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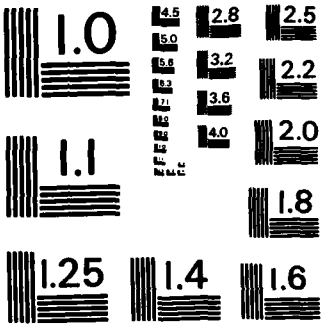

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NAVENVPREDRSCHFAC
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CR 82-11

FORECAST AIDS FOR PREDICTING TROPICAL CYCLONE ASSOCIATED GUSTS AND SUSTAINED WINDS FOR YOKOSUKA, JAPAN

Prepared By:

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Science Applications, Inc.
Monterey, California 93940

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Tropical cyclone
Typhoon

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Forecast aids are provided for predicting wind conditions at a station when a tropical cyclone passes within 360 n mi. The forecast aids were produced by analyzing a data set comprising the ratios of station wind values to tropical cyclone center wind values. Ratio values were then assigned to the position of the cyclone center. The 360 n mi radius circle about the station was divided into 71 equal area segments and the values of the mean and maximum ratio within each segment were subjectively analyzed to produce the forecast aids.

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CONTENTS

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1. INTRODUCTION

Forecasting wind conditions at a station during the passage of a tropical cyclone is a critical problem for operational environmentalists. The Air Force has produced forecast aids for predicting mean and maximum peak gusts for several western Pacific Air Force Bases (Pettett, 1980) for periods when a typhoon was within 360 n mi of a base. The need for similar forecast aids for Navy sites was recognized and the Naval Environmental Prediction Research Facility (NEPRF), Monterey, California was requested to produce the aids. Science Applications, Inc., under contract to NEPRF has conducted the research and development involved in producing forecast aid reports for Yokosuka, Japan and Cubi Point, Philippines.

2. PRODUCTION OF FORECAST AIDS

The forecast aids are based on a data period extending from the establishment of a U. S. Navy weather observation program at the station of interest through 1979. This is a 27 year period for Yokosuka (1953-1979) and 25 years for Cubi Point (1955-1979). Best track data for the tropical cyclones were extracted from Joint Typhoon Warning Center (JTWC) records for the periods when a tropical cyclone was within 360 n mi of the station of interest. Aviation hourly observations at three-hour intervals, obtained from the National Climatic Center (NCC), Asheville, NC, were extracted

for the periods identified as having a tropical cyclone within 360 n mi of the station.[1] The best track and weather observations were then merged into a new data base. From this data, ratios of storm center winds to station reported sustained winds were determined and assigned to the storm center position. The 360 n mi radius circle was divided into 71 equal areas (Fig.1).

The ratios identified with each area were summarized and maximum and mean gust ratios and standard deviations were determined. The number of ratios per area (sample size) and cumulative frequency distribution of the ratios were also computed. Computer plots of the gust ratios, sample size and area number values were generated. The gust ratio plots were then subjectively analyzed taking into consideration such factors as sample size for the mean gusts and cumulative distribution frequency for the maximum gusts.

The analyses of the data are presented as isolines which represent the climatological mean or maximum gust to be expected at the station as a percentage of the tropical cyclone center wind. The data base is separated into two classifications of cyclones, i.e., typhoons and lesser tropical cyclones. The classification is based on the

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[1]Aviation hourly observations are archived at NCC for the local times corresponding to 00,03,06,09,12,15,18,21 GMT only.

