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Keeping Ma'at: an astronomical approach to the orientation of the temples in ancient Egypt

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Abstract

For various reasons, Archaeoastronomy has not been one of the favourite disciplines of the Egyptologists in the past. Probably because of that, important questions such as the orientation of Egyptian temples and the relevance of astronomy in this respect had never been afforded with the necessary seriousness and deepness. The Egyptian-Spanish Mission for the Archaeoastronomy of ancient Egypt has, among its various priorities, the solution of this problem. In order to achieve that, we have measured the orientation of some 330 temples in the Valley, the Delta, the Oases and the Sinai so far. The aim is to find a correct and almost definitive answer to the question of whether the ancient Egyptian sacred constructions were astronomically aligned or not. Our data seem to answer this question in the affirmative sense. Besides, they offer a very interesting new perspective in the field of landscape archaeology, a new discipline hardly worked in Egypt so far, in which terrestrial landscape, dominated by the Nile, and celestial landscape, dominated by the sun and the stars, would combine in order to permit the establishment of Ma'at, the Cosmic Order, on Earth.

1. INTRODUCTION

During the last five years, the Egyptian-Spanish Mission on ancient Egyptian astronomy and archaeoastronomy, conducted under the auspices of the Egyptian Supreme Council of Antiquities, has been performing an ambitious scientific project with the aim of studying the cosmovision of the ancient civilization of the pharaohs. Part of the project consists of a re-analysis of the iconographic and historical sources that has allowed, among other things, a reassessment of the calendar theory (Belmonte 2003), challenging old fashioned paradigms, or a new proposal for the sky-maps of ancient Egypt (Lull and Belmonte 2006).

However, the most expensive part of the project, in time, effort and resources, has been the five campaigns devoted so far to measuring the orientation and studying the spatial location of ancient monuments across the Nile Valley and beyond. More than 500 pyramids, hypogea, chapels, sanctuaries or small and large temples have been measured so far. The fieldwork in successive campaigns was organized geographically but also with the intention of testing previous results with new exercises. Accordingly, the first campaign was devoted to Upper Egypt, the second to Middle Egypt, the third to the Oases of the Western Desert, the fourth to Lower Egypt, and the fifth with the aim of completing the sample and making some further tests, fundamentally. Four successive papers (Shaltout and Belmonte 2005, Belmonte and Shaltout 2006, Shaltout, Belmonte and Fekri 2007, and Belmonte, Shaltout and Fekri 2008, hereafter Papers 1, 2, 3 and 4, respectively) have been published about the temples in which, stage by stage, we have analysed the relation of temple orientation and their location within the local landscape, understanding landscape in its broadest meaning of both terrestrial (basically the Nile) and celestial (astronomical orientations) aspects. Our studies demonstrate that both components were necessary and indeed intimately correlated.

Figure 1 shows the location of the sites where we have assembled the data of the temples along the five campaigns. We have taken measurements in almost every archaeological location within Egypt, visiting not only extended areas such as Luxor or Memphis but also isolated monuments in the middle of nothing, such as Serabit el Khadim in Sinai or the lost city of Mons Claudianus. This include very well preserved temples, such as the one of Horus in Edfu, or monuments where just a few walls of the foundations were visible. The orientation has always been taken from inside looking outside, from the sanctuary of the temple to the gate, seldom across several halls, courts and pylons. In a few occasions, the opposite direction has also been considered or even the perpendicular to the main axis.

We wish to stress clearly that we were not seeking for extreme-precision alignments. Actually, as in previous campaigns, our main task was to measure as many sacred buildings as we were able to, giving a similar weight to those exceptionally well preserved and to temples where not more than a few walls are visible on site. Bearing this is mind, and considering the large number of monuments to be studied, we obtained our measurements using a high precision compass, correcting for local magnetic declination which is not expected to suffer alterations in Egypt, mainly a limestone and sandstone land, and a clinometer, both as isolated instruments or enclosed within a single tandem device. The instruments permit a theoretical ¼° precision for both kinds of measurements. However, owing to various considerations, an error close to ½º in both azimuth and angular height is probably nearer to reality. This would signify a mean error of order ±¾º in the determination of the corresponding declination. We can affirm without fear of being grossly in error that, for the latitudes of Egypt, a precision of ½º is perhaps the best we can expect in solar, lunar or very bright star observations near the horizon and, in the case of fainter stars, the errors in estimating the azimuth can range from more than one to several degrees. As a matter of fact, and according to our own experience, we consider our altazimuth data to be of good enough quality to pursue our main quest, i.e. to demonstrate the importance of certain families of astronomical alignments in ancient Egypt. In the case that any one temple or a certain pyramid complex might deserve further study, to test further developed theories in terms of seeking greater precision in the corresponding alignments, theodolite measurements could always be planned if necessary.

2. DISCUSSI0N

2.1. *Testing Nile orientations; the null hypothesis*

The majority of Egyptologists have traditionally considered ancient Egyptian temples to be orientated with respect to the Nile. On several occasions, this preconceived notion has precluded any serious or systematic attempt on the part of the Egyptological community to study the orientations of the temples, and most efforts up to a few years ago had come from dedicated archaeoastronomers, like Hawkins (1973) or Krupp (1988), whose conclusions were not always assimilated. Indeed, during our fieldwork in the last few years we have heard this opinion several times, even being asked by some reputed scholars why we were devoting so much efforts to a question that was crystal-clear. To be fair, we must also mention that Egyptologists on site have received us with open arms on several occasions and have been enchanted with our work, arguing that this was indeed a job that needed to be done. So, from the very beginning of our project, one of our primary objectives has been to test the Nile hypothesis in order to check if so many scholars could be wrong. In Paper 1 we demonstrated that they were indeed correct and that in Upper Egypt the Nile was the main source of "inspiration" for orientating sacred buildings, but that it was not the only one. In Paper 2 we tried to falsify the Nile hypothesis by performing fieldwork in a land with no river, the Oases of the Western Desert, and we found that when the Nile is absent, astronomical orientations certainly dominate the situation. Figures 2 and 3 repeat those exercises but with a larger amount of additional data obtained in later campaigns.

