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A PROCEDURE FOR FORECASTING PRECIPITATION TYPE USING NGM LOW LEVEL TEMPERATURES AND LFM MOS FROZEN PRECIPITATION PROBABILITIES

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ABSTRACT

IN EASTERN REGION TECHNICAL ATTACHMENT NO. 86-19(A) A PROCEDURE WAS SHOWN FOR FORECASTING PRECIPITATION TYPE USING NESTED GRID MODEL (NGM) LOW LEVEL TEMPERATURE FORECASTS. A TECHNIQUE IS PRESENTED FOR COMBINING THE RESULTS OF THAT PROCEDURE WITH MODEL OUTPUT STATISTICS (MOS) PROBABILITY OF FROZEN (POF) PRECIPITATION VALUES FROM THE LIMITED FINE-MESH MODEL (LFM) TO DETERMINE PRECIPITATION TYPE.

INTRODUCTION

THE RESULTS OF THE PROCEDURE FOR FORECASTING PRECIPITATION TYPE USING NGM LOW LEVEL TEMPERATURE FORECASTS ARE SHOWN IN TABLE 1. IN EASTERN REGION TECHNICAL ATTACHMENT NO. 86-19(A) A STUDY USING PREFERRED PROBABILITY OF PRECIPITATION TYPE (POPT) CATEGORY AND NGM FOUS PRECIPITATION TYPE FROM TABLE 1. WAS PLANNED FOR THE WINTER OF 1986-87. HOWEVER, A DETAILED COMPARISON OF PREFERRED POPT CATEGORY AND POF SHOWED THAT POF WAS A MORE ACCURATE PREDICTOR OF PRECIPITATION TYPE. SO POF WAS SUBSTITUTED FOR PREFERRED POPT IN THIS STUDY.

PROCEDURE

OBSERVED PRECIPITATION TYPE WAS STRATIFIED BY POF RANGES (<6, 6-15, 16-25, 26-35, 36-45, 46-55, 56-65, 66-75, 76-85, 86-95, AND >95) FOR THE WINTERS OF 1985-86 AND 1986-87. THE RESULTS ARE SHOWN IN TABLE 2. FOR THIS STUDY FROZEN PRECIPITATION WAS DEFINED AS SNOW, SLEET, OR A MIXTURE OF THE TWO. LIQUID PRECIPITATION WAS DEFINED AS RAIN OR FREEZING RAIN. MIXED PRECIPITATION WAS DEFINED AS ANY COMBINATION OF FROZEN AND LIQUID PRECIPITATION OCCURRING AT THE SAME TIME.

SINCE THE NGM PRECIPITATION TYPE FREQUENCIES IN TABLE 1. WERE ALREADY IN FOUR CATEGORIES BY INCREMENTS OF T1 AND T3 FOR ALL VALUES OF T5, IT WAS DECIDED TO EXAMINE THE RANGES OF POF IN EACH OF THE FOUR CATEGORIES FOR THE WINTERS OF 1985-86 AND 1986-87.

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

THE FORECASTS FOR THE 00Z FORECAST CYCLE WERE COMBINED WITH THE 12Z CYCLE. THIS COULD MASK OUT ANY DIURNAL EFFECTS THAT MAY EXIST, BUT A PRELIMINARY EVALUATION OF THE DATA INDICATES THAT DIURNAL VARIATIONS ARE SMALL.

RESULTS

THE RESULTS ARE SHOWN IN TABLE 3. SOME SUBJECTIVITY WAS NECESSARY IN DEVELOPING THE TABLE, ESPECIALLY WHERE LITTLE DATA WERE AVAILABLE.

