Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

ASTROISLAMICA
Journal of Islamic Astronomy

Verification of Kastner Visibility of Hilal Observation Results at Condrodipo Rukyat Center in 1444 H

[1]Nur Faizah, [2]Muhammad Muadz Dzulikrom*.

[1]Faizahnr12@gmail.com, [2]Muadzdzulikrom@gmail.com
[1] Universitas Islam Negeri Walisongo Semarang
[2] Universitas Islam Negeri Sunan Ampel Surabaya
*Korespondensi

ARTICLE INFO

Article history:
Submitted Maret 12, 2024
Accepted April 3, 2024
Published Juni 30, 2024

Keywords:
Verification, Kastner Visibility, Hilal

ABSTRACT

The Kastner Hilal visibility method is one of numerous contemporary observation techniques developed with the objective of monitoring the appearance of Hilal with greater precision. This paper presents a discussion of Hilal observations conducted at the Condrodipo Rukyat Center. The visibility results are analyzed using curve graphs, facilitating the assessment and validation of the observations. The findings demonstrate that employing the Kastner mathematical model can corroborate visibility with a substantial degree of concurrence, regardless of atmospheric constraints and sky conditions. However, the results of observer reports in the field are often inconsistent with model predictions, especially in conditions of low Hilal altitude and naked eye observations. Therefore, more rigorous scientific verification and reliable methodologies are needed to confirm observations for the integrity of the determination of the beginning of the lunar month.

ARTICLE INFO

Kata Kunci:
Verifikasi, Visibilitas Kastner, Hilal

ABSTRAK

Metode visibilitas Hilal Kastner adalah salah satu dari banyak metode observasi modern yang dikembangkan dengan tujuan memantau kemunculan Hilal dengan akurasi yang lebih tinggi. Kajian ini menyajikan pembahasan observasi Hilal yang dilakukan di Balai Condrodipo Rukyat. Hasil visibilitas dipelajari dengan menggunakan grafik kurva, sehingga memudahkan dalam menganalisis dan memverifikasi hasil pengamatan. Temuan penelitian menunjukkan bahwa penggunaan dengan model matematis Kastner dapat memverifikasi visibilitas dengan tingkat kesesuaian yang signifikan, terlepas dari kendala atmosfer dan kondisi langit. Namun, hasil laporan pengamat di lapangan seringkali tidak konsisten dengan prediksi model, terutama dalam kondisi ketinggian Hilal yang rendah dan pengamatan menggunakan mata telanjang. Oleh karena itu, diperlukan verifikasi secara sainstifik yang lebih ketat dan metodologi yang dapat diandalkan dalam mengonfirmasi hasil pengamatan demi integritas penetapan awal bulan hijriah.

INTRODUCTION

The theory regarding the criteria for the change of the lunar month is known as Hilal visibility, which is a parameter to define the possibility of the position of Hilal being visible. This theory of Hilal visibility is the result of combining Rukyat and Hisab methods to obtain an astronomical interpretation of the fiqh arguments used.[1]

A number of models of Hilal visibility criteria have been developed by various astronomers, including one by Kastner. In Kastner's visibility model, the visibility function is designed for objects closest to the sky (stars, comets, and planets).[2] From a scientific perspective, and based on the author's analysis, Kastner's Hilal visibility method has the advantage of being able to determine the contrast value between the Moon's illumination (extended sources) and the brightness of the background,

[1]Hasna Tudar Putri, "Redefinisi Hilal dalam Perspektif Fikih Dan Astronomi," *Jurnal Pemikiran Hukum Islam* 22, no. 1 (2022), 109.

[2]Sidney O. Kastner, "Calculation Of The Twilight Visibility Function Of Near-Sun Objects," *The Journal Of The Royal Astronomical Society Of Canada* 70 (1976).

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

including the light of the twilight sky and the night sky.[3] The scattering effect of solar radiation by atmospheric particles creates conditions where the twilight sky near the horizon is still bright enough to observe the Hilal.[4] This finding is corroborated by previous studies that have demonstrated the intricacy and precision of the variables in Kastner's visibility model.[5]

In a study conducted by Nabila Aliansyah Putri, it was found that Kastner's visibility is more complex than Odeh's.[6] This is due to the limited focus of Odeh's visibility on the research conducted by Stamm, the majority of which was conducted in European states. In contrast, Kastner's visibility is more appropriate for application in Indonesia, as it considers variations in atmospheric conditions (either clean, moderate, or dirty).

In addition to the observation of Hilal, the verification of Hilal observation results is a field of research that studies methods and techniques for observing, verifying, and validating the results of Hilal appearance in a particular location. In this context, the Condrodipo Hilal Rukyat Center serves as a case study. This observation location conducts regular Hilal observations on a monthly basis and has a proven track record of successful Hilal sightings, as evidenced by the testimony reports included in the Decree of the Minister of Religion (KMA) of the Republic of

---

[3]Judhistira Aria Utama and S. Siregar, "Usulan Kriteria Visibilitas Hilal Di Indonesia Dengan Model Kastner," *Jurnal Pendidikan Fisika Indonesia (Indonesian Journal of Physics Education)* 9, no. 2 (2013): 197–205.

