



CHUNGNAM NATIONAL UNIVERSITY

Geomagnetic Modeling with COMSOL Multiphysics¹

Goeun Ha¹, Seung-Sep Kim^{1,2}, Jeong-Hyeop Kim²

1. Chungnam National University, Astronomy, Space Science and Geology, Daejeon, Korea

2. Chungnam National University, Geology & Earth Environmental Sciences, Daejeon, Korea

Introduction

Here we aim to advance geomagnetic modeling approaches using COMSOL Multiphysics and improve the degree of detail that can be obtained from the measured magnetic field. First, we carried out benchmark tests by comparing the computed results using the widely used analytic solutions for rectangular bodies with arbitrary direction of magnetization with those from the AC/DC module of COMSOL Multiphysics. For this purpose, we built three types of synthetic models of different shaped ore bodies situated at different depths.

Computational methods

(1) Analytic method

Magnetic field at any point **P** due to a body of volume **V** and magnetization **J** is given by the well-known formula, $B = c \nabla^2 \int_V J(r)^{-1} dV$, where $c = \frac{\mu_0}{4\pi}$.

And we used MATLAB to calculate total field anomaly.

(2) COMSOL-based method

We used AC/DC module to build and calculate models and applied parameters are the same as Table 1.

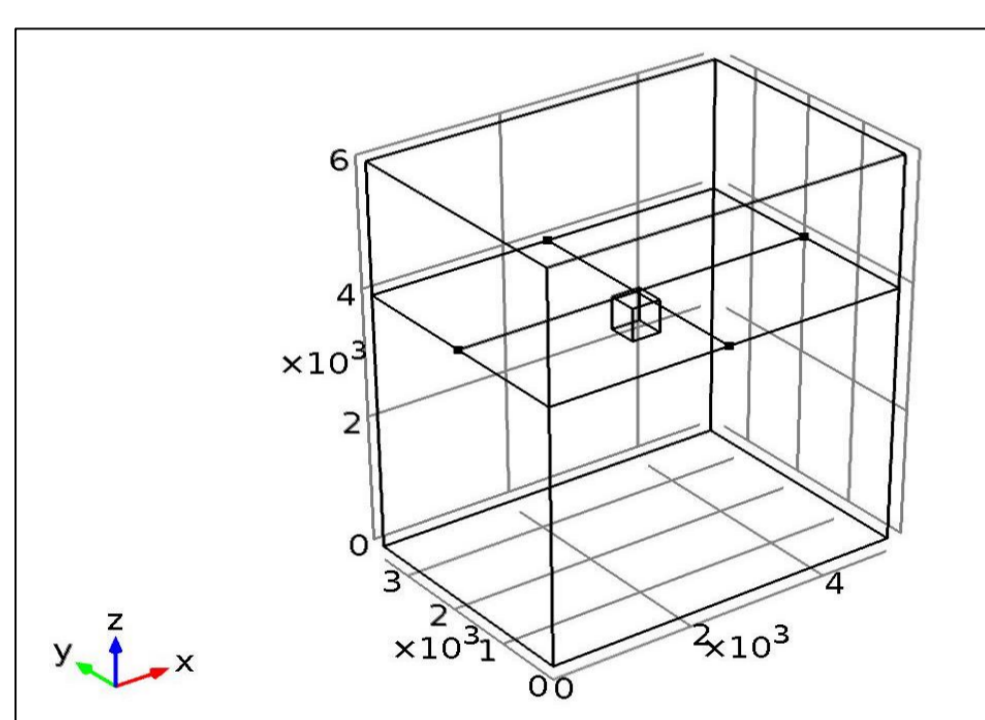


Fig.1 A model of one rectangular body (400m*400m*500m) situated at 100m depth.

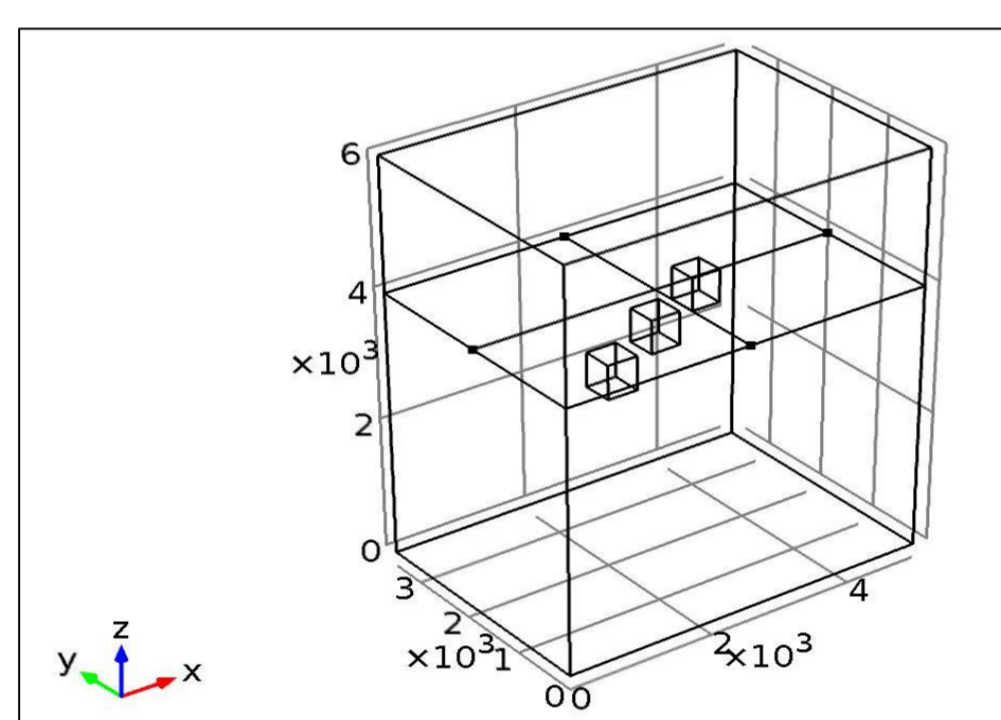


Fig.2 A model of three rectangular bodies situated at 100m, 300m and 500m depths.

