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ON THE ORIENTATION OF BYZANTINE CHURCHES IN THESSALONIKE

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ABSTRACT

The present paper studies the orientation of 32 churches in Thessalonike, that date from the 4th to the 20th century. It investigates whether there is a connection of their astronomical alignment to any significant solar date or to the date of the patron saint's festival. The majority of buildings under investigation (16) follow the city grid, parallel with the roman *decumanus maximus*, the modern Egnatia street, that is aligned to the rising sun during the winter solstice. Buildings outside the roman city have a variety of orientations. There are 7 cases of alignment on the patron's saint day (5 positive and 2 indecisive). However, the alignment may be to the sunrise (3) or to the byzantine *Third Hour* (4), the time the Divine Liturgy reaches its climax. This has greater consequences for the study of the orientation of byzantine churches, as it points to multiple solutions to the problem of the orientation towards the sunrise on patron saint's feast day.

KEYWORDS: *Thessalonike, astronomical alignment, azimuth, horizon, patron saint's day, sunrise, byzantine third hour, winter solstice, orientation of byzantine churches, orientation of roman cities.*

1. INTRODUCTION

The alignment of byzantine churches has recently been studied in detail. Some scholars (e.g. Pantazis & al. 2003a, 2003b, 2005, 2006; Liritzis & Vassiliou 2006, 2007; Iliades 2006) have reached the conclusion that there may have been an alignment of the main axis of a church to the sunrise on the patron saint's day. There is historical reference for such a practice for ancient Greek temples¹, even during Early Christian times²; however Byzantine sources, although insisting on the altar facing east, make no mention of a specific solar alignment at all³.

We investigated 32 churches in Thessalonike (figure 1) to verify if an astronomically significant alignment applies. Azimuth data, distances and profiles were provided by the Google Earth Pro⁴ software, unless stated otherwise. We also applied a mean refraction correction, using Prof. Clive Ruggles online declination calculator⁵. Reproduction of the ancient sky was through the Stellarium software⁶.

Alignments of churches in Thessalonike have appeared twice in the literature. The first one (unknown to us before the revision of our paper) does not have any astronomical connections (Badellas & al. 1983) and its data is based mainly on topographic plans and maps. The second one deals with the light inside Byzantine churches (Potamianos 1996, 2000) and has compass measurements of some of the churches under study.

In the classical era, the area of greater Thessalonike housed an agglomeration of many villages of which the most important was Therme. Its exact location is still debated; in any case, the coastal area of today's city was occupied at least since 4th-c. BCE. Thessalonike was founded by king Cassander of Macedonia on 316 BCE by the synoecism of the previous settlements. It was built according to the Hippodamian system, but the fortifications only covered the uphill area. The new city would elevate its importance in roman times, especially after the construction of *Via Egnatia* in the 2nd-c. BCE, since Thessalonike was the only port along its axis. A large italian community was established during the 1st-c. BCE. The lowland area between the hellenistic town and

the sea was suitable for a planned extension during the roman times; yet, the fortifications were no longer maintained⁷. But after the invasion of the Goths, in mid 3rd-c. the walls were rebuilt and enlarged, defining the new limits of the city, that persisted through roman, byzantine and ottoman times. During the same period, the city transformed from a provincial capital to an imperial residence. Constantine the Great built a new port at its west end in 322-323. From the 4th-c. onwards the width of the streets was occasionally reduced, with small streets changing course. The total abolition of the original city plan came during the 18th and 19th-c., when the roads themselves were often divided among the adjunct properties. It was also in the end of the 18th and the beginning of the 19th-c. that the city started to expand outside the walls⁸.

Major earthquakes and fires have plagued the city of Thessalonike. As a result, many churches were rebuilt on the ruins of older ones. It is known that most of the churches studied in the present paper were originally dedicated to saints or feast-days different from their present-day dedication; many of them to Virgin Mary. Historical and archaeological data on the churches under study were obtained from Papayannopoulos 1982, Demetriades 1983, Kourkoutidou-Nikolaidou & Tourta 1997.

Our results are summarized in table I. For each church we include its azimuth; the declination for the current epoch against the horizon and -where relevant- the city's fortification walls; the alignment. The date mentioned in the table is the date of the building whose axis is used for the calculations. This is usually the inauguration year of the original church, unless the axis has shifted due to rebuilds or renovations. The churches are divided in five groups (labeled A to E) based on their location.

¹ Aeschylus: *Agamemnon*, 519-520; Lucian: *De Domo*, 6; Plutarch: *Numa*, 14:4

² Clement of Alexandria: *Stromateis*, 7.618; Origen: *Contra Celsum*, 5:30; Tertullian: *Apologeticum*, 16

³ Athanasius of Alexandria: *Sermo major de fide*, 93; Basil Magnus: *De Spiritu Sancto*, 27:12-14 & 17:60-63; John Damascene: *De Fide Orthodoxa*, 4:12; Germanus I: *Historia mystica ecclesiae catholicae*, 11; 4th-c. *Apostolic Constitutions*, 2:57

⁴ Google Earth <http://earth.google.com/> (accessed 1 February 2015)

⁵ Clive Ruggles Basic Declination Calculator <http://www2.cliveruggles.com/index.php/tools/declination-calculator/> (accessed 25 August 2015)

⁶ Stellarium <http://www.stellarium.org/> (accessed 1 February 2015)

⁷ Marcus Tullius Cicero: *De Provinciis Consularibus*, 2:4

⁸ There are two easily accessible online resources for an overview of the history and archaeology of Thessalonike.

