

**ROYAL OBSERVATORY, HONG KONG**

**TECHNICAL NOTE (LOCAL) NO. 23**

**SUPPLEMENT NO. 1**

**ESTIMATION OF WIND CONDITIONS  
IN SELECTED MARINE AREAS  
FROM LAND STATION DATA**

by

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**June 1978**

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## SUMMARY

Based on one year of data (1975), the wind climatology of four marine areas, via Chusan, North Taiwan, East Taiwan and Ryukyu, has been deduced.

Wind speeds reported by ships within each area were compared with those reported by selected land stations. For each marine area, the station that correlated best with ship data was chosen for further analysis. Systematic bias in wind direction between land station and ship reports was considered. Regression equations were then derived to help forecasters estimate wind speeds in each of the four marine areas.

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## 1. INTRODUCTION

Weather and sea bulletins are issued twice daily by the Royal Observatory Central Forecasting Office for seventeen marine areas in the China seas and western North Pacific. These bulletins give the prevailing\* wind in each area during the 24-hour forecast period. When preparing these forecasts, information on the "present" situation is very desirable. This is however in many cases lacking because there may be insufficient reports from weather observing ships. To overcome this problem, a simple procedure to help forecasters estimate the prevailing winds in some of the marine areas was presented by Lam (1976). This report is an extension of the previous study to cover the following areas: Chusan, North Taiwan, East Taiwan and Ryukyu. The boundaries of these marine areas are shown in Figure 1.

The basic idea of this study is that the prevailing wind in a marine area should be related to the wind reported at some island or coastal station within or close to the area. In the following analysis, the prevailing wind is represented by the wind reports from voluntary observers aboard ships. Land station reports are related to ships' wind reports by regression equations. For further discussions concerning this analysis procedure, please refer to Lam (1976).

\*The word 'prevailing' in this note is used in the sense of prevailing over a marine area not in the more usual sense of prevailing over a long period.

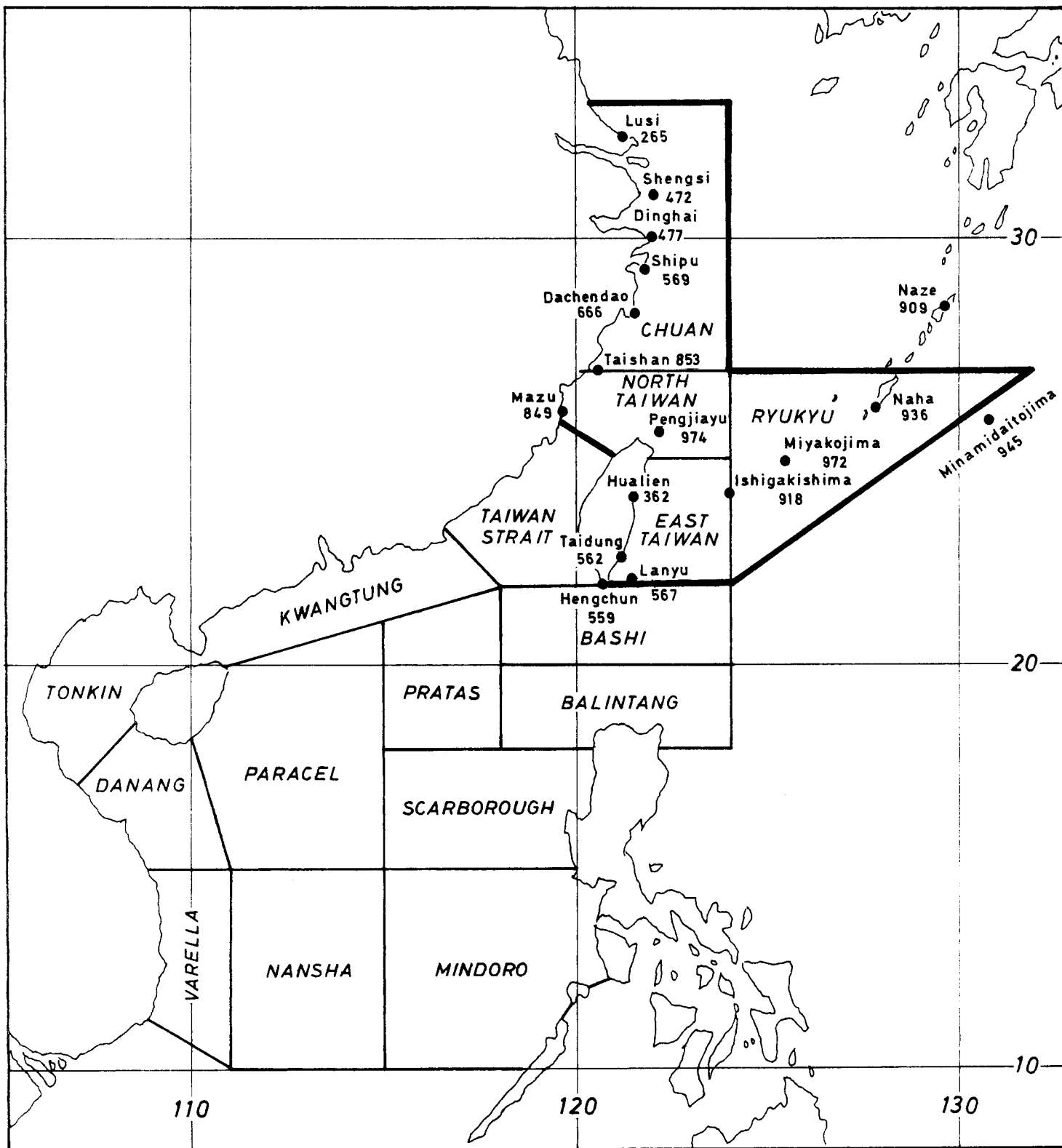


Figure 1 The marine areas covered by weather and sea bulletins issued by the Royal Observatory, Hong Kong. Land stations chosen for comparison with ships in this study are also marked.

## 2. METHOD OF ANALYSIS

### (a) Data

Ships' wind reports for one year (1975) in four marine areas viz. Chusan, North Taiwan, East Taiwan and Ryukyu were stored on magnetic tape together with simultaneous wind reports from selected land stations within or close to these areas. The choice of the land stations were mainly based on experience. Table 1 gives a list of the land stations selected. The locations of these stations are shown in Figure 1.

