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THE EFFECT OF EPHEMERIS DATA RETRIVAL BASED ON TIME ZONES ON THE CALCULATION OF THE BEGINNING OF PRAYER TIMES

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Abstract

Five-time praying is valid if someone do the action when it has entered its time. The determination of prayer times need data from Ephemeris which is based on the sun's motion. Here, the calculation needs sun's declination and equation of time. Then how if someone do an error in taking Ephemeris data to calculate the time prayer. Should it affect the result. This research also examines how was the effect of prayer time using the *taqribi* sun's motion in old books or *kitab falak kuno.* This article is library research using qualitative data presentation method. This research departs from the question that whether the difference in time zones will essentially affect the results of the calculation of the beginning of prayer time. The focus of this research is implied in whole globe of Earth by choosing four loci from China. This is due to the large area of China but using one type of time zone. From the calculation, the result is the ephemeris data retrieval errors in this calculation do not have a significant impact. There are three reasons why it is not that significant. First, when the Ephemeris data is calculated with trigonometric variables, it will produce smaller data than before. Second, Muslim only need the hour and minute not until the second. Third, there is an addition time to prayer times called *ihtiyat* or prudence.

Keywords: Ephemeris; Time Zone, Sun's Declination; Equation of Time; Prayer Times

A. Introduction

Prayer is a time-bound act of worship. The time of prayer is one of the criteria that allows folks to determine when they can pray. This is because one of the conditions for the validity of one's prayer is when it has entered the time prayer. However, if it has not entered the prayer time, the prayer will be invalid. Therefore, to know whether the prayer

time has come or not can be obtained from a calculation of the beginning of the prayer time.[1]

In determining the calculation of the beginning of prayer time, we need data related to the position of the sun contained in the Ephemeris in the form of sun's declination data and the equation of time. These two data are obtained by taking data at a predetermined time so that we cannot just take the data immediately. We need to identify the data at what time will be taken because this data is related to the time zone of the place. Thus, the time zone affects the data retrieval in the Ephemeris. The reason why the time zone affects data retrieval on Ephemeris is because the data available in Ephemeris is data that refers to Universal Time or Greenwich Mean Time. So that in taking data such as at noon, namely 12 o'clock, this 12 must be reduced first by the local time zone so that after the results are obtained, the hour results are referred to retrieve data in the form of sun's data or moon data in Ephemeris according to what is needed.

The time zone of a place is determined by the agreement of the country so that the country has a large share in determining time. Based on this statement, not all countries have time zones based on the geographical location of the country. So, the thought arises whether taking Ephemeris data based on the time zone of a country that is not based on geographical location will have an impact on the results of the calculation of the beginning of prayer time. If this has an impact on the results of the calculation then how the actual calculation of prayer time.

In addition, this problem also reflects in the use of *taqribi* (estimation) Ephemeris data, which was used by the previous Falak's books. The authors basically provide one date with only one sun's declination and one equation of time. They only give the readers to use one specific data instead of providing declination and equation of time each day as the Ministry of Religious Affairs provided. It makes the result of the formula use the rough data estimation. Therefore, this research also indirectly examines how far the

[1] Nur Amirah, "Analisis Penentuan Waktu-Waktu Haram Salat Di Sungguminasa Kecamatan Somba Opu Dalam Perspektif Ilmu Falak," *HISABUNA: Jurnal Ilmu Falak* 1, no. 2 (2020): 43, https://doi.org/https://doi.org/10.24252/hisabuna.v1i2.14953.

difference of the time prayer result of taking rough data compared to using dynamic data as in Ephemeris.

Literature Reviews

This research refers to the retrieval of Ephemeris data based on the time zone which is related to the geographical location of a place. There are several literatures that discuss prayer times, Ephemeris, geographic coordinates and time zones.

In article "Analisis Posisi Astronomis (Lintang dan Bujur) Terhadap Perbedaan Awal Waktu Shalat di Provinsi Maluku [2]", the paper explains that the difference in the beginning of prayer time in a place is influenced by the latitude and longitude of the place. This study does not pay attention to the time zone variable for sun's declination and equation of time data retrieval. In article "Perbandingan Tingkat Akurasi Hasil Perhitungan Awal Waktu Salat Menggunakan Jam Digital dan Ephemeris 2021[3]" discusses the accuracy of calculating the beginning of prayer time using digital clocks and comparing it with the Ephemeris. But in this research, time zone is not one of the focuses of this research.

Article "Relevansi Jadwal Waktu Salat Sepanjang Masa [4]" describes the relevance of a prayer time schedule that is used throughout time because it considers the Ephemeris data collection in the form of sun's declination and time averaging that always changes every time. So, this study examines whether the prayer time schedule used throughout the ages will have implications that are relevant at any time. However, this study does not discuss the existence of time zones for Ephemeris data collection and its effects.

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[2] SRI RAHMADANI PULU PULU, "Analisis Posisi Astronomis (Lintang Dan Bujur) Terhadap Perbedaan Awal Waktu Shalat Di Provinsi Maluku.," *JURNAL PENDIDIKAN MIPA*, 2022, https://doi.org/10.37630/jpm.v12i1.540.

