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Activity of the New Filament in the Perseid Meteor Stream

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Abstract. The activity profile of the new filament in the Perseid meteor stream and its 1986–1994 levels were analyzed from Ondřejov radar observations. The filament was first detected in 1986 at its minimum activity level. Its maximum flux was observed in 1993. A secondary maximum appeared in the period 1988–1989. The cross-section profile of the new cloud shows an activity peak at $L_{\odot} = 138\overset{\circ}{.}87 \pm 0\overset{\circ}{.}04$ (equinox 1950.0).

1. Introduction

The Perseid meteor stream has been characterized by a fairly stable activity structure profile for most of this century. Long-term radar observations in Sweden, Canada, Czechoslovakia, and elsewhere, placed the maximum activity peak near $L_{\odot} = 139\overset{\circ}{.}20$ (1950.0). Activity patterns have changed starting in 1988 when the shower activity began to show a new position of the main peak (Roggemans 1989) about ten hours before the ordinary maximum. It was suggested that this new filament was due to an ejection of meteoroid matter from the parent comet P/Swift-Tuttle during its perihelion passage in 1862, and that the new filament activity will be the dominant feature in the stream in forthcoming years (Roggemans 1992, Kresák 1993, Šimek & Pecina 1993, Wu & Williams 1993, Williams & Wu 1994, and others). This filament did not appear suddenly in 1988 - it had already been reported by Lindblad & Šimek (1986) from Onsala and by Šimek (1987) from Ondřejov long-term observations as a slight enhancement over the stream activity profiles.

The Ondřejov radar series of Perseid observations 1958–1962, 1972, 1980 – 1987 (further designated as 1958–1987), and 1988–1994, permit the determination of the contributions and activity of the new filament in recent years. The results can be compared with different models of meteoroid ejection, and may also be used for better understanding of the new filament activity in the stream.

2. Observations

The Ondřejov meteor radar operates in a pulsed back-scatter mode at 37.5 MHz with a pulse power of about 20 kW. The antenna is steerable in azimuth but fixed at an elevation angle of 45° above the horizon. The width of the antenna pattern between half-power points in the vertical plane is about ±26° and ±36° in the horizontal plane. During observations of meteor showers the antenna follows an azimuth differing by 180° from that of the shower radiant.

The meteor echoes were recorded on film continuously moving at a speed of 5.6 cm/min. Their durations were reduced with an accuracy of ±0.05 s.

The present analysis includes overdense echoes having durations in the interval $T \geq 1$ s. Such a range of durations was chosen as most effective for the analysis in order to exclude faint meteors which were subject to interference, and to minimize possible effects due to changes of the quality of the film records.

3. Activity profiles

The number of meteor echoes recorded by a radar depends not only on the flux of shower particles and those belonging to the sporadic background, which display strong diurnal variation but also on the geometrical configuration of the shower radiant with respect to the antenna sensitivity contours in the direction to the reflection point on the meteor trajectory in the atmosphere. Thus, one must first separate superimposed sporadic meteors included in the sample. The separation of sporadic background activity is based on the statistical distribution of méteor rates in each particular time interval during interval during non-shower periods.

