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Stonehenge Quadrangle, Solstice and Lunistice, Sun and Full Moon

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Here we discuss the orientation of the megalithic Quadrangle of Stonehenge, created by its four Station Stones. Stimulated by the recent proposal made by Timothy Darvill of a solar calendar embedded in the monumental sarsen stones, we investigate a possible role of the moon. At the same time, we invite the reader to use software to simulate the behavior of the moon, regarding lunistices (lunar standstills) and lunar phases. Thanks to software, we can appreciate how the full moon, rising and setting along the long side of the Quadrangle in the case of major lunistices, is heralding the solstice. The Metonic cycle could also be considered as involved in the solar calendar proposed by Darvill.

Torino, 21 November 2024

Keywords: Stonehenge, Stonehenge Quadrangle, Station Stones, Solstices, Major Lunar Standstill, Minor Lunar Standstill, Midwinter Moonrise, Midsummer Moonrise, Metonic Cycle.

Introduction

It was in 2016 that I found an interesting discussion about the Megalithic Quadrangles. The author of the article is A. Whitaker, 2010. I wrote (Sparavigna, 2016) stressing that megalithic structures in Europe exist, which have not a circular layout. Among them we find the "quadrangles". These stone structures are remarkable because their layouts incorporate some relations between astronomy and the latitude upon which they have been built (Whitaker, 2010). Two of the known megalithic quadrangles are those created by the Station Stones at Stonehenge and the cromlech of Crucuno at Carnac (Whitaker, 2010, Thom et al., 1973). According to Dibble, 1976, the geometry of the Station Stones is based on the 5,12,13 Pythagorean right triangle; that of Crucuno is the 3,4,5 Pythagorean right triangle. Let us note that, of the 16 primitive Pythagorean triples of numbers up to 100, Crucuno is related to the first triple and Stonehenge to the second triple.

Here we consider the Stonehenge Quadrangle and alignments of its sides with solstices and lunistices. We will show how the full moon could have been used to herald the solstices. We will also discuss the solar calendar proposed by Timothy Darvill, 2022. According to his study, the Stonehenge Stage II monument represents a solar calendar.

Latitude and Geometry

In Dibble, 1976, we can find stressed that Thom and coworkers have already discussed "the use of exact and approximate Pythagorean right triangles by Megalithic man" (Dibble, 1976). Thom and coworkers observed that "the *latitude* of Crucuno is remarkably close to that required if the diagonals of the rectangle are to point to the rising and setting positions of the Sun at the solstices as Charriere has suggested" (Dibble, 1976, and references therein). "Hawkins and White, referring to Newham and Charriere, point out that the latitude of Stonehenge is *practically optimum* for the summer solstice sunrise line to be perpendicular to the low summer moonrise line" (Dibble, 1976, and references therein). Once these lines are set, the winter moonset line "completes the simple geometry of the 5,12,13 right triangle, or, alternatively, the 22.5 degree right triangle" (Dibble, 1976, and references therein). According to Dibble, the Station Stones quadrangle is defined by geometry and astronomical directions, according to Stonehenge latitude. Please consider also Atkinson, 1976, discussing the geometry proposed by Dibble, 1976.

"Professor Dibble's interesting note raises questions about the significance of the Stonehenge Stations which deserve detailed examination. It has been said more than once that Stonehenge lies close to the latitude in which the azimuths of extreme northerly sunrise and extreme southerly moonrise are at right-angles, and that this accounts for the nearly rectangular figure of the four Stations" (Atkinson, 1976). Atkinson stressed that Station 94 had not yet excavated in 1976. The latitude of Stonehenge and the orthogonality of the lines we mentioned above is considered, and the proposal of the geometry too. Atkinson assumed a uniform horizon altitude of 30', saying that it "approximates the actual conditions at Stonehenge" (however, Atkinson *does not mention the effect of atmospheric refraction*). After some calculations, the author added: "We may thus perhaps conclude very tentatively (the short length of the sight-lines and the uncertainty in the exact figure justify nothing more) that the intention of the builders was to mark the extreme southerly and northerly settings of the Sun and the Moon in about ***2600 BC***, a date consistent with the hypothesis that the Stations were established in the period I" (Atkinson, 1976). Today, the Stonehenge Quadrangle is included in the period II, 2620–2480 (Darvill. 2022). "… it can plausibly be assumed that the remaining sides of the 'rectangle' were likely intended to mark the extreme rising at the same date. The ***relevant azimuths*** for 93-94 and 94-91 are 49°24' and 142°3', and the included angle at 94 would be 87°21' " (Atkinson, 1976). We will see in the following discussion that these azimuths are close to those that we can obtain with software Stellarium at 2600 BC (with simulated atmosphere). Atkinson is against the hypothesis of a perfect Pythagorean triangle, and the Quadrangle was an approximated rectangular figure. "It is for the excavators of the future to test this very tentative hypothesis" (Atkinson, 1976).

William E. Dibble is a retired physicist at Brigham Young University. Richard J. C. Atkinson was a prehistorian and archaeologist and directed excavations at Stonehenge for the Ministry of Works between 1950 and 1964.

Northernmost Sunrise and Southernmost Moonrise

Under this 'tentative hypothesis', at Stonehenge, we must consider summer solstice to be the symmetry axis of the quadrangle, and the southernmost direction of moonrise, the side perpendicular to the symmetry axis. As shown in Fig.3 of Sparavigna, 2016, to the southernmost direction of moonrise it corresponds the northernmost direction of moonset at lunistices (a lunistice is a lunar standstill). Moreover, we can also consider the phases of the moon, and lunistices and moon phases are actually under an investigation that started in April 2024, according to news. This is an interesting subject and all of us can investigate, using software, the rising/setting of the full moon at the northernmost and southernmost directions on lunar standstills (lunistices), close to the winter and summer solstices, along the sides of the quadrangle. Let us consider simulations starting from summer solstice, as mentioned by Dibble.

Why are we stressing the behavior of the moon close to summer solstice? A reason exists. In 2022, Timothy Darvill proposed a solar calendar embedded in the monumental sarsen stones of the site. "Recent remodelling of the developmental sequence at Stonehenge shows that the three sarsen structures—the Trilithons, Sarsen Circle and the Station Stone Rectangle [that is, the Quadrangle]—all belong to Stage 2 and were set up during the period 2620–2480 BC. Once in place, these components were not moved or changed, and their integrity is further supported by analysis showing that most of the stones derive from a single source on the Marlborough Downs" (Darvill, 2022, Nash et al., 2020). Then, the Quadrangle is part of the monumental Stonehenge. Darvill is giving the layout of the monument, here proposed in Fig.1. Therefore, the planned Stonehenge architecture seems to be including solstices and lunistices, as previously told in 2016.

"Originally four, there are now two remaining Station Stones [S91 and S93] which were probably put in place at the same time that the central sarsen stones were raised. In this photograph, the small stone in the background is one of them. They mark the corners of a ***perfect rectangle*** with its central point in the ***exact centre of the monument***. The reason for this alignment is uncertain, but they mirror the solstice alignment of the stones, and may also mark a lunar alignment" (English Heritage, 16 November 2024). Since all is perfect, also Pythagorean right triangles can be investigated.

In the following Figs.2-4, the monument is shown in Google Earth images.

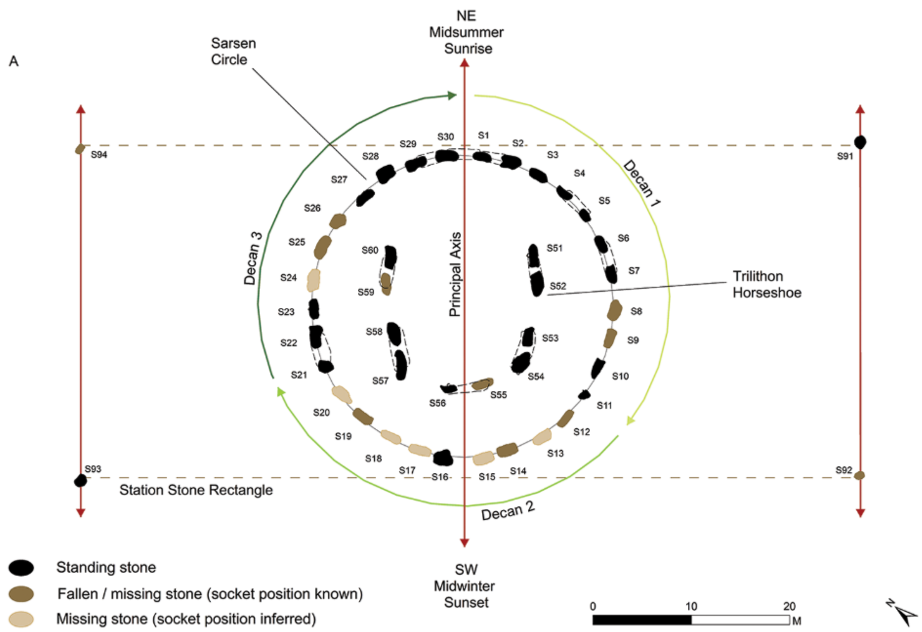


Fig. 1: Stonehenge Sarsen monument and the Quadrangle of the Station Stones as given by Darvill, 2022 (CC BY Creative Commons License).