[3] Nurul Ahyani, "PERBANDINGAN TINGKAT AKURASI HASIL PERHITUNGAN AWAL WAKTU SALAT MENGGUNAKAN JAM DIGITAL DAN EPHEMERIS 2021," *Jurnal Al-Hakim: Jurnal Ilmiah Mahasiswa, Studi Syariah, Hukum Dan Filantropi*, 2021, https://doi.org/10.22515/alhakim.v3i1.3867.

[4] Riza Afrian Mustaqim, "RELEVANSI JADWAL WAKTU SALAT SEPANJANG MASA," *Jurnal Alwatzikhoebillah : Kajian Islam, Pendidikan, Ekonomi, Humaniora*, 2020, https://doi.org/10.37567/alwatzikhoebillah.v6i2.282.

Based on journal article of "Zona Waktu dan Implikasinya Terhadap Penetapan Awal Waktu Shalat Pengaruh Zona Waktu Terhadap Penetapan Awal Waktu Shalat [5]", has the same explanation as Rahmi's previous journal Article "Penyatuan Zona Waktu dan Pengaruhnya terhadap Penetapan Awal Waktu Shalat[6]". In the latest article, they propose two ways to determine the beginning of prayer time, namely by adding or subtracting one hour from the prayer schedule that has been calculated in the central part of Indonesia so that the eastern and western parts just adjust to the central part and propose a second way to calculate the beginning of prayer time by converting sun's declination, time leveling and standard longitude. This research does not discuss the effect of taking ephemeris data based on time zones on the calculation of the beginning of prayer time. In addition, they just focus on Indonesia locus meanwhile this research put focus on globe view.

Based on "Jadwal Sholat Digital Menggunakan Metode Ephemeris Berdasarkan Titik Koordinat Smartphone[7]" article, they examine the calculation of prayer times using Ephemeris data and geographic coordinate data based on Smartphone. However, this research does not discuss the effect of the time zone on Ephemeris data retrieval. "Koreksi Ketinggian Tempat Terhadap Fikih Waktu Salat: Analisis Jadwal Waktu Sholat Kota Bandung [8]" discusses that in addition to geographical coordinates in the form of latitude and longitude, there is one variable that also affects the calculation of the beginning of prayer time. This variable is elevation or altitude. It is known that the city of Bandung has various elevations so that it can be considered regarding its influence on the

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[5] Nailur Rahmi and Irma Suriani, "Zona Waktu Dan Implikasinya Terhadap Penetapan Awal Waktu Shalat Pengaruh Zona Waktu Terhadap Penetapan Awal Waktu Shalat," *PROCEEDING IAIN Batusangkar*, 2020.

[6] Nailur Rahmi, "Penyatuan Zona Waktu Dan Pengaruhnya Terhadap Penetapan Awal Waktu Shalat," *Juris* 13, no. 1 (2014): 75–83.

[7] Safiq Rosad, Anton Yudhana, and Abdul Fadlil, "Jadwal Sholat Digital Menggunakan Metode Ephemeris Berdasarkan Titik Koordinat Smartphone," *IT JOURNAL RESEARCH AND DEVELOPMENT*, 2019, https://doi.org/10.25299/itjrd.2019.vol3(2).2285.

[8] Encep Abdul Rojak, Amrullah Hayatudin, and Muhammad Yunus, "KOREKSI KETINGGIAN TEMPAT TERHADAP FIKIH WAKTU SALAT: Analisis Jadwal Waktu Sholat Kota Bandung," *Al-Ahkam*, 2017, https://doi.org/10.21580/ahkam.2017.27.2.1858.

calculation of the beginning of prayer time according to Fiqh. However, this study does not discuss the effect of time zone on the calculation of the beginning of prayer time.

Another article, "Implementasi Titik Koordinat Tengah Kabupaten Atau Kota Dalam Perhitungan Jadwal Waktu Salat [9]" discusses the difference in taking the coordinates of a district or city that is submitted as a reference point for determining the prayer time. So that the taking of this coordinate point will affect the prayer time schedule. This research also does not discuss the effect of taking time zones on the results of calculating the beginning of prayer time. Based on this explanation, this research needs to be raised because so far researchers have not found similar research.

B. Metodhs

This research is classified into library research by reviewing existing literature and processing data with excel and using qualitative data presentation methods. This research departs from the question that whether the difference in time zones will essentially affect the results of the calculation of the beginning of prayer time. This is because the determination of sun's declination data collection and time averaging in the ephemeris is taken based on the conversion of the time zone of a place into universal time. This is because the data available in the ephemeris is sorted by time referring to Universal Time. To answer that, the researcher used the results of the calculation of the beginning of prayer time in each time zone. The researcher calculated the beginning of prayer time based on the time zone and its geographical location. In addition, the researcher also categorized the time zones of a country based on geographical location and not based on the geographical location of the country but based on the country's decision. Therefore, after doing this, the researcher will analyze whether the time zone has a significant effect on the difference in the results of the calculation of the beginning of prayer time.

[9] Moelki Fahmi Ardliansyah, "IMPLEMENTASI TITIK KOORDINAT TENGAH KABUPATEN ATAU KOTA DALAM PERHITUNGAN JADWAL WAKTU SALAT," *Al-Ahkam*, 2017, https://doi.org/10.21580/ahkam.2017.27.2.1981.

