THE MICROWAVE PROPAGATION IN ATMOSPHERIC TURBULENCE WITH SNOWFALL

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1.Introduction

In the microwave propagation, when some attenuation of the field intensity produced by atmospheric turbulence, snowfall often causes the restration of the field intensity immediately. this restration lasts during snowfall, and when it is snow over, as soon as the field intensity return to the former condition.

This phenomena had discovered by author in 1959, as to 11-GHz TV-link system at Hakodate where is situated on the south end of Hokkaido. While the periods of the phenomena were occured, the weather is clear with occasional snowfall. The restrations of the field intensity evaluated as level ups of 1-2.5dB. At present, the phenomena founds not only at the ground microwave propagation but also at satellite microwave propagation.

The physical and mathematical analysis of the phenomena tried by author in 1988-1989. This paper presents the examples of transitions in field intensity and a result of an mathematical analysis of the phenomena.

2.The Microwave Propagation in Atmospheric Turbulence with Snowfall

Fig.2.1 and Fig.2.2 shows the topography and the profile from Mt. Niyama to Mt. Hakodate. The propagation path through above hilly districts(A-zone), plain(B-zone) and sea(C-zone) as shown in the figures.

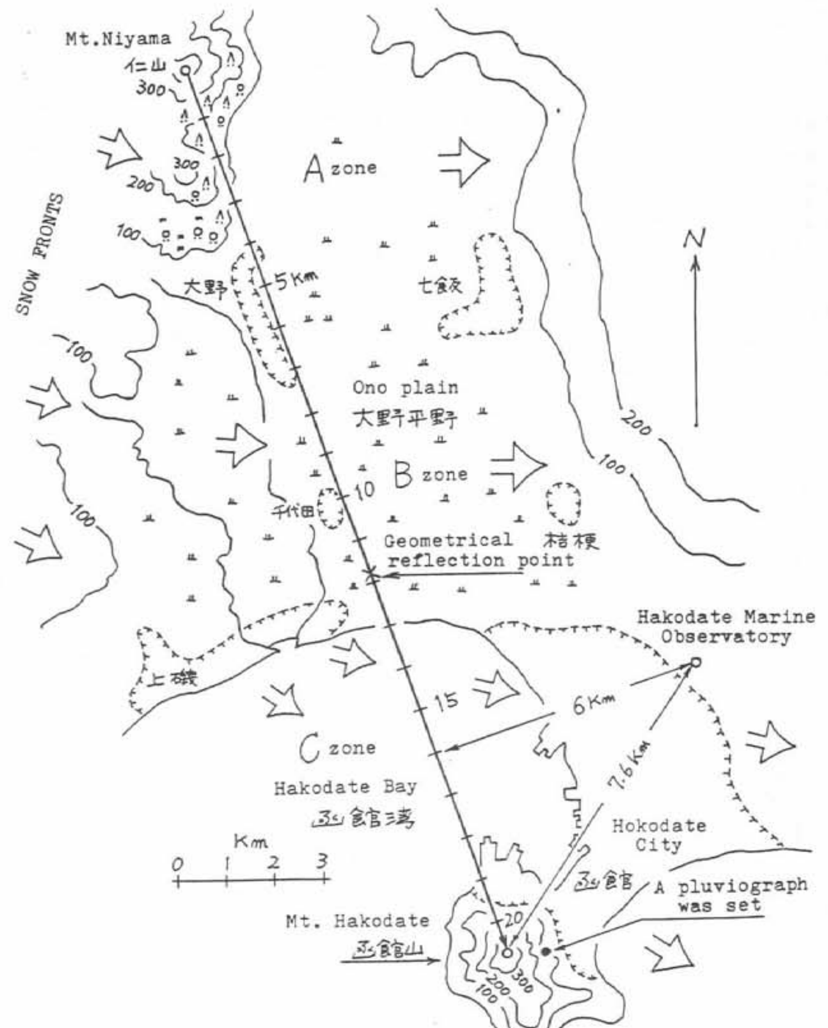

Fig.2.1 The Topography of Hakodate Districts.

