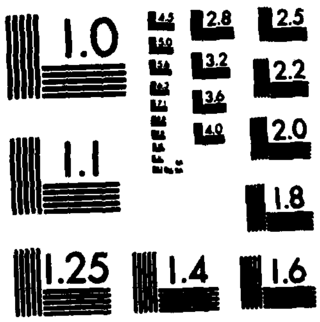
AD-A122 908 TERRAIN ADJUSTED TROPICAL CYCLONE WIND PROBABILITIES 1/1
(U) SCIENCE APPLICATIONS INC MONTEREY CA J D JARRELL
DEC 82 NEPRF-CR-82-14 N00228-81-C-H361

UNCLASSIFIED F/G 4/2 NL

END
DATE
FILMED
2 83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVENVPREDRSCHFAC Contractor Report CR 82-14	2. GOVT ACCESSION NO. AD-A122908	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Terrain Adjusted Tropical Cyclone Wind Probabilities		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Jerry D. Jarrell		8. CONTRACT OR GRANT NUMBER(s) N00228-81-C-H361
9. PERFORMING ORGANIZATION NAME AND ADDRESS Science Applications, Inc. 2999 Monterey-Salinas Highway Monterey, CA 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 63207N PN XW0513 TA CC00 NEPRF WU 6.3-14
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Department of the Navy Washington, DC 20361		12. REPORT DATE December 1982
		13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Environmental Prediction Research Facility Monterey, CA 93940		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Tropical cyclone
Typhoon
Strike probability

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

A problem involving overestimates of tropical cyclone wind probabilities for locations that are heavily terrain-influenced is described. Previous studies on this topic are reviewed. A method is described to adjust wind probabilities for terrain, and it is applied for the two Navy ports of Cubi Point, RP, and Yokosuka, JA. Probabilities with and without terrain modifications are tested, and the results are analyzed and compared. The study concludes that the resulting lower wind probabilities are a substantial improvement over the unmodified probabilities.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

1. Introduction

The present version of the Navy tropical cyclone WIND probability model assumes the winds are over water. For locations in rough terrain this assumption causes serious overestimates of the probabilities of 30 and 50 kt winds. This report describes a method by which wind probabilities are terrain adjusted. Independent testing of the method is reported and comparisons are made of probabilities with and without the modification. Two western Pacific Navy ports, Cubi Point on Subic Bay in the Philippines, and Yokosuka in Japan, were selected for demonstration sites of wind probability terrain modification. These sites were chosen because of a combination of fleet importance coupled with good terrain protection from typhoon winds. It is presupposed that this latter factor is the reason that over water wind probabilities are too high for these bases.

2. Background

The forerunner for this work was an Air Force study of typhoons passing in the vicinity of Air Force Bases in the Pacific by Atkinson and Penland (1967)[1] and recently updated by Pettett (1980)[2]. In these studies, the winds observed at the base were described as a percentage of central winds in the passing typhoons, while the typhoons were located in various grid spaces on a grid centered on the station. Similar studies were recently completed for Cubi Point and Yokosuka by Englebretson and Jarrell (1982)[3,4]. Figure 1 shows the grid used on these latter studies.

Figure 2 depicts the maximum, median and minimum percentage of the tropical cyclones center winds observed at the station when a tropical storm or depression was

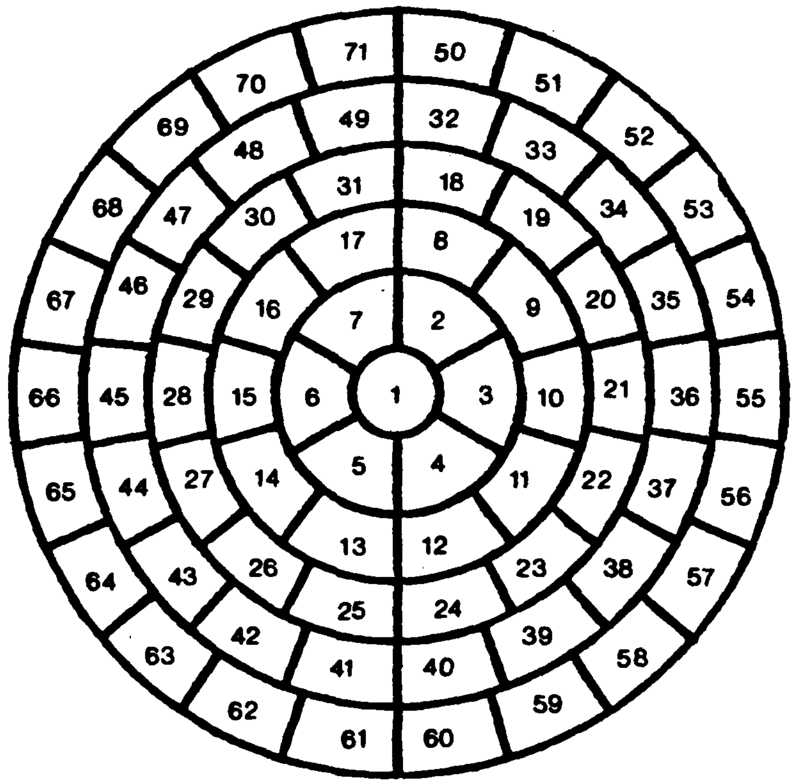


Figure 1. A 360 n mi radius circle divided into 71 equal area (5734.5 n mi^2) segments which can be centered on the station of interest. The circle is comprised of an inner circle and five surrounding rings. The radial thickness of each ring is approximately 60 n mi, but is not a constant. The segments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

