NOAA Technical Memorandum NWS WR-107

MAP TYPES AS AID IN USING MOS PoPs IN WESTERN U.S.

Ira S. Brenner

Weather Service Forecast Office
Phoenix, Arizona

August 1976

UNITED STATES
DEPARTMENT OF COMMERCE
Rogers C. B. Morton, Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

NATIONAL WEATHER
SERVICE
George P. Cressman, Director

TABLE OF CONTENTS

LIST OF FIGURES

MAP TYPES AS AID IN USING MOS PoPs IN WESTERN U.S.

ABSTRACT

The purpose of this study was to investigate the correlation between individual map types and the performance characteristics of Model Output Statistics (MOS) probability forecasts. The data sample used was June - August 1975 (summer season) and December - February 1976 (winter season). Brier Scores and improvement ratios were computed for map type and MOS probability forecasts for various western United States stations for four 12-hour periods. With two exceptions, it was found that map types do not distinguish when more (or less) weight should be given to MOS PoP forecasts. A by-product result of this study showed that map types did provide excellent guidance material for forecasters to use in preparation of extended forecasts and/or outlooks.

I. INTRODUCTION

The map-type program, as developed by MacDonald and Rasch [1], has been in operation since early 1975. The three map types correlating highest with the P.E. 50-kPa analysis and associated 12-, 24-, 36-, 48- and 72-hour prognoses, are determined by NOAA computers and transmitted over teletype Circuit C (Figure 1). During the past year, the Scientific Services Division (SSD) of Western Region Headquarters has been 1) correlating these map types with verification of MOS probabilities; and 2) verifying and comparing map-type probabilities for summer and winter seasons for various western United States stations with corresponding MOS probabilities. While MOS and map-type PoPs were compared, this was done mostly for intellectual curiosity, as map-type PoPs were not intended as competition to MOS. For example, MacDonald and Rasch showed that for an independent sample of nearly 14,000 cases, the type probabilities improved over climatology by only 4.6%, while MOS improvement over climatology was around 20%.

In addition to the main purpose of this study, namely, to establish MOS performance characteristics within individual map types, it was hoped that one spinoff result would show map-type PoPs to be useful as guidance material in preparation of extended forecasts and/or outlooks. Such expectations appeared reasonable in light of the MacDonald and Rasch study. Their project involved a sufficiently large-scale grid (182 points), which allowed large-scale characteristics of the flow pattern to govern map-type selection. This, coupled with the generally accepted idea that longer range computer prognoses (48-96 hours) handle forecasts of the large-scale flow pattern rather well, was the basis for expecting map-type PoPs to be a good extension of PoP guidance beyond that covered by MOS.

II. METHODOLOGY

The data sample used for this study involved only 0000 GMT forecasts for the summer season (June 1, 1975 - August 31, 1975), and both 0000 GMT and 1200 GMT forecasts for the winter season (December 1, 1975 - February 29, 1976). Stratification of the data was based on individual map-types and deviation of map-type probability from climatology for each station. Climatology for the 12-hour periods were obtained from WRTM #2 [2]. For each station, climatological probabilities of both 12-hour periods in each of the three months of the season involved were averaged. The results were then averaged together to get one climatological probability per season. The climatological probabilities were determined in this manner (i.e., averaged over the complete season) in order to parallel the map-type probabilities, which were also determined for the combined three-month period of the respective season.

Map Type I constituted most of the cases in the summer sample, leaving only small samples of other individual types. Although a statistical test of significance was not performed on these smaller samples, it was felt from a subjective standpoint that all types other than type I should be combined as one data sample. Data for 18 Western Region stations were used. These two sets of map-type data were then compared with the performance of MOS PoPs. Results were determined for four periods corresponding to the first four periods of the MOS forecasts (12, 24, 36 and 48 hours).

The summer study was initiated as a test of the feasibility of the project by the former assistant chief of SSD, Woodrow Dickey, and completed after his retirement. Test results confirmed the feasibility of the study. Consequently, study of the winter season was enlarged by increasing the number of Western Region stations from 18 to 42. Also, the averaging process for map Type I was performed [1]. This process involves averaging map Type I probabilities with the probabilities of the next highest correlated map-type, and considering these averages as the most useful map-type probabilities.

III. RESULTS

A. Summer

Any conclusions from study of the summer data must be tentative, as the available data sample was small. Aside from an abnormal amount of missing data, only 0000 GMT forecasts for 18 verification stations were used. The total data sample involved less than 800 cases per period, and therefore precluded any worthwhile stratification of data by individual map-types. This prevented our being able to relate MOS-PoP weighting to individual types. However, some useful information did come out of studying the summer data.

First, the summer data (Figure 2) was stratified by the deviation of type PoPs from climatological probabilities. When the type PoP exceeded the climatological probability so that the difference (Type PoP - climatological PoP) was less than minus 10 percent (i.e., -11, -12, etc.), the data was accumulated by periods and summarized in the row labeled 'LT -10 PCT'.

For differences within minus to plus 10 percent, the row labeled 'WI - TO +10 PCT' was used. Finally, if the difference was positive and greater than plus 10 percent (i.e., plus 11 and greater), the data was tabulated for use in the row labeled 'GT +10 PCT'. Results yielded by combining all the data by periods are given in the 'TOTAL' row. For each appropriate period of the above categories, the Brier Scores for the type PoPs ('TYPE') and MOS PoPs ('MOS'), the improvement of the types over MOS ('IM/MOS'), and the number of cases ('N') were computed.

