NOAA Technical Memorandum NWS SR – 226

THE TEMPERATURE AND PRECIPITATION VERIFICATION PROGRAM AT WFO CORPUS CHRISTI TEXAS

Gregory E. Wilk

National Weather Service
Weather Forecast Office
Corpus Christi, Texas

Scientific Services Division
Southern Region
Fort Worth, Texas

November 2005

UNITED STATES
DEPARTMENT OF COMMERCE
Carlos M. Gutierrezs, Secretary

National Oceanic and
Atmospheric Administration
Conrad C. Lautenbacher

National Weather Service
David L. Johnson, Assistant
Administrator for Weather Services

This publication has been reviewed
and is approved for publication by
Scientific Services Division
Southern Region

David B. Billingsley, Chief

Scientific Services Division

Fort Worth, Texas

TABLE OF CONTENTS

I. Introduction

This paper discusses the temperature and precipitation verification programs at Weather Forecast Office (WFO) Corpus Christi TX (CRP). Every month, station temperature and precipitation verification statistics are provided to the meteorologists at CRP. Cool season (October through March) and warm season (April through September) temperature and precipitation verification statistics are also computed and presented to the operational staff. For each of these six month periods, each forecaster receives his or her individual verification statistics. Finally, a temperature and precipitation forecast contest is conducted every six months, with the top three forecasters announced at the end of each contest. The goals of the verification program are to help provide the best temperature and precipitation forecasts for the Corpus Christi area of responsibility, and to improve forecasts by comparing individual forecasts with MOS forecasts. Office temperature and precipitation verification statistics for the past several months have been some of the best in the NWS Southern Region.

II. Brief History of the Corpus Christi Verification Program

The temperature verification program began at WFO CRP in 1998, with Corpus Christi (CRP), Victoria (VCT), and Laredo (LRD) as verification sites. Initially, only monthly verification statistics were provided. However, by the year 2000, six month cool season (October through March) and warm season (April through September) guidance and station statistics were provided, showing errors, biases, and "near hits" (the percentage of station forecasts within three degrees Fahrenheit of the observed value; henceforth known as 3^{o}F or less. Additionally in 2000, individual temperature verification statistics began to be provided to each forecaster for the warm and cool seasons. In 2001, an office temperature verification contest was initiated, and office precipitation verification began. Early in 2003, the Interactive Forecast Processing System (IFPS) was used to create forecasts. At this time, WFO CRP decided to go to a short-term and long-term forecasting strategy (rather than a public versus aviation/marine forecast regiment). Under the short-term/long-term concept, the short-term forecaster creates grids of various weather elements (*e. g.*, wind, temperature, weather) for as many as the first three periods (*i. e.*, today, tonight and tomorrow), or as few as no periods (during very active weather), with the long-term forecaster responsible for the remaining periods. Given this variability of short-term forecaster responsibility, a method was devised to keep track of how many forecast periods the short term forecaster provided in the IFPS, allowing individual verification statistics to continue. In March 2004, Alice (ALI), Rockport (RKP), and Cotulla (COT) became verification sites, bringing the total number of sites to six. Finally, by the end of the 2004 warm season, a six month precipitation verification forecast contest began. A description of the WFO CRP temperature and precipitaion verification program is presented below.

III. Temperature Verification

A program called SOOVER is used for temperature verification for individual station statistics. The SOOVER program was developed by Jamie Frederick, at that time a lead forecaster at WFO Tulsa (now the Information Technology Officer at that office). The SOOVER program provides mean Model Output Statistics (MOS) and Coded Cities Forecast (CCF) absolute errors, mean biases, and the percentage of forecasts which fall into a particular error range (as specified by the office). Average absolute errors are computed using the difference between forecast and observed temperatures regardless of sign:

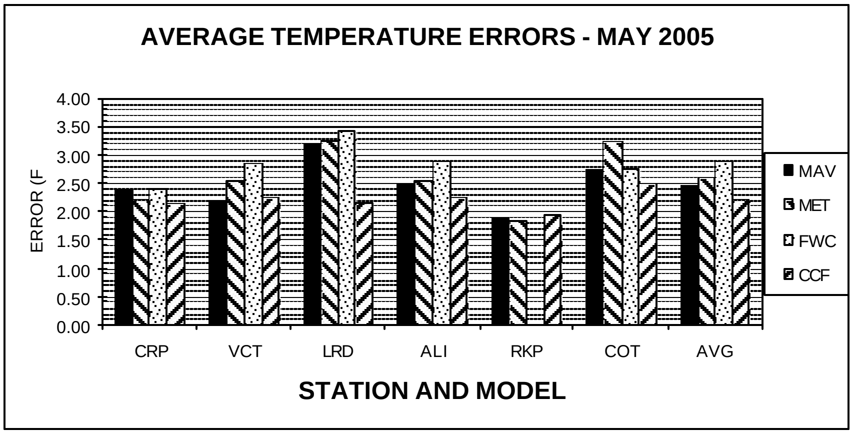
$$|\,\text{Error}\,| = (1/N) \sum |\,(f_i - o_i)\,| \qquad (1)$$

where Σ is the summation from i equals 1 to i equals N, f_i is the forecast temperature for the ith forecast, o_i is the observed temperature for the ith forecast, and N is the number of forecasts for that period. The average CCF and MOS bias is the arithmetic average of the differences between the observed temperatures and forecast temperatures for each period:

$$\text{Bias} = (1/N) \sum (f_i - o_i) \qquad (2)$$

The bias indicates whether temperature forecasts have been consistently too warm or too cold. At this time, SOOVER tallies the aforementioned verification statistics for the CCF, and for the MAV-MOS (generated from the Global Forecast System model, or GFS), MET-MOS (generated from the North American Mesoscale model, or NAM), and FWC-MOS (generated from the Nested Grid Model, or NGM) forecasts for the first five periods. The SOOVER program is also dynamic in that it can compile statistics over a user-defined period of time. To store these forecasts, a program is run every twelve hours that extracts the MOS and CCF forecasts from the database and places them into a file (one file for each verification site). Another program (run every twelve hours) obtains the maximum and minimum temperature data. When SOOVER is run, the program compiles the aforementioned statistics for the 0000 UTC cycle, 12 00 UTC cycle, and combined 0000 and 1200 UTC cycles corresponding to the forecasts and model runs mentioned above.

The verification statistics output by SOOVER are presented to the forecasters every month in both graphical and tabular format. Figures 1 and 2 are examples of two graphs created every month that are placed in the office break room, so that forecasters can quickly review the overall results. Figure 1 shows the average absolute CCF and MOS (MAV, MET, and FWC) errors for a month (along with an average for all six verification sites), while Figure 2 shows a 12 month trend of CCF and MOS absolute errors, graphically and in a tabular format.