Fig. 2 shows a histogram where the difference between the orientation of the temple and the course of the Nile versus frequency is presented. The histogram has been produced with the data of 170 temples in Upper, Middle and Lower Egypt, with the particularity that in the Delta the difference is with respect to the closest river branch. The plot clearly demonstrates that temple orientation with the main gate located in front of (axis perpendicular to) the Nile is the most common way of orientating the buildings. Furthermore, axes nearly parallel to (at ~0º or 180º) or perpendicular to the river, but facing the other way (~270º), were also common. This demonstrates beyond any reasonable doubt that local topography (the course of the Nile) was very important at the moment of settling the foundations of the temples.

In contrast, Figure 3 shows the orientation diagram of 95 temples in the deserts and oases of Egypt, where there is no river to justify the orientation. The diagram shows the typical form of a Maltese Cross which is probably related to a certain preference for solar and cardinal orientations that could not be obtained without a celestial reference. As a matter of fact, the answer to the controversy is fascinating, both hypotheses should certainly be correct. This is what we have seen during these years and demonstrated in previous works on the topic, notably Papers 1 to 4. Even more, we are almost convinced that certain places throughout Egypt had an especially sacred character because they presented double (topographic and astronomical) alignments, such as Karnak or Denderah, and some customs, like the selection of cardinal or quarter-cardinal orientations in certain regions, would follow a similar line of reasoning.

2.2. *Challenging new hypotheses; astronomy in action.*

During our campaigns, we tried to measure as many monuments as we were able to, in an attempt to put at our disposal as much statistical weight as possible. The idea was to put an end to the controversy about the question of whether the Egyptian temples were astronomically orientated or not. The results of the experiment are presented in Figure 4 and are very suggestive. As a matter of fact, eleven peaks are significant in the plot and we believe that they correspond to seven possible different families of astronomical alignments of Egyptian temples. These could be classified as follows (same Roman numbers as in Fig. 4):

I. **The eastern (or "equinoctial") family**. The peak corresponds to a declination of –1º±¾º. This suggests an orientation to the equinoctial sun when the disk has completely risen above the horizon. This might imply that the ancient Egyptian were able to determine the day of the equinoxes with a reasonable precision. However, another solution is possible. This family could be the result of an orientation in the Meridian line (probably to due-north) and later the gate of the temple would have been open by establishing the perpendicular through standard topographic techniques. The pyramid complexes could be the paradigmatic example of such a procedure (see Figure 5), where the N-S axis of the pyramid would have been the first element of the construction obtained in the foundation ceremonies (Spence 2000, Belmonte 2001). We can find arguments in favour of one or other alternative and the probable solution is that both kind of monuments ought to be included within the group. These would include "equinoctially" orientated monuments, such as the Sphinx or the solar temples of the 5th Dynasty at Abu Ghurob, and 90º-rotated axis temples such as those of the pyramid complexes of the Old and Middle Kingdoms.

II. **The solstitial family**. With a peak at –24º±¾º, this group is dominated by a series of temples orientated to sunrise at the winter solstice, although other solstitial orientations have also been documented. This is the dominating astronomical custom in the temples of Upper Egypt (see Paper 1 and Figure 6) and was also found at many other locations within Egyptian geography. Hence, we would catalogue it as universal within ancient Egyptian culture. On the one hand, there has been discussion relating to the importance of the winter solstice with respect to the extended Mediterranean idea that the Birth of the Sun happened exactly as this solar time-mark. On the other hand, the summer solstice could have been important in ancient Egypt as a date close to the average arrival of the Inundation. Besides, it has been argued that this time marker could be closely related to the origin of the 365 day civil calendar. Associated to this family, we have the peculiar **II⊥** peak. We are convinced that this group of temples, orientated to an interval of declinations centred at nearly 54º, includes monuments whose axis was obtained by rotating 90º anticlockwise a previous orientation determined by winter solstice sunrise.

III. **The seasonal sun family**. This group of temples corresponds to monuments orientated to a peculiar interval of positive and negative declinations of 11½±½º and –11º±¾º, peaks III+ and III–, respectively. We speculate on the idea that this family had also a solar origin. One of the most interesting cases in this family is that of the temples of Aton at Tell el Amarna. One of these temples is clearly orientated to a distinctive notch on the eastern horizon similar to an *akhet* sign. Actually, it has been suggested that this geographical accident gave its name to the city, *Akhetaten*, the Horizon of Aton. Since the main gate of the temple is, at the same time, perpendicular to the Nile, the orientation and location of the temple of Aton could have simply been dictated by topographic features. However, there is a striking additional possibility. Sunrise at the *akhet* would have occurred on dates close to October 22nd and February 20th. Surprisingly, or not, these dates are similar to those when the famous sun illuminating phenomenon occurs at the great temple of Abu Simbel (see Paper 1 and Figure 7). For Abu Simbel, we have proposed a relation to the beginning of two of the seasons of the Egyptian calendar, *Peret* and *Shemu*, "Going Forth" and "Drought", respectively. In the reign of Akhenaten (*c.* 1352-1336 B.C.), the seasons of the calendar did not exactly correspond to the climate seasons (although this happened for Ramses II). However, these dates still divide the year in two periods, one of 120 days (exactly four Egyptian months of 30 days, or one calendar season) and another of 245 days, and they might have acted as harbingers of the real sowing and harvest seasons, respectively. Another temple complex of this family would be the sanctuary of the sun-god Re at Heliopolis and, as a matter of fact, it would be logical to expect a solar-related orientation for it. Hence, we have finally proposed the hypothesis that this group of temples would actually integrate a so-called seasonal sun family of orientations, with possible members all around Egypt. In fact, the "solstitial family" could be interpreted as a more specialized subgroup of this.