Figure 2 shows the summer results. When the type PoPs were compared with the MOS PoPs, the 'TYPES' verified surprisingly well. From the 'TOTAL' row, we see that the combined improvement of the 'TYPES' over MOS by periods oscillates generally within plus or minus 5 percent, with MOS doing best in the first period. When the various deviations from climatological categories were examined, it was found that the bulk of the summer cases were when type probabilities were within plus or minus 10 percent of climatological probabilities. Since the combined MOS Brier Scores differed very little from the type Brier Scores, and also since most of the types used involved near-climatological probabilities, it would appear that <u>MOS handles the overall summer climatological regime quite well</u>. The very small number of cases involved in the climatological deviation categories of 'LT -10 PCT' and 'GT +10 PCT', makes any conclusion from these results tentative.

Due to the small data sample within each type, Type I was considered alone, and the remaining types were combined. Type I is basically a 'near-climatology' type. Yet, Type I improvements over MOS show a steady increase with time, and are positive for the last three periods (i.e., 12-48 hours). This is significant, as it shows that when Type I is indicated, the quality of MOS PoPs decreases more sharply with time than does map-type PoPs. Certainly, this result indicates that forecasters should include consideration of map-type probabilities when preparing PoPs or outlooks for beyond 24 hours.

B. <u>Winter</u>

The winter season data sample was considered large enough to permit more solid conclusions, and also to show the performance of MOS PoPs by individual map-types. The results are shown in Figure 3. The labelling conventions and stratification used are the same as for the summer season.

The 'TOTAL' results of the combined data improvements of the map-types PoPs over MOS PoPs by periods never reached positive values, although the trend was <u>towards</u> less negative values with time. This, perhaps, is an indication that the MOS skill decreases with time more rapidly than type PoPs for the winter season, and that considerable weight can be placed on map-type PoPs when preparing extended period forecasts.

Despite large differences in the number of cases, the improvement over MOS for the last three periods in the 'LT -10 PCT' and 'GT +10 PCT' deviation from climatological categories are similar and very poor. MOS apparently handles these categories quite well. The improvements of the types over MOS for the same periods are better for the 'WI -10 to +10 PCT' category and also show a steady trend towards lesser negative values with time. Again, the indication here is that the type PoPs for this latter near-climatological category provide fairly reliable guidance for the forecaster for the extended periods.

The trend mentioned above for the 'WI -10 to +10 PCT' category, as would be expected, is also present when Type I is considered separately. Type I, with by far the largest number of cases, is also a near-climatological pattern. As with the Type I summer pattern, MOS data show a steady loss of skill with time. However, the improvements of the type PoPs over MOS for the winter never reach positive values within the four periods; yet, the trend is definite enough to continue to support the hypothesis that type PoPs can be used successfully as extended guidance for winter map Type I.

Individual examination of winter map types showed that Types 2 and 6 (both very dry) were associated with the lowest (i.e., best) MOS Brier Scores for just about every period. This suggests that MOS PoPs should be given considerable weight when 50-kPa Types 2 and 6 are forecast. However, the dry regimes associated with these two map-types contribute significantly to low Brier Scores (Glahn and Jorgensen [3]). An opposite effect exists with map Types 7 and 10. These are rather wet patterns, and as a result, the MOS Brier Scores, where applicable, were the largest (i.e., poorest) of this sample in every period, despite the small number of cases. As a result of the above discussion, it would be inaccurate to use the magnitude of the MOS Brier Score as a measure of how well MOS does within a particular type. A much better indicator would be the improvement of the individual map-type PoPs over MOS PoPs.

A closer analysis of the individual map-types showed Types 4 and 7 as being associated with the best performance of MOS. Map Type 4 is a moderately wet pattern for the western United States. Yet, the MOS Brier Scores in all four periods were almost as low as those yielded by the dry patterns! These low MOS Brier Scores, as well as the considerable improvements of MOS over the type PoPs are considered significant. <u>This indicates that forecasters should weight MOS very heavily when Type 4 is indicated, and if deviations from MOS are made, they should be small.</u>

The results from Type 7 (wet regime) unfortunately are tainted by a relatively small data sample. Nevertheless, the improvement column for the last three periods on Figure 3 is considered sufficiently significant to mention. It appears that MOS PoPs in the last three periods are equal or worse than the type PoPs. Since the type PoPs are conditional climatologies, a possible conclusion of this unexpected result is that under the regime of Type 7, MOS doesn't give any significant refinement of the type probabilities beyond the first period.

The remaining types (i.e., I, 2, 3, 6, 10) do not reveal any conclusive performance characteristics of MOS, nor do they display any unique trends that would indicate relating MOS performance to these types as being useful guidance for short or extended forecasting.

The results obtained when map-Type I is averaged with the second highest correlated map-type are given in Figure 4. As would be expected, this modification subtracted cases from the 'WI - TO +10 PCT' category and redistributed them in the other two remaining categories. Significant alterations in the improvements over MOS resulted in nearly every period of every category. The beneficial changes, however, were in the 'WI - TO +10 PCT' and 'GT +10 PCT' categories. Both these categories now show a rather encouraging trend towards less negative and more positive values with time (Figure 5). The winter improvements over MOS for all three averaged categories combined by periods (Figure 6), do not reflect this improvement, as the deterioration of the 'LT -10 PCT' category results contributed unfavorably. Of interest also is the fact that the individual winter Type I improvements over MOS deteriorated when averaging was performed (Figure 7). Apparently, this averaging produced a large number of additional cases where the new Type I probability was less than climatology by more than 10 percent. These results indicate that in most cases, when Type I is indicated, the averaging process gives inferior guidance.

Stations where the averaging of map-Type I produces climatological deviations of less than minus 10 percent will tend to be grouped together. In these areas, it would be advantageous to modify the probabilities back in the direction of the pure map-Type I. Figure 8 gives an example. In this case, map-Type I was indicated for the 48-hour forecast (Figure 8a); map-Type 9 was the second highest correlator (Figure 8b). The major difference between the two patterns is the much stronger ridging into the Pacific northwest for map-Type 9. As a result, the averaging process dramatically reduced the probabilities in this region from the values indicated for map-Type I. The averages are plotted in Figure 9. The shaded area depicts the region where the average type probability minus the climatological probability was less than -10 percent, with the unshaded area being within 10 percent of climatology. The shaded area, therefore, will likely experience a precipitation pattern more characteristic of Type I in 48 hours, rather than an average of Types I and 9. For the unshaded areas, the averaged probabilities should be considered.

