Press Releases

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JAMSTEC

Effects of Rotational Speed Change on the Earth's Magnetic Field
–Potential Contribution to the Relationship between Climate Change and Geomagnetic Field Variation–

1. Overview

Takehiro Miyagoshi and Team Leader Yozo Hamano of the Japan Agency for Marine-Earth Science and Technology (hereinafter referred to as JAMSTEC: Asahiko Taira, President) Institute for Research on Earth Evolution have investigated the relationship between changes in the earth's magnetic field (the geomagnetic field) and climate change over cycles of tens to hundreds of thousands of years. They conducted the first simulation of the geodynamo (generation of the geomagnetic field by the convection of the liquid metal present at the earth's core) (*1) that takes into account changes in the earth's rotational speed caused by the growth and decline of continental ice sheets during glacial-interglacial cycles (*2).

Their findings showed that the changes in rotational speed that occur during glacial-interglacial cycles cause changes in the convection of the earth's liquid metal outer core; they are the first to quantitatively show that this causes variation in the earth's magnetic field. A change in rotational speed of about 2% caused a disproportionately large change in the geomagnetic field of about 20 to 30%; in addition, a time delay was found to exist between the change in rotational speed and the change in the earth's magnetic field. In addition, a large variation of approximately 10% in the heat flux transported from the core to the mantle occurred with the change in rotational speed.

These findings, in addition to contributing to clarifying the mechanisms of variation of the earth's magnetic field, are anticipated to provide a major clue for understanding the relationship between climate change and variation of the geomagnetic field.

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Title: Magnetic Field Variation Caused by Rotational Speed Change in a Magnetohydrodynamic Dynamo
Authors: Takehiro Miyagoshi and Yozo Hamano
Affiliation: Institute for Research on Earth Evolution, Japan Agency for Marine-Earth Science and Technology

*1 Simulation of Geodynamo: As the equations (magnetohydrodynamic equations) that describe liquid metal flow in the earth’s core and behavior of magnetic fields are highly complicated, supercomputer simulation is an extremely useful method for research on the geodynamo process (see *3). These findings were developed based on the geodynamo simulation model published by Miyagoshi et al. (August 28, 2008 and February 11, 2010 press releases).

*2 Glacial-Interglacial Cycle: Cyclical repetition of glacial periods when continental ice sheets develop at high latitudes and interglacial periods when ice sheets decline.

*3 Dynamo Process: Electric current is generated when inductive material (liquid iron in the case of the earth) moves (convection in the case of the earth) through an electric field. Under the appropriate conditions, this electric current is known to make the existing magnetic field stronger. This is known as the dynamo process.

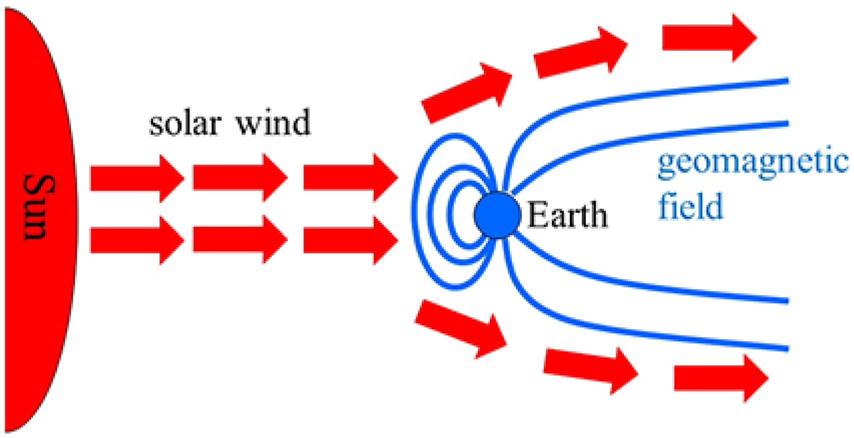

Figure 1 Schematic diagram of solar wind and the geomagnetic field.
The solar wind constantly blowing from the sun is deleterious to life. The geomagnetic field protects the earth’s surface environment from the solar wind.

