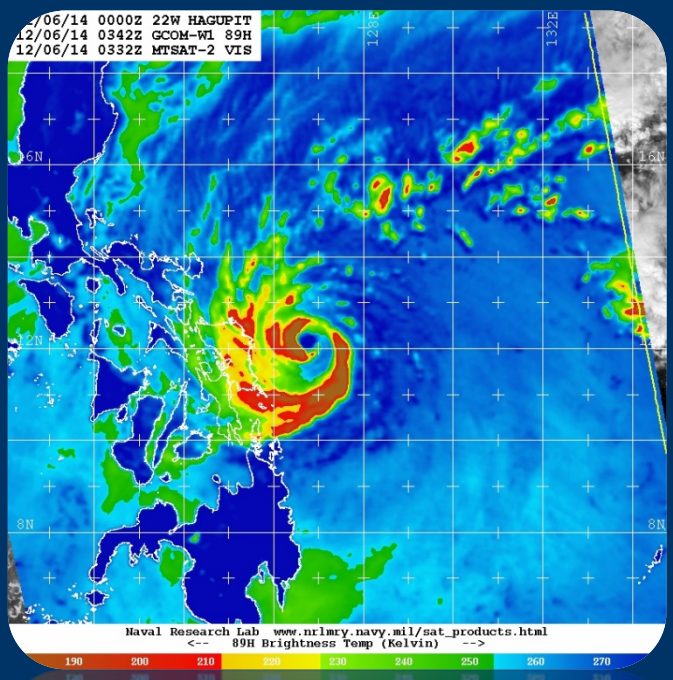
Annual Tropical Cyclone Report
2014



STEVEN P. SOPKO

Captain, United States Navy

Commanding Officer

ROBERT J. FALVEY

Director, Joint Typhoon Warning Center

Cover: GCOM-W1 89h image of Typhoon 22W (HAGUPIT), 06 December 2014, as it approaches the central island of Samar, Philippines. Image courtesy of the Naval Research Laboratory (NRL). http://www.nrlmry.navy.mil/TC.html

Executive Summary

The Annual Tropical Cyclone Report (ATCR) is prepared by the staff of the Joint Typhoon Warning Center (JTWC), a jointly manned United States Air Force/Navy organization under the operational command of the Commanding Officer, Joint Typhoon Warning Center.

The original JTWC was established on 1 May 1959 when the Joint Chiefs of Staff directed Commander-in-Chief, US Pacific Command (USCINCPAC) to provide a single tropical cyclone warning center for the western North Pacific region. USCINCPAC delegated the tropical cyclone forecast and warning mission to Commander, Pacific Fleet. A subsequent USCINCPAC directive further tasked Commander, Pacific Air Force to provide for tropical cyclone (TC) reconnaissance support to the JTWC. Currently, JTWC operations are guided by USPACOM Instruction 0539.1 and Pacific Air Forces Instruction 15-101.

This edition of the ATCR documents the 2014 TC season and details operationally or meteorologically significant cyclones noted within the JTWC Area of Responsibility. Details are provided to describe significant challenges and/or shortfalls in the TC warning system and to serve as a focal point for future research and development efforts. Also included are tropical cyclone reconnaissance statistics and a summary of tropical cyclone research or tactics, techniques and procedures development that members of JTWC were involved in.

The western North Pacific Ocean returned to below average activity again, with only 23 TCs observed compared to the long term average of 31. However, 7 of the 23 cyclones attained super typhoon intensity. Despite the low number of cyclones, the onset of El Nino conditions shifted the genesis region eastward, causing major DoD installations to experience strong cyclone impacts. Okinawa had two direct strikes and two additional passages within 300 miles. Guam had three cyclones pass within 300 miles. Department of Defense bases in South Korea were impacted by one cyclone and mainland Japan was impacted by four.

The Southern Hemisphere activity remained below the long term average of 28, with 14 cyclones in the southern Indian Ocean / western Australia region and 10 in the South Pacific / eastern Australia region. The northern Indian Ocean experienced normal activity of five cyclones, with two in the Arabian Sea and three in the Bay of Bengal. The most significant cyclones in the northern Indian Ocean were Tropical Cyclone 03B (Hudhud) in the Bay of Bengal and 04A (Nilofar) in the Arabian Sea, both reached peak intensities of 115 knots.

Weather satellite data remained the mainstay of the TC reconnaissance mission to support the JTWC. Air Force satellite analysts exploited a wide variety of conventional and microwave satellite data to produce over eleven thousand position and intensity estimates (fixes), primarily using the USAF Mark IVB and the USN FMQ-17 satellite direct readout systems. Geo-located microwave satellite imagery overlays available via the Automated Tropical Cyclone Forecast (ATCF) system from Fleet Numerical Meteorology and Oceanography Center and the Naval Research Laboratory Monterey, CA were also used by JTWC to make TC fixes.

JTWC also continues to utilize radar derived TC position information from numerous U.S. owned/operated weather radars as well as from international sources. However, budget challenges have delayed the replacement of the WSR-88D Doppler Weather Radar at Kadena AB.

JTWC continued to collaborate with TC forecast support and research organizations such as the Fleet Numerical Meteorology and Oceanography Center (FNMOC), Naval Research Laboratory, Monterey (NRLMRY), Naval Post Graduate School, the Office of Naval Research, Air Force Weather Agency (AFWA), and NOAA Line Offices for continued development of TC reconnaissance tools, numerical models and forecast aids.

The Technical Services Team (formally TECHDEV) continued significant collaboration with the research and development community. Among a variety of promising projects (described in Chapter 5 of this report), Technical Services implemented the Weighted Analog Intensity (WANI) application developed at the Naval Postgraduate School. This intensity aid uses the JTWC track forecast to match the top ten analogs from the JTWC best track archive. A weighted consensus intensity forecast and intensity spread guidance are created from these ten historical cyclones.

Behind these efforts are the dedicated team of men and women, military and civilian at JTWC. Special thanks to the entire JTWC N6 Department for their continued outstanding IT support and the administrative and budget staff who worked tirelessly to ensure JTWC had the necessary resources to accomplish the mission despite extremely volatile financial times.

A Special thanks also to: FNMOC for their operational data and modeling support; the NRLMRY and ONR for its dedicated TC research; the National Oceanic and Atmospheric Administration National Environmental Satellite, Data, and Information Service for satellite reconnaissance support; Dr. John Knaff, Mr. Jeff Hawkins, Dr. Mark DeMaria, and Mr. Chris Velden for their continuing efforts to exploit remote sensing technologies in new and innovative ways; Mr. Charles R. “Buck” Sampson, Ms. Ann Schrader, and Mr. Mike Frost for their outstanding support and continued development of the ATCF system.

JTWC Personnel 2014

N1 Staff
CDR Mike Cornelius, *Executive Officer*
AGDC Enrique Acosta, *Senior Enlisted Advisor*
Ms. Kerri Kanbara, *Administrative Officer*
Mr. Roberto Macais, *Administrative Assistant*

N4 Staff
Ms. Kehau Koa, *Budget Analyst*
LSC Arcyria Lockley, *Logistics and Supply*

N6 Staff
Mr. Joshua Nelson, *Information Technology Officer*
Mr. Angelo Alvarez, *System Administrator*
Mr. Andrew Rhoades, *Information Assurance Officer*
Mr. Albert Leyendecker, *System Administrator*
IT1 Jeffery Gross, *Information Technology*
IT2Isaac Wilson, *Information Technology*

J3 Staff
Mr. Robert Falvey, *Director*
LT Chad Geis, *Operations Officer*
LT Thomas Mills, *Operations Officer*
Mr. Edward Fukada, *Technical Advisor*
Mr. Matt Kucas, Chief Technical Services
Mr. Brian Strahl, Technical Development and Research Coordinator
Mr. James Darlow, Technical Services

Command Duty Officers (CDO)
AG1 Nadine McBee
AG1 Cecil Jordan
AGC Christopher McKinstry
LT Chris Chitwood
LT Denie Kiger
LT Dominique Krieger
LT Nicholas Kutchak
LT Justin Van Es

Typhoon Duty Officers (TDO)
LT Joshua Carter
LT Thai Phung
Mr. Matt Kucas
Mr. Stephen Barlow
Mr. Brian Strahl
Mr. Richard Ballucanag
Mr. Aaron Lana

Satellite Operations
Capt Brenda Arincorayan*, OIC Satellite Operations*
TSgt Jeffrey Quast, *Analyst/NCOIC*
TSgt Ricky Frye, *Analyst/NCOIC*
SSgt Donald Chappotin*, Analyst*
SSgt Brittany Bermea, *Analyst*
SrA Karen Long, *Analyst*
SrA Kolby Rapp, *Analyst*

SrA Terrance Schalin, *Analyst*
Mr. James Darlow, *Analyst*
Mr. Dana Uehara, *Analyst*

Geophysical Technician (GT)
AG1 Jamaine Parks
AG2 Jack Tracey
AG2 Heather Johnston
AG2 Christian Wilcox
AG3 Bristol Rigby
AG3 Jake Wilson
AG3 Christopher Hoole
AGAN Janie Sherrock

Table of Contents

Chapter 1 Western North Pacific Ocean Tropical Cyclones

Section 1 Informational Tables

Table 1-1 is a summary of TC activity in the western North Pacific Ocean during the 2014 season. JTWC issued warnings on 23 cyclones. Table 1-2 shows the monthly distribution of TC activity summarized for 1959 - 2014 and Table 1-3 shows the monthly average occurrence of TC's separated into: (1) typhoons and (2) tropical storms and typhoons. Table 1-4 summarizes Tropical Cyclone Formation Alerts issued. The annual number of TC's of tropical storm strength or higher appears in Figure 1-1, while the number of TC's of super typhoon intensity appears in Figure 1-2. Figure 1-3 illustrates a monthly average number of cyclones based on intensity categories. Figures 1-4 and 1-5 depict the 2014 western North Pacific Ocean TC tracks and intensities.

Table 1-1

WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES FOR 2014
(01 JAN 2014 - 31 DEC 2014)

TC	NAME*	PERIOD**		WARNINGS ISSUED	EST MAX SFC WINDS KTS
01W	LINGLING	18 JAN / 0000Z	19 JAN / 2100Z	8	30
02W	KAJIKI	30 JAN / 1800Z	01 FEB / 1800Z	9	35
03W	FAXAI	28 FEB / 0000Z	05 MAR / 1200Z	23	80
04W	FOUR	22 MAR / 0000Z	22 MAR / 1800Z	4	25
05W	PEIPAH	03 APR / 0000Z	10 APR / 0600Z	30	35
06W	TAPAH	27 APR / 1200Z	01 MAY / 0600Z	16	70
07W	HAGIBIS	14JUN / 0600Z	18 JUN / 0000Z	12	40
08W	NEOGURI	03 JUL / 0000Z	10 JUL / 1200Z	31	140
09W	RAMMASUN	10 JUL / 1200Z	19 JUL / 0000Z	35	140
10W	MATMO	17 JUL / 1200Z	23 JUL / 1200Z	25	85
11W	HALONG	28 JUL / 1200Z	10 AUG / 0000Z	51	140
12W	NAKRI	02 AUG / 0600Z	03 AUG / 1800Z	7	40
07E	GENEVIEVE	07 AUG / 0600Z	11 AUG / 1800Z	19	140
13W	FENGSHEN	07SEP / 0000Z	09 SEP / 1200Z	11	65
14W	FOURTEEN	07SEP / 0600Z	08SEP / 0000Z	4	30
15W	KALMAEGI	10 SEP / 1800Z	16 SEP / 1800Z	25	80
16W	FUNG-WONG	17 SEP / 1200Z	23 SEP / 1200Z	25	50
17W	KUMMURI	24 SEP / 1200Z	28 SEP / 0000Z	19	55
18W	PHANFONE	28 SEP / 1800Z	06 OCT / 0600	31	135
19W	VONGFONG	02 OCT / 1800Z	14 OCT / 0000Z	46	155
20W	NURI	31 OCT / 0000Z	06 NOV / 0000Z	25	155
21W	SINLAKU	26 NOV / 0600Z	29 NOV / 1800Z	15	55
22W	HAGUPIT	01 DEC / 0000Z	12 DEC / 0000Z	45	155
23W	JANGMI	28 DEC / 0000Z	31 DEC / 0000Z	13	45

* As designated by the responsible RSMC

** Dates are based on the issuance of JTWC warnings on system.

Table 1-2
DISTRIBUTION OF WESTERN NORTH PACIFIC TROPICAL CYCLONES
FOR 1959 - 2014

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total ≥64kt	Total 34-63kt	Total ≤33 kt
1959	0 / 0 0 0	1 / 0 1 0	1 / 0 1 1	1 / 1 0 0	0 / 0 0 0	1 / 0 0 1	3 / 1 1 1	8 / 5 1 2	9 / 4 2 3	3 / 2 1 0	2 / 2 0 0	2 / 2 0 0	31	17	7	7
1960	1 / 0 0 1	0 / 0 0 0	1 / 0 0 1	1 / 1 0 0	1 / 0 1 0	3 / 0 2 1	3 / 2 1 0	9 / 8 1 0	5 / 0 4 1	4 / 4 0 0	1 / 1 0 0	1 / 1 0 0	30	19	8	3
1961	1 / 0 1 0	1 / 0 1 0	1 / 1 0 0	1 / 0 1 0	4 / 2 1 1	6 / 1 1 4	5 / 3 2 0	7 / 3 1 3	6 / 5 1 0	7 / 3 2 2	2 / 1 0 1	1 / 1 0 0	42	20	11	11
1962	0 / 0 0 0	1 / 0 1 0	0 / 0 0 0	1 / 1 0 0	3 / 2 0 1	0 / 0 0 0	8 / 5 1 2	8 / 7 0 1	7 / 3 1 3	5 / 3 1 1	4 / 3 0 1	2 / 0 2 0	39	24	6	9
1963	0 / 0 0 0	0 / 0 0 0	1 / 0 0 1	1 / 1 0 0	0 / 0 0 0	4 / 3 1 0	5 / 3 1 1	4 / 3 0 1	4 / 2 2 0	6 / 5 1 0	0 / 0 0 0	3 / 2 1 0	28	19	6	3
1964	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	3 / 2 0 1	2 / 2 0 0	8 / 6 1 1	8 / 3 5 0	8 / 5 2 1	7 / 3 3 1	6 / 4 2 0	2 / 1 0 1	44	26	13	5
1965	2 / 1 1 0	2 / 0 2 0	1 / 0 1 0	1 / 1 0 0	2 / 1 0 1	4 / 3 1 0	6 / 4 1 1	7 / 3 2 2	9 / 5 3 1	3 / 2 0 1	2 / 1 1 0	1 / 0 1 0	40	21	13	6
1966	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	2 / 2 0 0	1 / 1 0 0	4 / 3 1 0	9 / 5 3 1	10 / 5 3 2	4 / 1 1 2	5 / 1 2 2	2 / 1 0 1	38	20	10	8
1967	1 / 0 1 0	0 / 0 0 0	2 / 1 1 0	1 / 1 0 0	1 / 0 1 0	1 / 1 0 0	8 / 3 3 2	10 / 3 4 3	8 / 5 3 0	4 / 2 1 1	4 / 4 0 0	1 / 0 1 0	41	20	15	6
1968	0 / 0 0 0	1 / 0 0 1	0 / 0 0 0	1 / 1 0 0	0 / 0 0 0	4 / 2 0 2	3 / 1 2 0	8 / 3 4 1	4 / 4 0 0	6 / 5 1 0	4 / 4 0 0	0 / 0 0 0	31	20	7	4
1969	1 / 1 0 0	0 / 0 0 0	1 / 0 1 0	1 / 1 0 0	0 / 0 0 0	0 / 0 0 0	3 / 2 1 0	3 / 2 1 0	6 / 2 0 4	5 / 4 1 0	2 / 1 1 0	1 / 0 1 0	23	13	6	4
1970	0 / 0 0 0	1 / 1 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	2 / 1 1 0	3 / 2 1 0	7 / 4 2 1	4 / 2 2 0	6 / 3 2 1	4 / 1 3 0	0 / 0 0 0	27	12	12	3
1971	1 / 0 1 0	0 / 0 0 0	1 / 0 1 0	2 / 2 0 0	5 / 2 3 0	2 / 2 0 0	8 / 6 2 0	5 / 3 1 1	7 / 5 1 1	4 / 3 1 0	2 / 1 1 0	0 / 0 0 0	37	24	11	2
1972	1 / 1 0 0	0 / 0 0 0	1 / 0 0 1	0 / 0 0 0	0 / 0 0 0	4 / 2 2 0	5 / 4 1 0	5 / 3 2 0	6 / 4 1 1	5 / 4 1 0	2 / 2 0 0	3 / 2 1 0	32	22	8	2
1973	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	7 / 4 3 0	6 / 2 3 1	3 / 2 0 1	4 / 4 0 0	3 / 0 3 0	0 / 0 0 0	23	12	9	2
1974	1 / 0 1 0	0 / 0 0 0	1 / 0 1 0	1 / 0 1 0	1 / 0 0 0	4 / 1 2 1	5 / 2 3 0	7 / 2 3 2	5 / 3 2 0	4 / 4 0 0	4 / 2 2 0	2 / 0 2 0	35	15	17	3
1975	1 / 1 0 0	0 / 0 0 0	0 / 0 0 0	1 / 0 0 1	0 / 0 0 0	0 / 0 0 0	1 / 0 1 0	6 / 4 1 1	5 / 4 1 0	6 / 3 2 1	3 / 2 1 0	2 / 0 2 0	25	14	8	3
1976	1 / 1 0 0	1 / 0 1 0	0 / 0 0 0	2 / 1 1 0	2 / 2 0 0	2 / 2 0 0	4 / 2 2 0	4 / 1 3 0	5 / 4 1 0	0 / 0 0 0	2 / 1 1 0	2 / 0 2 0	25	14	11	10
1977	0 / 0 0 0	0 / 0 0 0	1 / 0 1 0	0 / 0 0 0	1 / 0 0 1	1 / 0 1 0	4 / 3 0 1	2 / 0 2 0	5 / 2 3 0	4 / 3 1 0	2 / 2 0 0	1 / 0 1 0	21	11	8	2
1978	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	0 / 0 0 0	3 / 0 3 0	4 / 3 1 0	8 / 3 4 1	4 / 3 1 0	7 / 4 1 2	4 / 1 2 1	0 / 0 0 0	32	15	13	4
1979	1 / 1 0 0	0 / 0 0 0	1 / 1 0 0	1 / 1 0 0	2 / 0 1 1	0 / 0 0 0	5 / 2 2 1	4 / 2 0 2	6 / 3 3 0	3 / 2 1 0	2 / 1 1 0	3 / 1 1 1	28	14	9	5
1980	0 / 0 0 0	0 / 0 0 0	1 / 0 0 1	1 / 0 1 0	4 / 2 2 0	1 / 0 1 0	5 / 3 1 1	3 / 2 0 1	7 / 5 1 1	4 / 2 2 0	1 / 1 0 0	1 / 0 1 0	28	15	9	4
1981	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	1 / 0 1 0	1 / 0 1 0	2 / 2 0 0	5 / 2 3 0	8 / 2 5 1	4 / 4 0 0	2 / 1 1 0	3 / 2 1 0	2 / 2 0 0	29	16	12	1
1982	0 / 0 0 0	0 / 0 0 0	3 / 2 1 0	0 / 0 0 0	1 / 1 0 0	3 / 1 2 0	4 / 2 2 0	5 / 5 0 0	6 / 3 2 1	4 / 3 0 1	1 / 1 0 0	1 / 1 0 0	28	13	7	2
1983	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	1 / 0 0 0	1 / 0 1 0	3 / 3 0 0	6 / 2 3 1	3 / 1 1 1	5 / 3 2 0	5 / 3 2 0	2 / 0 2 0	25	12	11	2
1984	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	2 / 0 2 0	5 / 4 1 0	7 / 2 3 2	4 / 1 3 0	8 / 5 4 1	3 / 3 0 0	1 / 1 0 0	30	16	13	3
1985	2 / 0 2 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	3 / 2 0 1	1 / 1 0 0	7 / 5 2 0	5 / 3 2 0	5 / 4 1 0	1 / 0 1 0	2 / 1 1 0	27	17	9	1
1986	0 / 0 0 0	1 / 1 0 0	0 / 0 0 0	1 / 1 0 0	2 / 1 1 0	2 / 1 1 0	2 / 2 0 0	5 / 4 1 0	2 / 2 0 0	5 / 3 2 0	4 / 2 2 0	3 / 2 1 0	27	19	8	0
1987	1 / 1 0 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	0 / 0 0 0	2 / 1 1 0	4 / 4 0 0	4 / 3 1 0	7 / 5 1 1	2 / 2 0 0	3 / 1 2 0	1 / 1 0 0	25	18	6	1
1988	1 / 1 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	3 / 1 1 1	2 / 1 1 0	5 / 2 3 0	8 / 2 6 0	4 / 4 0 0	2 / 2 0 0	1 / 0 1 0	27	14	12	1
1989	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	2 / 2 0 0	2 / 1 1 0	6 / 2 3 1	8 / 3 3 2	4 / 2 2 0	6 / 6 0 0	3 / 3 0 0	2 / 1 0 1	35	21	10	4
1990	1 / 1 0 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	2 / 2 1 0	4 / 2 1 0	4 / 2 2 0	5 / 5 0 0	5 / 4 1 0	5 / 2 3 0	4 / 3 1 0	1 / 1 0 0	32	21	10	1
1991	0 / 0 0 0	0 / 0 0 0	2 / 1 1 0	1 / 1 0 0	1 / 1 0 0	1 / 1 0 10	4 / 4 0 0	8 / 3 3 2	6 / 4 2 0	3 / 3 0 0	6 / 3 3 0	0 / 0 0 0	32	20	10	2
1992	1 / 1 0 0	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	3 / 2 1 0	4 / 2 2 0	8 / 4 4 0	5 / 4 1 0	6 / 5 1 0	5 / 3 1 1	0 / 0 0 0	33	21	11	11
1993	0 / 0 0 0	0 / 0 0 0	2 / 1 1 0	2 / 0 2 0	1 / 1 0 0	2 / 1 0 1	5 / 3 2 0	8 / 6 1 1	5 / 4 1 0	6 / 3 2 1	4 / 1 1 2	3 / 3 0 0	38	21	9	8
1994	1 / 0 1 0	0 / 1 0 0	1 / 0 0 0	0 / 0 0 0	2 / 1 0 1	2 / 0 2 0	9 / 3 4 2	9 / 6 3 0	8 / 4 4 0	7 / 5 1 1	/ 0 0 0	2 / 1 1 0	41	21	15	5
1995	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	2 / 0 2 0	3 / 2 1 0	7 / 4 2 1	7 / 4 1 2	8 / 5 1 2	2 / 0 2 0	3 / 0 1 2	34	15	11	8
1996	1 / 0 0 1	1 / 0 0 1	0 / 0 0 0	2 / 0 1 1	2 / 1 1 0	0 / 0 0 0	7 / 6 1 0	10 / 4 3 3	7 / 6 1 0	5 / 2 1 2	6 / 1 3 2	3 / 1 1 1	44	21	12	11
1997	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	2 / 1 1 0	3 / 1 2 0	3 / 3 0 0	4 / 3 1 0	8 / 6 1 1	4 / 3 1 0	6 / 4 1 1	1 / 1 0 0	1 / 1 0 0	33	23	8	2
1998	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	3 / 0 1 2	3 / 2 1 0	8 / 4 1 3	6 / 2 1 3	3 / 0 3 0	4 / 1 1 2	27	9	8	10
1999	1 / 0 1 0	1 / 0 1 0	0 / 0 0 0	3 / 2 1 0	0 / 0 0 0	1 / 1 0 0	5 / 1 1 3	9 / 4 2 3	6 / 2 4 0	2 / 1 1 0	3 / 1 1 1	3 / 0 0 3	34	12	12	10
2000	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	4 / 1 1 2	0 / 0 0 0	8 / 2 3 3	9 / 4 3 2	6 / 4 1 1	3 / 2 1 0	3 / 1 1 1	1 / 0 0 0	34	15	10	9
2001	0 / 0 0 0	1 / 0 0 1	0 / 0 0 0	1 / 0 1 0	2 / 2 0 0	2 / 2 0 0	6 / 4 1 1	7 / 3 3 1	5 / 5 0 0	3 / 3 0 0	3 / 1 2 0	4 / 2 2 0	33	20	9	4
2002	1 / 0 1 0	1 / 1 0 0	1 / 0 0 1	1 / 0 1 1	2 / 1 0 1	3 / 2 1 0	6 / 3 2 1	8 / 4 3 1	3 / 1 2 0	5 / 3 0 2	1 / 1 0 0	1 / 1 0 0	33	18	8	7
2003	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	3 / 1 1 1	2 / 1 1 0	2 / 2 0 0	5 / 4 1 0	3 / 3 0 0	6 / 2 1 3	3 / 3 0 0	1 / 0 1 0	27	17	6	4
2004	0 / 0 0 0	1 / 0 1 0	1 / 0 1 0	1 / 1 0 0	3 / 2 1 0	5 / 5 0 0	2 / 1 1 0	9 / 6 2 1	3 / 1 1 1	3 / 3 0 0	2 / 2 0 0	2 / 0 2 0	32	21	9	2
2005	1 / 1 0 0	0 / 0 0 0	1 / 1 0 0	1 / 1 0 0	0 / 0 0 0	1 / 1 0 0	4 / 1 3 0	6 / 6 0 0	5 / 4 1 0	3 / 2 0 1	2 / 1 1 0	1 / 0 1 0	25	18	6	1
2006	0 / 0 0 0	0 / 0 0 0	1 / 0 1 0	0 / 0 0 0	1 / 1 0 0	1 / 1 0 0	3 / 2 1 0	8 / 3 4 1	5 / 3 0 2	4 / 2 1 1	2 / 2 0 0	2 / 1 0 1	27	14	8	5
2007	0 / 0 0 0	0 / 0 0 0	1 / 0 0 0	0 / 0 0 0	1 / 0 0 0	0 / 0 0 0	3 / 2 1 0	6 / 3 2 1	5 / 2 2 1	5 / 3 2 0	6 / 3 1 2	0 / 0 0 0	27	15	8	4
2008	1 / 0 1 0	0 / 0 0 0	0 / 0 0 0	1 / 1 0 0	4 / 3 1 0	1 / 1 0 0	2 / 2 0 0	5 / 1 4 0	6 / 3 3 0	3 / 0 3 0	3 / 0 3 0	1 / 1 0 0	27	12	15	0
2009	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	2 / 0 0 0	2 / 1 1 0	3 / 1 1 1	5 / 3 2 0	7 / 4 1 2	4 / 3 1 0	4 / 1 1 2	1 / 0 0 1	1 / 0 1 0	28	15	7	6
2010	1 / 0 0 1	0 / 0 0 0	1 / 0 0 1	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	2 / 2 0 0	5 / 2 3 0	4 / 3 1 0	4 / 2 2 0	1 / 0 0 1	1 / 0 0 1	19	9	6	4
2011	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	2 / 0 0 2	2 / 1 1 0	3 / 0 2 1	4 / 2 1 1	4 / 2 1 1	7 / 2 5 0	1 / 0 0 1	1 / 0 1 0	3 / 0 1 2	27	7	11	9
2012	0 / 0 0 0	1 / 0 1 0	1 / 0 1 0	0 / 0 0 0	1 / 1 0 0	4 / 2 2 0	4 / 3 1 0	5 / 4 1 0	3 / 2 1 0	5 / 2 3 0	2 / 1 0 1	1 / 0 1 0	27	15	10	2
2013	1 / 0 1 0	1 / 0 0 1	0 / 0 0 0	0 / 0 0 0	0 / 0 0 0	4 / 1 3 0	3 / 2 1 0	5 / 2 2 1	8 / 4 3 1	7 / 6 0 1	3 / 1 1 1	1 / 0 0 1	33	15	12	6
2014	2 / 0 1 1	0 / 0 0 0	1 / 1 0 0	2 / 1 1 0	0 / 0 0 0	1 / 0 1 0	4 / 3 1 0	2 / 1 1 0	5 / 2 2 1	1 / 1 0 0	3 / 2 1 0	2 / 1 0 1	23	12	8	3

1) If a tropical cyclone was warned on prior to the last two days of a month, it was attributed to the first month, regardless of how long the system lasted.
2) If a tropical cyclone began on the last day of the month and ended on the first day of the next month, that system was attributed to the first month. However, if a tropical cyclone began on the last day of the month and continued into the next month for only two days, it was attributed to the second month.

TABLE 1-3 WESTERN NORTH PACIFIC TROPICAL CYCLONES													
TYPHOONS (1945 - 1958)													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.4	0.1	0.3	0.4	0.7	1.1	2	2.9	3.2	2.4	2	0.9	16.4
CASES	5	1	4	5	10	15	28	41	45	34	28	12	228
TYPHOONS (1959 - 2014)													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.2	0.1	0.2	0.4	0.7	1.1	2.5	3.4	3.3	2.9	1.5	0.6	16.9
CASES	11	3	11	24	41	59	140	191	182	163	85	36	946
TROPICAL STORMS AND TYPHOONS (1945 - 1958)													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.4	0.2	0.5	0.5	0.8	1.6	2.9	4	4.2	3.3	2.7	1.2	22.3
CASES	6	2	7	8	11	22	44	60	64	49	41	18	332
TROPICAL STORMS AND TYPHOONS (1959 - 2014)													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.5	0.2	0.4	0.6	1.1	1.8	3.9	5.5	4.9	4.0	2.5	1.2	26.6
CASES	27	12	24	36	64	99	216	307	276	222	139	68	1490

TABLE 1-4 TROPICAL CYCLONE FORMATION ALERTS FOR THE WESTERN NORTH PACIFIC OCEAN 1976 - 2014					
YEAR	INITIAL TCFAS	TROPICAL CYCLONES WITH TCFAS	TOTAL TROPICAL CYCLONES	PROBABILITY OF TCFA WITHOUT WARNING*	PROBABILITY OF TCFA BEFORE WARNING
1976	34	25	25	26%	100%
1977	26	20	21	23%	95%
1978	32	27	32	16%	84%
1979	27	23	28	15%	82%
1980	37	28	28	24%	100%
1981	29	28	29	3%	97%
1982	36	26	28	28%	93%
1983	31	25	25	19%	100%
1984	37	30	30	19%	100%
1985	39	26	27	33%	96%
1986	38	27	27	29%	100%
1987	31	24	25	23%	96%
1988	33	26	27	21%	96%
1989	51	32	35	37%	91%
1990	33	30	31	9%	97%
1991	37	29	31	22%	94%
1992	36	32	32	11%	100%
1993	50	35	38	30%	92%
1994	50	40	40	20%	100%
1995	54	33	35	39%	94%
1996	41	39	43	5%	91%
1997	36	30	33	17%	91%
1998	38	18	27	53%	67%
1999	39	29	33	26%	88%
2000	40	31	34	23%	91%
2001	34	28	33	18%	85%
2002	39	31	33	21%	94%
2003	31	27	27	13%	100%
2004	35	32	32	9%	100%
2005	26	25	25	4%	100%
2006	23	22	26	4%	85%
2007	27	26	27	4%	96%
2008	23	23	28	0%	82%
2009	26	22	28	15%	79%
2010	24	18	19	25%	95%
2011	32	26	27	19%	96%
2012	31	26	27	16%	96%
2013	36	31	33	14%	94%
2014	32	23	23	28%	100%
MEAN	35	28	30	21%	93%
CASES	1354	1073	1152		
* Percentage of initial TCFAs not followed by warnings.					

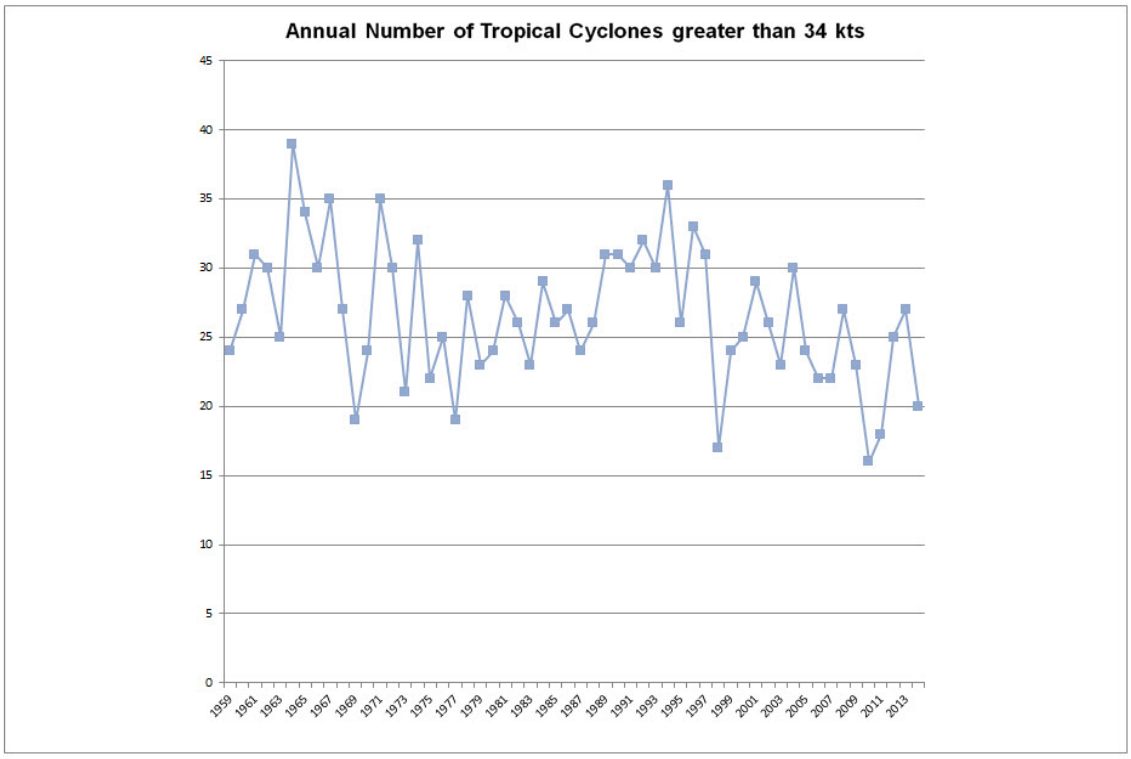


Figure 1-1. Annual number of western North Pacific TCs greater than 34 knots intensity.

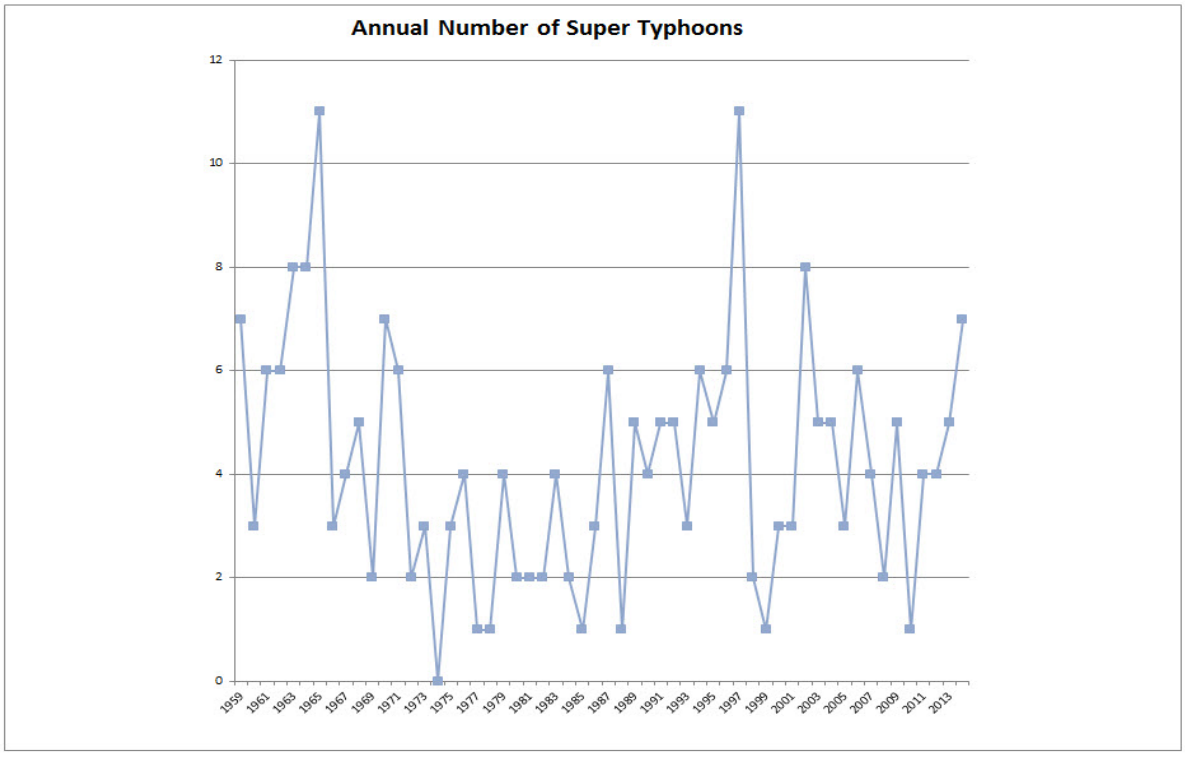
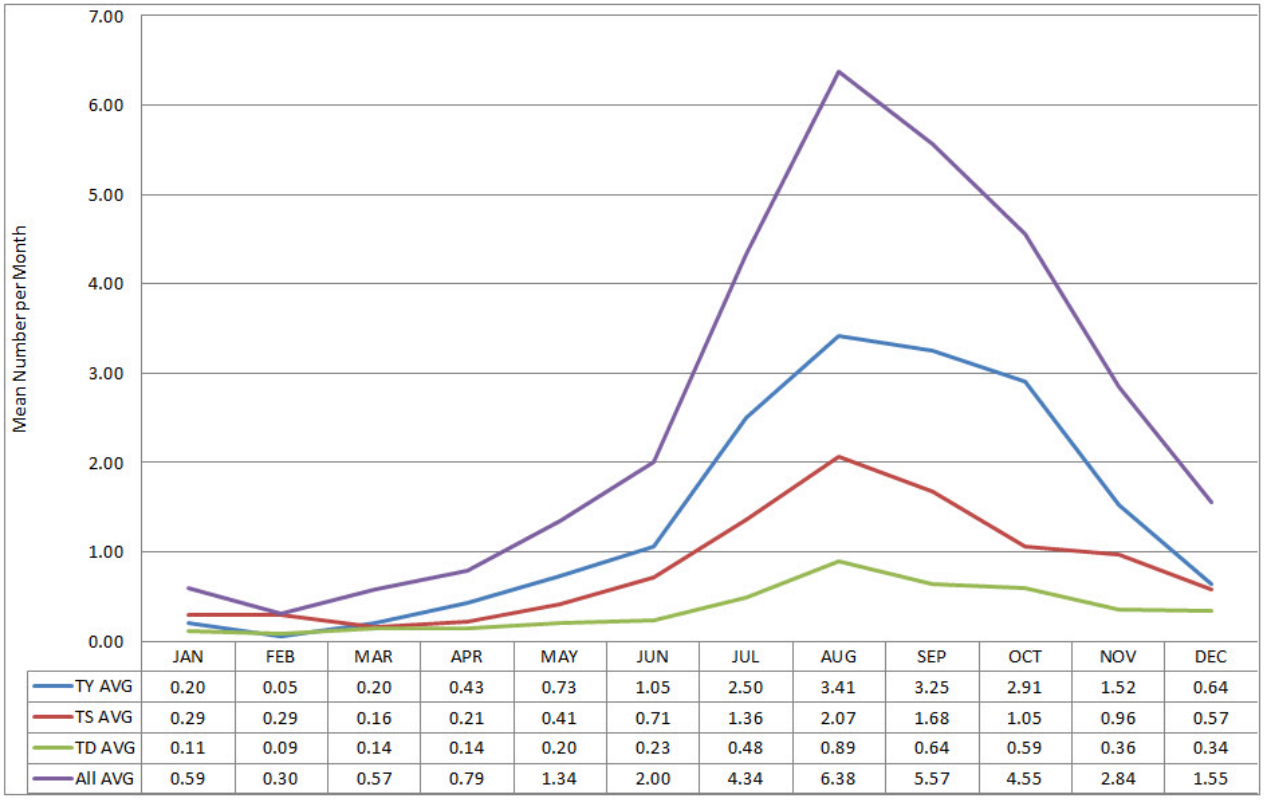


Figure 1-2. Annual number of western North Pacific TCs greater than 129 knots intensity.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TY AVG	0.20	0.05	0.20	0.43	0.73	1.05	2.50	3.41	3.25	2.91	1.52	0.64
TS AVG	0.29	0.29	0.16	0.21	0.41	0.71	1.36	2.07	1.68	1.05	0.96	0.57
TD AVG	0.11	0.09	0.14	0.14	0.20	0.23	0.48	0.89	0.64	0.59	0.36	0.34
All AVG	0.59	0.30	0.57	0.79	1.34	2.00	4.34	6.38	5.57	4.55	2.84	1.55

Figure 1-3. Average number of western North Pacific TCs (all intensities) by month 1959-2014.

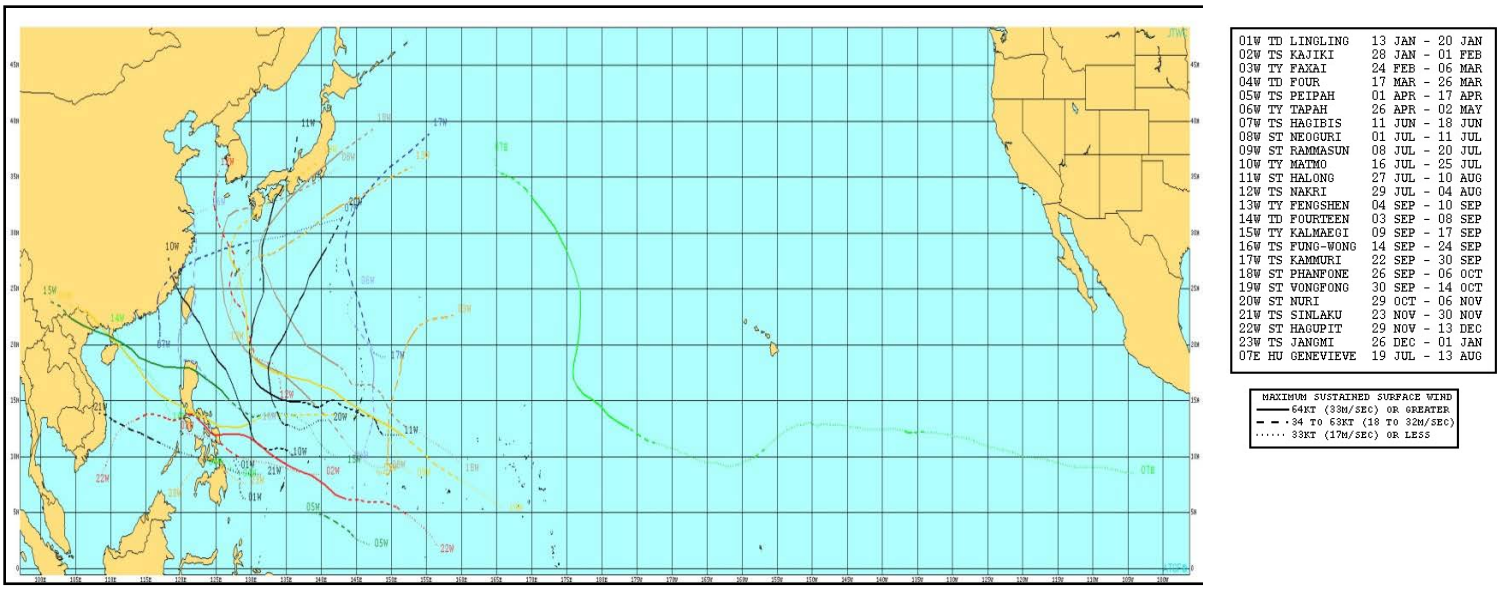


Figure 1-4. Western North Pacific Tropical Cyclones 01W – 23W and 07E.

Section 2 Cyclone Summaries

This section presents a synopsis of each cyclone that occurred during 2014 in the western North Pacific Ocean. Each cyclone is presented, with the number and basin identifier used by JTWC, along with the name assigned by Regional Specialized Meteorological Center (RSMC) Tokyo.

Dates are also listed when JTWC first designated various stages of pre-warning development: LOW, MEDIUM, and HIGH (concurrent with TCFA). These classifications are defined as follows:

> "Low" formation potential describes an area that is being monitored for development, but is unlikely to develop within the next 24 hours.
>
> "Medium" formation potential describes an area that is being monitored for development and has an elevated potential to develop, but development will likely occur beyond 24 hours.
>
> "High" formation potential describes an area that is being monitored for development and is either expected to develop within 24 hours or development has already started, but warning criteria have not yet been met. All areas designated as "High" are accompanied by a Tropical Cyclone Formation Alert (TCFA).

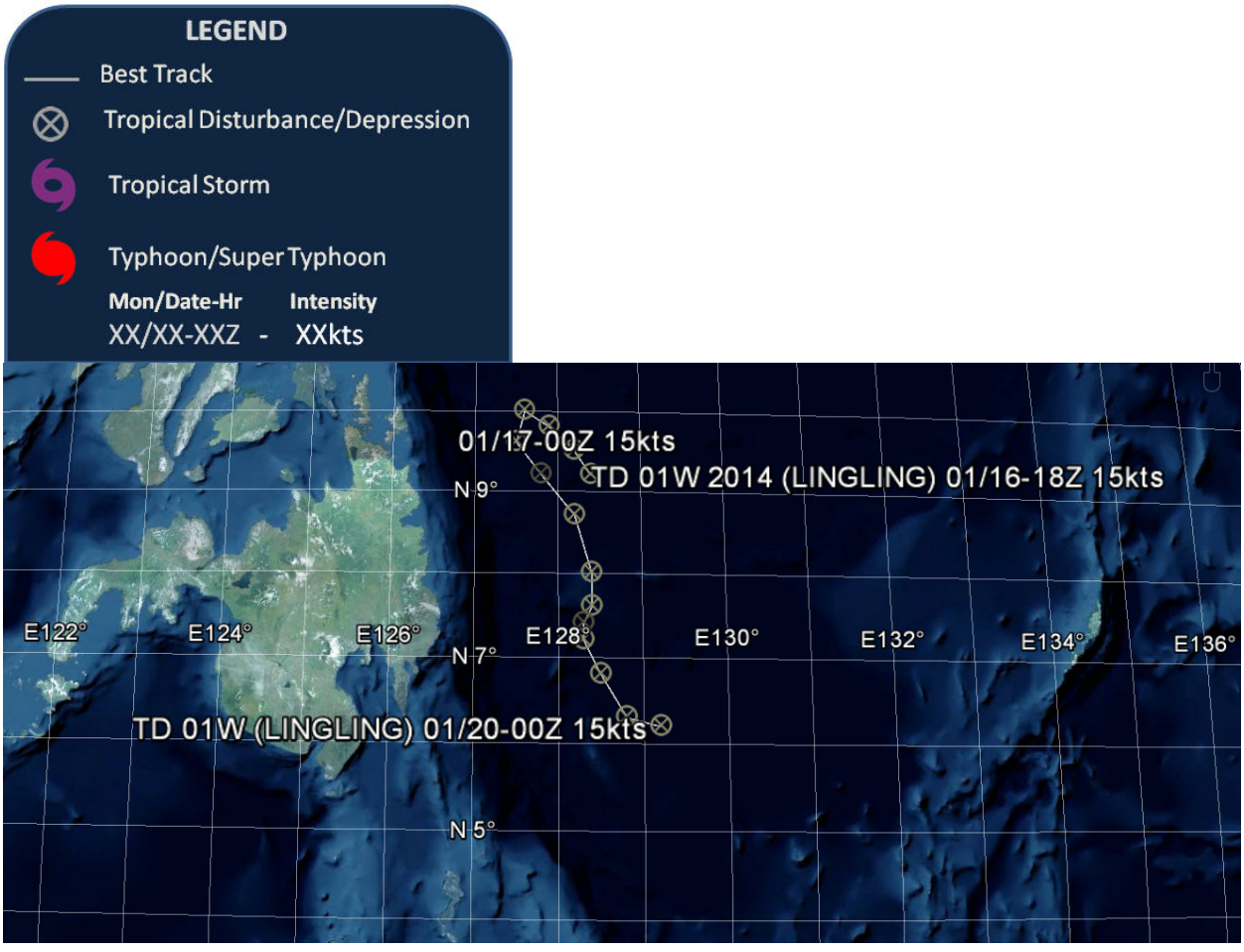
Initial and final JTWC warning dates are also presented with the number of warnings issued by JTWC. Landfall over major land masses with approximate locations is presented as well.

The JTWC post-event reanalysis best track is also provided for each cyclone. Data included on the best track are position and intensity noted with cyclone symbols and color coded track. Best track position labels include the date-time, track speed in knots, and maximum wind speed in knots. A graph of best track intensity and fix intensity versus time is presented. The fix plots on this graph are color coded by fixing agency.