C. Result And Discussions

1. Time Zone Concept

A time zone is a division of a region or zone based on a common standard time for social, economic, legal and other purposes. The Earth takes 24 hours to rotate in synodical way, so the time zones on Earth are divided into 24 time zones. One full rotation on earth is equal to 360 degrees so that if divided by 24 then every hour is equal to 15 degrees. [10]. The determination of time zones is related to geographical longitude. Based on longitude lines, there is one special longitude line, namely the prime meridian line, which is also called 0 degrees longitude. The determination of longitude is different from the determination of 0 degrees latitude which can be measured based on the apparent motion of the sun. There are no specific guidelines for determining 0 degrees longitude so the determination is based on agreement. The role of the prime longitude is to guide the time with 0 degrees as the universal time benchmark.[11].

Basically, the use of civil time becomes complicated when we move east or west. The civil or sidereal time of each place is different due to differences in geographical longitude. Thus, it becomes very impractical if two parties make an agreement with a specified time but the civil time of the two parties is different. This is what gave rise to the idea of the time zone concept. The concept of time zones did not necessarily exist at the beginning of the Gregorian year. The emergence of this concept departs from a problem that occurs[12].

The person who came up with the concept of time zones was a Canadian architect named Sandford Fleming. In the beginning, there was a case where there was a time difference between the arrival and departure schedules of trains. It started when Fleming missed a train in Ireland in 1876 due to a misprinted train schedule caused by time

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[10] Youla Afifah Azkarrula and Sartika, "An Analytical Evaluation of Fiqh and Science Perspective Concerning Hajj: Tarwiyah Dan Arafat," *Al Qalam* 39, no. 1 (2022): 40–54, https://doi.org/10.32678/alqalam.v39i1.

[11] Muh. Ma'rufin Sudibyo, *Sang Nabi Pun Berputar* (Solo: Tinta Medina, 2011).

[12] Abraham Herdyanto, "8 Sejarah Zona Waktu, Dari Internasional Sampai Ke Indonesia," IDN Times, 2021, https://www.idntimes.com/science/discovery/abraham-herdyanto/sejarah-zona-waktu-internasional-dan-indonesia?page=all.

confusion. Thus, he saw that there was no standardization of time that could be used because civil time in each place was different. At that time, humans still depended on solar time which focused on the shadow cast by the sun on the sundial (*bencet*) to show the time on their clocks. The use of sidereal time is what causes time differences between places so that it will lead to miscommunication between parties and this situation causes the size of time to never be precise and always change in every place.[13].

In 1878, Fleming came up with the idea of a global standardized time concept for the entire world that divided the world into 24 time zones at intervals of 15 degrees of arc. The reason for this system was that the Earth shifts 15 degrees every hour. He suggested his idea at various international conferences. Then a conference "The International Meridian Conference" was held to discuss and agree on the proposed concept of time zones held in Washington DC, America in October 1884. The conference was held at the invitation of President Chester A. Arthur. In this conference there were 41 delegates from 25 countries namely: Astro-Hungary, Brazil, Chile, Colombia, Costa Rica, Denmark, France, Germany, England, Guatemala, Hawaii, Italy, Japan, Mexico, Netherlands, Paraguay, Russia, Salvador, San Domingo, Spain, Sweden, Switzerland, Turkey, Venezuela and the United States of America.[14].

At the conference it was agreed that the Earth's prime meridian line should cross the Greenwich Observatory in England, Greenwich Mean Time (GMT) was agreed as the world's time standard. The reason for setting the Observatory as 0 degrees longitude is because 70% of the shipping fleet at that time had used Greenwich as a reference. [15]. On January 1, 1885, 25 countries adopted Fleming's system. The history of the use of this time system varies from country to country so the implementation did not happen right

[13] Berau of Transportation Statistics, "History of Time Zones," United States Department of Transportation, 2021, https://www.bts.gov/geospatial/time-zones.

[14] Sudibyo, *Sang Nabi Pun Berputar*.

[15] Sudibyo.

away. By 1929, most countries in the world had adopted Fleming standard time and the concept of time zones. [16].

In reality, not all countries in the world apply time zones based on their geographical location when referring to the division of time zones calculated arithmetically. This is due to several reasons, one of which is that it is easier for a region to carry out administration in the same area. Thus, time zones are more likely to be divided according to country borders and parts rather than based on a strict division of longitude. This applies to any country and is incorporated into their laws or regulations. Currently, time zones in the world range from UTC-12:00 to UTC+14:00.

2. Countries with Abnormal Time Zones

In fact, after it was discovered that not all countries apply a time zone system based on arithmetically calculated geographical location for several reasons, some countries have abnormal time zones. This abnormal time zone means that the country has a time zone that is not appropriate. This can be described as a country that has a small area but has many time zones and vice versa if a country has a large area but only has a few time zones or even only one time zone.

In the world, there are several countries that have the most and least time zones: France with 12 time zones, USA with 11 time zones, Russia with 11 time zones, UK with 9 time zones, Australia with 8 time zones and China with 1 time zone. If a comparison is made, China is larger in area than Australia but Australia has more time zones than China. This is what makes the existence of abnormal time zones. With these examples, it is certain that the determination of a country's time zone does not only depend on its geographical location but also based on the agreement of the country to divide the country into how many time zone parts. This is for the benefit of the country's administration, economy and other purposes. Data on these countries can be seen in table 1.

