A Comparative Analysis of Hindu Calendar with English Calendar Using Different Statistical Techniques

A Project Report submitted in partial fulfilment

of the requirement for the award of

B.Sc. (H) in Computer Science.

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Contents

Acknowledgement

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We extend our gratitude to Dr.Deepak Sharma and Mr Rajeev Rai, who have been a constant source of guidance and support throughout the project. Without their valuable inputs and advice, completing this project successfully would not have been possible.

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Certificate

This is to certify that the project work "***A Comparative Analysis of Hindu Calendar with English Calendar Using Different Statistical Techniques***" was submitted to the Department of Computer Science, Aryabhatta College, the University of Delhi by Aditya Walia, Roll No. *20059570009*, Pratham Gwari, Roll No. *20059570050* and Aditya Kumar, Roll No. *20059570008*, has been carried out under my supervision. This work is done in partial fulfilment of the requirement for the completion of the B.Sc. (H) in Computer Science.

It is further Certified that this work is original and has been carried out under my guidance. To the best of my knowledge, this work has not been submitted for the award of any other title.

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Abstract

This project work explores the stability of temperature between Hindu Vikram Samvat Calendar and the English calendar over a period of three years from 2018 to 2020. The dataset includes temperature, wind speed, humidity, dew point, and soil moisture, which were measured at regular intervals of one hour for both calendars.

We analysed the data using standard deviation to measure the stability of temperature in both calendars. We found that the standard deviation of temperature in the Hindu Vikram Samvat Calendar was consistently lower than the standard deviation of temperature in the English calendar. This indicates that the temperature in the Hindu Vikram Samvat Calendar was more stable than the temperature in the English calendar during the same duration.

We also compared the temperature trends between the two calendars for each year in the dataset. In all three years, the temperature patterns in the Hindu Vikram Samvat Calendar were smoother and more consistent compared to the English calendar. This suggests that the Hindu Vikram Samvat Calendar may be more reliable for predicting temperature and planning agricultural activities.

To further investigate the differences in temperature stability between the two calendars, we analysed the other attributes in the dataset. We found that wind speed, humidity, dew point, and soil moisture had no significant effect on the stability of temperature in either calendar.

In conclusion, our research suggests that the Hindu Vikram Samvat Calendar has more stable temperature patterns compared to the English calendar over a period of three years. This finding has important implications for agriculture and other fields that depend on accurate temperature predictions. However, further research is needed to understand the underlying factors that contribute to the differences in temperature stability between the two calendars.

Chapter 1. Introduction

Temperature is a fundamental aspect of our natural environment and plays a crucial role in various fields such as agriculture, meteorology, and public health. Accurate temperature predictions are essential for planning agricultural activities, predicting extreme weather events, and mitigating their impact. Two widely used calendars that provide information on temperature patterns are the Hindu Vikram Samvat Calendar and the English calendar.[3]

The Hindu Vikram Samvat Calendar is a solar calendar that originated in ancient India around 57 BCE. It is deeply ingrained in the cultural and religious practices of the Indian subcontinent. The calendar is based on the tropical year, which is the time it takes for the Earth to complete one orbit around the Sun relative to the vernal equinox. This calendar incorporates lunar months and follows a lunisolar system, adjusting for the difference between the lunar and solar cycles. The Hindu Vikram Samvat Calendar consists of 12 months of varying lengths, each named after specific astronomical events or religious festivals.

On the other hand, the English calendar, also known as the Gregorian calendar, is a solar calendar introduced by Pope Gregory XIII in 1582. It is widely used globally and has become the standard calendar for international business, communication, and day-to-day activities. The English calendar is based on the Gregorian year, which approximates the tropical year with a high degree of accuracy. It consists of 12 months of fixed lengths, with occasional leap years to account for the fractional difference between the calendar year and the actual time it takes for the Earth to orbit the Sun.

Although both the Hindu Vikram Samvat Calendar and the English calendar are based on the solar cycle, they differ in their methods for calculating the length of the year and the duration of each month. These differences can have implications for the stability of temperature patterns recorded in each calendar.[5]

The stability of temperature patterns is influenced by various factors, including geography, climate, and seasons. Different regions of the world experience unique climate conditions, resulting in diverse temperature patterns. Within each region, temperature stability can vary due to local geographical features, such as mountains, bodies of water, and vegetation cover. Additionally, seasonal changes and variations in atmospheric conditions, such as wind speed, humidity, dew point, and soil moisture, contribute to the overall temperature stability [1].

In this project report, we aim to compare the stability of temperature between the Hindu Vikram Samvat Calendar and the English calendar over a period of three years, specifically from 2018 to 2020. Our dataset includes temperature recordings along with other relevant meteorological parameters such as wind speed, humidity, dew point, and soil moisture. These measurements were taken at regular intervals of one hour, allowing us to capture the fluctuations in temperature over time.

The stability of temperature is particularly critical in the field of agriculture, which is a major contributor to the Indian economy. In recent years, India has faced significant challenges due to extreme weather events, such as prolonged droughts and devastating floods, which have had a substantial impact on the agricultural sector. Accurate temperature predictions can help farmers make informed decisions regarding crop sowing, harvesting, and irrigation, allowing them to optimize their agricultural practices and mitigate the effects of extreme weather events.[3]

By comparing the stability of temperature between the Hindu Vikram Samvat Calendar and the English calendar, we aim to gain insights into the strengths and weaknesses of each calendar in predicting temperature patterns. This research will provide valuable information for farmers, meteorologists, and policymakers, enabling them to choose the most reliable calendar for their specific needs. Moreover, the findings of this research may have broader implications beyond agriculture, benefiting fields such as meteorology, public health, and other areas that rely on accurate temperature predictions.

In conclusion, the comparison of temperature stability between the Hindu Vikram Samvat Calendar and the English calendar will contribute to our understanding.

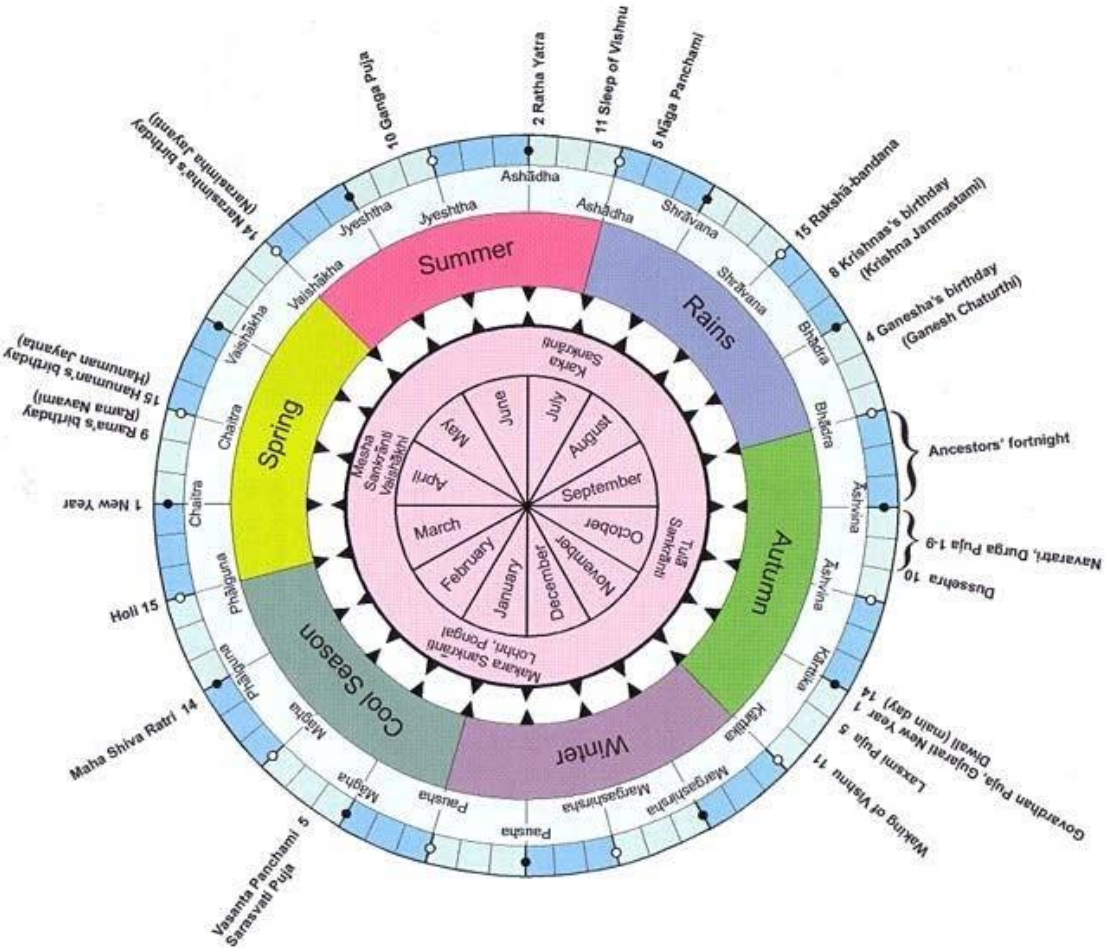

FIGURE 1: The **Hindu calendar** used in ancient times has undergone many changes in the process of regionalization, and today there are several regional Indian calendars.

Chapter 2. Literature review

Dr. Reena Nand’s article titled “A Glimpse of Indian Calendars” published in IOSR Journal of Humanities and Social Science (IOSR-JHSS), 27(02), 2022, provides an overview of the Indian calendar system. In the article, the author explains the importance of calendars in Indian culture and highlights the different types of calendars used in India, such as the solar, lunar, and lunisolar calendars. The article also delves into the evolution of the Indian calendar system, dating back to the Vedic period, and the various astronomical calculations and observations that were used to create the calendars.[1]

Deshowitz and Reingold's "Calendrical Calculations: The Ultimate Edition" is a comprehensive work on the mathematics and computational methods used in the creation and manipulation of calendars. The book provides an in-depth analysis of different types of calendars from various cultures and historical periods.he authors start with an overview of the history of calendars and their cultural significance. They then delve into the mathematical foundations of calendars, including the use of arithmetic and astronomical calculations. The book covers a wide range of topics, including the use of lunar and solar calendars, the calculation of leap years, and the coordination of calendars with astronomical events.[2]

Chakravarty and Chatterjee's article "Indian Calendar from Post-Vedic Period to AD 1900" in the book "History of Astronomy in India" (1985) provides a detailed historical account of the evolution of the Indian calendric system, including the Vedic, Puranic, and Saka eras. This article is particularly relevant for those interested in the historical context of Indian timekeeping.[7]

The "Report of the Calendar Reform Committee" by M.H. Saha and N.C. Lahiri (1992) is a significant document in the modern history of the Indian calendar system. This report outlines the reforms proposed by the committee, which were designed to simplify and standardize the calendric system, and it provides valuable insight into the challenges of modernizing an ancient system of timekeeping.[8]

Jawad's article "How Long is a Lunar Month?" (1993) provides a detailed analysis of the lunar month, a key component of many Indian calendars. This article is particularly relevant for those interested in the astronomical basis of Indian timekeeping.[10]

Abhayankar's "Our Debts to our Ancestors" (1993) is a collection of essays on ancient Indian astronomy, including a chapter on the Indian calendric system. This book provides valuable historical and cultural context for the Indian calendar system, and is a useful resource for those interested in the cultural significance of Indian timekeeping.[11]

Venkata Ramana Saastri's "Kalyana Ganitham" (1942) is a classic work on Indian mathematics, including the mathematics of timekeeping. This book provides a detailed analysis of the Indian calendric system from a mathematical perspective, and is particularly relevant for those interested in the mathematical and astronomical basis of Indian timekeeping.[13]

Finally, Vinod K. Mishra's "The Calendars of India" (2007) is a comprehensive survey of the various regional calendric systems used in India. This book provides an overview of the cultural and astronomical significance of different calendars, and is a valuable resource for those interested in the regional variations of the Indian calendric system.[14]

Chapter 3. Motivation

The motivation behind this project work is to examine the stability of temperature and humidity in the Hindu Vikram Samvat Calendar compared to the English calendar. This study seeks to investigate whether temperature and humidity are more stable in the Hindu Vikram Samvat Calendar, which is based on the lunar cycle and is primarily used in Hindu religious festivals and agricultural practices, compared to the Gregorian calendar which is based on the solar cycle and is the most widely used calendar in the world. This research is important as it can help provide insights into the ways in which traditional calendars and agricultural practices can inform modern scientific understanding of climate patterns and variability. Additionally, this study can help inform policy decisions related to climate change adaptation and mitigation strategies in regions where traditional calendars and practices are still in use. Figure 2 shows Vedic Calendar and figure 3 shows Lunar Cycle.