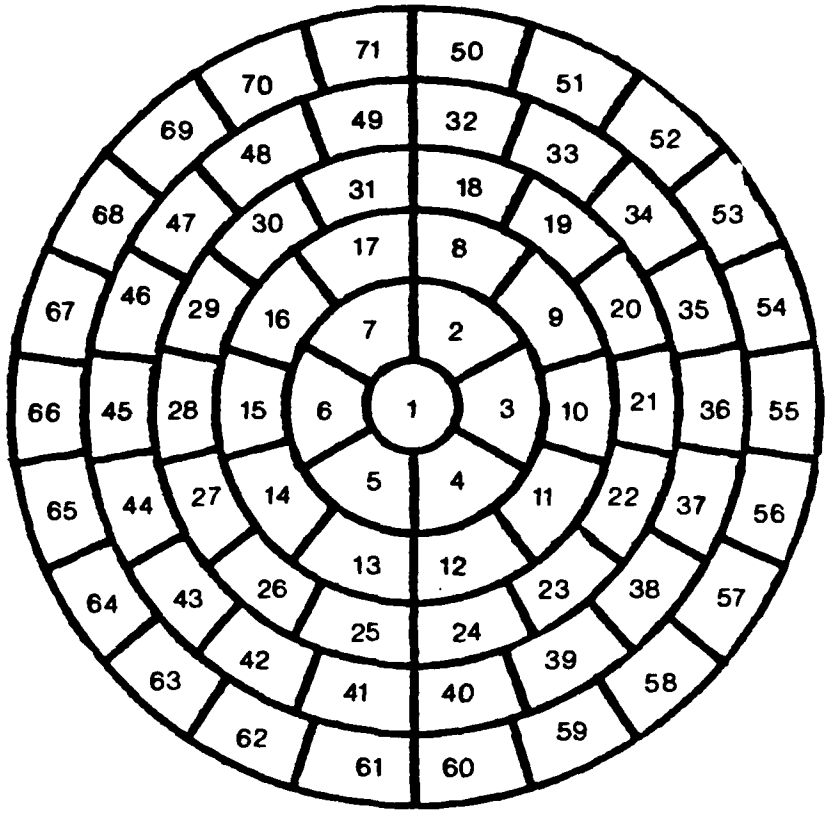

Figure 1. A 360 n mi radius circle divided into 71 equal area (5734.5 n mi^2) segments which can be centered on the station of interest. The circle is comprised of an inner circle and five surrounding rings. The radial thickness of each ring is approximately 60 n mi, but is not a constant. The segments are numbered from the inner circle and spiral outward.

cyclone center wind speed at the time of the station wind obervation. A set of analyses is provided for each cyclone classification. In addition, a table containing all the data necessary to produce figures 1 through 5 is provided. The data in the table will assist local reanalysis if required.

3. USE OF THE FORECAST AIDS

The forecast aids can be utilized as follows:

1) Locate the actual or forecast tropical cyclone center position on the appropriate forecast aid analysis; 2) determine the maximum gust ratio value by interpolating between the contours; and 3) apply this ratio (percentage) to the cyclone center wind value to obtain the maximum or mean gust values to be used as a forecast aid in making the wind forecast. For example, if a tropical cyclone has center winds of 100 kt and a ratio of .65 was determined above, then 65% of the center wind gives forecast gusts to 65 kt for the station.

Sustained one-minute maximum and average wind values can be found by applying a factor of 2/3 to the gust values. This factor is the inverse of the 1.5 to 1 ratio of gusts to sustained winds that was used in the Air Force reports and verified as follows: A study of the wind observations recorded at Cubi Point (1953-1979) and Yokosuka (1955-1979) was made as part of the development of the methodology used in producing these forecast aids. That data set included the

NCC tape archived data, hand augmented with gust data. A uniform ratio of gust to sustained wind speed of 1.5:1 was found over various speed ranges and at both stations. The data set included all station observations (Cubi Point 3449 and Yokosuka 2114) with sustained winds of 10 knots or more when a tropical cyclone was within 360 n mi of the station. This ratio was found to be reasonable for all tropical cyclone intensity classifications and station wind conditions.

Forecasters should recognize that all of the gust information is based on the archived sustained winds (aviation observations at three hour intervals from NCC) multiplied by 1.5. In determining this multiplier, local effects as they relate to various wind directions were only indirectly taken into account. That is, the ratios assigned to each area relate only to storms centered in that area. The storm center location relative to the station location strongly influences the station wind velocity. Therefore, some degree of local effects are inherent in the analyzed ratio patterns.

Table 1 summarizes the data used in producing the forecast aids and other general information. The data in Table 1 is sufficient to reproduce figures 1 through 5 should local reproduction or modifications be desired. The ratio values in Table 1 represent the relationship of station sustained winds to tropical cyclone center winds. To derive

the forecast aids for gust values the 1.5 multiplier must be applied.

Figures 2 through 5 are the forecast aid analyses. The contours are labelled as percentages which were derived from the ratios of station winds to tropical cyclone center winds. Note that the maximum contour values on figures 3 and 5 are less than 100 percent. For example, the mean gust aid for typhoon strength tropical cyclones (Fig.5) shows only a 70 percent contour around the station. Table 1, segment 1 for tropical cyclones of 64 kt or greater shows 3 cases of typhoon strength centers being located within the area of segment 1. The mean sustained wind to typhoon center wind ratio for the 3 cases is .513 to 1. None of the immediate surrounding areas, segments 2 through 7 (total of 34 cases), have mean ratios as high as area 1. Applying the 1.5 multiplier to the ratios of segments 1 through 7 results in the data that supports the 70 percent contour.

The interpretation of figure 5 is that Yokosuka has not on the average experienced winds at the official observation point of as great an intensity as the official typhoon center winds during typhoon passages. While these findings are based on a reasonable sample size, caution should be used in applying these results when a typhoon center is expected to pass over or very near the station.

Inconsistent gust values will be obtained from the aids when a tropical cyclone center wind change results in a

change of cyclone classification and therefore a change of forecast aid. For example, use of figure 3 for a tropical storm forecast to pass over the station with 60 kt center winds would indicate mean gusts of about 42 kt. A change in center wind to 65 kt and the use of figure 5 indicates about 49 kt mean gusts. An intermediate value is the likely best guidances in such cases.