IV. **The *Sopdet* family**. The main peak of this family would correspond to a declination of –17¾º±¾º, covering most of the period of the Middle and New Kingdoms. The star *Sopdet*, our Sirius, the brightest star of the ancient Egyptian skies, was very important as the Harbinger of the actual Flooding at least from the Middle Kingdom onwards, when the phenomenon of its heliacal rising (*Peret Sopdet*) is mention in the hieroglyphic texts on several occasions (Belmonte 2003), although its name is also largely mentioned in the Pyramid Texts within the context of the stellar scatology of the Old Kingdom (Faulkner 1969). This family of orientations would also have representatives all over Egypt.

V. **The Canopus family**. With a peak at –53¾º±¾º, this stellar interpretation of this family is far more complicated because we can not prove the importance of Canopus for the ancient Egyptians, notwithstanding the fact that it was their second brightest star in the sky (Allen 1963). Canopus changed its declination from –56¼º to –52½º during the course of Egyptian history (–54½º, –54º and –53º for the beginning of the Middle Kingdom, of New Kingdom and of the Late Period, respectively) and would adequately fit the data. However, in our present state of knowledge we do not know how to justify this relation either from the religious, economical or social point of view, in contrast to the case of *Sopdet*, which played a major role in Egyptian culture.

VI. **The Meridian (or northern) family**. With two major peaks, VI+ and VI–, located at declinations of 60º±¾º and –61º±¾º, respectively; these "peaks of accumulation" clearly speak of the great importance of near-Meridian, not to say precise N-S, orientations in ancient Egypt. In fact, it is highly probable that families I and VI are the two sides of the same coin. Indeed, both are representative of the predominance of cardinal orientations according to the manner in which the ancient Egyptians organized the Cosmos. We support the idea that this northern custom was effectively achieved through orientations to certain configurations of stars near the celestial pole, and that the circumpolar constellation of *Meskhetyu* would be the most appropriate target for this purpose (Belmonte 2001) as shown in Figure 8. *Meskhetyu*, the Plough, undoubtedly was one of the most important asterisms of Egyptian religion since at least the Old Kingdom, if not earlier, where it appears in the

Pyramid Texts as the “imperishable star” per excellence, to the Ptolemaic Period when it is profusely mentioned in connection to temple orientation (see Paper 1).

VII. **The family of quarter cardinal directions**. This family is related to a peak located at a declination of −39º±¾º (VII−) and its symmetric at some 40º (VII+). It would be defined by those temples with an orientation close to the SE-NW and SW-NE lines and we believe that it is a subgroup of the cardinal super-family. It is our contention that this orientation was achieved by the primary determination of a north alignment, which axis was later rotated by either 45º or 135º degrees clockwise for temples open to the east side of the horizon, which are the most frequent, or anticlockwise for temples open to the west side of the horizon. By performing such an action, simultaneous astronomical and Nile orientations could be achieved in several cases. Some of the Million Year Temples of kings of the New Kingdom, specially in Abydos and Western Thebes, are good representatives of this group (see Paper 4). However, the oldest temple excavated so far, whose plan has been partially recovered, structure HK29A at Hieraconpolis, would be the earliest example of the class (see Fig. 8).

In summary, by defining these seven families, we hope to have shown the importance of astronomical orientations in ancient Egypt. Indeed, by analyzing the previous paragraphs, we might reach the conclusion that actually only three customs of astronomical orientations were present in ancient Egypt throughout her land and in the course of her history: cardinal (i), solar (ii) and stellar (iii).

i. The cardinal custom would be integrated by families I (in most occasions), VI and VII and would be achieved by the observations of certain configurations (rising, setting, meridian transit, maximum elongation, etc.) of stars in the north, predominantly, it not exclusively, stars of *Meskhetyu*. This procedure would initially give a near Meridian axis that would later offer various alternatives: a gate opening north, a gate opening south, a gate opening east (or west) or a new axis by turning the original by 45º or 135º, with the gate opening near NE (or NW) or SE (or SW), respectively.

ii. The solar custom will be formed by families I (in a few occasions), II, II⊥ and III and would basically be related to important points of the annual cycle of the seasons, or in some cases to especial dates in the civil calendar such as *Wepet Renpet*, Egyptian New Year´s Eve, or the eves of the other two seasons *Peret* and *Shemu*, as suggested in Papers 1, 2, 3 and 4. Paradigmatic examples would be the solar temple of Niuserre at Abu Ghurob (I), Karnak (II and II⊥) and Abu Simbel (III).

iii. The stellar custom would be represented by families IV and V. We have no doubts of the pertinence and relevance of the alignments to *Sopdet*. However, we have minor doubts if many of the presumable alignments to Canopus should be interpreted in a different way. In this case, it is difficult to see how new field data will provide a final answer. Hence, new epigraphic information confirming the importance of this bright southern star would be highly desirable.

A final point to discuss is how once an alignment was yielded by astronomical observations in a certain direction (e.g. Meridian or solstitial ones) , the new axis at 45º, 90º, 135º (in both clock-wise or anti-clockwise directions) or 180º were obtained. The answer to this question could be encountered in a recent hypothesis (Miranda, Belmonte and Molinero, 2007), which suggests that the sign of Seshat (the divinity mostly involved in temple orientation ceremonies, notably the stretching of the cord), carried by the goddess upon her head in all representations, might perhaps have been a schematic and symbolic representation of an archaic transit instrument, similar to a Roman *groma*, that would have later become the emblem of the goddess. This instrument would have had eight radii and a viewpoint, and could have been used at the "stretching of the cord" ceremonies since the dawn of Egyptian history, directly offering the eight directions under discussion from a single astronomical or topographical observation.