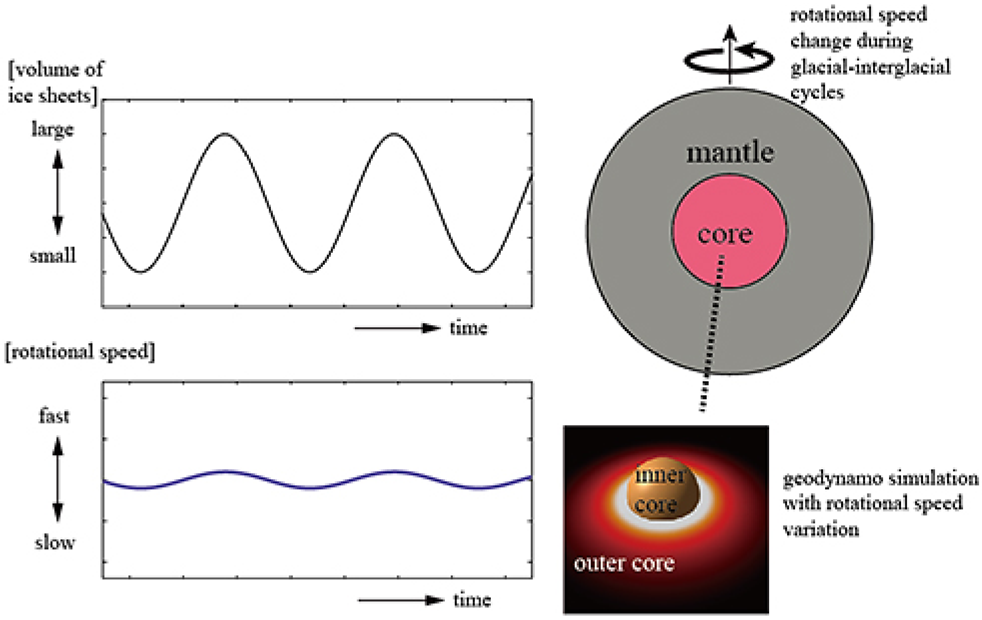

Figure 2 (Left Top and Bottom) Variations in earth's rotational speed are expected owing to the growth and decline of ice sheets with climate change. Rotational speed is likely to increase with the growth of ice sheets at high latitudes and decrease during the interglacial period as ice sheet decline. The timescales of glacial-interglacial cycle are tens to hundreds of thousands of years. (Right) The interior of the earth is composed of rocky mantle and a metallic core. The core is divided into a liquid outer core and a solid inner core; the earth's magnetic field is produced by the convection of the former. The effect of rotational speed change on the earth's magnetic field was studied by conducting computer simulations of the geomagnetic field generation (geodynamo) process.

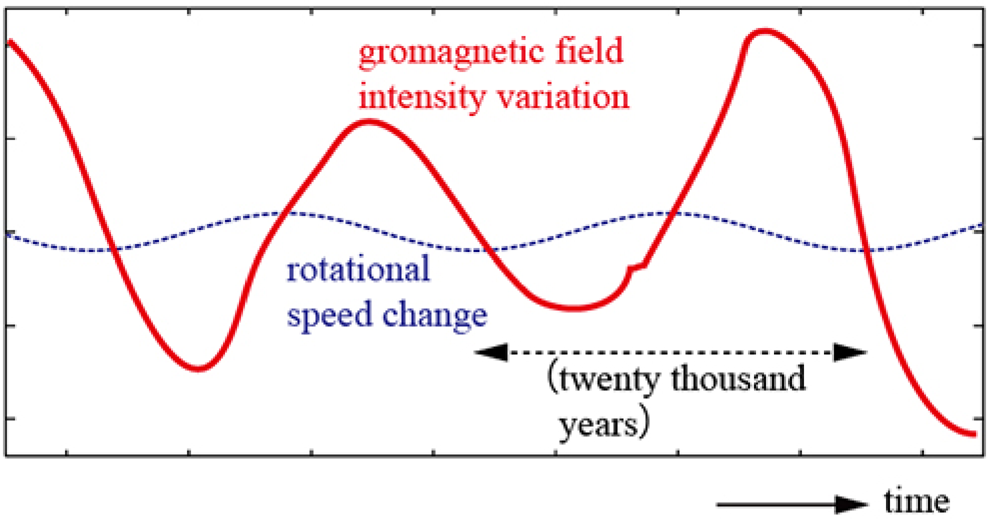

Figure 3 A schematic picture of variation of the geomagnetic field obtained from the simulation.
The simulation results revealed that for an approximately 2% oscillation in the earth's rotational speed over a 20,000 year cycle, a large variation of 20 to 30% in the magnetic energy within the core and in the dipole magnetic field was observed. As the response to the effect of irregular convection in the core is nonlinear, even if rotational speed is changed at a constant magnitude, the geomagnetic field displays increasingly complex fluctuations with time. Also, a time lag was found to occur between the

change in rotational speed and magnetic field variation (the magnetic field reaches its maximum somewhat later than does the rotational speed).

Contacts:
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
(For the study)
Takehiro Miyagoshi, Scientist
Yozo Hamano, Team Leader
Mantle and Core Dynamics Research Team, Deep Earth Dynamics Research Program, Institute for Research on Earth Evolution (IFREE)
(For publication)
Kazushige Kikuchi, Director
Planning Department Press Office