REFERENCE

Pettett, J.E., 1980: Prediction of Typhoon-Induced Peak Winds at Four Pacific Stations. 1WW/TN-80/001.

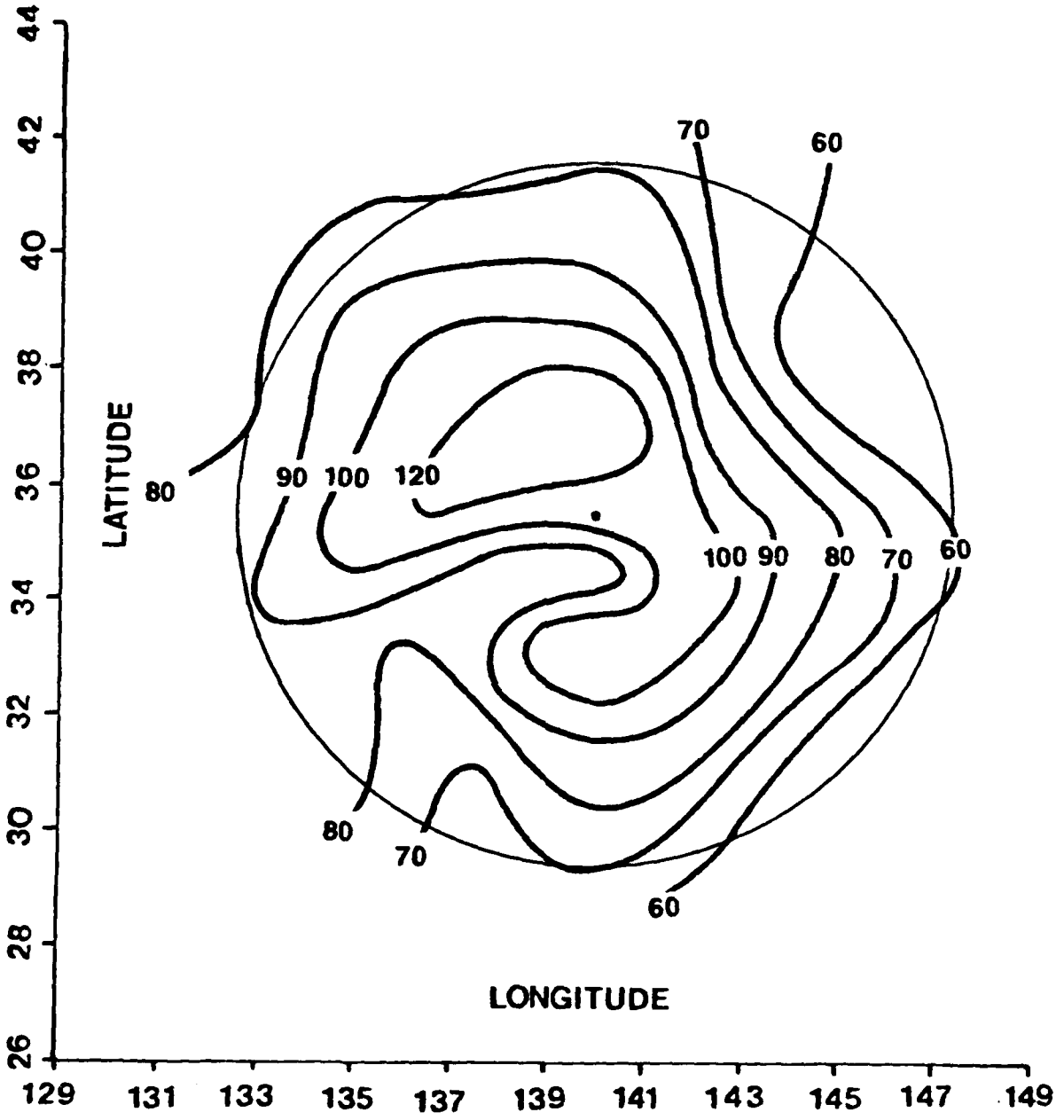

Figure 2. Maximum Gust Ratios (labelled as percentage) for Yokosuka when a tropical cyclone of less than typhoon strength (<64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the maximum gust expected with the given center position and wind speed. Multiply the maximum gust speed by 0.67 to find the maximum one-minute average sustained wind speed.

