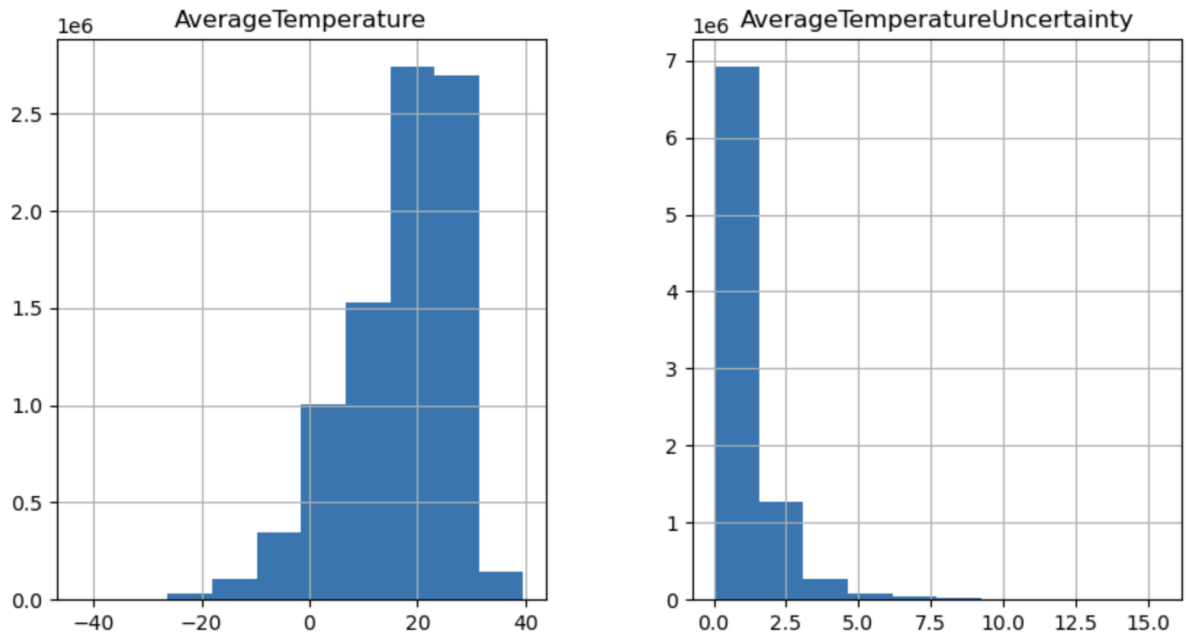


Exploratory Data Analysis

Histogram for AverageTemperature and AverageTemperatureUncertainity

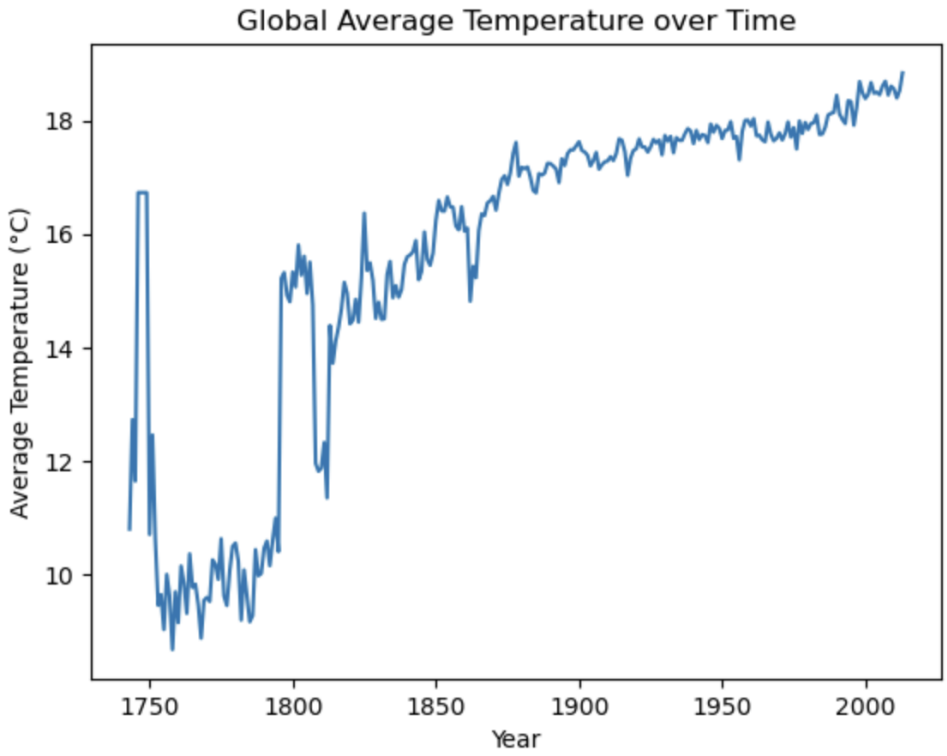
```
cities.hist(figsize=(10,5))
```

```
array([[<AxesSubplot: title={'center': 'AverageTemperature'}>,
        <AxesSubplot: title={'center': 'AverageTemperatureUncertainty'}>]],
      dtype=object)
```



