Visualization of Brazilian Weather

Finn Heydemann*

June 2023

Abstract

This paper presents the visualization and analysis of weather data in Brazil from 2000 to 2021. The study focuses on temperature and precipitation patterns across different regions of the country. The findings reveal that stations closer to the equator experience stable temperatures at a high level throughout the year, while those in the southern regions exhibit greater temperature drops during winter. Additionally, the southern and northern stations receive more precipitation compared to the central region, which appears drier. These insights provide valuable information for policymakers in developing targeted strategies for climate change adaptation and mitigation. The visualization of weather data contributes to a better understanding of regional climate variations and supports evidence-based decision-making for managing climate-related challenges in Brazil.

1 Background and Motivation

The visualization of weather data holds immense significance in understanding the unique attributes of climate regions, empowering individuals to make well-informed choices regarding various sectors such as agriculture. Furthermore, there is a growing emphasis on scrutinizing and validating the trends of climate warming on our planet. By accurately predicting future weather conditions in different regions, policymakers can effectively strategize and implement measures to mitigate the impacts, particularly in densely populated urban areas. In light of these factors, an extensive visualization of weather data covering the period from 2000 to 2021 has been meticulously conducted for Brazil, the largest country in South America.

* Matriculation Number: [redacted]
E-Mail: [redacted]
github.com/gjmm07

2 Material and Methods

To accomplish this task, a publicly available dataset comprising weather data from 623 weather stations dispersed throughout Brazil has been chosen as the primary resource [1]. Each station is assigned a unique code and is situated at specific geographic coordinates, enabling the collection of weather data at hourly intervals. The recorded information includes vital meteorological variables such as temperature, precipitation, and atmospheric pressure.

Given that weather stations were gradually added over time, some stations only commenced recording data after 2000, while others have data dating back to that year. To facilitate a comprehensive analysis while minimizing the dataset without sacrificing pertinent information, eight stations from each of the five distinct regions ("north," "northeast," "central west," "southeast," and "south") have been selected. In this selection process, particular attention has been given to ensuring representation across the entire country by including the weather station farthest away in each cardinal direction (compare figure 1).

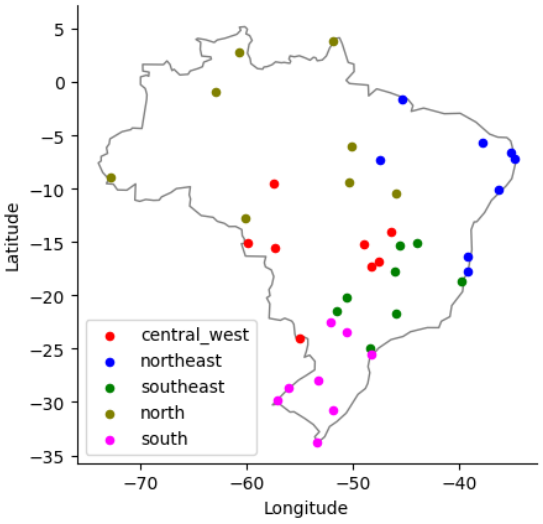

Figure 1: Selected weather stations across Brazil, clustered by region

The focus of the visualization primarily revolves around two key weather variables: temperature and precipitation. By narrowing down the selection to these features, the dataset remains manageable while still retaining crucial information regarding weather patterns throughout Brazil.

3 Results

Given their distinct characteristics, the two weather features, temperature and precipitation, are analyzed individually.

3.1 Temperature

To gain insights into the temperature variations across different zones in Brazil, the average temperature is calculated and represented using a diverging color map. Figure 2 illustrates that stations closer to the equator exhibit significantly higher average temperatures compared to those located in the southern regions, which are farther away from the equator.

