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Investigation of the Appearance of *Fajr ṣādiq* as the Basis for Determining the Beginning of *Subuh* Prayer Time Using a Sky Quality Meter at Mount Kerinci.

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Abstract

This study aims to investigate the appearance of *Fajr ṣādiq* as the basis for determining the beginning of the *Subuh* (dawn) prayer time using a Sky Quality Meter (SQM) in the foothills of Mount Kerinci, Jambi Province. The background of this research arises from differences in the solar depression angle criteria used to determine the beginning of *Subuh*, particularly between −18° and −20°, as well as empirical findings indicating the significant influence of night-sky quality and atmospheric conditions on the visibility of dawn. This research employs a quantitative-descriptive approach with continuous observations conducted for 14 days from 23 October to 6 November 2025. Night-sky brightness data were analyzed using a sixth-order polynomial gradient fitting method to detect inflection points in the increase of brightness, which were interpreted as the appearance of *Fajr ṣādiq*. The results show that the quality of the night sky during the observation period ranged from 14 to 17 MPASS, far below the ideal threshold of 20.35 MPASS. A significant increase in dawn brightness was detected when the Sun was at a depression angle between −11° and −14°, which differs from commonly used reference criteria. This discrepancy is concluded to be the result of non-ideal weather and atmospheric conditions rather than a correction of the established criteria for the beginning of *Subuh* time. This study emphasizes the importance of long-term observations and the selection of ideal sky conditions in empirical studies of *Subuh* prayer time determination.

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A. Introduction

On 15 March 2021, one of the largest Islamic organizations in Indonesia, Muhammadiyah, established a criterion for the beginning of *Subuh* prayer time that differs from the government’s standard, based on the decision of the 13th Tarjih and Tajdid Council of Muhammadiyah in 2020 [1]. This decision revised the criterion from a solar depression angle of −20 degrees to −18 degrees at the eastern horizon, effectively delaying the beginning of *Subuh* by approximately eight minutes. This view is supported

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by the opinions of the majority of Muslim scholars with expertise in astronomy accessible to the Tarjih Council. In addition, several countries also apply a criterion for the beginning of *Subuh* at solar depression angles of −18° or lower, as shown in Table 1. [2]

Tabel 1. Solar depression angle for *Fajr* in various countries.

No	Country / Group of Countries	Solar Depression Angle at *Fajr*
1.	*Shiah Ithna Ashari (Jaafari)*	-16°
2.	*Islamic Society of North America*	-15˚
3.	*Muslim World League*	-18˚
4.	*Umm al-Qura University*	-18.5˚
5.	*Egyptian General Authority of Survey*	-19.5˚
6.	*University of Islamic Science, Karachi*	-18˚
7.	Malaysia	-20˚

The determination of the beginning of *Subuh* prayer time relies heavily on observation of a natural phenomenon known as *Fajr ṣādiq*, which is characterized by the appearance of a thin white light on the eastern horizon. However, various observations of *Fajr ṣādiq* have produced differing results. One such difference arose from observations conducted by the Islamic Science Research Network (ISRN) of UHAMKA Jakarta at a national seminar entitled '"Evaluasi Awal Waktu Shalat *Subuh* Menurut Sains dan Fikih" held on 9 May 2017. Tono Saksono, Ph.D., concluded that *Fajr ṣādiq* appears when the Sun is at a depression angle of −18 degrees. In contrast, Prof. Thomas Djamaluddin of LAPAN, Ustadz Syarief Hakim representing the Hisab Council of PERSIS, and Drs. Siril Wafa representing the Falakiyah Council (LF) of PBNU stated at the same event that *Fajr ṣādiq* appears when the Sun is at a depression angle of −20 degrees, consistent with the criterion applied in the official determination of *Subuh* prayer time [3]

The differing conclusions reported in previous studies are partly attributable to differences in observation locations. In terms of instrumentation, researchers have recently employed the Sky Quality Meter (SQM) as a light-detection device. Although SQM is primarily designed to measure the quality (darkness) of the night sky, its technical specifications enable it to detect the emergence of light at the eastern horizon effectively. Based on SQM data collected by the Badan Riset Indonesia (BRIN) Lembaga Antariksa dan Penerbangan Nasional (LAPAN) at observation sites in Garut, Kupang, Pontianak, Pasuruan, and Sumedang, it has been concluded that night-sky quality influences the timing of dawn appearance. The criterion for a night sky suitable for dawn observation is a darkness level of 20.35 MPASS [4].

