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Letters to the Editor

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MEASUREMENT AND ANALYSIS OF RADIO REFRACTIVE INDEX OVER KOLKATA WITH RESPECT TO ITS SEASONAL AND DIURNAL CHARACTERISTICS

1. A line-of-sight radio wave transmitted from a station is received at a distant location through tropospheric mode of propagation. The transmitted radio waves do not follow a strictly straight path but follows the earth's curvature to some extent. The path of the signal gets curved because of refraction and the degree of curvature is controlled by the refractive index of the medium, which leads to signal defocusing (Kukushkin and Sinitsin 1983). Hence the activities of the troposphere are of extreme importance to understand the role of this medium in communication links. In view of the above, a necessity thus arises to map the Radio Refractive Index of a particular location taking the seasonal and diurnal classification separately. Profiles of RRI (Radio Refractive Index) of different stations have been received earlier (Baynton 1965, Majumdar *et al.* 1976, Kulshrestha 1987). A model for calculating such gradients from ground based data is developed over Guwahati (Sharma *et al.* 1995).

2. The refractivity of the troposphere is a function of the atmospheric pressure, temperature and water vapour pressure as derived by Bean and Dutton (Bean & Dutton, 1968).

The total refractivity is given by

$$N = N_{dry} + N_{wet} \tag{1}$$

A model for the dry and wet refractivity is given by

$$N_{dry} = 77.6 \, P / T \tag{2}$$

and

$$N_{wet} = 3.73 * 10^5 * e / T^2 \tag{3}$$

Where 'P' is the atmospheric pressure in hPa, 'T' is the absolute temperature in Kelvin and 'e' is the water vapour pressure in hPa.

$$T = t + 273 \tag{4}$$

t = Temperature in °C.

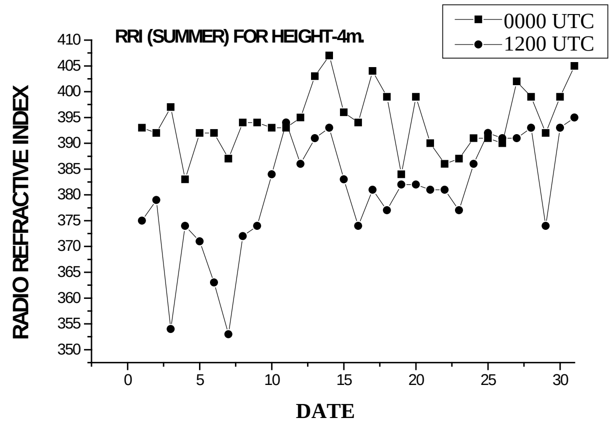

Fig. 1. Refractivity profile for summer for height : 4 m

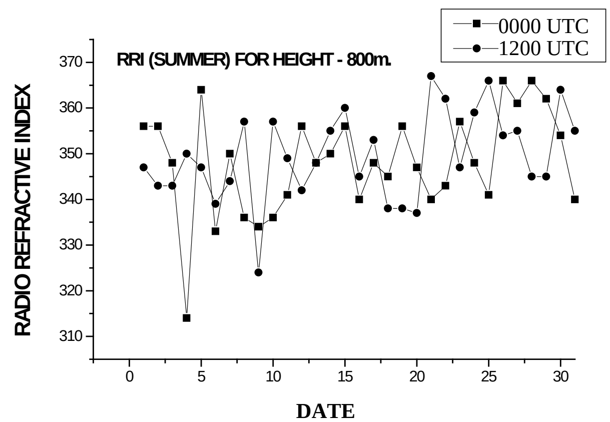

Fig. 2. Refractivity profile for summer for height : 800 m

$$e = 6.1078 * \exp [5417.1 * (1/273 - 1/T_d)] \tag{5}$$

T_d is the dew point temperature in Kelvin.

Hence the total refractivity is written as

$$N = 77.6 \, P / T + 3.73 * 10^5 * e / T^2 \tag{6}$$

3. For model computation of refractivity profile over Kolkata, the atmospheric temperature, pressure and dew point temperature are first examined at 0000 UTC and then at 1200 UTC from radio sonde observations throughout the ten year study (1997 to 2006). The refractivity for twice a day is calculated for two heights using Equation (6). The surface refractivity determined at 4 meter level and the elevated refractivity at around 800 meter heights are computed. Apart from this diurnal

