ARE THE GEOGRAPHICAL COORDINATES IMPORTANT?

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Abstract. *This paper presents how to visualize and how to transform geographic coordinates used in everyday life for various purposes that require precision and accurate localization. Geographic coordinates are based on latitude and longitude. Latitude and longitude make it possible to precisely locate any point on the Earth's surface. The equator is the imaginary circle on the Earth's surface, formed by its intersection with a plane passing through its center and perpendicular to its axis of rotation (the axis connecting the North Pole to the South Pole). The meridian is the circular arc (semicircle) on the surface of the Earth that connects the North Pole with the South Pole, the semicircle determined by the intersection of the Earth with a plane containing its axis of rotation. Meridian 0 or Meridian Origin is the semicircle joining the North Pole with the South Pole passing through the Royal Observatory location in Greenwich, London, UK. The position of Meridian 0 was adopted in 1884 at the International Meridian Conference, held in the United States. Correct transmission and precise interpretation of the position of a location based on geographic coordinates is very important, even vital in certain situations. The geographic position of a point, based on geographic coordinates, can be rendered in 3 distinct ways, depending on Latitude and Longitude:*

1. *Decimal Degree – DD (ro.: Grade Zecimale - GZ): 44,42750; 26,10278*
2. *DEGREE DECIMAL MINUTE – DDM (ro.:Grade Zecimale Minute - GZM): 440 25.650 N; 260 06.167 E*
3. *Degree Minute Second – DMS (ro.: Grade Minute Secunde - GMS): 44025'39''N, 260 06'10''E*

Thus, the transformation of geographical coordinates is of particular importance in practice, because these very commonly used coordinates can be written in various forms, and GNSS tools and specialized software records and displays these coordinates according to the user's settings (DD or DDM or DMS). That is why it is very important to know these types of geographic coordinates and to transform them among them.

Key words: *DD, DDM, DMS, geographic coordinates, transformation*

INTRODUCTION

The latitude of a point on the Earth's surface is given by the magnitude of the angle formed by the right that passes through that point and the center of the Earth, and the projection of that straight line on the plane of the Equator (Herbei and Ular, 2011). Points with the same latitude form a parallel (eg parallel 45º). Points on the Equator have the latitude of 0º. From the point of view of latitude, the Earth is divided into two hemispheres:

- the northern hemisphere - the section of the Earth between the equator plane and the North Pole;

- the southern hemisphere - the Earth section between the equator plane and the South Pole;

The points on the Earth's surface in the northern hemisphere have a latitude between 0º (Equator) and 90º (North Pole). The points on the Earth's surface in the southern hemisphere have a latitude between 0º (Equator) and -90º (South Pole) (HERBEI, 2015), (BEGOV UNGUR ET AL., 2016).

Very often, latitude is expressed using the N (northern hemisphere) and S (southern hemisphere) notations, thus avoiding the use of (+) and (-) signs. The longitude of a point on the surface of the Earth is given by the angle formed in the plane of the half-equator joining the center of the Earth with the intersection of the equator with the meridian 0 and the half-point joining the center of the Earth with the intersection of the equator with the meridian passing through that point. Points on meridian 0 have a longitude of 0.

From a longitudinal point of view, the Earth is again divided into two hemispheres:
- the eastern hemisphere - the section of Earth east of meridian 0, a section between meridian 0 and meridian 180º (antipodal meridian);
- the western hemisphere - the section of the Earth to the west of meridian 0, a section between meridian 0 and -180 ° meridian (antipodal meridian);

By convention, the antipodal meridian is both 180 ° meridian and -180 ° meridian.
The points on the surface of the Earth located in the eastern hemisphere have the longitude between 0º (meridian 0) and 180º. The points on the Earth's surface in the western hemisphere have the longitude between 0º (meridian 0) and -180º.
Very often, the longitude is expressed using E (eastern hemisphere) and V (western hemisphere) notations, thus avoiding the use of (+) and (-) signs.

