Evaluation of Global Gravitational Models Based on DGPS/leveling Data over Baghdad University (IRAQ)

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Abstract. GPS becomes one of the most technical favorite geodesy methods. A major dilemma in GPS survey lies in oval-based elevations, while orthometric heights are commonly used in engineering practice. Converting GPS heights into orthometric heights by applying a precise geode model is therefore necessary. This paper aims to model the local geoid in the using study region (h-H). Compared with many global gravitational models (GGMs) and three of them were selected, namely EGM96, EGM84, and EGM2008. The evaluations of the accuracy of these models and then choose the most accurate and closer to the local geode In the field of work, which is mounted on the campus of the University of Baghdad in the capital of Iraq. Techniques require the use of GGM to represent global differences or long wavelengths of the gravity field of the Earth; the gravitational field of the Earth takes into account much of the direct information about the distributions of mass density in the Earth. It then provides the basis for exploring oil and gas in this respect, and the detection of geodesics forms the basis for exploring minerals. The EGM08 is the closer GGMs to the observed local geodetic dataset, in terms of the difference of geoid undulation that have a maximum of 0.4011m), a minimum of 0.3996m), an average of -0.111256m), and a standard deviation of ±0.152859m).

Keywords. geoid, Ellipsoidal height, DGPS, Global Gravitational Models (GGMs).

1. Introduction
Another of the main objectives of geodetic surveying is to render survey applications with optimal precision in the shortest time. It is well understood that traditional leveling methods, such as geometric (spirit and precise) leveling, are the prevalent strategies for years of assessing orthometric heights [1].

The conventional leveling methodology is repetitive, time-consuming, and it applies to reference points to deliver on the relative dimensions. The creation of the Global Positioning System (GPS) based on satellite has enabled more reliable, more realistic, and economical use in geodesy and surveying occupations. Today, GPS supports a broad variety of geodetic applications from Earth’s crustal deformation tracking to GIS database (Geographical Information System) development.[2].
The GPS is a Three-dimensional surveying and positioning strategy provided to surveyors through digital technologies to solve complex location problems. GPS, sadly. Provided only height proportional to the Earth's statistical ellipse known as ellipsoidal height rather than the practical sense of the M.S.L.-related orthometric height. Therefore, parallel to the growth of G.P.S. and techniques, there is an increase in the study's purpose of obtaining cm precision of orthometric heights[3].

In this paper, the correctness of three geoid stature models, independently named EGM84, EGM96, and EGM2008, are assessed on a large part of Baghdad University campus speedy response to fit the best of them on the examination region so to overhaul its show is proposed. The assessment of the EGM08 depends on the correlations with other outer information—the paper centers on assessing EGM08 in part of the center in Iraq utilizing DGPS/leveling. The paper is structured as follows; first, it describes geoid modeling. The most used G.G.M.s in IRAQ.

2. The Methodology of Work

2.1. Geoid Modeling

The Geoid equals the equipotential surface that coincides with the mean sea level. But it makes sense because the oceans are made of water, equal the figure of the Earth.

It is the ocean surface over the continents (assuming no currents, waves, etc.). The spheroid is an excellent approximation to the Geoid to have a reference datum level to which estimations can be connected,[4].

Orthometric (H) heights Indicate to the reference surface of an isotope. The distance from that point to the geoid, measured along the normal vertical line to the geoid, is the orthometric height of a distinct point on the Earth's surface. The vertical line is curved Orthometric heights can be derived using various methods, including spirit leveling or trigonometric leveling, [5].

The effect of (GPS) All parts of studying is critical and boundless. Utilizing a reference ellipsoid, the X, Y, Z arrange characterized regarding WGS84. Ellipsoid stature can't be utilized in applications except if they are Adjusted into orthometric tallness described as an embraced equipotential surface. Using geoid height (N), orthometric height (H) can be related in terms to the ellipsoidal height (h) of a point:

\[ N = h - H \]

Where:
N is the geoidal height.
H is the orthometric height.
h is the ellipsoidal height

The geoidal heights or geoidal undulations are N, h is the height based on ellipsoid or GPS, and H is the height based on MSL orthometric. The association of ellipsoidal, orthometric, and geoid heights, as seen in Fig.1,[6].