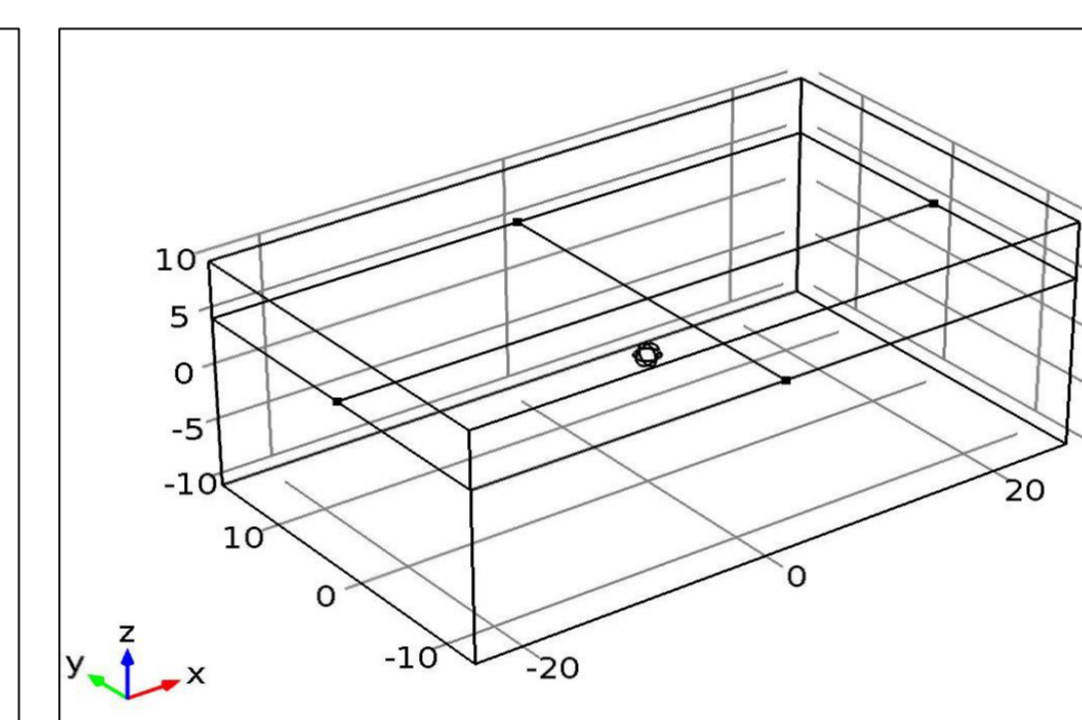


Fig.3 A model of one sphere body (R=1) situated at 5m depth.

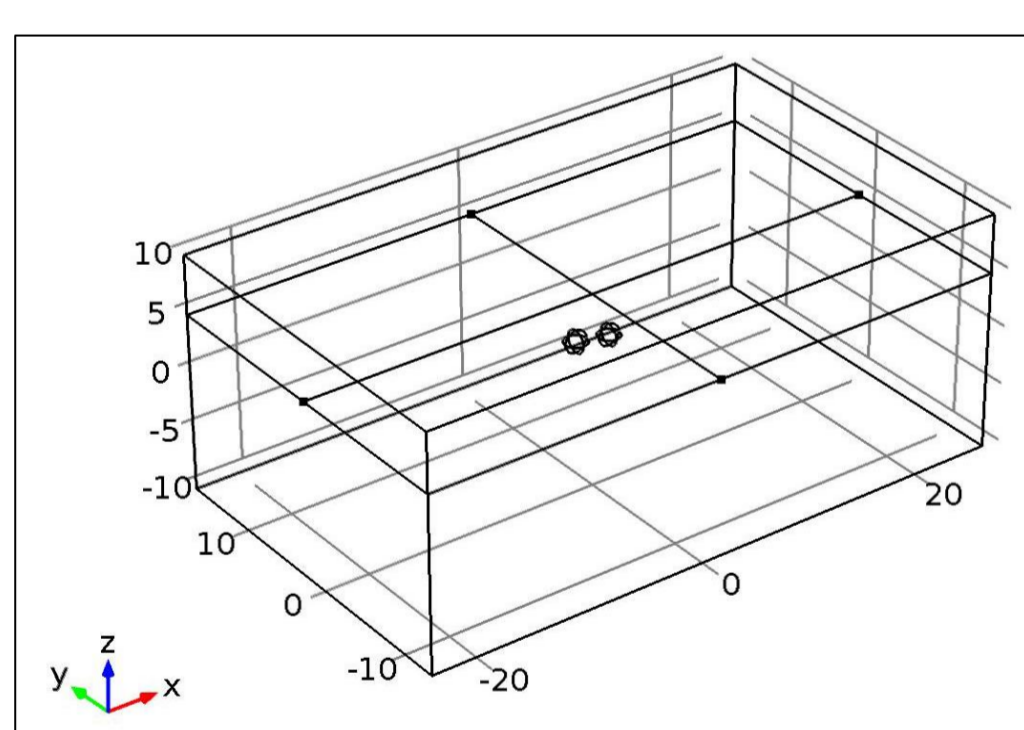


Fig.4 A model of two sphere bodies (R=1m) situated at 5m depth.

Description	Value
Relative permittivity of magnetite	3.5
Magnetic concentration in ore	0.25
Remnant magnetization of magnetite	60A/m
Geoelectric field (Daejeon, south Korea)	50161nT/m
Local inclination (Daejeon, south Korea)	52deg
Local declination (Daejeon, south Korea)	-7.7deg

Table 1. Model Parameters.

