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MISAWA
SNOW ACCUMULATION STUDY

by

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USAF
ENVIRONMENTAL TECHNICAL
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Scott Air Force Base, Illinois, 62225-5438

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13. Abstract: This report describes the development of statistically significant thresholds of 11 atmospheric variables for forecasting snow at Misawa Air Base, Japan. The 11 variables were: gradient-level temperature and dew-point temperature, 850-mb temperature, 700-mb temperature, thicknesses for five layers between 1,000 feet AGL and 500 mb, gradient wind direction, and gradient wind speed. USAFETAC did simple correlations of each variable with observed 6-hour snowfall amounts to develop a linear regression equation that would predict 6-hourly snowfall amounts. Since the linear regression did not show skill, the study was expanded to develop a decision tree for making a "yes" or "no" snow determination. The USAFETAC-developed decision tree scored well using dependent data, but not very well on independent data; it lost to persistence. USAFETAC does not recommend either technique for use in operational forecasting, but suggests further development and evaluation of the decision tree over a longer period of record.

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PREFACE

This report documents the results of USAFETAC Project 900807, as performed by USAFETAC's Operations Applications Development Section (DNO). The DNO analyst was William R. Schaub, Jr.

The tasking, from Detachment 13, 20th Weather Squadron (amended by 20WS/DO), asked USAFETAC to develop statistically significant thresholds of 11 atmospheric variables that could be used for forecasting snow at Misawa AB, Japan. The 11 variables were gradient-level temperature and dew-point temperature, 850-mb temperature, 700-mb temperature, thicknesses for five layers between 1,000 feet AGL and 500 mb, gradient wind direction, and gradient wind speed.

DNO started by making simple correlations of each variable with observed 6-hour snowfall amounts to develop a linear regression equation for predicting 6-hourly snowfall amounts. When the linear regression did not show skill, the study was expanded to produce a decision tree for making a "yes" or "no" snow determination. The decision tree scored well using dependent data, but not very well on independent data; in fact, it lost to persistence.

USAFETAC does not recommend either technique for use in operational forecasting, but suggests that the decision tree be developed further and evaluated with a longer period of record.

CONTENTS

FIGURES

1. INTRODUCTION.

1.1 Background. During the Siberian northwest monsoon, there is frequent and heavy snowfall in the western coastal regions of central Japan on the island of Honshu. These coastal regions are windward of a mountain range that extends the full length of the island. As cold air masses move over the warm Sea of Japan, heat and moisture transfer results in extensive cloudiness. The resultant snowfall along the west coast of Honshu has been attributed primarily to orographic lifting (Estoque and Ninomiya, 1976), a precipitation mechanism that contrasts with the lake-effect snows in the Great Lakes region of the United States. In the absence of orography, mesoscale convective systems develop on the leeward side of the Great Lakes and produce heavy snowfall in western and central New York (Niziol, 1987).

1.2 Focus of the Study. This study concerns Misawa Air Base, Japan (40° 2´ N, 141° 22´ E), situated near the northeast corner of Honshu on the leeward side of the mountains (see Figure 1). Misawa averages more than 120 inches of snow a year. The customer for this study (Detachment 13, 20th Weather Squadron) uses several tools for snow forecasting; these include local forecast studies, analysis of the Misawa upper-air sounding, and model-derived forecasts of surface and upper-air variables.

