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METEOROLOGY SUPPORT AT THE JOINT WARNING CENTER, GUAM DURING OPERATION DESERT STORM (ODS)

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1. INTRODUCTION

Since 1977, I have been associated with the U. S. Navy Reserve (after 4 years on active duty 1973-1977) and currently serve as the Training Officer (Lieutenant) for a Naval Reserve weather (oceanography) unit based in Dallas, TX. In the event of a war or major crisis, I am to report to the Naval Oceanography Command Center/Joint Typhoon Warning Center (NOCC/JTWC) located on the island of Guam in the middle of the Northwest Pacific Ocean (NWP).

My job description while working at the JTWC is that of Typhoon Duty Officer (the equivalent of a hurricane forecaster at the National Hurricane Center). The JTWC has an area of responsibility (AOR) that extends from the dateline (180° E) to the east coast of Africa (Fig. 1). This AOR includes 6 of the 8 active tropical cyclone basins (western North Pacific Ocean/South China Sea, Bay of Bengal, Arabian Sea, Southwest Pacific Ocean, Southeast Indian Ocean and Southwest Indian Ocean) with approximately 70% of the global total of tropical cyclones developing in this area (Fig. 2). During a normal year, the JTWC will warn on approximately 60 tropical cyclones during all 12 months and experience at least 35 multiple storm situations. Warnings are issued every 6 hours in the northern hemisphere with forecasts out to 72 hours and every 12 hours with forecasts out to 48 hours in the southern hemisphere. This difference is primarily due to the large expanse of open ocean areas and the limited number of U.S. assets. However, when a major tropical cyclone threatens U.S. assets, warnings are then issued every 6 hours.

In early February I was recalled to active duty to support Operation Desert Storm (ODS). During ODS I assisted the NOCC with the preparation of specific forecasts for various operations, but, due to the short duration of the war, I spent most of my time with JTWC forecasting tropical cyclones. Since most of the specific ODS operations remain classified, this paper will focus on the unclassified operations of the Joint Typhoon Warning Center.

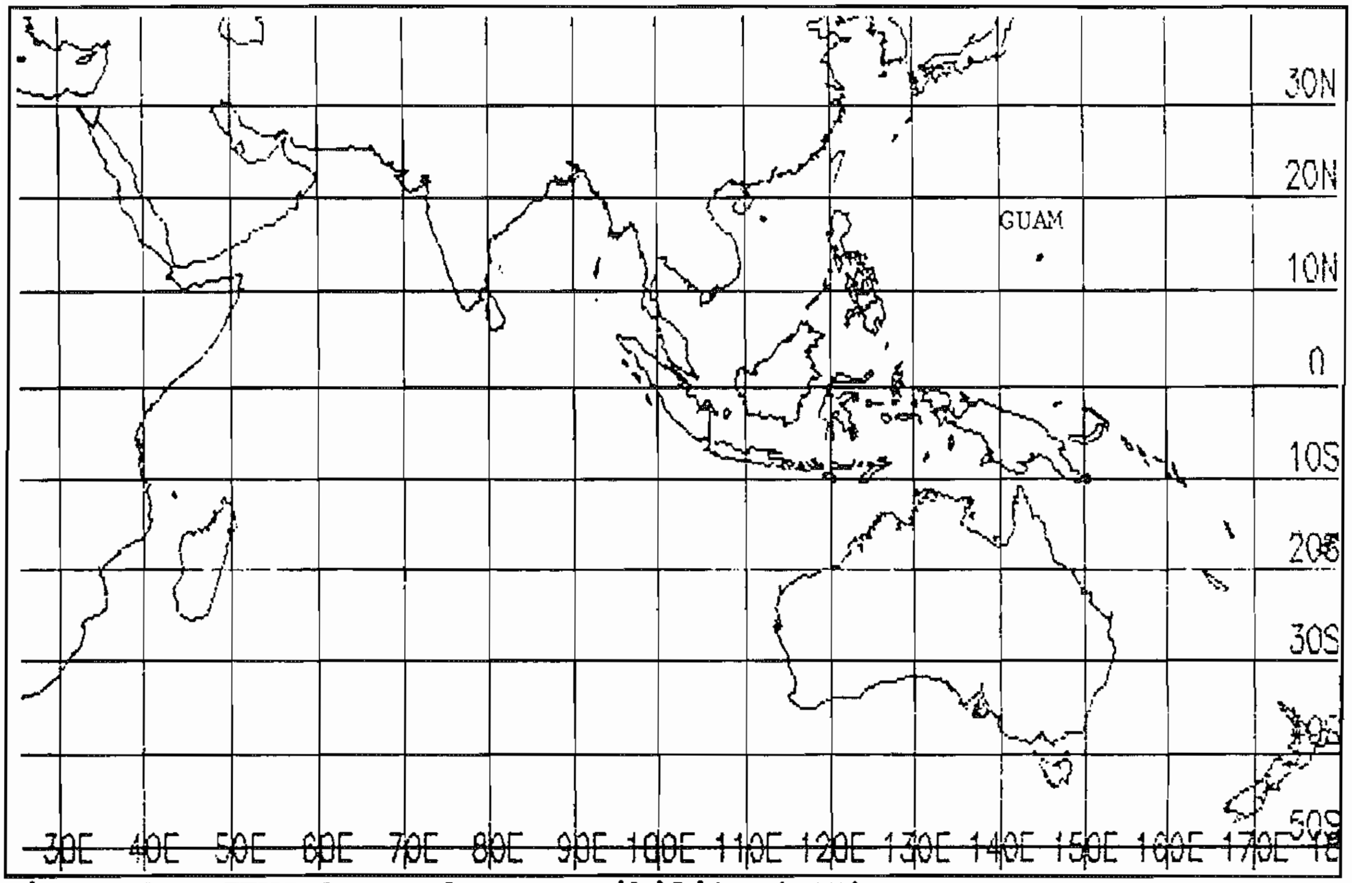


Figure 1. JTWC Area of Responsibility (AOR).

