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RESEARCH ARTICLE

Assessment of Accuracy of Indian Almanac for Daily Rainfall Prediction

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Abstract

Background/Objectives: Modern science is able to predict various aspects of weather including rainfall, but it still does not provide high accuracy when we consider longer duration predictions in the future, which are very important for Agriculture. In countries like India, Ancient knowledge-based rainfall predictions are being made till this day. This research paper is an attempt to predict daily rainfall based on a limited implementation of rules from various Panchangs, and assessment of accuracy of these predictions in an unbiased manner. **Methods**: These predictions have been compared against the revalidated and actual daily rainfall data for accuracy calculation. We have assessed accuracy for overall 30 versions/test scenarios, which contain 7 versions of Traditional Maharashtrian Panchang, 8 versions of Telugu Panchang, 1 version of Saptanadi. This is followed by 4 scenarios of comparison with actual data and 4 with Hourly predictions vs data. **Findings**: We achieved a respectable accuracy of 81%(For Traditional Maharashtrian Panchang) and 79% (Telugu Panchang) when tested with 40 years of revalidated daily rainfall data between 1st Jan 1980 to 31st Aug 2020 across the world in India and other continents. **Novelty**: The comparison is based on daily rainfall accuracy which has not been seen before. Also, for the first time, we are able to prove the global applicability of the Panchang rules for precipitation prediction. This study is not intended to comment on the overall accuracy of any of the Panchangs, makes best possible combination useful to Indian farmer. We intend to make these predictions available as a website and an API to make this research directly usable.

Keywords: Panchang; Conjunctions; Nakshatras; Ecliptic Longitude; Right Ascension; Rainfall Prediction; Weather Prediction

1 Introduction

The basis of this research is "Panchang" (Or Panchangam) which is a traditional Indian Almanac that has been in practice for over 5 millennia. Important meteorological predictions have been distilled by this method. They are normalized over a small area, based on astrological phenomena like planet-star conjunctions, transits, etc. Panchang consists of 5 components, namely Tithi, Vaara, Nakshatra, Yoga and Karana, along with other terms. Panchang predictions are carried out using some observed rules. Extensive study of these rules has been performed and then an attempt has been made to write a program which incorporates these set of rules and predicts daily rainfall or precipitation.

If we see the ancient manuscripts like Vedas or Upanishads, the Indian methods for weather prediction can be classified into two categories:

1.1 Theoretical methods

This method applies astronomical or planetary factors and computes the positions of celestial bodies and their conjunction.(ii) Observational methods.

The observational methods deal with atmospheric changes, including the dominant cloud type and their resulting rainfall.

Since ancient times, India has been using such traditional methods for studying astrology for horoscope predictions and even for other aspects like their influence on the prediction and forecasting rainfall. For this, the classical Hindu astrological almanac known as Panchang/ Panchangam is used. Panchang is a Theoretical Method and the calculations in this technique are based on Nakshatras and planetary positions in a specific time period.

The Panchang considered are Traditional Andhra and Maharashtra based Panchang. All the methods mostly use similar rules and logic.

The main objective of this research is to provide the best prediction of type of rainfall for a particular day, for a longer duration of prediction, well in advance, based on Panchang rules of Planetary and Nakshatra positions.

For achieving this, a limited implementation of the different types of Panchang has been done.

(Disclaimer: The Panchang and Astrological rules associated with the Panchang are typically used to do many different predictions but we have limited our study to consider the rules related to rainfall prediction only. Moreover, different combinations of rules have been tried out to identify the best performing/reasonable accuracy level rule-set amongst the combinations tried. Hence this paper should not be seen as a comment on the individual accuracy or comparative accuracies of any of the Panchangs. Moreover, since we have referred to generic rules based on other research papers and discussions with multiple experts, we have generically mentioned the names of Panchangs based on the area they are referred in. It is in no way any comment on the area where they belong to.)

Further, these predictions have been compared with the actual/revalidated daily rainfall measurements from Jan 1980 to Aug 2020. This study has been carried out for 7 locations in India and 14 locations across the world spanning all continents.

We have also taken the liberty to consider combinations of different types of rules in this comparison purely for the purpose of getting the best rainfall predictions which can stand the test of time, and make them usable for the farmers across the world, who need accurate predictions from a season to a year at least.

2 The Method

2.1 Types of Panchangam and Rules Referred

This study refers mainly to Andhra Pradesh based Panchangam (Pidaparthy Panchangam as described in Ref 1.), Traditional Maharashtrian Panchang, Saptanadi, and has rules taken from Brihat Samhita as well The Supplementary document has a detailed description of these Panchangs.

