PUBLS. INST. GEOPHYS. POL. ACAD. SC 2006

Correlation between IGRF2000 model and measured geomagnetic data on the territory of the Republic of Macedonia from measurements in 2003 and 2004

Sanja PANOVSKA [1], Todor DELIPETROV [2] and Blagoj DELIPETREV [3]

[1] Faculty of Mining and Geology, Department of Geology and Geophysics
Goce Delcev No. 89, 2000 Stip, Republic of Macedonia
email: panovskasanja@yahoo.com

Abstract

On the basis of the measurements carried out in 2003 and 2004 on the network of repeat stations in the Republic of Macedonia, correlation between IGRF and the 2003 model as well as the 2004 model and analysis between the models were made. It should take in consideration that the difference in altitude among repeat stations (15 points) is about 1300 meters (Galicica is at highest sea level of 1691 m and Nikolic at lowest of 300 m). During data processing, correction for altitude was not made, and measured data were corrected with the data from neighboring observatories Panagiuriste, Bulgaria, Tihany, Hungary and Aquila, Italy. The paper presents correlations between IGRF model and 2003 and 2004 model for all components of geomagnetic field. The time changes for 2003 and 2004 were also calculated.

1. Introduction

Analyses of the geomagnetic field were done using the measurements carried out in 2003 and 2004 on the territory of the Republic of Macedonia, on the grid of repeat stations of 2003. The value of elements of the geomagnetic field was calculated according to IGRF 2000 on the grid of repeat stations and the additional points outside the boundaries of the country. The isolines on the map represent the values of IGRF model. The isolines in other maps also indicate the differences with measured values. Resume is given on the first measurements performed in 2002 in Mts. Galicica, Ponikva and Plackovica. An analysis of time variations of the geomagnetic field in the repeat stations was also carried out.

The analyses of the gradient of measured data in 2004 reduced to the epoch 2004.5 on the territory of the country indicating that:

– The values of Declination generally increase towards East with mean gradient of some 0,002 °/km.
– The values of Total intensity increase towards the North with mean gradient of some 2,5 nT/кm.
– Horizontal component indicates increases of values towards South with mean gradient of some 5,1 nT/кm.
– The angle of Inclination increases towards North with mean gradient of some 0,009 °/km.
– The values of the Northern component of the geomagnetic field increase towards South with mean gradient of some 5,1 nT/кm.
– The values of the Eastern component increase generally towards East with mean gradient of some 0,8 nT/кm.
– Vertical component indicates an increase towards North with mean gradient of some 6,1 nT/кm.

2. International Geomagnetic Reference Field – 2000

The IGRF is a series of mathematical models describing the Earth's main field and its secular variation. Each model comprises a set of spherical harmonic coefficients (called Gauss coefficients), g_n^m, h_n^m, in a truncated series expansion of a geomagnetic potential function of internal origin:

$$V = a\sum_{n=1}^{N}\sum_{m=0}^{n}\left(\frac{a}{r}\right)^{n+1}\left(g_n^m \cos m\phi + h_n^m \sin m\phi\right)P_n^m(\cos\theta) \tag{1}$$

where a is the mean radius of the Earth (6371.2 km) and r, ϕ, θ are the geocentric spherical coordinates (r is the distance from the centre of the Earth, ϕ is the longitude eastward from Greenwich and θ is the colatitude (90° minus the latitude), in Eq. (1). The $P_n^m(\cos\phi)$ are Schmidt quasi-normalized associated Legendre functions of degree n and order m ($n \geq 1$ and $m \leq n$). The maximum spherical harmonic degree of the expansion is N. Coefficients for dates between the 5-year epochs are obtained by linear interpolation of the corresponding coefficients for the neighboring epochs. The IGRF coefficients and the computer programs for synthesizing the field components are available from many web pages throughout the world.

