

# OBSERVATIONAL CHARACTERISTICS OF THE LOW-LEVEL JET AT DALY WATERS DURING PROJECT KOORIN

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## ABSTRACT

Low-level jets were observed during Project Koorin (a special 29 days of hourly planetary boundary layer data) at Daly Waters, in the winter of 1974. Time-height cross-sections show a double jet structure in the mean, and on two days jet speeds of over 20 m/s when the tightest pressure gradients occurred. Twenty years of routine morning pilot balloon flights reveal the occurrence of one jet with a wind speed greater than 30 m/s.

## INTRODUCTION

Low-level jets have been extensively studied in the United States of America since the pioneering theoretical investigation by Blackadar (1957). The low-level jet is a diurnal phenomenon with low-level (i.e. about 600 m above the ground) supergeostrophic winds, usually observed for a period around dawn. Bonner and Paegle (1970) have successfully modelled the low-level jet by a combination of the diurnal variation of the eddy diffusivity and of the broadscale baroclinic gradient. In continental areas a diurnal variation of the wind is common, but the low-level jet only occurs to a significant extent when the interactions are assisting. Thus the maximum wind strength of the low-level jet, at a particular location, is related to the latitude as determining the period of the inertial oscillation; to the interaction of the variation of the boundary layer stabilities and geostrophic wind; and to the synoptic-scale geostrophic and baroclinic conditions.

The low-level jet occurs in Australia but has not been reported on in detail. An earlier study by Kininmonth and Coughlan (1968) used routine pibal observations to investigate the low-level jet at Daly Waters.

One of the objectives of Project Koorin, a continental boundary layer observational program (Clarke et al. 1979), was to collect detailed data on the low-level jet at Daly Waters. The following is a description of the low-level jet occurrences during a 29-day period of Project Koorin, (mid-July to mid-August 1974) and a comparison with some longer-term statistics.

## THE FIELD OBSERVATIONS

Daly Waters (16°16'S, 133°23'E) is located 210 m above sea level on an extensive and featureless savannah plain (Fig.1). It lies north of the normal winter latitude of the surface subtropical high pressure belt and is thus located in an easterly surface wind regime. Figure 2 shows the climatological mean monthly 850 and 700 mb contour charts for August over northern Australia (July being similar). In the mean, the easterly winds extend to 850 mb and change to upper westerly winds around 700 mb. Few subtropical cold fronts penetrate as far north as Daly Waters, and the weather is relatively undisturbed in the area at this time of the year. Thus the Daly Waters low-level jet occurs as an easterly, and this contrasts with the southerly Great Plains jet in the United States of America.

The data collection period was from 15 July to 13 August 1974. Pilot balloons were released on the hour and tracked by radar (Plessey WF3) and/or a double theodolite system to altitudes of up to 3000 m. The balloon positions were observed every six seconds and the data entered on punched paper tape for later computer processing. On a majority of days additional balloons were released on the half hour at 0930, 1030, 1130, 1630, 1730 and 1830 local time (LT=GMT plus 9.5 hours) and simultaneously tracked by the double theodolite system. Radiosondes were released every three hours. The wind and temperature data were analysed at 50 m intervals to 1000 m and then at 100 m intervals to 3000 m. For convenience, during the Koorin Project days were referred to by number instead of by date, with 15 July being Koorin Day 1.

## TIME-AVERAGED KOORIN DATA

All the available Koorin winds were averaged to the nearest half hour to derive a time-height cross-section of average vector wind speed (Fig. 3). The afternoon is characterised by a period of light winds, between 1300 and 1800 LT with the light winds extending to 3000 m. The mean wind speed then increases, with two low-level maxima developing, one of 8.1 m/s at 0200 LT and 350 m above the surface (i.e. an average wind shear of 2.3 m/s per 100 m), and the second of 8.6 m/s 0930 LT and 700 m above the surface. The two maxima were a common occurrence and were present for the two cases discussed below. The dynamics of the Daly Waters low-level jet will be examined elsewhere.