[4]Judhistira Aria Utama and Hilmansyah, "Penentuan Parameter Fisis Hilal Sebagai Usulan Kriteria Visibilitas Di Wilayah Tropis," *Jurnal Fisika Unnes* 3, no. 2 (2013): 122–27, https://doi.org/10.15294/jf.v3i2.3821.

[5]Data diproleh dari hasil wawancara dengan Bapak Judhistira Aria Utama

[6]Nabila Aliansyah Putri, "Studi Komparasi Kriteria Visibilitas Hilal Odeh Dan Kastner" (Universitas Islam Negeri Sunan Ampel Surabaya, 2023).

Indonesia, which determine the dates of Ramadan, Shawwal, and Zulhijjah.[7]

In the determination of the beginning of the month of Shawwal 1436 H or 2015 AD, a report was received from one of the observers at the Condrodipo Rukyat Center indicating that Hilal was successfully observed. The astronomical data on the height of Hilal indicated a height of 2 degrees.[8] This incident was repeated in the determination of the beginning of the month of Ramadan 1443 H or 2022 AD, where four observers managed to see Hilal at the Condrodipo Rukyat Center. The astronomical data on the height of Hilal indicated that it was 1 degree.

In light of the aforementioned explanation, the author conducted a research analysis on the results of the reported Hilal observation report, with the objective of determining whether the observed phenomenon was, in fact, the Hilal or another celestial object.

METHOD

This study presents a discussion of Hilal observations made at the Condrodipo Rukyat Hall. The study includes an in-depth examination of the entire calculation process, which is conducted using the Kastner mathematical model. This is followed by a detailed analysis of the verification process of the testimony, which presents the predicted time of Hilal's appearance from the background of the twilight sky. Finally, the results of visibility are studied using a curve graph, which makes it easier to analyze and verify the results of observations. This type of research is

---

[7]Direktorat Urusan Agama Islam dan Pembinaan Syari'ah, *Keputusan Menteri Agama RI: 1 Ramadhan, 1 Syawal, Dan 1 Dzulhijjah 1381H-1440H/1962M-2019M* (Jakarta: Kementrian Agama RI, 2019).

[8] Syarifuddin Fahmi, "Dinamika Rukyatul Hilal Di Condrodipo," Studi Analisis Rukyatul Hilal Di Balai Rukyah Condrodipo Gresik"" (Universitas Islam Negeri Walisongo Semarang, 2019).

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

qualitative research that analyzes the data of Hilal observation results.

The methodology employed in this study adheres to a scientific and statistical approach. This approach is essential for the analysis of the Hilal observation data, which serves as the primary instrument in this research.The research methodology employed is descriptive with a quantitative approach. The specific mathematical models from existing literature were intentionally selected to describe the natural phenomenon of observing the young crescent Moon/Hilal at specific times, locations, and with particular observation methods (either naked eye or aided by equipment like a telescope). The research process was systematic and comprehensive, entailing a thorough analysis of the observed Hilal. A topic analysis was conducted to gain an understanding of the context, criteria, and conditions present in the real-world situation during observation. The selection of pertinent theories and the provision of supporting evidence provided a robust foundation for this research endeavor.

This study uses these aspects are computed using Microsoft Excel software with topocentric settings, and adjustments are made to accommodate the effects of atmospheric refraction near the horizon. The positions of the Moon and Sun are utilized as data points, with Sun data calculated based on the VSOP2000 theory, while Moon data are derived from the ELP-MPP/02 theory. The data on delta T are referenced from Espenak & Jean Meus.

RESULTS AND DISCUSSIONS

A mathematical model of Kastner visibility

Sidney O. Kastner was a solar physicist and astrophysicist, born in Winnipeg, Canada in 1926 and died on August 25, 1999.

For the majority of his 50-year career, he was employed at NASA's Goddard Space Flight Center in Greenbelt, Maryland.[9] Salah satu jurnalnya "Calculation of The Twilight Visibility Function of Near-Sun Object" (1976), One of his journals, "Calculation of the Twilight Visibility Function of Near-Sun Objects" (1976), presents a mathematical function for the visibility of celestial objects at Sunset based on Rozenberg's (1966) observations of comets Bartaneva and Bayarova.[10] to observe celestial objects such as stars, planets, and comets at Sunset.

