A study of Geomagnetic Field and It's secular variation at the Location Brazilian Anomaly (25°S, 45°W).

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Abstract

In this paper we study and analysis the total intensity (F) and the horizontal component (H) of the geomagnetic field at the location namely Brazilian Anomaly (lat 25°S, long 45°W), in which the geomagnetic field intensity has a minimum value. We examine the relationship between the (F, H) 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 one century (1900-2000) , we found that the rate of change of field intensity (F) is roughly (9.3 % per century).

The geomagnetic field data is obtained by using IGRF10 model at Brazilian anomaly (long 45°W).

Introduction

The Earths magnetic field, as measured by a magnetic sensor on or above the Earth's surface, is actually a composite of several magnetic fields generated by variety of sources. These fields are superimposed on each other and through inductive processes interact with each other. The most important of these geomagnetic fields are:

1- The Earths main magnetic field generated in the conducting fluid outer core.

2- The crustal field generated in Earths crust and upper mantle.

3- The combined disturbance field from electrical currents flowing in the upper atmosphere and magnetosphere (1).

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, so the magnetic field may be used for satellite control (2).

To describe the characteristics of the geomagnetic field, there are set of Gaussian coefficient for use in the analytical models, are called the International Geomagnetic Reference Field (IGRF).Every five years, a group from the International Association of Geomagnetism and Aeronomy examines the measured geomagnetic field representation and produces the coefficients for that particular year in (nano-Tesla). In addition, previous (IGRFs), are occasionally updated using new data and named a Definitiv Geomagnetic Reference Field (DGRF). The most recent publication is the IGRF10 (3).

Description of the geomagnetic field

To measure the Earth's magnetic field in any place, we must measure the direction and intensity of the field. The parameters describing the direction of the magnetic field are declination (D), is the angle between the horizontal component of the magnetic field and the direction of the geographic north, inclination (I), is the angle between the horizontal plane and the total intensity and(I) are measured in units of degrees. The intensity of the total field (F) is described by the horizontal component (H), vertical component (Z), the north (X) and east (Y) components of the horizontal intensity, which is measured by units of nano Tesla (nT). These components are related by the following equations (4):

$$\left.\begin{aligned} &H = F\cos I, Z = F\sin I = H\tan I \\ &X = H\cos D, Y = H\sin D \\ &H^2 = X^2 + Y^2, F^2 = X^2 + Y^2 + Z^2 \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

All these elements is shown in fig {5}

Geomagnetic secular variation

The magnitude and direction of the surface geomagnetic field change with time. Although the magnetic field is sustained by dynamo within the Earth's core, part of the field threads its way through the mantle and up to the surface. The same convection motion that drives the geodynamo also causes the field, measured at the surface, to be time-dependent over historical timescales, phenomenon known as secular variation (s.v) (5).In addition, the dipole strength of the magnetic field is decreasing by 0.05% per year, and the portion of the dipole located in the northern hemisphere is drifting westward at 0.014 degree per year (2). The (s.v) is very small, but after a few years their accumulation is enough to make the magnetic field models out dated. So, magnetic models and charts must be periodically updated to accommodate the continual (s.v) of the filed.

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 (6). 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(7). The International Geomagnetic Reference Field (IGRF) and World Magnetic Model (WMM) are the most commonly used models for navigational purposes. Models are traditionally updated every five years.

International Geomagnetic Reference Field (IGRF)

The (IGRF) is a series of mathematical models describing the Earth's main field and its secular variation. For points located near the Earth's surface, it is possible to calculate the geomagnetic field B using the scalar magnetic potential V, were:

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

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:

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

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 colatitude, 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 spherical harmonic coefficients.(8)

Results and Discussion

In fig {1}, we plot the total intensity as a function of the altitude at the certain latitudes. We can see that the total intensity is decreased when the altitude increased, the strength of the geomagnetic field has a maximum value at (altitude=o km), and has a minimum value at the (altitude=10000 km), this may give explanation to, at the high altitude the effect of the geomagnetic filed is very small.