TABLE 1. LAND STATIONS SELECTED FOR COMPARISON WITH SHIP REPORTS IN EACH OF THE FOUR MARINE AREAS

Marine Area	Selected Land Stations
Chusan	Lusi (58265, 10), Shengsi (58472, 81) Dinghai (58477, 37), Shipu (58569, 125) Dachendao (58666, 206), Taishan (58853, 106)
North Taiwan	Mazu (58849, 91), Pengjiayu (58974, 102) Ishigakijima (47918, 6), Miyakojima (47927, 39) Taishan (58853, 106), Pingtan (58944, 25)
East Taiwan	Pengjiayu (58974, 102), Hualien (59362, 13) Heng Chun (59559, 24), Lanyu (59567, 325) Taidung (59562, 10), Ishigakijima (47918, 6)
Ryukyu	Pengjiayu (58974, 102), Naze (47909, 3) Ishigakijima (47918, 6), Miyakojima (47927, 39) Naha (47936, 35), Minamidaitojima (47945, 15)

Note : The names of stations are in accordance with those appearing in WMO Publication No. 9 Volume A. In parentheses after the name of each station, the first figure is the Station Index Number and the second figure is the height of the station in metres.

### (b) Analysis

The procedure described in Lam (1976) was followed.

A frequency distribution of ships' wind reports with respect to direction and speed was derived for each area (Tables 2a, b, c, d and Figure 2). Wind speeds reported by ships are related to land station wind speeds by linear regression. Results are given in Table 3. Based on these results, a station was chosen for each area for further analysis. The sample was divided into four groups according to the wind direction at the land stations. Frequency tables showing the occurrence of various ship-reported wind directions against specified station wind directions were constructed (Tables 4a, b, c, d). This information was used to assist in determining the boundaries of the four sectors; and, a regression equation is then derived for each of the sectors. The results are given in Table 5.

### 3. RESULTS

#### (a) Wind climatology of the four marine areas

The frequency distribution of ships' wind reports with respect to direction and speed for each marine area was derived from the 1975 data. Tables 2(a) - (d) give the result of this analysis. The number of reports involved are : Chusan 247, North Taiwan 596, East Taiwan 535 and Ryukyu 1844.

A feature common to all four areas is the peak centred at bearing  $020^{\circ}$  to  $040^{\circ}$  in the frequency distribution with respect to wind direction. This is illustrated in Figure 2. Since these marine areas are within the influence of the northeast monsoon, the presence of this peak is easily explained. As is well known, the intensity of monsoon winds in general decreases away from continental land mass. Consequently, the peak in the case of Ryukyu is the least prominent.

In the previous study involving Taiwan Strait and other marine areas which are to the southwest of the areas examined in this study, another peak in the southwest quadrant was noted. However, only relatively weak peaks could be noted in the southerly direction for the areas North Taiwan and East Taiwan. These are related to the summer monsoon. The relatively high percentage of easterly winds in Ryukyu is the consequence of the dominance of the subtropical ridge during the summer months.

Table 2(d) has been compared with data for the area 22233 (bounded by  $23-25^{\circ}\text{N}$ ,  $123-128^{\circ}\text{E}$ ) published in Marine Climatological Summaries by the Japan Meteorological Agency. It is noted that there is reasonable agreement among the tables compared. However, in some years the percentage of easterly winds is even higher than that shown in table 2(d).

#### (b) Linear regression without stratification of data

The result of linear regression analyses with wind speeds reported by ships as dependent variable and land station wind speeds as independent variable, irrespective of wind direction, are given in Table 3.

Considering the correlation coefficients and the availability of station reports, Dachendao (58666), Pengjiayu (58974), Lanyu (59567) and Miyakojima (47927) were selected for the marine areas Chusan, North Taiwan, East Taiwan and Ryukyu respectively. The four regression equations are :

(a) Chusan	$V(\text{ship}) = 0.390 V(58666) + 7.8$	S.E. = 7.0 knots
(b) North Taiwan	$V(\text{ship}) = 0.713 V(58974) + 4.4$	S.E. = 7.3 knots
(c) East Taiwan	$V(\text{ship}) = 0.495 V(59567) + 5.1$	S.E. = 7.5 knots
(d) Ryukyu	$V(\text{ship}) = 0.996 V(47927) + 4.5$	S.E. = 6.7 knots

$V(\text{ship})$  stands for wind speeds reported by ships in knots. The independent variables on the right hand side are the respective land station wind speeds in knots. S.E. stands for standard error.

#### (c) Relation between wind directions reported by ships and those reported by land stations

Contingency tables showing the occurrence of various wind directions reported by ships with specified station wind directions are given in Tables 4(a) - (d). Isopleths of equal frequency are included to bring out the pattern in the distribution.

In the case of Dachendao in Chusan, the northerly wind component tends to be larger in the land station report when winds are coming from the northeast quadrant. In the case of Penjiayu in North Taiwan, the easterly component tends to be larger in the land station report under similar situations.

Lanyu is situated at the southwestern corner of the marine area East Taiwan, about 40 nautical miles off the eastern coast of Taiwan. Taiwan acts as a land barrier so that easterly winds are deflected southward resulting in an increased northerly component. This is reflected in Table 4(c). Systematic deflections in wind direction are also noted in winds from the southwest quadrant.

Table 4(d) indicates that the wind direction reported at Miyakojima is reasonably representative of the Ryukyu area.

(d) Linear regression with stratification of data

The linear regression equations derived for each of the four areas, with the data stratified according to the wind direction at the selected land stations are given in Table 5. When compared with the regression equations without stratification of data, it may be noted that the standard errors have been reduced in most cases. There are two sectors with less than 10 data points. Because of the small sample size, the results of linear regression are naturally less reliable in these cases and should be ignored. Based on the equations, land station wind speeds corresponding to the occurrence of a wind speed of 34 knots (i.e. gale force winds) in each of the marine areas were derived and given in Table 6.

TABLE 2. PERCENTAGE FREQUENCY OF WIND REPORTS FROM SHIPS IN EACH OF THE FOUR MARINE AREAS CLASSIFIED ACCORDING TO DIRECTION AND SPEED (BASED ON 1975 DATA). Frequency values greater than 2% have been indicated by heavy lines.

(a) Chusan (No. of ship reports = 247)

Speed in Beaufort force	Direction in 10°													Total in %		
	CAIM	VARIABLE	35-01	02-04	05-07	08-10	11-13	14-16	17-19	20-22	23-25	26-28	29-31		32-34	
0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0
1	-	0.8	0.4	0.0	0.4	0.4	0.4	0.4	0.0	0.8	0.0	0.4	0.0	0.0	0.0	4.0
2	-	0.0	0.8	0.8	0.4	2.0	0.8	0.4	1.2	0.0	0.0	0.4	0.4	0.4	0.4	7.7
3	-	0.0	2.8	4.9	4.0	3.2	1.6	2.4	1.2	1.2	0.8	1.2	0.0	0.0	2.4	25.9
4	-	0.0	3.2	8.9	5.3	3.2	2.0	1.6	0.8	1.6	0.8	0.0	0.4	0.4	0.4	28.3
5	-	0.0	4.9	5.7	1.6	0.4	0.4	0.0	0.0	0.8	0.0	0.4	0.4	0.4	2.4	17.0
6	-	0.0	3.2	1.6	1.2	1.2	0.4	0.0	0.0	0.8	0.0	0.4	0.0	0.4	0.4	9.3
7	-	0.0	1.6	2.0	0.8	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	5.3
8	-	0.0	0.8	0.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	2.0
9	-	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
10	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total in %	0.0	0.8	17.8	25.1	13.8	10.9	5.7	4.9	3.2	5.3	1.6	2.8	1.2	6.9	100.0	

