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A TROPICAL CYCLONE DATA TAPE FOR THE EASTERN AND CENTRAL NORTH PACIFIC BASINS, 1949-1983: CONTENTS, LIMITATIONS, AND USES

Mary A. S. Davis, Gai M. Brown, and Preston W. Leftwich, Jr.
NHC, Miami, Florida

National Hurricane Center
Miami, Florida
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CONTENTS

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Mary A. S. Davis, Gail M. Brown, and Preston W. Leftwich, Jr.
NOAA, NWS, National Hurricane Center
Coral Gables, Florida 33146

ABSTRACT. A collection of data concerning tropical cyclones in the Eastern and Central North Pacific Oceans has been compiled at the National Hurricane Center. This data set consists of dates, tracks, and maximum sustained wind speeds of tropical cyclones occurring from 1949 to 1983. Surface pressures, when available, are also included. Sources, characteristics, and format of these data are discussed.

1. INTRODUCTION

The Research and Development Unit at the National Hurricane Center (NHC), Coral Gables, Florida archives the Eastern and Central North Pacific tropical cyclones onto magnetic tape for computer processing. For the 35-year period, 1949 through 1983, 432 tropical cyclones are documented. Tracks of these storms are shown in Figure 1. The Eastern North Pacific (ENP) extends from the coasts of the United States, Mexico, and Central America westward to 140° west longitude and from approximately 5° to 35° north latitude. The Central North Pacific (CNP) is an extension of this area to 180° west longitude. This report describes the content, limitations, and uses of the data.

This report is an update of an earlier NOAA Technical Memorandum, NWS NHC 16, written by Gail M. Brown and Preston W. Leftwich, Jr. in August 1982. Many changes have been made to the data. The data format has been completely revised to resemble that for the Atlantic Tropical Cyclone Basin (Jarvinen, Neumann, and Davis, 1984).

2. DATA SOURCES

An earlier study by Crutcher and Quayle (1974) indicated the lack of long-term records of tropical cyclones in the North Pacific Ocean east of 180°W. The period of then available data (1949-1971) was by far the shortest period of record for any of the six recognized tropical cyclone basins around the world. Before the advent of meteorological satellites, which came into daily opertaional use in 1965, data on ENP and CNP tropical cyclones were limited to chance encounters of ships at sea, rare passages of storms over land stations, and infre-

