Positioning with Astronomic and Geodetic Method

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SUMMARY

Geodesy is a science whose goal is to determine the whole or part of earth's shape. To determine its shape in other words to be showed in a coordinate system, we must obtain information with observations at proper points which are on physical surface. Among the information, there is also information obtained from astronomical observations which are done to celestial bodies. Geographical positions of earth's points can be obtained both astronomic and geodetic. Astronomic latitudes and longitudes (Φ, Λ) are achieved by astronomic observations. Geodetic latitudes and longitudes (φ, λ) are geographical coordinates relating to be chosen ellipsoid and today they can be achieved by GPS technology easily. Satellite based positioning technique GPS is widely used in engineering measurements and practical geodetic applications.

In this study, astronomic observations and GPS observations have been done in 7 points of a network with 17 points which has been established in the campus area of Karadeniz Technical University. So, both astronomic and geodetic latitudes – longitudes have been determined in these 7 points. In addition, astronomic and geodetic latitude – longitude values which belong the same points have been compared by each other.

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1. INTRODUCTION

Geodesy is a science to be interested in determining earth's shape and size. So, the most important activities fields of geodesy are activities which directed to identify nature and arrangement nature. The first is scientific purposeful and directed to determine earth's shape and size. The second is practical purposeful and directed to product every various map. To determine earth's positioning, information with observations has been obtained at proper points which are on physical surface. As being positioning methods, Terrestrial methods, Photogrammetric methods, Satellite Geodesy methods and Geodetic Astronomy have been used.

In this study, to position of chosen points, satellite geodesy and geodetic astronomy have been benefited. In satellite geodesy, geodetic latitude – longitude (φ, λ) values belonging to be chosen ellipsoid are obtained by satellites. Geodetic coordinates of points have been determined by using GPS technology. In geodetic astronomy, the result of astronomic observations and calculations, astronomic latitude – longitude (Φ, Λ) values belonging to observation points are obtained. Here, to determine astronomic coordinates has been benefited from astronomic sun observations.

2. LATITUDE and LONGITUDE DETERMINATION

Angular value of arc part between equator and parallel which passes any point on earth is latitude.

Such as Sterneck method, Harrebow-Talcot method, Sirkum- Meridian zenith distance method, Polaris method, Pewzow method, Struwe method, Latitude determination method with distance of Polaris and a south star, Latitude determination method with same zenith distances of two stars, Latitude determination as to Wayfinder and Latitude determination method with observing zenith angle and observation time in any moment, are latitude determination methods.

Angular value between meridian which passes any point on earth and meridian of Greenwich observatory is longitude. Longitude is the same mean as time determination.
Such as Meridian method, Döllen method, Zinger method, Longitude determination method with zenith distances in first vertical, Longitude determination method with symmetric observations, Longitude determination method with horizontal angles, Mayer method, Kwee Van Woerden method and Longitude determination method with observing zenith angle and observation time in any moment, are longitude determination methods.

In this study, we benefited from Latitude and Longitude determination method with observing zenith angle and observation time in any moment to determine latitude and longitude values of points.

2.1 Latitude and Longitude Determination with Observing Zenith Angle and Observation Time in Any Moment

To determine latitude; firstly hour angle (t) is determined;

$$t = UT + \Lambda + R - \alpha \tag{1}$$

Here, t: Hour angle
UT: Universal Time
Λ : Longitude
R : Sidereal Time
α : Rektaszension

Observation time which measured according to Turkey Summer Time (TST) is converted to Universal Time (UT). For this, difference time (ΔU) between wristwatch and radio watch are determined and time measure is converted to radio watch.

Radio watch. : $10^h00^m00^s$ Wristwatch: $10^h00^m44^s$

ΔU:-44^s , UT = (TST) -3h

Sidereal Time (R) and Rektaszension (α) values are calculated with linear interpolation from almanac according to time converted to UT. Obtained values are replaced in (1) equation then hour angle (t) is calculated. Declination value (δ) is calculated with linear interpolation from almanac according to time converted to UT and the azimuth of sun is calculated from sinus theorem in spherical triangle.

$$\sin a = \frac{\sin(90-\delta)\sin t}{\sin z} \tag{2}$$

a: Azimuth
z: Measured zenith angle
In spherical triangle, (90-δ) with (z) edge values and (t) with (a) angle values are replaced in "Neper" formula and then (90-Φ) edge is found.

$$\tan\left(\frac{90-\Phi}{2}\right) = \frac{\tan\frac{(90-\delta)+z}{2}\cos\frac{(a+t)}{2}}{\cos\frac{(a-t)}{2}} \tag{3}$$

With (3) equation, Φ latitude value is obtained.
To determine longitude; by the aid of being done observations and values taken from almanac

$$t = \arccos\left(\frac{\cos z}{\cos\Phi\cos\delta} - \tan\Phi\tan\delta\right) \tag{4}$$

hour angle (t) is calculated with known Φ latitude from (4) equation. Calculated hour angle and other interpolated values

$$\Lambda = t + \alpha - (UT + R) \tag{5}$$

are replaced in (5) equation. So longitude is determined.