In addition, if this document is viewed as a pdf, each map has been hyperlinked to the appropriate keyhole markup language (kmz) file that will allow the reader to access and view the best-track data interactively on their computer using Google Earth software. Simply hold the control button and click the map image. The link will open, allowing the reader to download and open the file.
Users may also retrieve kmz files for the entire season from:
http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/best_tracks/2014/2014s-KMZs/JTWC_BestTrack_Climatology_2014.kmz

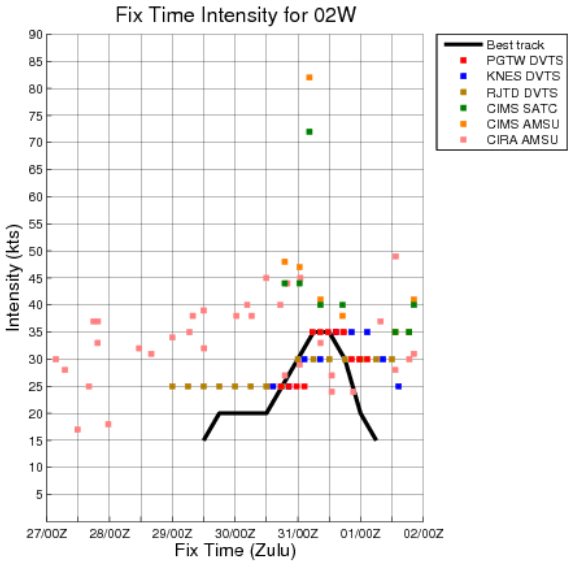
01W TROPICAL DEPRESSION LINGLING

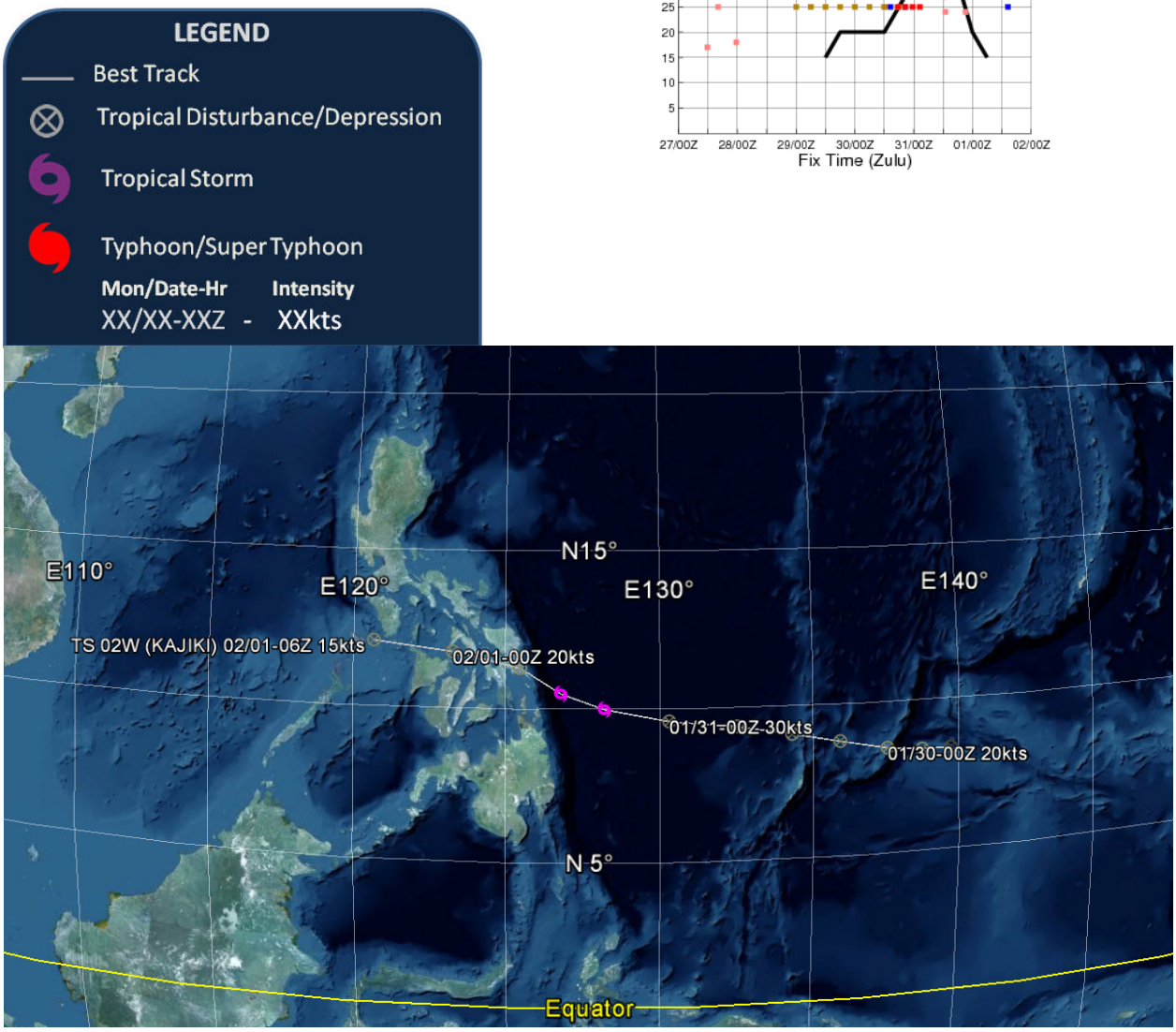
ISSUED LOW:	15 JAN/ 0600Z
ISSUED MED:	16 JAN/ 0600Z
FIRST TCFA:	16 JAN/ 1500Z
FIRST WARNING:	18 JAN/ 0000Z
LAST WARNING:	19 JAN/ 1800Z
MAX INTENSITY:	30
WARNINGS:	8



02W TROPICAL STORM KAJIKI

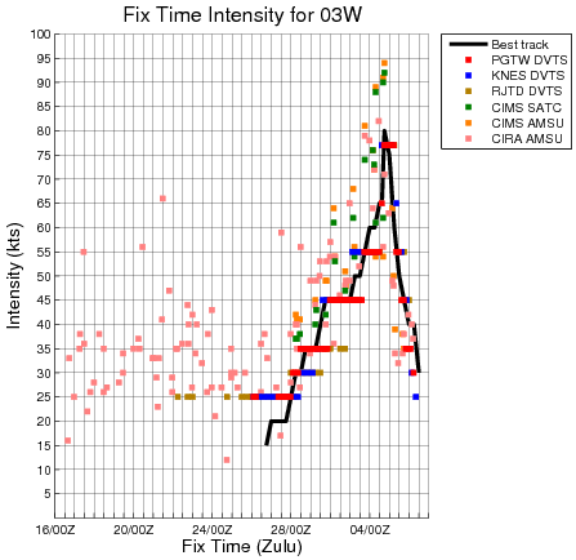
ISSUED LOW:	28 JAN/ 1400Z
ISSUED MED:	29 JAN/ 0300Z
FIRST TCFA:	29 JAN/ 0530Z
FIRST WARNING:	30 JAN/ 1800Z
LAST WARNING:	01 FEB/ 1800Z
MAX INTENSITY:	35
WARNINGS:	9

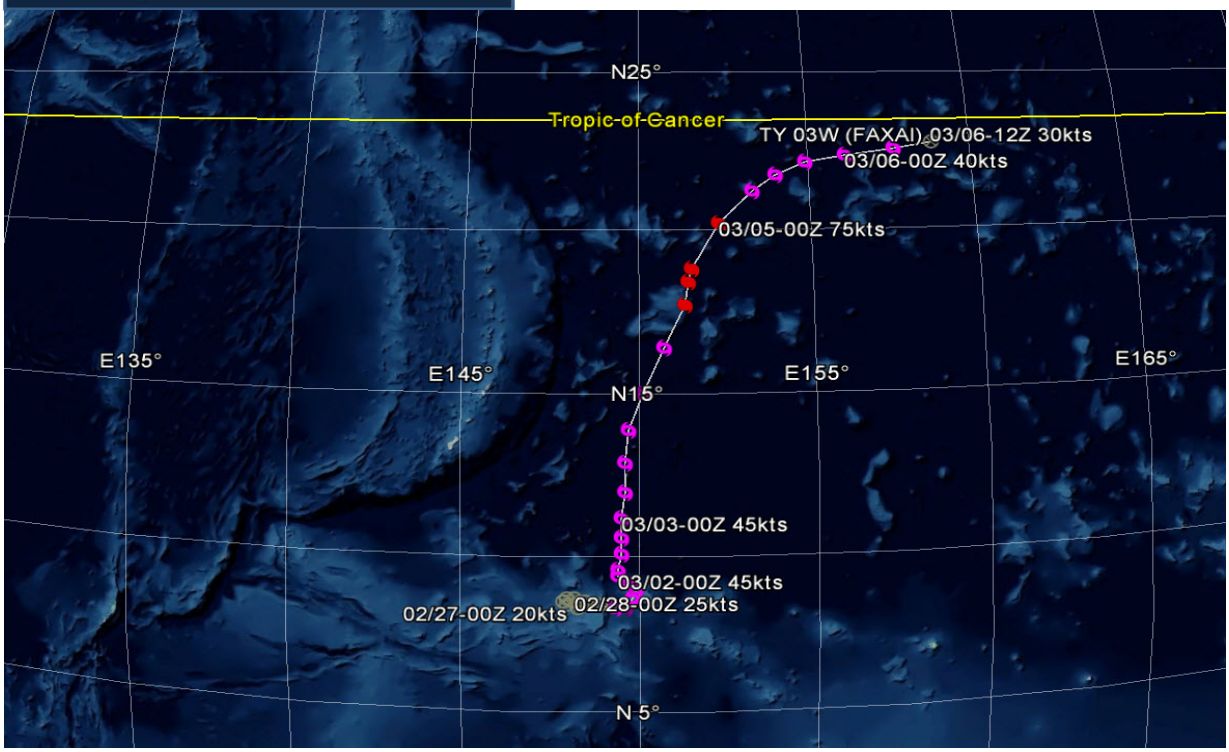




03W TYPHOON FAXAI

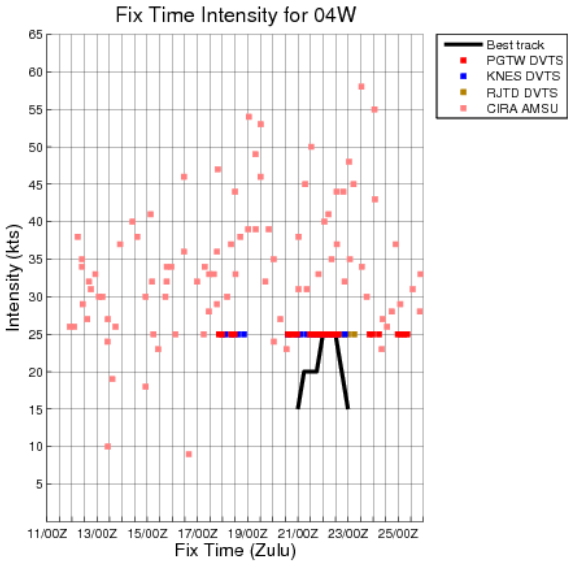
ISSUED LOW:	17 FEB/ 0600Z
ISSUED MED:	25 FEB/ 2000Z
FIRST TCFA:	26 FEB/ 0530Z
FIRST WARNING:	28 FEB/ 0000Z
LAST WARNING:	05 MAR/ 1200Z
MAX INTENSITY:	80
WARNINGS:	23

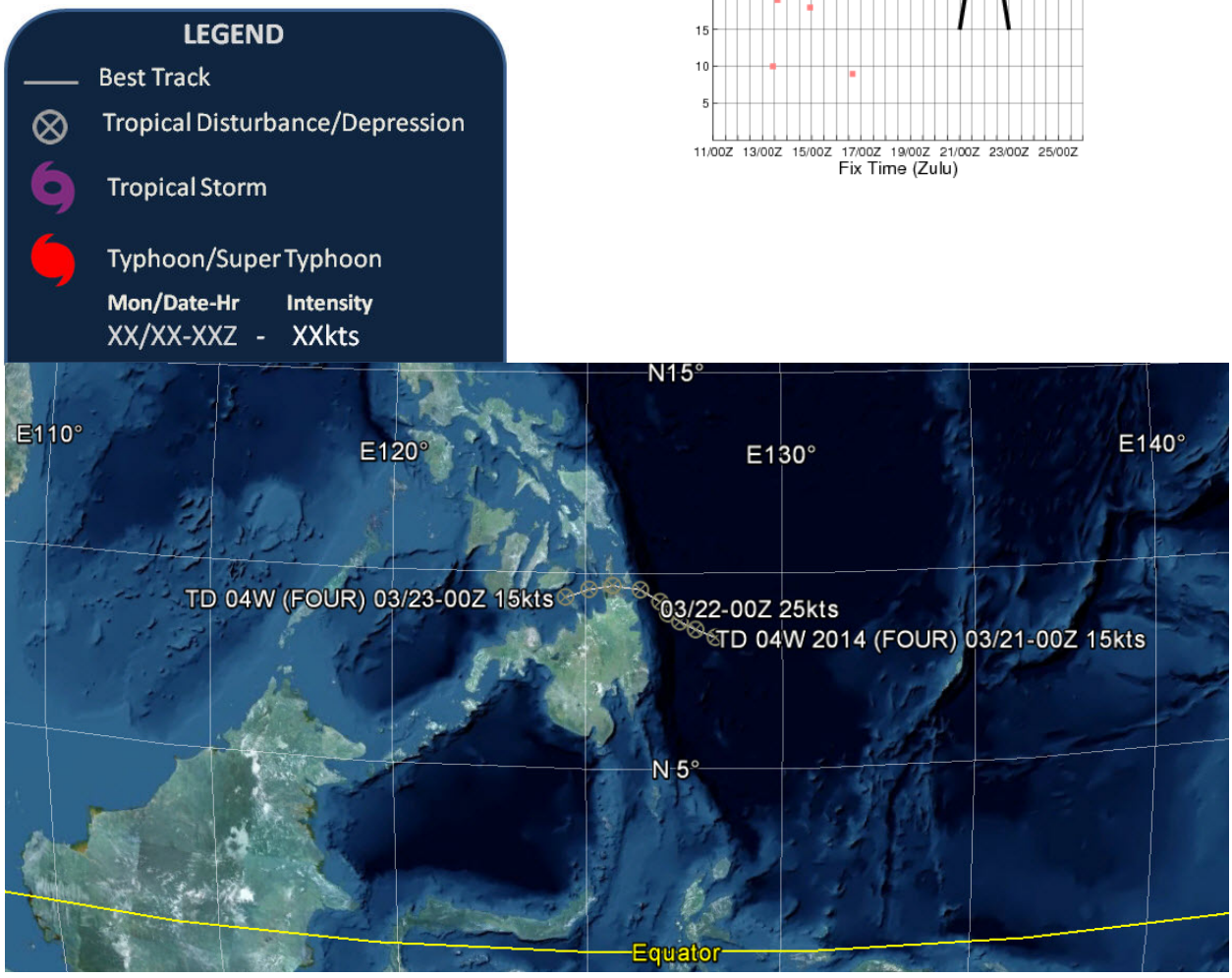




04W TROPICAL DEPRESSION FOUR

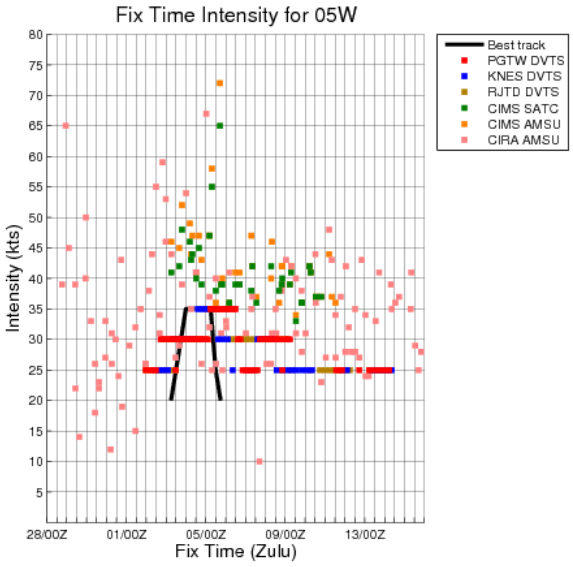
ISSUED LOW:	18 MAR/ 1500Z
ISSUED MED:	20 MAR/ 1500Z
FIRST TCFA:	20 MAR/ 2200Z
FIRST WARNING:	22 MAR/ 0000Z
LAST WARNING:	22 MAR/ 1800Z
MAX INTENSITY:	25
WARNINGS:	4

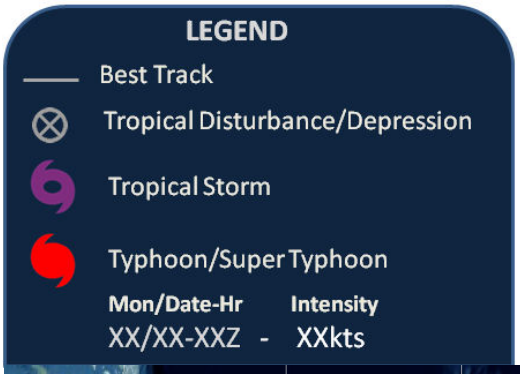


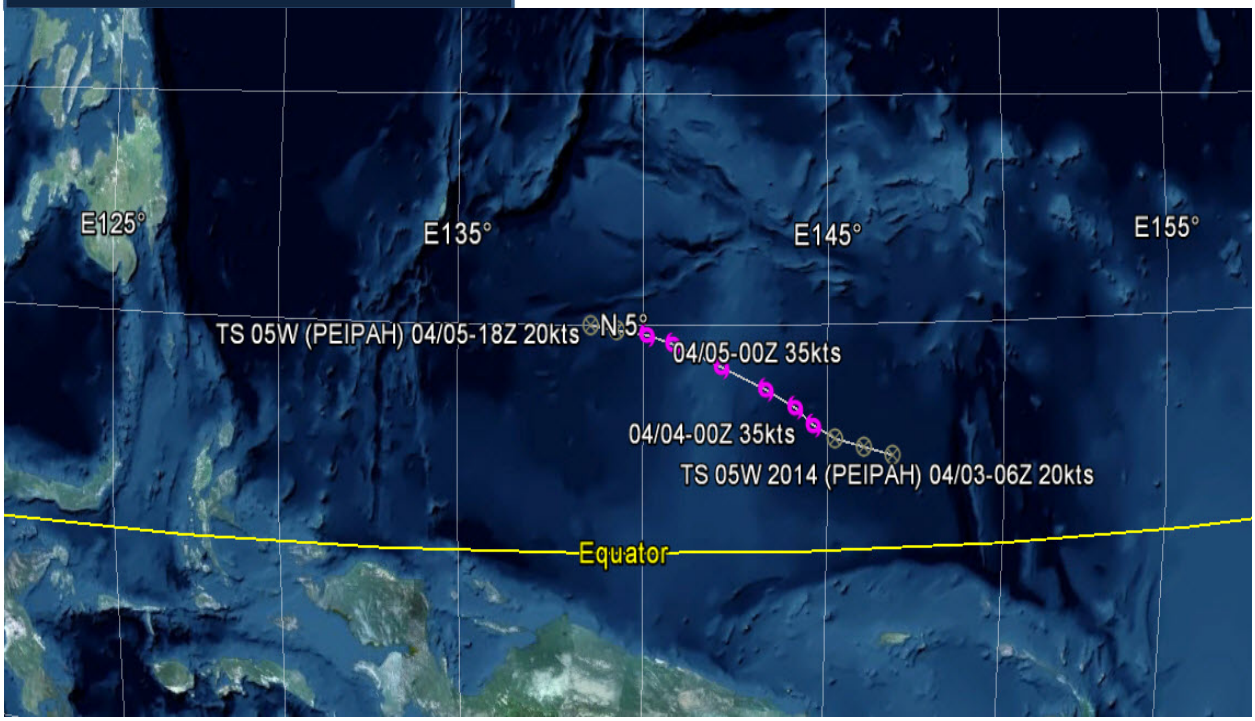


05W TROPICAL STORM PEIPAH

ISSUED LOW:	29 MAR/ 0830Z
ISSUED MED:	02 APR/ 0600Z
FIRST TCFA:	02 APR/ 2000Z
FIRST WARNING:	03 APR/ 0000Z
LAST WARNING:	10 APR/ 0600Z
MAX INTENSITY:	35
WARNINGS:	30

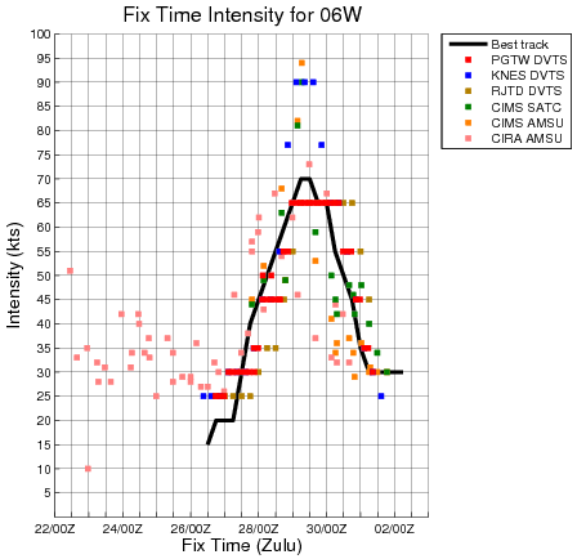


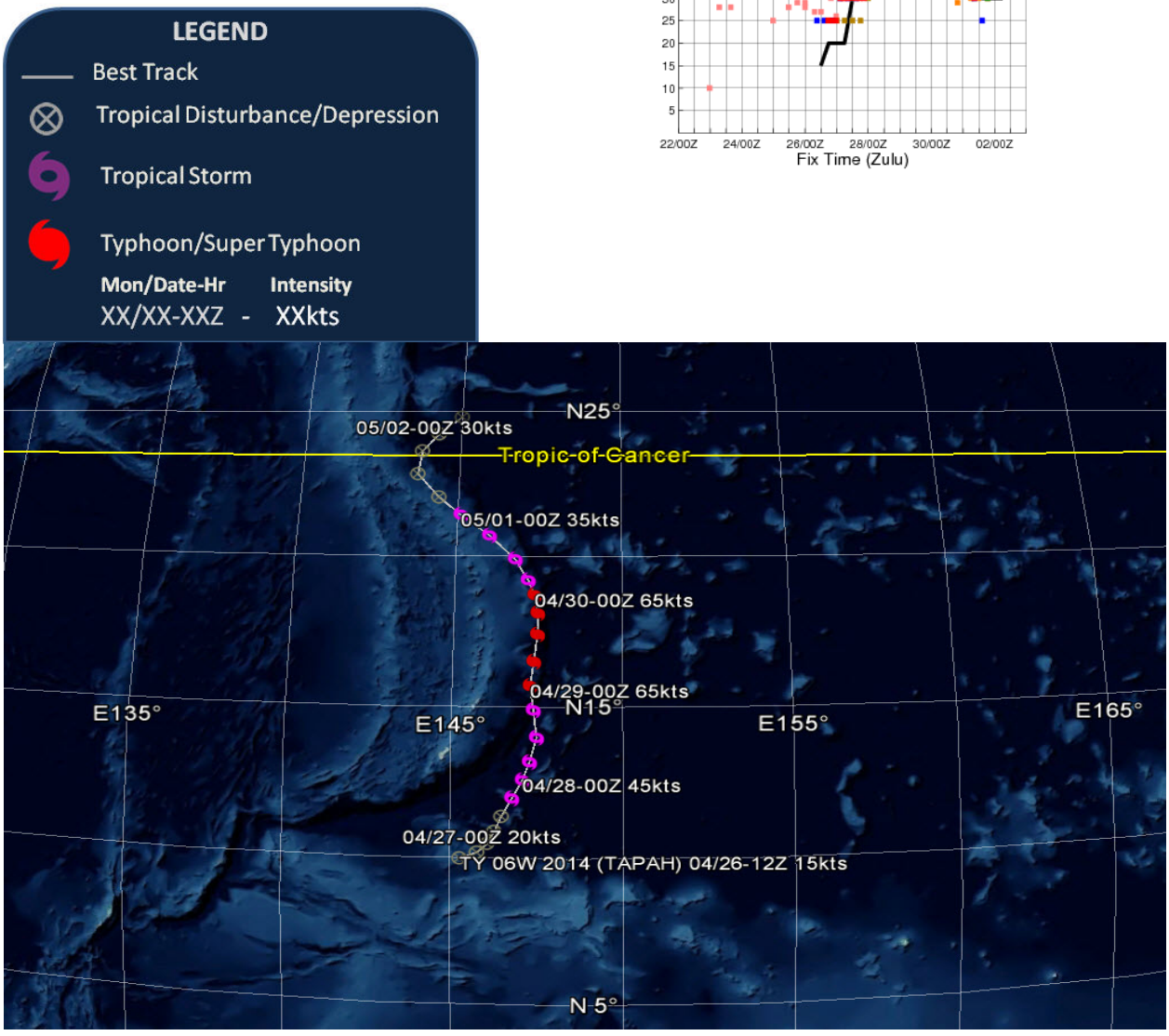




06W TYPHOON TAPAH

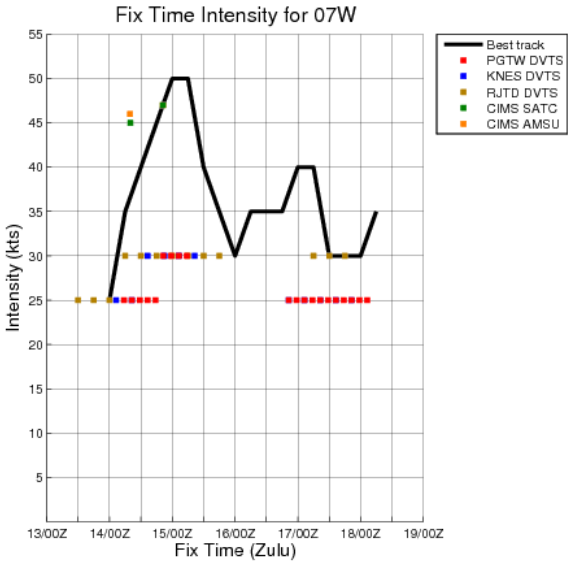
ISSUED LOW:	23 APR/ 2230Z
ISSUED MED:	26 APR/ 1430Z
FIRST TCFA:	27 APR/ 0230Z
FIRST WARNING:	27 APR/ 1200Z
LAST WARNING:	01 MAY/ 0600Z
MAX INTENSITY:	70
WARNINGS:	16

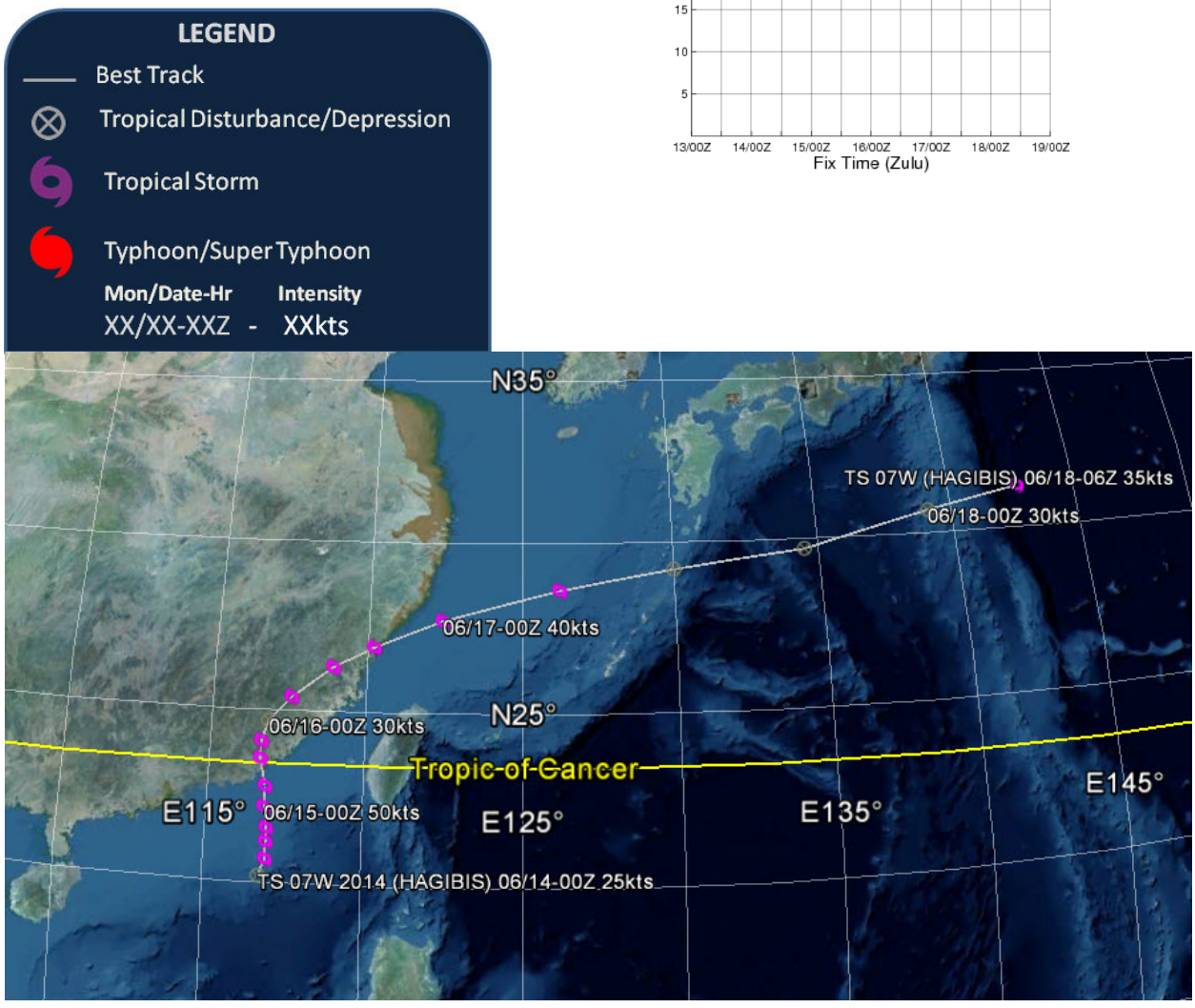




07W TROPICAL STORM HAGIBIS

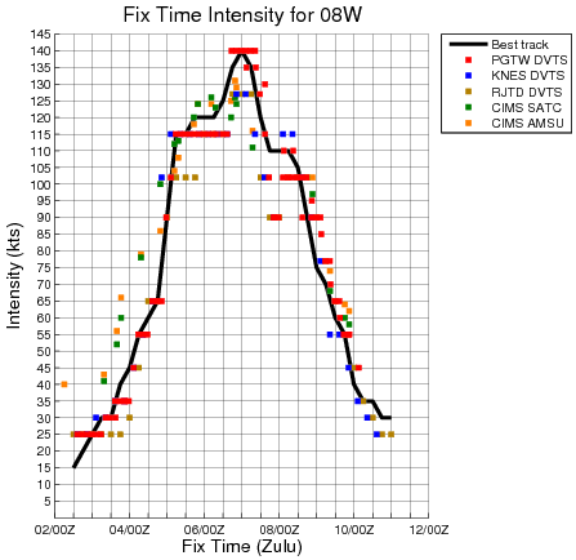
ISSUED LOW:	11 JUN/ 2300Z
ISSUED MED:	13 JUN/ 1900Z
FIRST TCFA:	14 JUN/ 0200Z
FIRST WARNING:	14 JUN/ 0600Z
LAST WARNING:	18 JUN/ 0000Z
MAX INTENSITY:	40
WARNINGS:	12

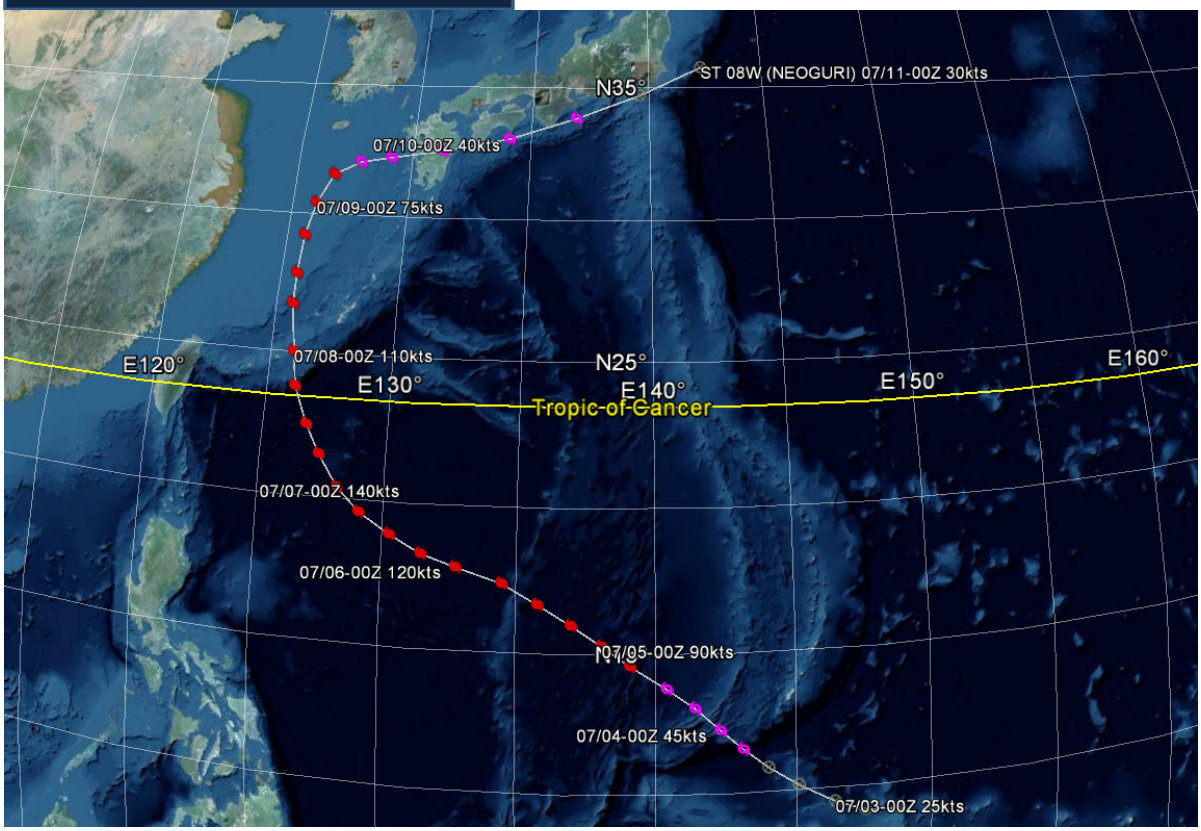




08W SUPER TYPHOON NEOGURI

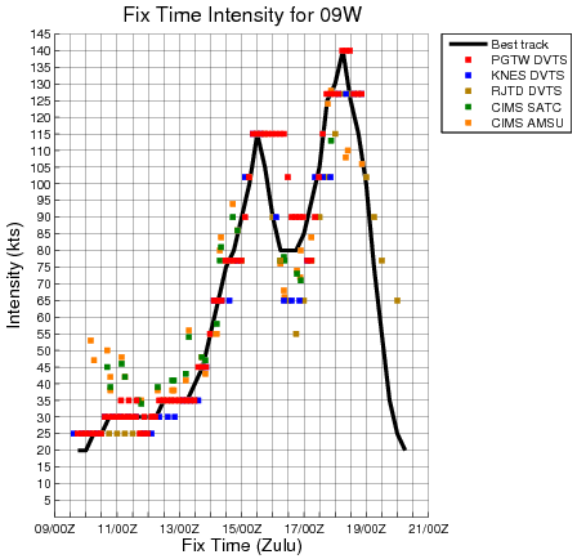
ISSUED LOW:	30 JUN/ 2200Z
ISSUED MED:	01 JUL/ 2000Z
FIRST TCFA:	02 JUL/ 2000Z
FIRST WARNING:	03 JUL/ 0000Z
LAST WARNING:	10 JUL/ 1200Z
MAX INTENSITY:	140
WARNINGS:	31

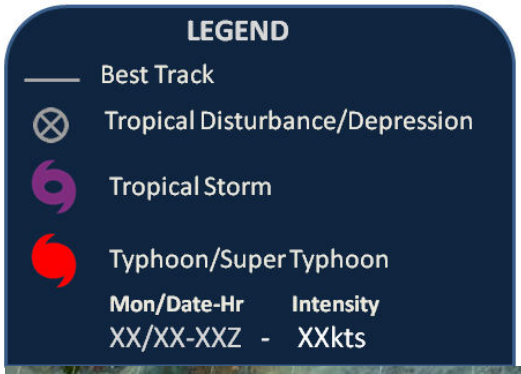


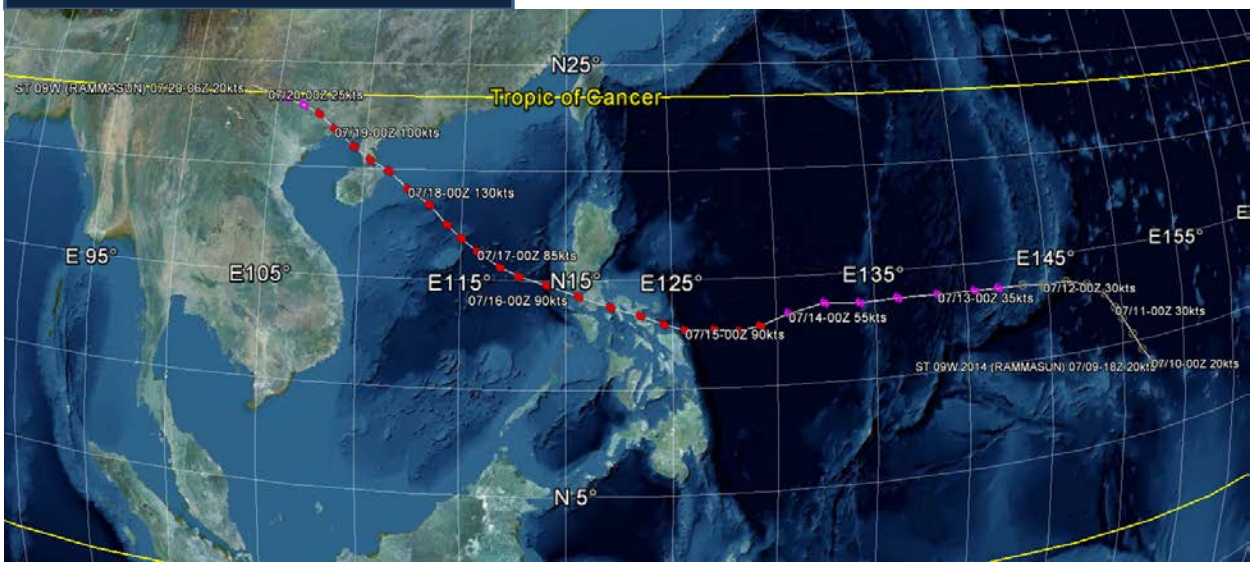


09W SUPER TYPHOON RAMMASUN

ISSUED LOW:	09 JUL/ 0600Z
ISSUED MED:	10 JUL/ 0130Z
FIRST TCFA:	10 JUL/ 0730Z
FIRST WARNING:	10 JUL/ 1200Z
LAST WARNING:	19 JUL/ 0000Z
MAX INTENSITY:	140
WARNINGS:	35

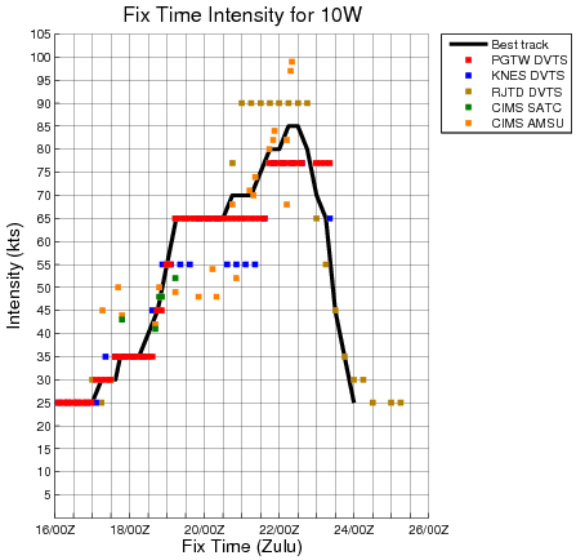


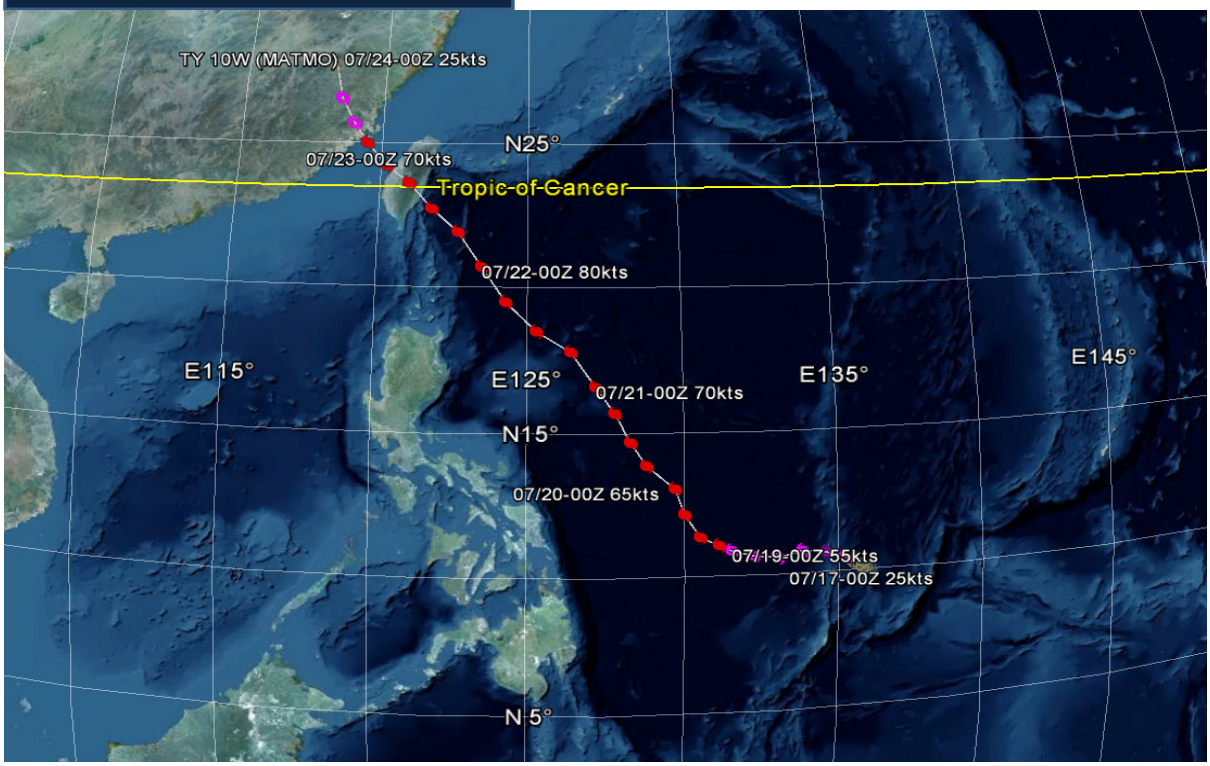




10W TYPHOON MATMO

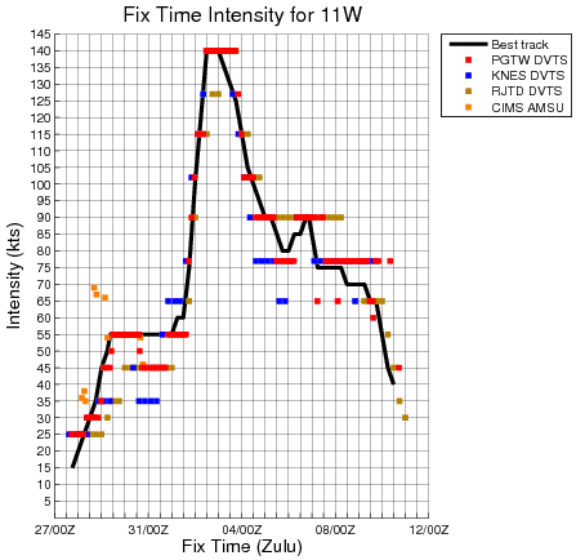
ISSUED LOW:	14 JUL/ 0600Z
ISSUED MED:	16 JUL/ 0600Z
FIRST TCFA:	16 JUL/ 1130Z
FIRST WARNING:	17 JUL/ 1200Z
LAST WARNING:	23 JUL/ 1200Z
MAX INTENSITY:	85
WARNINGS:	25

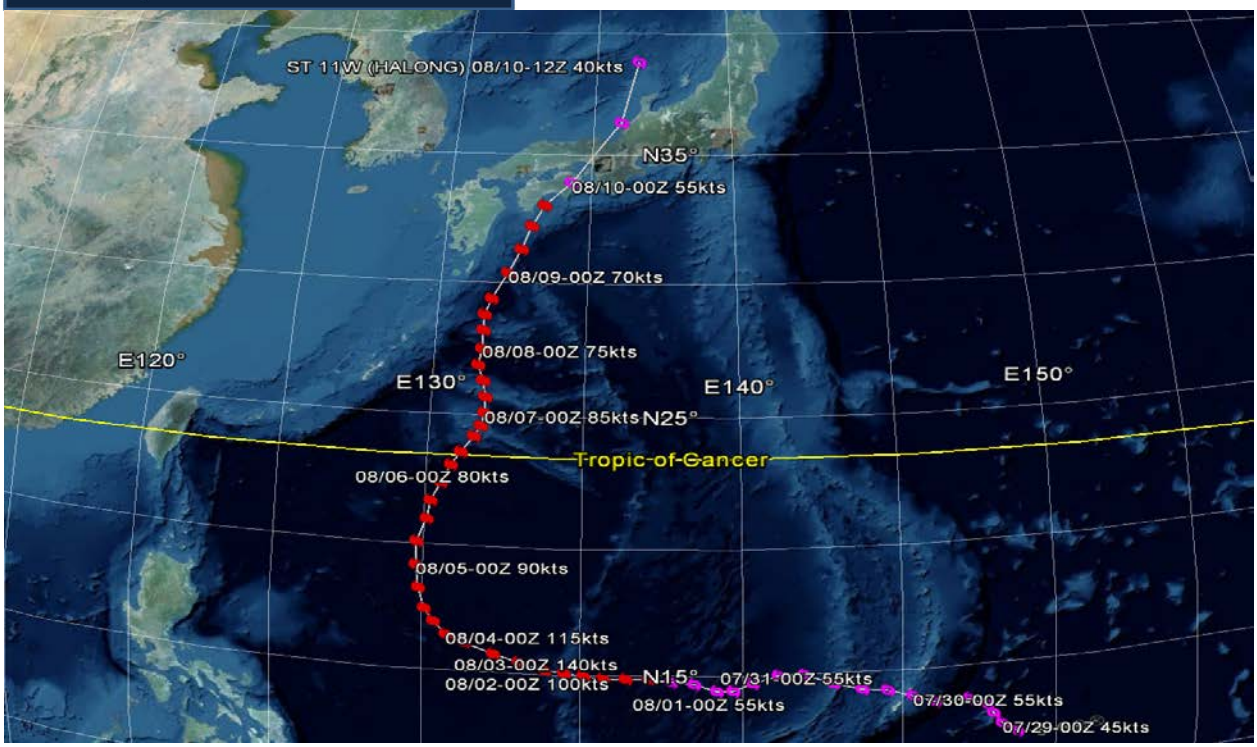




11W SUPER TYPHOON HALONG

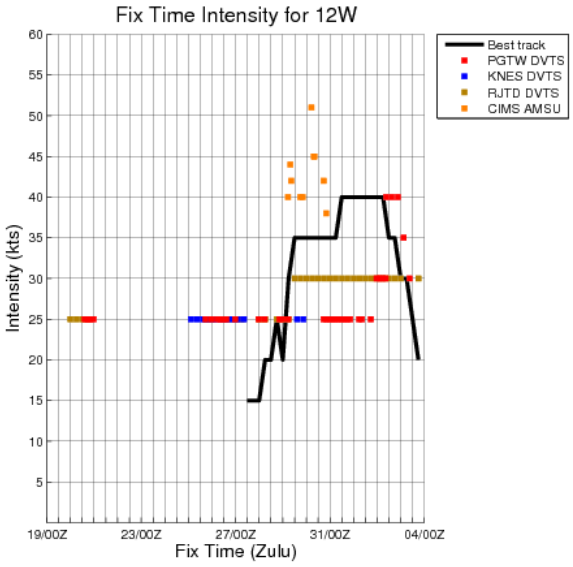
ISSUED LOW:	26 JUL/ 0600Z
ISSUED MED:	27 JUL/1730Z
FIRST TCFA:	28 JUL/ 0100Z
FIRST WARNING:	28 JUL/ 1200Z
LAST WARNING:	10 AUG/ 0000Z
MAX INTENSITY:	140
WARNINGS:	51

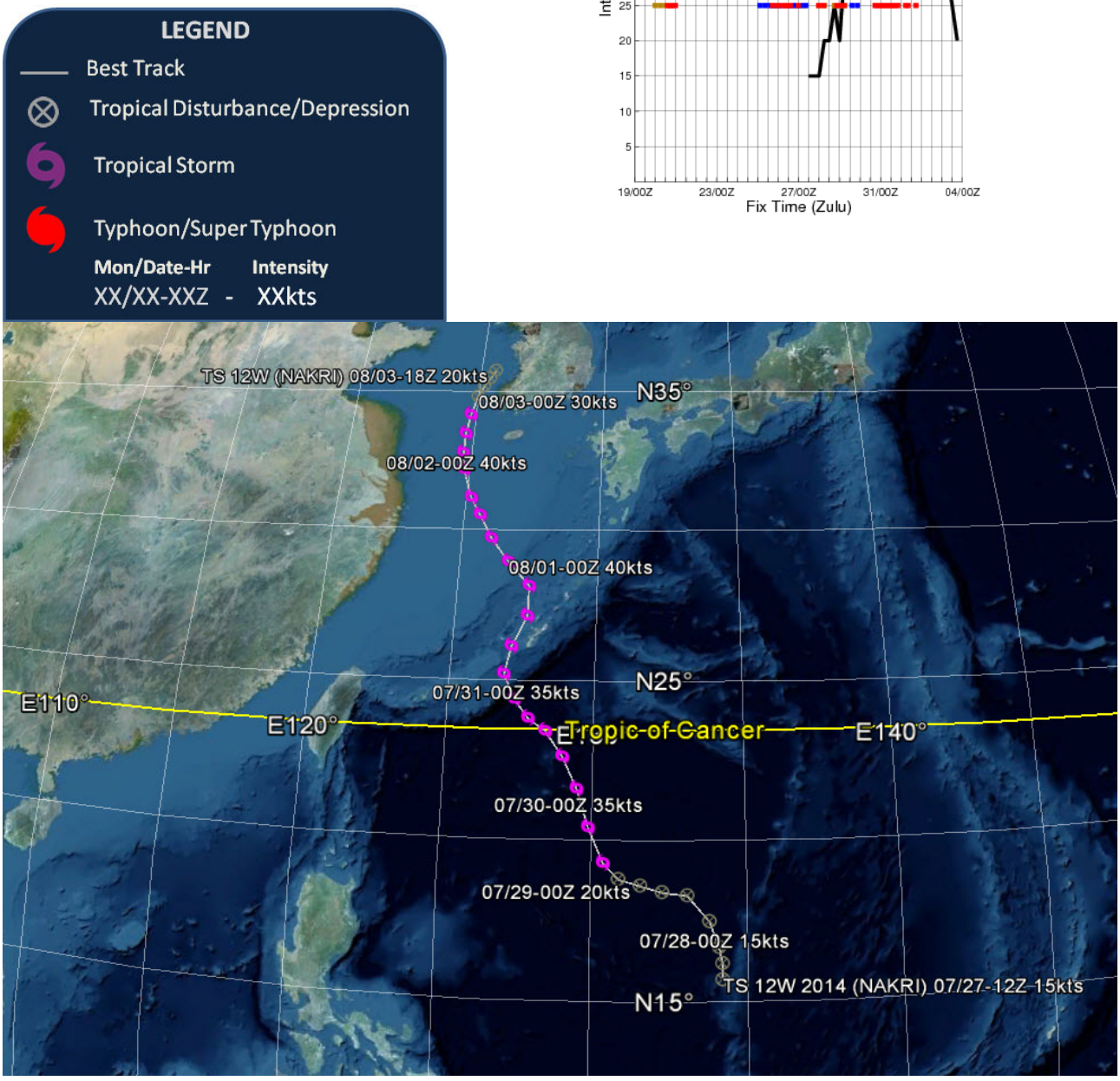




12W TROPICAL STORM NAKRI

ISSUED LOW:	19 JUL/ 0600Z
ISSUED MED:	19 JUL/ 1400Z
FIRST TCFA:	02 AUG/ 0530Z
FIRST WARNING:	02 AUG/ 0600Z
LAST WARNING:	03 AUG/ 1800Z
MAX INTENSITY:	40
WARNINGS:	7

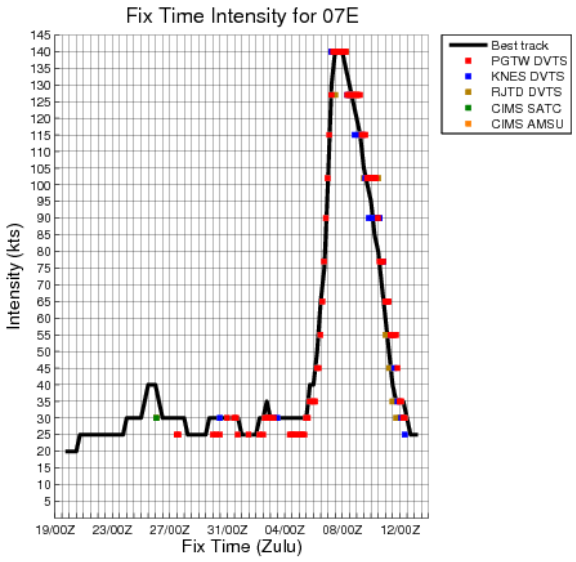


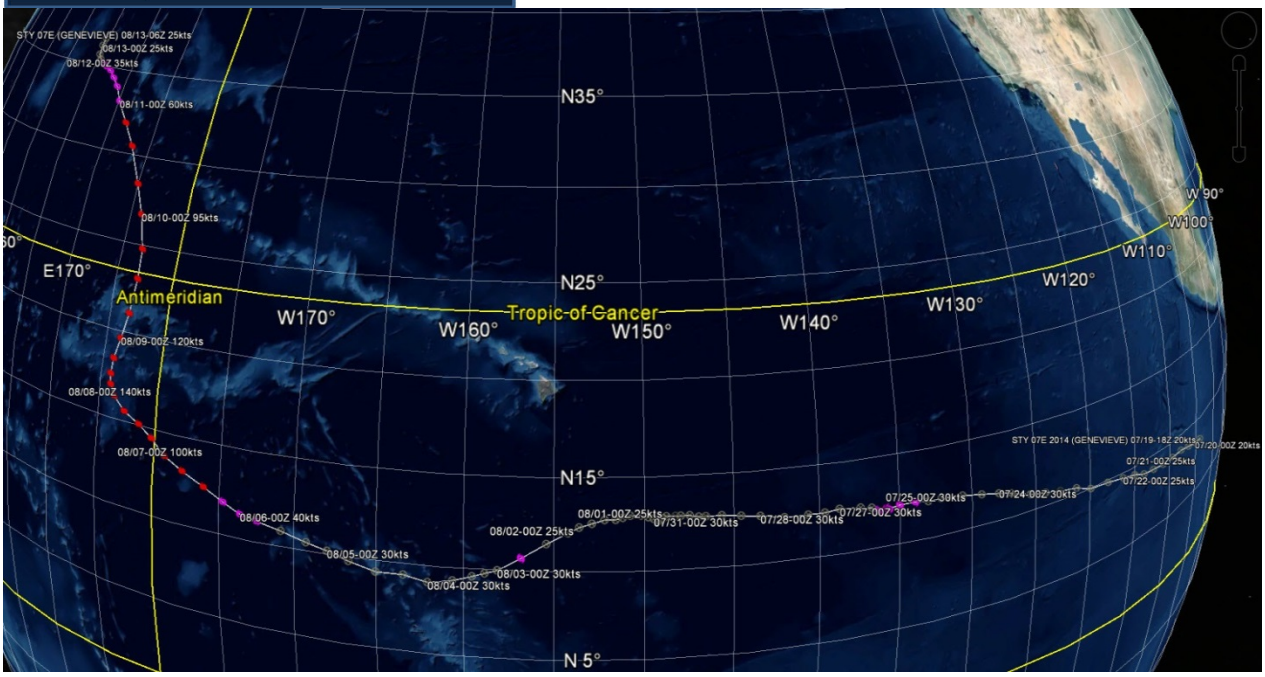


07E SUPER TYPHOON GENEVIEVE

(Assumed from CPHC 07 AUG/ 0600z)

