



Global Warming: A Detailed Look at Historical Trends, Variations and Issues of Burden and Responsibilities

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W200 - Fall 2021 | Project 2
MIDS Program

Project Overview

- Climate change as a major threat to humanity
- Project Goals:
 - Explore whether warming is taking place evenly (geographically and at various times of the year)
 - Connect GHG emissions rates to warming trends
 - Highlight the issues of cause and burden sharing

Research Questions

Theme 1: Have global warming trends evolved over time?

- 1.1: How do the heating rates change over the year for top-heated countries?
- 1.2: How does the trend of GHG emission look?

Theme 2: Is global warming taking place evenly?

- 2.1: Do different times of the year heat up evenly?
- 2.2: Do all places experience the same level of heating?
- 2.3: Is there a discernible difference in warming between the two hemispheres?

Theme 3: Which countries are the largest contributors and which countries are most affected?

- 3.1: Which countries are the largest contributors?
- 3.2: Which countries are most affected?

Data, Sanity Checks, and Processing

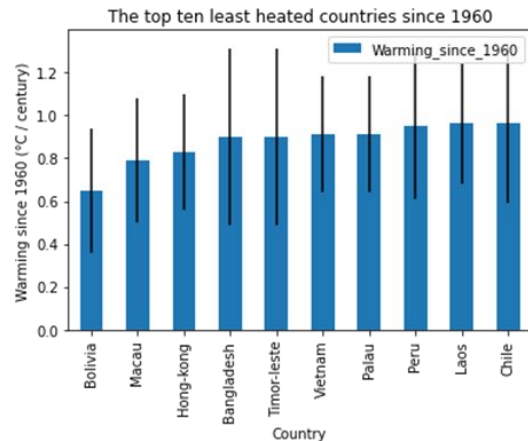
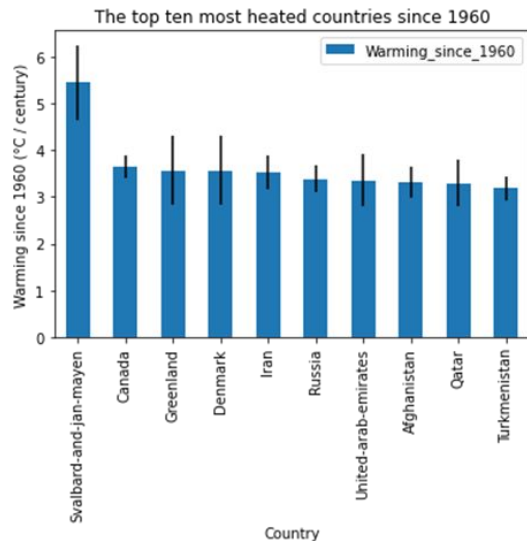
- **Primary Dataset: Berkeley Earth**
 - Sanity checks included finding ranges, examining missing values, identifying inherent biases
 - Processing: Data extraction and standardization
- **Supplemental Data: Climate Watch Greenhouse Gas Emissions**
 - Sanity checks included examining range, mean, and YOY % changes
 - Processing: Manually matching up country name discrepancies between data sets

Initial Analysis

How global is global warming?

Key Insights:

Even for those least heated countries, their temperatures have risen at least 0.65 °C/century. Global warming is indeed a worldwide issue.



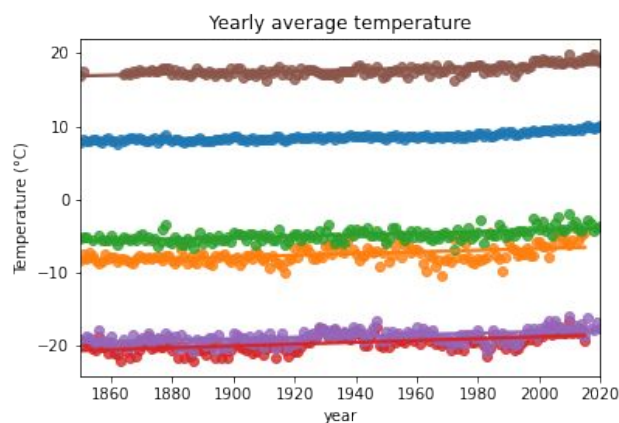
Theme 1

Have global warming trends evolved over time?

