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Effects of snowfall on wave propagation along a 7.7 km 18/26 GHz FWA link

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1. Introduction

It is expected that Wideband Inter-Networking engineering test and Demonstrate Satellite (WINDS) [1], to be launched in 2008, will pave the way to solve a present day digital divide problem [2]. To make the WINDS experiment successful, a 3-year project entitled ‘mitigation of digital divide via fusion of satellite and terrestrial networks’, was started in 2005; several institutions and universities are being participated in this project. As a member of this project, Hokkaido Tokai University (HTU) has been making a propagation experiment using Fixed Wireless Access (FWA) systems in 18 and 26 GHz bands; these frequencies are very close to those to be used by WINDS transponders.

In Sapporo, where HTU locates, we have a large amount of snowfall in winter. Therefore, we put an emphasis of our experiment on clarifying propagation characteristics of cm waves in snowfall, which are not well understood because propagation characteristics in snowfall depend on a large number of parameters such as frequency, drop-size distribution, fall speed, shape, density, water content, temperature, and so on (see e.g. [3]).

This paper presents a preliminary result of propagation experiment made along a 7.7 km terrestrial path using frequencies in 18 and 26 GHz bands.

2. Experimental System

Figure 1 shows the outline of the experimental system. Two sets of FWA systems, operating at about 18 and about 26 GHz, are installed side by side on the rooftop of Hokkaido Tokai university (HTU) and on a platform of the rooftop tower of NTT Docomo building in Tsukisamu, Sapporo. Each FWA system is equipped with both transmitting and receiving capabilities at either sites, which means that the propagation data on the path from HTU to NTT Docomo building and on its reciprocal path are both obtained for each 18 GHz band and 26 GHz band. Bit Error Rates (BER) are also measured by the FWA systems. However, no deterioration of BER is recorded so far during the propagation experiment, because the FWA systems are operated with a very large rain margin in both frequency bands.

For precise measurement of precipitation, a low-profile 2D-Video-Distrometer (2DVD) [4] , manufactured by Joanneum Research, is installed at HTU; the 2DVD system started its measurement on November 2006.

Table 1 summarizes the main characteristics of the experimental system. Horizontal polarization is used for both 18 GHz and 26 GHz systems. The length of propagation path is 7.7 km.

Figure 2 shows the propagation path profile, which indicates that sufficient clearance is realized at 18 GHz, because there does not exist any obstacle inside the first Fresnel zone at 18 GHz. The same thing can be said at 26 GHz because the size of the first Fresnel zone at 26 GHz is smaller than that at 18 GHz (not illustrated in the figure).

3. Experimental Results

Figure 3 shows a set of event data measured on 6-7 January 2007, when there fell substantial wet snow. Fig. 3(a) shows the precipitation induced attenuation (ATT) of the wave in 18 GHz band measured

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at HTU, and Fig. 3(b) the ATT in 26 GHz band at HTU. Because of wet snow, a large ATT was observed in both frequency bands. Fig. 3(c) shows the temperature at Sapporo District Meteorological Observatory of Japan Meteorological Agency (JMA), which is located about 7 km north of HTU. (Temperature data at HTU for this event is not available, because the temperature measurement at HTU just started on 17 January 2007.) Figs. 3(d) and 3(e) show precipitation at NTT Docomo and that at HTU, respectively.

Figure 4 shows another set of event data measured on 24-25 January 2007, when there fell dry snow. Figs. 4(a) and 4(b) clearly show that dry snowfall hardly attenuates cm waves. Fig.3(c) shows that the both temperatures at HTU (thick line) and at JMA (thin line) were definitely below 0°C when there were precipitation as shown in Figs. 4(d) and 4(e), which indicate we had dry snow. The temperature at HTU shown in Fig. 4(c) is generally higher than that at JMA because of the difference in elevation: HTU locates on a hill but JMA on a low flat area of the Ishikari Plain.

Figure 5 shows a relation between 26 GHz ATT and 18 GHz ATT, which is obtained by plotting the same percentage values of ATT in the cumulative distribution of monthly ATT for each frequency. In the figure, values at 0.01, 0.003, 0.001, and 0.0001 % are plotted. Let us call the ratio (26 GHz ATT)/(18 GHz ATT) as a frequency scale factor, FSF. Most of FSFs are clustered in the similar domain except for the FSF of October 2006 and that of January 2007. It can be shown that the FSF of January 2007 is dominated by snow, that of October 2006 by a heavy thunder storm, and the rest by rain. This fact implies that a large attenuation by the thunder storm may be due to melting ice particles, possibly due to melting graupel and/or melting hail.

