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NASA Technical Memorandum 73282

(NASA-TM-73282) AN ATLAS OF 1976 GEOS-3
RADAR ALTIMETER DATA FOR TROPICAL CYCLONE
STUDIES (NASA) 202 P HC A10/MP A01 CSCL 04B

N79-25666

G3/47
Unclas
23422

An Atlas of 1976 GEOS-3 Radar Altimeter Data for Tropical Cyclone Studies

H. Ray Stanley, Barbara Chan, Cindy Givens, and Ronald Taylor

April 1979



NASA

National Aeronautics and
Space Administration

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AC 804 824-3411

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for Tropical Cyclone Studies

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TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1.0	INTRODUCTION	1.1-1
2.0	ATLANTIC AREA	2.1-1
	2.1 General	2.1-1
	2.2 Subtropical Storm No. 1	2.2-1
	2.3 Tropical Storm Anna (Subtropical Storm No. 2)	2.3-1
	2.4 Hurricane Belle	2.4-1
	2.5 Hurricane Candice	2.5-1
	2.6 Tropical Storm Dottie	2.6-1
	2.7 Hurricane Emmy	2.7-1
	2.8 Subtropical Storm No. 3	2.8-1
	2.9 Hurricane Frances	2.9-1
	2.10 Hurricane Gloria	2.10-1
	2.11 Hurricane Holly	2.11-1
3.0	EASTERN PACIFIC/U. S. WEST COAST AREAS	3.1-1
	3.1 General	3.1-1
	3.2 Tropical Cyclone One	3.2-1
	3.3 Hurricane Annette	3.3-1
	3.4 Hurricane Bonny	3.4-1
	3.5 Tropical Cyclone Four	3.5-1
	3.6 Hurricane Hyacinth	3.6-1
	3.7 Hurricane Iva	3.7-1
	3.8 Tropical Storm Joanne	3.8-1
	3.9 Hurricane Kathleen	3.9-1
	3.10 Hurricane Liza	3.10-1
	3.11 Hurricane Madeline	3.11-1
4.0	CENTRAL AND WESTERN PACIFIC AREAS	4.1-1
	4.1 General	4.1-1
	4.2 Typhoon Marie	4.2-1
	4.3 Typhoon Olga	4.3-1
	4.4 Super Typhoon Pamela	4.4-1
	4.5 Super Typhoon Louise	4.5-1
5.0	INDIAN OCEAN AREA	5.1-1
	5.1 General	5.1-1
	5.2 Tropical Cyclone 20-76	5.2-1
	REFERENCES	

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
2-1	Tracks of North Atlantic Subtropical Cyclones, 1976	2.1-2
2-2	Tracks of 1976 Tropical Cyclones	2.1-3
4-1	Pacific Area Tropical Storms	4.1-6
4-2	Pacific Area Tropical Storms	4.1-7
4-3	Pacific Area Typhoons	4.1-8
4-4	Pacific Area Typhoons	4.1-9
4-5	Pacific Area Typhoons	4.1-10
4-6	Typhoon Marie	4.2-4
4-7	Typhoon Olga	4.3-5
4-8	Typhoon Pamela	4.4-2
4-9	Typhoon Louise	4.5-5
5-1	North Indian Ocean Tropical Cyclones	5.1-3

FOREWORD

This document's primary purpose is to provide the means for locating and extracting GEOS-3 altimeter data acquired for the analysis of specific hurricanes, typhoons, and other tropical cyclones. This data may also be extremely useful in the analysis of the behavior of the altimeter instrument in the presence of severe meteorological disturbances as well as provide a data base which can be useful in the resolution of apparently anomalous geoid or sea surface characteristics.

1.0 INTRODUCTION

This document is the result of recent efforts to correlate all of the GEOS-3 satellite altimeter schedule information with all of the available 1976 tropical cyclone positional information. The time period covers from January 28, 1976, through January 2, 1977. The geographical region includes all ocean area north of the equator divided into the following operational areas: the Atlantic area (which includes the Caribbean and Gulf of Mexico); the eastern Pacific area; the central and western Pacific area; and the Indian Ocean area.

During the 1976 season, an effort was maintained to schedule the GEOS-3 altimeter consistent with available tropical cyclone location information. However, the effort was not nearly as intense as that employed during the 1975 season. The results of the 1976 efforts appear consistent with the conclusions reached after the 1975 effort - that, with the large number of uncontrolled variables associated with the GEOS-3 altimeter operations, the success ratio is mainly due to chance.

The approach taken in producing this document consists of the following steps:

1. All available source material concerning tropical cyclones was collected.
2. The date/time/location information was extracted for each disturbance.
3. This information was compared with the GEOS-3 altimeter ON/OFF history information to determine the existence of any altimeter data close enough in both time and location to make the data potentially useful for further study (the very liberal criteria used was time less than 24 hours and location within 25 degrees).
4. Geographic plots (cyclone versus GEOS-3 orbit track) were produced for all of the events found showing the approximate location of the cyclone and the GEOS-3 orbit traces for the full day.
5. The geographic plots were annotated with the available cyclone track information and the pertinent GEOS-3 altimeter schedule information (orbit number, time of the point of closest approach, etc.).
6. The basic source material as well as the resulting geographic plots were grouped together and are presented for each of the tropical cyclones considered.

The altimeter mode information indicated on the daily GEOS/Cyclone plots can be decoded as follows:

<u>Mode #</u>	<u>Mode</u>
702	<ul style="list-style-type: none"> • Altimeter Intensive Mode • Data Rate - Lo (TM Form 1) • Altitude Data Rate - 10/sec • Waveform Data and Rate - 16 averaged waveform samples at one per ≈ 2.2 seconds each • Both pre and post bit-cal performed
703	<ul style="list-style-type: none"> • Global Mode Data • Lo Data Rate (TM Form 1) • Both pre and post bit-cal performed
711	<ul style="list-style-type: none"> • Altimeter Intensive Mode • Data Rate - Hi (TM Form 3) • Altitude Data Rate - 100/sec • Waveform Data and Rate - 8 even numbered instantaneous waveform samples at 100/sec each. 16 averaged waveform samples at one per ≈ 3.2 seconds each • Both pre and post bit-cal performed
708	<ul style="list-style-type: none"> • Altimeter Intensive Mode • Data Rate - Hi (TM Form 2) • Waveform Data and Rate - 16 instantaneous waveform samples at 100/sec each • Both pre and post bit-cal performed • 16 averaged waveform samples at one per ≈ 3.2 seconds each
802	<ul style="list-style-type: none"> • Altimeter Intensive Mode • Data Rate Lo (TM Form 1) • 16 averaged waveform samples at one per ≈ 2.2 seconds each

<u>Mode #</u>	<u>Mode</u>
803	<ul style="list-style-type: none"> • Global Mode Data • Lo Data Rate (TM Form 1)
808	<ul style="list-style-type: none"> • Altimeter Intensive Mode • Data Rate Hi (TM Form 2) • 16 instantaneous waveform samples at 100/sec each • 16 averaged waveform samples at one per 3.2 seconds each

Table 1-1 and Table 1-2 list those GEOS tracks which show the best possibility of correlation with tropical cyclone activity. These summary lists were compiled from all of the daily GEOS/cyclone plots. Table 1-1 is listed in time order while Table 1-2 is listed by storm and regional area, each table showing the GEOS revolution number, disturbance name and the page number of the corresponding GEOS/cyclone ground track plot. It should be pointed out that the GEOS-3 altimeter on/off information is basically schedule information and no attempt has been made to correlate this with the actual existence of data.

Table 1-1. Summary Listing of Scheduled GEOS
Revolution Number vs Cyclone

<u>Orbit #</u>	<u>Cyclone</u>	<u>Date</u>	<u>Page #</u>
5106	Typhoon Marie	4/04	4.2-5
5451	TC20-76	4/29	5.2-2
5684	Typhoon Olga	5/15	4.3-6
5720	Typhoon Olga	5/18	4.3-7
5734	Typhoon Olga	5/19	4.3-8
5741	Typhoon Olga	5/19	4.3-8
5755	Typhoon Olga	5/20	4.3-9
5762	Typhoon Olga	5/21	4.3-10
5762	Subtropical Storm Pamela	5/21	4.4-7
5770	Subtropical Storm #1	5/21	2.2-3
5776	Subtropical Storm #1	5/22	2.2-4
5783	Typhoon Olga	5/22	4.3-11
5790	Subtropical Storm #1	5/23	2.2-5
5791	Typhoon Olga	5/23	4.3-12
5798	Typhoon Olga	5/23	4.3-12
5805	Typhoon Olga	5/24	4.3-13
5812	Typhoon Olga	5/24	4.3-13
5826	Typhoon Olga	5/26	4.3-15
5834	Typhoon Olga	5/26	4.3-15
5934	Tropical Cyclone One	6/02	3.2-3
5955	Hurricane Annette	6/03	3.3-4
5961	Hurricane Annette	6/04	3.3-5
5969	Hurricane Annette	6/04	3.3-5
6020	Hurricane Annette	6/08	3.3-6
6026	Hurricane Annette	6/08	3.3-6
6318	Hurricane Bonny	6/28	3.4-3
6318	Tropical Cyclone Four	6/28	3.5-3
6756	Tropical Storm Anna	7/30	2.3-3
6763	Tropical Storm Anna	7/31	2.3-4
6777	Tropical Storm Anna	8/01	2.3-5
6871	Hurricane Belle	8/07	2.4-5
6879	Hurricane Belle	8/08	2.4-6
6879	Hurricane Hyacinth	8/08	3.6-4

Table 1-1 (cont.)

<u>Orbit #</u>	<u>Cyclone</u>	<u>Date</u>	<u>Page #</u>
6884	Hurricane Belle	8/08	2.4-6
6885	Hurricane Belle	8/08	2.4-6
6893	Hurricane Belle	8/09	2.4-7
6898	Hurricane Belle	8/09	2.4-7
6899	Hurricane Belle	8/09	2.4-7
6900	Hurricane Belle	8/09	2.4-7
6907	Hurricane Belle	8/10	2.4-8
6913	Hurricane Belle	8/10	2.4-8
7021	Hurricane Candice	8/18	2.5-3
7027	Hurricane Candice	8/18	2.5-3
7035	Hurricane Candice	8/19	2.5-4
7035	Tropical Storm Dottie	8/19	2.6-4
7036	Hurricane Candice	8/19	2.5-4
7036	Tropical Storm Dottie	8/19	2.6-4
7041	Hurricane Candice	8/19	2.5-4
7041	Tropical Storm Dottie	8/19	2.6-4
7049	Hurricane Candice	8/20	2.5-5
7049	Tropical Storm Dottie	8/20	2.6-5
7070	Tropical Storm Dottie	8/21	2.6-6
7076	Hurricane Emmy	8/22	2.7-4
7078	Hurricane Candice	8/22	2.5-7
7084	Hurricane Candice	8/22	2.5-7
7084	Hurricane Emmy	8/22	2.7-4
7090	Hurricane Emmy	8/23	2.7-5
7092	Hurricane Candice	8/23	2.5-8
7092	Hurricane Emmy	8/23	2.7-5
7098	Hurricane Candice	8/23	2.5-8
7098	Hurricane Emmy	8/23	2.7-5
7106	Hurricane Candice	8/24	2.5-9
7106	Hurricane Emmy	8/24	2.7-6
7107	Hurricane Iva	8/24	3.7-4
7112	Hurricane Emmy	8/24	2.7-6
7120	Hurricane Emmy	8/25	2.7-7
7127	Hurricane Emmy	8/25	2.7-7

Table 1-1 (cont.)

<u>Orbit #</u>	<u>Cyclone</u>	<u>Date</u>	<u>Page #</u>
7149	Hurricane Emmy	8/27	2.7-9
7155	Hurricane Emmy	8/27	2.7-9
7161	Hurricane Frances	8/28	2.9-3
7163	Hurricane Emmy	8/28	2.7-10
7164	Hurricane Iva	8/28	3.7-5
7169	Hurricane Emmy	8/28	2.7-10
7169	Hurricane Frances	8/28	2.9-3
7175	Hurricane Frances	8/29	2.9-4
7177	Hurricane Emmy	8/29	2.7-11
7177	Hurricane Frances	8/29	2.9-4
7182	Hurricane Emmy	8/29	2.7-11
7183	Hurricane Frances	8/29	2.9-4
7185	Hurricane Iva	8/29	3.7-6
7196	Hurricane Emmy	8/30	2.7-12
7198	Hurricane Frances	8/30	2.9-5
7204	Hurricane Emmy	8/31	2.7-13
7204	Hurricane Frances	8/31	2.9-6
7212	Hurricane Frances	8/31	2.9-6
7220	Hurricane Frances	9/01	2.9-7
7226	Hurricane Frances	9/01	2.9-7
7234	Hurricane Frances	9/02	2.9-8
7246	Hurricane Emmy	9/03	2.7-16
7246	Hurricane Frances	9/03	2.9-9
7248	Hurricane Frances	9/03	2.9-9
7253	Hurricane Emmy	9/03	2.7-16
7260	Hurricane Emmy	9/04	2.7-17
7261	Hurricane Emmy	9/04	2.7-17
7261	Hurricane Frances	9/04	2.9-10
7264	Tropical Storm Joanne	9/04	3.8-4
7313	Hurricane Kathleen	9/07	3.9-4
7397	Subtropical Storm #3	9/13	2.8-3
7405	Subtropical Storm #3	9/13	2.8-3
7411	Subtropical Storm #3	9/14	2.8-4
7425	Subtropical Storm #3	9/14	2.8-4

Table 1-1 (cont.)

<u>Orbit #</u>	<u>Cyclone</u>	<u>Date</u>	<u>Page #</u>
7562	Hurricane Liza	9/25	3.10-4
7588	Hurricane Gloria	9/27	2.10-3
7595	Hurricane Gloria	9/27	2.10-3
7596	Hurricane Gloria	9/27	2.10-3
7604	Hurricane Madeline	9/29	3.11-5
7605	Hurricane Gloria	9/28	2.10-4
7610	Hurricane Gloria	9/28	2.10-4
7618	Hurricane Gloria	9/29	2.10-5
7624	Hurricane Gloria	9/29	2.10-5
7632	Hurricane Gloria	9/30	2.10-6
7637	Hurricane Gloria	9/30	2.10-6
7640	Hurricane Liza	9/30	3.10-5
7645	Hurricane Gloria	10/01	2.10-7
7651	Hurricane Gloria	10/01	2.10-7
7652	Hurricane Gloria	10/01	2.10-7
7659	Hurricane Gloria	10/02	2.10-8
7665	Hurricane Gloria	10/02	2.10-8
7666	Hurricane Gloria	10/02	2.10-8
7673	Hurricane Gloria	10/03	2.10-9
7675	Hurricane Gloria	10/03	2.10-9
7679	Hurricane Gloria	10/03	2.10-9
7680	Hurricane Gloria	10/03	2.10-9
7689	Hurricane Gloria	10/04	2.10-10
7693	Hurricane Gloria	10/04	2.10-10
7959	Hurricane Holly	10/23	2.11-3
7964	Hurricane Holly	10/23	2.11-3
7965	Hurricane Holly	10/23	2.11-3
7973	Hurricane Holly	10/24	2.11-4
7986	Hurricane Holly	10/25	2.11-5
7993	Hurricane Holly	10/25	2.11-5
7994	Hurricane Holly	10/26	2.11-6
8001	Hurricane Holly	10/26	2.11-6
8002	Hurricane Holly	10/26	2.11-6
8006	Hurricane Holly	10/26	2.11-6
8007	Hurricane Holly	10/26	2.11-6
8008	Hurricane Holly	10/27	2.11-7

Table 1-1 (cont.)

<u>Orbit #</u>	<u>Cyclone</u>	<u>Date</u>	<u>Page #</u>
8016	Hurricane Holly	10/27	2.11-7
8020	Hurricane Holly	10/27	2.11-7
8021	Hurricane Holly	10/27	2.11-7
8022	Hurricane Holly	10/28	2.11-8
8030	Hurricane Holly	10/28	2.11-8
8035	Hurricane Holly	10/28	2.11-8
8036	Hurricane Holly	10/28	2.11-8
8048	Hurricane Holly	10/29	2.11-9
8049	Hurricane Holly	10/29	2.11-9
8063	Subtropical Storm Louise	10/30	4.5-6

Table 1-2. Summary Listing of Cyclone vs. GEOS Revolution Number According to Area

2.0 ATLANTIC AREA

<u>Cyclone Name</u>	<u>Date</u>	<u>GEOS Orbit</u>	<u>Page #</u>
Subtropical Storm #1	5/21	5770	2.2-3
Subtropical Storm #1	5/22	5776	2.2-4
Subtropical Storm #1	5/23	5790	2.2-5
Subtropical Storm #3	9/13	7397	2.8-3
Subtropical Storm #3	9/13	7405	2.8-3
Subtropical Storm #3	9/14	7411	2.8-4
Subtropical Storm #3	9/14	7425	2.8-4
Tropical Storm Anna	7/30	6756	2.3-3
Tropical Storm Anna	7/31	6763	2.3-4
Tropical Storm Anna	8/01	6777	2.3-5
Hurricane Belle	8/07	6871	2.4-5
Hurricane Belle	8/08	6879	2.4-6
Hurricane Belle	8/08	6884	2.4-6
Hurricane Belle	8/08	6885	2.4-6
Hurricane Belle	8/09	6893	2.4-7
Hurricane Belle	8/09	6898	2.4-7
Hurricane Belle	8/09	6899	2.4-7
Hurricane Belle	8/09	6900	2.4-7
Hurricane Belle	8/10	6907	2.4-8
Hurricane Belle	8/10	6913	2.4-8
Hurricane Candice	8/18	7021	2.5-3
Hurricane Candice	8/18	7027	2.5-3
Hurricane Candice	8/19	7035	2.5-4
Hurricane Candice	8/19	7036	2.5-4
Hurricane Candice	8/19	7041	2.5-4
Hurricane Candice	8/20	7049	2.5-5
Hurricane Candice	8/22	7078	2.5-7
Hurricane Candice	8/22	7084	2.5-7
Hurricane Candice	8/23	7092	2.5-8
Hurricane Candice	8/23	7098	2.5-8
Hurricane Candice	8/24	7106	2.5-9

Table 1-2 (cont.)

<u>Cyclone Name</u>	<u>Date</u>	<u>Orbit</u>	<u>Page #</u>
Tropical Storm Dottie	8/19	7035	2.6-4
Tropical Storm Dottie	8/19	7036	2.6-4
Tropical Storm Dottie	8/19	7041	2.6-4
Tropical Storm Dottie	8/20	7049	2.6-5
Tropical Storm Dottie	8/21	7070	2.6-6
Hurricane Emmy	8/22	7076	2.7-4
Hurricane Emmy	8/22	7084	2.7-4
Hurricane Emmy	8/23	7090	2.7-5
Hurricane Emmy	8/23	7092	2.7-5
Hurricane Emmy	8/23	7098	2.7-5
Hurricane Emmy	8/24	7106	2.7-6
Hurricane Emmy	8/24	7112	2.7-6
Hurricane Emmy	8/25	7120	2.7-7
Hurricane Emmy	8/25	7127	2.7-7
Hurricane Emmy	8/27	7149	2.7-9
Hurricane Emmy	8/27	7155	2.7-9
Hurricane Emmy	8/28	7163	2.7-10
Hurricane Emmy	8/28	7169	2.7-10
Hurricane Emmy	8/29	7177	2.7-11
Hurricane Emmy	8/29	7182	2.7-11
Hurricane Emmy	8/30	7196	2.7-12
Hurricane Emmy	8/31	7204	2.7-13
Hurricane Emmy	9/03	7246	2.7-16
Hurricane Emmy	9/03	7253	2.7-16
Hurricane Emmy	9/04	7260	2.7-17
Hurricane Emmy	9/04	7261	2.7-17
Hurricane Frances	8/28	7161	2.9-3
Hurricane Frances	8/28	7169	2.9-3
Hurricane Frances	8/29	7175	2.9-4
Hurricane Frances	8/29	7177	2.9-4
Hurricane Frances	8/29	7183	2.9-4
Hurricane Frances	8/30	7198	2.9-5
Hurricane Frances	8/31	7204	2.9-6
Hurricane Frances	8/31	7212	2.9-6

Table 1-2 (cont.)

<u>Cyclone Name</u>	<u>Date</u>	<u>Orbit</u>	<u>Page #</u>
Hurricane Frances	9/01	7220	2.9-7
Hurricane Frances	9/01	7226	2.9-7
Hurricane Frances	9/02	7234	2.9-8
Hurricane Frances	9/03	7246	2.9-9
Hurricane Frances	9/03	7248	2.9-9
Hurricane Frances	9/04	7261	2.9-10
Hurricane Gloria	9/27	7588	2.10-3
Hurricane Gloria	9/27	7595	2.10-3
Hurricane Gloria	9/27	7596	2.10-3
Hurricane Gloria	9/28	7605	2.10-4
Hurricane Gloria	9/28	7610	2.10-4
Hurricane Gloria	9/29	7618	2.10-5
Hurricane Gloria	9/29	7624	2.10-5
Hurricane Gloria	9/30	7632	2.10-6
Hurricane Gloria	9/30	7637	2.10-6
Hurricane Gloria	10/1	7645	2.10-7
Hurricane Gloria	10/1	7651	2.10-7
Hurricane Gloria	10/1	7652	2.10-7
Hurricane Gloria	10/2	7659	2.10-8
Hurricane Gloria	10/2	7665	2.10-8
Hurricane Gloria	10/2	7666	2.10-8
Hurricane Gloria	10/3	7673	2.10-9
Hurricane Gloria	10/3	7675	2.10-9
Hurricane Gloria	10/3	7679	2.10-9
Hurricane Gloria	10/3	7680	2.10-9
Hurricane Gloria	10/4	7689	2.10-10
Hurricane Gloria	10/4	7693	2.10-10
Hurricane Holly	10/23	7959	2.11-3
Hurricane Holly	10/23	7964	2.11-3
Hurricane Holly	10/23	7965	2.11-3
Hurricane Holly	10/24	7973	2.11-4
Hurricane Holly	10/25	7986	2.11-5
Hurricane Holly	10/25	7993	2.11-5
Hurricane Holly	10/26	7994	2.11-6

Table 1-2 (cont.)

<u>Cyclone Name</u>	<u>Date</u>	<u>Orbit</u>	<u>Page #</u>
Hurricane Holly	10/26	8001	2.11-6
Hurricane Holly	10/26	8002	2.11-6
Hurricane Holly	10/26	8006	2.11-6
Hurricane Holly	10/26	8007	2.11-6
Hurricane Holly	10/27	8008	2.11-7
Hurricane Holly	10/27	8016	2.11-7
Hurricane Holly	10/27	8020	2.11-7
Hurricane Holly	10/27	8021	2.11-7
Hurricane Holly	10/28	8022	2.11-8
Hurricane Holly	10/28	8030	2.11-8
Hurricane Holly	10/28	8035	2.11-8
Hurricane Holly	10/28	8036	2.11-8
Hurricane Holly	10/29	8048	2.11-9
Hurricane Holly	10/29	8049	2.11.9

Table 1-2 (cont.)

3.0 EASTERN PACIFIC & U. S. WEST COAST

<u>Cyclone Name</u>	<u>Date</u>	<u>Orbit</u>	<u>Page #</u>
Tropical Cyclone One	6/02	5934	3.2-3
Hurricane Annette	6/03	5955	3.3-4
Hurricane Annette	6/04	5961	3.3-5
Hurricane Annette	6/04	5969	3.3-5
Hurricane Annette	6/08	6020	3.3-6
Hurricane Annette	6/08	6026	3.3-6
Hurricane Bonny	6/28	6318	3.4-3
Tropical Cyclone Four	6/28	6318	3.5-3
Hurricane Hyacinth	8/08	6879	3.6-4
Hurricane Iva	8/24	7107	3.7-4
Hurricane Iva	8/28	7164	3.7-5
Hurricane Iva	8/29	7185	3.7-6
Tropical Storm Joanne	9/04	7264	3.8-4
Hurricane Kathleen	9/04	7313	3.9-4
Hurricane Liza	9/25	7562	3.10-4
Hurricane Liza	9/30	7640	3.10-5
Hurricane Madeline	9/29	7604	3.11-5

Table 1-2 (cont.)

4.0 CENTRAL & WESTERN PACIFIC AREAS

<u>Cyclone Name</u>	<u>Date</u>	<u>Orbit</u>	<u>Page #</u>
Typhoon Marie	4/04	5106	4.2-5
Typhoon Olga	5/15	5684	4.3-6
Typhoon Olga	5/18	5720	4.3-7
Typhoon Olga	5/19	5734	4.3-8
Typhoon Olga	5/19	5741	4.3-8
Typhoon Olga	5/20	5755	4.3-9
Typhoon Olga	5/21	5762	4.3-10
Typhoon Olga	5/22	5783	4.3-11
Typhoon Olga	5/23	5791	4.3-11
Typhoon Olga	5/23	5798	4.3-11
Typhoon Olga	5/24	5805	4.3-12
Typhoon Olga	5/24	5812	4.3-12
Typhoon Olga	5/25	5826	4.3-13
Typhoon Olga	5/26	5834	4.3-14
Super Typhoon Pamela	5/21	5762	4.4-7
Super Typhoon Louise	10/30	8063	4.5-6

Table 1-2 (cont.)

5.0 NORTH INDIAN OCEAN AREA

<u>Cyclone Name</u>	<u>Date</u>	<u>Orbit</u>	<u>Page #</u>
Tropical Cyclone 20-76	4/29	5451	5.2-5

2.0 ATLANTIC AREA TROPICAL AND SUBTROPICAL CYCLONES

2.1 General

The data presented in this section on tropical and subtropical cyclones occurring in the Atlantic area were extracted from the National Hurricane Center's document, "Annual Data and Verification Tabulation Atlantic Tropical Cyclones 1976," and from the Monthly Weather Review's article "Atlantic Hurricane Season of 1976," by Miles B. Lawrence. During the 1976 season, there were a total of 10 cyclones that occurred in this area as listed below:

Subtropical Storm No. 1	(05/21/76 - 05/25/76)
Tropical Storm "Anna" (Subtropical Storm No. 2)	(07/28/76 - 08/06/76)
Hurricane "Belle"	(08/06/76 - 08/10/76)
Hurricane "Candice"	(08/18/76 - 08/24/76)
Tropical Storm "Dottie"	(08/17/76 - 08/21/76)
Hurricane "Emmy"	(08/20/76 - 09/04/76)
Hurricane "Frances"	(08/27/76 - 09/07/76)
Subtropical Storm No. 3	(09/13/76 - 09/17/76)
Hurricane "Gloria"	(09/26/76 - 10/04/76)
Hurricane "Holly"	(10/22/76 - 10/28/76)

Ground track plots of the Atlantic subtropical cyclones are shown in Figure 2-1 and track plots for the Atlantic tropical cyclones are shown in Figure 2-2.

Results of the comparison of the cyclone information and the GEOS-3 schedule information indicates that all of the cyclones may have associated GEOS altimeter data. All information as available for these cyclones along with any promising GEOS ground track maps are presented in the following sections.

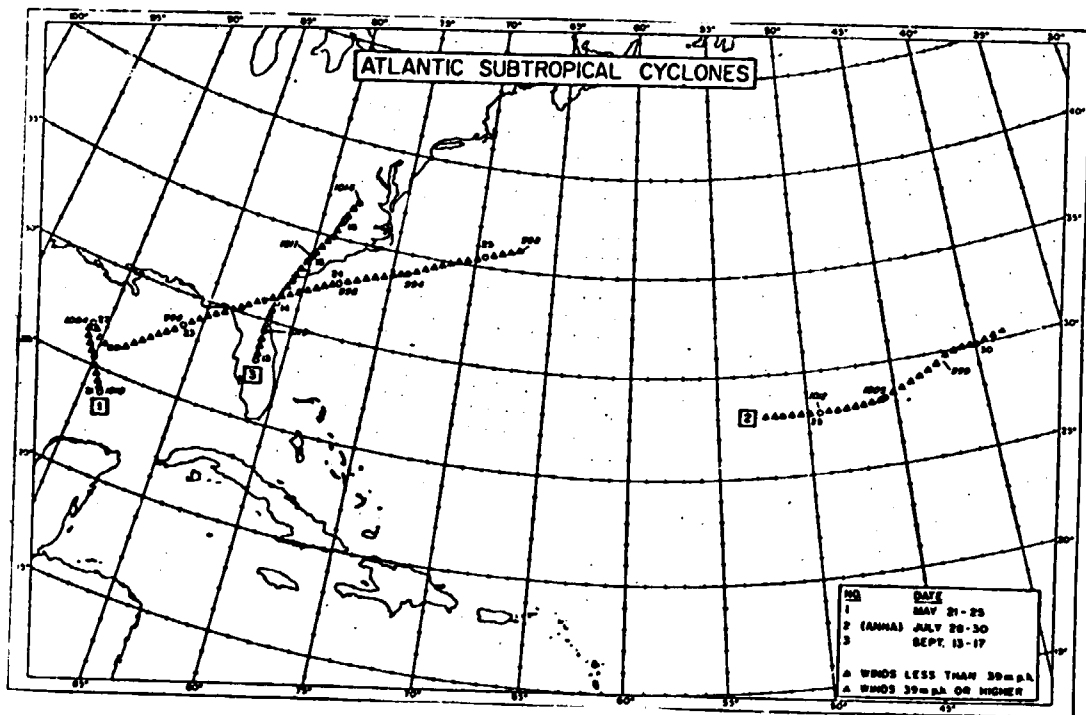
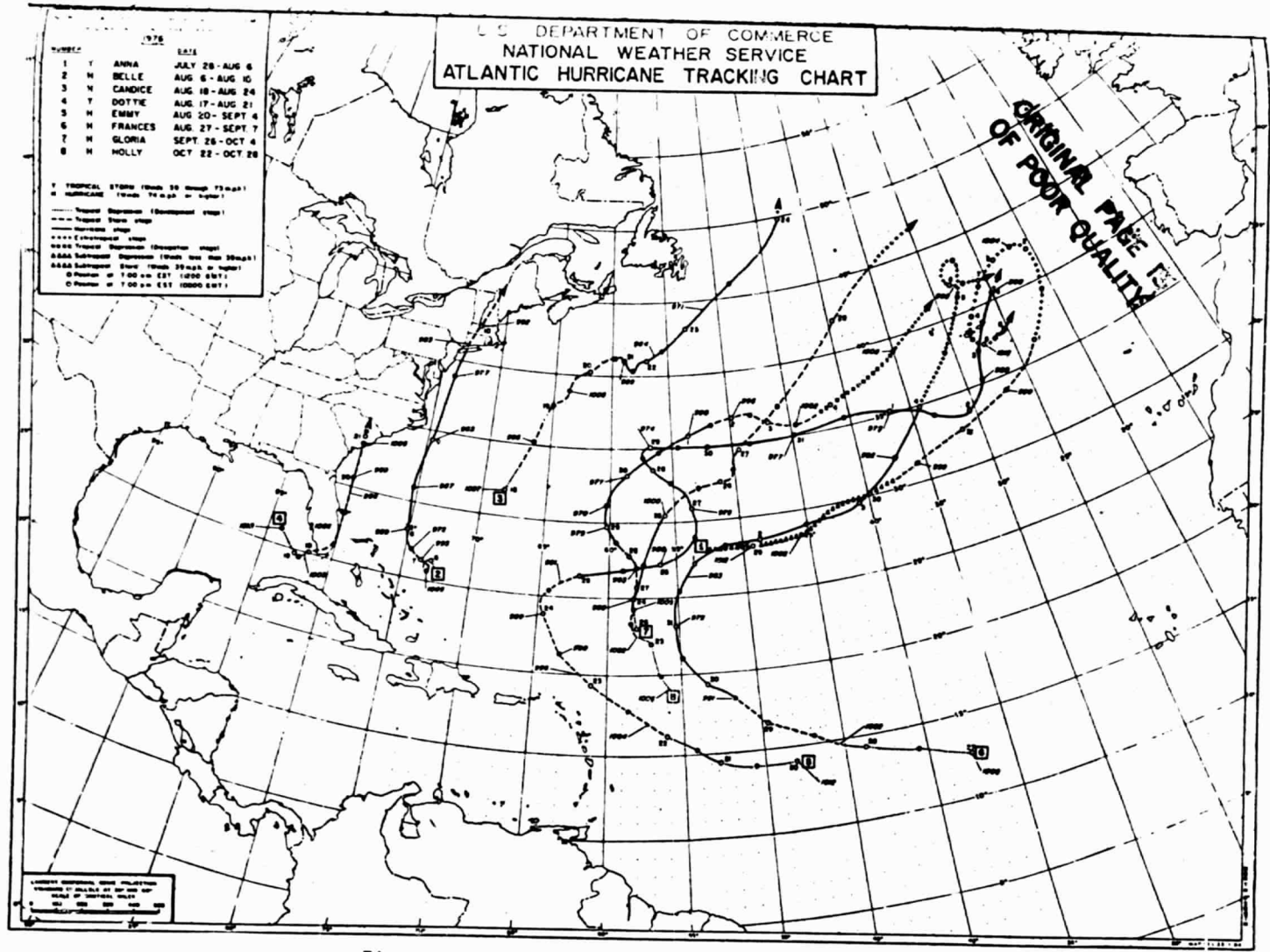
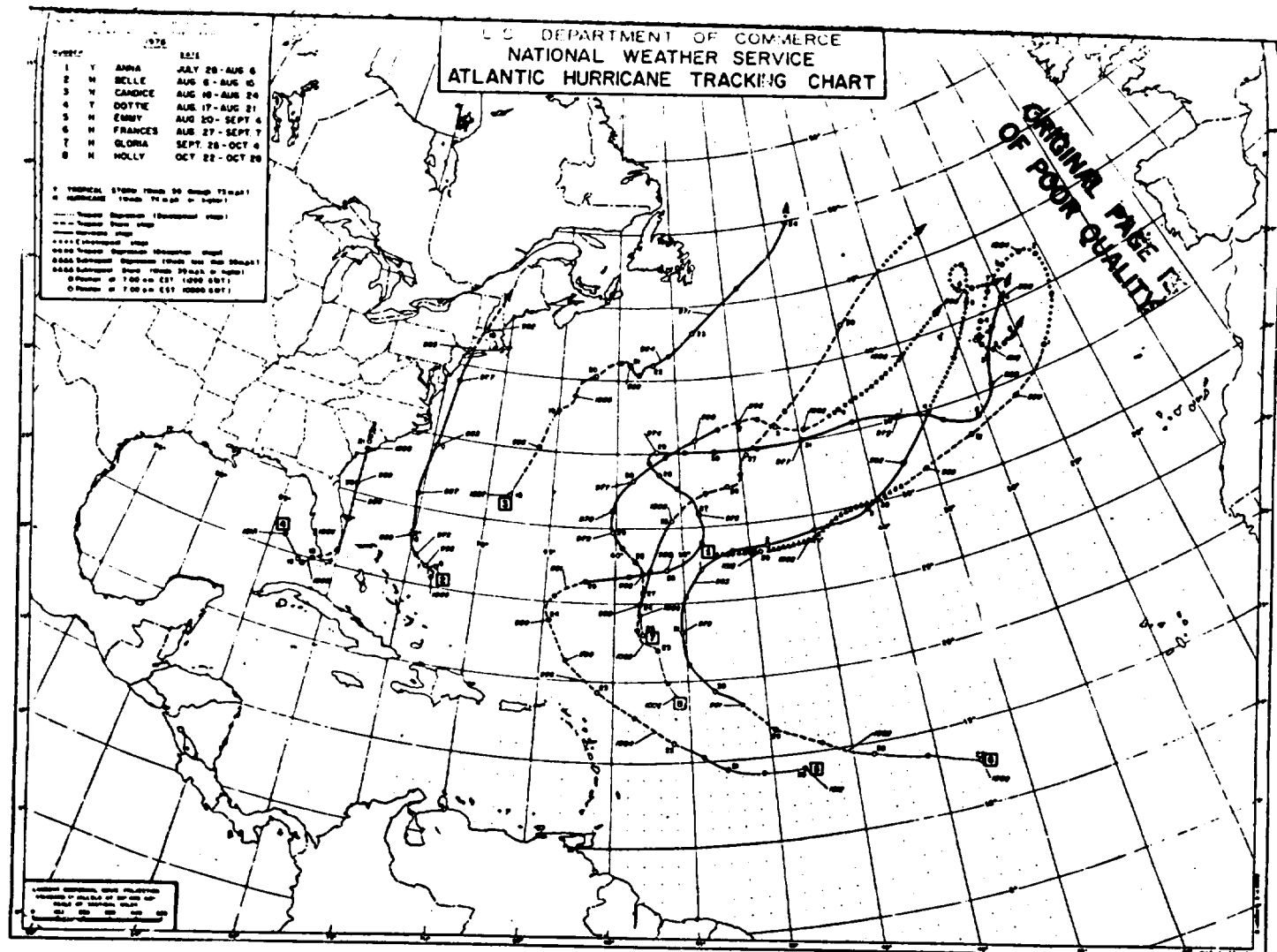


Figure 2-1. Tracks of North Atlantic Subtropical Cyclones, 1976.



