4. THE MEAN GEOSTROPHIC FLOW AT 200 MB IN JUNE 1970 BETWEEN 20°S AND 45°S

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Introduction

The climatology of the subtropical jet stream in the Southern Hemisphere is incomplete because of the lack of upper air data. It is well known that in winter the jet stream speed exceeds 50 m s^{-1} close to the 200 mb level over Australia (Radok and Clarke, 1958; Phillpot, 1959; Muffatti, 1963; Spillane, 1968; Weinert, 1968) and about 45 m s^{-1} over South America (Jenkinson, 1955) while the maximum over South Africa is weaker (Phillpot, 1962; Reiter, 1963). Over the oceans Reiter (1963) has suggested that additional wind maxima might be found wherever the subtropical high pressure belt is interrupted by long wave troughs in the westerlies, but insufficient data have been available to test this hypothesis. Jenne *et al* (1971) and van Loon *et al* (1971) give a comprehensive account of the geostrophic wind at 200 mb in the Southern Hemisphere but they too had little data over the subtropical oceans.

Although the upper air data coverage for the June 1970 Basic Data Set is far from adequate (Lamond *et al*, 1972) it is the best June data set yet compiled for the Southern Hemisphere. Inferences from SIRS and other satellite data have increased the confidence in the analyses over the oceans, and a study of the wind maximum as revealed on the mean 200 mb chart for June 1970 should therefore be useful. This maximum cannot be properly termed "the subtropical jet stream" because the wind field is determined in geographic coordinates rather than relative to the daily jet core. Hence the polar front jet will also have some influence on the resulting mean pattern.

Compilation of Data

Because 200 mb geopotential contour charts are not yet digitised, wind fields could not be readily computer derived. Thus geostrophic winds were manually computed from a mean 200 mb geopotential field (Fig 4.1) by taking meridional height differences over a grid at 20 degrees longitude intervals every 2 degrees of latitude between 19°S and 45°S.

This assumes the applicability of the geostrophic wind relationship under these conditions and also that the mean 200 mb flow was zonal. Although Fig 4.1 shows that the flow was only approximately zonal it is contended that errors introduced by this assumption would be small. Data presented by van Loon *et al* (1971) and Jenne *et al* (1971) showed that in the long term, in subtropical latitudes, differences between resultant mean 200 mb geostrophic wind speeds and mean zonal speeds for winter rarely exceeds 0.4 m s^{-1} (the largest difference being 0.9 m s^{-1}). In the shorter term the data of Maher and McRae (1964) show that during the period 1957-61 differences for June were rarely more than 0.5 m s^{-1}.

Mean wind speeds at 200 mb derived from observations in June 1970 were adequate only to permit verification of the computed geostrophic winds along meridians through Australia, South Africa and South America, and of these only in the vicinity of 140°E were the stations sufficiently spread to enable the accuracy to be assessed over the whole range of latitudes.

Mean observed 200 mb wind speeds for June 1970 (from WMO, 1970; supplemented by Bureau of Meteorology, Australia, 1970) for all stations within 8 degrees of longitude of selected meridians were compared with the computed geostrophic winds. Comparisons are presented in Fig 4.2 for longitudes 120°E, 140°E, 160°E, 20°E and 60°W. In Australian longitudes (120°E-160°E) the agreement is good although there is a tendency for computed values to underestimate, except near, and to the north of, the peak at 160°E, where there is general overestimation. Agreement over South America (60°W) is also fairly good but over South Africa (20°E) the computed values are consistently high (up to 10 m s^{-1}). The reasons for this are not clear.