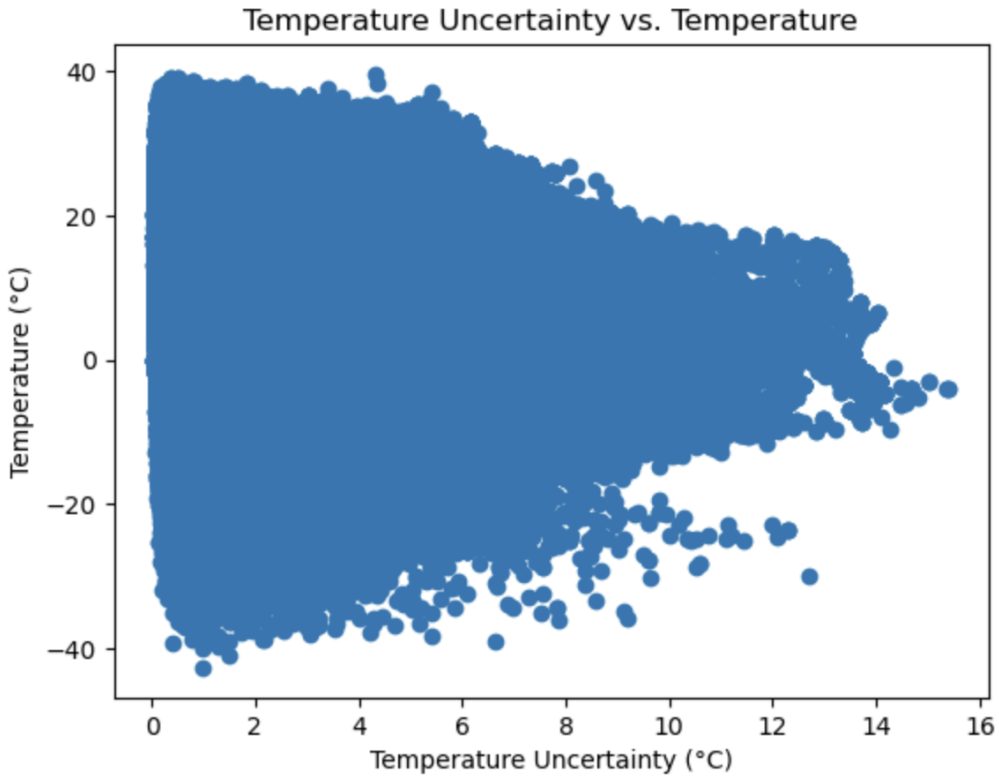
Global Average Temperature over Time

```
cities['dt'] = pd.to_datetime(cities['dt'])

# Group data by year and calculate average temperature
yearly_temps = cities.groupby(cities['dt'].dt.year)['AverageTemperature'].mean()

# Create a line plot of average temperature over time
plt.plot(yearly_temps.index, yearly_temps.values)
plt.xlabel('Year')
plt.ylabel('Average Temperature (°C)')
plt.title('Global Average Temperature over Time')
plt.show()
```