How do the heating rates change over the year for the top-heated countries?

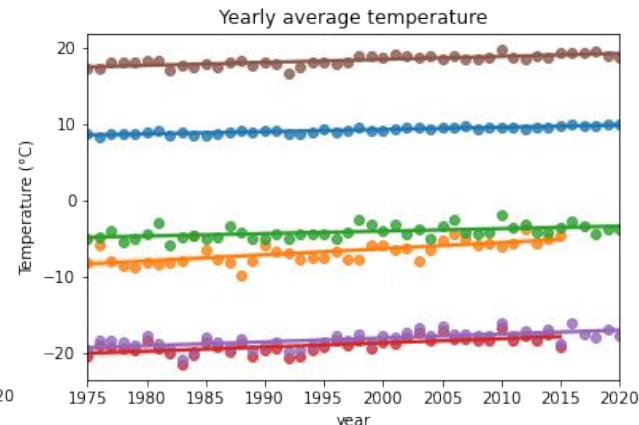
Key Insights:

The temperature increase has been largely accelerated over the last 45 years.



linear fitting line function

- Global $y=0.00902x-8.9$
- Svalbard-and-jan-mayen $y=0.01148x-29.7$
- Canada $y=0.01020x-24.6$
- Greenland $y=0.01263x-44.0$
- Denmark $y=0.00951x-37.1$
- Iran $y=0.00935x-0.4$



linear fitting line function

- Global $y=0.02921x-49.1$
- Svalbard-and-jan-mayen $y=0.08038x-167.0$
- Canada $y=0.03240x-68.8$
- Greenland $y=0.05483x-128.3$
- Denmark $y=0.05125x-120.5$
- Iran $y=0.03932x-60.1$

Theme 1

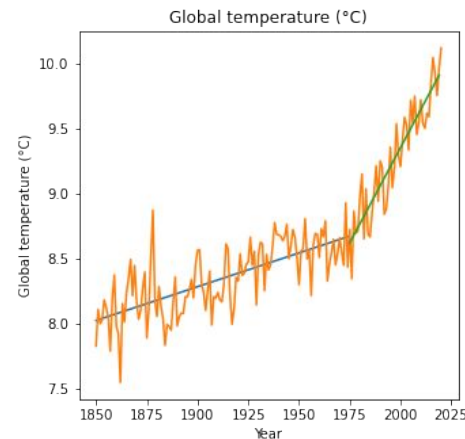
Have global warming trends evolved over time?

How do the heating rates change over the year for the top-heated countries?

Key Insights:

The temperature increase has been largely accelerated over the last 45 years.

	linear fitting slope after 1850	linear fitting slope after 1975
Global	0.009024	0.029208
Svalbard-and-jan-mayen	0.011481	0.080377
Canada	0.010198	0.032397
Greenland	0.012633	0.054833
Denmark	0.009515	0.051250
Iran	0.009351	0.039317



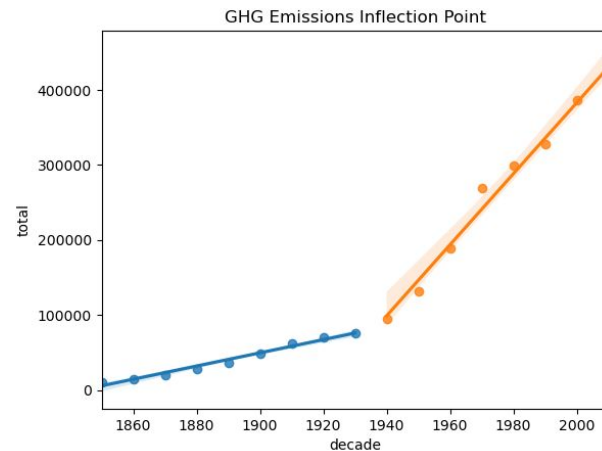
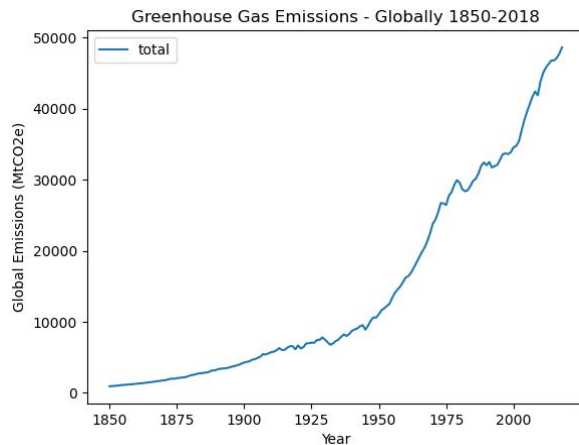
Theme 1

Have global warming trends evolved over time?