1) In fig {2}, we plot the total intensity as a function of the geomagnetic latitude at the certain altitude .We can see from this figure that the total intensity of the field increase when the latitude increase, and this fact we can see it clearly at the low altitude (0-4000 km), but at the high altitude there is no clear change in the field intensity. This indicated to that at low altitude, the Earth's field is approximately that of a magnetic dipole while at high altitude it is strongly distorted.

2)In fig {3}, we plot the horizontal component of the geomagnetic field (H) as a function of the geomagnetic latitude .We can see that the horizontal intensity increase when the latitude increase in the region (-25 to 0 degree), and at the equator(0 degree) which equivalent to (10 geomagnetic latitude) the horizontal component has the maximum value , and start decrease rapidly when the latitude increase .This fact, we can see it obviously at the low altitude (0-2500 km), but there is no clear change at the high altitude (4000-10000 km).

3)In fig {4} we plot the total intensity (F) as a function of the time for the (1900-2000).We can see from this curve that the field intensity decrease with the time, the rate of change in field intensity , is about (9.3 % per century).

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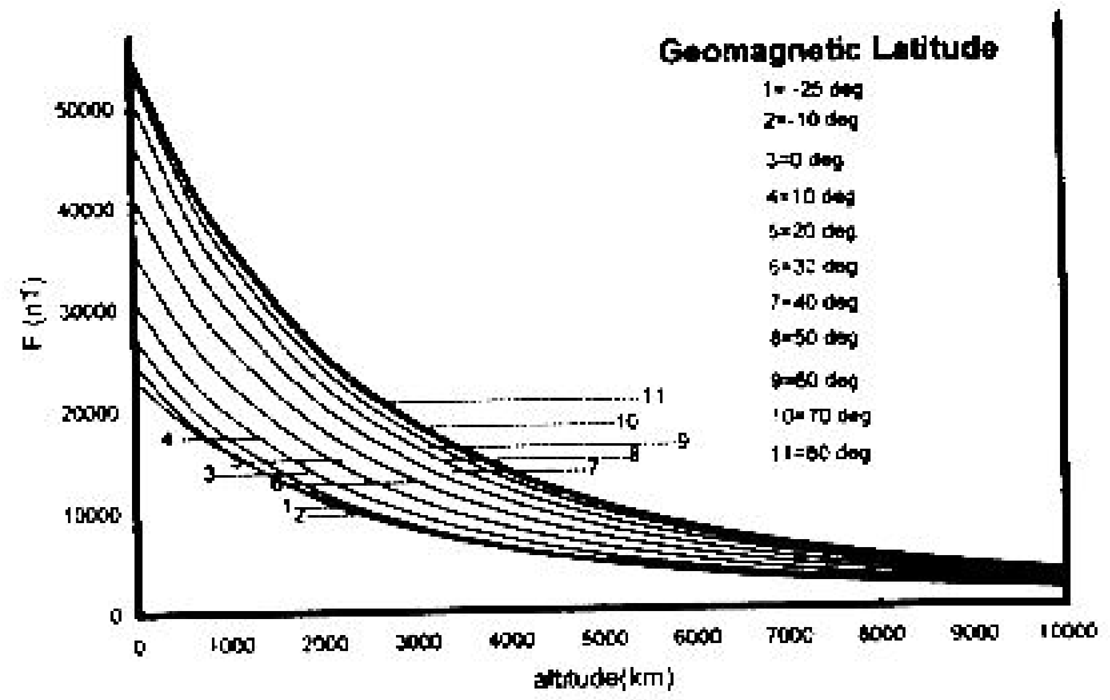
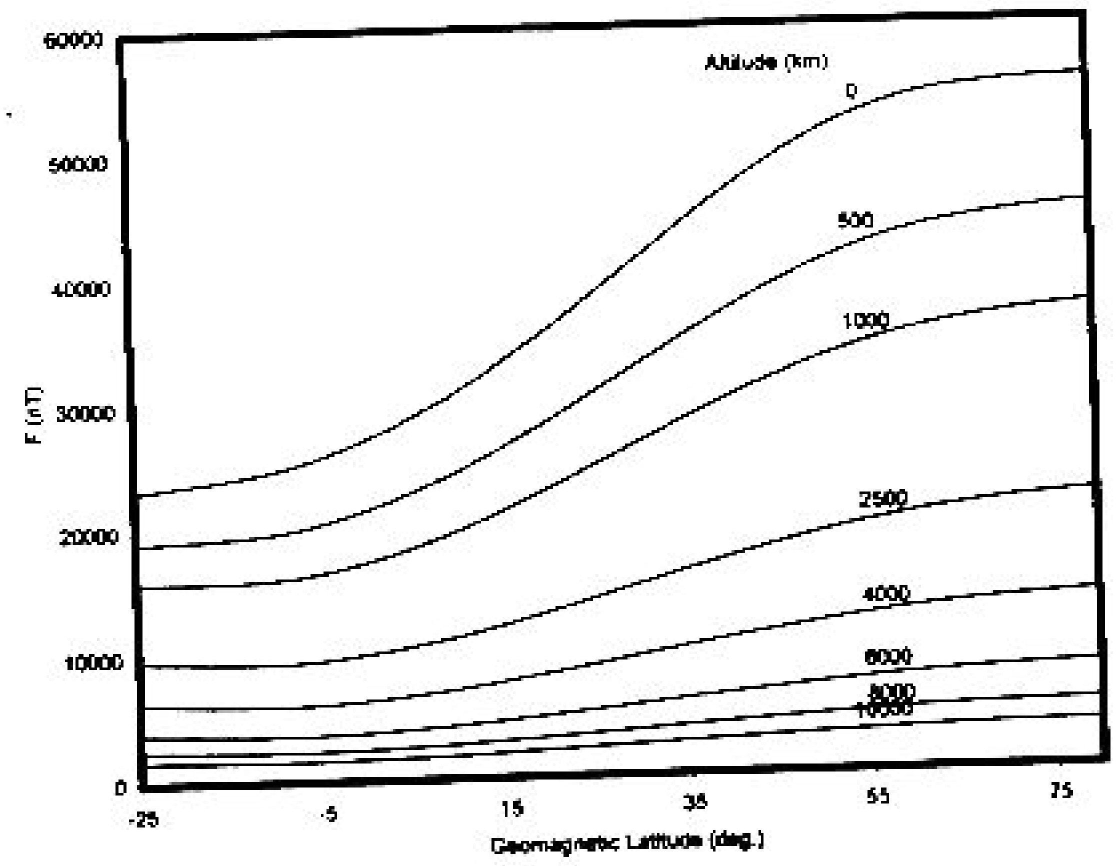
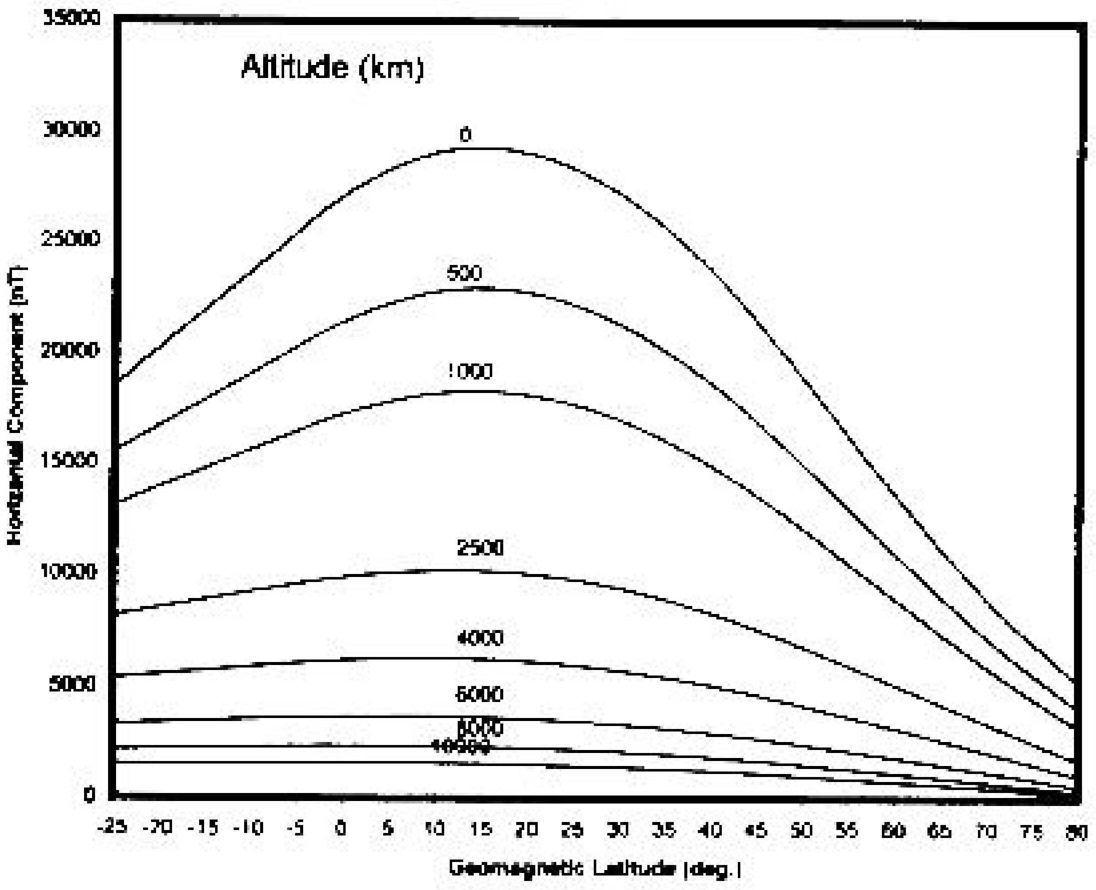