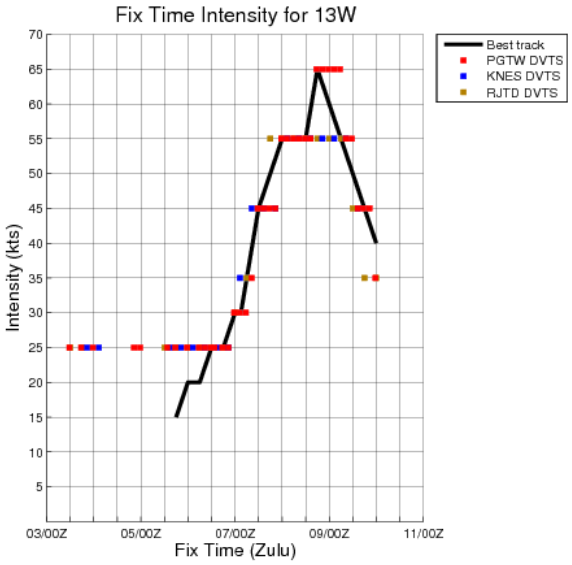
ISSUED LOW: N/A
ISSUED MED: N/A
FIRST TCFA: N/A
FIRST WARNING: 07 AUG/ 0600Z
LAST WARNING: 11 AUG/ 1800Z
MAX INTENSITY: 140
WARNINGS: 19

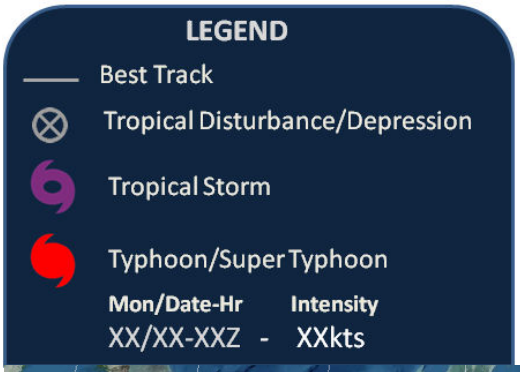


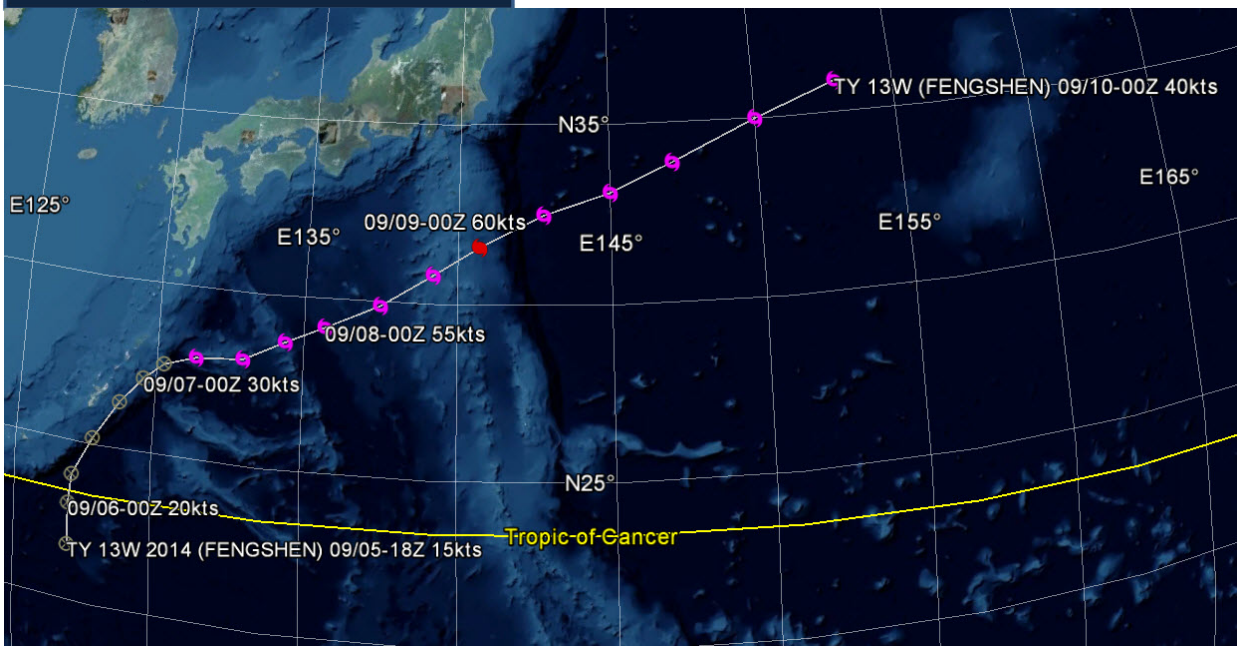


13W TYPHOON FENGSHEN

ISSUED LOW:	03 SEP/ 0600Z
ISSUED MED:	04 SEP/ 2200Z
FIRST TCFA:	06 SEP/ 0200Z
FIRST WARNING:	07 SEP/ 0000Z
LAST WARNING:	09 SEP/ 1200Z
MAX INTENSITY:	65
WARNINGS:	11

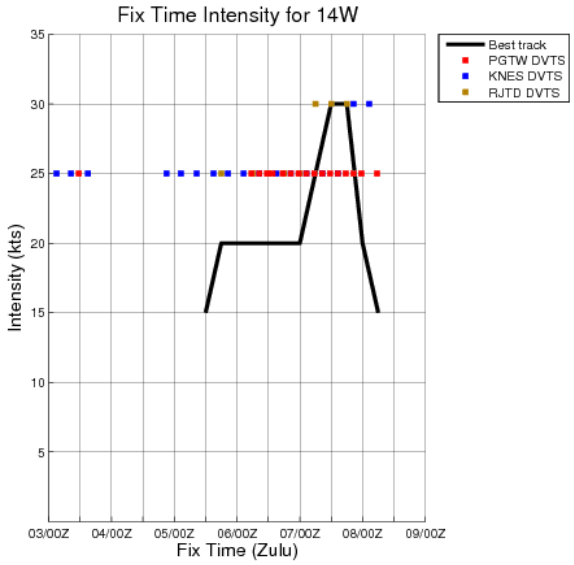


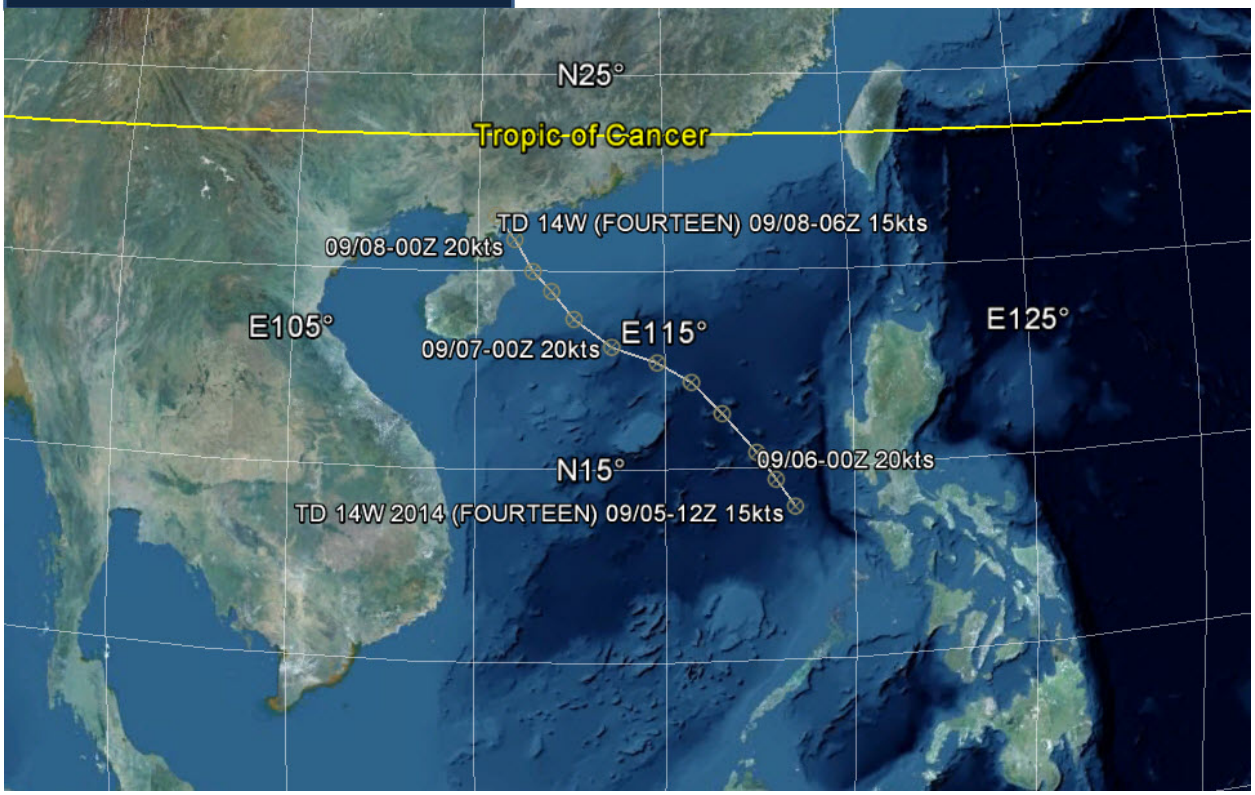




14W TROPICAL DEPRESSION FOURTEEN

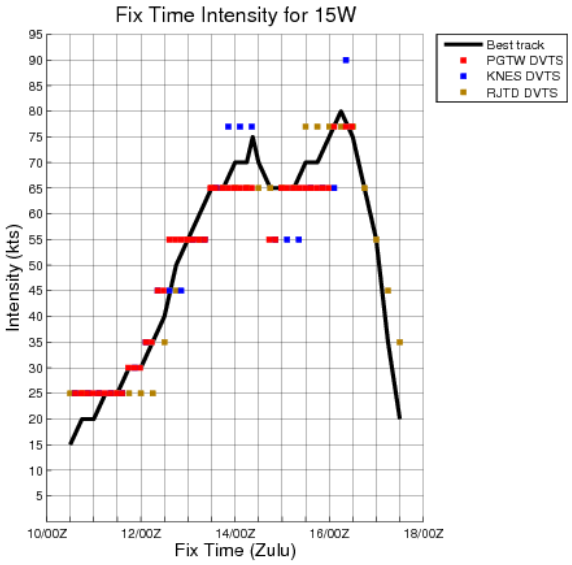
ISSUED LOW:	31 AUG/ 1300Z
ISSUED MED:	05 SEP/ 2030Z
FIRST TCFA:	06 SEP/ 0730Z
FIRST WARNING:	07 SEP/ 0600Z
LAST WARNING:	08SEP/ 0000Z
MAX INTENSITY:	30
WARNINGS:	4

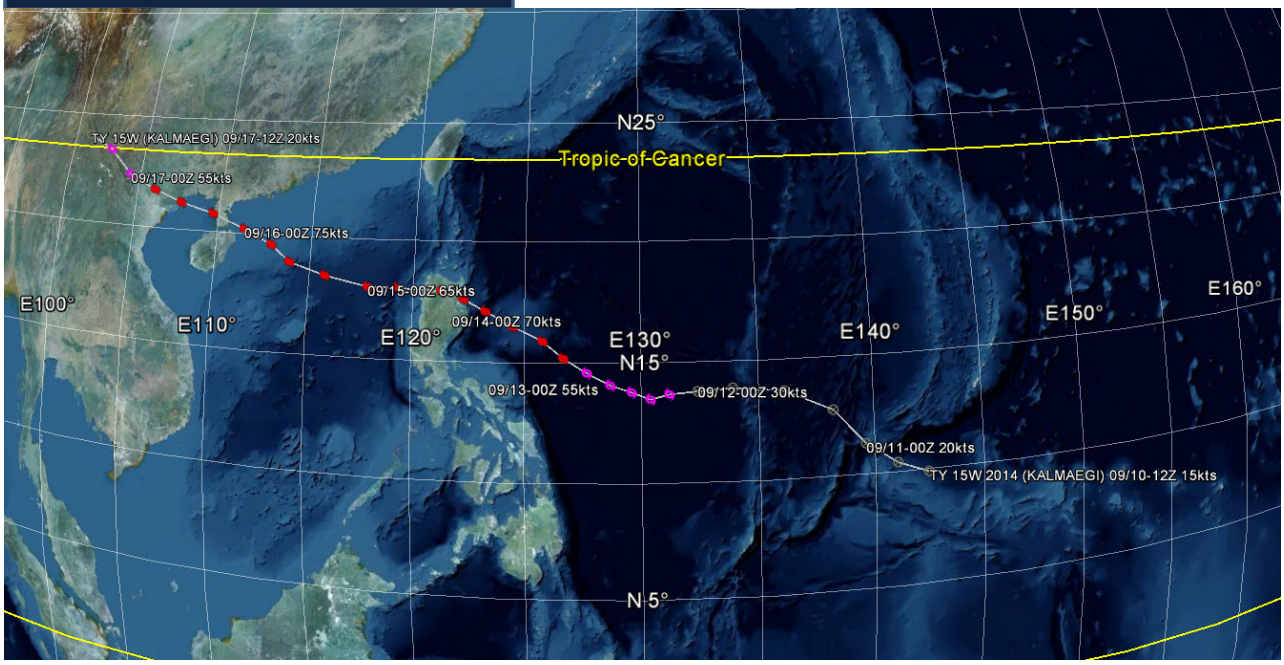




15W TYPHOON KALMAEGI

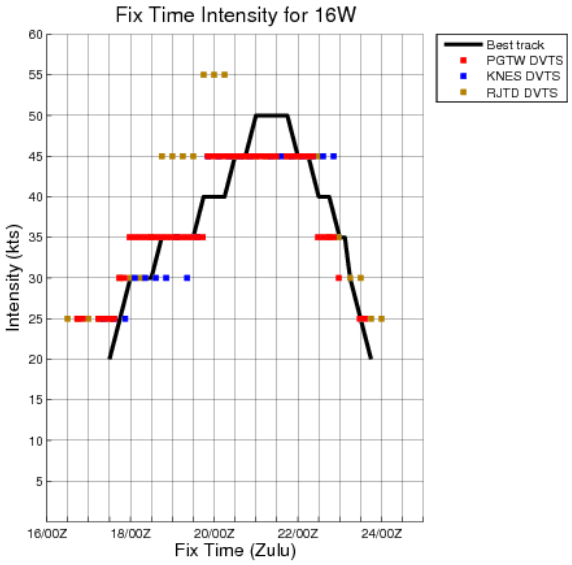
ISSUED LOW:	10 SEP/ 0600Z
ISSUED MED:	10 SEP/ 1400Z
FIRST TCFA:	10 SEP/ 1700Z
FIRST WARNING:	10 SEP/ 1800Z
LAST WARNING:	16 SEP/ 1800Z
MAX INTENSITY:	80
WARNINGS:	25

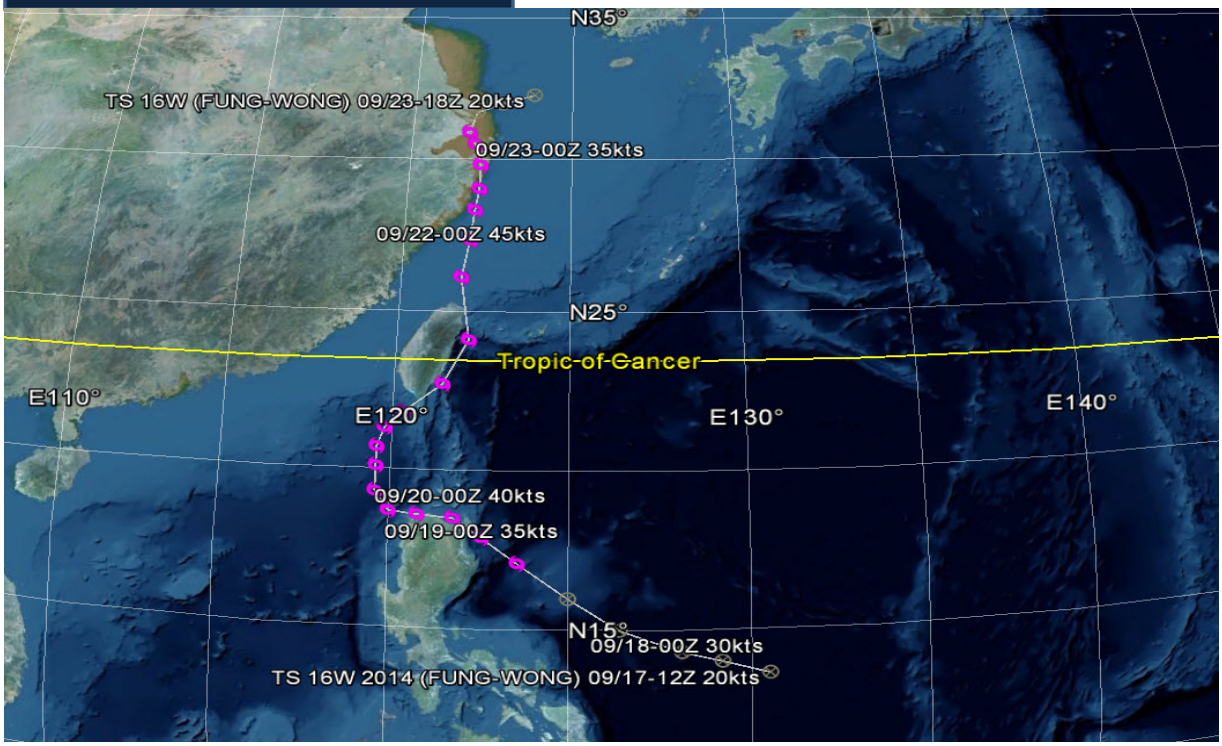




16W TROPICAL STORM FUNG-WONG

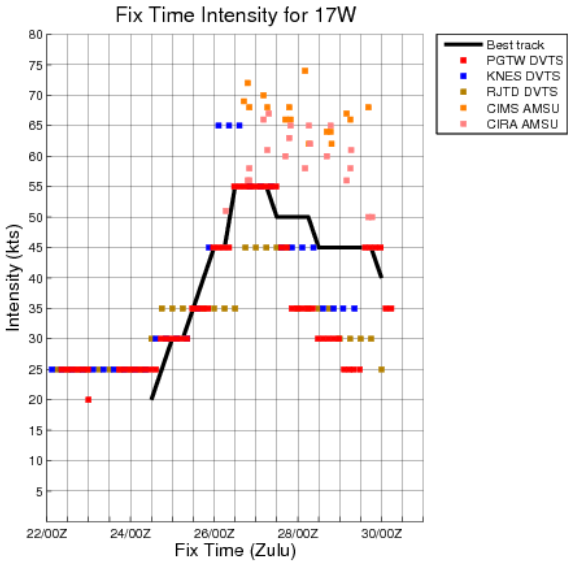
ISSUED LOW: 15 SEP/ 0130Z
ISSUED MED: 15 SEP/ 2300Z
FIRST TCFA: 16 SEP/ 2000Z
FIRST WARNING: 17 SEP/ 1200Z
LAST WARNING: 23 SEP/ 1200Z
MAX INTENSITY: 50
WARNINGS: 25

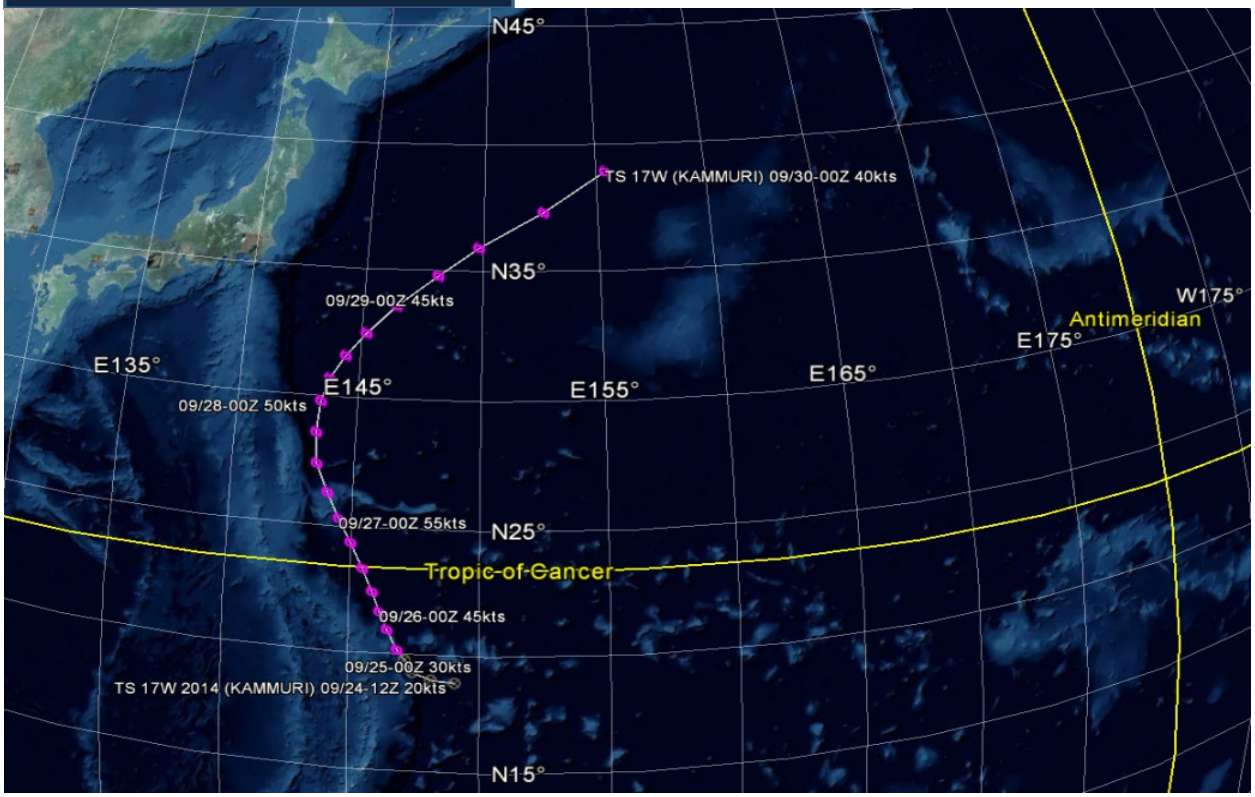




17W TROPICAL STORM KUMMURI

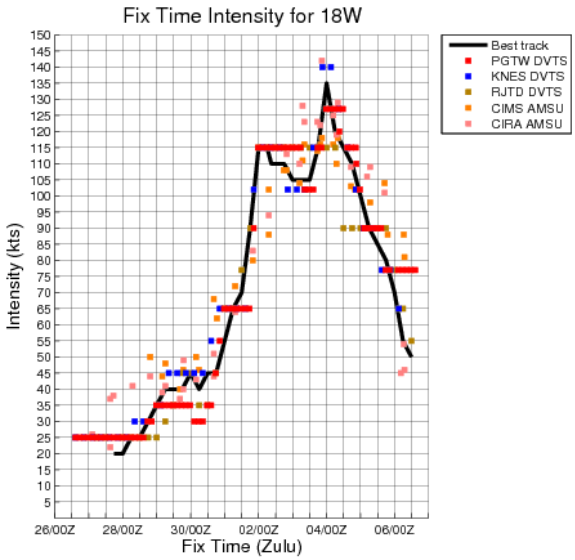
ISSUED LOW: 21 SEP/ 1200Z
ISSUED MED: 22 SEP/ 0600Z
FIRST TCFA: 22 SEP/ 1900Z
FIRST WARNING: 24 SEP/ 1200Z
LAST WARNING: 28 SEP/ 0000Z
MAX INTENSITY: 55
WARNINGS: 19

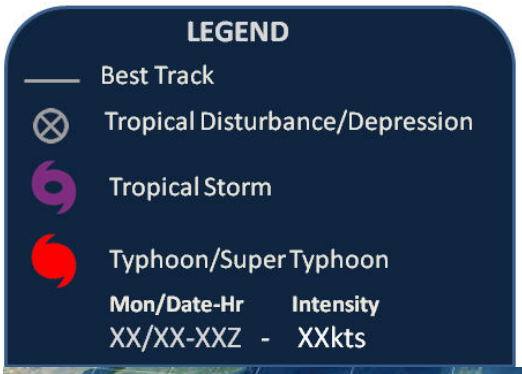


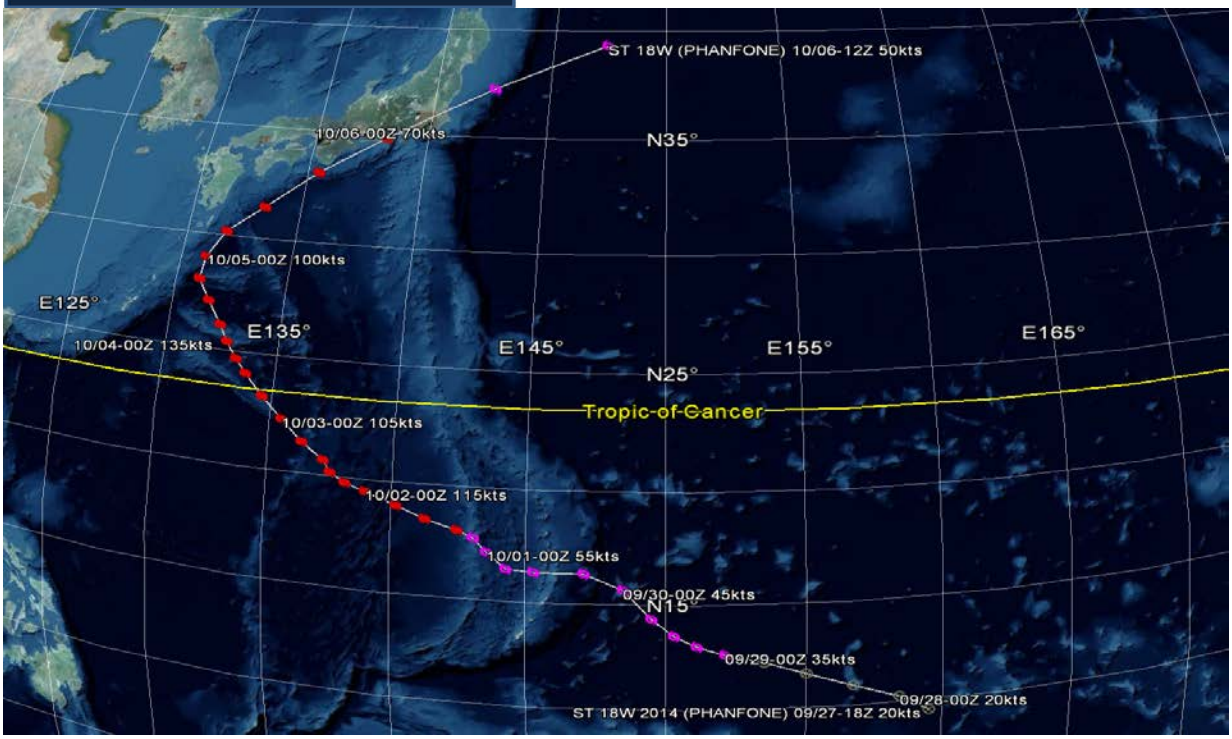


18W SUPER TYPHOON PHANFONE

ISSUED LOW:	26 SEP/ 1500Z
ISSUED MED:	26 SEP/ 1800Z
FIRST TCFA:	26 SEP/ 2230Z
FIRST WARNING:	28 SEP/ 1800Z
LAST WARNING:	06 OCT/ 0600
MAX INTENSITY:	135
WARNINGS:	31

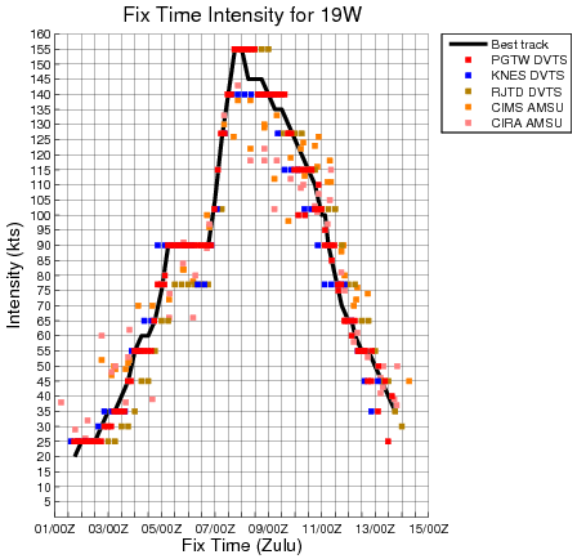


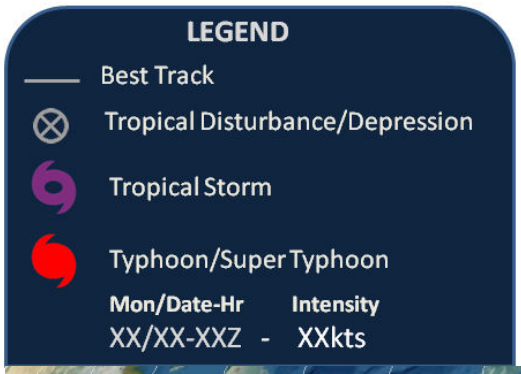


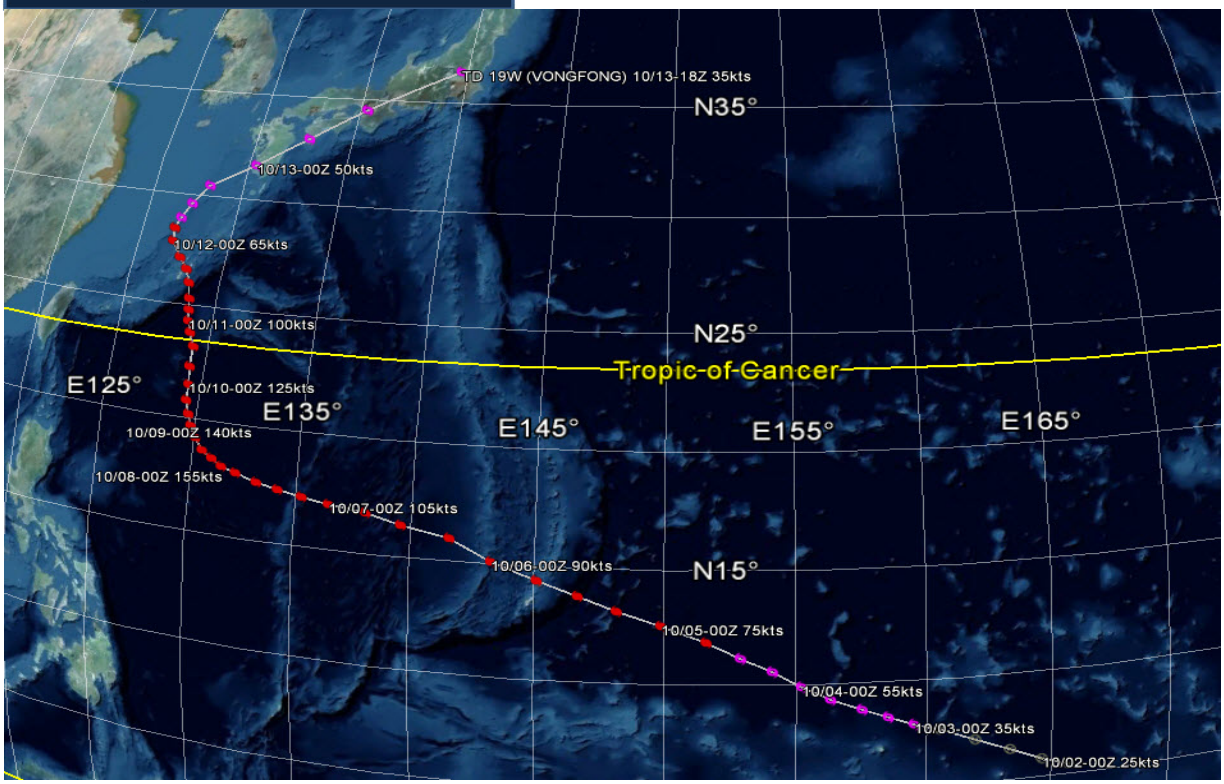


19W SUPER TYPHOON VONGFONG

ISSUED LOW: 01 OCT/ 1700Z
ISSUED MED: N/A
FIRST TCFA: 02 OCT/ 0300Z
FIRST WARNING: 02 OCT/ 1800Z
LAST WARNING: 14 OCT/ 0000Z
MAX INTENSITY: 155
WARNINGS: 46

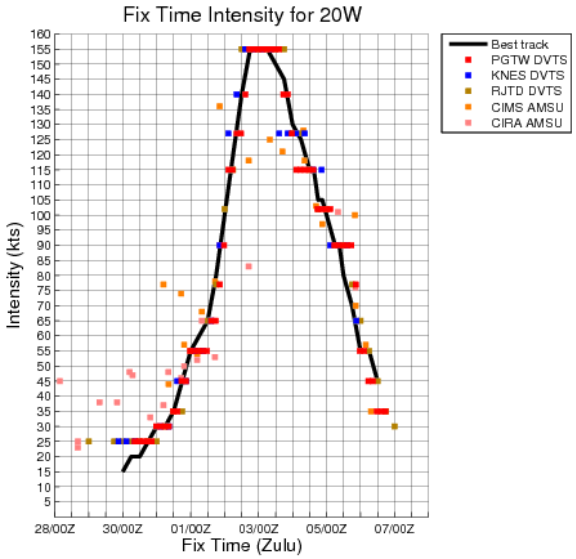


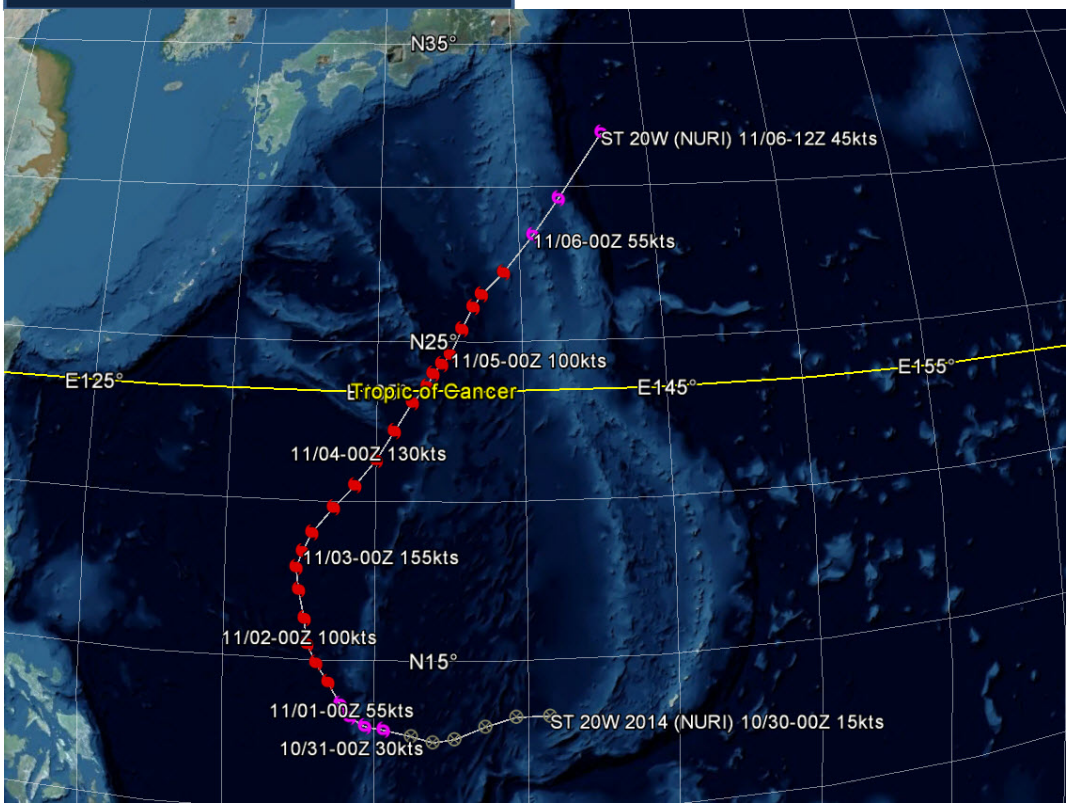




20W SUPER TYPHOON NURI

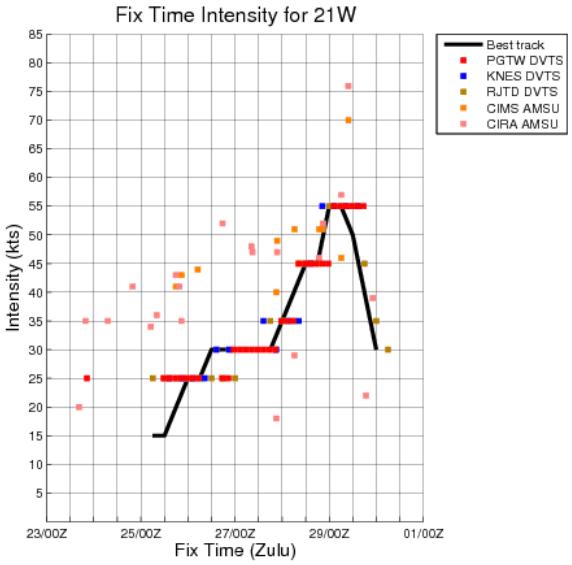
ISSUED LOW:	28 OCT/ 0600Z
ISSUED MED:	30 OCT/ 0600Z
FIRST TCFA:	30 OCT/ 0900Z
FIRST WARNING:	31 OCT/ 0000Z
LAST WARNING:	06 NOV/ 0000Z
MAX INTENSITY:	155
WARNINGS:	25

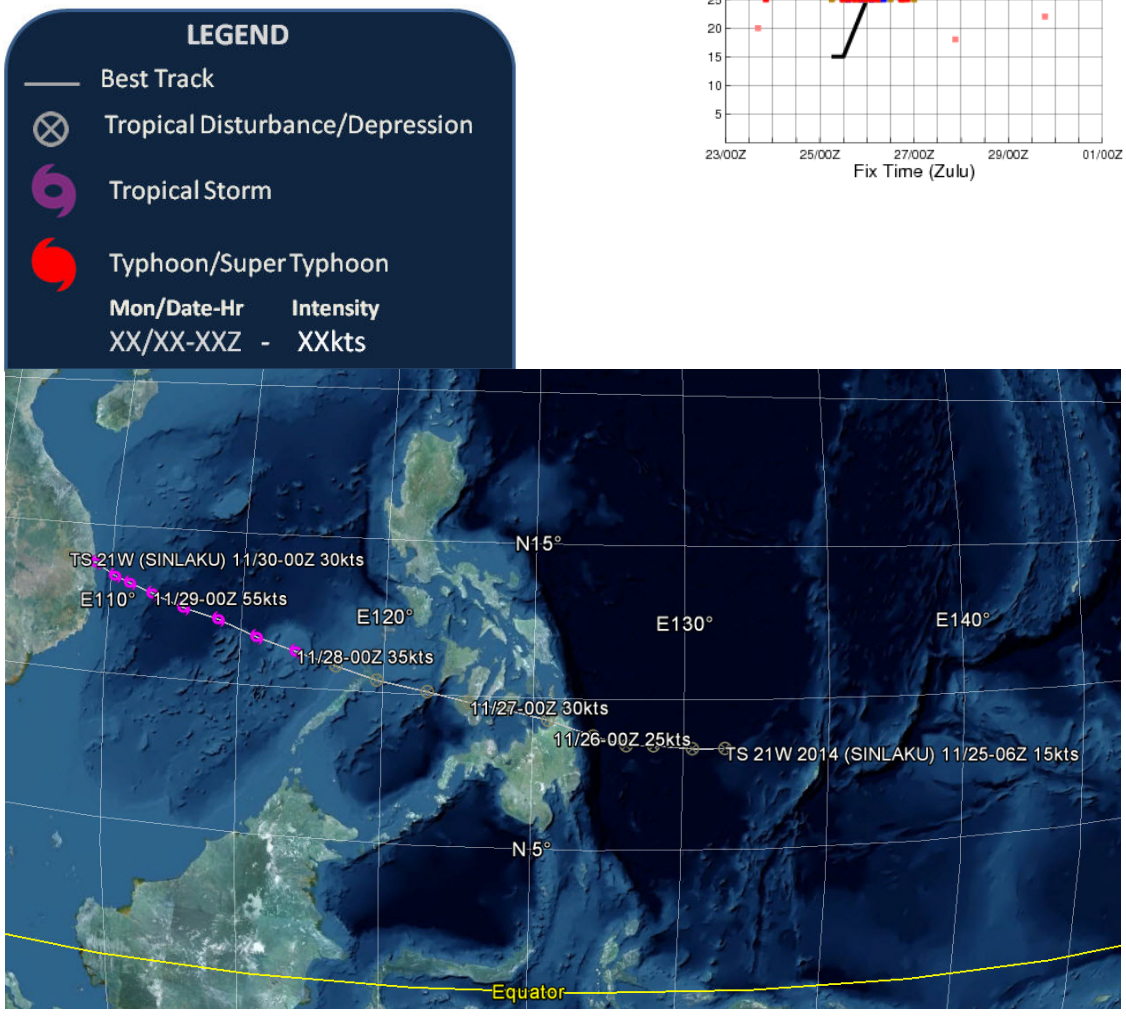




21W TROPICAL STORM SINLAKU

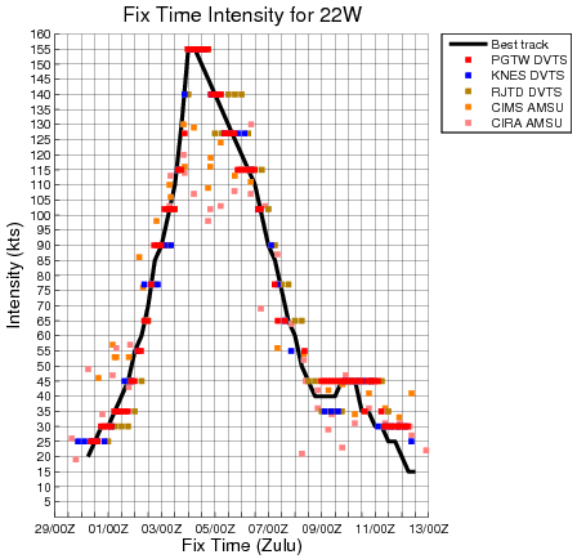
ISSUED LOW:	25 NOV/ 0600Z
ISSUED MED:	N/A
FIRST TCFA:	26 NOV/ 0500Z
FIRST WARNING:	26 NOV/ 0600Z
LAST WARNING:	29 NOV/ 1800Z
MAX INTENSITY:	55
WARNINGS:	15

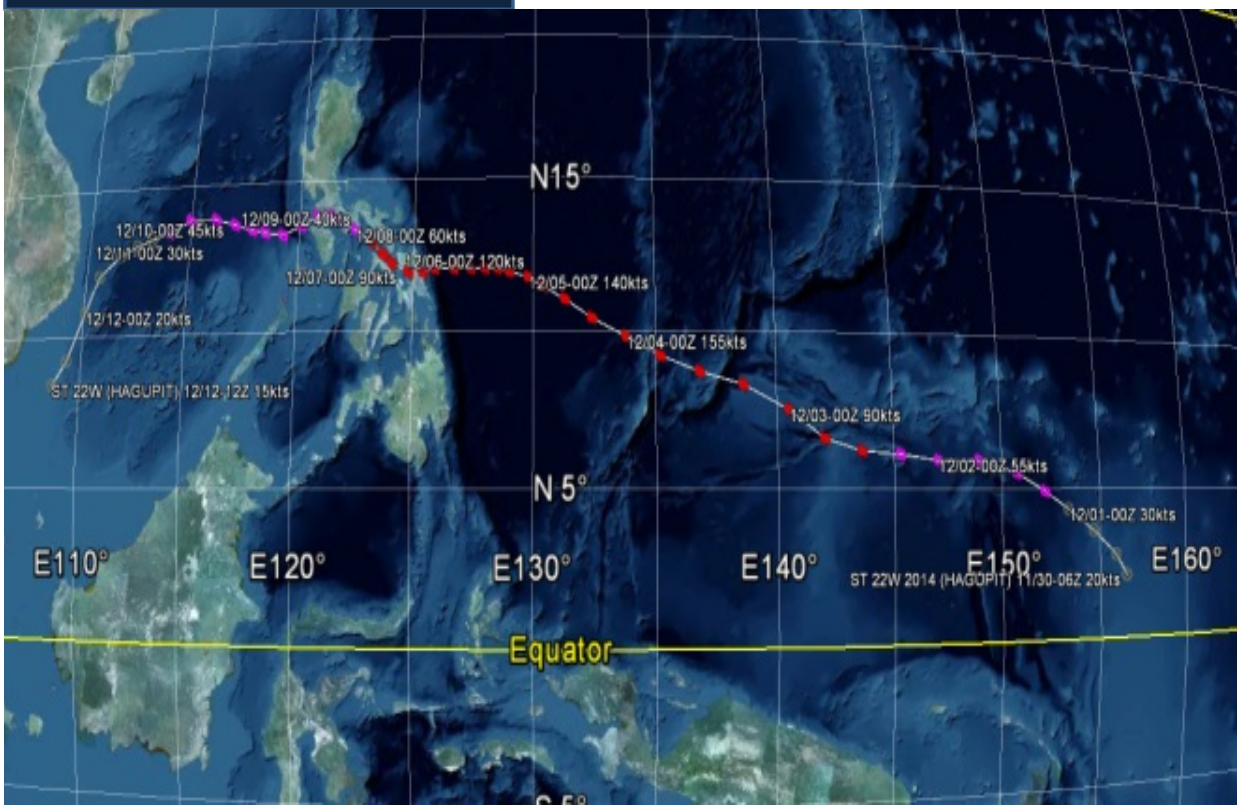




22W SUPER TYPHOON HAGUPIT

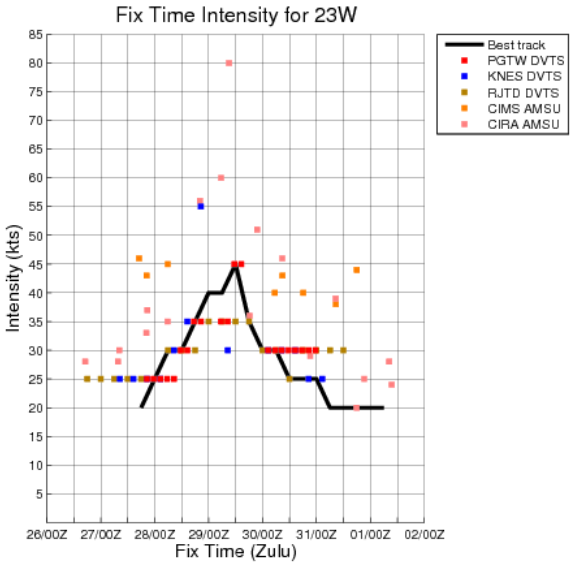
ISSUED LOW:	30 NOV/ 0600Z
ISSUED MED:	13 NOV/ 1300Z
FIRST TCFA:	30 NOV/ 1800Z
FIRST WARNING:	01 DEC/ 0000Z
LAST WARNING:	12 DEC/0000Z
MAX INTENSITY:	155
WARNINGS:	45

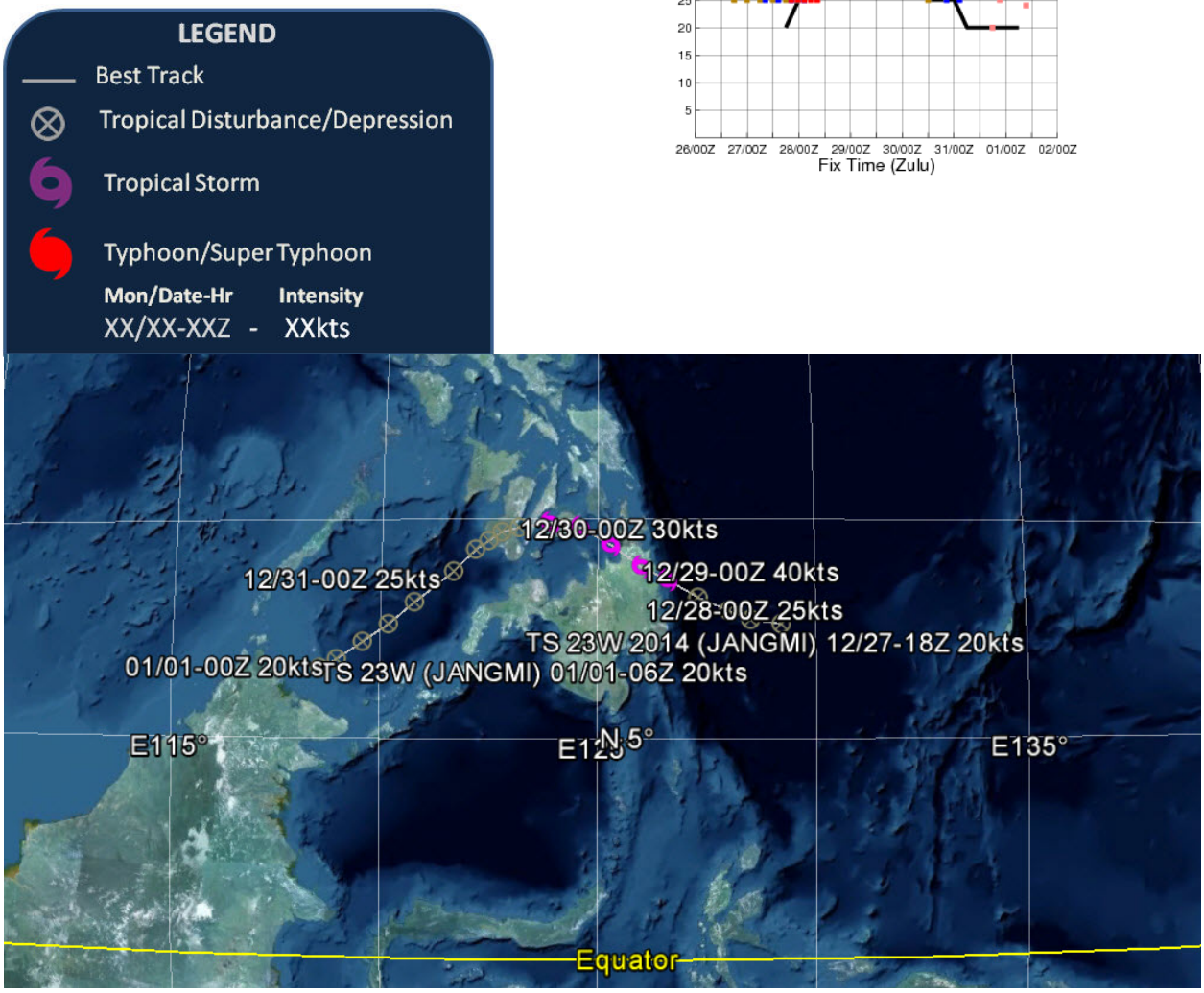




23W TROPICAL STORM JANGMI

ISSUED LOW: 27 DEC/ 0600Z
ISSUED MED: 27 DEC/ 1830Z
FIRST TCFA: 27 DEC/ 1930Z
FIRST WARNING: 28 DEC/ 0000Z
LAST WARNING: 31 DEC/ 0000Z
MAX INTENSITY: 45
WARNINGS: 13





Section 3 Detailed Cyclone Reviews

Tropical Storm 12W (Nakri)

Tropical Storm (TS) 12W (Nakri) formed as a prototypical monsoon depression over the east Philippine Sea in late July 2014. The system slowly intensified while meandering poleward (Figure 1-5) toward Okinawa and the other Ryukyu Islands.

