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Edited by
Ivan Šprajc
and
Peter Pehani

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Anthropological Notebooks year XIX, supplement 2013

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CONTENTS

Equinoxes in Mesoamerican Architectural Alignments: Prehispanic Reality or Modern Myth?

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Abstract
While the equinoctial Sun is commonly believed to have been an important target of Mesoamerican architectural orientations, the results of systematic archaeoastronomical research accomplished during recent decades do not sustain this opinion. Analyzing particular alignments that have been claimed to refer to the equinoxes, we show that such a relationship exists in very few cases, for which reason their intentionality remains questionable; instead of the true astronomical equinoxes, the quarter-days of the year were much more likely referents of several allegedly equinoctial alignments.

KEYWORDS: Mesoamerica, architecture, astronomical alignments, equinoxes

POVZETEK
Čeprav se na splošno domneva, da je Sonce ob enakonočju predstavljalo pomembno tarčo pri usmeritvi stavb v Mezoameriki, pa rezultati sistematičnih arheoastonomskih raziskav iz zadnjih desetletij tega mnenja ne podpirajo. Z analizo posameznih usmeritev, ki naj bi se nanašale na enakonočja, smo pokazali, da takšna zveza obstaja v zelo redkih primerih, zato je njihova načrtnost vprašljiva; nekatere domnevno enakonočne usmeritve se tako bolj verjetno nanašajo na dneve četrtin leta.

KLJUČNE BESEDE: Mezoamerika, arhitektura, astronomske usmeritve, enakonočja

Introduction
Every year on the March equinox, numerous archaeological sites surviving as a material testimony of ancient Mesoamerican civilizations are flooded by increasingly large numbers of visitors. Particularly crowded are some of the largest and most famous sites, such as Teotihuacan, Chichén Itzá and El Tajín in Mexico. While multiple groups of modern

pilgrims dressed in white (and pertaining to different versions of esoteric movements whose ambitions are to revitalize ancient wisdom) expect to receive supernatural energy and spiritual enlightenment, many other people simply want to share the experience and see whether anything happens.

This modern tradition has little to do with prehispanic astronomical concepts, and it is surprising that even in scholarly literature, particularly in general archaeological works not focused specifically on astronomical matters, the importance of equinoxes in prehispanic times continues to be highlighted in ways that are entirely inconsistent with the results of serious archaeoastronomical research carried out during recent decades. The equinoxes are often mentioned in tandem with the solstices, apparently because, for many Western-minded modern people sharing superficial but evidently ethnocentric astronomical notions, they represent the only significant moments of the tropical year. Nobody seems to care that, while the solstices are marked by easily perceivable extremes of the Sun's annual path along the horizon, the equinoxes are not directly observable and can only be determined with relatively sophisticated methods (cf. Ruggles 1999: 148f, 150f). While the search for equinoctial and solstitial orientations was a general trend in early archaeoastronomical work, largely based on preconceived ideas (Ruggles 2007: 314ff), it is still rather common in Mesoamerican studies. The purpose of this paper is to call attention to specific cases and to evaluate the viability of arguments about the existence of equinoctial alignments. In order to do that, however, we must first summarize the current knowledge on the astronomical significance of Mesoamerican architectural orientations.

Orientation patterns in Mesoamerica

The results of systematic research accomplished so far indicate that the orientations of civic and ceremonial buildings in Mesoamerica largely refer to sunrises and sunsets on certain dates. For central Mexico and the Maya Lowlands it has also been shown that the dates recorded by orientations tend to be separated by multiples of 13 and 20 days. It has thus been argued that the architectural alignments allowed the use of observational calendars composed of calendrically significant intervals, and that these observational schemes – considering the distribution of the most frequently recorded dates in the tropical year – served to facilitate an efficient scheduling of agricultural activities and the corresponding rituals (Aveni & Hartung 1986; Aveni, Dowd & Vining 2003; Šprajc 2001; Šprajc & Sánchez 2012; Šprajc, Sánchez & Oštir 2011).

In view of the prevalent clockwise skew from cardinal directions, observed in Mesoamerican architectural orientations since the very beginning of serious archaeoastronomical research (Marquina & Ruiz 1932; Macgowan 1945; Fuson 1969), it has long been clear that the purpose of recording equinoctial sunrises or sunsets could not have been a dominant underlying motive. The available data clearly show that, among the dates most frequently targeted by orientations, the solstices appear rather prominently, but not so the equinoxes. Ponce de León (1982: 60, note 33; 1991: 422ff) and Tichy (1991: 29ff, 56ff) noticed that the orientations close to the east-west direction tended to mark the dates falling two days after and before the spring and autumn equinoxes, respectively, rather than the true equinoxes. This orientational trend, confirmed by systematic research in central Mexico (Šprajc 2001: 75ff), is particularly evident in the data sample recently collected in the Maya Lowlands. In the curvigrams of east and west declinations – which present relative frequency distributions, considering errors assigned to individual declination values on the basis of uncertainties in azimuths – a group of near-equinoctial values can be observed among both east and west declinations, but in neither case are they centered on 0° but rather on approximately -1° (east) and 1° (west) (Figure 1). Unlike the other most frequently recorded pairs of dates, those corresponding to the east declinations around -1° (March 19 and September 25) do not delimit calendrically significant intervals. It is more likely that these orientations were functional only to the west, since the corresponding dates are the so-called quarter-days, March 23 and September 21 (± 1 day), which fall two days after and before the spring and fall equinoxes, respectively; these dates, together with the solstices, divide the year into four equal periods of approximately 91 (= 7 × 13) days each.[1]