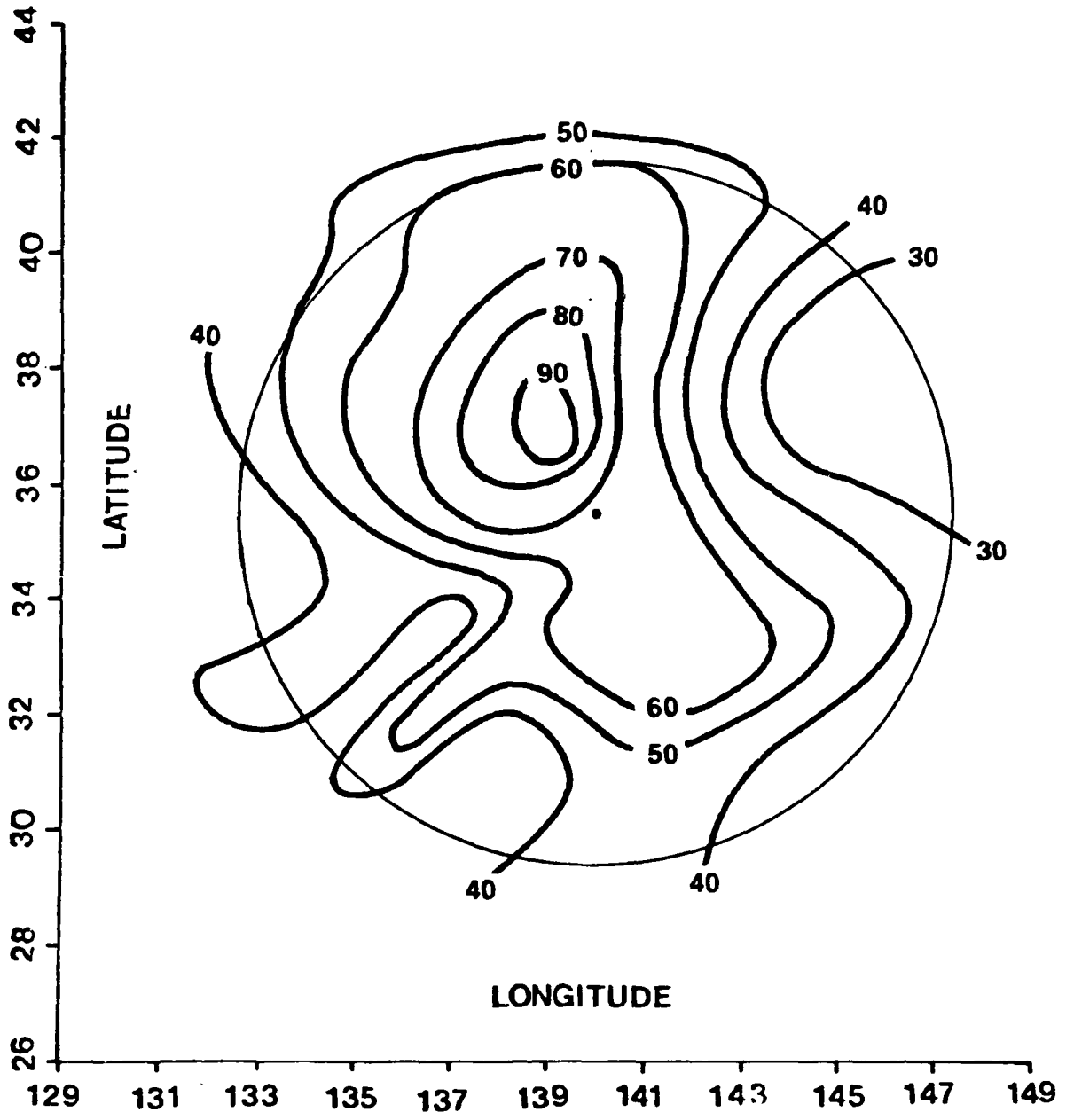

Figure 3. Mean Gust Ratios (labelled as percentage) for Yokosuka when a tropical cyclone of less than typhoon strength (<64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the mean gust expected with the given center position and wind speed. Multiply the mean gust speed by 0.67 to find the mean one-minute average sustained wind speed.

