# ATMOSPHERIC ELECTRIC AND IONOSPHERIC MEASUREMENTS IN THE GEOPHYSICAL OBSERVATORY NAGYCENK: SOME EARLIER AND RECENT RESULTS

P. Bencze

Measurements planned in the Geophysical Observatory Nagycenk of the Geodetic and Geophysical Institute of the Hungarian Academy of Sciences in Sopron were aimed at investigation of the electromagnetic field of the Earth. Thus, besides geomagnetic and earth (telluric) currents — as horizontal electric components of the electromagnetic field atmospheric electric measurements (vertical electric component) were also intended. At that time — at the end of the nineteen fifties, it was thought that the atmospheric electric field corresponds to the vertical electric component of the electromagnetic field. Shortly, it turned out that this does not correspond to the facts, however, atmospheric electric measurements were continued.

As it was not possible to buy atmospheric electric instruments, it was necessary to construct and build them in the Laboratory. The relatively most simple instruments were an equipment for recording of point discharge currents and an apparatus for measurement of the atmospheric electric potential gradient (field strength).

Point discharge currents are recorded using a tip made of rust-proof steel put at the end of a mast on the roof of the atmospheric electric station in a height of 8 m. Currents are recording with a sensitive galvanometer. The potential gradient is measured by a radioactive collector placed in a height of 1 m above the ground and the grid current of a (radio) tube operated in an inverted connection. The potential gradient measuring equipment has been checked by removing the radioactive preparation, and connecting a resistance of $10^12$ ohm parallel with the resultant resistance consisting of the isolation resistance of the collector, from the input resistance of the tube electrometer and from the inner resistance of a quadrant electrometer (Bencze and Märcz 1980). Applying a known voltage to this circuit and measuring the voltage on the above mentioned resultant resistance the insulation, the input and the transitional resistances representing the transitional resistance of the radioactive preparation could be determined. In this way devi-

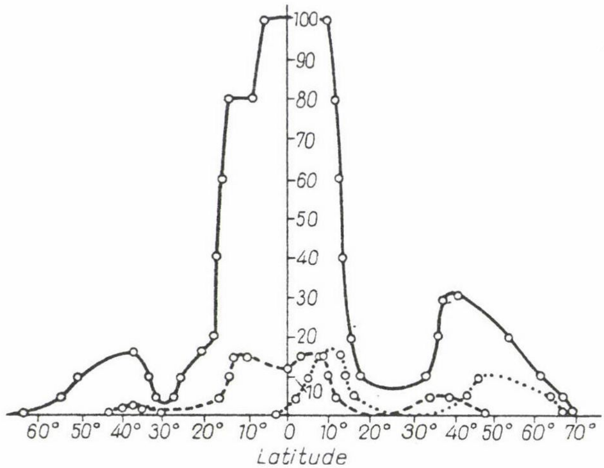


Fig. 1. Latitude variation of thunderstorm activity. ······ average number of thunderstorm days for July, ---- average number of thunderstorm days for October, —— average number of thunderstorm days per year

ation of the potential gradient measured by the equipment and the actual value could be computed. Both measurements are carried out since 1960 and continued to date (Bencze and Märcz 1967a, 1981, Bencze 2001a, 2001b). Processed data were published in the Geophysical Observatory Reports.

Recording of point discharge currents is motivated by determination of the electric charge exchange between the Earth's surface and higher layers of the atmosphere. Quantity of charge transported by point discharge currents is established by the determination of the area formed by the recorded current variations and the base line (Bencze and Märcz 1963). It has been found that diurnal variation of both positive and negative charges indicate a maximum in the afternoon, as well as quantity of negative charges is greater, than that of positive charges. Concerning the seasonal variation, both positive and negative charges show maximum values in summer. The seasonal variation of the quantities of charge transported by point discharge has been explained by latitudinal variation of thunderstorm activity, thunderstorm area shifted in winter to the south (Bencze 1963) (Fig. 1).

