

Some cases of westward moving disturbances in the Mawson-Davis area, Antarctica

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Westward moving cloudbands have been observed in the area of Antarctica between the Australian stations of Mawson and Davis when there was cyclonic activity along the coast to the east. An examination of several events of this character, which occurred during the summer of 1983/84 and in January 1972, has been carried out. It was found that the passage of the cloudbands was accompanied by a barograph trace minimum, with precipitation occurring on the rising barometer following a sharp fall. The vertical structure of one event, when rare inland upper wind data were available, is discussed. A strong middle to upper tropospheric baroclinic zone appeared to develop over the Lambert Glacier-Prince Charles Mountains area as warm air from a cyclone to the east met colder air flowing off the east Antarctic Plateau.

Introduction

Coastal stations in east Antarctica are often lashed by hurricane force winds with blinding snow when Southern Ocean depressions approach the coast (Schwerdtfeger 1984). This study is concerned with the less spectacular weather experienced by stations, which at the time, are west of the longitude of such intense cyclonic activity.

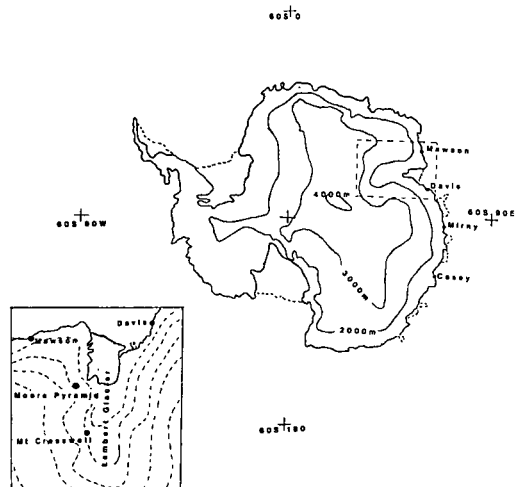
The region to be studied includes the Australian coastal stations of Mawson and Davis and the continental area between them. In this area lies the Lambert Glacier, the largest valley glacier on earth. The extent of the valley containing the glacier can be seen in Fig. 1. It is one of the most significant topographical features in Antarctica. Flanking the glacier are the extensive rock outcrops of the Prince Charles Mountains. The area of the Lambert Glacier and its catchment is nearly equal to that of Western Australia.

The synoptic weather pattern of interest occurs when cyclones are active in longitudes near Casey station, with that station receiving the violent weather mentioned above. The structure of cloudbands moving westward into the study area during this type of synoptic situation will be examined for two different summers.

Davis antarctic summer 1983/84

During the period 17 December 1983 to 13 January 1984, a 500 hPa long wave trough at 55 degrees south was generally located at longitudes between Davis and Casey (see Fig. 2). Several cyclones approached close enough to Casey to produce a series of severe wind events. The weather at Davis during this period was mostly mild

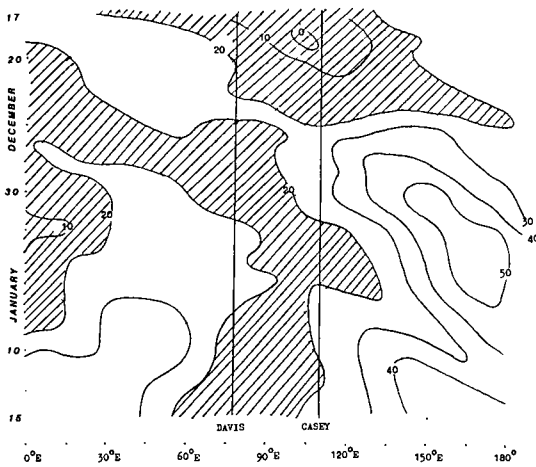
Fig. 1 Map of Antarctica with place names used in text.



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Fig. 2 Five-day mean heights (geopotential decametres minus 500) at 500 hPa for 55°S from 17 December 1983 to 15 January 1984 in the eastern hemisphere.



with light winds; however on five occasions areas of high cloud (usually in bands) approached the station from the east.

