

## MONITORING AND FORECASTING THE STATE OF THE SOUTH ATLANTIC MAGNETIC ANOMALY

3-03

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### Introduction

The models of Geomagnetic Field of the Earth (IGRF: International Geomagnetic Reference Field), are published from 1900 up to 2010 at intervals of 5 years. Barraclough (1978) published and normalized all available models coefficients of the spherical harmonics analysis for the magnetic field of the earth from 1550 up to 1978. From this models, Gianibelli (2006) calculated the energy evolution for dipole and cuadrupole effects at the surface of the Earth, from 1550 to 2005 and made a forecast for the period 2010-2500. The energy of cuadrupole with respect of the dipole energy is less than 2% at the present. The evaluation of the energies from IGRF coefficients, corresponding to the orders 1,2,3 and 4, and the prediction of them up to 2500, is presented in Fig. 1. This result was

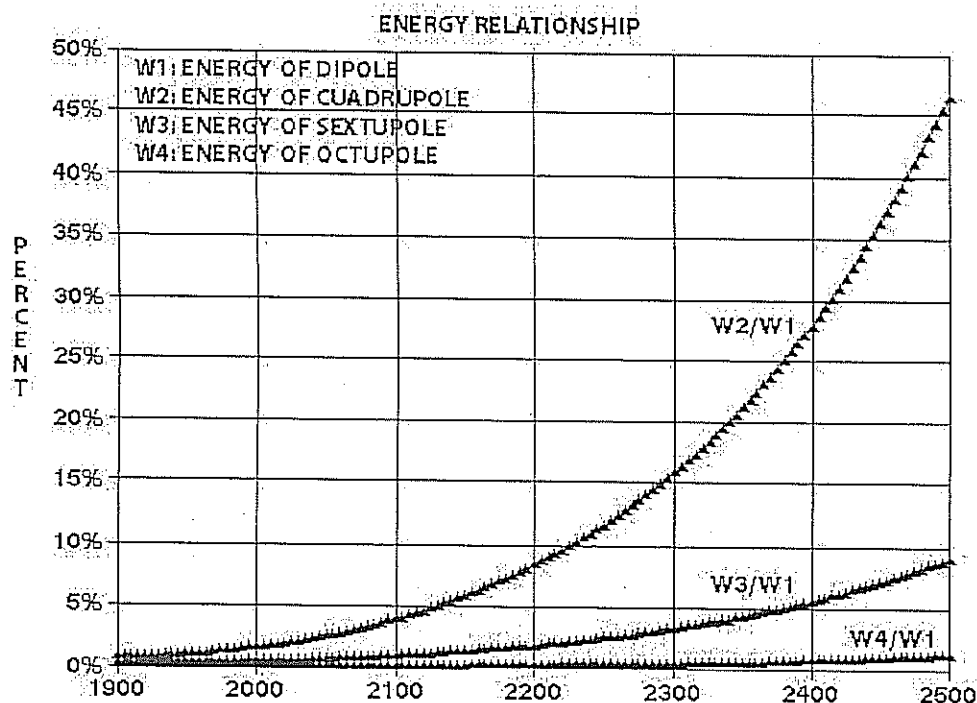


Fig. 1 - Energy relationship versus dipole energy W1.

Table 1 - Results obtained from annual mean values analysis.

OBS: YEAR	HUA F:nT	LQA F:nT	VSS F:nT	PIL F:nT	HER F:nT	LAS F:nT	TRW F:nT	ORC F:nT	AIA F:nT	DRV F:nT
2000	26290	23790	23300	23470	26230	23840	26480	33090	39430	69380
2050	23850	21150	21820	20620	20870	21150	23080	27370	34480	67200
2100	21100	18860	20050	17770	15450	18910	19680	21650	29530	64980
ΔF 1:	-5190	-4930	-3250	-5700	-10780	-4930	-6800	-11440	-9900	-4400

calculated by a linear model of each coefficient of spherical harmonics analysis (SHA) of orders 1,2,3 and 4, and the most important result is that order 2 of the SHA represents the effects of magnetic field at the surface of the Earth and the evolution of the South Atlantic Magnetic Anomaly (SAMA). The Magnetic Observatories in the SAMA region, and in the South Hemisphere are (Fig. 2): Huancayo (HUA), La Quiaca (LQA), Pilar (PIL), Vassouras (VSS), Hermanus (HER), Las Acacias (LAS), Trelew (TRW), Islas Orcadas del Sur (ORC), and Vernadsky (AIA). The Magnetic Observatory of Dumond D’Urville (DRV) is also plotted because is close to the Geomagnetic South Pole region and is monitoring the change of intensity. The annual mean values of HUA are important because they allow to monitor the possible future

