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STATISTICS OF THE SUBTROPICAL JET STREAM OVER THE AUSTRALIAN REGION

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ABSTRACT

The position and structure of the lowest-latitude maximum wind speed in the westerlies over the Australian region at the 200 mb level (referred to here as the subtropical jet axis) are investigated for all months for the period 1956 to 1961. Classification is made according to month at each 10 degree meridian from 110°E to 170°E, of mean speed, mean latitude, and 60 and 80 percent departures on either side of means. The mean latitude of the subtropical jet-stream is found to vary from month to month, with a latitude range of 26°S to 32°S. This north-south shift does not always occur simultaneously at all longitudes, and the mean latitude may differ by as much as 4 degrees in the one month at different meridians. The day to day fluctuations along any longitude were greatest during the summer months (standard deviations of about 6 or more degrees), being almost twice the deviation during the winter months.

July is the month of highest mean core speed (140 kt), and January and February the months of lowest core speed (70 kt), with a period of steady rise or fall between these extremes. May is the month of steepest rise and November that of steepest decline in the mean speed. Standard deviations of speed are greatest in May (35 kt) and only in the low twenties during the summer months.

1. INTRODUCTION

Previous investigations have indicated a speed maximum in the westerlies over Australia in the proximity of 200 mb (Phillpot, 1959; Muffatti, 1963; Krishnamurti, 1960). This study of the horizontal and temporal structure of the subtropical jetstream is based on data extracted from the daily 200 mb charts of the Central Office of the Bureau of Meteorology for the six years 1954 to 1961. Muffatti published statistics of mid-season months for three longitudes, 120°E, 140°E and 160°E, for this period. This paper is supplementary, to cover all months and every 10° of meridian from 110°E to 170°E.

2. DATA EXTRACTION, PRESENTATION AND DISCUSSION

Daily 200 mb charts were examined, and latitudes and speeds of the lowest latitude jetstream axis (where the axis is defined as a line following the highest wind speed in the westerlies) at each 10 degrees longitude from 110°E to 170°E, were noted. Monthly means were then calculated for speeds and longitudes. A graphical display of mean latitudes of the subtropical jet axis at each 10 degree meridian, with time (in months) as the ordinate, is presented in Fig. 1. The monthly mean latitude can be seen to fluctuate, with two main northward 'peaks' of similar latitude (26°S) in May and November, and over the continental longitudes, 120°E, 130°E and 140°E, a lesser 'peak' in September. The steepest southward 'dip' occurs in February (to 31°S), with lesser 'dips' in July or August, and in October, over continental longitudes. Smoothing associated with sparseness of data may account for the absence of the minor 'peaks' and 'dips' over the oceans. Enclosures of frequency occurrences of the order of 80 and 60 percent are also displayed.

