BADANIA FIZJOGRAFICZNE
R. XI – SERIA A – GEOGRAFIA FIZYCZNA (A71)

DOI 10.14746/bfg.2020.11.4 str. 65–74

AN ATTEMPT TO USE GOOGLE EARTH PRO IMAGES FOR SELECTED GEODETIC WORKS − FOR EXAMPLE OF WOLNOŚCI SQUARE IN POZNAŃ (POLAND)

JAROSŁAW KUBIAK*, PAULINA MAGDA

Wydział Nauk Geograficznych i Geologicznych,
Uniwersytet im. Adama Mickiewicza w Poznaniu, ul. B. Krygowskiego 10, 61-680 Poznań
ORCID: 0000-0001-5706-8493

Abstract: The article concerns issues pertaining to satellite geodesy and the possibilities of using the available source materials such as high-resolution satellite maps for selected works which require a high degree of accuracy in determining the location of topographic objects. The purpose of the work was to indicate the potential use of Google Earth maps for selected geodetic works (preparing topographic descriptions, sketch maps) in order to facilitate and accelerate the process. Works were carried out in an urban area, Wolności Square in Poznań (Poland) where 58 checkpoints were located. In order to design them, maps from the Google system from four periods were used. The research used the Global Navigation Satellite Systems set consisting of a Leica GS08 + satellite receiver and a Leica CS15 controller, geodetic software for work design (Trimble GNSS Planning Online) and calculations (C-Geo 8) as well as cartographic materials and data obtained from the Municipal Center of Geodetic and Cartographic Documentation in Poznań: the master map, catalog data and topographic descriptions of the reference points. The results show that the accuracy of the location of points offered by Google is greater than declared by the system operators. However, it is not sufficient for applications in the assumed geodetic works.

Keywords: Global Navigation Satellite Systems, Google Earth Pro maps, Topographic Objects Database, topographic descriptions, satellite measurement

INTRODUCTION

The dynamic development of technology that is taking place with regard to measurement tools, calculations and processing of topographic information (Hycner 2004; 2007) as well as the increasing availability of spatial data significantly facilitate and accelerate the works. Satellite photographs are currently a very popular source of data. The possibility of using them in different types of analyses has been presented in their work by, among others, Rango and Itten (1976), Rosenthal and Dozier (1996), Lewiński and Poławski (2003), Riggs and Hall (2004), Skocki (2004), Wolniewicz (2005), Kaczyński and Ewiak (2006), Mularz et al. (2007), Ciołkosz and Białousz (2008), Mularz and Drzewiecki (2008), Białousz et al. (2010), Berezowski and Chormański (2011), Tomaszewska et al. (2011) and Ostrowski and Falkowski (2016).

Access to cutting-edge tools and data may result in a situation when it will be possible to perform some activities required from a surveyor (such as drawing sketch maps, preparing topographic descriptions) without the need to conduct an on-site field inspection. An indispensable prerequisite, however, is obtaining high accuracy data as specified in the legislation pertaining to geodesic (Ministry of the Interior and Administration 2011).

During the research work, an attempt was made to verify the accuracy of the coordinates of points on the maps made available by Google Earth Pro. The presented images are metric: they enable to make measurements and determine geographic coordinates. The accuracy of location of selected topographic objects was compared with the data from the measurements conducted using the GNSS/RTK satellite navigation technique and with the catalogue data obtained from the Municipal Center of Geodetic and Cartographic Documentation (MODGiK) in Poznań.

OBJECTIVE AND AREA OF RESEARCH

The objective of the work performed was to assess the usefulness of the available high-resolution Google Earth Pro maps for selected geodesic and surveying work, including in particular for the purpose of preparing topographic descriptions and sketch maps. The collected data and the conclusions ensuing from the experience gathered are the result of activities performed in the course of preparation of the engineer's degree thesis.

On the basis of the coordinates of points obtained from the field inspection and the catalogue data an attempt was made to determine the accuracy of location of reference points on Google Earth Pro maps. The accuracy assumed was in conformity with the legal acts pertaining to performing geodetic works (Ministry of the Interior and Administration 2011).