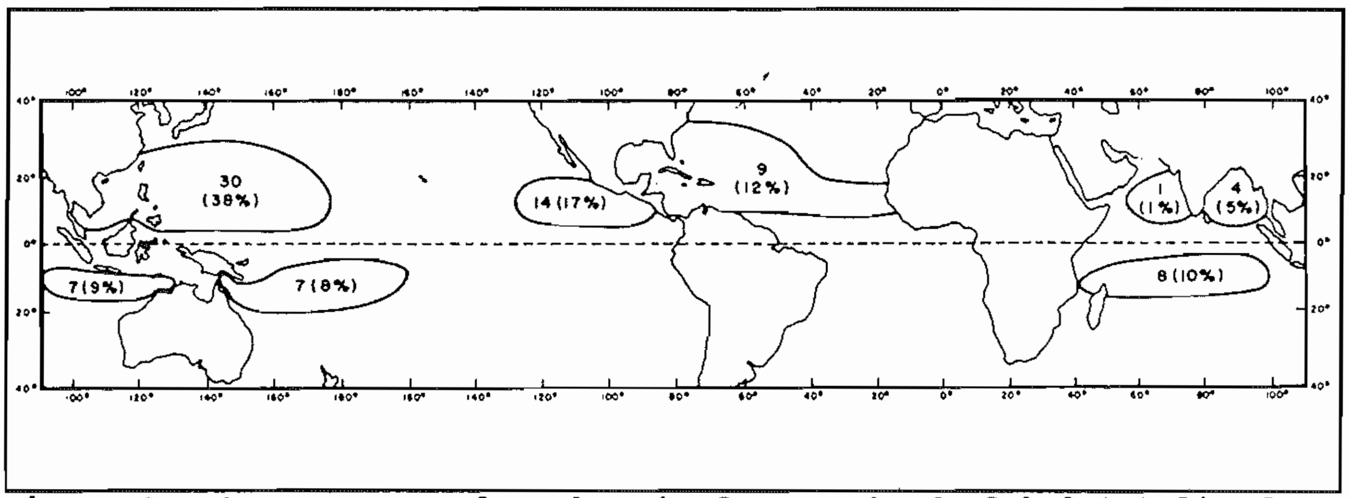


Figure 2. Average annual number (and percent of global total) of tropical cyclones ($\geq$ 34 kt) for each ocean basin (Gray, 1968).

2. TROPICAL CYCLONE FORECASTING PROCEDURES

A. Track Forecasts

Most tropical cyclone forecast centers use similar procedures for positioning tropical cyclones and preparing forecast tracks, which usually includes the use of plastic overlays and grease pencils. However, due to the frequent occurrence of multiple storm situations and the requirement for additional personnel to augment the watch during such situations, the JTWC developed and implemented the Automated Tropical Cyclone Forecast (ATCF) system in 1988.

The ATCF system is designed to run on local personal computers that both receive and transmit data to and from the Fleet Numerical Oceanography Center (FNOC) in Monterey, CA, extract and consolidate analysis and forecast data input by the TDO, and generate the warning message and various warning-related graphics. This enables the TDO to spend more time analyzing the synoptic environment and the various objective forecast aids (models) rather than performing menial and time consuming tasks such as numerical checksums, spell checks, etc. The ATCF system now allows one TDO to easily work 3 tropical cyclones at one time (a common situation during the NWP season), which in the recent past would require the addition of another TDO.

An updated "working best track" for a tropical cyclone is maintained throughout the lifetime of a storm. The initial position of a tropical cyclone is determined primarily by satellite over the sparse data regions of the open ocean areas (note: Air Force reconnaissance flights into tropical cyclones ceased in August 1987). The TDO also has various objective analysis products available from the FNOC and other government meteorological agencies (e.g. NMC). However, the three most important pieces of data available to the TDO are hand plotted and analyzed surface/gradient level and 200mb streamline charts and environmental satellite data. By combining the streamline analyses with visual and enhanced infrared satellite data, the forecaster can better comprehend the overall organization and surrounding environment associated with a tropical cyclone which can assist in determining future motion.

Once the initial position of a tropical cyclone has been determined, the TDO then prepares the forecast track by using various objective forecast aids received by the ATCF system from FNOC. However, persistence is weighted heavily during the first 12 hour forecast period and is usually blended to some degree into the other aids.

The forecast aids available to the JTWC are climatological, statistical, and dynamic and the option to generate a blend of the best past-performing models. During climatological situations, such as in the case of "straight-runners" (storms that basically track west-northwestward), the climatological models tend to be the best performers (with the dynamic models running a close second), whereas the dynamic models perform best during aclimatological situations (mainly due to better handling of storm interaction with the steering environment. However, the forecast track of a tropical cyclone should always be tempered by persistence, continuity (both time and space), and the forecaster's meteorological experience in the early forecast periods.

Although an active duty TDO's tour length is only for 2 years, a JTWC forecaster gains "immediate experience" due to the nearly continuous warning mode in which the center operates. JTWC's average 24-, 48- and 72-hour forecast errors during the past 5 years are 112nm, 236nm, and 370nm, respectively, which compares well with other tropical cyclone forecast centers, despite the continuous turnover of forecasters.

B. Intensity Forecasts

Due to the loss of aircraft reconnaissance, initial tropical cyclone intensities are based upon satellite analyses and a technique developed by Dvorak (1984). The algorithm developed by Dvorak extracts two temperatures from the IR data and relates them to current intensity (Fig. 3). A 55 km (30 nm) circle centered on the eye is used to find the surrounding temperature. The intensity of a tropical cyclone increases

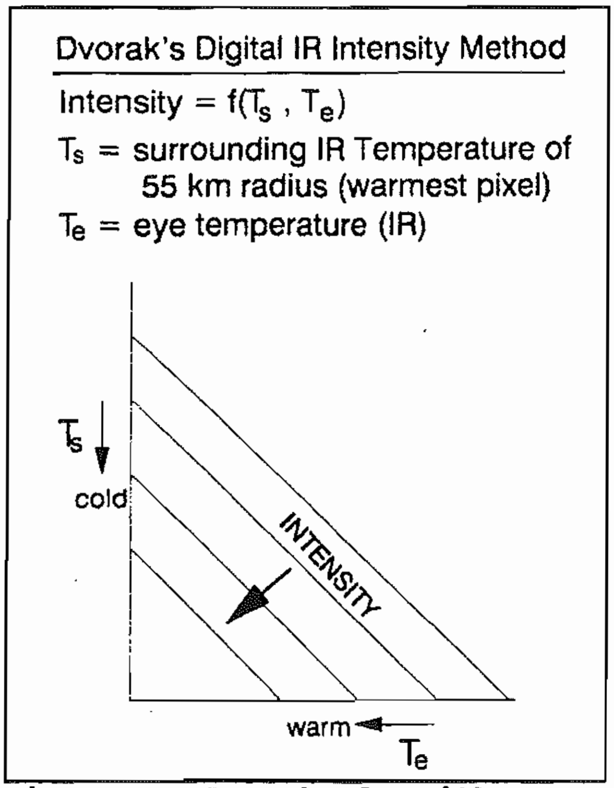


Figure 3. Dvorak algorithm for estimating tropical cyclone intensity from digital IR data

MAXIMUM SUSTAINED WIND SPEED (KT) AND MINIMUM SEA-LEVEL PRESSURE (MSLP) AS A FUNCTION OF DVORAK T-NUMBER.

