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A comparison study between the internal and external geomagnetic Field at the location (3.5°N, 96°E).

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Abstract:
In this paper we have examined the effect of the altitude and latitude on the total intensity (F) and the horizontal component (H) of the internal and external geomagnetic field at the location (lat 3.5°N, long 96°E) west of Sumatra (one of the Indonesia's islands).We examine the relationship between the (F_{in}, F_{out}) with altitude at a certain latitude, and relationship between (F,H) with the latitude at the certain altitude .We study also the nature of the secular variation of the geomagnetic field at the same location during the epoch (1965-2010) .

Introduction:
The geomagnetic field results from the superposition of an internal component (the main field) and an external component.(1).

The main magnetic field around the Earth produced by a dipole coinciding with the centre of the Earth and dipole axis inclined with respect to the rotation axis of the earth (2).The origin of the external field comes from the interaction of the solar wind and the magnetic field of the earth. The two areas have a great effect on each other. The study of the geomagnetic field is very important ,because of the magnetic field has the ability to change the orientation of the spacecraft when used correctly the magnetic field may be used for satellite control.(3).

Geomagnetic field components
In general , the strength of magnetic field at any point can be specified by means of the rectangular components X,Y,Z,H and F defined as follws : X is the component along the horizontal direction in the geographical meridian; Y is the horizontal component transverse to the geographical meridian; Z is the vertical component ; H is the magnitude of the horizontal component; F is the total intensity. These components connected by the following relation(4)

$$\left.\begin{aligned} F^2 &= X^2 + Y^2 + Z^2 \\ H^2 &= X^2 + Y^2 \end{aligned}\right\} \qquad [1]$$

Geomagnetic field Models:
Magnetic reference field models provide an easy way to calculate the component of the magnetic field. A reference field model is a mathematical algorithm whose parameters are based on an analysis of magnetic observations either over the entire world or a part of the world (5).Geomagnetic field models are prepared by a variety of organizations and countries. For particular analysis year, a field fitting procedure called (Spherical Harmonic Analysis), allows the model contribution from above and below

the spherical surface of the analysis to be separately represented by a double series of Legendre polynomial coefficients, identified by increasing ""degree" and "order" numbers (6).

Internal magnetic field model

The main geomagnetic field can be represented by a spherical harmonic series, the first term being the simple dipole term. A gradient of the potential determines the magnetic vector field.

A group of geomagnetic field odelers associated with the International Association of Geomagnetism and Aeronomy (IAGA) Division V, Working Group 8, periodically examines various geomagnetic field representations from which the Earth's main field and its secular variation can be computed. They produce a set of coefficients to represent the main field at a particular epoch, usually every five years, and name it the International Geomagnetic Reference Field (IGRF). Also, if a previous IGRF is modified using new data not available at the time of its production, it is called a Definitive Geomagnetic Reference Field (DGRF) (7).

The geomagnetic field B results from the scalar magnetic potential V , were:

$$B = -\nabla V \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[2]$$

Such scalar potential satisfies Laplace's equation:

$$\nabla^2 = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots[3]$$

Due to the spherical symmetry of the problem, the solution can be conveniently expressed in terms of Legendre function . The scalar magnetic field can be expanded in terms of the geographical coordinates as:

$$V = a\sum_{n=1}^{N}\sum_{m=0}^{n}\left(\frac{a}{r}\right)^{n+1}\left(g_n^m \cos m\varphi + h_n^m \sin m\varphi\right)P_n^m(\cos\theta) \ldots\ldots\ldots\ldots\ldots\ldots[4]$$

Where a is the mean radius of the earth {6371.2km}, r is the radial distance from the centre of the earth, φ is the longitude eastward from Greenwich, θ is the geocentric co-latitude, and $P_n^m(\cos\varphi)$ is the associated Legendre function of degree n and order m . N is the maximum spherical harmonic degree of the expansion, { g_n^m, h_n^m } set of the internal spherical harmonic coefficients.(8)