Fig. 1. Location of the study area

Location of the study area presents Fig. 1. As a test area chosen Wolności Square in Poznań (Poland). For that area, Google Earth Pro has satellite maps ranging from 2001 to 2018. The square is located in an open area, with no objects that would be too tall to make measurements with the Real Time Kinematic (RTK) method impossible. Characteristic landmarks, easy to identify and find in the area, were chosen as the control points (Fig. 2). The selected stations included corners of green areas in the form of rectangles protected by curbs, pedestrian crossings (corners), the entry to the Wolności Square, the Wolności Fountain and technical equipment.

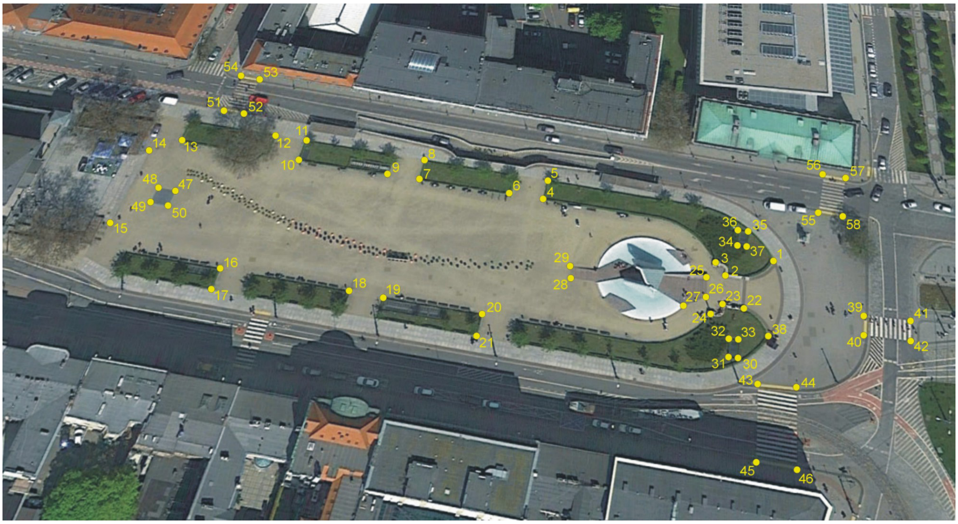

Fig. 2. Location of checkpoints on the 2017 satellite image
(source: own study based on Google Earth Pro)

SOURCE MATERIALS

In the course of research use was made of high-resolution satellite images from the Google Earth Pro system from four time intervals (the years 2017, 2016, 2011 and 2009). The choice was made on the basis of their characteristics: the selected images have been made at slight overcast and in good sunlight conditions. Such characteristics enable unambiguous determination of the location of individual control points.

Images made available by Google Earth Pro are provided by Landsat 8 satellite. They are characterised by high quality and captured with a greater frequency (Perez 2020). Their resolution, depending on the area covered by the image, ranges from 15 m to 15 cm. They are protected by copyright, however Google allows their use for non-commercial purposes, provided that the attributes are maintained.

Other source materials used in the course of the research included cartographic documents, namely the master map of the studied area and catalogue data of the reference points. The aforesaid information was obtained from the Municipal Centre for Geodesy and Cartography in Poznań (Poland).

On the basis of Google Earth Pro imagery analyses geographic coordinates of selected measurement stations were determined, including 58 points in the 2017 imagery, 54 points in the 2016 imagery and 52 points both in the 2011 and 2009 imagery.

RESEARCH METHODS AND RESULTS

The master map of the studied area obtained from the Municipal Center of Geodetic and Cartographic Documentation (MODGiK) in Poznań was uploaded to the C-Geo program, which enables the import of data obtained from measurements made with surveying instruments and their subsequent processing. From among the designed stations, plane coordinates of 41 points forming the Topographic Objects Database on a scale 1 : 500 – BDOT500. Points designating pedestrian crossings are not included in the master map therefore it was not possible to determine their geodesic coordinates (Ministry of Administration and Digitization 2015).

Proper planning of the measuring campaign before commencing the field work using the Global Navigation Satellite Systems was an important element of the process (Lewiński, Poławski 2003). In order to ensure high accuracy of the results a number of criteria have to be met, the most important of which are the appropriate number of satellites that are visible (Ministry of the Interior and Administration 2012). Other factors that may impact the accuracy of observations include cloudiness, precipitation and landscape elements that may increase the elevation angle (e.g. high buildings, trees, landform). Which is why an area as unobstructed as possible was selected as the test field in urban environment.

