"Physics of Auroral Phenomena", Proc. XXVII Annual Seminar, Apatity, pp. 77-80 , 2004

Polar
Geophysical
Institute

ABOUT THE REGISTRATION OF WAVE PERTURBATIONS IN THE POLAR LOWER IONOSPHERE AFTER AN EXPLOSION OF THE VITIM METEORITE

V.D. Tereshchenko, O.F. Ogloblina, V.A. Tereshchenko, S.M. Chernyakov *(Polar Geophysical Institute KSC RAS)*

Abstract. During the intrusion of space bodies into the Earthly atmosphere the various physical phenomena are observed and to investigate them is a good contribution to the knowledge of the nature of these phenomena and properties of the medium, in which they happen. In the paper, the ionospheric effects of the Vitim meteorite explosion are investigated.

Introduction

On September 24, 2002 at 16:49 universal time in the Mamsko-Chuisky region of the Irkutsk oblast, near Vitimsky and Mama settlements a fall of a large meteorite took place (Shumilov et al., 2003).

According to different evaluations, the trotyl equivalent of the Vitim meteorite radiation power constituted 200 tons. The kinetic energy of the body corresponded approximately to 2.3 kilotons of trotyl, the initial mass was approximately 160 tons and the speed reached 25 km/s.

The fall of a celestial body was accompanied with light, audio, geomagnetic, seismic and mechanical phenomena, which were recorded by ground and space means of observations.

Under the evidences of the eyewitnesses the fast flying sphere with a tail was seen in the sky, which then made for taiga behind the hills to the northeast from Bodaibo town. After the shining object has vanished from the field of view, a very harsh powerful explosion was heard and the sky was coloured in white.

At the seismic station of Bodaibo at 16:51 and at 16:53, universal time, September 24, 2002, two unclear entrances similar to oscillations from a far-away earthquake are recorded.

5 minutes after the flashout of a fireball the magnetic perturbation was registered, which lasted for about 5 hours and reached an amplitude of almost 60 nT. It was registered at the Irkutsk magnetic observatory located about 900 km away from the place of the suggested fall of the meteorite. During the magnetic perturbation above the impact area of the celestial body an aurora was seen. In many places of the area of the meteorite falling, barriers of wood, caused by the shock wave from destruction (or explosion) in the air of a high-speed space body were found.

The studying of manifold physical appearances at the intrusion into the atmosphere of space bodies contibutes to the knowledge of the nature of meteoric phenomena and properties of the medium, in which they happen. The present paper deals with the research of ionospheric effects of the Vitim bolid.

Results of observations

At the observatory of Tumanny (Murmansk oblast; 69.0 N, 35.7 E) which is about 4000 km away from the meteorite fall area, short-term splashes (duration of 10-40 minutes) of temporary variations of medium wave radioreflections' amplitudes of ordinary and extraordinary polarizations (Tereshchenko et. al., 2003) were registered.

The first noticeable splash of intensity of the radio noise was observed at 17:40 - 17:50, the second one - 21:00 - 21:45, the third one - at 22:35 - 22:55 and the fourth one - at 0:10-0:35 UT. If one considers, that these perturbations come from the detonation point along the ionosphere, their speeds should be about 1.2 km/s and 150 - 300 m/s. Such speeds meet the rates of propagation of slow magneto-hydrodynamic (MGD) and infrasound waves.

The fluctuations of the amplitude of an echo registered at 22:35 - 22:55 coincided with the incoming of a wave of pressure from the explosion of the Vitim meteorite in Apatity (Shumilov et al., 2003).

The observed data of amplitudes of reflections at heights of 60-129 km in the polar ionosphere after 22 hours of universal time are represented in Figure. 1. The solid line shows the temporary behaviour of amplitude of an ordinary wave, and dashed line - an extraordinary wave. In the Figure the wave perturbations of amplitude at mesospheric and thermospheric heights are visible.

The magnetic field on the day of measurements and in the previous and subsequent days was rather quiet, substorms were not observed. However, 10 minutes after the falling of the bolid the microvariations of the geomagnetic field with the amplitude of about 6 nT and almost 5 hours duration time (Figure. 2, dashed curve) were registered. Their forms correspond to perturbations registered in Irkutsk (Figure. 2, solid curve).

