Original Scientific Paper | Received: 09-02-2016 | Accepted: 20-04-2016

Analysis of Geographic Coordinates of the Meteorological Post at Zrinjevac

Drago ŠPOLJARIĆ[1], Božidar KANAJET[2]

[1]University of Zagreb, Faculty of Geodesy, Kačićeva 26, 10000 Zagreb, Croatia
drago.spoljaric@geof.hr
[2]University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Pierottijeva 6, 10000 Zagreb, Croatia

Abstract. The Meteorological Post at Zrinjevac built in 1884 is a public meteorological station where many citizens and visitors can obtain information about temperature, humidity and air pressure in the centre of the town. Based on the available documentation, the paper presents the analysis of geographic coordinates of the post, their reliability (accuracy) – referring to whether they determine the real position of the post and who and when determined them. There are also the analysed coordinates given that were established by Ivan Stožir in 1884, then the coordinates read by Guro Pila in 1890 from the new special map of Austro-Hungarian Monarchy and converted in 1941 by Nikolaj Abakumov from rectangular coordinates from the cadastral plan, and finally, the coordinates determined by means of modern GNSS measuring systems. There are also the changes of the form and the contents of the post show window described that took place on the occasion of two great restorations in 1959 and 1993 and were done in accordance with its modernisation. The clock with the 24-hour dial is also described. The times of sunrise and sunset in Zagreb have been checked and recalculated.

Keywords: meteorological post, Zrinjevac, geographic coordinates, clock, 24-hour clock face, sunrise and sunset time

1 Introduction

The meteorological post at Zrinjevac is one of the oldest meteorological stations in Zagreb only about twenty years "younger" than the station at Grič (1861). However, it is not included in the network of the meteorological stations of the Meteorological and Hydrological Service since it was not set up according to the regulations of the World Meteorological Organisation (URL 1) – *No person visiting Zrinjevac can miss the post, some people set their watches, the other observe the weather forecast, some other the thermometer, and some stop in front of the pressure gauge and hygrometer.* (Hirc 2008), and many people get information about the time of sunrise and sunset.

The construction of the meteorological post was financed by the army doctor Adolf Holzer, the city physician (the physician responsible for the health care in the city), a councillor of the State Health Council and pool physician in Lipik (HBL 2002), and also the first Croatian physician of balneology (URL 2). Apart from his profession, he was also occupied with amateur observation of the influences the weather had on human health, *which inspired him to have the meteorological post built in Zagreb* (Fatović-Fernenčić 2002). According to Holzer's idea, the post was supposed to be set at the Ban Josip Jelačić Square. The City Government discussed it at the end of 1883 and accepted the proposal provided that the meteorological post was not built at Jelačić Square, *but at the Zrinjski Square because of the traffic* (*Spomenica na razkriće meteorološkog stupa 1884*, Kanajet 2000). A year after that, the post was built at the end of September on the northern side of the city square and park Zrinjevac at its central axis (Fig. 1). *The meteorological post is the ornament to the Zrinjski Square due to its nice appearance, as well as of the whole city, it stands on a rectangular base lifted with one stair from the road level, and measures 2,3 meters; its height up to the top of the weathercock is 4 meters, each side of the post is 1,18 met.* (*Spomenica na razkriće meteorološkog stupa* 1884).

It is made of Istrian marble according to the plan of the architect Herman Bollé (URL 3, Zagrebački leksikon 2006) and surrounded with low forged iron fence (see

Izvorni znanstveni rad | Primljeno: 09-02-2016 | Prihvaćeno: 20-04-2016

Analiza geografskih koordinata meteorološkog stupa na Zrinjevcu

Drago ŠPOLJARIĆ[1], Božidar KANAJET[2]

[1]Sveučilište u Zagrebu, Geodetski fakultet, Kačićeva 26, 10000 Zagreb
drago.spoljaric@geof.hr
[2]Sveučilište u Zagrebu, Rudarsko geološko naftni fakultet, Pierottijeva 6, 10000 Zagreb

Sažetak. Meteorološki stup na Zrinjevcu, izgrađen 1884., javna je meteorološka postaja s koje se brojni građani i posjetitelji informiraju o temperaturi, vlazi i tlaku zraka u gradskom središtu. U radu su, prema dostupnoj dokumentaciji, analizirane geografske koordinate stupa, njihova pouzdanost (točnost) – određuju li stvarni položaj stupa u prostoru ili ga smještaju znatno dalje u odnosu na njegov stvarni položaj te tko ih je i kada odredio. Navedene su i analizirane koordinate koje je 1884. sastavio Ivan Stožir, zatim koordinate koje je 1890. Gjuro Pilar očitao s nove specijalne karte Austro-Ugarske Monarhije, a 1941. Nikolaj Abakumov preračunao iz pravokutnih očitanih s katastarskog plana i na koncu koordinate određene suvremenim GNSS mjernim sustavima. Opisane su promjene izgleda i sadržaja izloga stupa pri dvjema velikim obnovama (restauracijama) 1959. i 1993. u skladu s njegovim osuvremenjivanjem. Opisana je i ura s 24-satnom podjelom brojčanika. Provjerena su i ponovno izračunana vremena izlazaka i zalazaka Sunca u Zagrebu.

Ključne riječi: meteorološki stup, Zrinjevac, geografske koordinate, ura, 24-satni brojčanik, vremena izlazaka i zalazaka Sunca

1. Uvod

Meteorološki stup na Zrinjevcu jedna je od najstarijih meteoroloških postaja u Zagrebu, samo dvadesetak godina „mlađa“ od postaje na Griču (1861). Premda nije u mreži meteoroloških postaja Državnoga hidrometeorološkog zavoda jer nije postavljen po propisima Svjetske meteorološke organizacije (URL 1), *Ovaj stup ne mine nitko, tko dodje na Zrinjevac, jedni si ravnaju uru, drugi gledaju vremenokaz, treći toplomjere, dok se četvrti zaustavljaju pred tlakomjerom i vlagomjerom* (Hirc 2008), a mnogi se informiraju i o vremenu izlaska i zalaska Sunca.

Izgradnju meteorološkog stupa financirao je vojni liječnik Adolf Holzer, gradski fizik (liječnik koji nadzire zdravstvo grada), vijećnik Zemaljskoga zdravstvenog vijeća i kupališni liječnik u Lipiku (Hrvatski biografski leksikon 2002) i prvi hrvatski balneolog (URL 2). Uz svoj poziv bavio se i amaterskim motrenjem dnevnih promjena vremena sa svrhom praćenja utjecaja promjene vremena na ljudsko zdravlje što ga je i ponukalo da u Zagrebu dade podignuti meteorološki stup (Fatović-Fernenčić 2002). Prema Holzerovoj zamisli stup je trebalo postaviti na Trgu bana Josipa Jelačića. O tome je krajem 1883. godine raspravljalo Gradsko poglavarstvo prihvativši prijedlog uz uvjet da se meteorološki stup ne postavi na Jelačićev trg, *već da bi se ovaj stup s prometnoga obzira postavio na Zrinjski trg* (*Spomenica na razkriće meteorološkog stupa* 1884, Kanajet 2000). Godinu dana potom, krajem rujna 1884., stup je izgrađen na sjevernoj strani gradskoga trga i perivoja Zrinjevac u njegovoj središnjoj osi (sl. 1). *Stup meteorološki sa svoje ukusne izvedbe uresom je Zrinjskoga trga i cieloga grada, stoji na četvornoj osnovi, podignutoj za jednu stepenicu od cestovne razine, a izmjerenoj 2,3 metra; visina mu do vrška vjetrenjače iznosi 4 metra, svaka je stranica stupa 1,18 met. široka* (*Spomenica na razkriće meteorološkog stupa* 1884).

Izgrađen je od istarskoga mramora po nacrtu arhitekta Hermana Bolléa (URL 3, Zagrebački leksikon 2006) i ograđen niskom kovanom željeznom ogradom (sl. 1 gore). Na sjevernoj strani podnožja postavljena je crna mramorna ploča s natpisom: *Posvetio gradu Zagrebu dr. Adolf Holzer, kr. zemaljski zdravstveni savjetnik, vitez reda*

Fig. 1 Meteorological post at Zrinjevac at the end of 1940 or at the beginning of 1950s (Photo: T. Dabac) and today
Slika 1. Meteorološki stup na Zrinjevcu krajem 1940-ih ili početkom 1950-ih (foto: T. Dabac) i danas

Fig. 1 above). On the northern side of the pedestal, there is a black marble plate with the inscription: *Dedicated to the City of Zagreb by Dr. Adolf Holzer, state health advisor, knight of the order of Franjo Josip I 1884* (*Spomenica na razkriće meteorološkog stupa* 1884). On the podium around the post, there is an inscription carved: *The science reveals the natural secrets deeper and deeper forcing us irresistibly to accept the unchangeable undiscovered eternal deity.*[1] The meteorological instruments (provided in Göttingen) are installed on the three lateral sides of the square post, as well as the thematic panels with meteorological data, tables and diagrams. There are the *aneroid barometer, hair tension hygrometer, mercury thermometer and mercury barometer* on the northern side, and *weather dial (the combination of aneroid and a new assembled hygrometer)* on the eastern side. The meteorological data for Zagreb *average annual barometer indication 751 millimetre, mean annual temperature 11.3° Celsius, mean annual precipitation, prevailing winds north-east and south-east, mean maximum temperature 35.6° Celsius, minimum -14.8° Celsius, and two diagrams for recording the temperature and air pressure daily change* at the bottom are placed on the southern side of the post. On the western side, there is a clock with 24-hour dial (made by the watchmaker König from Zagreb) whose small hand makes a full circle every day. *On the glass plate below the clock, there are geographic data given for the City of Zagreb: latitude 45° 47' 4"; longitude from Ferro 33° 33' 19", from Greenwich 15° 53' 42", from Paris 13° 3' 19"; altitude for the red height landmark 121,98 meters. Further, there are the differences between the time in Zagreb and the time in six most important towns given ... .*

The appearance and the contents of the show window on the front side of the post have been changed a few times. The most extensive changes were made during two radical restorations in 1959 and in 1993. Namely, there is a coat of arms of the City of Zagreb on the eastern side of the post near the top of the show window, and on its left and right side, there are the year of construction (1884) and the year of the reconstruction of the park and the Music Pavilion (1992) given. According to (URL 2), *the park was entered into the Register of Specially Protected Monuments of Nature, not of culture. In case of such registration, the interventions in the park should be made according to the highest requirements, if possible the restorations. In this sense, the Music Pavilion was reconstructed in 1992, after that in 1993 the Meteorological Post, ...* In September 2015, the damages were improved, after a delivery vehicle had hit the post and damaged its construction and statics, however, the instruments and the show windows of the post had not been damaged (Lebarović 2016, URL 13).

The present arrangement of meteorological instruments, tables and graphs differs from the arrangement in the period of post construction. Some instruments have been replaced by modern models, thus for example, the new Lambrecht meteograph – thermograph, hygrograph and barograph in the central part of the show window (Fig. 2), installed during the first reconstruction of the post (1959) or a few years later (Ozimec 2016). On the upper panel there is the wind rose graph, and below the graph[2] of the mean daily temperature for each season (determined on the basis of 130 years of temperature measurement at Grič, 1861-1990).

On the eastern side of the post, a large thermometer (Fig. 3, left), i.e. *mercury thermometer* (ibid.) was replaced

[1] After the first reconstruction in 1959 (Zagrebački leksikon 2006), the inscription was ground, and the low iron fence removed (still visible on the photograph of T. Dabac at the beginning of the 1950s, Fig. 1 up), as well as the black marble plate. In the second reconstruction of the post in 1993, the inscription on the pedestal, as well as the marble plate were not returned. The dedication originating from the marble plate is placed today on the board of the western window.

[2] Some panels with tables and graphs / charts were placed in the second pillar reconstruction in 1993. That same year, the coat of arms of Zagreb transferred from the west to the east side of the pillar. From that time, billboards were colored in olive-green with gold letters, while after the first restoration was light blue and black letters (see Fig. 4, below). Panels with descriptions, tables, charts and geographical coordinates and billboards around the instruments are so designed and constructed that they can be easily removed or replaced (see Fig. 2 and 9 right).

Fig. 2 Northern side of the post: Mr. Z. Lebarović returns the Lambrecht meteograph at its place after the clock mechanism has been adjusted and thermo, baro and hygrograph paper replaced

Slika 2. Sjeverna strana stupa: gosp. Z. Lebarović vraća Lambrechtov meteorograf na njegovo mjesto nakon navijanja satnog mehanizma i zamjene termo, baro i higrogram trake

Franje Josipa I. 1884 (*Spomenica na razkriće meteorološkog stupa* 1884). Na podestu oko stupa uklesan je natpis *Sve dublje i dublje razodkriva nam znanost prirodne tajne i neodoljivom nas snagom sili k priznanju nepromjenljivoga neodkrovnoga vječnoga božanstva*[1]. Na tri bočne strane kvadratična stupa postavljeni su meteorološki instrumenti (nabavljeni u Göttingenu) i tematski panoi s meteorološkim podatcima, tablicama i dijagramima. Na sjevernoj su strani *aneroidni tlakomjer, vlagomjer na vlasi, toplomjer sa živom i posudni tlakomjer sa stupom od žive, a na istočnoj vremenokaz (kombinacija aneroida i novim načinom sastavljenog vlagomjera)*. Meteorološki podatci za Zagreb *popriečno godišnje stanje tlakomjera 751 milimetar, srednja godišnja toplina 11.3° Celsija, srednja godišnja oborina, vladajući vjetrovi sjeveroiztok i jugoiztok, srednji maximum toplote 35.6° Celsija, minimum –14.8° Celsija* i pri dnu *dva diagrama za bilježenje promjena toplote i zračnoga tlaka danomice* su na južnoj strani stupa. Na zapadnoj strani postavljena je ura s 24-satnim brojčanikom (djelo zagrebačkog urara Königa), čija mala kazaljka svakog dana jednom prijeđe puni krug. *Na staklenoj ploči pod satom pobilježeni su podatci geografski za grad Zagreb: geografska širina 45° 47' 4"; geografska dužina od Ferra 33° 33' 19", od Grenviča 15° 53' 42", od Pariza 13° 3' 19"; visina nad morskom površinom mjerena za crveni biljeg visine 121,98 metara. Nadalje su razlike izmedju zagrebačkoga i vremena od šest najvažnijih gradova označene,* (...).