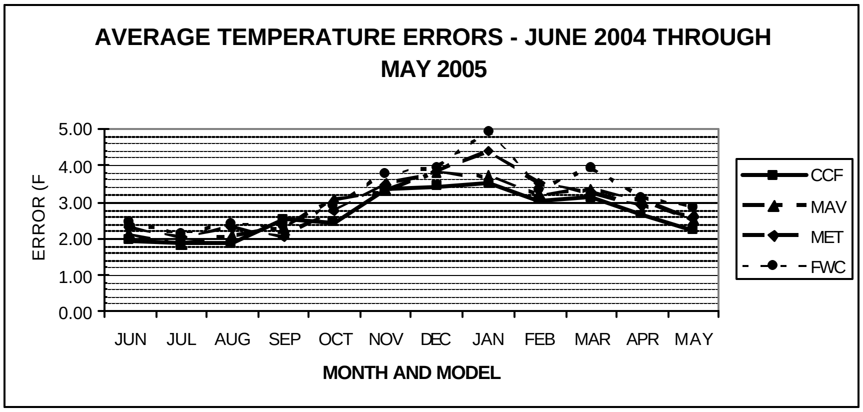


Station	MAV	MET	FWC	CCF
CRP	2.38	2.23	2.42	2.14
VCT	2.18	2.56	2.84	2.26
LRD	3.21	3.26	3.43	2.17
ALI	2.49	2.54	2.87	2.25
RKP	1.88	1.83	N/A	1.95
COT	2.73	3.23	2.78	2.48
AVG	**2.48**	**2.61**	**2.87**	**2.21**

Figure 1: Average absolute temperature errors (maximum and minimum temperature errors for all periods combined) for the CCF, MAV, MET, and FWC for each verification site. Note that an average (AVG) for all six verification sites is provided in the graph. This graph is placed in the break room for all forecasters to easily investigate the monthly verification results.

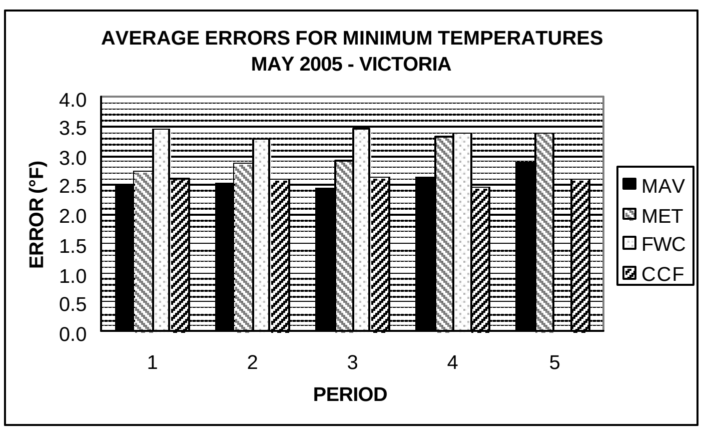
Next, graphs of CCF and MOS absolute errors and biases for maximum and minimum temperatures are created for each verification site (examples shown in Figures 3 and 4), along with a table depicting the percentage of CCF forecasts differing from observations by 3^{o}F or less (Table 1). Another table is also compiled, providing overall CCF and MOS errors, biases, and percentage of forecasts 3^{o}F or less from observed in a one-page format (Table 2). A key is provided below the table.

Every April and October, six month station verification statistics are computed for the October through March (cool) and April through September (warm) seasons, respectively, for each verification site. Similar to the monthly results, graphs of CCF and MOS absolute average errors and average biases for maximum and minimum temperatures for each station are presented to the staff, together with a table of the percentage of CCF forecasts 3^{o}F or less than observed. Also, a summary table (not shown) is provided similar to that shown in Table 2. Figures 5 and 6 are examples of some graphs produced for a six month period.



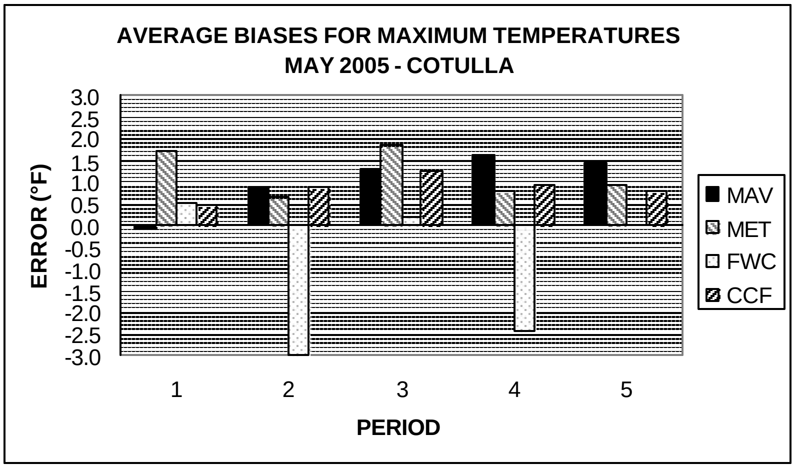
MONTH	MAV	MET	FWC	CCF
JUN	2.13	2.31	2.44	1.97
JUL	1.87	2.03	2.13	1.88
AUG	2.09	2.30	2.40	1.86
SEP	2.30	2.04	2.33	2.53
OCT	3.10	2.80	2.93	2.45
NOV	3.31	3.48	3.79	3.34
DEC	3.84	3.84	3.95	3.45
JAN	3.71	4.37	4.91	3.51
FEB	3.22	3.51	3.33	3.06
MAR	3.35	3.28	3.93	3.11
APR	3.03	2.90	3.15	2.64
MAY	2.48	2.61	2.87	2.21

Figure 2: Twelve month trend of CCF and MOS errors. This graph is actually displayed in color for easier interpretation, and is placed in the break room for all forecasters to easily investigate the monthly verification results.



Period	MAV	MET	FWC	CCF
1	2.50	2.74	3.45	2.61
2	2.52	2.87	3.29	2.58
3	2.45	2.93	3.47	2.63
4	2.63	3.33	3.40	2.47
5	2.89	3.38	N/A	2.59
AVG	**2.60**	**3.05**	**3.40**	**2.58**

Figure 3: Average absolute temperature errors for minimum (low) temperatures for the CCF, MAV, MET, and FWC for the verification site Victoria. A similar absolute error graph for each verification site is provided for maximum and minimum temperatures.