2-1-3

Figure 2-2. Tracks of 1976 Tropical Cyclones



2-1-3

Figure 2-2. Tracks of 1976 Tropical Cyclones

SUBTROPICAL STORM #1

May 21-25, 1976

On May 21, reports from the NOAA Buoy EB04 (26°N, 90°W) and ship observations indicated a low-pressure system was developing over the central Gulf of Mexico. The low gained strength and drifted northwest until becoming nearly stationary on May 22 just north of EB04.

A developing trough in the westerlies over the Mississippi Valley began to influence the low on May 23 and the system strengthened to subtropical storm intensity. The storm accelerated toward the east-northeast at 20 kt and crossed north Florida and southwest Georgia that afternoon. The system continued into the Atlantic and merged with a frontal system by May 25.

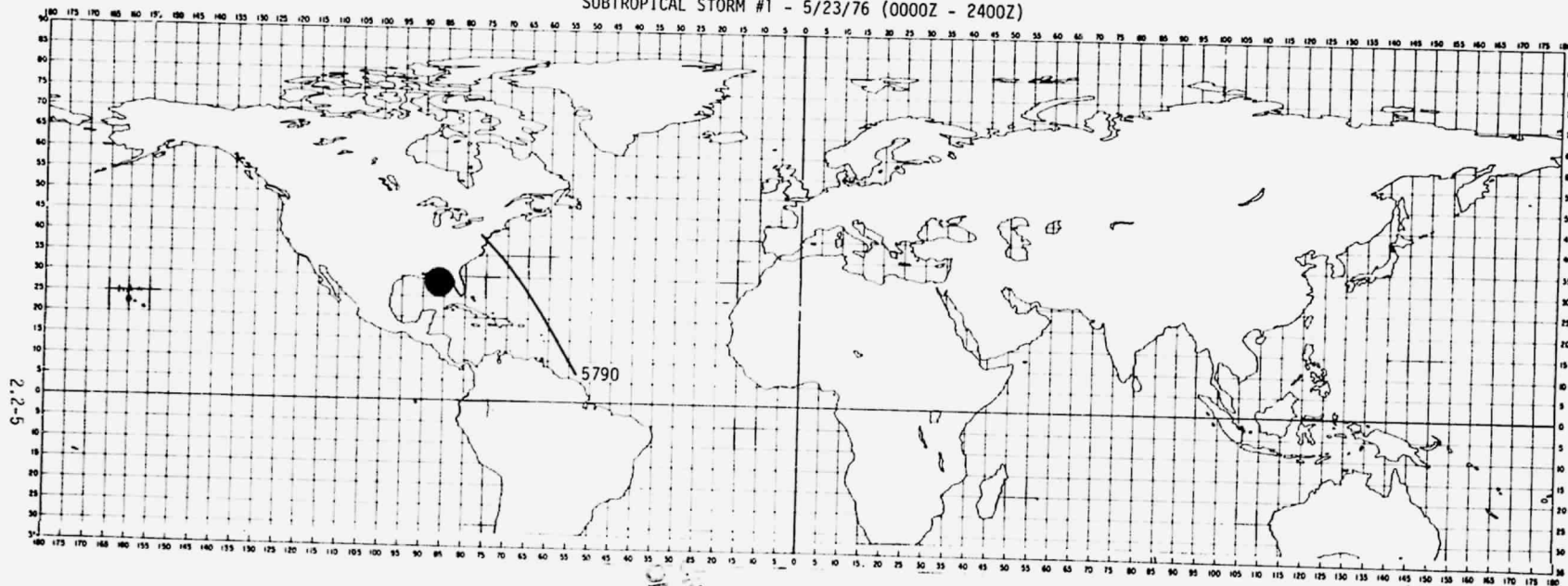
The development of the storm had some characteristics of a tropical system while in the Gulf of Mexico, but the environment remained cold and the approach of an upper trough prevented any further warming of the system. However, the upper trough did contribute to the strengthening of the low and a lowest pressure of 994 mb was estimated on May 24 when the storm was offshore of the Carolinas. Highest winds were 45 kt.

Tides of 1-2 ft above normal occurred along the Gulf coast from Tampa to Pensacola, and combined with large swells, caused beach erosion in this area. Heavy rainfall was reported over eastern South Carolina with 5 inches at Charleston. Damage from the storm was minimal and rainfall was beneficial to the southeastern states since precipitation had been below normal in this area.

DISTURBANCE: SUBTROPICAL STORM #1
 DATE: May 21 - 25, 1976

Date	Time	Position		Pressure (MBS)	Wind (KTS)	Stage
		Latitude	Longitude			
5/21	1200Z	24.0N	89.0W	1010		Low
5/22	0000Z	25.4N	90.0W	1004		Low
	1200Z	27.0	91.0			
5/23	0000Z	26.3N	89.0W	998		Subtropical Storm
	1200Z	28.5	86.0			
5/24	0000Z	31.0N	82.0W	996		Subtropical Storm
	1200Z	33.0	78.0			
5/25	0000Z	34.0N	74.0W	994		
	1200Z	35.5	69.5			

SUBTROPICAL STORM #1 - 5/23/76 (0000Z - 2400Z)



LOCATION

TIME	LATITUDE	LONGITUDE
0000Z	28.5N	86.0W
1200Z	31.0	82.0
2400Z	32.8	78.0

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
5790	-49.62	053156	0544Z	053501	054455	808	178

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TROPICAL STORM ANNA
(Subtropical Storm No. 2)
July 28 - August 6, 1976

The first named storm of the 1976 season began as a subtropical depression late on July 28, several hundred miles southeast of Bermuda. As the system moved toward the east-northeast, it gradually strengthened, reaching subtropical storm force early on July 30, approximately 100 nm southwest of the Azores.

A ship, M/S *Pointe Allegre*, confirmed the presence of the second subtropical storm of the season by passing through the center at 0200 GMT July 30. This vessel reported a barometric fall from 1014 to 999 mb followed by a rapid rise to 1010 mb, all of this within a 1 hour period. The ship experienced heavy thunderstorms with gusts to 60 kt and winds shifting from southeast to south-southwest to northwest.

The storm continued toward the east-northeast and began to rapidly acquire tropical characteristics, as inferred from satellite pictures. It was named Tropical Storm Anna on the afternoon of July 30 and then continued in a northeasterly direction sustaining winds of about 40 kt.

As Anna crossed south of the Azores on August 1, its path became blocked by a surface ridge to the east and north. The cloud pattern became disorganized and tropical characteristics were lost. After the storm became extratropical, a ship encountered the system 400 nm northeast of the Azores and at 1200 GMT August 2, an east wind of 46 kt and a 998.5 mb central pressure were reported. The storm's motion was blocked for the next 3 days as it made a slow counterclockwise loop through the Azores. By now the system was quite weak and passed east of the Azores as a 1015 mb low pressure system on August 6.

There were no wind reports from the Azores above gale force except after Anna had become extratropical, and there were no reports of damage or casualties.

DISTURBANCE : TROPICAL STORM ANNA (Subtropical Storm #2)

DATE: July 28 - August 6, 1976

Date	Time	Position		Pressure (MBS)	Wind (KTS)	Stage
		Latitude	Longitude			
7/28	1830Z	28.0N	52.2W			
7/29	0600Z 1230Z 1830Z	28.2N 28.2 27.9	50.1W 49.9 48.0	1012	25	Subtropical Depression
7/30	0030Z 0630Z 1230Z 1800Z	28.3N 30.0 30.1 30.5	45.6W 41.9 39.9 37.7	1005	30 30 40 40	Subtropical Depression Subtropical Storm Tropical Storm
7/31	0000Z 0600Z 1200Z 1800	31.3N 31.9 32.5 33.2	35.7W 33.6 31.5 29.4	999	40 40 40 40	Tropical Storm
8/1	0000Z 0600Z 1230Z	33.9N 35.0	27.1W 24.9	999	35	Tropical Storm Extratropical

HURRICANE BELLE

August 6-10, 1976

The precursor of Belle moved westward off of the African Coast on July 28. It was the 20th tropical system of 1976 to be tracked across the Atlantic and was well defined. On July 31, in the mid-Atlantic, the system was better organized than most waves seen in this area. Satellite pictures indicated a possible lower-tropospheric circulation and much convection.

The wave traveled across the Atlantic at about 20 kt. While the wave itself continued westward into the Caribbean, the major convection separated just east of the Leeward Islands and moved northwestward and slowed down, reaching a position just east of the northern Bahamas on August 5.

By this time, the convection was concentrated over a circular area 300-400 nm wide. And late on August 5, a well-defined cirrus-level outflow was indicated. Finally, early on August 6, surface winds reached 25 kt with a minimum central pressure of 1012 mb and the system was upgraded to a tropical depression.

Intensification was rather steady from August 6 to early on August 9 when a central pressure of 957 mb was reached with a maximum sustained surface wind speed of 105 kt. NOAA research aircraft reported spot winds as high as 130 kt, but these winds were measured at or near 700 mb and were not evaluated to be representative of sustained surface winds.

As Belle increased in strength, its status was upgraded to tropical storm on the evening of August 6 and to a full hurricane during late afternoon on August 7.

As a tropical depression and for the first few hours as a tropical storm, Belle's position remained about 250 nm east-northeast of Nassau in the Bahamas. Actually during this time there was a small cyclonic looping motion. But soon after reaching tropical storm intensity, acceleration began toward the northwest and toward the north by August 8. This northward motion continued for the next two days while forward speed increased to 20-25 kt.

Landfall was made early on August 10 (0500 GMT or 0100 EDT) on the south coast of Long Island. The point of landfall is estimated to be in the vicinity of Jones Beach on western Long Island.

The storm moved northward across Long Island, then over Long Island Sound, reaching the Connecticut coast near Bridgeport. Belle's course continued across west central Massachusetts into southwest New Hampshire, finally north-eastward into western Maine. During this later period, over New Hampshire and Maine, tropical characteristics were lost.

As is the case with almost every storm that moves very near and parallel to the U.S. east coast, it was necessary to place a hurricane watch and/or warning over a rather large segment of the Eastern Seaboard. Belle was no exception. The entire coastline from Georgia northward to Maine was eventually placed under a hurricane watch.

Hurricane warnings were first announced for the Outer Banks of North Carolina from Kitty Hawk to Cape Lookout. This was on the afternoon of August 8. By the evening of August 9, warnings had extended northward through Maine.

By midday on August 9, the public advisories started mentioning central or eastern Long Island as the point of landfall. Coastal storm tides of 8 ft or more above normal were emphasized as well as high winds near landfall. An inland flash flood threat was expressed for much of the northeast as heavy rain had already been occurring not associated with Belle. In addition, tides of 12-15 ft above normal in some bays and inlets were considered possible near the center.

However, the storm had been on a weakening trend for about 24 hours prior to landfall, so that at the time of landfall the estimated maximum sustained winds were 65 kt and minimum sea level pressure was up to near 980 mb.

One of the reasons for this significant weakening before landfall is the fact that Belle's northward motion remained at speeds less than 25 kt. This allowed more time for the storm to travel over the colder waters of the Atlantic.

Estimates of damage caused by strong winds were minimal. Reports indicate that maximum sustained winds were mostly less than hurricane force over most of the warning area. Steady northwest 55-65 kt winds were estimated along the Outer Banks of North Carolina during the period that Belle passed just offshore. Moving northward, the next highest wind reported was 50 kt with gusts to 60 kt at Ocean City, MD. Along the New Jersey coast, 30-40 kt was common but the *Bottom* estimated 55 kt with gusts to 80 kt, and *Manasquan* estimated 70 kt gusts.

Tidal variation associated with the storm surge was generally about 3 ft above normal over much of the warning area. However, at some locations from New Jersey southward, tides were somewhat below normal due to an offshore wind component.

Rainfall amounts of 4-5 inches during the 24 hour period of Belle's passage were common over much of the warning area as well as quite a distance inland, especially in the western and northern mountains of New England.

Because of widespread precipitation throughout the area for a day or two immediately prior to the hurricane, there was considerable small stream flooding and flooded roads. Crop damage was spotty and although there were some losses to bottomland crops, the New England Crop and Live-Stock Reporting Service said "Damage from Hurricane Belle was much less than anticipated...".

In New England, there were three deaths which were attributed to Belle: two drowned in southern Vermont when a foot bridge was swept from under them. In Connecticut, a woman was killed in Barkhamstead when her car skidded into a tree. At Norfolk, VA, a traffic accident due to heavy rain resulted in one death. In New York, a falling tree was responsible for one fatality. Therefore, five storm-related deaths are accounted for.

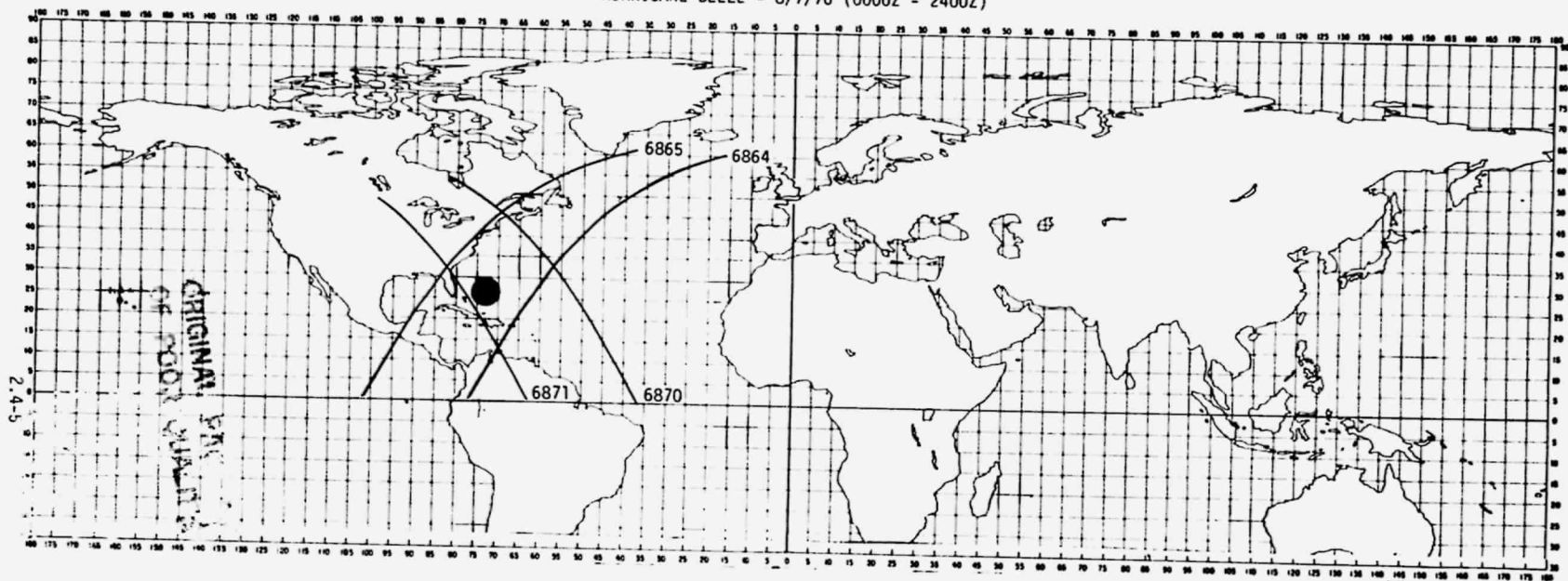
Reports of dollar damage as well as how many persons evacuated are difficult to estimate. The largest figure available for evacuation is that of 250,000 people along the New Jersey shore. A combined figure of near 30,000 people has been given for New York City and Suffolk County, New York. Connecticut reports approximately 5000 evacuated. Down on the North Carolina coast, 10,000 people evacuated. Unknown thousands were most likely evacuated elsewhere in New England and along the Eastern Seaboard. It can therefore be concluded that nearly half a million people evacuated in anticipation of the danger of Belle's storm surge.

The total damage estimate for the United States is \$100 million. This is mainly a result of agricultural crop damage in the northeast United States, although other property damage (dwellings, boats, commercial and beachfront structures) accounts for a considerable percentage. This figure is based primarily on data provided by the Property Claim Services of the American Insurance Association.

DISTURBANCE: HURRICANE BELLE
 DATE: August 6-10, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/7	0030Z	26.1N	72.9W	993	40	Tropical Storm
	0630Z	25.8	73.1		45	
	1200Z	26.2	73.7		50	Hurricane
	1830Z	26.6	74.3		65	
8/8	0030Z	27.1N	74.8W	964	77	Hurricane
	0630Z	27.5	75.2		84	
	1301Z	28.5	75.1		84	
	1803Z	29.4	75.4		80	
8/9	0030Z	31.1N	75.0W	965 971	90	Hurricane
	0630Z	32.4	75.2		90	
	1228Z	34.7	74.8		75	
	1800Z	36.8	74.5		70	
8/10	0030Z	39.5N	73.5W		77	Hurricane Tropical Storm
	0553Z	41.0	73.5		50	

HURRICANE BELLE - 8/7/76 (0000Z - 2400Z)

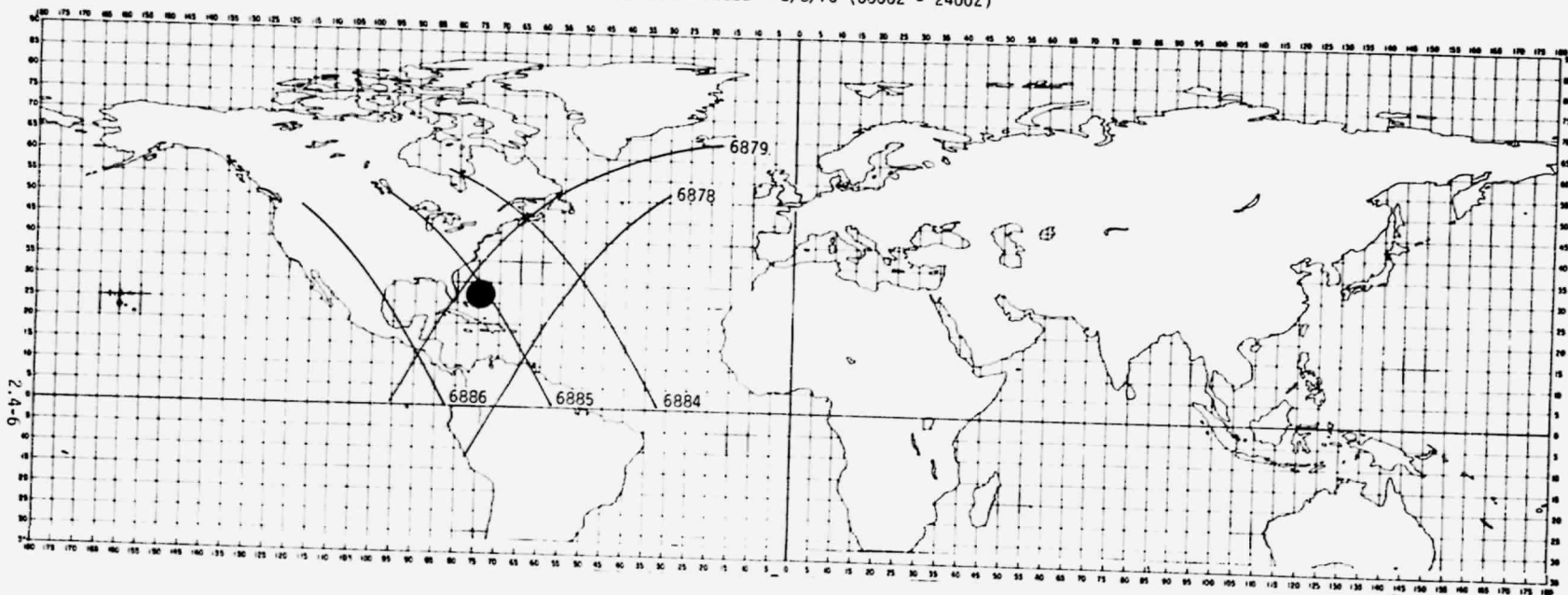


LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	26.0N	73.5W
0600Z	26.0	73.0
1200Z	26.3	73.6
1800Z	26.7	74.0
2400Z	27.0	74.5

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
6864	113.57	032732	0411Z	No			
6865	88.25	050919	0549Z	No			
6870	-38.36	133814	1350Z	No			
6871	-63.68	152001	1528Z	152306	152948	808	177

HURRICANE BELLE - 8/8/76 (0000Z - 2400Z)

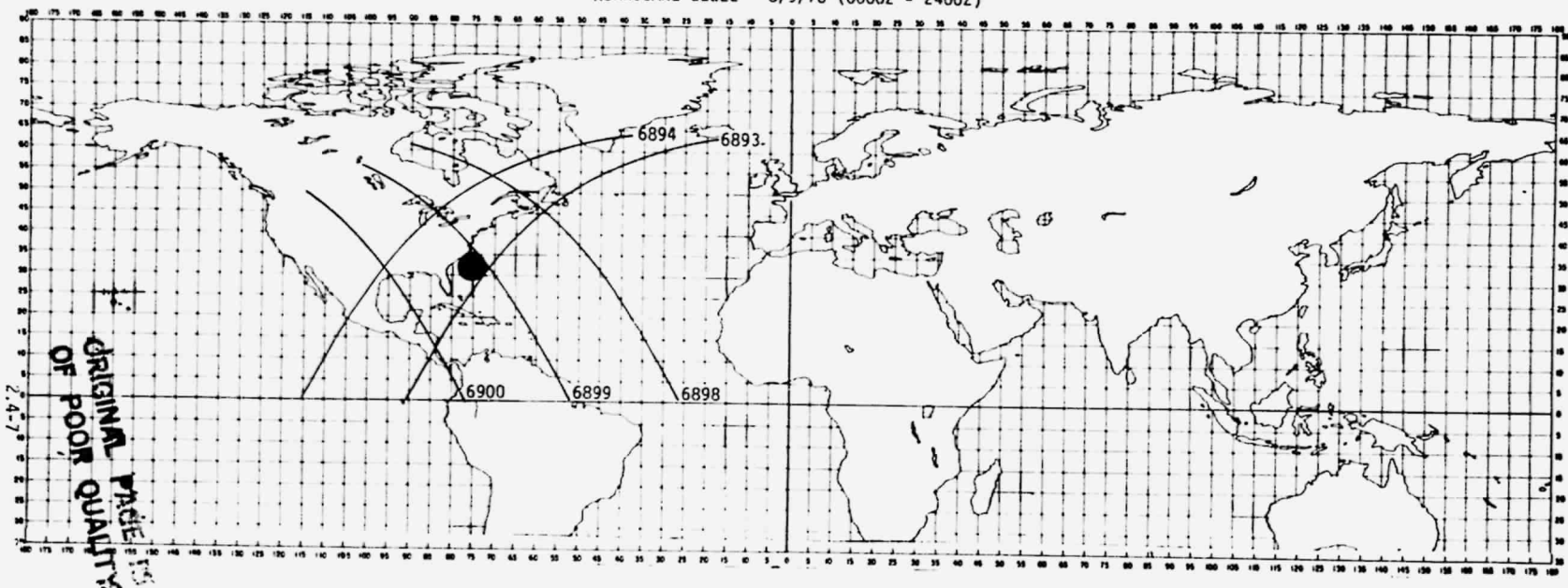


LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	27.0N	74.5W
0600Z	27.5	75.3
1200Z	28.2	75.3
1800Z	29.3	75.3
2400Z	31.0	75.3

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
6878	119.05	031235	0357Z	No			
6879	93.73	045417	0535Z	052907	054118	808	185
6884	-32.88	132312	1336Z	131239	133043	802	192
6885	-58.20	150459	1512Z	150744	151608	808	193
6886	-83.52	164646	1651Z	No			

HURRICANE BELLE - 8/9/76 (0000Z - 2400Z)



LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	31.0N	75.3W
0600Z	32.4	75.3
1200Z	34.3	74.9
1800Z	36.8	74.3
2400Z	38.9	73.9

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
6893	99.22	043914	0520Z	051401	052557	808	103
6894	73.89	062102	0557Z	No			
6898	-27.39	130810	1323Z	124900	133021	802	
6899	-52.72	144957	1501Z	145116	150213	808	109
6900	-78.03	163143	1638Z	163817	164241	808	110

HURRICANE CANDICE

August 18-24, 1976

Candice originated as a baroclinic system. As early as August 11, a cold low was clearly evident at 200 mb, centered about 500 nm southeast of Bermuda. At this time there was no reflection of the system on the surface pressure analysis; in fact, a surface ridge of high pressure extended north-south along 60°W longitude. The outline of the cold low was clearly seen on a movie loop made from successive satellite pictures.

This upper low drifted northwestward for the next few days and convective cloudiness increased, but it was not until August 15 that a broad low pressure area was detected on surface charts. Meanwhile, the low at 200 mb was becoming less well defined; by August 17 only an upper trough west of the surface low could be identified and the flow above the surface low became increasingly anticyclonic. This suggested a general warming of the system and a transformation to tropical structure.

At 1200 GMT August 18, about 200 nm west of Bermuda, the low was classified as a tropical depression as satellite pictures showed increasingly better organization and a ship reported winds gusting to 40 kt. Development continued and it was named later on the same day.

As the storm moved northeastward about 15 kt, slight weakening occurred beginning on the afternoon of August 19 and continuing until the following afternoon, when the storm again began to deepen. It became a hurricane during the night of August 20. Maximum intensity was reached on the afternoon of August 22 when the lowest pressure dropped to 964 mb and maximum sustained winds were 80 kt.

Early on August 24, the hurricane was overtaken by a rapidly moving cold front east of Cape Race, Newfoundland. It rapidly lost its identity as a tropical system while accelerating northeastward over the open Atlantic.

Candice initially took a north-northeast course around the periphery of a 1031 mb high centered just west of the Azores. By August 21 the central pressure of the high had dropped to 1026 mb and as steering currents became balanced, the hurricane drifted southeastward for about 24 hours. It began to be influenced by a prefrontal trough on August 22, after which it accelerated northeastward.

There were no known casualties or damages associated with Candice.

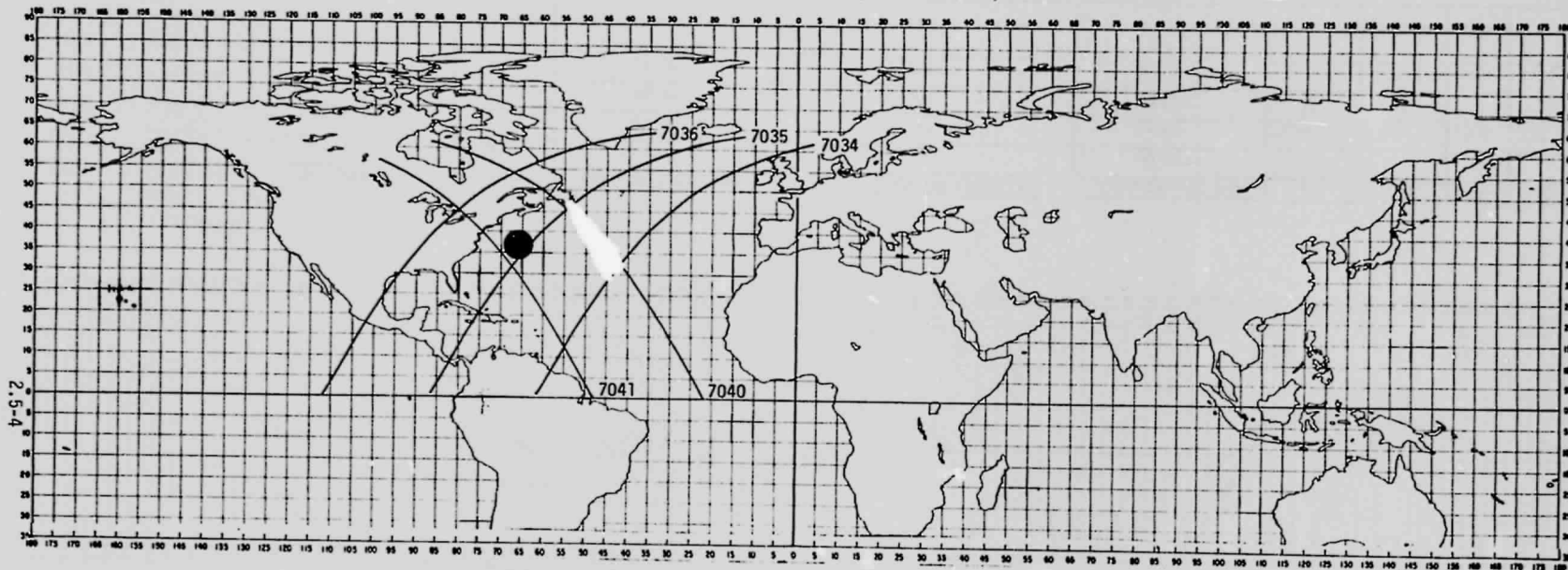
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DISTURBANCE: HURRICANE CANDICE

DATE: August 18-24, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/18	1830Z	34.0N	67.7W		27	Tropical Depression
8/19	0030Z 0630Z 1154Z 1830Z	35.3N 37.0 37.5 38.1	66.3W 65.2 65.2 64.1	996	40 45 55 45	Tropical Storm
8/20	0000Z 0630Z 1230Z 1830Z	39.0N 40.0 40.2 40.6	63.7W 62.5 61.7 61.1	1006	40 45 45 45	Tropical Storm
8/21	0030Z 0630Z 1204Z 1830Z	41.3N 41.2 41.0 40.4	60.0W 58.9 59.3 58.8	989	45 45 45 45	Tropical Storm
8/22	0030Z 0630Z 1231Z 1831Z	40.3N 40.8 41.1 41.2	57.8W 57.8 56.7 56.8		65 65 65 65	Hurricane
8/23	0030Z 0630Z 1230Z 1830Z	41.6N 42.5 43.2 44.6	55.6W 54.2 52.8 50.9		65 65 65 65	Hurricane
8/24	0030Z 0630Z	46.1N 47.2	48.1W 45.7		65 65	Hurricane Extratropical

HURRICANE CANDICE - 8/19/78 (0000Z - 2400Z)