How does the trend of GHG emissions look?

Key Insights:

- GHG emissions rose steadily from 1850 until the mid-1900, at which point the change rate of global emissions increased.
- This trend both foreshadows and mirrors the global warming trend



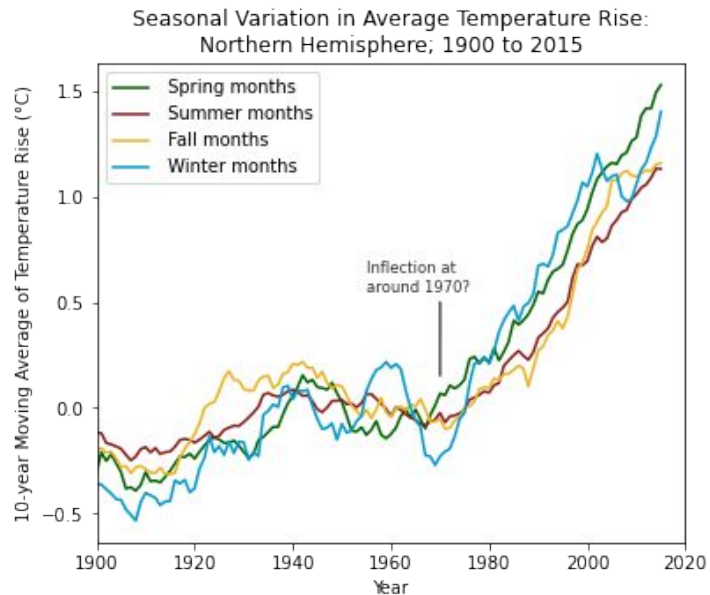
Theme 2

Is global warming taking place evenly?

Do different times of the year heat up evenly?

Key Insights:

- Visible differences between different seasons
- Colder months tend to heat up more
- Inflection point in the around 1970, but only for northern hemisphere
 - Echoes findings from the heating trend analysis
 - A first hint on the differences between the two hemispheres?



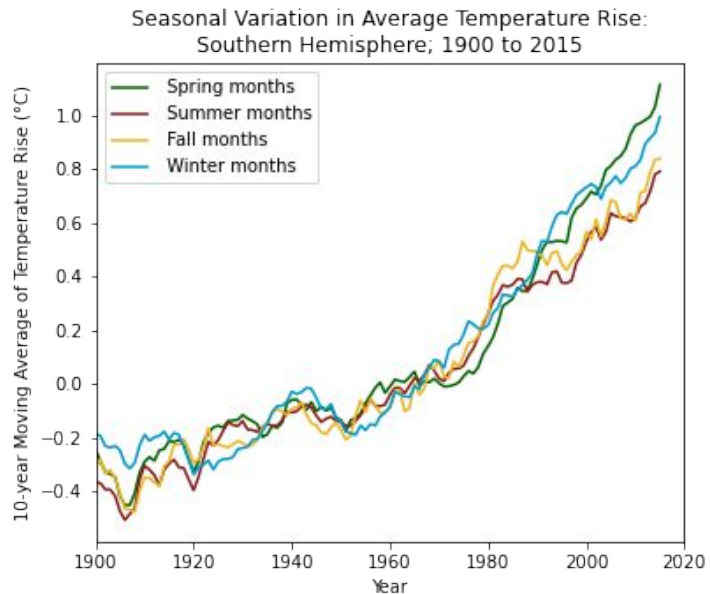
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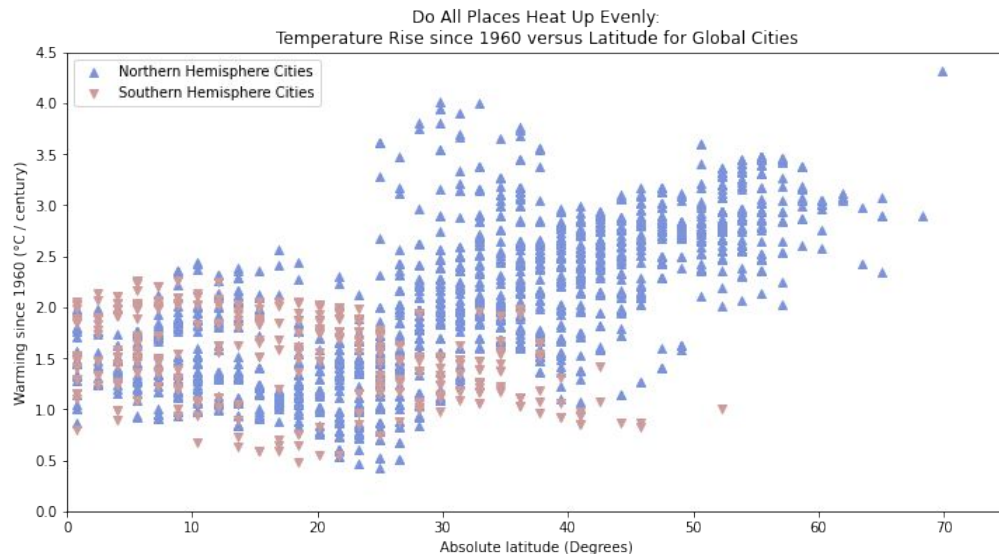
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Is global warming taking place evenly?