![Figure 1. Ellipsoid Height Relationship to Geoid Height, [13]](image-url)
2.2. Global Geopotential Models (GGMs)

Different GGMs have been established by various conferences over the last 30 years. To better determine orbits and height structures in science and engineering, our understanding of the Earth's gravity field, both in terms of accuracy and spatial resolution, must be dramatically enhanced. The GGM is used to calculate the long-wavelength portion of the gravitational field of the Earth and consists of a collection of fully condensed, spherical harmonic coefficients derived from the integration of gravity data from satellite measurements, land, and ship-track, Anomalies of underwater gravity resulting from satellite radar altimetry and airborne gravity data[7].

Instances, the more important well-known GGMs applied for geoid demonstrating calculations are the Earth Geopotential Models (EGM 2008), (EGM96), and (EGM84). The nature of choosing the GGMs utilized extraordinarily influences the exactness of the processed geoid. These worldwide models have been created from the mix of satellite irritation investigation With satellite field gravity and altimetry information. A short depiction for three GGMs, the most well-known worldwide, is followed,[8].

**Earth Gravitational Model of 1984 (EGM84)**

The EGM84 is a gravitational model of the Earth that gave us a lot of geopotential coefficients to degree and request 180. A 30-minute overall geoid tallness model for the first W.G.S. 84 ellipsoid is precomputed from EGM84. The coefficient and geoid stature records have related programming and archives: three FORTRAN projects can introduce from the network providing geoid tallness at some random scope and longitude. EGM84 was affirmed for legitimate use by the United States Department of Defense (DoD) as reported in D.M.A. TR8350.2, Second Edition, 1 September 1991,[9].

**Earth Gravitational Model of 1996 (EGM96)**

The EGM96 is a gravitational model of the earth that gave us a lot of geopotential coefficients to a degree, and request 360 corresponds to the spatial resolution of 55 km. This model is created in a joint effort by The National Organization for Imaging and Mapping, NASA Goddard, and Ohio State University Space Flight Center. According to LSM (least square Method), calculations are based on the aggregation method, JGM-2 / OSU91A geode model (JU 2 / Ohio State University 91a) used as a reference for longwave effects.

A 15-minute overall geoid tallness record is precomputed from the EGM96. The coefficient and geoid tallness records have related programming and reports: a FORTRAN program, named F477, grants to compute undulation dependent on geographic directions. EGM96 was affirmed for legitimate use by DOD. as 4 July 1997. EGM96, incorporating newly accessible gravimetry information, has upgraded the past mainland geoid model,[9].

**Earth Gravitational Model of 2008 (EGM2008)**

The EGM2008 is a gravitational model of the Earth, provided by a minimum square combination of the gravitational model ITG-GRACE03S (with its associated blunder covariance lattice) a 5'x5' free-air gravity irregularity matrix. This matrix results by integrating details referring to terrestrial, altimetry inspired, and airborne gravity. Their ghost material was updated with geologically determined gravitational data over regions where only lower targets were eligible for gravity information. Up to degree / request 2159, EGM2008 is generated with certain additional words up to degree/request 2190,[10].

EGM2008 depends On the ITG-GRACE03S gravity field model GRACE (Gravity Recovery and Atmosphere Experiment), which provides a fundamentally precise description of the long-and medium-frequency gravity field scale up to 180.0 degrees and order. Model ITG-GRACE03S joins right around six years of GRACE gravity field perceptions. And different wellsprings of gravity information, especially point gravity estimations.
Consequently, the EGM2008 circular consonant coefficients should be extended to degree 2190 instead of 2159 or 2160 when utilized in practical applications.

Commission errors for semi/geoid undulations of EGM2008 are calculated to be ~15 cm. The most severe deficiencies encountered in bumpy areas of Asia and South America (around ~30-40 cm) and Antarctica (around 100 cm). Instead, certain areas of Europe, Oceania, North America, notice the least commission mistakes. Given the utilization of thick arrangements of altimetry-inferred gravity – the seas,[11].

The EGM2008 semi/geoid commission blunders are, for the most part, sat the degree of ~ 5 cm for those regions with high surface gravity available. The Earth Geopotential Model 2008 (EGM2008) is the latest adaptation of a progression of geopotential models developed by the National Geospatial-Intelligence Agency. It incorporates core consonant coefficients obtained from the GRACE satellite, gravity irregularities obtained from satellite altimetry, and various earthly gravity irregularities.

