6.3 ELECTRIC FIELD MEASUREMENTS WITH STRATOSPHERIC BALLOONS

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Electric fields and currents in the middle atmosphere are important elements of the modern picture of this region. Balloon instruments, reaching the level of the stratosphere, have been used extensively for the experimental work. The research has shown good progress, both in the MAP period and in the years before and after. Our knowledge has been increased about, e.g., the upper atmosphere potential, the electric properties of the medium itself and about the coupling with magnetospheric (ionospheric) fields and currents. Also various measurements have brought about a discussion of the possible existence of hitherto unknown sources. Throughout the MAP period the work on a possible definition of an electric index has continued.

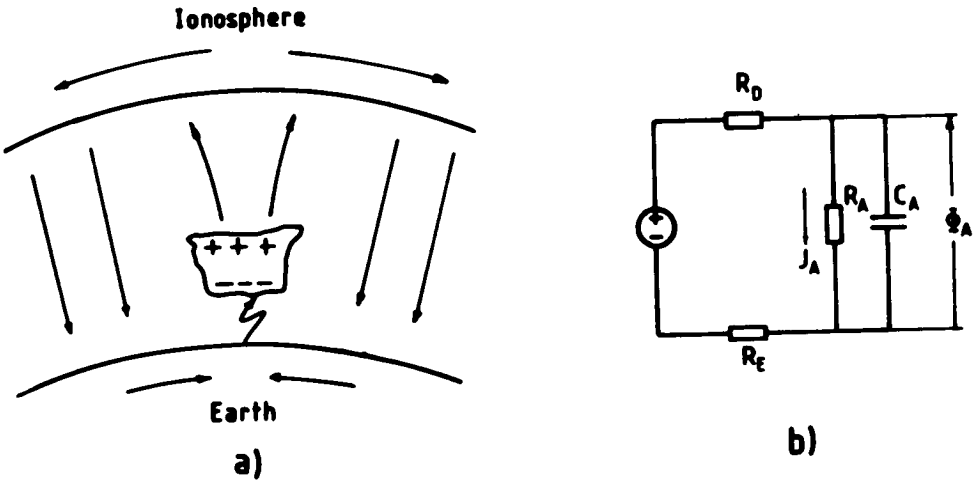

Figure 1. Schematic representation of the global electric circuit. In the classical picture thunderstorms are charging the upper atmosphere to a high potential (200-300 kV). A return current is, in fair-weather regions, flowing to the ground. a) illustrates the concept and b) is a simple equivalent electric diagram. From Volland [1984].

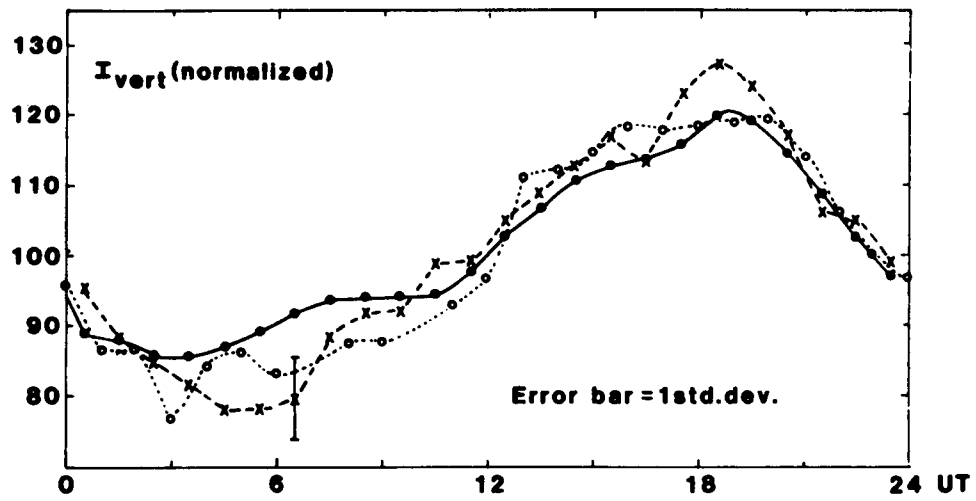

Figure 2. The upper atmosphere potential displays a "quiet day" curve, which is the average over many days. This typical variation is versus UT and is due to the uneven distribution of the continents. Three curves are shown: a) the original Carnegie curve marked ———, b) airplane measurements marked o- - -o, and c) balloon measurements marked x- - - x. From D'Angelo et al. [1982].