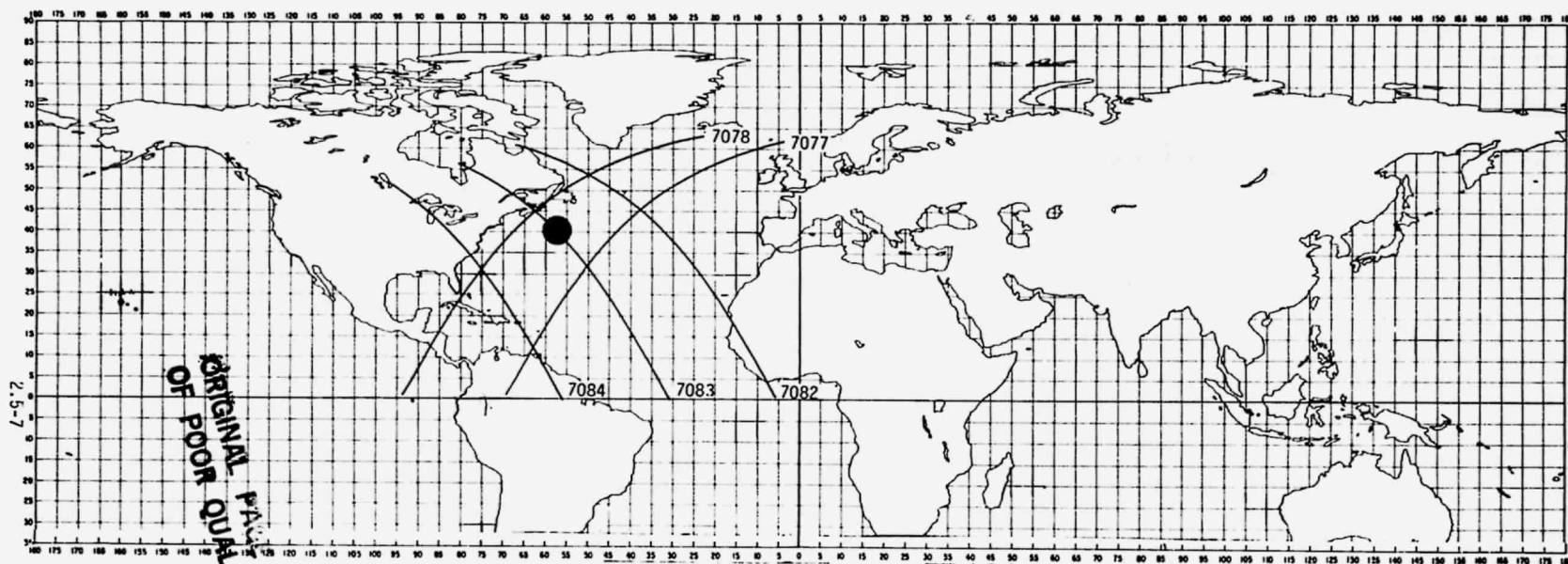


LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	35.3N	66.4W
0600Z	36.3	65.9
1200Z	37.5	65.1
1800Z	38.1	64.3
2400Z	39.0	63.7

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7034	128.03	035043	0433Z	No			
7035	103.36	153231	0611Z	060809	061911	708	143
7036	78.04	071418	0748Z	075200	075930	808	144
7040	-23.25	140126	1416Z	No			
7041	048.57	154313	1554Z	154227	155620	808	

HURRICANE CANDICE - 8/22/76 (0000Z - 2400Z)

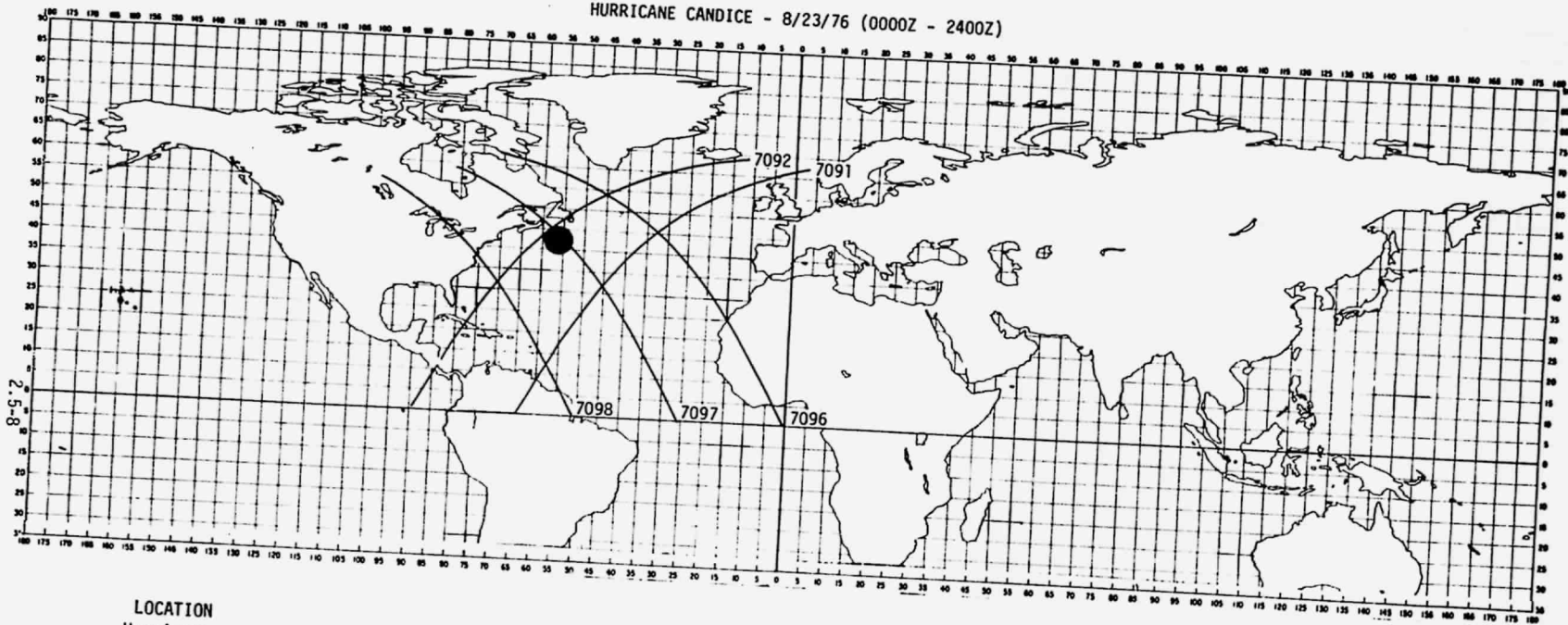


LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	40.3N	57.9W
0600Z	40.9	58.0
1200Z	41.6	56.8
1800Z	41.4	56.5
2400Z	41.7	56.1

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7077	119.80	044725	0527Z	No			
7078	94.47	062912	0704Z	070329	071610	708	190
7082	-6.81	141620	1434Z	No			
7083	-32.13	145807	1511Z	No			
7084	-57.45	163954	1650Z	164247	165108	808	196

HURRICANE CANDICE - 8/23/76 (0000Z - 2400Z)



LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	41.7N	56.1W
0600Z	42.3	54.6
1200Z	43.1	52.7
1800Z	44.2	51.9
2400Z	46.0	48.0

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7091	125.29	043222	0512Z	No			
7092	99.96	061409	0650Z	065004	070049	808	103
7096	-1.32	130117	1319Z	No			
7097	-26.64	144304	1456Z	No			
7098	-51.97	162451	1635Z	163150	163852	808	107

TROPICAL STORM DOTTIE

August 17-21, 1976

Dottie began spectacularly and ended ignominiously. The initial low center which became Dottie formed about 150 nm northwest of Key West during the evening of August 17 in response to a strong upper level trough which moved rapidly southward into the eastern Gulf of Mexico. On the next morning, the center consolidated between Dry Tortugas and Key West as pressure fell 8 mb in 24 hours in the area. The depression drifted slowly east and northeast during the next 24 hours with the pressure falling to 1004 mb at Key West during the early morning hours of August 19.

The system moved northeast rapidly during the morning and was named Dottie that afternoon as it reached the Atlantic near Palm Beach. The depression was not upgraded to a storm in the morning because of the uncertainty that the center might remain over land. However, post-analysis indicates storm strength was attained by 1200 GMT. Air Force reconnaissance reports indicated 35 kt winds near the middle Keys around mid-morning and 35-45 kt gusts were reported in the middle and upper Keys and on Grand Bahama during the day. In addition, 24 hour rainfall amounts of 5 inches were common in the Greater Miami area with one report of over 8 inches in Coral Gables.

Building high pressure north of the storm indicated Dottie would turn more to the west. Also, conditions appeared favorable for further strengthening. Accordingly, gale warnings were issued at 2200 GMT August 19 from Jacksonville, FL, to Virginia Beach, including Pamlico and Albermarle Sounds, and a hurricane watch from Savannah, GA, to Cape Hatteras, NC. The hurricane watch was extended to Jacksonville at 1000 GMT the next morning when it appeared the center was slowing and turning more to the west. However, the storm continued north and moved inland near Charleston, SC during the evening.

Dottie strengthened after moving off the Florida coast and an Air Force plane found the storm's minimum central pressure of 996 mb and maximum estimated surface winds of 45 kt around 0600 GMT August 19 when the center was about 75 miles northeast of Daytona Beach. Strong high-level winds over the storm caused weakening thereafter and Dottie was barely of tropical storm strength at landfall.

Gusts of 35-40 kt were reported at beach locations near Wilmington, NC. Tides were 3.5 ft above normal at Atlanta Beach, NC, and ranged from 1-2 ft above normal from Jacksonville Beach to the North Carolina Outer Banks. Carolina Beach had a storm rainfall of 7.78 inches with amounts of 4-6 inches over the remainder of coastal North Carolina near Wilmington.

The low pressure center which was the remnant of Dottie moved back over the water on August 22. It almost retraced the storm track, south and then southwest across central Florida into the Gulf of Mexico where it lost its identity on August 25. No strong winds or significant shower activity were associated with the low and it has not been included in the track.

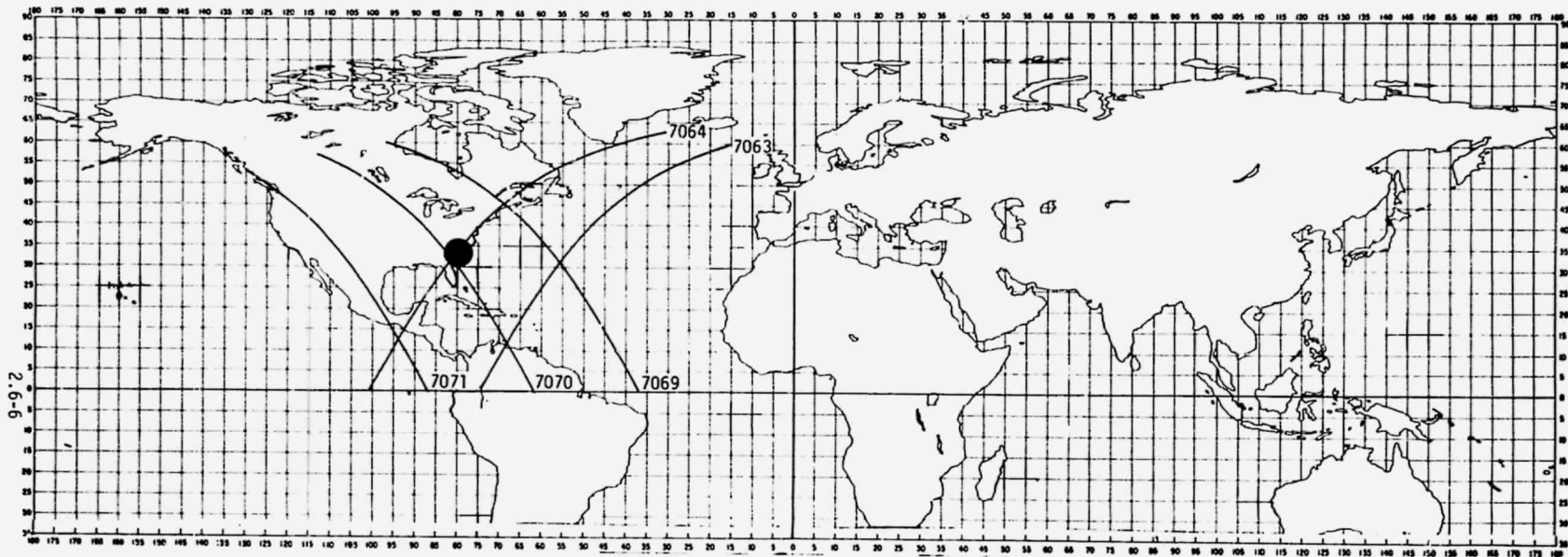
Four deaths resulted from Dottie when a fishing boat was down on August 19 near Grand Bahama Bank. Damage from the storm was minor, occurring mainly as beach erosion from Georgia to North Carolina.

DISTURBANCE: TROPICAL STORM DOTTIE

DATE: August 17-21, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/19	1230Z	25.0N	81.5W		25	Tropical Depression
	1830Z	26.5	80.0		25	
8/20	0030Z	28.6N	79.8W		30	Tropical Depression
	0700Z	29.9	80.3		45	
	1230Z	30.6	79.9		45	
	1830Z	32.1	80.0		45	
8/21	0030Z	32.8N	79.8W		45	Tropical Storm

TROPICAL STORM DOTTIE - 8/21/76 (0000Z)



LOCATION
Tropical Depression

TIME	LATITUDE	LONGITUDE
0000Z	32.7N	80.0W
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---	---	---
---	---	---
---	---	---

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7063	114.82	050227	0546Z	No			
7064	89.00	064414	0724	No			
7069	-37.61	151309	1526Z	No			
7070	-62.93	165456	1705Z	165800	170512	808	184
7071	-83.26	183643	1843Z	No			

HURRICANE EMMY

August 20 - September 4, 1976

A tropical disturbance moved off the African coast on August 15. After traveling westward at 15-20 kt for several days, a depression formed 1000 nm east of the Lesser Antilles on August 20. This depression gradually strengthened as it slowed to 10 kt and became Tropical Storm Emmy on August 22 at a position 300 nm east of the Leeward Islands.

Emmy was now moving northwest about 15 kt and by late on August 24, recurvature began. Emmy had reached hurricane force on August 25 and was heading eastward, an unprecedented course for the time of year at this low latitude. The rapid development of an unseasonal low pressure system in the mid-Atlantic northeast of Emmy was responsible for the early recurvature.

Emmy resumed a north to northwest course from August 26-28 encountering strong upper level westerlies and again turning to the east on August 29. The hurricane maintained an easterly direction for the next several days. On September 2, Emmy turned northward, crossing the central Azores. Weakening commenced as Hurricane Frances approached and Emmy was finally absorbed by the large circulation of Frances on September 4.

The storm's highest intensity was reached on August 29 when a reconnaissance aircraft reported a wind of 90 kt and a central pressure of 974 mb.

Several ships were buffeted by the high seas and winds of Emmy, but there were no reports of significant damage. A Venezuelan Air Force plane carrying a school choir to Europe crashed while attempting to land at Lajes Air Force Base in the Azores while the storm was in progress and 68 people were killed.

DISTURBANCE: HURRICANE EMMY

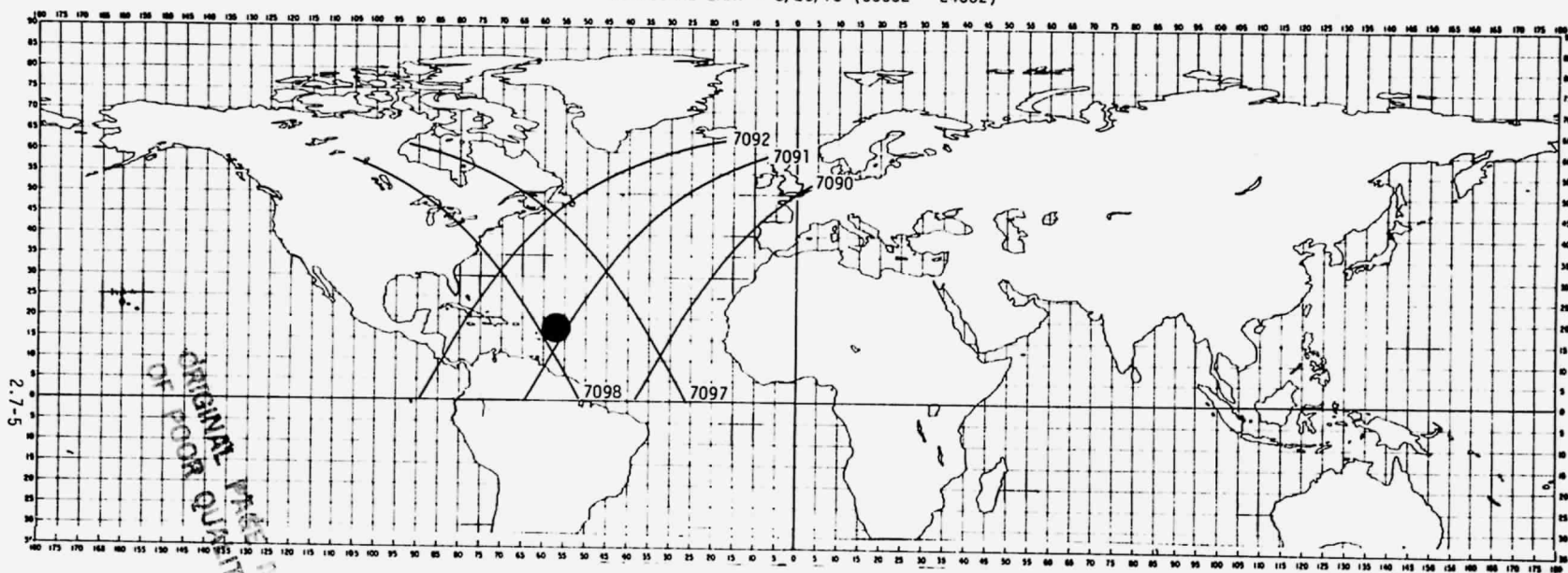
DATE: August 20 - September 4, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/22	1231Z	15.8N	55.6W	1003	33	Tropical Depression Tropical Storm
	1830Z	16.9	57.4		50	
8/23	0030Z	17.7N	58.6W		50	Tropical Storm
	0630Z	18.6	59.7		55	
	1230Z	19.7	61.0		60	
	1830Z	20.3	62.0		60	
8/24	0030Z	21.3N	62.9W	999	60	Tropical Storm
	0630Z	22.3	63.2		60	
	1107Z	23.5	64.9		70	Hurricane Tropical Storm
	1830Z	24.6	64.7		55	
8/25	0030Z	25.4N	64.5W	989	45	Tropical Storm
	0630Z	26.3	63.4		45	
	1230Z	26.7	62.0		60	Hurricane
	1830Z	26.7	60.0		65	
	2314Z	26.8	59.2		65	
8/26	0030Z	26.8N	58.8W	975	65	Hurricane
	0630Z	26.8	57.4		65	
	1230Z	27.2	55.7		65	
	1801Z	27.7	54.9		75	
8/27	0030Z	28.9N	53.6W		65	Hurricane
	0630Z	29.9	53.6		77	
	1230Z	30.6	53.5		77	
	1830Z	31.9	54.1		77	
8/28	0030Z	32.5N	55.2W	978	90	Hurricane
	0630Z	33.3	56.0		90	
	1230Z	33.6	57.0		70	
8/29	0030Z	34.7N	57.4W		102	Hurricane
	0630Z	34.7	57.3		102	
	1230Z	34.9	56.6		102	
	1830Z	35.1	55.7		102	

DISTURBANCE: HURRICANE EMMY (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/30	0030Z	35.0N	53.4W		102	Hurricane
	0630Z	35.0	52.7		77	
	1230Z	34.9	51.9		70	
	1830Z	34.5	50.6		65	
8/31	0030Z	34.9N	48.2W		65	Hurricane Tropical Storm
	0630Z	34.7	46.4		55	
	1230Z	35.2	44.7		45	
	1830Z	35.4	42.5		50	
9/1	0030Z	35.8N	39.9W		50	Tropical Storm
	0630Z	35.5	37.3		50	
	1230Z	35.0	36.5		45	
	1830Z	34.8	34.9		45	
9/2	0030Z	33.8N	33.0W		45	Tropical Storm
	0630Z	33.2	31.6		50	
	1230Z	33.6	30.6		50	
	1800Z	34.4	29.2		50	
9/3	0030Z	35.8N	28.3W		50	Tropical Storm
	0630Z	36.8	28.4		50	
	1231Z	37.2	28.3		50	
	1800Z	38.0	28.1		40	
9/4	0030Z	38.8N	26.8W		40	Tropical Storm

HURRICANE EMMY - 8/23/76 (0000Z - 2400Z)

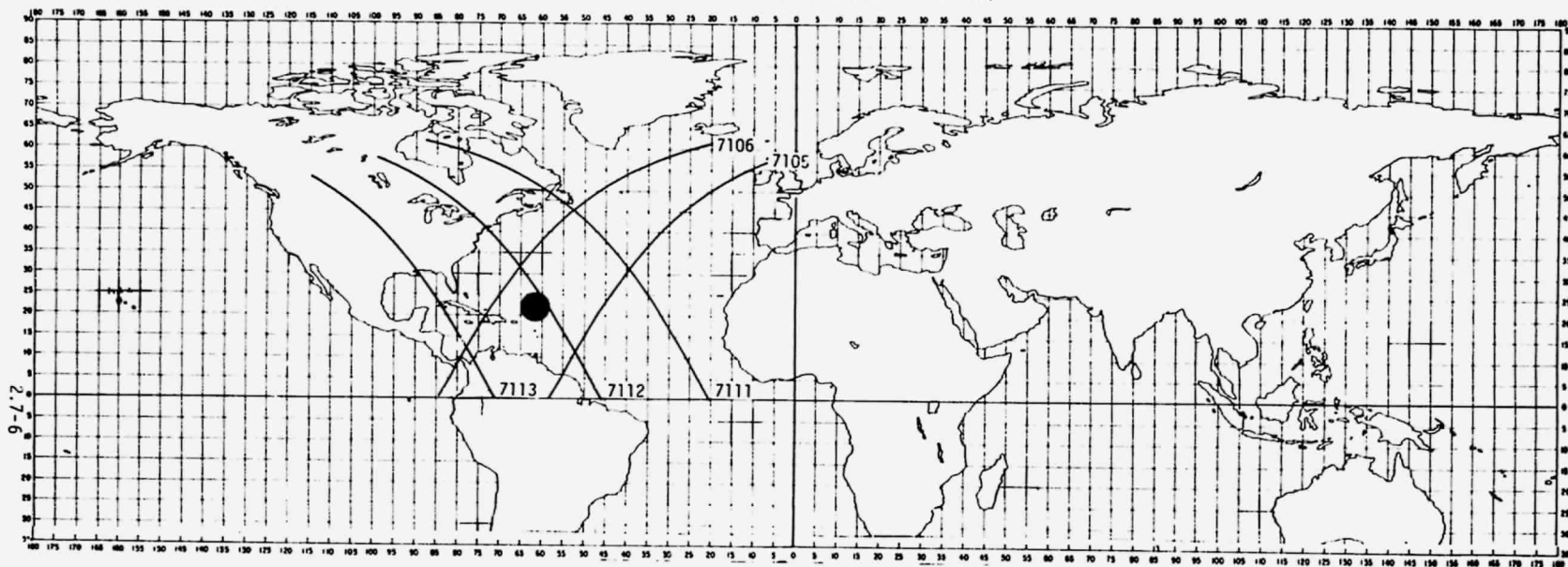


LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	17.2N	58.4W
0600Z	18.5	60.0
1200Z	19.6	61.0
1800Z	20.1	61.8
2400Z	21.3	62.8

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7090	150.61	025035	0338Z	032059	034253	802	102
7091	125.29	143222	0517Z	No			
7092	99.96	061409	0655Z	065004	070049	808	103
7097	-26.64	044304	1452Z	No			
7098	-51.97	162451	1630Z	163150	163852	808	108

HURRICANE EMMY - 8/24/76 (0000Z - 2400Z)



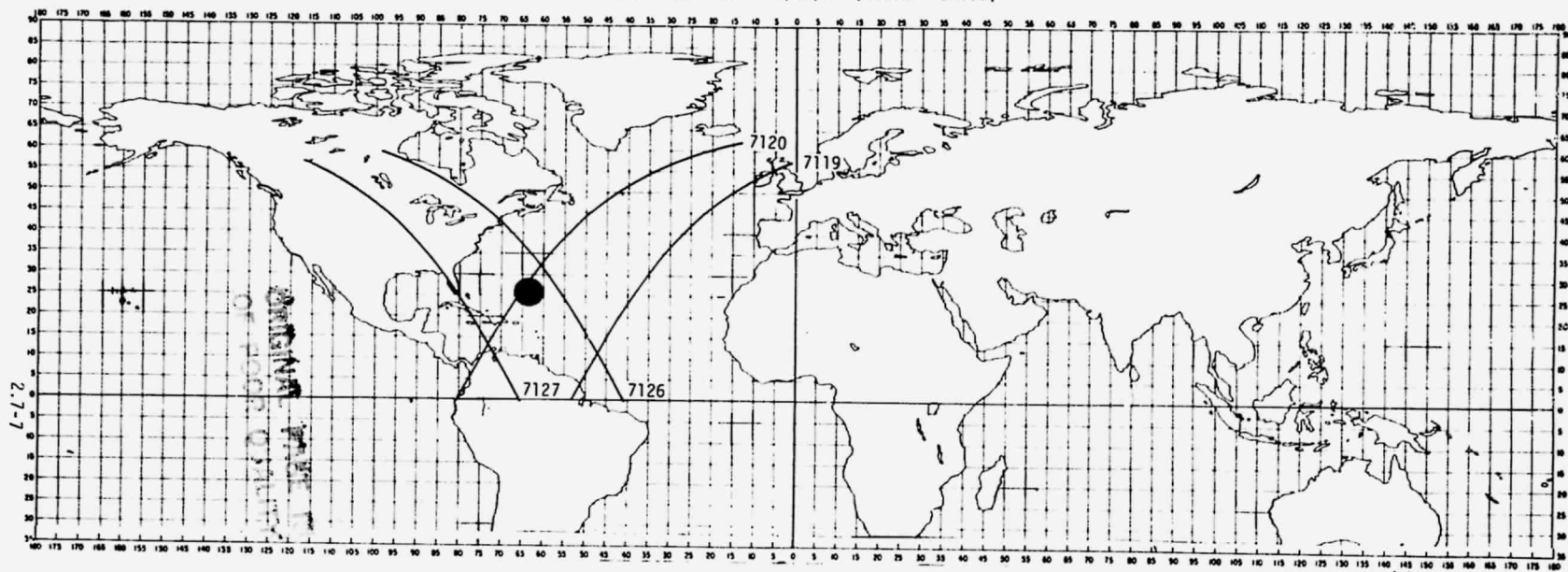
LOCATION

Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	21.3N	62.8W
0600Z	22.4	63.6
1200Z	23.8	65.0
1800Z	24.7	64.8
2400Z	25.4	64.7

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNITQ.#
7105	130.77	041720	0503Z	No			
7106	105.44	055907	0641Z	063546	064602	708	114
7111	-21.16	142802	1440Z	No			
7112	-46.49	160949	1618Z	154821	162326	808	
7113	-71.81	175136	1756Z	No			

HURRICANE EMMY - 8/25/76 (0000Z - 2400Z)

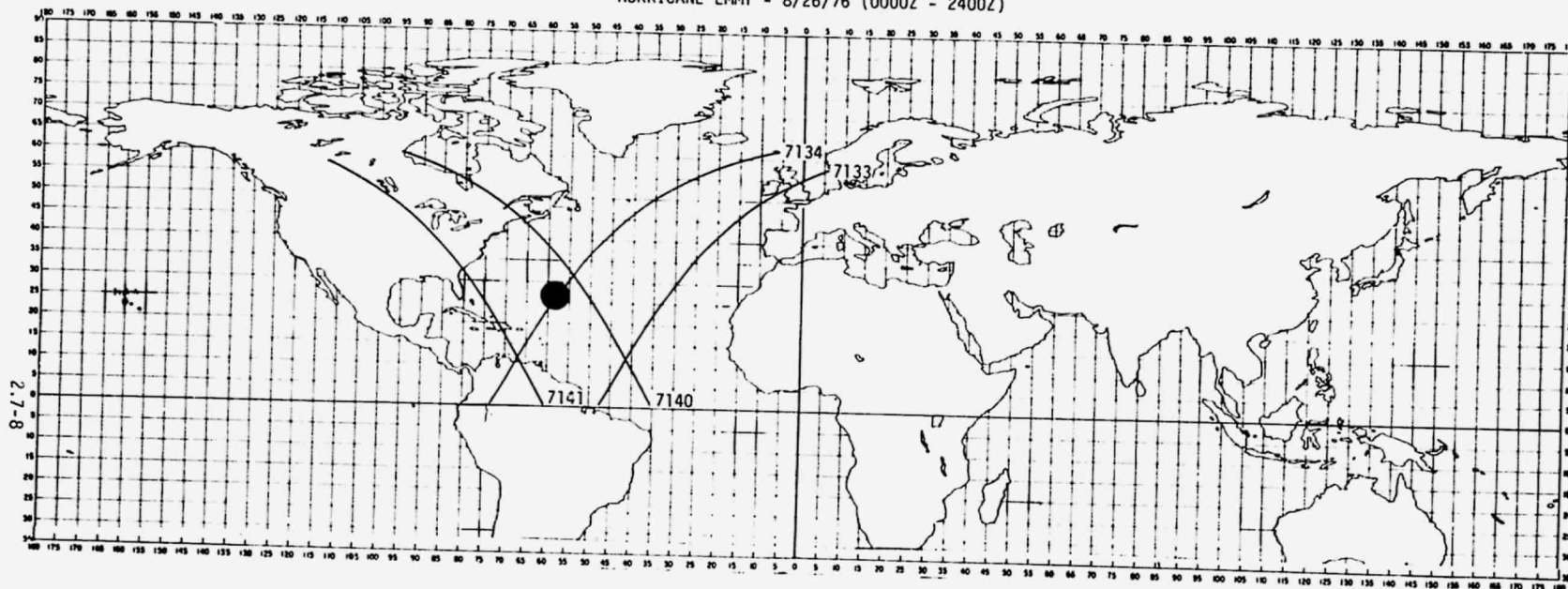


LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	25.4N	64.7W
0600Z	26.1	63.8
1200Z	26.5	62.1
1800Z	26.7	60.0
2400Z	26.8	59.1

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7119	136.24	040218	0447Z	No			
7120	110.92	054405	0626Z	062154	063115	808	126
7126	-41.01	155447	1604Z	No			
7127	-66.33	173634	1742Z	174030	174459	808	130

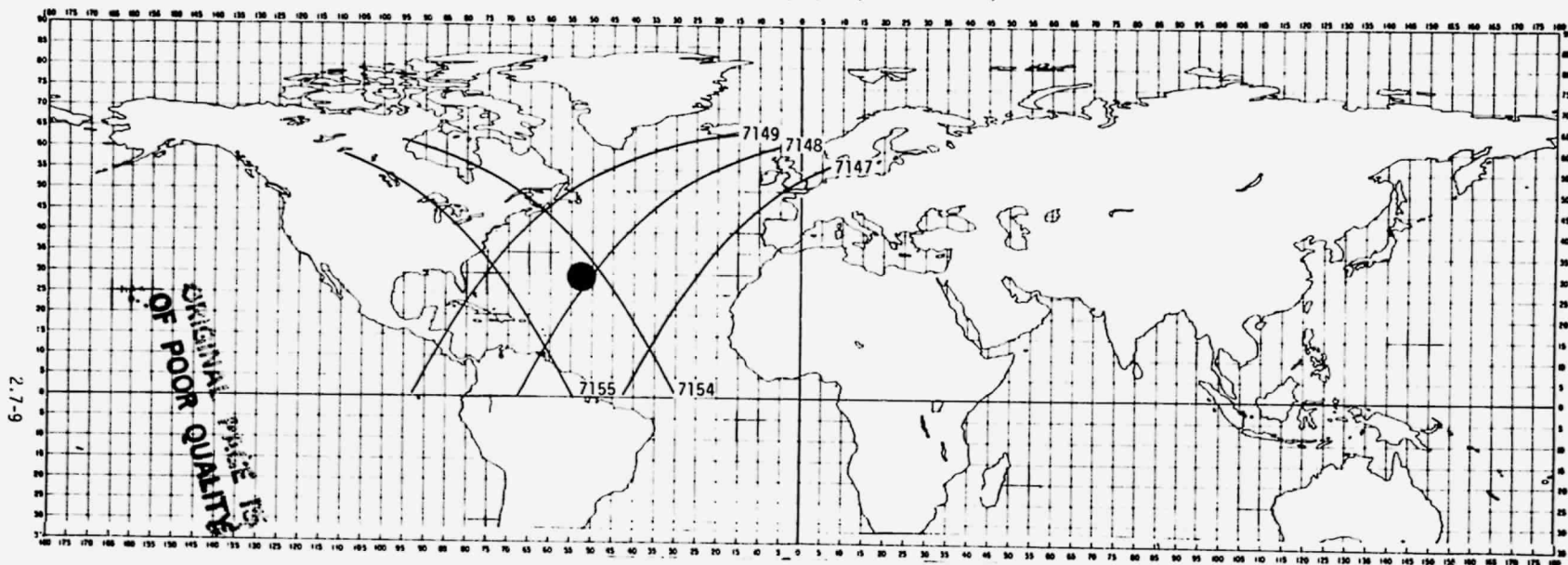
HURRICANE EMMY - 8/26/76 (0000Z - 2400Z)



TIME	LOCATION	
	LATITUDE	LONGITUDE
0000Z	26.8N	59.1W
0600Z	27.0	57.6
1200Z	27.1	55.9
1800Z	27.9	54.6
2400Z	28.9	53.8

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7133	141.72	034716	0432Z	No			
7134	116.40	052903	0611Z	No			
7140	-35.53	153945	1548Z	No			
7141	-60.85	172132	1727Z	No			

HURRICANE EMMY - 8/27/76 (0000Z - 2400Z)



2.7-9

LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	28.9N	53.8W
0600Z	30.0	53.3
1200Z	30.7	53.5
1800Z	31.7	54.1
2400Z	32.5	55.2

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7147	147.20	033214	0417Z	No			
7148	121.88	051401	0555Z	No			
7149	96.56	065548	0734Z	073108	074244	808	147
7154	-30.05	152443	1534Z	No			
7155	-55.37	170630	1713Z	171102	171759	808	151

SUBTROPICAL STORM #3

September 13-17, 1976

On September 12, the interaction between a midtropospheric low and a diffuse stationary front caused the formation of a surface low pressure system over central Florida. This low moved northward and developed into a subtropical storm late on September 13 as the center moved offshore just north of Jacksonville, FL. After only a short overwater trajectory the storm crossed the coast just below Charleston, SC on September 14. The system, now weakening overland, moved north-northeast through the mid-Atlantic states, finally dissipating over Virginia on September 17.

A large high pressure system located over the mid-Atlantic states, north of the low, produced a strong pressure gradient which caused gale force winds off the Georgia and Carolina coasts during the passage of the storm. Charleston reported gusts to near 50 kt in the downtown area shortly before the storm center reached the coast. Heavy rains accompanied the storm over eastern Georgia, South Carolina and southeastern North Carolina. Most reporting stations in those areas reported between 3 and 6 inches. Tides were 2-3 ft above normal along the Carolina coasts. Damage was mainly confined to minor beach erosion and local stream flooding.