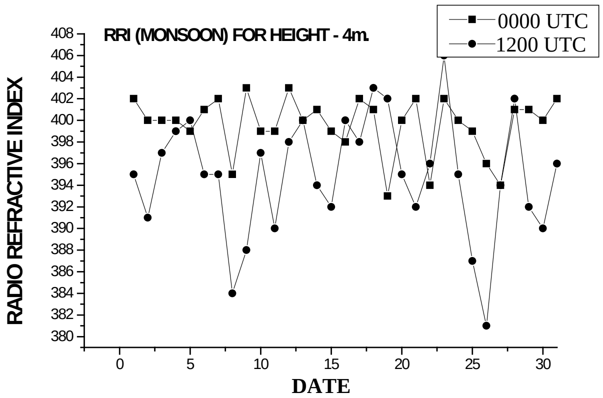

Fig. 3. Refractivity profile for monsoon for height : 4 m

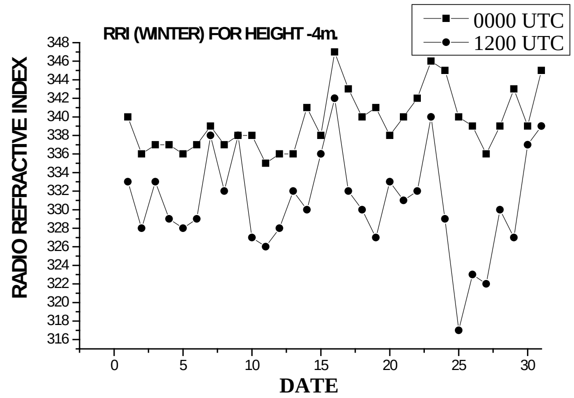

Fig. 5. Refractivity profile for winter for height : 4 m

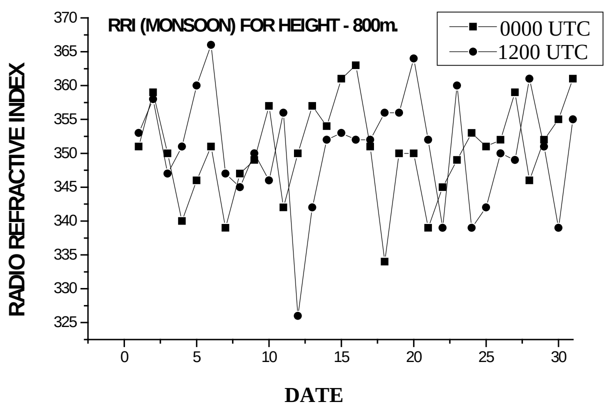

Fig. 4. Refractivity profile for monsoon for height : 800 m

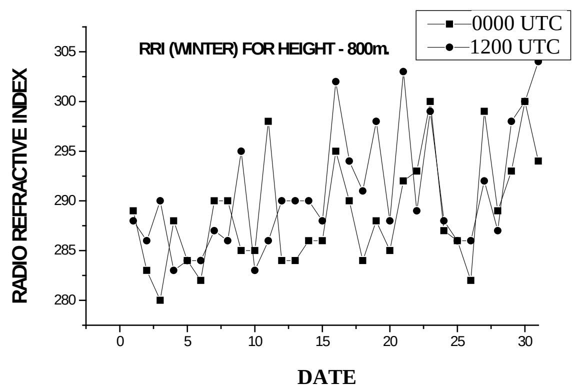

Fig. 6. Refractivity profile for winter for height : 800 m

classification, refractivity are also critically examined from seasonal point of view. Data for 1st May for the years 1997 to 2006 have been studied and the average value is determined. Similarly the figures have been calculated for each date of the month of May from the above mentioned ten year period. In this manner exercise has been done for the month of July, to cover monsoon season and January for winter.

4. (*i*) *Season – Summer, Height : 4 m* - The average value of RRI at 0000 UTC is N = 394 which is higher than that of 1200 UTC having N = 381. The RRI of 0000 UTC does not fluctuate much from its mean value. But for 1200 UTC situations, the RRI have lower values in the beginning of the season but gradually its value increases as summer heat intensifies and then become almost those of the 0000 UTC equivalent (Fig. 1).

(*ii*) *Season – Summer, Height : 800 m* - The characteristics graph of the RRI at 800 m for summer season for both 0000 and 1200 UTC are found to be analogous to each other. The average RRI for 0000 UTC (N = 348) is marginally lower than that of 1200 UTC (N = 349). The 0000 UTC and 1200 UTC graph show a uniformity in its values throughout the month (Fig. 2).

(*iii*) *Season - Monsoon, Height : 4 m* - The average RRI parameter for monsoon period at the ground surface is N = 400 for the morning and N = 395 for the evening observations. A swing from values 380 to 410 are observed in 1200 UTC. Such variation in day-to-day figures are absent in the morning study. The RRI maintains a standard value all through the month (Fig. 3).

