Estimation of the Extremely Large Geomagnetically Induced Current expected in Japan

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The geomagnetically induced current (GIC) happens to damage transformers of electrical power line systems in high-latitude countries like Canada and Sweden where the geomagnetic disturbances are enhanced. Eventually, severe GICs sometimes cause disasters due to power line failure like the accident in 1989 in Canada. Thus, there have been many works about GIC in the high-latitude countries [i.e., Pulkkinen et al., 2005]. On the other hand, the low-latitude countries like Japan seem to be regarded to be free from dangers of the GIC disasters [Pulkkinen et al., 2008]. Indeed, Watari et al. [2009] revealed that the GICs measured at some transformer station in Hokkaido are as small as several Ampere. These values are negligibly small compared with the permissible current of a transformer. It is noted that the measurements by Watari et al. [2009] were carried out in the period of extremely quiet solar activity.

The result by Watari et al. [2009] seems to indicate that Japan is safe from the GIC disasters. However, it should be noted that the ground conductivity structure is quite different between Hokkaido and other Japanese areas like the most industrialized and highly-populated Kanto plain. This difference invokes the following geoelectric characters in Japan; the geomagnetically induced electric field at Kakioka in Kanto plain is sometimes about 10-times larger than that at Memambetsu in Hokkaido. Namely, this fact of the geomagnetically induced electric field suggests that information of GICs in Hokkaido may not be applied to GICs in other areas in Japan. In addition, this fact also suggests significant effect of the ground conductivity structure to evaluation of the induced electric field and GICs. Concludingly, the GIC should be studied based on a realistic 3D ground conductivity model in Japan.

Next, it should be noted that we do not know the extreme values of GICs in Japan. Evaluation of vulnerability of the electrical system in our society requires the extremes. To evaluate the extremes, we need to estimate the extreme geomagnetic disturbances in Japan and perform a numerical simulation of GICs with a realistic 3D ground conductivity model. One attempt to evaluate the extreme geomagnetic disturbances is statistical analysis of the occurrence probability of SIs at Memambetsu. We found that the occurrence probability of SI intensity divided by the duration (nT/min) obeys a power law rule like Gutenberg-Richter law of Earthquake occurrence. Based on this analysis, we roughly estimate the most severe SI in 1000 years can have the increase rate as large as 1000nT/min. As for the latter issue, the Japanese team started to compile the 3D ground conductivity model in Japan (i.e, Uyeshima et al., 2000) and JEMINI project for the 3D regional model of the electric conductivity in Japan will be launched soon (Oshiman, private communication).

In the coming 2013 JpGU meeting, we have the GIC session in order to discuss what we should do for estimation of the extremes of the GICs and/or induced electric

field in Japan. The scope of this session includes not only estimation of the extremes of the GICs and/or induced electric field but also the attempt toward precious analysis of the ground- and low-altitude satellite geomagnetic data by using the realistic 3D model of the ground electric conductivity and the realistic magnetosphere-ionosphere current system. The latter attempt will open a new field of research of the Earth's geomagnetism. This is a real collaboration between the space scientists and the solid-Earth geomagnetists.

References

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