## KOORIN DAYS 28 AND 29

The maximum wind speed observed during the period of the Koorin Project was 22.7 m/s at 450 m on Koorin Day 28. The time-height cross-section of wind speed for the morning and previous afternoon is shown in Fig. 4, together with the height of the low-level temperature inversion. This maximum wind speed was observed on the 0800 LT pilot balloon release, one hour after sunrise. As in Fig. 3 for the mean wind speed, a second prominent low-level maximum (17.8 m/s at 350 m) was observed on the 2205 LT flight. A similar structure was found by Hoecker (1963) in studies in the Texas-Oklahoma-Arkansas area of the United States of America. The wind speed maxima occurred above the level of temperature inversion. Wind shears below the maxima were high: 5.0 m/s per 100 m at 0800 LT and (on the basis of a wind of 17.5 m/s at 250 m) 7.0 m/s per 100 m at 2205 LT.

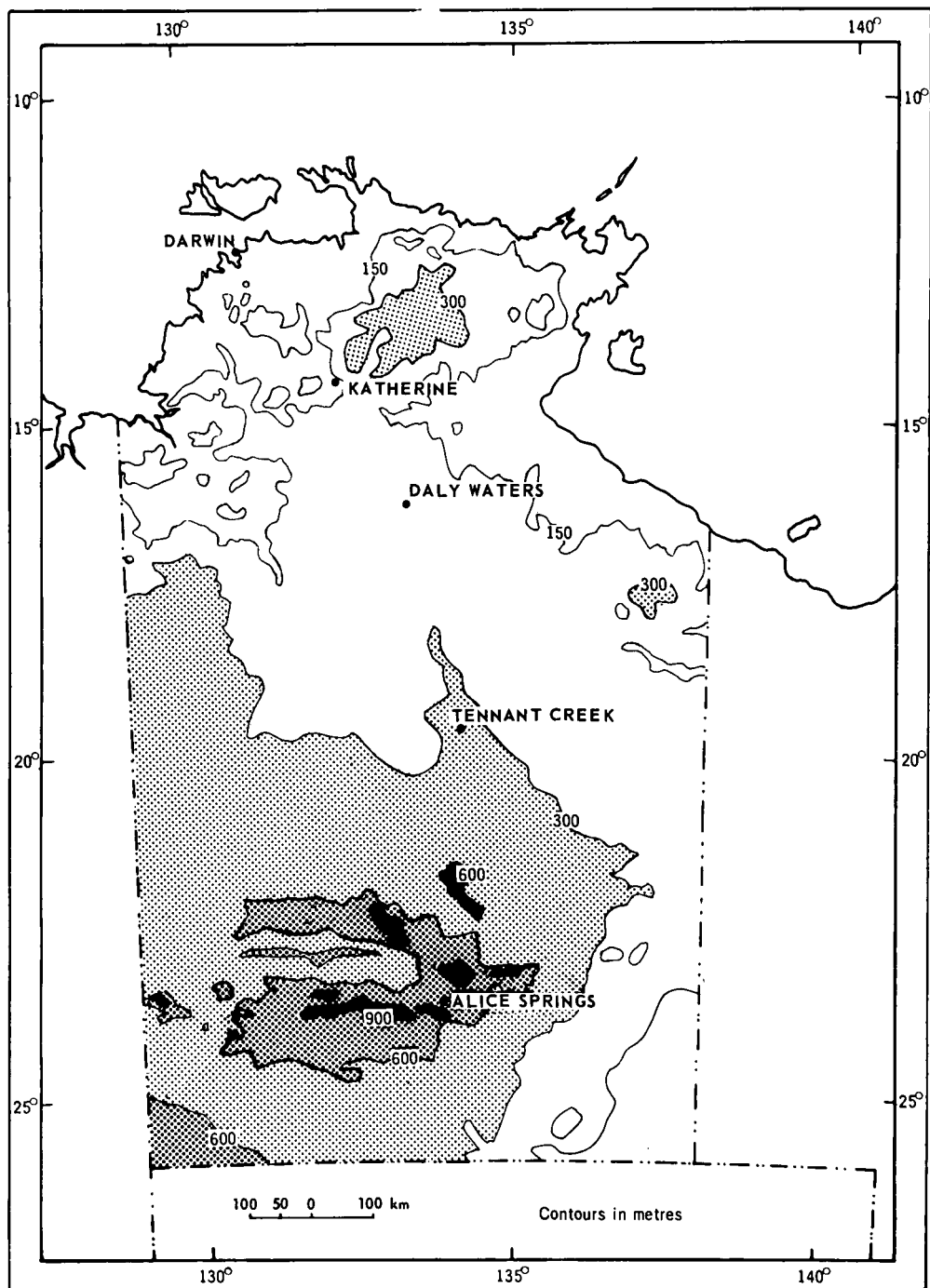
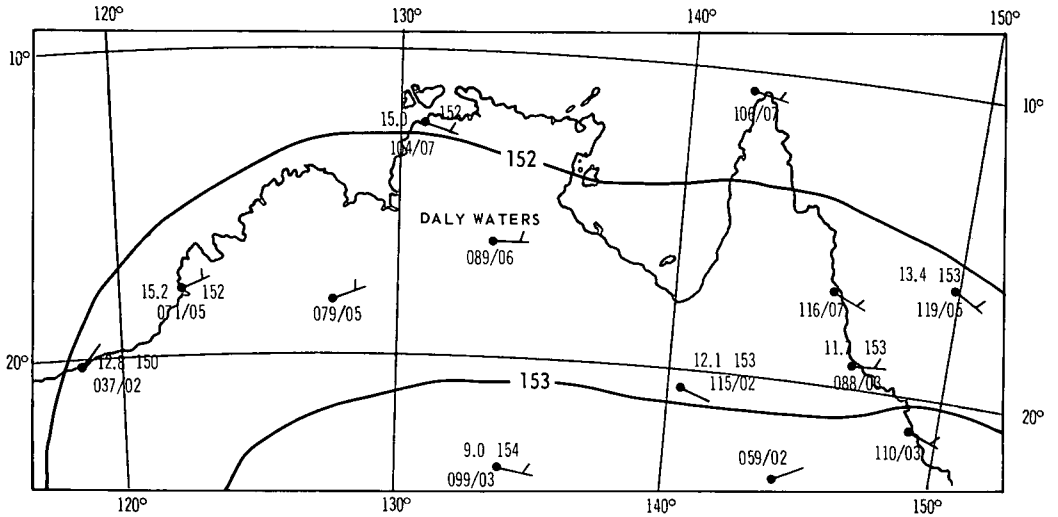
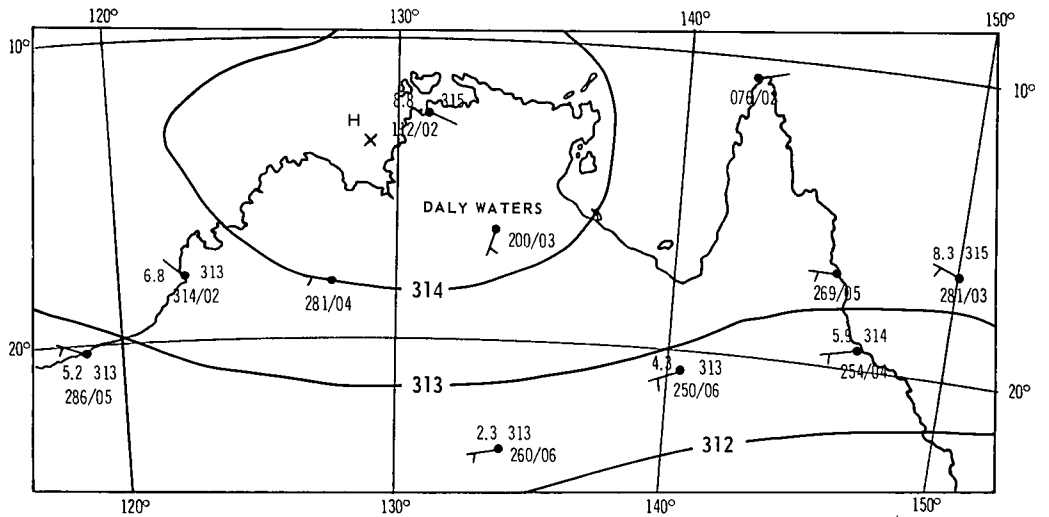


Fig. 1 Map of the Northern Territory showing the location of Daly Waters.



(a)



(b)

Fig. 2 Mean monthly isopleths of geopotential height (dekametres) for August at (a) 850 mb and (b) 700 mb (Wind speeds in m/s). (From Maher and Lee 1977).