(*iv*) *Season – Monsoon, Height : 800 m* - The patterns for 0000 UTC and 1200 UTC for the elevated RRI structure in the monsoon month resembles that of the ground values. The average number for the former is 350 and that of the latter is 351. The fluctuation in the RRI values from the mean value are more in the 1200 UTC period than those in the 0000 UTC (Fig. 4).

(*v*) *Season – Winter, Height : 4 m* - In the winter season at 4 m height, the day to day calculated RRI both 0000 and 1200 UTC have average values different. Here the average value at 0000 UTC (N = 339) is more than that of 1200 UTC, where N = 331 (Fig. 5).

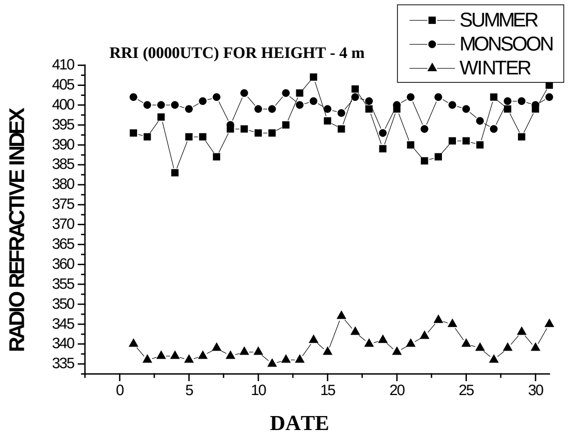

Fig. 7. Refractivity profile for 0000 UTC for height : 4 m

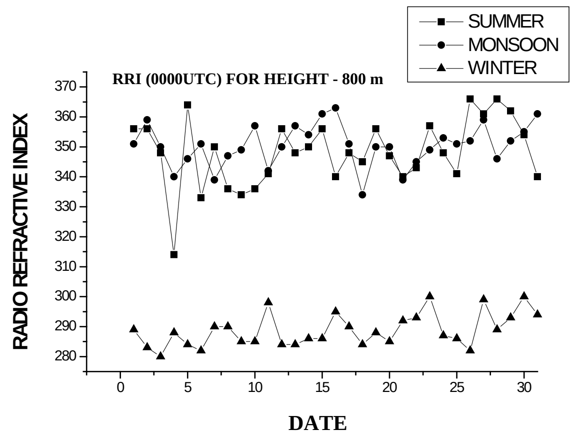

Fig. 9. Refractivity profile for 0000 UTC for height : 800 m

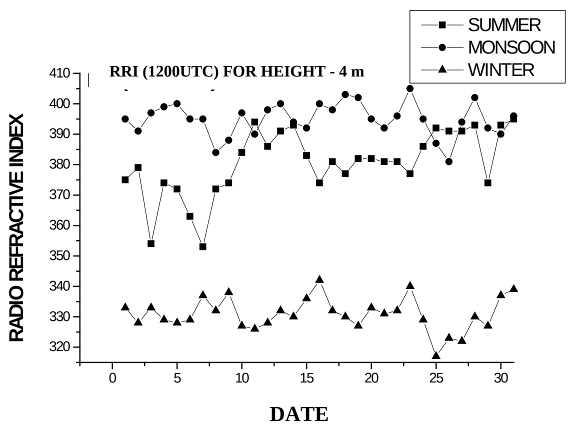

Fig. 8. Refractivity profile for 1200 UTC for height : 4 m

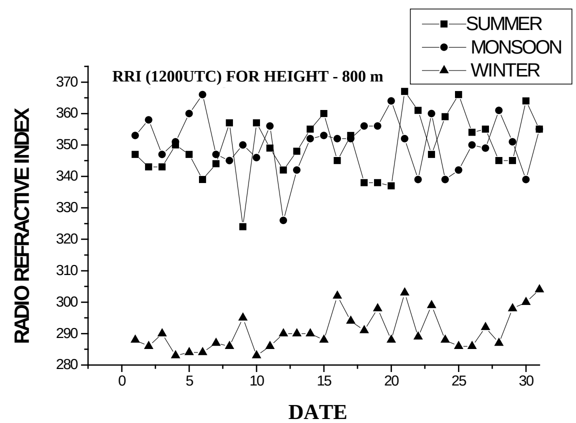

Fig. 10. Refractivity profile for 1200 UTC for height : 800 m

(*vi*) *Season – Winter*, *Height : 800 m* - At the height of 800 m, the average refractivity at 1200 UTC (N = 291) is seen to be marginally higher than that determined in the 0000 UTC (N=289) period (Fig. 6).

5. *Seasonal characteristics* - (*i*) For the early morning hour observing period at the 4 m level, RRI has more or less same value in the summer and monsoon months. But the winter experiences a much lower value (Fig. 7).