TABLE 2. (cont'd)

(b) North Taiwan (No. of ship reports = 596)

Speed in Beaufort force	Direction in 10°													Total in %		
	CALM	VARIABLE	35-01	02-04	05-07	08-10	11-13	14-16	17-19	20-22	23-25	26-28	29-31		32-34	
0	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5
1	-	1.7	0.5	0.2	0.2	0.0	0.0	0.3	0.5	0.2	0.0	0.2	0.0	0.0	0.3	4.0
2	-	0.8	0.3	1.2	0.3	1.2	1.0	1.0	0.7	0.7	0.8	0.3	0.3	0.3	0.3	9.1
3	-	0.2	1.7	2.5	4.2	1.8	1.5	1.2	1.7	1.5	1.2	0.3	0.5	0.3	0.3	18.6
4	-	0.0	2.3	7.2	4.7	1.3	1.2	1.2	2.0	1.7	1.2	0.3	0.8	0.5	0.5	24.5
5	-	0.0	2.9	6.5	3.0	0.5	0.2	0.0	0.3	0.7	0.7	0.3	0.2	0.5	0.5	16.8
6	-	0.0	1.8	6.5	2.9	0.2	0.3	0.2	0.2	0.8	0.0	0.0	0.2	0.2	0.2	13.3
7	-	0.0	0.8	4.7	2.2	0.2	0.2	0.0	0.2	0.0	0.0	0.0	0.2	0.5	0.5	8.9
8	-	0.0	0.2	2.3	0.8	0.2	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	3.9
9	-	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
10	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total in %	1.5	2.7	10.6	31.7	18.3	5.4	4.5	3.9	5.5	5.5	3.9	1.7	2.2	2.7	100.0	

TABLE 2. (cont'd)

(c) East Taiwan (No. of ship reports = 535)

Speed in Beaufort force	Direction in 10°														Total in %	
	CALM	VARIABLE	35-01	02-04	05-07	08-10	11-13	14-16	17-19	20-22	23-25	26-28	29-31	32-34		
0	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3
1	-	0.6	0.2	0.9	0.2	0.2	0.6	0.7	0.0	0.0	0.4	0.2	0.0	0.0	0.0	4.1
2	-	0.0	0.9	0.9	1.3	1.3	2.1	1.1	1.3	1.3	0.9	0.4	0.4	0.2	0.2	12.0
3	-	0.2	1.7	3.5	2.8	1.9	2.2	2.4	1.9	1.9	0.6	0.4	0.2	0.2	0.2	21.1
4	-	0.0	1.1	4.5	2.2	1.5	2.2	2.4	1.5	1.5	1.1	0.6	0.2	0.4	0.4	21.3
5	-	0.0	0.7	5.0	0.7	0.6	0.6	1.3	0.9	0.9	0.4	0.0	0.0	0.0	0.0	13.6
6	-	0.0	1.9	7.1	3.0	0.2	0.2	0.0	0.9	0.9	0.6	0.2	0.2	0.4	0.4	14.6
7	-	0.0	1.3	3.2	0.7	0.0	0.6	0.0	0.4	0.4	0.0	0.0	0.0	0.4	0.4	6.7
8	-	0.0	0.4	3.4	0.7	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	4.7
9	-	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
10	-	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
11	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total in %	1.3	0.7	8.6	28.8	15.9	7.5	5.6	8.4	8.0	7.1	3.9	1.7	0.9	1.5	100.0	

TABLE 2. (cont'd)

(d) Ryukyu (No. of ship reports = 1844)

Speed in Beaufort force	Direction in 10°														Total in %													
	CALM	VARIABLE	35-01		02-04		05-07		08-10		11-13		14-16			17-19		20-22		23-25		26-28		29-31		32-34		
0	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4
1	-	1.5	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	4.1
2	-	0.2	0.7	0.7	1.5	1.4	1.7	1.7	1.4	1.7	1.7	1.0	1.4	1.4	1.4	0.9	0.9	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.2	0.4	0.4	11.0
3	-	0.0	0.9	1.7	2.4	2.3	2.4	2.4	2.3	2.4	2.1	2.1	2.1	2.1	1.7	1.7	0.9	0.9	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.7	0.7	18.1
4	-	0.0	1.7	4.3	4.7	2.8	2.9	2.8	2.8	2.9	2.9	2.9	2.9	2.2	2.9	2.9	1.1	1.1	0.6	0.6	0.6	0.6	0.6	0.7	0.7	1.1	1.1	27.9
5	-	0.0	2.5	3.1	3.3	2.0	0.9	2.0	2.0	0.9	1.2	1.2	1.2	1.2	1.7	1.7	0.5	0.5	0.1	0.1	0.1	0.1	0.1	0.4	0.4	0.9	0.9	17.9
6	-	0.0	2.0	3.7	1.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.3	0.6	0.6	0.6	11.1
7	-	0.0	1.5	1.2	0.2	0.4	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.3	0.3	4.8
8	-	0.0	0.4	0.5	0.3	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.3	1.9
9	-	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
10	-	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
11	-	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
12	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total in %	2.4	1.6	10.0	15.7	14.1	10.0	9.3	8.3	10.0	9.3	8.3	8.0	8.0	8.1	3.5	1.7	2.5	4.6	100.0									