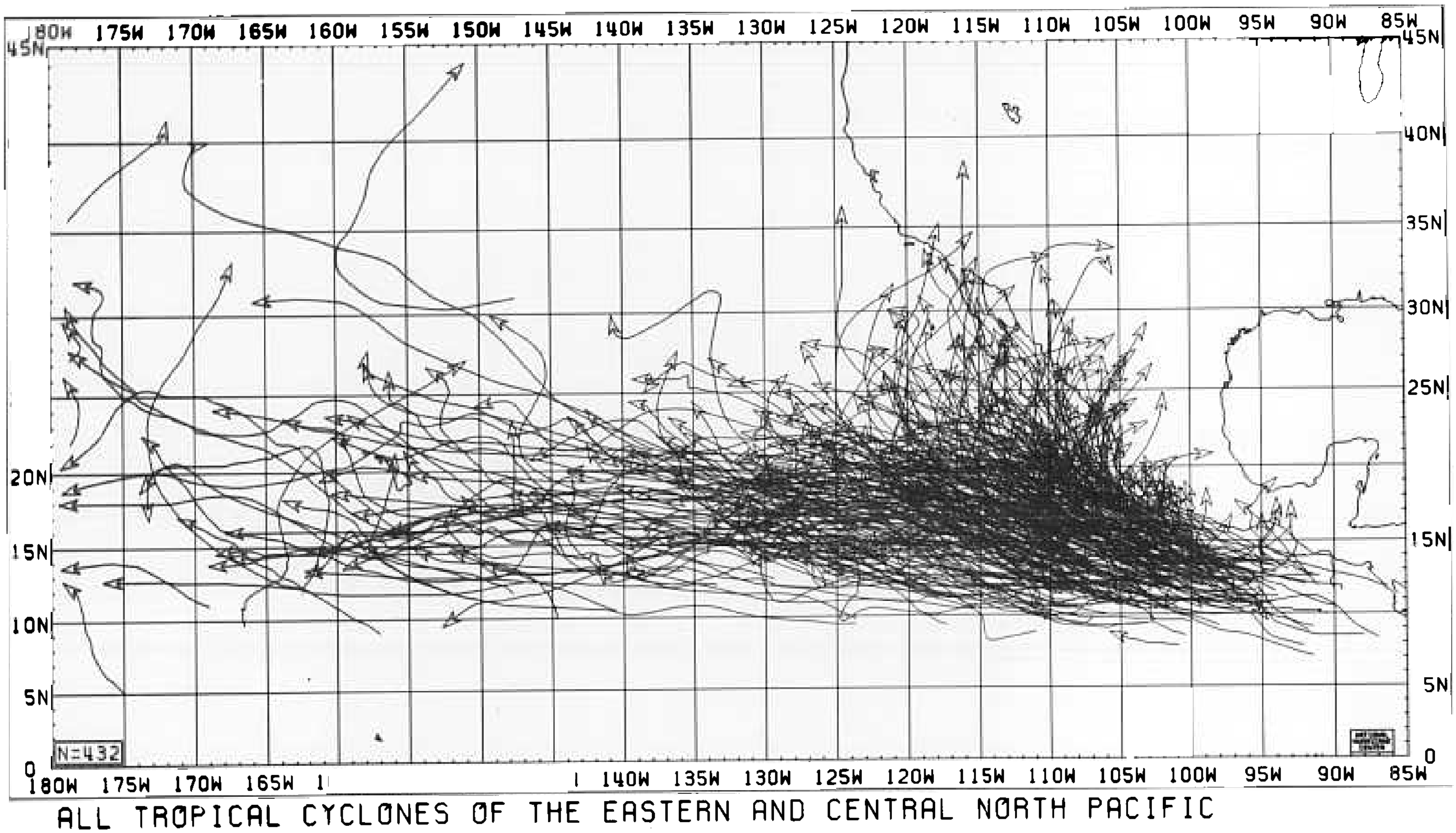


Figure 1. Composite computer plot of all 432 tropical cyclones included in the data set.

quent aerial reconnaissence. The greatest number of reports was recieved from ships at sea. Generally, these ships were travelling in the periphery of a storm's circulation, so the distance to the storm center was unknown. As warnings became better, even fewer ships encountered storms. Aerial reconnaissance was confined to periods when a storm was threatening land. Undoubtedly, some storms were never detected.

The first location by satellite of a storm in the ENP was made by TIROS III on July 19, 1961 (Mull, 1962). Subsequent operational coverage supplemented wind data and greatly increased the capability for detection and tracking of storms. The importance of satellites for detecting tropical cyclones in the ENP and CNP is supported by the increase in the mean number of observed tropical cyclones per year from 8.6 for 1949-64 to 14.8 for 1965-83.

The original impetus for compilation of these storm tracks were the implementation of several techniques for statistical prediction of tropical cyclone motion in the Eastern North Pacific Ocean. Among these are EPCLPR and EPANLG (Neumann and Leftwich, 1977) and EPHC77 (Leftwich and Neumann, 1977). Development of the models required tracks of past cyclones as a statistical base for the prediction equations. Under sponsorship of the United States Navy in 1971, the National Climatic Center revised and reissued its data as Tropical Cyclone Data Card Deck 993. These and additional storm tracks for the period 1949-75 were acquired from the U.S. Navy located in Monterey, California. Initially, storm positions were given at 12-hour intervals. Interpolations of these positions to 6-hour intervals were made by use of a scheme devised by Akima (1970), with some subjective modifications. Since 1976, storm positions, at 6-hourly intervals, have been obtained directly from the Eastren Pacific Hurricane Center (EPHC) located in Redwood City, California.

Criteria for constructing the tracks were based on the concept of the "best-track". Through a process of careful post-analysis of all available sources of information, including aircraft reconnaissance fixes, ship reports, advisories issued by EPHC, satellite data, and original operational tracks, these storm positions were subjectively smoothed. Resultant 6-hourly positions provided a reasonable rendition of actual continuous storm tracks.