Trimble GNSS Planning is a helpful tool for proper planning of satellite measurements. On the basis of the data entered by the user, such as the location of the measurement area, the altitude, elevation angle, date and time zone, and the estimated duration of the measurements, the program makes it possible to observe the constellation of satellites. It enables to check the number of satellites available from individual systems: GPS, Glonass, Galileo, BeiDou, QZSS, IRNSS.

During the research work use was made of Leica GS08+ satellite receiver with Leica CS15 controller. The instrument uses three satellite navigation systems, i.e. GPS, Glonass and Galileo. During the planned time of the measurements (between 8:00 and 11:00) approximately 20 satellites were available.

After the measuring campaign had been planned, implementation of the task began: stations first designated on Google Earth Pro maps were found in the field and their measurement was performed using the Global Navigation Satellite Systems/Real Time Kinematic method (GNSS/RTK). During the measurement, data correction stream "NAVGEO_POJ_3_1" was used from the reference station marked RTCM-Ref 0029 with the following coordinates: X = 5 808 213.910 [m]; Y = 6 428 602.919 [m]; H = 98.045 [m]. Measurements were made in the reference system ETRF2000 (PL-2000), using the GRS80 ellipsoid model and the PL-KRON86-NH_biquadratic geoid model. The coordinates were presented in the Gauss-Krüger projection of the Transverse Merkator type. The PL-2000 system has been the only geodetic coordinate system in force in Poland since January 1, 2010, used for the purposes of making maps in scales larger than 1 : 10,000 – in particular the cadastral map and the master map.

The observations were recorded in one second interval. The elevation angle was set at 10^0, and antenna height at 2 metres. Measurement of each point was performed for at least 30 epochs. During that time, between 11 and 18 satellites were available. The average standard deviation of plane coordinates was 12 mm. It proved impossible to make measurements using that method at station number 34.

As part of in-house studies, the collected observations were imported to the calculation program C-Geo 8, which compared the coordinates of the points from the GNSS/RTK measurements with readings from the master map.

Deviations obtained ranged from 6 mm (station number 9) to 47 cm (station number 35) on the X coordinate and from 8 mm (station number 10) to 30 cm (station number 47) on the Y coordinate. The largest differences between the measurement data and data from the master map were observed at stations number 50, 49, 48, 47, 37, 36, 35, 27 and 20. Their coordinates' differences exceed the permitted level of 10 cm (Ministry of Administration and Digitization 2015).

Mean coordinates' values were calculated using the C-Geo program. However, during subsequent work, coordinates from the GNSS/RTK measurement were used since they indicate the current state of the objects in the field and have been obtained in a precise way, in conformity with all the formal requirements.

In order to compare the geographic coordinates (blh) made available by the program with the PL-2000 system geodetic coordinates obtained from the measurements, transformation of the coordinates was performed in accordance with the requirements contained in Technical Guidelines G-1.10 (Kadaj 2001). The necessary calculations were also made using the C-Geo 8 program. The results obtained are presented in the Table 1.

The largest deviation vectors of points location on the 2017 Google Earth Pro map in comparison with the field measurements were observed at 15 stations. These mainly concerned points located at the edges of pedestrian crossings and by the fountain. Their values ranged between 1 and 2 m, whereas the maximum location error amounted to 2.68 m (station number 44). On the 2016

