

Project data archive: Synchronous measurements of atmospheric electrical field and geomagnetic field in Antarctica (South Pole station) 1991-1993

Scientific problems of the experiment

Until now, "cross-pollination" of two geophysical disciplines - geomagnetism and atmospheric electricity was very weak. This is due to the fact that usually it is believed that the atmospheric electric field is completely dependent on local meteorological processes. As a result, the magnetospheric community and the community of atmospheric electricity practically do not interact.

In particular, studies of the geomagnetic field disturbances usually do not take into account relationship with the gradient of atmospheric potential (i.e., the vertical electric field E_z). In the ULF range (frequencies from mHz to Hz) geomagnetic pulsations and transient processes recorded by ground-based magnetometers, are presumably created only by a magnetic mode. Does the pulsation structure also include an electrical mode? There is no unambiguous answer to this question. Attempts to detect the manifestation of ULF waves in the atmospheric E_z field ended with contradictory results.

Theoretical modeling of the ionosphere electric field transfer into the surface atmosphere showed that the E_z response can reach several tens of V/m. Moreover, "electrostatic" Pc5 pulsations with amplitudes of 20-30 mV/m were registered on the balloons around local midnight with a very clear weather, while no such signal was observed in the magnetometer data.

The question of the possibility of the electric THo-mode excitation in the atmosphere-earth waveguide during the sudden commencement of a magnetic storm (SC) also remains controversial, although the ideas about the "instantaneous" transfer of the electromagnetic disturbance by the THo-mode in the ionosphere-earth waveguide is often used to interpret propagation from polar latitudes to low ones.

Unlike geomagnetic observations, regular monitoring of the atmospheric electric field with a high time resolution is almost non-existent. The proposed database can be used to study the influence of geomagnetic disturbances of various types on atmospheric electricity.

Description of the experiment

The vertical electrical field E_z and the electric current "air to ground" J_z were observed at the South Pole station, Antarctica (geomagnetic latitude: 74.2 °S), to study the influence of geomagnetic disturbances at auroral latitudes on atmospheric electricity over a three-year period from 1991 to 1993 (PI - prof. E. Bering, Houston University, <https://uh.edu/research/spg/data.html>).

The Antarctic Plateau is ideal for observing atmospheric electricity variations due to the absence of anthropogenic influences, weak and stable winds and the absence of clouds at low altitudes (more than 30% of days meet the condition "good weather"). Ideal observing conditions in Antarctica solve the long-standing problem of the relationship between atmospheric electricity and space weather disturbances.

The J_z and E_z instruments were deployed in January 1991 and had been designed for continuous operation without human operator intervention. A sensor consisting of the two hemispherical conductive membranes separated by a Teflon insulating disc is used to measure atmospheric current. Registration system electronics is inside the sphere.

The electric field is measured with a field-mill sensor. The sensitive elements of the electric field are two antennas with a length of 30 cm, which rotate in a vertical plane at a speed of 1800 revolutions per minute. Two groups of identical instruments were used for J_z and E_z registration, which were separated by a distance of 600 m to distinguish between disturbances of local and global origin. The advantages of these observations are that there is no thunderstorm activity and industrial interference in Antarctica, therefore more subtle effects may be detected there.

Description of experiment data for each year, the following data are organized in subdirectories:

- \ OMNI | data on the parameters of the interplanetary medium OMNI (1 min)
- \ SPA_Ez \ Atmospheric field E_z (V / m) and current J_z (A / m^2) at the SPA station (1 min)
- \ SPA_mag \ magnetic data (X- and Y-components) SPA (10 sec)
- \ SPA_rio \ riometer data on the absorption of cosmic radio noise at the SPA station (10 sec) Daily quick-look (QL) pictures for the events selection were made for the researchers in the \ QL-plots \ directory with the following parameters:
 - variations of the solar wind pressure P and the B_z component of the interplanetary magnetic field;
 - E_z (at the nearest spaced out points)
 - J_z (overlaid measurements at the spaced out points)
 - riometer at the frequency ?? MHz
 - magnetic data (X- and Y - components)

If there is no file with E_z data, then the day was not drawn. As an example of QL pictures, the figure shows the event on January 2, 1993.

The figure shows quasi-periodic modulation of the field and current with a time scale of ~ 1 hour, starting at about 08 UT and continuing for several hours. Similar signals in the Y- and Z-components of ground-based magnetograms can be seen.

Geomagnetic observations at Vostok station by Soviet Antarctic expeditions

The digitized analogue magnetic records of the Soviet Antarctic expeditions to the Vostok station for 1966, 1968 and 1970-1971 are now available for free access.

Despite of the recent deployment of observatories in Antarctica and automatic stations in the polar cap region observations near the geomagnetic Pole conducted by a highly sensitive flux gate magnetometer with a recording frequency of 20 Hz remain unique. These data provide an opportunity to study the nature of specific impulse and wave electrodynamic disturbances in the polar cap and their relationship with dynamic processes in near-Earth space, for example, discrete Pc1 pulsations, serpentine emission, Pc3-4 pulsations, etc.

The data archive is freely available via FTP on the website of the World Data Center for Solar-Terrestrial Physics.

The database includes the following directories: Vostok-mag_wav / - files of digitized 20 Hz data in WAV format. The file length is variable and is determined by the conditions of the digitizing process. The directory contains a sub-directory Soft / with a program for converting WAV files to text;
Vostok-mag_20Hz / - daily data files with a recording frequency of 20 Hz of the two horizontal components;
Vostok_QL-sonograms / - QL sonograms (dynamic spectra) in the frequency range 0.1 - 5.0 Hz at 6-hour intervals;
Vostok_mag-1s / - averaged data in a text format with a step of 1 sec;
Vostok_QL-magnetograms / - Quick-look data magnetograms averaged over 1 second time steps.