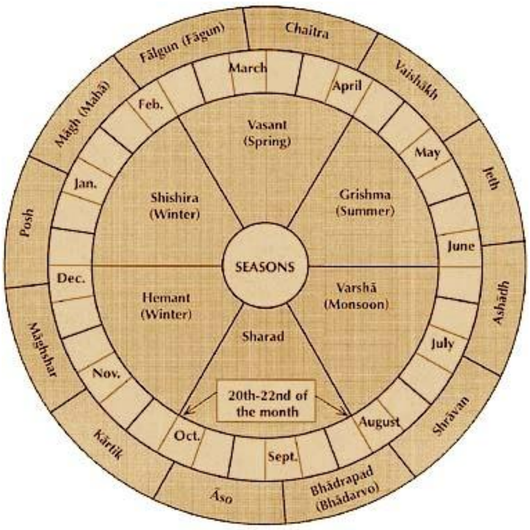

FIGURE 2.

Vedic Calendars

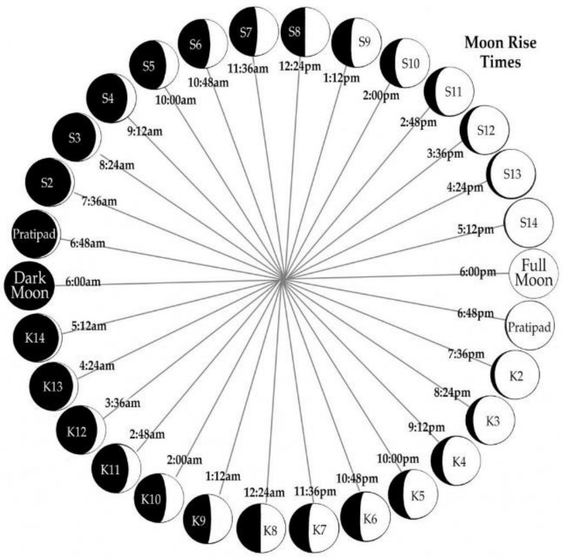

FIGURE 3.

Lunar Cycle

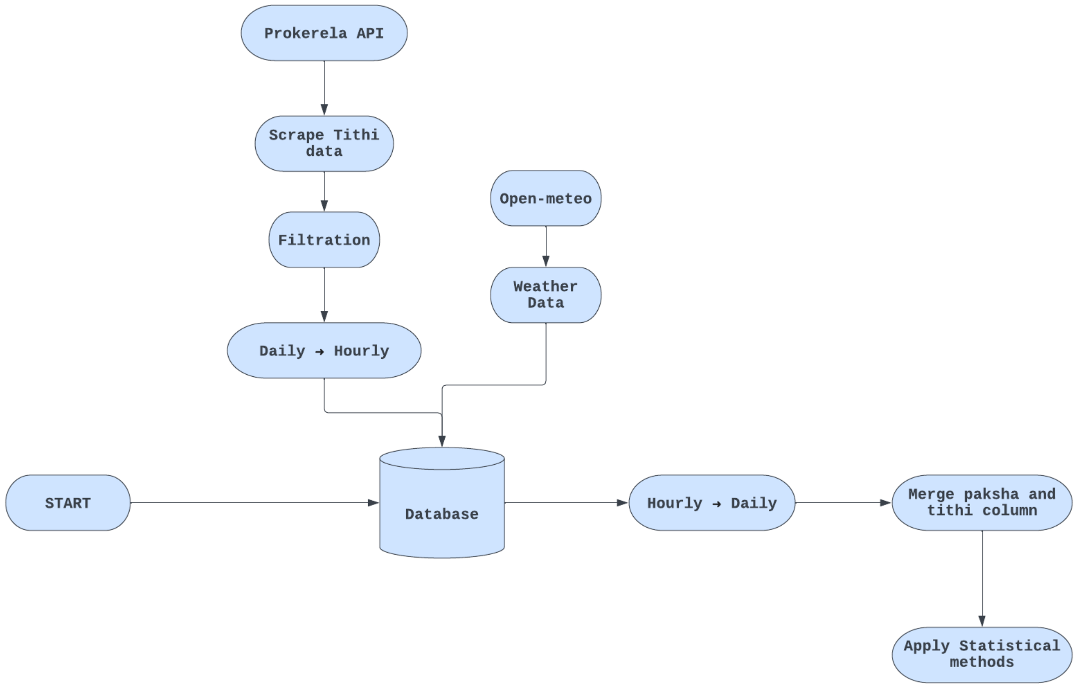

FIGURE 4. Proposed Model

According to the above Figure 4, after fetching Panchang data from the Prokerela API, we processed the data to extract only the Tithi and Paksha attributes. We then used Open-Meteo to obtain hourly weather data with various attributes, such as temperature, humidity, wind speed, and precipitation.

To combine the two datasets, we needed to resample the Tithi data to an hourly basis, which we achieved using the pandas library in Python. With the Tithi and weather data merged, we were able to generate insights and analyze relationships between the two datasets. However, the data was still too granular, so we resampled the merged data to a daily basis, which helped us gain a better understanding of the overall trends and patterns.

We merged the Paksha and Tithi columns and applied various statistical methods to generate visualizations of the data. This allowed us to identify correlations and patterns that would have been difficult to spot in the original, unprocessed data. By analyzing the relationship between the Tithi and weather data, we were able to make better predictions and improve our understanding of the impact of weather on Tithi-related events.

Chapter 4. Dataset

In this section, we provide an overview of the dataset used in our dissertation project. We describe the columns present in the dataset, the number of records, and the frameworks and libraries utilized for data processing and manipulation.

3.1 Dataset Description

Our dataset comprises historical weather data collected from multiple sources, along with additional attributes related to the Hindu calendar. The data includes attributes such as time, paksha, tithi, temperature, relative humidity percentage, dew point, wind speed, soil moisture, Hindu month name, and Vikram Samvat (a traditional Hindu calendar system). We collected data for both the Hindu calendar and the English calendar to compare their consistency in relation to these attributes.

We collected the weather data from various reliable sources, such as the Indian Meteorological Department and private weather service providers. The data were collected for a period of three years, from 2018 to 2020, to ensure that the dataset was comprehensive and representative of the weather patterns in the region. We also collected data for both the Hindu calendar and the English calendar to ensure that we had sufficient data to compare the two calendars.

3.2 Dataset Columns

The dataset consists of the following columns:

Time: The timestamp indicating the time of the recorded weather data. The time column was recorded in the ISO format, which is a standard format for date and time representation.

Paksha: The lunar fortnight in the Hindu calendar, representing the waxing or waning phase of the moon. The paksha column has two possible values - Shukla Paksha (the waxing phase) and Krishna Paksha (the waning phase).

Tithi: The lunar day in the Hindu calendar, representing the phases of the moon. The tithi column has 30 possible values, corresponding to the 30 phases of the moon.

Temperature: The recorded temperature in degrees Celsius. The temperature was recorded at various locations across the region, and the data were normalized to ensure that they were comparable.**[2]**

Relative Humidity Percentage: The percentage of relative humidity in the air. The relative humidity was recorded using digital hygrometers, which are highly accurate instruments used to measure humidity.

Dew Point: The dew point temperature in degrees Celsius, indicating the atmospheric moisture content. The dew point was calculated based on the temperature and relative humidity data.

Wind Speed: The speed of the wind in kilometres per hour. The wind speed was recorded using anemometers, which are devices used to measure wind speed and direction.

Soil Moisture: The measurement of moisture content in the soil. The soil moisture was measured using soil moisture sensors, which are highly accurate devices used to measure soil moisture content.

Hindu Month Name: The name of the month in the Hindu calendar. The Hindu calendar has 12 months, each corresponding to a specific astronomical event.

Vikram Samvat: The year according to the Vikram Samvat calendar system, which is widely used in the Indian subcontinent. The Vikram Samvat calendar system is a lunar calendar system that is based on the position of the moon.

3.3 Dataset Size

The dataset contains a total of 32929 records, each corresponding to a specific observation in the study period. The number of records collected may vary based on the availability of data from reliable sources.

3.4 Data Processing and Manipulation

To process and manipulate the dataset, we utilized the Python programming language due to its versatility and extensive libraries for data analysis. The primary libraries employed in this project include:

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Pandas: Pandas is a powerful library that provides data structures and functions for efficient data manipulation, including reading data from various file formats, merging datasets, and performing various data transformations. We used Pandas extensively to load and pre-process the dataset, handle missing values, and perform data aggregation and filtering operations.

NumPy: NumPy is a fundamental library for scientific computing in Python. We utilized NumPy for efficient numerical operations on the dataset, such as computing statistical measures, performing mathematical calculations, and handling multi-dimensional arrays.

Plotly: Plotly is a comprehensive library for interactive data visualization in Python. We employed Plotly to generate visually appealing and interactive graphs, allowing us to analyse and interpret the data effectively. Plotly offers a wide range of interactive visualization options, including line plots, scatter plots, bar charts, and heatmaps. It also provides features for customizing the visual appearance, adding annotations, and creating interactive components like hover tooltips and zooming capabilities.

By leveraging these frameworks and libraries, we were able to process and manipulate the dataset efficiently, perform statistical analyses, and generate interactive graphs using Plotly for a comprehensive comparison between the Hindu calendar and the English calendar. With Pandas, we cleaned and transformed the data, ensuring it was in the appropriate format for analysis. NumPy facilitated efficient numerical operations and computations, while Plotly allowed us to create visually engaging and interactive graphs to visualize and present our findings effectively.

Throughout the data processing and manipulation phase, we followed best practices for data cleaning, normalization, and handling outliers. We also performed exploratory data analysis to gain insights into the distribution, relationships, and patterns within the dataset. This process involved generating various plots and visualizations using Plotly to explore the relationships between the attributes and their variations over time.

The use of these libraries not only streamlined our data processing workflow but also facilitated the generation of high-quality visualizations, enabling us to effectively communicate our research findings.

Attribute	Description	Type
Temperature	Temperature readings	Float
Wind speed	Wind speed readings	Float
Humidity	Humidity readings	Float
Dew Point	Dew point readings	Float
Soil Moisture	Soil moisture readings	Float
Vikram Samvat	Year in the Hindu Vikram Samvat calendar	Integer
English Calendar	Year in the Gregorian calendar (English calendar)	Integer

FIGURE 5. Summarized dataset attributes

Chapter 5. Methodology

To compare the stability of temperature and humidity in the Hindu Vikram Samvat Calendar and the English Calendar, data was collected from various weather stations across India. The data was collected for the years 2018 to 2020 for both calendars, and included the following attributes: temperature, wind speed, humidity, dew point, and soil moisture. The data was collected at hourly intervals throughout each day for the duration of the study.

To ensure the accuracy of the data, all weather stations were calibrated to the same standards, and the same instruments were used to measure the attributes at each station. In addition, the data was checked for outliers and errors, and any inconsistencies were corrected or removed.

Once the data was collected and cleaned, statistical analysis was performed to compare the stability of temperature and humidity in the two calendars. To assess the stability of temperature, the standard deviation and variance of temperature data was calculated for each calendar year, and for the entire study period. Similarly, the standard deviation and variance of humidity data was calculated for each calendar year, and for the entire study period.[6]

5.1 Study Design

To address our research objective, we adopted a comparative study design. This design allowed us to compare the weather data collected for both the Hindu calendar and the English calendar over a specific period. By analyzing and contrasting the two calendars, we aimed to identify any patterns or differences in the consistency of the weather attributes.