Results

(1) 3D surface plots

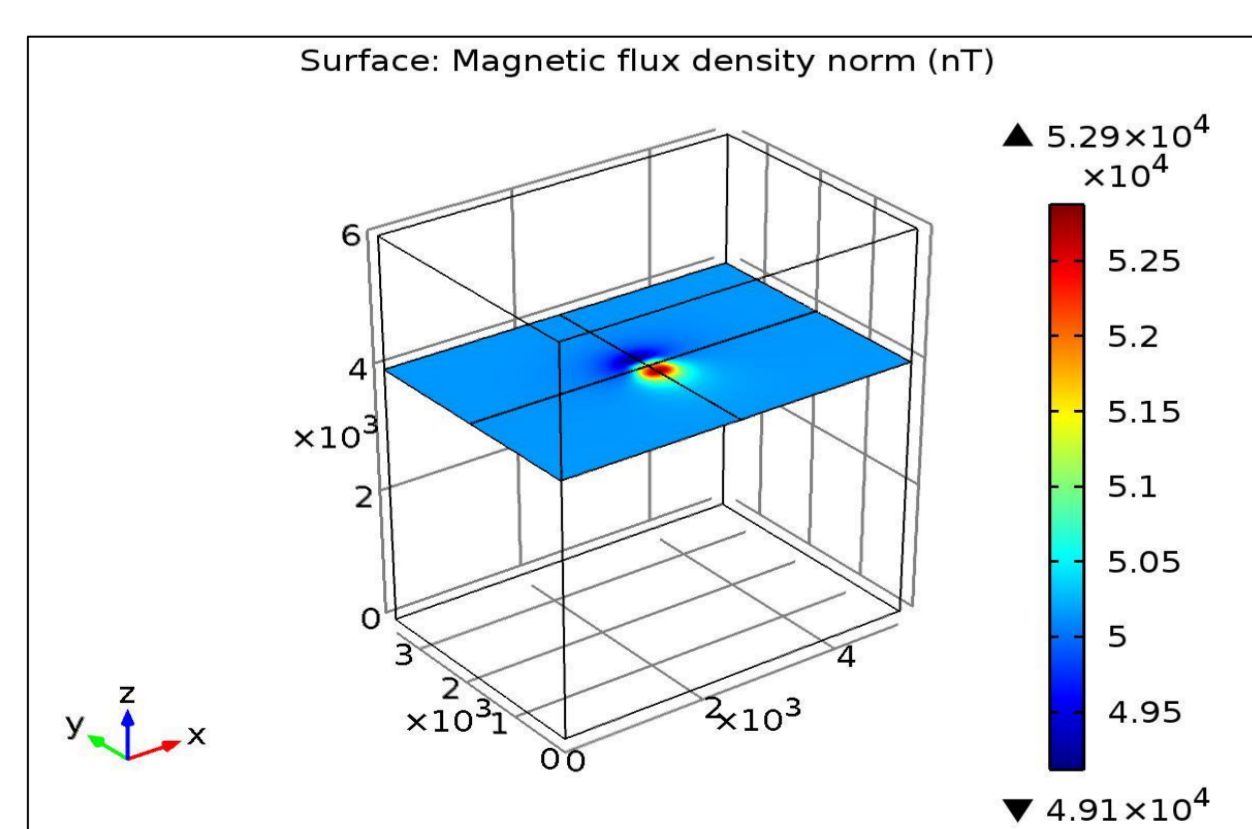


Fig.5 Surface plot of model 1 from COMSOL Multiphysics.

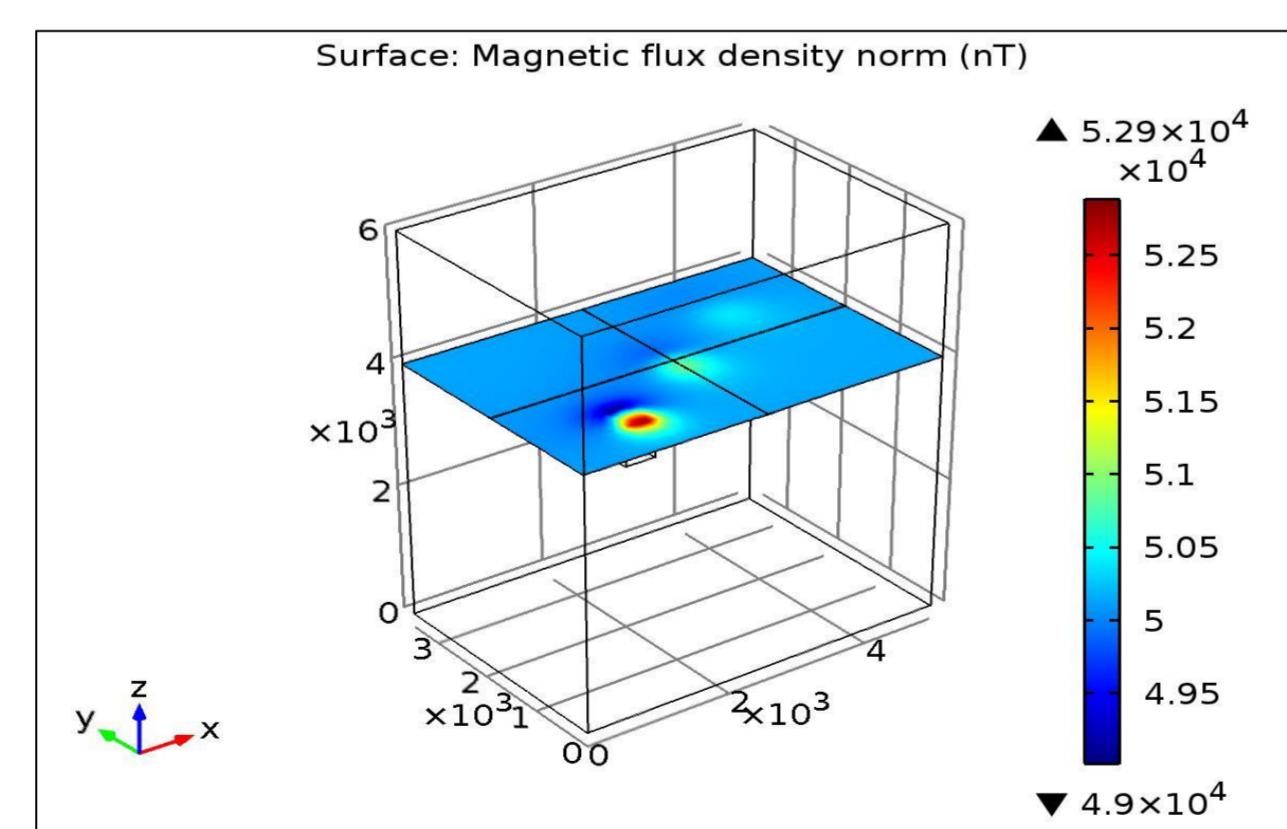


Fig.6 Surface plot of model 2 from COMSOL Multiphysics.

