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THE IMPORTANCE OF INTEGRATING THE AZERBAIJAN NATIONAL VERTICAL DATUM INTO THE EUROPEAN VERTICAL REFERENCE SYSTEM: DETERMINING AZERBAIJAN NATIONAL GEOID MODEL

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***Abstract*.** Height information is of great importance in engineering measurements and geodesy, and therefore it constitutes one of the main subjects of physical geodesy. As it is known, the ellipsoid height of the measurement point is obtained when GNSS measurements and calculations are used. However, orthometric heights measured and calculated from the mean sea level are used in engineering projects and GIS (Geographic Information Systems) applications carried out in countries. Therefore, ellipsoid heights determined by GNSS need to be converted into orthometric heights using a high-accuracy national geoid model. By determining the national geoid in question, the ellipsoid heights obtained from GNSS can be directly converted into the national vertical datum of the relevant country. On the other hand, elevations in topographic maps used both in infrastructure works for engineering purposes and for military purposes are produced based on the national vertical datum of the relevant country.

On the other hand, even though the topographic maps currently used in the state organizations of the Republic of Azerbaijan are harmonized with NATO map standards, but the national height system of Azerbaijan has not been integrated into the European Vertical Reference System (EVRS) yet. However, it is believed that the integration of the national height system of Azerbaijan into the EVRS will provide favorable opportunities for international cooperation activities in the field of mapping and will make an important contribution to the sustainable development of the country's economy.

In this article, necessity of integrating Azerbaijan's national height system into the EVRS and determining a national geoid model are discussed.

Keywords: mean sea level, geoid, quasigeoid, vertical reference system, orthometric height, normal height, levelling network

Introduction

Country vertical control networks (based on levelling and gravity networks) are created to determine the country vertical datum. For this purpose, precise geometric leveling measurements are performed. Because, heights are defined in the Earth's gravity field. The vertical datum, defined as the zero-height surface, is the starting surface of the leveling networks in question. A country's vertical datum is determined by obtaining mean sea level using the data recorded at the tide gauge stations installed on sea shores. Therefore, for example, one of these tide gauge stations is decided as vertical datum starting point (e.g. Antalya tide gauge station in Turkey) and all other leveling points are connected to this starting point (mean sea level) with leveling measurements. Thus, a vertical datum determined for each country or a region is defined according to an arbitrarily chosen starting point(s) [1]. On the other hand, we can say that the geoid is the reference surface for geometric leveling measurements. In many countries, including Turkey, the geoid is considered to coincide with the Mean Sea Level (MSL) obtained by using sea level determination measurements performed at tide gauge points.

Height information is of great importance in engineering measurements and geodesy, and therefore it constitutes one of the main subjects of physical geodesy. As it is known, the ellipsoid height of the measurement point is obtained when GNSS measurements and calculations are used. However, orthometric heights measured and calculated from the mean sea level are used in engineering projects and GIS (Geographic Information Systems) applications carried out in countries. Therefore, ellipsoid heights determined by GNSS need to be converted into orthometric heights using a high-accuracy national geoid model [1].

We can obtain orthometric height (elevation) information from a topographic map. Topographic maps are detailed and accurate graphic representations of some features (e.g. contours, mountains, roads, boundaries, buildings, rivers, lakes, vegetation, etc.) that exist on the Earth's surface. Using the coordinate and elevation info given on a topographic map, one can easily determine the relative or absolute positions of these mapped features. The distinctive characteristic of a topographic map is the use of elevation contour lines to show the shape of the Earth's surface. Elevation contours are imaginary lines connecting points having the same elevation on the surface of the land above or below a reference surface, which is usually mean sea level. Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes [2]. In practice, it is impossible to design various engineering and construction works, exploit natural resources, and strengthen the country's defense capability without using either electronic (vector or raster) or analog (paper) topographic maps.

What is a geoid and what is it needed for?

The vertical datum is a collection of specific points on the Earth with known heights either above or below mean sea level. Near coastal areas, mean sea level is determined with a tide gauge. In areas far away from the shore, mean sea level is determined by the shape of the geoid [3].

In order to determine the shape and dimensions of the Earth more accurately, the proof of the Earth model based on physical and geometric synthesis was made by A. C. Clairaut (1713–1765). With developing measurement and calculation technology and methods, the shape and dimensions of the Earth will continue to be determined more precisely in the future. To achieve this goal, physical land and ocean surface should be considered together. Because approximately 70% of the Earth consists of the ocean surface.

Gauss in 1828 stated that the shape of the Earth, in the geometric sense, is a surface that intersects the plumb lines (deflection of the vertical) at right angles and overlaps intermittently with the ocean surface. This surface, which is considered to continue on the still ocean surface and under the land, was named "geoid" by J. B. Listing in 1872. A much more valid definition for geoid was given by Helmert. Helmert introduced the definition of still ocean surface. According to this definition this surface is not affected by winds, temperature of the tides, pressure and salinity differences. This definition tells us that the geoid is an equipotential surface of the Earth's gravitational field and has a physical meaning (Figure 1).