[16] "Here's Why Sandford Fleming Came up with the Idea of Standard Time Zones," Inuth, 2017, https://www.inuth.com/trends/science/heres-why-sandford-fleming-came-up-with-the-idea-of-standard-time-zones/.

Table 1. Time zones from abnormal countries

Country	Total	Time Zone	
France	12	UTC−10:00	French Polynesia
		UTC−09:30	Marquesas Islands
		UTC−09:00	Gambier Islands
		UTC−08:00	Clipperton Island
		UTC−04:00	Guadeloupe, Martinique, Saint Barthelemy, Saint Martin
		UTC−03:00 (PMST)	French Guiana, Saint Pierre and Miquelon
		UTC+01:00 (CET)	France mainland
		UTC+03:00	Mayotte
		UTC+04:00	Réunion
		UTC+05:00	Kerguelen Islands, Crozet Islands
		UTC+11:00	New Caledonia
		UTC+12:00	Wallis and Futuna
United State of America	11	UTC−12:00	Baker Island, Howland Island
		UTC−11:00 (ST)	American Samoa, Jarvis Island, Kingman Reef, Midway Atoll, Palmyra Atoll
		UTC−10:00 (HAT)	Hawaii, Aleutian Islands, Johnston Atoll
		UTC−09:00 (AKT)	Alaska
		UTC−08:00 (PT)	Nevada, Idaho
		UTC−07:00 (MT)	Arizona, Colorado, Montana, New Mexico, Utah, Wyoming, Kansas, Nebraska, Oregon, North Dakota, South Dakota,
		UTC−06:00 (CT)	Gulf Coast, Tennessee Valley, U.S. Interior Highlands, Great Plains, Texas
		UTC−05:00 (ET)	Michigan, Bajo Nuevo Bank, Navassa Island
		UTC−04:00 (AT)	Puerto Riko, U.S. Virgin Islands
		UTC+10:00	Guam, Northern Mariana Islands
		UTC+12:00	Wake Island
Rusia	11	UTC+02:00	Kaliningrad
		UTC+03:00	Rusia (Europe)
		UTC+04:00	Samara, Udmurtia
		UTC+05:00	Bashkortostan, Chelyabinsk, Khanty–Mansia, Kurgan, Orenburg, Perm Krai, Sverdlovsk, Tyumen, and Yamalia

		UTC+06:00	Altai Krai, Altai Republic, Kemerovo, Novosibirsk, Omsk and Tomsk
		UTC+07:00	Khakassia, Krasnoyarsk Krai and Tuva
		UTC+08:00	Buryatia, Zabaykalsky Krai and Irkutsk
		UTC+09:00	Amur
		UTC+10:00	The Jewish Autonomous Area, Khabarovsk Krai, Magadan, Primorsky Krai, Republic of Sakha and Sakhalin Island
		UTC+11:00	
		UTC+12:00	Chukotka and Kamchatka Krai
United Kingdom	9	UTC−08:00	Pitcairn Islands
		UTC−05:00	Cayman Islands
		UTC−04:00	Anguilla, Bermuda, British Virgin Islands, Montserrat, Turks and Caicos Islands
		UTC−03:00	Falkland Islands
		UTC−02:00	South Georgia and the South Sandwich Islands
		UTC (GMT)	United Kingdom, Saint Helena, Ascension and Tristan da Cunha, Guernsey, Isle of Man, Jersey
		UTC+01:00 (CET)	Gibraltar
		UTC+02:00 (EET)	Akrotiri and Dhekelia
		UTC+06:00	British Indian Ocean Territory
Australia	8	UTC+05:00	Heard and McDonald Island
		UTC+06:30	Cocos (Keeling) Islands
		UTC+07:00	Christmas Island
		UTC+08:00	Western Australia
		UTC+09:30	South Australia, Northern Territory
		UTC+10:00	Queensland, New South Wales, Australian Capital Territory, Victoria, Tasmania
		UTC+10:30	Lord Howe Island
		UTC+11:00	Norfolk Island
China	1	UTC+08:00	

3. Classification of a Country's Time Zones by Geography and Agreement

Determining the local time zone is not as simple as determining the longitude coordinates and computing and matching them to the 24 time zones because the time zones do not actually represent real time zones. As stated earlier, the determination of a country's time zone is not based solely on its geographical coordinates. Time zones are chosen politically to fit within political boundaries.

