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SOLAR-TERRESTRIAL INFLUENCES ON THE D-REGION AS SHOWN BY THE LEVEL OF ATMOSPHERIC RADIO NOISE

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Measurements of the integrated atmospheric radio noise field strength at 27 kHz, used here, were made in the period 1965 - 75 at three unified European stations: Uppsala (60°N), Kuhlungsborn (54°N) and Prague-Panska Ves (50.5°N). For some cases, also measurements at 5 kHz from Prague-Panska Ves were available.

In earlier papers it has been shown by the superposed epoch method that during Forbush-decreases the level of atmospheric radio noise also decreases at middle latitudes. In case of occurrence of both Forbush-decrease and geomagnetic storm, the level of atmospheric radio noise generally increases (SATORI, 1976). In course of the theoretical interpretation, using the VLF waveguide mode theory, the attenuation of VLF electromagnetic waves has been computed considering electron density changes due to the Forbush-decrease, variations of the cut-off rigidity and particle precipitation (SATORI, 1978).

We consider the large-scale meteorological situation by comparing solar disturbed and undisturbed periods under similar weather situations. In order to show the effects of the precipitating high-energy particle (HEP) flux and of the Forbush-decrease on the noise level of all three stations simultaneously, the correlation of the noise level between pairs of stations were computed as deviations from the monthly median, ΔE (dB), day by day for all six periods studied here. We computed the correlation coefficients for noon as well as for night values. These correlation coefficients were compared with those for solar undisturbed periods.

- As expected, the correlation of the noise level is highest when the HEP and the FORBUSH-decrease during disturbed periods predominantly control the propagation conditions. The influences on the noise level are more distinct at Uppsala than at Panska Ves.

- The average correlation coefficient between Uppsala and Kuhlungsborn for the disturbed periods is $r = 0.72$ ($n = 22$) for the day-time (1200-1600 LMT) and $r = 0.71$ ($n = 21$) for the night-time noise level (2200-0200 LMT). It decreases to $r = 0.4$ ($n = 26$) and $r = 0.43$ ($n = 26$), respectively, for undisturbed periods.

- For the correlation between Kuhlungsborn and Panska Ves there were no significant differences between the analogous correlation pairs $r = 0.69$ ($n = 22$), $r = 0.75$ ($n = 22$) and $r = 0.68$ ($n = 27$). But the noise level variation for a disturbed period is very similar at all three stations.

By some case-studies of the level of atmospheric radio noise it has been demonstrated that after geoactive flares the nearly simultaneous effects of Forbush-decrease and that of the post-storm-event (PSE) result in different noise level changes, depending on the strength of the Forbush-decrease and that of the geomagnetic storm (the energy spectra of precipitating electrons), as well as on the onset and the duration of events as compared to each other.

Fig. 1 shows the extremely strong event of August, 1972 from the point of view of both Forbush-decrease and geomagnetic storm. The geomagnetic activity is characterized by Ap-indices, the Forbush-decrease is given in percent of the basis of Moscow neutron monitor data. We studied both the day-time (1200-1600 LMT) and the night-time (2200-0200 LMT) noise level changes as deviations from the monthly medians ΔL (dB). The seasonal variation is also removed from the medians of noise level.

Using the terminology of different phases of post-storm event, namely PSE I, PSE II, PSE III (after LAUTER et al., 1979), it may be seen that during PSE I the noise level at the different observatories decreases on 27 kHz and also on 5 kHz, simultaneously with the main depression of Forbush-decrease both day and night. During PSE II, the noise level increases at day, depending on latitude and frequency, but its enhancement is much more moderate as compared to the PSE II in absorption (LAUTER et al., 1979). This circumstance may be connected both with the differential energy spectra of precipitating electrons and with the modification of noise level by the still lasting Forbush-decrease. During PSE III, the noise level increases again and it is more developed than PSE III in the LF absorption. This increase may be connected with the hardening of energy spectra of precipitating electrons and with the fact that the Forbush-decrease already ended. At night the picture is similar, but the PSE II is longer, than at day; its first part is destroyed, but the second part of PSE II is well developed, when the Forbush-decrease ended. There is a moderate noise level rise corresponding to PSE III.