External magnetic field model

The magnetic field disturbances caused by the major magnetospheric current systems can be seen everywhere on the Earths surface. The distortions can be described by several external source fields caused by magnetospheric current systems (9). To describe the contribution of the external component in the geomagnetic field , the equation 4 become:

$$V = a\sum_{n=1}^{N}\sum_{m=0}^{n}\left(\frac{a}{r}\right)^{n+1}\left(g_n^m \cos m\varphi + h_n^m \sin m\varphi\right)P_n^m(\cos\theta) + a\sum_{n=1}^{N}\sum_{m=0}^{n}\left(\frac{r}{a}\right)^{n}\left(q_n^m \cos m\varphi + s_n^m \sin m\varphi\right)P_n^m(\cos\theta) \quad ...[5]$$

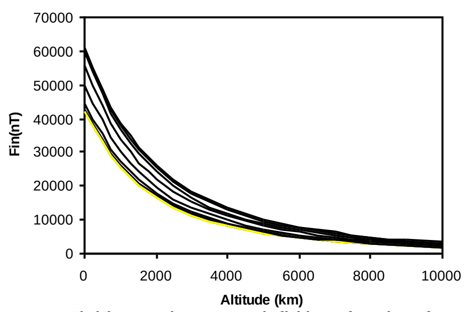
where (q_n^m , s_n^m) set of the external spherical harmonic coefficients (10).

Data sources

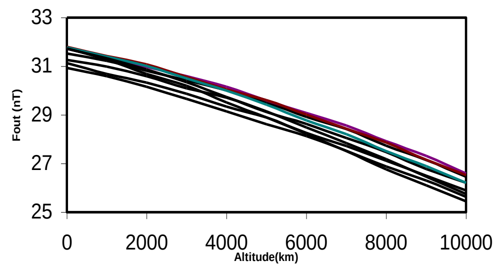
In this paper we use the service allows us to specify a certain point in space and then to calculate a variety of parameters of the Earth's magnetic field taking into account contributions from the internal and external sources. It is based on the external sources, magnetospheric field models T89c developed by Dr. Nikolai Tsyganenko and the internal sources, DGRF/IGRF geomagnetic field models for Epoch years 1965-2010.

Results and discussion:

1) In fig {1,2}, we plot the intensity of the internal and external geomagnetic field as a function of the altitude at the certain latitudes. In fig {1},we can see that the F_{in} is decrease when the altitude increase within large range from (60102 nT-3383 nT), while in fig {2}, the F_{out} change with the small range from (31.73nT-25.45).This may explanation to ,the core contribution dominates the field from the earth's surface up to about 1.5 earth's radii. Beyond 1.5 earth's radii, the earth's magnetic field is increasingly affected by the solar wind interaction with the earth's magnetosphere and the internal field is poor representation of the total field. The data of fig{1,2} are summarized in Table 1,2.



Fig(1).Internal geomagnetic field as a function of the altitudes at a certain latitudes.



Fig(2).External geomagnetic field as a function of the altitudes at certain latitudes.

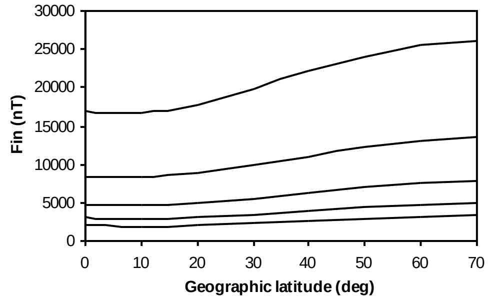
Table (1). Data of the internal field vs altitudes at differences latitudes

ltitude(k)	$F_{in}(0^0)$	$F_{in}(3.5^0)$	$F_{in}(10^0)$	$F_{in}(20^0)$	$F_{in}(30^0)$	$F_{in}(40^0)$	$F_{in}(50^0)$	$F_{in}(60^0)$	$F_{in}(70^0)$
0	42920.27	41907.77	42125.88	44778.85	50067.3	55594.1	59619.66	61107.94	60102.38
1000	26009.16	25412.45	25533.84	27147.95	30371.82	33825.13	36559.22	38095.23	38464.08
2000	17002.02	16597.92	16687.53	17707.16	19815.89	22146.89	24117.37	25439.88	26101.9
3000	11744.01	11451.2	11522.84	12198.01	13653.2	15306.81	16771.86	17850.86	18510.65
4000	8460.846	8240.065	8298.645	8765.194	9811.914	11028.52	12143.28	13010.99	13592.42
5000	6301.835	6130.744	6179.069	6513.372	7291.551	8212.503	9077.489	9775.71	10268.28
6000	4822.445	4686.867	4727.074	4973.983	5568.282	6281.887	6964.895	7530.278	7942.57
7000	3773.911	3664.723	3698.359	3885.403	4349.504	4913.515	5461.067	5922.949	6267.488
8000	3009.701	2920.274	2948.764	3093.672	3462.942	3916.202	4361.41	4742.181	5031.12
9000	2439.215	2365.208	2389.341	2503.805	2802.369	3171.964	3538.442	3855.39	4098.992
10000	2004.741	1942.747	1963.444	2055.179	2300.067	2605.278	2910.258	3176.417	3383.087

