# The path of the sun from Macuilxochitepec: solar alignments of a Franciscan church in Atlixco, Puebla.

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**Abstract**:

The first religious order to arrive in New Spain was the Order of Friars Minor, in 1524. They built churches dedicated to different religious figures throughout New Spain, using indigenous labor. One of these emblematic examples is the church of Santa María de la Asunción in Acapetlahuacan, located on the slopes of Cerro Macuilxochitepec, Atlixco, Puebla, in central Mexico. This paper discusses the results obtained for the church's solar alignments, as its orientation reflects both Catholic and indigenous influences. Specifically, it analyzes the possible association of these alignments with the Zapotec tradition known as cocijo, or with the festivals of Saint Francis of Assisi and the Assumption of Mary.

**Keywords:** Acapetlahuacan, Atlixco, Archaeoastronomy, Franciscans, Architecture.

## Introduction

Three years after the conquest of Tenochtitlan, the first twelve Franciscans, belonging to the Order of Saint Francis of Assisi, arrived at the port of Veracruz. Their purpose was the evangelization of the indigenous people, eradicating idolatry and replacing it with the veneration of various Catholic saints. Over the years, several churches were built at strategic locations throughout New Spain. This religious order brought the teachings of Isidor of Seville, who says that when erecting a temple, it has to be faced to the equinoctial east so that a line could be drawn from east to west, dividing the sky into two

equal parts; this was done so that those who meditated and prayed could face east (Sevilla, 1980, p. 239).

These lines offer us a guideline for how the Franciscans were to orient the religious temples they built in New Spain. From the last third of the 20th century onward, there was a surge of interest in research on the astronomical orientations of 16th-century churches in Mexico, as we describe below.

In the mid-1970s, researcher Franz Tichy published a series of studies aimed at determining whether colonial churches followed the same astronomical orientation pattern as pre-Hispanic temples, based on the hypothesis that many of these churches were built on top of *teocallis* (Tichy, 1976). After compiling data for hundreds of churches in central Mexico and Oaxaca, he found a diversity of orientation patterns, most of them aligned to dates other than the equinox (Tichy, 1991). In the 1990s, Stanislaw Iwaniszewski highlighted the significance of the number 20 depicted on the Church of San José in Paxtepec, Veracruz, as it is oriented 20 days before the celebration of the town's patron saint (Iwaniszewski, 1999, pp. 109-119). In his dissertation, Juan Rafael Zimbrón presents horizon calendars not only for pre-Hispanic sites but also for the colonial churches of Milpa Alta and Xochimilco (Zimbrón, 2013). In 2020, Arturo Montero published “Cocotzin: Our Lady of Los Remedios,” in which he states that the Sanctuary is oriented 73 days before and after the summer solstice, one of the most important calendrical-astronomical families in Mesoamerica (Montero García, 2020). Hans Martz and Cecilia González (2021) presented three case studies of church orientations in the state of Tabasco, highlighting the interval of sevenths in the orientation of Oxolotlán and Tenosique. In more recent years, Arturo Gómez presented his thesis on the orientation of 16th-century Franciscan convents in the state of Puebla, offering a possible astronomical interpretation of the 20 churches studied (Gómez Ruiz, 2023), showing a mixture of prehispanic and catholic traditions. These studies are some examples of relevant research on the astronomical orientations of 16th-century churches in Mexico.

Pre-Hispanic architecture throughout Mesoamerica followed alignment patterns toward a significant point on the horizon, taking into account the sun's movement throughout the year. Consequently, some buildings were aligned with a specific date, resulting in a

number that was a multiple of 13 or 20 days. From these multiples, the Mesoamerican astronomical calendar families originated, as they were associated with agricultural activities or rituals performed during the year. It is not surprising that when the Franciscan Order arrived in New Spain, and their temples were built with indigenous labor, some of them shared the same orientation as the main *teocalli* of their *altepetl* (a form of city-state), thus inheriting the indigenous worldview.

In this work we present in detail the results obtained regarding the astronomical orientation of the Church of Santa María de la Asunción, Acapetlahuacan, built in the 16th century on the slope of the Macuilxochitepec hill, in the municipality of Atlixco, State of Puebla, Mexico.