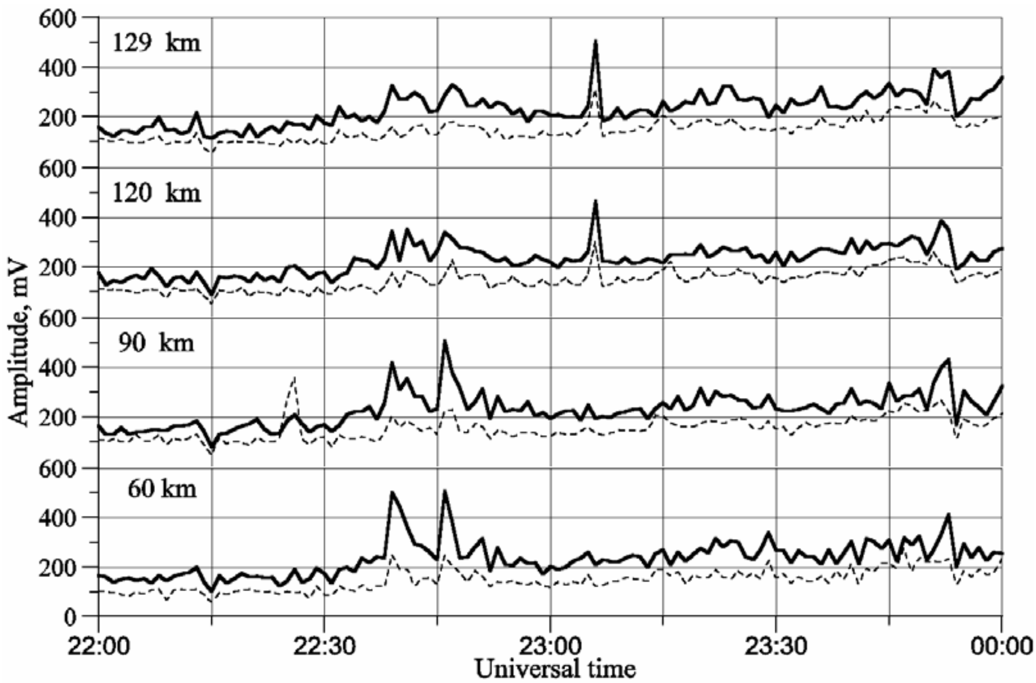

Fig. 1. Amplitudes of reflections of ordinary (solid line) and extraordinary (dashed line) radiowaves at fixed heights

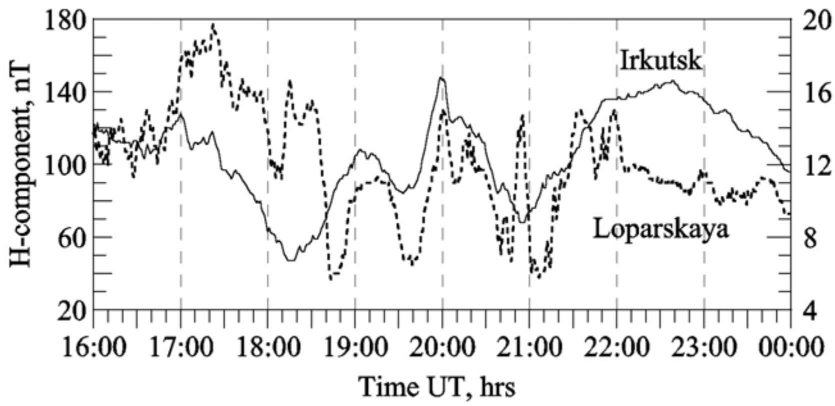

Fig. 2. Microvariations of the geomagnetic field in September 24, 2002

The amplitude of magnetic perturbations in Irkutsk was an order higher, than in Loparskaya, and they had begun 5 minutes earlier. Similar perturbations of the geomagnetic field were recorded in Irkutsk after the falling of the Tungus meteorite (Ivanov, 1961). The time interval was about 10 minutes between the flashout of the meteorite and the response of the ionosphere 4000 km away corresponds to the speed of wave propagation of approximately 7 km/s. A wave detected in geomagnetic variations is called gyrotropic one and can be interpreted as exit of the perturbation of a S_q - current system by an acoustic wave from the falling of meteorite.

