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ON THE ORIENTATION OF EARLY CHRISTIAN CHURCHES IN PRÆFECTURA ILLYRICUM

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ABSTRACT

We measure the orientation of 297 early Christian churches (mainly in the Eastern Illyricum) by remote sensing (i.e. Google Earth). Of this, we select a subset of 194 churches that do not seem restricted in their placement by their surroundings, and conclude that 98% of them point within the solar sunrise arc. The mean orientation is towards the equinox sunrise, although the concept of equinox seems ambiguous. Even if there is some circumstantial evidence, there seems to be no accepted custom of orientation based on the date of foundation, on the sunrise on the patron saint's feast, or towards the sunrise on major feasts.

KEYWORDS: Archaeoastronomy, Cultural Astronomy, Early Christian Churches, Illyricum, Orientation, Astronomical Alignment, Azimuth, Equinox, Solstice.

1. RATIONALE

Ever since the early Christian times, sources insist on turning eastwards to pray[1] and the orientation of churches reflects this custom. However, as the sun rises on a different position on the horizon each day, how is east to be determined? Propositions put forward regarding the eastwards orientation include the sunrise: on the day the construction begun, on the patron saint's feast day, at major feasts, at equinox; all have appeared in the literature in relation to the orientation of churches (for a review see Gonzalez-Garcia, 2015). Equinoctial orientation is attested rather early in the Christian literature,[2] but the the oldest known texts for patronal orientation or for orientation based on the date of foundation, are a thousand years later (McCluskey, 2015); they are relatively modern conceptions (Vogel, 1962). Early Christian basilicas may be important in answering this question, as they may show the rising of the relevant traditions.

Praefectura Illyricum was one of four praetorian prefectures which divided the Late Roman Empire. In the present study, we focus mainly on the early Christian churches in eastern Illyricum, which originally covered the dioceses of Macedonia, Dacia and Pannonia (Figure 1). There is a *de facto* division in Illiricum, between the southern part (including Macedonia Prima) where the inscriptions are mainly in Greek, and the northern part (from Macedonia Secunda and northwards) where the inscriptions are predominantly in Latin. For the purpose of this study, we call these areas "Hellenic" and "Latin".

Over 1000 early Christian churches have been excavated in the area (for brief information, references and plans of 982 of them see Varalis, 2001). In spite of this huge number, their orientation has not been studied in detail. Just 24 of them have been surveyed (Badellas &al, 1988; Potamianos, 1996; Tsioumas, 2001; Pantazis & Lambrou, 2006; Iliades, 2006) and 21 analysed via Google Earth (Dallas, 2015; Dallas & Apostolou, 2016). Of the above studies, three focus on Thessaloniki and two on the early Christian era.

The evidence for orientation must be sought in systematic measurements of a large body of buildings (Table 1). We located 297 churches in Google Earth satellite images. They date from the mid-4th to the early-9th c., with more than half of them from the 6th c. To be exact, 13 churches date from the 4th c.; 78 from the 5th; 171 from the 6th; 27 from the 7th; 5 from the 8th; 1 from the 9th. For each church, we measured —via the Ruler tool in Google Earth— the azimuth of the visible features on the west to east axis (mainly the roof ridge and the north and south walls) in all good quality satellite images and then calculated their mean value; this is the azimuth of the church (Figure 2). Then we took a height profile in Google Earth from the sanctuary of the church along the measured azimuth and found the horizon height. Finally, we calculated the declination (δ), as well as the date in the Julian calendar the sun rose on its axis during the era of its construction.[3]

Figure 1. Map of the area of the Roman Empire under study, ca. 400 CE, showing the administrative divisions, as well as the major cities. The demarcation between Eastern and Western Empires is noted in red. Source: Wikimedia Commons. [4]

In most cases, the ruins of the churches are visible in the satellite photographs. In a few cases, the church itself is not visible, but we are able to place a plan of the archaeological site on top of the satellite photograph and measure that. On many occasions, we measured a later structure built on top of the original church. If the bibliography does not make clear that this new church follows the foundations of the first one, we discard it. If the church is built on

[1] Clement of Alexandria: *Stromateis*, 7.618; Origen: *Contra Celsum*, 5:30; Tertullian: *Apologeticum*, 16; Athanasius of Alexandria: *Sermo major de fide*, 93; Basil Magnus: *De Spiritu Sancto*, 27:12–14 and 17:60–63; John Damascene: *De Fide Ortodoxa*, 4:12; Germanus I: *Historia mystica ecclesiae catholicae*, 11; *cf.* also *Apostolic Constitutions*, 2:57; *Didascalia Apostolorum*, 12:57