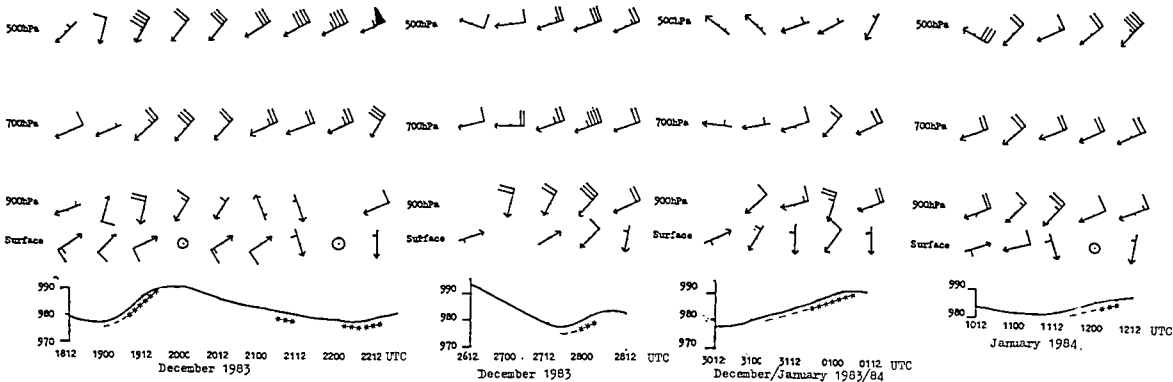
Figure 3 is a time section of upper winds and mean sea level (MSL) barograph traces at Davis for parts of the above period. The times of arrival of the cloudbands are noted on this time section together with the periods of precipitation. In all but one of these events the arrival of the cloud was accompanied by a minimum in the barograph trace with the precipitation occurring with rising pressure. The meridional component of the middle tropospheric winds was northerly during the precipitation events and for a large proportion of the whole period.

One of the authors' personal observations was that the weather was fine and clear beneath the cloudbands while they were located above the ice cap to the east of the station. Snowfall and low scud cloud developed as the bands moved off the plateau. Davis is located on an area of ice-free rock (Vestfold Hills) and is some 23 km from the foot of the ice cap. A remote station (Platcha) at the foot of the ice cap was continuously manned for seven months during 1961 (Lied 1963). This station frequently experienced strong katabatic winds which suffered marked dissipation before reaching Davis. It is possible that this deceleration of the drainage flow off the ice cap may produce low-level convergence which could result in up motion beneath the cloudbands. Unfortunately, Platcha was only manned during one of the snowfall episodes in this summer. On this occasion, a light east-northeasterly katabatic (3-5 m/s) was reported there just prior to the falling snow at Davis, where a 3 m/s onshore southwesterly wind was reported.

A marked feature of the wind regime at Davis is the relatively high frequency of onshore southwesterly winds in summer and, to a lesser extent, during the transitional months (Streten 1986). These winds have the diurnal characteristics of a sea-breeze circulation and are observed at stations on the seaward edge of extensive rock areas when open water is present. This sea-breeze may be capable of providing added moisture for cloud and snow development, and low-level onshore winds (southwesterlies to northerlies) may be seen to have been present prior to the snow events (Fig. 3). A consequence of this sea-breeze phenomenon at Davis may be that cloudbands are more likely to produce precipitation in this area than further inland or in adjacent coastal areas. The 1961 Platcha observations mentioned above, indicate that Davis experienced significantly more days of falling snow than Platcha.

Another feature of the cloudbands was that on some occasions small vortices formed (as identified from satellite imagery) as the bands moved westward off the

Fig. 3 Time sections for Davis, of precipitation events associated with westward moving cloudbands during the period covered by Fig. 2. MSL pressure tendency in hectopascals. '***' denotes periods of precipitation and '-----' denotes periods when the cloudbands were over Davis prior to precipitation occurring. Upper wind plots where flag/barb/half-barb represent 25/5/2.5 m/s respectively.**



ice cap near Davis. One of these vortices continued westward along the coast and ultimately produced storm force winds in the Mawson area. Westward moving cloud vortices were also observed (from satellite imagery) over the Lambert Glacier-Prince Charles Mountains region during this particular summer.