This method was subsequently adopted by Judhistira Aria Utama for the calculation of Hilal visibility based on its characteristics. These include the position of the Moon after conjunction, which is often close to the position of the Sun, and the appearance of the Moon, which varies from a point light source, akin to a star, to an extended light source, dependent on the age of the Moon and its elongation.[11]

The Kastner method visibility is a term that refers to the difference in brightness between a celestial object and the background sky. Its primary objective is to assess the clarity with which the celestial body is visible.[12] The contrast of these objects is influenced by the light scattered by the sky. In its calculation, the Kastner method considers the brightness of the object inside and outside the Earth's atmosphere, as well as the optical

---

[9]Joel Kastner, "Sidney O. Kastner (1926-1999)," BAAS Bulletin Of The AAS, 2000.

[10]Kastner, "Calculation Of The Twilight Visibility Function Of Near-Sun Objects."

[11]Utama and Siregar, "Usulan Kriteria Visibilitas Hilal Di Indonesia Dengan Model Kastner."

[12]T. B Ramadhan, Thomas Djamaluddin, and Judhistira Aria Utama, "Re-Evaluation of Hilaal Visibility Criteria in Indonesia By Using Indonesia and International Observational Data," in *Proceeding of International Conference On Research, Implementation And Education Of Mathematics And Sciences 2014* (Yogyakarta: Yogyakarta State University, 2014), 87–92.

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

extinction of the atmosphere with respect to the object's altitude,[13] the distribution of twilight sky brightness is contingent upon the angle of the Sun's depression,[14] and contributions from the brightness of the night sky.[15]

The following equations used to predict Katsner's visibility that have been modified by Binta and Judhistira have several steps, including:[16]

1. Determining the position of the Moon (Zenith Distance, Azimuth, Elongation, Visual Apparent Magnitude, Semi Diameter) and Sun (Azimuth, Depression Angle)
2. To calculate the brightness of the moon outside the Earth's atmosphere (*extra atmosphere luminance crescent*), the brightness of objects outside the atmosphere is expressed in the equation:

$$L*= 1/A\times 2{,}51(10-Mvis)$$
$$A = (0{,}5\times \pi r2)[1+\cos(180° - ARCL)]$$

3. Calculating the Moon's luminance *below atmosphere seeing topocentric*

$$Lmoon= e-kx$$

4. To calculate background *sky brightness during twilight*, Twilight sky brightness formula:

$$Ls=290[10\log L+2{,}5]$$

Log L is a form of luminance involving zenith, solar

---

[13]Leroy E Doggett, P. Kenneth Seidelmann, and bradley E. Schaefer, "Lunar Crescent Visibility," *Icarus* 107, no. 2 (1994): 388–403, https://doi.org/https://doi.org/10.1006/icar.1994.1031.

[14]Abdurrahman Özlem, "A Simplified Crescent Visibility Criterion," *International Crescent Observation Project*, 2014.

[15]Kastner, "Calculation Of The Twilight Visibility Function Of Near-Sun Objects."

[16]Binta Yunita, Judhistira Aria Utama, and Waslaluddin, "Visibilitas Hilal Dalam Modus Pengamatan Berbantuan Alat Optik Dengan Model Kastner Yang Dimodifikasi," in *Proceeding Seminar Nasional Fisika Dan Aplikasinya* (Bandung: Universitas Padjadjaran, 2016), 254.

depression and Sun-Moon azimuth angle difference expressed in:

$$\mathrm{Log}L = -(7{,}5\times10^{-5}\,z+5{,}05\times10^{-3})\theta + (3{,}67\times10^{-4}\,z-0{,}458)h+9{,}17\times10^{-3}z+3{,}525,\ \text{dengan}\ \theta\leq\theta_o$$

The above equation is used if the transition angle is greater than or equal to the Moon-Sun azimuth difference

$$\mathrm{Log}L = -0{,}0010\,\theta + (1{,}12\times10^{-3}z-0{,}470)h - 4{,}17\times10^{-3}\,z + 3{,}225,\text{dengan}\ \theta>\theta_o$$

The above equation is used if the transition angle is less than the Moon-Sun azimuth difference, then:

- find the transition angle (θo), Find the transition angle serves to calculate the value of L whether using the first or second equation.

$$\theta_o=-(4{,}12\times10^{-2}\,z+0{,}582)h+0{,}417z+97{,}5$$

- find the angle of depression of the Sun using

$$h=-Sin^{-1}(Sin\emptyset Sin\delta+Cos\emptyset Cos\delta\mathrm{Cos}(s-\propto)$$

5. Calibrating the brightness of the twilight sky (Ls) looks for the contribution of the night sky (La), and determines the brightness of the background (Lsa) with the formula:

$$Ls = 290 \text{ x } (10\log L+2{,}5)$$
$$La = 290 + 105 \text{ x Exp } (-(90\text{-}z)^2/1600)$$
$$Lsa = Ls + La$$

6. Determining the brightness of the night sky (*night sky luminance*).

$$La=290+105\exp(-90-z)^2/1600$$

7. Determining optical correction values for background brightness and Moon brightness
   - Binocular vision correction (Fb) with a value of 1.41 or V2
   - Correction of light absorption by the Telescope lens (F1):

$$F1 = 1/t^0 \text{ x } (1\text{-}(Ds/D)^2))$$

   - Correction of light dispersion by pupil (Fp)