U nekoliko je navrata mijenjan izgled i sadržaj izloga na pročeljima stupa. Najopsežnije promjene učinjene su tijekom dviju temeljitih obnova (restauracija) 1959. i 1993. godine. Naime, na istočnoj je strani stupa pri vrhu izloga grb Grada Zagreba, a s njegove lijeve i desne strane su godine izgradnje meteorološkog stupa (1884) i restauracije perivoja odnosno Glazbenog paviljona (1992). Prema Knežević (URL 2) *perivoj je još 1970. upisan u Registar posebno zaštićenih spomenika prirode, kao spomenik prirode, ne kulture. Registracija nameće svim intervencijama u perivoju najviše zahtjeve, po mogućnosti restauraciju. U tom je smislu 1992. obnovljen Glazbeni paviljon, potom 1993. Meteorološki stup*, (...) . U rujnu 2015. godine sanirana su oštećenja nakon što je u stup udarilo dostavno vozilo i time poremetilo njegovu konstrukciju i statiku, no pritom nisu oštećeni instrumenti i izlozi stupa (Lebarović 2016, URL 13).

Današnji se raspored meteoroloških instrumenata, tablica i grafikona razlikuje od rasporeda iz doba izgradnje stupa. Pojedini instrumenti zamijenjeni su suvremenijim modelima, tako je, primjerice, u središnjem dijelu sjevernoga izloga noviji Lambrechtov meteorograf - termograf, higrograf i barograf (sl. 2), postavljen u prvoj obnovi stupa (1959) ili nekoliko godina kasnije (Ozimec 2016). Na panou iznad je grafikon ruže vjetra, a ispod grafikon[2] srednje dnevne temperature za svako godišnje doba (određen na temelju 130 godina mjerenja temperature na Griču, 1861–1990).

Na istočnoj je strani stupa veliki termometar (sl. 3, lijevo) odnosno toplomjer sa živom (ibid.) premješten u prvoj obnovi stupa sa sjeverne strane. Na panou ispod njega je tablica[2] s meteorološkim podatcima za svaki mjesec u godini o srednjem tlaku i relativnoj vlažnosti,

[1] Nakon prve obnove stupa 1959. (Zagrebački leksikon 2006) natpis je izbrušen, a uklonjena je niska željezna ograda (još vidljiva na fotografiji T. Dabca iz početka 1950-ih, sl. 1 gore) i crna mramorna ploča. U drugoj obnovi stupa 1993. godine natpis na podestu kao i mramorna ploča nisu vraćeni. Posveta s mramorne ploče danas se nalazi na panou zapadnog izloga.

[2] Pojedini su panoi s tablicama i grafikonima/dijagramima postavljeni u drugoj obnovi stupa 1993. godine. Iste je godine grb Grada Zagreba premješten sa zapadne na istočnu stranu stupa. Iz toga su doba panoi maslinastozeleni, a slova zlatna, dok su nakon prve obnove bili svijetloplavi, a slova crna (vidi sl. 4 dolje). Panoi s natpisima, tablicama, grafikonima i geografskim koordinatama i panoi oko instrumenata tako su konstruirani i izvedeni da ih je moguće jednostavno ukloniti ili zamijeniti (vidi sl. 2 i 9 desno).

Fig. 3 Thermoemter (*mercury thermometer*) and weather dial in the eastern and southern show window of the meteorological post

Slika 3. Termometar (*toplomjer sa živom*) i vremenokaz u istočnom i južnom izlogu meteorološkog stupa

during the first reconstruction of the post on the northern side. On the panel below, there is a table[2] with meteorological data for each month in a year related to the mean pressure and relative humidity, the average number of cloudy and clear days, precipitation quantity calculated on the basis of the observations on the post in the period from 1961 – 1990. Above the thermometer, there is the coat of arms of the City of Zagreb with the year of the post construction (1884) and the year of the second reconstruction of the post (1993). In the central part of the southern show window, there is *weather dial* – the combination of barometer and hygrometer (Fig. 3, right) that was placed on its eastern side until the second reconstruction of the post (see Fig. 4, above). On the panel above, there is a graph[2] of the annual wind rose, and below a graph[2] of the average annual air temperature and the annual dynamics of the precipitation amount determined on the basis of the observations in the same period.

The clock with the 24-hour dial and the panel with geographic coordinates[2] and the altitude have remained on the western side of the post. Above them, there is an inscription from the previous marble plate *Dedicated to the City of Zagreb by Dr. Adolf Holzer, ...* and below them the table with the sunrise and sunset times in Zagreb (the data taken over from Meteorological and Hydrological Service/DHMZ or from the Astronomical Almanac) that was probably added during the second reconstruction of the post in 1993 (Špoler-Ćanić 2016, Lebarović 2016).

What the meteorological post looked like in the period between the two restorations (1959 and 1993) is to be seen on the photographs from that period (Fig. 4). On the black and white photo from 1979 (Fig. 4 above), the eastern side of the post with a big thermometer and weather dial[3] can be very well seen, however without table or graph. On the central photo[4] (Fig. 4 left) from the mid-1980s (Lebarović 2016), we can see what the western side of the post and its show window looked like. The appearance and the contents are different from the present post (Fig. 4 right). The frame was white at that time, just like the clock face, and the panels were light blue. The inscription *Dedicated to the City of Zagreb by Dr. Adolf Holzer,...* was missing, and there was the coat of arms of the City of Zagreb at its place (today on the eastern side of the post). The characters of the title/description text were different – geographic data and altitudes, and there are also a few altitudes. The values of latitude φ and longitude λ (only from Greenwich meridian) were different from today's values. In the lower part of the show window, there is a world map with the time zone division covering the panel with the indistinct background contents.

Although many people have written about the meteorological post guided by their thematic interests, a few of them have mentioned its geographic coordinates (for example, Pilar 1890, Abakumov 1941, 1942 and Kanajet 2013), but no one has analysed them, as far as it is known to the authors. When, how and who has read them, do they determine the real position of the post in space or is it located significantly further as related to its real position?

[3] vremenokaz is placed today on the southern side of the post.

[4] There is also Mr. Z. Lebarović on the photo (the first on the left side, with the brass cylinder in his hands on which the paper tape with the scale (thermo, baro and hygrograph) is placed for the purpose of continuous recording of e.g. temperature, pressure and humidity. Ever since 1960, the watch makers Lebarović (URL 5) have been taking care of the meteorological post , as well as of numerous other public city clocks in the Republic of Croatia.

Fig. 4 Eastern (above) and western (below left) side of the meteorological post (the photos from the second half of the XX. ct., URL 3, 4) and the present appearance of the show window on the western side of the post (below right)
Slika 4. Istočna (gore) i zapadna (dolje lijevo) strana meteorološkog stupa (fotografije iz druge polovice XX. st., URL 3, 4) i današnji izgled izloga na zapadnoj strani stupa (dolje desno)

srednjem broju vedrih i oblačnih dana, količinom oborina, izračunani na temelju motrenja na stupu u razdoblju 1961–1990. Iznad termometra grb je Grada Zagreba s godinom postavljanja stupa (1884) i godinom druge obnove stupa (1993). U središnjem je dijelu južnog izloga vremenokaz – kombinacija barometra i higrometra (sl. 3 desno), koji se do druge obnove stupa nalazio na njegovoj istočnoj strani (vidi sl. 4 gore). Na panou iznad je grafikon[2] godišnje ruže vjetra, a ispod grafikon[2] srednje godišnje temperature zraka i godišnjeg hoda količine oborina određeni na temelju motrenja u gore navedenom razdoblju.

Ura s 24-satnim brojčanikom i pano s geografskim koordinatama[2] i nadmorskom visinom ostali su na zapadnoj strani stupa. Iznad njih je natpis s nekadašnje mramorne ploče *Posvetio gradu Zagrebu dr. Adolf Holzer*, a ispod tablica s vremenima izlazaka i zalazaka Sunca u Zagrebu (podatci preuzeti od Državnog hidrometeorološkog zavoda ili iz Astronomical Almanaca), vjerojatno dodana u drugoj obnovi stupa 1993. godine (Špoler-Ćanić 2016, Lebarović 2016).

Kako je izgledao meteorološki stup između dviju restauracija (1959. i 1993. godine), predočit će nam fotografije iz toga doba (sl. 4). Na crnobijeloj fotografiji iz 1979. (sl. 4 gore) dobro je vidljiva istočna strana stupa s velikim termometrom i vremenokazom[3], ali bez ijedne tablice ili grafikona. Na središnjoj fotografiji[4] (sl. 4 lijevo) iz sredine 1980-ih (Lebarović 2016) vidimo kako je izgledala zapadna strana stupa i pripadajući izlog. Njegov je sadržaj i izgled različit od današnjega (sl. 4 desno). Ondašnji je okvir bijel kao i brojčanik ure, a panoi svijetloplavi. Nedostaje natpis *Posvetio gradu Zagrebu dr. Adolf Holzer*, umjesto kojega je tada bio grb Grada Zagreba (danas na istočnoj strani stupa). Druga su vrsta slova naslovnog/opisnog teksta – geografski podatci i nadmorske visine, a i nekoliko je nadmorskih visina. Vrijednosti širine φ i dužine λ (samo od Griničkog meridijana) razlikuju se od današnjih. U donjem je dijelu izloga karta svijeta s podjelom na vremenske zone (pojase), koja prekriva pano s nejasnim pozadinskim sadržajem.

Premda su o meteorološkom stupu, prema tematskom interesu, pisali mnogi, rijetki su spominjali njegove geografske koordinate (primjerice Pilar 1890, Abakumov 1941, 1942 i Kanajet 2013) ali nitko ih, koliko je autorima poznato, nije analizirao. Kada, kako i tko ih je očitao, određuju li stvarni položaj stupa u prostoru ili ga smještaju znatno dalje u odnosu na njegov stvarni položaj?

2. Geografske koordinate meteorološkog stupa

Staklena ploča s geografskom širinom i dužinom od početnog meridijana Ferra, Pariza i Greenwicha i nadmorskom visinom (sl. 5, lijevo) postavljena je na stup u doba njegove izgradnje (*Spomenica na razkriće meteorološkog stupa* 1884). Geografski su podatci i na današnjem panou (sl. 5, desno), nedostaje geografska dužina od Fera i Pariza. Usporedimo li „ondašnje“ i „današnje“

[3] Danas se vremenokaz nalazi na južnoj strani stupa.
[4] Na fotografiji je i g. Z. Lebarović (prvi s lijeve strane, u rukama drži mesingani valjak na koji se postavlja papirnata traka sa skalom (termo, baro i higrogram) za kontinuirano bilježenje promjene temperature, tlaka i vlage. Od 1960. godine o meteorološkom se stupu brinu urari Lebarovići (URL 5), a brinu se i za brojne javne gradske satove u RH.

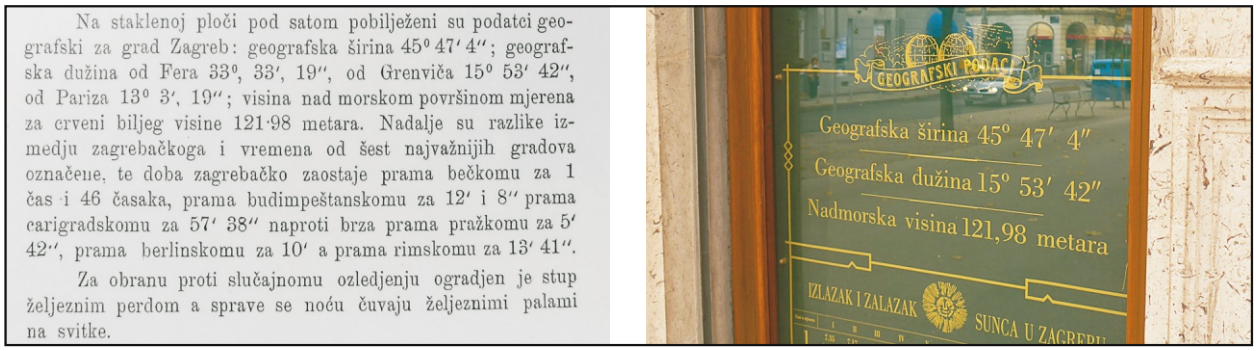


Fig. 5 The values of geographic coordinates of the post in the period of its construction in 1884 and today (right)
Slika 5. Vrijednosti geografskih koordinata stupa u doba postavljanja 1884. (lijevo) i danas (desno)

2. Geographic coordinates of the meteorological post

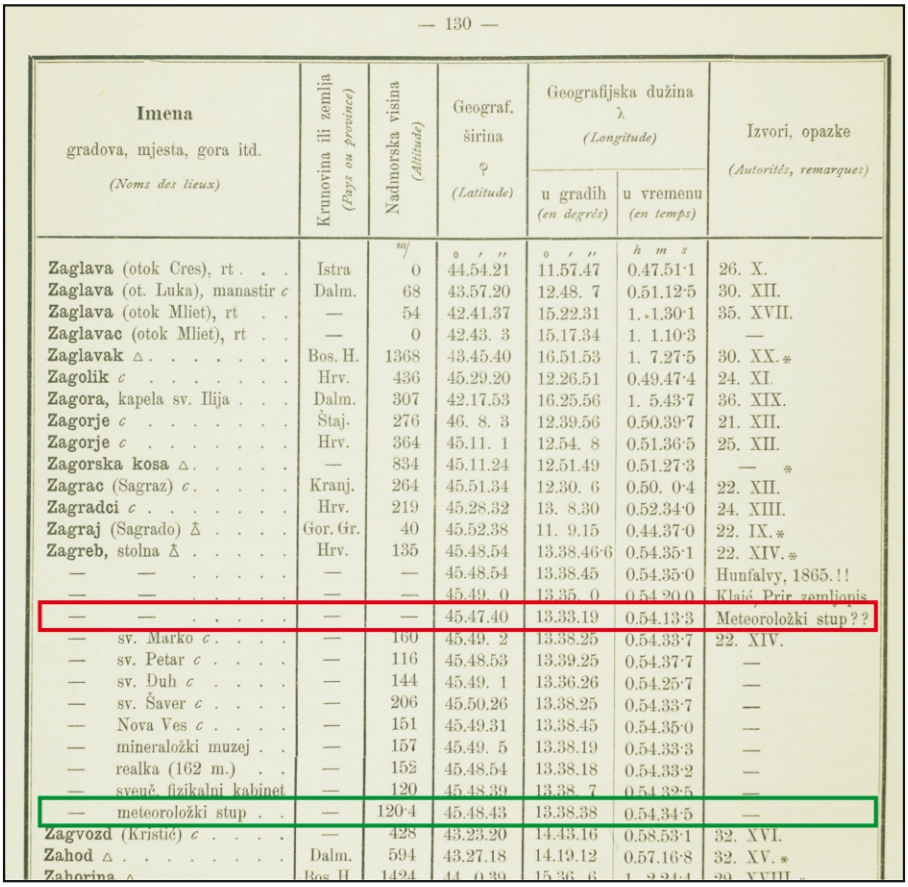
The glass plate with the latitude and longitude from the initial meridian of Ferro, Paris and Greenwich, and the altitude (Fig. 5, left) was set onto the post in the period of its construction (*Spomenica na razkriće meteorološkog stupa* 1884). The geographic data are given on the present panel as well (Fig. 5, right), however, the longitudes from Ferro and Paris are missing. If we compare the coordinates "from that time" with the "today's" coordinates, we shall see that they are not the same. However, are they reliable (accurate)?