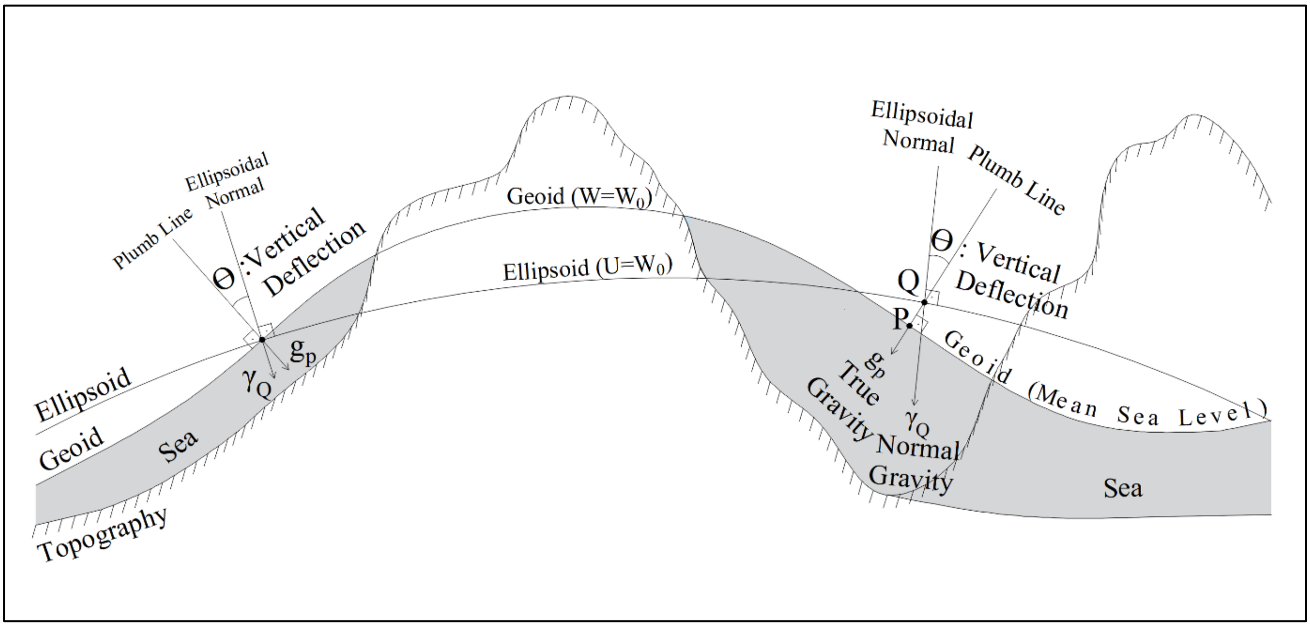

Figure 1. Geoid-ellipsoid relationship

As can be seen from the above definitions, geoid is a universally accepted vertical datum. Geoid is a datum used for “orthometric” and “dynamic” heights. On the other hand, gravity and leveling data are very important for height definition with physical meaning. Heights that have physical meaning are orthometric, normal and dynamic heights. Based on these height systems some geoid types can be stated such as gravimetric, hybrid, astrogeodetic, etc. Additionally, a quasigeoid is defined in Molodensky theory and is used instead of gravimetric geoid. Quasigeoid forms the starting surface (datum) for normal heights and is used in some countries, especially Russia. On the other hand, the reference ellipsoid is the starting surface for ellipsoid heights. It is not suitable for practical engineering applications and therefore is not directly used in infrastructure projects.

In short; Geoid is the equipotential surface of the Earth’s gravity field which best fits global mean sea level. In practice, the definition of mean sea level (MSL) is used to determine the geoid. Because, determining MSL is easier than complex geoid determination theories. Leveling networks established in countries are connected to the country's vertical datum by connecting to MSL. Therefore, MSL provides the height of a point on land from the geoid (after corrections such as sea surface topography). MSL is a suitable starting surface for practical engineering applications. Therefore, if engineering projects are designed based on geoid-based elevation systems, it is clear that no negative situation will be encountered at the end of the project. In other words, when working with heights related to the geoid, water will flow downwards, for example, the same height value will be obtained at every point on the surface of a lake.

A vertical datum that has a physical meaning also provides continuity between regions such as country borders and coastlines in an intercontinental and global sense. Because the use of different height systems between neighboring countries may cause controversial results on country (land and sea) borders. In addition, as a result of defining a vertical datum with a physical meaning and the associated height system, engineering projects comply with the laws of physics valid in the world we live in (For example, water flowing from top to bottom, drilling oil and natural gas wells in the seas, construction of bridges and viaducts between two opposite shores, etc.). It can be done in compliance with. In short, choosing the right elevation system (ellipsoid or orthometric elevation) to be used in engineering projects is an important issue that determines whether these projects will be successful or not.

Nowadays, the question sometimes arises as to why ellipsoidal heights are not used for daily engineering services. The main reason why ellipsoid heights determined by GNSS are not used directly in engineering and infrastructure studies is that this height has only a geometric meaning and is not based on the physical reality of nature. However, orthometric heights defined according to the average sea surface are defined depending on the physical reality of nature. Therefore, if the height system to be used does not have a physical meaning, for example, it will not be possible to tell which side is "up" and which side is "down" in harmony with the earth surface. On the other hand, the orthometric height difference between two points is very close to the height difference found by leveling. Therefore, orthometric corrections to geometric leveling measurements are very small values. This is one of the most important reasons why orthometric height is preferred for practical applications.

The elevation system, which has a physical meaning, and a vertical datum defined accordingly form an inseparable whole. This best explains why we should use the geoid as the appropriate vertical datum of a country.

A height system with physical meaning is expressed by the following general formula.

$$W_A = \sum_{i=0}^{A} g_i \, \Delta L_i \qquad (1)$$

In this formula,

W_A – is the gravity potential at point A;

g_i – gravity values measured along the leveling lines in the field;

ΔL_i – refers to the height differences measured by leveling.