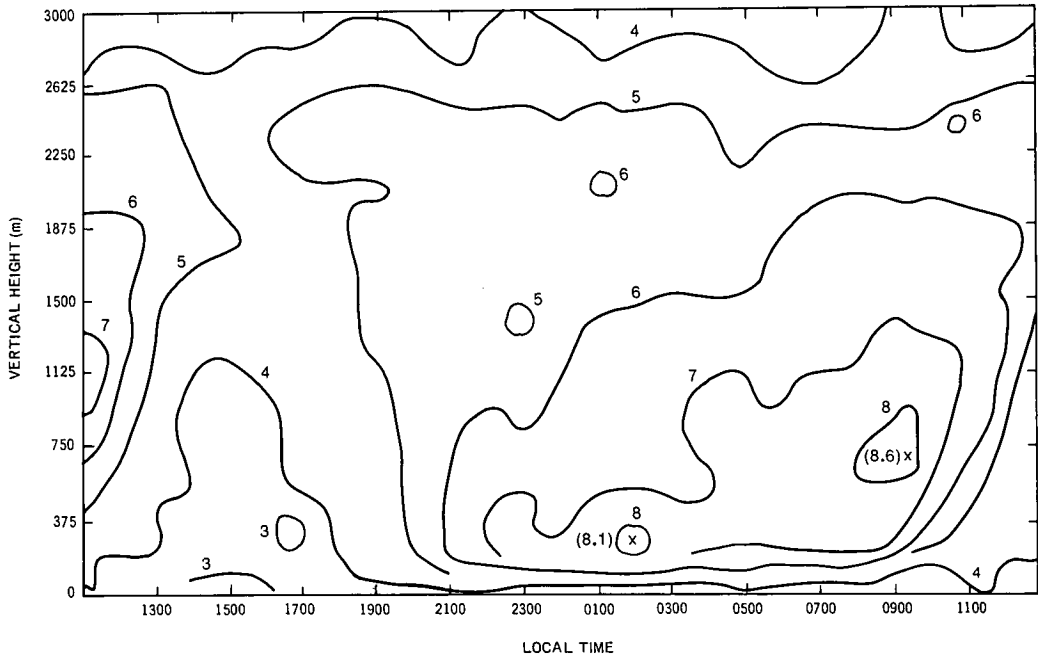


Fig. 3 Height-time section of average half hourly vector speed (m/s) for all observations during Project Koorin.