Prince Charles Mountains January 1972

During this month observations were carried out at Mount Cresswell and Moore Pyramid (see insert, Fig. 1) in the Prince Charles Mountains. Late in the month, a band of cloud approached these stations from the east, producing snow and greatly reduced visibility. The synoptic pattern during this period (Fig. 4) shows a Southern Ocean cyclone developing and moving towards

Casey causing severe winds at that station. By 0000 UTC on 1 February (the day after this sequence) the mature low was nearly over Casey.

The westward passage of a middle to upper tropospheric trough through Mt Cresswell in the Prince Charles Mountains, during the development period of the cyclone, can be seen from a time section (Fig. 5). This time section shows upper winds (for Mt Cresswell), and station level barograph traces and station plots (for both Mt Cresswell and Moore Pyramid). It may be noted that the trough sloped westward with height. Note also that the station level winds at Mt Cresswell did not change direction but only decreased in speed with the passage of the station level trough (marked by the barograph trace minimum). Table 1 indicates that Mt Cresswell experiences a constantly strong south-southwesterly surface wind.

Fig. 4 MSL pressure analyses 0000 UTC 28 January 1972 to 0000 UTC 31 January 1972 (hectopascals).

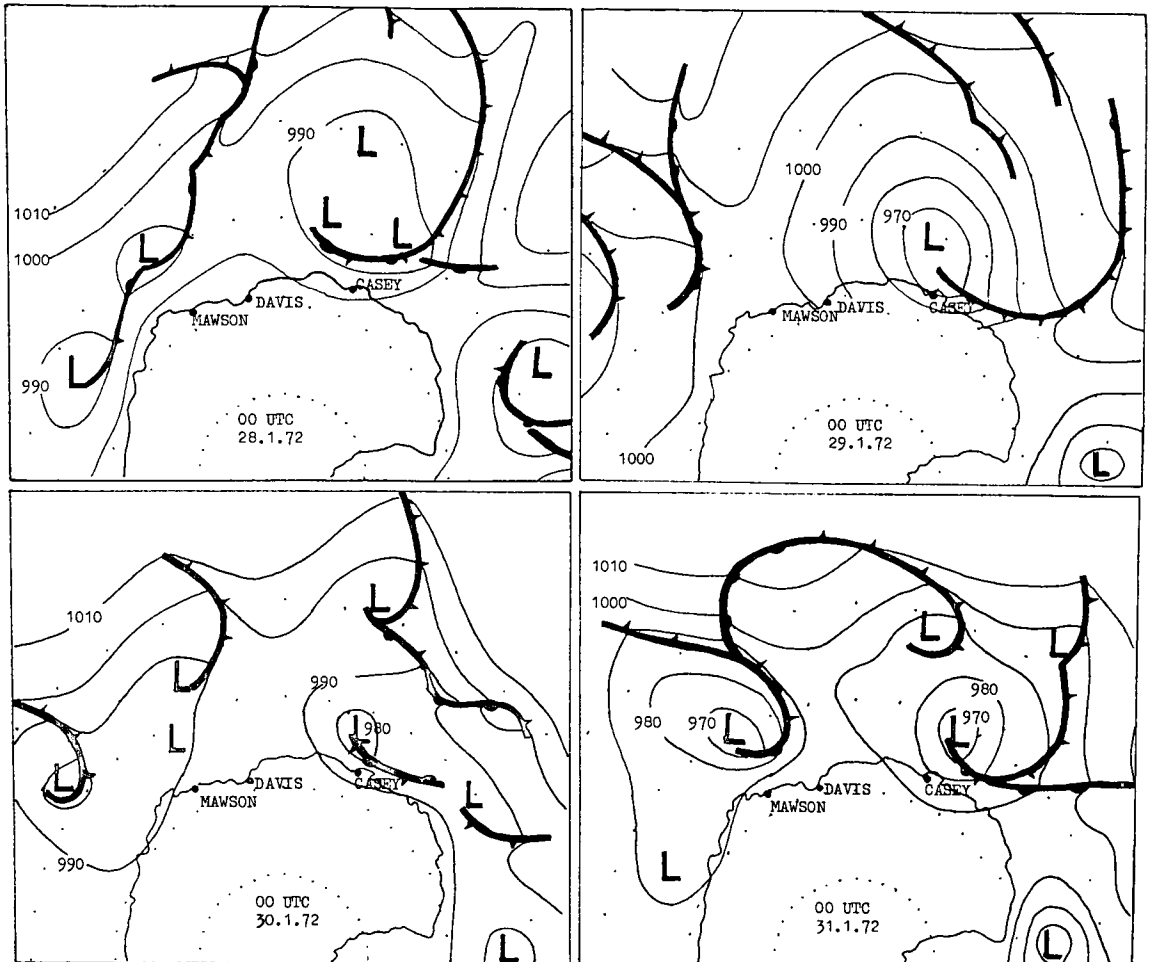


Table 1. Surface wind frequency analyses for Mt Cresswell and Moore Pyramid for January at 0900 and 1500 local standard time (LST).