2.2 Utilizing Panchang Rules For Weather Prediction

As it can be seen from the description of various concepts used in the Panchang, the rules for rainfall predictions are based on

- Positions of various planets in particular Nakshatras,
- Conjunction of planets in particular Nakshatras or Zodiacs,
- Planets being ahead of each other
- Planets rising in particular Nakshatra
- Retrograde motion of planets

Since we have referred to an English translated version of the rules in some cases, sometimes it may become confusing whether the author refers to a constellation, whether it meant Zodiac or Nakshatra. We have tried to apply both the understanding and check which gives better results.

For applying these rules, we need to check for the positions of these planets with respect to an observer on the earth at a particular location. Thus the code we have developed, considers a location and a date range as an input.

For checking the positions of the planets, we refer to ephemeris and the concepts of Ecliptic Longitude and Right Ascension. This basically refers to an ecliptic coordinate system, which is a celestial coordinate system commonly used for representing the apparent positions, orbits, and pole orientations of Solar System objects. Because most planets (except Mercury) and many small Solar System bodies have orbits with only slight inclinations to the ecliptic, using it as the fundamental plane is convenient. The system's origin can be the center of either the Sun or Earth, its primary direction is towards the vernal (March) equinox, and it has a right-hand convention. It may be implemented in spherical or rectangular coordinates. Since we are considering the geo-centric system for Panchangam based calculations, we have considered the earth as the center of the system. Please refer to Figures 1 and 2 . Also refer to the Supplementary document section 2.2.2 for more details.

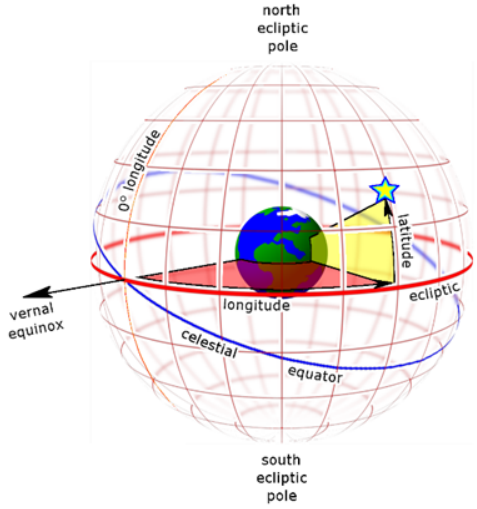

Fig 1. The Right Ascention [(1)]

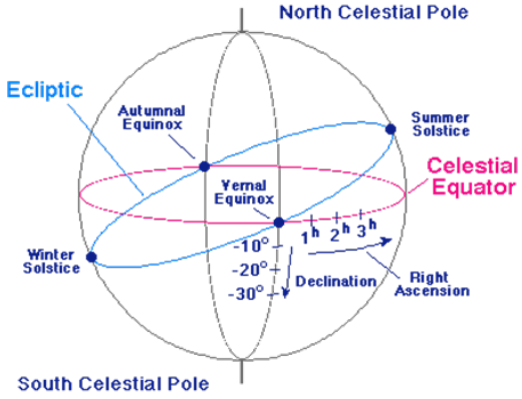

Fig 2. The Ecliptic Longitude [(2)]

The algorithm thus calculates the position of each heavenly body (including the sun and the moon) as per ephemeris, and relates it to the Zodiacs and Nakshatras.

Further, it checks these positions against the conditions for Scanty, Copious and No rainfall, and notes all the conditions which have been found to be matching. Based on the number of matching conditions, the final prediction is chosen. To elaborate

with an example, the results may show that 3 conditions of planetary positions are pointing to scanty rainfall whereas 1 condition shows copious rainfall. In such a case, the prediction will pick up Scanty as the prediction for the day. We have also tried multiple sets of such rules and picked the one with maximum accuracy as can be seen from the results table. In another version, the logic has been changed to consider prediction as Copious if any single rule for Copious is true, else Scanty if rules for Scanty exist or if there is no specific rule for No rainfall; else default to No Rainfall.

2.2.1 Algorithm Summary

To summarize, the steps followed are:

- Input – Location Lat/Long, date range
- For each date in the date range,
- Calculate the ecliptic longitude(EL) and Right Ascension(RA) for the planets based on the location of the place for which prediction is to be made.
- Calculate Planetary position
- Calculate Conjunctions
- Calculate rising and setting of planets
- Find nakshatra of all the conjunctions and transitions of planets
- Compare the data with given conditions of rainfall
- Populate number of conditions favoring no rainfall, scanty and copious rainfall
- Based on the conditions met and the result logic, predict the rainfall for the day

2.2.2 Rainfall Measurements[3]

The measurement of quantity of rainfall in the present Panchangam is given in terms of an ancient traditional unit Aadhakam.