Soon after the construction of the post, the Croatian scientist[5] found out that the coordinates of the post are wrong. In his book Geographic coordinates or the *Position of the Main Points of Dalmatia, Croatia and Slavonia and Partly of the Neighbouring Countries, especially Bosnia and Herzegovina, Istria, Kranjska* (printed in 1890), he wrote on the 11. page: *In our literature, the position of the city of Zagreb is recorded regularly in minutes or completely inaccurately.*[11] *On the meteorological post at Zrinjski Square, there is the position given that would locate Zagreb three kilometres southwards from Stenjevec. All these deficiencies were eliminated by publishing a special map of Austro-Hungarian Monarchy, ...* . And on the 130. page of *Geographic Coordinates...*, he mentioned an unidentified point (see Fig. 6, third row below the name Zagreb) with the coordinates that he had most probably taken over/copied from the post (the column Sources, notes: Meteorological post??). These coordinates differ from the coordinates written on the glass plate at the time of the post construction (see Fig. 5 left), although they should be equal.

Let us check the Pilar's statement visually by marking the real position of the meteorological post and by "mapping" the coordinates of the post on Google Earth and by "mapping" the coordinates of the post from the Memorial (1884) φ_{na_stupu} = 45° 47' 4" and λ_{na_stupu} = 15° 53' 42" and from Geographic Coordinates (1890) φ_{Pil_stup} = 45° 47' 40" and λ_{Pil_stup} = 15° 53' 33" (see Fig. 7). Let us read at the same time on the mentioned virtual globe, map (URL 7) the coordinates φ_{GE} and λ_{GE} of the marked (real) position of the post (Table 2). We neglect thereby the differences in coordinates because of various coordinate systems/datum (local Bessel and global WGS84 ellipsoid) being anyway in the order of magnitude of a few hundred meters in length, and a few tens of meters in width (for the longitude of about 17", i.e. of about 365 m, and for latitude of about 1", i.e. of about 31 m).

We check the Pilar's statement with a simple calculus. At φ = 45° 47', the length of the parallel arc of 1" is 21,5 m, and the difference of longitudes on that parallel $\Delta\lambda = \lambda_{GE}$ -

[5] Gjuro Pilar (22. IV. 1846 - 19. V. 1893) is a Croatian geologist and palaeontologist. He studies at the Faculty of Natural Sciences in Brussels where he earned his PhD in 1868, and in 1875 he became a full professor at the University in Zagreb, a full member of JAZU (Yugoslav Academy of Sciences and Arts), and the director of the Mineralogy and Geology Department in the Natural History Museum in Zagreb. He was twice elected a dean of the Faculty of Philosophy in Zagreb (1879-80 and 1890-91), and in 1884/85 a principal of the University in Zagreb. In 1874, Pilar was a cofounder of the Croatian Mountaineering Association, and in 1885 also of the Croatian Natural and Historical Society and its first vice president. He lectured mineralogy, petrography, geology, palaeontology, and for some time astronomy at the University (1886-87 and 1890-91). Pilar was a universal geoscientist; he was occupied with the lack of water in the karst area of the Dinarides (and founded the karst hydrogeology), he elaborated the theory of inner forces of the Earth and their activity. Numerous geological issues were the object of Pillar's research: the causes of glaciations, speleological objects of Gorki kotare, the causes of the earthquake in Đakovo (1884), mining in Croatia, the presence of coal in the area of Glina in Pokuplje, tertiary fossils in Pokuplje, geology of Western Bosnia, and others (URL 6). And finally, because of thematic research made in this work, we should point out the Pilar's most popular and well known work *Geographic Coordinates or Positions of the Main Point of Dalmatia, Croatia, Slavonia, and partly of the Neighbouring Countries,...* printed in 1890 only three years before the author's death (Čolić 1994).



— 130 —

Imena gradova, mjesta, gora itd. (Noms des lieux)	Krunovina ili zemlja (Pays ou province)	Nadmorska visina (Altitude)	Geograf. širina φ (Latitude)	Geografijska dužina λ (Longitude) u gradih (en degrés)	Geografijska dužina λ (Longitude) u vremenu (en temps)	Izvori, opazke (Autorités, remarques)
		m	° ′ ″	° ′ ″	h m s	
Zaglava (otok Cres), rt . . .	Istra	0	44.54.21	11.57.47	0.47.51·1	26. X.
Zaglava (ot. Luka), manastir *c*	Dalm.	68	43.57.20	12.48. 7	0.51.12·5	30. XII.
Zaglava (otok Mliet), rt . .	—	54	42.41.37	15.22.31	1. 1.30·1	35. XVII.
Zaglavac (otok Mliet), rt . .	—	0	42.43. 3	15.17.34	1. 1.10·3	—
Zaglavak △	Bos. H.	1368	43.45.40	16.51.53	1. 7.27·5	30. XX. *
Zagolik *c*	Hrv.	436	45.29.20	12.26.51	0.49.47·4	24. XI.
Zagora, kapela sv. Ilija . . .	Dalm.	307	42.17.53	16.25.56	1. 5.43·7	36. XIX.
Zagorje *c*	Štaj.	276	46. 8. 3	12.39.56	0.50.39·7	21. XII.
Zagorje *c*	Hrv.	364	45.11. 1	12.54. 8	0.51.36·5	25. XII.
Zagorska kosa △	—	834	45.11.24	12.51.49	0.51.27·3	— *
Zagrac (Sagraz) *c*	Kranj.	264	45.51.34	12.30. 6	0.50. 0·4	22. XII.
Zagradci *c*	Hrv.	219	45.28.32	13. 8.30	0.52.34·0	24. XIII.
Zagraj (Sagrado) △	Gor. Gr.	40	45.52.38	11. 9.15	0.44.37·0	22. IX. *
Zagreb, stolna △	Hrv.	135	45.48.54	13.38.46·6	0.54.35·1	22. XIV. *
— —	—	—	45.48.54	13.38.45	0.54.35·0	Hunfalvy, 1865.!!
— —	—	—	45.49. 0	13.35. 0	0.54.20·0	Klaić, Prir. zemljopis
— —	—	—	45.47.40	13.33.19	0.54.13·3	Meteorološki stup??
— sv. Marko *c*	—	160	45.49. 2	13.38.25	0.54.33·7	22. XIV.
— sv. Petar *c*	—	116	45.48.53	13.39.25	0.54.37·7	—
— sv. Duh *c*	—	144	45.49. 1	13.36.26	0.54.25·7	—
— sv. Šaver *c*	—	206	45.50.26	13.38.25	0.54.33·7	—
— Nova Ves *c*	—	151	45.49.31	13.38.45	0.54.35·0	—
— mineraložki muzej . .	—	157	45.49. 5	13.38.19	0.54.33·3	—
— realka (162 m.) . .	—	152	45.48.54	13.38.18	0.54.33·2	—
— sveuč. fizikalni kabinet	—	120	45.48.39	13.38. 7	0.54.32·5	—
— meteorološki stup . .	—	120·4	45.48.43	13.38.38	0.54.34·5	—
Zagvozd (Kristić) *c*	—	428	43.23.20	14.43.16	0.58.53·1	32. XVI.
Zahod △	Dalm.	594	43.27.18	14.19.12	0.57.16·8	32. XV. *
Zahorina △	Bos. H.	1424	44. 0.39	15.36. 6	1. 2.24·4	29. XVIII.

Fig. 6 The copy of a part of the page 130 in the Pilar's book with the coordinates of selected points in Zagreb (recorded geographic data for the city of Zagreb)

Slika 6. Kopija dijela 130. stranice Pilarove knjige s koordinatama odabranih točaka u Zagrebu (pobilježeni podatci geografski za grad Zagreb)

koordinate, uočit ćemo da su jednake. No jesu li pouzdane (točne)?

Ubrzo nakon izgradnje stupa hrvatski znanstvenik Gjuro Pilar[5] utvrđuje da su koordinate stupa pogrešne. U svojoj knjizi *Geografijske koordinate ili položaji glavnijih tačaka Dalmacije, Hrvatske, Slavonije i dielomice susjednih zemalja, imenito Bosne i Hercegovine, Istre, Kranjske* (tiskane 1890. godine) na XI. stranici piše: *U našoj literaturi je položaj grada Zagreba redovito u minutah ili pače posve netočno zabilježen*[11]. *Na meteorološkom stupu na Zrinskom trgu naznačena je pozicija, koja bi stavila grad Zagreb na tri kilometra južno od Stenjevca. Svi su ti nedostaci odstranjeni obielodanjenjem specijalne karte austro-ugarske monarkije, ...* . Na 130. stranici *Geografijskih koordinata*. navodi neimenovanu točku (vidi sl. 6, treći redak ispod imena Zagreb) s koordinatama koje je, najvjerojatnije, preuzeo/prepisao sa stupa (stupac Izvori, opazke: Meteorološki stup??). Te se koordinate razlikuju od koordinata upisanih na staklenu ploču u doba postavljanja stupa (vidi sl. 5 lijevo) premda bi morale biti jednake.

Vizualno provjerimo Pilarovu tvrdnju označavanjem stvarnog položaja meteorološkog stupa na Google Earth i „kartiranjem" koordinata stupa iz Spomenice (1884) φ_{na_stupu} = 45° 47' 4" i λ_{na_stupu} = 15° 53' 42" i iz *Geografijskih koordinata* (1890) φ_{Pil_stup} = 45° 47' 40" i λ_{Pil_stup} = 15° 53' 33" (vidi sl. 7). Ujedno očitajmo na spomenutom virtualnom globusu, karti (URL 7) koordinate φ_{GE} i λ_{GE} označenog (stvarnog) položaja stupa (tablica 2). Pritom zanemarimo razlike u koordinatama zbog različitih koordinatnih sustava/datuma (lokalni Besselov i globalni

[5] Gjuro Pilar (22. IV. 1846 – 19. V. 1893) hrvatski je geolog i paleontolog. Studirao je na Fakultetu prirodnih znanosti u Bruxellesu, gdje je doktorirao 1868., a 1875. postao je redoviti profesor na Sveučilištu u Zagrebu, redoviti član Jugoslavenske akademije znanosti i umjetnosti (JAZU) te ravnatelj Mineraloško-geološkog odjela Naravoslovnoga muzeja u Zagrebu. Dvaput je bio dekan Mudroslovnoga fakulteta u Zagrebu (1879/1880 i 1890/1891), a rektor Sveučilišta u Zagrebu 1884/1885. Pilar je 1874. bio suosnivač Hrvatskoga planinarskog društva, a 1885. i Hrvatskoga naravoslovnog društva i njegov prvi dopredsjednik. Na Sveučilištu je predavao mineralogiju, petrografiju, geologiju, paleontologiju, neko vrijeme i astronomiju (1886/1887 i 1890/1891). Pilar je bio vrlo svestran geoznanstvenik; bavio se bezvodicom dinaridskoga krša (postavivši temelje krškoj hidrogeologiji), izložio je teoriju o unutrašnjim silama Zemlje i njihovu djelovanju. Mnogobrojna geološka pitanja bila su predmetom Pilarovih istraživanja: uzroci oledbe, speleološki objekti Gorskoga kotara, uzroci đakovačkoga potresa u 1884., rudarstvo u Hrvatskoj, raširenost ugljena u glinskome Pokuplju, tercijarne okamine Pokuplja, geologija zapadne Bosne i dr. (URL 6). Zbog tematskih istraživanja u ovome radu treba istaknuti i Pilarevo u javnosti najpoznatije djelo Geografijske koordinate ili položaji glavnijih tačaka Dalmacije, Hrvatske, Slavonije i dielomice susjednih zemalja, ... tiskano 1890., samo tri godine prije autorove smrti (Čolić 1994).

Fig. 7 The position of the meteorological post on Google Earth
Slika 7. Položaji meteorološkog stupa na Google Earth-u

λ_{na_stupu} = 4' 59" = 299" is equal to the length of 6428,5 m, i.e. 6,4 km. The length of the meridian arc of 1" is 30,9 m, and the difference $\Delta\varphi = \varphi_{GE} - \varphi_{na\_stupu}$ = 1' 37" = 97" is equal to the length of 2997,3 m, i.e. 3 km. We calculate the differences between the coordinates φ_{GE}, λ_{GE} and φ_{Pil_stup}, λ_{Pil_stup} in the same way. The difference $\Delta\lambda = \lambda_{GE} - \lambda_{Pil\_stupu}$ corresponds to the length of 6622 m (6,6 km), and the difference $\Delta\varphi = \varphi_{GE} - \varphi_{Pil\_stupu}$ corresponds to the length of 1884,9 m (1,9 km).