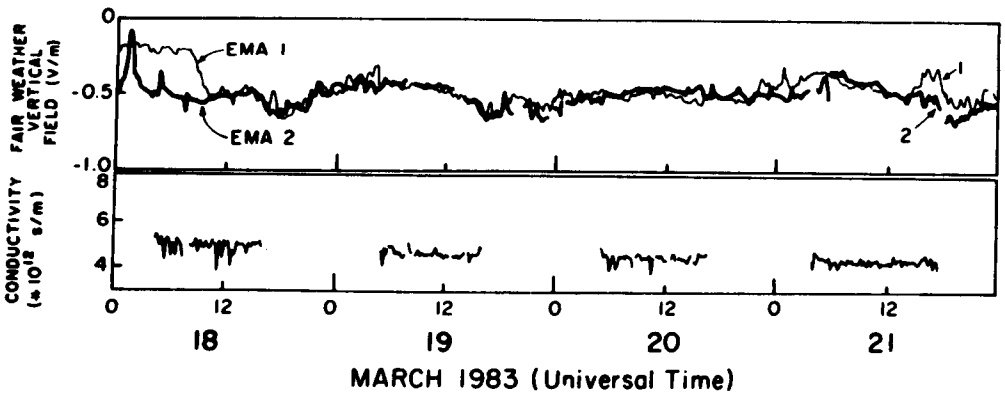

Figure 3. Two simultaneous measurements of the vertical electric field at 26 km altitude by two balloons separated by over 1500 km. These measurements have shown that also variations on a shorter time scale occur synchronized over a larger area supporting the concept of a uniform upper atmosphere potential. From Holzworth et al. [1984].

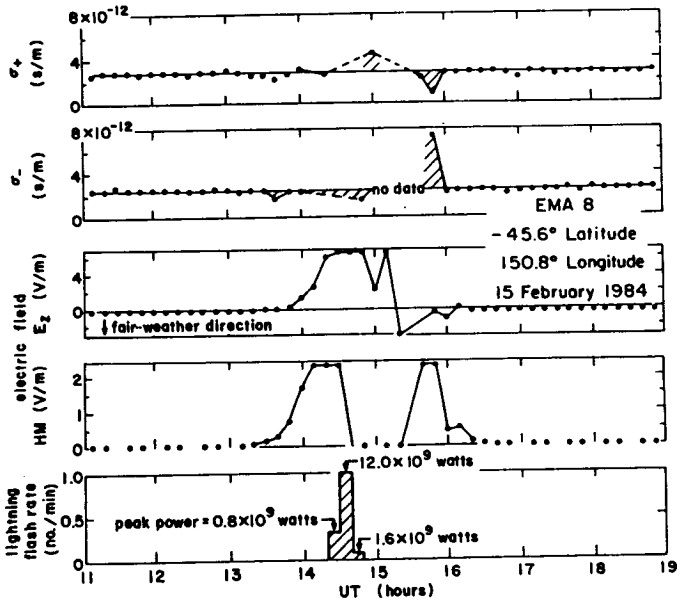

Figure 4. New observations related to the global circuit are still being reported. Fluctuations of both the positive and negative conductivity above a thunderstorm have been observed in several cases. The observations suggest a relationship between the battery and the resistor R_D in the equivalent diagram of Figure 1. From Holzworth et al. [1986].

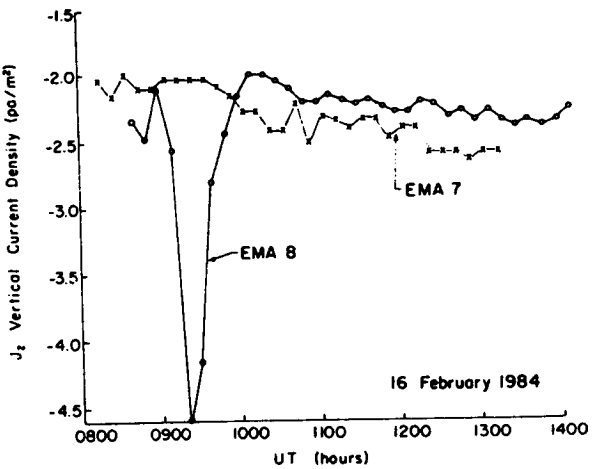

Figure 5. This is another example of measurements which cannot be explained by the simple circuit. A solar proton event has increased the conductivity of the upper polar atmosphere where a balloon experiment observed a clear increase in the vertical current (o-o-o-). A problem is, however, that a balloon measurement outside the polar region (x-x-x-) did not show a simultaneous decrease in vertical current which should be expected due to a worldwide decrease in the upper atmosphere potential (represented in Figure 1 by the voltage over the capacitor C_A). From Holzworth et al. [1987].

