

II. GLOBAL CURRENT AND FAIR WEATHER ELECTRICITY

ATMOSPHERIC ELECTRIC CURRENTS AT WIDELY SPACE STATIONS

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Simultaneous measurements of atmospheric electric variables at widely spaced stations in the past have produced evidence of a global component in electric field and current density (Mauchly, 1926; Paramonoff, 1950). A worldwide daily variation of hourly averages is recognizable if data over long periods of time are considered or if averaged over many stations. At particular locations as in polar regions, on mountain tops or over the oceans global variations can sometimes be even recognized after averaging over a few days (Kasemir, 1972). Yet the variability due to local generation and transport of charges at surface stations usually overshadows global components. An encouraging advancement in experimentally verifying global components in electric field variation was made by Markson (1977) in a comparison of 15 minute averages of aircraft data taken in the Gulf of Alaska and in the Bahamas. At aircraft altitudes above the exchange layer local generation diminish in significance and a global component became noticeable. A new approach to depress locally produced variations in atmospheric electric currents at surface levels has been shown by Ruhnke (1969). Long wire antennas with effective areas larger than local space charge inhomogeneities can effectively enhance the ratio of global to local components. Because this is easier accomplished in the time domain of seconds and minutes rather than hours and days it becomes interesting to search for a global component of the air earth current density in this short time domain.

The goal set for the research presented here was to verify experimentally the possibility that in the time domain of seconds and minutes a global component in current density exists. Long wire antennas were used at two widely spaced stations (Waldorf, Maryland, USA and Vilsandi, Estonia, USSR) to record Maxwellian current density (conduction current plus displacement currents). The effective areas were 150 m² at Waldorf and 1720 m² at Vilsandi. With such antennas during periods of low winds area averaging effects could be noticeable for time periods up to 10 minutes. Digital recordings once each second were made from 0:00 GMT to 0800 GMT each day. In this time period we could best expect calm conditions simultaneously at both stations. Fair weather periods of 10 minute duration were defined at each site by computers if the standard deviation of the interval was less than 10⁻¹² A/m². This represented about 5% of the best condition at each site and provided a chance of a few 10 minute periods per month of simultaneous fair weather conditions. An analysis of the data of August 1979 was made so far. In Vilsandi 56 fair weather periods occurred out of 1488 possible; in Waldorf we had 48 cases. Of these cases, six occurred simultaneously at both stations. These were analyzed in more detail. The case of August 5, 1979 is shown in Fig. 1 as an example.

All six cases showed positive linear correlations by inspection but also a random noise mainly at higher frequencies. After averaging over 10 seconds, correlations improved noticeably and a statistical analysis was performed to consider correlation coefficients and significance. All records of quiet periods had a certain similarity. Standard deviation was approximately 0.8-10⁻¹² A/m² and a dominant period of about 80 seconds

appeared in the fluctuations. This made it difficult to estimate significance of the correlation analysis as one could assume that local generations with similar amplitude and period affect the measurements at random at both stations but produce recordings of amazing likeness. To test for significance 60 random sample pairs were produced from the six pairs of observations and the assumption was made that recordings taken at different times and different days should be random. These 60 cases showed an average correlation coefficient of -0.03 with a standard deviation of 0.21 . In comparison the correlation coefficients of all six simultaneous recordings were all positive with an average coefficient of $+0.35$, a maximum value of $+0.63$ and a minimum value of $+0.17$. The probability that this set of correlation coefficients occurred by a random process is 1 in 50,000. We conclude therefore, that the correlation of current variations between Vilsandi and Waldorf are real with a high degree of probability.

The consequence of this finding is considerable. The variability of the current density is difficult to explain by the usual assumption that the global current density is generated by the sum of all thunderstorms. It is unlikely that about one thousand thunderstorms occurring simultaneously, lasting each for about 20 minutes and producing each about 1 ampere net current for the global component can add up to fluctuations like in Fig. 1. Some of the recordings between Vilsandi and Waldorf seem to have phase delays up to 40 seconds, which is very difficult to explain by electromagnetic theory if sources of the currents are located in the earth's atmosphere. It is possible that global ionization rates vary with the periodicity found in our records and, therefore, modulate an otherwise fairly continuous thunderstorm current. Furthermore ionospheric, magnetospheric and solar influences may be considered to explain the fine structures of the atmospheric electric current. There also seems to be a need to correlate the fine structures of the current density with other geophysical variables, like magnetic variations or cosmic ray activities. It may be hoped that further explorations of the Maxwellian current density as a new geophysical variable will increase the confidence in our analysis and open the way to a synoptic observation network in atmospheric electricity.

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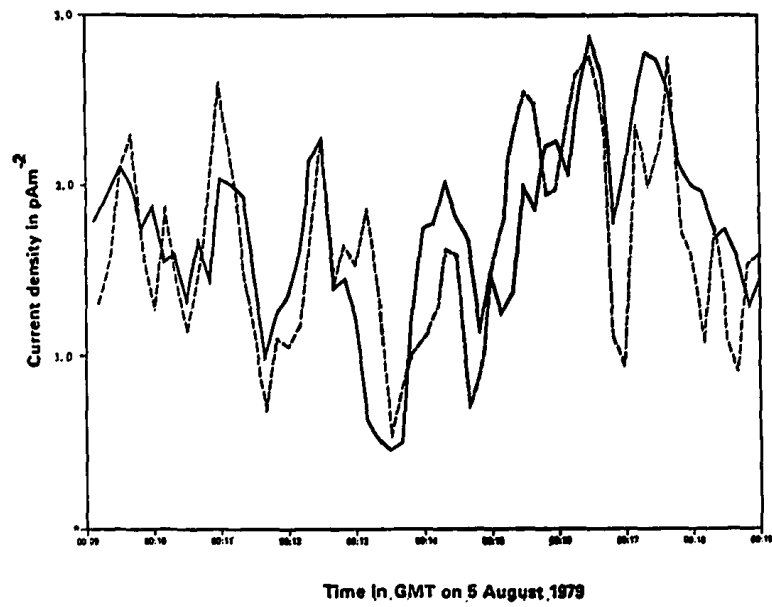


Fig. 1 Simultaneous Variations of Density of Maxwellian Atmospheric Electric Current at Waldorf, Maryland, USA (—) and Vilsandi, Estonia, USSR (---) Data points are averages over 10 seconds.