E.G.M. 2008 is the latest geopotential earth model developed by the least-square blend of the ITG-GRACEEO35 gravitational model and its corresponding blunder covariance system gravitational data acquired from a region's worldwide arrangement-mean disturbances of free-air gravity marked on a 5-circular minute lattice section. This lattice was framed by consolidating knowledge concerning earthbound, altimetry-determined, and airborne gravity. With gravitational data implied by the geology, their ghastly material has been enhanced over zones where available. It does not consolidate any of the vertical knowledge G.P.S./Leveling or Astronomic redirections [12].

Just because This gravitational model is finished with the round consonant degree and request 2159, and includes numerous coefficients exceeding 2190 and 2159. EGM2008 's spatial (half-frequency) targets on the equator are (ostensibly) 9.3x9.3 km, which is several times greater than EGM996. EGM96 Over and more seasoned G.G.M.s, E.G.M. 2008 speaks to progress by six in goals, and by variables of three to six in exactness relying upon the gravitational amount and geographic territory, [10].

2.3. Evaluation of GGMS
To perform the process of evaluating the accuracy of the geode model in a specific geographic region, the geoid undulations for all observed points (local geoid) Nobs are compared with the ripple values for the global patterns chosen in this paper. Later, The difference between the values shall be determined by all differences at each point. So, the global model precision index will reflect this standard deviation. By way of an equation:

\[ dN = N_{\text{OBS}} - N_{\text{GGM}} \] (2)

where

- \( N_{\text{OBS}} \) is the difference between ellipsoidal heights "h" and orthometric heights "H."
- \( N_{\text{GGM}} \) is geode undulations for Geode Global Models.

3. Study Area and Available Data
The chosen study area is the campus of the University of Baghdad in the heart of the capital, Baghdad, on the side of Al-Rusafa in the Al-Jadiriya complex, Al-Karrada neighborhood, surrounded by the Tigris River from three directions, meaning that it is located in a peninsula near the Ministry of Science and Technology and is shown in as shown in fig.2. Located between longitude and latitude 44 22 54.19 m,3616 12.4m. The chosen area extends between the longitude (33.2701 IDS) easting and the latitude (44.38172 IDS) northing, which covers an area of around 3km².

The number of points observed is 57 points used the Differential Global Positioning system (DGPS) and leveling together for the same observed issues, known as geometric local Geoid, to determine geoid height (h-H). The Ellipsoid measurement can be obtained with the DGPS, while the orthometric size can be obtained using the leveling tool.
4. Results and Discussion

Local geoid and Global Gravitational Models

The geometric local Geoid by applying the equation (1) that can be obtained the geode undulation values for the points observed Available

The number of points used is 57 by DGPS measurements and leveling being performed for these points. Unfortunately, the points are not regularly distributed throughout the study area's territory, and they have been obtained from different sources. The coordinates of GPS points are in the World Geodetic System 1984 (WGS84) coordinate system. The statistics of the used DGPS/leveling results are presented in Table (1), the local geoid's height values.

Global gravitational models (GGMs) Data [EGM08, EGM96, EGM84].

For computing geoid undulation(N), by using EGM2008, Online calculations are used web site:https://geographiclib.sourceforge.io/cgi-bin/GeoidEval.

The geoid height can be calculated above WGS84 ellipse using internal completion in a network of values for Earth Gravity models, EGM84, or EGM96, EGM2008. The great advantage in this way is that it can be calculated in real-time and for three models. Selecting the location in terms of latitude and longitude; for example, see this program works as shown in the fig.3, results are presented in Table (2):

![Figure 2](image)

**Figure 2.** The points which are monitored by (DGPS/LEVELING) for the study Region.

![Figure 3](image)