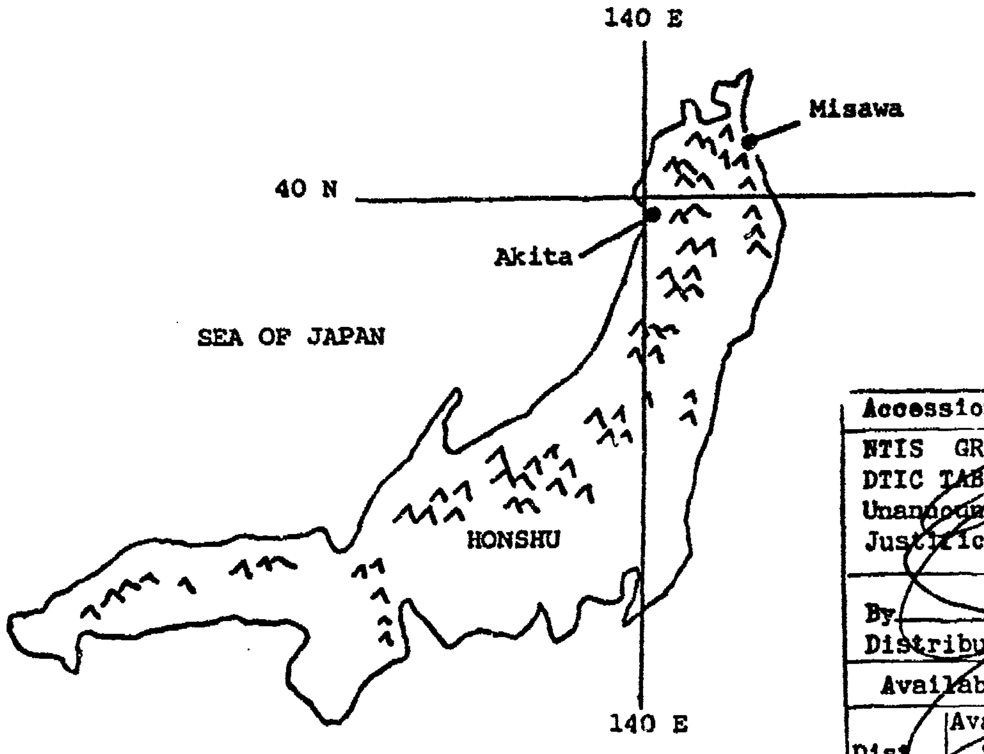

Figure 1. Area of Interest.

1.3 Atmospheric Variables Used. Detachment 13 provided USAFETAC with 11 basic atmospheric variables. These were collected over one winter season and part of another from forecast bulletins issued twice daily by the Air Force Global Weather Central (AFGWC). The amount of data supplied was the minimum necessary to attempt a study. Det 13 asked USAFETAC to perform a statistical analysis of the 11 variables supplied to see if any value of any variable could be related to the amount of observed 6-hour snowfall. "Basic," "time-phased," and "trend" variables are shown and explained below.

Basic Variables[1]	**Definitions**
GRADTEMP	Gradient-level temperature over Misawa.
GRADDEWT	Gradient-level dew point temperature over Misawa.
TEMP850	Temperature at 850 mb over Misawa.
TEMP700	Temperature at 700 mb over Misawa.
THKNS1	Thickness from 1,000 ft AGL (above ground level) to 500 mb over Misawa.
THKNS2	Thickness from 1,000 ft AGL to 700 mb over Misawa.
THKNS3	Thickness from 1,000 ft AGL to 850 mb over Misawa.
THKNS4	Thickness from 850 mb to 500 mb over Misawa.
THKNS5	Thickness from 850 mb to 700 mb over Misawa.
GRWNDDIR	Gradient wind direction over Misawa.
GRWNDSPD	Gradient wind speed over Misawa.

Time-phased Variables[2]

GRADTEM_
GRADDEW_
TEMP85_
TEMP70_
THKNS1_
THKNS2_
THKNS3_
THKNS4_
THKNS5_
GWNDDIR_
GWNDSPD_

Trend Variables[3]

GRDTDIFF
GRDDDIFF
T850DIFF
T700DIFF
THK1DIFF
THK2DIFF
THK3DIFF
THK4DIFF
THK5DIFF
WDIRDIFF
WSPDDIFF

1 Variables valid at time of snowfall measurement
2 Same as basic variables, but valid 6 hours prior to snowfall measurement
3 Changes in basic variables during the 6 hours prior to snowfall measurement

Figure 2. List of Variables. Units: temperatures in Celsius (C), thicknesses in geopotential meters, gradient wind directions in degrees, and gradient wind speed in knots.

1.4 Correlations Requested. Threshold values for each of the 11 basic variables were requested for forecasting 6-hour snowfall amount. Det 13 recommended the following correlations with 6-hour observed snowfall:

- **basic variables**--those with the same valid time (0000Z plus every 6 hours) as snowfall measurement.
- **time-phased variables**--those with valid times 6 hours prior to each snowfall measurement.
- **trend variables**--the changes in variables during the 6 hours prior to each snowfall measurement.

1.5 The Correlation Scheme. DNO used the pairing scheme shown in Figure 3 to compute the requested correlations by the Pearson product-moment correlation method. Although the correlations shown below were low, linear regression was attempted on the basic and time-phased variables (the predictors) to develop predictive equations for 6-hour snowfall amount in inches (the predictand). All attempts at regression, using the statistically best combinations of variables, resulted in snowfall estimates far below the amounts actually observed; the results are not presented. Had more variables been available (e.g., moisture and winds at upper levels), results may have been more encouraging. Ishihara (1968) was successful in obtaining realistic predictions of average daily snowfall in 35 areas of the Hokuriku District of west central Honshu. With much more surface and upper-air data at his disposal, Ishihara was able to include water vapor transport, instability energy, winds aloft, relative vorticity, divergence, and vertical motion as predictors in the linear regression.