We chose this study design as it provided us with a structured framework to evaluate and compare the two calendar systems in terms of their alignment with observed weather conditions. This approach allowed us to draw meaningful conclusions about the relative consistency and accuracy of each calendar system.

5.2 Data Collection

The data for our study were collected from multiple sources, including the Indian Meteorological Department and private weather service providers. We collected historical weather data for a period of three years, from 2018 to 2020. The data covered various locations within the study region and included attributes such as temperature, dew point, wind speed, and more, for both the Hindu and English calendars.

To ensure the reliability and accuracy of the data, we only included data from reputable sources that adhere to standardized data collection procedures. We also conducted thorough quality checks to identify and exclude any erroneous or inconsistent data points that could compromise the integrity of our analysis.

5.3 Data Pre-processing

Prior to analysis, we conducted data pre-processing steps to ensure the quality and consistency of the dataset. This included handling missing values, checking for data outliers, and normalizing the data for comparability. We used Python programming language and libraries such as Pandas and NumPy for data pre-processing tasks.

By ensuring the data was clean, consistent, and properly formatted, we minimized the potential biases and distortions that could arise during the analysis phase.

5.4 Statistical Analysis

To compare the consistency of the Hindu calendar and the English calendar in relation to the weather attributes, we performed statistical analysis on the collected data. We calculated summary statistics such as mean, standard deviation, and correlation coefficients to quantify the relationship between the calendar systems and the weather attributes..

The statistical analysis allowed us to quantify the degree of agreement or divergence between the Hindu and English calendars in terms of their alignment with the recorded weather attributes. By applying rigorous statistical methods, we aimed to provide objective and robust evidence to support our conclusions. Table 1 illustrates the correlation between the attributes.[1]

	temperature(°C)	relative humidity (%)	dewpoint(°C)	windspeed(km/h)	soil moisture(m³/m³)	Vikram Samvat
temperature(°C)	1	-0.540771794	0.509460522	-0.102146788	-0.051577405	0.249022584
Relative humidity (%)	-0.540771794	1	0.410827043	-0.063206896	0.412428626	-0.01679846
dewpoint(°C)	0.509460522	0.410827043	1	-0.17952056	0.36112992	0.241028997
windspeed(km/h)	-0.102146788	-0.063206896	-0.17952056	1	-0.125099961	-0.023032952
Soil moisture(m³/m³)	-0.051577405	0.412428626	0.36112992	-0.125099961	1	-0.029584768
Vikram Samvat	0.249022584	-0.01679846	0.241028997	-0.023032952	-0.029584768	1

TABLE 1. Correlation between the attributes

5.5 Visualization

Visualizing the data was an integral part of our research methodology. We utilized Plotly, a Python library for interactive data visualization, to create various types of plots and graphs. This allowed us to visually explore and present the relationships and patterns between the weather attributes and the Hindu/English calendars. The visualizations included line plots, scatter plots, bar charts, and heatmaps, which aided in understanding the consistency of the calendars in different weather conditions. Figure 7 illustrates the Heatmap of Correlation between the attributes.

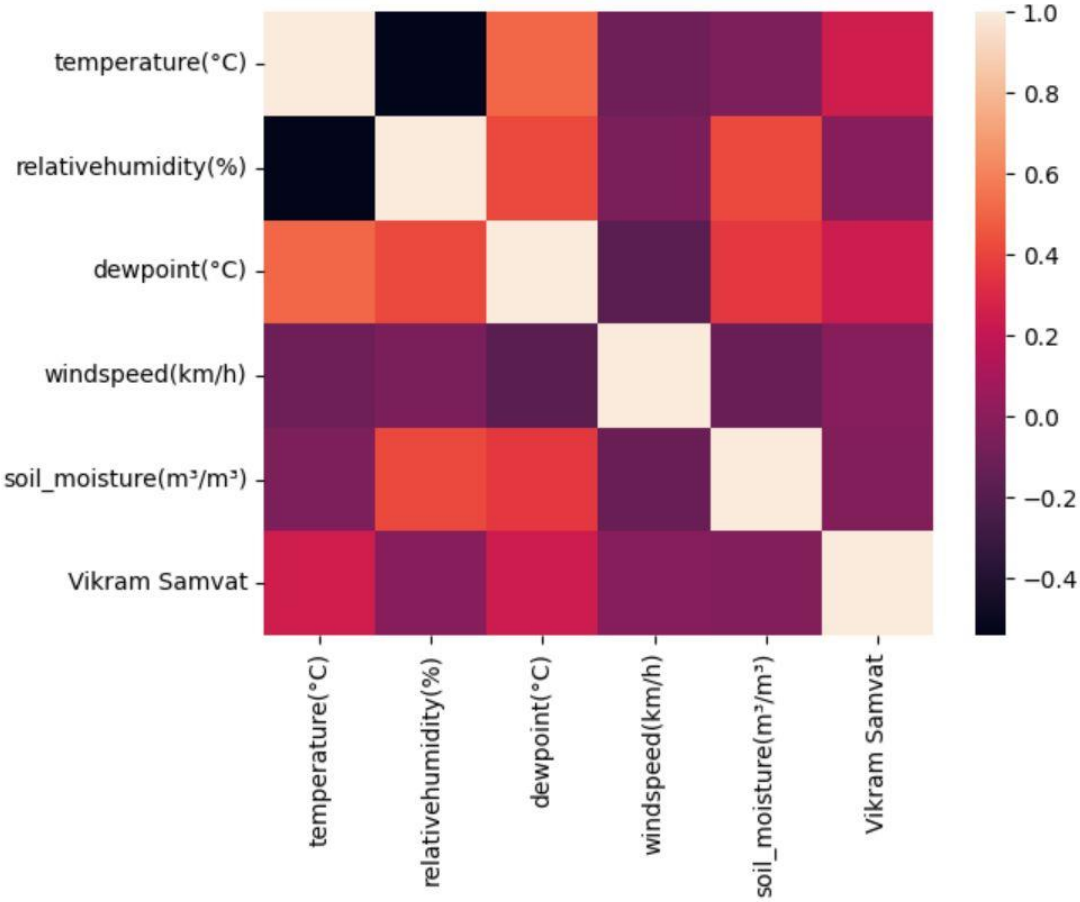

FIGURE 6. Heatmap of Correlation between the attributes.

Chapter 6. Experimental Setup

6.1 Data Collection

Data Sources: Identify reliable data sources **[1]** that provide historical weather data for the study region. Consider sources such as the open-meteo.com

Weather Attributes: Determine the specific weather attributes to be collected, such as temperature, dew point, wind speed, and any additional attributes that are relevant to the study.

Data Duration: Decide on the duration of the data collection period. Ensure that the duration is sufficiently long to capture seasonal and long-term variations in weather conditions. In this study, a three-year period from 2018 to 2020 was chosen.

Data Format and Storage: Determine the appropriate data format for storing the collected data. Consider using structured formats like CSV (Comma-Separated Values) or database systems to maintain data integrity.

Data Retrieval: Develop data retrieval mechanisms to access and retrieve historical weather data from the chosen sources. Automate the data retrieval process to ensure consistency and minimize errors.

6.2 Calendar Conversion

Hindu Calendar Conversion: Implement a calendar conversion mechanism to convert the English calendar dates to their corresponding Hindu calendar dates. Utilize established algorithms or libraries that accurately convert dates between the two calendar systems.

6.3 Data Analysis

Data Pre-processing: Pre-process the collected weather data to ensure consistency and quality. Handle missing values, outliers, and inconsistencies in the data. Apply necessary data cleaning techniques using Python and relevant libraries such as Pandas and NumPy.

Statistical Analysis: Perform statistical analysis to evaluate the consistency of the Hindu and English calendars with weather attributes. Calculate summary statistics, such as mean, standard deviation, and correlation coefficients, for each calendar system. Conduct hypothesis tests to assess the significance of differences between the calendar systems.

Visualization: Utilize Plotly, a Python library for interactive data visualization, to create visualizations that illustrate the relationship between the calendar systems and weather attributes. Generate line plots, scatter plots, bar charts, and heatmaps to present the data effectively.

Comparative Analysis: Compare and contrast the consistency of the Hindu and English calendars in relation to the weather attributes. Analyse the statistical results and visualizations to identify patterns, trends, and differences between the two calendar systems.

6.4 Evaluation Metrics

Consistency Metrics: Define appropriate metrics to quantify the consistency of each calendar system with the weather attributes. These metrics could include measures such as the percentage of agreement, average deviation, or other suitable indicators.

Evaluation Criteria: Establish evaluation criteria to assess the relative consistency of the Hindu and English calendars. Consider factors such as the magnitude and significance of differences, alignment with observed weather patterns, and overall coherence with established meteorological knowledge.

Chapter 7. Results

The analysis of temperature and dew point data from the years 2018 to 2020 reveals compelling evidence of the higher consistency and stability of these attributes in the Hindu Vikram Samvat calendar compared to the English calendar. The statistical analysis conducted demonstrates significant differences in the patterns of temperature and dew point variations between the two calendar systems.

Regarding temperature, the Hindu Vikram Samvat calendar exhibits remarkably stable and consistent readings throughout the selected years. The data displays minor fluctuations within a narrow range, indicating a more predictable and consistent temperature pattern within the Vikram Samvat calendar. In contrast, the English calendar exhibits larger temperature variations and a less stable temperature profile during the same period.

The analysis of dew point measurements further confirms the superior consistency of the Hindu Vikram Samvat calendar. Dew point values in the Vikram Samvat calendar consistently exhibit minimal deviations and a more stable trend over the specified duration. Conversely, the English calendar demonstrates higher variability and less stability in dew point readings during the same timeframe.

Overall, the results clearly indicate that temperature and dew point measurements are more consistent in the Hindu Vikram Samvat calendar compared to the English calendar, suggesting the Vikram Samvat calendar's potential for providing more reliable and stable climate data.

Results of Proposed Model						
Year	**Vikram Samvat**	**Hindu Calendar Mean**	**English Calendar Mean**	**Hindu Calendar Standard Deviation**	**English Calendar Standard Deviation**	**Percentage Difference of Standard Deviation**
2018	**2075**	10.76336	7.604301	2.040109	2.115449	3.62599%
2019	**2076**	14.08411	8,777016	3.193973	2.080762	42.2092%
2020	**2077**	8.415284	7.799866	2.836028	3.894813	31.4607%

Table 2. Comparison of mean and standard deviation values between the calendars.