Table 1. Average coordinate values from GNSS/RTK measurement and transformation

Point	2017				2016				2011				2009			
	dX [m]	dY [m]	X* [m]	Y* [m]	dX [m]	dY [m]	X* [m]	Y* [m]	dX [m]	dY [m]	X* [m]	Y* [m]	dX [m]	dY [m]	X* [m]	Y* [m]
1	+0.46	-0.88	847.32	098.09	-0.78	-0.48	847.94	097.89	+1.16	-0.31	846.97	097.81	+0.71	-0.12	847.20	097.71
2	-0.14	-0.76	841.63	086.54	-0.33	-0.30	841.72	086.31	+0.11	-0.03	841.51	086.17	+0.45	-0.16	841.34	086.24
3	-0.36	-0.79	844.34	084.11	-1.10	-0.76	844.71	084.09	-0.32	-0.41	844.32	083.92	+0.23	-0.20	844.04	083.81
4	-0.88	-0.66	859.80	045.08	-0.95	-0.47	859.84	044.98	+0.39	-0.66	859.17	045.08	+0.05	-0.46	859.34	044.98
5	-0.31	-0.66	865.70	045.86	-1.42	-0.48	866.26	045.76	+0.35	-0.18	865.37	045.61	+0.36	-0.52	865.37	045.78
6	-0.74	-0.15	860.60	037.78	-1.30	-0.04	860.88	037.73	-0.40	-0.17	860.44	037.79	+0.14	+0.05	860.16	037.68
7	-0.68	-0.99	863.43	015.48	-0.99	-1.03	863.58	015.50	-0.32	-0.95	863.25	015.46	+0.23	-0.40	862.98	015.18
8	-0.05	-1.04	869.61	016.29	-1.17	-0.34	870.16	015.94	+0.62	-0.86	869.27	016.20	+0.61	-0.45	869.28	016.00
9	-0.83	-0.76	864.39	008.42	-1.32	-0.50	864.64	008.29	+0.11	-0.01	863.92	008.04	+0.11	+0.20	863.92	007.94
10	-0.45	-1.13	867.08	985.78	-1.01	-0.91	867.36	985.66	+0.21	-0.55	866.75	985.49	+0.20	-0.35	866.75	985.38
11	-0.20	-0.99	873.68	986.51	-0.95	-0.89	874.06	986.46	+0.05	-0.40	873.56	986.21	+0.38	-0.40	873.39	986.21
12	-0.30	-0.35	874.67	979.28	-1.10	-0.70	871.09	955.88	+0.32	+0.04	874.36	979.09	–	–	–	–
13	-0.60	-1.19	870.84	956.12	-1.18	-0.18	867.82	949.29	+0.01	-0.96	870.53	956.01	+0.34	-0.21	870.37	955.64
14	-0.61	-0.86	867.53	949.62	-0.78	-0.48	847.94	097.89	-0.29	-0.31	867.37	949.35	+0.26	+0.32	867.10	949.04
15	-0.72	-0.99	846.51	946.41	–	–	–	–	-0.16	+0.13	846.23	945.85	-0.16	-0.21	846.23	946.02
16	-0.43	-0.40	836.04	974.53	–	–	–	–	–	–	–	–	+0.17	-0.02	835.74	974.34
17	-0.57	-0.67	830.41	973.93	-1.19	-0.41	830.72	973.80	+0.03	-0.12	830.11	973.66	+0.03	+0.08	830.12	973.56
18	-0.27	-0.46	832.28	004.31	-0.95	-0.58	832.62	004.37	+0.38	+0.12	831.95	004.02	+0.38	+0.12	831.95	004.02
19	-0.12	-0.89	831.31	011.45	-0.62	-0.44	831.56	011.23	+0.49	-0.50	831.01	011.26	+0.49	-0.70	831.00	011.36
20	-0.57	-0.49	828.59	034.11	-1.01	-0.69	828.80	034.20	-0.01	+0.07	828.31	033.83	+0.32	+0.07	828.14	033.82
21	-0.68	-0.71	822.98	033.54	-1.11	-0.61	823.20	033.48	-0.68	+0.62	822.98	032.87	-0.12	+0.02	822.70	033.17
22	-0.45	-0.63	834.29	091.22	-1.06	-0.90	834.60	091.36	+0.16	-0.81	833.99	091.32	+0.15	-0.40	834.00	091.11
23	+0.03	-0.75	834.62	085.68	-0.57	-1.07	834.92	085.84	+0.30	-0.17	834.49	085.38	+0.31	-0.58	834.48	085.59
24	-0.34	-0.86	832.93	082.77	-0.28	-0.59	832.90	082.64	+0.27	-0.45	832.62	082.56	+0.27	-0.45	832.62	082.56
25	-0.96	-0.77	841.27	083.13	-1.15	-0.32	841.36	082.90	–	–	–	–	–	–	–	–
26	-0.56	-0.61	836.53	082.57	-0.13	-0.72	836.32	082.62	–	–	–	–	–	–	–	–
27	-0.47	-0.75	833.55	077.73	+0.20	-0.14	833.22	077.42	–	–	–	–	–	–	–	–

