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GRIFFISS AFB LAKE-EFFECT SNOW STUDY

by

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13. Abstract: This report describes USAFETAC's efforts in developing 11 new decision trees for forecasting lake-effect snow at Griffiss AFB, NY. To develop the new methods, USAFETAC modified a snow forecasting decision tree created by the National Weather Service Forecast Office (NWSFO) at Buffalo, NY (Niziol, 1987). In addition to other changes, 10 of the 11 USAFETAC-developed trees were modified to use stability indices as input variables. All 12 trees were verified against a dependent period of record (1973 to 1986) and an independent period of record (1987 to 1988). Results showed that all 10 modified decision trees that used stability indices were effective in forecasting lake-effect snow at Griffiss AFB, with little statistical difference among them.

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PREFACE

Under USAFETAC Project 90814, USAFETAC/DNO sought to determine whether or not a National Weather Service snow forecasting model in use by Det 8, 26WS, at Griffiss AFB, NY, actually worked. During the winter of 1989-90, Griffiss forecasters used a lake-effect snow forecast decision tree developed by the National Weather Service Forecast Office (NWSFO) at Buffalo, NY (Niziol, 1987). This method for predicting lake-effect snow was based on model-derived forecast variables. USAFETAC's goal was to tailor the NWS decision tree for Griffiss AFB, NY, and produce a useful lake-effect snow forecasting tool for that station.

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1. INTRODUCTION.

1.1 Purpose. The purpose of USAFETAC Project 90814 was to determine whether or not a lake-effect snow forecasting method used by AWS weather forecasters at Griffiss AFB, NY (Det 8, 26 WS) actually improved snow forecasts. During the 1989-90 winter, Griffiss forecasters used a lake-effect snow forecast decision tree developed by the National Weather Service Forecast Office (NWSFO) at Buffalo, NY (Niziol, 1987), a procedure based on model-derived forecast variables. USAFETAC was charged with tailoring this decision tree for Griffiss AFB and producing a useful lake-effect snow forecasting tool.

1.2 The Original Buffalo Decision Tree. To forecast the onset of lake-effect snow using the original Buffalo decision tree (shown in Figure 1), all three of the following conditions must be met:

•*The temperature difference between Lake Ontario and the 850-mb level must be 13°C or more.*

$$(T_{ONT} - T_{850} \geq 13)$$

•*Wind direction in the boundary layer and at the 850-mb level must be between 230 and 080 degrees.*

$$(230 \leq \theta_{850} \leq 080)$$

•*Directional wind shear between the boundary layer and 700 mb must be less than 60 degrees.*

$$(-60 \leq \theta_{700\text{-}BL} \leq 60)$$

$$\text{where: } \theta_{700\text{-}BL} = \theta_{700} - \theta_{BL} \qquad (1)$$

1.3 The "Modified" Buffalo Decision Tree. USAFETAC modified the Buffalo decision tree (at the customer's request) by changing the required wind direction range between the boundary layer and 850 mb from 230-080 to 240-350 degrees. The new method created through this change will be referred to here as the "modified Buffalo tree."

1.4 USAFETAC Variations. Several other variations of the Buffalo decision tree were developed for Griffiss AFB. One difference between the old and new trees was the *range* each variable must satisfy before forecasting snow (Figure 2). For example, the required temperature difference between the lake and 850 mb was changed to greater than 6 degrees, versus the original 13. How these new threshold values were determined will be discussed in Section 3. A stability index was also added to the first modification, and several formulations of the stability index were tested (Table 1).

1.5 Verification. The 11 most promising variations tailored for Griffiss AFB, as well as the modified Buffalo tree, were verified. Verification showed little difference between any of the USAFETAC-developed trees, and all the new Griffiss AFB trees had more skill than the modified Buffalo tree (See Section 4).

