Salat / Fasting Time in Northern Regions

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Abstract:
In this paper we examine the issue of Fasting -and by extension Salat- in high latitude northern (or southern) areas of the globe where the day's length is unusually long or short. We set out to find where and when this occurs. To approach the problem systematically, we defined "normal" day from a Muslim perspective using physiological considerations, then we use that definition as criteria to classify the days.
Days that are normal are treated as such, however, for days that are not normal, we recommend following the schedule of a standard latitude. The standard latitude is the highest latitude with normal days all year round, and we argue that such latitude is 45°, and we call the region between ± 45° "the normal region".

Introduction:

For Muslims, performing the Fasting of Ramadan or Salat could present a challenge in the northern latitudes in the northern hemisphere (southern latitudes for the southern hemisphere) because these rituals are marked by the apparent motion of the sun in the sky. The timing is suitable for lower to moderate latitudes where the day/night cycle is "normal" and doing say Fasting is possible. However, at high latitudes it ranges from possible to impossible depending on the location and the time of the year. For example, for places near the poles, the days extend to months, and therefore, some special treatment is required.
Before getting into the details of such treatment, we examine how and why these phenomena occur in the first place.

Day's Length and Axis Tilt:

As the earth orbits the sun, its axis has a tilt of about 23.5° degrees (23° 26´ 21.448´´) Such a tilt causes the seasons, and also makes summer days longer in the northern hemisphere (the opposite for the southern hemisphere).
The length of the day depends on the latitude of the location, or how far is it from the equator.
Places in the **Polar Circle** which is the areas who's latitude is above 66.5° N (66° 33´ 44´´ N) for the northern hemisphere (Arctic circle), would experience at least one 24 hours day during the summer, and in the extreme case, it is six month day at the pole. During winter, it is at least one 24 hours night, and at the pole it is six month night. The opposite is true for the southern hemisphere polar circle (Antarctic Circle) which is the area below 66.5° S.

While the earth orbits around the sun, the angle between the sun rays and the earth's surface changes slowly from -23.5° to 23.5° with zero at the equinoxes. The maximum tilt towards the sun represents the height of summer, and is called the Summer Solstice and it occurs on June 21 which is the longest day of the year in the northern hemisphere.

Figure 1 shows the earth with maximum tilt towards the sun (summer solstice). We notice that the portion of the northern hemisphere that has light (marked with golden hatching) is bigger than the portion that at night (green hatched area). Also notice that the polar circle (red line) would stay in the day portion as the earth rotates around itself.

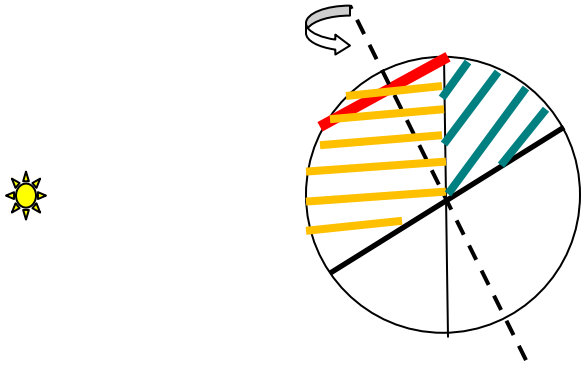

Figure 1. Day and night during the summer solstice

We can look at the figure from the other side to represent the winter solstice (we have to reverse the color definitions: gold is night, and green is day, and the sun would be on the other side), and in that case, the polar circle would be in the night, also, the day part is smaller than the night side, and that is how the tilt of earth causes the change in the day's length.

Twilight:

If the earth didn't have an atmosphere, the change from day to night and vice versa would be sudden, but due to the effect of atmosphere, light is dispersed. The dispersion of light depends on the local atmospheric conditions as well as the level of pollution and particulate in the air. This diffusion of light as a result of dispersion causes change from day to night and from night to day to be a gradual one, giving rise to the phenomenon of twilight.

Twilight is the light before sunrise (dawn) and after sunset (dusk). Traditionally, it is divided into three periods: civil, nautical and astronomical twilight corresponding to angle of solar depression (center of the sun) at 6°, 12°, and 18° degrees respectively. The meaning of solar depression (or solar altitude) is shown in figure 2. It is generally accepted that the end of twilight occurs at 18 degrees, and such an angle is used for determining Isha and Fajr with some variations that are used by different countries and organizations from 15° for ISNA to the more conservative 20° in Egypt.