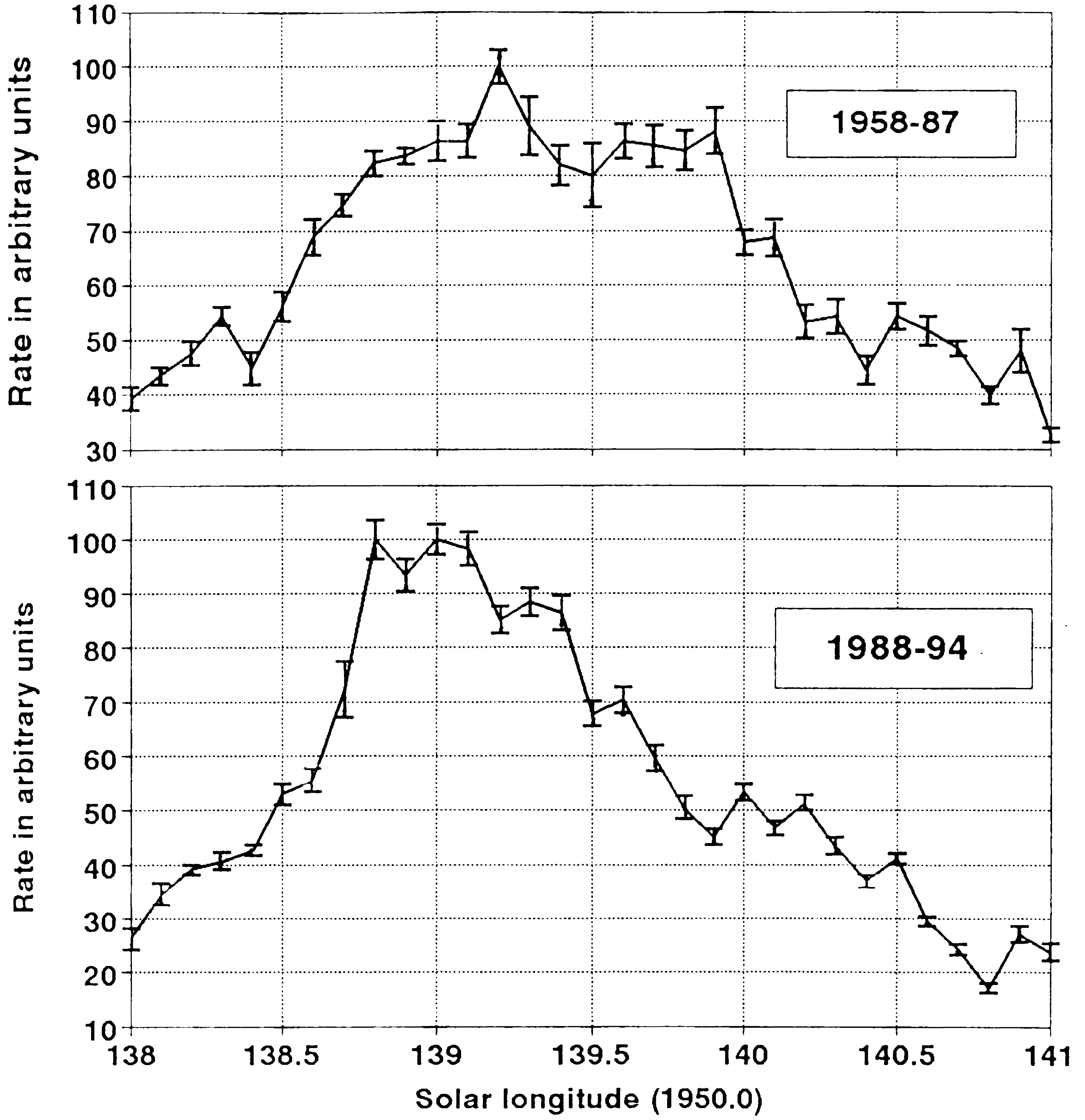

Figure 1. Perseid activity profiles in two periods. The error bars indicate standard deviation of the mean value.

Hourly rates are usually considered as basic data samples for the analysis. The sporadic rates were found by means of a mean normalized background model. The complete iterative normalizing method of the stream activity profile calculation and sporadic background activity determination was described by Šimek (1985) and Šimek & McIntosh (1986).

Since the method is more efficient when the data cover a broad interval of solar longitudes, shower profiles were computed within the interval $133^\circ.0 \leq L_\odot \leq 145^\circ.0$ (eq. 1950.0). The main purpose of this paper is to investigate the appearance of the new activity peak observed during recent years. Therefore, different periods were analyzed to find particular years when the new activity profile exhibits different characteristics than in previous periods. Shower echo rates in arbitrary units are presented in Fig. 1 in the range of $138^\circ.6 \leq L_\odot \leq 141^\circ.0$, in the periods 1958–1987 and 1988–1994, respectively. More minor peaks appear in the former period. The new component of activity certainly appeared in 1988. Perseid activity from 1988–94 abundance is most apparent in the solar longitude range $138^\circ.6 \leq L_\odot \leq 139^\circ.0$, and we analysed this part of the stream with a higher resolution of one hour intervals.

The 1988–94 activity profiles in Fig. 1 represent the shower structure combined from two principal components: the previous activity nature 1958–87 and the activity component associated with the new filament.

Observed shower hourly rates in the duration class $T \geq 1$ s corresponding with a radio magnitude brighter than +1.3 (Šimek, 1987), for 1988–94 and 1958–87 respectively, were corrected for the antenna response function derived from calculations of the relevant shower profile presented in Fig. 1, and divided by the pertinent sporadic background level also included in the shower profile calculations. The last step follows from the assumption that the mean background level does not change over the entire period of observations, which is not strictly correct. We suppose that the observed variations of the background level are products of such effects as solar activity, external noise, state of the upper atmosphere and quality of the film record. The combination of these factors should also affect observed shower rates.

Table 1. New filament activity levels in respect to the mean 1958–1985 level in %.

1986	1987	1988	1989	1990	1991	1992	1993	1994
7 ± 10	41 ± 13	62 ± 15	80 ± 17	38 ± 13	43 ± 13	128 ± 21	260 ± 33	64 ± 15

Calculating the activity profile of the new filament we found that it first occurred in 1986. The distribution of the new filament activity levels along the stream orbit is presented in Table 1 resulting from subtraction of the mean Perseid profiles 1986–94 and 1958–85 including activity levels of individual years in the range $138^\circ.64 \leq L_\odot \leq 139^\circ.0$. We conclude that the maximum level of activity associated with the new filament occurred between 1992 and 1993, which cannot be confirmed from ground-based observations. Mean cross-section activity profiles in terms of mean hourly rates are shown in Fig. 2. Its peak was found at $L_\odot = 138^\circ.87 \pm 0^\circ.04$.