According to the illustration (Fig. 7) and to the calculus, the Pilar's described positioning of the post – Stenjevec, three kilometres southward – is correct.

Let us go back to the fact that the coordinates of the unnamed point in *Geographic coordinates* (Sources, notes: Meteorological post??) that Pilar probably took over from the post differ in the latitude 36" and in the longitude 9" from the coordinates published in the Memorial. In units of length, this difference is 1,11 km in latitude and 0,19 km in longitude.

Why are the coordinates different? Have the differences in latitude and longitude appeared because of the typing error (*Tippfehler*) in several versions[6] of the lists of coordinates? In the preface of *Geographic coordinates ...* (page V), Pilar wrote: *This list of geographic coordinates could not be made perfect by an individual person... The writer invested a lot of effort to make the numbers of the list as correct as possible. However, there were so far only a few tabular parts with numbers having no corrections. The corrections of this part contain a special supplement. It would be the best, if everyone would make corrections alone according to this supplement before the usage.* Thus for example, if we "loose" zero (0) from the value of seconds of the post latitude taken over φ_{Pil_stup} = 45° 47' 4**0**" or three (3) from the value of minutes of the post longitude taken over λ_{Pil_stup} = 13° 3**3**' 19", the values of longitude become equal. In a special supplement of *Geographic coordinates* (*Supplements and Corrections*, page 134-142), the supposed typing error, i.e. the corrections of post latitude and longitude are not mentioned. Let us consider also the mutual differences of post longitudes from three at that time[7] reference meridians: Ferro ($\lambda^{F}_{na\_stupu}$ = 33° 33' 19"), Paris ($\lambda^{P}_{na\_stupu}$ = 13° 3' 19") and Greenwich ($\lambda^{G}_{na\_stupu}$ = 15° 53' 42") (Fig. left) mentioned in the Memorial. The differences in longitude between the Greenwich and Paris

[6] In the second part of 1884, Pilar started to collect geographic positions for the selected points available in literature, and mostly from the new special map of the Monarchy. The first list from 1886 for *his own use* (page VII, Introduction) contains the geographic positions of about 100 points. At the end of July 1887, Pilar had a clearly rewritten list of 1200 positions. At the end of 1889, Pilar prepared and had the final list of over 4000 points with geographic coordinates printed. *The printing started at the end of November 1889 and the list itself with the index was completed after five months of continuous work in April 1890* (page VII). For the purpose of revising the printed list, Pilar made a new list (manuscript) *because it was possible to detect any writing or printing mistake more easily in this way.*

[7] In the second half of the 19th century, the prime meridian for navigational charts in the Monarchy was Greenwich, and for topographic maps Ferro (URL 8). Thus, in the special map the theoretical meridian of the island Ferro was taken as the prime meridian that was considered to be located 20° of the arc westwards from the Paris meridian (Pilar 1890).

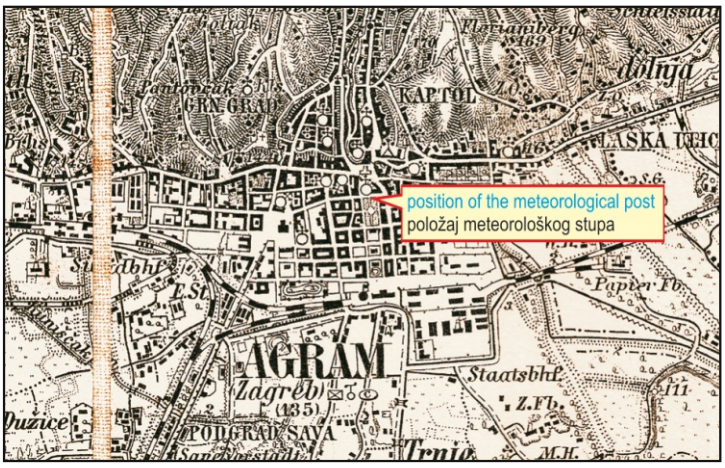


Fig. 8 The clipping of the sheet Agram (Zagreb) 1882 of the special map of Austro-Hungarian Monarchy with the designated position of the meteorological post at Zrinjevac

Slika 8. Isječak lista Agram (Zagreb) 1882 specijalne karte Austro-Ugarske Monarhije s označenim položajem meteorološkog stupa na Zrinjevcu

WGS84 elipsoid) koje su ionako reda veličine nekoliko stotina metara po duljini, a po širini nekoliko desetaka metara (za duljinu oko 17" odnosno oko 365 m, a za širinu oko 1" odnosno oko 31 m).

I jednostavnim računom provjerimo Pilarovu tvrdnju. Na $\varphi = 45° 47'$ duljina luka paralele od 1" iznosi 21,5 m, a razlika duljina na toj paraleli $\Delta\lambda = \lambda_{GE} - \lambda_{na\_stupu} = 4' 59" = 299"$ jednaka je duljini od 6428,5 m, odnosno 6,4 km. Duljina luka meridijana od 1" iznosi 30,9 m, a razlika $\Delta\varphi = \varphi_{GE} - \varphi_{na\_stupu} = 1' 37" = 97"$ jednaka je duljini od 2997,3 m odnosno 3 km. Na isti način izračunajmo razlike između koordinata $\varphi_{GE}, \lambda_{GE}$ i $\varphi_{Pil\_stup}, \lambda_{Pil\_stup}$. Razlika $\Delta\lambda = \lambda_{GE} - \lambda_{Pil\_stupu}$ odgovara duljini od 6622 m (6,6 km), a razlika $\Delta\varphi = \varphi_{GE} - \varphi_{Pil\_stupu}$ odgovara duljini od 1884,9 m (1,9 km).

Prema ilustraciji (sl. 7) i prema izračunu Pilarovo je opisno pozicioniranje stupa – Stenjevec, tri kilometra južno – ispravno.

Vratimo se činjenici da se koordinate neimenovane točke u *Geografijskim koordinatama* (Izvori, opazke: *Meteorološki stup??*), koje je Pilar najvjerojatnije preuzeo sa stupa, razlikuju, u širini 36", a u duljini 9", od koordinata objavljenih u *Spomenici*. U dužinskim jedinicama ta razlika iznosi 1,11 km u širini i 0,19 km u duljini.

Zašto se te koordinate razlikuju? Jesu li razlike u širini i duljini jednostavno nastale zbog pogreške pri prepisivanju (*tipfeler*) nekoliko verzija[6] popisa koordinata? U predgovoru *Geografijskih koordinata* ... (str. V) Pilar piše: *Ovaj popis geografijskih koordinata nije mogao izaći savršen iz ruke pojedinca.* (...) *Pisac si je dao mnogo truda, da brojevi popisa budu što korektniji. Nu dosada malo ima tabelarnih dijela sa brojevi, a da ne ima izpravaka. Izpravke ovoga djela sadržaje posebni dodatak. Najbolje bi bilo, da si svaki djelo po tom dodatku prije porabe sam izpravi.* Tako primjerice, „izgubimo" li iz vrijednosti sekundi preuzete širine stupa $\varphi_{Pil\_stup} = 45° 47' 4\mathbf{0}"$ nulu (0), vrijednosti širina postaju jednake, ili iz vrijednosti minuta preuzete duljine stupa $\lambda_{Pil\_stup} = 13° 3\mathbf{3}' 19"$ tri (3), vrijednosti dužina postaju jednake. U posebnom dodatku *Geografijskih koordinata* (*Dodatci i izpravci*., str.134-142) pretpostavljeni *tipfeler* odnosno ispravke širine i dužine stupa nisu navedene. Razmotrimo i međusobne razlike u Spomenici navedenih geografskih dužina stupa od tri, za ono doba[7], referentna meridijana: Ferra ($\lambda^F_{na\_stupu} = 33° 33' 19"$), Pariza ($\lambda^P_{na\_stupu} = 13° 3' 19"$) i Greenwicha ($\lambda^G_{na\_stupu} = 15° 53' 42"$) (sl. 5, lijevo). Razlike dužina između Griničkog i Pariškog meridijana $\Delta\lambda$Gree-Pariz = 2° 50' 23" i između Ferro i Pariškog meridijana $\Delta\lambda$Ferro-Pariz = 20° 30' 00" ne slažu se s poznatim/službenim[8] razlikama 2° 20' 14" i 20° 00' 00". Je li i ovdje nastala pogreška pri prepisivanju odnosno izradi sloga za tisak *Spomenica na razkriće meteorološkog stupa*? Primjerice, ako minutama u duljini od Pariza $\lambda^P_{na\_stupu} = 13° 3' 19"$ dodamo, na mjesto desetica,

[6] Pilar je u drugom dijelu 1884. počeo prikupljati geografske položaje za odabrane točke dostupne iz literature, a najveći dio iz nove specijalne karte Monarhije. Prvi popis iz 1886. za *vlastitu porabu* (str. VII, Uvod) sadrži geografske položaje oko 100 točaka. Koncem srpnja 1887. imao je Pilar na *čisto prepisan popis od 1200 položaja*. Krajem 1889. Pilar priprema i predaje u tisak konačni popis s preko 4000 točaka s geografskim koordinatama. *Sa štampanjem počelo se je na izmaku studenoga g. 1889. i nakon pet mjeseci neprekidna slaganja zaključeno bje štampanje samoga popisa sa kazali na kraju travnja 1890* (str VII). Pilar je za potrebe revizije toga otisnutog popisa sastavio novi popis (manuskript) *jer se je na ovaj način svakoj pisarskoj ili tiskarskoj pogrieški laglje u trag ući moglo.*

[7] U Monarhiji je u drugoj polovici 19. st. početni meridijan za pomorske karte Greenwich, a za topografske Ferro (URL 8).Dakle, u specijalnoj karti *Za prvi meridijan uzet je teoretički meridijan otoka Ferra, za koji se uzelo, da leži 20° luka zapadno od parižkoga meridijana* (Pilar 1890).

[8] *Francuski kralj Louis XIII. odredio je da francuska mornarica i kartografi računaju geografsku dužinu od merdijana koji prolazi kroz otočić Ferro, oživljujući tako ptolemejsku tradiciju. Pariz se po meridijanu Ferroa nalazio na 20° E. Mnoge su europske zemlje preuzele određivanje geografske dužine po meridijanu Ferroa. Francuski kralj Louis XIV. dao je nalog za izgradnju kraljevske zvjezdarnice u Parizu 1666., a od 1667. Francuzi su počeli računati longitudu po meridijanu te zvjezdarnice (2° 20' 14" E od Greenwicha). Taj je početni meridijan kasnije preuzela i Austro-Ugarska.* (URL 8)

meridian $\Delta\lambda_{Gree\text{-}Pariz}$ = 2° 50' 23" and between Ferro and Paris meridian $\Delta\lambda_{Ferro\text{-}Pariz}$ = 20° 30' 00" do not agree with the known/official[8] differences 2° 20' 14" i 20° 00' 00". Has the error occurred here in rewriting, i.e. in preparing the movable components for printing of the *Spomenica na razkriće meteorološkog stupa ...* ? For example, if we add to the minutes in the longitude from Paris $\lambda^{P}_{on\ the\ post}$ = 13° 3' 19" one "left out" three instead of ten, then the difference $\Delta\lambda_{Ferro\text{-}Pariz}$ is equal, and $\Delta\lambda_{Gree\text{-}Pariz}$ is closer to the accepted values.

The coordinates of the post, both those from the *Memorial* and those from *Geographic coordinates*, position the post significantly further as related to its real position, which Pilar found out soon after the construction of the post. Which coordinates are incorrectly quoted (Tippfehler)? At least two facts confirm that the coordinates taken over by Pilar from the post (Meteorological post??) are wrong:

1) geographic coordinates on the today's panel are equal to the coordinates written on the glass plate at the time of the post construction in 1884, and
2) Pilar's comment in *Geographical coordinates* (see footnote 11, on page XI): *On the meteorological post at Zrinski square, there is a position indicated that would position the city of Zagreb three kilometres southwards from Stenjevec.*

In *Geographic coordinates ...* Pilar mentioned also the coordinates of the post (Fig. 6, *Names* – meteorological post) that he had read from the sheet Agram (Zagreb) 1882 (Fig. 8, belt/zone 22., column XIV., the year of publication 1882.) of the special map of Austro-Hungarian Monarchy[9] (Pilar 1890, Čolić 1994). And in the Introduction (page VII - XVII), Pilar described in details the procedure that he used to determine the geographic positions of *towns, localities, mountains etc.* pointing out that *... the geographic position had been determined according to the special map by means of multiple measurements and various methods.* When determining the geographic positions, he measured their distances from the edge of the sheet of special map using *a calliper that provides the distance with the accuracy of 1/10 millimetre. Since the arc second on the special map presents 0.41 mm, and 0.3 mm in length (on zone maps 22 across 0.283 mm), this method could provide satisfactory results. In order to perform checking, I regularly used a compass method that is significantly quicker..., but, less reliable.*

In the chapter *On reliability of geographic coordinates* obtained from special maps (page IX-XI), he claimed that *It is sufficient for practical usage of every list of geographic coordinates to know the positions of the locations with the accuracy of one tenth of a minute, hence, with the error of ± 3 arc second. Sailors used to be quite satisfied with such positions. The positions from the special map were determined accurately with the error of ± 1 arc second.*

Unlike the Pilar's detailed description of determining the coordinates from the special map and their reliability in determining the coordinates given in the Memorial, we do not know much, but only that *on 10. June 1884, the representatives of the authority found and selected the present location on the northern part of the prolonged axis of the Zrinjski square as the most appropriate, and that the devices were set up by prof. Stožir[10] who compiled the meteorological and geographic data.* The coordinates of the post were known at the time of its festive opening on 30. September 1884 (Memorial 1884), but whether Stožir, just like Pilar, read them from the sheet of the new special map a few years later is not evident. The mentioned sheet of the new special map was published in 1882, about two years before the post was built, which means that it was available to him. Should Stožir not have had the mentioned "special map", there were also other maps available, for example, the old *ordnance map* at the scale of 1 : 28 800[11] or topographic general map 1 : 300 000 of the Institute of Military Geography in Vienna from 1881 (Zagreb on geodetic and cadastral maps and in land registers, page 94). The coordinates of the post – of the place where its construction started in 1884 – could be determined by Stožir also from the cadastral plan

[8] „The French king Louis XIII. decided that the French navy and the cartographers should calculate the longitude from the meridian passing through the island Ferro, which revived the Ptolemy tradition. According to the Ferro meridian, Paris was located at 20° E. Many European countries took over the determination of longitude according to the Ferro meridian. The French king Louis XIV. ordered the construction of the royal observatory in Paris in 1666, and since 1667, the French started to calculate the longitude according to the meridian of that observatory (2° 20' 14" E from Greenwich). This prime meridian was later taken over by Austro-Hungarian Monarchy as well." (URL 8)

[9] The special map 1:75000 for the entire Austro-Hungarian Monarchy with Bosnia and Herzegovina was made on 72 sheets in the period of 16 years (1873-1889) on the basis of the third or F*ranciscan-Josephinian survey* of the Monarchy (1869-1887)

[10] Ivan Stožir (1834-1908) was a Croatian meteorologist of Slovenian origin. He studies at the Polytechnic University in Vienna and worked as a professor at the high school in Zagreb. He was a director (for 30 years) and performed systematic meteorological measurements at the observatory in Grič. He founded (1888) the meteorological station at the top of the mountain Medvednica (1032 m), as well as the meteorological stations in Petrinja and Glina. He also established the exact time service and organised the recording and monitoring of earthquakes in Croatia. He was the first to introduce (1889) regular ozone measurements in Zagreb (URL 9).

