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A SEASONAL ANALYSIS OF THE PERFORMANCE OF THE PROBABILITY OF PRECIPITATION TYPE GUIDANCE SYSTEM

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1. INTRODUCTION

The current probability of precipitation type (PoPT) system (Bocchieri and Maglaras, 1983) has been providing probability and categorical guidance for freezing precipitation (ZR), frozen precipitation (SNOW), and liquid precipitation (RAIN) to forecasters since 1982. It was developed by the Techniques Development Laboratory (TDL) by using the Model Output Statistics (MOS) technique (Glahn and Lowry, 1972) as applied to output from the Limited-Area Fine-Mesh (LFM-II) model (Newell and Deaven, 1981). Past AFOS-era Verification (AEV) statistics (Dagostaro, 1985) for any given cool season (October-March) have indicated that the PoPT system provides useful guidance and performs very well, overall, especially for the SNOW category.

Maglaras (1986) stated that the equations used to produce the forecasts are biased towards winter time situations and can produce erroneous categorical forecasts of SNOW during the fall and spring. Although a single set of equations is valid for the entire period from September-May, most of the SNOW cases used for equation development occurred in winter (roughly December-March). Thus, the values of the predictor coefficients in the equations reflect the upper level to surface thermal relationships that occur during the winter. For example, given the same 850-mb temperature and cloud cover at a particular station on January 1 and April 1, the surface temperature on April 1 will be higher due to the higher sun elevation, longer day, warmer ground, etc., as long as intense convection is not present.

In order to confirm the statements in Maglaras (1986), verification data from approximately 200 conterminous United States stations for five cool seasons (1983-84 thru 1987-88) were examined. The stations used for this study are shown in Tables 1 and 2. The cool season stratification for this study was expanded to include the second half of September and all of April and May. In order to quantify the performance of the MOS PoPT system during the various times of the year, the data were stratified into three seasons: FALL (September 16-November 30), WINTER (December 1-March 15), and SPRING (March 16-May 31). The data were also grouped by the National Weather Service administrative regions of Eastern, Southern, Central and Western. Of course, the meteorological periods for FALL, WINTER and SPRING vary across the country, and are dependent upon station elevation, but these stratifications are representative of the nation on average.

As expected, the data revealed seasonal differences in the performance of the PoPT system, while interesting regional differences in the performance of ZR and SNOW forecasts also were noted. These differences will be discussed in the following sections, and some insights will be given as to what may have caused some of the variations. Verification data for projections of 18, 30, and 42 hours from both 0000 and 1200 UTC, and for all three seasons, are shown in Tables 3-5 for the entire nation. Tables 6-8, 9-11, 12-14, and 15-17 show verification data for stations in the Eastern, Southern, Central, and Western Regions, respectively. The data are presented in contingency table form with scores for bias, probability of detection (POD), and false alarm ratio (FAR) as defined by the following equations:

$$\text{Bias} = \frac{\text{number of forecasts of an event}}{\text{total number of occurrences of an event}}$$

$$\text{POD} = \frac{\text{number of correct forecasts of an event}}{\text{total number of occurrences of an event}}$$

$$\text{FAR} = 1 - \frac{\text{number of correct forecasts of an event}}{\text{number of forecasts of an event}}$$

The primary objective of operational forecasters is to predict the occurrence of significant weather events such as snow and freezing rain. As a result, the POD will be the principal measure of accuracy used in this study. Also, since SNOW and ZR forecasts are the focus of this paper, not all of the scores for RAIN are included, and the RAIN category is not discussed.

Eastern Region

Hartford	CT
Bridgeport	CT
Washington	DC
Wilmington	DE
Covington/Cincinnati	KY
Boston	MA
Baltimore	MD
Portland	ME
Bangor	ME
Caribou	ME
Raleigh-Durham	NC
Asheville	NC
Greensoro	NC
Wilmington	NC
Charlotte	NC
Cape Hatteras	NC
Concord	NH
Atlantic City	NJ
Newark	NJ
Albany	NY
Binghamton	NY
Massena	NY
Buffalo	NY
Rochester	NY
Syracuse	NY
New York-Laguardia	NY
New York-Kennedy	NY
Cleveland	OH
Columbus	OH
Youngstown	OH
Akron Canton	OH
Dayton	OH
Toledo	OH
Philadelphia	PA
Allentown	PA
Harrisburg	PA
Scranton	PA
Williamsport	PA
Atlantic City	PA
Pittsburgh	PA
Bradford	PA
Erie	PA
Columbia	SC
Greenville	SC
Charleston	SC
Lynchburg	VA
Norfolk	VA
Richmond	VA
Roanoke	VA
Washington-Dulles	VA
Wallops Island	VA
Burlington	VT
Charleston	WV
Huntington	WV
Beckley	WV
Elkins	WV

Southern Region

Birmingham	AL
Huntsville	AL
Mobile	AL
Montgomery	AL
Little Rock	AR
Fort Smith	AR
Tallahassee	FL
Atlanta	GA
Macon	GA
Augusta	GA
Savannah	GA
Athens	GA
New Orleans	LA
Lake Charles	LA
Shreveport	LA
Baton Rouge	LA
Jackson	MS
Meridian	MS
Albuquerque	NM
Tucumcari	NM
Farmington	NM
Truth or Consequences	NM
Oklahoma City	OK
Tulsa	OK
Memphis	TN
Bristol	TN
Chattanooga	TN
Knoxville	TN
Nashville	TN
Dallas-Ft. Worth	TX
Waco	TX
Abilene	TX
Wichita Falls	TX
Lufkin	TX
Lubbock	TX
Midland	TX
San Angelo	TX
El Paso	TX
Amarillo	TX
San Antonio	TX
Houston	TX
Austin	TX

Table 1. Station Used for the verification of the PoPT system from the Eastern and Southern Regions.

