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Sessions I - IV

THE LOWER IONOSPHERE RESPONSING TO SOME PHENOMENA RELATED TO EVENTS ON THE SUN

A.M. Gokov, O.F. Tyrnov

Kharkiv National University, 4, Svobody Sq., 61077 Kharkiv, Ukraine;
e-mail: Alexander.M.Gokov@univer.kharkov.ua

Introduction.

The number of phenomena arising on the Sun and having considerable effects on plasma near the Earth is rather great. Most of them require a study more detailed than is known at present. The report deals with the results of the partial reflection technique [1,2] investigations of solar flares and solar storm commencements (SSC) affecting parameters of the middle latitude ionosphere D-region. The measurements of partially-reflected signals and radio noise were conducted using the equipment from [2] in the vicinity of Kharkiv. The main parameters of the facility are as follows: the operating frequencies being f = 2-3 MHz, the duration of sounding pulses being 25 mcs with the repetition frequency F = 1 Hz.

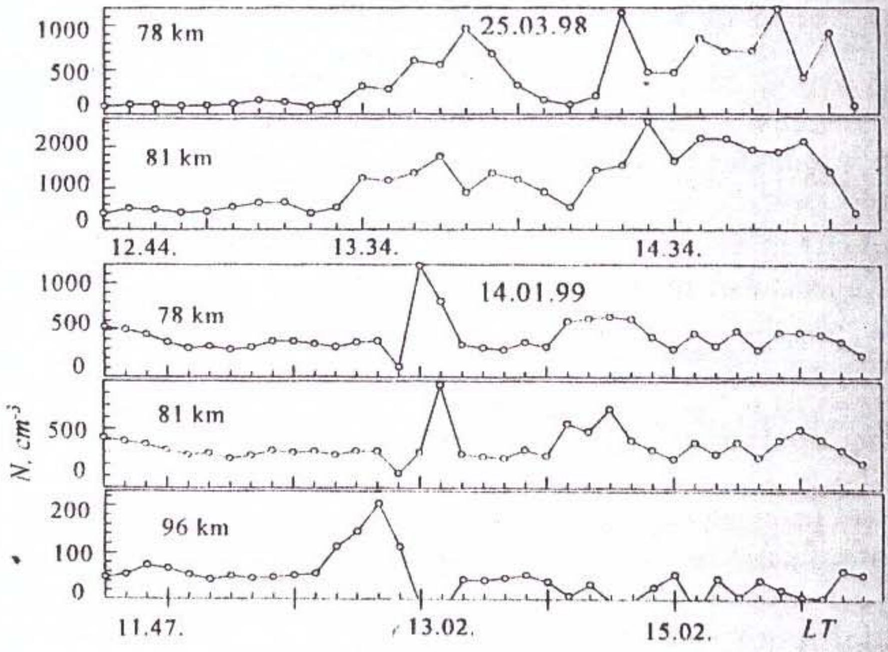
1. Solar flares. Experimental investigations.

Height-time changes in the partial reflection amplitudes of signals, $A_{o,x}(z,t)$, and the radio noise, $A_{no,x}(z,t)$, and in the D-region parameters for 8 sudden ionospheric disturbances, SIDs, (using 4 events of SIDs within duration $t_1 < 30$ min and $t_1 > 30$ min) were analyzed (here «o» and «x» indexes correspond to ordinary and extraordinary magnetic-ionic components, t is the time, z is the height above the Earth). For SIDs in the D-region, disturbances of the waves with the periods of $T < 5$ min, fading of about 20-25 min, were found to be generated or enhanced. A possible cause of such behaviour of the partial reflection signals may be generation or amplification of the acoustic-gravitational waves (AGWs) as a result of sharp intensity enhancing of the X-radiation of the Sun during SIDs. In the measurements, a pronounced increasing (1.5-4 times) in the electron density, N, at the heights z = 70-85 km during SIDs. The $N(z)$ profiles calculated for each subsequent period of 3-4 min during SIDs were observed to differ both as to their forms and N-values (at the fixed heights); after the event, the N-values in the D-region mainly recovered over several minutes up to the same values as those before SIDs [3,4]. The $N(z,t)$ calculations were made by means of the differential absorption technique [1] using regularization according to the Tikhonov [5]. An error in the $N(z,t)$ calculations was < 30%.