[11] *before the new special map of Austro-Hungarian Monarchy was started, it was possible to get the copies of original images of the old ordnance map drawn in coal ...these copies were often rather vaguely copies and difficult to read* (Geographic coordinates ... , page. XV).)

jednu „ispuštenu" trojku, onda je razlika $\Delta\lambda_{Ferro\text{-}Pariz}$ jednaka, a $\Delta\lambda_{Gree\text{-}Pariz}$ približna prihvaćenim vrijednostima.

Koordinate stupa, i one iz *Spomenice* i one iz *Geografijskih koordinata*, smještaju stup znatno dalje u odnosu na njegov stvarni položaj, što je i Pilar ustanovio ubrzo nakon postavljanja stupa. Koje su koordinate pogrešno navedene (*tipfeler*)? Bar dvije činjenice potvrđuju da su koordinate koje je Pilar preuzeo sa stupa (Meteorološki stup??) pogrešne:

1) Geografske koordinate na današnjem panou jednake su koordinatama upisanima na staklenu ploču u doba postavljanja stupa 1884. godine.
2) Pilarov komentar u *Geografijskim koordinatama* (vidi fusnotu 11, str. XI): *Na meteorološkom stupu na Zrinskom trgu naznačena je pozicija, koja bi stavila grad Zagreb na tri kilometra južno od Stenjevca.*

Pilar u *Geografijskim koordinatama* navodi i koordinate stupa (sl. 6, stupac *Imena* – meteorološki stup), koje je očitao s lista Agram (Zagreb) 1882 (sl. 8, pojas/zona 22., kolona XIV., godina publikacije 1882.) specijalne karte Austro-Ugarske Monarhije[9] (Pilar 1890, Čolić 1994). U Uvodu (str. VII – XVII) podrobno opisuje postupak kako je određivao geografske položaje *gradova, mjesta, gora* itd., istaknuvši da je *geografijski položaj opredieljen po specijalnoj karti višekratnim mjerenjima i raznimi metodami.* Pri određivanju geografskih položaja mjerio je njihove udaljenosti od ruba lista specijalne karte *šublerom koji daje duljinu na 1/10 milimetara točno. Buduć da sekunda luka na specijalnoj karti predstavlja 0.41 mm, a u duljini 0.3 mm (na kartah zone 22 poprieko 0.283 mm), to se je tom metodom dalo postići veoma udovoljavajućih rezultata. Kod kontrolne radnje upotriebio sam naprotiv redovito šestilom metodu, koja je znatno brža ..., nu zato manje pouzdana.*

U poglavlju *O pouzdanosti geografijskih koordinata* izvadjenih iz specijalnih karata (str. IX–XI) tvrdi: *Za praktičnu porabu pako svakoga popisa geografijskih koordinata dovoljno je, da se poznaju položaji mjesta na jednu deseti nu minute točno, dakle sa pogriješkom od ± 3 sekunde luka. Mornari se redovito sa takovimi položaji zadovoljavaju. Položaji iz specijalne karte njekom pomnjom odredjeni točno su sa pogriješkom od ± 1 sekunde luka.*

Za razliku od Pilarova detaljnog opisa određivanja koordinata, sa specijalne karte i njihove pouzdanosti o određivanju koordinata navedenih u Spomenici ne znamo mnogo, samo da *dne 10. lipnja 1884. pronadjoše najprikladnijim i odabraše poglavarstveni izaslanici sadašnje mjesto na sjevernom kraju produžene osi Zrinjskoga trga*, a da je *namještajem sprava rukovodio prof. Stožir*[10], koji je i meteorološke geografske podatke sastavio. Koordinate stupa su, dakle, u doba njegova svečanog otvaranja 30. rujna 1884. poznate (Spomenica 1884), no je li ih Stožir očitao s lista nove specijalne karte, kao i Pilar nekoliko godina kasnije, nije razvidno? Spomenuti je list publiciran 1882., oko dvije godine prije postavljanja stupa, i prema tome bio mu je dostupan. U slučaju da Stožir nije imao spomenutu „vojnu specijalku", bile su mu na raspolaganju i druge karte, primjerice stara *generalštabskarta* u mjerilu od 1 : 28 800[11] ili topografska pregledna karte 1 : 300 000, bečkog Vojnogeografskog instituta iz 1881. (Zagreb na geodetsko-katastarskim zemljovidima i zemljišnim knjigama, str. 94). Koordinate stupa, mjesta na kojem će početkom lipnja 1884. započeti njegova gradnja, mogao je Stožir odrediti i s katastarskog plana Gornjeg grada Zagreba (mjerilo 1:1440, list 4) zemljovida *Slob. kralj. glavni grad Zagreb* iz 1864. (Zagreb na geodetsko-katastarskim zemljovidima i zemljišnim knjigama, str. 84), izrađenog na temelju Prve katastarske izmjere[12] (Škalamera 1994, Ivković i dr. 2012). Nadalje, mogao je odrediti koordinate i iz *Nacrta Zagreba* D. Albrechta (smanjenog izvoda iz izvornog plana Slob. kralj. glavni grad Zagreb) izdan pomoćju gradskog mjernika 1864. u mjerilu 1:5760 ili iz Nacrta grada Zagreba iz 1878. u mjerilu 1:11 520 (Zagreb na geodetsko-katastarskim zemljovidima i zemljišnim knjigama, str. 88–89 i 91). Kako prof. Stožir po svom obrazovanju nije bio kartograf/geodet, moguće je da mu je koordinate pripremio netko s potrebnim stručnim znanjem. Možda je to bio ondašnji *novi gradski mjernik i prvi moderni zagrebački urbanist* Rupert Melkus (1833–1891) koji je 1870. izradio projekt za

[9] Specijalna karta 1:75000 za cijelu Austro-Ugarsku Monarhiju s Bosnom i Hercegovinom izrađena je na 752 lista za 16 godina (1873.-1889.) na temelju treće ili franc-jozefinske izmjere Monarhije (1869.-1887.)

[10] Ivan Stožir (1834-1908) hrvatski je meteorolog slovenskoga podrijetla. Studirao je na Politehnici u Beču, a radio kao gimnazijski profesor u Zagrebu. Bio je ravnatelj (punih 30 godina) i obavljao sustavna meteorološka mjerenja na meteorološkom opservatoriju na Griču. Osnovao je (1888) meteorološku postaju na vrhu Medvednice (1032 m), kao i meteorološke postaje u Petrinji i Glini. Utemeljio je službu točnoga vremena i organizirao bilježenje i proučavanje potresa u Hrvatskoj. Prvi je uveo (1889) redovna mjerenja ozona u Zagrebu (URL 9).

[11] *prije nego je otpočela publikacija nove specijalne karte austro-ugarske monarkije, moglo se je dobiti ugljofotografovanih kopija originalnih snimaka stare generalštabs karte (...) te su kopije kao i prediduće bile često veoma nejasno kopirane i dosta težko čitljive* (Geografijske koordinate, str. XV).

[12] izvedene *na osnovu Zakona o stabilnom katastru iz 1817. g. i carskog patenta iz 1851. g., od 1857. do 1862. godine. Geodetski je bila dobro pripremljena i izvedena u kloštarivaničkom koordinatnom sustavu, što joj je osiguravalo visoku točnost. Obavljena je grafičkom metodom detaljne čestične izmjere s geodetskim stolom i kipreglom. Kartiranje izvornih katastarskih planova izvršeno je u mjerilu 1:1440 za intravilan, tj. za izgrađeni dio Gornjeg i Dolnjeg grada, Kaptola, Nove Vesi i Vlaške ulice i u mjerilu 1:2880 za ekstravilan ostalih područja i susjednih poreskih općina. Izgrađeni dio Zagreba snimljen je i kartiran na 10 listova (Škalamera 1994). Iz podataka prve katastarske izmjere izrađivani su svi službeni planovi grada Zagreba za različite potrebe* (Ivković i dr. 2012).)

of the Upper Town Zagreb (the scale 1:1440, sheet 4) on the map *Free Royal Town Zagreb* from 1864 (Zagreb on geodetic and cadastral maps and in land registers, page 84) made on the basis of the First cadastral survey[12] (Škalamera 1994, Ivković et al. 2012). Furthermore, he could have determined the coordinates also from the *Plan of the Town Zagreb* 1878 at the scale of 1 : 11.520 (Zagreb on geodetic and cadastral maps and in lend register, page 88-89 and 91). Since professor Stožir was not a cartographer/geodesist by profession, the coordinates might have been prepared for him by someone having the necessary professional knowledge. It could have been the *new town surveyor and the first modern urban planner in Zagreb of that time* Rupert Melkus (1833-1891) who designed the reconstruction of the square-park Zrinjevac in 1870 (URL 2). Regardless of who had read/determined the coordinates of the post, professor Stožir or the *town* surveyor, or from what sources (map or plan), they vary significantly from the true position of the post. These differences in the longitude about 5' and in the latitude 1,5' significantly go beyond the total influences of possible errors, e.g. in reading the coordinates from a map or plan, in the conversion of rectangular coordinates into spherical coordinates, and similar (Alilović 2016), hence, they are roughly inaccurate.

Fifty years later Abakumov wrote in the article Geographic coordiantes of Zagreb (1941): There is a post at Zrinjevac with the following inscription:

Geographic position of Zagreb:
Geographic latitude = 45° 48' 43"
Geographic longitude from Ferro = 33° 38' 38"
Geographic longitude from Greenwich = 15° 58' 52"
Geographic longitude from Paris = 13° 38' 38"
Altitude = 121.98 metres.

The mentioned inscription (*Geographic position of Zagreb*) and the list of coordinates (latitudes and longitudes from three reference meridians of that time) vary from today's coordinates (see Fig. 5, on the right), and more important, the values of coordinates are also different. The coordinates quoted by Abakumov are equal to the coordinates that Pilar published (1890) in

Fig. 9 Illustration of the light blue panel with the coordinates and altitudes (according to the photograph on the Fig. 4, below on the left)
Slika 9. Ilustracija svijetloplavog panoa s koordinatama i nadmorskim visinama (prema fotografiji na sl. 4. dolje lijevo)

Geographic coordinates... (page 130, – meteorological post, see also the Table 1). It can be presumed therefore that the glass plate with the coordinates that was put onto the post at the time of its construction was replaced (probably after 1890) by a new plate with the coordinates that Pilar read from the sheet Agram (Zagreb) 1882 of the special map of the Monarchy. Abakumov took the coordinates over from the replaced glass plate[13] mentioning that *it was unfortunately not defined how these coordinates had been obtained*, which means that he did not have knowledge of Pilar's Geographic coordinates, and that the procedure of their determination had not been described in the publication. Abakumov determined the coordinates of the post himself and described the method of their *calculation. Using the rectangular coordinates taken from the cadastral plans (1915) of the town Zagreb at the scale of 1:1000, we calculated the geodetic latitude of the post at Zrinjevac, i.e.: φ = 45° 48' 34,5"* (Abakumov 1941). *Now we can calculate also the difference of geodetic longitude of the post at Zrinjevac from Greenwich. It is: λ = 15° 58' 46"* (Abakumov 1942). The latitude is different by 8,5" (262 m), and the longitude by 6" (129 m) from the values given on the post at that time. These differences are within the limits of accuracy of the plan (scale) and the readings of rectangular coordinates and their transformation into spherical coordinates. Although Abakumov did not mention the reliability (accuracy) of the determined coordinates, the previous differences confirm that the coordinates were determined with the accuracy sufficient for this analysis.

And finally, we can read the values of geographic coordinates of the post and of some altitudes (Fig. 9) from the photograph made at the mid 1980s (Fig. 4 below on the left).

[12]derived ... *on the basis of the Law on Stable Cadastre from 1817 and the imperial patent from 1851, from 1857 to 1862. It was geodetically well prepared and made in the Kloštar Ivanič Coordinate System, which provided high accuracy. It was performed by means of graphic method of detailed survey with plane table and kipregel. The mapping of the original cadastral plans was made at the scale of for intravilan, i.e. for the built-up part of the Upper and Lower Town, Kaptol, Nova Ves and Vlaška street, and in the scale of 1.2.880 for the extravilan of the other area and the neighbouring tax municipalities. The built-up part of Zagreb was surveyed and mapped on 10 sheets ...* (Škalamera 1994). *All official plans of the town Zagreb were made for various purposes sung the data of the first cadastral survey* (Ivković, et al. 2012).