"Stonehenge has long been thought to incorporate some kind of calendar, although its specific purpose and exactly how it worked remain far from clear. At the beginning of the twentieth century, Lockyer proposed that the monument represented a 'May Calendar' based on 'clock-stars'. Later, Hawkins advanced its interpretation as a 'Neolithic computer', aligned to eight extreme positions of the sun and moon, for the purposes of time-reckoning and predicting eclipses. Thom, meanwhile, favoured a calendar of 16 months, using the solstices, equinoxes, May/Lammas and Martinmas/Candlemas as turning points in the cycle. These and many other interpretations, however, are all unsatisfactory, as they often use non-contemporaneous elements of the monument, reference astronomical alignments that do not withstand close scrutiny, or perpetuate the discredited idea of a 'Celtic Calendar'" (Darvill, 2022, mentioning Ruggles, 1997, and Hutton 1996).

“Many Bronze and Iron Age cultures were known, or strongly suspected, to encode astronomical data in their megalithic monuments (Krupp,1983). For example, one of the most famous ancient megalithic sites of all, Stonehenge (UK, circa 2500 BCE), is thought to be arranged to celebrate either the summer or winter solstice or both (Hawkins, 1962; Parker-Pearson, 2013). Recent work suggests it also encodes a solar calendar (Darvill, 2022)” (Sweatman, 2024).

Fig.2: The Quadrangle in an image courtesy Google Earth. Here we use the stone numbers according to Fig.1 (Darvill, 2022).

Fig.3: The Quadrangle in an image courtesy Google Earth, rotated to have the vertical axis according to the symmetry axis of the monument, which is the also the direction of the sunrise on summer solstice. Here we use the stone numbers according to Fig.1 (Darvill, 2022).

Fig. 4: The Stonehenge Quadrangle, S91, S92, S93 and S94, and the direction of moonrise and moonset of the moon on major standstills. Please consider the position of S94 as approximated. The geometry of the Quadrangle is not so bad indeed, close to the triple 5,12,13. To see the other stones at Stonehenge site, see please the Figure 6 in Hawkins, 1966.

Stage II of the temple

"The construction of a more complex circle began during 2600 BC by introducing precious bluestones and sandstones to form the center of the temple. The process of radiocarbon dating tells us that the first bluestones came from various quarries in the Preseli Hills, West Wales …, and arrived at Stonehenge in 3000 BC. However, it was not until 2400-2200 BC that the bluestones were erected. Prior to the setting of the inner horseshoe arrangement of bluestones at Stonehenge, these were part of Bluestonehenge Stone Circle, a site next to the River Avon near Amesbury. The larger sandstones (sarsens and the trilithon) are set in a horseshoe shape to surround the bluestones." Evans, 2024.

Considering Figure 6 in Hawkins, 1966, the bluestone horseshoe is made of 19 stones. Also the image proposed by Netchev, 2022, is showing 19 bluestones in the horseshoe

"Metonic cycle, in chronology, is a period of 19 years [within 2 hours] in which there are 235 lunations, or synodic months, after which the Moon's phases recur on the same days of the solar year, or year of the seasons. The cycle was discovered by Meton (fl. 432 BC), an Athenian astronomer" (Britannica). Are the 19 bluestones of Stonehenge representing the Metonic cycle?

June 11, 2025

We have previously said that an archaeoastronomers team is searching links between directions and moon-phases. We have also told that all of us can investigate the moonrise and moonset with software. Of course, the direct investigation at the Stonehenge site is fundamental to evaluate the role of the natural horizon, because software usually provides directions according to the astronomical horizon.

Considering again Dibble, 1976, "Hawkins and White, referring to Newham and Charriere, point out that the latitude of Stonehenge is practically optimum for the summer solstice sunrise line to be perpendicular to the low summer moonrise line". Let us use mooncalc.org (many thanks to MoonCalc.org and Torsten Hoffmann for the web site providing on-line software) and year 2025, June 11. https://www.mooncalc.org/#0 . We have a full Moon (Fig.5), rising in the direction of the long side of the quadrangle.

Fig. 5a

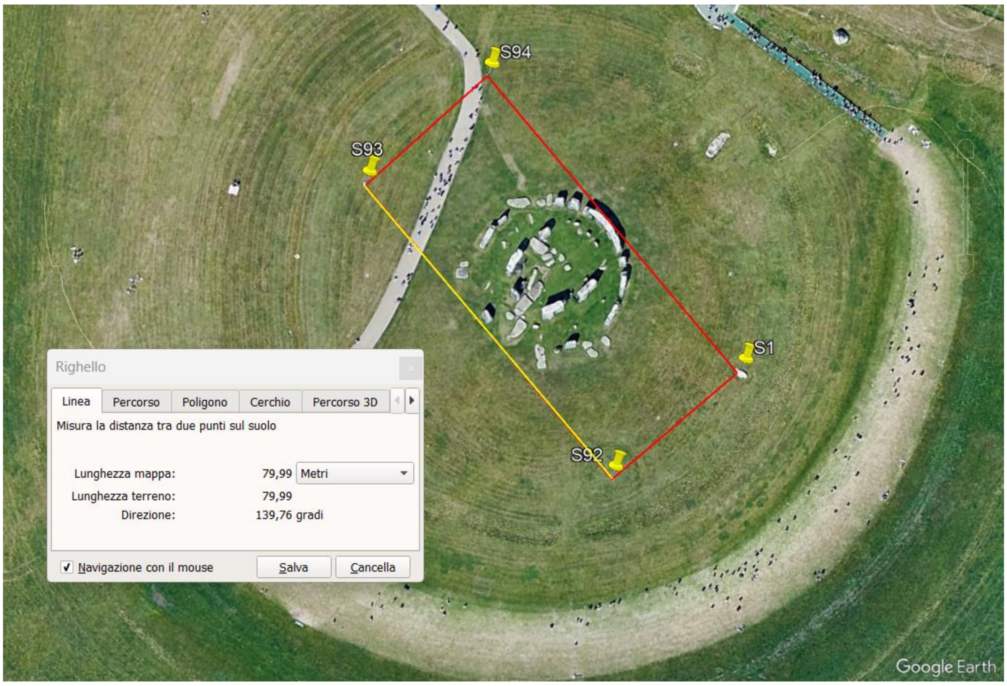


Fig.5b

Fig. 5: 5a) Mooncalc.org simulation. Please consider that the directions of sunrise and sunset (yellow and orange lines) are according to the astronomical horizon. We can see the simulated moonrise on June 11, 2025 (full Moon). Let us assume, as in Atkinson, a uniform horizon altitude of 30', that is, 0.5° and simulate; we have a moonrise azimuth of 141.20°+/−0.10°. To determine the uncertainty of moonrise azimuth, as provided by software, we used www.mooncalc.org/#1 , altitude 0.46°, azimuth 141.09°, and www.mooncalc.org/#2 , altitude 0.55°, azimuth 141.28°. The ***effect of atmosphere refraction*** is included in the simulation. 5b) We can compare with the azimuth of the long side of the Quadrangle, as determined by Google Earth tool (many thanks for satellite imagery and tools); it is 139.75°+/−0.10°.

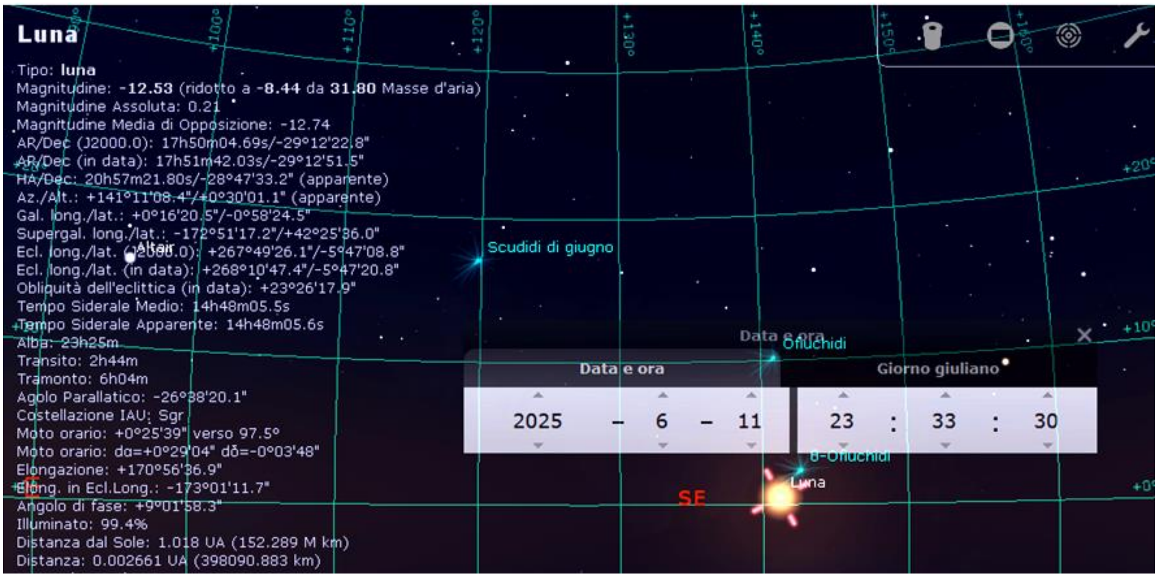


Fig. 6: Stellarium software provides an azimuth of 141°11', that is 141.18°, at 30' of altitude.