The analysis

A spectral analysis of amplitude fluctuations of radioechoes demonstrates presence of oscillations with periods of 3, 5 minutes and more (Figure. 3).

The apparent velocity of wave perturbations is determined by the splash of intensity of signals, scattered in the lower ionosphere (Figure. 1). In the considered case it is not less than 180 m/s. The calculated values of periods and velocities of atmospheric waves agreed well with the observed data obtained during the research of ionospheric effects from the falling of the American "Skylab" space station in July, 1979 (Sorokin et. al., 1982).

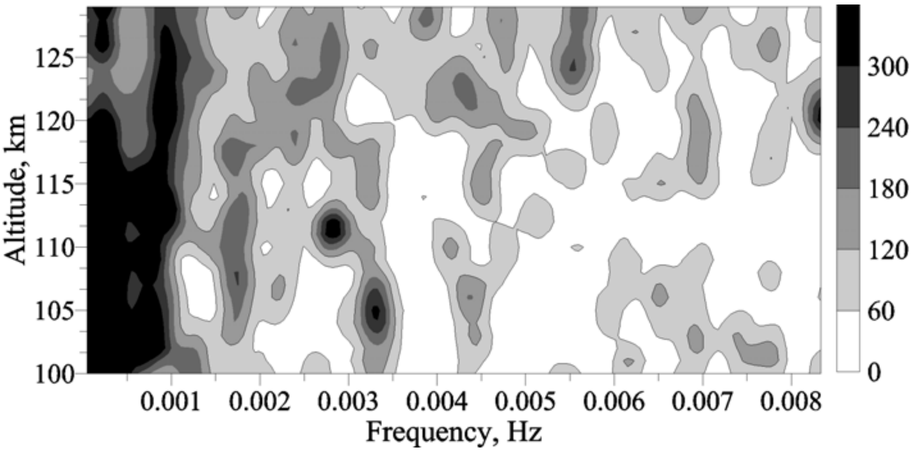

Fig. 3. The altitude behaviour of the spectrum of power of amplitude fluctuations for an hourly sequence of data (22:50 - 23:50 UT) in September 24, 2002.

The spectral analysis of the measurements of reflection amplitudes at the altitude of 47 km has shown, for the twelve hours sequences of data on September 23-24 and 24-25, that the declination of the spectrum during the meteorite falling was more abrupt, than on the previous day. It testifies of the environment increase of temperature after the of the meteorite falling

In Figure 4 spectra of amplitude fluctuation of signals dissipated in the ionosphere at the altitude 120 km during the period from 16 up to 18 UT are presented.

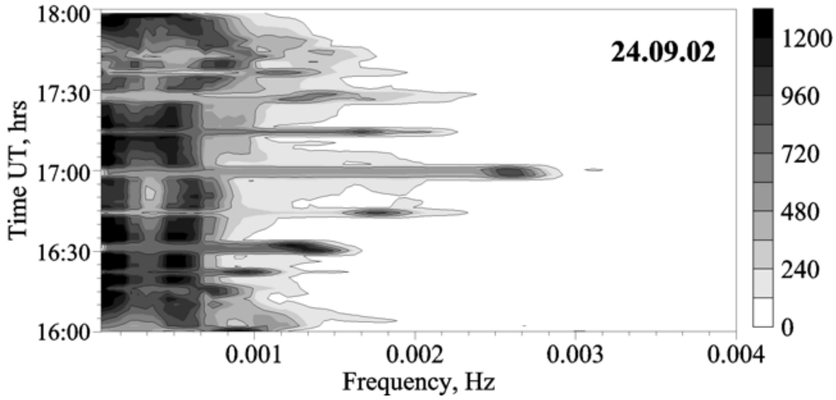

Fig. 4. Temporary behaviour of an hour spectrum of amplitude fluctuations power of an ordinary wave at the altitude of 120 km

From the analysis of the above spectra it follows, that after the meteorite falling on a thermospheric waveguide gyrotropic waves come the first with a period of 15 minutes, then - slow MGD waves with the period of about 7 minutes. Similar perturbations appear also in microvariations of the geomagnetic field (Figure 5).