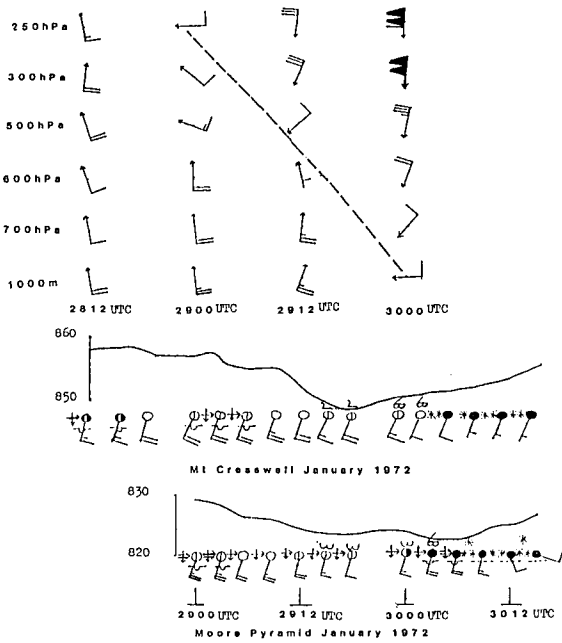
SURFACE WIND ANALYSIS – PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION																
<i>MOORE PYRAMID 70° 18' S, 65° 06' E 1460.0 m Elevation Based on 3 years of records</i>																
DIRN	JANUARY 0900 LST SPEED (KM/H)									JANUARY 1500 LST SPEED (KM/H)						
	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	A L	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	A L
N																
NE																
E																
SE			1	3	1	1					5	6	2	1		13
S	1	4	16	8	7	1					6	17	13	7	1	47
SW	1	2	22	21	7	1					3	14	15	5	1	38
W			1	2	1					1						1
NW																
ALL	2	7	43	31	16	2					13	37	30	12	2	
<i>MOUNT CRESSWELL 72° 44' S, 64° 23' E 1161.3 m Elevation Based on 4 years of records.</i>																
DIRN	JANUARY 0900 LST SPEED (KM/H)									JANUARY 1500 LST SPEED (KM/H)						
	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	A L	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	A L
N																
NE																
E											1					1
SE										1						1
S		1	2	3	1	4	1	11		2	7	19	10	8	1	46
SW			5	25	31	18	4	84		1	2	20	16	11	2	52
W			1	2	2	1		5			1					1
NW																
ALL	1	8	30	34	23					3	12	39	26	19	3	

The cloudband arrived after the passage of the station level trough. Personal observation by one of the authors indicated that the cloudband was associated with falling snow as it approached from the base of the Lambert Glacier. There is no knowledge of the type of weather associated with the cloudband as it traversed the eastern slopes into the glacier. At Mt Cresswell, upward vertical motion was indicated by the backing winds with height together with the strong upslope component of these winds after the arrival of the station level trough. Of

significance are the strong (50 m/s) upper tropospheric northerly winds extending well into the antarctic interior indicating a strong meridional thermal gradient in the middle troposphere over Mt Cresswell.

At Moore Pyramid, the cloud arrived before the trough passage at station level, while the bad weather commenced soon after the pressure began rising. Unlike the events at Mt Cresswell, there was a surface wind change with the trough passage. Table 1 indicates that the surface wind at Moore Pyramid is a little weaker and less

Fig. 5 Time section of upper winds (as in Fig. 3) for Mt Cresswell (see Fig. 1) from 1200 UTC 28 January 1972 to 0000 UTC 30 January 1972 together with station level pressure tendency and station plots (surface wind, cloud type and present weather using normal plotting convention) for both Mt Cresswell and Moore Pyramid from 1200 UTC 28 January 1972 to 1500 UTC 30 January 1972.