With mooncalc.org and Stellarium, which are giving results with a negligible difference of about 1', we find a difference between the moonrise azimuth and the direction of the long side of the Quadrangle, given by Google Earth, of 1°27'. Since software is providing the position of the center of the moon, we could consider the upper limb of the moon. The apparent diameter of the moon is 30', so we reduce the altitude of the center to 15' or 0.25°. At an altitude of the upper limb of 30', the azimuth is 140.52°, https://www.mooncalc.org/#3 . The difference is reduced to 46'.

The tilt of the Earth's axis

A difference continues to exist between azimuths of moonrise and of the long side of the Quadrangle. We used Google Earth, so the azimuth of the long side of the Quadrangle can be different, when measured directly at Stonehenge. Assuming that a difference exists, we have to stress that the axis of the Earth has a motion of precession, accompanied by a change of its tilt. Using Stellarium, we can see that, at Stonehenge on June 21, 2025, the **sun**, at an altitude of 30', has an azimuth of 50°39'. In 2601 BC, the proleptic Julian calendar gives the solstice on July 12; Stellarium gives us, at an altitude of 30', and on 15 July -2600, the northernmost azimuth of 49°38'. We have a difference of about a degree, due to *the change of the tilt of Earth's axis*. Then, the fact that today a difference exists between the southernmost direction of moonrise and the long axis of the Quadrangle is not surprising. Note please that we are dealing with simulations and Google Earth tools. Of course, direct measurements of the long and short sides of the Quadrangle and of moonrise azimuths at Stonehenge are better than simulations to establish the role of the horizon.

Stellarium uses the Julian and the proleptic Julian calendar for dates before October 15, 1582. "Go to the date October 4, 1582, using the 'Date/time window' (F5). Fast forward the time using the bottom menu or the key 'l' and keep your eye on the date you see. Did you find anything interesting? Try entering any date between October 5th and October 14th of 1582. Stellarium doesn't allow you to enter these dates, because they don't exist!! This is because of the calendar reforms by Pope Gregory in 1582" (columbia.edu). I tested the dates of Stellarium software with the occultation of Aldebaran observed by Copernicus (Sparavigna, 2017), and in other cases (Software Stellarium e le occultazioni dei pianeti, in Italian).

Stellarium tells us that the change of the sunrise azimuth on solstices in 4600 years is of about one degree (at Stonehenge). Since the azimuths of lunistices are linked to the sun azimuth, we can suppose that the difference that we measure today between the direction of the long side of the Quadrangle and moonrise azimuth is due to the change of Earth's axis tilt.

Regarding the moon, being the moon's apparent diameter of 30', it means that, if the moon's azimuth changed of one degree, the position of the moon changed of two-moon-diameters.

Let us test the case with Stellarium. We have seen that, about 2601 BC, the summer solstice was about 15 July -2600 (proleptic Julian Calendar). Search for the southernmost full moonrise close to the summer solstice, we find -2592, July 11. See please Fig.7a: azimuth 142°01', for altitude 30'. For the sun on the same day, see please Fig.7b.

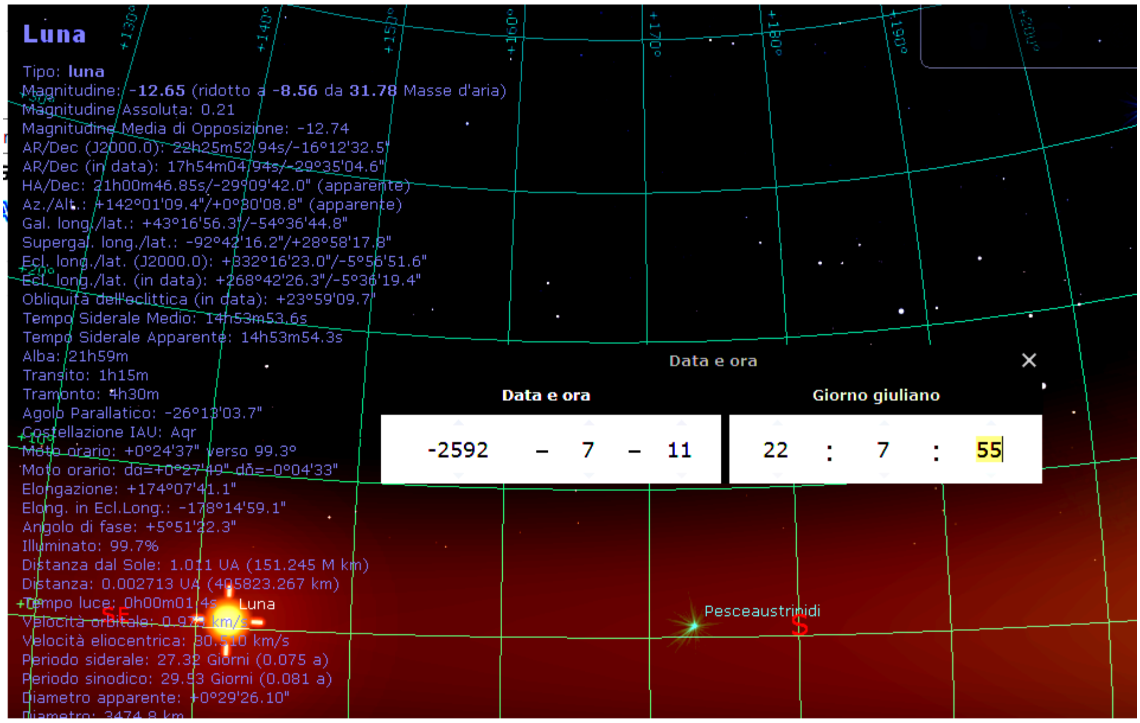


Fig.7a

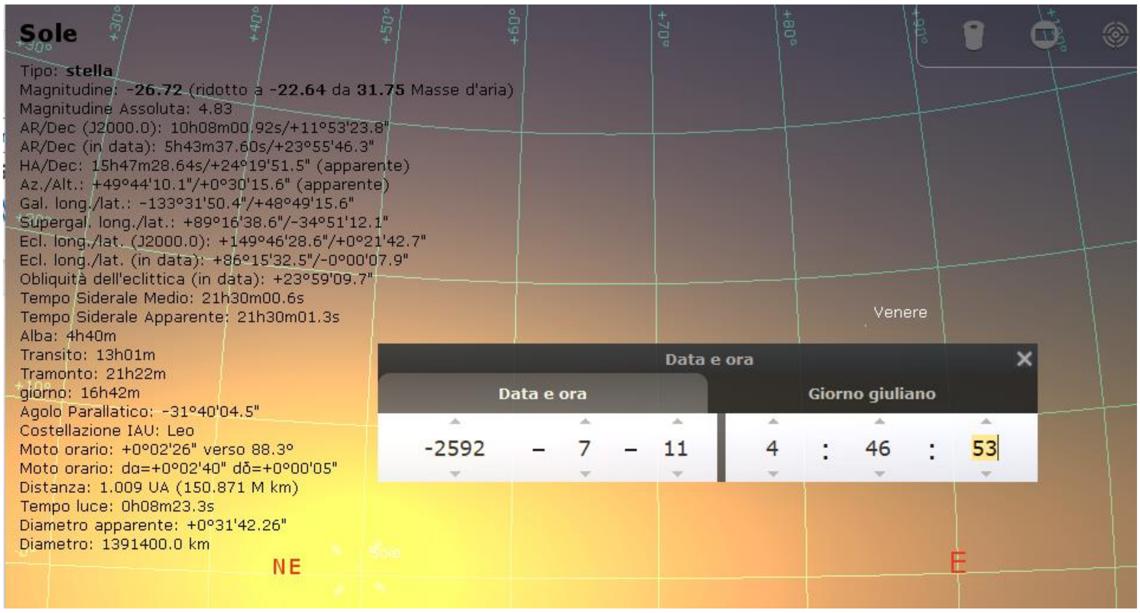


Fig.7b

Then, Fig.7a tells us that the azimuth is 142°01', for altitude 30'. For the sun, 49°44' at an altitude of 30'. In Fig.7c, we compare them with the Quadrangle. Of course, it would be better to have the measurements on the site of Stonehenge (with GPS, being careful to determine the azimuth and not the grid angle). Let us remember, Atkinson, 1976: "The relevant azimuths for 93-94 and 94-91 are 49°24' and 142°3', and the included angle at 94 would be 87°21'". Good agreement with software, moreover, Atkinson considered the atmospheric refraction.