DECISION TREE FOR LAKE-EFFECT SNOW OVER WESTERN NEW YORK

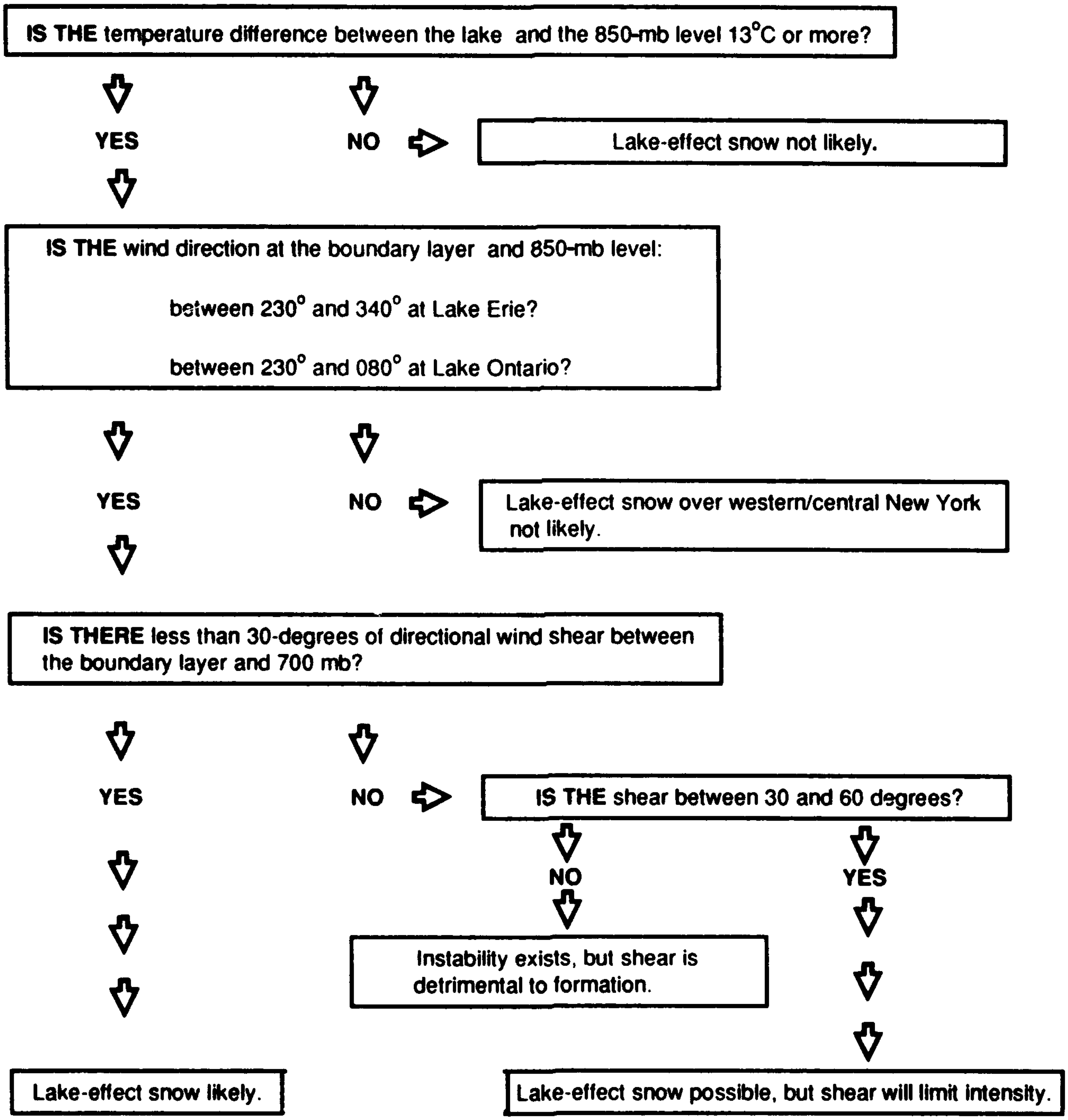

Figure 1. Lake- Effect Snow Forecasting Decision Tree Used as a Guide at the Buffalo NWSFO (Adapted from Niziol ,1987).

DECISION TREE FOR LAKE EFFECT SNOW AT GRIFFISS AFB, NY

IS DELTAT (Lake Ontario temperature reported on Rochester observation minus 850-mb temperature at Buffalo) greater than 6°C?

↓ YES ↓

ARE BLWNDIR (boundary layer (lowest 50 mb) wind direction at Buffalo) and WNDIR850 (wind direction at 850 mb at Buffalo) both between 240° and 350°?

↓ YES ↓

IS DIRSHR (700-mb wind direction minus 1,000-mb wind direction at Buffalo) between -30 and 60 degrees?

Note: Negative values imply backing; positive values, veering.

↓ YES ↓

IS INDEX 1 (one of four stability indices developed for Griffiss AFB--see Table 1) less than or equal to -4?