**Figure 3.** [Online geoid calculations by using the Geoid Eval utility].
| Point No. | Northing (m) | Easting (m) | Ellipsoidal height h (m) | Orthometric height H (M.S.L) (m) |
|-----------|--------------|-------------|--------------------------|----------------------------------|
| BU01      | 3681622.477  | 442158.483  | 34.5552                  | 36.271                           |
| BU02      | 3681641.119  | 441821.245  | 35.1578                  | 36.906                           |
| BU03      | 3681646.752  | 442271.423  | 34.5022                  | 36.369                           |
| BU04      | 3681717.383  | 441480.99   | 36.3873                  | 38.242                           |
| BU05      | 3681756.014  | 441869.274  | 35.7915                  | 37.345                           |
| BU06      | 3681848.047  | 442032.804  | 34.1972                  | 35.934                           |
| BU07      | 3681828.833  | 442952.868  | 35.4727                  | 37.025                           |
| BU08      | 3681905.955  | 441876.638  | 35.2064                  | 37.173                           |
| BU09      | 3681912.62   | 441946.785  | 34.2758                  | 36.153                           |
| BU10      | 3681911.887  | 442069.661  | 35.3165                  | 36.867                           |
| BU11      | 3681949.221  | 442265.198  | 35.1257                  | 37.07                            |
| BU12      | 3682018.665  | 442240.00   | 35.3347                  | 36.95                            |
| BU13      | 3681583.049  | 442107.802  | 34.548                   | 36.319                           |
| BU14      | 3681594.571  | 441776.986  | 34.4333                  | 36.075                           |
| BU15      | 3681625.908  | 441584.439  | 36.2443                  | 37.621                           |
| BU16      | 3681625.188  | 441875.697  | 35.5055                  | 37.17                            |
| BU17      | 3681645.93   | 441789.195  | 35.3775                  | 36.937                           |
| BU18      | 3681655.103  | 441697.41   | 36.2296                  | 37.427                           |
| BU19      | 3681659.146  | 441896.620  | 36.5345                  | 36.278                           |
| BU20      | 3681668.477  | 441829.946  | 35.5159                  | 37.191                           |
| BU21      | 3681695.023  | 442026.201  | 34.4483                  | 36.251                           |
| BU22      | 3681695.209  | 442201.861  | 34.5521                  | 36.261                           |
| BU23      | 3681712.222  | 442293.025  | 34.1764                  | 35.93                            |
| BU24      | 3681734.101  | 442394.825  | 34.4988                  | 36.361                           |
| BU25      | 3681742.759  | 441923.005  | 35.5912                  | 37.19                            |
| BU26      | 3681764.947  | 441920.809  | 34.4304                  | 36.085                           |
| BU27      | 3681763.181  | 442217.27   | 35.3766                  | 37.033                           |
| BU28      | 3681774.058  | 441942.077  | 34.1916                  | 36.051                           |
| BU29      | 3681790.089  | 441784.888  | 35.2071                  | 37.18                            |
| BU30      | 3681794.279  | 442322.228  | 35.0626                  | 36.55                            |
| BU31      | 3681816.006  | 441828.500  | 35.3295                  | 37.167                           |
| BU32      | 3681815.803  | 442068.830  | 34.4222                  | 36.073                           |
| BU33      | 3681829.915  | 442181.706  | 35.4517                  | 37.182                           |
| BU34      | 3681848.047  | 442032.804  | 35.0313                  | 36.68                            |
| BU35      | 3681856.927  | 441783.731  | 35.3022                  | 37.195                           |