4. CASE STUDY

The network with 17 points has been established in the campus area of Karadeniz Technical University. In 7 points of this network, both GPS and astronomic sun observations have been done. Thus, geodetic and astronomic geographic coordinates have been obtained.

4.1 GPS Observations

GPS observations have been done by using 3 GPS receiver whose marks are ASHTECH Z–SURVEYOR and ASHTECK Z-XTREME. In each point of network, surveying has been done according to Static GPS Surveying Method during half an hour with 10 second data record interval. These measurements have been evaluated in GeoGenius software. Results of evaluation adjusted coordinates belonging to WGS-84 ellipsoid have been obtained.

4.2 Sun Observations

In observations, Wild T2 theodolite has been used. Sun observations have been done to be put Roelof prism to ocular of theodolite. Middle of cross hair has been coincided with section point of four sun visions and thus application has been done to centre of the sun.

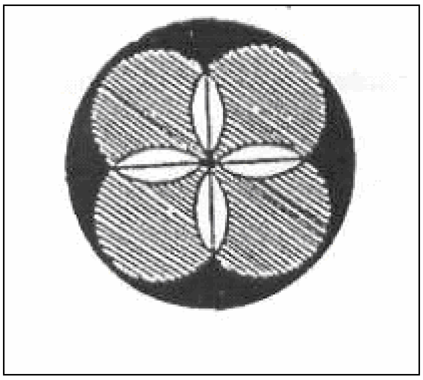

Figure 1. Roelef prism

When middle of cross hair has been coincided with section point of four sun visions, observation time has been recorded preciously. At the same time, horizontal and vertical direction readings have been done. Observations have been done in the two case of instrument too.

5. INVESTIGATION

At last astronomic observations, obtained latitude and longitude values have been showed in Table 1. At last GPS observations, obtained latitude and longitude values have been showed in Table 2.

Table 1. Longitude and latitude values obtained from astronomic observations.

Point number	Astronomic Longitude	Astronomic Latitude
GP14	$39^0 46^{'} 13.86^{''}$	$40^0 59^{'} 26.80^{''}$
GP13	$39^0 46^{'} 58.47^{''}$	$40^0 59^{'} 45.88^{''}$
GP10	$39^0 46^{'} 41.05^{''}$	$40^0 59^{'} 39.28^{''}$
GP04	$39^0 46^{'} 58.92^{''}$	$40^0 58^{'} 58.60^{''}$
GP06	$39^0 45^{'} 24.20^{''}$	$40^0 59^{'} 22.28^{''}$
GP09	$39^0 46^{'} 44.62^{''}$	$40^0 59^{'} 53.28^{''}$
GP15	$39^0 47^{'} 11.37^{''}$	$40^0 59^{'} 53.96^{''}$

Table 2. Longitude and latitude values obtained from geodetic observations.

Point number	Astronomic Longitude	Astronomic Latitude
GP14	$39^0 46^{'} 33.41^{''}$	$40^0 59^{'} 31.27^{''}$
GP13	$39^0 46^{'} 29.99^{''}$	$40^0 59^{'} 40.08^{''}$
GP10	$39^0 46^{'} 22.27^{''}$	$40^0 59^{'} 51.61^{''}$
GP04	$39^0 46^{'} 08.61^{''}$	$40^0 59^{'} 51.52^{''}$
GP06	$39^0 45^{'} 55.08^{''}$	$40^0 59^{'} 42.11^{''}$
GP09	$39^0 46^{'} 15.32^{''}$	$40^0 59^{'} 40.66^{''}$
GP15	$39^0 46^{'} 40.92^{''}$	$40^0 59^{'} 39.40^{''}$

In Table 3 and Tale 4, obtained coordinates in the result of observations have been compared with each other and differences have been seen as degree and second of degree.

Tablo 3. Longitude and latitude differences between astronomic and geodetic observations (degree)

Point number	Longitude Difference (degree^0)	Latitude Difference (degree^0)
GP14	-0,005430^0	-0,001242^0
GP13	0,007909^0	0,001611^0
GP10	0,005216^0	-0,003426^0
GP04	0,013976^0	-0,014699^0
GP06	-0,008577^0	-0,005508^0
GP09	0,008140^0	0,003506^0
GP15	0,008459^0	0,004045^0

Tablo 4. . Longitude and latitude differences between astronomic and geodetic observations (second of degree)

Point number	Longitude Difference (second")	Latitude Difference (second")
GP14	-19,55"	-4,47"
GP13	28,47"	5,80"
GP10	18,78"	-12,33"
GP04	50,31"	-52,92"
GP06	-30,88"	-19,83"
GP09	29,30"	12,62"
GP15	30,45"	14,56"

6. CONCLUSION

In this study, astronomic sun observations and GPS observations have been done in 7 points of the network with 17 points and in these points astronomic-geodetic coordinates have been obtained. Differences between latitude and longitude values which have been obtained with geodetic and astronomic methods change from 5" to 50" second. These differences have been derived from errors of sun observations. Consequently, it can be said that and precision of sun observations is not good enough to position. Therefore, for precious studies must be benefited from Polaris. In addition to, these differences must be taken into consideration in precious geodetic studies or calculations.

7. REFERENCES

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BIOGRAPHICAL NOTES

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