Study on Rainfall Characteristics for the Millimeter-wave Communication Systems - Comparisons of Rainfall rate data from Several observation methods.

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Abstract

Rainfall characteristics for designing the optimum millimeter-wave communication systems from two rainfall data set was analyzed. Two rainfall data sets were compared; one-minute rainfall rate data, one-hour synoptic observation data. Each data set has different observation method, sampling frequency. We looked for tendency and quality confidence between two data sets. We showed several results using one-minute rainfall data by millimeter-wave attenuation model. A climatological one-minute rainfall rate data set over Korean Peninsula will be made after data quality control procedure

1. Introduction

During the rate 1960s and especially in the mid-1970s, attention was focused on microwave communications on the problem of saturation of frequency bands, and it was found necessary to use higher frequencies (Moupfouma, 1987). Recently high frequency-wave more than 10GHz are widely used for satellite communication. It is well known that the basic consideration for wave attenuation is rainfall intensity (Oguchi, 1983). It is required that sampling frequency for rainfall should be smaller than 1 minute. In Korea modern meteorological observation was set on since 1904. There are 28 stations have more than 30 year-long hourly rainfall record data. But 10-minute interval record or more shorter interval data was recorded on 20 stations since 1981. The only available one-minute interval rainfall record is one-minute rainfall rate data stored on analogue record paper. Recently Meteorological Research Institute (METRI) has been digitized and archived the pre-record analogue records. In this study we analyzed this rainfall rate data and compared with one-hour synoptic observation rain data.

2. Data and Methods

One-minute interval rainfall rate data extracted from analogue records and one-hour interval rainfall data from the climate database system of Korea Meteorological Administration (KMA) was used. Each data has different measurement method. One-minute interval rainfall rate gauge records the rainfall rate value by converting the numbers of raindrops into rainfall rate. Otherwise one-hour synoptic observation is measured the rainfall amount by mass cylinder. Of course these two data should be coincident with each other in quantity if it measured the same station and same time. But most of the data are not. We assume that one-hour synoptic data as no systematic observation bias. We construct one-hour accumulation rainfall data, we call it data A from now on in this paper, in order to compare with that of one-hour synoptic observation data , we call it data B from now on in this paper.

The Moupfouma distribution describes well the rainfall rate cumulative distribution for the design of satellite and terrestrial communication system (Moupfouma and Martin, 1995). We compared the one-minute interval rainfall rate data with Moupfouma distribution. To utilize the one-minute interval rainfall data, we showed some results of millimeter wave attenuation model for designing the optimum millimeter-wave communication systems. Several models for estimation of the cumulative attenuation statistics on earth-space paths have been developed.

3. Results and Discussions

Although the two data set show same trend, 98% of the data A is greater than that of data B on the samples. It means that the one-minute rainfall rate gauge always overestimate the rainfall amount. We need to correct the data A and data B. For our sample data case, we set simple linear relation between data A and data B. We assume that the data B is credible because one-hour interval synoptic observation simply measure the accumulated amount of rainfall during one hour. So it is simply described between data A and B as

$$B = 0.62*A - 0.04.$$

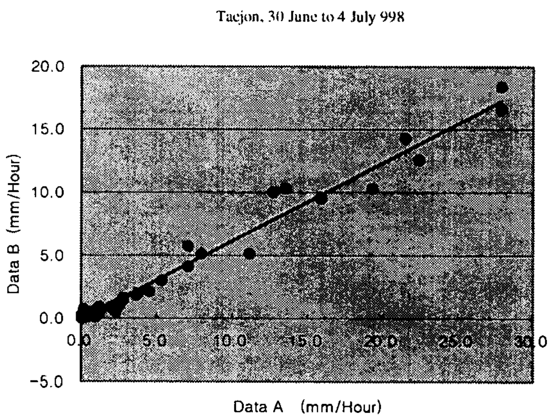

Fig. 1. Data relation between data A(accumulated one-minute rainfall rate) and data B(one-hour synpotic observation data).

We looked for the distribution of one-minute rainfall rate cumulative distribution on sample case. We choose the sample on Taejon and Chongju station located in the middle part of South Korea. In this case the data is too small to show the Moupfouma distribution.

