Milankovitch Cycles –Ancient Supporting Facts from Rāmāyaṇa and Sūryasiddhānta for Recent Discoveries

Rupa Bhaty &
Sameer Barve

Abstract

Jyotiṣa is an ancient Indian astronomy system and is one of the six Vedic limbs. In the Vedic context, it was associated with the study of celestial bodies – Khagol śāstra. The Brāhmaṇas contains a wealth of astronomical facts that culminated in epic and pauranic legends. Siddhānta, on the other hand, are extensions of the Vedas and Brāhmaṇas. Sūryasiddhānta's antiquity is traced back to ~12000 BCE using the Milankovitch cycle. As per the research of Bhaty and Oak [1] and Barve Sameer [2], this epoch falls at the terminus ante quem of Late Pleistocene times. The Rāmāyaṇa has descriptions of extreme and prolonged winters with snowy/frosty conditions in central and southwestern areas. In this paper, we examine the Sūryasiddhānta evidence based on the Earth's aphelion and perihelion positions giving longer winters and shorter summers from this paper [1]. In this work, we have shown how observations that are consistent with current discoveries were documented in ancient Indian texts including the Rāmāyaṇa and Sūryasiddhānta. This historical information is still very helpful when studying climate sciences. This paper, in our opinion, will emphasize the significance of ancient Vedic and Indic knowledge and its modern applicability.

Full Paper

The ancient Indian texts are full of astronomical references that include the sunset or sunrise occurring near the vicinity of nakṣatras, the beginning or end of seasons on a particular nakṣatra, or even planet afflicting nakṣatras. These references are pointers to the situation in the sky prevalent to their respective epochs and we can calculate the epoch going back in time using basic mathematics. While this method helps us date that specific reference or text, this doesn't tell us exactly the intensity of seasons in each hemisphere of the Earth.

1. Introduction

In this paper, we will discuss the intensity of seasons as recorded in our ancient texts using modern techniques such as Milankovitch Cycles. The projection of Earth's equator in the sky is known as the celestial equator which is inclined to the plane of the ecliptic by 23.45° in current times. The ecliptic is the plane in which Earth revolves around the Sun. The current inclination between the celestial equator and the ecliptic is known as "The obliquity of the ecliptic" and it keeps changing between 22.6° to 24.2°. The obliquity of the ecliptic is responsible for seasonal intensity on the Earth's northern and southern hemispheres. There are various references from ancient texts that talk about seasons and intensity at a particular location. We intend to explore these references using Milankovitch cycles whose detailed analysis was given by scientist Milutin Milankovitch in the 20th century. Before we go into the analysis of the verses from Rāmāyaṇa let's understand the tools by which we will be evaluating the phenomena identified in the text to arrive at conclusion.

2. Precession as a Mathematical Tool

2.1 Axial Precession

The rotational axis of the Earth keeps pointing to the different parts of the sky, which greatly affects the view of the sky seen from a particular location. This phenomenon, which mainly occurs due to the gravitational pull of the Sun and the Moon, is known as *Axial Precession* and it follows a circular path. This path passes nearby few stars near the celestial north and south poles that would eventually become pole stars. The rate of axial precession is

~50.3 arc seconds/year. Hence, it takes roughly 25800 years to complete one full cycle of precession.

2.2 Precession of Equinoxes

As a result of the axial precession mentioned above, positions of equinoxes and solstices keep changing at the same rate pointing to different nakṣatras at different times at the backdrop of the Sun. There are 27 nakṣatras along the ecliptic and the cardinal points remain in one nakṣatra for roughly 960 years. Using this fact, it is possible to go back in time and ascertain a date of a particular event inferred, or, of an observation recorded in any text, by considering the nearest nakṣatra as a reference.

2.3 Apsidal Precession

Moreover, there is another type of precession that is observed. It is known as *Apsidal Precession* since it involves the precession of Earth's orbital apsidal points. In this phenomenon, the major axis – also called The *line of apsides*, of the Earth's orbit around the Sun experiences precession thereby producing a change in perihelion (nearest) and aphelion (farthest) passages of the Earth with respect to the Sun. This precession takes about ~21000 years for one full revolution. The effect of this precession is that the Earth's perihelion and aphelion passages get shifted by about 1 day in 58 years. By knowing the current dates of perihelion and aphelion passages of the Earth and knowing the rate of apsidal precession, it is possible to calculate these dates in far antiquity and validate the same against references available in various texts. The perihelion condition gives an illusion of time slipping away faster than that of the aphelion condition.