## Geographical context and etymology

Our study takes place in the Municipality of Atlixco, located in the State of Puebla, Mexico (see figure 1). It borders to the north with the Municipality of Puebla, to the east with the plains of Tepeji, to the south with the valleys of Chiautla and Matamoros, and to the west with Morelos and the Sierra Nevada (Sánchez de la Barquera Arroyo, 1996, p. 21). The word Atlixco means water on the surface or superficial; water in the valley (Carrillo Vivas, 1989, p. 2). In pre-Hispanic times this place was known as *Cuauhquechollan*, which means place abundant in eagles with rich feathers (Durán, 1880, p. 237).


Figure 1. The location of Atlixco (black dot) within the State of Puebla, Mexico. Designed using Google Earth.

*Macuilxochitepec* means "hill five flower". This name originated from the god Macuilxochitepec, who was the god of games or *Patolli* (Peñafiel, 1914, p. 86). Today, the hill is known as San Miguel Hill because there is a hermitage dedicated to Saint Michael at its summit. In the Matricula de Tributos (n.d.), Macuilxochitepec Hill appears first, crowned with the number five, and the eagle representing *Cuauhquechollan* appears second. However, in the Codex Mendoza (2014), the order is reversed.

Now, *Acapetlahuacan* means "Place of those who have reed *petate*" (Robelo, n.d., p. 208). In contrast, Héctor Silva Andraca believes that it means place of the lordship where command is shared; in short, it is a border place, mark or Marquisate (Silva Andraca, 1974, p. 85).

## Historical context

Acapetlahuacan was the old indigenous neighborhood at the time of the arrival of the first Spaniards to Atlixco and is the place where the first church was built by the Franciscans in the region.

Torquemada tells us that Acapetlahuacan was founded overnight by the indigenous people of Huexotzinco:

> Four or five thousand Indians, laden with straw for their huts, poles, and maguey plants, along with their wives and children, built many houses and morning, they had more than thirty, whose thatched roofs appeared very old and worn from use, the poles smoky, and in them lived their inhabitants with their wives, children, dogs, cats, and chickens. Made and formed a town, where roosters crowed, dogs barked, and children cried, and they treated one another as if it had been established many years before (Torquemada, 2010, p. 437).

This fact is very important since this miraculous foundation event occurred in 1537 (for more details see Silva, 1974, pp. 89-93).

In a document from 1533 kept in the Municipal Archive of the City Council of Puebla, the name of the valley of Atlixco appears as “valley of Acapetlahuacan”, but with the alias “Atlisco”. Before the 1530s, the correct name of the valley was used, which was Acapetlahuacan or Huaquechula la Vieja; however, over the years, this alias prevailed, since today the current municipality is known as Atlixco (AMAP supplement to book I, f.2, according to Paredes Martínez, 1991, note 3: p. 43).

The Franciscan friar Bernardino de Sahagún tells us that a river called *Nexatl* flowed between the towns of Huexotzinco and Acapetlahuacan; this river descended from the Popocatépetl volcano. *Nexatl* means "river of ashen appearance," Nenatl meaning ash (Sahagún, 1938, p. 292 and p. 358). The town of Acapetlahuacan maintained its autonomy until 1883. It had the right to a seat on the Atlixco City Council, as well as its own judges, jail, and local police force. Both the judge and the police had their offices across from the chapel of San Diego de Alcalá (Díaz Solís, 1938. p. 17), now known as the Church of La Soledad, and the offices were located where the Felipe Carrillo Puerto Elementary School now stands.

**Construction of the Church of Santa María de la Asunción**

On one of the slopes of the Macuilxochitepec hill, the Church of the Order of Friars Minor was erected (see figure 2). As stated by Engineer D. José G. Aguilera, the hill is formed of rocks that are andesitic breccia and volcanic twill; the andesite is hornblende, very similar to that of the Iztaccihuatl and Malinche volcanoes (Peñafiel, 1914, p. 83). According to the Franciscan Juan de Torquemada:

> In the part that is now on the slope of a small hill that is in the same place; the main chapel was built by Father Fray Toribio Motolinía, according to the account of Pedro del Castillo, the oldest man who lived there and says that it was he and Catalina Pérez, wife of Juan Pérez Romero, who laid the first foundation stones and helped to do the work. The rest of the church, which is vaulted and very beautiful, was finished by Father Fray Juan de Alameda and this is how the first town was founded in the upper part where it was at the beginning (Torquemada, 2010, p. 436).

