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LUCAS HEIGHTS RESEARCH LABORATORIES

SOME ATMOSPHERIC DISPERSION, WIND AND TEMPERATURE STATISTICS FROM JERVIS BAY, AUSTRALIAN CAPITAL TERRITORY 1972 TO 1974

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ABSTRACT

A meteorological study of winds, temperatures and Pasquill stability categories was conducted in the coastal conditions at Jervis Bay in the Australian Capital Territory. Three Pasquill stability categorisation schemes were compared. These indicated a predominance of neutral to slightly unstable conditions. During the daytime, north bay breezes and north-east sea breezes were most common together with on-shore south-east winds. Off-shore south-west winds prevailed during winter and were observed most frequently at night.

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WIND; METEOROLOGY; NEW SOUTH WALES; CLIMATES; TEMPERATURE MEASUREMENT; EXPERIMENTAL DATA

CONTENTS

1. INTRODUCTION

A summary is given of meteorological data collected at Jervis Bay, a coastal settlement of the Australian Capital Territory, between early 1972 and mid-1974. An earlier report [Clark and Bendun 1974] described the reasons for changing the survey site from Murray's Beach, Jervis Bay, formerly the proposed site for a nuclear power station, to the Jervis Bay settlement. The remoteness of Jervis Bay from the Lucas Heights Research Laboratories led to significant problems in the maintenance of instrumentation and the collection of good quality meteorological data. As a result, data from the acoustic sounder were of such poor quality that further analysis was not justified. Since then, the acoustic sounder has been moved to Lucas Heights and has operated with improved efficiency [Clark 1982].

The meteorological data were used in a number of different schemes to define the prevailing atmospheric stability categories. These are compared and summarised by wind direction and time of day. In addition, statistics are presented on the diurnal and seasonal variations of wind directions and speeds, and dry and wet bulb temperatures. This information from a coastal location contributes to a mesometeorological data base which is appropriate to atmospheric dispersion studies in Australia.

2. INSTRUMENTATION, CALIBRATION AND PERFORMANCE STATISTICS

Instruments to collect wind, temperature, atmospheric stability and solar radiation data were installed at Jervis Bay to allow both climatological analyses and classification of the atmospheric dispersion conditions. Statistics on the location and performance of the instruments are given in Table 1. The Dines anemograph is an instrument that cannot be conveniently calibrated in a wind tunnel. Consequently, after completion of the Jervis Bay study, this instrument was removed to Lucas Heights and, over a two-week period, 30-minute average wind speeds were collected and compared with similar data taken at the same altitude from a new and more sensitive Climatronics anemometer. The results indicated that the Dines anemograph had a threshold of 0.9 m s^{-1}, underestimated low speeds and overestimated high speeds. The new calibration factors were applied to all the Dines data collected between June 1972 and July 1974 at Jervis Bay. During the study at Jervis Bay, the acquisition of wind statistics for more than 85 per cent of all times was considered acceptable.

The dry and wet bulb thermistors were ventilated naturally and placed in the same Stevenson screen as the mercury thermometers belonging to the Bureau of Meteorology observation station at Jervis Bay. Dry and wet bulb temperatures were compared periodically with the thermistor outputs to generate sets of calibration curves. Difficulties in keeping the wet bulb wick moist led to its poor performance. The only method available for calibration of the temperature difference (ΔT) system required substitution of known resistances (equivalent to given ΔT values) into the bridge circuit. Subsequent analysis of the temperature difference statistics indicated an excessive frequency of unstable (< -1 °C/100 m) temperature gradients, even when the sensors were in close proximity to the ground [Prendergast and Crawford 1974]. This was probably due to the inadequacy of calibration procedures. For this reason, the temperature difference data are not discussed. Temperatures and net radiation data were recorded as continuous traces on a Honeywell multichannel chart recorder.

To operate efficiently, the acoustic sounder needs continual fine tuning and inspection, neither of which was available at Jervis Bay. It also performed poorly because of the inadequate acoustic shielding of the transceiver by a low earthen wall. As a result, there was no justification for analysis of the facsimile records beyond that reported by Clark and Bendun [1974]. With the exception of net all-wave radiation (averaged over 1 hour), all data were extracted as 30-minute averages. Meteorological measurements from Jervis Bay with better than 80 per cent data recovery were considered acceptable, given the resources available to the study. This performance value should be compared with the 90 per cent goal which is recommended by the US Nuclear Regulatory Commission [USNRC 1974].

3. TEMPERATURE STATISTICS

The dry and wet bulb temperatures have been treated differently because of poor quality of the wet bulb data (Table 1). In Table 2, which is based on 30-minute average data, results are presented for times at which both the dry and wet bulb temperatures are available; 'good data' indicates the frequency (%) of occurrence. Statistics for July to October represent 1973 data only and those marked November apply only to the last two thirds of November 1972; the wet bulb sensor did not operate in November 1973. Uncertainties in the initial wet bulb calibrations in 1972 might account for the high November values.

The diurnal trend in temperatures is examined in the averages taken every 3 hours. Between 1200 and 1500 EST, there is only a slight change in temperature. This probably reflects the advent and intensification of the sea breeze which is cooler and moist. McGrath [1972] has discussed the sea breeze influence on coastal and inland temperatures in the Sydney region. She found that if the sea breeze arrives before the maximum temperature has been reached, the temperature remains nearly constant during the afternoon, an observation that is in accord with the Jervis Bay data. A similar trend is evident in dry bulb temperatures which span the longer period from January 1972 to June 1974 (Table 3). The averages in Table 3 are generally a little lower than the equivalent data in Table 2.

4. ATMOSPHERIC STABILITY CATEGORISATION SCHEMES APPLIED AT JERVIS BAY

There is no agreement among meteorologists on a universal scheme to define the prevailing stability categories related to atmospheric dispersion conditions. Initially, Pasquill [1961] and Gifford [1961] classified the downwind variation of the horizontal and vertical diffusion parameters by general weather observations. Since then other workers have attempted to quantify these observations further in terms of various meteorological parameters. Three schemes are compared, two of which were developed by the Australian Atomic Energy Commission [Clark and Bendun 1974; Clark 1982]. Because these schemes rely on estimates of horizontal wind direction turbulence they could be considered more appropriate to estimates of horizontal diffusion (σ_y). The third scheme of Smith [1972] was developed specifically to define the vertical dispersion (σ_z) conditions.

Each of the stability categorisation schemes relies on a combination of meteorological measurements. The Clark/Bendun scheme depends on wind direction turbulence and wind speed, that of Smith on net all-wave radiation and wind speed, and Clark's turbulence method on wind direction turbulence alone. At Jervis Bay, as a consequence of the different availabilities of these meteorological data, each stability scheme has variable 'good quality' data. Between June 1972 and July 1974 the turbulence method had 87 per cent data recovery whereas the Clark/Bendun and Smith schemes recovered 83 and 71 per cent respectively. Because the turbulence method was based on the most reliable data, it performed best at Jervis Bay.

In the comparison of the three categorisation schemes the amount of good quality data is further diminished because there is a reliance on the simultaneous availability of the different estimates. Simultaneous estimates are compared as frequencies (%) by night (1900 to 0700 EST, Table 4) and day (0700 to 1900 EST, Table 5). Further explanation may be required. For example, the top row in Table 4 represents the fraction of events classified as category A, after application of the Smith [1972] stability estimates at a particular time, which are classified as other categories when using the turbulence method at the same time. The numbers in the lower right hand corners of each table are the total numbers of half-hourly observations.

At night, a majority (74 per cent) of the Smith [1972] stability estimates fall into the categories D to E. Both the turbulence method and the Clark and Bendun scheme predict similar distributions at night with 60 per cent of the estimates occurring in categories C to D. During the day, the Clark/Bendun scheme indicates more of the unstable category A and less of category D than either the turbulence method or the Smith method, each of which predicts a majority in categories C to D. Overall the best agreement is between the turbulence and Clark/Bendun schemes with this being greatest during the night (Table 6). This is not surprising since the turbulence method is really a simplification of the Clark/Bendun scheme. A similar spread of stability estimates using different schemes has been reported at other sites [*e.g.* Sedefian and Bennett 1980; Lalas *et al.* 1979; Miller 1978; Fulle 1976].

It is interesting to contrast the application of these schemes in a marine environment to that further inland at Lucas Heights [Clark 1982] At night a trimodal distribution is predicted by the turbulence method at Lucas Heights, with the major peak at category C (38.5 per cent) and two smaller peaks at categories E (18.6 per cent) and G (20.4 per cent), compared to categories C to D at Jervis Bay. The distribution in the Smith scheme is also skewed towards the more stable categories E to F at the inland site. During the day, most of the turbulence method and Smith stabilities fall into the categories B to C at Lucas Heights by contrast with the more stable categories C to D at Jervis Bay. In summary, the marine climate at Jervis Bay appears less stable at night and more stable during the day than at Lucas Heights.