3. Obliquity of Ecliptic

The angle of inclination between the celestial equator and the ecliptic is known as The o*bliquity of the ecliptic* and it keeps changing between 22.6° to 24.2°. It is this angle that decides how mild or intense the seasons will be at a given location on Earth. At present, this angle is roughly 23.45° due to which tropical latitudes of Cancer and Capricorn are located at 23.45° north and south respectively to the Equator.

The tropic of Cancer divides mainland India into two halves — north and south. It tells us that the southern part of India falls in a tropical region that receives more heat from the Sun. The obliquity of the ecliptic keeps changing cyclically as given above over about 41,000 years. The more the obliquity, the more extreme the seasons.

4. References from Rāmāyaṇa

The Rāmāyaṇa is known as *"Ādi Kāvya"* (The First Poem) in Indian culture and has a plethora of astronomical observations. We have selected a few observations that pertain to the seasons, the change of seasons, and their intensity as observed during those times. These observations occur at different locations as given in the Rāmāyaṇa text which allows us to make important conclusions as given below-

4.1 Direct Astronomical References

Description— Ayodhyā Kāṇḍa Geeta Press (GP) - 2.3.4, Oriental Institute Baroda (Baroda) - 2.3.4 [3]

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-"This auspicious month of *Caitra* is sacred with its blossoming groves. Let all the arrangements be made for the installation of Rāma as heir apparent. On hearing this, all the members of the assembly applauded the king tumultuously."

Author Notes: The lunar month *of Caitra* coincided with *Śarada* ṛtu during Rāmāyaṇa times as noted by Shri Nilesh Oak. Let's keep the direct statement that *Caitra* coincided with *Śarada* as an inference for later analysis. This auspicious month of *Caitra* is sacred with its blossoming groves. This reference tells us that if the month *Caitra* coincided with *Śarada* ṛtu, then such an event would have happened around 9000 BCE or even earlier by tracking precession of equinoxes. This inference will help us later to date Rāmāyaṇa using more references.

Description— Araṇya Kāṇḍa GP (3.16.12) [4]**, Baroda (3.15.12)** [5]

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-"At this time people do not sleep under the open sky. With the month of Puṣya approaching, nights feel cool and look red due to frost. They prolong into three yāma." (Gītā supersite)

"Precluded is the reclining under the open sky as the nights are led by the Puṣya constellation, they will now be with brownish-grey fog and chilly, and prolonged are the lengths of nights whereby the three watches of the night will be quickly slipping away." (valmikiyarāmāyan.net)

*Author Notes***:** Here the Gita supersite (IIT Kanpur) has wrongly translated "with the month for *Puṣya*" to equate it with contemporary times. The verse explicitly says *Puṣya* and not "*Pauṣa*". For the names of months, the vowel elongation or the word *māsa* is applied within Sanskrit nouns. Note that evidence of "*caitraḥ śrīmānayaṃ māsaḥ*", in Ayodhyā Kāṇḍa (2.3.4) and "*āśvayuje māsi*" in Kiṣkindhā Kāṇḍa (4.53.9), both have *māsa* word used for the observed month. Thus, it is clear that *Puṣya* here is the direct reference to the *Puṣya nakṣatra*. Sunset on *Puṣya* coincided with *Hemanta* during Rāmāyaṇa times as noted by Shri Nilesh Oak and the same is corroborated here with the etymological references. Let's keep the direct statement as an inference for later analysis.

Description — Araṇya Kāṇḍa GP (3.16.8) [4]**, Baroda (3.15.8)** [5] **— Autumn**

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-"As the Sun has resorted to the direction (south) that serves the god of death, the North devoid of (the Sun) shines like a woman without the vermilion mark on the forehead."

*Author Notes***:**It clearly states the Sun is in the southern hemisphere. When the Sun is in the southern hemisphere the chronology of seasons experienced is autumn, winter, and then spring. This clears the fog and gives clarity to understand *Caitra* in *Śarada* - autumn which continued to *Puṣya* during *Hemanta* - winters. Araṇya Kāṇḍa ends with the *Hemanta* season. Kiṣkindhā begins in early spring.