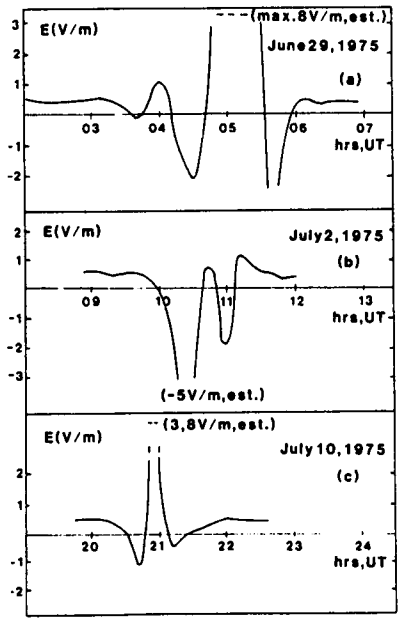

Figure 6. Also tropospheric structures of less magnitude than a full size thunderstorm can be electrified as observed with balloon instruments. Shown here are three examples of "dipole like" structures observed from a balloon passing by. The polarity of the central part is opposite to that of a typical thundercloud. From Madsen et al. [1983].

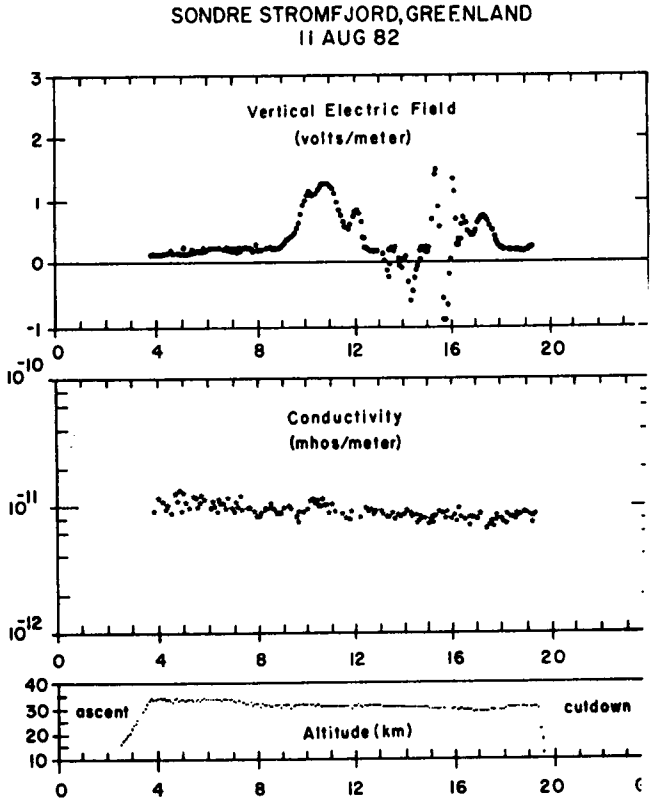

Figure 7. This is another example of the electric field over a non-thunder electrified cloud system, in this case a large storm over Greenland. Again, a major part shows the "fair region" field polarity. From Barcus et al. [1986].

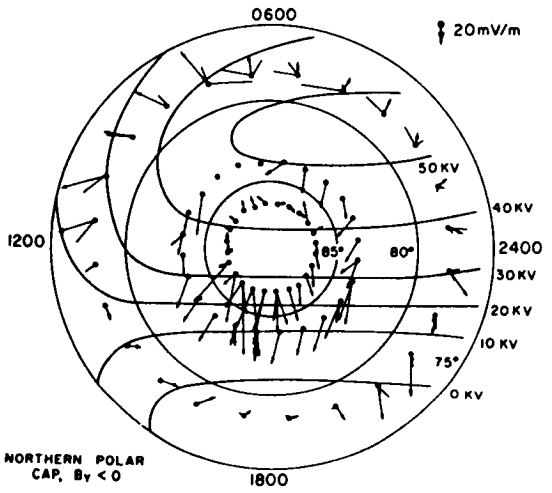

Figure 8. This is an example of ionospheric/magnetospheric electric fields mapping down through the middle atmosphere. In this case we see the polar cap plasma convection associated electric field. The classical "equalizing layer" in the upper atmosphere is obviously not a screen against external fields. From Mozer et al. [1974].

