A PROPERTY OF D/U EXAMINED BY USING THE DATA OBTAINED IN A RAIN SCATTER EXPERIMENT AT 14.3 GHz

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1. Introduction

The scattered wave from rain is one of the possible cause of interference between communication links operating at the same frequency. The scattered wave from rain is regarded as the undesired wave in the interference problem. The degree of interference depends on both the strength of the undesired wave and that of the desired wave.
A useful quantity for the assessment of the degree of rain scatter interference is the "desired-to-undesired power ratio" (D/U).

In conventional analyses of the rain scatter interference problem, the strength of the desired wave is assumed to be constant. However, at high frequencies, i.e. above about 10 GHz, the strength of the desired wave is no longer constant because of the rain attenuation.

This paper shows a statistical property of D/U in the case of the desired wave as well as the undesired wave being affected by rain attenuation. The statistical analysis of D/U was made by using the data which were obtained in a rain scatter experiment at 14.3 GHz [1].

2. Definition of D/U

Let us consider a typical interference situation illustrated in Fig.1. In this situation, the undesired power, U, is the received power of the rain scattered wave, P_r. The desired power, D, is the received power of the down-link satellite signal. The definition of D/U is as follows:

$$D/U = D - P_r \tag{1}$$

Since the desired power D includes the down-link rain attenuation, A_D, Eq.(1) becomes

$$D/U = (D_o - A_D) - P_r = D_o - (P_r + A_D) \tag{2}$$

where D_o is the desired power in the absence of rain attenuation. Eq.(2) states that the rain attenuation of the desired wave is incorporated into D/U in such a way that the undesired power P_r increases effectively to $P_r + A_D$.

Since D_o is constant in (2), statistical properties of D/U are represented by those of $P_r + A_D$. Hence, in the subsequent section, the statistical analysis is made on $P_r + A_D$.

3. Experimental result

Outline of the 14.3 GHz rain scatter experiment is illustrated in Fig.2. The 14.3 GHz wave was transmitted from a 13-m antenna at

Kashima toward a Japanese geostationary satellite BSE (medium scale Broadcasting Satellite for Experimental purposes). The wave scattered by rain at 2 km height was received by a 1.6-m antenna at Inubo. A beacon signal at 11.7 GHz from BSE was received by the 13-m antenna at Kashima. Some parameters of the experiment are listed in Table 1.

In the data analysis, the following assumptions were made to obtain the cumulative distribution of $P_r + A_D$ at 14.3 GHz for the interference situation illustrated in Fig.1.

1) With the aid of the reciprocity theorem, the received power at Inubo is interpreted as the undesired power P_r at Kashima on the reciprocal path with the interfering station being imagined to be installed at Inubo.
2) The rain attenuation of the down-link wave, A_D, at 14.3 GHz can be estimated from the rain attenuation of the beacon signal at 11.7 GHz by using the following frequency scaling law:

$$A_D[14.3\ \text{GHz}] = b \times A_D[11.7\ \text{GHz}] \qquad (3)$$

where b is a constant depending on rain types. The constant was determined experimentally by comparing the up-link attenuation at 14.3 GHz and the down-link attenuation at 11.7 GHz, and it was found to take the value of $1.6 \sim 1.65$ [2]. This paper assumes that b = 1.6.

The cumulative distribution of $P_r + A_D$ obtained with the above assumptions is shown by the solid curve in Fig.3. In the figure, the cumulative distribution of P_r alone is also shown (dashed curve). Fig.3 shows that the effective undesired power, $P_r + A_D$, is larger than P_r at any percentage of time. The difference between $P_r + A_D$ and P_r becomes large when the percentage of time becomes small.

In conventional analyses of the rain scatter interference problem, the degree of interference is assessed by the cumulative distribution of P_r. However, the use of the cumulative distribution of P_r for the assessment of rain scatter interference at higher frequencies underestimates the degree of interference because of the negligence of rain attenuation of the desired wave. At higher frequencies, the assessment of rain scatter interference should be made on the basis of $P_r + A_D$.

4. Concluding remarks

It is emphasized that the statistical data of D/U (or effective undesired power, $P_r + A_D$) are necessary for the conservative assessment of the degree of rain scatter interference. Developement of the estimation method for statistics of D/U (or $P_r + A_D$) is strongly required.