IV. CONCLUSIONS

1. MOS does exceptionally well in all four periods when winter Type 4 is indicated.
2. MOS does relatively poorly in the second through fourth periods when winter Type 7 is indicated.
3. MOS handles the typical summer patterns quite well.
4. Use of 48-hour and 72-hour map-type forecasts as guidance for preparation of extended forecasts and outlooks is warranted.
5. The map-Type I probability averaging procedure should not be used during winter when the type PoP for a given station (or area) is lower than climatology by more than 10%.

V. RECOMMENDATIONS

1. Continue this study until at least two years of each of the four seasons are tabulated.
2. For purposes of simplifying the data collection procedures, verify for each upcoming season the same 18 stations that are used in the Western Region MOS vs. MAN program.
3. Alert Western Region Forecast Offices to the fine MOS performance within winter map-Type 4.
4. Append the 96-hour map-type forecast to the 0000 GMT message currently being transmitted twice daily on Circuit C.

VI. REFERENCES

[1] MACDONALD, ALEXANDER E., and RASCH, GLENN E. *Map Type Precipitation Probabilities for the Western Region,* NOAA Technical Memorandum, WR-96, February 1975.

[2] MILLER, LUCIANNE. *Climatological Precipitation Probabilities,* ESSA Technical Memorandum, WR-2, December 1965.

[3] GLAHN, HARRY R., and JORGENSEN, DONALD L. *Climatological Aspects of the Brier P-Score,* Monthly Weather Review, Vol. 2, No. 2, pp. 136-141, January 1970.

```
FXUS3 KWBC  260000
500MB MAP TYPE CORRELATIONS MAY 26
INITL 12 HR 24 HR 36 HR 48 HR 72 HR
04355 04879 04858 02842 04830 04827
01796 02820 02827 04832 02821 01804
02729 01801 01762 01777 01811 02768
```

FIGURE 1

TYPE VS MOS   SCIENTIFIC SERVICES   SUMMER 1975

DEVIATION FROM CLIMAT	PERIOD 1 *TYPE	MOS	IM/MOS	N	PERIOD 2 *TYPE	MOS	IM/MOS	N	PERIOD 3 *TYPE	MOS	IM/MOS	N	PERIOD 4 *TYPE	MOS	IM/MOS	N
LT -10 PCT	.0021	.0446	+95.3	23	.0019	.0307	+93.8	14	.0309	.0472	+34.5	36	.0021	.0256	+91.7	8
WI - TO + 10 PCT	.0767	.0737	-4.1	681	.0769	.0802	+4.1	678	.0679	.0679	-00.0	658	.0616	.0638	+3.4	437
GT +10 PCT	.2656	.2325	-14.2	32	.2307	.2225	-3.7	42	.2336	.2073	-12.7	57	.2212	.2580	+14.2	24
TOTAL	.0826	.0797	-3.6	736	.0843	.0874	+3.5	734	.0787	.0781	-.8	751	.0690	.0730	+5.5	469

****

****

TYPE	PERIOD 1 *TYPE	MOS	IM/MOS	N	PERIOD 2 *TYPE	MOS	IM/MOS	N	PERIOD 3 *TYPE	MOS	IM/MOS	N	PERIOD 4 *TYPE	MOS	IM/MOS	N
TYPE 1	.0749	.0726	-3.2	535	.0731	.0765	+4.4	468	.0704	.0768	+8.3	375	.0696	.0835	+16.6	248
ALL OTHERS COMBINED	.1030	.0987	-4.4	201	.1040	.1065	+2.3	266	.0870	.0782	-11.3	376	.0684	.0638	-6.7	221
TOTAL	.0826	.0797	-3.6	736	.0843	.0874	+3.5	734	.0787	.0781	-.8	751	.0690	.0730	+5.5	469

FIGURE 2

DEVIATION FROM CLIMAT	PERIOD 1 *TYPE	MOS	IM/MOS	N	PERIOD 2 *TYPE	MOS	IM/MOS	N	PERIOD 3 *TYPE	MOS	IM/MOS	N	PERIOD 4 *TYPE	MOS	IM/MOS	N
LT -10 PCT	.074	.061	-20.5	1273	.097	.079	-22.9	1441	.102	.087	-17.6	1380	.103	.088	-17.5	1343
WI - TO + 10 PCT	.138	.107	-29.5	3732	.138	.116	-19.6	3732	.142	.127	-11.8	3806	.139	.128	-8.7	3676
GT +10 PCT	.217	.152	-43.5	443	.228	.184	-24.1	287	.223	.188	-18.4	287	.233	.201	-15.8	280
TOTAL	.129	.100	-29.9	5448	.132	.109	-20.6	5460	.136	.120	-13.4	5473	.135	.122	-10.9	5299