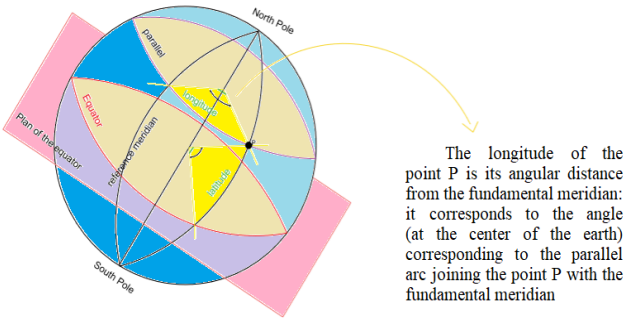


Figure 1 Latitude and longitude

MATERIAL AND METHOD

Calculating the transformation of GPS coordinates (HERBEI, 2009), (SMULEAC ET AL., 2017) expressed as decimals (decimal coordinates) into geographical coordinates expressed in degrees, minutes and seconds is very simple, taking into account that a grade has 60 minutes and that one minute has 60 seconds.

The most important transformations and how to achieve them are as follows:
1. **Transformation 1**: DMS – DD. To calculate the DD coordinates, the DMS grades together with the DMS / 60 minutes and the DMS / 3600 seconds
2. **Transformation 2**: DMS – DDM. DDM grades remain the same as DMS, and in minutes the DMS / 60 seconds are added
3. **Transformation 3**: DDM – DMS. DMS grades remain the same as DDMs, and minutes are the pre-semicolon, and seconds are calculated by multiplying the semicolon value (eg 0.650) by 60
4. **Transformation 4:** DD – DMS. DMS grades are the pre-decimal value, the minutes are calculated by multiplying the values before comma by 60 (eg 0.4275 x 60 = 25.65), and

seconds are calculated by multiplying the value after the comma obtained in seconds by 60 (eg 0.65 x 60 = 39).

The following figure illustrates these 4 transformations.

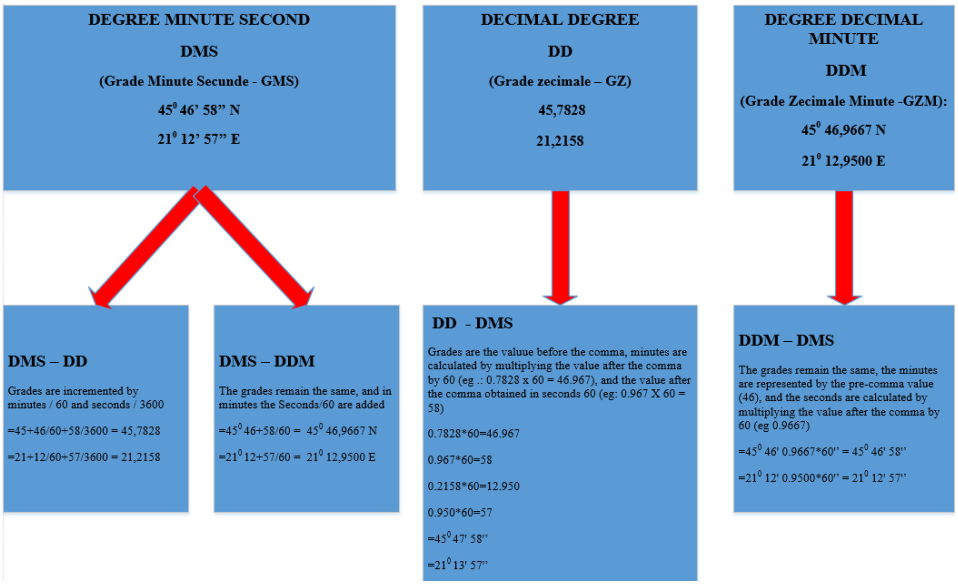


Figure 2 Transformation scheme

RESULTS AND DISCUSSIONS

Two or three coordinates of a spherical coordinate system from any location on Earth that is aligned with the axis around which the Earth revolves is called the Geographic Coordinate System.

The transformation of geographical coordinates is of particular importance in practice because these very commonly used coordinates can be written in various forms, and GNSS tools and specialized software records and displays these coordinates according to user settings (DD or DDM or DMS).

That is why it is very important to know these types of geographic coordinates and to be able to perform transformations between them.

