SERIAL CORRELATION OF METEOR RADAR RATES

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Fluctuations in meteor rates. A fundamental concept in meteor astronomy is the rate of occurrence of meteors (hourly rate). The diurnal and seasonal behaviour of meteor radar rates has been the subject of many studies in the past. In these studies the tacit assumption is made that the observed rate variations are of an astronomical nature. Radar rate changes of an instrumental nature, or rate variations induced by changes in the atmospheric conditions, are generally neglected.

Long-term and short-term meteor rate variations associated with solar activity have been reported (Lindblad 1976, 1978). These rate variations are believed to be caused by a solar controlled variation of the properties of the Earth's atmosphere. Fig. 1 shows the results of an analysis of nighttime radar echo rates recorded at the Onsala Space Observatory in Sweden in 1953-74. An inverse correlation between meteor radar hourly rates and solar cycle activity is evident. In Fig. 2 meteor radar rates for the same observational period are presented in a super-posed epoch analysis with respect to the solar wind sector structure (top curve). The corresponding variation of the geomagnetic C_p index is also shown (lower curve). A dependence of the radar rates and geomagnetic activity on position within the interplanetary sector structure is evident. The phenomenon is ascribed to a geomagnetic heating of the upper atmosphere which produces a variation in the density gradient of the neutral atmosphere at meteor heights.

Persistence of meteor rates. The statistical significance of the day to day variability demonstrated in Fig. 2 is difficult to assess, since meteor rates one day are not independent of the rates on a previous day. The purpose of the present investigation is to make a preliminary study of the persistence of meteor rates. The data samples studied are Onsala radar rates 1953-74 and Christchurch rates 1 February 1960 - - 31 January 1961 and 1 February 1963 - 31 August 1965 (Ellyett and Keay 1963, Keay and Ellyett 1969).

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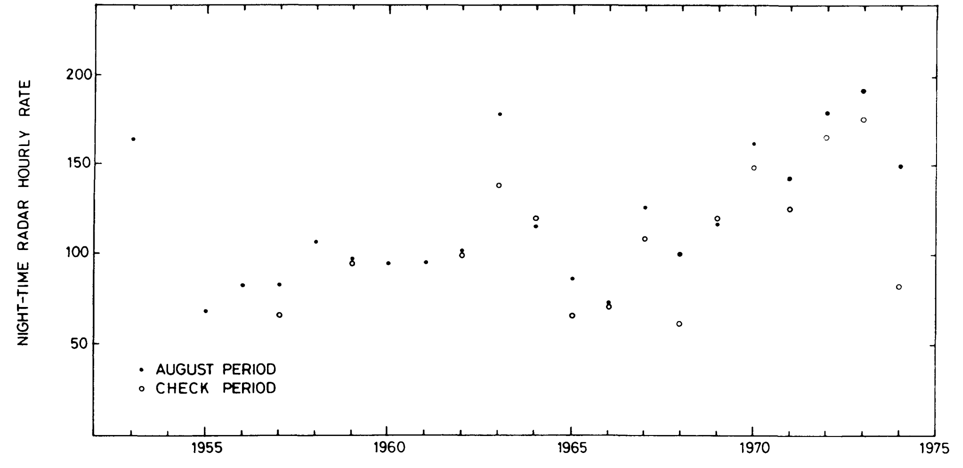

Fig. 1. Long-term variation of Onsala radar rates.

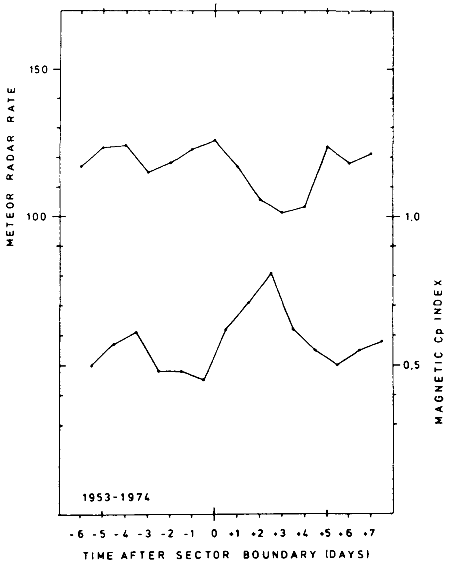

Fig. 2. Short-term variation of Onsala radar rates with respect to interplanetary sector structure.