Period	MAV	MET	FWC	CCF
1	-0.10	1.71	0.52	0.45
2	0.86	0.63	-3.00	0.87
3	1.30	1.83	0.20	1.27
4	1.61	0.76	-2.45	0.93
5	1.41	0.93	N/A	0.76
AVG	**1.02**	**1.17**	**-1.18**	**0.86**

Figure 4: Average temperature biases for maximum (high) temperatures for the CCF, MAV, MET, and FWC for the verification site Cotulla. A similar bias graph for each verification site is provided for maximum and minimum temperatures.

Table 1: An example of a table showing the percentage of forecasts three degrees Fahrenheit (3°F) or less from observed, along with the percentage of forecasts falling outside of that range. This example is for the Laredo site. Similar tables are created for all six verification sites.

May 2005 Forecaster error (CCF) by category (%)
LRD

May 2005 Maximum Temperatures				May 2005 Minimum Temperatures			
Forecast period	**≤ -4**	**-3/+3**	**≥ +4**	**Forecast period**	**≤ -4**	**-3/+3**	**≥ +4**
1st period high	**16**	**77**	**7**	**1st period low**	**16**	**71**	**13**
2nd period high	**17**	**73**	**10**	**2nd period low**	**13**	**74**	**13**
3rd period high	**13**	**70**	**17**	**3rd period low**	**17**	**73**	**10**
4th period high	**17**	**73**	**10**	**4th period low**	**16**	**77**	**7**
5th period high	**17**	**76**	**7**	**5th period low**	**14**	**76**	**10**

Finally, individual temperature verification statistics are given to each forecaster for the previous cool or warm season. Since a short-term forecaster may contribute as many as three periods or as little as zero periods to the CCF during a forecast cycle, a method was devised to keep track of the number of periods the short-term and long-term forecaster provided. During the midnight shift (0000 UTC cycle/morning forecast package) and daytime shift (1200 UTC
Table 2: Absolute errors, biases, and CCF forecasts 3F or less from observed for all six

verification sites. The term "overall" for MOS errors indicates which model either had the highest or lowest errors for all periods or for all but one period. The term "overall" for MOS biases indicates what trend the model had for all periods or all but one period. Also, note the key below the table. This key specifies how to read the elements in each column. A similar table is provided for the six month verification statistics.

TEMPERATURE FORECAST RESULTS FOR APRIL 2005

MAXIMUM TEMPERATURE ERRORS	**CRP**	**VCT**	**LRD**	**ALI**	**RKP**	**COT**
Number of periods CCF error was <= 3.0F / <=2.0F	5 / 1	5 / 0	2 / 0	5 / 1	5 / 0	4 / 0
Number of periods CCF error < MAV error (3% or more)	4	5	5	4	3	4
Number of periods CCF error < MET error (3% or more)	4	5	4	5	2	4
Number of periods CCF error < FWC error (3% or more)	3	5	4	4	N/A	3
Lowest MOS errors (overall)	MIX	MIX	MET	MAV	MET	MAV
Highest MOS errors (overall)	MIX	MIX	M/F	FWC	MAV	MET

MINIMUM TEMPERATURE ERRORS	**CRP**	**VCT**	**LRD**	**ALI**	**RKP**	**COT**
Number of periods CCF error was <= 3.0F / <=2.0F	5 / 0	4 / 0	5 / 1	3 / 0	4 / 0	3 / 0
Number of periods CCF error < MAV error (3% or more)	5	2	4	4	3	5
Number of periods CCF error < MET error (3% or more)	3	3	3	2	2	4
Number of periods CCF error < FWC error (3% or more)	3	4	2	2	N/A	4
Lowest MOS errors (overall)	MET	M/E	MIX	MET	MET	MIX
Highest MOS errors (overall)	MAV	FWC	MIX	MIX	MAV	M/E

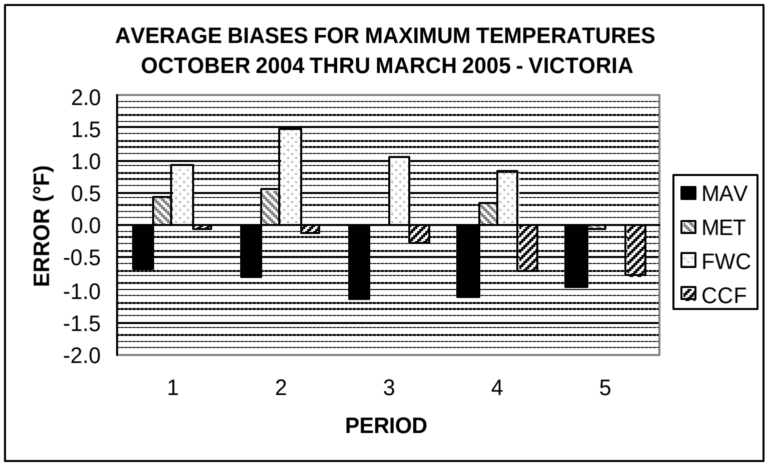
MAXIMUM TEMPERATURE BIASES	**CRP**	**VCT**	**LRD**	**ALI**	**RKP**	**COT**
Overall CCF bias trend	C/SC	W/SW	SC/C	MIX	C/VC	SW/N
Overall MAV bias trend	C	W	VC	SC	C/VC	N/SC
Overall MET bias trend	SC	SW/W	C/VC	MIX	SC/C	C
Overall FWC bias trend	SC/C	VW/W	C/VC	C/SC	N/A	MIX

MINIMUM TEMPERATURE BIASES	**CRP**	**VCT**	**LRD**	**ALI**	**RKP**	**COT**
Overall CCF bias trend	N/SW	SW	SC	SW/W	SC/C	W
Overall MAV bias trend	SC	SW	N/SC	W	SC/C	W/VW
Overall MET bias trend	MIX	W/VW	MIX	W/SW	SC	W/VW
Overall FWC bias trend	C/SC	VW	MIX	SW/W	N/A	W/VW

%CCF FORECASTS 3F OR LESS FROM OBSERVED	**CRP**	**VCT**	**LRD**	**ALI**	**RKP**	**COT**
Maximum temperature percentage range 3F or less	64-86	71-79	53-73	68-80	69-84	59-68
Minimum temperature percentage range 3F or less	57-68	52-65	61-80	44-69	63-79	55-64
CCF max temp forecast not in 3F range warm or cold?	CD	WM	MIX	MIX	CD	WM
CCF min temp forecast not in 3F range warm or cold?	WM	WM	MIX	WM	MIX	WM