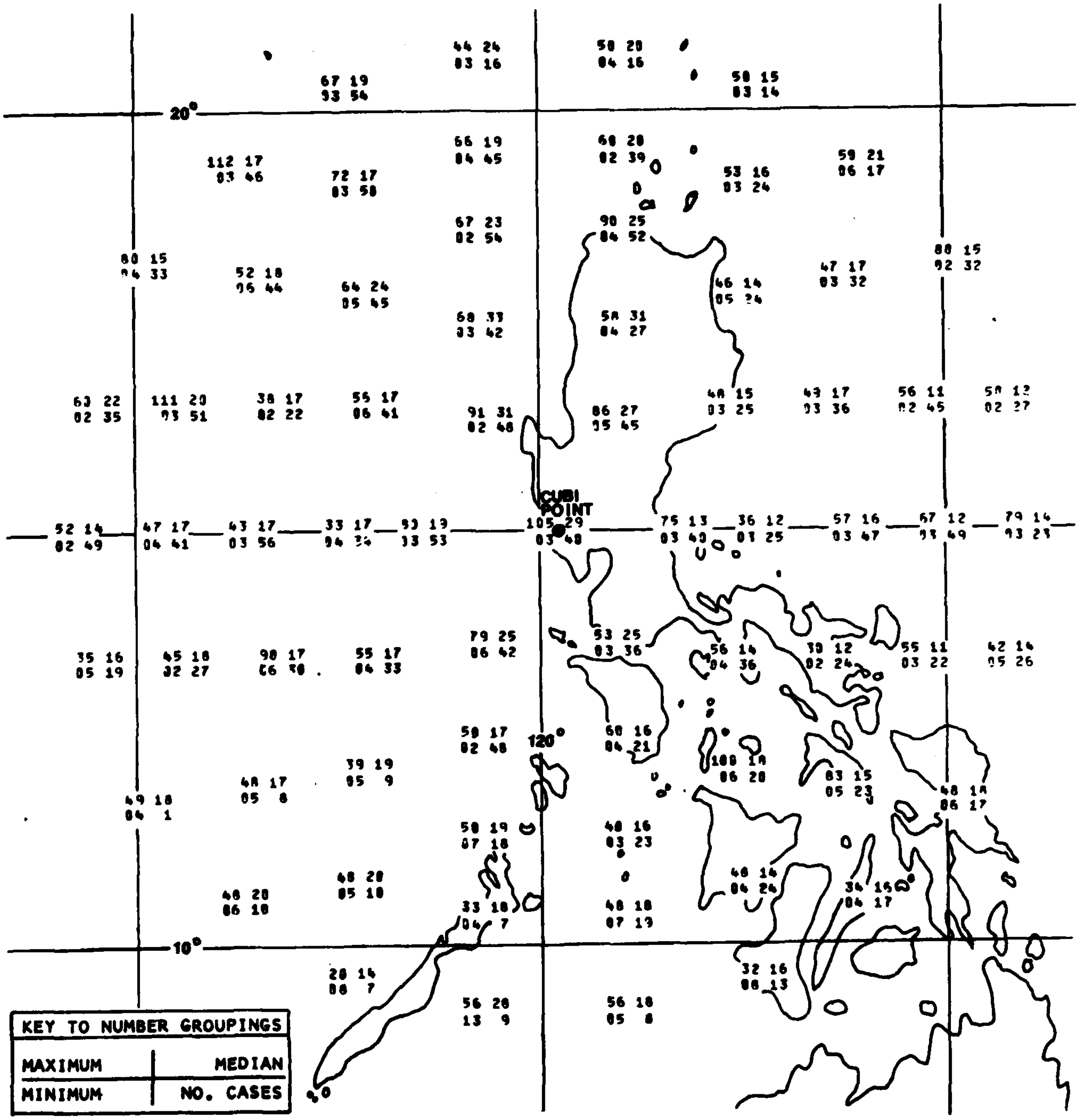


Figure 2. Depiction of the maximum, median, and minimum percentage of center winds from Cubi Point, RP, when a tropical storm or depression was located in the grid spaces.

located in the grid spaces. These percentages are often referred to as wind ratios, a convention which will be followed in later sections. Figure 3 shows the comparable maximum, median and minimum wind ratios when a typhoon was located in the grid spaces. Figures 4 and 5 are a similar set of diagrams for Yokosuka.

Figure 6 shows a graph of the typhoon wind ratio data from grid space 1 (central grid space from Figure 3) for Cubi Point. Knowing, for example, that a typhoon with 90-kt center winds will be in this grid space, the curve of Figure 6, treated as a cumulative distribution, can be used to estimate the probability of 30- or 50-kt winds. In this example, in order to receive 30-kt winds at the station, we must observe 30/90 or 33% of the maximum. From Figure 6 we see that the ratio was below 33% in about 65% of the past cases. Thus we conclude the probability of above 30-kt winds is about 35% (100-65). Similarly for 50-kt winds we must observe a wind ratio of 50/90 or 56%. Since ratios in excess of 50% have not been observed we conclude the probability is near zero of a 90-kt typhoon causing 50-kt winds at Cubi Point while it is located in sector 1. These probabilities are conditional, valid only if the conditions (the typhoon is in grid space 1 and has 90-kt center winds) are met.