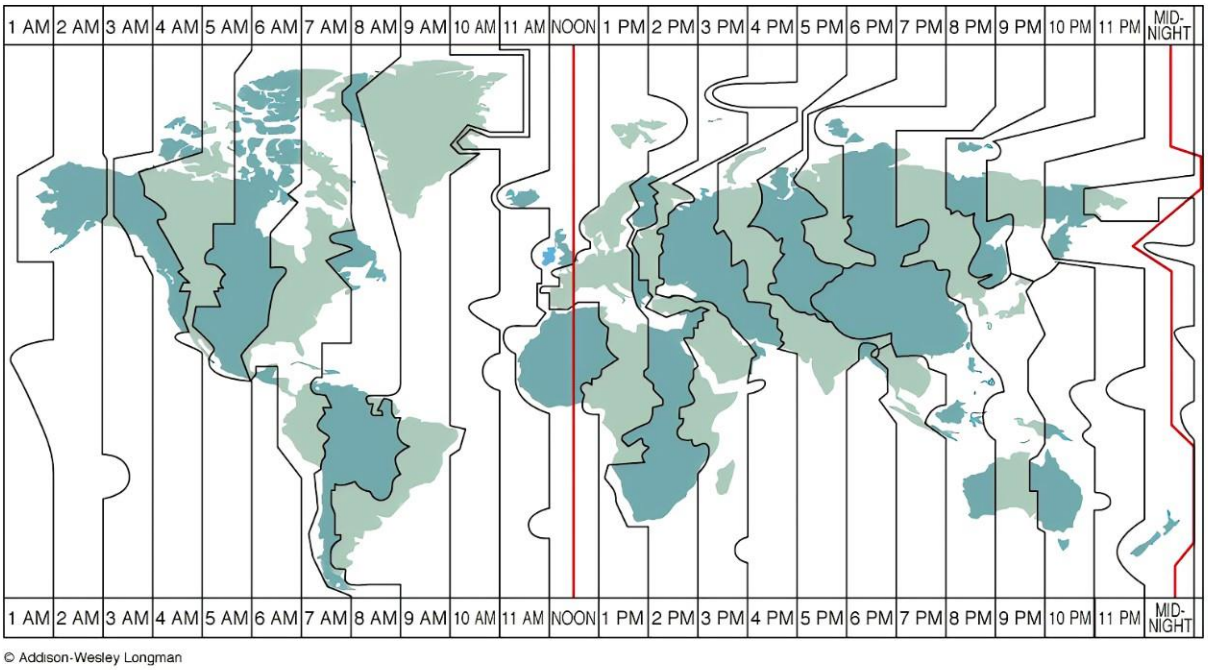

Figure 1. Map of Time Zone Divisions in the World

Based on Figure 1, it is found that in the field data, the division of time zones is not necessarily based on the geographical coordinates of the country. If we take one sample of a country that has a time zone that does not match the area of its territory, it is China. The map shows that China is only in the UTC+08:00 time zone which does not correspond to its area. Whereas in reality, if we follow the division of time zones based on geographical coordinates, China is located in the time zone UTC+05:00 to UTC+08:00. This shows that China has four time zones instead of one. However, one time zone was established by China for the sake of the administration and politics of the country.

4. The Concept of Calculating the Beginning of Prayer Time

In determining the beginning of prayer time, Allah through the Angel Gabriel only explained it to the Prophet by paying attention to natural phenomena or signs that focus on the movement of the sun rather than based on a formula. Over time, the observation of the phenomenon, namely the observation of the position of the sun, began to be changed by coming up with formulas that could be used anywhere. There are various formulas that can be used to determine the calculation of the beginning of prayer time. One of them is the calculation of the beginning of prayer time using a formula based on the Ephemeris based on several variables, namely sun's declination and time averaging.

These two variables when taken from Ephemeris data will require conversion of time zones into universal time. Therefore, the time zone is needed at the beginning to determine the retrieval of sun's declination and time leveling data.

To calculate the beginning of prayer time, the variables needed are latitude of place, longitude of place, longitude of region, time zone, altitude of place, sun's declination, time leveling, desired ihtiyat (descend correction), semi-diameter of the sun, refraction and the agreed sun altitude at Isha and dawn. The use of different sun's altitudes results from observations made by experts to determine the height of the sun as described in the hadith of the Prophet Muhammad. In addition, each latitude has a different duration of irradiation and a different angle of insolation in each place.

The formula for determining the beginning of prayer time is as follows [17]:

a. Zuhr

Area correction	= (regional longitude – longitude of place)/15
Zuhr	= True time – equation of time + area correction + ihtiyat

b. Asr

Cotan sun's altitude	= tan (abs (declination – latitude of place)) + 1
Cos hour angle	= sin sun's altitude / cos latitude of place / cos declination – tan latitude of place x tan declination
Asar	= True time – Equation of time + area correction + (hour angle/15) + ihtiyat

c. Maghrib

DIP[18]	= 1,76 / 60 x $\sqrt{altitude\ of\ place}$
Sun's altitude	= - (DIP + sun's semi diameter + refraction)
Cos hour angle	= sin sun's altitude / cos latitude of place / cos declination – tan latitude of place x tan declination
Maghrib	= True time – Equation of time + area correction + (hour angle/15) + ihtiyat

d. Isha

Sun's altitude	= -m[19] - (DIP + sun's semi diameter + refraction)
Cos hour angle	= sin sun's altitude / cos latitude of place / cos declination – tan latitude of place x tan declination

[17] Ahmad Izzuddin, *Ilmu Falak Praktik* (Semarang: PT Rizki Putra, 2012).

[18] the difference in position between the true horizon and the horizon seen by an observer.

[19] At the altitude of the sun at the time of 'Isha', following the country's agreed regulations.

