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SOLAR OR METEOROLOGICAL CONTROL OF LOWER IONOSPHERIC FLUCTUATIONS (2-15 AND 27 DAYS) IN MIDDLE LATITUDES

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Several types of short- and long-term effects of solar activity on the lower ionosphere have been discussed in the literature. They are related to solar flares, the sector structure of the interplanetary magnetic field and some periodicities in sunspots or solar radio flux. The most evident periodicities of the Sun are the 11 year cycle of its activity and the differential rotation period near 27 days (25-30 days). The response of the lower ionosphere to the 11 year solar cycle is considered by many authors. Here, the following questions are discussed: which periods between 2 and 15 days and near 27 days occur in ionospheric absorption during the interval July 1980 - July 1985 and are these periods related to similar periods in solar Ly-α flux, geomagnetic activity, or neutral wind near 95 km observed in Collm (GDR).

We use day-time absorption data obtained by the A3 method for the following radio-paths: Allouis-Sofia (164 kHz), Deutschlandfunk-Panská Ves (1539 kHz), Pristina-Sofia (1412 kHz) and Luxemburg-Panská Ves (6090 kHz). With the use of these data the electron density variations in the lower ionosphere can be analyzed. The amplitude spectra of time series are obtained. As a criterion for statistical significance, the confidence level 0.1 is selected. Within the range of periods of 2-15 days, the highest amplitudes are exhibited by the spectral lines at: 2.4-3.2, 4-6, 10.5-12 and about 13.5-14 days. All time series have also well expressed spectral lines between 26 and 28 days. We investigate the development of these fluctuations in time. The data are grouped by seasons. The observed fluctuations display a well expressed seasonal course. Fluctuations with the shortest period (2.4-3.2 days) have their main maximum in summer and a secondary one in winter. The 4-6-day fluctuations are most obvious during the equinox while the long-period 10.5-12 and about 13.5-14 day fluctuations have their basic maxima in winter and the secondary ones in equinox.

An attempt is made to clarify the nature of the observed fluctuations in absorption. The height region responsible for the radiowave absorption studied is ionized by the H-Lyman-alpha flux (121.6 nm - measured by the SME satellite). The statistically signifi- cant spectral lines existing in the Ly-α amplitude spectrum are only those with periods between 25 and 28 days (connected with solar rotation) and near 13.5 days. Consequently, only the 13.5-14- and about 27-day fluctuations in absorption could be generated by the variations of the Ly-α flux. In order to trace the connection between these fluctuations, we use a complex demodulation. This method allows us to obtain the instantaneous characteristics of the fluctuation under consideration. Figure 1 presents the time variations of the instantaneous amplitudes of the 13.5-day fluctuations in the Ly-α flux and in absorption for 164 kHz and 1412 kHz paths. The periods of amplification of this fluctuation in the Ly-α flux are denoted by arrows. It is obvious that a connection between the amplification of fluctuations in Ly-α on the one hand, and in absorption on the other, hardly exists (perhaps with the exception of the period April-May 1982 when an activation of fluctuations in absorption is observed). The 13.5-day fluctuation, existing in the lower ionosphere, has its basic maximum in winter. It seems that in the lower ionosphere the 13.5-day fluctuation is mainly due to meteorological and not to solar activity variations.

The fluxes of high energy particles are an important ionization source of the ionospheric D-region. Their precipitation can play a dominant role not only during geomagnetic storms, but several days after. We analyse the geomagnetic aa(N)-index as an indirect characteristic of particle precipitation in middle latitudes of the Northern Hemisphere. The statistically significant spectral lines are those corresponding to periods of: 4-6, 8, 11.5 and 13.5-15 days. Comparing the statistically significant periods during the seasons for the absorption and the aa(N)-index, we notice a comparatively good coincidence only in the interval of 4-6 days. This is the only fluctuation that could partly stimulate analogous fluctuation in the ionospheric absorption.

