Space weather effects on meteorological and atmospheric electrical parameters

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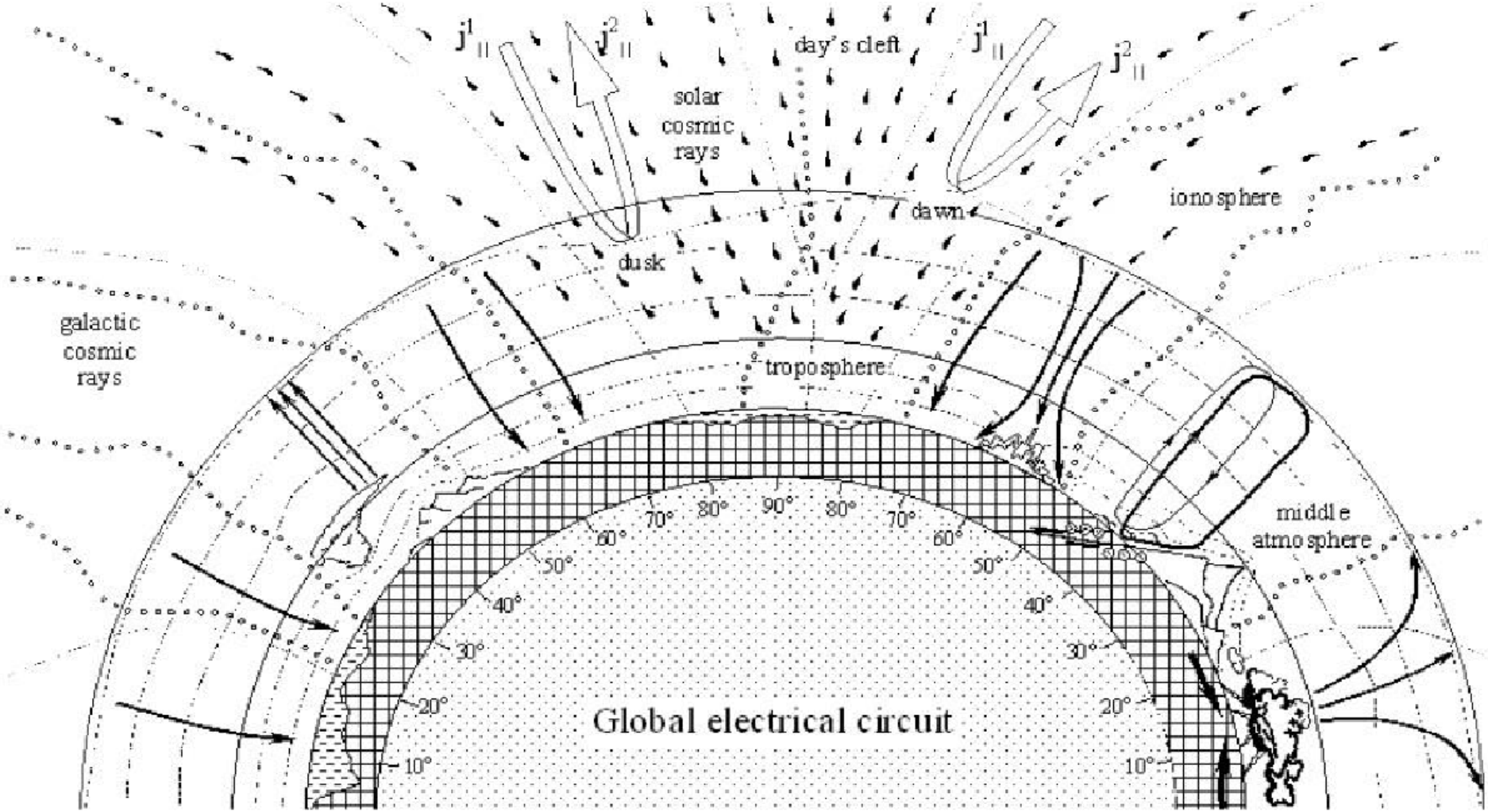
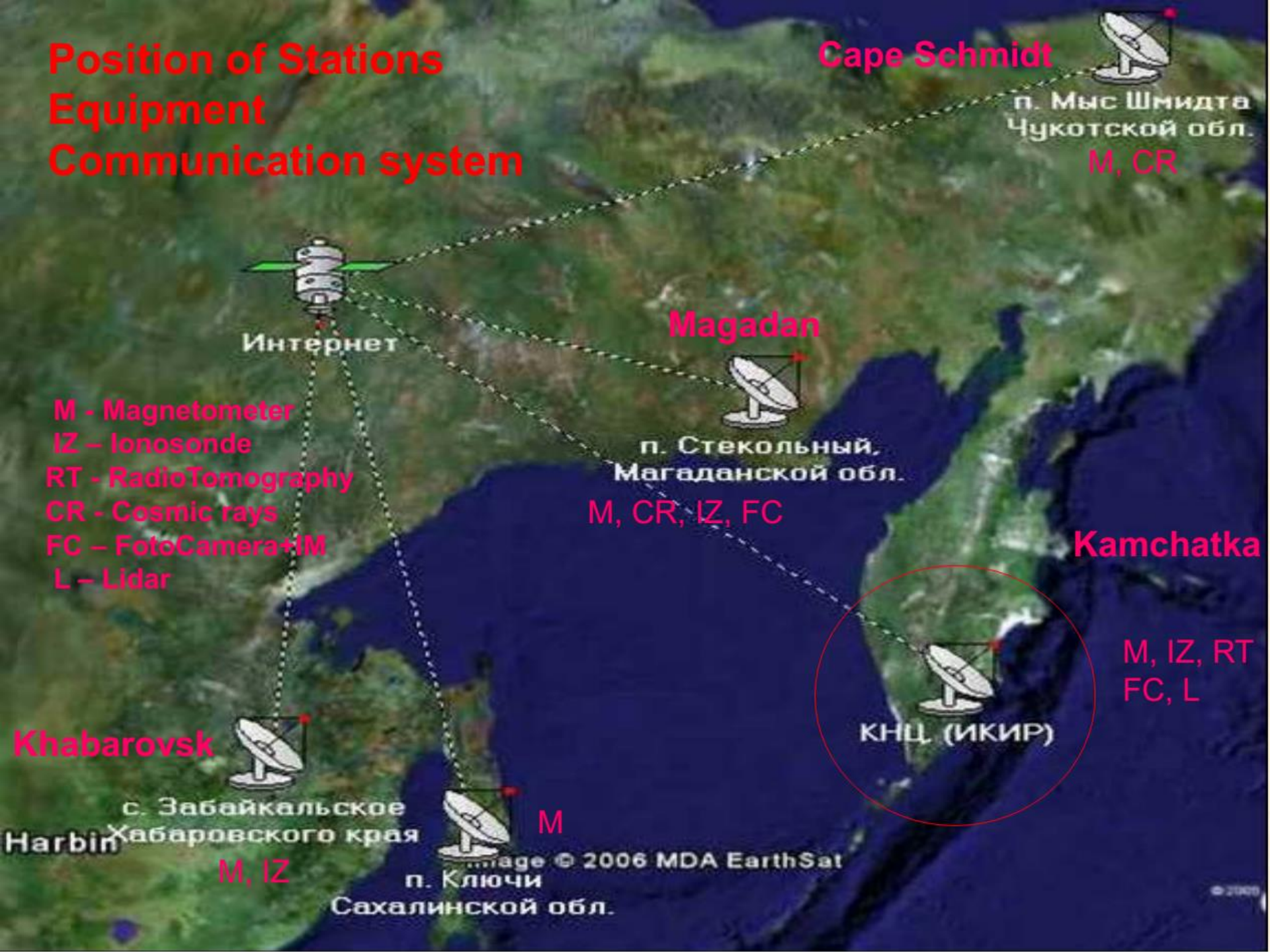
In the reviews by [Bucha, 1980, Lastovicka, 1996], possible mechanisms of influence of geomagnetic storms on the troposphere are described, they are:

- dynamic mechanism associated with intensification of acoustic-gravitation atmospheric waves and planetary scale waves;
- electrical mechanism associated with global electric circuit and penetration of cosmic rays into the atmosphere;
- optical mechanism associated with the changes of atmosphere transparency and chemical content in the stratosphere under the effect of short-wave radiation from the Sun and the galactic cosmic rays (GCR).

In the paper by [Markson, 1981], a hypothesis of solar activity effect on atmospheric electricity was suggested for the first time. Its essence is that the conductivity of the global electric circuit changes under the effect of cosmic rays (one of the main atmosphere ionizers). The global electric circuit is a closed current system the main generators of which are tropical thunderstorms according to the model of spherical capacitor. The currents of these generators flow into the lower ionosphere through the air drag above it and complete through the undisturbed remote atmosphere and Earth’s surface.


$j^1_{\parallel}$
$j^2_{\parallel}$
day's cleft
$j^1_{\parallel}$
$j^2_{\parallel}$
solar
cosmic
rays
ionosphere
dawn
dusk
galactic
cosmic
rays
troposphere
middle
atmosphere
90°
80°
70°
60°
50°
40°
30°
20°
10°
Global electrical circuit


Position of Stations
Equipment
Communication system
Cape Schmidt
п. Мыс Шмидта
Чукотской обл.
M, CR
Интернет
Magadan
п. Стекольный,
Магаданской обл.
M, CR, IZ, FC
M - Magnetometer
IZ – Ionosonde
RT - RadioTomography
CR - Cosmic rays
FC – FotoCamera+IM
L – Lidar
Kamchatka
M, IZ, RT
FC, L
КНЦ (ИКИР)
Khabarovsk
с. Забайкальское
Хабаровского края
M, IZ
Harbin
M
п. Ключи
Сахалинской обл.
Image © 2006 MDA EarthSat

Kamchatka is an active geodynamic region in a subduction zone.