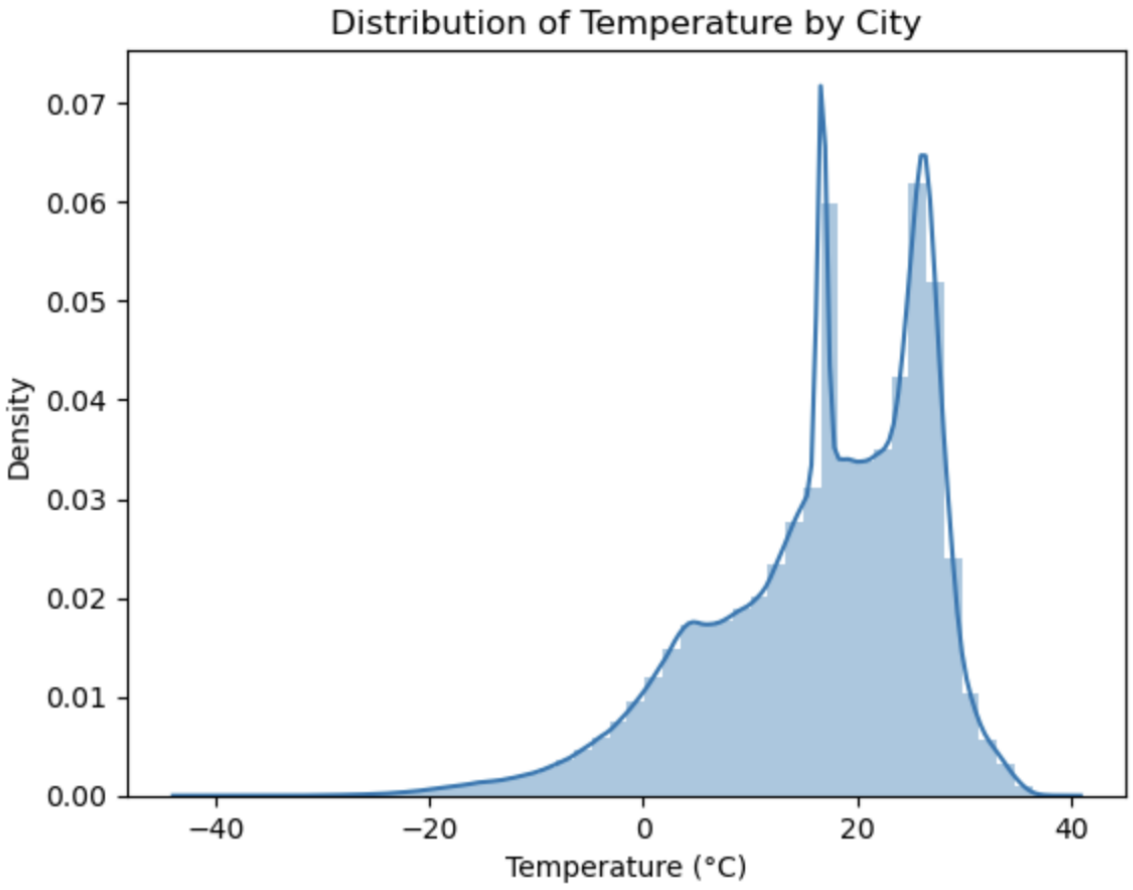
Temperature Uncertainty vs. Temperature

```
plt.scatter(cities['AverageTemperatureUncertainty'], cities['AverageTemperature'])
plt.xlabel('Temperature Uncertainty (°C)')
plt.ylabel('Temperature (°C)')
plt.title('Temperature Uncertainty vs. Temperature')
plt.show()
```