Most interesting results of the point discharge observations seem to be results of a detailed analysis and classification of point discharge current variations according to the type of their temporal variation. Point discharge is produced by enhanced atmospheric electric field at peaks, edges, which takes place as a result of charge separation in clouds. Charge separation is initiated by upwelling air in low pressure

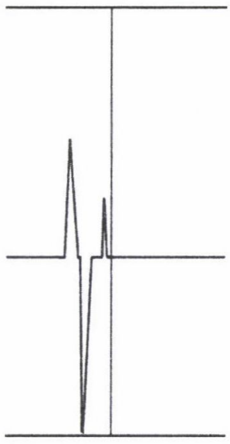

Fig. 2. Point discharge currents produced by a thundercloud of positive polarity

areas in the lower atmosphere. Study of current variations has shown that there are essentially single current variations of positive or negative sign, variations consisting of positive and negative currents following each other, and a series of positive – negative – positive current variations, or variations in reversed order (Bencze 1966). Single variations of positive or negative sign can be attributed to unipolar clouds. A pair of positive or negative departures may be due to successive unipolar clouds. A series of positive – negative – positive field variations can be due to a thunder cloud equivalent to an electric dipole with a positive charge center above and a negative one below. Thus, a thundercloud of such polarity approaching the observing site first effect of the upper positive pole would prevail followed in time by the effect of the lower negative pole with the thundercloud above the observing site and then again the effect of the upper pole would prevail as the thundercloud is moving off (Fig. 2). In case of the series negative – positive – negative, effect of an electric dipole of opposite polarity is observed.

Measurement of the atmospheric electric potential gradient were used not only for determination of its daily variation, which is characteristic of the environment's undisturbed state from atmospheric electric point of view (undisturbed state means no larger deviation from the daily variation observed above oceans). In continental areas, there are only a few places, first of all high mountains, where these undisturbed conditions are given. Our measurements have shown that the daily variation of the atmospheric electric potential gradient is only a little disturbed, first of all in winter (Bencze and Märcz 1967a).

The main topic of study of the atmospheric electric potential gradient in these years has been investigation of temporal variations (fluctuations) of the potential gradient called atmospheric electric agitation. Fluctuations have been divided into four arbitrary selected period bands (0–6, 6–12, 12–24 and 24–60 min) and daily, as well as seasonal variation in the mean amplitude of these period bands determined (Bencze 1964). The daily variation of these period bands indicates different form, however, the seasonal variation shows winter maximum in case of all period bands. It has been established that both location of the station and effect of the global thunderstorm activity are responsible for the atmospheric electric agitation. It has also been found that the mean amplitude of the agitation is proportional to the magnitude of the atmospheric electric potential gradient. In a further study, connection of agitation with amplitude of the potential gradient and the wind, with sky cover and different air masses is analysed (Bencze 1965). Daily variation of the occurrence frequency shown by the agitation of the period band 0–6 min indicated daily variation with maximum occurrence by day in summer months, but afternoon maximum in winter months. Occurrence frequency was greater in winter, than in summer. In case of the period band 6–12 min, daily variation of the occurrence frequency indicated maximum occurrence by day in summer, but maxima shifted to night in the winter months. Occurrence frequency of this period band is greater in winter than in summer, however magnitude of the occurrence frequency decreased as compared with the former period band. The occurrence frequency of the period band 12–24 min shows similar variations, however, magnitude of the occurrence frequency decreased further. Considering the occurrence frequency of the period band 24–60 min, the daily variation does not follow a systematic change in course of the year, but magnitude of the occurrence frequency increased significantly. A study of the daily and seasonal variations of the dominant period band on the basis of their occurrence frequency has shown that in summer agitation belonging to the 0–6 and 6–12 min bands are the most frequent, while in winter the 12–24 and 24–60 min period bands are dominant.

For registration of the less affected by local conditions (atmospheric pollution, humidity, wind) characteristic of the global atmospheric electric circuit is the vertical current occurring in fine weather areas of the Earth as load maintained by the global thunderstorm activity as generator in the circuit. Thus, the circuit consists of a generator connected to the atmospheric electric equalising layer in the bottom of the ionosphere. The circuit is continued in this layer in the direction of fine weather

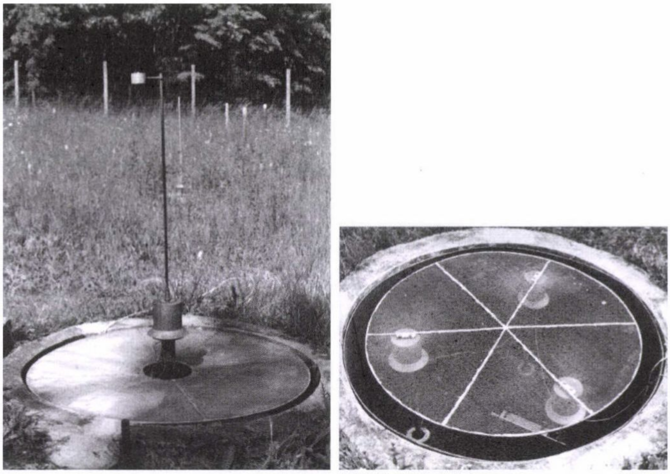

Fig. 3. Collector screen for measurement of the vertical current

areas, there closed to the ground by the vertical current and back to thunderstorm areas. Besides vertical current the potential gradient and conductivity are characteristics of the atmospheric electric circuit. For registration of the vertical currents a collector screen of 1 $m^2$ surface was placed to ground level isolated (Fig. 3). The vertical current was recorded by a picoampermeter of high input resistance (Bencze et al. 1984). Unfortunately registration of vertical current have only been carried out up to one or two years.