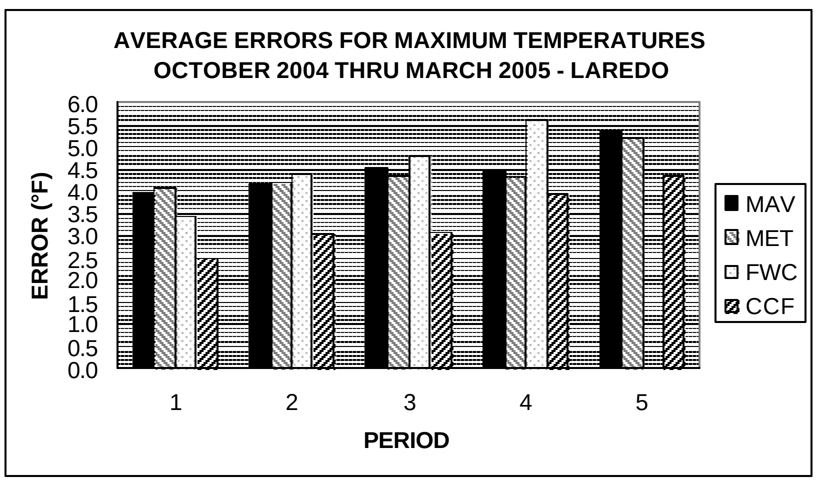
Bias and Forecast Trend Key (overall trend of the biases for the periods; an exception or two are possible):
W – Warm (bias from +1 to +2F) C – Cold (bias –1 to –2F) CT – Cooler with time WT – Warmer with time
SW – Slightly warm (+0.2F < bias < 1.0F) SC – Slightly cool (-1.0F < bias < -0.2F)
VW – Very warm (bias > 2.0F) VC – Very cool (bias < -2.0F) NT – No Trend
N – Neutral (-0.2F < bias <0.2F) WM – Too Warm CD - Too Cold
M/E: Mix between MAV and ETA M/F: Mix between MAV and FWC E/F Mix between ETA and FWC

Note: "MIX" means one or more of the MOS methods did not produce a distinct overall trend (e.g. MAV and FWC shared the highest errors), or that no conclusion in the trend could be ascertained.



Period	MAV	MET	FWC	CCF
1	-0.68	0.43	0.90	-0.06
2	-0.81	0.54	1.48	-0.12
3	-1.13	-0.01	1.04	-0.28
4	-1.12	0.34	0.82	-0.70
5	-0.97	-0.07	N/A	-0.79
AVG	-0.94	0.25	1.06	-0.39

Figure 5: Average temperature biases for maximum (high) temperatures for the CCF, MAV, MET, and FWC for the verification site Victoria during the period October 2004 through March 2005. A similar graph for each verification site is created for maximum and minimum temperature biases for the first five periods.



Period	MAV	MET	FWC	CCF
1	3.97	4.07	3.43	2.48
2	4.17	4.18	4.40	3.02
3	4.51	4.37	4.82	3.07
4	4.44	4.33	5.62	3.93
5	5.37	5.20	N/A	4.34
AVG	4.49	4.43	4.57	3.37

Figure 6: Average temperature errors for maximum (high) temperatures for the CCF, MAV, MET, and FWC for the verification site Laredo during the period October 2004 through March 2005. A similar graph for each verification site is created for maximum and minimum temperature errors for the first five periods.

cycle/afternoon forecast package), the long term forecaster creates a one-line text file from the Graphical Forecast Editor (GFE). This file, called a “forecaster verification” file, provides the date and forecast cycle, the short-term forecaster number, the long-term forecaster number, and the number of periods done by the short-term forecaster. Every six months, a locally created program is run, which ingests the necessary forecaster verification files, the temperature forecast file that contains the CCF and MOS forecasts for each verification site, and the observed temperature file. The forecaster verification file identifies the short-term and long-term forecasters, and the number of periods the short-term forecaster created. Once all the forecasts are separated by forecasters, the program determines the differences between observed, CCF, and MOS temperatures for that period. When the calculations for all forecasts are completed, CCF, MAV, MET, and FWC average absolute errors, biases, and the number of forecasts 3F or less from observed are tabulated for the first five periods for maximum and minimum temperatures. These computations are done for all six verification sites, with the output placed in a file containing all of the individual forecaster’s verification statistics. Each forecaster file is then e-mailed to that forecaster so he or she can compare their CCF forecasts with the MOS forecasts. Tables 3 through 5 show examples of how some of the verification data are presented to each forecaster.

Table 3: Maximum and minimum absolute temperature errors for an individual forecaster at Corpus Christi for a six-month period. A “-99.0” indicates no forecasts were available for this period (and is used in other tables to indicate no forecasts were available). Average absolute temperature errors are provided for all six verification sites.

TEMPERATURE ERRORS FOR CORPUS CHRISTI

MAXIMUM TEMPERATURE ERRORS

PERIOD	CCF	FWC	MET	MAV
1	1.5	1.9	1.5	1.8
2	2.6	2.7	2.4	2.4
3	2.0	2.3	3.0	2.1
4	2.5	2.7	3.1	2.4
5	3.1	-99.0	3.7	3.3
AVE	2.4	2.4	2.8	2.5

MINIMUM TEMPERATURE ERRORS

PERIOD	CCF	FWC	MET	MAV
1	1.4	1.3	2.5	1.3
2	1.2	2.3	1.8	1.6
3	2.4	3.6	2.7	2.7
4	3.3	3.9	3.3	3.3
5	2.6	-99.0	3.5	2.8
AVE	2.4	3.0	2.8	2.5

Table 4: Maximum and minimum temperature biases for an individual forecaster at Corpus Christi for a six-month period. Temperature biases are computed for all six verification sites.

TEMPERATURE BIASES FOR CORPUS CHRISTI

MAXIMUM TEMPERATURE BIASES

PERIOD	CCF	FWC	MET	MAV
1	-0.1	0.5	0.6	0.1
2	-0.7	-0.2	1.9	0.2
3	-0.7	0.4	1.0	-0.7
4	0.2	0.3	1.8	0.8
5	-1.3	-99.0	-2.7	-1.0
AVE	-0.6	0.3	0.6	-0.2

MINIMUM TEMPERATURE BIASES

PERIOD	CCF	FWC	MET	MAV
1	0.2	-0.5	1.9	0.1
2	-0.5	-0.5	-0.1	-0.4
3	-0.3	-0.2	0.6	-0.2
4	-0.5	0.4	-0.2	-0.4
5	0.1	-99.0	1.4	-0.2
AVE	-0.2	-0.1	0.4	-0.3

Table 5: The number and percentage of CCF and MOS maximum temperature forecasts 3 degrees F or less from observed temperatures for Period 1 during a six month period. Forecasts "too cold" have errors of -4 degrees F or greater; while "too warm" have errors 4 degrees F or greater. These tables are generated for the first five periods for both maximum and minimum temperatures, and for all six verification sites.