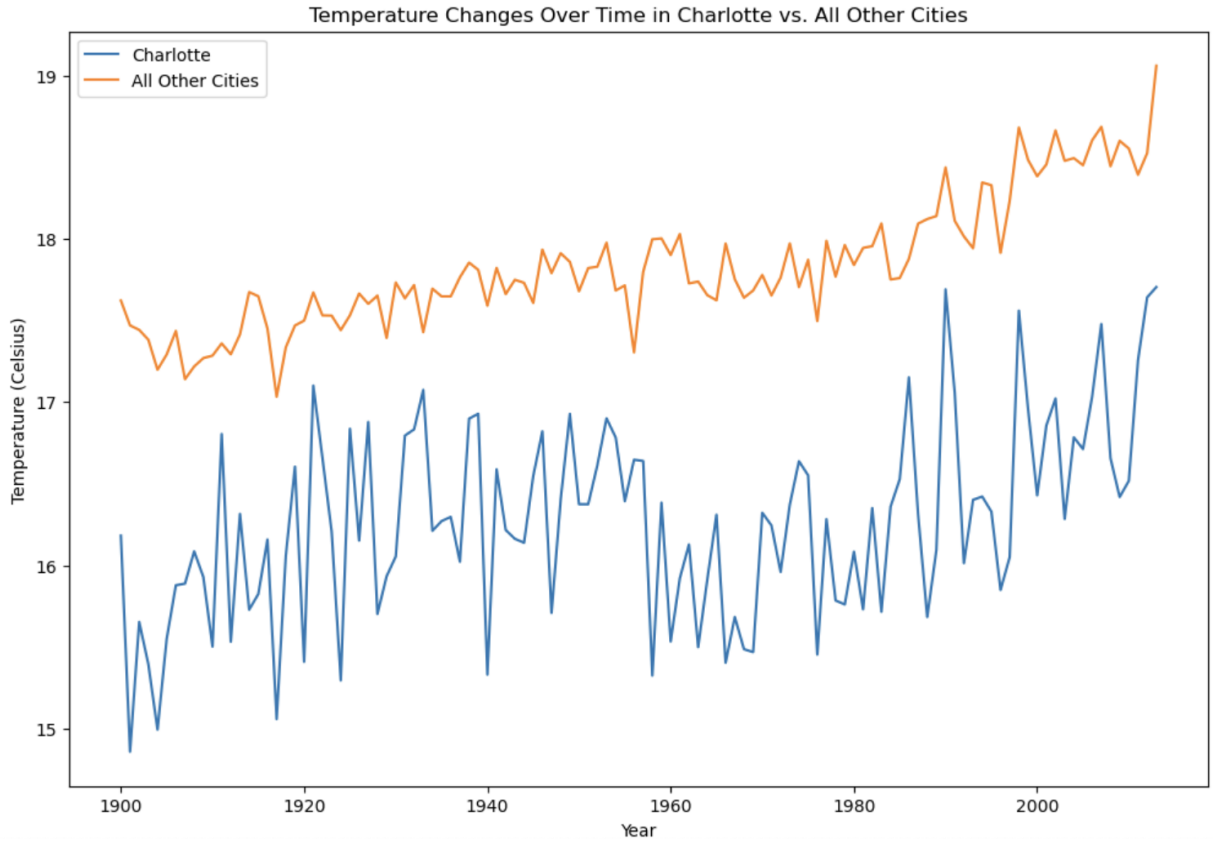
Distribution of Temperature by City

```
sns.distplot(cities['AverageTemperature'])
plt.xlabel('Temperature (°C)')
plt.title('Distribution of Temperature by City')
plt.show()
```