5. WIND CLIMATOLOGY

Preliminary results from the Jervis Bay settlement [Clark and Bendun 1974] identified the presence of bay and sea breezes during the day and off-shore winds with a westerly component at night. Wind speed and direction frequency distributions are plotted as Bailley-type wind roses by season and time of day. The distributions are based on the 30-minute average data with 0000 EST equivalent to the time period 0000 to 0030 EST etc. On summer nights (Figures 1 and 2), winds from the north-west and south-east predominate with speeds mostly in the range 2 to 4 m s^{-1}. By 0900 EST, the north bay breeze has already developed. The north-east sea breeze is observed later in the day with south-east winds persisting at all hours. Wind speeds in the range 4 to 8 m s^{-1} are observed more frequently during the day. South-east 'sea breezes' were also observed by Clark [1982] in acoustic sounder studies at Lucas Heights. These south-east winds had a similar vertical structure to the north-east sea breeze in which an elevated acoustic echo was associated with a temperature inversion layer, wind speed and direction discontinuities.

In the transition seasons between summer and winter (autumn, Figures 3 and 4; spring, Figures 7 and 8), similar diurnal trends are observed in the wind data. At night, south-west winds are most common with similar smaller contributions from the north-west, south-east and south sectors. The arrival of the north bay breeze is delayed to 1200 EST in autumn although it is observed in the 0900 EST data from spring. In autumn, south-east winds become dominant in the afternoon wind roses, whereas north-east sea breezes are more often observed in spring.

South-west winds completely dominate the winter nocturnal wind regime (Figures 5 and 6). It is interesting to note a comparative lack of light winds at night when the 2 to 4 m s^{-1} range dominates. The south-west winds persist throughout the day with little or no bay or sea breeze influence. However, south-east winds are slightly more important than those from the south-west in the 1500 EST data. Although there may be some synoptic scale influences on winds during all seasons, drainage of air from the inland escarpment or from other local topographic features may cause south-west winds at night and in winter.

To investigate further the nature of winds at Jervis Bay, a comparison is made between diurnal variations of Smith [1972] stability categories and wind directions (Table 7). Between 0000 and 0600 EST, winds from the south-west through north-west sectors are associated with relatively more stable conditions (categories E to G) than those from the south and south-east sectors (category D). From 0600 to 0900 EST, there is a rapid transition from the stable, nocturnal regime to the unstable daytime conditions (categories B to C). The neutral stability category (D) has a large presence all day. The north bay breeze, which is first observed at 0900 EST, is associated with relatively more unstable conditions than daytime winds from other directions.

6. SUMMARY

Meteorological conditions at the Jervis Bay settlement are typical of a coastal climate. There is only a small diurnal range of temperatures. During the day, bay breezes from the north develop earlier and are associated with more unstable conditions than the north-east sea breezes and other winds. South-east 'sea breezes' can also be observed during the afternoon. In winter, south-west winds are strong in the daytime but associated with more stable conditions and lower speeds by night when they are possibly enhanced by off-shore cool air drainage effects. Wind speeds followed the expected diurnal variation. During the daytime, wind speeds in the range 4 to 8 m s^{-1} became more important, but over all times, speeds of 2 to 4 m s^{-1} were most frequently observed.

Comparison of three Pasquill atmospheric stability categorisation schemes indicated a maximum agreement of 37 per cent, with 79 per cent of cases falling within one stability category of agreement. The Clark/Bendun [1974] scheme and the turbulence method of Clark [1982] are more appropriate to horizontal diffusion estimates, and both peaked in the slightly unstable (C to D) categories. The Smith [1972] scheme, which was developed for vertical diffusion estimates, predicted the neutral category (D) most frequently. Although different schemes may be more appropriate to horizontal or vertical dispersion, variations observed at Jervis Bay were consistent with studies made at other sites.

7. ACKNOWLEDGEMENTS

At the Jervis Bay settlement, rangers from the Department of Conservation and Agriculture were responsible for reporting instrument malfunctions and making the daily chart changes. Under adverse circumstances, Mr Kurt Bendun kept the instruments operating as efficiently as possible. Without Ms Beate Tinnermann's painstaking data extraction, this report would not have been possible. This assistance is most gratefully acknowledged.

8. REFERENCES

Clark, G.H. [1982] - A study of air pollution meteorology parameters on the southern extremity of Sydney. *Proc. Conf. The Urban Atmosphere — Sydney a Case Study*, Leura, NSW, May. Organised by the Atmospheric Science Section, CSIRO Division of Fossil Fuels.

Clark, G.H. & Bendun, E.O.K. [1974] - Meteorological research studies at Jervis Bay, Australia. AAEC/E309.

Fulle, D. [1976] - A comparison of three stability classification systems using surface and radiosonde data for four cities in the western United States. Preprint Volume, *Third Symp. Atmospheric Turbulent Diffusion and Air Quality*. Sponsored by the American Meteorological Society, Raleigh, North Carolina, 19-22 October, pp.141-148.

Gifford, F.A. [1961] - Use of routine meteorological observations for estimating atmospheric dispersion. *Nucl. Safety*, 2(4)47- 57.

Lalas, P.P, Catsoulis, V. & Petrakis, M. [1979] - On the consistency of stability classification schemes when applied to non-homogeneous terrain. *Atmos. Environ.*, 13:687-691.

McGrath, C.A. [1972] - The development of the sea-breeze over Sydney and its effect on climate and air pollution. M.Sc. Thesis, Macquarie University, NSW.

Miller, C.W. [1978] - A critique of the determination of atmospheric stability categories for assessing airborne releases of radionuclides. *Health Phys*, 34(5)489-492.

Pasquill, F. [1961] - The estimation of the dispersion of windborne materials. *Meteorol. Mag.*, 90(1063)33-49.

Prendergast, M.M. & Crawford, T.V. [1974] - Actual standard deviations of vertical and horizontal wind direction compared to estimates from other measurements. *Symp. Atmospheric Diffusion and Air Pollution*. Sponsored by the American Meteorological Society, Santa Barbara, California, 9-13 September, pp.1-6.

Sedefian, L. & Bennett, E. [1980] - A comparison of turbulence classification schemes. *Atmos. Environ.*, 14:741-750.

Smith, F.B. [1972] - A scheme for estimating the vertical dispersion of a plume from a source near ground level. *Proc. Third Meeting of Expert Panel on Air Pollution Modelling*. NATO-CHHS Report 14, North Atlantic Treaty Organisation, Brussels, XVII-1 to XVII-14.

USNRC [1974] - Regulatory guide 1.23. Onsite meteorology program. US Nuclear Regulatory Commission, Washington, D.C.

TABLE 1
INSTRUMENTATION, CALIBRATION AND PERFORMANCE STATISTICS AT JERVIS BAY SETTLEMENT

Instrumentation	Data	Height (m)	Operating Period	Calibration Method	Performance (% of Operating Period)
Dines anemograph	Wind speed Wind direction Direction turbulence	10	23.6.72 to 31.7.74	By comparison with an *in situ* anemometer	87 89 88
Thermistor temperature sensors	Dry bulb	1.5	22.12.71 to 31.7.74	Comparison with thermometers in the same Stevenson screen	85
	Wet bulb	1.5	10.11.72 to 31.7.74		58
	Difference	3 to 33	22.12.71 to 31.7.74	Known variable resistors in the bridge circuit	81
Funk net all-wave radiometer	Net radiation	3	22.12.71 to 31.7.74	Periodically by the National Testing Authority	85
Acoustic sounder	Facsimile record	~ 50 to 1372	23.6.72 to 31.7.74	Not applicable	40