The foregoing example may seem paradoxical in that it may appear impossible to have a 90-kt typhoon pass essentially over the station and yet the station observes no more than 50-kt winds. This is the very idea of terrain protection; in an actual event such as this, ninety knot winds may not have been measured anywhere, partly because there are so few anomometers. Additionally the post

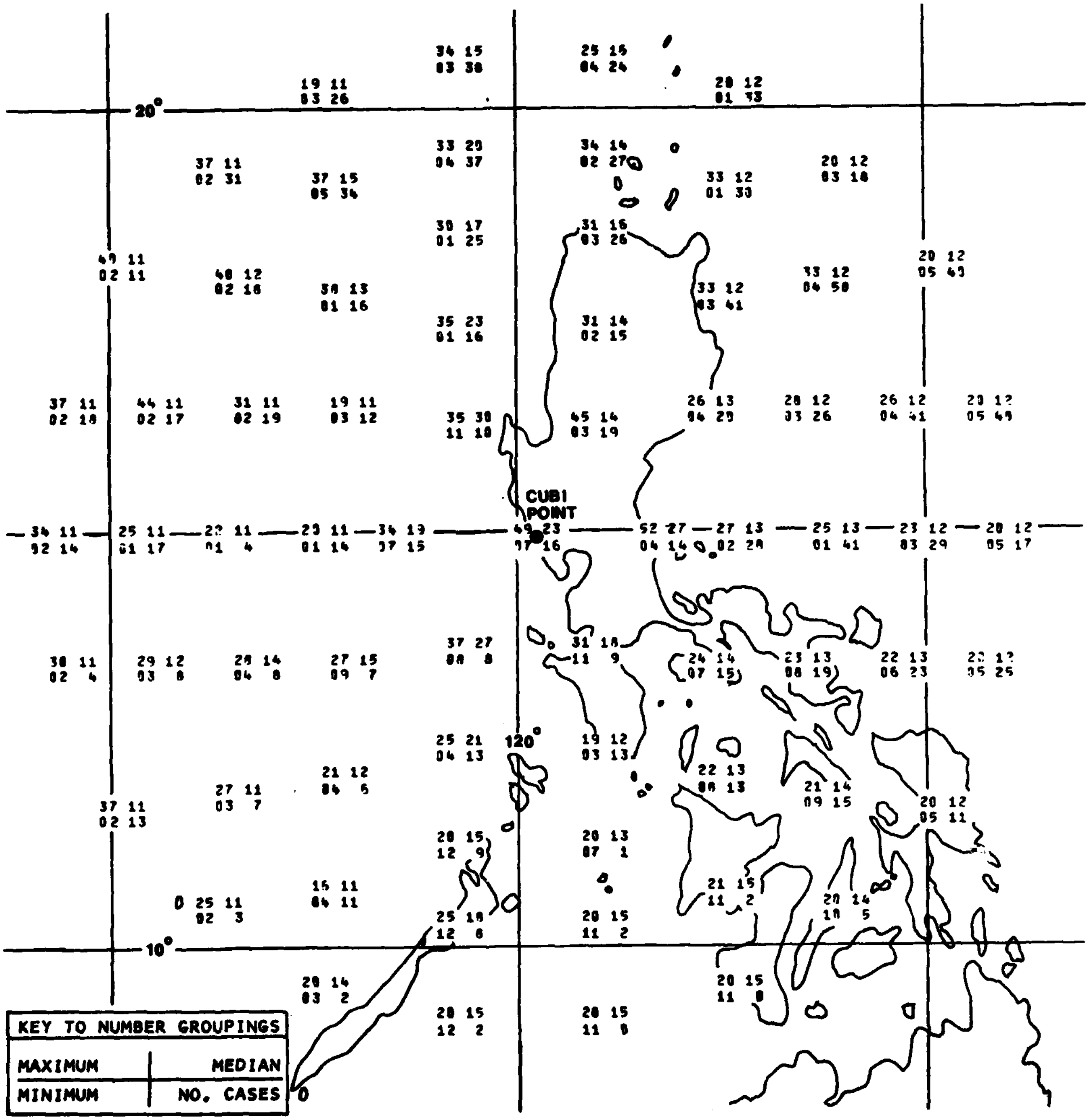


Figure 3. Depiction of the maximum, median, and minimum percentage of center winds from Cubi Point, RP, when a typhoon was located in the center grid spaces.

