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IONOSPHERIC ABSORPTION ON 1539 KHZ IN RELATION TO SOLAR IONIZING RADIATION

J. Boska

Geophysical Institute
Czechoslovak Academy of Sciences
141 31 Prague 4, Czechoslovakia

ABSTRACT

Radio wave absorption data on 1539 kHz for the summer period of 1978-1980 are considered in relation to variations of solar X-ray and Lα radiation. It is shown that under non-flare conditions Lα dominates in controlling absorption and that X-rays contribute about 10% to the total absorption. Optimum regression equations show that absorption is proportional to the m-th power of ionizing flux, F_{ion}, where m < 1. The role of correcting Lα values, measured by the AE-E satellite, is discussed.

It is generally accepted that Lyman-α radiation plays the dominant role in the formation of the D region. But the contribution of different ionizing radiations in the lower ionosphere has not been established too well. In this paper the results of a statistical analysis of A3 absorption data are presented in relation to solar X-ray (1-8 Å) and Lyman-α fluxes. Radiowave absorption data measured on 1539 kHz at the Panska Ves Observatory, Czechoslovakia, (reflection point 50°16'N, 11°47'E, distance 390 km, equivalent frequency, 0.7 MHz) are used. The data set consists of the summer months (June-August) of 1978-1980, separately for the afternoon and forenoon at χ = 60° and 70°. SWF events and absorption data considerably affected by geomagnetic storms have been excluded. X-ray flux data were taken from Solar-Geophysical Data bulletins (1979-1981). In the case of Lyman-α irradiance the question of experimental data is more complicated. The Lyman-α flux values used in this paper were adopted from AE-E satellite measurements (HINTEREGGER, 1981). It is very well known that there are open questions about absolute Lyman-α flux values measured by the AE-E satellite. Figure 1 shows the development of monthly mean values of Zurich sunspot number R_z, solar flux at 10.7 cm and also Lyman-α flux for the whole period under study. An unexpected enhancement of Lyman-α flux value can be seen at the beginning of 1979. It should also be noted that the values of Lyman-α flux observed during cycle 21 are higher than for cycle 20, and this increase is not matched by corresponding increases in the sunspot number or in the solar flux at 10.7 cm. As BOSSY and NICOLET (1981) have demonstrated, the differences can be explained only by systematic errors and cannot be neglected. We have corrected these Lyman-α flux values in the following way. As can be seen from Figure 1, the ratio of Lyman-α to Lyman-β fluxes also significantly increased at the beginning of 1979. If we take into consideration that the Lyman-α to Lyman-β ratio decreases in a solar active region (BONNET, 1981), we may claim that this ratio should not increase with increasing solar activity. We can assume that the ratio of Lyman-α to Lyman-β is close to its value for average solar activity and has not changed during the whole period studied. We have used this assumption to correct the Lyman-α flux values. As can be seen from Figure 1 the corrected Lyman-α flux values are in better agreement with the development of solar activity. In this study both corrected and uncorrected Lyman-α data were used.

To derive the relation between absorption and ionizing fluxes, we calculate expressions of the type

$$L = A F_x^m + B F_\alpha^m + C$$

where L is radio wave absorption (in decibels), and F is the flux of ionizing radiation, using the least-squares method for all data sets with m between 0.3 -
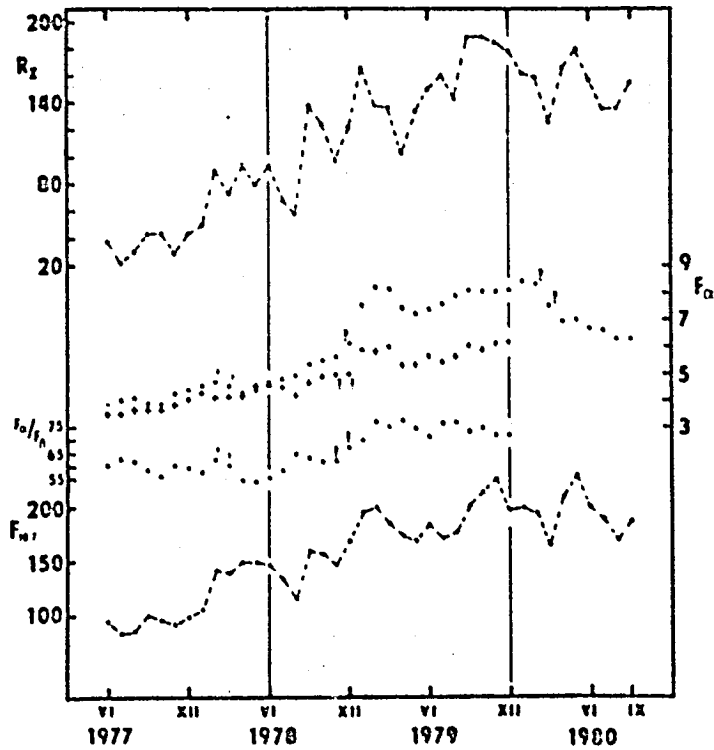
Figure 1. The development of monthly mean values of Zurich
sunspot number R_z, solar flux at 10.7 cm $F_{10.7}$, the solar
Lyman-α flux F_α (circles, uncorrected values; crosses, cor-
rected values) and ratio of Lyman-α to Lyman-β fluxes, F_α/F_β,
over the period 1977-1980. ("?" indicates insufficient number
of data.)

