UNIVERSITY of BRADFORD

This report covers a piece of analysis and effective visualization on the effects of climate change in urban centres with London and New York as focal points.

A COMPARATIVE REPORT ON TEMPERATURE TRENDS IN LONDON AND NEW YORK: INSIGHTS INTO GLOBAL CLIMATE CHANGE (1900–2013)

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INTRODUCTION

In the modern world, climate change is a pressing issue. However, its defining characteristics are rising global temperatures, altered weather patterns, and extreme weather events worldwide. Moreover, because of their dense populations, industrial activity, and topographical characteristics, urban places can act as indicators of these changes. To examine temperature patterns and provide a comparative perspective on how various locations are affected by climate change, this study uses historical land temperature data extracted from Kaggle.

BACKGROUND/LITERATURE REVIEW

Effective analysis and visualization present special problems due to the magnitude and complexity of datasets. Their homogeneous nature and quick evolution make them more challenging to manage efficiently than the scope of Big Data. Although gathering and analyzing data is only one aspect of the problem, properly presenting these findings using the appropriate visualization tools is also as important.

However, the study dataset focuses on the land temperature records of New York and London from 1900 to 2013. The data exhibits diverse geographical contexts and offers a comprehensive perspective of temperature trends in two internationally recognized urban locations.

Understanding the fundamentals of time series analysis and important concepts like urban heat islands, where cities tend to have higher temperatures than rural areas due to human activity, is crucial to better understanding the relationship between urban environments and climate trends.

Literature Gaps

Most contemporary research focuses on studies of individual cities. There is not a thorough comparison and visualization of temperature patterns between London and New York.

PROBLEM STATEMENT

Based on the analysis of the dataset, this report seeks to answer questions surrounding temperature trends over time, seasonal variations, and the potential impacts of urbanization on climate change. To this end, certain questions were posed: How have temperature trends evolved in London and New York over the last century? Are there distinct seasonal or long-term variations? What do the differences between these two cities reveal about the global climate change narrative?

DISCUSSION

The study of climate change in New York and London between 1900 and 2024 provides a view into the effects of global change on urban cities. Therefore, the research dataset collected from Kaggle was thoroughly examined, analyzed, and used to achieve the aim of this report. The significant effects of climate change in London and New York and their causes are listed here.

LONDON

The temperature has increased by 1.5 °C since 1900 (Met Office, 2020), and the sea level has risen by 15 cm since 1900 (IPCC, 2019). Extreme weather events include floods in 1953 and 2014 and heatwaves in 2003 and 2018 (UK Climate Projections, 2018). Precipitation Changes: Winter rainfall has increased by 10% since 1960 (Met Office, 2020). Health effects include illnesses brought on by the heat and mental health issues (Public Health England, 2018).

Causes

Emissions of greenhouse gases: CO2 emissions have increased by 40% since 1990 (DECC, 2015). Urbanization: Heat Island impact, Urban Area Growth (Greater London Authority, 2019). Transportation and historical industrial emissions are examples of industrial activities (UK Climate Projections, 2018).

Noteworthy Events

In 1921, the Thames River experienced a severe flood (Environment Agency, 2019); in 1953, the North Sea experienced flooding (Met Office, 2020); in 2003, there was a heatwave (38°C) (Met Office, 2020); in 2014, the Thames Valley experienced flooding (Environment Agency, 2019); and in 2018, there was a heatwave (35.3°C) (Met Office, 2020).

A case study was considered for the analysis of significant climate change occurrences in London from 1900 to 2024.

Case Study: London's Heatwave of 2003

A strong heatwave struck London in August 2003, causing serious health problems and financial damages.

Description of the Event:

Extremely high temperatures defined the 2003 heatwave; on August 10, 2003, the Kew Gardens weather station recorded a maximum temperature of 38°C (100.4°F) (Met Office 2020).

Effects:

1. Mortality: During the heatwave, an estimated 2,045 more deaths happened in England and Wales, with London being the most impacted city (Office for National Statistics 2003).

2. Health: According to the Health Protection Agency (2003), there was a notable rise in heat-related disorders such as heat exhaustion and heat stroke.