I. Issue #7 of March 1983 (in Greek with English abstracts) of the magazine "Archaeologia kai Technes":

<http://www.archaiologia.gr/αρχειο-τεχνών/?fc=1134&is=1039> (accessed 8 July 2015)

II. The PDF files (in English and Greek) in the website of the museum at Lefkos Pyrgos <http://www.lpth.gr/> (accessed 8 July 2015)



Figure 1. The 32 churches under study. In yellow are the markers for the 11 churches in Group A (inside the eastern walls); orange for the 6 churches in Group B (city centre); blue for the 3 churches in Group C (coastal zone); green for the 4 churches in Group D (outside the walls); pink for the 8 churches in Group E (upper city).

2. INSIDE THE EASTERN WALLS

Group A of the present study includes 11 churches in a narrow area just inside the eastern walls of the city. This area was hardly inhabited during antiquity. It was Caesar Galerius who expanded the Roman Thessaloniki in this area, building the Rotunda, his Triumphal Arch, his Palace and the Hippodrome. This area had a predominantly christian population throughout the ottoman times, so it is no surprising that so many churches survived.

2.1 The churches

2.1.1 Rotunda

The Rotunda was built shortly after 300. It is a massive circular building with an oculus at the apex of the dome, like the Pantheon in Rome. It was repurposed as a Christian church with the addition of an apse to the east and a new entrance to the west (the original entrance was from the south). The most probable date for the conversion was during the reign of Theodosius the Great (end of the 4th-c.). The church was originally sanctioned to the Archangels or Aghioi Asomatoi (celebrated 8 November).

Table I. The Churches of Thessalonike

Church	Date	Azimuth	Declination (for horizon)	Declination estimate (for walls)	Alignment	
GROUP A: INSIDE THE EASTERN WALLS						
1	Rotunda	~400	124° 06' ± 36'	-24° 06' ± 30'	-23.5°	RG / WS
2	Panagouda	12 th c.	126° 12' ± 24'	-24° 36' ± 30'	-24°	RG
3	Nea Panaghia	12 th c.	124° 12' ± 12'	-23° 51' ± 24'	-23°	RG
4	Mikri Metamorfosi	~1340	123° 48' ± 42'	-23° 31' ± 24'	-23°	RG
5	Aghios Panteleemon	1548	123° 42' ± 54'	-23° 31' ± 42'	-23.5°	RG
6	Aghios Georgios	1815	124° 42' ± 54'	-24° 21' ± 42'	-23°	RG
7	Aghios Ypatios	1818	118° 18' ± 54'	-19° 13' ± 48'	-15°	
8	Panaghia Dexia	1956	90° 24' ± 30'	+2° 18' ± 24'		ME
9	Hypapanti	1841	126° 18' ± 24'	-25° 12' ± 24'	-25°	RG
10	Aghios Antonios	18 th c.	125° 36' ± 48'	-24° 21' ± 42'		RG
11	Aghios Konstantinos	1972	125° 26' ± 06'	-24° 43' ± 42'	-1°	RG
GROUP B: CITY CENTRE						
1	Aghia Sophia	5 th c.	122° 00' ± 24'	-22° 30' ± 30'		RG
2	Aghios Demetrios	5 th c.	122° 06' ± 18'	-22° 30' ± 24'		RG
3	Acheiropoietos	5 th c.	123° 42' ± 24'	-23° 41' ± 30'		RG
4	Panaghia Halkeon	1028	125° 42' ± 42'	-24° 58' ± 30'		RG
5	Aghios Athanassios	14 th c.	123° 54' ± 24'	-23° 49' ± 24'		RG
6	Aghios Nikolaos Tranos	1928	124° 48' ± 12'	-24° 35' ± 24'		RG
GROUP C: COASTAL ZONE						
1	St. John Baptistery	5 th c.	136° 48' ± 24'	-33° 07' ± 30'		CL?
2	Aghios Menas	8 th c.	135° 54' ± 18'	-32° 28' ± 24'		CL?
3	Aghios Gregorios Palamas	1914	133° 42' ± 24'	-30° 55' ± 30'		CL
GROUP D: OUTSIDE THE WALLS						
1	Tritis Septemvriou Basilica	4 th c.	111° 42' ± 48'	-13° 54' ± 42'		PS
2	Sintrivaniou Basilica	5 th c.	75° 06' ± 18'	+14° 50' ± 24'		
3	Ivanof Park Basilica	420	83° 54' ± 48'	+7° 26' ± 42'	+10°	PS
4	Democratias Church	450	103° 54' ± 12'	-8° 36' ± 24'	-4.5°	
GROUP E: UPPER CITY						
1	Osios David	5 th c.	113° 06' ± 30'	-15° 32' ± 30'		PS
2	Moni Vlatadon	14 th c.	96° 30' ± 30'	-1° 50' ± 30'	-1°	PS
3	Aghios Nikolaos Orphanos	14 th c.	142° 48' ± 36'	-36° 45' ± 30'	-34° / -27°	PS
4	Taxiarches	14 th c.	120° 42' ± 24'	-21° 03' ± 30'		PS?
5	Panaghia Lagoudiani	1802	122° 00' ± 18'	-22° 16' ± 24'		RG
6	Profitis Elias	14 th c.	136° 18' ± 54'	-32° 37' ± 42'		
7	Aghioi Apostoloi	1313	114° 12' ± 30'	-15° 21' ± 30'		
8	Aghia Ekaterini	13 th c.	101° 48' ± 18'	-6° 12' ± 24'		PS?

