Atmospheric electric field measurement for the study of space and atmospheric climate changes

*Masashi Kamogawa[1], Yasuhiro Minamoto[2], Akira Kadokura[3], Mitsuteru Sato[4]

1. Global Center for Asian and Regional Research, University of Shizuoka, 2. Laboratory for Environmental Research at Mount Fuji, 3. National Institute of Polar Research, 4. Hokkaido University

The atmospheric electric field is an electric field perpendicular to the ground and has an average value of about 100 V/m in fair weather. This value varies daily, peaking around 2000 UTC, with a range of variation within tens of percent of the average. This diurnal variation is known to be similar throughout the globe in fair weather. This diurnal variation is called Carnegie Curve after the Carnegie research vessel that contributed to the discovery.

It has been pointed out since around the 1920s that the reason for understanding that the same diurnal variation globally occurs regardless of local time is that the entire earth consists of an electric circuit, called global electrical circuit. The electric circuit consists of a capacitor in which the ionosphere/mesosphere (Approximately 60 km altitude) and the conductive ground (including sea areas), both of which have high atmospheric conductivity, become spherical shell electrodes, and sandwich the atmosphere with low atmospheric conductivity. Although the conductivity of the atmosphere between these electrodes is low, it is slightly conductive due to the ionization of the atmosphere by cosmic rays and natural radionuclides. This yields electric current flows from the ionosphere to the earth in fair weather region due to the atmospheric electric field caused by the potential difference between the two electrodes. This means a discharge process. The atmosphere, therefore, plays a role of resistance in the global electrical circuit. On the other hand, since cloud-to-ground lightning and charged rainfall transport electric charges into the ionosphere and the ground during the thunderstorm activity which continuously and globally. Therefore, the capacitance is always charged in the thunderstorm region, and simultaneously discharged in the fair weather region. The ionospheric potential in the global electric circuit can be understood to some extent by observing the atmospheric electric field in the fair weather region.

Because the atmospheric electric field during fair weather varies greatly due to the presence of radioactive materials and transport of air pollution, many researchers point out that it is affected by global changes in radioactive materials (nuclear bomb tests, nuclear power plant accidents,) as well as climate change. In addition, the ionosphere/magnetosphere and the global electrical circuit are considered to be electrically coupled and not unrelated to space weather.

From the above history, it is considered that the measurement of atmospheric electric field on the ground surface can greatly contribute to the study of space weather and atmospheric climate change. We have conducted the measurement of the atmospheric electric field in Antarctica, where there is no air pollution. Although there is no air pollution in the polar regions, drifting snow is known to be a noise source for measurement. Therefore, we examined the atmospheric electric field generated by these drifting snow and developed a methodology to easily distinguish between drifting snow and fair weather. This made it possible to establish an environment for investigating the relationship between global electrical circuits and climate change and space weather.