Variations of the prevailing wind in the lower thermosphere play a very important role in the meteorological control of the lower ionosphere. Therefore, we use the neutral wind measured at Collm (GDR) by the D1 method as a neutral atmosphere parameter representing the effect of dynamics on the radiowave absorption. For the zonal wind statistically significant spectral lines have periods: 6-7, 10.4-12 and 14-15 days and for the meridional wind periods: 2.4, 4-6, 8.2-9, 10.8-12 and 14-15 days. We investigate the seasonal course of these fluctuations. The long-period (10-12-days) fluctuations have the basic maximum in winter and a secondary one in equinox. The result is analogous to the seasonal course of the long period fluctuations in absorption. The comparison between the seasonal courses of the two fluctuations shows a perfect coincidence. Consequently, we can say that these fluctuations are related. The 4-6-day fluctuations in the neutral wind are best expressed in the equinox. This fact is identical with the seasonal course of the analogous fluctuations in absorption. The comparison between the two fluctuations shows a similarity, but not so well expressed as it was with the 10.5-12 day fluctuation. It is almost beyond doubt that the short-period 2.4-3.2-day fluctuation in absorption is closely connected with the analogous fluctuation in the neutral wind (such a high frequency fluctuation exists neither in the Ly-α flux, nor in the aa(N)-index). The seasonal course of this fluctuation observed in wind coincides with those in absorption, i.e. the main maximum in summer, a secondary one in winter.

The last investigated is the fluctuation with a period of about 27 days. Figure 2 shows the time variations of the instantaneous amplitudes of 27-day fluctuations in the Ly-α flux and in absorption with the use of the complex demodulation method. The following results are obvious:

1) When the Ly-α flux has very well expressed 27-day fluctuations

(as in July-August 1982), there is of course an ionospheric response, but the 27-day fluctuations in absorption are not the strongest ones.
2) There is a very well visible seasonal course of a 27-day fluctuation in absorption with winter maxima.
3) The periods of winter amplifications of 27-day fluctuations in absorption occur when they are almost absent in Ly-α flux (as in winter 1984/85). This last result is rather strange. It provoked us to analyse another time interval. We chose 1970-1980 . For this interval no Ly-α data are available to us, so the solar radio flux $F_{10.7}$ was used. The result was the same: an opposite course between the amplitudes of 27-day fluctuations in absorption and in solar radio flux.

What could be the reason for this opposite relationship between the amplitudes of 27-day fluctuations in absorption and in the solar ionizing flux? It is well known that the vertical propagation of planetary waves through critical levels in the stratosphere can occur only if the mean winds are westerly but less than a critical velocity (predominantly in winter season). The stratospheric circulation depends on the temperature distribution, which reacts to changes of ozone connected with solar UV perturbations. Recent studies of solar UV related changes of ozone have shown that during periods of amplifications of 27-day fluctuations in the solar UV flux (or in $F_{10.7}$, Ly-α flux) ozone in the stratosphere has a measurable response. This reaction could create critical levels in the stratosphere during winter. These levels do not permit the vertical propagation of the planetary waves with a period of about 27 days which are excited in the lower atmosphere. These waves cannot penetrate to mesospheric altitudes and cannot influence the electron density distribution or ionospheric absorption. When 27-day variations are almost absent in solar fluxes, then there are no conditions for creating critical levels in the winter stratosphere. Then the planetary waves with a period of about 27 days excited in the lower atmosphere can propagate vertically upwards and influence the ionospheric absorption.

Summarizing, we may say that the probable meteorological origin of the observed fluctuations in radiowave absorption seems to offer a possibility of monitoring fluctuations in the upper mesosphere and lower thermosphere in the planetary wave period range by means of radiowave absorption measurements.