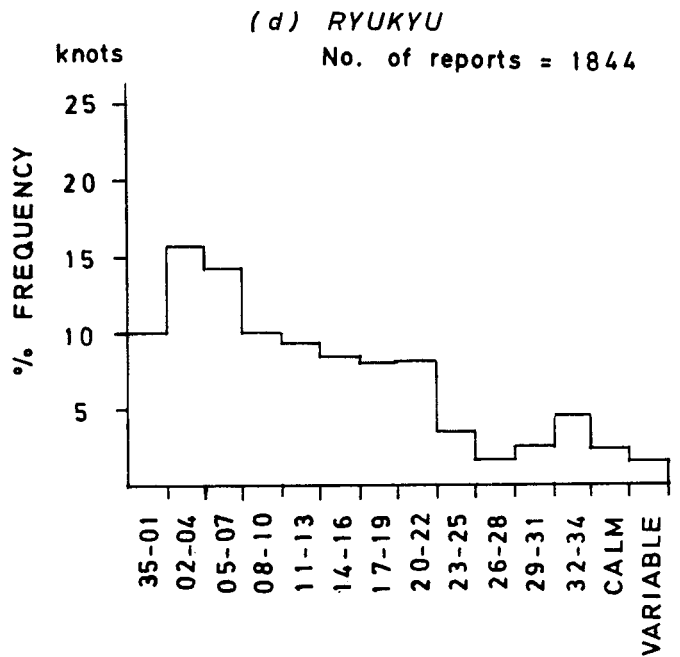
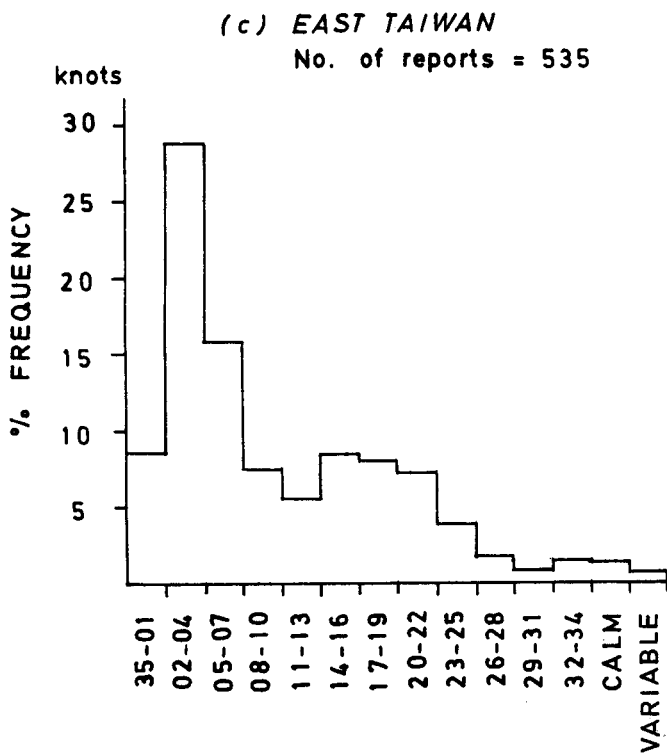
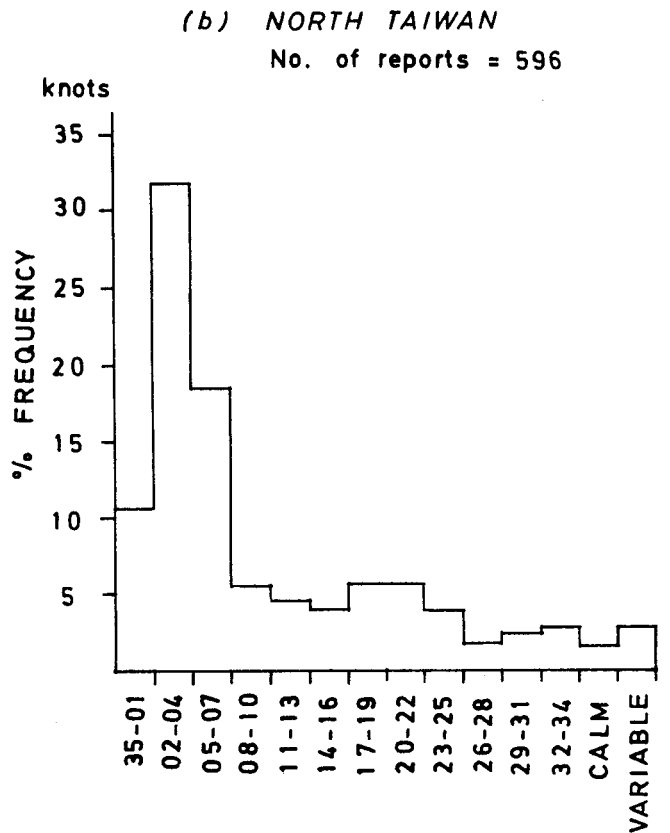
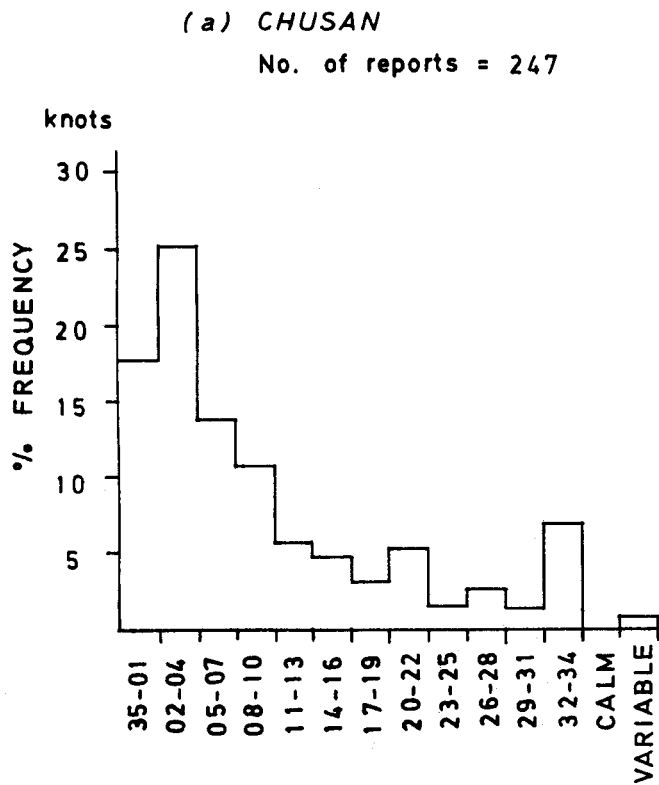


Figure 2 Frequencies of wind directions reported by ships. Directions are given in tens of degrees.

TABLE 3. RESULTS OF LINEAR REGRESSION ANALYSIS

Dependent Variable	Independent Variable	Correlation Coefficient	Standard Error (in knots)	Sample Size
Chusan	Lusi	0.21	8.4	124
	Shengsi	0.31	7.6	240
	Dinghai	0.28	7.7	240
	Shipu	0.41	7.7	118
	Dachendao	0.48	7.0	241
	Taishan	0.51	7.5	120
North Taiwan	Mazu	0.57	7.4	563
	Penjiayu	0.58	7.3	566
	Ishigakishima	0.29	8.6	591
	Miyakoshima	0.43	8.1	589
	Taishan	0.53	8.3	266
	Pingtang	0.65	7.4	268
Pratas	Pengjiayu	0.38	8.5	512
	Hualien	0.20	9.0	511
	Hengchun	0.52	7.9	528
	Lanyu	0.59	7.5	520
	Taidung	0.34	8.7	520
	Ishigakishima	0.48	8.1	531
Bashi	Penjiayu	0.35	7.7	1756
	Naze	0.43	7.5	1831
	Ishigakishima	0.45	7.5	1832
	Miyakojima	0.59	6.7	1831
	Naha	0.52	7.1	1828
	Minamidaitojima	0.40	7.7	1811

TABLE 4. WIND DIRECTIONS REPORTED BY SHIPS COMPARED WITH SIMULTANEOUS REPORTS FROM SELECTED LAND STATIONS

(a) Chusan. The selected station was Dachendao.  
Sample size = 235.

