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Forecasting Development



Forecasting Research Technical Report No. 355

SUMMARY of TROPICAL CYCLONE ACTIVITY and FORECASTS in the 2000
NORTHERN HEMISPHERE SEASON

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June 2001

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1. INTRODUCTION

A summary of tropical cyclone activity in the northern hemisphere for the 2000 season is presented below together with an assessment of the performance of the Met Office global model in predicting the tracks of these tropical cyclones.

Tropical cyclones are experienced in the North Pacific, North Atlantic and North Indian Oceans and nearby tropical seas. For the purpose of tropical cyclone verification the northern hemisphere is divided into four basins; the North-West Pacific (west of 180°E to the Malay Peninsula), the North-East Pacific (east of 180°E), the North Atlantic and the North Indian Ocean (west of the Malay Peninsula). Mean error statistics for each basin are presented together with a table of statistics for the whole northern hemisphere. The global model produces a 6-day forecast every 12 hours. Verification is performed at 24 hour intervals up to forecast time T+120.

The global model resolution in operation during the season was 0.83°x 0.55°x 30 levels. This is equivalent to a horizontal resolution of 93km x 62km at the equator. The tropical cyclone verification scheme identifies the centre of a tropical cyclone in the model by locating a local maximum of relative vorticity at 850hPa. A surface fitting technique is used to locate the centre accurately.

The terms used in the statistics tables are explained below :-

Possibly verified	- No. of forecasts fulfilling requirements 1, 2 & 4 below.
Detection Rate	- Percentage of possibly verified forecasts which also fulfil requirement 3 below.
Mean DX	- Mean of positional errors in the East-West direction.
Mean DY	- Mean of positional errors in the North-South direction.
Mean AT	- Mean of positional errors in the Along Track direction.
Mean CT	- Mean of positional errors in the Cross Track direction.
Skill	- Percentage skill of model against CLIPER.
Mean DPE	- Mean of direct positional errors.

All errors are measured in kilometres except where indicated.

- (*)
1. Observed maximum wind at least 31 knots at the verifying time.
 2. Forecast tropical cyclone centre equatorwards of 45 degrees.
 3. Forecast tropical cyclone centre relative vorticity above a critical limit for verification (0.7×10^{-4} per second).
 4. Observation within 6 hours of verifying time present for use in verification.

Forecast skill is defined as:-

$$(\text{CLIPER DPE} - \text{Model DPE}) / \text{CLIPER DPE} \times 100\%$$

Positive skill indicates the model forecast is better than CLIPER.

Negative skill indicates the CLIPER forecast is better than the model.

A diagrammatic explanation of other error statistics and their sign conventions can be found in Appendix A. Full details of the TC verification scheme can be found in *NWP Gazette, Vol.1, No.2, December 1994*.

Advisory positions from JTWC Hawaii, NHC Miami and CPHC Honolulu are used as verifying observations of storm location when track verification is carried out immediately after a storm has ended. Best track data from these centres has been obtained for this season's storms and the track forecasts verified again. Statistics for verification against best-track observations are presented in detail. Some statistics for verification against real-time observations are included for the purposes of a comparison and are denoted 'RT'. Some mean error statistics for last season are also included for the purposes of a comparison. Forecast tracks are only verified when a depression reaches tropical storm status.

2. TROPICAL CYCLONE ACTIVITY

	NWP	NEP	NAT	NI	TOTAL
Tropical Depressions (<34 knots)	8(10)	2(5)	4(4)	0(0)	14(19)
Tropical Storms (>34 knots, <64 knots)	10(12)	13(3)	6(4)	2(2)	31(21)
Hurricanes/typhoons (>64 knots)	15(11)	6(6)	8(8)	2(3)	31(28)
Total	33(33)	21(14)	18(16)	4(5)	76(68)

Basin name abbreviations:- NWP = North-West Pacific (west of 180°E)
NEP = North-East Pacific (east of 180°E)
NAT = North Atlantic
NI = North Indian

The number in brackets indicates the figure for the 1999 season.

3. SUMMARY OF ALL NORTHERN HEMISPHERE STORMS

3.1 North-West Pacific Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	250	199	156	116	82	55
Detection Rate (%)	100	100	100	95	95	96
Mean DX	-2	-10	-70	-194	-268	-254
Mean DY	-2	0	2	-22	-53	-103
Mean AT	-8	-44	-73	-107	-115	-129
Mean CT	-3	-2	-48	-99	-90	-13
Mean Skill (%)	*****	14	29	33	*****	*****
1999 Skill (%)	*****	30	40	35	*****	*****
Mean DPE	43	141	267	401	496	623
* 1999 DPE	40	125	208	331	490	367
RT DPE #	36	143	263	397	492	618

* DPE for all North-West Pacific storms in 1999 season

DPE in 2000 calculated using real time observations as opposed to best track.

Comments :

A plot of the observed tracks of all storms in this basin can be found in Fig. 1.

Although there was a similar number of storms to 1999, there were many more verifiable forecasts due to storms being longer lived. Forecast errors were higher than in 1999 and, up to T+72, were near to the values seen in the 1996 and 1997 seasons. Skill against CLIPER was slightly down on 1999, but higher than any previous year. There was a slight slow bias in forecasts overall.

Figs. 2 and 3 show forecast errors and skill scores for the last few seasons.

3.2 North-East Pacific Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	136	99	68	45	31	21
Detection Rate (%)	100	100	97	100	100	100
Mean DX	2	-3	-15	0	36	123
Mean DY	-4	12	14	13	11	-29
Mean AT	-8	-27	-10	-7	-34	-132
Mean CT	1	14	-10	-10	15	18
Mean Skill (%)	*****	25	33	39	*****	*****
1999 Skill (%)	*****	17	36	46	*****	*****
Mean DPE	31	107	184	250	342	420
* 1999 DPE	25	88	191	331	542	853
RT DPE #	25	108	184	249	343	420

* DPE for all North-East Pacific storms in 1999 season

DPE in 2000 calculated using real time observations as opposed to best track.

Comments :

A plot of the observed tracks of all storms in this basin can be found in Fig. 4.

There were many more storms than in 1999, although these were generally short-lived and there were less verifiable forecasts at T+96 and T+120. Forecast errors were lower than 1999 at all forecast ranges except T+24. Skill scores against CLIPER were the best ever achieved for this basin. There was a slight slow bias in forecasts. The detection rate for storms was very good this year. Only a couple of forecasts failed to predict an active storm when one was present.

Figs. 5 and 6 show forecast errors and skill scores for the last few seasons.

3.3 North Atlantic Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	131	101	79	63	46	37
Detection Rate (%)	100	100	100	100	100	97
Mean DX	3	2	8	35	35	89
Mean DY	2	67	134	180	155	80
Mean AT	-12	-18	22	52	-26	-95
Mean CT	0	-4	-7	23	65	42
Mean Skill (%)	*****	18	38	43	*****	*****
1999 Skill (%)	*****	35	43	46	*****	*****
Mean DPE	22	144	247	349	412	520
* 1999 DPE	30	120	226	310	374	446
RT DPE #	29	144	250	354	417	522

* DPE for all North Atlantic storms in 1999 season

DPE in 2000 calculated using real time observations as opposed to best track.

Comments :

A plot of the observed tracks of all storms in this basin can be found in Fig. 7.

There were more storms than in 1999, but less verifiable forecasts overall. Forecast errors were higher than in 1999, but still near to the values seen in the few years prior to 1999. Skill scores against CLIPER were also slightly down on 1999 values. There were no significant biases in forecasts.

Figs. 8 and 9 show forecast errors and skill scores for the last few seasons.

3.4 North Indian Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	23	15	9	4	0	0
Detection Rate (%)	100	100	100	100	*****	*****
Mean DX	22	21	63	231	*****	*****
Mean DY	-7	22	51	-61	*****	*****
Mean AT	-22	-29	-33	-288	*****	*****
Mean CT	4	29	12	-90	*****	*****
Mean Skill (%)	*****	-14	5	*****	*****	*****
1999 Skill (%)	*****	23	50	45	*****	*****
Mean DPE	61	145	251	498	*****	*****
* 1999 DPE	43	115	172	216	260	291
RT DPE #	49	147	245	477	*****	*****

* DPE for all North Indian storms in 1999 season

DPE in 2000 calculated using real time observations as opposed to best track.

Comments :

A plot of the observed tracks of all storms in this basin can be found in Fig. 10.