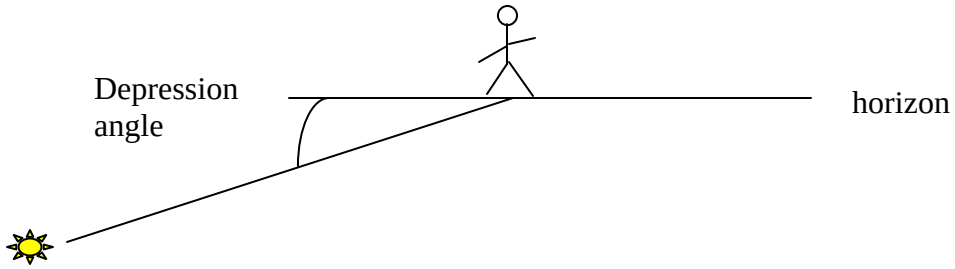

Figure 2. The solar depression angle (Solar Altitude)

Light Level Measurement and Photometry:

The times for Isha and Fajr are described in terms of the light condition of the sky, for example, Isha's time is when the redness in the sky is gone, and it is thoroughly dark, while the Fajr time is when the first light of the dawn is recognizable at the end of the night. The above definitions are not easy to use, so people tried to relate them to something that can be measured more readily like the dip angle. However, those descriptions are still dependent on subjective judgment of the observer, and the only way to make it less dependant on the observer is to measure the light intensity using sensors and relate that to the Sharia definition of Isha and Fajr times.

The amount of light in the environment is measured by the lux. It is the intensity of light as perceived by the human eye, and is defined as the luminous flow per unit area: lux = (lm/m^2). Typical values are (under normal atmospheric conditions, and no moon light) :

Illumination (lux)	**Environment Condition**
600	Sunrise./sunset: The upper edge of the sun is at the horizon
6	Civil Twilight: The sea horizon is clearly defined, large objects distinguishable
0.06	Nautical Twilight: The sea horizon is not normally defined.
0.0006	Astronomical Twilight: The diffused sun light contribution is less than other objects in the sky.

So far, there is no agreed upon standards that relate the light intensity with the Isha and Fajr times.

Effect of Latitude and Time of the Year on the Length of Day:

To illustrate the effect of the time of the year on the length of the day, we start with March 21 which represents the spring equinox, where the day and night are equal, and the earth is not tilted towards the sun.

Figure 3 shows the solar altitude or the height of the sun in the sky (sometimes negative values are called dip angle) as the day changes from 0 at mid night through 24 hours (local solar time). The graphs show several latitudes: 0° latitude which corresponds to the equator, 21.4° N that represents Mecca's latitude, also, 45° N, 48° N, 60° N, and

66.5° N which represents the arctic circle, and 80° N which represents areas close to the pole.
The lower gray area represents the night, while the yellow upper area is the day area, and the white area in between is the twilight area.
Let us take Mecca's latitude curve (21.4° N, with red curve and square markers). At midnight (0 hour), the solar altitude angle (dip angle) is -69° degrees, as time progresses, the dawn starts at about 4:30 a.m. (local solar time) in the morning, and we enter the twilight zone. The sun rises at 6:00 a.m., as the altitude angle is zero. At midday, the sun altitude is 69° degrees in the sky overhead. The sun sets at 6:00 p.m., and we enter the twilight zone, which ends at about 7:30 p.m., and the night starts and continues to complete the 24 hours.
Notice in this figure, for latitude 80° N, the sun doesn't get into the night zone, so the further north we are the less night we have.

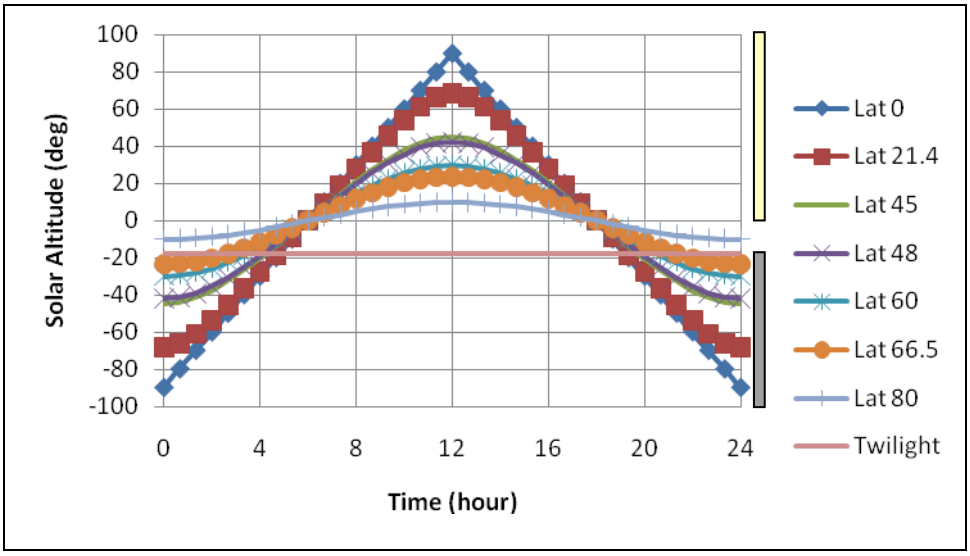

Figure 3. The Day/Night curves on March 21 (Spring Equinox)

Another observation is that all the curves share the noon point.