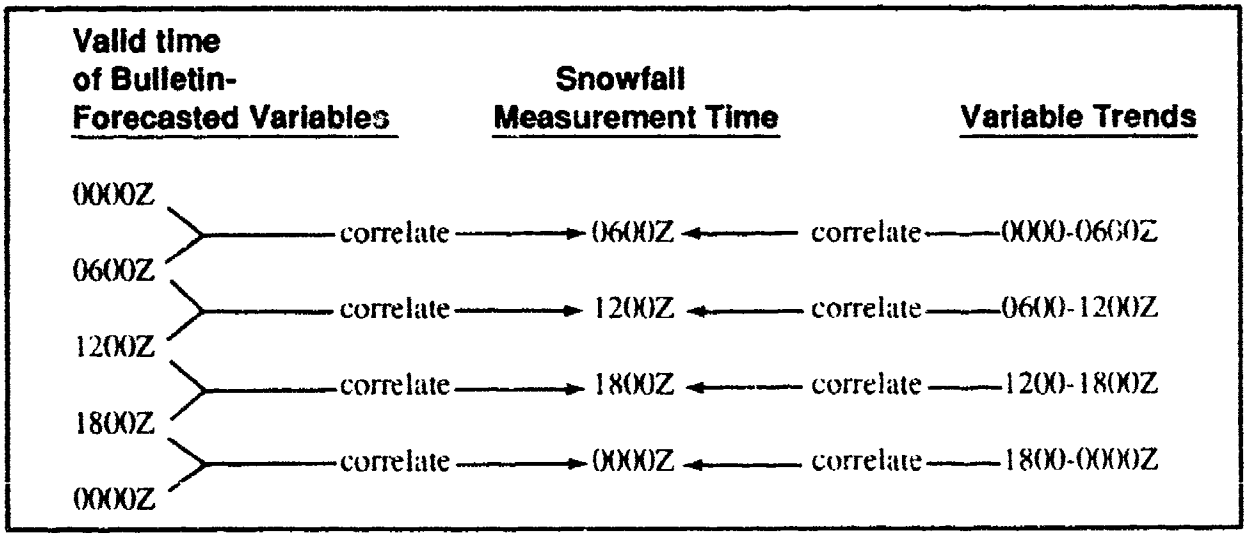

Figure 3. Correlation Scheme. Variables and variable trends are correlated with 6-hour observed snowfall amounts, as shown by arrows.

1.6 The Snow Forecasting Decision Tree. After confirming the unfavorable correlation and regression results, USAFETAC used knowledge gained from a study on lake-effect snow at Griffiss AFB, New York (De Block and Schaub, 1990) to develop a snow forecasting decision tree for Misawa. This decision tree (shown in Figure 4) includes all the basic variables provided by the customer except gradient-level dew point temperature. In order to use the decision tree to determine whether snow is likely, all the threshold values of the variables must be met. Of many trees tested, this one verified best and showed the most forecasting skill--see Section 4 for a comparison of forecast skill between the decision tree, the snow forecasts issued by Misawa, an objective snow amount estimation technique used at Misawa, and persistence. USAFETAC believes that snow forecasting at Misawa can be improved by using the tree, but this study provides only initial guidance in developing a forecast aid; it is not an approved forecast study. As more data is gathered, the actual thresholds used in this study may change significantly.