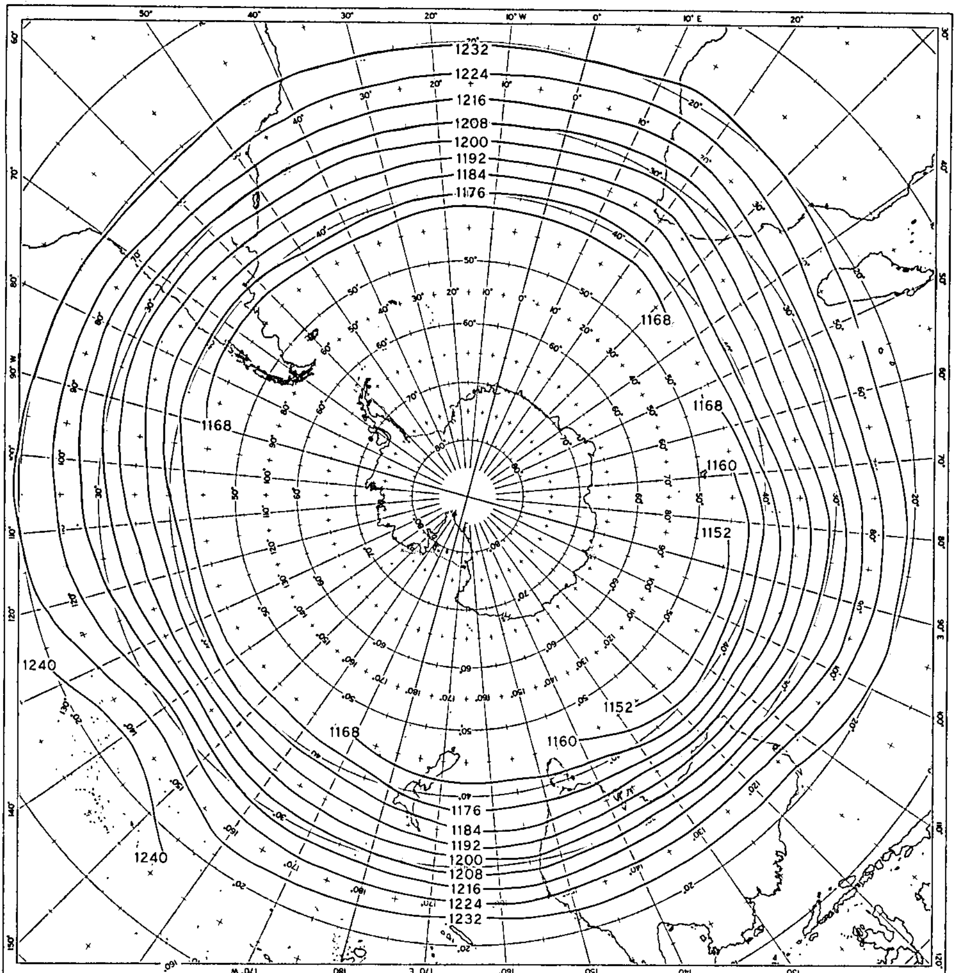

Fig 4.1 Mean 200 mb geopotential contours (decametres) between 20°S and 45°S for June 1970.

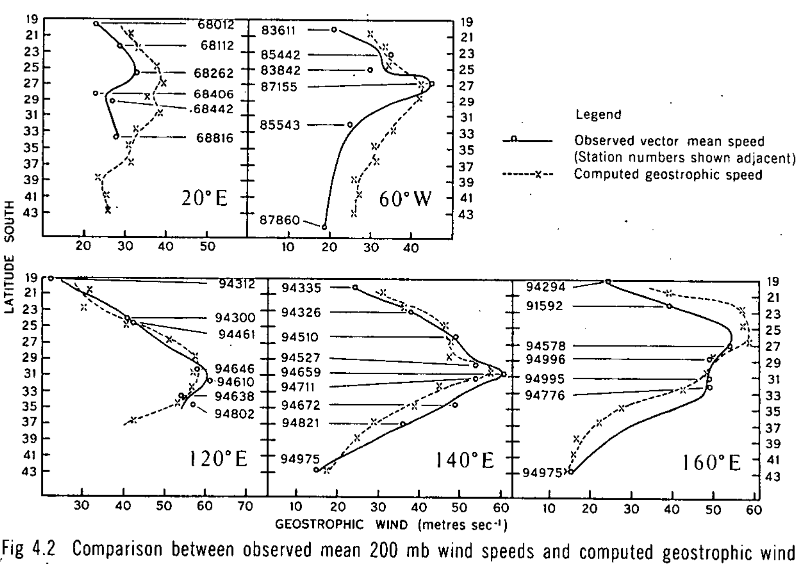

Fig 4.2 Comparison between observed mean 200 mb wind speeds and computed geostrophic wind speeds for June 1970 at selected longitudes. International index numbers of observing stations used are shown at the appropriate latitudes. Also shown are the respective smoothed meridional profiles.