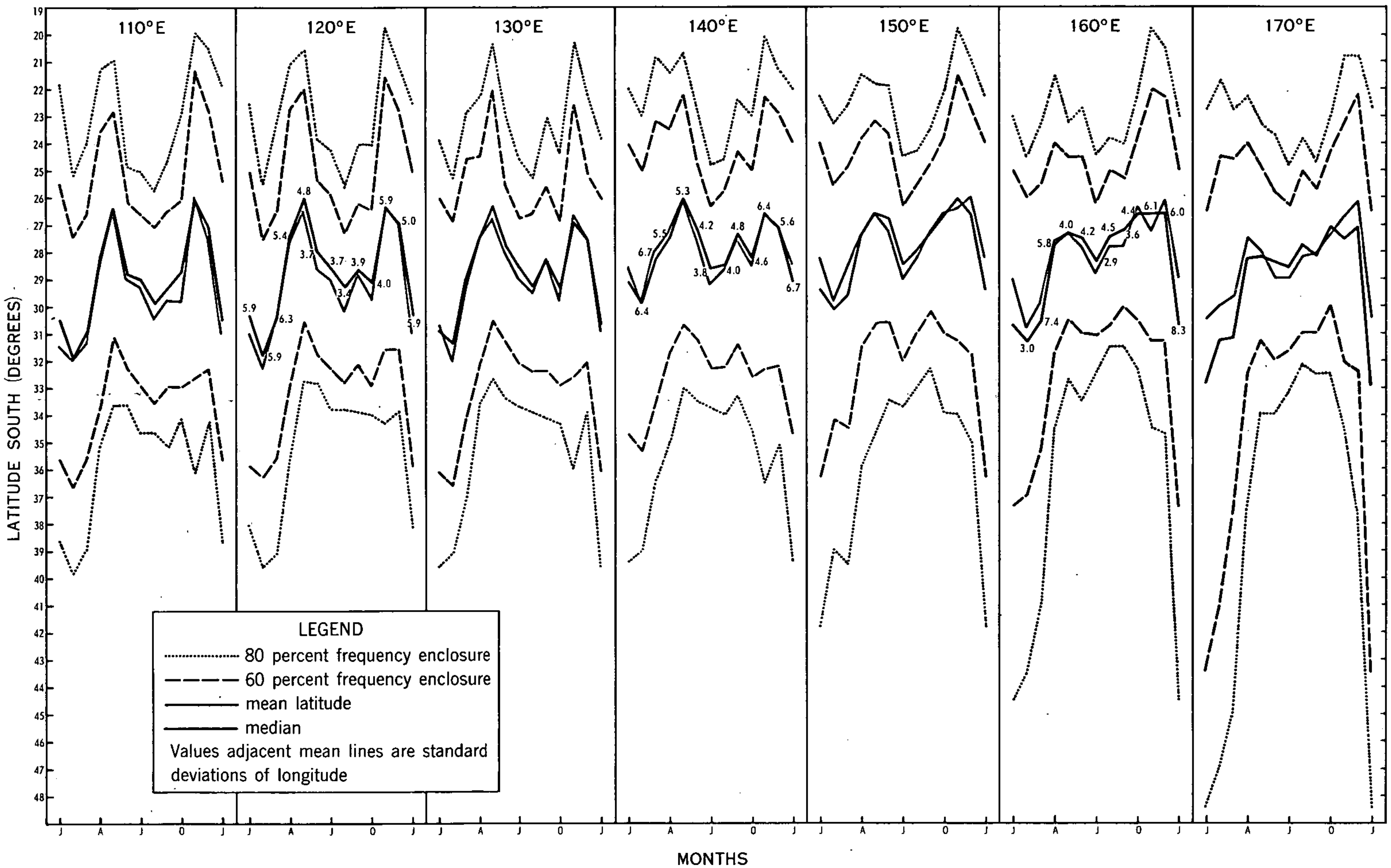

Fig. 1 Monthly mean and median latitudes of the 200 mb subtropical jetstream axis, and 60 & 80 percent frequency enclosures — 6 years [1956 - 1961]

Due to their great bulk, displays of the cumulative percentage distributions for each longitude and month, for latitude and for speed, cannot be presented. However, as an example of the greater fluctuations in latitude of the jet axis during the summer months, a comparison of the January and July cumulative percentage distributions at 120°E, 140°E and 160°E, is presented in Fig. 2. It can be seen that although the median does not alter a great deal, more of the extreme southward departures occur in January (typical of all summer months influenced by a more southerly jet) particularly over oceanic areas. Latitudinal distribution is near normal at all longitudes for winter months, but in summer the latitudinal range is almost double that in winter, with a greater number of extremes tending to the south of the mean.

It was apparent that the mean latitudes of any particular month could differ considerably from year to year, although only on rare occasions did they deviate beyond the 60 percent boundaries of Fig. 1. Fig. 3 is a plot of the annual variation of mean latitude for the six individual years at 120°E. It can be seen from this example that May 1959 was a month of unusually low latitude of the subtropical jetstream, and the year 1959 one of great fluctuation in the month to month mean latitudes.

Fig. 4 depicts mean latitudes of the subtropical jetstream axes for each month, with longitude as the ordinate. Differences of up to 4 degrees in the mean latitude can be seen to exist between some points along the mean ofaxes. In some cases this was due to "forking" of the jetstream axis, caused by predominating "cut-off lows" over the eastern part of the area. As the more northerly jet core was always selected, this caused a slight weighting northward in the overall averages for these longitudes. In other cases fusion of the subtropical jetstream with a polar jet occurred with slight 'dips' in the overall mean lines.

Fluctuations by longitude of monthly mean latitudes of the subtropical jet axis of individual years are generally greater during summer, whilst the means for the winter months of individual years are all nearly at the same latitude. A visual display of this is provided in Fig. 5, which is a plot of the six individual year means for February and August, these being the months of extreme and least variations in the year to year mean positioning. An outstanding feature was the "trough" in the mean latitude lines of most years at longitudes 130°E to 150°E from January to March, and a southward orientation of the jetstream axis east of 150°E. This was attributed to the frequent occurrence of long-standing isobaric lows over Tasmania during the summers of these years, with northward arching of the jetstream axis to the north of the lows. A deep ridge usually developed east of this low pressure centre, with the jetstream axis east of 150°E dipping sharply to the south.

In mapping the subtropical jetstream of the northern winter around the globe and for the six years 1955 to 1960, Krishnamurti (1960) found that the subtropical and polar front current systems oscillated in an out-of-phase path. In this present study of the subtropical jetstream behaviour over the Australian region, there seemed to be a tendency during the summer months and when the jet axis was at its most southerly placement, for actual fusion of the subtropical jetstream with an intruding polar jet stream. When in such cases a more northerly jet existed to the east, and when cases of several intersections of a particular longitude by a single jet axis occurred, data extraction was transferred to the lowest latitude system even though this was generally the weaker system. Occurrences of fusion of the subtropical jetstream and a polar jetstream were mainly confined to east of 140°E and south of 45°S, and were usually associated with the existence of cut-off lows over the Tasman Sea. Predominating troughs and ridges over parts of the area during some months also had an effect on the determination of "peaks" and "dips" in the mean latitudes of the jet axis. A cursory inspection of the February and March 200 mb charts indicated a prevalence of ridges east of 150°E and west of 140°E, and troughs between 140°E and 150°E. The effect of these on the subtropical jetstream mean latitudes can be seen in Fig. 4, where a "peak" is seen in the means for these months at about 140°E.