DECISION TREE FOR SNOW AT MISAWA AB, JAPAN

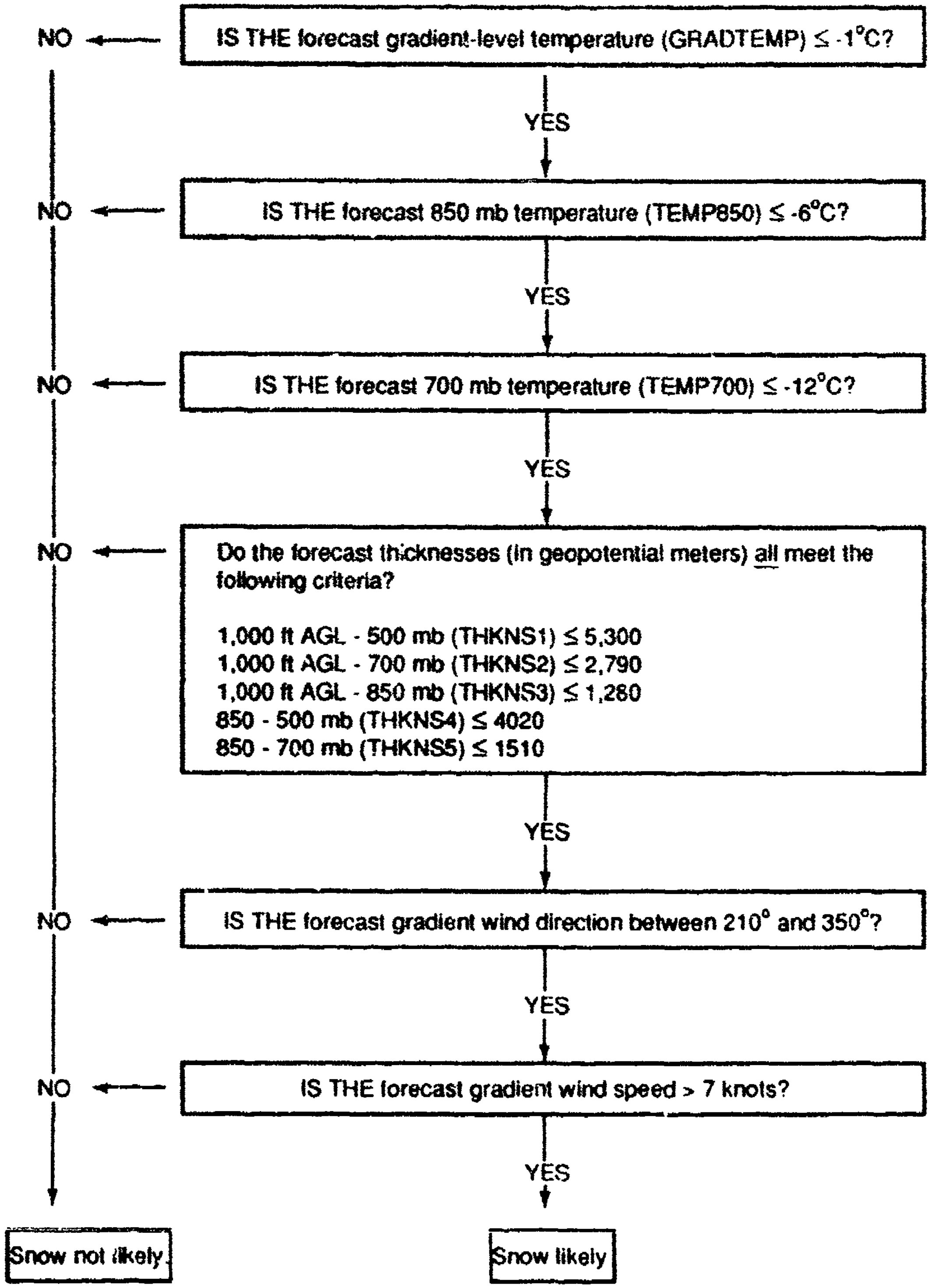

Figure 4. Snow Forecasting Decision Tree for Use as a Guide at Misawa Air Base, Japan.

2. DATA AND LIMITATIONS.

2.1 Variable Data Provided. Det 13 provided the 11 basic variables shown in Figure 2 for these periods of record: 11 January 1989 to 27 February 1989, and 23 October 1989 to 16 March 1990. Data was collected from forecast bulletins FJAS KGWC and FXPA 40 KGWC, issued daily at 0000Z and 1200Z by the Air Force Global Weather Central (AFGWC). FJAS KGWC is based on the AFGWC Macroscale Cloud Model; it provides gradient-level temperature and dew point temperature, 850-mb temperature, and 700-mb temperature for Misawa valid every 6 hours for 48 hours from issue time. FXPA 40 KGWC is based on the AFGWC Asian Boundary Layer Model, the AFGWC Macroscale Cloud Model, and the coarse mesh grid system data (from Global Spectral Model); it provides gradient-level wind direction and speed, as well as thickness for five layers, valid every 6 hours for 36 hours from issue time. To develop the Misawa snow forecasting decision trees, the data from 23 October 1989 to 16 March 1990 was used. For independent verification of the trees, only 6 weeks of data (11 January 1989 to 27 February 1989) was used.

2.2 Actual Snow Data Provided. Along with the basic variables, Det 13 also provided data on actual 6-hour snow amount forecasts and 6-hour snow amount estimates made as a Misawa forecasting guide following objective procedures recommended by Cook (1980). The actual 6-hour snow amount forecasts are included in Misawa forecasts issued every 6 hours and valid for 24 hours. To obtain snow amount estimates from Cook's method, the 300-mb analysis is used. The warmest temperature found within 15 degrees of latitude upstream from Misawa is subtracted from the 300-mb temperature over Misawa. The absolute value of that difference is divided by two and used as the estimated snowfall in inches for a 24-hour period. The estimate is reduced by half if there is cold air advection at 700 mb within 8 degrees of latitude upstream from Misawa. The estimated 24-hour snowfall amount is then divided by four to obtain 6-hour snow amount estimates. Finally, the data on Misawa's 6-hour snow amount forecasts, and estimates from Cook's method, were verified against observed snowfall; this is described in Section 3.

2.3 Period of Record (POR) Limitations. An obvious limitation on the results of this study was the short POR that included only one full winter season and part of another. As shown by Rodney (1986), a POR near 10 years is considered adequate to provide a stable arithmetic mean of a variable. With the arithmetic mean stable, a variable has a relatively low error of prediction. This is important in regression analysis, where a variable is used as a predictor. A longer POR may have improved the results of this study and resulted in a significantly different decision tree.

