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Relationship among Water Vapour Pressure, Temperature, Relative Humidity ,Height and Refractive Index and their Effect on Tropospheric Scintillations on Ka band signals in South Indian region

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ABSTRACT

To study the relationship among the Water Vapour Pressure, monthly average temperature and Relative Humidity and their effect on tropospheric scintillations in south Indian region.For that estimated the statistical characteristics of local metreological parameters . And also observed the effect of these parameters on Tropospheric Scintillations and to be compare with the theoretical background and meteorological parameters. For this proposed New prediction model for the scintillation effect could be develop and need to specify the improvements to existing models in Indian Region .

Index Terms : Monthly average Temperature, Relative Humidity, Water Vapor Pressure.

I. INTRODUCTION

Tropospheric Scintillation(Refractive Effects)

Warming up process of earth surface cause the excitement of troposphere layer. This condition will induce turbulence into the layer.The turbulence is random fluctuations in the refractive index along path of signal transmission will contribute increase to rapid variations in the received radio signal amplitude.The effect of signal degrading is known as scintillation. It is seasonally dependent, and varies day to day with the local climate.

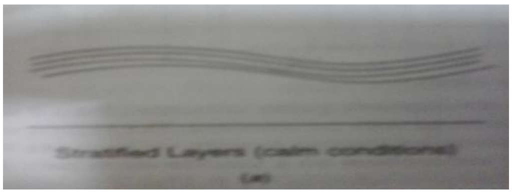

Fig.1.Stratified layers (calm conditions)

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Tropospheric scintillation is practically usually exist to varying degrees on any earth-space link, but at high frequencies (>10 GHz) or low elevation angles the level of scintillation fade significant. Hence the need of being taken into account in the communication system's link budget.

Thus, signal level fluctuations owing to scintillation must be understood for the purpose of correct design of satellite.

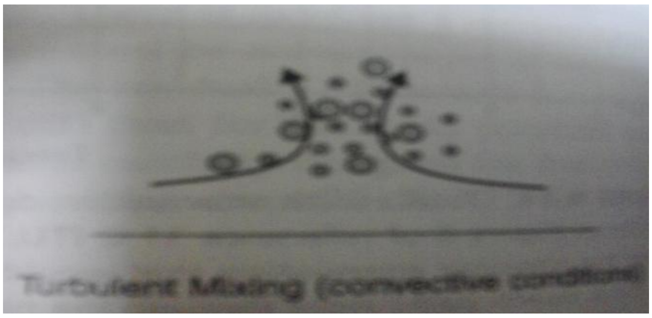


Fig.2.Turbulent mixing(convective conditions)

Tropospheric scintillations

- **Amplitude Scintillation.**
- **Angle Scintillation.**

The amplitude scintillation is a significant cause of degradation in several emerging low availability satellite communication systems operating at Ka-Band(30/20 GHz) frequencies and using small aperture antennas.

Components of tropospheric scintillation:

- Due to turbulence developed by convective heating and wind gradients.
- Due to pure scattering by a random distribution of scatterers.
- Apparent scintillation caused by temporal variation of rain drop size distribution which produces a rapidly varying signal attenuation.

II. AIM

This proposal work aimed to develop an improved prediction model from the statistical behaviour of the tropospheric Scintillation effects compared with estimated statistics to existing models.To evaluate the performance of tropospheric scintillation at clear sky conditions and Wet conditions in Indian Region.

Theoretical and analytical work:

To estimate the statistics of tropospheric scintillation in Indian region based on the parameters in Recommendation ITU-R-P-618-9,10,11 and 12 models And Rec.ITU-R-P-453-9 model.

To observe the relationship between the scintillation intensity and the local environmental parameters.

Experimental and analytical work:

To analyse the experimental satellite signal measurements.

To compare statistical behaviour of tropospheric scintillation with the theoretical background.

To compare their link parameters with meteorological parameters.