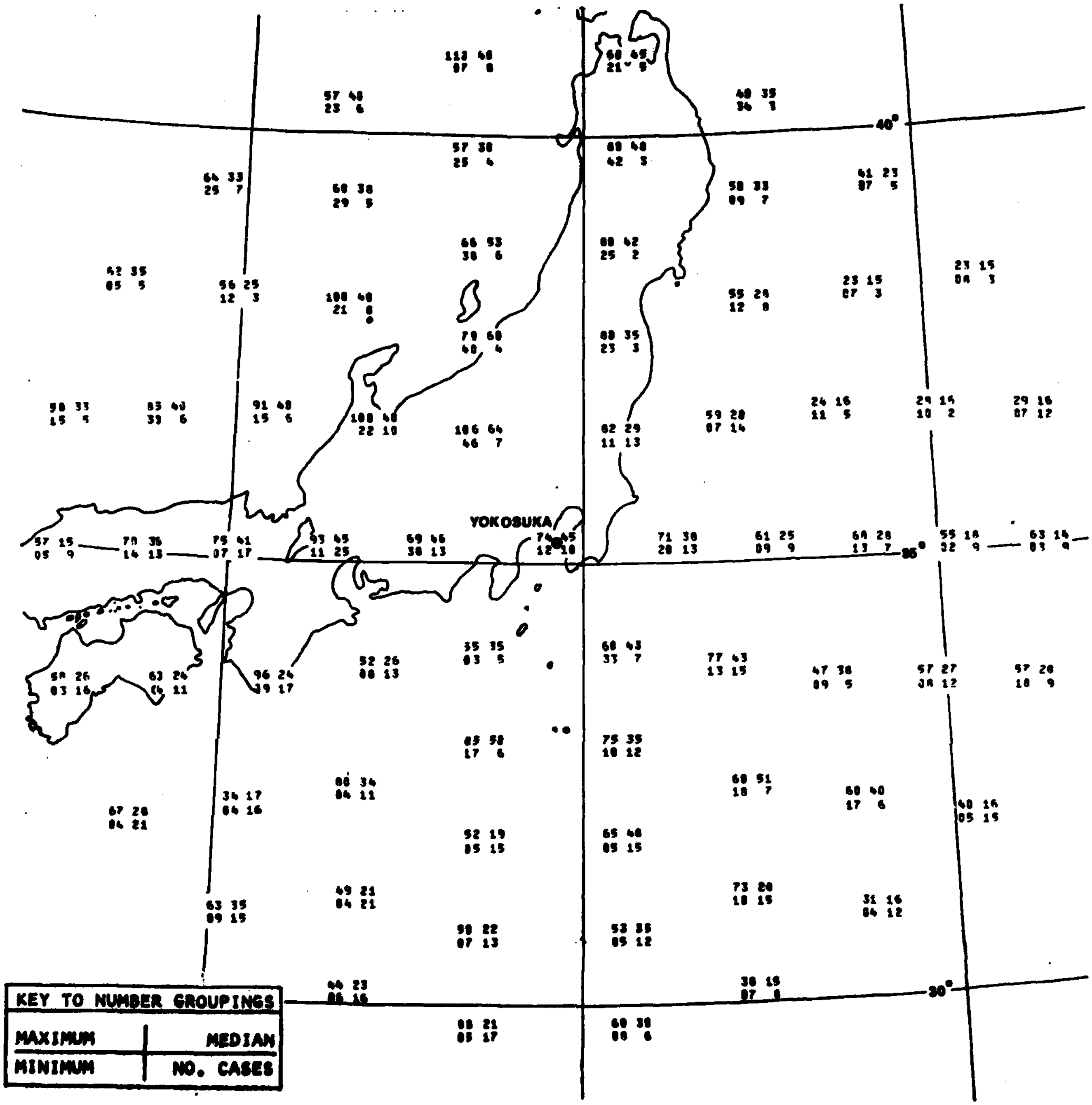


Figure 4. Depiction of the maximum, median, and minimum percentage of center winds from Yokosuka, JA when a tropical storm or depression was located in the grid spaces.