Fig. 2 shows the extraordinary event of December 1971, when a strong geomagnetic storm (max. Kp = 7+) occurred with a very weak absorption response mainly at higher latitudes, when the precipitation of particles has also been observed by satellite 1971-089A (LARSEN et al., 1976; LASTOVICKA and RAPOPORT, 1979). It has to be noted that over Ottawa the quasi-trapped fluxes may be 3 - 4 orders of magnitude larger than those over other mid-latitude stations in central Europe (10°E). The Forbush-decrease was also strong and it ended only after the period studied here. The noise level changes show the daylight responses to the Forbush-decrease, which have been moderated at higher latitudes by the opposite effect of the geomagnetic storm. Therefore a virtual opposite latitude dependence of the effect of Forbush-decreases may be seen. The night noise level changes are ambiguous.

Fig. 3 shows an event with a moderate Forbush-decrease and geomagnetic storm. The Forbush-decrease begins three days earlier than the geomagnetic storm. In this case the changes of the atmospheric radio noise level show a picture quite similar to the LF absorption post-storm effect both day and night. In the noise level at daylight hours the PSE I is less, the PSE III is more intensive as compared to the LF absorption in Kuhlungsborn.

Fig. 4 shows a collection of different events referring to the effect of the geomagnetic storm and the Forbush-decrease for Kuhlungsborn in daylight hours. The days of occurrence of the geomagnetic storms are indicated by the vertical line. In case of the event of March, 1970, the opposite effects of the Forbush-decrease and the geomagnetic storm practically cancel each other.

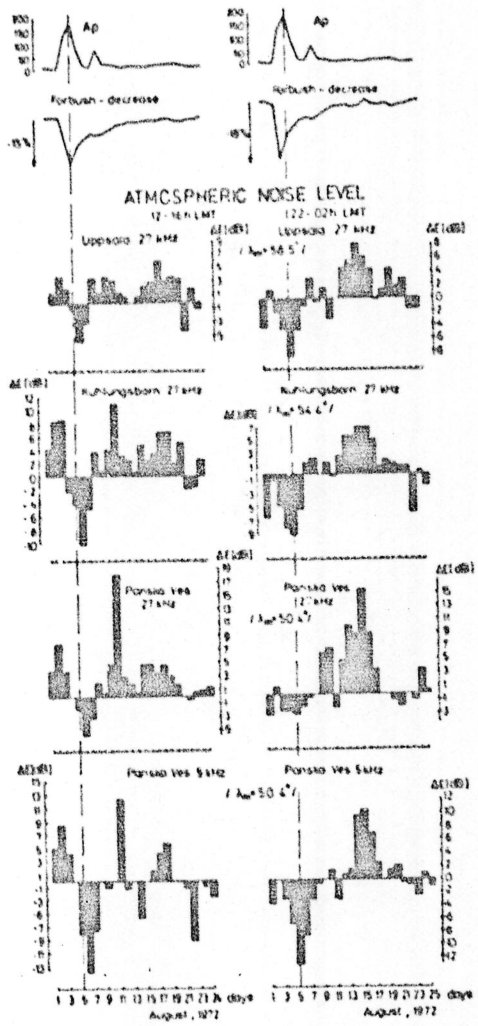

Figure 1.

Summarizing we can see that the VLF noise level changes due to the joint effect of Forbush-decreases and geomagnetic storms show a much more varied picture as compared to the LF absorption post storm effects in case of different events. But by means of the VLF noise level the direct influence of the galactic cosmic rays in the lower D-region may be studied.

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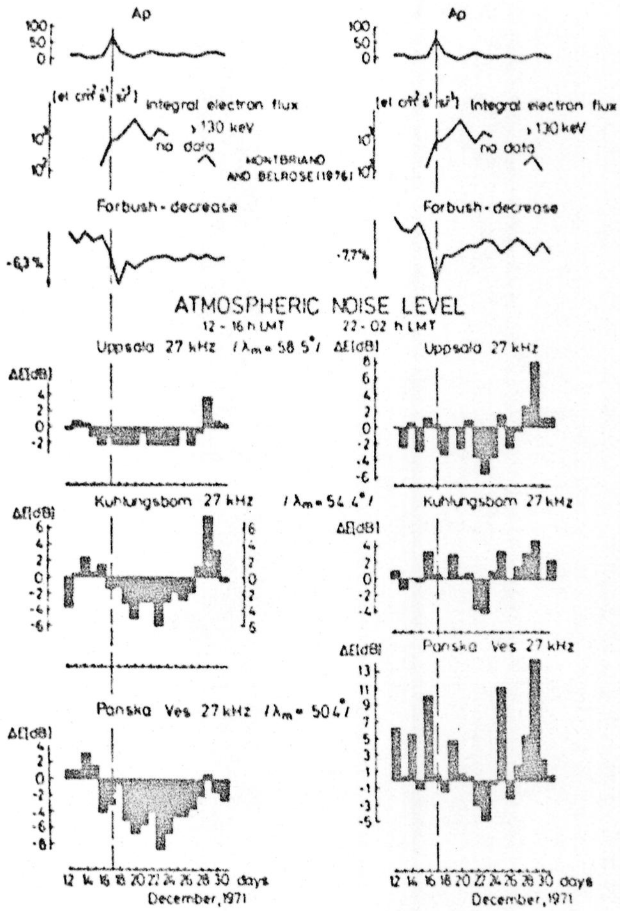

Figure 2.