III. RESEARCH METHODOLOGY

To processed the local meteorological data from ISRO/NRSC, Hyderabad. And simulating the mathematical model of scintillation prediction using MATLAB based on local meteorological data. Estimated tables and graphs using Originpro Tool. Next, analyzed the scintillation statistics from the prediction model. And last, repeated the simulation, analysis and comparison**.**

IV. PROBLEM STATEMENT

Due to solar radiation the ground surface heats up, boundary layer of atmosphere excites which it causing refractive index to be varied slightly generates as the atmosphere turbulent. When wave travels through this turbulent mixing atmosphere, it will experience alternation and scattering which received called as scintillation. Scintillation is generally will be happened in all region of atmosphere. But it is significant at troposphere layer with the communication link at the frequency above 10 GHz. The Tropospheric scintillation is a phenomenon of rapid signal fluctuation that occurred due to small scale variation in refractive index at troposphere layer .

V. SCINTILLATIONS PREDICTION MODEL IN INDIAN REGION

Earth Station	**Specifications**
Hyderabad	Frequency 20.2GHz &30.5GHz satellite link, elevation angle 20.62 diameter 2.2m,Balanagar,Hyderabad,India,and 6 months data(2017).
Bangalore	Frequency 20.2GHz &30.5GHz satellite link, elevation angle21.96 ,diameter 2.4m,Banglore,India,and 6 months data(2017).
Nagpur	Frequency 20.2GHz &30.5GHz satellite link, elevation angle 21.10,diameter 2.8m,Nagpur,India,and 6 months data(2017).
Madras	Frequency 20.2GHz &30.5GHz satellite link, elevation angle 20,diameter 2.6 m, Madras,and 6 months data(2017).
Bombay	Frequency 20.2GHz &30.5GHz satellite

link, elevation angle 14,diameter 1.8 m,Bombay,India,and 6 months data(2017).

Table.1.Spacifications

This prediction model makes scintillation statistics easier to be estimated. It has been proposed for frequency range of Ka Band(30/20 GHz).Statistic of scintillations can be estimated from the local environmental parameters.This model determine the parameter σ, the standard deviation of the instantaneous signal amplitude in dB.The parameter σ referred as scintillation intensity. The parameters : Antenna size, D and efficiency, η

Antenna elevation angle, θ

Operating frequency, *f*

Average local monthly temperature, *t*

Average local monthly relative humidity, H

VI. MATHEMATICAL MODEL FOR CALCULATION OF THE SCINTILLATION INTENSITY

Step1*:* Calculate the saturation water vapour pressure, es, (hPa)

es=6.1121 x exp[(17.502xt)/(t+240.97)]

Step2*:* Compute the wet term of the radio refractivity, Nwet

Nwet= 3732 H es/273+t

Step3*:* Calculate the standard deviation of the signal amplitude, σref, used as reference:

σref=3.6x10ˆ-3+10ˆ-4xNwet

Step 4: Calculate the effective path length L according to:

$$L = \frac{2h_L}{\sqrt{\sin^2\theta + 2.35 \times 10^{-4}} + \sin\theta}$$

where *hL* is the height of the turbulent layer,

the value to be used is *hL* =1000 m.

Step 5: Estimate the effective antenna diameter, *Deff*, from the geometrical diameter, D, and the antenna efficiency η:

$$D_{eff} = \sqrt{\eta}\, D$$

Step6:Calculate the antenna averaging factor from:

g(x)=√(3.86(x^2+1)^11/12.sin(11/6arctan1/x)-7.08x^5/6)

where x=1.22Deff^2(f/L),

f in GHz Carrier frequency

Step 7: Calculate the standard deviation of the signal for the considered period and propagation path:

$$\sigma = \sigma ref . f^{7/12} \; g(x) /(\sin\theta)^{1.2}$$

Step8:Calculate the time percentage factor, a(p),for the time percentage ,p ,of concern in the range $0.01<p<50$