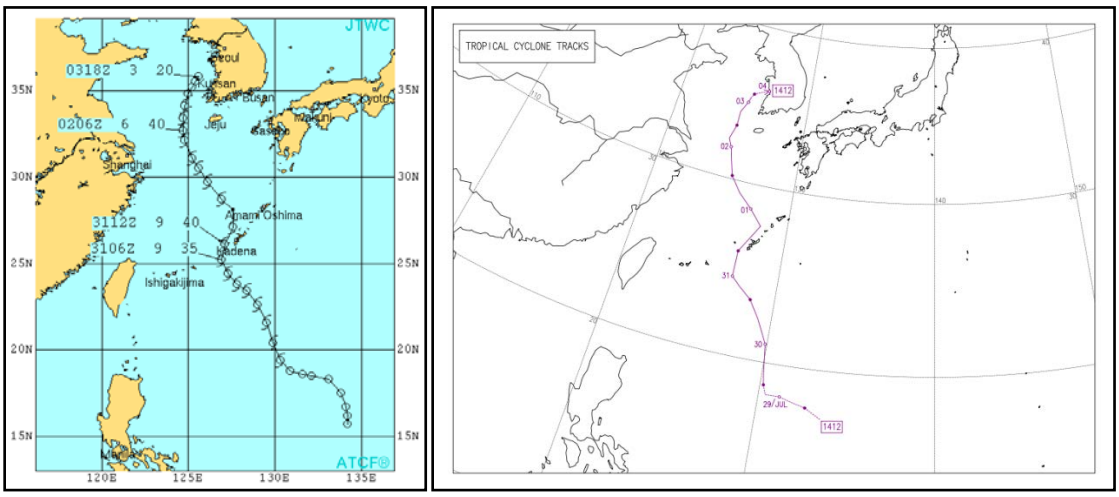


Figure 1-5: TS 12W (Nakri) best track (JTWC left and JMA right).

Monsoon depressions present unique difficulties to tropical forecasters, satellite analysts and METOC personnel due to their non-tropical cyclone characteristics:

- Large cyclonic circulations (average size using outer most closed isobar ~ 600 nm diameter) that develop within the monsoon trough
- A loosely organized cluster of deep convective elements, which may form an elongated band of deep convection in the eastern semicircle
- Low-level wind distribution that features a core of light winds which may be surrounded by a band of gales or a highly asymmetric wind field
- Lack of a distinct cloud system center, rendering the conventional Dvorak intensity estimate technique unusable
- Multiple small, weak mesovortices that rotate cyclonically about a centroid
- Monsoon depressions that develop in the western North Pacific Ocean often acquire persistent central convection and accelerated core winds, marking their transition into conventional tropical cyclones

Currently, it's JTWC's policy not to issue tropical cyclone warnings on monsoon depressions until they consolidate into tropical cyclones, i.e., they have acquired "persistent central convection and accelerated core winds" as defined in the AMS Glossary of Meteorology. JTWC's primary mission to issue warnings on tropical cyclones is unequivocally stated in *USPACOMINST 0539.1, Tropical Cyclone Operations in U.S. Pacific Command*. This instruction also outlines the purpose of Tropical Cyclone Conditions of Readiness (TCCOR) as "preparedness postures assumed by military activities threatened by tropical cyclones." Although a strong

monsoon depression can induce wind speeds on the order of TCCOR thresholds, it will remain in “non-warning” status as long as its structural characteristics more closely resemble a monsoon depression than a tropical cyclone. This can generate considerable and unnecessary confusion as DoD METOC personnel recommend preparations for tropical cyclone-like local impacts in the absence of a tropical cyclone warning.

According to Lander (2004), “two-thirds of western North Pacific tropical cyclones derive from monsoon depressions,” which eventually “acquire persistent central deep convection and are often classified as tropical storms on the first warning due to the presence of extensive areas of gales.” This implies a significant change where “the size of the monsoon depression is an important consideration because the large vortex structure of the monsoon depression must somehow be transformed to have a small inner core of intense winds and precipitation” (Beattie, 2013). As will be discussed later in this review, research concerning this transformation is limited. Consequently, there are wide-ranging opinions regarding the best practices for operational analysis and forecasting of monsoon depressions and their potential transition into tropical cyclones.

Unlike the majority of western North Pacific monsoon depressions, TS 12W never fully transitioned into a tropical cyclone, i.e., it never acquired persistent central convection and accelerated core winds, except for a brief period of time (based on subjective analysis of scatterometer data). Not surprisingly, Dvorak intensity estimates remained relatively low, ranging from T1.0 (25 knots) to a peak of T2.0 (30 knots). JTWC leadership made the initial decision to not issue tropical cyclone warnings based on previously cited policy, and instead closely coordinated with the 17th Operational Weather Squadron to issue weather watches and warnings for Okinawa for resource protection purposes. Due to the expansive, strengthening wind field with peripheral storm-force wind gusts exceeding 50 knots, the system had a major impact on DoD assets, particularly on Okinawa, where peak surface wind gusts exceeded 50 knots well in advance of the arrival of the storm center. At Kadena Air Base, maximum sustained surface winds of 40 knots gusting to 51 knots were observed (Captain Klick, 18 OSS Wx Flight Commander, personal communication).

TS 12W continued to track slowly poleward toward the Korean Peninsula while maintaining 35 to 40 knot maximum sustained surface winds displaced well away from the center of circulation. On 02 Aug 0600Z, JTWC initiated tropical cyclone warnings based on ASCAT scatterometer data (Figure 1-6), which provided, for the first time, evidence of a contracting, symmetric wind field with a radius of maximum winds of 80 to 100 nm (more typical of a tropical cyclone).

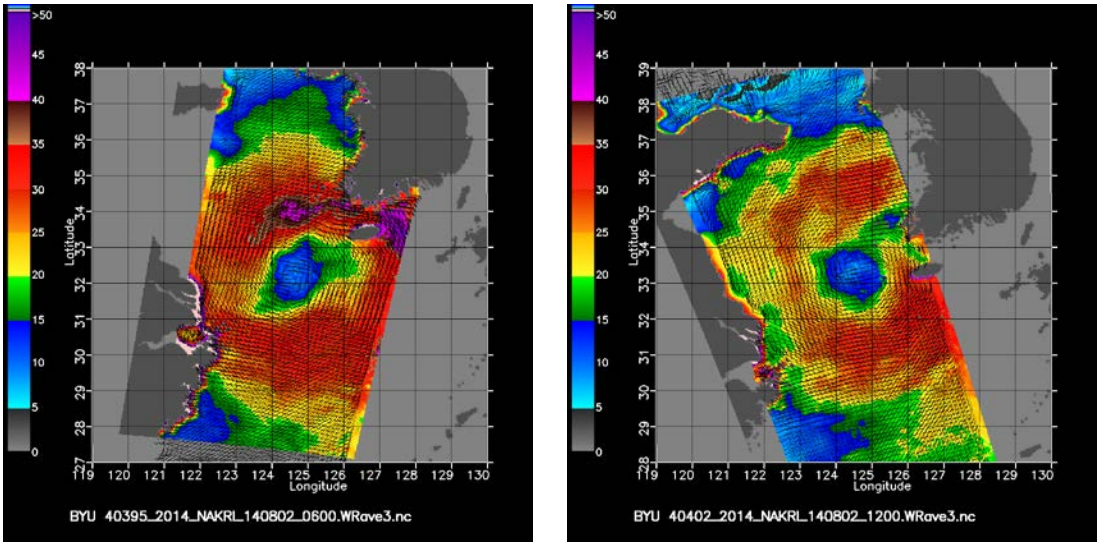


Figure 1-6: BYU high-resolution ASCAT scatterometer imagery (based on 02 Aug / 0107Z (left) and 02 Aug / 1224Z (right) ASCAT data).

Figure 1-7 shows the evolution of the expansive wind field and peripheral gale-force winds that impacted the Ryukyu Islands as well as the asymmetric weak wind core, with a radius of maximum winds (RMW) exceeding 100nm. As the monsoon depression tracked north of the Ryukyu Islands, the wind core became more symmetric (see 02 Aug / 0107Z and 02 Aug / 1224Z images) and the RMW contracted to less than 100nm for a brief period of time before the system made landfall over the Korean Peninsula.

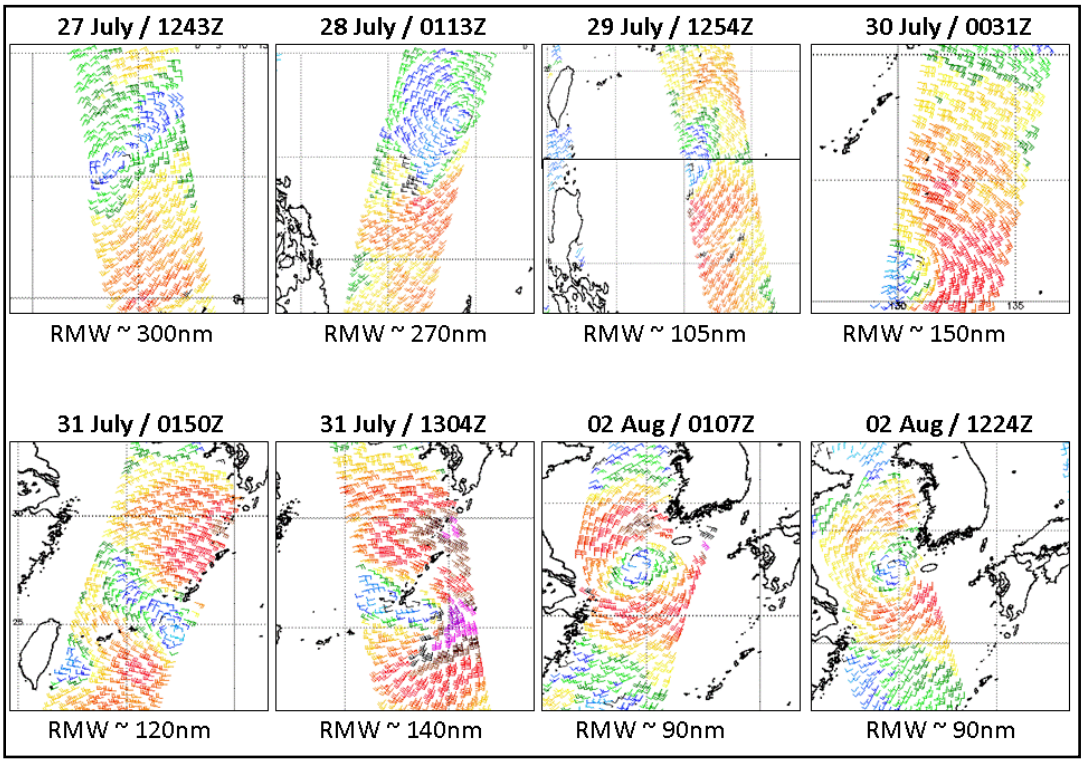


Figure 1-7: Evolution of 12W's wind field, reflected in a time-series of ASCAT scatterometer imagery (with author's subjective estimate of RMW) (data source: NOAA NESDIS).

As TS 12W approached the southwest coast of South Korea, the expansive wind field weakened rapidly, as expected, due to frictional effects resulting from interaction with land as well as increasing vertical wind shear. 12W dissipated prior to making landfall.

In addition to the expansive wind field, 12W exhibited minimal centralized convection throughout its lifecycle, a classic characteristic of monsoon depressions. The lack of central convection is evident in the following three figures, which show several ASCAT scatterometer images from Figure 1-7 with nearly coincident microwave images. Note that the central core of the system is marked by a 100-nm radius red circle centered on the JTWC best track position.

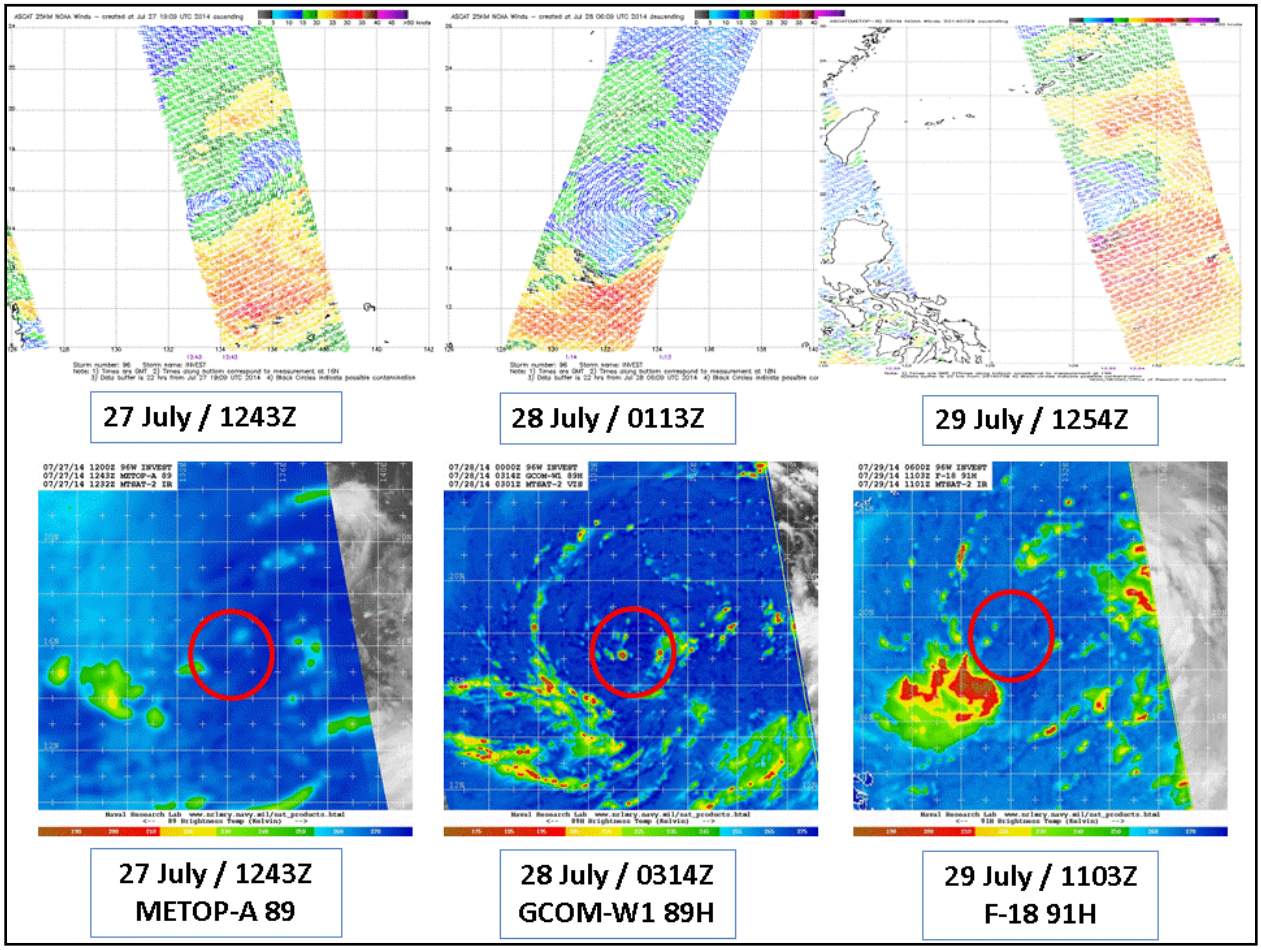


Figure 1-8: Comparison of 12W's surface wind field (ASCAT data) and nearly coincident microwave satellite imagery during the 27 to 29 July period (data sources: NOAA NESDIS (top), NRL TC page (bottom)).

During the early phase of development, from 27 through 29 July, deep convection associated with 12W formed primarily along the periphery of the system while core convection (within the red circle) remained sparse and disorganized (Figures 1-8,1-9, and 1-10). The convective structure, while uncharacteristic of a tropical cyclone, was essentially consistent with Beattie's (2013) description of a typical monsoon depression: "…ring of convection was broader in the southwest and northeast quadrants of the circulation, especially when those regions of convection were

embedded in the leading edge of the equatorial westerly flow converging with the trade easterlies prior to monsoon depression formation."

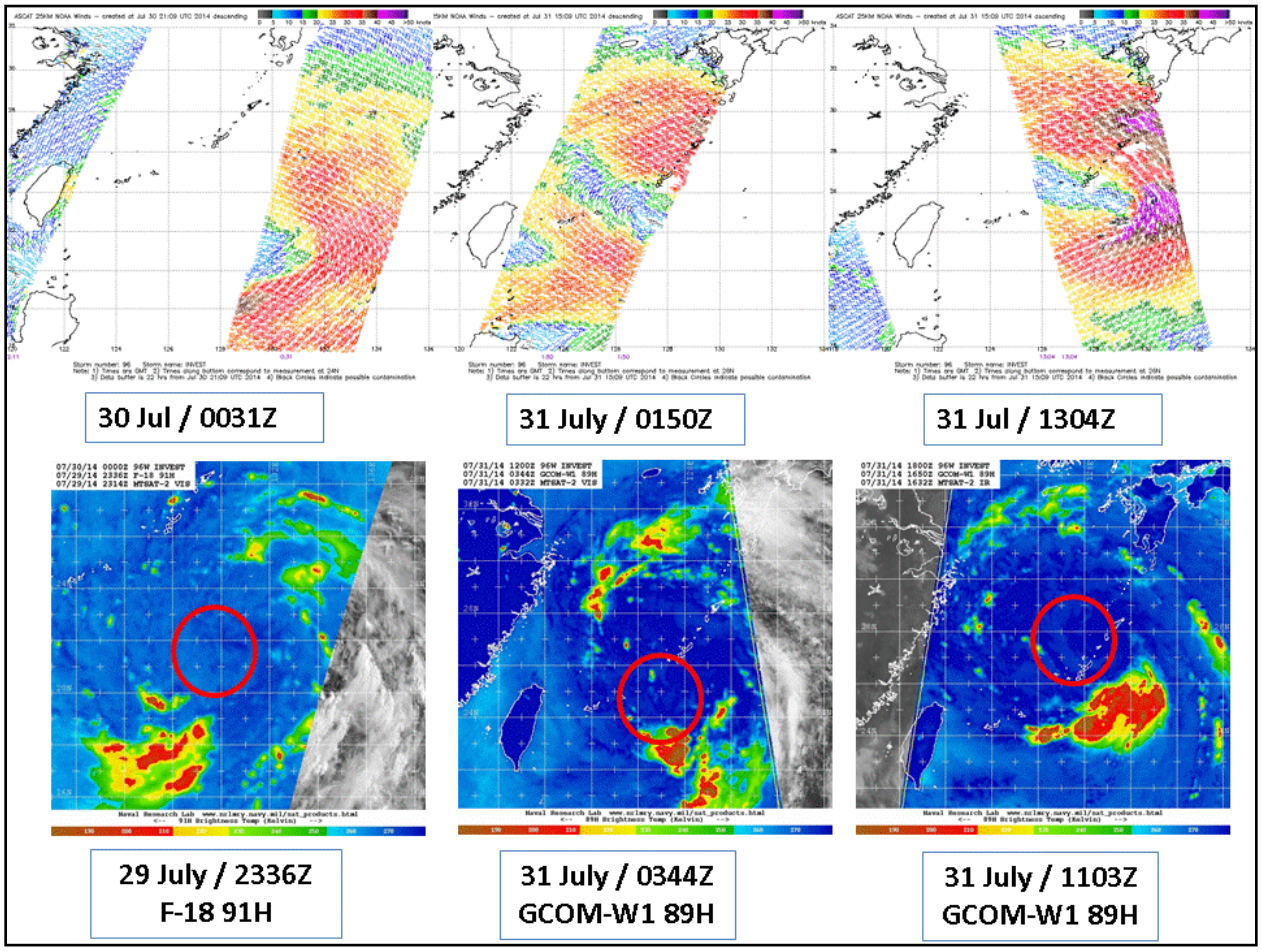


Figure 1-9: Comparison of surface wind field (ASCAT data) and nearly coincident microwave satellite imagery during the 30 to 31 July period (data sources: NOAA NESDIS (top), NRL TC page (bottom)).

From 30 through 31 July, broad convective banding remained confined to the periphery of the system (Figure 1-9). Imagery indicates that an area of intense deep convection initially developed along the southwestern flank (29 July / 2336Z) of the system and rotated gradually to the southeast quadrant (31 July / 1103Z). This convection appears to have been associated with a surge of strong convergent flow measuring 40 to 45 knots. These strong peripheral winds are not unusual with monsoon depressions as "the special characteristics of the monsoon depression are the higher winds and deep convection that are wrapped around a broad region of minimum pressure and minimum cloudiness" (Beattie, 2013). Despite the presence of the band of strong gale-force winds, 12W did not exhibit tropical cyclone characteristics.

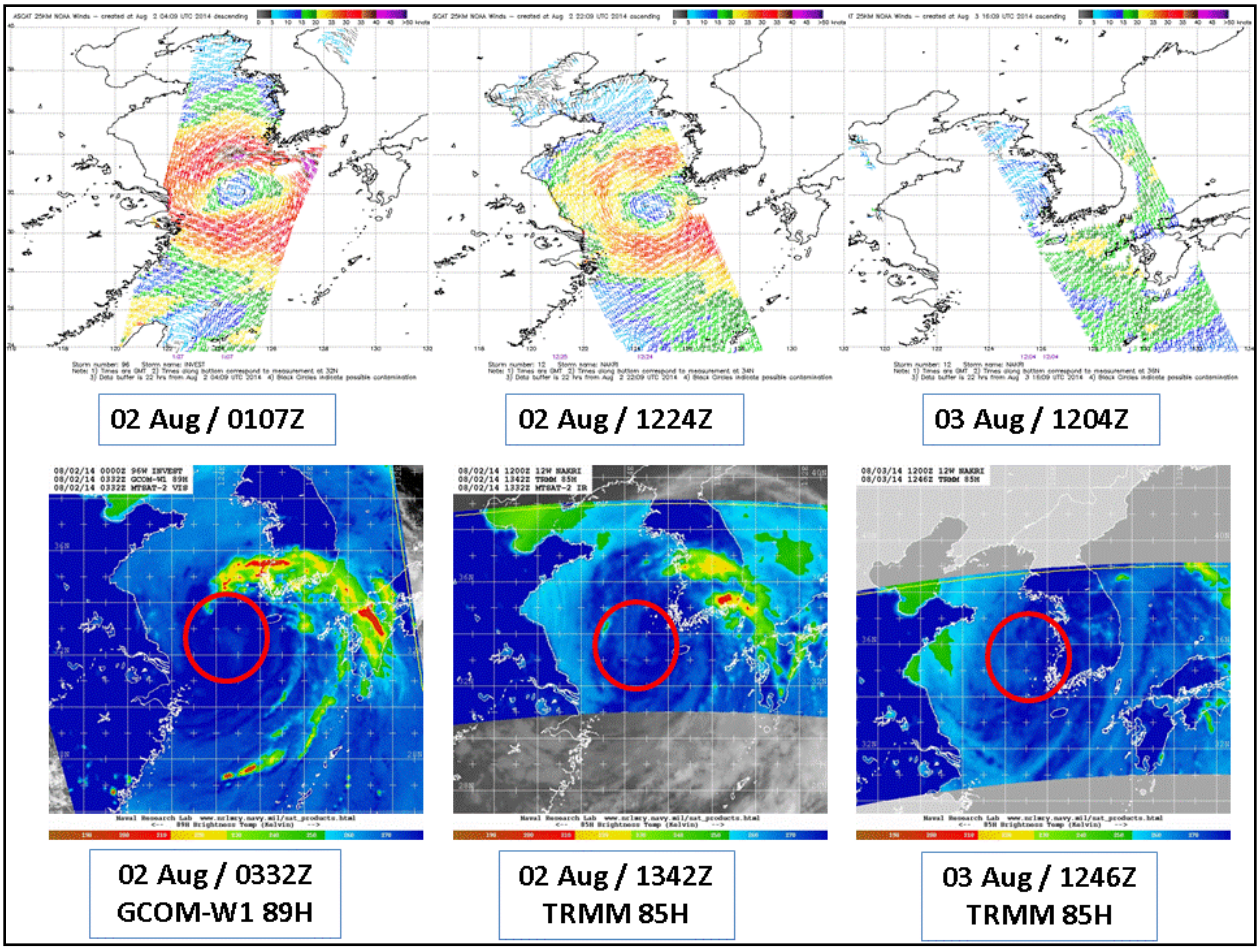


Figure 1-10: Comparison of surface wind field (ASCAT data) and nearly coincident microwave satellite imagery during the 02 to 03 August period (data sources: NOAA NESDIS (top), NRL TC page (bottom)).

On 02 Aug, TS 12W developed extensive deep convective banding, which wrapped broadly around the northern portion of the low-level circulation. At this point, 12W appeared to begin transitioning into a tropical cyclone as the core winds contracted. Analysis at 02 Aug / 0107Z indicated a 90nm RMW, which persisted until at least 02 Aug / 1224Z according to ASCAT data. Given the improved convective banding and shrinking RMW, as well as resource protection concerns, the senior JTWC forecaster strongly recommended initiating tropical cyclone warnings as the system approached the Korean Peninsula. JTWC leadership concurred and the 17th Operational Weather Squadron Lead Forecaster and the 607th Weather Squadron Director of Operations were immediately notified and briefed on the reasoning for initiating tropical cyclone warnings. However, post-storm review concluded that the system more likely remained a monsoon depression during this period.

JTWC received some criticism for delaying TC warnings early in TS 12W's lifecycle despite the strength of the system's peripheral wind field. However, as demonstrated in this review, 12W was an unusually persistent monsoon depression that perhaps never fully transitioned into a tropical cyclone, and therefore did not fulfill the requirements for issuing warnings outlined in USPACOM Instruction 0539.1. JTWC and DoD forecast partners ensured that US Government resources were protected, in this case, through careful collaboration and the timely dissemination of local weather watches and warnings. "Artificially" declaring this and other monsoon depressions as

tropical cyclones and issuing warnings could mislead local forecasters who, upon receiving a TC warning, may consequently expect the more accurate position estimates and forecast closest-points-of-approach associated with classic tropical cyclones. Such assumptions and misunderstandings can lead to suboptimal TCCOR and sortie actions.

As noted earlier, current research on monsoon depressions is lacking. Beattie (2012) notes that "little is known about the processes that influence the formation, structure, and development of the monsoon depressions in the western North Pacific." There is neither a peer-reviewed adaptation of the Dvorak technique, nor a clear alternative to the Dvorak technique, for assessing monsoon depression intensity. Additionally, there is no documented procedure for identifying the transition from a monsoon depression to a tropical cyclone. Until the necessary research is conducted and new methodologies are developed for monsoon depressions, there will continue to be "differences of opinion about monsoon depressions and monsoon gyres in relation to tropical cyclone formation and as to the outer wind structure (or size) of the tropical cyclone that might result" (Beattie, 2013).

Improving monsoon depression analysis and forecast procedures and associated resource protection will require expanding research, canvassing DoD METOC customers for feedback on JTWC's existing procedures, and regularly training DoD local forecasters on the unusual nature of these systems. Specifically, forecasters should understand the broad nature of a monsoon depression's wind field, the lack of convective organization and the often-observed presence of multiple mesovortices within the broad central circulation. All of these features introduce significant uncertainty to position analyses, track predictions and closest point-of-approach projections. Additionally, these forecasters must recognize that monsoon depressions can produce severe weather in the subtropics just like other non-tropical cyclone phenomena such as monsoon gyres, waves in the easterlies, shear lines, upper-level lows, subtropical cyclones, and midlatitude cyclones / fronts. Watches and warnings for these non-tropical cyclone events should be standardized, straightforward, and fully consistent with existing TCCOR protocols, enabling seamless resource protection regardless of storm classification.

References:

Beattie, J. C., and R. L. Elsberry, 2012: Western North Pacific monsoon depression formation. *Weather and Forecasting*, **27**, 1413-1432.

Beattie, J. C., and R. L. Elsberry (2013), Horizontal structure of monsoon depressions in the western North Pacific at formation time, Geophys. Res. Lett., **40**, 983–987.

Lander, M. A., 2004: Monsoon depressions, monsoon gyres, midget tropical cyclones, TUTT cells and high intensity after recurvature: Lessons learned from the use of Dvorak's techniques in the world's most prolific tropical-cyclone basin. *Extended Abstract 7A.5, 26th Conf. on Hurricanes and Tropical Meteorology*, Amer. Meteor. Soc., Miami, FL.

Dvorak, Vernon F., 1984, Tropical Cyclone Intensity Estimates Using Satellite Data, NOAA Technical Report NESDIS 11, Washington DC

Chapter 2 North Indian Ocean Tropical Cyclones

This chapter contains information on northern Indian Ocean TC activity during 2014 and the monthly distribution of TC activity summarized for 1975 - 2014. North Indian Ocean tropical cyclone best tracks appear following Table 2-2.

Section 1 Informational Tables

Table 2-1 is a summary of TC activity in the north Indian Ocean during the 2014 season. Five cyclones occurred in 2014, with two systems reaching an intensity greater than 64 knots. Table 2-2 shows the monthly distribution of Tropical Cyclone activity for 1975 - 2014.

Table 2-1

NORTH INDIAN OCEAN SIGNIFICANT TROPICAL CYCLONES FOR 2014

(01 JAN 2014- 31 DEC 2014)

TC	NAME*	PERIOD**		WARNINGS ISSUED	EST MAX SFC WINDS KTS
01B	ONE	04 JAN / 0600Z	05 JAN / 1800Z	7	40
02A	NANAUK	10 JUN / 0000Z	13 JUN / 0600Z	14	55
03B	HUDHUD	08 OCT / 0000Z	12 OCT / 1200Z	19	115
04A	NILOFAR	25 OCT / 1200Z	30 OCT / 1800Z	22	115
05B	FIVE	06 NOV / 0000Z	07 NOV / 1800Z	8	35

* As designated by the responsible RSMC

** Dates are based on Issuance of JTWC warnings on system.

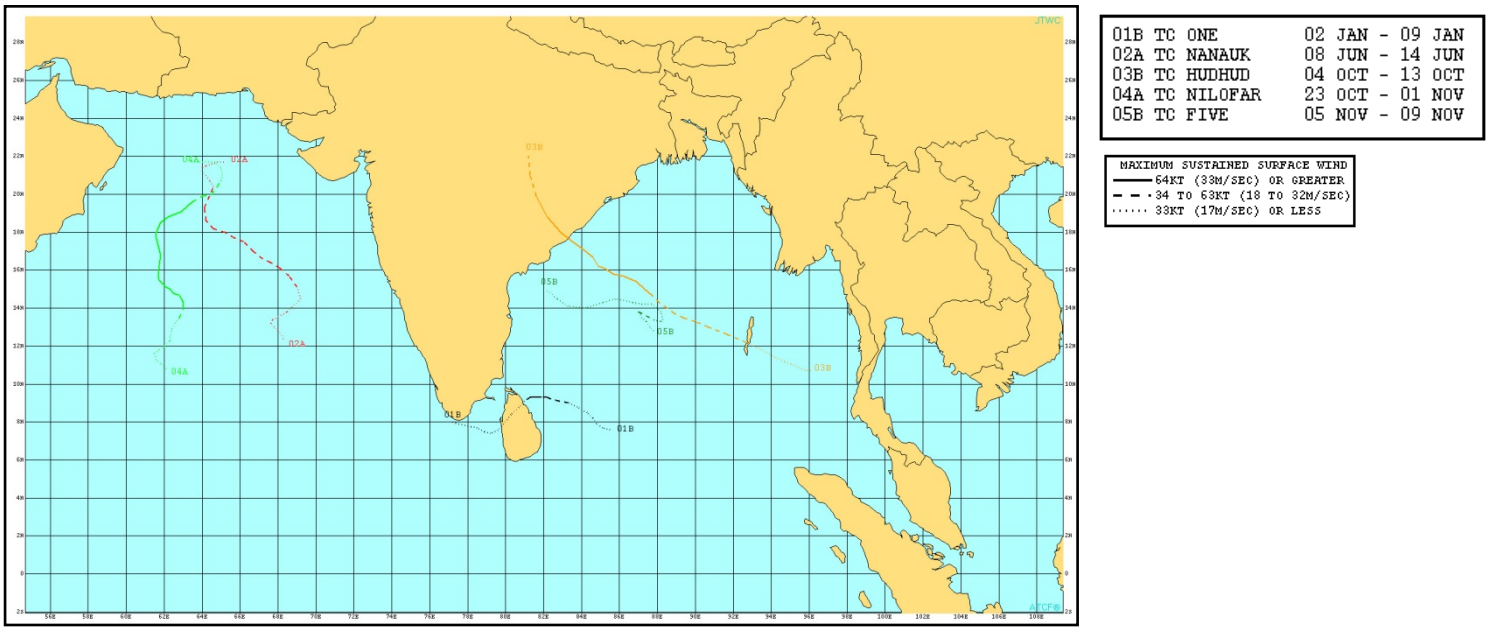


Figure 2-1. North Indian Ocean Tropical Cyclones.

Table 2 - 2
DISTRIBUTION OF NORTH INDIAN OCEAN TROPICAL CYCLONES
FOR 1975 - 2014

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total ≥64kt	Total 34-63kt	Total ≤33 kt
	1	0	0	0	2	0	0	0	0	1	2	0		6	
1975	0 1 0	0 0 0	0 0 0	0 0 0	2 0 0	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 2 0	0 0 0	3	3	0
	0	0	0	1	0	1	0	0	1	1	0	1		5	
1976	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 1 0	0 0 0	0 0 0	0 1 0	0 1 0	0 0 0	0 1 0	0	5	0
	0	0	0	0	1	1	0	0	0	1	0	2		5	
1977	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	1 1 0	1	4	0
	0	0	0	0	1	0	0	0	0	1	2	0		4	
1978	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	2 0 0	0 0 0	2	2	0
	0	0	0	0	1	1	0	0	2	1	2	0		7	
1979	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 1 0	0 0 0	0 0 0	0 1 1	0 1 0	0 1 1	0 0 0	1	4	2
	0	0	0	0	0	0	0	0	0	0	1	1		2	
1980	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 0	0	2	0
	0	0	0	0	0	0	0	0	1	0	1	1		3	
1981	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	1 0 0	1 0 0	2	1	0
	0	0	0	0	1	1	0	0	0	2	1	0		5	
1982	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 2 0	1 0 0	0 0 0	2	3	0
	0	0	0	0	0	0	0	1	0	1	1	0		3	
1983	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 1 0	0 1 0	0 0 0	0	3	0
	0	0	0	0	1	0	0	0	0	1	2	0		4	
1984	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	2 0 0	0 0 0	2	2	0
	0	0	0	0	2	0	0	0	0	2	1	1		6	
1985	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 1 0	0 1 0	0	6	0
	1	0	0	0	0	0	0	0	0	0	2	0		3	
1986	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 0 0	0	3	0
	0	1	0	0	0	2	0	0	0	2	1	2		8	
1987	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 2 0	0 0 0	0 0 0	0 0 0	0 2 0	0 1 0	0 2 0	0	8	0
	0	0	0	0	0	1	0	0	0	1	2	1		5	
1988	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 1 0	1 1 0	0 1 0	1	4	0
	0	0	0	0	1	1	0	0	0	0	1	0		3	
1989	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 0 0	1	2	0
	0	0	0	1	1	0	0	0	0	0	1	1		4	
1990	0 0 0	0 0 0	0 0 0	0 0 1	1 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 1	0 1 0	1	1	2
	1	0	0	1	0	1	0	0	0	0	1	0		4	
1991	0 1 0	0 0 0	0 0 0	1 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 0 0	2	2	0
	0	0	0	0	1	2	1	0	1	3	3	2		13	
1992	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 2 0	0 1 0	0 0 0	0 0 1	0 2 1	2 1 0	0 2 0	3	8	2
	0	0	0	0	0	0	0	0	0	0	2	0		2	
1993	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	2 0 0	0 0 0	2	0	0
	0	0	1	1	0	1	0	0	0	1	1	0		5	
1994	0 0 0	0 0 0	0 1 0	1 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 0	0 0 0	1	4	0
	0	0	0	0	0	0	0	0	1	1	2	0		4	
1995	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 0	2 0 0	0 0 0	2	2	0
	0	0	0	0	1	3	0	0	0	2	2	0		8	
1996	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	1 2 0	0 0 0	0 0 0	0 0 0	1 1 0	2 0 0	0 0 0	4	4	0
	0	0	0	0	1	0	0	0	1	1	1	0		4	
1997	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 1 0	0 1 0	0 0 0	2	2	0
	0	0	0	0	2	1	0	0	1	1	2	1		8	
1998	0 0 0	0 0 0	0 0 0	0 0 0	1 1 0	1 0 0	0 0 0	0 0 0	0 1 0	0 1 0	2 0 0	1 0 0	5	3	0
	0	1	0	0	1	1	0	0	0	2	0	0		5	
1999	0 0 0	0 1 0	0 0 0	0 0 0	1 0 0	0 1 0	0 0 0	0 0 0	0 0 0	2 0 0	0 0 0	0 0 0	3	2	0
	0	0	0	0	0	0	0	0	0	2	1	1		4	
2000	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	1 0 0	0 1 0	1	3	0
	0	0	0	0	1	0	0	0	1	1	1	0		4	
2001	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 0	0 0 1	0 0 0	1	2	1
	0	0	0	0	2	0	0	0	0	0	2	1		5	
2002	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 1 0	0	5	0
	0	0	0	0	1	0	0	0	0	0	1	1		3	
2003	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 1 0	2	1	0
	0	0	0	0	2	0	0	0	0	2	1	0		5	
2004	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	1 0 0	0 0 0	1	4	0
	2	0	0	0	0	0	0	0	0	2	1	2		7	
2005	0 1 1	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 1 0	0 2 0	0	6	1
	1	0	0	1	0	0	1	0	2	0	1	0		6	
2006	0 1 0	0 0 0	0 0 0	1 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 2 0	0 0 0	0 1 0	0 0 0	1	5	0
	0	0	0	0	1	3	0	0	0	1	1	0		6	
2007	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	1 2 0	0 0 0	0 0 0	0 0 0	0 1 0	1 0 0	0 0 0	3	3	0
	0	0	0	1	0	0	0	0	1	2	2	1		7	
2008	0 0 0	0 0 0	0 0 0	1 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 1 1	0 2 0	0 1 0	1	5	1
	0	0	0	1	1	0	0	0	1	0	1	1		5	
2009	0 0 0	0 0 0	0 0 0	0 1 0	1 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 1 0	0 1 0	1	4	0
	0	0	0	0	2	1	0	0	0	1	1	0		5	
2010	0 0 0	0 0 0	0 0 0	0 0 0	1 1 0	1 0 0	0 0 0	0 0 0	0 0 0	1 0 0	0 1 0	0 0 0	3	2	0
	0	0	0	0	0	1	0	0	0	1	3	1		6	
2011	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 1 0	0 3 0	1 0 0	1	5	0
	0	0	0	0	0	0	0	0	0	2	1	1		4	
2012	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 0	0 1 0	0 1 0	0	4	0
	0	0	0	0	1	0	0	0	0	1	3	1		6	
2013	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	1 0 0	2 1 0	1 0 0	4	2	0
	1	0	0	0	0	0	1	0	0	2	1	0		5	
2014	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	0 0 0	0 0 0	2 0 0	0 1 0	0 0 0	2	3	0
(1975-2014)															
MEAN	0.2	0.1	0.0	0.2	0.7	0.6	0.1	0.0	0.3	1.1	1.4	0.6		5.1	
CASES	7	2	1	7	28	22	3	1	13	42	55	23		204	

1) If a tropical cyclone was warned on prior to the last two days of a month, it was attributed to the first month, regardless of how long the system lasted.
2) If a tropical cyclone began on the last day of the month and ended on the first day of the next month, that system was attributed to the first month. However, if a tropical cyclone began on the last day of the month and continued into the next month for only two days, it was attributed to the second month.

Section 2 Cyclone Summaries

Each cyclone is presented, with the number and basin identifier assigned by JTWC, along with the RSMC assigned cyclone name. Dates are also listed when JTWC first designated Low and Medium[1] stages of development:

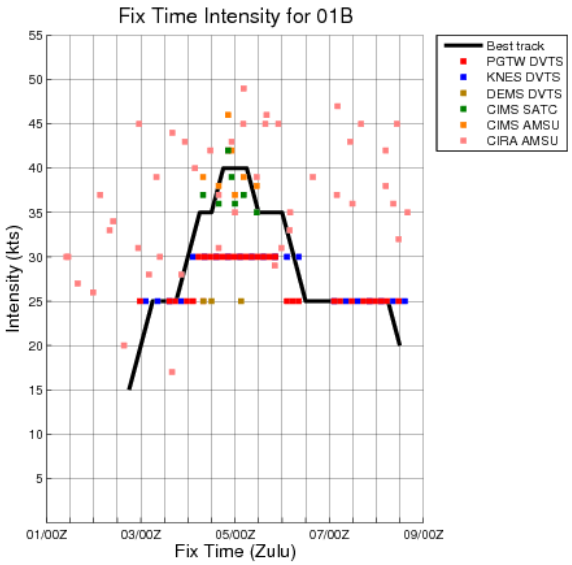
The first Tropical Cyclone Formation Alert (TCFA) and the initial and final warning dates are also presented with the number of warnings issued by JTWC. Landfall over major landmasses with approximate locations is presented as well.

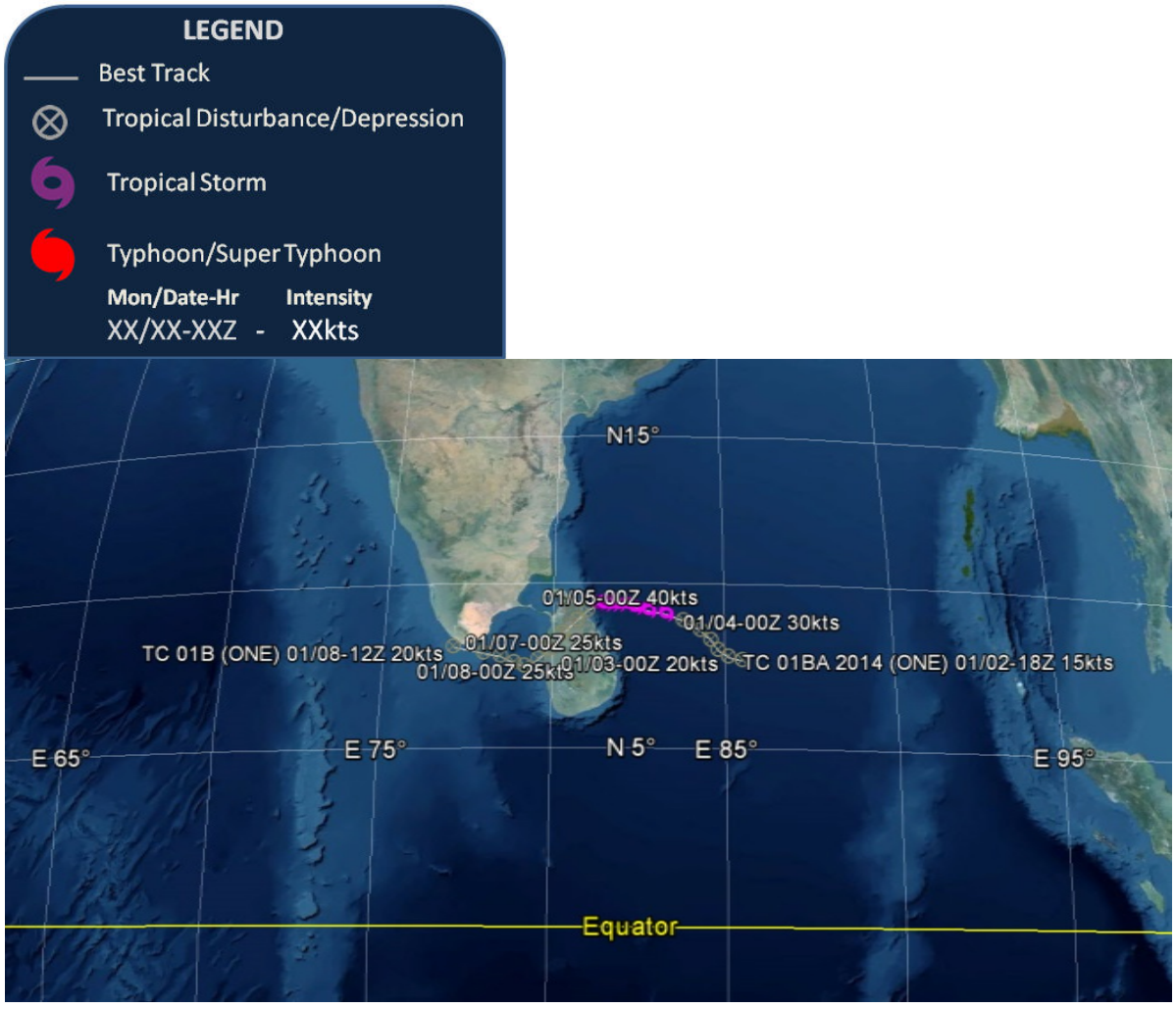
The JTWC post-event reanalysis best track is also provided for each cyclone. Data included on the best track are position and intensity noted with cyclone symbols and color coded track. Best track position labels include the date-time, track speed in knots, and maximum wind speed in knots. A graph of best track intensity versus time is presented. Fix plots on this graph are color coded by fixing agency.