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The darkness of the night sky is strongly influenced by atmospheric conditions and the geographical characteristics of the observation site. Consequently, not every location is suitable for high-quality astronomical observation. Locations with good night-sky quality are typically situated at higher elevations above sea level and far from densely populated areas. Highland regions have lower air density, resulting in reduced atmospheric light scattering, whereas residential areas act as sources of artificial light that increase sky brightness through scattering. Mount Kerinci, as one of the highest peaks in Indonesia, offers unique geographical characteristics that are both visually impressive and methodologically challenging for observing the appearance of *Fajr ṣādiq*. Despite its natural beauty, Mount Kerinci also presents particular challenges due to the limited number of studies on dawn observations conducted in high-altitude, low-light environments such as those found at Mount Kerinci. This situation raises questions about how the geographical characteristics and environmental conditions of Mount Kerinci affect the visibility of *Fajr ṣādiq*, and how these factors can be understood in a more contextual and comprehensive manner.

Previous studies have shown that artificial light pollution and atmospheric conditions have a significant influence on the detection of dawn. Bastoni found that regions with darker skies tend to detect dawn earlier than areas affected by light pollution [5]. In the context of Islamic jurisprudence, a hadith narrated by Ibn Abbas (r.a.) states that the Messenger of Allah (saw.) said: 'There are two kinds of dawn: one dawn that prohibits eating and permits prayer, and another dawn in which prayer is not permitted and eating (for sahur) is allowed' (Narrated by Ibn Khuzaimah). The dawn associated with the beginning of *Subuh* time is known as *Fajr ṣādiq*. Its natural sign is the appearance of light spreading across the horizon with a whitish color. In contrast, the dawn in which *Subuh* prayer is not permitted is called *Fajr kādhib*, which appears as a vertical light extending upward into the sky like a wolf's tail [6]. However, the precise astronomical determination of the moment of *Fajr ṣādiq* still requires repeated empirical investigation.

B. Method

This study employs a quantitative-descriptive approach. Observations were conducted at the mosque in Sungai Rumpun Village, Gunung Tujuh District, Kerinci Regency (1°45'52.68" S; 101°19'42.33" E). The primary instrument was a Sky Quality Meter (SQM) model LU-DL, which records night-sky brightness in MPASS units at 12-

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second intervals. Data were collected every night from 18:30 to 05:30 WIB for 14 consecutive days. The data were analyzed through the following steps: (1) selection of full-night data, (2) conversion of time to solar altitude, (3) data trimming within the range of −24° to 10 MPASS, (4) calculation of the gradient of brightness change, and (5) sixth-order polynomial fitting to determine the inflection point of the gradient as an indicator of the appearance of *Fajr ṣādiq*.

The analytical technique used was the polynomial fitting of the gradient curve. This procedure began by trimming the data from approximately 03:30 onward, followed by data binning or moving-average smoothing. The binning process involved averaging data over a specific interval. The binned MPASS values were then used to determine the slope (gradient) of the MPASS curve with respect to solar altitude (moving average). After obtaining the gradients between successive data points, these values were approximated using a sixth-order polynomial curve. Once the polynomial equation was obtained, setting Y = 0 yielded the smallest corresponding X value, which represents the inflection point or the time of dawn appearance. [7]

Observations were conducted at the mosque in Sungai Rumpun Village, Gunung Tujuh District, Kerinci Regency, Jambi Province. The geographic coordinates of the site are 1° 45′ 52.68″ S and 101° 19′ 42.33″ E. This location represents the easternmost point of the Kayu Aro Kerinci tourism area, making it an optimal site for minimizing external variables, particularly artificial light from nearby settlements. In addition, night-sky quality at the observation site was evaluated using data from https://www.lightpollutionmap.info/ (accessed on 14 February 2025). The map indicates that the study area is characterized by low levels of artificial light pollution compared to urban and peri-urban regions, supporting its suitability as a location for astronomical observations and for detecting the appearance of *Fajr ṣādiq*. This condition strengthens the assumption that variations in observed sky brightness are more strongly influenced by atmospheric factors than by permanent anthropogenic light sources.

