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Anomalies in the aerological data of Mangalore and Ahmedabad

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सार — भारतीय स्टेशनों के वर्ष 1978, 1979 और 1980 से सम्बंधित वायु विज्ञानीय आंकड़ों के अध्ययन के दौरान, मंगलूर के राविन आंकड़ों और अहमदाबाद के रेडियोसौंदे आंकड़ों में गम्भीर विसंगतियों का पता चला। इन विसंगतियों की प्रकृति पर ध्यान दिया गया जो कि कई वर्षों से अनदेखी ही रही। मंगलूर के राविन आंकड़ों में विसंगति इस स्टेशन और अन्य प्रायद्वीपीय स्टेशनों के रेखांशिक पवन प्रोफाइलस की असंगता से पता चला। इसका पता स्टेशन में रेडियो पवन जांच उपकरण के त्रुटिपूर्ण अभिविन्यास से पता चला जिसको अब ठीक कर दिया गया है। ग्रीष्म मानसून महीनों के लिए अहमदाबाद में मासिक माध्म तापमान लगभग सभी क्षोभमंडलीय स्तरों पर बम्बई और जोधपुर में अधिक पाए गए हैं। परिणामस्वरूप, बम्बई-अहमदाबाद-जोधपुर सेक्टर में दाब-पवन संबंध बायस वैले ट्स के नियम के विरोध में जाते हैं। यह विसंगति बनी रहती है और अहमदाबाद में आभासी क्षोभमंडलीय ऊष्माद्वीप के मूल का पता चलाना शेष रहता है।

ABSTRACT. In the course of a study of the aerological data of Indian stations for the years 1978, 1979 and 1980 anomalies of a serious nature were noticed in the rawin data of Mangalore and the radiosonde data of Ahmedabad. Attention is drawn to the nature of these anomalies which have remained unnoticed for several years. The anomaly in the rawin data of Mangalore came to notice from the incompatibility of the meridional wind profiles of this station with those of other Peninsular stations. This was traced to the incorrect orientation of the radio wind-finding equipment at the station which has since been rectified. The monthly mean temperatures at Ahmedabad for the summer monsoon months were found to be higher than those of Bombay and Jodhpur at almost all tropospheric levels. As a consequence, pressure-wind relationships in the Bombay-Ahmedabad-Jodhpur sector contradict Buys Ballots' law. This anomaly persists and the origin of the 'spurious tropospheric heat island' over Ahmedabad remains to be traced.

1. Introduction

In the course of studies relating to the inter-annual variations of the weather and climate of India, we undertook a detailed examination of the aerological data of Indian stations for the years 1978, 1979 and 1980 for six months, May to October. This brought to light certain major discrepancies in the rawin data of Mangalore and the radiosonde data of Ahmedabad. It is the purpose of this paper to highlight the nature of these discrepancies for the benefit of the users of the aerological data of these two stations.

2. Anomaly in the rawin data of Mangalore

Utilising the monthly mean rawin data we prepared profiles of the zonal (u) and meridional (v) components of the winds for all the stations for the study period. Examination of the v-profiles of the Peninsular stations revealed a conspicuous anomaly in the case of Mangalore as compared with neighbouring stations. This can be seen from Fig. 1 (a) in which the monthly mean v-profiles for Mangalore and Trivandrum are shown for the months, June to September, for the years 1978, 1979, and 1980. Note that the meridional winds in the upper troposphere are northerly for Trivandrum while they are southerly at Mangalore. As this looked suspicious we decided to go backwards and examined the rawin data of Mangalore and Trivandrum for the previous years up to 1973 (the year of starting the rawin station at Mangalore). This showed that the v-profiles of Mangalore and Trivandrum for the southwest monsoon months were similar for the years 1973 and 1974; from 1975 onwards the anomaly had set in. This can be seen from Fig. 1(b) in which the v-profiles of the two stations are depicted for the monsoon months of 1973, 1974 and 1975. We conjectured that this anomaly was most probably due to incorrect orientation of the wind-finding equipment at Mangalore from 1975 onwards. From a study of the data we estimated that the direction taken as north was about 15° to the west of true north. The inspecting officer who was deputed to Mangalore for check up at our request to the Deputy Director General of Meteorology (Instruments) found that the instrument was 13° out of true orientation in the manner suspected by us. The defect was rectified on 6 February 1986. The rawin data of Mangalore prior to this date up to and including 1975 need correction by subtraction of 13° from the reported direction of the wind.