↓ YES ↓

Lake-effect snow IS likely.

Figure 2. Example of a Lake-Effect Snow Forecasting Decision Tree For Use as a Guide at Griffiss AFB, NY.

TABLE 1. Stability Indices. Temperatures and dew points at 850 and 700 mb are for Buffalo.

INDEX 1 =	*(850-mb temp - Lake Ontario temp) + (850-mb temp - 850-mb dew point)*
INDEX 2 =	*850-mb temp - Griffiss temp*
INDEX 3 =	*(850-mb temp - Griffiss temp) + (850-mb temp - 850-mb dew point)*
INDEX 4 =	*(850-mb temp - Griffiss temp) + (850-mb temp - 850-mb dew point) + (700-mb temp - 850-mb temp)*

2. DATA AND LIMITATIONS.

2.1 Data used in the Study. The customer asked that the following data be used: surface weather observations for Griffiss AFB: upper-air observations for Albany and Buffalo, NY, and Maniwaki, Canada; and temperature for Lake Ontario. To develop the Griffiss decision trees, data from 1973 to 1986 was used. Data from 1987 to 1988 was used for independent verification of the developed trees. Variable elements used are shown in Table 2.

TABLE 2. List of Variables, Reporting Stations, and Frequency.

Variables	Reporting Stations	Frequency
•Visibility, present weather, temperature, dew point, wind direction and speed, 6- and 24-hour snowfall[1]	Griffiss AFB, NY	Hourly
•1,000-mb height and wind speed •950-mb wind speed •850-mb height, wind direction/speed, temperature/dew point •700-mb height, wind direction/speed, temperature/dew point •Wind direction shear from 1,000 to 700 mb •Wind direction shear from 1,000 to 850 mb •Mean wind direction/speed from 950-1,000 mb •Mean wind direction/speed from 850-1,000 mb •Mean wind direction/speed from 700-1,000 mb •Lowest inversion below 500 mb •Second lowest inversion below 500 mb	Albany & Buffalo, NY and Manawaki, Canada	00 & 12Z
•Lake Ontario water temperature[2]	Rochester, NY	Once daily

1. Calculated in this study from 6-hour snow depth measurements.
2. Measured at city inlet and appended to Rochester surface weather observation between 13 & 15Z.

2.2 Surface Data. Surface observations for Griffiss AFB between October and April were used. To determine snow amount, the change in snow depth reported on the 6-hourly observation was calculated. Snow amount was set to zero when loss of snow cover occurred. Although not as accurate as actual 6-hour snowfall measurements, this method was consistent throughout the period of record.

2.3 Upper-Air Data. Temperature, dew point, and wind data was obtained from radiosonde soundings at Albany and Buffalo, NY, and Maniwaki, Canada, from 1973 to 1988. Only October-April data was used.

2.4 Lake Temperature. The Lake Ontario temperature is shown as a remark on the Rochester, NY, surface observation between 1300 and 1500Z: Rochester has reported lake temperature this way since 1983. Inspection of the data showed large (up to 10°C) day-to-day lake temperature oscillations. The lake temperature sensor was located in the Rochester city water inlet, about 12 meters below the surface and 1.6 km offshore. With strong westerly winds, lake water mixing caused temperature oscillations at the inlet. To smooth these oscillations, a computer algorithm was developed to calculate a 5-day running mean lake temperature. If more than 5 days in a row were missing, the algorithm started over again with the next valid temperature. From the smoothed temperatures, mean daily lake temperatures were computed and a full year's climatology constructed. Lake temperature climatology for 1973 to 1982 was used rather than actual observations.

3. METHODOLOGY.

3.1 Approach. Starting with the modified Buffalo decision tree, USAFETAC developed and tested a new lake-effect snow forecasting aid for Griffiss AFB. An effort was also made to obtain snow predictors through linear regression on the surface and upper-air variables. Since a literature review showed the importance of atmospheric stability in snow prediction, several stability indices (shown in Table 1) were also developed and tested.

3.2 Procedure. Surface, upper-air, and lake temperature observations were combined into one data set. The upper-air data was considered to be valid 6 hours either side of the observation time. For example, a 00Z upper-air sounding was associated with a 20Z surface observation, and a 07Z surface observation was matched to a 12Z sounding. When a Lake Ontario temperature was available, it was considered valid for the entire Zulu day; otherwise, the lake temperature climatology for that day was used.