In figure 4, we examine the graphs a month later (on April 21) where the angle of the earth with respect to the sun is about 11.6° degrees. We notice that all the graphs are moving up from the night portion to the day portion (maximum dip angle for Mecca is -57° at midnight, indicating that the day is getting longer and the night is getting shorter. Now the polar circle area 66.5° N doesn't get into the night zone (persistent twilight), and the area close to the pole is firmly in the day part all the time. We notice that the 60 N is hardly having a night portion.

As time progresses, we move to May 21 in figure 5. It is clear that the day is getting longer and the night is getting shorter. The sun is higher at midday (almost normal over Mecca at noon), and the 60° N region would experience persistent twilight.

Figure 6 shows the graph on June 21 which is the summer solstice, and that corresponds to the longest day of the year for the northern hemisphere. In his case, for latitude of 45° N the night is very short (about 3 hours total).

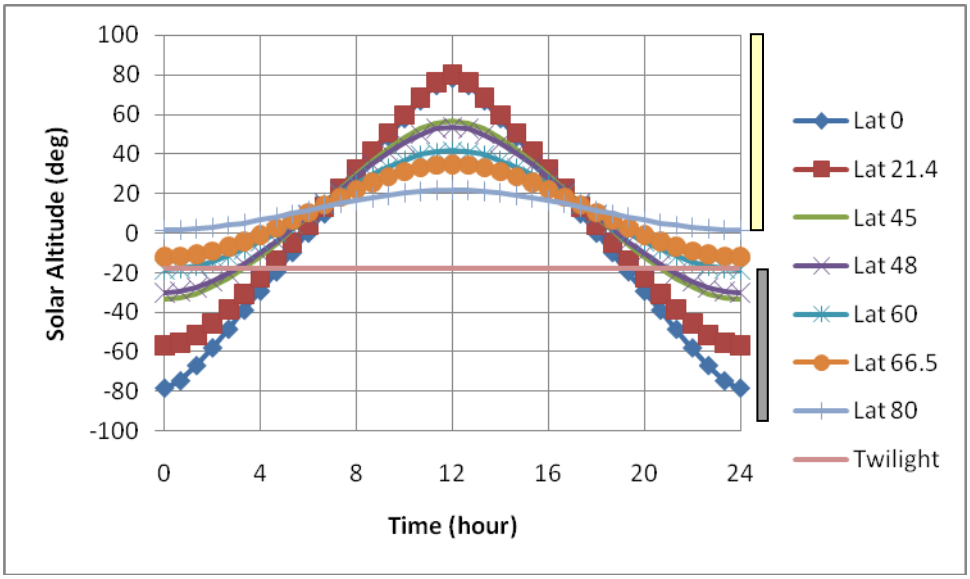

Figure 4. The Day/Night curves on April 21

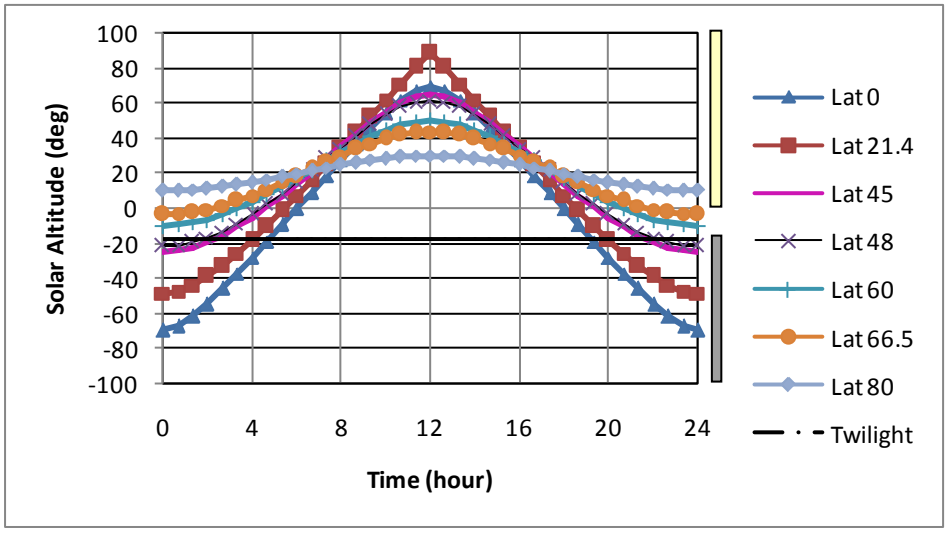

Figure 5. The Day/Night curves on May 21