Direction in 10° reported by ships	Station Wind Direction in 10°																TOTAL			
	01	03	05	07	09	11	13	15	17	19	21	23	25	27	29	31		33	35	36
01 - 02	16	4	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	33
03 - 04	20	9	0	3	1	0	1	0	0	0	0	0	0	0	0	0	2	3	3	39
05 - 06	6	8	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	22
07 - 08	2	10	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	3	3	18
09 - 10	3	3	0	2	2	0	1	1	4	0	0	0	0	0	0	0	0	1	1	18
11 - 12	0	0	0	0	0	2	1	1	1	2	0	0	0	0	0	0	0	0	0	8
13 - 14	0	0	0	0	0	2	2	0	0	2	0	0	0	0	0	0	1	0	0	10
15 - 16	0	1	0	1	0	0	0	1	1	3	1	0	1	0	0	0	0	0	0	8
17 - 18	0	0	0	0	0	0	0	0	0	5	1	0	1	0	0	0	0	0	0	7
19 - 20	0	0	0	0	0	0	0	1	1	2	0	0	1	0	0	0	0	0	0	4
21 - 22	1	1	0	0	0	0	0	3	4	4	1	0	0	0	0	0	0	0	0	10
23 - 24	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	4
25 - 26	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
27 - 28	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	1	1	5
29 - 30	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	3
31 - 32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	5	5
33 - 34	5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	5	12	12
35 - 36	6	4	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	14	27	27
TOTAL	62	42	0	16	5	6	9	10	20	4	0	0	5	0	1	3	3	44	235	235



TABLE 4. WIND DIRECTIONS REPORTED BY SHIPS COMPARED WITH SIMULTANEOUS REPORTS FROM SELECTED LAND STATIONS

(c) East Taiwan. The selected station was Lanyu. Sample size = 506.

Direction in 10° reported by ships	Station Wind Direction in 10°														TOTAL				
	01	03	05	07	09	11	13	15	17	19	21	23	25	27		29	31	33	35
01 - 02	32	32	0	3	0	0	0	0	0	0	2	0	1	0	0	0	0	1	71
03 - 04	34	48	1	3	3	1	1	0	0	1	0	2	1	0	1	0	0	1	97
05 - 06	21	36	1	3	1	0	0	0	0	1	0	0	1	0	0	0	0	0	64
07 - 08	7	14	1	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0	28
09 - 10	7	8	1	4	6	2	0	0	0	1	0	0	0	0	0	0	0	0	29
11 - 12	1	6	0	6	2	0	1	0	0	0	0	0	0	0	0	0	0	0	17
13 - 14	0	4	1	3	4	0	0	2	2	2	3	2	2	0	0	0	0	0	25
15 - 16	1	7	0	2	0	2	1	2	0	4	8	1	2	0	0	0	0	0	30
17 - 18	0	0	0	0	2	1	0	1	4	8	7	4	10	0	0	0	0	0	37
19 - 20	1	1	0	0	0	1	1	0	0	2	3	2	7	1	0	0	0	0	19
21 - 22	1	0	0	0	0	0	0	0	0	1	7	6	8	0	0	1	0	0	24
23 - 24	0	1	0	2	0	0	0	0	0	0	4	3	8	1	0	0	0	0	19
25 - 26	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	5
27 - 28	0	1	0	0	1	0	0	0	0	1	0	0	2	1	0	0	0	0	6
29 - 30	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	4
31 - 32	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
33 - 34	2	1	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	6
35 - 36	7	13	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	22
TOTAL	114	176	5	28	22	7	7	6	6	21	35	21	51	3	1	0	1	2	506

TABLE 4. WIND DIRECTIONS REPORTED BY SHIPS COMPARED WITH SIMULTANEOUS REPORTS FROM SELECTED LAND STATIONS

(d) Ryukyu. The selected station was Miyakoshima.  
Sample size = 1725.

Direction in 10° reported by ships	Station Wind Direction in 10°																		TOTAL
	01	03	05	07	09	11	13	15	17	19	21	23	25	27	29	31	33	35	
01 - 02	89	26	18	8	1	0	2	2	0	0	0	1	0	1	0	1	2	19	170
03 - 04	40	60	40	17	2	6	0	0	0	0	1	0	0	0	0	1	1	4	174
05 - 06	14	38	48	34	15	14	6	1	1	1	0	0	0	1	0	0	1	0	174
07 - 08	9	13	38	34	14	13	10	0	1	1	1	1	0	1	0	1	0	2	144
09 - 10	3	11	9	28	15	21	8	7	3	3	0	1	0	0	0	1	0	0	124
11 - 12	4	4	7	10	11	17	18	6	12	12	0	1	0	0	0	0	0	0	112
13 - 14	1	4	4	6	7	10	23	5	14	14	2	1	1	1	0	1	0	0	105
15 - 16	5	0	0	3	2	3	6	23	25	21	5	5	0	1	0	2	0	3	104
17 - 18	2	3	1	3	1	3	7	12	24	34	13	7	1	0	0	0	0	2	113
19 - 20	2	4	1	0	1	0	1	4	12	38	21	4	0	1	1	2	0	3	95
21 - 22	3	2	2	1	1	1	2	1	5	17	39	8	1	0	1	2	0	1	87
23 - 24	3	0	2	0	1	1	1	4	3	12	12	3	4	0	0	2	2	0	50
25 - 26	0	1	0	0	3	0	0	1	0	3	1	2	2	1	1	4	0	3	22
27 - 28	3	1	0	1	0	0	0	1	1	5	1	2	1	2	1	1	0	1	21
29 - 30	2	3	1	0	1	0	0	1	0	1	2	3	3	3	1	2	1	3	27
31 - 32	12	4	3	1	0	1	0	0	0	2	2	1	0	1	2	1	3	9	42
33 - 34	26	6	1	2	0	0	0	1	1	1	0	2	0	2	1	2	2	13	60
35 - 36	53	13	3	3	1	0	1	1	0	0	0	1	0	2	0	0	0	23	101
TOTAL	271	193	178	151	76	90	87	122	90	165	100	43	13	17	8	23	12	86	1725