One Kuncham of rainfall = One Aadhakam of rainfall = 1.6 cm of rain water

Four Kunchams of rainfall = Four Aadhakams of rainfall = One Dronam Rain = 6.4 cm of rain water

For the present study, since the Panchangam rules we found are aligned to only 3 categories – No rainfall, Scanty and Copious rainfall, we have considered the following

No rainfall/Very less rainfall Rainfall amount realised in a day is less than 1 Adhakam or 16 mm

Scanty rainfall Rainfall amount realised in a day is between 1 and 4 Adhakam i.e. between 16 mm and 64 mm

Copious rainfall Rainfall amount realised in a day is more than 4 Adhakam or 64 mm

These have been noted in the results table. Please refer to section 2.2.3 in supplementary section for more details and comparison with IMD.

[Ref: Panchangam Calculations by Karanam Ramakumar]

2.3 Test Strategy and Execution

The aim of this study is to objectively assess the accuracy of rainfall prediction for a longer duration of time.

Hence we have taken a measure as Daily rainfall prediction.

The main test scenarios are

1) What is the overall average accuracy shown by Panchang for various combinations across a long duration based on daily rainfall accuracy average?

2) What level of accuracy is shown by Panchang (various combinations) within a year – monthly average accuracy of daily rainfall predictions

3) What level of accuracy is shown year on year – yearly average accuracy of daily rainfall for various versions of the Panchang

4) If we try to predict hourly accuracy, what kind of results do we get with a reasonable rainfall measurement considered per range?

2.3.1 Comparisons

The accuracy calculation for daily rainfall predictions has been done between Panchang predictions and the revalidated data extracted from MERRA data sets with data from 1st Jan 1980 to 31st Aug 2020. (Please refer to Supplementary document Sec 2.3.1 for more details)

This provides a good enough range for rainfall comparison, is recent enough to imbibe the changes due to Climate change observed across the world.

Further, the actual rainfall data from 2500+ locations for 1 year has also been compared with the Panchang predictions and has been noted in the results. Data from IMD was considered for this purpose. [4]

Moreover, we found actual rainfall datasets for 162 years for Sydney, Australia and Kansas, US. Comparisons with these datasets have also been incorporated in the study. (Kansas data https://www.ncdc.noaa.gov/cdo-web/ and Sydney data http://www.bom.gov.au/climate/data/stations/)

All these comparisons have been done for 7 locations across India and 13 (and in some cases 10) locations across the world. These locations are Bangalore, Chattisgarh, Chandigarh, Chennai, Guwahati, Hyderabad, Pune in India and Alberta, Brasilia, Hanoi, Harare, Jakarta, KansasCity , Riyadh , Sydney, Andalusia, France, Lincoln, Tokai, London. The exact Latitude and Longitudes have been mentioned in the Supplementary section.

2.3.2 Calculations

For each of the locations, the data being compared is first qualified as No rainfall, Scanty or Copious based on the range considered as described above. Then for the same date and location, the code for Panchang prediction is executed, which populates a csv file with Panchang based prediction as well as a binary comparison result value (1 : Panchang prediction matches with reference, 0 : Panchang prediction does not match with reference).

This is done for the entire date range, and the average accuracy % is calculated as an average of this binary value. This % has been mentioned against each of the versions compared in the results section.

3 Results and Discussion

As a part of this research, we have made 30 different versions and compared the results. The intention is to find out which set of rules provides the best possible accuracy in India as well as Internationally.

For every version, the set of rules implemented, detailed analysis with graphs and averages is available on request.

3.1 Traditional Maharashtrian Panchang

The Table 1 provides a description of each of the version based on what kind of rules were implemented, based on traditional Maharashtrian Panchang rules. It notes the observations and conclusion for each of the versions, and an accuracy % value. It has been observed that version 1.4 is the best performing version across all versions (Accuracy 81.04% for Indian locations and 81.05% for International locations). For ease of reference, the table 7 has been also retained in the supplementary document section 3.1.

Table 1. Traditional Panchang Results

Version	Description	Observation	Conclusion	Accuracy Achieved
1.0	Traditional Panchang calculations based on set of rules indicating copious, scanty or no rainfall. Contains rules about conjunctions of planets, planets or moon in a particular Nakshatra, etc.	Base model, performed much better than expected. Dip during monsoon months.	Accuracy is good, but may be increased by using different rules	73.00%
1.0.1	International location results for version 1.0	Base model, compared with International data.	Accuracy is quite good, suggesting that the rules being considered may be internationally relevant	74.10%
1.1	Traditional Panchang calculations plus some Brihat Samhita rules	Accuracy dropped over the base version for all the 7 cities	Adding Brihat Samhita caused complexities to increase and therefore the accuracy dipped over the base model	71.50%
1.2	Change of rules (Mars and Venus in same Nakshatra) , baseline 1.0; Logic changed to consider contrasting results from different rules to give output as no rainfall	Increased accuracy	Increased accuracy, Logic for contrasting results=no rainfall seems to be increase accuracy	80.59%
1.2.1	Rerun for International locations with version 1.2	The accuracy of the model over International data improved greatly over v1.0.1	International location accuracy being close to 81% is very good	80.78%