$a(p)=0.0061(\log10p)^3+0.072(\log10p)^2.71\log10p+3.0$

Step9:Calculate the Scintillation fade depth for the time percentage by:

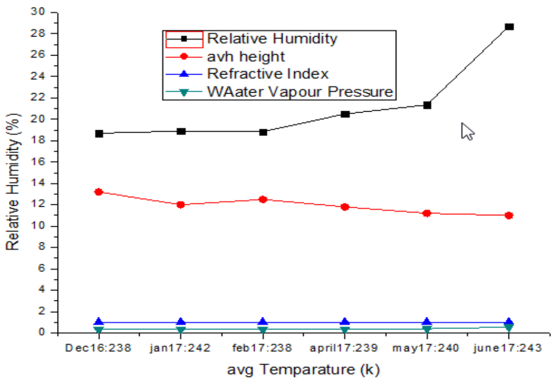
$$As(p)=\sigma(p).\sigma \text{ dB}$$

VII. RESULT ANALYSIS

Hyderabad :Station information and sounding indices

- Station identifier: VOHY ,
- Station number: 43128
- Observation time: 160101/0000 ,
- Station latitude: 17.45 (°N)
- Station longitude: 78.46 (°E) ,
- Station elev ation: 545.0

	A(X)	F1(Y)	D1(Y)	C1(Y)	E1(Y)
Long Name	avg Temparature	Relative Humidity	avh height	Refractive Index	WAater Vapour Pressure
Units	k	%	km		hPa
Comments					
1	Dec16:238	18.7	13.2	1.00011	0.304
2	jan17:242	18.9	12	1.0001	0.3276
3	feb17:238	18.85	12.5	1.0001	0.3163
4	april17:239	20.5	11.8	1.0001	0.3365
5	may17:240	21.36	11.2	1.00091	0.3803
6	june17:243	28.7	11	1.00091	0.5446



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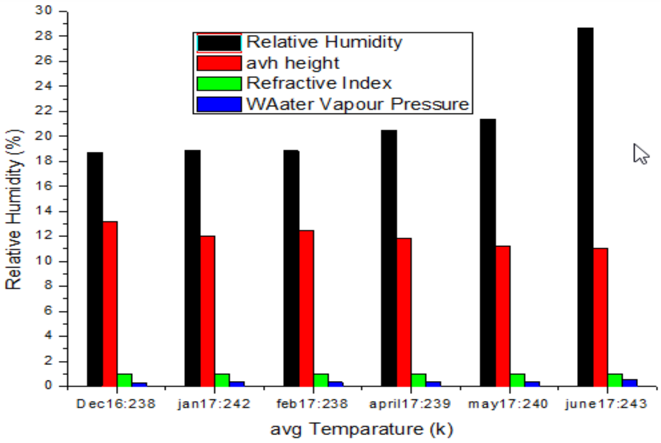

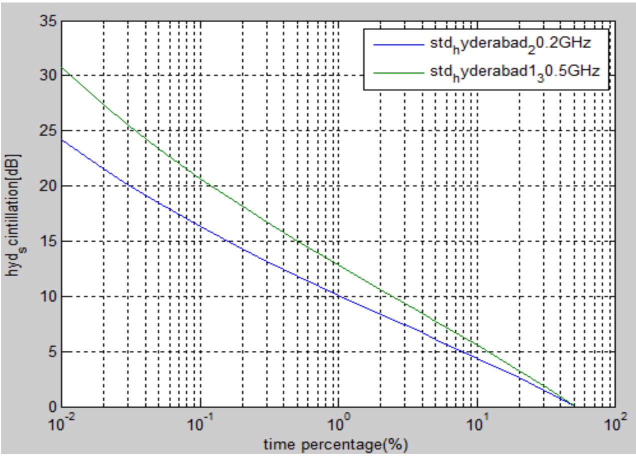

Bangalore: Station information and sounding indices:

- Station number: 43295 ,
- Observation time: 170922/0000,
- Station latitude: 12.96 ,
- Station longitude: 77.58,
- Station elevation: 921.0

	A(X)	B1(Y)	G1(Y)	C1(Y)	E1(Y)
Long Name	Temparture	Relative Humidity	avg height	Water Vpour Pressure	Refractive Index
Units	K	%	km	hPa	
Comments	Banglore				
1	Dec16:233.8	22.3	13.9	0.2029	1.0002
2	jan17: 235.5	22.9833	12.23	0.2424	1.00011
3	feb17: 232.85	14.4294	13.123	0.1846	1.00019
4	april17: 238.8	31.5403	12.515	0.3384	1.00011
5	may17: 239.30	44.4312	12.331	0.3693	1.00011
6	june17: 242.94	55.6388	11.133	0.5026	1.0001

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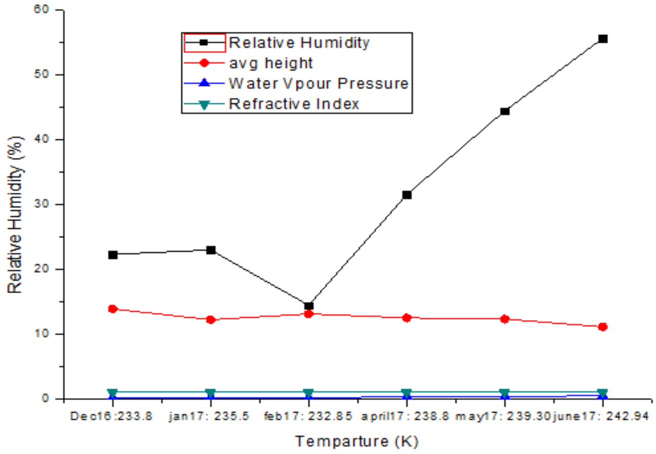
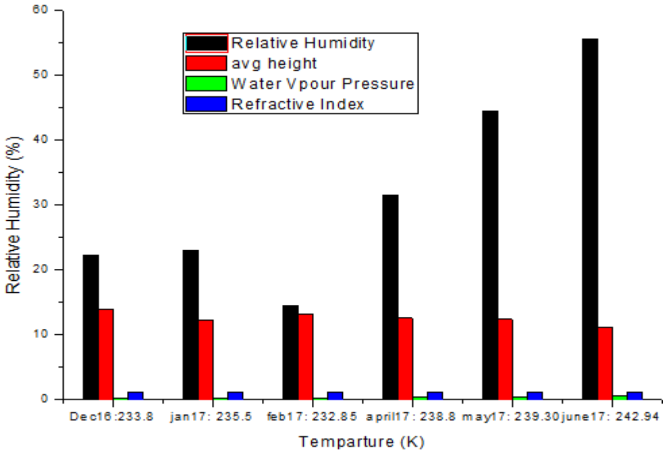
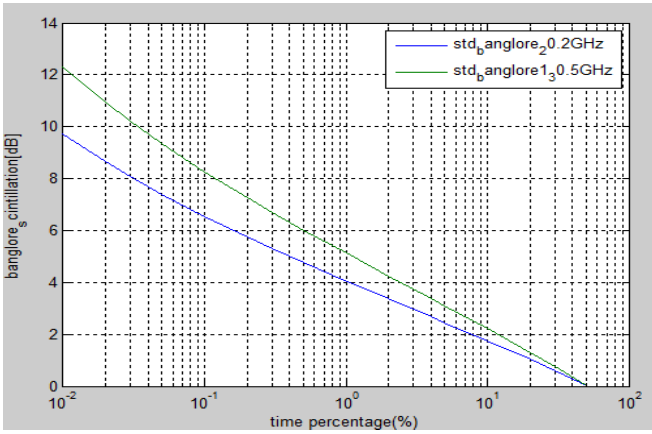