The previous chronicle also tells us that the church was built on the slope of Cerro Macuilxochitepec because the mosquitoes at the base of the hill made such a feat impossible. However, for researcher Héctor Silva, the reason for building the Franciscan church on the slope was more to prevent access to the hilltop, since there had been a teocalli there that, over time, became subsumed into religious syncretism, in addition to its perfect location for defense against military attacks (Silva, 1974, p. 100). Marco Díaz disagrees with this last point, since the conquest of Atlixco had not yet been violent, so it was unlikely that any uprisings would occur, and therefore defensive architecture would have been pointless (Díaz, 1969, p. 43).

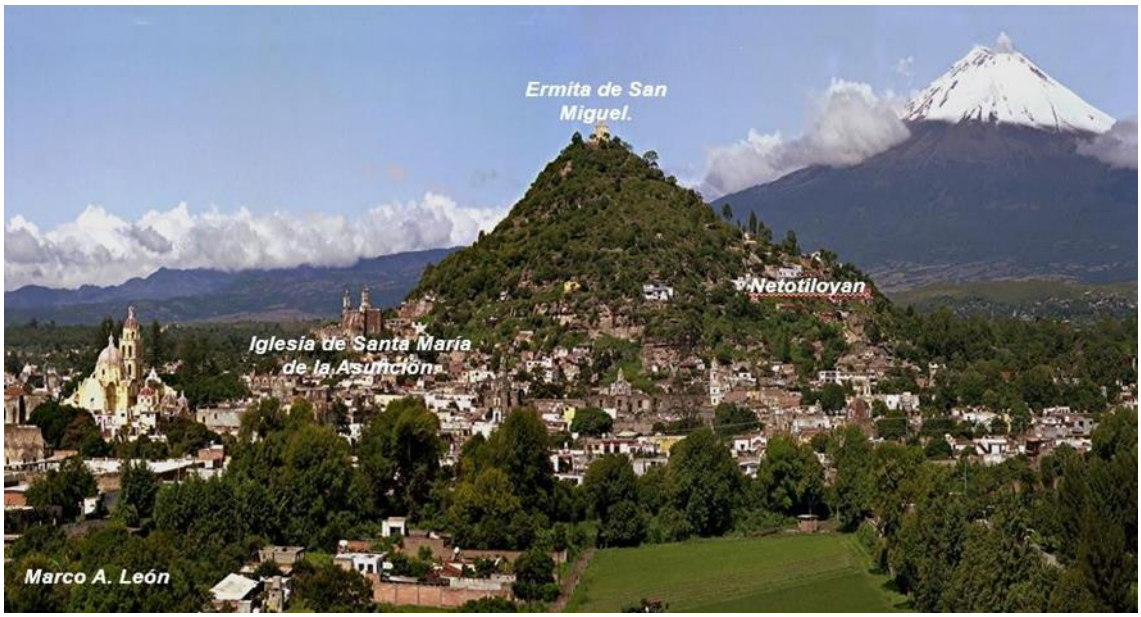


Figure 2. View of Macuilxochitepec with its three iconic landmarks. Photograph by Marco A. León.

As we saw earlier, Father Toribio de Benavente, better known as Motolinia, built the chapel, although Friar Juan de Alameda was the principal architect of the Franciscan church. John Mc Andrew (1965, p. 514) proposes that construction of the church began in 1539, while George Kübler (1983, p. 269) states that it began after 1540. It has also been proposed that the church had three construction phases: the first from 1540 to 1550, the second from 1560 to 1570, and the last from 1571 to 1580 (Martínez del Sobral y Campa, 1987).

Access to the church atrium is through two openings, one with steps and the other with a ramp. The atrium itself is small, its space once enclosed by a wall whose original design was lost due to renovations carried out in the 18th century. The wall features curved rhythms and alternated by twelve niches that served for the Stations of the Cross (Díaz, 1969, pp. 44-45). The entrance to the church has a segmental arch with two jambs of fine profiles. Above the door is a niche containing a sculpture of Saint Francis with six stone flowers (Uribe Salgado, 1989, p. 8). The church was constructed with two-toned stones: dark stone up to a certain height, and then red stone above that. Around the entire nave appear parallel moldings where dark stone crosses with equal ends are aligned, rectangular in shape; in the apse the crosses have trefoil ends (Díaz, 1969, see

figures 3 and 4). The central altarpiece that is currently there does not correspond to the 16th century, due to the modifications that the church underwent in the 18th century; this altarpiece shows scenes from the life of Mary that culminate with her coronation (Díaz, 1969, p. 57).