Continued on next page

Table 1 continued

1.3	Baseline 1.2; Conjunction degrees consideration changed to 8 degrees	The results were very close v1.2, but v1.2 still reigned supreme in terms of overall accuracy.	This version has similar results, so v1.2 is still the baseline version for further developments	80.48%
1.4	Baseline 1.2; Change in understanding. Constellation to be interpreted as Nakshatra instead of Zodiac (the translated rules in reference document mentions Constellation. Earlier interpretation was that this means Zodiac, but changed to Nakshatra and tried again. There is an overlap between Zodiac and Nakshatra	Further modification to the rules as per the instructions of the expert, allowed an additional 1 percent increase in accuracy	With this modification, this version is giving the best accuracy, although the monsoon months are still showing a dip	81.05%
1.4.1	Baseline 1.4, International	Further modification to the rules as per the instructions of the expert, allowed an additional 1 percent increase in accuracy	With this modification, this version is giving the best accuracy	81.04%
1.5	Baseline 1.4 plus specific Brihat Samhita rules for month of July	This addition reduced accuracy level compared to baseline model	The baseline accuracy is still higher than this version so this v1.5 is not the final API option.	80.12%
1.5.1	Baseline 1.4 plus July Brihat Samhita rules for International locations	Shows very low accuracy for month of July.	Although the overall accuracy is high, the dip for July does not help, so this version is not being considered as baseline further	82.68%
1.7	Baseline 1.4, added Karti period, range for comparison – <=1mm No rainfall >1mm to <64mm – Scanty >64mm –Copious	With addition of Kaarti period, the accuracy for monsoon months increased, but accuracy for other months decreased	This version gives better results only in certain months. This is as expected as Kaarthi rules need to be applied in liaison with other conditions	75.00%
1.7.1	International locations for baseline version 1.7	The monthly changes incorporated into the baseline do not go in sync with the weather changes observed for international locations as displayed by the results above in version 1.4.1.	The earlier versions are much better for international locations. Kaarti period is not applicable to International locations in terms of increasing accuracy	47.70%

3.2 Traditional Telugu Panchangam

Similar to Traditional Maharashtrian Panchang, the Traditional Telugu Panchangam results have been noted in Table 2. These rules also show a good accuracy with version 2.5 with an accuracy of 77.3% for Indian locations and 79.18% for International locations. Table 2 is also available in Supplementary document in section 3.2

Table 2. Telugu Panchang Results

Version	Description	Observation	Conclusion	Accuracy Achieved
2.0	All rules mentioned in [3] except for Mercury retrograde and Rise and Set of planets	Base Model for Traditional Telugu Panchangam with a much lower accuracy than the base model of Traditional Panchang	Some changes are required in the code to extract better accuracy	43.68%
2.1	All rules plus Mercury retrograde and Rise and Set of planets as per position	Addition of some rules from a research paper increased the accuracy by 18 percent	Some additional rules from a different age old wisdom may increase the accuracy. Additional work required	61.73%

Continued on next page

Table 2 continued

2.2	All rules plus Mercury retrograde and Rise and Set of planets as per degrees	Implementing the rise and set logic in a different way as compared to v2.1 did not increase the accuracy and v2.1 is still the best model.	v2.1 is chosen as the baseline model for further implementations and modifications.	44.40%
2.3	Some rules removed and some other added, without retrograde	Adding some common rules Traditional Panchang and removal of Retrograde rules increased the accuracy	Usage of some other Panchang rules for Traditional Telugu Panchangam is not the right way to move forward and so this version will not be used further after implementing v2.4	67.86%
2.4	Some rules removed and some other added, with retrograde	Adding some common rules Traditional Panchang and removal of Retrograde rules increased the accuracy	Usage of some other Panchang rules for Traditional Telugu Panchangam is not the right way to move forward and so this version will not be used further	72.90%
2.5	Base 2.1, with Brihat Samhita	Including Brihat Samhita rules for No rainfall conditions increased the accuracy over the baseline model	v2.5 is now the baseline model for all further modifications and implementations	77.30%
2.5.1	Comparison with Alberta – International data, baseline version 2.5	v2.5 provides commendable results for international locations too	This proves that v2.5 could be utilized for all locations around the world	79.18%
2.8	Baseline 2.5, Add July Brihat samhita rules	Adding specific rules for the month of July in v2.5 leads to a decrease in accuracy	v2.5 is still the baseline model for all further modifications and implementations	74%
2.8.1	Baseline 2.5, Add July Brihat samhita rules - International	v2.8.1 echos the same trend of results as shown by v2.8	v2.8 could not pass the accuracy benchmark set by v2.5, so it will not be used further for modification purposes.	74%