[2] Isidorus Hispalensis: *Etymologiae*, 15:4.7

[3] The data is available in an online map at *https://drive.google.com/open?id=1q7Q0cYMLZWV7sIIqc56xzos62D4&usp=sharing*

[4] *https://commons.wikimedia.org/wiki/File:The_Roman_Empire_ca_400_AD.png* (accessed June 2017).

an ancient temple, we also discard it. Next, we consider if the natural or artificial environment we can see in satellite or location photographs influences the placement of the church. Thus, we remove from our data set churches built: following a city grid (all of the towns in the area built on a regular Hippodamian system pre-date christianity), along fortifications, next and parallel to an older one, or in awkward places that restrict the way they can be oriented. The 194 churches left over, are called "unconstrained" for the purposes of this paper.

Table 1. Mean values and standard deviation for azimuth and declination in all geographical areas.

	All	Azimuth (°)		Declination (°)		Uncon-strained	Azimuth (°)		Declination (°)	
		mean	std dev	mean	std dev		mean	std dev	mean	std dev
Illiricum	*297*	94.2	19.5	−0.7	14.8	*194*	93.0	17.3	−0.3	13.0
Creta	*49*	92.3	18.4	0.6	15.0	*30*	93.5	16.3	−0.7	13.5
Achaea	*65*	91.8	15.5	1.0	12.4	*46*	92.5	14.8	−0.1	11.2
Thessalia	*25*	93.5	14.1	-1.1	11.7	*18*	91.8	13.9	0.5	11.1
Epirus Vetus	*20*	90.8	19.9	0.1	14.9	*13*	86.7	20.8	2.4	15.8
Epirus Nova	*11*	81.3	17.4	12.6	15.8	*5*	81.8	16.3	6.4	10.8
Macedonia Prima	*60*	99.4	22.4	−4.4	16.3	*36*	95.6	17.9	−1.5	13.1
Macedonia Secunda	*13*	107.4	13.4	−10.0	9.9	*7*	102.8	16.7	−5.7	11.9
Thracia	*4*	83.8	17.8	6.6	14.1	*4*	83.8	17.8	6.6	14.7
Dalmatia	*12*	96.9	26.5	0.7	15.9	*6*	75.6	36.7	3.6	10.3
Praevalitana	*4*	104.7	25.9	−8.9	17.4	*3*	116.2	19.0	−15.2	15.6
Dardania	*9*	98.8	27.2	−4.7	19.4	*6*	97.2	26.7	−4.1	18.6
Dacia Mediterranea	*13*	90.0	13.8	1.9	10.0	*12*	89.9	14.3	2.1	10.4
Dacia Ripensis	*5*	82.9	20.0	7.3	15.8	*3*	88.6	21.9	3.0	17.1
Moesia & Pannonia	*7*	98.8	9.6	−5.1	6.0	*5*	99.0	10.1	−5.0	6.3

2. RESULTS

Finally, we are ready to answer some questions on the orientation of early Christian churches in Illiricum.

2.1. *Do the orientations follow a normal distribution?*

Shapiro-Wilks test for normality show that the "unconstrained" declination data can be a product of a normal distribution. This is true for the full data set, as well as for all the geographical subsets.

2.2. *Are the churches oriented towards the east?*

All the churches in the present study point towards the eastern part of the sky. A single one has an almost N-S orientation, but this may be a civil building after all. A total of 27 churches point outside the solar sunrise arc. If we exclude the churches that are restricted in their orientation and those which are less than 2° outside the solstices, we are left with 6 churches, just 2% of our sample. Thus, early Christian churches in Illiricum are oriented towards the solar sunrise.

2.3. *Is there an alignment to solstices?*

There are 9 alignments close to the winter solstice sunrise, with 4 of these following the winter solstice aligned city grid of Thessaloniki. There are 7 alignments close to the summer solstice sunrise, with 2 of these in Heraclea Lyncestis oriented like the nearby theatre. Therefore, there is no connection of the orientation to the solstices.