Fig. 6 illustrates the annual variation of the mean speed of the 200 mb subtropical jetstream axis for each 10° meridian, from 110°E to 170°E. It is seen that the mean speed increases steadily from a late summer minimum of 70 kt to a mid-winter maximum of 140 kt, then decreases steadily from winter to summer. The standard deviations of wind speed for each month at 120°E, 140°E and 160°E, have been plotted adjacent to the mean speed lines of

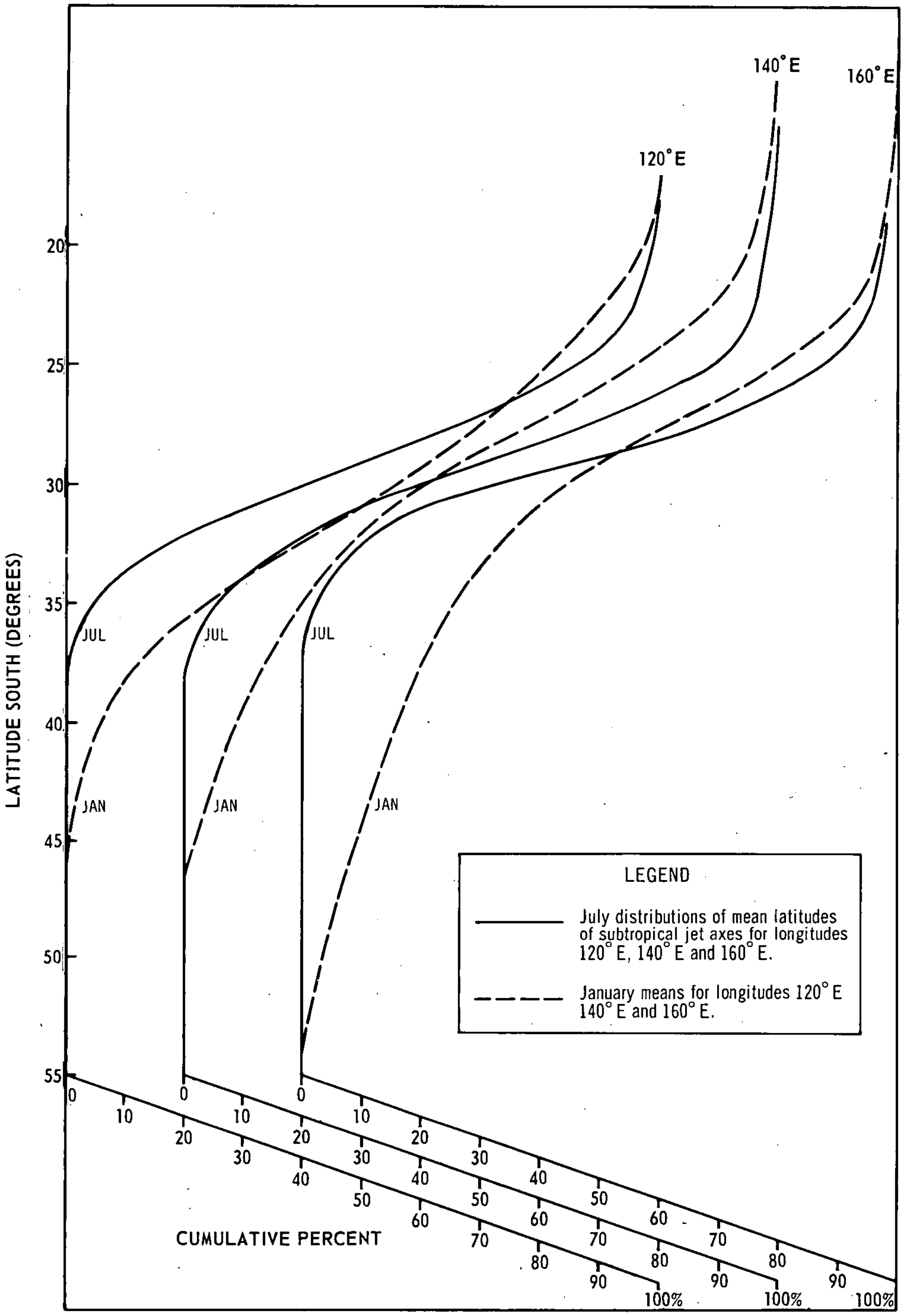

Fig. 2 Cumulative percentage frequency distribution of the latitude of the 200 mb subtropical jetstream axis for July and January. (6 years : 1956 – 1961)

