BRIEF RESEARCH REPORT
published: 30 March 2022
doi: 10.3389/fphy.2022.804711

Introduction of the Hezar International Gravity Formula

Mehdi Hassanpour[1], Mohammad Reza Rezaie[2]*, Saeedeh Khezripour[3], Mohammad Rashed Iqbal Faruque[1]* and Mayeen Uddin Khandaker[4]*

[1]Space Science Centre (ANGKASA), Institute of Climate Change (IPI), Universiti Kebangsaan Malaysia, Bangi, Malaysia, [2]Department of Nuclear Engineering, Faculty of Modern Sciences and Technologies, Graduate University of Advanced Technology, Kerman, Iran, [3]Department of Photonics, Faculty of Modern Science and Technology, Graduate University of Advanced Technology, Kerman, Iran, [4]Centre for Applied Physics and Radiation Technologies, School of Engineering and Technology, Sunway University, Subang Jaya, Malaysia

OPEN ACCESS

Edited by:
Frank Franz Deppisch, University College London, United Kingdom

Reviewed by:
Emmanuel N. Saridakis, Baylor University, United States
Kazuharu Bamba, Fukushima University, Japan
Polina Lemenkova, Université libre de Bruxelles, Belgium

***Correspondence:**
Mehdi Hassanpour
mhassanpour67@yahoo.com
Mohammad Reza Rezaie
mr.rezaie@kgut.ac.ir
Mohammad Rashed Iqbal Faruque
rashed@ukm.edu.my

Specialty section:
This article was submitted to Interdisciplinary Physics, a section of the journal Frontiers in Physics

Received: 29 October 2021
Accepted: 03 March 2022
Published: 30 March 2022

Citation:
Hassanpour M, Rezaie MR, Khezripour S, Faruque MRI and Khandaker MU (2022) Introduction of the Hezar International Gravity Formula. Front. Phys. 10:804711. doi: 10.3389/fphy.2022.804711

The National Cartographic Center of Iran measured the differences in gravity between the Hezar summit and peak of Mount Damavand using a CG-5 gravity meter. The gravity recorded at the Hezar summit (4,499.416 m) was 213 mGal (0.00213 m/s^2) lower than the reading recorded at the peak of Mount Damavand (5,605.730 m). Recently, the exact value of gravity at the Hezar summit and peak of Damavand mount have been measured. This study attempts to modify the conventional version of Hezar International Gravity Formula (HIGF) to calculate the experimental gravity in the Earth's summits and land surfaces. Apart from describing the 213 mGal difference in gravity between Hezar summit and peak of Mount Damavand, HIGF is also in agreement with practical gravity with distance from sea level and latitude (93% confidence level). The results indicated that the experimental HIGF as $g = 978{,}031.85\ (1 + 0.0053024\ \sin^2\theta - 0.000032309786\ \sin^2 2\theta) - 0.27\,h$ was in agreement with the practical gravity compared to the 1984 International Gravitational Formula (IGF84).

Keywords: Earth gravity, hezar summit, IGF84, HIGF, coefficients

INTRODUCTION

The Earth is spheroidal and its surface is spheroid. In 1930, the International Gravity Formula (IGF) was adopted to calculate the theoretical value of gravity at any point on the spheroid. The 1930 IGF was based on Clairaut's model, which was first developed in 1777. The 1930 IGF also incorporated the Potsdam datum. However, the 1930 IGF was further modified in 1967 by Geodetic Reference System (GRS 67), which was then refined and described by Woollard in 1979 using accurate satellite data by Jacobs in 1974. The GRS 67 was compatible with the International Gravity Standardisation Net 1971 datum. The differences between the 1930 IGF and GRS 67 were discussed by Lysonski [1]. The IGF does not explicitly depend on the Earth's flattening because it is a theoretical gravity model [2]. Moreover, various systematic errors in computing the normal gravity were observed at the topographical surface on the Earth [3]. Hence, the new formulation of gravity required the computation of normal gravity at different points. The two Earth Gravitational Models (EGM) that are the best models to calculate gravity include EGM96 and EGM2008 [4], while the best-known IGFs are GRS30, GRS1967, GRS80 and WGS84 [5, 6]. Of which, the WGS84 equation was modified by several scholars [1, 6–8].