2.4. *Is there an alignment to equinox?*

Our modern definition of "equinox" means the day when the sun has a declination of 0°. In our sample, there are 17 churches with declination between −1° and 1°. However, there are 76 churches in our full sample pointing to the sunrise between 11 and 31 of March (Figure 5). The term "equinox" is ambiguous (Ruggles, 1997, 2017; Gonzalez-Garcia & Belmonte, 2006), with 18, 21, 25 and 28 of March assigned to equinox in Roman and Medieval periods. The double peak is also found in the English churches dedicated to All Saints, 25 March being listed in medieval calendars as the date of the Roman equinox and 27 March being listed as the date of the Resurrection. (McCluskey, 2007).

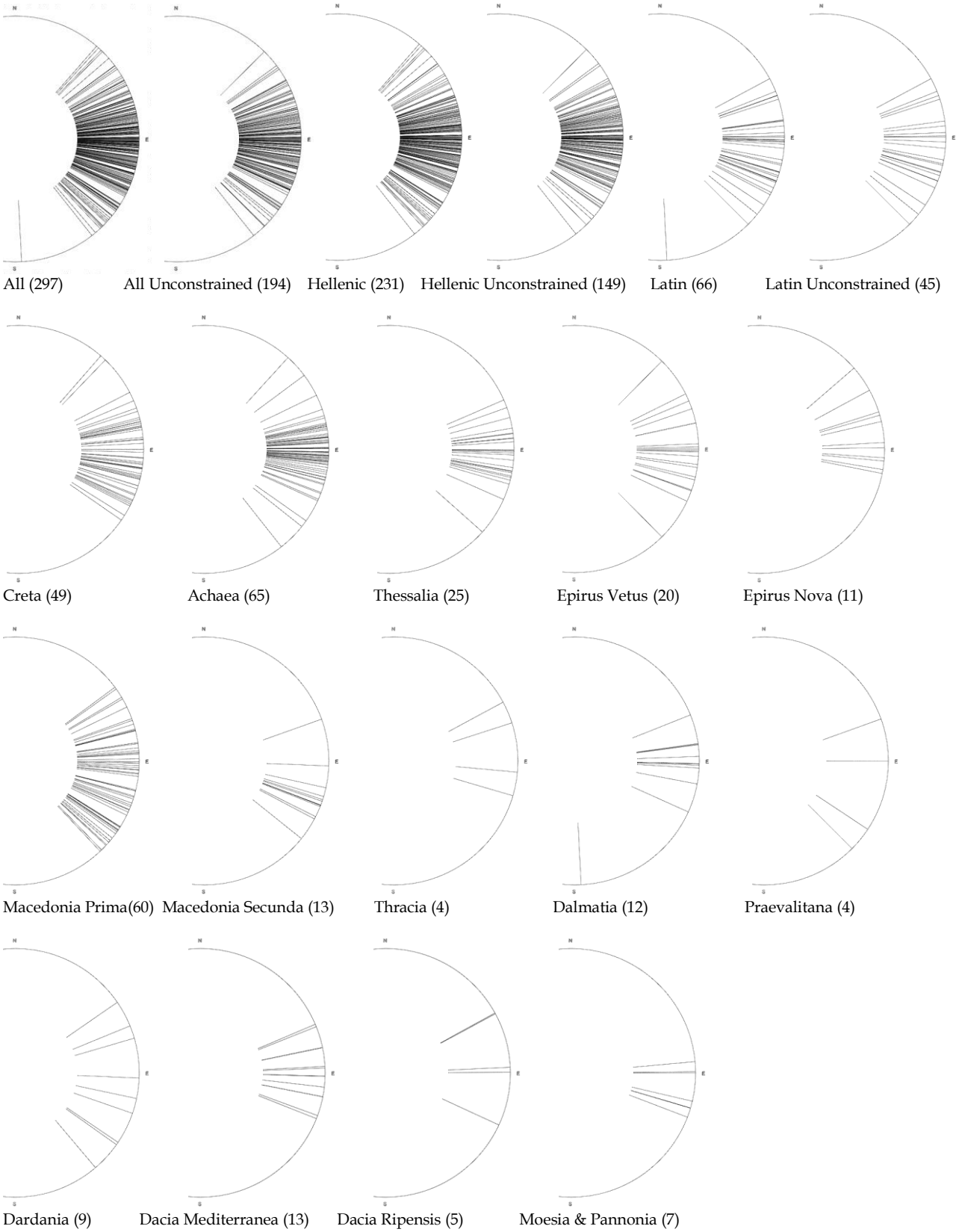

Figure 2. Azimuth diagrams for all 297 churches in the present study, the 194 unconstrained churches (divided in Hellenic and Latin areas), as well as separate azimuth diagrams for all the churches in each province studied.