T-NUMBER	WIND SPEED	MSLP (MB) (NW PACIFIC)
0.0	<25	< 1003
0.5	25	< 1003
1.0	25	≤ 1003
1.5	25	1002
2.0	30	1000
2.5	35	997
3.0	45	991
3.5	55	984
4.0	65	976
4.5	77	966
5.0	90	954
5.5	102	941
6.0	115	927
6.5	127	914
7.0	140	898
7.5	155	879
8.0	170	858

Table 1.

as the surrounding temperature (T_s) decreases. The warmest IR pixel in the eye is the other temperature, and intensity increases as the eye temperature (T_e) increases. Dvorak expresses intensity in terms of an index or "T-number" corresponding to typical daily intensity changes (Zehr, 1989). Table 1 indicates the relationship between the T-number and maximum sustained wind speed (kt) and equivalent minimum sea-level pressure (MSLP) for northwest Pacific Ocean tropical cyclones (Atkinson and Holliday, 1977).

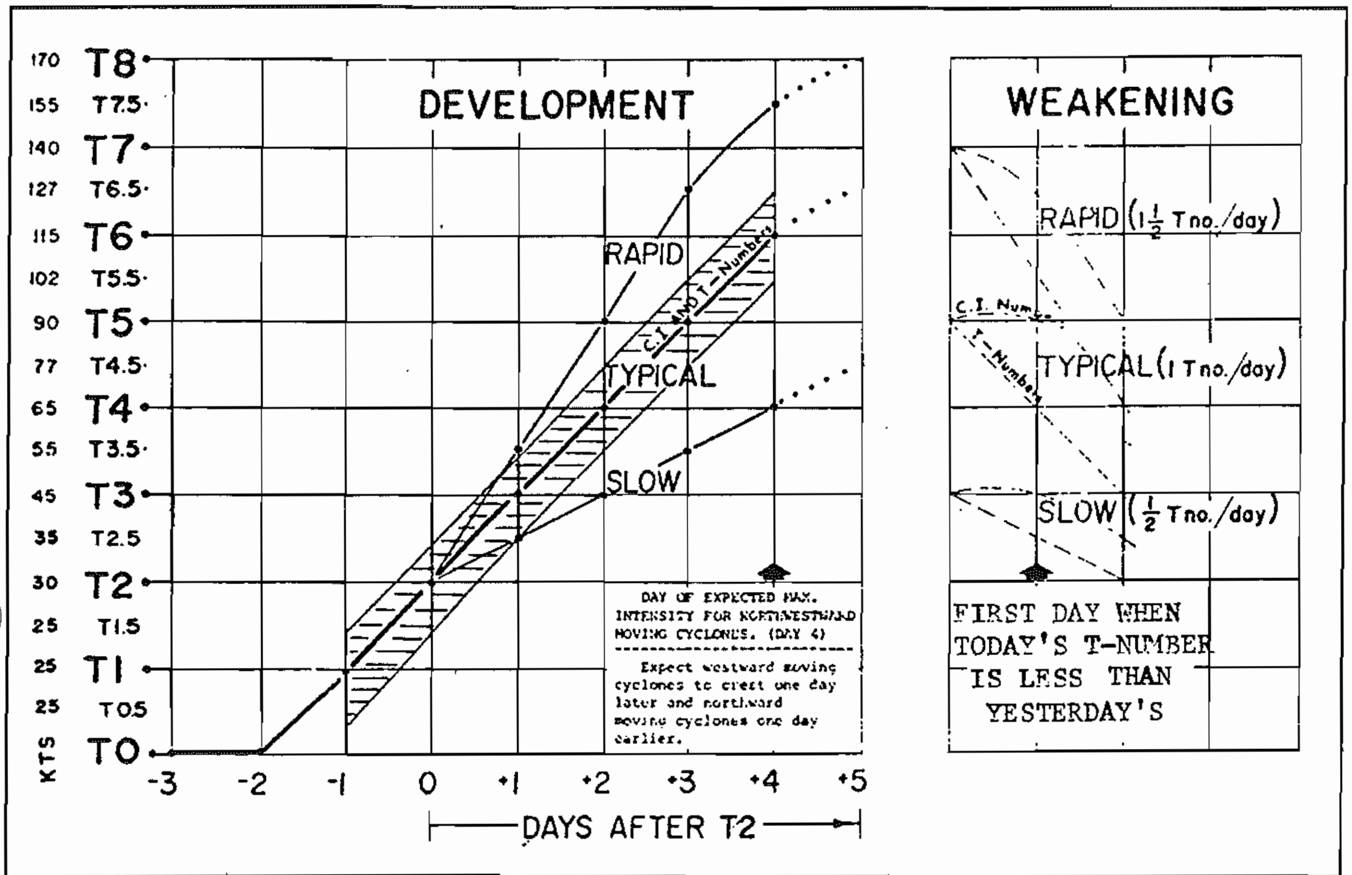


Figure 4. Intensity change curves for a model cyclone (Dvorak, 1975)

The Dvorak satellite intensity analysis technique (with some minor modifications) has worked well in the JTWC's AOR for several years now. However, tropical cyclone intensity forecasting is a little less objective than intensity analysis. Included in Dvorak's analysis method is an objective forecast scheme (Fig. 4) that can be used to determine the future intensity of a tropical cyclone based on the current intensity and past 24 hour intensity trend. A typical intensity change is one T-number per day (20-25 kt per day) and this is usually the "first guess" for an intensity forecast unless the TDO feels that environmental conditions favor a slower or faster rate of intensity change.