Almost all of the above mentioned models are theoretical models to estimate Earth's gravity. Therefore, this study focuses on the formulation of an experimental model to estimate Earth's gravity. The study revealed that the WGS84 model cannot explain the experimental gravity of the

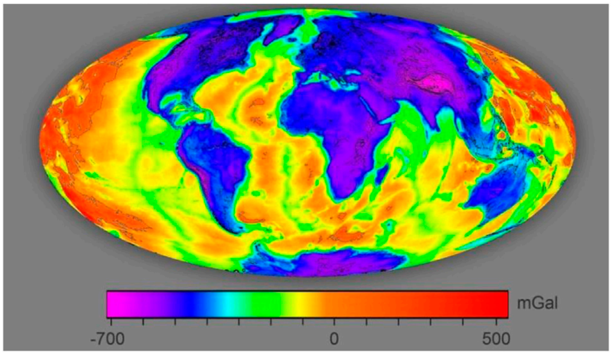

FIGURE 1 | Bouguer gravity anomaly of the world [11].

summits and the Earth's surface, including the difference of −203 mGal in gravity between the peaks of the Hezar and Damavand mountains (4,499.416 m and 5,605.730 m, respectively) [9]. According to the physical geodetic survey performed at the National Cartographic Center of Iran (NCC), the gravity of summit Hezar is 203 mGa l lower than that of Mount Damavand's peak. Therefore, the Hezar summit unexpectedly has a low gravity value throughout Iran. In the present study, we introduced a new four-coefficient gravimetric formula where the coefficients are calculated using experimental gravity data from four-point sets around the world. This experimental gravity equation was introduced in the form of the Hezar International Gravitational Formula (HIGF). The gravity at different elevations and latitudes can be measured using the HIGF and compared with the modified IGF84 (WGS84) [8]. The main novelty of this study is the formulation of four coefficients gravity formula based on the gravity measurement above sea level. In the following section, details of the HIGF equation are explained.

The Four Coefficients Gravity Formula

Since the Earth is spherical, the gravity is calculated using **Eq. 1**:

$$g = G\frac{M}{r^2} \tag{1}$$

Where G is the gravitational constant, M is the mass of the Earth and r is the distance from the centre of the Earth.

The effects of non-spherical Earth, rotation of the Earth, distance of the elliptical Earth, free air correction [8] and the Bouguer phenomenon [10] on gravity were also investigated. The IGF with four coefficients was introduced as **Eq. (2)** [1, 5–7].

$$g = A + B\sin^2\theta + C\sin^2 2\theta - Dh \tag{2}$$

Where h and θ denote the height and latitude, respectively.

The changes in gravity due to the heights of the ellipsoidal Earth are introduced as 0.3086h [8]. The effect of Bouguer anomaly defined by the function of the density of the rock (ρ = 2.65 $g.m^3$) and the height (h) is denoted as 0.04193ρh [8]. Therefore, accurate gravitational values can be obtained everywhere depending on the global Bouguer gravity anomaly illustrated in **Figure 1** [11].

The detail for **Eq. (2)** calculation is as below:

Earth is considered to be in three forms. In the first form, the Earth is ellipsoidal in uniformity with a radius, r, with $r = R_e$ ($-F\, Sin^2\theta$), where F is denoted in **Eq. 3**.

$$F = \frac{R_e - R_o}{R_e} \tag{3}$$

F is the asymmetry parameter of the spherical, R_e is the radius of the Earth at the equator and θ is the latitude. In the second form, the geoid is considered to be approximately +150 to −150 m above or below the elliptical Earth. The final form refers to the uneven distance on the surface of the Earth (h) from the elliptical Earth. According to the non-sphericity of the Earth and the changes in distance from the centre of the Earth, the interval change between each point on Earth and the centre of Earth is defined in **Eq. (4)**:

$$r = R_e(1 - F\,Sin^2\theta) + h \tag{4}$$

$$r = R_e\left(1 - FSin^2\theta + \frac{h}{R_e}\right) \tag{5}$$

$$g = g_e\left(1 - 2\frac{h}{R_e} + 2FSin^2\theta + 3F^2Sin^4\theta + 3\left(\frac{h}{R_e}\right)^2 - 6Sin^2\theta\right) \tag{6}$$