3. Anomaly in the radiosonde data of Ahmedabad

While examining the upper air temperatures at the aerological stations we came across a curious anomaly in the Bombay-Ahmedabad-Jodhpur sector. It was noticed that the monthly mean upper air temperatures at standard isobaric levels were systematically higher over Ahmedabad than the corresponding temperatures over Bombay and Jodhpur for all the six months, May to October, during the three years. This looked very unlikely since it is known that during the summer monsoon months temperatures increase progressively from south to north across the country at tropospheric

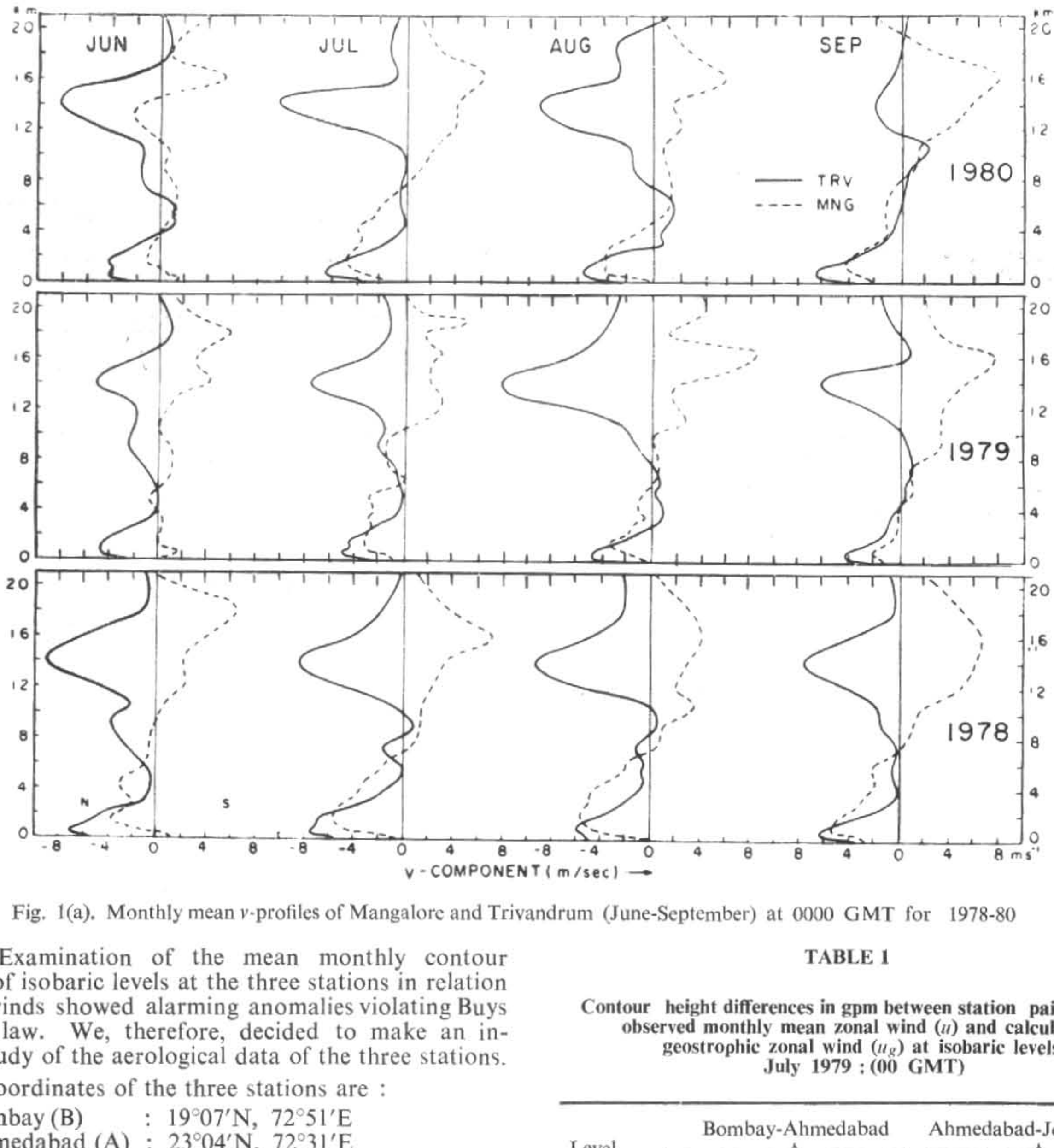

Fig. 1(a). Monthly mean v-profiles of Mangalore and Trivandrum (June-September) at 0000 GMT for 1978-80

levels. Examination of the mean monthly contour heights of isobaric levels at the three stations in relation to the winds showed alarming anomalies violating Buys Ballots' law. We, therefore, decided to make an in-depth study of the aerological data of the three stations.