Climate Change Connection:

Numerous studies connected the 2003 heatwave to climate change:

1. Temperature increase: Since 1900, London's temperature has increased by 1.5°C, making heatwaves more likely (Met Office, 2020).
2. Urban heat island effect: During heatwaves, in particular, London's urban heat island impact makes temperature increases worse (Greater London Authority, 2019).

NEW YORK

According to NOAA (2020), temperatures have risen by 2.5°C since 1900, and the sea level has risen by 30 cm since 1900 (IPCC, 2019). Hurricane Sandy (2012) and blizzards in 2010 and 2016 are examples of extreme weather events (NOAA, 2020). Precipitation Changes: Since 1950, there has been a 20% rise in periods of intense rainfall (NOAA, 2020). Health effects include mental health disorders and respiratory problems (NYC Department of Health, 2019).

Causes

Emissions of greenhouse gases: CO2 emissions have increased by 30% since 1990 (EPA, 2020). Urbanization: The growth of metropolitan areas and the impact of the heat island (NYC Department of City Planning, 2020). Transportation and historical industrial emissions are examples of industrial activities (NOAA, 2020).

Notable Events

Long Island Express hurricane in 1938; heatwave-related blackout in 1977 (NYC et al., 2020); Blizzard in 2010; Hurricane Sandy in 2012; and Blizzard in 2016 (NOAA, 2020).

A case study of notable climate change events in New York between 1900 and 2024:

Case Study: Hurricane Sandy (2012)

In October 2012, Hurricane Sandy, commonly called Superstorm Sandy, devastated New York City due to climate change.

Description of the Event:

On October 29, 2012, Hurricane Sandy hit New York City, bringing devastating winds, storm surges, and flooding (NOAA, 2020).

Effects:

1. According to the NYC Department of Health (2013), there were twenty-four deaths in New York City and forty-four deaths in New York State.
2. Displacement: According to the NYC Mayor's Office (2013), more than 100,000 residents have been relocated.
3. Economic Losses: According to the NYC Comptroller's Office (2013), the estimated damages and economic losses total $19 billion.

Trends in Temperature

Since 1900, the temperature in London has risen by 1.5°C (Met Office, 2020), while the temperature in New York has risen by 2.5°C (NOAA, 2020), which aligns with the patterns of global warming (IPCC, 2019).

Rise in Sea Level

According to the IPCC report (2019), the sea level in London has risen by 15cm since 1900, whereas NOAA (2020) stated that the sea level in New York has risen by 30cm.

The Effect of Urban Heat Islands

According to the NYC Department of City Planning (2020), New York's urban heat island effect has raised temperatures by up to 7°C, while a Greater London Authority report (2019) outlined that London has increased temperatures by up to 5°C. Visualization tools, such as 3D modeling and thermal imaging, show how urban development affects microclimates (Oke, 1987).

Analysis by Comparison

Although extreme weather events and temperature increases occur in both cities, New York is more susceptible to sea level rise due to its coastal location. According to Kossin et al. (2017), visualization makes this comparative study easier, which helps policymakers create focused plans.

ANALYSIS AND VISUALIZATION

METHODOLOGY

The dataset is a record of land temperature data covering temperature records from 1900 to 2013 in London and New York. Different visualization methods have been developed to present the data effectively.

The chosen methods of visualization and analysis ensure clarity and precision in addressing the research questions and provide a coherent narrative around the findings of this research.

Long-term Temperature Trends:

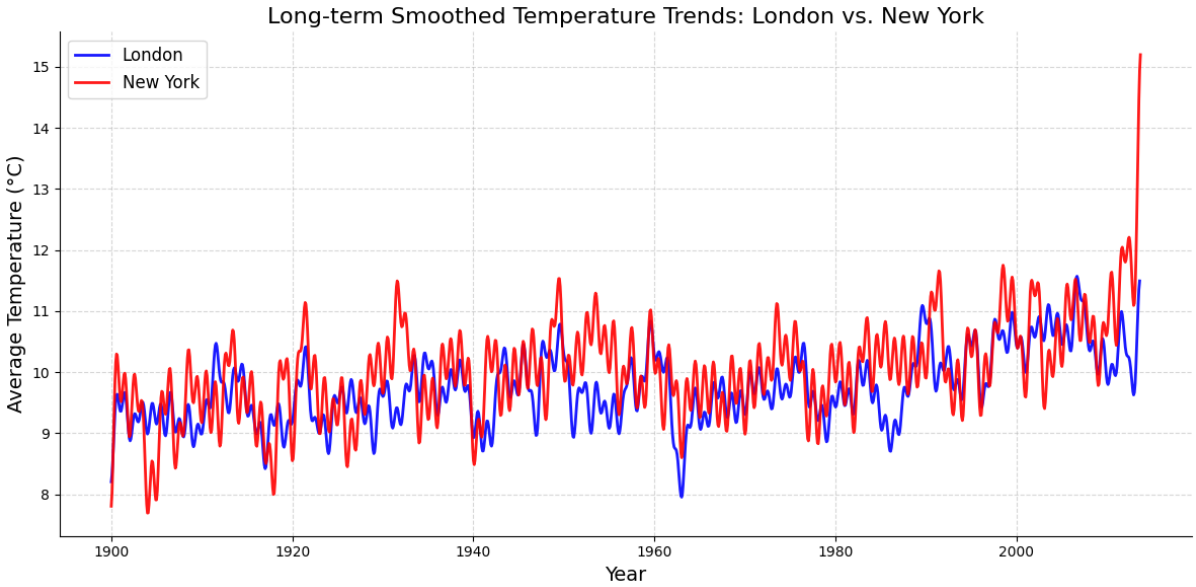

fig 1. Long-term Smoothed Temperature Trends: London vs New York

- **Visualization:** Smoothed line plots.
- **Algorithm Used:** Line Plot with Smoothing.
- **Result:** From the visualization above, it is evident that the gradual increase in temperature over the century can be attributed to global warming effects as proven in the clear long-term warming trends of both cities. New York experiences more volatile changes when compared to the more stable temperature changes in London. This can be a result of the influence of different factors such as urban heat islands, geographic location, and different local climate conditions.
- **Justification:** Smoothed line plots were crucial for highlighting the gradual warming trends over time. The dataset likely contains natural fluctuations and noise, which can obscure the overall patterns.

Seasonal Variation:

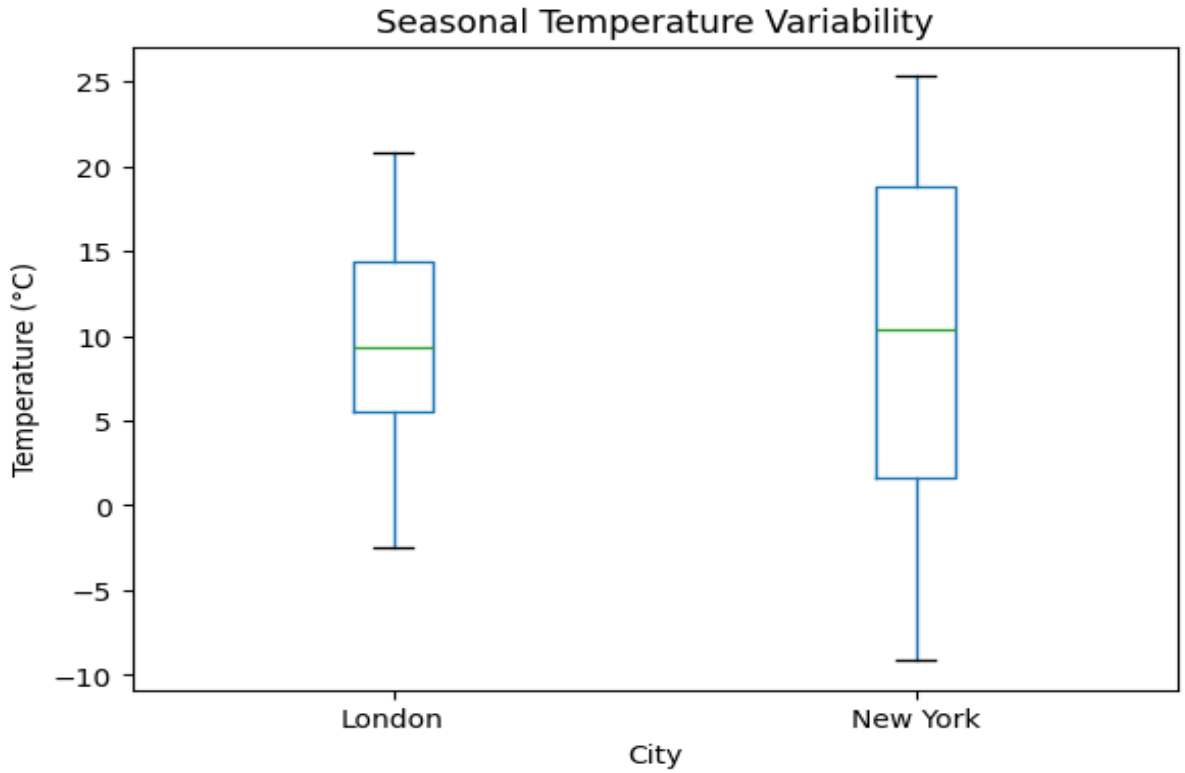

fig 2. Seasonal Temperature Variability

- **Visualization:** Boxplots.
- **Algorithm Used:** Boxplot for Summary Statistics.
- **Result:** From the boxplot, we can determine that New York exhibits more extreme seasonal temperature variations with a broader temperature range, from -10°C to 25°C in comparison to London, where the temperature range is narrower, from -5°C to 20°C.
- **Justification:** Boxplots effectively summarize the seasonal temperature distributions, providing insights into median values, quartiles, and outliers. This is ideal for condensing large volumes of data into a single visual representation.

Data Forward-Filling:

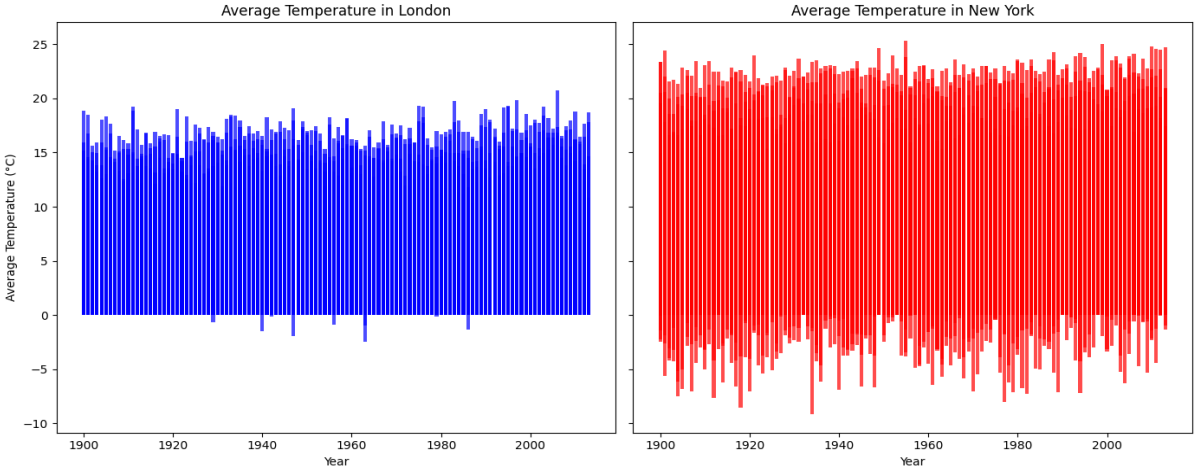

fig 3. Average Temperature in London vs. New York

- **Visualization:** Used in conjunction with line plots.
- **Algorithm Used:** Forward-Fill Imputation.
- **Result:** These charts show that while both cities experience similar seasonal temperature trends, it is noteworthy to mention that over more than a century, London has rarely experienced temperatures below 0°C, unlike New York, which has constantly experienced more extreme weather events over the same period.
- **Justification:** Forward-filling addresses this issue of measurement gaps by propagating the last known value to fill gaps, ensuring the dataset remains consistent and suitable for time-series analysis.

