Ancient eclipse records in India

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Abstract

Records of eclipses in are scattered over copper plates, temple inscriptions and other documents. Over the last several decades, the Government of India has had systematic plan of collecting this corpus under Corpus Indicanum and other regional repositories. We have analysed these records and identified a total of 1250 eclipse records half of which are Solar and half are Lunar. Since Solar eclipses are rare, we have focused our analysis on Solar eclipses. We have isolated eclipses recorded by 2 or more observers and find 114 eclipses which satisfy this criterion. We compare the data with the reports from East Asia catalogued by Tanikawa et al. (2010). We find that while the ΔT calculations agree as a general trend, there are some others which are significantly different. We also list 9 eclipses reported by Hari (2003) based on records of a 15th Century Indian astronomer that could have possible records in East Asia.

Introductions

Eclipses are considered inauspicious in India as in other parts of the world. It is a period during which Sun and Moon are perceived to be in trouble. Rana, 2011 has summarised the myths related to eclipses in different parts of the world. In India, eclipses are periods when donations are said to have the maximum impact. Hence extensive donations are made and recorded in copper plates, stone etchings etc. We have studied these records and we present our results here. In the next section we briefly mention the myths related to eclipses in India. In section 3 we discuss the data collected by us. In section 4 we report our analysis and conclusions.

Indian myths about eclipses

From the Rig Vedic period (~1200 BC) eclipses are believed to occur when a demon Swarbhanu tries to eat the Sun or the moon (Rig Veda 5.40, 5-9; Subbarayappa and Sarma, 1985 p 196). Briefly, the story appears as follows.

Gods and their antagonists, the Asuras desired to become immortal. To achieve this, they needed nectar from sea. To extract this nectar, they needed to churn the seas. Since neither of them had the strength to achieve this, they worked together and extracted the nectar. When the nectar came out, the Gods sent a beautiful woman – Mohini to distract the Asuras. But one Asurea, Rahu realised what is going on. He took the form of a God and tried to get some of the nectar. Sun and the Moon realised what was happening and tried to stop him. Mohini cut off his head. But since he had already taken a few drops of the nectar he became immortal in 2 parts his head forming one part and the body the other part. The head is referred to Rahu and the body is called Ketu. The immortal Rahu was angered by this and since then, he is forever trying to take revenge on the Sun and the Moon. In the original version solar eclipses occur when Rahu catches up with the Sun and Lunar Eclipses occur when Ketu catches up with the Moon. In later versions Ketu becomes a comet and it is Rahu alone that causes both the eclipses.

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With the rise of mathematical astronomy in India by Aryabhata (~500 AD; Balachandra Rao and Venugopal, 2008), the term Rahu is used to refer to the point of intersection of the ascending node of the point of intersection between equator and the ecliptic and Ketu is the descending node. The location of these points can be mathematically tracked and eclipses are predicted to occur when the Sun and the Moon are both at Rahu or Ketu.

Rahu and Ketu are also called 'dark planets' since unlike other planets, they are invisible in the sky. Unlike other seven 'planets' (Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn), which move counter clockwise in the sky, Rahu and Ketu make clockwise.

Eclipse records in ancient India

Records in Copper plates, stone inscription etc.

Since eclipses are considered inauspicious, they are considered a good occasion to make donations to the gods and the records of these donations are found all over the country. These are also listed in publications of the Government of India. We have studies the reports of such records in Annual Reports on Epigraphy of the Archaeological Survey of India; *Epigraphia Carnataka*; Inscriptions of Kaokatiya of Warangal; South Indian Inscriptions; and *Karnataka University Epigraphic Series*; EI, *Epigraphia Indica*. We found 1250 records between 400 AD and 1800 AD (see also, Vahia and Subbarayappa, 2011). They are in traditional dates and converted to Gregorian calendar as per widely accepted method of Swamikannu Pillai. Out of these about 1200 records are confirmed by NASA records, (Espenak, 2011) subject to the assumption that there may be up to 1 bit error in the recording and that the year conversion is as done by us. In 13% the eclipse is not seen, in 18% it is on a slightly different day and there seems to have been a recording error. However, the records do not mention either the time of eclipse or the depth of the eclipse. We therefore assume that if an eclipse is seen, it must me at the level of 50% or more[2].

In order to ensure that we are analysing the best data, we have taken eclipses that are reported by 2 or more observers. We find 114 such records. In some of these records the mismatch between Indian records and NASA predictions are drastic (Vahia et al., 2013). However, in 21 cases, (figure 1) it is possible to calculate ΔT directly and compare it with the data given in Tanikawa et al., (2010). As can be seen, the records are broadly in agreement.

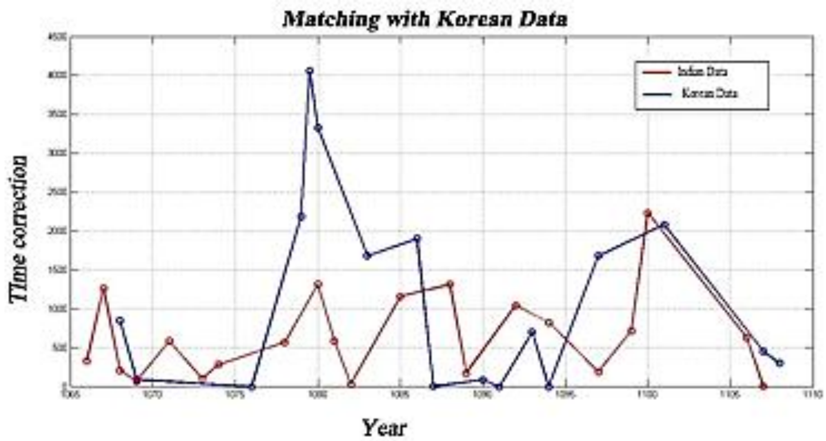

Figure 1: ΔT calculations for Indian eclipses compared with the data from Tanikawa et al, 2010;.