Figure 3. Side view of the Church of Santa María de la Asunción. Photograph by Marco A. León.

In Fray Alonso Ponce's account, we learn that the Franciscan church was already finished, with an upper and lower cloister, dormitories, and an orchard, along with an old and medium-sized convent. As we saw earlier, this building sits atop a rocky outcrop (that is, next to a spring, or in a place where water originated), on a slope of Macuilxochitepec Hill. Many steps led up, and just as many down, to reach the orchard. He also mentions that near the convent, a little higher up, there is a very devout hermitage of San Toribio (judging by where said hermitage is located, currently, above

the Franciscan church there is a chapel in honor of the Virgin of Guadalupe) and on the summit of the hill another of San Miguel, in which on his saint's day mass is said and all the people of the Spaniards belonging to the Villa de Carrión go up to hear it (Ciudad Real, 1873, p. 160).

Sixteenth-century chronicles mention different names for the Franciscan church. Friars Juan de Torquemada (Torquemada, 2010, p. 436) and Agustín de Betancurt (Betancurt, 1697, p. 72) state that its name is the Visitation of Our Lady; however, Friar Alonso Ponce (Ciudad Real, 1873, p. 160) and the Matricula de Huexotzinco (this register is particularly noteworthy as it contains the glyph for Santa María de Jesús Cuauhquechollan) refer to it as Santa María de Jesús. Don Juan de Palafox y Mendoza (1997, p. 60), Don Juan Maldonado de Montejo (1599), and the researcher Margarita B. Martínez del Sobral (1987) refer to the church as being dedicated to Saint Francis. Today, the Church is dedicated to Santa María de la Asunción, whose feast day is August 15.

Both Mc Andrew (1965, p. 223) and Díaz (1969, p. 44) maintain that the church was built on a pre-Hispanic platform. Peter Tscholl and Herbert Nickerl, in their catalog, show us two examples of jugs from Acapetlahuacan: zoomorphic jugs with animal heads on the front and the animal's tail on the back (Tschohl and Nickel, 1972, pp. 169-170). The 1960 issue of the magazine "Estado" featured photographs of three large, solid stone monoliths, one of which was identified as the Two-Headed Lion (Revista Estado, 1960, p. 13). Archaeologist Miguel Medina Jean of the INAH (National Institute of Anthropology and History) found two of the three pieces in the former home of Don Espiridión Díaz Solís. The whereabouts of the missing monolith are unknown, although archaeologist Medina was able to obtain a photograph of said monolith, but it is impossible to know what deity it could be (personal communication, May, 2024).

Figure 4. Front view of the Church of Santa María de la Asunción. Photograph by Emir Brando Tepepa Esquivel.

### Orientation measurements and field observations

The church is located at 18° 54′ 39" N, 98° 26′ 15″ W, at an altitude of 1885 meters above sea level. Prominent on the eastern horizon are the hills of Xitlala, Ocotzone, Zitzimitl, Mazatecatl, Nanahuachi, Tecopile, Texistle, and Zoapiltepec; while on the western horizon are the hills of Cuiclaxca, San Miguel, Xilotepec, Xonacayocan, Cuatepetl, and far to the northwest, the Popocatépetl volcano. These hills are of paramount importance as they shaped the worldview of the pre-Hispanic era, where the landscape became ritualistic when observing the sunrises and sunsets on specific dates of the year. It should be noted that the sun's path does not include several of these prominences on the horizon; in particular, it loses the summit of the Popocatépetl volcano. Our study, rather than analyzing a possible horizon calendar, focuses on the solar alignments of the convent church.