Strong vertical wind shear is detrimental to maintaining a vertical warm-core structure and usually results in slow intensification or even a decrease in intensity. System interaction with orographic features or cold water can also result in a slower than normal intensity increase or a weakening trend.

A faster than normal intensity increase is one of the more challenging aspects to tropical cyclone forecasting in the NWP basin. Of the thirty tropical cyclones that will normally develop in this basin, 6 to 8 of the storms will undergo rapid deepening (decrease in MSLP of 1.25 mb/hr for 24 hours, Holliday and Thompson, 1979) or explosive deepening (decrease in MSLP of 2.5 mb/hr for 12 hours or 5.0 mb/hr for six hours, Dunnavun, 1981). Those phenomena occur most frequently in late Spring and in the Fall, and between Guam and the Philippine Islands. Based on a dynamic tropical cyclone model developed by Emanuel (1989) and analyses of several years of synoptic data, rapid intensification appears to be associated with a large sea-surface/lower stratospheric temperature differential and weak (no-shear) environmental winds.

3. SOME TROPICAL CYCLONES DURING ODS 1991

During my 3 month recall to active duty at the JTWC, I had the opportunity to issue forecasts for 16 tropical cyclones (12 southern hemisphere and 4 northern hemisphere storms), including the devastating Bay of Bengal tropical cyclone that struck Bangladesh. Seven of the storms were classified as erratic moving storms due to either making small loops or remaining quasi-stationary for up to 48 hours (as was the case with many of the southern hemisphere storms). Included in this section are three tropical cyclones which cover the intensity spectrum from weak tropical storm (35-40 kt) to supertyphoon ($\geq$130kt).

A. Tropical Storm Vanessa (03W)

Tropical Storm Vanessa developed at 1200 UTC on 23 APR 1991 after tracking westward for nearly 5 days as a broad circulation from the surface to 300 mb. However, the MSLP near the center was in excess of 1008 mb which is unusually high for tropical cyclogenesis in the NWP. When the first warning was issued, synoptic data indicated the MSLP was only 1007 mb. However, a nearby upper-air sounding indicated winds of 30 to 35 kt only 1000 ft above the surface and extended vertically to 10000 feet MSL. It was believed that those winds would eventually work down to the surface due to the downward transport of horizontal momentum within the deep convection near the system center. Six hours after the initial warning(23/1800Z), several ship reports within 90 nm of the center indicated sustained winds of 30 to 40 kt. Figure 5 is the preliminary final best track of Tropical Storm Vanessa (WP0391) and Table 2 contains the forecast statistics (position errors are in nautical miles and wind errors are the relative speed difference in knots). Since Vanessa was a classic "straight-runner", 24-, 48-, and 72-hour forecast errors (71, 108, and 132 nm) were better than JTWC's average. However, tropical cyclones can also make your error statistics take a beating as will be shown in the next case of Typhoon Tim.

