EFFICIENCY OF SHORT-TERM PREDICTION FOR THE MAIN SOLAR FLARES ON THE BASIS OF LONG-PERIOD PULSATIONS OF MICROWAVE RADIO EMISSION

V. Fridman and O. Sheiner

Radiophysical Research Institute
B. Pecherskaya 25, Nizhny Novgorod, 603600, Russia

ABSTRACT

The results of application the procedure of short-term prediction for the main solar flares on the basis of the growth of long-period ($T > 20$ min) pulsations of microwave radio emission are presented.

Keywords: Microwave Radio Emission, Forecast, Geoefficient Solar Flare

In spite of the efficiency of the space observatories at present ground-based solar observatories were intended for applied tasks are cheaper, more reliable, and provide for long time of observations. Moreover radio observations have advantages over other observational ranges, such that high sensitivity and smaller dependence of weather.

Quasi-periodic pulsations of solar radio emission are a reflection of wave and oscillating processes in the solar atmosphere and comprise a whole field of investigations during recent decades (Kobrin, 1976). The forecast interest in these investigations was strengthened after the discovery of the growth of long-period pulsations (LPP) with a period of more than 20 minutes of the centimeter solar radio emission (the observations of the solar radio emission flux with a 2-m dish) before proton flares in the events of August 1972 (Kobrin M.M., et al., 1973), (see Fig. 1).

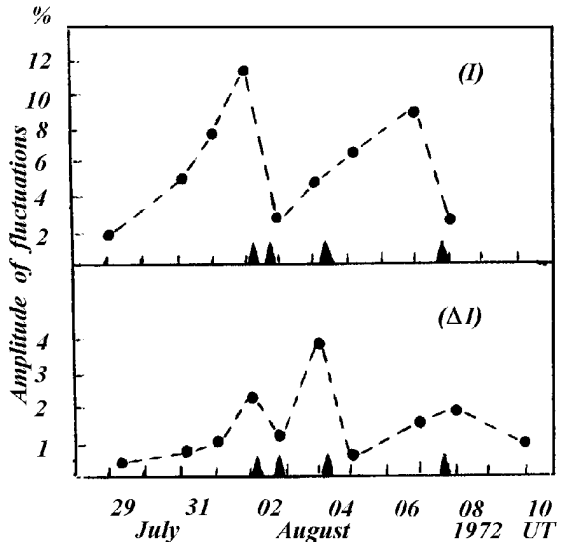

Figure 1. *Behavior of amplitude of fluctuations in July–August, 1972.*

The time of proton events is marked on x-axes of the figure from which it is seen that 2 days before the events there is a marked growth of the LPP amplitude. There is the decrease in amplitude after the events. At the same time, futher analysis of pulsations with periods less than 20 minutes did not show any growth in connection with the proton events. This effect has also been noticed by other authors during observations of active region radio emission at longer wavelength (Bhonsle, 1976). We can make the conclusion as well that LPP did not observed during calm periods or their amplitude was less than the equipment sensitivity threshold (Kobrin, 1981). The retrospective studies of this effect were carried out by the observations of the solar radio emission at $\lambda \sim 3$ cm during periods preceding proton events in 1970–1980 to create the procedure of short-term prediction for the main solar flares on the basis of growth of long-period pulsations with a period of more than 20 minutes of the centimeter solar radio emission (Kobrin M.M., et al., 1997).

The main solar flares are that we can expect particles p^+ with intensity $I(E \geq 5 \text{ MeV}) \geq 1 \text{ cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$.

During the observations two parameters of the solar radio emissions were measured: the intensity I and the slope of the spectrum ΔI being a difference of intensities at two adjacent frequencies. The second parameter turned out to be more informative in revealing peculiarities of LPP dynamics before flares and the procedure of such measurements made it possible in most cases to reduce significantly the level of short-period pulsations and eliminate fluctuation effects of centimeter wave propagation in the Earth atmosphere.

The combine analysis of observational periods before main solar flares and calm periods were carried out during the XX and XXI cycles of solar activity.

The statistic investigations based on all the observations made it possible to create a short-term prediction procedure for proton flares using well-known principles of forecasting. An algorithm of the forecast procedure has been proposed. It consists of the comparison of the mean LPP amplitude in a current series of observations and that one in a calm (nonflare) period taking into account the specific features of the equipment and observation procedure. A forecasting rule suggested (i+1) and (i+2) days as proton event forecast days if the mean LPP am-

plitude of (i) day is twice or more than that of the calm period (Semenova S. V., et al., 1987).

It is better to present the results of study in Conjugate Table.

Forecast	Observations: yes	no	sum
yes	I	II	
no	III	IV	
sum			

The number I means the proving foresast of flare — "yes–yes," number II means the false forecast of flare — "yes–no," number III means the missing of flare — "no–yes," number IV means the absence of proton flare — "no–no". Bellow we present the results of analysis during periods preceding proton events in 1970–1977, so called "instructed" observations.

Forecast	Observations: yes	no	sum
yes	11	5	16
no	3	28	31
sum	14	33	47

A check of forecasting procedure during periods preceding main solar flares in 1977–1980 has shown:

Forecast	Observations: yes	no	sum
yes	36	22	58
no	4	316	320
sum	40	338	378

A check of all data has shown that in time interval of 24 hours the forecast probability of proton events is about 0.8, the probability of proton flare absence is about 0.9, the probability of missing proton flare is 0.1, and the probability of false forecast is 0.3.

In conclusion we have to emphasize that our investigation show the possibility of using the monitoring radiodata for short-term (1–2 days) forecasting of solar proton flare. In spite of their (radiodata) advantages before the data of other frequency ranges it is necessary to mention that proposed method of forecasting requires the complicated equipment and the observation with long duration. The improvement of the forecasting method is possible together with the improvement of the knowledge about physical nature of the effect discovered.

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