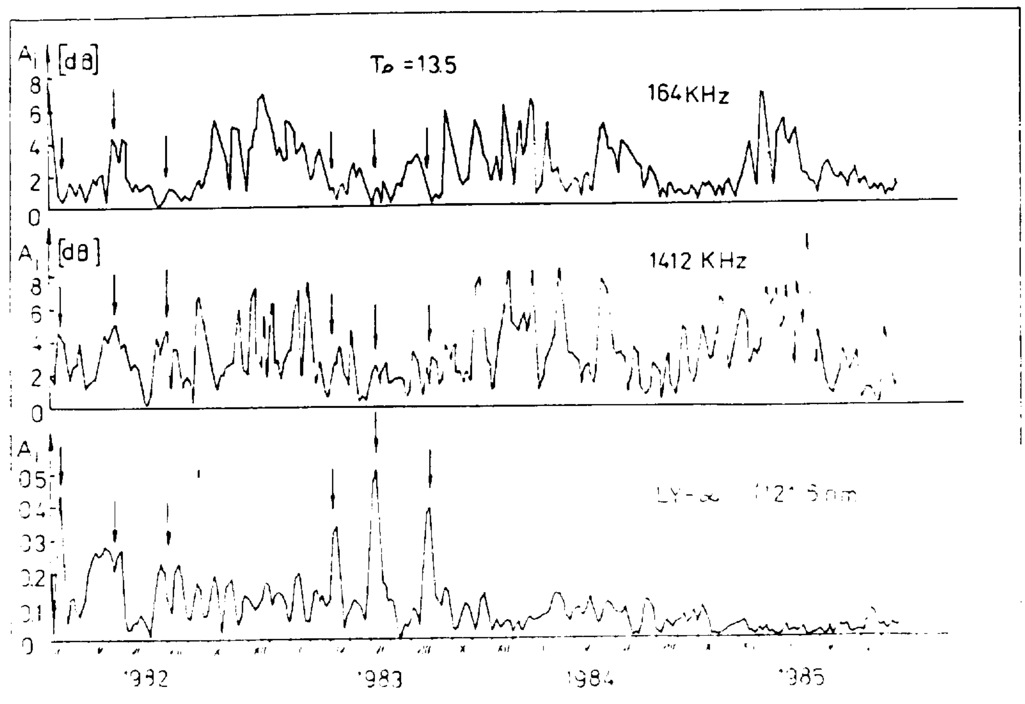

Fig. 1. The time variations of the instantaneous amplitudes of the 13.5-day fluctuation in the Lyman-alpha flux and in the ionospheric absorption for 164 kHz and 1412 kHz radio-paths.

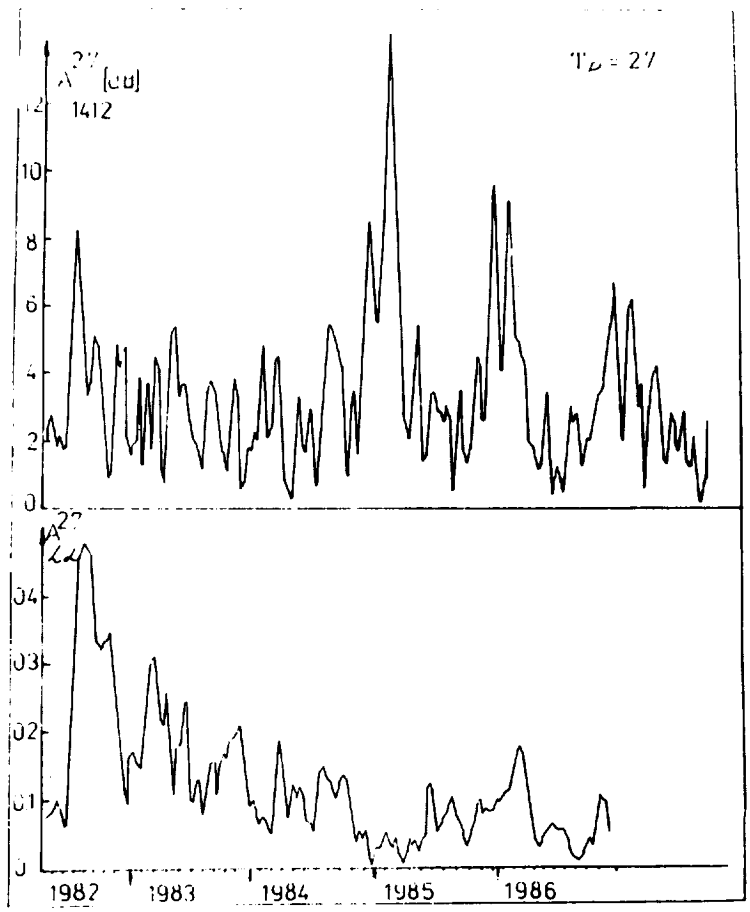

Fig. 2. The time variations of the instantaneous amplitudes of the 27-day fluctuation in the Lyman-alpha flux and in the ionospheric absorption for the 1412 kHz radio-path.