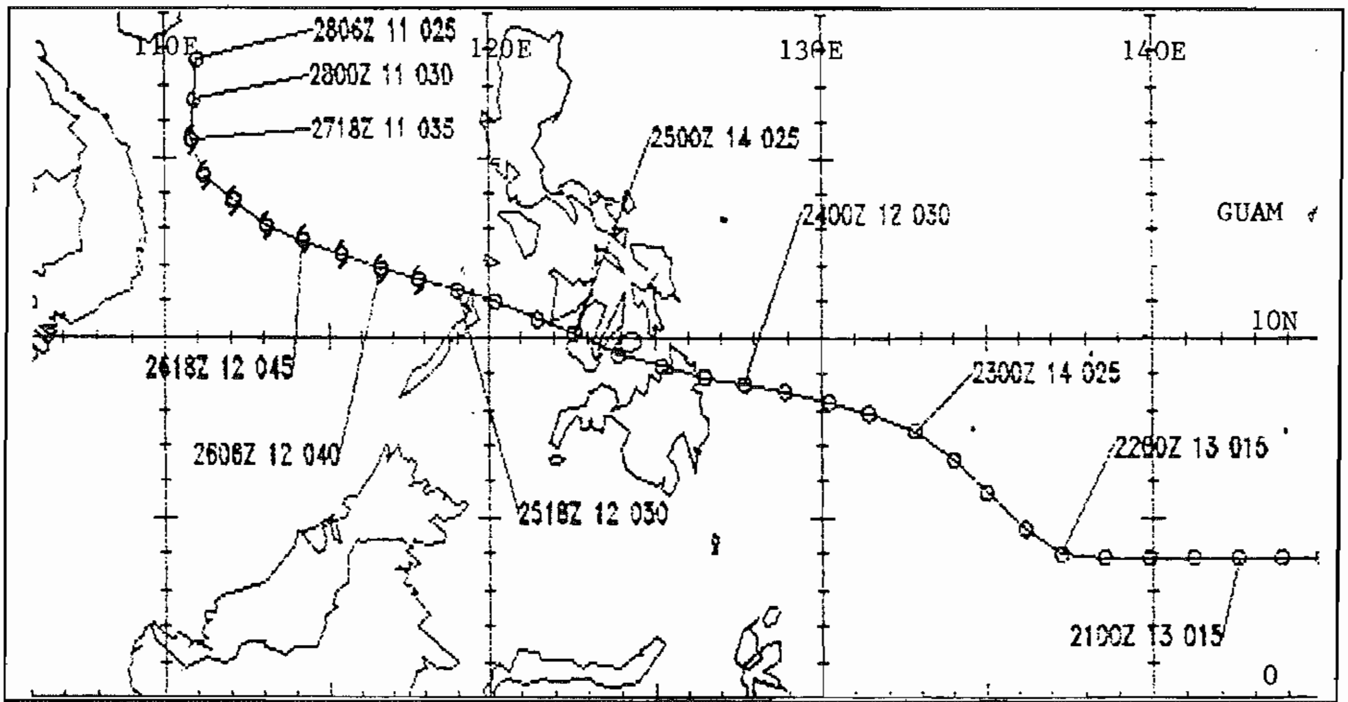


Figure 5. Preliminary Final Best Track for Tropical Storm Vanessa

STATISTICS FOR JTWC ON STORM WP0391 **(VANESSA)**

	WRN	BEST TRACK			POSITION ERRORS				WIND ERRORS			
DTG	NO.	LAT	LONG	WIND	00	24	48	72	00	24	48	72
91042312	1	8.2N	130.2E	25	5	53	74	68	5	5	10	5
91042318	2	8.5N	128.9E	30	13	24	84	114	0	5	10	5
91042400	3	8.7N	127.7E	30	11	85	150	158	0	10	5	5
91042406	4	8.9N	126.5E	30	8	115	156	135	0	10	0	5
91042412	5	9.2N	125.2E	30	13	84	105	121	0	10	5	0
91042418	6	9.5N	123.9E	30	21	63	95	127	0	10	5	5
91042500	7	10.1N	122.6E	25	5	13	37	141	0	0	0	10
91042506	8	10.5N	121.5E	25	5	13	63	188	0	-5	0	15
91042512	9	11.0N	120.2E	30	16	58	71		0	0	10	
91042518	10	11.3N	119.0E	30	29	90	73		5	-5	0	
91042600	11	11.6N	117.8E	35	29	48	145		0	-5	5	
91042606	12	11.9N	116.6E	40	13	54	242		-5	-5	10	
91042612	13	12.3N	115.4E	40	11	37			0	15		
91042618	14	12.7N	114.2E	45	5	72			0	20		
91042700	15	13.1N	113.1E	45	5	145			0	15		
91042706	16	13.8N	112.1E	45	13	186			0	15		
91042712	17	14.5N	111.2E	40	18				0			
91042718	18	15.5N	110.8E	35	5				0			
91042800	19	16.6N	110.9E	30	17				0			
91042806	20	17.7N	111.0E	25	0				0			

Table 2. Error statistics for Tropical Storm Vanessa

B. Typhoon Tim (02W)

Typhoon Tim developed at 0000 UTC on 21 MAR 1991 southeast of Guam in an early season, weak monsoon trough located over an area of above normal sea-surface temperatures. Tim began as a broad area of disorganized convection beneath an extremely large upper-level anticyclone (2500 nm diameter). There was a 4 to 1 ratio between the diameter of the upper-level anticyclone (ULAC) and the diameter of the outermost closed isobar of the surface circulation. The first warning prognostic reasoning message mentioned that most of the available kinetic energy was being used by the system to maintain and drive the ULAC rather than spin up the low-level vortex and, as a result, slower than normal intensification could be expected in the first 24 hours. A normal rate of intensification was expected during the 24 to 48 hour period, then no change in intensity due to its expected passage over cooler waters.

The track forecast was rather complex given the large break in the subtropical ridge to the north of the system. All the dynamic models indicated the ridge to the north would strengthen and that Tim would track westward. However, given that there was no upper-air data between Guam and the northern Philippine Islands and Taiwan for the models to work with, that scenario was considered suspect, especially since satellite imagery indicated two well-defined shortwave troughs tracking east-southeastward toward the break in the ridge axis. Figure 6 is a graphic presentation of the objective forecast aids available to support the first warning, the warning #1 forecast track (dashed line), and the final best track for Typhoon Tim.

The dynamic aids OTCM and FBAM, which are two of the JTWC's three best performing aids, indicated a westward track while the remaining aids indicated a northwest and eventual west-northwest track. However, there was concern about the large break in the subtropical ridge to the north of Tim which would cause the system to track northward along 150° E and miss Guam entirely.

In Figure 6 you will notice that the warning #1 forecast track is outside the objective forecast aids "envelope". The normal procedure is to stay somewhere within the "envelope" and the forecast was referred to as a "gutsy call" after it went out. However, based on the actual track and the error statistics for Tim (Table 3), the first two forecasts (warnings #1 and #2) weren't "gutsy" enough in the 48- and 72-hour forecast periods! This is an example of a common problem faced by tropical cyclone forecasters at the JTWC and elsewhere-- insufficient data over the open ocean areas for model initialization, particularly over the northern Pacific Ocean and the southern Indian Ocean.

This case also brings up the forecast problem of issuing the first few warnings on a nearly stationary, "sloppy" system. With an ill-defined circulation center constantly shifting around as the system attempts to organize, there is little or no reliable persistence with which the forecast models can work.

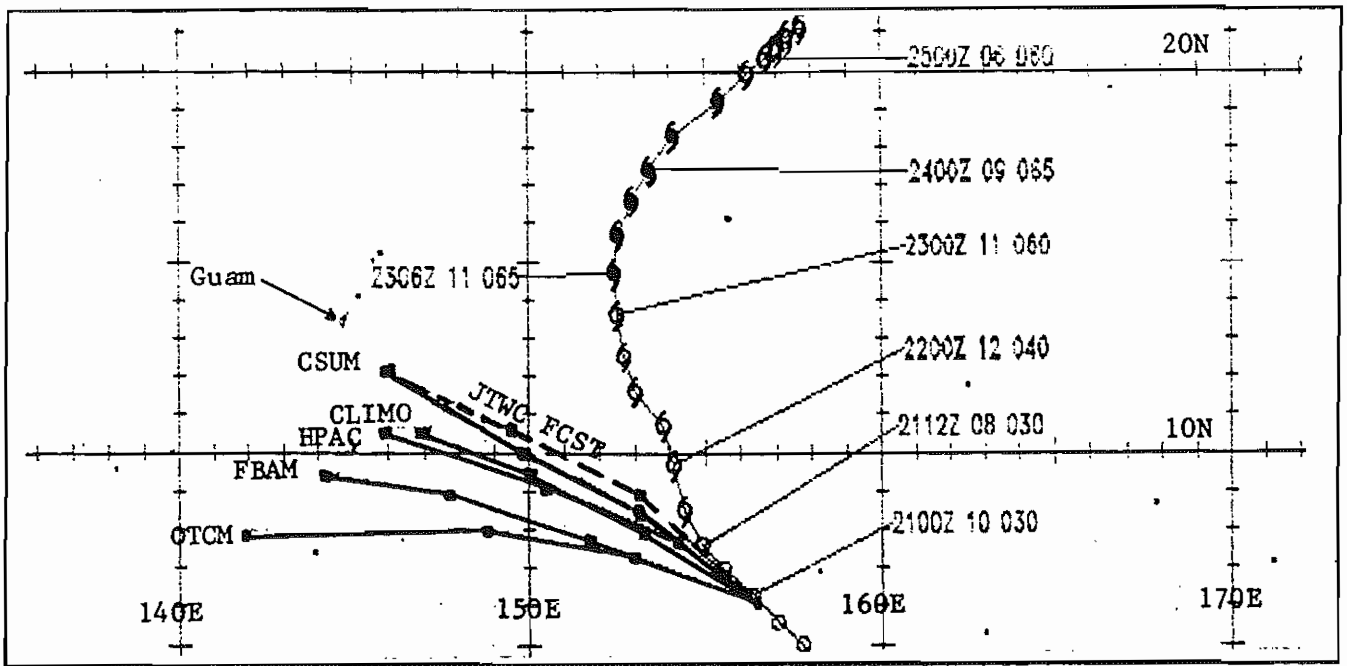


Figure 6. Warning #1 Objective Forecast Aids and Forecast Track, and Final Best Track for Typhoon Tim