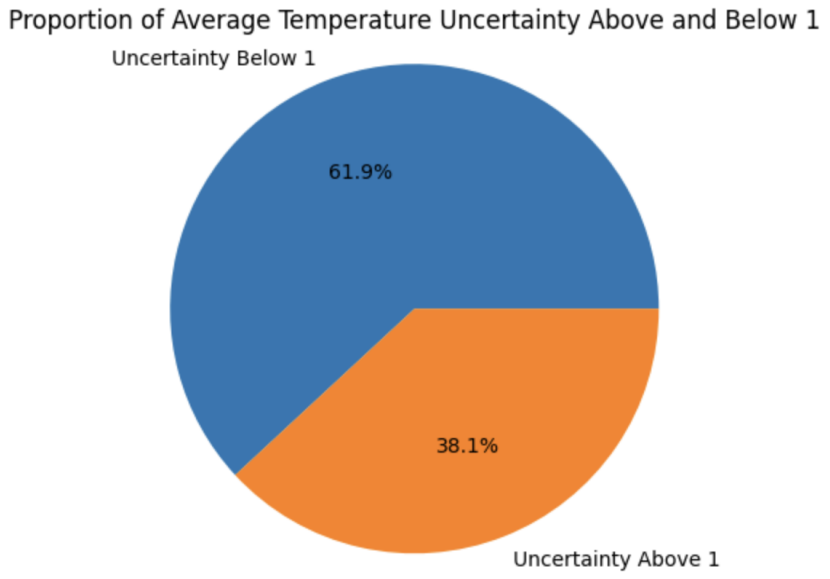
Temperature Change Over Time in Charlotte vs. All Other Cities

```
clt = cities[cities['City'] == 'Charlotte'].copy()
other_cities = cities[cities['City'] != 'Charlotte'].copy()

# Filter Charlotte data to include only the years after 1900
clt = clt[clt['dt'].str.startswith('19') | clt['dt'].str.startswith('20')].copy()
other_cities = other_cities[other_cities['dt'].str.startswith('19') | other_cities['dt'].str.startswith('20')].copy()

# Convert the date column to a datetime object
clt['dt'] = pd.to_datetime(clt['dt'])
other_cities['dt'] = pd.to_datetime(other_cities['dt'])

# Group the data by year and calculate the mean temperature for each year
clt_yearly_temp = clt.groupby(clt['dt'].dt.year)['AverageTemperature'].mean()
other_cities_yearly_temp = other_cities.groupby(other_cities['dt'].dt.year)['AverageTemperature'].mean()

# Create a line chart to compare the temperature changes over time in Charlotte and all other cities
plt.figure(figsize=(12,8))
sns.lineplot(x=clt_yearly_temp.index, y=clt_yearly_temp.values, label='Charlotte')
sns.lineplot(x=other_cities_yearly_temp.index, y=other_cities_yearly_temp.values, label='All Other Cities')
plt.title('Temperature Changes Over Time in Charlotte vs. All Other Cities')
plt.xlabel('Year')
plt.ylabel('Temperature (Celsius)')
plt.legend()
plt.show()
```



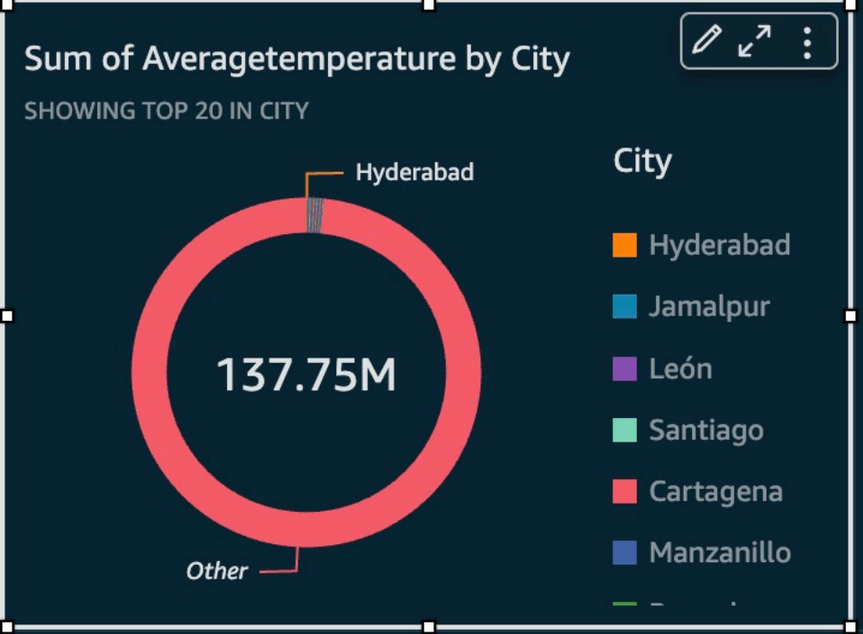
Proportion of Average Temperature Uncertainty Above and Below 1

```
plt.pie(uncertainty_counts, labels=['Uncertainty Below 1', 'Uncertainty Above 1'], autopct='%1.1f%%')
plt.title('Proportion of Average Temperature Uncertainty Above and Below 1')
plt.axis('equal')
plt.show()
```