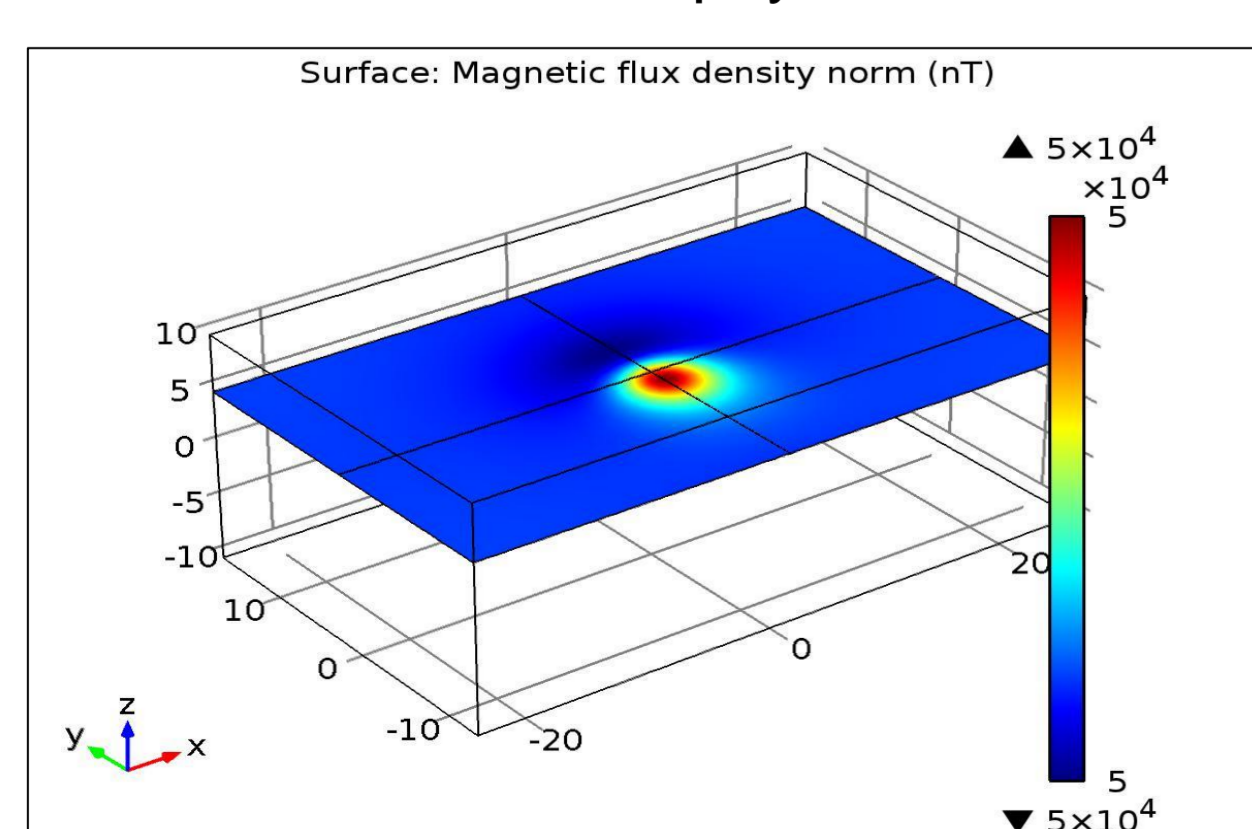


Fig.7 Surface plot of model 3 from COMSOL Multiphysics.

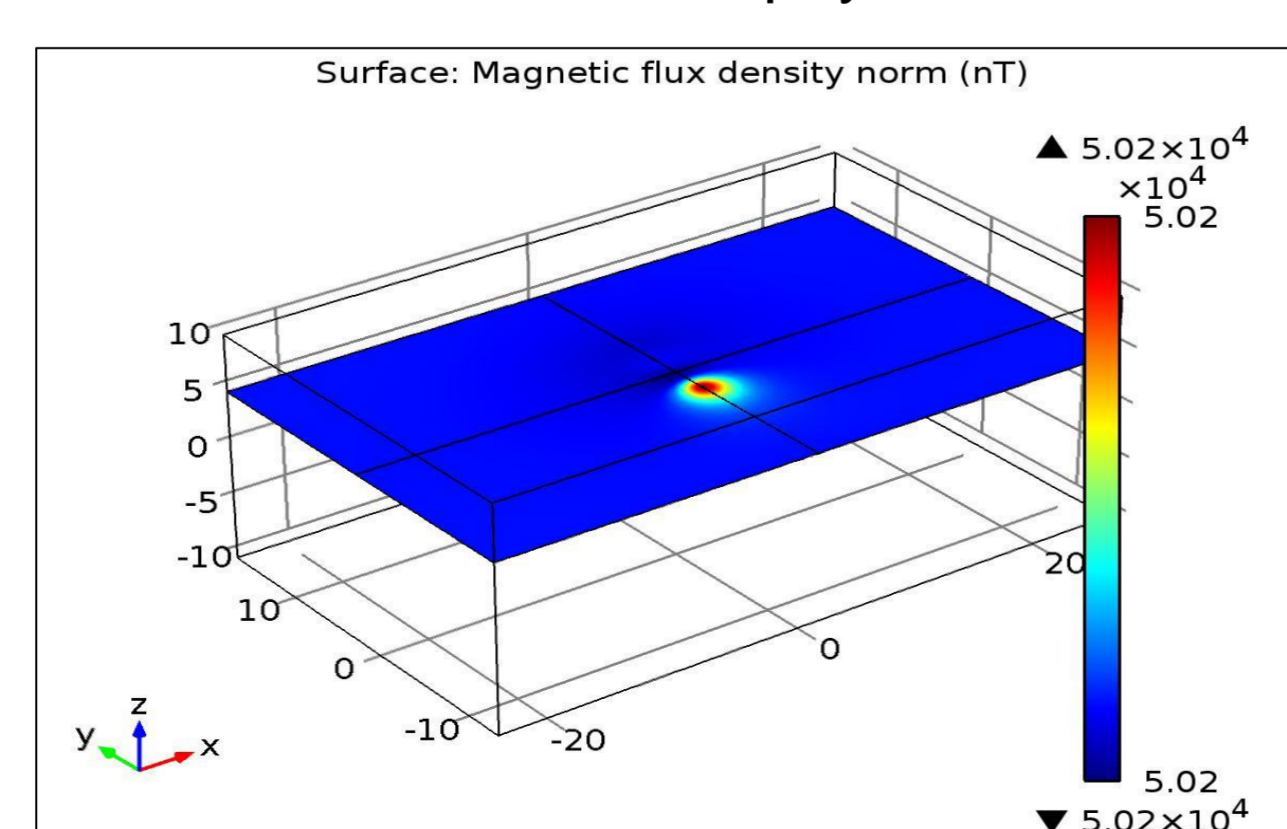


Fig.8 Surface plot of model 4 from COMSOL Multiphysics.

(2) 2D line graphs

Curves based on the values in surface plots and analytic solutions are illustrated in [Fig.7], [Fig.8] and [Fig.9].