Do all places experience the same level of heating?

Key Insights from Latitude Analysis:

- Colder places tend to heat up more, but again only in northern hemisphere
- Different pattern in southern hemisphere - a uniform heating rate
- Outlier groups at latitudes of around:
 - (a) 8°N to 20°N; and
 - (b) 23°N to 40°N



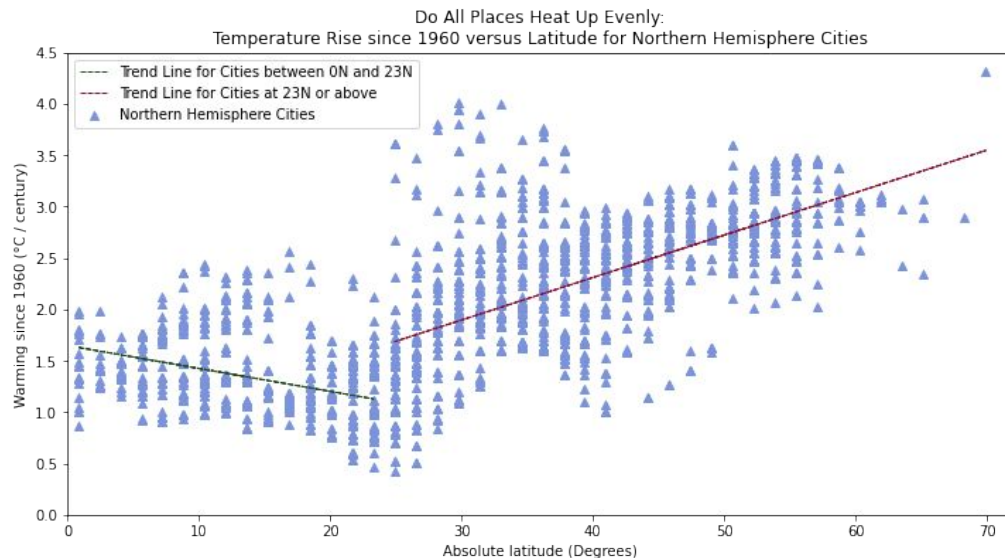
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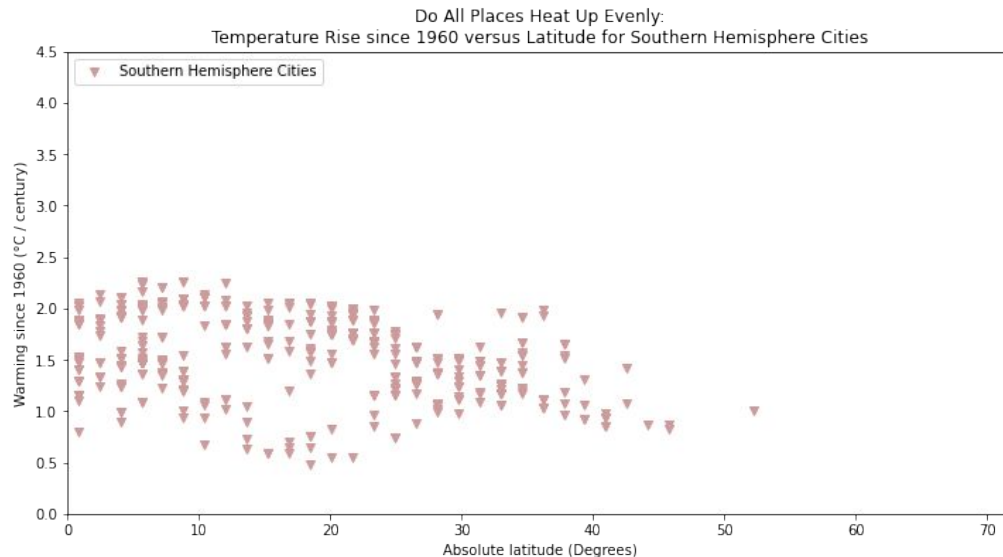