4. Conclusions

We find that activity associated with the new filament occurred before 1988, perhaps as early as 1986. Its activity in the period 1986–1994 within the solar longitude interval $138^\circ.64 \leq L_\odot \leq 139^\circ.0$ culminated in 1993 yielding $260 \pm 33\%$ of the mean level of 1958 – 1985. The combined contribution of the number of new meteoroids exceeded 50% of all meteors forming the new cloud of particles

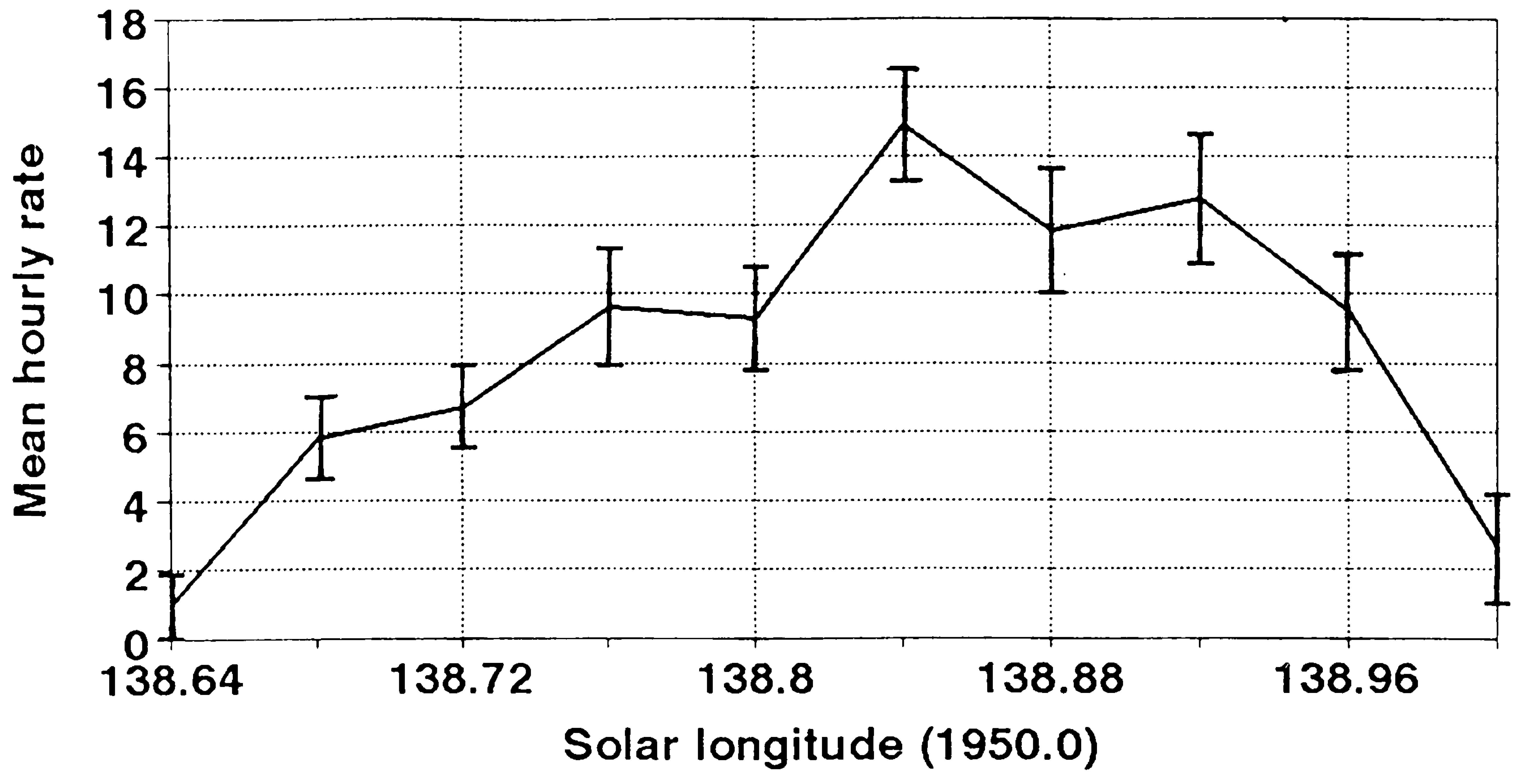

Figure 2. Activity profile of the new filament.

producing echo durations $T \geq 1$ s in 1986–1994 period. Wu & Williams (1993) and Williams & Wu (1994) predicted from the visual observations comprising also fainter meteors the filament activity culmination in 1994. However, this was not confirmed by our observations. A secondary maximum is apparent in 1988–1989. Both peaks could be identified with two independent ejections of meteoroids from comet Swift-Tuttle which is analyzed elsewhere (Pecina & Šimek, 1995). The profile of the new cloud along the Earth's orbit shows maximum activity at $L_\odot = 138^\circ\!.87 \pm 0^\circ\!.04$ (equinox 1950.0) which agrees with the position given by Williams & Wu (1994). The Perseid observations during the next few years will still be of great importance for the analysis of the activity of this new filament in the stream.

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