In addition, if this document is viewed as a pdf, each map has been hyperlinked to the appropriate keyhole markup language (kmz) file that will allow the reader to access and view the best-track data interactively on their computer using Google Earth software. Simply hold the control button and click the map image; the link will open allowing the reader to download and open the file.
Users may also retrieve kmz files for the entire season from:
http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/best_tracks/2014/2014s-KMZs/JTWC_BestTrack_Climatology_2014.kmz

01B TROPICAL CYCLONE ONE

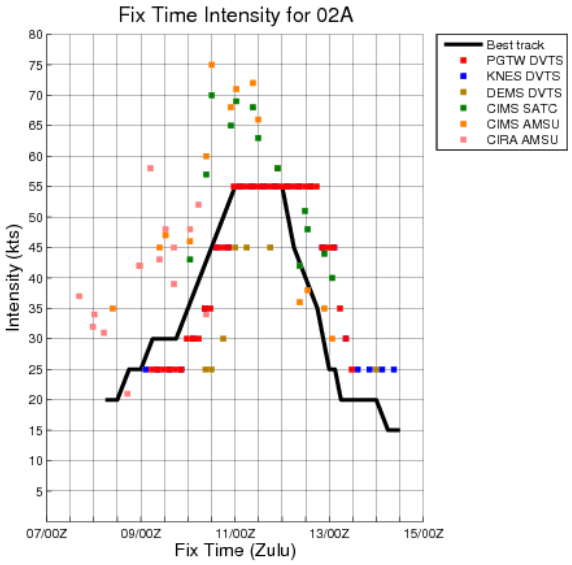
ISSUED LOW:	02 JAN/ 1900Z
ISSUED MED:	03 JAN/ 1800Z
FIRST TCFA:	04 JAN/ 0300Z
FIRST WARNING:	04 JAN/ 0600Z
LAST WARNING:	05 JAN/ 1800Z
MAX INTENSITY:	40
WARNINGS:	7

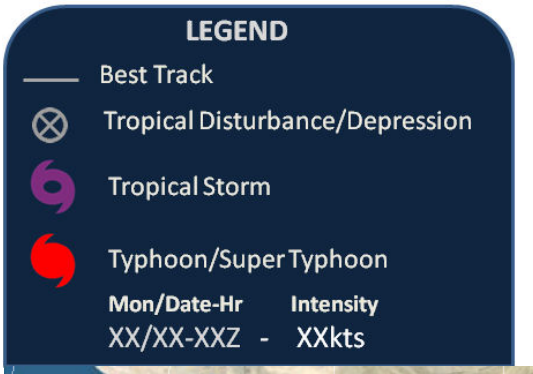


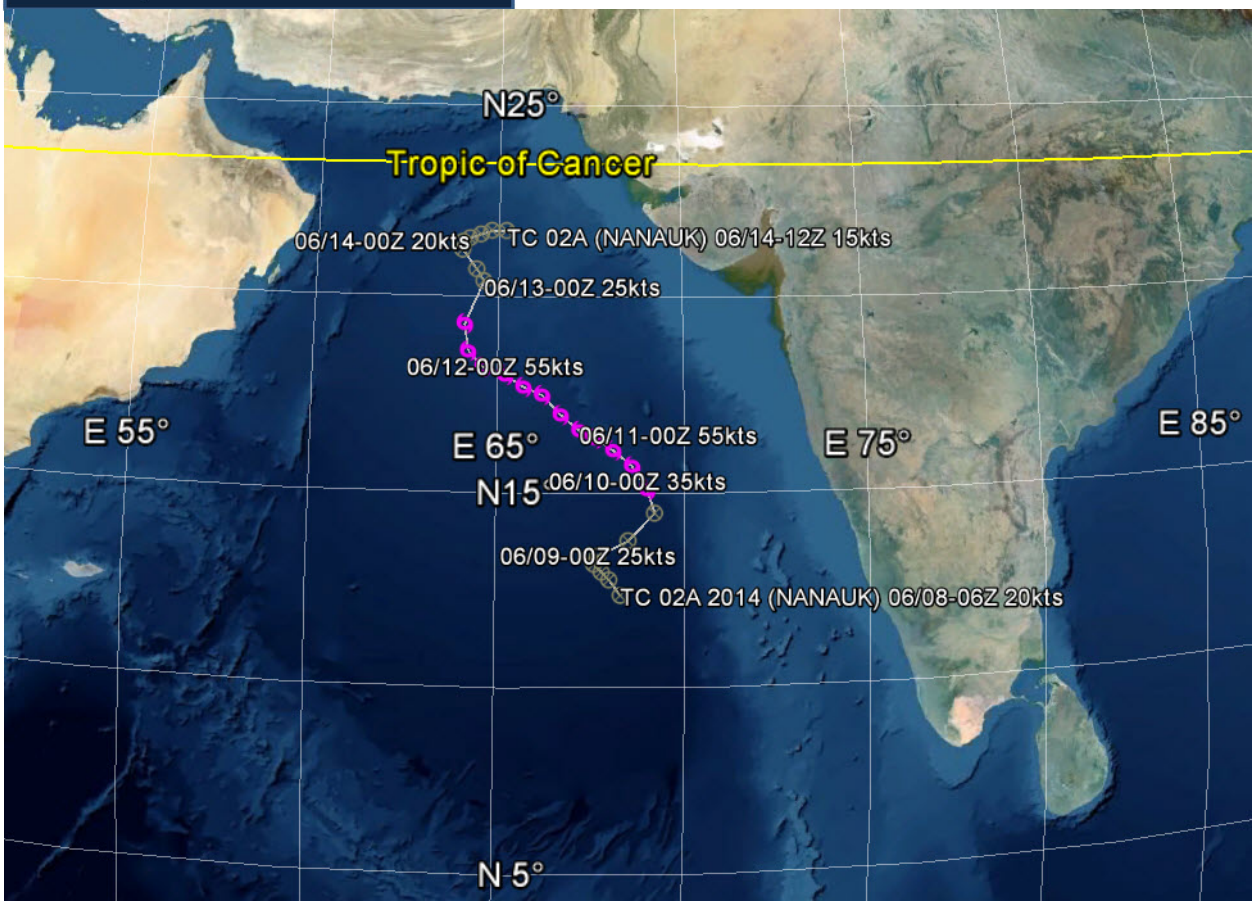


02A TROPICAL CYCLONE NANAUK

ISSUED LOW:	08 JUN/ 1400Z
ISSUED MED:	08 JUN/ 1800Z
FIRST TCFA:	09 JUN/ 1330Z
FIRST WARNING:	10 JUN/ 0000Z
LAST WARNING:	13 JUN/ 0600Z
MAX INTENSITY:	55
WARNINGS:	14

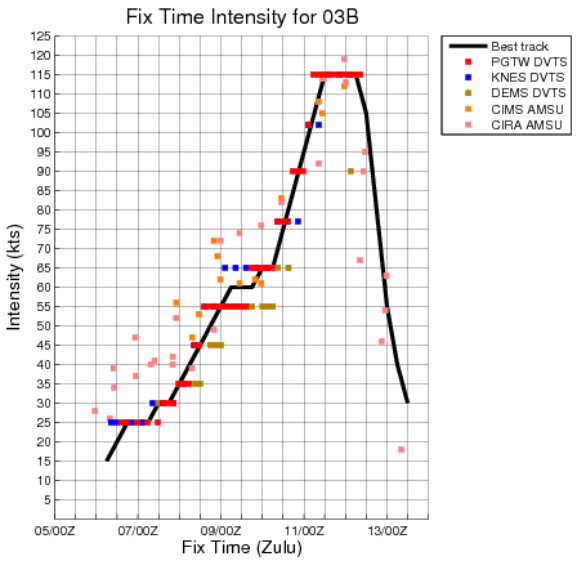


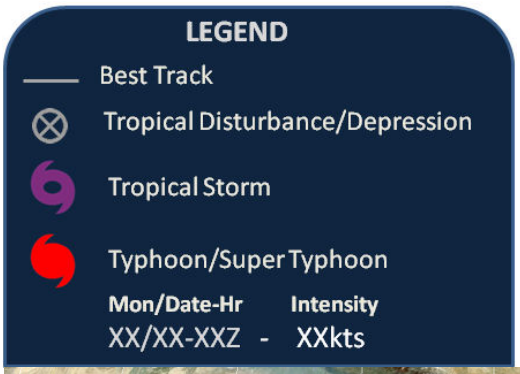


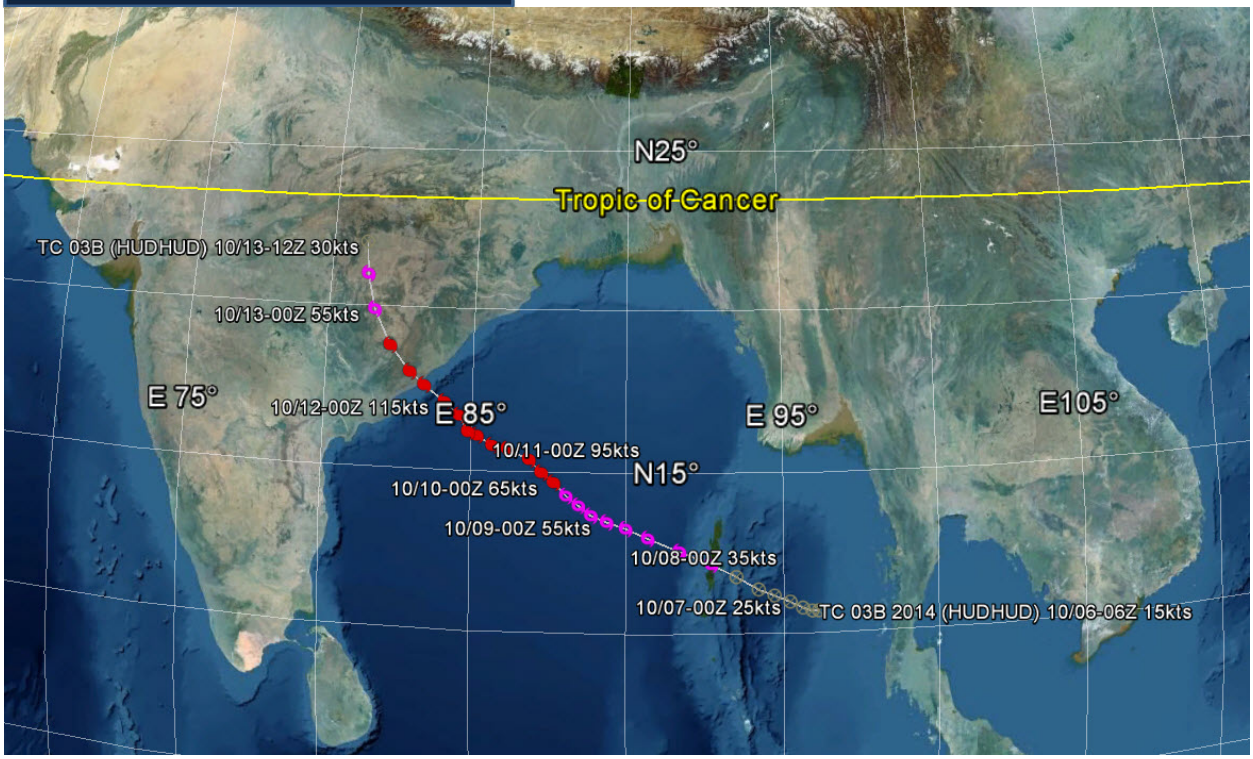


03B TROPICAL CYCLONE HUDHUD

ISSUED LOW:	06 OCT/ 1800Z
ISSUED MED:	07 OCT/ 0300Z
FIRST TCFA:	07 OCT/ 1330Z
FIRST WARNING:	08 OCT/ 0000Z
LAST WARNING:	12 OCT/ 1200Z
MAX INTENSITY:	115
WARNINGS:	19

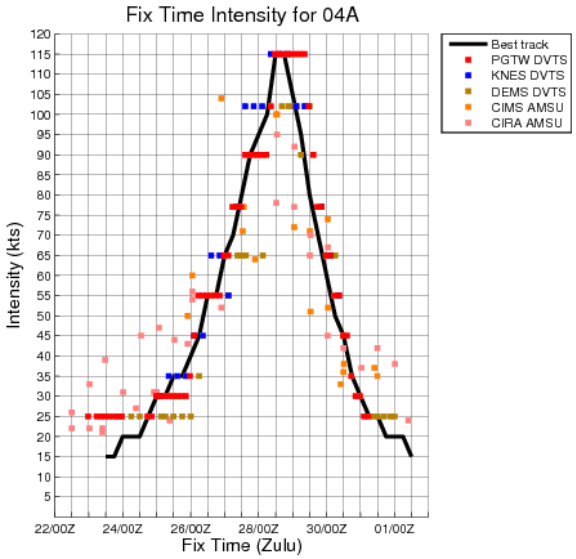


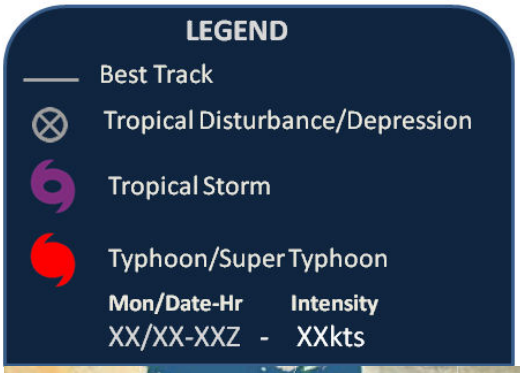


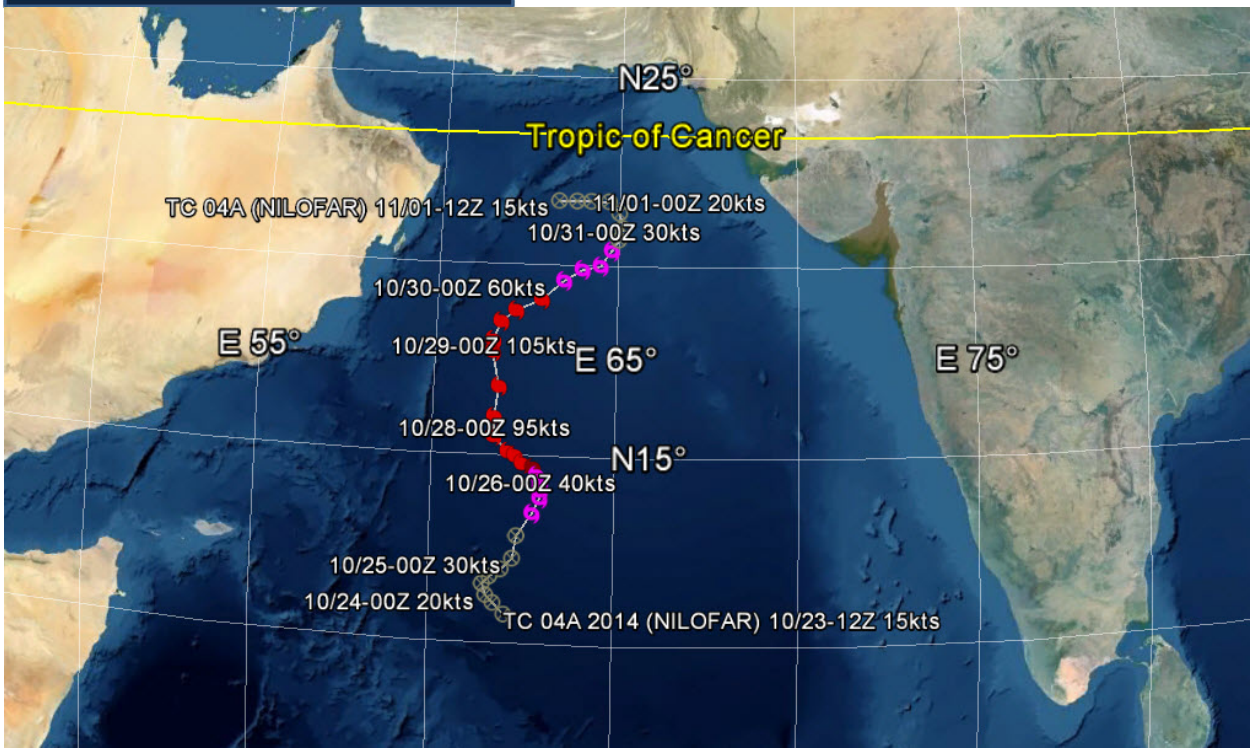


04A TROPICAL CYCLONE NILOFAR

ISSUED LOW:	23 OCT/ 0000Z
ISSUED MED:	24 OCT/ 0600Z
FIRST TCFA:	24 OCT/ 2200Z
FIRST WARNING:	25 OCT/ 1200Z
LAST WARNING:	30 OCT/ 1800Z
MAX INTENSITY:	115
WARNINGS:	22

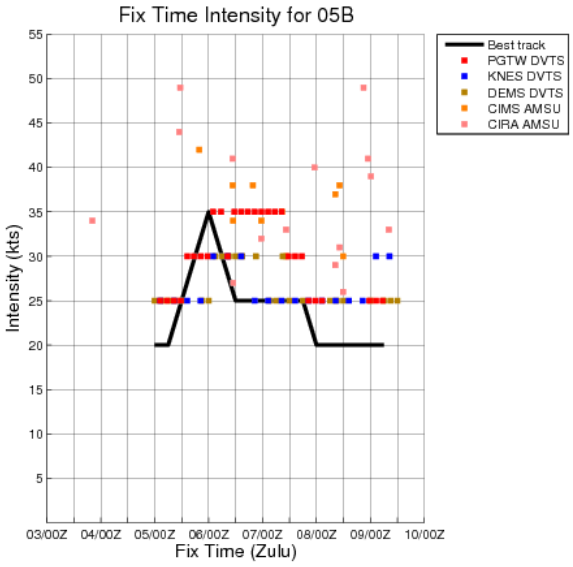


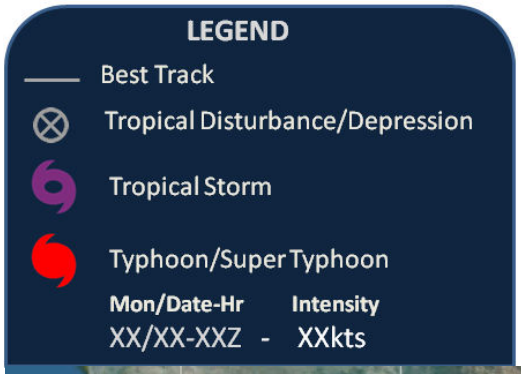


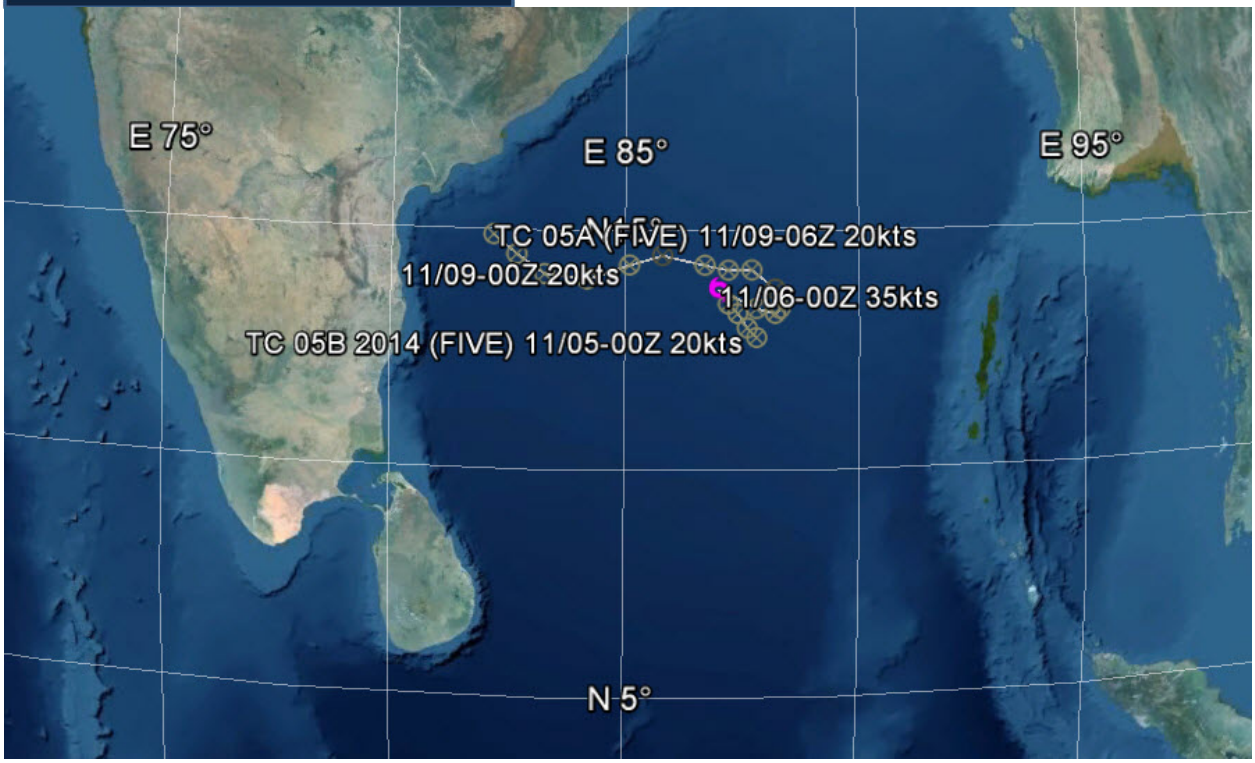


05B TROPICAL CYCLONE FIVE

ISSUED LOW:	04 NOV/ 1800Z
ISSUED MED:	05 NOV/ 1000Z
FIRST TCFA:	05 NOV/ 2000Z
FIRST WARNING:	06 NOV/ 0000Z
LAST WARNING:	07 NOV/ 1800Z
MAX INTENSITY:	35
WARNINGS:	8







Chapter 3 South Pacific and South Indian Ocean Tropical Cyclones

This chapter contains information on South Pacific and South Indian Ocean TC activity that occurred during the 2014 tropical cyclone season (1 July 2013 – 30 June 2014) and the monthly distribution of TC activity summarized for 1975 - 2014.

Section 1 Informational Tables

Table 3-1 is a summary of TC activity in the Southern Hemisphere during the 2014 season.

Table 3-1

SOUTHERN HEMISPHERE TROPICAL CYCLONES FOR 2014

(01 JULY 2013- 30 JUNE 2014)

TC	NAME*	PERIOD**		WARNINGS ISSUED	EST MAX SFC WINDS KTS
01S	ONE	27 OCT/ 0000Z	28 OCT/ 0000Z	3	40
02S	ALESSIA	22 NOV/ 0600Z	27 NOV/ 1800Z	7	45
03S	AMARA	16 DEC/ 1800Z	23 DEC/ 1200Z	15	130
04S	BRUCE	17 DEC/ 1800Z	24 DEC/ 1200Z	15	140
05S	CHRISTINE	28 DEC/ 0600Z	30 DEC/ 1800Z	11	100
06S	BEJISA	29 DEC/ 0600Z	06 JAN/ 1800Z	16	115
07P	IAN	05 JAN/ 1800Z	13 JAN/ 1800Z	17	130
08S	COLIN	09 JAN/ 1800Z	15 JAN/ 1200Z	13	120
09S	DELIWE	16 JAN/ 1200Z	18 JAN/ 0000Z	5	50
10P	JUNE	17 JAN/ 1200Z	19 JAN/ 0600Z	5	45
11P	DYLAN	29 JAN/ 0000Z	31 JAN/ 0000Z	5	45
12P	EDNA	04 FEB/ 1200Z	03 FEB/ 1800Z	4	55
13S	EDILSON	05 FEB/ 0000Z	07 FEB/ 1800Z	7	55
14S	FOBANE	06 FEB/ 1800Z	14 FEB/ 0600Z	16	60
15S	GUITO	18 FEB/ 1800Z	22 FEB/ 0600Z	9	65
16P	KOFI	28 FEB/ 0600Z	03 MAR/ 1800Z	8	50
17P	GILLIAN	08 MAR/ 1200Z	11 MAR/ 0000Z	16	140
18P	LUSI	9 MAR/ 1800Z	13 MAR/ 1800Z	9	70
19P	HADI	10 MAR/ 0600Z	11 MAR/ 0600Z	3	40
20P	MIKE	19 MAR/ 0600Z	19 MAR/ 1800Z	2	35
21S	HELLEN	28 MAR/ 1800Z	01 APR/ 0000Z	8	130
22S	IVANOE	04 APR/ 1200Z	06 APR/ 1200Z	5	45
23P	ITA	04 APR/ 1800Z	14 APR/ 0600Z	20	140
24S	JACK	18 APR/ 1800Z	22 APR/ 0600Z	8	90

* As designated by the responsible RSMC

** Dates are based on the issuance of JTWC warnings on the system.

Table 3-2 provides the monthly distribution of Tropical Cyclone activity summarized for 1975 - 2014.

Table 3-2
DISTRIBUTION OF SOUTH PACIFIC AND SOUTH INDIAN OCEAN TROPICAL CYCLONES
FOR 1958 - 2014

YEAR	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTALS
1958 - 1977 AVERAGE*													
-	-	-	-	0.4	1.5	3.6	6.1	5.8	4.7	2.1	0.5	-	24.7
1981 - 2014													
1981	0	0	0	1	3	2	6	5	3	3	1	0	24
1982	1	0	0	1	1	3	9	4	2	3	1	0	25
1983	1	0	0	1	1	3	5	6	3	5	0	0	25
1984	1	0	0	1	2	5	5	10	4	2	0	0	30
1985	0	0	0	0	1	7	9	9	6	3	0	0	35
1986	0	0	1	0	1	1	9	9	6	4	2	0	33
1987	0	1	0	0	1	3	6	8	3	4	1	1	28
1988	0	0	0	0	2	3	5	5	3	1	2	0	21
1989	0	0	0	0	2	1	5	8	6	4	2	0	28
1990	2	0	1	1	2	2	4	4	10	2	1	0	29
1991	0	0	1	1	1	3	2	5	5	2	1	1	22
1992	0	0	1	1	2	5	4	11	3	2	1	0	30
1993	0	0	1	1	0	5	7	7	2	2	2	0	27
1994	0	0	0	0	2	4	8	4	9	3	0	0	30
1995	0	0	0	0	2	2	5	4	5	4	0	0	22
1996	0	0	0	0	1	3	7	6	6	4	1	0	28
1997	1	1	1	2	2	6	9	8	3	1	3	1	38
1998	1	0	0	3	2	3	7	9	6	6	0	0	37
1999	1	0	1	1	1	6	6	8	7	2	0	0	33
2000	0	0	0	0	0	3	6	5	7	6	0	0	27
2001	0	1	0	0	1	1	4	6	2	5	0	1	21
2002	0	0	0	2	4	1	4	5	4	2	3	0	25
2003	0	0	1	0	2	5	5	7	5	2	1	1	29
2004	0	0	0	1	1	3	6	3	7	1	1	0	23
2005	0	0	1	1	2	2	7	7	4	2	0	0	26
2006	0	0	0	1	2	1	6	5	5	3	0	0	23
2007	0	0	0	0	1	2	2	5	6	6	1	1	24
2008	1	0	0	0	3	4	7	5	6	3	0	0	29
2009	0	0	0	1	2	2	7	4	8	3	0	0	27
2010	0	0	0	0	2	4	5	6	5	2	0	0	24
2011	0	0	0	1	1	2	6	7	2	2	0	0	21
2012	0	0	0	0	0	4	5	6	2	1	1	2	21
2013	0	0	0	1	1	4	7	5	2	3	1	0	24
2014	0	0	0	1	1	4	5	4	6	3	0	0	24
(1981 - 2014)													
MEAN	0.3	0.1	0.3	0.7	1.5	3.2	5.9	6.2	4.8	3.0	0.8	0.2	26.9
CASES	9	3	9	23	52	109	200	210	163	101	26	8	913

* (GRAY, 1978)

1) If a tropical cyclone was warned on prior to the last two days of a month, it was attributed to the first month, regardless of how long the system lasted.
2) If a tropical cyclone began on the last day of the month and ended on the first day of the next month, that system was attributed to the first month. However, if a tropical cyclone began on the last day of the month and continued into the next month for only two days, it was attributed to the second month.

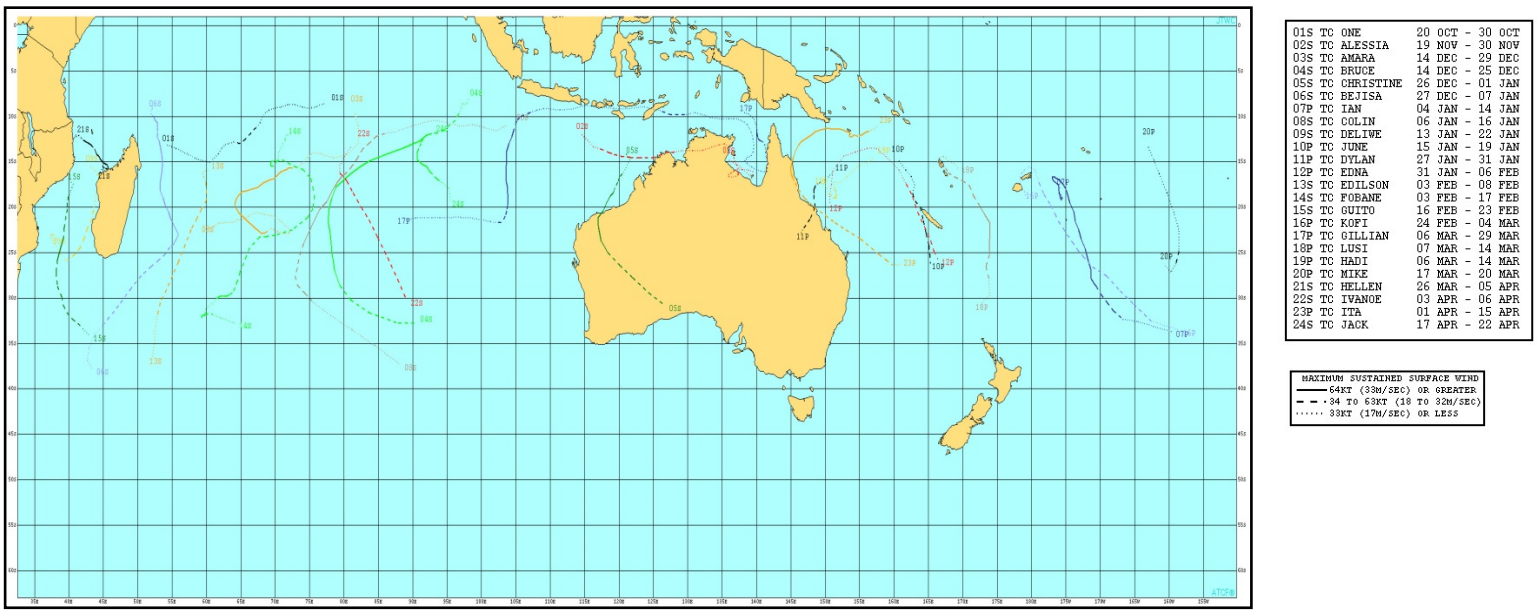


Figure 3-1. Southern Hemisphere Tropical Cyclones.

Section 2 Cyclone Summaries

Each cyclone is presented, with the number and basin identifier assigned by JTWC, along with the RSMC assigned cyclone name. Dates are also listed when JTWC first designated various stages of development.

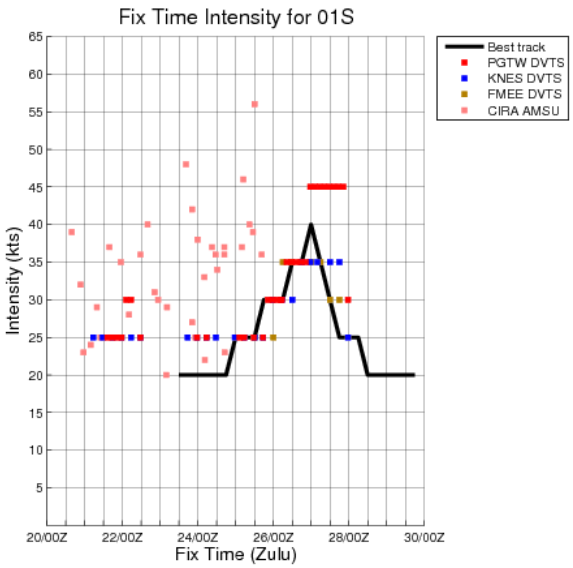
The first Tropical Cyclone Formation Alert (TCFA) and the initial and final warning dates are also presented with the number of warnings issued by JTWC. Landfall over major landmasses with approximate locations is presented as well.

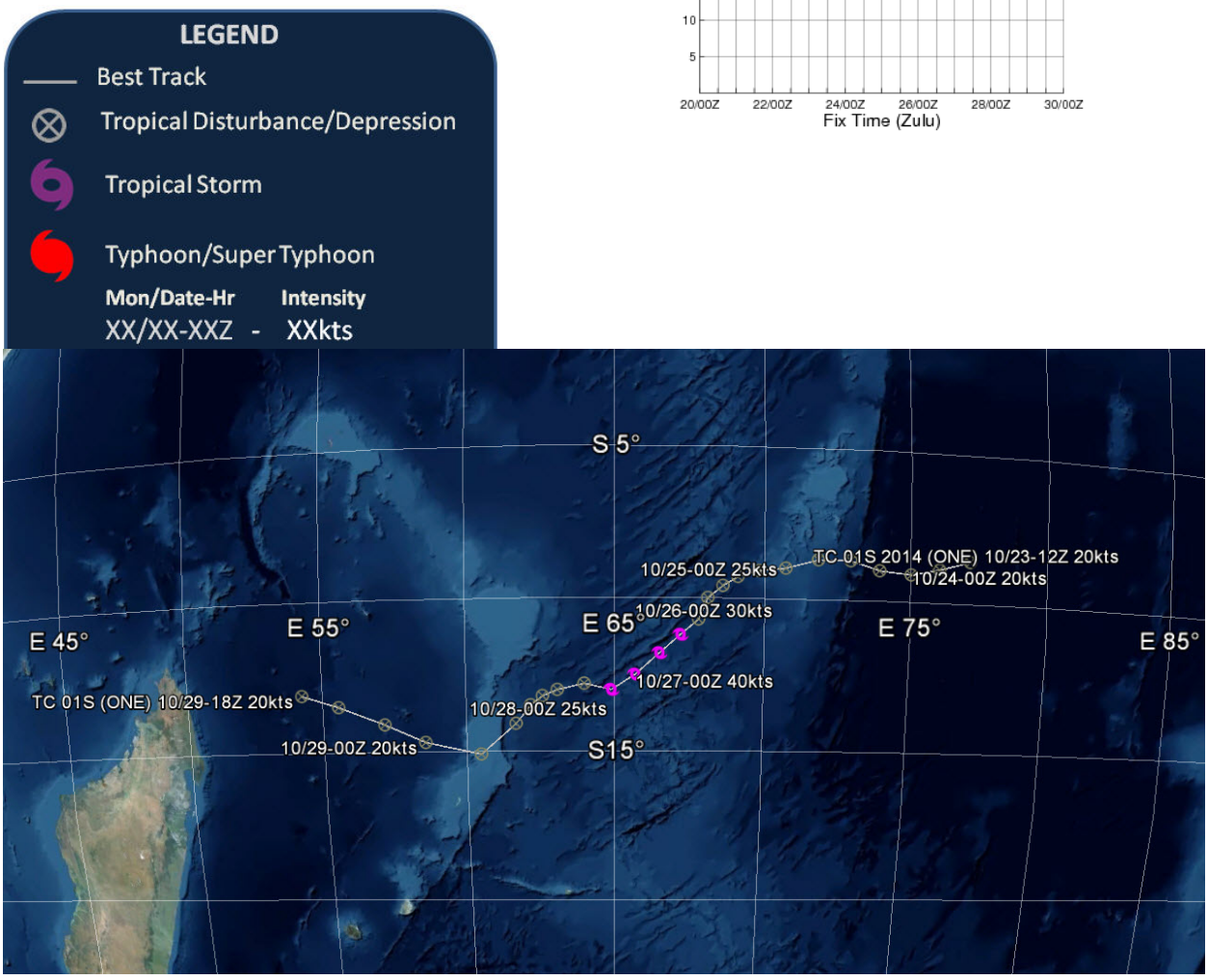
Data included on the best track are position and intensity noted with cyclone symbols and color coded track. Best track position labels include the date-time, track speed in knots, and maximum wind speed in knots. A graph of best track intensity versus time is presented. Fix plots on this graph are color coded by fixing agency.

In addition, if this document is viewed as a pdf, each map has been hyperlinked to the appropriate keyhole markup language (kmz) file that will allow the reader to access and view the best-track data interactively on their computer using Google Earth software. Simply hold the control button and click the map image; the link will open allowing the reader to download and open the file.
Users may also retrieve kmz files for the entire season from:
http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/best_tracks/2014/2014s-KMZs/JTWC_BestTrack_Climatology_2014.kmz_

01S TROPICAL CYCLONE ONE

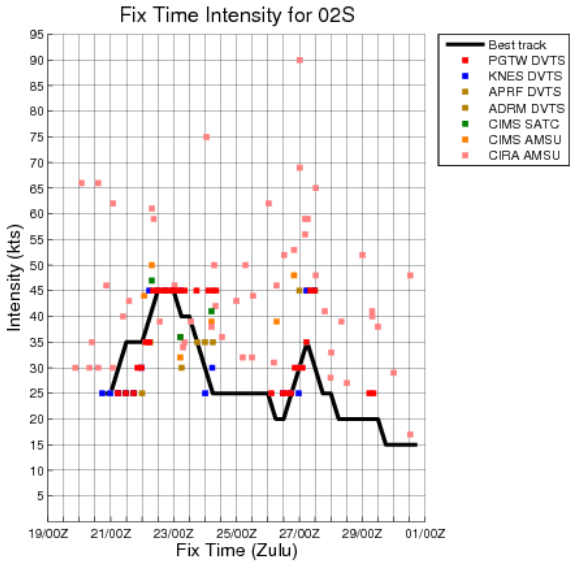
ISSUED LOW:	N/A
ISSUED MED:	N/A
FIRST TCFA:	25 OCT/ 2300Z
FIRST WARNING:	27 OCT/ 0000Z
LAST WARNING:	28 OCT/ 0000Z
MAX INTENSITY:	40
WARNINGS:	3

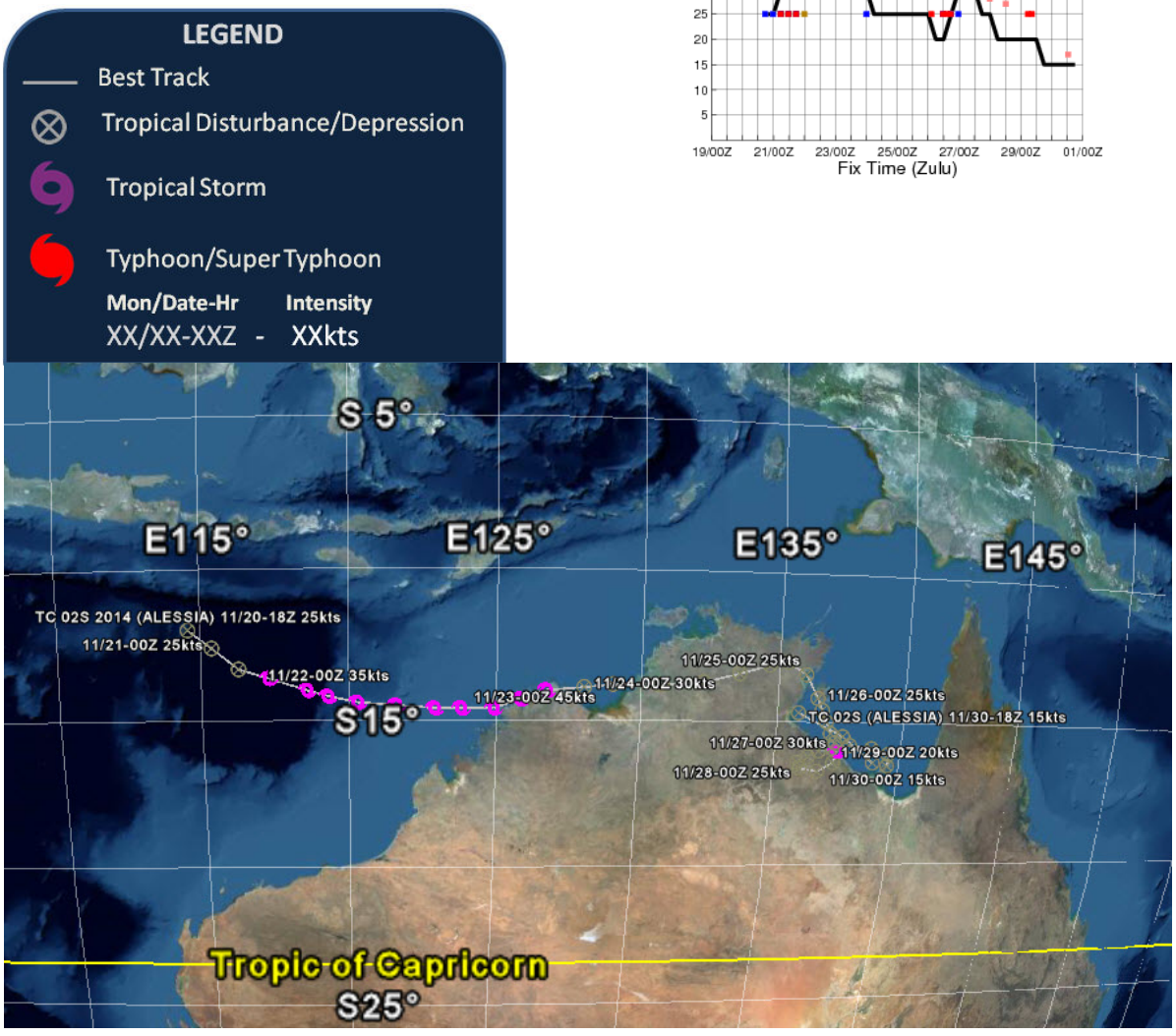




02S TROPICAL CYCLONE ALESSIA

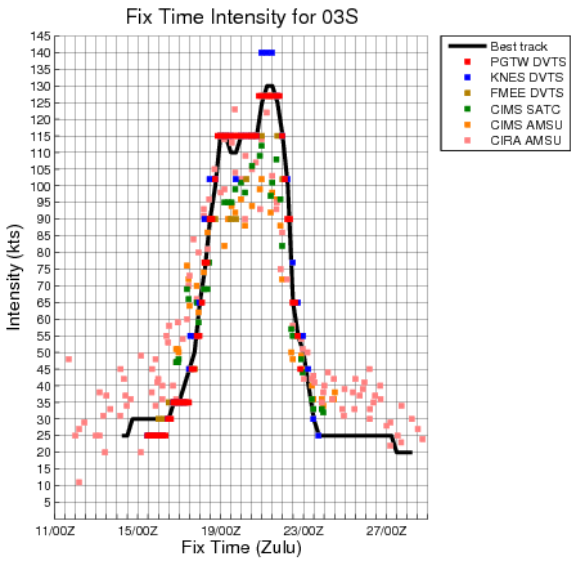
ISSUED LOW:	20 NOV/ 0630Z
ISSUED MED:	20 NOV/ 1800Z
FIRST TCFA:	20 NOV/ 1800Z
FIRST WARNING:	22 NOV/ 0600Z
LAST WARNING:	27 NOV/ 1800Z
MAX INTENSITY:	45
WARNINGS:	7

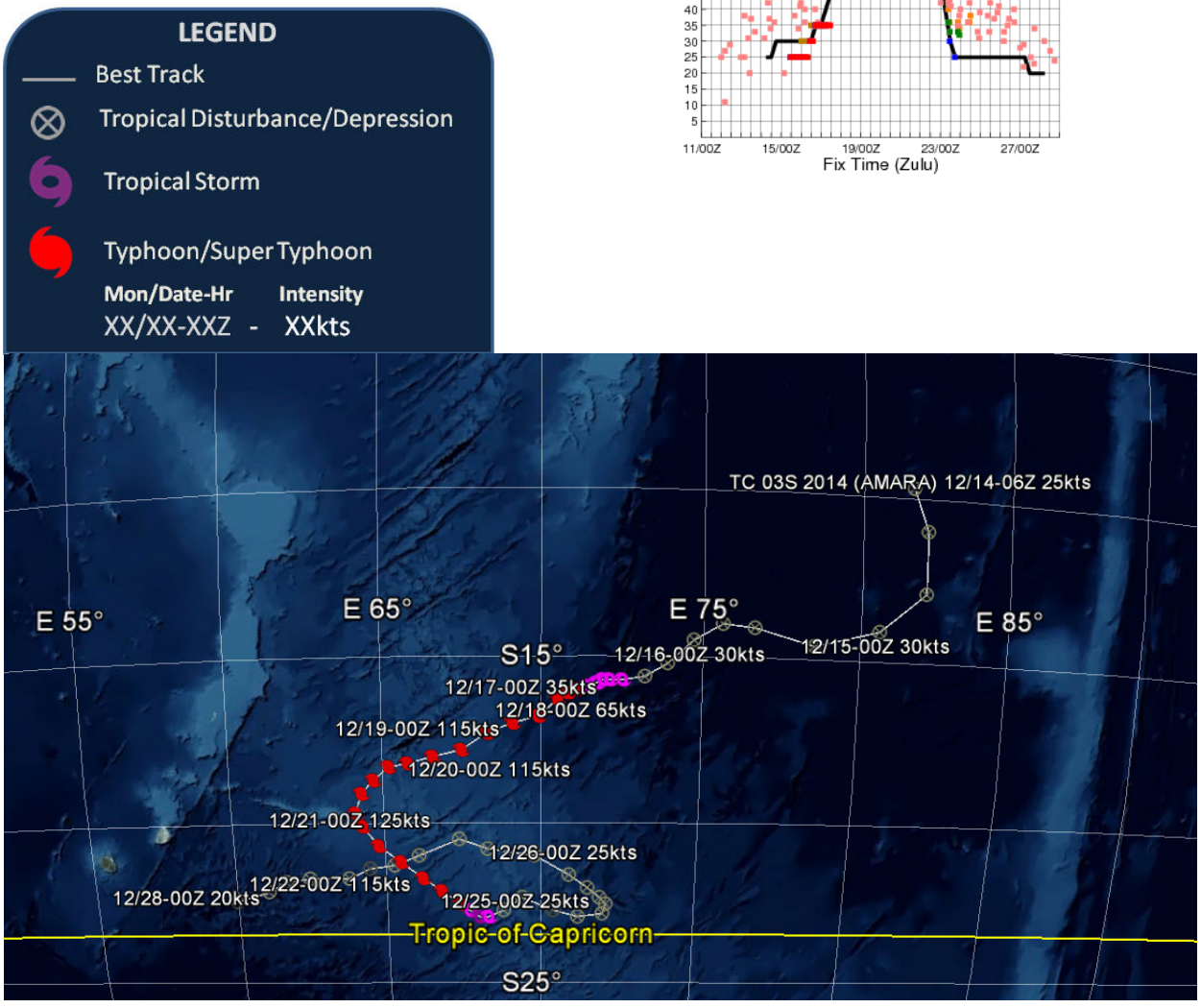




03S TROPICAL CYCLONE AMARA

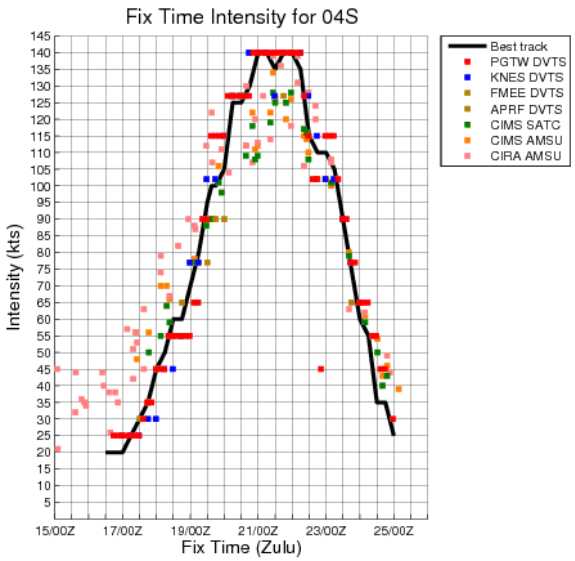
ISSUED LOW:	13 DEC/ 1400Z
ISSUED MED:	14 DEC/ 0700Z
FIRST TCFA:	15 DEC/ 1500Z,
FIRST WARNING:	16 DEC/ 1800Z
LAST WARNING:	23 DEC/ 1200Z
MAX INTENSITY:	130
WARNINGS:	15

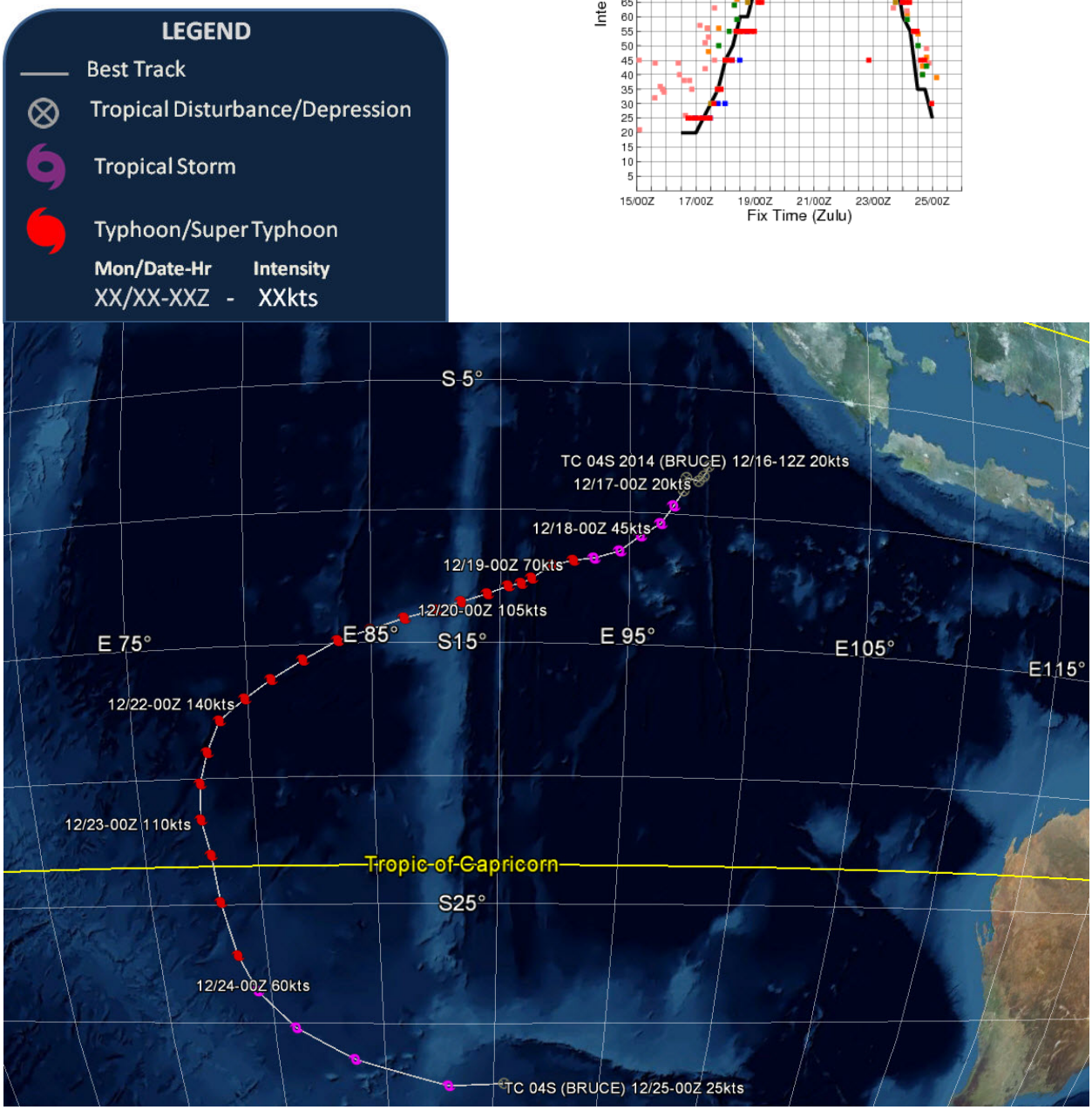




04S TROPICAL CYCLONE BRUCE

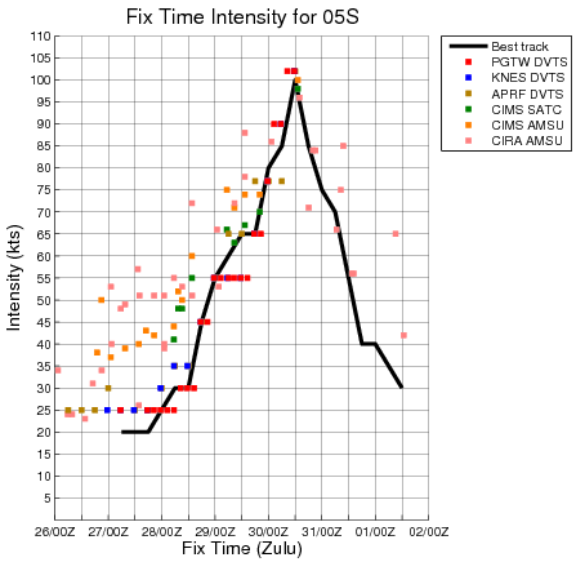
ISSUED LOW:	15 DEC/ 1500Z
ISSUED MED:	16 DEC / 1500Z
FIRST TCFA:	17 DEC/ 0300Z
FIRST WARNING:	17 DEC/ 2100Z
LAST WARNING:	24 DEC/ 1200Z
MAX INTENSITY:	140
WARNINGS:	15

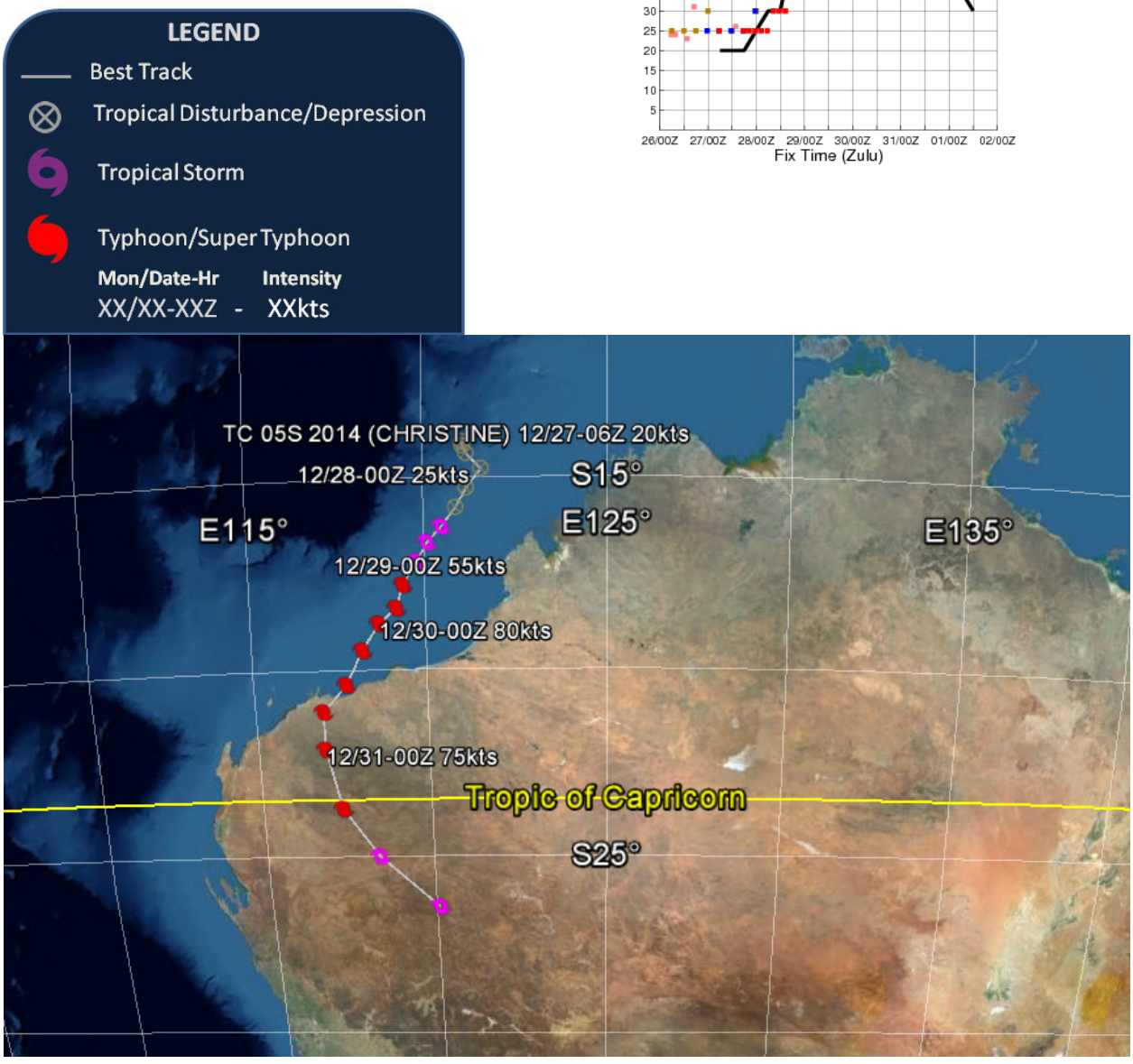




05S TROPICAL CYCLONE CHRISTINE

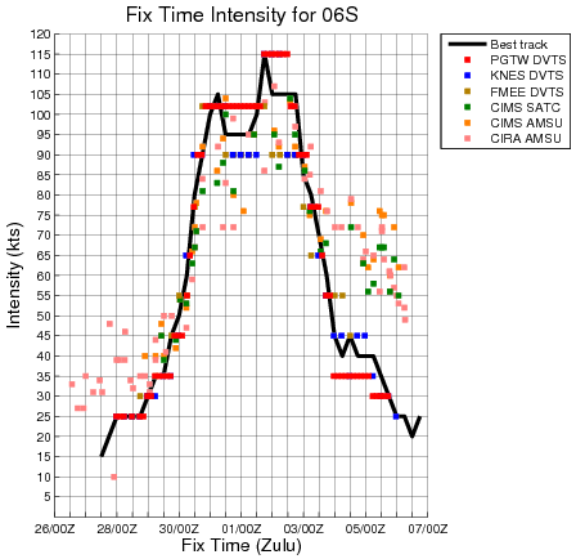
ISSUED LOW:	26 DEC/ 0530Z
ISSUED MED:	26 DEC/ 1800Z
FIRST TCFA:	27 DEC/ 0730Z
FIRST WARNING:	28 DEC/ 0600Z
LAST WARNING:	30 DEC/ 1800Z
MAX INTENSITY:	100
WARNINGS:	11