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Figure 1. The mosque in Sungai Rumpun Village has an unobstructed eastern horizon with no residential areas in that direction, and the site exhibits very good sky darkness according to the light pollution map

The observation period lasted for two weeks, from 23 October 2025 to 5 November 2025. These dates were selected because throughout the night and during the appearance of dawn, the Moon remained below the horizon and therefore did not interfere with the detection of dawn light. The instrument was activated only at night, approximately from 18:30 to 05:30 WIB. Data acquisition was limited to values up to 10 MPASS, as conditions brighter than this threshold are considered sufficiently bright for the purposes of this study.

The primary instrument used in this research was a Sky Quality Meter (SQM) model LU-DL, which employs a Fresnel lens and thus has a narrow field of view (FOV) of approximately ±20°. This model is widely regarded as an international standard for dawn studies because:

1. it does not capture lateral light,
2. it records light only from a specific direction, and
3. it is ideal for detecting subtle changes in light intensity during the pre-dawn period.

The SQM device uses a TSL237 silicon photodiode sensor with a spectral response range of 320–700 nm [8]. This range closely matches the spectral response of the human eye (V-band), meaning that the resulting data approximate human visual perception while being significantly more sensitive. Consequently, the SQM is capable of detecting intensity variations that are imperceptible to the naked eye. The SQM was configured to record data five times per minute (using odd-numbered intervals), corresponding to the smallest unit of resolution required in prayer-time schedules, or equivalently set to one measurement every 12 seconds. The SQM was oriented toward the eastern horizon with an elevation angle of approximately 20° in order to avoid reflected light from the ground or surrounding objects below the instrument.

Figure 2. Installation of the SQM with housing at the mosque in Sungai Rumpun Village.