TYPE	PERIOD 1 *TYPE	MOS	IM/MOS	N	PERIOD 2 *TYPE	MOS	IM/MOS	N	PERIOD 3 *TYPE	MOS	IM/MOS	N	PERIOD 4 *TYPE	MOS	IM/MOS	N
1	.138	.110	-25.3	3166	.147	.125	-18.0	3254	.151	.133	-13.3	3457	.140	.132	-6.6	3354
2	.108	.072	-49.9	146	.156	.106	-46.7	258	.106	.102	-3.4	111	.159	.110	-44.9	111
3	.154	.113	-35.8	826	.139	.112	-23.6	609	.120	.107	-12.6	590	.138	.119	-16.4	495
4	.141	.089	-58.9	225	.118	.094	-26.5	243	.126	.104	-20.8	242	.150	.115	-30.1	279
5	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0
6	.053	.040	-33.3	829	.066	.054	-21.2	996	.088	.075	-18.1	975	.094	.077	-21.2	957
7	.187	.143	-30.5	186	.270	.267	-1.3	26	.256	.302	15.3	61	.251	.242	-3.6	103
8	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0
9	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0
10	.231	.160	-44.2	70	.219	.169	-29.9	74	.215	.133	-61.3	37	.000	.000	.0	0
TOTAL	.129	.100	-29.9	5448	.132	.109	-20.6	5460	.136	.120	-13.4	5473	.135	.122	-10.9	5299

FIGURE 3

DEVIATION FROM CLIMAT	PERIOD 1 *TYPE	MOS	IM/MOS	N	PERIOD 2 *TYPE	MOS	IM/MOS	N	PERIOD 3 *TYPE	MOS	IM/MOS	N	PERIOD 4 *TYPE	MOS	IM/MOS	N
LT -10 PCT	.119	.084	-40.9	1704	.122	.099	-23.8	1816	.134	.101	-32.2	1759	.137	.106	-28.9	1741
WI - TO + 10 PCT	.123	.098	-25.2	3125	.127	.106	-19.7	3161	.128	.121	-6.0	3212	.128	.121	-5.5	3085
GT +10 PCT	.205	.148	-37.9	619	.204	.174	-17.3	483	.204	.179	-13.9	502	.199	.178	-11.8	473
TOTAL	.131	.100	-31.5	5448	.132	.109	-20.6	5460	.137	.120	-14.2	5473	.137	.122	-13.0	5299

****

****

TYPE	PERIOD 1 *TYPE	MOS	IM/MOS	N	PERIOD 2 *TYPE	MOS	IM/MOS	N	PERIOD 3 *TYPE	MOS	IM/MOS	N	PERIOD 4 *TYPE	MOS	IM/MOS	N
1	.140	.110	-27.7	3166	.147	.125	-17.9	3254	.153	.133	-14.4	3457	.144	.132	-9.6	3354
2	.108	.072	-49.9	146	.156	.106	-46.7	258	.106	.102	-3.4	111	.159	.110	-44.9	111
3	.154	.113	-35.8	826	.139	.112	-23.6	609	.120	.107	-12.6	590	.138	.119	-16.4	495
4	.141	.089	-58.9	225	.118	.094	-26.5	243	.126	.104	-20.8	242	.150	.115	-30.1	279
5	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0
6	.053	.040	-33.3	829	.066	.054	-21.2	996	.088	.075	-18.1	975	.094	.077	-21.2	957
7	.187	.143	-30.5	186	.270	.267	-1.3	26	.256	.302	15.3	61	.251	.242	-3.6	103
8	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0
9	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0	.000	.000	.0	0
10	.231	.160	-44.2	70	.219	.169	-29.9	74	.215	.133	-61.3	37	.000	.000	.0	0
TOTAL	.131	.100	-31.5	5448	.132	.109	-20.6	5460	.137	.120	-14.2	5473	.137	.122	-13.0	5299

