WORST MONTH STATISTICS OF RAIN ATTENUATION AT 35 AND 82GHz

Seiho URATSUKA, Toshio IHARA, Katsumi KITAMURA, Takeshi MANABE, Yuji IMAI and Yoji FURUHAMA

Radio Research Laboratories, Koganei-shi, Tokyo 184, Japan

1. Introduction

For designing communication link using millimeter waves it is quite important to take rain attenuation characteristics into consideration. However, it is not always sufficient to use yearly statistics of rain attenuation for the design because of seasonal variation of rainfall. Therefore we sometimes need more detailed information like worst month statistics. There are many data on worst month statistics about the microwave rain attenuation or rain rate , but few data are on millimeter wave bands.

Millimeter wave propagation experiments on 1.3 km path have been conducted at Radio Research Laboratories (RRL) since April 1979. Data on rain attenuations at 35 and 82 GHz and rain rate have been accumulated for five years (April 1979- March 1984).

In this paper worst month statistics of rain attenuation and rain rate are analysed and discussed. As the results of these analysis it is found that the ratio of worst-month to yearly statistics versus yearly statistics of attenuations is independent of frequency.

2. Worst month statistics

Fig. 1 shows the worst month cumulative distributions of attenuations at 35 and 82 GHz and rain rate along with these yearly distributions, where the worst month percentage means five-year average worst month time percentage defined in Rep.723-1 of CCIR [1]. Let P_{ij} be the time percentage of exeeding a threshold level A_j in the i-th month and the annual worst month percentage for level A_j is the highest P_{ij} among 12 months. The average of five annual worst month percentages is defined as five-year average worst month P_{hj}. Hereafter "worst month percentage" is used for meaning of "five-year average worst month percentage".

Generally, the worst month percentages are a few or several times as large as yearly ones. Here we define Y_j is yearly percentage of rain attenuation or rain rate and Q_j is the ratio of the worst month percentage to Y_j. It is well known that for the rain attenuation and rain rate the relation between the Q_j and Y_j is expressed by follwing equation:

$$Q_j = A\, Y_j^{\,B} \qquad (1)$$

where A and B are constants [2], [3]. The relations obtained from sets of our data are plotted in Fig. 2. Next, for these three data sets, the regression curves in the form of Eq.(1) are obtained by means of least-squares method. These curves show an excellent agreement with each other and are expressed by Eq.(1) with A=1.24 and B=-0.19. If we know the relation of yearly percentages between millimeter wave rain attenuation at any frequency and rain rate, we may derive worst month percentage of millimeter wave rain attenuation from yearly percentage of rain rate.

Semi-empirical models about worst month statistics were given by Crane and Debrunner[4] and Brussaard and Watson[5]. According to these models the relation between Qj and C_0j is shown in Fig. 3 by solid and dotted lines, where C_0j is the average monthly probability of occurance of rain attenuation or rain rate that exceed a given threshold. Our data show a good agreement with the Brussaard and Watson model.

3.Discussion

It is necsesary to know the worst month percentage in order to design millimeter wave communication links, but usually it is difficult to obtain worst month statistics at given frequency beforehand. In RRL many efforts have been made to establish a method for the prediction of rain attenuation statistics from rain rate statistics[6],[7]. Fig. 2 shows that the Yj - Qj relation is independent of frequency. This fact suggests that we may infer the worst month statistics of rain attenuation at any frequency from yearly statistics of rain rate using a proper prediction method of rain attenuation. The 1.3 km path may be shorter than the scale of inhomogeneity of rainfall. The similar results are expected even along the longer path where the uniformity of rain fall can not be assumed, but the further studies should be conducted.

