

Analysis of geomagnetic field changes with tsunami generation in the 2011 Tohoku Earthquake

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Earth's electric and magnetic changes associated with earthquakes and tsunamis have been investigated previously. However, the apparent changes of the Earth's magnetic field signal simultaneously observed at multiple observation sites near the epicenter of the tremendously huge earthquake are rarely reported.

Our observation sites were situated at an epicentral distance of a few hundred km from the March 11, the 2011 Off the Pacific Coast of Tohoku Earthquake (Tohoku Earthquake) of Mw 9.0. In this study, we present our successful observations of Earth's magnetic field changes caused by tsunami from the 2011 earthquake that occurred off the Pacific coast of Tohoku, Japan. The key point of this report is that we successfully observed Earth's magnetic field changes caused due to the huge tsunami effects and that we make a qualitative comparison between magnetic field and GPS-TEC (total electron content) changes.

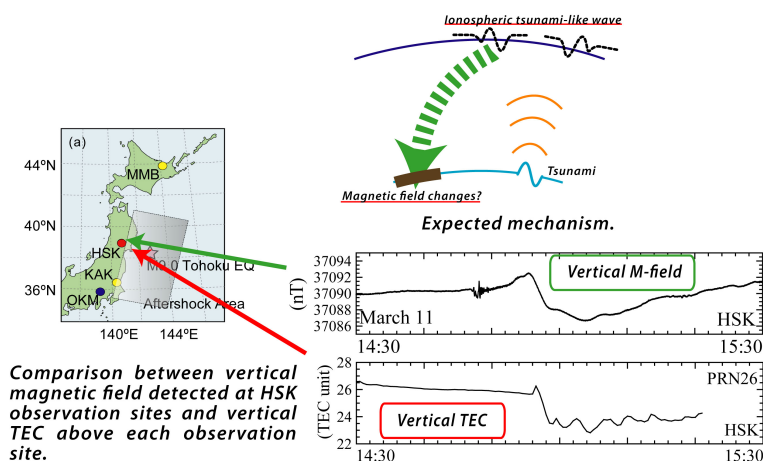
Our observation systems were established at Hosokura, Miyagi prefecture in NE Japan and at Okutama, in Tokyo. Their systems consist of a fluxgate magnetometer, GPS clock and recorder with 0.03 or 0.01 nT resolution. A vertical component accelerometer is also installed at Hosokura observatory. Since March 2004, we have observed 3 components of the geomagnetic field using a pair of fluxgate magnetometers at Hosokura mine in northeast Japan. One of them has been placed at the main gallery ~70m bellow the ground surface and another in a hole 1m bellow. The sampling interval of the lower magnetometer is 0.5 sec and the upper 1 sec. The observation clock has been synchronized by use of GPS signals. At Okutama station, we have also observed 3 components of the geomagnetic field using a fluxgate magnetometer with GPS clock at 32 Hz sampling since December 2003. The sensor is placed in a hole 1m below the ground surface near a mountain stream.

The 2011 off the Pacific coast of Tohoku Earthquake, so-called the Great East Japan Earthquake, was a mega-thrust earthquake with a magnitude 9.0 (Mw) off the coast of Japan that occurred at 14:46:18 JST on 11 March 2011. Our observation results show that the magnetic field began to change almost simultaneously with tsunami generation and propagation. These changes were detectable at multiple observation points before the arrival of tsunami waves at coastal areas.

Additionally, we compared the magnetic field with TEC changes: we found that the vertical component of the magnetic field (Hz) at HSK is very similar to TEC changes above HSK. That is, this suggests that remarkable magnetic field changes at HSK was generated by changes in the conductivity and/or current of the ionospheric layer.

These are very important and noteworthy results: Further efforts can suggest new systems for early warning of destructive tsunami using a combination of magnetic and other measurements.

Keywords: 2011 Tohoku Earthquake, geomagnetic field changes, TEC, tsunami, acoustic wave



Comparison between vertical magnetic field detected at HSK observation sites and vertical TEC above each observation site.