Thus, we chose to exemplify ten points located on the entire surface of the Earth, their coordinates being:

1. **Timisoara** (USAMVB)
   - lat: 45°46'58"N
   - long: 21°12'57"E
2. **North America** (Chicago)
   - lat: 41°52'41"N
   - long: 87°37'47"W
3. **North America** (Mexico)
   - lat: 21°27'34"N
   - long: 101°28'32"W
4. **Africa** (Cairo)
   - lat: 30° 2'37"N
   - long: 31°14'10"E
5. **Asia** (Tokyo)
   - lat: 35°40'49"N
   - long: 139°41'23"E
6. **South America** (Bogota)
   - lat: 4°42'40"N
   - long: -74° 4'20"W
7. **Australia** (Sydney)
   - lat: - 33°52'8"S

- long: 151°1'33"E

8. **Europe** (Switzerland)
- lat: 46°51'1"N
- long: 8°1126"E

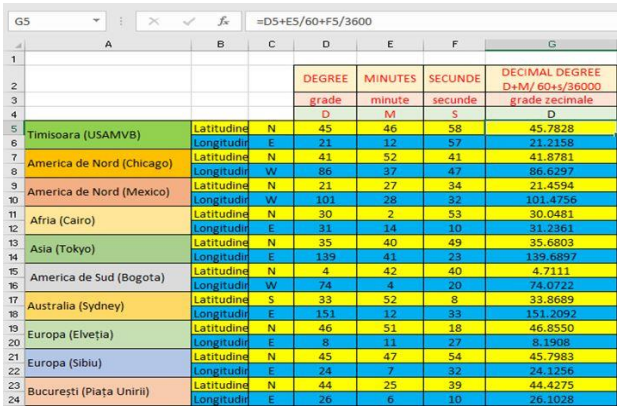
9. **Romania** (Sibiu)
- lat: 45°47'54"N
- long: 24° 7'32"E

10. **Bucharest** (Piața Unirii)
- lat: 44°25'39"
- long: 26° 6' 10"

In order to make these transformations, we have created an automatic calculation template using Microsoft Excel.

1. TRANSFORMING THE GEOGRAPHICAL COORDINATE FROM DMS INTO DD

In the following figure, the transformation of geographic coordinates from degrees, minutes and seconds to decimal degrees is presented.



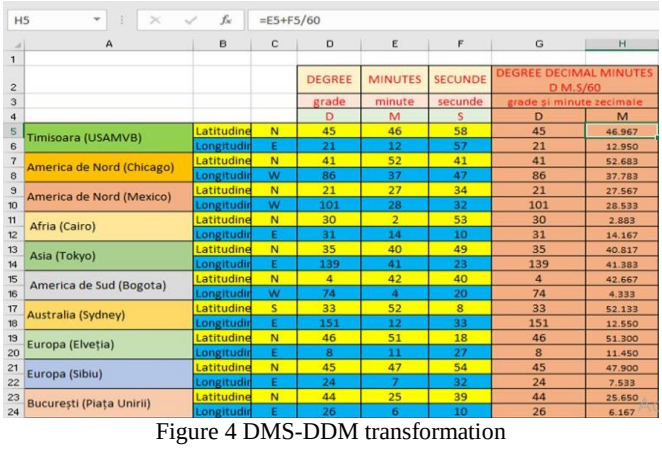
G5 =D5+E5/60+F5/3600

				DEGREE	MINUTES	SECUNDE	DECIMAL DEGREE D+M/ 60+s/36000
				grade	minute	secunde	grade zecimale
				D	M	S	D
Timisoara (USAMVB)	Latitudine	N		45	46	58	45.7828
	Longitudir	E		21	12	57	21.2158
America de Nord (Chicago)	Latitudine	N		41	52	41	41.8781
	Longitudir	W		86	37	47	86.6297
America de Nord (Mexico)	Latitudine	N		21	27	34	21.4594
	Longitudir	W		101	28	32	101.4756
Afria (Cairo)	Latitudine	N		30	2	53	30.0481
	Longitudir	E		31	14	10	31.2361
Asia (Tokyo)	Latitudine	N		35	40	49	35.6803
	Longitudir	E		139	41	23	139.6897
America de Sud (Bogota)	Latitudine	N		4	42	40	4.7111
	Longitudir	W		74	4	20	74.0722
Australia (Sydney)	Latitudine	S		33	52	8	33.8689
	Longitudir	E		151	12	33	151.2092
Europa (Elveția)	Latitudine	N		46	51	18	46.8550
	Longitudir	E		8	11	27	8.1908
Europa (Sibiu)	Latitudine	N		45	47	54	45.7983
	Longitudir	E		24	7	32	24.1256
București (Piața Unirii)	Latitudine	N		44	25	39	44.4275
	Longitudir	E		26	6	10	26.1028

Figure 3 DMS-DD transformation

2. TRANSFORMING THE GEOGRAPHICAL COORDINATE FROM DMS INTO DDM

In the following figure, the transformation of geographic coordinates from degrees, minutes and seconds into decimal degrees minutes is presented.