Smoothing is performed for two reasons. First, small-scale oscillatory (trochoidal) motions of a storm's center are transitory in nature and not representative of the more conservative motion of the entire storm system. Recent evidence of such motion based on satellite imagery of Hurricane Belle (1976), in the Atlantic Ocean, is documented by Lawrence and Mayfield (1977). Actual errors in positioning tropical cyclones are a second consideration (Neumann, 1975; Sheets and Grieman, 1975). All data sources are subject to this problem whether it results from poor positioning of a satellite picture grid or navigational errors experienced by ships and aircraft.

In all cases, therefore, 6-hourly positions represent large-scale motion, rather than precise locations of the eye.

Where possible, tracks have been extended to include land positions once a storm crossed a coastline. Rapid dissipation along the mountainous west caost of the North American continent usually occurs, making storms difficult to track. Therefore extrapolations of earlier storm motions were performed with the aid of synoptic weather maps and satellite pictures.

In 1980, a thorough review of the storm tracks was made by Arnold Court under contract (NA-79WD-C-00006) from the National Weather Service. His work concentrated on extensions of tracks inland and resulted in additions and/or modifications to 81 storm tracks in the original data set. A final review, including checks for consistency as well as errors, was made once the data had been placed in a computer card deck.

3. CENTRAL NORTH PACIFIC STORMS

The majority of information concerning storms in the CNP was extracted from Shaw (1981). Although Shaw gathered information concerning storms as far back as 1832, only those beginning in 1949 or later are included in this data set. Systems which failed to attain at least tropical storm strength east of 180° west longitude were excluded. Those that attained at least minimum tropical storm strength and continued west of 180° were included through their dissipation stages. Additional information was obtained from a few editions of the Annual Typhoon Report of the Joint Typhoon Warning Center (JTWC) in Guam. Several CNP storms for which only one position was available were excluded because data for at least 12 hours are required in the development of statistical prediction models.

4. DATA FORMATS

All storms are listed in chronological order according to their first recorded day. Names are in alphabetical sequence except where CNP storms appear since they follow a separate naming system. The general format established for these data is also documented by Jarvinen, Neumann, and Davis (1984) for Atlantic Ocean tropical cyclone data. New data are added at the end of each tropical cyclone season.

The master card deck used to generate the original computer tape consists of three types of cards: title, data, and classification. For each storm there is one title card which contains all identifying information. First is the sequence number for easy cataloging of the data. The month, day (first recorded day of the storm), and year follow in that order. The next three numbers refer to the number of days the storm existed (M), the storm number for that year, and the cumulative storm number (SNBR), where the first storm in 1949 is 1 and the last storm in 1983 is 432. Next follows the storm name. Before the naming of tropical cyclones in the ENP in 1960, a "NOT NAMED" message fills this space. Note that all CNP storms are named, even those as early as 1950. The final integer value is a land crossing index (XING). This is either zero (0), indicating that the storm did not affect land, or one (1), indicating that it did. A storm is defined to have affected land if it came within approximately 50 nautical miles or crossed the coastline of the United States, Mexico, Central America, or the Hawaiian Islands.

The title card is followed by one or more data cards, one for each day of the storm's existence. Each contains four sets of values corresponding to the times 0000, 0600, 1200, and 1800 GMT. Included in each set are the storm position (latitude and longitude, degrees of longitude west of 180° are added to 180°, e.g., 160°E = 200° W, both to the nearest tenth of a degree), maximum sustained wind speed, and the central pressure.

The classification card indicates the maximum intensity of the storm. This index is either TS (tropical storm) or HR (hurricane).

Tables 1 through 3 indicate the exact location of each parameter on the three types of cards. Computer cards for Liza, 1976, and an unnamed storm, 1951, are illustrated in Figure 2. Cards such as these were transferred to tape in card image, 80-byte records. A short FORTRAN program which may be used to access data from the magnetic tape is given in Appendix II.