3.3 Hourly Assessment

This assessment compares Hourly rainfall prediction with the revalidated data. Here, we have changed rainfall range consideration, no rainfall = upto 5 mm, 5mm to 10mm Scanty and > 10mm copious rainfall considered as the amount of rainfall in 1 hour will always be less. However, we have not found any references to back this assumption.

The results are actually all the more accurate, with random test giving 81.2% accuracy for baseline version 1.4 of Traditional Maharashtrian Panchang and 75.7% for Traditional Telugu Panchangam version 2.5.

Moreover, the 40 years' comparison of hourly data for Pune gave an accuracy of 86.4% (version 1.4) and 78.2%(version 2.5). Details about this can be seen from Table 3.

Table 3. Hourly Assessment Results

Version	**Description**	**Observation**	**Conclusion**	Accuracy Achieved
3.1	Baseline 1.4 (Traditional Maharashtrian) was tested for hourly data. There are 2 different types of test cases, the first being 4 months of data for 8 random years wherein 2 of them belong to the same decade. The second part is the hourly data for one entire random year.	Hourly predictions for the 2 locations provided positive results for the 1.4 version	This proved to be a good test of the capabilities of version 1.4 for Hourly data.	81.2%

Continued on next page

Table 3 continued

3.2	Baseline 2.5 (Traditional Telugu) was tested for hourly data similar to 3.1. (There are 2 different types of test cases, the first being 4 months of data for 8 random years wherein 2 of them belong to the same decade. The second part is the hourly data for one entire random year.)	Hourly predictions for the 2 locations provided positive results for the 2.5 version	This proved to be a good test of the capabilities of version 2.5 for Hourly data.	75.7%
3.3	Pune - Hourly results comparison for 40 years. Baseline 1.4 (traditional)	Hourly predictions for the Pune location provided positive results for the final version	This proved to be a good test of the capabilities of this version.	86.4%
3.4	Pune - Hourly results comparison for 40 years. Baseline 2.5 (Telugu)	Hourly predictions for the Pune location provided positive results for the final version	This proved to be a good test of the capabilities of this version.	78.2%

3.4 Actual Data Comparison

This is the comparison of 1year data with a 0.25 x 0.25 resolution dataset for India with the Panchang predictions for year 2020. Here, version 1.4 gave 88.9% accuracy whereas version 2.5 gave 71.90% accuracy. We also tried the comparison with 12 years of Kansas data (81.6%) and 160 years of Sydney data (77%) to check for International results and it returned very good accuracy. Table 4 depicts the details.

Table 4. Actual Data comparison

Version	Description	Observation	Conclusion	Accuracy Achieved
4.1	Baseline 1.4, actual 1 year data for 2864 locations for year 2020 in India, rainfall range as per adhakam [Ref. Panchangam Calculations by Karanam Ramakumar]	Very high accuracy found for the year 2020.	The results are very promising with one year actual data comparison.	88.90%
4.2	Baseline 1.4, actual 1 year data for 2864 locations in 2020 in India [4] with different rainfall range 0mm to 1mm : No rainfall, >1mm and <65mm: Scanty, >=65mm: Copious	Although accuracy found for the year 2020 is not as high as the original adhakam based range, it is not too bad at an overall level. Having said that, the Monsoon months are having very poor accuracy.	The results are very promising with one year actual data comparison even with a slightly changed rainfall range understanding.	71.90%
4.3	12 year Kansas actual datacompared with Panchang Predictions baseline 1.4 (Please refer Supplementary section for more details about the data considered)	12 years data	Consistent results for International data for hourly comparison	81.6
4.4	Sydney 162 yrs data compared with Panchang Predictions baseline 1.4 (Please refer Supplementary section for more details about the data considered)	162 years data	Consistent results for International data for hourly comparison	77%

3.5 Saptanadi Rules based predictions

The Saptanadi rules though, gave an accuracy of only 48% and we need to study this further to understand more rules and the accuracy may improve. Only one version was tested in this case, which has been depicted in Table 5.