TABLE 2
AVERAGED TEMPERATURES (°C) FROM JERVIS BAY
DATES: 10.11.72 TO 30.6.74

		Times (EST)										Extreme Values	
Month	Type	0300	0600	0900	1200	1500	1800	2100	2400	Min.	Max.	Min.	Max.
Jan.	Dry bulb	19.3	18.9	20.9	21.9	22.1	20.8	20.3	19.5	18.1	22.9	14.2	28.9
	Wet bulb	14.5	14.8	17.2	18.4	18.4	17.4	16.5	15.2	14.6	19.4	5.4	24.4
	Good data %	46.8	48.4	59.7	72.6	71.0	67.7	59.7	50.0				
Feb.	Dry bulb	19.6	19.4	21.6	23.7	24.0	22.6	20.5	20.00	18.3	24.4	11.4	39.7
	Wet bulb	16.0	15.9	17.8	19.1	19.2	18.5	16.8	16.4	14.6	19.7	11.0	27.9
	Good data %	48.2	46.4	46.4	42.9	55.4	55.4	51.8	51.8				
Mar	Dry bulb	17.7	16.8	20.2	22.0	22.0	20.3	19.1	17.8	16.1	22.7	11.6	25.7
	Wet bulb	15.3	14.6	17.2	18.1	18.3	17.4	16.6	15.5	13.7	18.8	8.4	22.6
	Good data %	53.2	54.8	59.7	72.6	66.1	62.9	62.9	58.1				
Apr.	Dry bulb	16.4	16.0	18.7	20.8	20.8	19.2	18.0	17.0	15.1	21.6	8.7	28.7
	Wet bulb	14.3	14.0	15.6	16.7	16.8	16.2	15.6	14.8	13.3	17.3	8.6	21.0
	Good data %	85.0	85.0	83.3	83.3	81.7	81.7	81.7	81.7				
May	Dry bulb	13.4	13.2	15.9	18.8	18.6	16.4	15.2	13.9	12.0	19.6	7.8	26.7
	Wet bulb	11.5	11.5	13.2	14.5	14.5	13.6	13.0	11.9	10.5	15.1	7.4	18.7
	Good data %	66.1	67.7	66.1	64.5	58.1	62.9	67.7	64.5				
June	Dry bulb	11.7	11.5	13.0	16.1	15.7	13.6	12.7	11.9	10.8	16.3	6.2	21.1
	Wet bulb	10.00	9.8	10.8	12.6	12.2	11.4	10.9	10.3	9.0	12.8	5.4	16.5
	Good data %	45.8	50.8	45.8	47.5	247.5	45.8	44.1	42.4				
July	Dry bulb	11.3	11.1	13.1	16.1	15.9	14.0	12.7	12.2	10.00	16.7	7.2	20.3
	Wet bulb	9.8	9.7	11.0	12.9	12.8	11.6	10.7	10.4	8.3	13.4	6.3	15.7
	Good data %	100.00	100.00	100.00	96.8	100.00	100.00	100.00	100.0				
Aug.	Dry bulb	10.7	10.1	12.9	15.5	15.7	13.4	12.6	11.6	9.2	16.5	5.6	19.6
	Wet bulb	9.8	9.3	11.1	12.7	12.5	11.2	10.5	10.5	8.2	13.3	4.4	17.1
	Good data %	90.3	87.1	90.3	90.3	87.1	90.3	93.5	90.3				
Sept.	Dry bulb	12.7	12.3	16.4	19.0	19.0	16.4	15.0	13.9	11.5	19.8	7.0	32.7
	Wet bulb	11.1	10.8	13.6	15.0	14.7	13.3	12.5	12.1	10.00	15.6	6.6	21.8
	Good data %	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.0				
Oct.	Dry bulb	13.7	12.8	15.7	17.5	17.1	15.5	14.5	14.1	12.1	19.0	8.0	25.1
	Wet bulb	11.4	10.8	12.5	13.9	13.7	12.4	11.6	11.7	9.8	15.2	6.6	19.4
	Good data %	58.1	61.3	58.1	54.8	54.8	51.6	58.1	58.1				
Nov.	Dry bulb	12.0	13.5	15.9	17.0	16.6	15.4	14.6	12.7	13.9	17.7	10.3	23.2
	Wet bulb	11.6	13.5	15.4	16.4	16.1	15.3	14.4	12.6	13.9	16.8	10.3	19.4
	Good data %	2.0	5.9	23.5	35.3	33.3	29.4	19.6	3.9				
Dec.	Dry bulb	18.5	18.3	20.5	21.4	21.3	20.4	19.6	18.7	17.3	22.2	13.6	30.6
	Wet bulb	14.6	14.3	17.0	17.6	17.3	16.8	16.2	15.2	15.0	18.7	8.1	24.2
	Good data %	41.9	41.9	56.5	64.5	56.5	56.5	45.2	43.5				

TABLE 3
AVERAGED TEMPERATURES (°C) FROM JERVIS BAY
DATES: 10.1.72 TO 30.6.74

		Times (EST)										Extreme Values	
Month	Type	0300	0600	0900	1200	1500	1800	2100	2400	Min.	Max.	Min.	Max.
Jan.	Dry bulb	17.6	17.7	20.1	21.4	21.2	19.8	19.0	18.2	16.3	22.5	11.8	30.3
	Good data %	95.7	95.7	97.8	97.8	98.9	98.9	96.8	93.5				
Feb.	Dry bulb	18.1	18.2	21.1	23.0	22.9	21.3	19.5	18.6	16.6	24.1	9.6	39.7
	Good data %	88.2	87.1	84.7	83.5	90.6	88.2	88.2	89.4				
Mar.	Dry bulb	17.2	16.6	20.3	22.1	22.1	19.8	18.6	17.7	15.6	23.1	9.1	28.9
	Good data %	83.9	83.9	83.9	86.0	87.1	87.1	86.0	84.9				
Apr.	Dry bulb	15.6	15.2	18.4	20.5	20.5	18.0	17.0	16.1	14.1	21.6	8.7	28.7
	Good data %	86.7	84.4	83.3	85.6	85.6	85.6	84.4	85.6				
May	Dry bulb	12.8	12.7	15.7	18.3	18.2	15.5	14.3	13.3	11.4	19.0	7.0	26.7
	Good data %	80.6	77.4	76.3	74.2	76.3	80.6	82.8	82.8				
June	Dry bulb	11.2	10.8	12.9	15.6	15.6	13.1	12.3	11.5	9.7	16.5	5.3	21.2
	Good data %	98.9	98.9	97.8	95.5	96.6	100.0	98.9	100.0				
July	Dry bulb	10.1	9.8	12.8	16.0	15.8	12.6	11.3	10.8	8.7	16.9	4.1	21.5
	Good data %	100.0	100.0	100.0	98.4	100.0	100.0	100.0	100.0				
Aug.	Dry bulb	10.4	9.7	13.4	16.3	15.7	13.0	12.1	11.1	8.9	17.1	5.6	21.7
	Good data %	95.2	95.2	93.5	95.2	95.2	93.5	95.2	95.2				
Sept.	Dry bulb	12.2	11.7	16.8	19.2	19.1	15.8	14.2	13.1	10.8	20.4	5.5	32.7
	Good data %	100.0	98.3	100.0	100.0	98.3	100.0	95.0	100.0				
Oct.	Dry bulb	12.9	12.7	16.6	18.3	17.7	15.3	13.9	13.5	11.4	19.5	5.7	28.2
	Good data %	79.0	80.6	79.0	77.4	77.4	75.8	79.0	77.4				
Nov.	Dry bulb	13.1	14.0	16.7	18.2	17.6	16.0	14.5	13.7	11.9	19.0	9.8	23.2
	Good data %	46.7	46.7	46.7	46.7	48.3	46.7	46.7	46.7				
Dec.	Dry bulb	16.5	16.6	19.1	20.7	20.2	19.1	17.9	16.9	15.3	21.8	9.9	30.6
	Good data %	88.7	90.3	88.7	90.3	88.7	91.9	91.9	91.9				

TABLE 4
COMPARISON OF FREQUENCIES (%) OF PASQUILL STABILITY CATEGORIES USING THE SMITH [1972], TURBULENCE, CLARK [1982], AND CLARK/BENDUN [1974] SCHEMES

Time = Night Dates: 23.6.72 to 31.7.74 Turbulence Method

Smith [1972]	A	B	C	D	E	F	G	Total
A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	0.00	0.01	0.03	0.06	0.02	0.00	0.03	0.15
C	0.00	0.07	0.34	0.22	0.40	0.08	0.27	1.39
D	0.40	1.10	14.41	17.77	6.64	1.96	4.69	46.97
E	0.10	0.53	5.60	8.68	4.80	1.87	5.64	27.22
F	0.04	0.48	3.73	4.18	2.73	0.74	0.85	12.75
G	0.20	0.52	3.57	2.65	2.62	0.85	1.11	11.52
Total	0.74	2.71	27.68	33.56	17.22	5.49	12.59	100.00
								13345

No data observed on 5135 half-hour occasions

Time = Night Dates: 23.6.72 to 31.7.74 Clark/Bendun Scheme

Smith [1972]	A	B	C	D	E	F	G	Total
A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	0.00	0.01	0.03	0.04	0.03	0.00	0.03	0.15
C	0.00	0.13	0.27	0.32	0.33	0.07	0.27	1.39
D	0.00	4.64	13.10	17.42	5.50	1.64	4.66	46.96
E	0.00	2.16	6.12	7.77	3.92	1.64	5.60	27.21
F	0.00	1.33	3.75	4.35	1.92	0.58	0.83	12.76
G	0.00	1.37	3.00	3.36	2.04	0.67	1.08	11.52
Total	0.00	9.65	26.28	33.26	13.75	4.60	12.46	100.00
								13340

No data observed on 5135 half-hour occasions

Time = Night Dates: 23.6.72 to 31.7.74 Clark/Bendun Scheme

Turbulence	A	B	C	D	E	F	G	Total
A	0.00	0.00	0.00	0.58	0.14	0.00	0.00	0.71
B	0.00	0.54	1.57	0.53	0.00	0.00	0.00	2.64
C	0.00	7.60	10.70	9.39	0.00	0.00	0.00	27.69
D	0.00	1.53	12.46	17.89	2.22	0.00	0.00	34.11
E	0.00	0.00	1.66	4.60	10.50	0.00	0.00	16.76
F	0.00	0.00	0.00	0.42	0.57	4.39	0.00	5.39
G	0.00	0.00	0.00	0.00	0.00	0.13	12.57	12.70
Total	0.00	9.67	26.40	33.41	13.43	4.52	12.57	100.00
								15537

No data observed on 2936 half-hour occasions

NB. Total in the lower right hand corner is the number of 30-minute observations.

