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A Procedure for Improving First Period Model Output Statistics Precipitation Forecasts

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Editor's Note:

This technique was developed from warm season (convective) data. Given the spottiness of convective precipitation, it is remarkable that it works so well. WSFO Portland has noted that the results were even better during the past cold season.

A PROCEDURE FOR IMPROVING FIRST PERIOD MODEL OUTPUT STATISTICS PRECIPITATION FORECAST

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ABSTRACT

A TECHNIQUE IS PRESENTED FOR USING THE 700 MILLIBAR TRAJECTORY FROM THE NMC TRAJECTORY BULLETIN (FTJXX) TO MODIFY PRECIPITATION PROBABILITY FORECASTS PREPARED AT NMC FROM MODEL OUTPUT STATISTICS (MOS).

INTRODUCTION

THE TECHNIQUE DEVELOPMENT LABORATORY OF THE NATIONAL WEATHER SERVICE DEVELOPED A STATISTICAL METHOD CALLED MODEL OUTPUT STATISTICS (MOS) FOR OBJECTIVELY DETERMINING PROBABILITY OF PRECIPITATION (POP).

THE FIELD FORECASTER COULD IMPROVE UPON THE MOS POP GUIDANCE FORECASTS IF HE COULD FIND SOME SKILLFUL PREDICTOR OF PRECIPITATION NOT ALREADY CONSIDERED IN THE DEVELOPMENT OF THE MOS POP EQUATIONS. IT HAD BEEN OBSERVED ON MANY OCCASIONS THAT THE PATH OF THE 700 MILLIBAR TRAJECTORY FROM THE FTJXX BULLETIN SHOWED SKILL IN FORECASTING THE OCCURRENCE OR NON-OCCURRENCE OF PRECIPITATION DEPENDING ON WHETHER IT WENT THROUGH AN AREA OF PRECIPITATION OR NOT AS OBSERVED ON SURFACE LEVEL ANALYSES. THIS SUGGESTED A PROJECT TO EXAMINE THE FEASIBILITY OF USING THE 700 MILLIBAR TRAJECTORY FORECASTS TO MODIFY THE MOS POP GUIDANCE ISSUED FROM NMC.

PROCEDURE

THE RELATIVE FREQUENCY OF MEASURABLE PRECIPITATION (EQUAL TO OR GREATER THAN .01 INCHES) WAS DETERMINED FOR CASES OF SIMILAR MOS POP VALUES AND STRATIFIED ACCORDING TO THE OCCURRENCE OR NON-OCCURRENCE OF PRECIPITATION ALONG THE PATH OF THE 700 MILLIBAR TRAJECTORY. COMBINED RESULTS ARE REFLECTED IN TABLE 1. STRONG SKILL IS INDICATED WHEN THE PATH OF THE TRAJECTORY TRAVELED THROUGH OBSERVED PRECIPITATION - 72 PERCENT OF THOSE CASES RESULTED IN MEASURABLE PRECIPITATION. WHEN THE TRAJECTORY TRAVELED THROUGH NO OBSERVED PRECIPITATION ONLY 16 PERCENT OF THE CASES RESULTED IN MEASURABLE PRECIPITATION.

COMBINED DATA FOR THREE STATIONS LOCATED IN MAINE AND NEW HAMPSHIRE WERE USED TO PRESERVE GEOGRAPHIC HOMOGENEITY AND AT THE SAME TIME YIELD SUFFICIENT CASES FROM WHICH TO ARRIVE AT CONCLUSIONS. THE THREE STATIONS CHOSEN WERE CONCORD, NEW HAMPSHIRE, PORTLAND AND CARIBOU, MAINE.

THE MIDDLE TIME FRAMES OF THE TRAJECTORY BULLETIN WERE USED IN ORDER TO CORRESPOND TO A FIRST PERIOD FORECAST. FOR THE 0000 GMT BULLETIN, THE 06Z THRU 18Z TIME FRAME WAS USED AND FOR THE 1200 GMT BULLETIN, THE 18Z THRU 06Z TIME FRAME WAS USED.