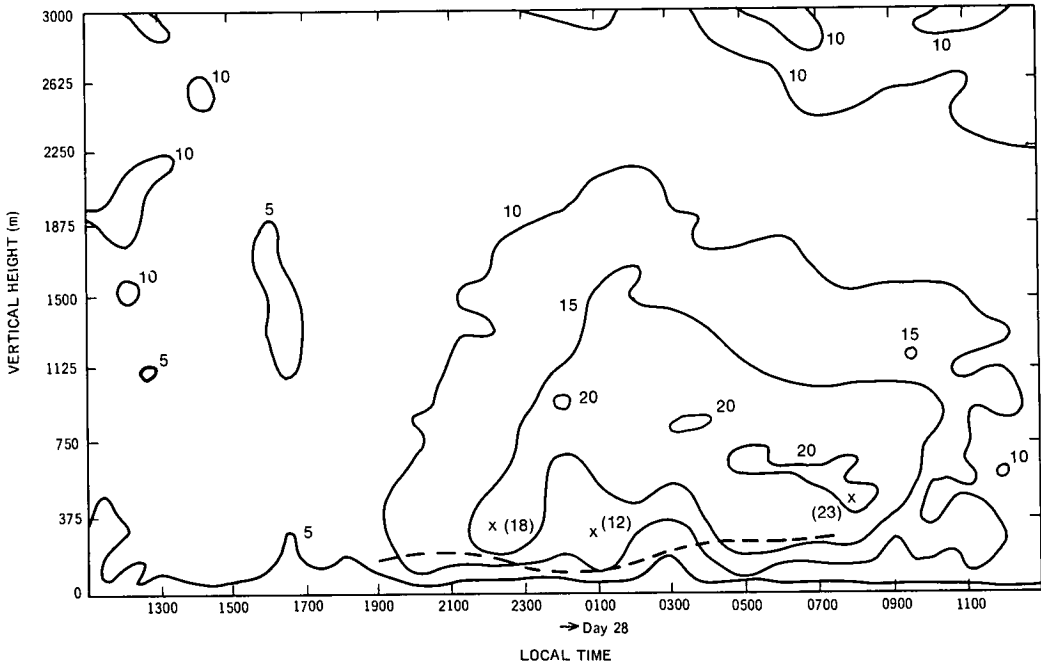


Fig. 4 Height-time section of wind speed (m/s) for Koorin Days 27 and 28. Temperature inversion shown as a dashed line.

Wind directions for the afternoon and morning on this occasion were between east and southeast with a period of southeast winds below 300 m between 1900 LT and 2300 LT. By 1100 LT the winds were beginning to back southerly at 3000 m.

The mean sea level synoptic charts are shown in Fig. 5 (a) to (c) for three days (27, 28 and 29). During day 27, a cold front moved across the south of the Australian continent, and the continental subtropical high pressure centre was characterised by weak pressure gradients. The cold front was located on the eastern Australian coast by day 28, and the continental high had intensified, while on day 29 the high had further intensified but had moved further eastward as a broad trough entered southwest Western Australia. For the Daly Waters area this sequence is further revealed in Table 1 by the variation of the 0900 LT pressure gradients over the area and the speeds of the wind maxima. Also in Table 1 are the times and heights of significant wind maxima. For the period of Koorin the strongest low-level jet occurred when there was an intense high to the south of Daly Waters, so the strength of the jet is directly related to the strength of the pressure gradient over the area.

Table 1 Comparison of the north-south pressure gradient in the Daly Waters area and significant speed maxima of the low-level jets.

Koorin Day No.	26	27	28	29
0900 LT MSL pressure				
Tennant Creek	1018.9	1019.0	1021.4	1021.0
Darwin	1015.4	1015.5	1014.7	1015.5
Difference (mb)	3.5	3.5	6.7	5.5
Low-level Jet				
Maximum (m/s)	12.5	11.3	21.2	20.8
Time	0002	0058	0401	2312
Height (m)	150	350	850	250
Maximum (m/s)	9.7	9.8	22.7	19.6
Time	1000	0603	0800	0507
Height (m)	750	400	450	250

Figure 6 gives the time-height cross-section of wind speeds for days 28 and 29, and comparison with Fig. 4 (days 27 and 28) shows weaker maxima, and a second temperature inversion at about 2 km on day 29.

Kininmonth and Coughlan (1968) quote a selection of routine pilot winds for Daly Waters for July 1965 with the extreme wind speed of 22 m/s on the 16th at 0300 LT. This speed is comparable with the wind maximum on day 28.

## LONG-TERM CLIMATOLOGY

Table 2 shows the frequency of occurrence of wind speeds observed by the routine 0300 LT pilot balloon flight at Daly Waters, from 1950 to 1970, at 300, 900 and 0900 and 1200 m levels. At 0300 LT the approximate time of

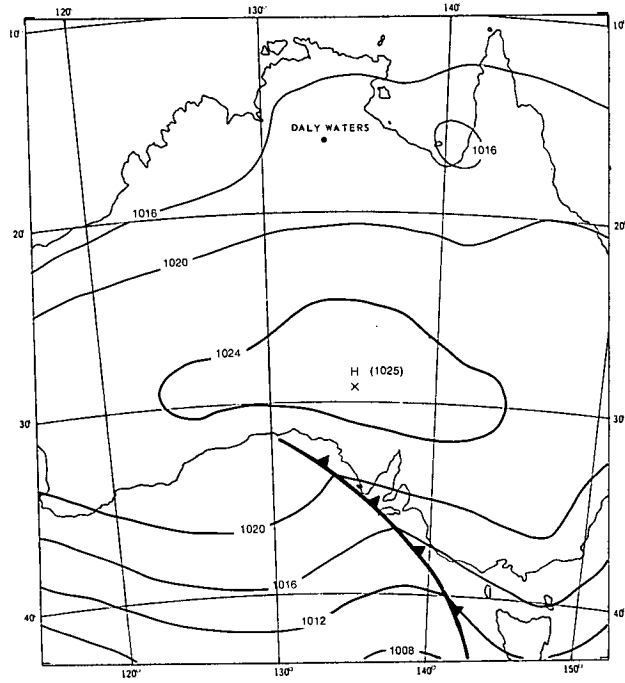


Fig. 5(a) Mean sea level pressure chart for 9 am Koorin Day 27.