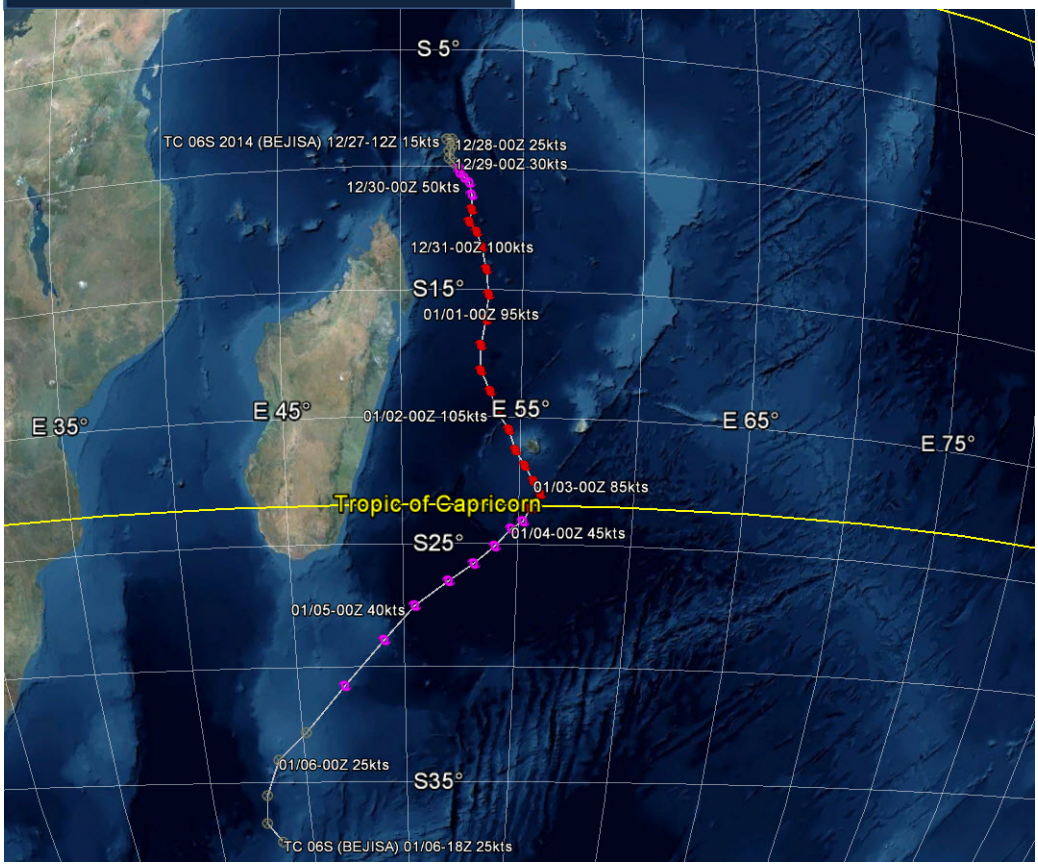




06S TROPICAL CYCLONE BEJISA

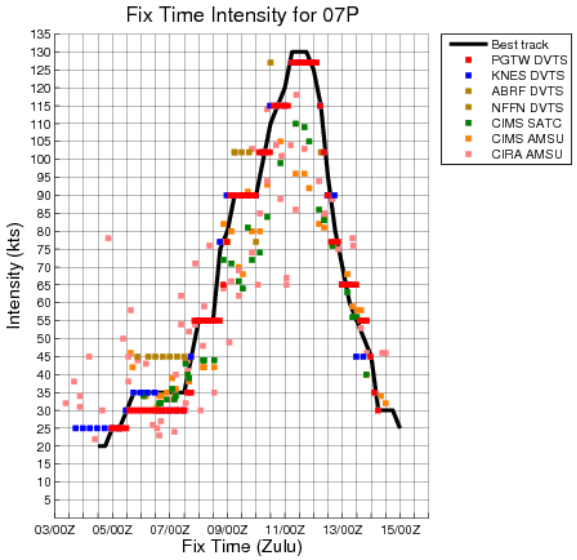
ISSUED LOW:	27 DEC/ 1800Z
ISSUED MED:	28 DEC/ 1000Z
FIRST TCFA:	29 DEC/ 0200Z
FIRST WARNING:	29 DEC/ 0600Z
LAST WARNING:	06 JAN/ 1800Z
MAX INTENSITY:	115
WARNINGS:	16

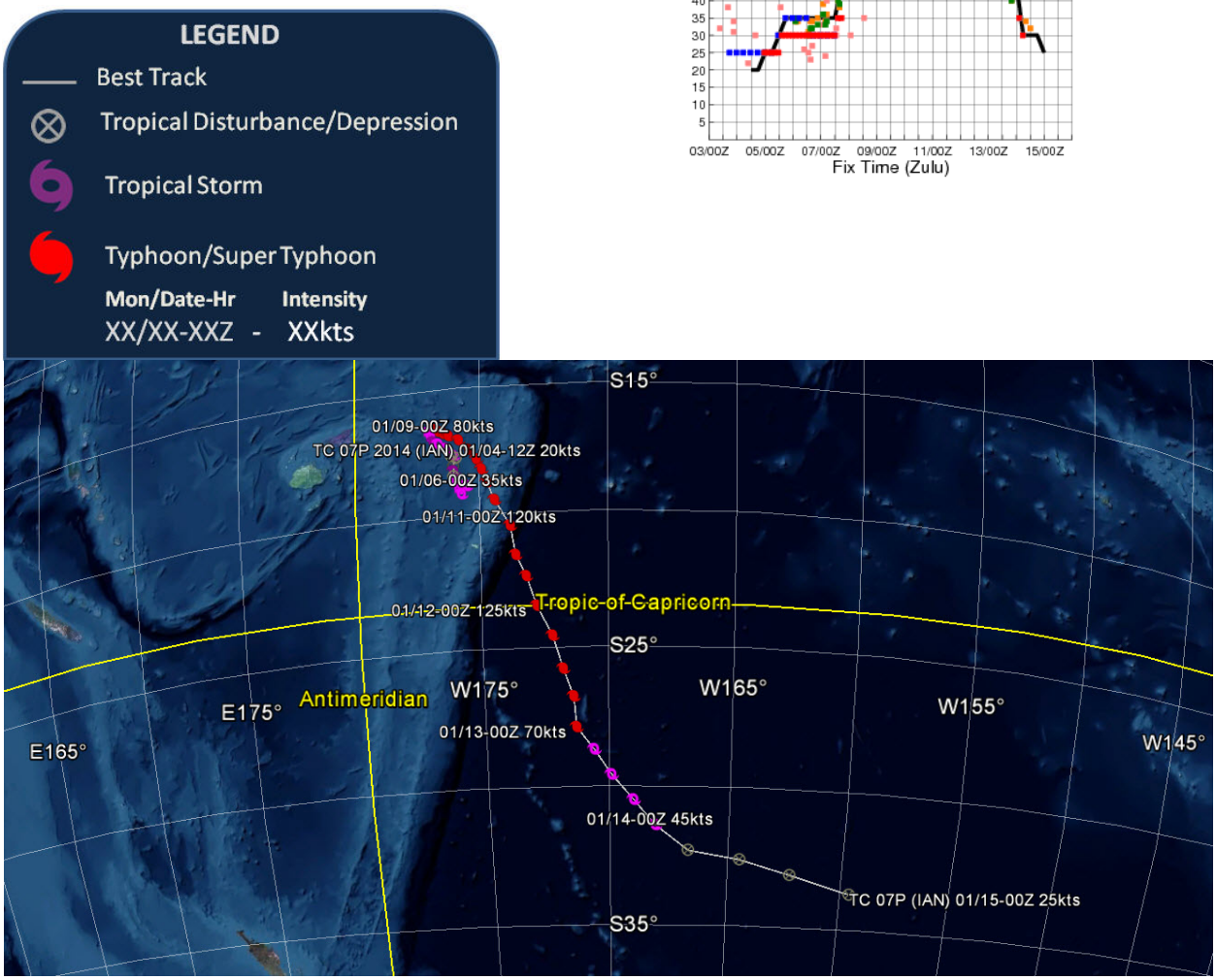




07P TROPICAL CYCLONE IAN

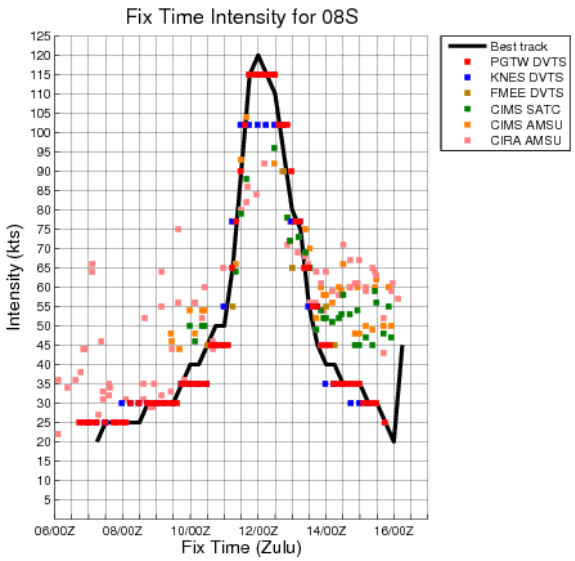
ISSUED LOW:	04 JAN /1200Z
ISSUED MED:	04 JAN/ 2300Z
FIRST TCFA:	05 JAN/ 0230Z
FIRST WARNING:	05 JAN/ 1800Z
LAST WARNING:	13 JAN/ 1800Z
MAX INTENSITY:	130
WARNINGS:	17

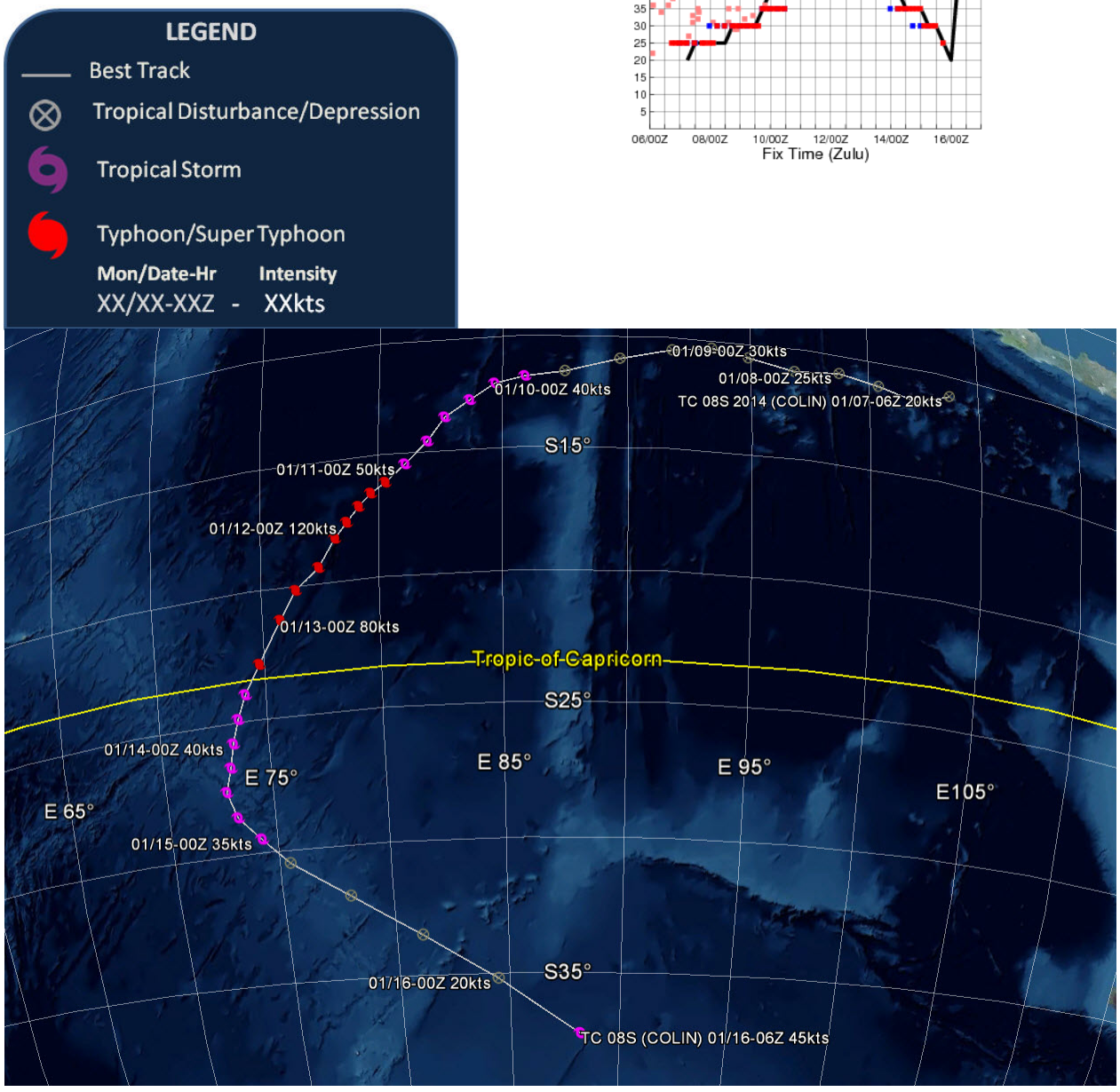




08S TROPICAL CYCLONE COLIN

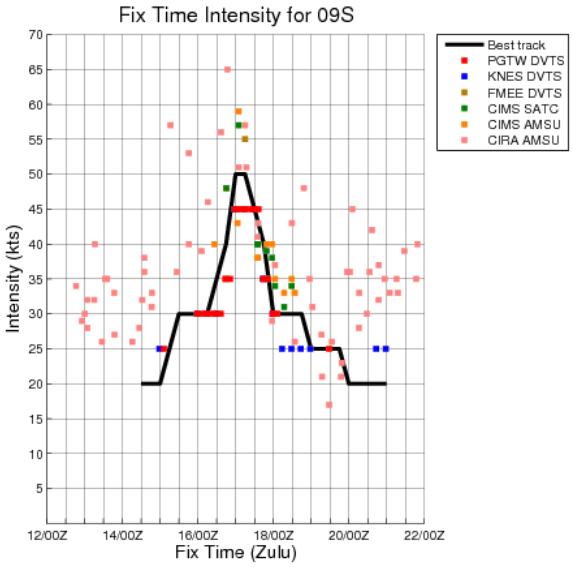
ISSUED LOW:	06 JAN/ 1800Z
ISSUED MED:	07 JAN/ 0300Z
FIRST TCFA:	08 JAN/ 2200Z
FIRST WARNING:	09 JAN/ 1800Z
LAST WARNING:	15 JAN/ 1200Z
MAX INTENSITY:	120
WARNINGS:	13

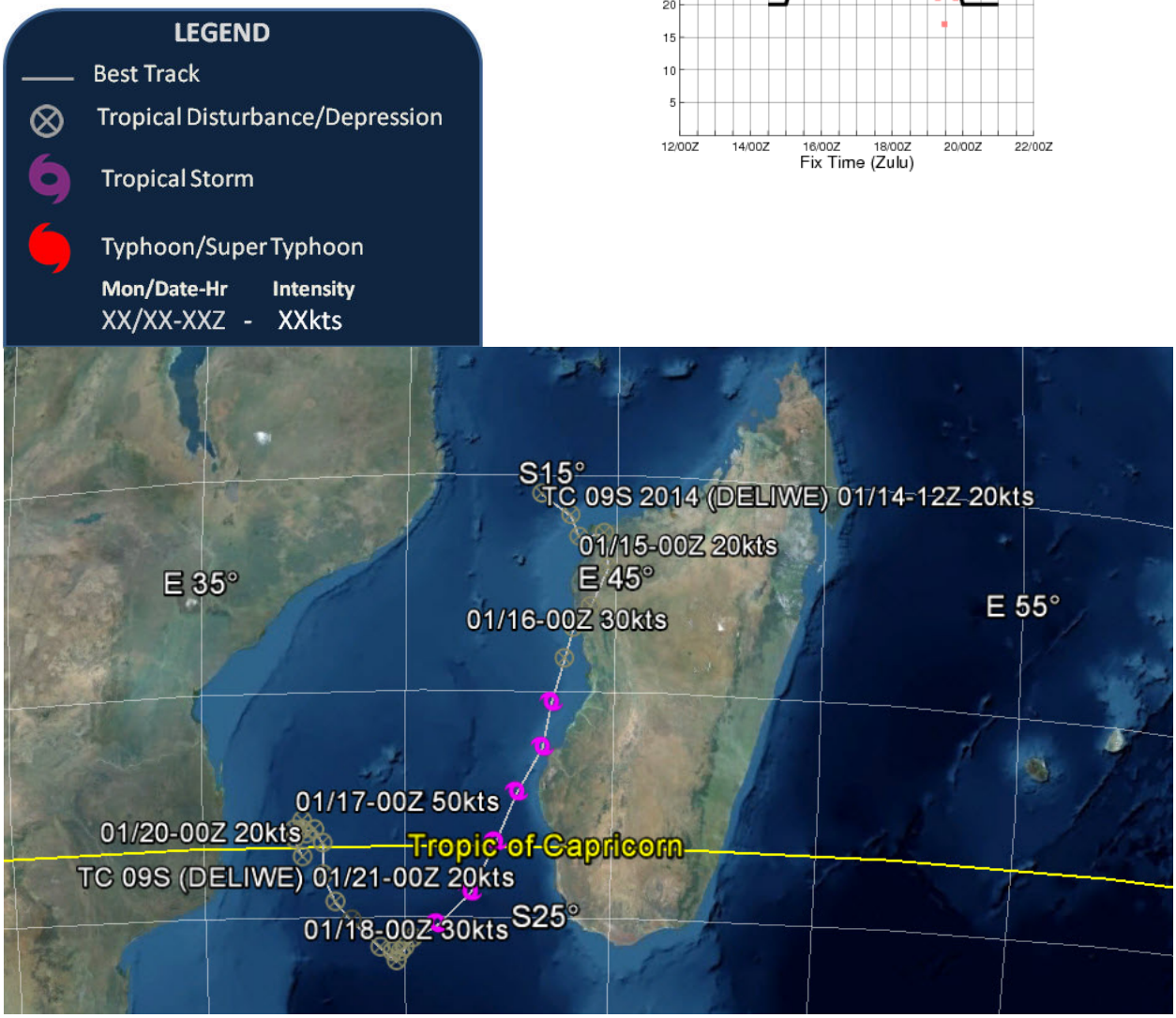




09S TROPICAL CYCLONE DELIWE

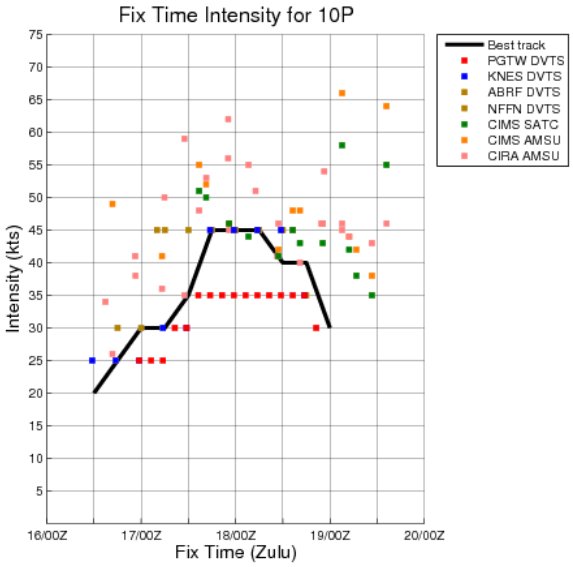
ISSUED LOW:	15 JAN/ 0030Z
ISSUED MED:	Skipped
FIRST TCFA:	15 JAN/ 2000Z
FIRST WARNING:	16 JAN/ 1200Z
LAST WARNING:	18 JAN/ 0000Z
MAX INTENSITY:	50
WARNINGS:	5

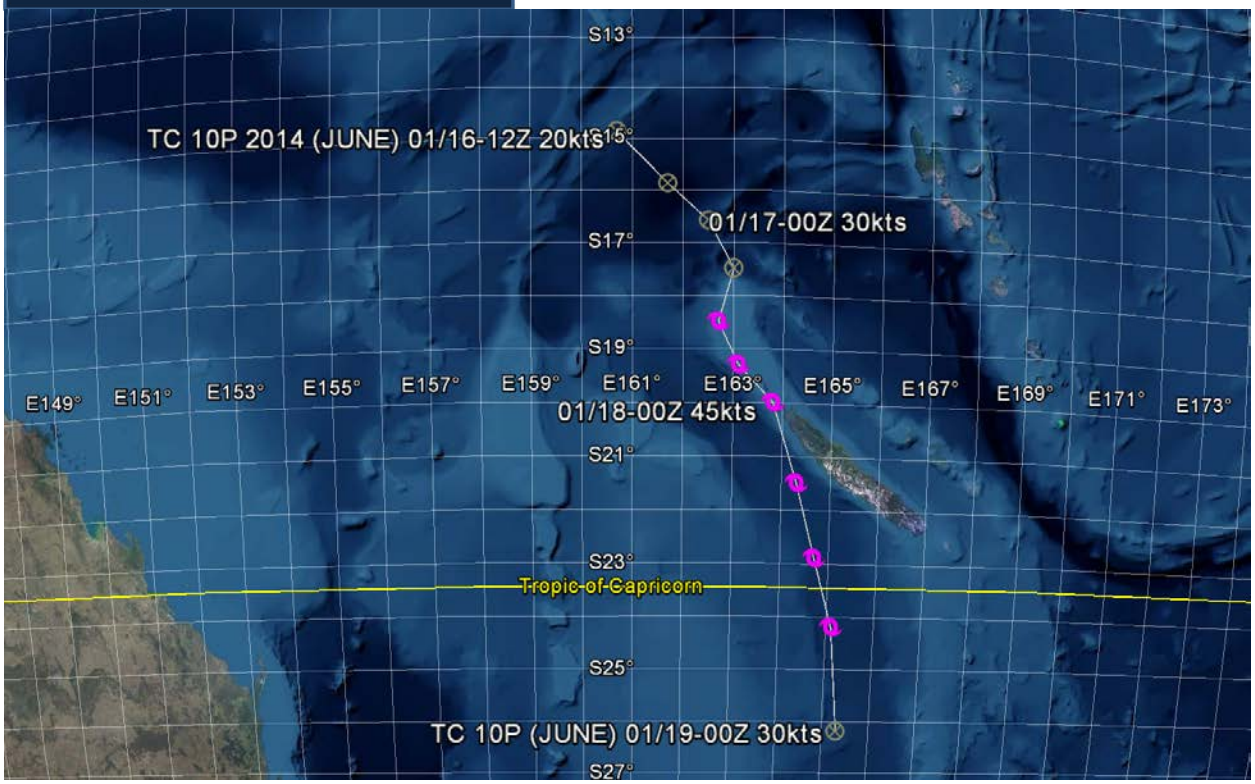




10P TROPICAL CYCLONE JUNE

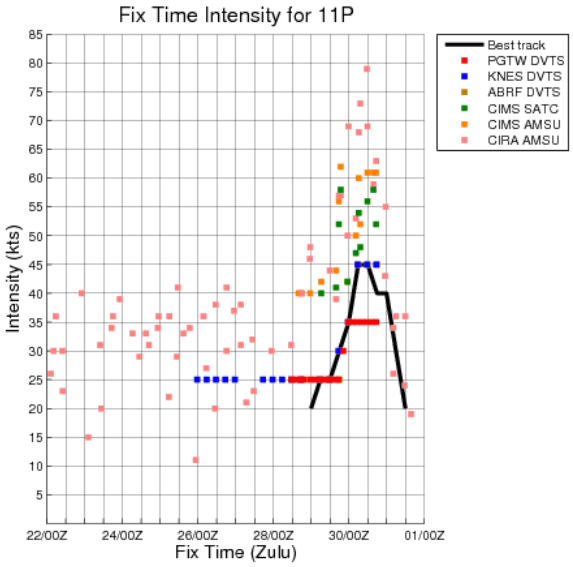
ISSUED LOW: 16 JAN/ 0600Z
ISSUED MED: 16 JAN/ 1500Z
FIRST TCFA: 17 JAN / 0300Z
FIRST WARNING: 17 JAN/ 1200Z
LAST WARNING: 19 JAN/ 0600Z
MAX INTENSITY: 45
WARNINGS: 5

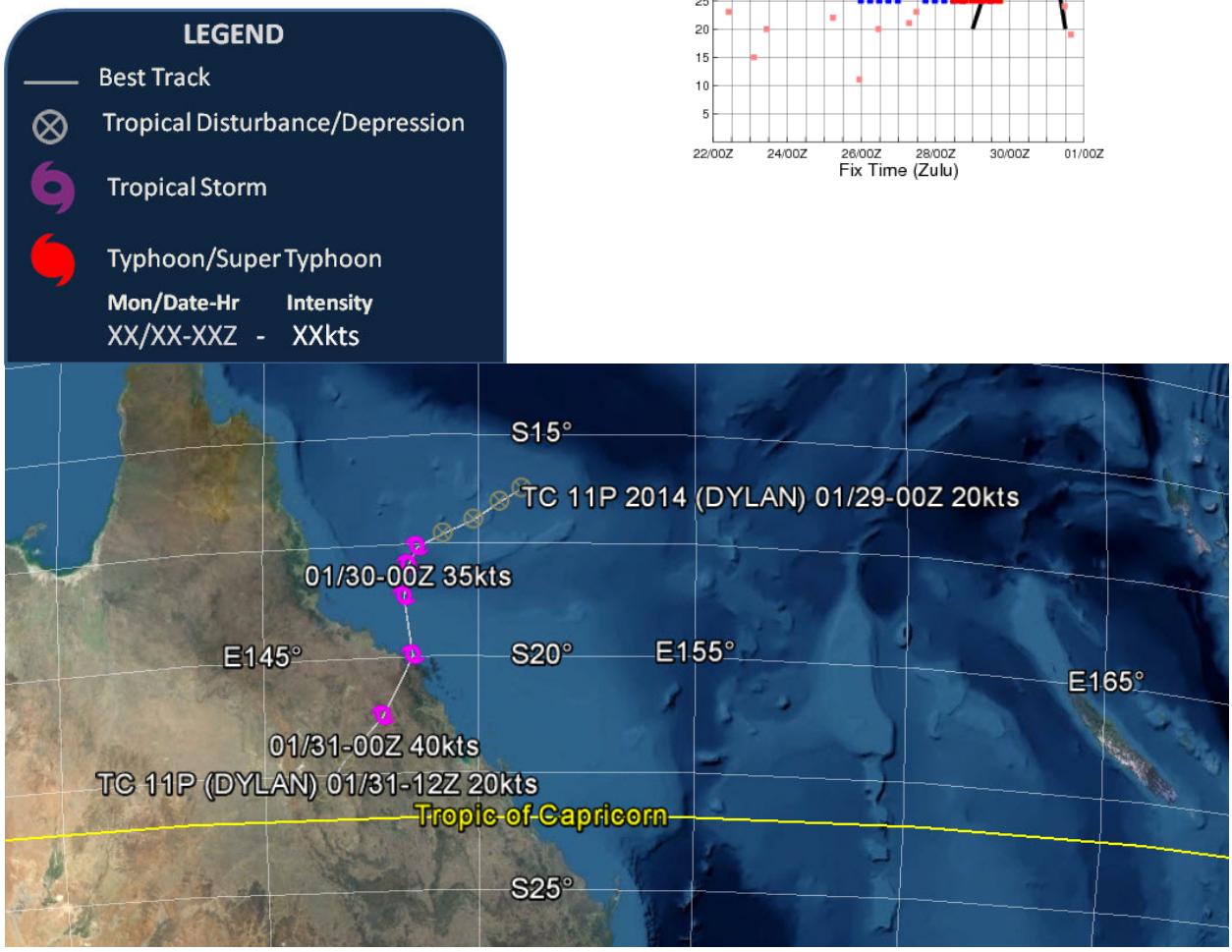




11P TROPICAL CYCLONE DYLAN

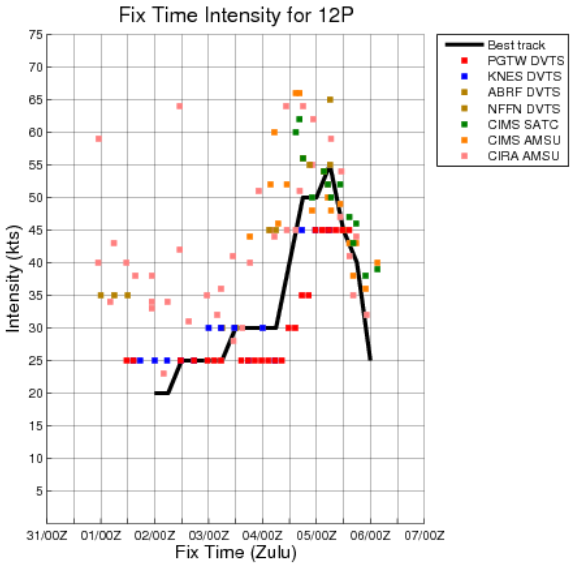
ISSUED LOW:	24 JAN/ 0000Z
ISSUED MED:	27 JAN/ 0600Z
FIRST TCFA:	28 JAN / 0300Z
FIRST WARNING:	29 JAN/ 0000Z
LAST WARNING:	31 JAN/ 0000Z
MAX INTENSITY:	45
WARNINGS:	5

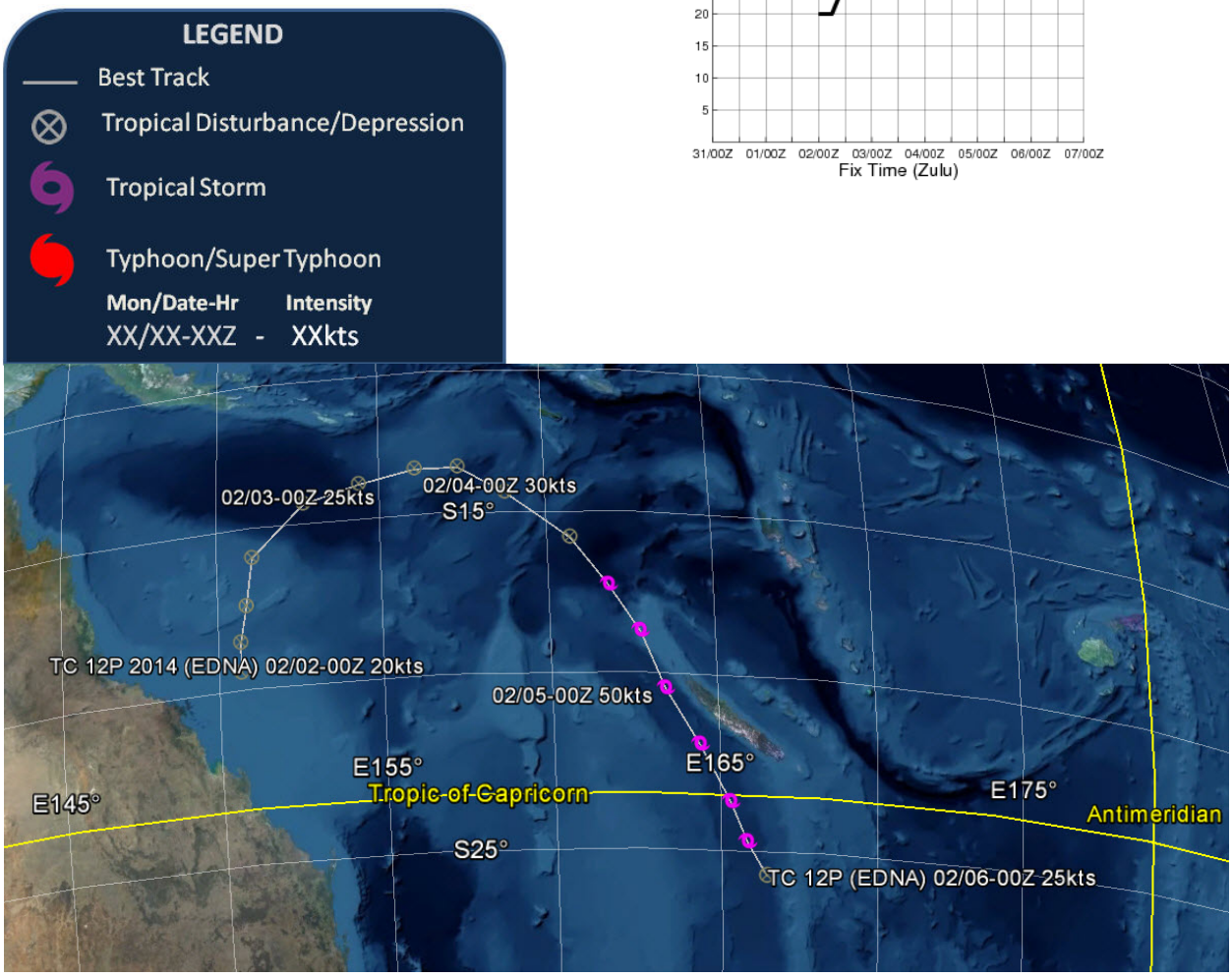




12P TROPICAL CYCLONE EDNA

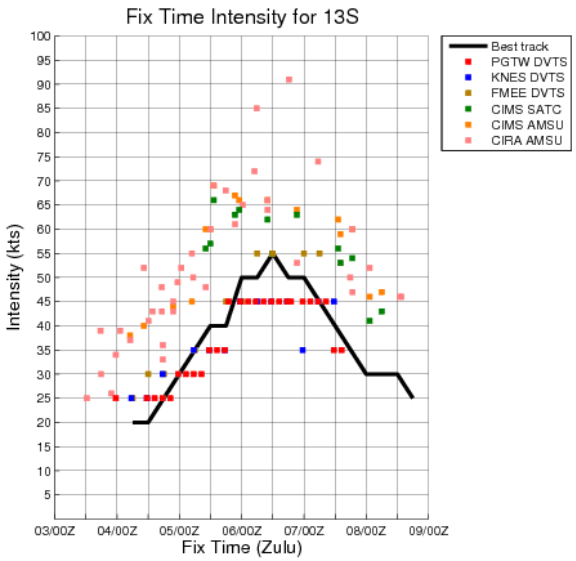
ISSUED LOW:	N/A
ISSUED MED:	01 FEB/ 0600Z
FIRST TCFA:	03 FEB / 2300Z
FIRST WARNING:	04 FEB/ 1500Z
LAST WARNING:	03 FEB/ 2300Z
MAX INTENSITY:	55
WARNINGS:	4

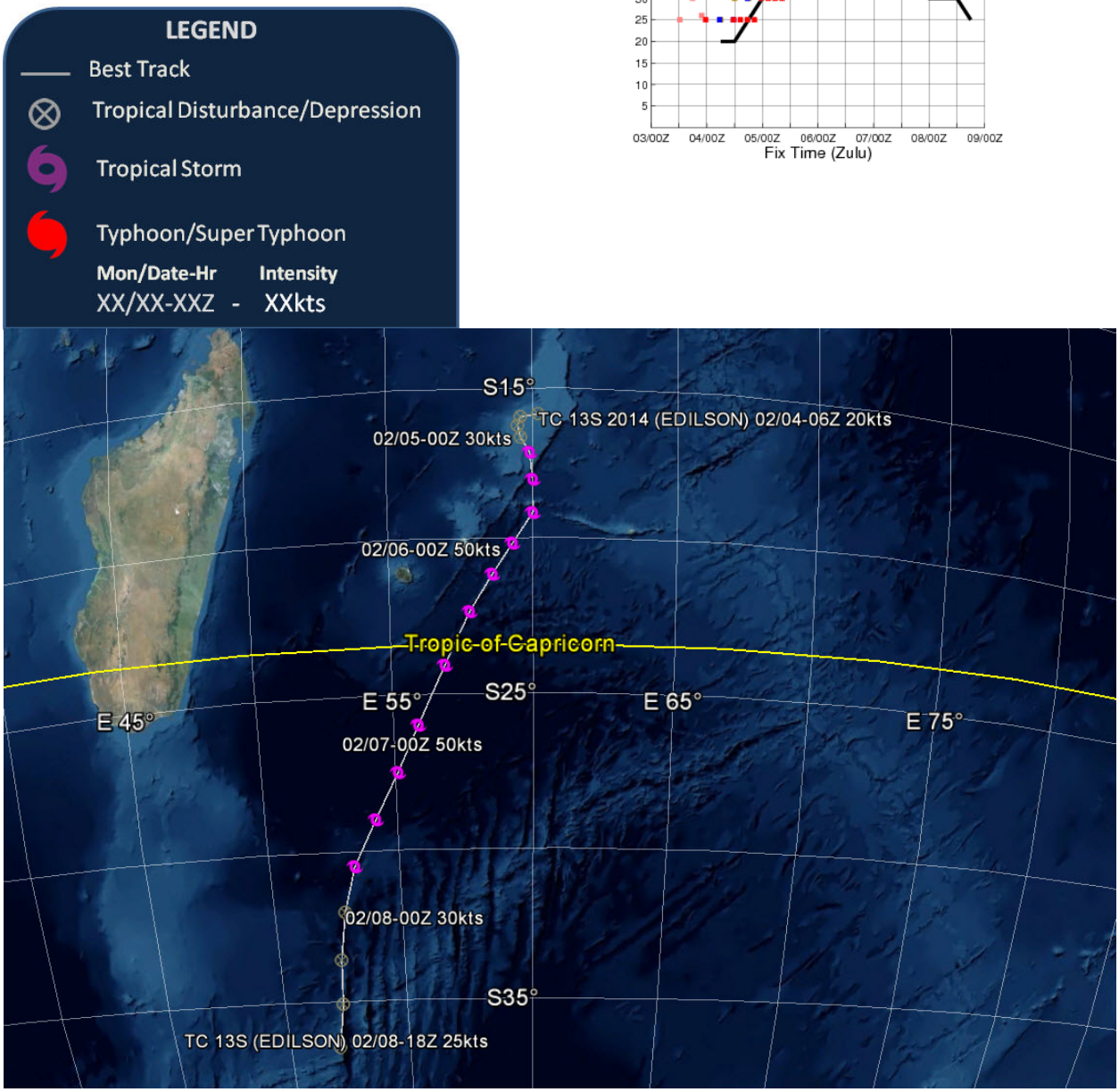




13S TROPICAL CYCLONE EDILSON

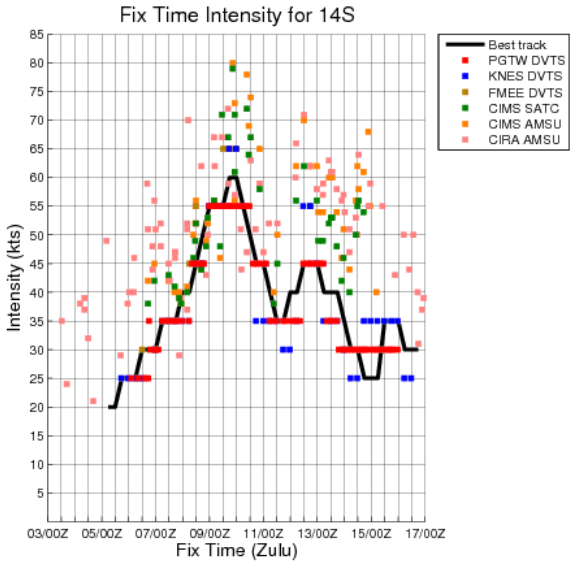
ISSUED LOW: 03 FEB/ 1800Z
ISSUED MED: 04 FEB/ 0400Z
FIRST TCFA: 04 FEB / 1530Z
FIRST WARNING: 05 FEB/ 0000Z
LAST WARNING: 07 FEB/ 1800Z
MAX INTENSITY: 55
WARNINGS: 7

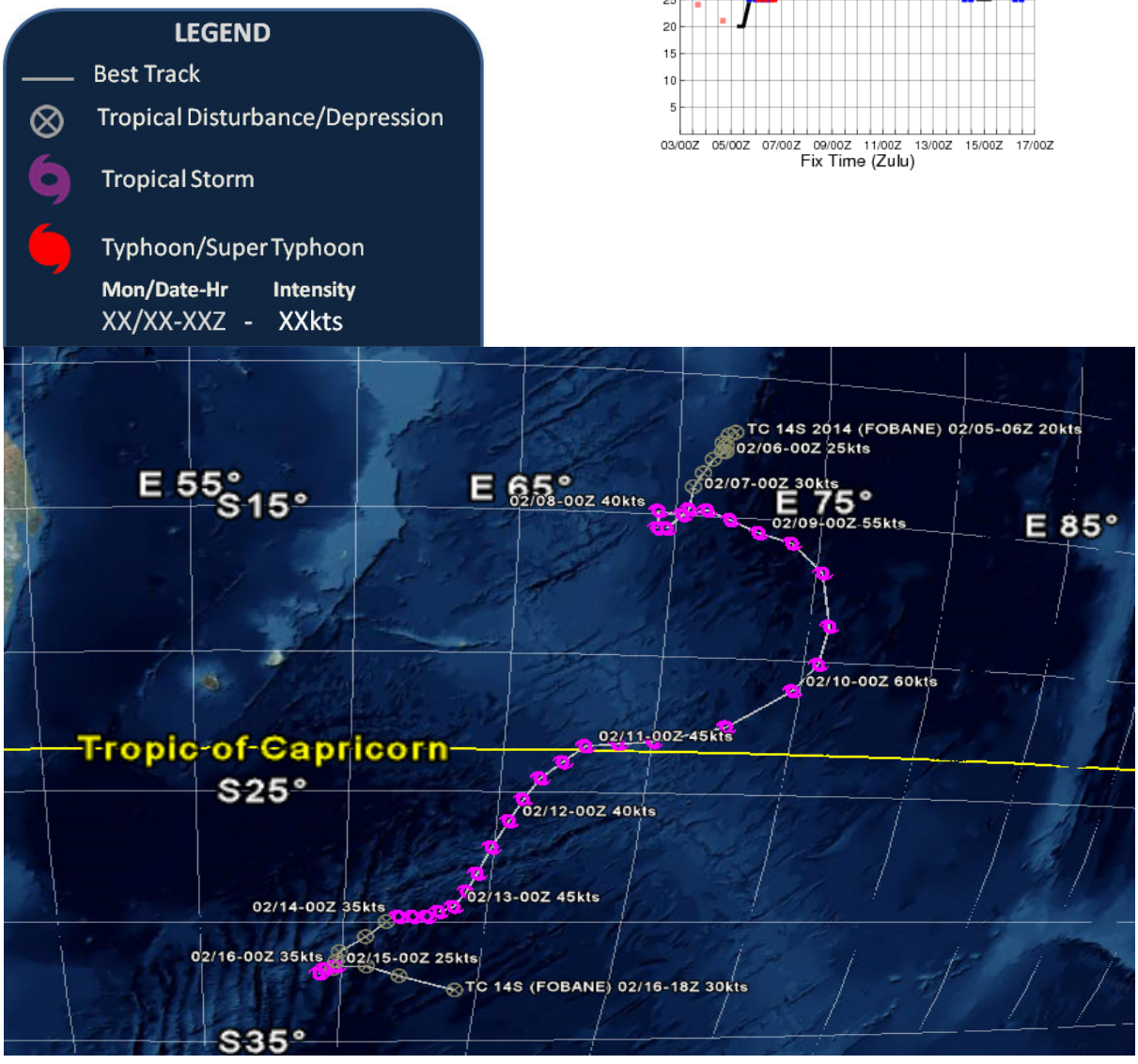




14S TROPICAL CYCLONE FOBANE

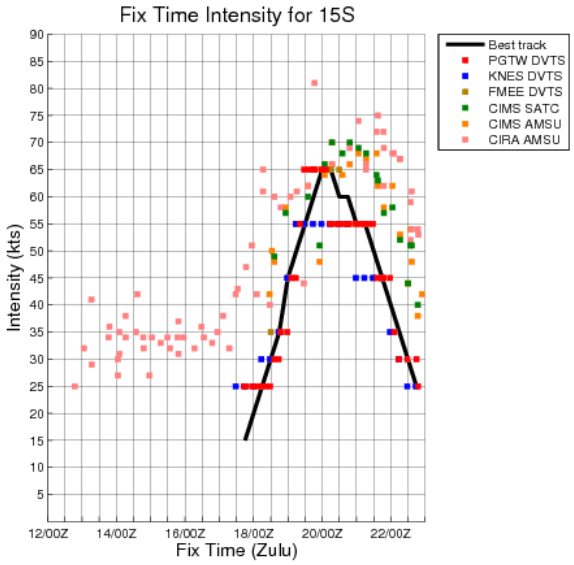
ISSUED LOW:	03 FEB/ 2000Z
ISSUED MED:	04 FEB/ 1800
FIRST TCFA:	05 FEB/ 2330Z
FIRST WARNING:	06 FEB/ 1800Z
LAST WARNING:	14 FEB/ 0600Z
MAX INTENSITY:	60
WARNINGS:	16

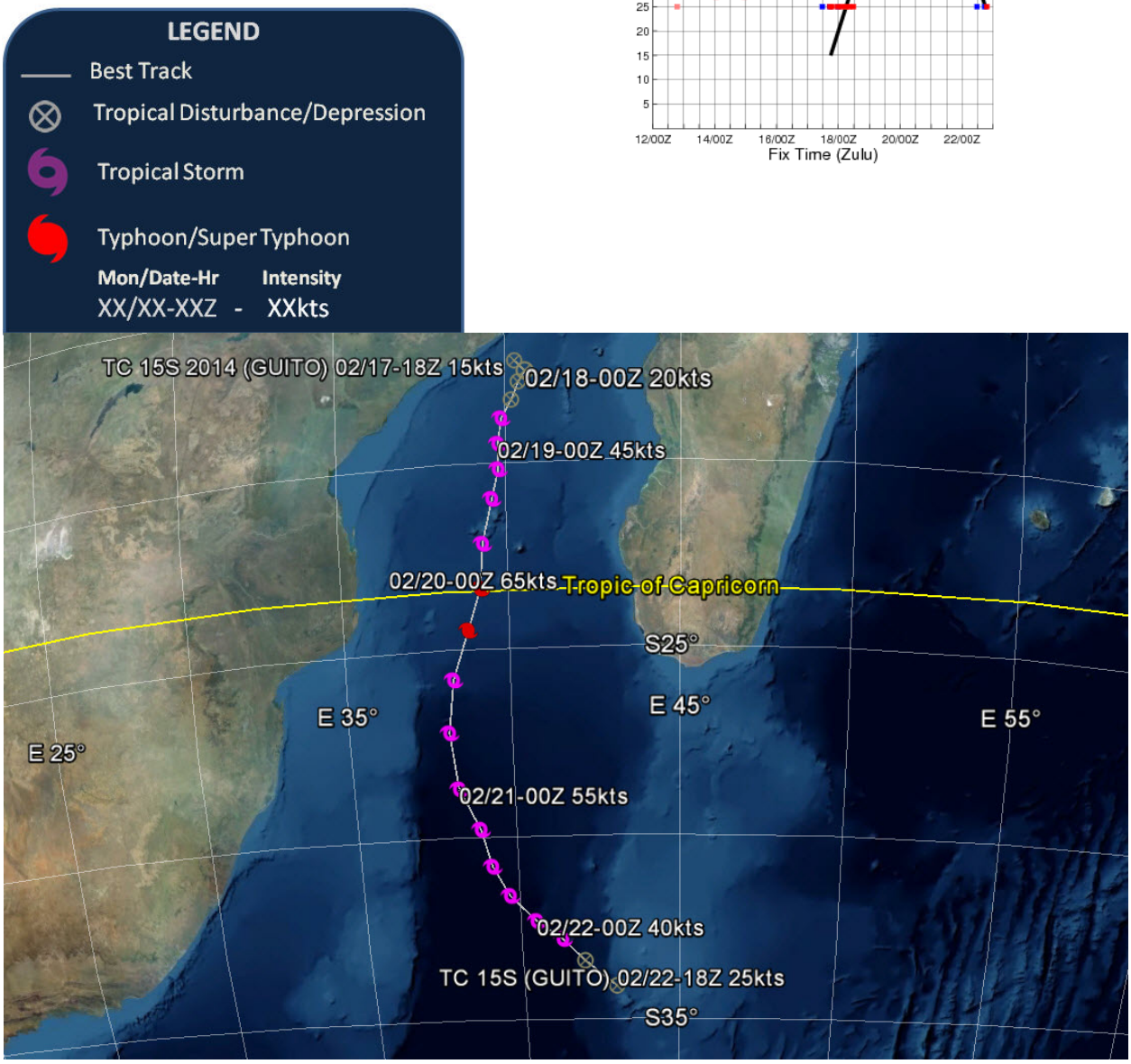




15S TROPICAL CYCLONE GUITO

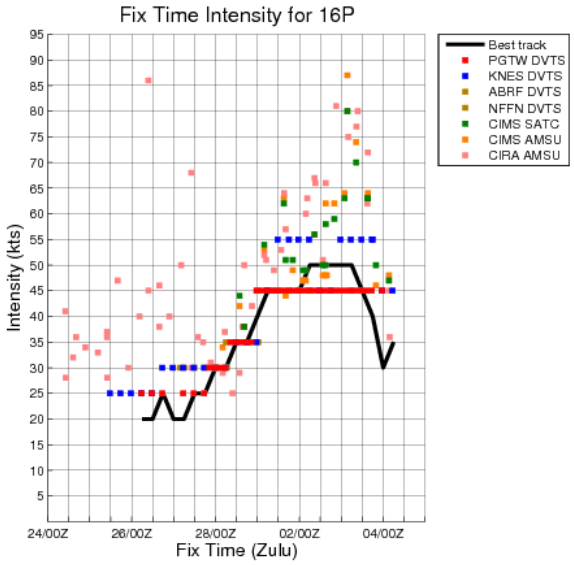
ISSUED LOW:	15 FEB/ 1800Z
ISSUED MED:	16 FEB/ 0300Z
FIRST TCFA:	17 FEB / 1800Z
FIRST WARNING:	18 FEB/ 2100Z
LAST WARNING:	22 FEB/ 0600Z
MAX INTENSITY:	65
WARNINGS:	9

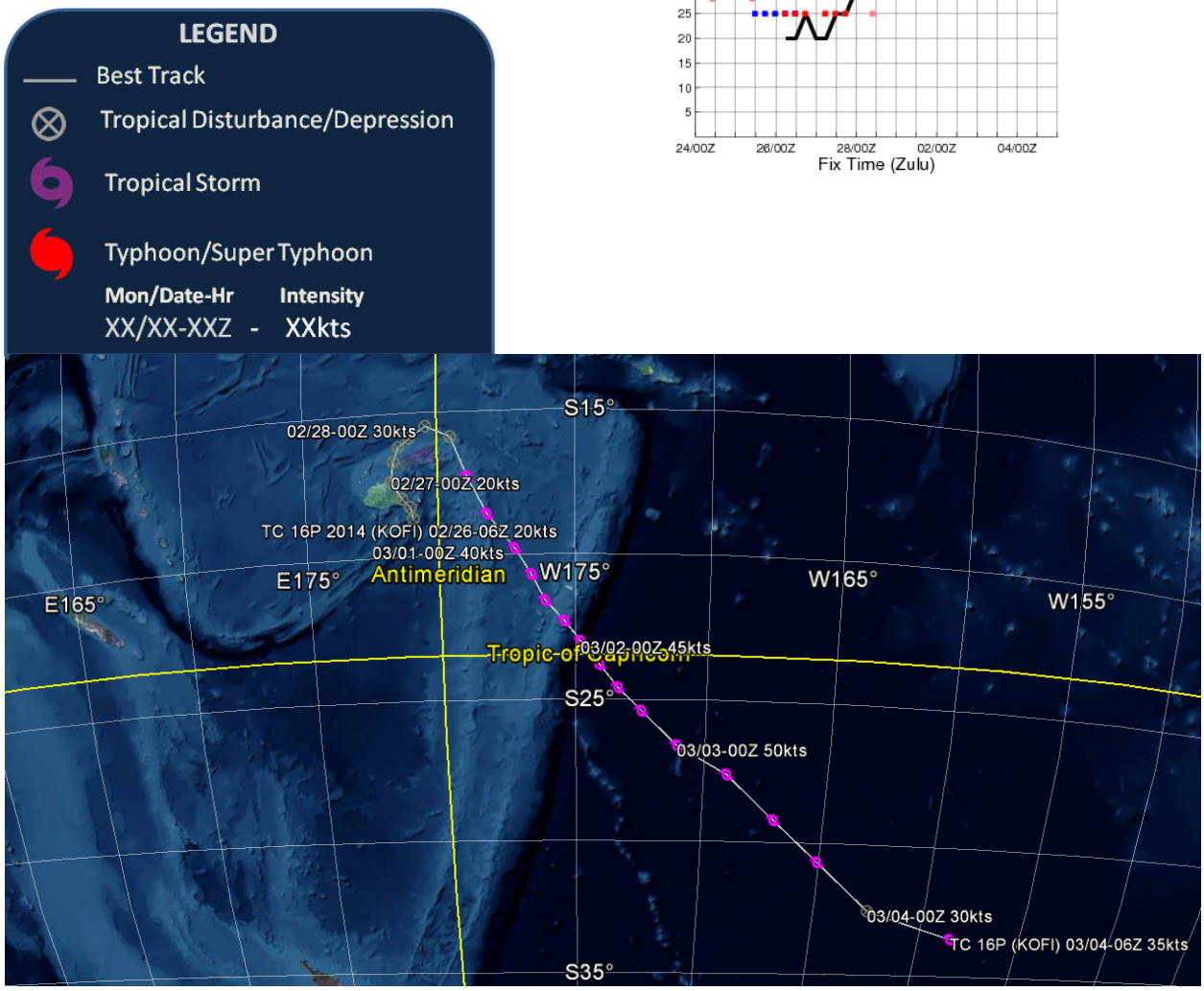




16P TROPICAL CYCLONE KOFI

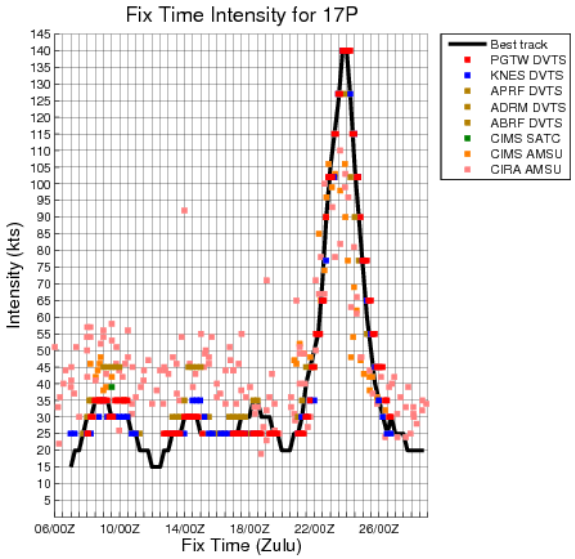
ISSUED LOW:	25 FEB/ 0000Z
ISSUED MED:	25 FEB/ 0600Z
FIRST TCFA:	27 FEB / 2100Z
FIRST WARNING:	28 FEB/ 0600Z
LAST WARNING:	03 MAR/ 1800Z
MAX INTENSITY:	50
WARNINGS:	8