Table 1. Title Card - Format and Contents

Computer Card Columns	Contents
1 - 5	Card sequence number
7 - 8	Month
10 - 11	Day (first recorded day of the storm)
13 - 16	Year
20 - 21	Value of M (M = number of days storm existed)
23 - 24	Storm number for that year
31 - 34	Cumulative storm number (1 begins 1949)
36 - 46	Storm name
52	Land crossing index

Table 2. Storm Data Card - Format and Contents

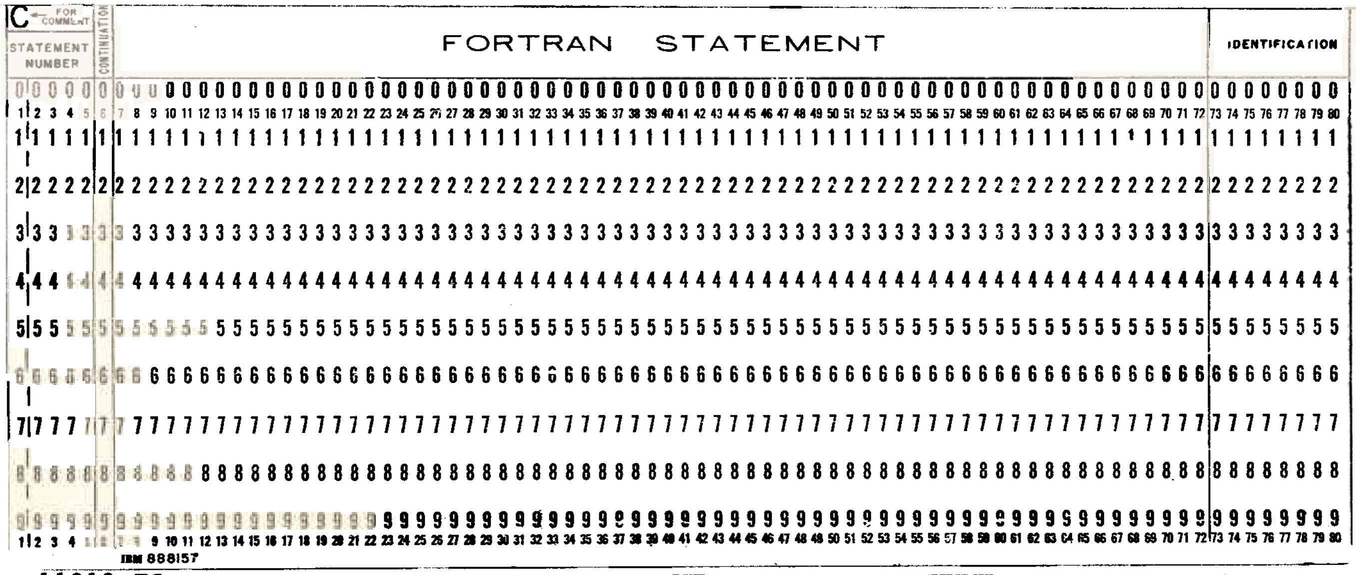
Computer Card Columns	Contents
1 - 5	Card sequence number
7 - 8	Month
10 - 11	Day
13 - 15	Latitude at 0000Z
16 - 19	Longitude at 0000Z
21 - 23	Wind speed at 0000Z
25 - 28	Central pressure at 0000Z
30 - 32	Latitude at 0600Z
33 - 36	Longitude at 0600Z
38 - 40	Wind speed at 0600z
42 - 45	Central pressure at 0600Z
47 - 49	Latitude at 1200Z
50 - 53	Longitude at 1200Z
55 - 57	Wind speed at 1200Z
59 - 62	Central pressure at 1200Z
64 - 66	Latitude at 1800Z
67 - 70	Longitude at 1800Z
72 - 74	Wind speed at 1800Z
76 - 79	Central pressure at 1800Z

Table 3. Classification Card - Format and Contents

Computer Card Columns	Contents
1 - 5	Card sequence number
7 - 8	Maximum strength of storm

```
34090 HR
34084 10/02X2881086 035     *                *                *                *
34082 10/01*2381092 120     *2501094 115     *2631094 110     X2751092 070     *
34080 09/30*1981083 120     *2041085 120     *2141087 120 0946*2261089 120 0971*
34070 09/29*1851079 100     *1881079 105     *1901080 110     *1931081 120 0971*
34060 09/28*1631086 065     *1691085 080     *1751083 085     *1801081 090     *
34050 09/27*1481089 040     *1521088 045     *1561087 045     *1591087 055     *
34040 09/26*1311080 025     *1361087 030     *14101090 030    *1441090 035     *
34030 09/25*                *                *                *1301070 025     *
34020 09/25/1976 M= 8 13 SNBR= 316 LIZA       XING=1

00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```