Interactive Visualization Using TensorFlow Embedding Projector

An interactive 3D visualization using TensorFlow Embedding Projector has been prepared to explore the relationships between average temperatures, cities, and years.

This tool allows us to:

- Investigate temperature patterns and trends in London and New York.
- Explore clustering and relationships between cities and time.
- Identify outliers and anomalies in the data.

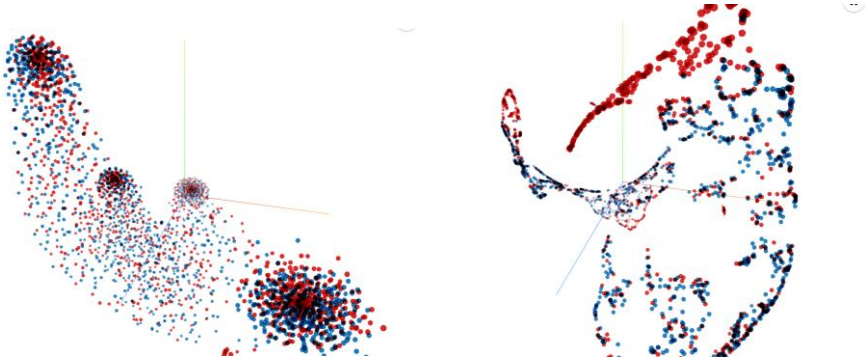

fig 4. TensorFlow Imagery

Linear Regression on Long-term Trends

Linear regression analysis for London and New York reveals a significant upward trend in average temperatures over time, confirming long-term climate change. The models show a positive slope, indicating annual temperature increases, supported by a strong R-squared value. The findings highlight the need to explore regional climatic influences and contributing factors further.

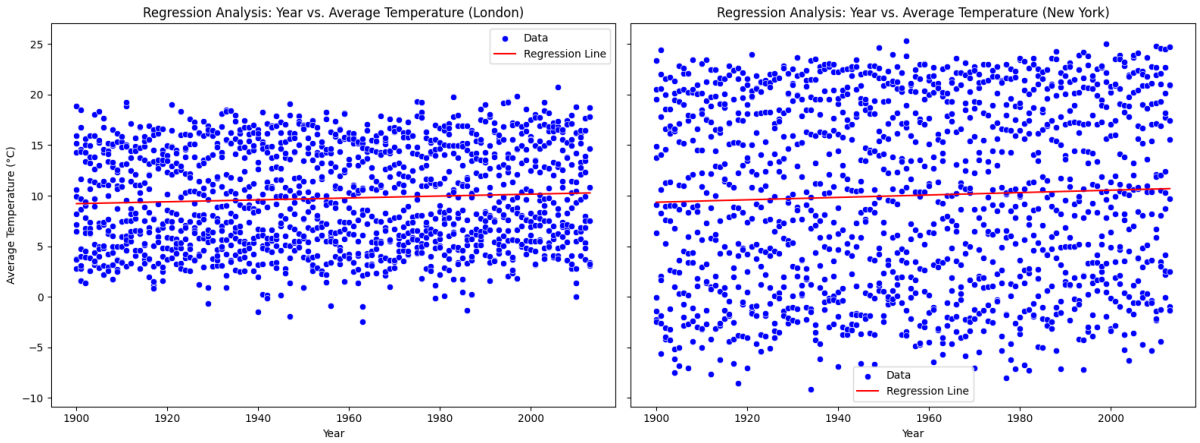

fig. 5 *Regression Plot for London and New York*

CONCLUSION

By observing seasonal variations while focusing on temperature trends, it has been revealed that the two cities share a common warming trend.

New York's temperature trends have fluctuated greatly over the last century because of its continental climate and urban heat island effect. On the other hand, London has experienced a gradual and more stable warming trend.

London and New York's depiction of climate change highlights the necessity of mitigation and adaptation measures. Effectively displaying climate data can influence resilience in urban planning, public awareness, and policy decisions (Sheppard, 2016).

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APPENDIX

- We all equally contributed to the research and development of this report.
- The attached files (features.tsv and metadata.tsv) provide the data for this visualization, enabling a deeper understanding of the dataset.