WS: winter solstice RG: roman city grid CL: coastal line ME: magnetic east PS: patron saint ? : indecisive

2.1.2 Panagouda

The church of Panaghia Gorgoepikoos, known as Panagouda to the locals, is dedicated to the Nativity of the Virgin (8 September). The present-day church was built in 1818, upon the ruins of an older church of the same dedication, mentioned in a 1789 codex, which was destroyed by fire on 1817. It is a three-aisled basilica, typical of the 19th-c. ecclesiastical architecture of Macedonia, but larger than the size allowed by the ottoman authorities of the era. It has been recently proposed that this church overlies the site of the monastery of "Vassilikon" attested in Byzantine sources and dating from the 12th to the 14th-c.

2.1.3 Nea Panaghia

The church of Nea or Trani Panaghia is dedicated to the Dormition of the Virgin (15 August). It was built in 1727 on the spot of a 12th-c. monastery that burned down around 1690. It is a three-aisled basilica with a pi-shaped gallery.

2.1.4 Mikri Metamorfosi tou Sotiros

The small church of the Transfiguration of the Savior (6 August) dates from around 1340, and has remained more or less unchanged until the addition of a small narthex to the west in 1936. Recent studies have showed this is not the church mentioned in a 1364 chrysobull, but was also originally dedicated to the Virgin.

2.1.5 Aghios Panteleemon

Recent research has identified the church now dedicated to St. Panteleemon (27 July) with the Virgin Peribleptos, also known as the monastery of "kyr-Isaac" after its founder, although this is still debated. The church frescos are dated to the end of the 13th or the beginning of the 14th-c., but the building may be older, as the monastery dates from the 12th-c. The surrounding portico has been demolished, but the rest of the church is in excellent shape as it was repaired in the early 20th-c.

2.1.6 Aghios Georgios

The church of St. George (22 April) was built in 1758 on the remains of an older church, which, according to the tradition, was built in 1591 in order to transfer the icons and relics from the Rotunda when the Ottomans converted it into a mosque.

2.1.7 Aghios Ypatios and

2.1.8 Panaghia Dexia

This modern church of Panaghia Dexia is dedicated to the Presentation of the Virgin Mary into the Temple (21 November) and was erected in 1956 in the place of a smaller church dedicated to St. Hypatios (31 March), dating from 1818. The latter had replaced an even older church, also dedicated to St. Hypatios, which is mentioned in 18th-c. written sources. The azimuth of Aghios Ypatios was calculated by placing an 1938 aerial photograph (Vitti 1996, p. 25) on top of the Google Earth background.

2.1.9 Hypapanti

The post-byzantine church of Hypapanti (Candlemas, 2 February) is dated to 1841. Mentions in written sources state that a much older church dedicated to the Virgin Mary on this location was rebuilt in 1531. It is also a typical three-aisled basilica.

2.1.10 Aghios Antonios

The church of St. Anthony (17 January) dates from the 18th-c. and is a two-aisled basilica. A part of a tower from the east walls of the city has been incorporated in the north-east corner of the building.

2.1.11 Aghios Konstantinos

The modern church of St. Constantine (21 May) was built in 1972 in place of an older church which according to the tradition, was built ca. 1600 at the location of martyrdom of Osios Kyrillos (not the well-known St. Cyrill) on 6 July 1566.

2.2 Discussion

It is clear that the churches in Group A have azimuths that lie just south of the solar sunrise arc. We proceeded to calculate the declination of the churches against the natural horizon (figure 2). But the horizon in byzantine and ottoman periods was obscured by the east walls of the city, until their demolition in the 1860s. The southern part of the city-walls was located between the modern *Ethnikis Amynis* and *Filikis Hetaireias* streets; further to the north, the walls can be traced just to the west of the modern University campus. The height of the city-walls has been estimated between 8 and 10 meters. We attempted a calculation of the declination when the walls were still standing; we believe that our results are accurate within a degree.