[13]We have not found in the quoted references when the first glass plate was replaced by a new one.

preuređenje trga-perivoja Zrinjevac (URL 2). Bez obzira tko je očitao/odredio koordinate stupa, prof. Stožir ili *gradski mjernik*, i iz kojeg izvora (karte ili plana), one se znatno razlikuju od stvarnog položaja stupa. Te razlike, u duljini oko 5', a širini 1,5', znatno prelaze sumarne utjecaje mogućih pogrešaka, npr. pri očitanju koordinata s karte ili plana, preračunavanju pravokutnih u sferne koordinate i slično (Alilović 2016) i prema tome, grubo su pogrešne.

Pedesetak godina kasnije, u članku *Geografske koordinate Zagreba* Abakumov (1941) piše: *Na Zrinjevcu se nalazi jedan stup sa natpisom:*

Geografski odnošaji Zagreba:
Širina geografska = 45° 48' 43"
Dužina geografska od Ferra = 33° 38' 38"
Dužina geografska od Greenwicha = 15° 58' 52"
Dužina geografska od Pariza = 13° 38' 38"
Visina nad morem = 121, 98 metara.

Spomenuti natpis (*Geografski odnošaji Zagreba*) i popis koordinata (*širina* i *dužine* od tri onodobna referentna meridijana) razlikuju se od današnjih (vidi sl. 5 desno) i, što je važnije, razlikuju se i vrijednosti koordinata. Koordinate koje navodi Abakumov jednake su koordinatama koje je (1890) Pilar objavio u *Geografijskim koordinatama* (str. 130, – meteorološki stup, vidi i tablicu 1). To sugerira da je staklena ploča s koordinatama, postavljena na stup u doba njegove izgradnje, zamijenjena (vjerojatno nakon 1890.) novom na koju su upisane koordinate koje je Pilar očitao s lista Agram (Zagreb) 1882 specijalne karte Monarhije. Abakumov je, dakle, preuzeo koordinate sa zamijenjene staklene ploče[13] navodeći pritom da *na žalost nije spomenuto, na kakav su način dobivene ove koordinate*, što znači da nije znao za Pilarove *Geografijske koordinate* i u publikaciji opisan postupak njihova određivanja. Abakumov i sâm određuje koordinate stupa i opisuje kako ih je *sračunao. Iskoristivši pravokutne koordinate uzete s katastarskih planova (1915) grada Zagreba u 1:1000 sračunali smo geodetsku geografsku širinu stupa na Zrinjevcu i to: φ = 45° 48' 34,5"* (Abakumov 1941). *Sada možemo izračunati i razliku geodetske zemljopisne duljine stupa na Zrinjevcu od Greenwicha. Ona iznosi: λ = 15° 58' 46"* (Abakumov 1942). Širina se razlikuje za 8,5" (262 m), a duljina za 6" (129 m) od naznačenih na stupu u to doba. Te su razlike u granicama točnosti plana (mjerilo) i očitanja pravokutnih koordinata te transformacije istih u sferne. Iako Abakumov ne spominje pouzdanost (točnost) određenih koordinata, prethodne razlike potvrđuju da su koordinate određene sa zadovoljavajućom točnošću za ovu analizu.

I na koncu, s fotografije snimljene sredinom 1980-ih (sl. 4 dolje lijevo) možemo pročitati vrijednosti geografskih koordinata stupa i nekoliko nadmorskih visina (sl. 9).

Uočavamo da se vrijednosti širine φ i dužine λ (od Griničkog meridijana), zabilježene u ° i ', razlikuju od današnjih, a da su uz nadmorsku visinu stupa zabilježene i visine Griča i Sljemena. Dakle, koordinate i visina stupa preuzete su s prijašnjeg panoa i zaokružene na stupnjeve i minute odnosno na metre. Taj je svijetloplavi pano s koordinatama i visinama postavljen vjerojatno 1959. godine pri prvoj obnovi stupa zamijenivši dotadašnji natpis s kojega je 1941. godine i Abakumov preuzeo koordinate.

Usporedimo sada koordinate meteorološkog stupa na Zrinjevcu neposredno prepisane sa stupa i preuzete iz drugih izvora (*Spomenice na razkriće meteorološkog stupa*, Pilar, Abakumov, fotografija) i izračunajmo razlike između koordinata sa stupa/*Spomenice* i navedenih izvora (tablica 1).

Usporedimo i koordinate sa stupa s koordinatama određenim pametnim telefonom i priručnim *Garminovim* GPS-om[14], očitane s Geoportala (http://geoportal.dgu.hr/#/) te izmjerene geodetskim GNSS sustavom (tablica 2).

Koordinate koje se danas nalaze na stupu (identične koordinatama u doba njegove izgradnje) znatno se razlikuju od koordinata koje je Pilar očitao sa *specijalke* (1890), a Abakumov preračunao iz koordinata preuzetih s katastarskog plana (1941) i od koordinata određenih priručnim uređajima, očitanim s Geoportala te izmjerenim geodetskim GNSS sustavom. Te su razlike (tab 1, 2) ujednačene ali znatno veće od mogućih razlika uvjetovanih, primjerice, točnošću određivanja koordinata i/ili različitim elipsoidima (Bessel, WGS84) na koje se koordinate odnose.

O nadmorskoj visini stupa reći ćemo samo ukratko. Na današnjem je panou s koordinatama, kao i u doba

[12]izvedene *na osnovu Zakona o stabilnom katastru iz 1817. g. i carskog patenta iz 1851. g., od 1857. do 1862. godine. Geodetski je bila dobro pripremljena i izvedena u kloštarivaničkom koordinatnom sustavu, što joj je osiguravalo visoku točnost. Obavljena je grafičkom metodom detaljne čestične izmjere s geodetskim stolom i kipreglom. Kartiranje izvornih katastarskih planova izvršeno je u mjerilu 1:1440 za intravilan, tj. za izgrađeni dio Gornjeg i Dolnjeg grada, Kaptola, Nove Vesi i Vlaške ulice i u mjerilu 1:2880 za ekstravilan ostalih područja i susjednih poreskih općina. Izgrađeni dio Zagreba snimljen je i kartiran na 10 listova (Škalamera 1994). Iz podataka prve katastarske izmjere izrađivani su svi službeni planovi grada Zagreba za različite potrebe* (Ivković i dr. 2012).

[13]U citiranoj literaturi nismo pronašli kada je prvopostavljena staklena ploča zamijenjena novom..

[14]Prije određivanja GNSS koordinata stupa „kontrolirali" smo i provjerili točnost našeg priručnog GPS-a i pametnog telefona uspoređivanjem koordinata geodetske mesingane ploče na Trgu bana J. Jelačića određenih spomenutim uređajima s koordinatama upisanim na ploči.

Table 1 Coordinates of the meteorological post from various sources
Tablica 1. Koordinate meteorološkog stupa iz različitih izvora

(1) φ_{na_stupu} λ_{na_stupu} (Bessel)	(2) φ_{spom} λ_{spom} (Bessel)	(3) φ_{Pil_stup} λ_{Pil_stup} (Bessel)	(4) φ_{Pil_karta} λ_{Pil_karta} (Bessel)	(5) φ_{Abak} λ_{Abak} (Bessel)	(6) φ_{foto} λ_{foto} (Bessel)
45° 47' 4" 15° 53' 42"	45° 47' 4" 13° 03' 19" (od Gr. mer. / from Gr. mer. 15° 53' 42")	45° 47' 40" 13° 33' 19" (od Gr. mer. / from Gr. mer. 15° 53' 33")	45° 48' 43" [15]13° 38' 38" (od Gr. mer. / from Gr. mer. 15° 58' 52")	45° 48' 34,5" 13° 38' 32" (od Gr. mer. / from Gr. mer. 15° 58' 46")	45° 49' (od Gr. mer. / from Gr. mer. 15° 59')
$\Delta\varphi = \varphi_{na\_stupu} - \varphi_n$ $\Delta\lambda = \lambda_{na\_stupu} - \lambda_n$	0" 0"	– 0' 36" 0' 09"	– 1' 39" – 5' 10"	– 1' 30,5" – 5' 04"	– 1' 56" – 5' 18"

(1) preuzete/prepisane sa stupa, 2015. / taken over/rewritten from the post, 2015.
(2) preuzete iz *Spomenica na razkriće meteorološkog stupa* , 1884. / taken over from *Spomenica na razkriće meteorološkog stupa ...*, 1884.
(3) preuzete sa stupa, Meteorološki stup?? (Pilar, *Geografijske koordinate*), 1890. / taken over from the post, Meteorological post?? (Pilar: *Geographic coordinates ...*), 1890.
(4) očitane s karte, - meteorološki stup (Pilar, *Geografijske koordinate*), 1890. / read from the map, - meteorological post (Pilar: Geographic coordinates ...), 1890.
(5) izračunane iz pravokutnih koordinata (Abakumov, *Geografske koordinate Zagreba*), 1941. / calculated from the rectangular coordinates (Abakumov: Geographic coordinates of Zagreb), 1941.
(6) preuzete s fotografije (sl. 4. lijevo), oko 1985. / taken over from the photograph (Fig. 4 left), in mid-1985.

We can first notice that the values of latitude φ and longitude λ (from Greenwich meridian) recorded in ° and ' vary from the present values and that also the heights of Grič and Sljeme are recorded along with the altitude. Hence, the coordinates and the height of the post were taken over from the previous panel and rounded to degrees and minutes, i.e to meters. This light blue panel with the coordinates and heights was installed probably in 1959 at the time of the first reconstruction of the post replacing the previous inscription from which Abakumov took over the coordinates in 1941.

Let us know compare the coordinates of the meteorological post at Zrinjevac that were rewritten from the post and taken over from other sources (Spomenica na razkriće meteorološkog stupa 1884, Pilar, Abakumov, photograph) and calculate the differences between the coordinates on the post/Memorial and in mentioned sources (Table 1).

Let us compare also the coordinates from the post with the coordinates determined with smart phone and *Garmin's handy GPS*[15], downloaded from the Geoportal (http://geoportal.dgu.hr/#/) and measured with geodetic GNSS system (Tab. 2).

The coordinates given today on the post (identical to the coordinates at the time of its construction) differ significantly from the coordinates that Pilar read from the *special map* (1890), a Abakumov converted from the coordinates taken over from the cadastral plan (1941) and the coordinates determined with handy devices, downloaded from Geoportal and measured with the geodetic GNSS system. These differences (Tab 1, 2) are

[14]Before determining the GNSS coordinates of the post, we had „controlled " and checked the accuracy of our GPS handy and smart phone by comparing the coordinates on the geodetic brass plate at the J. Jelačić ban Square determined with the mentioned devices with the coordinates inscribed on the plate.

[15]Although the longitude from Ferro was marked on the special map of the Monarchy, Pilar mentioned in the list of *geographic coordinates* the longitude from Paris meridian (20° eastwards from Ferro, and 2° 20' 14" eastwards from Greenwich meridian), although it had been agreed a few years earlier (1884) that the prime (reference) meridian passed through Greenwich observatory near London.

Table 2 Measured GNSS coordinates of the meteorological post and downloaded from Geoportal
Tablica 2. Izmjerene GNSS koordinate meteorološkog stupa i očitane s Geoportala

(7) φ_{Garmin} λ_{Garmin} (WGS 84)	(8) φ_{tel} λ_{tel} (WGS 84)	(9) φ_{Geop} λ_{Geop} (WGS 84)	(10) φ_{GNSS_RTK} λ_{GNSS_RTK} (WGS 84)
45° 48' 41" 15° 58' 40"	45° 48' 38" 15° 58' 42"	45° 48' 41" 15° 58' 41"	45° 48' 41" 15° 58' 41"
– 1' 37" – 4' 58"	– 1' 34" – 5' 00"	– 1' 37" – 4' 59"	– 1' 37" – 4' 59"

(7) izmjerene priručnim Garminovim GPS-om, 2015. / measured with Garmin's handy GPS, 2015
(8) izmjerene pametnim telefonom, 2015. / measured with smart phone, 2015
(9) očitane s Geoportala, 2015. / downloaded from Geoportal, 2015
(10) izmjerene geodetskim GNSS sustavom, 2016. / measured with geodetic GNSS system, 2016.

izgradnje stupa 1884. godine, zabilježena *visina nad morskom površinom mjerena za crveni biljeg visine 121,98 metara* (vidi sl. 5). Prema fotografiji iz sredine 1980-ih (sl. 4 dolje lijevo, sl. 9) na ondašnjem je panou upisano nekoliko vrijednosti nadmorskih visina – stupa (122 m), Griča (157 m) i Sljemena (1035 m). Visina stupa odnosila se na već spomenuti *crveni biljeg* koji je u obnovama uništen (izbrušen), a, nažalost, nije dodana neka druga oznaka (reper) na koju bi se zabilježena visina odnosila. Prema tome, najsvrsishodnije je nadmorsku visinu referirati na podnožje stupa ili na polukružno kameno proširenje ispod izloga na sjevernoj strani stupa 60-ak cm iznad podesta. Nadmorske visine podnožja stupa (okolnog nogostupa) očitane s Geoportala (Hrvatska osnovna karta) i izmjerene geodetskim GNSS mjernim sustavom jednake su $H_{Geoportal} = H_{GNSS\text{-}RTK} = 120{,}3$ m.

3. Ura s 24-satnim brojčanikom i tablica s vremenima izlazaka i zalazaka Sunca

Na zapadnoj stranici ima svjetski sat, kojemu je skazaljka podieljena na dvaput dvanaest sati. Brojke na gornjoj polovici skazaljke označuju dnevne satove od 6 sati u jutro do 6 sati navečer, brojke na dolnjoj polovici noćne satove od 6 sati na večer do 6 sati u jutro. Kazala sata pokazuju zagrebačko doba. Nutarnji kolut kreće se s kazali, na njem pobilježeno je do 30 znamenitih gradova, a crni potez, koji se kod dotičnih imena gradskih gubi, kazuje dotičnoga mjesta dobu prama zagrebačkomu vremenu (*Spomenica na razkriće meteorološkog stupa* 1884). Ta ista ura, postavljena na meteorološki stup prije 130 godina, i danas neumorno odbrojava i pokazuje obdanične i noćne sate na svome 24-satnom rimskom brojčaniku (sl. 10). Nedostaju samo unutarnji kolut s popisom tridesetak gradova i *crni potez* koji pokazuje vrijeme u dotičnom gradu u odnosu na zagrebačko.