TABLE 5
COMPARISON OF FREQUENCIES (%) OF PASQUILL STABILITY CATEGORIES USING THE SMITH [1972], TURBULENCE, CLARK [1982], AND CLARK/BENDUN [1974] SCHEMES

Time = Day	Dates: 23.6.72 to 31.7.74			Turbulence Method				
Smith [1972]	A	B	C	D	E	F	G	Total
A	0.26	1.04	0.97	0.56	0.10	0.04	0.04	3.01
B	0.93	5.48	6.65	5.53	0.56	0.17	0.60	19.92
C	0.45	4.72	11.75	13.39	1.32	0.32	0.98	32.93
D	0.31	1.76	11.06	18.91	1.82	0.42	1.35	35.64
E	0.02	0.24	1.11	1.82	0.43	0.16	1.01	4.80
F	0.01	0.19	0.65	0.83	0.34	0.07	0.13	2.22
G	0.02	0.05	0.49	0.46	0.23	0.08	0.13	1.48
Total	2.01	13.49	32.68	41.50	4.82	1.26	4.23	100.00
								12768

No data observed on 5712 half-hour occasions

Time = Day	Dates: 23.6.72 to 31.7.74			Clark/Bendun Scheme				
Smith [1972]	A	B	C	D	E	F	G	Total
A	1.17	0.50	0.81	0.47	0.02	0.03	0.00	3.01
B	5.56	3.27	6.32	4.12	0.14	0.53	0.00	19.93
C	4.42	5.17	12.27	9.46	0.25	0.86	0.00	32.93
D	1.79	5.04	15.33	11.96	0.35	1.17	0.00	35.63
E	0.24	0.64	1.77	1.08	0.15	0.92	0.00	4.80
F	0.17	0.37	0.96	0.57	0.04	0.11	0.00	2.22
G	0.07	0.26	0.63	0.36	0.05	0.11	0.00	1.48
Total	13.42	15.25	38.58	28.02	0.99	3.74	0.00	100.00
								12765

No data observed on 5712 half-hour occasions

Time = Day	Dates: 23.6.72 to 31.7.74			Clark/Bendun Scheme				
Turbulence	A	B	C	D	E	F	G	Total
A	1.85	0.10	0.00	0.00	0.00	0.00	0.00	1.95
B	11.26	1.34	0.58	0.00	0.00	0.00	0.00	13.19
C	0.00	9.42	11.59	12.55	0.00	0.00	0.00	33.56
D	0.00	3.71	23.74	13.90	0.00	0.00	0.00	41.35
E	0.00	0.83	2.45	1.38	0.06	0.00	0.00	4.72
F	0.00	0.00	0.21	0.55	0.44	0.00	0.00	1.20
G	0.00	0.00	0.00	0.01	0.46	3.57	0.00	4.03
Total	13.11	15.40	38.57	28.39	0.95	3.57	0.00	100.00
								15121

No data observed on 3355 half-hour occasions

NB: Total in the lower right hand corner is the number of 30-minute observations

TABLE 6
SIMULTANEOUS COMPARISON OF DIFFERENT ATMOSPHERIC DISPERSION CATEGORISATION SCHEMES

Schemes	Agreement (%)			
	Night		Day	
	Exact	± 1 category	Exact	± 1 category
Smith and Turbulence	23	56	37	79
Smith and Clark/Bendun	25	61	29	74
Turbulence and Clark/Bendun	57	95	29	86

TABLE 7
FREQUENCIES (%) OF PASQUILL STABILITY CATEGORIES VERSUS WIND DIRECTION BY HOUR OF THE DAY

	Pasquill Stability Categories							
Direction	A	B	C	D	E	F	G	Total
0000 EST								
N	0.00	0.00	0.00	2.14	2.50	1.07	0.71	6.42
NE	0.00	0.00	0.00	3.74	1.78	0.18	0.53	6.24
E	0.00	0.00	0.00	2.85	0.36	0.71	0.18	4.10
SE	0.00	0.00	0.00	11.59	2.85	0.36	0.36	15.15
S	0.00	0.00	0.00	9.80	2.67	1.43	0.18	14.08
SW	0.00	0.00	0.00	8.91	7.84	5.53	3.57	25.85
W	0.00	0.00	0.00	2.50	3.03	1.25	1.78	8.56
NW	0.00	0.18	0.18	4.28	7.66	3.21	4.10	19.61
Total	0.00	0.18	0.18	45.81	28.70	13.73	11.41	100.00
								561.00
0300 EST								
N	0.00	0.00	0.00	2.72	1.27	0.54	0.54	5.07
NE	0.00	0.00	0.00	4.35	1.81	0.18	0.00	6.34
E	0.0.	0.00	0.00	2.17	0.54	0.18	0.18	3.08
SE	0.00	0.00	0.00	10.87	1.27	0.18	0.36	12.68
S	0.00	0.00	0.00	13.41	2.90	0.72	0.18	17.21
SW	0.00	0.00	0.00	8.15	10.69	6.16	5.62	30.62
W	0.00	0.00	0.00	1.81	1.45	0.72	0.91	4.89
NW	0.00	0.00	0.00	3.80	9.96	3.62	2.72	20.11
Total	0.00	0.00	0.00	47..28	29.89	12.32	10.51	100.00
								552.00
0600 EST								
N	0.00	0.00	0.00	2.53	1.27	0.18	0.18	4.16
NE	0.00	0.00	0.00	3.62	2.17	0.18	0.00	5.97
E	0.00	0.00	0.00	2.71	0.18	0.18	0.18	3.25
SE	0.00	0.00	0.00	11.21	0.54	0.54	0.18	12.48
S	0.00	0.00	0.18	15.55	1.99	0.36	0.72	18.81
SW	0.00	0.00	0.00	13.74	8.50	5.42	3.80	31.46
W	0.00	0.00	0.00	1.99	2.35	2.53	0.90	7.78
NW	0.00	0.00	0.18	6.15	6.15	2.17	1.45	16.09
Total	0.00	0.00	0.36	57.50	23.15	11.57	7.41	100.00
								553.00
0900 EST								
N	0.73	7.51	3.85	2.38	0.00	0.00	0.00	14.47
NE	1.10	2.20	2.20	2.01	0.00	0.00	0.00	7.51
E	0.00	0.37	0.92	0.73	0.00	0.00	0.00	2.01
SE	0.00	0.92	6.04	6.23	0.00	0.00	0.00	13.19
S	0.00	1.47	7.14	8.79	0.00	0.00	0.00	17.40
SW	0.00	1.83	8.42	11.54	0.00	0.00	0.18	21.98
W	0.00	0.37	4.76	3.85	0.00	0.00	0.00	8.97
NW	0.55	4.95	6.04	2.93	0.00	0.00	0.00	14.47
Total	2.38	19.60	39.38	38.46	0.00	0.00	0.18	100.00
								546.00

TABLE 7 (Continued)

	Pasquill Stability Categories							
Direction	A	B	C	D	E	F	G	Total
1200 EST								
N	1.54	15.96	5.58	0.58	0.00	0.00	0.00	23.65
NE	1.73	6.15	2.69	1.54	0.00	0.00	0.00	12.12
E	0.00	0.77	1.15	0.00	0.00	0.00	0.00	1.92
SE	0.58	5.19	7.88	5.77	0.00	0.00	0.00	19.42
S	0.00	2.50	7.69	4.42	0.00	0.00	0.00	14.62
SW	0.00	4.04	6.54	2.12	0.00	0.00	0.00	12.69
W	0.00	2.50	3.27	0.96	0.19	0.00	0.00	6.92
NW	0.77	4.23	2.88	0.77	0.00	0.00	0.00	8.65
Total	4.62	41.35	37.69	16.15	0.19	0.00	0.00	100.00
								520.00
1500 EST								
N	0.00	6.91	14.20	2.88	0.00	0.00	0.00	23.99
NE	0.96	8.45	7.87	1.73	0.00	0.00	0.00	19.00
E	0.00	1.92	2.69	0.77	0.00	0.00	0.00	5.37
SE	0.00	1.34	12.48	10.17	0.00	0.00	0.00	23.99
S	0.00	0.38	3.07	3.07	0.00	0.00	0.00	6.53
SW	0.00	0.00	6.33	4.03	0.19	0.00	0.00	10.56
W	0.00	0.00	2.50	1.73	0.00	0.00	0.00	4.22
NW	0.00	1.34	3.45	1.54	0.00	0.00	0.00	6.33
Total	0.96	20.35	52.59	25.91	0.19	0.00	0.00	100.00
								521.00
1800 EST								
N	0.00	0.00	2.40	14.42	4.25	2.77	0.18	24.03
NE	0.00	0.00	2.22	7.21	2.22	0.37	0.00	12.01
E	0.00	0.00	0.92	3.33	2.03	0.37	0.18	6.84
SE	0.00	0.00	1.11	17.56	2.59	0.92	0.92	23.11
S	0.00	0.00	0.00	4.99	0.74	0.00	0.00	5.73
SW	0.00	0.00	0.00	4.44	4.25	2.03	0.55	11.28
W	0.00	0.00	0.18	2.59	0.74	1.66	0.55	5.73
NW	0.00	0.00	0.74	4.99	2.40	1.85	1.29	11.28
Total	0.00	0.00	7.58	59.52	19.22	9.98	3.70	100.00
								541.00
2100 EST								
N	0.00	0.00	0.00	3.22	5.19	3.58	2.68	14.67
NE	0.00	0.00	0.00	3.94	3.04	1.43	0.72	9.12
E	0.00	0.00	0.00	4.47	0.72	0.18	0.36	5.72
SE	0.00	0.00	0.00	11.99	4.47	1.25	0.54	18.25
S	0.00	0.00	0.00	5.55	0.89	1.07	0.18	7.69
SW	0.00	0.00	0.00	7.51	8.59	3.40	3.76	23.26
W	0.00	0.00	0.00	2.15	2.15	0.72	1.07	6.08
NW	0.00	0.00	0.18	5.01	5.19	2.68	2.15	15.21
Total	0.00	0.00	0.18	43.83	30.23	14.31	11.45	100.00
								559.00

NB: Total in lower right hand corner is the number of 30-minute observations.