```
11310 TS
11300 09/15*2171094         *2171102 [redacted]   *2191109 [redacted]   *                *
11290 09/14*2181078         *2191081         *2191084         *2181088         *
11280 09/13*2091067         *2121069         *2141072         *2161075         *
11270 09/12*1861057         *1921057         *1981058         *2041062         *
11260 09/11*                *                *1711056         *1791056         *
11250 09/11/1951 M= 5  7 SNBR=  20 NOT NAMED  XING=0

00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

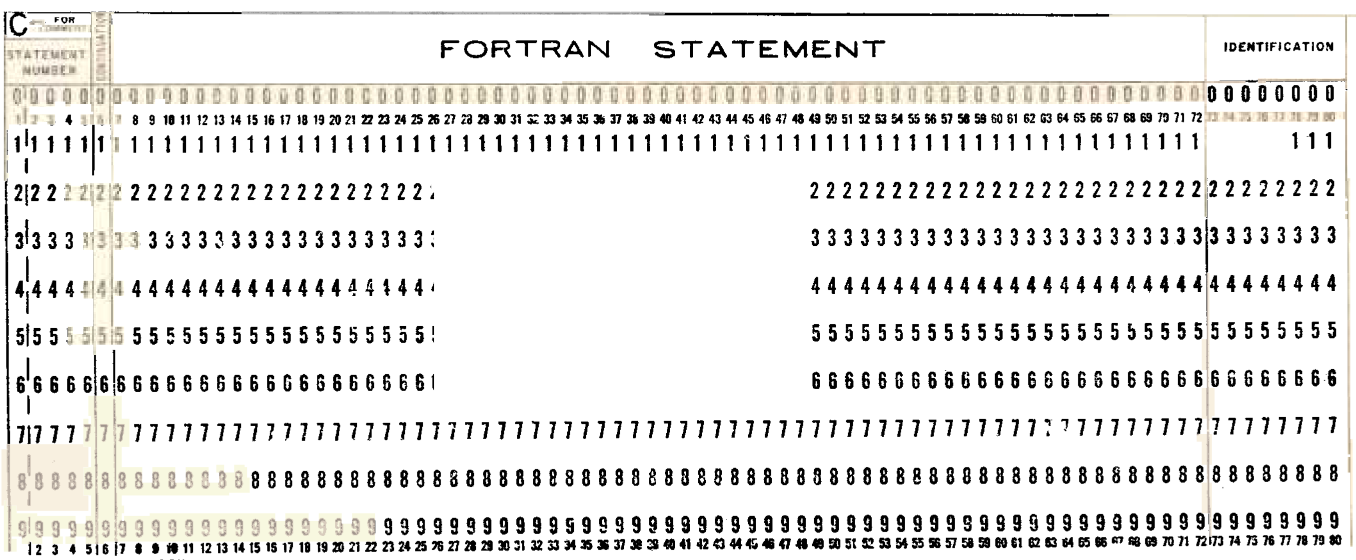


Figure 2. Computer cards for a) Hurricane Liza and b) unnamed storm, 1951.

5. WIND SPEED

Wind speeds were assigned to corresponding storm positions. Wind values throughout this data set are subjective estimates of the maximum surface wind which ordinarily occurs at the eye wall. These values are specified in knots, rounded to the nearest 5-knot value. For example, 67 knots became 65 knots, while 68 knots became 70 knots. By definition, these winds represent 1-minute averages rather than peak gusts; however, because of the subjective nature of estimates based on fragmented information available to forecasters, this definition implies a precision which never exists. Discussions concerning relationships of gusts to average winds in tropical cyclones may be found in papers by Dunn and Miller (1964), pp. 61-67; Padya (1975); and Atkinson and Holliday (1977).