U doba postavljanja ure upisane su ispod nje na staklenu ploču s geografskim podatcima i *razlike izmedju zagrebačkoga i vremena od šest najvažnijih gradova označene, te doba zagrebačko zaostaje prama bečkomu za 1 čas i 46 časaka, prama budimpeštanskomu za 12' i 8" prama carigradskomu za 57' 38" naproti brza prama pražkomu za 5' 42", prama berlinskomu za 10' a prama rimskomu za 13' 41"*. Danas tih razlika s razlogom nema. Od 1884. godine kada je zaključkom *International Meridian Conference* Zemlja podijeljena na 24 vremenska pojasa (zone) širine 15° s početnim Griničkim meridijanom, vremenske razlike između gradova (zona) službeno se ne iskazuju u minutama i sekundama već u satima[16]. Sukladno tome uvedeno je pojasno (zonsko) vrijeme[17] (URL 10, 11, Tomac, Špoljarić 2016) koje kolokvijalno nazivamo i građansko.

Pri dnu izloga (ispod panoa s geografskim koordinatama) nalazila se, između dviju obnova stupa, karta svijeta s podjelom na vremenske zone (sl. 4, sredina) koja je

[15]Premda je na specijalnoj karti Monarhije označena dužina od Ferra, Pilar u popisu *geografijskih koordinata* navodi dužinu od Pariškog meridijana (20° istočno od Ferra, a 2° 20' 14" istočno od Griničkog meridijana), iako je nekoliko godina ranije (1884) dogovoreno da početni (referentni) meridijan prolazi Griničkom zvjezdarnicom nedaleko Londona.

[16]Iako je prvobitno zamišljeno da postoje isključivo satne vremenske zone, pojedine su zemlje uvele polusatne zone, a neke na svome teritoriju primjenjuju samo jednu vremensku zonu.

[17]Do početka 20. st. većina zemalja u svijetu prihvatila je pojasno vrijeme kao službeno. Vremenske zone, iz praktičnih razloga, nisu nužno ograničene meridijanima, već, po potrebi, prate državne granice.

Fig. 10 The clock with 24-hour dial and the western side of the post (D. Lebarović removes the board with the inscribed dedication to A. Holzer in order to set the clock, photograph: Z. Ivanišević)
Slika 10. Ura s 24-satnom podjelom i zapadna strana stupa (D. Lebarović skida pano s posvetom A. Holzeru radi navijanja ure, foto: Z. Ivanišević)

adjusted but significantly larger than the possible differences conditioned for example by the accuracy of determining the coordinates and/or various ellipsoids (Bessel, WGS84) that the coordinates are related to.

In short about the altitude of the post. On the present board with coordinates, just like at the time of the construction of the post in 1884, *the altitude is recorded for the red height designation 121,98 meters* (see Fig. 5). According to the photograph from the mid-1980s (Fig. 4 below left, Fig. 9), several values of altitudes were written on the board of that time – of the post (122 m), Grič (157 m) and of Sljeme (1035 m). The altitude of the post was related to the already mentioned *red designation* that was destroyed in the processes of reconstruction (ground), and unfortunately, no other mark (benchmark) was added that the recorded altitude would refer to. It is therefore most purposeful to refer the altitude to the post base or to the semicircular lower stone frame below the window on the northern side of the post about 60 cm above the pedestal. The altitudes of the post base (of the surrounding walkway) downloaded from Geoportal (the Croatian Base Map) and measured with geodetic GNSS measuring system are equal to $H_{Geoportal} = H_{GNSS\text{-}RTK} = 120{,}3$ m.

3. The clock with the 24-hour dial and the table with the times of sunsets and sunrises

On the western side, there is a world clock with the dial divided into twelve hours two times. The numbers on the upper half of the dial indicate the daily hours from 6 o'clock in the morning to 6 o'clock in the evening, the numbers on the lower half of the dial indicate the night hours from 6 o'clock in the evening to 6 o'clok in the morning. The clock dial shows Zagreb time. The inner cycle has the moving hands and there are 30 notable towns recorded in it, and the black line that dissappears at the places with the names of towns indicates the time in adeqaute town according to Zagreb time (*Spomenica na razkriće meteorološkog stupa* 1884). The very same clock that was installed on the post 130 years ago, counts down and indicates the day and night hours tirelessly even today on its 24-hour dial with Roman numerals (Fig. 10). Only the inner cycle with the list of about thirty towns and the *black line* indicating the time in certain town related to Zagreb town are missing.

At the time when the clock was set up, there were also *the differences between the time in Zagreb and in six most important towns indicated* below the clock on the glass plate with geographic data, *and the time in Zagreb is lagging behind the time in Vienna for 1 hour and 46 minutes, behind the time in Budapest for 12' and 8", behind the time in Constantinople for 57' 38", behind the time in Prague for 4' 42", behind the time in Berlin for 10', and behind the time in Rome for 13' 41".* Today, there are no such *differences*. Ever since 1884, when the Earth was divided according to the decision of the *International Meridian Conference* into 24 time zones with the latitude of 15° and the prime meridian in Greenwich, the time difference among the towns (zones) are officially not indicated in minutes and seconds, but in hours[16]. Consequently, the zone time was introduced[17] (URL 10, 11, Tomac, Špoljarić 2016) colloquially called civil time.

At the bottom of the window (below the board with geographic coordinates), there was a world map at the time between two reconstructions of the post that had the division into time zones (Fig. 4, in the middle) and

[16]Although only the time zones with hourly offset were planned originally, some countries have introduced the zones with half-hour offset, and some of them apply only one time zone in their territory.

[17]Until the beginning of the 20. century, the majority of countries in the world adopted the zone time as their official time. The time zones are not necessarily limited with meridians for practical reasons, but follow the boundaries of countries where appropriate.

Table 3 Newly calculated times of sunrise and sunset in Zagreb
Tablica 3. Iznova izračunana vremena izlazaka i zalazaka Sunca u Zagrebu

IZLAZAK I ZALAZAK SUNCA U ZAGREBU SUNRISE AND SUNSET IN ZAGREB												
Dan u mjesecu / Day of the month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	7:35 16:24	7:16 17:04	6:33 17:44	5:35 18:26	4:42 19:05	4:07 19:41	4:07 19:53	4:36 19:28	5:14 18:37	5:52 17:39	6:33 16:46	7:14 16:16
10	7:33 16:34	7:04 17:17	6:17 17:57	5:18 18:38	4:29 19:17	4:03 19:48	4:13 19:49	4:47 19:15	5:25 18:20	6:03 17:22	6:46 16:34	7:23 16:14
20	7:28 16:47	6:49 17:32	5:58 18:10	5:00 18:51	4:17 19:29	4:03 19:52	4:23 19:42	4:59 18:59	5:38 18:01	6:17 17:05	7:00 16:23	7:31 16:16

Fig. 11 The present board with the times of sunsets and sunrises in Zagreb
Slika 11. Današnji pano s vremenima izlazaka i zalazaka Sunca u Zagrebu

prekrivala pano s nejasnim pozadinski sadržajem (vremenske razlike između Zagreba i šest, za ono doba *najvažnijih*, gradova) za što u nama dostupnim izvorima zasad nismo pronašli nikakve informacije, a ne sjeća se niti gosp. Lebarović. Karta je uklonjena 1993. godine (Špoler-Ćanić 2016), a umjesto nje je postavljen pano s vremenima izlazaka i zalazaka Sunca u Zagrebu (sl. 11), preuzetih od Državnog hidrometeorološkog zavoda (DHMZ)[18] ili preuzetih iz astronomskog godišnjaka npr. Astronomical Almanaca.

Vremena izlazaka i zalazaka Sunca iznova su izračunana (URL 12) za geografske koordinate φ = 45° 48' 43", λ = 15° 58' 52" i visinu stupa H = 122 m (tablica 3), koje su svojedobno odredili Pilar (1890) i Abakumov (1941 i 1942). Izračunani su izlasci i zalasci Sunca i za geografske podatke koji su danas na stupu φ = 45° 47' 4", λ = 15° 53' 42" i visinu stupa H = 122 m.

Usporedimo li vremena s panoa (sl. 11) i iz tablice 3 uočit ćemo da se gotovo ne razlikuju (rijetko je razlika manja od minute). Vremena izlazaka i zalazaka Sunca izračunanih za geografske podatke koji su danas na stupu uglavnom se razlikuju od novoizračunanih vremena (tablica 3) za jednu do dvije minute. To samo potvrđuje da se i prijašnji izračun nije odnosio na položaj stupa definiran koordinatama koje se danas na njemu nalaze. Kako su vremena izlazaka i zalazaka vjerojatno preuzeta od DHMZ-a, izračuni se najvjerojatnije odnose za geografske koordinate jedne od službenih meteopostaja u Zagrebu (npr. Grič ili Maksimir).

4. Zaključak

Na sjevernoj strani parka Zrinjevca, po mnogima *najstarijeg, najvećeg, najživljeg i najljepšeg gradskog parka*, izgrađen je 1884. meteorološki stup s kojega se brojni građani i posjetitelji informiraju o temperaturi, vlazi i tlaku zraka u gradskom središtu. Tu su i tematske tablice i dijagrami s prosječnim godišnjim i višedesetljetnim meteorološkim podatcima u Zagrebu, tablica s vremenima izlazaka i zalazaka Sunca i ploča s geografskim koordinatama stupa. A nezaobilazna ura već stotinu i trideset godina neumorno odbrojava i pokazuje obdanične i noćne sate na svome 24-satnom brojčaniku.

U nekoliko je navrata, radi osuvremenjivanja stupa, mijenjan sadržaj izloga na njegovim pročeljima. Najopsežnije promjene učinjene su tijekom dviju temeljitih obnova (restauracija) 1959. i 1993. godine.

Niska željezna ograda i crna mramorna ploča s natpisom *Posvetio gradu Zagrebu dr. Adolf Holzer* uklonjena je pri prvoj obnovi, a meteorograf zamijenjen novim

[18]Nadležnost nad navedenim meteorološkim stupom ima Grad Zagreb, dok Državni hidrometeorološki zavod (DHMZ) katkad sudjeluje u renoviranju stupa kao što je to bio slučaj prije nekoliko godina. Također pomaže savjetima ako se to zatraži (URL 1).

covered the board with vague background (the time differences between Zagreb an six *most important* towns? at that time). So far, we have found not information in the available sources about the background, and neither Mr. Lebarović remembers. The map was removed in 1993 (Špoler-Ćanić 2016), and the board with the times of sunsets and sunrises was set up instead (fig. 11) that were obtained from Meteorological and Hydrological Service/DHMZ[18] or taken from the Astronomical Almanac.

The times of sunrise and sunset have been calculated again (URL 12) for the geographic coordinates φ = 45° 48' 43", λ = 15° 58' 52" and the height of the post H = 122 m (tab. 3) that were formerly determined by Pilar (1890) and Abakumov (1941 and 1942). The sunrises and sunsets were also calculated for the geographic data present today on the post φ = 45° 47' 4", λ = 15° 53' 42" and the height of the post H = 122 m.

If we compare the times given on the board (Fig. 11) and in the table 3, we can notice that they hardly differ (the difference is rarely smaller than a minute). However, the times of sunrise and sunset calculated from the geographic data to be found on the post today differ from the newly calculated times (Tab. 3) by one or two minutes. It only confirms that the previous calculation did not refer to the position of the post defined with the coordinates that are indicated on the post today. Since the times of sunrise and sunset have been taken over from DHMZ, the calculations refer most probably to the geographic coordinates of one of the official meteorological stations in Zagreb (e.g. Grič or Maksimir).

4. Conclusion

On the northern side of the park Zrinjevac, being the *oldest, liveliest and the most beautiful city part* according the opinions of many people, the meteorological post was built in 1884 providing the information about temperature, humidity and air pressure in the city centre for the citizens and numerous visitors. There are also thematic tables and graphs with average annual and several-decades meteorological data in Zagreb, the table with the times of sunrise and sunset, and the board with the geographic coordinates of the post. The unavoidable clock counts down persistently and indicates the day and night hours on its 24-hour dial.

The contents of the window on the front side of the post have been changed several times for the purpose of its updating. The most extensive changes were made during the two thorough reconstructions (restorations) in 1959 and 1993.

The low iron fence and black marble plate with the inscription *Dedicated to the town Zagreb by dr. Adolf Holzer, ...* was removed during the first reconstruction, and the meteogram was replaced with a new model. In the second reconstruction of the post, the inscription was placed onto the board of the western window, and there were a few new thematic boards added with tables and graphs. In the same year, the coat of arms of Zagreb was moved to the eastern side of the post. At that time, the boards were olive green, and the letters golden. In September 2015, the damages of the post were repaired, after it had been hit by the delivery vehicle, which damaged its construction and statics. (URL 13).

The values of geographic coordinates on the post have also been changed (Fig. 12). The first coordinates were *compiled* in 1884 by Ivan Stožir. According to the available sources, it is not quite clear whether he had read them from a map (e.g. the special map of the Austro-Hungarian Monarchy from 1882) or from the cadastral plan of the town Zagreb from 1864. Since Stožir was no cartographer or geodesist, the coordinates were probably determined by the *town surveyor* of that time. Regardless of who and from what sources determined the coordinates, they contain rough errors and place the post *three kilometres southwards of Stenejvac*. A few years later, Gjuro Pilar determined (read) the coordinates himself from the sheet Agram (Zagreb)1882 of the special map of Austro-Hungarian Monarchy after he had noticed that they are incorrect, and published them in the book *Geographic Coordinates or the Positions of the Main Points of Dalmatia, Croatia, Slavonia and ...* in 1890. About fifty years later, in 1941, Nikolaj Abakumov determined the coordinates of the meteorological post from the plan of the town Zagreb from 1915. They differ from Pilar's coordinates 8" in the latitude, and 6" in the longitude, which is within the limits of accuracy reading and calculation of coordinates. Pilar's coordinates remained there until the second reconstruction of the post in 1993, and in 1959 (the first reconstruction of the post) they were given in degrees and minutes. In the second reconstruction of the post, the first determined (Stožir's) coordinates were returned again, and they are indicated on the post even today. The coordinates of the post were determined in 2015 with the omnipresent smart phone, the Garmin's handy GPS, the geodetic GNSS system, and downloaded from the Geoportal. They differ by 1" to 3" among themselves. Unlike the previous coordinates that are related to Bessel ellipsoid, the last

[18]The City of Zagreb has the jurisdiction over the mentioned meteorological post, and Meteorological and Hydrological Service (DHMZ) sometimes participates in the reconstruction of the post, as it was the case a few years ago. It also provides advices when required. (URL 1).