Description — Araṇya Kāṇḍa GP (3.16.25) [4]**, Baroda (3.15.23)** [5] **— Winter beginning**

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-"Owing to the fall of snow, further owing to the softness and coldness of sun, the water deep down the wells is generally agreeable for drinking."

Description — Kiṣkindhā Kāṇḍa GP (4.41.45,46) [4]**, Baroda (4.40.42,43)** [6] **— Spring**

The dialogue between Sugrīva and his *Vānara* party is happening during the beginning of *Vasanta*- spring season and they all are in Kiṣkindhā which is identified near today's Hampi in Karnataka.

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-"The divine people who have earned a place in heaven stay there at the end of their life on earth. Beyond, lies the dreadful world of deceased ancestors. You can't enter that place."
'O heroic monkeys that is **the capital of Yama** (God of death) **covered with pitch darkness**. You can go to that place. Beyond that, there is no access for the earthlings.

*Author Notes***:** Now, look at the words "*tamasā āvṛtā*"; which means *covered with darkness,* from the verse given above. Normally, colloquially Yama's abode is misunderstood to be a "dark place". But here the *shloka* is describing an astronomical phenomenon called polar night. The phenomenon happens when the sun is in the northern hemisphere and the southern polar zone is dark for six months during that time. In the northernmost and southernmost parts of the Earth, a phenomenon known as the polar night causes the night to linger for 24 hours. Only within the polar circles, this phenomenon takes place. Antarctica is the only landmass in the Southern Hemisphere that is sufficiently south to experience polar nights. This phenomenon and the seasons happen due to the obliquity/axial tilt.

Description — Kiṣkindhā Kāṇḍa GP (4.53.9) [4] **(Baroda edition does not list this verse.)**

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-'We were sent out scheduling time calculating from the month of Āshvayuja (Āśvin). Even that time fixed for us has also lapsed. Thereby, what is to be done next?'

Author Notes: The lunar month of *Aśvin* is mentioned to be passed and distanced, this was the first month of spring (4.53.9). The spring equinox has also passed. The spring equinox, summer solstice, and autumn equinoxes occur in the first six months of the year when the sun is in the northern hemisphere. As a result, the Antarctic Circle suffers winters and darkness for a total of six months, and this is clear from the above shloka of Kiṣkindhā Kāṇḍa (4.41.45,46). The month of *Aśvin* was experiencing *Vasanta* (spring) season which is the time when the polar night can be witnessed in the southern polar cap. This can only happen during the 10500 - 15000 BCE.

The month of *Aśvin* occurs between mid-September and mid-October in modern times. Furthermore, we have found that *Aśvin* month is at the first month of *Vasanta* therefore the other evidence like *Caitra* month at *Śarada* and following *Śarada*, the *Puṣya* nakṣatra setting with the Sun during *Hemanta* of Araṇya Kāṇḍa, which is before Kiṣkindhā Kāṇḍa, automatically fall in place. The events have been recorded fairly well by sage Valmiki.

Description — Yuddha Kāṇḍa GP (6.4.48-51) [7]**, Baroda (6.4.43-45)** [8]

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-"Dhruva, the very bright pole-star (which is recognized by the contiguity of the stars presided over by the seven Brāhmaṇa sages) is becoming clear. All the pure great sages having bright light are shining are shining around Dhruva star."
"The royal sage Triśanku, our paternal grandfather, born in the high-souled Ikṣvāku dynasty, is purely shining (as a star) in front, along with his family priest."
"Appeareth Viśākhā stars, are shining clearly without any evil influence. This supreme constellation is of our Ikṣvākus, the high-souled."

Author Notes: When Brahmarāśi (Abhijit — Vega) is seen in the north as appearing with clarity, which would mean the timing after dusk. At the same time, in the due south, exactly opposite Vega, *Triśanku* (cluster of Crux) stars were appearing with *Viśākhā*. We simulated this for the whole year to find the condition of Vega opposite to Crux appearing at meridian during the late dusk time with *Viśākhā* appearing between them and found it to be appearing during late autumns and early winters.

4.2 Direct seasonal references to Hemanta and Śiśira

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-"O daughter of *Videha* behold these *kimsuka* trees in full bloom everywhere. With the passing of winter, they appear bright as though they are garlanded by their own flowers."