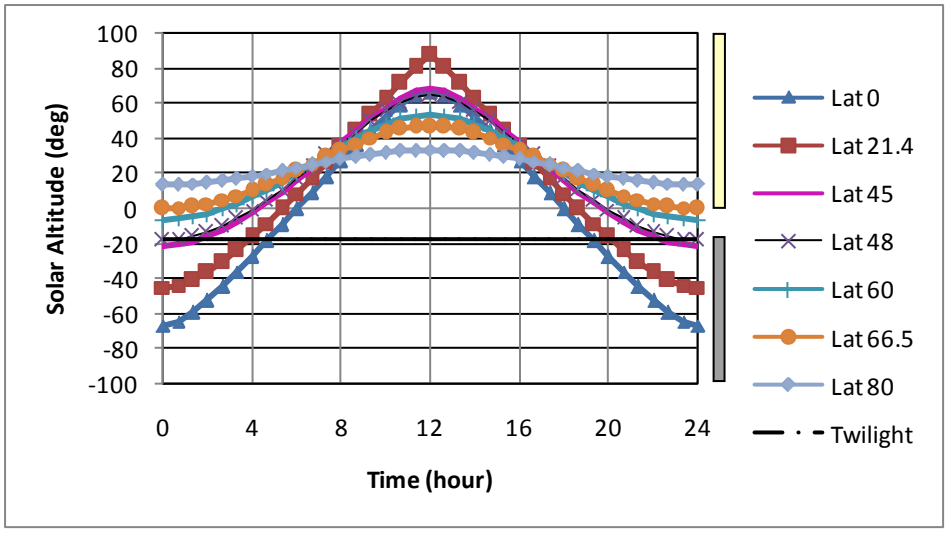

Figure 6. The Day/Night curves on June 21 (Summer Solstice)

From figure 6, we see that places which are close to the polar circle would experience permanent dusk, ”glare”, or midnight or persistent twilight .
Therefore, locations north of 48° latitude would not meet the requirement for Isha time on some days during summer (no true night). For example, for a location at 60° N, such a phenomenon would extend from April 21 to August 24.

As the year progresses on from the summer solstice, the trend is reversed and the day gets shorter until we hit the fall equinox around September 21 where the day is equal to the night. From that day on, the day will continue to get shorter while the night gets longer until we reach the winter solstice on December 21, with the shortest day (longest night) of the year.

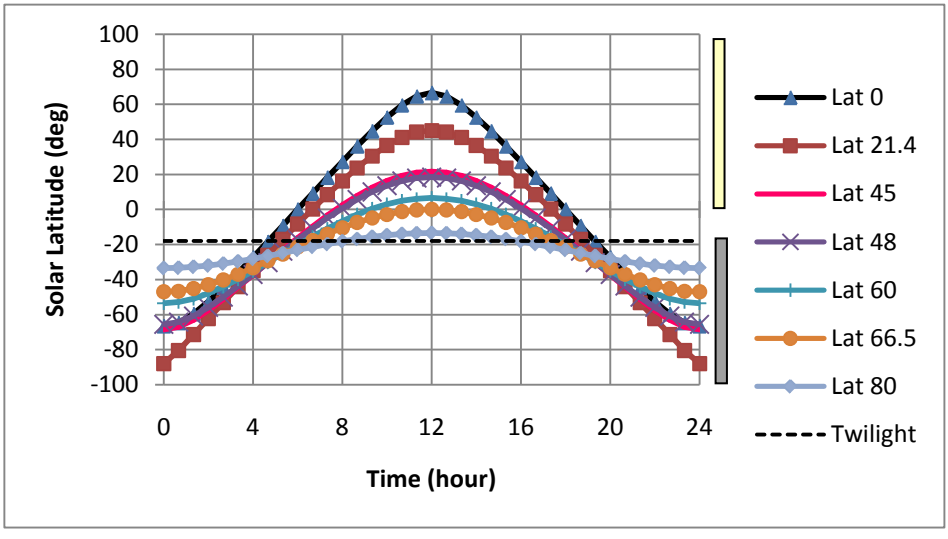

Figure 7. The Day/Night curves on December 21 (Winter Solstice)

We notice in figure 7 that the arctic circle and above don't go into the day part. At noon, for the 45° degrees latitude, the sun height (altitude) is 21.5° in the sky, compared to 68.5° degrees during the summer solstice.