REFERENCES

1) Awaka, J., Kozu, T., Nakamura, K., and Inomata, H.; "Experimental results on bistatic rain scattering at 14.3 GHz," IEEE Trans. Ant. Prop., AP-32, 12, pp.1345-1350, 1984.
2) Kozu, T., Nakamura, K., Awaka, J., and Takeuchi, M.; "14 GHz FM-CW radar for observation of precipitation," Trans. IECE, J66-B, 11, pp.1394-1401, 1983 (in Japanese).

TABLE 1 Parameters of experiment

Rain Scatter experiment			
Transmitting site	Kashima	Scattering path length	35.6 km
Frequency	14.3 GHz	Scattering height	2 km
Transmitting power	100 W	Scattering angle	85.5°
Transmitting antenna		**Propagation experiment using beacon signal of BSE**	
Diameter	13 m	Frequency	11.7 GHz
Gain	63.1 dB	Location of earth station	Kashima
Beam width	0.1°	Antenna of earth station	
Polarization	Vertical	Diameter	13 m
Receiving site	Inubo	Gain	61.2 dB
Minimum detectable level of the receiver	-100 dBm	Beam width	0.12°
Receiving antenna		Polarization	Vertical
Diameter	1.6 m		
Gain	45.9 dB		
Beam width	0.9°		
Polarization	Vertical		

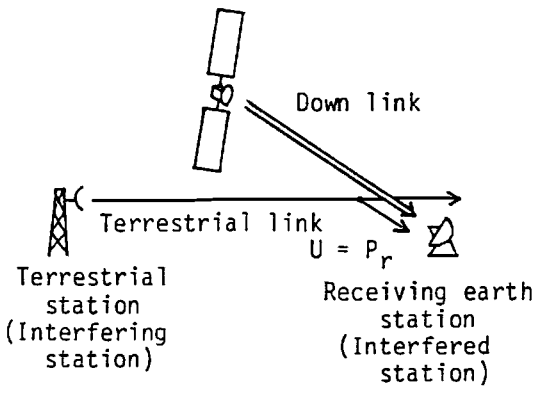

Fig.1 A typical interference situation due to rain scattering

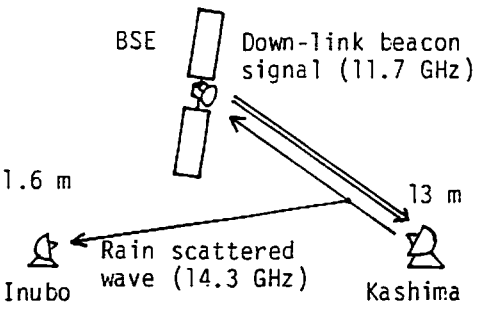

Fig.2 Outline of the rain scatter experiment at 14.3 GHz

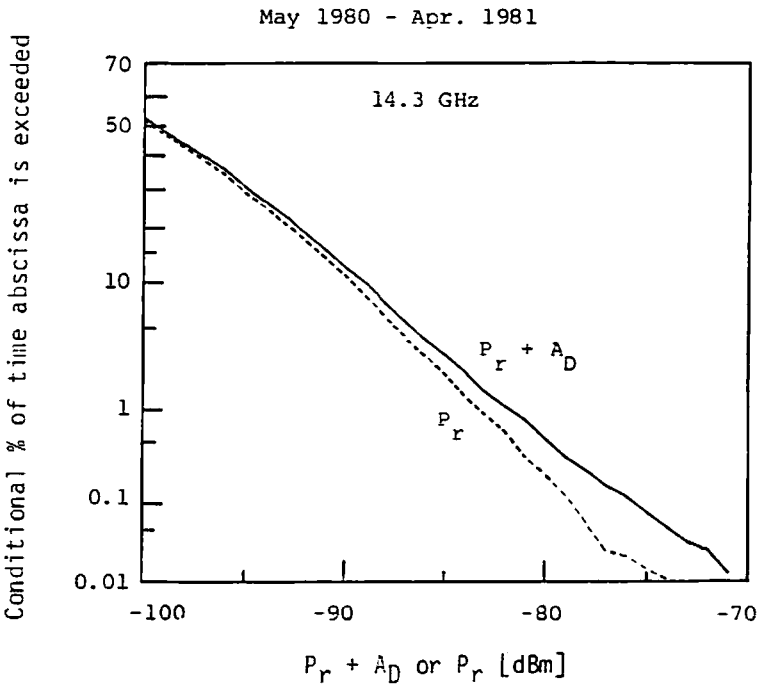

Fig.3 Cumulative distribution of $P_r + A_D$ and that of P_r.

The ordinate shows the conditional percentage of time: the total conditional time which includes all the rainy time is assumed to be 10 % of the total observation time.