HOW WELL DID THE NGM PRECIPITATION TYPE FORECASTS PERFORM IN COMPARISON TO THE COMBINED NGM/POF METHOD OF FORECASTING PRECIPITATION TYPE? THE COMBINED NGM/POF FORECASTS WERE SUPERIOR TO THE NGM TYPE FORECASTS. THE PRECIPITATION TYPE FORECASTS FROM EACH WERE CONVERTED TO CATEGORICAL FORECASTS AND VERIFIED. ALL DEFINITE FORECASTS (APPROXIMATELY 100 PERCENT FREQUENCY OF OCCURENCE) OF RAIN AND OF SNOW WERE DELETED FROM THE VERIFICATION PROCESS). THESE ACCOUNTED FOR 889 CASES, WHICH WERE ALMOST 25 PERCENT OF THE OF THE TOTAL 3663 CASES USED IN DEVELOPING THE TABLES USED TO FORECAST THE PRECIPITATION TYPE. THE VERIFICATION RESULTS ARE SHOWN IN TABLE 4. FOR VERIFICATION PURPOSES A FREQUENCY GREATER THAN OR EQUAL TO 50 PERCENT FOR FROZEN PRECIPITATION WAS TREATED AS A CATEGORICAL FORECAST OF FROZEN PRECIPITATION. A FREQUENCY LESS THAN 50 PERCENT WAS CONSIDERED A CATEGORICAL FORECAST OF LIQUID PRECIPITATION. REGARDLESS OF THE SCORE USED, THE COMBINED NGM/POF METHOD OF TYPING PRECIPITATION WAS SUPERIOR TO THE NGM FOUS TEMPERATURE METHOD BY ITSELF.

CONCLUSION

THIS STUDY HAS DEVELOPED A TECHNIQUE FOR IMPROVING PRECIPITATION FORECASTS BY OBJECTIVELY USING NGM LOWER LEVEL TEMPERATURES AND MOS POF VALUES. EVEN THOUGH THE DATA SAMPLE IS SMALL AND FOR A PARTICULAR AREA, IT CLEARLY POINTS THE WAY TOWARD ADDITIONAL STUDIES.

	T1>1			T1=1			1>T1>97 & T3<2			98>T1>89 & T3<98		
				1>T1>95 & T3>1			98>T1>95 & 2>T3>97			T1<90		
							96>T1>89 & T3>97					
T5	RAIN	SNOW	MIX	RAIN	SNOW	MIX	RAIN	SNOW	MIX	RAIN	SNOW	MIX
>06	1.000	.000	.000	1.000	.000	.000	1.000	.000	.000	1.000	.000	.000
06	.981	.019	.000	.967	.032	.000	.750	.250	.000	.700	.300	.000
05	.977	.023	.000	.952	.048	.000	.727	.273	.000	.600	.400	.000
04	.975	.025	.000	.929	.071	.000	.500	.340	.160	.450	.500	.050
03	.973	.027	.000	.925	.075	.000	.463	.370	.167	.300	.600	.100
02	.968	.032	.000	.810	.095	.095	.409	.409	.182	.100	.700	.200
01	.871	.072	.049	.720	.160	.120	.361	.532	.107	.096	.793	.111
00	.861	.082	.057	.662	.200	.138	.317	.578	.105	.060	.877	.063
99	.650	.200	.150	.625	.214	.161	.258	.638	.104	.043	.922	.035
98	.587	.288	.125	.564	.295	.131	.183	.714	.103	.032	.936	.032
97	.556	.344	.100	.529	.353	.118	.168	.736	.096	.022	.948	.030
96	.521	.399	.080	.364	.545	.091	.136	.775	.089	.019	.954	.027
95	.500	.467	.033	.214	.714	.072	.113	.825	.062	.017	.961	.022
94	.450	.550	.000	.156	.783	.061	.099	.844	.057	.014	.967	.019
93	.333	.667	.000	.080	.866	.054	.071	.881	.048	.012	.971	.017
92	.200	.800	.000	.038	.925	.033	.033	.926	.041	.011	.989	.000
<92	.000	1.000	.000	.000	1.000	.000	.000	1.000	.000	.000	1.000	.000

TABLE 1. RELATIVE FREQUENCY OF PRECIPITATION TYPE FOR TEMPERATURE T5 FROM NGM FOUS MESSAGES BY CATEGORY OF T1 AND T3.

WINTERS 1985-1986 AND 1986-1987

POF	LIQUID	FROZEN	MIXED
<6	.979	.018	.003
6-15	.796	.152	.052
16-25	.613	.320	.067
26-35	.505	.413	.082
36-45	.382	.539	.079
46-55	.307	.624	.069
56-65	.248	.687	.065
66-75	.207	.737	.056
76-85	.097	.869	.034
86-95	.045	.931	.024
>95	.001	.998	.001

TABLE 2. RELATIVE FREQUENCY OF PRECIPITATION TYPE FOR MOS POF RANGES.