2.4 Data Limitations. Although there were enough basic variables to allow development of a useful snow forecasting decision tree, there was not enough information for development of a regression equation to predict 6-hour snowfall amount. Ishihara (1968) noted the importance of the 850-mb dew point depression as a predictor for snow accumulation. He also noted that the 500-mb temperature is important because of its relationship with instability and the mid-tropospheric cold low over the Sea of Japan in winter. Nagata (1987) used a 24-year period of record for January to show the importance of upper-level winds as related to daily snowfall amounts in western coastal areas of Honshu. For the Tohoku District of Honshu, where Misawa Air Base is located, Nagata found a positive correlation (correlation coefficient 0.392) between winds aloft and daily snowfall. The positive correlation occurred when winds at Akita were southeasterly up to 600 mb, with speed increasing with height. In the study by De Block and Schaub (1990), dew point depression at 850 mb and upper winds to 700 mb were essential ingredients for development of lake-effect snow forecasting decision trees. From these examples, one can see that upper-level moisture and wind information would have been helpful in this study.

3. METHODOLOGY.

3.1 Approach. As the customer requested, the correlation scheme shown in Figure 3 was used to correlate all 11 input variables with 6-hour observed snowfall. An effort was also made to obtain a predictive equation for 6-hour snowfall amount (the predictand) through linear regression on the basic and time-phased variables (the predictors). The second part of this approach, which went beyond Det 13's original request, resulted in development (from basic variables) of a decision tree for use as a snow forecasting guide.

3.2 Procedure. Data from both PORs were combined into one data set. Before analysis, plots of observed 6-hour snowfall (including zero) versus each basic variable were made to examine the appearance of the distributions and evaluate any outliers. Some erroneous data was detected and corrected. For development of the snow forecasting decision tree, observations were sorted according to snow (trace or more) or no-snow cases. In that way, distributions of the variables could be analyzed for both cases.

3.3 Correlations. Correlations were done between all 11 basic variables and observed 6-hour snowfall amounts to determine the degree of linear relationship. A summary of correlation results is shown in Figure 5.

*Basic Variables	Correlation Coefficients	Time-Phased Variables	Correlation Coefficients	Trend Variables	Correlation Coefficients
GRADTEMP	-0.253	GRADTEM_	-0.227	GRDTDIFF	-0.082
GRADDEWT	-0.226	GRADDEW_	-0.199	GRDDDIFF	-0.069
TEMP850	-0.242	TEMP85_	-0.224	T850DIFF	-0.053
TEMP700	-0.217	TEMP70_	-0.217	T700DIFF	0.006
THKNS1	-0.247	THKNS1_	-0.233	THK1DIFF	-0.053
THKNS2	-0.251	THKNS2_	-0.231	THK2DIFF	-0.041
THKNS3	-0.273	THKNS3_	-0.240	THK3DIFF	-0.102
THKNS4	-0.190	THKNS4_	-0.183	THK4DIFF	-0.007
THKNS5	-0.244	THKNS5_	-0.234	THK5DIFF	-0.030
GRWNDDIR	0.039	GWNDDIR_	0.015	WDIRDIFF	0.025
GRWNDSPD	0.[illegible]39	GWNDSPD_	0.169	WSPDDIFF	0.105

** Variable definitions and units of measure:*

GRADTEMP	Gradient-level temperature over Misawa (°C).
GRADDEWT	Gradient-level dew-point temperature over Misawa (°C).
TEMP850	Temperature at [illegible] mb over Misawa (°C)
TEMP700	Temperature at 700 mb over Misawa (°C).
THKNS1	Thickness 1,000 ft AGL (above ground level)-500 mb over Misawa (geopotential meters).
THKNS2	Thickness 1,000 ft AGL-750 mb over Misawa (geopotential meters).
THKNS3	Thickness 1,000 ft AGL-850 mb over Misawa (geopotential meters).
THKNS4	Thickness 850-500 mb over Misawa (geopotential meters).
THKNS5	Thickness 850-700 mb over Misawa (geopotential meters).
GRWNDDIR	Gradient wind direction over Misawa (degrees).
GRWNDSPD	Gradient wind speed over Misawa (knots).

Figure 5. Correlations of Model-Derived Atmospheric Variables with Observed 6-hour Snowfall Amounts (including zero and trace) for Misawa Air Base, Japan.

A variable and snowfall amount are linearly independent (no predictive relationship) if the correlation coefficient is zero, while a correlation coefficient of -1 or 1 indicates total dependence. With a positive correlation coefficient, an increase in magnitude of the variable is accompanied by an increase in magnitude of snowfall amount. In the case of a negative correlation coefficient, an increase in magnitude of the variable is accompanied by a decrease in magnitude of snowfall amount. A best-fit straight line through plots of snowfall amount versus variable has a positive or negative slope, respectively. None of the variables showed particularly high degrees of linear relationship with snowfall amount. As pointed out by Essenwanger (1986), low correlations may be due in part to a nonlinear relationship between the variables and snowfall amount.

3.4 Linear Regression. Although correlation results were not encouraging, attempts were made to develop a predictive equation for 6-hour snowfall amount by linear regression. Regression was performed with each of the basic variables separately, combinations of the statistically best basic variables, and combinations of the statistically best basic and time-phased variables. Trend variables were not included as predictors because of their low correlation results. The coefficient of determination, R^2 (where 1.0 is a perfect regression and 0.0 shows no relationship), did not exceed 0.13. A coefficient of determination of 0.13 indicates the predictors could account for only 13 percent of the variability in snowfall. In all cases, observed 6-hour snowfall amounts were vastly underestimated. For these reasons, regression results are not presented.