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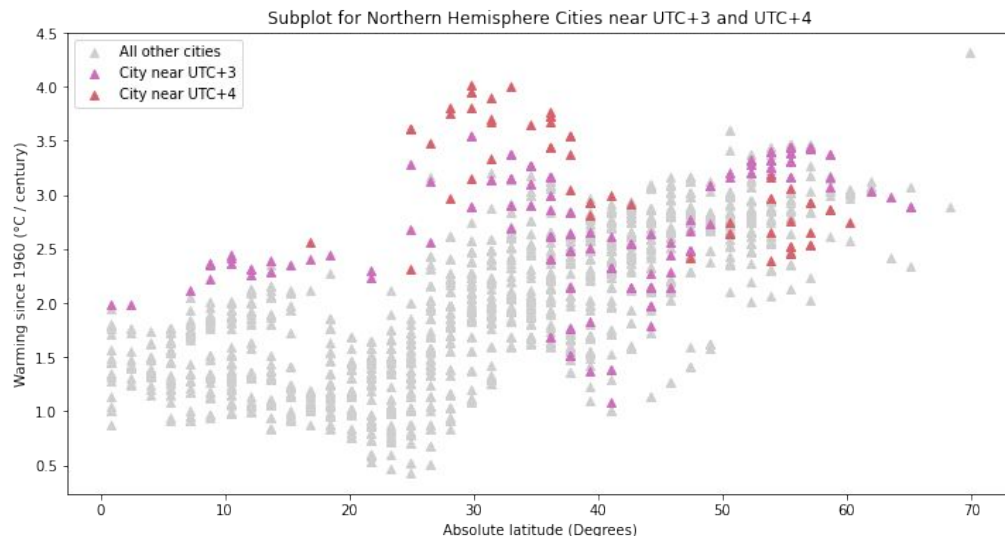
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Key Insights from Longitude Analysis:

- Supplements the latitude analysis using a “natural time zone” concept
- Longitude of outlier groups found:
 - (a) 8° to 20°N: UTC+3
 - (b) 23°N to 40°N: UTC+3 & UTC+4
- Outliers found in 15 countries, mostly countries in Middle East and near Arabia