Optical solar flare effects on a state of the lower part of the ionosphere near the Earth were separately investigated. Using partial reflection signal records of 1997-1999, 10 events of such a type were analyzed. Information on the flares was taken from the World Data Center. For each such event, behaviour of $A_{o,x}(z,t)$, $A_{no,x}(z,t)$ and $N(z,t)$ were analyzed both during the event and during several tens of minutes-hours before and after it. The main features of a D-region response can be briefly given as follows: several minutes (~6-15) after a flare (sometimes in respect to its outset, more often in respect to its maximum), «splash»-increases of $A_{o,x}(z,t)$ being several times larger (frequently through the whole D-region) with subsequent quasi-periodic changes are observed. Their duration, as a rule, is about 10-20 min, sometimes being up to an hour, the periods being T~5 min. At the same time, the electron density increases by 50-200%, similar quasi-harmonic changes in the height-time $N(z,t)$ variations being observed as well. Height-time dependences of $\langle A^2_{o,x} \rangle$

(z,t) and $N(z,t)$ obtained during the optical flares (25.03.1998, 13.46 - 13.51 LT; 14.01.1999, 11.55 -12.15(max) - 13.17 LT; 15.01.1999, 12.41 - 13.15(max) - 13.20 LT) are given in Fig. 1.

The investigations carried out for 10 flares of radiofrequency radiation allowed to establish the following main peculiarities: as a rule, 5-12 min after a flare (in respect to its maximum) one observes a sharp increasing in absorption of a radio waves having t ~ 10 - 20 min (the values of $A_{o,x}$ (z,t) and $A_{no,x}(z,t)$ being increased 1.5-2 times or more); then the $A_{o,x}(z,t)$ and $A_{no,x}(z,t)$ amplitudes also increase (the characteristic time being about tens of se-conds) several times, and one observes qua-si-harmonic changes in $A_{o,x}(z,t)$ and $A_{no,x}(z,t)$, as a rule, with the periods of $T < 5$ min, which are called acou-stic - gravitational wa-ves generated or en-chanced in the lower ionosphere due to in-creasing in the X-ra-diation of the Sun. An example of the height-time changes in $\langle A^2_o \rangle (z,t)$ and $N(z,t)$ for a flare of 18.03.1998 is given in Fig. 2 (the flare time: 12.50 - 13.12 (max) - 13.44 LT).



2. Reaction to solar storm commencements.

It is known that a solar storm commencement causes at the first moment an increase in precipitating charged particles from the magnetosphere which after SSC are quickly mixed up with magnetospheric plasma coming from interplanetary space. This solar plasma cloud, some time later, is a cause of the second geomagnetic storm phase over which propagating of anomalous phenomena of ionospheric ionization up to the middle latitudes is possible. Over this period, high energy protons (together with high energy electrons mainly causing ionization