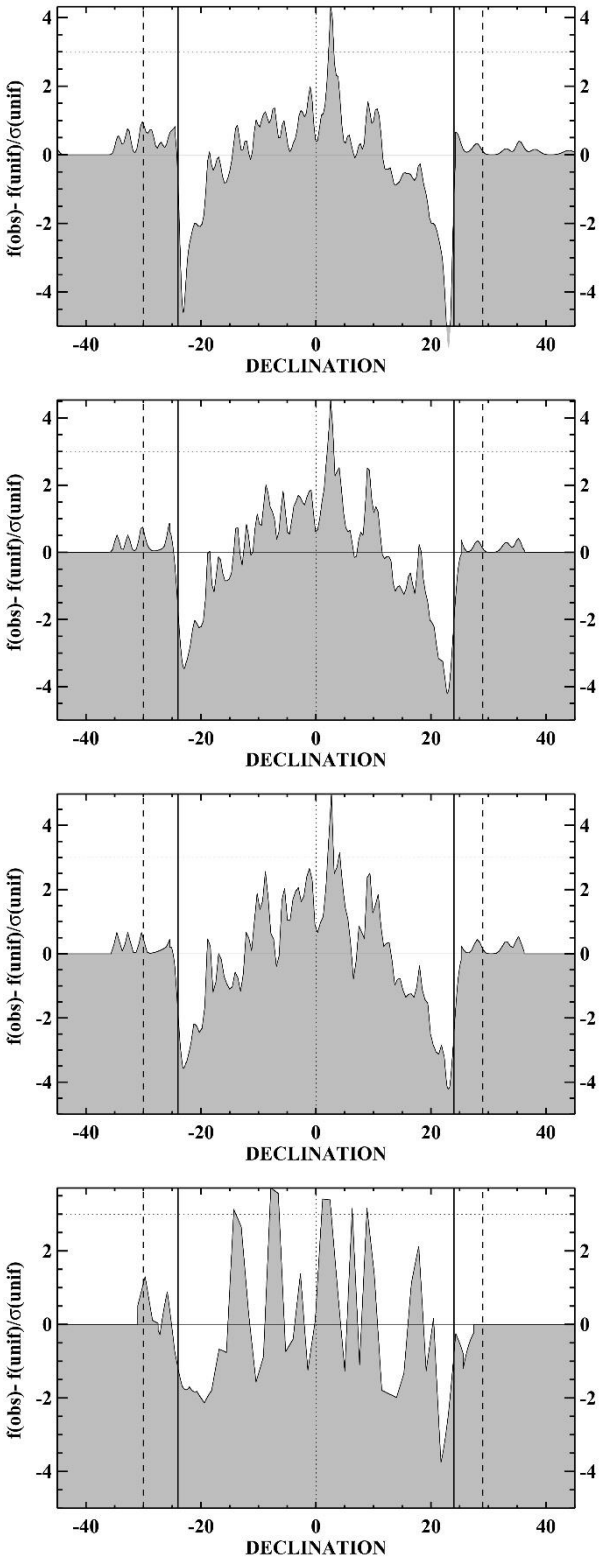

Figure 3. Declination curvograms for our study. An Epanechnikov kernel is employed, with a bandwidth twice the size of the error. Comparison of the distribution of churches' declination against the declination of the sun. From top to bottom: all 297 churches; the 194 unconstrained churches; the 149 unconstrained Hellenic churches; the 45 unconstrained Latin churches.

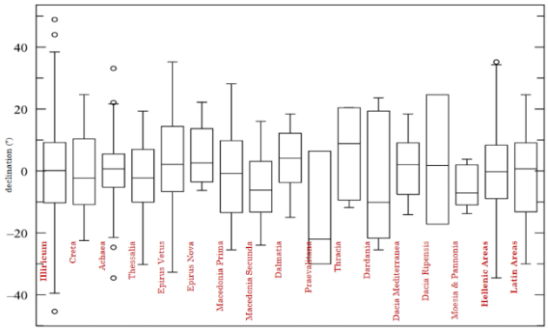

Figure 4. Boxplot of the declination of all 297 churches divided in geographic areas.