28	-0.58	-0.97	839.12	052.74	-1.33	-0.83	839.50	052.68	–	–	–	–	–	–	–	–
29	-0.40	-1.04	842.00	052.56	-0.59	-0.40	842.10	052.24	–	–	–	–	–	–	–	–
30	-0.38	-0.79	821.69	088.49	-1.44	-0.81	822.22	088.50	-0.44	-0.04	821.72	088.12	+0.23	-0.37	821.38	088.28
31	-0.16	-1.02	821.83	086.87	-1.22	-0.50	822.36	086.61	-0.23	+0.12	821.86	086.30	+0.12	-0.28	821.69	086.50
32	+0.11	-2.41	825.64	088.12	-0.57	-2.04	825.98	087.94	+0.09	-1.62	825.66	087.73	+0.43	-2.43	825.48	088.14
33	-0.14	+0.91	825.54	088.26	-0.82	+1.13	825.88	088.16	-0.50	+2.01	825.72	087.71	+0.17	+1.48	825.38	087.98
34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	-0.33	-0.72	853.81	092.60	-0.39	-1.21	853.84	092.84	-0.29	-0.12	853.79	092.30	+0.27	-0.32	853.50	092.40
36	-0.42	-0.78	854.10	090.87	-1.29	-0.27	854.54	090.62	-0.08	+0.37	853.93	090.30	+0.15	-0.04	853.82	090.50
37	-0.64	+0.66	849.97	091.34	–	–	–	–	-0.09	+1.83	849.70	090.76	+0.25	+1.42	849.52	090.96
38	-1.59	-1.00	826.86	095.47	-1.22	-0.81	826.68	095.38	-0.66	-0.60	826.40	095.27	+0.00	-0.38	826.07	095.16
39	-0.59	+0.91	834.16	117.32	-0.90	+0.78	834.31	117.38	+0.33	+0.53	833.70	117.51	+0.33	+0.33	833.70	117.60
40	-0.64	+0.83	829.20	116.64	-0.34	+0.84	829.04	116.64	+0.34	+0.10	828.70	117.01	+0.35	-0.31	828.70	117.22
41	-0.58	-0.63	833.40	126.56	-0.39	-0.94	833.30	126.71	+0.38	-0.45	832.92	126.46	+0.38	-0.24	832.92	126.36
42	-0.58	-0.67	828.46	125.90	-0.90	-0.18	828.62	125.66	+0.00	-0.44	828.17	125.79	+0.33	-0.43	828.00	125.78
43	-1.90	-0.88	815.62	092.53	-1.54	-0.12	815.44	092.15	-0.65	-0.11	814.99	092.14	-0.98	-0.32	815.16	092.25
44	-2.68	-1.03	815.11	100.58	-2.31	-0.99	814.92	100.56	-1.10	-0.42	814.31	100.28	-1.76	-0.43	814.65	100.28
45	+0.98	-1.39	799.76	091.45	+0.72	-0.52	799.89	091.02	+1.60	-0.24	799.45	090.88	+1.93	+0.11	799.28	090.70
46	+1.04	-0.92	798.75	099.24	+0.98	-0.65	798.79	099.10	+1.97	-0.16	798.29	098.86	+1.97	+0.04	798.30	098.76
47	-0.40	-0.62	856.38	958.84	-0.96	-0.21	856.66	958.64	+0.26	-0.26	856.04	958.66	+0.48	+0.15	855.94	958.46
48	-0.22	-0.68	856.84	954.46	-0.47	-0.54	856.96	954.39	+0.42	-0.32	856.52	954.28	+0.42	-0.32	856.52	954.28
49	-0.32	-0.77	852.47	953.98	-0.45	-0.32	852.54	953.75	-0.01	-0.38	852.31	953.78	+0.33	-0.04	852.14	953.61
50	-0.81	-0.74	852.16	958.34	-0.93	-0.71	852.22	958.32	+0.06	-0.14	851.73	958.04	+0.40	+0.06	851.56	957.94
51	+0.86	-0.77	882.57	965.01	+1.82	-0.54	882.10	964.89	+1.81	-0.53	882.10	964.89	+2.14	+0.01	881.94	964.62
52	+0.90	-0.23	881.92	969.23	+0.90	-0.19	881.92	969.22	+1.57	-0.25	881.58	969.24	+1.79	-0.04	881.48	969.14
53	-2.09	-0.88	892.52	966.25	-2.28	-0.28	892.61	965.95	-1.17	-0.33	892.06	965.98	-0.84	-0.12	891.89	965.87
54	-2.06	-1.08	891.84	971.06	-2.86	-1.01	892.24	971.02	-1.09	-0.72	891.36	970.88	-0.87	-0.51	891.24	970.78
55	+0.72	-0.57	861.50	109.61	+0.29	-0.58	861.72	109.61	+1.05	+0.18	861.33	109.23	+1.28	+0.19	861.22	109.22
56	-1.70	-0.88	871.08	111.50	-2.44	-0.36	871.46	111.24	-1.11	-0.27	870.79	111.20	-0.77	-0.27	870.62	111.20
57	-2.05	-1.11	870.52	116.48	-1.99	-0.92	870.50	116.39	-0.77	-0.50	869.88	116.17	-0.54	-0.69	869.77	116.28
58	+0.63	-0.51	860.77	114.73	+0.70	-0.85	860.73	114.90	+1.25	-0.10	860.46	114.52	+1.58	-0.09	860.29	114.52