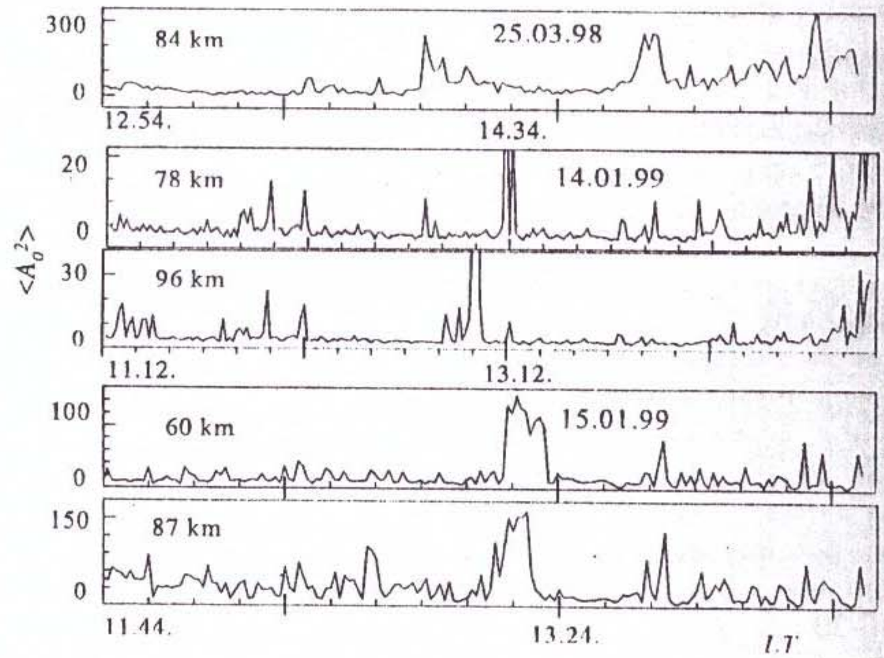


Fig. 1

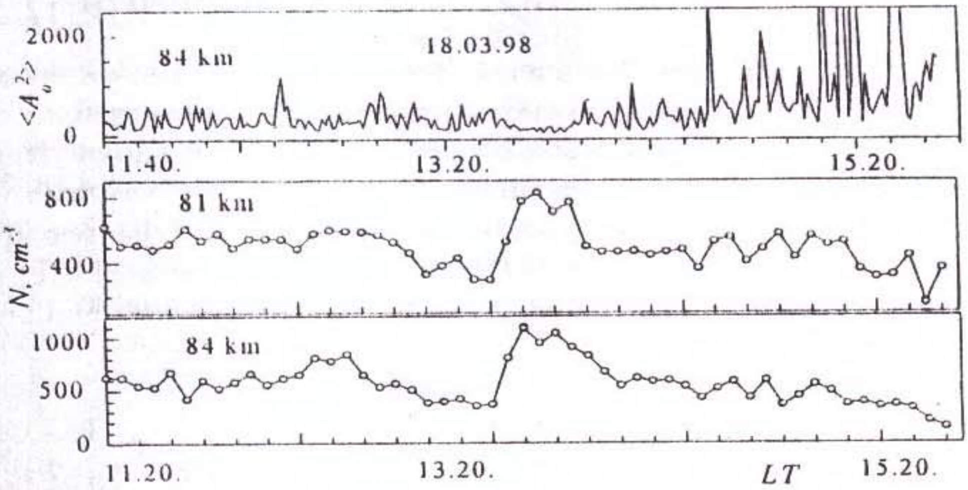


Fig. 2

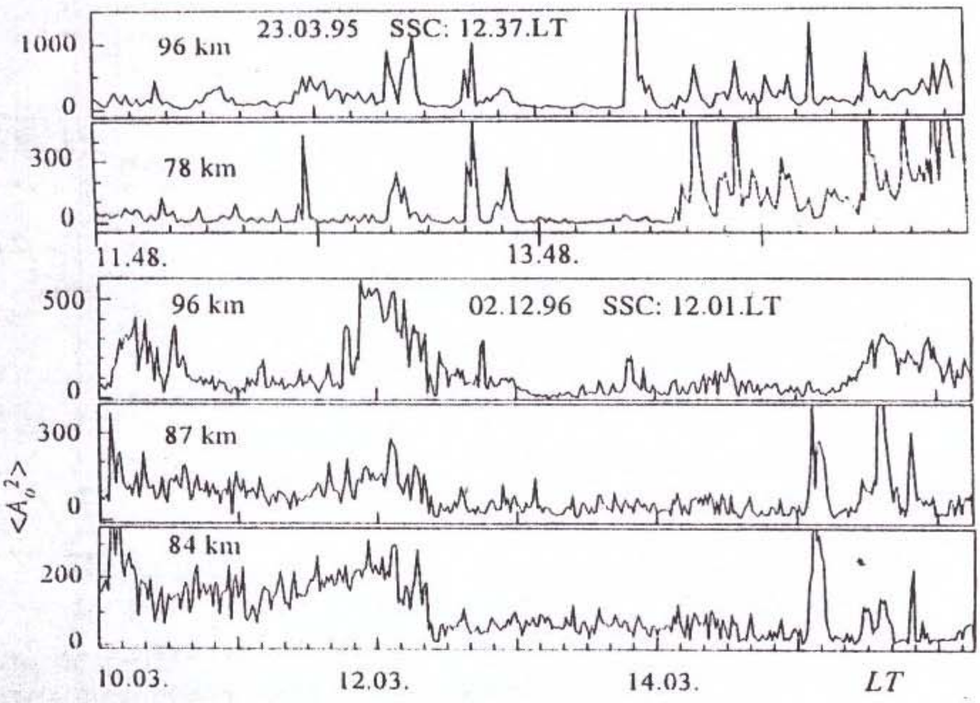


Fig. 3a

anomalies at z< 100 km) play also an important part as ionization source.

We investi-gated reactions of the middle latitude ionospheric D-region to 2 SSCs o 02.12.1996 at 10.01 UT and of 23.03.1995 at 10.37 UT. Figs. 3a and 3b show height-tim changes in $<A^2_o>(z,t)$ and $N(z,t)$. Note the main features in the D-region responding to the se events. About 30-60 min after the event, throu-ghout the whole D-region, one has ob served a sharp increase in absorbing radio waves (sounding frequencies being 2.3 MHz with the duration up to several hours, which is accompanied by bursts in depen-dence $<A^2_o>(z,t)$ ($<A^2_o>(z,t)$ increasing units - tens of times). In the height-time varia-tions o $N(z,t)$, over these time intervals, $N(z,t)$ increasing by more than 50-100% is observed fo about 5-30 min. (Note that on 23.03.1995, 6-7 min after SSC, short time (about 2 min precipitating of electrons was observed; it was clearly pronounced in the height-time varia tions of $<A^2_o>(z,t)$ and $N(z,t)$. At the same time, the electron density at 78-93 km wa increased by 50-150% over about 5-10 min).