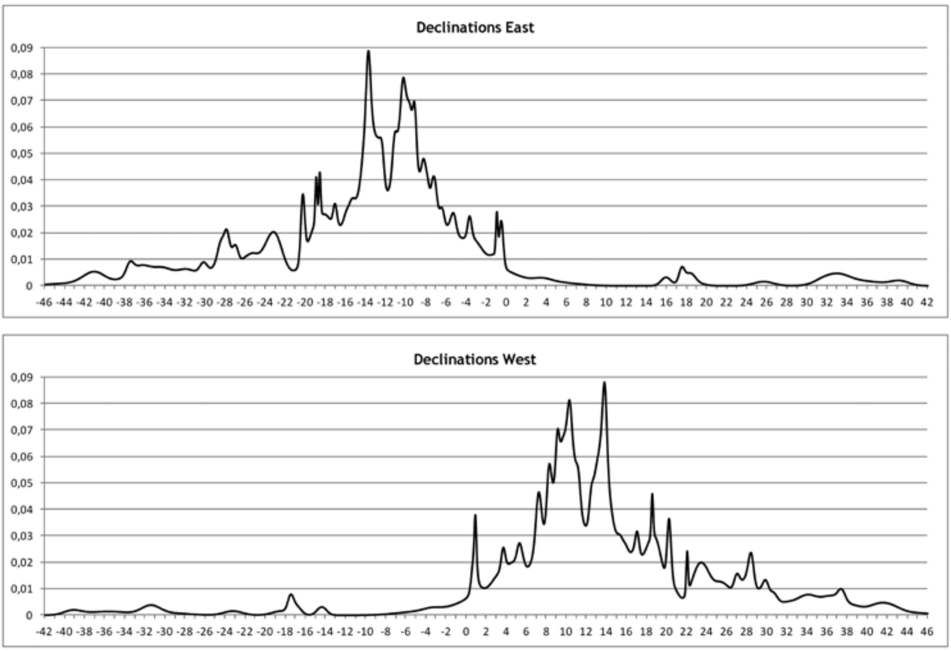

Figure 1: Relative frequency distribution of declinations corresponding to architectural orientations in the Maya Lowlands.

[1] The results of the research in central Mexico also indicate that many important buildings were located on spots that allowed prominent mountain peaks on the horizon to be used as natural markers of sunsets and sunrises on relevant dates, including quarter-days of the year (Šprajc 2001). Particularly interesting examples are Teotihuacan and Cuicuilco, which are, paradoxically, two of the sites most invaded by modern equinoctial pilgrims. While at the astronomical equinoxes no phenomena can be observed that might corroborate the visitors' preconceptions, both sites offer a visual spectacle on the quarter-days: observing on top of the Sun Pyramid at Teotihuacan, the Sun rises over Cerro Colorado, the most prominent mountain on the eastern horizon, while for an observer on the round pyramid at Cuicuilco, the rising Sun aligns with Cerro Papayo, a notable feature on the eastern horizon of the Valley of Mexico (Šprajc 2001: 170ff, 208ff).

In sum, the systematic studies accomplished so far, based on large samples of alignment data, provide no compelling evidence indicating that the true astronomical equinoxes were targeted by Mesoamerican architectural orientations. In fact, the persistent popularity of the idea about the existence of equinoctial orientations has been nurtured by relatively few specific cases, which have received disproportionate attention, probably because of the aforementioned ethnocentric prejudices. In the following case-by-case discussion we will analyze particular alignments that have been claimed to refer to the equinoxes, in order to assess the likelihood of their intentionality.

Claimed equinoctial alignments in Mesoamerica

Uaxactún

One of the best known cases, first discussed by Ricketson (1928a; 1928b) and thereafter referred to on innumerable occasions as a solstitial and equinoctial observatory, is Group E of Uaxactún, Petén, Guatemala. Its main components are Temples E-I, E-II and E-III, erected on an elongated platform flanking a plaza on its east side, and Structure E-VII-sub, a pyramid on the west side of the plaza. Having measured various alignments that may have been observationally functional (the differences among them being due to different possible observation points), Aveni and Hartung (1989) established that the best fit to a functioning solar observatory corresponds to the observation point being situated at the upper end of the eastern stairway of the first construction stage of Structure E-VII-sub, because from this point the rising Sun at the solstices would have appeared just left and right of Temples E-I and E-III, respectively, while at the equinoxes it would have aligned with the upper mid-point of the terraces built upon the eastern platform to support Temple E-II (and rising above natural horizon to the angular height of 3.5°). When Temple E-II was erected, however, it blocked the view to the rising equinoctial Sun along the alignment, rendering it non-functional. The authors, therefore, conclude that Group E ‘should be regarded as a functioning (though not precise) *solstice* observatory only and not as an equinoctial one’ (Aveni & Hartung 1989: 445).

