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Radio refractivity over equator and south Arabian Sea from Monex-1979 data

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ABSTRACT. Surface and radiosonde observations collected by Russian ships during May and June of Monex-1979 experiment have been analysed and radio refractive indices were calculated for levels upto 500 mb. Typical vertical profiles for different location over sea and for equator have been arrived at. Time and space variation of the Radio Refractive Index (RRI) over equator have been investigated around the time of onset of monsoon.

An increase in RRI values was brought about around 18 May between 850 and 700 mb levels as observed by Russian ships in south Arabian Sea. This shows a change in moisture character of the airmass due to monsoon arrival and this hints that the influx of moisture is mainly in the mid-troposphere rather than at surface level. There does not seems to be any diurnal variations in RRI either at surface or at higher levels.

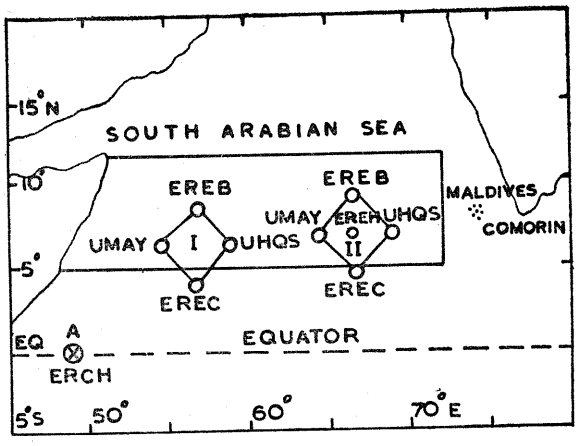
1. Introduction

The meteorological conditions in the lower and mid troposphere play a significant role in deciding the radiohorizon, signal strength, trapping of radiowaves and anomalous propagation of radiowaves. Radiorefractive index is the function of the three main meteorological parameters that influence the radio wave propagation, namely temperature, pressure and humidity. Bean and Dutton (1968) have studied the synoptic radio meteorology for U. S. A. Kulshrestha and Chatterjee (1966, 1967) have given the radio climatology for India. Kulshrestha (1975) has also given the radio refractivity for sea areas adjoining the Indian subcontinent for different months. However it is of interest to study the radiorefractivity over equator and also how the monsoon arrival is reflected in radio-refractivity over the south Arabian Sea. The same is tried here using the Monex—1979 data.

2. Data and programme

The ship *Priboy* was stationary at Long. 49 deg. E on the equator between 19 and 30 May and took surface and upper air observations. During the first half of May *Academic Korolov* and *Academic Shirshov* made cruises along equator between Long. 50 deg. to 62 deg. E. They took surface observations. These were the data for the study pertaining to equatorial regions.

Four ships *Academic Korolov, Academic Shirshov, Volna* and *Priliv* formed a stationary polygon between 16 to 29 May around about 7 deg. N, 57 deg. E. Both surface and upper air observations were taken at 6 hourly intervals. Then the ship dispersed. During 7 to 14 June 1979 the above ships again formed a polygon around about 6.9 deg. N, 66.3 deg. E. Another ship *Priboy* occupied the central point. While the first polygon can be taken as representative of the onset phase of monsoon, data for the second polygon will represent the set conditions of monsoon. The ships' position and the south Arabian Sea portion are shown in Fig. 1. The location of the ship, *Priliv* (EREC) is just one degree latitude outside south Arabian Sea in the Indian Ocean area. However since



I-SHIP'S I POLYGONAL POSITION DURING 16-29 MAY 1979

II-SHIP'S II POLYGONAL POSITION DURING 07-14 JUNE 1979

A-SHIP PRIBOY'S STATIONARY POSITION DURING 19-30 MAY 1979

Fig. 1

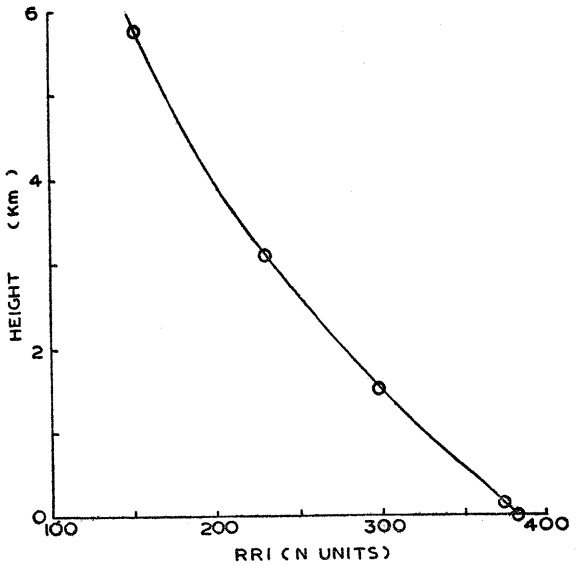


Fig. 2. Average profile of RRI for equator (taken at 49°E)