STATISTICS FOR JTWC ON STORM WP0291 (TIM)												
	WRN	BEST TRACK			POSITION ERRORS				WIND ERRORS			
DTG	NO.	LAT	LONG	WIND	00	24	48	72	00	24	48	72
91032100	1	6.3N	156.3E	30	5	76	251	538	0	0	-10	-5
91032106	2	7.0N	155.5E	30	13	130	318	637	0	5	-10	0
91032112	3	7.6N	154.9E	30	8	151	376	757	0	0	-10	0
91032118	4	8.5N	154.4E	35	26	181	448	828	0	0	-10	10
91032200	5	9.7N	154.1E	40	16	124	354	603	-5	-5	0	15
91032206	6	10.7N	153.8E	40	21	69	261	393	-5	-15	-5	0
91032212	7	11.6N	153.0E	45	24	157	380	413	-5	-15	-5	5
91032218	8	12.5N	152.7E	50	8	175	396	402	0	-5	0	10
91032300	9	13.6N	152.5E	60	23	126	332		0	5	5	
91032306	10	14.7N	152.4E	65	26	152	309		-5	5	10	
91032312	11	15.7N	152.5E	65	6	165	222		0	0	10	
91032318	12	16.6N	152.9E	70	6	154	216		0	0	10	
91032400	13	17.4N	153.4E	65	8	74			0	0		
91032406	14	18.3N	154.1E	65	12	90			0	5		
91032412	15	19.2N	155.4E	65	6	231			0	10		
91032418	16	19.9N	156.2E	60	38	322			0	15		
91032500	17	20.3N	156.7E	60	24				-5			
91032506	18	20.6N	157.0E	50	13				0			
91032512	19	20.9N	157.3E	45	12				0			
91032518	20	21.1N	157.7E	35	5				0			
				AVERAGE	15	148	322	571				

Table 3. Error statistics for Typhoon Tim

C. Tropical Cyclone 02B (Bangladesh Storm)

The Bay of Bengal is known as the genesis region for some of the most intense and, unfortunately, most deadly tropical cyclones in recorded history. A few examples of the devastation caused by Bay of Bengal storms are:

1737 - 300,000 people killed in Calcutta, India
1876 - 100,000 to 400,000 people killed in Backergunge, India
1970 - 200,000 to 500,000 people killed in East Pakistan (currently Bangladesh)

Unfortunately, to this list must now be added the enormous loss of life as a result of Tropical Cyclone 02B-- at last count, more than 140,000 people had been killed in Chittagong, Bangladesh (including the outlying coastal areas) and more than 8 million people left homeless.