Significantly, the azimuth given by Aveni and Hartung (1989: Table 35.1) for the sightline connecting the centers of Structure E-VII-sub and Temple E-II is 90°54’ (closely agreeing with the value S89°03’E formerly determined by Ricketson, 1928a: 437). The widespread occurrence of orientations skewed about 1° clockwise from cardinal directions, both in the Maya area and in central Mexico (Šprajc 2001; Šprajc and Sánchez 2012), suggests they had an astronomical basis; while they cannot be related with the equinoctial Sun, the corresponding declinations calculated for the western horizon are neatly centered on the value reached by the Sun on the quarter-days of the year (cf. Figure 1). Given the relative heights of Structure E-VII-sub and the temples on the eastern platform, and in view of the evidence indicating that the final eastern platform was built before the final version of Structure E-VII (Aveni & Hartung 1989: 459, note 10), an observer standing at the doorway of Temple E-II may well have been able to see the natural horizon above Structure E-VII-sub and the quarter-day sunsets along its axis.[2] When

[2] According to our calculations based on cartography, the horizon altitude in that direction is slightly above 2.5°.

this view was obstructed by the later and higher stages of Structure E-VII, the alignment would have become non-functional; but it is possible that the observation point was actually on top of Structure E-VII, whose substructure also exhibits a slight clockwise skew from cardinal directions (Aveni & Hartung 1989: 458, note 1).[3]

We do not pretend to solve the question concerning possible observational practices associated with either Group E of Uaxactún or other similar compounds very common in the Maya Lowlands. However, the foregoing discussion allows the conclusion that even Group E of Uaxactún – which appeared to be the only assemblage of this type incorporating a true equinoctial and observationally functional sightline (all others have notably different orientations: Aveni, Dowd & Vining 2003) – fails to provide convincing evidence of the existence of such an alignment.

Dzibilchaltún

The Temple of the Seven Dolls or Structure 1-sub at Dzibilchaltún, Yucatán, Mexico (Andrews and Andrews 1980: 82ff), is one of the increasingly popular focuses of modern equinoctial pilgrimages. A common belief, never substantiated by a sound argument, is that the passage shaped by four east-west aligned doorways of this building was intentionally oriented to the rising Sun at the equinoxes. The widely publicized photographs showing the solar disk nicely framed by the doorways (Figure 2) contribute to the popularity of the event. Nobody seems to care that the axial orientation of the temple, skewed about 1° clockwise from cardinal directions (Figure 3), does not correspond to the equinoctial position of the Sun on the horizon and that virtually the same picture can be taken from different points and during several consecutive days, but only after the Sun has reached a substantial altitude above the horizon. Since the causeway leading westward from the temple (Sacbé 1) is skewed 1°40' north of due west,[4] and because its central axis extended eastward passes a few meters north of the center of the temple (cf. Stuart et al. 1979; Andrews & Andrews 1980: 14, Fig. 2), the appropriate points for observing the phenomenon are located along a line running considerably south of – but not exactly parallel to – the central axis of the causeway. The line also runs several meters south of Stela 3, which would appear to be a convenient marker of the observation spot, because it stands on a platform in the middle of Sacbé 1, some 130 m west of the temple (Figure 4).

[3] To discuss the alleged solstitial alignments incorporated in Group E of Uaxactún is beyond the scope of this paper, but we see no contradiction in the possibility that they were functional in the eastern direction, as proposed by Ricketson (1928a; 1928b) and Aveni and Hartung (1989), whereas the target of the quarter-day alignment was the setting Sun. While the height of later stages of Structure E-VII resulted in the presumed solstitial alignments becoming non-functional, the quarter-day direction, if embedded in the orientation of Structure E-VII, may have continued in use.

[4] This value, obtained in 2010 by our own field measurements along the southern edge of Sacbé 1, can be easily verified on Google Earth images (http://www.google.com/earth/index.html). The azimuth of 93°30' given for the causeway by Coggins and Drucker (1988: 18) is misleading; it corresponds approximately to the line from Structure 66 to Structure 1-sub, but the two buildings are not located at the extremes of a single causeway, as the authors imply. While Sacbé 1 leads eastward from the core area of Dzibilchaltún to Structure 1-sub, Sacbé 2 runs westward from the central part of the site, terminating at Structure 66, but the two causeways are neither coaxial nor exactly parallel to each other (cf. Andrews & Andrews 1980: 14, Fig. 2; Stuart et al. 1979).

Figure 2: Rising Sun viewed through the doorways of the Temple of the Seven Dolls at Dzibilchaltún, Yucatán, Mexico, around an equinox.

Figure 3: Google Earth image of the group of the Temple of the Seven Dolls at Dzibilchaltún; note that the architectural compound, including the temple itself (on the right), is skewed slightly clockwise from cardinal directions.

Figure 4: View to the west through the doorway of the Temple of the Seven Dolls at Dzibilchaltún, with Structure 7, Stela 3 and Sacbé 1 in the background.