(*ii*) In the evening hours at surface level, the refractivity in winter have much lesser values in comparison to those of monsoon. The values of summer lies between the two (Fig. 8). The difference of the mean value of refractivity of month of summer/monsoon study with that of winter, remains almost equal in both the morning and late afternoon experiments.

(*iii*) At the higher altitude in the morning hours the monsoon and summer months have almost same RRI (Fig. 9).

(*iv*) At the same height in the evening period, the computed values of RRI are found to be in analogous with that of the lower level. Winter, here too have diminished values (Fig. 10).

6. *Diurnal variation* – (*i*) At the summer morning observation time, the average RRI falls by 11.7 % from 4 m to 800 m height whereas in the evening period it falls by 8.1 %.

The refractivity at the evening time at surface is 3.4 % less than that of morning period. At higher altitude (800 m.) the 1200 UTC increases nominally by 0.3 % (Fig. 11).

(*ii*) In the monsoon season, the average RRI falls by 12.3 % from 4 m to 800 m at 0000 UTC and by 11.2 % at 1200 UTC.

At the 4 m level the RRI falls by 1.16 % from morning to evening and it goes up by only 0.04 % at 800 m height (Fig. 12).

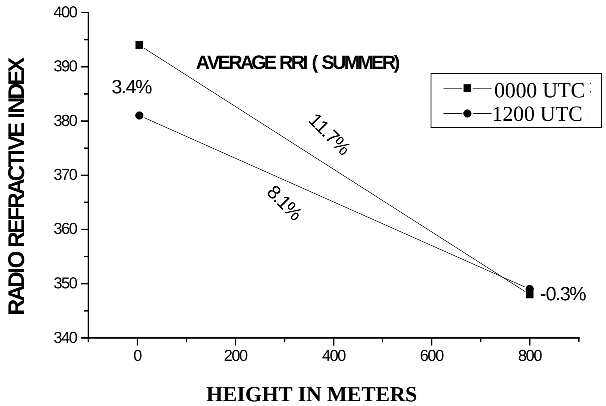

Fig. 11. Average refractivity profile for summer

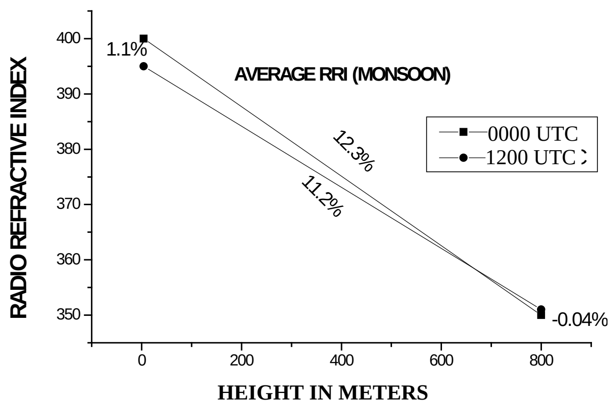

Fig. 12. Average refractivity profile for monsoon

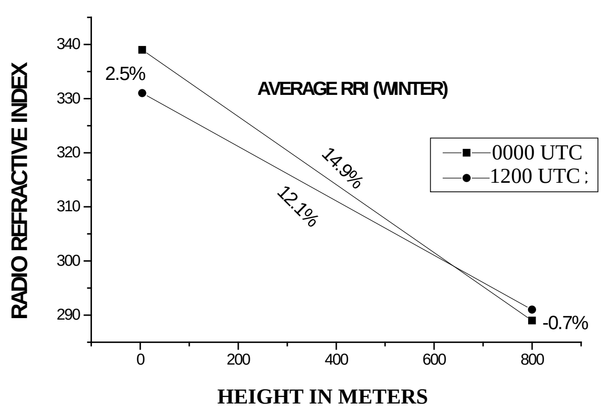

Fig. 13. Average refractivity profile for winter

(*iii*) It is seen that the average RRI in the winter month falls by 14.9 % from 4 m to 800 m height at 0000 UTC and that at 1200 UTC it falls by 12.1 %.

There is a fall of 2.5 % RRI in the winter season from 000 UTC to 1200 UTC at the surface, whereas the same rises by 0.7 % at 800 m level (Fig. 13).

7. It is observed that the values of RRI at an altitude of 800 m always have higher values in the evening hours compared to that of morning. In contrast the surface refractivity has values higher in the morning and lower in the evening. The probability of the presence of atmospheric boundary layer that forms due to the vertical diffusion of heat and moisture attributes to the above fact (Schiavone 1982). This atmospheric boundary layer disorients itself only after sunset.

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