Estimation of Tropospheric Scintillations for Indian Climatic Conditions at Ka-Band Frequencies

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***ABSTRACT---** To estimate the scintillations effects in troposphere for the Indian climate. Here the scintillations are the one of the most important prop-agation impairment at high frequencies(>10GHz) and low elevation angles(<10°) in the satellite communication systems particularly in adaptive link control systems design. India's climate is tropical climate and vary with respect seasonally.*

Up to below 4 km range atmosphere is called tropical region. Scintillations defined by received signal passing through this tropical climate which has turbulent mixed up with rapid signal fluctuations because due to the solar radiation earth surface heated up and small scale variations occurred in refractive index of the medium[1].

Keywordsy - Temperature, Pressure, Humidity, Scintillations.Ka band frequency, elevation angle.

I. INTRODUCTION

Due to the heat energy from sun incident on earth's surface warms-up, molecules are excited and at the boundary turbulent layer created. When the received are passing through this turbulence layer and mixed up and small scale variations occurred in refractive index of troposphere, due to rapid fluctuations in amplitude and angle of the received ka band frequency signals when propagating along path. Scintillations are occurred due to convective heating and gradients produces turbulences and apparent scintillations due to variations in rain drop distribution[1].

Ka band future satellite communication systems using ISRO. By reduced availability of spectrum and reduced interference leads in the quality of service improvement. For that available some Statistical models which are used in practice. In the ka band frequency statistical model performance to be tested for most accurate one should be recommended for the use. One of ISRO centre of SAC proposed propagation experiment at Ka band over Indian Climate. The satellite used. with linear polarization. measurements equipments Earth station, microwave radars, metrological sensors, radio meters are installed for the measurements to analyse and process data. Two methods used for statistical prediction .An outcome of data collection and analysis would be recommend a technique for prediction of scintillations in ka band over Indian areas and to estimate scintillations in tropical climate at 30/20GHz region. India has unique future that it has a tropical climate with different metrological conditions, various geographical regions and rainfall rate areas and different elevation angles for the satellites.

Satellite communication: Geo satellites at Ka band links from sub satellite point in latitude or longitude beyond 81.34° not visible.

An elevation angle decreases at the visible portion from sub satellite zenith point to zero, evolution path of circular fringe to satellite from sub satellite point of longitude at latitude from 0 to 81.34° and longitude 10° of earth station . At 70° latitude the maximum elevation angle 11.5° and at 80° latitude decreased to 1.33°. Ray bending and ducting due to Scintillations and large scale refractive index produces fades of 20dBs. The minimum elevation angle of 5° uses commercial systems[6].

GSAT 4

Metrological data collected from different sites in India at Ka band. The different attenuation characteristics are presented for various locations at Ka band for common interface and common design of system. Metrological equipments are identical in all the sites. Equipments: Ka band receiver(beacon), distrometer, radiometers, mw rain radar, tipping bucket rain gauge, data loggers and automatic weather stations[9].

Table1:GSAT 4 Specifications at Ka Band

Carrier frequency	GHz	20.2	30.5
polarization	-	Linear V&H	Linear V&H
isolation	dB	30	30
EIRP	dBW	24	24
		+-7 +-1	+-7 +-1
Stability of frequency	ppm	-55 -60	-55 -60

Earth station

Received power will be measured by earth station from satellite transmitter at 30.5GHz and 20.2GHz, antenna diameter of 120cm, down converted to 20MHz and 10MHz respectively, bandwidth of 300KHz dual stage frequency convertion.to produce differential in phase and quadreture signals used for find the beacon signal amplitude and phase of satellite using fast Fourier transform. Receiver allowed

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25dB and an accuracy of 0.5dB sampling range of data measure between 5 and 20MHz.Dual polarization and dual frequency will be measured at a rate of 20Hz by earth station. Two RF blocks used to down convert horizontal and vertical signals.