About 40 m west of Structure 1-sub there are three pairs of buildings aligned in a north-south direction. The central doorway of Structure 7, the eastern one of the central pair of buildings, lies on the line of points suitable for observing the equinox Sun through the doorways of Structure 1-sub, and might represent an archaeologically preserved marker. From that vantage point, the azimuth of the vertical axis of symmetry of the opening shaped by the four east-west aligned doorways of Structure 1-sub is 93°31', and the angular altitude of the lower edge of the opening (front threshold) is about 7°15' (our measurements). Since the resulting declination is -0°41', the equinoctial Sun aligns with the opening somewhat above its lower edge. However, observing this way, it would have been difficult to pinpoint the equinox date: due to the relatively short distance to Structure 1-sub and the consequent apparent size of the passage shaped by its doorways, the decision about which is the relevant altitude of the Sun with respect to the doorways would have been quite subjective, and the determination of the date corresponding to the alignment would have depended on both the exact point of observation and the observer's height (Figure 2). It is hard to imagine why the builders would have designed an observational device with such poor precision.

It is noteworthy that, as in the case of Uaxactún discussed above, the orientation of the Temple of the Seven Dolls is skewed about 1° north of west (Figure 3), pertaining to the alignment group for which the sunsets on quarter-days of the year represent a much more likely target. These dates could have been determined not only by direct observation of the setting Sun along the axis of symmetry of the four doorways (cf. Figure 4), but also by observing light-and-shadow effects produced by pairs of windows and smaller openings in the eastern and western walls of the temple (Šprajc 1995).

Coggins and Drucker (1988), defining the group of Structure 1-sub as an observatory assemblage, argued that one of its functions was to determine the equinoxes. Choosing Stela 3 and Structure 66 – the latter is situated at the west end of Sacbé 2, about 2.2 km away – as the most likely observation points, they do not find any prominent architectural feature of Structure 1-sub that would match the equinoctial position of the Sun; but they contend that its windows and doorways, through which the Sun was visible several days after/before the equinox, served as anticipatory or predictive markers (Coggins & Drucker 1988: 24, Table 1, Fig. 11). The doorways are said to have marked sunrises on March 16, which in A.D. 692 was the katun ending 9.13.0.0.0 8 Ahau 8 Uo. In the absence of explicit Long Count dates associated with this architectural group, the authors claim that the cited date, to which they attribute special importance on the basis of indirect evidence, is encoded in the iconography of Structure 1-sub. Aside from depending on their interpretation of iconographic elements, their argument is flawed by erroneous dates they associate with the alignments.[5] In sum, the complex observational scenario presented

[5] For example, Coggins and Drucker (1988: 24, Tab. 1, Fig. 11) assert that, observing either from Structure 66 or from Stela 3, the Sun could have been sighted through the central doorways of Structure 1-sub on March 16. Instead, since for an observer standing at Stela 3 the azimuth, altitude and declination of the central doorways are 93°50', ca. 1°54' and ca. -3°00', respectively (our measurements), this alignment would have marked the Sun's position on March 13 ± 1 day. We did not take readings from Structure 66; however, since it lies along the same alignment, but at a distance of about 2 km to the west (cf. Stuart et al. 1979), the angular height of Structure 1-sub viewed from that point (0.5° at most) would have shifted the corresponding date to March 11 or 12.

by Coggins and Drucker – in spite of their emphasis on the equinoctial character of the ‘observatory’ – contains no unequivocal evidence indicating the importance of the equinoxes, let alone the existence of equinoctial alignments.

Observing from Structure 41, located just south of the western terminus of Sacbé 1, the rising Sun at the equinoxes appears on top of Structure 1-sub, located some 630 m away (azimuth: 90°24’, altitude: 1°05’, declination: -0°08’). The alignment could have been functional in the eastern direction only if Structure 41 had been built before Structure 1-sub was covered by the later building (cf. Andrews & Andrews 1980: 82ff). Since the chronological relation between the two structures is not known, the issue remains unsolved. It should also be noted that, while the axes of both structures approximately agree with the line connecting them (which might be an indicator of intentionality) the alignment may well be coincidental, particularly because Structure 41 is a relatively minor and unsophisticated building (Maldonado 2002: 480).

Copán

In his study of the Sepulturas group at Copán, Honduras, Hohmann (1995: 104ff, Fig. 195) suggests that Structures 9N-81 and 9N-83, oriented exactly east-west, compose an equinoctial alignment, but does not provide the corresponding horizon altitudes. According to our calculations based on cartography, the eastern and western horizon contours along the east-west axis of the architectural group rise to more than 6° and 2°, respectively. The alignment, therefore, corresponds to neither sunrises nor sunsets at the equinoxes, but may have been intended to record sunsets on the quarter-days of the year.