As can be seen from here, the height component has a meaning on its own. The reason for this is that, as can be seen from equation (1), there is a relationship between height and gravity potential. Here lies the reason why it is mandatory to use height information that has a physical meaning in practical engineering applications and in determining country borders.

The relationship between ellipsoid heights, which have a geometric meaning and are obtained by GNSS, and orthometric heights, which are defined in relation to the geoid and have a physical meaning, can be seen in figure 2 and equation (2).

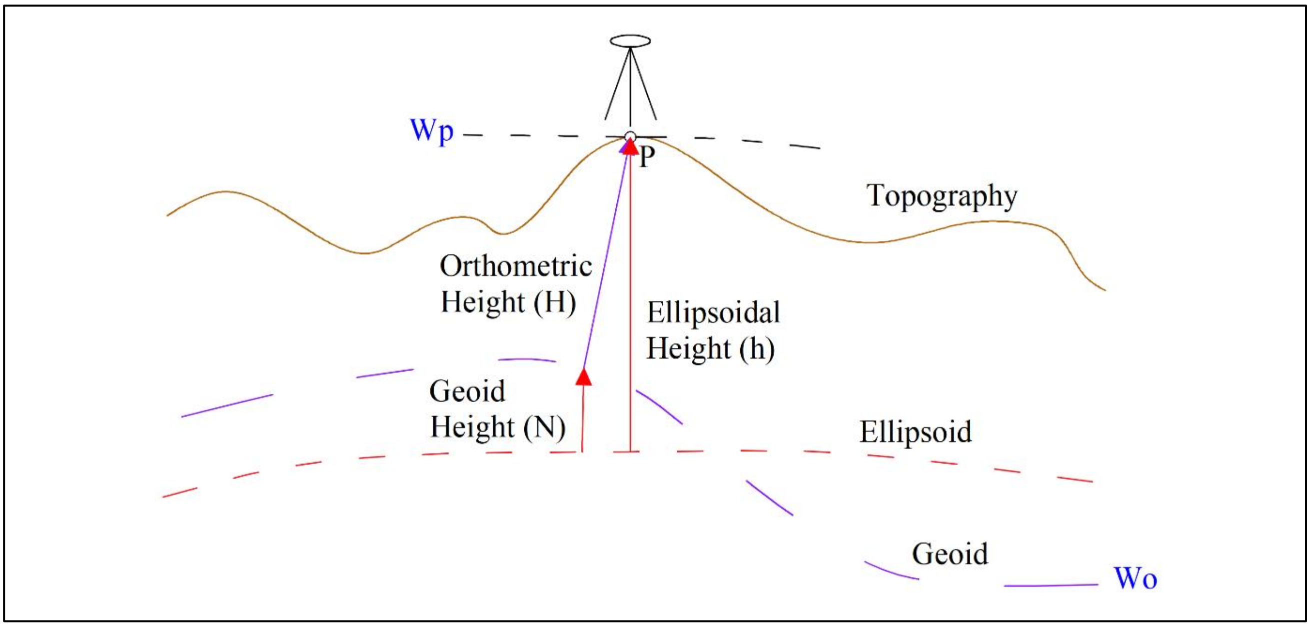

Figure 2. Relationship between Ellipsoid Height and Orthometric Height

$$h = H + N \qquad (2)$$

Here;

h – ellipsoid height of point P;

H – Helmert orthometric height of point P;

N – geoid height of point P.

Thus, if the geoid height is known, the Helmert orthometric height value of that point can be easily calculated with equation (2). As a result, orthometric heights calculated based on real gravity values measured in the field are the most accurate height system for country surveys and practical engineering applications.

Current Situation in Azerbaijan

There is a limited amount and scope of information regarding the geodetic infrastructure of Azerbaijan, and an evaluation has been made in the light of scientifically available data. Therefore, the suggestions regarding Azerbaijan National Geoid determination has been prepared based on the limited information we have.

As far as is known, the geodetic infrastructure (horizontal and vertical datum) used by the Soviet Union (USSR) was used in Azerbaijan for many years. In the following years, in parallel with the developments in the world, the need to establish a real-time continuously operating reference GNSS network (CORS) emerged in Azerbaijan, and as a result of the studies carried out on this subject, a CORS network named AZPOS (Azerbaijan Positioning Observation System) with 37 stations was established. 3D coordinates obtained using AZPOS network data are in the WGS84 system (Figure 3).