For many years ship observations were the primary source of wind data over the ocean. Mariners favor state-of-the-sea determination via the Beaufort scale (U.S. Navy Oceanographic Office, 1966) because it is a one-step method. However, over the past 30 years some ships have been equipped with anemometers. A study by Shinners (1963) found that anemometer versus state-of-the-sea measured winds were (1) lower up to about 20 knots, (2) approximately the same from 20 to 30 knots, and (3) greater above 30 knots. In essence, state-of-the-sea measured winds are underestimates of the actual wind at higher speeds.

The first wind data from aircraft reconnaissance in the ENP were obtained in 1956. Although aircraft reconnaissance measures the flight-level winds anywhere from 500 to 10,000 feet, the surface winds are subjective estimates based upon observation of the sea state and/or tables relating flight-level winds to surface winds.

Development of techniques to determine wind speed from the shape of the cloud field, as depicted in satellite pictures, by Dvorak (1973 and 1975), and Hebert and Poteat (1975), has tremendously increased credibility of wind estimates in recent years. Satellite imagery is now the major source of data in all tropical cyclone basins.

Classifications (TS or HR) of storms prior to 1954 are from National Climatic Center data files. The quantity of wind speed data greatly increased in 1965 with documentation of intensity at various stages of the tracks by Mariners Weather Log (MWL) and later by Monthly Weather Review (MWR). As a result, it was possible to distinguish depression stages of both formative and dissipative periods. A small quantity of wind speeds was found in the Climatological National Data Summary, but most were estimated from MWL and MWR or taken from official advisories issued by the EPHC. Because of the extremely subjective nature of wind speed estimates, the user is cautionsd not to make overly precise interpretations of these values.

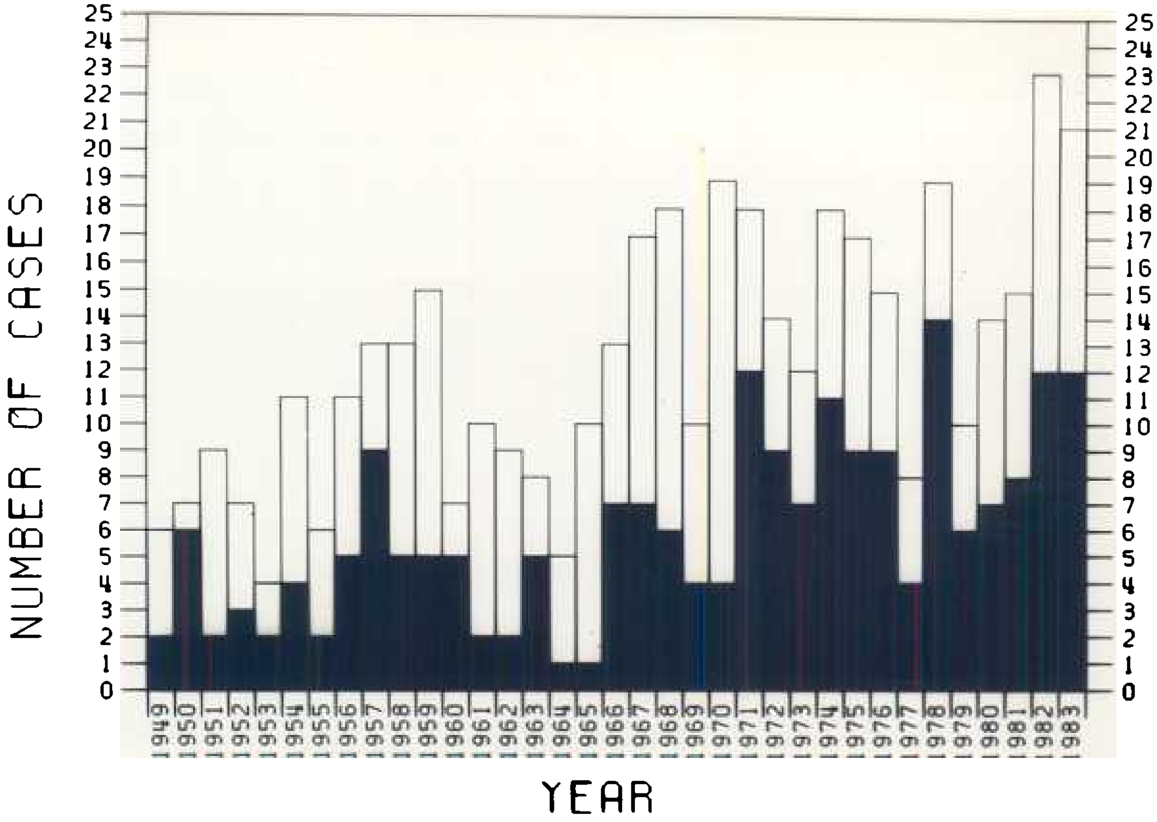


Figure 3. Annual frequency from 1949 to 1983 of 432 Eastern and Central North Pacific tropical cyclones that reached tropical storm strength (open bar) of which there were 209 that reached hurricane strength (closed bar).