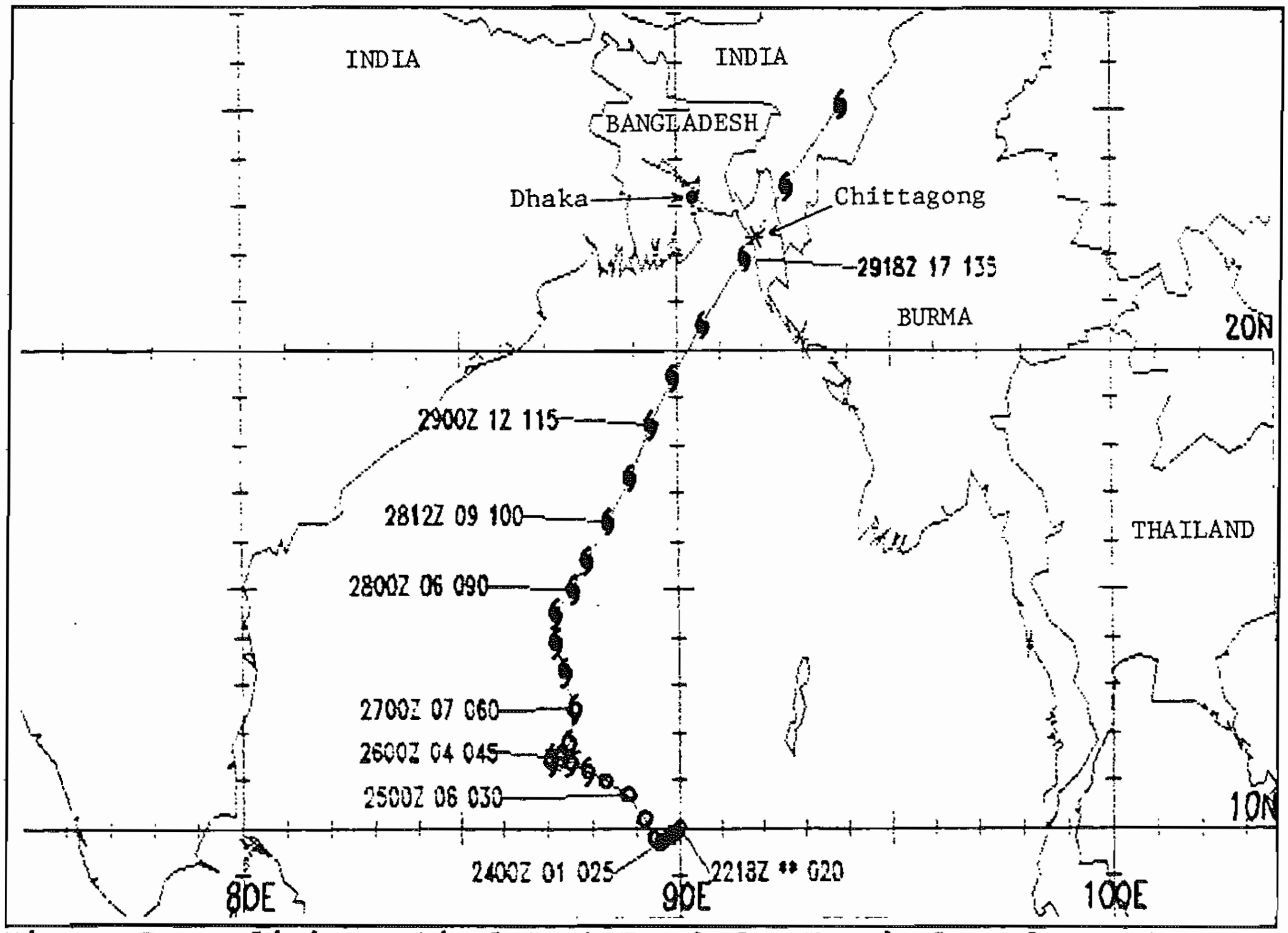


Figure 7. Preliminary Final Best Track for Tropical Cyclone 03B

TC 02B developed at 0000 UTC on 25 APR 1991 over the south central Bay of Bengal in an early season monsoon trough and over an area of above normal sea-surface temperatures. This system began as a large concentration of deep convection beneath a large ULAC, similar to that associated with Typhoon Tim. However, the low-level circulation associated with TC 02B covered the entire Bay of Bengal with southwesterly cross-equatorial flow of 20 to 25 kt occurring as far as 500 nm east and south of the center. Figure 7 is a graphic depiction of the preliminary final best track for TC 02B. Final error statistics were not available when I departed Guam 12 hours after the deadly storm made landfall. However, the running error statistics indicated that the JTWC handled this system extremely well, especially after 28/00Z when the storm began a steady climatological track to the north-northeast at forward speeds of 9 to 17 kt.

Based on the sea-surface temperature/lower stratospheric temperature differential and the no-shear environment in which the storm was embedded, TC 02B had the potential to reach an intensity of 135 kt-- a very aclimatological intensity for that time of the year. The following paragraphs are excerpts from the prognostic reasoning messages for warnings #8 and #9, issued at 26/12Z and 26/18Z, respectively:

...(261200Z1) SATELLITE IMAGERY DURING THE PAST 6 HOURS INDICATES TC 02B HAS REMAINED NEARLY STATIONARY WHILE MAKING A SMALL LOOP AND THIS IS THE REASON FOR RELOCATION. TC 02B HAS CONTINUED TO BECOME BETTER DEVELOPED AS THE CIRCULATION BEGINS TO CONTRACT. THE CENTRAL DEEP CONVECTION AND CONVECTIVE BANDING FEATURES HAVE INCREASED WITH SOME CLOUD TOPS NEAR -90C AND AN INDICATED DVORAK INTENSITY OF A STRONG T3.0 TO T3.5. LATEST IMAGERY ALSO INDICATES A POSSIBLE WARM SPOT DEVELOPING IN THE CENTRAL CONVECTION WHICH IS A PRECURSOR TO EYE DEVELOPMENT. THE UPPER-LEVEL OUTFLOW IS EXCELLENT ALL QUADRANTS WITH WELL-DEFINED POLEWARD AND EQUATORWARD OUTFLOW CHANNELS. TC 02B REMAINS IN A NO-SHEAR, WEAK STEERING ENVIRONMENT WHICH FAVORS A SLOW DRIFT TO THE NORTHWEST AND THE POSSIBILITY OF RAPID INTENSIFICATION. HOWEVER, RAPID INTENSIFICATION WILL NOT OCCUR UNTIL AN EYE BECOMES VISIBLE...

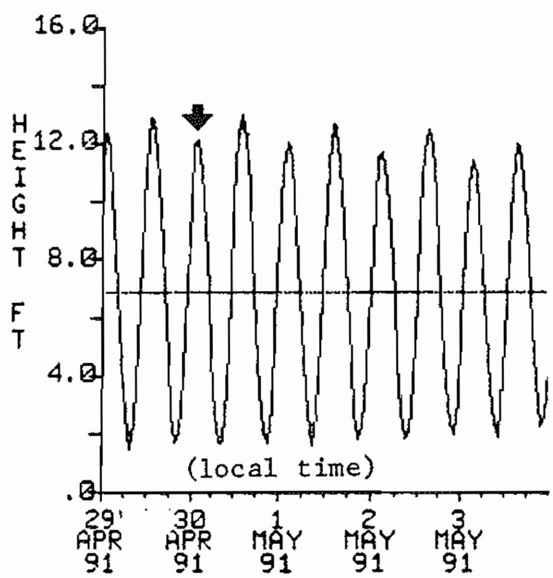
...(261800Z7)SATELLITE IMAGERY DURING THE PAST 6 HOURS INDICATES TC 02B CONTINUES TO DEVELOP AND INTENSIFY WHILE REMAINING NEARLY STATIONARY AND COMPLETING A SMALL LOOP. A WARM SPOT IN THE CENTRAL DEEP CONVECTION, A PRECURSOR TO EYE DEVELOPMENT, HAS PERSISTED FOR MORE THAN 6 HOURS. HOWEVER, TC 02B IS A VERY LARGE SYSTEM AND IT WILL TAKE ANOTHER 6 TO 12 HOURS FOR THE SYSTEM TO CONTRACT ENOUGH TO GENERATE AN EYE FEATURE. OUTFLOW REMAINS EXCELLENT ALL QUADRANTS WITH TWO WELL-DEFINED OUTFLOW CHANNELS. TC 02B IS LOCATED IN A COL AREA WHICH IS PRODUCING LITTLE OR NO VERTICAL SHEAR AND ALSO WEAK STEERING FLOW. AS A RESULT, TC 02B IS FORECAST TO STEADILY INTENSIFY AND DRIFT SLOWLY NORTHWESTWARD. SOME ERRATIC MOVEMENT SHOULD ALSO BE EXPECTED...

The JTWC remained in nearly continuous contact with the American embassy in Dhaka, Bangladesh after 28/12Z when the system began a steady track to the north-northeast. During the period from 28/00Z to 29/00Z, all objective forecast aids were in remarkable agreement and converged on the area of southeast Bangladesh, particularly in the area of Chittagong. Figure 8 is the astronomical tide data for Chittagong.