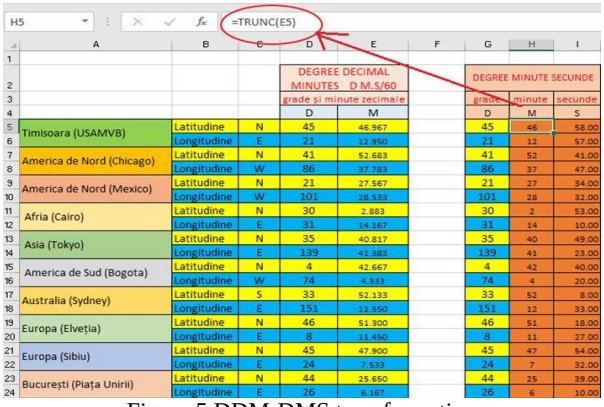
H5 =E5+F5/60

			DEGREE	MINUTES	SECUNDE	DEGREE DECIMAL MINUTES D M,S/60	
			grade	minute	secunde	grade și minute zecimale	
			D	M	S	D	M
Timisoara (USAMVB)	Latitudine	N	45	46	58	45	46.967
	Longitudir	E	21	12	57	21	12.950
America de Nord (Chicago)	Latitudine	N	41	52	41	41	52.683
	Longitudir	W	86	37	47	86	37.783
America de Nord (Mexico)	Latitudine	N	21	27	34	21	27.567
	Longitudir	W	101	28	32	101	28.533
Afria (Cairo)	Latitudine	N	30	2	53	30	2.883
	Longitudir	E	31	14	10	31	14.167
Asia (Tokyo)	Latitudine	N	35	40	49	35	40.817
	Longitudir	E	139	41	23	139	41.383
America de Sud (Bogota)	Latitudine	N	4	42	40	4	42.667
	Longitudir	W	74	4	20	74	4.333
Australia (Sydney)	Latitudine	S	33	52	8	33	52.133
	Longitudir	E	151	12	33	151	12.550
Europa (Elveția)	Latitudine	N	46	51	18	46	51.300
	Longitudir	E	8	11	27	8	11.450
Europa (Sibiu)	Latitudine	N	45	47	54	45	47.900
	Longitudir	E	24	7	32	24	7.533
București (Piața Unirii)	Latitudine	N	44	25	39	44	25.650
	Longitudir	E	26	6	10	26	6.167

Figure 4 DMS-DDM transformation

3. TRANSFORMING THE GEOGRAPHICAL COORDINATE FROM DDM INTO DMS

In the following figure, the transformation of the geographical coordinates into decimal degrees minutes in degrees, minutes, seconds is presented.



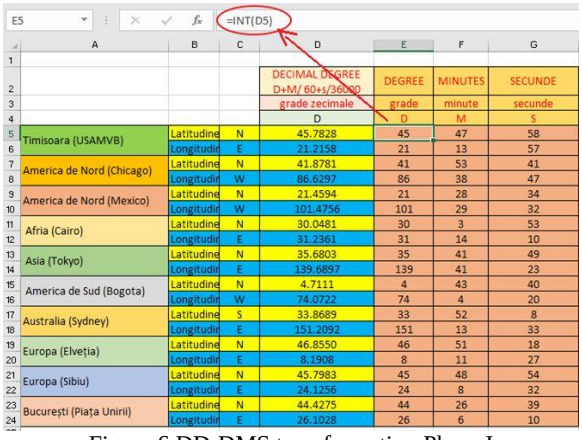
Timisoara (USAMVB)	Latitudine	N	45	46.967	45	46	58.00
	Longitudine	E	21	12.950	21	12	57.00
America de Nord (Chicago)	Latitudine	N	41	52.683	41	52	41.00
	Longitudine	W	86	37.783	86	37	47.00
America de Nord (Mexico)	Latitudine	N	21	27.567	21	27	34.00
	Longitudine	W	101	28.533	101	28	32.00
Afria (Cairo)	Latitudine	N	30	2.883	30	2	53.00
	Longitudine	E	31	14.167	31	14	10.00
Asia (Tokyo)	Latitudine	N	35	40.817	35	40	49.00
	Longitudine	E	139	41.383	139	41	23.00
America de Sud (Bogota)	Latitudine	N	4	42.667	4	42	40.00
	Longitudine	W	74	4.333	74	4	20.00
Australia (Sydney)	Latitudine	S	33	52.133	33	52	8.00
	Longitudine	E	151	12.550	151	12	33.00
Europa (Elveția)	Latitudine	N	46	51.300	46	51	18.00
	Longitudine	E	8	11.450	8	11	27.00
Europa (Sibiu)	Latitudine	N	45	47.900	45	47	54.00
	Longitudine	E	24	7.533	24	7	32.00
București (Piața Unirii)	Latitudine	N	44	25.650	44	25	39.00
	Longitudine	E	26	6.167	26	6	10.00