MAXIMUM TEMPERATURE FORECASTS 3F FROM OBSERVED FOR PERIOD 1

NUMBER					PERCENTAGE				
RANGE	CCF	FWC	MET	MAV	RANGE	CCF	FWC	MET	MAV
TOO COLD	0	2	1	1	TOO COLD	0.0	7.7	3.8	3.8
3F OR LESS	24	23	24	24	3F OR LESS	92.3	88.5	92.3	92.3
TOO WARM	2	1	1	1	TOO WARM	7.7	3.8	3.8	3.8

IV. Precipitation Verification

For station precipitation verification, a locally created program is used to generate statistics for each month, for the cool season, and for the warm season. This program generates CCF, MAV, MET, and FWC average POP and Brier Scores (BS) for the 00Z through 12Z time frame (nighttime), the 12Z through 00Z time frame (daytime), and for combined daytime and nighttime time frames for the first five periods. The Brier Score is the mean square error of all

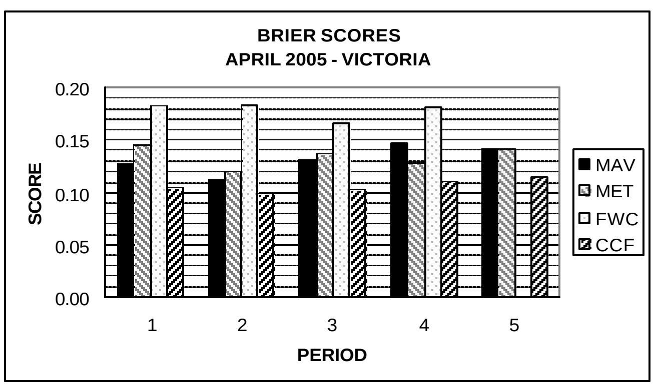
POP forecasts. The standard National Weather Service Brier Score, defined below, is one-half the original score defined by Brier (1950):

$$BS = (1/N) \sum (f_i - o_i)^2$$

For POP verification, assuming 10 percent probability intervals (except for the 5% POP), where Σ is the summation from i equals 1 to i equals N, f_i = forecast probability (either CCF or MOS, 0, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0); for the *ith* case, o_i = observed precipitation occurrence (0 or 1), and N is the number of cases. By this formula, a perfect Brier Score would be 0.0 (i.e, average POP of 100% for every measurable rainfall event), while the worst Brier Score would be 1.0 (average POP of 0% for every measurable rainfall event).

To present these monthly statistics to the staff, average Brier scores per period for all events for all six stations are shown graphically, an example of which is shown in Figure 7. Next, a table is generated which summarizes the remaining verification statistics (Table 6). In this table, Brier Scores and average POPs for measurable and trace rainfall events are summarized for the daytime (12Z to 00Z) and nighttime (00Z to 12Z) intervals, while average POPs for all non rainfall events are summarized for all intervals. Similar tables are produced for each six month period.

For the warm season and cool season, graphs are generated for measurable rainfall, trace rainfall, and no rainfall for the daytime and nighttime periods (examples are shown in Figures 8 through 10). For all six verification sites, graphs of Brier Scores are also presented for the



Period	MAV	MET	FWC	CCF
1	0.128	0.146	0.183	0.104
2	0.112	0.120	0.184	0.099
3	0.131	0.137	0.167	0.102
4	0.148	0.129	0.182	0.111
5	0.142	0.142	N/A	0.115
AVG	**0.132**	**0.135**	**0.179**	**0.106**

Figure 7: Brier Scores for April 2005 at Victoria. Similar graphs are created for the remaining verification sites each month.

Table 6: Example of a monthly Precipitation Summary Table for April 2005. A similar table is generated for the six month verification data.

PRECIPITATION FORECAST RESULTS FOR APRIL 2005

DAYTIME BRIER SCORES	CRP	VCT	LRD	ALI	RKP	COT
Numb er of periods CCF scores were better than MAV scores	3	2	2	5	1	0
Number of periods CCF scores were better than MET scores	3	4	0	1	1	0
Number of periods CCF scores were better than FWC scores	4	4	2	4	N/A	1
Best MOS scores (overall)	MIX	MAV	M/E	MET	MET	M/E
Worst MOS scores (overall)	MIX	FWC	FWC	MAV	MAV	FWC

NIGHTTIME BRIER SCORES	CRP	VCT	LRD	ALI	RKP	COT
Number of periods CCF scores were better than MAV scores	4	5	2	3	0	0
Number of periods CCF scores were better than MET scores	4	5	2	1	0	5
Number of periods CCF scores were better than FWC scores	3	4	1	1	N/A	1
Best MOS scores (overall)	MAV	M/E	MIX	MIX	MIX	MAV
Worst MOS scores (overall)	FWC	FWC	MIX	MIX	MIX	MET

DAYTIME POPS MEASURABLE RAIN	CRP	VCT	LRD	ALI	RKP	COT
Number of events / rainfall amount	1 / 0.09	4 / 0.43	0 / 0	2 / 0.06	0 / 0	0 / 0
Periods CCF POPs >= 30% / > = 50%	3 / 0	4 / 0	N/A	5 / 0	N/A	N/A
Number of times CCF POP = 0	0	0	N/A	0	N/A	N/A
Number of periods CCF POP >= MAV POP	5	2	N/A	5	N/A	N/A
Number of periods CCF POP >= MET POP	4	4	N/A	3	N/A	N/A
Number of periods CCF POP >= FWC POP	4	4	N/A	4	N/A	N/A
Highest MOS POPs (overall)	MET	MAV	N/A	MET	N/A	N/A
Lowest MOS POPs (overall)	FWC	FWC	N/A	M/F	N/A	N/A