From that point, the day will start to increase in length until we reach the spring equinox on March 21 where the night and day are equal.

The cycle repeats again: The day increases to a maximum on the summer solstice, then decreases to be equal to the night at the fall equinox, then it continues to shorten until it reaches a minimum at the winter solstice, then it increases to be equal to the night at the spring equinox. Therefore, studying one quarter of this cycle will be sufficient to understand the whole cycle. Figure 8 shows the day/night cycle for latitude 45° from the spring equinox to the summer solstice.

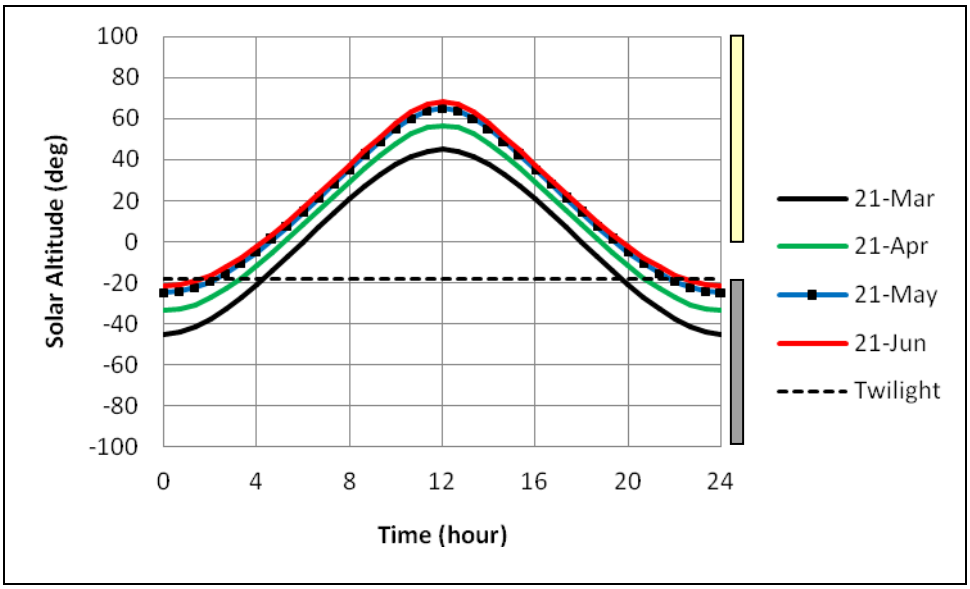

Figure 8. Daytime change as time of the year changes for 45 latitude

Survey of Fiqhi Opinion:

From the above analysis, we can see that some regions would have days that extend 24 hours and beyond, while others would experience persistent twilight depending on the latitude of the location. The religious rules for Fasting and Salat are well established for "normal" regions that don't experience these "anomalies", therefore, different methods have been suggested by scholars to accommodate the new situations.

Dr Mohamed Hawari did a good survey of opinions about the subject of Fasting in high latitude areas. Another good summery is done by professor Ilyas in his book *Astronomy of Islamic Times For the Twenty First Century*. We summarize the current opinions here:

The Fiqh Council meeting in Mecca on February 4, 1982 in its opinion considered three cases:
The first case is if the day (or night) extends 24 hours and beyond then, people should use the timing of the closest region that does have day and night.
The second case is where twilight periods of the evening and morning can't be distinguished (persistent twilight), then the Isha and Fajr should be estimated using the schedule when they were distinguishable..
Case three, if there is day and night within the 24 hours period, then, Salat and Fasting should be done using the normal procedures irrespective of the length of the day or night. Those who can't do it for health reasons are under the exception for sick people.

Shikh Mustafa Zarka has objected to the above opinion on grounds that the decision doesn't address the case when the Fasting extends close to 24 hours. Fasting that long doesn't make much sense. He recommended using Mecca's time, or using the timing of the furthest northern Islamic frontiers in the past.

The Azhar Fatwa Committee in their decision on April 24, 1983 stated that in places where it is difficult to fast, people could use Mecca's time, starting with local Fajr, then using Mecca's schedule. Others suggested using closest "normal" region schedule.

<u>Other ways for dealing with persistent twilight:</u>
Shikh Faysal Mawlawi advocated the use of nautical twilight for areas when the sun doesn't set below 12 degrees.
Another approach is called: Middle of Night method: Isha is before the midpoint of the night (sunset to sunrise) by a certain amount, while Fajr is after the midpoint.
Another approach for persistent twilight that has been suggested is the Seventh Parts method: In this case, the "night" is divided into seven parts. Isha is after the first, and Fajr in the last one.