	CATEGORY ONE				CATEGORY TWO		
POF	RAIN	SNOW	MIXED	POF	RAIN	SNOW	MIXE
<6	.981	.017	.002	<6	.859	.084	.057
6-15	.904	.083	.013	6-15	.776	.153	.071
16-25	.844	.119	.037	16-25	.654	.247	.099
26-35	.801	.149	.050	26-35	.615	.266	.119
36-45	.736	.190	.074	36-45	.558	.308	.134
46-55	.718	.201	.081	46-55	.523	.356	.121
56-65	.651	.253	.096	56-65	.400	.506	.094
66-75	.571	.353	.076	66-75	.384	.535	.081
76-85	.472	.513	.015	76-85	.330	.600	.070
86-95	.222	.771	.007	86-95	.295	.636	.069
>95	.100	.900	.000	>95	.110	.875	.015

	CATEGORY THREE				CATEGORY FOUR		
POF	RAIN	SNOW	MIXED	POF	RAIN	SNOW	MIXE
<6	.875	.083	.042	<6	.700	.200	.100
6-15	.566	.320	.113	6-15	.500	.333	.167
16-25	.327	.543	.130	16-25	.240	.720	.040
26-35	.290	.611	.099	26-35	.124	.846	.030
36-45	.232	.682	.086	36-45	.055	.920	.025
46-55	.188	.729	.083	46-55	.025	.956	.019
56-65	.171	.754	.075	56-65	.020	.962	.018
66-75	.158	.782	.060	66-75	.019	.968	.013
76-85	.123	.827	.050	76-85	.018	.976	.006
86-95	.083	.877	.040	86-95	.014	.983	.003
>95	.007	.986	.007	>95	.000	.999	.001

TABLE 3. RELATIVE FREQUENCY OF PRECIPITATION TYPE FOR NGM LOWER LEVEL TEMPERATURE CATEGORIES AND MOS POF RANGES COMBINED.

	NGM/POF	NGM
P.O.D.	.940	.929
F.A.R.	.187	.122
C.S.I.	.845	.823
PCT. CORRECT	88.6	87.8
BIAS	1.052	1.058

TABLE 4. SKILL OF PRECIPITATION TYPE FORECASTS FROM COMBINED NGM/POF FORECASTS AND NGM LOWER LEVEL TEMPERATURE FORECASTS.

COMMENTS ON THE USE OF THE RESULTS IN THIS STUDY

SEVERAL CHANGES HAVE BEEN MADE TO THE NESTED GRID MODEL SINCE OPERATIONAL 0-48 HOUR NUMERICAL FORECASTS BEGAN IN MARCH 1985. TWO SIGNIFICANT CHANGES CHANGES TOOK PLACE THAT COULD AFFECT THE RESULTS OF THIS STUDY AND THE RESULTS FOUND IN THE EASTERN REGIONAL TECHNICAL ATTACHMENT NO. 86-19(A).

FROM THE TIME OF ITS BEGINNING OPERATIONAL FORECASTS, OBJECTIVE AND SUBJECTIVE EVALUATIONS OF THE NGM HAVE DEMONSTRATED THAT THE MODELING SYSTEM PRODUCED RELIABLE FORECASTS. HOWEVER, SYSTEMATIC ERRORS IN THE FORECASTED TEMPERATURES, CAUSED BY THE OMISSION OF CERTAIN PHYSICAL PROCESSES IN THE MODEL, WERE IDENTIFIED.

IN JULY OF 1986 A MORE COMPLETE FORMULATION OF PHYSICAL PROCESSES WERE INTRODUCED INTO THE NGM. LONGWAVE AND SHOTWAVE RADIATION INCLUDING A DIURNAL CYCLE, SURFACE FLUXES OF HEAT AND MOISTURE OVER LAND, AND A NEW TURBULENT MIXING PROCESS WERE ADDED TO THE MODEL. IMPORTANT MODIFICATIONS WERE ALSO MADE TO THE REPRESENTATION OF CUMULUS CONVECTION BY THE MODEL.

IMPLEMENTATION OF THE NEW PHYSICS WAS TO IMPROVE THE NGM'S FORECASTS OF SENSIBLE WEATHER SUCH AS PRECIPITATION, LOW LEVEL TEMPERATURES, SURFACE INDUCED CIRCULATIONS SUCH AS LAND/SEA BREEZES, THE DIURNAL VARIATION OF LOW LEVEL WINDS, AND MAXIMUMAND MINIMUM TEMPERATURES.