2.1 IGRF model for 2004.5 for the territory of the Republic of Macedonia

IGRF model was used to calculate all components of the geomagnetic field of the Republic of Macedonia. Then, data were extrapolated to cover the whole territory of Macedonia in which the Surfer program was applied. Kriging was used as a grid method. The result is isolines maps of all components of geomagnetic field that can be used in many applications. Figures 1 – 4 represent the maps of isolines of IGRF model for 2004.5 epoch. The calculator used to calculate IGRF elements of the geomagnetic field for the epoch 2004.5 is Geomagix of USGS available at the web site:

http://geomag.usgs.gov/geomag/geomagAWT.html

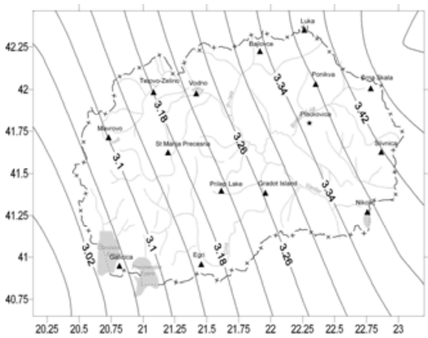

Fig. 1. Map of declination (D) from the IGRF 2000 model for epoch 2004.5.

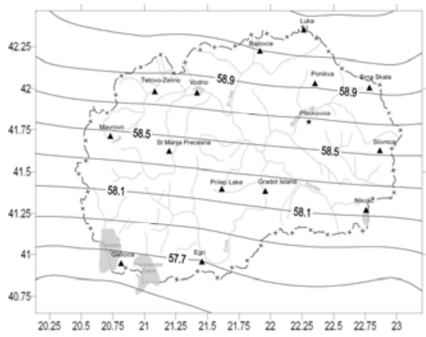

Fig. 2. Map of inclination (I) from the IGRF 2000 model for epoch 2004.5.

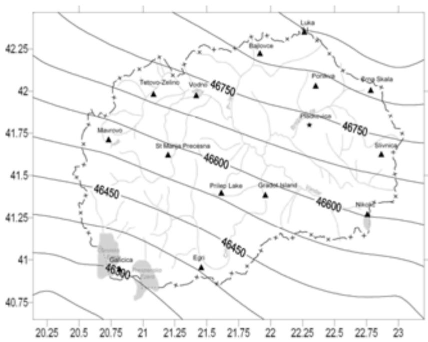

Fig. 3. Map of total intensity (T) from the IGRF 2000 model for epoch 2004.5.

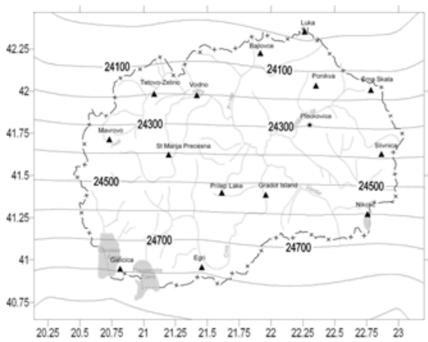

Fig. 4. Map of the horizontal component (H) from the IGRF 2000 model for epoch 2004.5.

3. The differences between IGRF model and measured results

Comparison between mean annual values and calculated IGRF values were carried out on 15 repeat stations in 2003 and 2004. The values are calculated based on IGRF 2000 model for the epoch 2003.5 and 2004.5. The model IGRF values were removed from the annual mean values to get the residual ΔD, ΔI, ΔF, ΔH, ΔX, ΔY and ΔZ values. Maps for the differences of the components of the geomagnetic field between the compared models are shown in the following figures (Fig 5 - 8):

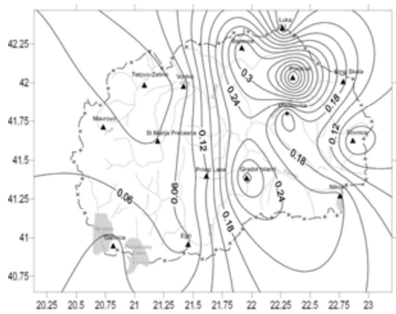

Fig. 5. Map of differences between measured values of Declination and the IGRF 2000 model values for epoch 2004.5.

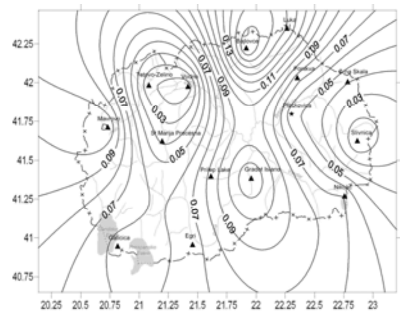

Fig. 6. Map of differences between measured values of Inclination and the IGRF 2000 model values for epoch 2004.5.