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[2] During the conference Dr.Tanikawa pointed out that the assumption that an eclipse is visible only if it is 50% or higher may be too restrictive and eclipses of even 20% have been recorded in other cultures.

In figure 2, we have given the detailed comparison with the ΔT values obtained by us over the entire dataset compared with the values from other observations (Tanikawa et al., 2010). As can be seen, while the general trend between the two data set is comparable, about 20% of the eclipses give ΔT value much higher than that from other observations. This may be because we have assumed that an eclipse of 50% or higher will be the only ones visible to unaided eyes.

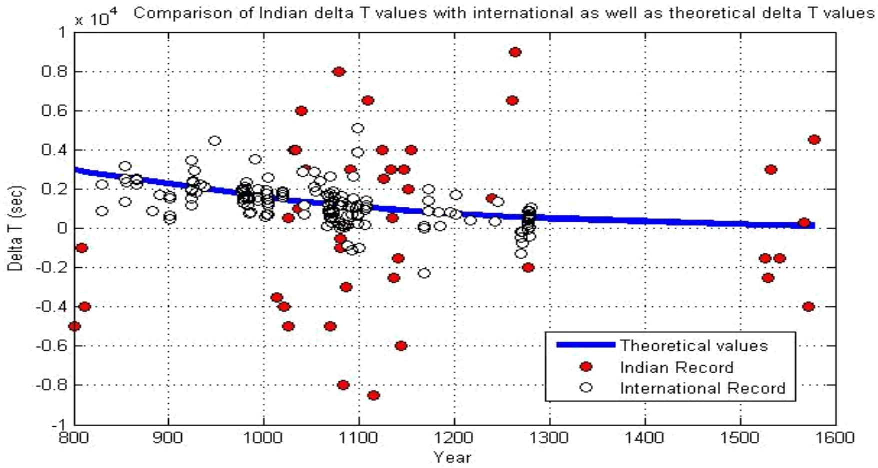

Figure 2: Coparision of he Indian data with the international records.

Other data from India

Indian astronomer Parameswara of 15th Century has recorded several eclipses in detail. Nine of these eclipses are discussed in detail (Hari, 2003). These are:

1. On Kali **16,43,524 (9 Nov 1398)**, the gnomonic shadow at the commencement was eleven and the end (of the eclipse) occurred in the afternoon. In this case, the duration (of the eclipse) was more than nine *nāḍikās* and hence the Sun also had to be computed by experts by the method of successive approximation.
2. On Kali day **16,47,156 (19 Oct 1408)** as the eclipse ended, the Sun was setting with a quarter *nāḍi* to go.
3. On Kali **16,48,722 (Feb 1, 1413)** at the first contract, the Sun's gnomonical shadow was twenty-four.
4. On Kali **16,52,000 (23 Jan 1422)** a clear solar eclipse was observed in the region of Nava. The gnomonic shadow at the moment of contact at this eclipse has been stated by some to be forty, while others stated it as thirty-five, on individual (reckonings).
5. Solar eclipse was observed in Gokarṇa on Kali day **16,53,387 (10 Nov 1425)**; it was not, however, seen on the banks of the Nīlā river.
6. Kali **16,55,130 (19 Aug 1430)** a solar eclipse was seen in Gokarna which was not observed at the confluence of rive Nīlā and the sea. However a discoloration at the fringes of the solar orb was suspected by some students (of astronomy) even here on the banks of Nīlā on the above date.
7. On Kali **16,55,484 (8 Aug 1431)**, at the time of last contact, the gnomonic shadow of the Sun was five and a half.
8. On Kali **16,55,662 (2 Feb 1432)** on the banks of the Nīlā river the Sun was seen by keen viewers slightly eclipsed. The gnomonic shadow at the first contract of this eclipse was fifteen and at the last contact it was nine and a half. On this day, the eyes of those observing

> the Sun's orb were not hurt; it is therefore to be presumed that the heat then was much subdued.

Eclipses 1 to 4 and 6 are eclipses whose path passes through India and East Asia and therefore the records of these eclipses must also exist in Japan and they need to be further investigated.

Discussions and conclusions.

In early Indian mythology, eclipses occur when the nemesis of the Gods – the Asuras, and in particular Rahu threatens Sun or Moon. Hence any donations to the Gods in terms of acts of charity, on the occasion of the eclipse will bear rich rewards. Hence large scale donations tend to occur at eclipses and these are recorded. India therefore has an extensive, but highly scattered and unevenly distributed record of observations of eclipses. However, in virw of the documentation process undertaken by the Government of India over the last several decades, it is possible to collate this data. This has been done in Subbarayappa and Vahia. About 85% of these eclipses are completely consistent with An comparison of this data with NASA simulations (Epenak, 2011) shows that about 18% of the eclipse records are slightly off, suggesting error by scribes while 13% of the eclipses are not found in the NASA records. The rest 79% of the eclipses records match well with the NASA data. We then calculate ΔT from these records and find that they are broadly in agreement with records from East Asia (Tanikawa et all, 2010). However, there are also some major differences with Indian records reporting eclipses that should not have been visible in India at all (Vahia et al., 2013). These need to be studied in detail.

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