According to the small amount of the last two terms, **(Eq. 6)** can be reiterated as **Eq. 7**.

$$g = g_e(1 + 2FSin^2\theta + 3F^2Sin^4\theta) - 2\frac{g_e}{R_e}h \tag{7}$$

The acceleration due to Earth's rotation is represented by **Eq. 8**.

$$a_R = R\omega^2 = (r + h)Cos\theta\omega^2 \tag{8}$$

The component of a_R in the direction of r is presented as **Eqs 9**, **10**.

$$a_r = a_R Cos\theta \tag{9}$$

$$a_r = (r + h)Cos^2\theta\omega^2 \tag{10}$$

Using **Eq. (5)** and **(Eq. 10)** can also be modified into **Eq. 11**.

$$a_r = R_e\omega^2Cos^2\theta - \frac{F\,R_e\,\omega^2}{4}Sin^2 2\theta + h\omega^2Cos^2\theta \tag{11}$$

The effects of rotation on Earth's gravity is obtained by substituting **Eq. 7** and **(11)** with **Eq. 12**.

$$g = g_e\left(1 - \frac{R_e\,\omega^2}{g_e} + \left(2F + \frac{R_e\,\omega^2}{g_e}\right)Sin^2\theta + 3F^2Sin^4\theta + \frac{2F\,R_e\,\omega^2}{4\,g_e}Sin^2 2\theta\right) - \left(2\frac{g_e}{R_e} + \omega^2Cos^2\theta\right)h \tag{12}$$

By ignoring $\omega^2Cos^2\theta$, because $\omega^2 << 1$, **Eq. (12)** is expressed as **Eq. 13**.

TABLE 1 | The gravity of many locations in the world calculated using HIGF and IGF84 [13–15].