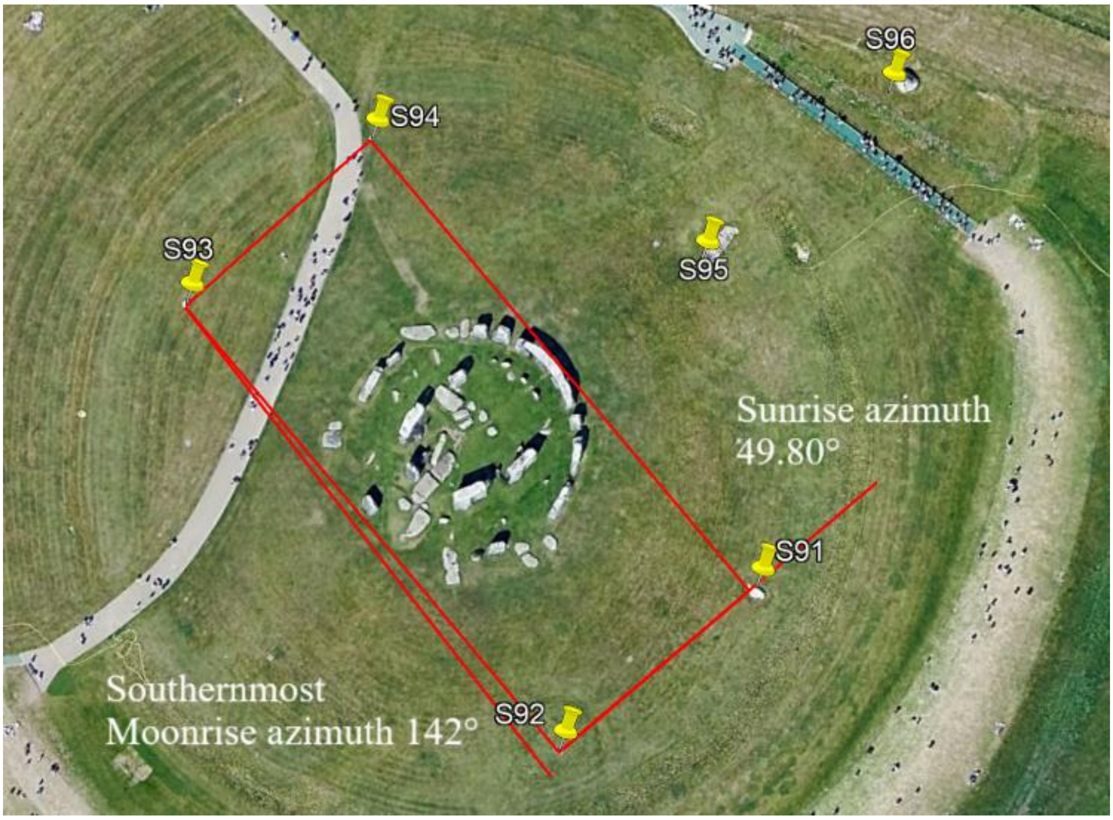


Fig. 7c: The azimuths of sunrise and full moonrise on 11 July -2592. The direction of the moonrise was about 2 degrees different from the direction of the long axis of the Quadrangle (as previously told, the directions of long and short sides of the Quadrangle must be measured on the ground).

Being the apparent diameter of the moon of 30', it means that the difference of 2° (see Fig.7c) is a four-moon-diameters difference.

About the sun, do you know the case of Newgrange? "When Newgrange was built over 5000 years ago, the winter solstice sunbeam would have made its way to the back recess of the central chamber. Due to changes in the tilt of the Earth's axis the sunbeam now stops 2 metres from the back recess." (www.knowth.com).

Atkinson, 1976, considered the change of the Earth's axis tilt: "for the astronomical definition of rising the critical latitude varies between 49°49' N, for 3150 BC and 50°3' N, for 1700 BC, these dates being respectively the upper and the lower 95% confidence limits for the corrected radiocarbon dates for Stonehenge I and Stonehenge IIIa. … Since the latitude of Stonehenge is about 51°11'N, it follows that the site lies some 75 miles too far north for this pair of extreme azimuths to be orthogonal". Atkinson is referring to the two sides of the Quadrangle.

June 21, 2024

In the case of 11 June 2025, the southernmost rising of the full moon is heralding the summer solstice. Could Stonehenge people have used the full moon heralding the solstice for a solar calendar, as proposed by Darvill? This is a proper question. As we will discuss, the sun and the moon could have been used for a “horizon solar calendar” (Kelley & Milone, 2005). Let us go back to 2024 (Fig.8a), June 21. https://www.mooncalc.org/#4 . And we can see that the simulation is telling a full moon on the summer solstice. This is a very interesting result. The Moon could have been used by people to calibrate the calendar. Note that, assuming to observe the center of the moon, at an altitude of 0.55°, mooncalc.org given azimuth 141.18°. Using Stellarium, we can find that the difference between software results is negligible, if we consider the same altitude (of course, rounded to two decimal places). Stellarium given 141°11’44.5”, that is 141.19°.

Fig.8a

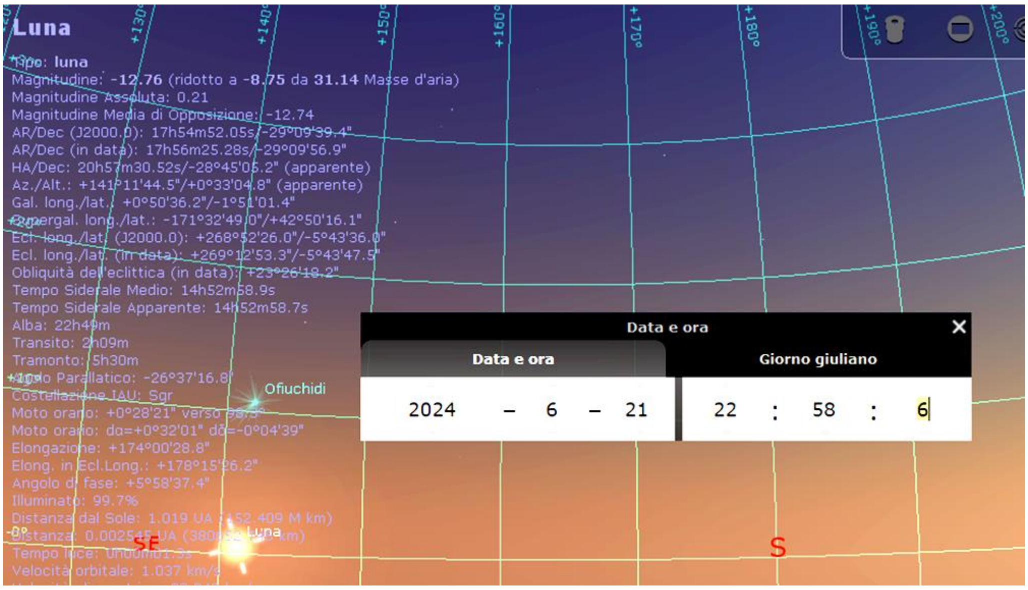


Fig.8b

Fig.8: a) Moonrise simulated by mooncalc.org on 21 June 2024, in the upper panel, b) and data from Stellarium, lower panel.

On June 21, 2024, there was a Major Lunar Standstill Moonrise. “A live broadcast from Griffith Observatory of the full Moon rising on the eastern horizon at its most southerly position in over 18 years. Join us online (*weather permitting*) to watch this event”. An Astronomy article (archived, authors Fabio Silva, Amanda Chadburn and Erica Ellingson), published 11 June 2024, and updated 20 June 2024, entitled “A Stonehenge mystery could be solved this June”, tells that “a hypothesis has been around for 60 years that part of Stonehenge aligns with moonrise and moonset at what is called a major lunar standstill”. Hawkins, 1963, is mentioned.

It seems that weather has not permitted observation (the next full moon, 11 June 2025, allows observation). In fact, Clive Ruggles (archived) wrote that on June 21, 2024, the “observations during English Heritage’s livestream on the evening of June 21 were unfortunately rained off, we were blessed with near-perfect conditions on the following evening (June 22, 2024, see picture; click on it to enlarge)” (Ruggles, 2024). The aim of Ruggle’s project is to check the “Stonehenge’s lunar sightlines, making allowance for the ***shift in the moon’s extreme position over the past 4500 years***” (Ruggles, 2024).

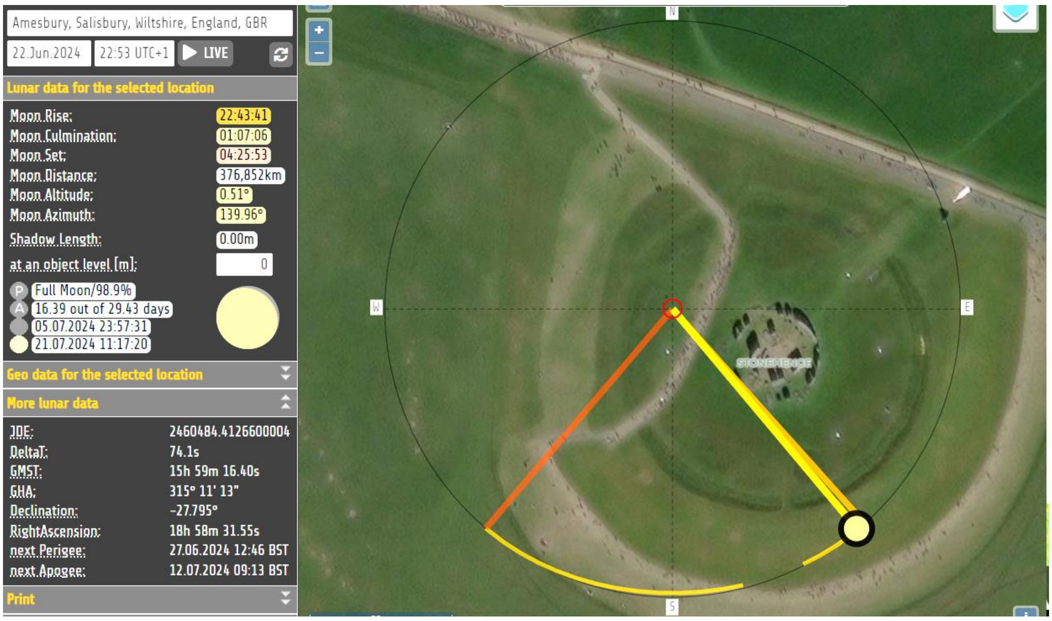


Fig.9: Moonrise simulated by mooncalc.org on 22 June 2024 (full moon).