3. CONCLUSIONS

With the five field campaign performed in the lands of Egypt so far, we have accomplished some of the most relevant objectives we had in mind for our archaeoastronomy project of ancient Egyptian culture. The principal dilemma we wanted to solve was whether the temples of this civilization were astronomically orientated or not. Epigraphic sources clear mentioned solar and stellar targets as the references for temple orientations. However, the scientific community only agreed on the planning of orientations according to the Nile and the relevant inscriptions were sometimes considered as mere remembrance of long forgotten practices. We have now measured 330 temples and shrines throughout the geography of Egypt belonging to all periods of her history. This represents approximately 95% or all the temples in any state of preservation still existing in the country and our sample is indeed statistically significant.

We will not go into the details on the many fascinating discoveries we have obtained in the course of this research as most of them are summarized in the conclusions of Papers 1, 2 , 3 and 4. However, we want to stress a few particular results that are real highlights of the analysis of the complete series of data, which should change the mind of the specialists with respect to Egyptian archaeoastronomical studies. These are:

i. The temples of the Nile Valley and the Delta were orientated according to the Nile as our data have clearly illustrated, but …
ii. The temples were also astronomically orientated beyond any reasonable doubt as all the successive analyses we have done to our data fully demonstrate. This means that the ancient Egyptians had to deal with special situations to accomplish both necessities. This problem was solved by the selection of appropriate orientations of one or the other class at different sites so that they would be more or less compatible with the Nile course (quarter-cardinal directions are a good example of this), or by the deliberate election of selected places in Egypt were the Nile prescription and a conspicuous astronomical orientation were simultaneously achieved, as in the case of the temple of Karnak, a paradigmatic example of this latter situation.
iii. Among astronomical orientations, there were three, and only three, kinds of targets. One was probably related to different celestial configurations of the stars of *Meskhetyu* in order to get a near or accurate Meridian orientation.

> This primary axis could have been rotated later by an eighth, a quarter or half a circumference to obtain any possible cardinal or quarter-cardinal direction (families I, VI and VII). The second kind of targets had a markedly solar character and was fundamentally related to important time-marks of the annual cycle and/or the civil calendar (families I, II, II⊥ and III). Finally, the third group of targets was formed by the two brightest stars of the ancient Egyptian skies, Sirius and Canopus (families IV and V, respectively). These customs were present during most of Egyptian history and in the different areas of the country as largely discussed in Papers 1 to 4, although some minor interesting peculiarities have been discovered.

At the turn of the century the authors envisaged a project to answer a quite simple question. Where the ancient Egyptian temples astronomically orientated? Now, a few years later, we are really proud of the quantity and variety of the results we have obtained along this period of intensive work. These have been the gateway for new requirements and questions. Indeed, much more work could be and should be done. However, we consider our sample to be statistically representative beyond any doubt and we are convinced that new data will only serve to reinforce or tinge our results. As a matter of fact, this summary paper clearly illustrates something that we could only have imagined at the very beginning of our project: ancient Egyptians undoubtedly scrutinized the sky in a permanent search for their correct orientation not only in time but also in space in a permanent effort to keep Ma'at on Earth.

