Analysis of directional dependence of site diversity gain using rain radar data

Yushi Inose1, Hajime Fukuchi1

1Department of Aerospace Engineering, Tokyo Metropolitan University, 6-6 Asahigaoka, Hino-shi, Tokyo, Japan

In order to estimate the site diversity effect more accurately, we analyzed directional dependence of the site diversity using rain radar data measured in Japan. The expression of site diversity gain written in ITU-R P.618 says that diversity gain depends on the direction. However, we found that directional dependence cannot always be seen.

Index Terms — Site diversity, rain attenuation, Diversity gain.

1. Introduction

In the case of the satellite communication using high frequency band, rain attenuation is a big problem. Site diversity is one of the countermeasures against rain attenuation. Site diversity gain can be calculated by the expression in Recommendation ITU-R P.618. This expression says that diversity gain depends on the angle made by the azimuth of the propagation path with respect to the baseline between sites. We analyze directional dependence of site diversity by calculating rainfall intensity cumulative distribution using rain radar data.

2. Used data

In this research, we used rainfall data measured by radar. These data are mesh data whose size is 128km×128km (256 points × 256 points). It includes 65536 points data in one scene. Specifications of these data are shown in Table I

TABLE I Specification of radar rain data

Specification of radar rain data			
Place	Kanto region	Kyushu region	
Latitude of the center point [°]	35.71	32	
Longitude of the center point [°]	139.882	131	
Time interval	5 minutes		
Duration	4 years (July 2009-June 2013)		
Mesh interval	0.5km×0.5km(resampled)		

3. Analysis

We chose the location of the main station and substation as shown in Fig.1 and define them as S_m , S_1 , and S_2 . We extracted rainfall intensity within 5km toward a satellite direction from each stations. Moreover, we summed up each data and defined as ΣR_m , ΣR_1 and ΣR_2 . From these data, rainfall intensity cumulative distribution can be calculated. In the case of applying site diversity between S_m and S_1 , S_2 , we also calculate rainfall intensity cumulative distribution. By comparing the data before and after the application of site diversity, we calculated site diversity effect.

In this paper, θ is defined as angle made by the azimuth of the propagation path with respect to the baseline between ground stations. In the case of S_m and S₁, θ is 0°. In the case of S_m and S₂, θ is 90°. We analyzed directional dependence of site diversity using the data of two patterns. Changing the location of main station, we analyzed 5 cases shown in Fig.2.



Fig.1. Arrangement of ground stations



Fig.2. Locations of main station

4. Results

Rainfall intensity cumulative distributions of case A and D in Kanto region are shown in Fig.3 and Fig.4.



cumulative distribution of case D in Kanto

From these results, we found that there are little difference when the time percentage is more than 0.01%. Results site diversity applied are shown in Fig.5 and Fig.6.



Fig.6. Case D after site diversity

Fig.5 shows that rainfall intensity of diversity 0° is bigger than of diversity 90° . Therefore, diversity 90° is better than diversity 0° . This dependence is similar to ITU-R P.618. On the other hand, Fig.6 shows that there is little difference between diversity 0° and diversity 90° .

When the time percentage is 0.01%, we take the difference of rainfall intensity between diversity and non-diversity. Results are shown in TABLE II.

 TABLE II

 Difference of rainfall intensity at 0.01% in Kanto

case	Difference between diversity	Difference between diversity	
	0° and non-diversity [mm/h]	90° and non-diversity [mm/h]	
А	157	237	
В	195	227	
С	207	280	
D	257	255	
Е	177	177	

In the case A, B and C, we found that diversity 0° is better than diversity 90° . Thus, there is directional dependence. In the case of D and E, there is no directional dependence.

5. Conclusion

In this research, we can analyze directional dependence of site diversity in more detail using radar rain data.

There is directional dependence in case A, B and C. It is a similar tendency with the ITU-R expression. However, it cannot be seen in case D and E. Thus, we found that directional dependence of site diversity is not always seen in Japan.

In the next research, we will analysis other area data and other directions.

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