The atmospheric electric field has not only a static part, but also an electromagnetic field, too, originating in lightning discharges. Experiments for registration of the ELF (extremely low frequency) band of this electromagnetic field began in order to extend the ULF frequency band used in magnetotellurics to higher frequencies. An inverted long wave-length L antenna and amplifier of a portable seismic equipment and a hot-wire recorder were used to record variations in this frequency band including Schumann resonances (Ádám and Bencze 1963).

Concerning ionospheric investigations, they began in the middle of the nineteen sixties. After it turned out that the atmospheric electric field does not correspond to the vertical electric component of the Earth's electromagnetic field. The ionosphere is closely coupled to the geomagnetic field e.g. by ionospheric current systems, the magnetic field of which appears in form of variations of the geomagnetic field. According to an agreement with the National Meteorological Institute, where vertical incidence sounding of the ionosphere has been carried out since the beginning of

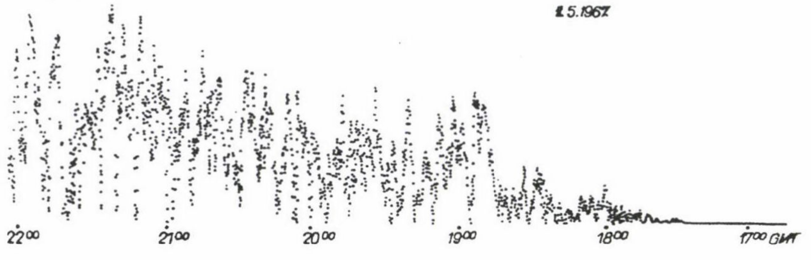


Fig. 4. Sky wave record

the International Geophysical Year 1957–1958 and thus, the upper ionosphere has been studied, the Geophysical Research Laboratory of the Hungarian Academy of Sciences began the investigation of the lower ionosphere. At that time, the most simple procedures for study of the lower ionosphere used commercial transmitters working in the LF, MF and HF frequency bands. Frequency of the selected transmitter depends on the height region, from where information on the state of the ionosphere is needed. Concerning distance of the station, the transmitter should not be farther than a distance, which can be reached by radio waves needing only one single reflection from the ionosphere.

As transmitted radio waves are propagating partly along the Earth's surface (ground wave), partly backscattered from the ionosphere (sky wave), the two types of waves must be separated to get information about the state of the ionosphere. Sky waves bearing information can be separated from ground waves, if using a frame antenna it is just in a plane perpendicular to the transmitter-receiver direction. These waves are amplified by a heterodyne receiver tuned solely to the wave- length of the selected transmitter. Constancy of the receiver's tuning is achieved by using crystal filters in the different stages (Bencze et al. 1976). If sky waves of LF or MF transmitters reflected from altitudes of about 100 km are used, their relative amplitude can only be determined by day in case of large amplification receiver. Sky waves are namely, strongly absorbed by day in the D-region of the ionosphere, on the contrary, at night smaller amplification is also enough because of the vanishing D-region (Fig. 4). This method called A3 method enables determination of the ionospheric radio wave absorption. Initially two radio stations were selected, Ceskoslovensko (272 kHz) and Budapest (539 kHz). However, for application of this method, the field strength (transmitter power) of the transmitter must be constant. Unfortunately, transmitter power of Budapest was changed during the day, thus it was not suit-