We also looked for the result of millimeter wave attenuation model using data A. The examined result for one-minute rainfall rate data from 12 weather stations over Korea is partly acceptable for input of millimeter wave attenuation model (ITU, 1997; Crane, 1980; Stutzman and Dishman, 1982). In order to estimate attenuation values due to rain in Korean site, annual distributions of rainfall rate for 25 local sites were developed using long-term period measurement data(ETRI, 1998). Fig. 2 Shows an example of the rainfall rate distribution at Taejon City.

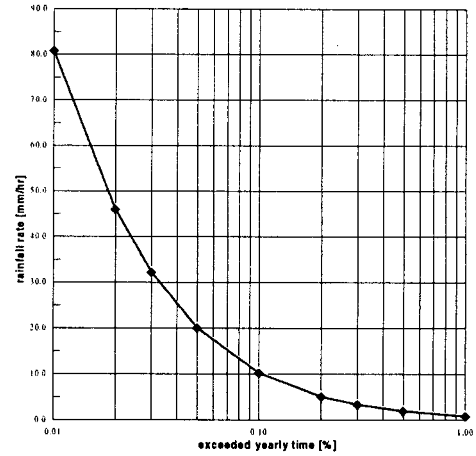

Fig. 2. Annual rainfall rate distribution at Taejon, Korea.

Based on the above rainfall rate distribution and attenuation models, the characteristic of the rain attenuation can be estimated for the Ku-band(12, 14 GHz), Ka-band(20, 30 GHz), and millimeter wave band(40 GHz) frequencies, respectively. In this estimation, Taejon to satellite path, which has 45° elevation angle and transmits vertical signal, was assumed.

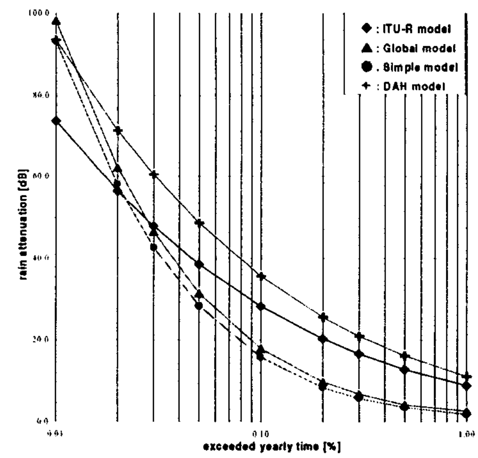

Fig. 3. Rain attenuation distribution (40 GHz)

We have another data set for one-minute interval rainfall record from AWS(Automatic Weather System) operated by KMA. We will compare this data with data A. We also utilize the millimeter wave attenuation model. The typical pattern of one-minute rainfall rate statistics should be constructed using this data. For the safe satellite system design, it is very important that which model is selected to the local rain condition appropriately, finally new prediction model which is most appropriate to the Korean rain condition based on the long-term attenuation measurements, should be developed.

4. Acknowledgement

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5. References

Crane, R. K, 1980, Prediction of attenuation by rain, *IEEE Transactions on Communications*, Vol. COM-28, No. 9, 1717 ~ 1733.

ETRI, 1998, A study on the rain effects on a satellite link, Annual Report(Koran), No. 8MS1100-01-2200P, 80pp.

ITU-R, 1997, Propagation data and prediction methods required for the design of earth-space telecommunications systems, *Recommendation ITU-R P. 618-5.*

Moupfouma, F. and L. Martin, 1995, Modeling of the rainfall rate cumulative distribution for the design of satellite and terrestrial communication systems, International J. of Satellite Communications, Vol. , 105-115.

Moupfouma, F., 1987, More about rainfall rates and their prediction for radio systems engineering, IEE proceedings, Vol. 134, No. 6, 527-537.

Oguchi, T., 1983, Electromagnetic wave propagation and scattering in rain and other hydrometeors, IEE proceedings, Vol. 71, No. 9, 1029-1078.

Stutzman, W. L. and W. K. Dishman, 1982, A simple model for the estimation of rain-induced attenuation along earth-space paths at millimeter wavelengths," *Radio Science*, Vol.17, No.6, 1465 ~ 1476.