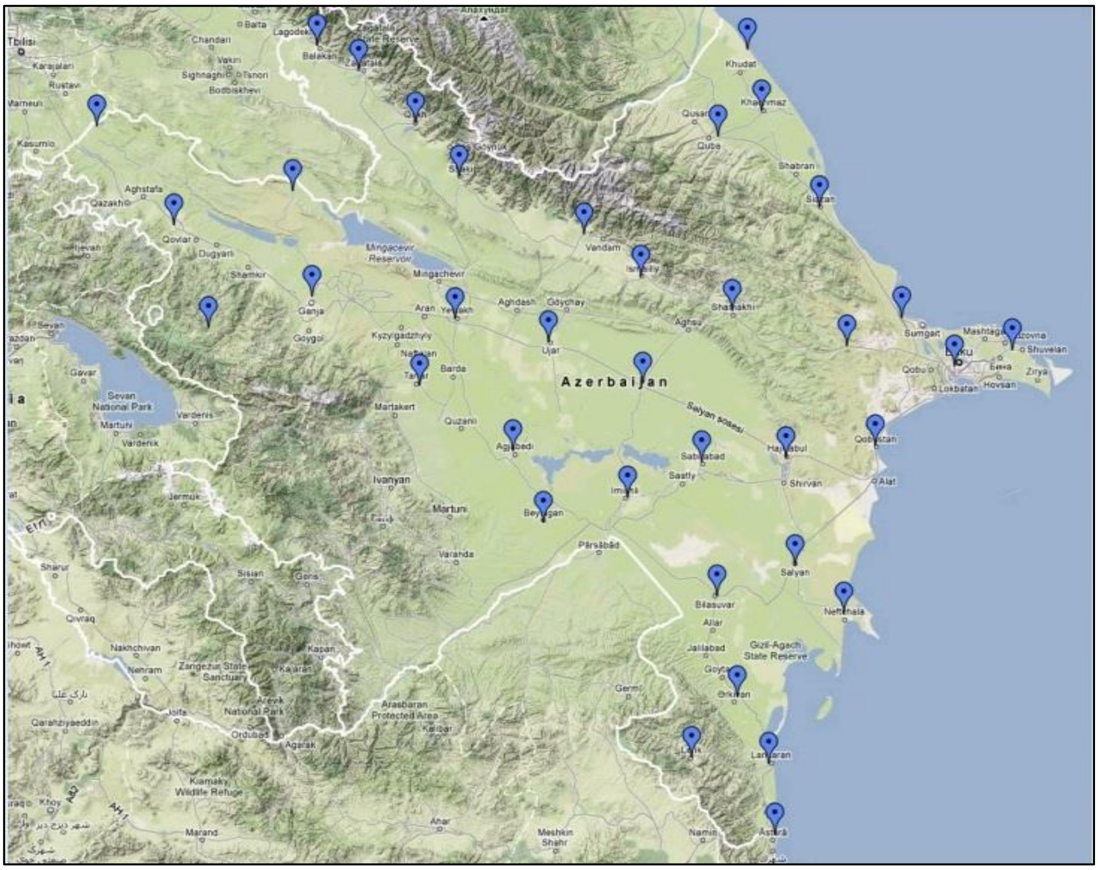

Figure 3. AZPOS network

In addition, in order to facilitate the preparation of the geodetic basis of these maps within the framework of the project “creation the Azerbaijan International Fundamental GPS Base (AIFGB)”, GPS measurements were carried out in 2000 at 55 class I and II triangulation points on the territory of the republic. Of these points, 7 are located on the territory of the Nakhchivan Autonomous Republic [4].

According to the AIFGB project, three-dimensional coordinates (X, Y, Z) and time-dependent rates of change (Vx, Vy, Vz) of each point were determined in the International Terrestrial Reference Frame (ITRF) system with an accuracy of several cm. Orthometric heights (H) were determined based on the average level of the Baltic Sea. In the measurement works Trimble 4000 SSE and Ashtech Z – Surveyor GPS receivers were used. The distance between points is 30–60 km (Figure 4).

Figure 4. Azerbaijan International Fundamental GPS Base (AIFGB) project map

On the other hand, Azerbaijan's classical geodetic infrastructure is in the SK-42 system (based on the Krassovsky 1940 ellipsoid), whose starting point is the Pulkovo Observatory (Saint Petersburg) in Russia. Azerbaijan's vertical datum (elevation system) is still based on the Baltic Sea mean sea level. In other words, this vertical datum (Baltic height system; BHS: Baltic Height System) has always been used in engineering services in Azerbaijan from past to present. BHS is a system created in the 1950s by Russia, Estonia, Latvia, Lithuania and Poland, located in the east of the Baltic Sea. This system was created based on long-term average sea level observations recorded between 1825 and 1840 at the Kronstadt (St. Petersburg) tide gauge station in the Gulf of Finland and was updated in 1977 and named BHS77. Therefore, all topographic maps and engineering studies produced according to the SK-42 datum were made according to the orthometric heights in the BHS vertical datum.

Despite the fact that the geodetic basis, cartographic projection and design of the mentioned topographic maps were prepared according to NATO standards but, as indicated in the technical specifications of the AIFGB project, the relief height on the maps was calculated based on the average level of the Baltic Sea. It is for this reason that a note about height adjustment was indicated at the bottom of the frame of each map (Height Correction: Find corresponding height value in the map by subtracting 16 m. from the Ellipsoidal Height in WGS-84 computed by GPS receivers) (Figure 5).