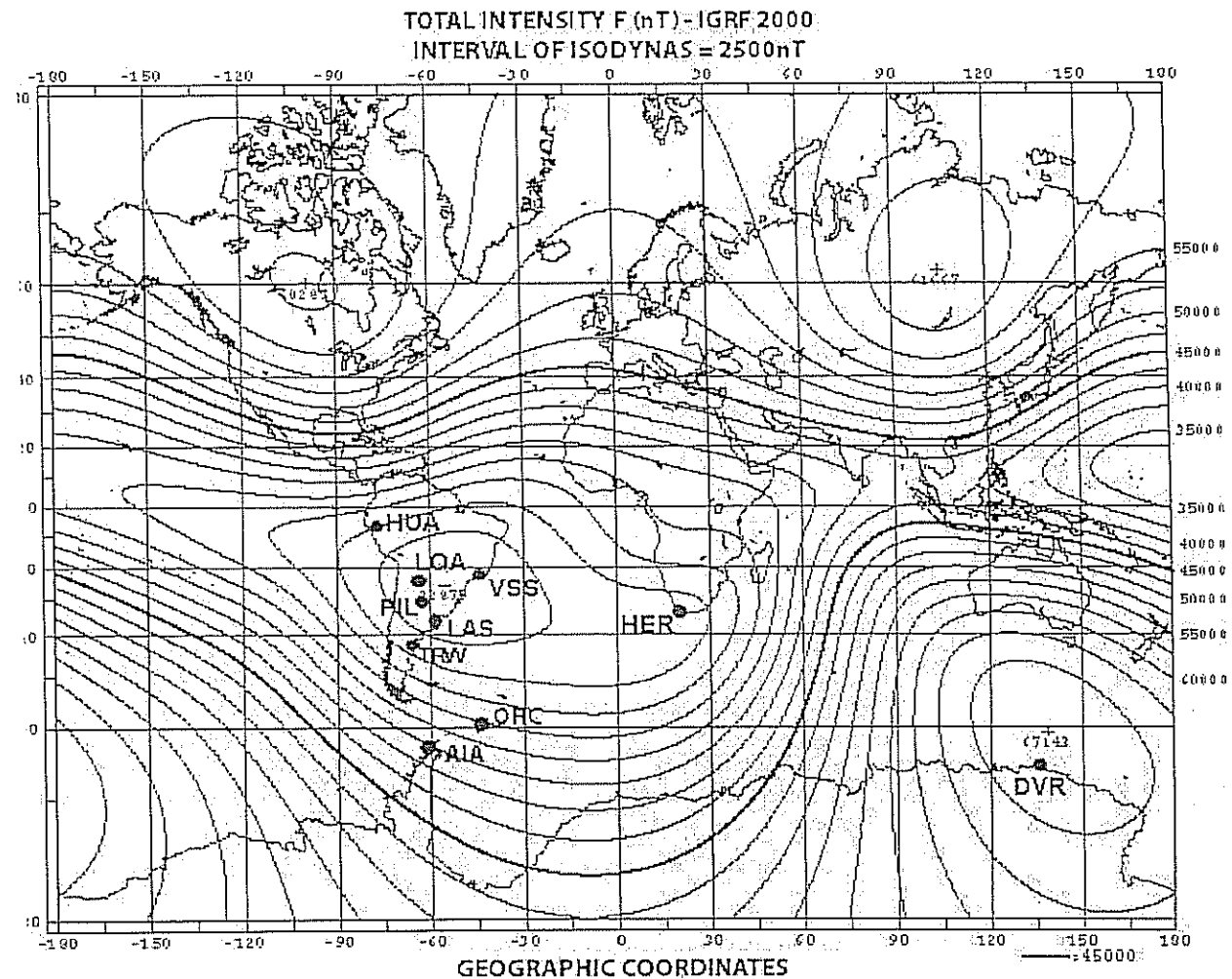


Fig. 2 - Distribution of Magnetic Observatories.

Table 2 - Results obtained from the IGRF model.

OBS: YEAR	HUA F:nT	LQA F:nT	VSS F:nT	PIL F:nT	HER F:nT	LAS F:nT	TRW F:nT	ORC F:nT	AIA F:nT	DRV F:nT
2000	26069	23507	23431	23622	26358	23593	26844	33630	39889	66693
2050	24138	21382	22388	20962	21273	20990	22906	28526	34385	65587
2100	22208	19257	21345	18301	16188	18387	18968	23421	28882	64480
F 2:	-3861	-4250	-2086	-5321	-10171	-5207	-7875	-10209	-11007	-2213

Table 3 - Discrepancies of estimated values for 2100

OBS:	HUA F:nT	LQA F:nT	VSS F:nT	PIL F:nT	HER F:nT	LAS F:nT	TRW F:nT	ORC F:nT	AIA F:nT	DRV F:nT
F 1:	-5190	-4930	-3250	-5700	-10780	-4930	-6800	-11440	-9900	-4400
F 2:	3861	-4250	-2086	5321	10171	5207	7875	10209	11007	-2213
DIFF:	-1329	-679	-1164	-379	-609	277	1075	-1231	1107	-2188

changes of magnetic equator position.

### Data analysis and results

The annual mean values of total magnetic intensity (F) of each observatory is analyzed and the tendency through time is calculated.

The objective of this paper is to obtain the values of F from this linear time series model for 2000 and to predict the tendency for 2050 and 2100 for each observatory and compare the results obtained by the IGRF model for the same observatories in the same date. From this comparison it is possible to predict the state of SAMA in the future from two different elementary methods.