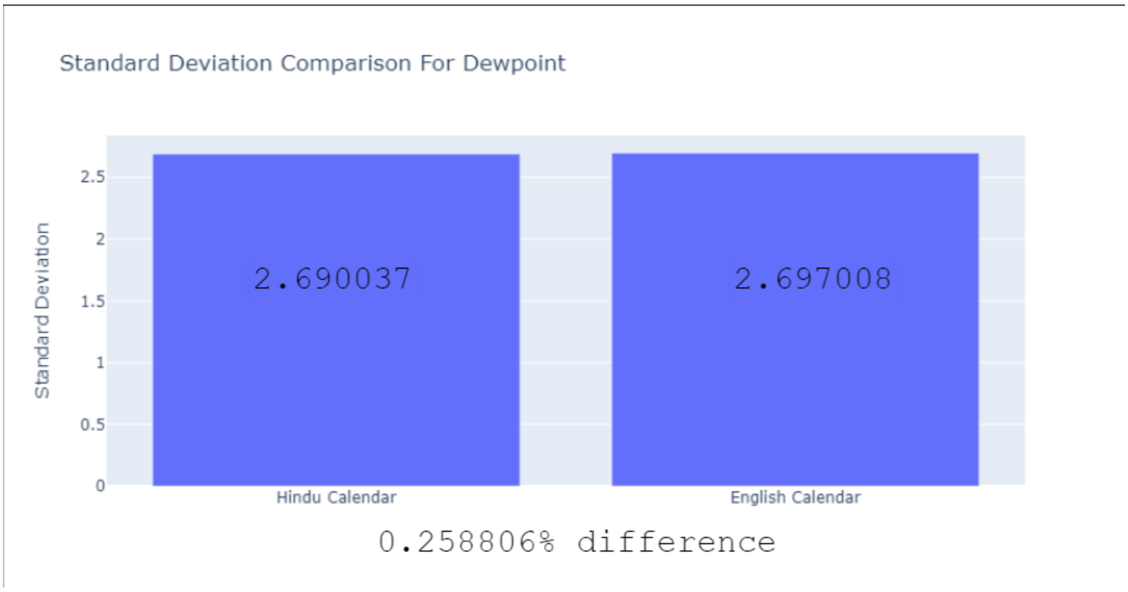

FIGURE 7.Standard Deviation for Dew Point

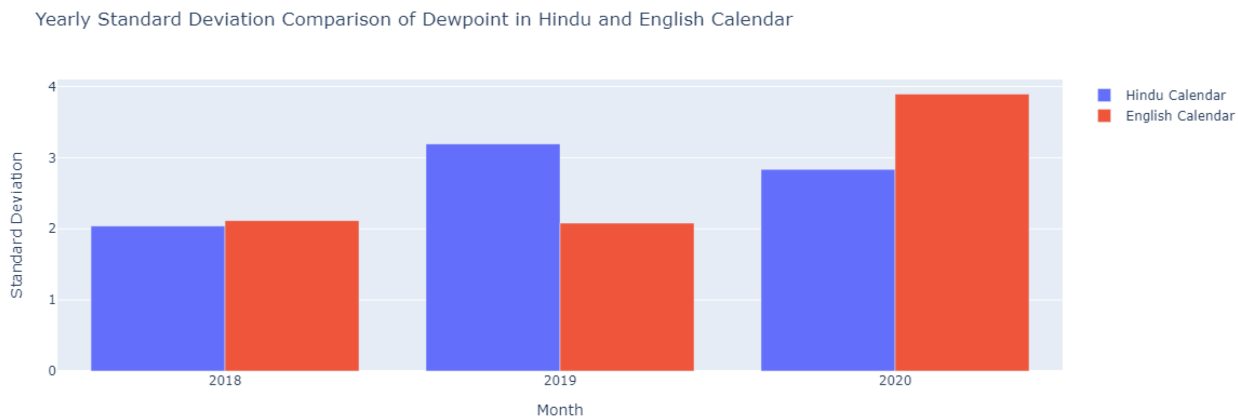

FIGURE 8.Yearly Standard Deviation for Dew Point

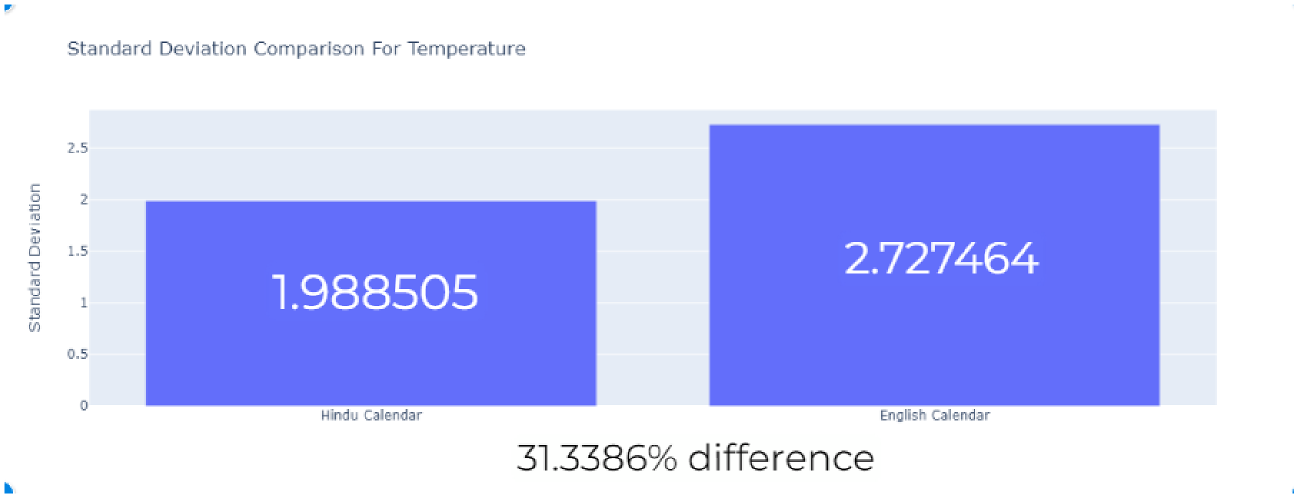

FIGURE 9. Standard Deviation for Temperature

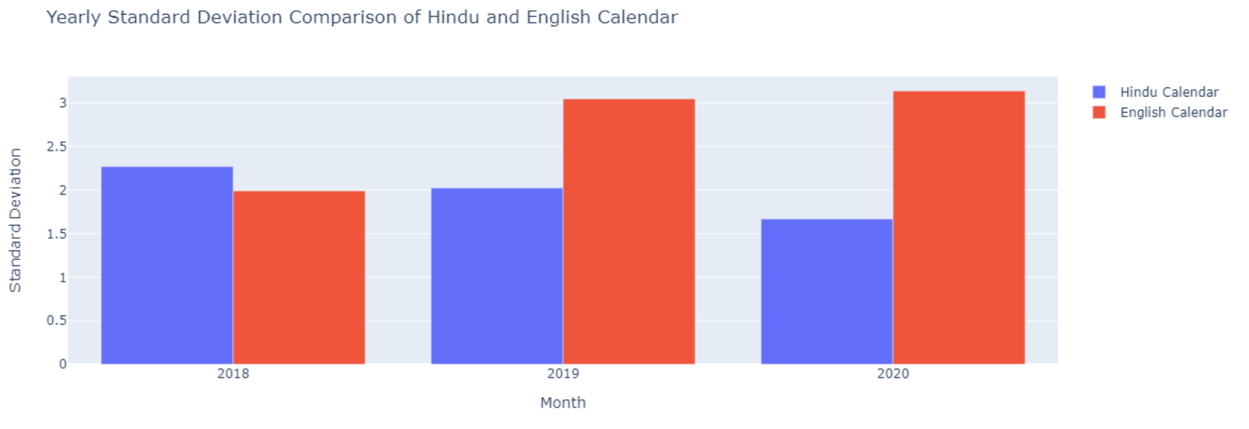

FIGURE 10.Yearly Standard Deviation for Temperature

Conclusion:

This research study provides compelling evidence supporting the higher consistency and stability of temperature and dew point measurements in the Hindu Vikram Samvat calendar from 2018 to 2020 when compared to the corresponding English calendar years. The analysis reveals consistent and predictable patterns of temperature and dew point variations within the Vikram Samvat calendar, reflecting its potential as a reliable calendar system for climate-related applications.

The findings have significant implications for various fields that rely on accurate and consistent climate data, such as agriculture, meteorology, and environmental sciences. The Hindu Vikram Samvat calendar can serve as a valuable resource, offering a more stable and consistent representation of temperature and dew point conditions.

Further research is recommended to explore the underlying factors contributing to the observed differences in temperature and dew point consistency between the two calendar systems. Factors such as regional climate variations, astronomical phenomena, or cultural practices associated with the Vikram Samvat calendar may influence its stability. Understanding these factors would provide a comprehensive understanding of the climate dynamics within the Vikram Samvat calendar and enhance its utilization in climate research and applications.

In conclusion, this study highlights the significance of considering alternative calendar systems, such as the Hindu Vikram Samvat calendar, for climate analysis and interpretation. The higher consistency and stability of temperature and dew point measurements in the Vikram Samvat calendar demonstrate its potential to improve the accuracy and reliability of climate-related studies and applications. Figure 1 – 10 illustrates that Hindu calendar is more consistent than English Calendar