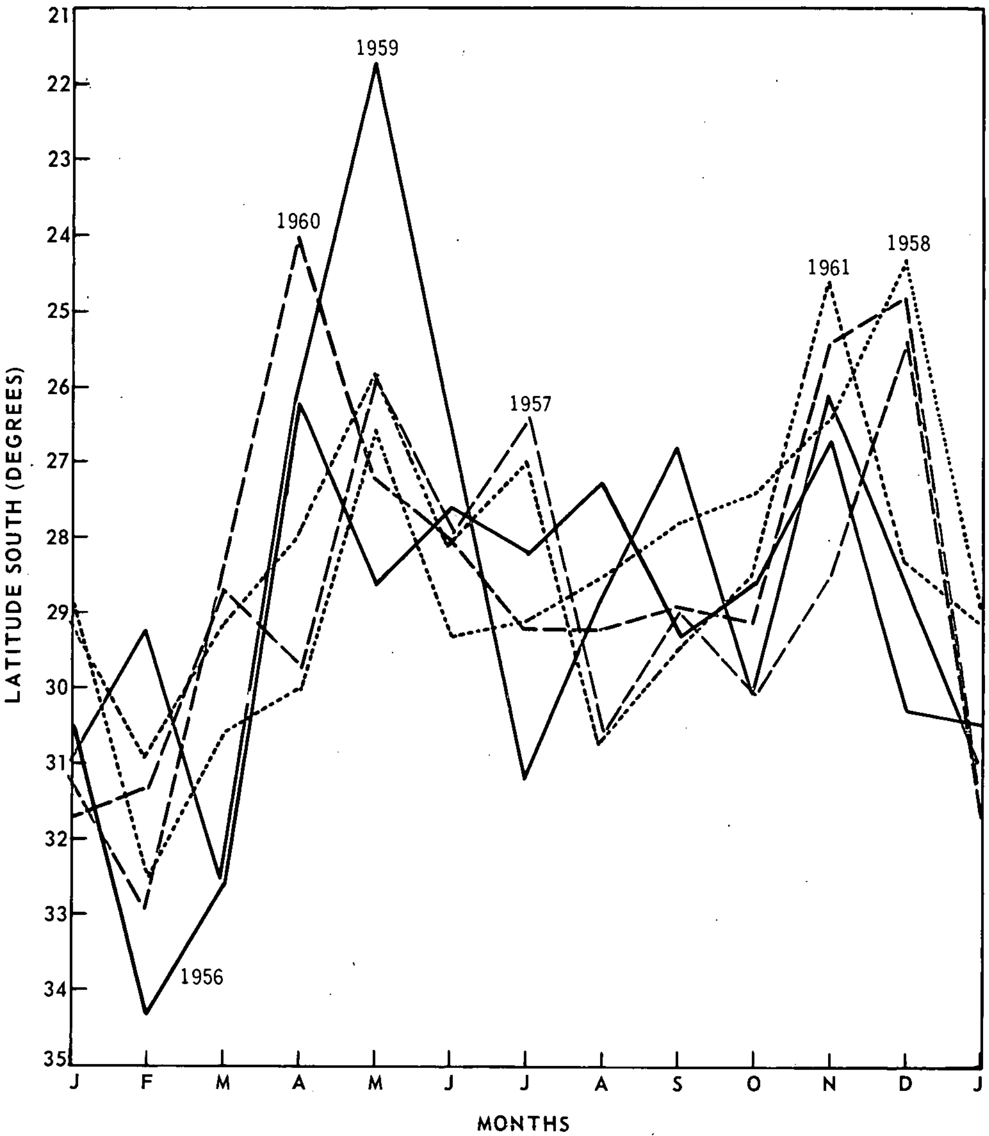

Fig. 3 Annual variation of mean latitude of 200 mb subtropical jetstream axis at 120°E - 6 years (1956 – 1961).