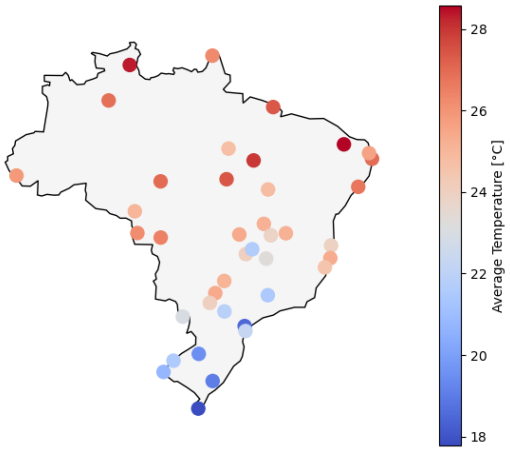

Figure 2: Average temperature at selected weather stations

To gain deeper insights into the average temperature patterns, a representative station is selected from each region for further investigation. The data presented in Figure 3 reveals interesting findings. Stations situated in southern regions tend to experience significant drops in temperature during the winter quarters (Q2 and Q3). Conversely, stations located near the equator exhibit minimal temperature fluctuations throughout the year. Moreover, stations positioned farther south and away from the ocean, specifically the Atlantic Ocean on Brazil's east coast, encounter higher temperature amplitudes. This is particularly noticeable during the third quarter of the year, where temperatures can range from 2 °C to over 30 °C for southern station A809 and from 11 °C to 42 °C for central western station A922. In contrast, the most northern station A135, in addition to its relatively stable median temperature across all quarters, also displays minimal temperature variation throughout the year.

To further investigate, the temperature course over a certain time range the raw hourly recorded temperature is plotted. To cancel out the noise from hourly temperature recording and see the underlying pattern, a moving average filter is plotted onto the raw data. A moving average filter period of 30 days has shown to be sufficient (compare figure 4).

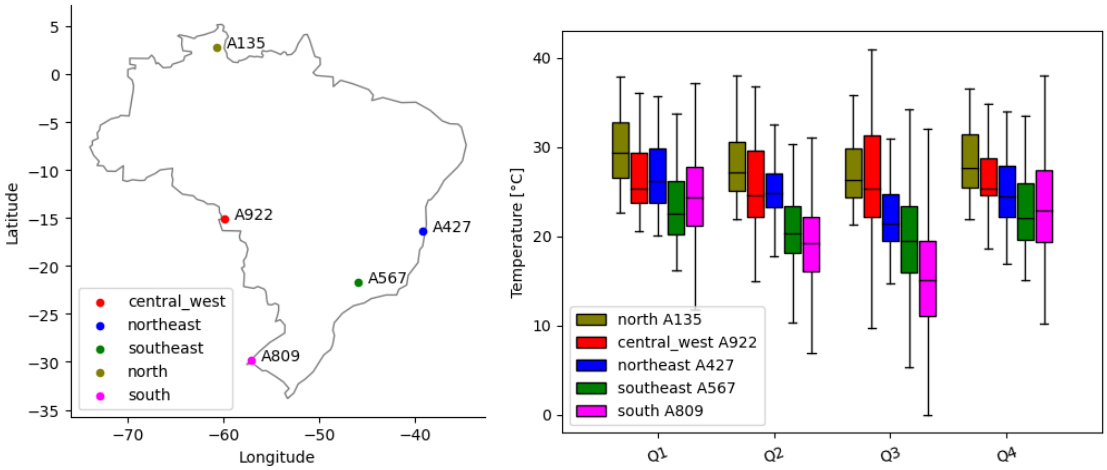

Figure 3: Comparing temperature course of weather stations from every region in 2019 grouped by quarter