There was less activity in this basin than in 1999 and no forecasts verified beyond T+72. Forecast errors were higher than 1999's record low values, but were still lower than any previous year at T+24 and T+48. Skill scores were slightly down on 1999's values. There was a slow bias in forecasts overall.

Figs. 11 and 12 show forecast errors and skill scores for the last few seasons.

3.5 Combined Statistics for whole Northern Hemisphere

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	540	414	312	228	159	113
Detection Rate (%)	100	100	99	97	97	97
Mean DX	1	-5	-34	-82	-117	-70
Mean DY	-2	20	40	42	22	-29
Mean AT	-9	-33	-34	-45	-72	-118
Mean CT	-1	3	-28	-46	-23	11
Mean Skill (%)	*****	17	32	37	*****	*****
1999 Skill (%)	*****	30	41	45	*****	*****
Mean DPE	38	134	244	357	440	551
* 1999 DPE	33	114	209	314	433	565
RT DPE #	32	135	242	356	440	549

* DPE for all Northern hemisphere storms in 1999 season

DPE in 2000 calculated using real time observations as opposed to best track.

Comments :

Forecast errors for the whole northern hemisphere in 2000 were slightly higher than those for 1999 at T+24 to T+72. However, they were near to 1999 values at T+96 and T+120. Overall, errors were still lower than in any year prior to 1999. Skill scores against CLIPER were slightly lower than in 1999, but again were better than any year prior to 1999. There was a slight slow bias in forecasts overall. Detection percentages were good, with only 3% of longer range forecasts not being verifiable due to erroneous dissipation in the model.

There was very little difference between forecast positional errors derived using real time observations and those derived using best track observations.

Figs. 13 to 16 show forecast errors, skill scores, along and cross track errors over the last few seasons.

Further Tropical Cyclone Information

The Met Office pages on the World Wide Web contain information on tropical cyclone forecasting at the Met Office. Monthly bulletins of tropical cyclone activity and forecasts are held together with observed and forecast track information of recent storms, track prediction error statistics, lists of names, images, movies and photographs and details of advances made in tropical cyclone track prediction at the Met Office.

The Met Office web site is:- <http://www.metoffice.com>

Tropical Cyclone information can be found on the home page under the "World Weather News" heading.

The information above is also available on *Metnet* (Met Office internal web) under Julian Heming's home page. Contact Julian Heming (julian.heming@metoffice.com) for further information on tropical cyclone forecasting at the Met Office.

Previous Reports

Seasonal summaries of tropical cyclone activity and forecasts have been issued since the 1994-5 southern hemisphere season:-

Southern Hemisphere 1994-5 :	Forecasting Systems Technical Note No.2
Northern Hemisphere 1995 :	Forecasting Systems Technical Note No.4
Southern Hemisphere 1995-6 :	Forecasting Systems Technical Note No.6
Northern Hemisphere 1996 :	Forecasting Systems Technical Note No.7
Southern Hemisphere 1996-7 :	Forecasting Systems Technical Note No.8
Northern Hemisphere 1997 :	Forecasting Systems Technical Note No.9
Southern Hemisphere 1997-8 :	Forecasting Systems Technical Note No.12
Northern Hemisphere 1998 :	Forecasting Systems Technical Note No.13
Southern Hemisphere 1998-9 :	Forecasting Research Technical Report No.311
Northern Hemisphere 1999 :	Forecasting Research Technical Report No.330
Southern Hemisphere 1999-2000 :	Forecasting Research Technical Report No.342

The reports can also be found on-line under the "Forecast Verification" section of the tropical cyclone pages on the Met Office web site and on *Metnet*.

Acknowledgements

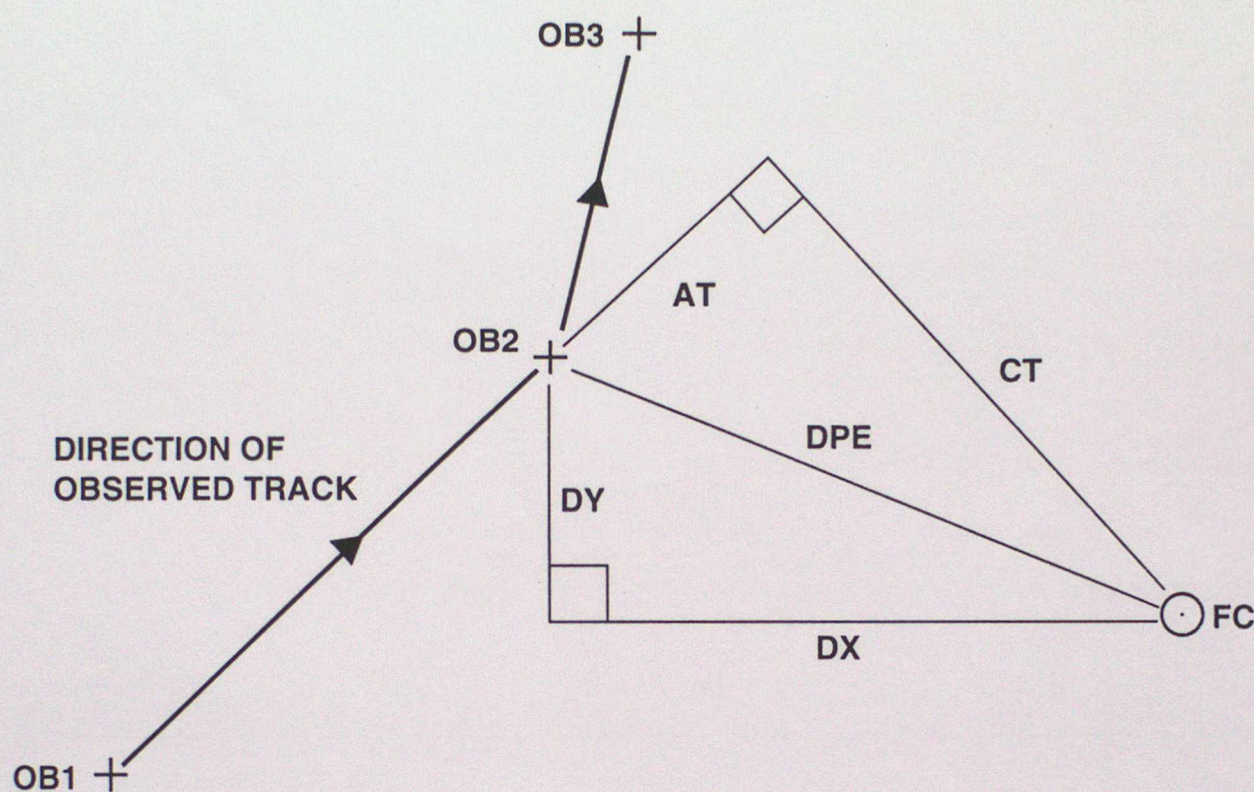
CLIPER models for various basins were supplied by Mr.S.Lord, NMC, Washington, USA and Mr.C.Mauck, FNOC, Monterey, USA.

GrADS software used to produce track plotting charts was supplied by Mr.S.Lord and Dr.M.Fiorino.

Best track observations for the northern hemisphere were obtained from the National Hurricane Center, Miami and the Joint Typhoon Warning Center, Hawaii.

APPENDIX A

Diagrammatic Explanation of Forecast Errors



OB1-3 : Observed positions

FC : Forecast position verifying against observation OB2

DPE : Direct positional error

DX : Error in the East-West direction

DY : Error in the North-South direction

AT : Error in the Along Track direction

CT : Error in the Cross Track direction

All errors are measured in kilometres

Sign Conventions

DPE values are always positive.

DX errors are positive if the forecast position lies eastwards of the observed position.