3.2.1 To determine if a lake-effect snow event had occurred, both the following criteria had to be met:

- An increase in the 6-hourly snow depth report at Griffiss AFB

- Boundary layer (first 50 mb) and 850-mb wind directions were both between 240 and 350 degrees.

A value of 1 was then assigned for use in correlating lake-effect snow events with other factors. If the criteria were not met, a "non-event" was identified and assigned a value of zero. A snow event had to meet only the first criterion.

3.2.2 Directional wind shear ($\Delta\theta$) used in the decision tree was obtained by

$$\theta_{700\text{-}1,000} = \theta_{700} - \theta_{1,000} \tag{2}$$

where θ_{700} is the 700-mb wind direction and θ_{1000} is the 1,000-mb wind direction. For example, given a wind direction of 270° at 700 mb and 300° at 1,000 mb, the magnitude of the directional shear between 1,000 and 700 mb would be negative 30°, which implies 30° of backing. Positive values indicate *veering* with height.

3.2.3 Our initial attempts to use the modified Buffalo decision tree resulted in snow forecasts when the air temperature was greater than 10°C. Therefore, all observations in which the ambient air temperature was greater than 2.2°C (36°F) were excluded from this study.

3.3. Linear Regression. In an attempt to obtain snow predictors for Griffiss AFB, the variables in Table 2 were correlated with lake-effect snow events, all snow events, 6-hour snowfall, and 24-hour snowfall. The intent was to use linear regression on the most highly correlated variables to develop predictive equations for lake-effect snow, all snow, 6-hour snowfall, and 24-hour snowfall. However, because application of the Pearson product-moment correlation method resulted in low values, we didn't attempt to develop predictive equations. Also, we dropped the upper-air data for Albany and Maniwaki at this point because they were no more statistically significant than those for Buffalo.

3.4 Decision Tree Development. Given the customer's specification that both the boundary layer and 850-mb wind directions (predictors BLWNDIR and WNDIR850) must be between 240° and 350° for lake-effect snow, a statistical procedure was employed to obtain the remaining predictors for the Griffiss AFB decision trees. Frequency distributions of the following predictors were examined.

- DELTAT - Lake Ontario temperature minus 850-mb temperature at Buffalo.

- DIRSHR - 700-mb wind direction minus 1,000-mb wind direction at Buffalo (negative values imply backing; positive values, veering).

3.4.1 Using frequency distributions of DELTAT and DIRSHR calculated for lake-effect snow events and non-events separately, the relationship between the 95th percentile values for lake-effect snow events and the 50th percentile values for non-events were examined (Figure 3). If the predictor's 95th percentile value for the lake-effect snow events appeared at or below the 50th percentile value for non-events (if it was associated with less than half of the non-events), it was selected for use in the decision trees. As it turned out, three values for DELTAT (6°C, 7°C, and 8°C) were all closely qualified, and they were selected. Values of DIRSHR that qualified fell in the range from 30° of backing to 60° of veering.

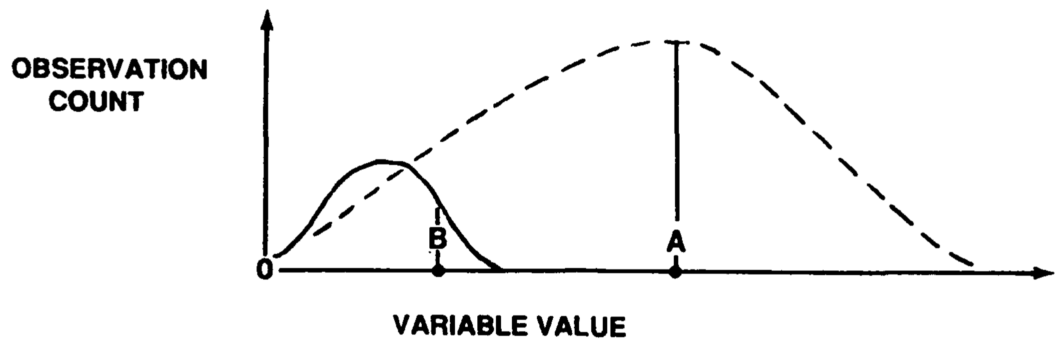

Figure 3. Superimposed Frequency Distributions of a Variable for Cases of Lake-Effect Snow Events (Solid Curve) and No Lake-Effect Snow Events (Dashed Curve). Point A represents the 50th percentile for no lake-effect snow events; Point B represents the 95th percentile for lake-effect snow events. Therefore, the value at B will be used as a threshold in the decision tree. If the value of the variable is less than or equal to B, lake-effect snow would be forecast.

