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DEFINING A GEOELECTRIC INDEX

I. B. IVERSEN*

National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173

Abstract: In recent years (at least since 1978) a possible definition of a geoelectric index has been frequently discussed. This index, derived from experimental data, should give a useful description of the electrical state of the atmosphere to be referred to when dealing with various related studies. A likely variable to be used is the electrical potential of the upper atmosphere relative to the ground, and much discussion is about how to record it continuously. Another part of the discussion is about the importance of having such an index available in analogy with, for example, the geomagnetic index *Kp*. It is argued that more than one index will be desirable.

1. Introduction

The studies of electric and magnetic fields around the Earth are old sciences within geophysics. One could say that the "modern period" for the study of both fields began in the second half of the eighteenth century. At that time Benjamin FRANKLIN carried out his famous kite experiment, and at that time it was also realized that fluctuations in the magnetic field of the Earth could be connected with the aurora.

Since that time a gradual development has been seen in all geophysical sciences and after 1957 an enormous step forward was taken for geomagnetism due to the beginning of the satellite age. The modern picture of the complicated magnetosphere could then be put together step by step.

A similar fast development was not seen in the beginning in the study of Atmospheric Electricity, obviously because this science does not benefit much from satellite measurements. The situation has, however, changed later, and the interest in atmospheric electricity has been growing. This is partly caused by the intensive exploration of the magnetosphere and the interplanetary space as a number of phenomena observed in those regions seem to be connected with electric phenomena in the lower atmosphere. Also the scope of the electric field science is broadening. In order to obtain a more complete understanding of the physics, many types of wave phenomena and transient events must be included into the investigations. It is today more appropriate to talk about Atmospheric Electrodynamics (VOLLAND, 1984).

As the study of geomagnetism developed, a number of magnetic indices were defined. They indicate the degree of local and worldwide magnetic disturbance due to currents in the magnetosphere and in the ionosphere. The indices are produced and published in a routine basis. This way of describing magnetic disturbances has proved very useful as background information when dealing with related measurements

* On leave from Danish Space Research Institute, Denmark.

and the indices have permitted studies of correlations between various phenomena otherwise not possible.

2. The Global Circuit

A global electric circuit exists within the Earth's atmosphere. Everywhere on the Earth, above the surface, a downward electric field (and current) is observed on fair-weather conditions. This was explained by WILSON (1920) as being due to a steady worldwide occurrence of thunderstorms. Such storms act as electric generators and are charging the well conducting higher level (80–100 km) of the atmosphere to a few hundred kV. A return current to the ground is then flowing in all fair weather regions; in this way the global circuit is closed. A total current of the order of 1500 amp has been estimated. Statistically the charging process has a daily (UT) variation due to the uneven distribution of the continents and this variation is also reflected in the upper atmosphere potential and in the total current.

3. The Index and How to Obtain It

A geoelectric index could, *e.g.*, be a figure describing the strength of the global circuit (represented by the upper atmosphere potential) or the deviation from the daily average. A major problem is, however, that the necessary measurements are not yet carried out on a routine basis.

No direct way of measuring the upper atmosphere potential is available. Such a measurement would require a voltmeter connected to the upper atmosphere with an isolated electric wire. However, a number of indirect, but less accurate, methods exist. The vertical electric field could be measured from the ground (by field mills or other instruments), but many points of measurements would be needed in order to average over local disturbances (*e.g.* caused by pollution) and experience shows that this kind of measurement is very difficult and very uncertain. More reliable are measurements with balloons or airplanes, by which methods the potential is derived by integration and extrapolation of the lower atmosphere measurements. Fluctuations in the potential are seen in the field measurements directly. Only one or a very few measuring points will be needed because the potential is a worldwide parameter.

The index could also be based on some kind of monitoring of the generator (the thunderstorms). This can only be carried out by detecting the electromagnetic emissions from the lightening flashes. The number of observation points can also in this case be rather low, a satellite could record the light emission from a reasonable fraction of total worldwide number of lightenings, or ground based receivers could detect the radio frequency noise. If noise at the Schumann resonance frequency of about 7 Hz is recorded one station may be enough because of the worldwide nature of this field.

4. The Purpose of Having the Index

If the index is produced successfully a number of potential users can be envisaged. They are, for example:

1) Physicists studying atmospheric electricity.

2) Climatologists and geophysicists in the field of thunderstorm physics.

3) Researchers interested in the possible relationship between the solar wind and the weather on the Earth.

4) Physicists concerned with the connection between the atmospheric electric field and phenomena in the ionosphere and the magnetosphere, especially the electric field. It is relevant to point out that more than one index might be necessary due to the variety of interests.

5. The Present Situation

The idea of having a geoelectric index is now some years old (MARKSON, 1979; HOLZWORTH *et al.*, 1984) and the problems are presently being discussed in the IAGA working group II-A on Middle Atmosphere Electrodynamics by a sub-committee chaired by prof. H. VOLLAND at the University of Bonn. When trying to reach an agreement on the definition of the index several considerations should be taken:

1) The index must be reliable and of potential value for many users.

2) The index should be widely accepted by related international Commissions (*e.g.* also within IAMAP).

3) The index should be based on relatively inexpensive measurements.

4) Somebody must be willing (regularily, for many years) to do the measurements, perform the calculations and arrange for the publication.

This point is quite important. If nobody is willing to produce the index agreed on or if no financial source is available, any definition will be of no use. On the contrary, the organization which is willing to spend time and money on producing the index will inevitably also have a major influence on the definition of it.

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