DISTURBANCE: SUBTROPICAL STORM #3
 DATE: September 13-17, 1976

Date	Time	Position		Pressure (MBS)	Wind (KTS)	Stage
		Latitude	Longitude			
9/13	1200Z	28.0N	81.5W			
9/14	0000Z	29.5N	81.5W	1015		
	1200Z	31.0	81.0			
9/15	0000Z	32.3N	80.7W	1011	40	
	1200Z	33.9	80.0			
9/16	0000Z	35.0N	79.0W			
	1200Z	36.0	78.8			
9/17	0000Z	37.0N	78.0W	1014		

HURRICANE FRANCES

August 27 - September 7, 1976

Frances followed an unusual track through the central Atlantic, similar to the path of Emmy, with which it coexisted for 6 days.

A tropical wave crossed the African coast on August 24 and became a depression 3 days later as it moved westward in the trade wind belt. The first reconnaissance flight into the system found winds of 50 kt and a minimum pressure of 1002 mb on August 28, at which time the new storm was designated Frances.

Early on August 28 Frances crossed about 1000 nm to the south of Hurricane Emmy, near longitude 53°W. Shortly thereafter the storm took a northwestward turn into the weakness in the Bermuda-Azores high left by Emmy.

The storm became a hurricane on August 30 and reached its maximum intensity on September 1, when winds of 100 kt were measured by reconnaissance aircraft along with a minimum pressure of 963 mb.

Frances continued to follow in the trough left by Emmy, and turned toward the east during September 1. This hurricane recurved south of latitude 30°N which, except for Emmy's first eastward turn, was unprecedented for that time of year. At that time, the two hurricanes, together with a low near the Azores and a frontal trough to the northwest, produced an enormous area of negative surface pressure anomalies stretching from Europe westward through the Azores to Bermuda, and from the Virgin Islands to Newfoundland.

As Frances turned toward the east and then northeast toward the Azores, it gradually weakened. Satellite pictures suggest that it had lost tropical characteristics by the morning of September 4. The extratropical stage of the storm passed through the eastern Azores on the next day. Then the remaining low pressure center made a counterclockwise loop to the north of the Azores. For several days after that, the residual weak circulation in the cloud pattern could be tracked as it moved southwestward, parallel to, and a short distance south of the earlier track of Frances.

No reports of damage or casualties caused by Frances were received.

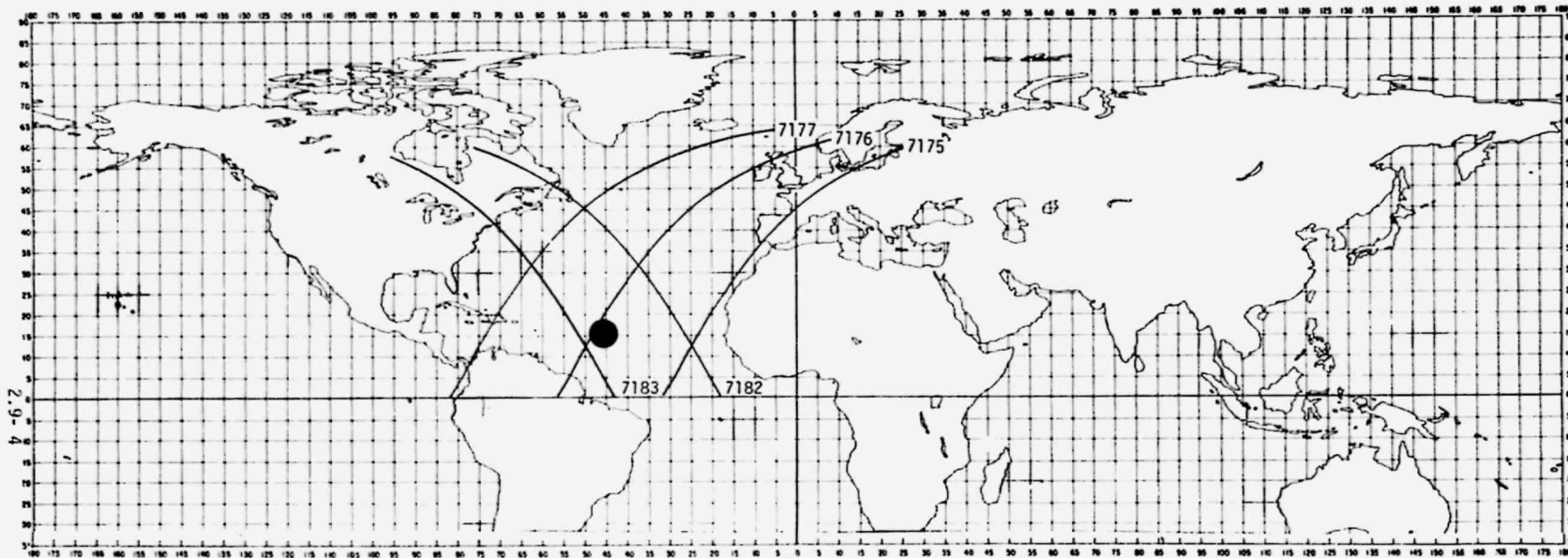
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DISTURBANCE: HURRICANE FRANCES

DATE: August 27 - September 7, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/28	1830Z	14.5N	45.3W		30	Tropical Depression
8/29	0030Z 0630Z 1230Z 1815Z	15.0N 16.1 16.5 17.8	46.4W 47.8 49.6 50.6	998 994	35 45 50 60	Tropical Storm
8/30	0030Z 0630Z 1230Z 1750Z	18.7N 18.8 19.7 20.4	51.6W 52.7 53.9 54.3	988	65 65 65 60	Hurricane
8/31	0030Z 0530Z 1100Z 1758Z	21.1N 22.0 23.0 24.1	54.3W 54.9 54.8 55.2	980 975 978	65 60 65 85	Hurricane
9/1	0030Z 0630Z 1230Z 1830Z	25.1N 26.3 26.9 28.0	54.8W 54.2 53.6 52.5		90 90 90 95	Hurricane
9/2	0030Z 0630Z 1230Z 1800Z	28.2N 28.2 28.3 28.7	51.2W 49.7 48.6 47.3		95 95 95 85	Hurricane
8/3	0030Z 0630Z 1231Z 1830Z	28.9N 28.8 29.7 30.4	44.6W 42.6 40.8 39.1		71 65 65 60	Hurricane Tropical Storm
9/4	0030Z	32.2N	36.6W		55	Tropical Storm

HURRICANE FRANCES - 8/29/76 (0000Z - 2400Z)



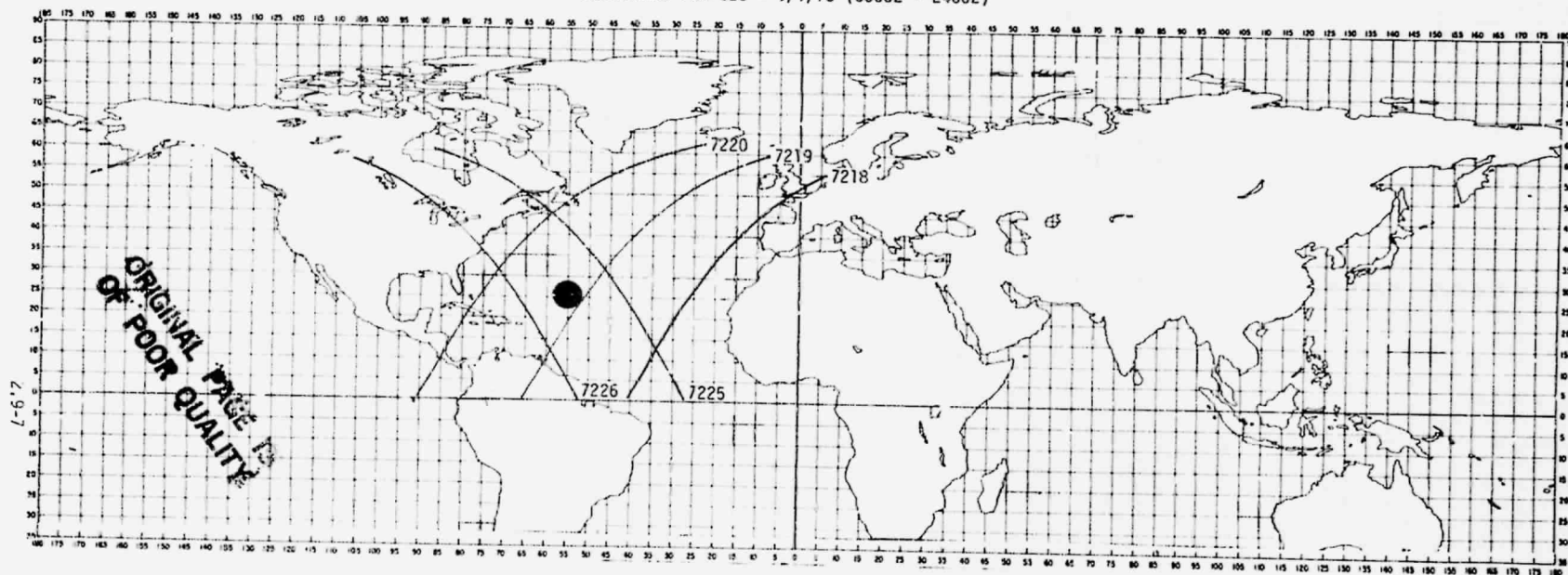
LOCATION

Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	15.0N	46.4W
0600Z	16.1	47.8
1200Z	16.6	49.6
1800Z	17.5	50.6
2400Z	18.5	51.5

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7175	158.16	030211	0351Z	134601	035516	802	167
7176	132.84	044358	0529Z	No			
7177	107.51	162545	0706Z	070251	071247	808	168
7182	-19.02	145440	1552Z	No			
7183	-44.41	163627	1641Z	161511	165010	802	

HURRICANE FRANCES - 9/1/76 (0000Z - 2400Z)



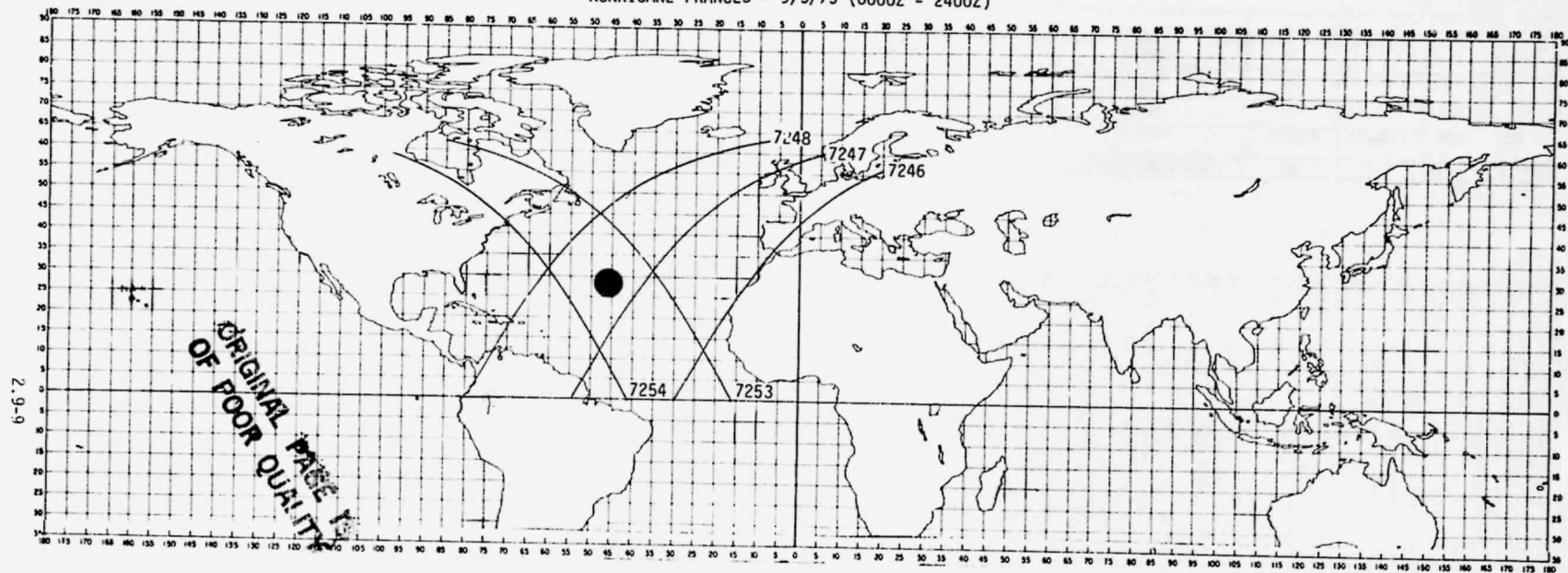
LOCATION

Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	25.2N	55.0W
0600Z	26.3	54.3
1200Z	27.2	53.8
1800Z	28.0	52.5
2400Z	28.5	51.5

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7218	149.28	035852	0445Z	No			
7219	123.95	054039	0623Z	No			
7220	98.63	072226	0801Z	075810	080918	808	124
7225	27.97	155121	1601Z	No			
7226	-53.30	173308	1739Z	173800	174011	808	128

HURRICANE FRANCES - 9/3/75 (0000Z - 2400Z)



LOCATION
Hurricane

TIME	LATITUDE	LONGITUDE
0000Z	28.9N	45.6W
0600Z	29.0	43.5
1200Z	29.2	41.5
1800Z	30.1	39.5
2400Z	31.6	37.0

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7246	160.24	032848	0407Z	041253	042201	802	144
7247	134.91	051035	0552Z	No			
7248	109.49	065222	0729Z	072954	073918	808	146
7253	-17.01	152117	1531Z	No			
7254	-42.34	170304	1710Z	No			

HURRICANE GLORIA

September 26 - October 4, 1976

Gloria originated as a tropical wave which moved westward off of the African coast on September 18. This wave traveled toward the west-northwest at 10 kt, reaching a location approximately 400 nm northeast of the Leeward Islands of the Caribbean on September 26. While this was occurring, an upper-tropospheric cold low moved toward the southwest from a position in the central Atlantic midway between the Leeward Islands and the Azores.

On September 23, the upper low came close enough to the wave so that the cloud features, which were not enhanced by the combining synoptic systems, started to show signs of becoming better organized. On September 26, the low-level circulation became sufficiently well defined to locate a tropical depression 400 nm northeast of the Leeward Islands.

The depression moved northward to northwestward at less than 10 kt for a few days while gradually intensifying. It became Tropical Storm Gloria at 1200 GMT on September 27 and a hurricane at 0600 GMT two days later.

At the time Gloria reached hurricane intensity, the storm was located about 300 nm southeast of Bermuda and heading in a northwesterly direction. This was the only time that there was a threat to any land area and this was not considered to be a serious problem as the storm was forecast to turn back to the north and then northeast before coming very close to Bermuda.

During this time a series of short-wave troughs in the westerlies were moving across the Canadian Maritime Provinces and out over the North Atlantic. So as Gloria moved farther north, it became increasingly more likely that it would recurve toward the northeast. This finally occurred early on September 30 and the hurricane moved eastward to northeastward for the next several days while gradually weakening.

Maximum winds decreased to tropical storm strength on October 2 while Gloria was centered about 600 nm south of Cape Race, Newfoundland. Two days later, Gloria weakened to a depression and became extratropical on October 5 just north of the Azores.

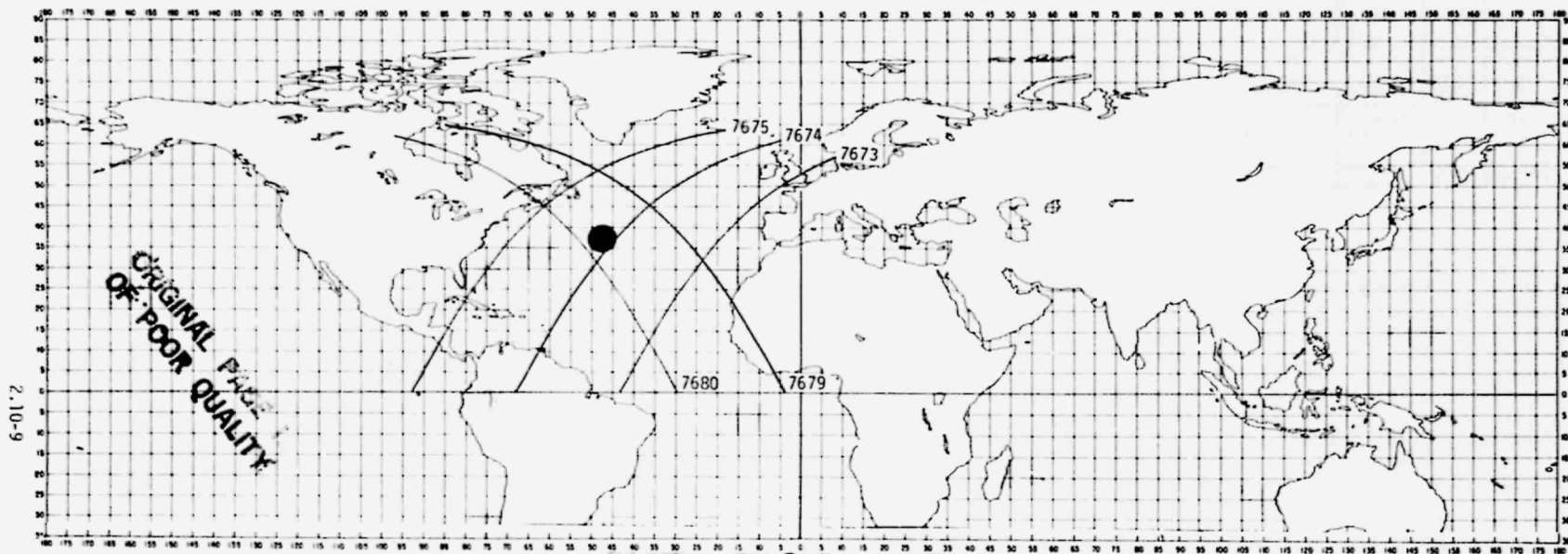
No damage or deaths are known to have been caused by Gloria. Maximum sustained surface winds are estimated to have been 90 kt and the minimum sea level pressure was 970 mb. These figures are based on aircraft reconnaissance and satellite imagery.

DISTURBANCE: HURRICANE GLORIA

DATE: September 26 - October 4, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
9/27	1301Z	25.9N	58.0W		35	Tropical Storm
	1830Z	26.2	58.1		35	
9/28	0030Z	27.1N	57.9W		45	Tropical Storm
	0630Z	27.6	58.0		45	
	1230Z	27.8	58.5		45	
	1840Z	28.3	59.0		45	
9/29	0030Z	28.8N	59.2W	980	45	Tropical Storm
	0630Z	29.2	59.7		45	
	1330Z	29.6	60.1		65	Hurricane
	1830Z	30.3	60.2		77	
9/30	0030Z	31.1N	59.9W	980	77	Hurricane
	0630Z	32.2	59.7		84	
	1200Z	33.0	58.8		90	
	1830Z	34.1	57.2		90	
10/1	0030Z	34.7N	56.0W		90	Hurricane
	0630Z	35.1	54.7		83	
	1230Z	35.7	53.6		77	Tropical Storm
	1830Z	35.6	52.5		60	
10/2	0030Z	36.2N	51.5W		60	Tropical Storm
	0630Z	36.4	50.5		60	
	1230Z	37.1	49.8		60	
	1830Z	37.0	49.0		55	
10/3	0030Z	36.7N	47.7W		55	Tropical Storm
	0630Z	35.8	46.7		55	
	1230Z	35.9	46.9		55	
	1830Z	36.1	46.6		45	

HURRICANE GLORIA - 10/3/76 (0000Z - 2400Z)



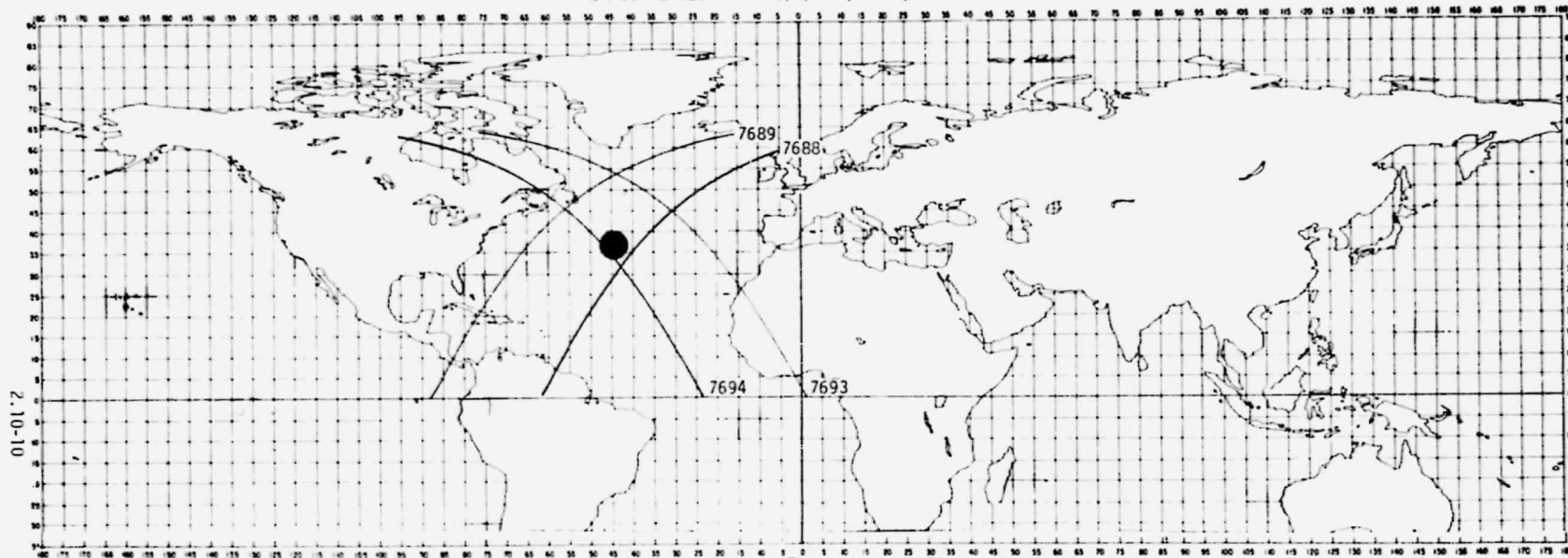
LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	37.3N	48.0W
0600Z	36.5	46.8
1200Z	35.9	46.9
1800Z	36.1	46.5
2400Z	35.7*	44.6*

* best track estimate

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7673	147.36	075019	0833Z	083324	084213	802	172
7674	122.04	093206	1011Z	No			
7675	96.72	111353	1148Z	114139	120047	808	173
7679	-4.57	180102	1816Z	181709	182435	802	177
7680	-29.89	194248	1953Z	195659	200444	802	178

HURRICANE GLORIA - 10/4/76 (0000Z)



2.10-10

LOCATION
Tropical Depression

TIME	LATITUDE	LONGITUDE
0000Z	35.7N*	44.6W*
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---	---	---
---	---	---

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7688	127.52	091704	0957Z	No			
7689	102.20	105851	1134Z	112719	114443	708	104
7693	0.91	174559	1801Z	180314	181025	802	108
7694	-24.40	192746	1938Z	No			

* best track estimate

HURRICANE HOLLY

October 22-28, 1976

A relatively weak wave moved off the coast of Africa into the Atlantic on October 14. Six days later, satellite pictures revealed that the cloudiness associated with this wave had become rather concentrated at a location 700 nm east of the Leeward Islands. Organization continued and late on October 22 the system reached depression stage. Now moving northwestward, the depression intensified to storm strength on October 23 and to a minimal hurricane on the following day near latitude 25°N, longitude 58°W. This intensity was maintained for only 24 hours, after which it dropped back to tropical storm status. This status continued until the storm lost its identity as it merged with a strong cold front over the North Atlantic on October 28.

Upper air conditions were not considered particularly favorable for tropical development when the system first reached the depression stage on October 22. At 200 mb the flow was generally cyclonic over the developing storm as an upper low was located just to the north of the depression. By the time Holly became a hurricane, however, the upper low had opened into a trough lying from 5° to the west of the hurricane's position. This configuration resulted in anticyclonic flow over the storm at 200 mb.

As the hurricane moved northeastward, the higher latitude portion of the upper trough moved eastward rapidly enough to overtake the storm. This interaction resulted in weakening of the storm and some loss of tropical structure even before it merged with the cold front.

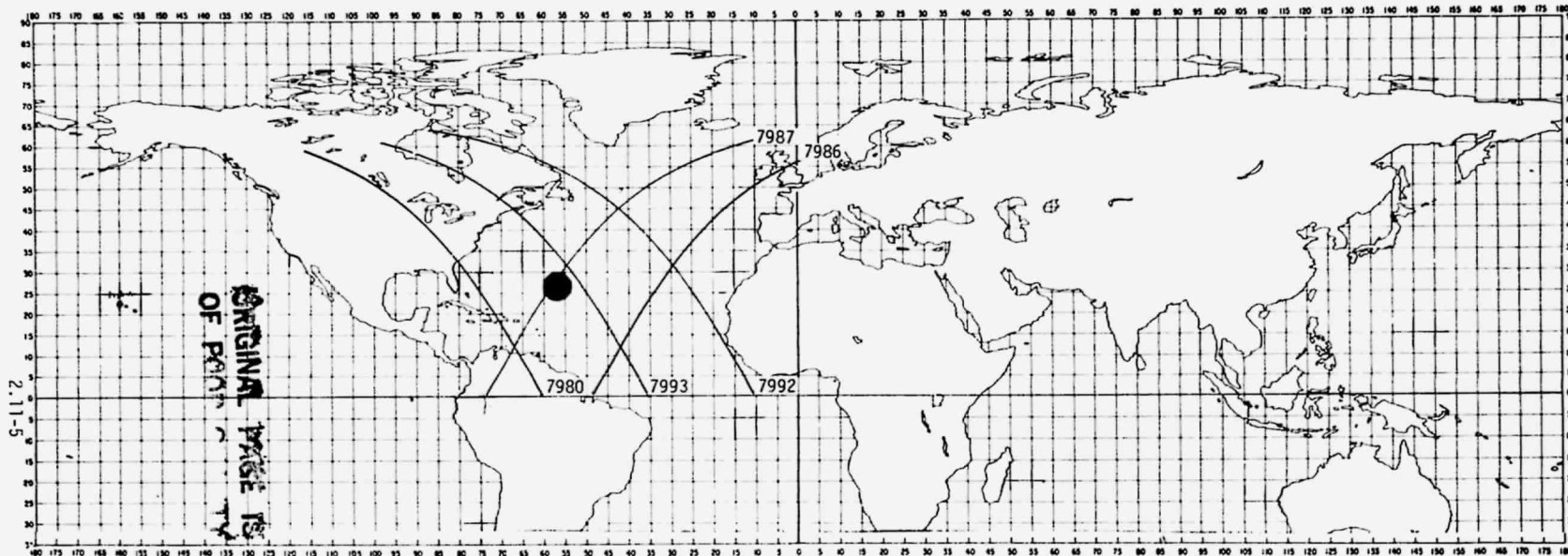
Holly's lowest pressure was 990 mb on October 24, and the highest wind reported by reconnaissance aircraft was 65 kt on the same day.

DISTURBANCE: HURRICANE HOLLY

DATE: October 22-28, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
10/23	1830Z	22.7N	58.2W		32	Tropical Depression
10/24	0030Z	23.3N	58.4W	990	32	Tropical Depression
	0630Z	24.1	58.1		32	
	1231Z	25.2	57.7		35	Tropical Storm Hurricane Tropical Storm
	1744Z	25.9	57.7		65	
	1831Z	26.1	57.7		45	
10/25	0030Z	27.2N	57.1W	1000	50	Tropical Storm
	0630Z	28.9	56.8		50	
	1256Z	31.0	55.3		50	
	1831Z	31.5	53.7		50	
10/26	0030Z	31.8N	50.4W		50	Tropical Storm
	0630Z	33.5	48.8		50	
	1230Z	32.5	51.3		40	
	1830Z	32.7	50.4		40	
10/27	0030Z	33.4N	50.2W		40	Tropical Storm
	0630Z	34.0	50.0		40	
	1230Z	34.5	49.5		40	
	1830Z	35.8	47.8		40	
10/28	0030Z	37.2N	45.3W		40	Tropical Storm
	0630Z	39.5	42.8		35	
	1230Z	42.5	39.0		35	Tropical Depression
	1830Z	45.0	34.5		30	

HURRICANE HOLLY - 10/25/76 (0000Z - 2400Z)



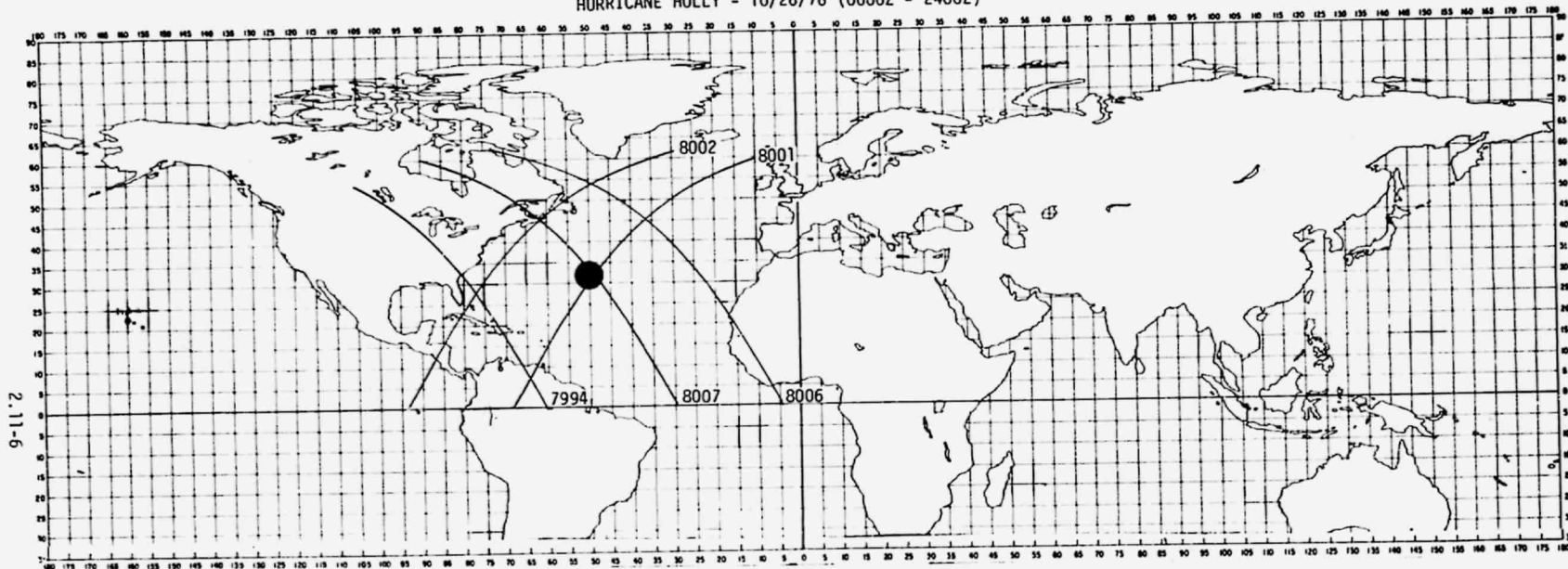
2.11-5

LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	27.2N	57.5W
0600Z	28.9	56.8
1200Z	30.8	55.0
1800Z	31.5	53.5
2400Z	32.2	50.5

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7980	-66.74	003749	0042Z	No			
7986	141.31	104831	1133Z	113138	113930	802	104
7987	115.99	123018	1311Z	No			
7992	-10.61	205913	2114Z	No			
7993	-35.94	224100	2251Z	224751	230207	808	113

HURRICANE HOLLY - 10/26/76 (0000Z - 2400Z)



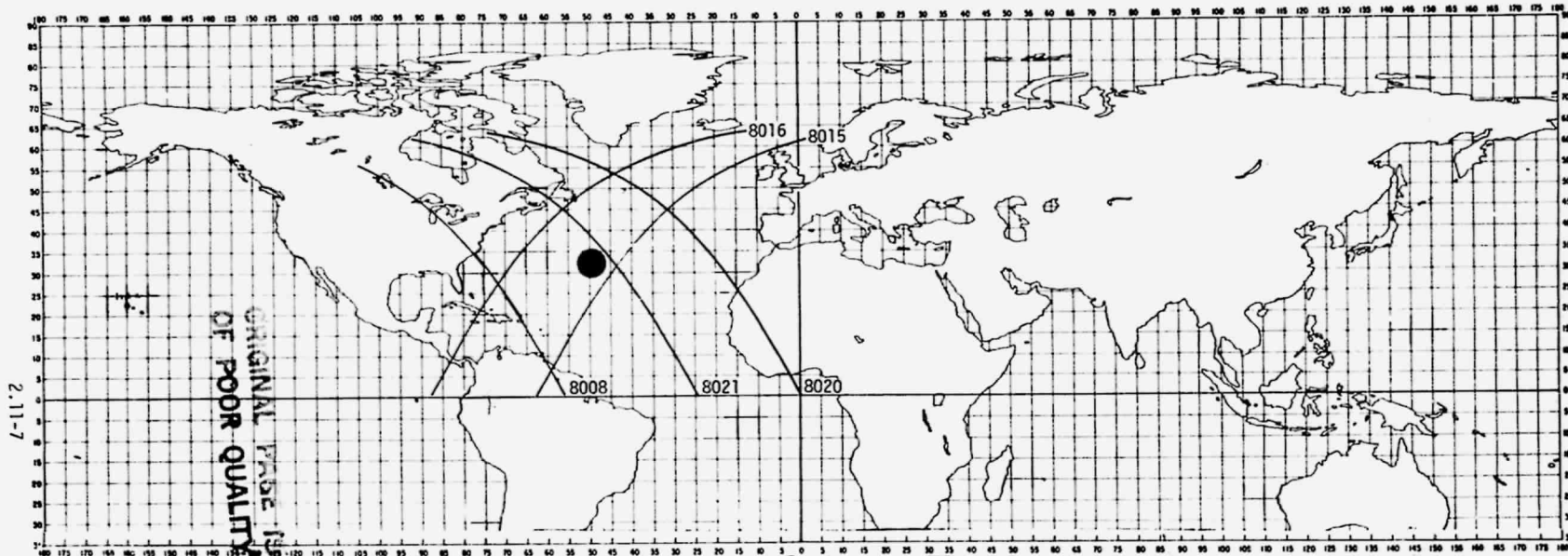
2.11-6

LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	32.2N	50.5W
0600Z	33.4	48.8
1200Z	32.5	51.3
1800Z	32.7	50.5
2400Z	33.0	49.8