3.4.2 The 12 lake-effect snow forecast decision trees developed for Griffiss AFB and verified in this study are shown in Table 3. Tree A is the modified Buffalo tree, Tree B is purposely verified without a stability index (INDEX), and Trees C through L are composed of combinations of DELTAT and INDEX. The actual tree can be obtained by replacing the ranges identified in Table 3 into the branches of Figure 2. Note that to infer a forecast of lake-effect snow, all of the criteria in a particular tree must be met. The "variables" shown in Table 2 are defined as follows:

•DELTAT - Lake Ontario temperature reported on Rochester observation minus 850-mb temperature at Buffalo.

•BLWNDIR - Boundary layer (lowest 50 mb) wind direction at Buffalo.

•WNDIR850 - Wind direction at 850 mb at Buffalo.

•DIRSHR - 700-mb wind direction minus 1,000- mb wind direction at Buffalo. Negative values imply backing; positive values, veering.

•INDEX - Stability index developed for Griffiss AFB (See Table 1).

TABLE 3. Dependent and Independent Verification of Lake-Effect Snow Forecast Decision Trees (A-L) for Griffiss AFB, NY. All variable criteria must be met to predict lake-effect snow.

	= VARIABLES =				HEIDKE SKILL SCORES	
Tree	DELTAT	BLWNDIR and WNDIR850	DIRSHR	INDEX(I)	Dependent Data Set 1973-86	Independent Data Set 1987-88
A	>13	24-35	0 to -30	------	0.27	0.16
B	>7	24-35	-30 to 60	------	0.43	0.33
C	>6	24-35	-30 to 60	I1 ≤-4	0.45	0.36
D	>7	24-35	-30 to 60	I2 ≤ 0	0.43	0.34
E	>8	24-35	-30 to 60	I2 ≤ 0	0.43	0.34
F	>6	24-35	-30 to 60	I2 ≤ 0	0.43	0.34
G	>7	24-35	-30 to 60	I3 ≤ 5	0.45	0.36
H	>8	24-35	-30 to 60	I3 ≤ 5	0.45	0.36
I	>6	24-35	-30 to 60	I3 ≤ 5	0.45	0.35
J	>7	24-35	-30 to 60	I4 ≤ 2	0.45	0.36
K	>8	24-35	-30 to 60	I4 ≤ 2	0.45	0.37
L	>6	24-35	-30 to 60	I4 ≤ 2	0.45	0.36

4. RESULTS.

4.1 Verification of Decision Trees. All 12 decision trees were verified against all observations for the 1973 to 1986 period of record by using standard verification matrices. Table 4 shows the verification matrix for the modified Buffalo decision tree. The numbers in the matrix represent the number of observations in which lake-effect snow did *not* occur (NO) or *did* occur (YES) on the abscissa against whether the tree did *not* forecast lake-effect snow (NO) or *did* forecast it (YES) on the ordinate. The numbers outside the matrix are row and column totals. In this example, there were 33,458 observations of no lake-effect snow when the tree had forecast none, and 1,614 observations of no lake-effect snow when the tree *did* forecast snow. Similarly, there were 4,788 observations of lake-effect snow when the tree forecast none, and 1,679 observations of lake-effect snow when the tree *did* forecast snow. Also shown in Table 4 is the Heidke skill score calculated for all 12 decision trees. The Heidke skill score ranges from zero to one, where zero represents no skill and one represents total accuracy. In meteorological applications, Heidke skill scores near 0.40 are considered good.

TABLE 4. Verification Matrix and Heidke Skill Score Calculation for the Modified Buffalo Lake-Effect Snow Forecast Decision Tree.

Observed Lake-Effect Snow:		NO	YES	TOTAL
Modified Buffalo Decision Tree Forecast	**NO**	33,458 (A)	4,788	38,246 (R1)
	YES	1,614	1,679 (B)	3,293 (R2)
	TOTAL:	35,072 (C1)	6,467 (C2)	41,539 (T)

Heidke Skill Score: $F\text{-}D/T\text{-}D$, where $F = A+B$ and $D = (C1R1 + C2R2)/T$

Modified Buffalo Tree Score = 0.27

4.2. Independent Verification. As an independent test of the 12 decision trees, we verified them against winter observations from 1987 to 1988 and calculated Heidke skill scores. The independent verification also showed considerable skill for the Griffiss AFB decision trees. Verification results for both the dependent and independent databases are summarized in Table 3.

