Modeling the daily mean values of regional geomagnetic total force field changes in Japan

Satoshi Fujiwara[1*], Teruaki Nishiki[2], Hiroki Shirai[2], Hideo Hamazaki[2], and Vadim P. Golovkov[3]

[1]*Mizusawa Geodetic Observatory, Geographical Survey Institute, 42-2 Uchi-kumagasawa, Kuroishi-machi, Mizusawa, Iwate 023-0101, Japan*
[2]*Geographical Survey Institute, 1 Kitasato, Tsukuba, Ibaraki 305-0811, Japan*
[3]*Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN), Troitsk, Moscow region 142092, Russia*

(Received May 17, 2000; Revised October 4, 2000; Accepted October 4, 2000)

A spatial-temporal model of the daily mean values of the geomagnetic total force field was constructed for Japan for the time interval from 1997 to 1999. The daily mean data of six geomagnetic observatories and nine continuous geomagnetic stations in Japan were used for the model. Temporal functions of the model were constructed using the Natural Orthogonal Components method, and the spatial functions are polynomial functions of the horizontal positions. The accuracy of the model is within approximately a few nT, and it can be used for eliminating external fields for geomagnetic surveys or detecting local geomagnetic changes for monitoring crustal activities. Each function, which is calculated using the mathematical (statistical) method, has physical meaning, such as the intensity of the globally symmetrical equatorial ring current and secular changes in the main field. The temporal and spatial functions can be then used for geophysical study of the Earth.

1. Introduction

Since the geomagnetic field observed on the Earth's surface contains changes due to the Earth's external field and the internal core, common changes are observed in a rather wide region. We need to eliminate the common changes in order to detect small local changes in the geomagnetic field such as piezomagnetic effects in the Earth's crust and volcanomagnetic effects.

The easiest way to eliminate common changes is to take the simple difference between the data at a field station and the data observed simultatiously at a reference station. The simple difference will be reasonable if the two stations are close to each other, but this method cannot sufficiently cancel out common geomagnetic activity in some cases. Rikitake (1966) used weighted differences and Steppe (1979) used a weighted linear combination of several stations for the reference data in order to solve this problem. Kadokura (1990) used the Principal Component Analysis (the Natural Orthogonal Components method) to find the common changes, which are usually the principal part of the geomagnetic changes. Although these improved methods are of higher quality than the simple difference method, we have to determine the parameters using data observed at each station.

We can get the geomagnetic values at any spatial point and at any time in the model without additional analysis for a new station by using spatial-temporal models of the geomagnetic field such as the IGRF (IAGA Division V, Working Group 8, 1995). The global model IGRF has many discrepancies in Japan (Burdelnaya *et al.*, 1999). One in particular is that the time variation model cannot be used for the daily mean. We developed a new regional model which accurately describes the geomagnetic field variations in Japan and can determine time variations of a few weeks. The new model should have functions like the IGRF, which has position (latitude and longitude) and time inputs (day, month and year) and an output for the model value. Contrary to Burdelnaya *et al.* (1999), this model must use the daily mean time series to expand the data into temporal functions (e.g. Golovkov and Zvereva, 1998).

The present model study has two main purposes. One is to detect local variations of several nT for reasons including eliminating the external field for geomagnetic survey data at field stations, and the other is to obtain a secular variation field for geophysical study of the Earth. The time interval for the model should be as short as one day for crustal activity and other studies.

2. Data and Method

The Geographical Survey Institute (GSI) has been conducting geomagnetic surveys in Japan since 1948. One of the main purposes of the surveys is to detect anomalous changes of the Earth's surface magnetization due to crustal activities such as earthquakes and volcanic activities. Eleven continuous geomagnetic stations with proton and fluxgate magnetometers were installed in 1996 because continuous observation is greatly superior to repeat observations at field stations for this purpose. The data is automatically transmitted to the GSI through public telephone lines. We also use data from 6 GSI (MIZ, ESA and KNZ) and the Japan Meteorological Agency (MMB, KAK and KNY) geomagnetic observatories

*Now at Research and Development Bureau, Science and Technology Agency, 2-2-1 Kasumigaseki, Chiyoda, Tokyo 100-8966, Japan.