Figure 5 DDM-DMS transformation

4. TRANSFORMING THE GEOGRAPHICAL COORDINATE FROM DD INTO DMS

This transformation is carried out in three stages, with a formula for each stage as we specified in the introduction of the paper.

In the first step, we used the formula =INT(D5) in Excel to calculate the degrees, the value before the comma.



Timisoara (USAMVB)	Latitudine	N	45.7828	45	47	58
	Longitudin	E	21.2158	21	13	57
America de Nord (Chicago)	Latitudine	N	41.8781	41	53	41
	Longitudin	W	86.6297	86	38	47
America de Nord (Mexico)	Latitudine	N	21.4594	21	28	34
	Longitudin	W	101.4756	101	29	32
Afria (Cairo)	Latitudine	N	30.0481	30	3	53
	Longitudin	E	31.2361	31	14	10
Asia (Tokyo)	Latitudine	N	35.6803	35	41	49
	Longitudin	E	139.6897	139	41	23
America de Sud (Bogota)	Latitudine	N	4.7111	4	43	40
	Longitudin	W	74.0722	74	4	20
Australia (Sydney)	Latitudine	S	33.8689	33	52	8
	Longitudin	E	151.2092	151	13	33
Europa (Elveția)	Latitudine	N	46.8550	46	51	18
	Longitudin	E	8.1908	8	11	27
Europa (Sibiu)	Latitudine	N	45.7983	45	48	54
	Longitudin	E	24.1256	24	8	32
București (Piața Unirii)	Latitudine	N	44.4275	44	26	39
	Longitudin	E	26.1028	26	6	10

Figure 6 DD-DMS transformation Phase I

In the second step, the minutes are calculated, multiplying the value after the comma by 60, using Excel formula =MOD(D5,1)*60.

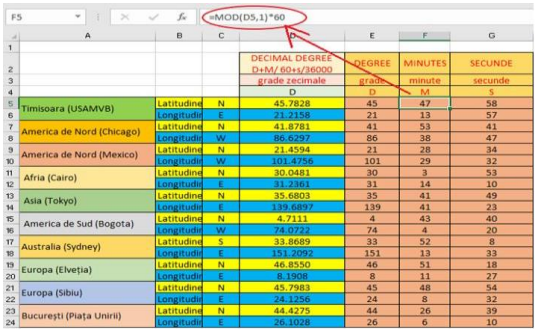


Figure 7 DD-DMS transformation Phase II

In the final stage, the third phase determines the seconds, multiplying the value after the comma obtained in stage II, using in Excel the formula: =MOD(F5,1)*60.

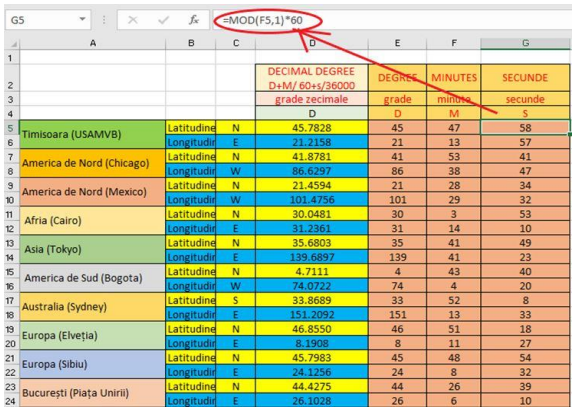


Figure 8 DD-DMS transformation Phase III

The data resulting from these transformations has been verified using the Google Earth application using the coordinate display mode in the application (TOOLS → OPTIONS → 3D VIEW).

