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A Comparison of (Geoid Undulation) Calculated from (GPS/Leveling) and (EGM08) Methods for Wasit Province in Iraq

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Abstract: The aim of the present research is to calculate adjusted geoid undulation based on (GPS/leveling) method through observation of Iraq official vertical network using Global Navigation Satellite System (GNSS) technique.there are many ways to calculate geoid undulation such as (Bouguer and Free air Anomalies) which rely on ground gravity data and (GPS/leveling) method which is considered to be the most precise way to calculate geoid undulation. The accuracy of geoid was also estimated by comparing the (GPS/leveling) method with the geoid undulation (EGM08) model for the study area. The result of this research can assist a lot to enhance the accuracy of elevations obtained from (GNSS) and support the establishment of Local geoid.
Keywords: Geoid undulation, (GPS/leveling), GNSS, Wasit province Iraq.

INTRODUCTION

In last decades Global Navigation Satellite System (GNSS) or as known Global Positioning System (GPS) technique is considered a revolutionary technique in the field of geodetic survey in comparison with traditional techniques (level, theodolite and total station). The height obtained from GNSS technique is ellipsoid height and to have a physical meaning in a surveying or engineering application it must be transformed to orthometric height. Therefore, a geoid model has to be used to do this transformation process [1]. In Iraq there is no specific geoid that can be used in order to get proper orthometric height.

In April 2008, the USA military service survey launched the Global Geoid Model (EGM2008) and made it available to everyone for free on the internet.

This model is a scientific revolution in the field of global geoid models, where the degree of modeling has reached (2160) compared with all previous global geoid models which reached to (360) degree.

This high degree comes back in representation the geoid undulation to the geodetic database (Especially gravitational anomalies) Huge which used in model development (EGM2008) which covered almost every surface of the earth whether land or sea which was not available to any international entity before that. The wavelength of this model which has 2160 degree is equal 0.083333 degrees and it is equal 5'. This means that the degree of clarity of the model is equal 9.2 km. and the model will be calculated the geoid undulation every 9.2 KM. The accuracy of the model which are determined when comparing the results of the model with accurate ground measurements is the most important from degree of clarity of any global model. In order to evaluate the accuracy of EGM2008 model in a geographical area or country the measurements of the geoid at some points will collect and compare with geoid undulation values resulting from the global model. The differences between the two values at each point will calculate then calculate the standard deviation of all these differences to be a value indicative of the accuracy of the global geoid model [2]. Some previous studies related to this study, fit gravimetric local and global quasigeoids to GPS /leveling data [3], combined leveling with GPS measurements and geoid information [4] and evaluated the performance of the EGM08 model over the Baltic Sea region with emphasis to Estonia by using GNSS/Leveling [5].

Area of Study

The study area is the part of the middle of Iraq in Wasit province located between 31°59'12.84" to 33° 0'33.20" North and 45°31'1.26" to 46°50'11.10" East. Wasit Governorate is located in the Middle East section of the Sedimentary Plain, The province is characterized by the multiplicity of governorates that are adjacent to it, The borders of Wasit province from the north with

both Diyala province and Baghdad province Either from the west of Babylon province and Diwaniya province Either from the southwest Thi Qar province Either from the southeast Mesan province,The eastern border of Wasit province is considered part of the international border between Iraq and Iran. Wasit Governorate is part of the Sedimentary Plain, Most parts of Wasit province do not go much higher than level (25 m) Above sea level With the exception of border areas adjacent to the Iraqi-Iranian border show Figure 1.

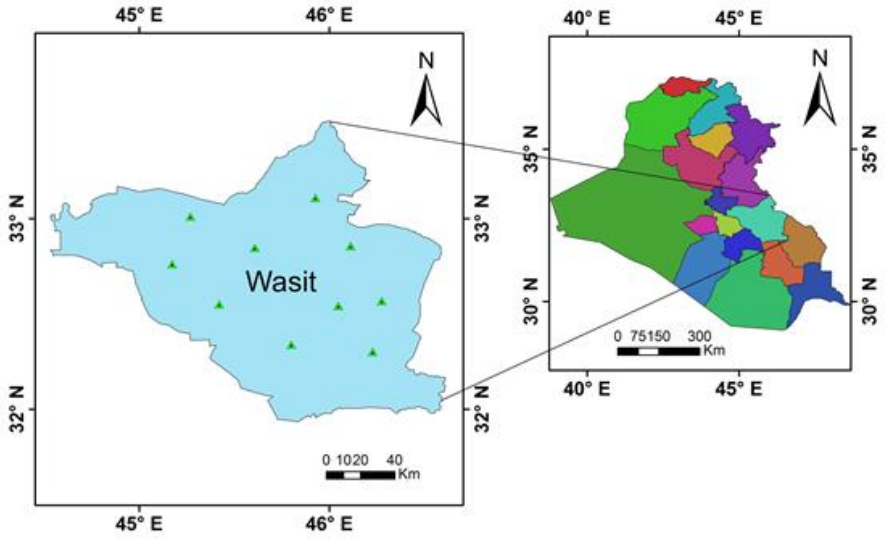

Fig-1: Location Map of the Study Area with Distribution of Points Observed By GPS