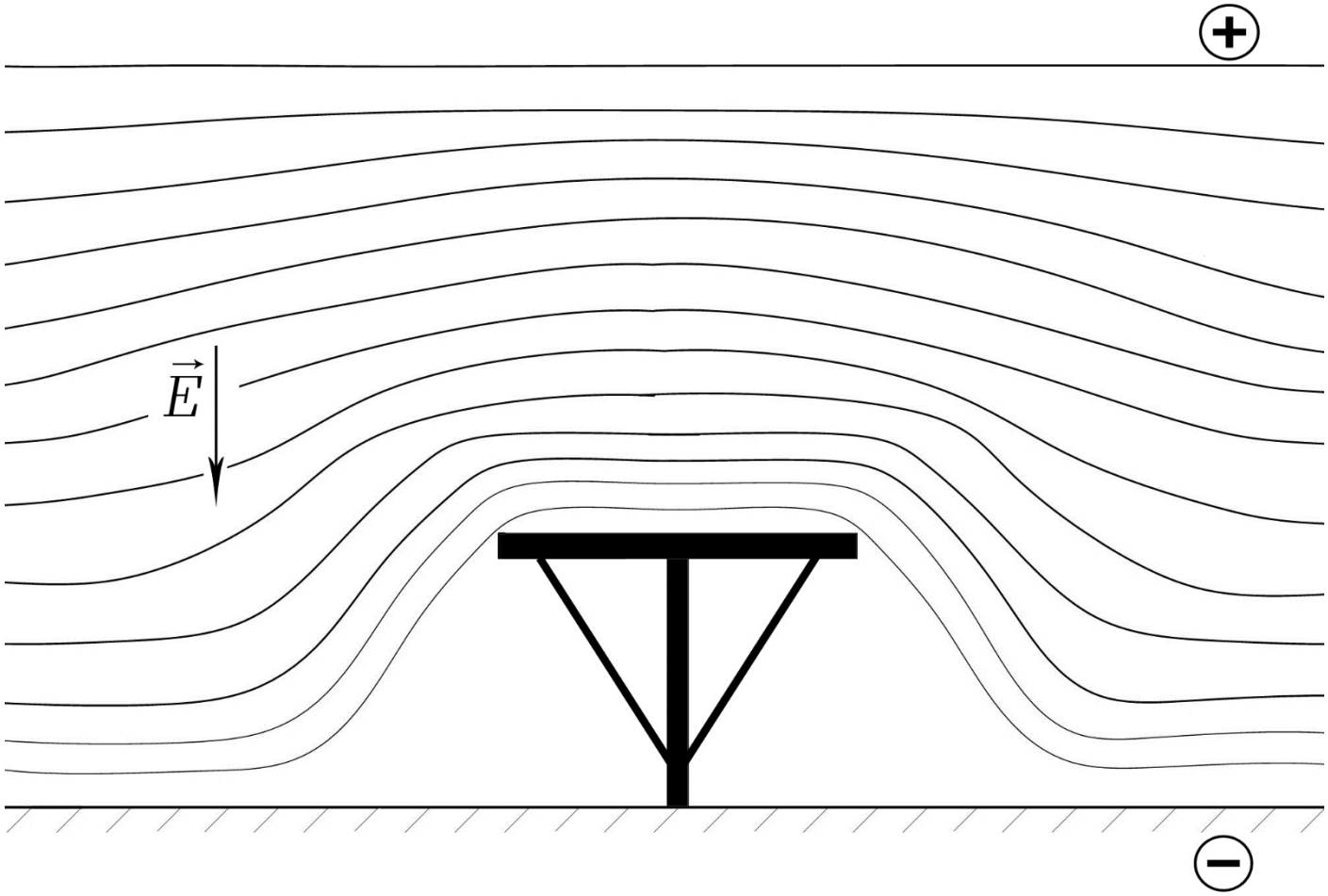
Earthquakes, radioactive gas emanation modes, volcanic ash blowouts may affect measurements.

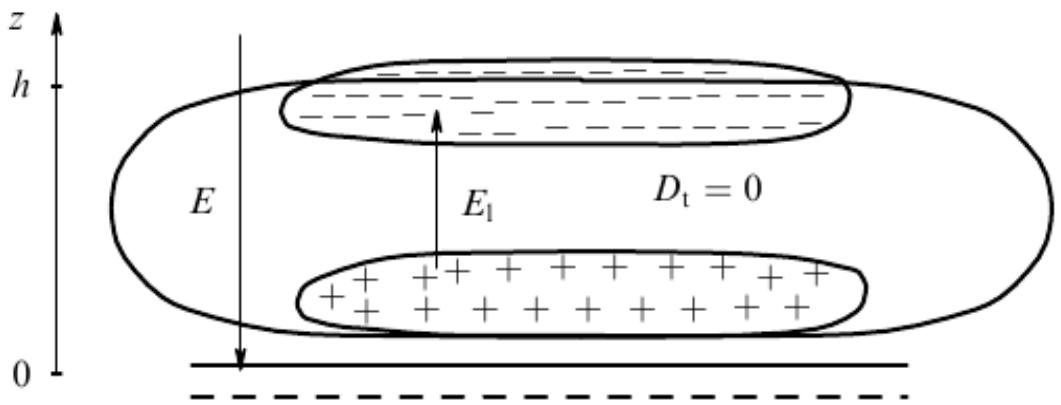
Atmospheric electrical field



Sensor potential gradient of electric field “Pole-2” at GFO “Paratunka” (spring, early winter, late winter)

Earth's atmospheric electricity
'Pole-2'





Measurements in the surface layer of the atmosphere are based on the theory of the **electrode effect**.