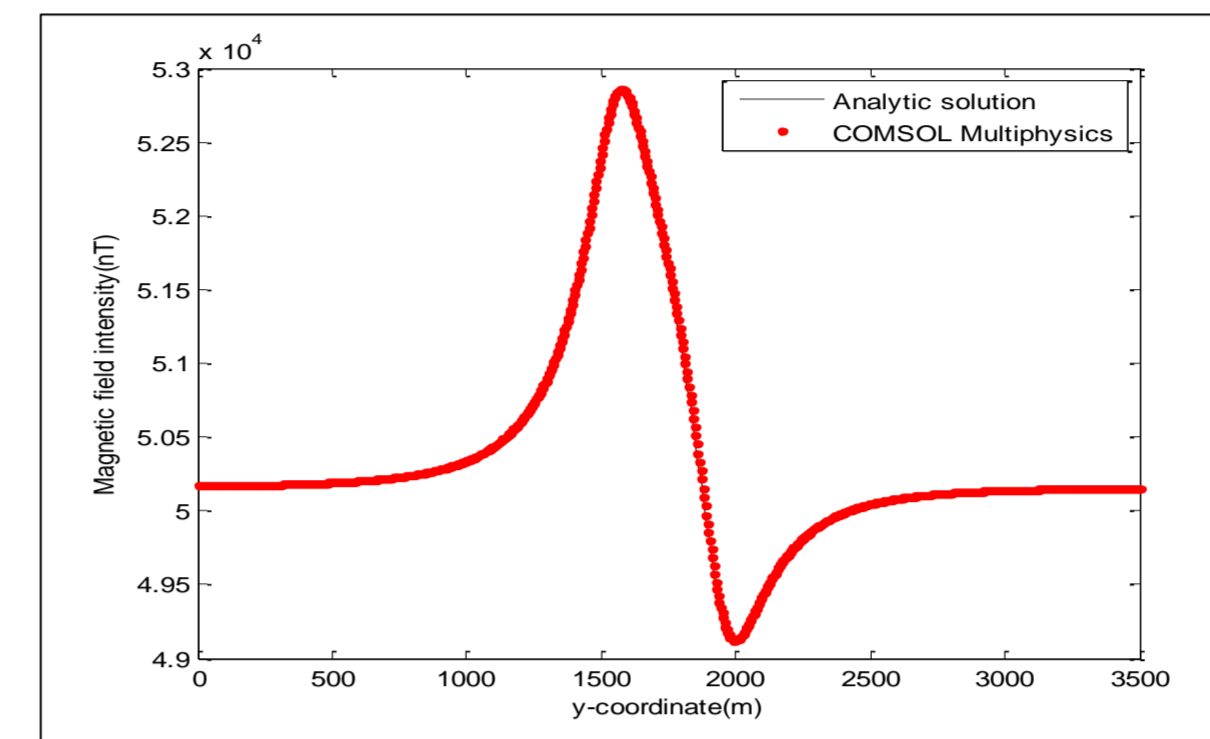


Fig.9 Line graph of model 1 in y-axis direction.

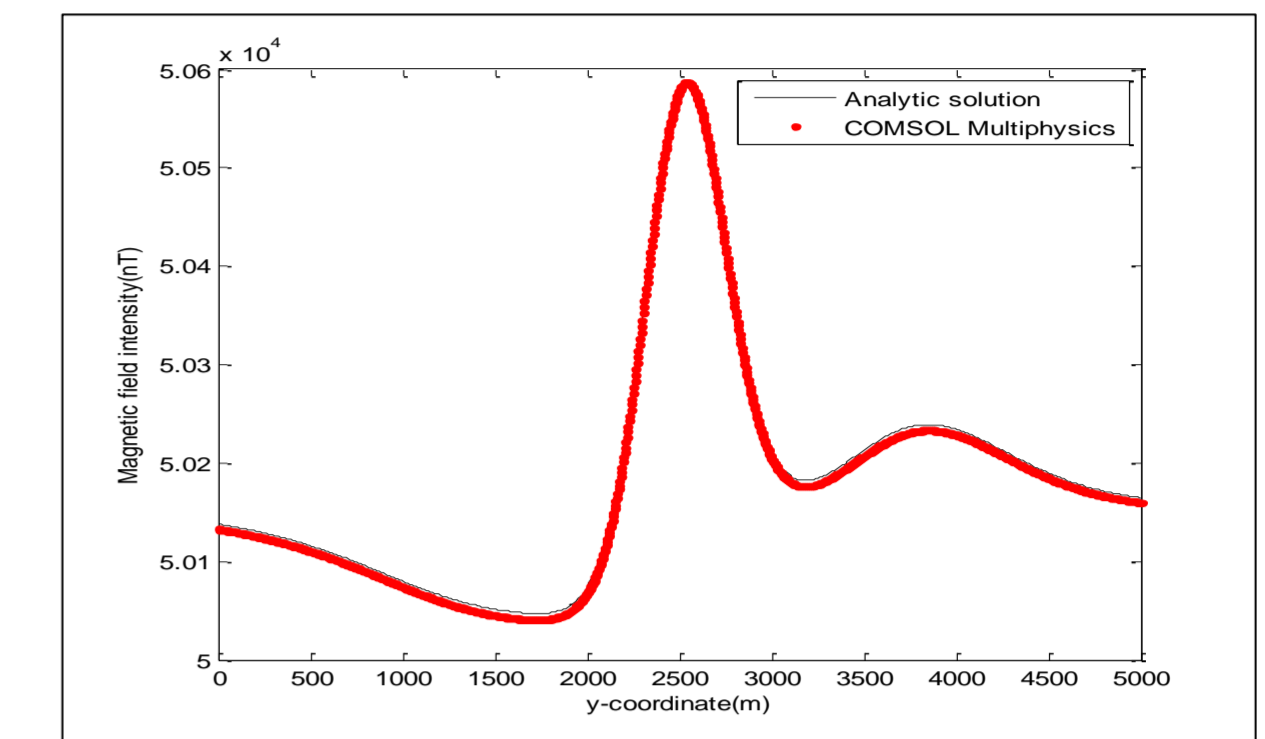


Fig.10 Line graph of model 2 in x-axis direction.