Professor Hamidullah in his book *Introduction to Islam* suggested that regions above latitude of 45° should use the timing of the 45° all year long, and that goes for Salat and Fasting..

<u>Normal Islamic Day:</u>
While the objection of Shikh Zarka in the previous section is legitimate one, the problem can be framed better if we can define what is a "normal" day.
The Hadith of the Dajal establishes the concept of "abnormal" day when the prophet (P) talked about days that were equivalent to a year, a month, and a week, and told about the need to give it special consideration because of its length when it comes to Salat. Clearly Salat is done at specific parts of the day, but if the day is not "normal" then, special treatment has to be done. Fasting is addressed in similar way.
The next logical step is to define what is normal when it comes to a day. Our approach is to examine the activities that should occur during the day and see if we can draw some conclusions.

In a normal fasting day, we have to break our fast. Also, it is strongly recommended to have a Suhur or a meal before starting the next fasting day, therefore, it is important to have two meals: Breakfast and Suhur.
In order to have two meals, it is important to have the second meal on an empty stomach. The time it takes the food to pass through the stomach is not uniform and varies significantly with the composition of the meal. For example, parsley takes 1.25 hours, 3 hours for broccoli, 4 hours for turnip, while some dairy product like whole milk hard cheese can take up to 5 hours. The time is also affected by the stress level and gender. However, for rough estimate, it takes around 6 hours for total emptying of the stomach. So we could argue that a "normal" fasting day should be less than 18 hours in a 24 hours period, else, it is classified as "abnormal", and special treatment would apply.

Reference Latitude:

Having established the concept of a normal day, we need to find the highest latitude at which the days are normal, and beyond that latitude, some or all the days are "abnormal". Finding that location is important because we can use it as a reference for other regions that lack the "regular" night day cycle.

Taking 18° for Isha and Fajr twilight calculations, the northernmost location that has day and night is around 48°N. Using longitude of 83.3°W on June 21, the times are:

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
2:14	5:32	1:35	5:50	9:37	12:54

We notice that sunrise to sunset is 16 hours, and the fasting day is about 19.25 hours, which according to our criteria represents an "abnormal" day.

For 45° N, at same longitude (and 18°):

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
3:12	5:46	1:35	5:43	9:24	11:56

The sunrise to sunset is 15.75 hours, and the fasting day is about 18.2 hours.
This latitude very close to meeting the requirement for "normal day".

For comparison, at the latitude of Mecca (21.4° N, at 18°), the schedule looks like:

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
5:26	6:51	1:35	4:45	8:18	9:43

In this case, the sunrise to sunset is 13.45 hours, while fasting day is 14.87 hours

Using 15° dip angle, it is possible to use higher latitudes for reference region. For example:

For 45° N with 15° dip angle

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
3:49	5:46	1:35	5:43	9:24	11:20

Sunrise to sunset is 15.6 hours, and fasting day is 17.6 hours, which seems to meet the requirement.

For comparison, using the 15° dip angle for Mecca latitude, the schedule is:

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
5:40	6:51	1:35	4:45	8:18	9:29

Where the sunrise to sunset is 13.45, and the fasting day 14.63 hours

For 48° N with 15° dip angle

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
3:16	5:33	1:35	5:50	9:37	11:52

Sunrise to sunset is 16.1 hours, and the fasting day is 18.3 hours, which is slightly above our limit.

For 50° N with 15° dip angle

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
2:43	5:23	1:35	5:54	9:46	12:26

Sunrise to sunset is 16.3 hours, while the fasting day is 19 hours.

Based on the above, we choose 45° N as a suitable reference latitude with 15° dip angle.

Notes:

- The region between ±45° is called the ***"Normal Region"*** and contains no "abnormal" days.

- The use of 18° is possible but would entail a bit longer fasting day, and the digestion time is slightly less than six hours which might be acceptable.

Short day case:

In the winter, the day could become pretty short as we go north. Since we used the schedule for the parallel of 45° N as a standard or reference when the day was too long, for consistency, we will use the same referance when the day is short during the winter. Otherwise, we will have a very short day that goes to zero as we go north.