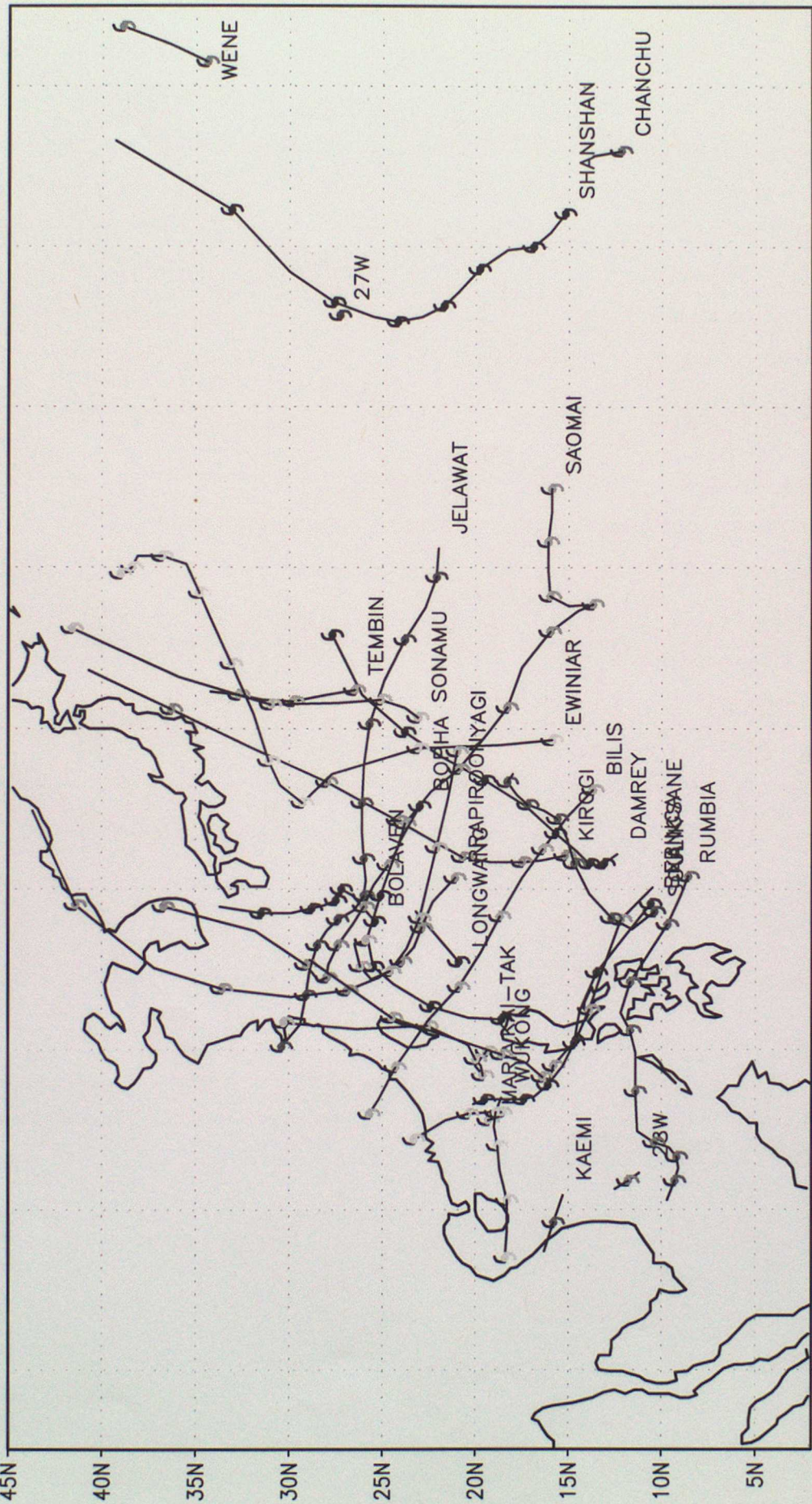
DY errors are positive if the forecast position lies polewards of the observed position.

AT errors are positive if the forecast position lies ahead of the observed position along the tropical cyclone track.

CT errors are positive if the forecast position lies right of the observed track in the northern hemisphere and left of the observed track in the southern hemisphere.

Figure 1

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH-WEST PACIFIC BASIN



DAMREY 20000507	LONGWANG 20000519	KIROGI 20000703	KAI-TAK 20000706	TEMBIN 20000719
BOLAVER 20000726	CHANCHU 20000729	JELAWAT 20000802	EWINIAR 20000810	WENE 20000816
BILIS 20000819	KAEMI 20000822	PRAPIROON 20000827	MARIA 20000829	SAOMAI 20000903
WUKONG 20000907	BOPHA 20000907	SONAMU 20000915	SHANSHAN 20000918	27W 20000929
28W 20001009	YAGI 20001022	XANGSANE 20001027	BEBINCA 20001101	RUMBIA 20001129
SOULIK 20001230				

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

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SYMBOLS REPRESENT 00Z POSITIONS