ACKNOWLEDGEMENTS

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FIGURES AND CAPTIONS

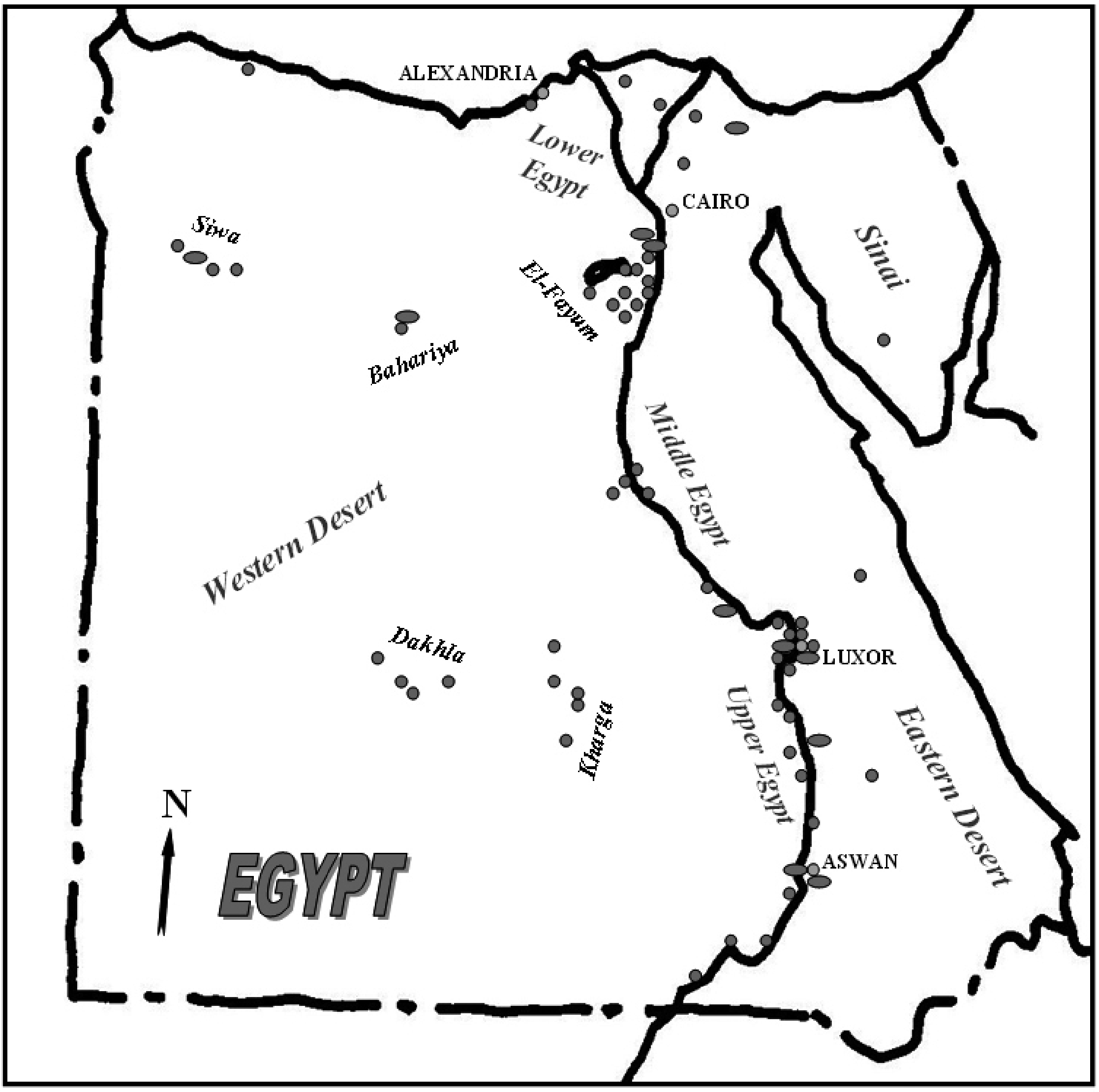

Figure 1. Map of Egypt showing the location of sites, from the Western and Eastern Deserts to the Nile Valley, where the orientation data yielded by our five field campaigns have been assembled. Dots stand for sites with just one or a few (two or three) sanctuaries on site. Ellipses stand for imposing archaeological sites where several temples, sometimes as much as ten, could be measured within a single location.

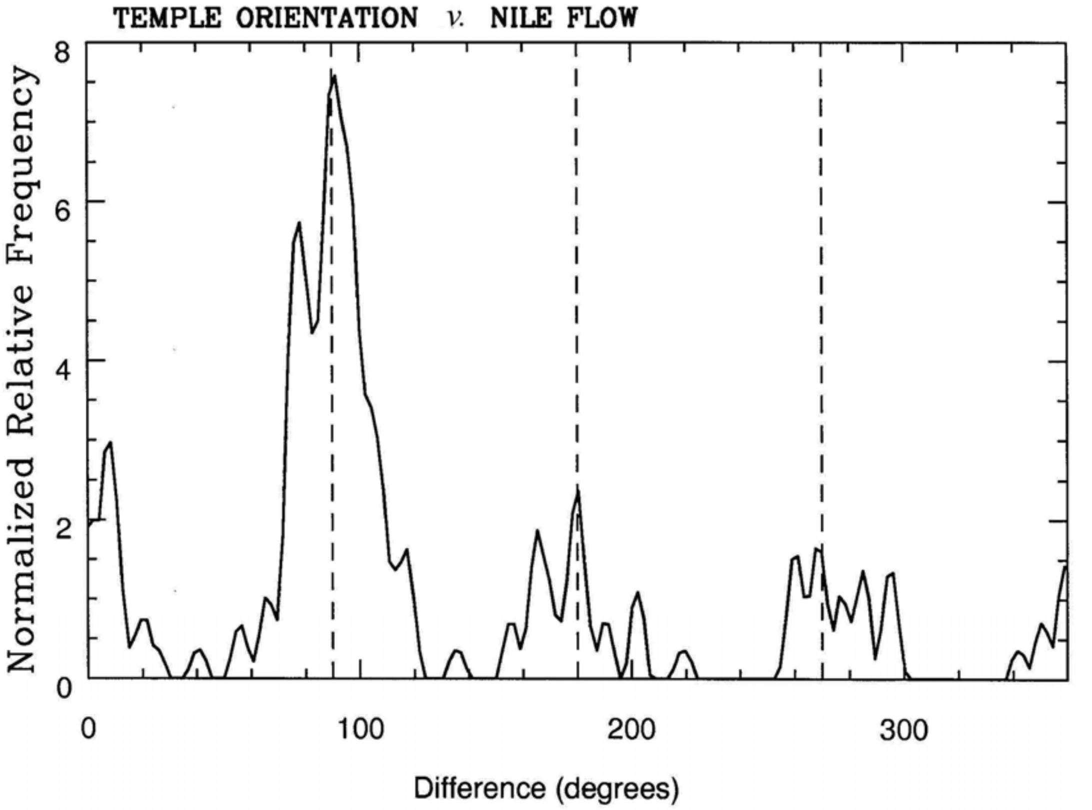

Figure 2. Testing the Nile hypothesis. Histogram representing the difference in orientation between the main axes of 170 temples of the Nile Valley and the average course of the river (or river branch in the case of the Delta) at their corresponding locations, for an interval of ±1º, larger than our estimated error of ½º, allowing for probable historical changes in the river flow. Temple orientation with the main gate located in front of (axis perpendicular to) the Nile is the most common way of orientating the buildings. Axes parallel to (at ~0º or 180º) or perpendicular to the river, but facing the other way (~270º) were also common. This demonstrates beyond any reasonable doubt that local topography (the course of the Nile) was very important at the moment of settling the foundations of the temples but was not the only factor to be considered. See text for further discussion.