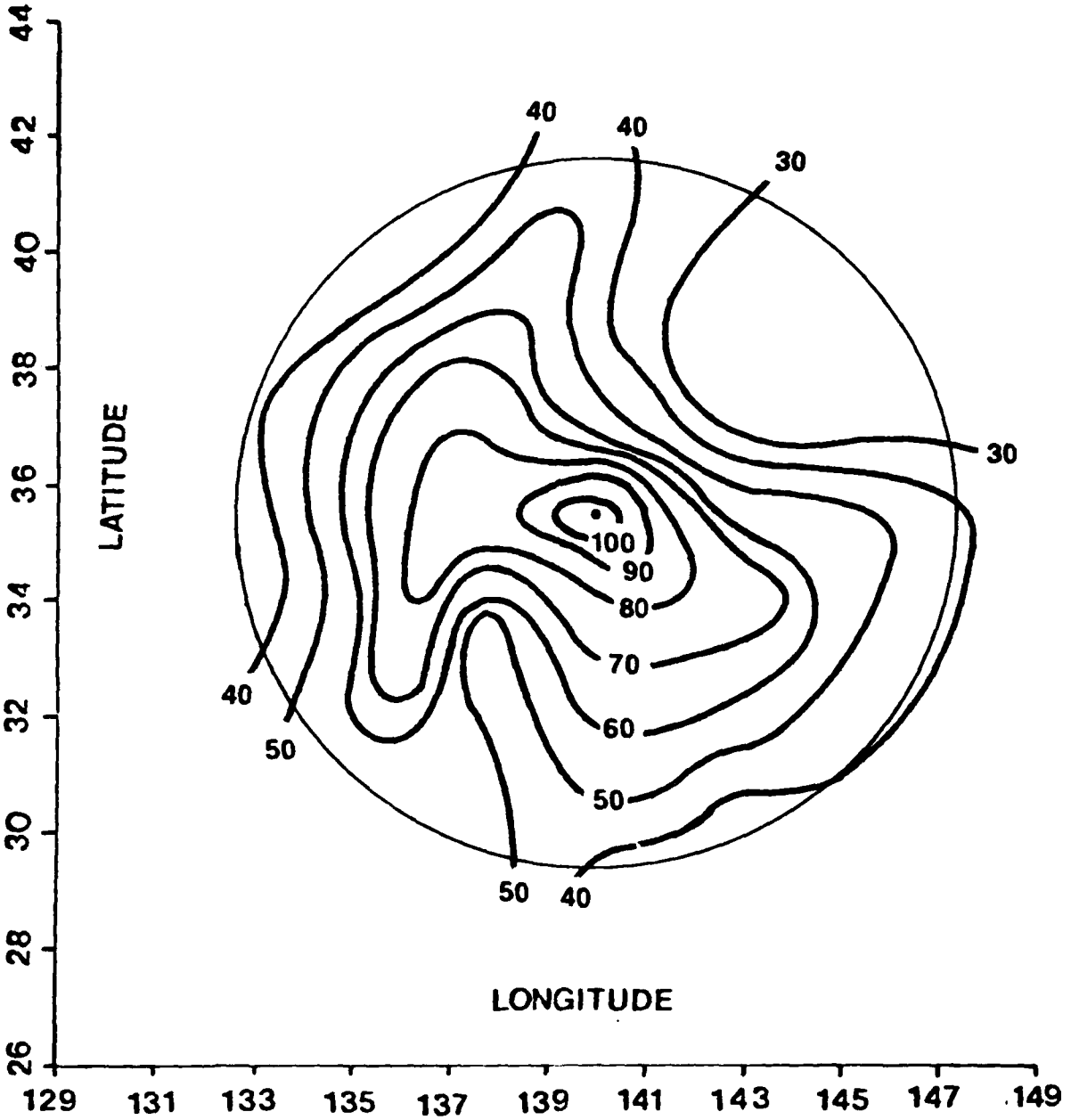

Figure 4. Maximum Gust Ratios (labelled as percentage) for Yokosuka when a tropical cyclone of typhoon strength (≥64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the maximum gust expected with the given center position and wind speed. Multiply the maximum gust speed by 0.67 to find the maximum one-minute average sustained wind speed.