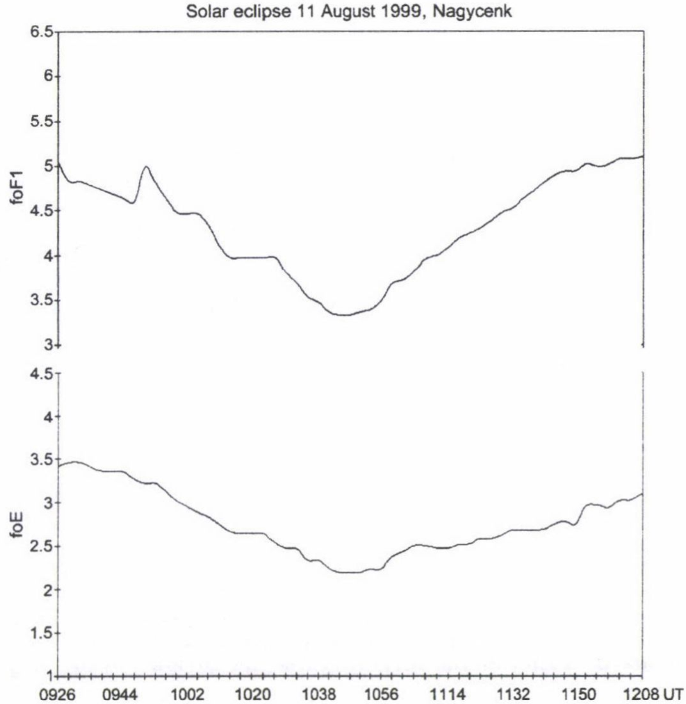


Fig. 5. Variations of the critical frequencies foE and foF1 proportional to the maximum electron density in the E and F1 regions related to the total solar eclipse of August 11, 1999

able for us. Processing of data proved that the so called winter anomaly of ionospheric absorption is also present at the latitude of our observatory (Bencze and Märcz 1967b). This anomaly is due to excess ionization in winter caused by enhanced transport of NO, an easily ionisable component of the atmosphere from above.

Experiments related to vertical incidence sounding of the ionosphere began in 1992 following reduction of the staff in the Hungarian Meteorological Service. Time table of the staff reduction was to abolish those activities, which are only loosely linked to meteorology. Thus, vertical incidence sounding carried out in framework of the Meteorological Service in Békéscsaba has also been stopped. The equipment, an ionosonde type IPS 42 made in Australia was offered to our Institute. Installation of the ionosonde in our observatory took a long time. It was necessary to build the antenna system (transmitter and receiver) fixed to a tower of 30 m height. For placing the tower, increase of the observatory area was needed not to disturb measurement of the absolute value of the geomagnetic field components. The transferred

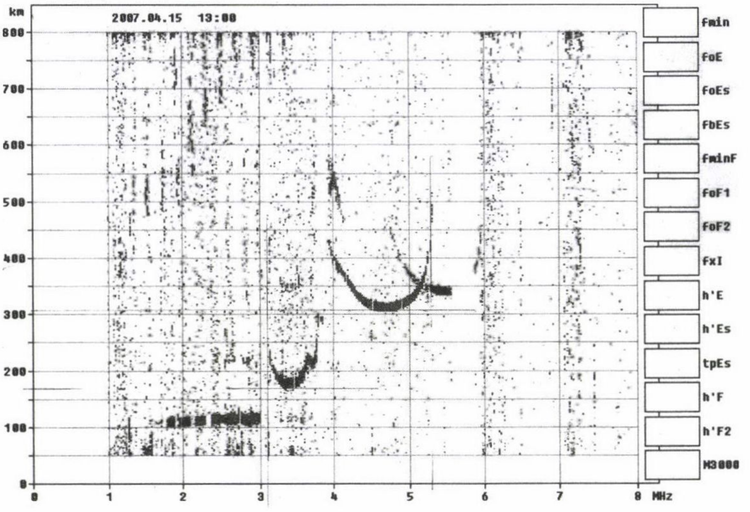


Fig. 6. Ionogram recorded by the new ionosonde

ionosonde worked in analogue mode and this circumstance necessitated conversion of the equipment into digital mode. This has been done by J. Titheridge, who developed both the additional hardware and software parts for IPS 42 ionosondes. However the ionosonde could not produce ionograms of good quality, since the high frequency part of the ionogram was mostly not usable. But the low frequency part of the ionogram could be used e.g. for study of ionospheric sporadic E for estimation of the distance between patches of increased electron density within the stratification (Bencze et al. 2004). Another possibility of using the ionosonde proved to be the total solar eclipse of August 11, 1999. During the eclipse soundings were made every 3 minute and this frequent measurements enabled determination of electron density change in the E, F1 regions of the ionosphere, decrease of electron density with advance of the totality and its return to value observed before the eclipse (Bencze et al. 2007) (Fig. 5).

Meanwhile a new ionosonde constructed in the Space Research Center of the Polish Academy of Sciences arrived, which works with two identical antennas perpendicular to one another. This exact symmetry is needed because both the transmitter and the receiver antenna are used both for transmission and reception. This construction enables the possibility of drift measurements. An ionogram is shown in Fig. 6.

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