Our primary result is that there is no connection to significant solar date or to the sunrise of the feast day of the patron saint, except for the Rotunda. Aghios Antonios practically lies against the city walls and is never lit by sunrise. Panaghia Dexia also merits a mention. A compass was most probably used to find the east; on the day of the foundation ceremony in 1956, the magnetic declination for Thessalonike was 44', resulting to an azimuth of just over 90°.

Under Caesar Galerius, the Rotunda and his Triumphal Arch were erected as parts of the same building program as his palace, which lay further to the south. The foundation of a roman town followed a specific ritual that was originally an Etruscan tradition⁹. The city grid was defined by a series of streets running north-south, called *cardines*, and their perpendiculars, called *decumani*¹⁰. All the monumental structures to the north of the *Via Regia*, the *decumanus maximus* of the city, have been erected in a district of Thessalonike which was hardly inhabited during antiquity. An orientation of the city grid with an axis near the winter solstice is common in roman towns (Magli 2008, González-García & al 2014, Bertarione & Magli 2015). All such towns, oriented near the solstice line or with slightly greater azimuth, are oriented to the climbing sun, at a relative low altitude, maximizing sunlight throughout the year. This explains the winter solstice orientation of Rotunda.

⁹ Frontinus: *De Limitibus*, 27

¹⁰ Hyginus Gromaticus: *Constitutio*, 1

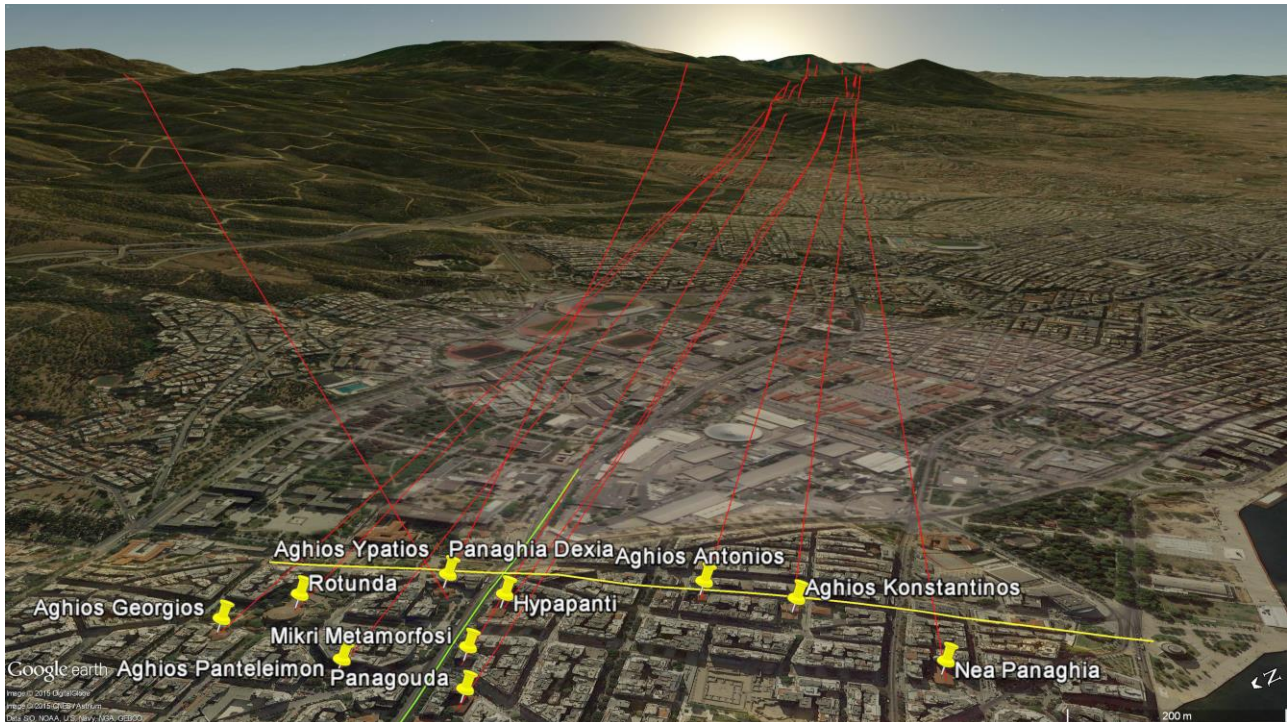


Figure 2. The current position of winter solstice sunrise over East Thessalonike. Red lines are the azimuths of the churches under study; yellow line is the approximate location of the east fortification walls of the city; green line is the modern Egnatia street.

As a result, the orientation of the churches in Group A is defined by the azimuth of the *decumanus maximus*. The modern Egnatia str. has an azimuth of 124.5° . But the last 140m or so of the roman road turned southwards to the gate located approximately at the small cove next to Sintrivaniou square; this would give to the street in that area an azimuth of around 127° . It is also of note, that during the 4th-c. the east end of *Leoforos* was deviated under the Arch of Galerius and towards a new gate located at the north side of Egnatia street (Velenis 1998, p. 111); thus these 140m had an azimuth of about 130° ; this part of the road was in use until the 1950s. Yet, even the church of Hypapanti, which is right on that spot, follows the roman rather than the byzantine city plan.