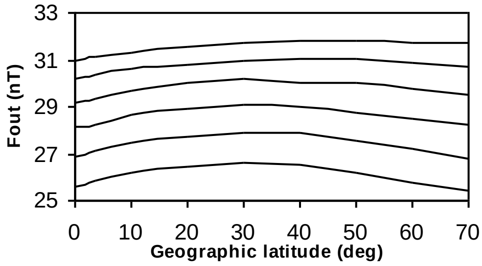
Table (2). Data of the external field vs altitudes at differences latitudes.

Altitude(km)	$F_{out}(0^0)$	$F_{out}(3.5^0)$	$F_{out}(10^0)$	$F_{out}(20^0)$	$F_{out}(30^0)$	$F_{out}(40^0)$	$F_{out}(50^0)$	$F_{out}(60^0)$	$F_{out}(70^0)$
0	30.92992	31.26787	31.13728	31.52428	31.72334	31.79906	31.77184	31.7268	31.73783
1000	30.59297	30.98161	30.68306	31.22339	31.34789	31.41735	31.39315	31.33496	31.28114
2000	30.15493	30.58676	30.32309	30.81315	30.96902	31.0725	31.01822	30.86778	30.68974
3000	29.65637	30.09751	29.86737	30.41858	30.59101	30.55961	30.5059	30.34172	30.19089
4000	29.13846	29.70959	29.34314	30.00833	30.16007	30.05029	29.996	29.74122	29.51694
5000	28.61695	29.11786	28.89446	29.51525	29.59831	29.60186	29.42023	29.14412	28.89048
6000	28.1377	28.6332	28.26217	28.91885	29.07937	29.0181	28.78003	28.49316	28.22304
7000	27.53216	28.05031	27.72346	28.42622	28.56064	28.43994	28.21595	27.84834	27.51472
8000	26.8801	27.46962	27.1249	27.73698	27.91738	27.86772	27.51745	27.18198	26.76359
9000	26.29943	26.78283	26.5	27.14664	27.31465	27.16192	26.89405	26.46432	26.10402
10000	25.63377	26.20611	25.88996	26.45846	26.5874	26.52414	26.20992	25.75442	25.45074

2) In fig {3,4}, we plot the intensity of the internal and external geomagnetic field as a function of the geographic latitude at the certain altitude .We can see from fig {3} that the F_{in} increase when the latitude increase, specially within low altitude, but at the high altitude there is no clear change in the field intensity. While in Fig{4} there is aclear change in F_{out} with the different geographic latitude at high altitude. The data of fig{3,4} are summarized in Table 3,4.



Fig(3).Internal geomagnetic field as a function of the geographic latitudes at certain altitudes.



Fig(4).External geomagnetic field as a function of the geographic latitudes at certain altitudes.

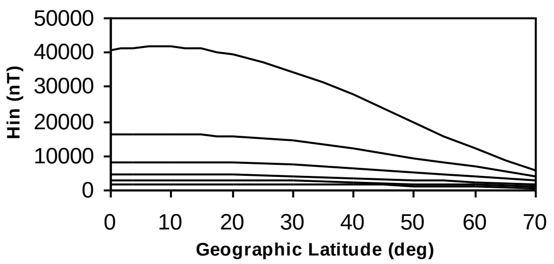
Table (3). Data of the internal field vs latitude at differences altitudes.