TABLE 5. RESULTS OF LINEAR REGRESSION WITH STRATIFICATION OF DATA

Area	Station wind direction	Linear regression equation	Correlation coefficient	Standard error (knots)	Range of station wind speeds (knots)	Range of ship wind speeds (knots)	No. of data points
Chusan	060 - 120	$V(\text{ship}) = 0.281 V(\text{Dachendao}) + 7.9$	0.26	4.0	4 - 20	2 - 20	28
	130 - 230	$V(\text{ship}) = 0.277 V(\text{Dachendao}) + 6.4$	0.38	5.2	2 - 28	1 - 24	49
	240 - 280	$V(\text{ship}) = 0.176 V(\text{Dachendao}) + 7.1$	0.18	2.8	6 - 12	6 - 12	5
	290 - 050	$V(\text{ship}) = 0.342 V(\text{Dachendao}) + 10.0$	0.41	7.6	0 - 62	2 - 44	159
North Taiwan	080 - 130	$V(\text{ship}) = 0.620 V(\text{Pengjiayu}) + 4.8$	0.58	6.4	2 - 43	2 - 37	115
	140 - 220	$V(\text{ship}) = 0.178 V(\text{Pengjiayu}) + 7.7$	0.15	6.4	4 - 28	0 - 28	85
	230 - 340	$V(\text{ship}) = 0.539 V(\text{Pengjiayu}) + 3.9$	0.62	5.8	2 - 34	0 - 36	84
	350 - 070	$V(\text{ship}) = 0.687 V(\text{Pengjiayu}) + 7.2$	0.54	7.2	0 - 37	0 - 46	282
East Taiwan	060 - 130	$V(\text{ship}) = 0.450 V(\text{Lanyu}) + 5.1$	0.46	4.3	2 - 22	2 - 22	61
	140 - 280	$V(\text{ship}) = 0.265 V(\text{Lanyu}) + 7.0$	0.38	6.9	2 - 51	0 - 37	153
	290 - 340	$V(\text{ship}) = 0.870 V(\text{Lanyu}) + 2.3$	0.94	5.7	2 - 25	0 - 24	3
	350 - 050	$V(\text{ship}) = 0.556 V(\text{Lanyu}) + 5.0$	0.62	7.7	0 - 63	0 - 50	303
Ryukyu	090 - 130	$V(\text{ship}) = 0.855 V(\text{Miyakojima}) + 6.3$	0.51	5.5	1 - 24	0 - 30	220
	140 - 240	$V(\text{ship}) = 0.836 V(\text{Miyakojima}) + 3.8$	0.55	5.3	1 - 25	0 - 45	595
	250 - 340	$V(\text{ship}) = 1.488 V(\text{Miyakojima}) + 1.3$	0.62	6.9	1 - 17	0 - 37	85
	350 - 080	$V(\text{ship}) = 0.991 V(\text{Miyakojima}) + 5.7$	0.56	7.4	0 - 31	0 - 60	931

Table 6 WIND SPEED AT LAND STATIONS CORRESPONDING TO A WIND SPEED OF 34 KNOTS IN THE MARINE AREAS ACCORDING TO THE REGRESSION EQUATIONS

Area	Land Station	Land station wind direction	Land station wind speed
Chusan	Dachendao	all directions	*
North Taiwan	Pengjiayu	350 - 070	39
		other directions	*
East Taiwan	Lanyu	350 - 050	52
		other directions	*
Ryukyu	Miyakojima	350 - 080	29
		other directions	*

\*The figure derived from the regression equation is significantly larger than the highest land station wind speed encountered in this study (refer Table 5).

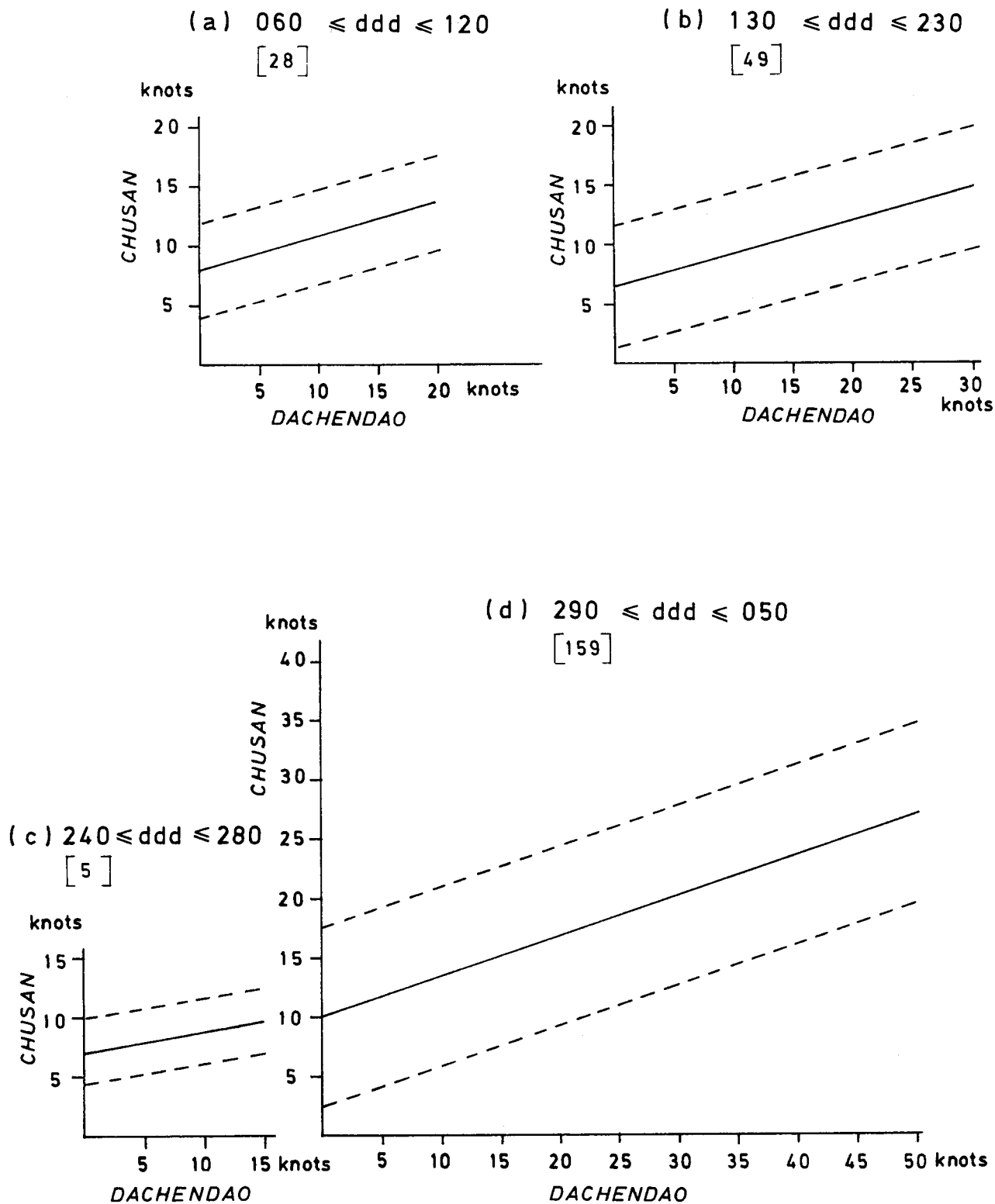


Figure 3 Wind speed in Chusan as reported by ships as a function of the wind speed at Dachendao. The data have been stratified according to the wind direction (ddd) at Dachendao. The two dashed lines include points within one standard deviation from the regression line. Sample sizes are indicated by the numbers in the square brackets.

