

551.510.62 : 551.553.21

AN ANALYSIS OF MONTHLY AND SYNOPTIC SCALE VARIATION OF RADIO REFRACTIVE INDEX DURING PRE-MONSOON AND MONSOON ONSET PHASE

1. India Meteorological Department has defined onset of South West monsoon on the following criteria:

(i) *Wind field* - Depth of westerlies should be maintained upto 600 hPa in the box equator to Lat. 10 deg. N and Long. 55 to 80 deg. E. The zonal wind speed over the area bounded by Lat. 5 to 10 deg. N and Long. 70 to 80 deg. E should be of the order of 15 to 20 knots at 925 hPa.

(ii) *Out going long wave radiation* - OLR values should be below 200 W/m² in the box confined Lat. 5 to 10° N and Long. 70 to 75° E.

Since the changes in moisture content in lower and middle troposphere from pre-monsoon to monsoon onset in turn affect Radio Refractive Index (RRI), the focus of study is to understand changes in RRI in transition from pre-monsoon to monsoon onset over the station Thiruvananthapuram in Kerala. A number of studies [Bean and Riggs, 1959; Jehn, 1960; Maheswari, 1962; Venkataraman *et al.*, 1963; Sharma and Subramanian, 1983] have been undertaken with a view to investigate how the RRI could be utilized as a synoptic parameter. Kulshrestha and Chatterjee 1966 found that the highest values of RRI could be utilized as a synoptic parameter. Kulshrestha *et al.* 1966 found that the highest values of RRI during the monsoon season occur along the coasts, south peninsula and Assam. In the present work, an attempt has been made to study the monthly variations of the RRI with height over a station and variation associated with onset phase of the southwest monsoon

2. The propagation and the refraction of radio signals up to UHF in the troposphere and stratosphere relies on the variations of the refractive index n of air (~1.0003) (Dutton and Thayer 1961). To make figures easy, a new value is defined - the refractivity or modified radio refractive index given by the following relation [Smith and Weinturb, 1953]:

$$N = (n-1) \times 10^6 = 77.6 P/T + 3.73 \times 10^5 e/T^2$$

where P is the pressure in hPa, T the temperature in degree Kelvin and e the water vapour pressure in hPa. The two terms on r.h.s. represent the contributions due to dry air (N_d) and water vapour (N_m) respectively.

Thus, $N = N_d + N_m$. These two parts have been separated out and the results for the later have been outlined.

Radiosonde data at 0000 UTC of Thiruvananthapuram for the years 2004 to 2006, rainfall data of Kerala for the month of May and June 2004 and 2005 and NCEP reanalysis data have been used in this work for the computation of RRI.

The monthly mean value of refractive index at different pressure levels was computed from Radiosonde data of individual 0000 UTC ascents and wet component (N_m) of RRI has been analysed. Fig. 1 depicts the variation of monthly mean N_m at 1000, 925, 850 and 700 hPa levels over Thiruvananthapuram for the year 2005. In the lower troposphere N_m has a monthly variation; being minimum during winter (December, January & February) and maximum during May and steady for monsoon period.

Our analysis of the daily variation of N_m shows significant rise, particularly in connection with onset phase of monsoon. Since a single N_m value might not be a good representation of the day, the average of consecutive five-days' N_m values has been considered more appropriate to show the trend of variation at the central day. Further, the analysis was extended and selected for the period from April to third week of June for three years (2004 to 2006). Fig. 2 depicts the five-day moving average of the wet component (N_m) of the RRI at different levels over Thiruvananthapuram for 2005. From Fig. 2, the following observations are made:

A significant rise of about 20 N units for the wet component of Radio Refractive Index is observed at all the four levels between 20th and 25th May. A steep slope (sharp rise) is observed for the levels 925 hPa and 850 hPa. In short, high value of N_m for the pentad ending on May 25th indicates that the moisture content of all the four levels increases and approaches a steady value, which is well in advance of the arrival of southwest monsoon over the station (*i.e.*, the onset of monsoon in India). The date of onset of monsoon for 2005 is 5th June, which is just two weeks after the N_m registers a high value (sharp rise).

N_m shows fluctuations at 1000, 925 and 850 hPa levels up to middle of May, and afterwards remain more or less steady. However, at 700 hPa, fluctuation continues even after this period. This is because after the monsoon onset, day to day fluctuations in moisture are more at 700 hPa rather than in the lower troposphere. The steadiness of N_m is first observed for the lower troposphere as compared to higher levels.

