Study of GIC’s Geophysical Sources During Extreme Geomagnetic Storm on 10–12 May 2024

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Geomagnetically induced currents (GICs) in power lines in northwest Russia were studied during one of the most intense geomagnetic storms of the space age (10–12 May 2024). The analysis spanned from 17 UT on 10 May to 06 UT on 12 May. During the main phase (~17:15 UT on 10 May to ~04:30 UT on 11 May), GICs were strongest at the southern station (KND), while during the recovery phase (after ~04:30 UT on 11 May), the northern station (VKH) experienced higher GICs. This reflects the auroral oval's expansion and southward displacement during the main phase, followed by its return during recovery. Evening and night sector GICs (~15–30 A) were driven by westward electrojet intensifications during substorms and supersubstorms, while morning sector GICs (~01–04 UT) were induced by Pc5/Pi3 pulsations during substorm recovery. Two supersubstorms (SSSs) revealed distinct GIC origins: night-sector GICs during the first SSS were linked to its polar edge, while day-sector GICs during the second SSS were caused by eastward electrojet intensifications tied to SSS development in the night sector. The largest GIC peaks (~50–62 A) resulted from the superposition of multiple sources, including substorms, Pc5/Pi3 pulsations, and local magnetic disturbance caused by solar wind pressure jumps. This study highlights the complicity of geomagnetic sources of GICs, showing that GIC intensity does not scale linearly with substorm strength. However, intense substorms, such as SSSs, can enhance GICs even in the daytime MLT sector.