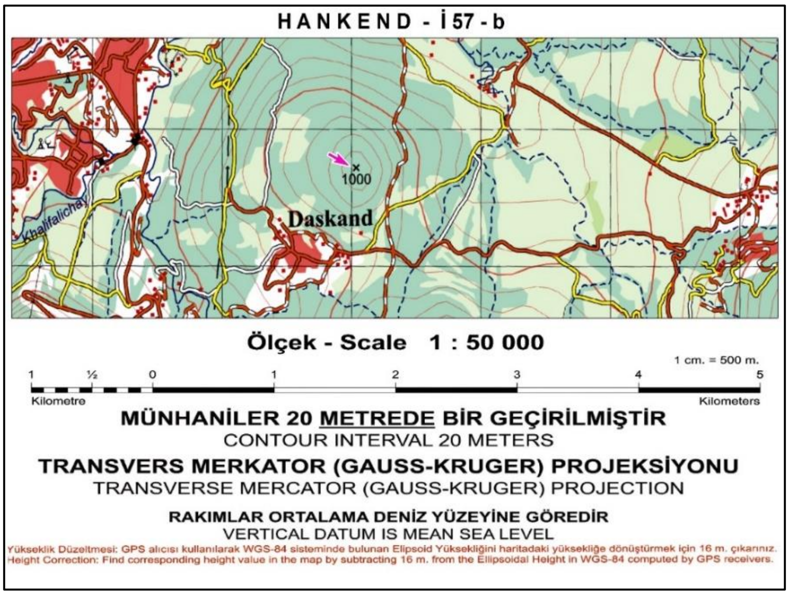

Figure 5. 1 : 50 000 scale topographic map prepared in NATO standards

When comparing the height values on maps prepared within the framework of the MGCP (Multinational Geographic Cartographic Project), for the Karabakh region of the Azerbaijan Republic with the corresponding height values on topographic maps in the SK-42 coordinate system, it was found that the heights of the peaks of the same name above sea level differ from each other from 10 meters to 35 meters (Figure 6).

Comparison 1

Comparison 2

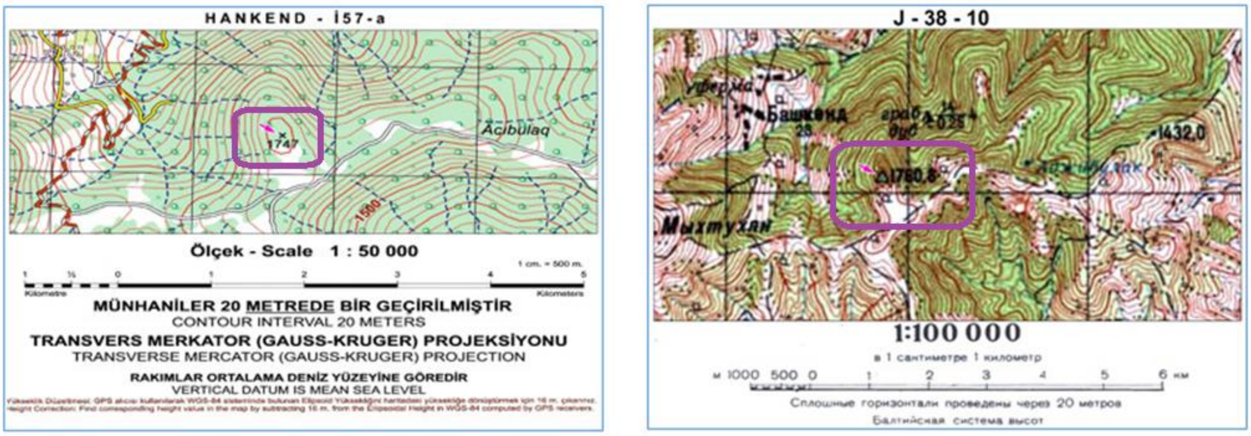

Figure 6. Comparison of elevation values on 1 : 50 000 scale topographic maps prepared according to NATO standards within the (MGCP) with corresponding elevation values on SK-42 coordinate system maps

If it is taken into account that the terrain relief in both WGS-84 and SK-42 coordinate system topographic maps is calculated based on the Baltic elevation system, then there should be no difference in the elevation value.

The initial zero value taken from the mean level of the Baltic Sea was transferred to the entire territory of the Soviet Union at that time, including the territory of the Republic of Azerbaijan, in order to determine the absolute heights on topographic maps. The problem is that there are always errors in the transmission of level values over long distances, and the errors increase as you move towards the edges.

To reduce the errors in the heights of points whose height is determined in leveling routes in accordance with the requirements of the instructions for determining height values, a leveling route starting from the average level of one sea must be connected to the average level of another sea or to another point, the height of which is considered as reference. After this, the difference in heights between the starting point and the last point should be distributed equally to the absolute heights of the leveling route. This process is called adjustment of the leveling network [5].

Due to the fact that the territory of the Republic of Azerbaijan is located far from the seas connected to the World Ocean, and the nearby Caspian Sea is not geographically connected to the ocean, it is likely that leveling routes starting from the Baltic Sea were not connected to the seas of the World Ocean in this direction.

In topographic maps prepared for the European continent, the reference values used in the elevation system are closely related to each other. That is, leveling routes originating from the average level of the seas of the surrounding continent are connected with the average levels of other seas of the surrounding continent. In Europe, 1971–1986 and 1994–2007, a number of international leveling works were carried out in order to connect existing networks of high-altitude systems and improve their accuracy. Compared to the former Soviet Union, the territory of the European continent is not large. However, a lot of leveling work has been done here. This means that height values were not transmitted over long distances, and leveling routes were periodically adjusted, as a result of which errors were reduced. Of course, the leveling work carried out from time to time had a positive effect on the accuracy of the elevation system of NATO topographic maps [6].

As mentioned above, extensive leveling work has been carried out within the framework of international projects on the European continent. However, there is no precise geoid available for Europe with an accuracy of a few centimeters which fulfils the requirement for the practical applications.