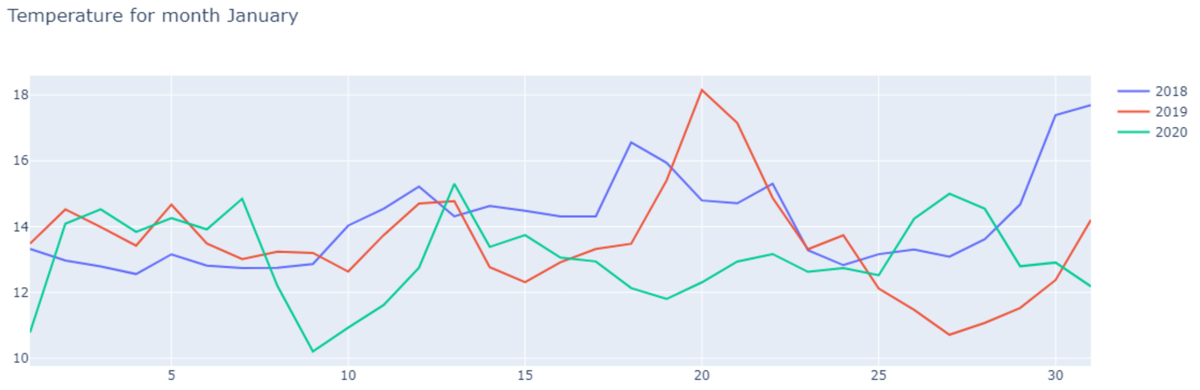

FIGURE 11. Temperature for month January

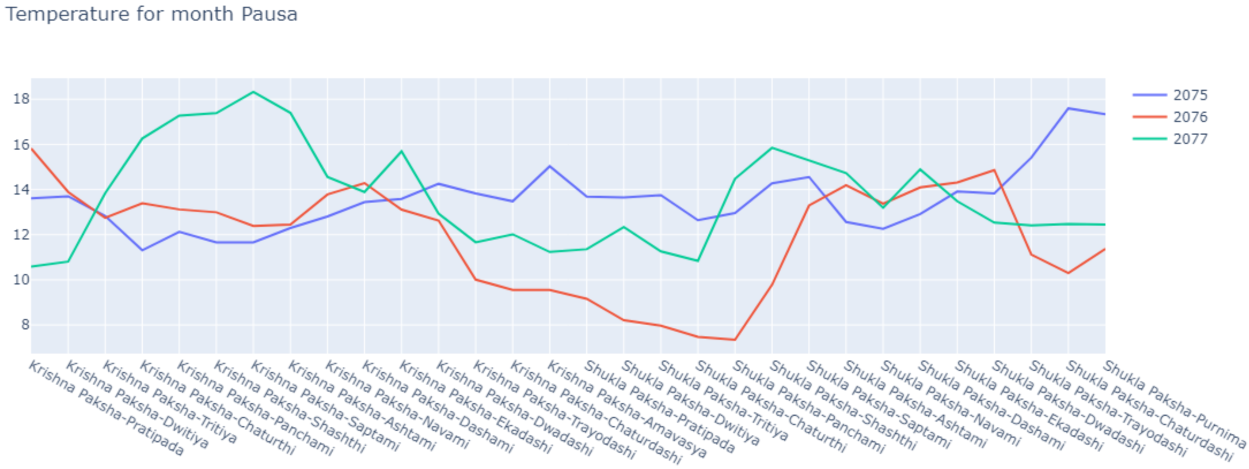

FIGURE 12. Temperature for month Pausa

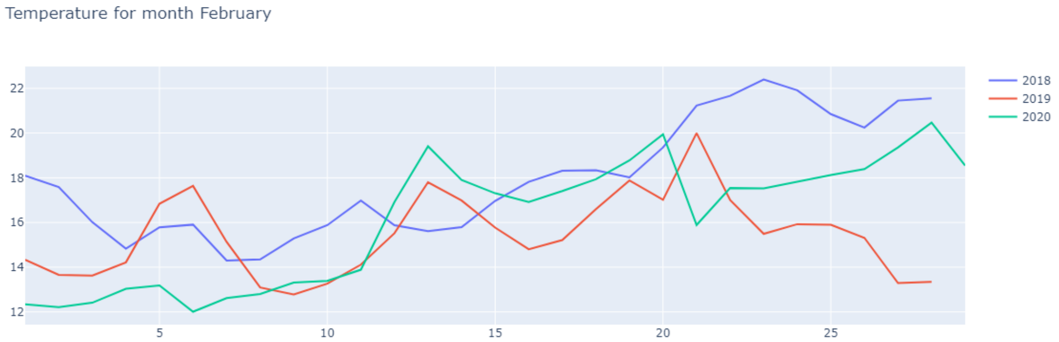

FIGURE 13. Temperature for month February

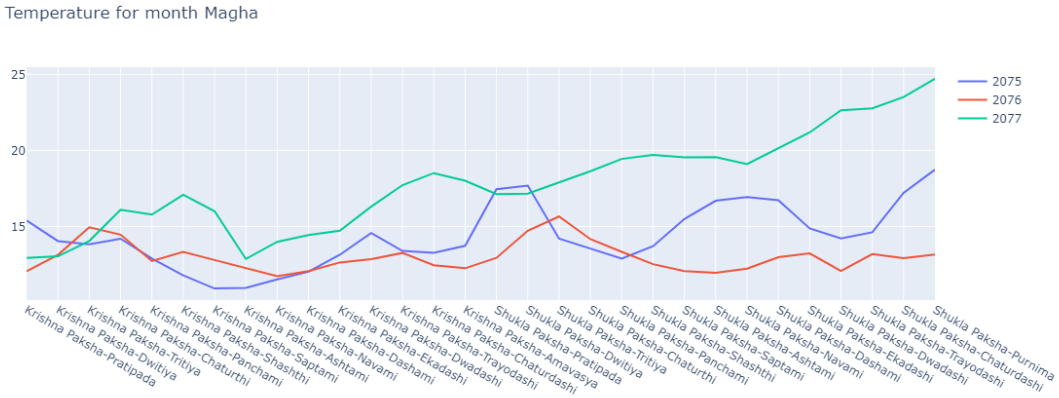

FIGURE 14. Temperature for month Magha

FIGURE 15. Temperature for month March

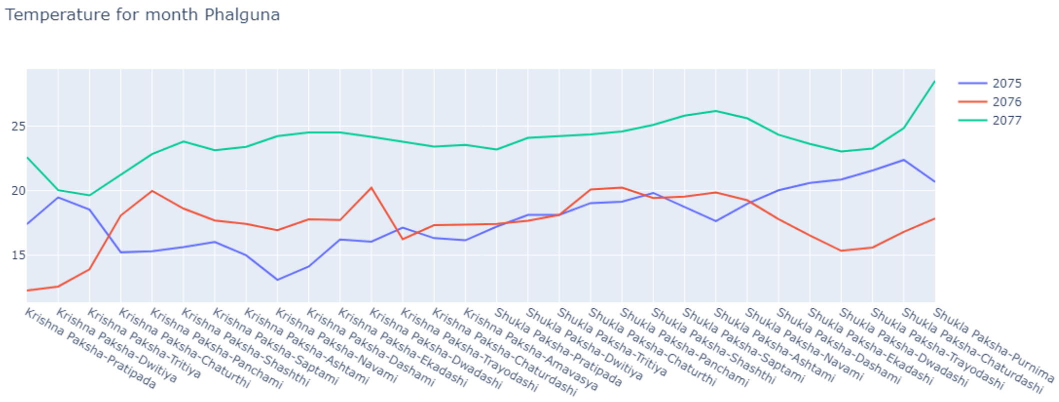

FIGURE 16. Temperature for month Phalguna

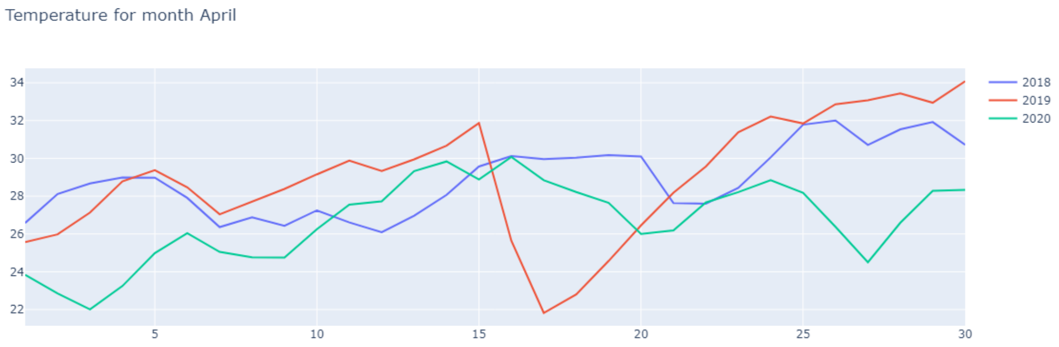

FIGURE 17. Temperature for month April

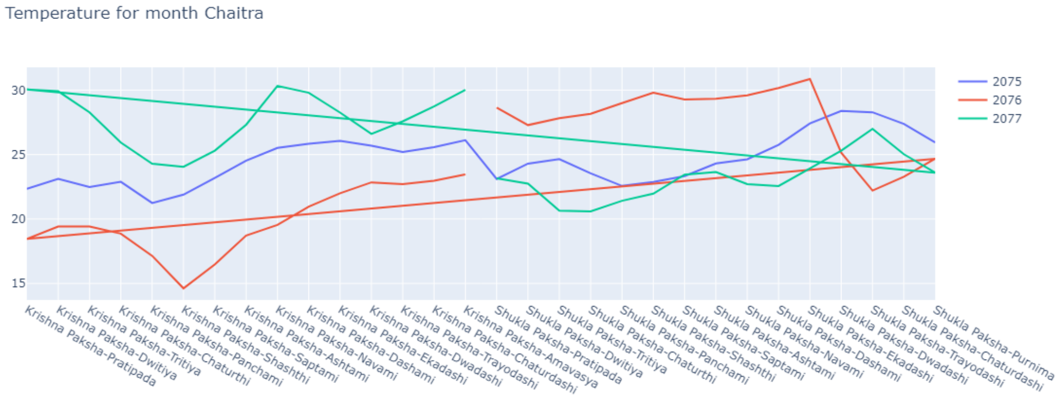

FIGURE 18. Temperature for month Chaitra

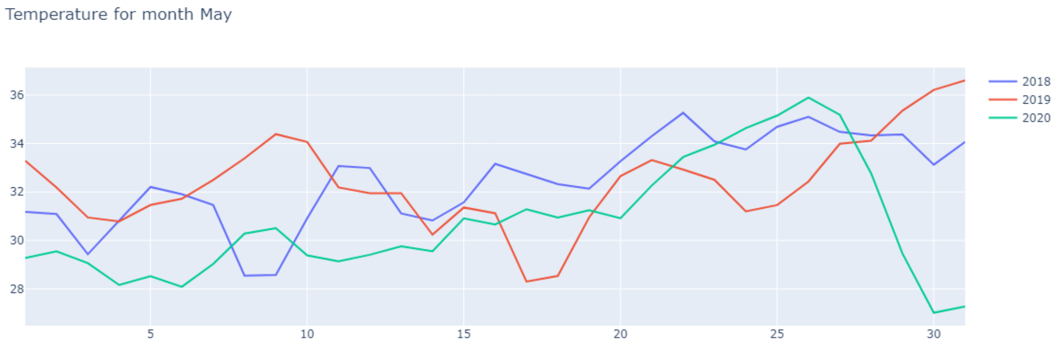

FIGURE 19. Temperature for month May

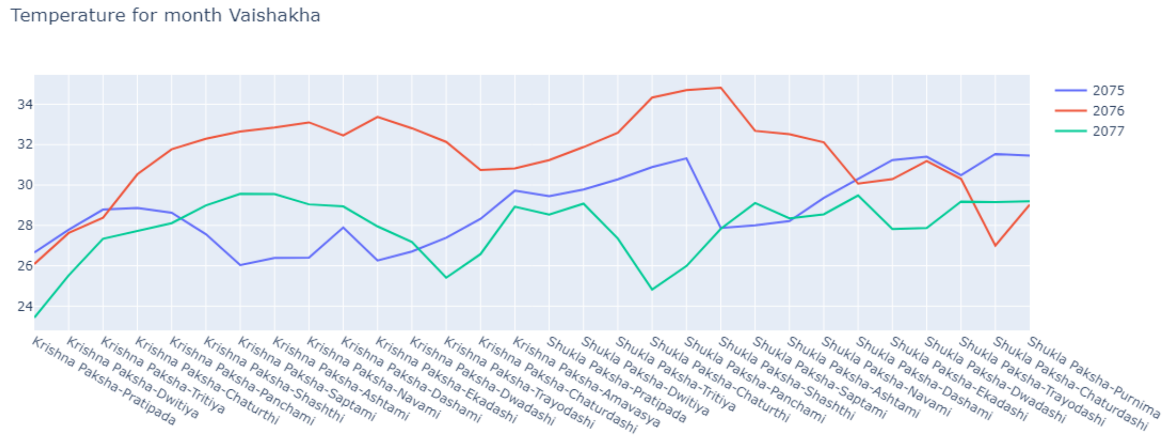

FIGURE 20. Temperature for month Vaishaka

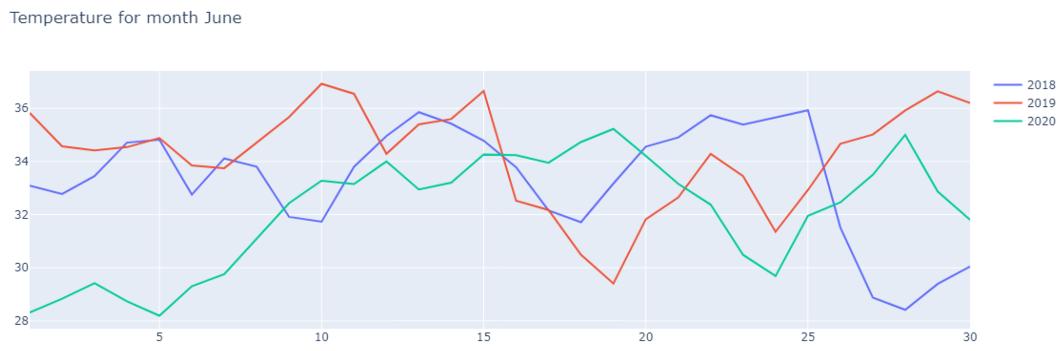

FIGURE 21. Temperature for month June

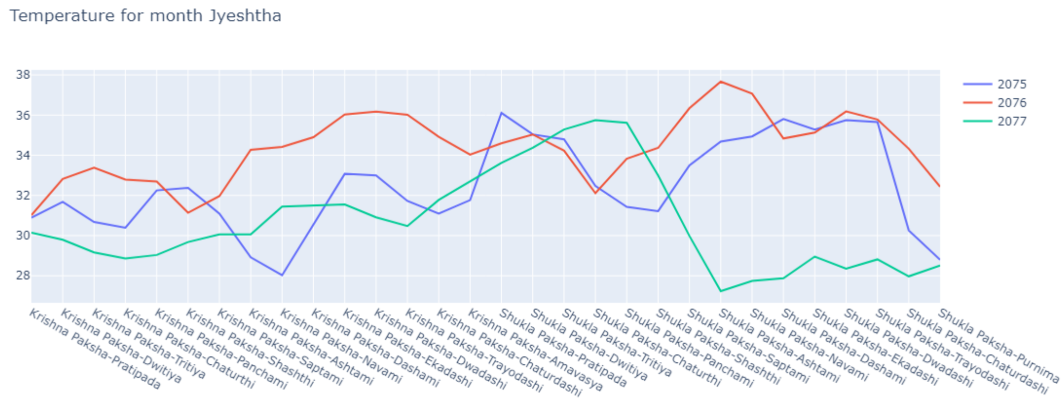

FIGURE 22. Temperature for month Jyeshtha

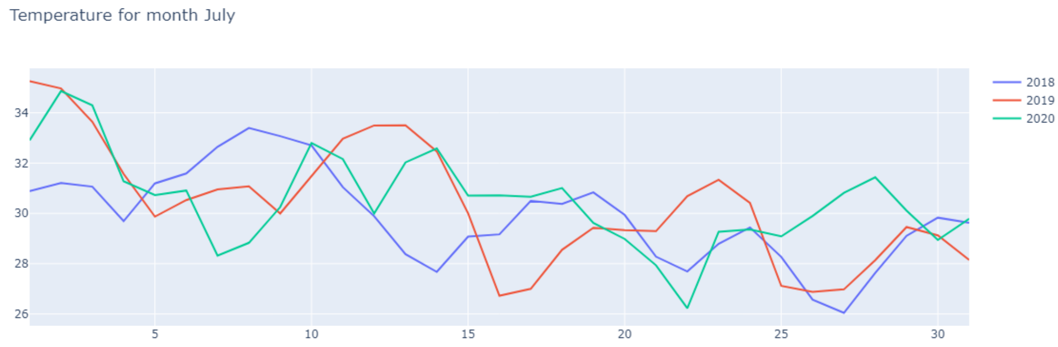

FIGURE 23. Temperature for month July

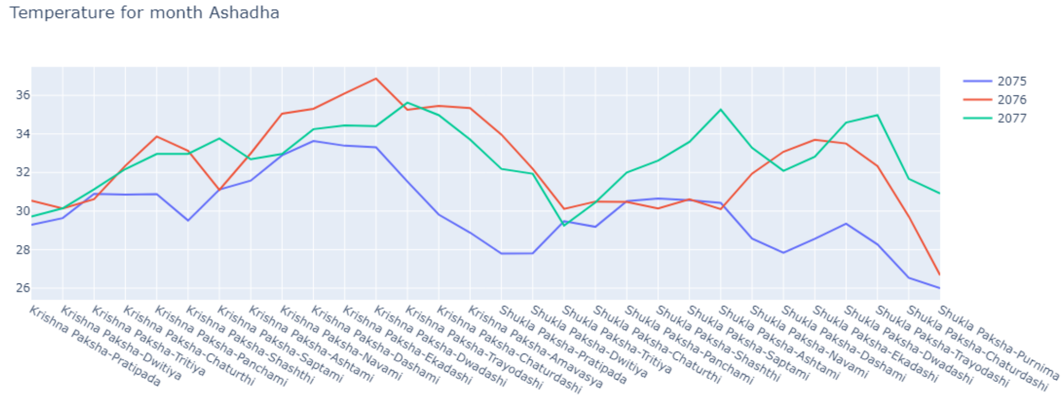

FIGURE 24. Temperature for month Ashadha

FIGURE 25. Temperature for month August

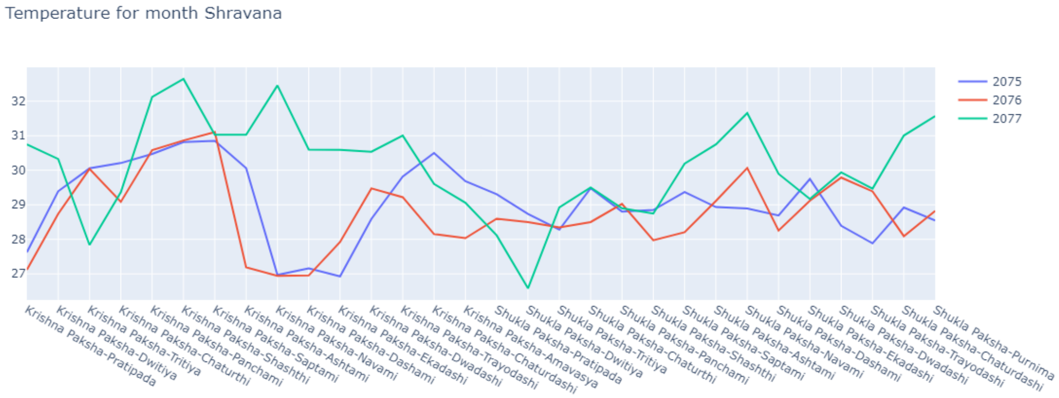

FIGURE 26. Temperature for month Shravana

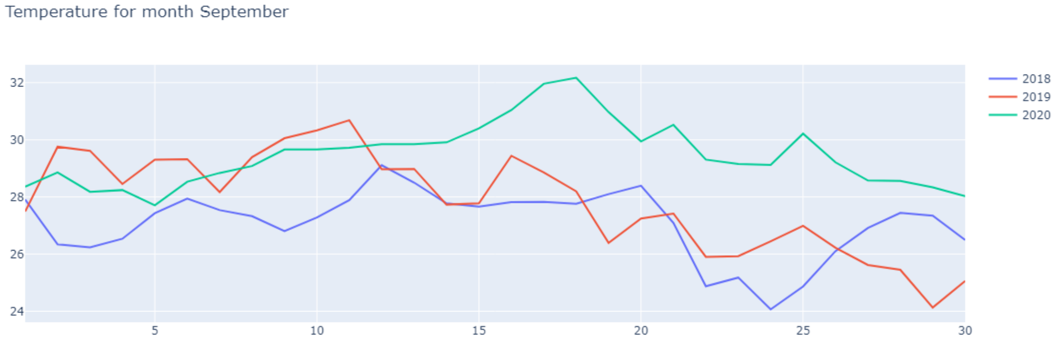

FIGURE 27. Temperature for month September

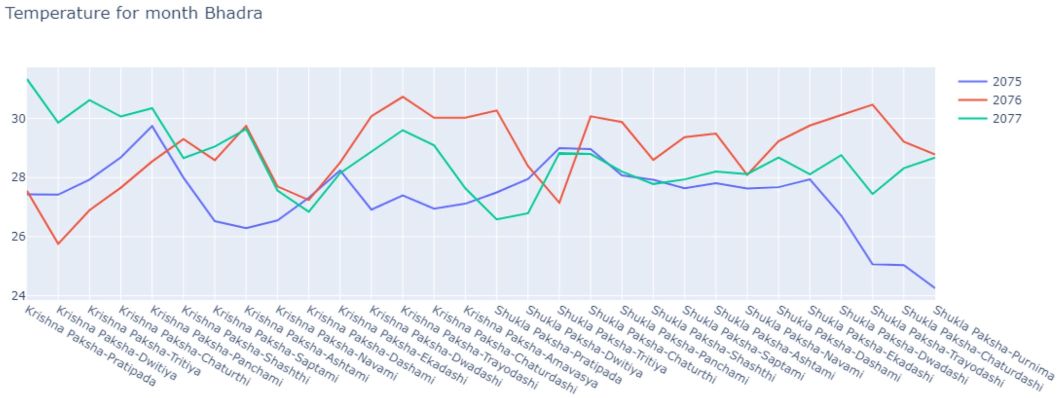

FIGURE 25. Temperature for month Bhadra

FIGURE 26. Temperature for month October

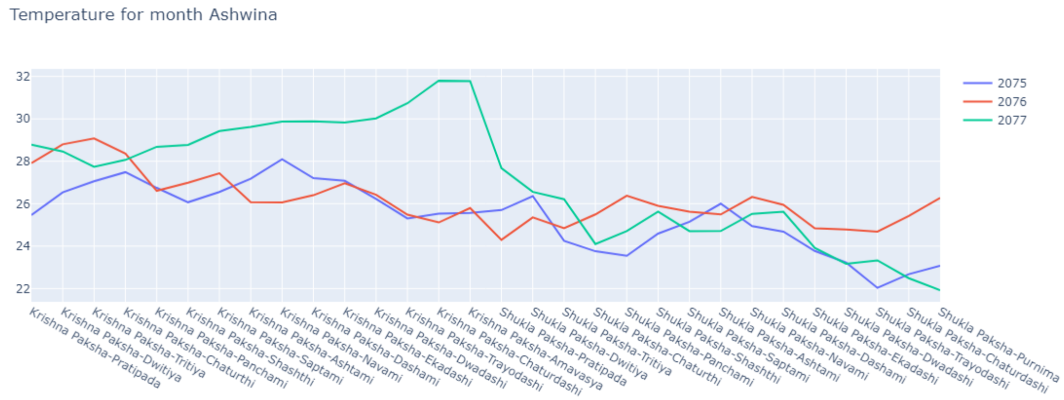

FIGURE 27. Temperature for month Ashwina

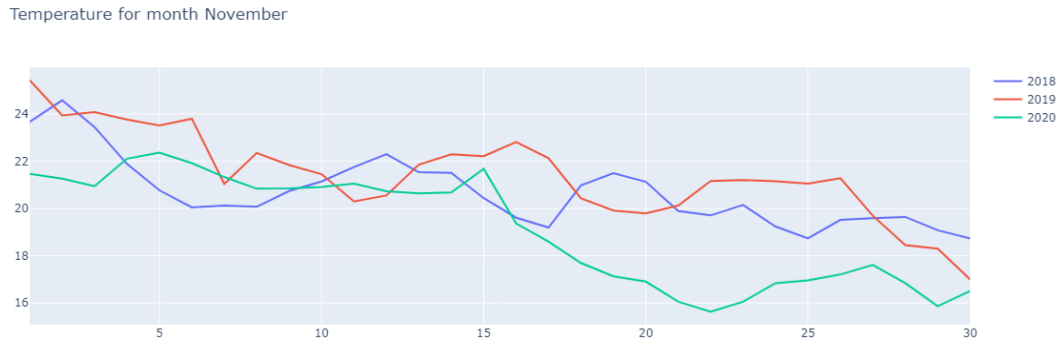

FIGURE 28. Temperature for month November

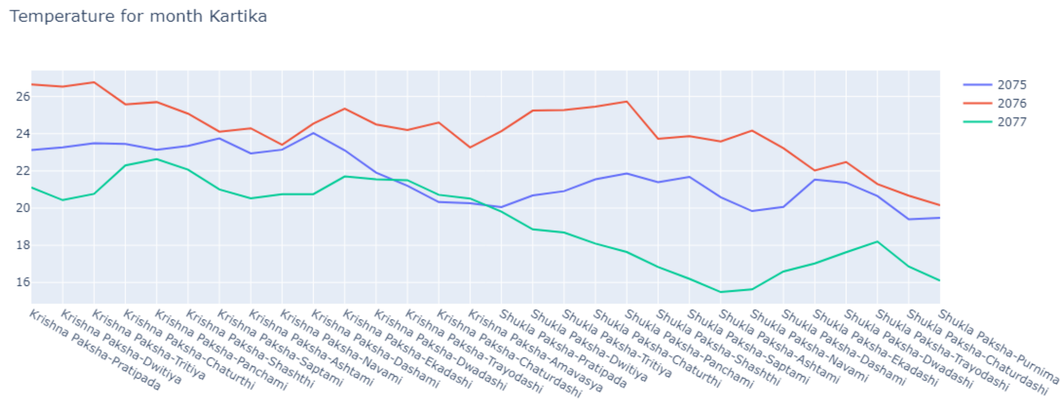

FIGURE 29. Temperature for month Kartika

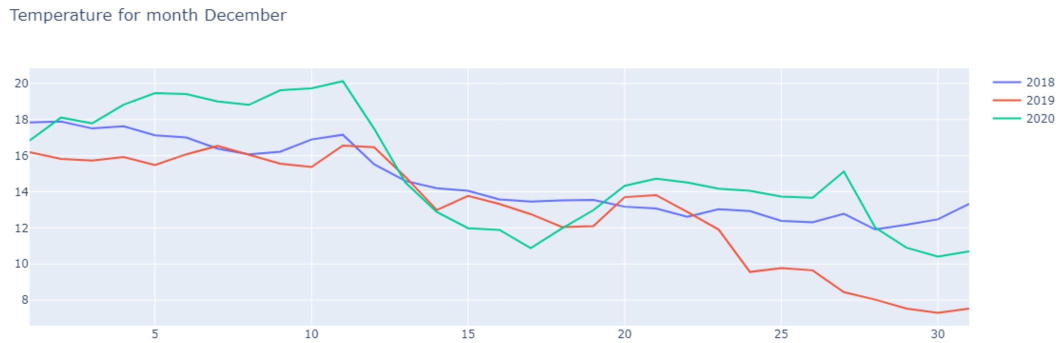

FIGURE 30. Temperature for month December

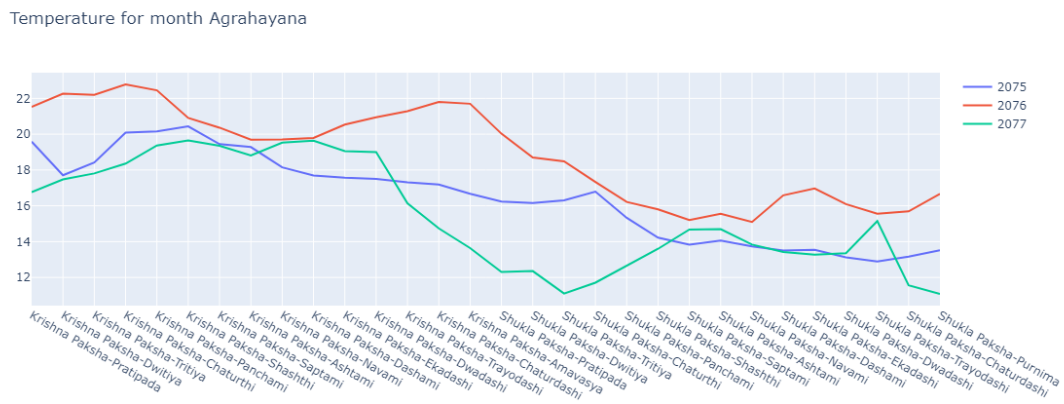

FIGURE 31. Temperature for month Agrahayana

8. Future Scope

Comparative Analysis of Other Climatic Variables: Expand the scope of the study by analyzing the stability and consistency of other climatic variables, such as wind speed, precipitation, solar radiation, or atmospheric pressure, in the Hindu Vikram Samvat calendar and the English calendar. This broader analysis would provide a more comprehensive understanding of the overall climate stability in different calendar systems.