Tikal

According to our measurements, the westward azimuth of the visual line connecting the centers of the entrances to the upper sanctuaries of Temples I and III at Tikal, Petén, Guatemala, is 269°54’, equal to that given by Aveni and Hartung (1988: 9, 12, Table 2). Although the alignment reproduces the true east-west direction almost perfectly, it cannot relate to the equinoxes, as suggested by Aveni and Hartung (*ibid.*) and Malmström (1981: 253f, Fig. 22.1; 1997: 169ff, Figs. 48, 50). This is because the equinoctial sunrises or sunsets along this line could only have been observed on the natural horizon (with an altitude of about 0°). In fact, due to their heights, both temples mutually obstruct the view of the natural horizon. As rightly noted by Hartung (1980: 148), there was evidently no opening in the back wall of either building; hence the equinoctial observations were not possible once the construction was completed. If we nonetheless assume that both temples composed an observationally functional alignment, the heights of their roof combs must be taken into account. Observing in front of the upper sanctuary of Temple I westward, the angular altitude of the roof comb of Temple III is 3°36’; the declination corresponding to this altitude and the azimuth of 269°54’ is 0°55’. Inversely, observing from the entrance to the sanctuary of Temple III, the roof comb of Temple I, rising to 2°36’ of altitude, marks the declination of 0°47’. Remarkably, the two declinations are very similar, but do not correspond to the positions of the Sun at the equinoxes but rather on the quarter-days of the year, March 23 and September 21 (Figure 5; Šprajc, Richter & Sánchez 2012). Considering that these dates are frequently recorded by orientations, they may well have motivated the relative placement of the two temples; to support this possibility, however, independent evidence and/or comparable spatial patterns at other sites would be needed.

Figure 5: Tikal, Petén, Guatemala; rising Sun above the roof comb of Temple I, observed from Temple III on September 21, 2011 (photo: Dieter Richter).

Chichén Itzá

The most famous prehispanic building believed to reflect the importance of the equinox Sun is undoubtedly El Castillo of Chichén Itzá, Yucatán, Mexico. Year after year thousands of visitors gather at the spring equinox to observe the light-and-shadow effect produced before sunset on the northern balustrade of the pyramid, giving impression of the descent of a rattlesnake with illuminated dorsal triangles (Rivard 1969; Arochi 1976; Carlson 1999). The ophidian heads decorating the base of the northern stairway make this visual effect even more persuasive. Rivard (1969: 52), who was the first to describe the phenomenon in some detail, characterizing it as a 'hierophany', observed:

> None of the other three stairways bears any decoration nor are large serpent heads to be found at its base. One might have expected such heads at the bottom of the southern stairway since the phenomenon is visible one hour after sunrise on the eastern side also. Their absence (if they were originally absent) would seem to indicate that the hierophany was of supreme significance only at the end of the day and not at its beginning.

These circumstances, as well as the fact that, around the winter solstice, a comparable effect can be observed on the northern stairway of a similar pyramid at Mayapán, also known as El Castillo (Arochi 1991; Aveni, Milbrath & Peraza 2004), seem to suggest the intentionality of both phenomena. It should be underscored, however, that the play of illuminated triangles at Mayapán is visible during about a month before and after the December solstice and, likewise, the Chichén phenomenon does not change much during a few days before and after the equinox (Aveni et al. 2004: 130f). Moreover, the most attractive illumination of the balustrade occurs about one hour before the sunset. For these reasons it is impossible to ascertain – even assuming the intentionality of the light-and-shadow effect – which was the date targeted by the builders; and it would have certainly been impossible for them to determine whatever date by observing this phenomenon only. If the play of light and shadow at El Castillo of Chichén Itzá is the result of a conscious architectural design, it could only have had a symbolic function (as already suggested by Aveni, 2001: 295, 298ff); in view of the lack of equinoctial alignments elsewhere, however, it seems more likely that the quarter-days of the year were targeted. If, indeed, the four stairways had 91 steps each, as noted by Landa (Tozzer 1941: 178), we may recall that the solstices and the quarter-days, rather than the equinoxes, divide the year into four equal parts of approximately 91 days each. Even if there were serpent heads at the foot of each stairway (as also stated by Landa (*ibid.*), but never confirmed archaeologically) a special importance of the northern direction is indicated not only by the north-facing main entrance of the upper sanctuary but also by the layout of the substructure, whose single stairway descends from the upper temple northwards (Carlson 1999: 140f). If the significance of the northern stairway reflects the builders' desire to witness the serpent's descent near sunset, as suggested by Rivard (see above), this would agree with the above-mentioned results of the analyses of large samples of alignment data, showing that the quarter-days were recorded on the western horizon.

According to Ponce de León (1991: 430f), the equinoctial Sun reaches the altitude equivalent to the inclination of the western stairway of El Castillo precisely when its azimuth coincides with that of the stairway; in other words, at the equinoxes the rays of the ascending Sun pass 'grazing' along the stairway in the moment when they align with its axis. Interestingly, the author discusses several Mesoamerican temples where the 'grazing Sun' phenomenon may have been observed, but in other cases the azimuths and inclinations of stairways correspond to solar declinations on the quarter-days of the year. El Castillo de Chichén Itzá, therefore, leads him to infer that it was only during the Postclassic that the knowledge of the true equinox may have been acquired (Ponce de León 1991: 431, note 17). While this is an interesting hypothesis, additional evidence is needed to support it. It should also be recalled that the 'grazing Sun' effect is not easy to observe and would have hardly allowed accurate determination of the intended date. It could have had, however, a symbolic significance, and the cases analyzed by Ponce de León certainly call for further systematic research, which should shed light on the validity of the 'grazing Sun' hypothesis.