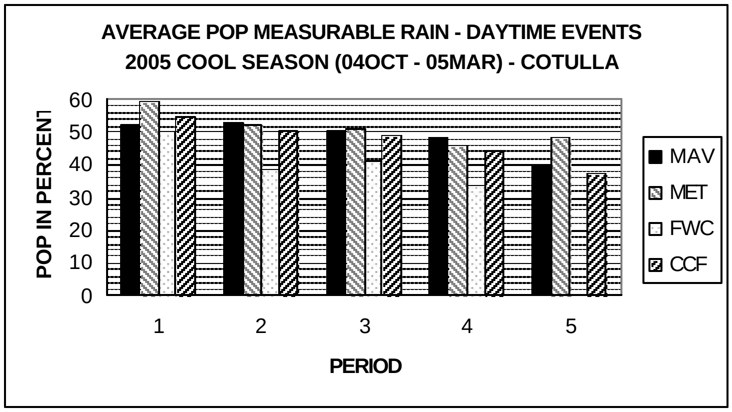
NIGHTTIME POPS MEASURABLE RAIN	CRP	VCT	LRD	ALI	RKP	COT
Number of events / rainfall amount	3 / 0.12	6 / 0.82	1 / 0.22	2 / 0.08	0 / 0	1 / 0.05
Periods CCF POPs >= 30% / > = 50%	0 / 0	3 / 0	3 / 0	0 / 0	N/A	5 / 1
Number of times CCF POP = 0	0	0	0	0	N/A	0
Number of periods CCF POP >= MAV POP	4	5	5	4	N/A	2
Number of periods CCF POP >= MET POP	5	5	2	3	N/A	5
Number of periods CCF POP >= FWC POP	4	4	2	4	N/A	4
Highest MOS POPs (overall)	M/E	M/E	MET	MET	N/A	MAV
Lowest MOS POPs (overall)	FWC	FWC	M/F	FWC	N/A	E/F

DAYTIME POPS TRACE EVENTS	CRP	VCT	LRD	ALI	RKP	COT
Number of events	5	3	3	2	2	4
Periods CCF POPs >= 30% / >= 20%	0 / 0	0 / 0	0 / 0	0 / 0	1 / 3	0 / 4
Number of periods MAV POPs >= 30% / >= 20%	0 /0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 1
Number of periods MET P OPs >= 30% / >= 20%	0 /0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Number of periods FWC POPs >= 30% / >= 20%	0 /0	0 / 0	0 / 0	0 / 0	N/A	0 / 1

NIGHTTIME POPS TRACE EVENTS	CRP	VCT	LRD	ALI	RKP	COT
Number of events	2	3	2	2	5	2
Periods CCF POPs >= 30% / >= 20%	0 / 3	0 / 1	0 / 5	0 / 5	0 / 5	0 / 5
Number of periods MAV POPs >= 30% / >= 20%	0 / 1	0 / 0	0 / 2	0 / 2	0 / 1	0 / 0
Number of periods MET POPs >= 30% / >= 20%	0 / 1	0 / 1	2 / 2	0 / 0	0 / 2	0 / 3
Number of periods FWC POPs >= 30% / >= 20%	0 / 0	0 / 0	0 / 0	0 / 0	N/A	0 / 1

POPS FOR NO RAINFALL EVENTS (DAY AND NIGHT)	CRP	VCT	LRD	ALI	RKP	COT
Number of events	49	44	54	52	53	53
Periods CCF POPs >= 10% / >= 20%	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Number of periods MAV POPs >= 10% / >= 20%	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Number of periods MET POPs >= 10% / >= 20%	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Number o f periods FWC POPs >= 10% / >= 20%	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Highest MOS POPs (overall)	MAV	MAV	M/E	MAV	MAV	MET
Lowest MOS POPs (overall)	FWC	FWC	FWC	FWC	MET	M/F

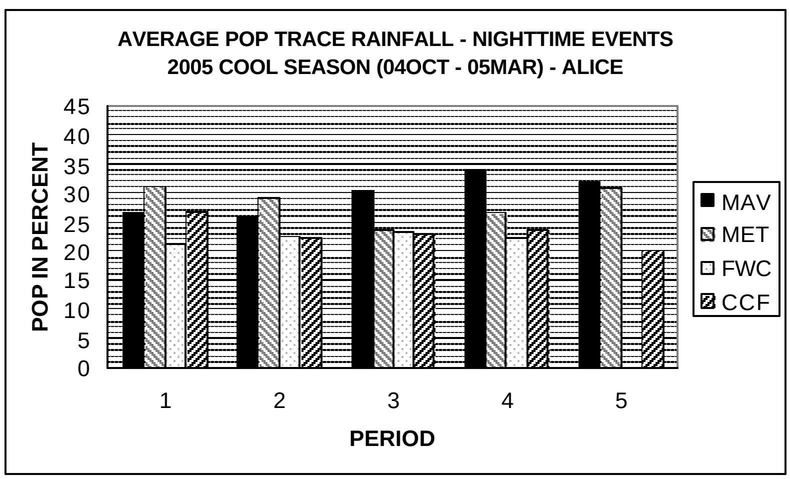
Note: "MIX" means that the FWC, MET, and MAV had a better result than the other two models for at least one period.
M/E: Mix between MAV and ETA M/F: Mix between MAV and FWC E/F Mix between ETA and FWC



Period	MAV	MET	FWC	CCF
1	52.7	59.2	50.0	55.0
2	53.1	52.2	38.7	50.5
3	50.7	51.0	41.2	49.0
4	48.4	45.8	33.6	44.3
5	40.1	48.1	N/A	37.1
AVG	**49.0**	**51.3**	**47.1**	**47.2**

Total = 3.39 inches; Events = 21

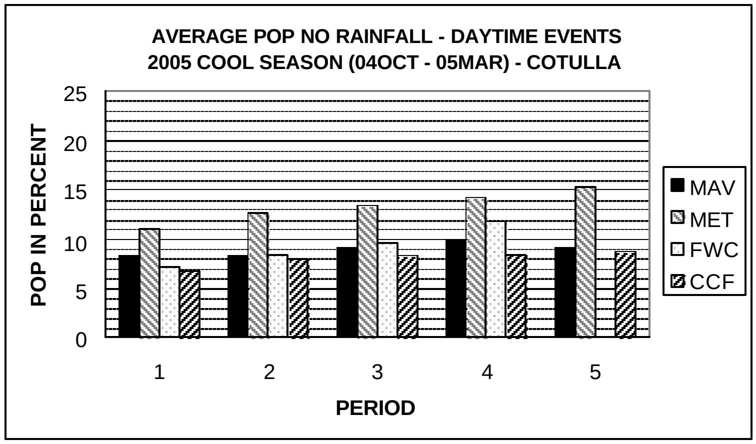
Figure 8: Example of a CCF and MOS POP graph for measurable precipitation events for a six month period. This graph indicates the average POP for measurable rainfall events during the daytime (12Z to 00Z) at Cotulla. Similar graphs are generated for all six verification sites for daytime and nighttime measurable rainfall events.