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…and the rest of this chapter is about frost and hima.
-"Pleasant *Hemanta ṛtu*, pre-winter season has set in after the passage of *Śarada ṛtu*, post-rainy season at Panchavatī where the noble souled Rāma is staying comfortably."

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-"Wherever I am, the Wind god blows with hesitation. So are the Sun and the Moon afraid of me. Afraid of me the Sun duly discharges his duties."

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-"Winter has ended and the season of flowers has set in, O Saumitri The trees are full of flowers as if competing with one another."

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-"Lakshmana, look at the end of winter, forest loaded with flowers, are of no use to me. Event observation is of the beginning of spring season description made at Citrakuta. After which they reach lake Pampā."

Description near Godāvarī; Araṇya Kāṇḍa GP (3.16.15 and 3.16.25) [4]**, Baroda (3.15.15 and 3.15.23)** [5]
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-"The western breeze by itself will be cool to touch, but presently charged with snow it is wafting doubly chilly in the early hours."

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-“Owing to the fall of snow, further owing to the softness and coldness of the Sun, the water deep down the wells is generally agreeable for drinking.”

Brief Analysis of Rāmāyaṇa seasons with the help of Milankovitch Cycles (GP (4.27.48) [4]**, Baroda (4.26.23)** [6]**)**

In our times the summers are harsher than winters due to three factors clubbed up, the first one is due to obliquity, the second one due to the apsidal precession, and the third one is due to the eccentricity of Earth’s orbit. During greater degrees of obliquity, the northern arctic circle (90^o - 24^o = 66^o) is less exposed to Sun than today’s time (90^o - 23.5^o = 66.5^o), giving polar caps a reason to accumulate snow more. Due to apsidal precession, Sun is nearer to earth during winters in our times making winters amiable, but during Rāmāyaṇa times Sun was nearer to Earth during summers making summers harsher like Australia’s experiences in modern times. But since the sun was nearer to earth during summers, applying Kepler’s law the season appeared to pass quickly. Thus, the experientially summers were shorter and winters were longer in the northern hemisphere.

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-“Control your anger and wait for autumn. Pardon these (intervening) four months (which put a halt on your war effort). Stay with me on this mountain infested with lions. Brace up to kill the enemy.”

*Author Notes***:** Event observation is of the beginning of the rainy season after Vāli is killed and Sugrīva’s coronation takes place, a description made at Kiṣkindhā by Sugrīva. *Aśvayuja māsa* of spring also passes by then and then comes the description of harsh winters which were harsher as compared to modern times. Below mentioned verses, give the description, suggesting the impact of late Pleistocene times in Southern India which is opposite to our times which is tropical with abundant harvests.

Kiṣkindhā GP (4.48.5,8-11) [4]**, Baroda (4.47.5,7-9)** [6] **— Description of Śiśira in Kiṣkindhā**

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Sundara-Kāṇḍa

Sundara Kāṇḍa references are mostly of spring and tropical climate and this corroborates that Lanka was experiencing Autumn of tropical climate in the southern hemisphere when the northern hemisphere was experiencing spring.

Yuddha-Kāṇḍa: GP (6.4.54, 97) [7]**, Baroda (6.4.47,65)** [8]

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-"The waters are crystal-clear, with good taste. The woodlands are laden with fruit. The fragrant air is not blowing much. Trees are bearing seasonal flowers."

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-"They crossed *Sahya* Mountain and *Malaya* Mountain and systematically approached the ocean having terrific sound."

Event observation is made at the edge of Mahendragiri, i.e., the last edge of Malaya/Agastyamalai. The observation that Agastya will be seen from Mahendragiri for the true south has already been made by Sugrīva in Kiṣkindhā Kāṇḍa. But instead of Canopus-Agastya becoming clear in the evening the Crux-Triśanku is mentioned in Yuddha Kāṇḍa. Post *Aśvyujau māsi*, i.e., *Aśvin* month, the summers passed quickly and perhaps they again waited for the rainy season to exhaust. Summers and rainy seasons are not elaborated much in Rāmāyaṇa as they may have appeared to have passed quickly. This effect of time, i.e., *passing by quickly*, happens when the earth is near the Sun in its elliptical orbit. This phenomenon is elucidated in section 2.3. This elucidates why late autumns, winters, and early spring descriptions are in more lot than others.