At a symposium held in Warsaw on June 8-11, 1994, EUREF (European Reference Frame EUREF), a sub-commission of the International Association of Geodesy (IAG – International Association of Geodesy), in order to solve the problem of using the capabilities of modern satellite navigation technology and to contribute to the unification of different elevation systems in Europe, Adopted a decision on the establishment European Vertical GPS Reference Network (EUVN) (Resolution No. 3). The most important practical and scientific aspects of EUVN are:

– contribution to a unique European height datum;

– connection of European tide gauge benchmarks as contribution to monitoring absolute sea level variations;

– establishing of fiducial points for the European geoid determination;

– Preparation of European Vertical Kinematic Network.

The EUVN includes 195 points all over Europe, 79 EUREF points, 53 nodal points of the Leveling Networks of Eastern and Western Europe and 63 tide gauges.

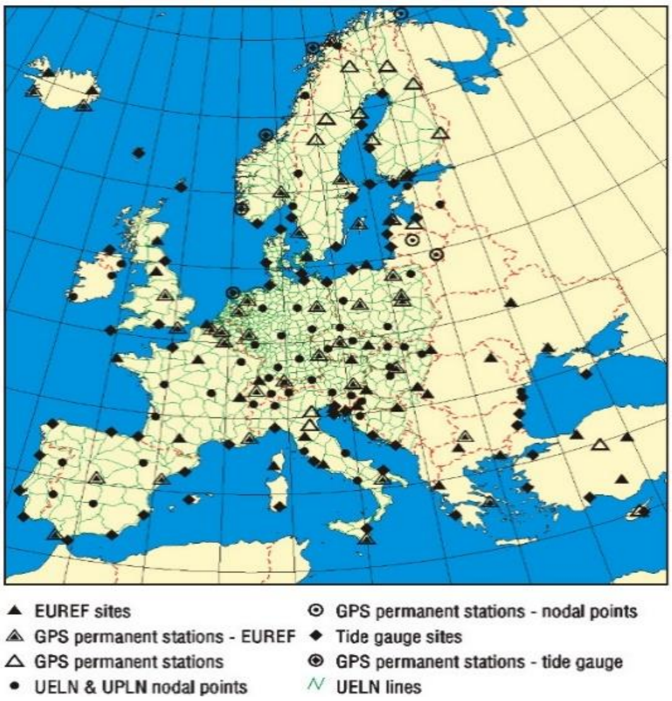

Figure 7. European Vertical GPS Reference Network

As a result of the completion of the EUVN project, a new geoid for the European continent will be defined and it will be possible to change the errors in determining elevation points within a few centimeters [2]. In addition, this project will develop a geokinematic elevation reference system for Europe by linking level points determined by traditional methods to heights measured using GPS [7].

The national elevation systems of European countries are determined via mean sea levels obtained from mareograph stations operating in the Baltic, North Sea, Mediterranean and Black Seas surrounding the continent. The difference between the levels of these seas can reach several decimeters. These differences are caused by different distances between the sea surface and the geoid. In addition, the zero levels measured at mareograph stations do not refer to the mean sea level, since the determination of the mean level of the sea in a still state is historical in nature. For example, the zero point of the city of Amsterdam was determined in 1684 according to the state of the rising and receding sea.

In Europe, three different systems for calculating height are used: normal, orthometric and normal-orthometric. The orthometric height system is used in Türkiye, Belgium, Denmark, Finland, Italy and Switzerland, but the normal height system is used in France, Germany, Switzerland and in most countries of Eastern Europe [8]. As briefly explained above, in the orthometric height system, the absolute heights of points on the earth surface is calculated from the geoid surface along a vertical (plumb) line.

In the Russian Federation and the states of the former Soviet Union, a system of normal heights is used. In the normal height system, the absolute height of points on the land surface is calculated from the surface of a quasi-geoid along the normal line. A normal line is a line that is tangent to a curve at one point and perpendicular to the tangent at the same point. If we draw pieces down along normal lines under the influence of the earth's gravity, a surface will be defined below. Soviet and Russian geophysicist scientist Mikhail Sergeyovich Molodensky is proposed to call this surface quasi-geoid. In open seas and oceans, the surfaces of the geoid and quasi-geoid coincide [9]. Normal heights can be accurately calculated based on the Earth's gravity values [10].

Although the AZPOS network, which is currently used in Azerbaijan, provides coordinates in 3 dimensions, the third dimension (the height information) is the ellipsoid height of the measurement point. In other words, the heights obtained in real time from the AZPOS system are ellipsoid heights that only have geometric meaning and are defined based on the WGS84 reference ellipsoid. Therefore, it is not possible to use these ellipsoidal heights directly in many engineering and infrastructure works. Therefore, ellipsoid heights obtained in real time in the field must be converted into orthometric heights using a suitable method in order to be used in engineering studies and topographic map production.