Central Region

Denver	CO
Grand Junction	CO
Colorado Springs	CO
Pueblo	CO
Des Moines	IA
Mason City	IA
Sioux City	IA
Dubuque	IA
Waterloo	IA
Peoria	IL
Moline	IL
Springfield	IL
Rockford	IL
Chicago-Ohare	IL
Indianapolis	IN
Fort Wayne	IN
South Bend	IN
Evansville	IN
Topeka	KS
Wichita	KS
Concordia	KS
Dodge City	KS
Goodland	KS
Russell	KS
Louisville	KY
Lexington	KY
Detroit	MI
Flint	MI
Lansing	MI
Muskegon	MI
Sault Ste Marie	MI
Traverse City	MI
Houghton Lake	MI
Alpena	MI
Grand Rapids	MI
Minneapolis	MN
Duluth	MN
International Falls	MN
Rochester	MN
St. Louis	MO
Columbia	MO
Kansas City	MO
Springfield	MO
Bismarck	ND
Fargo	ND
Minot	ND
Williston	ND
Omaha	NE
Grand Island	NE
North Platte	NE
Scottsbluff	NE
Sioux Falls	SD
Aberdeen	SD
Huron	SD
Pierre	SD
Rapid City	SD
Madison	WI
Green Bay	WI
La Crosse	WI
Eau Claire	WI
Milwaukee	WI
Lander	WY
Rock Springs	WY
Sheridan	WY
Casper	WY
Cheyenne	WY

Western Region

Tuscon	AZ
Red Bluff	CA
Arcata	CA
Daggett	CA
Boise	ID
Pocatello	ID
Great Falls	MT
Billings	MT
Helena	MT
Kalispell	MT
Missoula	MT
Glasgow	MT
Havre	MT
Tonopah	NV
Ely	NV
Las Vegas	NV
Elko	NV
Winnemuca	NV
Lovelock	NV
Portland	OR
Burns	OR
Pendleton	OR
Eugene	OR
Medford	OR
Redmond	OR
Salem	OR
North Bend	OR
Astoria	OR
Salt Lake City	UT
Bryce Canyon	UT
Cedar City	UT
Seattle-Tacoma	WA
Spokane	WA
Olympia	WA
Yakima	WA
Quillayute	WA

Table 2. Same as Table 1, except for the Central and Western Regions.

2. RESULTS FOR THE NATION

As Table 3 shows, there was no overforecasting of SNOW during FALL, with bias scores for the nation at or below 1.01. For WINTER, (Table 4) the bias was nearly perfect with values between 1.00-1.03. However, overforecasting did occur in SPRING. Table 5 indicates that bias scores were between 1.05-1.27, and the greatest amount of overforecasting occurred for the 1200 UTC cycle.

SNOW POD and FAR scores for WINTER were excellent. The POD was between 0.91-0.95, while the FAR was 0.10 or less. For FALL and SPRING, these scores were inferior by about 0.10. However, the FAR for SPRING was much worse (generally 0.10-0.20 higher than for FALL and WINTER). Most likely this was due to the overforecasting of SNOW.

The results for the ZR forecasts varied from season to season. The scores revealed considerable underforecasting for FALL (bias scores between 0.41-0.80), overforecasting during WINTER (most scores much higher than 1.00), and extreme underforecasting during SPRING (0.05-0.27).

The WINTER POD scores for ZR were between 0.24-0.35, while the FAR was 0.68-0.77. For FALL, these scores were worse, but slight accuracy for forecasting ZR was still noted. However, for SPRING, the PoPT system exhibited little accuracy for forecasting ZR. The POD scores for SPRING were 0.06 or less. However, the FAR was only slightly worse than during WINTER.

FALL SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	29	46	75	150
B	SN	17	1293	161	1471
S	RA	16	147	5914	6077
	TOT	62	1486	6150	7698
	BIAS	0.41	1.01	1.01	
	POD	0.19	0.88	----	
	FAR	0.53	0.13	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	47	61	97	205
B	SN	65	1173	149	1387
S	RA	18	108	5815	5941
	TOT	130	1342	6061	7533
	BIAS	0.63	0.97	1.02	
	POD	0.23	0.85	----	
	FAR	0.64	0.13	----	

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	41	65	104	210
B	SN	68	1127	189	1384
S	RA	27	148	5798	5973
	TOT	136	1340	6091	7567
	BIAS	0.65	0.97	1.02	
	POD	0.20	0.81	----	
	FAR	0.70	0.16	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	29	52	76	157
B	SN	50	1312	215	1577
S	RA	35	163	5880	6078
	TOT	114	1527	6171	7812
	BIAS	0.73	0.97	1.02	
	POD	0.18	0.83	----	
	FAR	0.75	0.14	----	

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	26	54	81	161
B	SN	39	1294	244	1577
S	RA	42	173	5911	6126
	TOT	107	1521	6236	7864
	BIAS	0.66	0.96	1.02	
	POD	0.16	0.82	----	
	FAR	0.76	0.15	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	36	54	131	221
B	SN	91	1122	272	1485
S	RA	49	114	5830	5993
	TOT	176	1290	6233	7699
	BIAS	0.80	0.87	1.04	
	POD	0.16	0.76	----	
	FAR	0.80	0.13	----	

---- = not calculated

Table 3. MOS PoPT verification contingency tables for the entire nation based on the five FALL (September 16 - November 30) seasons from 1983-1987. Data are included for the 18-, 30-, and 42-hr projections from the 0000 and 1200 UTC cycles, respectively.