2.4. The criterion for estimating the optimum equations is the value of C
(about 5 - 10% of the total absorption). All values of m, A, B, C for these
optimum expressions are given in Table 1 for uncorrected Lyman-α data and in
Table 2 for corrected data. For some data sets it was not possible to derive
optimum equations.

Let us first consider the exponent m. Its values are distributed between
0.3 - 1 for the uncorrected data and between 0.35 - 0.8 for the corrected values
of Lα. A considerable part of the m values is close to the value of 0.5 to be
expected from the equilibrium equation. In all cases in which we were able to
derive m for both data sets the exponents m are smaller for the corrected than
for the uncorrected data.

This result differs from the results of an analogous analysis of absorption
on the frequency 2775 kHz and 1178 kHz for the period 1969-1972 made by
LASTOVICKA and BOSKA (1982), where the value of m was evidently m > 1. The
cause of this difference is not clear yet. Ratios of X-ray and Lyman-α con-

Table 1

		60°					70°				
	m	A	B	C	L_x/L_1	m	A	B	C	L_x/L_1
1978 a	–	–	–	–	–	0.8	1.7	10.85	3.80	0.04
1979 f	0.75	3.1	10.4	3.7	0.09	–	–	–	–	–
1979 a	0.30	3.90	29.3	10.9	0.08	1.0	1.7	5.8	1.97	0.06
1980 f	0.45	10.4	15.3	6.2	0.36	0.65	5.1	9.3	4.6	0.22
1980 a	0.5	6.6	16.6	8.5	0.20	0.6	3.4	12.5	4.9	0.11

Table 2

		60°					70°				
	m	A	B	C	L_x/L_1	m	A	B	C	L_x/L_1
1978 f	0.35	13.6	19.2	5.7	0.37	–	–	–	–	–
1978 a	–	–	–	–	–	0.55	1.7	16.5	4.2	0.04
1979 f	0.45	6.9	19.8	4.23	0.19	–	–	–	–	–
1979 a	–	–	–	–	–	0.8	3.1	10.3	3.9	0.10

tributions to total absorption, L_x/L_1, for the equations from Table 1 and 2, have been calculated using mean ionizing fluxes for all the individual data sets. The values of L_x/L_1 lie between 0.04 - 0.37 and clearly display the dominant role of Lyman-α radiation in absorption. The typical contribution of X-rays to the total absorption under non-flare conditions is about 10%. For the corrected data sets, the contribution of X-rays is slightly greater than for the uncorrected data. Median values of the correlation coefficients between radio wave absorption and ionizing fluxes are: $\rho L_1 = 0.33$ and $\rho L_x = 0.40$, respectively. For Lyman-α the correlation is slightly weaker than for X-rays and this result was not significantly influenced by correcting the Lyman-α flux. This is probably due to the Lyman-α variability being small compared to the variability of X-rays.

It can be concluded that the correction of Lyman-α data did not change the results of the analysis significantly. The derived values of the exponent m are in good agreement with the theoretical assumptions.

REFERENCES

Bonnet, R. M. (1981), Space Sci. Rev., 29, 131.
Bossy, L. and M. Nicolet (1981), Planet. Space Sci., 29, 907.
Hinteregger, H. E. (1980), Paper No. C.1.1.6, presented at XXIII COSPAR Meeting, Budapest.
Hinteregger, H. E. (1981), Paper No. 2.D.3, presented at IAGA Assembly, Edinburgh.
Lastovicka, J. and J. Boska (1982), J. Atmos. Terr. Phys., 44, 793.
Solar Geophysical Data, NOAA, Boulder, Colorado, 1979-1981.