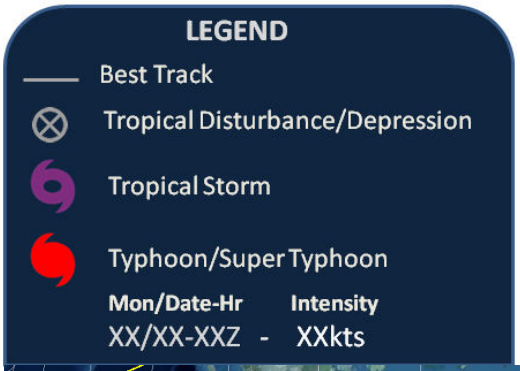


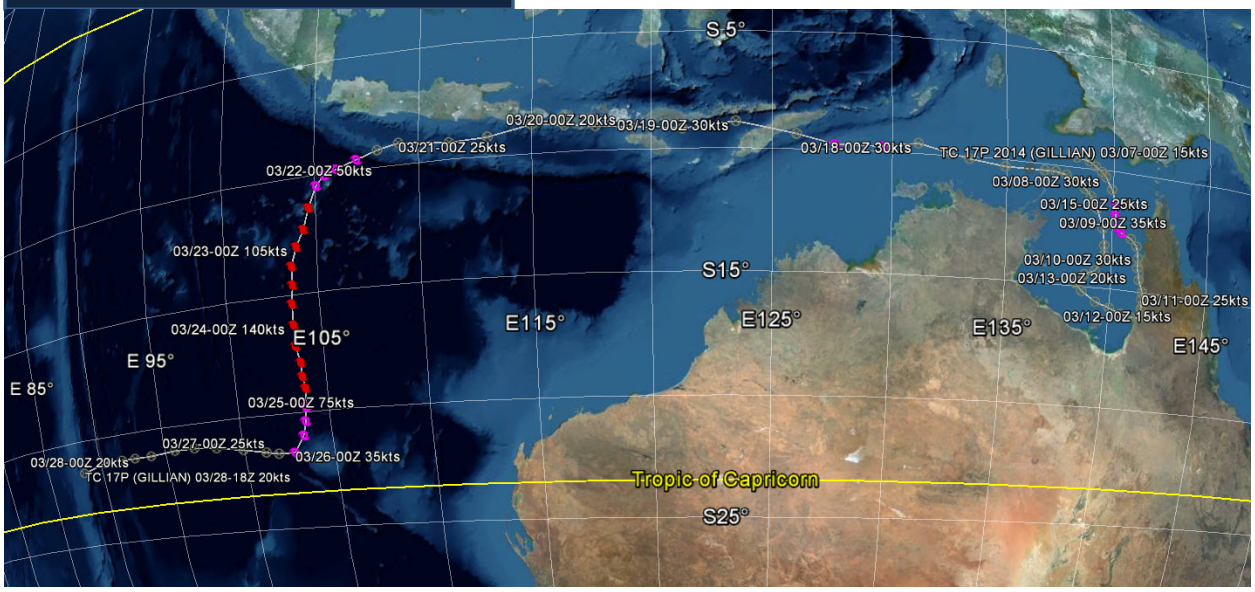


17P TROPICAL CYCLONE GILLIAN

ISSUED LOW: N/A
ISSUED MED: N/A
FIRST TCFA: N/A
FIRST WARNING: 08 MAR/ 1200Z
LAST WARNING: 11 MAR/ 0000Z
MAX INTENSITY: 140
WARNINGS: 16

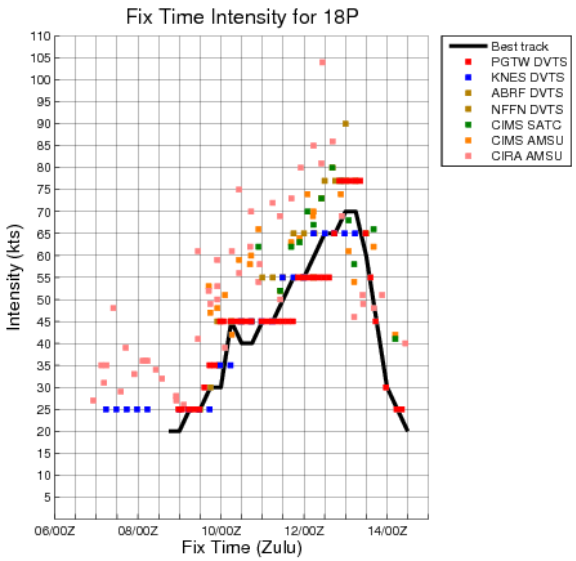


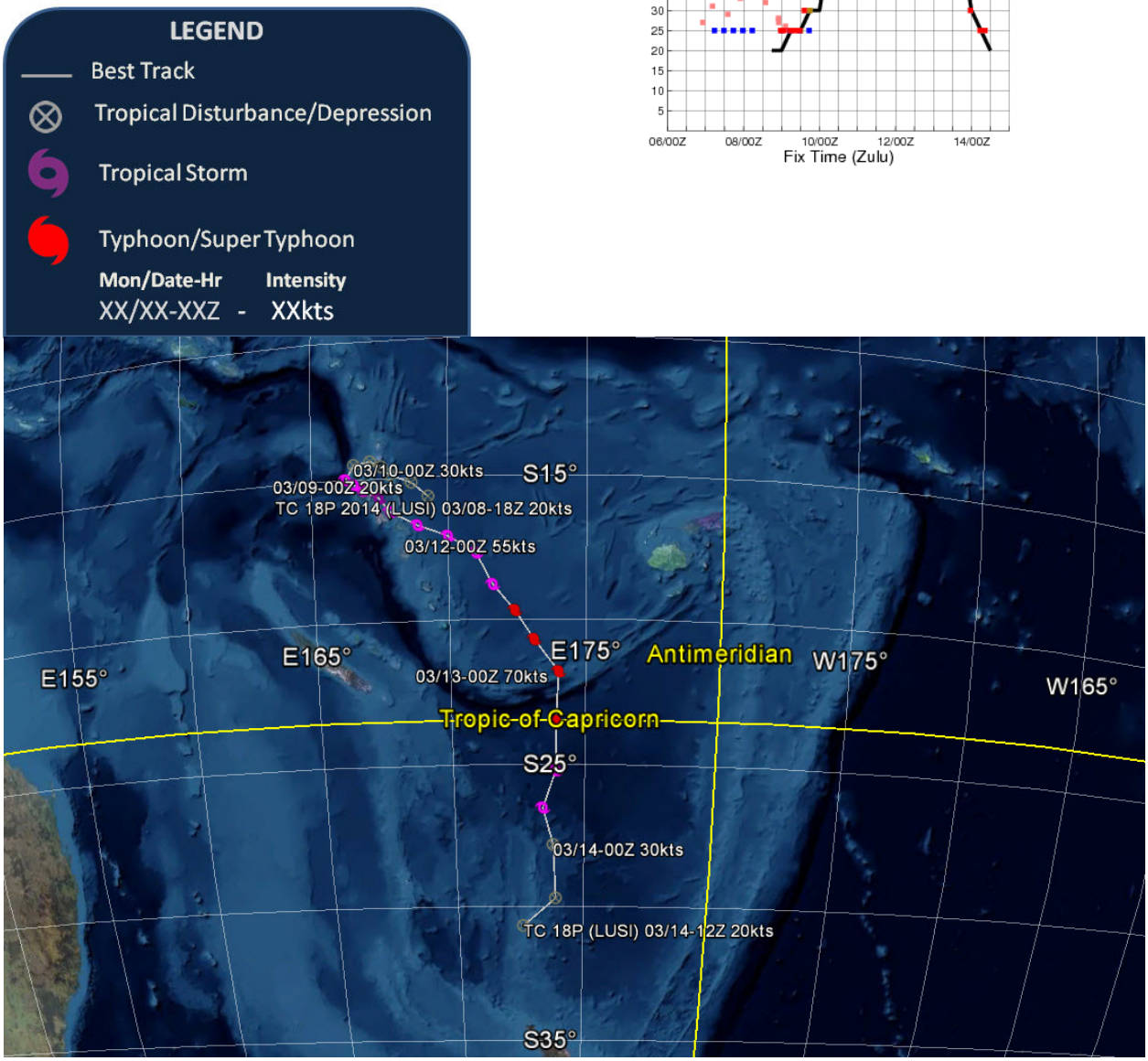




18P TROPICAL CYCLONE LUSI

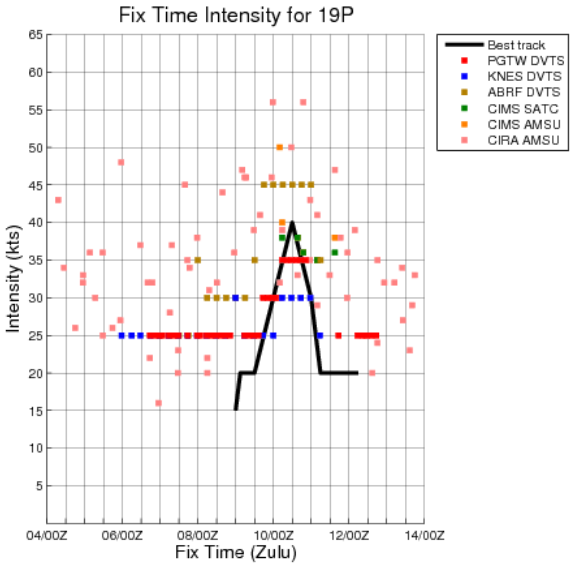
ISSUED LOW:	08 MAR/ 1500Z
ISSUED MED:	09 MAR/ 0200Z
FIRST TCFA:	09 MAR / 0900Z
FIRST WARNING:	9 MAR/ 1800Z
LAST WARNING:	13 MAR/ 1800Z
MAX INTENSITY:	70
WARNINGS:	9

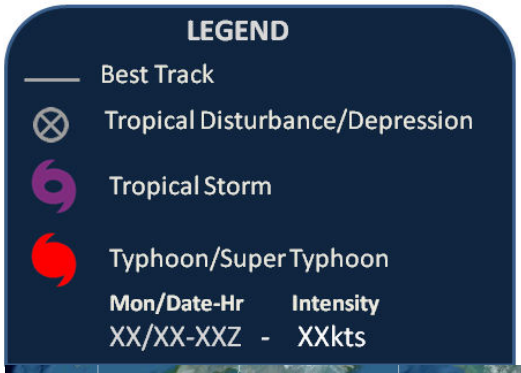


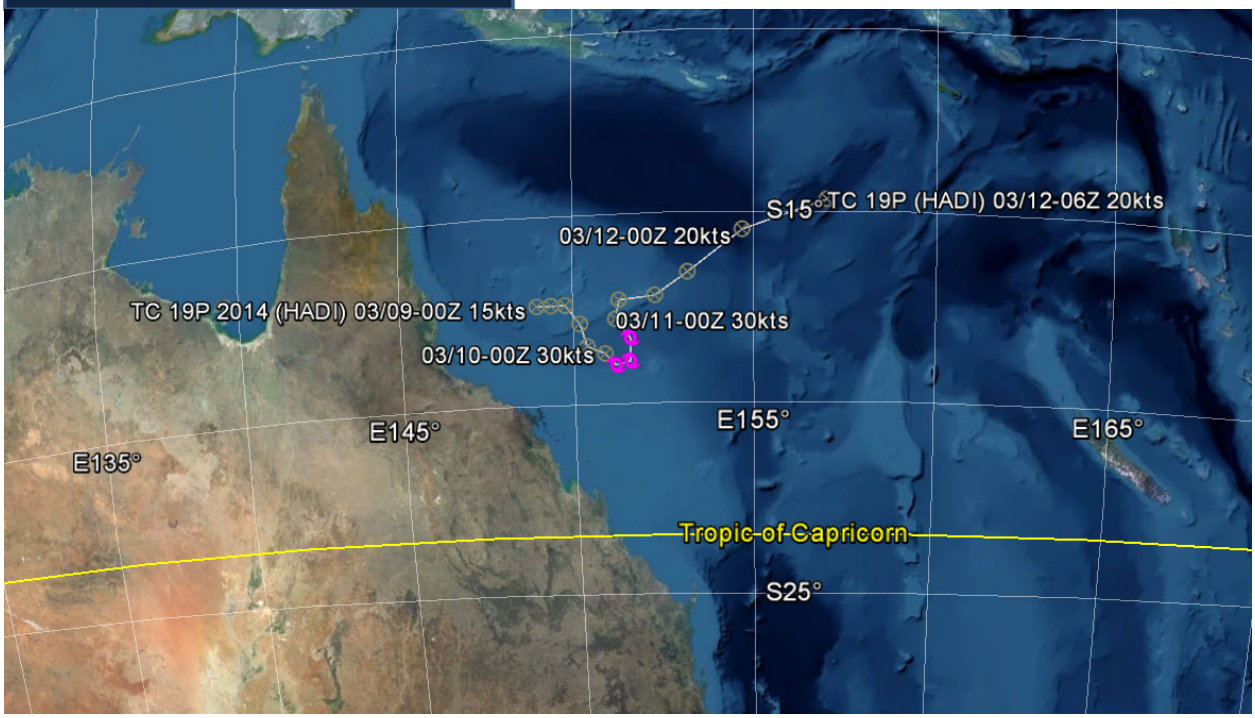


19P TROPICAL CYCLONE HADI

ISSUED LOW:	05 MAR/ 0600Z
ISSUED MED:	06 MAR/ 1330Z
FIRST TCFA:	07 MAR/ 0200Z
FIRST WARNING:	10 MAR/ 0600Z
LAST WARNING:	11 MAR/ 0600Z
MAX INTENSITY:	40
WARNINGS:	3

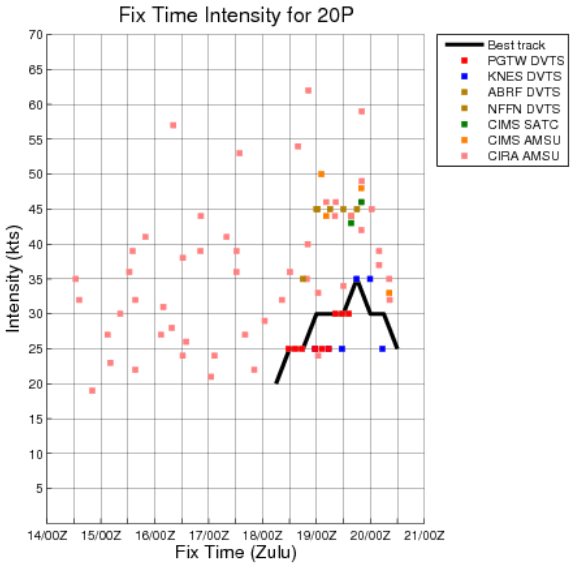


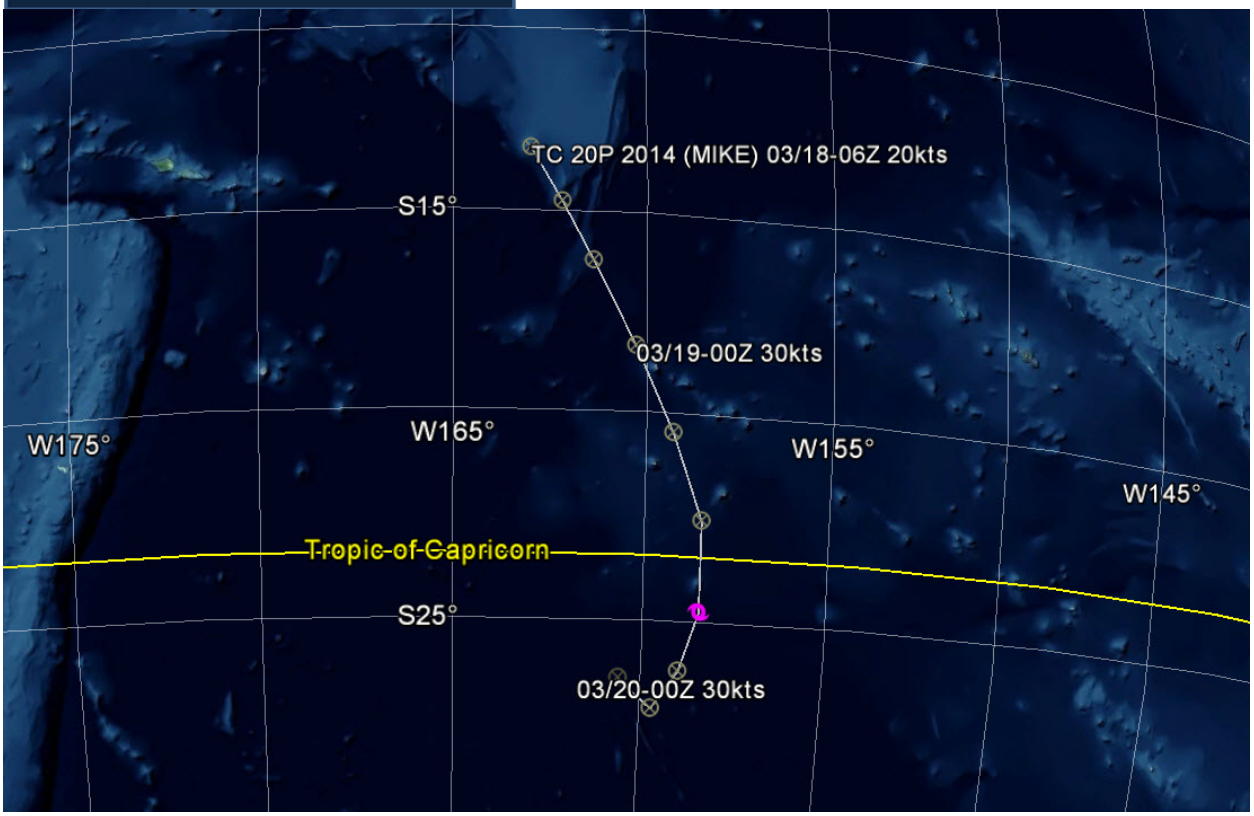




20P TROPICAL CYCLONE MIKE

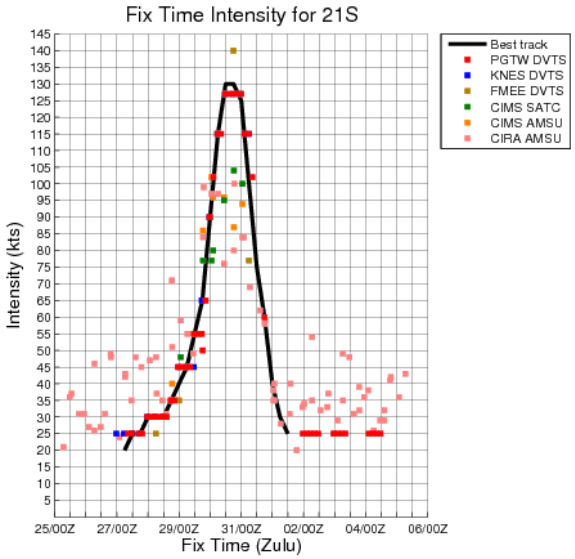
ISSUED LOW:	18 MAR/ 0600
ISSUED MED:	18 MAR/ 1500Z
FIRST TCFA:	19 MAR / 0230Z
FIRST WARNING:	19 MAR/ 0600Z
LAST WARNING:	19 MAR/ 1800Z
MAX INTENSITY:	35
WARNINGS:	2

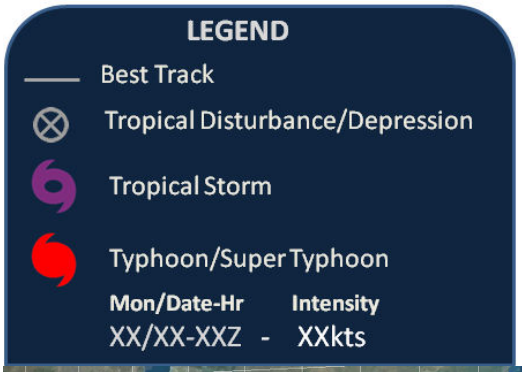


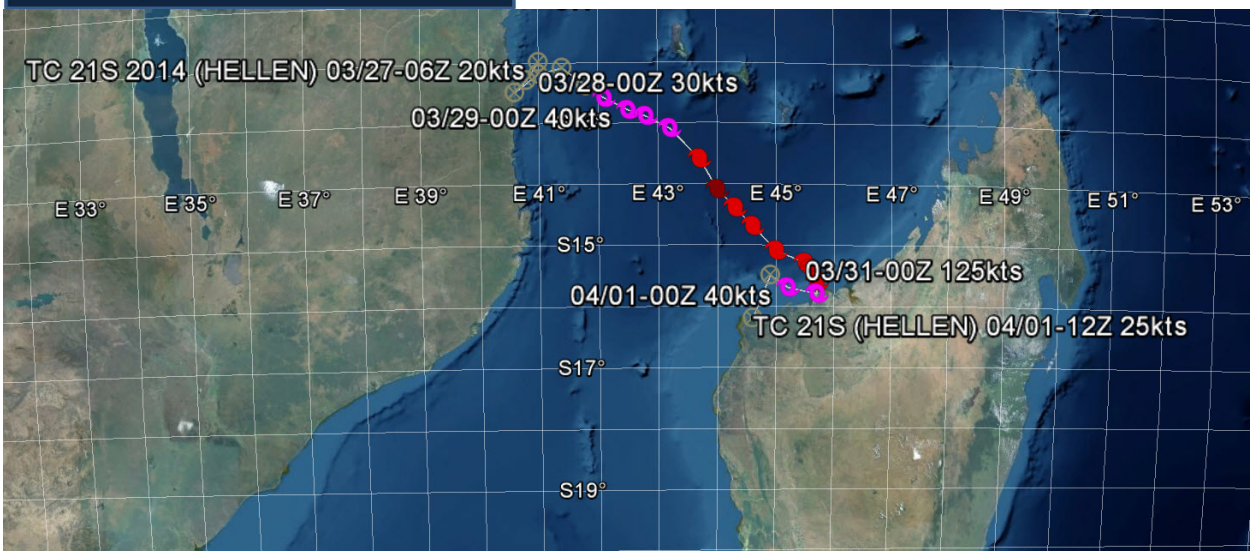


21S TROPICAL CYCLONE HELLEN

ISSUED LOW:	25 MAR/ 2130Z
ISSUED MED:	26 MAR/ 0630Z
FIRST TCFA:	26 MAR/ 2000Z
FIRST WARNING:	28 MAR/ 1800Z
LAST WARNING:	01 APR/ 0000Z
MAX INTENSITY:	130
WARNINGS:	8

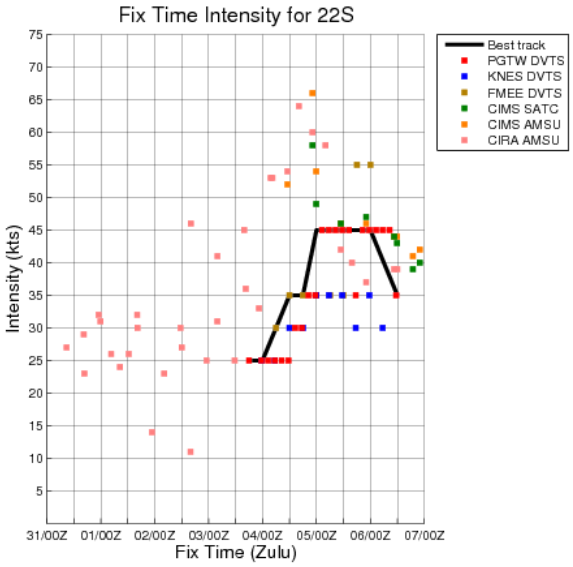


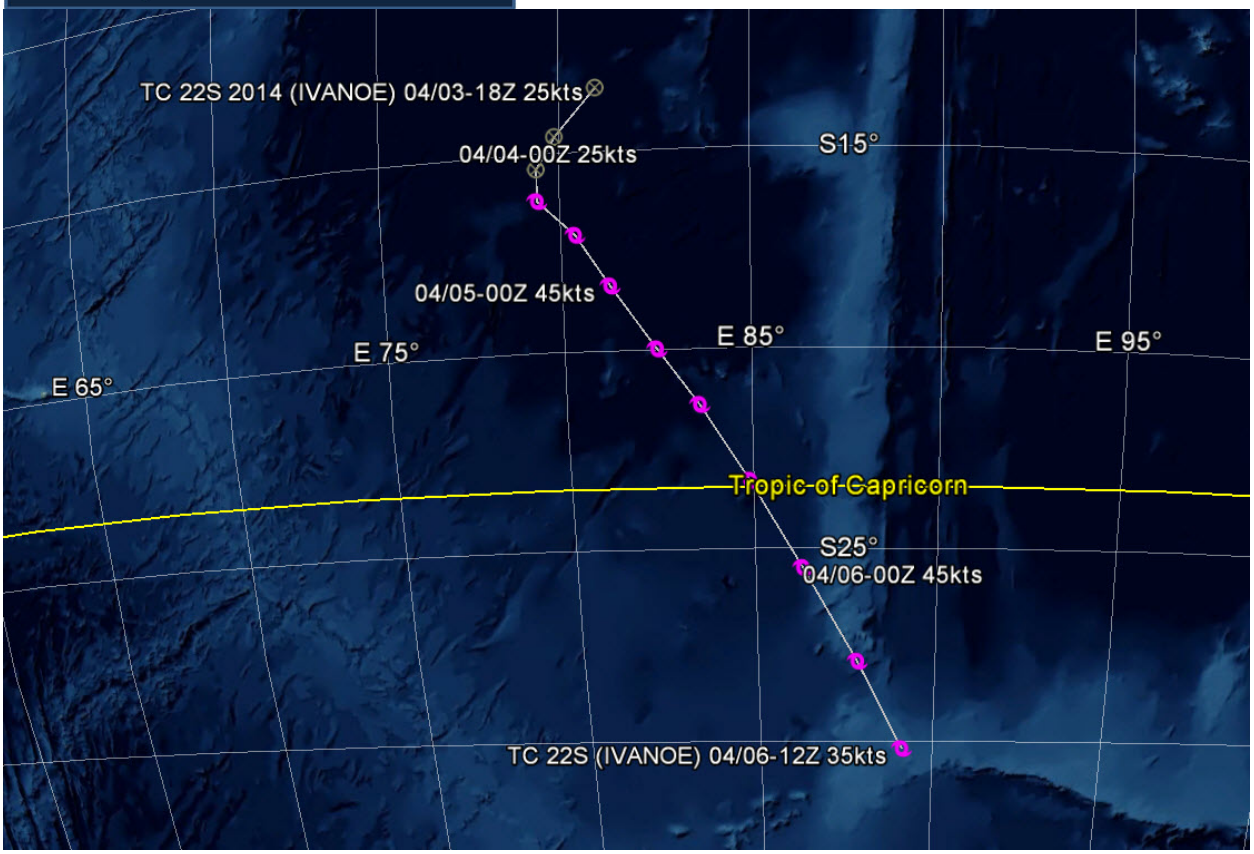




22S TROPICAL CYCLONE IVANOE

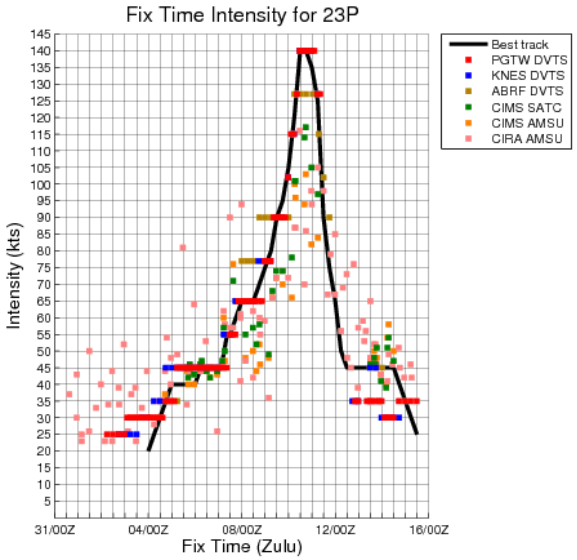
ISSUED LOW:	01 APR/ 0600Z
ISSUED MED:	03 APR/ 1800Z
FIRST TCFA:	04 APR / 0400Z
FIRST WARNING:	04 APR/ 1200Z
LAST WARNING:	06 APR/ 1200Z
MAX INTENSITY:	45
WARNINGS:	5

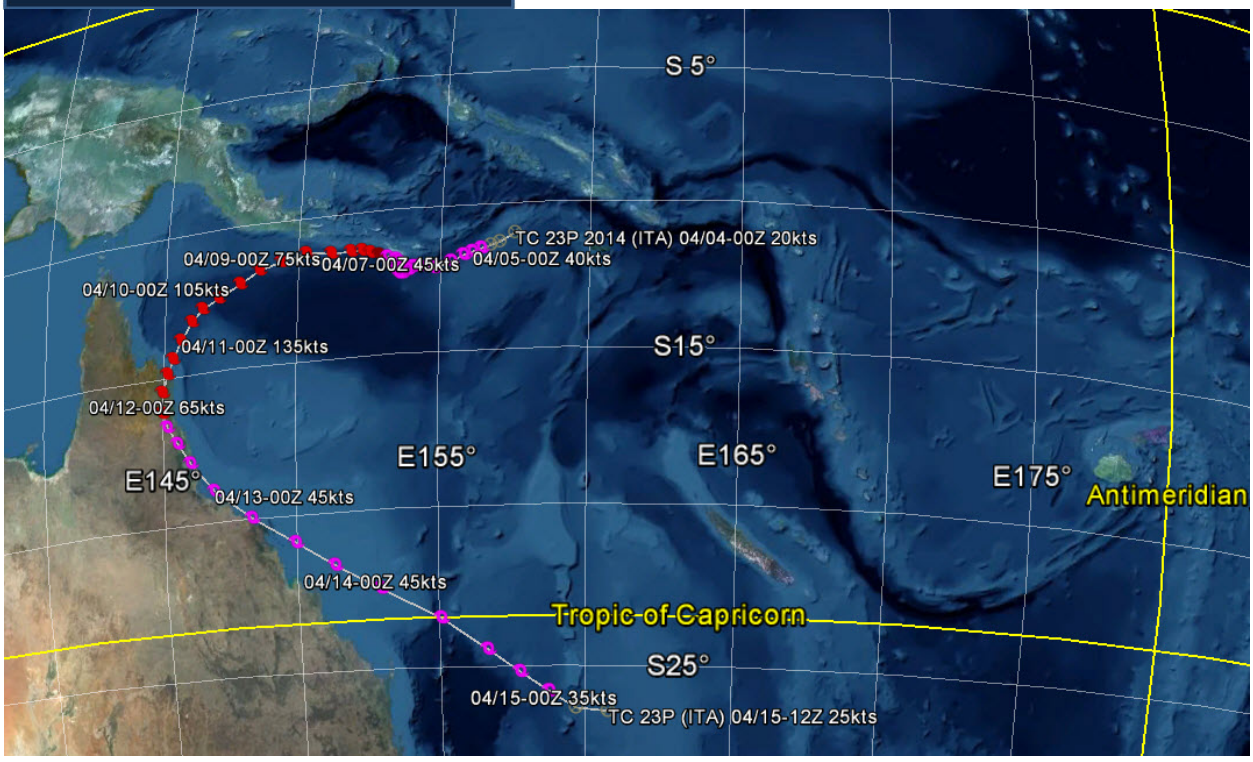




23P TROPICAL CYCLONE ITA

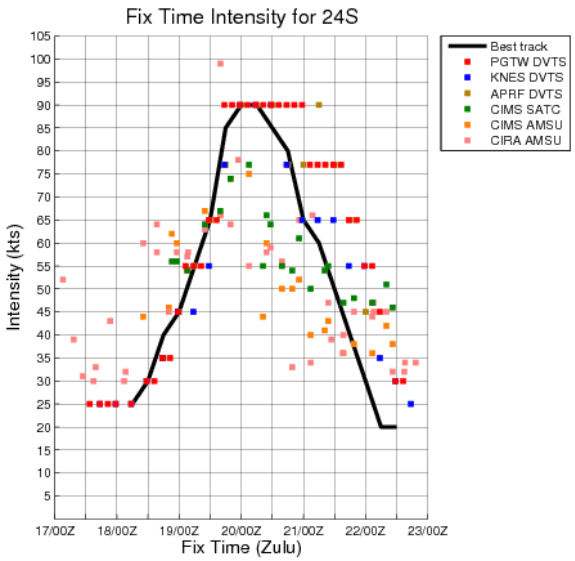
ISSUED LOW:	01 APR/ 0600Z
ISSUED MED:	02 APR/ 0600Z
FIRST TCFA:	03 APR / 0330Z
FIRST WARNING:	04 APR/ 1800Z
LAST WARNING:	14 APR/ 0600Z
MAX INTENSITY:	140
WARNINGS:	20

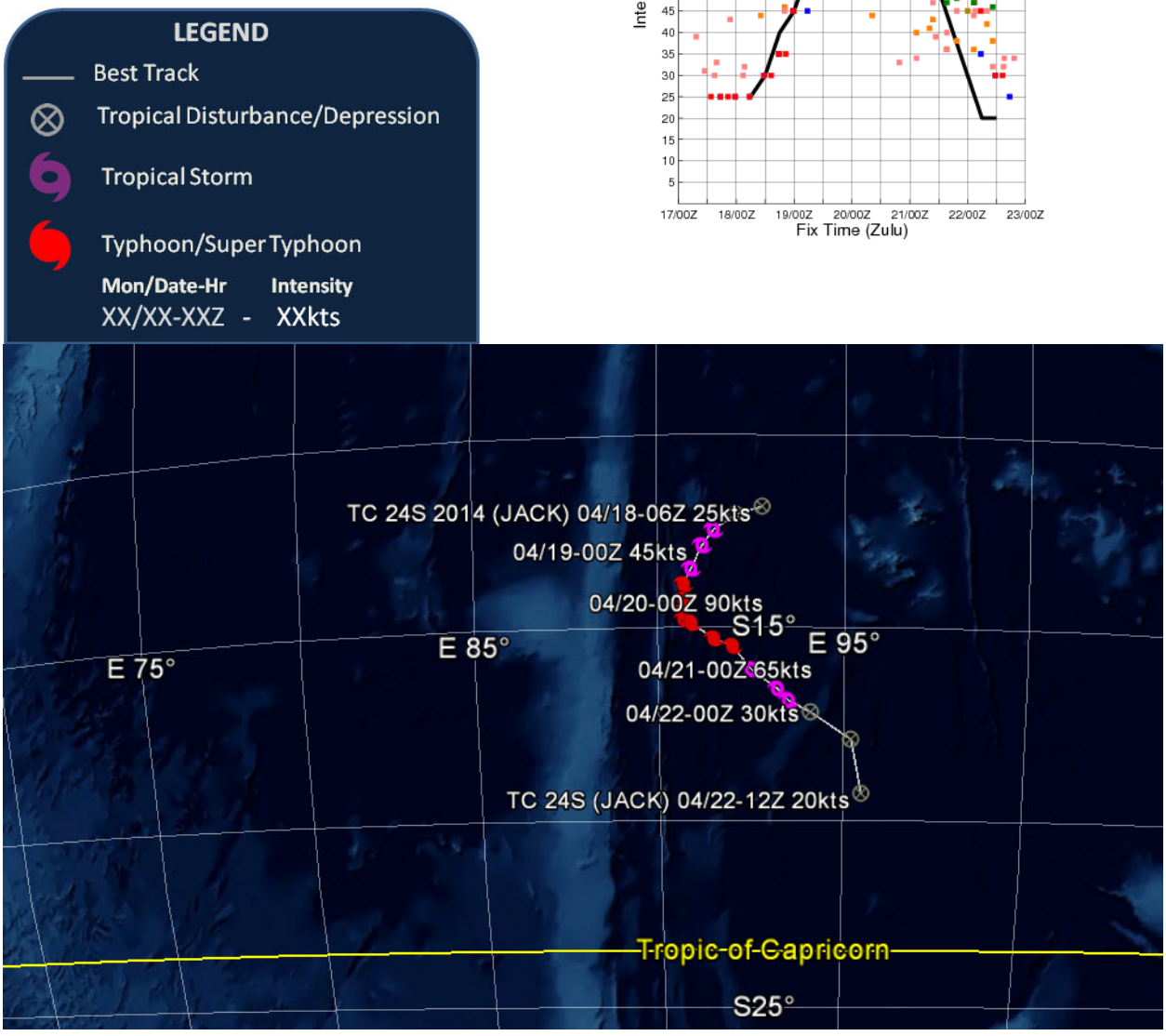




24S TROPICAL CYCLONE JACK

ISSUED LOW:	16 APR/1800Z
ISSUED MED:	17 APR/ 1800Z
FIRST TCFA:	18APR/ 1400Z
FIRST WARNING:	18 APR/ 1800Z
LAST WARNING:	22 APR/ 0600Z
MAX INTENSITY:	90
WARNINGS:	8





Chapter 4 Tropical Cyclone Fix Data

Section 1 Background

Weather satellite data continued to be the mainstay for the TC reconnaissance mission at JTWC. JTWC satellite analysts produced 12,561 position and intensity estimates. A total of 8260 of those 12,561 fixes were made using microwave imagery, amounting to well over 65 percent of the total number of fixes. The USAF primary weather satellite direct readout system, Mark IVB, and the USN FMQ-17 continued to be invaluable tools in the TC reconnaissance mission. Section 2 tables depict fixes produced by JTWC satellite analysts, stratified by basin and storm number. Following the final numbered storm for each section, is a value representing the number of fixes for invests considered as Did Not Develop (DND) areas. DNDs are areas that were fixed on but did not reach warning criteria. The total count of DND fixes was 1099 for all basins, which accounts for approximately 9% of all fixes in 2014.

Section 2 Fix summary by basin

TABLE 4-1

WESTERN NORTH PACIFIC OCEAN FIX SUMMARY FOR 2014

Tropical Cyclone	Name	Visible/Infrared	Microwave/Scatterometry	Total
01W	Lingling	36	142	178
02W	Kajiki	32	66	98
03W	Faxai	73	156	229
04W	N/A	64	97	161
05W	Peipah	97	179	276
06W	Tapah	67	115	182
07W	Hagibis	39	71	110
08W	Neoguri	74	162	236
09W	Rammasun	81	149	230
10W	Matmo	74	133	207
11W	Halong	112	253	365
12W	Nakri	100	210	310
07E	Genevieve	49	129	178
13W	Fengshen	49	114	163
14W	N/A	39	62	101
15W	Kalmaegi	61	107	168
16W	Fung-wong	57	149	206
17W	Kammuri	60	163	223
18W	Phanfone	81	202	283
19W	Vongfong	101	272	373
20W	Nuri	65	177	242
21W	Sinlaku	47	98	145
22W	Hagupit	103	226	329
23W	Jangmi	38	89	127
DND		**184**	**273**	**457**
Totals		**1783**	**3794**	**5577**
Percentage of Total		**31.97%**	**68.03%**	**100**

TABLE 4-2

NORTH INDIAN OCEAN (BAY OF BENGAL/ARABIAN SEA)
FIX SUMMARY FOR 2014

Tropical Cyclone	Name	Visible/Infrared	Microwave/Scatterometry	Total
01B	N/A	47	63	110
02A	Nanauk	50	98	148
03B	Hudhud	62	138	200
04A	Nilofar	78	174	252
05B	N/A	36	77	113
DND		**191**	**276**	**467**
Totals		**464**	**826**	**1290**
Percentage of Total		**35.97%**	**64.03%**	**100**

TABLE 4-3

SOUTH PACIFIC & SOUTH INDIAN OCEAN
FIX SUMMARY FOR 2014

Tropical Cyclone	Name	Visible/Infrared	Microwave/Scatterometry	Total
01S	N/A	66	67	133
02S	Alessia	63	74	137
03S	Amara	76	227	303
04S	Bruce	80	182	262
05S	Christine	45	101	146
06S	Bejisa	81	207	288
07P	Ian	79	184	263
08S	Colin	76	181	257
09S	Deliwe	56	126	182
10P	June	21	46	67
11P	Dylan	33	81	114
12P	Edna	35	87	122
13S	Edilson	40	101	141
14S	Fobane	90	231	321
15S	Guito	43	106	149
16P	Kofi	47	82	129
17P	Gillian	157	332	489
18P	Lusi	45	84	129
19P	Hadi	45	137	182
20P	Mike	19	51	70
21S	Hellen	78	92	170
22S	Ivanoe	21	65	86
23P	Ita	108	175	283
24S	Jack	42	101	143
DND		**578**	**550**	**1128**
Totals		**2024**	**3670**	**5694**
Percentage of Total		**35.55%**	**64.45%**	**100**

Chapter 5 Technical Development Summary

Section 1: Operational Priorities

The top operational priority of the Joint Typhoon Warning Center is sustained development and support of The Automated Tropical Cyclone Forecast System (ATCF). ATCF is the DOD's primary toolkit for analyzing and forecasting tropical cyclones (TCs), and is the principal software platform through which emerging research transitions into JTWC operations. Without ATCF, JTWC could not generate TC formation alerts or warnings. The systems tracks all TC activity and invest areas, automatically processes objective forecasting aids, produces TC formation alert, warning text and graphical products, and provides core capabilities for analyzing TCs and their environment. Additionally, ATCF provides JTWC Contingency of Operations Plan (COOP) backup capabilities to FWC-Norfolk and analytic support to FWC-San Diego for tasks such as setting TCCOR, forecasting on-station wind speed, designating OTSR "MODSTORM" locations, and preparing diverts and advisories. JTWC upgraded to the latest version of ATCF (v5.7) in June 2014. This upgrade incorporated new data displays such as composite microwave imagery overlays and radar, and a host of other improvements to the efficiency of data processing and filtering. Additional details of ATCF enhancements, delivered and proposed for future release, are discussed in Section 2.

JTWC has also prioritized integrating a state-of-the-art platform to facilitate visualization and evaluation of meteorological data. In 2015, the Commander, US Navy Meteorology Oceanography Command authorized acquisition of the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS-II) as the Navy's next-generation weather display and analysis system. JTWC technical services staff is facilitating incorporation of the AWIPS-II system into operations by developing standard operating procedures and site-specific applications. An initial operating capability (IOC) is scheduled in 2016. Although AWIPS II promises a generational leap in data synthesis capabilities, it cannot currently replicate ATCF functionality.

Section 2: Research and Development Priorities

The top 5 JTWC R&D priorities, as outlined in the 2015 annual report of the Office of the Federal Coordinator for Meteorological Services and Supporting Research – Tropical Cyclone Working Group are:

1. Deterministic and probabilistic forecast guidance for tropical cyclone intensity change, particularly the onset, duration, and magnitude of rapid intensification events and eyewall replacement cycles, as well as over-water rapid weakening events
2. Techniques to improve the utility and exploitation of microwave satellite, ocean surface wind vectors, and radar data for fixing tropical cyclones (e.g. develop a "Dvorak-like "technique using microwave imagery), or for diagnosing RI, ETT, ERC, etc.
3. Improved and extended (out to 7 days) deterministic and probabilistic forecast track guidance to assist forecasters in the Identification, and then reduction of, the occurrence of guidance and official track outliers, focusing on both large speed errors (e.g., accelerating recurvers and stalling storms) and large direction errors (e.g., loops), and on specific forecast problems,

including interactions between upper-level troughs and tropical cyclones, track forecasts near/over land--especially elevated terrain, and extratropical transition.

4. Statistically based real-time guidance on guidance to assist in the determination of official track and intensity forecasts. This could include multi-model consensus approaches, single- or multi-model ensembles
5. Enhancements to the operational environment to increase forecaster efficiency, by expediting analysis, forecast, coordination, and/or communication activities. In particular, transitioning of successful guidance products to integrated operational forecast systems such as the ATCF or AWIPS.

Section 3: Technical Development Projects

JTWC personnel have initiated and scheduled numerous efforts to address the operations and research and development priorities presented in Sections 1 and 2 of this report.

1. Tropical cyclone intensity change

a. Intensity Consensus (S5YY & S5XX)

JTWC made minor revisions to the primary intensity consensus aids, S5YY and S5XX, based on inputs from NRL's review of 2013 performance. LGEM forecasts were temporarily removed from the western North Pacific tropical cyclone intensity consensus, S5YY, due to an ongoing numerical calculation issue. Additionally, NRL sensitivity tests indicated that incorporating the SHIPS-RI short-range rapid intensification aid, RI30, increases tropical cyclone intensity consensus forecast skill. Therefore, this aid was added to the S5YY consensus in early 2015.

The following table lists the ATCF objective aid identifiers for the current primary members of JTWC's operational intensity forecast consensuses: S5YY (intensity, western North Pacific basin) and S5XX (intensity, Indian Ocean and Southern Hemisphere basins).

S5YY	S5XX
DSHN (SHIPS)	AVS5 (STIPS)
DSHA (SHIPS)	JGS5 (STIPS)
GFDN	NVS5 (STIPS)
COTI	UKS5 (STIPS)
CHII	WBS5 (STIPS)
HWFI	AFS5 (STIPS)
RI30	GFNI
	COTI
	CHII

Table 5-1: Primary objective aids comprising the operational JTWC tropical cyclone intensity (S5YY and S5XX) consensuses (as of Spring 2015).

b. Expansion of SHIPS-RI routine in ATCF:

NRL expanded the SHIPS Rapid Intensification Index (SHIPS-RII) to all JTWC forecast basins in 2014. The index provides the probability of 30-knot intensification during a 24-hour forecast period for active tropical cyclones (Kaplan et al. 2010). The index is generated in ATCF and available for forecaster interrogation during each forecast cycle.

c. Weighted Analog Intensity Technique

JTWC initiated an operational assessment of the Weighted Analog Intensity Prediction (WANI) technique (Tsai and Elsberry 2014). The WANI method provides intensity forecast skill and spread guidance for designated TC tracks based on situation-dependent analogs in the multi-decadal, historical best track dataset. Track and intensity analogs are selected by comparing the time of year, track speed and direction, and initial intensity of the designated TC track with storms in the historical record. A weighted average of these past cyclone intensities (i.e., their best track intensities) is calculated; analog data that more closely match the current JTWC forecast track and initial intensity receive more weight. The resultant mean intensity value is the Weighted Analog Intensity (WANI) forecast. Additionally, the ten analog intensities are used to calculate an intensity forecast range, which is expected to contain the verifying best track intensities roughly 70% of the time.

Verification statistics from the 2014 western North Pacific TC season indicate that WANI performance was on-par with the S5YY multi-member consensus and JTWC subjective intensity forecasts, particularly at 96 and 120 hours (Figure 5-1).

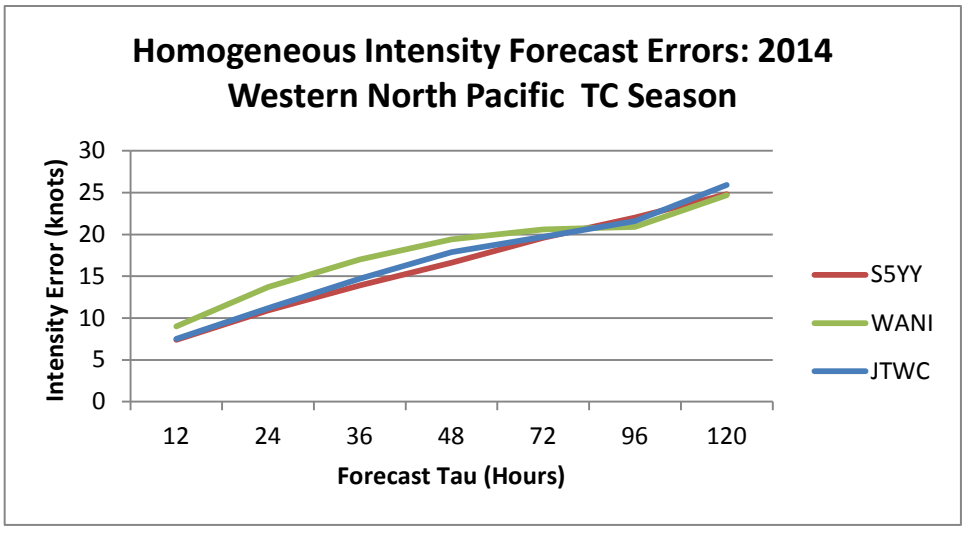


Figure 5-1: Comparison of intensity forecast performance: JTWC subjective forecasts, S5YY intensity consensus, and WANI intensity forecast average errors. The number of cases at each forecast tau are 379, 355, 330, 299, 238, 186, and 138, respectively.

2. Application of environmental satellite data

a. RapidScat data integration

JTWC Satellite Analysts and forecasters began applying scatterometer data from the RapidScat sensor onboard the International Space Station for operational tropical analysis. Partners at the Naval Research Laboratory, Fleet Numerical Meteorology and Oceanography Center, and NOAA have worked diligently to process these data and provide them to JTWC through web servers and ATCF.

b. OSVW intensity estimates

The satellite operations department began producing and recording tropical cyclone intensity and 34-kt wind radii estimates from ASCAT scatterometer data. These data are expected to improve both subjective and objective best track intensity estimates, particularly during scenarios in which the Dvorak technique is prone to larger errors.

3. Improved and extended track forecast guidance

a. CONW

COAMPS-TC run with NAVGEM lateral boundary conditions (COTC) replaced COAMPS-TC run with GFS lateral boundary conditions (CTCX) in JTWC's official track consensus, CONW. Otherwise, the track consensus remained unchanged in 2014, with the members listed in table 5-2.

CONW
NVGI
EGRI
JGSI
GFNI
AVNI
ECMI
COTI
JENI
HWFI
AEMI

Table 5-2: Primary objective aids comprising the operational JTWC tropical cyclone track (CONW) consensus (as of Spring 2015).

b. Evaluation of seven-day forecasting capability

Since implementing 5-day warnings, JTWC 4- and 5-day TC track accuracy has improved approximately 25%. JTWC believes that steady improvements in numerical weather prediction and new technologies may now make it feasible to provide statistically skillful forecast

guidance out to 7 days, providing decision makers even more advance notice of potential TC threats. A feasibility study for seven-day track and intensity forecasting found that the quantity of track forecast guidance diminishes after five days, and six- and seven-day forecast guidance for intensity and structure is even more limited. Thus, the current phase of the seven-day forecasting study focuses solely on gathering and developing additional seven-day forecast data for further evaluation. New data sources under consideration include the ECMWF medium-range ensemble mean vortex track for track forecasting and a seven-day Weighted Analog Intensity forecasting technique for intensity forecasting.

c. Acquisition and evaluation of ECMWF ensemble

A statistical evaluation of the European Centre for Medium-Range Weather Forecasting (ECMWF) tropical cyclone ensemble indicated very encouraging track forecast performance during the 2014 western North Pacific TC season. Based on the findings of that evaluation, JTWC has begun processing the EC ensemble mean vortex tracker for operational application during calendar year 2015. If the tracker is found to positively impact the track consensus during end-of-year testing, it will be incorporated into CONW during calendar year 2016.

d. Model testing

JTWC continues to process and evaluate forecast data from multiple numerical models discussed in the 2013 ATCR, including ACCESS-TC, AFWA MEPS, FIM9, Arpege, TWRF, and ECMWF ensemble track clusters.

e. Model upgrades

The UK Met Office global model received a significant upgrade in 2014, including the incorporation of a new dynamical core and an increase horizontal resolution from approximately 25 km to approximately 17 km in the mid-latitudes (UK Met Office 2015). Numerous upgrades to other numerical modeling systems in use at JTWC are occurring in calendar year 2015, including:

- COAMPS-TC (June 2015): FNMOC implemented version 5.2, which includes an upgraded vortex initialization scheme, modified terrain, and improved drag coefficient formulation. Retrospective testing indicates increased mean track forecast accuracy at tau 72-120, reduced track directional bias, and a smaller bias toward under-forecasting the intensity of strong cyclones (FNMOC COAMPS-TC 2015).