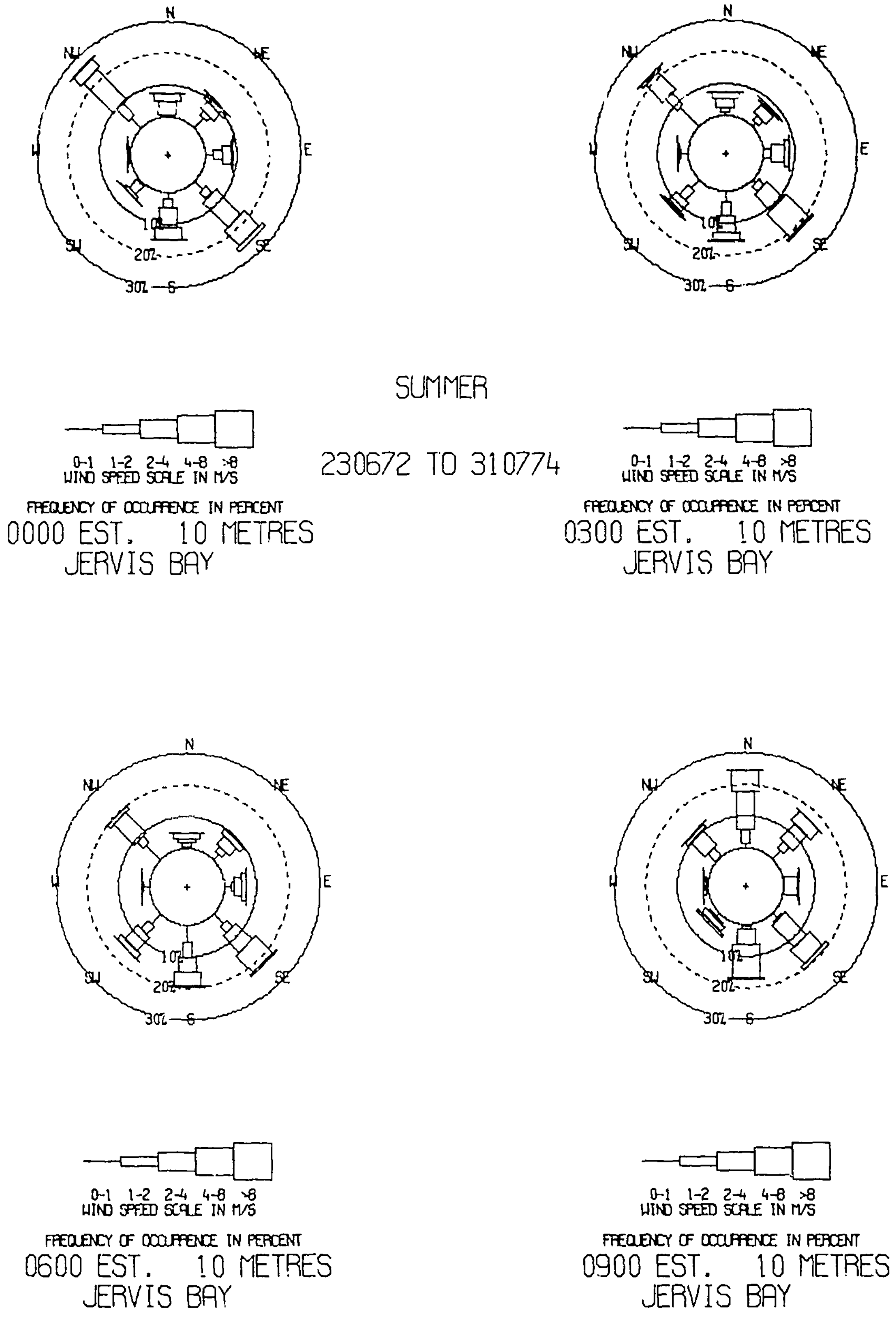
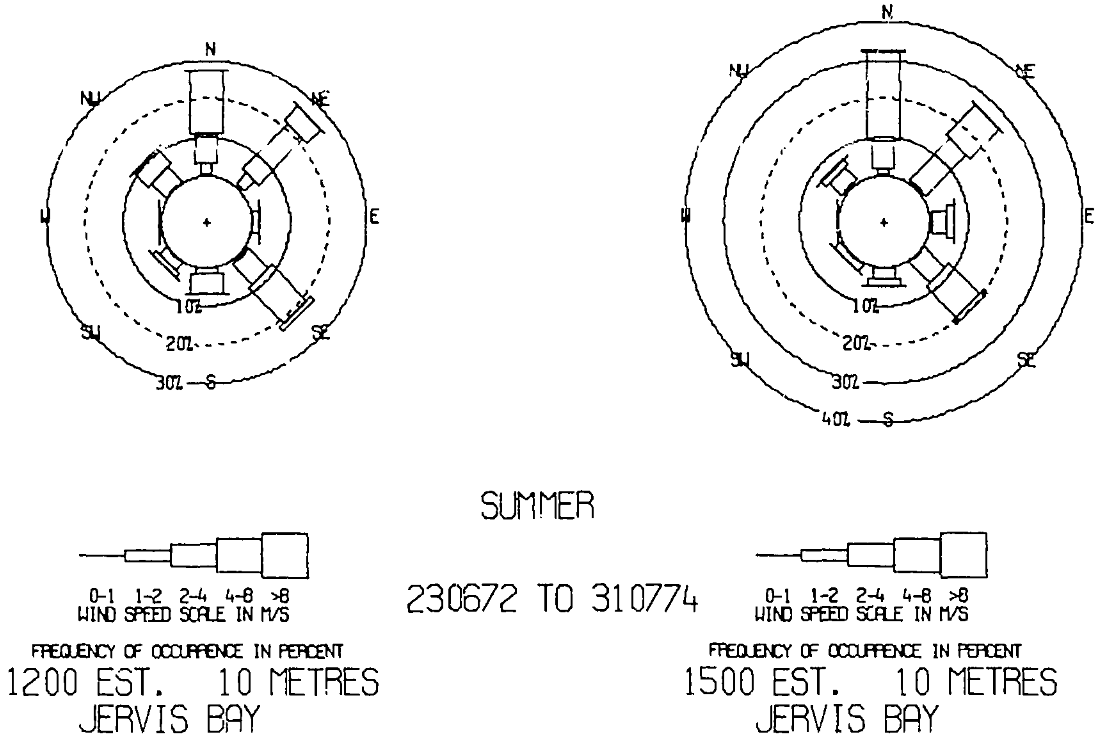


Figure 1 Jervis Bay, 10 m, Bailley-type wind roses for Summer at 0000, 0300, 0600 and 0900 EST