THE SOURCE OF PRECIPITATION DATA WAS THE LOCAL AREA SURFACE ANALYSIS. THE 0600 GMT AND 1800 GMT ANALYSES WERE USED IN CONJUNCTION WITH THE 0000 GMT AND 1200 GMT TRAJECTORY BULLETINS RESPECTIVELY.

FOR THE PURPOSE OF THIS STUDY, A PRECIPITATION FORECAST WAS DEFINED AS A MOS POP, OR MODIFIED MOS POP, OF 50 PERCENT OR GREATER AND, CONVERSELY, A POP LESS THAN 50 PERCENT WAS DEFINED AS A NO PRECIPITATION FORECAST.

DEPENDENT DATA WERE INITIALLY FOR THE PERIOD APRIL 01, 1986 TO AUGUST 31, 1986. A TEST WAS CONDUCTED ON INDEPENDENT DATA FOR SEPTEMBER OF 1986. ALL THOSE DATA WERE COMBINED TO ARRIVE AT A FINAL MODIFIED POPS.

RESULTS

TABLE 2 SHOWS THE FREQUENCY OF PRECIPITATION ON THE STRATIFIED DEPENDENT DATA. THIS PRESENTATION SHOWS THAT A SHIFT IN THE MOS POPS SHOULD BE MADE BASED ON THE NATURE OF THE 700 MILLIBAR TRAJECTORY PATH. LOOKING AT THE "TRAJECTORY THROUGH PRECIPITATION" COLUMN, MOS POPS OF 0, 2, AND 5 HAVE ONLY A FEW CASES INVOLVED. THE REAL PAYOFF BEGINS WITH MOS POP VALUES OF 10 PERCENT OR GREATER WHERE A SHIFT UPWARD IN THE POP IS DEFINITELY INDICATED. A MOS POP OF 10 PERCENT CAN CLEARLY BE RAISED TO 50 PERCENT. WHEN THE TRAJECTORY PATH IS THROUGH PRECIPITATION ALL THE MOS POPS CAN BE RAISED WITH THE GREATEST CHANGE INDICATED IN THE LOWER POP VALUES.

THE THIRD COLUMN OF TABLE 2 SHOWS THE FREQUENCIES WHEN THE TRAJECTORIES WERE FORECAST TO BE THROUGH AREAS OF NO OBSERVED PRECIPITATION. WITH THIS SITUATION, WHEN MOS POP IS 80 PERCENT PRECIPITATION OCCURRED ONLY 62.5 PERCENT OF THE TIME. PRECIPITATION OCCURRED 52.2 PERCENT OF THE TIME WHEN THE MOS POP WAS 70 PERCENT. FOR MOS POPS LESS THAN 70 PERCENT, PRECIPITATION WAS MEASURED SIGNIFICANTLY LESS THAN 50 PERCENT OF THE TIME. THIS COLUMN CLEARLY SHOWS THAT THE MOS POP CAN BE REDUCED WHENEVER THE TRAJECTORY PATH IS THROUGH AN AREA OF NO OBSERVED PRECIPITATION. KEEPING IN MIND THAT A MOS POP (OR MODIFIED MOS POP) OF 50 PERCENT OR GREATER IS A PRECIPITATION FORECAST AND A POP OF LESS THAN 50 PERCENT IS A NO PRECIPITATION FORECAST, TABLE 2 INDICATES THAT A MOS POP OF 10 PERCENT OR HIGHER CAN BE MODIFIED TO A PRECIPITATION FORECAST WHEN THE TRAJECTORY IS THROUGH OBSERVED PRECIPITATION. MOREOVER, WHEN THE TRAJECTORY IS THROUGH AN AREA OF NO OBSERVED PRECIPITATION, A MOS POP OF 70 PERCENT OR HIGHER CAN BE THE MODIFIED CRITERION FOR A PRECIPITATION FORECAST.