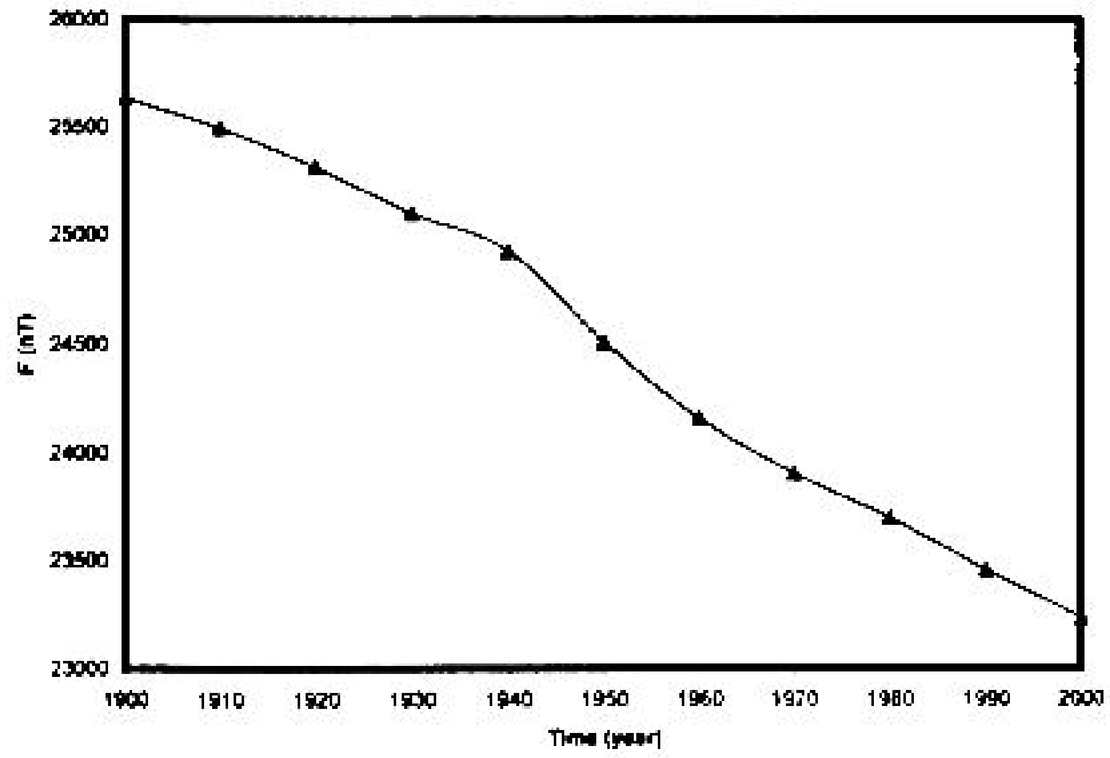
Fig(1).Total field intensity as a function of the altitudes at certain latitudes



