ISSN No. 2231-0045 VOL.II* ISSUE-IV*MAY-2014

Periodic Research

Computer Network Simulation with Microwave and Effects of Dust Storms

Abstract

Dust storm effect on microwave signal attenuation, depolarization and scattering has attracted many researchers recently. The effects of dust storms on propagation of electromagnetic wave at millimeter wave band are investigated. The propagation of microwave is affected by dust particles by way of signal attenuation. In the present endeavor the motivation is to investigate specifically the propagation characteristics of microwave and millimeter wave energy in the adverse atmospheric conditions under sand and dust storms. Attention is paid to the significant variation in attenuations for adverse weather condition under sand and dust storms. Attempt is also made to quantify the radar backscatter at millimeter wave frequencies due to various constituents present in the dust storm.

Keyword: Attenuation, Dust Storms, Propagation, Electromagnetic Wave, Millimeter Wave Band.

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Introduction

Now a day's Computer Science and Engineering Applications are being widely used in various forms such as missile guidance radar, weather detecting radar, missile tracking radar etc. In spite of these, radars are also used for detecting rain drop, hailstone, formation of rain and snow, thunderstorms, tornadoes and hurricanes. It may be noted that the atmospheric propagation effects dominate the design consideration relating to microwave and millimeter wave systems. In addition to this rain, cloud, fog, hail etc., may cause significant signal attenuation and back scatter? Because of the typical interaction of the electro-magnetic energy with various atmospheric constituents, a thorough understanding of the subject is necessary to access the capabilities and limitations of the microwave and millimeter wave system. The basic parameters which are used in Computer Simulation Technique are scattering cross-section, polarization (plan, circularly, elliptically), depolarization, XPD, Visibility, millimeter wave scattering model, Radiative transfer theory are explained.

Material and Methods:

Computer Simulation Technique for Attenuation

In order to consider the attenuation of dust constituents based on computer simulation, the profile structure of these constituents in atmosphere must be taken into accounts. The length of communication link is assumed to be L, which contains the layers of different constituents of storms blown to the height of the link due to dust storms. As the storms are assumed to contain three constituents, the entire section is represented in the form of three layer in cascade. Further the layer with sand particles extends from Z = 0 to Z = L1 layer with silt particles extends from Z = L1 to L2 layer with clay particles extends Z=L2 to z=L3.

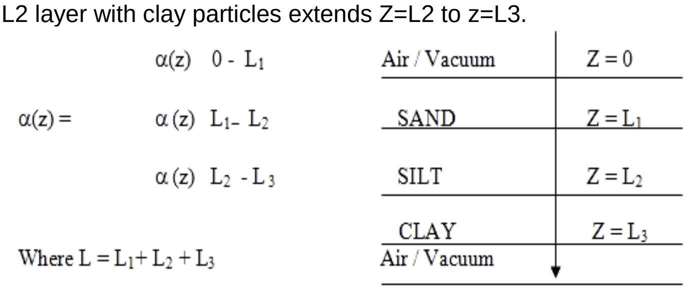


Fig 1.0 : Simulating layers of different dust particles in storm

The attenuation coefficients for small non-spherical particle can be calculated using the scattering amplitude matrix of small ellipsoid which approaches to spheroid under the condition a = b where a, b and c are axes of ellipsoid. Scattering and absorption cross-section of spherical dust particles are

$$\alpha_{ext} = (k^4/6\pi) \int_0^{\pi} \sin\beta/2\, P(\beta)\, d\beta \{ |a_\theta|^2 + [1/2 \cos^2\theta' \sin^2\beta + \sin^2\theta' \cos^2\beta]|a_r - a_\theta|^2 + 2[\sin^2\theta' \cos^2\beta + 1/2 \cos^2\theta' \sin^2\beta]\, Re[\, a^*_\theta (a_r - a_\theta)] \}$$

$$\alpha_{abs} = \int_0^{\pi} \sin\beta/2\, d\beta\, P(\beta) \left\{ b_\theta^2 + [\cos^2\theta' \sin^2\beta/2 + \sin^2\theta' \cos^2\beta]\,(br - b_\theta) \right\}$$