Latitude(deg)	F_{in} (0km)	F_{in} (2000km)	F_{in} (4000km)	F_{in} (6000km)	F_{in} (8000km)	F_{in} (10000km)
0	40462.6	17002.02	8460.846	4822.445	3009.701	2004.741
3.5	41335.2	16687.53	8298.645	4727.074	2948.764	1963.444
10	41750.3	16597.92	8240.065	4686.867	2920.274	1942.747
20	39509.9	17707.16	8765.194	4973.983	3093.672	2055.179
30	34537.4	19815.89	9811.914	5568.282	3462.942	2300.067
40	27746.6	22146.89	11028.52	6281.887	3916.202	2605.278
50	19949.3	24117.37	12143.28	6964.895	4361.41	2910.258
60	12247.1	25439.88	13010.99	7530.278	4742.181	3176.417
70	6103.2	26101.9	13592.42	7942.57	5031.12	3383.087

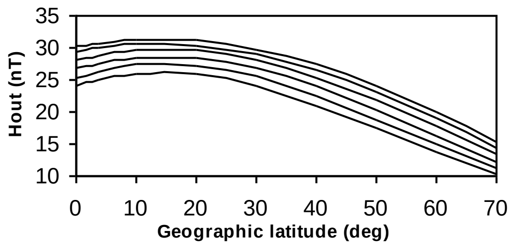
Table (4). Data of the external field vs latitude at differences altitudes.

Latitude(deg)	F_{out} (0km)	F_{out} (2000km)	F_{out} (4000km)	F_{out} (6000km)	F_{out} (8000)	F_{out} (10000km)
0	30.92992	30.15493	29.13846	28.1377	26.8801	25.63377
3.5	31.13728	30.32309	29.34314	28.26217	27.1249	25.88996
10	31.26787	30.58676	29.70959	28.6332	27.46962	26.20611
20	31.52428	30.81315	30.00833	28.91885	27.73698	26.45846
30	31.72334	30.96902	30.16007	29.07937	27.91738	26.5874
40	31.79906	31.0725	30.05029	29.0181	27.86772	26.52414
50	31.77184	31.01822	29.996	28.78003	27.51745	26.20992
60	31.7268	30.86778	29.74122	28.49316	27.18198	25.75442
70	31.73783	30.68974	29.51694	28.22304	26.76359	25.45074

3) In fig {5,6}, we plot the horizontal component of the internal and external geomagnetic field as a function of the geographic latitude .We can see from fig {5},that the H_{in} increase when the latitude increase in the region (0 to 10 degree), , and start decrease rabidly when the latitude increase .This fact can we see it obviously at the low altitude (0-4000 km), but there is no clear change at the high altitude (4000-10000 km) .In fig {6}we can see that there is obvious change in H_{out} for deferent altitudes (0km-10000km) when the latitude increment. The data of fig{5,6} are summarized in Table 5,6.



Fig(5).Horizontal component of the internal geomagnetic field as a function of geographic latitudes at certain altitudes.



Fig(6).Horizontal component of the external geomagnetic field as a function of geographic latitudes at certain altitudes.

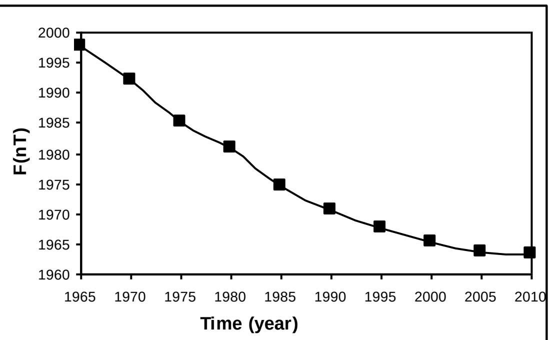
Table (5). Data of the horizontal component of the internal field vs. latitude at differences altitudes.

Latitude (deg)	H_{in}(0km)	H_{in}(2000km)	H_{in}(4000km)	H_{in} (6000km)	H_{in}(8000km)	H_{in}(10000km)
0	40462.6	16125.4	8038	4582.9	2859.8	1904.3
3.5	41335.2	16396.7	8153.5	4642.4	2894.5	1926.4
10	41750.3	16552.4	8223.4	4679.7	2916.8	1940.9
20	39509.9	15912.7	7962.6	4550.3	2843.9	1895.9
30	34537.4	14336.6	7295.5	4211.3	2649.1	1773.9
40	27746.6	12076.6	6313.3	3702.5	2352.6	1586
50	19949.3	9442.6	5135.5	3077.5	1981.5	1347.7
60	12247.1	6768.3	3886.7	2392.5	1565	1075.5
70	6103.2	4352.2	2671	1695	1128.6	784.8