Therefore, let us consider 2024 (Fig.9), June 22, https://www.mooncalc.org/#4bis . Assuming to observe the center of the moon, at an altitude of 0.51°, mooncalc.org given azimuth 140°. Then, on 21 June 2024, the azimuth was 141.18°, and on 22 June 2024, it was 140°. ***Being the moon’s apparent diameter of 30’, it means that the position changed of more than two-moon-diameters.***

Major Standstill

Why we consider year 2024 and 2025? The Griffith Observatory, in an article regarding the lunar standstill, is telling that on November 18, 2024, we have a Major Standstill Northern Moonrise. The site explains the following: “The major lunar standstill results from the rotation of the Moon’s inclined orbit over an 18.6-year cycle. Because the greatest monthly excursion of the Moon changes very little during a standstill, we can observe the phenomenon for the rest of 2024 and much of 2025”. Therefore

2024 and 2025 can be considered for the major lunar standstills (northern and southern) and for testing simulations with software. Let us stress that also the software mooncalc.org is giving the moon with the northernmost direction of sunrise and sunset on November 18, 2024, as shown by the following Fig.10a, https://www.mooncalc.org/#5 . Note that the sunset is aligned with the longer side of the Quadrangle. In Fig. 10b, the simulation obtained by means of Stellarium is also given (same altitude).

Mooncalc.org azimuth: 317.66°, that is 317°39’30”

Stellarium azimuth: 317°39’10”

Fig.10a

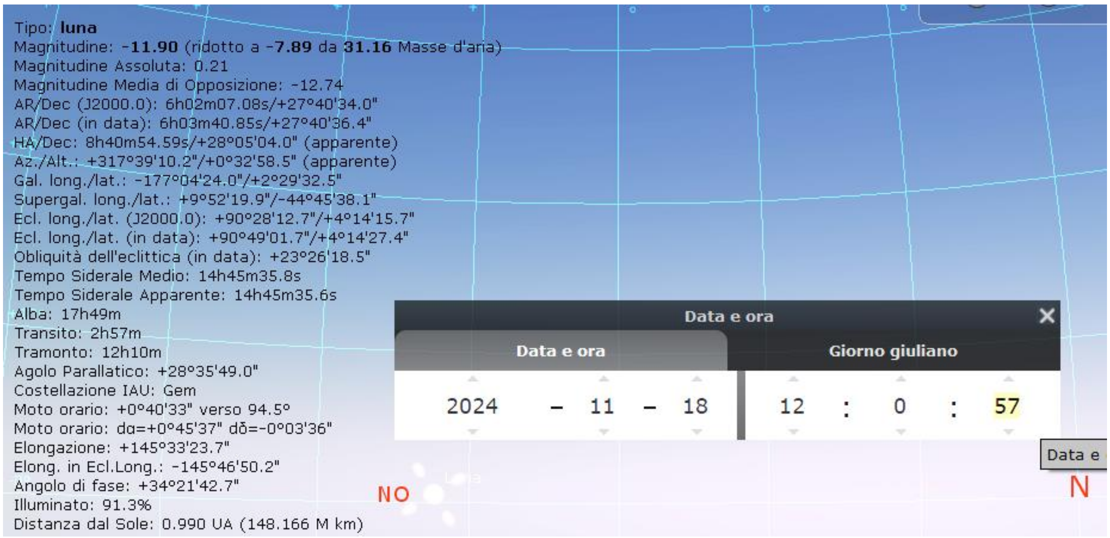


Fig.10b

Fig. 10: a) Mooncalc.org simulation. We can see the simulated moonrise and moonset on November 18, 2024. b) The panel shows a simulation obtained with Stellarium.

In Fig.10, we can see that mooncalc.org software tells us that the next full moon is on 15 December 2024. So let us simulate, as in the following Fig.11, https://www.mooncalc.org/#6

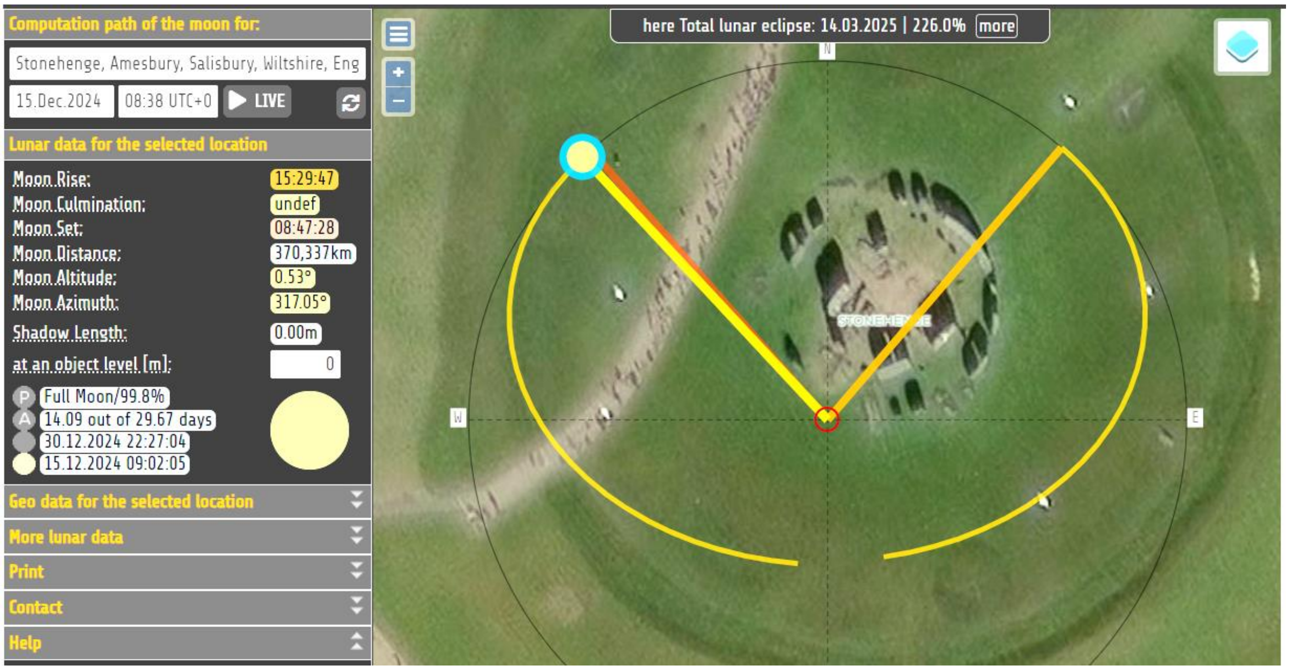


Fig. 11: Mooncalc.org simulation. We can see the simulated moonrise and moonset on December 15, 2024.

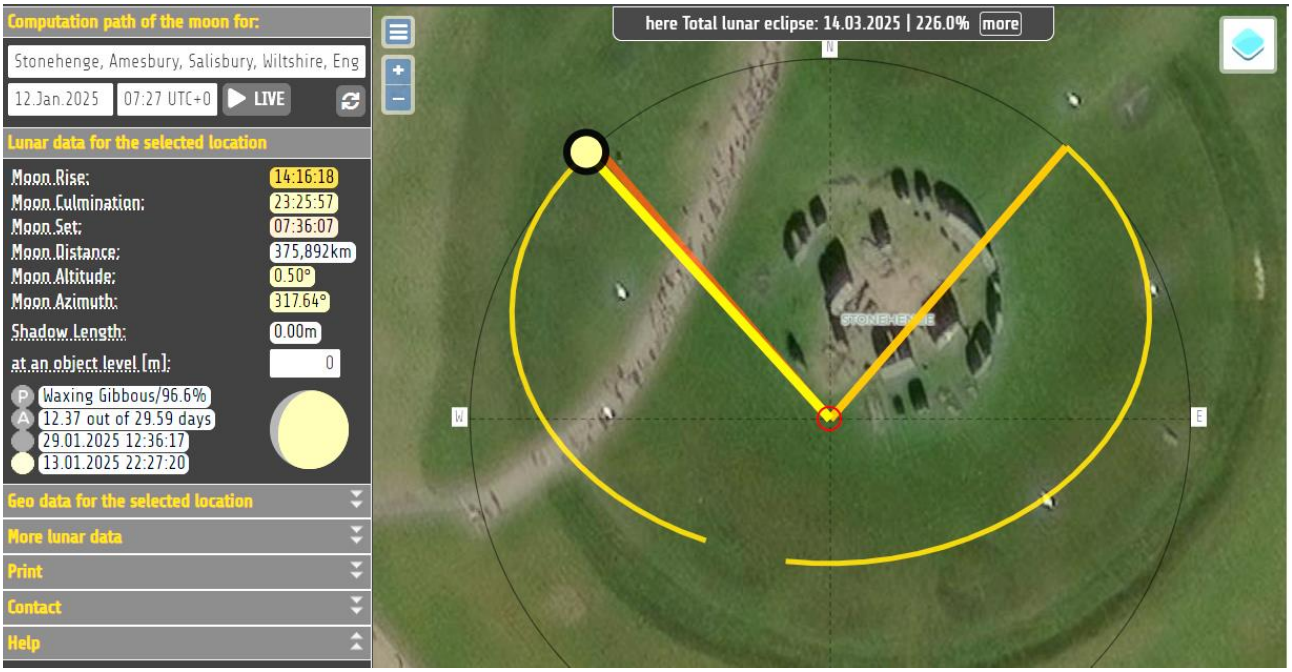


Fig. 12: We can also simulate on January 12, 2025.