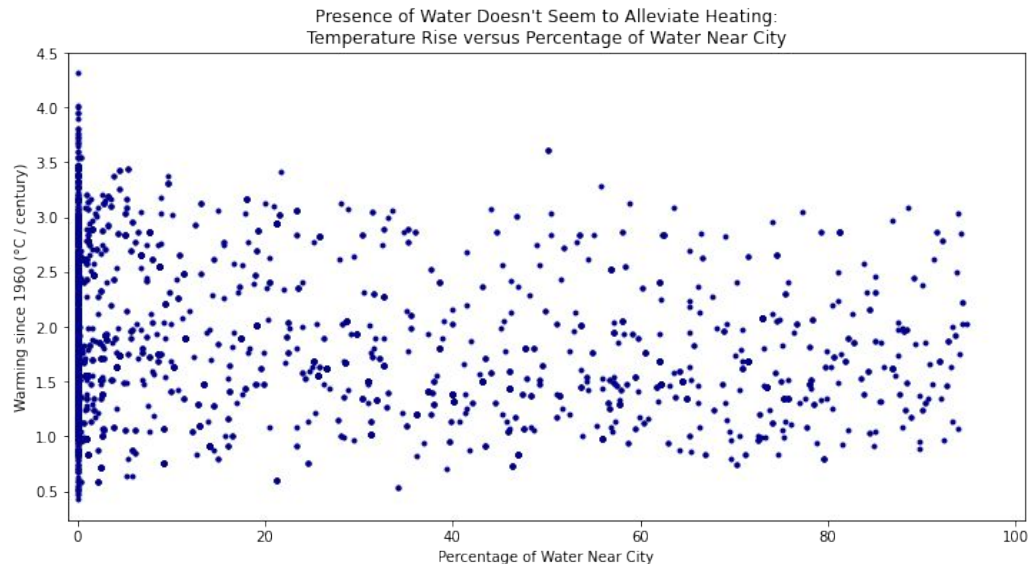
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Key Insights from Nearby Water Content Analysis:

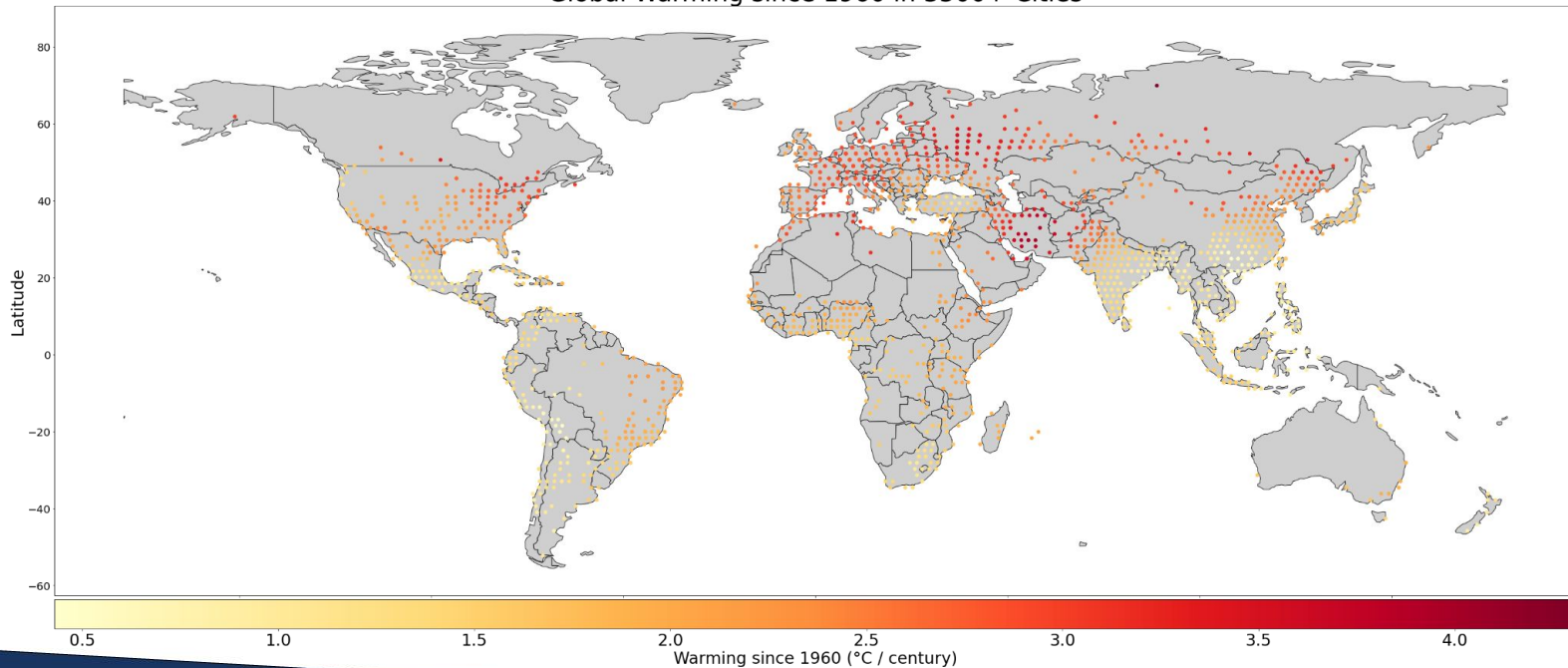
- Expected: cities near large bodies of water to show less heating
- Turns out not to be the case



Theme 2

Is global warming taking place evenly?