Where

$a_r = \varepsilon_s - 1 / 1 + vdA_2$, $a_\theta = \varepsilon_s - 1 / 1 + vdA_1$, $b_r = klm\,(a_r)$, $b_\theta = klm\,(a_\theta)$

and

$$\alpha_{ext} = \int_0^{\pi} \sin\beta/2\, P(\beta)\, d\beta = 1^2$$

$$A_1 = \int_0^{\infty} ds/(s + a^2)\, Rs$$

$$A_2 = \int_0^{\infty} ds/(s + c^2)\, Rs$$

Where, $Rs = [(s + a^2)(s + b^2)(s + c^2)]^{1/2}$ And $vd = abc/2\,(\varepsilon_s - 1)$

εs : relative permittivity of spheroidal dust particle

θ' : $\pi - \theta$

θ : $0 \le \theta \le \pi$

β : $0 \le \beta \le \pi$

And α_{ext} : $\sigma_{sca} + \sigma_{abs}$

Analytical Treatment of Simulation for Attenuation

During the passage of microwave and millimeter wave through the medium containing san and dust particles, the waves will be attenuated as a consequence of two phenomena, scattering, and absorption. Let N(a)da be the number of dust particles per unit volume of storm with radii in the interval a to a+da. If □ ext be the extinction cross section of dust particles then the total power removed from the wave with incident Pointing vector Sr by the dust particles in volume element of unit cross sectional area and thickness dl is given as

$$\frac{dS_r}{dl} = -S_r \int_0^{\pi} \sigma_{ext}\, N(a)\, da$$

By denoting the integral in this equation by a (attenuation),

$$\alpha = \int_0^{\infty} \sigma_{ext}\, N(a)\, da \text{ and putting } N(a) = n\,P(a)$$

Where, n is the number of particles in unit volume of storm and P (a), probability density function.The value of α for spherical and non – spherical dust particle can be obtained by following equations.

$$\alpha_{sph} = \frac{434 \times 9.43 \times 10^{-9} \times 3}{V^r (4\pi a^3)} \int_0^{\infty} \sigma_{ext}\, a^3 P(a)\, da \text{ dB/km}$$

$$\alpha_{non-sph} = \frac{434 \times 9.43 \times 10^{-9} \times 3}{V^r (4\pi abc)} \int \sigma_{ext}\, abc\, P(s)\, ds \text{ dB/km}$$

Simulation Technique Of Radiated Signal

Apart from the two concepts discussed earlier the evolution of extinction cross-section (σext) can also be made using the dipole radiation concept. Now the extinction cross section (σext) which is the sum of scattering cross section (σs) and absorption cross section (σa) can be given by

$$\sigma_{ext} = \sigma_a + \sigma_s = [\, 8/3a^2 (k_o a)^4 + 12\, a2\, (k_o a)$$

$$(\varepsilon 1 - 1)^2 + \varepsilon_2^2 \left| \frac{\varepsilon - 1}{\varepsilon + 2} \right| 2$$

These attenuation coefficients can be utilized to quantity the attenuation of the signal while propagating through the sand and dust storms. The attenuation due to N/2 dipoles in unit volume of storm can be obtained as

$$\alpha = \left(\frac{\alpha(d) \sin^2\beta \cos^2\beta}{\alpha(d) \sin^2\beta \cos^2{}_2\beta + (k/2)(1 - 2\sin^2\beta\cos^2\beta)} \right) \left(\frac{9.43 \times 10^{-9} \times 3}{2V (4\pi a^3)} \right)$$