For the Caracol tower at Chichén Itzá, Aveni, Gibbs and Hartung (1975: 982f) provided support to the former proposal by Ricketson (1928a; 1928b), observing that a diagonal line from inner right to outer left jambs of window 1, opening to the west, corresponds to the sunset on the equinoxes. While a photograph supports their finding (Aveni et al. 1975: Fig. 9), they are careful enough to mention both the possibility that some of the blocks composing the window have shifted from their original positions and the difficulties involved in observing the event (which could be seen only from the floor level, due to the oddly inclined and apparently misplaced block of the inner right jamb); for these reasons, the 'solar equinox alignment in window 1 remains problematical' (*ibid.*: 985). The fact that no other similar devices have been found further weakens the intentionality of the equinoctial alignment, and even of other astronomical sightlines presumably incorporated in the Caracol (cf. Schaefer 2006: 42ff).[6]

Templo Mayor of Tenochtitlan

Fray Toribio de Benavente o Motolinía (1971: 51), a Spanish friar who arrived to Mexico soon after the Conquest, writes that the Aztec feast of Tlacaxipehualiztli 'fell when the sun was in the middle of Uchilobos, which was the equinox'. This comment, referring to the main temple in the Aztec capital of Tenochtitlan, as well as the map of the city attributed to Cortés, where the face of the Sun is shown between the twin sanctuaries of the temple (Aveni 2001: Fig. 84), suggest that the building currently known as *Templo Mayor* was aligned to sunrise or sunset on a certain date. In the attempt to reconcile Motolinía's statement and the image on the map of Cortés with the orientation of the temple, which is skewed notably south of east, Aveni and Gibbs (1976: 513ff) and Aveni, Calnek and Hartung (1988) proposed that the observations were made at the equinoxes from a spot at the ground level west of the temple; due to the building's height, the rising Sun appeared in the notch between the two upper sanctuaries only after it had moved considerably south of the east-west line. Since they did not observe any notable change in the temple's orientation throughout its various construction stages, Aveni et al. (1988: 297), after discussing different possibilities to overcome the problem, concluded that this conformity 'may be taken to imply either that the differences of linear height between observer and sun disk were always kept constant in the engineering problem, or that the desire to preserve the equinox orientation, once established, simply was abandoned.'

The difficulty of the first option, apparently reflected in the authors' remark that 'a number of pieces of the orientation puzzle still do not fit perfectly' (*ibid.*), is in that the angular height of the notch with respect to observer could have hardly been kept constant: as the temple grew in height, the observation point would have had to be moved either farther away or to a higher level above natural ground. While this scenario finds no support in archaeological evidence, the alternative option – implying that the alignment was preserved in the late buildings but lost its function – contradicts Motolinía's comment, which obviously refers to the latest construction stage of the temple used at the time of the Spanish Conquest. The problem, however, has another solution, which is in perfect accord with both Motolinía and archaeological evidence.

Aveni and Gibbs (1976) and Aveni, Calnek and Hartung (1988) assumed that the orientation of the early and best preserved Phase II of the Templo Mayor was maintained

[6] Inspecting the windows of the Caracol tower in 2010, we noticed that the inner right blocks of window 1 are now missing.

in subsequent construction stages. This assumption was supported by the north-south alignment azimuths, which remained virtually the same throughout the temple's construction history. Precise measurements in the Templo Mayor precinct revealed, however, that the east-west running walls of Phase III adopted a different orientation, which was maintained in all the following phases up to the Conquest, and incorporated also into many adjacent structures. One of the two sunset dates corresponding to the east-west axis of the temple's late construction stages, including the last one, is April 4, which in the sixteenth-century Julian calendar corresponded to March 25. In 1519, this was the last day of the month of Tlacaxipehualiztli, according to the correlation of the Mexica and Julian calendars established by Caso (1967: 58, Table IV) and supported by different kinds of evidence (Prem 1991). Various sources, including Motolinía (1971:45), indicate that the main feast of every month was celebrated on its last day (Caso 1967: 39, 51; Prem 1991: 395). On the other hand, March 25, the Feast of the Annunciation was, in medieval Europe, commonly identified with the vernal equinox (McCluskey 1993: 110f, 114; Newton 1972: 22ff).[7] We can thus conclude that Motolinía's (1971: 51) statement quoted above did not refer to the astronomical equinox (the date of which would have hardly been known to a non-astronomer at that time). Rather, he only noted the correlation between the day of the Mexica festival – which in the last years before the Conquest coincided with the sunset along the axis of the Templo Mayor – and the date of the Christian (Julian) calendar that corresponded to the traditional day of the spring equinox (for the whole argument see: Šprajc 2000; 2001: 383ff).

Both the text in Motolinía and the drawing of the Templo Mayor in the map of Tenochtitlan attributed to Cortés, where the Sun disk is shown between the twin sanctuaries, have frequently been interpreted as references to the observation of *sunrises*, but the sources are far from explicit. The fact that Marquina (1960: 113), paraphrasing Motolinía, mentions the Sun 'in front of Huichilobos' shows clearly that the text is ambiguous and may well refer to *sunsets* along the building's axis. The very fact that the temple faces west suggests a special importance of that direction.