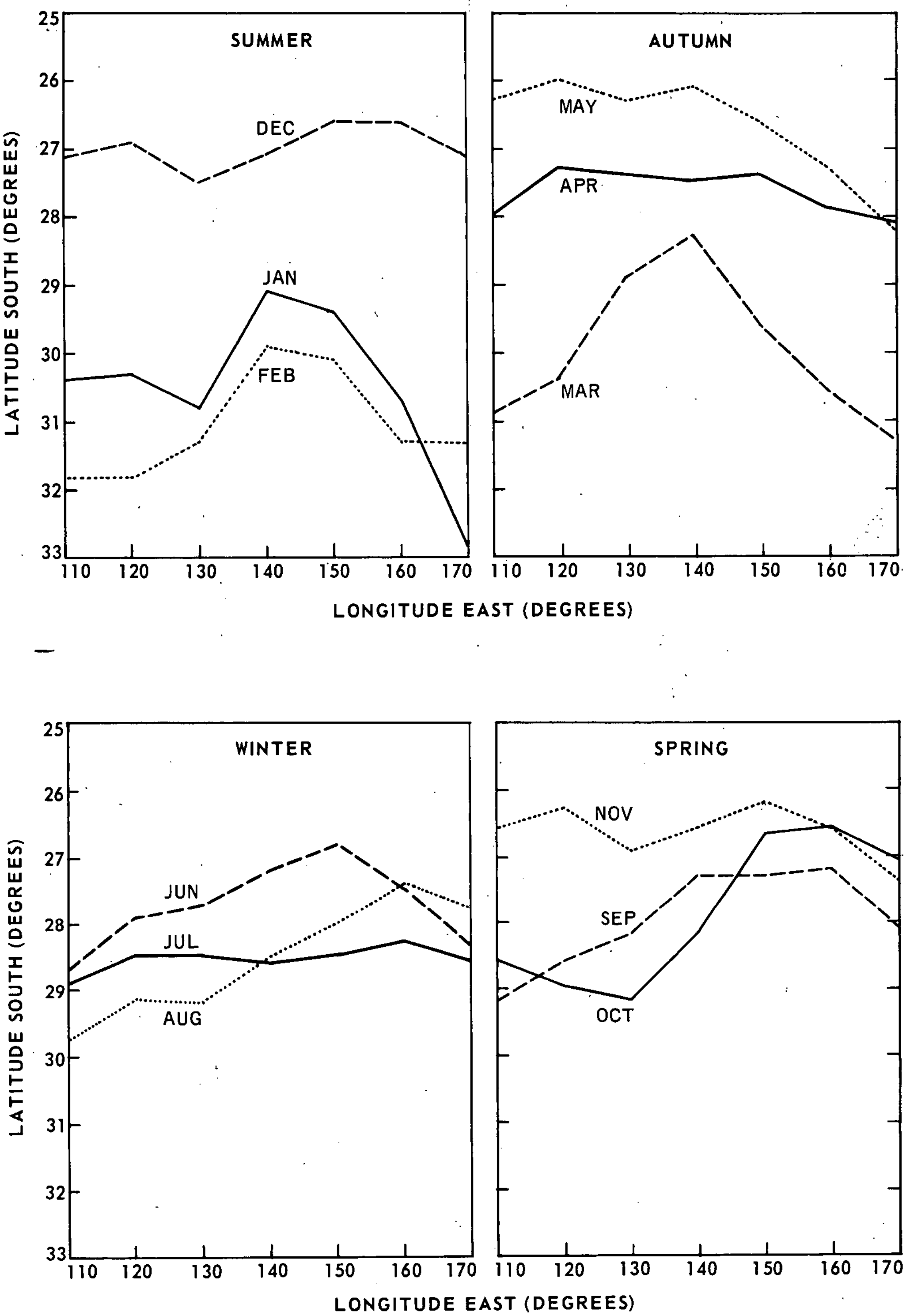

Fig. 4 Mean latitudes of the 200 mb subtropical jetstream axes from 110°E to 170°E - 6 years (1956 – 1961).

