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MEAN ZONAL WIND CIRCULATION OVER INDIA

Certain comments have been published by Koteswaram (1957) on the author's paper (Mooley 1956) on "Zonal wind circulation and vertical temperature distribution along the Indian longitudes during the monsoon and winter seasons". The author would like to make the following observations in the same context.

The author (Mooley 1956) selected the longitudinal range 71½°—80½°E for the preparation of the vertical cross-sections for monsoon and winter seasons based on data for limited number of years because such a procedure will provide sufficient number of stations extending over a considerable latitudinal range; moreover, for longitudes east of 80½°E radiosonde data from India, Pakistan, Burma or Tibet did not exist north of 27°N and that would present difficulty in locating zonal wind maximum if this existed at 27°N or further north. As radiosonde data for Peshawar were available for 1944-47 only, it was not considered advisable to use data for other radiosonde stations for years beyond 1949. Mean cross-sections based on radiosonde and pilot balloon data for the period 1944-49 for monsoon and winter for the above-mentioned longitudinal range were prepared. In addition, for winter, zonal wind components for latitudes 30½°N, 27°N, 23°N and 21°N obtained from upper wind normals based on data upto 1950 for level 1 and 12 km for the same longitudinal range

were stated to indicate the trend exhibited by the available normal wind data.

The legends to Figs. 3, 5 and 6 as well as the text of the paper make it clear that the cross-sections of 'observed' mean zonal winds constructed by the author in support of double maxima are based on data for 1944-49 and not on data upto 1950 as stated by Koteswaram (1957).

Koteswaram has also mentioned that the normals at 12 km were based on very few observations. However, at 11 km the trend of higher zonal wind at 27°N was not indicated by the pibal 'normals' although the number of observations was about double, the actual numbers being 22 at Ambala, 52 at Agra, 68 at 23°N and 89 at 21°N.

If the observations at 12 km on which 'pibal' normals were based are considered very few north of 21°N, it is obvious (as can be made out from Table 6 of the author's paper) that the observations at 12 km on which Fig. 6 of this paper was based are still very few as data for Fig. 6 refer to the years 1944-49 only. Under these circumstances it is difficult to place more reliance on Fig. 6 than in the trend of pibal normals.

Koteswaram doubts the reliability of Jodhpur radiosonde data. It is agreed that radiosonde data of an individual station on some occasions do appear to be wrong. But difficulty arises in believing that mean winter values of a particular station based on the data for a number of years are not reliable particularly when there is no radiosonde station nearby to serve as a comparative standard, the nearest station being beyond 300 miles. From a study of the annual means for Delhi and Poona, the author (Mooley 1956) has shown that there are considerable variations from year to year. Annual means for Jodhpur given in Table 1 (p. 406) for winter (mean of January and February) for post-1949 years also indicate considerable variation from year to year.

It is seen that the upper troposphere over Jodhpur in post-1952 years has been rather significantly warmer than in pre-1953 years. The mean values used by the author (Mooley 1956) and Koteswaram, Raman, and Parthasarathy (1953) do not appear to be unreliable when mean values for later years are considered. To test whether any reliance can be placed on Jodhpur data, mean zonal wind for latitude 23°N at the level of wind maximum obtained by using the data for Karachi and Veraval as given in Table 3 in the paper by Koteswaram, Raman and Parthasarathy can be compared with that obtained by using Jodhpur data to see whether any fair agreement exists. The zonal wind for 23°N at 200-mb level relative to the wind at 700-mb level obtained by using the Karachi and Veraval temperature data comes out to be westerly 40 mps. When the mean zonal wind (westerly 8 mps) at 700-mb level is added, a wind of 48 mps at 200-mb level at 23°N results. This is in fair agreement with the wind of about 90 knots (46·5 mps) obtained from Fig. 5 of the author's paper.