Results

Hemispheric Pattern

Smoothed isotachs of computed 200 mb geostrophic wind speed (Fig 4.3) show that:

- a maximum speed belt could be represented continuously around the hemisphere with the axis at about 30°S and core speeds of at least 35 m s^{-1}. The maximum was most clearly defined in Australian longitudes (where the maximum speed was about 60 m s^{-1}) and least defined in the western Indian Ocean;
- two distinct maxima could be detected over about half the hemisphere, from the mid-Atlantic across South Africa into the Indian Ocean with the speed in each branch gradually increasing until they merged over Western Australia. This apparent confluence could be a contributing factor to the high speeds over Australia and the existence of two maxima could contribute to the relatively low speeds over South Africa and the western Indian Ocean;
- the main perturbations in the maximum wind axis occurred just east of Australia and near the west coast of South America. There appeared to be no major perturbations in the sectors where the dual axes occurred.

The relationship between the maximum wind axis and the axis of maximum frequency of subtropical surface anticyclones (Neal, 1972) during the month is shown in Fig 4.4. The maximum wind axis closely follows the major anticyclone high frequency axis around the hemisphere except in the Tasman Sea-New Zealand sector (150°E-170°W) where the core speeds were very high (60 m s^{-1}) and the axis was located well to the north of the anticyclone axis.

Meridional Profiles

Smoothed meridional profiles of 200 mb geostrophic wind speed in June 1970 were constructed at 20 degree longitude intervals. Typical profiles are shown in Fig 4.5. Also shown for comparison are long term mean meridional profiles ("normals") which were derived in the same way as for June 1970 from data presented by Taljaard *et al* (1969), Jenne *et al (op cit)* and van Loon *et al (op cit)*.

Speeds in the Australian sector between latitudes 27°S and 33°S were considerably higher than both the normals and those found by Maher and McRae (1964), but they compare favourably with speeds found by Weinert (1968) for the six year period 1956-1961. However as Weinert's values were compiled by averaging with respect to the daily subtropical jet axis, his speeds should be considerably higher than either those of Maher and McRae or of those given here. Thus the fact that the June 1970 values are similar to Weinert's is probably indicative of the high frequency of occurrence of very strong jet streams at preferred latitudes in the Australian sector during the month although intrusions of the polar front jet into lower latitudes may have had a contributing effect. Table 4.1 shows the highest observed values in Australian longitudes during June 1970.

Table 4.1 Highest observed 200 mb wind speed during June 1970 between latitudes 20°S and 45°S

Longitude (°E)	115-125	125-135	135-145	145-155	155-165	165-175	175°E-175°W
Speed (m s^{-1})	98	92	105	90	87	87	93

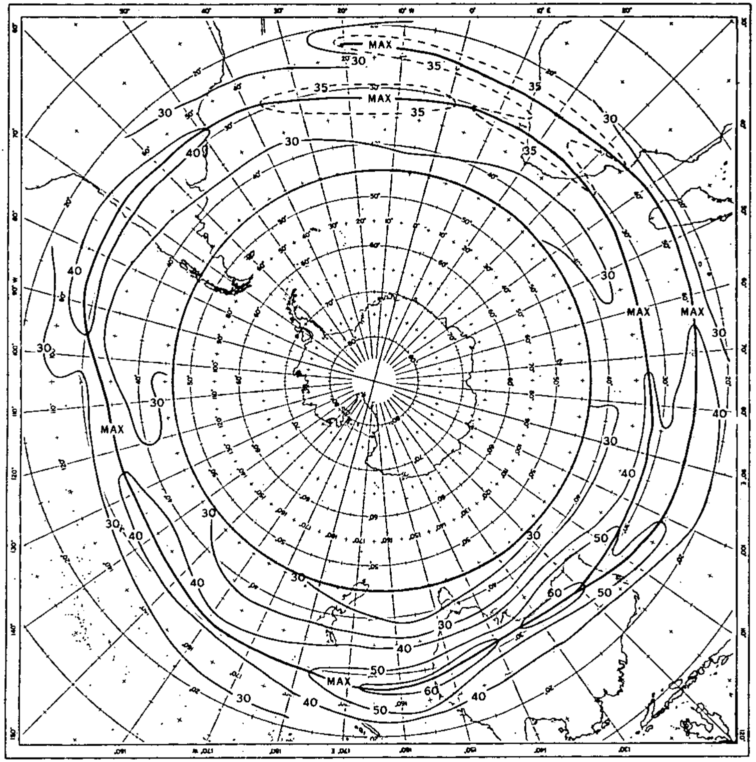

Fig 4.3 Smoothed isotachs (m sec^{-1}) of 200 mb mean geostrophic wind speed between 20°S and 45°S for June 1970. The maximum wind axis is shown as a heavy continuous line.