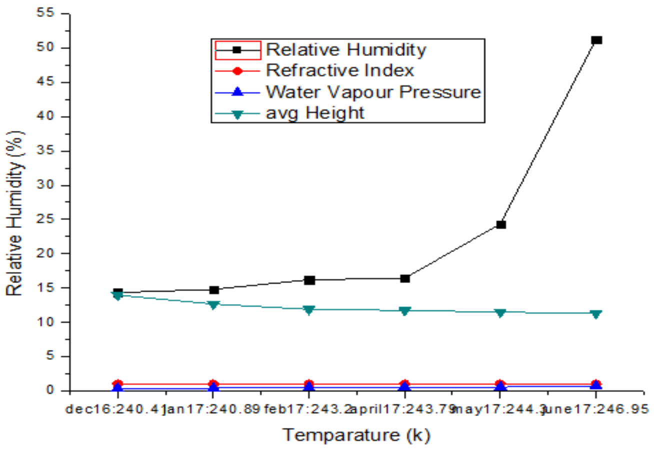


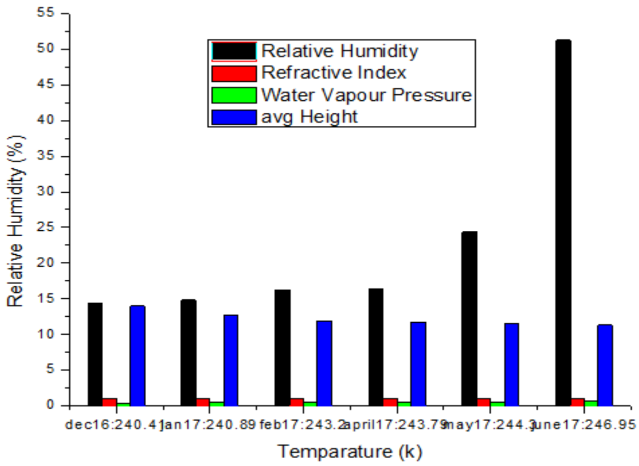
Nagpur: Station information and sounding indices

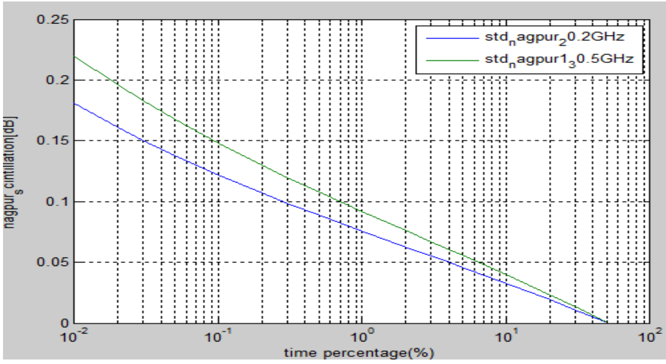
- Station identifier: VANP,
- Station number: 42867
- Observation time: 161202/1200,
- Station latitude: 21.10,

- Station longitude: 79.05
- Station elevation: 310.0

	A(X)	C1(Y)	D1(Y)	E1(Y)	B(Y)
Long Name	Temparature	Relative Humidity	Refractive Index	Water Vapour Pressure	avg Height
Units	k	%		hPa	km
Comments	Nagpur				
1	dec16:240.41	14.3476	1.0002	0.3958	13.96
2	jan17:240.89	14.8053	1.00012	0.4152	12.67
3	feb17:243.2	16.2216	1.00012	0.5171	11.89
4	april17:243.79	16.4273	1.00011	0.5471	11.75
5	may17:244.3	24.361	1.00011	0.574	11.5
6	june17:246.95	51.2444	1.00011	0.732	11.3