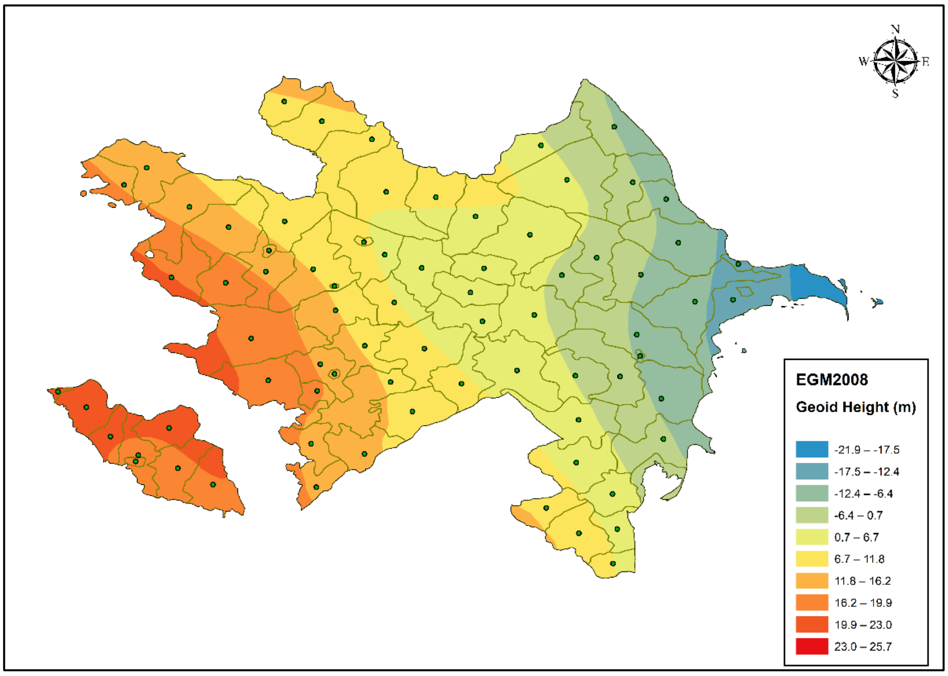

Figure 8. EGM2008 geoid heights for Azerbaijan

In many studies, it is possible to calculate orthometric heights by using global geoid models. However, it is still not possible for the absolute accuracy of global geoid models to provide results better than ±1 meter. Because the accuracy of data used in these models does not cover the whole world. For this reason, it is appropriate to use global geoid models for 1/25000, 1/100000 and smaller scale studies. It is considered that determining national and regional geoid will be the most appropriate solution for engineering projects and public investments (Figure 8).

Although there is no detailed and accurate information based on scientific basis about the vertical datum used in Azerbaijan and therefore the geoid, it is generally accepted that the accuracy of the conversion parameters between the WGS84 system and the SK42 system is around ±1 meter on average. Conversion parameters between WGS84 and SK42 datums are given in table.

Due to the uncertainties briefly explained above in the Azerbaijan geoid, it is clear that errors of up to a few meters in the ellipsoid heights of the points will occur as a result of the transformations made using the transformation parameters in Table. For this reason, using the conversion parameters given in Table in areas such as engineering measurements, road and railway projects, and irrigation projects that require precise elevation information will cause significant errors.

Table. Transformation parameters between SK42 and WGS84 systems (Musayev and Gojamanov 2021) [4].

Parameter Name	From SK42 to WGS84
ΔX (meter)	25 m
ΔY (meter)	–141 m
ΔZ (meter)	–78.5 m
S (ppm)	0
ω_X (´´)	0
ω_Y (´´)	–0.350
ω_Z (´´)	–0.736

What needs to be Done Regarding Geoid Model Determination and Integrating Azerbaijan National Vertical Datum into EVRS?

As can be seen from what has been briefly explained so far, the height of Azerbaijan's modern AZPOS system (ellipsoid height) and its current vertical datum (height system) do not match. This is an important problem with a high potential to lead to negative consequences in projects and applications based on altitude information. In addition to all these, the urgent solution of this problem becomes much more important in order to integrate with the world regarding vertical datum and to create unity and standards in maps produced on a country basis.

In addition to solving this important problem, the best solution would be for Azerbaijan to abandon the SK42 datum and switch to the international terrestrial reference system (ITRF), which is accepted all over the world, with a detailed and accurate planning in the AZPOS system. Thus, 3D coordinates will be published in the ITRF system in real time in the AZPOS system. In addition, by calculating a geoid and/or quasi geoid suitable for Azerbaijan, both the Azerbaijan National Vertical Datum will be defined and the (Helmert and/or Normal) orthometric heights required for practical engineering studies will be obtained in real time using AZPOS correction data. It can be published to those making measurements in the field. With such a project, Azerbaijan will have an up-to-date, accurate coordinate system and datum at international standards, and will be technically integrated with the world. Thus, integrating Azerbaijan National Vertical Datum into EVRS is considered a very useful issue for the near future. To realize this aim, first of all, the Azerbaijan national geoid model should be created. After that, the Azerbaijan vertical datum should be defined and the integration of this datum into EVRS should be carried out in collaboration with the relevant academic and national institutions of Azerbaijan, Türkiye and Europe.

Additionally, calculating a national geoid (or Quasi geoid) based on modern techniques will also be very useful for cadastral studies in Azerbaijan. In order to fully decide which type of geoid should be determined in Azerbaijan, it is necessary to obtain more detailed information (e.g. gravity measurement status, number of gravity points, gravity datum, leveling measurement status, information on the national leveling network, etc.) from authorized public institutions.

Conclusions

There is no accurate and up-to-date geoid to meet today's needs in Azerbaijan. It is necessary to create a country's national vertical datum and geoid using modern techniques and measurement methods. Because, all country surveys and engineering studies are carried out using Helmert or Normal Orthometric Heights, which are based on a national/international vertical datum determined according to the average sea level. For this, it is necessary to determine the gravimetric geoid (Helmert orthometric height) and/or quasi-geoid (Normal orthometric height). For the gravimetric geoid, there is a need to examine the gravity and leveling measurements and calculations made so far in Azerbaijan. It must be decided which of the Black Sea, Mediterranean, Caspian Sea, Baltic Sea or others will be considered as the starting point for the average sea level. Accordingly, the Azerbaijan elevation system should be updated and the Azerbaijan Geoid should be determined with high accuracy. For all these, the "Modernization of the Azerbaijan Height System and Determination of the Azerbaijan National Geoid" project must be implemented.