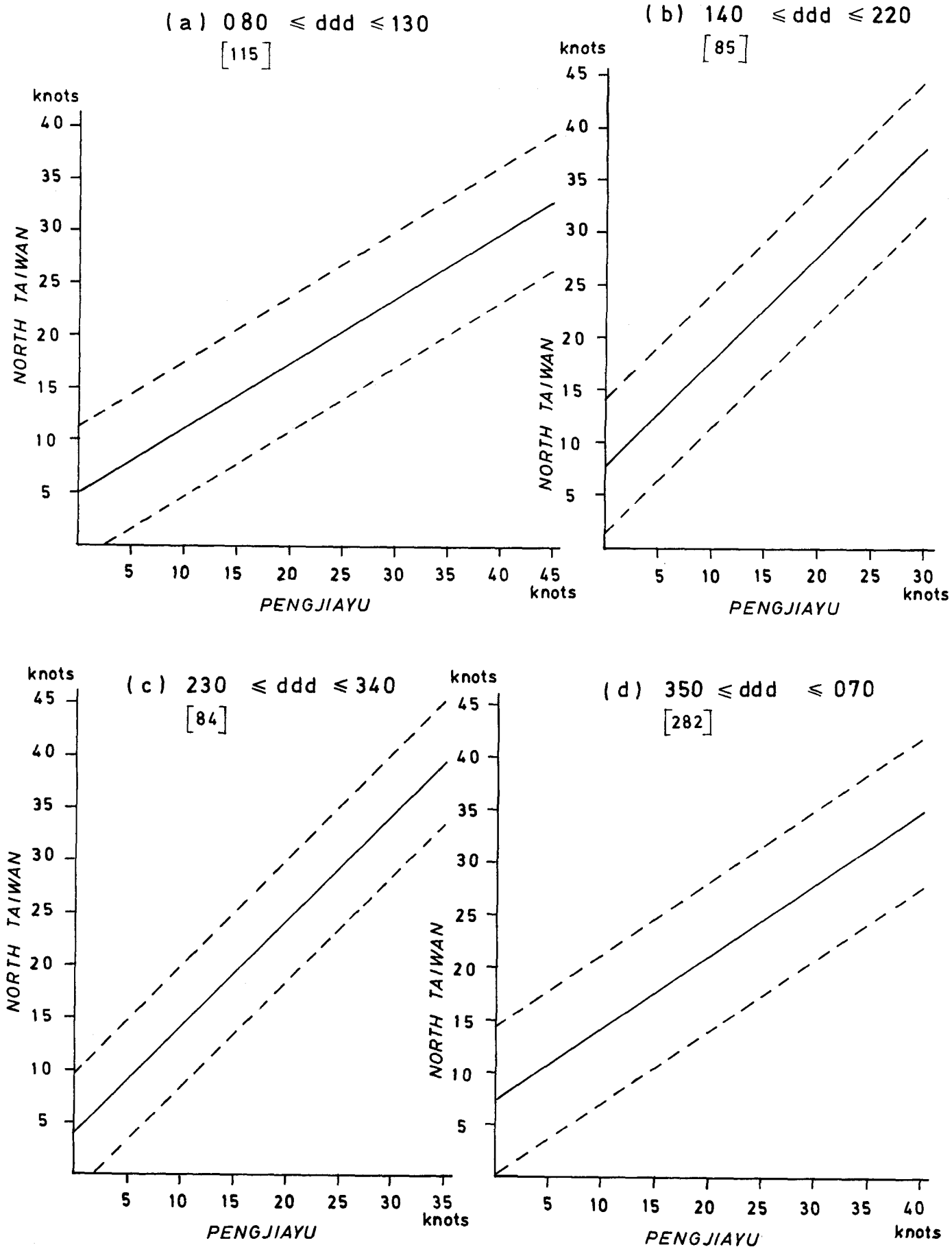


Figure 4 Wind speed in North Taiwan as reported by ships as a function of the wind speed at Pengjiayu. The data have been stratified according to the wind direction (ddd) at Penjiayu. The two dashed lines include points within one standard deviation from the regression line. Sample sizes are indicated by the numbers in the square brackets.