METHODOLOGY

Precise orthometric heights for ten points were collected from state commission survey in Iraq according to mean sea level in the Faw area. Point's locations with geodetic heights were obtained using the differential global position system (DGPS) type Topcon (GR3), this data shown in Table 1. A GNSS receiver was used in static method to observed 10 points twice and for five hours each time. These points' data (Rinex) send to GPS data processing service which is a free for users via the Internet through OPUS website which are returned to the user after being corrected. Calculation of all coordinates were curred out based on Datum (ITRF00) reference frame and global ellipsoid (WGS84). The geoid undulation from earth gravitational model (EGM08) for the ten points calculated using (All Trans EGM08) software versus the geoid heights from GPS/Leveling for the study area. Table 2 shows the geoid height difference for the 10 points and Figure 3 and Figure 4 show chart and contour map respectively for this difference and Table 3 the summary of statistics.

Relationship between Geoid, Ellipsoid and Orthometric Height

It is important to note that geodetic heights obtained with satellite surveys are measured with respect to the ellipsoid. That is, the geodetic height of a point is the vertical distance between the ellipsoid and the point as illustrated in Figure 2.

As is evident these are not equivalent to elevations which also called orthometric heights given with respect to the geoid. The geoid is an equipotential gravitational reference surface that is used as a datum for elevations. To convert geodetic heights to elevations, the geoid height which represents vertical distance between ellipsoid and geoid must be known. Then geoid height can be expressed as

$$N = h - H \qquad (1)$$

Where H is the elevation above the geoid (orthometric height), h is the geodetic height (determined from satellite surveys) and N is the geoidal height.

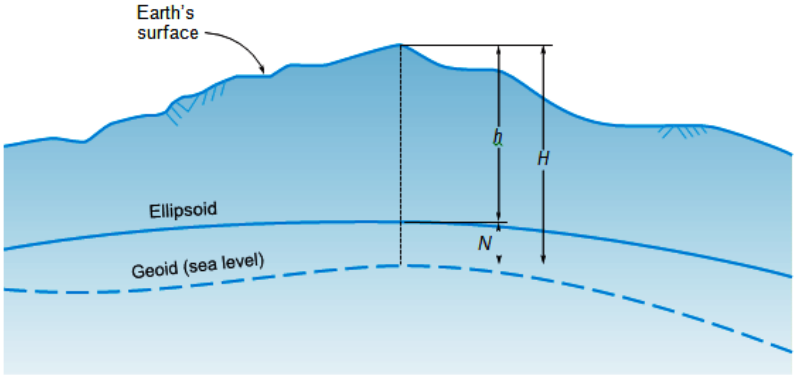

Fig-2: the Relationship between geoid, ellipsoid and orthometric Height

Figure 2 shows the correct relationship of the geoid and the WGS84 ellipsoid. The ellipsoid is above the geoid, and geoid height measured from the ellipsoid is negative. The geoid height at any point can be estimated with mathematical models developed by combining gravimetric data with distributed networks of points where geoidal height has been observed [6]. One such model is EGM2008 which has a high-resolution and it is available for global use from the National Geodetic Survey (NGS). It uses latitude and longitude as arguments for determining geoid heights at anywhere in the World.

RESULTS AND DISCUSSION

These method is based on the direct determination of the orthometric (H) and ellipsoidal (h) heights, for the purpose of calculating the undulation height values N of the geoid of these points. And also determine the geoid height using of the Earth Gravitational Model 2008 (EGM2008).The Table 2 Illustrate the results for two geoid undulation And the difference between them using in this research.

Table-1: Final geodetic, IGRS coordinates (ITRF00 DATUM) ellipsoid and Orthometric heights

Points	Latitude	Longitude	Ellipsoidal height (m)	Orthometric height (M.S.L-FAW) (m)
Wa01	32.50252136	45.80867666	13.724	20.414
Wa02	32.51384224	45.84230054	10.723	17.411
Wa03	32.52224977	45.80665341	10.110	16.715
Wa04	32.17974849	46.02293765	8.998	17.311
Wa05	32.54940358	45.41980854	14.919	20.549
Wa06	32.76120256	45.17207653	18.725	23.312
Wa07	32.90660503	45.06397973	21.765	25.681
Wa08	32.56743696	46.2750348	7.485	14.794
Wa09	32.92739153	44.78023288	24.391	27.571
Wa10	33.10894525	45.92640409	56.544	60.482