C. Results And Discussion

Night-Sky Darkness at Mount Kerinci

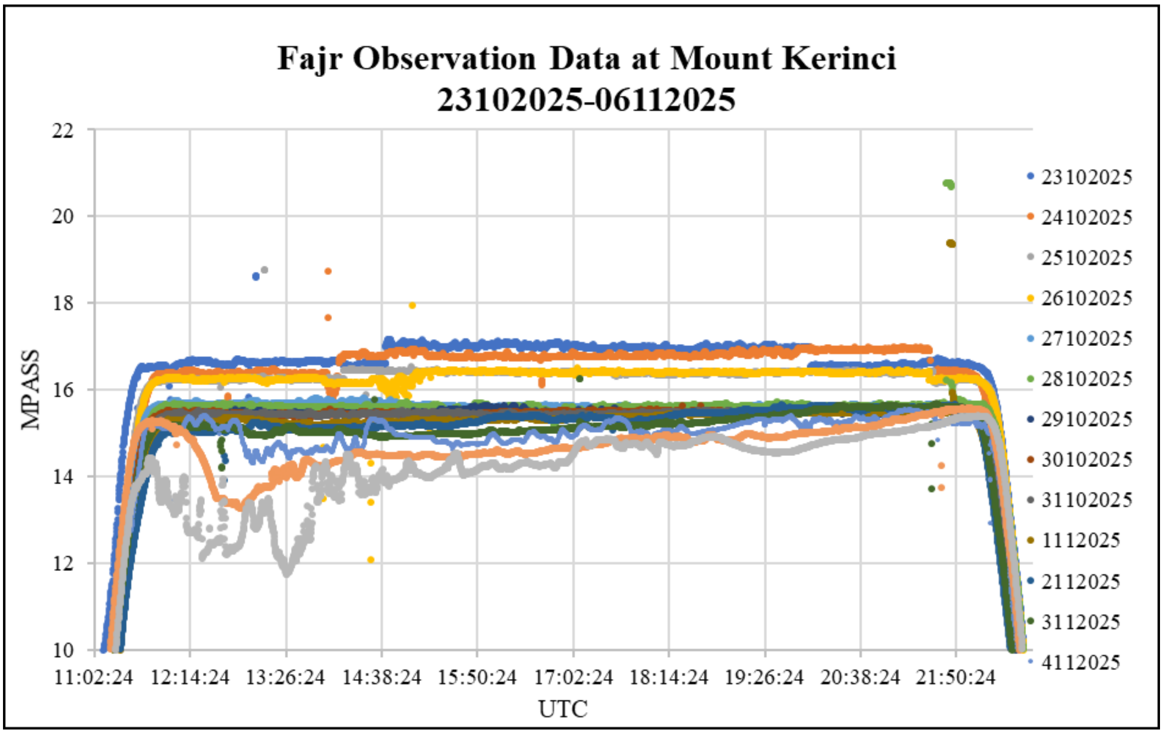

Figure 3. Graph of dawn observation data at Mount Kerinci.

This research was conducted from 22 October 2025 to 6 November 2025. These dates were selected to avoid interference from moonlight during the appearance of dawn, specifically from the New Moon phase until before the Full Moon. The results of 14 days of observation indicate that almost every night exhibited fluctuations in sky darkness values. This pattern suggests that weather conditions during the observation period were dominated by cloudy and rainy conditions.

Data trimming was applied from 22:00 WIB (15:00 UTC) to 02:00 WIB (19:00 UTC) in order to determine the average quality of the night sky in the Kerinci tourism area. The processed data shown in Figure 2 indicate that the night-sky quality toward the eastern horizon at the observation site was relatively bright. The highest darkness value

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was recorded on the first day of observation, reaching approximately 17 MPASS. The average night-sky darkness value presented in Table 2 during the observation period was around 15 MPASS. All of these darkness values indicate that the night-sky quality during the observation period was far below the minimum threshold required for reliable dawn observation, namely 20.35 MPASS.

Table 2. Average Night-Sky Quality

Date Observation	Average Night-Sky Quality (MPASS)
23102025	17,01
24102025	16,79
25102025	16,41
26102025	16,41
27102025	15,62
28102025	15,58
29102025	15,49
30102025	15,49
31102025	15,46
01112025	15,36
02112025	15,33
03112025	15,12
04112025	14,96
05112025	14,69
06112025	14,50

Fajr ṣādiq **at Mount Kerinci**

The determination of the time of dawn appearance was based on the solar depression angle (dip), obtained by converting time into solar dip. SQM data processing to determine the time of dawn appearance employed the polynomial gradient fitting method. The first stage of data processing was data trimming. The data selected for further analysis were within the range of −24° to a night-sky quality value of 10 MPASS. This trimming was performed to ensure that the curve-fitting process more closely followed the data distribution and to improve accuracy.

To obtain the gradient values, successive MPASS data points were compared. Thus, the X variable represents the solar depression angle (solar elevation), while the Y variable represents the gradient. Curve fitting was performed using a sixth-order polynomial. After the polynomial equation was obtained, the highest X value corresponding to Y = 0 was determined. This highest X value represents the time of *Fajr* appearance.

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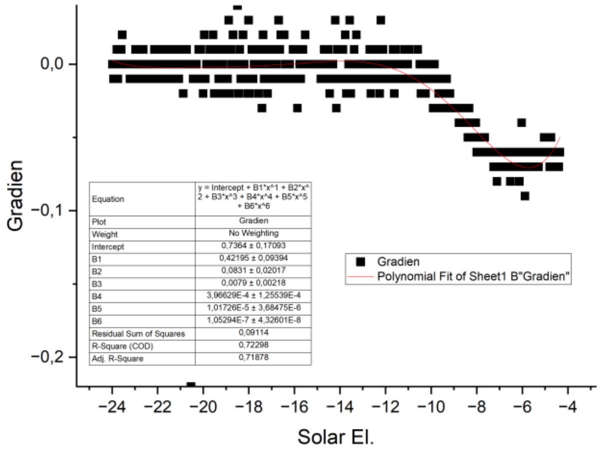

Figure 4. Gradient Curve Fitting Graph of Observation Data on 25 October 2025.