The time for the shortest day of the year is:

For winter solstice (December 21) at 45° N (18° dip angle)

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
6:19	8 :7	12:31	2:36	4:54	6: 40

The day's length is 16.9 – 8.12 = 8.78 hours, and the fasting day is 16.9 – 6.32 =10.58 hours

For comparison, the times at Mecca's latitude are:

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
5:45	7:5	12:31	3:34	5:56	7:15

The day's length in this case is 17.93 – 7.08 = 10.85 Hours, and the fasting day is 17.93 – 5.75 = 12.18 hours

For winter solstice (December 21) at 45° N (15° dip angle)

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
6:37	8 :7	12:31	2:36	4:54	6: 22

The day's length is 16.9 – 8.12 = 8.78 hours, and the fasting day is 16.9 – 6.62 =10.28 hours
For comparison, the times at Mecca's latitude are:

Fajr	Sunrise	Zuhr	Asr	Magrib	Isha
5:51	7:5	12:31	3:34	5:56	7:09

The day's length in this case is 17.93 – 7.08 = 10.85 Hours, and the fasting day is 17.93 – 5.85 = 12.08 hours

Therefore, the 45° parallel (reference latitude) will give a maximum fasting day of 17.6 hours (17 h 36 m), and a minimum of 10.28 hours (10 h 17 m). For Mecca, the maximum fasting time is 14.63 hours (14 h 38 m), and the minimum is 12.07 hours (12 h 5 m).

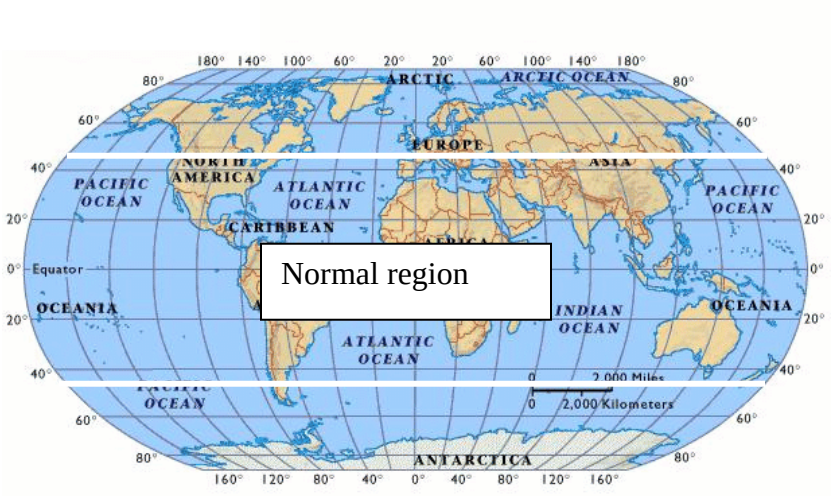

Figure 9. The "Normal region"

In figure 9 we show the "normal region" that is bounded by parallel 45° N, and 45° S, while areas outside this region would contain abnormal days at least some of the time.

Rule:

If the person lives within the normal region, then fasting will be conducted normally. For people who live outside the normal region, the length of the fasting day should be less than 17 h 36 m, if it is above that, then, the 45° parallel timing should be followed. During the short periods, the length of the fasting day should not be below 10 h 17 m. If it is shorter, then, the 45° parallel timing should be followed.
The reference time is noon since it is common time for the longitude.
Salam timing is treated similarly.

Issues:

The above rule suffers the possibility of having sudden changes in the length of the day of fasting which could have some effect on the person. To illustrate the point I will use the following example:

Suppose that for the sake of argument that our criteria is that we need the fasting day not to exceed 17.6 hours. If we live at parallel 55°, then the schedule for the month of August would look like:

Day	Fajr	Sun_R	Zuhr	Asr	Magrb	Isha	Higri	Fasting
TH 1	3.00	5.69	13.64	17.88	21.58	24.23	24.00	18.58
FR 2	3.08	5.72	13.64	17.87	21.55	24.15	25.00	18.47
SA 3	3.16	5.75	13.64	17.85	21.51	24.07	26.00	18.36
SU 4	3.23	5.78	13.64	17.84	21.48	24.00	27.00	18.25
MO 5	3.31	5.81	13.64	17.82	21.45	23.92	28.00	18.14
TU 6	3.38	5.84	13.64	17.81	21.41	23.85	29.00	18.04
WE 7	3.44	5.87	13.63	17.79	21.38	23.78	30.00	17.94
TH 8	3.51	5.90	13.63	17.77	21.34	23.71	1.00	17.83
FR 9	3.57	5.93	13.63	17.76	21.31	23.64	2.00	17.73
SA 10	3.64	5.96	13.63	17.74	21.27	23.58	3.00	17.64
SU 11	3.70	5.99	13.62	17.72	21.24	23.51	4.00	17.54

We notice that the first 10 days don't meet our criteria therefore, we switch to the 45° parallel schedule:

Day	Fajr	Sun_R	Zuhr	Asr	Magrb	Isha	Higri	Fasting
TH 1	4.63	6.29	13.64	17.66	20.98	22.64	24.00	16.35
FR 2	4.66	6.31	13.64	17.65	20.96	22.61	25.00	16.30
SA 3	4.69	6.33	13.64	17.64	20.94	22.57	26.00	16.25
SU 4	4.72	6.35	13.64	17.63	20.92	22.54	27.00	16.20
MO 5	4.75	6.37	13.64	17.62	20.89	22.51	28.00	16.15
TU 6	4.77	6.39	13.64	17.61	20.87	22.48	29.00	16.09
WE 7	4.80	6.41	13.63	17.60	20.85	22.45	30.00	16.04
TH 8	4.83	6.43	13.63	17.59	20.82	22.41	1.00	15.99
FR 9	4.86	6.45	13.63	17.58	20.80	22.38	2.00	15.94
SA 10	4.89	6.47	13.63	17.57	20.77	22.35	3.00	15.89
SU 11	4.92	6.49	13.62	17.56	20.75	22.32	4.00	15.83

So we fasted the last 10th day at a length of 15.89 hours (15h 54 m), and then we switch back to our timing in the 11th day at fasting day length of 17.54 hours (17 h 33m). It means that we have a difference between two consecutive days of 1.65 hours (1 h 39 m). To avoid this situation, we could decide to follow the 45° timing always as long as we live outside the normal area, and that would be similar to Professor Hamedullah approach.

Conclusion:

In this work, we examined how the day's length changes with latitude and with time of the year. Since Fasting and Salat are timed using the apparent movement of he sun in the sky, at high latitudes, different methods have to be used because the "normal" features of day and night are missing. To enable systematic solution of the problem, we introduced the concept of a "Shari normal day" as a day that has a maximum of 17 hours and 36 minutes of fasting within 24 hours using physiological reasoning.

Then, we determined a "normal region" which is a region that has no abnormal days, and we argued that the limits of such a region are the parallel 45° degrees 9North and south). We also defined "reference latitude" as the highest latitude that doesn't have abnormal days.

Therefore, for regions that are above 45° degrees (or below in the southern hemisphere), are considered not normal and would have some "abnormal" days that would require special treatment: The day is examined: if it is normal (fasting time is between 10 h 17 m, and 17 h 36 m), then, Fasting and Salat are done using the usual rules. If the day is "abnormal", then, we use the schedule of the 45° degrees. We use noon as the common point between the local time and the 45° degree schedule.

We have pointed to the issue of sudden changes in the length of the day of fasting when using this method, and we suggested that we might consider using the 45° timing on a permanent basis to avoid this problem.

Acknowledgements:

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http://www.islamicity.com/prayertimes/Salat.pdf

بالنسبة للبلاد التي يضطرب فيها أوقات الليل والنهار قرر المجمع الفقهي الإسلامي- التابع لرابطة العالم الإسلامي- في شأنهم ما يلي:

تنقسم الجِهات التي تقع على خطوط العرض ذات الدَّرجات العالية إلى ثلاث:

الأولى: تلك التي يستمر فيها الليل أو النهار أربعًا وعشرين ساعة فأكثر بحسب اختلاف فصول السنة.

ففي هذه الحال تقدَّر مواقيتُ الصلاة والصِّيام وغيرهما في تلك الجهات على حسب أقرب الجهات إليها ممّا يكون فيها ليل ونهار متمايزانِ في ظَرف أربع وعشرين ساعة.

الثانية: البِلاد التي لا يَغيب فيها شفق الغُروب حتّى يطلع الفجر، بحيث لا يتميّز شفق الشروق من شفق الغروب، ففي هذه الجهات يقدَّر وقت العِشاء الآخرة والإمساك في الصوم وقت صلاة الفجر، بحسَب آخر فترة يتمايَز فيها الشَّفَقان.

الثالثة: تلك التي يظهر فيها الليل والنّهار خلال أربع وعشرين ساعة وتتمايَز فيها الأوقات، إلا أنّ الليل يطول فيها في فترة من السنة طولاً مُفْرِطًا، ويطول النهار في فترة أخرى طولاً مُفرطًا.

ومَن كان يقيم في هذه البلاد التي يتمايَز فيها الليل من النهار بطلوع فجر وغروب شمس، إلا أنّ نهارَها يطول جدًّا في الصيف، ويقصُر في الشتاء، وَجَبَ عليهم أن يُمسكوا كلّ يوم منه عن الطعام والشّراب وسائر المُفْطِرات من طلوع الفجر إلى غروب الشمس في بلادهم مادام النهار يتمايز في بلادهم من الليل، وكان مجموع زمانهما أربعًا وعشرين ساعة، ويحلُّ لهم الطعام والشراب والجِماع في ليلهم فقط وإن كان قصيرًا.