There is disagreement between Fig. 2 of the author's paper and the indications of pibal data in respect of monsoon zonal wind distribution in the upper troposphere between 20° and 31°N (the northern limit upto which the section of geostrophic winds extends) and as such no conclusion has been drawn in the matter. In general, there is some difficulty in comparison between the calculated winds and the pibal data during monsoon. The question which arises is, how far the monsoon (mean of July and August) pibal data, particularly in higher levels, can be considered representative of the season in view of prevalence of extensive low and medium clouds in most of the days? Koteswaram has stated that the westerly component in the upper troposphere as seen in Fig. 2 of the author's paper is due to reliance on Jodhpur data. While this is not outside the realm of possibility, an examination of the mean monthly heights of the isobaric surfaces which are readily available from the published monthly weather reports for July and August 1951-54, reveals that the height of 200-mb level over Delhi is lower than at Poona except

TABLE 1

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Mb	1950	1951	1952	1953	1954	1955	1956	1957	Mooley	Koteswaram and others (mean of Dec, Jan & Feb)
900	288·4 (57)	287·5 (58)	290·0 (60)	290·5 (59)	289·2 (59)	289·6 (59)	290·1 (58)	288·4 (56)	290·0	
850	283·9 (55)	284·8 (56)	285·7 (60)	286·4 (59)	285·5 (59)	285·3 (59)	285·9 (58)	284·5 (56)	285·5	
800	281·4 (57)	281·1 (56)	281·6 (60)	282·6 (59)	282·0 (59)	281·2 (59)	282·1 (58)	281·2 (56)	281·6	
700	275·0 (55)	274·4 (56)	274·3 (59)	275·9 (59)	275·2 (59)	274·7 (59)	275·3 (58)	275·3 (56)	275·0	275·1
600	267·1 (55)	266·7 (56)	265·4 (58)	268·4 (58)	267·5 (59)	266·9 (59)	268·2 (58)	268·2 (56)	267·4	
500	257·6 (56)	257·5 (56)	255·9 (59)	259·1 (58)	258·3 (59)	258·4 (59)	259·7 (57)	259·3 (55)	258·3	258·3
400	245·5 (55)	246·3 (56)	243·8 (56)	248·0 (57)	248·5 (59)	248·8 (59)	249·2 (55)	249·2 (53)	247·0	
300	230·8 (55)	233·4 (52)	229·7 (50)	234·5 (52)	235·7 (57)	236·3 (52)	236·4 (50)	238·1 (48)	232·8	232·5
250	—	226·1 (40)	221·5 (48)	227·9 (48)	227·4 (54)	228·9 (47)	229·2 (43)	231·0 (45)	224·8	
200	215·1 (35)	219·1 (26)	215·9 (46)	225·1 (44)	219·1 (52)	221·9 (40)	223·3 (35)	222·6 (39)	217·2	216·9

Figures in brackets indicate the number of observations

TABLE 2

Mean height (gpm) of 200-mb surface

	1951		1952		1953		1954		Mean for 1951-54	
	Mean height	Ht. from mean temp. distribution	Mean height	Ht. from mean temp. distribution	Mean height	Ht. from mean temp. distribution	Mean height	Ht. from mean temp. distribution	Mean height	Ht. from mean temp. distribution
Delhi	12357 (46)	12481	12569 (45)	12535	12605 (32)	12582	12646 (39)	12611	12586 (162)	12553
Poona	12571 (37)	12566	12652 (38)	12592	12612 (39)	12589	12600 (56)	12579	12608 (170)	12582

Figures in brackets indicate the number of observations

during 1954. Mean seasonal figures computed from monthly mean heights are given in Table 2 (p. 406). Heights computed from mean temperature distribution are also shown in this table.

Thus, even at 200-mb level the mean values of the geopotential at Delhi and Poona would indicate a westerly component at the mean latitude ($23\frac{1}{2}$°N) during the years 1951 to 1953, while in 1954 an easterly component would be indicated; the composite picture for 1951-54 would also indicate a westerly component. The above instance has been given to bring out the variation in the mean picture from one year to the other and also the difficulty in ruling out one trend from the other while considering mean pictures based on the data of a limited number of years. It may be mentioned that the heights obtained from the mean temperature distribution for 1944-49 also indicate a westerly wind, the heights of 200-mb surface being 12506 for Delhi and 12522 for Poona.

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December 31, 1957.

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