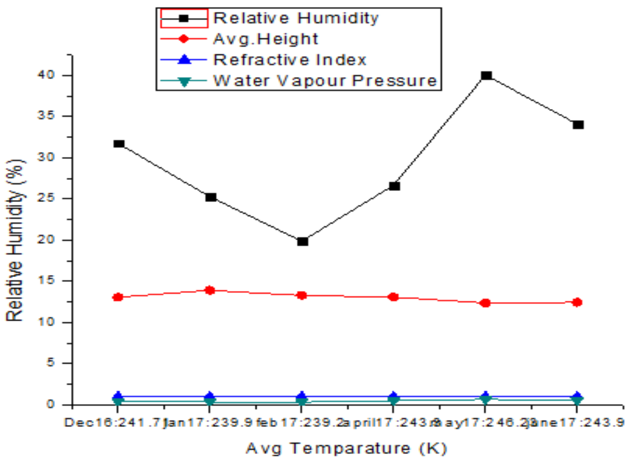




Madras: Station information and sounding indices

- Station identifier: VOMM
- Station number: 43279
- Observation time: 161218/1200
- Station latitude: 13.00
- Station longitude: 80.18
- Station elevation: 16.0

	C1(Y)	D1(Y)	E1(Y)	A(X)	F1(Y)
Long Name	Relative Humidity	Avg.Height	Refractive Index	Avg Temparature	Water Vapour Pressure
Units	%	km		K	hPa
Comments					
1	31.74	13.08	1.00012	Dec16:241.71	0.4487
2	25.27	13.91	1.00011	jan17:239.9	0.3766
3	19.88	13.29	1.00011	feb17:239.2	0.3517
4	26.65	13.09	1.00011	april17:243.3	0.522
5	40.03	12.39	1.00012	may17:246.23	0.684
6	34.09	12.455	1.00012	june17:243.9	0.5524



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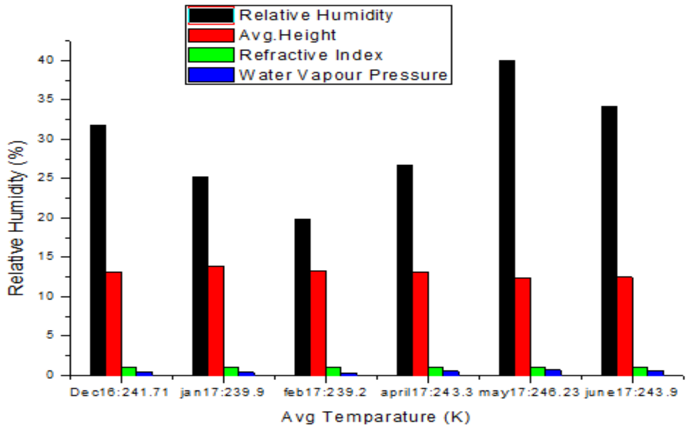
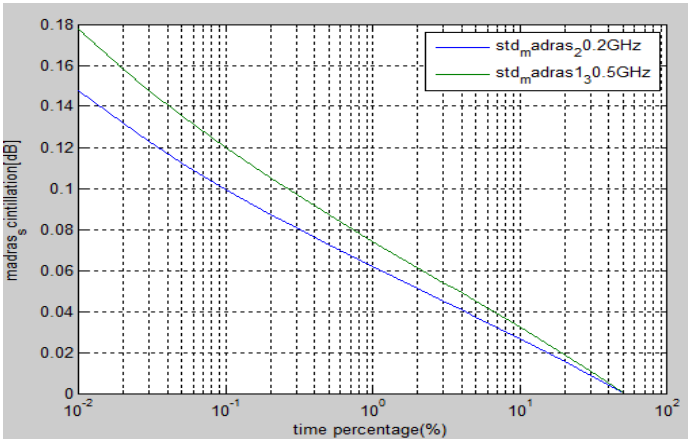
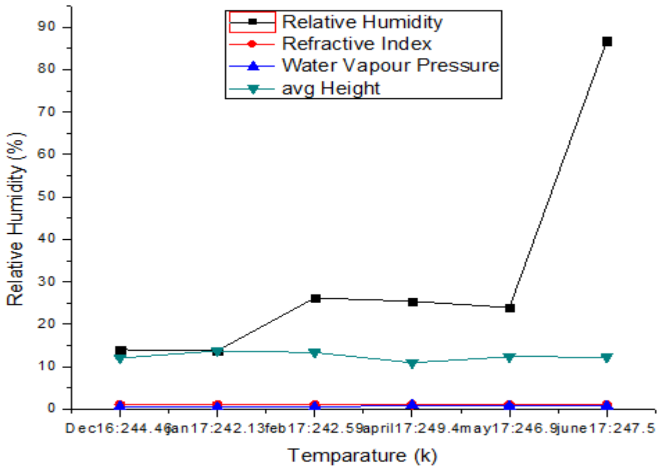