Finally, let us recall that, whereas the hypothesis forwarded by Aveni and Gibbs (1976) and Aveni, Calnek and Hartung (1988) implies an alignment to a celestial target well above the horizon, the astronomically and calendrically significant patterns of dates recorded by Mesoamerican architectural orientations are consistent with horizon-based observations. Indeed, orientations similar to that of the late stages of the Templo Mayor of Tenochtitlan (5°36' south of east) seem to have been common in the neighboring area of Texcoco (Šprajc 2001: 322, 324f, 330). The agreement between the text in Motolinía and one of the two sunset dates corresponding to the archaeologically attested orientation of the late phases of the Templo Mayor is thus hardly coincidental and offers probably the most convincing support to the conclusion that this structure, as so many others, was intentionally oriented to the Sun's positions on the horizon, although not at the equinoxes.

[7] Even if the canonical date of the ecclesiastical equinox established in A.D. 325 by the Council of Nicaea was March 21, the Roman tradition associating the equinox with March 25 also survived (Newton 1972: 22ff).

Alta Vista

In their analysis of astronomical aspects of Alta Vista, Zacatecas, Mexico, located almost exactly on the Tropic of Cancer, Aveni, Hartung and Kelley (1982a; 1982b) affirm that a passage called Laberinto and aligned to the Cerro Picacho on the eastern horizon marks sunrises at the equinoxes with impressive precision. They support their statement with both alignment data and photographs. Among the alignments detected in Mesoamerican archaeological sites and claimed to refer to the equinoxes, this is one of the very few that are both exact and clearly marked by material remains preserved *in situ*.

Aposento de Moctezuma

According to Galindo (2003: 64ff), the platform constituting the so-called Aposento de Moctezuma, on the eastern slope of Cerro de Chapultepec within Mexico City, is oriented to Mount Tláloc, which marks the equinoctial position of the Sun on the eastern horizon. The orientation of this structure, in view of the author's description, cannot be determined with precision, making it difficult to reliably establish its possible astronomical referent and to assess its intentionality.

Teotihuacan

Aveni and Hartung (1982: 28f; Hartung & Aveni 1991: 34f) mention that the alignment involving the Pyramid of the Sun and two petroglyph complexes located to the west (labeled TEO 11 and TEO 16) marks the equinoctial sunsets with considerable accuracy. The problem concerning the intentionality of this alignment is that the two groups of rock carvings are of different types and that, due to the large number of petroglyphs in the area of Teotihuacan, one can trace numerous lines connecting them. That two of these designs align with both the Pyramid of the Sun and the equinoctial sunsets certainly calls attention, but one wonders how (un)likely it is, in statistical terms, for this arrangement to have been produced by chance (cf. Ruggles & Saunders 1984).

Cempoala

As pointed out by Galindo (1996) and confirmed by our measurements, the orientation of the Postclassic Templo de las Caritas at Cempoala, Veracruz, Mexico, corresponds quite accurately to sunrises at the equinoxes. The intentionality of this correspondence remains questionable, however, because the same orientation agrees also with sunsets on the quarter-days of the year. Significantly, the orientation of the much larger Templo Mayor of the same site also corresponds to quarter-day sunsets, but cannot be related to sunrises at the equinoxes (Sánchez & Šprajc 2012).

Other cases

A number of other equinoctial alignments have been claimed to exist in Mesoamerican architecture and urban patterns. Aside from being impossible, it would be pointless to discuss all these proposals, because they involve methodological incoherencies that prevent their verification. Some authors present deficient or imprecise data, leaving the possibility that other astronomical referents – if any – may have been involved; others construct alignments connecting different architectural elements of a single building, different buildings at a site, or different architectural groups or sites in an area, without employing any consistent methodology in alignment selection and analysis. Several of these problems are often combined, and the resulting astronomical hypotheses thus remain entirely speculative. Two cases should illustrate the point.

In the distribution of archaeological sites in the Holmul region in Belize, Tomasic (2009) identifies solstitial and equinoctial alignments, but recognizes that errors of up to 2° are involved. Since only three alignments are discussed, such low precision data do not allow their possible astronomical referents to be determined with any confidence. Furthermore, two architectural groups, claimed to mark equinoctial and summer solstice sunrise directions from Holmul, were found as a result of survey transects that were made in these directions precisely because of their preconceived astronomical significance. This procedure, obviously, raises methodological objections, because one wonders how many other sites or building complexes would have been found had the surveyors followed other directions; considering high settlement density in the Maya Lowlands, this is by no means a pedant question. Clearly, only objectively collected data on site distribution and typology in an area may serve as a reliable basis for assessing possible astronomical potentials of intervening alignments. Alternatively, if unique cases are dealt with, some other indications of underlying intent should be sought; in the absence of independent contextual evidence, a building clearly oriented to another one, for instance, may at least hint at a deliberate spatial relation between the two.

