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A METHOD OF LONG-TERM RADAR SHOWER DATA ANALYSIS

M. Simek

Astronomical Institute of the Czechoslovak Academy of Sciences
Ondrejov, Czechoslovakia

Long-term radar observations of any meteor shower yield good data for a study of the features of its cross-section structure in detail. The hourly rates of meteor echoes represent usually the basic data from which shower characteristics are derived. Unfortunately, the hourly rate does not depend only on the activity of the shower in question but also on the position of the shower radiant (i.e., its zenith distance), on the mutual radiant-antenna position and, on the parameters of the radar system. We know that the knowledge of the response function of the radar is necessary for good interpretation of the hourly echo counts.

The response function introduced by MCINTOSH (1966) corresponds to the radar sensitivity for different radiant zenith distances. It varies with meteor mass, slightly with the population exponents and with the meteor velocity. In most cases we do not know the response function well enough and, therefore, many authors use, for shower activity analysis, daily rates (or a fraction of a day, say 6, 8, 10 or any other number of hours of observation which repeats every day). Then a knowledge of the response function is irrelevant, but, every day of observation is them represented by only one value on the activity curve. The fine structure of the shower activity is then lost.

The basic idea for using the hourly echo counts without knowing the response of the radar is based on the fact that the same diurnal variation of geometrical observational conditions repeat every day. We are neglecting here the daily motion of the radiant and the four minutes a day difference between siderival and standard time. Let us suppose that the cross-section patterns of the shower do not change drastically from year-to-year except for the activity level. This is the case for the Geminids, Perseids, Quadrantids and other meteor streams.

Previous studies by several authors covered often only one or at best a few years of observation from one station only; these results do not yield a homogenious view an the stream and its structure. Radar observations and their lack of dependency on weather conditions enables complete analysis when satisfactorily long time series of data are available. We must also not forget that the shower radiant will not be above the observer's horizon for the whole 24 hours period, and that the antenna characteristics will permit observations only for some fraction of the day. It is very worthwhile to supplement the data set, using the results of other radars situated on different geographical longitudes.

When dealing with overdense echoes the condition of identical transmitting powers for the radars is not very serious. The wavelength should not be very different, within, say, some 20%, which is satisfied by most meteor radars operating in the wavelength range of 8 - 10m.

Particular difficulties, however, arise when combining the data from radars with different antenna characteristics.

We start the analysis using a preliminary model of the cross-section patterns of the shower. The model is usually just a rough estimation of the behavior of the activity within at least 48 hours of the shower observation. After subtraction of the sporadic background, the data are organized as a series of sets for each individual year. One set of data in a particular year is represented by measured hourly echo shower rates with respective solar longitude for say 8 - 9 hours through all days of shower observation. One set must necessarily contain at least two members. Similarly, we have another set for 9 - 10 hours and so on. In this way the shower rates for every single year are organized. The same equinox must be used. Each set is then normalized to the sum of the model data at the appropriate solar longitudes. We then obtain a new model of the shower pattern. This process is repeated for a sufficient number of times until the last resulting model is identical with the previous one. The convergence usually occurs after 4 to 6 iterations. As a by-product of this method we also obtain the response function of the radar system without a knowledge of its antenna characteristics. The method is described in more detail in SIMEK (1985).

This whole procedure has been applied to the Swedish Perseid observations from 1953 to 1978, and published by LINDBLAD and SIMEK (1985). The data was first divided into two parts: daytime observations and night-time observations (see LINDBLAD and SIMEK, 1983). Results were, in general almost identical. The cross-section patterns for combined day and night observations for echo durations $\geq$ 1s are presented in Fig. 1. The scale is here normalized to 100 at the maximum.

Canadian Perseid observations were carried out in the period 1958 to 1974. The same method was applied and the resulting cross-section patterns for echo durations $\geq$ 1s are presented in Fig. 2. Detailed analysis is presented by SIMEK and MCINTOSH (1986).

The Czechoslovak meteor radar program covered the Perseid activity for 11 years between 1958 and 1984. As with recent Swedish and Canadian data analysis, we concentrated our interest on the $\geq$ 1s echo duration group.