Period	MAV	MET	FWC	CCF
1	26.6	31.0	21.3	26.8
2	25.9	29.1	22.6	22.3
3	30.4	23.7	23.1	23.0
4	33.9	26.5	22.3	23.8
5	31.9	30.8	N/A	20.0
AVG	**29.7**	**28.2**	**22.3**	**23.2**

Events = 20

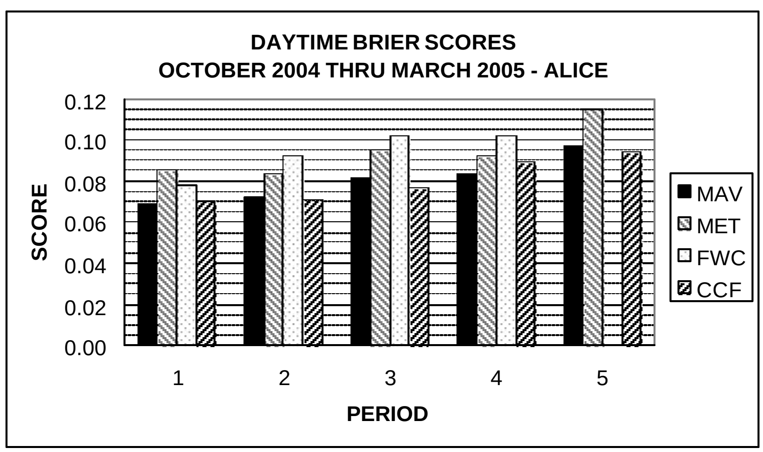
Figure 9: Example of a CCF and MOS POP graph for trace rainfall events for a six month period. This graph indicates the average POP for trace rainfall events during the nighttime (00Z to 12Z) at Alice. Similar graphs are generated for all six verification sites for daytime and nighttime trace rainfall events.



Period	MAV	MET	FWC	CCF
1	8.4	11.2	7.2	6.9
2	8.3	12.8	8.5	8.0
3	9.2	13.4	9.7	8.4
4	10.0	14.3	11.8	8.5
5	9.2	15.3	N/A	8.7
AVG	**9.0**	**13.4**	**11.7**	**8.1**

Events = 141

Figure 10: Example of a CCF and MOS POP graph for non rainfall events for a six month period. This graph indicates the average POP for non rainfall events during the daytime (12Z to 00Z) at Cotulla. Similar graphs are generated for all six verification sites for daytime and nighttime non-rainfall events.



Period	MAV	MET	FWC	CCF
1	0.069	0.085	0.078	0.070
2	0.072	0.083	0.092	0.071
3	0.081	0.095	0.102	0.077
4	0.083	0.092	0.102	0.089
5	0.097	0.115	N/A	0.094
AVG	**0.080**	**0.094**	**0.094**	**0.080**

Figure 11: Example of a CCF and MOS POP Brier Scores for a six month period. This graph indicates the scores during the daytime (12Z to 00Z) at Alice. Similar graphs are generated for all six verification sites for daytime and nighttime periods.

daytime and nighttime periods, and the combined Brier Scores for both periods (see Figure 11 for an example). In addition, a summary table similar to the monthly summary table shown in Table 6 is created (for those who just want to see a quick summary rather than peruse several graphs).

Finally, individual precipitation verification statistics are provided to each forecaster for the previous six month period. Similar to the temperature verification for individual forecasters, a locally created program was written to ingest CCF and MOS forecast data, along with observed precipitation and the forecaster verification files. The forecaster verification file identifies the short-term and long-term forecasters, and the number of periods the short-term forecaster created. Once all of the data have been separated by forecasters, CCF and MOS precipitation verification statistics (average POP and Brier Scores) are computed for each forecaster for each verification site. These results are placed in an output file (separate from the verification file for temperatures). Each forecaster file is then e-mailed to that forecaster so he or she can compare their CCF forecasts with the MOS forecasts. Tables 7 through 9 show examples of how some of the precipitation verification data are presented to each forecaster.

Table 7: Example of a forecaster's precipitation verification statistics for a six month period. Here, average POPs for measurable rainfall are displayed for Corpus Christi. Average POPs for trace rainfall events and no rainfall events are also provided. Total rainfall shown is the amount of rain which occurred for the period the person forecast, and thus could include the same rainfall event in more than one period. These statistics for all six verification sites are given to each forecaster.

POP AVERAGES PER PERIOD FOR MEASURABLE RAINFALL AT CORPUS CHRISTI

FCST DAY	PERIOD	PCPN	CCF	FWC	MET	MAV
PERIOD	1	0.82	66.7	40.3	58.0	76.7
PERIOD	2	3.90	60.0	25.7	36.3	63.7
PERIOD	3	3.55	47.5	26.0	58.5	57.3
PERIOD	4	8.24	36.7	25.0	42.2	35.8
PERIOD	5	8.03	25.0	-99.0	12.5	33.9
TOTALS		24.54	40.2	27.6	39.0	44.5

V. Forecaster Contests

Once each forecaster's temperature and precipitation verification files have been e-mailed, forecaster contests are initiated to determine who provided the best temperature and precipitation forecasts during the six month period. Although the forecaster contests are in the spirit of friendly competition, the goal is to provide an incentive to produce the best possible forecasts during their shifts. Only the top three forecasters are announced for each contest. The first place forecaster for each contest receives a certificate; the winner of the temperature contest receives the "Johnny Tempo Award", while the winner of the precipitation forecast receives the "Rain Man Award".

Table 8: Example of an individual forecaster's averages for trace rainfall events and for non rainfall events. Also, note the summary of periods of measurable rainfall, trace rainfall, and no rainfall events, as well as the number of times the person forecast a POP of '0' when measurable rainfall occurred. Similar verification results are provided for all six verification sites.

POP AVERAGES FOR TRACE EVENTS AT CORPUS CHRISTI

FCST DAY	PERIOD	CCF	FWC	MET	MAV
AVERAGE FOR PERIOD	1	30.0	5.0	32.0	37.0
AVERAGE FOR PERIOD	2	-99.0	-99.0	-99.0	-99.0
AVERAGE FOR PERIOD	3	40.0	13.0	35.0	22.0
AVERAGE FOR PERIOD	4	25.0	13.3	19.8	34.7
AVERAGE FOR PERIOD	5	31.3	-99.0	38.8	34.8
TRACE AVERAGES		28.8	12.3	28.4	33.8

```
PERIODS WITH MEASURABLE RAINFALL     =  12
# OF FORECASTS WITH RAIN AND CCF '0' =       0
PERIODS WITH TRACE  RAINFALL         =  12
PERIODS WITH NO  RAINFALL            =  110
```

AVERAGES FOR NO RAINFALL AT CORPUS CHRISTI

FCST DAY	PERIOD	CCF	FWC	MET	MAV
NO RAIN	1	4.5	3.9	8.3	10.8
NO RAIN	2	2.9	3.1	9.5	6.8
NO RAIN	3	4.3	4.5	9.5	10.5
NO RAIN	4	5.0	7.6	10.4	11.0
NO RAIN	5	7.8	-99.0	17.3	10.0
AVERAGE		4.7	4.5	10.7	9.7

Table 9: Example of an individual forecaster's Brier Scores for a six month period. Brier Score results are provided for all six verification sites.