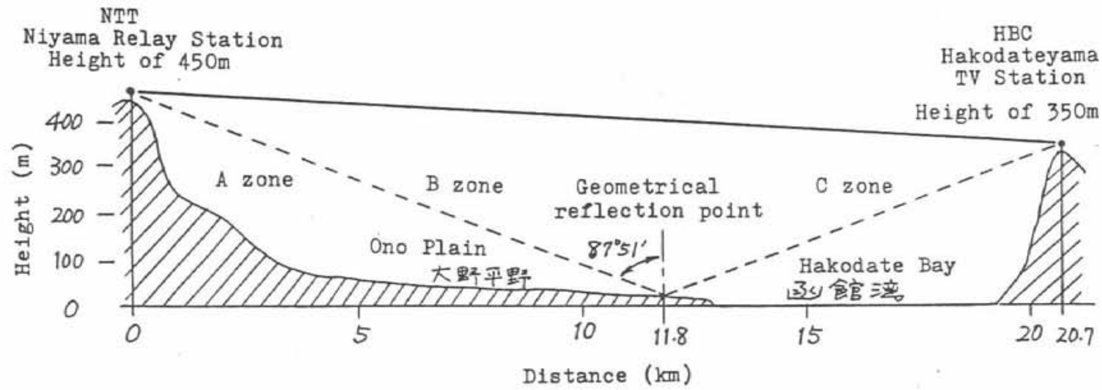

Fig.2.2 The Profile from Mt. Niyama to Mt. Hakodate.

The restrations of field intensity occured by snowfall at A-zone and sometimes at C-zone. Atmospheric turbulence is active above these zones, attenuation of 2-3dB produced by them.
When it was cloudy, or at night, atmospheric turbulence not always active to produce the attenuation, therefore the restration did not occur.
Fig.2.3 and Fig.2.4 shows the examples of the field intensity transitions. The restrations occured by snowfall at mainly A-zone with levels up of about 2.5dB.
In fig.2.3, increasing of snowfall and snowing area produces larger restrations than they were not so.
An individual snowing area is called a cell. It moves from the west to the east independent of the other. There were noteworthy effects found in the transitions of field intensity at the begin and the end when a cell crossing to the propagation path.
Fig.2.5 gives another example that found in the propagation of 12GHz wave from Japanese broadcasting satellite that called BS-2b.
Both of three examples have a common ground in which restration of field intensity just synchronizing with snowfall.

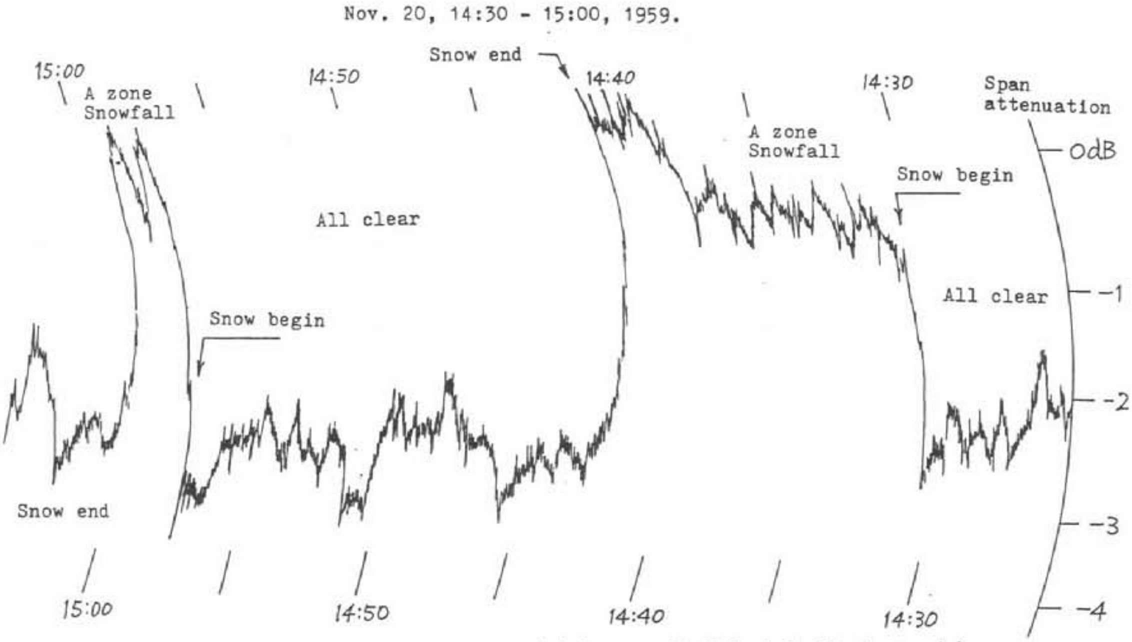

Fig.2.3 The Transition of Field Intensity.