In Fig.12, we can go further on to the moonset on 12 January 2025. https://www.mooncalc.org/#7 . The azimuth passes from the value of 317° (15 Dec 2024) to the value of 317.64° (12 Jan 2025). We have a difference of a moon-diameter. In the cases shown above, the direction of the moonset seems to agree with the long side of the Quadrangle (in the sense that we have previously discussed).

The full moon of 15 December 2024, with its northernmost setting along the long side of the Quadrangle seems heralding the winter solstice, whereas the moonrise of 11 June 2025, the southernmost rising of the full moon along the long side of the Quadrangle, is heralding the summer solstice. Could Stonehenge people have used the full moons with southernmost rising and northernmost setting, which are heralding the solstices, for calibrating the solar calendar as proposed by Darvill? This is a question that we can ask ourselves.

However, we must stress that Darvill's work of 2022 proposed an embedding of a solar calendar into the monumental circle of the sarsen stones, that is, it is a monumentalizing of a conceptual calendar. It is different from the "horizon solar calendar", related to the rising and setting of sun and moon on the natural horizon.

"The core of the year is represented by the Sarsen Circle. Here, each of the 30 uprights represents a solar day within a repeating 30-day month. Running sun-wise from the main axis, with S1 representing Day 1, S11 and S21 become significant, as they divide the month into three 'weeks' or 'decans', each of 10 days; the anomalous stones mark the start of the second and third decans. Twelve monthly cycles of 30 days, represented by the uprights of the Sarsen Circle, gives 360 solar days. While no stones within the central setting can specifically be identified with the 12 months, it is possible that the poorly known stone settings in and around the north-eastern entrance somehow marked this cycle. Completing the basic tropical year requires an additional five days: an intercalary month of days known in later calendars as epagomenal days. The five components of the Trilithon Horseshoe, situated prominently in the centre of the structure, fit this role. ... Adding the intercalary month gives 365 solar days. Making the solar calendar a perpetual one, in which the days, decans and months keep pace with the seasons and the movements of the sun to describe a tropical solar year with accuracy, requires periodic adjustment, specifically, the addition of one day every four years to create a leap-year of 366 solar days. The four Station Stones provide a means of keeping tally so that a sixth day could be added to the intercalary month every fourth year" (Darvill, 2022).

This is the solar calendar proposed by Darvill: (30x12+5= 365)-day year, plus a day every four years.

A horizon solar calendar

Kelley and Milone, 2005, are mentioning the horizon solar calendar. "Within the Aubrey Hole ring perimeter are four "Stations", 91, 92, 93 and 94, which form a rectangle of important solar alignments … At the latitude of Stonehenge, 51°11', this rectangle describes the ***approximate alignment*** of extreme aspects of the ***horizon solar calendar***, i.e., the amplitude of the Sun's motion and those of the Moon for both major and minor standstills … The declinations indicated by alignments among pairs of the four stations are given in the Table, the data of which are taken from Hawkins (1965). Dibble (1976) noted that the rectangle made by the four Stations is composed of two triangles very nearly matching 5x12x13 Pythagorean triangles" (Kelley & Milone, 2005).

Table from Kelley and Milone, 2005.

Stations	Azimuth	Declination	Event	Calendar mark
93-94	51.5°	+23.9	Sunrise	Summer solstice
91-92	229.1	−23.9	Sunset	Winter solstice
91-94	319.6	+29.0	Moonset	Major standstill
91-93	297.4	+18.7	Moonset	Minor standstill
93-92	140.7	−29.0	Moonrise	Major standstill
93-91	117.4	−18.7	Moonrise	Minor standstill

"Among themselves, the stations could not have provided high-precision alignments. In 1966, however, ***three postholes*** were discovered in a car-park to the northwest. Their locations are marked in concrete on the road surface. Newham (1972) suggests that in combination with stations 91, 92, and 94, and the Heelstone, both solar (setting, summer solstice) and lunar (setting, northern major standstill; setting, northern minor standstill; and setting, midway between the standstills) alignments were achievable with posts set into these holes. They may have been erected in order to help in the layout of the Stations (Newall 1953/1959/1981). ***If, and only if, the full moon is considered, the directions 91-94 and 91-93 refer to winter solstice moonsets*** (that is, a moonset when the Sun is at the winter solstice) ***at the times of major and minor lunar standstills, respectively***. Similarly, ***if only the full moon is considered, 93-92 and 93-91 refer to summer solstice moonrises at the time of major and minor lunar standstills, respectively***. When Hawkins (1965) refers to "Midwinter Moonrise," for example, in connection with these alignments, he is referring to this phenomenon. It must be remembered that the Moon goes through its entire amplitude in a mere month, but that the amplitude varies in size from lunation to lunation, continuously changing over the period of 18.6 years of the nodal regression cycle. Thus, from night to night, the Moon will rise, and set, at a sequence of intermediate azimuths within its rising and setting amplitude. It is this circumstance that suggests the use of the Aubrey Holes as an eclipse predictor" (Kelley & Milone, 2005, and references therein).

Let us consider the setting of a full moon on a minor lunar standstill (Fig.13) and compare it with a full moon on a major lunar standstill (Fig.14). Let us remember that the tilt of the Earth's axis changed.

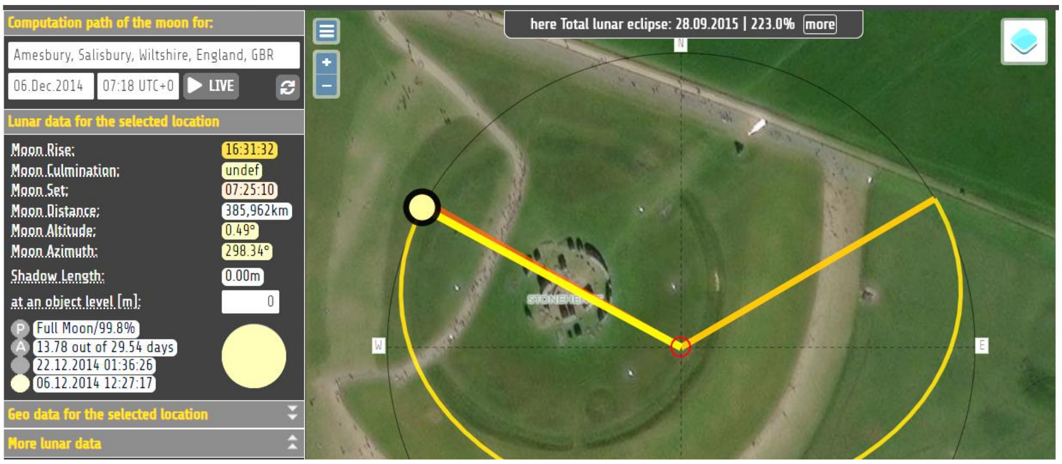


Fig. 13: Moonset of the full moon on a minor lunar standstill. 6 December 2014.

The Fig.13 is according to https://www.mooncalc.org/#8 . The red circle is on S91. The azimuth is about 298.4°. Using Google Earth, the diagonal of the rectangle from S91 and S93 we have 297° (as in the Table by Kelley and Milone, 2005, given above).