the polygonal position as it is has been considered for analysis where centre falls in south Arabian Sea, we consider the radio refractivities arrived at from these ships to represent south Arabian Sea in general. The various ships are referred by their call signs as *Priliv* (EREC), *Priboy* (EREH), *Volna* (EREB), *Academic Shirshov* (UMAY) and *Academic Korolov* (UHQS).

3. Method and analysis

The radio referactivity is computed using the equation :

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

where P is the pressure, T is the temperature and e is the water vapour pressure. P and e are in millibars while T is in degrees Kelvin. Surface refractivity was calculated for all the four observations 00, 06, 12 and 18 GMT in a day. Similarly N values for surface, 1000, 850, 700 and 500 mb were computed.

The study is under two parts : (*i*) for equatorial region and (*ii*) for the souh Arabian Sea areas which were covered by the two polygons. Again the analysis of surface values is discussed first from which time and space variations if any can be, found out. Then the vertical profile can be discussed.

4. Discussion

(*i*) *Equatorial Seas*

Between 16 and 25 May, the ship *Priboy* was stationary over equator at Long. 49 deg. E. Except at one occasion on 28th and 29th the surface radio refractivity was constant at 385. Hence there is no time variation of '*N*' value at equator. Even diurnally no change was observed. Then values for 1000, 850, 700 and 500 mb levels were also calculated for each occasion. No appreciable variation in the '*N*' values was observed at 1000, 700 and 500 mb levels. However, at 850 mb level the variation was about 20 (value varied from 288 to 312). The vertical profile of radiorefractivity is given in Fig. 2. Only for 850 mb average was taken while for other levels the values were practically constant.

During 25 to 29 May, the ship *Priboy* moved over equator from Long. 49 deg. E to 61 deg. E. This data could be used to see the existence of any spatial variations. *Academic Shirshov* and *Korolov* took observations over equator in the first week of May. These supplemented the *Priboy* data. Table 1 shows these values. It is clear that there is no appreciable change in the N values at surface level over equator between Long. 49 deg. E to 62 deg. E around the time of onset of monsoon.

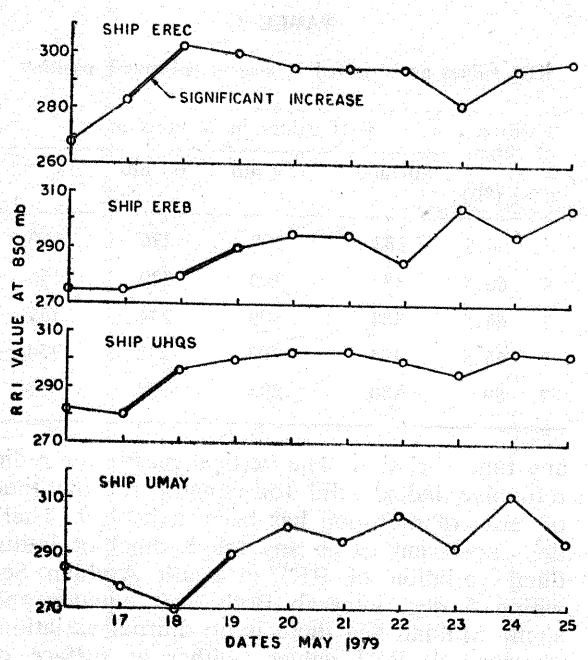


Fig. 3

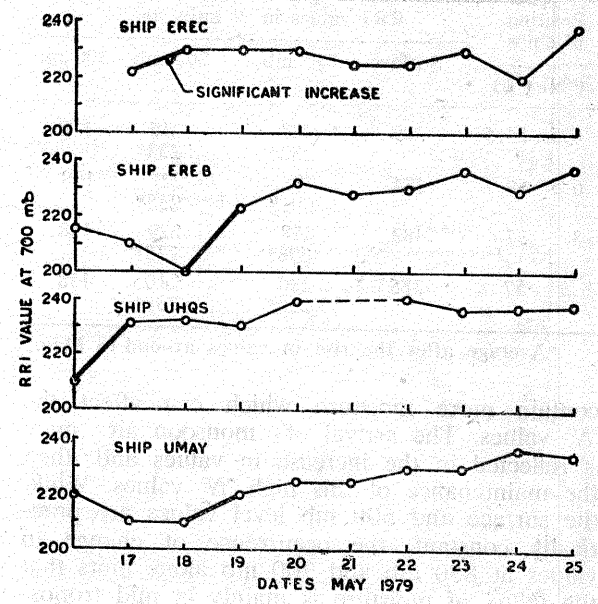


Fig. 4

TABLE 1

Surface RRI values along equator

Long. (o)	RRI (*N* units)	Long. (o)	RRI (*N* units)
49	385	57	385
50	385	59	385
51	380	61	380
56	388	62.2	380