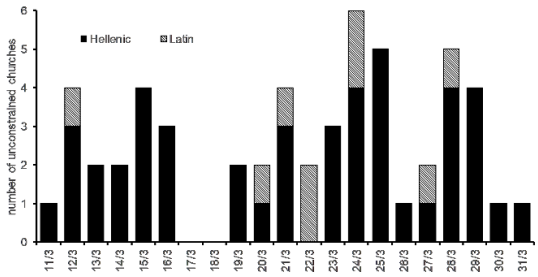

Figure 5. Number of unconstrained churches oriented towards the sunrise between 11 and 31 March, in Hellenic and Latin areas.

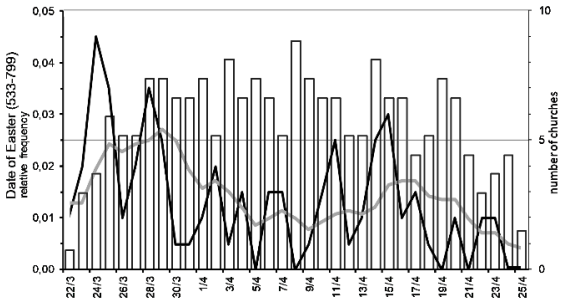

Figure 6. Number of churches oriented towards the sunrise during the Easter season (black line) and their running average (grey line) against the relative frequency of the date of Easter between 533 and 799.

2.5. *Is there a patron saint alignment?*

Unfortunately, the majority of early Christian basilicas have no known dedication. In some churches may be a tradition connecting the ruins with a saint, but no hard proof (e.g. an inscription). Additionally, the dedication of the later church in the location may be different to the original dedication. In total, we had 81 churches with assumed dedications. Of these, 5 are aligned to the sunrise on the patron saint festival and a further 9 are aligned with less accuracy or to a not-as-well-known saint with the same name. The result shows that the patronage orientation is not important, but the fact that 3 are Thessaloniki and 6 in Creta may hint towards a localized custom.

However, there is another angle on this matter. A church that functions daily, as a cathedral or a parish church, should receive sufficient light throughout the year. A martyrion or a pilgrimage site may be built in such way as to maximize the light for the specific period in the year that the celebrations are made (Potamianos, 1996). This relates to observations in Thessaloniki where there are alignments to the byzantine third hour, the time when the liturgy reaches its climax (Dallas, 2015, Liritzis & Vassiliou 2002, 2006).

2.6. *Is there a difference between hellenic and latin provinces?*

There may not be a major difference between the Hellenic and Latin areas in the way equinox is calculated (Figure 5), the feast of Annunciation being the most prominent day for determining "true east". However, the Kolmogorov-Smirnoff test shows that the declination data from Hellenic and Latin areas may not be a product of the same distribution. It is obvious that excluding the peak at equinox the other peaks do not coincide (Figure 3). Unfortunately, we cannot do a detailed analysis, as the sample in the Latin areas is small.

2.7. *Is there a connection with other feasts?*

The suggestion that the orientation of the church was found on the day of Easter[5] does not fit well with the data. The peak after equinox cumulates at 15 April. This (as well as the shape of the curve) may suggest that if the orientation was found before building the foundation of the church, it did not happen during the Easter season (Figure 6).

During the Ottoman period in Greece there were organized mason groups that travelled for specific projects; their building season lasted from the feast of St. George (23 April) to the feast of St. Demetrius (28 October). In contrast, we expect that local workforce had built the majority of early Christian churches in this study. Anyway, there is no correlation of peaks in the declination with the feast of either saint.

2.8. *Is there a connection to the construction time?*

It has been proposed that the alignment to the sunrise was performed at the time the construction of the church started. If this is the case, we should notice a variation on the orientation depending on geographical latitude and altitude, because builders on southern and warmer climates were able to start their work earlier in the season. Thus (Figure 4), we notice: the mean declination of churches in Crete is a little lower than churches in Achaea; mean declination in Epirus Nova is more to the north than Epirus Vetus; but the mean declination in Macedonia Prima is less than Creta, Achaia, or Epirus. Precipitation may also play a role. Epirus Vetus has a higher mean declination than Thessalia, although they are at the same latitude. However, Epirus gets three times more rain in March than Thessalia, delaying the start of the building season. On the other hand, by orienting the church southwards, they builders can optimize the solar gain for winter; this may explain the low values of the mean declination in Moesia, Pannonia, Dardania, Praevalitana and Macedonia Secunda. Our sample in Dalmatia shows a preference of orientation slightly north of east, but this is not followed in later churches (Piplović, 1995). There are also interesting individual cases (e.g. the church built at the highest altitude has a summer solstice alignment).