Table 5. Saptanadi Results

Version	Description	Observation	Conclusion	Accuracy Achieved
5.0	Saptanadi rules with a different range 0.0: No Rainfall0.1 - 35.5: Scanty35.6 – 64.5: Copious64.6 >= : Very Heavy	The initial version accuracy has come to very less.	Saptanadi rules may need more discussion with experts and combination with other rules. Decided to suspend the Saptanadi related research for further versions	48%

3.6 Comparison of results

3.6.1 India Results

All these results, including monthly accuracy values in descending order of overall accuracy have been depicted in Table 6. These results show how the version 1.4 gives the most accuracy. It may also be observed that the accuracy for three monsoon months of June to August dips in case of all versions except for version 1.7, but this version considers a different range of rainfall for comparison. Moreover, the overall accuracy is lower.

Table 6. Results Comparison - India

Version	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Overall average	Comments
4.1	87%	99%	99%	98%	97%	85%	83%	76%	86%	63%	98%	99%	89%	Comparison of 1 year with actual, baseline 1.4
1.4	89%	92%	91%	95%	91%	77%	61%	65%	71%	70%	86%	85%	81.1%	Reasonable accuracy across months and years. Best version found
1.2	89%	92%	91%	95%	91%	77%	61%	65%	71%	70%	86%	85%	81.0%	
1.3	89%	91%	91%	95%	90%	77%	60%	66%	70%	68%	87%	84%	80.7%	
1.5	90%	92%	90%	96%	90%	80%	38%	67%	73%	73%	88%	86%	80.3%	
2.5	77%	81%	85%	80%	75%	73%	66%	70%	72%	80%	85%	85%	77%	
1.7	87%	89%	89%	87%	48%	64%	83%	85%	72%	58%	64%	82%	76%	
1	87%	85%	80%	77%	86%	68%	56%	60%	65%	68%	82%	80%	75%	
2.8	69%	74%	83%	77%	73%	72%	65%	66%	70%	78%	83%	78%	74%	
2.4	70%	74%	83%	77%	74%	70%	61%	65%	69%	75%	80%	77%	73%	
4.2	85%	96%	89%	87%	84%	49%	41%	34%	52%	61%	91%	95%	72%	
1.1	87%	85%	80%	77%	86%	64%	43%	45%	65%	68%	82%	80%	72%	
2.3	64%	66%	80%	76%	73%	68%	58%	63%	65%	68%	74%	60%	68%	
2	54%	53%	54%	50%	47%	50%	50%	51%	51%	59%	63%	60%	54%	
2.1	54%	53%	54%	50%	47%	50%	50%	51%	51%	59%	63%	60%	54%	
5.1	29%	33%	30%	40%	51%	63%	58%	74%	62%	55%	45%	36%	48%	
2.2	47%	45%	47%	41%	41%	41%	45%	46%	41%	50%	46%	43%	44%	

3.6.2 International Results

All these results, including monthly accuracy values in descending order of overall accuracy have been depicted in Table 7. These results also show how the version 1.4 gives the best accuracy considering both monthly and overall accuracy. It may also be observed that the accuracy for the monsoon months of June to August does not dip as much in case of these versions. The best accuracy can be seen for version 1.5.1 but the July accuracy is dismal in this case so cannot be considered as the best version overall. Hence 1.4 emerges as the best version considering the International results as well.

Table 7. Results Comparison -International

Version	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Overall average	Comments
1.5.1	90%	93%	91%	95%	91%	88%	38%	78%	80%	75%	88%	87%	83%	Very low accuracy for July and for India (v 1.5)
4.3	85%	91%	94%	93%	89%	86%	68%	67%	72%	73%	76%	86%	82%	Actual Kansas data, baseline version 1.4
1.4.1	82%	84%	84%	90%	88%	86%	71%	76%	79%	72%	82%	79%	81.1%	Baseline version 1.4, matches with Indian data results as the best version
1.2.1	80%	83%	85%	87%	89%	85%	73%	75%	80%	72%	84%	77%	80.8%	
2.5.1	73%	76%	81%	76%	74%	80%	82%	84%	80%	82%	83%	80%	79%	
4.4	79%	80%	80%	85%	82%	80%	67%	71%	73%	73%	79%	81%	78%	
2.8.1	69%	72%	79%	73%	71%	75%	73%	77%	74%	76%	79%	76%	75%	
1.0.1	79%	78%	74%	73%	83%	74%	66%	68%	73%	70%	79%	74%	74%	
1.7.1	58%	59%	58%	59%	48%	34%	33%	30%	30%	48%	54%	59%	48%	

3.7 Yearly Comparisons

The Yearly comparison is also available on request. Observations from Yearly comparison:

- The results are consistent over the 40 years of data compared.
- Certain years like 1983 and 1995 feature in most of the cases as the least accurate years. Further research is needed to ascertain the reason.

The sample graphs from the version 1.4 which summarizes the accuracy can be referred to from Figures 3, 4, 5, 6, 7 and 8.