The methodology used to determine the church's orientation and its relationship to celestial phenomena make use of digital tools and on-site observations whose effectivity has been proved in previous investigations (Gómez, 2023; Gómez-Ruiz and Molero, 2024). Satellite images from the Google Earth (GE) platform were used, selecting

photographs with minimal distortion due to the capture angle—that is, those shots where the building's walls were less visible and only the roof was shown. In an initial test, satellite images prior to 2023 were used to define the on-site observation campaign for that year. In subsequent years, the quality of the images available in GE for the Atlixco location improved considerably, so the measurements reported here include images from recent years, specifically from June 2, 2024, June 15, 2024, and March 15, 2025 (eye height 300 ft), which most closely resemble an orthophoto. Positioning the program's measuring ruler along the walls, ten measurements on each image were taken (five in each wall; 30 measurements in total) to obtain the azimuth angle and its standard deviation, which is considered the statistical uncertainty. In this way, we obtained an azimuth of 80.6º ± 0.6º to the east (coinciding with the south slope of Zitzimitl Hill), and correspondingly 260.6º ± 0.6º to the west (towards a ravine between San Miguel and Xilotepec Hills). Some authors have argued that the resolution of satellite images is one of the main sources of error in azimuth estimation using GE's rule. Following Romain's (2023) considerations, we estimate the resolution of the images used to be approximately 50 cm (the structure of car windshields is visible, but not the rearview mirrors), so for a wall length of approximately 34 meters, the estimated azimuth error is 0.8 degrees. Therefore, the total margin of error in the azimuth measurement (statistical uncertainty and that related to resolution) is approximately one degree. A plan of the convent is shown in Figure 5, also indicating these orientation measurements taken on the church.

The corresponding solar alignments were estimated by calculating the associated declinations and also using the online program Peakfinder (Soldati, 2026), displaying the horizon model at the geographical location of the religious building and aligning the intersection of the solar path with the measured azimuths. The horizon heights were obtained using the same program on the lines of intersection, which were 1.4° for the eastern horizon and 1.3° for the western horizon. Therefore, the azimuth measurements translate (using the horizon heights) into the following declinations: 9° 13′ 43" (east) and -8° 34′ 57" (west). The predicted alignment dates are April 13 and August 29 for the eastern horizon, and February 25 and October 14 for the western horizon. The accuracy

in estimating the alignment days is approximately ± 2.5 days, taking into account the total uncertainty margin reported for the azimuth measurements.

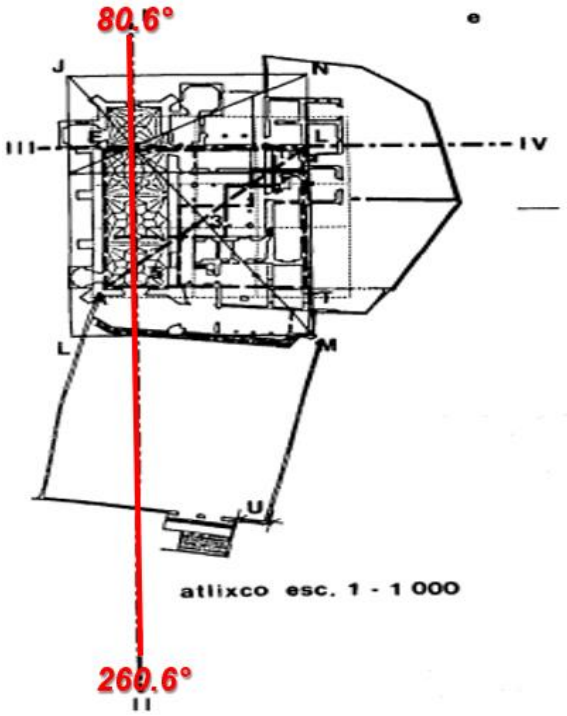


Figure 5. Plan of the Church of Santa Maria de la Asunción, Acapetlahuacan, Atlixco. The red line shows the axis of symmetry of the temple, and its orientation is also indicated. Taken from Martinez del Sobral (1987).

Several previous studies have warned about the uncertainties of GE tools in estimating the azimuthal angle (that could be up to a few degrees), so an important part of our methodology is the field verification of solar alignments on the predicted dates. Therefore, we proceeded to register the sunsets of February 25 and 26, 2023, by means of photographs from the dome of the Church of Santa Maria de la Asunción, Acapetlahuacan. It should be noted that for this record, special care was taken in the location of the camera and the inclusion of visual reference points that ensured the alignment of the photographs with the wall of the building, which in this case was the north wall. This record confirmed the church's alignment with the direction between two prominent features on the western horizon (see Figure 6) and thereby verified that the calculations made with our methodology were sufficiently accurate. The photographs

presented show a better alignment with the building's axis on February 25, 2023, which according to Peakfinder should correspond to an azimuth of 260.3º; this latter result is also verified using the NOAA Solar Calculator (https://gml.noaa.gov/grad/solcalc/), within an accuracy of one minute in the time specified for the solution of the solar equation. Additionally, a few minutes before sunset, a beam of light from the oculus in the facade was recorded, focusing on the left side of the central image of the altarpiece (see Figure 7). The number of days between the winter solstice and February 25 is 65, a number symbolically represented on the horizon by a *cocijo* (see Discussion for a more detailed description).