Under the influence of various ionizers, aerosols and ions of different signs are formed in the atmosphere. They have different mobility. Positive ions move to the surface of the Earth, and negative - upwards. Uncompensated space charge is formed by the surface. Thus, an "**electrode layer**" with the local field E1 is formed, which compensates the main field E.

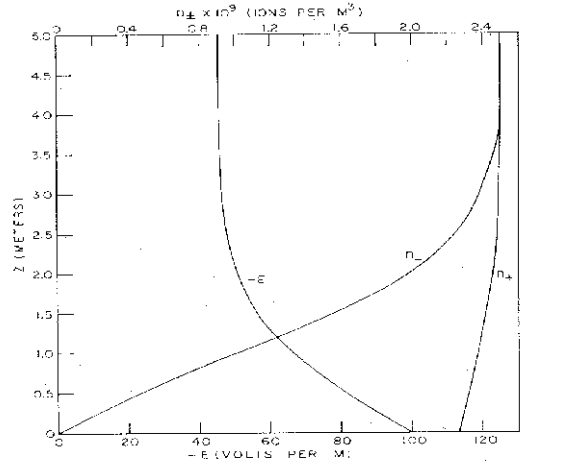
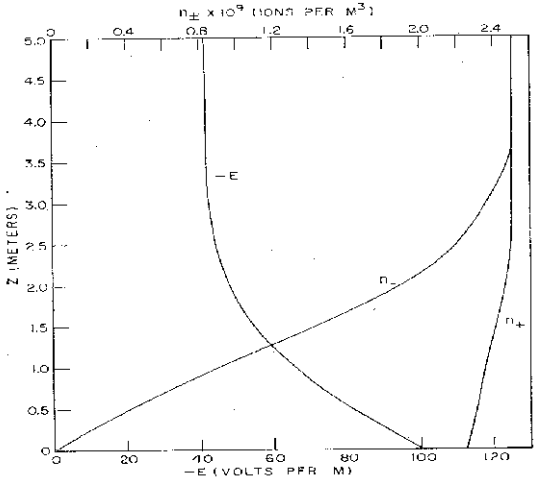
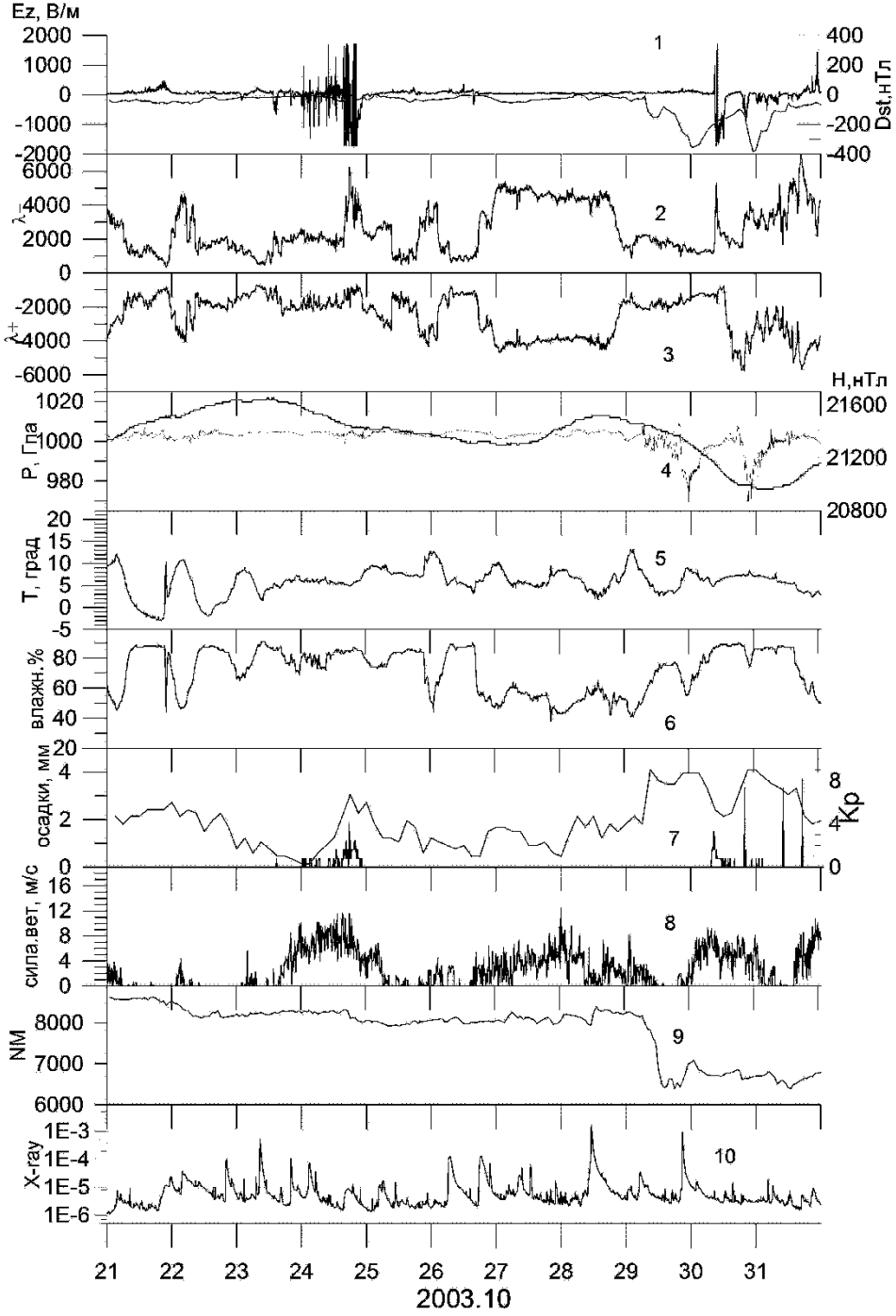