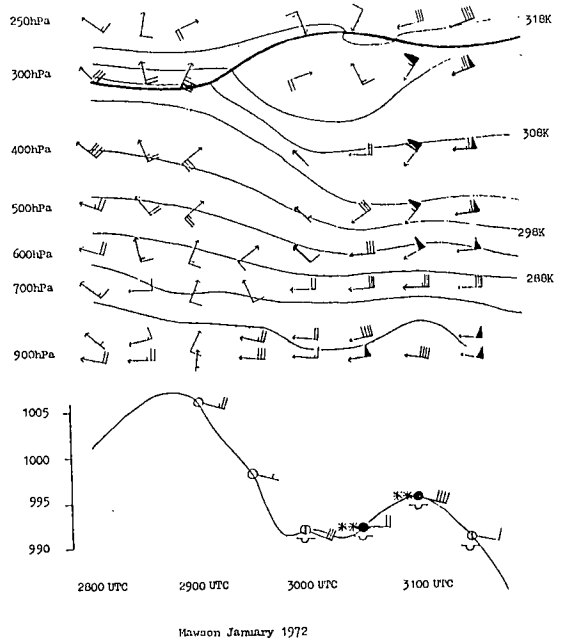


Similarly, from 0000 UTC 28 January to 1100 UTC 29 January the troposphere at Davis underwent marked warming (Fig. 7) and the MSL pressure fell there. The pressure rose around 1100 UTC 29 January as cloud increased with reports of falling snow and scud cloud up to 0000 UTC 30 January. Tropospheric warming ceased at this time and cooling commenced around 1100 UTC 30 January. The warming commenced as the wind shifted to the northeast in the middle to upper levels at 1100 UTC 27 January. Coincident with the increase in strength of middle to upper level northeasterly winds was the MSL pressure minimum and the arrival of the warmest air. This followed rapid development of the cyclone just north of Casey.

Formation of ice cap cloudband

It seems probable that warmer Southern Ocean air flowed around the eastern flank of the cyclone near Casey onto the antarctic ice cap. A 500 hPa high on the east Antarctic Plateau just west of Vostok, during the period 28 to 31 January, would favour westward advection of this air at middle levels. Vostok during this period had anomalously high 500 hPa heights up to 5320 geopotential metres compared with the normal January values of around 5100 geopotential metres. On

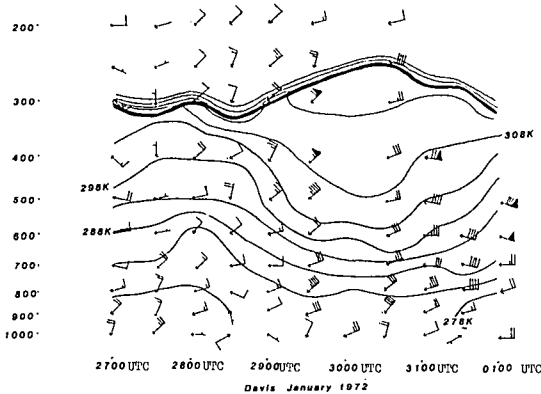
Fig. 6 As for Fig. 5 except for Mawson, from 0000 UTC 29 January 1972 to 0000 UTC 31 January 1972 together with isentropes (thin lines) and tropopause (thick line).



constant in direction than at Mt Cresswell. The latter station is presumably more affected by the great low-level drainage flow into the Lambert Glacier. Average surface wind speeds in this drainage area during a traverse in 1957 (Mather 1959) were comparable with surface winds at the notoriously windy Mawson over the same period.

From Fig. 6 the trough arrived at Mawson by 0000 UTC 30 January at upper levels and 12 hours later at lower levels, maintaining its sloping structure. A time section of isentropes and tropopause heights (also shown in Fig. 6) shows warming throughout the troposphere and a rising tropopause after 29 January. The middle to upper level winds began to strengthen by 31 January by which time the warmest air had reached Mawson. The pressure began falling as the tropospheric warming commenced (29 to 30 January) and rose when this warming ceased. Snowfall again occurred with rising pressure.