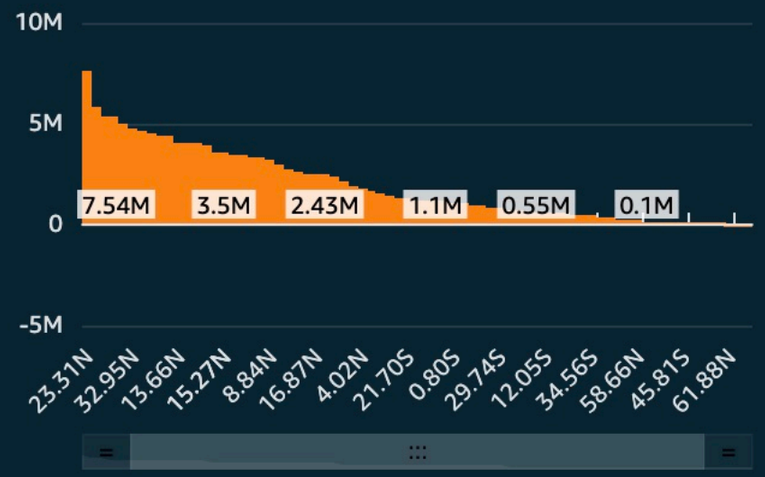


Sum of Averagetemperature by City

SHOWING TOP 20 IN CITY

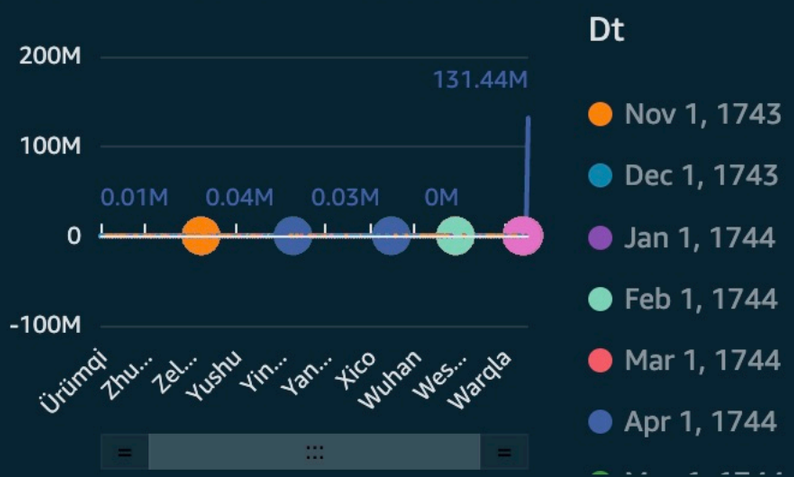


Sum of Averagetemperature by Latitude

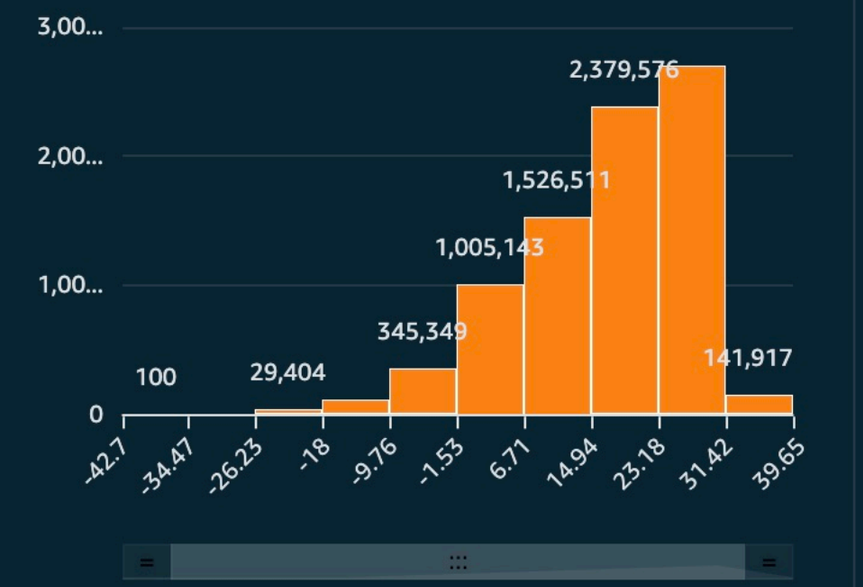