Location	Elevation m	Latitude Rad	IGF84 mGal	HIGF mGal	Experimental mGal	Exp-HIGF mGal	Exp-IGF84 mGal
Esbjerg, Jutland (Denmark)	16.387	0.96803535	981,541.9	981,519.03	981,553.1	34.06534	11.24571
Hirtshals, Jutland (Denmark)	26.881	1.00503,668	981,715.4	981,694.41	981,718.8	24.38761	3.354,099
Hvinningedal Kirke, Jutland (Denmark)	119.523	0.980407466	981,569.8	981,,551.36	981,622.1	70.73796	52.33907
Longelse Kirke, Langeland (Denmark)	19.437	0.958602893	981,495	981,471.97	981,506.3	34.329	11.30771
Middelfart, Fyn (Denmark)	33.999	0.968891609	981,540.6	981,518.46	981,561.1	42.63823	20.52811
Mommark, Als (Denmark)	17.217	0.958651239	981,495.9	981,472.81	981,509.5	36.69183	13.58645
Nyborg, Fyn (Denmark)	3.823	0.965266211	981,532.3	981,508.88	981,541.5	32.61635	9.216,541
Sjørup, Jutland (Denmark)	47.214	0.984824196	981,613.3	981,592.23	981,614.2	21.97052	0.942,994
Spjald, Jutland (Denmark)	66.251	0.978968966	981,579.3	981,558.78	981,596.4	37.62206	17.11457
Thisted, Jutland (Denmark)	43.104	0.99364893	981,656.6	981,635.76	981,667.4	31.6417	10.78859
Århus, Jutland (Denmark)	85.181	0.980684973	981,581.7	981,561.98	981,605	43.02238	23.30801
Geological Museum (Indonesia)	719	0.120398571	977,885.3	977,910.73	977,976.4	65.66558	91.11439
Merapi Volcano Observatory (Indonesia)	107	0.136135682	978,094.8	978,096.19	978,202.8	106.6073	108.0324
Auckland (New Zealand)	79	0.643153829	979,868.3	979,846.61	979,943.3	96.68971	75.02251
Hastings (New Zealand)	20	0.692081168	980,132.9	980,107.77	980,083.6	−24.1664	−49.261
Lower Hutt (New Zealand)	3	0.719715664	980,279.5	980,253.3	980,289.5	36.20487	10.0062
Opotiki (New Zealand)	10	0.663341529	979,990.5	979,965.65	980,003.2	37.55351	12.69503
Rotorua (New Zealand)	286	0.66563943	979,916.9	979,902.63	979,962.6	59.97105	45.71076
Russell (New Zealand)	5	0.615490361	979,754.8	979,731.1	979,820.7	89.59854	65.91314
Te Araroa (New Zealand)	5	0.656854664	979,959.5	979,934.6	979,907	−27.6041	−52.494
Wellington (New Zealand)	122	0.720588329	980,247.3	980,225.64	980,261.8	36.16201	14.54507
Whangamomo (N ewZealand)	156	0.683238283	980,045.9	980,026.27	980,072.8	46.52511	26.85495
Christchurch A (New Zealand)	7	0.759509171	980,483.6	980,457.2	980,504.6	47.39548	20.97563
Christchurch (New Zealand)	5	0.759509171	980,484.2	980,457.74	980,504.1	46.35548	19.85843
Dunedin (New Zealand)	10	0.800524234	980,695.3	980,668.97	980,,737	68.03248	41.68252
Hokitika (New Zealand)	2	0.745604656	980,413.2	980,386.72	980,408.1	21.38022	−5.13813
Monowai (New Zealand)	165	0.799098998	980,640.1	980,619.72	980,647.7	27.97575	7.604,542
Mt Cook (New Zealand)	748	0.763348895	980,274.8	980,277	980,267.3	−9.70086	−7.53718
Queenstown (New Zealand)	314	0.785979882	980,526.1	980,511.44	980,499.5	−11.9448	−26.584
Takaka (New Zealand)	3	0.712647081	980,243.2	980,217.11	980,270.4	53.28886	27.19041
Panahgah (Iran)	4,202.318	0.592001196	978,345.8	978,484.96	978,780.4	295.4399	434.5799
Equater	0	0	978,032.7	978,031.85	978,031.9	0.05	−0.78
Pole	0	1.570796327	983,218.6	983,217.77	983,217.8	0.033919	−0.80048
Abshar Yakhi (Iran)	5,297.899	0.627183369	978,178.7	978,358.97	978,491.3	132.3296	312.5801
Tochal Summit (Iran)	3,982	0.626301803	978,580.5	978,,709.95	978,827.9	117.9474	247.4313
Ncc (Iran)	1,181	0.623043099	979,428.8	979,450.31	979,430.7	−19.6124	1.854,253
Astara (Iran)	20	0.668260914	980,012.2	979,987.59	980,047.3	59.71155	35.12162
Damavand Summit (Iran)	5,605.73	0.627473093	978,085.1	978,277.27	978,392.2	114.9268	307.0507
Hezar (Iran)	4,499.416	0.515075809	977,898.4	978,052.17	978,178.2	126.0299	279.8172
Gosfand Sara (Iran)	3,027.38	0.626608806	978,876.6	978,969.2	979,053.5	84.29915	176.9253
Abali (Iran)	3,177	0.624688246	978,821	978,919.42	979,032.6	113.18	211.6409
Tochal7 (Iran)	3,795	0.626265325	978,638	978,760.26	978,893.1	132.8357	255.1025
Tochal5 (Iran)	3,004	0.625861456	978,880.1	978,971.86	979,070.4	98.53945	190.2862
Tochal2 (Iran)	2,414	0.625399991	979,059.9	979,128.91	979,183.6	54.69404	123.681
Tochal1 (Iran)	1,888	0.625069426	979,220.6	979,269.31	979,290.3	20.98863	69.68228
Lowshan (Iran)	799	0.638404788	979,622.5	979,628.77	979,,612.3	−16.4694	−10.2099
Lahijan (Iran)	127	0.649235778	979,883.8	979,863.77	979,,951.9	88.12703	68.14594

$$g = g_e\left(1 - \frac{R_e\,\omega^2}{g_e} + \left(2F + \frac{R_e\,\omega^2}{g_e}\right)Sin^2\theta + 3F^2Sin^4\theta + \frac{2F\,R_e\,\omega^2}{4\,g_e}Sin^2 2\theta\right) - \left(2\frac{g_e}{R_e}\right)h \tag{13}$$

The second part of **Eq. (13)** involving free-air correction presents the gravity changes due to the height of the ellipsoidal Earth, 0.3086 h [8]. Moreover, the effect of the Bouguer anomaly in **Eq. (13)** requires the formulation of the overall Bouguer effect as a function of the density of the rock ($\rho = 2.65\,g/cm^3$) and the height (h) denoted as 0.04193 ρh [8]. Therefore, accurate gravity can be measured everywhere depending on the global Bouguer gravity anomaly (**Figure 1**) [11].