Isya = True time – Equation of time + area correction + (hour angle/15) + ihtiyat

e. Fajr/Subh

Sun's altitude = -n[20] - (DIP + sun's semi diameter matahari + refraction)

Cos hour angle = sin sun's altitude / cos latitude of place / cos declination – tan latitude of place x tan declination

Fajr/Subh = True time – Equation of time + area correction + (hour angle/15) + ihtiyat

In calculating the times for Fajr and Isha prayers in each country, the sun's height is different. This is due to the influence of geographical latitude on the position of the sun. In addition, the value of the sun's altitude for prayer timing also varies with the seasons. The value of sun's altitude varies from 15°-20°. There are several criteria for sun's altitude according to several countries, namely [21]

Table 2. Use of Sun's altitude for praying times

Organization	Altitude for Fajr (°)	Altitude Isya (°)	Country
Universiti of Islamic Science, Karachi	18	18	Pakistan, Bangladesh, India, Afghanistan, parts of Europe
Islamic Society of North America	15	15	Parts of USA and Canada, parts of UK
World Islamic League	17	18	Europe, Far East, parts of USA
Um al-Qura', Mekah	90 minutes after sunset in normal months but 120 minutes after sunset in Ramadan	19	Arabian Peninsula
Egyptian General Organisation of Surveying	17,5	19,5	Africa, Syria, Iraq, Lubnan, parts of the USA

Malaysia and most of Indonesia use a sun's altitude of 18° for Isha prayer time and 20° for Fajr prayer time.

[20] At the altitude of the sun at dawn, following the country's agreed rules.

[21] Saadan Man et al., eds., *Dimensi Penyelidikan Astronomi Islam* (Kuala Lumpur: Universiti Malaya, 2013).

5. Comparison of Ephemeris Calculation of the Beginning of Prayer Times Between the Use of Geographic Time Zones and Country Time Zones

In this case, the sample that authors conducted is China because it has a huge diversity of longitude and latitude while China has only one time zone. This time zone is applied to the whole country while its land shows it has more than one time zone if it based on geography. It implies that China's time zone is based on the country's agreement rather than the geography. The authors choose four provinces with current coordinates due to the comparison for each time zone based on geography and the one that they used. China adopts GMT +8 as their time zone to its whole country.

Figure 2. Geographic Map of China

In addition, China has massive population so it is known as the most populous country in the world. If it is compared with other abnormal countries, China has a big population of Muslim. Besides, China has a great influence on the economic sector thus it attracts many investors, even those who are Muslim, to the country. It makes the needed of time prayer for this country is more important than other abnormal non-Muslim

countries. In this research, the authors take four loci with different longitudes but still in adjacent latitude. This is intended to minimize differences in the prayer times result. This action was taken because large differences in latitude will cause significant differences in the prayer times within the same longitude.[22] Below the data of each current point:

Table 3. Coordinates of four loci in this research

No	Point	Longitude	Latitude	Province	City/Part
1	Kashgar Prefecture	75.9797 E	39.4547 N	Xinjiang	Ugyur
2	A-K'O-SAI	94.25 E	39.466667 N	Gansu	Jiuquan[23]
3	Ordos city	109.783 E	39.6 N	Inner Mongolia	Ordos
4	Jinzhou district	121.82083 E	39.386665 N	Liaoning	Dalian

If it looks at the coordinate system, several parts of China should not use time zone +8 based on its geographical location. China has a long territory and covers time zone +5 to +8. Therefore, there is a 3-hour difference in ephemeris data when applying +8 data throughout its territory. According to the geographical coordinates, the time zone of each point on table 3 in ascending order are +5, +6, +7 and +8. While some parts such as Xinjiang province lays from +5 to +6 time zone geographically.

Then, table below represent the authors' calculation of time prayer on 20 March 2024 for four different point in China based on table 3.

Table 4. Result of time prayer

Time Prayer		Kashgar Prefecture	A-K'O-SAI	Ordos city	Jinzhou District
Fajr	Geo	4: 25: 46	4: 12: 44	4: 10: 28	4: 22: 43
	TZ	7: 25: 58	6: 12: 52	5: 10: 32	4: 22: 43
	Diff	3: 00: 13	2: 00: 08	1: 00: 04	0: 00: 00
Zuhr	Geo	12: 06: 26	11: 53: 22	11: 51: 15	12: 03: 06
	TZ	15: 06: 28	13: 53: 23	12: 51: 15	12: 03: 06
	Diff	3: 00: 02	2: 00: 01	1: 00: 00	0: 00: 00

[22] Nurul Sahrani, Rasyawan Syarif, and Rahmatiah HL, "Pengaruh Variabilitas Gerak Semu Matahari Terhadap Perubahan Waktu Salat Diberbagai Garis Lintang Perspektif Ilmu Falak," *HISABUNA: Jurnal Ilmu Falak* 5, no. 1 (2024): 56–79, https://doi.org/https://doi.org/10.24252/hisabuna.v5i1.48051.

[23] formerly known as Suzhou.