Table 3. Inflection Points of *Fajr* Brightness Increase Derived from Data Processing.

Date Obsevation	*Inflection Points Time*	*Adjusted R-squared*
23102025	-13,22°	95,033 %
24102025	-14,19°	49,907 %
25102025	-12,40°	71,878 %
26102025	-12,99°	72,357 %
27102025	-14,37°	71,045 %
28102025	-11,34°	78,842 %
29102025	-13,19°	83,963 %
30102025	-13,75°	82,869 %.
31102025	-14,18°	78,875 %
01112025	-14,38°	76,252 %
02112025	-14,64°	82,979 %
03112025	-14,19°	43,415 %
04112025	-12,80°	35,114 %
05112025	-12,79°	84,641 %
06112025	-11,57°	85,972 %

A summary of all processed results is presented in Table 4.2. The data processing indicates that a significant increase in dawn brightness detected by the SQM during observation occurred within the range of solar depression angles from −14° to −11°. These values differ substantially from the reference criteria, namely the standard values adopted by various countries for the beginning of *Subuh* prayer time as shown in Table 2.2, as well as the recommendations found in classical falak (Islamic astronomy) literature in Table 2.3. Results that deviate considerably from the reference standards are most likely attributable to the condition of the raw data obtained during the observations. Such non-ideal data conditions may be caused by several factors, including the following:

1. Presence of residential lighting without proper shielding

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Based solely on the SQM data profile shown in Figure 3, the relatively flat curve with minimal light fluctuation might suggest that the bright night-sky conditions during the observation period were caused by surrounding residential areas. However, the area around the mosque is not densely populated and contains very few houses, with the mosque being the easternmost structure in the area. The nearest house is located approximately 20 m to the south of the mosque, and there is only one such house. There are no residential settlements to the east and north of the mosque, while the nearest houses to the west are located about 30 m away. Therefore, residential settlements are not considered a significant disturbing variable affecting the data.

2. Scattering by mountain aerosol particles

   Studies on aerosols in active volcanic regions [9] indicate an increase in sky brightness at middle to high altitudes. The presence of volcanic aerosols can act as reflective media for zodiacal light, enhance light-scattering effects, and increase natural skyglow. However, during and prior to the observation period, Mount Kerinci did not experience any volcanic eruptions. Therefore, the presence of volcanic aerosol particles is not considered a variable influencing the data.

3. Moonlight

   Moonlight is sufficiently intense to “wash out” stars in the night sky and can significantly affect observations of dawn appearance. For this reason, careful attention was paid to lunar conditions by selecting the observation period from 23 October 2025 to 6 November 2025, during which the Moon was below the horizon around the time of dawn and thus did not interfere with the observations.

4. Weather conditions

   Cloud cover strongly affects measurements of sky brightness [10]. Clouds scatter light across all visible wavelengths, and temperature conditions may also cause dew formation on the SQM lens. These factors are considered the primary reasons why the SQM data obtained in this study were not ideal. During the observation period, Indonesia was experiencing La Niña conditions from September onward, resulting in an unusually prolonged rainy season. Such conditions increase the likelihood that cloud cover was present on the eastern horizon on most observation dates. Consequently, none of the observation nights achieved the minimum night-sky quality threshold of 20.35 MPASS. These unfavorable weather conditions were further exacerbated by the repeated formation of tropical cyclone precursors

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beginning in August 2025, including systems designated as 90S and 93S in September, which later developed into Cyclone Senyar.