By introducing $A = g_e\,(1 - \frac{R_e\,\omega^2}{g_e})$, $B = g_e\,(2F + \frac{R_e\,\omega^2}{g_e})$, $C = \frac{F\,R_e\,\omega^2}{2}$, *and* $D = (2\frac{g_e}{R_e})$, **Eq. (13)** can be rewritten as **Eq. (2)**.

Coefficients A, B, C and D were calculated through the theoretical investigation of IGF84. In this study, coefficients A, B, C, and D were determined, and the HIGF formula was introduced using the experimental Earth gravitation data. The

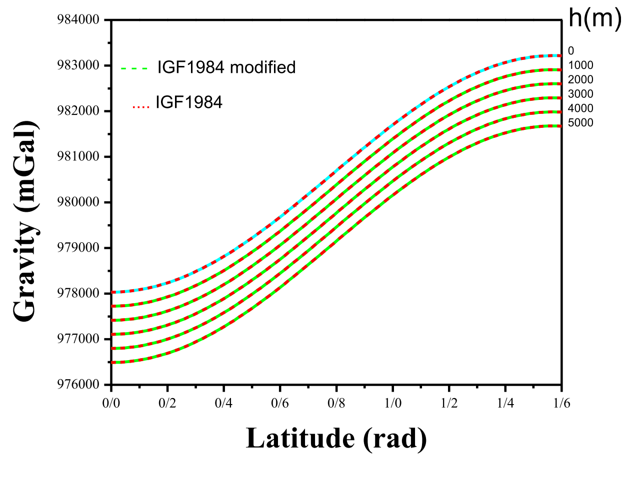

FIGURE 2 | Behaviours of g84 m and g84 versus latitude at different heights.

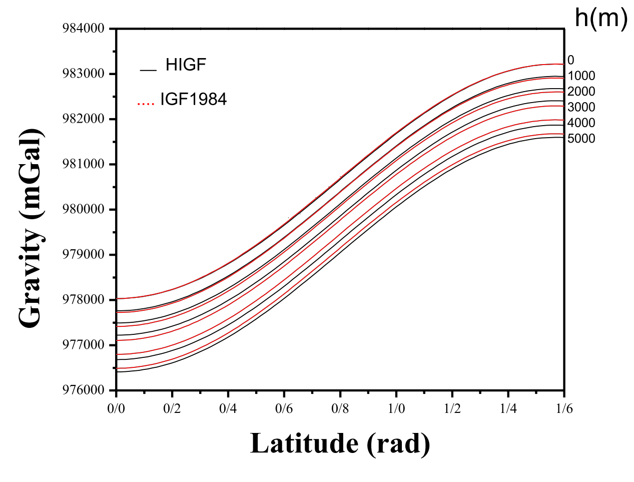

FIGURE 3 | Behaviours of the HIGF and IGF84 as a function of latitude at different heights.

TABLE 2 | Chi-square of HIGF, IGF84 and practical data.

Chi square of HIGF and practical data	Chi square of IGF84 and practical data
0.291,008	0.787,851

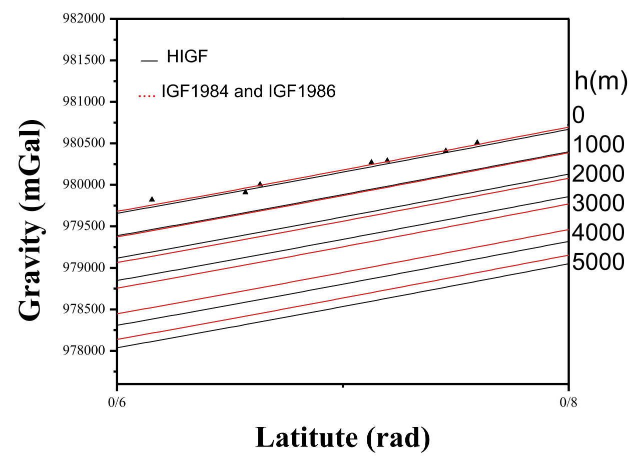

FIGURE 4 | Practical data at an elevation range of 0–100 m and latitude of 0–90° with the HIGF and IGF84 profile.