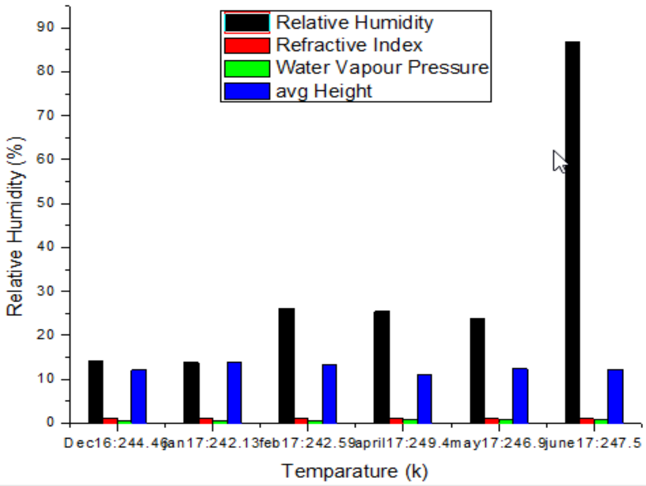
Bombay: Station information and sounding indices

- Station identifier: VABB
- Station number: 43003
- Observation time: 170411/0000
- Station latitude: 19.11
- Station longitude: 72.85
- Station elevation: 14.0

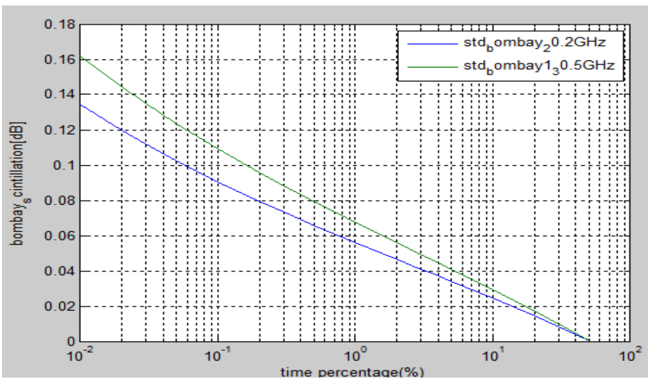
	A(X)	C1(Y)	D1(Y)	E1(Y)	B(Y)
Long Name	Temparature	Relative Humidity	Refractive Index	Water Vapour Pressure	avg Height
Units	k	%		hPa	km
Comments					
1	Dec16:244.46	14.052	1.00012	0.5816	12.06
2	jan17:242.13	13.78	1.00012	0.467	13.74
3	feb17:242.59	26.2	1.00011	0.488	13.35
4	april17:249.4	25.42	1.00012	0.9124	10.97
5	may17:246.9	23.93	1.00012	0.7313	12.36
6	june17:247.5	86.76	1.00012	0.7689	12.29