The Swedish, Canadian and Czechoslovak data all show very similar features for the fine mean structure of the Perseid meteor stream activity. When combining all three resulting patterns together, each individual point at a particular solar longitude was averaged using a weight inversely proportional to its standard deviation. The observed shower data base contains some 300000 meteor echoes with durations $\geq$ 1s. The position of peak activity was found at a solar longitude of 139.20° $\pm$ 0.02° (equinox 1950.0). It should be understood that the stream shows slightly different features in the cross-sectional patterns from year to year. Therefore, the histogram in Fig. 3 describes the most probable pattern of the stream along the Earth's path. The peak is less pronounced than for a single year's observation, and is slightly flatter. Note that, because of the 6 hour shift per year in the diurnal cycle, peak activity cannot be observed from one station in those years when it appears around the time of the radiant culmination.

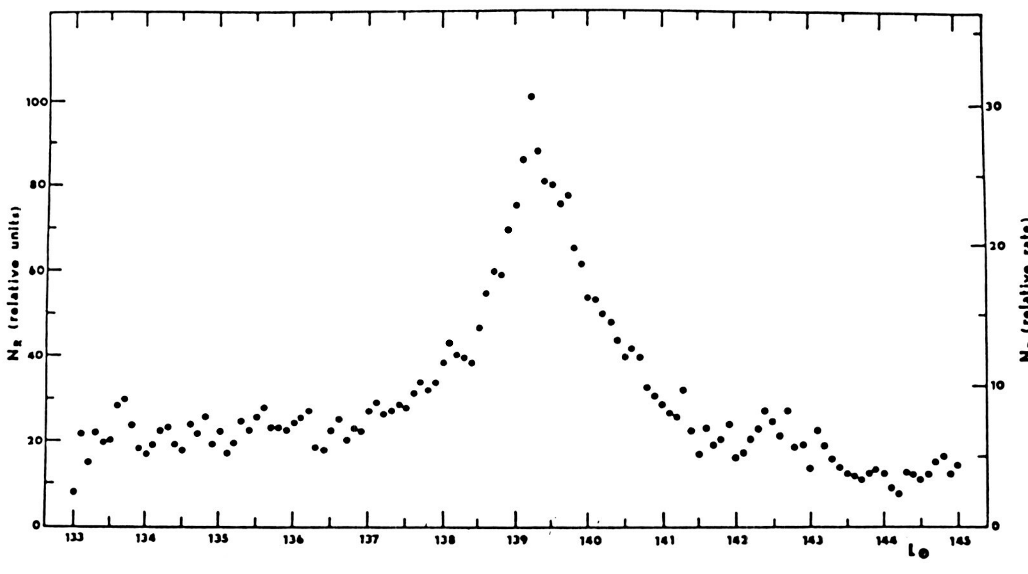

Fig. 1 Relative Perseid meteor flux producing meteor echoes having durations $\geq$ 1s as a function of solar longitude L (epoch 1950.0). Swedish observations.