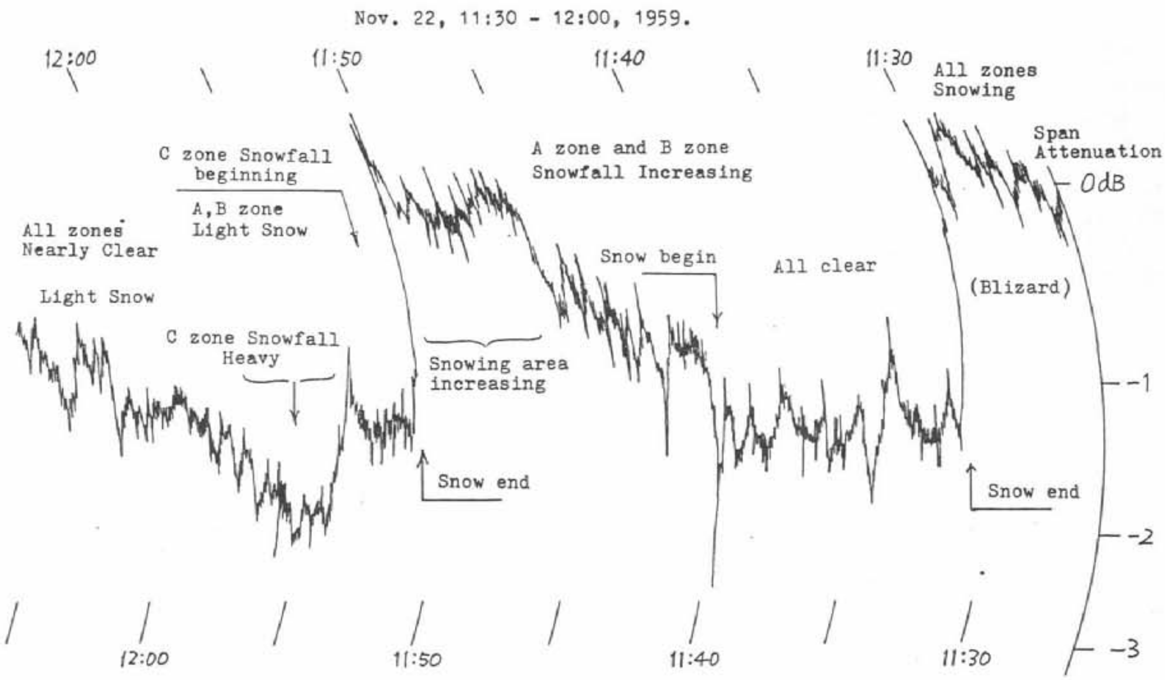

Fig.2.4 The Transition of Field Intensity.

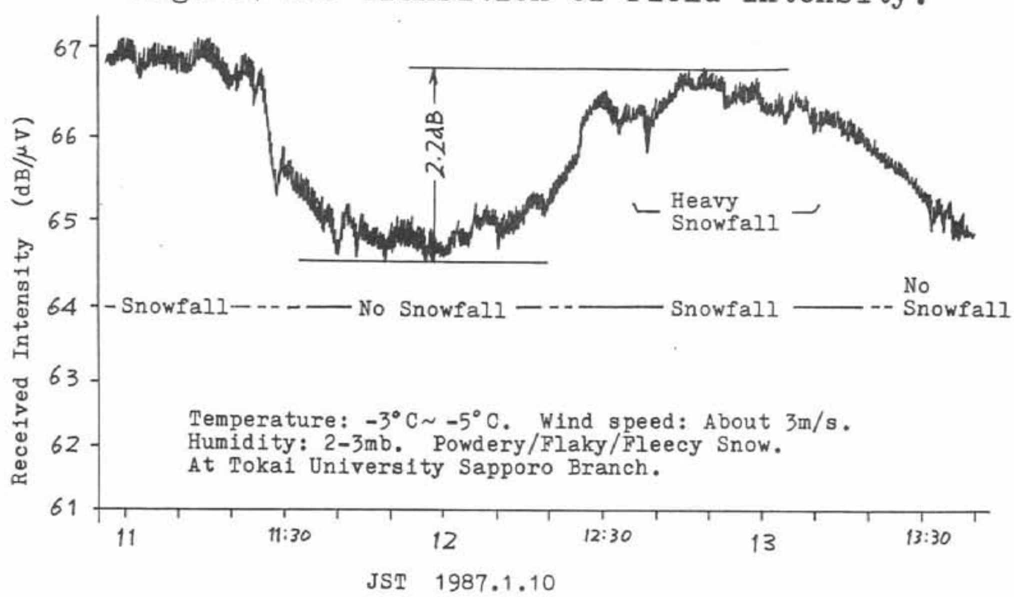

Fig.2.5 The Transition of Field Intensity of 12GHz Broadcasting Satellite Wave.