Relative Humidity
Refractive Index
Water Vapour Pressure
avg Height
Relative Humidity (%)
Dec16:244.46
jan17:242.13
feb17:242.59
april17:249.4
may17:246.9
june17:247.5
Temparature (k)



Relative Humidity
Refractive Index
Water Vapour Pressure
avg Height
Relative Humidity (%)
Dec16:244.46
jan17:242.13
feb17:242.59
april17:249.4
may17:246.9
june17:247.5
Temparature (k)



std_bombay_2 0.2GHz
std_bombay1_3 0.5GHz
bombay_scintillation[dB]
time percentage(%)

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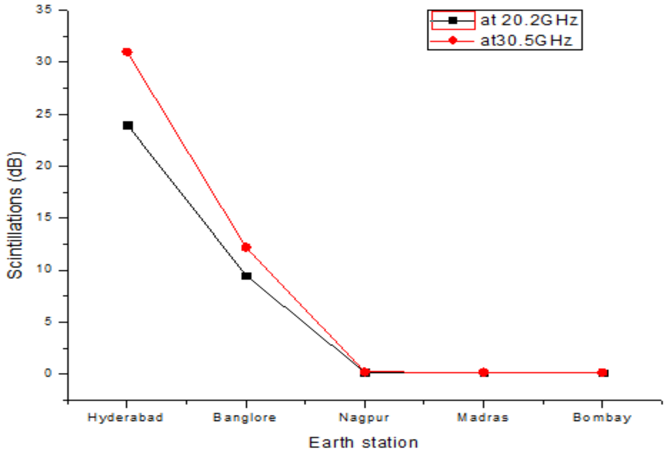

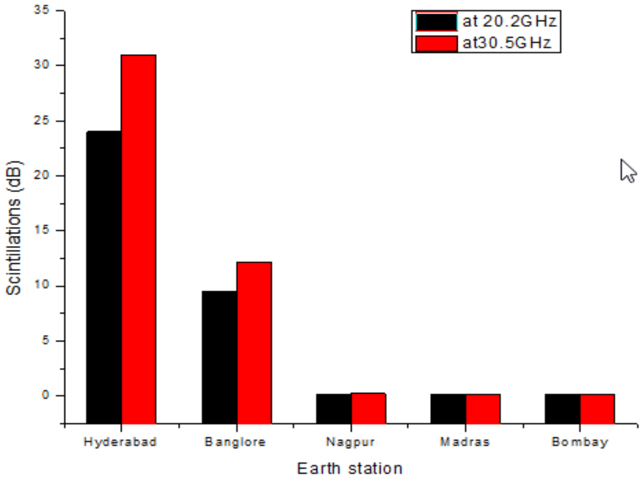

Experimental Observations:

•Scintillation intensity increases with increasing RF frequency.

•Tropospheric Scintillations are directly proportional to standard deviation, RF frequency and Radio Refractive Index.

•Refractive Index is directly proportional to height from the surface

•Refractive Index is inversely proportional to Temperature, Relative Humidity and Water Vapour Pressure.

•Scintillation intensity decreases with increasing antenna size and elevation angle

• Tropospheric Scintillations are inversely proportional to antenna size, elevation angle

•The signal level due to tropospheric scintillation is to be an asymmetrical distribution.

•the asymmetry increases with scintillation intensity.

VIII. CONCLUSION

The scintillation statistics were determined based on tropical climate region meteorological data. This is proven with the simulation and result analysis. Scintillations statistics are estimated at 31 dB for 30.5GHz is higher in value than scintillation intensity for 20.2 GHz band which is 24dB.Since the effect of scintillation is strongly frequency dependent, signal with shorter wavelength will encounter more severe variation. Hence Ka band communication link are more affected by scintillation phenomenon than Ku and other lower band communication link. The aspects of scintillation are of interest to communications system design and remote sensing.To improve the prediction of propagation effects, which is essential for SC system design for Adaptive Link Control systems in particular in Indian Region.

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