(ii) South Arabian Sea

The centres of polygonal positions were along Lat. 6.5 deg. N and Lat. 7 deg. N respectively. Hence they can be considered as representing the conditions of south Arabian Sea. The first point noted was that there was no diurnal variation in the '*N*' values either at surface or at upper levels. The values are within the specified range found by Kulshrestha (1975). Comparing the values from the observation of ships stationed diagonally opposite, the existence of any latitudinal or longitudinal change within 5 deg. was investigated. Both latitudinally and longitudinally there is no significant variation in surface refractivity. The values are within $\pm$ 5 deviation only. Same is the case with higher level '*N*' values also.

The refractivity values for 850 and 700 mb levels deserve close scrutiny. Figs. 3 and 4 give the values observed at these two levels respectively for each day. *Priliv* and *Academic Korolov* showed an increase in value on 18th while *Volna* and *Academic Shirshov* showed a rise on 19th at 850 mb. The rise in value is more than 15 except for *Volna* which is about 10. The values are maintained afterwards.

The temperatures are correct within $\pm$ 1 deg. and hence the error due to contribution of dry term in the equation for RRI can be about 2 for 850 mb and 700 mb. The error in humidity observation at upper air can be about 10 per cent. This inaccuracy can cause an error of about 10 in RRI due to contribution from wet terms for 850 mb and about 8 or 700 mb. Fig. 4 gives the RRI values at 700 mb. There also *Academic Shirshov* and *Volna* show an increase in RRI on 18th, *Academic Korolov* on 17th and *Priliv* on 18th. The values are maintained afterwards. In the light of the argument put forward, the rise in values can be considered a significant rise. Hence a rise in RRI values is observed around 18th at 850 and 700 mb levels by all ships.

This can be understood as follows :

There is an air mass transport from southern hemisphere to northern hemisphere around the time of onset of monsoon. This is believed to

TABLE 2

Position of ships (°N)	(°E)	RRI values in N units at Surface	850 mb	700 mb	500 mb
6.5	54.5	389	277 282*	215 233*	158
6.5	59	384	287 301*	227 238*	158
3	57	383	278 298*	229 235*	158
8.5	57	385	280 292*	210 230*	158

*Average after the rise in values around 18 May.

contain more moisture which can affect the 'N' values. The arrival of monsoon air mass is reflected in the increase in values and then the maintenance of this high 'N' values. While the surface and 500 mb level values are practically constant, the occurrence of change in values at 850 mb and 700 mb alone hints that the influx of moisture is mainly in mid troposphere rather than at surface level.

Table 2 gives the vertical profile values of RRI for each ship for first polygonal position. For 850 and 700 mb levels along averages before and after the increase is brought about have been arrived at and shown separately.

Regarding the observations by ship in second polygon between 2 and 13 June 1979 the values for all levels are steady within $\pm$ 5. The averages have been worked out and the profiles arrived at (Table 3). The significant point to note is that the average value for 850 and 700 mb is close to the value observed during I polygon phase after the rise has occurred.

5. Conclusions

There is no space variation of radio refractive index at surface and higher levels along the equatorial regions considered nor is there any time variation. The vertical profile for radio refractive index valid for equator for the time of onset of monsoon has been arrived at. There does not seem to be any longitudinal or latitudinal variation of RRI in south Arabian Sea within 5 deg. interval. Both over equator and south Arabian Sea there is no diurnal variations observed in RRI values either at surface or at higher levels upto 500 mb. An increase in RRI values was observed around 18 May at 850 mb and 700 mb levels, probably due to the moisture change from the monsoon airmass.

TABLE 3

RRI values as observed in second polygonal position

Position of ships (°N)	(°E)	RRI values in N units at Surface	850 mb	700 mb	500 mb
5	66.5	383	300	236	160
9	66.5	387	300	229	156
7	64.5	384	300	234	159
7	66.5	384	302	232	154
7	69	380	298	234	158

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