To cite one more example, Méndez et al. (2005) found an equinoctial alignment in the Temple of the Sun at Palenque, Chiapas, Mexico. In fact, this is only one of a number of astronomical alignments they identified, both in the complex architectural composition of this building and in its relation to the surrounding architecture and topography. However, their alignment selection criteria are neither made explicit nor respected in practice: instead of analyzing all possible corner-to-corner, pillar-to-pillar or other sightlines along comparable features, they choose those that match the astronomical targets they believe to have been significant: the solstices, equinoxes, zenith and nadir passages of the Sun, and lunar standstills. While it is certainly possible that some of these alignments were achieved on purpose, the authors' procedure seems to be biased by their own prejudices: none of their celestial events figures prominently among the targets of axial orientations in Mesoamerica, including the Maya area (Aveni & Hartung 1986; Aveni, Dowd & Vining 2003; Šprajc 2001; Šprajc & Sánchez 2012; Sánchez & Šprajc 2012). It is fair to add that a comprehensive analysis of all possible alignments in the Temple of the Sun would be, indeed, a formidable task, and not a particularly productive one if no other comparable buildings were also included.

Summary

The cases discussed above represent a very mixed bag, but we hope we have been able to show that, in spite of the popularity of equinoctial pilgrimages to Mesoamerican archaeological sites, and although even many serious researchers still believe that the Sun at the equinoxes had an important role in the precepts dictating architectural design and urban planning, the evidence in favor of this opinion is, at best, scanty.

In Group E at Uaxactún, the Temple of the Seven Dolls at Dzibilchaltún, El Caracol of Chichén Itzá and the Templo Mayor of Tenochtitlan, the alignments that could have been related to the equinoxes are not unequivocally attested in archaeological record, but are rather constructed on the basis of certain assumptions. In the case of the Sepulturas group at Copán, the equinoctial hypothesis is ruled out by the effect of horizon altitudes. Temples I and III of Tikal compose an alignment whose intentionality has no visible support, because neither of the two buildings is oriented to the other; if we nonetheless assume an astronomically-based rationale of their spatial relationship, the resulting observationally functional alignments could only have served to record solar positions on quarter-days of the year. The Aposento de Moctezuma does not allow its orientation to be established with sufficient precision. The line connecting the Sun Pyramid of Teotihuacan and two petroglyph areas agrees with equinoctial sunsets, but the intentionality of this correspondence is, in view the circumstances discussed above, open to question. A similar caution applies to the line connecting Structure 41 and the Temple of the Seven Dolls at Dzibilchaltún. The famous light-and-shadow effect at El Castillo of Chichén Itzá could not have served as a precise marker of any date; if it only had a symbolic significance, the commemorated dates may have been either the true equinoxes or some other nearby dates, including quarter-days. Finally, many allegedly equinoctial alignments, which involve certain buildings on a site, architectural features within a building, or sites in an area, have been selected arbitrarily and considered significant only because they fit the preconceptions about the importance that the equinoxes should have had. Consequently, the alignments embedded in the Laberinto passage at Alta Vista and in the Templo de las Caritas at Cempoala seem to be the only equinoctial directions clearly indicated in the preserved architectural remains. Having only two cases, however, we cannot ascertain whether they, indeed, reflect the purpose of recording the equinoxes.

The doubt cast on most, if not all, of the claimed equinoctial alignments discussed above is based particularly on the known distribution patterns of architectural orientations in Mesoamerica. The buildings clearly exhibit their axial orientations; the fact that the corresponding horizon declinations evidently cluster around certain values indicates that the important civic and ceremonial structures were, in most cases, deliberately oriented to celestial events on the horizon. Since most of the east-west axes lie within the angle of solar movement along the horizon, it is also highly likely that they refer to the Sun's positions on certain dates. One of the most evident declination groups is centered on approximately 1°, probably referring to the quarter-days, but truly equinoctial orientations are virtually absent. It is for this reason that, for several of the cases discussed above, we have suggested the quarter-day Sun as a more likely target.

While it would be imprudent – despite the foregoing arguments – to dismiss outright the possibility that some alignments were intended to record the true equinoxes, it does seem significant that the scarcity of equinoctial dates, in contrast to relatively frequent references to the solstices, has also been observed in Maya inscriptional records (Nikolai Grube, personal com., 2011). In agreement with this fact is the ethnographic information given by Vogt (1997: 111) for the Tzotzil Maya of Zinacantan, Chiapas, Mexico: while they are acutely aware of the solstitial positions of the Sun, and even have names for the solstices in their own language, there are no words in Tzotzil to describe the equinox, nor do the modern Zinacantecos seem to be aware of the equinox positions of the Sun on the horizon. If the equinoxes, indeed, appear in Maya codices, as has been argued (cf. Bricker & Bricker 1988; Bricker & Vail 1997), we should recall that they are all from the Postclassic period; this might suggest that the concept of the equinox came to be understood only in later times.

These cautions notwithstanding, we can conclude that the popularity of ideas about the importance of equinoxes in prehispanic Mesoamerica is, with respect to the real significance they may have had, tremendously disproportionate. If the goal of modern pilgrimages to archaeological sites is to recover the ancient wisdom on ancestrally important dates, the equinoxes are definitely the least suitable for these purposes. To judge by the alignment data, we can be reasonably certain about which were the most special days in one or another civic and ceremonial center. Equinoctial invasions should thus be replaced by visits more evenly distributed through the year; such rescheduling may not guarantee a more effective transmittal of ancestral values and spiritual energy, but would certainly have beneficial effects for the conservation of Mesoamerican archaeological heritage.

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