THE RADIATIONAL HEATING CALCULATIONS THAT WERE INTRODUCED IN THE NESTED GRID MODEL IN JULY 1986 WERE DESCRIBED IN TECHNICAL PROCEDURES BULLETIN 363 AS PRODUCING A PROGRESSIVELY COLDER TEMPERATURE FIELD, AT THE RATE OF ABOUT -1.5 DEGREES IN 48 HOURS, AT ALMOST ALL LEVELS. THE COLD ERROR CONTINUED FOR MORE THAN A YEAR.

IN 1987 TWO MODIFICATIONS, ONE MAJOR AND ONE MINOR, WERE INTRODUCED INTO THE NGM TO REDUCE ERRORS IN THE FORECAST TEMPERATURES.

1. IN AUGUST A CHANGE TO THE NEAR-SURFACE AIR TEMPERATURES USED TO CALCULATE RADIATION.

2. IN OCTOBER AT EACH LEVEL, THE HEMISPHERICALLY-AVERAGED POTENTIAL TEMPERATURE WAS KEPT CONSTANT DURING THE FORECAST, AT ITS INITIAL VALUE.

THE RESULT OF THESE TWO CHANGES WAS TO REDUCE THE COLD BIAS OF NGM FORECAST TEMPERATURES AND A SMALL REDUCTION IN THE AREAS OF PRECIPITATION.

THE RESULTS OF THE THIS STUDY AND THE PREVIOUS ONE (EASTERN REGION TECHNICAL ATTACHMENT NO. 86-19(A) COULD BE ALTERED BY THESE CHANGES. HOWEVER, THE CHANGES IN JULY 1986 HAD NO DISCERNIBLE IMPACT ON THE USE OF THE ORIGINAL PRECIPITATION TYPE STUDY USING NGM LOW LEVEL TEMPERATURES DURING THE WINTER OF 1986-87. THE RESULTS OF THAT STUDY STILL PERFORMED VERY WELL IN MAINE AND NEW HAMPSHIRE.

THE CHANGES MADE TO THE NGM THIS PAST FALL COULD ALSO ALTER THE RESULTS OF THAT STUDY AND THIS ONE AS WELL. HOWEVER, IN USING BOTH FROM OCTOBER 1987 TO MID JANUARY 1988 NO CHANGE HAS BEEN NOTICED AS BOTH HAVE PERFORMED VERY WELL ALSO. MAYBE SOME CHANGES WILL SHOW UP LATER IN THE WINTER SEASON.

IF THE CHANGES TO THE MODEL RESULT IN WARMING OF THE LOWER LEVEL TEMPERATURE FORECASTS PRODUCED BY THE MODEL, THEN A FEW POINTS NEED TO BE MADE ABOUT USING THIS STUDY AND THE PREVIOUS ONE.

1. MORE SNOW EVENTS WILL OCCUR WITH A RAIN OR BORDERLINE RAIN-SNOW NGM TYPE FORECAST. THIS WILL HAPPEN MORE AT 48 HOURS THAN IN EARLIER TIME PERIODS AS THE AMOUNT OF ADDED WARMING SHOULD BE GREATEST AT THAT TIME.

2. ANY FORECAST OF SNOW FROM THE NGM TEMPERATURE VALUES WILL BE AN EVEN STRONGER FORECAST OF SNOW. THIS IS TRUE BECAUSE THE VALUES THAT NOW DETERMINE SNOW WOULD HAVE BEEN EVEN COLDER HAD ANY WARMING NOT BEEN ADDED. THIS WOULD HAVE PRODUCED HIGHER PROBABILITIES OF THE PRECIPITATION BEING FROZEN.

3. THE COMBINING OF THE MOS POF VALUES WITH THE NGM LOWER LEVEL TEMPERATURE FORECASTING METHOD SHOULD HAVE A MINIMIZING EFFECT ON ANY DRASTIC CHANGES. SINCE THE POF VALUES ARE OBTAINED BY USING MOS PROCEDURES ON LFM DERIVED PARAMETERS AND THE LFM IS A RELATIVELY UNCHANGING MODEL, THE POF VALUES SHOULD PARTIALLY COUNTERBALANCE ANY WARMING THAT MAY OCCUR IN THE NGM LOWER LEVEL TEMPERATURE FORECASTS.

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