Table-2: EGM08 geoid height values and N^{GPS} values for the 10 points

Points	**N (EGM08)**	**N^{GPS} = h - H**	**$\Delta N = N^{EGM08} - N^{GPS}$**
Wa01	-6.789	-6.690	0.099
Wa02	-6.825	-6.688	0.136
Wa03	-6.721	-6.605	0.116
Wa04	-8.422	-8.313	0.109
Wa05	-5.727	-5.630	0.097
Wa06	-4.654	-4.587	0.067
Wa07	-4.057	-3.916	0.141
Wa08	-7.467	-7.309	0.158
Wa09	-3.366	-3.180	0.186
Wa10	-4.134	-3.938	0.196

Table-3: Statistics of the differences between N^{GPS} and N^{EGM08} at the ten points (Units in Meter)

Geoid Undulation	Minimum (m)	Maximiu (m)	Mean (m)	Standard Deviation (m)
GNSS/Leveling	3.180	8.313	5.686	1.615
EGM2008	3.3661	8.4218	5.81627	1.599
Difference	0.067	0.196	0.130	0.039

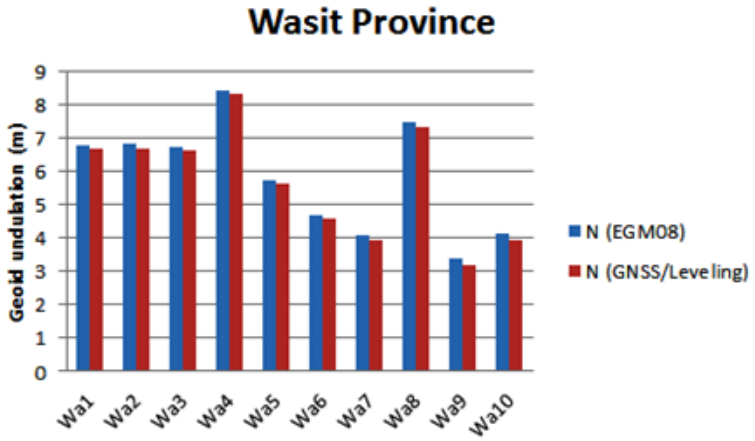

Fig-3: Chart Show the Difference between Geoid Undulation (EGM08) and Geoid Undulation from (GPS/Leveling)

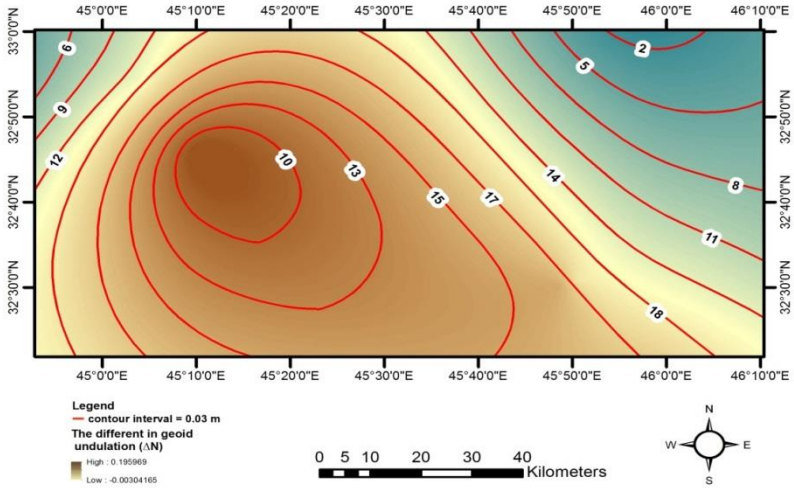

Fig-4: Contour Map Show the Different in Geoid Undulation

CONCLUSIONS

To assess the accuracy of the geoid model in a specific geographical area, the measurements of undulation of some points (h-H) are collected, and compared them with the undulation values obtained by the global model. Then, the difference between the values at each point is calculated with their standard deviation for all the differences. Thus, this standard deviation will represent the indicator of the accuracy of the global model. In this study, the Global Positioning System (GPS) method and the high precise leveling were used to compute the values of the local geoid undulation.

A comparison between the (GPS/leveling) methods with geoid undulation EGM2008 model for the study area was carried out and presented in Table 3. The comparison results show that the geoid undulation accuracy is within ± 0.039 m. The geoid undulation accuracy is almost good as the area of study is about 17153 km^2 which is relatively a small region compared to the geoid surface, These results also suggest that it is better to improve global geoid (EGM08) by Using

geodetic data as well as ground gravity data to achieve the best possible accuracy in the study area.

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