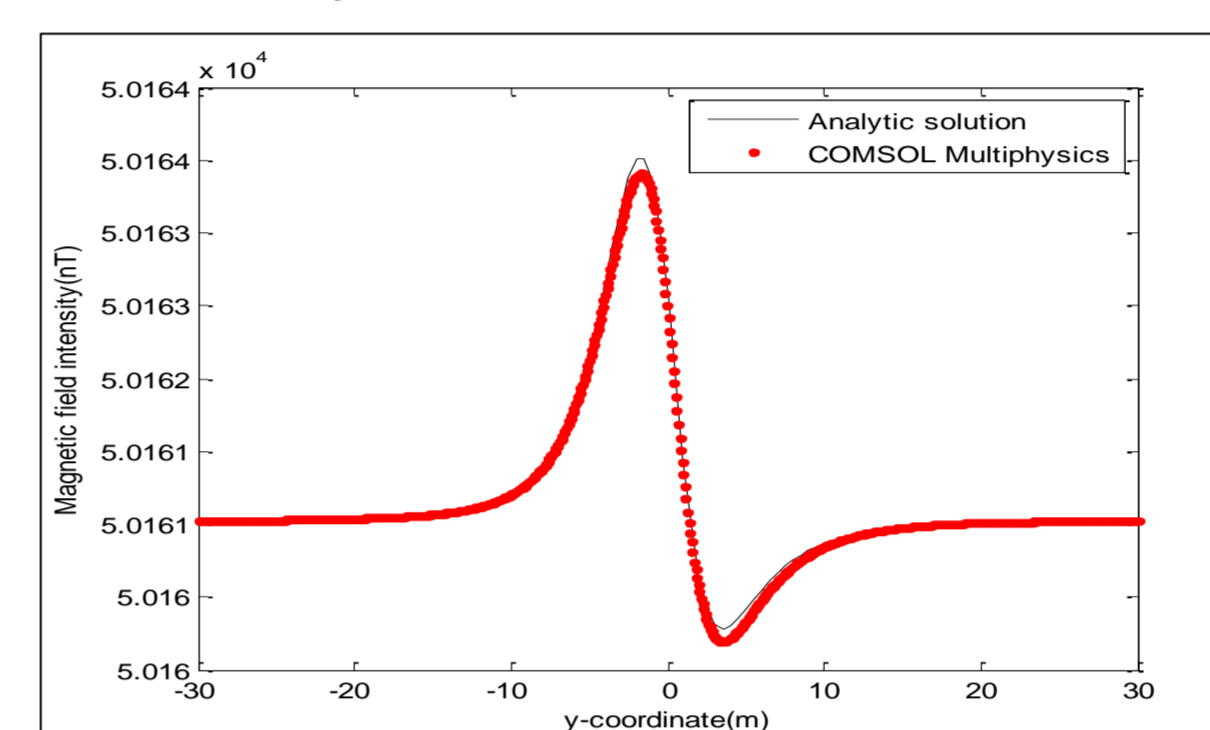


Fig.11 Line graph of model 3 in y-axis direction.

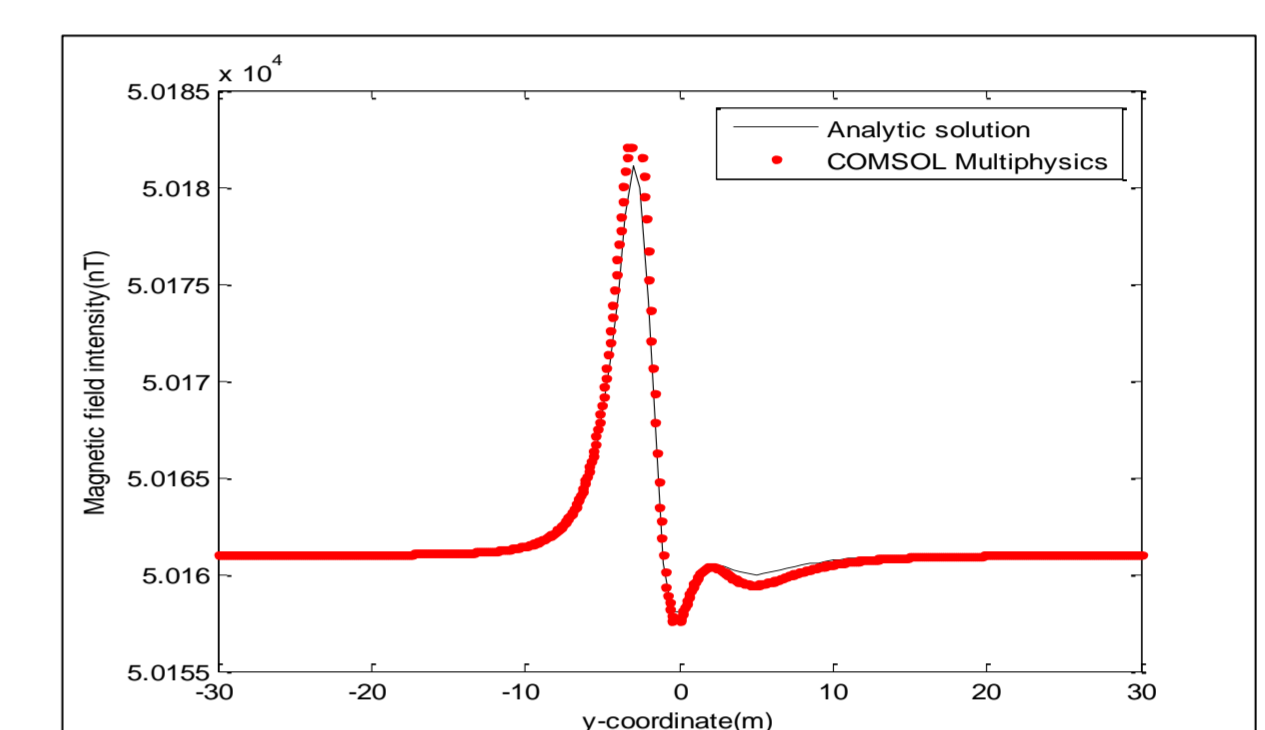


Fig.12 Line graph of model 4 in y-axis direction.

We also compared the results by changing inclination and declination of magnetization, confirming they have similar magnitudes as well as shapes.