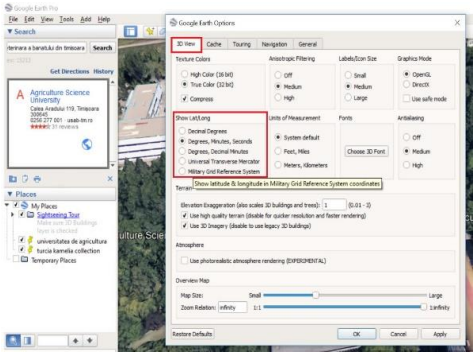
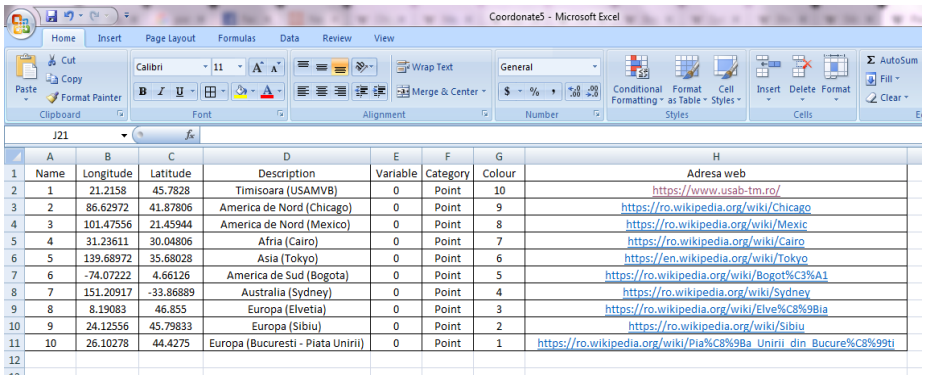


Figure 9 How to view geographic coordinates

Figure 10 Final result

Based on the transformed points and the DD coordinates we created an Excel table with the following fields: Name, Longitude, Latitude, Description, Variable, Category, Color, Web. This database has been saved in CSV format so it can be imported into Google Earth.



Coordonate5 - Microsoft Excel

	A	B	C	D	E	F	G	H
1	Name	Longitude	Latitude	Description	Variable	Category	Colour	Adresa web
2	1	21.2158	45.7828	Timisoara (USAMVB)	0	Point	10	https://www.usab-tm.ro/
3	2	86.62972	41.87806	America de Nord (Chicago)	0	Point	9	https://ro.wikipedia.org/wiki/Chicago
4	3	101.47556	21.45944	America de Nord (Mexico)	0	Point	8	https://ro.wikipedia.org/wiki/Mexic
5	4	31.23611	30.04806	Afria (Cairo)	0	Point	7	https://ro.wikipedia.org/wiki/Cairo
6	5	139.68972	35.68028	Asia (Tokyo)	0	Point	6	https://en.wikipedia.org/wiki/Tokyo
7	6	-74.07222	4.66126	America de Sud (Bogota)	0	Point	5	https://ro.wikipedia.org/wiki/Bogot%C3%A1
8	7	151.20917	-33.86889	Australia (Sydney)	0	Point	4	https://ro.wikipedia.org/wiki/Sydney
9	8	8.19083	46.855	Europa (Elvetia)	0	Point	3	https://ro.wikipedia.org/wiki/Elve%C8%9Bia
10	9	24.12556	45.79833	Europa (Sibiu)	0	Point	2	https://ro.wikipedia.org/wiki/Sibiu
11	10	26.10278	44.4275	Europa (Bucuresti - Piata Unirii)	0	Point	1	https://ro.wikipedia.org/wiki/Pia%C8%9Ba_Unirii_din_Bucure%C8%99ti
12								

Figure 11 Database structure –CSV file

In order for them to be reported in Google Earth, we chose the Decimal Degrees format for the coordinates.