| BU36      | 3681897.294  | 442192.973  | 35.3493                  | 37.157                           |
| BU37      | 3681907.554  | 441815.337  | 35.3007                  | 37.170                           |
| BU38      | 3681904.639  | 442304.514  | 34.6622                  | 36.310                           |
| BU39      | 3681953.127  | 441902.214  | 35.1395                  | 36.831                           |
| BU40      | 3681950.55   | 441990.214  | 35.1395                  | 36.831                           |
| BU41      | 3681967.148  | 442386.084  | 34.5303                  | 36.332                           |
| BU42      | 3681967.438  | 442361.283  | 34.6088                  | 36.277                           |
| BU43      | 3681978.494  | 442107.310  | 35.2754                  | 37.029                           |
| BU44      | 3681999.104  | 441545.031  | 36.0344                  | 37.578                           |
| BU45      | 3682045.226  | 441711.390  | 34.2044                  | 36.055                           |
| BU46      | 3682043.878  | 442091.660  | 35.0048                  | 36.395                           |
| BU47      | 3682065.388  | 442359.017  | 34.2077                  | 36.217                           |
| BU48      | 3682114.854  | 442016.286  | 34.2957                  | 35.939                           |
| Point No. | Nobs(h-H)(m) | N(EGM08) | N(EGM96) | N(EGM84) |
|----------|--------------|-----------|-----------|-----------|
| BU01     | -1.7158      | -1.6129   | -2.2424   | -3.1893   |
| BU02     | -1.7482      | -1.6025   | -2.2317   | -3.1762   |
| BU03     | -1.8668      | -1.6158   | -2.2453   | -3.1931   |
| BU04     | -1.8547      | -1.5907   | -2.2196   | -3.1619   |
| BU05     | -1.5535      | -1.6015   | -2.2307   | -3.1759   |
| BU06     | -1.7368      | -1.6067   | -2.236    | -3.1825   |
| BU07     | -1.5523      | -1.6055   | -2.2348   | -3.1814   |
| BU08     | -1.9666      | -1.5987   | -2.2277   | -3.1733   |
| BU09     | -1.8772      | -1.6006   | -2.2297   | -3.1758   |
| BU10     | -1.5505      | -1.6043   | -2.2335   | -3.1804   |
| BU11     | -1.9443      | -1.6093   | -2.2386   | -3.1871   |
| BU12     | -1.6153      | -1.6072   | -2.2363   | -3.1848   |
| BU13     | -1.771       | -1.6122   | -2.2417   | -3.1882   |
| BU14     | -1.6417      | -1.6021   | -2.2314   | -3.1754   |
| BU15     | -1.3767      | -1.5957   | -2.2248   | -3.1675   |
| BU16     | -1.6645      | -1.6008   | -2.2301   | -3.1741   |
| BU17     | -1.5595      | -1.6014   | -2.2306   | -3.1749   |
| BU18     | -1.1974      | -1.5985   | -2.2276   | -3.1713   |
| BU19     | -1.7435      | -1.6043   | -2.2336   | -3.1787   |
| BU20     | -1.6751      | -1.6022   | -2.2314   | -3.176   |
| BU21     | -1.8027      | -1.6075   | -2.2368   | -3.183   |
| BU22     | -1.7089      | -1.6127   | -2.2422   | -3.1896   |
| BU23     | -1.7536      | -1.615    | -2.2446   | -3.1927   |
| BU24     | -1.8622      | -1.6176   | -2.2472   | -3.1961   |
| BU25     | -1.5988      | -1.6034   | -2.2327   | -3.1781   |
| BU26     | -1.6546      | -1.6029   | -2.2321   | -3.1776   |
| BU27     | -1.6564      | -1.6117   | -2.2412   | -3.1889   |
| BU28     | -1.8594      | -1.6033   | -2.2326   | -3.1783   |
| BU29     | -1.9729      | -1.5983   | -2.2274   | -3.172   |
| BU30     | -1.4874      | -1.6142   | -2.2437   | -3.1922   |
| BU31     | -1.8375      | -1.5991   | -2.2282   | -3.1732   |
| BU32     | -1.6508      | -1.6063   | -2.2355   | -3.1823   |
| BU33     | -1.7303      | -1.6093   | -2.2387   | -3.1862   |
| BU34     | -1.6487      | -1.6045   | -2.2337   | -3.1803   |
| BU35     | -1.8928      | -1.5969   | -2.2259   | -3.1707   |
| BU36     | -1.8077      | -1.6083   | -2.2375   | -3.1854   |
| BU37     | -1.8693      | -1.5968   | -2.2258   | -3.1709   |
| BU38     | -1.6478      | -1.6114   | -2.2408   | -3.1894   |
| BU39     | -1.7223      | -1.5867   | -2.2154   | -3.1584   |
Evaluation of GGMS in the Study Area