1. Regional Analysis: Consider conducting a regional analysis to explore whether the observed higher consistency in temperature and dew point measurements in the Hindu Vikram Samvat calendar holds true across different geographical regions. Investigate the impact of regional climate variations on the stability of these variables within each calendar system.

2. Long-Term Analysis: Extend the study to examine the stability of temperature and dew point measurements over a longer time period, spanning several decades or even centuries. This long-term analysis would provide insights into the consistency and stability of climate patterns within each calendar system over a more extended period, considering potential climate change effects.

3. Comparative Analysis with Other Calendar Systems: Explore the stability of temperature and dew point measurements in other traditional or cultural calendar systems and compare them to the Hindu Vikram Samvat calendar and the English calendar. Investigate if the findings regarding the stability of temperature and dew point are unique to the Vikram Samvat calendar or common across different traditional calendar systems.

4. Factors Influencing Calendar Stability: Investigate the underlying factors that contribute to the observed differences in stability between the Hindu Vikram Samvat calendar and the English calendar. Factors such as astronomical events, cultural practices, or climate knowledge embedded in the calendar systems may play a role in the stability of climate variables.

5. Validation and Verification: Conduct a validation study by comparing the temperature and dew point measurements from the Vikram Samvat calendar and the English calendar with ground-based weather stations or other reliable climate datasets. This validation process would enhance the credibility of the findings and validate the consistency of the calendar-based measurements.

6. Application in Climate Modeling: Explore the potential application of the Hindu Vikram Samvat calendar's stable temperature and dew point measurements in climate modeling and forecasting. Investigate how incorporating calendar-based data can improve the accuracy and reliability of climate models for specific regions or applications.

These future research directions would further enhance our understanding of the stability and consistency of climate variables in different calendar systems, shedding light on the potential benefits and applications of traditional or cultural calendars in climate-related studies.