Figure 6 shows the fall velocity of snowflake versus its diameter measured by the 2DVD on 25 January 2007. Figure 6 indicates that fall velocity of snowflake is much smaller than that of raindrop reported by Gunn and Kinzer [5].

4. Concluding Remark

We here show a preliminary result only, but are planning to make detailed studies, for example, by using an appropriate bright band model [6].

Acknowledgment

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Table 1 Main characteristics of experimental system

	18 GHz FWA	26 GHz FWA
Frequency	18.44 GHz (*1) 19.69 GHz (*2)	25.256 GHz (*1) 26.264 GHz (*2)
Path length	7.6 km	7.6 km
TX power	20 dBm	20 dBm
Modulation	4 PSK	4 PSK
Band width	18 MHz	25 MHz
Antenna diameter	60 cm	60 cm
Antenna Gain	38.5 dBi	41 dBi
Polarization	Horizontal	Horizontal
Fine day RX level	about -36 dBm	about -37 dBm
Noise level	about -90 dBm	about -90 dBm

*1 TX: NTT Docomo, RX: Hokkaido Tokai Univ.
*2 TX: Hokkaido Tokai Univ., RX: NTT Docomo

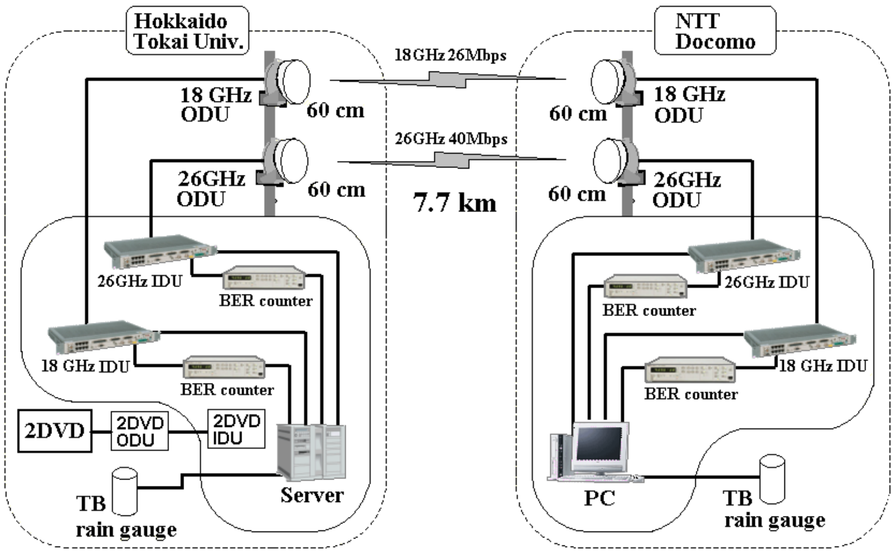

Figure 1: Outline of experimental system

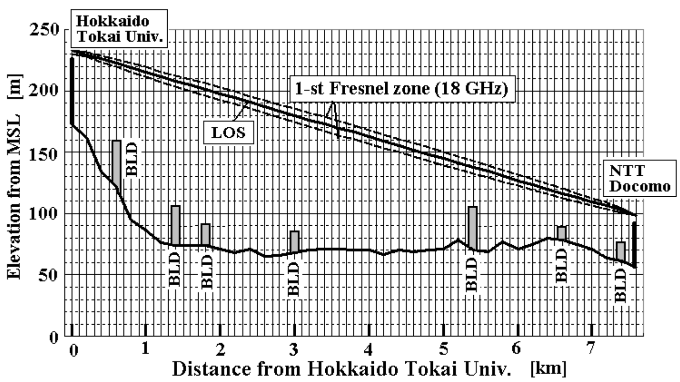

Figure 2: Profile of propagation path

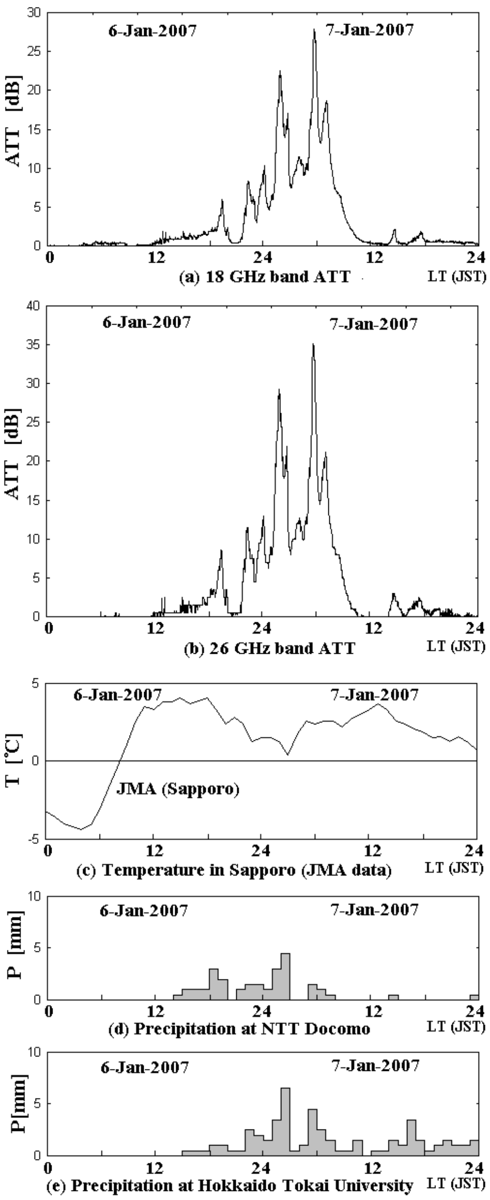

Figure 3: Event data on 6-7 Jan. 2007

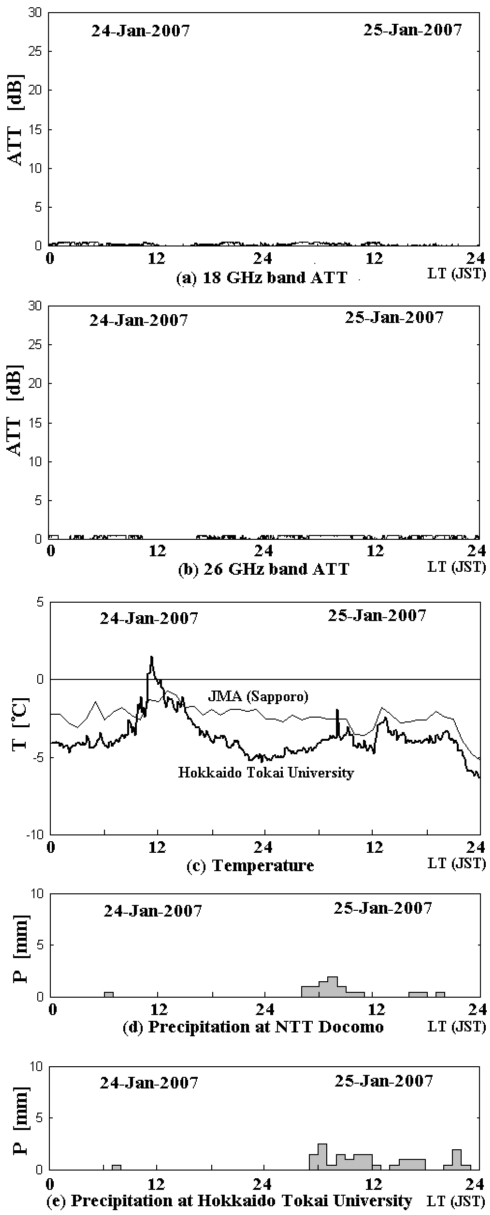

Figure 4: Event data on 24-25 Jan. 2007

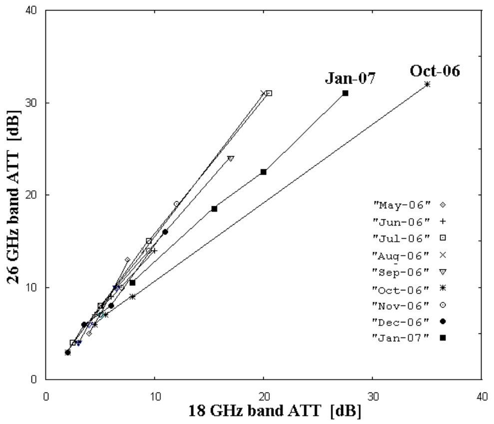

Figure 5: 26 GHz ATT vs 18 GHz Att obtained from cumulative distribution for each month

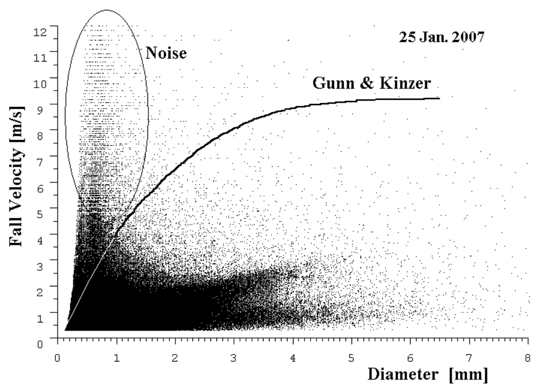

Figure 6: 2DVD data on 25 Jan. 2007