WINTER SEASON

18-HR PROJECTION

0000 UTC

		ZR	SN	RA	TOT
O	ZR	151	288	184	623
B	SN	200	8457	288	8945
S	RA	126	396	5339	5861
	TOT	477	9141	5811	15429
	BIAS	0.77	1.02	0.99	
	POD	0.24	0.95	----	
	FAR	0.68	0.07	----	

1200 UTC

		ZR	SN	RA	TOT
O	ZR	265	279	210	754
B	SN	317	8016	234	8567
S	RA	238	365	5180	5783
	TOT	820	8660	5624	15104
	BIAS	1.09	1.01	0.97	
	POD	0.35	0.94	----	
	FAR	0.68	0.07	----	

30-HR PROJECTION

0000 UTC

		ZR	SN	RA	TOT
O	ZR	245	289	230	764
B	SN	320	8018	293	8631
S	RA	268	408	5140	5816
	TOT	833	8715	5663	15211
	BIAS	1.09	1.01	0.97	
	POD	0.32	0.93	----	
	FAR	0.71	0.08	----	

1200 UTC

		ZR	SN	RA	TOT
O	ZR	182	271	161	614
B	SN	289	8311	284	8884
S	RA	312	562	4915	5789
	TOT	783	9144	5360	15287
	BIAS	1.28	1.03	0.93	
	POD	0.30	0.94	----	
	FAR	0.77	0.09	----	

42-HR PROJECTION

0000 UTC

		ZR	SN	RA	TOT
O	ZR	181	281	161	623
B	SN	281	8313	331	8925
S	RA	287	615	4918	5820
	TOT	749	9209	5410	15368
	BIAS	1.20	1.03	0.93	
	POD	0.29	0.93	----	
	FAR	0.76	0.10	----	

1200 UTC

		ZR	SN	RA	TOT
O	ZR	262	285	205	752
B	SN	419	7812	335	8566
S	RA	416	495	4821	5732
	TOT	1097	8592	5361	15050
	BIAS	1.46	1.00	0.94	
	POD	0.35	0.91	----	
	FAR	0.76	0.09	----	

(Column headings ZR, SN, RA, TOT are FORECAST; row labels are OBS.)

---- = not calculated

Table 4. Same as Table 3 except for the five WINTER (December 1 - March 15) seasons from 1983-84 through 1987-88.

SPRING SEASON

18-HR PROJECTION

0000 UTC		FORECAST				1200 UTC		FORECAST			
		ZR	SN	RA	TOT			ZR	SN	RA	TOT
O	ZR	3	55	90	148	O	ZR	6	56	40	102
B	SN	2	867	125	994	B	SN	4	785	101	890
S	RA	3	122	4944	5069	S	RA	9	199	4857	5065
	TOT	8	1044	5159	6211		TOT	19	1040	4998	6057
	BIAS	0.05	1.05	1.02			BIAS	0.19	1.17	0.99	
	POD	0.02	0.87	----			POD	0.06	0.88	----	
	FAR	0.63	0.17	----			FAR	0.68	0.25	----	

30-HR PROJECTION

0000 UTC		FORECAST				1200 UTC		FORECAST			
		ZR	SN	RA	TOT			ZR	SN	RA	TOT
O	ZR	4	50	46	100	O	ZR	7	74	64	145
B	SN	4	750	144	898	B	SN	6	831	87	924
S	RA	19	177	4913	5109	S	RA	11	271	4735	5017
	TOT	27	977	5103	6107		TOT	24	1176	4886	6086
	BIAS	0.27	1.09	1.00			BIAS	0.17	1.27	0.97	
	POD	0.04	0.84	----			POD	0.05	0.90	----	
	FAR	0.85	0.23	----			FAR	0.71	0.29	----	

42-HR PROJECTION

0000 UTC		FORECAST				1200 UTC		FORECAST			
		ZR	SN	RA	TOT			ZR	SN	RA	TOT
O	ZR	4	61	86	151	O	ZR	3	53	40	96
B	SN	1	801	120	922	B	SN	9	703	119	831
S	RA	9	196	4861	5066	S	RA	14	236	4817	5067
	TOT	14	1058	5067	6139		TOT	26	992	4976	5994
	BIAS	0.09	1.15	1.00			BIAS	0.27	1.19	0.98	
	POD	0.03	0.87	----			POD	0.03	0.85	----	
	FAR	0.71	0.24	----			FAR	0.88	0.29	----	

---- = not calculated

Table 5. Same as Table 3 except for the five SPRING (March 16 - May 31) seasons from 1984-1988.

3. REGIONAL RESULTS

In general, the regional results were similar to those of the nation. However, there were some interesting differences among the regions, which will be discussed in the following sub-sections.

3.1 EASTERN REGION

Tables 6-8 show results from the Eastern Region. The WINTER scores for SNOW and ZR generally followed the national trends with no substantial departures from the national averages. For SPRING, the overforecasting of SNOW was greater than for the other regions. Bias scores ranged from 1.14-1.46. This resulted in POD scores that were almost as good as the WINTER scores (0.86 or higher), but with relatively poor FAR values (0.21-0.39).

In addition to the lack of accuracy associated with forecasting ZR in SPRING, the PoPT system displayed little accuracy for forecasting ZR in FALL. POD scores for FALL were between 0.03-0.15, and the corresponding FAR values were 0.44-0.82.

EASTERN REGION
FALL SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	5	12	28	45
B	SN	3	200	55	258
S	RA	1	41	2069	2111
	TOT	9	253	2152	2414
	BIAS	0.20	0.98	1.02	
	POD	0.11	0.78	----	
	FAR	0.44	0.21	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	8	13	33	54
B	SN	4	175	31	210
S	RA	4	34	2118	2156
	TOT	16	222	2182	2420
	BIAS	0.30	1.06	1.01	
	POD	0.15	0.83	----	
	FAR	0.50	0.21	----	

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	6	15	33	54
B	SN	5	162	35	202
S	RA	1	49	2107	2157
	TOT	12	226	2175	2413
	BIAS	0.22	1.12	1.01	
	POD	0.11	0.80	----	
	FAR	0.50	0.28	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	2	22	27	51
B	SN	6	207	58	271
S	RA	3	58	2071	2132
	TOT	11	287	2156	2454
	BIAS	0.22	1.06	1.01	
	POD	0.04	0.76	----	
	FAR	0.82	0.28	----	

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	3	24	26	53
B	SN	5	193	69	267
S	RA	3	67	2070	2140
	TOT	11	284	2165	2460
	BIAS	0.21	1.06	1.01	
	POD	0.06	0.72	----	
	FAR	0.73	0.32	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	2	12	44	58
B	SN	8	171	46	225
S	RA	1	38	2140	2179
	TOT	11	221	2230	2462
	BIAS	0.19	0.98	1.02	
	POD	0.03	0.76	----	
	FAR	0.82	0.23	----	

---- = not calculated

Table 6. Same as Table 3 except for the Eastern Region for the FALL season.