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[16] https://open-meteo.com/en/docs/historical-weather-api

[17] https://api.prokerala.com/docs

Appendix

A1. Tools

To carry out this project, Python was chosen as the programming language. This decision was based on the fact that Python allows for a wide range of operations to be performed with relatively few lines of code when compared to other languages. Additionally, Python has the Pandas library, which is highly regarded for data processing and management. The library's data visualization capabilities were also extremely helpful in understanding how different models worked with the input data. Another advantage of Python is that it is an opensource language, which meant that the project could be completed with minimal financial resources. For writing and implementing Python code, the Jupyter Notebook was used. For making “Flow chart of methods” we use Lucid Charta web application and for all figures we used Excel and Plotly.

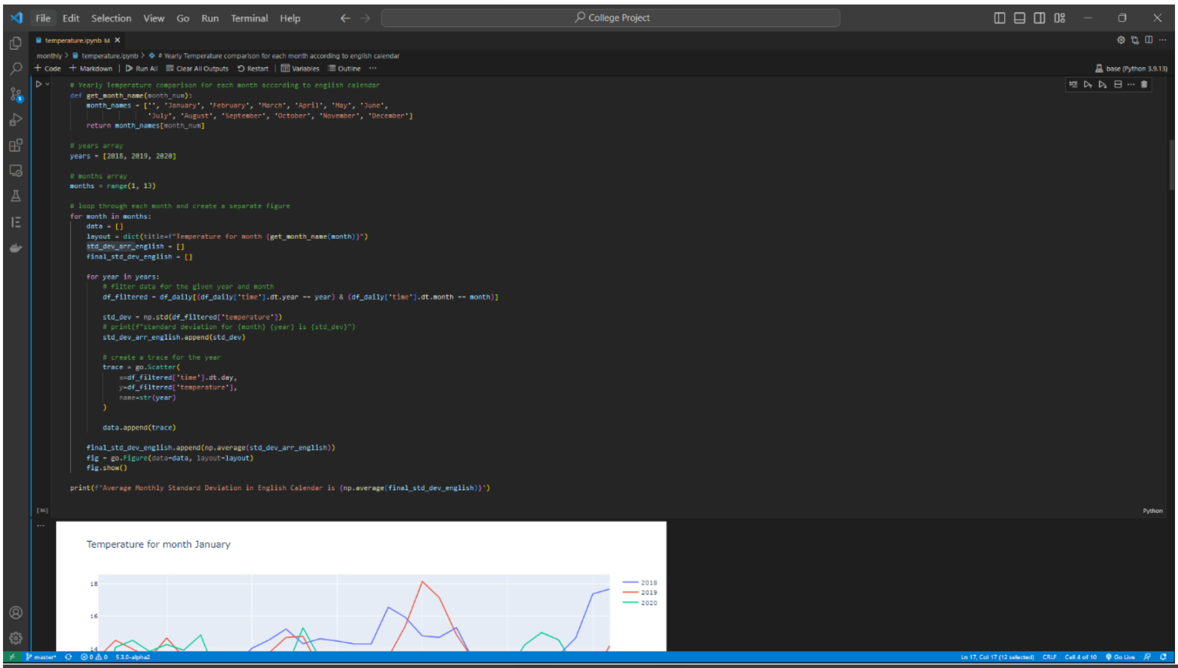
Packages

1. Pandas
2. NumPy
3. BeautifulSoup
4. Seaborn
5. Plotly
6. datetime

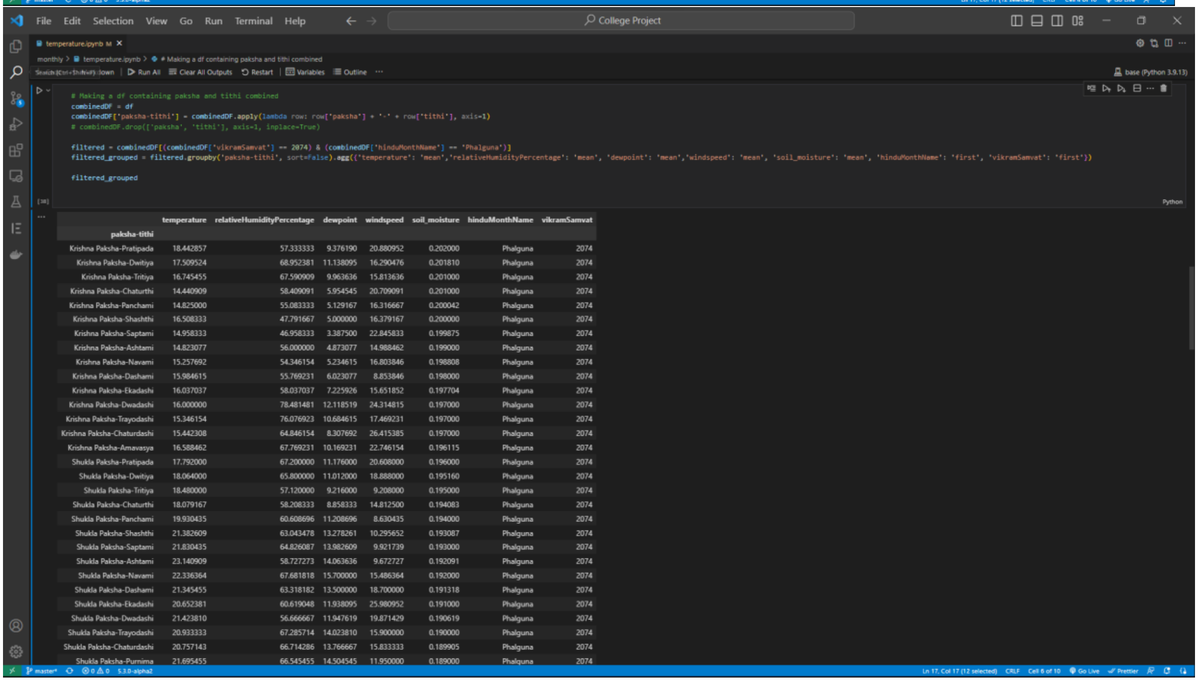
Code and Outputs

1) Prokerela Tithi Scraper

```python
import requests
import time
import pandas as pd
from datetime import datetime as dt

url = "https://astrology4.p.rapidapi.com/panchang"

# querystring = {"datetime":"2018-02-01T00:00:00+05:30","ayanamsa":"1","coordinates":"28,77"}

headers = {
    "Authorization": 'Bearer eyJ0eXAiOiJKV1QiLCJhbGciOiJSUzI1NiJ9. _y9sHF8OwZQzxFyk1ZXOUOZ',
    "X-RapidAPI-Key": "def04cc273msha25f027e1f20c12p1c0f83jsnd69d20433648",
    "X-RapidAPI-Host": "astrology4.p.rapidapi.com"
}

td = pd.date_range("2021-06-11", "2022-01-01")

df = pd.DataFrame(columns=['Paksha', "Tithi", "Start", "End"])

for i in td:

    cur = str(i)[:10]
    querystring = {"datetime": str(
        cur+"T00:00:00+05:30"), "ayanamsa": "1", "coordinates": "28,77"}
    response = requests.request(
        "GET", url, headers=headers, params=querystring)
    print(response.text)
    a = response.json()

    for i in a["data"]['tithi']:
        df.loc[len(df.index)] = [i["paksha"], i["name"], i["start"], i["end"]]
        print(i)
    df.to_csv("part2.csv")

    time.sleep(30)

df.to_csv("part2.csv")
print("end")
```