- GFS (January 2015): NCEP introduces numerous improvements to the Global Forecast System, including an increase in horizontal grid resolution from approximately 27 km to approximately 13 km for the first 240 hours of the model simulation (NWS TIN 14-46).

- GEFS (October 2015): The upgraded NCEP Global Ensemble Forecast System will feature an increase in horizontal grid resolution from approximately 55 km to approximately 33 km for the

first 192 hours of the model forecast, and increase in vertical resolution from 42 to 64 levels, and incorporation of an Ensemble Kalman Filter (EnKF) data assimilation scheme (Hou et al 2015).

- NAVGEM (June 2015): The latest version (NAVGEM 1.3) features an increase in horizontal grid resolution from approximately 37 km to approximately 31 km, an increase in the number of vertical levels from 50 to 60, an upgraded physics package, and the capability to assimilate data from several additional satellite platforms (FNMOC NAVGEM 2015).

- GFDN (July 2015): FNMOC upgrades GFDN to the latest operational version of the GFDL model code, including a horizontal resolution increase to 1/18th degree in addition to vortex initialization and model physics improvements described in the GFDL discussion below.

- GFDL (June 2015): Improvements to the vortex initialization and model physics are implemented. The improvements reduced tropical cyclone intensity forecast errors during the testing phase (NWS TIN 15-26). The GFDL deterministic model and 10-member ensemble ran on experimental HFIP computer resources and forecasts were made available to JTWC for evaluation beginning in July 2014. GFDL modeling has expanded to all JTWC forecast basins for 2015.

- GFDL ensemble (Summer 2015): Ensemble members increase from 10 to 12 (GFDL 2015).

- HWRF (June 2015): The HWRF model becomes operational for tropical cyclones occurring in the western North Pacific, Southern Pacific, and Indian Ocean, and the system's simultaneous modeling capability increases from 5 to 7 cyclones. HWRF model package upgrades include a horizontal resolution increase in all three domains to 18/6/2 km, a modified vortex initialization scheme, and improved physics (NWS TIN 15-25).

- MEPS ensemble (July 2015): AFWA implements a rolling ensemble capability, running one member of the 12-member, 20 km ensemble every two hours (557 WW 2015).

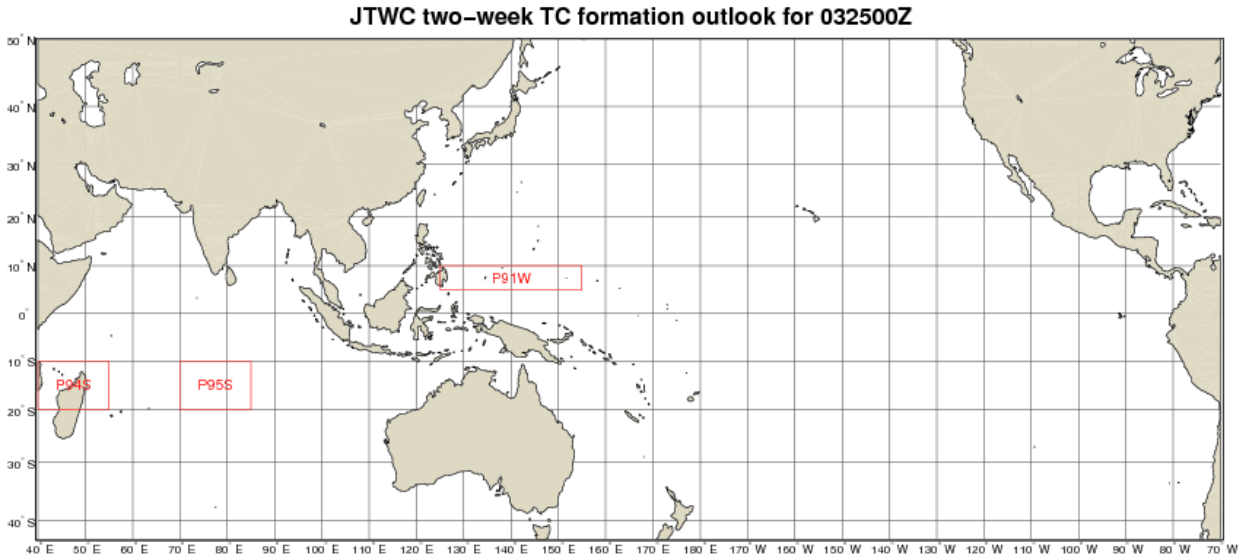
f. Two-week subjective TC formation outlooks

JTWC, in collaboration with NOAA organizations, the Naval Postgraduate School, the University of Albany, the Australia Bureau of Meteorology, and the Taiwan Central Weather Bureau, again provided input to the week one and two tropical cyclone forecasts produced by NOAA/NWS's Climate Prediction Center's (CPC) weekly Global Tropics Hazards (GTH) Assessment. This assessment, published weekly by Wednesday at 0000Z, is available directly from CPC's GTH website (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/), and is also accessible from a hyperlink provided on JTWC's public webpage.

Expanding upon the successful GTH prediction effort, JTWC has implemented an experimental, in-house procedure to predict tropical cyclone formation within the area-of-responsibility

during a two-week forecast period. JTWC forecasters have regularly, but informally, identified candidate areas for tropical cyclone formation in the extended range (one to two weeks) through inspection of dynamic model fields and other data sources. This experimental two-week forecasting procedure formalizes extended-range prediction by cataloging suspect areas and collating associated track, intensity, and formation probability data. The goals of this project are to provide skillful extended-range forecast guidance for JTWC customers, improve early identification of candidate areas for tropical cyclone formation, and mitigate inaccuracies sometimes noted in objective forecast guidance during the first few warning cycles for a newly-formed tropical cyclone.

Candidate areas for tropical cyclone formation identified during the experimental two-week forecast process are designated as "preinvests." Technical Services issues preinvest forecasts every administrative workday, typically Monday through Friday, at 0000Z. A geographical formation region (box-shaped), potential tropical cyclone formation (first warning) timeframe, and subjective formation confidence (percentage) are included in each preinvest forecast. Extended range prediction tools are thoroughly reviewed for TC genesis signals during the preinvest forecasting process. Preliminary track and intensity forecast data, if available, are provided to forecasters for each preinvest area. These data will be incorporated into the Automated Tropical Cyclone Forecast system (ATCF) during CY 2015 and 2016.



Preinvest P91W: TC formation expected to occur between 04011200Z and 04031200Z. Subjective confidence: 20%
Preinvest P95S: TC formation expected to occur between 03300000Z and 04010000Z. Subjective confidence: 30%
Preinvest P94S: TC formation expected to occur between 03281200Z and 03291200Z. Subjective confidence: 40%

Figure 5-2: Example experimental, two-week tropical cyclone formation outlook graphic showing the projected location, timing, and probability of development for several "preinvest" areas.

4. Statistical based TC track confidence guidance

a. Evaluation of situation-dependent error swath based on GPCE

JTWC personnel and partners at NRL are developing techniques to improve and expand upon existing track forecast confidence guidance. These efforts include incorporating

situation-dependent uncertainty (GPCE) into the TC warning graphic 34-knot danger area (NRL lead) and relating GPCE uncertainty to historical forecast errors (JTWC lead). Both efforts aim to improve battlespace maneuverability and safety by increasing available sea space in highly certain forecast scenarios and accurately highlighting danger areas in highly uncertain forecast scenarios.

Enhancements to the operational environment

b. Geospatial data display tool

JTWC is developing a geospatial data interface for hand-analyzed tropical streamlines and other tropical cyclone datasets. The interface uses the Google Maps Javascript API, which does not require specialized geospatial display software to function on the user's computer. Forecasters and meteorological technicians can simply access and display the interface and associated datasets through their web-browsers (Figure 5-3).

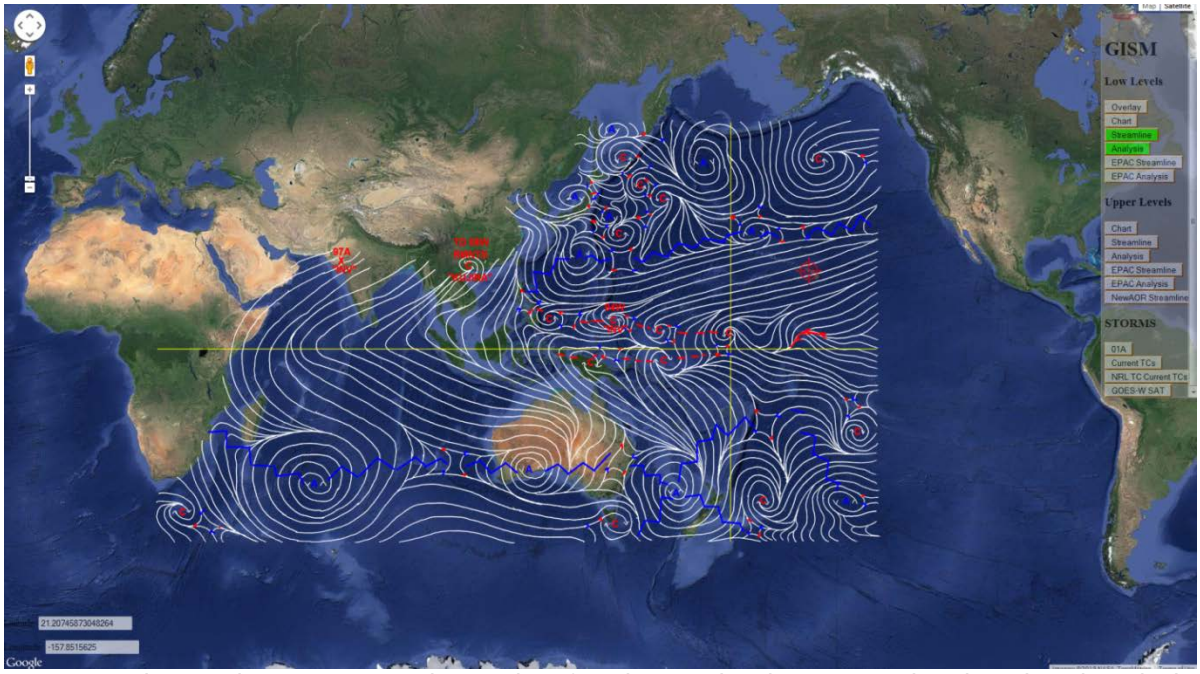


Figure 5-3: Example Google Maps Javascript API interface image showing JTWC's hand-analyzed tropical streamline data

5. Other projects

a. Climatology packages

JTWC composed detailed reviews of historical tropical cyclone activity impacting various DoD installations throughout the organization's area of forecast responsibility. These climatology packages detail the track and intensity characteristics of TCs that pass near each installation, and include analyses of basin-wide activity as well as a comparison of El Niño and La Niña years. The climatology packages will be made available in .ppt, .pdf, and .kmz formats to JTWC customers through the Navy Enterprise Portal, Oceanography (NEP-Oc) webpage.

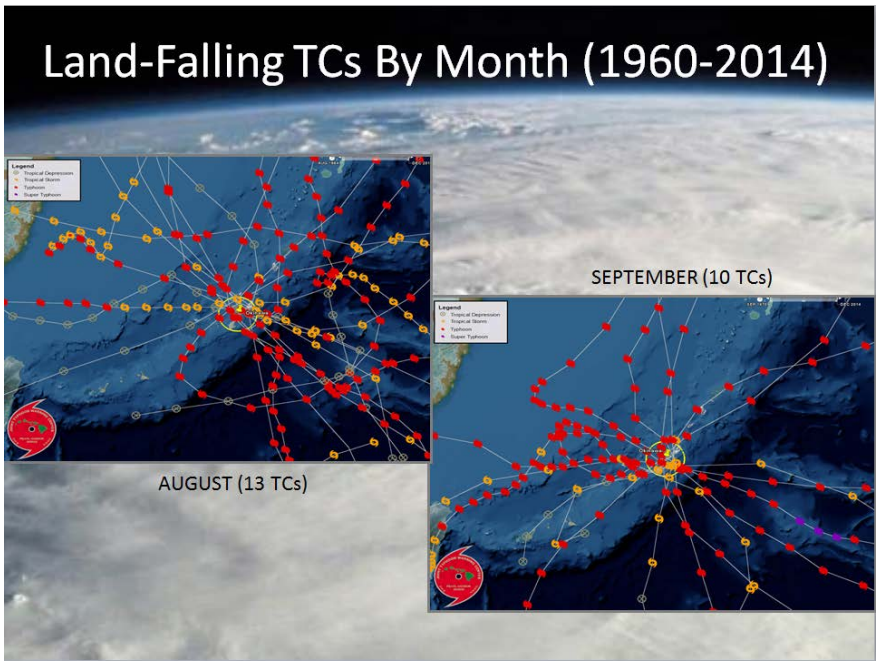


Figure 5-4: Example image from the asset climatology packages developed at JTWC. This graphic shows the tracks of all TCs that made landfall in Okinawa in August and September during the 1960 through 2014 period (image source: Google Earth software).

Section 4: Scientific and technical exchanges

Participating in national and international-level meetings and conducting technical exchanges with members of the scientific community is essential to the success of JTWC's strategic development efforts. Budgetary restrictions in place during 2014 curtailed JTWC's participation in these events, prompting cancellation of the biennial Tropical Cyclone Conference and the ATCF requirements meeting. The following is a list of JTWC's 2014 conference attendance and technical exchange meetings.

- Hosted technical exchanges with Naval Postgraduate School representative Dr. Russell Elsberry. JTWC continues to evaluate multiple forecasting tools and techniques developed by Dr. Elsberry and his colleagues, including ensemble track clusters, weighted intensity analog forecasts, and extended-range TC formation and track forecasts from model ensembles.

- Hosted technical exchange with Australian Bureau of Meteorology Centre for Australian Weather and Climate Research (CAWCR) representative Dr. Noel Davidson. Dr. Davidson discussed several areas of innovative, ongoing research at CAWCR, including near real-time analysis of the Okubo-Weiss-Zeta (OWZ) parameter derived from ACCESS model fields. These OWZ data can differentiate tropical disturbances with elevated potential to develop into tropical cyclones (Tory et al 2013). A leading OWZ researcher, Dr. Kevin Tory (also from CAWCR), has graciously provided these data to JTWC for evaluation during the past year.

- Hosted technical exchange with Naval Research Laboratory representatives Dr. Carolyn Reynolds and Dr. James Doyle. Dr. Reynolds and Dr. Doyle updated JTWC staff on the current status and future plans for the NAVGEM and COAMPS-TC forecast models, respectively.

- Hosted technical exchange with University of Rhode Island representative Dr. Isaac Ginis. Dr. Ginis discussed the 2014 GFDL forecast model upgrade and shared some recent research findings regarding TC-ocean interaction.

- Served in working groups for the WMO Eighth International Workshop on Tropical Cyclones (IWTC-VIII), which convened in Jeju, South Korea, in December 2014. The team composed and contributed two original summaries of operational intensity and extratropical transition forecasting procedures to IWTC subject matter rapporteurs.

- Participated in the NCEP 6th Annual Ensemble Users Workshop.

- Presented JTWC subtropical cyclone operational procedures and analysis methods at 31st Annual American Meteorological Society Hurricane Conference.

- Participated in the 2014 NCEP Production Suite Review.

References

557th Weather Wing (557 WW): Operational AFWA Ensemble Information. Accessed August 2015. [Available online at https://weather.af.mil/confluence/display/AFPUBLIC/Operational+AFWA+Ensemble+Information#OperationalAFWAEnsembleInformation-MEPSSpecifications]

Fleet Numerical Meteorology and Oceanography Center (FNMOC): COAMPS-TC v5.2 Annual Configuration Upgrade (2015). Accessed August 2015. [Available online at https://nepoc.oceanography.navy.mil/catalog/binary?assetId=12582912&refId=14745600]

Fleet Numerical Meteorology and Oceanography Center (FNMOC): NAVGEM 1.3 Executive Summary. Accessed August 2015. [Available online at https://nepoc.oceanography.navy.mil/catalog/binary?assetId=12419072&refId=14581760]

Geophysical Fluid Dynamics Laboratory (GFDL): 2015 Hurricane Model Ensemble. Accessed August 2015. [Available online at http://data1.gfdl.noaa.gov/hurricane/gfdl_ensemble/aboutV2015.html]

Goerss, J.S. and C.R. Sampson, 2014: Prediction of consensus tropical cyclone intensity forecast error. *Wea. Forecasting*, **29**, 750–762.

Hou, D., Y. Zhu, X. Zhou, R. Wobus, J. Peng, Y. Luo, and B. Cui, 2015: The 2015 upgrade of NCEP's Global Ensemble Forecast System (GEFS). 27th Conference on Weather Analysis and Forecasting/23rd Conference on Numerical Weather Prediction, 28 June – 03 July, Chicago, IL.

National Weather Service (NWS): Technical Implementation Notice (TIN) 14-46. Accessed August 2015. [Available online at http://www.nws.noaa.gov/om/notification/tin14-46gfs_cca.htm]

National Weather Service (NWS): Technical Implementation Notice (TIN) 15-25. Accessed August 2015. [Available online at http://www.nws.noaa.gov/os/notification/tin15-25hwrf.htm]

National Weather Service (NWS): Technical Implementation Notice (TIN) 15-26. Accessed August 2015. [Available online at http://www.nws.noaa.gov/os/notification/tin15-26gfdl.htm]

Tory, K.J., R.A. Dare, N.E. Davidson, J.L. McBride, and S.S. Chand, 2013: The importance of low-deformation vorticity in tropical cyclone formation. *Atmos. Chem. Phys.*, **13**, 2115-2132.

Tsai, H.-C., and R.L. Elsberry, 2014: Applications of situation-dependent intensity and intensity spread predictions based on a weighted analog technique. *Asia-Pac. J. Atmos. Sci.*, **50(4)**, 507-518.

United Kingdom Met Office: Even Newer Dynamics for General atmospheric modelling of the environment (ENDGame). Accessed August 2015. [Available online at http://www.metoffice.gov.uk/research/areas/dynamics/endgame]

United Kingdom Met Office: Met Office Numerical Weather Prediction models. Accessed August 2015. [Available online at http://www.metoffice.gov.uk/research/modelling-systems/unified-model/weather-forecasting]

Chapter 6 Summary of Forecast Verification

Verification of warning position and intensities at 24-, 48-, and 72-, 96-, 120-hour forecast periods are made against the final best track. The (scalar) track forecast, along-track and cross track errors (illustrated in Figure 6-1) were calculated for each verifying JTWC forecast. These data are included in this chapter. This section summarizes verification data for the 2014 season, and contrasts it with annual verification statistics from previous years.

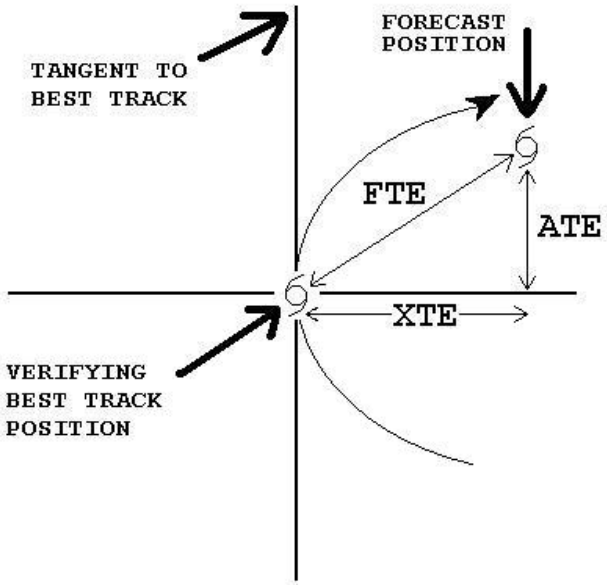


Figure 6-1. Definition of cross-track error (XTE), along track error (ATE), and forecast track error (FTE). In this example, the forecast position is ahead of and to the right of the verifying best track position. Therefore, the XTE is positive (to the right of track) and the ATE is positive (ahead of the best track). Adapted from Tsui and Miller, 1988.

Section 1 Annual Forecast Verification

TABLE 6-1
MEAN FORECAST ERRORS (NM) FOR WESTERN NORTH PACIFIC
TROPICAL CYCLONES FROM 1959 - 2014

	24-Hour					48-Hour					72-Hour					96-Hour					120-Hour				
Year (Note)	Cases	TY Mean Error	TC Mean Error (3)	Cross Track Mean Error (2)	Along Track Mean Error (2)	Cases	TY Mean Error	TC Mean Error (3)	Cross Track Mean Error (2)	Along Track Mean Error (2)	Cases	TY Mean Error	TC Mean Error (3)	Cross Track Mean Error (2)	Along Track Mean Error (2)	Cases (1)	TY Mean Error	TC Mean Error (3)	Cross Track Mean Error (2)	Along Track Mean Error (2)	Cases (1)	TY Mean Error	TC Mean Error (3)	Cross Track Mean Error (2)	Along Track Mean Error (2)
1959		117					267																		
1960		177					354																		
1961		136					274																		
1962		144					287					476													
1963		127					246					374													
1964		133					284					429													
1965		151					303					418													
1966		136					280					432													
1967		125					276					414													
1968		105					229					337													
1969		111					237					349													
1970		98	104				181	190				272	279												
1971		99	111	64			203	212	118			308	317	177											
1972		116	117	72			245	245	146			382	381	210											
1973		102	108	74			193	197	134			245	253	162											
1974		114	120	78			218	226	157			256	348	245											
1975		129	138	84			279	288	181			442	450	290											
1976		117	117	71			232	230	132			336	338	202											
1977		140	148	83			266	283	157			290	407	228											
1978		120	127	71	87		241	271	151	194		459	410	218	296										
1979		113	124	76	81		219	226	138	146		319	316	182	214										
1980		116	126	76	86		221	243	147	165		362	389	230	266										
1981		117	124	77	80		215	221	131	146		342	334	219	206										
1982		114	113	70	74		229	238	142	162		337	342	211	223										
1983		110	117	73	76		247	260	164	169		384	407	263	259										
1984		110	117	64	84		228	232	131	163		361	363	216	238										
1985		112	117	68	80		228	231	138	153		355	367	227	230										
1986		117	126	70	85		261	261	151	183		403	394	227	276										
1987		101	107	64	71		211	204	127	134		318	303	186	198										
1988	353	107	114	58	85	255	222	216	103	170	183	327	315	159	244										
1989	585	107	120	69	83	458	214	231	127	162	343	325	350	177	265										
1990	551	98	103	60	72	453	191	203	110	148	334	299	310	168	225										
1991	673	93	96	53	69	570	187	185	97	137	467	298	287	146	229										
1992	890	97	107	59	77	739	194	205	116	143	610	295	305	172	210										
1993	744	102	112	63	79	596	205	212	117	151	469	320	321	173	226										
1994	920	96	105	56	76	762	172	186	105	131	623	244	258	152	176										
1995	521	105	123	67	89	409	200	215	117	159	315	311	325	167	240										
1996	868	85	105	56	76	707	157	178	89	134	604	252	272	137	203										
1997	905	86	93	55	76	783	159	164	87	134	665	251	245	120	202										
1998	354	127	124	58	98	257	263	239	127	178	189	392	370	201	274										
1999	433	88	106	59	74	300	150	176	102	119	191	225	234	139	155										
2000	605	75	81	45	57	467	136	142	80	98	363	205	209	118	144										
2001	627	66	73	42	49	512	114	122	75	78	395	169	180	110	120	191		289	169	200	139		420	237	299
2002	657	50	66	37	47	535	94	116	67	79	421	144	166	88	120	260		232	107	183	201		292	131	230
2003	602	59	73	41	52	495	119	128	68	94	397	186	186	89	147	238		241	107	197	173		304	126	249
2004	766	52	70	41	48	646	94	122	69	84	537	180	173	95	121	328		206	111	147	242		274	147	195
2005	507	41	61	38	38	407	81	102	59	72	316	138	156	76	120	168		213	106	164	111		263	122	200
2006	512	47	62	39	40	405	85	104	61	73	327	133	151	77	112	206		216	115	155	141		309	167	222
2007	343	45	61	24	42	260	72	100	58	69	189	89	148	83	102	105		189	107	127	63		215	117	155
2008	354	45	66	38	46	261	104	120	75	78	192	201	198	110	140	138		300	163	219	87		447	246	313
2009	498	46	66	35	47	395	102	123	65	90	303	179	183	102	130	227		258	145	183	174		298	158	213
2010	253	57	59	33	42	192	101	101	63	65	140	157	160	95	102	92	154	223	134	147	54	154	279	174	179
2011	455	56	61	36	43	365	85	93	54	66	290	117	129	74	91	177	159	177	103	121	164	233	252	150	163
2012	535	48	50	30	34	439	87	89	52	61	340	121	127	67	93	248	160	163	82	123	178	218	224	105	176
2013	448	39	46	29	31	332	65	74	47	49	232	96	102	61	71	152	156	156	92	105	87	248	240	142	161
2014	406	49	49	29	34	362	81	82	48	56	258	119	123	71	85	200	164	167	102	111	146	218	227	147	146
Avg (1978-2014)	569	84	93	53	65	458	163	173	99	121	359	254	260	146	183	195	159	216	117	156	140	214	289	155	207
5yr Avg	419	50	53	31	37	338	84	88	53	59	252	122	128	74	88	174	159	177	103	121	126	214	244	144	165

(1) JTWC extended warning period from 72hrs to 120hrs in 2001. 96-hour and 120-hour data is not available prior to 2001.
(2) Cross-track and along-track errors were adopted by the JTWC in 1986. Right angle errors (used prior to 1986) were recomputed as cross-track errors after the fact to extend the data base.
(3) Mean forecast errors for all warned systems in Northwest Pacific.

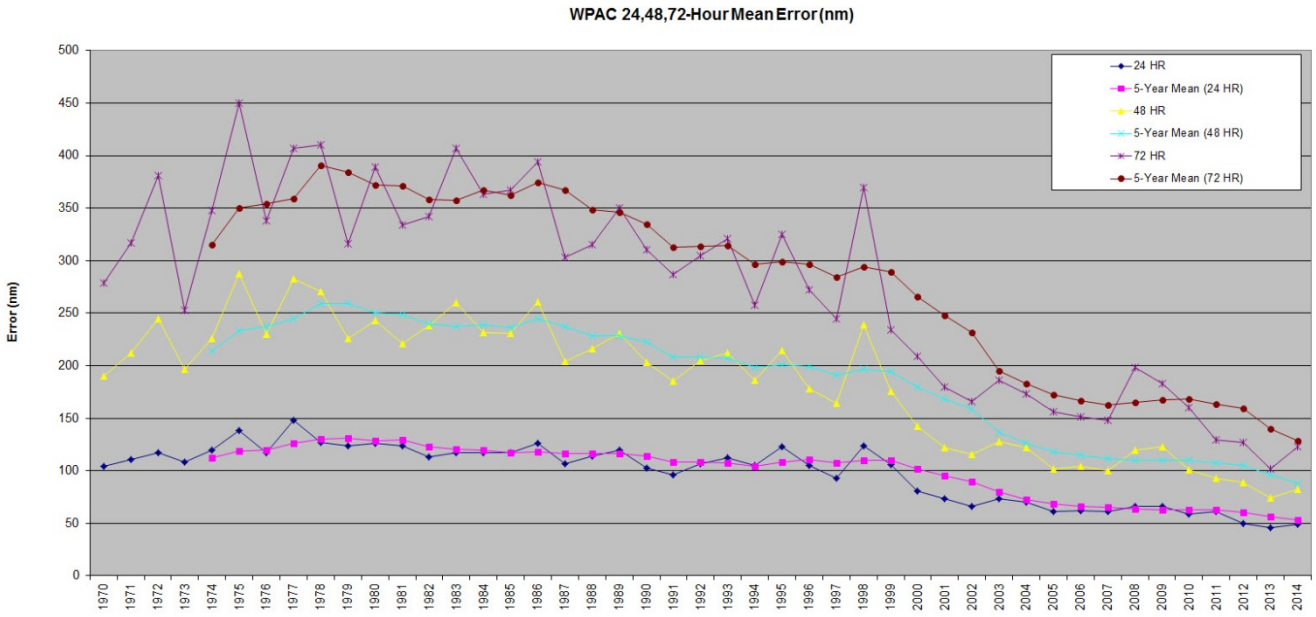


Figure 6-2. Graph of JTWC forecast errors and five year running mean errors for the western North Pacific at 24, 48, and 72 hours.

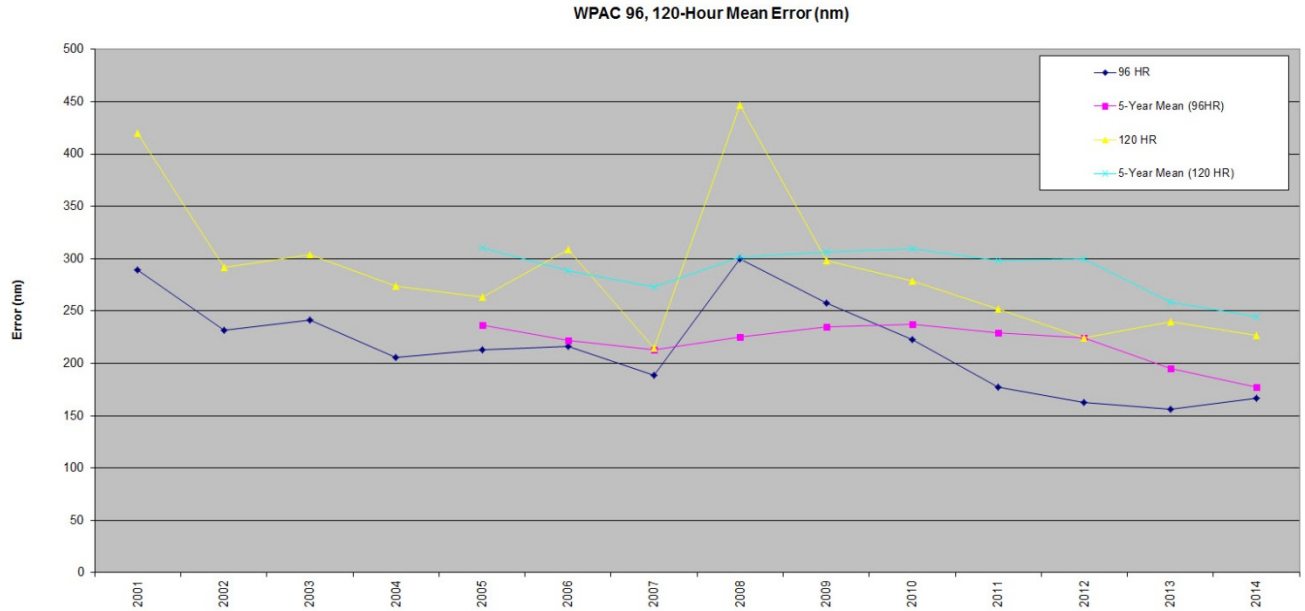


Figure 6-3. Graph of JTWC forecast errors and five year running mean errors for the western North Pacific at 96 and 120 hours.

Table 6-2
MEAN FORECAST TRACK ERRORS (NM) FOR NORTH INDIAN OCEAN

TROPICAL CYCLONES FROM 1985-2014

	24-HOUR				48-HOUR				72-HOUR				96-HOUR				120-HOUR			
YEAR (Notes)	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error
1985	30	122	102	53	8	242	119	194	0											
1986	16	134	118	53	7	168	131	80	5	269	189	180								
1987	54	144	97	100	25	205	125	140	21	305	219	188								
1988	30	120	89	63	18	219	112	176	12	409	227	303								
1989	33	88	62	50	17	146	94	86	12	216	164	11								
1990	36	101	85	43	24	146	117	67	17	185	130	104								
1991	43	129	107	54	27	235	200	89	14	450	356	178								
1992	149	128	73	86	100	244	141	166	62	398	276	218								
1993	28	125	87	79	20	198	171	74	12	231	176	116								
1994	44	97	80	44	28	153	124	63	13	213	177	92								
1995	47	138	119	58	32	262	247	77	20	342	304	109								
1996	123	134	94	80	85	238	181	127	58	311	172	237								
1997	42	119	87	49	29	201	168	92	17	228	195	110								
1998	55	106	84	51	34	198	135	106	17	262	188	144								
1999	41	79	59	38	22	184	130	116	10	374	309	177								
2000	24	61	47	26	16	85	69	37	1	401	399	38								
2001	41	61	40	37	31	115	71	71	22	166	44	154								
2002	30	84	41	63	18	137	92	83	10	185	92	133								
2003	37	108	66	69	31	196	115	132	7	354	210	252								
2004	46	81	53	52	36	140	95	85	9	173	144	86								
2005	67	62	41	40	49	116	71	73	18	118	35	109								
2006	19	64	37	44	13	92	58	60	0		-	-								
2007	38	61	38	36	23	94	56	65	10	140	92	93								
2008	59	70	46	44	38	99	71	55	24	127	94	127								
2009	25	93	42	74	10	206	79	169	1	387	102	373								
2010	63	52	31	33	42	90	67	44	22	170	116	84	11	332	175	259	6	587	154	545
2011	46	56	38	34	35	96	59	63	23	118	59	87	12	108	44	95	4	156	65	118
2012	19	67	38	42	7	51	34	31	3	30	22	15	0				0			
2013	99	49	27	37	75	80	37	66	52	102	61	69	32	138	68	109	17	207	104	167
2014	59	40	27	26	40	55	36	36	25	76	52	45	16	136	101	84	8	182	139	112
Avg (1985-2014)	48	92	65	52	31	156	107	91	17	241	164	137	14	179	97	137	7	283	116	236
5Yr Avg	57	53	32	34	40	74	47	48	25	99	62	60	14	179	97	137	7	283	116	236

(1) JTWC extended warning period from 72hrs to 120hrs in 2010. 96-hour and 120-hour data is not available prior to 2010.

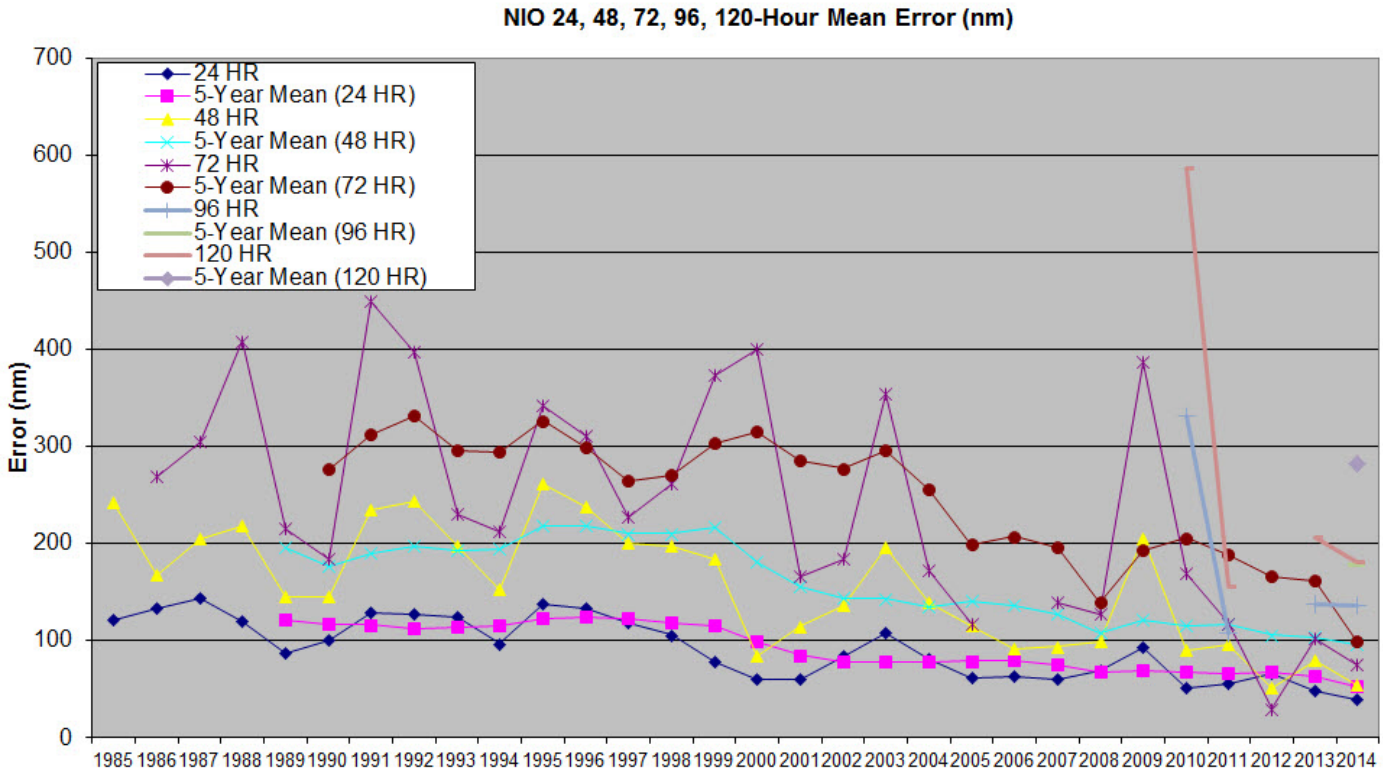


Figure 6-4. Graph of JTWC forecast errors and five year running mean errors for the north Indian Ocean at 24, 48, 72, 96, and 120 hours. (Note: No 96 HR, 120 HR data for 2012)

TABLE 6-3
MEAN FORECAST ERRORS (NM) FOR SOUTHERN HEMISPHERE
TROPICAL CYCLONES 1985 - 2014

	24-Hour				48-Hour				72-Hour				96-Hour				120-Hour			
Year (Notes)	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error	Cases	Mean Error	Cross Track Mean Error	Along Track Mean Error
1985	257	134	79	92	193	236	132	169												
1986	227	129	77	86	171	262	164	169												
1987	138	145	90	94	101	280	138	153												
1988	99	146	83	98	48	290	144	246												
1989	242	124	73	84	186	240	136	166												
1990	228	143	74	105	177	263	152	178												
1991	231	115	69	75	185	220	129	152												
1992	230	124	64	91	208	240	129	177												
1993	225	102	57	74	176	199	114	142												
1994	345	115	68	77	282	224	134	147												
1995	222	108	55	82	175	198	108	144	53	291	190	169								
1996	298	125	67	90	237	240	129	174	46	277	133	221								
1997	499	109	72	82	442	210	135	163	150	288	175	248								
1998	305	111	52	85	245	219	108	169	81	349	171	261								
1999	322	113	64	80	245	226	132	159	59	286	164	198								
2000	313	72	45	47	245	135	86	84	58	180	139	94								
2001	147	84	44	61	113	148	86	105	11	248	197	133								
2002	200	82	43	60	146	133	75	93	5	102	41	91								
2003	279	74	37	57	221	127	68	90	37	123	54	99								
2004	277	77	45	52	233	142	89	92	47	210	102	162								
2005	214	70	44	44	170	116	77	72	41	199	117	136								
2006	191	65	37	46	140	116	69	79	32	201	101	151								
2007	186	74.9	41	52	131	147	80	105	3	173	146	73								
2008	269	61	38	40	211	106	64	72	27	97	53	65								
2009	166	74	42	51	118	128	74	89	14	114	89	54								
2010	206	66	40	45	161	109	67	57	125	149	76	109	89	207	117	145	64	276	159	191
2011	164	53	32	34	127	81	50	54	88	109	62	76	54	173	114	107	31	274	205	151
2012	187	58	33	41	145	99	53	72	117	149	71	116	91	202	96	162	64	272	149	192
2013	216	49	28	34	175	80	45	54	140	114	63	78	103	138	72	101	69	166	76	131
2014	180	53	28	39	132	90	47	65	95	133	64	102	69	162	83	122	50	198	98	147
Avg (1985-2014)	235	95	54	67	185	177	100	123	61	190	110	132	81	176	96	127	56	237	137	162
5Yr Avg	187	59	34	41	143	98	56	65	97	128	71	89	81	176	96	127	56	237	137	162

(1) JTWC extended warning period from 72hrs to 120hrs in 2010. 96-hour and 120-hour data is not available prior to 2010.

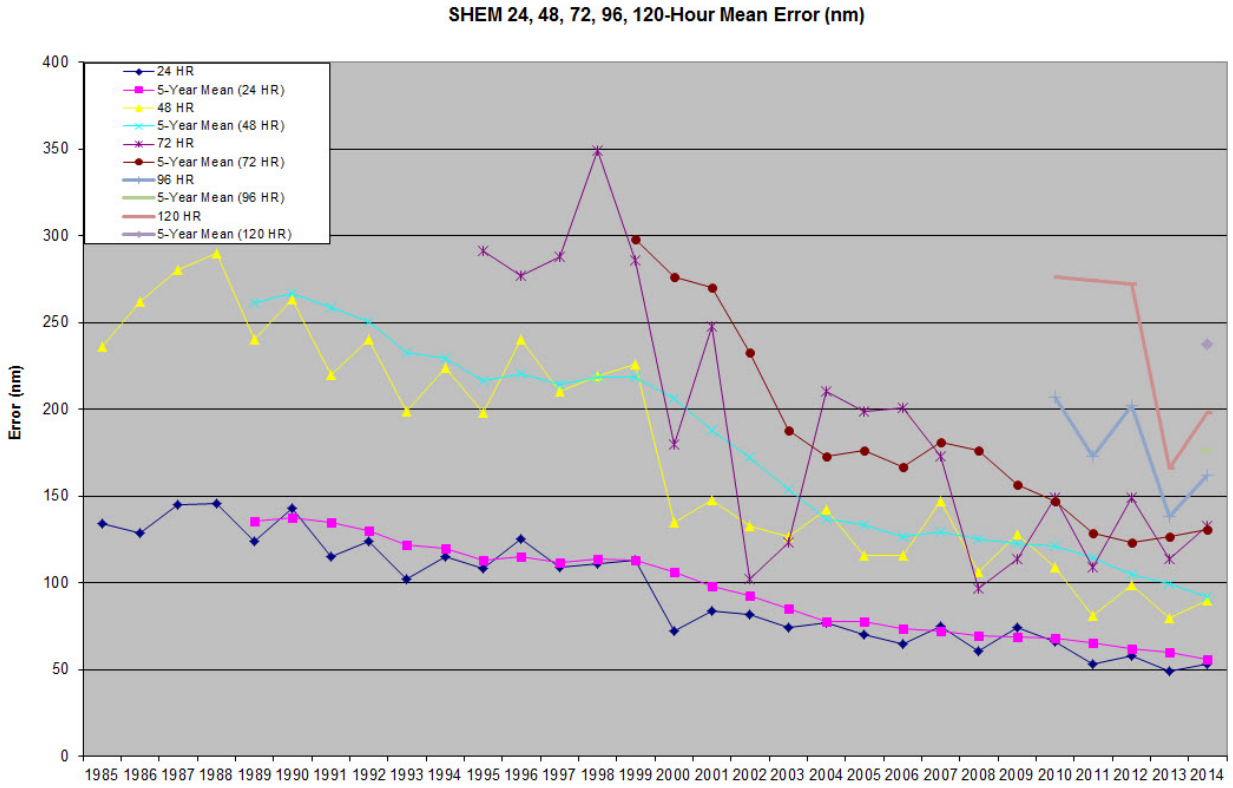


Figure 6-5. Graph of JTWC forecast errors for the Southern Hemisphere at 24, 48, 72, 96, and 120 hours.

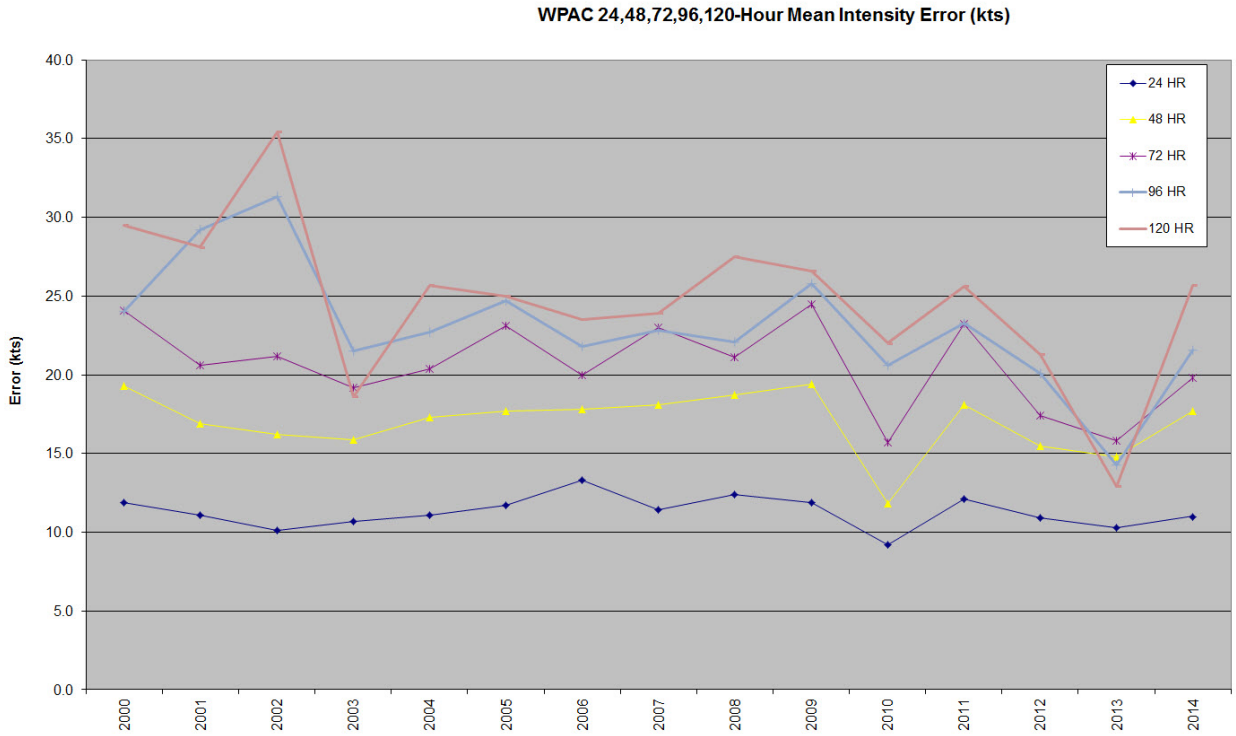


Figure 6-6. Graph of JTWC intensity forecast errors for the western North Pacific at 24, 48, 72, 96, and 120 hours.

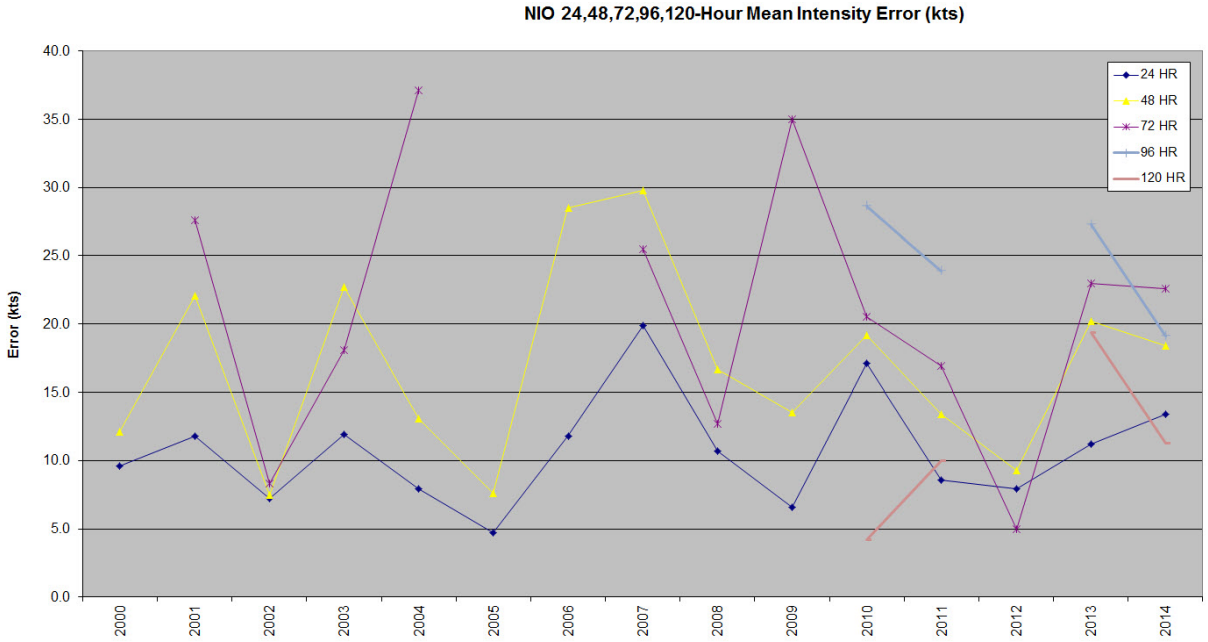


Figure 6-7. Graph of JTWC intensity forecast errors for the North Indian Ocean at 24, 48, 72, 96, and 120 hours. (Note: No 96 HR, 120 HR data for 2012)

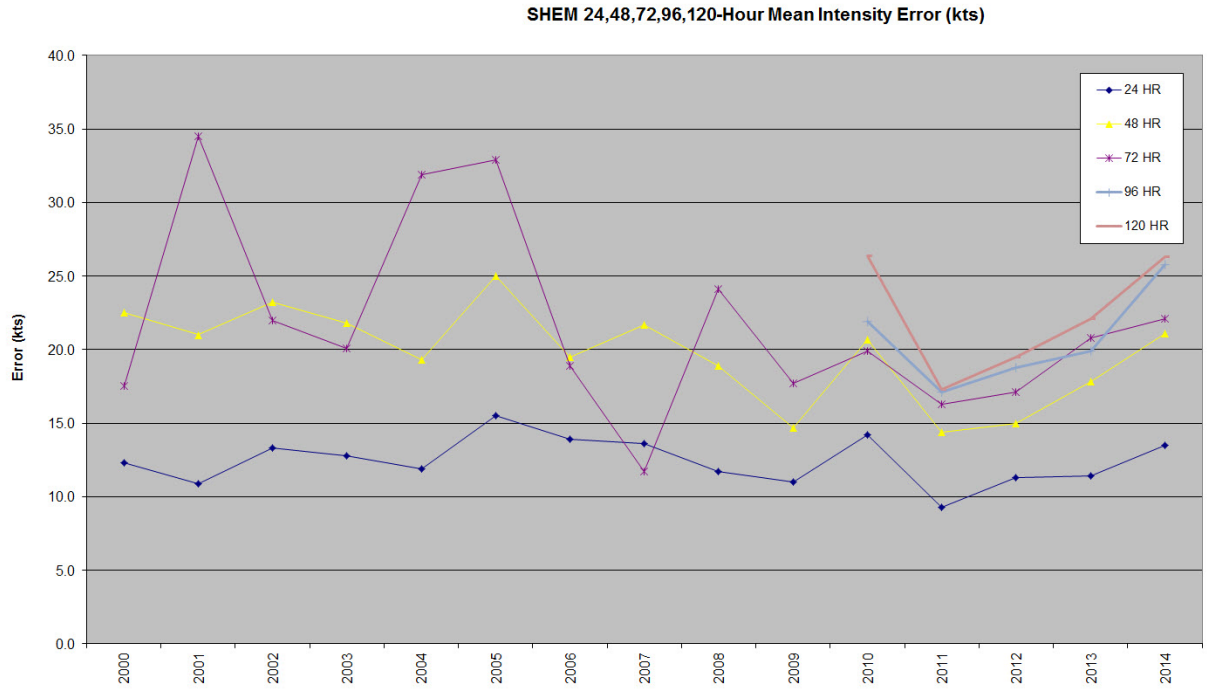


Figure 6-8. Graph of JTWC intensity forecast errors for the Southern Hemisphere at 24, 48, 72, 96, and 120 hours.