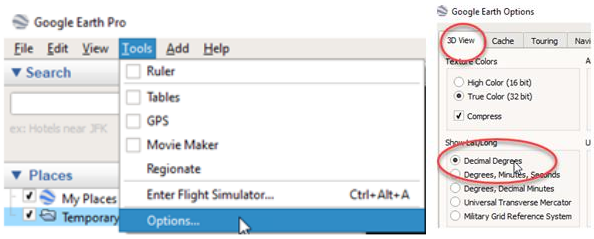


Fig 12 Setting the coordinates DD in Google Earth

From the File - Import menu, the CSV file was imported by setting the data format, the latitude and longitude fields used, the symbol format, their color, the field chosen for naming the points, etc. The points in the database are thus imported into Google Earth, each

having the attributes defined in the Database. These points can be exported in a GIS format, namely KMZ files.

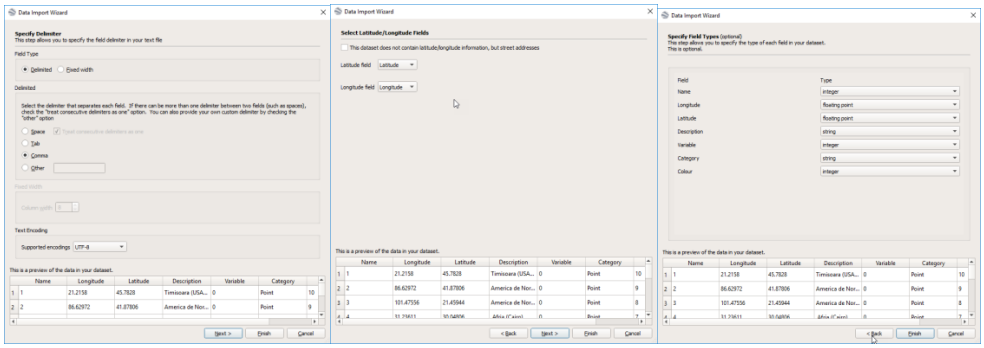


Fig. 13 Setting import parameters

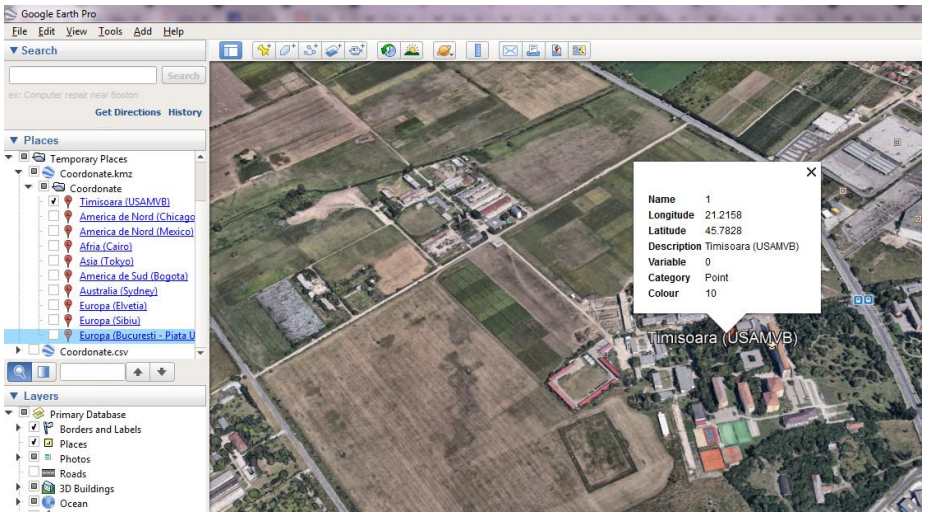


Fig 14 Viewing points in Google Earth

CONCLUSIONS

The transformation of geographic coordinates is of particular importance in practice because these very commonly used coordinates can be written in various forms, and GNSS tools and specialized software record and display these coordinates according to user settings (DD or DDM or DMS). Transforming geographic coordinates is a simple but necessary method for determining the coordinates of a point, which can be written in a number of ways, so that you can find the exact location of the point and avoid misinterpretation of its coordinates.

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https://support.google.com/maps/answer/18539?co=GENIE.Platform%3DDesktop&hl=ro&fbclid=IwAR01roply3TUptTReN_EAZzPDgd5saoRQvFo1K_ED3rnEujWvTNByv2g7KM

https://mapszoom.com/ro/coordinates.php?town=Navigator&fbclid=IwAR1zd8FwfbFShJzRtRnfUA0S6iCfFCXm5dUpgqXnZk0S_tRevrA1LaZ-AIQ