Asr	Geo	15: 32: 27	15: 19: 21	15: 17: 09	15: 29: 03
	TZ	18: 32: 23	17: 19: 18	16: 17: 07	15: 29: 03
	Diff	2: 59: 56	1: 59: 57	0: 59: 58	0: 00: 00
Maghrib	Geo	18: 12: 29	17: 59: 22	17: 57: 12	18: 08: 59
	TZ	21: 12: 21	19: 59: 16	18: 57: 09	18: 08: 59
	Diff	2: 59: 52	1: 59: 55	0: 59: 57	0: 00: 00
Isha	Geo	19: 41: 43	19: 28: 36	19: 26: 37	19: 38: 06
	TZ	22: 41: 34	21: 28: 30	20: 26: 34	19: 38: 06
	Diff	2: 59: 51	1: 59: 54	0: 59: 56	0: 00: 00

In table 4, there are two results in each locus. “Geo” in the table is standing for the time zone which based on the coordinates. This calculation does not follow the nation’s time zone (+8) but based on the area’s longitude. For instance, Kashgar Prefecture with 75.9797 E will include on GMT +5 or equal to 75 E. In this case, the “Geo” will retrieve the Ephemeris data in hour of 7 as in KEMENAG Ephemeris table. Thus, the sun’s declination and equation of time will follow the hour of 7. Meanwhile, “TZ” in the table is standing for the nation’s time zone where China uses GMT +8. Thus, the calculation will use the sun’s declination and equation of time data on hour of 4 in KEMENAG Ephemeris table. Not only the declination of sun and equation of time, the authors calculate the area correction in different way. In “TZ”, the authors use the nation’s time zone multiply by fifteen as the regional longitude. But, for “Geo”, the authors use the nearest time zone as the latitude’s display.

Based on table 4, from a small scale (GMT +5 to GMT +8), the results show the difference on hour, which it means that the different retrieval of Ephemeris data will have no significant difference between the geography time zone and time zone they used. It only affects the last digit of the result on minute to second. There are several reasons why there are small differences due to different ephemeris data collection depending on the time zone difference. Firstly, the ephemeris data shows a small difference for each hour. On calculating time prayer, it only needs sun’s declination and equation of time on ephemeris data. If sun’s declination and equation of time are taken in one day, it can be shown as follows:

Table 5. The difference of sun's declination and equation of time each hour in KEMENAG Ephemeris

GMT	Sun's Declination	Difference of declination each hour	Equation of Time	Difference on equation of time each hour
0	-4° 23' 26"		-0° 10' 30"	
1	-4° 22' 27"	0° 00' 59"	-0° 10' 29"	0° 00' 01"
2	-4° 21' 29"	0° 00' 58"	-0° 10' 29"	0° 00' 00"
3	-4° 20' 30"	0° 00' 59"	-0° 10' 28"	0° 00' 01"
4	-4° 19' 31"	0° 00' 59"	-0° 10' 27"	0° 00' 01"
5	-4° 18' 32"	0° 00' 59"	-0° 10' 27"	0° 00' 00"
6	-4° 17' 34"	0° 00' 58"	-0° 10' 26"	0° 00' 01"
7	-4° 16' 35"	0° 00' 59"	-0° 10' 26"	0° 00' 00"
8	-4° 15' 36"	0° 00' 59"	-0° 10' 25"	0° 00' 01"
9	-4° 14' 37"	0° 00' 59"	-0° 10' 24"	0° 00' 01"
10	-4° 13' 38"	0° 00' 59"	-0° 10' 24"	0° 00' 00"
11	-4° 12' 40"	0° 00' 58"	-0° 10' 23"	0° 00' 01"
12	-4° 11' 41"	0° 00' 59"	-0° 10' 22"	0° 00' 01"
13	-4° 10' 42"	0° 00' 59"	-0° 10' 22"	0° 00' 00"
14	-4° 09' 43"	0° 00' 59"	-0° 10' 21"	0° 00' 01"
15	-4° 08' 44"	0° 00' 59"	-0° 10' 20"	0° 00' 01"
16	-4° 07' 46"	0° 00' 58"	-0° 10' 20"	0° 00' 00"
17	-4° 06' 47"	0° 00' 59"	-0° 10' 19"	0° 00' 01"
18	-4° 05' 48"	0° 00' 59"	-0° 10' 19"	0° 00' 00"
19	-4° 04' 49"	0° 00' 59"	-0° 10' 18"	0° 00' 01"
20	-4° 03' 50"	0° 00' 59"	-0° 10' 17"	0° 00' 01"
21	-4° 02' 52"	0° 00' 58"	-0° 10' 17"	0° 00' 00"
22	-4° 01' 53"	0° 00' 59"	-0° 10' 16"	0° 00' 01"
23	-4° 00' 54"	0° 00' 59"	-0° 10' 15"	0° 00' 00"
24	-3° 59' 55"	0° 00' 58"	-0° 10' 15"	0° 00' 00"

Based on the table 5, the degree difference in the sun's declination ranges from 58 second of arc to 59 second of arc, almost reach one minute of arc each hour while the equation of time has a difference around one second of arc per three hours. This result shows that the small difference is not enough to affect the prayer time result. This is because in the calculation process, the sun's declination and equation of time are calculated with trigonometric variables (sinus, cosine, tangent, cosecant, secant and cotangent) which will produce smaller data than before.

Here, the authors will use sun's declination and equation of time from table 5 to calculate prayer time in Jinzhou District. The authors use this locus because this area is in GMT +8 geographically and same with the nation's decision. Therefore, the authors apply eight multiples by fifteen as the regional latitude for the area correction. Below, the result of the calculations which uses data from table 5.