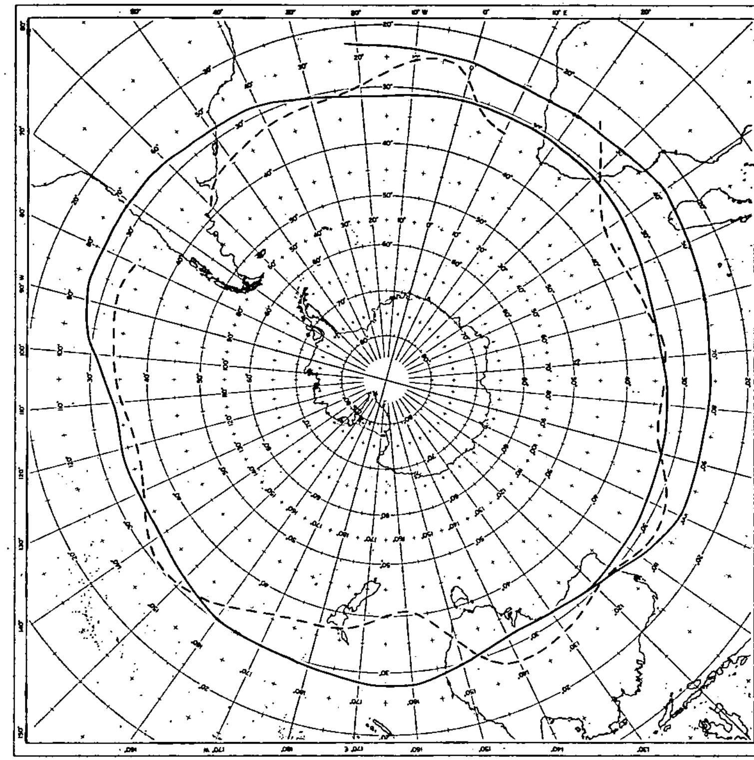

Fig 4.4 The relationship between the axis of maximum wind (full line) and the high frequency axis of surface anticyclone centres (dashed line) in June 1970.

At most meridians around the hemisphere the shape of the profiles in June 1970 closely resembled the normals. Apart from the various latitudinal shifts in the peaks and the evidence of a double maximum (20°W through Greenwich to 100°E) the most anomalous behaviour occurred at 100°W. It is difficult to adequately account for the irregular appearance of the June 1970 profile at this longitude.

The maximum wind axis was further poleward than normal at longitudes 140°E, 180°, 140°W and 120°W (*ie*, most of the Pacific sector) and further equatorward than normal at longitudes 20°E, 60°E, 80°W, 60°W and 40°W (*ie*, most of the South American and South African sectors). Peak speeds were considerably higher than normal in the Australian sector (120°E-160°E) and to a lesser extent at 140°W and over South America (80°W-60°W) whilst speeds somewhat below normal were found at 40°E and 60°E.

All profiles from 20°W (through the Greenwich meridian) to 100°E showed evidence of a double peak although this feature was most prominent at 20°W, 20°E and 100°E. (Profiles for 20°W and 100°E are given in Fig 4.5.) In the normal profiles, a double peak was evident at 40°E while the peaks were generally very broad at other longitudes between 20°W and 100°E. This does not necessarily support the existence of a dual maximum in the long term but it does indicate either multiple maxima or considerable year to year latitudinal variation of a single wind maximum in these longitudes.

The June 1970 and normal June hemispheric zonal mean profiles are shown in Fig 4.6. The 1970 profile shows a more pronounced peak than normal with a maximum value near 29°S of 40.5 m s^{-1}, about 2 m s^{-1} above normal.

Conclusions

This study has been sufficient to suggest the following characteristics of the mean geostrophic flow in subtropical latitudes at 200 mb in June 1970:

(1) There was some evidence of two maxima over roughly half the hemisphere from 20°W (through Greenwich) to 100°E.