5. Use of protective housing

   The SQM housing is intended to protect the instrument from rain and direct sunlight. However, in dawn observations this protective measure can become counterproductive. Installing the SQM at an inclination of approximately 20° in elevation may allow reflected light from the ground or nearby objects to be detected by the sensor. Although this elevation angle is intended to prevent light from surrounding surfaces from entering the sensor directly, the presence of a lens in the housing can cause light bending or refraction, redirecting reflected light toward the sensor.

Future observations are recommended to employ a microcontroller-based SQM system. The use of a microcontroller enables the SQM to operate continuously for months or even years, allowing observations to be conducted only when weather conditions are favorable. Such an approach has been implemented in the SOOF (Automated Dawn Observation System), which uses a Raspberry Pi as its microcontroller. In addition, the use of a baffle is recommended as a replacement for the housing. Because the SQM does not need to be oriented toward the zenith, it can be placed under a roof for rain protection, eliminating the need for a housing enclosure. A baffle can effectively block lateral and upward stray light that does not originate from dawn, thereby improving measurement accuracy.

D. Conclusion

During the observation period, night-sky quality in the foothills of Mount Kerinci ranged from 14 to 17 MPASS, which is significantly lower than the ideal value indicated by light pollution maps. This discrepancy was mainly caused by weather conditions, including cloud cover and condensation on the SQM and housing lenses, which scattered non-dawn light. The increase in dawn brightness detected by the SQM occurred when the Sun was at a depression angle of −11° to −14°. However, these results cannot be used as a reference for determining the beginning of *Subuh* prayer time because the minimum required sky quality of 20.35 MPASS was not achieved. Consequently, the derived values deviate substantially from the established reference range of −18° to −20°.

References

[1] Pimpinan Pusat Muhammadiyah, "Keputusan Pimpinan Pusat Muhammadiyah Nomor 734/Kep/I.0/B/2021 tentang Tanfidz Keputusan Musyawarah Nasional XXXI Tarjih Muhammadiyah tentang Kriteria Awal Waktu *Subuh*," 2021, *Yogyakarta*.

[2] H. Putraga, "Tinjauan Saintifik Awal Waktu *Subuh* di Sumatera Utara," in *Prosiding Observatorium dan Astronomi Islam (POAI)*, 2020, p. 34.

[3] T. Firmansyah, "ISRN: Waktu shalat *Subuh* dan isya perlu dievaluasi," 2017. [Online]. Available: https://www.republika.co.id/berita/duniaislam/islam-nusantara/17/08/21/ov1amm377-isrnwaktu-shalat-*Subuh*-dan-isya-perlu-dievaluasi

[4] A. Damanhuri and A. Solikin, "Batas kualitas langit yang ideal untuk lokasi observasi awal waktu *Subuh*," *Al-Marshad J. Astron. Islam dan Ilmu-Ilmu Berkaitan*, vol. 8, no. 1, 2022, doi: 10.30596/jam.v8i1.9355.

[5] M. Basthoni, "Efek polusi cahaya terhadap penentuan awal waktu *Subuh* di Indonesia," Universitas Islam Negeri Walisongo, Semarang, Indonesia, 2022.

[6] A. J. R. Butar-Butar, *Fajar dan syafak dalam kesarjanaan astronomi Muslim dan ulama Nusantara*. Yogyakarta: LKiS, 2018.

[7] A. A. Rochman, D. Herdiwijaya, and H. Setyanto, "Tingkat kepercayaan fitting polinomial kurva gradien data SQM untuk menentukan kemunculan fajar," *J. Multidiscip. Acad.*, vol. 1, no. 1, pp. 16–24, 2019.

[8] Unihedron Instruments, "SQM-LU-DL Operator's Manual," 2025. [Online]. Available: https://www.unihedron.com/projects/darksky/cd/SQM-LU-DL/SQM-LU-DL_Users_manual.pdf

[9] B. Holben and others, "Aerosol Properties in Volcanic Regions," *J. Geophys. Res. Atmos.*, 2001.

[10] K. Krisciunas, "Effects of Thin Clouds on Sky Brightness," *Publ. Astron. Soc. Pacific*, 2017.