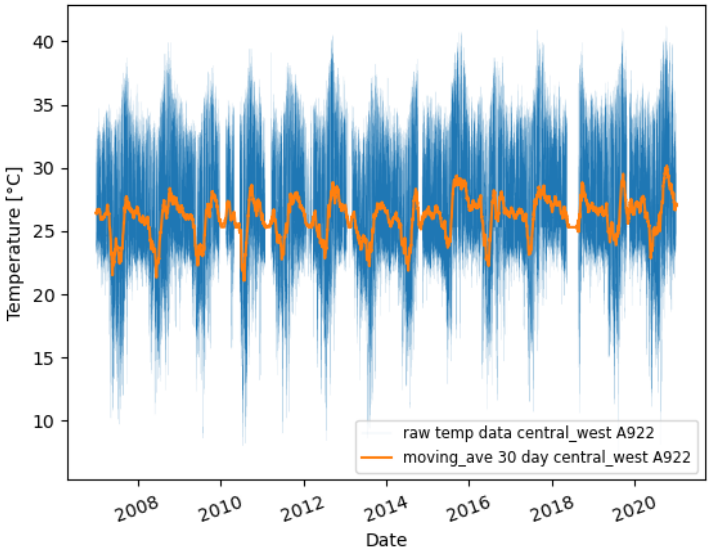

Figure 4: Raw temperature and moving average (30 days) of station "A922" (central west)

When plotting the moving average (with a filter period of 30 days) for four geographically distant stations, the results seen in figure 3 can be confirmed. While the temperature at the stations located close to the equator (between latitude 5° and -10°) remain relatively stable year-round, the southern station (latitude approximately -22°) experiences significant temperature drops during the winter months. During the early

and late months, the averaged temperature in all four regions only differs marginal (compare figure 5).

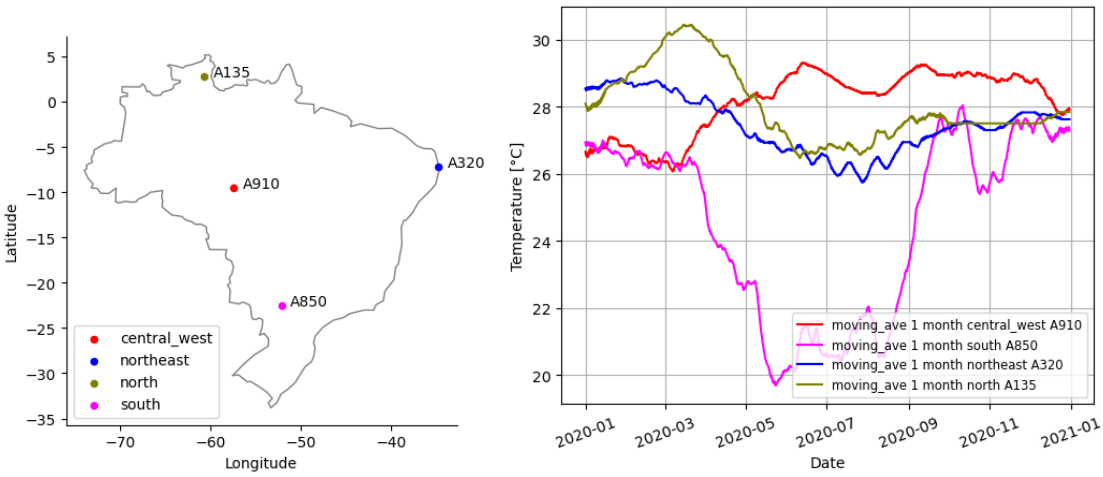

Figure 5: Moving average (30 days) temperature course of weather stations from four regions in 2020

To examine climate warming[1], the moving average temperature course with marked yearly extremes of two stations are plotted for comparison. The central western station (Figure 6, right) demonstrates a clear trend of warmer summers and winters, indicating climate warming. On the other hand, the southern station does not exhibit a discernible pattern of temperature changes.

[1] Strictly speaking, climate refers to weather averaged over 30 years. However, due to the limited dataset timeframe, the weather is analyzed over a shorter duration.