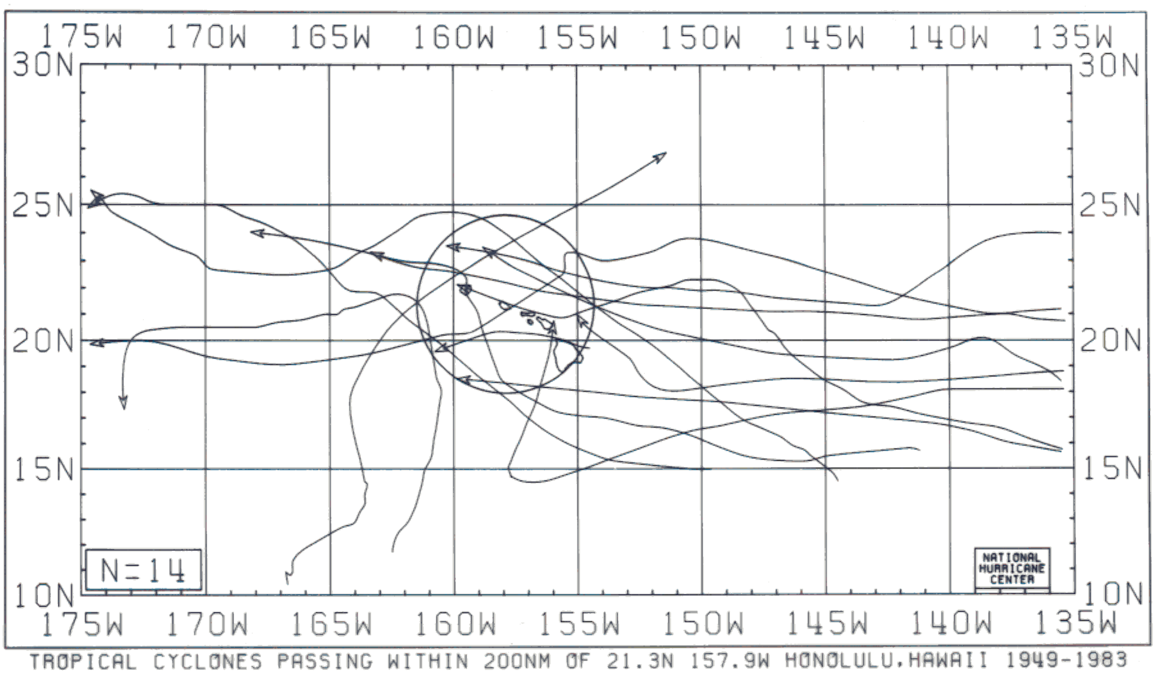


Figure 4. Plotted tracks of tropical cyclones listed in Table 4.

Table 4. Storms passing within 200 nmi of Honolulu, Hawaii, 1949-1983

Map Index	Starting Date	Storm Name	Closest Point of Approach (CPA)	Date at CPA	Dist at CPA (nmi)	Maximum Intensity	Intensity at CPA
1	8/12/1950	HIKI	23.0N 156.6W	8/16	125	X	H
2	9/01/1957	DELLA	19.0N 159.9W	9/03	161	X	T
3	11/29/1957	NINA	20.6N 161.0W	12/02	181	X	H
4	8/07/1958	NOT NAMED	20.3N 158.0W	8/08	58	T	D
5	8/02/1959	DOT	21.0N 159.0W	8/07	64	X	H
6	9/12/1963	IRAH	21.1N 157.8W	9/18	9	T	D
7	8/11/1972	DIANA	20.7N 154.8W	8/20	177	X	T
8	8/05/1976	GWEN	23.1N 157.5W	8/17	111	T	D
9	9/14/1981	JOVA	22.5N 157.0W	9/20	87	T	D
10	7/07/82	DANIEL	20.4N 156.0W	7/22	120	D	D
11	7/26/82	GILMA	18.4N 158.4W	8/01	176	D	D
12	11/19/83	IWA	23.3N 158.4W	11/24	118	H	H
13	7/23/83	GIL	22.2N 157.9W	8/03	53	T	T
14	10/08/83	RAYMOND	21.3N 157.5W	10/23	8	D	D