(2) In general the maximum wind axis closely followed the high frequency axis of surface anticyclones except in the Tasman Sea-New Zealand sector (150°E-170°W) where the wind axis was well to the north of the anticyclone axis.

(3) In the hemispheric zonal mean meridional profile the maximum wind axis was located near 29°S with a peak speed of 40.5 m s^{-1}. The peak in this profile was slightly more pronounced than normal which could indicate either a higher than average occurrence of jet cores near 29°S or higher than average maximum daily speeds.

(4) Speeds in the Australian region (120°E-160°E) were significantly higher than those found by Maher and McRae (1964) between latitudes 27°S and 33°S but were more comparable with those of Weinert (1968). This suggests a high frequency or persistence of very strong jets over Australia in June 1970 and a study of the daily charts should verify this.

(5) Speeds were somewhat above normal at 140°W and over South America but below normal in the region just east of South Africa (40°E-60°E).

In this study the wind maximum on the mean 200 mb geopotential chart was examined. It is likely that a somewhat different location of the maximum speed axis, higher peak speeds, and stronger shears would be found if a mean jet stream were obtained by averaging with respect to daily locations of the subtropical jet axis.

Acknowledgments

The assistance of Messrs. I.J. Butterworth and K. Murphy in computations and in the preparation of diagrams is gratefully acknowledged.

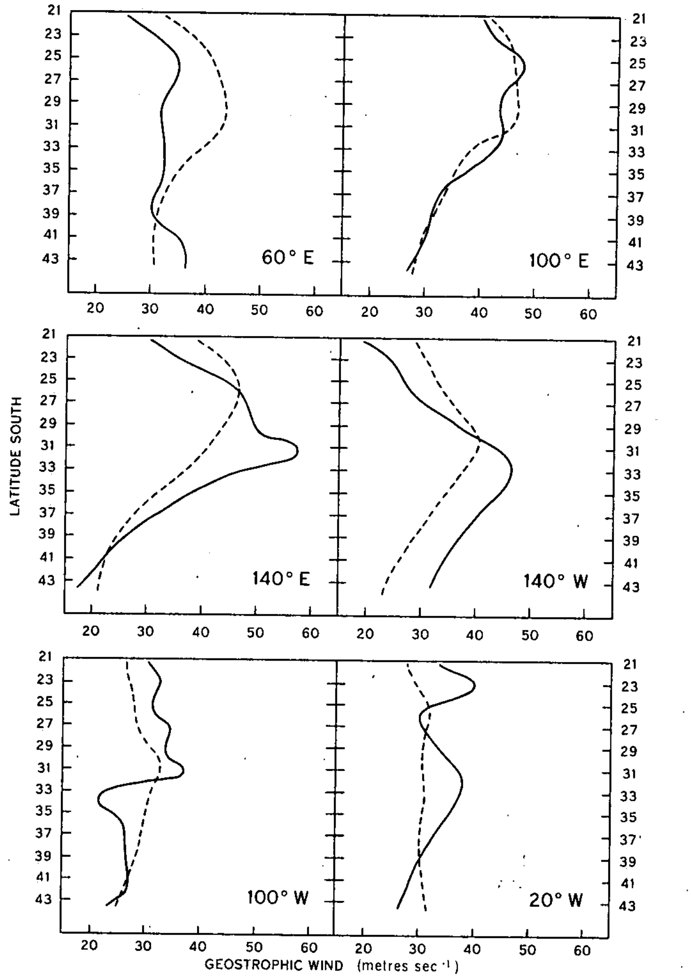

Fig 4.5 Smoothed profiles of mean 200 mb geostrophic wind speed (full lines) at selected meridians in June 1970. Dashed lines indicate "normal" June profiles derived from data presented by Jenne *et al* (1971) and van Loon *et al* (1971).

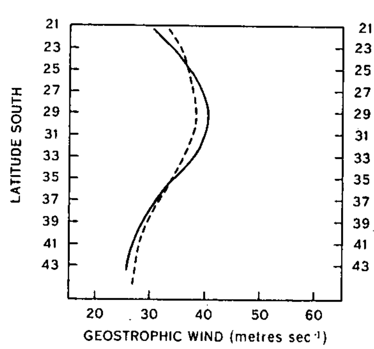

Fig 4.6 Smoothed hemispheric mean profiles of 200 mb geostrophic wind speed for June 1970 (full line) and "normal" (dashed line).