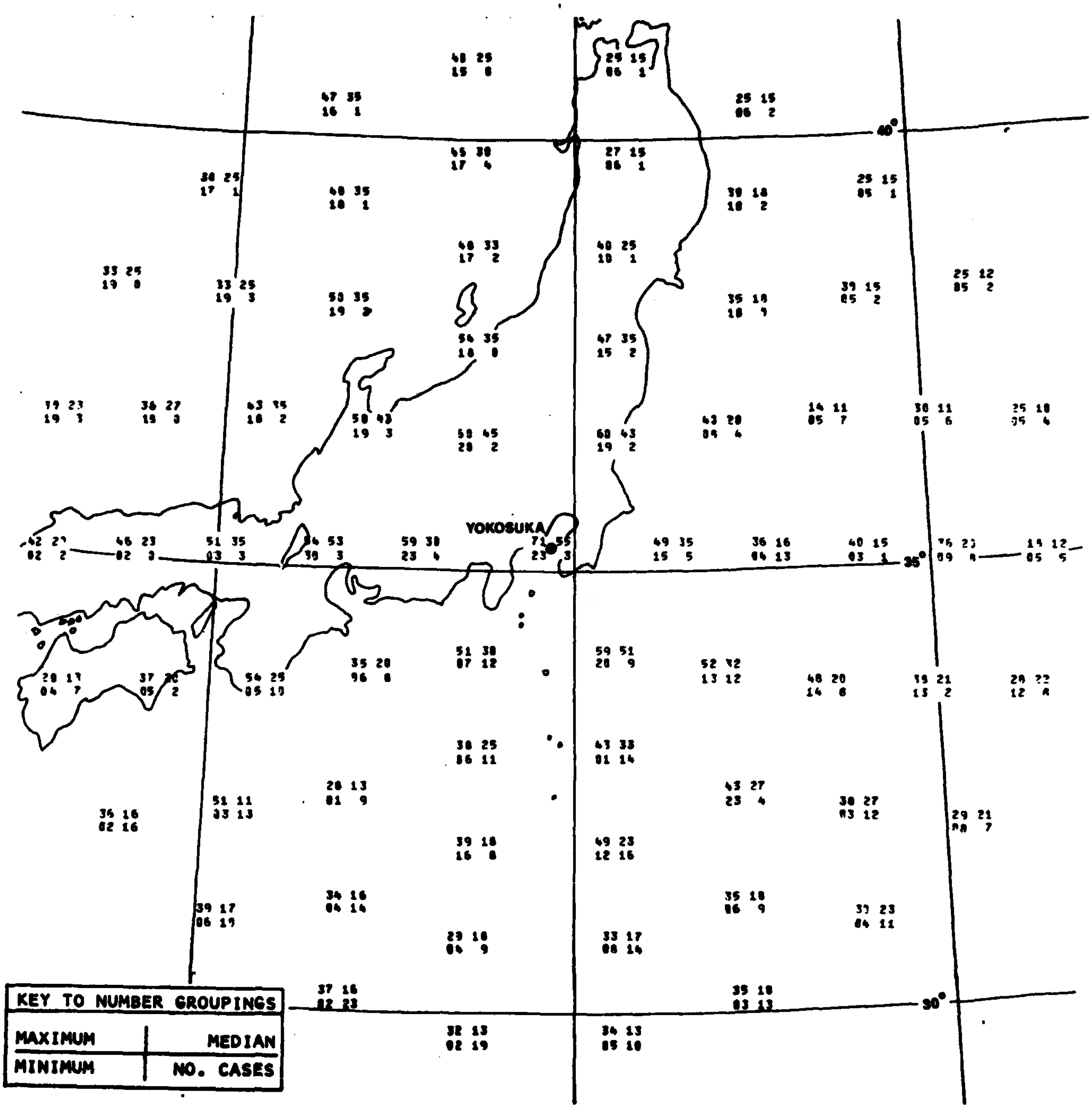


Figure 5. Depiction of the maximum, median, and minimum percentage of center winds from Yokosuka, JA when a typhoon was located in the grid spaces.

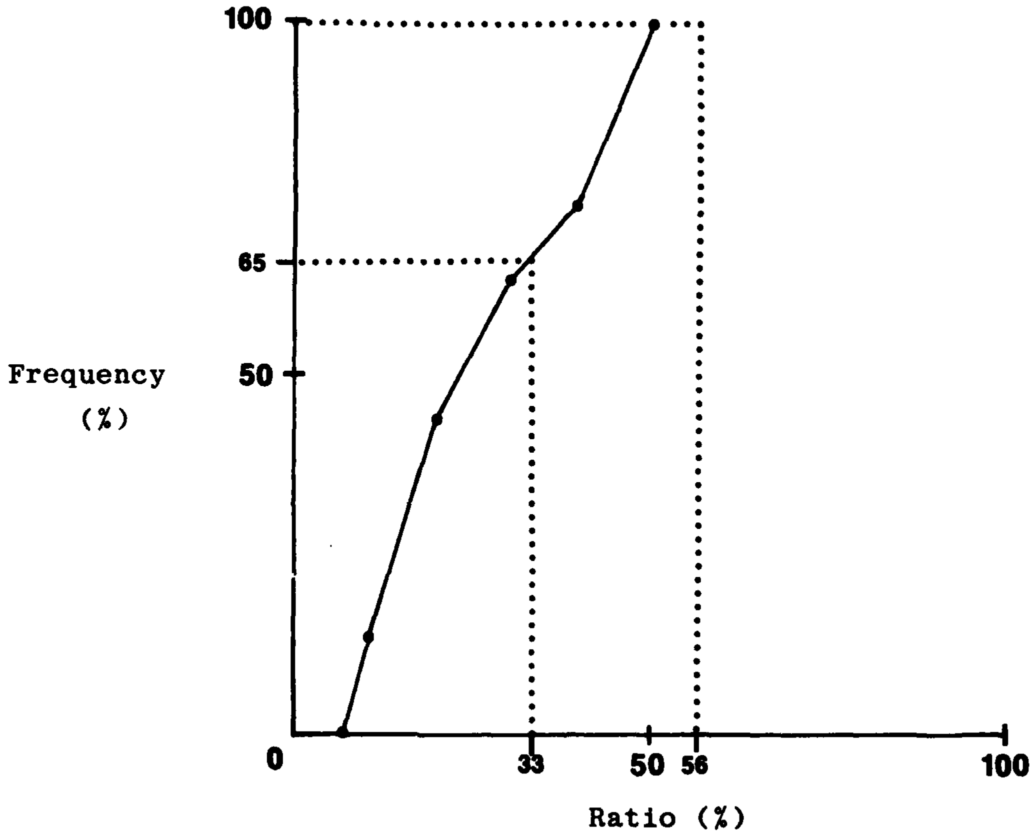


Figure 6. Cumulative frequency distribution of the ratio of winds observed at Cubi Point to typhoon center wind for typhoons located on grid space 1 (see Figures 1 and 3). The dotted lines refer to an example cited in the text.

analysis value of 90 kt represents a potential maximum wind usually determined by minimum sea level pressure. Actual sustained winds occurring, while usually not measured, may well be substantially above or below that potential depending on terrain influence. Notice from Figure 3 that 16 typhoons (winds over 63 kt) have passed through the central grid space yet sustained typhoon force winds have never been observed at Cubi Point.

The terrain wind probability program allows for the typhoon being in any grid space and having center winds of any value from 20 to 150 kts. The product of the conditional wind probability times the probability of the conditions being met is referred to as a marginal wind probability. The actual wind probabiltiy is the sum of these marginal wind probabilities over all grid spaces and all maximum central wind speeds for a particular forecast time.

This process of computing and summing marginal probabilities is much slower than the equivalent overwater computation. Consequently it is cheaper to first compute the overwater probability and then compute the terrain probability only if the overwater probability is significant (over 1%). This procedure was adopted on the WINDP modification. Figure 7 illustrates the wind probability output message for Typhoon Nancy (Oct 82) before and after the terrain modification.