Link budget[9]

Table2:Llink budget

Parameters	30.5GHz	20.2GHz
Satellite EIRP	24dBW	24dBW
Total clear sky losses	210dB	213dB
Power at antenna feed	-191dB	-186dB
Antenna gain	47dBi	45dBi
Received power at clear sky	-111dBm	-110dBm
Threshold signal power	-147dBi	-147dBi
Figure of merit G/T	18DBK^{-1}	16DBK^{-1}
RESOLUTION BW	31Hz	31Hz
Received SNR	42dB	43dB
Threshold SNR	11dB	11dB
Max Dynamic Range	32dB	33dB

II. RADIO REFRACTIVE INDEX

When signal receiver from the satellite which is passing through the boundary turbulent layer which is created by solar radiation heating up the surface of the earth which is caused rapid signal fluctuations occurred, caused small scale variations occurred in signal amplitude and phase angle[3] .

Refractive index in terms of radio refractivity is given by

$$n=1+Nx10^{-6}$$

This signal crossing the turbulent mixed up with humidity, tempartrure and water vapour pressure. Then radio refractivity N is

$$N=(n-1)x10^{6}(ppm)$$

The total refractivity contains clear dry, Ndry and wet term, Nwet

where

$$Nwet=373e/T^{2}\ ppm$$

$$Ndry=77.6\ P/T\ ppm$$

Total refractivity is given by

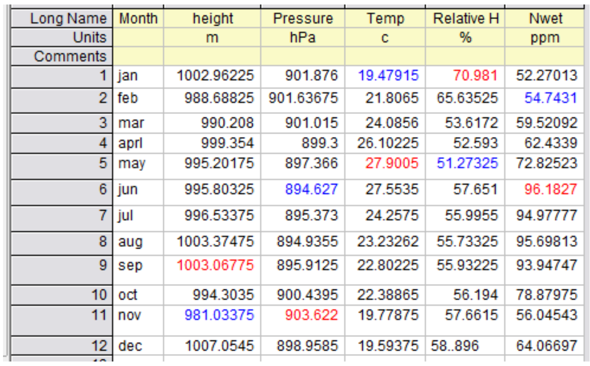
$$N=(4810e/T+P)77.6/T$$

Units ppm-parts per million,
T is Temparature in Kelvin,
P-pressure in mbar
e-water vapour pressure.

III. ESTIMATION OF SCINTILLATIONS

Scintillations estimated by analysed four years raw data which was collected from NRSC(National remote sensing Centre, Hyderabad and Wyomining University. Here wet term radio refractivity, Nwet considered in wet condition. relative humidity and temperature averaged four years2014 to2018[4].

Table3:estimated radio refractivity wrt metreological parameters.



Long Name	Month	height	Pressure	Temp	Relative H	Nwet
Units		m	hPa	c	%	ppm
Comments						
1	jan	1002.96225	901.876	19.47915	70.981	52.27013
2	feb	988.68825	901.63675	21.8065	65.63525	54.7431
3	mar	990.208	901.015	24.0856	53.6172	59.52092
4	aprl	999.354	899.3	26.10225	52.593	62.4339
5	may	995.20175	897.366	27.9005	51.27325	72.82523
6	jun	995.80325	894.627	27.5535	57.651	96.1827
7	jul	996.53375	895.373	24.2575	55.9955	94.97777
8	aug	1003.37475	894.9355	23.23262	55.73325	95.69813
9	sep	1003.06775	895.9125	22.80225	55.93225	93.94747
10	oct	994.3035	900.4395	22.38865	56.194	78.87975
11	nov	981.03375	903.622	19.77875	57.6615	56.04543
12	dec	1007.0545	898.9585	19.59375	58..896	64.06697

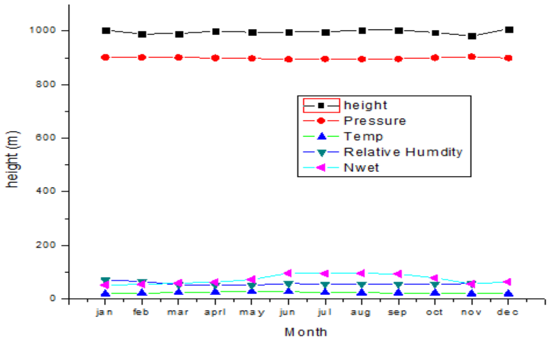


Fig.1.graph for metreological parameters

Scintillation Intensity or Standard Deviation[2]