Sum of Averagetemperature by City and Dt

SHOWING TOP 200 IN CITY AND BOTTOM 25 IN DT

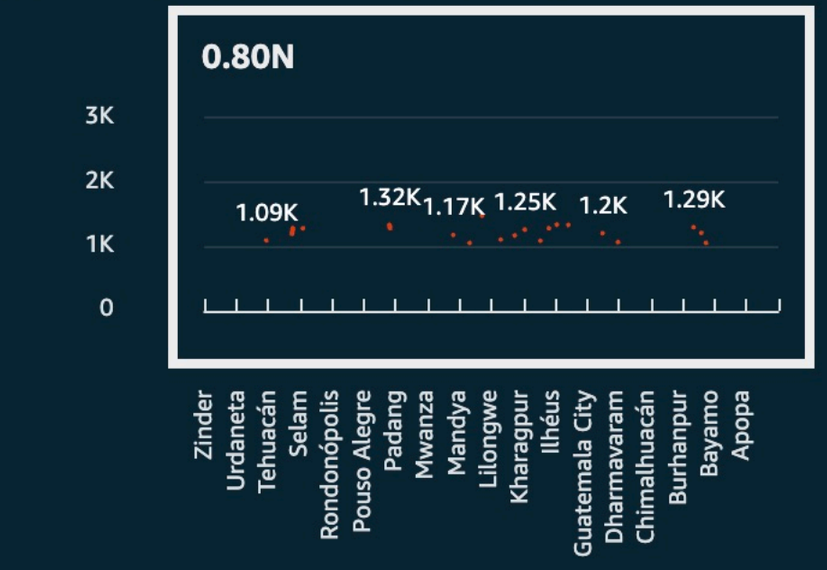


Distribution of AverageTemperature

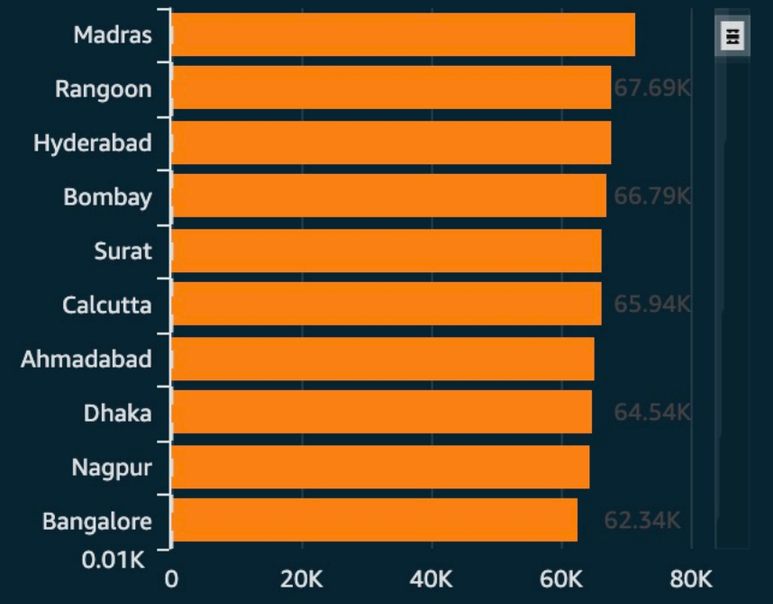


Sum of Averagetemperatureuncertainty by City a...