Figure 2

North-West Pacific Tropical Cyclone Forecast Positional Errors

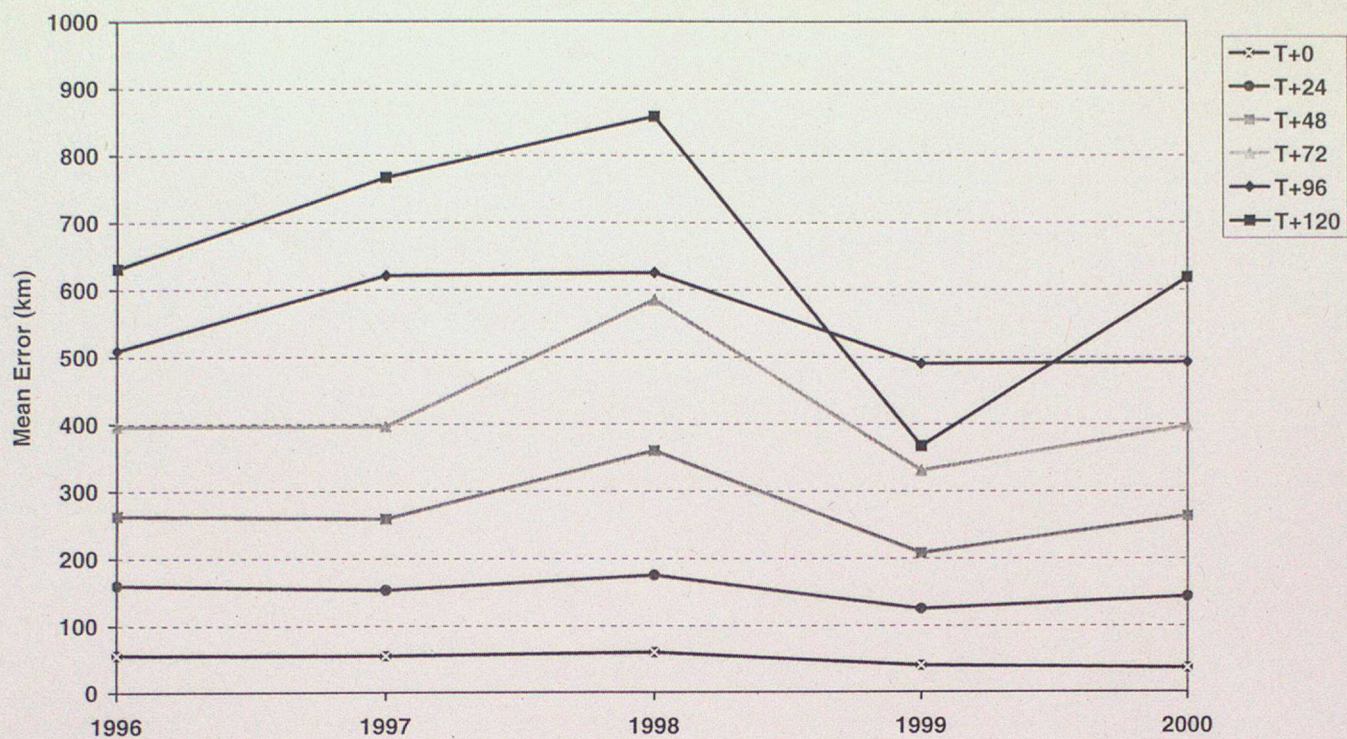


Figure 3

North-West Pacific Tropical Cyclone Forecast Skill against CLIPER

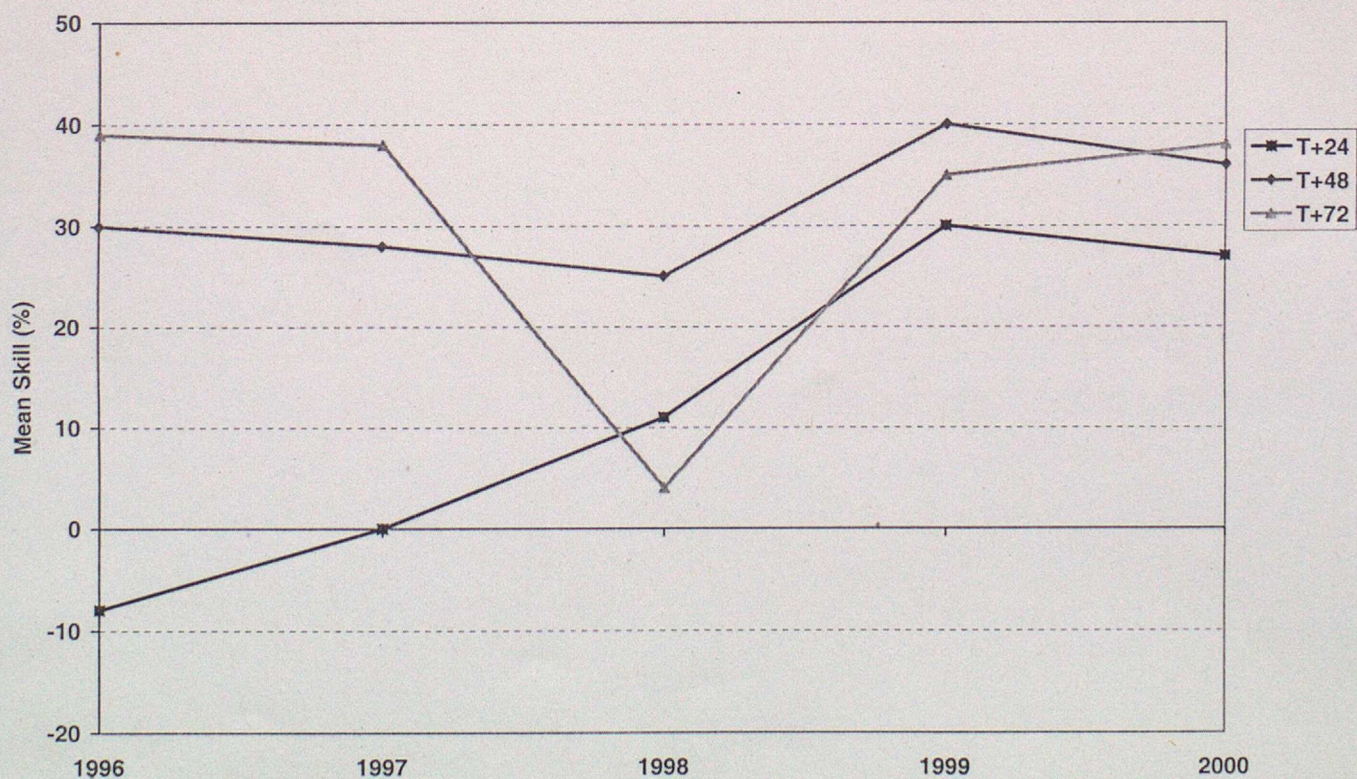
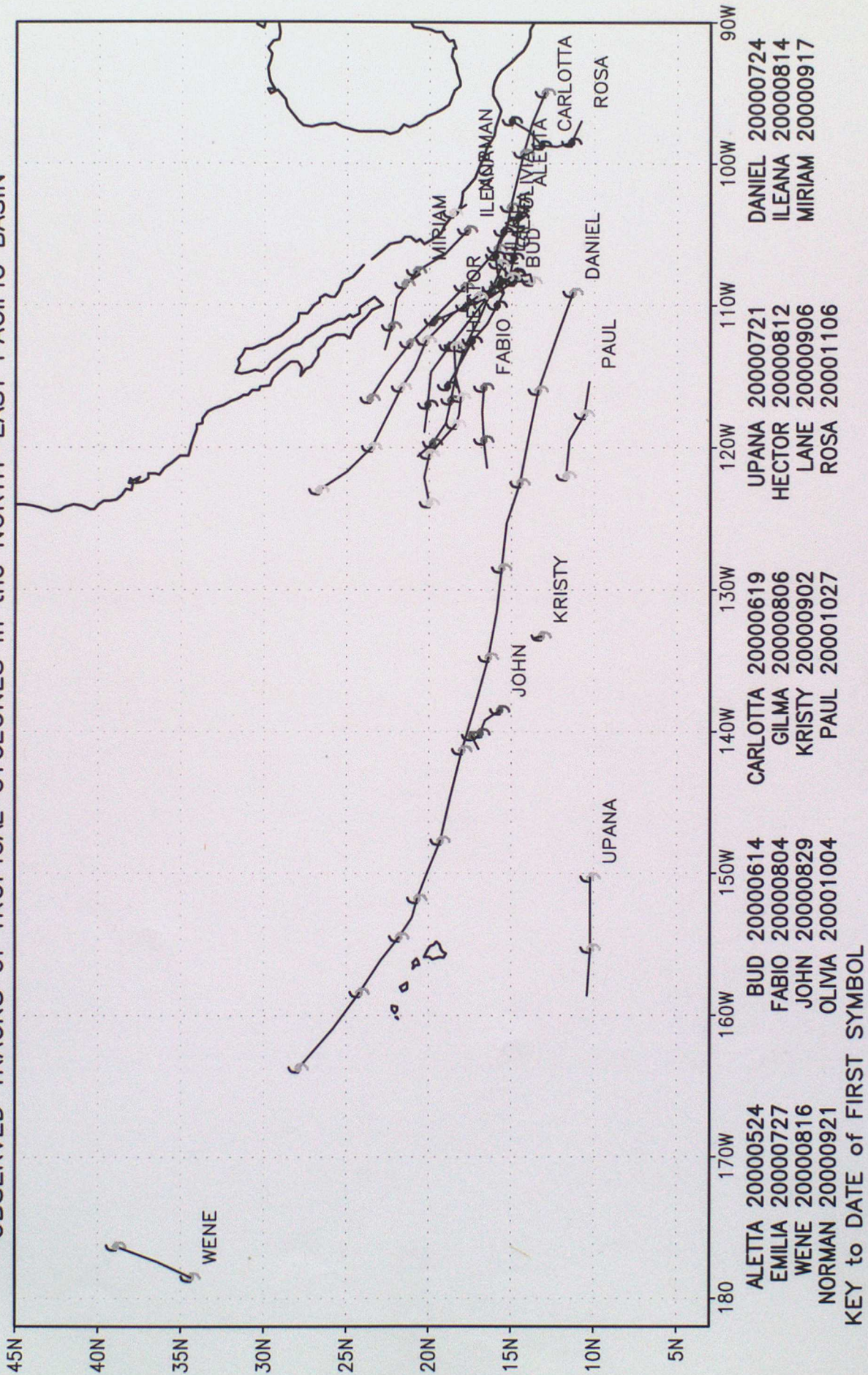