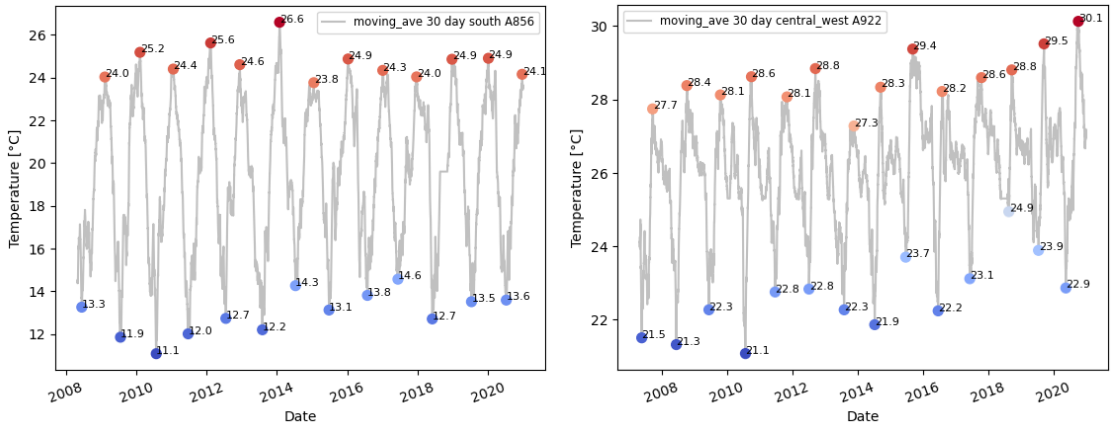

Figure 6: Moving average (30 days) temperature course of weather station "A856" (south, left) and "A922" (central west, right) from 2008 to 2021 with year high and low marked

3.2 Precipitation

When visualizing the average precipitation per hour using a sequential color map (refer to Figure 7), unlike the temperature map (Figure 2), a distinct pattern is not readily observed. However, it is noteworthy that the southern and northern stations receive more precipitation compared to the central region of Brazil, which appears drier.

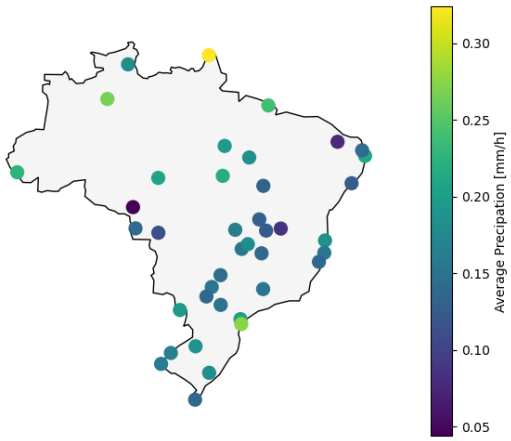

Figure 7: Average precipitation per hour at selected weather stations

To conduct a closer analysis of this observation, one station from each region is selected, and the accumulated precipitation is plotted for the year 2019. As depicted in figure 8, the central western and southeastern stations (red and green) exhibit similar precipitation patterns, with higher amounts of rainfall during the early and late months of the year. Conversely, the northern stations (olive for north and blue for northeast)

experience significantly higher moisture levels, with over 2 meters of rainfall per year and an increase in precipitation starting from May. The southern station (pink) falls in between, receiving over 1.5 meters of rainfall annually.