Fig. 7 Time section for Davis, 0000 UTC 27 January 1972 to 0000 UTC 1 February 1972 (thin lines, isentropes in degrees kelvin; thick line, tropopause; upper wind plots as in Fig. 3).



reaching the Lambert Glacier region this warm air contrasted strongly with much colder southerly air to the west. The strength of the upper winds at Mt Cresswell indicates that a strong middle to upper level baroclinic zone had formed in the region. The resulting meridional temperature gradient would, by thermal wind arguments, give the winds an increasing northerly component with height in the troposphere. This was observed at Mt Cresswell, Mawson and Davis following the passage of the trough.

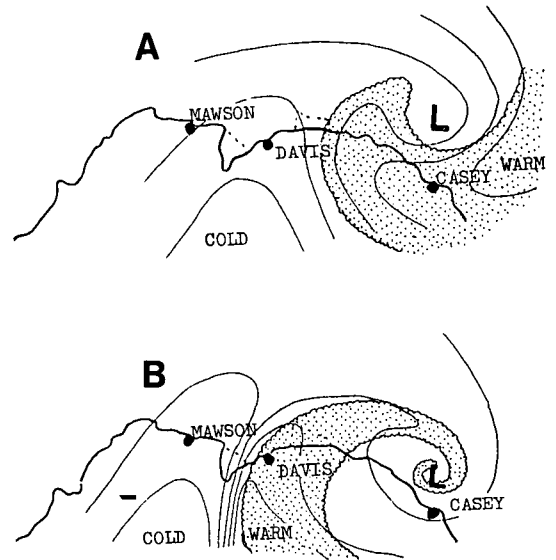
A schematic diagram is presented in Fig. 8 in an attempt to illustrate these processes. Isotherms representing a level in the middle troposphere (say 500 hPa) have been drawn. Stage A shows the developing cyclone near Casey, with a cloudband and thermal ridge extending onto the adjacent ice cap. In stage B the mature cyclone is near Casey, with the cloudband and thermal ridge near Davis. A marked temperature gradient has developed near and above the Lambert Glacier area just ahead of the cloudband.

Other observations of westward moving cloudbands

N.A. Streten (personal communication) has noted the following two examples of cloudbands approaching from the east in this region.

In late 1960 an inland base camp was established for some weeks in the southern Prince Charles Mountains at 72.6 degrees south 62.9 degrees east and several cases of cloudbands passing from east to west were observed at this site.

Fig. 8 Schematic diagram of (A) developing and (B) mature cyclone near Casey with middle troposphere thermal structure and cloudband. 'L' denotes MSL positions of cyclone, shaded areas show positions of cloudband and thin lines are 500 hPa isotherms.



In December 1982 an active cloudband with snow was observed on the antarctic supply vessel *Nella Dan* then crossing Prydz Bay to the west of Davis; the cloud approached from the east and produced falling snow coincident with rising pressure.

Summary

During a month-long period in the antarctic summer of 1983/84 when the long wave pattern favoured cyclonic development in the Casey region, the mid-upper tropospheric winds at Davis were dominated by a predominantly northerly component. A series of westward moving cloudbands, showing trough-like characteristics, passed through Davis producing snow and low scud cloud. Satellite imagery indicates that the cloudbands extended into the Lambert Glacier area. Small cloud vortices sometimes formed in the cloudbands as they moved off the antarctic ice cap.

During January 1972, when the sparse network was supplemented by upper wind data from the Lambert Glacier region, the observations indicate a further case of a westward moving cloudband associated with a trough sloping westward with height. Cyclonic development was occurring near Casey, while at the same time weak middle to upper tropospheric winds at Davis suddenly strengthened. It is thought that warm air advection around the southern flank of the cyclone

met with colder air flowing northwards from the Lambert Glacier region, forming a strong baroclinic zone which was ultimately advected westward towards Mawson. Strong middle to upper tropospheric winds observed at Mt Cresswell, Mawson and Davis with an increasing northerly component with height were consistent with a strong meridional temperature gradient. Precipitation occurred at both coastal and inland stations on a rising barometer following a sharp fall. Coastal radiosonde data indicate that rising pressure occurred just after the warmest tropospheric air arrived at the stations.

Acknowledgments

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