Global Warming since 1960 in 3500+ Cities



Theme 2

Is global warming taking place evenly?

Is there a discernible difference in warming between the two hemispheres?

Key Insights:

- Yes, there is !
- From the graphs for the previous analysis, southern hemisphere shows :
 - no visible inflection point near 1970
 - a much more uniform rate of heating across latitude
 - in general, a lower rate of warming

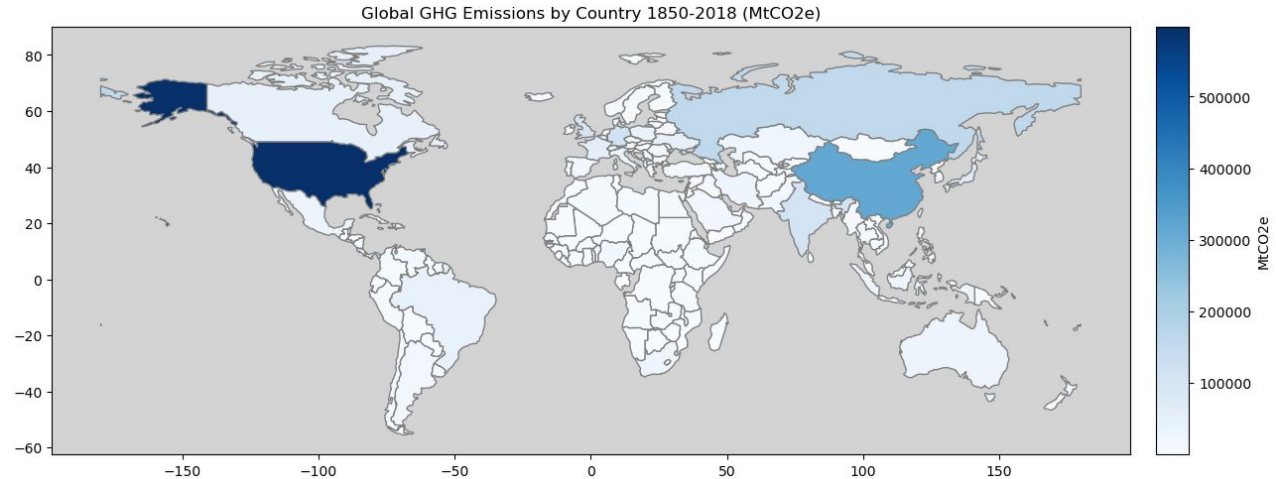
Theme 3

Which countries are the largest contributors and which are most affected?

Which countries are the largest contributors and which will be most affected?

Key Insights:

- The US, China, Russia, Germany, and India have contributed most to GHG since 1850