4.3. Implications for Griffiss AFB. Although the modified Buffalo decision tree (Tree A in Table 3) did not score as well as the others, this does not reflect on the effectiveness of the Buffalo decision tree for making Buffalo forecasts. However, for purposes of lake-effect snow forecasting at Griffiss AFB, it is recommended that one of the decision trees with a stability index be used as a guide for forecasting lake-effect snow.

5. SUMMARY.

5.1 Development and Verification. USAFETAC/DNO developed 11 new decision trees for forecasting lake-effect snow at Griffiss AFB, NY. The Buffalo, NY, NWSFO decision tree, modified by requiring the boundary layer and 850-mb wind directions to be between 240° and 350°, served as a model for the rest. Surface data for Griffiss AFB, upper-air data for Buffalo, and Lake Ontario water temperatures for 1973 to 1986 were analyzed statistically to obtain optimal values for the other decision tree variables for use at Griffiss AFB. Of the 11 resultant decision trees, stability indices were developed and used in 10. All the trees were verified against both the dependent period of record (1973 to 1986) and an independent period of record (1987 to 1988). Results showed that the modified Buffalo decision tree had a lower Heidke skill score (0.27) when verified against the dependent period of record than the other decision trees (0.43 to 0.45). When verified against the independent period of record, skill scores were proportionally lower, as expected.

5.2 Recommendations. USAFETAC recommends that the customer select any of the 10 USAFETAC decision trees with a stability index as a guide in forecasting lake-effect snow at Griffiss AFB. Statistically, there are no differences among these methods, and ease of implementation should dictate which is chosen.

BIBLIOGRAPHY

Dewey, K.F., "Lake-Effect Snowfall in Buffalo and a Look at the Record Breaking 1976-77 Snowfall Season," *National Weather Digest*, 2, pp. 31-36, 1977.

Dewey, K.F., "Lake Erie Induced Mesosystems--An Operational Forecast Model," *Monthly Weather Review*, 107, pp. 421-425, 1979.

Dewey, K.F., "An Objective Forecast Method Developed for Lake Ontario Induced Snowfall Systems," *Journal of Applied Meteorology*, 18, pp. 787-793, 1979.

Dice, H., et. al., *A Checklist for Forecasting Lake Effect Snow Showers at Niagara Falls, New York.* Det 5, 12 WS, Niagara Falls Municipal Airport, Niagara Falls, New York, 1959.

Dietz, G.C., and B. Kelker, "A Classic Lake Effect Snowstorm at Buffalo, New York, on 15 Nov 74," *Weatherwise*, 28(5), pp. 204-207, 1975.

Estoque, M.A., and K. Ninomiya, "Numerical Simulation of Japan Sea Effect Snowfall," *Tellus*, 28, pp. 243-253, 1976.

Hsu, H-M., "Mesoscale Lake Effect Snowstorms in the Vicinity of Lake Michigan: Linear Theory and Numerical Simulations," *Journal of Atmospheric Science*, 44, pp. 1019-1040, 1987.

Jiusto, J.E., and M.L. Kaplan, "Snowfall from Lake Effect Storms," *Monthly Weather Review*, 100, pp. 62-66, 1972.

McVehil, G.E., et. al., *Project Lake Effect: A Study of Lake Effect Snowstorms*, Cornell Aeronautical Laboratory, Inc., Buffalo, New York., Report No. CAL VC 2355 P 2., 1967.

Niziol, T.A., "Record-Setting Lake-Effect Snowstorm at Buffalo, New York," *National Weather Digest*, 7(4), pp. 19-24, 1982.

Niziol, T.A., "Operational Forecasting of Lake Effect Snow in Western and Central New York State", *Preprint, Eleventh Conference on Weather Forecasting and Analysis*, Boston, MA., pp. 200-205, 1986.

Niziol, T.A., "Operational Forecasting of Lake Effect Snowfall in Western and Central New York," *Weather and Forecasting*, 2, pp. 310-321, 1987.

Weinbeck, R.S., "Lake Effect Snows of Rochester and Buffalo, New York," *National Weather Digest*, 8(3), pp. 42-45, 1983.

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