TABLE 3 IS THE MODIFIED MOS POPS THAT ARE BASED ON THE FREQUENCIES IN TABLE 2. SOME SUBJECTIVITY HAD TO BE USED IN THOSE INSTANCES WHERE THE NUMBER OF CASES WAS SMALL.

TABLE 4 COMPARES THE SCORES OF THE MOS POPS TO THE SCORES OF THE MODIFIED MOS POPS IN TABLE 3 USING THE DEPENDENT DATA. THIS SCORING SHOWS AN IMPROVEMENT OF THE MODIFIED MOS POPS OVER THE MOS POPS: BRIER SCORE HAD A 15.7 PERCENT IMPROVEMENT AND THE CRITICAL SUCCESS INDEX HAD A 24.3 PERCENT IMPROVEMENT!

THE MONTH OF SEPTEMBER 1986 WAS USED FOR THE INDEPENDENT DATA. THE SCORES OF THESE TEST DATA ARE SHOWN IN TABLE 5. THE MONTH OF SEPTEMBER 1986 WAS A RELATIVELY DRY MONTH IN THIS AREA. THERE WERE 40 EVENTS OF PRECIPITATION OUT OF A TOTAL OF 180 CASES. THIS RESULTS IN PRECIPITATION 22.2 PERCENT OF THE TIME WHILE CLIMATOLOGY GIVES US 30 PERCENT. NEVERTHELESS, THIS TECHNIQUE SHOWED SKILL. THE SCORES ALL SHOWED IMPROVEMENT WITH THE EXCEPTION OF THE FALSE ALARM RATIO. REGARDLESS, THE CRITICAL SUCCESS INDEX (WHICH INCORPORATES THE FALSE ALARM RATIO) SHOWED SKILL - MOS POPS .426 AND MODIFIED MOS POPS .582, A 36.6 PERCENT IMPROVEMENT OVER MOS POPS. COMPARING THE BRIER SCORES: MOS POP WAS .1050 WHILE THE MODIFIED MOS POPS WAS .0962 - AN IMPROVEMENT OF 8.4 PERCENT. FURTHERMORE, THERE WAS A 7.0 PERCENT BRIER SCORE IMPROVEMENT OVER THE LOCAL STATION FORECASTERS, EVEN THOUGH THEY WERE AWARE OF THE TECHNIQUE PRESENTED HERE.

CONCLUSION AND COMMENTS

WE SEE NO REASON WHY THIS TECHNIQUE SHOULD NOT WORK AT ANY LOCATION. OTHER GEOGRAPHICAL AREAS MAY DIFFER IN THE VALUES OF THE MODIFIED POPS. HOWEVER, THE IMPROVING TREND SHOULD RESULT REGARDLESS OF THE AREA OF APPLICATION.

RIGID OBJECTIVITY WAS OBSERVED WHILE COMPILING THESE DATA. THERE WERE CASES WHEN THE TRAJECTORY PATH WAS THROUGH PRECIPITATION THAT WAS A RESULT OF A KNOWN LOCAL PHENOMENON, SUCH AS THE GREAT LAKES EFFECT OR OROGRAPHIC EFFECTS. YET, IN THIS STUDY THOSE INCIDENTS WERE CONSIDERED AS PATHS THROUGH OBSERVED PRECIPITATION AND TABULATED AS SUCH. WITH MERELY A LITTLE SUBJECTIVITY A FIELD FORECASTER COULD FURTHER IMPROVE THE VERIFICATION SCORES BEYOND THOSE REALIZED BY THIS TECHNIQUE.

BASED SOLELY ON THE PATH OF THE 700 MILLIBAR TRAJECTORY, IMPROVEMENT OF THE FIRST PERIOD FORECAST IS CLEARLY INDICATED. THE METHOD OF OBSERVING PRECIPITATION MIGHT BE MORE ACCURATE IF ONE WERE TO USE THE RADAR SUMMARY CHART. THE PRECIPITATION BETWEEN REPORTING STATIONS IS INDICATED ON THIS CHART WHEREAS ON THE LOCAL SURFACE ANALYSIS THIS PRECIPITATION MIGHT NOT SHOW UP.