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
7994	-61.26	002247	0029	002737	003327	808	115
8001	121.47	121516	1255Z	125914	130338	808	118
8002	96.15	135703	1433Z	143233	144357	808	119
8006	-5.13	204411	2059Z	210004	210741	808	123
8007	-30.46	222558	2236Z	224203	224752	808	126

HURRICANE HOLLY - 10/27/76 (0000Z - 2400Z)

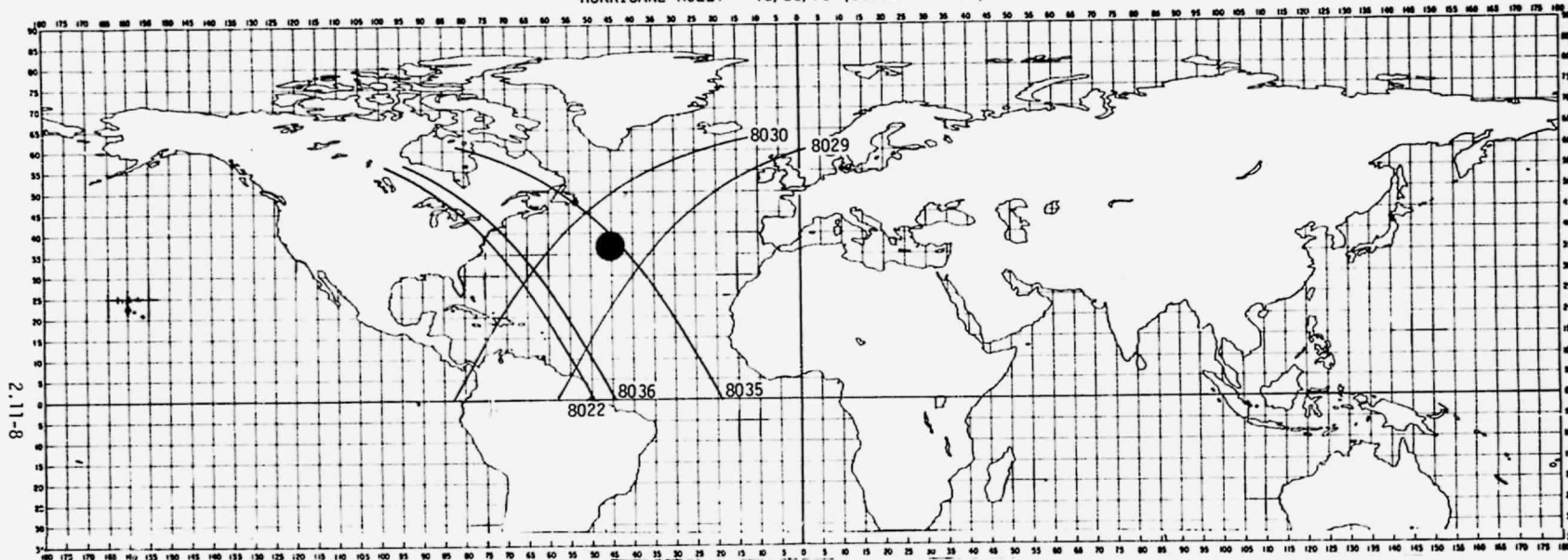


LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	33.0N	49.8W
0600Z	34.0	50.0
1200Z	33.5	49.0
1800Z	35.7	48.1
2400Z	37.2	45.3

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
8008	-55.78	000745	0015Z	000955	001911	808	127
8015	126.95	120013	1245Z	No			
8016	101.63	134200	1418Z	141514	142841	808	131
8020	0.34	202909	2045Z	204723	205331	808	137
8021	-24.98	221056	2222Z	222955	223324	808	140

HURRICANE HOLLY - 10/28/76 (0000Z - 2400Z)



2.11-8

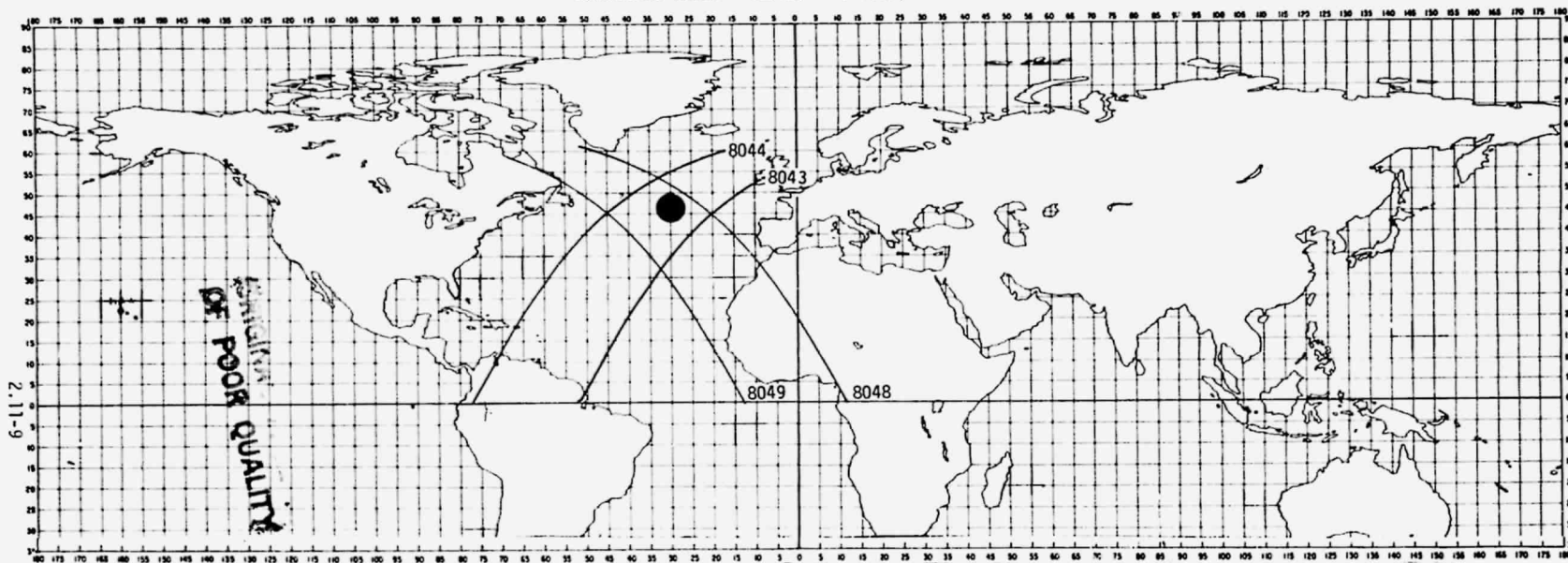
LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	37.2N	45.3W
0600Z	39.4	42.8
1200Z	41.5	39.5
1800Z	45.0	35.0
2400Z	46.5*	30.0*

* best track estimate

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
8022	-50.30	235243	0001Z	235741	000530	808	142
8029	132.43	114511	1225Z	No			
8030	107.11	132658	1403Z	135607	141403	808	148
8035	-19.50	215554	2208Z	211553	221850	808	154
8036	-44.82	233741	2347Z	234416	235124	808	156

HURRICANE HOLLY - 10/29/76 (0000Z)



LOCATION
Tropical Depression

TIME	LATITUDE	LONGITUDE
0000Z	46.5N*	30.0W*
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
8043	137.91	113009	1207Z	No			
8044	112.59	131156	1345Z	No			
8048	11.30	195905	2015Z	201953	203504	808	162
8049	-14.02	214052	2153Z	215811	220427	808	163

* best track estimate

3.0 EASTERN PACIFIC/U. S. WEST COAST AREAS

3.1 GENERAL

All of the data presented in this section on the tropical cyclones occurring in the eastern Pacific were extracted from the Monthly Weather Review article by E. B. Gunther. During the 1976 season, there were 18 tropical cyclones that occurred in this area as listed below:

*Tropical Cyclone One	(06/02/76 - 06/03/76)
*Hurricane Annette	(06/03/76 - 06/14/76)
*Hurricane Bonnie	(06/25/76 - 06/29/76)
*Tropical Cyclone Four	(06/28/76 - 06/30/76)
Tropical Storm Celeste	(06/14/76 - 07/19/76)
Hurricane Diana	(07/15/76 - 07/22/76)
Tropical Storm Estelle	(07/26/76 - 07/29/76)
Tropical Storm Fernanda	(07/27/76 - 07/30/76)
Tropical Storm Gwen	(08/05/76 - 08/14/76)
*Hurricane Hyacinth	(08/06/76 - 08/14/76)
Tropical Cyclone Eleven	(08/07/76 - 08/08/76)
Tropical Cyclone Twelve	(08/16/76 - 08/19/76)
*Hurricane Iva	(08/24/76 - 09/02/76)
*Tropical Storm Joanne	(08/29/76 - 09/08/76)
*Hurricane Kathleen	(09/07/76 - 09/10/76)
*Hurricane Liza	(09/25/76 - 10/01/76)
*Hurricane Madeline	(09/29/76 - 10/08/76)
Tropical Storm Naomi	(10/25/76 - 10/29/76)

Results of the comparison of the cyclone information and the GEOS-3 schedule information indicates that 10 cyclones may have associated GEOS altimeter data. These cyclones are marked by an * in the above tabulation. Information as available for these tropical cyclones along with any promising GEOS ground track maps are presented in the following sections.

3.2

TROPICAL CYCLONE ONE

June 2-3, 1976

The first cyclone of the 1976 season began 1200 GMT June 1 as a disturbed area near 11°N, 112°W. Moving slowly northwest, the disturbance was upgraded to a tropical depression at 1800 GMT June 2 near 12°N, 113°W. Sustained winds near the center were estimated at 30 kt with gusts to 40 kt. By 0000 GMT June 3 the depression had moved to near 13°N, 113°W and winds near the center had decreased to 25 kt with gusts to 35 kt. Turning west, the depression weakened rapidly. The last advisory issued on the cyclone was at 0600 GMT June 3 with the center near 13°N, 116°W.

DISTURBANCE: TROPICAL CYCLONE ONE

DATE: June 2-3, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
6/2	1800Z	12.5N	112.5W		30	Tropical Depression
6/3	0000Z	13.5N	113.5W		25	Tropical Depression
	0600Z	13.0	116.0			

June 3-14, 1976

The second tropical cyclone of the season began as a tropical disturbance at 1800 GMT June 4 near 11°N, 95°W. Six hours later the disturbance was upgraded to a tropical depression near 11°N, 95°W with 25 kt winds. Satellite imagery indicated little change over the next 72 hours with a loosely defined cyclonic circulation at night becoming better organized during the daylight hours. By 0600 GMT June 6 the winds increased to 40 kt near the center and the depression was upgraded to Tropical Storm Annette near 12°N, 96°W. Moving west at 5 kt, Annette was upgraded to hurricane status at 0600 GMT June 7 about 350 n mi south of Acapulco, Mexico. Winds had increased to 65 kt near the center with gusts to 85 kt. Satellite imagery indicated an eye beginning to form near the center by 1200 GMT June 7. Moving west-northwest at 8 kt over 88°F water, Annette continued to intensify. On June 9 U. S. Air Force reconnaissance aircraft flew into Annette locating the center at 14.6°N, 105.0°W at 1707. Surface winds were estimated at 90 kt and minimum surface pressure computed at 925 mb. The aircraft also reported a well-defined eye with a closed wall. Hurricane Annette reached its maximum intensity with 120 kt winds and gusts to 140 kt at 1200 GMT June 10 near 16°N, 108°W, about 300 n mi southwest of Manzanillo, Mexico. Annette continued to move westward for another 12 hours then turned northwest toward colder (78°F) water. Annette's eye was no longer visible on satellite pictures after 0600 GMT June 11 as the hurricane, under the influence of an upper level trough, moved northward over colder water. Annette was downgraded to a tropical storm with 60 kt winds at 1200 GMT on June 12 near 18°N, 113°W. Weakening rapidly, the storm was downgraded to a tropical depression with 25 kt winds at 1800 GMT June 13 near 19°N, 113°W. Two more advisories were issued on the depression before convective activity near the center dissipated by 0600 GMT June 14 near 21°N, 115°W.

DISTURBANCE: HURRICANE ANNETTE

DATE: June 3-14, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
6/3	0000Z	11.0N	95.0W		25	Tropical Depression
	1200Z	13.0	97.0			
6/4	0000Z	13.0N	97.0W			Tropical Depression
	1200Z	14.0	97.0			
6/5	0000Z	13.5N	95.0W			Tropical Depression
	1200Z	12.0	95.5			
6/6	0000Z	12.0N	96.0W		40	Tropical Storm
	0600Z	12.0	96.0			
	1200Z	11.0	97.0			
6/7	0000Z	11.2N	98.5W		65	Hurricane
	0600Z	10.8	98.8			
	1200Z	11.8	98.2			
6/8	0000Z	13.0N	100.0W			Hurricane
	1200Z	13.5	101.5			
6/9	0000Z	14.0N	103.0W	925	90	Hurricane
	1200Z	14.5	104.5			
	1707Z	14.6	105.0			
6/10	0000Z	15.2N	106.1W		120	Hurricane
	1200Z	16.0	108.5			
	1800Z	16.1	109.4			

DISTURBANCE: HURRICANE ANNETTE (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
6/11	0000Z	16.0N	110.5W			Hurricane
	1200Z	17.0	111.5			
6/12	0000Z	17.5N	112.0W		60	Tropical Storm
	1200Z	18.0	113.0			
6/13	0000Z	18.3N	112.5W		25	Tropical Depression
	1200Z	18.8	113.0			
	1800Z	19.2	113.2			
6/14	0000Z	19.5N	114.0W			Tropical Depression
	0600Z	20.9	115.0			
	1200Z	21.0	115.0			

June 25-29, 1976

Bonny began as a tropical disturbance over 86°F water near 12°N, 100°W at 0600 GMT June 22. Moving northwest, the disturbance was upgraded to a tropical depression with 30 kt winds near 16°N, 103°W, about 200 n mi west of Acapulco, Mexico, at 1800 GMT June 25. Turning west and moving at 7 kt, the depression was upgraded to tropical storm status at 1200 GMT June 26 near 16°N, 105°W. Winds near the center were estimated at 45 kt with gale winds extending out 75 n mi from the center. By 0000 GMT June 27 winds had increased to 55 kt and gale winds extended to 90 n mi from the center which was then near 16°N, 106°W. Moving west at 10 to 12 kt, Bonny was upgraded to hurricane status at 1200 GMT June 27 near 17°N, 109°W or 135 n mi southeast of Socorro Island. Winds had increased to 65 kt with gusts to 75 kt near the center and gale winds extended out 100 n mi from the center. At 1939 GMT June 27 a NOAA reconnaissance aircraft flew through Bonny locating the center at 17.2°N, 110.7°W or 90 n mi south of Socorro Island. The surface wind was estimated at 63 kt and pressure computed at 987.4 mb. Continuing west at 10-12 kt, Bonny began to move over colder (76°F) water and weaken. At 0000 GMT June 28 Bonny was downgraded to a tropical storm near 17°N, 112°W. Moving a little faster to the west, the storm was downgraded to a tropical depression with 30 kt winds near 18°N, 115°W at 1200 GMT June 29. The final advisory on the depression was issued at 1800 GMT June 29 with the center near 16°N, 117°W.

DISTURBANCE: HURRICANE BONNY

DATE: June 25-29, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
6/25	1800Z	16.0N	103.0W		30	Tropical Depression
6/26	0000Z	16.0N	103.0W		45	Tropical Storm
	1200Z	15.8	105.1			
6/27	0000Z	16.5N	106.5W	987.4	55	Hurricane
	1200Z	17.0	109.4		65	
	1939Z	17.2	110.7		63	
6/28	0000Z	17.3N	111.6W		30	Tropical Storm
	1200Z	17.7	114.8			Tropical Depression
6/29	0000Z	16.2N	115.5W			Tropical Depression
	1200Z	15.8	117.0			
	1800Z	16.2	117.2			

3.5

TROPICAL CYCLONE FOUR

June 28-30, 1976

The fourth tropical cyclone of the season began as a large area of thunderstorm activity 300 n mi in diameter in the Gulf of Tehuantepec at 1200 GMT June 28. By 1800 the area began to show definite cyclonic circulation and was classified as a tropical depression near 13°N, 96°W. By 0000 GMT June 29 the center, with 30 kt winds, had moved to near 14°N, 95°W. Moving north at 6 kt, the depression moved onshore near Salina Cruz, Mexico, at 0000 GMT June 30.

ORIGINAL PAGE IS
OF POOR QUALITY

DISTURBANCE: TROPICAL CYCLONE 4
DATE: June 28-30, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
6/28	1200Z	13.0N	96.0W			Tropical Depression
	1800Z	13.0	96.0			
6/29	0000Z	14.5N	95.3W		30	Tropical Depression
	1200Z	14.8	95.6			
6/30	0000Z	16.0N	95.5W			Tropical Depression

August 6-14, 1976

Hyacinth began as a disturbed area near 9°N, 97°W at 1800 GMT August 5. Moving west-northwest at 11 kt over 85°F water, the disturbance began to show signs of cyclonic circulation and was upgraded to a tropical depression at 1800 GMT August 6 near 12°N, 102°W. Later satellite information indicated that the center was slightly southwest of that position. Winds increased to 35 kt by 0600 GMT August 7 and the depression was upgraded and named Tropical Storm Hyacinth with the center near 12°N, 102°W. By 0000 GMT August 8 winds near the center had increased to 55 kt. Winds near the center of Hyacinth increased to 70 kt by 1200 GMT on August 9 and the storm was upgraded to hurricane intensity near 15°N, 110°W. By 1800 GMT August 9 Hyacinth, with 85 kt winds near the center, had developed a small, well-defined eye about 10 n mi in diameter near 15°N, 111°W. The *Maritime Justice*, 140 n mi south of Hyacinth at 1800 GMT August 9, reported 35 kt winds from the west and continuous heavy rain. Moving west-northwest at 6 kt, Hyacinth continued to intensify over 84°F water. Winds increased to 95 kt by 0000 GMT August 10 with the center near 15°N, 111°W. The *Maritime Justice*, 160 n mi to the southwest, reported violent rain showers with 30 kt westerly winds. The hurricane moved to near 15°N, 112°W by 0600 GMT August 10 with winds near the center increasing to 100 kt. The eye, which had developed only 12 hours earlier, was no longer visible on satellite imagery by 0600 GMT August 10. By 1800 GMT August 10 Hyacinth had moved to near 16°N, 114°W. Winds began to decrease near the center of Hyacinth after 0600 GMT August 11 as the hurricane accelerated west-northwest at 15-20 kt 500 n mi northeast of nearly stationary Tropical Storm Gwen. By 1200 GMT August 11 Hyacinth had moved to near 17°N, 117°W with 85 kt winds near the center. It continued to move west-northwest, accelerating to 25 kt by 1800 GMT August 12, with the center near 22°N, 128°W at that time. Winds decreased to 70 kt as the hurricane, now moving over cooler (74°F) water, continued to weaken. As Hyacinth passed to the north, Tropical Storm Gwen began to intensify and move northward, eventually passing 330 n mi to the east of Hyacinth at 1200 GMT August 13. Hyacinth, turning west, was downgraded to a tropical storm with 55 kt winds near 22°N, 130°W at 0000 GMT August 13. The storm turned southwestward at 1200 on the 13th and was downgraded to a tropical depression with 30 kt winds near 20°N, 137°W at 0000 GMT August 14. By 0600 GMT August 14 the depression had moved to near 20°N, 139°W. It then turned northward merging with Gwen, now a tropical depression, near 23°N, 139°W at 1200 GMT August 14. The last advisory issued by the Eastern Pacific Hurricane Center on Hyacinth was at 1200 GMT August 14 with the center near 22°N, 139°W. Gwen continued to drift westward into the Central Pacific Hurricane Center's forecast area carrying with it the remnants of Hurricane Hyacinth.

DISTURBANCE: HURRICANE HYACINTHDATE: August 6-14, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/6	1800Z	12.1N	102.2W			Tropical Depression
8/7	0000Z	12.0N	101.5W		35	Tropical Storm
	0600Z	12.0	102.0			
	1200Z	12.5	103.5			
8/8	0000Z	12.5N	106.0W		55	Tropical Storm
	1200Z	13.0	107.0			
8/9	0000Z	14.5N	108.5W		70 85	Hurricane
	1200Z	15.0	110.2			
	1800Z	15.0	111.0			
8/10	0000Z	14.8N	111.5W		95 100	Hurricane
	0600Z	15.1	112.1			
	1200Z	15.5	112.8			
8/11	0000Z	16.5N	114.5W		85	Hurricane
	1200Z	17.5	117.5			
8/12	0000Z	19.3N	120.8W		70	Hurricane
	1200Z	21.5	124.5			
	1800Z	22.0	128.0			
8/13	0000Z	22.0N	130.5W		55	Tropical Storm
	1200Z	22.0	134.5			

DISTURBANCE: HURRICANE HYACINTH (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/14	0000Z	20.5N	137.0W		30	Tropical Depression
	1200Z	22.0	139.0			

HURRICANE IVA

August 24 - September 2, 1976

Iva began as a disturbance near 13°N, 94°W, or 420 n mi southeast of Acapulco, Mexico, at 1800 GMT August 23. Moving west at 12 kt over 93°F water with warmer (85°F) water to the north and east, the disturbance intensified rapidly. Satellite pictures showed the disturbance as an area of intense thunderstorm activity 300 n mi in diameter. By 0000 GMT August 24 cyclonic circulation appeared about the center on satellite time-lapse loops and the disturbance was upgraded to a tropical depression near 13°N, 96°W. Winds increased to 35 kt by 1800 GMT August 25 and the depression was upgraded and named Tropical Storm Iva near 13°N, 104°W, about 320 n mi southwest of Acapulco. Turning west-northwest and moving at 10 kt, Iva continued to intensify, drawing warm, moist air northward from the Intertropical Convergence Zone 400 n mi to the south. By 1600 GMT August 26 NOAA 5 high-resolution satellite imagery showed Iva with a small eye approximately 10 n mi in diameter. Winds near the center increased to 65 kt by 1800 GMT August 26 and the storm was upgraded to hurricane status near 15°N, 108°W, about 300 n mi southwest of Manzanillo, Mexico. Continuing west-northwest, Iva passed 70 n mi south of Socorro Island at 0000 GMT August 28. Winds near the center increased to 110 kt and winds on Socorro Island were easterly 55 kt. By 0600 GMT August 28, the hurricane's eye had increased to 25 n mi in diameter and winds near the center had increased to 115 kt. Socorro Island, 85 n mi to the east, reported southeasterly 45 kt winds. By 1200 GMT winds on Socorro Island had decreased to 25 kt with Iva now 140 n mi to the west. As Iva continued on a west-northwesterly track, it began to move over cooler (80°F) water and slowly weaken. By 0900 GMT August 29 the eye was no longer visible on satellite imagery. Winds continued to decrease as the hurricane moved west-northwest at 9 kt into an extensive field of low stratus and stratocumulus clouds. By 1200 GMT August 30 Iva was moving over 76°F water and winds near the center had decreased to 60 kt. The hurricane was downgraded to a tropical storm near 21°N, 122°W at 1200 GMT August 30. It continued to weaken rapidly as it moved northwest into the field of low clouds and over still colder (70-74°F) water. By 0000 GMT September 1, the storm was downgraded to a tropical depression near 23°N, 126°W. The final advisory was issued at 0000 GMT September 2 with the depression dissipating rapidly near 25°N, 128°W.

DISTURBANCE: HURRICANE IVA

DATE: August 24 - September 2, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/24	0000Z	13.0N	96.0W			Tropical Depression
	1200Z	13.5	99.0			
8/25	0000Z	13.2N	101.0W			Tropical Storm
	1200Z	13.2	103.3		35	
	1800Z	13.5	104.0			
8/26	0000Z	13.6N	104.7W			Hurricane
	1200Z	15.0	107.0		65	
	1800Z	15.2	107.8			
8/27	0000Z	16.0N	108.2W			Hurricane
	1200Z	16.8	109.5			
8/28	0000Z	17.6N	111.5W		110	Hurricane
	0600Z	18.2	112.4		115	
	1200Z	18.2	113.5			
8/29	0000Z	19.0N	115.2W			Hurricane
	1200Z	19.5	118.0			
8/30	0000Z	20.0N	119.5W			Tropical Storm
	1200Z	20.7	122.0		60	
8/31	0000Z	21.0N	123.5W			Tropical Storm
	1200Z	22.5	125.0			

DISTURBANCE: HURRICANE IVA (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
9/1	0000Z	23.4N	126.4W			Tropical Depression
	1200Z	24.5	127.5			
9/2	0000Z	24.9N	128.5W			Tropical Depression

August 28 - September 8, 1976

The fourteenth tropical cyclone of the season began as a disturbance at 1200 GMT August 26 near 4°N, 80°W, about 150 n mi west of the Columbian Coast. The disturbance, centered within a large area of convective thunderstorm activity 300 n mi in diameter, moved northwest at 15-18 kt to near 8°N, 84°W, about 45 n mi west of the De Osa peninsula on the Costa Rican coast by 1200 GMT August 27. Turning west-southwest and moving at 18 kt away from the coast, the center of the disturbance moved to near 6°N, 87°W by 0000 GMT August 28. It then turned west and, slowing to 12-14 kt, began to intensify. By 0000 GMT August 29 satellite pictures indicated a definite circulation about the center of the disturbance and it was upgraded to a tropical depression with 25 kt winds near 8°N, 92°W. Turning west-northwest and moving at 11 kt over 81°F water, winds increased to 30 kt by 0000 GMT August 30 with the center near 10°N, 96°W. The depression then turned west at 10 kt and began to weaken. By 1800 GMT August 30 satellite imagery indicated that the circulation had ceased about the center and the depression was downgraded to a tropical disturbance again near 10°N, 99°W. The disturbance then moved rapidly west-northwest at 18 kt and appeared to be dissipating into an area of widely scattered thunderstorm activity 300-400 n mi in diameter. However, between 0600 and 1200 GMT August 31 the thunderstorm activity increased again and coalesced into a solid area 300 n mi in diameter. Within 12 hours satellite imagery indicated a cyclonic circulation about the center of the activity and the disturbance was upgraded to a tropical depression again at 0000 GMT September 1 near 11°N, 107°W. Turning west-southwest, the depression moved to near 10°N, 110°W by 1800 GMT then turned northwest and, moving at 8 kt over 82°F water, began to intensify. By 1200 GMT September 3 winds near the center had increased to 40 kt and the depression was upgraded and became Tropical Storm Joanne near 14°N, 114°W. It moved northwest to near 15°N, 115°W by 0000 GMT September 4 then turned west-southwest and began to weaken slowly. Low clouds pushing down from the north continued to weaken the storm to the extent that it was downgraded to a tropical depression with 30 kt winds near 14°N, 117°W by 0000 GMT September 5. Turning west and continuing to weaken, the depression moved near 12°N, 124°W where the final advisory was issued at 0600 GMT September 8.

DISTURBANCE: TROPICAL STORM JOANNE

DATE: August 29 - September 8, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
8/29	0000Z	7.8N	92.2W		25	Tropical Depression
	1200Z	8.5	94.5			
8/30	0000Z	10.0N	96.0W		30	Tropical Disturbance
	1200Z	9.8	98.8			
	1800Z	~10.0	~99.0			
8/31						
9/1	0000Z	11.0N	107.0W			Tropical Disturbance
	1200Z	10.0	109.5			
9/2	0000Z	11.0N	111.0W			
	1200Z	12.0	111.5			
9/3	0000Z	13.2N	113.0W		40	Tropical Storm
	1200Z	14.0	114.0			
9/4	0000Z	15.0N	114.9W			
	1200Z	14.6	115.6			
9/5	0000Z	14.4N	117.3W		30	Tropical Depression
	1200Z	14.5	118.5			

DISTURBANCE: TROPICAL STORM JOANNE (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
9/6	0000Z	13.5N	120.0W			Tropical Depression
	1200Z	13.0	121.5			
9/7	0000Z	12.0N	122.3W			Tropical Depression
	1200Z	13.0	126.0			
9/8	0000Z	13.2N	124.5W			Tropical Depression
	0600Z	12.5	124.5			

September 7-10, 1976

Kathleen, the fifteenth tropical cyclone of the season, began as a disturbance 300 n mi southwest of Acapulco, Mexico, at 0000 GMT September 6. The disturbance, centered near 13°N, 103°W within an area of intense thunderstorm activity 600 n mi in diameter, began to move rapidly west-northwest. By 0600 GMT September 7 the disturbance had moved to near 15°N, 109°W, about 360 n mi southwest of Manzanillo and, with 25 kt winds near the center, was upgraded to a tropical depression. By 1800 GMT the depression had moved only 12 n mi south of its 0600 GMT position. Winds near the center increased to 35 kt by 0000 GMT September 8 and the depression was upgraded and named Tropical Storm Kathleen near 15°N, 105°W, about 360 n mi southwest of Manzanillo. Moving northwest over 83°F water, Kathleen intensified rapidly with winds reaching 55 kt by 0600 GMT September 8 with the center near 16°N, 110°W about 180 n mi south-southeast of Socorro Island. Winds on the Island increased steadily as Kathleen approached from the south reaching 50 kt from the southeast by 0000 GMT September 9. The storm passed 60 n mi to the west of the Island at 0300 GMT and by 0600 GMT winds on Socorro, still from the southeast, had decreased to 35 kt. Kathleen was then 60 n mi northwest of the Island. Turning north-northwest, the storm passed over the western edge of an area of very warm (87°F) water off the southern tip of Baja California. Drawing additional energy from the warm water on its eastern side, Kathleen began to intensify and accelerate rapidly northward. By 1800 GMT the center had moved to near 23°N, 113°W, about 180 n mi west of the tip of Baja California. The *Conon Forest*, 80 n mi north-northeast of the center, reported easterly 35 kt winds and intermittent heavy rain. The *American Leader*, 160 n mi east of the storm and near the tip of Baja, reported southeasterly 45 kt winds. Turning to the north and moving at a fairly rapid 20 kt, Kathleen was upgraded to a hurricane with 70 kt winds near the center at 0000 GMT September 10 near 25°N, 114°W. The *Conon Forest*, 40 n mi to the east, reported southeast 40 kt winds and the *American Leader*, 130 n mi east-southeast of Kathleen, reported southerly 40 kt winds. At 0046 GMT September 10 U. S. Air Force reconnaissance aircraft located the center of Kathleen at 25.3°N, 114.8°W. Surface winds were estimated at 80 kt and the pressure at 986 mb. A second flight through the hurricane at 0145 GMT September 10 estimated the surface winds at 55 kt and pressure at 990 mb. Kathleen was downgraded to a tropical storm with 55 kt winds at 0600 GMT September 10 near 27°N, 114°W after a brief existence as a hurricane. Accelerating rapidly northward at 30-33 kt, Kathleen crossed the western tip of the Point Eugenia peninsula on the west coast of Baja California between 0700 and 0800 GMT September 10. It moved onshore 140 n mi south of Ensenada, Mexico, at 1130 GMT September 10. Kathleen then continued northward over the Sierra San Pedro and Juarez mountains entering southern California near Calexico at 1800. Racing across the southern California desert, Kathleen began to weaken. The storm moved northward through Death Valley and into western Nevada 140 n mi southeast of Reno by 0600 GMT September 11. Although the center of the storm was difficult to locate after 0600, gusty winds and rain continued to spread northward into eastern Oregon, Idaho, Montana, Utah and Wyoming.

Normally, tropical cyclones weaken rapidly as they move inland. Kathleen did not. While south of Socorro Island the storm had a classic cyclonic configuration roughly 600 n mi in diameter. It never developed an eye that could be identified on available satellite imagery. As the storm passed west of Socorro Island it picked up considerable energy from the warm waters off the tip of Baja California and carried it rapidly northward in an elongated cloud mass extending 700-800 n mi north into southern California and Arizona. The configuration of the cloud mass, which was 300-400 n mi wide, was determined, at least partially, by the circulation of a low-pressure system lingering off the southern California coast. That circulation was also instrumental in developing the heavy rains and accelerating the storm northward in a whip-like Fujiwhara fashion (Fujiwhara, 1931). As Kathleen moved north through Death Valley and into western Nevada, the low off the southern California coast was pulled inland bringing additional rain to central California and weakening Kathleen.