As(p)=A(p).σ, σ= [σref.f^7/6.g(x)]/(sinϴ)^.55 and A(p)=Ae(p) for enhancement due to scintillations in signals and A(p)=Af(p) for faded signal due scintillations in signals for signal enhancement model

$$Ae(p)=-.01711(logp)^{3}+0.61643(logp)^{2}+1.00243(logp)+4.94481$$

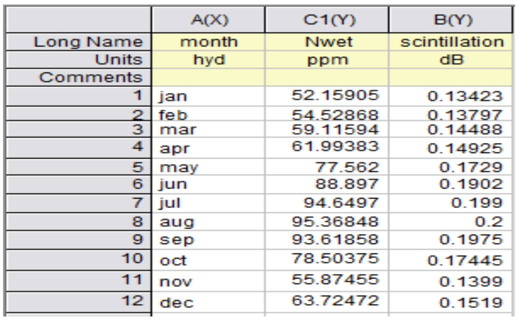
signal fade model

$$Af(p)=-0.02953(logp)^{3}+0.37146(logp)^{2}-0.3962(logp)+2.75758$$

Where p is time percentage factor, range from 0.001<=p<=50 where σref is the reference threshold standard level.

IV. RESULTS

Table4:monthly averaged radio refractivity and scintillations



	A(X)	C1(Y)	B(Y)
Long Name	month	Nwet	scintillation
Units	hyd	ppm	dB
Comments			
1	jan	52.15905	0.13423
2	feb	54.52868	0.13797
3	mar	59.11594	0.14488
4	apr	61.99383	0.14925
5	may	77.562	0.1729
6	jun	88.897	0.1902
7	jul	94.6497	0.199
8	aug	95.36848	0.2
9	sep	93.61858	0.1975
10	oct	78.50375	0.17445
11	nov	55.87455	0.1399
12	dec	63.72472	0.1519

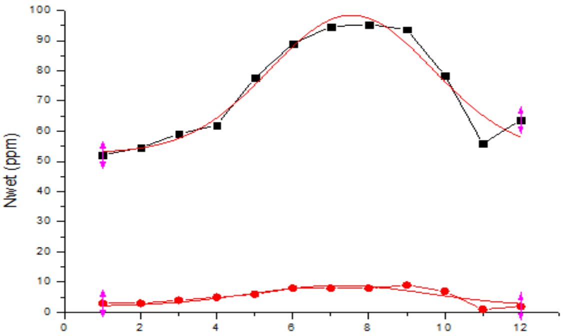
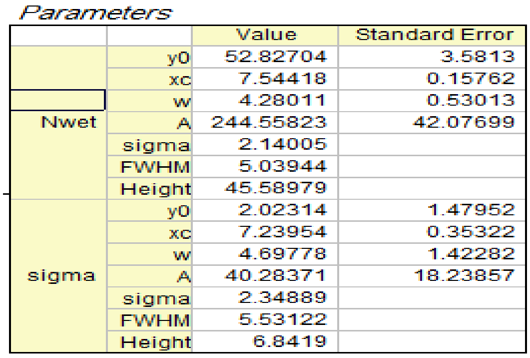