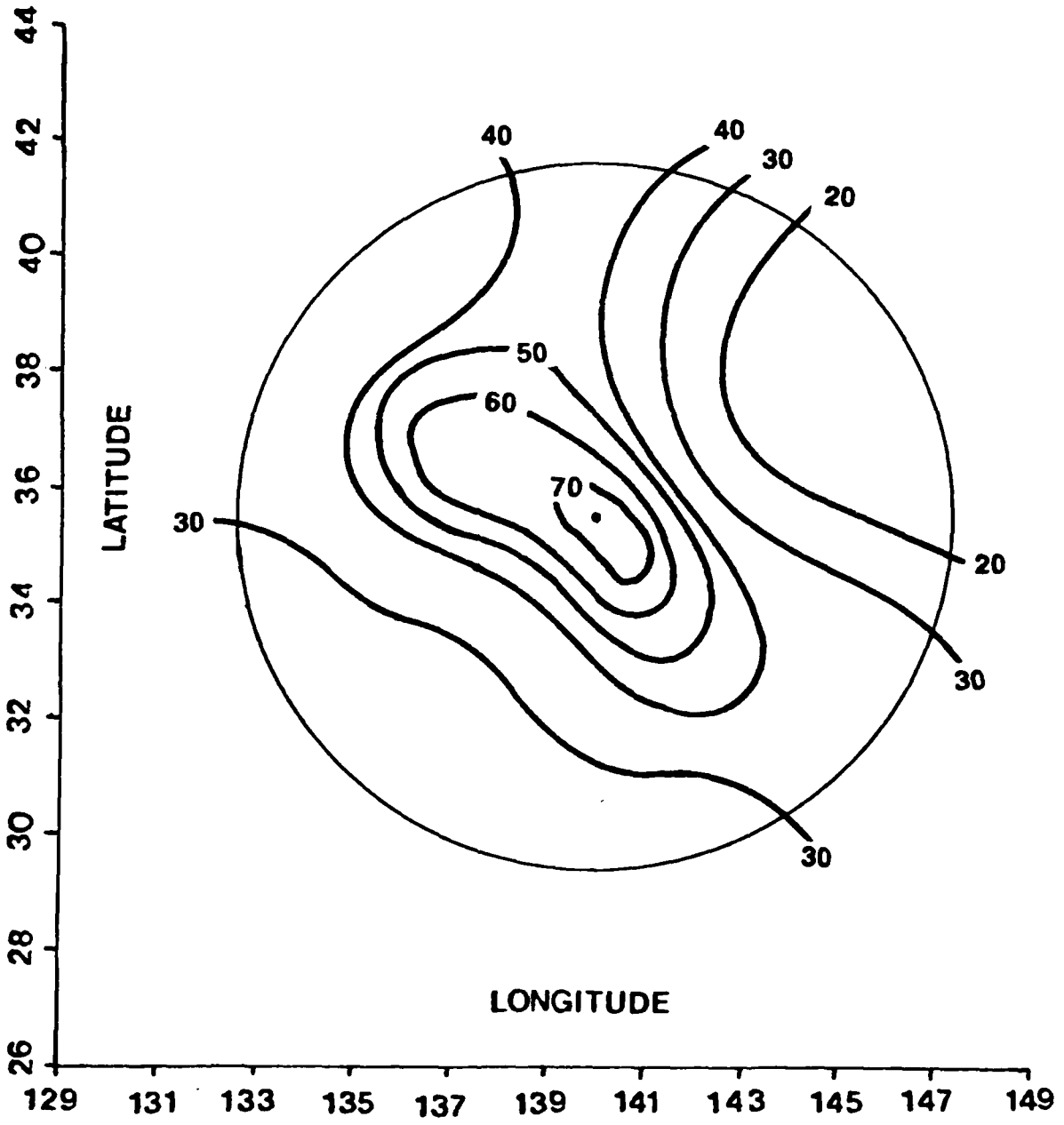

Figure 5. Mean Gust Ratios (labelled as percentage) for Yokosuka when a tropical cyclone of typhoon strength ($\geq$64 kt) is centered within 360 n mi of the station. Locate the typhoon center by latitude and longitude and interpolate the ratio (percentage) value. Multiply the typhoon center wind speed by this percentage to get the wind speed value of the mean gust expected with the given center position and wind speed. Multiply the mean gust speed by 0.67 to find the mean one-minute average sustained wind speed.

Table 1. A listing of the data used in producing figures 1 through 5, and other general information. Table contents by column are: segment number, latitude and longitude of segment center, maximum ratio, mean ratio, standard deviation of ratios, number of ratios (sample size), and cumulative frequency distribution expressed as the percentage of ratios occurring between 0.0 and the maximum ratio or 1.0 in 0.1 increments.

Tropical cylone less than 64 kts

CENTER POINT							CUM FREQ DIST*N									
SEG	LAT	LONG	MAX	MEAN	S.DV.	N										
1	35.3	139.7	.743	.442	.154	10	0	10	20	20	80	90	90	100		
RING NUMBER 1																
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N									
2	36.5	140.6	.824	.373	.202	13	0	23	54	62	77	85	92	92	100	
3	35.3	141.4	.714	.427	.152	13	0	8	31	54	69	85	92	100		
4	34.1	140.6	.600	.437	.104	7	0	0	0	43	71	100				
5	34.1	138.8	.547	.350	.191	5	20	20	40	60	60	100				
6	35.3	138.0	.690	.492	.096	13	0	0	0	31	62	85	100			
7	36.5	138.8	1.057	.636	.185	7	0	0	0	0	29	29	86	86	86	100
RING NUMBER 2																
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N									
8	37.6	140.6	.800	.471	.240	3	0	0	33	67	67	67	67	100		
9	36.7	142.1	.588	.260	.176	14	21	50	71	71	86	100				
10	35.3	142.7	.607	.270	.160	9	11	33	67	78	89	89	100			
11	33.9	142.1	.767	.415	.198	15	0	27	27	47	60	87	93	100		
12	33.0	140.6	.750	.371	.198	12	17	25	33	67	75	83	92	100		
13	33.0	138.8	.848	.491	.225	6	0	17	33	33	50	67	83	83	100	
14	33.9	137.3	.520	.264	.114	13	8	31	62	92	92	100				
15	35.3	136.7	.933	.478	.198	25	0	4	20	40	60	76	88	92	92	100
16	36.7	137.3	1.000	.537	.278	10	0	0	30	50	50	70	70	80	80	100
17	37.6	138.8	.698	.591	.116	4	0	0	0	25	25	50	100			
RING NUMBER 3																
SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N									
18	38.7	140.6	.444	.397	.048	2	0	0	0	50	100					
19	38.0	142.4	.548	.310	.116	8	0	13	63	88	88	100				
20	36.8	143.5	.240	.155	.050	5	0	80	100							
21	35.3	144.0	.679	.319	.169	7	0	29	57	86	86	86	100			
22	33.8	143.5	.465	.338	.137	5	20	20	20	60	100					
23	32.6	142.4	.600	.446	.140	7	0	14	14	43	43	100				
24	31.9	140.6	.647	.421	.165	15	7	13	13	40	53	93	100			
25	31.9	138.8	.522	.234	.124	15	13	53	73	87	93	100				
26	32.6	137.0	.800	.342	.199	11	18	18	36	73	91	91	91	100		
27	33.8	135.9	.957	.275	.198	17	6	35	76	88	94	94	94	94	94	100
28	35.3	135.4	.750	.385	.177	17	6	18	29	47	82	88	94	100		
29	36.8	135.9	.909	.408	.250	6	0	33	33	50	83	83	83	83	83	100
30	38.0	137.0	1.000	.511	.216	8	0	0	13	50	50	88	88	88	88	100
31	38.7	138.8	.655	.535	.091	6	0	0	0	17	33	83	100			