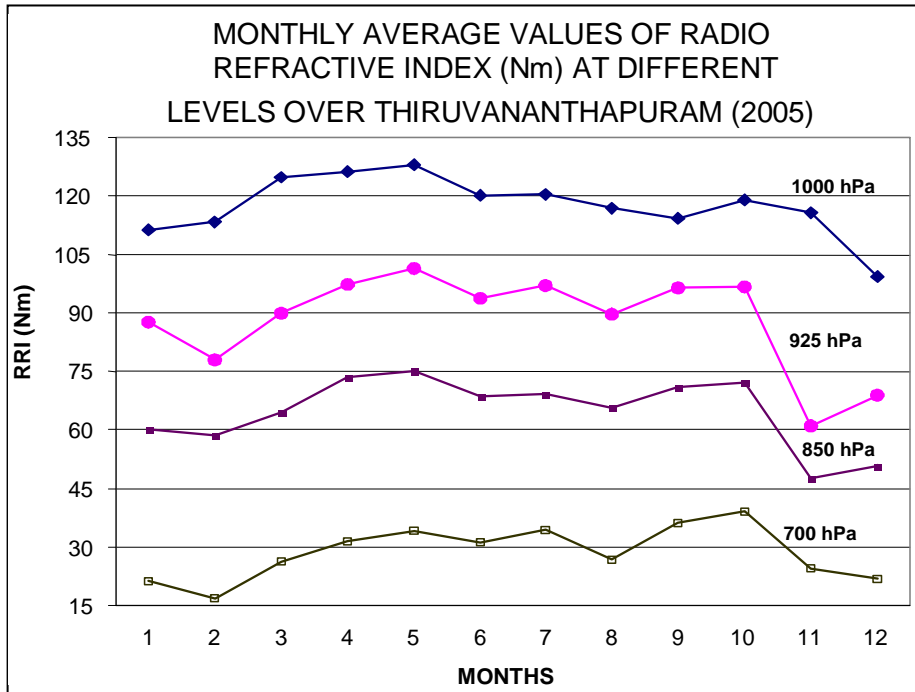


Fig. 1. Variation of monthly mean Nm at 1000, 925, 850 and 700 hPa levels over Thiruvananthapuram for the year 2005

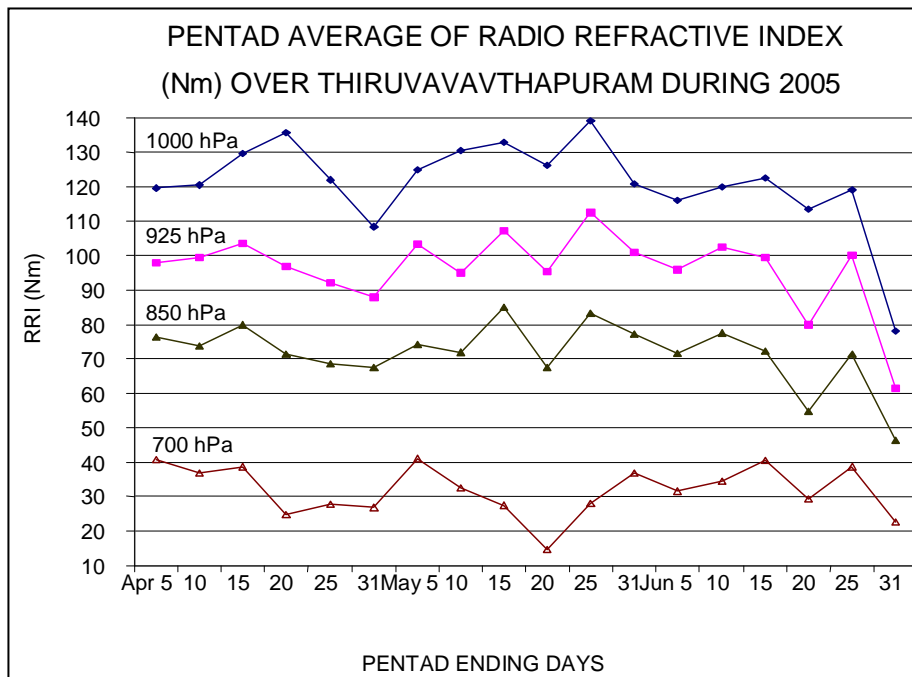


Fig. 2. Five-day moving average of the wet component (Nm) of the radio refractive index at different levels over Thiruvananthapuram for 2005

It is evident from the data that all the above mentioned indications appear correct for the pentad ending on 5th May for the year 2006. Date of onset of southwest monsoon for 2006 was 26th May, which is 3 weeks after Nm registered a high value for all the four levels.