3. CITY CENTRE

Group B of the present study includes 6 churches located at the very centre of the roman city. This part of the city (at least the more uphill) was already inhabited in hellenistic times and built according to the Hippodamian system. Although this was the centre of the roman city, the core of urban life and the city's main functions shifted eastwards in mid-byzantine times.

3.1 The Churches

3.1.1 Aghia Sophia

St. Sophia (Pentecost, or Mid-Pentecost¹¹) is the only church in the group that is located south of Egnatia street. Originally it was a much larger five-aisle basilica built in the 5th-c.; this was probably destroyed by the earthquakes of 620-630, and the current church built on its place. Although modified through its history because of natural disasters, its conversion into a mosque and back to a church, its axis has not changed.

3.1.2 Aghios Demetrios

The first small church was built on the location of the martyrdom of St. Demetrios (26 October) after 313. A three-aisle basilica took its place in the 5th-c., but it was damaged by the same earthquakes the plundered Aghia Sophia. The impressive five-aisle basilica that replaced it managed to survive until the

¹¹ The best known feast for Aghia Sophia is celebrated on 14 September; but this is connected to St. Sophia and her three martyred daughters. Nowadays, the church of Aghia Sophia in Thessalonike has its feast day on Pentecost. However, the churches of Aghia Sophia in Constantinople, in Thessalonike and other early churches associated with the Holy Wisdom, were originally celebrating on mid-Pentecost (Fountoulis 1984, p.108-114; Kalokyris 1988).

fire of 1917. The current building was completed in 1949, incorporating the sections that survived the fire and reproducing all others faithfully.

3.1.3 Acheiropoietos

This is a large 5th-c. three-aisled basilica dedicated to Virgin Mary (Akathist Hymn to the Holy Virgin, mobile feast). It was modified in the 7th and again in the 14th and 15th-c. The current building is lower than the original, because it lacks the higher roof of the nave and its windows. The name Acheiropoietos refers to the famous icon in the church, and first appears in a 1320 document.

3.1.4 Panaghia Halkeon

This church dedicated to the Dormition of the Virgin (15 August) was built in 1028, and currently is well below the street level, mainly because it is surrounded by debris of the 1917 fire. Its current name represents the turkish one, after the copper workshops in the area; the original byzantine name is not known. It is thought that it may have been built on the site of an ancient temple of Hephaestus.

3.1.5 Aghios Athanassios

This church dedicated to St. Athanasius (18 January) is located southeast of Acheiropoietos and was built in 1818 on the ruins of an older building. On a 1329 chrysobull there is a mention to a church dedicated to St. Athanasius, but is not certain that this is the one. The ruins of the older building were visible until the end of the 19th-c.

3.1.6 Aghios Nikolaos Tranos

The small church of St. Nicolas (6 December) was built in 1928 to the east of the remains of Aghios Nikolaos Tranos (the "great", to distinguish from Aghios Nikolaos Orphanos) dating from 1864. A stream of churches can be found in the historical record of the area (mid 18th-c., 1406, 1110); however there are no archaeological remains from the byzantine era around the present church.

3.2 Discussion

The churches in Group B have azimuths slightly smaller than the churches in Group A. This part of the city was partly established in hellenistic times (Vickers 1972). However, we should note that no excavation has unearthed a street that can be dated older than the roman period. Comparing different maps representing ancient Thessalonike (Schoenebeck 1940, p. 481; Theoharides 1980, p. 401; Vitti 1996, map 2; Velenis 1998, p. 18; Bakirtzis 2003) we

see that the last two have exactly the form that the church orientations point at: a bend at the grid at the crossing of modern Egnatia and Aghia Sophia streets. Aghios Demetrios and Agia Sophia, the oldest buildings, have lower azimuth, and the newer churches gradually shift a little southwards.

4. COASTAL ZONE

Group C of the present study includes 3 churches build between the roman city and the sea coast. The harbour area appears separately, since it has distinct commercial and maritime functions.

4.1 The Churches

4.1.1 St. John Baptistery

Underneath the old basilica of Aghia Sophia, another building was excavated, which had an azimuth 5.3° higher than the church (Theoharidou 1988, drawing 1). Just across the street to the south, but at a much lower level, the excavators discovered a building which is still debated whether it was built on purpose and annexed to Aghia Sophia, or it was a repurposed roman or even hellenistic Nymphaeon.

This building is not visible in Google Earth. The only clean remains are of the baptistery itself, shaped like a hexagonal maltese cross. In situ measurements were performed with a Suunto Tandem compass/clinometer; the magnetic headings were corrected using the IGRF12 model¹².

4.1.2 Aghios Menas

The church dedicated to St. Menas (11 November) was originally built before the 8th-c.; it was destroyed so many times that it got the nickname of "burned monastery" during the ottoman times. Its current shape reflects the building of 1852, and although burned again in 1890, it still incorporates part of the early christian basilica.