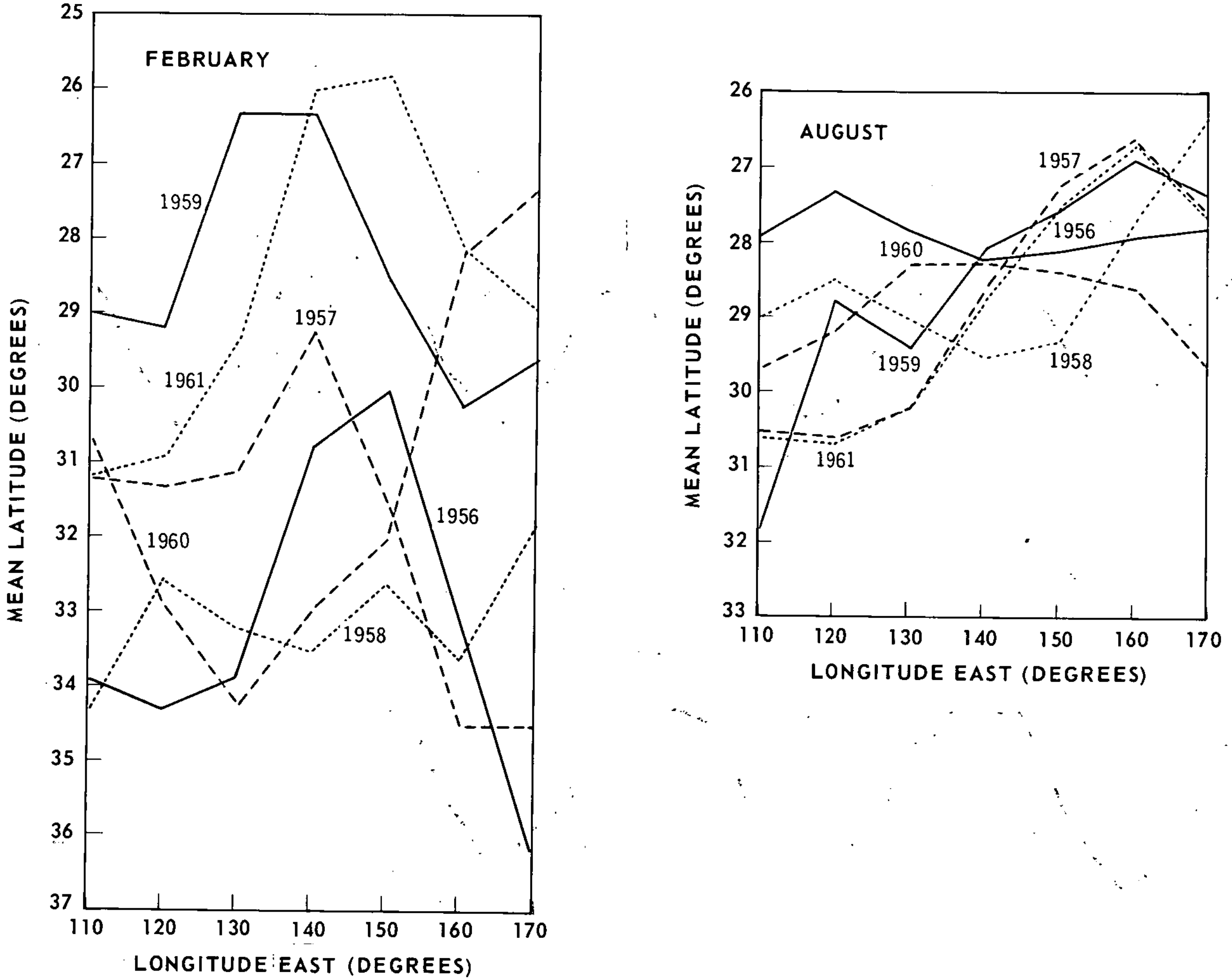

Fig. 5 Mean latitudes of the 200 mb subtropical jetstream axis - 6 years (1956 – 1961).

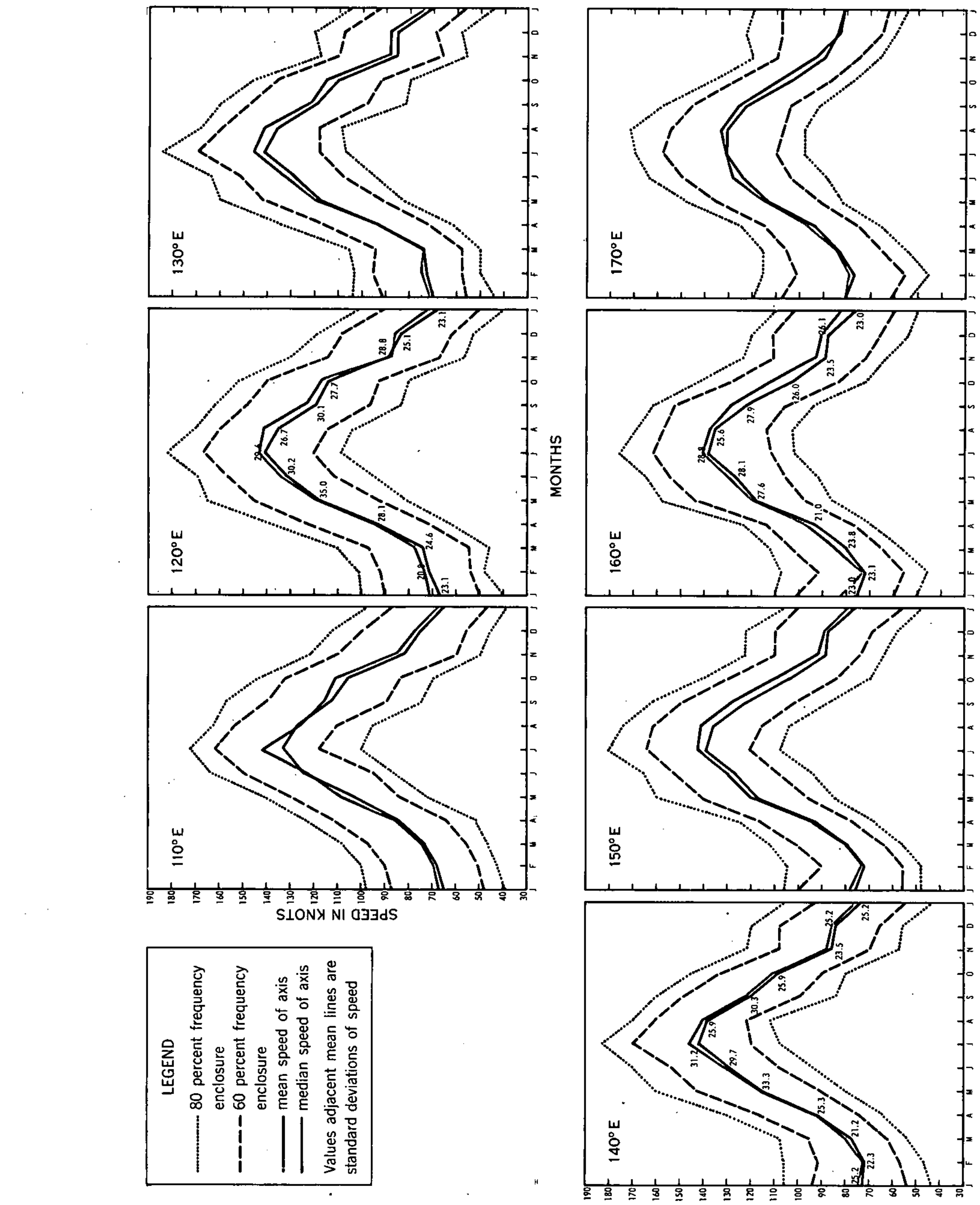

Fig. 6 Median, mean and 60 & 80 percent frequency enclosures of the 200 mb subtropical jetstream core speeds - 6 years [1956 - 1961]