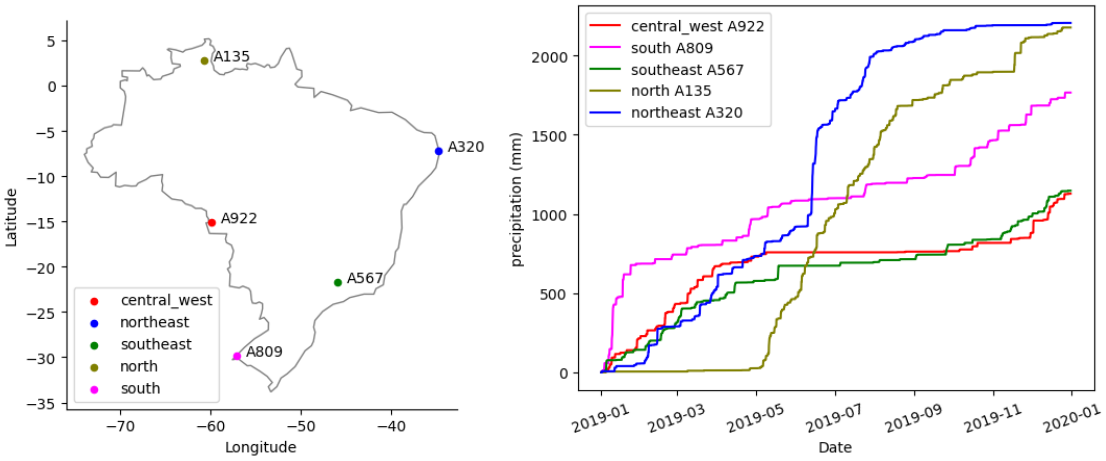

Figure 8: Accumulated precipitation over the year 2019 from one station of every region

4 Discussion and conclusion

The visualization of weather data in Brazil from 2000 to 2021 has provided valuable insights into temperature and precipitation patterns across different regions. The analysis focused on two key weather variables: temperature and precipitation.

Regarding temperature, the results showed that stations closer to the equator exhibited significantly higher average temperatures compared to those located in the southern regions, which are farther away from the equator. Further investigation revealed that stations located further south experienced greater temperature drops during the winter, while stations near the equator exhibited minimal temperature fluctuations throughout the year. Stations further south and far from the ocean also experienced higher temperature amplitudes, particularly during the third quarter of the year. The use of a moving average filter helped identify underlying temperature patterns and confirm the temperature variations observed in the analysis.

In terms of precipitation, it was observed that the southern and northern stations received more precipitation compared to the drier central region of Brazil. To further analyze this observation, one station from each region was selected, and the accumulated precipitation for the year 2019 was plotted. The results showed that the central western and southeastern station representing their region exhibited similar precipitation patterns, with higher amounts of rainfall during the early and late months of the year. In contrast, the northern stations experienced significantly higher moisture levels, with over 2 meters of rainfall per year and an increase in precipitation starting from May. The southern station fell in between, receiving over 1.5 meters of rainfall annually.

These results provide valuable information for policymakers and stakeholders in understanding temperature and precipitation patterns across Brazil. The insights gained from the visualization of weather data can guide decision-making processes related to climate change adaptation and mitigation strategies. For example, the findings on temperature variations can help inform strategies for managing seasonal temperature fluctuations and addressing potential climate warming trends. The observations on precipitation patterns can assist in developing effective water resource management plans, agricultural practices, and flood prevention measures in different regions.

Overall, the visualization of weather data in Brazil has contributed to a better understanding of regional climate characteristics and can support evidence-based decision-making for climate-related issues. The findings emphasize the importance of considering the unique attributes of each region in developing tailored strategies to address climate change impacts effectively.

For further insights, it is worth noting that the provided GitHub repository [2] includes interactive plots that offer enhanced exploration capabilities. However, due to their interactive nature, these plots are not printable and therefore not included in this paper. Nonetheless, readers can utilize the repository to generate and interact with a variety of plots, enabling a more dynamic and engaging analysis experience.

References

[1] Kaggle: Climate Weather Surface of Brazil - Hourly `https://www.kaggle.com/datasets/PROPPG-PPG/hourly-weather-surface-brazil-southeast-region`

[2] Finn Heydemann @ github: DS_Data_Visualization_2023_Finn_Heydemann `https://github.com/gjmm07/DS_Data_Visualization_2023_Finn_Heydemann`