The coordinates of the three stations are :

Bombay (B) : 19°07′N, 72°51′E
Ahmedabad (A) : 23°04′N, 72°31′E
Jodhpur (J) : 26°18′N, 73°01′E

It may be noted that the three stations lie very nearly along the same meridian. The methodology adopted in our study was : (a) to compute the monthly mean zonal geostrophic winds at standard isobaric levels for the B/A and A/J sectors utilising the contour heights evaluated from the radiosonde data and compare these with the mean observed winds between the station pairs and (b) to compute the temperature differences between the stations pairs utilising the vertical shear of the observed mean zonal winds and compare these values with the observed temperature differences. Both these involve the assumption that the monthly mean zonal winds in the B-A-J sector are nearly geostrophic which is a reasonable assumption in this case. The relevant geostrophic and thermal wind equations utilised for the computations are :

$$u_g = -(g/f)\,(\partial z/\partial y)_p$$
$$\partial u_g/\partial z = -(g/fT)\,(\partial T/\partial y)_p$$

TABLE 1

Contour height differences in gpm between station pairs ($\triangle Z$), observed monthly mean zonal wind (u) and calculated geostrophic zonal wind (u_g) at isobaric levels July 1979 ; (00 GMT)

Level (mb)	Bombay-Ahmedabad			Ahmedabad-Jodhpur		
	$\triangle Z$(gpm) (B—A)	u (ms^{-1})	u_g (ms^{-1})	$\triangle Z$(gpm) (A—J)	u (ms^{-1})	u_g (ms^{-1})
850	6	6.7	2.6	24	5.8	10.8
700	—7	3.0	—3.0	24	—0.1	10.8
600	—23	—0.5	—9.8	34	—2.2	15.2
500	—33	—3.0	—14.0	46	—3.3	20.6
400	—62	—4.5	—26.4	66	—3.0	29.6
300	—114	—9.2	—48.5	111	—5.2	49.8
250	—151	—11.7	—64.2	146	—6.2	65.5
200	—190	—16.8	—80.9	171	—7.7	76.7
150	—257	—20.1	—109.4	212	—10.0	95.1
100	—323	—23.3	—137.4	257	—16.8	115.2

where the symbols have the usual meaning. For computations the finite difference equivalents of the equations were made use of, with $\triangle y$=438 km for the B/A sector and $\triangle y$=359 km for the A/J sector.