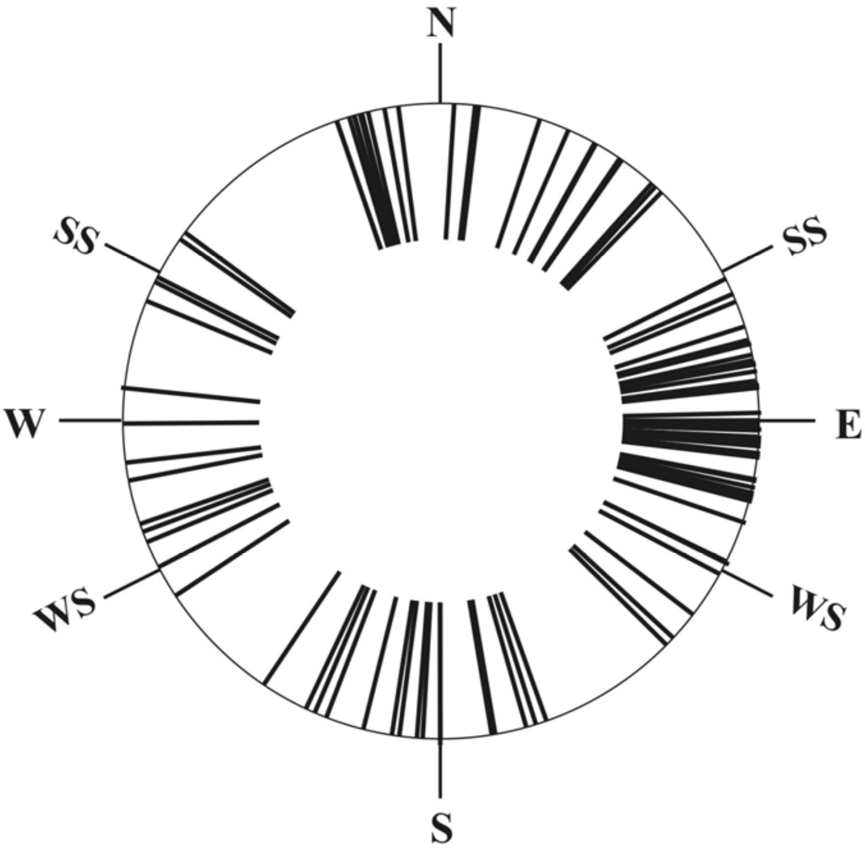

Figure 3. Falsifying the Nile hypothesis. Orientation diagram of the data assembled for temples measured outside the Nile Valley, where the river influence should be absent. Notice the Maltese Cross form of the diagram typical of astronomical orientations with a preference for cardinal and solar orientations.

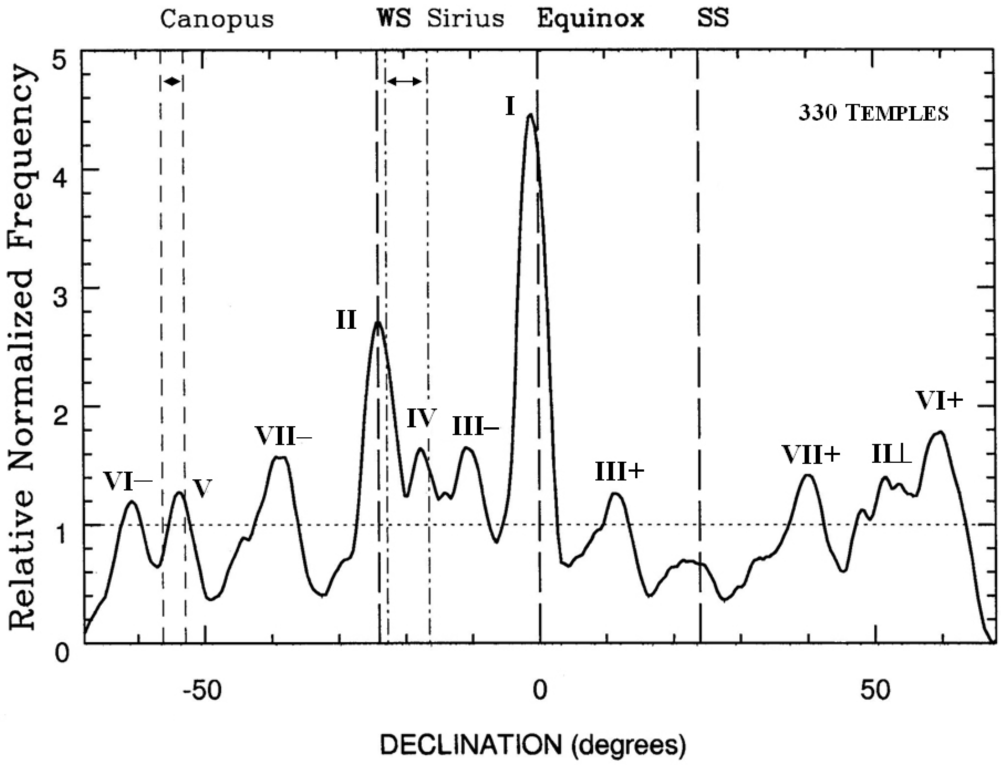

Figure 4. The core of the astronomical hypothesis. Declination histogram of some 330 temples of ancient Egypt obtained from the data measured in our five field campaign across Egypt and their analyses as presented in Papers 1, 2, 3 and 4. Each peak is identified by a Roman numeral referring to each of the seven families of astronomical orientations as defined in Paper 3 and explained in detail in this work. Only peaks with values of the frequency above the average (dot-line) have been taken into account. Long-dashed lines stress the extreme and medium positions of the sun at the solstices and equinoxes, respectively. The lines for Sirius (dot-dashed) and Canopus (short-dashed) straddle the extreme declinations of these stars, the brightest ones of the skies of ancient Egypt, from the beginning to the end of her civilization. See the text for further discussion.