Results and Discussion

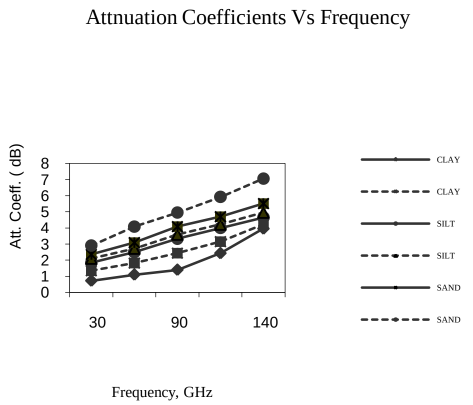
In order to calculate the attenuation coefficients from spherical and non-spherical dust particles are solved numerically with the help of the numerical values of permitivity of dry and moist dust particles are taken as

Table 1.0 Simulating Value of Dielectric constant

S.N.	Particles	Dielectric Constant (□)	
		Dry	Moist
1	Sand	3.776 – j 0.255	6.786 – j 0.321
2	Silt	4.031 – j 0.214	8.236 – j 0.221
3	Clay	4.495 – j 0.255	9.236 – j 0.221

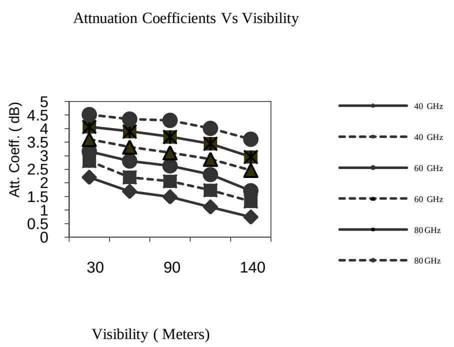
In order to examine the simulating behaviur of microwave signal in sand and dust storms above equations are solved numerically with respect to frequency, visibility, particle size and incidence angle, the result obtained are mentioned in table 1-3 and plotted in Fig.(2)-(5). It is found that attenuation coefficients are increases with increasing frequency and decreases with increasing visibility. The attenuation for dust a particle observed in this model are similar to observation made by Singh, S et al (1996) [9]. It is further observed that non-spherical dust particles are found higher value of attenuation than spherical dust particles. Attenuation coefficients in clay particles are greater as compared with sand and clay particles as Fig.2 and Fig.3.

This is in corroborated with the fact that attenuation coefficients depends directly on size of dust particle suspended in the atmosphere, which are usually spherical where as the larger particles are ellipsoidal or spherical. At low visibility, the particle concentration is very, which renders the effective permittivity of the dusty medium nearer to dust particle permittivity. This increase the attenuation coefficients by offering higher mismatch between air and dusty medium and higher attenuation coefficients at low visibility. At high the particle concentration, the visibility will be very low which renders the effective permittivity of the dusty medium nearer to air. This decreases the attenuation coefficients by offering better mismatch between air and dusty medium and lower attenuation coefficients at high visibility.This is in corroborated with the fact that attenuation coefficients depends directly on size of dust particle suspended in the atmosphere, which are usually spherical where as the larger particles are ellipsoidal or spherical. At low visibility, the particle concentration is very, which renders the effective permittivity of the dusty medium nearer to dust particle permittivity. This increase the attenuation coefficients by offering higher mismatch between air and dusty medium and higher attenuation coefficients at low visibility. At high the particle concentration, the visibility will be very low which renders the effective permittivity of the dusty medium nearer to air. This decreases the attenuation coefficients by offering better mismatch between air and dusty medium and lower attenuation coefficients at high visibility.