DISTURBANCE: HURRICANE KATHLEEN

DATE: September 7-10, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
9/7	0600Z	15.0N	109.0W		25	Tropical Depression
	1200Z	14.5	109.5			
9/8	0000Z	15.5N	109.3W		35	Tropical Storm
	0600Z	16.0	110.0		55	
	1200Z	16.5	111.5			
9/9	0000Z	18.0N	112.5W			Tropical Storm
	1200Z	21.0	112.3			
9/10	0000Z	25.0N	114.0W	986 990	70	Hurricane
	0046Z	25.3	114.8		80	
	0145Z				55	
	0600Z	26.8	114.4		55	Tropical Storm
	1200Z	30.0	115.5			

September 25 - October 1, 1976

Liza, the hurricane that brought death and destruction to the city of La Paz on the tip of the Baja California peninsula, began September 25 as an area of intense thunderstorm activity 400 n mi diameter centered near 12°N, 106°W. By 1800 GMT September 25 satellite pictures indicated a cyclonic circulation near the center of the disturbance and it was upgraded to a tropical depression with 25 kt winds near 13°N, 107°W. Winds increased to 35 kt by 1800 GMT September 26 and the depression was upgraded and became Tropical Storm Liza near 14°N, 108°W, about 620 n mi south of La Paz. Turning north and moving at 5 kt over warm (85°F) water, Liza began to intensify. By 1800 GMT September 27 the center, with 55 kt winds, had moved to about 16°N, 108°W. At 1730 GMT September 28 U. S. Air Force reconnaissance aircraft located the center near 18.0°N, 108.0°W, or 400 n mi south of La Paz. Surface winds were estimated at 40 kt and sea level pressure at 971 mb. Although not discernible on satellite imagery, Liza had developed a 15 n mi diameter closed wall eye. Moving north at 5 kt, the storm's winds increased to 65 kt by 1800 GMT September 28 and Liza was upgraded to a hurricane near 18°N, 108°W. At 1923 GMT September 28 a second flight through the hurricane by Air Force reconnaissance aircraft fixed the center at 18.0°N, 108.2°W. Surface winds were estimated at 65 kt and sea level pressure at 968 mb. Winds increased to 70 kt near the center near 18°N, 108°W by 0000 GMT September 29. Air Force reconnaissance penetrating the hurricane at 1204 GMT September 29 computed the surface pressure near the center at 948 mb. The hurricane's eye, visible for the first time on infrared satellite imagery, had become elliptical with the major axis 14 n mi long oriented north-northwest to south-southeast (340° - 160°). Continuing north, Liza began to move over warmer (86°F) water. The ship *Inger*, 110 n mi east northeast of Liza and 30 n mi off the Mexican coast at 1500 GMT, reported southeasterly 50 kt winds and violent rain showers. The Air Force made another flight through Liza at 1800 GMT September 29 locating the center at 19.3°N, 107.9°W. Surface winds were estimated at 110 kt and pressure at 941 mb. The eye was again circular with concentric walls 10 and 30 n mi in diameter. *Inger*, still 110 n mi east-northeast of the center, reported southeasterly 60 kt winds and continued violent rain showers. The *Phryne*, 120 n mi south-southeast of Liza, reported southwesterly 35 kt winds and 16 ft swells. By 0000 GMT September 30 Liza, with 110 kt winds, had moved to near 20°N, 108°W, about 280 n mi south of La Paz. The *Inger*, 120 n mi east of the hurricane and 15 n mi off the coast, reported southeasterly 45 kt winds and 24 ft seas. At 1500 the ship *Richard*, 110 n mi south-southeast of the hurricane, reported a sudden drop in sea surface temperature from 88° to 80°F.

Moving north at 8 kt over warm (86°F) water, Liza continued to intensify gathering additional energy from the warmer (88°F) water along its eastern side. At 1725 GMT September 30 the Air Force flew another reconnaissance

flight through the center of the hurricane locating the center at 22.1°N, 109.3°W about 140 n mi south of La Paz. Surface winds were estimated at 125 kt and pressure at 939 mb. The diameter of the eye had increased to 20 n mi with a 2 n mi thick closed wall. By 0000 GMT October 1 Liza was 50 n mi east-southeast of La Paz near 24°N, 109°W. At 0200 GMT October 1 Liza, with 115 kt winds and gusts to 130 kt, passed 45 n mi to the east of La Paz. An estimated 5-6 inches of rain fell over the southern end of the Baja peninsula resulting in considerable damage and several hundred deaths. Moving rapidly northward over the southern end of the Gulf of California, Liza moved onshore with 100 kt winds on the west coast of Mexico 45 n mi north of Los Mochis at 1300 GMT October 1. Weakening rapidly, the storm accelerated across northern Mexico at 25 to 30 kt.

DISTURBANCE: HURRICANE LIZA

DATE: September 25 - October 1, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
9/25	1800Z	13.0N	107.0W		25	Tropical Depression
	1200Z	13.0	107.0			
9/26	0000Z	13.0N	108.0W		35	Tropical Depression
	1200Z	14.0	109.0			Tropical Storm
	1800Z	14.0	108.5			
9/27	0000Z	14.5N	109.0W		55	Tropical Storm
	1200Z	16.0	108.3			
	1800Z	16.0	108.0			
9/28	0000Z	16.3N	109.0W	971	40	Tropical Storm
	1200Z	17.5	108.5			Hurricane
	1730Z	18.0	108.0			
	1800Z	18.0	108.1			
	1923Z	18.0	108.2			
9/29	0000Z	18.5N	108.0W	948	70	Hurricane
	1200Z	19.0	108.0		110	
	1800Z	19.3	107.9			
9/30	0000Z	20.0N	108.0W	939	110	Hurricane
	1200Z	21.5	109.0		125	
	1725Z	22.1	109.3			
	1800Z	22.2	109.1			
10/1	0000Z	23.8N	109.4W			Hurricane
	0600Z	25.2	109.3			
	1200Z	26.2	109.5			Tropical Storm
	1800Z	28.8	108.6			

September 29 - October 8, 1976

Madeline began as a disturbance at 0000 GMT September 27 near 9°N, 91°W, about 300 n mi south of the Guatemalan coast and 700 n mi southeast of Acapulco, Mexico. At 2100 GMT September 28 the *Seatiger*, 70 n mi south of the disturbance, reported south-southwesterly 40 kt winds and continuous heavy rain. With satellite pictures indicating a cyclonic circulation about the center, the disturbance was upgraded and named Tropical Storm Madeline with 35 kt winds near the center near 10°N, 90°W at 0000 GMT September 29. By 1200 satellite imagery showed considerable weakening of the storm and Madeline was downgraded to a tropical depression with 30 kt winds near 10°N, 91°W. By 1800 GMT September 30 winds had diminished to 25 kt and with circulation no longer evident about the center, the depression was downgraded to a tropical disturbance near 11°N, 92°W, about 500 n mi southeast of Acapulco. The disturbance then turned west and, moving at 4 kt, began to slowly regenerate. By 1800 it had moved to near 12°N, 95°W. Satellite imagery indicated a cyclonic circulation about the center by 0000 GMT October 3 and the disturbance was upgraded to a tropical depression with 30 kt winds near 12°N, 95°W, about 400 n mi southwest of Acapulco. Turning southwest, the depression moved to near 10°N, 97°W by 1800 GMT October 4 remaining nearly stationary for the next 18 hours. By 0000 GMT October 5 winds near the center had increased to 35 kt and the depression was upgraded again to Tropical Storm Madeline near 10°N, 97°W, about 400 n mi south-southeast of Acapulco. Madeline turned north-northwest after 1200 GMT October 5 and, with warmer (85°F) water on its northeast side, began to intensify rapidly. By 0000 GMT October 6 the storm had moved to near 12°N, 98°W and winds had increased to 55 kt. The storm was upgraded to hurricane status with 70 kt winds near 13°N, 100°W, about 220 n mi south of Acapulco at 1800 GMT October 6. At 1815 GMT October 6 Air Force reconnaissance aircraft located the center of Madeline at 13.1°N, 100.4°W with winds estimated at 65 kt and surface pressure at 984 mb. Madeline's eye, first visible on satellite pictures at 1615, was reported as well-defined with a 30 n mi diameter. By 0000 GMT October 7 Madeline, with 70 kt winds, had moved to near 14°N, 101°W, about 200 n mi south-southwest of Acapulco. At 1117 GMT October 7 Air Force reconnaissance aircraft again located the center of Madeline at 14.9°N, 102.0°W, about 170 n mi southwest of Acapulco and 160 n mi south of Zihuatanejo. Surface winds were estimated at 75 kt and the eye had increased to 40 n mi in diameter. Moving north over 82°F water with warmer (85°F) water along its eastern side, Madeline continued to intensify. By 1800 winds had increased to 110 kt with the center near 15°N, 102°W. The *Norse Viking*, 100 n mi northeast of the center and 30 n mi off the coast, reported easterly 60 kt winds and continuous heavy rain. The *Ecuadorian Reefer*, 70 n mi east-northeast of the hurricane, reported southeasterly 55 kt winds and intermittent heavy rain. By 0000 GMT October 8, Madeline, with 115 kt winds, had moved to near 16°N, 102°W, about 140 n mi west of Acapulco and 100 n mi south of Zihuatanejo. The *Chevron Genoa*, 140 n mi to the east, reported east-southeasterly wind and continuous heavy rain. At 0300 GMT October 8 Air Force reconnaissance

aircraft located the center of Madeline near 16°N, 102°W with winds estimated at 120 kt and surface pressure at 941 mb. A second penetration by the aircraft at 0209 reported a pressure of 940 mb and eye diameter of 30 n mi. Winds increased to 125 kt with gusts to 140 kt by 0600 GMT October 8 with the center near 17°N, 102°W, about 70 n mi west of Acapulco and 50 n mi southwest of Zihuatanejo. The *Austral Lightning*, 50 n mi to the northwest, reported northerly 100 kt winds and continuous heavy rain. The *Finn Leon Hardt*, 120 n mi to the east, reported southeasterly 40 kt winds. By 0900 GMT the *Austral Lightning* was 60 n mi south-southwest of the hurricane. The ship continued to report continuous heavy rain with the wind having shifted to southwest 75 kt. Madeline moved onshore 45 n mi northwest of Zihuatanejo at 1100 GMT October 8 and weakened rapidly after moving inland.

DISTURBANCE: HURRICANE MADELINE

DATE: September 29 - October 8, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage	
		Latitude	Longitude				
9/29	0000Z	10.0N	90.5W		35	Tropical Storm	
	1200Z	10.0	91.0		30	Tropical Depression	
9/30	0000Z	10.5N	91.0W			Tropical Depression	
	1200Z	10.5	92.0			Tropical Disturbance	
10/1	0000Z					Tropical Disturbance	
	1200Z						
10/2	0000Z					Tropical Disturbance	
	1200Z						
10/3	0000Z	11.8N	95.5W		30	Tropical Depression	
	1200Z	11.2	97.0				
10/4	0000Z	10.8N	97.0W			Tropical Depression	
	1200Z	10.5	98.0				
10/5	0000Z	10.5N	97.5		35	Tropical Storm	
10/6	0000Z	12.0N	98.5W		55	Tropical Storm	
	1200Z	13.0	99.5		984	70	Hurricane
	1800Z	13.1	100.3				

DISTURBANCE: HURRICANE MADELINE (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage	
		Latitude	Longitude				
10/7	0000Z	14.0N	101.0W		70	Hurricane	
	1117Z	14.9	102.0		75		
	1200Z	15.0	102.0				
10/8	0000Z	16.0N	102.0W	940	125	Hurricane	
	0209Z						
	0600Z	17.0	102.1				
	1200Z	18.2	102.0				Tropical Storm

4.0 CENTRAL AND WESTERN PACIFIC AREAS

4.1 GENERAL

All of the data on the tropical cyclones occurring in these areas were extracted from the Joint Typhoon Warning Center (JTWC) document.

Storms as identified by the JTWC document are listed (Table 4-1) together with their periods of occurrence and general description of intensity.

In 1976, the number of Western Pacific tropical cyclones remained below the long term average. There were 25 numbered tropical cyclones in the JTWC area of responsibility, all of which progressed to tropical storm or typhoon intensity. Of the 25 storms, 14 attained typhoon intensity, including four super typhoons. The month of March was the only month without a numbered cyclone, while three months (February, March, and December) were without a typhoon (Table 4-2).

The storm season had an early debut with Typhoon Kathy forming in January. The near equatorial trough was firmly established by April and maintained itself throughout most of the remainder of the year. An exception was late September and most of October, when the westerly flow along the equator gave way to easterly trades.

1976 saw a large number of days (53) of multiple-storm situations. As early as May, simultaneous storms were generated when Olga and Pamela tracked across the western Pacific causing extensive damage to the Philippines and to Guam. June through September saw six additional two-storm situations and one three-storm situation. Although the season started quickly, the latter part of the season tapered off earlier than normal. For 36 days in September and October, normally a very active period, there were no warnings issued. Not since 1958, when 30 days passed without a depression, has such a lull in activity occurred during this time of the year. It is interesting to note that twin storms in the northern and southern hemisphere occurred during April when Tropical Storm Nancy formed in the Pacific, north of the equator, and TC 19-76 did likewise, south of the equator.

Most of the damage during 1976 was associated with three of the four super typhoons. Damage estimates to public and private property for Pamela and Fran combined exceeded one billion dollars. Fran also accounted for 133 dead in Japan. While Pamela was responsible for 10 dead on Truk, the super typhoon miraculously caused only one fatality as it passed over Guam. Therese sank 12 ships, and left 1300 homeless due to heavy rains in southern Japan. During May, Olga caused enhanced monsoonal rains over the Philippines which led to over 200 deaths and thousands homeless. In addition, Typhoon Billie generated great waves which resulted in the drowning of 41 fishermen and swimmers as the storm passed through the Ryukyu Islands. It was subsequently responsible for 4 deaths in Taipei

and caused millions of dollars of damage to facilities during its passage over northern Taiwan. Although Marie caused no known fatalities, it brought millions of dollars of damage to crops and structures in the Palau Islands. In September, Iris sank a Panamanian freighter and killed four as it tracked slowly across the South China Sea.

The only Central Pacific tropical cyclone spawned during 1976 was in the month of September. A disturbance observed on the 20th ultimately developed into Hurricane Kate, and at one time became a threat to the Hawaiian Islands. It later recurved, passing northeast of Hawaii. Kate ended a 24 month absence of tropical cyclone activity in the Central Pacific, being the first hurricane since August 1974. Table 4-3 gives the frequency of storms by month for the Central Pacific.

Ground track plots for all of the western Pacific cyclones are shown in Figures 4-1 through 4-5.

In the following sections, GEOS-3 ground track plots and additional cyclone information are given for the four Pacific area tropical cyclones which appear to have accompanying GEOS altimeter data. These are:

Marie TC-03
Olga TC-05
Pamela TC-06
Louise TC-23

Table 4-1.

STORM	DATE	MAXIMUM SURFACE WIND	MINIMUM OBSERVED SEA LEVEL PRESSURE	DISTANCE TRAVELED
Typhoon Kathy (TC-01)	(01/28/76 - 02/02/76)	80	969	1966
Tropical Storm Lorna (TS-02)	(02/27/76 - 03/01/76)	35	---	806
Typhoon Marie (TC-03)	(04/03/76 - 04/14/76)	115	929	955
Tropical Storm Nancy (TS-04)	(04/25/76 - 05/02/76)	55	984	1279
Typhoon Olga (TC-05)	(05/12/76 - 05/27/76)	100	934	2443
Super Typhoon Pamela (TC-06)	(05/14/76 - 05/27/76)	130	921	2570
Typhoon Ruby (TC-07)	(06/23/76 - 07/04/76)	120	934	2798
Typhoon Sally (TC-08)	(06/24/76 - 07/03/76)	116	923	2981
Super Typhoon Therese (TC-09)	(07/11/76 - 07/20/76)	135	903	2290
Tropical Storm Violet (TS-10)	(07/21/76 - 07/25/76)	55	---	650
Tropical Storm Wilda (TS-11)	(07/22/76 - 07/24/76)	45	992	898
Typhoon Anita (TC-12)	(07/23/76 - 07/25/76)	65	979	864
Typhoon Billie (TC-13)	(08/03/76 - 08/10/76)	125	914	1854
Tropical Storm Clara (TS-14)	(08/05/76 - 08/07/76)	40	---	263
Tropical Storm Dot (TS-15)	(08/18/76 - 08/23/76)	50	989	1408
Tropical Storm Ellen (TS-16)	(08/20/76 - 08/24/76)	45	993	1243
Super Typhoon Fran (TC-17)	(09/03/76 - 09/13/76)	130	913	2616
Tropical Storm Georgia (TS-18)	(09/09/76 - 09/15/76)	40	992	1325
Typhoon Hope (TC-19)	(09/14/76 - 09/17/76)	70	981	1604
Typhoon Iris (TC-20)	(09/14/76 - 09/21/76)	75	967	756
Typhoon Joan (TC-21)	(09/19/76 - 09/24/76)	70	---	1368
Hurricane Kate (TC-22)	(09/21/76 - 10/02/76)			
Super Typhoon Louise (TC-23)	(10/30/76 - 11/07/76)	140	895	2754
Tropical Storm Marge (TS-24)	(11/06/76 - 11/11/76)	60	977	1836
Tropical Storm Nora (TS-25)	(12/03/76 - 12/08/76)	45	992	456
Tropical Storm Opal (TS-26)	(12/09/76 - 12/10/76)	35	996	338

Table 4-2. Frequency of Tropical Storms and Typhoons by Month and Year

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
AVERAGE (1945-57)	0.4	0.1	0.4	0.5	0.8	1.3	3.0	3.9	4.1	3.3	2.7	1.1	22.0
1959	0	1	1	1	0	0	3	6	6	4	2	2	26
1960	0	0	0	1	1	3	3	10	3	4	1	1	27
1961	1	1	1	1	3	2	5	4	6	5	1	1	31
1962	0	1	0	1	2	0	6	7	3	5	3	2	30
1963	0	0	0	1	1	3	4	3	5	5	0	3	25
1964	0	0	0	0	2	2	7	9	7	6	6	1	40
1965	2	2	1	1	2	3	5	6	7	2	2	1	34
1966	0	0	0	1	2	1	5	8	7	3	2	1	30
1967	1	0	2	1	1	1	6	8	7	4	3	1	35
1968	0	0	0	1	1	1	3	8	3	6	4	0	27
1969	1	0	1	1	0	0	3	4	3	3	2	1	19
1970	0	1	0	0	0	2	2	6	4	5	4	0	24
1971	1	0	1	3	4	2	8	4	6	4	2	0	35
1972	1	0	0	0	1	3	6	5	4	5	2	3	30
1973	0	0	0	0	0	0	7	5	2	4	3	0	21
1974	1	0	1	1	1	4	4	5	5	4	4	2	32
1975	1	0	0	0	0	0	2	4	5	5	3	0	20
1976	1	1	0	2	2	2	4	4	5	1	1	2	25
AVERAGE (1959-76)	0.6	0.4	0.4	0.9	1.3	1.6	4.6	5.9	4.9	4.2	2.5	1.2	28.4

Table 4-3. Frequency of Central Pacific Storms by Month and Year. (Number in parenthesis indicate storms reaching hurricane intensity)

	JAN- JUN	JUL	AUG	SEP	OCT	NOV- DEC
1967	0	0	0	0	1	0
1968	0	0	2	0	0	0
1969	0	0	0	0	0	0
1970	0	0	1	0	0	0
1971	0	1 (1)	1	0	0	0
1972	0	0	3 (1)	1	0	0
1973	0	1 (1)	0	0	0	0
1974	0	0	2 (1)	0	0	0
1975	0	0	0	0	0	0
1976	0	0	0	1 (1)	0	0
AVERAGE	0	.2 (.2)	.9 (.3)	.2 (.2)	.1	0

4.1-6

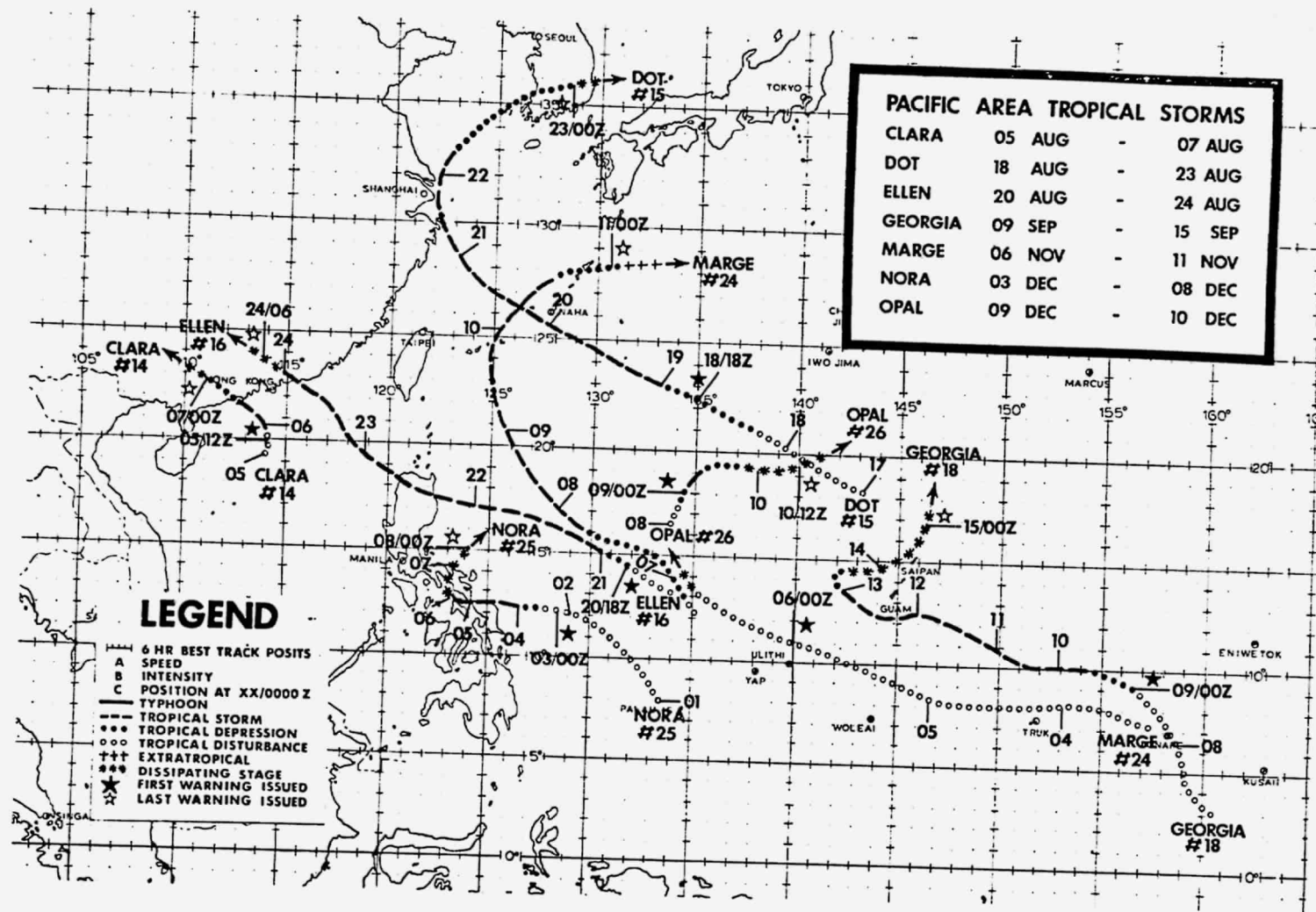


Figure 4-1

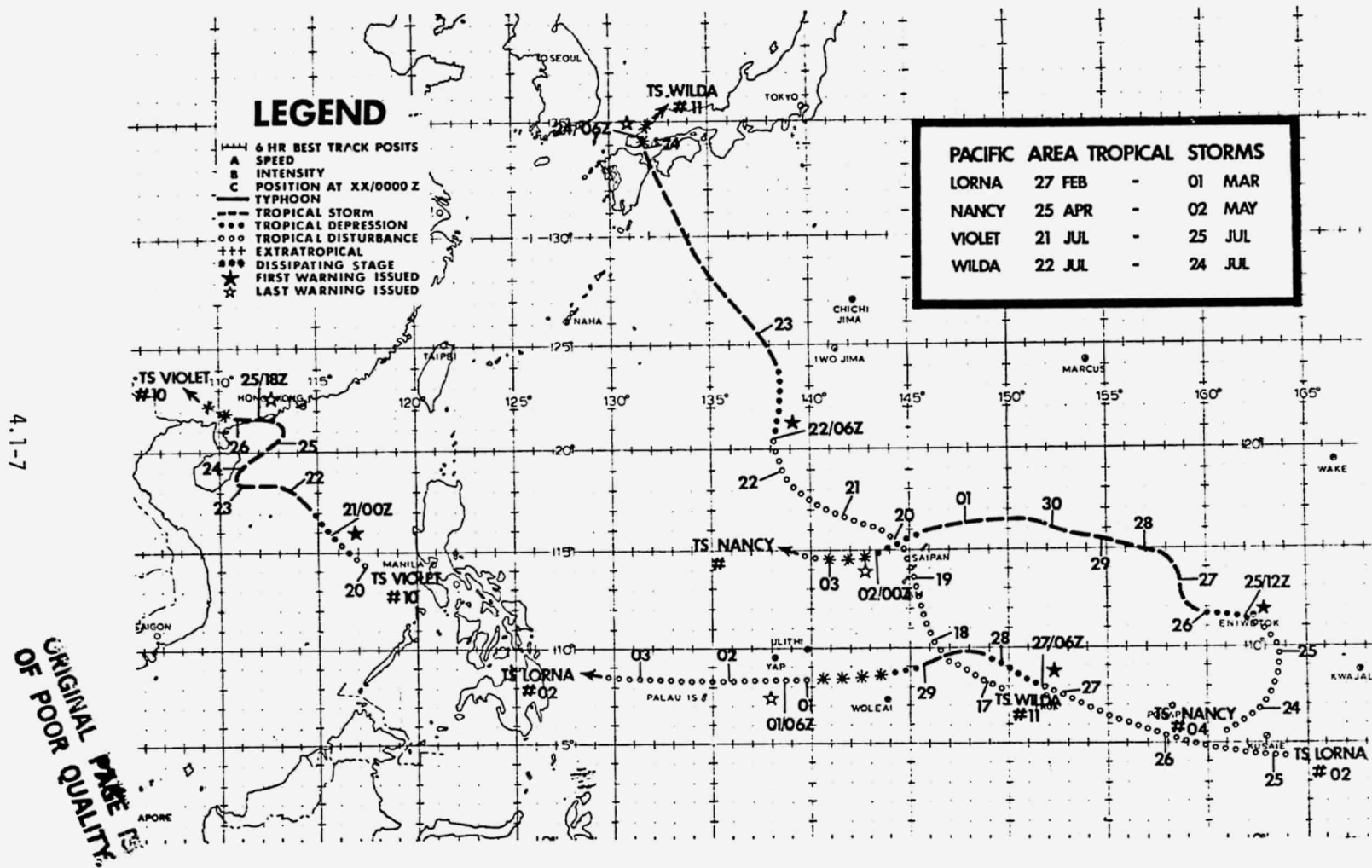


Figure 4-2

4.1-8

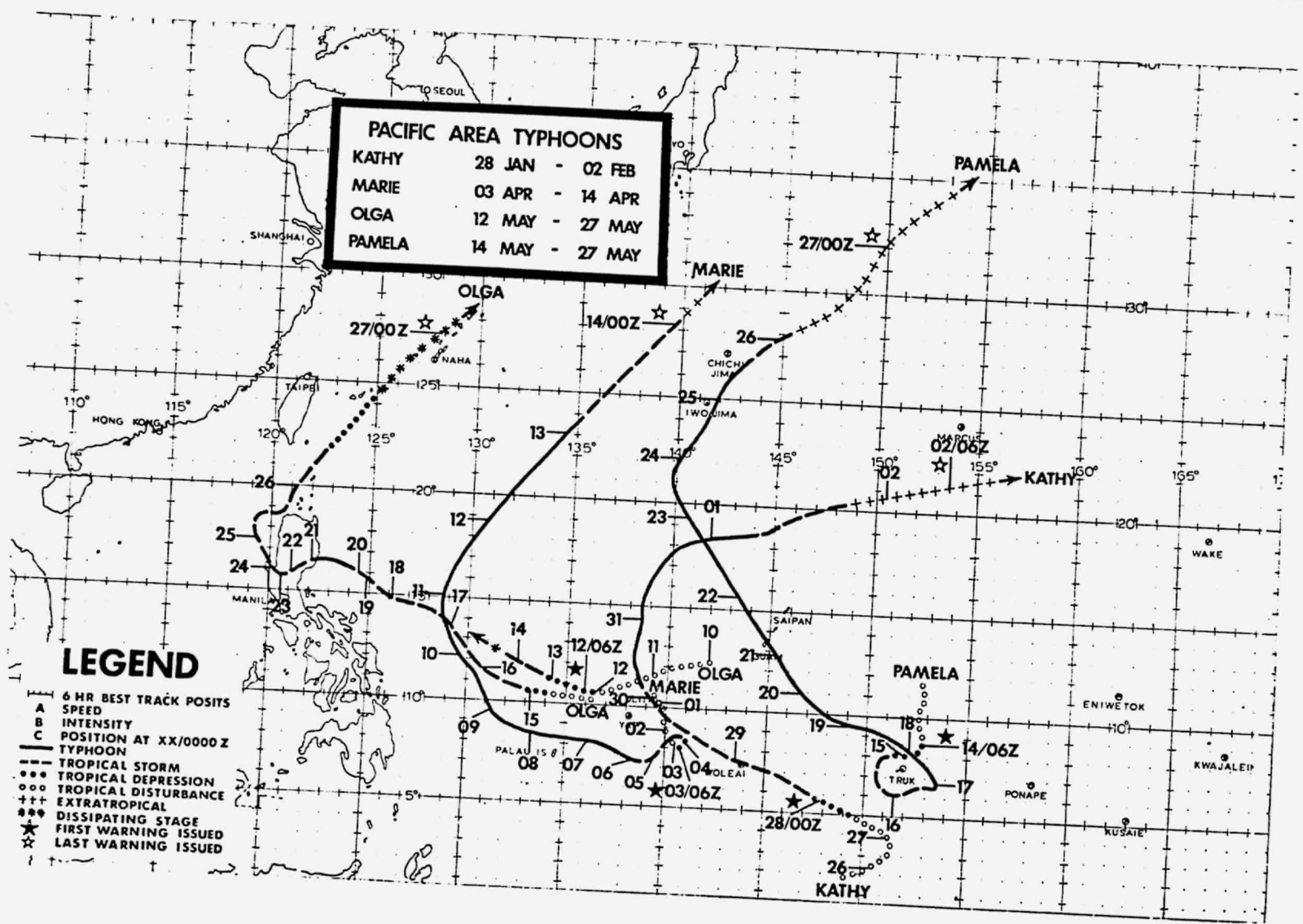


Figure 4-3

4.1-9

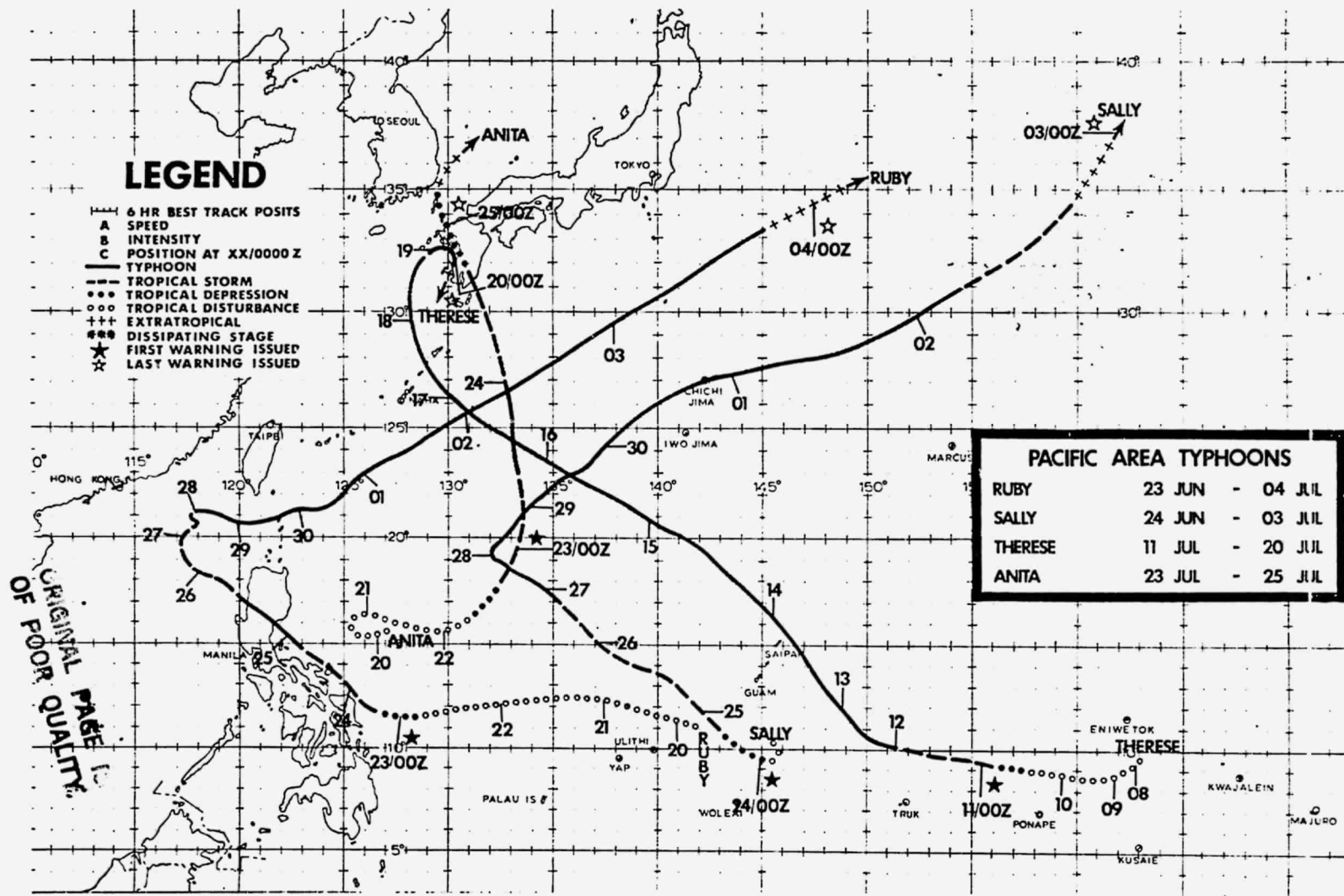


Figure 4-4

PACIFIC AREA TYPHOONS		
BILLIE	03 AUG	- 10 AUG
FRAN	03 SEP	- 13 SEP
HOPE	14 SEP	- 17 SEP
IRIS	14 SEP	- 21 SEP
JOAN	19 SEP	- 24 SEP
LOUISE	30 OCT	- 07 NOV

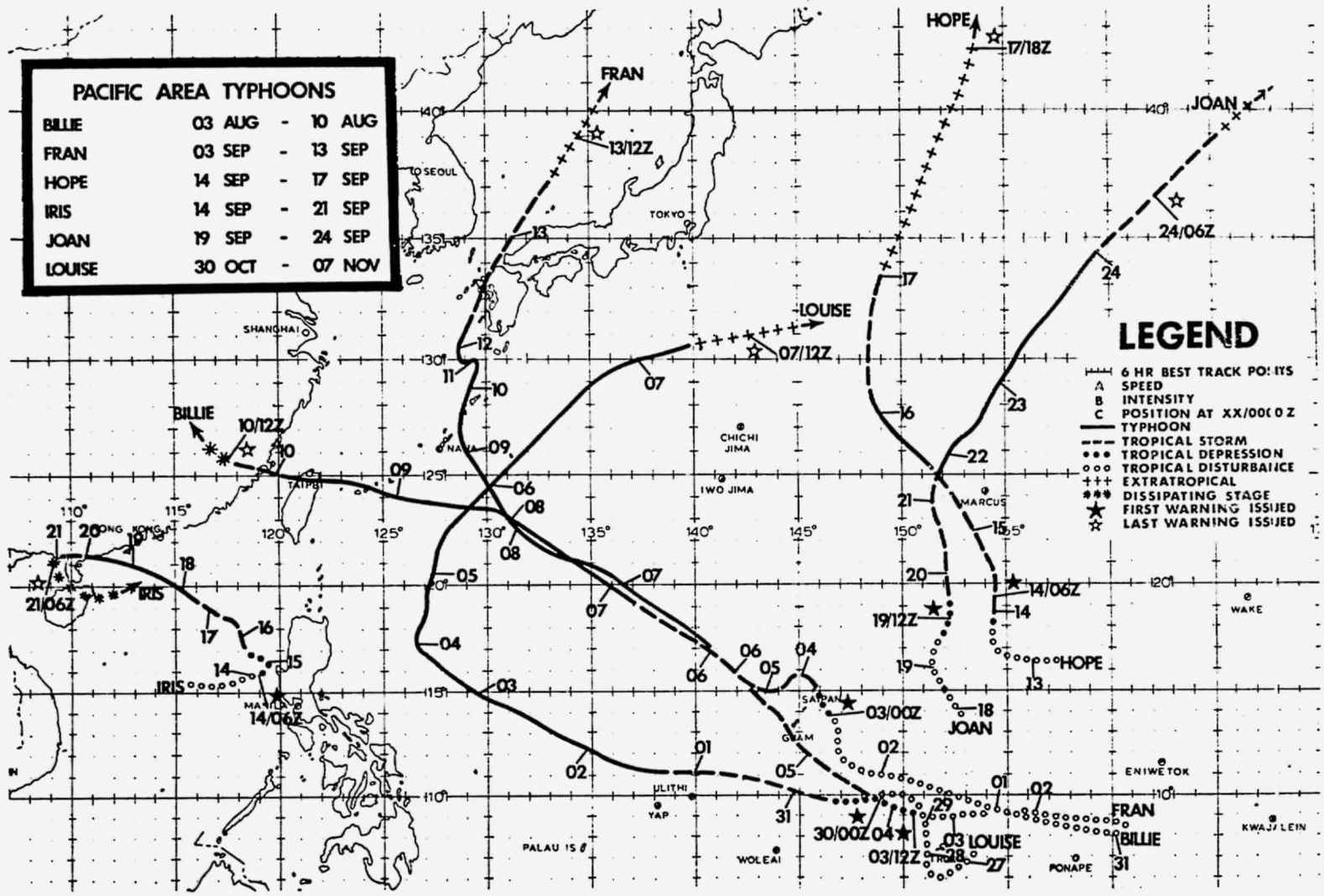


Figure 4-5

4.1-10

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TYPHOON MARIE
(TC-03)
April 3-14, 1976

On the 1st of April a tropical disturbance was detected by satellite near 10N, 140E. Synoptic data revealed a weak surface cyclonic circulation with an associated upper level anticyclone. The system drifted slowly southward for the next 2 days. At 0030Z on the 3rd, a formation alert was issued when synoptic data indicated the system had intensified to 25 kt, and increasing upper level outflow to the north promised good potential for further intensification. At 0600Z on the 3rd the first warning was issued. Six hours later the system was upgraded to Tropical Storm Marie when synoptic data confirmed aircraft reports of 35 kt winds.