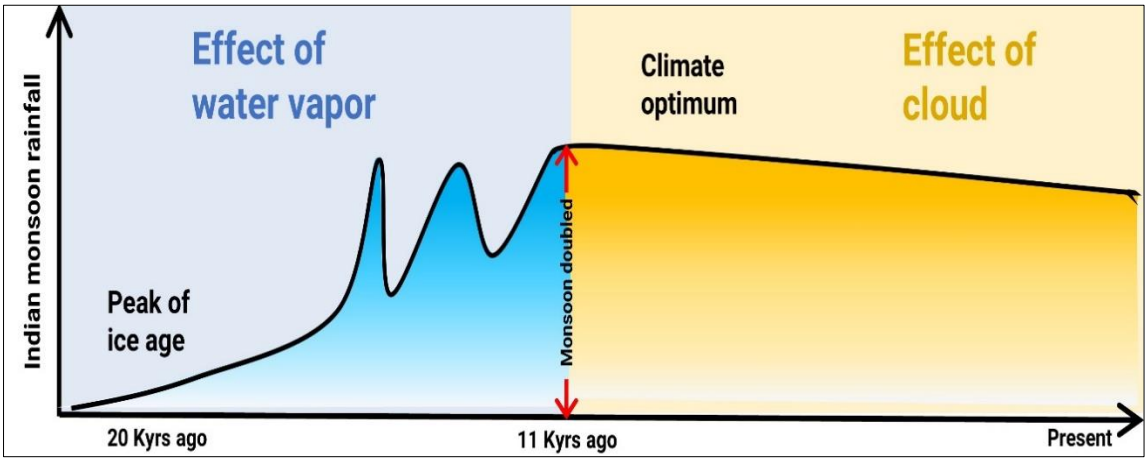

Figure 1: Indian monsoon pattern showing effect of water vapour and clouds

Analysis: -

1. Summers are shorter and winters longer, thus description of autumn, winters, and early spring are more w.r.t summer and rainy seasons. The rainy season exactly closes on 1 month before the autumnal equinox, which is evident from the waters becoming crystal clear in the remote south. This doesn't happen in Holocene and our times.

2. Araṇya.16.9 (□□□ □□□), 11(□□□□ □□□□□□□), 15 (□□□ □□□□□□□), 18 (□□□ □□□□□ □□□□□□□), 23 (□□□ □□□□□), 24 (□□□□□□□□□□), 25 (□□□□□ □□□□□□) [7], [5]. "Hima" is mentioned in the same sarga 19 times and an instance of snowfall in Godāvarī region is recorded. Rivers are extremely cold, with mist, fog, frost, etc., and Sun appearing like a Moon is also being observed. Western wind disturbance is also mentioned in this Sarga. Note the effect of water vapour till 9000 BCE from the peak of the ice age as shown in the figure below - [9]

3. Note that in Rāmāyaṇa, Agastya is not associated with the waters becoming crystal clear during autumn. It is because Agastya behaved like a pole star during Ramayana times, and was not visible from northern latitudes. [2]

4. The alignment of the cardinal points during Rāmāyaṇa times is given below. The same is also shown in the conclusion section with the help of a diagram.

Cardinal points	12000-13000 BCE	Lunar month names
Spring equinox	Hasta	Bhādrapada / Aśvin / Kārtika
Summer solstice	Uttarā Āṣādhā	Mārgaśīrṣa / Pauṣa
Autumnal equinox	Uttarā Bhādrapadā	Phālguna / Caitra / Vaiśākha
Winter solstice	Punarvasu	Jyeṣṭhā / Āṣāḍha / Srāvaṇa

5. References from Sūryasiddhānta

5.1 References for end of Krita Yuga and two pole stars (Sūryasiddhānta 1.57)

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(Planetary positions during end of Krita Yuga near Aries and Libra zodiac signs)

The Sūryasiddhānta also mentions two-pole star at Kṛitānta [10] similar to that of Rāmāyaṇa-
(Sūryasiddhānta 12:43,44)

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The two-pole star condition and their simultaneous visibility has been discussed greatly in a different paper by one of the co-authors [2]. This paper has examined proper motion and declination for the stars Vega and Canopus across different epochs covering a time span more than the precession cycle along with the graphs for each star. The author has also provided references from different texts such as Sūryasiddhānta, Rāmāyaṇa, Mahābhārata, Taittirīya Brāhmaṇa, and even Amarkośa. These references make a compelling case for the 12000 BCE epoch to be the one with two bright pole stars near respective celestial poles that is also corroborated by modern sky simulator software tools. These tools have the capability of projecting the sky with good amount of accuracy for old epochs such as 12000 BCE and we have provided two screenshots from Stellarium tool.