PRECIPITATION FREQUENCY

ALL MOS POPS	TRAJECTORY THROUGH PRECIPITATION	TRAJECTORY NOT THROUGH PRECIPITATION
.302 (268/886)	.718 (163/227)	.159 (105/659)

TABLE 1. THE NUMBER OF OBSERVED PRECIPITATION EVENTS. THE FREQUENCY IS MUCH HIGHER WHEN THE TRAJECTORY MOVES THROUGH AN AREA OF OBSERVED PRECIPITATION. THE FIGURES IN PARENTHESES SHOW THE TOTAL NUMBER OF CASES.

PRECIPITATION FREQUENCY

MOS POP	TRAJECTORY THROUGH PRECIPITATION	TRAJECTORY NOT THROUGH PRECIPITATION	COMBINED
0	0 (0/1)	.009 (1/111)	.009 (1/112)
2	0 (0/1)	0 (0/51)	0 (0/52)
5	.250 (1/4)	.040 (3/75)	.051 (4/79)
10	.500 (8/16)	.058 (7/120)	.110 (15/136)
20	.593 (16/27)	.250 (24/96)	.325 (40/123)
30	.581 (18/31)	.186 (11/59)	.322 (29/90)
40	.619 (13/21)	.426 (20/47)	.485 (33/68)
50	.900 (27/30)	.298 (14/47)	.532 (41/77)
60	.810 (17/21)	.381 (8/21)	.595 (25/42)
70	.833 (25/30)	.522 (12/23)	.698 (37/53)
80	.900 (27/30)	.625 (5/8)	.842 (32/38)
90	1.00 (12/12)	0 (0/1)	.923 (12/13)
100	.667 (2/3)	X	.667 (2/3)

TABLE 2. PRECIPITATION FREQUENCY FOR EACH MOS POP SHOWING THE SEPARATION OF TRAJECTORIES THROUGH PRECIPITATION AND THOSE THROUGH NO PRECIPITATION. THE LAST COLUMN SHOWS THE COMBINED CASES. THE FIGURES IN PARENTHESES SHOW THE NUMBER OF CASES.

MODIFIED MOS POPS

MOS POP	TRAJECTORY THROUGH PRECIPITATION	TRAJECTORY NOT THROUGH PRECIPITATION
0	10	0
2	10	0
5	30	5
10	50	10
20	60	20
30	60	20
40	60	30
50	80	30
60	80	40
70	80	50
80	90	60
90	100	60
100	100	60

TABLE 3. MODIFIED MOS POPS FROM DEPENDENT DATA (APRIL 01, 1986 THROUGH AUGUST 31, 1986).

DEPENDENT DATA

SCORES	MOS POPS	MODIFIED MOS POPS
BRIER	.1488	.1253
PROBABILITY OF DETECTION	.550 (149/271)	.672 (182/271)
FALSE ALARM RATIO	.341 (77/226)	.281 (71/253)
CRITICAL SUCESS INDEX	.428	.532
BIAS	.884 (226/271)	.934 (253/271)
PERCENT CORRECT	77.5 (687/886)	81.9 (726/886)

TABLE 4. STATISTICS FROM DEPENDENT DATA (APRIL 01. 1986 THROUGH AUGUST 31. 1986). THE BRIER SCORE SHOWED A 15.7 PERCENT IMPROVEMENT OVER THE MOS POPS AND THE CRITICAL SUCCESS INDEX SHOWED A 24.3 PERCENT IMPROVEMENT OVER THE MOS POPS. THE FIGURES IN PARENTHESES REPRESENT TOTAL NUMBER OF CASES.