Influenced by a weak steering flow, the storm turned eastward in a counter-clockwise loop, and during the evening of the 4th began taking a slow, southerly heading. Tropical Storm Marie intensified, and by 0600Z on the 5th had attained typhoon strength. Twelve hours later the typhoon had acquired a 6 kt movement toward the west-northwest, and for the next 48 hours maintained 65 kt winds. On the evening of the 7th, the typhoon once again began to intensify, as upper tropospheric winds over the Philippine Islands backed, indicating deeper troughing to the west and a more efficient link of the storm's outflow channel with the mid-latitude westerlies. This intensification continued slowly during the subsequent 84 hours at a rate of about 1/2 mb per hour.

At 1500Z on the 7th Typhoon Marie passed 40 nm north of Palau with peak gusts of 75 kt and a minimum sea level pressure of 993 mb recorded at Koror. While no deaths or injuries were reported, damage of more than \$4 million was incurred on the Palau Islands. Crop destruction was extensive as was damage to buildings and public utilities. As a result, Palau was declared a major disaster area.

By 0000Z on the 8th a weakness in the subtropical ridge appeared near the eastern coast of the Philippines. In response, Marie turned northward and recurved. During the typhoon's western-most position at 2100Z on the 10th, the system reached its maximum intensity of 115 kt. The lowest sea-level pressure was 929 mb recorded by aircraft at 2031Z on the 10th. Typhoon Marie maintained 115 kt winds for 24 hours as its northeast movement increased to 11 kt. By 1800Z on the 11th Marie began to weaken while accelerating on a northeast track, closely following the 700 mb flow. Two days later the final warning was issued as Marie became extratropical.

DISTURBANCE: #3 MARIE

DATE: April 3-14, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
4/3	0600Z	8.2N	140.4E		30	Tropical Depression Tropical Storm
	1200Z	8.1	140.7		35	
	1800Z	8.2	140.9		40	
4/4	0000Z	8.3N	141.0E		40	Tropical Storm
	0600Z	8.6	140.7		45	
	1200Z	8.3	140.0		50	
	1800Z	7.7	139.8		55	
4/5	0000Z	7.5N	139.6E		60	Tropical Storm Typhoon
	0600Z	7.4	139.4		65	
	1200Z	7.3	139.2		65	
	1800Z	7.2	138.8		65	
4/6	0000Z	7.4N	138.2E		65	Typhoon
	0600Z	7.8	137.7		65	
	1200Z	8.0	137.1		65	
	1800Z	8.2	136.5		65	
4/7	0000Z	8.2N	136.1E		65	Typhoon
	0600Z	8.3	135.6		65	
	1200Z	8.3	134.9		70	
	1800Z	8.3	134.2		75	
4/8	0000Z	8.5N	133.3E		80	Typhoon
	0600Z	8.7	132.6		80	
	1200Z	8.9	132.0		85	
	1800Z	9.2	131.5		85	
4/9	0000Z	9.7N	131.2E		90	Typhoon
	0600Z	10.4	131.0		95	
	1200Z	11.1	130.5		100	
	1800Z	11.7	129.9		100	
4/10	0000Z	12.4N	129.4E		105	Typhoon
	0600Z	13.1	129.1		105	
	1200Z	13.8	128.8		110	
	1800Z	14.4	128.7		115	

DISTURBANCE: #3 MARIE (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
4/11	0000Z	15.2N	128.8E		115	Typhoon
	0600Z	16.0	129.0		115	
	1200Z	16.9	129.4		115	
	1800Z	17.9	130.0		110	
4/12	0000Z	18.8N	130.7E		105	Typhoon
	0600Z	19.8	131.5		100	
	1200Z	21.0	132.4		90	
	1800Z	22.1	133.3		80	
4/13	0000Z	23.1N	134.3E		70	Tropical Storm
	0600Z	24.0	135.3		60	
	1200Z	25.0	136.3		50	
4/14	0000Z	28.2N*	139.7E*			Extratropical

* Position estimated from best track map.

4.2-4

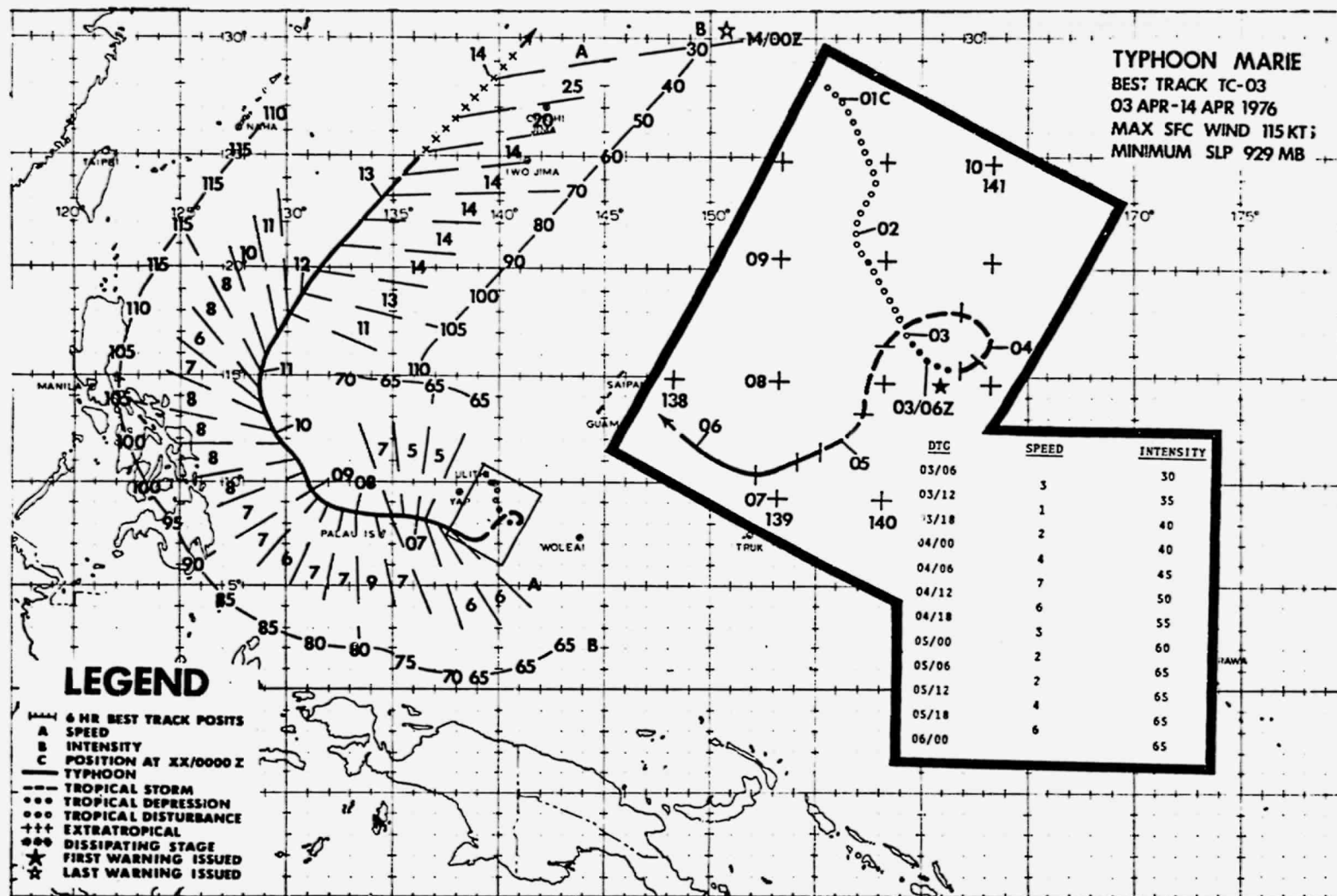
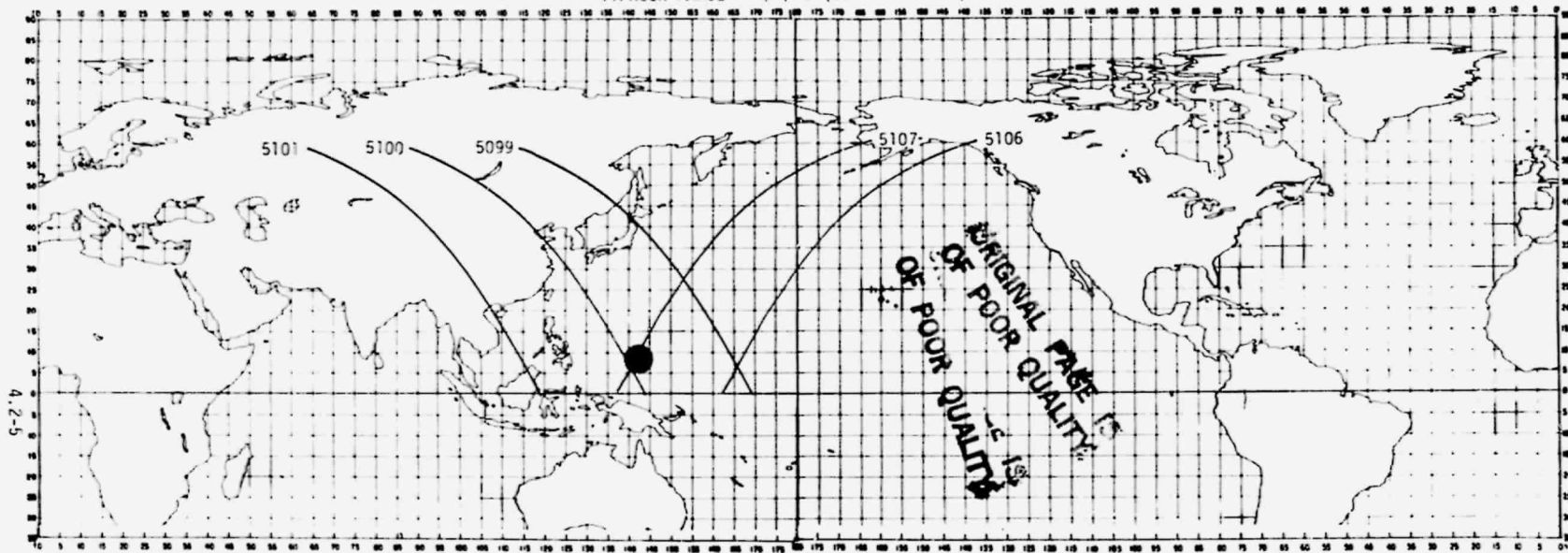


Figure 4-6

TYPHOON MARIE - 4/4/76 (0000Z - 2400Z)



LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	8.3N	141.0E
0600Z	8.6	140.7
1200Z	8.3	140.0
1800Z	7.7	139.8
2400Z	7.5	139.6

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
5099	168.57	091915	0924Z	No			
5100	143.24	110102	1103Z	No			
5101	117.92	124249	1245Z	No			
5106	-08.68	211144	2204Z	215437	220925	802	375
5107	-34.01	225331	2342Z	No			

TYPHOON OLGA
(TC-05)
May 12-27, 1976

Typhoon Olga originated within a very active trough near 10N and between 130 and 155E. As early as May 4, several surface circulations were evident throughout this zone. By the 12th, a center analyzed near 10N, 140E showed indications that it would be the dominant circulation, and the first warning was issued at 0600Z on the 12th. From the onset, Olga was a unique system, having diffuse characteristics which it maintained throughout its life. One such trait was the lack of vertical stacking, observed when comparing satellite and aircraft positions. The low level circulation was often ill defined, and on several occasions multiple circulations could be identified.

Originally, Olga was tracked by satellite as a tropical disturbance moving toward the southwest, following the center of the upper level anticyclone. After 1200Z on the 12th a more climatological track toward the west-northwest was observed, but at half the speed normal for this time of year. This movement, along the southern edge of the subtropical ridge, persisted through the afternoon of the 13th when Olga was upgraded to a tropical storm. Later that night satellite data indicated the presence of a second circulation 120 nm to the east of the storm center. By the 14th the original center had dissipated and the convective energy had consolidated around this second center. The relocated system then proceeded toward the west-northwest while it slowly intensified, and attained tropical storm intensity for the second time. On the 16th Olga responded to a short wave trough in the westerlies and moved toward the north. However, on the 17th the storm resumed its west-northwest heading as the short wave progressed rapidly toward the east. It was at this point that satellite data indicated Olga was entering unfavorable upper level shearing environment provided by a 200 mb ridge over Southeast Asia, which persisted throughout the remainder of Olga's life.

On the 18th Olga began to slow its forward movement in response to a long wave trough moving off the east coast of China. At this point it was expected that the storm would recurve ahead of the trough, but instead, Olga began a counterclockwise loop, and slowly intensified despite the unfavorable upper level shear. On the 20th Olga completed its loop and attained typhoon intensity. After completing the loop the storm tracked toward the west at 6 kt, continuing to intensify. Between aircraft reports at 0330Z and 1947Z on the 20th, there was a drop in the central pressure of 44 mb (from 978 to 934 mb), a rate of 2.7 mb per hour. With this rapid deepening, Olga made landfall on the east side of Luzon near 16.5N at approximately 0000Z on the 21st with winds estimated at 100 kt.

After landfall the small core of high winds subsided quickly. For the next 24 hours Olga's center meandered toward the southwest along the east coast of Luzon passing near Bayler Bay with winds of 45 kt at storm center.

Seeking the path of least resistance, Olga tracked through the Luzon lowlands during the next 48 hours exiting the island through Lingayen Gulf on the 24th. During its slow journey across Luzon, at 2 to 4 kt, Olga enhanced the southwest monsoon over southern Luzon, bringing rains in excess of 50 inches at Cubi Point and perhaps higher at other areas. The resulting floods contributed to over 200 deaths and thousands of homeless. For the next 24 hours Olga tracked toward the northwest through the Gulf reintensifying to 40 kt. On the 25th, the low level circulation separated from the hard core convection and tracked toward the northeast at an accelerated rate. Olga dissipated to the west of Okinawa on the 27th as it was absorbed into a subtropical disturbance west of the island.

DISTURBANCE: #5 OLGA

DATE: May 12-27, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
5/12	0600Z	10.5N	136.2E		25	Tropical Depression
	1200Z	10.7	135.4		30	
	1800Z	10.9	134.9		30	
5/13	0000Z	11.2N	134.3E		30	Tropical Depression
	0600Z	11.4	133.9		35	
	1200Z	11.5	133.5		40	Tropical Storm
	1800Z	11.7	133.0		40	
5/14	0000Z	12.0N	132.5E		35	Tropical Storm
	0600Z	12.2	132.0		35	
	1200Z	12.5	131.4		30	
	1800Z	10.4	134.1		30	
5/15	0000Z	10.5N	133.3E		35	Tropical Storm
	0600Z	10.7	132.6		35	
	1200Z	11.0	131.9		40	
	1800Z	11.3	131.4		45	
5/16	0000Z	11.7N	130.8E		50	Tropical Storm
	0600Z	12.1	130.3		50	
	1200Z	12.6	129.9		50	
	1800Z	13.3	129.6		50	
5/17	0000Z	13.9N	129.2E		50	Tropical Storm
	0600Z	14.3	128.4		45	
	1200Z	14.6	127.5		45	
	1800Z	14.8	126.7		45	
5/18	0000Z	14.9N	126.1E		45	Tropical Storm
	0600Z	15.0	125.6		50	
	1200Z	15.2	125.4		50	
	1800Z	15.5	125.2		50	
5/19	0000Z	15.8N	124.7E		50	Tropical Storm
	0600Z	15.5	124.4		50	
	1200Z	15.5	124.7		55	
	1800Z	15.7	124.8		55	

DISTURBANCE: #5 OLGA (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
5/20	0000Z	16.1N	124.5E		60	Typhoon
	0600Z	16.3	123.9		65	
	1200Z	16.5	123.3		70	
	1800Z	16.5	122.7		85	
5/21	0000Z	16.5N	122.1E		100	Tropical Storm
	0600Z	16.4	121.7		50	
	1200Z	16.3	121.4		45	
	1800Z	16.2	121.2		40	
5/22	0000Z	16.0N	121.1E		35	Tropical Storm
	0600Z	15.9	121.0		35	
	1200Z	15.9	120.9		35	
	1800Z	15.8	120.8		35	
5/23	0000Z	15.8N	120.6E		35	Tropical Storm
	0600Z	15.8	120.5		35	
	1200Z	15.8	120.4		35	
	1800Z	15.9	120.3		35	
5/24	0000Z	16.1N	120.2E		40	Tropical Storm
	0600Z	16.5	120.0		40	
	1200Z	16.8	119.8		40	
	1800Z	17.2	119.6		40	
5/25	0000Z	17.5N	119.4E		40	Tropical Storm
	0600Z	17.9	119.2		40	
	1200Z	18.4	119.2		40	
	1800Z	18.8	120.6		35	
5/26	0000Z	20.1N	121.1E		35	Tropical Storm Tropical Depression
	0600Z	22.0	122.8		30	
5/27	0000Z	27.2N*	128.5E*		20	Dissipating

* Position estimated from best track map 4.3-4

4.3-5

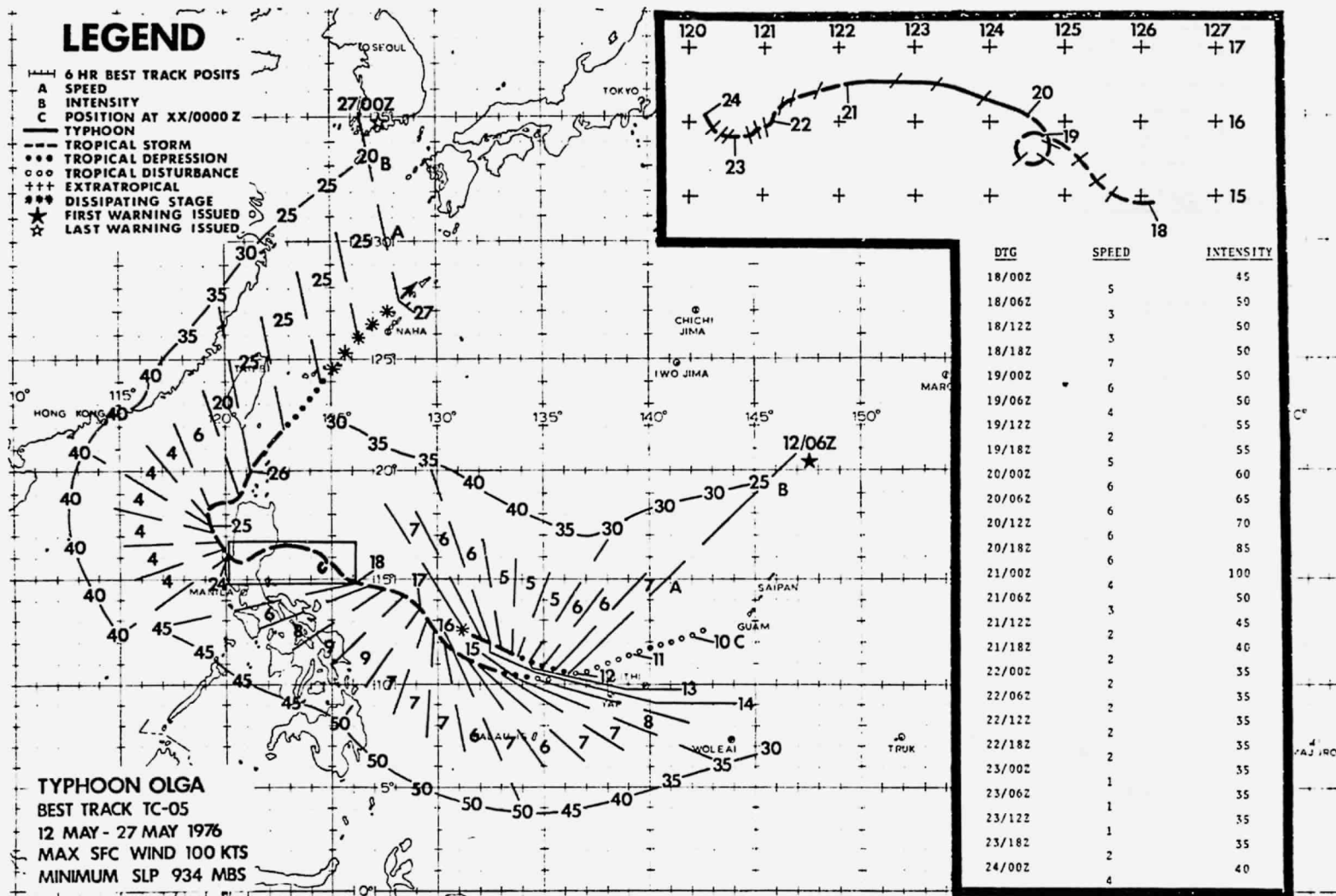
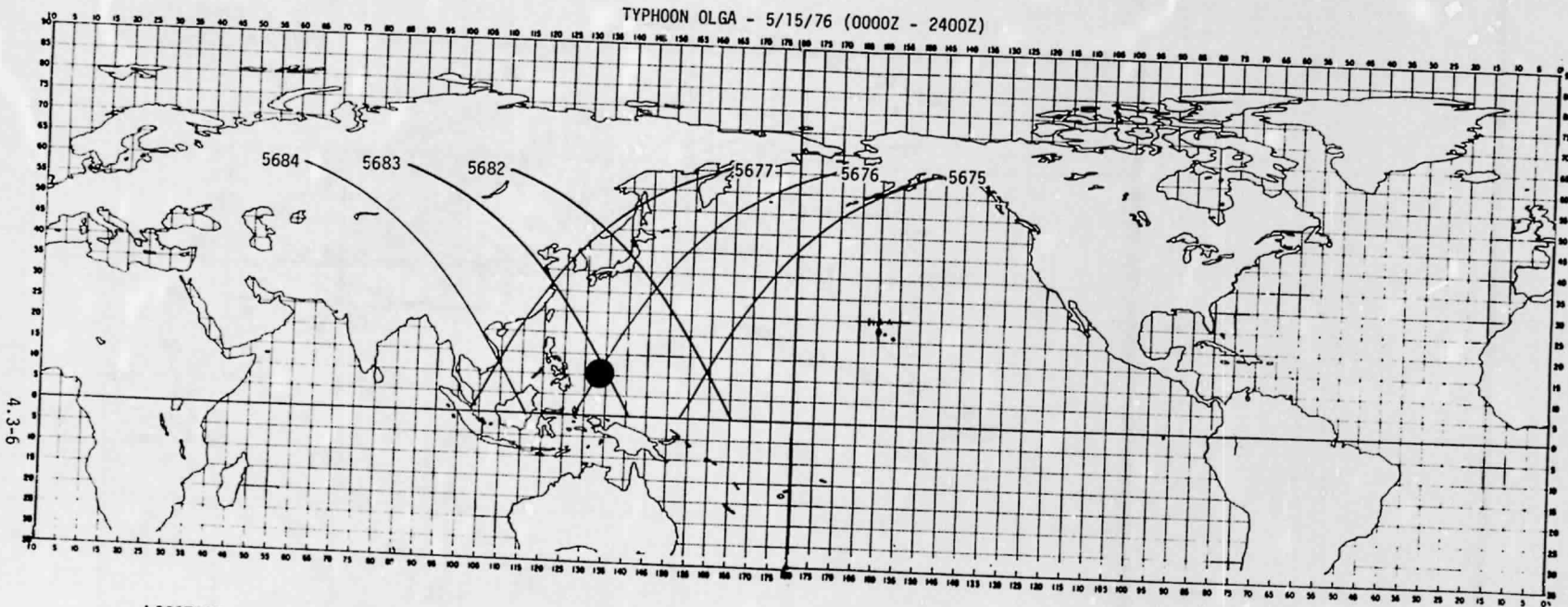


Figure 4-7

TYPHOON OLGA - 5/15/76 (0000Z - 2400Z)

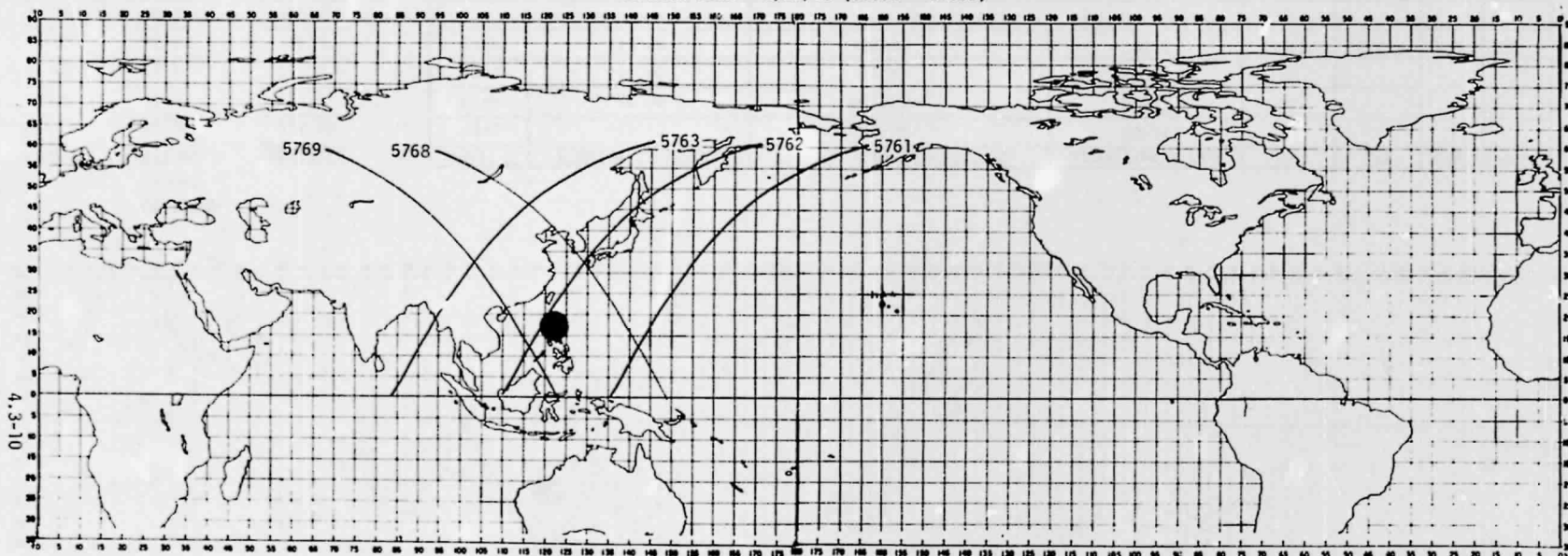


LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	10.6N	133.3E
0600Z	10.7	132.6
1200Z	11.0	131.9
1800Z	11.3	131.4
2400Z	11.7	130.8

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
5675	-17.47	022648	031??	No			
5676	-42.80	040833	0457Z	No			
5677	-68.12	055022	0635Z	No			
5682	165.26	141917	1426Z	No			
5683	139.93	160104	1604Z	No			
5684	114.61	174251	1745Z	173720	174649	802	527

TYPHOON OLGA - 5/21/76 (0000Z - 2400Z)

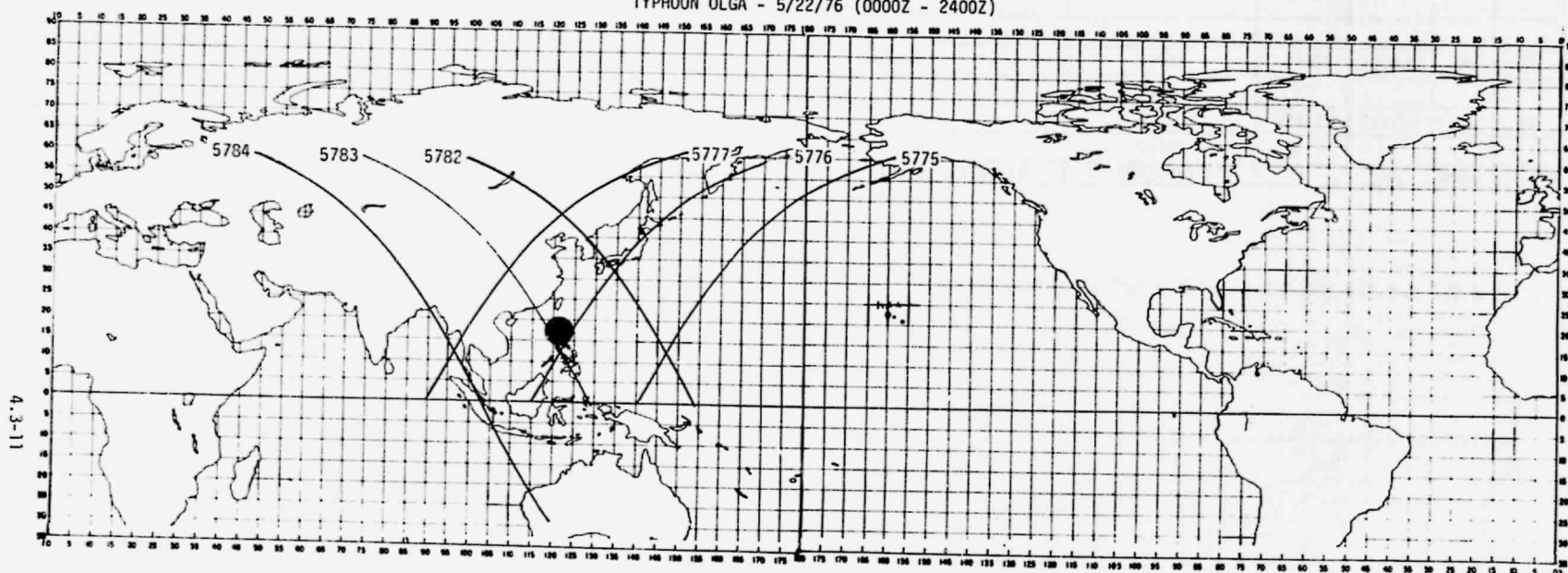


LOCATION
Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	16.5N	122.1E
0600Z	16.4	121.7
1200Z	16.3	121.4
1800Z	16.2	121.2
2400Z	16.0	121.1

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
5761	-35.25	042012	0508Z	No			
5762	-60.57	060159	0647Z	064812	070523	802	153
5763	-85.89	174346	0826Z	No			
5768	147.48	161241	1620Z	No			
5769	122.16	175428	1759Z	No			

TYPHOON OLGA - 5/22/76 (0000Z - 2400Z)



4.3-11

LOCATION

Tropical Storm

TIME	LATITUDE	LONGITUDE
0000Z	16.0N	121.1
0600Z	15.9	121.0
1200Z	15.9	120.9
1800Z	15.8	120.8
2400Z	15.8	120.6
—	—	—

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
5775	-29.77	040511	0454Z	No			
5776	-55.10	054658	0633Z	No			
5777	-80.42	072845	0812Z	No			
5782	152.96	155740	1606Z	No			
5783	127.63	173927	1745Z	No			
5783,84	102.31	192114	1923	191359	192537	802	174

SUPER TYPHOON PAMELA
(TC-06)
May 14-27, 1976

Pamela, the fourth typhoon of 1976, was also the first super typhoon of the season. Destined to become one of the more destructive storms of history, Pamela was first detected on the morning of May 13 as a tropical disturbance near the eastern edge of the near equatorial trough approximately 230 nm north of Truk. For the next 24 hours the disturbance was difficult to track with the sparse synoptic data available, however, satellite pictures indicated a general southward movement. On the morning of the 14th the disturbance began to move to the southwest and at 0600Z it was upgraded to TD 06. By that evening the depression was moving west at 5 to 7 kt. At 0339Z on the 14th aircraft indicated surface winds near 40 kt and a sea level pressure of 998 mb; at 0600Z TD 06 was upgraded to Tropical Storm Pamela. Shortly thereafter Pamela began to move to the south at 9 to 10 kt, intensifying to 45 kt by 1800Z.