As seen from the screenshots below, the two pole stars Vega near north pole and Canopus near south pole can be seen clearly that signifies their respective position in the north and south directions during ~12000 BCE.

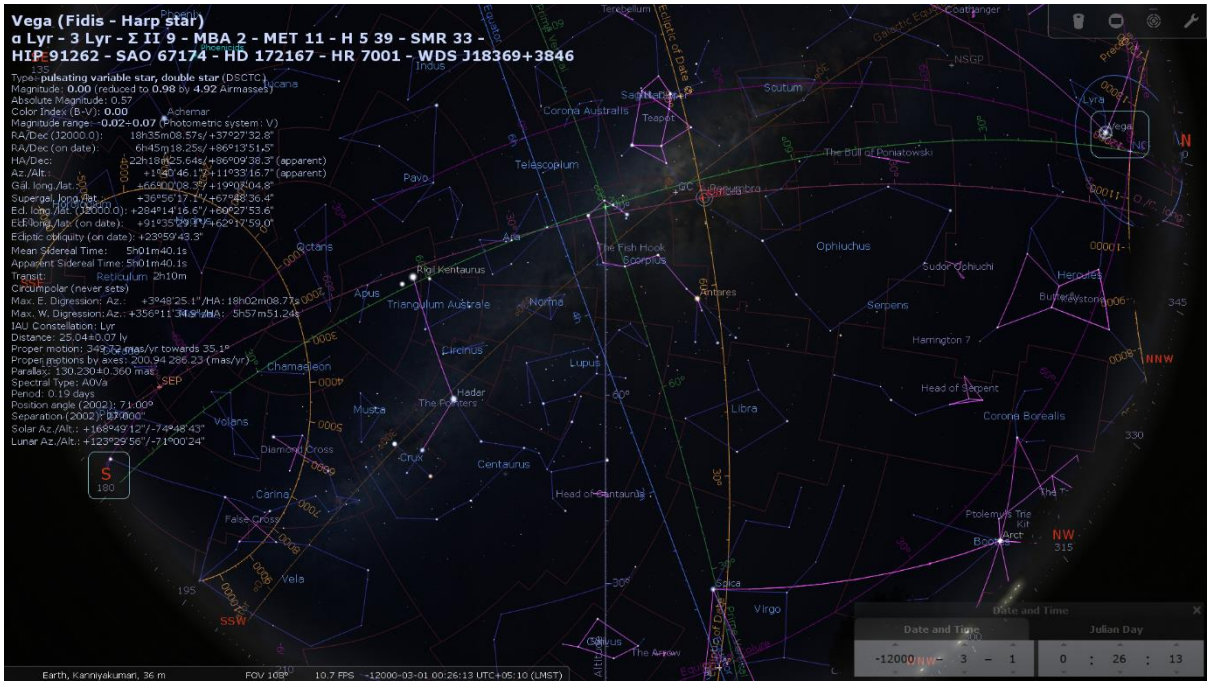

Figure 2: Star Vega in deep north during 12000 BCE as seen from Kanyakumari [11]