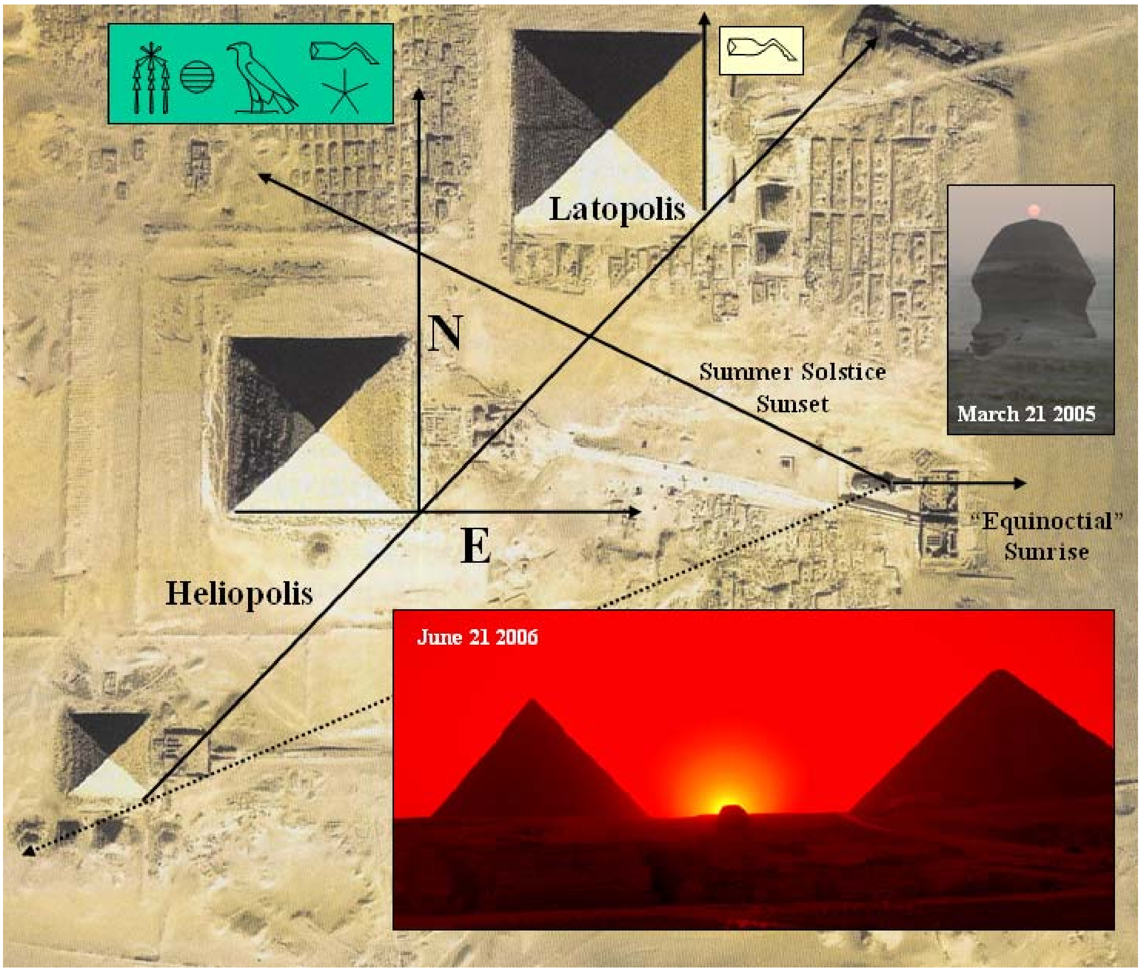

Figure 5. Schematic diagram where we show the astronomical and topographical relations between the different monuments erected in the Giza Plateau, notably the Sphinx and the pyramids, and certain elements of the sky or nearby geography. The relation with Letopolis and Heliopolis was first proposed by Goyon (1970). However, in this diagram, we additionally relate the original northern orientation of the pyramids, based on the observation of *Meskhetyu*'s Meridian transit (Belmonte 2001), and the similar name of the province which had the Letopolis as capital, the Bull´s Foreleg. Astronomical connections of the Sphinx with equinox sunrise and summer solstice sunset (behind *Akhet Khufu*, the Horizon of Khufu, see Paper 3) are also stressed. However, another possible astronomical connection between the Sphinx and winter solstice sunset at the SE corner of Menkaure´s pyramid (dot-line) needs further evaluation. Photographs by Juan A. Belmonte.

Figure 6. Sunrise at the winter solstice in the main axis of the temple of Karnak. The phenomenon would have been more accurate 4000 years ago when the temple was first aligned. This huge complex of temples was located at one of the few places in the Egyptian geography where the solstitial line, connecting winter sunrise and summer sunset, was at the same time perpendicular to the Nile. Solstitial orientations were very frequent in ancient Egypt, perhaps reflecting the importance of the solar cult in a way that we do not fully understand yet but that we are starting to envisage. Photograph by Juan A. Belmonte.