FIGURE 4

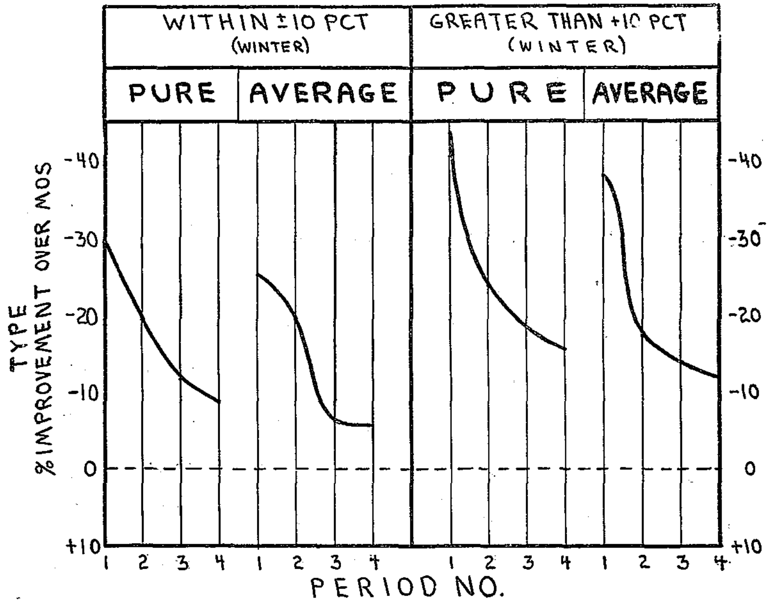


FIGURE 5

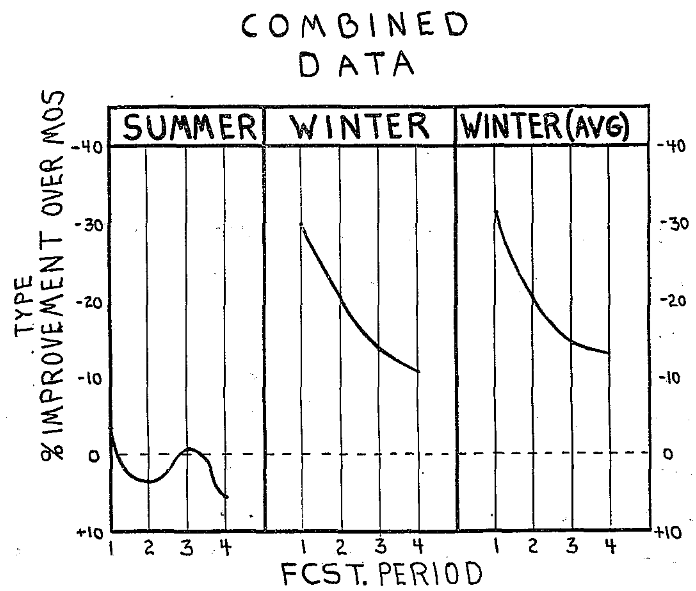


FIGURE 6

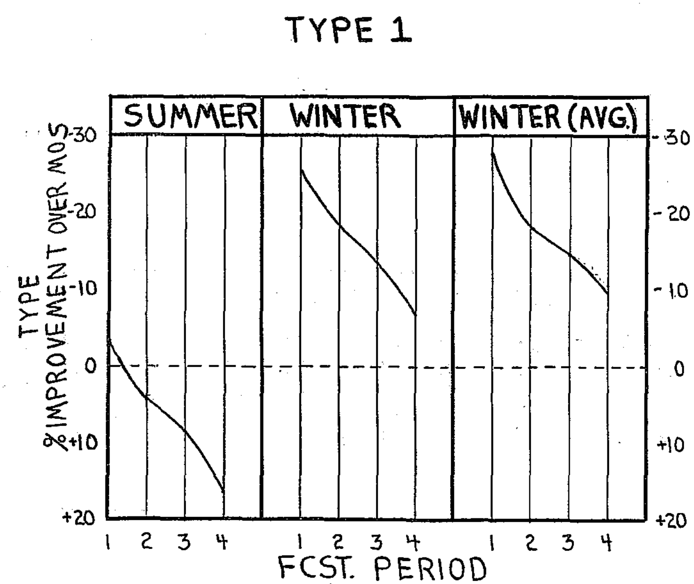


FIGURE 7

WINTER TYPE I

12Z December 25, 1964
662 Cases

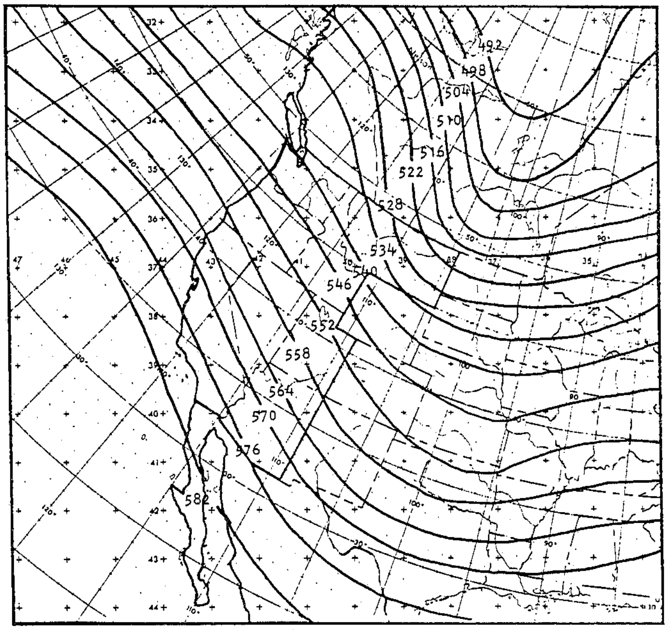
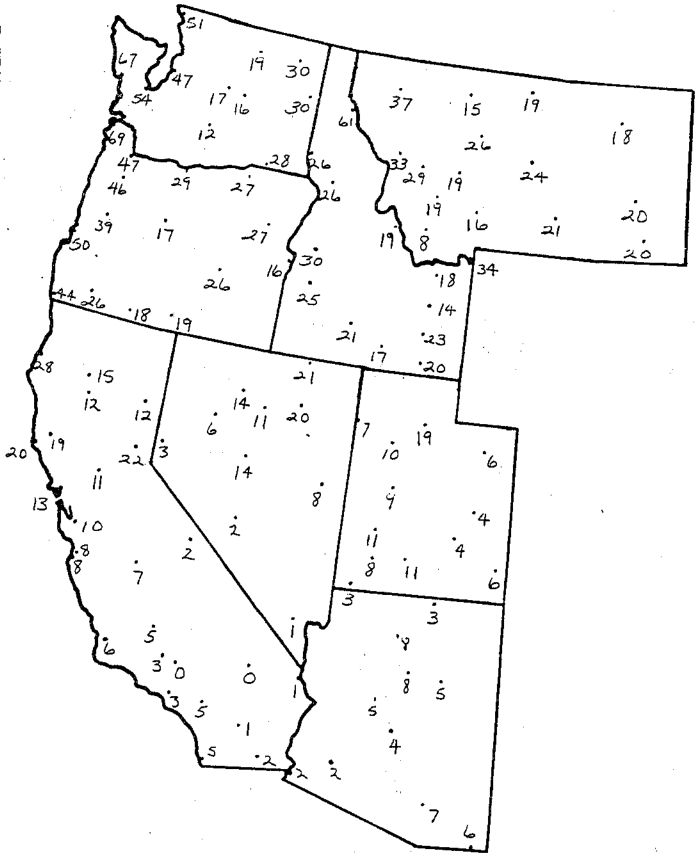