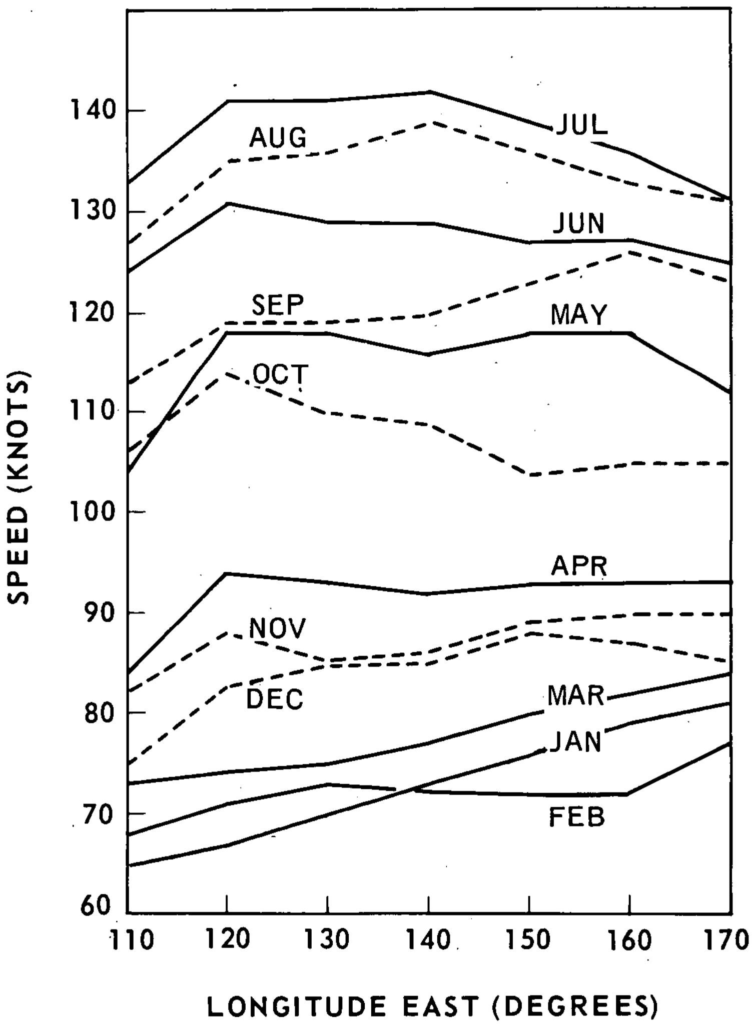

Fig. 7 Mean monthly speeds of the 200 mb jetstream axes from 110°E to 170°E -6 years (1956 – 1961).

Fig. 6. These are greater during winter months and months of steep increase or decrease in the mean wind, being greatest in May (35 kt), the month of steepest increase, and only in the low twenties from November to March. The medians, and 80 and 60 percent enclosures, of frequency occurrences calculated from cumulative percentage frequency curves are also presented.

Fig. 7 is a display of mean speeds of the subtropical jetstream axes of each month, with distance (degrees longitude) as the ordinate. Unbroken lines are for months of increasing speed of the axis and dashed lines for months of speed decline. January and February are the months of lowest mean speed, with a slight increase in March, a sudden increase in April, and with May as the month of highest increase at all longitudes. It is apparent that month to month changes in speed vary with longitudes during the same month. For example, the decrease in speed from July to September is greater over the western section, with only a slight decrease over the eastern half. In October, a strong decrease in speed occurs in the eastern section, with only a slight decrease west of 130°E. November brings another strong decrease at all longitudes, December only a slight decrease, and January another strong decrease which is greater over the continent. February on the other hand shows an increase in speed over the continent, but speed decline is still taking place east of 140°E. Means over oceanic regions are generally not as consistent as means over the continent and, when assessing results, the subjectivity of analysis extrapolation into these regions of sparse or no data should be borne in mind, although in January for instance the mean speed increased uniformly from 60 kt at 110°E to 80 kt at 170°E. It may be seen that of the two main northerly shifts of the jet axis during the year, the earlier (May) is associated with a steep rise in the mean core speed, and the second (November) with a steep speed decline.

Means and standard deviations of latitude and speed of the subtropical jetstream axis for each month, at longitudes 120°E, 140°E and 160°E, are given in Table 1, together with serial correlation coefficients (24-hour lag) of latitude and of speed, as well as correlation coefficients between latitude and speed, and between 24-hour change of latitude and 24-hour change of speed.

SYMBOLS USED IN TABLE 1.

$\overline{\phi}$	=	mean latitude of jet axis (degrees south)
$\overline{v}$	=	mean speed at jet axis (knots)
σ_{ϕ}	=	standard deviation of latitude
σ_{v}	=	standard deviation of speed
$\sigma_{\Delta\phi}$	=	standard deviation of 24-hour change of latitude
$\sigma_{\Delta v}$	=	standard deviation of 24-hour change of speed
r_{ϕ}	=	serial correlation coefficient of latitude (24-hour lag)
r_{v}	=	serial correlation coefficient of speed (24-hour lag)
$r_{\phi, v}$	=	correlation coefficient between latitude and speed
$r_{\Delta\phi, \Delta v}$	=	correlation coefficient between 24-hour change of latitude and of speed
N	=	number of observations