Conclusions.

Analyzing of the experimental results obtained during the considered events on the Sun shows the following. Such events are, as a rule, accompanied by precitipations of the high energy electrons and protons, lea-ding to short-time (of the order of units-tens of minutes) increases by about 50-200% (sometimes more) of the electron density both in the lower ($z < 75$ km) and in the upper ($z > 75$ km) middle latitude D-region of the iono-sphere. Such processes in this height range are accompanied by generating and en-hancing of acoustic-gravitational waves with characteristic periods of about units of minutes and characteristic durations of $t \sim 10$-30 min.

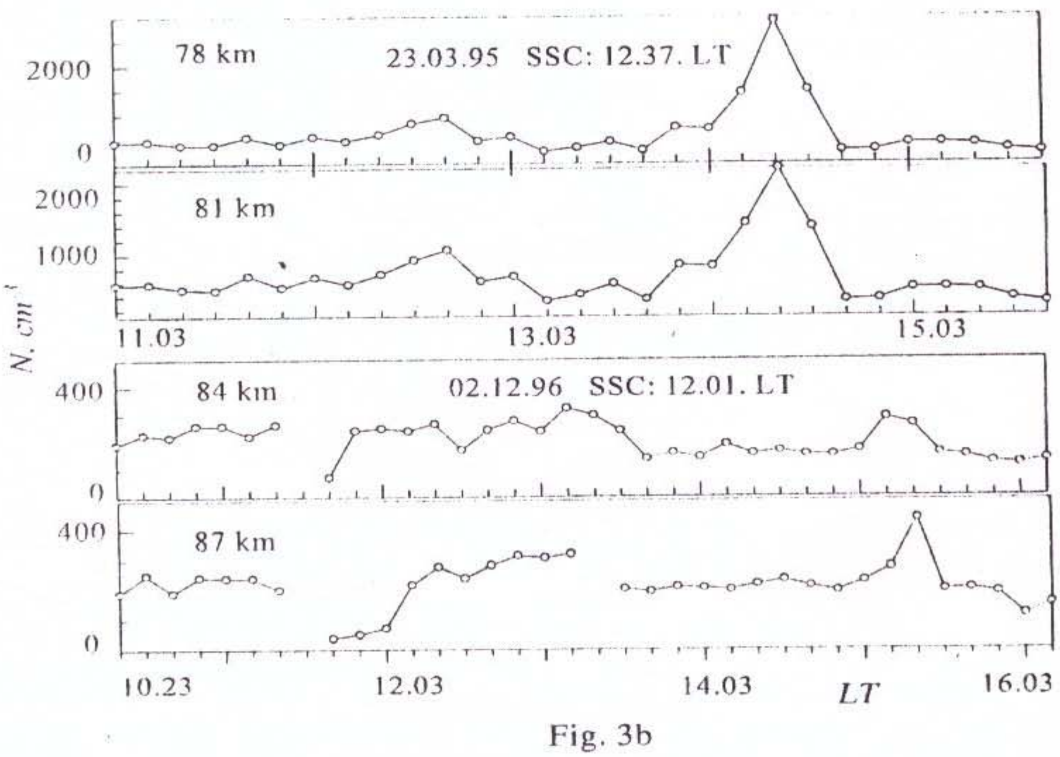


Fig. 3b

References:

1. **Belrose J.S.**, Radio wave probing of the ionosphere by the partial reflection of radic waves (from heights below 100 km), *J. Atmos. Terr. Phys.*, **32**. № 3, 567-596, 1970.
2. **Tyrnov O.F., K.P. Garmash, A.M Gokov, et al.**, The Radiphysical Observatory for Remote Sounding of the Ionosphere, *Turkish J. of Physics*, **18**, № 11, 1260-1265, 1994.
3. **Gokov A.M., Gritchin A.I.**, Characteristics of Some Disturbances in the Ionospheric D-region during Magnetic Storms and Solar Flares, *Kosmicheskie issledovanija*, **34** №6, 585-589, 1996 (in Russian).
4. **Gokov A.M. and O.F. Tyrnov**, Disturbances in the middle latitude ionospheric D region during magnetic storms, *In: Proceedings of the 6th International Krimean Microwave Conference CriMiCo'96, 16-19 September 1996, Sevastopol, Crimea Ukraine*, 398-400, 1996.
5. **Garmash K.P. and L.F.Chernogor**, Profiles of the ionospheric D-region electron density under quiet and disturbed conditions from data on partial reflections *Geomagnetizm i aeronomiya*, **36**, № 2, 75-81, 1996 (in Russian).