3.5 Decision Tree Development. After the linear regression requested by Det 13 did not show skill, an attempt was made to provide a "yes or no" snow forecast. Techniques from a previous study (De Block and Schaub, 1990) were used to develop the snow forecasting decision tree shown in Figure 4. The decision tree provides a "yes or no" determination of snow occurrence based on 10 of the forecasted basic variables. When the variables meet the threshold values shown, snow is likely to occur; otherwise, snow is unlikely. As a starting point, plots of observed 6-hour snowfall amounts (including zero) versus each basic variable were made to see the ranges within which most of the snow cases occurred. Observations were then sorted according to "snow" (trace or more) or "no-snow" cases, and frequency distributions of the basic variables were produced for each case separately.

3.5.1 If snow only occurred when the gradient-level temperature was less than -1° C, and if it never occurred when the temperature was *greater* than -1° C, determining the threshold for the decision tree would be easy. Unfortunately, data showed that snow and no-snow cases both occurred at -1° C. A subjective statistical method was then employed to select the value (threshold) that produced snow more times than no snow; this involved using the highest possible percentile value from the temperature distribution for snow cases without exceeding the 50th percentile temperature for no-snow cases. As it turned out, the 95th percentile value for snow cases was the highest possible value. As shown in Figure 6, if the variable's 95th percentile value for the snow cases appeared at or below the 50th percentile value for no-snow cases (if it were associated with less than half of the no-snow cases), it was selected for use in the developmental decision trees. This selection process yielded threshold values for each basic variable except gradient-level dew point temperature, which was excluded because its 95th percentile for snow cases was above its 50th percentile value for no-snow cases (-3° C and -6° C, respectively). For gradient wind direction and speed, it proved best to determine an optimum range of gradient wind direction for snow occurrence and a minimum speed above which snow might occur. That determination was made by analyzing the plots of 6-hour snowfall amounts versus those variables, and by experimenting with different ranges in the decision trees.

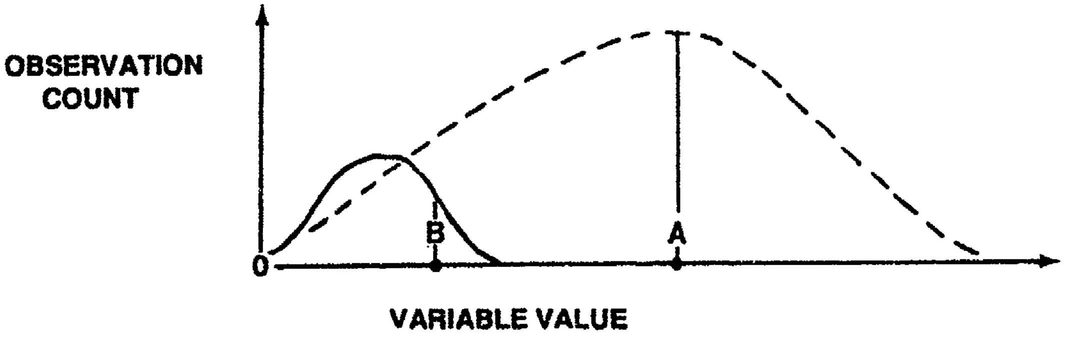

Figure 6. Superimposed Frequency Distributions of a Variable for Snow Cases (solid curve) and No-Snow Cases (dashed curve). Point A represents the 50th percentile for no-snow cases; Point B represents the 95th percentile for snow cases. In this example, the value at B would be used as a threshold in the decision tree. If the value of the variable were less than or equal to B, snow was likely.

3.6 Verification Statistics. To develop the final tree, the variables used (and their thresholds) were varied. A Heidke skill score (which ranges from zero to one, where zero represents no skill and one represents total accuracy) was calculated for each tree using the dependent data set. The tree with the best Heidke skill score was also verified using the independent data set. As a further measure of the final decision tree's skill, it was compared with the skills of the Misawa snow forecast, Cook's method, and persistence.

4. RESULTS.

4.1 Verification of Decision Trees. More than 60 decision trees were developed and tested using different combinations of the basic variables. All were verified against all observations in the POR from 23 October 1989 to 16 March 1990 (dependent data set) using standard verification matrices. Figure 7 shows the verification matrix used with the best Misawa decision tree as the example. The numbers in the matrix represent the number of observations where snow *did not* occur (no) and *did* occur (yes) on the abscissa, against whether the tree *did not* forecast snow (no) or *did* forecast snow (yes) on the ordinate. The numbers outside the matrix are row and column totals. The matrix shows that there were 268 observations of no-snow when the tree forecast none (hits), and 80 observations of no-snow when the tree *did* forecast snow (false alarms). Similarly, there were 32 observations of snow when the tree forecast no snow (misses), and 194 observations of snow when the tree forecast snow (hits). A chi square test indicated that this distribution was significantly different from random chance (at the 0.005 level). Also shown in Figure 7 are the equations and calculations for the Heidke skill score, probability of detection, and false alarm rate. The best decision tree Heidke skill score of 0.63 was quite good. It also had a high probability of detection (0.86) for the occurrence of snow and a low false alarm rate (0.29).