4.1.3 Aghios Gregorios Palamas

This church of St. Gregory Palamas (14 November, a local saint) was built in 1914 after the destruction of the older three-aisle basilica built in the end of the 13th-c. and dedicated to Virgin Mary. It became the cathedral of the city at the end of the 16th-c, dedicated to St. Demetrius (26 October). This area of the city was the first to have a proper city plan during the ottoman period, as a result of the fire of 1890.

¹² NOAA Magnetic Field Calculators <http://www.noaa.gov/geomag-web/> (accessed 2 April 2015)

4.2 Discussion

The two churches in Group C seem to be rotated about 15° southwards in relation to the Group B. Their azimuths lies well outside the solar sunrise arc, therefore we do not expect to find an astronomical significance. This orientation can be associated to the ancient coast line, which was inland of the modern one. The coastline's shape was followed by the oldest buildings in the area, resulting in a different street topography outside the roman town. This persisted in the ottoman era (Karadimou-Gerolymou 1995, p. 30). Aghios Menas may not be as close to the coastline as Aghios Gregorios Palamas, but it is close to the port of Constantine the Great. We expect this area to have many buildings along the shore, imposing their own local topography. In the pre-1917 city plans the streets in the north of Aghios Menas and Aghios Gregorios Palamas are at angles of 13° and 12° against Egnatia street. This added to the azimuth of the *decumanus maximus* would give azimuths of 135° and 137° respectively, in the first case being a close match to the azimuth of the church.

Regarding St. John Baptistery, we measured the axes of the hexagon, and we came with a value for the azimuth that matches the other two buildings in group C. No axis of the baptistery matches the azimuth of Aghia Sophia or of the building under the old basilica. In addition, the road south of the baptistery in the pre-1917 city plans, has an angle of 12° against Egnatia str. for an azimuth of 137°, matching closely the measured azimuth of the building.

5. OUTSIDE THE WALLS

Group D of the present study includes 4 early christian churches just outside of the fortifications of the city. The first two were part of the great cemetery that has been discovered outside the eastern walls of the city. This area later hosted christian, muslim and jewish cemeteries. The other two were part of the corresponding cemetery outside the western walls of the city.

5.1 The Churches

5.1.1 Early Christian Basilica at Tritis Septemvriou Street

This basilica was discovered in 1980 during the construction of the street. Presently is not open to the public, but can be seen under a bridge. Due to the metal fence that surrounds the monument and the nearby military camp, compass readings were unreliable. The azimuth measurements were performed by placing the plan of the monument on top of the Google Earth background. The church is dated to

380-450 (Makropoulou 1983). Next to it is the Martyrdom of Alexandros of Pydna (14 March); 58 graves have been excavated in the area.

5.1.2 Early Christian Basilica at Syntrivaniou Square

This 5th-c. cemetery basilica is located less than 100 meters from the eastern walls of the city. It was discovered, along with 35 graves and another large building, in 2009 during the construction of a subway station. After its study, it was disassembled and is no longer accessible. We measured its azimuth by placing photographs of the excavations (Makropoulou 2014) on top of an old Google Earth background that was taken at the right time.

5.1.3 Early Christian Basilica at Ivanof Park

This basilica is located close to junction of the modern Aghiou Demetriou and Langada streets, just 120m west of *Litea* gate. It is layered between hellenistic and ottoman graves. It is not typical to the churches of the era, looking more like a house-church and similar to the ones found in Syria; however, coins found during the excavation date it around 420 (Makropoulou 1999). The church has been connected from historical references to the church of Chiona, Agape and Irene (16 April), three sisters martyred in Thessalonike on 304.

5.1.4 Early Christian Church at Demokratias Square

This small church dated 450-457 was discovered during the construction of a subway station. It is located less than 70 meters from the western walls of the city. Although this was also the location of an older cemetery, there are no graves temporal to the church. After its study, it was buried and is no longer accessible. We measured its azimuth by placing photographs and plans of the excavations (Makropoulou 2014) on top of an old Google Earth background that was taken at the right time.

5.2 Discussion

The four early christian churches in Group D are outside the city walls, so their orientation was not restricted by the city grid.

The Tritis Septemvriou basilica is archaeoastronomically interesting, since it is connected to the martyrdom of St. Alexandros of Pydna. We proceeded to calculate the sunrise position on the feast day (14 March) for the era of the church, correcting for the switch from the Julian to the Gregorian calendar.

The relevant calculations are in table II. We notice that the axis of the church points not to the sunrise, but to the sun at a height of approximately 20°.