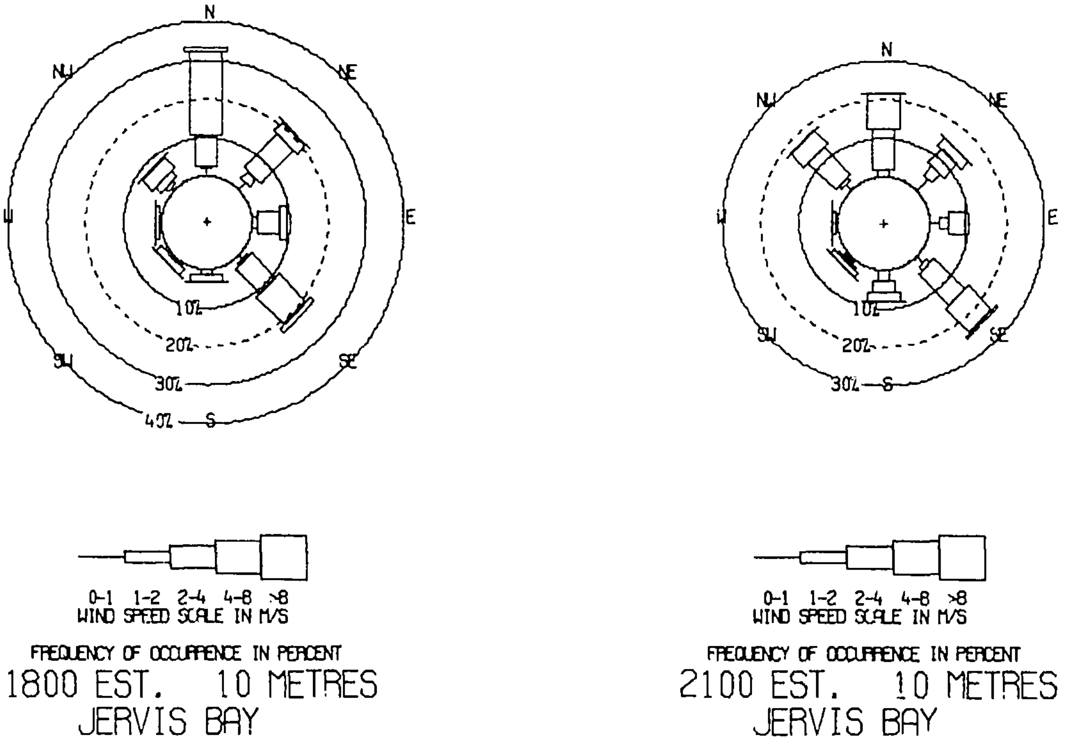
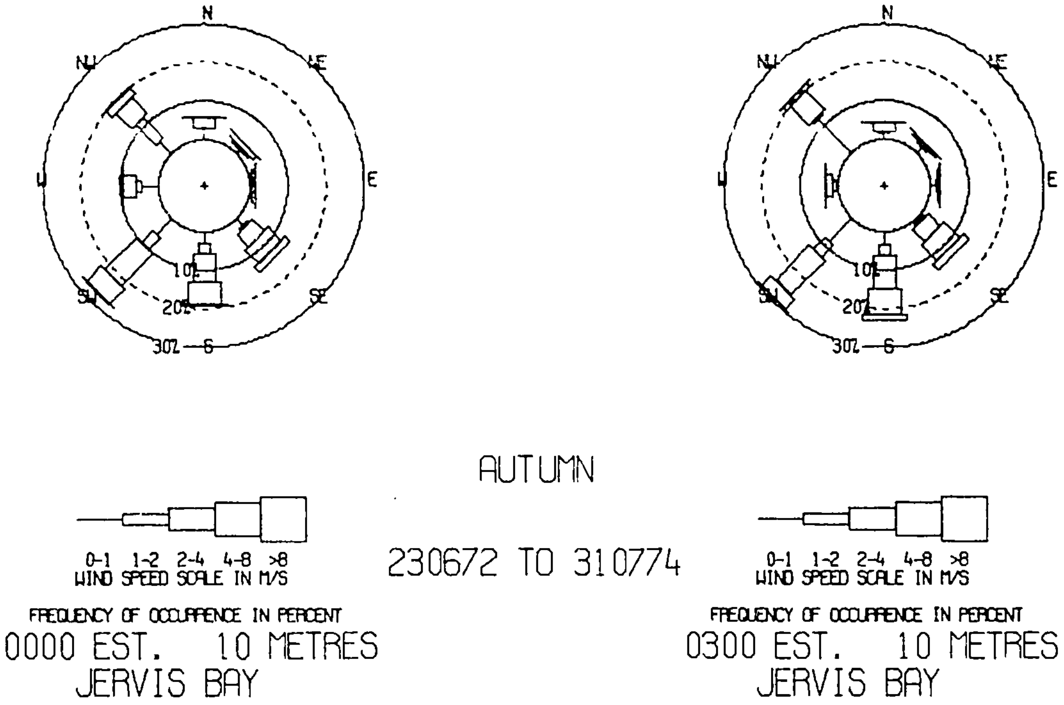


Figure 2 Jervis Bay, 10 m, Bailley-type wind roses for Summer at 1200, 1500, 1800 and 2100 EST



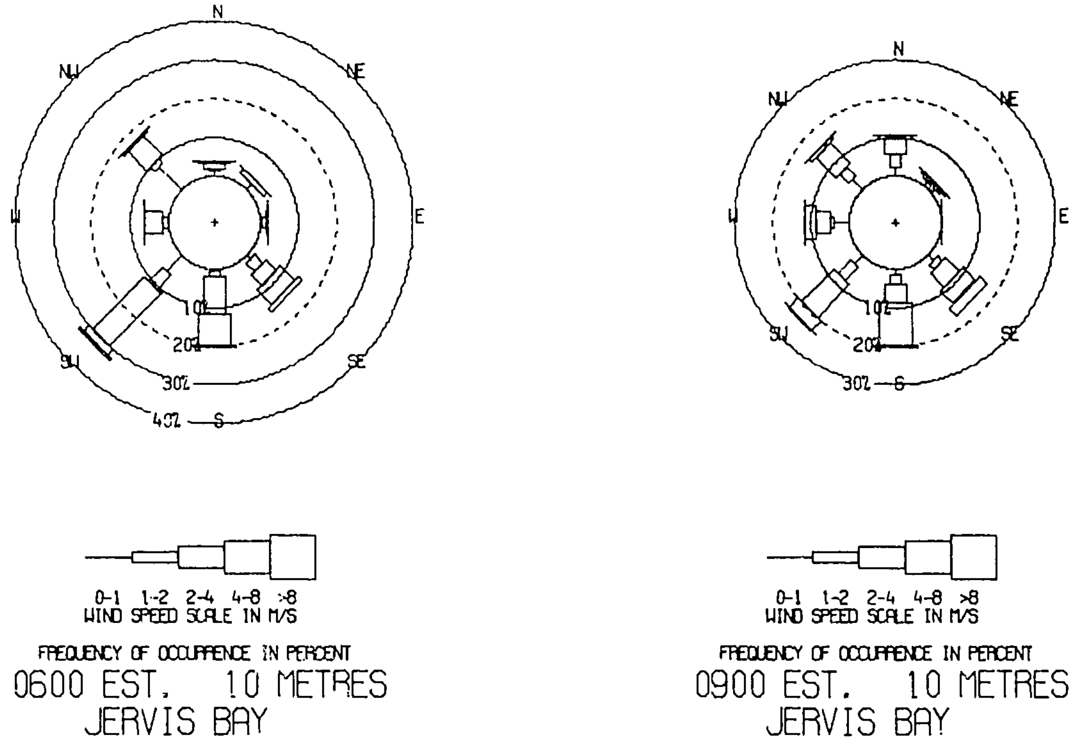
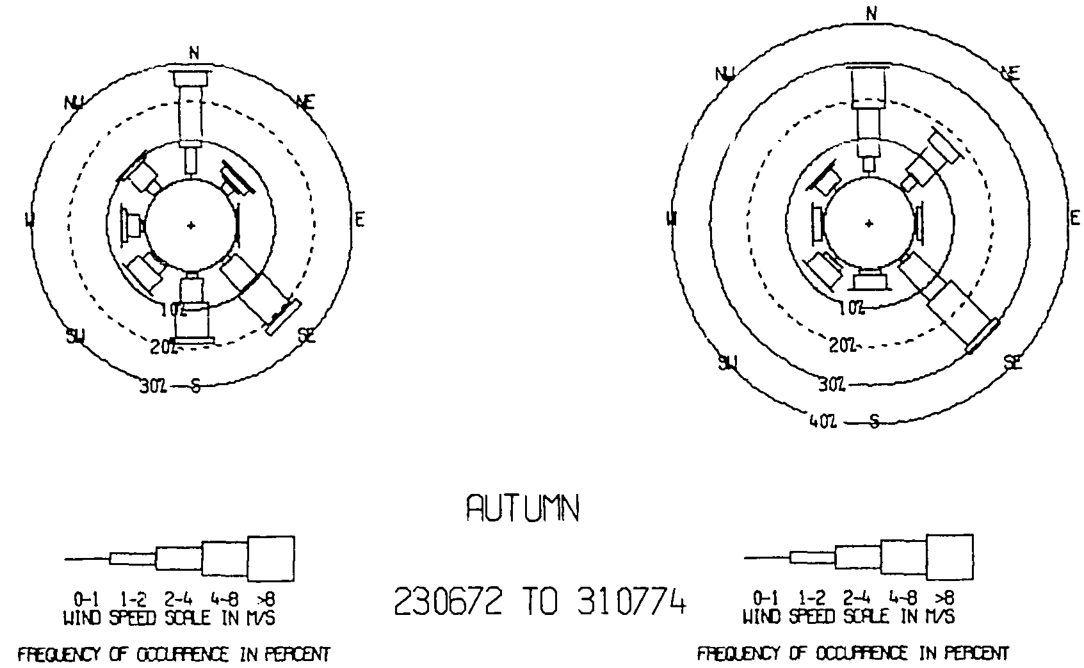


Figure 3 Jervis Bay, 10 m, Bailley-type wind roses for Autumn at 0000, 0300, 0600 and 0900 EST