* abbreviated coordinate entry has been used: X (5808 ...) and Y (6427 ...)

map, the largest deviation vectors were observed at 30 stations. They included the points designating the fountain, pedestrian crossings, green areas and the stairs. The maximum location error amounted to 2.86 m (station number 54). On the 2011 map, the largest deviation vectors were recorded at 12 stations designating the edges of pedestrian crossings. The maximum location error amounted to 1.97 m (station number 46). As far as the year 2009 is concerned, the largest deviations were noted for 10 points, also designating the edges of pedestrian crossings. The maximum location error amounted to 2.14 m (station number 51).

SUMMARY AND CONCLUSIONS

The obtained results confirm that Google Earth Pro provides a better accuracy than that declared by system operators (the mean accuracy of points location in towns is determined to amount to 1 m). It is not sufficient, however, for the purposes of surveying work.

Images from 2009 and 2011 were characterised by the greatest accuracy. The average location error amounted to 0.45 m and 0.47 m, respectively. The 2016 and 2017 images are not that accurate. The average location error amounted to 0.83 m and 0.75 m, respectively. For some measurement points, the average error was overstated in each time interval. These were the stations designating pedestrian crossings, namely objects not included in the catalogue of the BDOT500 database.

It must be noted that the images made available by Google Earth Pro have not been designed to be used in surveying work. Nevertheless, despite their insufficient accuracy, they may be considered as a valuable material supporting the surveyor's work. With no doubt, at the moment (putting aside the legal aspects of using that data source for commercial purposes) they cannot fully replace the activities performed in the field, such as making sketch maps and preparing topographic descriptions (documents forming part of appraisal reports required pursuant to the law in force).

Acknowledgment: The article has been written owing to the financial support received from the Dean of the Faculty of Geographical and Geological Sciences of Adam Mickiewicz University in Poznań (Poland). We wish to thank the Municipal Centre for Geodesic and Cartographic Documentation in Poznań for providing us with the master map and reference points data catalogues and the company TERGEO Usługi Geodezyjne i Kartograficzne [TERGEO Geodesic and Cartographic Services] based in Poznań for providing us with the use of the measuring equipment.

REFERENCES

Berezowski T., Chormański J., 2011: *Analiza możliwości wykorzystania zdjęć satelitarnych w celu pozyskania informacji o przestrzennym rozmieszczeniu pokrywy śnieżnej jako parametru w modelu opad–odpływ*. Przegląd Naukowy − Inżynieria i Kształtowanie Środowiska, 51, 15–26.

Białousz S., Chmiel J., Fijałkowska A., Różycki S., 2010: *Wykorzystanie zdjęć satelitarnych i technologii GIS w aktualizacji jednostek glebowo-krajobrazowych − przykłady dla opracowań małoskalowych*. Archiwum Fotogrametrii, Kartografii i Teledetekcji, 21, 21–32.

Ciołkosz A., Białousz S., 2008: *Zastosowanie teledetekcji satelitarnej w badaniach środowiska w Polsce*. Nauka, 3, 79–96.

Hycner R., 2004: *Podstawy katastru*. Wydawnictwa Naukowo-Dydaktyczne Akademii Górniczo-Hutniczej, Kraków.