3. Testing

The terrain modification was entered and tests were conducted on 1980-1981 tropical cyclones which passed within 300 n mi of Cubi Point or Yokosuka. It should be

Strike and Wind Probability Message Before Modification

STRIKE AND WIND PROBABILITY FORECASTS
NANCY 080600Z

KADENA AB	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
30 KNOT	000202	12IN02	24IN02	36IN02	48IN02	60IN02	72IN02
YOKOSUKA	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12IN02	24IN02	36IN02	48IN02	60IN02	72IN02
30 KNOT	001717	121066	24IN68	36IN68	48IN68	60IN68	72IN68
YOKOTA AB	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12IN01	24IN01	36IN01	48IN01	60IN01	72IN01
30 KNOT	001313	120654	24IN55	36IN55	48IN55	60IN55	72IN55
CHEJU-DO	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
30 KNOT	000101	12IN01	24IN01	36IN01	48IN01	60IN01	72IN01
MISAWA JA	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
30 KNOT	00ININ	12IN02	24IN02	36IN02	48IN02	60IN02	72IN02

Strike and Wind Probability Message After Modification

STRIKE AND WIND PROBABILITY FORECASTS
NANCY 080600Z

KADENA AB	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
30 KNOT	000202	12IN02	24IN02	36IN02	48IN02	60IN02	72IN02
*YOKOSUKA	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12IN01	24IN01	36IN01	48IN01	60IN01	72IN01
30 KNOT	000202	120235	24IN35	36IN35	48IN35	60IN35	72IN35
YOKOTA AB	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12IN01	24IN01	36IN01	48IN01	60IN01	72IN01
30 KNOT	001313	120654	24IN55	36IN55	48IN55	60IN55	72IN55
CHEJU-DO	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
30 KNOT	000101	12IN01	24IN01	36IN01	48IN01	60IN01	72IN01
MISAWA JA	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
50 KNOT	00ININ	12ININ	24ININ	36ININ	48ININ	60ININ	72ININ
30 KNOT	00ININ	12IN02	24IN02	36IN02	48IN02	60IN02	72IN02

*THESE WIND PROBABILITIES ALLOW FOR TERRAIN

Figure 7. Depiction of a western Pacific wind probability message for Typhoon Nancy, October 1982 before and after the terrain modification. Notice that only the wind probabilities for Yokosuka are changed. Had Subic Bay been significantly threatened, those wind probabilities would also have been terrain modified.

noted that no forecasts from these cyclones were used at any point in the development process so they represent independent test data. There were 13 storms passing Cubi Point and 5 passing Yokosuka.

Table 1 compares the average 24-hour wind probabilities before and after the terrain adjustment. The reduction is quite dramatic and reflects the effective wind protection afforded both bases by hilly terrain. The average overwater probabilities may appear surprisingly high to some readers. This is true because those with near zero (<1%) 30 kt probabilities are excluded since they were not modified. A second factor is the preselection of tropical cyclones which came within 300 n mi of the two bases thus biasing the data sample. This bias occurs because we already know the cyclones came within 300 n mi of one of the bases. The real probability of that base receiving 30-kt winds is much higher than it would be if it were simply forecast to pass within 300 n mi, which is the probability we calculate. The bias is less in short range forecasts because the fact of the cyclone being within the 300 n mi circle is nearly as well known in the short range forecasts as in the observation. Because of this bias we expect to see observations of 30- and 50-kt winds exceed what would normally be expected by chance. This should be reflected similarly in verification of the overwater as well as the terrain modified probabilities.

Table 2 compares the observed to the expected occurrences by both the overwater and terrain adjusted models for both sites. In the Cubi Point data, the actual occurrences of 30 and 50 kt winds compares markedly better in every case to expectation based on the terrain adjusted probabilities than to that based on the unmodified probabilities.

	CUBI POINT				YOKOSUKA			
	30 KT		50 KT		30 KT		50 KT	
	INST	T.INT	INST	T.INT	INST	T.INT	INST	T.INT
Before	.180	.342	.032	.097	.068	.201	.010	.056
After	.014	.077	.000	.003	.015	.086	.000	.001
Cases	132				47			

Table 1. Average 24-hour wind probabilities by overwater assumption (before) and terrain modification (after). Cases where the unmodified 30 kt probability was less than 1% are excluded from the averages since these were not modified. INST and T.INT are instantaneous and time integrated probabilities.

In the Yokosuka data the comparison was unchanged or improved in 13 of the 16 comparisons. There is a hint in the 30 kt results that probabilities might be underestimated by the terrain adjusted model. In reality this result is consistent with the test sampling bias and does not reflect on the reliablility of the terrain adjusted probabilities. The same results not being evident at Cubi Point is viewed as a statistical aberration, albeit a rather minor departure from the norm.

		Cubi Point				Yokosuka			
		0hr	24h	48hr	72hr	0hr	24hr	48hr	72hr
30-kt Instantaneous	Overwater Expected	16	24	15	5	4	3	2	1
	Terrain Expected	1	2	1	0	1	1	1	0
	Observed	0	0	0	0	2	3	2	2
30-kt Time Integrated	Overwater Expected	16	45	53	45	4	9	7	4
	Terrain Expected	1	10	14	13	1	4	3	2
	Observed	0	3	11	16	2	5	4	3
50-kt Instantaneous	Overwater Expected	2	4	3	1	1	0	0	0
	Terrain Expected	0	0	0	0	0	0	0	0
	Observed	0	0	0	0	0	0	0	0
50-kt Time Integrated	Overwater Expected	2	13	19	18	1	3	2	2
	Terrain Expected	0	0	1	1	0	0	0	0
	Observed	0	0	0	0	0	0	0	0

Table 2. Expected occurrences of 30 and 50 kt winds based on a comparison of overwater and terrain adjusted observations versus actual observations.

4. Conclusion

Of the two models (the WINDP model that assumes winds are over water, and the WINDP model that considers the site terrain), the terrain adjusted model consistently forecast lower, more realistic probabilities for the terrain protected locations. Both the Cubi Point and the Yokosuka data sets confirm that the terrain adjusted wind probabilities are a suitable measure of the threat of 30- and 50-kt winds at these bases. It is recommended, based on the results of this study, that terrain influence studies be completed for all locations where wind probabilities are calculated and where terrain influences are evident. For those sites where terrain influences have been documented, it is recommended that the WINDP be modified based on those studies.