EASTERN REGION
WINTER SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	60	116	77	253
B	SN	45	2918	96	3059
S	RA	53	185	1944	2182
	TOT	158	3219	2117	5494
	BIAS	0.62	1.05	0.97	
	POD	0.24	0.95	----	
	FAR	0.62	0.09	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	68	98	82	248
B	SN	93	2870	79	3042
S	RA	103	135	1719	1957
	TOT	264	3103	1880	5247
	BIAS	1.06	1.02	0.96	
	POD	0.27	0.94	----	
	FAR	0.74	0.08	----	

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	73	101	79	253
B	SN	91	2883	88	3062
S	RA	102	159	1731	1992
	TOT	266	3143	1898	5307
	BIAS	1.05	1.03	0.95	
	POD	0.29	0.94	----	
	FAR	0.73	0.08	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	75	106	66	247
B	SN	87	2918	67	3072
S	RA	131	282	1737	2150
	TOT	293	3306	1870	5469
	BIAS	1.19	1.08	0.87	
	POD	0.30	0.95	----	
	FAR	0.74	0.12	----	

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	74	115	64	253
B	SN	73	2938	79	3090
S	RA	97	312	1761	2170
	TOT	244	3365	1904	5513
	BIAS	0.96	1.09	0.88	
	POD	0.29	0.95	----	
	FAR	0.70	0.13	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	80	98	70	248
B	SN	154	2808	104	3066
S	RA	148	187	1616	1951
	TOT	382	3093	1790	5265
	BIAS	1.54	1.01	0.92	
	POD	0.32	0.92	----	
	FAR	0.79	0.09	----	

---- = not calculated

Table 7. Same as Table 3 except for the Eastern Region for the WINTER season.

EASTERN REGION
SPRING SEASON

18-HR PROJECTION

		0000 UTC	FORECAST					1200 UTC	FORECAST		
		ZR	SN	RA	TOT			ZR	SN	RA	TOT
O	ZR	0	27	31	58	O	ZR	1	17	19	37
B	SN	0	260	27	287	B	SN	1	232	25	258
S	RA	0	41	1858	1899	S	RA	1	83	1843	1927
	TOT	0	328	1916	2244		TOT	3	332	1887	2222
	BIAS	0.00	1.14	1.01			BIAS	0.08	1.29	0.98	
	POD	0.00	0.91	----			POD	0.03	0.90	----	
	FAR	1.00	0.21	----			FAR	0.67	0.30	----	

30-HR PROJECTION

		0000 UTC	FORECAST					1200 UTC	FORECAST		
		ZR	SN	RA	TOT			ZR	SN	RA	TOT
O	ZR	1	19	17	37	O	ZR	1	37	20	58
B	SN	2	222	34	258	B	SN	2	250	16	268
S	RA	3	77	1861	1941	S	RA	2	104	1772	1878
	TOT	6	318	1912	2236		TOT	5	391	1808	2204
	BIAS	0.16	1.23	0.99			BIAS	0.09	1.46	0.96	
	POD	0.03	0.86	----			POD	0.02	0.93	----	
	FAR	0.83	0.30	----			FAR	0.80	0.36	----	

42-HR PROJECTION

		0000 UTC	FORECAST					1200 UTC	FORECAST		
		ZR	SN	RA	TOT			ZR	SN	RA	TOT
O	ZR	2	30	31	63	O	ZR	1	22	12	35
B	SN	0	247	21	268	B	SN	4	206	27	237
S	RA	4	69	1841	1914	S	RA	1	112	1818	1931
	TOT	6	346	1893	2245		TOT	6	340	1857	2203
	BIAS	0.10	1.29	0.99			BIAS	0.17	1.43	0.96	
	POD	0.03	0.92	----			POD	0.03	0.87	----	
	FAR	0.67	0.29	----			FAR	0.83	0.39	----	

---- = not calculated

Table 8. Same as Table 3 except for the Eastern Region for the SPRING season.

3.2 SOUTHERN REGION

As Tables 9-11 reveal, the WINTER ZR forecasts were best in the Southern Region when compared to other regions. This occurred even though the Southern Region had only one-third the number of cases of ZR compared to the Central Region, which had the highest number of cases. The POD scores ranged from 0.39-0.51, while the FAR was from 0.57-0.76. Part of the reason for this success was that ZR was considerably overpredicted. With the exception of the 18-hr projection from 0000 UTC, the bias scores were much greater than 1.00. For FALL and SPRING, there were not enough cases of ZR to draw any conclusions.

WINTER SNOW forecasts were relatively poor for the Southern Region. SNOW was somewhat underforecast, with bias scores between 0.80-0.99. The POD scores were between 0.63-0.80; the FAR were 0.19-0.24. The small number of snow events in the Southern Region likely contributed greatly to the low scores. No conclusions can be drawn from FALL SNOW data since very few events (about 10 SNOW events per projection) were observed. In SPRING, the SNOW scores were only slightly worse than WINTER, but only about 20 SNOW events occurred per projection.