Figure 4

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH-EAST PACIFIC BASIN



24 HOURLY BEST TRACK OBSERVED POSITIONS
SYMBOLS REPRESENT 00Z POSITIONS

Figure 5

North-East Pacific Tropical Cyclone Forecast Positional Errors

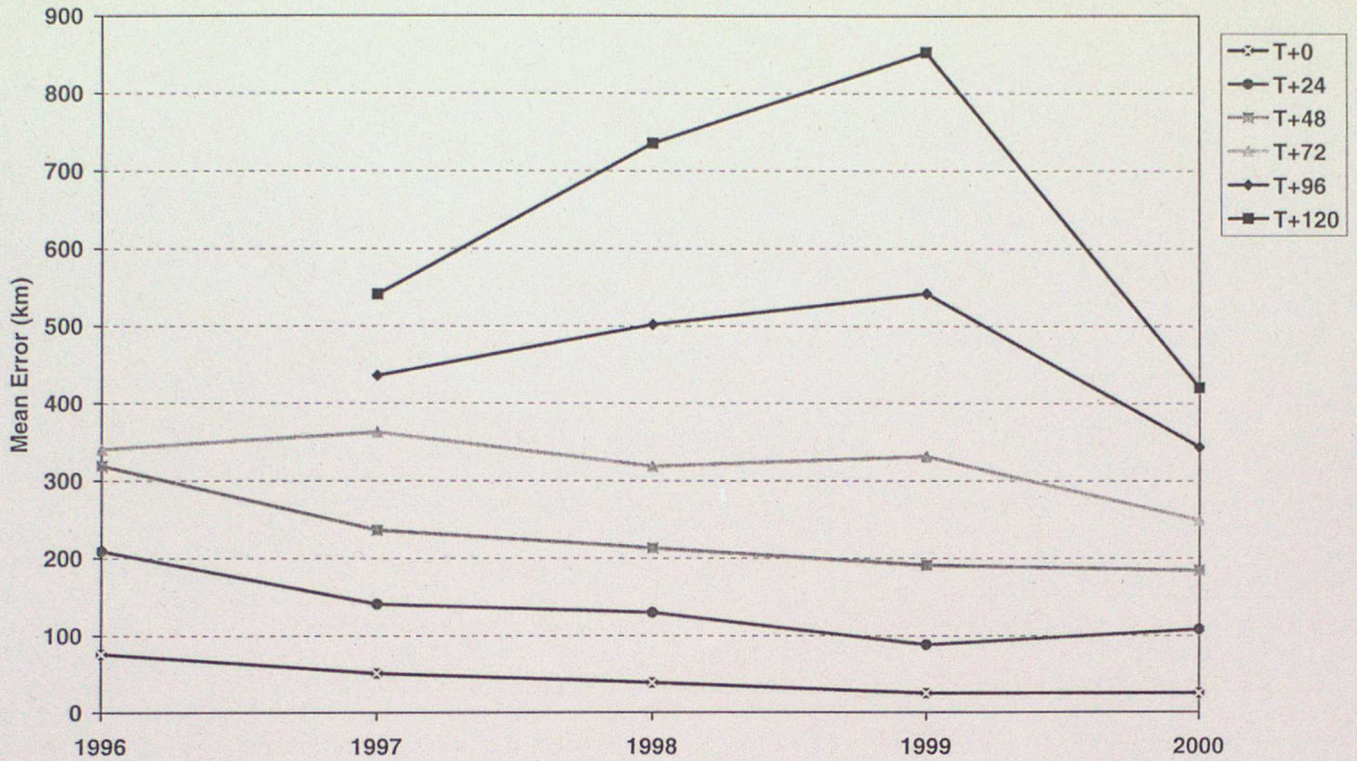
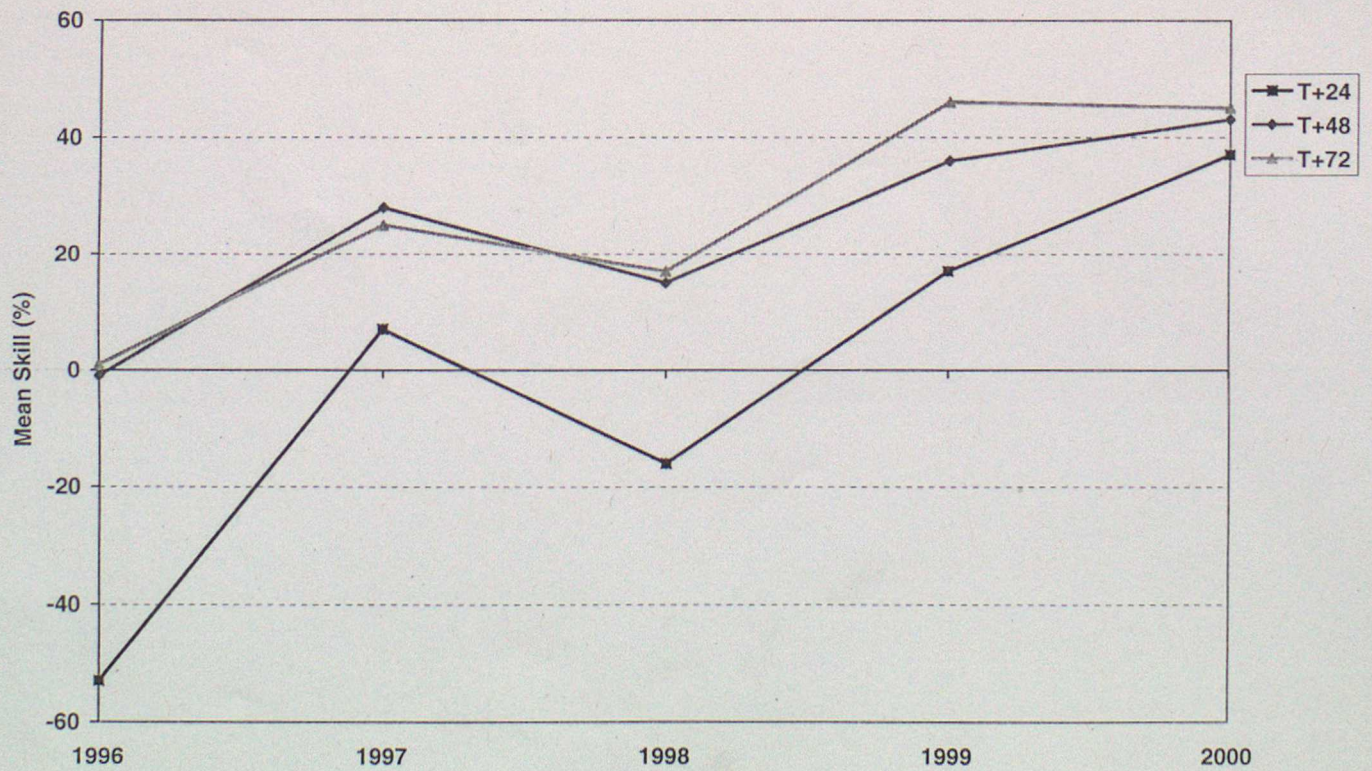
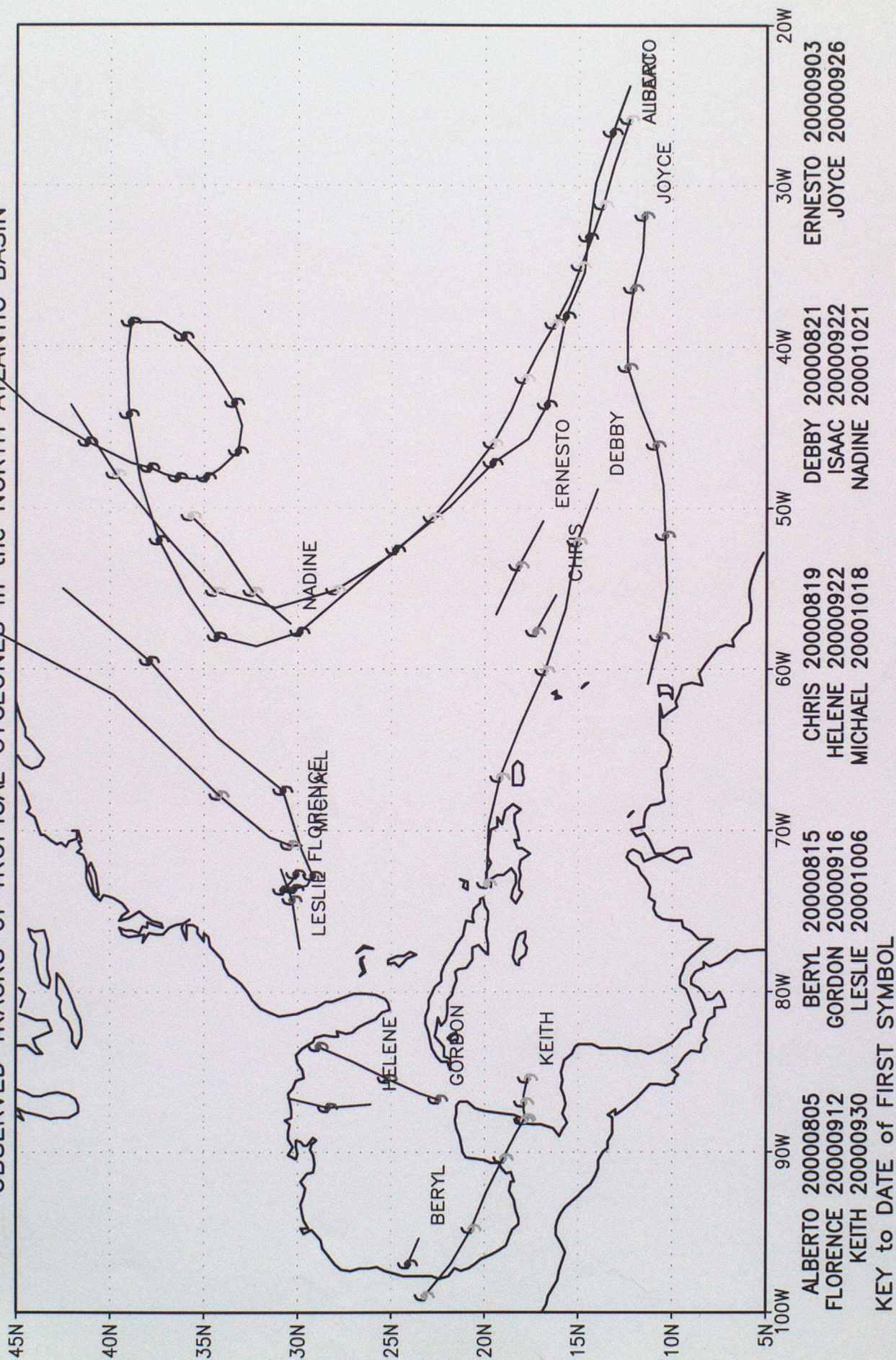