SHOWING BOTTOM 20 IN LATITUDE AND TOP 739 IN CITY

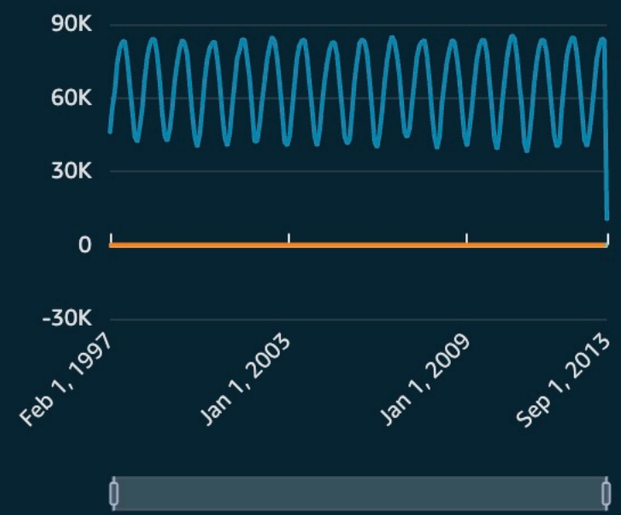


Sum of Avg temp for major cities



Temperature trend over time

SHOWING TOP 200 IN DT AND BOTTOM 25 IN CITY

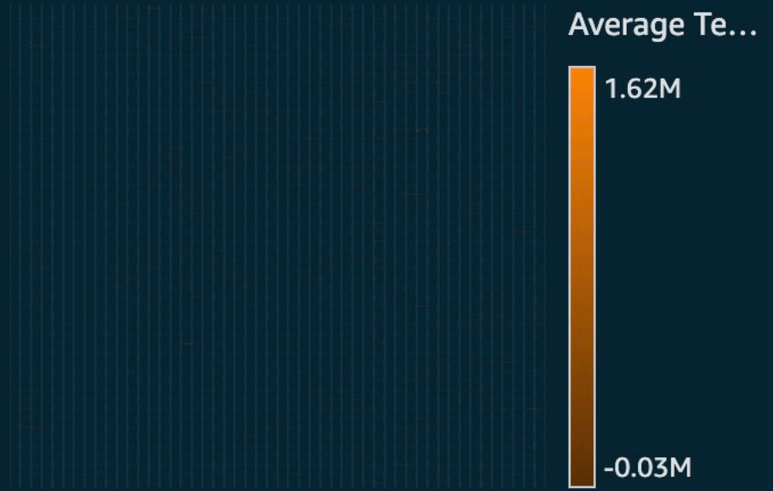


City

- A Coruña
- Aachen
- Aalborg
- Aba
- Abadan
- Abakaliki
- Abakan
- Abbotsford

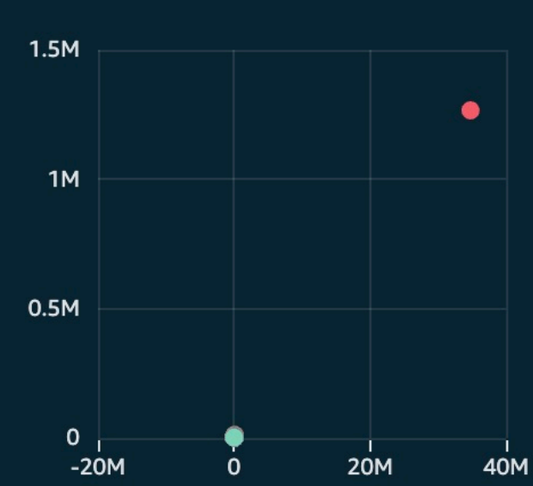
Average temperature by latitude and longitude

SHOWING TOP 50 IN LATITUDE AND BOTTOM 50 IN LONGITUDE



Relationship between average temperature and uncertainty

SHOWING TOP 2500 IN CITY



City

- Springfield
- Worcester
- León
- Rongcheng
- Birmingham
- Brest
- Cambridge