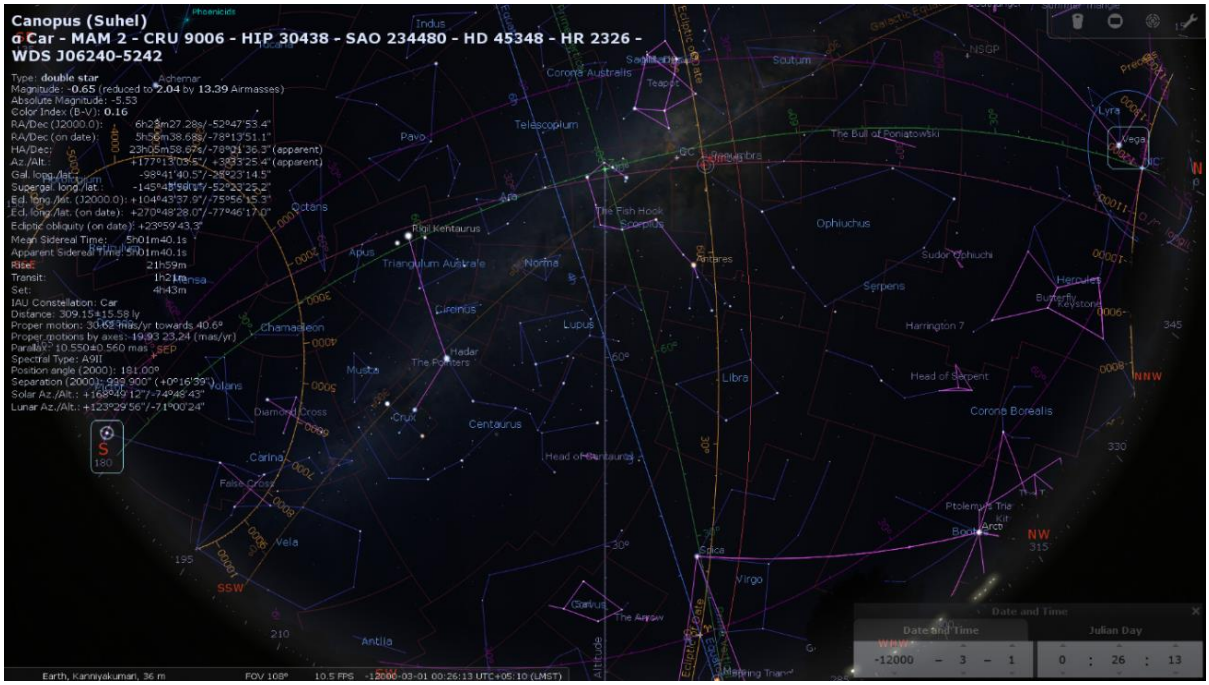

Figure 3: Star Canopus in deep south during 12000 BCE as seen from Kanyakumari [11]

5.2 Aphelion and Perihelion condition

Sūryasiddhānta 12:08 [10]

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Above is the Bhāṣatīkā (translation) of Shri MP Dwivedi. There are questions posed to Suryadeva by Mayasura where how the light is measured, how many types of measurements are there for sun rays (kiyatītatkaraprāptirmānā), and what is the use of them, are being asked, for which, the answer is given as under.

Sūryasiddhānta 12:46 [10]

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"The sun is closest to the Earth during Grīṣma which causes Sun's (ray's) rapidity when in Deva Bhāga, i.e., Northern Hemisphere but farthest from the Earth during Hemanta which causes Sun's (ray's) slowness otherwise."

The apsidal position of Earth w.r.t sun is almost opposite of today's time as stated in 12:46**.** [Here karaḥ comes from (√kṛ), a ray of light, sunbeam, moonbeam, and has come as a similar meaning in Rāmāyaṇa, etc.

6. Conclusion

In this paper, we have attempted to explore ancient textual references from Rāmāyaṇa and Sūryasiddhānta for astronomical and seasonal observations. The same were analysed with the help of modern scientific methods such as Milankovitch cycles for axial precession, apsidal precession, obliquity, etc. to verify the scenario described in textual references. Using this analysis, it was possible to predict the epoch for both of these texts to be at least as old as ~12000 BCE. Moreover, a possible scenario for apsidal points and climate conditions was projected that is corroborated not only by the textual references but also by modern techniques such as long-term climate changes.

The schematic below shows the alignment of the Sun and the Earth against the background of equinox and solstice points during ~12000 BCE. It is clear that the Sun was nearer to the Earth when northern hemisphere had summer and vice versa. Since the Earth moves quickly when its nearest to the Sun in elliptical orbit, this also explains that summer lasted for fewer days than winter making them shorter than current times.