Fig. 1. Solution for equal negative and positive mobilities.

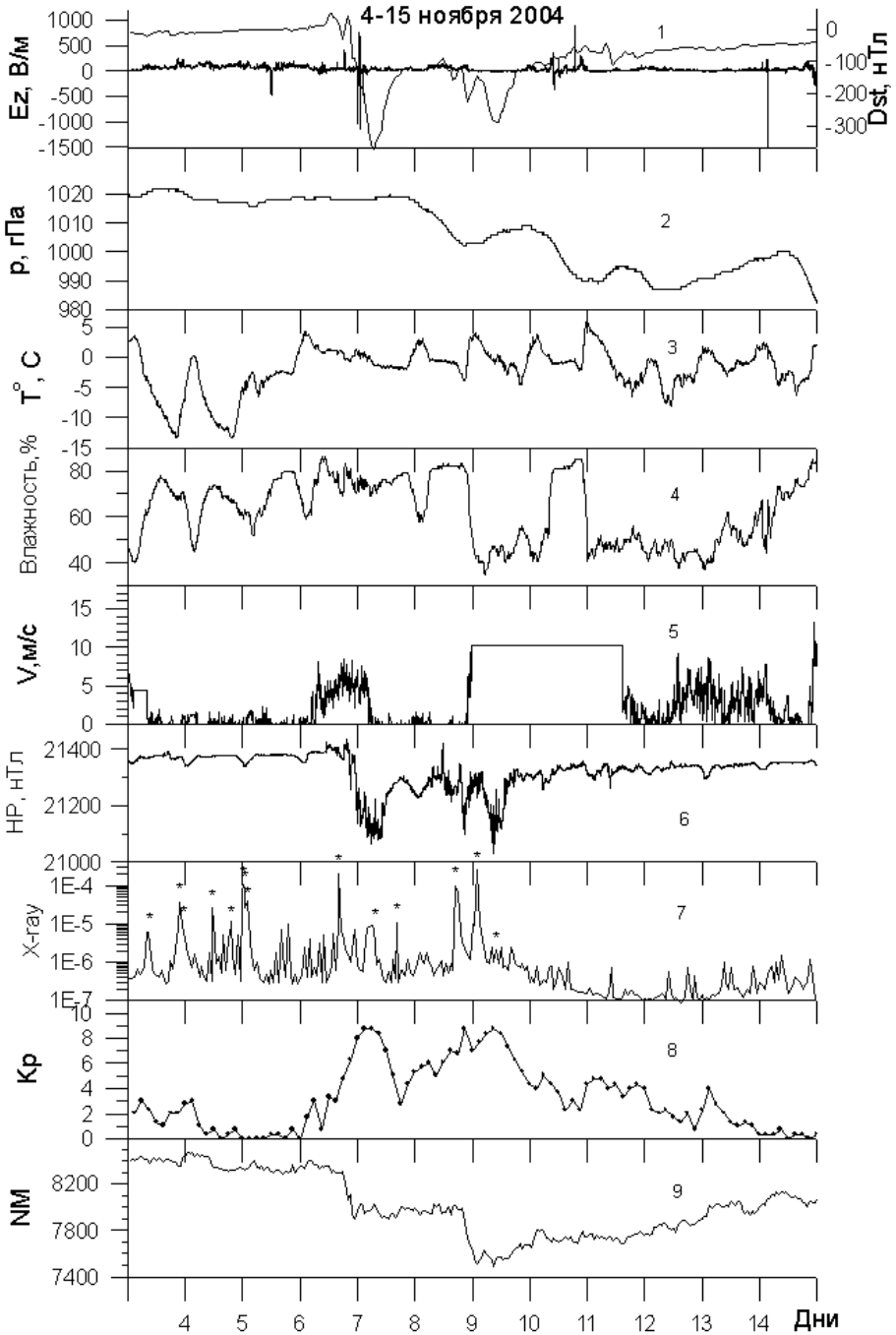


Hoppel W.A. Theory of the electrode effect // J.Atm.and Terr. Phys.1967.V.29, N.6.P.709-721

Kupovikh G.V., Morozov V.N., Schwvartz Y.M. Theory of the electrode effect in Atmosphere. – Taganrog: 1998. – 123 p



Magnetic storm
October 2003
observatory
Paratunka



Magnetic storm
November 2004
observatory
Paratunka

Meteorological effects:

- The observable anomalous increases of temperature and humidity in the process of development of solar activity in October 2003 caused the formation of clouds of different form including cumulonimbus clouds accompanied by rainfall and thunderstorm processes.