Fig. 8a

WINTER TYPE I

Percent Frequency of Precipitation Occurrence



WINTER TYPE 9

00Z January 16, 1966
30 Cases

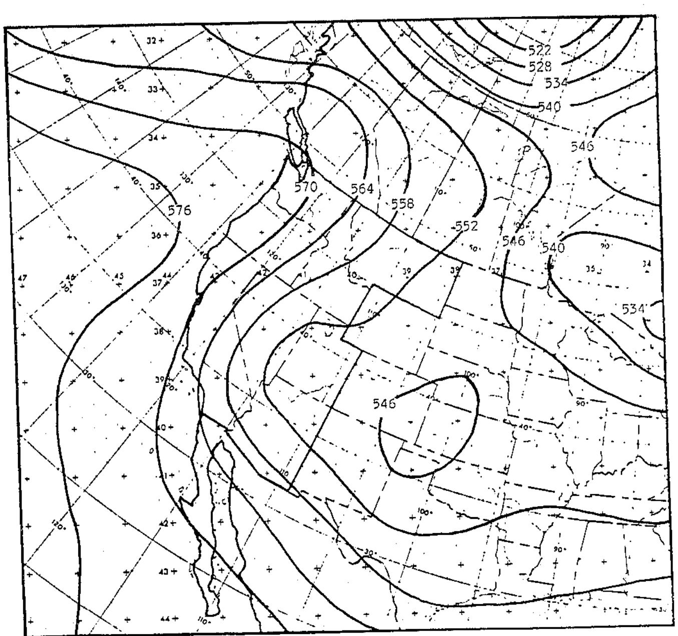


Fig. 8b

WINTER TYPE 9

Percent Frequency of Precipitation Occurrence

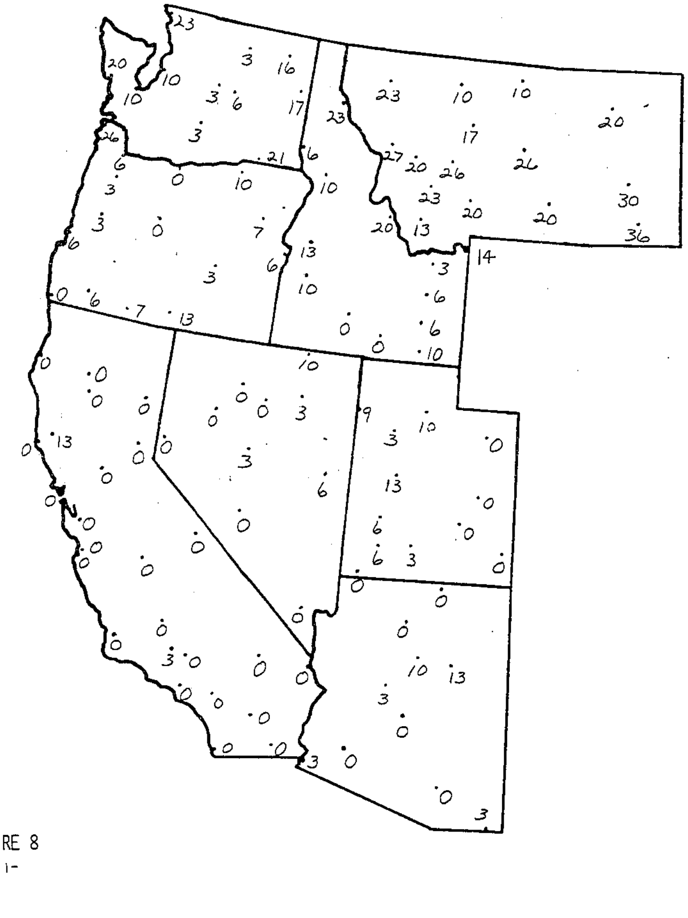


FIGURE 8

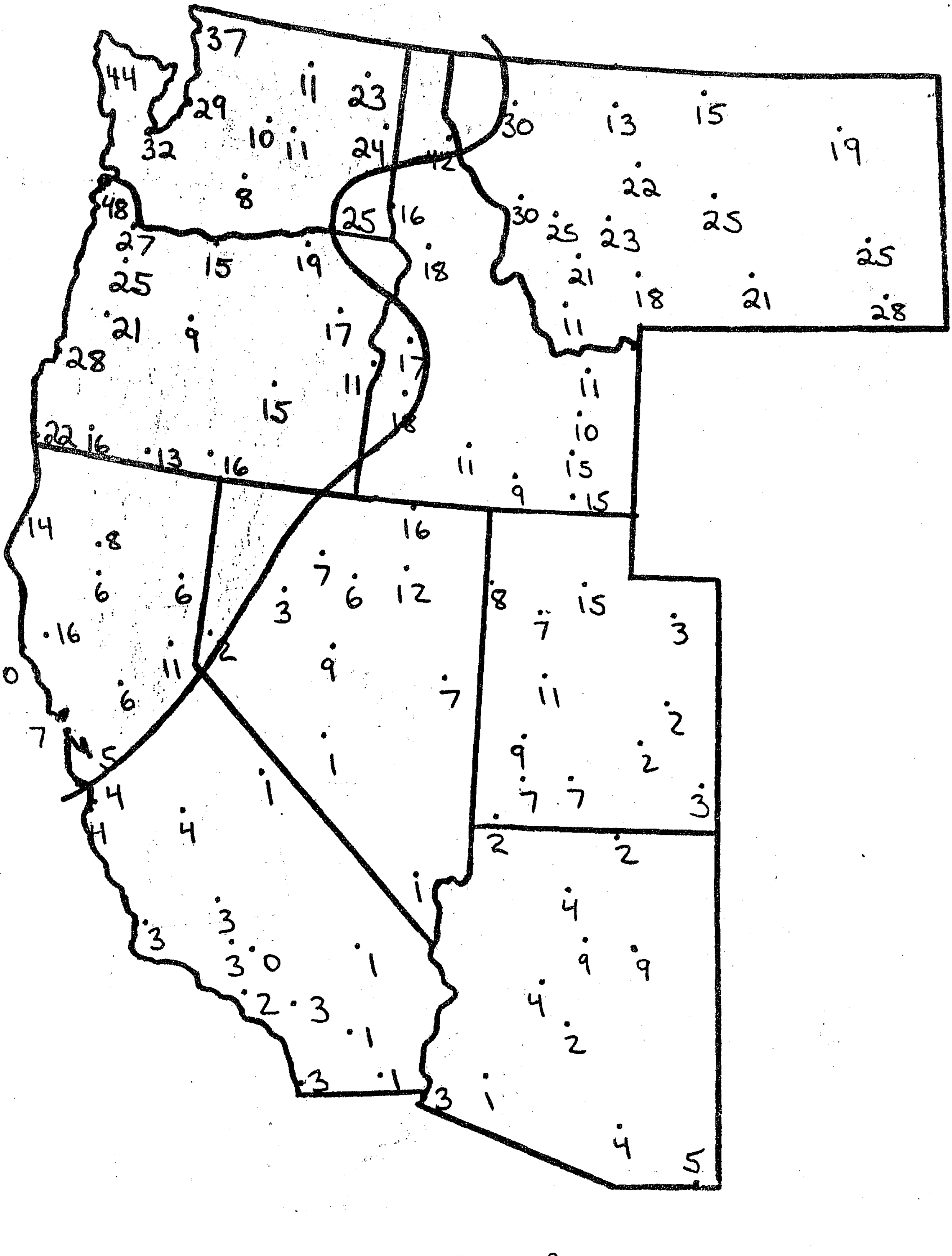

37
44
11
23
29
10
11
24
32
30
13
15
19
42
22
8
48
25
16
30
25
23
25
27
15
19
18
25
21
18
21
25
28
21
9
17
11
28
17
11
15
11
18
10
22
16
13
16
11
15
9
15
14
8
16
7
6
12
6
6
3
8
15
7
3
16
2
9
10
11
6
7
11
2
7
5
1
9
2
4
1
7
7
3
2
2
4
4
1
4
3
3
9
9
3
0
1
4
2
3
2
1
3
1
3
1
4
5

FIGURE 9

Western Region Technical Memoranda: (Continued)

No. 45/2 Precipitation Probabilities in the Western Region Associated with Spring 500-mb Map Types. Richard P. Augulis, January 1970. (Out of print.) (PB-189434)
No. 45/3 Precipitation Probabilities in the Western Region Associated with Summer 500-mb Map Types. Richard P. Augulis, January 1970. (Out of print.) (PB-189414)
No. 45/4 Precipitation Probabilities in the Western Region Associated with Fall 500-mb Map Types. Richard P. Augulis, January 1970. (Out of print.) (PB-189435)
No. 46 Applications of the Net Radiometer to Short-Range Fog and Stratus Forecasting at Eugene, Oregon. L. Yee and E. Bates, December 1969. (PB-190476)
No. 47 Statistical Analysis as a Flood Routing Tool. Robert J. C. Burnash, December 1969. (PB-188744)
No. 48 Tsunami. Richard P. Augulis, February 1970. (PB-190157)