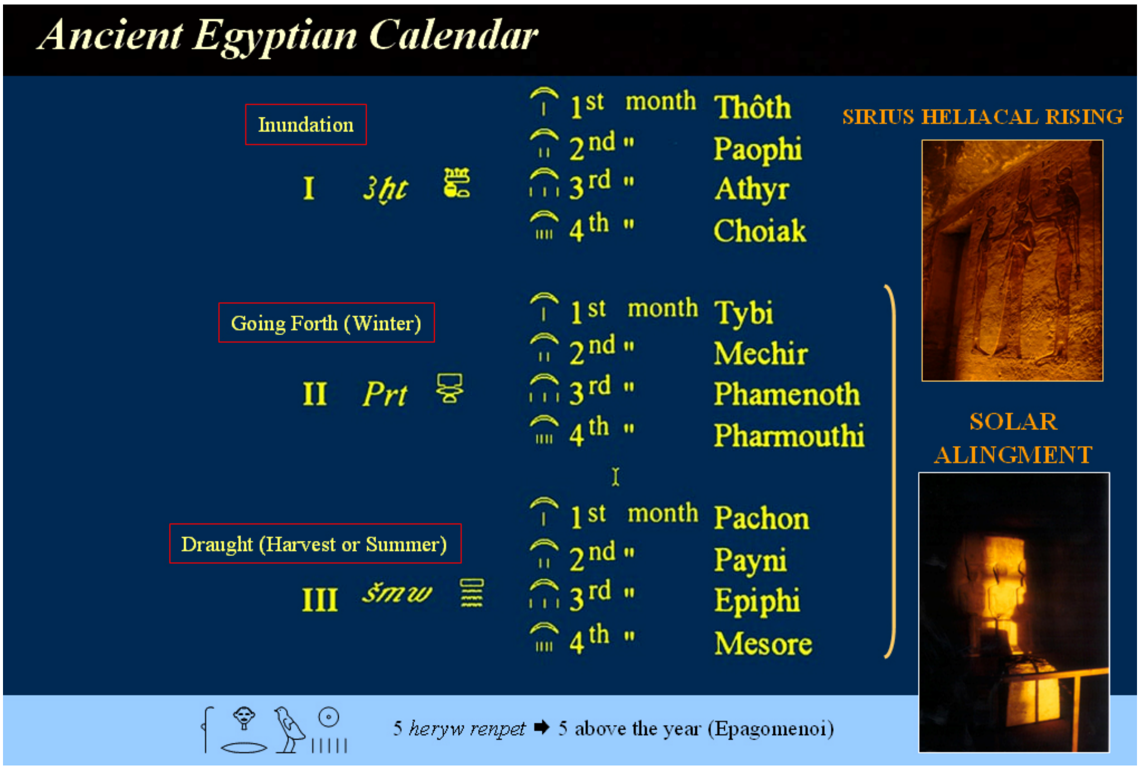

Figure 7. A diagram expressing the probable relation between the Egyptian calendar and the temples of Abu Simbel. On the one hand, the minor temple, dedicated to Queen Nefertari in her *Sopdet* dressing (upper right image) would be related with the heliacal rising of this star and the arrival of the Inundation (although the temple is not orientated in the adequate manner); a coincidence occurring for a period of years during the reign of Ramses II at the precise location of the temples. On the other hand, the splendid hierophany of the well-known solar illumination phenomenon in the sanctuary of the major temple (lower right image) would occur at the eve of the other two seasons of the civil calendar, the 1st day of the month of Thibi and the 1st of Pachon, respectively. Photographs by Juan A. Belmonte.

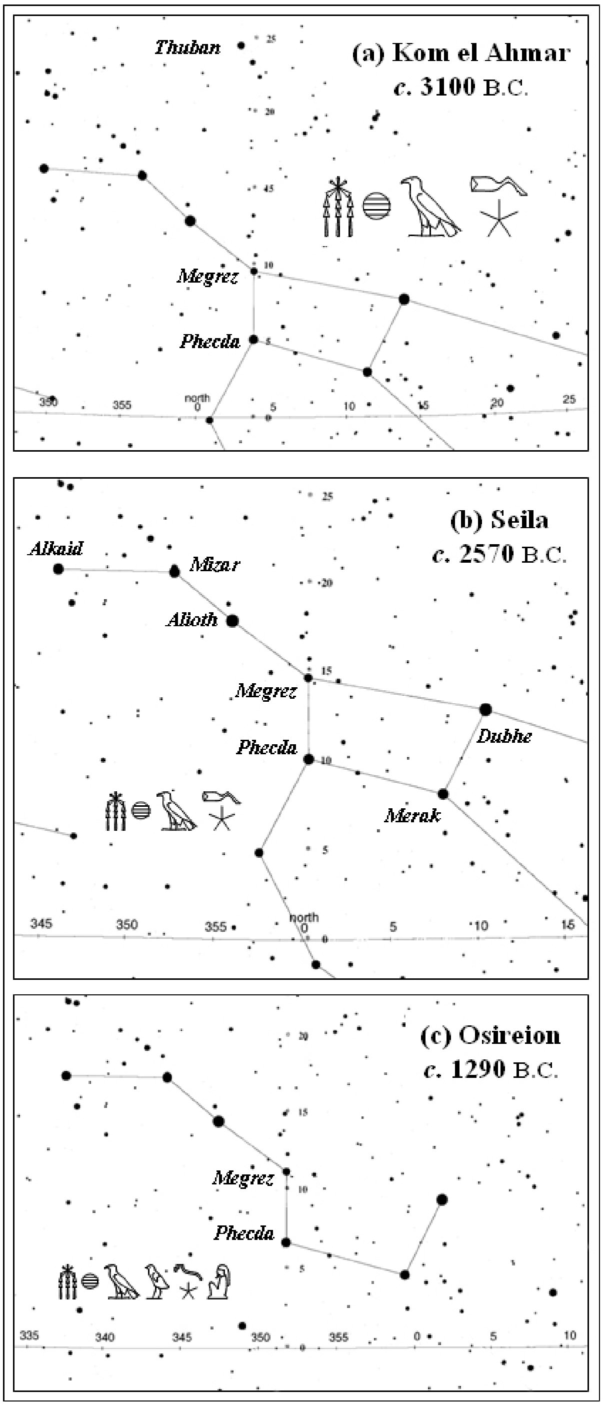

Figure 8. The simultaneous meridian transit (a particular astronomical configuration) of two stars of *Meskhetyu* (the Plough), notably Megrez and Phecda, as the possible reference for the northern orientation of three singular monuments pertaining to different periods of Egyptian history. (a) Pre-dynastic structure HK29A at Hieraconpolis (Kom el Ahmar). The original north alignment was later rotated 45º clockwise so that this early sanctuary would also be almost perpendicular to the Nile at this particular spot (family VII). (b) Precise N-S orientation of the minor step pyramid of King Snefru at Seila, in the heights to the east of the Oasis of Fayum. This procedure could have been followed to accurately orientate the pyramids of the 4th Dynasty for many generations (Belmonte 2001). (c) The same case as (a), but almost 2000 years later for the Osireion of the temple of Seti I in Abydos. Notice the displacement of the azimuth of the simultaneous transit *versus* time caused by precession.