INDEPENDENT DATA

SCORES	MOS POPS	MODIFIED MOS POPS
BRIER	.1050	.0962
PROBABILITY OF DETECTION	.500 (20/40)	.800 (32/40)
FALSE ALARM RATIO	.259 (7/27)	.319 (15/47)
CRITICAL SUCESS INDEX	.426	.582
BIAS	.675 (27/40)	1.175 (47/40)
PERCENT CORRECT	85.0 (153/180)	87.2 (157/180)

TABLE 5. STATISTICS FROM INDEPENDENT DATA (SEPTEMBER 1986). THE BRIER SCORE SHOWED A 7.0 PERCENT IMPROVEMENT OVER THE MOS POPS AND THE CRITICAL SUCCESS INDEX SHOWED A 36.6 PERCENT IMPROVEMENT OVER THE MOS POPS. THE FIGURES IN PARENTHESES REPRESENT THE TOTAL NUMBER OF CASES.

FREQUENCIES OF COMBINED DEPENDENT AND INDEPENDENT DATA

MOS POPS	TRAJECTORY THROUGH PRECIPITATION	TRAJECTORY NOT THROUGH PRECIPITATION	COMBINED
0	.000 (0/1)	.008 (1/131)	.008 (1/132)
2	.000 (0/2)	.000 (0/59)	.000 (0/61)
5	.250 (1/4)	.041 (4/97)	.050 (5/101)
10	.500 (10/20)	.047 (7/149)	.101 (17/169
20	.548 (17/31)	.213 (26/122)	.281 (43/153
30	.641 (25/39)	.171 (13/76)	.330 (38/115
40	.556 (15/27)	.418 (23/55)	.463 (38/82)
50	.848 (28/33)	.286 (14/49)	.512 (42/82)
60	.815 (22/27)	.381 (8/21)	.625 (30/48)
70	.829 (29/35)	.500 (12/24)	.695 (41/59)
80	.909 (30/33)	.700 (7/10)	.860 (37/43)
90	1.000 (15/15)	.000 (0/1)	.938 (15/16)
100	.800 (4/5)	X	.800 (4/5)

TABLE 6. PRECIPITATION FREQUENCIES FOR THE COMBINED DEPENDENT AND INDEPENDENT DATA (APRIL THROUGH SEPTEMBER OF 1986). THE FIGURES IN PARENTHESES REPRESENT THE TOTAL NUMBER OF CASES.

FINAL MODIFIED MOS POPS

MOS POPS	TRAJECTORY THROUGH PRECIPITATION	TRAJECTORY NOT THROUGH PRECIPITATION
0	10	0
2	10	0
5	30	0
10	50	10
20	60	20
30	60	20
40	60	30
50	80	30
60	80	40
70	80	50
80	90	60
90	100	70
100	100	70

TABLE 7. FINAL MODIFIED POPS USING BOTH THE DEPENDENT AND INDEPENDENT DATA. THE TIME PERIOD IS THE SUMMER SEASON OF 1986 (APRIL THROUGH SEPTEMBER).

COMBINED DATA (DEPENDENT AND INDEPENDENT)

SCORES	MOS POPS	FINAL MODIFIED MOS POPS
BRIER	.1412	.1199
PROBABILITY OF DETECTION	.543 (169/311)	.688 (214/311)
FALSE ALARM RATIO	.332 (84/253)	.287 (86/300)
CRITICAL SUCCESS INDEX	.428	.539
BIAS	.814 (253/111)	.965 (300/111)
PERCENT CORRECT	78.8 (846/1066)	82.8 (883/1066)

TABLE 8. STATISTICS FOR THE COMBINED DEPENDENT AND INDEPENDENT DATA FOR THE SUMMER SEASON OF 1986 (APRIL THROUGH SEPTEMBER). THE BRIER SCORE SHOWED A 15.1 PERCENT IMPROVEMENT OVER THE MOS POPS AND THE CRITICAL SUCCESS INDEX SHOWED A 25.9 PERCENT IMPROVEMENT.