HIGF formula indicated high coincidence with the experimental data compared to the IGF84 formulation.

There are many gravitational formulas based on the format of **Eq. (2)**, including FIG 1984 (WGS84) [5, 6], FIG 1987 (the modified version of WGS84) [1, 7] and the previous version of HIGF [9]. These formulas can be expressed as **Eqs 14, 15** respectively.

$$g_{84} = 978032.68\left(1 + 0.0053024\sin^2\theta - 0.0000058\sin^2 2\theta\right) - 0.3086h \tag{14}$$

$$g_{84m} = 978032.68\left(1 + 0.00193185138639\sin^2\theta\right)\left(1 - 0.00669437999013\sin^2\theta\right)^{-0.5} - 0.3086h \tag{15}$$

Where the behaviour of gravity variation versus elevation or free air effect ($-0.3073\,h$) is close to $\Delta g_h = -(0.3087691-0.0004398\sin^2\theta)\ h+7.2125 \times 10^{-8}h^2 \approx -0.3087\,h$ [12]. The effect of the Bouguer anomaly is included in **Eqs (2)**, **(14)** and **(15)** through the addition of the term $0.04193\ \rho h = 0.04193 \times 2.65\ h = 0.1111\ h$. Gravity at many points within Iran and across the world was calculated using **Eqs (2)**, **(14)** without considering the Bouguer anomaly. However, when the Bouguer anomaly was included in the equations, the gravity formulas yielded the same offset values ($0.1111\ h$). Meanwhile, the gravity of many points around the world was measured using the CG-5 gravimeters and other devices [13, 15, 16] (**Table 1**). Comparatively, the gravity calculated using **Eqs (2)**, **(14)** revealed a slight difference to that of the experimental data. Hence, to estimate accurate gravity, a new gravity formula was proposed in this study using the Gauss-Jordan matrix elimination algorithm and practical gravitation data as the experimental HIGF.

INTRODUCING HEZAR INTERNATIONAL GRAVITY FORMULA

According to **Eq. (2)**, there is a polynomial equation for Earth's gravity using four constant coefficients. These four constant coefficients can be determined with an accurate measurement of gravity at four different points with different coordinates and elevations. For instance, by choosing the poles, equator, summits of Damavand and Hezar as four points on Earth, the four equations of gravity for the four points on Earth are denoted in **Eq. (16)**.

$$\begin{aligned} g_D &= A + BSin^2\theta_D + CSin^2 2\theta_D - Dh_D \\ g_H &= A + BSin^2\theta_H + CSin^2 2\theta_H - Dh_H \\ g_E &= A + BSin^2\theta_E + CSin^2 2\theta_E - Dh_E \\ g_P &= A + BSin^2\theta_P + CSin^2 2\theta_P - Dh_P \end{aligned} \tag{16}$$

Where g_P, g_E, g_D, g_H; θ_P, θ_E, θ_D, θ_H; and h_P, h_E, h_D, h_H refer to the gravity, latitude, and elevation of the Poles, Equator, the peaks of Mount Damavand and Hezar, respectively. These equations can also be represented in the form of matrix $MX = Y$ as in **Eq. (17)**.

$$X = \begin{pmatrix} A \\ B \\ C \\ D \end{pmatrix}, Y = \begin{pmatrix} g_D \\ g_H \\ g_E \\ g_P \end{pmatrix}, M = \begin{pmatrix} 1 & Sin^2\theta_D & Sin^2 2\theta_D & -h_D \\ 1 & Sin^2\theta_H & Sin^2 2\theta_H & -h_H \\ 1 & Sin^2\theta_E & Sin^2 2\theta_E & -h_E \\ 1 & Sin^2\theta_P & Sin^2 2\theta_P & -h_P \end{pmatrix} \tag{17}$$

Using the matrix geometry and the definitions of **(Eq. 16, 17)** can be converted to $X = MM^{-1}Y$ and by solving it, the matrix of coefficients (X) can be calculated.