3.The Physical and Mathematical Analysis

The restrations had occured in the conditions as below: The atmospheric pressure is high. When no snowfall, the sky clears up. The temperature keeps below freezing point. Snow-particles are flaky or fleecy. The wind speed is about 3m/s.

According to above conditions, author proposes the physical explanation as follows:

The atmospheric turbulence causes the attenuation of the receiving intensity by the multipath propagation. When snow-fall, mass of snow-particles disturbs the conditions of multipath propagation instantly. But the ammount of attenuation by snow is smaller than the decrease of field intensity according to atmospheric turbulence.

Therefore, it looks like the field intensity nearly restores to the conditions of no atmospheric turbulence.

And, this paper presents a result of mathematical analysis. Let's Q_t as the total cross section of a snow-particle, M_0 as the number of particles per cubic meter, D_s as snowfall area, v_s as the volume of a snow-particle, σ_K as the standard deviation of phase disturbance what produced by atmospheric turbulence, then, approximate expression of total attenuation given by,

$$\Gamma = \exp\left[-Q_t M_0 D_s - (\sigma_K^2/2)\, e^{-2M_0 D_s v_s}\right].$$

Where, the 1st term gives the attenuation by scattering from snow-particles, and 2nd term gives the attenuation by atmospheric turbulence, the effect by gas absorption is neglected.

The total number of snow-particles of which contained in the propagation path evaluated as $M_0 D_s$, and the volume of medium for which substituted by snow-particles as $M_0 D_s v_s$.

If snow-particles contents increase, the 1st term of above equation, the attenuation is in compensation for decreasing of the 2nd term.

Fig.3.1 shows as a result of calculation for 11GHz wave.

The calculated maximum restration is 1.3 dB for flaky snow.

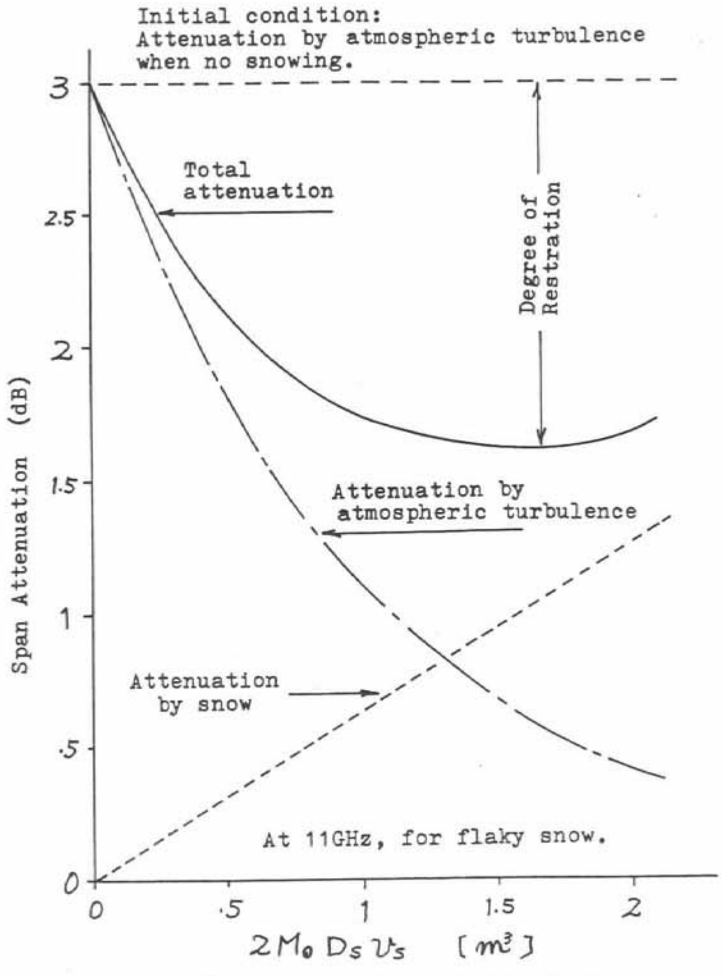

Fig.3.1 A Calculated Attenuation under The Influence of Atmospheric Turbulence and Snowfall.

4.Conclusion

The restration of field intensity by snowfall had thought as the special phenomena that produced by the conditions peculiar to the district and weather.

Now, author believes it very common in centimeter waves propagation, so long as there are atmospheric turbulence and moderate volume of dry snow-particles.

However, in milimeter waves propagation, the obvious restration would not be found, because the attenuation by snowfall is larger than that in centimeter waves.