Fig2.Gaussian fitted graph for measured data

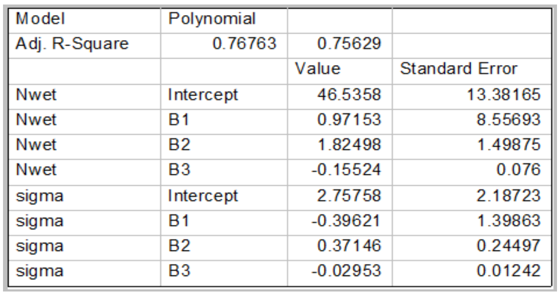
Table5:Gaussian fitted values



Parameters

		Value	Standard Error
Nwet	y0	52.82704	3.5813
	xc	7.54418	0.15762
	w	4.28011	0.53013
	A	244.55823	42.07699
	sigma	2.14005	
	FWHM	5.03944	
	Height	45.58979	
sigma	y0	2.02314	1.47952
	xc	7.23954	0.35322
	w	4.69778	1.42282
	A	40.28371	18.23857
	sigma	2.34889	
	FWHM	5.53122	
	Height	6.8419	

Table6: Polynomial fitted values to Nwet and Standard deviation



Model	Polynomial		
Adj. R-Square	0.76763	0.75629	
		Value	Standard Error
Nwet	Intercept	46.5358	13.38165
Nwet	B1	0.97153	8.55693
Nwet	B2	1.82498	1.49875
Nwet	B3	-0.15524	0.076
sigma	Intercept	2.75758	2.18723
sigma	B1	-0.39621	1.39863
sigma	B2	0.37146	0.24497
sigma	B3	-0.02953	0.01242

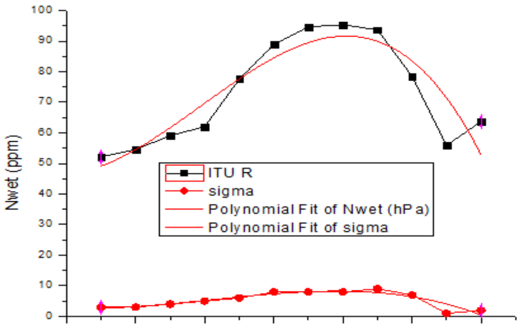


Fig.3.Polynoimial fitted curve

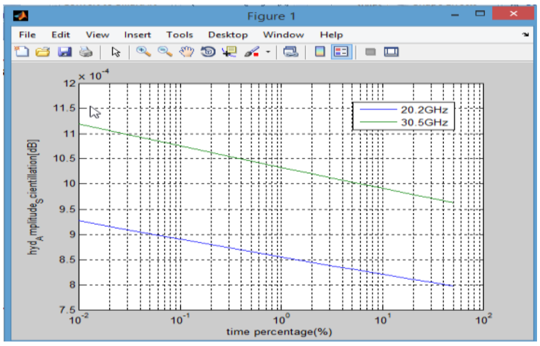


Fig4. Scintillation Intensity for 20.2GHz and 30.5GHz Frequencies

The relationship among monthly averaged temperature, relative humidity and water vapour pressure characteristics are plotted. The amplitude scintillations are directly proportional to the wet term radio refractivity and the wet term refractivity directly proportional to the temperature and inversely proportional to the relative humidity. Monthly averaged relative humidity is directly proportional to the height and temperature inversely proportional of the turbulent layer from earth's surface.

Relative humidity is Inversely proportional to the temperature. The measured fades stretch up to .00115dB and 0.00094dB at 0.01% of time at 30.5GHz, 20.2GHz of frequencies and 1000m of turbulent layers height. Signal stretched to 0.01055 dB from 20.2 GHz to 30.5GHz and the standard error is 1.47952dB in scintillation and 3.5813 dB in radio refractivity.

Refractive index is 1.00005283. the variation in refractive index is 0.00005283 from standard refractive index.

V. CONCLUSION

Measured data analyzed and estimated on tropospheric scintillations on ka band satellite signals for Indian climate which is used in adaptive link control in the design of satellite communication system. The new prediction of scintillations observed by using Gaussian distribution and third order polynomial fit to the measured values of India's tropical climate. The standard deviation is increased with the increased frequency and decreased elevation angle , is proven with simulation. Statistics were estimated at different attenuated levels , higher values in ka band. because scintillations effect very strong with high frequency. Small signals wavelength leads more fluactions. The Ka band signal communication link affected strongly by phenomenon of scintillations.

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