Fig(2).Total field intensity as a function of the Geomagnetic latitudes at certain altitudes.



Fig(3).Horizontal component as a function of the Geomagnetic latitudes at certain altitudes.



Fig(4).Secular variation of the geomagnetic field (1900-2000).Sit (Brazilian anomaly).

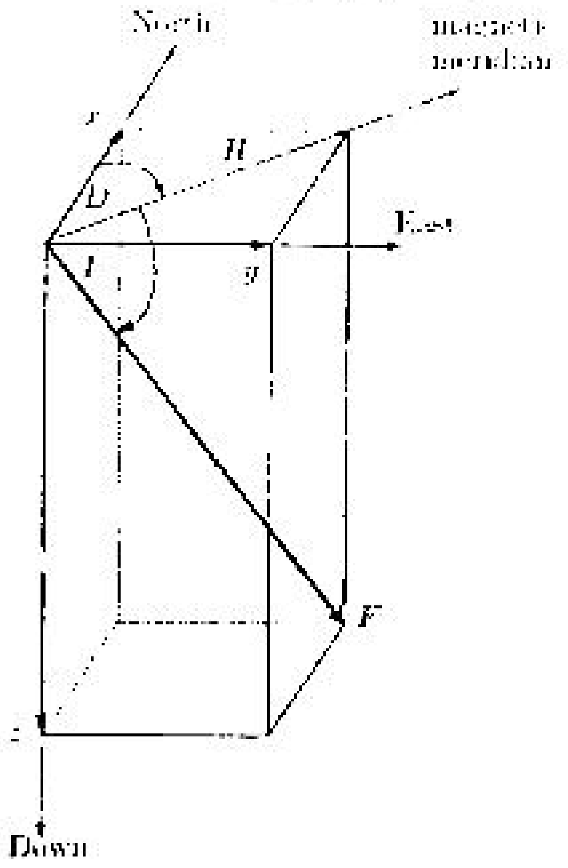


Fig (5).Geomagnetic elements(2)

مجلة ابن الهيثم للعلوم الصرفة والتطبيقية المجلد21 (1) 2008

دراسة المجال المغناطيسي الأرضي ومدى تغيره على المدى البعيد عند منطقة برازيليا (25 درجة جنوبا، 45 درجة غربا)

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الخلاصة

تناولنا في هذا البحث دراسة علاقة الشدة الكلية (F) والمركبة الأفقية (H) للمجال المغناطيسي الأرضي عند منطقة برازيليا الشاذة التي خط عرضها (25 درجة حنوبا)،وخط طولها (45 درجة غربا)،والتي عندها تكون شدة المجال المغناطيسي الأرضي اقل ما يمكن، اذ تم دراسة طبيعة العلاقة بين (F, H) مع الارتفاع عن سطح البحر عند خطوط العرض المختلفة ، وكذلك العلاقة بين (F, H) مع خطوط العرض عند ارتفاعات مختلفة عن سطح البحر. كما تمت دراسة طبيعة التغير الحاصل في شدة المجال المغناطيسي مع الزمن في هذا الموقع وللمدة (1900–2000)، وقد وجد ان نسبة التغير في شدة المجال المغناطيسي الأرضي مساوية إلى (9.3% لكل قرن) تقريبا. إن جميع البيانات المتعلقة بشدة المجال المغناطيسي الأرضي تم الحصول عليها من خلال الأنموذج العالمي للمجال الأرضي (IGRF10) عند خط طول (45 درجة غربا).