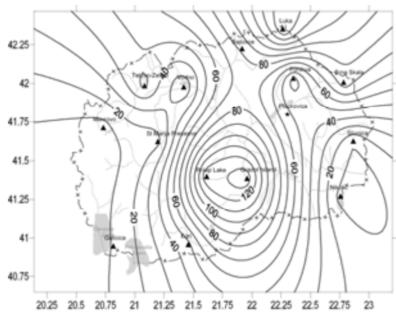

Fig. 7. Map of differences between measured values of Total intensity and the IGRF 2000 model values for epoch 2004.5.

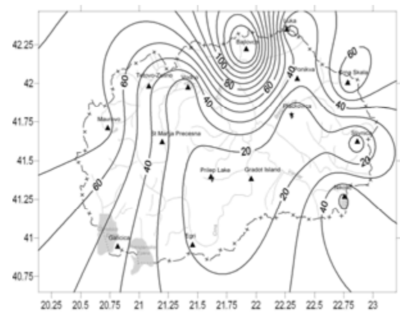

Fig. 8. Map of differences between measured values of the Horizontal component and the IGRF 2000 model values for epoch 2004.5.

4. The differences between 2003 and 2004

The analyses of measurements carried out in 2003 and 2004 were done after reduction of data from neighboring geomagnetic observatories in Aquila, Tihany and Panaguirishte. Figures 9 - 12 give maps of isolines of measured values of all components of geomagnetic field for 2003.5 and 2004.5 with dashed and full lines, respectively. The isolines of the two models are drawn with the same values in order to indicate the time evolution. The isolines of declination, the northern and eastern component have clear tendency towards East, whereas other components indicate small variation.

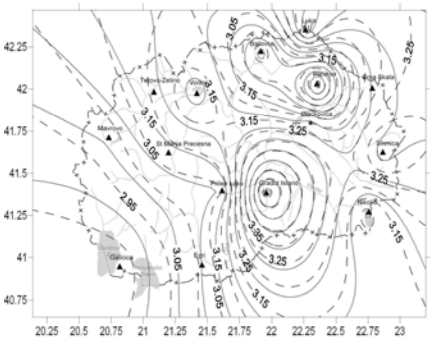

Fig. 9. Map of values of Declination of the geomagnetic field, epoch 2003.5 (dashes lines) and 2004.5 (full lines).

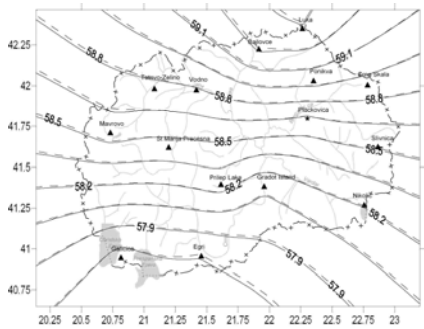

Fig. 10. Map of values of Inclination of the geomagnetic field, epoch 2003.5 (dashes lines) and 2004.5 (full lines).

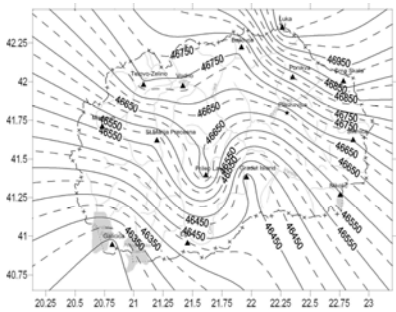

Fig. 11. Map of values of Total intensity of the geomagnetic field, epoch 2003.5 (dashes lines) and 2004.5 (full lines).

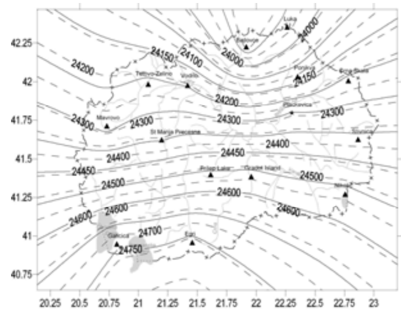

Fig. 12. Map of values of Horizontal component of the geomagnetic field, epoch 2003.5 (dashes lines) and 2004.5 (full lines).