		OBSERVED 6-HOUR SNOWFALL		
		NO	YES	TOTAL
BEST MISAWA DECISION TREE FORECAST	NO	268 (A)	32	300 (R1)
	YES	80	194 (B)	274 (R2)
	TOTAL	348 (C1)	226 (C2)	574 (T)

Heidke Skill Score = (F-D)/(T-D)

where F = A+B and D = (C1R1 + C2R2)/T

Best Misawa tree score = 0.63

Probability of Detection = B/C2 = 0.86

False Alarm Rate = (R2 - B)/R2 = 0.29

Figure 7. Verification Matrix and Heidke Skill Score Calculation for the Best Misawa Snow Forecast Decision Tree.

4.1.1 As an independent test of the best Misawa snow forecasting decision tree, the tree was verified using observations from 11 Jan 89 to 27 Feb 89. Verification results for the best Misawa decision tree are shown below. Although a lower score is expected from independent verification, the drop in skill to 0.24 indicates the importance of a longer POR for forecast study development. The small number of observations in the independent data set may have exaggerated this problem.

VARIABLES* AND THRESHOLD VALUES

GRADTEMP	TEMP850	TEMP700	THKNS1	THKNS2	THKNS3	THKNS4	THKNS5	GRWNDDIR	GRWNDSPD
≤-1	≤-6	≤-12	≤5300	≤2790	≤1280	≤4020	≤1510	210-350	>7

HEIDKE SKILL SCORE

Dependent Data Set	Independent Data Set
0.63	0.24

**Variable definitions and units of measure:*

GRADTEMP - Gradient-level temperature over Misawa (°C).
TEMP850 - Temperature at 850 mb over Misawa (°C).
TEMP700 - Temperature at 700 mb over Misawa (°C).
THKNS1 - Thickness 1,000 ft AGL (above ground level)-500 mb over Misawa (geopotential meters).
THKNS2 - Thickness 1,000 ft AGL-750 mb over Misawa (geopotential meters).
THKNS3 - Thickness 1,000 ft AGL-850 mb over Misawa (geopotential meters).
THKNS4 - Thickness 850-500 mb over Misawa (geopotential meters).
THKNS5 - Thickness 850-700 mb over Misawa (geopotential meters).
GRWNDDIR - Gradient wind direction over Misawa (degrees).
GRWNDSPD - Gradient wind speed over Misawa (knots).

Figure 8. Dependent and Independent Verification of Best Misawa Snow Forecast Decision Tree.

4.1.2 Following the same procedure used in verifying the decision tree, Heidke skill scores were calculated for the actual 6-hour snowfall forecasts issued by Misawa, 6-hour snowfall estimates obtained from Cook's method, and persistence. The data was sorted according to snow (yes) and no-snow (no). Persistence was considered a "yes" if an observed 6-hour snowfall of trace or more was followed by another, or if an observation of no snowfall was followed by another of no snowfall. Otherwise, persistence was considered a "no." The Heidke skill scores were then compared to those for the decision tree. Based on the dependent data set, persistence scored best at 0.66. The Misawa forecast skill and the decision tree's skill were about the same (0.60 and 0.63, respectively). Cook's method had a very low 0.01 score. In the independent data set test, persistence again scored best at 0.67. The Misawa forecast skill was 0.49; the decision tree's, 0.24. Cook's method scored low at 0.11. Based on these limited test results, persistence showed more skill at predicting snow occurrence than the Misawa forecasters, the decision tree, and Cook's method, which had very poor skill. While the decision tree scored about the same as the Misawa forecast in the dependent data set test, its lower score in the independent data set test can be attributed not only to the small number of observations but to forecaster experience at Misawa.

4.2 Implications for Misawa. Although the correlations of basic, time-phased, and trend variables with observed 6-hour snowfall amounts were low, and although linear regression on the basic and time-phased variables to develop a predictive equation for 6-hour snowfall amounts was unsuccessful, the snow forecasting decision tree (Figure 4) shows promise as a guide for snow forecasting at Misawa. With a modest rate of misses and false alarms, it should prove useful in recognizing situations conducive to snow.

5. SUMMARY.

5.1 The Basic Study. The purpose of this study, for Misawa Air Base, Japan, was to develop a predictive equation for 6-hour snowfall amount based on observed 6-hour snowfall and model-derived variables for PORs from 11 January 1989 to 27 February 1989 and from 23 October 1989 to 16 March 1990. USAFETAC performed simple correlations of forecasted variables with observed snowfall. Despite the low correlation coefficients obtained, linear regression was attempted. Both single and multiple regression equations generated from the best combinations of variables gave unrealistically low 6-hour snowfall estimates. The poor regression results may be attributed in part to the short POR, lack of upper-level moisture and wind variables, and nonlinear relationships between the variables and snowfall amount.