Figure 6. Sunset in between San Miguel y Xilotepec hills, observed from the vault of the Franciscan church of Atlixco on February 25 and 26, 2023. The white line indicates the axis of symmetry along the north wall. Photographs by Arturo Gómez.


Figure 7. Photographs towards the main altarpiece of the Franciscan temple of Atlixco, about 15 minutes before sunset on February 26, 2023. Photographs by Arturo Gómez.

An inspection was carried out at the point where the sun sets on the western horizon. Upon arrival at the site, agricultural terraces were observed, which may have been reused since there was little evidence of pre-Hispanic ceramics in the cultivated fields, possibly associated with rituals (see Figure 8, left). Also visible from this location is Cerro El Chumil, one of the most important hills in the State of Morelos, as well as Amecac Viejo, an important archaeological site in the State of Puebla (see Figure 8, right).

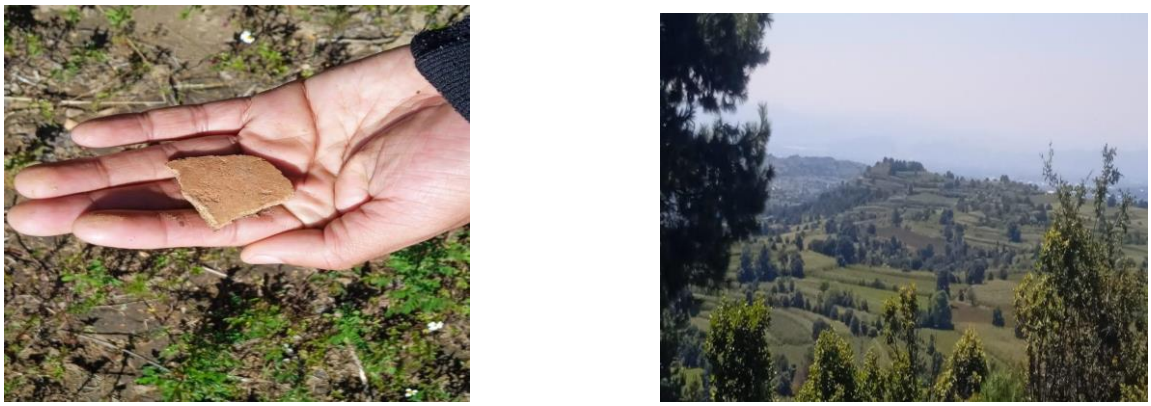

Figure 8. Pre-Hispanic ceramics (left) and view towards Amecac Viejo (right). Photograph by Emir Brando Tepepa Esquivel.

On August 29th, 2025, sunrise was recorded over the southern slope of Zitzimitl Hill (see Figure 9), confirming the alignment with the axis of the church. It should be noted that the photograph was taken next to the church. The hill was also inspected for any pre-Hispanic evidence. It's important to clarify that the INEGI topographic maps at a scale of 1:50,000 refer to the hill as Zitzimitl; however, the Mapcarta website lists the hill as Acatl, a Nahuatl word meaning reed or cane. While on the hill, we met a man named Jesús, from Santa María Malacatepec, in the municipality of Ocoyucan, who told us that the hill's name is Ecatl. According to archaeologist Miguel Medina, this could be a derivation or corruption of Ehécatl, also a Nahuatl word meaning wind. Both Ecatl and Ehécatl sound very similar (personal communication, 2025).