5. Analyses of measured values 2002-2004

Figure 13 show time variation of magnetic declination, inclination and total vector for three repeat stations (Galicica, Plackovica and Ponikva) in Macedonia. Data from three neighboring geomagnetic observatories (Aquila, Tihany and Panaguirishte) are used to reduce measurements to a given epoch, 2002.5, 2003.5 and 2004.5. The diagrams indicate regular variation of intensity of total vector and inclination, for values of some 30 nT/annually and some 0,02°/annually, respectively**.** Declination indicates higher and irregular variation, particularly for the Ponikva repeat station. This nature of variation requires longer period of observation.

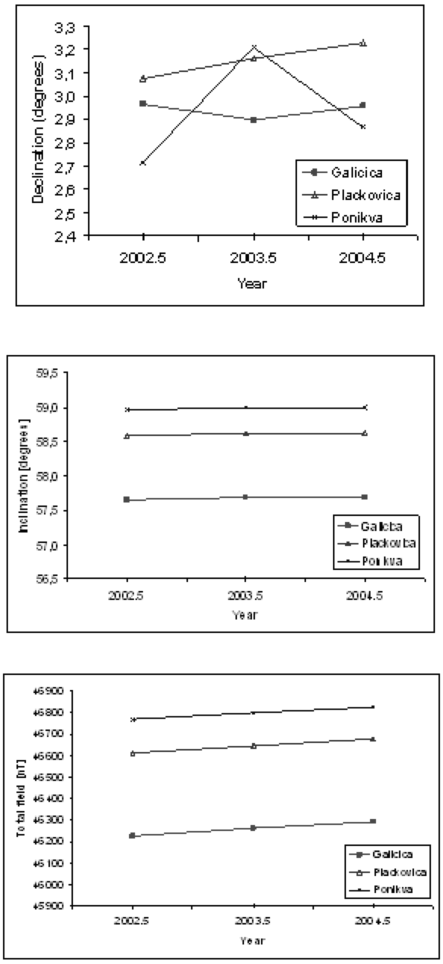

Fig. 13. Time variation of Declination, Inclination and Total intensity for repeat stations Galicica, Plackovica and Ponikva.

6. Conclusion

Comparison of the analyses between measured results and those of IGRF model shows that the results of repeat stations vary in the intervals (Table 1.):

Table 1.

Max. and min. differences between measured values and IGRF values of repeat stations

$0{,}006^{o} < \Delta D_{2004.5\text{-}IGRF} < 0{,}512^{o}$
$0{,}011^{o} < \Delta I_{2004.5\text{-}IGRF} < 0{,}172^{o}$
$5{,}9\ nT < \Delta F_{2004.5\text{-}IGRF} < 139{,}7\ nT$
$2{,}1\ nT < \Delta H_{2004.5\text{-}IGRF} < 162{,}7\ nT$
$1{,}5\ nT < \Delta X_{2004.5\text{-}IGRF} < 154{,}7\ nT$
$4{,}7\ nT < \Delta Y_{2004.5\text{-}IGRF} < 217{,}1\ nT$
$1{,}5\ nT < \Delta Z_{2004.5\text{-}IGRF} < 178\ nT$

The correlation of results between measurements in 2003 and 2004 indicate the following variations (Table 2):

Table 2.

Max. and min. differences between measured values 2003.5 and 2004.5 of repeat stations

$0{,}041^{o} < \Delta D_{2004.5\text{-}2003.5} < 0{,}093^{o}$
$0{,}0001^{o} < \Delta I_{2004.5\text{-}2003.5} < 0{,}021^{o}$
$21{,}3\ nT < \Delta F_{2004.5\text{-}2003.5} < 34{,}9\ nT$
$3{,}1\ nT < \Delta H_{2004.5\text{-}2003.5} < 17{,}5\ nT$
$1{,}4\ nT < \Delta X_{2004.5\text{-}2003.5} < 15{,}7\ nT$
$18{,}1\ nT < \Delta Y_{2004.5\text{-}2003.5} < 40{,}5\ nT$
$19{,}7\ nT < \Delta Z_{2004.5\text{-}2003.5} < 38{,}3\ nT$

References

Delipetrov, T., 2003, Basics of Geophysics, Faculty of Mining and Geology, Stip, Republic of Macedonia.

International Association of Geomagnetism and Aeronomy (IAGA), Division V, Working Group 8

Rasson, L. J., Delipetrov, M., 2004, Magnetic Repeat Station Network Description, Dourbes, Belgium.

Surfer Help: Kriging, www.goldensoftware.com

USGS Geomagnetic Field Calculator:

http://geomag.usgs.gov/geomag/geomagAWT.html