

Probing the Global Electric Circuit from Fair Weather to Space Weather: Observations and Modelling

Sujay Pal^a, Rakhijul Alam Faruque^b, Sushanta Kumar Mondal^c, Yasuhide Hobara^d

^aDepartment of Physics, Srikrishna College, Nadia, West Bengal

^bNetaji Subhas Open University, Kalyani Regional Campus

^cSidho Kanho Birs University, Purulia, West bengal

^dThe University of Electro-Communications, Tokyo, Japan

In this presentation, we summarize a set of ground-based atmospheric electricity measurements aimed at characterising both the DC and AC components of the Global Electric Circuit (GEC) across quiet and disturbed conditions. Using co-located Atmospheric Electric Field (AEF) mill and VLF/LF radio receiver at a low-latitude station Bagula (BGL), we show that the fair-weather diurnal variations of VLF sferics amplitude and AEF closely track cloud-to-ground lightning rate, with primary minima delayed by ~2-3 hours relative to the Carnegie minimum and secondary maxima attributable to European thunderstorm activity - demonstrating that simultaneous sferics-AEF monitoring can capture both local disturbed weather and global GEC forcing. Extending this to space-weather timescales, AEF and VLF sferics data from four stations (BGL, Purulia, Kakioka, Chofu) during the 10-11 May 2024 super geomagnetic storm show a ~21-34% enhancement in mid-latitude AEF, plausibly associated with both the Forbush Decrease and the subsequent Solar Energetic Particle (SEP) event, whereas AEF at the low-latitude stations showed no significant storm-related effect (Faruque et al., 2026). In contrast, the marked enhancement in low-latitude VLF sferics amplitude and lightning rate is more closely tied to the SEP event, with its timing pointing to enhanced atmospheric ionisation and conductivity as the likely driver.

At the local-pollution scale, comparison of AEF with Air Quality Index at BGL and Purulia shows moderate-to-strong seasonal correlations ($r = 0.59-0.75$ at BGL in winter/post-monsoon), with occasional AEF polarity reversals during extreme pollution episodes attributed to negative space-charge layer formation (Faruque et al., 2025). To disentangle these overlapping influences, a fair-weather AEF simulation based on a reduced RC circuit model was carried out to investigate the relative contributions of global GEC forcing (Carnegie curve), local meteorology/boundary-layer parameters, aerosol/pollution loading, and lightning-driven local injection currents to the observed BGL PG curve, including its polarity-reversing episodes. The combined observational and simulation approach provides a framework for investigating the relative contributions of global electric-circuit processes, local meteorology, aerosols, lightning and solar-terrestrial disturbances to atmospheric electricity over low-latitude India.