UNCLASSIFIED EXTREME TIDAL HEIGHTS
STATION: CHITTAGONG
LOCATION: 2220N 9150E

29 APR 91				
HEIGHTS:	12.33	1.49	13.08	1.63
LOCAL TIME:	0100	0800	1324	2024
ZULU TIME:	1900	0200	0724	1424
30 APR 91				
HEIGHTS:	12.25	1.56	13.02	1.71
LOCAL TIME:	0130	0830	1348	2048
ZULU TIME:	1930	0230	0748	1448
1 MAY 91				
HEIGHTS:	12.08	1.66	12.84	1.83
LOCAL TIME:	0200	0854	1418	2118
ZULU TIME:	2000	0254	0818	1518
2 MAY 91				
HEIGHTS:	11.81	1.78	12.53	2.01
LOCAL TIME:	0230	0924	1454	2148
ZULU TIME:	2030	0324	0854	1548
3 MAY 91				
HEIGHTS:	11.46	1.96	12.11	2.23
LOCAL TIME:	0300	0954	1524	2218
ZULU TIME:	2100	0354	0924	1618

UNCLASSIFIED TIDE STATION PREDICTION
DATES: 29 APR 91 - 09 MAY 91
STA: CHITTAGONG
TIME MERIDIAN: 09000E



MEAN LEVEL ABOVE DATUM (6.9FT)

Figure 8. Frequency of Tidal Extrema for Chittagong, Bangladesh

TC 02B could not have crossed the coast of Bangladesh at a worse time (approximately 29/1900Z). Figure 8 indicates that astronomical high tide occurred at Chittagong at 29/1930Z (30/0130 local time)-- almost identical to the time of eye passage.

The eye diameter of TC 02B was approximately 40 nm just prior to making landfall. Adding another 5 to 10 nm for the radius of maximum winds meant that the final radius of 135+ kt winds would have been 50 to 60 nm in diameter! Those winds, along with an expected storm surge of 20+ ft, and a 12+ ft astronomical tide approaching more than 20 million poverty stricken people meant that a disaster was imminent. Although the JTWC had advised the American embassy to begin relief efforts more than 48 hours before the storm made landfall, a sense of urgency could still be felt in the following message traffic between the two offices:

UNCLAS//NO3145//
SUBJ: TROPICAL CYCLONE WARNING RECEIPT
MSGID/GENADMIN/NAVOCEANCOMCEN GQ//
REF/A/RMG/NAVOCEANCOMCEN GQ/290755Z APR 91//
AMPN/REF A IS TROPICAL CYCLONE 02B WARNING NR 19//
RMKS/
1. IMMEDIATE DELIVERY REQ TO AMEMBASSY DHAKA.
2. TROPICAL CYCLONE 02B IN THE BAY OF BENGAL IS REGARDED AS A VERY DANGEROUS THREAT TO PROPERTY AND LIVES IN THE COUNTRY OF BANGLADESH. REFERENCE A IS OUR MOST RECENT WARNING ON THIS STORM AND HAS BEEN RE-TRANSMITTED TO YOUR EMBASSY.
3. THIS TROPICAL CYCLONE IS NOW ESTIMATED TO HAVE MAXIMUM SUSTAINED WINDS OF 130 KNOTS (150 MPH) WITH GUSTS TO 160 KNOTS (185 MPH). THESE WIND ESTIMATES ARE REPORTED USING THE UNITED STATES STANDARD OF ONE MINUTE AVERAGING AND ARE HIGHER THAN WINDS REPORTED USING OTHER AVERAGING TECHNIQUES. AT 0600 UTC ON 29 APRIL, THE CYCLONE WAS LOCATED NEAR 19.4N LATITUDE 89.8E LONGITUDE AND WAS MOVING NORTH-NORTHEAST AT 11 KNOTS (13 MPH). THIS CYCLONE IS COMPARABLE TO SEVERE HURRICANES WHICH OCCASIONALLY STRIKE THE EAST COAST OF THE UNITED STATES. ADDITIONALLY, THE CYCLONE WILL CAUSE ABNORMALLY HIGH SEAS, SEVERE WIND DAMAGE, AND SUBSTANTIAL FLOODING THROUGHOUT THE NEXT 72 HOURS TO THE REGION EXTENDING EASTWARD FROM CALCUTTA TO THE IRRAWADDY RIVER PLANE IN BURMA.
4. REQUEST YOU ACKNOWLEDGE RECEIPT OF REFERENCE A AND THIS MESSAGE IF POSSIBLE. THE CORRECTED PHONE NUMBERS OF THE JOINT TYPHOON WARNING CENTER IS 671-344-4224 OR 671-344-5240 IF YOU WISH TO DISCUSS THE CYCLONE.//

****291046Z AMERICAN EMBASSY REPLY****

ZOV DETECTED

PRIORITY

P 291046Z APR 91

FM AMEMBASSY DHAKA

TO NAVOCEANCOMCEN GQ

BT
UNCLAS DHAKA 03233

E.O. 12356: N/A
TAGS: EAID
SUBJECT. TROPICAL CYCLONE WARNING RECEIPT
REF: (A) RMG/NAVOCEANCOMCEN REQ 290155Z
- (B) NAVOCEANCOMCEN GQ JTWC
ACKNOWLEDGE RECEIPT OF REFS A AND B. POST HAS ALERTED AMERICAN CITIZENS IN BANGLADESH ABOUT THE STORM THROUGH ITS WARDEN SYSTEM. USAID MISSION IS ALSO WORKING CLOSELY WITH THE BDG AND OTHER MISSIONS TO ASSURE PREPAREDNESS.
BT

When I returned to work on the morning of the 30th after a 48 hour break between watches, the satellite loop indicated TC 02B was indeed headed for Chittagong. Words can not fully describe the sickening feeling of helplessness we all felt for the people of southeast Bangladesh is we watched the system plow onshore.

4. SUMMARY

Tropical cyclone forecasting is one of the more challenging aspects of operational meteorology. Although numerical modeling changes during the past 30 years have helped to improve forecasts in the mid-latitudes, statistics also reveal that dynamic numerical models still perform poorly in the tropics, particularly in those regions 15° either side of the equator. It is in this latter region where the greatest improvement in tropical cyclone forecasting has been realized through the use of more sophisticated numerical forecast models. Overall, though, forecasting tropical cyclones still rests primarily upon two major factors: (1) persistence and (2) the age old saying-- "there is no substitute for experience".

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