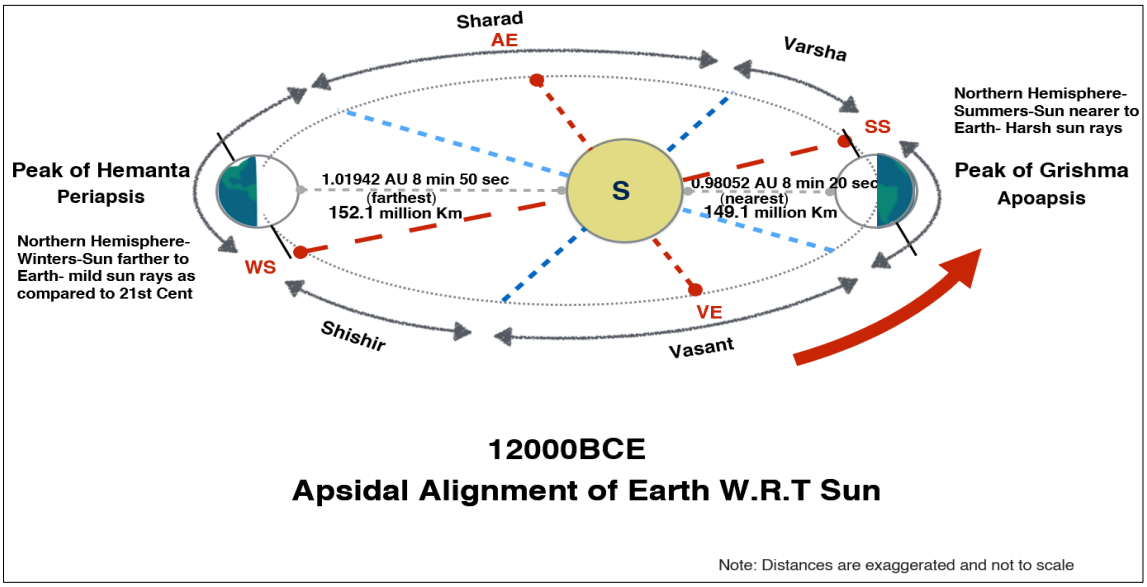

Figure 4: Apsidal alignment of the Earth with respect to the Sun during 12000 BCE

The following diagram shows the alignment of equinox and solstice points against the nakṣatras along with the seasons that was prevalent to the epoch of ~12000 BCE. Few verses from Ramāyaṇa have been shown along with Vega and Canopus as pole stars near their respective celestial north and south poles. This will give a fair idea about the geometry of

cardinal points respective background nakṣatras eventually allowing us to deduce the correspondence between lunar months and solar seasons for the epoch ~12000 BCE.

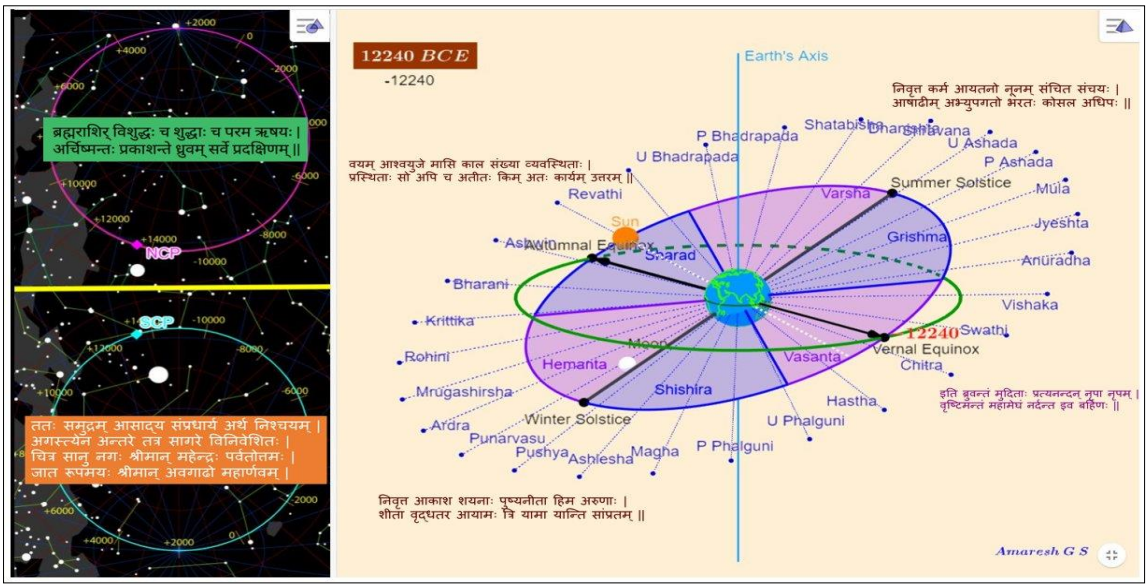

Figure 5: Geometry of cardinal points in the vicinity of nakṣatras during 12000 BCE

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