3. During 2004 a cyclone formed over South Eastern Arabian sea (5th to 9th May) and existed over Lakshadweep Island with highest rainfall recorded at the Island station Aminidivi on the 6th May (1168.5 mm). (Indian Daily Weather Report, 2004, from May 5th to May 9th). RRI due to moisture, rose abruptly two weeks ahead of its approach (last week of April). As such Nm is highest for April for this year. It is observed that the refractive index values (wet term) show a marked rise up to about 700 hPa with the approach of the cyclone and continues to remain at more or less the same value with advance of monsoon; onset being on May 18th. This would, therefore, enable one to anticipate the propagation characteristics of radio frequency waves with approach of tropical cyclone, low pressure systems, onset of monsoon etc.

Over South Kerala, depth of westerlies was maintained above 600 hPa by 5th June 2005. The zonal wind speed over the area became of the order of 15 to 20 knots and relative humidity rose from 65% to 90% at the level of 700 hPa during 1st to 5th June 2005. Similar changes are observed in other 2 years also as moisture build up in the layer surface to 700 hPa takes place due to synoptic variability.

4. Rapid advance of Southwest monsoon is very much reflected in variation of RRI values. This is because the water vapour content in the troposphere increases with the onset of monsoon. The enhancement of low level values first occurs just before 2-3 weeks ahead of onset of Southwest monsoon by at least 20 N units, with the persistency during the next few days, as the water vapour content in the troposphere builds up even about 2 weeks prior to the monsoon onset. In case the monsoon onset occurs in association with the formulation of a monsoon onset vortex, the increase in Nm is slow and abrupt within 3 to 5 days prior to the monsoon onset over Kerala.

5. The authors are grateful to IMD for providing necessary data for this study and are sincerely thankful to

Dr. R. V. Sharma. Dy. Director General of Meteorology (Retd.), Regional Meteorological Centre, Mumbai for his valuable suggestion in improving the present work and constant encouragement.

References

- Bean, B. R. and Riggs, L. P., 1959, "Climatology of ground based radio ducts", *J. Res. Nat. Bur. Stand.*, **63(d)**, p91.
- Bean, B. R., Riggs, L. P. and Horn, J. D., 1959, "Synoptic study of the vertical distribution of the radio refractive index", *Ibid.*, **63D(2)**, p249.
- Dutton, E. J. and Thayer, G. D., 1961, "Techniques for computing refraction of radio waves in the troposphere", NBS Tech Note 97.
- Indian Daily Weather Report, 2004, (From May 5th to May 9th) issued by India Meteorological Department.
- Jehn, K. H., 1960, "The use of potential refractive index in synoptic scale Radio Meteorology", *J. Met.*, **17**, p264.
- Kulshrestha, S. M. and Chatterjee, K., 1966, "Radio-climatology of India: Radio refractive index near the ground surface", *Indian J. Met. & Geophys.*, **17**, p367.
- Maheshwari, R. C., 1962, "RRI structure over northern India and its synoptic variation", *Indian J. Met. & Geophys.*, **13**, p57.
- Sharma, R.V. and Subramanian, D. V., 1983, "RRI associated with the onset phase of southwest monsoon", *Mausam*, **34**, 3, p338.
- Smith (Jr.), E.K. and Weinturb, S., 1953, "Expression for Astronomical refraction", *Proc.Inst. Radio Engrs*, N.Y, 41, 1035.
- Venkataraman, K. S., Srivastava, H. N. and Chawla, B. K., 1963, *Indian J. Met. & Geophys.*, **14**, 3, p333.

V. K. MINI
S. R. PRABHAKARAN NAYAR*

*India Meteorological Department,
Thiruvananthapuram – 695033, India
e mail: minijayalal@yahoo.co.in*

**Department of Physics, University of Kerala,
Thiruvananthapuram – 695 581, India
(Received 23 July 2009, Modified 11 November 2011)
e mail: srpnayar@gmail.com*