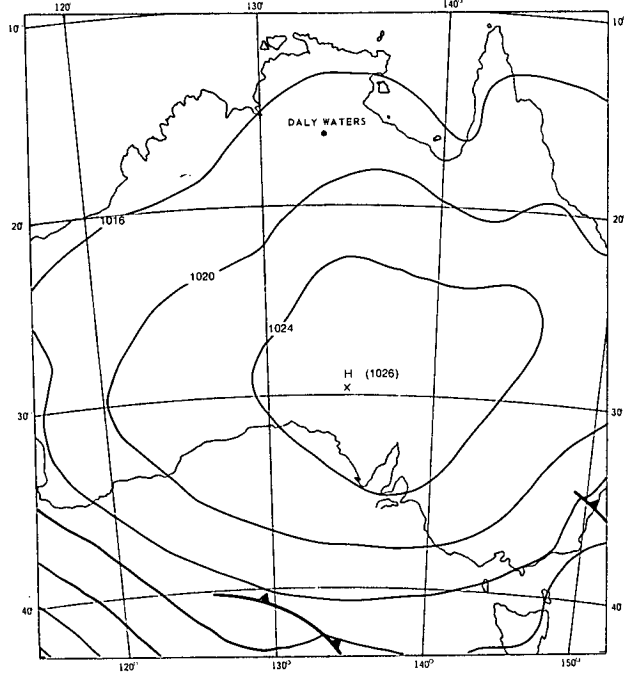


Fig. 5(b) Mean sea level pressure chart for 9 am Koorin Day 28.

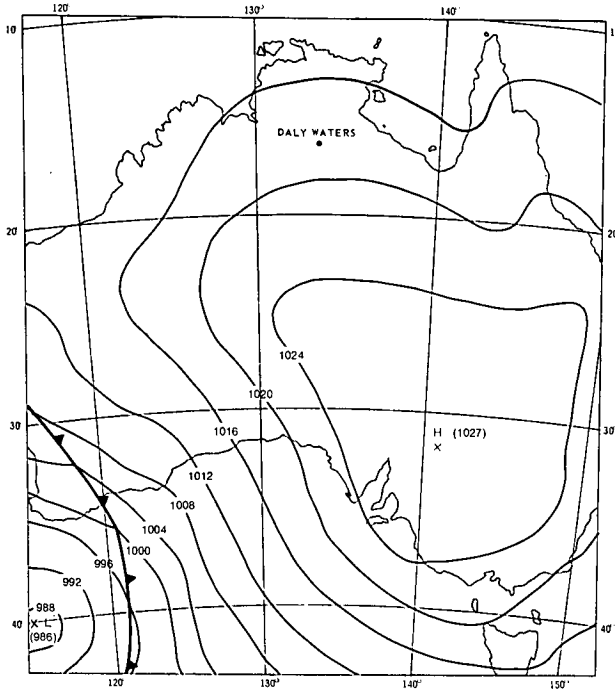


Fig. 5(c) Mean sea level pressure chart for 9 am Koorin Day 29.