As a result; it is clear that Azerbaijan needs modern and up-to-date horizontal-vertical datums. The height information obtained with AZPOS in the WGS84 datum is ellipsoidal height, and since it has only geometric meaning, it is not possible to use it directly in many engineering studies. In this context, determining the Azerbaijan National Geoid is an extremely important issue. Since geoid heights can be easily calculated by determining the Azerbaijan gravimetric and/or Quasi-geoid, geoid heights can be published in real time to AZPOS users making measurements in the field, and thus, errors arising from height information will be eliminated in all engineering projects and accurate and real-time orthometric heights will be obtained. This means saving money, time and labor for Azerbaijan.

In addition, a modern and high-accuracy vertical datum and geoid integrated with EVRS and neighboring countries will have been determined.

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Xülasə

Azərbaycan hündürlük sisteminin Avropa hündürlük sisteminə inteqrasiyanın əhəmiyyəti: Azərbaycan milli geoid modelinin müəyyən edilməsi

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Mühəndis ölçmə işlərində və geodeziyada hündürlük sistemi məlumatları mühüm əhəmiyyətə malik olub və fiziki geodeziyanın əsas predmetlərindən birini təşkil edir. Məlum olduğu kimi, bugün yer səthində istənilən nöqtənin ellipsoid hündürlüyü Qlobal Peyk Naviqasiya Sisteminin (GNSS) geodeziya ölçmələri və hesablamalarından istifadə etməklə əldə olunur. Buna baxmayaraq, dünyanın bir çox ölkələrində orta dəniz səviyyəsindən ölçülən və hesablanan ortometrik yüksəkliklər hələ də mühəndislik layihələrində və CİS (coğrafi informasiya sistemləri) tətbiqlərində istifadə olunur. Buna görə də GNSS tərəfindən müəyyən olunan ellipsoid hündürlüklərini yüksək dəqiqliyə malik milli geoid modelindən istifadə edərək, ortometrik hündürlüklərə çevirmək lazımdır. Sözügedən milli geoidi təyin etməklə, GNSS-dən alınan ellipsoid hündürlükləri birbaşa müvafiq ölkənin milli şaquli (hündürlük) məlumatlarına çevirmək mümkündür. Digər tərəfdən, həm mühəndislik, həm də hərbi məqsədlər üçün infrastruktur işlərində istifadə edilən topoqrafik xəritələrdə hündürlüklər (yüksəkliklər) müvafiq ölkənin milli şaquli sistem məlumatlarına əsasən hazırlanır.

Hal-hazırda Azərbaycan Respublikasının dövlət qurumlarında istifadə olunan topoqrafik xəritələr NATO xəritə standartlarına uyğunlaşdırılsa da, Azərbaycanın milli hündürlük sistemi hələ də Avropa Şaquli İstinad Sisteminə (European Vertical Reference System, EVRS) inteqrasiya olunmayıb.

Azərbaycanın milli hündürlük sisteminin EVRS-ə inteqrasiyası xəritəçəkmə sahəsində beynəlxalq əməkdaşlıq fəaliyyəti üçün əlverişli imkanlar yaradacaq və ölkə iqtisadiyyatının davamlı inkişafına mühüm töhfə verəcək.

Məqalədə Azərbaycanın milli hündürlük sisteminin EVRS-ə inteqrasiyasının zəruriliyindən və milli geoid modelinin müəyyənləşdirilməsindən bəhs edilir.

Açar sözlər: dənizin orta səviyyəsi, geoid, kvazigeoid, şaquli istinad sistemi, ortometrik yüksəklik, normal yüksəklik, nivelir şəbəkəsi

Аннотация

Значение интеграции Азербайджанской системы высот в европейскую систему высот: определение национальной модели геоида Азербайджана

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Данные системы высот имеют большое значение в инженерных изысканиях и геодезии и поэтому составляют один из основных предметов физической геодезии. Как известно, сегодня эллипсоидальную высоту любой точки земной поверхности получают с помощью геодезических измерений и расчетов Глобальной навигационной спутниковой системы (ГНСС). Однако до сих пор во многих странах мира ортометрические высоты, измеренные и рассчитанные по среднему уровню моря, используются в инженерных проектах и приложениях ГИС (географических информационных систем). Поэтому высоты эллипсоида, определенные с помощью GNSS, необходимо преобразовать в ортометрические высоты с использованием высокоточной национальной модели геоида. С другой стороны, отметки (высоты) на топографических картах, используемых при инфраструктурных работах как инженерного, так и военного назначения, готовятся на основе данных национальной вертикальной системы соответствующей страны.

Несмотря на то, что топографические карты, используемые в настоящее время в государственных организациях Азербайджанской Республики, адаптированы к картографическим стандартам НАТО, национальная система высот Азербайджана еще не интегрирована в Европейскую вертикальную систему высот EVRS (European Vertical Reference System).

Интеграция национальной системы высот Азербайджана в EVRS создаст благоприятные возможности для международного сотрудничества в области картографии и внесет важный вклад в устойчивое развитие экономики страны.

В статье обсуждается необходимость интеграции национальной системы высот Азербайджана в EVRS и определения национальной модели геоида.

Ключевые слова: средний уровень моря, геоид, квазигеоид, вертикальная система отсчета, ортометрическая высота, нормальная высота, сетка уровней

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