Table 6. Result of Prayer Time with different Ephemeris data

GMT	Fajr	Zuhr	Asr	Maghrib	Isha
0	4: 41: 17	12: 06: 13	15: 23: 05	17: 57: 37	19: 25: 54
1	4: 41: 13	12: 06: 12	15: 23: 06	17: 57: 39	19: 25: 56
2	4: 41: 10	12: 06: 12	15: 23: 08	17: 57: 42	19: 25: 59
3	4: 41: 05	12: 06: 11	15: 23: 09	17: 57: 45	19: 26: 01
4	4: 41: 01	12: 06: 10	15: 23: 10	17: 57: 47	19: 26: 04
5	4: 40: 58	12: 06: 10	15: 23: 12	17: 57: 50	19: 26: 07
6	4: 40: 53	12: 06: 09	15: 23: 13	17: 57: 52	19: 26: 09
7	4: 40: 50	12: 06: 09	15: 23: 16	17: 57: 56	19: 26: 13
8	4: 40: 46	12: 06: 08	15: 23: 17	17: 57: 58	19: 26: 15
9	4: 40: 41	12: 06: 07	15: 23: 18	17: 58: 00	19: 26: 17
10	4: 40: 38	12: 06: 07	15: 23: 20	17: 58: 03	19: 26: 21
11	4: 40: 34	12: 06: 06	15: 23: 21	17: 58: 05	19: 26: 23
12	4: 40: 29	12: 06: 05	15: 23: 22	17: 58: 08	19: 26: 25
13	4: 40: 26	12: 06: 05	15: 23: 24	17: 58: 11	19: 26: 29
14	4: 40: 21	12: 06: 04	15: 23: 25	17: 58: 13	19: 26: 31
15	4: 40: 17	12: 06: 03	15: 23: 27	17: 58: 15	19: 26: 33
16	4: 40: 14	12: 06: 03	15: 23: 29	17: 58: 19	19: 26: 37
17	4: 40: 09	12: 06: 02	15: 23: 30	17: 58: 21	19: 26: 39
18	4: 40: 06	12: 06: 02	15: 23: 32	17: 58: 24	19: 26: 42
19	4: 40: 02	12: 06: 01	15: 23: 33	17: 58: 26	19: 26: 45
20	4: 39: 57	12: 06: 00	15: 23: 34	17: 58: 29	19: 26: 47
21	4: 39: 54	12: 06: 00	15: 23: 36	17: 58: 32	19: 26: 50
22	4: 39: 50	12: 05: 59	15: 23: 37	17: 58: 34	19: 26: 53
23	4: 39: 45	12: 05: 58	15: 23: 39	17: 58: 36	19: 26: 55
24	4: 39: 42	12: 05: 58	15: 23: 41	17: 58: 39	19: 26: 58

From table 6, subtraction of the largest and smallest results from Fajr to Isha produces differences of 1 minute 35 second ,15 second, 36 second, 1 minute 2 second, and 1 minute 4 second respectively. Then, roughly the difference in the use of Ephemeris data is only around 1-2 minutes at each prayer time. It implies that the ephemeris data retrieval errors in this calculation do not have a significant impact as shown in table 6.

Secondly, the last digit of time prayer's result will be rounded up to "minute" because Muslim only need the hour and minute not until the second. There are two criteria of the rounding up process; first criteria: for Fajr, Zuhr, Asr, Maghrib, and Isha if the last digit is more than one second, then it will be rounded up to one minute unless for sunrise, any second must be discarded; second criteria: any second must be rounded up to one minute for five-time prayers unless for sunrise, any second must be discarded. This policy makes the "second" of prayer time result is not that necessary.

Thirdly, after rounding seconds to minutes, there is an addition time to prayer times called *ihtiyat* or prudence. *Ihtiyat* is a form of prudence so the praying is not to precede the beginning of the prayer time and not to exceed the end of the prayer time. Moreover, *ihtiyat* could cover other location in a small scope of coordinates. Thus, the difference of "second" is not significant for this practical use. In fact, more additional minutes are needed for muezzin to reciting adhan before praying. These imply that the "second" time is not that significant.

D. CONCLUSION

Determining the beginning of prayer time is crucial in the eyes of worship. There are several ways to determine it. A hasib can use the easiest way to calculate it, namely by using ephemeris. This method involves several variables, namely latitude, longitude, declination, equation of time, time zone, refraction, altitude, semi diameter, and altitude of the sun (in this case it depends on the type of prayer time and the country that adheres to it because of differences in latitude). In the basic formula, the determination of ephemeris data retrieval can be calculated by subtracting 12 and the time zone. So that at this stage, the time zone becomes an important variable in the calculation. But with the cases of countries whose time zones do not match the geographical location will cause confusion in the calculation.

However, based on the results of the analysis in this paper, the results of using ephemeris data at different hours only provide differences in the range of seconds to minutes. Roughly, the biggest difference is 1 to 2 minutes. Then, this result will not take a bog part in affecting the time prayer due to three reasons. First, the ephemeris data shows a small difference for each hour. When the Ephemeris data is calculated with

trigonometric variables, it will produce smaller data than before. Second, Muslim only need the hour and minute not until the second. Third, there is an addition time to prayer times called *ihtiyat* or prudence.

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