Figure 6

North-East Pacific Tropical Cyclone Forecast Skill against CLIPER



OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH ATLANTIC BASIN



24 HOURLY BEST TRACK OBSERVED POSITIONS
SYMBOLS REPRESENT 00Z POSITIONS

Figure 8

North Atlantic Tropical Cyclone Forecast Positional Errors

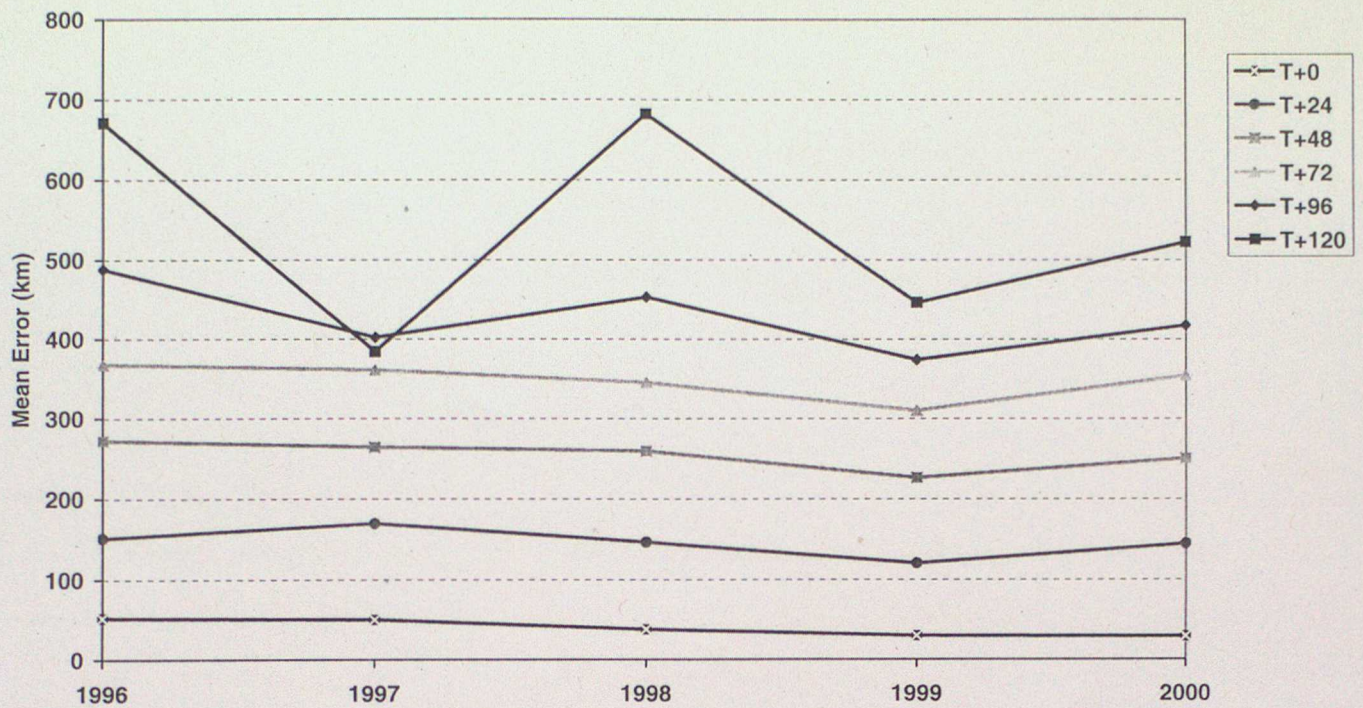


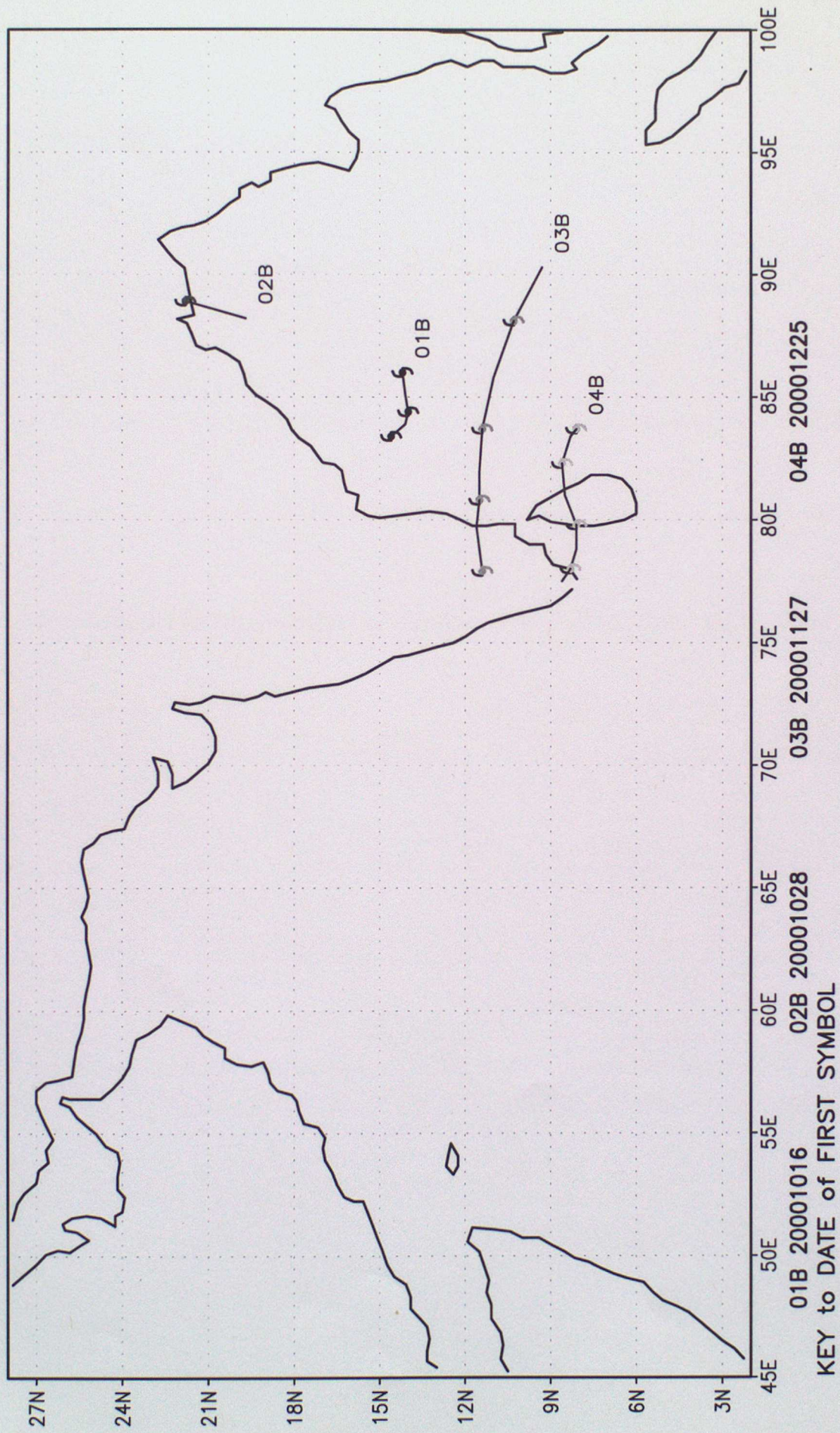
Figure 9

North Atlantic Tropical Cyclone Forecast Skill against CLIPER