Intensity Index for Table 4 is as follows:

D - Tropical Depression
H - Hurricane
T - Tropical Storm
X - Extratropical Cyclone

For further information see definitions in Appendix I.

8. SUMMARY

Development of statistically-based tropical cyclone prediction models requires historical data including dates, tracks, maximum sustained wind speeds, and central pressures. Such information for tropical cyclones in the Eastern and Central North Pacific Ocean during the period 1949-1983 has been compiled at the National Hurricane Center. Pre-1965 data are extremely limited; however, the advent of operational satellite coverage in 1965 greatly increased observational capabilities. Compiled data have been stored via electronic computer. Data from succeeding tropical cyclone seasons will be added to the current data set.

ACKNOWLEDGMENTS

The author wishes to acknowledge that this is an update to the previous Technical Memorandum NWS NHC 16 "A Compilation of Eastern and Central North Pacific Tropical Cyclone Data" by Gail M. Brown and Preston W. Leftwich, Jr. They compiled all the original data onto the original computer file. However, recently many changes have been made to the file as indicated herein.

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APPENDIX I. TERMINOLOGY

EXTRATROPICAL CYCLONE: Tropical cyclone modified by interaction with nontropical environment. No wind speed criteria. May exceed hurricane force.

GMT: Greenwich Mean Time. Also called "Z" or Zulu time. Mean solar time of the meridian at Greenwich, England, used as the basis for standard time throughout the world.

HURRICANE: A tropical cyclone of which the center (eye) is the warmest area (warm-core) and in which the maximum sustained surface wind (1-minute mean) is $\geq$ 64 knots (119 km/h).

KNOT: A unit of speed equal to 1 nautical mile per hour. One nautical mile per hour is equivalent to 1.1508 statute mph or 0.5144 m/s.

MILLIBAR: A pressure unit of 1000 dyne/cm^2, convenient for reporting atmospheric pressures. The average sea-level surface pressure is 1013.2 mb.

TROPICAL CYCLONE: A nonfrontal low pressure system developing over tropical or subtropical waters and having a closed circulation of winds rotating counterclockwise in the Northern Hemisphere (clockwise in the Southern Hemisphere). This term encompasses tropical depressions, tropical storms, and hurricanes.

TROPICAL DEPRESSION: A tropical cyclone in which the maximum sustained surface wind is $\leq$ 33 knots (61 km/h).

TROPICAL STORM: A tropical cyclone in which the center is the warmest area (warm-core) and in which the maximum sustained surface wind ranges from 34 to 63 knots (63 to 117 km/h).

APPENDIX II. A SAMPLE FORTRAN PROGRAM TO READ AND WRITE THE DATA

```
      DIMENSION REC(20)
C  THIS PROGRAM ASSUMES THAT THE DATA TAPE IS MOUNTED ON UNIT 3 AND
C   THAT THE LINE PRINTER IS UNIT 6.
      REWIND 3
C  INITIALIZE RECORD COUNTER
      NRECS = 0
    5 CONTINUE
C  READ ONE RECORD AT A TIME
      READ(3,10,END=30) REC
C  'END=30' STOPS READING OF TAPE AT 'END OF FILE' (EOF)
   10 FORMAT(20A4)
C  COUNT RECORDS.
      NRECS = NRECS + 1
C  PRINT DATA IN EACH RECORD
      WRITE(6,15) REC
   15 FORMAT(10X,20A4)
      GO TO 5
   30 CONTINUE
      WRITE(6,35) NRECS
   35 FORMAT(35X, 19HNUMBER OF RECORDS =, I6)
      REWIND 3
      STOP
      END
```