5. References

1. Atkinson, G.D., and H.B. Penland, 1967: Typhoon Weather Models, Kadena AB, Okinawa, 20th Weather Squadron, Scientific Services Technical Study 12.

2. Pettett, J.E., 1980: Prediction of Typhoon-Induced Peak Winds at Four Pacific Stations. Air Weather Service TN-80-001.

3. Englebretson, R., and J.D. Jarrell, 1982: Forecast Aid for Predicting Tropical Cyclone Associated Gusts and Sustained Winds for Cubi Point, RP, NEPRF Contractor Report CR 82-10.

4. Englebretson, R., and J.D. Jarrell, 1982: Forecast Aid for Predicting Tropical Cyclone Associated Gusts and Sustained Winds for Yokosuka, JA, NEPRF Contractor Report CR 82-11.

DISTRIBUTION

COMMANDER IN CHIEF
U.S. PACIFIC FLEET
PEARL HARBOR, HI 96860

COMTHIRDFLT
PEARL HARBOR, HI 96860

COMSEVENTHFLT
FLEET METEOROLOGIST, N30W
FPO SAN FRANCISCO 96601

COMTHIRDFLT
NSAP SCIENCE ADVISOR
CODE N702/01T
PEARL HARBOR, HI 96860

COMSEVENTHFLT
NSAP SCIENCE ADVISOR
BOX 167
FPO SEATTLE 98762

COMMANDER
U.S. NAVAL FORCES, JAPAN
FPO SEATTLE 98762

COMMANDER
U.S. NAVAL FORCES,
PHILIPPINES, BOX 30/N3
FPO SAN FRANCISCO 96651

COMMANDER
AMPHIBIOUS GROUP 1
METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96601

COMMANDING OFFICER
USS CONSTELLATION (CV-64)
MET. OFFICER, OA DIV
FPO SAN FRANCISCO 96635

COMMANDING OFFICER
USS CORAL SEA (CV-43)
MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96632

COMMANDING OFFICER
USS ENTERPRISE (CVN-65)
MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96636

COMMANDING OFFICER
USS MIDWAY (CV-41)
MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96631

COMMANDING OFFICER
USS RANGER (CV-61)
MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96633

COMMANDING OFFICER
USS BLUE RIDGE (LCC-19)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96628

COMMANDING OFFICER
USS NEW ORLEANS (LPH-11)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96627

COMMANDING OFFICER
USS OKINAWA (LPH-3)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96625

COMMANDING OFFICER
USS TRIPOLI (LPH-10)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96626

COMMANDING OFFICER
USS TARAWA (LHA-1)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96622

COMMANDING OFFICER
USS BELLEAU WOOD (LHA-3)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96623

COMMANDING OFFICER
USS PELELIU (LHA-5)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96624

COMMANDING OFFICER
USS LASALLE (AGF-3)
ATTN: MET. OFFICER
FPO NEW YORK 09577

CINCPAC
STAFF CINCPAC J37
BOX 13
CAMP SMITH, HI 96861

SPECIAL ASSISTANT TO THE
ASST. SECNAV (R&D)
RM. 4E741, THE PENTAGON
WASHINGTON, DC 20350

CHIEF OF NAVAL OPERATIONS
(OP-952)
U.S. NAVAL OBSERVATORY
WASHINGTON, DC 20390

CHIEF OF NAVAL OPERATIONS
NAVY DEPT. OP-986G
WASHINGTON, DC 20350

CHIEF, ENV. SVCS. DIV.
OJCS (J-33)
RM. 2877K, THE PENTAGON
WASHINGTON, DC 20301

DET. 2, HQ, AWS
THE PENTAGON
WASHINGTON, DC 20330

NAVAL DEPUTY TO THE
ADMINISTRATOR, NOAA
RM. 200, PAGE BLDG. #1
3300 WHITEHAVEN ST. NW
WASHINGTON, DC 20235

OFFICER IN CHARGE
NAVOCEANCOMDET
U.S. NAVAL AIR FACILITY
FPO SEATTLE 98767

OFFICER IN CHARGE
U.S. NAVOCEANCOMDET
APO SAN FRANCISCO 96519

OFFICER IN CHARGE
U.S. NAVOCEANCOMDET
FLEET ACTIVITIES
FPO SEATTLE 98770

COMMANDING OFFICER
USS KITTY HAWK (CV-63)
MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96634

COMMANDING OFFICER
NORDA, CODE 101
NSTL STATION
BAY ST. LOUIS, MS 39529

COMNAVOCEANCOM
NSTL STATION
BAY ST. LOUIS, MS 39529

COMNAVOCEANCOM
ATTN: J. OWNBEY (N542)
NSTL STATION
BAY ST. LOUIS, MS 39529

COMMANDING OFFICER
NAVOCEANO LIBRARY
NSTL STATION
BAY ST. LOUIS, MS 39522

COMMANDING OFFICER
FLENUMOCEANCEN
MONTEREY, CA 93940

COMMANDING OFFICER
NAVWESTOCEANCEN
BOX 113
PEARL HARBOR, HI 96860

COMMANDING OFFICER
U.S. NAVOCEANCOMCEN
BOX 12, COMNAVMARIANAS
FPO SAN FRANCISCO 96630

COMMANDING OFFICER
U.S. NAVOCEANCOMFAC
FPO SEATTLE 98762

COMMANDING OFFICER
U.S. NAVOCEANCOMFAC
BOX 63, NAS (CUBI PT)
FPO SAN FRANCISCO 96654

PRESIDENT
NAVAL WAR COLLEGE
ATTN: GEOPHYSICS OFFICER
NEWPORT, RI 02840

COMMANDING OFFICER
USS POINT LOMA (AGDS-2)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96677