Figure 10

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH INDIAN BASIN



24 HOURLY BEST TRACK OBSERVED POSITIONS
 SYMBOLS REPRESENT 00Z POSITIONS

Figure 11

North Indian Tropical Cyclone Forecast Positional Errors

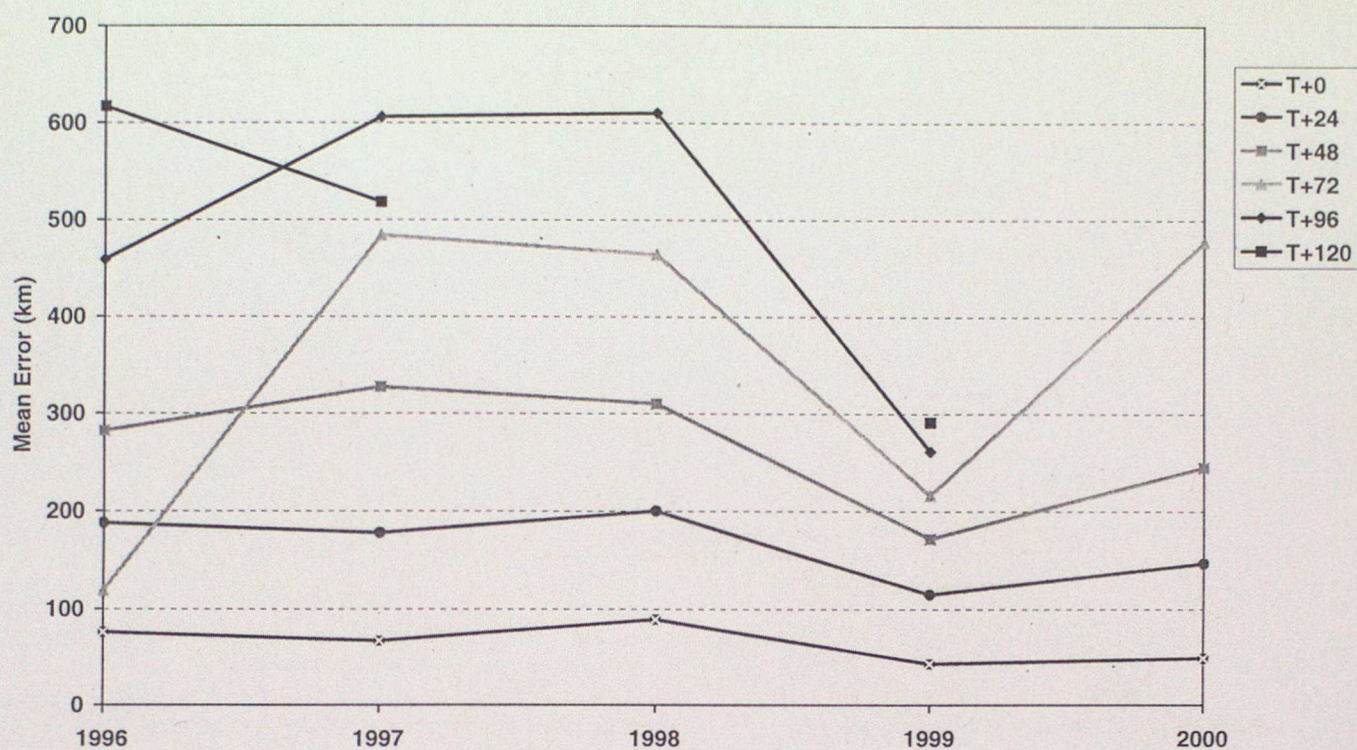


Figure 12

North Indian Tropical Cyclone Forecast Skill against CLIPER

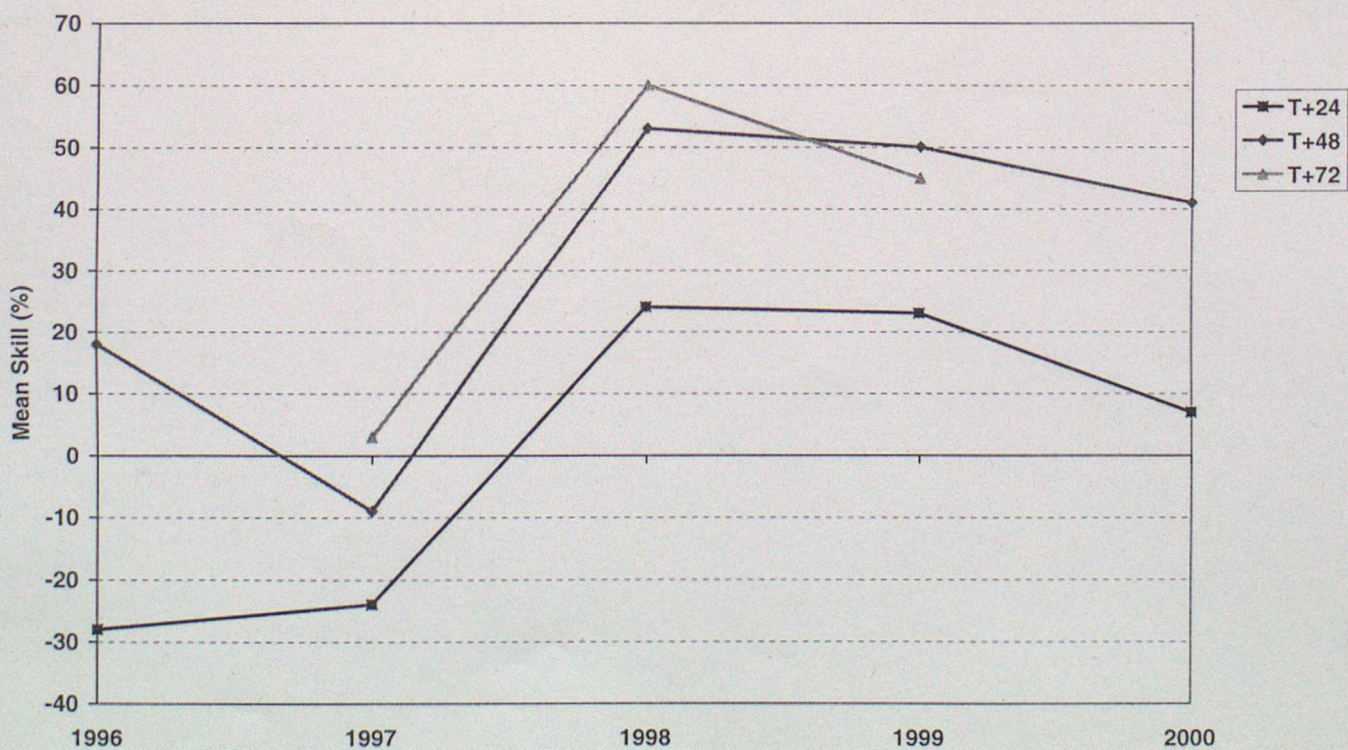


Figure 13