- Consequence of powerful solar flares and the growth of radiation in the optical range of the Sun EMR were accompanied by anomalous increase of atmosphere temperature and humidity that caused excitation of anomalously powerful thunderstorm processes during the geomagnetic storm on November 8, 2004.

Meteorological effects:

- Negative diurnal decrease of atmospheric pressure was discovered. Its source is unknown.

- Formation of clouds and precipitation from the time of the solar flare on November 6, 2004 resulted in the decrease of the general background level of electric field in comparison to fair weather conditions.

Meteorological effects:

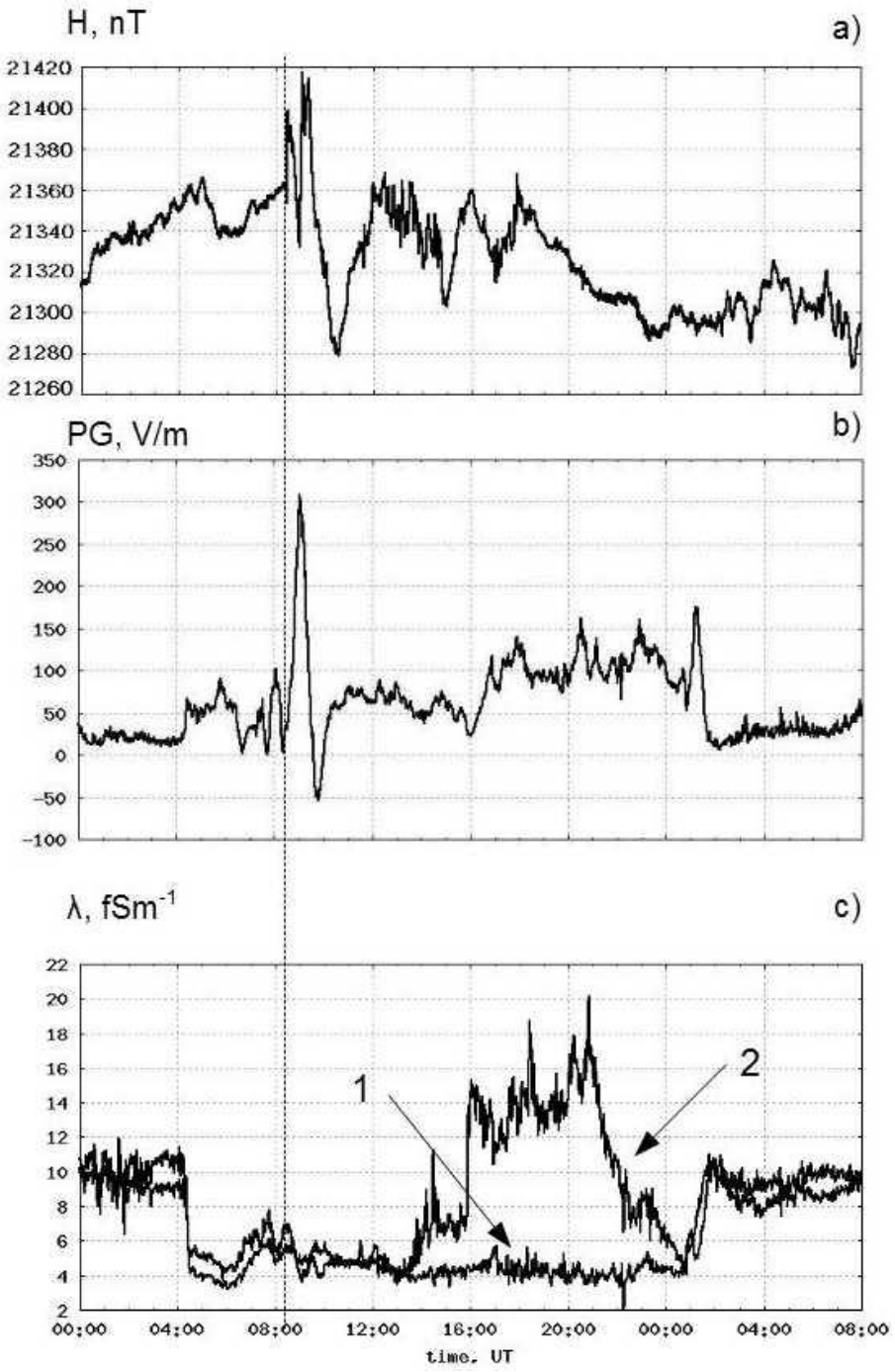
- Time coincidence of regular meteorological processes disturbances with the consequence of powerful solar flares, accompanied by the radiation increases in the near ultraviolet band, visible and infra-red spectra, allow us to consider them as additional inflow of thermal energy into the lower atmosphere.