The mean experimental coefficients A, B, C and D of the experimental HIGF were calculated by substituting the coordinate and gravitational data of the poles, equatorial vertices, Damavand and Hezar summits along with four other sets of different points presented in **Table 1**.

RESULTS AND DISCUSSION

The coefficient of the associated matrix following the resolution was calculated and substituted into **Eq. (1)**. Hence, the experimental HIGF is presented as **Eq. 18**.

$$\begin{aligned} g = 978031.85\,(1 + 0.0053024 \sin^2\theta - 0.000032309786 \sin^2 2\theta) \\ - 0.27h \end{aligned} \tag{18}$$

The gravity of many points in the world was calculated using the HIGF (**Eq. (18)**). The differences between the HIGF and practical gravity of these points are presented in **Table 1**.

Figure 2 presents the behaviour of g_{84m} and g_{84} by adding the free air effect or $\Delta_{gh} = -(0.3087691-0.0004398sin^2\theta)h + 7.2125 \times 10^{-8}h^2 \approx -0.3086\,h$ to **Eqs (2)**, **(14)**. **Figure 2** also illustrates the differences between g_{84m} and g_{84} at different heights and latitudes. According to **Figure 2**, no differences were observed between g_{84m} and g_{84} formulations. Therefore, the g_{84} or IGF84 with four coefficients was used to compare/analyse the differences between HIGF and IGF84 gravity formulations. **Figure 3** depicts the differences between HIGF and IGF84 gravity formulations at different heights and latitudes. According to **Figure 3**, HIGF and IGF84 exhibited a good match near sea level and at different altitudes. Contrarily, HIGF's behaviour is not similar to that of IGF84 above sea level because the HIGF formulation is based on experimental data and is a better formulation for the extraction of gravity above sea level compared to the formulation of IGF84. **Table 1** summarises the gravity at many points calculated by HIGF and IGF84, their practical data [13–15] along with the differences between HIGF, IGF84, and practical gravity.

Tables 1 and **2** also depict the chi-square {Sum [(Obs-Exp)^2/Exp]} for HIGF and IGF84 as (Obs) and practical data as (Exp). According to **Table 2**, the chi-square values for Obs and Exp data were 0.291,008 and 0.787,851, respectively. Therefore, HIGF is more consistent with the experimental results compared to IGF84. **Figure 4** illustrates the practical data at the heights of 0–100 m and latitudes of 0–90° in comparison with the HIGF and IGF84 formula. Based on the figure, HIGF and IGF84 are in good agreement with the experimental results (triangular mark) at lower altitudes. However, above sea level, HIGF performed similarly to the experimental data due to the low chi-square values at high altitudes. Therefore, the HIGF is more consistent with the experimental results compared to IGF84.

The differences between the gravity of the peaks of Hezar and Mount Damavand using HIGF and IGF84 are as follows:

$$\begin{aligned} [\text{gHezar} - \text{gDamavand}]\text{HIGF} = -214\text{mGal} \\ [\text{gHezar} - \text{gDamavand}]\text{IGF84} = -187\text{mGal} \end{aligned} \tag{19}$$

The experimental data indicated that the difference in the gravity of the peaks of Hezar and Mount Damavand was −203 mGal [9]. According to this data, the difference between HIGF, IGF84 and the experimental data were 11 and 16 mGal. Therefore, the HIGF is a better formula than IGF84. Based on the results in **Table 1**, HIGF can be introduced as an experimental Earth gravity formulation of every point in the sea and above sea level.

CONCLUSION

The rotating ellipsoidal Earth served as the basis for the International Gravity Formula adopted at the General Assembly of the International Union of Geodesy and Geophysics (IUGG). One particular ellipsoid of revolution is also called the normal Earth. The Geodetic Reference System 1967, Geodetic Reference System 1980 and World Geodetic System 1984 are all the "normal Earth" models. This paper is based on the theoretical normal Earth model formulation with 4 coefficients. These 4 coefficients in World Geodetic System 1984 were calculated using theoretical calculation. However, in this paper they were extracted by experimental calculation. Whereby, in this paper, an experimental gravity equation as Hezar International Gravity Formula (HIGF) was introduced using the experimental gravity of Earth data. In conclusion, HIGF provides accurate results as it is in better agreement with the practical data compared to IGF84.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

MH, and SK, and MR, gave significant involvement to design, analysis, characterization, experimental, and application. MR, contributed to the conception and analytical approach of the article for important intellectual content. MRIF and MUK provided critical revision of the article.