BRIER SCORES FOR ALL EVENTS AT VICTORIA

FCST DAY	PERIOD	CCF	FWC	MET	MAV
AVERAGE FOR PERIOD	1	0.081	0.104	0.109	0.080
AVERAGE FOR PERIOD	2	0.122	0.164	0.134	0.122
AVERAGE FOR PERIOD	3	0.136	0.214	0.174	0.149
AVERAGE FOR PERIOD	4	0.102	0.135	0.130	0.120
AVERAGE FOR PERIOD	5	0.124	-9.999	0.136	0.134
AVERAGES		0.114	0.154	0.137	0.123

The temperature forecast contest uses the six forecaster files that were created for that person's verification statistics. These files contain the CCF and MOS forecasts for each day and period, along with the observed temperatures. Differences between the CCF forecast and observed temperature are computed. Next, the available MAV, MET, and FWC forecasts are averaged, and the difference between the average MOS forecast and observed temperature is computed. Differences between the CCF error and the average MOS error are compared. The CCF error is adjusted in the following manner. For the first period, only 20% of the error difference between the CCF error and average MOS error is used (let us call this difference the "error difference"). This error difference increases to 60% by period five (*i.e.*, 20% for the first period, increasing by 10% each period, up to 60% for period five). If the CCF error is smaller than the average MOS error for that forecast, then that percentage error difference is subtracted from the CCF error. However, if the CCF error is larger than the average MOS error, then the percentage of that error difference is added to the CCF error. This way, the forecaster is rewarded for beating MOS, but punished for losing to MOS.

After all of the CCF errors are adjusted for each forecast, the adjusted CCF errors are summed and averaged. The average adjusted CCF error is the forecaster's "score" for that verification site. Forecaster scores are determined for all six sites and averaged to compute a final score. The forecaster with the lowest final score wins the coveted Johnny Tempo Award. An example of this certificate is shown in Figure 12. Station temperature verification results over the past several months indicate that WFO CRP has greatest temperature improvements over MOS in the Southern Region for the first three periods, and improves MOS forecasts through period eight.

THE JOHNNY TEMPO AWARD

has been award to

<u>Joe Meteorology</u>

For the best temperature forecasts during the period <u>April 2004</u> to <u>September 2004</u>

AT WFO CORPUS CHRISTI TX

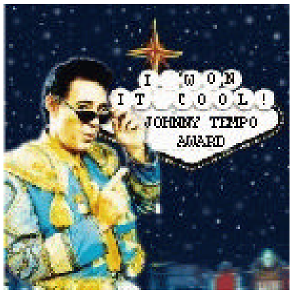


Figure 12: Example of the Certificate for the Johnny Tempo Award given to the forecaster with the best temperature score for all six verification sites. This contest is done in the spirit of friendly competition to hopefully improve temperature forecasts.

Similar to the temperature forecast contest, the precipitation forecast contest compares each CCF forecast with observed rainfall, and an average of the available MAV, MET and FWC forecast. A Brier Score for each forecast is computed for the CCF and average MOS forecast. The differences between the CCF and average MOS score is compared (let us call this "difference in score"). Similar to the temperature forecast contest, for the first period only 20% of the difference in score is used to adjust the CCF score. However, this adjustment increases by 10% for each period, increasing to 60% by period five. If the CCF score is better (worse) than the average MOS score, the CCF score is reduced (increased) by that percentage of the difference in score. These adjusted scores are computed for all forecasts, then averaged for each station. This adjusted Brier Score is computed for each verification site and averaged. The forecaster with the lowest final average adjusted Brier Score wins the coveted Rain Man Award. An example of this certificate is shown in Figure 13. Station precipitation verification results over the past several months indicate that WFO CRP is one of the better performing WFOs in Southern Region when comparing MOS and CCF forecasts.

THE DUSTIN HOFFMAN RAIN MAN AWARD

has been award to

Joe Meteorology

For the best precipitation forecasts during the period April 2004 to September 2004

AT WFO CORPUS CHRISTI TX

Figure 13: Example of the Certificate for the Rain Man Award given to the forecaster with the best precipitation score for all six verification sites. This contest is done in the spirit of friendly competition to hopefully improve precipitation forecasts.

VII. Summary

In an ongoing effort to improve temperature and precipitation forecasts at WFO Corpus Christi TX, station verification statistics are presented to the staff every month. Also, six month verification statistics are generated in October and April for the warm and cool seasons, respectively. Since the short term forecaster can provide forecasts for as many as three periods or for as little as zero periods, a method was devised to keep track of the number of periods the short term and long term forecasters provided for that forecast cycle. This enables each forecaster to receive a six month summary of their temperature and precipitation verification statistics, and to compare their statistics with the MAV, MET and FWC guidance. As an additional incentive and in the spirit of friendly competition, a temperature and precipitation forecast contest is conducted every six months. In each contest, the top three forecasters are announced, with the winner of each forecast receiving a certificate. We believe that these procedures help WFO CRP forecasters provide the best possible forecasts to their customers by determining how well MAV, MET, and FWC guidance performs at each station, how station CCF forecasts compare with individual MOS forecasts, what MOS biases exist at each station, and how each forecaster's statistics compare with MOS guidance. Verification statistics during the past several months has indicted that WFO CRP temperature forecasts improve MOS temperature forecasts for the first several periods, and that the WFO's precipitation statistics are among the best in the Southern Region.

VIII. Acknowledgements

The author would like to thank Ron Morales, Science and Operations Officer at WFO CRP for his suggestions and for his help in editing the first two drafts of this paper. Also, thanks to David (Rusty) Billingsley, Chief of the Science Services Division (SSD) in Southern Region, and Bernard Meisner Deputy SSD Chief, for their comments, suggestions and critical editing. Finally, I would also like to thank Mark Fox, Regional Training Officer in Southern Region for the verification statistics.

IX. References

1. Brier, Glenn W., 1950: Verification of forecasts expressed in terms of probability. *Mon. Wea. Rev.*, **78**, 1-3.

2. Frederick, James, 1999: AWIPS Interactive Forecast Verification. *15th International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology*, Dallas, Texas, January 10-15, 1999.