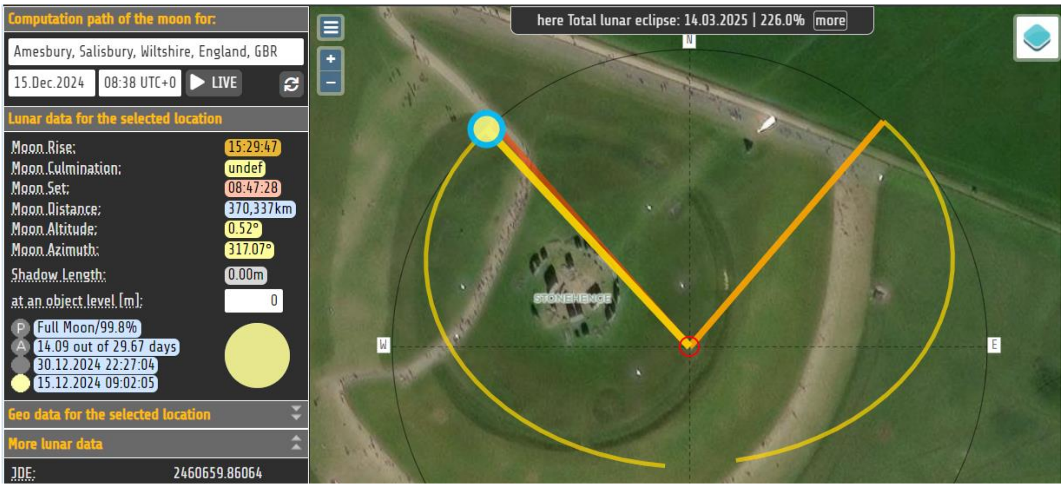


Fig. 14: Moonset of the full moon on a major lunar standstill. 15 December 2024, https://www.mooncalc.org/#9 . The red circle is on S91. The azimuth is about 317°. Using Google Earth, the side from S91 to S94 has an azimuth of about 320°. (in the Table by Kelley and Milone, 2005, 319.6°).

"As the moon goes all the way round the sky every month, the same as the sun does in a year, and travels in nearly the same path, clearly it must also go north and south every month as the sun does. So in midsummer when the sun runs high upon the meridian, we expect to find full moons running low, and likewise in midwinter the full moon always runs high, as almost everyone has sometimes or other noticed" (Todd, 1922).

The place

Parker Pearson, 2012, discussed the place where Stonehenge is, and solstices and lunistices.

"We had stumbled upon the reason why Stonehenge is where it is. The northeast entrance of Stonehenge is positioned at one of a pair of natural ridges, between which are parallel stripes of sediment-filles gullies and chalk bedrock. It is not particularly unusual for Neolithic monuments to incorporate such aspects of the natural world into their design, but what is exceptional here is that this particular natural feature, by sheer coincidence, is aligned on the solstice axis. There is absolutely no doubt that the builders of Stonehenge were aware of the presence of this geological formation, because they enhanced the two natural ridges by digging the avenue's ditches along their outside edges and heaping soil on topo of each ridge to form parallel banks" (Parker Pearson, 2012).

"This explains why the Stonehenge builders were so concerned ***to mark the solstice alignment of midsummer sunset and midsummer sunrise*** in the monument's architecture: it was already inscribed in the ground. Perhaps this is also why, in Stonehenge's earliest use, wooden posts were set up to reference ***major standstills of moonrise and moonsets that would be best seen at midsummer and midwinter full moon***" (Parker Pearson, 2012).

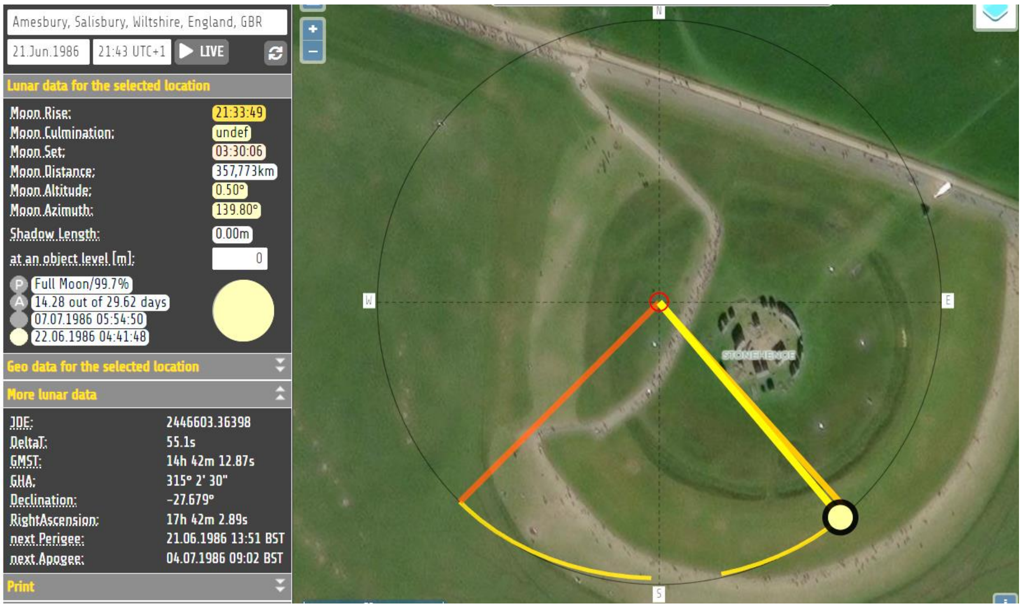
"The presence of these natural ridges may also explain why there are Early Mesolithic postholes under the car park". At that time, "the periglacial stripes would have been easier to see …, and the ridges would have been more prominent that they are today after millennia of weathering" (Parker Pearson, 2012).

29 ½ Sarsen Stones

Childress, 2000, reported about Hawkins' proposal of Stonehenge as a "computer" to predict an eclipse of Sun or Moon, occurring "within 15 days of midwinter - the month of the winter Moon", and the same for the summer Moon. Hawkins' theory received immediate criticism from the academy. In 1966, Atkinson criticized Hawkins' book 'Stonehenge decoded' in his 'Decoder Misled?', in Nature, 210. Childress noted that "Atkinson's reluctance to believe that Stonehenge was some sort of astronomical computer is probably largely due to the popular believe that ancient man simply didn't have a state of civilization that allowed him to pursue such topics of higher knowledge". However, "there seems little doubt to even the most conservative archaeologist that Stonehenge is some sort of astronomical temple. There are a number of simple astronomical truths that can be discerned from Stonehenge. For instance, there are 29.53 days between full moons and there are 29 and a half monoliths in the outer Sarsen Circle. There are 19 of the huge 'Blue Stones' in the inner horseshoe which has several possible explanations and uses. ***There are nearly 19 years between the extreme rising and setting points of the moon. Also, if a full moon occurs on a particular day of the year, say on the summer solstice, it is 19 years before another full moon occurs on the same day of the year.*** … It is also suggested that the five large trilithon archways represent the five planets visible to the naked eye: Mercury, Venus, Mars, Jupiter and Saturn" (Childress, 2000).

Of the Sarsen circle, stone S11 is smaller than the other stone (Darvill, 2022). Also S21 is smaller than the other stones (see Figs. 2 and 3 in Darvill, 2022).

Fig. 15: This is a screenshot of Stellarium. On June 21, 2005, we had the midsummer full moon. Compare please with the panel in Fig.8a. The moon has the same illumination (full moon).



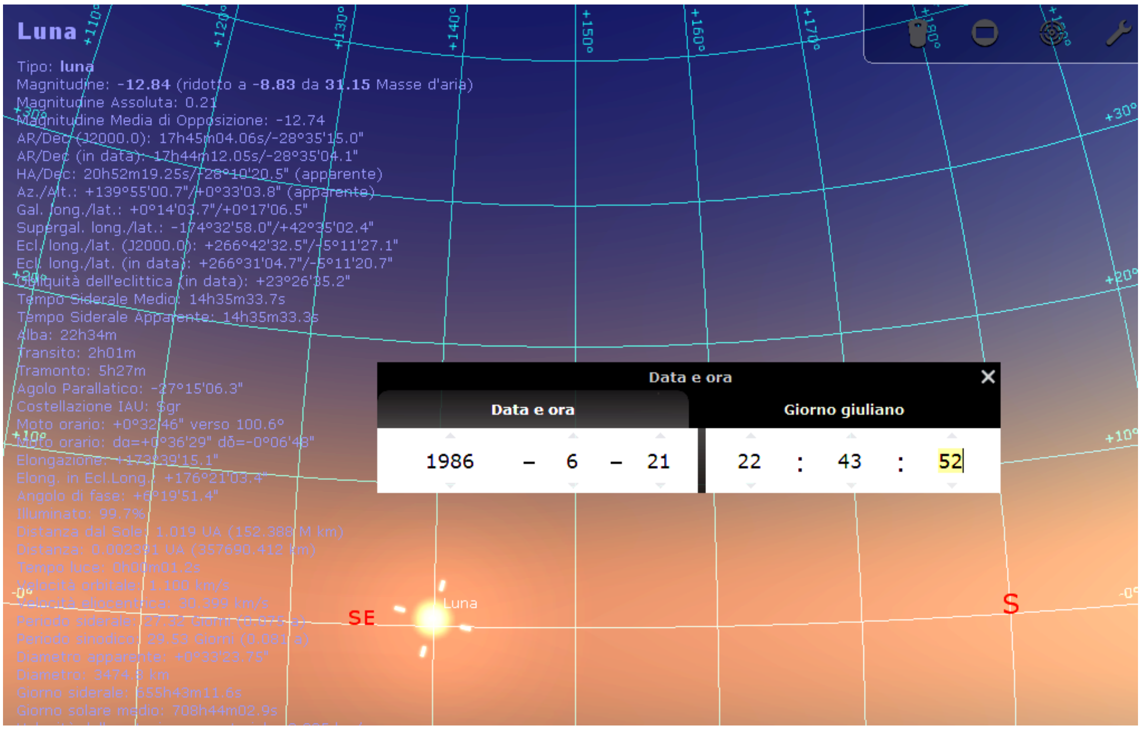


Fig. 16: With mooncalc.org and Stellarium, on June 21, 1986, we had the midsummer full moon.