The next morning satellite data showed that Pamela was moving toward the south-southeast. Truk synoptic data at 1800Z indicated a sea level pressure of 998.6 mb, a 7.1 mb fall over the previous 24 hours. By 2200Z Truk had a surface pressure of 997.9 mb and northeasterly winds of 30 kt. At this time Pamela was forecast to trace a counter-clockwise loop around Truk. At 0348Z on the 15th an aircraft fixed Pamela 75 nm southeast of Truk and proceeded on a northeast track gathering peripheral information. Later that afternoon reports indicated destructive winds at Satawan Atoll. The aircraft was diverted to the region of the atoll where the crew observed an extensive area of 55 to 65 kt flight level winds with surface winds estimated as high as 100 kt. At 0740Z on the 16th warning number 09 was amended to upgrade the storm to Typhoon Pamela. Pamela at this time was a small but intense typhoon. The maximum winds were located on the south side of the 150 nm diameter central dense overcast.

During the next 36 hours Pamela continued to intensify as it moved erratically at 3 to 6 kt, turning northwestward on the morning of the 17th. From the morning of the 16th until the morning of the 18th, Satawan Atoll continued to be buffeted with southwesterly and southerly surface winds of 50 to 55 kt. Damage was widespread on the tiny atoll, but no deaths were reported.

By the morning of the 18th Pamela had accelerated to 7 kt, passing within 50 nm of Truk. A minimum sea level pressure of 993.4 mb was recorded at 0400Z and a peak wind of 49 kt was observed an hour later. At 0327Z aircraft found maximum surface winds of 85 kt, a minimum pressure of 951 mb and a circular eye 10 nm in diameter. From the afternoon of the 17th to the afternoon of the 18th Truk recorded nearly 11 inches of rain which initiated mud slides killing 10 persons. Massive damage was inflicted on crops.

Pamela's erratic movements can be attributed to the influence of the Tropical Upper Tropospheric Trough (TUTT). On the 13th the TUTT began to establish itself north of the disturbance. Through the evening of the 15th the TUTT moved steadily south-southwestward, applying pressure to the upper anticyclone above Pamela. This pressure accounted for Pamela's southward and westward movement, and for the cyclone's slow intensification. By the morning of the 16th the TUTT had receded northward relieving the southward pressure, enhancing outflow and allowing the tropical storm to intensify. This release of pressure would have allowed the storm to move toward a climatological west-northwest tracking, however, by the 15th, an incuded mid-tropospheric high pressure cell between Pamela and Typhoon Olga (in the Philippine Sea) had intensified, building eastward and forcing Pamela toward the east. By early morning on the 17th Olga had moved considerably to the west, the ridge had relaxed, and Pamela swung north and then northwest completing the loop around Truk.

From 0600Z on the 18th to 0600Z on the 19th Typhoon Pamela moved toward the northwest at an average speed of 9 kt, intensifying at a rate of 10 kt each 6 hours. At 1200Z on the 19th Pamela reached its super typhoon intensity of 130 kt with gusts to 160 kt, which it maintained for 18 hours. At 2112Z on the 19th reconnaissance aircraft reported the minimum measured sea level pressure at 921 mb while observing concentric eye wall clouds with diameters of 10 and 20 nm. By the afternoon of the 20th, an eastward moving short-wave trough had created a weakness in the mid-tropospheric subtropical ridge north of Pamela. This, coupled with an elongated high pressure cell east of the typhoon, forced Pamela to acquire the north-northwestward track which would bring it over Guam.

A possible threat to the island had been identified as early as the 16th, and all forecasts subsequently issued indicated that Pamela was expected to pass within 100 nm of Guam. At 0450Z on the 19th the Commander, Naval Forces Marianas (COMNAVMAR) set Typhoon Condition III for Guam. At 2330Z on the 18th COMNAVMAR set Typhoon Condition II and at 2330Z on the 19th Condition I was set.

During the next 24 hours northeasterly winds on Guam slowly intensified as Pamela approached the island. At 1800Z on the 20th the National Weather Service (NWS) at Taguac reported 73 kt winds at the 3000 ft level while surface winds were only 30 kt. At 0315Z on the 21st reconnaissance aircraft from the 54th Weather Reconnaissance Squadron, Andersen AFB, Guam fixed the typhoon 30 nm southeast of the island. Less than 90 minutes later the northwestern edge of the eye was over the southeast coast of Guam.

The large, relatively calm eye, some 20 nm in diameter, required up to 3 hours to cross the center of the island. Both Andersen AFB and the NWS at Taguac continually experienced winds exceeding 50 kt as the eye passed south of these stations. Most installations which had wind indicators lost their anemometers prior to the peak winds. The maximum observed wind gust was 138 kt reported by the NWS Taguac at 0946Z. The minimum recorded surface pressure was 931.7 mb at NAS Brewer Field, some 5 nm northeast of the center. The lowest pressure of approximately 930 mb

(indicated by aircraft and land stations) supports estimated peak sustained winds of 120 kt with gusts of 145 kt. Pamela's winds gusted as much as 80 kt between peak and lull in a matter of minutes, resulting in extremely large pressure differences (60-70 lbs per square foot) on windward and leeward sides. Few unreinforced structures were able to withstand the intermittent pressure and wrenching effects. NWS Taguac recorded 33 inches of rain during Pamela's passage, with 27 inches falling in a 24-hour period.

Although the winds of Pamela were 25 kt weaker than those of Typhoon Karen which flattened the island in November 1976, the slow 7 kt movement rendered Pamela more destructive. The 226 square mile island was buffeted by winds in excess of 100 kt for 6 hours, by winds of typhoon force for 18 hours and by winds exceeding 50 kt for 30 hours. The last warning on Pamela by JTWC was issued at 2320Z on the 20th. The alternate JTWC at Yokota AB, Japan assumed all warning responsibilities for Pamela and Olga during the next 5 days.

All Naval and Air Force units had been given adequate warning and had evacuated most of their ships and aircraft. Despite extensive preparations, damage to civilian and military facilities was severe, exceeding \$500 million. Ten small ships and tugs which had sought refuge in Apra Harbor, were either sunk or ran aground, and numerous other small craft were sunk or damaged. One ship, the U. S. Coast Guard Cutter Basswood, courageously rode out the storm anchored in Apra Harbor where it recorded a peak gust of 120 kt and a minimum sea level pressure of 933.1 mb.

Miraculously, only one death occurred on Guam due to Pamela's passage. This low loss of life was attributed to the timely and accurate forecasts issued on the storm. A comprehensive account of lessons learned from Pamela is given in the Super Typhoon Pamela After-Action Report, prepared by CINCPAC REP GUAM/TTPI in August 1976.

After devastating Guam, Pamela continued to maintain its 120 kt intensity for an additional 36 hours, moving northwestward at an average speed of 10 kt. Saipan experienced gusts of 55 kt and received 10 inches of rain as the storm passed 120 nm west of the island. As Pamela continued to threaten the northern Mariana Islands, mop-up operations were in full swing on Guam. Although the civilian and military factions were well-organized and worked closely together, recovery efforts took months.

On the morning of the 23rd Pamela, still packing winds of 115 kt, slowed to 8 kt, and by that evening had passed through a weakness in the mid-tropospheric subtropical ridge, recurving to the northeast. At 2000Z on the 24th, Pamela passed 15 nm to the east of Iwo Jima blanketing the island with 75 kt winds. By 1800Z on the 25th the system had weakened into a tropical storm. The cooler sea surface temperatures and tremendous vertical shear rapidly stripped the storm of its tropical characteristics, and by the afternoon of the 26th Pamela had become extratropical.

Pamela's 15 day trek took it a distance of 2570 nm during which a total of 52 warnings were issued, 40 of them as a typhoon.

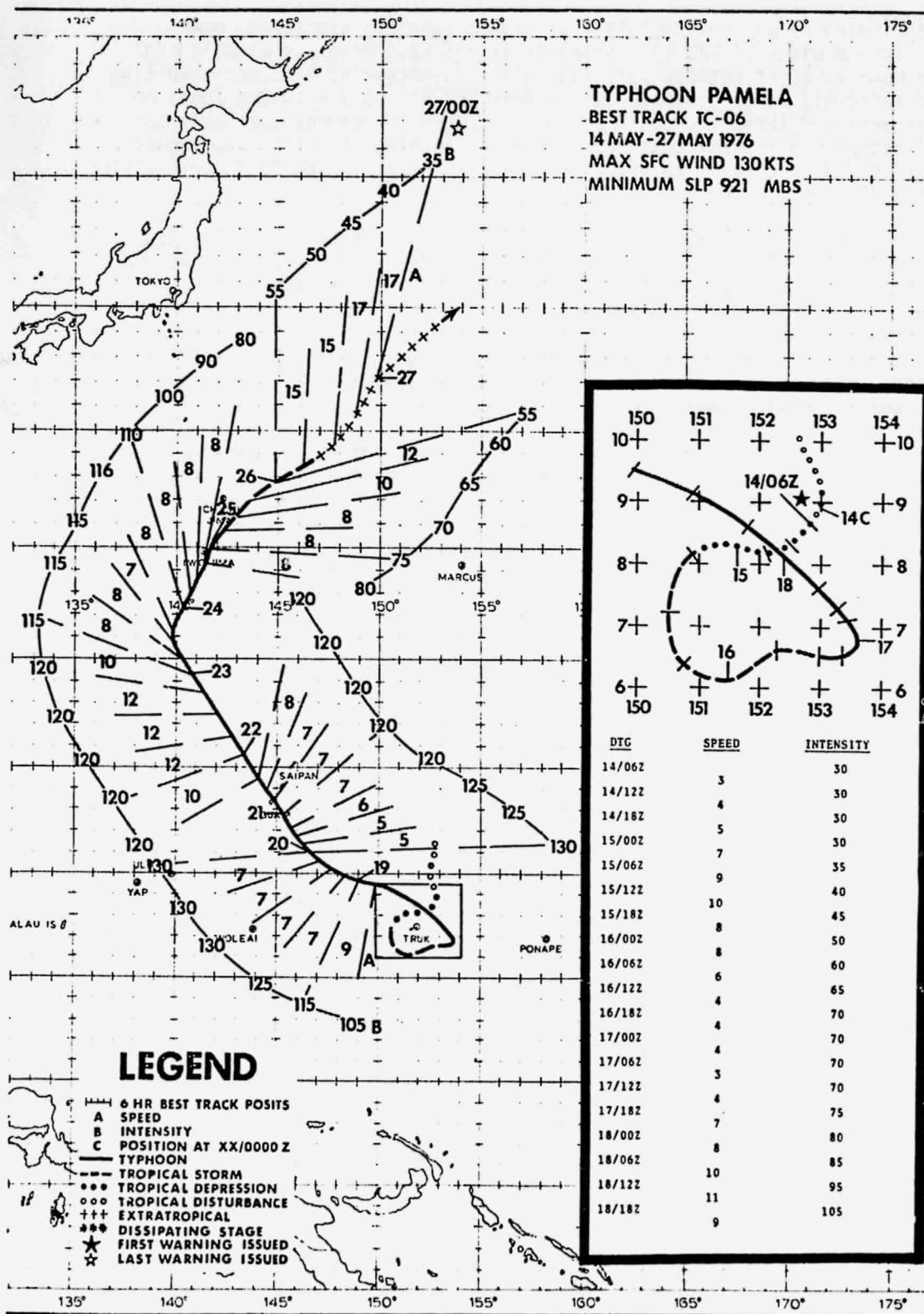


Figure 4-8
 4.4-4

DISTURBANCE: #6 PAMELA

DATE: May 14-27, 1976

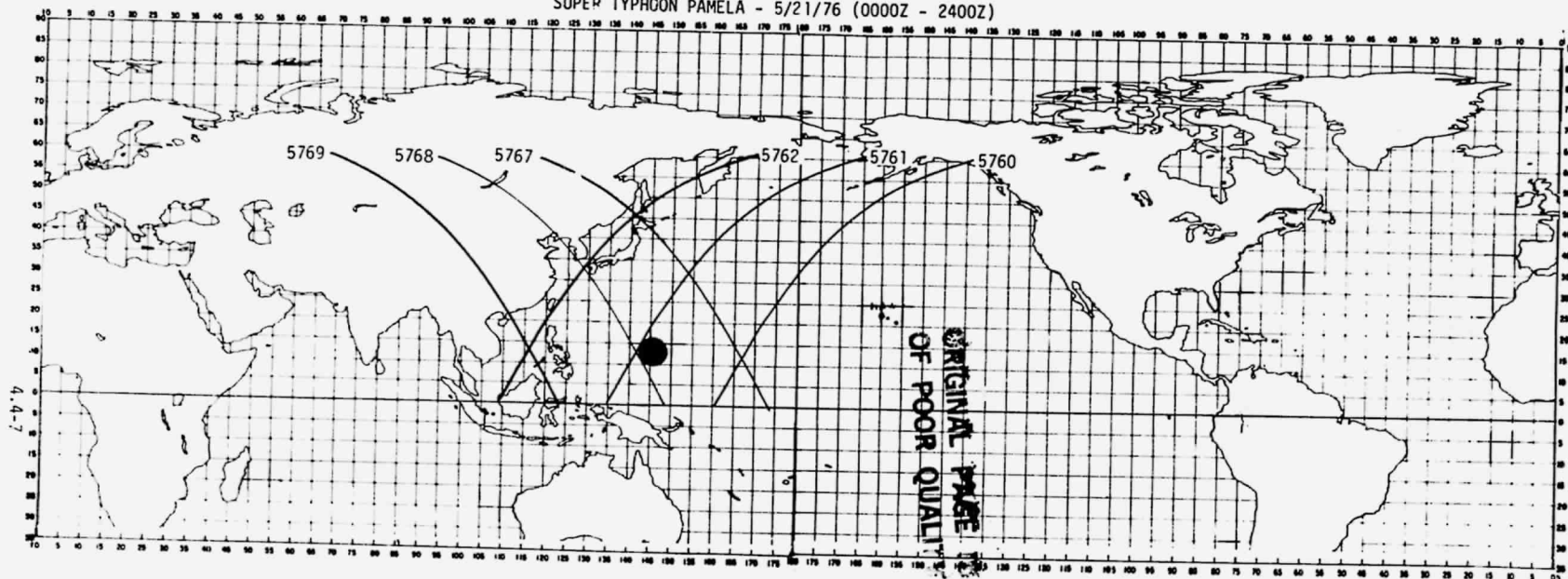
Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
5/14	0600Z	8.6N	152.8E	1005.7	30	Tropical Depression
	1200Z	8.4	152.5		30	
	1800Z	8.2	152.1		30	
5/15	0000Z	8.3N	151.6E	998.6	30	Tropical Depression
	0600Z	8.2	150.9		35	
	1200Z	7.3	150.5		40	Tropical Storm
	1800Z	6.4	150.7		45	
5/16	0000Z	6.1N	151.5E		50	Tropical Storm
	0600Z	6.6	152.4		60	
	1200Z	6.5	153.0		65	Typhoon
	1800Z	6.5	153.4		70	
5/17	0000Z	6.8N	153.6E		70	Typhoon
	0600Z	7.1	153.5		70	
	1200Z	7.3	153.3		70	
	1800Z	7.6	153.0		75	
5/18	0000Z	8.1N	152.4E		80	Typhoon
	0600Z	8.6	153.8		85	
	1200Z	9.1	150.9		95	
	1800Z	9.5	149.9		105	
5/19	0000Z	9.6N	148.9E		115	Typhoon
	0600Z	9.9	158.3		125	
	1200Z	10.2	147.7		130	Super Typhoon
	1800Z	10.6	147.2		130	
5/20	0000Z	11.0N	146.6E		130	Super Typhoon Typhoon
	0600Z	11.3	146.2		125	
	1200Z	11.6	145.9		125	
	1800Z	12.1	145.7		120	
5/21	0000Z	12.9N	145.4E		120	Typhoon
	0600Z	13.3	144.9		120	
	1200Z	13.9	144.4		120	
	1800Z	14.6	144.0		120	

DISTURBANCE: #6 PAMELA (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
5/22	0000Z	15.5N	143.4E		120	Typhoon
	0600Z	16.4	142.7		120	
	1200Z	17.5	142.0		120	
	1800Z	18.5	141.3		120	
5/23	0000Z	19.3N	140.7E		115	Typhoon
	0600Z	20.0	140.2		115	
	1200Z	20.7	139.9		115	
	1800Z	21.4	139.8		110	
5/24	0000Z	22.2N	140.2E		110	Typhoon
	0600Z	22.9	140.6		100	
	1200Z	23.7	141.0		90	
	1800Z	24.3	141.4		80	
5/25	0000Z	25.0N	141.7E		75	Typhoon
	0600Z	25.7	142.2		70	
	1200Z	26.3	142.8		65	Tropical Storm
	1800Z	27.0	143.5		60	
5/26	0000Z	27.8N	144.6E		55	Tropical Storm
	0600Z	28.4	146.2		50	
5/27	0000Z	32.0N*	150.0E*		35	Extratropical

* Position estimated from best track map.

SUPER TYPHOON PAMELA - 5/21/76 (0000Z - 2400Z)



LOCATION
Typhoon

TIME	LATITUDE	LONGITUDE
0000Z	12.9N	145.4E
0600Z	13.3	144.9
1200Z	13.9	144.4
1800Z	14.6	144.0
2400Z	15.5	143.4
—	—	—

ORBIT	EQUATOR CROSSING	TIME OF EQUATOR CROSSING	APPROXIMATE PCA	ON	OFF	MODE	UNIQ.#
5760	-9.92	023825	0328Z	No			
5761	-35.25	042012	0506Z	No			
5762	-60.57	060159	0646Z	064949	070121	802	153
5767	172.80	143054	1439Z	No			
5768	147.48	161254	1616Z	No			
5769	122.16	175428	1756Z	No			

SUPER TYPHOON LOUISE
(TC-23)
October 30 - November 7, 1976

Louise, the 14th and final typhoon of the season, was also the most intense of 1976. The disturbance that was to become Louise was first detected by satellite data on the morning of October 27 about 75 nm east of Truk. During the next 3 days the disturbance showed little intensification as it meandered through the northern Truk District. Late on the 29th the system began moving toward the west, and by the morning of the 30th satellite data indicated that it was intensifying. The first warning was issued at 0000Z on the 30th as TD 23.

Reconnaissance aircraft at 1515Z on the 30th indicated that the central pressure had fallen to 996 mb, and at 1800Z the depression was upgraded to Tropical Storm Louise. During the next 36 hours Louise moved west-northwestward at 14 kt, then westward at 11 kt as its winds increased at a rate of 5 kt every 6 hours. At 0311Z on the 1st of November aircraft observed 70 kt flight level winds and found that the central pressure of the storm had fallen to 976 mb. At 0600Z Louise was upgraded to a typhoon while 100 nm northwest of Ulithi Atoll.

Beginning on the 1st, a series of rapidly moving, mid-tropospheric short-wave troughs created a weakness in the subtropical ridge between 125E and 130E. On the afternoon of the 1st Louise began to respond to this weakness by acquiring a northwestward track. Almost simultaneously, the typhoon commenced more rapid deepening, attaining 105 kt winds by the morning of the 2nd. From 0311Z on the 1st to 0310Z on the 2nd reconnaissance aircraft indicated a fall in the central pressure of 43 mb, a rate of 1.8 mb per hour. This deepening was in response to favorable upper-level outflow channels to the northeast and south. Further deepening to 905 mb had occurred by 1435Z on the 2nd, a fall of 28 mb in 11 hours.

During the early morning of the 3rd Super Typhoon Louise attained its maximum intensity of 140 kt which it maintained for nearly 36 hours. The lowest recorded pressure was 895 mb observed by aircraft at 0830Z on the 3rd.

From the morning of the 2nd until the afternoon of the 3rd Louise maintained its northwestward track moving at 14 to 16 kt. Then, on the afternoon of the 3rd, the storm slowed to 6 kt as it recurved around the western periphery of the mid-tropospheric subtropical ridge. By 0000Z on the 4th, Louise began to accelerate to 9 kt, moving in a north-northeastward direction and slowly weakening. Louise continued this movement for more than 30 hours as it traversed the broad axis of the subtropical ridge. Late on the afternoon of the 5th the typhoon, which had weakened to 115 kt, began to accelerate on a northeast track.

From 0000Z on the 4th until 1800Z on the 6th Louise weakened at the unusually slow rate of 5 kt per 6 hours. This slow weakening resulted from two conditions: (1) A broad surface high pressure cell centered over northern Honshu prevented significant equatorward penetration of frontal systems; and (2) The extremely strong jet stream (exceeding 200 kt) over eastern Japan provided an excellent outflow channel. At 0300Z on the 6th, Minamidaito Jima, 40 nm north-northeast of Louise, reported east-northeasterly winds of 40 kt and a sea level pressure of 984.8 mb. Two hours later the storm passed 15 nm southeast of the island with maximum winds estimated near 95 kt.

By the 7th, cooler sea surface temperatures and very strong vertical shear were taking their toll as Louise moved north of 30N. Reconnaissance aircraft at 0359Z on the 7th indicated that Louise was rapidly losing its tropical character and was becoming extratropical. The Airborne Reconnaissance Weather Officer also observed that the lower half of the wall cloud was "rotating rapidly," a phenomenon sometimes reported when a storm is becoming extratropical.

At 0600Z on the 7th, moving east-northeast at 25 kt, Louise became extratropical. As an extratropical system the remains of Louise moved northward to combine with another surface low. The resulting system had deepened to 947 mb by the 10th and became one of the most severe extratropical storms of the year, ultimately producing surf in excess of 30 ft in the Hawaiian Islands.

DISTURBANCE: #23 LOUISE

DATE: October 30 - November 7, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
10/30	0000Z	10.0N	148.8E		25	Tropical Depression
	0600Z	9.8	148.2		30	
	1200Z	9.7	147.3		30	
	1800Z	9.8	146.1		35	Tropical Storm
10/31	0000Z	10.2N	144.8E		40	Tropical Storm
	0600Z	10.6	143.4		45	
	1200Z	11.0	142.1		50	
	1800Z	11.2	141.0		55	
11/1	0000Z	11.2N	139.8E		60	Tropical Storm Typhoon
	0600Z	11.2	138.6		65	
	1200Z	11.4	137.3		75	
	1800Z	11-7	136.1		90	
11/2	0000Z	12.2N	134.8E		105	Typhoon
	0600Z	12.8	133.6		120	
	1200Z	13.6	132.2		135	
	1800Z	14.3	130.8		140	Super Typhoon
11/3	0000Z	14.9N	129.5E		140	Super Typhoon
	0600Z	15.7	128.2		140	
	1200Z	16.3	127.4		140	
	1800Z	16.8	126.9		140	
11/4	0000Z	17.3N	126.7E		140	Super Typhoon
	0600Z	18.1	126.8		135	
	1200Z	19.0	127.0		130	
	1800Z	19.8	127.2		125	Typhoon
11/5	0000Z	20.6N	127.4E		120	Typhoon
	0600Z	21.5	127.6		115	
	1200Z	22.5	128.2		110	
	1800Z	23.5	129.1		105	
11/6	0000Z	24.6N	130.3E		100	Typhoon
	0600Z	25.9	131.7		95	
	1200Z	27.4	133.3		90	
	1800Z	28.9	135.2		85	

DISTURBANCE: #23 LOUISE (Continued)

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
11/7	0000Z	30.0N	137.3E		70	Typhoon Tropical Storm Extratropical
	0600Z	30.6	139.8		55	
	1200Z	31.0	142.6		45	

5.0 NORTH INDIAN OCEAN AREA

5.1 GENERAL

All of the data presented in this section on the cyclones occurring in the North Indian Ocean area were extracted from the Joint Typhoon Warning Center (JTWC) Document, "1976 Annual Typhoon Report."

During 1976, there were five tropical cyclones in the North Indian Ocean: three in the Bay of Bengal and two in the Arabian Sea. Table 5-1 presents the tropical cyclone distribution by month for 1976 and for the preceding five years. Except for the absence of activity during November, 1976 was climatologically normal. A total of 28 warnings were issued on the five cyclones, none of which exceeded 55 kt intensity. TC 25-76 occurred in the newly acquired JTWC area of responsibility, which this year was extended from 62E to the coast of Africa.

The five tropical cyclones occurring in this area, their ground tracks together with their periods of occurrence are shown in Figure 5-1. Other pertinent data are listed in Table 5-2.

Results of the comparison of the cyclone information and the GEOS-3 schedule information indicates only one possible intersection and even that possibility does not appear very likely. Information as available, however, is given in the next section.

5.2 TC 20-76

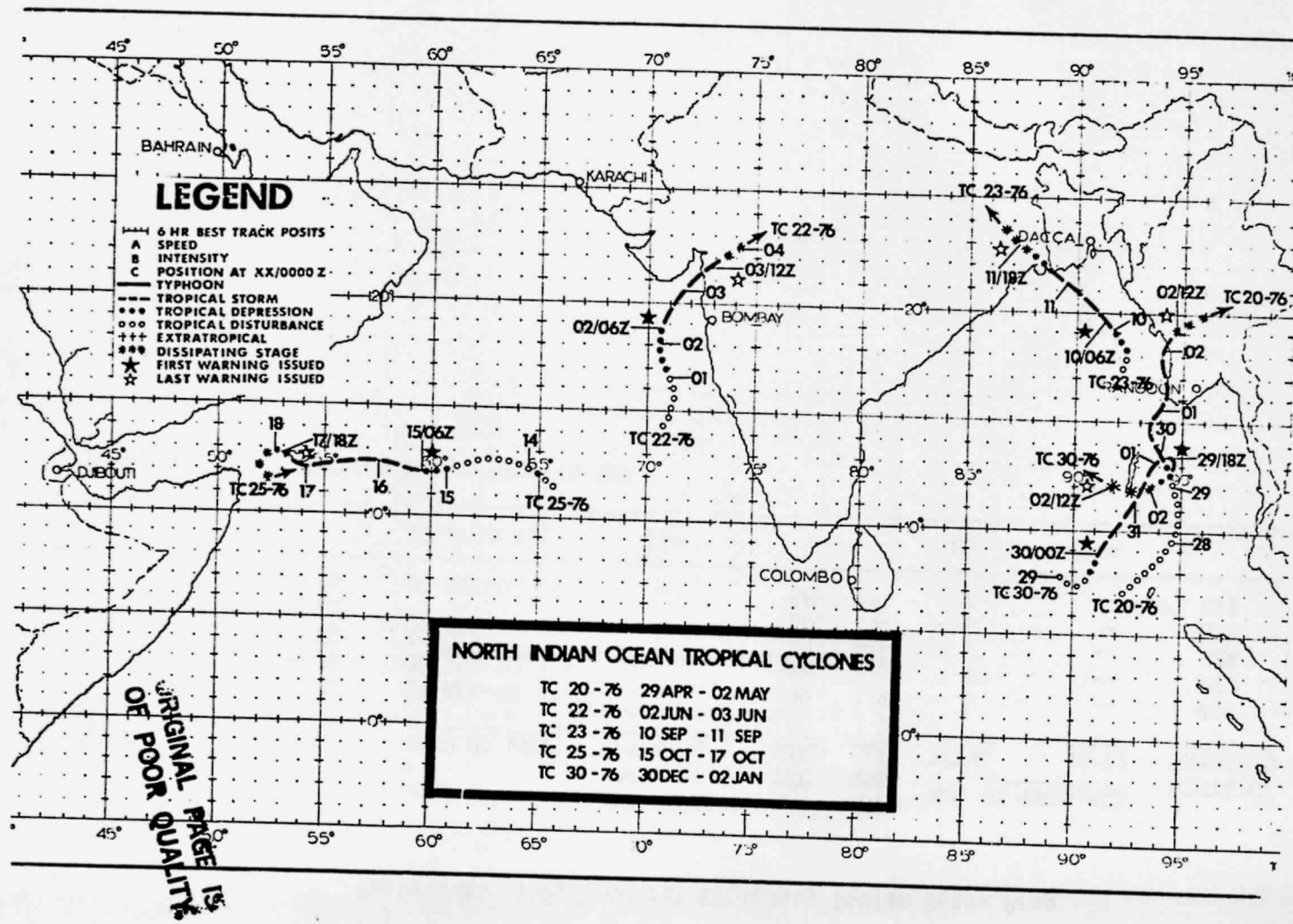
Tropical Cyclone 20-76 was the first cyclone in the Indian Ocean for the 1976 season. Maximum winds attained by this storm were 50 knots. The one data pass was on 4/29, during the infancy of the storm's development. Following are the best cyclone position track maps and satellite track maps.

Table 5-1. Frequency of North Indian Ocean
Cyclones by Month and Year

YEAR*	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1971	0	0	0	0	0	0	0	0	0	1	1	0	2
1972	0	0	0	1	0	0	0	0	2	0	1	0	4
1973	0	0	0	0	0	0	0	0	0	1	2	1	4
1974	0	0	0	0	0	0	0	0	0	0	1	0	1
1975	1	0	0	0	2	0	0	0	0	1	2	0	6
1976	0	0	0	1	0	1	0	0	1	1	0	1	5
AVG**	0.1	***	0.1	0.3	0.7	0.7	0.6	0.4	0.5	1.0	1.1	0.5	5.7

- * 1971-1974 represent Bay of Bengal cyclones only
- ** 1877-1960 average (including Arabian Sea) Mariners Worldwide Climatic Guide to Tropical Storms at Sea (H. L. Crutcher and R. G. Quayle)
- *** Less than 0.05 per month.

5.1-3



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Figure 5-1

Table 5-2. 1976 Tropical Cyclones, Indian Ocean Area

<u>CYCLONE</u>	<u>TYPE</u>	<u>NAME</u>	<u>PRD OF WRNG</u>	<u>CALENDAR DAYS OF WARNING</u>	<u>MAX SFC WIND</u>	<u>MIN OBS SLP</u>	<u>NO. OF WARNINGS</u>		<u>DISTANCE TRAVELED</u>
							<u>TOTAL</u>	<u>AS TY</u>	
	TC	20-76	29 APR-02 MAY	4	50	---	7	--	403
	TC	22-76	02 JUN-03 JUN	2	40	---	3	--	163
	TC	23-76	10 SEP-11 SEP	2	40	---	5	--	324
	TC	25-76	15 OCT-17 OCT	3	50	---	6	--	372
	TC	30-76	30 DEC-02 JAN	4	55	---	7	--	511
1976 TOTALS				15*			28	--	

* OVERLAPPING DAYS INCLUDED ONLY ONCE IN SUM

DISTURBANCE: TC 20-76

DATE: April 29 - May 2, 1976

Date	Time	Position		Pressure (MB)	Wind (KTS)	Stage
		Latitude	Longitude			
4/29	1800Z	13.1N	94.2E		35	Tropical Storm
4/30	0000Z 0600Z 1200Z 1800Z	13.4N 14.0 14.8 14.5	94.0E 93.6 93.5 93.8		40 45 45 50	Tropical Storm
5/1	0000Z 0600Z 1200Z 1800Z	16.0N 16.5 16.9 17.3	94.2E 94.4 94.3 94.1		50 40 35 40	Tropical Storm
5/2	0000Z 0600Z 1200Z	17.9N 18.3 18.8	94.1E 94.2 94.4		45 45 35	Tropical Storm Dissipating

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1. Report No. NASA TM-73282	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle An Atlas of 1976 GEOS-3 Radar Altimeter Data for Tropical Cyclone Studies		5. Report Date January 1979	
		6. Performing Organization Code	
7. Author(s) H. Ray Stanley, NASA Wallops Flight Center Barbara Chan, Cindy Givens, Ronald Taylor, EG&G/WASC		8. Performing Organization Report No.	
		10. Work Unit No.	
9. Performing Organization Name and Address EG&G/Washington Analytical Services Center, Inc. Wolf Research and Development Group P. O. Box 476 Pocomoke City, Maryland 21851		11. Contract or Grant No. NAS6-2639	
		13. Type of Report and Period Covered Technical Memorandum	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Wallops Flight Center Wallops Island, Virginia 23337		14. Sponsoring Agency Code	
		15. Supplementary Notes	
16. Abstract <p>This document's primary purpose is to provide the means for locating and extracting GEOS-3 altimeter data acquired for the analysis of specific hurricanes, typhoons, and other tropical cyclones. These data are also expected to be extremely useful in the analysis of the behavior of the altimeter instrument in the presence of severe meteorological disturbances as well as provide a data base which can be useful in the resolution of apparently anomalous geoid or sea surface characteristics. Geographic locations of 1976 tropical cyclones have been correlated with the closest approaching orbits of the GEOS-3 satellite and its radar altimeter. The cyclone locations and altimeter data were correlated for the entire 1976 season. The area of coverage includes the entire northern hemisphere. This document is a sequel to NASA TM-X-69364 which covered the majority of the 1975 season.</p>			
17. Key Words (Suggested by Author(s)) Hurricane, Tropical Cyclone, GEOS-3, Altimetry, Typhoon		18. Distribution Statement Unclassified - unlimited STAR Category 47	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 198	22. Price*