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

De = 7 exp(-0,5[A/100]2

Fp = D/MDc)2, jika De < D/M

Fp = 1,0, jika De > D/M

- Correction of light collection by the Telescope (Fa)

  Fa = (De/D)2

- Correction of light dispersion due to magnification of the Telescope (Fm)

  Fm = M2

- Correction of magnification of celestial bodies (Fr)

  Fr = (2ϴM/900")0,5, jika 20ϴM > 900" Fr = 1,0, jika 20ϴM < 900",

- Summing corrections for background brightness (Fb) and the brightness of the Moon (Fi):

  $F_b = F_b \, F_I \, F_p \, F_a \, F_m$

  $F_I = F_b \, F_I \, F_p \, F_a \, F_r \, F_s$

8. Determine effective background brightness (Bef) and effective object brightness (Lef) with correction:

   Bef = Lsa / F1

   Lef = Le /Fb

9. Calculates the visibility function (Δm), if the result is negative then the Hilal visibility is negative, if the result is positive then the Hilal visibility is positive:

   R = Lef / Bef

   $\Delta m = 2{,}5 \; Log \; R$

A study of the Hilal observation in the Condrodipo Rukyat Center.

Balai Rukyat Condrodipo, situated in Kembangan Village, Kebonmas Sub-district, Gresik Regency, East Java Province, has been designated as the official site for rukyatul Hilal since December 2004. The hall is situated in close proximity to the grave of Mbah Condrodipo,[17] and is equipped with specific latitude and longitude coordinates, with an altitude of 120 meters above sea level.[18] The topography of the area is characterized by white limestone hills, which are situated in Gresik Regency and border the Java Sea, Madura Strait, Surabaya City, Sidoarjo Regency, Mojokerto Regency, and Lamongan Regency. The climate is tropical with low rainfall.[19] The highland position of the area allows for unobstructed observation of the Hilal, particularly to the northwest.

The center is equipped with a variety of rukyat equipment, including telescopes, theodolites, rubu' mujayyab, and location wickets. Rukyatul Hilal is held at this location on a monthly basis, particularly during the months of worship, such as Ramadan, Shawwal, and Zulhijjah.[20]

This observation location conducts regular Hilal observations on a monthly basis and has a proven track record of successful Hilal sightings, as evidenced by the testimony reports included in the Decree of the Minister of Religion (KMA) of the Republic of Indonesia, which determine the dates of Ramadan, Shawwal, and Zulhijjah.[21] In the determination of the beginning of the month of Shawwal 1436 H or 2015 AD, a report was received from one of the observers at the Condrodipo Rukyat Center

---

[17]M Syafik Hoo, "Menengok Balai Rukyat Condrodipo Gresik, Langganan Melihat Hilal," n.d., https://jatim.nu.or.id/metropolis/menengok-balai-rukyat-condrodipo-gresik-langganan-melihat-Hilal-2e3yN.

[18]H Abdul Muid, "Balai Rukyat Gresik Condrodipo," www.wikimapia.org, 2008.

[19]Pemerintahan Kabupaten Gresik, "Geografi," 2013.

[20]Restu Trisna Wardani, "Keberhasilan Rukyatul Hilal Oleh Muhammad Inwanuddin Pada Ramadan 1431 H Dan Muharram 1439 H Dalam Perspektif Nalar 'Irfani "" (Tesis: UIN Walisonggo, 2022).

[21]Direktorat Urusan Agama Islam dan Pembinaan Syari'ah, *Keputusan Menteri Agama RI: 1 Ramadhan, 1 Syawal, Dan 1 Dzulhijjah 1381H-1440H/1962M-2019M.*

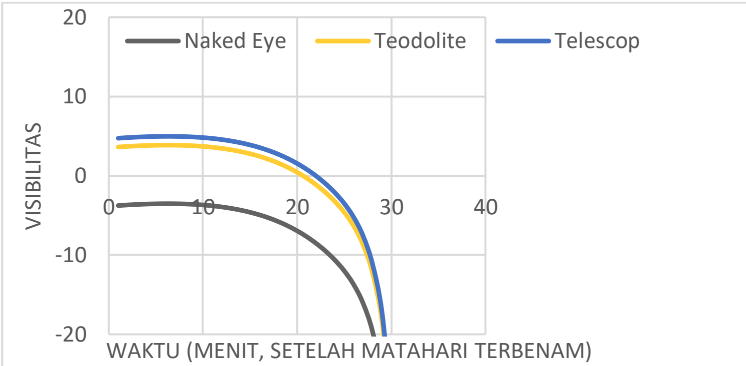
Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

indicating that Hilal was successfully observed. The astronomical data on the height of Hilal indicated a height of 2 degrees.[22] This incident was repeated in the determination of the beginning of the month of Ramadan 1443 H or 2022 AD, where four observers managed to see Hilal at the Condrodipo Rukyat Center. The astronomical data on the height of Hilal indicated that it was 1 degree.