Meteorological effects:

- In fair weather conditions, oscillations with the periods of heat tidal atmospheric waves (T ~ 12, 24 h) were observed in the power spectra of atmosphere temperature and humidity. They are determined by the Sun thermal radiation. During powerful solar flares accompanied by the additional heat inflow into the lower troposphere, the diurnal variation and the feedback between the atmosphere temperature and humidity were disturbed. When the predominant constituent with T ~ 24 h was presented in the spectrum of air humidity, an additional component with T ~ 48 h (planetary waves) appeared.

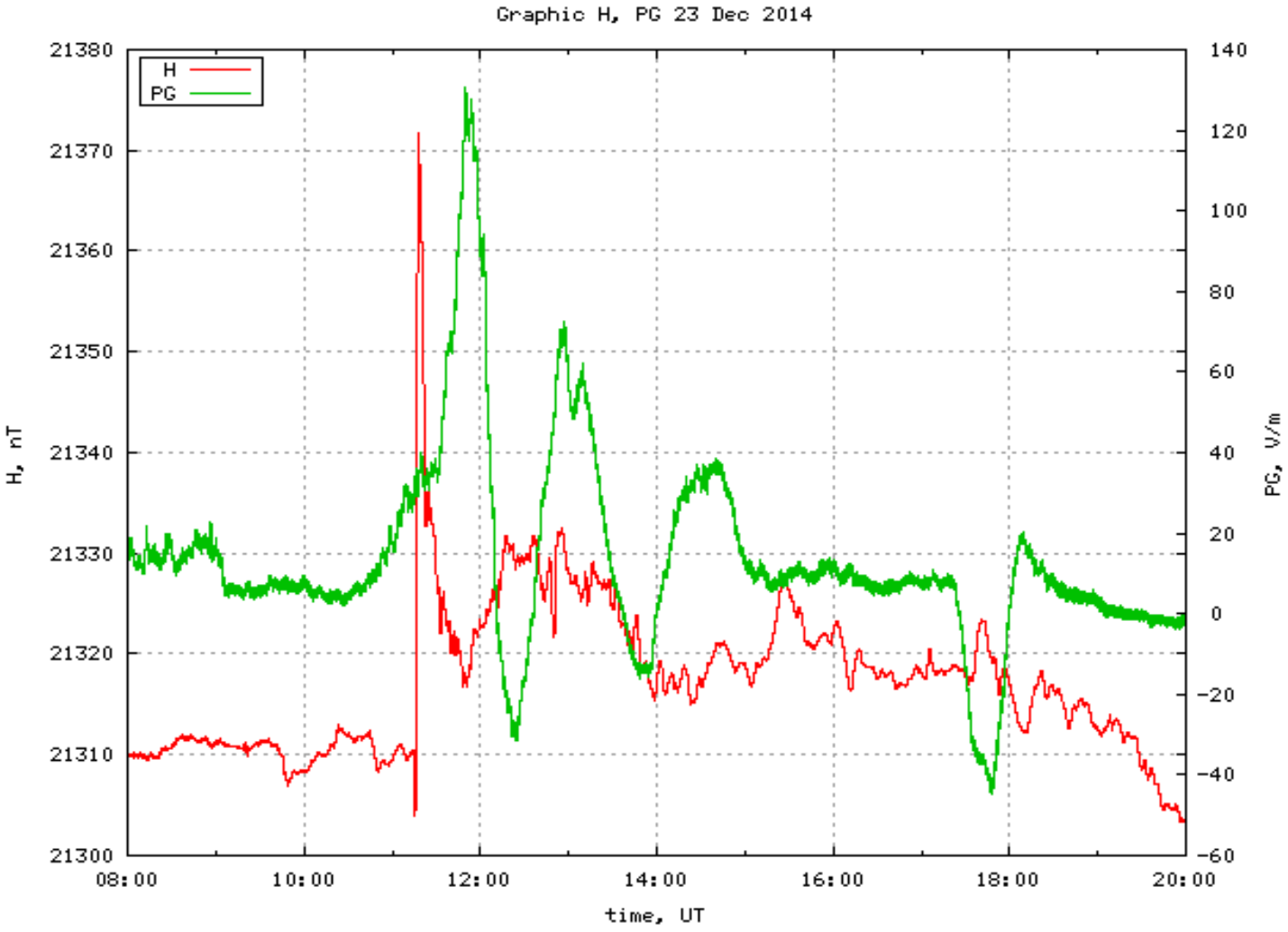
Meteorological effects:

- In fair weather conditions, in the power spectra of atmospheric pressure, a wide spectrum of oscillations of 12, 24, 48 h was observed but the component with T ~ 48 prevailed. As the solar activity developed, the character of the spectrum remained. During the geomagnetic storm, the intensity of the component with T ~ 48 h increased by an order in comparison to fair weather conditions.



