Drastic time variations of transfer function of geomagnetically induced current (GIC)

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Geomagnetically induced currents (GICs) flow in power grid in response to geomagnetic field variations. Because of the potential threat of power outage, GIC is regarded as one of the important aspects of space weather. We calculated the transfer function in frequency domain that describes a linear relationship between the GICs measured at 3 substations in Japan and the geomagnetic field measured at the Kakioka observatory. The transfer function is found to show a drastical time variation. For the periods at 2-10 minutes, the amplitude of the transfer function in night time is about 1 order of magnitudes larger than in day time. The day-night difference reduces for the periods >100 minutes. In addition, the amplitude of the transfer function tends to increase with local rainfall amount. These regular and irregular variations associated with local weather can be explained in terms of resistivity of earthing resistivity. The resistivity of the non-frozen soil decreases by about 40% when the temperature increases from 15˚C to 35˚C, resulting in the reduction of the earthing resistivity. Rainwater permeating into the soil also results in reduction of the earthing resistivity. Reduction of the earthing conductivity gives rise to magnification of the GICs. These results imply that a weather condition strongly affects the magnitude of GIC in Japan and challenge the conventional wisdom that the transfer function is almost steady in this time scale.