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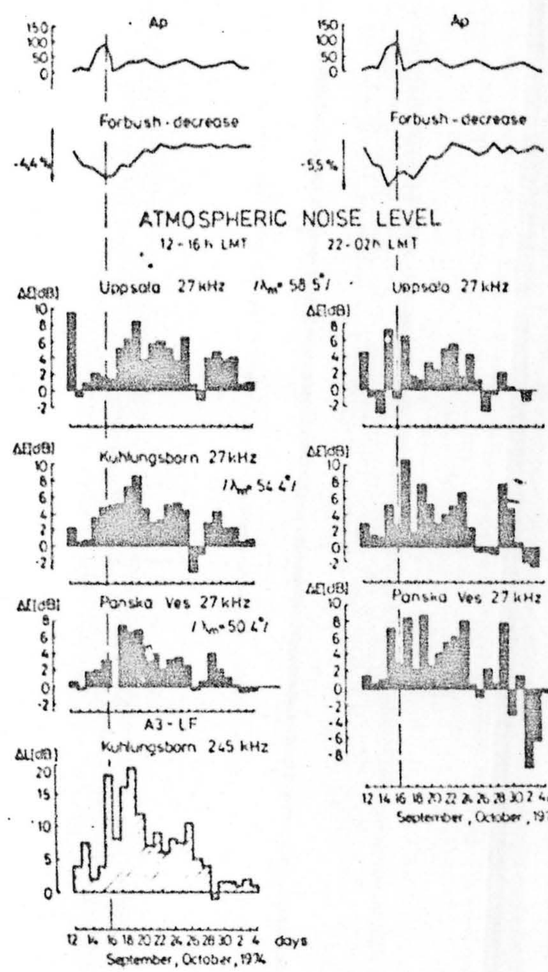
Lauter, E. A., A. Grafe, B. Nikutowski, J. Taubenheim and C. U. Wagner (1979), Gerlands Beitr. Geophysik, Leipzig, 88, 73.
Satori, G. (1976), Acta Geod. Geoph. Mont. Hung., 11, 229.
Satori, G. (1978), Acta Geod. Geoph. Mont. Hung., 13, 475.



Ap
Forbush - decrease
ATMOSPHERIC NOISE LEVEL
12 - 16 h LMT
22 - 02h LMT
Uppsala 27 kHz
Kuhlungsborn 27 kHz
Panska Ves 27 kHz
A3 - LF
Kuhlungsborn 245 kHz
September, October, 1974

Figure 3.

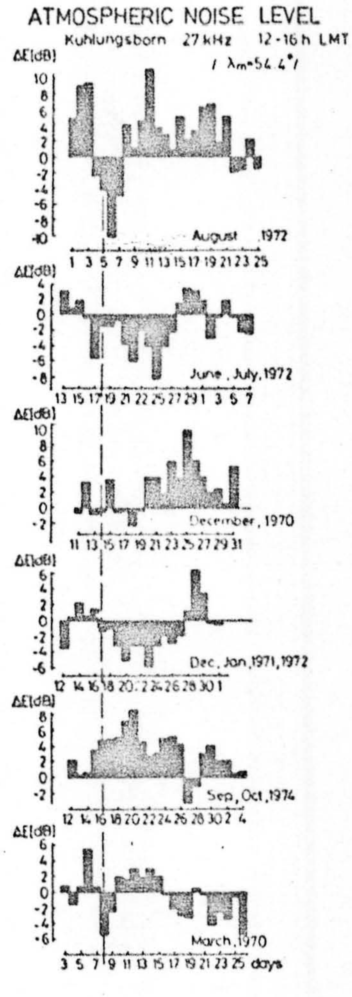

ATMOSPHERIC NOISE LEVEL
Kuhlungsborn 27 kHz 12-16 h LMT
/ λm=54.4°/
ΔE[dB]
August 1972
June, July, 1972
December, 1970
Dec, Jan, 1971, 1972
Sep, Oct, 1974
March, 1970
days

Figure 4.