However, the statistics do not show a correlation between altitude and declination or between latitude and declination; therefore, there is no proof that the orientation was determined by sunrise at the beginning of the construction of the church.

2.9. *Are the peaks in the declination diagram significant?*

The only significant peak (Figure 3) of the declinations is at the equinox, as it rises above the 4σ level. All other peaks are below the 3σ level. The most prominent of these is at mid-April or end-August ($\delta = 10°$) which can be associated with the end of Easter season or the end of the Ecclesiastical year (Figure 7) and is most prominent in the churches of Achaea.

In the Latin areas, we notice other peaks: at $\delta = -8°$ which may be connected with the Cathedra Petri Antiochiae, a prominent orientation in medieval Slovanian Churches (Čaval, 2009); at $\delta = -14°$ which is associated with All Saints, an important dedication of early medieval churches, albeit in England (Hoare & Sweet, 2000). However, the sample in the Latin areas is too small for a proper analysis.

The peaks at $\delta = 10°$ and at $\delta = -8°$ are reminiscent of the peaks around $\delta = \pm 11°$ that are found in the ancient Egyptian temples (Belmonte &al, 2009). However, as Fabio Silva notes elsewhere in the present volume, these peaks do not hold up to maximum likelihood analysis; this may also be the case in our present study.

The study of the orientation of early Christian churches in Illyricum shows that apart from the equinox sunrise orientation, there is no other discernible pattern. However, some of the lesser orientations merit a further study on a local scale.

[5] Easter dates provided by Dr. R.H. van Gent in *http://www.staff.science.uu.nl/~gent0113/easter/eastercalculator.htm* (accessed August 2017)

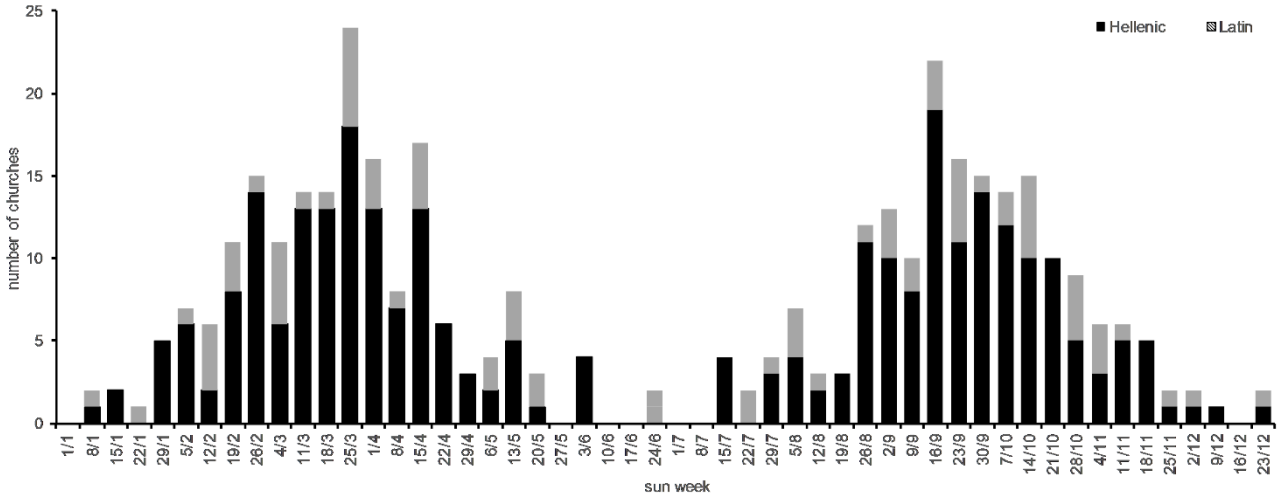

Figure 7. The orientation of all churches oriented within the sunrise arc, tabulated per week for the Julian calendar at the time of their construction, divided in Hellenic and Latin areas. Each church appears twice (for spring and autumn).

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