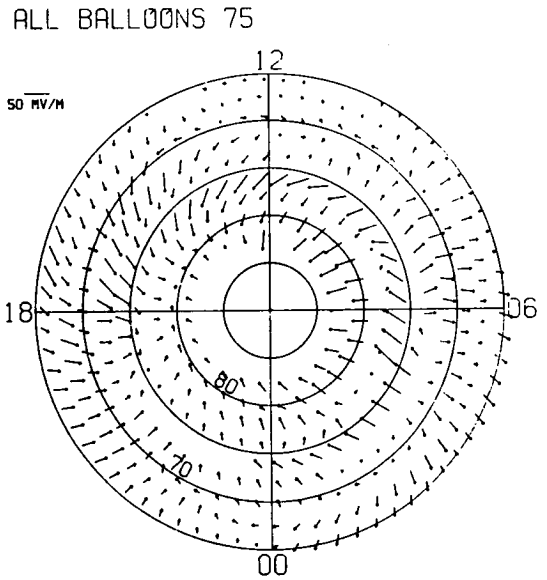

Figure 9. This example is equivalent to that seen in Figure 8. The convection pattern is shown over a wider latitude range based on a larger amount of data. From Iversen and Madsen [1978].

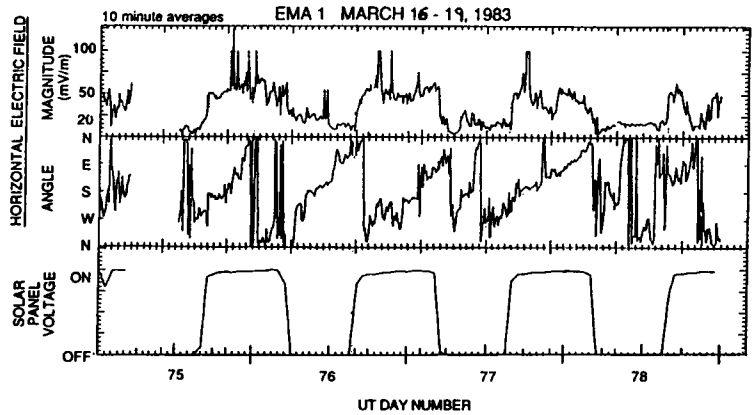

Figure 10. Many sources for the electric fields observed in the middle atmosphere are located below or above but also internal sources exist. The top and middle panels of this figure show the horizontal electric field magnitude and direction (relative to magnetic north) for four days of a superpressure balloon flight at 27 km altitude and 45° southern latitude. The point is that the observed rotational (counter clockwise) period of ~ 18 hours cannot be explained by any known ionospheric or tropospheric source. On the other hand, it is possible to relate the observation to an atmospheric inertial wave (Coriolis force driven) which for the actual latitude has this period. From Holzworth [1989].

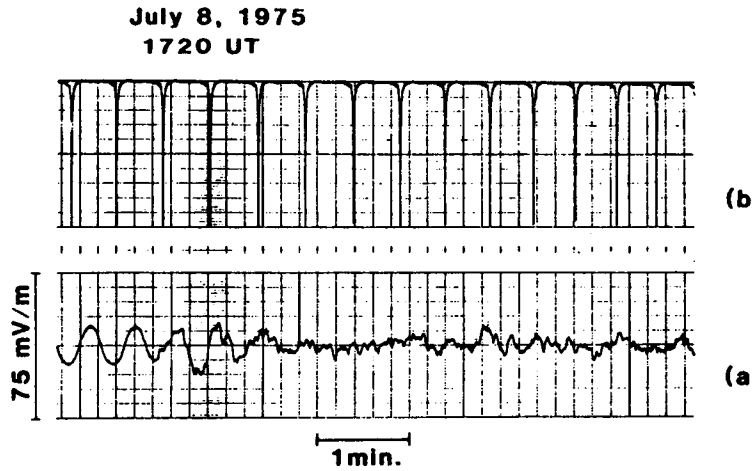

Figure 11. This is another example of an internal source for electric fields in the middle atmosphere (in the stratosphere). These small-scale fields are produced by air turbulence. From D'Angelo et al. [1983].

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