RING NUMBER 4

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DISTRN
32	39.7	140.7	.800	.556	.173	3	0 0 0 0 67 67 67 100
33	39.2	142.4	.500	.309	.125	7	14 14 43 71 100
34	38.2	143.9	.225	.142	.065	3	33 67 100
35	36.8	144.9	.100	.063	.037	2	100
36	35.3	145.2	.553	.256	.194	9	33 56 67 67 78 100
37	33.8	144.9	.567	.294	.154	12	17 33 58 75 83 100
38	32.4	143.9	.600	.418	.146	6	0 17 17 50 67 100
39	31.4	142.4	.727	.336	.189	15	7 33 53 67 73 93 93 100
40	30.9	140.7	.533	.333	.150	12	17 25 33 67 92 100
41	30.9	138.7	.500	.238	.110	13	8 46 69 92 100
42	31.4	137.0	.490	.214	.136	21	33 48 76 90 100
43	32.4	135.5	.343	.171	.092	16	38 56 88 100
44	33.8	134.5	.600	.274	.184	11	18 36 73 73 73 100
45	35.3	134.2	.700	.381	.147	13	0 15 23 69 85 92 100
46	36.8	134.5	.850	.501	.179	6	0 0 17 50 50 83 83 83 100
47	38.2	135.5	.560	.327	.181	3	0 33 67 67 67 100
48	39.2	137.0	.600	.426	.112	5	0 0 20 60 80 100
49	39.7	138.7	.571	.371	.130	4	0 0 50 75 75 100

RING NUMBER 5

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DISTRN
50	40.7	140.7	.600	.434	.128	5	0 0 20 20 80 100
51	40.3	142.5	.400	.381	.027	3	0 0 0 100
52	39.4	144.1	.414	.219	.120	5	20 40 80 80 100
53	38.3	145.4	.229	.147	.063	3	33 67 100
54	36.8	146.2	.286	.161	.072	12	25 67 100
55	35.3	146.4	.633	.197	.181	9	33 78 78 89 89 89 100
56	33.8	146.2	.566	.316	.127	9	0 33 56 78 89 100
57	32.3	145.4	.400	.175	.110	15	33 60 80 100
58	31.2	144.1	.314	.181	.084	12	25 67 92 100
59	30.3	142.5	.375	.178	.096	8	25 75 88 100
60	29.9	140.7	.600	.315	.181	6	17 33 50 50 83 100
61	29.9	138.7	.880	.267	.194	17	18 47 71 82 94 94 94 94 100
62	30.3	136.9	.444	.252	.121	16	13 44 63 88 100
63	31.2	135.3	.632	.336	.148	15	7 27 40 60 93 93 100
64	32.3	134.0	.667	.288	.157	21	14 19 57 86 90 90 100
65	33.8	133.2	.500	.257	.121	16	19 25 69 88 100
66	35.3	133.0	.567	.206	.168	9	33 67 67 89 89 100
67	36.8	133.2	.579	.357	.146	5	0 20 40 80 80 100
68	38.3	134.0	.615	.376	.211	5	20 20 40 60 60 80 100
69	39.4	135.3	.640	.369	.131	7	0 0 43 71 86 86 100
70	40.7	136.9	.565	.427	.121	6	0 0 17 50 67 100
71	40.7	138.7	1.100	.501	.308	8	13 13 13 50 63 63 75 88 88 100

CENTER POINT — Tropical cyclones of 64 kt or greater

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
1	35.3	139.7	.714	.513	.209	3	0 0 33 33 33 67 67 100