SOUTHERN REGION
FALL SEASON

18-HR PROJECTION

0000 UTC		FORECAST ZR	SN	RA	TOT
O	ZR	0	0	1	1
B	SN	0	6	4	10
S	RA	0	4	977	981
	TOT	0	10	982	992
	BIAS	0.00	1.00	1.00	
	POD	0.00	0.60	----	
	FAR	1.00	0.40	----	

1200 UTC		FORECAST ZR	SN	RA	TOT
O	ZR	0	0	3	3
B	SN	0	5	4	9
S	RA	0	0	949	949
	TOT	0	5	956	961
	BIAS	0.00	0.56	1.01	
	POD	0.00	0.56	----	
	FAR	1.00	0.00	----	

30-HR PROJECTION

0000 UTC		FORECAST ZR	SN	RA	TOT
O	ZR	0	0	3	3
B	SN	0	5	4	9
S	RA	1	0	955	956
	TOT	1	5	962	968
	BIAS	0.33	0.56	1.01	
	POD	0.00	0.56	----	
	FAR	1.00	0.00	----	

1200 UTC		FORECAST ZR	SN	RA	TOT
O	ZR	0	0	1	1
B	SN	0	7	4	11
S	RA	2	7	984	993
	TOT	2	14	989	1005
	BIAS	2.00	1.27	1.00	
	POD	0.00	0.64	----	
	FAR	1.00	0.50	----	

42-HR PROJECTION

0000 UTC		FORECAST ZR	SN	RA	TOT
O	ZR	0	1	1	2
B	SN	1	4	6	11
S	RA	4	3	997	1004
	TOT	5	8	1004	1017
	BIAS	2.50	0.73	1.00	
	POD	0.00	0.36	----	
	FAR	1.00	0.50	----	

1200 UTC		FORECAST ZR	SN	RA	TOT
O	ZR	1	0	2	3
B	SN	0	5	4	9
S	RA	3	2	959	964
	TOT	4	7	965	976
	BIAS	1.33	0.78	1.00	
	POD	0.33	0.56	----	
	FAR	0.75	0.29	----	

---- = not calculated

Table 9. Same as Table 3 except for the Southern Region for the FALL season.

SOUTHERN REGION
WINTER SEASON

18-HR PROJECTION

		0000 UTC FORECAST ZR	SN	RA	TOT			1200 UTC FORECAST ZR	SN	RA	TOT
O	ZR	33	27	19	79	O	ZR	56	19	35	110
B	SN	29	278	42	349	B	SN	44	239	24	307
S	RA	15	40	1438	1493	S	RA	42	37	1527	1606
	TOT	77	345	1499	1921		TOT	142	295	1586	2023
	BIAS	0.97	0.99	1.00			BIAS	1.29	0.96	0.99	
	POD	0.42	0.80	----			POD	0.51	0.78	----	
	FAR	0.57	0.19	----			FAR	0.61	0.19	----	

30-HR PROJECTION

		0000 UTC FORECAST ZR	SN	RA	TOT			1200 UTC FORECAST ZR	SN	RA	TOT
O	ZR	47	17	46	110	O	ZR	32	27	20	79
B	SN	64	216	29	309	B	SN	51	256	42	349
S	RA	47	40	1509	1596	S	RA	52	51	1381	1484
	TOT	158	273	1584	2015		TOT	135	334	1443	1912
	BIAS	1.44	0.88	0.99			BIAS	1.71	0.96	0.97	
	POD	0.43	0.70	----			POD	0.41	0.73	----	
	FAR	0.70	0.21	----			FAR	0.76	0.23	----	

42-HR PROJECTION

		0000 UTC FORECAST ZR	SN	RA	TOT			1200 UTC FORECAST ZR	SN	RA	TOT
O	ZR	31	25	23	79	O	ZR	47	15	48	110
B	SN	50	236	63	349	B	SN	66	194	50	310
S	RA	28	50	1405	1483	S	RA	68	39	1482	1589
	TOT	109	311	1491	1911		TOT	181	248	1580	2009
	BIAS	1.38	0.89	1.01			BIAS	1.65	0.80	0.99	
	POD	0.39	0.68	----			POD	0.43	0.63	----	
	FAR	0.72	0.24	----			FAR	0.74	0.22	----	

---- = not calculated

Table 10. Same as Table 3 except for the Southern Region for the WINTER season.

SOUTHERN REGION
SPRING SEASON

18-HR PROJECTION

0000 UTC

		ZR	SN	RA	TOT
O	ZR	0	0	5	5
B	SN	0	14	6	20
S	RA	0	4	657	661
	TOT	0	18	668	686
	BIAS	0.00	0.90	1.01	
	POD	0.00	0.70	----	
	FAR	1.00	0.22	----	

1200 UTC

		ZR	SN	RA	TOT
O	ZR	0	1	0	1
B	SN	0	16	7	23
S	RA	1	4	567	572
	TOT	1	21	574	596
	BIAS	1.00	0.91	1.00	
	POD	0.00	0.70	----	
	FAR	1.00	0.24	----	

30-HR PROJECTION

0000 UTC

		ZR	SN	RA	TOT
O	ZR	0	1	0	1
B	SN	0	16	7	23
S	RA	0	3	578	581
	TOT	0	20	585	605
	BIAS	0.00	0.87	1.01	
	POD	0.00	0.70	----	
	FAR	1.00	0.20	----	

1200 UTC

		ZR	SN	RA	TOT
O	ZR	0	0	5	5
B	SN	0	17	3	20
S	RA	0	13	633	646
	TOT	0	30	641	671
	BIAS	0.00	1.50	0.99	
	POD	0.00	0.85	----	
	FAR	1.00	0.43	----	

42-HR PROJECTION

0000 UTC

		ZR	SN	RA	TOT
O	ZR	0	0	6	6
B	SN	0	12	8	20
S	RA	0	3	646	649
	TOT	0	15	660	675
	BIAS	0.00	0.75	1.02	
	POD	0.00	0.60	----	
	FAR	1.00	0.20	----	

1200 UTC

		ZR	SN	RA	TOT
O	ZR	0	0	1	1
B	SN	0	16	6	22
S	RA	1	3	567	571
	TOT	1	19	574	594
	BIAS	1.00	0.86	1.01	
	POD	0.00	0.73	----	
	FAR	1.00	0.16	----	

(Columns: FORECAST ZR, SN, RA, TOT; rows: OBS)

---- = not calculated

Table 11. Same as Table 3 except for the Southern Region for the SPRING season.