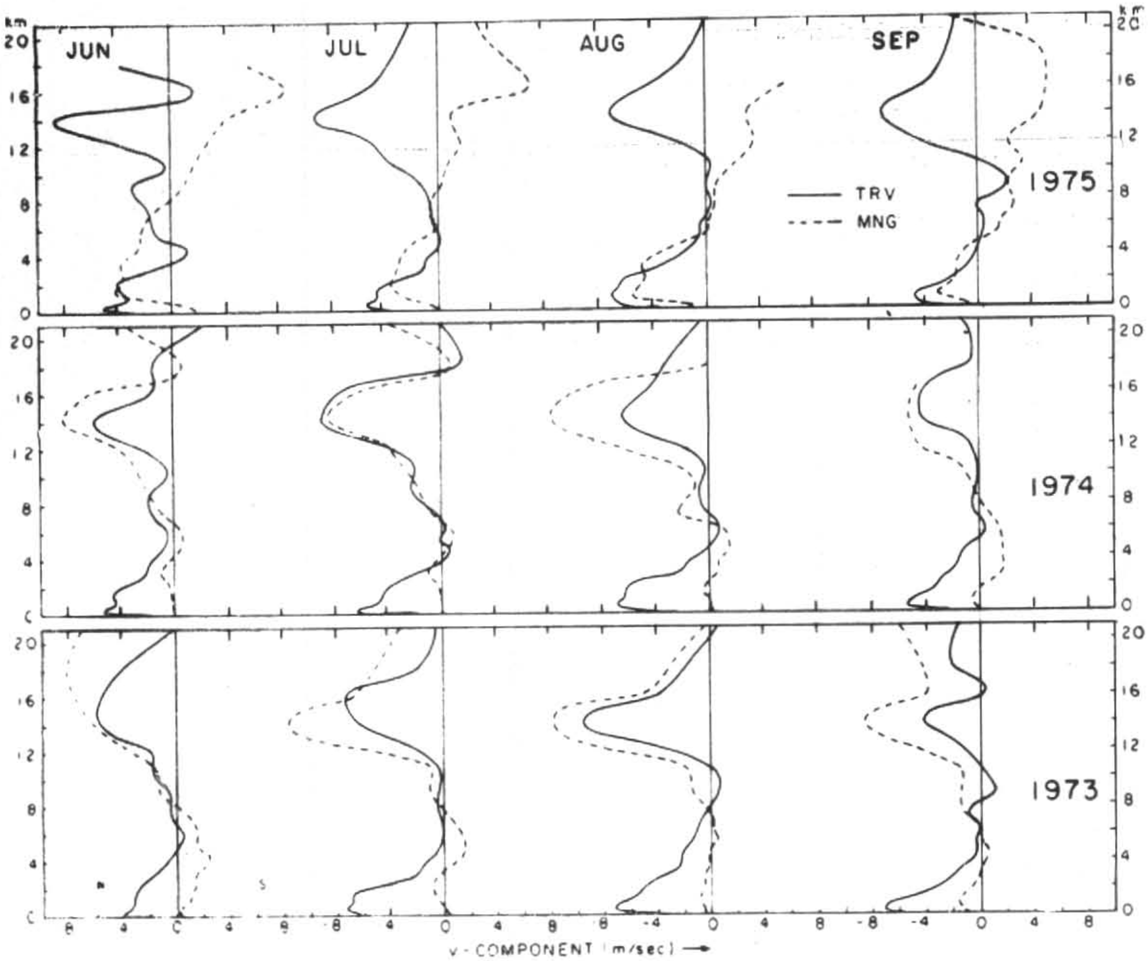

Fig. 1(b). Monthly mean v-profiles of Mangalore and Trivandrum (June to September) at 00 GMT for 1973-75

As a first step in the study, the normal aerological data of the three stations for the period up to 1975 available in the climatological publications of the IMD were examined for compatibility between winds and pressure gradients. It was noticed that approximate compatibility obtained in this data between the observed mean zonal winds of the station pairs and the calculated geostrophic winds utilising the contour heights, for the four months, January, April, July and October. This led to the conclusion that the anomaly noticed in the data for the years 1978-1980 has its origin apparently after 1975.

4. Comparison of observed and geostrophic zonal winds

A detailed examination was then made of the computed zonal geostrophic winds and the observed zonal winds at the 10 isobaric levels 850, 700, 600, 500, 400, 300, 250, 200, 150 and 100 mb levels in the B/A and A/J sectors for the six months May to October of 1979 (Monex year) utilising separately the 00 GMT and 12 GMT aerological data. The following discrepancies were noticed :

B/A sector

(*i*) In this sector the geostrophic winds in the upper troposphere are found to be strong easterlies in all the six months; the actual winds are, however, westerly in May and October.

(*ii*) The observed easterlies in the upper troposphere during June to September have speeds in the range 5 to 20 ms^{-1} whereas the computed geostrophic easterlies have speeds in the range 20 to 100 ms^{-1}.

A/J sector

(*i*) In this sector the geostrophic winds are found to be westerly throughout the troposphere in all the six months with speeds reaching 50 to 100 ms^{-1} in the upper troposphere; the actual winds in the upper troposphere are, however, easterly in the months of July and August with speeds in the range 3 to 15 ms^{-1}.

(*ii*) In the months May-June and September-October the actual westerlies are much weaker than the geostrophic westerlies which are 5 to 10 times stronger.

As an illustration, the relevant data for the month of July 1979 are given in Table 1.

The above discrepancies show the existence of large systematic errors in the radiosonde data of the Bombay-Ahmedabad-Jodhpur sector in recent years. Some insight into the nature of these errors is obtained from the finding that the geostrophic easterlies are much stronger than the actual easterlies in the B/A sector and geostrophic westerlies are much stronger than the actual

TABLE 2

Differences (δT) in °C between the observed temperature differences ($\triangle T$) and calculated temperature differences ($\triangle T'$) at isobaric levels in the B/A and A/J sectors