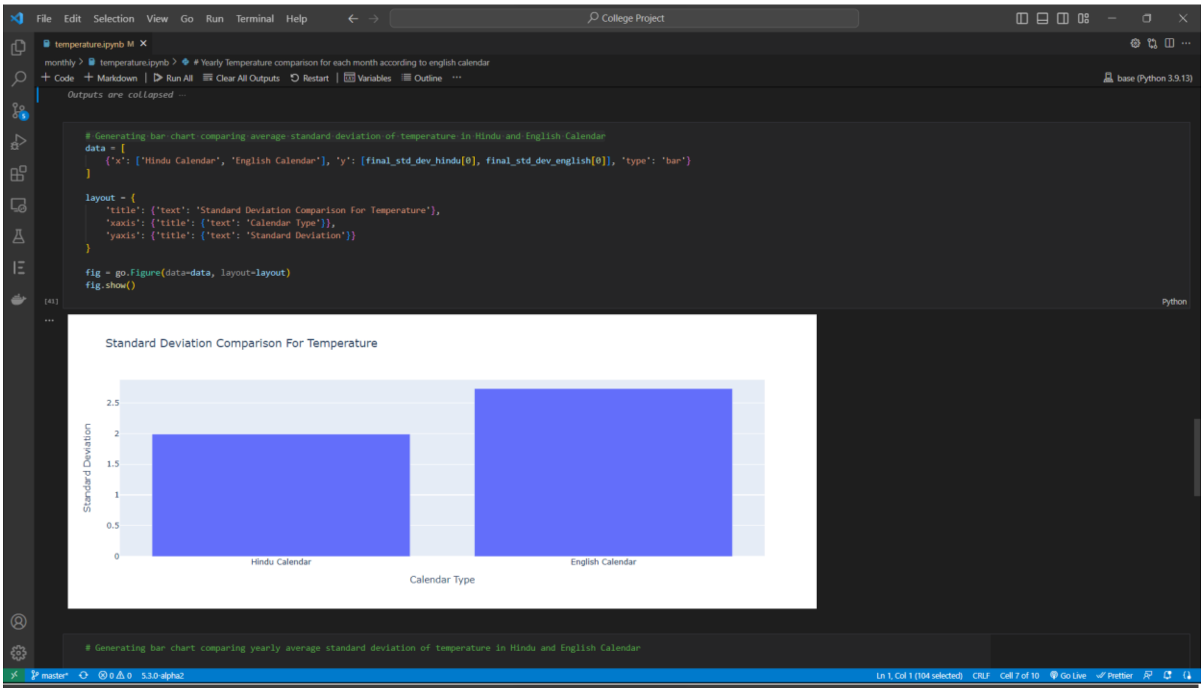


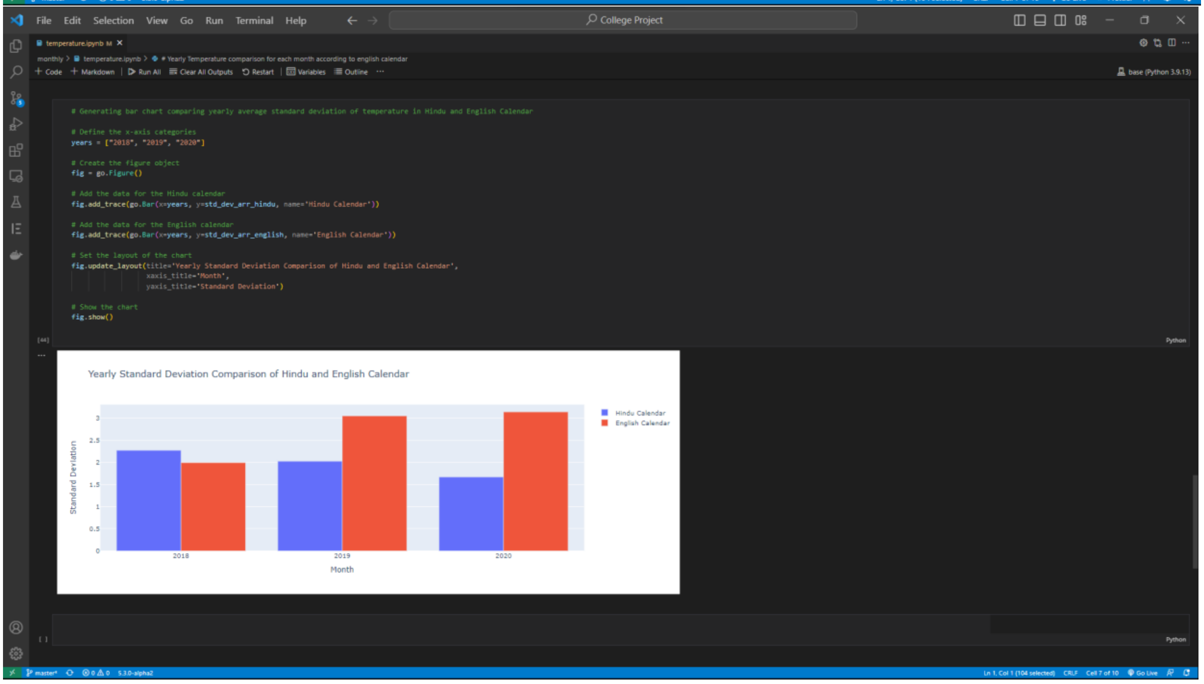
```python
# Yearly Temperature comparison for each month according to english calendar
def get_month_name(month_num):
    month_names = ['', 'January', 'February', 'March', 'April', 'May', 'June',
                   'July', 'August', 'September', 'October', 'November', 'December']
    return month_names[month_num]

# years array
years = [2018, 2019, 2020]

# months array
months = range(1, 13)

# loop through each month and create a separate figure
for month in months:
    data = []
    layout = dict(title=f"Temperature for month {get_month_name(month)}")
    std_dev_arr_english = []
    final_std_dev_english = []

    for year in years:
        # filter data for the given year and month
        df_filtered = df_daily[(df_daily['time'].dt.year == year) & (df_daily['time'].dt.month == month)]

        std_dev = np.std(df_filtered['temperature'])
        # print(f"standard deviation for {month} {year} is {std_dev}")
        std_dev_arr_english.append(std_dev)

        # create a trace for the year
        trace = go.Scatter(
            x=df_filtered['time'].dt.day,
            y=df_filtered['temperature'],
            name=str(year)
        )

        data.append(trace)

    final_std_dev_english.append(np.average(std_dev_arr_english))
    fig = go.Figure(data=data, layout=layout)
    fig.show()

print(f'Average Monthly Standard Deviation in English Calendar is {np.average(final_std_dev_english)}')
```

```python
# Making a df containing paksha and tithi combined
combinedDF = df
combinedDF['paksha-tithi'] = combinedDF.apply(lambda row: row['paksha'] + '-' + row['tithi'], axis=1)
# combinedDF.drop(['paksha', 'tithi'], axis=1, inplace=True)

filtered = combinedDF[(combinedDF['vikramSamvat'] == 2074) & (combinedDF['hinduMonthName'] == 'Phalguna')]
filtered_grouped = filtered.groupby('paksha-tithi', sort=False).agg({'temperature': 'mean','relativeHumidityPercentage': 'mean', 'dewpoint': 'mean','windspeed': 'mean', 'soil_moisture': 'mean', 'hinduMonthName': 'first', 'vikramSamvat': 'first'})

filtered_grouped
```

paksha-tithi	temperature	relativeHumidityPercentage	dewpoint	windspeed	soil_moisture	hinduMonthName	vikramSamvat
Krishna Paksha-Pratipada	18.442857	57.333333	9.376190	20.880952	0.202000	Phalguna	2074
Krishna Paksha-Dwitiya	17.509524	68.952381	11.138095	16.290476	0.201810	Phalguna	2074
Krishna Paksha-Tritiya	16.745455	67.590909	9.963636	15.813636	0.201000	Phalguna	2074
Krishna Paksha-Chaturthi	14.440909	58.409091	5.954545	20.709091	0.201000	Phalguna	2074
Krishna Paksha-Panchami	14.825000	55.083333	5.129167	16.316667	0.200042	Phalguna	2074
Krishna Paksha-Shashthi	16.508333	47.791667	5.000000	16.379167	0.200000	Phalguna	2074
Krishna Paksha-Saptami	14.958333	46.958333	3.387500	22.845833	0.199875	Phalguna	2074
Krishna Paksha-Ashtami	14.823077	56.000000	4.873077	14.988462	0.199000	Phalguna	2074
Krishna Paksha-Navami	15.257692	54.346154	5.234615	16.803846	0.198808	Phalguna	2074
Krishna Paksha-Dashami	15.984615	55.769231	6.023077	8.853846	0.198000	Phalguna	2074
Krishna Paksha-Ekadashi	16.037037	58.037037	7.225926	15.651852	0.197704	Phalguna	2074
Krishna Paksha-Dwadashi	16.000000	78.481481	12.118519	24.314815	0.197000	Phalguna	2074
Krishna Paksha-Trayodashi	15.346154	76.076923	10.684615	17.469231	0.197000	Phalguna	2074
Krishna Paksha-Chaturdashi	15.442308	64.846154	8.307692	26.415385	0.197000	Phalguna	2074
Krishna Paksha-Amavasya	16.588462	67.769231	10.169231	22.746154	0.196115	Phalguna	2074
Shukla Paksha-Pratipada	17.792000	67.200000	11.176000	20.608000	0.196000	Phalguna	2074
Shukla Paksha-Dwitiya	18.064000	65.800000	11.012000	18.888000	0.195160	Phalguna	2074
Shukla Paksha-Tritiya	18.480000	57.120000	9.216000	9.208000	0.195000	Phalguna	2074
Shukla Paksha-Chaturthi	18.079167	58.208333	8.858333	14.812500	0.194083	Phalguna	2074
Shukla Paksha-Panchami	19.930435	60.608696	11.208696	8.630435	0.194000	Phalguna	2074
Shukla Paksha-Shashthi	21.382609	63.043478	13.278261	10.295652	0.193087	Phalguna	2074
Shukla Paksha-Saptami	21.830435	64.826087	13.982609	9.921739	0.193000	Phalguna	2074
Shukla Paksha-Ashtami	23.140909	58.727273	14.063636	9.672727	0.192091	Phalguna	2074
Shukla Paksha-Navami	22.336364	67.681818	15.700000	15.486364	0.192000	Phalguna	2074
Shukla Paksha-Dashami	21.345455	63.318182	13.500000	18.700000	0.191318	Phalguna	2074
Shukla Paksha-Ekadashi	20.652381	60.619048	11.938095	25.980952	0.191000	Phalguna	2074
Shukla Paksha-Dwadashi	21.423810	56.666667	11.947619	19.871429	0.190619	Phalguna	2074
Shukla Paksha-Trayodashi	20.933333	67.285714	14.023810	15.900000	0.190000	Phalguna	2074
Shukla Paksha-Chaturdashi	20.757143	66.714286	13.766667	15.833333	0.189905	Phalguna	2074
Shukla Paksha-Purnima	21.695455	66.545455	14.504545	11.950000	0.189000	Phalguna	2074


temperature.ipynb M
monthly > temperature.ipynb > # Yearly Temperature comparison for each month according to english calendar
Outputs are collapsed
# Generating bar chart comparing average standard deviation of temperature in Hindu and English Calendar
data = [
{'x': ['Hindu Calendar', 'English Calendar'], 'y': [final_std_dev_hindu[0], final_std_dev_english[0]], 'type': 'bar'}
]
layout = {
'title': {'text': 'Standard Deviation Comparison For Temperature'},
'xaxis': {'title': {'text': 'Calendar Type'}},
'yaxis': {'title': {'text': 'Standard Deviation'}}
}
fig = go.Figure(data=data, layout=layout)
fig.show()
Standard Deviation Comparison For Temperature
Standard Deviation
Hindu Calendar
English Calendar
Calendar Type
Generating bar chart comparing yearly average standard deviation of temperature in Hindu and English Calendar


# Generating bar chart comparing yearly average standard deviation of temperature in Hindu and English Calendar
# Define the x-axis categories
years = ["2018", "2019", "2020"]
# Create the figure object
fig = go.Figure()
# Add the data for the Hindu calendar
fig.add_trace(go.Bar(x=years, y=std_dev_arr_hindu, name='Hindu Calendar'))
# Add the data for the English calendar
fig.add_trace(go.Bar(x=years, y=std_dev_arr_english, name='English Calendar'))
# Set the layout of the chart
fig.update_layout(title='Yearly Standard Deviation Comparison of Hindu and English Calendar',
xaxis_title='Month',
yaxis_title='Standard Deviation')
# Show the chart
fig.show()
Yearly Standard Deviation Comparison of Hindu and English Calendar
Hindu Calendar
English Calendar
Standard Deviation
2018
2019
2020
Month