Furthermore, the author will limit the data used as a reference in the research analysis. The author will focus on data from one year of rukyatul Hilal implementation at the Bukit Condrodipo Gresik Rukyat Center. The data will concern the results of the success of seeing Hilal. The results of the minutes obtained revealed that there were several instances where the testimonies did not align with Kastner's predictions.

Verification of Hilal observations at the Condrodipo Rukyat Hall serves to validate the success of Kastner visibility. While the model is capable of verifying testimonies with an accuracy level of 4 degrees, field conditions frequently diverge from predictions due to factors such as atmospheric conditions and Hilal visibility. The following graph depicts the results of Hilal visibility tests conducted using the Kastner model to determine the beginning of the month of Rabiul Awal 1444 H, with an extinction coefficient of k=0.4 in a moderate atmosphere.

[22]Syarifuddin Fahmi, "Dinamika Rukyatul Hilal Di Condrodipo," Studi Analisis Rukyatul Hilal Di Balai Rukyah Condrodipo Gresik"."



Graph 1 Illustrates The Visibility Of Hilal Kastner On Safar 29, 1444 H, As Observed With The Naked Eye, Theodolite, And Telescope.

In the graph above, the beginning of the month of Rabiul Awal 1444H is determined by the Hilal altitude, which is 4° 45' 24" and the elongation between the Sun and the Moon, which is 6° 55' 22". The blue trend line, which was generated using a telescope, and the yellow trend line, which was generated using a teodolite, are predicted to observe the Hilal from minute 1 to minute 17, or for 16 minutes from Sunset. This is because a positive visibility value can be observed, which indicates that the Hilal illumination is greater than the brightness of the twilight sky.

The field observation report, conducted in the field with western sky conditions at the time in question, was adjusted to account for moderate atmospheric conditions with a value of k = 0.4. Hilal was successfully observed at 17:27 WIB with the naked eye by H. Inwanuddin[23] in this case, Kastner's visibility was not a factor. This is demonstrated by the clear observation that the black trend line, when viewed with the naked eye, indicates that the predicted time (negative visibility value) is unable to discern Hilal due to the brightness of the twilight sky being more dominant than the illumination of Hilal. Consequently, the results of

[23]The Data Presented Here Were Obtained From The Minutes Of The Hilal Observation Conducted At The Beginning Of The Month Of Rabiul Awal 1444 H.

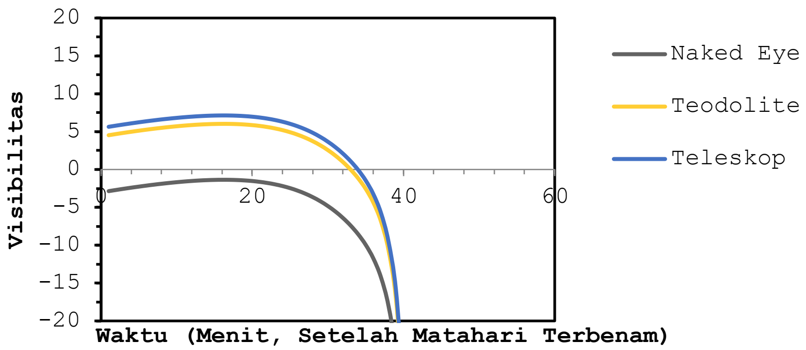
Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

testimony using the naked eye are irrelevant and unacceptable. Conversely, if a testimony report is provided using optical aids, it can be accepted as it aligns with the prediction.

The results of the observation report at the Condrodipo Rukyat Center from 1444 H were obtained primarily through the use of the naked eye. Following verification with Kastner's visibility, some results were found to be irrelevant, and thus the results of the testimony with the naked eye could not be accepted. In addition to claiming to successfully verify Hilal cases with low altitude, Kastner visibility can certainly claim the results of successful Hilal observations. When the prediction is positive, the contrast illumination value of the Hilal light also increases. However, this is not easily observable due to the influence of atmospheric extinction at the time of observation on the visibility of the Hilal.[24]

One case concerns the determination of the beginning of the month of Ramadan 1444H. It is argued that the testimony of the naked eye is irrelevant because the negative visibility value due to the scattering of twilight light is greater than the contrast of the Moon's illumination. However, the potential for visibility can be greatly enhanced by the use of optical aids with a magnification of 10x or more. The following graph depicts the visibility of Kastner's method for determining the beginning of Ramadan 1444H in a moderate atmosphere with an extinction value of k = 0.4.

[24]Abdul Mufid and Thomas Djamaluddin, "The Implementation of New Minister of Religion of Brunei, Indonesia, Malaysia, and Singapore Criteria towards the Hijri Calendar Unification," HTS Teologiese Studies / Theological Studies 79, no. 1 (June 30, 2023): 8, https://doi.org/10.4102/HTS.V79I1.8774.