5.2 The Expanded Study. USAFETAC took the basic request a step further by developing a snow forecasting decision tree for Misawa based on the 11 basic variables. Threshold values of the basic variables were determined by comparing their 95th percentile values for snow cases with their 50th percentile values for no-snow cases. If the 95th percentile values for snow cases were less than the 50th percentile values for no-snow cases, they were selected as threshold values for inclusion in the decision tree. The gradient-level dew point temperature did not qualify for inclusion. For the gradient wind direction and speed, it was most beneficial to experimentally obtain a preferred gradient wind direction range for snow, along with a minimum speed, for inclusion in the trees. The best decision tree, which included all basic variables except gradient-level dew point temperature, had a Heidke skill score of 0.63 with the dependent data set (23 October 1989 to 16 March 1990), and a score of 0.24 with the independent data set (11 January 1989 to 27 February 1989). The score of 0.63 is considered good.

5.3 Skill Comparisons. The decision tree skill was tested further by comparing its skill to Misawa's snow forecasting skill, Cook's (1980) method of estimating snowfall amount, and persistence. Results showed that persistence scored best in both the dependent and independent data set tests. Cook's method scored poorly in both tests. The Misawa snow forecasting skill was about the same as the decision tree's in the dependent data set test, but it outscored the decision tree in the independent data set test.

5.4 Recommendations. USAFETAC does not recommend use of either the regression technique or the decision tree in operational forecasting. The decision tree should, however, be evaluated for usefulness as a guide in determining the likelihood of snow at Misawa. As more data is collected, the thresholds used in the decision tree can be adjusted in an effort to improve its performance.

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GLOSSARY

AFGWC	Air Force Global Weather Central (Offutt AFB, Nebraska)
AGL	Above ground level
GRADDEWT	Gradient-level dew-point temperature over Misawa
GRADDEW_	Same as GRADDEWT, except valid 6 hours prior to snowfall measurement
GRADTEMP	Gradient-level temperature over Misawa
GRADTEM_	Same as GRADTEMP, except valid 6 hours prior to snowfall measurement
GRDDDIFF	Change in GRADDEWT during the 6 hours prior to snowfall measurement
GRDTDIFF	Change in GRADTEMP during the 6 hours prior to snowfall measurement
GRWNDDIR	Gradient wind direction over Misawa
GRWNDSPD	Gradient wind speed over Misawa
GWNDDIR_	Same as GRWNDDIR, except valid 6 hours prior to snowfall measurement
GWNDSPD_	Same as GRWNDSPD, except valid 6 hours prior to snowfall measurement
R^2	Coefficient of determination
TEMP700	Temperature at 700 mb over Misawa
TEMP70_	Same as TEMP700, except valid 6 hours prior to snowfall measurement
TEMP850	Temperature at 850 mb over Misawa
TEMP85_	Same as TEMP850, except valid 6 hour prior to snowfall measurement

THKNS1	Thickness from 1,000 ft AGL to 500 mb over Misawa
THKNS1_	Same as THKNS1, except valid 6 hours prior to snowfall measurement
THKNS2	Thickness from 1,000 ft AGL to 700 mb over Misawa
THKNS2_	Same as THKNS2, except valid 6 hours prior to snowfall measurement
THKNS3	Thickness from 1,000 ft AGL to 850 mb over Misawa
THKNS3_	Same as THKNS3 except valid 6 hours prior to snowfall measurement
THKNS4	Thickness from 850 mb to 500 mb over Misawa
THKNS4_	Same as THKNS4, except valid 6 hours prior to snowfall measurement
THKNS5	Thickness from 850 mb to 700 mb over Misawa
THKNS5_	Same as THKNS5, except valid 6 hours prior to snowfall measurement
T700DIFF	Change in TEMP700 during the 6 hours prior to snowfall measurement
T850DIFF	Change in TEMP850 during the 6 hours prior to snowfall measurement
THK1DIFF	Change in THKNS1 during the 6 hours prior to snowfall measurement
THK2DIFF	Change in THKNS2 during the 6 hours prior to snowfall measurement
THK3DIFF	Change in THKNS3 during the 6 hours prior to snowfall measurement
THK4DIFF	Change in THKNS4 during the 6 hours prior to snowfall measurement

THK5DIFF	Change in THKNS5 during the 6 hours prior to snowfall measurement
USAFETAC	USAF Environmental Technical Applications Center
WDIRDIFF	Change in GRWNDDIR during the 6 hours prior to snowfall measurement
WSPDDIFF	Change in GRWNDSPD during the 6 hours prior to snowfall measurement
Z	Zulu (Greenwich Mean Time)

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