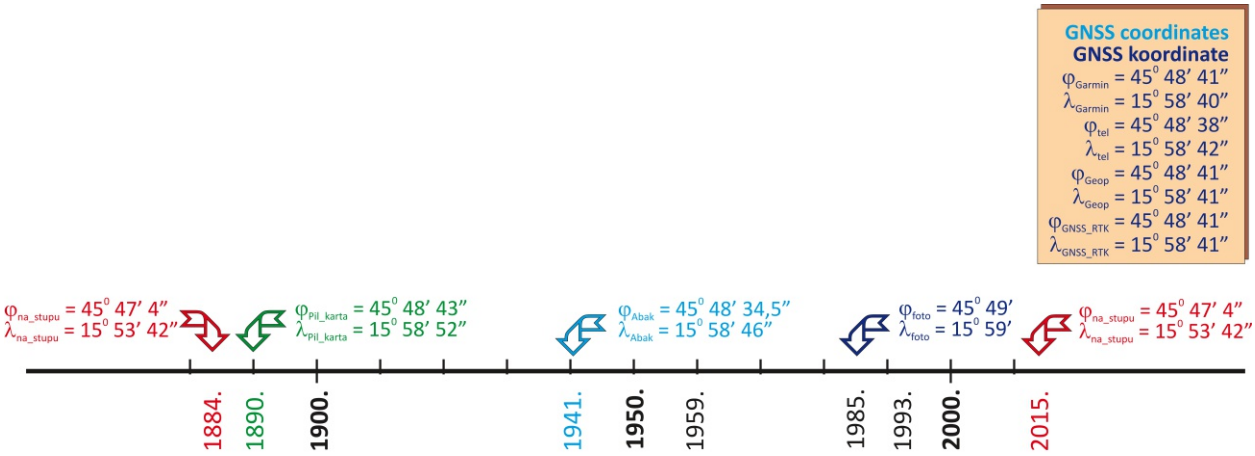


Fig. 12 The chronology of determining the coordinates of the post and their values
Slika 12. Kronologija određivanja koordinata stupa i njihove vrijednosti

modelom. U drugoj obnovi stupa natpis je postavljen na pano zapadnog izloga i dodano je nekoliko novih tematskih panoa s tablicama i dijagramima. Iste je godine grb Grada Zagreba premješten sa zapadne na istočnu stranu stupa. Iz toga su doba panoi maslinastozeleni, a slova zlatna. U rujnu 2015. sanirana su oštećenja stupa nakon što je u njega udarilo dostavno vozilo poremetivši mu konstrukciju i statiku (URL 13).

Mijenjane su i vrijednosti geografskih koordinata na stupu (sl. 12). Prve je koordinate *sastavio* 1884. Ivan Stožir. Prema dostupnim izvorima nije razvidno je li ih očitao s karte (npr. nove specijalne karte Austro-Ugarske Monarhije iz 1882.) ili s katastarskog plana grada Zagreba iz 1864. godine. Kako Stožir nije bio kartograf ili geodet, vjerojatno je koordinate odredio ondašnji *gradski mjernik*. Bez obzira tko ih je i iz kojeg izvora odredio, one su grubo pogrešne i smještaju stup *tri kilometra južno od Stenjevca*. Nekoliko je godina kasnije Gjuro Pilar, uočivši da su koordinate pogrešne, sâm odredio (očitao) iste s lista Agram (Zagreb) 1882 specijalne karte Austro-Ugarske Monarhije i objavio 1890. u knjizi *Geografijske koordinate ili položaji glavnijih tačaka Dalmacije, Hrvatske, Slavonije i ...* . Pedesetak godina potom, 1941. godine, Nikolaj Abakumov određuje koordinate meteorološkog stupa iz plana grada Zagreba iz 1915. godine. One se razlikuju od Pilarovih 8" u širini a 6" u dužini, što je u granicama točnosti očitanja i preračunavanja koordinata. Pilarove koordinate ostaju sve do druge obnove stupa 1993., a od 1959. (prve obnove stupa) zaokružene su na stupnjeve i minute. U drugoj obnovi stupa ponovno su vraćene prvoodređene (Stožirove) koordinate koje su i danas na njemu. Koordinate stupa određene su i 2015. sveprisutnim pametnim telefonom, priručnim Garminovim GPS-om, geodetskim GNSS sustavom te očitane s Geoportala. One se međusobno razlikuju 1" do 3". Za razliku od prethodnih koordinata koje se odnose na Besselov elipsoid, ove se posljednje odnose na WGS84. Razlike u koordinatama zbog različitih koordinatnih sustava/datuma (lokalni Besselov i globalni WGS84 elipsoid) su na našim širinama oko 17" za duljinu a oko 1" za širinu. U konkretnom slučaju te razlike nisu veće od 11" u duljini i 8" u širini. U konačnici, ako izdvojimo iz analize grubo pogrešne koordinate koje se danas nalaze na stupu (identične koordinatama u doba njegove izgradnje), razlike između koordinata koje je Pilar očitao sa *specijalke*, a Abakumov preračunao iz koordinata preuzetih s katastarskog plana i koordinata određenih priručnim uređajima, očitanim s Geoportala i izmjerenih geodetskim GNSS sustavom su ujednačene i unutar razlika uvjetovanih, primjerice, točnošću očitanja koordinata i/ili različitim elipsoidima na koje se koordinate odnose.

I danas je meteorološki stup na Zrinjevcu nezaobilazan i zanimljiv ne samo građanima koji se *u prolazu* informiraju o meteorološkim podacima u najužem gradskom središtu, već i brojnim posjetiteljima (turistima) koji se fotografiraju (danas omiljeni *selfiji*) uz njegov skladan i stameni stas i uspoređuju koordinate sa svojih pametnih telefona s onima na stupu.

Zbog navedenoga predlažemo postavljanje novog panoa s koordinatama stupa izmjerenih geodetskim GNSS mjernim sustavom

$\varphi_{WGS84} = 45° 48' 41"$
$\lambda_{WGS84} = 15° 58' 41"$,

a dosadašnju nadmorsku visinu uništenog biljega na stupu zamijeniti novoodređenom visinom H = 120,3 m koja se odnosi na podnožje stupa (okolni nogostup) ili visinom polukružnog kamenog proširenja ispod izloga na sjevernoj strani stupa 60-ak cm iznad podesta.

coordinates refer to WGS84. The difference in coordinates at our territory amounts to about 17" for the longitude and about 1" for the latitude due to various coordinate systems/datums (local Bessel and global WGS84 ellipsoid). In a concrete case, these differences are not larger than 11" in the longitude and 8" in the latitude. Finally, if we separate from the analysis roughly inaccurate coordinates indicated today on the post (identical to the coordinates at the time of its construction), the differences between the coordinates read by Pilar from the *special map* and converted by Abakumov from the coordinates taken over from the cadastral plan, and the coordinates determined with handy devices, and downloaded from Geoportal and measured by means of geodetic GNSS system are adjusted even within the scope of differences conditioned by for example the accuracy of reading the coordinates and /or by various ellipsoids that the coordinates refer to.

The meteorological post at Zrinjevac is even today an inevitable and interesting object not only for the citizens who catch up *in passing* on the meteorological data in the immediate city centre, but also for the visitors (tourists) who take photos (today, popular selfies) near its *harmonious and monumental figure* and compare the coordinates from their smart phones with those on the post.

Referring to all above mentioned, we recommend the setting of a new board with the coordinates of the post measured with GNSS measuring system

$\varphi_{WGS84} = 45° 48' 41''$

$\lambda_{WGS84} = 15° 58' 41''$,

and the replacement of the previous altitude of the destroyed designation on the post with the newly determined height H = 120,3 m that refers to the post base (surrounding walkway) or with the height of the semicircular stone extension below the window on the northern side of the post about 60 cm above the pedestal.

References / Literatura

Abakumov, N. 1941. Geografske koordinate Zagreba. Priroda. br. 2. god. XXXI. 33–36. Hrvatsko prirodoslovno društvo. Zagreb.

Abakumov, N. 1942. Određivanje zemljopisnih duljina. Priroda. br. 1 i 2. god. XXXII. 25–28. Hrvatsko prirodoslovno društvo. Zagreb.

Alilović, M. 2016.Usmena komunikacija (12. siječnja).

Čolić, P. K. 1994. Suvremeni pogled na Pilarovo djelo „Geografijske koordinate ...". Zbornik znanstvenog skupa o Gjuri Pilaru (1846.–1893.). Slavonski Brod 1993. Ur. Gušić, I.; Sakač, K. HAZU. Posebna izdanja. Knjiga 11. 135–172.

Fatović-Ferenčić, S. 2002. Holzer Adolf. Hrvatski biografski leksikon. vol. 5. LZ Miroslav Krleža. 605–606.

Hirc, D. 2008. Stari Zagreb. Kaptol i Donji grad. Svezak drugi. Matica Hrvatska. Zagreb.

Hrvatski biografski leksikon: Gn – H, Ur. Macan, T. LZ Miroslav Krleža. Zagreb. 2002. 605–606.

Ivković, M.; Džapo M.; Redovniković, L. 2012. Katastarske izmjere grada Zagreba. Geodetski list, 4, 303–320.

Jenić, M. Ministarstvo kulture RH. Kulturna baština. Dokumentacijske zbirke, Zbirka fotografske dokumentacije. 2016. Usmena i pisana komunikacija (14., 20. i 21. siječnja).

Kanajet, B. 2000. Meteorološki stup na Zrinjevcu. Geodetski list, 3, str. 200.

Kanajet, B. 2013. Koordinate hidrometeorološkog stupa na Trgu Nikole Šubića Zrinskog u Zagrebu. Geodetski list, 3, 215–216.

Lebarović, Z.; Lebarović, D. Urarska radnja Lebarović (2015 i 2016). Usmena komunikacija (21. studenog, 8. veljače).

Ozimec, Ž. DHMZ. 2016. Usmena komunikacija (21. siječnja).

Pilar, G. 1890. Geografijske koordinate ili položaji glavnih točaka Dalmacije, Hrvatske, Slavonije i dielomice susjednih zemalja, imenito Bosne i Hercegovine, Istre, Kranjske. JAZU. Knjiga X. Zagreb.

Spomenica na razkriće meteorološkog stupa… , Državni arhiv u Zagrebu (Fond Gradsko poglavarstvo Zagreba). no 23096. 1884.

Škalamera, Ž. 1994. Teritorijalni razvitak grada Zagreba u zrcalu zemljovida i geodetsko katastarske dokumentacije. Katalog izložbe Zagreb na geodetsko-katastarskim zemljovidima i u zemljišnim knjigama. Zagreb.

Špoler-Ćanić, K. DHMZ. 2016. Usmena i pisana komunikacija (12. i 18. siječnja).

Tomac, G.; Špoljarić, D. 2016. Online efemeride – jednadžba vremena i pravo Sunčevo vrijeme, izlasci i zalasci Sunca i pripadajući azimuti. Kartografija i geoinformacije. vol. 14. br. 24, 26–41.

Vranić Rob, A. Gradski zavod za zaštitu spomenika kulture i prirode 2016. Usmena komunikacija (13. siječnja).

Zagrebački leksikon: M – Ž. Ur. Bilić, J.;Ivanković, H. LZ Miroslav Krleža. Zagreb. 2006. Str. 49, 585.

URL 1: Državni hidrometeorološki zavod (DHMZ).
http://klima.hr/razno.php?id=faqs (30. 11. 2015)
URL 2: Knežević, S. O Zrinjevcu, simbolu Zagreba u doba kad je postajao metropolom ...
http://www.tportal.hr/kultura/kulturmiks/292051/Najstariji-najveci-najzivlji-i-najljepsi-zagrebaci-park.html (27. 11. 2015)
URL 3: Meteorološki stup, prvi poklon građana Zrinjevcu
http://cro-eu.com/galerija-fotografija/displayimage.php?pos=-15431. (2. 12. 2015)
URL 4: Urarska radionica za izradu i popravak satova Lebarović
http://www.urar-lebarovic.hr/ (27. 11. 2015)
URL 5: Zrinjevac
http://www.zgportal.com/o-zagrebu/simboli-grada-zagreba/park-zrinjevac/ (27. 11. 2015)
URL 6: Gjuro Pilar. Hrvatska enciklopedija
http://www.enciklopedija.hr/Natuknica.aspx?ID=48232 (27. 11. 2015)
URL 7: Google Earth
https://sh.wikipedia.org/wiki/Google_Earth (18. 12. 2015)
URL 8: Faričić. Povijesni problem određivanja geografske dužine (2): Početni meridijan
http://www.geografija.hr/teme/povijesni-problem-odredivanja-geografske-duzine-2-pocetni-meridijan/ (18. 12. 2015)
URL 9: Stožir Ivan. Hrvatska enciklopedija
http://www.enciklopedija.hr/Natuknica.aspx?ID=58292 (18. 12. 2015)
URL 10: Wikipedia - Time zone
http://en.wikipedia.org/wiki/Time_zone (20. 12. 2015)
URL 11: Time Zone Abbreviations - Worldwide List
http://www.timeanddate.com/time/zones/ (20. 12. 2015)
URL 12: On line efemeride, aplikacija za izračun vremena izlaska i zalaska Sunca i pripadajućih azimuta
http://astrogeo.geoinfo.geof.hr/online_ephemeris/sunrise_sunset/index.html (20. 12. 2015)
URL 13: Biser Zrinjevca – Meteorološki stup se sanira zbog prometne nezgode
http://www.zagrebancija.com/hr-kvartovi/meteoroloski-stup-se-sanira-zbog-prometne-nezgode_327727 (19. 1. 2016.).