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The Onsala radar equipment operated at 32.6 MHz and recorded meteor echoes of duration > 0.02 secs corresponding to visual meteors brighter than about fifth zenithal magnitude. The experimental technique has been described elsewhere (Lindblad 1967). The radar recordings are carried out during pre-selected time periods in August and September. The operational schedule consists of a nighttime program 21-03 hrs UT and a daytime program 07-13 hrs UT. In the present study 6-hour averaged meteor rates for a given night or day period are analyzed. The antenna beam is pointed so as to obtain identical observing conditions for the night and day programs for radiants culminating at 06 hrs. Since the Earth´s apex - and also the Perseid radiant - culminates at 06 local time, the diurnal rate curve is similar for the day and night programs. Assuming that most meteor activity comes from the apex direction, a similar statement will apply to southern hemisphere rates recorded near the vernal equinox.

Serial correlation. The length of the time series investigated for serial correlation needs to be carefully considered. If the data sample extends for several months a seasonal trend in the rates will appear. If a short time period is used the reduced sample size will produce statistical fluctuations in the correlation coefficients. It may therefore be necessary to combine data from several years. In this case a solar cycle trend may appear. All trends have to be removed or minimized before the serial correlation coefficients are computed. In the Onsala data the observing periods are of 10-20 days length. The Christchurch radar program was a continuous survey. Intervals of 6-10 weeks length were chosen for the present study. The seasonal effect in both samples is thus negligible. In order to increase sample size it was necessary in analyzing the Onsala data to combine rate data from different years. The period (1959-62) is chosen here as an illustrative example since the Onsala data did not show a marked solar cycle variation during this interval (Fig. 1).

Fig. 3A demonstrates the serial correlation in the Onsala hourly rates for the August data 1959-62. Serial correlation coefficients between 6-hour averaged rates were computed for 0.5 day intervals. Fig. 3A shows that the serial correlation coefficient approaches zero value in about 3 days. Similar results were obtained for other periods. Radar hourly rates on a given night are thus statistically independent of the meteor activity three nights earlier.

The Perseid meteor shower is noticable in radar recordings mainly as an increase in the number of long duration echoes - the influence of shower activity on the total echo rate being small. Rates for all echoes and for echoes of long duration (T > 1 sec) are shown separately in Fig. 3A. As one would expect the long duration echo count rate shows a higher degree of serial correlation than the total echo count rate.

Fig. 3B analyzes Christchurch data for the period 1 February - 14 April. This period was selected since it represents a typical non--shower period. The period was studied for the years 1961, 1963, 1964 and 1965 separately (Fig. 3B). The same (local) time intervals were

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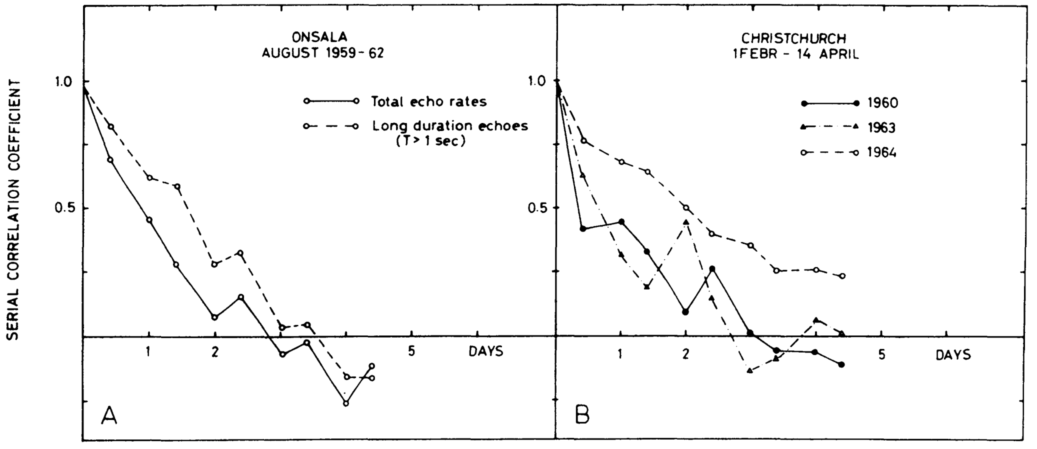

Fig. 3. Serial correlation of meteor radar rates.

selected for computation of the night and day rates as in the previous study. Inspection of the diagram shows that the correlation coefficients for the 1960 and 1963 data approach zero after a time lag of about 3 days. The 1965 curve (not shown) approached zero after a time lag of 2.5 days. The results are similar to those obtained in the Onsala data. The deviating slope of the 1964 curve indicates shower activity. It is interesting to note that Keay and Ellyett (1969) reported unusual meteor activity during March 1964.

Summarizing the above discussion we have for typical non-shower periods found a serial correlation in meteor radar rates. The question arises if this correlation indicates some large-scale structure in the meteoroid influx - such as, for example, unknown minor streams; or if it may be adequately explained by other effects, such as solar wind induced short-term fluctuations in the echo rates (Fig. 2). Further studies are necessary in order to answer this question.

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