Be careful, in 2025, the midsummer full moon is on June 11, 2025, as shown by mooncalc.org.

Then, to observe the midsummer full moon on June 21, we have to wait 19 years.

Let us suppose Darvill's solar calendar embedded in the monumental Stonehenge. It is a calendar with 30x12+5 days, plus one day every four years. If people at the Stonehenge temple used a 365-day year, they could have observed that after 19 years, four days were required to be added to synchronize the solar calendar and the full moon. In this case, we must assume that, besides the sun, people at Stonehenge observed the moon too (and in fact, we have the Quadrangle).

Then, the base solar calendar proposed by Darvill, 30x12+5 days, could be corrected of one day every four years as proposed by Darvill, or corrected of four (or five) days every 19 years, according to the Metonic cycle. Please consider that the cycle of the lunar standstills is different from the Metonic cycle.

The “nodal regression accounts for the difference between the lunar sidereal period of 27.321 days, and the draconic period of 27.212 days. The draconic period is the time it takes the Moon to make one orbit returning to the same node. The time it takes for a node to make a single revolution is referred to as the 18.61-year lunar cycle, not to be confused with the 19-year Metonic cycle or the Saros cycle of 19 eclipse years” (Cudnik, 2023).

“The lunar standstill and the Metonic cycle are not perfectly matched, but they are very close. Especially close for the unwritten astronomical knowledge of people living in 2500 BCE.” (Boyle, 2024).

Parker Pearson, 2023, after remembering Gerald Hawkins’ best-seller, Stonehenge Decoded, and the “prehistoric computer for calculating movements of the sun and the moon, including lunar eclipse”, tells that “archaeoastronomer Clive Ruggles has adopter a cautious and more realistic view of the monument’s likely solar and lunar alignments and explains that their relative imprecision indicates that the people at Stonehenge were symbolically referencing these solar and lunar events in monumental form, not constructing an observatory or an accurate calendar. The calendar theory has re-emerged in 2022 in a paper by Tim Darvill” (Parker Pearson, 2023). This year, 2024, sees Clive Ruggles investigating lunar standstill and the phases of the moon.

Timothy Darvill’s proposal of a solar calendar embedded in the monumental Stonehenge is the only real new theory regarding this site, because does not consider the moon. Let us stress also that the Quadrangle being oriented according to lunar standstills is a well-known fact, and also that Atkinsons has provided data about 2600 BC.

Parker Pearson, 2023, observes that Darvill “mixes numerical categories (e.g. three stones of a trilithon have to be counted as equal to one single sarsen circle upright to represent one day)”. That is: sarsen circle (30x12) + 5 (five trilithons) = 365 days. Then, to avoid mixing numerical categories, we could consider the two upright stones of a trilithon to represent two days. Consequently, we could modify Darvill’s calendar as follows: sarsen circle (29x6+30x6) + 10 (five trilithons) + 1 (altar stone) = 365 days. Is this numerology? Yes. Actually, it is the same numerology that we find in the Göbekli Tepe calendar (Sweatman, 2024). No archaeoastronomer has raised any questions about this Göbekli Tepe calendar. No one.

Observing the midsummer full moon, people at Stonehenge could add four or five days every 19 years (according to Darvill, a day every four years, because Darvill does not consider the moon in the calendar). However, we must repeat Childress, 2000: “There are 19 of the huge ‘Blue Stones’ in the inner horseshoe which has several possible explanations and uses. There are nearly 19 years between the extreme rising and setting points of the moon. Also, if a full moon occurs on a particular day of the year, say on the summer solstice, it is 19 years before another full moon occurs on the same day of the year” (Childress, 2000).

The monumental Stonehenge could be considered a *representation* of the sun and moon cycles, without necessarily being an observatory. The presence of postholes seems to indicate that posts were used for this purpose. That is, Stonehenge was a “temple of time”. About the analogy between the Stonehenge calendar and the Civil Egyptian Calendar, that we find in Darvill, 2022, I discussed in arXiv, 2024.

Pictures

When pictures are made at moonrise/moonset at Stonehenge latitude, please consider that today the extremal position of the moon is different by about four-moon-diameters, than that the satellite had in 2600 BC. This is what we have using the simulations by Stellarium, and also remembering Atkinson, 1976: "The relevant azimuths for 93-94 and 94-91 are 49°24' and 142°3'", a rather good agreement with software.

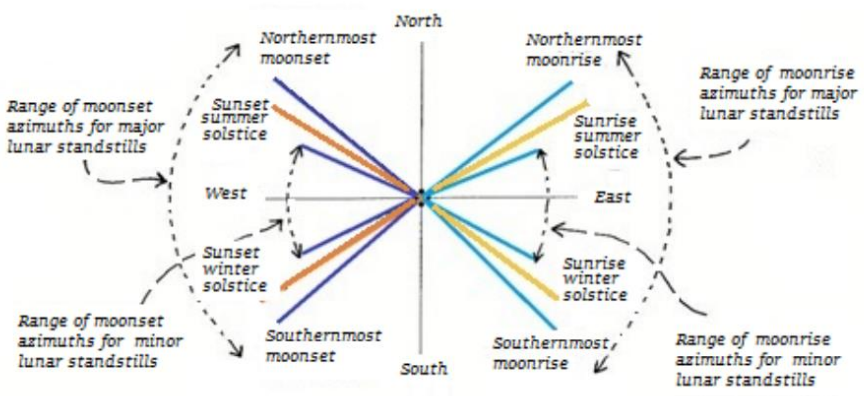
The term "lunistice"

In Kelley and Milone, 2005, it is told that "when Hawkins (1965) refers to "Midwinter Moonrise," … he is referring" to the full moon of winter solstice. In fact, in Cornell, 1981, we find the "midwinter moonrise". In Cornell, 1981, "The first stargazers: An introduction to the origins of astronomy", we do not find major or minor lunar standstills, but the "midwinter moonrise" and "midwinter moonset". However, the term "lunistice" had been previously used. The term "lunistice" existed before locutions as "midwinter moonrise" or "major standstill"; Loudon, 1869, defined a "boreal lunistice, when the moon approaches as she can in each lunation (or period between one new moon and another) to our zenith", and the "austral lunistice, when she is at the greatest distance from the zenith, for the action of the moon varies greatly according to her obliquity". Loudon, 1869, mentioned Toaldo.

As I told in 2018, today, "in the English literature concerning archaeoastronomy, we find used the locution 'lunar standstill', which was apparently introduced by Alexander Thom in 1971, in his book Megalithic Lunar Observatories" (Wikipedia, mentioning Vincent, 2005). "However, a term already existed to describe the same astronomical phenomenon: it was 'lunistice', proposed by Joseph De la Lande in the eighteenth century" (Sparavigna, 2018). It is told in Loudon, 1835 and 1869, that the term was coined by De la Lande. Joseph Jérôme Le François De la Lande, (Bourg-en-Bresse, 11 July 1732 - Paris, 4 April 1807) was an astronomer and Director of the Paris Observatory. From 1795 to 1801 he compiled the most complete list of his time, with the indications of the position of 47.390 stars (Histoire Céleste Française). The turning point of his existence happened when he moved to Berlin, for the measurement of the lunar parallax, which was started at Cape of Good Hope, by Nicolas Louis De la Caille. It was in 1750. De la Lande and De la Caille (1713-1762) used a triangulation method to determine the distance of the moon from the earth (Proctor, 1873).

About lunistices

Of all the objects of the sky, the sun is the fundamental one; it has a clear and simple apparent motion, characterized by solstices and equinoxes, and by zenith passages in the tropical zone. From the winter solstice to the summer solstice, the sun increases its height in the sky and the angle between its rising and setting azimuths increases. It has an exactly opposite behavior from the summer solstice to the winter solstice. The moon is obviously the other body attracting our attention: based on its phases many aspects of a natural calendar had been devised. However, the motion in the sky of our satellite was, for the ancients, more complex to analyze. The moon does not behave like the sun. On each month, the moon is like the sun on a year. For about 14 days, the moon behaves like the sun during the time period from the summer solstice to the winter solstice, decreasing its altitude in the sky and having rising and setting azimuths moving southwards. For the other 14 days, the moon behaves like the sun from the winter solstice to the summer solstice; the moon increases its altitude in the sky and the rising and setting azimuths move northwards. While the solar cycle of solstices is completed in about 365 days, the cycle of the moon lasts 18.6 years (the cycle of standstills). During this cycle the moon has a major standstill; on it, the moon reaches its maximum declination North, so that the moonrise azimuth is the northernmost possible one. In the same month, two weeks later, it has its rising at the southernmost possible azimuth, being closer to the South and lower on horizon. Consequently, the angle spanned by the azimuth of moonrise and moonset is having its maximum value. During the cycle, a major standstill corresponds to the maximum declination of the Moon varying from roughly 28.5° to -28.5°, with a total movement of 57°. After about 9.3 years the moon has a minor lunar standstill; the moon will change its declination during the nodal period from +18.5° to −18.5°, which is a total movement of 37°, and then the angle spanned by the azimuth of moonrise and moonset is reduced to its minimum value (see the following sketch).



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