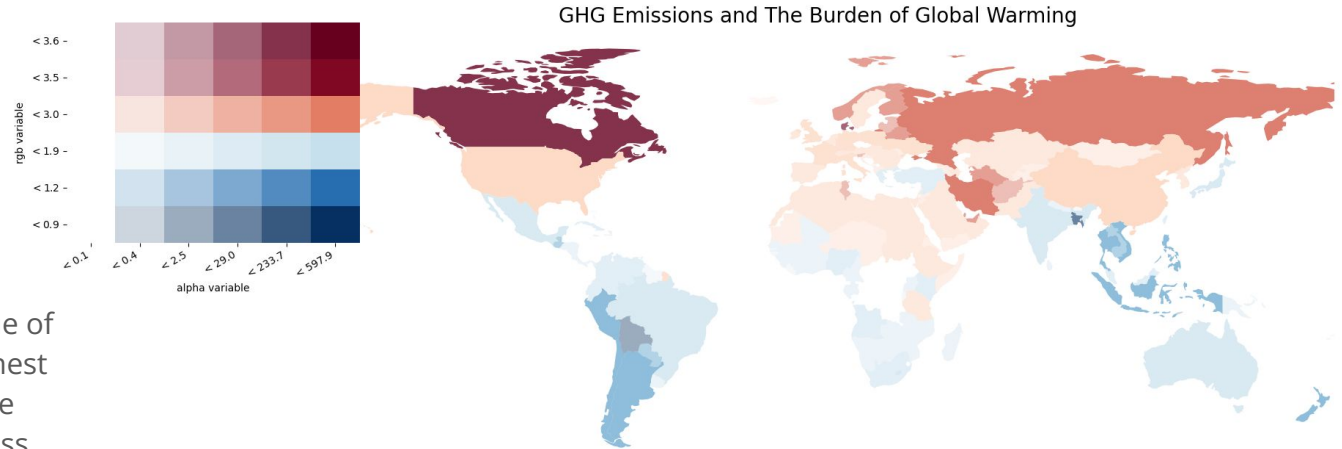
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Which countries are the largest contributors and which are most affected?

Which countries are the largest contributors and which will be most affected?

Key Insights:

- Despite their outsized contributions to the issue of global warming, the highest emissions countries have experienced relatively less warming since 1960.



Theme 3

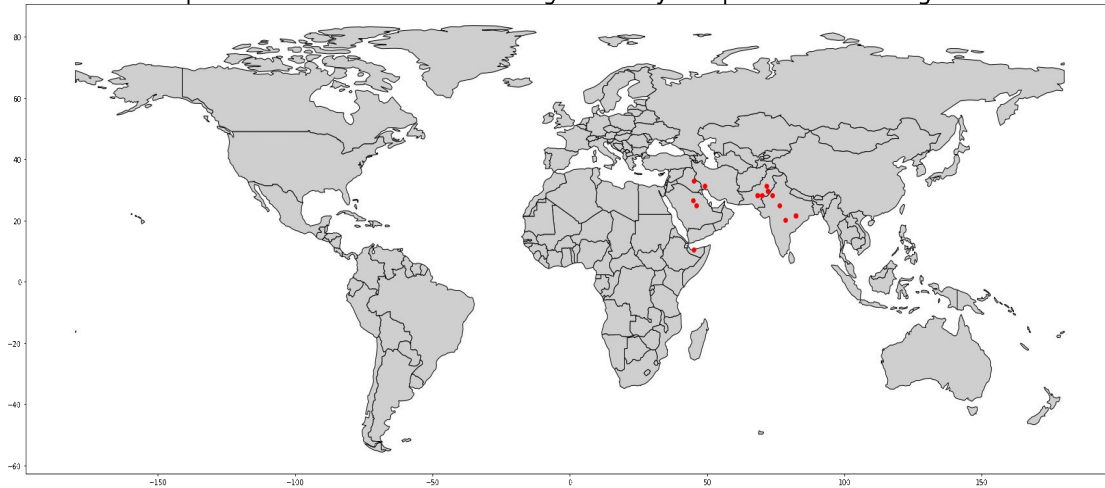
Which countries are the largest contributors and which are most affected?

Which countries will be most affected?

Key Insights:

- Data from United Nations World Urbanization Prospects 2018: list of ~1,800 cities with population > 300k
- Filter out “large cities” from Berkeley data and project which ones will have monthly average temperature > 35°C
- Concentrated in a few regions - and mostly not the largest emitters

Cities with Population above 300K and Average Monthly Temperature Reaching 35°C: Baseline



Conclusions

How Global Is Global Warming?

Global warming is indeed a worldwide issue.

Have Global Warming Trends Evolved Over Time?

Yes. The temperature increase has been largely accelerated over the last 45 years.

Is Global Warming Taking Place Evenly?

No. The pattern of heating is not uniform, with variation between hemispheres, countries and times of the year. Colder seasons and places tend to heat up more, though not without exceptions and outliers.

Which Countries Are the Largest Contributors and Which Are Most Affected?

Despite their outsized contributions to the issue of global warming, the highest emissions countries have experienced relatively less warming since 1960.