No. 49 Predicting Precipitation Type. Robert J. C. Burnash and Floyd E. Hug, March 1970. (PB-190962)
No. 50 Statistical Report on Aeroallergens (Pollens and Molds) Fort Huachuca, Arizona, 1969. Wayne S. Johnson, April 1970. (PB-191743)
No. 51 Western Region Sea State and Surf Forecaster's Manual. Gordon C. Shields and Gerald B. Burdwell, July 1970. (PB-193102)
No. 52 Sacramento Weather Radar Climatology. R. G. Pappas and C. M. Veliquette, July 1970. (PB-193347)
No. 53 Experimental Air Quality Forecasts in the Sacramento Valley. Norman S. Benes, August 1970. (Out of print.) (PB-194128)
No. 54 A Refinement of the Vorticity Field to Delineate Areas of Significant Precipitation. Barry B. Aronovitch, August 1970.
No. 55 Application of the SSARR Model to a Basin Without Discharge Record. Vail Schermerhorn and Donald W. Kuehl, August 1970. (PB-194394)
No. 56 Areal Coverage of Precipitation in Northwestern Utah. Philip Williams, Jr., and Werner J. Heck, September 1970. (PB-194389)
No. 57 Preliminary Report on Agricultural Field Burning vs. Atmospheric Visibility in the Willamette Valley of Oregon. Earl M. Bates and David O. Chilcote, September 1970. (PB-194710)
No. 58 Air Pollution by Jet Aircraft at Seattle-Tacoma Airport. Wallace R. Donaldson, October 1970. (COM-71-00017)
No. 59 Application of P.E. Model Forecast Parameters to Local-Area Forecasting. Leonard W. Snellman, October 1970. (COM-71-00016)