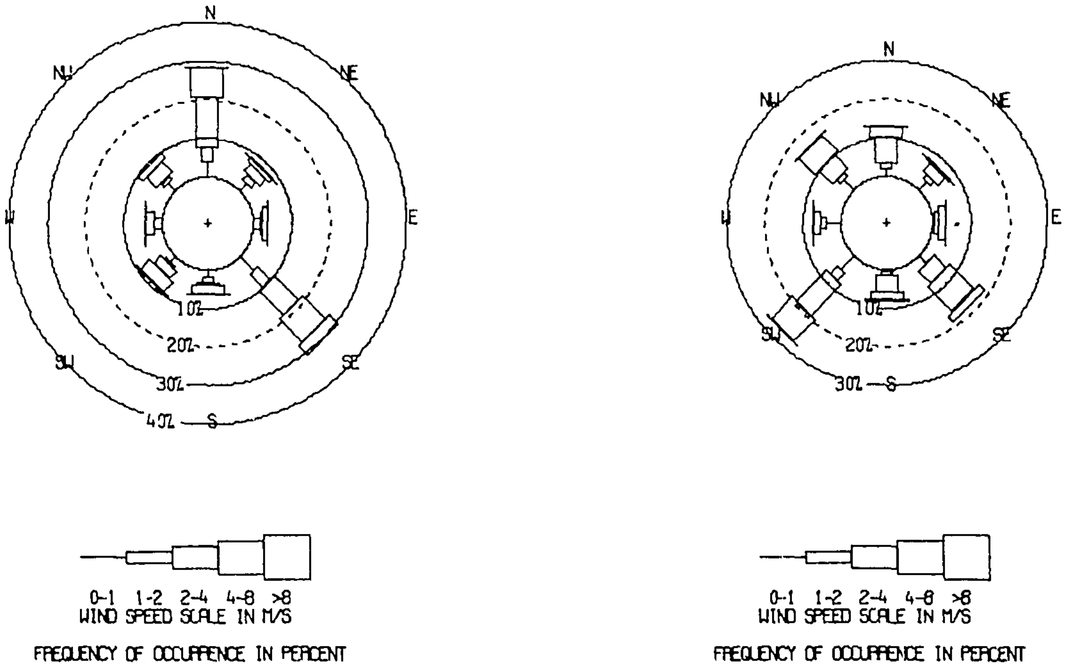


AUTUMN

230672 TO 310774

1200 EST. 10 METRES
JERVIS BAY

1500 EST. 10 METRES
JERVIS BAY



1800 EST. 10 METRES
JERVIS BAY

2100 EST. 10 METRES
JERVIS BAY

Figure 4 Jervis Bay, 10 m, Bailley-type wind roses for Autumn at 1200, 1500, 1800 and 2100 EST

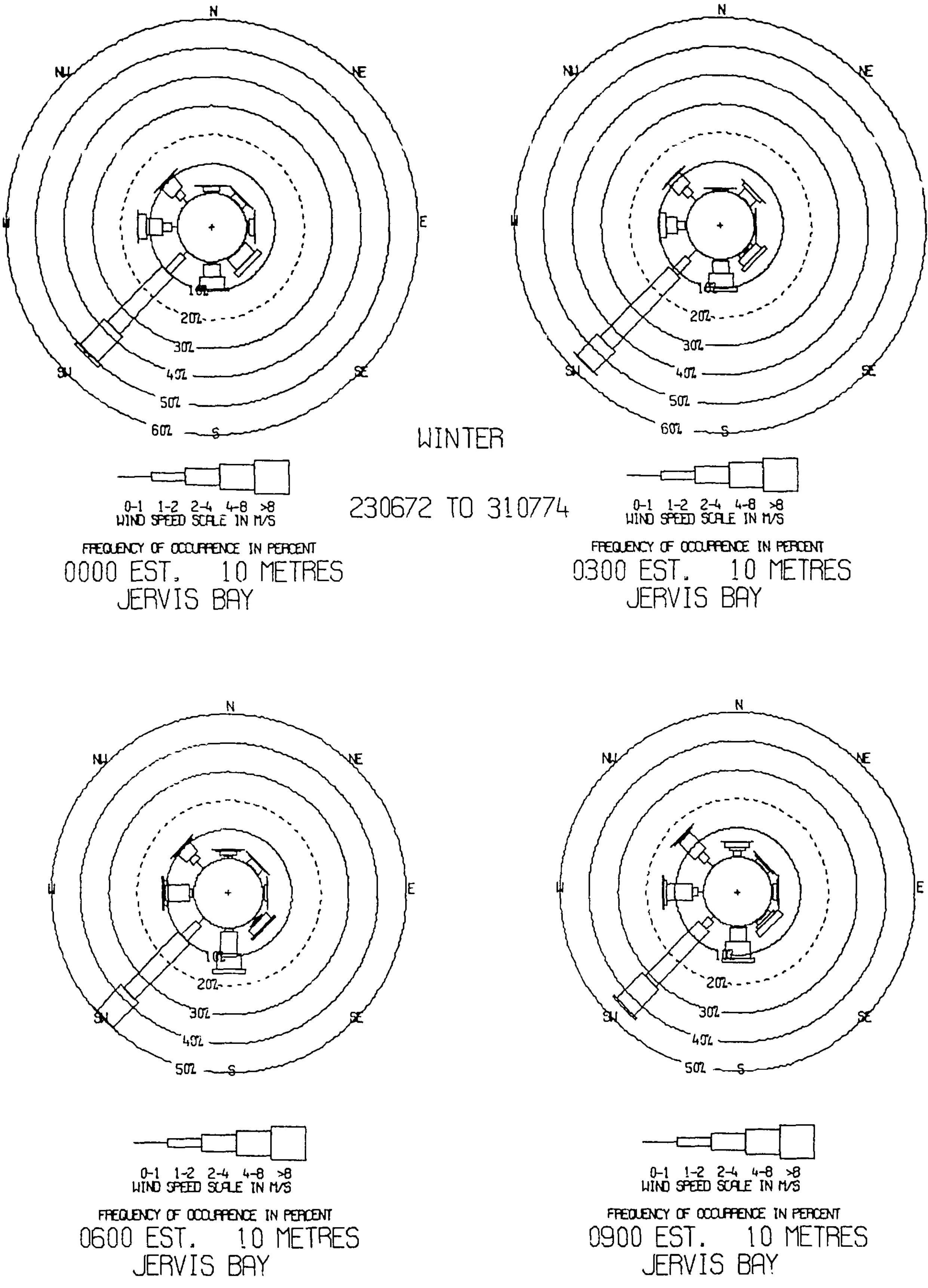


Figure 5 Jervis Bay, 10 m, Bailley-type wind roses for Winter at 0000, 0300, 0600 and 0900 EST

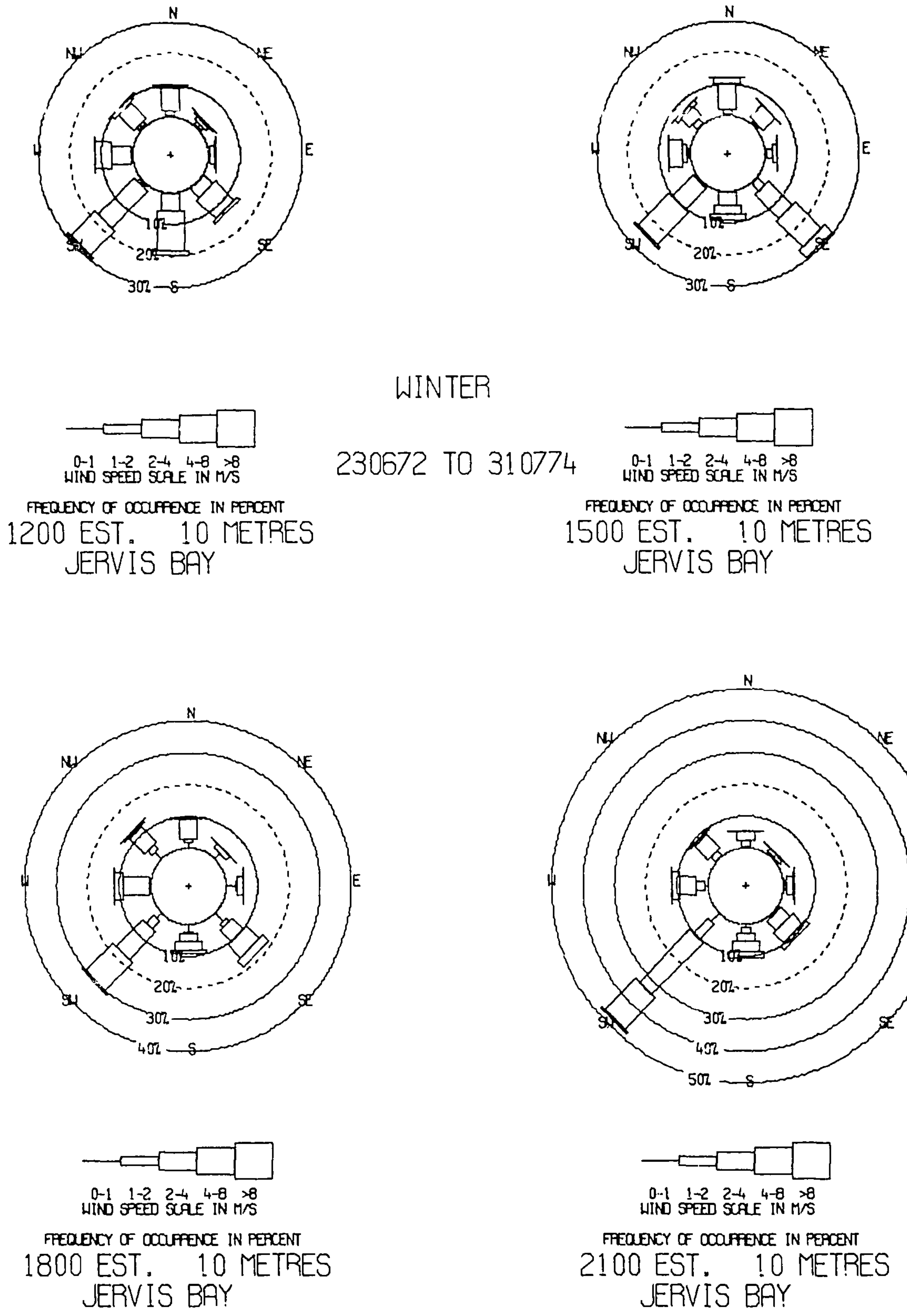


Figure 6 Jervis Bay, 10 m, Bailley-type wind roses for Winter at 1200, 1500, 1800 and 2100 EST