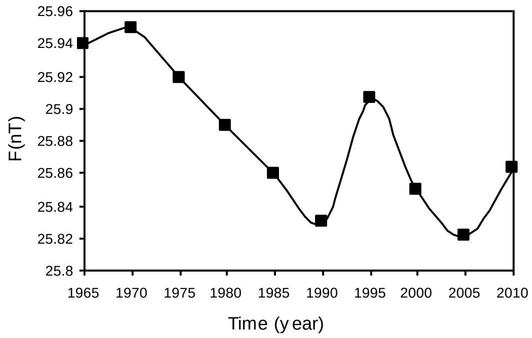
Table (6). Data of the horizontal component of the external field vs. latitude at differences altitudes.

latitude (deg)	H_{out}(0km)	H_{out}(2000km)	H_{out}(4000km	H_{out}(6000km)	H_{out}(8000km)	H_{out}(10000km)
0	30.17317	29.28276	28.10267	26.91635	25.43325	23.96414
3.5	30.76508	29.8739	28.7842	27.59601	26.30969	24.92569
10	31.25188	30.55912	29.66092	28.56326	27.37316	26.07681
20	31.14113	30.43698	29.63798	28.53437	27.33587	26.03767
30	29.82834	29.02482	28.12152	26.91858	25.61582	24.11327
40	27.42207	26.51528	25.30968	24.0075	22.60354	21.00214
50	24.01687	23.01065	21.80367	20.40098	18.9	17.40115
60	19.91231	18.90661	17.70113	16.4003	15.10298	13.71313
70	15.31176	14.40312	13.4	12.30366	11.21606	10.23963

4) In fig {7,8} we plot the intensity of the internal and external geomagnetic field as a function of the time for the (1965-2010) at the certain altitude (10000km).We can see from fig{7} that the (F_{in}) has a regular variation with time and there is large change in F_{in} with time and the field intensity decrease with the time (1997.683nT-1963.187nT), while in fig{8}, the F_{out} exhibits irregular variation with time and there is a small change in F_{out} (25.93nT-25.86nT) during the same epoch .This may explanation to, the external current in the ionized upper atmosphere and magnetosphere which cause variations in the intensity of the geomagnetic field vary on a much shorter time scale than the internal field. The data of fig{7,8} are summarized in Table 7.



Fig(7).The intensity of the internal geomagnetic field as a function of the time.



Fig(8).The intensity of the external geomagnetic field as a function of the time.

Table (7). Data of the internal & external geomagnetic field vs. time at certain altitudes.

Time (year)	F_{in}(10000km)	F_{out} (10000km)
1965	1997.683	25.93955
1970	1992.174	25.9486
1975	1985.26	25.91833
1980	1980.727	25.88841
1985	1974.579	25.85885
1990	1970.528	25.82963
1995	1967.567	25.9056
2000	1965.39	25.84918
2005	1963.77	25.8215
2010	1963.187	25.8631

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دراسة مقارنة بين المجال الجيومغناطيسي الداخلي والخارجي عند الموقع (٣.٥ درجة شمالا، ٩٦ درجة شرقا)

هدى عبد الهادي المهدي و احمد فاضل مخيبر
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الخلاصة:

اختبرنا في هذا البحث تأثير تغير الارتفاع وخط العرض على الشدة الكلية (F) والمركبة الأفقية (H) للمجال المغناطيسي الأرضي الداخلي والخارجي عند الموقع (٣.٥ درجة شمال، ٩٦ درجة شرقا) غرب سومطرة (وهي إحدى جزر اندونيسيا). حيث تم دراسة طبيعة العلاقة بين (F_{in}, F_{out}) مع الارتفاع عن سطح الأرض عند خطوط عرض مختلفة ، وكذلك العلاقة بين (F, H) مع خطوط العرض عند ارتفاعات مختلفة عن سطح الأرض. كما تمت دراسة طبيعة التغير الحاصل في شدة المجال المغناطيسي مع الزمن في هذا الموقع وللفترة (١٩٦٥-٢٠١٠).