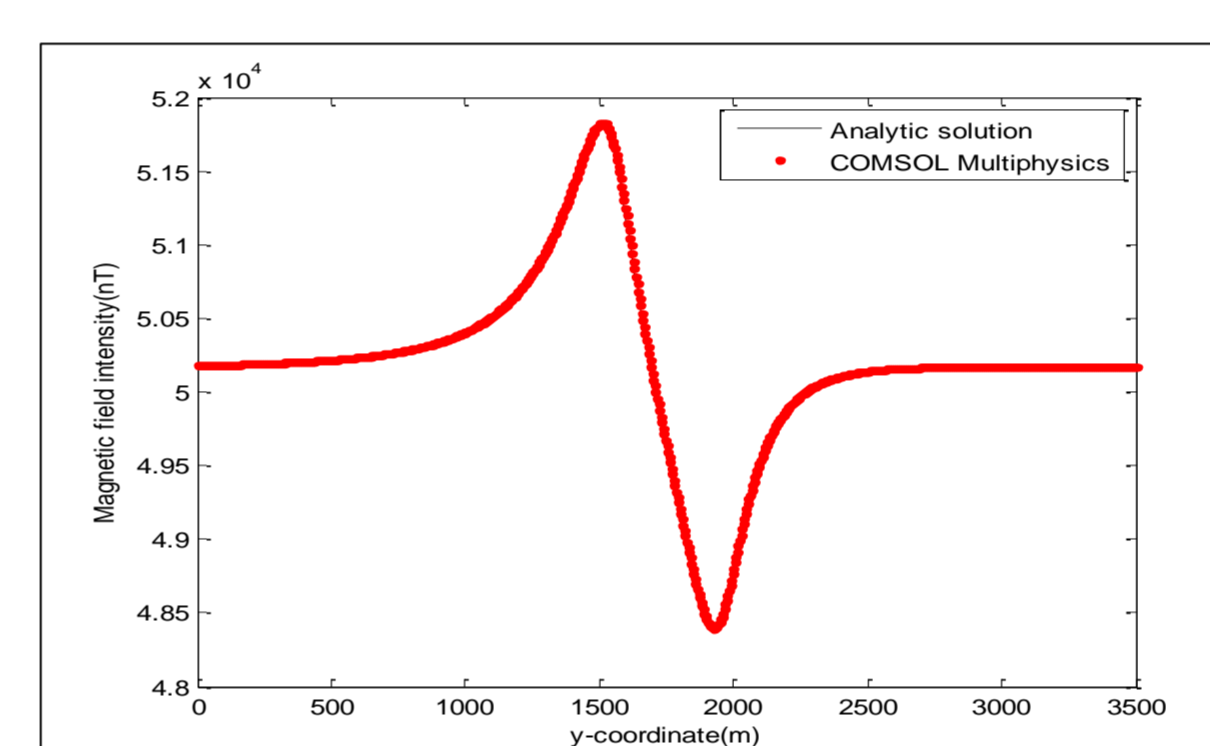


Fig.7 Line graph when inclination and declination are 10°, -7.7° respectively.

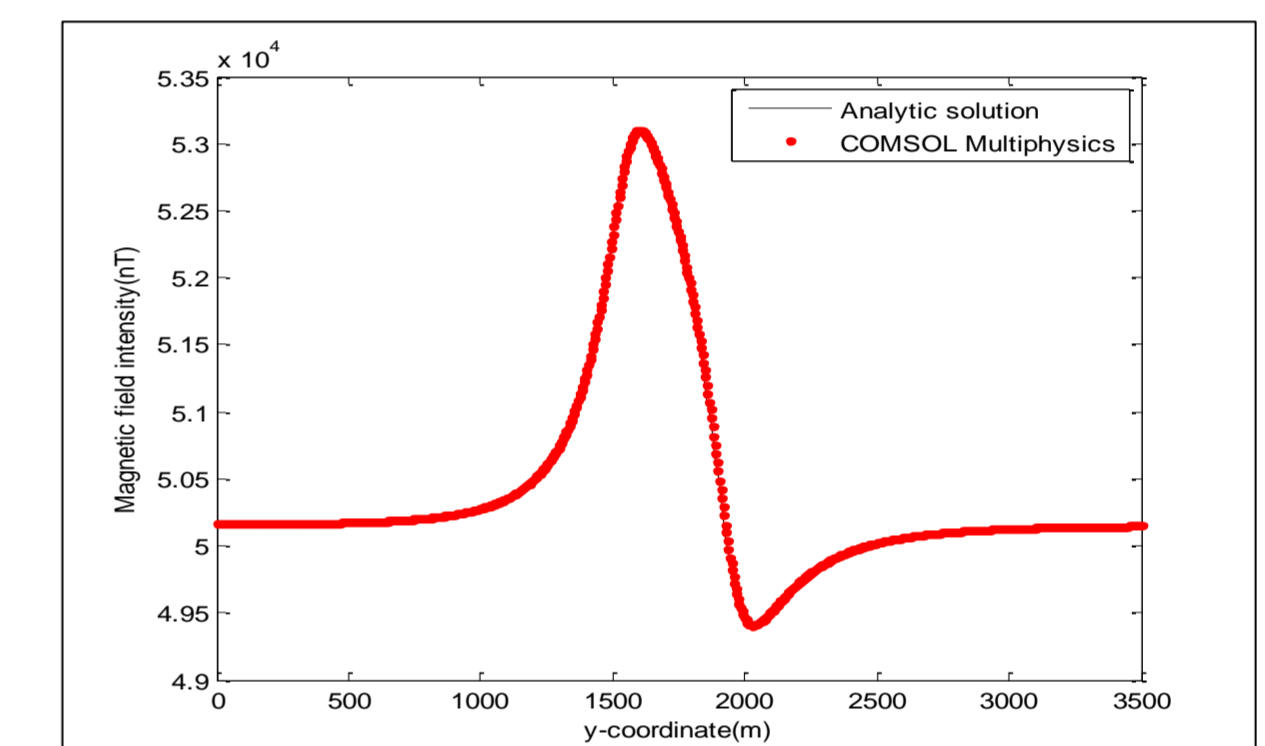


Fig.8 Line graph when inclination and declination are 70°, -7.7° respectively.