The byzantine *Third Hour* commemorated the descent of the Holy Spirit at Pentecost¹³. The day of the Pentecost is considered to be the day of the establishment of the Church as an institution. The Holy Communion of the Eucharist celebrated in the liturgy has an equivalent transformation as its principal aim. Thus, there is an intimate liturgical bond between the two (Potamianos 1996, p. 74). It roughly corresponds to our 09:00; but is properly defined as three hours after first light, which is very hard to quantify accurately. The interpretation that the church is aligned near the time the Divine Liturgy reaches its climax (the *Third Hour*) is a feasible one (Potamianos 1996, p. 108; Iliades 2006), and seems to be strengthened by the orientation of this early christian basilica.

Another interesting alignment is found in the case of the church in Ivanof park, connected to martyrs Chiona, Agape and Irene. We proceeded to calculate the sunrise position on their feast day (16 April) for epoch 420, correcting for the switch from the Julian to the Gregorian calendar. The relevant calculations are in table II. We conclude that this church is oriented to the sun as it rises over the western fortification walls.

Repeating the calculations for the basilica on Syntrivaniou square, we deduce that for epoch 400, the axis of the church points to the sunrise on 29 April or 13 August (± 3 days) and to the *Third Hour* around 6 June or 16 July. Similarly, for the church on Demokratias square, we deduce that for epoch 450, the axis of the church against the fortification walls points to the sunrise on 7 March or 4 October (± 2 days) and to the *Third Hour* around 31 March or 7 September.

6. UPPER CITY

Group E of the present study consists of 8 churches built higher up from the roman city. There was no dense habitation in the upper city (Ano Polis) in the middle and late byzantine periods. Large early christian houses in the area were converted into monasteries from the beginning of the middle byzantine period and occupied entire insulae. Outside their precincts there would have been houses for the monasteries' servants with their families and other adjacent structures, forming entire districts which took their names from the monasteries themselves (Bakirtzis 2003; and references within).

6.1 The Churches

6.1.1 Osios David

This humble church was the catholicon church of the Latomos Monastery named after the stone quarry in the area and believed to date from the 5th-c. The original square building (12×12 m) underwent a number of interventions due to damage caused by repeated disasters. The decoration is dated to the 12th and 13th-c. The church is currently dedicated to St. David (1 November, a local saint), but was originally dedicated to Prophet Zaccharias (8 February).

6.1.2 Moni Vlatadon

This monastery was founded in the middle of the 14th century by the Vlataioi brother monks on a natural plateau in front of the north city wall; it is the only one in operation throughout these centuries. Out of the old buildings, only the catholicon remains, called the church of the Transfiguration of the Saviour (6 August) even though the monastery was actually dedicated to the Almighty.

6.1.3 Aghios Nikolaos Orphanos

This is a small wooden-roofed basilica dating from the early 14th century. It was a catholicon dedicated to St. Nicolas (6 December), and probably owes its name to an orphanage run by the monastery. The original gate along Herodotou street has been saved, showing that the city plan in the location survives from the late byzantine period. The outer wall encloses today an area of 4,000 m². We estimated the azimuth against the eastern city walls, and the surrounding wall along Apostolou Pavlou street.

6.1.4 Taxiarches

A 14th-c. church dedicated to the Archangels Michael and Gabriel (8 November), originally the catholicon of a byzantine monastery of unknown name or original dedication. Its shape has been modified extensively, the most prominent feature being its expansion to the south and west. This church has been connected inconclusively to the monasteries of Nea Moni and Moni Akapniou.

6.1.5 Panaghia Lagoudiani

The current church is dedicated to the Virgin as Life Giving Source (mobile feast on Friday after Easter) and was built in 1802 in the site of a 14th-c. monastery, with rich folklore regarding its name and the discovery of its famous icon. It looks oddly placed within the modern city, but it fits tightly among the houses in 19th-c. city plans.

¹³ Acts of the Apostles, 2:1-15.

Table II. Sun Ephemeris for Churches in Thessaloniki

Church	Date (Julian)	Civil Dawn ($h = -6^\circ$)	Sunrise ($h = 0^\circ$)	Horizon Crossing	Church Axis Crossing	h at Axis Crossing
Tritis Septemvriou Basilica	400-03-14	06:11	06:40	07:03	08:35	20° 54'
Ivanof Park Basilica	420-04-16	05:14	05:45	* 06:35	06:39	9° 44'
Osios David	450-02-08	07:02	07:33	07:50	07:59	4° 37'
Aghia Ekaterini	1300-03-06	06:01	06:30	06:57	07:49	13° 59'
Aghios Nikolaos Orfanos	1320-12-06	07:19	07:52	* 09:08	09:50	16° 13'
Moni Vlatadon	1350-08-06	05:15	05:46	* 06:21	08:04	26° 27'
Taxiarches	1350-11-08	06:55	07:27	07:46	07:50	3° 31'

*: Artificial horizon
Data from *Stellarium* software, with atmospheric refraction turned on

6.1.6 Profitis Elias

The church of Prophet Elias (20 July) dates from around 1360. It is built close to the hellenistic and byzantine palace, in a complicated exterior of apses, domes and arches. The south and east sides are founded on debris from old ruined constructions.