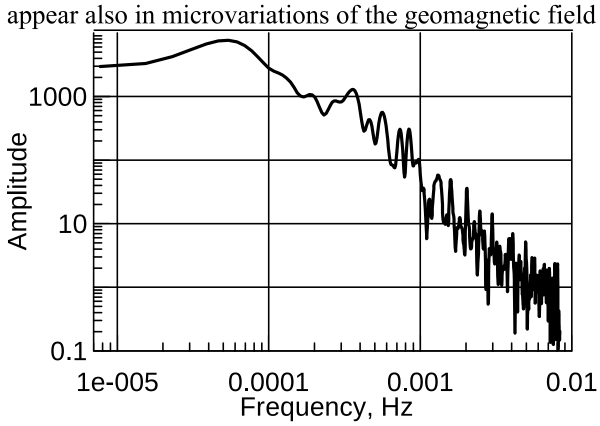

Fig. 5. The spectrum of power of a 6 hour data sequence of an amplitude of the geomagnetic field H-component at the Loparskaya observatory (16-22 UT, 24.09.2002)

It is suggested (Alperovich et. al., 1985), that an explosion generates a power acoustic impulse, which at first spreads as a shock wave, then it transforms to acoustic-gravity waves. During wave propagation the part of its energy is captured in waveguides: one of them is created by temperature minima of tropopause and mesopause (a mesospheric one), the second one - by regular high-altitude anisotropy of the ionosphere conductivity at heights of 80-120 km (a thermospheric one). Such a capture of waves predetermines their distribution at major distances.

Summary

After the fall of the Vitim meteorite on September 24, 2002 observations of wave processes in the lower ionosphere of high latitudes are fulfilled at the 2.7 MHz frequency with a radar of vertical sounding. It was established, that after the meteorite fall, in the polar atmosphere, the perturbations of duration of about 10-15 minutes with frequency periods of 3, 6, 7-15 minutes and more are recorded. After the incoming of the indicated perturbations, the temperature of the polar mesosphere is increased.

According to the data of measurements three groups of apparent velocities were defined: 150-300 m/s, 1.2 km/s and about 7 km/s. Apparently, the velocities correspond to acoustic-gravitational, slow MGD and gyrotropic waves. It is shown, that the acoustic perturbations from the falling of a large meteorite are spread in mesospheric and thermospheric waveguide channels to a distance not less than 4000 km.

The registration of a wave of pressure from an explosion of the meteorite at 22:20-22:50 UT 24.09.2002 in the network of microbarographs of PGI in Apatity as well as the similarity of the observed effects from the explosion with the registered ones after the falling of the Tungus meteorite and the American space station "Skylab" can serve as a proof of reality of represented results.

For confirmation of reliability of the results it is necessary to continue researches of airwaves properties, bound with different sources of disturbances in the lower ionosphere.

Acknowledgment. We are grateful to E.B. Vassilyev and T.V. Kovalevich for their valuable assistance in this paper.

References

1. Alperovitch L.S., Ponomorev E.A., Fedorovitch G.V. Geophysical phenomena, simulated by explosion: A Review // Physics of the Earth. – 1985. - № 11. – P. 9-20.
2. Ivanov K.G. About the reason the subsequent changes of a field in geomagnetic effect of the Tungus meteorite // Geomagnetism and Aeronomy. – 1961. – V. 1, N 4. – P. 616-618.
3. Sorokin V.M., Fedorovitch G.V., Ferberg B.A., Shashunkina V.M., Yudovich L.A. Iospheric effects of “Skylab” fall // Iospheric Forecasting. – M: Nauka, 1982. - P. 138-143.
4. Shumilov O.I., Kasatkina E.A., Tereshchenko E.D., Kulichkov S.N, Vasil´ev A.N. Detection of infrasound from the Vitim Bolide on September 24, 2002 (in Russian)// JETP Letters. – 2003. – V. 77, issue 2. – P. 121-123.
5. Tereshchenko V.D., Ogloblina O.F., Tereshchenko V.A. Gravity waves and infrasound in the polar mesosphere and lower thermosphere // Proc. of the 26 Annual Seminar on Physics auroral phenomena, Apatity, Russia, 25-28 February, 2003. - Apatity: KSC RAS, PGI, 2003. – P. 220-223.