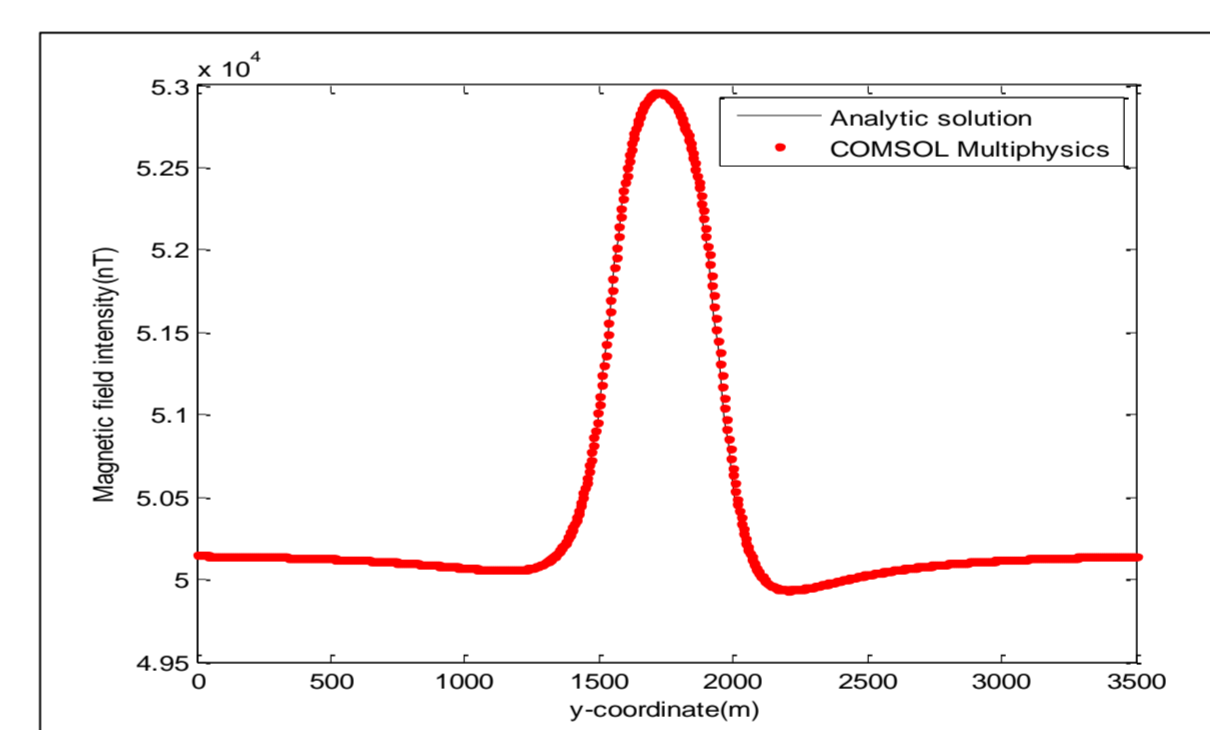


Fig.9 Line graph when inclination and declination are 120°, -7.7° respectively.

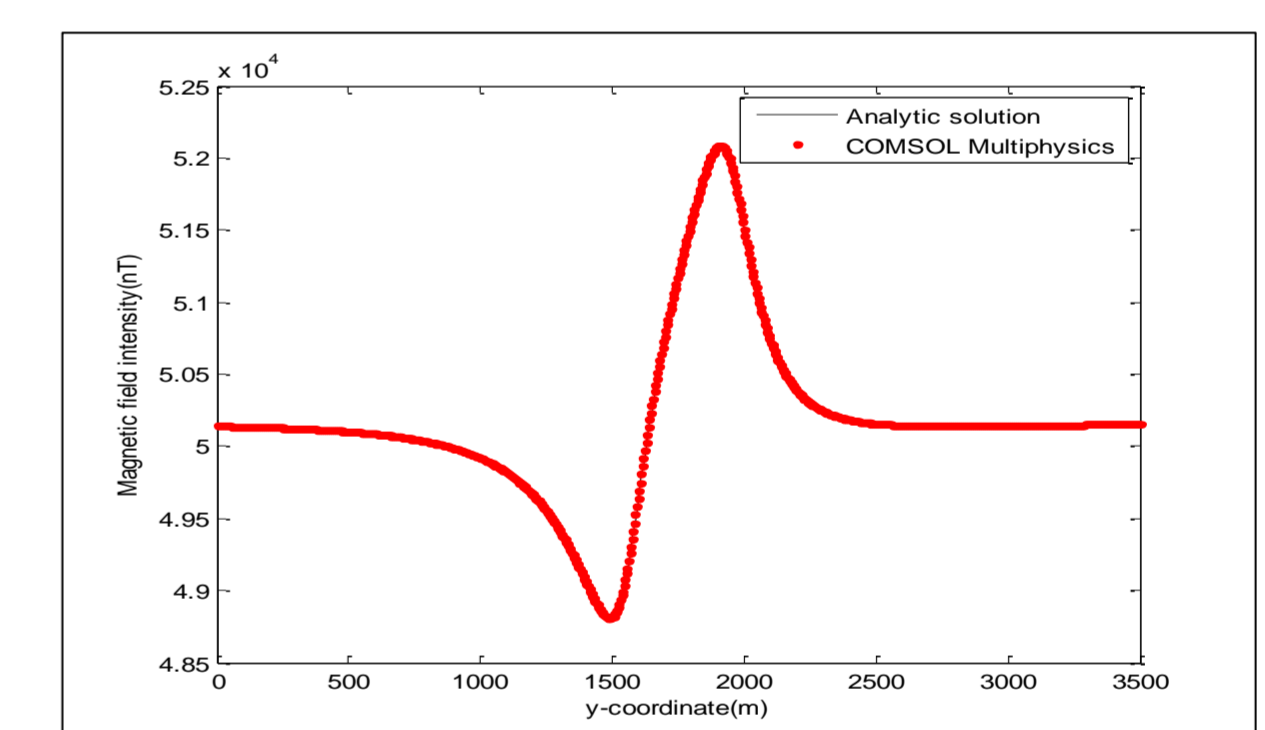


Fig.10 Line graph when inclination and declination are 180°, -7.7° respectively.

Conclusions

The results from the bench tests show the COMSOL-based approach is consistent with the analytic method that have been commonly used in the field of Geophysics. Both functionality and expandable capability of COMSOL Multiphysics can assist to find new insights in geomagnetic studies. For a more wide usage of COMSOL, the interfaces for geophysical measurements and other quantitative tools need to be developed.

References

- Sharma, P.V., *Geophysical Methods in Geology*. Vol. 2nd. 1986, New York: Elsevier.
- Kim, S.-S. and P. Wessel, *Directional median filtering for regional-residual separation of bathymetry*. *Geochem. Geophys. Geosyst.*, 2008. **9**: p. Q03005.
- Johnson, H.P., D.V. Patten, and W.W. Sager, *Age-dependent variation in the magnetization of seamounts*. *J. Geophys. Res.*, 1996. **101**(B6): p. 13701-13714.
- Contreras-Reyes, E., et al., *Crustal intrusion beneath the Louisville hotspot track*. *Earth. Planet. Sci. Lett.*, 2010. **289**: p. 323-333.