Magnetic storm
5 Apr 2010
observatory
Paratunka

Magnetic storm 23 Dec 2014 observatory Paratunka



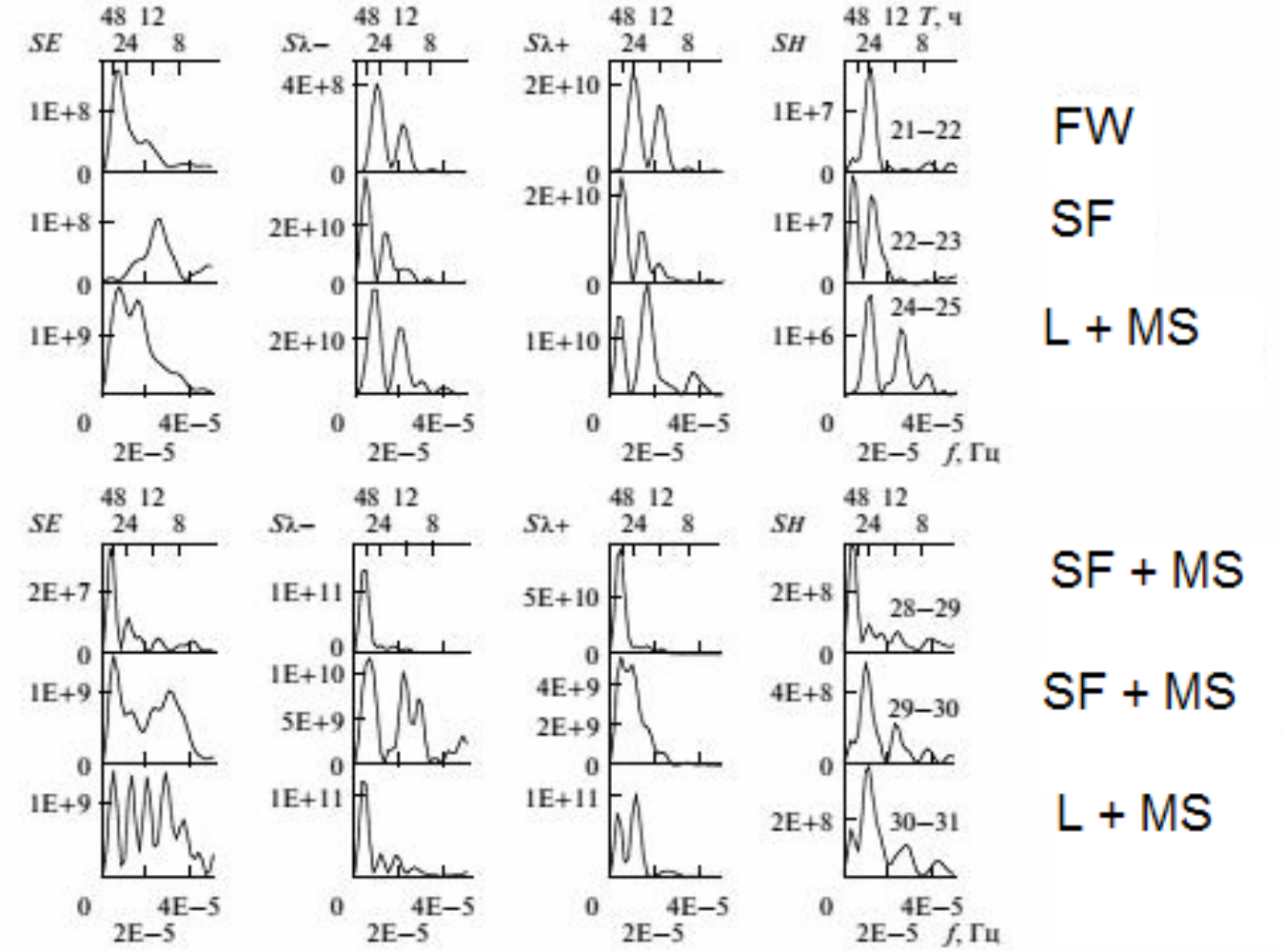
Effects in electric fields:

- Large oscillations of electric field were observed. They coincided with the sudden commencement of the magnetic storm. Such disturbances are likely to be caused by induction processes. The duration of this process was about 2 hours.

Effects in electric fields:

- Decrease of air electric conductivity is possibly caused by Forbush effect. Galactic cosmic ray flux which ionizes the atmosphere decreased.

- Increase of air electric conductivity, caused by positive ions, was observed in 8 hours after the beginning of the geomagnetic storm. It is likely to be associated with precipitation (snowfall).



Power spectra of electric field (SE), field electric conductivity (Sλ), h-component of magnetic field (SH) in the conditions of fair weather (FW), solar flares (SF), lightning (L) and magnetic storms (MS)

Effects in electric fields:

- During powerful solar flares and a magnetic storm, the components of almost equal intensity at T ~ 24 and 48 h are clearly seen in the power spectra of electric conductivity. Spectrum of the electric field was more complicated (due to the thunderstorm effects) but with the prevailing component with T ~ 48 h which intensity increased by one order in comparison to fair weather conditions.

Effects in electric fields:

- In the power spectra of galactic cosmic rays accompanying powerful solar flares, the component with T ~ 48 h prevailed. It increased by an order during Forbush-decrease. Simultaneous increase of the components with T ~ 48 h in the power spectra of air electric conductivity and electric field intensity indicates the fact that during powerful solar flares and magnetic storms, the acting ionizers of the lower troposphere are mainly the galactic cosmic rays.

Thank you!