Graph 2 Illustrates The Visibility Of Kastner's Hilal On 29 Sha'ban 1444H, As Observed Through The Naked Eye, Theodolite, And Telescope.

The graph above illustrates the determination of the beginning of the month of Ramadan 1444H. It is known that the Hilal altitude is 6° 59' 54'' and elongation 9° 05' 26'' with both theodolite and telescope predictions. The use of a telescope and a prediction based on the position of the moon and the Sun, respectively, yielded positive results, indicating that these methods are relevant. In contrast, observations with the naked eye yielded negative results, as the moon and Sun were not visible. However, observations with the naked eye were successful if the value of atmospheric extinction was k = 0.2, which is considered clean. In the field report, conditions were cloudy. Consequently, the results of testimony with the use of the naked eye did not correspond. However, testimony with aids was accepted, particularly given the evidence from the Hilal image as reinforcement for the appearance of the Hilal object.

The ICOP (Islamic Crescents Observation Project) website contains reports of Hilal observations in various countries, with the exception of the United States, where Dr. Javed Torabnejad is responsible for such reports. This discrepancy arises from the differing starting dates of the month of Rabiul Awal 1444H in these two countries. In Malaysia, the beginning of the month of

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

Rabiul Awal 1444 H will be on September 28, 2022, while in Indonesia it will be on September 27, 2022. [25]

A mathematical analysis of Kastner's Hilal visibility revealed discrepancies between observed and predicted values. These discrepancies were observed primarily in naked eye observations and the use of theodolites. Theodolite observations exhibited partial agreement, particularly when the Hilal height was low. However, when using a telescope, agreement was found despite some discrepancies in the predictions. Nevertheless, additional evidence, such as Hilal images, can be employed to reinforce the observations. The Kastner visibility recapitulation of the 1444H Hilal observations at the Condrodipo Rukyat Center indicates variations in the agreement of the results, which will be the focus of further research. The following is a summary of the data processing results presented by the author.

Table 1: provides a summary of the results of the Kastner visibility verification conducted in the year 1444 H.

Moon	ARCV	Elongation	Moon Age	Observation	Kastner Verification
29 Safar 1444H	6.09	6.18	12h 32m 05s	Naked Eye	Irrelevant
1 Rabiul Awal 1444H	17.47	17.80	1d 12h 31m	Naked Eye & Telescope	Relevant
30 Rajab 1444H	15.11	15.76	1d 03h 47m	Naked Eye, Teodolite and Telescope	Relevant
29 Syakban 1444H	8.51	9.09	17jh 18m 5s	Naked Eye, Teodolite and Telescope	Naked Eye : Irrelevant Optical Tools: Relevant
30 Syawal 1444H	6.87	9.06	18h 27m 51s	Naked Eye & Telescope	Naked Eye : Irrelevant Optical Tools: Relevant

[25] International Astronomical Center ICOP, "Visibility Of Rabee' Al-Awwal Crescent 1444 AH," 2022.

30 Zulkaidah 1444H	12.40	14.14	1d 05h 46m	Naked Eye, Teodolite and Telescope	Relevant
29 Zulhijjah 1444H	6.86	8.24	15j 58m 16d	Naked Eye & Telescope	Naked Eye : Irrelevant Optical Tools: Relevant

In general, observations in Indonesia face significant challenges, primarily related to sky conditions. This is particularly true for observations made using the naked eye, where the Hilal height is often low. This kind of incident is not a new phenomenon. Although it is acknowledged that the MABIMS standard employed by the Indonesian Ministry of Religious Affairs serves merely as a guideline in the preparation of the Hijriyah civil calendar and is not intended to guarantee Hilal observations,[26] whenever the Sun-Earth-Moon position reaches or exceeds the minimum values set forth in the standard, claims regarding successful Hilal observations invariably arise, particularly from the Condrodipo Rukyat Center. Nevertheless, such claims must be substantiated by reliable evidence. Therefore, observations that lack such evidence cannot be considered as new data that can alter existing theories or criteria.

In the previous determination of the beginning of Ramadan 1444 AH, the Meteorology, Climatology and Geophysics Agency (BMKG) predicted (and the prediction proved to be quite accurate) that most parts of Indonesia on Monday evening would experience cloudy weather and even rain (from light to heavy intensity). However, observations at the Condrodipo Rukyat Center reported that the Sun was last seen at around 15:00 WIB. However, in the aforementioned note, the option "clear" was selected to describe the sky in the west. Furthermore, there is no

[26]Sakirman, Judhistira Aria Utama, and Othman bin Zainon, "Intergrasi Hisab Rukyat Awal Ramadan 1442 H Dengan Model Visibilitas Kastner," *Elfalaky : Jurnal Ilmu Falak* 6, no. 2 (2022), https://doi.org/https://doi.org/10.24252/ifk.v6i2.30766.