On the southern slope of the Zitzimitl or Ecatl hill, a small rock shelter was found containing a cross surrounded by strips of white tissue paper, whose meaning is associated with rain (see Figure 10). It is worth noting that a river originating from Mazatecatl Hill flows alongside the shelter. At the summit, a mound was discovered (see Figure 11), along with a small amount of pottery and green obsidian, which, according to observations by Miguel Medina, dates to the Classic period and is linked to the Teotihuacan and Cholula trade networks (personal communication, 2025). This demonstrates the importance of Zitzimitl or Ecatl as a significant point on the eastern horizon, in conjunction with the Church of Santa María de la Asunción.


Figure 9. Photographs showing the alignment of the temple with the Zitzimitl or Ecatl hill (left) and the sunrise on August 29, 2025, over the same hill (right). Photographs by Emir B. Tepepa Esquivel and Arturo Gómez Ruiz.

Figure 10. A small cavity on the southern slope of the Zitzimitl or Ecatl hill; a cross can be seen in the background and around it the china papers in the form of strips whose meaning is rain. Photograph by Tito Davila.

Figure 11. Mound on the summit of Zitzimitl or Ecatl hill. Photograph by Guillermo Miron

## Discussion

Through these observations, the alignment of the church with relevant points on the horizon, both east and west, was confirmed. Pre-Hispanic evidence was found at these horizon points, suggesting that the church's orientation may not be accidental. This alignment also coincided with known calendar dates of sunrise and sunset at these points on the horizon: in the east, sunrise occurs 68/69 days before and after the summer solstice; while in the west, sunset occurs 65/66 days before and after the winter solstice. The number 65 is prominent in Zapotec territory (Galindo, 2002, p. 26), since, according to Friar Juan Córdova (Córdova, 1886, pp. 201-202), the Zapotecs divided the ritual year (Tonalpohualli in nahuatl, which consists of 260 days) into four main signs (i.e., *cocijos*) of 65 days each (260 / 4 = 65). Although more than 65 days pass on the eastern horizon, the *cocijo* is symbolically represented on the western horizon. This Mesoamerican calendar system is found in the Edificio Enjoyado of Monte Albán for sunrises on February 25 and October 17 (Galindo, 2002, p. 26), as well as on the pre-Hispanic causeway of Monte Tlaloc, which indicates the same dates to the east (Sprajc, 2001, pp. 328-329). Furthermore, Carlos Barrera (2019) found in the Mayan codices the

synchronicity of ritual and solar times based on a 4 by 65-day structure, yet another example of the importance of the number 65.

It should be noted that the construction of the Franciscan church took place before 1582, when the Julian calendar was in use in New Spain. The date August 29th, which in Julian terms would be August 19th, could be associated with the feast of the Assumption of Mary, whose feast day is August 15th. According to Abril and Sánchez (2023, pp. 208-245) there is evidence of some churches dedicated to the Assumption of Mary in Soria, Spain, oriented to August 15 in the Julian calendar; however we should notice that this date differs by 4 days with respect to our observed alignment. On the other hand, October 14th corresponds to Julian date October 4th and thus could have represented the feast of Saint Francis. This demonstrates that the astronomical orientation of the church could have been based on the saints whose patronages are still present in the church today.

## Conclusions

The church of the former Franciscan convent in Atlixco exhibits solar alignments that can be interpreted in several ways. On the one hand, its alignment at sunset on February 25th could link it to the beginning of the Zapotec year and, therefore, to the 65-day cycles that characterize the *cocijo*. However, it should be noted that such alignments in pre-Hispanic buildings occurred at sunrise, not sunset. On the other hand, considering the alignment dates in the Julian calendar, which was in use during the convent's construction, it is possible that the sunset in October is related to the feast day of Saint Francis on October 4th. Similarly, although with a difference of more days, the solar alignment in August is close to the celebration of Our Lady of the Assumption, the patron saint to whom the church is dedicated today. The two most plausible explanations, therefore, are the connection to the *cocijo* or the feast day of Saint Francis. More contextual information is needed to lean towards either of these two possibilities.

## Acknowledgements

We thank the anonymous reviewers for the comments that helped improve the manuscript and the arguments presented in this article. We express our gratitude to Father Alfredo Gutiérrez, parish priest of the Church of Santa Maria de la Asunción, Acapetlahuacan, and to Julián Pérez and Luis Fernando Tapia Schiavon, for their assistance in documenting the sunrises and sunsets at the church. We also thank archaeologist Miguel Medina, Guillermo Miron, and Tito Davila for guiding us on our visit to the hills, both to the east and west.

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