Hycner R., 2007: *Geodezja wczoraj dziś i jutro: w nauce, technice i w innych dziedzinach*. Acta Scientifica Academiae Ostroviensis, 27, 43–54.

Kaczyński R., Ewiak I., 2006: *Wysokorozdzielcze zobrazowania satelitarne a zdjęcia lotnicze*. Geodezja, 12 (2/1), 257–265.

Kadaj R., 2001: *Wytyczne Techniczne G-1.10. Formuły odwzorowawcze i parametry układów współrzędnych*. Główny Urząd Geodezji i Kartografii, Warszawa.

Lewiński S., Poławski Z., 2003: *Możliwość zasilania systemów informacji przestrzennej danymi satelitarnymi*. Człowiek i Środowisko, 27, 15–22.

Ministry of Administration and Digitization, 2015: Rozporządzenie Ministra Administracji i Cyfryzacji z dnia 2 listopada 2015 r. w sprawie bazy danych obiektów topograficznych oraz mapy zasadniczej (Dz.U. 2015 poz. 2028). [pdf] Ministry of Administration and Digitization. Warszawa. Available at: <http://isap.sejm.gov.pl> [Accessed 14 February 2020].

Ministry of the Interior and Administration, 2011: Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 9 listopada 2011 r. w sprawie standardów technicznych wykonywania geodezyjnych pomiarów sytuacyjnych i wysokościowych oraz opracowywania i przekazywania wyników tych pomiarów do państwowego zasobu geodezyjnego i kartograficznego (Dz.U. 2011 nr 263 poz. 1572). [pdf] Ministry of the Interior and Administration. Warszawa. Available at: <http://isap.sejm.gov.pl> [Accessed 14 February 2020].

Ministry of the Interior and Administration, 2012: Rozporządzenie Rady Ministrów z dnia 15 października 2012 r. w sprawie państwowego systemu odniesień przestrzennych (Dz.U. 2012 poz. 1247). [pdf] Ministry of the Interior and Administration. Warszawa. Available at: <http://isap.sejm.gov.pl> [Accessed 14 February 2020].

Mularz S., Drzewiecki W., Pirowski T., 2007: *Teledetekcyjne metody rejestracji krajobrazu*. Roczniki Geomatyki, 5 (8), 67–80.

Mularz S., Drzewiecki W., 2008: *Interpretacja głównych elementów krajobrazu na teledetekcyjnych obrazach lotniczych i satelitarnych*. Czasopismo Techniczne A, Wydawnictwo Politechniki Krakowskiej, 1, 101–107.

Ostrowski P., Falkowski T., 2016: *Zastosowanie wysokorozdzielczych, wielospektralnych zdjęć satelitarnych (VHR) do identyfikacji wybranych form rzeźby równi zalewowej*. Przegląd Geologiczny, 64 (12), 1040–1047.

Perez S., 2020: *Google Earth and Maps get sharper satellite imagery with new update*. [pdf] Available at: <https://techcrunch.com/2016/06/27/google-earth-and-maps-get-sharper-satellite-imagery-with-new-update> [Accessed 14 February 2020].

Rango A., Itten K.I., 1976: *Satellite Potentials in Snowcover Monitoring and Runoff Prediction*. Nordic Hydrology, 7, 209–230.

Riggs G., Hall D.K., 2004: *Snow Mapping with the MODIS Aqua Instrument*, [In:] *61st Eastern Snow Conference*. Portland, Maine, USA, 81–84.

Rosenthal W., Dozier J., 1996: *Automated Mapping of Montane Snow Cover at Subpixel Resolution from the Landsat Thematic Mapper*. Water Resources Research, 32, 115–130.

Skocki K., 2004: *Analiza pojemności informacyjnej i przydatności obrazów satelitarnych programu CORONA do badań stanu środowiska przyrodniczego Polski i jego zmian*. Teledetekcja Środowiska, 33, 87–112.

Tomaszewska M., Lewiński S., Woźniak E., 2011: *Wykorzystanie zdjęć satelitarnych MODIS do badania stopnia pokrycia terenu roślinnością*. Teledetekcja Środowiska, 46, 13–22.

Wolniewicz W., 2005: *Ocena potencjału geometrycznego zdjęć IKONOS i QuickBird*. Polskie Towarzystwo Informacji Przestrzennej. Roczniki Geomatyki, 3, 4, 219–232.