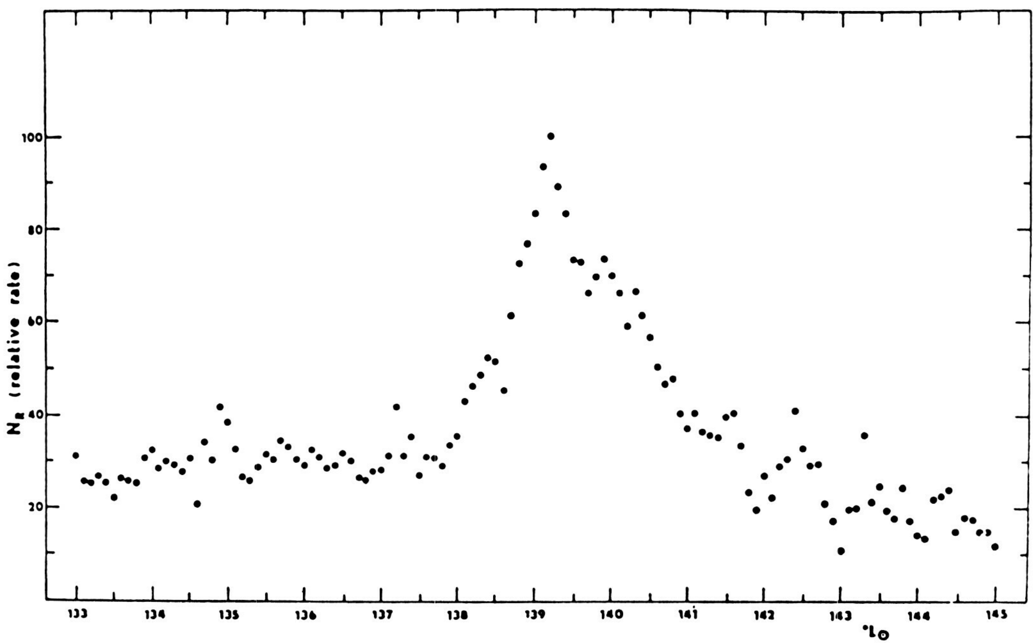

Fig. 2 Relative Perseid meteor flux producing meteor echoes having durations $\geq$ 1s. Canadian observations.

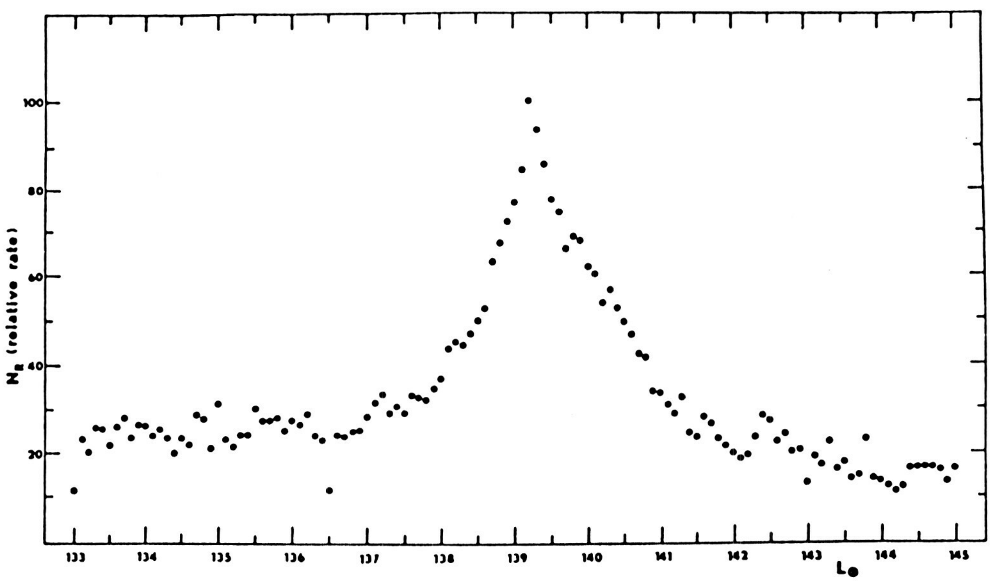

Fig. 3 Relative Perseid meteor flux producing meteor echoes having durations ≥ 1s. Resulting histogram of Swedish, Canadian and Czechoslovak observations.

One would expect that the activity patterns should reach zero level on both wings of the histogram. This is contrary to our result in Fig. 3. Residual shower activity before and after the central part of the histogram result from one sided normalization of the data when negative shower rates were discarded.

In addition to the response function of each radar, the variation of shower activity from year-to-year was determined. Long series of observations of the sporadic meteor complex yield very good data for the analysis of solar activity cycle and its influence on upper atmosphere phenomena.

Final detailed conclusions concerning the complete set of long-term Perseid radar observations from different stations require further analysis, which will be published later. Colleagues who are interested in contributing their own data from Perseid radar observations are invited to participate in this project. We plan to concentrate our interest in the future also on other meteor streams such as the Quadrantids and the Geminids.

References

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