RING NUMBER 1

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
2	36.5	140.6	.360	.216	.144	2	50 50 50 100
3	35.3	141.4	.486	.342	.125	5	0 20 40 60 100
4	34.1	140.6	.587	.458	.117	9	0 11 11 33 44 100
5	34.1	138.8	.514	.313	.132	12	8 17 50 58 92 100
6	35.3	138.0	.585	.401	.146	4	0 0 50 50 75 100
7	36.5	138.8	.400	.392	.008	2	0 0 0 100

RING NUMBER 2

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
8	37.6	140.6	.277	.169	.108	2	50 50 100
9	36.7	142.1	.187	.130	.042	4	50 100
10	35.3	142.7	.361	.176	.093	13	15 77 85 100
11	33.9	142.1	.515	.313	.116	12	0 25 42 83 92 100
12	33.0	140.6	.431	.316	.097	14	7 7 36 79 100
13	33.0	138.8	.380	.237	.101	11	9 36 64 100
14	33.9	137.3	.354	.209	.108	8	25 50 75 100
15	35.3	136.7	.538	.460	.111	3	0 0 0 33 33 100
16	36.7	137.3	.500	.391	.144	3	0 33 33 33 100
17	37.6	138.8				0	

RING NUMBER 3

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
18	38.7	140.6	.243	.243	.000	1	0 0 100
19	38.0	142.4				0	
20	36.8	143.5	.138	.092	.027	7	43 100
21	35.3	144.0	.377	.377	.000	1	100
22	33.8	143.5	.477	.240	.105	8	0 50 88 88 100
23	32.6	142.4	.426	.308	.073	4	0 0 75 75 100
24	31.9	140.6	.493	.256	.097	16	0 38 81 94 100
25	31.9	138.8	.394	.238	.075	8	0 63 75 100
26	32.6	137.0	.278	.126	.099	9	44 67 100
27	33.8	135.9	.538	.242	.153	10	20 40 60 80 90 100
28	35.3	135.4	.514	.285	.200	3	33 33 33 67 67 100
29	36.8	135.9	.477	.417	.060	2	0 0 0 50 100
30	38.0	137.0	.471	.390	.082	2	0 0 0 50 100
31	38.7	138.8	.319	.268	.051	2	0 0 50 100

RING NUMBER 4

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
32	39.7	140.7	.238	.238	.000	1	0 0 100
33	39.2	142.4	.092	.077	.015	2	100
34	38.2	143.9	.185	.164	.021	2	0 100
35	36.8	144.9	.185	.100	.045	6	67 100
36	35.3	145.2	.366	.193	.082	8	13 50 88 100
37	33.8	144.9	.304	.295	.009	2	0 0 50 100
38	32.4	143.9	.375	.222	.121	12	33 33 58 100
39	31.4	142.4	.347	.201	.104	9	22 56 67 100
40	30.9	140.7	.325	.196	.085	14	21 64 79 100
41	30.9	138.7	.289	.164	.078	9	22 56 100
42	31.4	137.0	.338	.165	.094	14	29 64 86 100
43	32.4	135.5	.508	.148	.127	13	46 85 85 92 92 100
44	33.8	134.5	.343	.284	.059	2	0 0 50 100
45	35.3	134.2				0	
46	36.8	134.5				0	
47	38.2	135.5	.325	.254	.055	3	0 33 67 100
48	39.2	137.0	.186	.186	.000	1	0 100
49	39.7	138.7	.457	.322	.123	4	0 25 50 50 100

RING NUMBER 5

SEG	LAT	LONG	MAX	MEAN	S.DV.	N	CUM FREQ DIST*N
50	40.7	140.7	.200	.200	.000	1	0 100
51	40.3	142.5	.267	.163	.104	2	50 50 100
52	39.4	144.1	.062	.062	.000	1	100
53	38.3	145.4	.078	.065	.013	2	100
54	36.8	146.2	.138	.086	.031	4	75 100
55	35.3	146.4	.179	.107	.044	5	40 100
56	33.8	146.2	.275	.210	.047	8	0 38 100
57	32.3	145.4	.291	.201	.072	7	14 43 100
58	31.2	144.1	.301	.211	.069	11	9 36 91 100
59	30.3	142.5	.200	.108	.052	13	62 100
60	29.9	140.7	.338	.150	.095	10	40 70 90 100
61	29.9	138.7	.317	.146	.084	19	42 68 95 100
62	30.3	136.9	.366	.164	.096	23	26 65 91 100
63	31.2	135.3	.385	.176	.086	10	10 70 90 100
64	32.3	134.0	.357	.163	.091	16	25 69 94 100
65	33.8	133.2	.200	.133	.059	7	29 100
66	35.3	133.0	.232	.209	.022	2	0 50 100
67	36.8	133.2	.295	.237	.045	3	0 33 100
68	38.3	134.0				0	
69	39.4	135.3	.244	.244	.000	1	0 0 100
70	40.3	136.9	.200	.200	.000	1	0 100
71	40.7	138.7				0	

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