3.3 CENTRAL REGION

Tables 12-14 show the results from the Central Region. In general, the PoPT system exhibited the best scores in the Central Region for all seasons. For WINTER, the SNOW forecasts were excellent since virtually no bias existed, the POD values approached 1.00, and the FAR values approached zero. The large number of SNOW and ZR cases undoubtedly contributed to the high scores. In fact, for the Central Region, SNOW accounted for about 80% of the precipitation cases during WINTER.

SNOW forecasts for FALL and SPRING were about equal to each other in accuracy, and only slightly worse than for WINTER. In fact, the SNOW forecasts for FALL and SPRING in the Central Region were as good as, or better than WINTER forecasts of SNOW in the Western Region, and much better than the SNOW forecasts in the Southern Region. For SPRING, SNOW was overforecast (i.e., the bias scores were between 1.02-1.19), but not as much as for the Eastern Region.

The Central Region ZR forecasts for WINTER were almost as accurate as the Southern Region ZR forecasts. Also, similar to the Southern Region, ZR was greatly overforecast (bias values generally much greater than 1.00), and this was one reason for the relatively good POD scores. It is interesting to note that there was little, if any, reduction in the accuracy of the ZR forecasts during FALL, which was accomplished without the overforecasting that occurred during WINTER. It should be noted here that the accurate Central Region ZR scores for FALL were the primary reason the national ZR scores for FALL were respectable.

CENTRAL REGION
FALL SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	24	28	33	85
B	SN	14	767	66	847
S	RA	13	73	1919	2005
	TOT	51	868	2018	2937
	BIAS	0.60	1.02	1.01	
	POD	0.28	0.91	----	
	FAR	0.53	0.12	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	39	40	48	127
B	SN	59	742	78	879
S	RA	14	56	1907	1977
	TOT	112	838	2033	2983
	BIAS	0.88	0.95	1.03	
	POD	0.31	0.84	----	
	FAR	0.65	0.11	----	

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	34	45	53	132
B	SN	59	720	105	884
S	RA	23	78	1896	1997
	TOT	116	843	2054	3013
	BIAS	0.88	0.95	1.03	
	POD	0.26	0.81	----	
	FAR	0.71	0.15	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	27	24	36	87
B	SN	43	783	99	925
S	RA	30	69	1875	1974
	TOT	100	876	2010	2986
	BIAS	1.15	0.95	1.02	
	POD	0.31	0.85	----	
	FAR	0.73	0.11	----	

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	23	24	41	88
B	SN	30	779	117	926
S	RA	32	70	1899	2001
	TOT	85	873	2057	3015
	BIAS	0.97	0.94	1.03	
	POD	0.26	0.84	----	
	FAR	0.73	0.11	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	33	38	68	139
B	SN	80	723	149	952
S	RA	45	58	1879	1982
	TOT	158	819	2096	3073
	BIAS	1.14	0.86	1.06	
	POD	0.24	0.76	----	
	FAR	0.79	0.12	----	

---- = not calculated

Table 12. Same as Table 3 except for the Central Region for the FALL season.

CENTRAL REGION
WINTER SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RN	TOT
O	ZR	43	115	52	210
B	SN	64	4293	78	4435
S	RA	58	120	813	991
	TOT	165	4528	943	5636
	BIAS	0.79	1.02	0.95	
	POD	0.20	0.97	----	
	FAR	0.74	0.05	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	127	138	50	315
B	SN	123	4178	62	4363
S	RA	82	136	772	990
	TOT	332	4452	884	5668
	BIAS	1.05	1.02	0.89	
	POD	0.40	0.96	----	
	FAR	0.62	0.06	----	

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	111	143	66	320
B	SN	139	4178	85	4402
S	RA	100	145	753	998
	TOT	350	4466	904	5720
	BIAS	1.09	1.01	0.91	
	POD	0.35	0.95	----	
	FAR	0.68	0.06	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	62	108	37	207
B	SN	98	4192	81	4371
S	RA	120	166	687	973
	TOT	280	4466	805	5551
	BIAS	1.35	1.02	0.83	
	POD	0.30	0.96	----	
	FAR	0.78	0.06	----	

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	60	108	41	209
B	SN	106	4193	96	4395
S	RA	151	167	660	978
	TOT	317	4468	797	5582
	BIAS	1.52	1.02	0.81	
	POD	0.29	0.95	----	
	FAR	0.81	0.06	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	126	142	46	314
B	SN	177	4081	86	4344
S	RA	180	188	611	979
	TOT	483	4411	743	5637
	BIAS	1.54	1.02	0.76	
	POD	0.40	0.94	----	
	FAR	0.74	0.07	----	

---- = not calculated

Table 13. Same as Table 3 except for the Central Region for the WINTER season.

CENTRAL REGION
SPRING SEASON

18-HR PROJECTION

	0000 UTC FORECAST ZR	SN	RA	TOT		1200 UTC FORECAST ZR	SN	RA	TOT
OBS ZR	3	23	40	66	OBS ZR	5	31	14	50
OBS SN	2	451	63	516	OBS SN	3	436	53	492
OBS RA	3	52	1587	1642	OBS RA	7	88	1661	1756
TOT	8	526	1690	2224	TOT	15	555	1728	2298
BIAS	0.12	1.02	1.03		BIAS	0.30	1.13	0.98	
POD	0.05	0.87	----		POD	0.10	0.89	----	
FAR	0.63	0.14	----		FAR	0.67	0.21	----	

30-HR PROJECTION

	0000 UTC FORECAST ZR	SN	RA	TOT		1200 UTC FORECAST ZR	SN	RA	TOT
OBS ZR	3	25	22	50	OBS ZR	6	29	28	63
OBS SN	2	425	74	501	OBS SN	4	428	42	474
OBS RA	16	84	1667	1767	OBS RA	9	109	1504	1622
TOT	21	534	1763	2318	TOT	19	566	1574	2159
BIAS	0.42	1.07	1.00		BIAS	0.30	1.19	0.97	
POD	0.06	0.85	----		POD	0.10	0.90	----	
FAR	0.86	0.20	----		FAR	0.68	0.24	----	