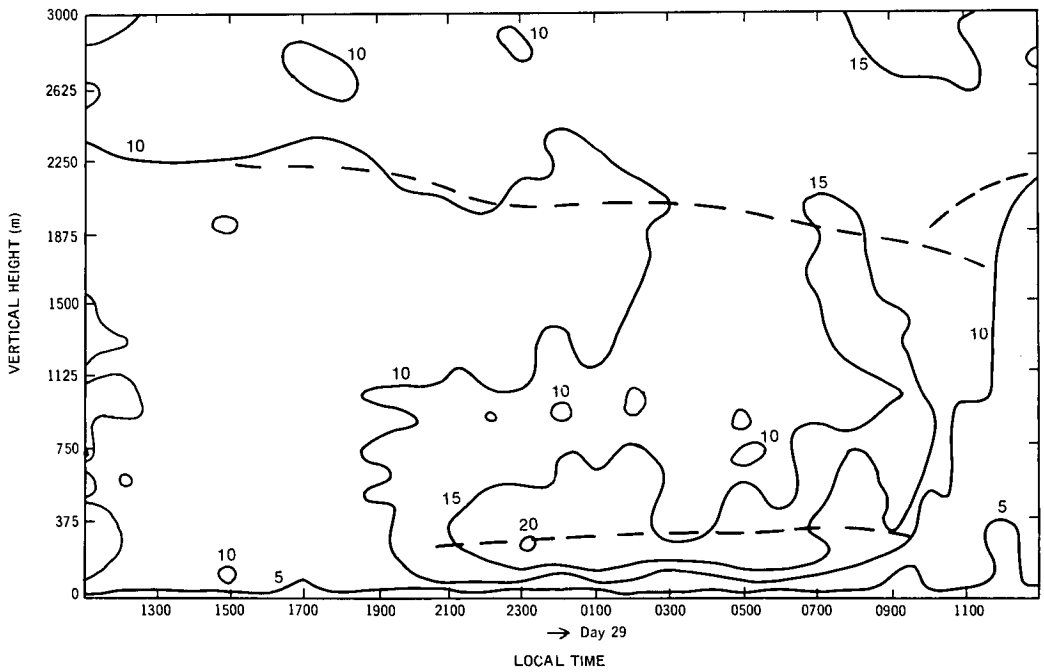


Fig. 6 Height-time section of wind speed (m/s) for Koorin Days 28 and 29. Temperature inversions shown as dashed lines.

Table 2 Frequency of Occurrence of Daly Waters 0300 LT routine pilot balloon winds for the period 1950 to 1970, classified by wind speed (m/s) at three levels for monthly and annual totals

Level	Month	Wind Speed Ranges (m/s)												Total			
		0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	Month		Annual		
300 m	ALL	980	2827	1671	436	95	17	4	3								6033
	%	16.2	46.9	27.7	7.2	1.6	0.3	0.06	0.04								
900 m	Jan	43	126	148	109	34	14	3	3								480
	Feb	43	111	127	103	39	12	6	3								444
	Mar	38	144	138	92	49	19	5	3	1							489
	Apr	29	110	143	101	60	32	16	3	2							496
	May	34	109	133	91	84	44	20	12	8	3						538
	Jun	32	98	132	94	82	47	29	10	4							528
	Jul	35	107	108	116	57	47	28	24	6	2						530
	Aug	31	90	114	93	81	43	28	13	1	2	1					497
	Sep	33	79	142	108	89	42	20	5	3							521
	Oct	36	85	145	118	101	41	16	3								545
	Nov	30	95	128	96	65	26	9	2	2							453
	Dec	42	114	128	113	55	21	2	1			1					477
	ALL	426	1268	1586	1234	796	388	182	82	27	8	1					5998
	%	7.1	21.1	26.4	20.6	13.3	6.5	3.0	1.4	0.5	0.1	0.01					
1200 m	ALL	894	1893	1634	955	368	98	49	14	5	1	1					5912
	%	15.1	32.0	27.6	16.2	6.2	1.7	0.8	0.3	0.08	0.01	0.01					

the low-level jet, the percentages of all wind speeds above 21 m/s are 0.04 at 300 m, 2.0 at 900 m and 0.4 at 1200 m. At each of the 900 and 1200 m levels there was one occurrence of a wind speed of more than 30 m/s. The directions of the winds with speeds above 21 m/s were east to south-southeast, except for the December occurrence in the 28 to 30 m/s range, which was westerly. This was not a low-level jet event, but could have been associated with a weakening tropical cyclone.

## CONCLUSIONS

Time-height sections of wind speeds from the Koorin Project at Daly Waters have been presented. In the mean, the persistence of the low-level jet is demonstrated and two individual days indicate the complex microstructure that is superimposed on the mean pattern. The Koorin data indicate that it is usual to find at least two jets, one about midnight and the second near the time of sunrise. During the Koorin Project, the maximum speed was 22.7 m/s on day 28 at a height of 450 m above the terrain. Routine pilot balloon data from 1950 to 1970 indicate maximum speeds in the low-level jet of above 30 m/s.

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