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

information regarding the timing of the Hilal sighting from start to finish, nor the observation method used. Given these considerations, it is challenging to accept the information related to the observation of the Hilal at the beginning of Ramadan 1443 AH as reliable data that can be used as proof.

Application of the Concept: Verification of Observations

The author identifies two types of observations: those that serve as subjects in the formation of criteria and those that serve as objects in the application of Hilal visibility criteria. In Indonesia, both the subject and object of the Hilal visibility criteria are Hilal observations. However, the role of Hilal observations in Indonesia is rarely utilized in the formation of criteria by the general public. Nevertheless, there are researchers who conduct observations in Indonesia as a subject. Furthermore, observations in Indonesia are often the subject of controversy, which can lead to discrepancies at the national and international levels. One example is the Condrodipo Rukyat Center, which is not always considered to meet the established standards.

The criteria/mathematical model cannot be directly applied for the verification of a Hilal observation/rukyatul Hilal. However, the criteria must be tested in the field first through several observations (rukyat) or experiments. This is necessary so that the criteria can predict the If the phenomenon of rukyatul Hilal can be observed with satisfactory results, then the mathematical model can be accepted as a criterion for verification (determining the validity/least) of a Hilal rukyatul report, especially for controversial cases.[27]

[27] Arsyita Baiti Musfiroh and Muhammad Himmatur Riza, "Analysis of the Early Determination of the Kamariah Month Perspectives of Fiqh and Astronomy," Astroislamica: Journal of Islamic Astronomy 1, no. 2 (2022), https://doi.org/10.47766/astroislamica.v1i2.969.

The existence of visibility or criteria in determining the beginning of the lunar month based on astronomical data and observations in accordance with scientific principles will produce results from visibility that are in accordance with the facts that occur in the field. Kastner's visibility is a balance between calculation and prediction for observation. Observations with the naked eye, theodolite, and telescope can be verified using Kastner's visibility, as evidenced by some of the cases described above. All observations, particularly those made with the unaided eye, are corroborated by substantial supporting evidence, such as Hilal images, which serve to corroborate the observations themselves. Consequently, it is of the utmost importance to verify the observations made with regard to the Hilal. In order to verify the results of Hilal observations using Kastner Hilal visibility, it is necessary to consider a number of different aspects. These include:

1. Traditional observation methods are limited.

   Although traditional methods of observing the Hilal have been employed for centuries, they may be subject to limitations in terms of accuracy and reproducibility. The verification of more scientific and standardized observation methods, such as Kastner's Hilal visibility, can assist in validating the results of traditional observations.

2. Modern Observation Techniques: Development

   Kastner Hilal visibility represents one of the numerous modern techniques developed with the objective of monitoring Hilal occurrence with greater accuracy. This research can be integrated into an initiative aimed at the development of new techniques or the enhancement of the reliability of existing ones.

3. Validation of Historical Data

   The corroboration of Hilal observations with Kastner Hilal visibility can also serve to corroborate historical data on the occurrence of Hilal in various locations. This

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

corroboration is of significance in the context of Islamic dating, as it enables the understanding of variations in Hilal observations over time and place.

4. Effect of Environmental Variables

   The visibility of the Hilal is influenced by several factors, including atmospheric conditions, geography, and the altitude of the observation site. This research aims to enhance our understanding of how these variables affect the observation of the Hilal and to identify ways to compensate for or account for them in the analysis.

5. The Relevance of this Material for Calendars and Religious Traditions

   Verification of Hilal observations with Kastner Hilal visibility is significant for determining the beginning of the month in the Islamic calendar and setting important dates in religious traditions. This research can help ensure that the establishment of such important dates is based on accurate and scientifically verified data.

Considering the aforementioned background, research on the verification of Hilal observation results using Kastner's Hilal visibility can be expected to make a valuable contribution to our understanding of the Hilal phenomenon and the importance of Hilal visibility in the context of religion and calendars.

CONCLUSION

The Kastner Hilal visibility method is one of numerous contemporary observation techniques developed with the objective of monitoring the appearance of Hilal with greater precision. This paper presents a discussion of Hilal observations conducted at the Condrodipo Rukyat Center. The visibility results are analyzed using curve graphs, facilitating the assessment and validation of the observations. The findings demonstrate that employing the Kastner mathematical model can corroborate visibility with a substantial degree of concurrence, regardless of atmospheric constraints and sky conditions. However, the results of observer reports in the field are often inconsistent with model predictions, especially in conditions of low Hilal altitude and naked eye observations. Therefore, more rigorous scientific verification and reliable methodologies are needed to confirm observations for the integrity of the determination of the beginning of the lunar month. In order to verify the observation of the hilal, it is necessary to consider a number of factors, traditional observation methods are limited, modern observation techniques: development, validation of historical data, effect of environmental variables, and the relevance of this material for calendars and religious traditions

BIBLIOGRAPHY

Abdul Muid, H. "Balai Rukyat Gresik Condrodipo." www.wikimapia.org, 2008.