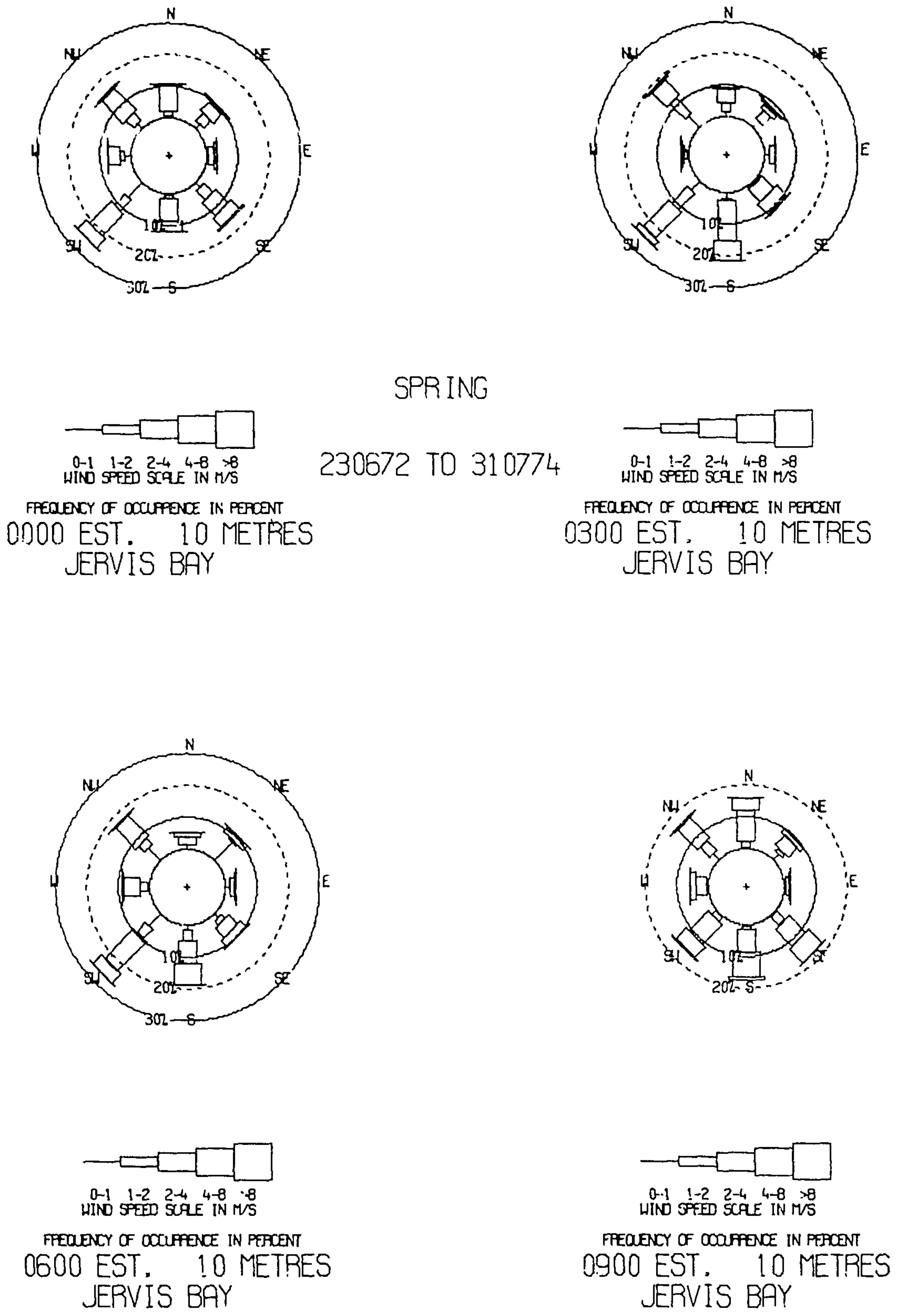


Figure 7 Jervis Bay, 10 m, Bailley-type wind roses for Spring at 0000, 0300, 0600 and 0900 EST

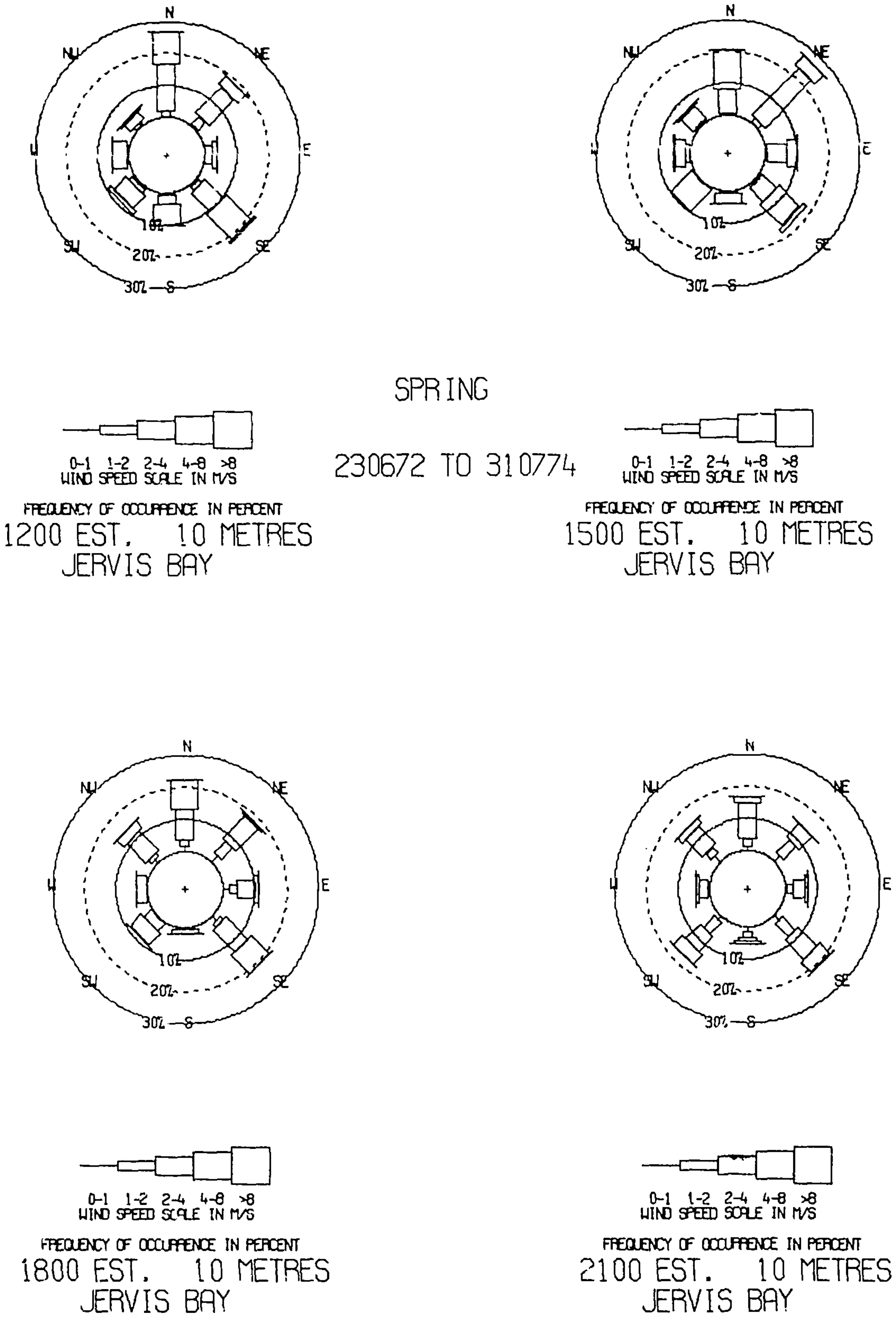


Figure 8 Jervis Bay, 10 m, Bailley-type wind roses for Spring at 1200, 1500, 1800 and 2100 EST