Table 1. Correlation of jet streams, speeds and latitudes

Month	Long. °E	$\bar{\phi}$	$\bar{v}$	σ_{ϕ}	σ_{v}	$\sigma_{\Delta\phi}$	$\sigma_{\Delta v}$	r_{ϕ}	r_{v}	$r_{\phi,v}$	$r_{\Delta\phi,\Delta v}$	N
Jan.	120	30.3	67.3	5.88	23.06	6.5	23	0.45	0.50	0.72	0.40	144
	140	29.0	73.0	6.71	25.20	5.8	21	0.61	0.63	0.62	0.56	173
	160	30.7	78.7	8.27	22.98	8.3	27	0.47	0.31	0.41	0.54	176
Feb.	120	31.8	71.4	5.86	20.83	6.2	21	0.20	0.48	0.33	0.27	158
	140	29.9	71.6	6.40	22.28	5.9	23	0.54	0.73	0.45	0.29	169
	160	31.3	72.2	8.00	23.15	8.1	26	0.31	0.33	0.55	0.50	167
Mar.	120	30.4	74.1	6.26	24.57	6.5	23	0.44	0.50	0.39	0.43	176
	140	28.3	76.8	6.73	21.20	6.4	24	0.47	0.37	0.52	0.58	184
	160	30.6	81.9	7.38	23.84	6.0	25	0.65	0.47	0.35	0.50	185
Apr.	120	27.5	94.3	5.39	28.12	5.0	28	0.55	0.51	0.36	0.35	172
	140	27.5	92.3	5.52	25.27	4.9	26	0.58	0.47	0.33	0.37	174
	160	27.8	93.1	5.80	21.03	5.6	23	0.54	0.40	0.17	0.24	170
May	120	26.0	118.1	4.76	34.98	3.8	35	0.49	0.70	0.36	0.21	186
	140	26.1	116.0	5.28	33.27	4.5	28	0.65	0.65	0.41	0.43	186
	160	27.3	117.5	4.02	27.59	5.0	28	0.23	0.48	0.12	0.23	186
June	120	27.9	131.6	3.67	30.23	3.6	30	0.51	0.53	0.17	0.24	179
	140	27.2	128.7	4.19	29.68	4.0	29	0.55	0.53	0.47	0.28	180
	160	27.5	126.7	4.21	28.10	4.1	28	0.53	0.49	0.31	0.23	180
July	120	28.5	140.9	3.69	29.64	3.6	31	0.54	0.42	0.36	0.27	177
	140	28.6	142.2	3.78	31.23	3.6	28	0.58	0.59	0.58	0.30	179
	160	28.3	136.3	2.88	28.76	3.1	34	0.43	0.31	0.36	0.13	179
Aug.	120	29.4	136.1	3.39	26.69	3.4	28	0.49	0.41	0.27	0.33	185
	140	28.5	138.7	3.96	25.85	3.7	28	0.49	0.42	0.30	0.29	186
	160	27.4	132.9	4.47	25.60	3.1	23	0.21	0.58	0.19	0.14	186
Sept.	120	28.6	119.2	3.89	30.11	4.7	31	0.28	0.50	0.16	0.28	179
	140	27.4	120.1	4.77	30.27	5.3	29	0.38	0.55	0.37	0.32	180
	160	27.4	125.8	3.59	27.91	4.8	32	0.31	0.32	0.42	0.45	180
Oct.	120	29.0	113.7	3.97	27.66	4.2	27	0.43	0.50	0.43	0.31	173
	140	28.2	108.8	4.60	25.94	4.5	26	0.51	0.48	0.49	0.41	180
	160	26.7	105.6	4.45	26.03	4.7	25	0.43	0.52	0.38	0.25	180
Nov.	120	26.3	88.1	5.86	28.77	7.0	29	0.27	0.41	0.50	0.65	175
	140	26.6	86.3	6.36	23.54	6.6	25	0.46	0.42	0.54	0.44	180
	160	26.6	89.9	6.09	23.48	5.9	24	0.51	0.47	0.44	0.33	180
Dec.	120	26.9	82.9	5.03	25.08	5.0	24	0.48	0.53	0.54	0.52	182
	140	27.1	85.4	5.59	25.21	6.3	25	0.36	0.51	0.58	0.51	186
	160	26.6	87.2	6.02	26.08	5.1	23	0.63	0.63	0.53	0.24	185

3. CONCLUSIONS

The danger of assuming mid-season months to be the criterion of any migratory trend of the subtropical jetstream axis is apparent from the results of this investigation, where May and November are seen to be the months of greatest changes in both placement and speed of the jetstream axis. The influence of one year's anomaly on the overall short term mean can be considerable and investigations over longer periods are necessary to obtain stable results.

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REFERENCES

Phillpot, H.R. 1959 Winds at 30,000 and 40,000 ft in the Australian-New Zealand-Fiji Area. Project Report 59/2645 of April 1959, Bureau of Met., Melbourne.

Muffatti, A.H.J. 1963 Proceedings of the Symposium on Tropical Meteorology. Rotorua, New Zealand. pp. 72-88.

Krishnamurti, T.N. 1961 J. Met. 18, 2, pp. 172-191.