42-HR PROJECTION

	0000 UTC FORECAST ZR	SN	RA	TOT		1200 UTC FORECAST ZR	SN	RA	TOT
OBS ZR	2	25	36	63	OBS ZR	2	25	19	46
OBS SN	1	406	67	474	OBS SN	5	395	61	461
OBS RA	5	83	1540	1628	OBS RA	11	106	1642	1759
TOT	8	514	1643	2165	TOT	18	526	1722	2266
BIAS	0.13	1.08	1.01		BIAS	0.39	1.14	0.98	
POD	0.03	0.86	----		POD	0.04	0.86	----	
FAR	0.75	0.21	----		FAR	0.89	0.25	----	

---- = not calculated

Table 14. Same as Table 3 except for the Central Region for the SPRING season.

3.4 WESTERN REGION

In contrast to the Central Region, Tables 15-17 show that the Western Region scores were quite poor. For WINTER, the SNOW forecasts were better than the Southern Region, but worse than the Eastern and Central Regions. Also, the ZR forecasts were worse than for any other region. In particular, the ZR POD scores ranged from 0.11-0.20, and the FAR values were between 0.76-0.83. However, despite the lack of accuracy, little bias existed in the ZR forecasts.

Although this appears to paint a gloomy picture, the SNOW forecasts were still quite good: bias values were between .95-.99, POD ranged from 0.85-0.88, and FAR fell within 0.08-0.13. Interestingly, the SNOW scores for FALL were similar to the WINTER scores. Bias values for FALL ranged from 0.81-1.00, the POD fell within 0.75-0.90, and the FAR values were between 0.08-0.11. For SPRING, the SNOW scores were worse, especially the FAR. Bias scores for SPRING varied considerably between cycles, and from projection to projection, so the overforecasting of SNOW does not appear to be a systematic problem. ZR forecasts had little accuracy during FALL and SPRING.

WESTERN REGION
FALL SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	0	6	13	19
B	SN	0	320	36	356
S	RA	2	29	949	980
	TOT	2	355	998	1355

	ZR	SN	RA
BIAS	0.11	1.00	1.02
POD	0.00	0.90	----
FAR	1.00	0.10	----

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	0	8	13	21
B	SN	2	251	36	289
S	RA	0	18	841	859
	TOT	2	277	890	1169

	ZR	SN	RA
BIAS	0.10	0.96	1.04
POD	0.00	0.87	----
FAR	1.00	0.09	----

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	1	5	15	21
B	SN	4	240	45	289
S	RA	2	21	840	863
	TOT	7	266	900	1173

	ZR	SN	RA
BIAS	0.33	0.92	1.04
POD	0.05	0.83	----
FAR	0.86	0.10	----

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	0	6	12	18
B	SN	1	315	54	370
S	RA	0	29	950	979
	TOT	1	350	1016	1367

	ZR	SN	RA
BIAS	0.06	0.95	1.04
POD	0.00	0.85	----
FAR	1.00	0.10	----

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	0	5	13	18
B	SN	3	318	52	373
S	RA	3	33	945	981
	TOT	6	356	1010	1372

	ZR	SN	RA
BIAS	0.33	0.95	1.03
POD	0.00	0.85	----
FAR	1.00	0.11	----

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	0	4	17	21
B	SN	3	223	73	299
S	RA	0	16	852	868
	TOT	3	243	942	1188

	ZR	SN	RA
BIAS	0.14	0.81	1.09
POD	0.00	0.75	----
FAR	1.00	0.08	----

---- = not calculated

Table 15. Same as Table 3 except for the Western Region for the FALL season.

WESTERN REGION
WINTER SEASON

18-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	15	30	36	81
B	SN	62	968	72	1102
S	RA	0	51	1144	1195
	TOT	77	1049	1252	2378
	BIAS	0.95	0.95	1.05	
	POD	0.19	0.88	----	
	FAR	0.81	0.08	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	14	24	43	81
B	SN	57	729	69	855
S	RA	11	57	1162	1230
	TOT	82	810	1274	2166
	BIAS	1.01	0.95	1.04	
	POD	0.17	0.85	----	
	FAR	0.83	0.10	----	

30-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	14	28	39	81
B	SN	26	741	91	858
S	RA	19	64	1147	1230
	TOT	59	833	1277	2169
	BIAS	0.73	0.97	1.04	
	POD	0.17	0.86	----	
	FAR	0.76	0.11	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	13	30	38	81
B	SN	53	945	94	1092
S	RA	9	63	1110	1182
	TOT	75	1038	1242	2355
	BIAS	0.93	0.95	1.05	
	POD	0.16	0.87	----	
	FAR	0.83	0.09	----	

42-HR PROJECTION

0000 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	16	33	33	82
B	SN	52	946	93	1091
S	RA	11	86	1092	1189
	TOT	79	1065	1218	2362
	BIAS	0.96	0.98	1.02	
	POD	0.20	0.87	----	
	FAR	0.80	0.11	----	

1200 UTC

		FORECAST ZR	SN	RA	TOT
O	ZR	9	30	41	80
B	SN	22	729	95	846
S	RA	20	81	1112	1213
	TOT	51	840	1248	2139
	BIAS	0.64	0.99	1.03	
	POD	0.11	0.86	----	
	FAR	0.82	0.13	----	

---- = not calculated

Table 16. Same as Table 3 except for the Western Region for the WINTER season.