NOAA Technical Memoranda NWS

No. 60 An Aid for Forecasting the Minimum Temperature at Medford, Oregon. Arthur W. Fritz, October 1970. (COM-71-00120)
No. 61 Relationship of Wind Velocity and Stability to SO_2 Concentrations at Salt Lake City, Utah. Werner J. Heck, January 1971. (COM-71-00232)
No. 62 Forecasting the Catalina Eddy. Arthur L. Eichelberger, February 1971. (COM-71-00223)
No. 63 700-mb Warm Air Advection as a Forecasting Tool for Montana and Northern Idaho. Norris E. Woerner, February 1971. (COM-71-00349)
No. 64 Wind and Weather Regimes at Great Falls, Montana. Warren B. Price, March 1971.
No. 65 Climate of Sacramento, California. Wilbur E. Figgins, June 1971. (COM-71-00764)
No. 66 A Preliminary Report on Correlation of ARTCC Radar Echoes and Precipitation. Wilbur K. Hall, June 1971. (COM-71-00829)
No. 67 Precipitation Detection Probabilities by Los Angeles ARTC Radars. Dennis E. Ronne, July 1971. (Out of print.) (COM-71-00925)
No. 68 A Survey of Marine Weather Requirements. Herbert P. Benner, July 1971. (Out of print.) (COM-71-00889)
No. 69 National Weather Service Support to Soaring Activities. Ellis Burton, August 1971. (Out of print.) (COM-71-00956)
No. 70 Predicting Inversion Depths and Temperature Influences in the Helena Valley. David E. Olsen, October 1971. (Out of print.) (COM-71-01037)
No. 71 Western Region Synoptic Analysis-Problems and Methods. Philip Williams, Jr., February 1972. (COM-72-10433)
No. 72 A Paradox Principle in the Prediction of Precipitation Type. Thomas J. Weitz, February 1972. (Out of print.) (COM-72-10432)
No. 73 A Synoptic Climatology for Snowstorms in Northwestern Nevada. Bert L. Nelson, Paul M. Fransioli, and Clarence M. Sakamoto, February 1972. (Out of print.) (COM-72-10338)
No. 74 Thunderstorms and Hail Days Probabilities in Nevada. Clarence M. Sakamoto, April 1972. (COM-72-10554)
No. 75 A Study of the Low Level Jet Stream of the San Joaquin Valley. Ronald A. Willis and Philip Williams, Jr., May 1972. (COM-72-10707)
No. 76 Monthly Climatological Charts of the Behavior of Fog and Low Stratus at Los Angeles International Airport. Donald M. Gales, July 1972. (COM-72-11140)
No. 77 A Study of Radar Echo Distribution in Arizona During July and August. John E. Hales, Jr., July 1972. (COM-72-11136)
No. 78 Forecasting Precipitation at Bakersfield, California, Using Pressure Gradient Vectors. Earl T. Riddiough, July 1972. (COM-72-11146)
No. 79 Climate of Stockton, California. Robert C. Nelson, July 1972. (COM-72-10920)
No. 80 Estimation of Number of Days Above or Below Selected Temperatures. Clarence M. Sakamoto, October 1972. (COM-72-10021)
No. 81 An Aid for Forecasting Summer Maximum Temperatures at Seattle, Washington. Edgar G. Johnson, November 1972. (COM-73-10150)
No. 82 Flash Flood Forecasting and Warning Program in the Western Region. Philip Williams, Jr., Chester L. Glenn, and Roland L. Raetz, December 1972. (COM-73-10251)
No. 83 A Comparison of Manual and Semiautomatic Methods of Digitizing Analog Wind Records. Glenn E. Rasch, March 1973. (COM-73-10669)
No. 84 Southwestern United States Summer Monsoon Source--Gulf of Mexico or Pacific Ocean? John E. Hales, Jr., March 1973. (COM-73-10769)
No. 85 Range of Radar Detection Associated with Precipitation Echoes of Given Heights by the WSR-57 at Missoula, Montana. Raymond Granger, April 1973. (COM-73-11030)
No. 86 Conditional Probabilities for Sequences of Wet Days at Phoenix, Arizona. Paul C. Kangieser, June 1973. (COM-73-11264)
No. 87 A Refinement of the Use of K-Values in Forecasting Thunderstorms in Washington and Oregon. Robert Y. G. Lee, June 1973. (COM-73-11276)
No. 88 A Surge of Maritime Tropical Air--Gulf of California to the Southwestern United States. Ira S. Brenner, July 1973.
No. 89 Objective Forecast of Precipitation Over the Western Region of the United States. Julia N. Paegle and Larry P. Kierulff, September 1973. (COM-73-11946/3AS)
No. 90 A Thunderstorm "Warm Wake" at Midland, Texas. Richard A. Wood, September 1973. (COM-73-11845/AS)
No. 91 Arizona "Eddy" Tornadoes. Robert S. Ingram, October 1973. (COM-74-10465)

NOAA Technical Memoranda NWSWR: (Continued)

No. 92 Smoke Management in the Willamette Valley. Earl M. Bates, May 1974. (COM-74-11277/AS)

No. 93 An Operational Evaluation of 500-mb Type Stratified Regression Equations. Alexander E. MacDonald, June 1974. (COM-74-11407/AS)

No. 94 Conditional Probability of Visibility Less Than One-Half Mile in Radiation Fog at Fresno, California. John D. Thomas, August 1974. (COM-74-11555/AS)

No. 95 Climate of Flagstaff, Arizona. Paul W. Sorenson, August 1974. (COM-74-11678/AS)

No. 96 Map Type Precipitation Probabilities for the Western Region. Glenn E. Rasch and Alexander E. MacDonald, February 1975. (COM-75-10428/AS)

No. 97 Eastern Pacific Cut-Off Low of April 21-28, 1974. William J. Alder and George R. Miller, January 1976.

No. 98 Study on a Significant Precipitation Episode in the Western United States. Ira S. Brenner, April 1975. (COM-75-10719/AS)

No. 99 A Study of Flash Flood Susceptibility--A Basin in Southern Arizona. Gerald Williams, August 1975. (COM-75-11360/AS)

No. 100 A Study of Flash-Flood Occurrences at a Site Versus Over a Forecast Zone. Gerald Williams, August 1975. (COM-75-11404/AS)

No. 101 Digitized Eastern Pacific Tropical Cyclone Tracks. Robert A. Baum and Glenn E. Rasch, September 1975. (COM-75-11479/AS)

No. 102 A Set of Rules for Forecasting Temperatures in Napa and Sonoma Counties. Wesley L. Tuft, October 1975. (PB 246 902/AS)

No. 103 Application of the National Weather Service Flash-Flood Program in the Western Region. Gerald Williams, January 1976. (PB 253 053/AS)

No. 104 Objective Aids for Forecasting Minimum Temperatures at Reno, Nevada, During the Summer Months. Christopher D. Hill, January 1976.

No. 105 Forecasting the Mono Wind. Charles P. Ruscha, Jr., February 1976.

No. 106 Use of MOS Forecast Parameters in Temperature Forecasting, John C. Plankinton, Jr., March 1976.