Northern Hemisphere Tropical Cyclone Forecast Positional Errors

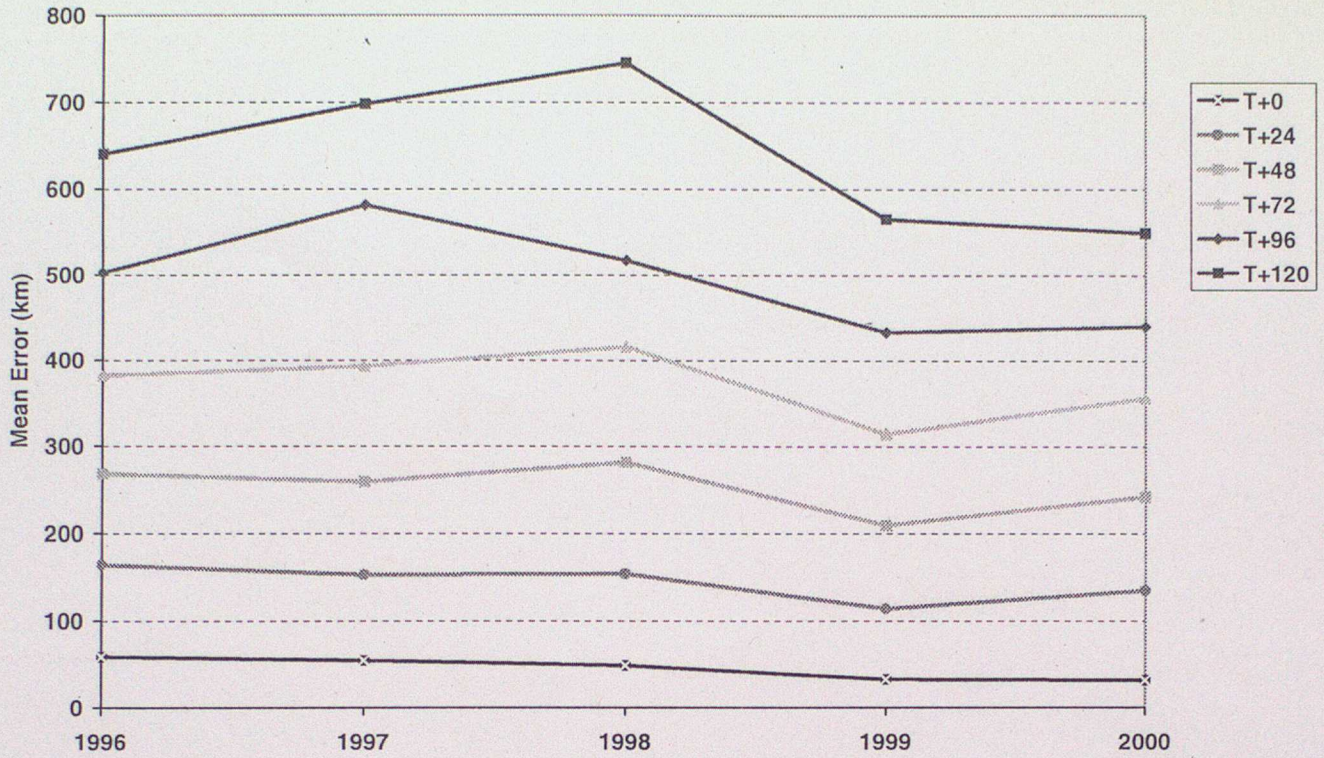


Figure 14

Northern Hemisphere Tropical Cyclone Forecast Skill against CLIPER

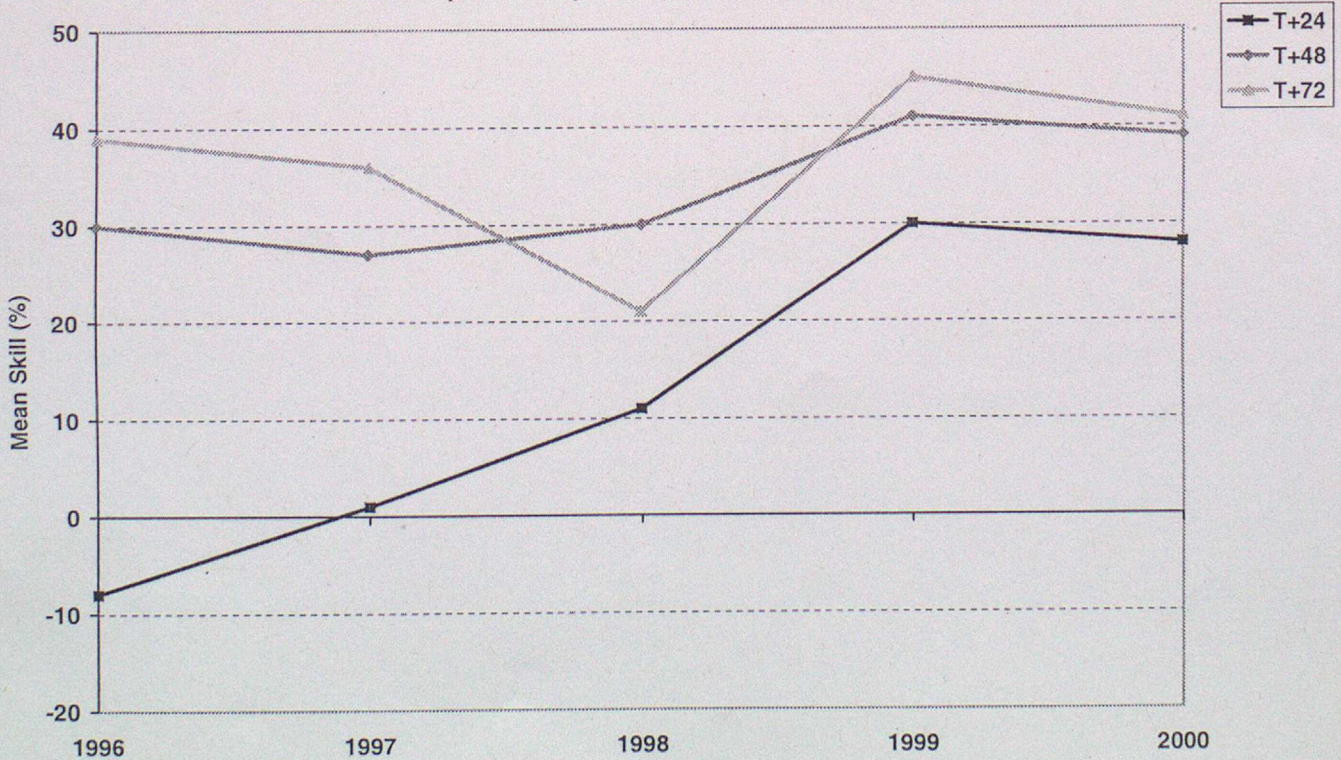


Figure 15

Northern Hemisphere Tropical Cyclone Along-Track Forecast Errors

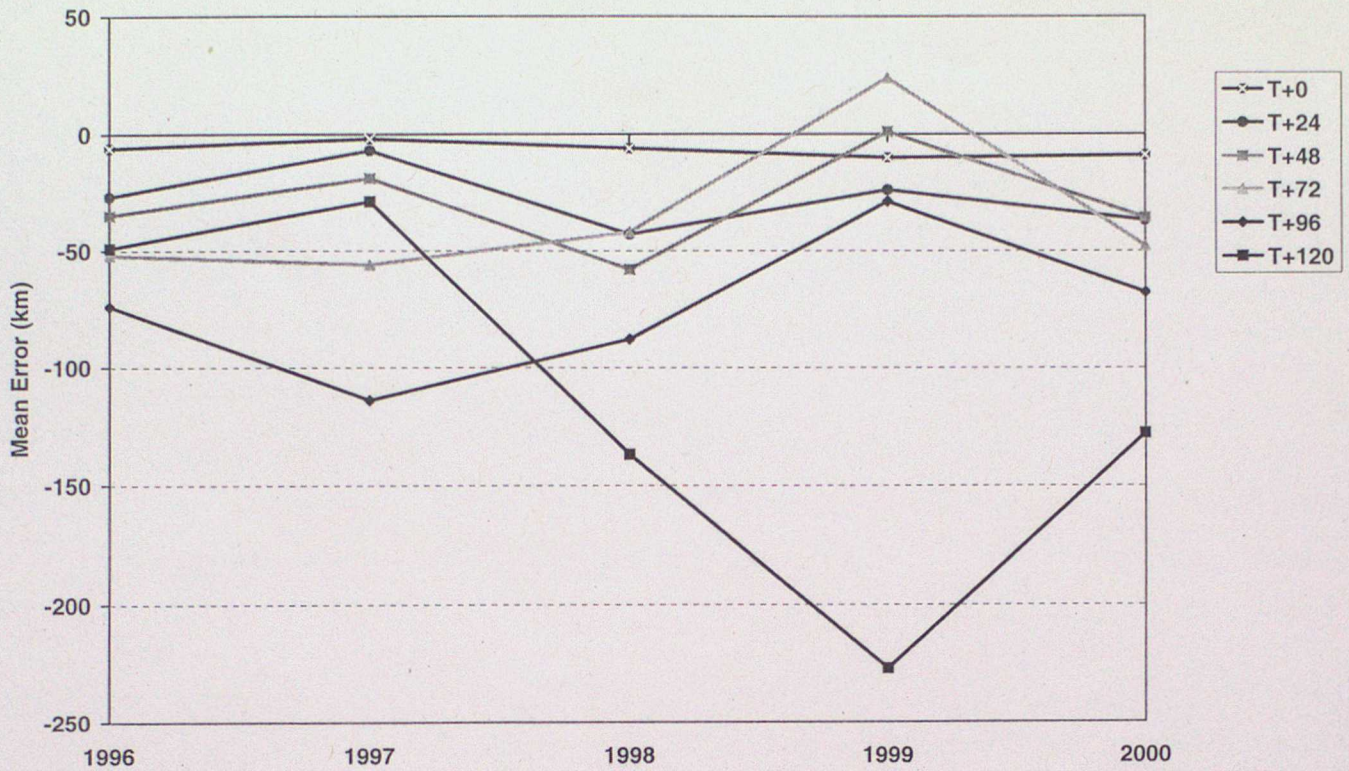


Figure 16

Northern Hemisphere Tropical Cyclone Cross-Track Forecast Errors