To perform the process of evaluating the accuracy of the geode model in a specific geographic region. The geoid undulations for all observed points of local Geoid (N obs) are compared with the ripple values for the global patterns chosen in this research, [NEGM08, NEGM96, and, NEGM84].

Later, All the variations are determined according to the difference between the values at each point. That standard deviation would then reflect the global model accuracy index. The three gravimetric models of the Geoid for the territory of (EGM2008 and EGM96, EGM84) were compared with 57 points with high accurate leveling and DGPS determinations to evaluate the performance of selected GGMs in the Area of study applying the previously mentioned equation (2). the statistics of the obtained results are shown in Table (3):

| Point No. | dN (EGM08) m | dN(EGM96) m | dN(EGM84) m |
|-----------|--------------|--------------|--------------|
| BU01      | -0.1029      | 0.5266       | 1.4735       |
| BU02      | -0.1457      | 0.4835       | 1.428        |
| BU03      | -0.251       | 0.3785       | 1.3263       |
| BU04      | -0.264       | 0.3649       | 1.3072       |
| BU05      | 0.048        | 0.6772       | 1.6224       |
| BU06      | -0.1301      | 0.4992       | 1.4457       |
| BU07      | 0.0532       | 0.6825       | 1.6291       |
| BU08      | -0.3679      | 0.2611       | 1.2067       |
| BU09      | -0.2766      | 0.3525       | 1.2986       |
| BU10      | 0.0538       | 0.683        | 1.6299       |
| BU11      | -0.335       | 0.2943       | 1.2428       |
| BU12      | -0.0081      | 0.621        | 1.5695       |
| BU13      | -0.1588      | 0.4707       | 1.4172       |
| BU14      | -0.0396      | 0.5897       | 1.5337       |
| BU15      | 0.219        | 0.8481       | 1.7908       |
| BU16      | -0.0637      | 0.5656       | 1.5096       |
| BU17      | 0.0419       | 0.6711       | 1.6154       |
| BU18      | 0.4011       | 1.0302       | 1.9739       |
| BU19      | -0.1392      | 0.4901       | 1.4352       |
To choose the best GGM to be used, a review of outcomes was carried out in (Baghdad University) zone. as shown in the table (4).

Table 4. Statistical Function for Geoid Undulations Difference (dN) Computed using, EGM2008, EGM96, and EGM96.

| Statistical function | dN (EGM08) m | dN(EGM96) m | dN(EGM84) m |
|----------------------|--------------|--------------|--------------|
| maximum              | 0.4011       | 1.0302       | 1.9739       |
| minimum              | -0.3996      | 0.2296       | 1.1791       |
| Range                | 0.8007       | 0.8006       | 0.7948       |
| Average              | -0.11125614  | 0.51795      | 1.46493      |
| St. Deviation        | 0.152859622  | 0.15286      | 0.15252      |
10

Figure 4. The geoid undulation differences (dN) between (N) and \((N_{\text{GGMs}})\).

The results are clear in the table (4) and shown clearly and explicitly in fig 4. The model (EGM08) is more accurate compared to the rest of the models, as it comes first, second is (EGM96), and last the (EGM84). A comparison of the DGPS / leveling method (local geoid) was performed using the EGM2008 geode corrugation model for the study area and presented in table (5).

Table 5. Geoid Undulations of GPS/Leveling observations and their values of the EGM2008 model.

| Method          | Maximum(m) | minimum(m) | Mean(m)  | St. Deviation |
|-----------------|------------|------------|----------|---------------|
| DGPS/Leveling   | -1.1974    | -2.0093    | -1.7161  | 0.15347       |
| (EGM08) m       | -1.5867    | -1.6176    | -1.604824| 0.006905      |
| Difference      | 0.4011     | -0.3996    | -0.111256| ±0.152859     |

The comparison results show that the accuracy of the geoid undulations is within ±0.18797 meters. The geodes' undulation's accuracy is almost perfect, with a study area of about 3 square kilometers, a relatively small area compared to the geodes' surface, in Fig.5. It can be found that the EGM08 is the closer GGMs to the local geodetic dataset measured, in terms of the geodetic undulation gap with a maximum of (0.4011 m), a minimum of (0.3996 m), an average of [-0.111256 m], and a standard deviation of [±0.152859].

Figure 5. Accuracy of geoid undulation difference between Geoid undulations (GPS/Leveling) observations and their values of the EGM2008 model.

5. Conclusions
The current study has investigated the GPS/leveling geoid modeling technique. Additionally, an evaluation of the performance of GGMs for several selected models in the study region has been carried out.
1. The value practically measured by field survey highest value (-1.1974 m) the lowest value (-2.0506 m).

2. When evaluating the accuracy of the models used in the study area, the study showed that the EGM2008 Earth Gravity Model represents more accurately a model of the true gravitational potential of the Earth compared to others.

   It was found that this model produces differences in geoid undulation in the study area ranging from (0.4011 m) to (0.3996 m) with an average of (0.111 m) and a standard deviation (SD.) Equal to [± 0.152 meters].

6. Recommendations
   Some recommendations for future research may be suggested:

   The lack of local Iraqi data tends to impact global spatial models. Therefore, the incorporation of local Iraqi data into any emerging global, regional models is strongly recommended. To enhance their efficiency in reflecting the medium and long gravitational field wavelength across Iraq, it is strongly recommended to use [GPS / leveling] across Iraq in the future with adequate and well-distributed points to boost the accuracy of geode detection in cooperation with all Iraqi survey authorities.

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