COMMANDER
NAVAIRSYSCOM, AIR 33
WASHINGTON, DC 20361

COMMANDER
NAVAIRSYSCOM
MET. SYS. DIV., AIR 553
WASHINGTON, DC 20360

NAVPGSCOL
MET. DEPT., CODE 63
MONTEREY, CA 93940

COMMANDER
AWS/DN
SCOTT AFB, IL 62225

USAFETAC/TS
SCOTT AFB, IL 62225

3350TH TECH. TRNG GROUP
TTGU/2/STOP 623
CHANUTE AFB, IL 61868

AFGL/LY
HANSCOM AFB, MA 01731

5WW/DN
LANGLEY AFB, VA 23665

OFFICER IN CHARGE
SERVICE SCHOOL COMMAND
DET. CHANUTE/STOP 62
CHANUTE AFB, IL 61868

HQ 1ST WEATHER WING/DN
HICKAM AFB, HI 96853

DET 5 1WW/CC
APO SAN FRANCISCO 96274

DET 17, 1WW/CC
APO SAN FRANCISCO 96328

DIRECTOR (12)
DEFENSE TECHNICAL INFO.
CENTER, CAMERON STATION
ALEXANDRIA, VA 22314

OFFICER IN CHARGE
NAVOCEANCOMDET
MONTEREY, CA 93940

DIRECTOR, OFFICE OF ENV.
& LIFE SCIENCES
RM. 3D129, THE PENTAGON
WASHINGTON, DC 20505

FEDERAL COORDINATOR FOR
MET. SERVICES &
SUPPORT. RSCH. (OFCM)
11426 ROCKVILLE PIKE
SUITE 300
ROCKVILLE, MD 20852

DIRECTOR, NATIONAL
HURRICANE CENTER, NOAA
GABLES ONE TOWER
1320 S. DIXIE HWY.
CORAL GABLES, FL 33146

DIRECTOR
INTERNATIONAL AFFAIRS
OFFICE, NOAA (OAX4)
6010 EXECUTIVE BLVD.
ROCKVILLE, MD 20852

DIRECTOR
NATIONAL HURRICANE
RESEARCH. LAB. (AOML)
1320 S. DIXIE HWY.
CORAL GABLES, FL 33146

NATIONAL WEATHER SERVICE
DR. E. FRIDAY, DEP. DIR.
GRAMAX BLDG.
8060 13TH ST.
SILVER SPRING, MD 20910

HEAD, ATMOS. SCI. DIV.
NATIONAL SCI. FOUNDATION
1800 G. STREET, NW
WASHINGTON, DC 20550

DIRECTOR, FEDERAL
EMERGENCY MANAGEMENT
AGENCY (FEMA)
WASHINGTON, DC 20472

THE EXECUTIVE DIRECTOR
AMERICAN MET. SOCIETY
45 BEACON ST.
BOSTON, MA 02108

COMMANDER (2)
NAVAIRSYSCOM
ATTN: LIBRARY, AIR-00D4
WASHINGTON, DC 20361

AMERICAN MET. SOCIETY
METEORO. & GEOASTRO
ABSTRACTS
P.O. BOX 1736
WASHINGTON, DC 20013

DIRECTOR, JTWC
BOX 17
FPO SAN FRANCISCO 96630

WORLD METEOROLOGICAL
ORGANIZATION, ATS DIV.
ATTN: N. SUZUKI
CH-1211, GENEVA 20
SWITZERLAND

DIRECTOR
ROYAL OBSERVATORY
NATHAN ROAD, KOWLOON
HONG KONG, B.C.C.

LIBRARY
METEORO. RSCH. INSTITUTE
1-1, NAGAMINE,
YATABE-MACHI, TSUKUBA-GUN
IBARAKI-KEN 305 JAPAN

TYPHOON RESEARCH LAB.
ATTN: LIBRARIAN
MET. RSCH. INSTITUTE
1-1 NAGAMINE,
YATABE-MACHI, TSUKUBA-GUN
IBARAKI-KEN, 305, JAPAN

JAPAN METEORO. AGENCY
3-4 OTEMACHI 1-CHOME,
CHIYODA-KU
TOKYO 100, JAPAN

UNIV. OF THE PHILIPPINES
METEOROLOGY DEPT.
COLLEGE OF ARTS & SCI.
DILMAN, QUEZON CITY 3004
PHILIPPINES

TECHNICAL LIBRARY
WEATHER BUREAU
NATIONAL DEFENSE DEPT.
LUNGSOD NG QUEZON
QUEZON, PHILIPPINES

NATIONAL WEATHER SERVICE
(PAGASA)
1424 QUEZON AVE.
QUEZON CITY, PHILIPPINES

DIRECTOR
TYPHOON RSCH & DEVEL.
OFFICE (PAGASA)
MINISTRY OF DEFENSE
1424 QUEZON AVE.
QUEZON CITY, PHILIPPINES

COORDINATOR, ESCAP/WMO
TYPHOON COMMITTEE
SECRETARIAT, C/O UNDP
MANILA, PHILIPPINES

CHIEF ATMOS. SCI. DIV.
WORLD MET. ORGANIZATION
P.O. BOX 5
GENEVA 20, SWITZERLAND