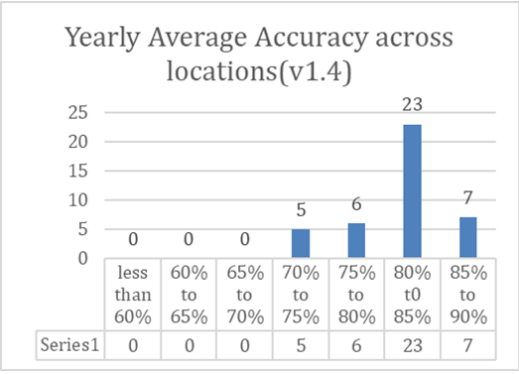

Fig 3. Distribution of Yearly Average of daily rainfall accuracy across locations

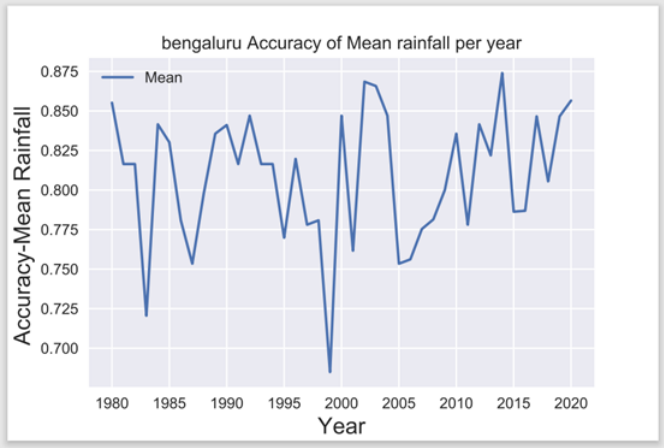

Fig 4. Sample daily rainfall accuracy graph for Bengaluru, India averaged per year, across 1980 to 2020

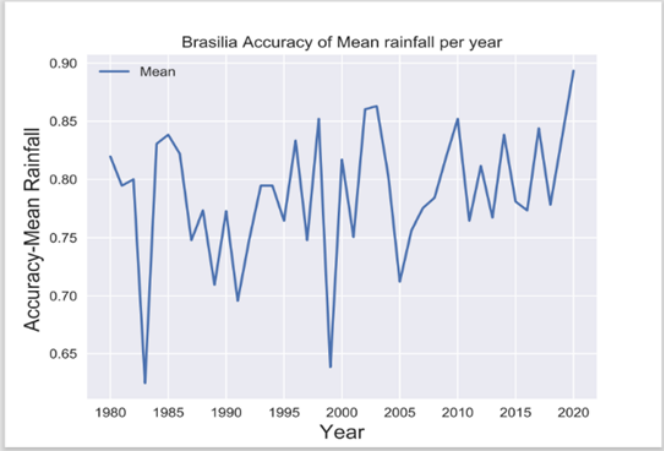

Fig 5. Sample daily rainfall accuracy graph for Brasilia, Brazil;