Baiti Musfiroh, Arsyita, and Muhammad Himmatur Riza. "Analysis of the Early Determination of the Kamariah Month Perspectives of Fiqh and Astronomy." *Astroislamica: Journal of Islamic Astronomy* 1, no. 2 (2022). https://doi.org/10.47766/astroislamica.v1i2.969.

Direktorat Urusan Agama Islam dan Pembinaan Syari'ah. *Keputusan Menteri Agama RI: 1 Ramadhan, 1 Syawal, Dan 1 Dzulhijjah 1381H-1440H/1962M-2019M*. Jakarta: Kementrian Agama RI, 2019.

Doggett, Leroy E, P. Kenneth Seidelmann, and bradley E. Schaefer. "Lunar Crescent Visibility." *Icarus* 107, no. 2 (1994): 388–403. https://doi.org/https://doi.org/10.1006/icar.1994.1031.

International Astronomical Center ICOP. "Visibility Of Rabee' Al-Awwal Crescent 1444 AH," 2022.

Kastner, Joel. "Sidney O. Kastner (1926-1999)." BAAS Bulletin Of The AAS, 2000.

Volume 3 No. 1 Juni 2024
P-ISSN: 2986-1675 E-ISSN: 2963-0290
Page: 70-91
DOI: https://doi.org/10.47766/astroislamica.v3i1.2786

Kastner, Sidney O. "Calculation Of The Twilight Visibility Function Of Near-Sun Objects." *The Journal Of The Royal Astronomical Society Of Canada* 70 (1976).

M Syafik Hoo. "Menengok Balai Rukyat Condrodipo Gresik, Langganan Melihat Hilal," n.d.

Mufid, Abdul, and Thomas Djamaluddin. "The Implementation of New Minister of Religion of Brunei, Indonesia, Malaysia, and Singapore Criteria towards the Hijri Calendar Unification." *HTS Teologiese Studies / Theological Studies* 79, no. 1 (June 30, 2023): 8. https://doi.org/10.4102/HTS.V79I1.8774.

Özlem, Abdurrahman. "A Simplified Crescent Visibility Criterion." *International Crescent Observation Project*, 2014.

Pemerintahan Kabupaten Gresik. "Geografi," 2013.

Putri, Hasna Tudar. "Redefinisi Hilal Dalam Perspektif Fikih Dan Astronomi." *Jurnal Pemikiran Hukum Islam* 22, no. 1 (2022).

Putri, Nabila Aliansyah. "Studi Komparasi Kriteria Visibilitas Hilal Odeh Dan Kastner." Universitas Islam Negeri Sunan Ampel Surabaya, 2023.

Ramadhan, T. B, Thomas Djamaluddin, and Judhistira Aria Utama. "Re-Evaluation of Hilaal Visibility Criteria in Indonesia By Using Indonesia and International Observational Data." In *Proceeding of International Conference On Research, Implementation And Education Of Mathematics And Sciences 2014*, 87–92. Yogyakarta: Yogyakarta State University, 2014.

Sakirman, Judhistira Aria Utama, and Othman bin Zainon. "Intergrasi Hisab Rukyat Awal Ramadan 1442 H Dengan Model Visibilitas Kastner." *Elfalaky : Jurnal Ilmu Falak* 6, no. 2 (2022). https://doi.org/https://doi.org/10.24252/ifk.v6i2.30766.

Syarifuddin Fahmi. "Dinamika Rukyatul Hilal Di Condrodipo," Studi Analisis Rukyatul Hilal Di Balai Rukyah Condrodipo Gresik"." Universitas Islam Negeri Walisongo Semarang, 2019.

Utama, Judhistira Aria, and Hilmansyah. "Penentuan Parameter

Fisis Hilal Sebagai Usulan Kriteria Visibilitas Di Wilayah Tropis." *Jurnal Fisika Unnes* 3, no. 2 (2013): 122–27. https://doi.org/10.15294/jf.v3i2.3821.

Utama, Judhistira Aria, and S. Siregar. "Usulan Kriteria Visibilitas Hilal Di Indonesia Dengan Model Kastner." *Jurnal Pendidikan Fisika Indonesia (Indonesian Journal of Physics Education)* 9, no. 2 (2013): 197–205.

Wardani, Restu Trisna. "Keberhasilan Rukyatul Hilal Oleh Muhammad Inwanuddin Pada Ramadan 1431 H Dan Muharram 1439 H Dalam Perspektif Nalar 'Irfani "." UIN Walisonggo, 2022.

Yunita, Binta, Judhistira Aria Utama, and Waslaluddin. "Visibilitas Hilal Dalam Modus Pengamatan Berbantuan Alat Optik Dengan Model Kastner Yang Dimodifikasi." In *Proceeding Seminar Nasional Fisika Dan Aplikasinya*, 254. Bandung: Universitas Padjadjaran, 2016.