References

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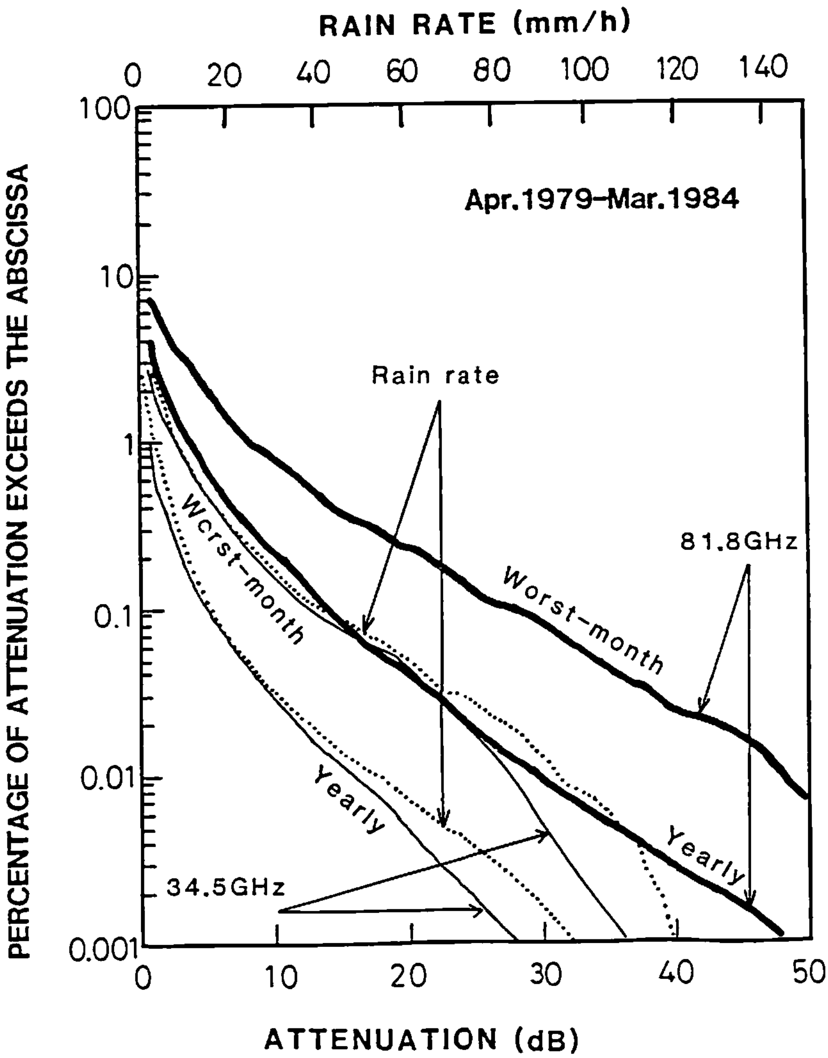

Figure 1 Worst month and yearly distributions of rain attenuation at 35 and 82 GHz and rain rate.

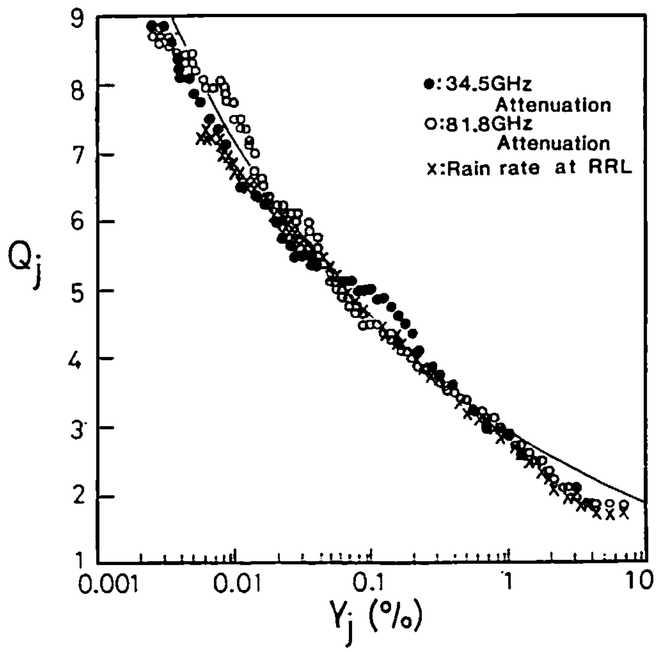

Figure 2 Ratio of worst month to yearly statistics Q_j as a function of the yearly percentage Y_j.

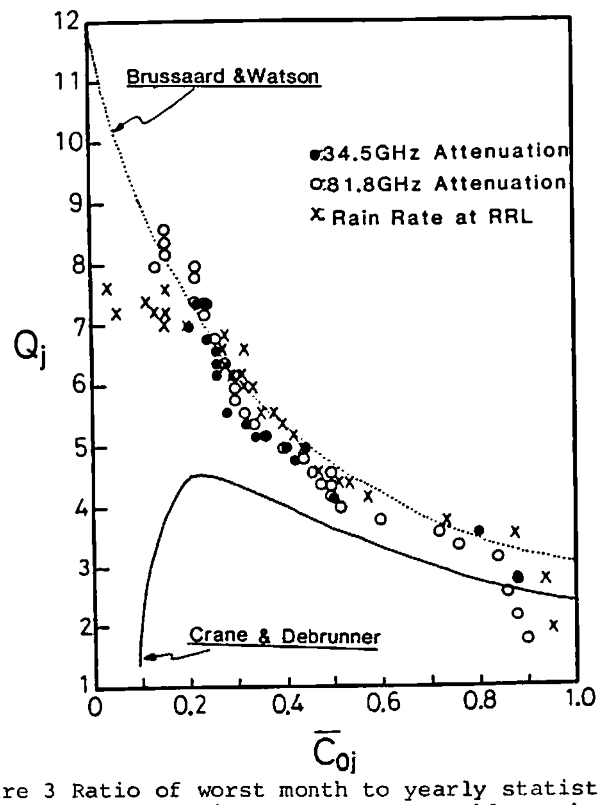

Figure 3 Ratio of worst month to yearly statistics Q_j as a function of average monthly probability of exceeding a given threshold C_{0j}.