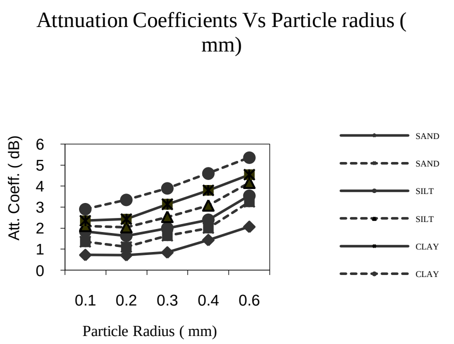
------------------------ Non-Spherical Particle
________________ Spherical Particle

Fig. 2: Variation of Attenuation Coefficients with Frequency for sand, silt and Clay dust particles at Visibility V= 0.1 Km



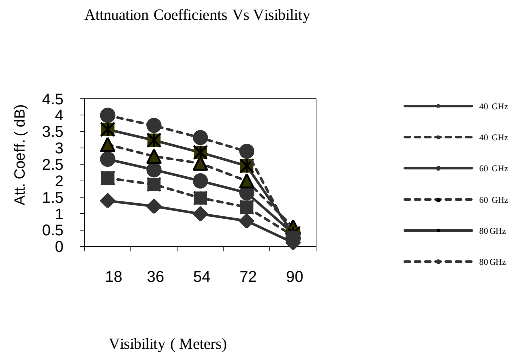
--------------------- Non-Spherical Particle
_________________ Spherical Particle

Fig. 3: Variation of Attenuation Coefficients with Visibility at different Frequency for dust particle in sand and dust storm.



--------------------- Non-Spherical Particle
________________ Spherical Particle

Fig. 4: Variation of Attenuation Coefficients with size of dust particle radius for sand ,silt and clay dust particle dust particle at visibility V = 0.1Km.



-------------------- Non-Spherical Particle
________________ Spherical Particle

Fig. 5: Variation of Attenuation Coefficients with incidence angle at different frequency for dust particle in sand and dust storm

The variation of attenuation with size of the dust particles and incidence angle are shown in fig.4 and fig.5,It shows that attenuations are decreases with increases in size of dust particle. From Fig.5, it is also observed that attenuation coefficients are decreases with incidence angle and minimum at 90-degree angle of incidence both for spherical and non-spherical dust particles.

Table 2
Variation of Attenuation Coefficients with frequency for spherical dust particles

S. No.	Freq. GHz	Attenuation Coefficients (dB) Visibility = 0.1 Km					
		In this Study			Singh S et al (1996) [16]		
		Sand	Silt	Clay	Sand	Silt	Clay
1	30	1.31	1.42	1.51	1.73	1.92	2.31
2	60	2.12	2.32	2.51	2.33	2.38	2.42
3	90	2.98	3.12	3.34	3.21	3.89	4.12
4	120	3.53	4.12	4.63	3.73	4.12	4.33
5	140	3.97	4.33	5.12	3.83	4.53	4.77

Table 3
Variation of Attenuation Coefficients with frequency for Non-spherical dust particles

S. No.	Freq. GHz	Attenuation Coefficients (dB) Visibility = 0.1 Km					
		In this Study			Singh S et aln (1996)[16]		
		Sand	Silt	Clay	Sand	Silt	Clay
1	30	1.41	1.62	1.61	1.93	2.12	2.51
2	60	2.22	2.52	2.71	2.53	2.58	2.62
3	90	3.01	3.22	3.54	3.41	4.09	4.32
4	120	3.63	4.22	4.83	3.93	4.32	4.53
5	140	4.07	4.53	5.32	4.17	4.73	4.97

Table 4
In this Study Variation of Attenuation Coefficients with frequency and Visibility

S. No.	Freq. GHz	Attenuation Coefficients (dB) Visibility = 0.1 Km			
		Singh. S et al (1996)[16]		In this study	
		Spherical	Non-Spherical	Spherical	Non-Spherical
1	20	1.51	1.72	1.32	1.48
2	40	1.93	2.12	1.73	1.86
3	60	2.64	3.21	2.21	2.51
4	80	3.23	3.61	2.98	3.23
5	100	3.98	4.32	3.12	4.23
6	120	4.31	5.23	3.72	4.12
7	140	5.66	6.31	4.23	5.03

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