Level (mb)	Bombay-Ahmedabad							Ahmedabad-Jodhpur						
	May	Jun	Jul	Aug	Sep	Oct	Mean	May	Jun	Jul	Aug	Sep	Oct	Mean
850	−2.8	−3.3	−1.8	−1.1	+1.2	−0.7	−1.4	2.4	1.9	2.5	0.4	1.8	2.2	1.9
700	−0.4	−2.4	−2.6	−1.3	−1.4	−1.5	−1.6	1.8	2.6	4.0	2.2	1.6	2.7	2.3
600	−0.5	−3.5	−2.0	−1.6	−2.4	−1.7	−2.0	3.1	3.6	3.4	1.7	3.2	2.7	3.0
500	−1.1	−2.0	−2.9	−1.9	−2.2	−1.4	−1.9	3.5	2.7	3.9	1.8	3.7	4.2	3.3
400	−2.4	−1.8	−3.7	−2.8	−1.3	−1.7	−2.2	4.1	2.7	3.8	2.8	2.2	3.4	3.2
300	−2.3	−3.4	−4.3	−4.0	−2.6	−2.4	−3.2	6.2	3.2	4.1	4.2	3.2	3.7	4.1
250	−1.9	−3.8	−4.5	−4.3	−3.8	−2.2	−3.4	5.4	4.2	4.8	4.6	4.5	5.2	4.8
200	−3.6	−4.0	−5.2	−4.6	−3.7	−3.0	−4.0	3.1	4.0	4.8	4.6	4.2	5.8	4.4
150	−4.7	−4.1	−6.4	−4.2	−3.9	−3.6	−4.5	—	4.1	6.0	3.7	4.4	4.6	4.6
100	−4.7	−2.0	−3.9	−6.1	−3.4	−2.0	−3.7	—	1.8	2.5	3.1	2.2	2.9	2.5

westerlies in the A/J sector. If we make the tentative assumption that the contour heights of isobaric surfaces derived from the radiosonde data are correct for Bombay and Jodhpur, then the observed anomalies can be qualitatively explained if there is a systematic error in the radiosonde data of Ahmedabad leading to overestimation of the heights of the isobaric levels at this station. This can arise if there are systematic positive errors in the temperatures evaluated by the radiosonde ascents over Ahmedabad.

5. Vertical shears of zonal winds and horizontal temperature differences

On the assumption that the observed monthly mean zonal winds at the stations are nearly geostrophic, the horizontal temperature differences between the station pairs were computed making use of the thermal wind relationship. The computed temperature differences ($\triangle T'$) were compared with the observed temperature differences ($\triangle T$) between the station pairs for the B/A and A/J sectors. In Table 2 are shown the differences $\delta T = (\triangle T - \triangle T')$ at the standard isobaric levels for the two sectors. These are based on the 00 GMT aerological data of the stations for the months May to October of 1979. The mean values averaged for the six months are also given in the table. The most striking feature is that the differences are systematically negative in the B/A sector and positive in the A/J sector. Assuming that there are no systematic errors in the radiosonde data of Bombay and Jodhpur and also the validity of the geostrophic relationship, the absolute magnitudes of δT give the errors in the temperature over Ahmedabad evaluated from the radiosonde observations. The opposite signs of δT in the two sectors show that the temperatures over Ahmedabad are overestimated. The errors are of the order of 1° to 2°C in the lower troposphere increasing to 3° to 5° C in the upper troposphere. One would expect the corresponding values of δT to be the same in the two sectors except for change of sign. The departures noticed can arise, at least partly, from systematic errors between the radiosonde data of Bombay and Jodhpur. This aspect has not been investigated.

6. Discussion and conclusions

We have found that the errors in the radiosonde data of Ahmedabad specifically highlighted by the aerological data for 1979 also exist in the data for 1978 and 1980. Although we have not been able to locate the date from which this anomaly has set in, it appears to be after 1975. To ascertain whether the anomalies still persist we examined the aerological data of Bombay, Ahmedabad and Jodhpur for 1985 and 1986 published in the "*Monthly Climate Data for the World*". It is found that the anomaly continues.

Unlike in the case of Mangalore, we have not been able to unravel the reason for the anomaly in the radiosonde data of Ahmedabad which has persisted unnoticed for about a decade. We brought this matter to the notice of the Additional Director General of Meteorology (Instruments), New Delhi who informed us after arranging an inspection of the Ahmedabad radiosonde station by an experienced officer that no malfunctioning of the equipments was noticed. We have also had discussions about this matter with Prof. P.R. Pisharoty of the Physical Research Laboratory, Ahmedabad. He brought to our attention that the thermal power station at Ahmedabad where a few thousand tons of coal are burnt daily is located about 1.5 km to the westsouthwest of the radiosonde station. Whether the heat released into the atmosphere from the power plant can be a cause for the observed anomaly remains to be explored. In any case, users of the radiosonde data of Ahmedabad should be cognisant of what has been revealed by the present study.

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