The results starting from annual mean values analysis of each observatory is presented in Table 1. Table 2 shows the values obtained from the IGRF model. The  $\phi F$  value changes from 2000 to 2100 is shown in each table.

In Tables 1 and 2,  $\phi F$  values are different, and in the case of DRV Observatory,  $\phi F$  is 50 % greater than the IGRF estimation from the annual mean values.

Table 3 is a resume of the discrepancy, which is the difference  $DIFF = \phi F_1 - \phi F_2$  calculated for each observatory.

### Conclusion

With this two methods, a continuous magnification of the total intensity of magnetic field depression of the SAMA region is predicted. The estimation of the annual mean changes for the time interval 2000-2100 in some observatories is less than the estimation from the IGRF change for the same epoch (LAS, TRW and AIA).

The values of DIFF show a change of sign and magnitude in nT. A great difference occurs in the region of south pole (DRV), and in the region of magnetic equator (HUA), and this is a possible situation is the fitting with a cut up of degree 10 in the model of the IGRF. In this scenario, changes in the solar wind that interacts with the magnetic field of the Earth in the SAMA region are expected, with an important deformation of the inner radiation belts to ionospheric levels according with SAMA evolution, the total magnetic field intensity reduction and the effects in the ionospheric pattern equivalent current systems. This possible situation is evaluated by the estimation of changes of the energy of the dipole and quadrupole fields effects at different ionospheric heights for 2000, 2050 and 2100.

ENERGY VARIATION WITH THE HEIGHT OF THE DIPOLE AND CUADRUPOLE ORDER  
CALCULATED BY THE COEFFICIENTS OF THE IGRF AND PREDICTED TO 2050 AND 2100

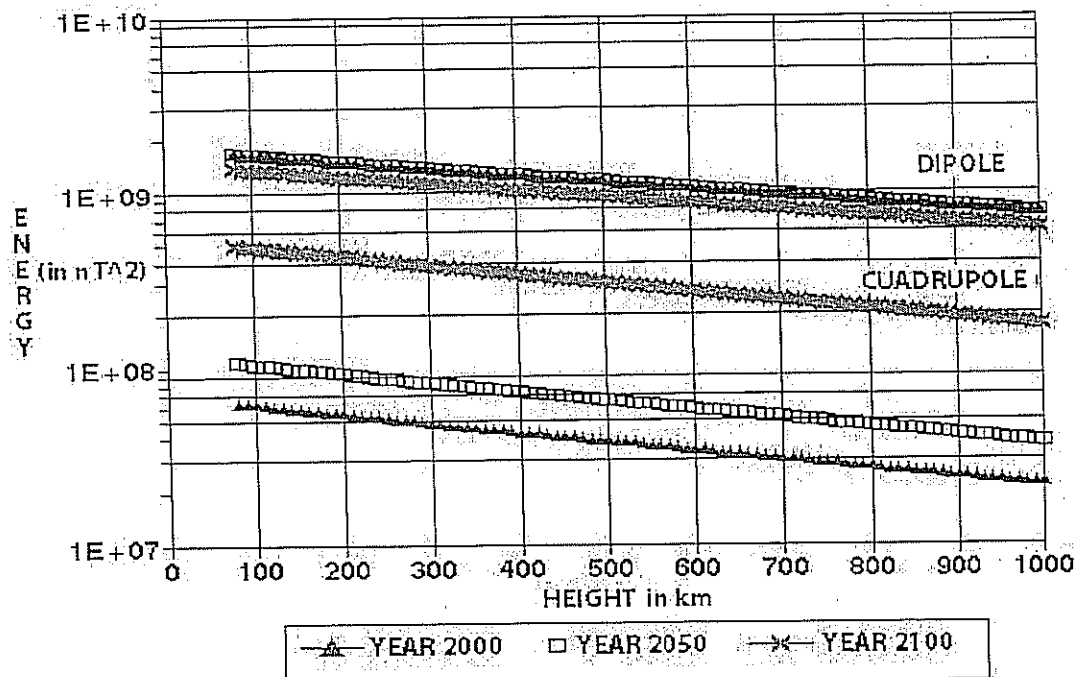


Fig. 3 - Energy variations for year 2000 and predicted for years 2050 and 2100.

This result is presented in Fig. 3.

In conclusion, the quadrupole energy from 2050 to 2100 is increasing with a magnitude greater than the increment from 2000 to 2050. Possibly, a change of solar wind-Earth magnetic field interactions may account for this trend.

The relatively low number of magnetic observatories in the South Hemisphere for monitoring the evolution of SAMA is a problem that should be considered in the near future. It is suggested to build in the future an improved network of observatories that monitor the absolute values of the geomagnetic elements at the surface of the Earth to model the IGRF with greater detail.

#### REFERENCES

- Barraclough, D. R. 1978, Spherical Harmonic Models of the Geomagnetic Field. Institute of Geological Sciences. Geomagnetic Bulletin 8. 1-66.
- Gianibelli, J. C. 2006. Sobre la Evolución temporal del Dipolo y Cuadrupolo del Campo Geomagnético. Geoacta, vol 31, 175-181.