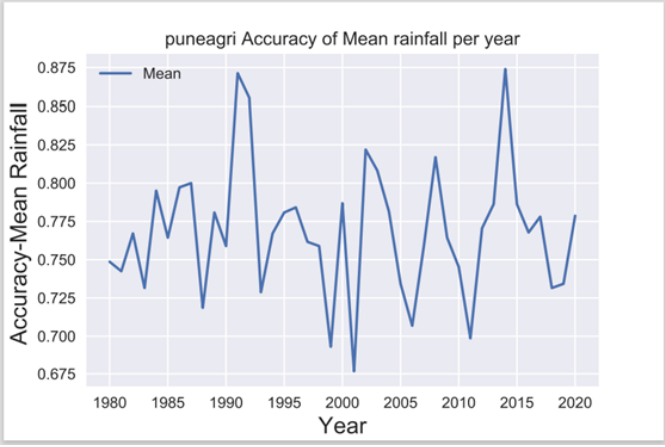

Fig 6. Sample daily rainfall accuracy graph for Pune, India averaged per year

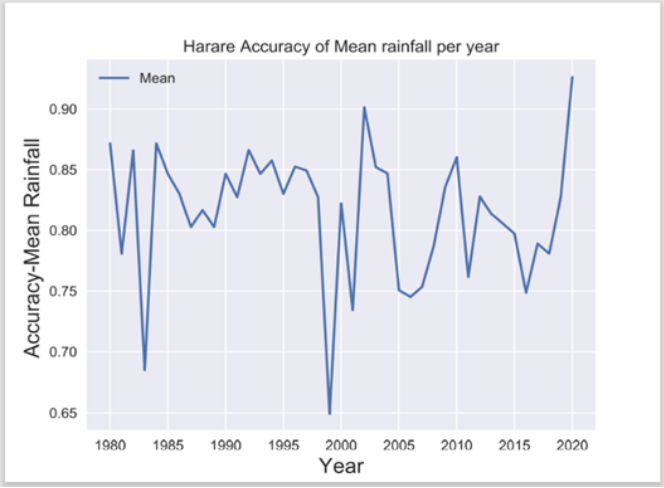

Fig 7. Sample daily rainfall accuracy graph for Harare, Zimbabwe

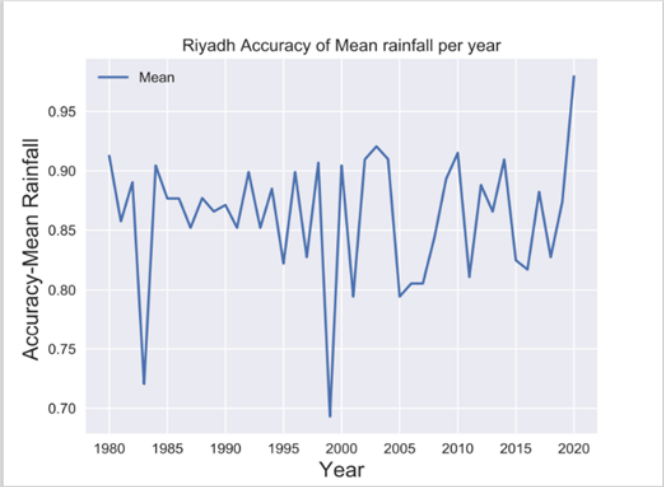

Fig 8. Sample accuracy graph for Riyadh, Saudi Arabia averaged per year

4 Conclusion

In the past centuries, people did not have the luxury of automated weather forecasting machines. However, they were able to develop incredibly wise and suitable theories and appropriate principles, often by just looking at the sky, which significantly matched with the scientific modern findings. Our study revealed that there is a scientific base to the observations, which were done probably consistently across centuries to develop this science, which is evident from the very accurate calculations depicted in various scriptures and used regularly in the Tithi calculation and the Yearly Panchangs which are published across the country. A more detailed information pertaining to the study can be found in the supplementary section of the paper.Using some of these, we have successfully been able to create prototypes for the Panchang models stated above.

We have developed and assessed accuracy for overall 30 versions/test scenarios, which contain 7 versions of Traditional Maharashtrian Panchang, 8 versions of Telugu Panchang, 1 version of Saptanadi tested for India and/or International locations. This was followed by 4 versions of comparison with actual data and 4 versions of comparisons with Hourly predictions vs revalidated data.

We achieved a respectable accuracy of 81%(For Traditional Maharashtrian Panchang) and 79% (Traditional Telugu Panchang) when tested with 40 years of revalidated daily rainfall data between 1st Jan 1980 to 31st Aug 2020. Moreover, the tests with actual data also show consistent results in India as well as across the world in different continents. This is very promising because for the first time, we are able to prove the global applicability of the Panchang rules for precipitation prediction.

Since these rules are based on planetary positions, which are very accurately calculated in the past/present and the future, these predictions can be run for any date range. This gives an excellent advantage over the other weather prediction systems as the accuracy is consistent for longer durations. This has been proven by the back-testing (hindcasting) of results across the last 40 years.

Based on the comparative accuracy achieved at an overall level as well as at a monthly level, we conclude that version 1.4 of the Traditional Maharashtrian Panchang is the best version of the combination of rules tried out, which provides excellent results across locations.

The system considers a latitude/longitude –position and the date range as an input hence the results can be accurately considered for areas like say a village. We could not confirm if these results will become applicable for a smaller area like a 1acre farm for want of actual data to compare. However, these predictions are a major improvement over the existing prediction systems which cannot maintain its accuracy for more than a few weeks in the future.

We have also published the comparison for hourly prediction of results, which are also very promising, but we have not found any backing logic for the rainfall range we have considered for categorizing the rainfall. Moreover, more data is needed to compare these predictions.

A possible weakness of this approach is that the mapping of the description of rainfall category to amount of rainfall measured in mm is not clearly described. To counter this, we have done a study with different range interpretations and found consistent results, albeit with lower accuracy. Moreover, there are only three categories of rainfall prediction in texts we studied. There is a need to study the texts further to identify granular categories and re-run these tests.

Since Agriculture is a rainfall dependent activity in most parts of the world, our attempt is to also enable this research to be used practically by the farmers across the world through a website and by enterprises through APIs.

Using this traditional wisdom with scientific knowledge, we conclude that Panchang based system is a highly accurate system of forecasting, which can give more accurate results for longer durations in future.

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