6.1.7 Aghioi Apostoloi

The church of Apostoles (30 June) is dated at the early 14th-c., and was originally the cathicon of a monastery dedicated to the Dormition of the Virgin (15 August). It lies very close to the western walls of the city. Of the monastery precinct, the south gate survives. Two roads (a horizontal and a vertical that ran parallel to the west city-wall) led to it.

6.1.8 Aghia Ekaterini

The church of St. Catherine (25 November) was built at the end of the 13th-c. or the beginning of the 14th-c., making it a little older than Aghioi Apostoloi. It was the location of a monastery probably dedicated to Christ. It also lies close to the western fortifications, just outside the presumed northern limits of the roman city.

6.2 Discussion

The churches in Group D have very different orientations. Excavations have traced the grid plan as far as the lower third of the upper city. In the rest of the Ano Polis and the acropolis, the streets did not follow a geometric system.

We do not think that the churches at higher altitude are better oriented to the east, because they have an unobstructive view of the eastern horizon (Badellas & al. 1983). We believe the monasteries with better alignment towards the east were just built in areas without large and/or many pre-existing buildings.

It must be noted that, owing to the natural rock and the slope of the ground in the upper city, it was impossible to make embankments. Profitis Elias is an exception; the embankments being on the south and east sides, they demonstrate the need to enlarge the church into free space, resulting in the south-west orientation.

The orientation of Panaghia Lagoudiani may reflect the presence of an ancient street parallel to hellenistic fortification walls, this area lying at the edge of king Cassander's town.

The orientation of Aghioi Apostoloi may explained by the proximity of the church to the western fortifications and by the local streets. Other structures discovered in the area also have a lower azimuth. This is the effect of the city walls in the vicinity having an azimuth of 28°.

The calculations (table II) show interesting astronomical connections for the other five churches in the area.

For Osios David on epoch 450 the alignment is towards the rising sun on the patron saint's feast day; the sun crosses the axis of the church one hour after civil dawn. This alignment came as a surprise to us, since at first sight an orientation following the local relief looks more plausible.

A similar alignment is valid for Taxiarches on 8 November 1350 (Julian calendar); we should repeat however, that the original dedication of Taxiarches monastery is unknown.

Aghios Nikolaos Orphanos is built on a rather smooth area and within a large enclosed space, so there is no apparent reason on its south to southwest orientation. But the simulation shows than on the patron saint's feast day on epoch 1320 the sun crosses at the *Third Hour*, in accordance with our finds about Tritis Septemvriou basilica.

Moni Vlatadon faces directly at the *Anna Palaiologina* gate. The gate and the *Trigonion* towers to the north of it impose the eastern horizon. Therefore, we check the sun path on the feast day against the east-

ern fortifications. We notice that the sun path crosses the church axis later than in the previous cases. This is plausible, not only because the church faces a more hilly terrain and the first light appears later than the mathematical calculations, but also because in August the daylight lasts longer.

The only feasible astronomical orientation for Aghia Ekaterini and epoch 1300 is for 6 March (Julian calendar) when the feast of the Finding of the Holy Cross is celebrated, a likely alignment for a monastery dedicated to Christ. However, this occurs earlier than the *Third Hour*, and we can find no liturgical justification for it.

7. CONCLUSION

In a city that has been continuously inhabited from antiquity to the present and whose main roads were in constant use, it is not surprising that Thessalonike's street plan more or less follows the plan of the ancient city. The churches in eastern and central Thessalonike testify to this fact. The grid of the roman city is aligned close to the winter solstice, and this is the most important factor for the orientation of the churches in Group A and Group B.

The churches in Group C have azimuths well outside the solar arc; this seems to trace the ancient shoreline. They also seem to follow the road paths of 19th-c. city at that area, being at an angle of about 12° southwards of the main street.

The churches in Group D are outside the city walls and therefore are not restricted by the city grid. In this case we find conclusive orientations for the patron's saint day for the basilica at Tritis Septemvriou str. (oriented towards the *Third Hour* on the feast day of St. Alexandros of Pydna), and for the basilica at Ivanof park (oriented towards the sunrise on the feast day of St. Chiona, Agape and Irene).

The churches in Group E have very different azimuths. This area lacked dense habitation in mid and late byzantine period and it did not follow a geometric city plan. This is also a likely place to look for astronomical alignments and we conclude that five churches in the area have a positive (Osios David, Aghios Nikolaos Orphanos, Moni Vlatadon) or possible (Aghia Ekaterini, Taxiarches) alignment to the sun on the patron's feast day.

We should note that none of the discovered astronomical orientations is to the point where the sun crosses the horizon. The axis of the church is oriented towards either the fully risen sun (Ivanof Park Basilica, Osios David, Taxiarches), or at the byzantine *Third Hour* (Tritis Septemvriou Basilica, Aghios Nikolaos Orphanos, Moni Vlatadon, Aghia Ekaterini). This has greater consequences to the study of the orientation of churches. It shows that there are at least two possible solutions for the alignment towards the sunrise on patron saint's feast day: the fully risen sun and the byzantine *Third Hour* when the liturgy reaches its climax.

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