WESTERN REGION
SPRING SEASON

18-HR PROJECTION

		0000 UTC FORECAST ZR	SN	RA	TOT			1200 UTC FORECAST ZR	SN	RA	TOT
O	ZR	0	5	14	19	O	ZR	0	7	7	14
B	SN	0	142	29	171	B	SN	0	101	16	117
S	RA	0	25	842	867	S	RA	0	24	786	810
	TOT	0	172	885	1057		TOT	0	132	809	941
	BIAS	0.00	1.01	1.02			BIAS	0.00	1.13	1.00	
	POD	0.00	0.83	----			POD	0.00	0.86	----	
	FAR	1.00	0.17	----			FAR	1.00	0.23	----	

30-HR PROJECTION

		0000 UTC FORECAST ZR	SN	RA	TOT			1200 UTC FORECAST ZR	SN	RA	TOT
O	ZR	0	5	7	12	O	ZR	0	8	11	19
B	SN	0	87	29	116	B	SN	0	136	26	162
S	RA	0	13	807	820	S	RA	0	45	826	871
	TOT	0	105	843	948		TOT	0	189	863	1052
	BIAS	0.00	0.91	1.03			BIAS	0.00	1.17	0.99	
	POD	0.00	0.75	----			POD	0.00	0.84	----	
	FAR	1.00	0.17	----			FAR	1.00	0.28	----	

42-HR PROJECTION

		0000 UTC FORECAST ZR	SN	RA	TOT			1200 UTC FORECAST ZR	SN	RA	TOT
O	ZR	0	6	13	19	O	ZR	0	6	8	14
B	SN	0	136	24	160	B	SN	0	86	25	111
S	RA	0	41	834	875	S	RA	1	15	790	806
	TOT	0	183	871	1054		TOT	1	107	823	931
	BIAS	0.00	1.14	1.00			BIAS	0.07	0.96	1.02	
	POD	0.00	0.85	----			POD	0.00	0.77	----	
	FAR	1.00	0.26	----			FAR	1.00	0.20	----	

---- = not calculated

Table 17. Same as Table 3 except for the Western Region for the SPRING season.

4. DISCUSSION

One conclusion from this study is that the PoPT system had little accuracy in regard to forecasting ZR during SPRING. Also, except for the Central Region, there is little accuracy for forecasting ZR during FALL.

As expected, there appeared to be a tendency to overforecast SNOW during SPRING, especially in the Eastern and Central Regions, but not during the FALL. Perhaps the upper-level to surface thermal relationships during SPRING are sufficiently different from WINTER to produce overforecasting for the PoPT system, but not during the FALL? For example, in SPRING, the thermal relationships differ from WINTER as a result of higher sun elevation, greater length of day, and warmer ground. For FALL, it would appear that the sun elevation and day length could be similar enough to WINTER conditions so as not to play a significant role in changing the thermal relationships, and ground temperature alone does not appear to change the thermal relationships enough to produce a large bias in PoPT SNOW forecasts. However, the lack of accuracy at forecasting ZR during FALL and SPRING could indicate that seasonal differences influence the ZR forecasts in FALL and SPRING.

Surprisingly, the PoPT system was most accurate at forecasting ZR for the Southern Region during WINTER. As stated earlier, part of this superior performance was due to overforecasting. Another, and possibly more important, reason may be that the synoptic situation which produces persistent, widespread areas of ZR occurs throughout the Southern Region (Goldsmith, 1990). Cold air intrusions into the deep South are usually shallow domes of Polar or Arctic air with only a gentle slope to the frontal surface aloft. When these shallow cold air masses are overrun by middle and upper level moisture, often the result is widespread areas of ZR that sometimes last for days. Further north, across portions of the Central and Eastern Regions, the cold air is usually deeper with a greater slope to the the frontal surface aloft. Thus, SNOW is the major precipitation type in these areas. Here, ZR is usually a transition precipitation type along the boundary between RAIN and SNOW, and this boundary is usually being advected. As a result, in northern areas, the PoPT system may correctly forecast the occurrence of ZR during an entire event, but the short duration of the ZR makes verifying the specific time of the ZR forecast very difficult. As stated in previous sections, the Central Region was the only region where ZR forecasts did reasonably well during FALL. This may be because the synoptic pattern discussed before occurs during FALL throughout the Central Region and then shifts to the Southern Region by WINTER.

Of course, the regional and seasonal variations in accuracy for the PoPT SNOW forecasts are closely related to the number of cases of SNOW. The more cases of SNOW there were, the more accurate the PoPT system was. The most likely reason for this was that a large number of SNOW cases in the verification sample implied there were also a substantial number of cases in the data sample used to develop the equations. With any statistical forecast system, the number of cases in the developmental sample plays an important role in the accuracy of the forecasts. As a result, the PoPT system was the most accurate at forecasting SNOW for the Central Region, followed by the Eastern, Western and Southern Regions. This relationship was true for all seasons, except for the FALL where the Western Region SNOW forecasts were better than for any other region.

5. SUMMARY AND CONCLUSIONS

Based on an analysis of 5 years of verification data stratified into the seasons of FALL, WINTER, and SPRING, and also stratified by the National Weather Service administrative regions of Eastern, Southern, Central and Western, several performance characteristics of the MOS PoPT forecast system were identified. These characteristics display both seasonal and regional variations.

The seasonal stratification revealed that there was a tendency to overforecast SNOW during the SPRING, but not during the FALL. Also, the PoPT system had little overall accuracy for forecasting ZR during the FALL and SPRING.

Regionally, the PoPT system performed the best for areas where SNOW and ZR occurred most frequently; thus, verification scores overall were best in the Central Region, followed by the Eastern, Western, and Southern Regions. However, there were some exceptions. ZR forecasts for the WINTER were best for the Southern Region, and SNOW forecasts for the FALL were best for the Western Region.

One final comment should be made here. The regional stratification of the verification data was based on administrative boundaries rather than on climatic zones. Many of the conclusions on the performance of the MOS PoPT system for a particular region may also apply to parts of another region as well. For example, stations in North and South Carolina are probably more similar to stations in the Southern Region than to stations in the northern half of the Eastern Region. Another example would be that, in terms of the relative frequency of snow, many stations in the Western Region along and east of the Cascade and Sierra Nevada mountain ranges are probably similar to stations in the Central Region.

6. ACKNOWLEDGMENTS

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