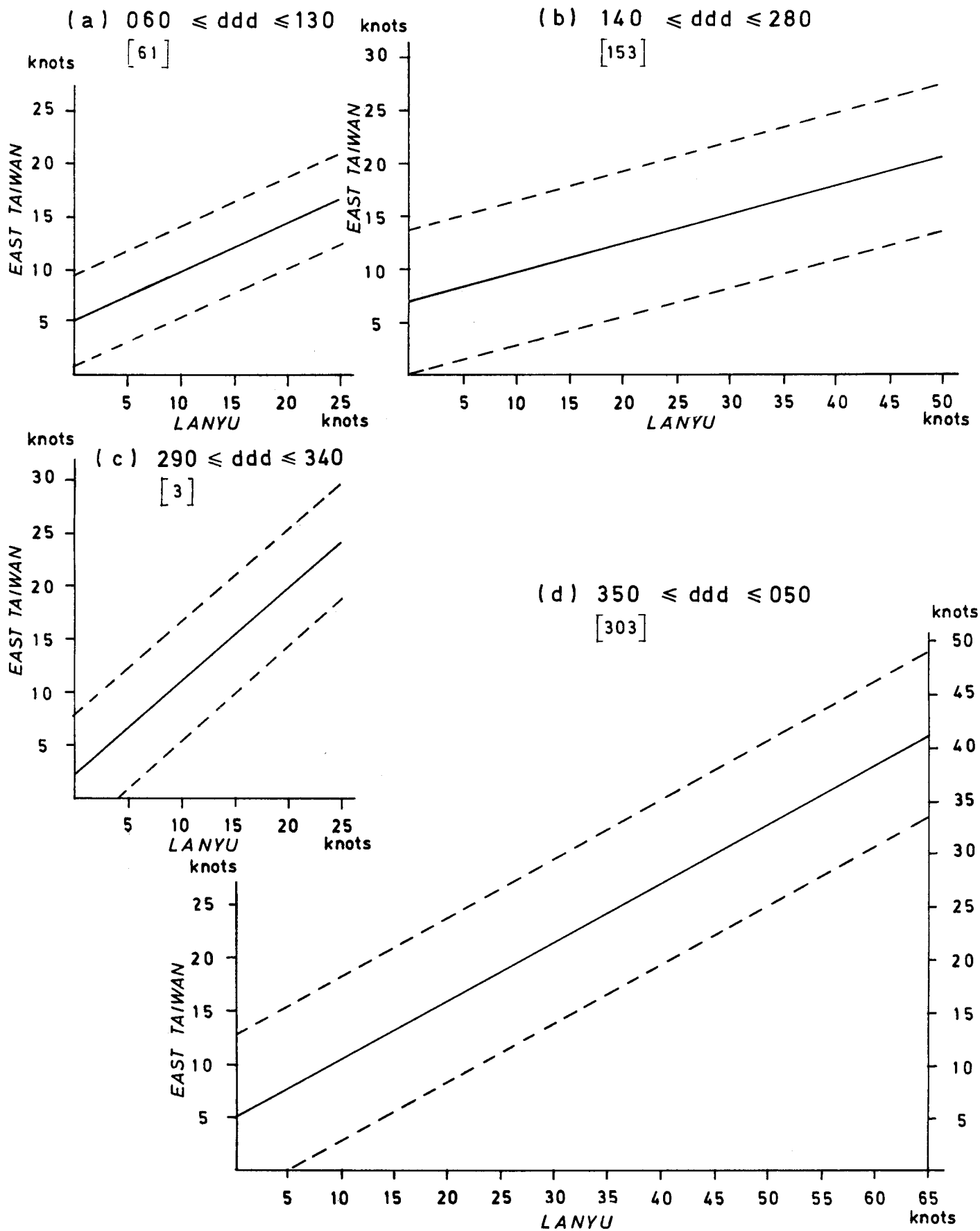


Figure 5 Wind speed in East Taiwan as reported by ships as a function of the wind speed at Lanyu. The data have been stratified according to the wind direction (ddd) at Lanyu. The two dashed lines include points within one standard deviation from the regression line. Sample sizes are indicated by the numbers in the square brackets.

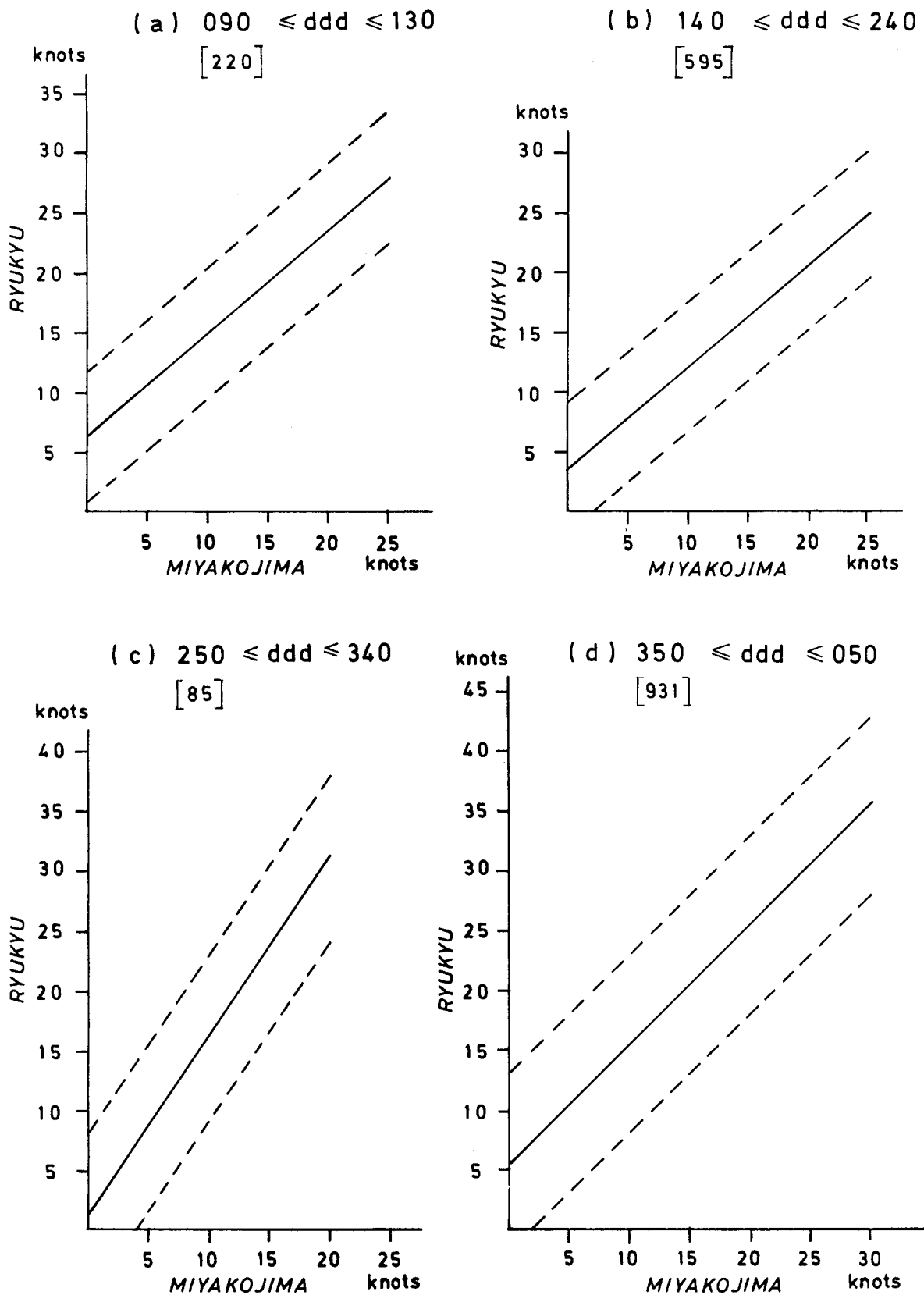


Figure 6 Wind speed in Ryukyu as reported by ships as a function of the wind speed at Miyakojima. The data have been stratified according to the wind direction(ddd) at Miyakojima. The two dashed lines include points within one standard deviation from the regression line. Sample sizes are indicated by the numbers in the square brackets.

#### 4. CONCLUSIONS

Based on one year of data (1975), the frequency distribution of winds over four marine areas viz Chusan, North Taiwan, East Taiwan and Ryukyu, with respect to direction and speed has been derived. This is intended to provide some guidance to forecasters. Some systematic differences in wind directions between land station reports and ship reports were noted and illustrated in Tables 3(a) - (d).

A set of regression equations has been produced for the estimation of winds over these areas, with selected land station wind reports as the predictor. This can be used by forecasters when estimating the wind speed in these sea areas, in the absence of other sources of information, when preparing forecasts for these areas. These equations have been transformed into graphical forms (Figures 3-6) to facilitate application.

In applying these results, it must be borne in mind that there are always spatial variations within each area. This may be the result of orography, sea-land contrast or varying relative positions with respect to major pressure systems.

## ACKNOWLEDGEMENTS

I am indebted to Mr. K.L. Tang and Mr. F.C. Lam who contributed to part of the data processing work. The efforts of voluntary observers aboard weather observing ships, who provided the wind observations used in the study are gratefully acknowledged.

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