FUNDING

This work was supported by the Research Universiti Grant, Universiti Kebangsaan Malaysia, Dana Impak Perdana (DIP), code: 2020-018.

REFERENCES

1. Moritz H. Geodetic Reference System 1980. *J Geodesy* (2000) 74(1): 128–33. doi:10.1007/s001900050278
2. Abdel Zaher M, Elbarbary S, El-Shahat A, Mesbah H, Embaby A. Geothermal Resources in Egypt Integrated with GIS-Based Analysis. *J Volcanology Geothermal Res* (2018) 365:1–12. doi:10.1016/j.jvolgeores.2018.09.013
3. Vajda P, Pánisová J. Practical Comparison of Formulae for Computing normal Gravity at the Observation point with Emphasis on the Territory of Slovakia. *Contrib Geophys Geodesy* (2005) 35(2):173–88.
4. Claessens SJ, Featherstone WE, Anjasmara IM. *Gravity, Geoid and Earth Observation*. Berlin, Heidelberg: Springer (2010). p. 473–9. doi:10.1007/978-3-642-10634-7_63Is Australian Data Really Validating EGM2008, or Is EGM2008 Just In/validating Australian Data?
5. Hackney R. *Gravity, Data to Anomalies. Encyclopedia of Solid Earth Geophysics*. Dordrecht: Springer (2020). p. 1–10.
6. Chu PC. Ocean Dynamic Equations with the Real Gravity. *Scientific Rep* (2021) 11(1):1–10. doi:10.1038/s41598-021-82882-1
7. Pail R, Goiginger H, Schuh WD, Höck E, Brockmann JM, Fecher T, et al. Combined Satellite Gravity Field Model GOCO01S Derived from GOCE and GRACE. *Geophys Res Lett* (2010) 37:1–5. doi:10.1029/2010gl044906
8. Okocha FC. Gravitational Study of the Hastings Salt Dome and Associated Faults in Brazoria and Galveston Counties, Texas. Texas: Stephen F. Austin State University (2017). Doctoral dissertation. doi:10.1130/abs/2017sc-289183
9. Rezaie MR, Hosseinzadeh P. Hezar International Gravity Formula. In: Proceeding of Annual Physics Conference of Iran 26th, 11-14 September 2010, Bu-Ali Sina University, Hamadan, Iran (2010). 1587-1590.
10. Sabri LM, Sudarsono B, Jamal J, Mawardi S. Generating Bouguer Anomaly Map from Airborne Gravity Data (A Case Study in South East Sulawesi). *Elipsoida: Jurnal Geodesi dan Geomatika* (2020) 3.
11. ESA. Bouguer Gravity Anomaly (2015). Available at: https://www.esa.int.
12. Hinze WJ, Aiken C, Brozena J, Coakley B, Dater D, Flanagan G, et al. New Standards for Reducing Gravity Data: The North American Gravity Database. *Geophysics* (2005) 70(4):J25–J32. doi:10.1190/1.1988183
13. TCL. NGCLI (2006). Available at: www.ncc.org.ir or http://gis.tavanir.org.ir/jeo86/sokan/y-hatam.pdf.
14. Fukuda Y, Takiguchi H, Kazama T, Nishijima J, Gulyaev S, Natusch T, et al. New Absolute Gravity Measurements in New Zealand. In: *International Symposium on Gravity, Geoid and Height Systems*, 2016. Cham: Springer (2017). p. 95–101. doi:10.1007/1345_2017_18
15. Fukuda Y, Higashi T, Takemoto S, Abe M, Dwipa S, Kusuma DS, et al. The First Absolute Gravity Measurements in Indonesia. *J Geodynamics* (2004) 38(3-5):489–501. doi:10.1016/j.jog.2004.07.009
16. Robertson HW, Garrick RA. Gravity Measurements in New Zealand with the Cambridge Pendulum Apparatus. *New Zealand J Geology Geophys* (1960) 3(4):626–42. doi:10.1080/00288306.1960.10420150

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.